

GENIE++ - A Multi-Block Structured Grid System

by

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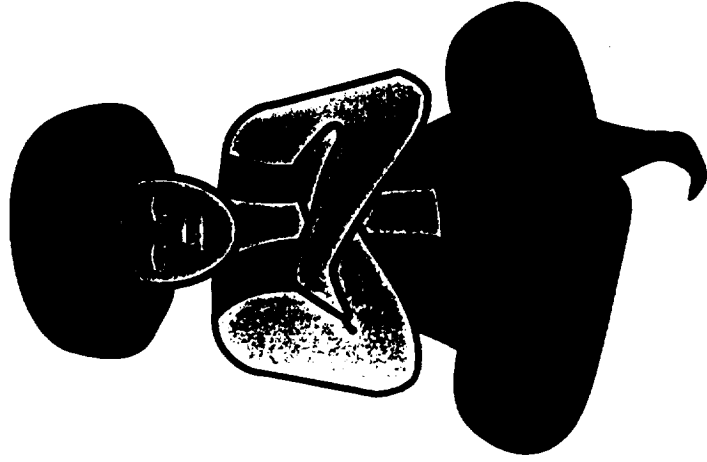
ABSTRACT

The computer code GENIE++ (Soni *et al.* 1992) is a continuously evolving grid system containing a multitude of proven geometry/grid techniques. The generation process in GENIE++ is based on an earlier version. The process uses several techniques either separately or in combination to quickly and economically generate sculptured geometry descriptions and grids for arbitrary geometries. The computational mesh is formed by using an appropriate algebraic method. Grid clustering is accomplished with either exponential or hyperbolic tangent routines which allow the user to specify a desired point distribution. Grid smoothing can be accomplished by using an elliptic solver with proper forcing functions. B-spline and Non-Uniform Rational B-splines (NURBS) algorithms are used for surface definition and redistribution. The built-in sculptured geometry definition with desired distribution of points, automatic Bezier curve/surface generation for interior boundaries/surfaces, and surface re-distribution is based on NURBS. Weighted Lagrange/Hermite transfinite interpolation methods, interactive geometry/grid manipulation modules, and on-line graphical visualization of the generation process are salient features of this system, which result in a significant time savings for a given geometry/grid application.

The development of the system, as well as computational examples of practical interest will be presented to demonstrate the success of these methodologies. Complete documentation is available using Mosaic. Versions are available for PC's, X window, and SGI systems. It is planned to place this code in the public domain by August 1995.

