WIND TUNNEL RESEARCH TECHNIQUES
TRANSONIC WIND TUNNELS
8-FOOT TRANSONIC PRESSURE TUNNEL

BY

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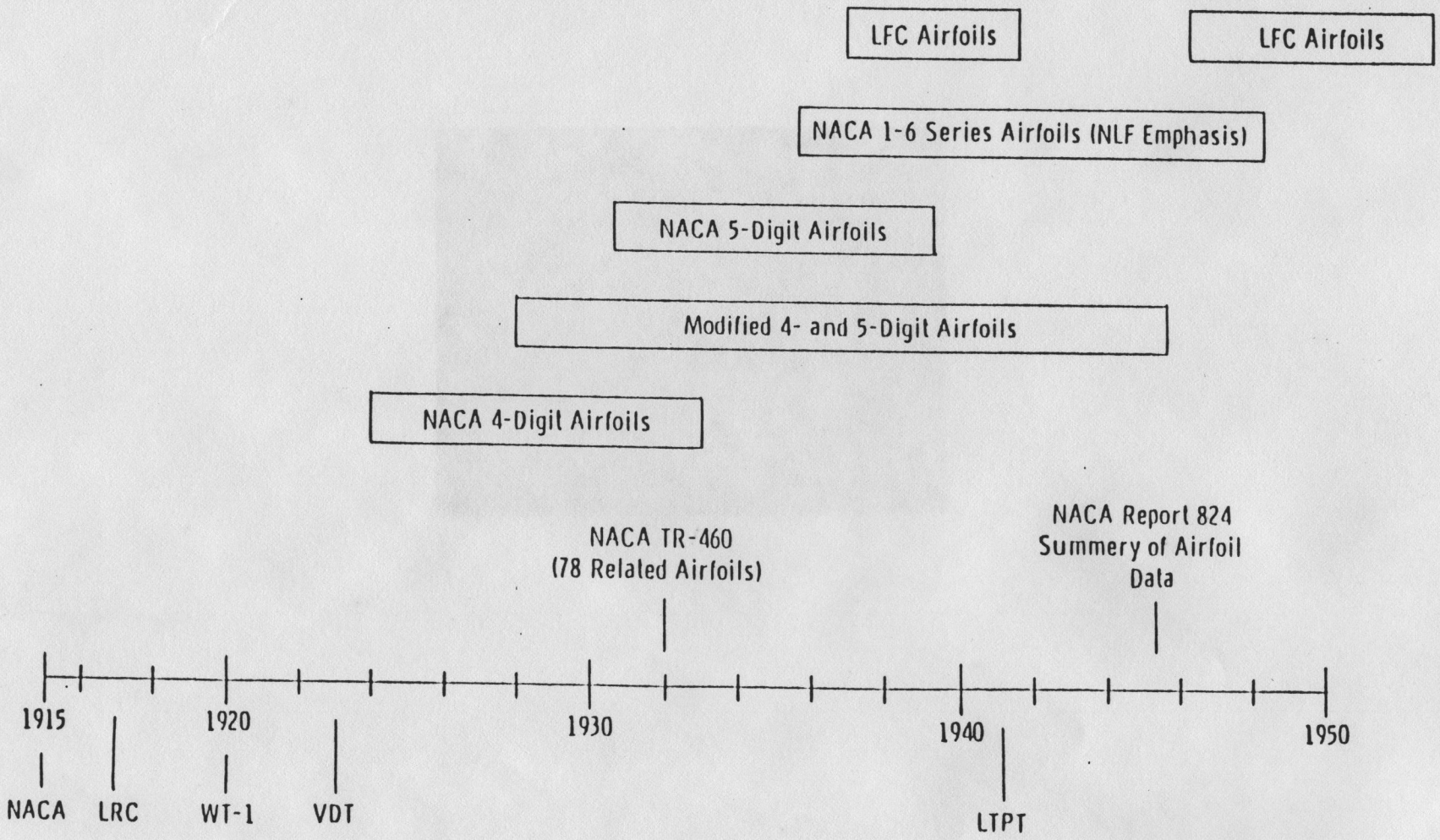
PRESENTATION TO GWU STUDENTS

