HYPERSONIC CFD APPLICATIONS AT NASA LANGLEY

USING CFL3D AND CFL3DE

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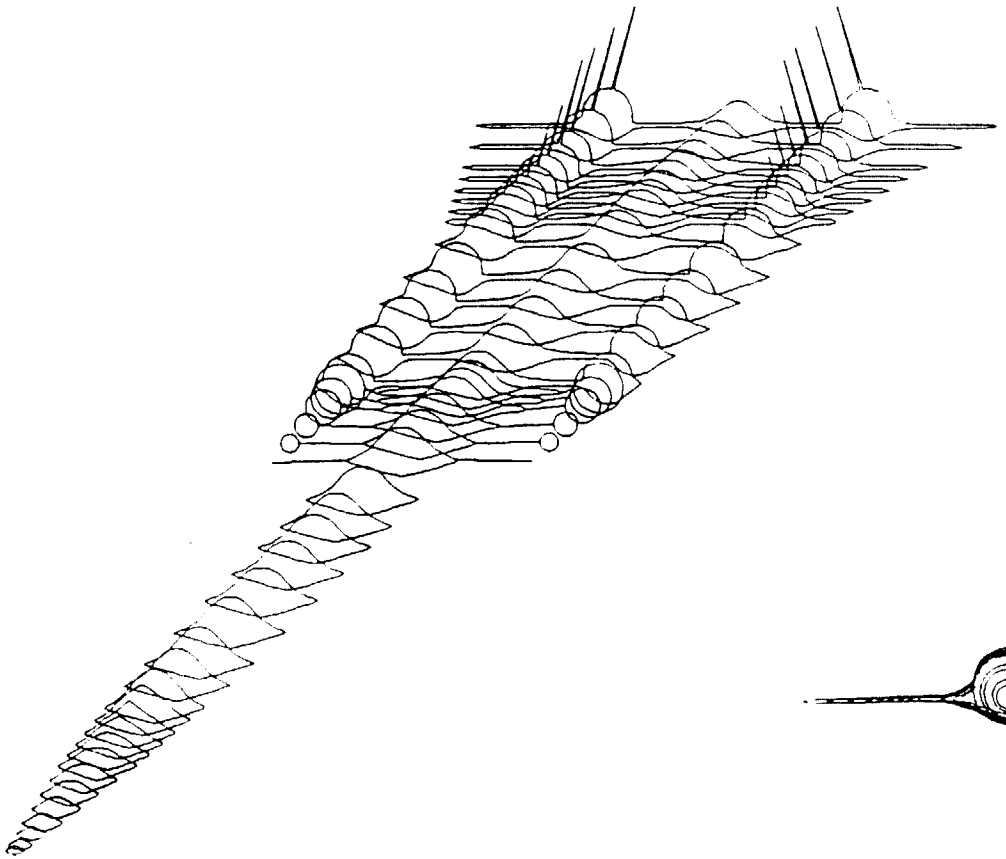
CFL3D/CFL3DE

- Time-dependent conservation law form of compressible Euler and Navier-Stokes equations
- Upwind-biased spatial differencing (Flux Vector Splitting - FVS and Flux Difference Splitting - FDS)
- Thin-layer, finite-volume implementation with algebraic turbulence model
- Zonal grids - longitudinally patched (for hypersonic flows)
  - CFL3D
    - 3-factor implicit time advancement algorithm
    - Thin-layer viscous in 3 directions - two wall corner model
  - CFL3DE
    - Streamwise-relaxation crossflow-AF, space-marching Euler or PNS, first or second order
    - Perfect gas or equilibrium air

INDUSTRY USE STATUS OF CODES

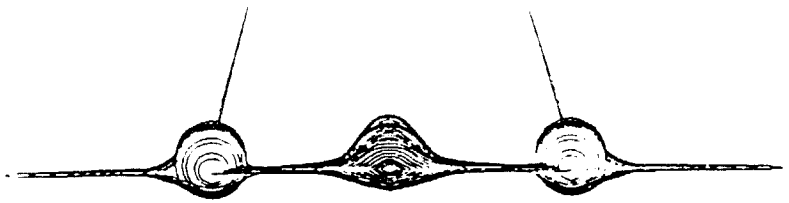
- NASP prime contractors - all instructed in code use at workshop August 2-3, 1988.
  - Production code for NASP for McDonnell Aircraft Company
  - Some use at General Dynamics
- Other industry use
  - Boeing
  - Northrup
  - United Technologies Research Center
- University use
  - Iowa State University
- Other government use
  - Naval Surface Warfare Center

SR71 - GEOMETRY DEFINITION



FOUR ZONES:

51X51X23
71X51X8
71X51X7
91X51X4

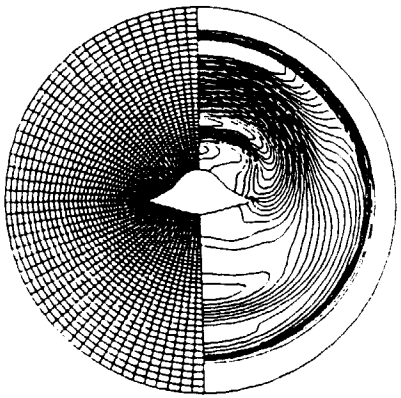


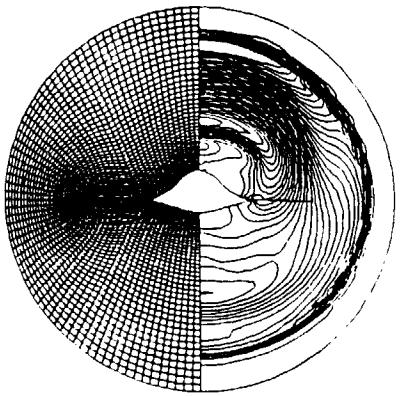
$M_\infty = 3.0 \quad \alpha = 0^o$

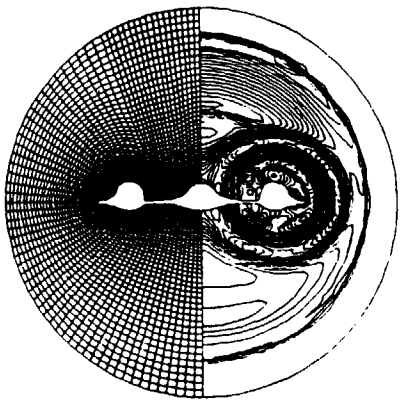
$\rho_\infty = 0.088 kg/m^3 \quad p_\infty = 5460 N/m^2$