MISSISSIPPI STATE UNIVERSITY/National Science Foundation

GENIE++: A Structured Multi-Block Grid System

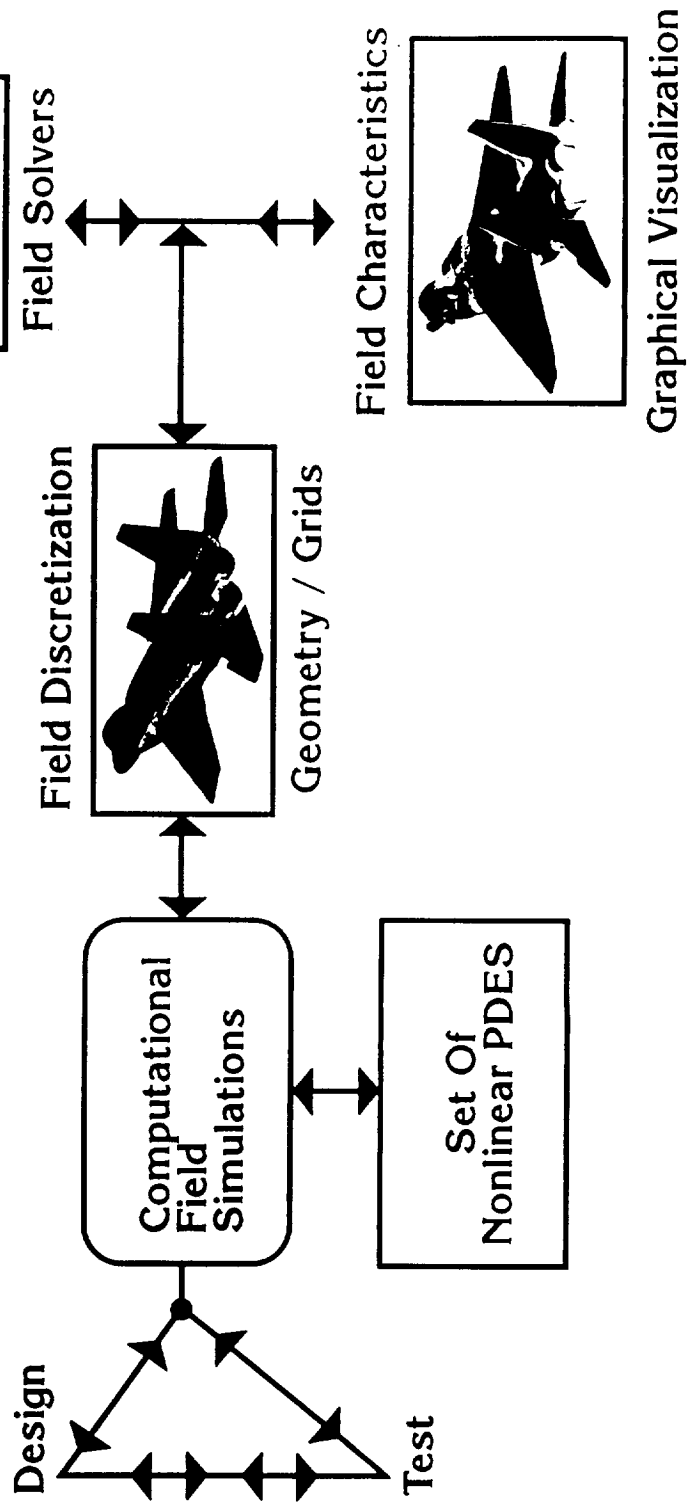


Bharat K. Soni
Hugh Thornburg
Tonya Williams
Nadesan Narenthiran

ENGINEERING
RESEARCH CENTER
**COMPUTATIONAL
FIELD SIMULATION**
COMPLEX GEOMETRY / COMPLEX PHYSICS



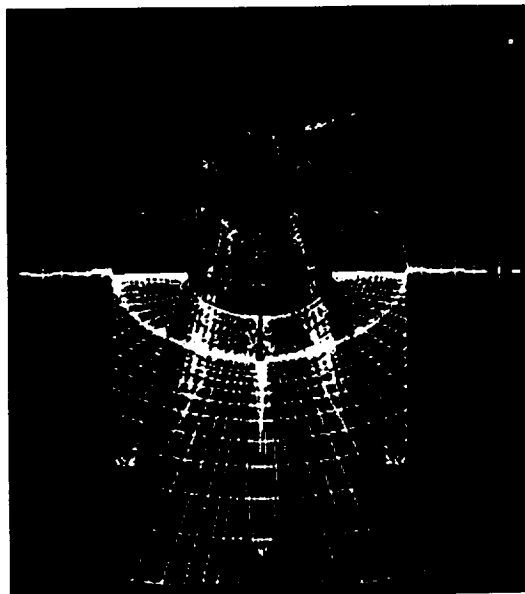
MOTIVATION



Grid Strategies

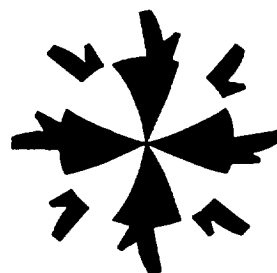
Structured

- Algebraic
- PDES
- Other



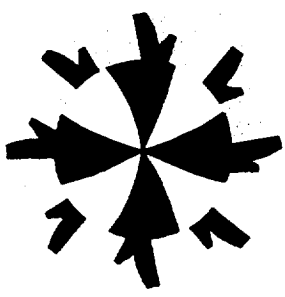
Unstructured

- Advancing Front
- Delaunay
- PDES
- Other

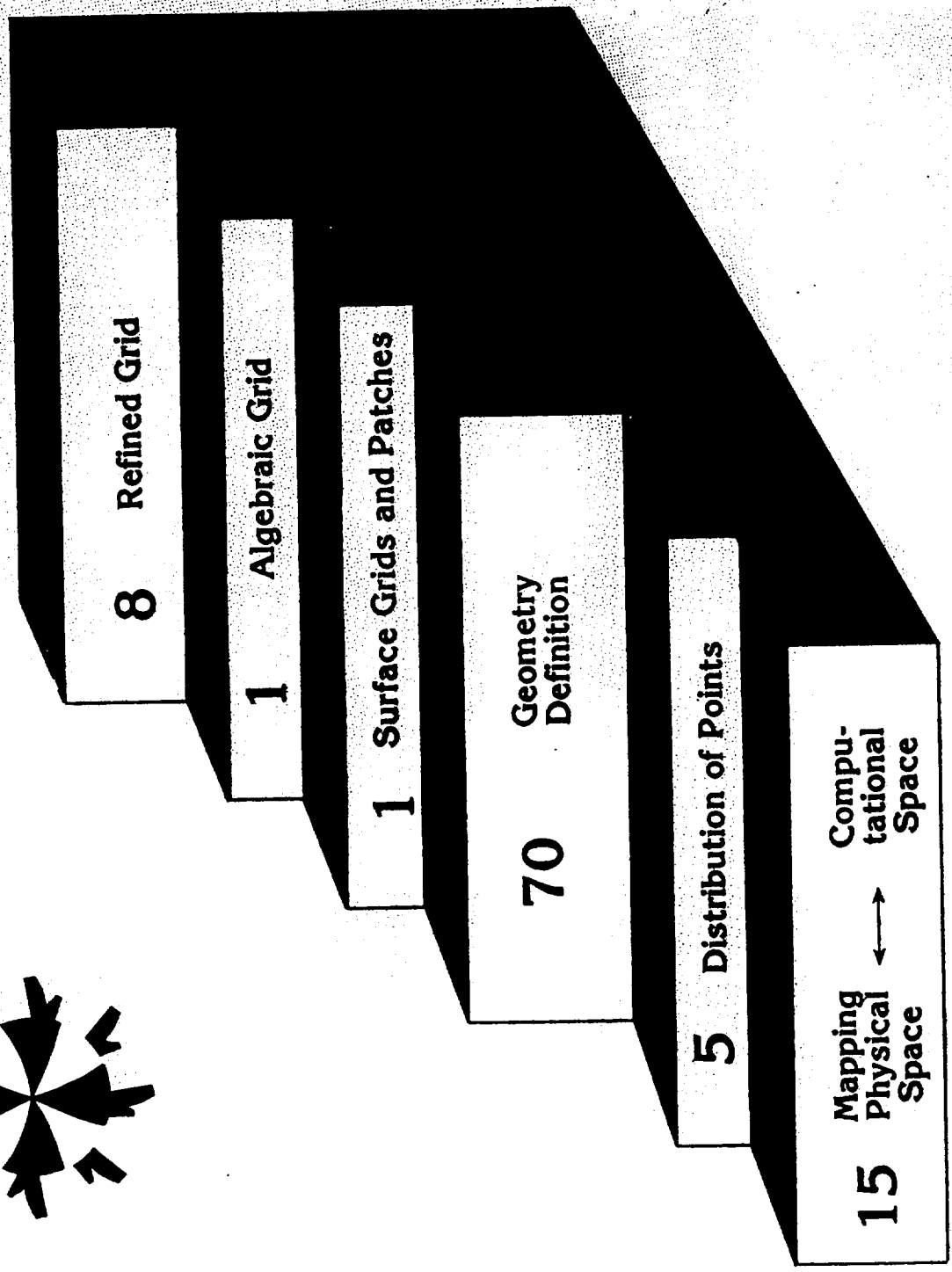


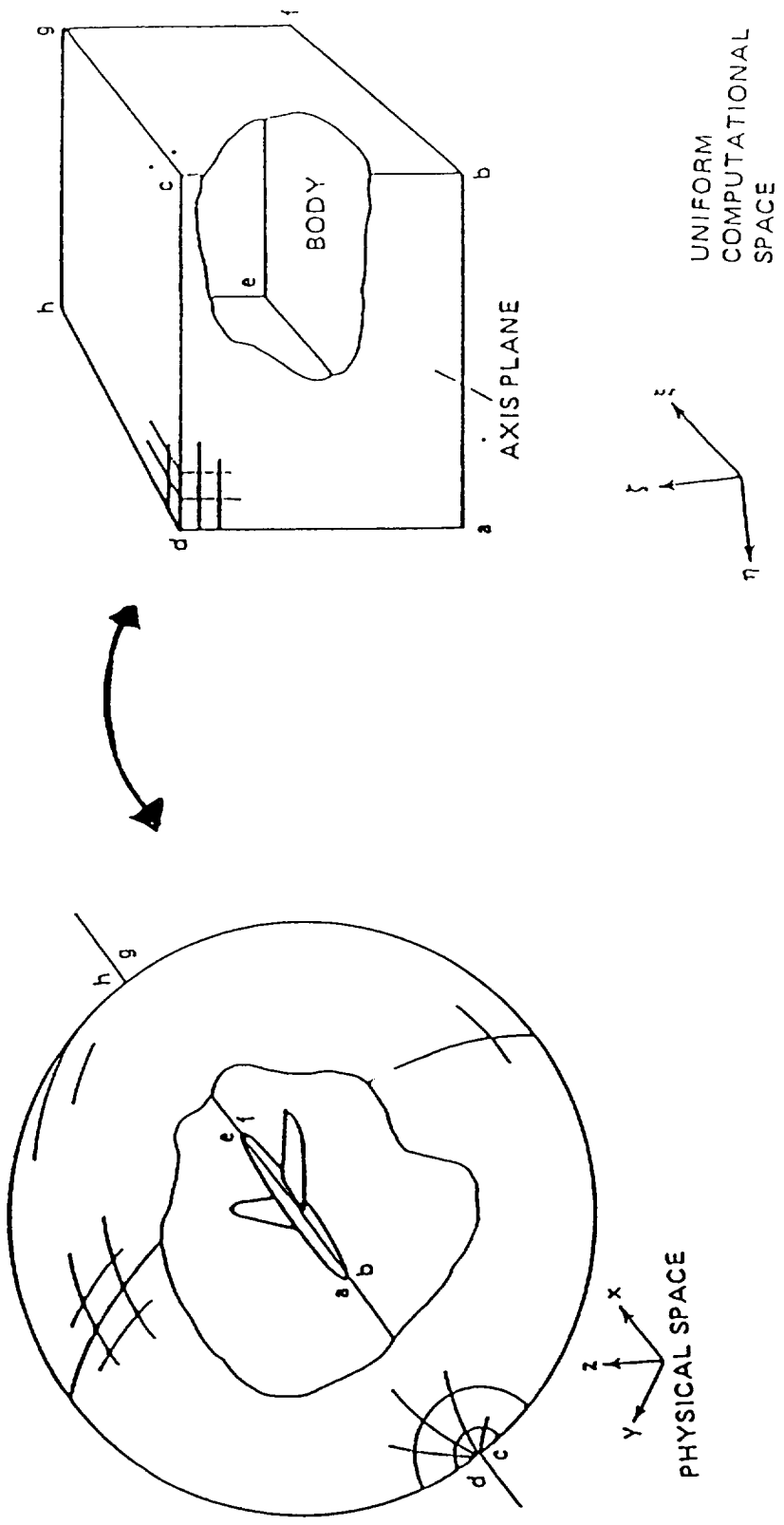
GRID INFLUENCE

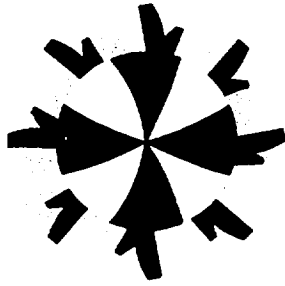
- Accuracy
 - Truncation Errors
 - Stability
 - Treatment of BCS
 - Economy (\$)
-
- All Positive or All Negative Volumes
 - Orthogonality (Not Too Skewed)
 - Smooth
 - Aspect Ratio



GENERATION STEPS





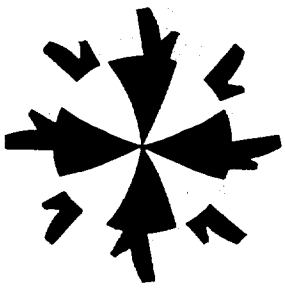


STRETCHING FUNCTIONS

* Exponential $\longrightarrow f(x) = \frac{e^{\alpha x} - 1}{\alpha e - 1}$

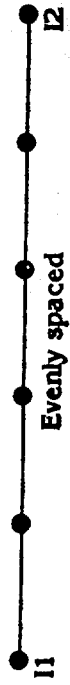
* Hyperbolic Tangent $\longrightarrow f(x) = 1 + \frac{\tanh(\alpha(x-1))}{\tanh \alpha}$

* Hyperbolic Sine $\longrightarrow f(x) = 1 - \frac{\sinh(\alpha(1-x))}{\sinh \alpha}$

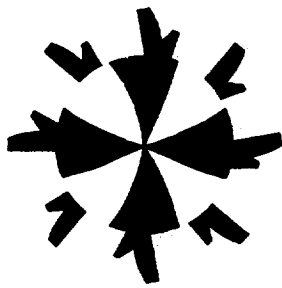


STRETCHING OPTIONS

Exponential Hyperbolic Tangent

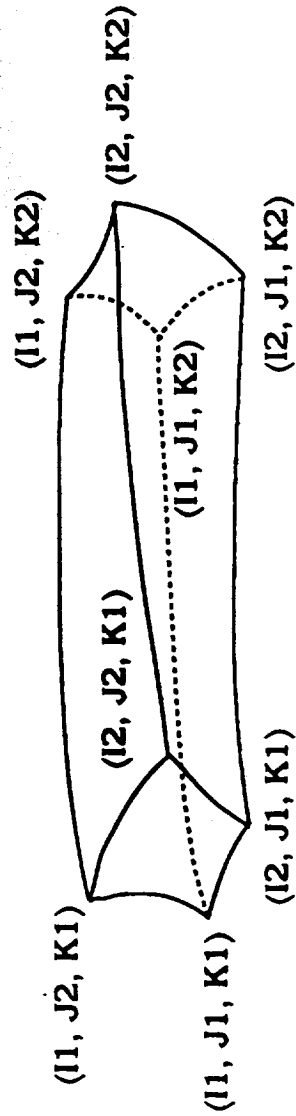
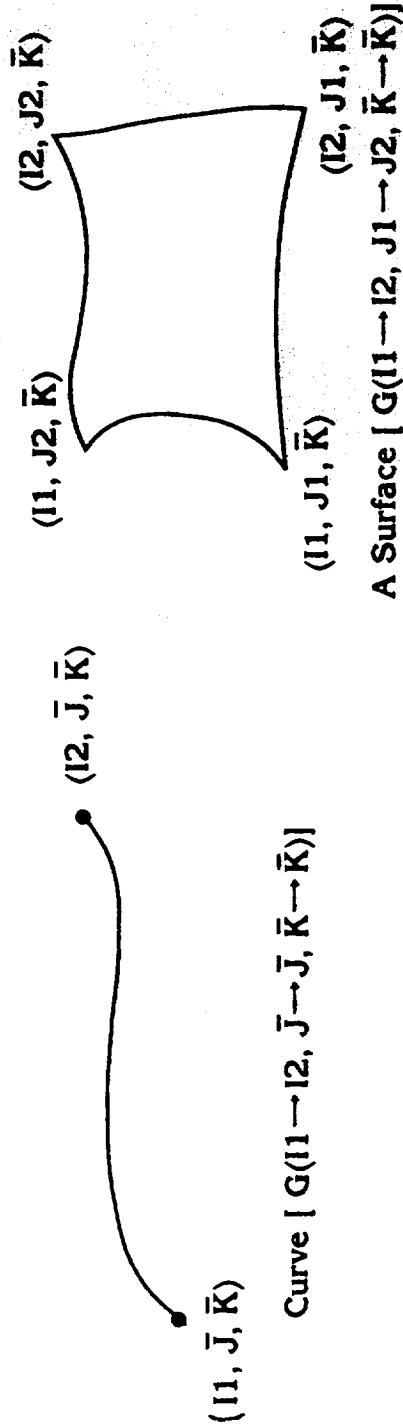


Options for Distributing Points



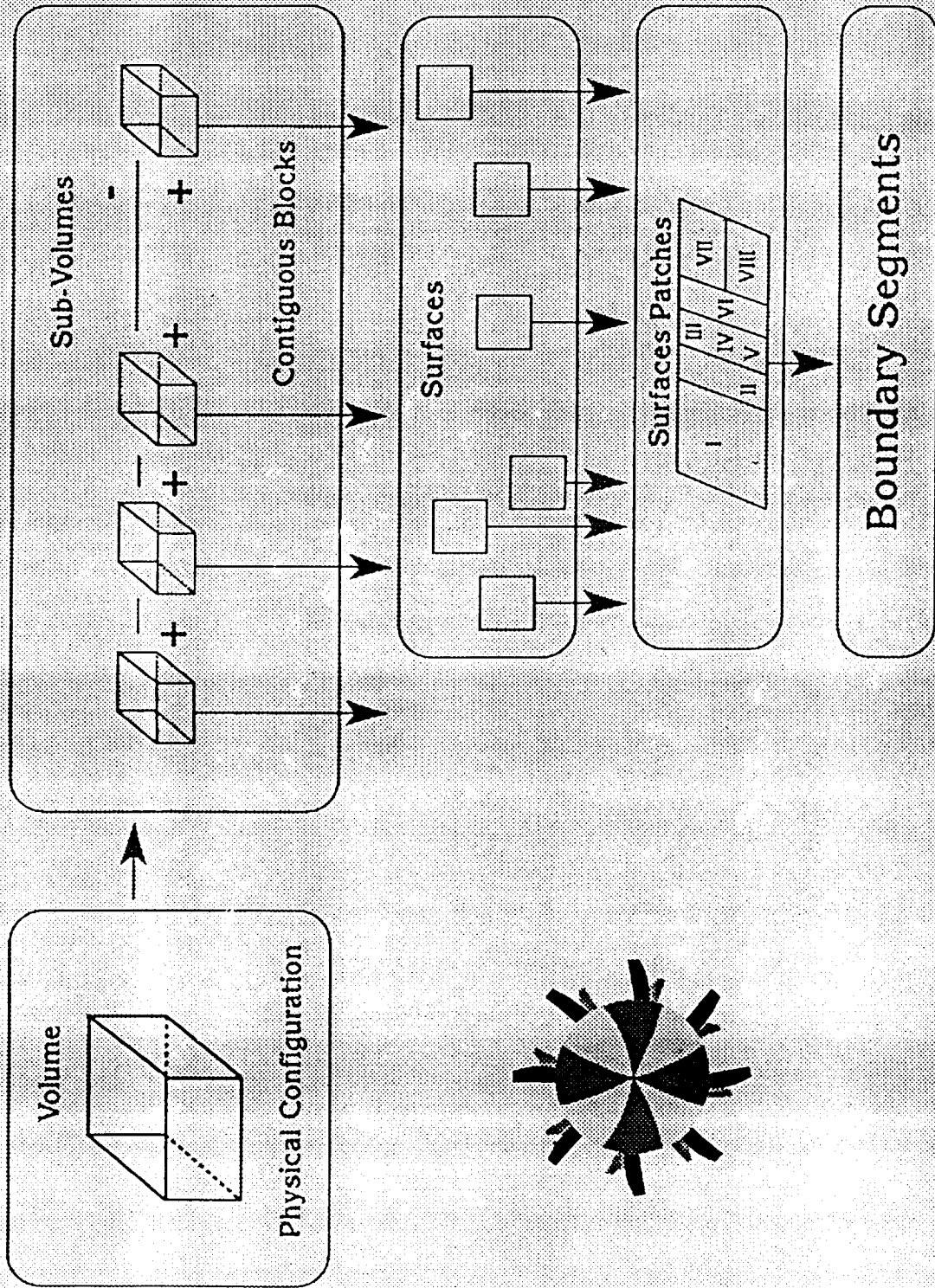
A BOUNDARY CURVE, SURFACE, OR VOLUME

$$G(I1 \rightarrow I2, \rightarrow J1 \rightarrow J2, K1 \rightarrow K2)$$



GENIE

Grid Generation Process / Geometry Definition

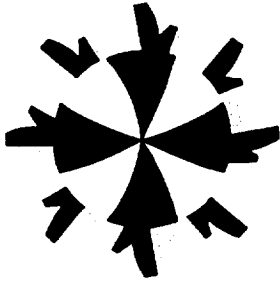


GEOMETRY GENERATION

- Semi-Interactive Construction
- Analytic:
 - Points, Line, Circle, Ellipse, Super-Ellipse,
 - Polynomial, Plane, Ruled Surface, Ellipsoid,
 - Hyperboloid, Paraboloid, NASA Airfoils, . . .
- Sculptured:
 - Spline-Akima, B-Spline, Rational B-Spline,
 - Polynomial-Hermite, LaGrange, Bezier,
 - Coon's Patch, NURBS, . . .

GEOMETRY MANIPULATION

- Body of Revolution
- Ruling, Marching, TFI, Coon's Patch
- Transformations: Translation, Rotation, Scaling, Mirror Image
- Cut. Paste, Patch, Blend, . . .
- Intersections and Projections



ALGEBRAIC

- * Fast
- * Precise Spacing Control
- * Interactive User Interface
- * Possible Overlapping
- * Requires High Degree of Understanding
- * Generalization!
- * Propagation of Slope Discontinuities

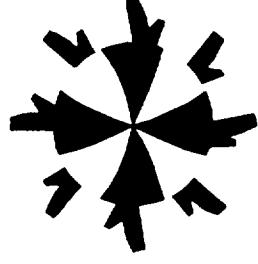
PDES

- * Inherent Smoothness
- * Resistant To Grid Line Overlapping
- * No Propagation of Slope Discontinuities
- * Competitive Enhancement of Smoothness, Orthogonality and Concentration
- * Readily Adaptable for Generalization
- * Distribution Loss

APPROACH

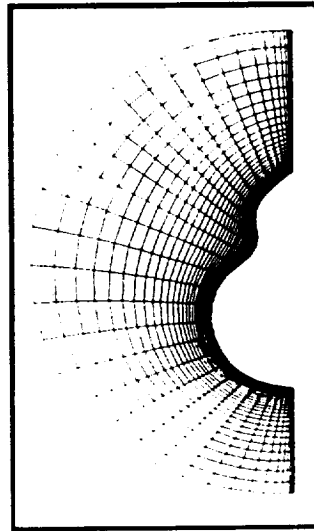
Objective: Accomplish orthogonality – smoothness without any distribution loss.