MARCH 3, 1989

BUILDING 1244, ROOM 232D

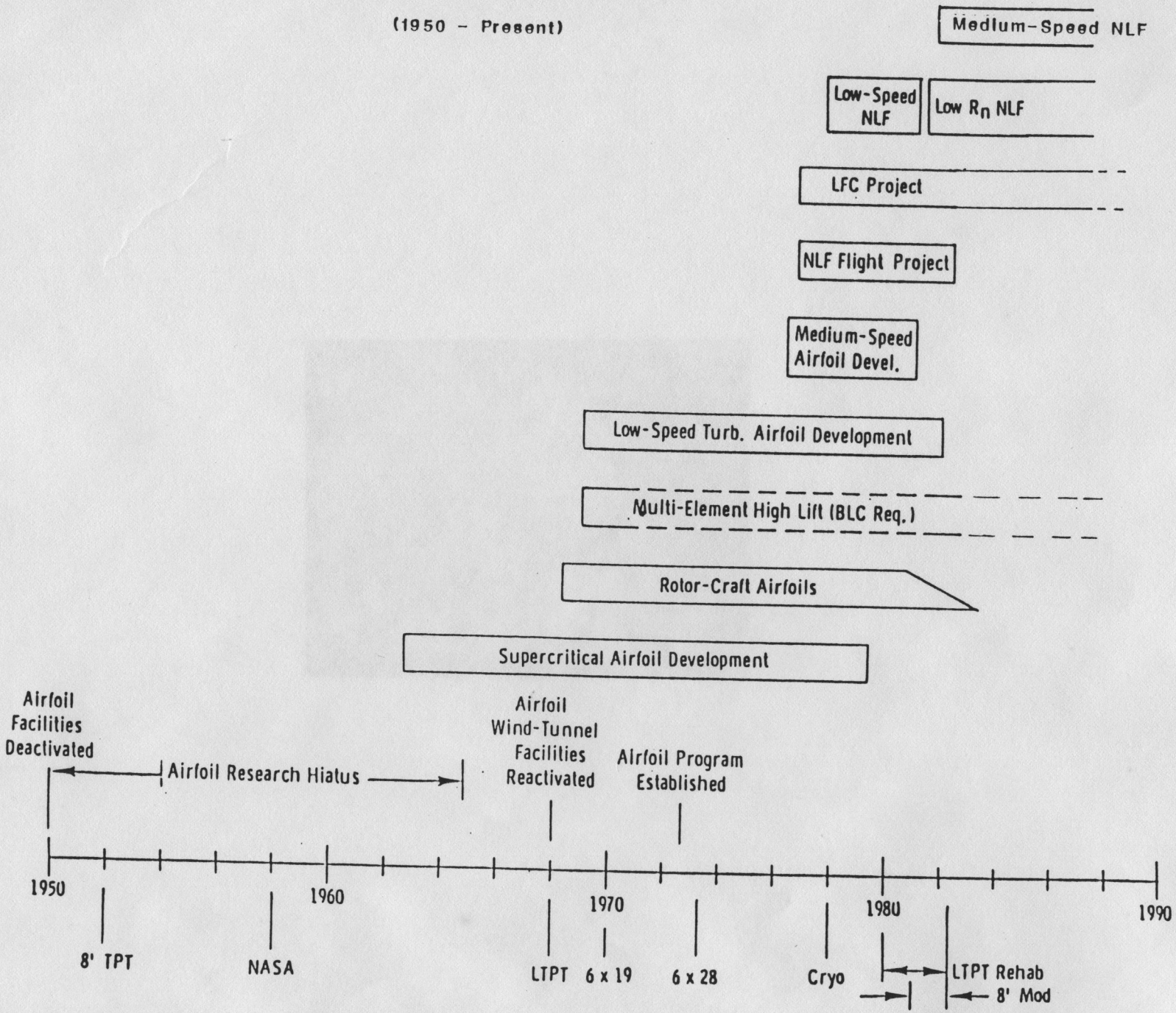
AIRFOIL RESEARCH CHRONOLOGY

(1915-1950)



AIRFOIL RESEARCH CHRONOLOGY

(1950 – Present)



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LANGLEY 8-FT. TRANSONIC PRESSURE TUNNEL