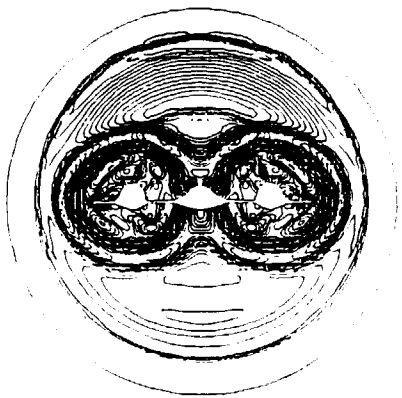
SR71 - EQUILIBRIUM AIR EULER SOLUTION

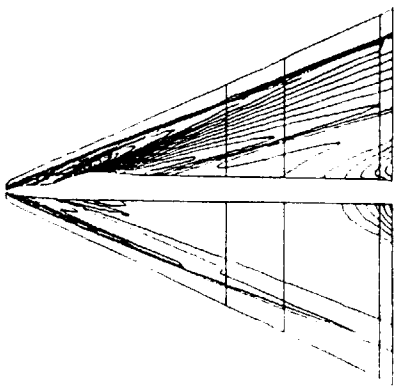
CROSS-SECTION PRESSURE DISTRIBUTIONS AND GRID DEFINITIONS

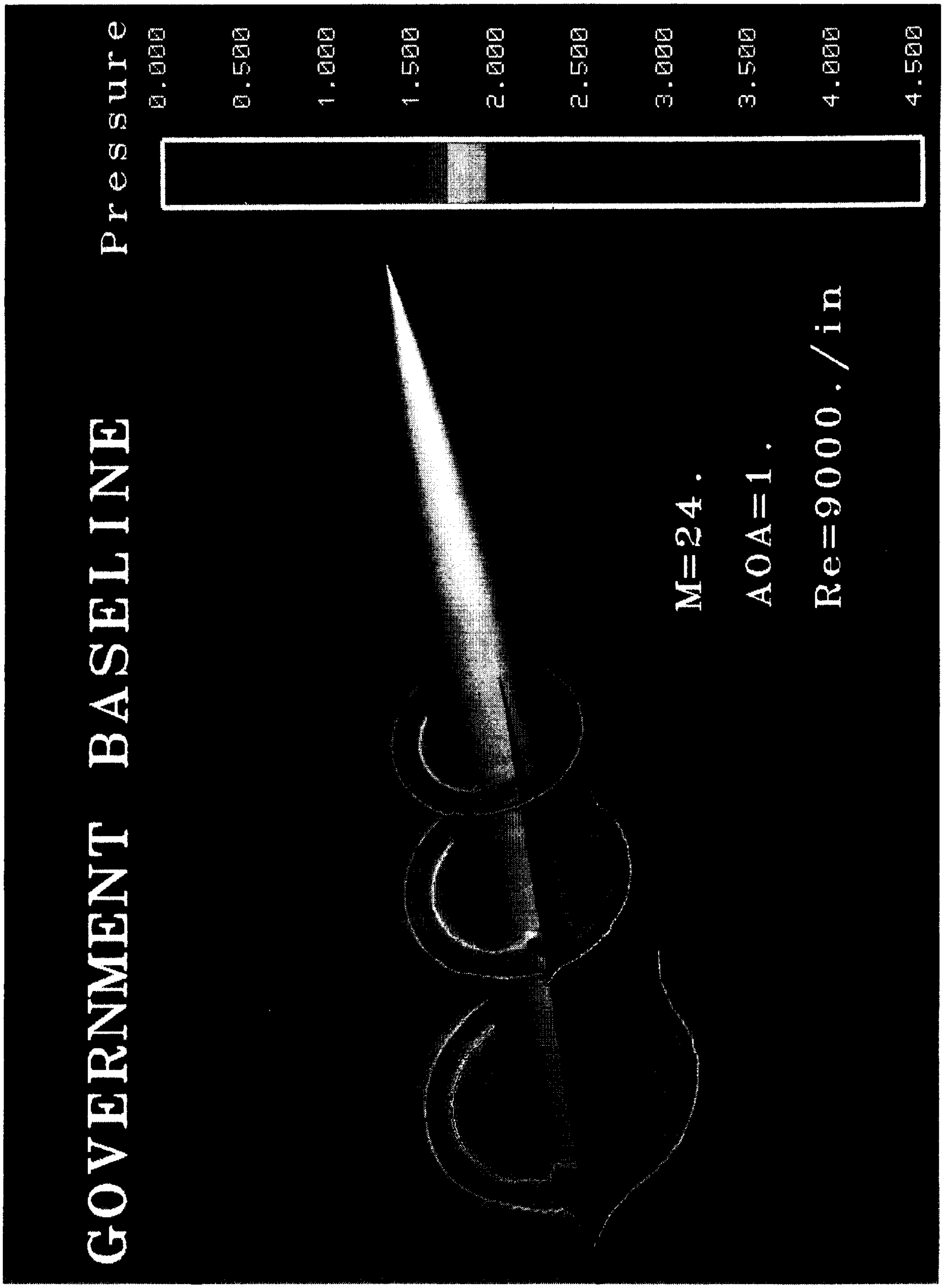


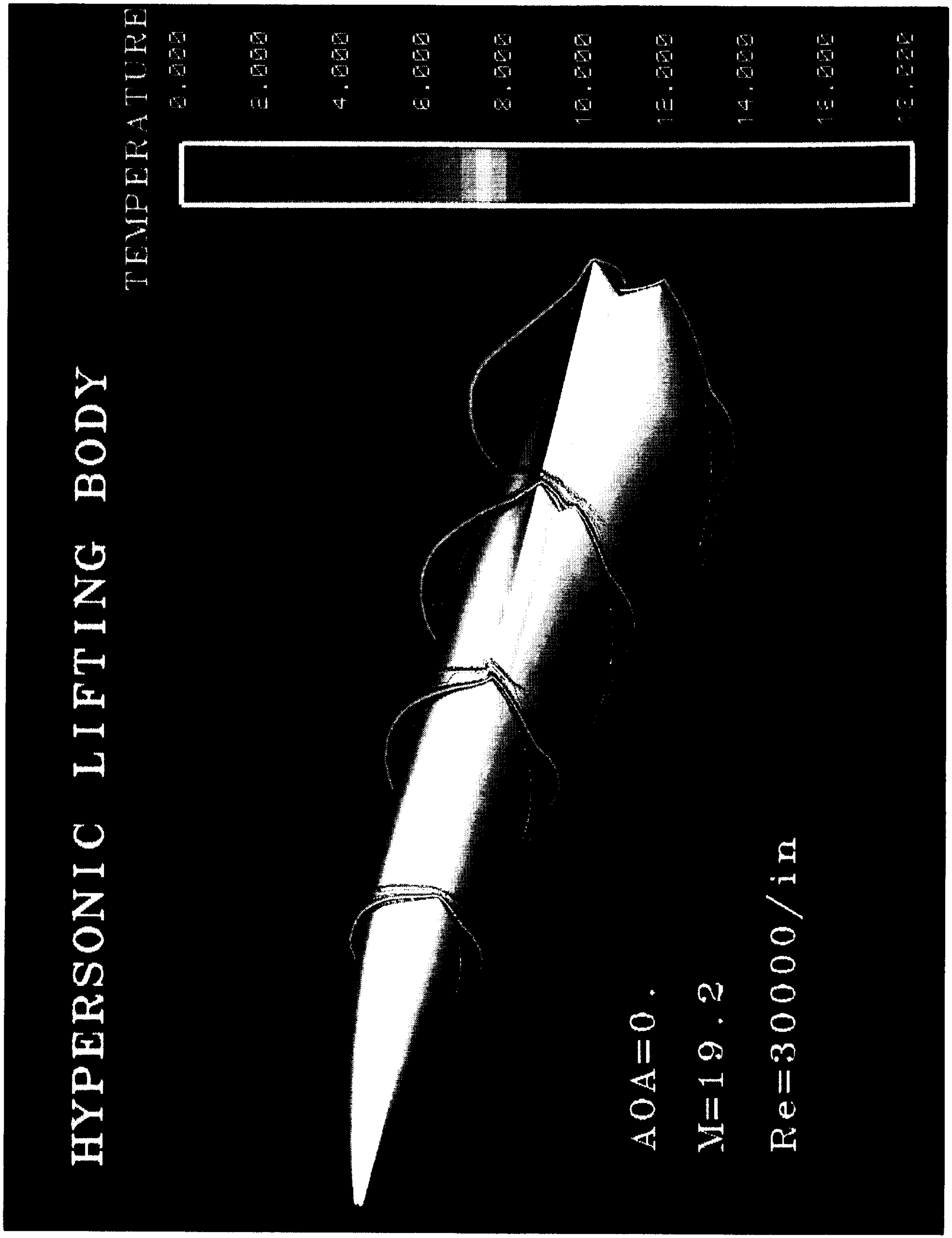


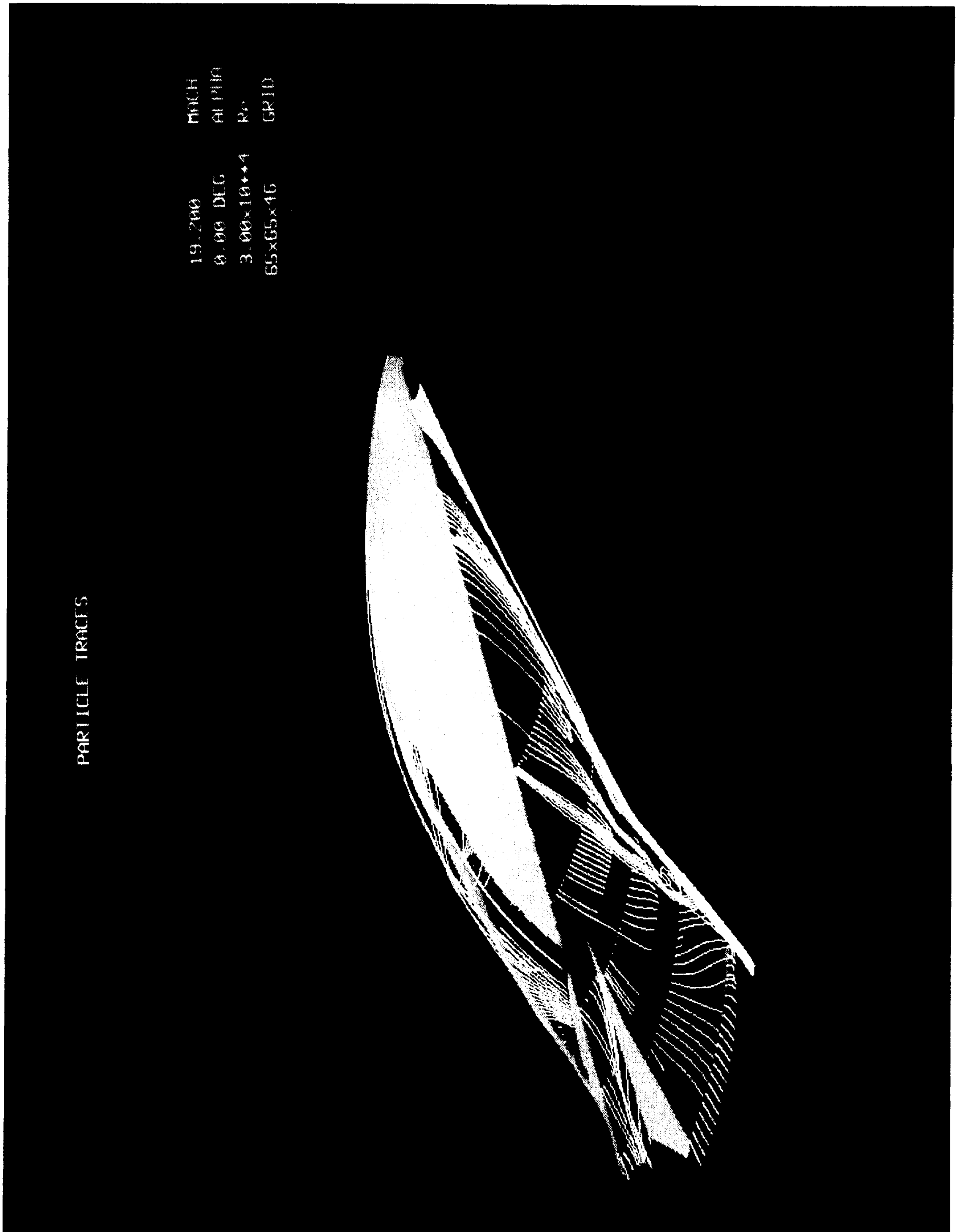






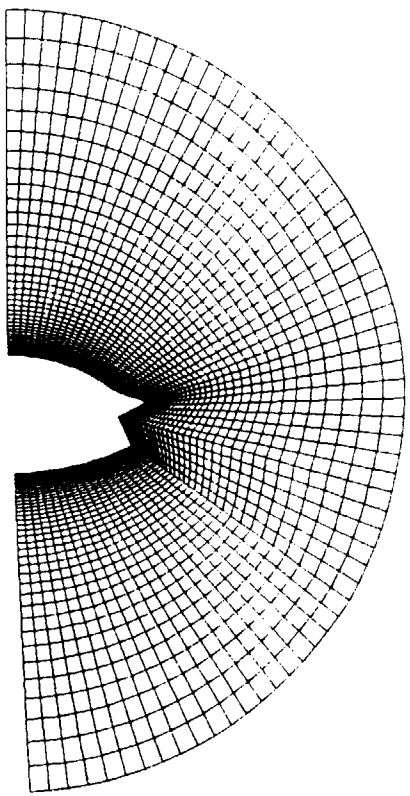