- **Work hard with Algebraic**
 - **Precise Spacing Control (Grid Spacings, Areas, Volume)**
 - **Inexpensive and Fast**
 - **Interior Bezier Curve/Surface Specification for Sub-blocks**
 - **Weighted Transfinite Lagrange and Hermite Interpolation**
 - **Precise Spacing Control (Grid Spacings, Areas, Volume)**
- **Use elliptic for a quick fix**
 - **Smart Forcing Functions**
 - **3-5 Iterations (maximum)**

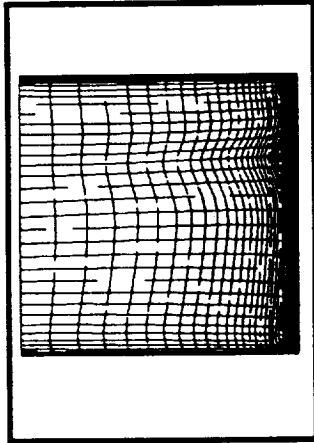


WEIGHTED TRANSFINITE INTERPOLATION

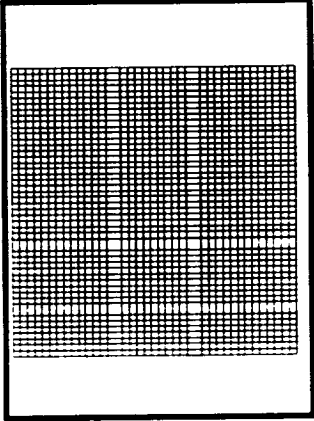
Physical Space Distribution Space Computational Space
 50 x 40



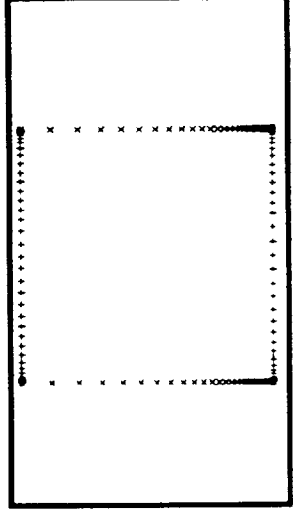
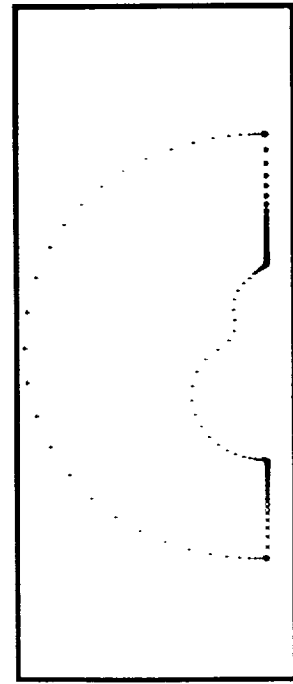
(x_{ij}, y_{ij})



(s_{ij}, t_{ij})



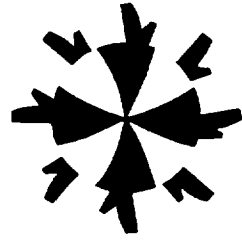
(i, j)



GENERAL ELLIPTIC GENERATION SYSTEM

$$\sum_{i=1}^3 \sum_{j=1}^3 g^{ij} r_{\xi}^i \bar{r}_{\xi}^j + \sum_{k=1}^3 \phi_k r_{\xi}^k = 0$$

$$g^{il} = \frac{1}{g} (g_{jm} g_{kn} - g_{jn} g_{km}) \quad i = 1, 2, 3; j = 1, 2, 3; (i, j, k) \text{ and } (l, m, n) \text{ cyclic}$$

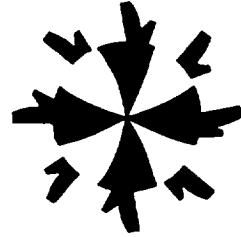


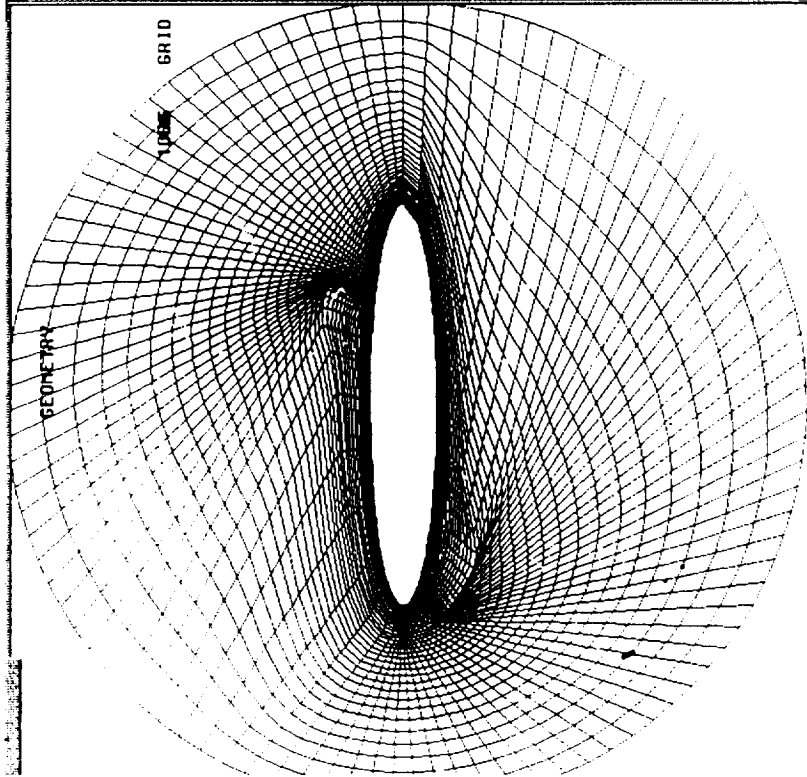
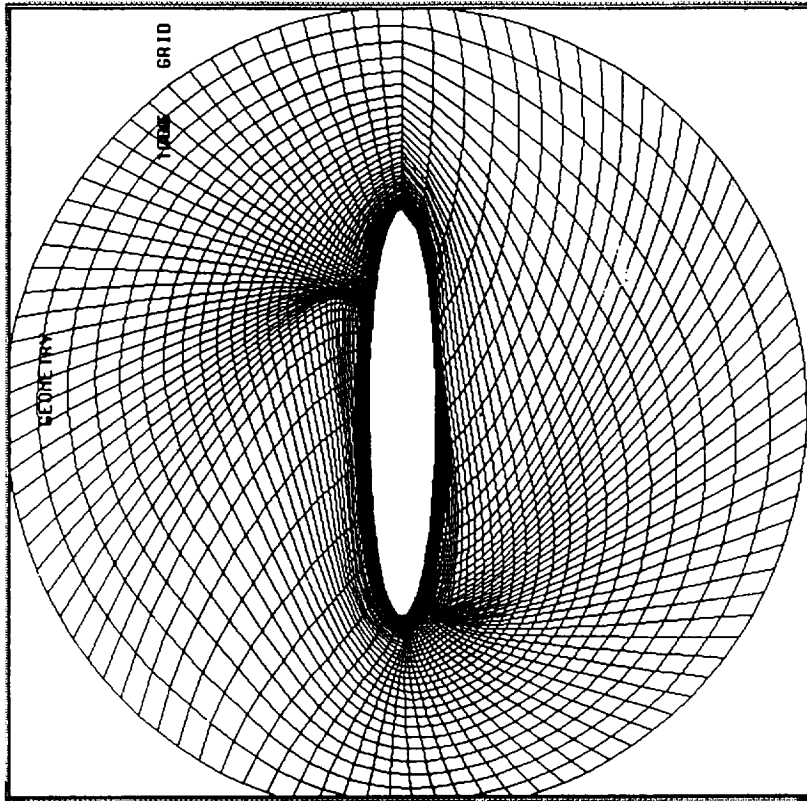
EVALUATION OF FORCING FUNCTIONS

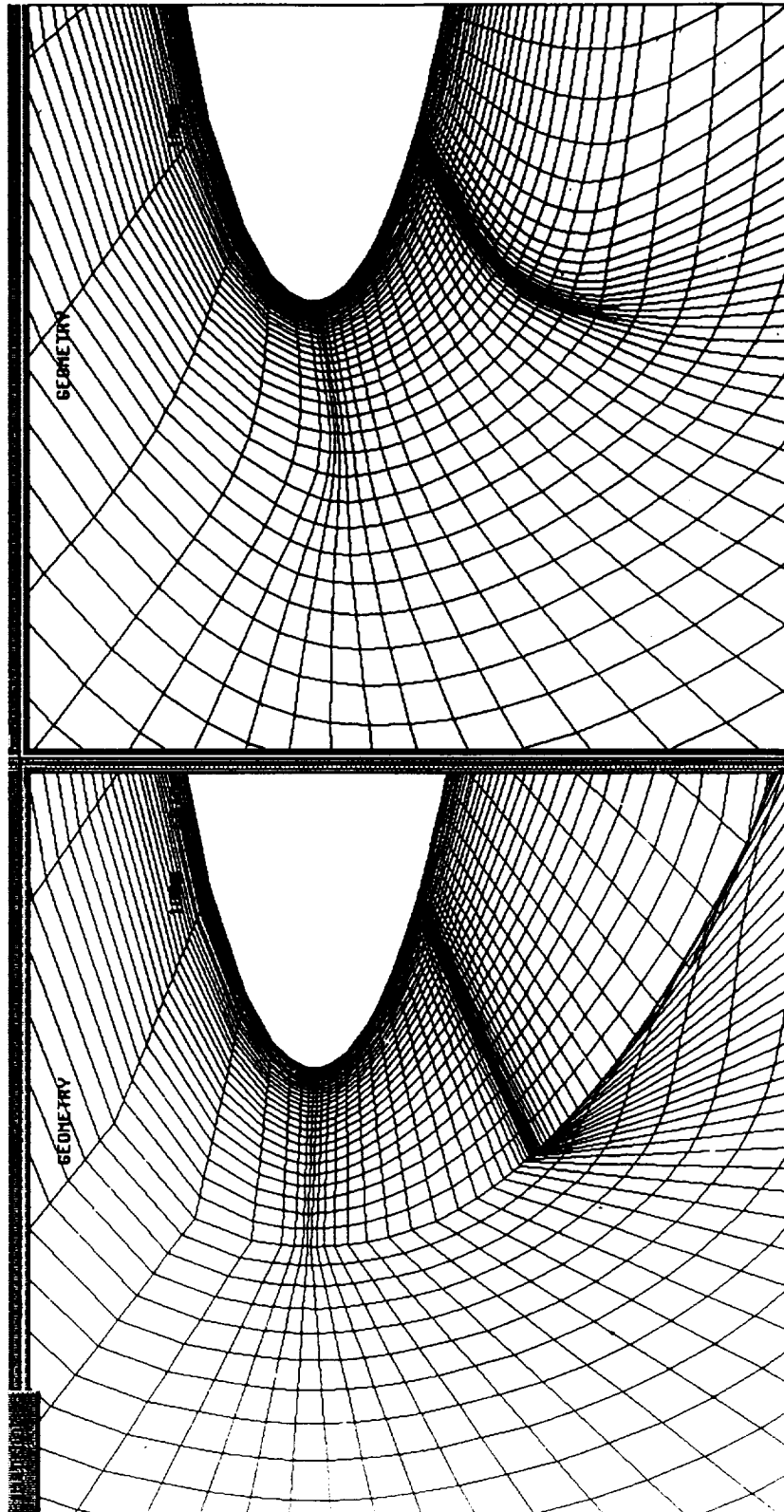
$$\sum_{i=1}^3 \sum_{j=1}^3 g^{ij} (g_{iq}) \xi^j + \sum_{k=1}^3 \phi_k g_{kq} - \sum_{i=1}^3 \sum_{j=1}^3 g^{ij} \left(\frac{(g_{ij}) \xi^k - (g_{jq}) \xi^i}{2} \right) = 0$$

$$q = 1, 2, 3$$

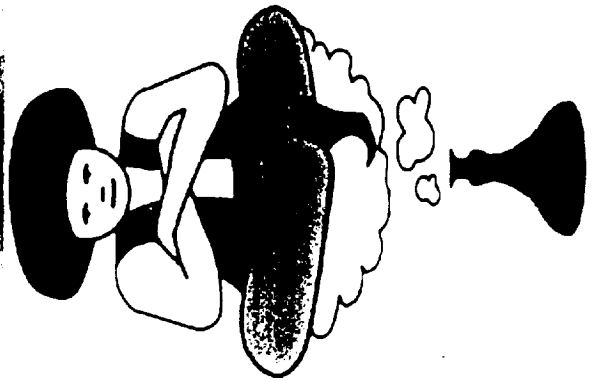
$$g_{ij} = \vec{r}_i \cdot \vec{r}_j = \|\vec{r}_i\| \cdot \|\vec{r}_j\| \cdot \cos \theta$$







GENIE Family of Auto Conversion Codes



GENIE++ User's Manual

Version 1.00

Dr. Bruce Wilson

Mississippi State University / National Science Foundation
Engineering Research Center for Computational Bridge Simulation

GENIE++

Characteristics

GENIE++

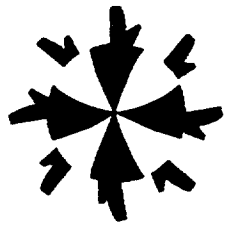


Geometry Mode

- Sculptured Curves
and Surfaces

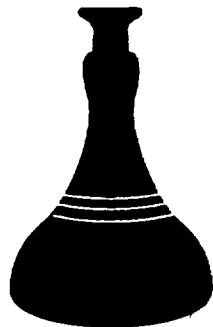
Computational Mode

- One Block at a Time
With One Extra Block in
On-Line Memory



GENIE
++

GENIE

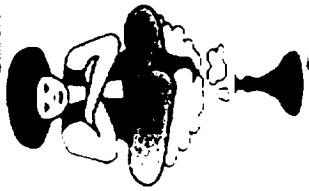


- DEFRIP
- UICRVS
- UISURF
- GMAN
- UIVOLS
- UIREFN
- UIMESR
- UIIØ
- UIDISP
- UIZONE
- UIOUT

INITIALIZATION OPTIONS

- 1 TOGGLE REAL TIME PLOTTING
- 2 TOGGLE PROMPTING
- 3 GIVE TITLE TO GRID
- 4 CHANGE CURRENT GRID BLOCK SIZE
- 5 CHANGE MAXIMUM GRID SIZES
- 6 CHANGE CURRENT BLOCK NUMBER
- 7 CHANGE MAXIMUM NUMBER OF BLOCKS
- 8 TOGGLE GRID GENERATION MODE
- 9 INITIALIZE DATABASE
- 10 INITIALIZE ZONAL INFORMATION
- 11 VIEW NON-BLOCK GRID
- 12 VIEW ONE BLOCK
- 13 VIEW ALL BLOCKS
- 14 EXIT INITIALIZATION
- 15 QUIT GRID GENERATION

INPUT OPTION NUMBER



Grande Champagne

This chapter is devoted to the study of the geographical conditions of the Champagne and its production in a single country, France, and more precisely in the Grande Champagne.