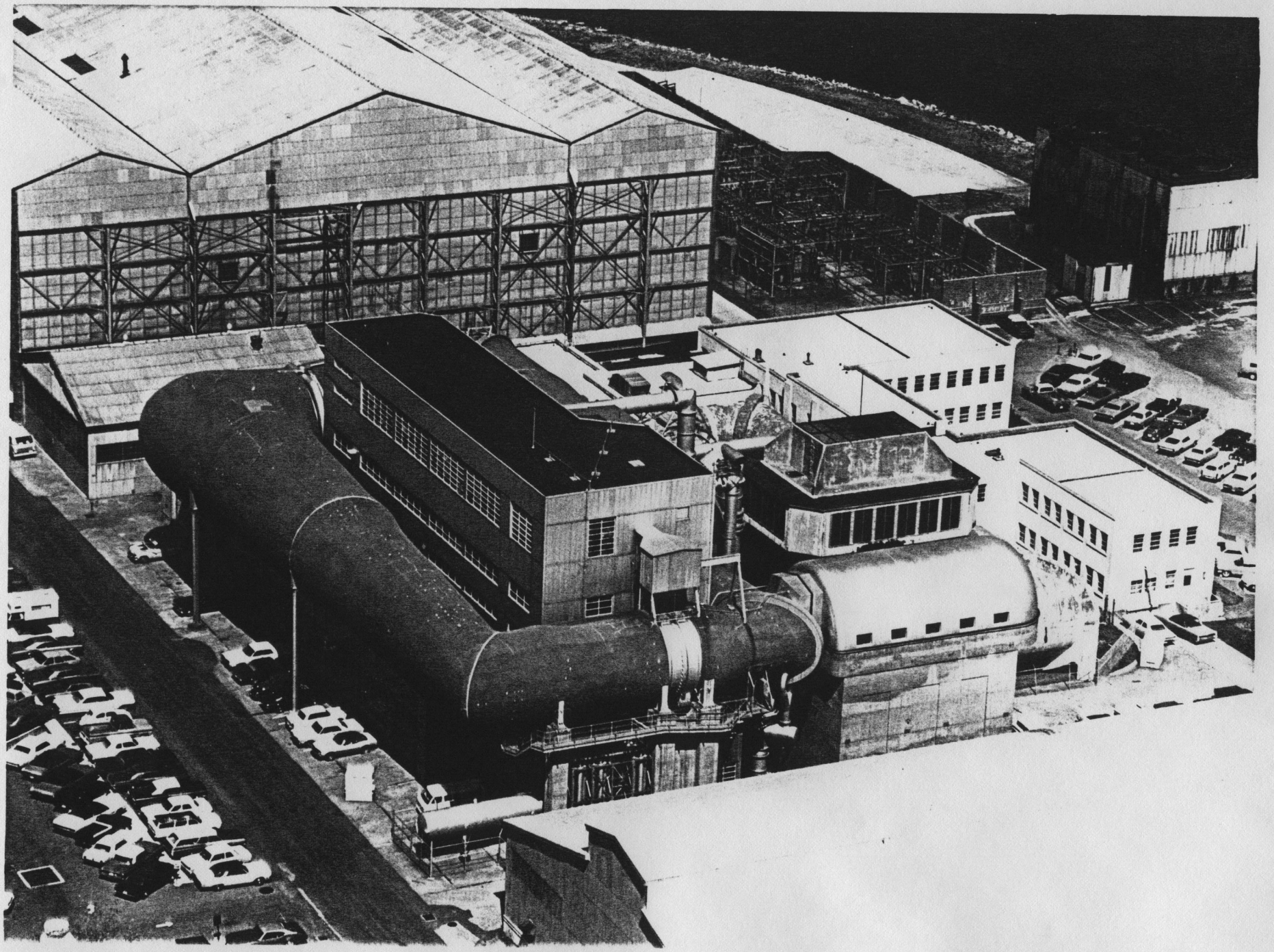
HISTORY

* Construction Start 1950
* On-Line 1952
* Major Modifications

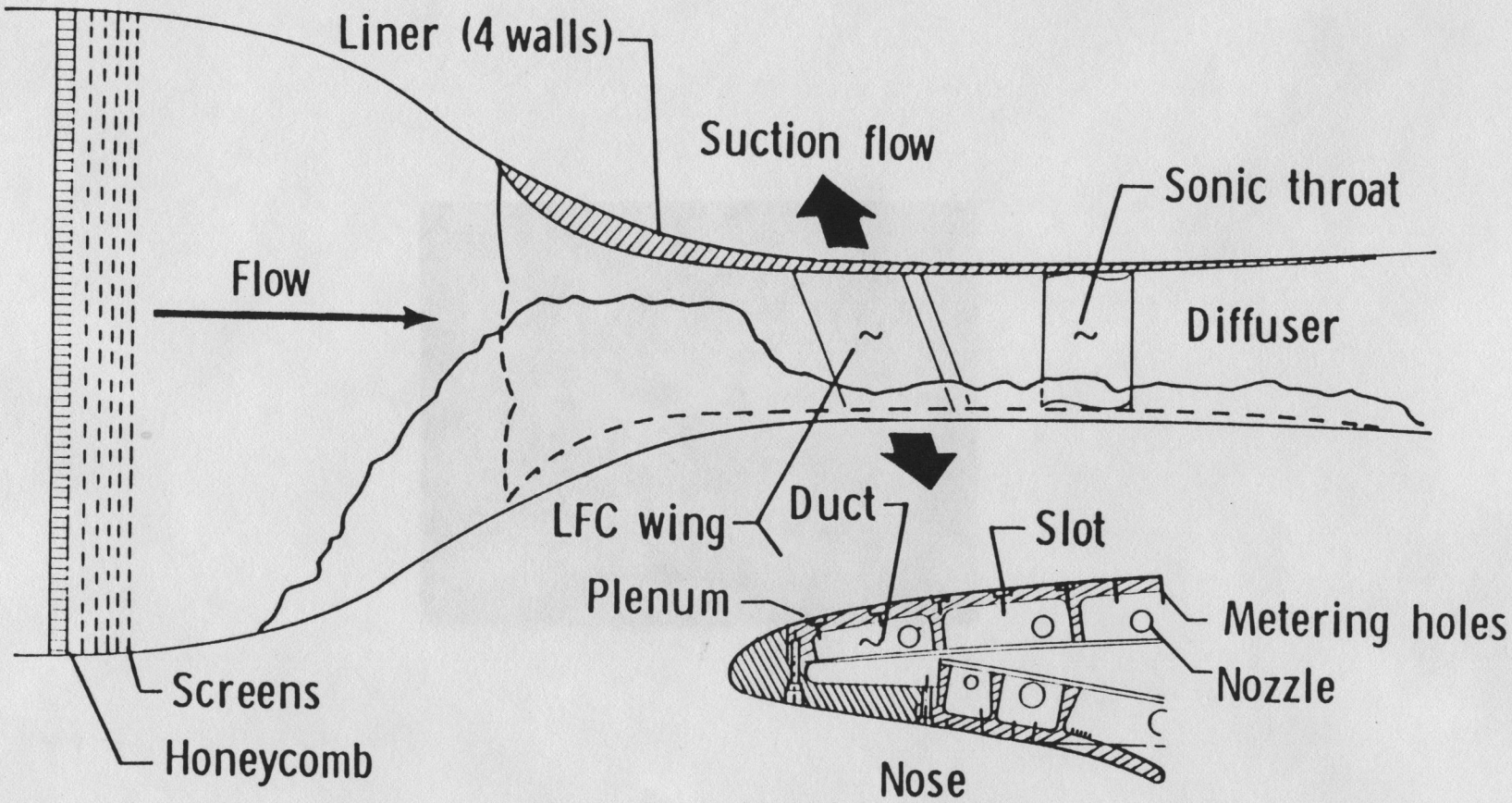
Date	Description