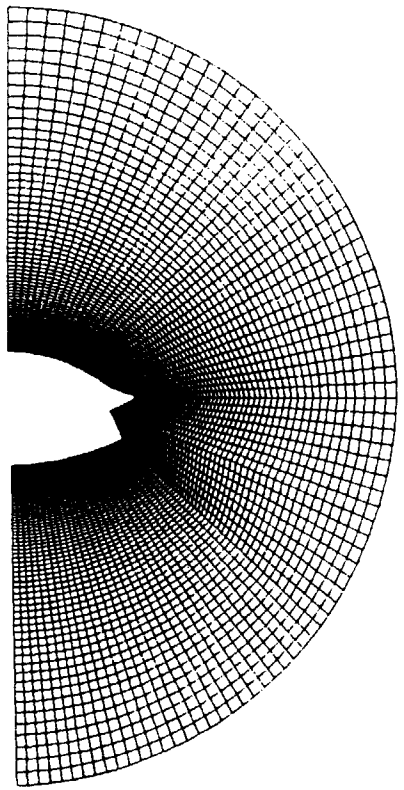


GRID DENSITY COMPARISON

CROSS-SECTION 45 (COWL PLANE)



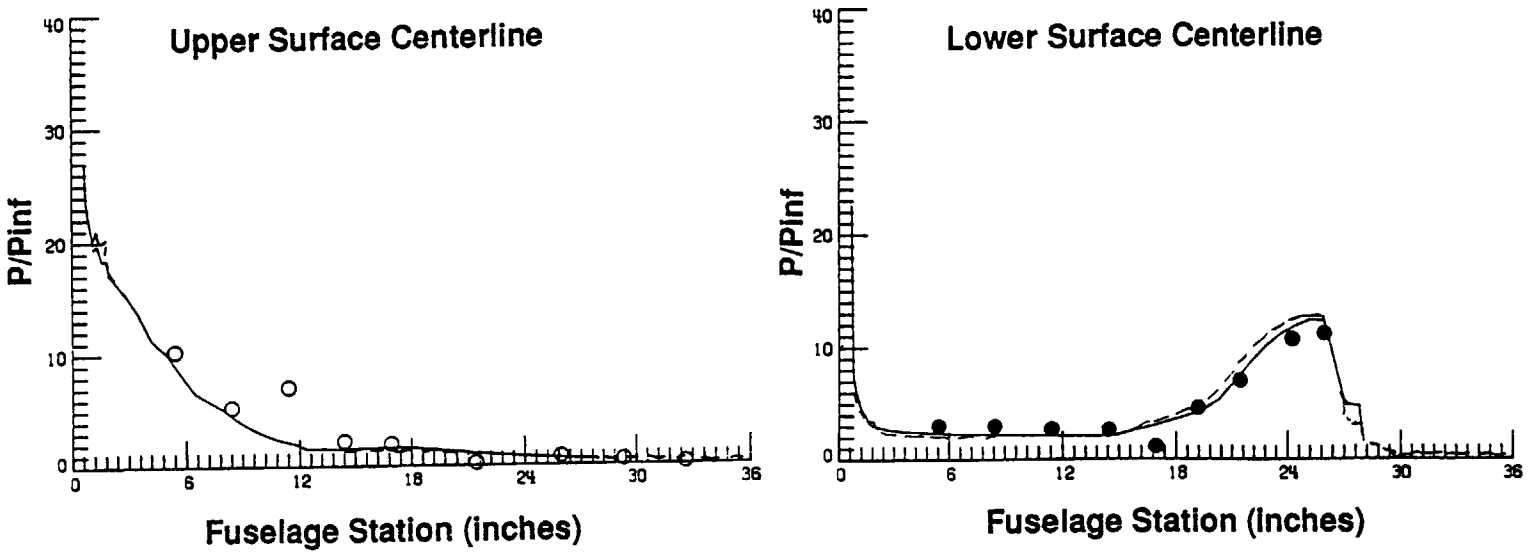
65 X 65 X 46 GRID
Y-PLUS ORDER 1.