Grande Champagne

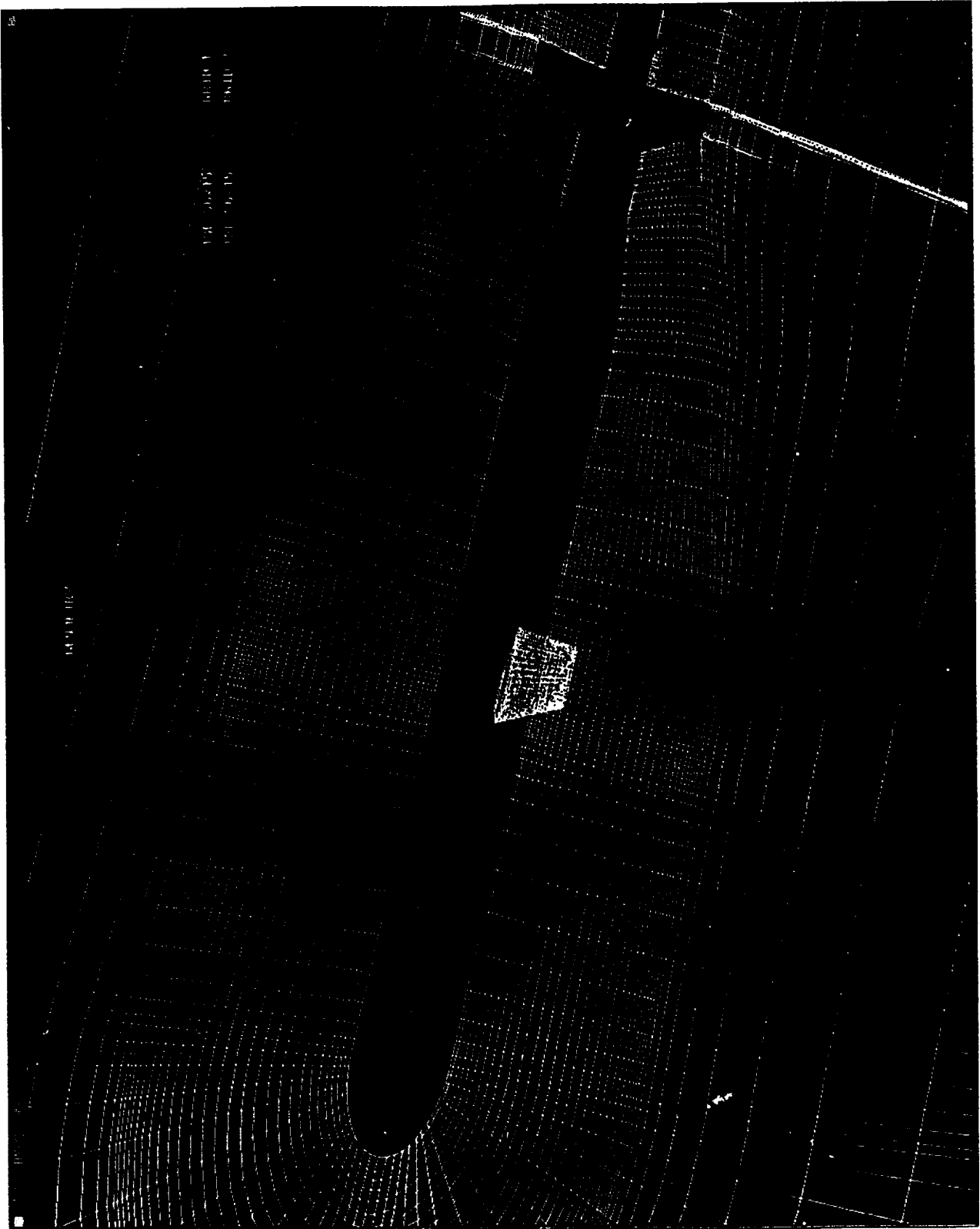
Choosing a good wine is a matter of taste, but there are some things to keep in mind. The following table gives you some ideas.

- 1. Quality of the wine
- 2. Price of the wine
- 3. Style of the wine
- 4. Volume of the wine
- 5. Quality of the wine
- 6. Style of the wine
- 7. Quality of the wine
- 8. Price of the wine
- 9. Style of the wine
- 10. Quality of the wine
- 11. Price of the wine

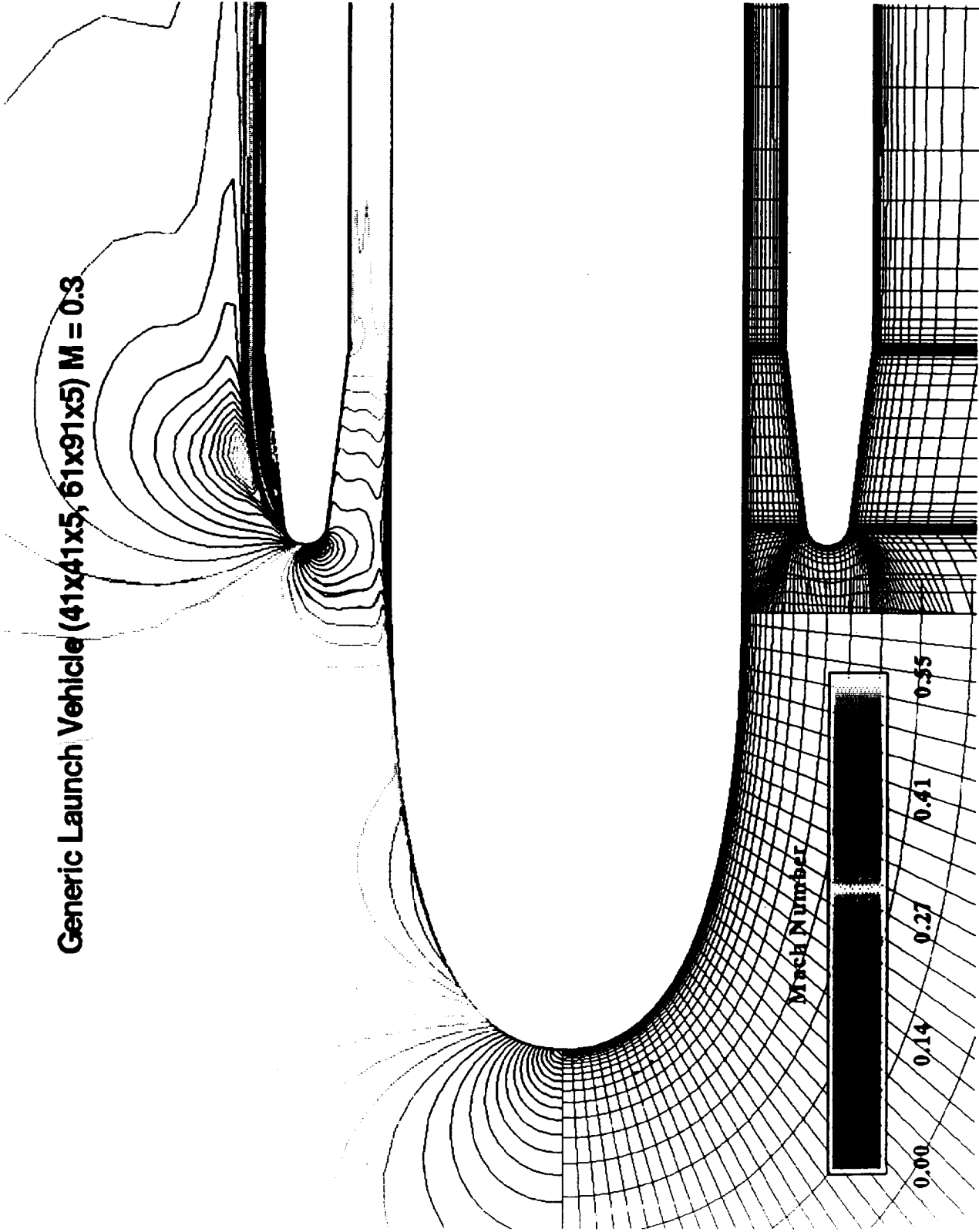
BOUNDARY SEGMENT DEFINED BY

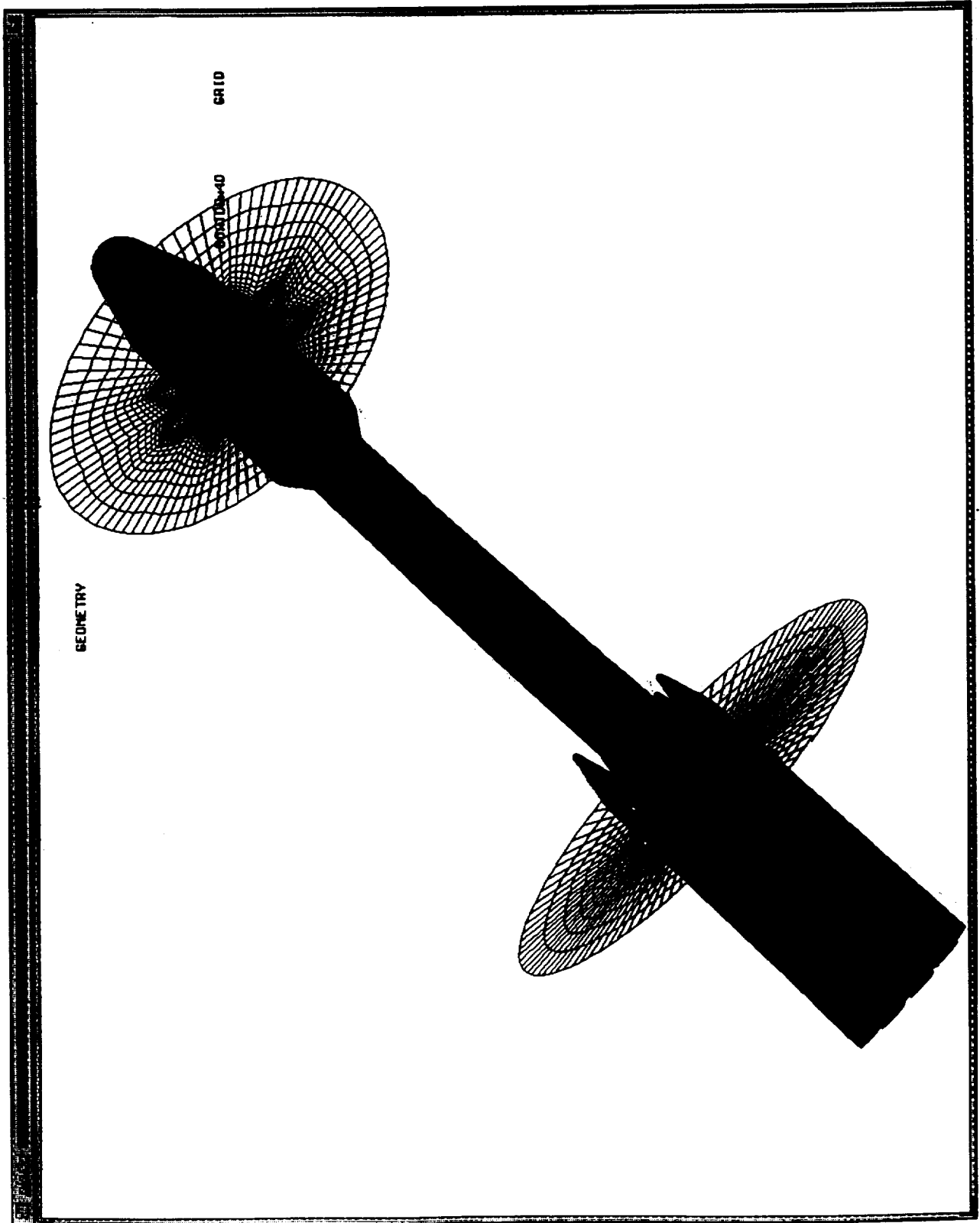
- 1 A CURVE PROJECTED ONTO A PARALLEL PLANE
- 2 OTHER CURVE PROJECTION OPTIONS
- 3 A STRAIGHT LINE
- 4 A 3D BEZIER / HERMITE CUBIC CURVE
- 5 SCULPTURED CURVE DEFINITION
- 6 CURVE MANIPULATION OPTIONS