1970	– New Automated Diffuser Spoiler
1980	– Flow Quality Improvements
1981	– Contoured Wall Liner
1982	– Upgraded Data System

L-71-3976

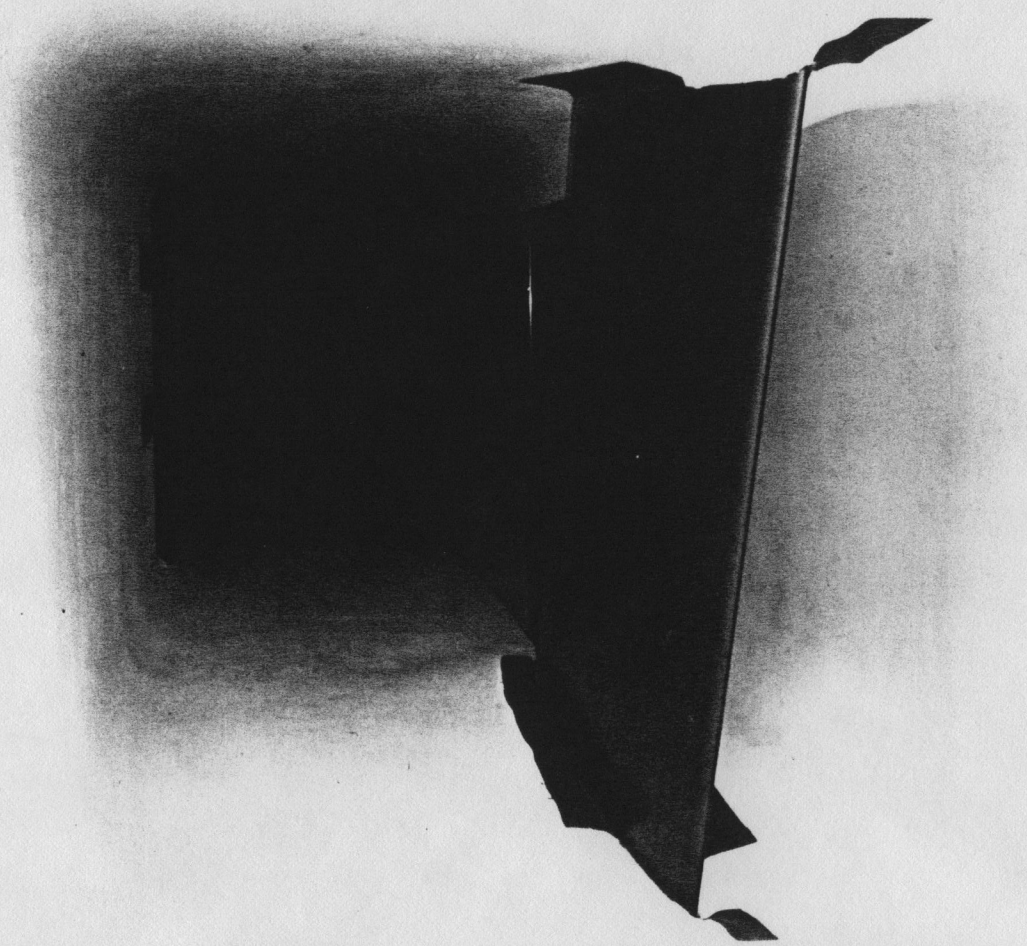
4.