80 X 130 X 56 GRID
Y-PLUS ORDER .001

PRESSURE COMPARISONS

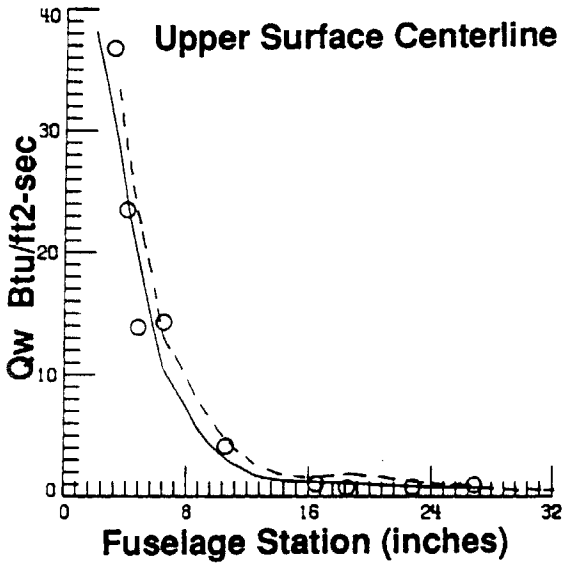
M = 12.55
Re = 2.7 million/ft.
Zero degrees angle of attack