INPUT OPTION NUMBER



Generic Launch Vehicle (41x41x5, 61x91x5) M = 0.3

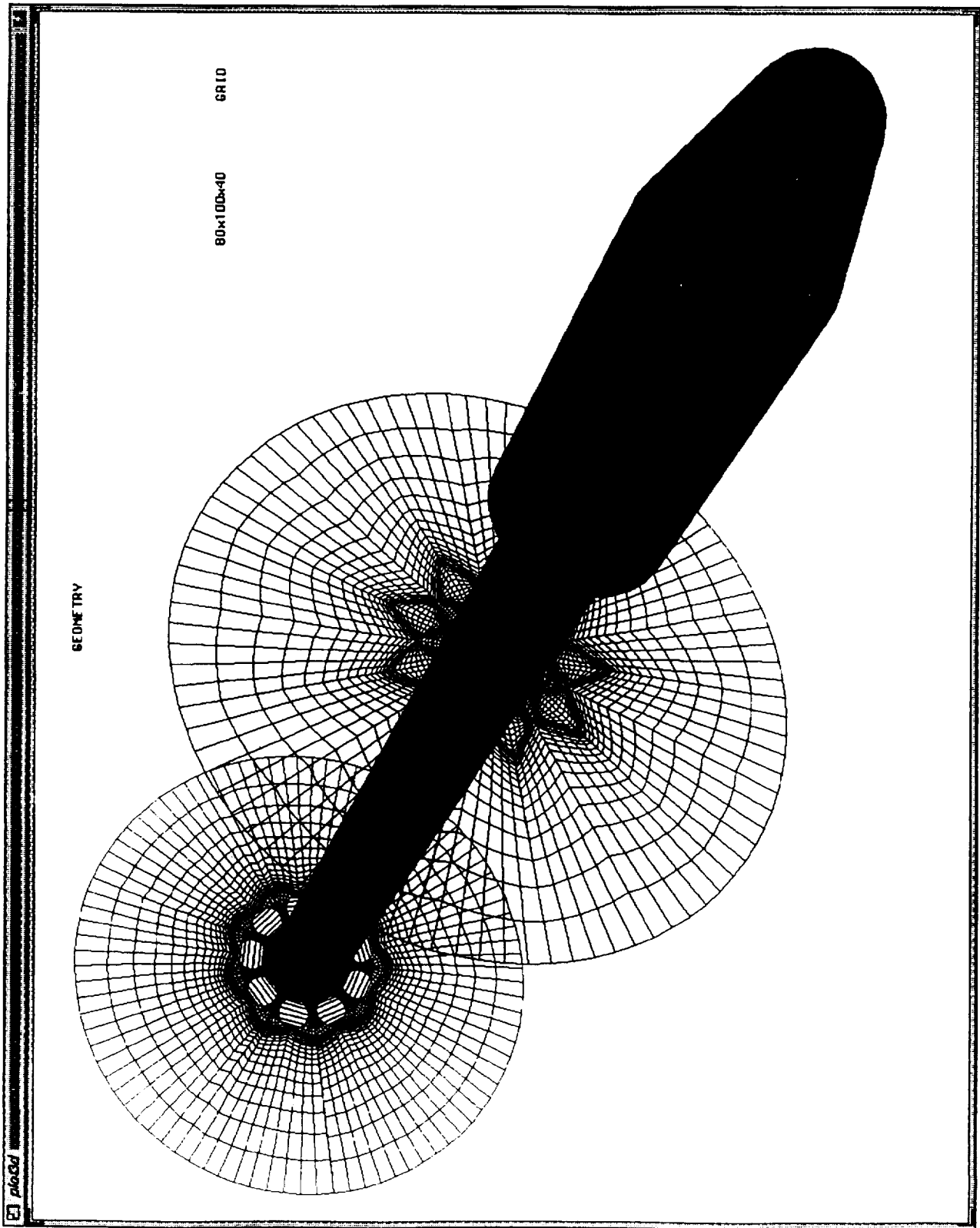


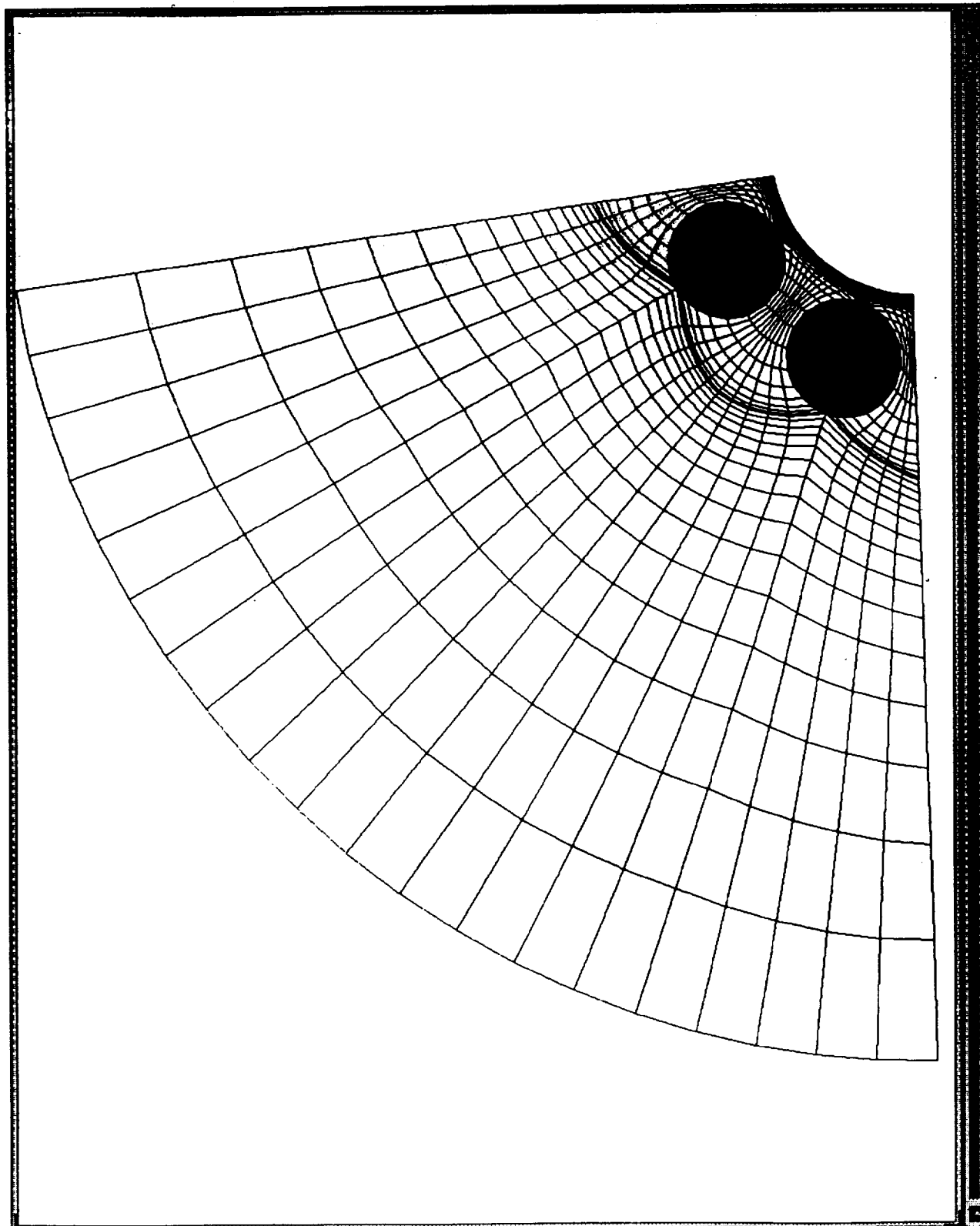


GRID

GEOMETRY

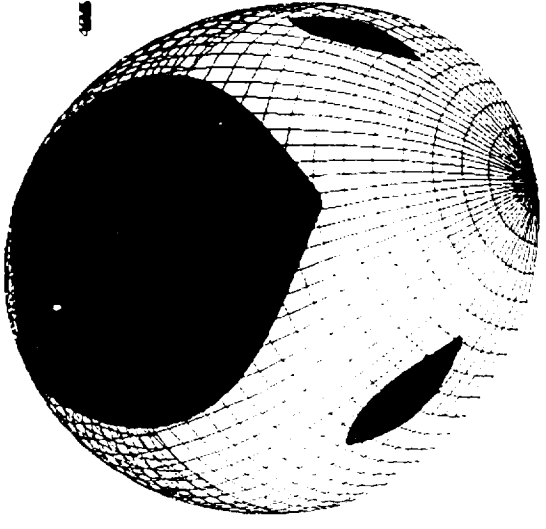
GEOMETRY





1105

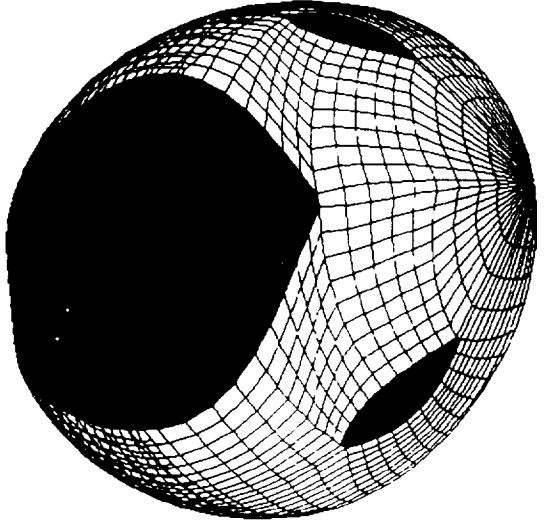
GEOMETRY



GRID

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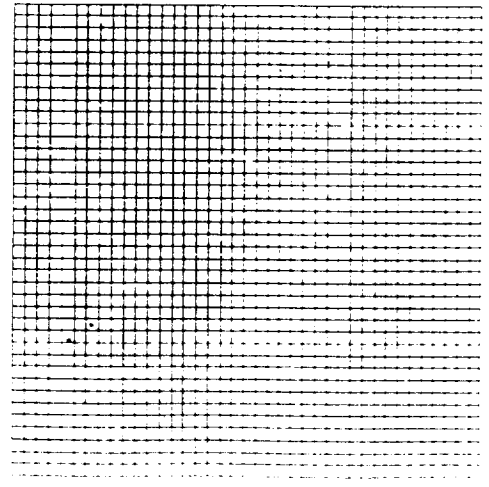
GEOMETRY



GRID

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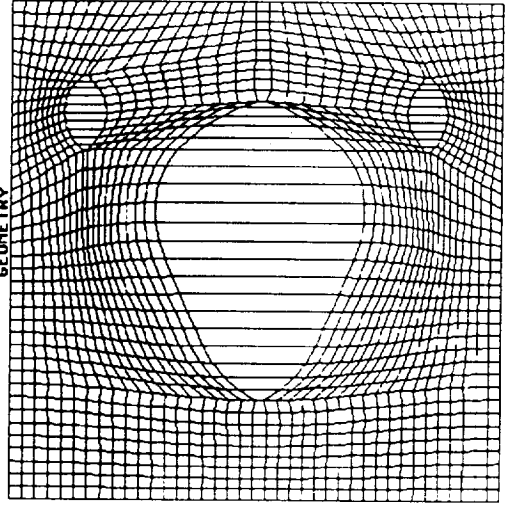
GEOMETRY



GRID

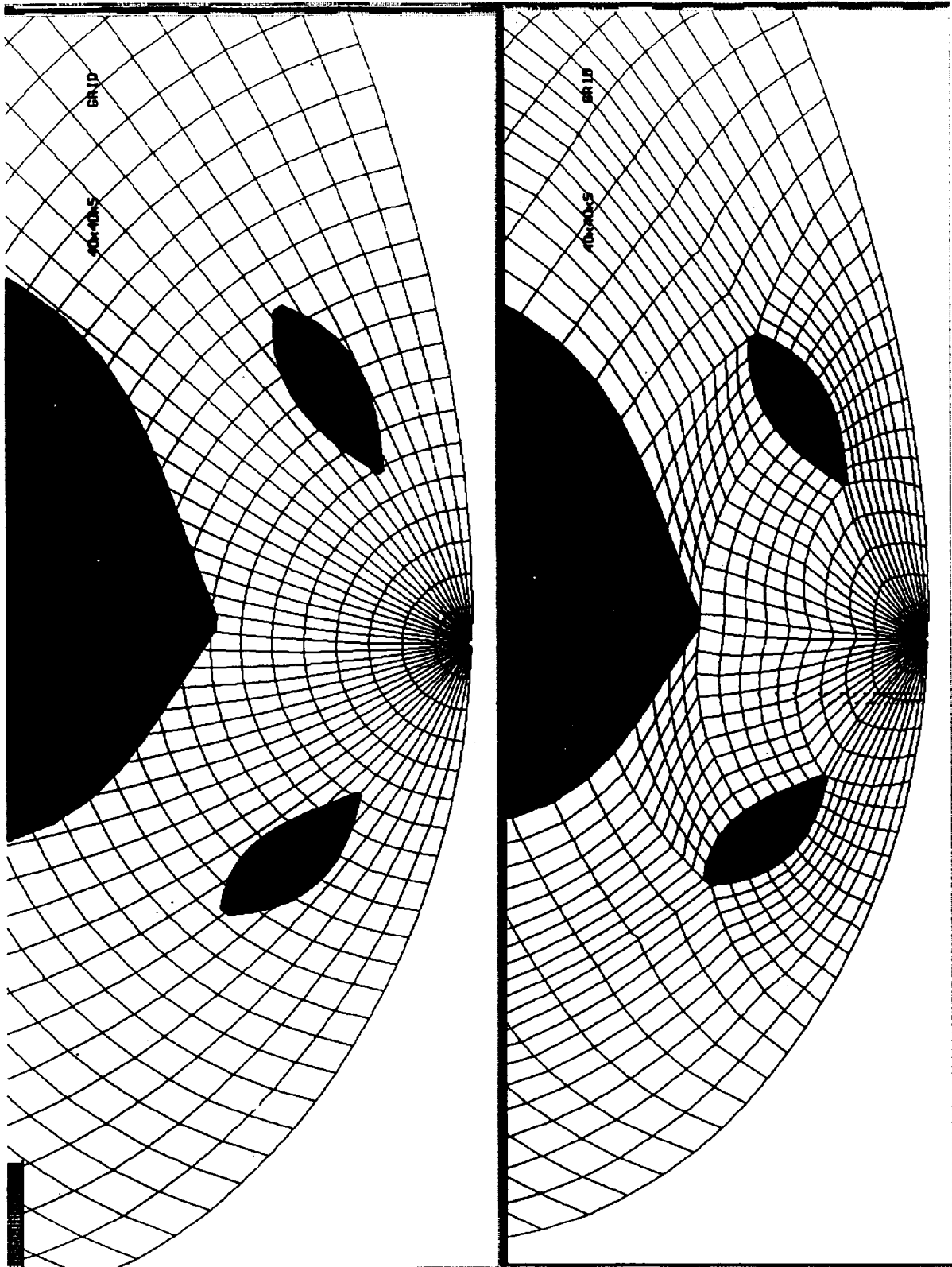
48485

GEOMETRY



GRID

48485





Entity Name List

- 128 1
- 128 2
- 128 3
- 128 4
- 128 5
- 128 6
- 128 7
- 128 8
- 128 9
- 128 10
- 128 11
- 128 12
- 128 13
- 128 14
- 128 15
- 128 16
- 128 17
- 128 18
- 128 19
- 128 20
- 128 21
- 128 22
- 128 23
- 128 24
- 128 25
- 128 26
- 128 27
- 128 28
- 128 29
- 128 30
- 128 31
- 128 32
- 128 33
- 128 34