TEST SETUP IN LRC/8-FT. TPT



LFC MODEL IN 8-FT TPT
DOWNSTREAM VIEW



LANGLEY 8-FT. TRANSONIC PRESSURE TUNNEL

CHARACTERISTICS

* TEST SECTION:

7.1x7.1x18 Ft., Closed Circuit, Continuous Flow, Variable Density, Slotted Walls, Humidity Controlled

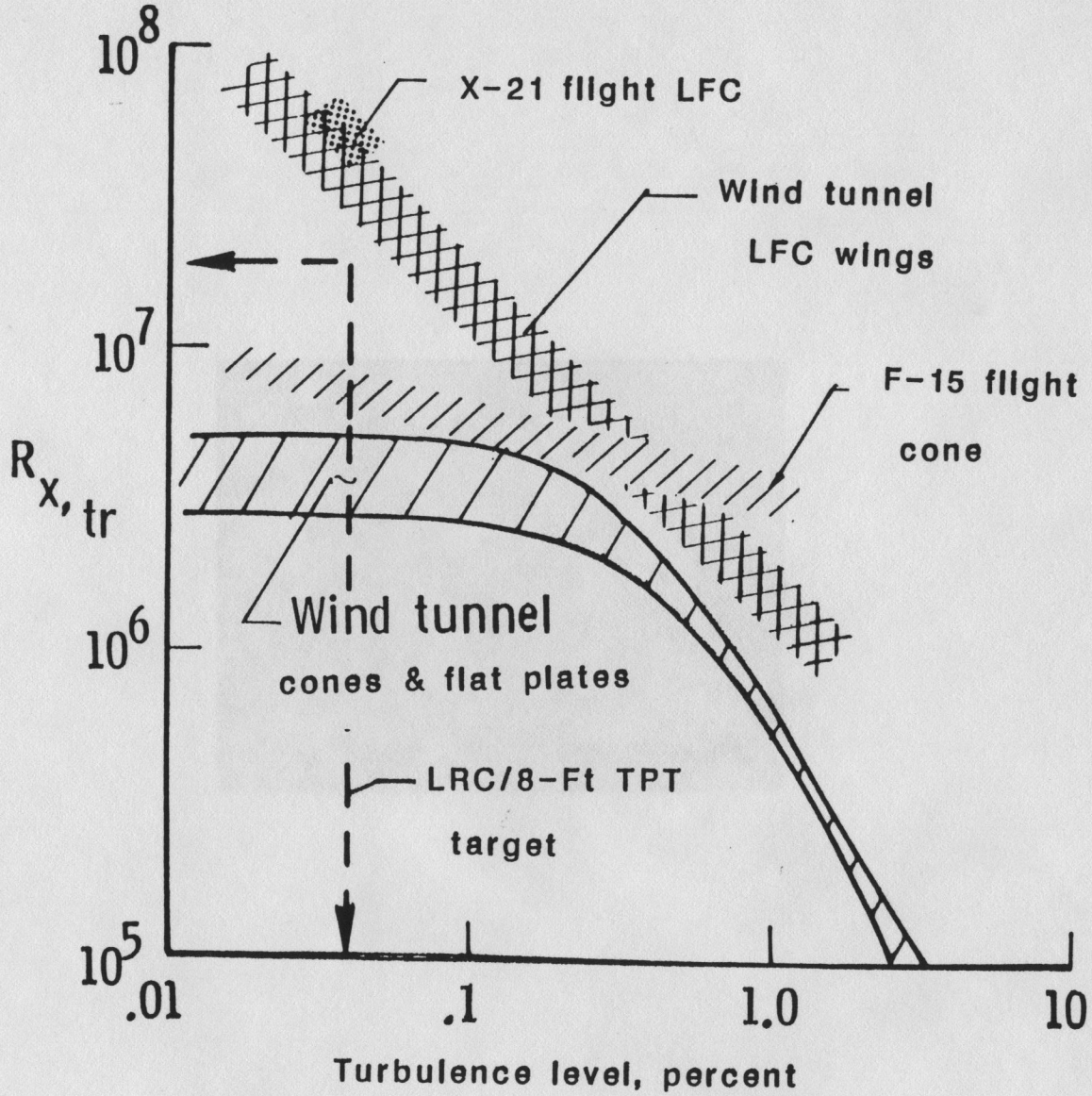
* PRIMARY USES:

Drag Reduction
Fighter Maneuverability
Transport Aerodynamics
DOD Assistance
Missile Aerodynamics
Industry Support

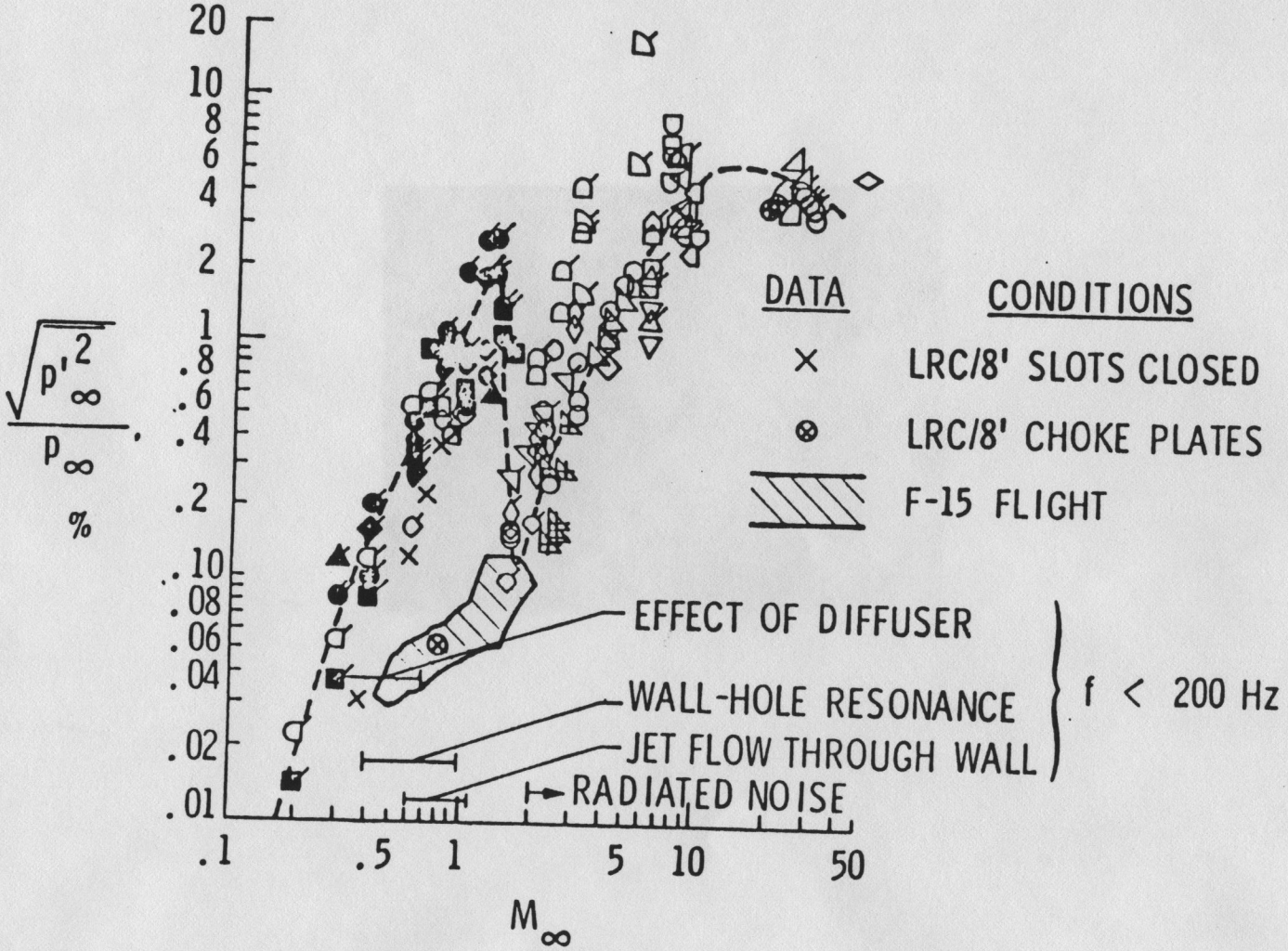
* UNIQUE FEATURES / CAPABILITIES:

Excellent Flow Quality
Dual Data Acquisition and Reduction System
Real-Time (1-sec update) Reduced Data Display
State-of-the-Art ESP Fast Pressure Scan (1024 Ch.)
Schlieren Flow Visualization

INFLUENCE OF TURBULENCE LEVEL ON TRANSITION



COMPARISON OF WIND TUNNEL AND FLIGHT ENVIRONMENTAL DISTURBANCE LEVEL WITH MACH NO.



LANGLEY 8-FT. TRANSONIC PRESSURE TUNNEL

CHARACTERISTICS

* OPERATING ENVELOPE:

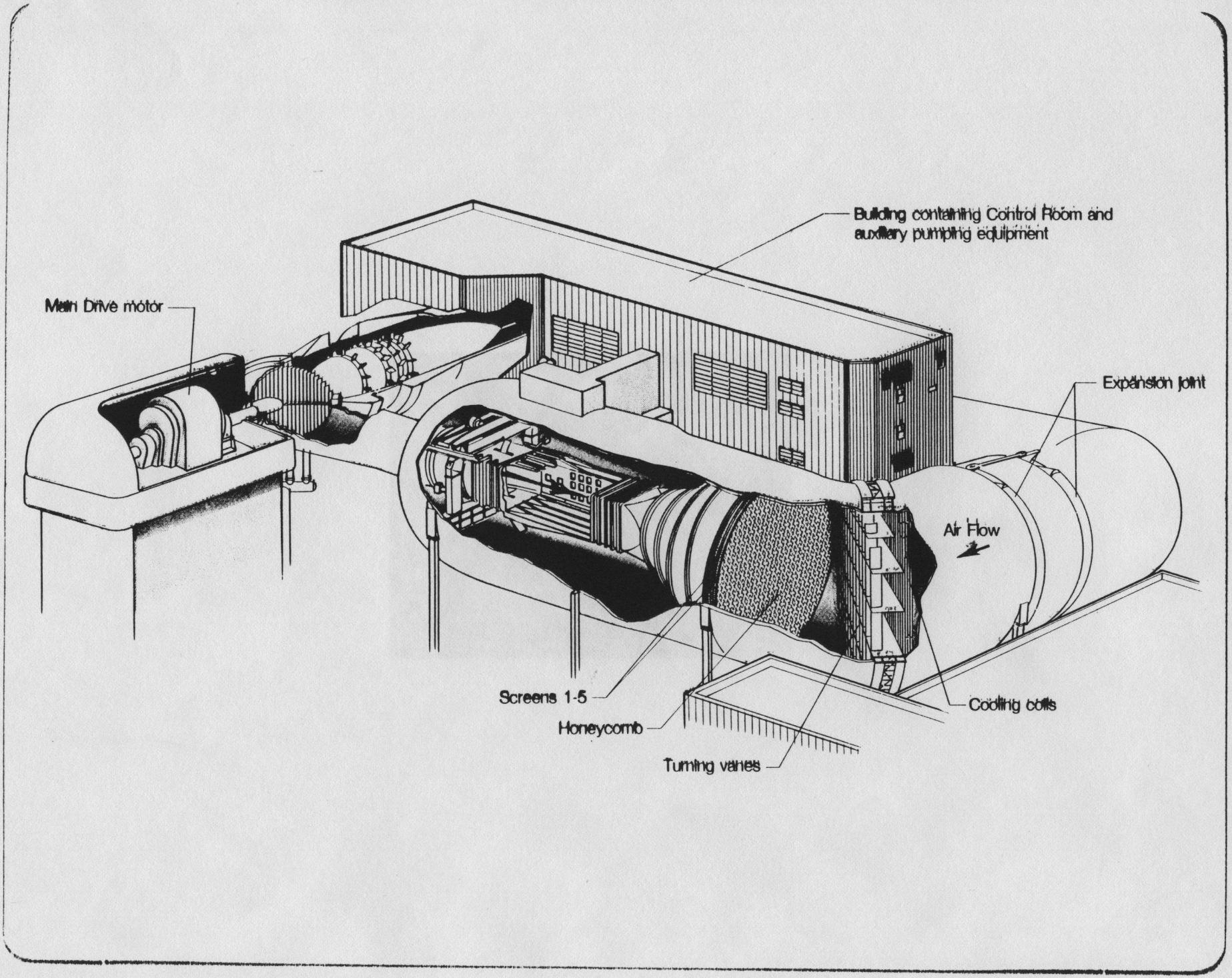
Mach Number	0.2–1.3
Reynolds Number/Ft	0.3–6 Million
Total Pressure	560–4240 psfa (0.25–2.0 Atm)
Dynamic Pressure	16–1260 psf
Total Temperature	100°–120°F (560°–580°R)