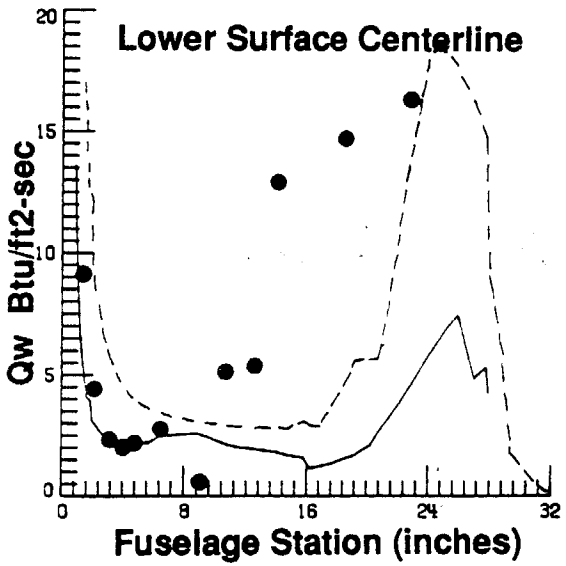


Open symbols - upper surface
Closed symbols - lower surface

HEAT TRANSFER COMPARISONS

M = 12.55
Re = 2.7 million/ft.
Zero degrees angle of attack



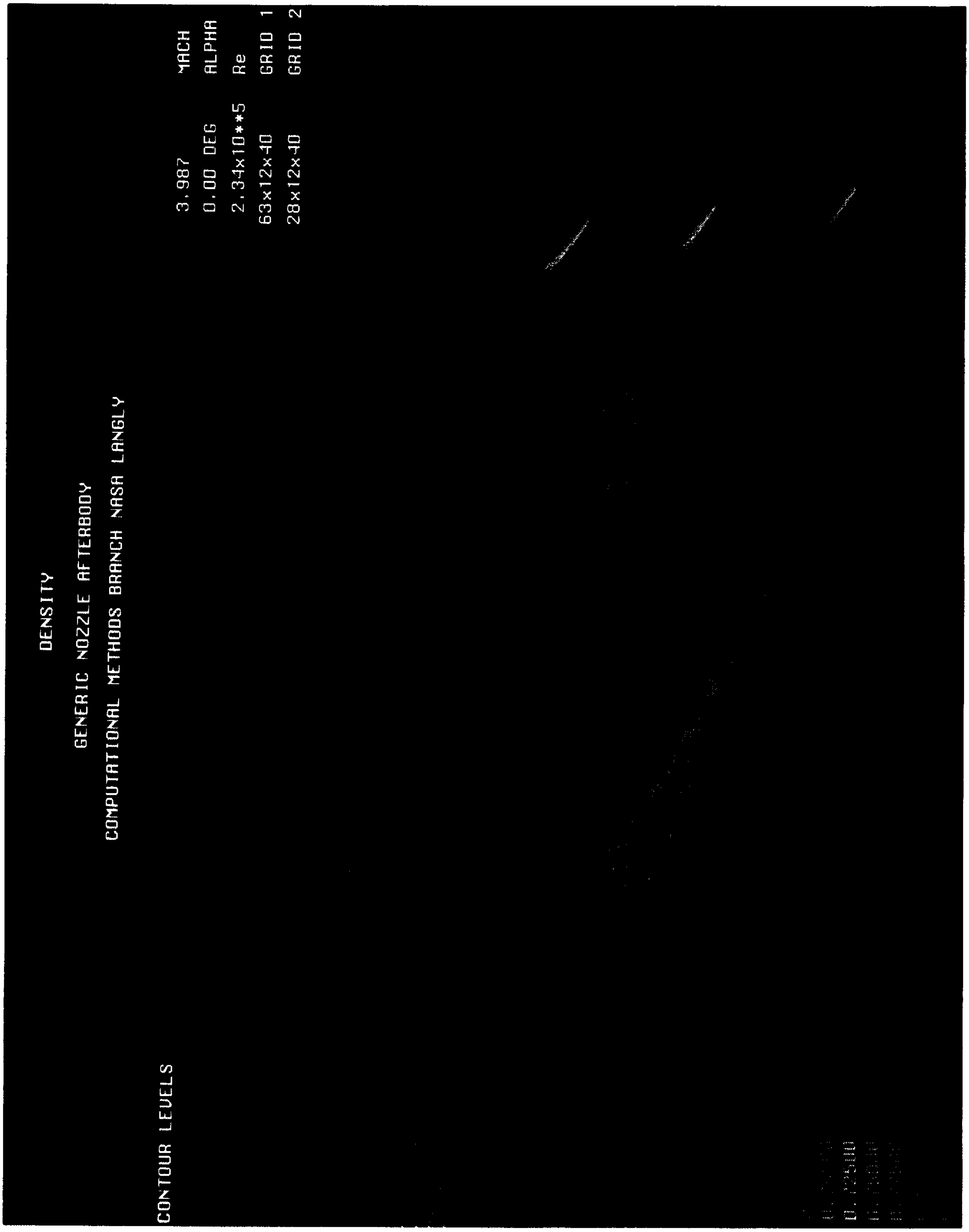


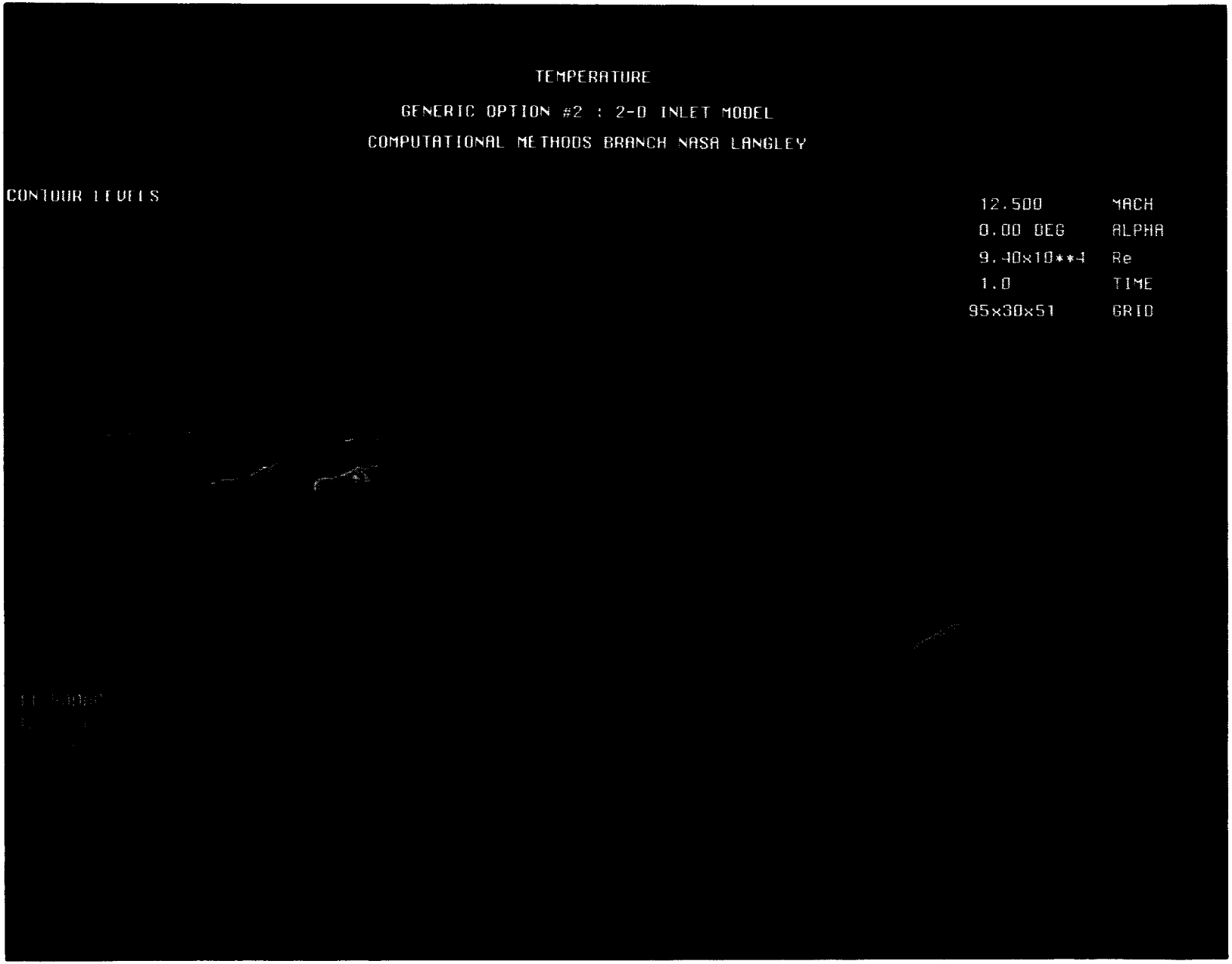
Open symbols - upper surface
Closed symbols - lower surface