Entity Properties

Entity: 128

Material: 1

Color: 1

Texture: 1

Scale: 1.0

Position: (0, 0, 0)

Rotation: (0, 0, 0)

Step: 1

Accept

Entity Properties

Entity: 128

Material: 1

Color: 1

Texture: 1

Scale: 1.0

Position: (0, 0, 0)

Rotation: (0, 0, 0)

Step: 1

Accept

Entity Properties

Entity: 128

Material: 1

Color: 1

Texture: 1

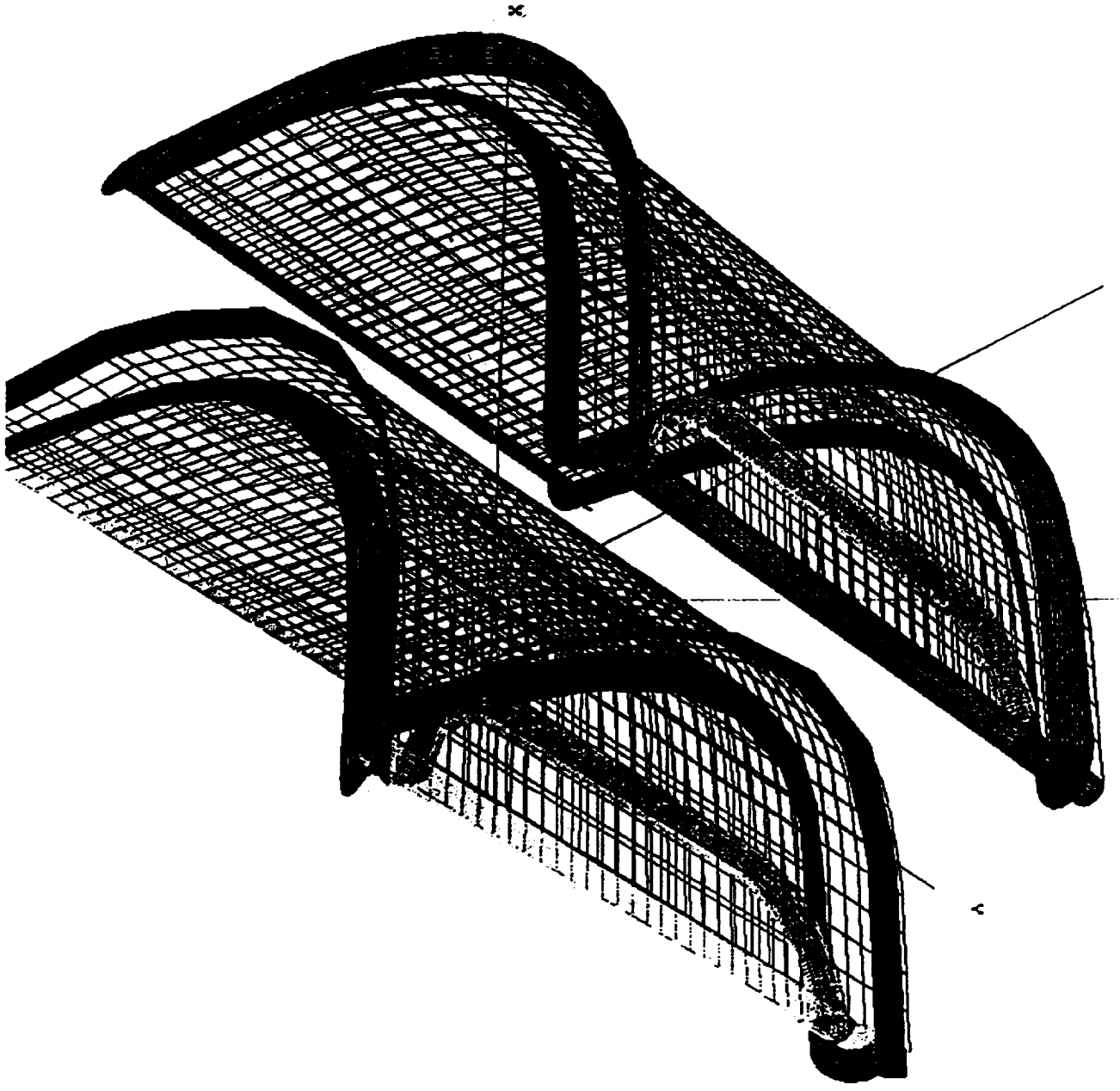
Scale: 1.0

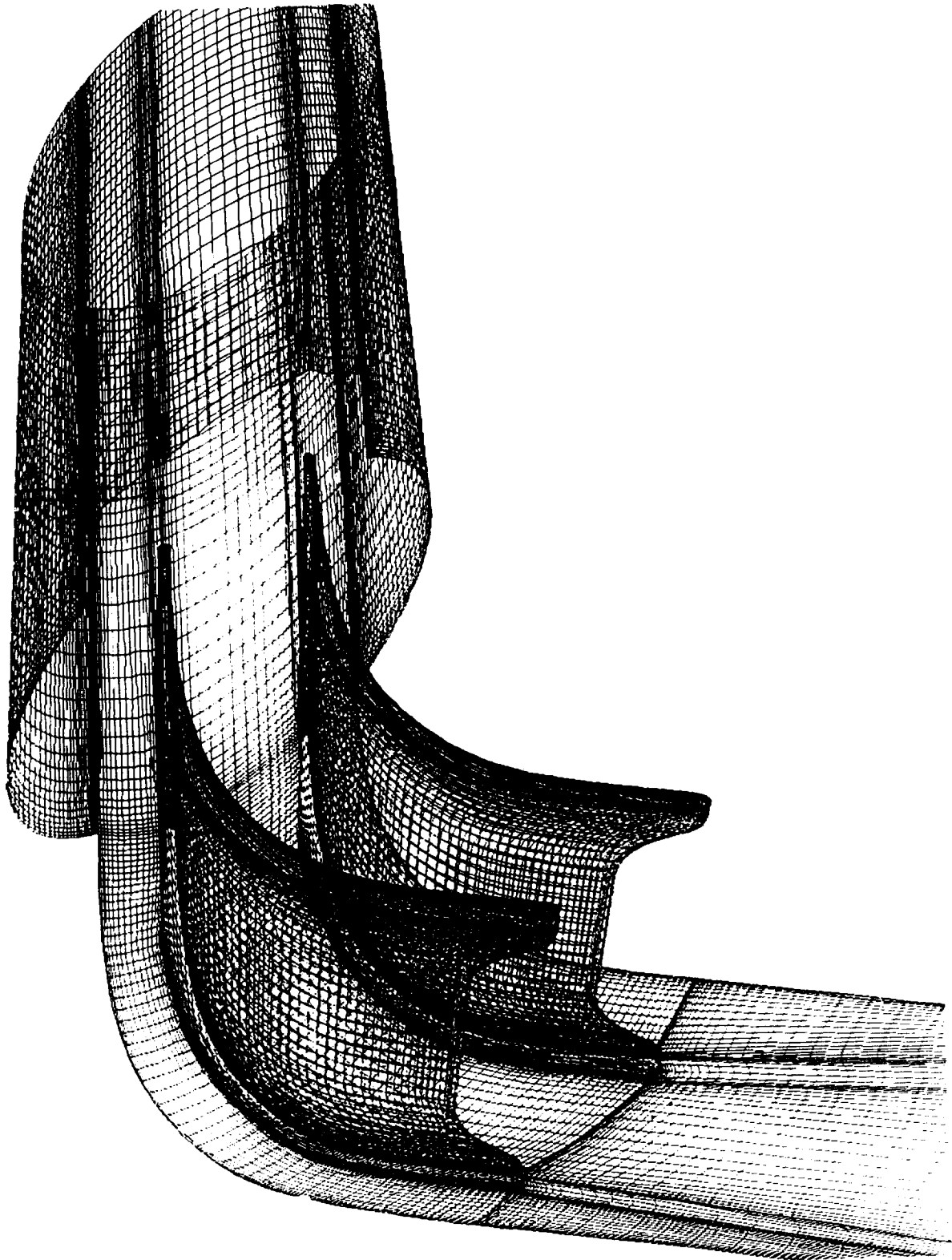
Position: (0, 0, 0)

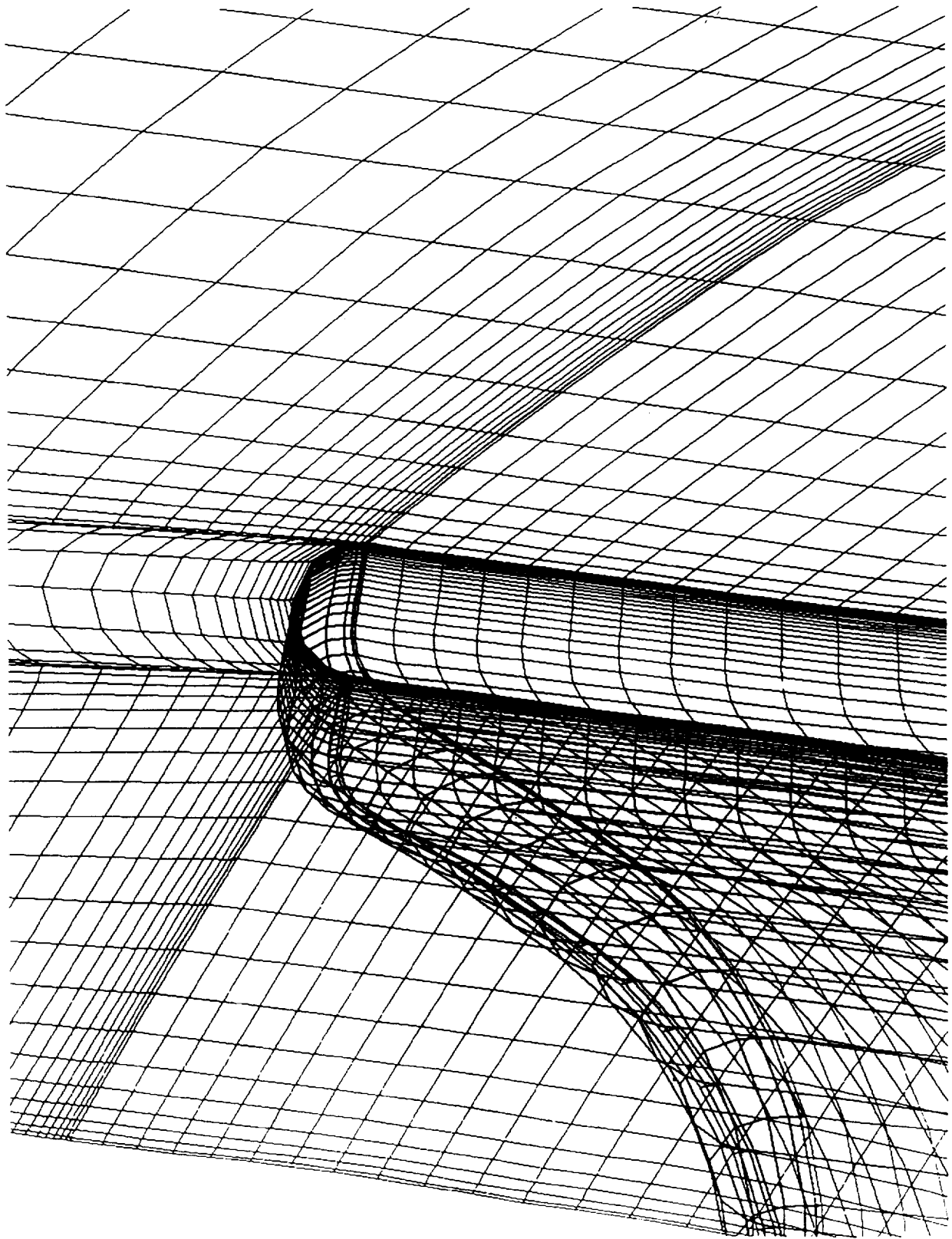
Rotation: (0, 0, 0)

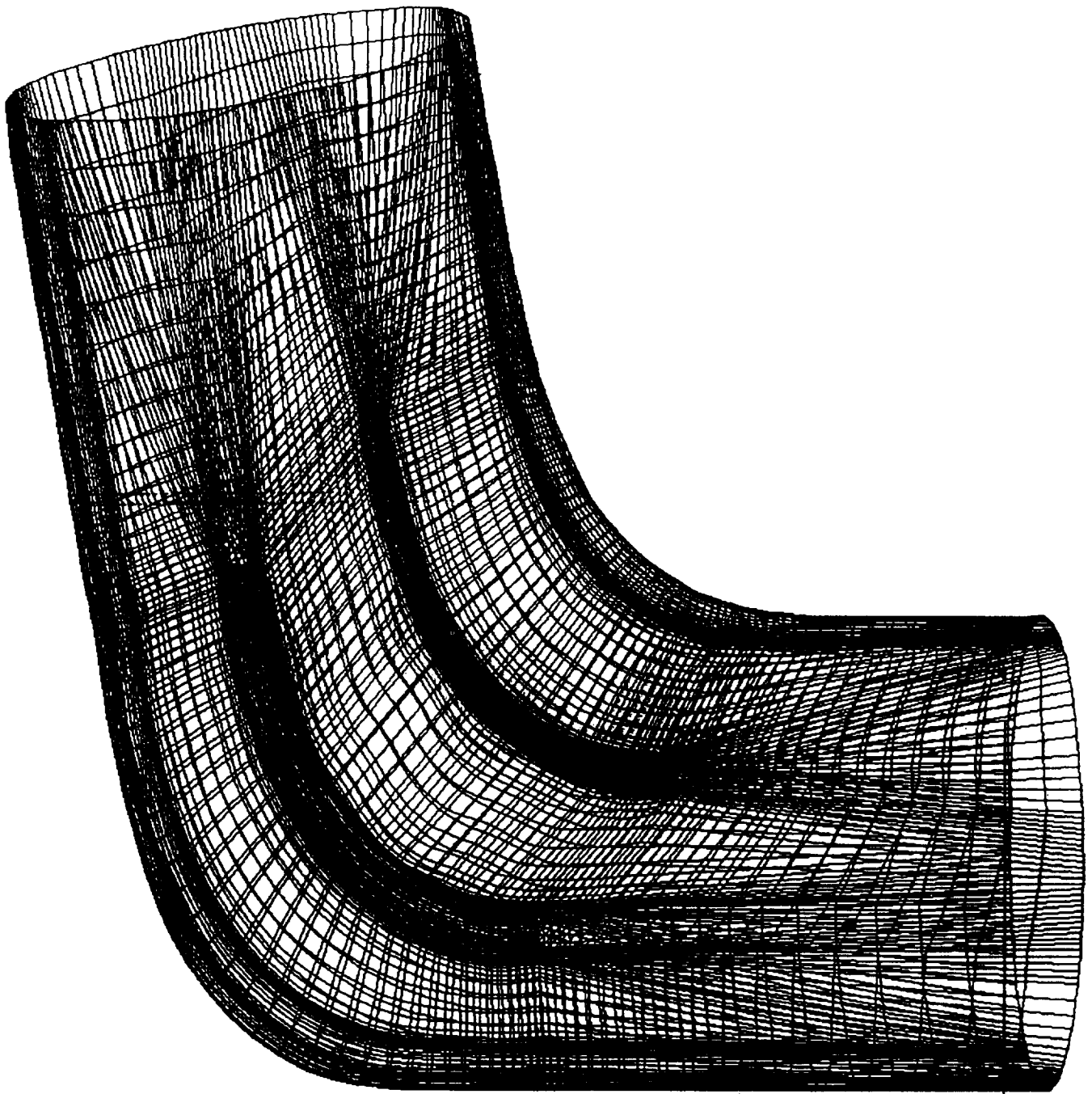
Step: 1

Accept

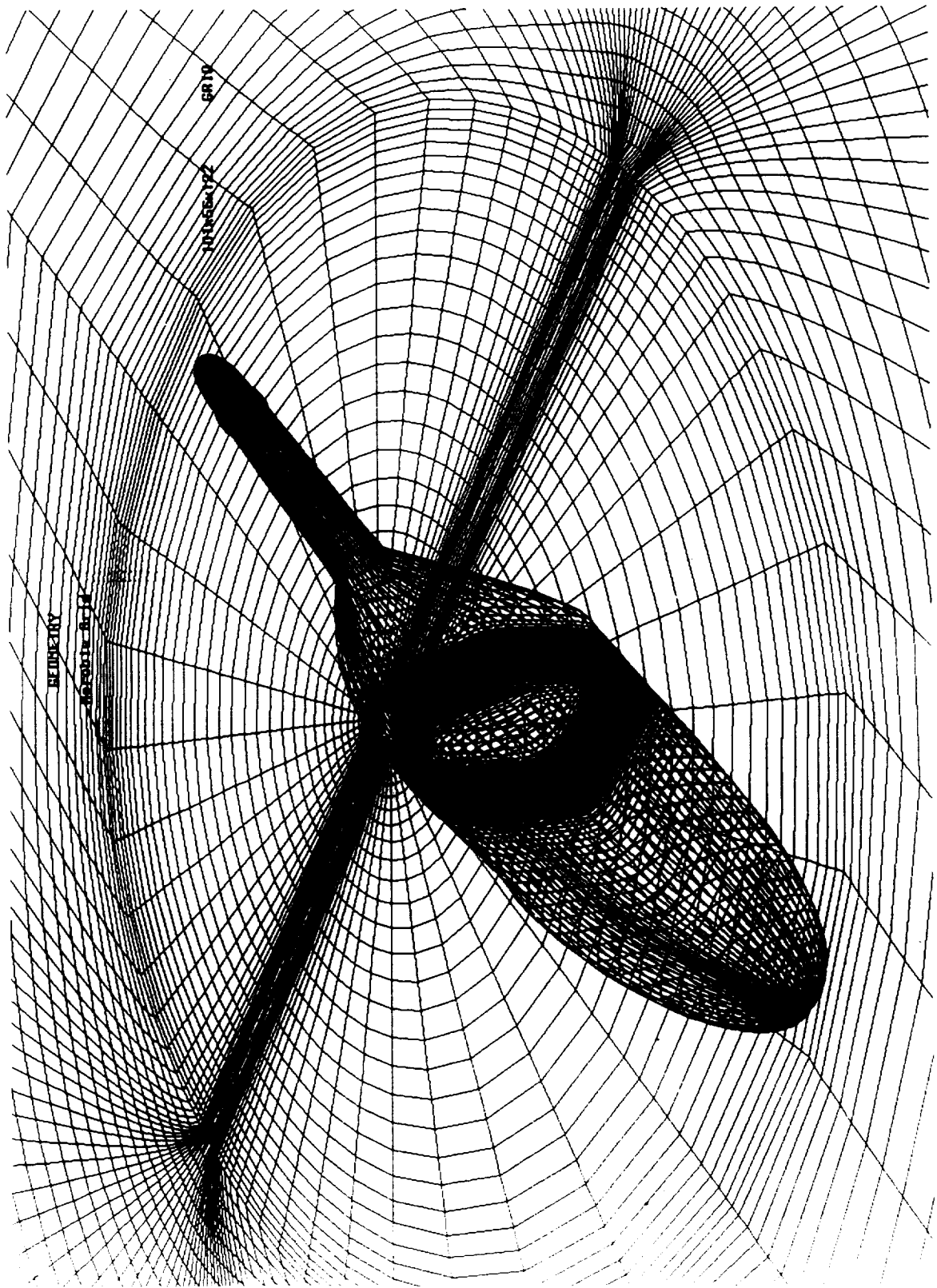




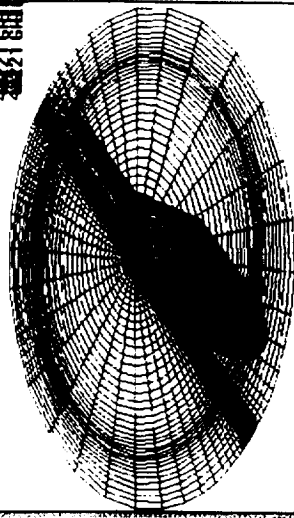
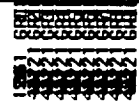




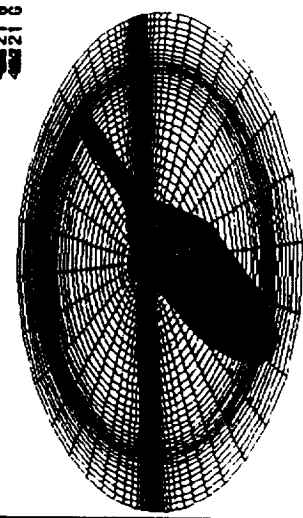
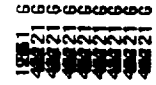
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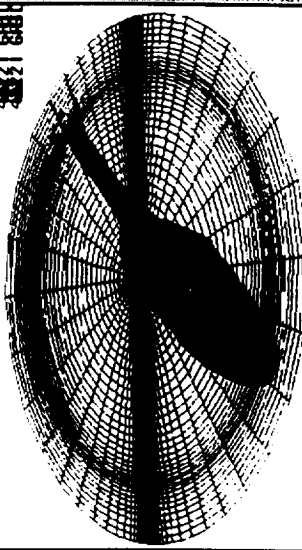
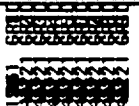
GEOMETRY
Chimera Grid



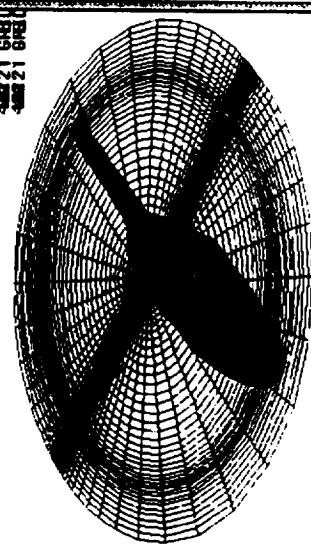
GEOMETRY
Chimera Grid



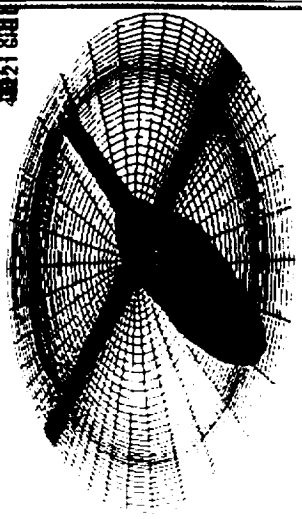
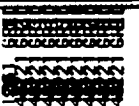
GEOMETRY
Chimera Grid



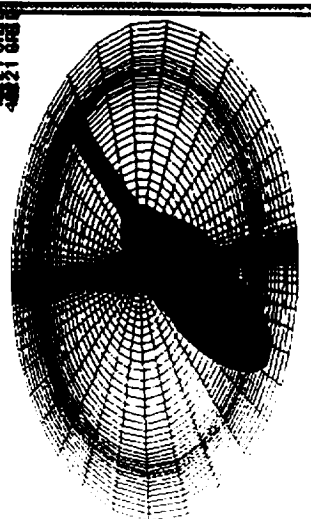
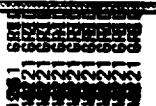
GEOMETRY
Chimera Grid