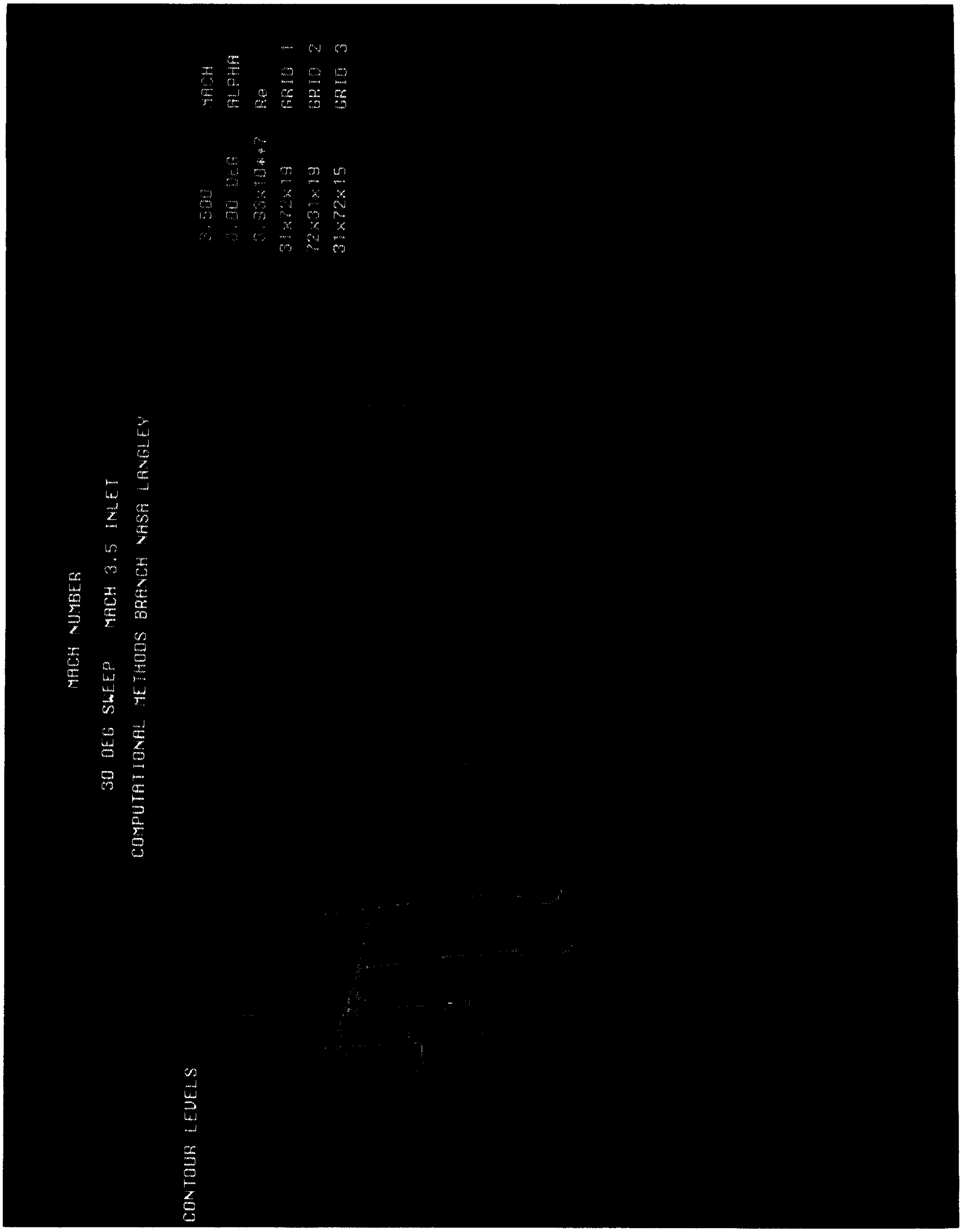
AERODYNAMIC COEFFICIENTS COMPARISON MCDONNELL BLENDED WING BODY CFD AND EXPERIMENT

M = 12.4, $\alpha = 6^{o}$, Re/L = 930,000/ft

	CN	%ERROR	CA	%ERROR
AFWAL PNS	0.07154	3.1	0.02002	.9
MDC CFL3D	0.06956	5.8	0.01949	3.5
LARC CFL3D	0.07247	1.8	0.02154	6.6
Experiment	0.07382		0.02020	
Experimental Uncertainty		7.5		6.4




TEMPERATURE
GENERIC OPTION #2 : 2-D INLET MODEL
COMPUTATIONAL METHODS BRANCH NASA LANGLEY
CONTOUR LEVELS
12.500 MACH
0.00 DEG ALPHA
9.40x10**4 Re
1.0 TIME
95x30x51 GRID



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FUTURE PLANS RELATED TO THE NATIONAL AERO-SPACE PLANE PROGRAM

- Continue to expand the envelope of capabilities for the code to include calculations of an entire NASP-like configuration
  - Improved zonal capabilities for inlets with sweep and combustors
  - Addition of non-equilibrium chemistry for combustor and nozzle/afterbody calculations
  - All capabilities scheduled for production code by 1/90 (NASP Technology Maturation Program)