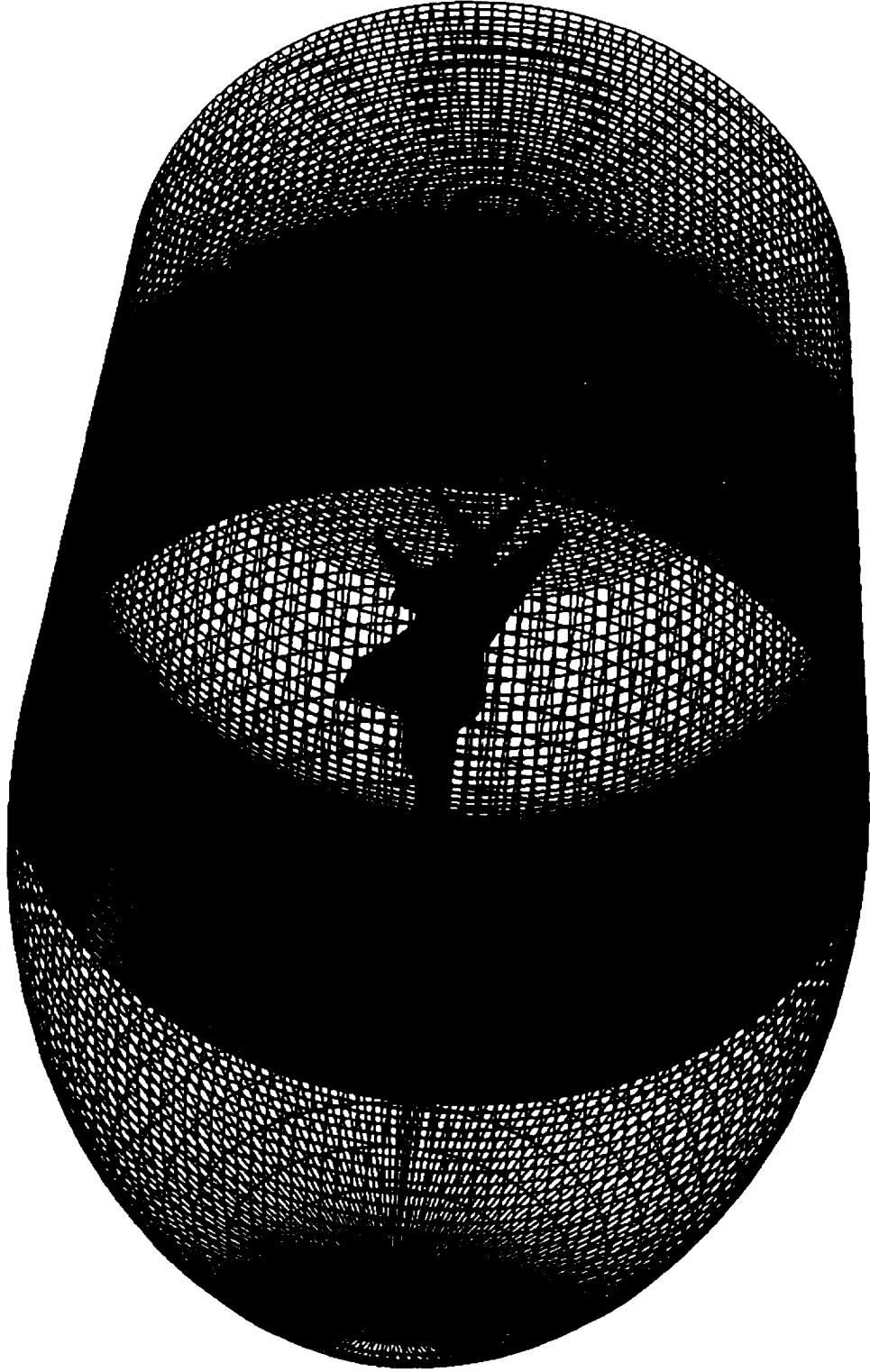


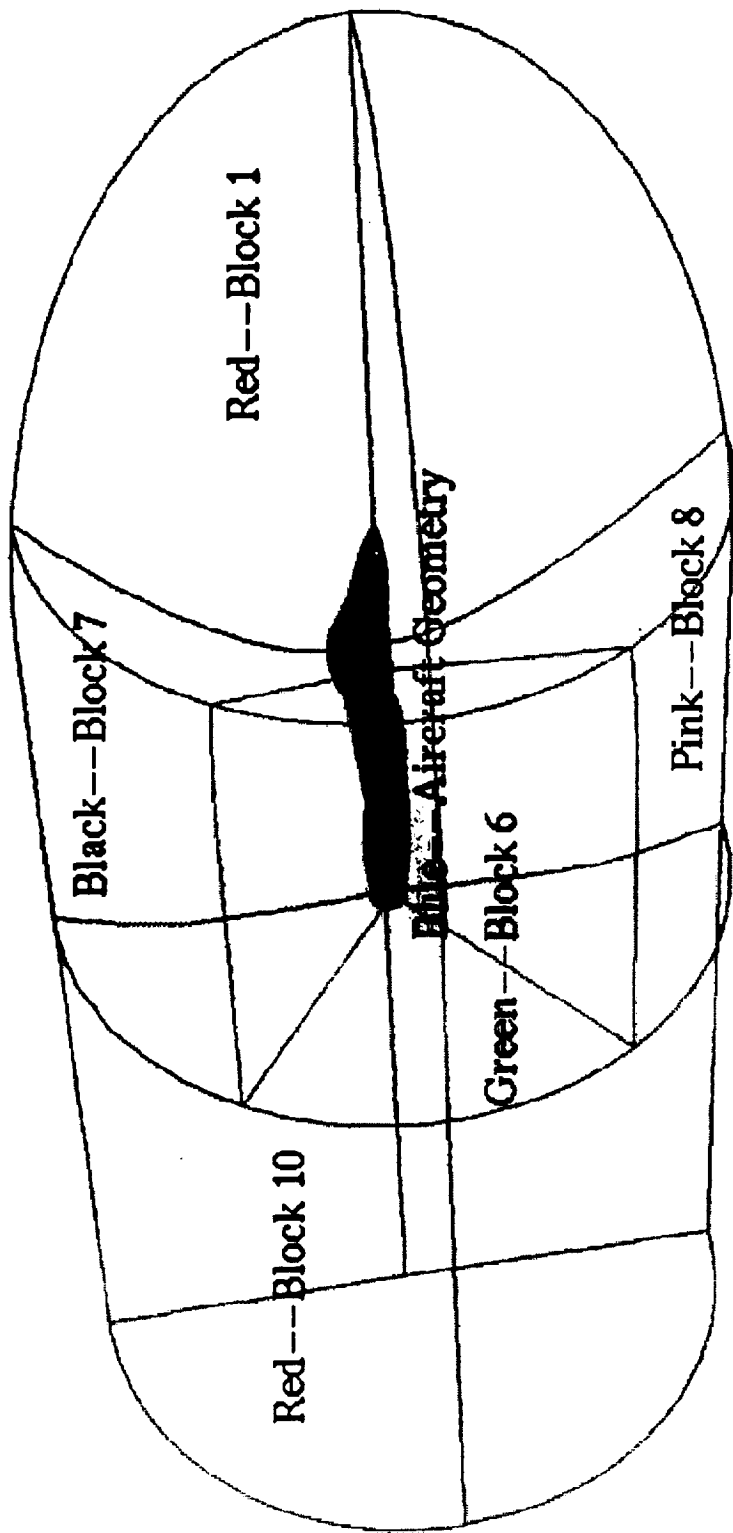
GEOMETRY
Chimera Grid



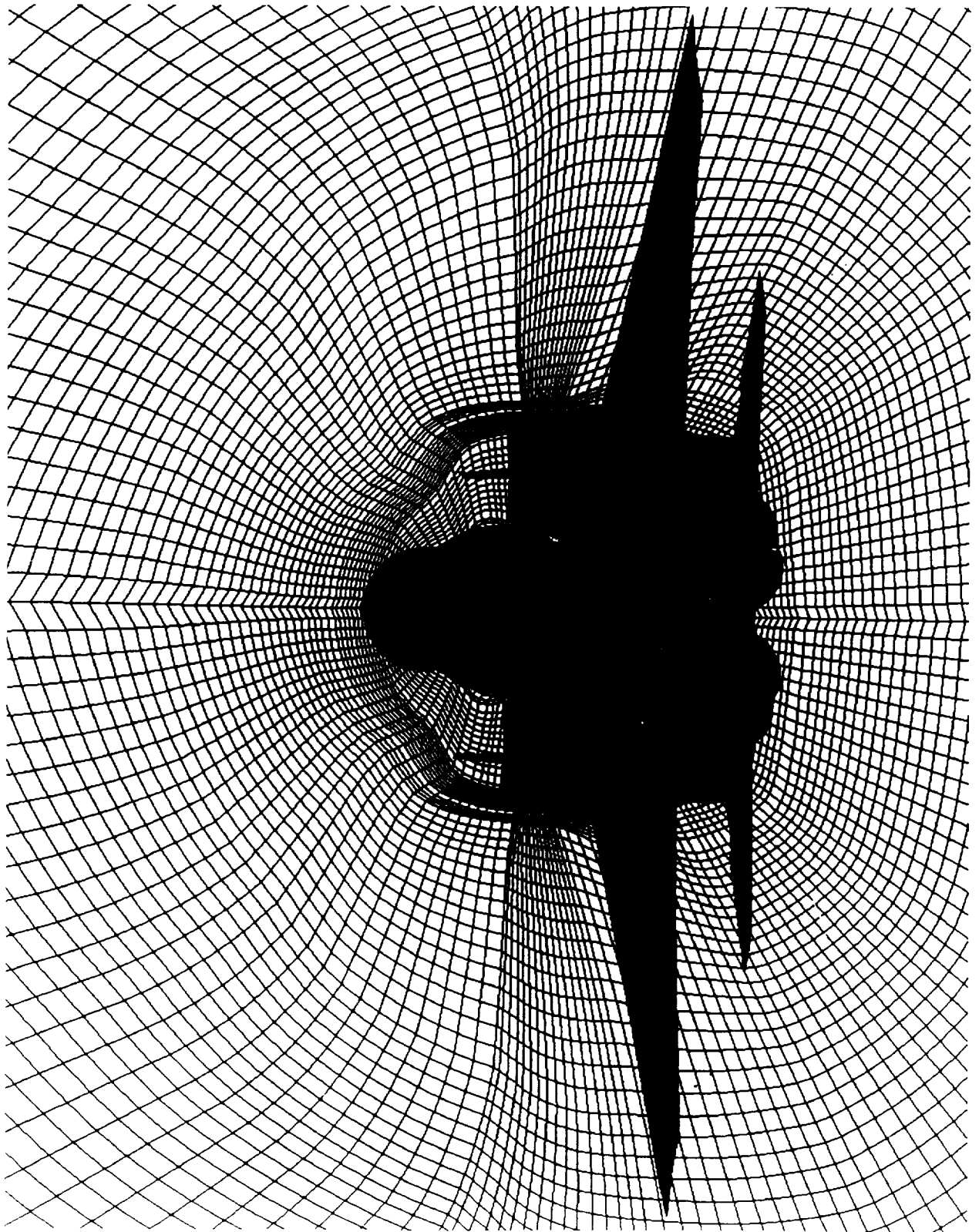
GEOMETRY
Chimera Grid

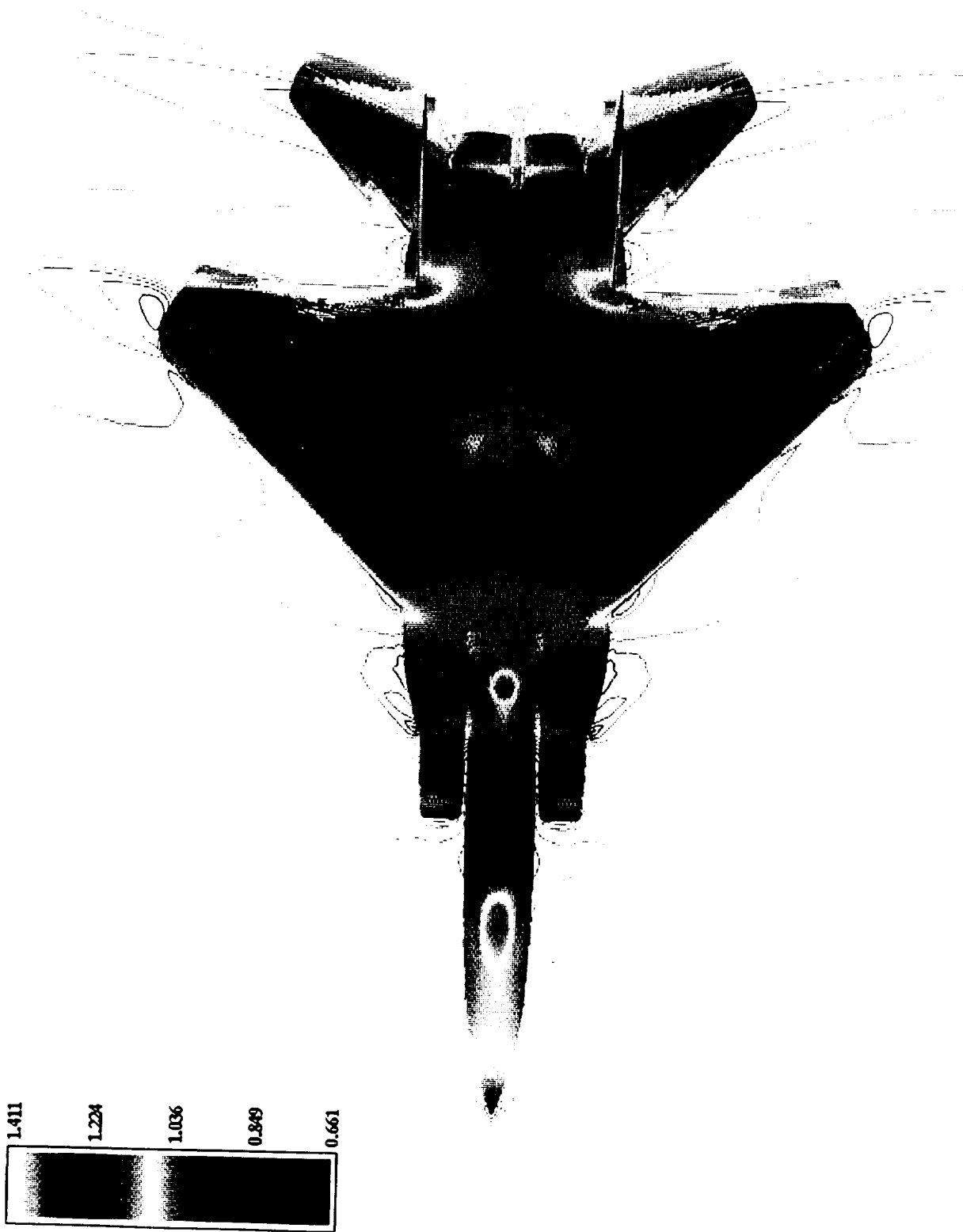




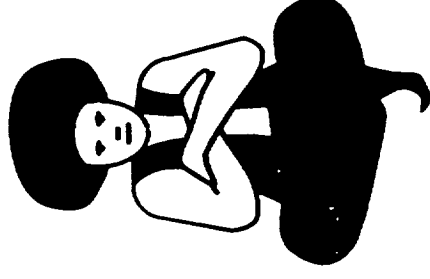


F15e Blocking Strategy





GENIE++



- Semi-Interactive - Simple Minded
- Portable, Modular
- Journal File Execution Control
- Batch-Interactive Execution
- CadType Geometry Construction
- SOA Grid Generation Algorithms
- Quality Control & Extensive Error Checking
- Online Graphical Visualization of Overall Process
- User Friendly & Researcher Friendly
- SGI, X-Window, PC Versions
- bsoni@erc.msstate.edu