* RELATIONSHIP TO OTHER FACILITIES:

Unique NASA Transonic Facility for Flow Quality, Laminar Flow Control, Fighter, Transport, and DOD Studies

L-89-1339

15a


Building containing Control Room and auxiliary pumping equipment
Main Drive motor
Expansion joint
Air Flow
Screens 1-5
Honeycomb
Turning vanes
Cooling coils

L-89-1340

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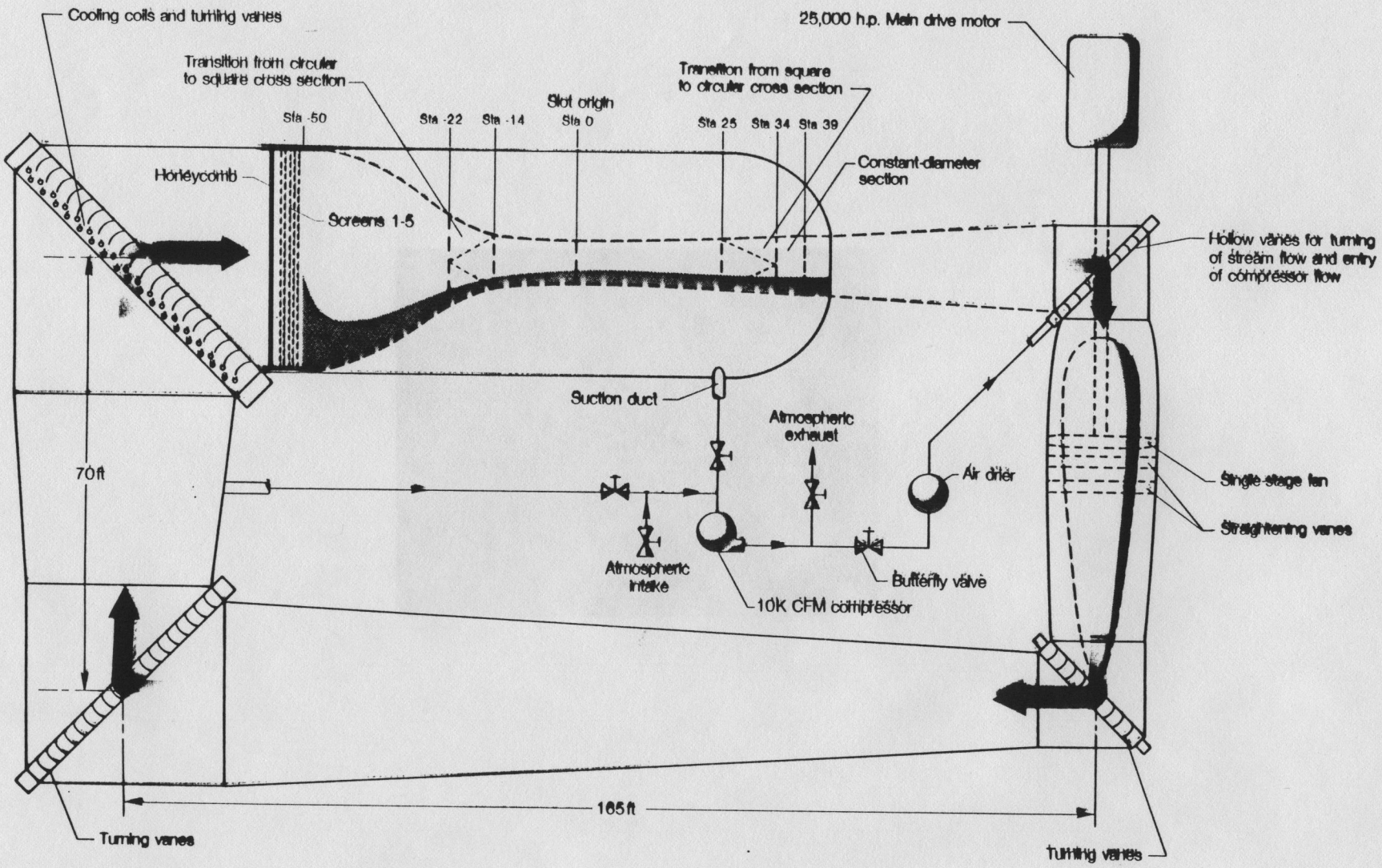
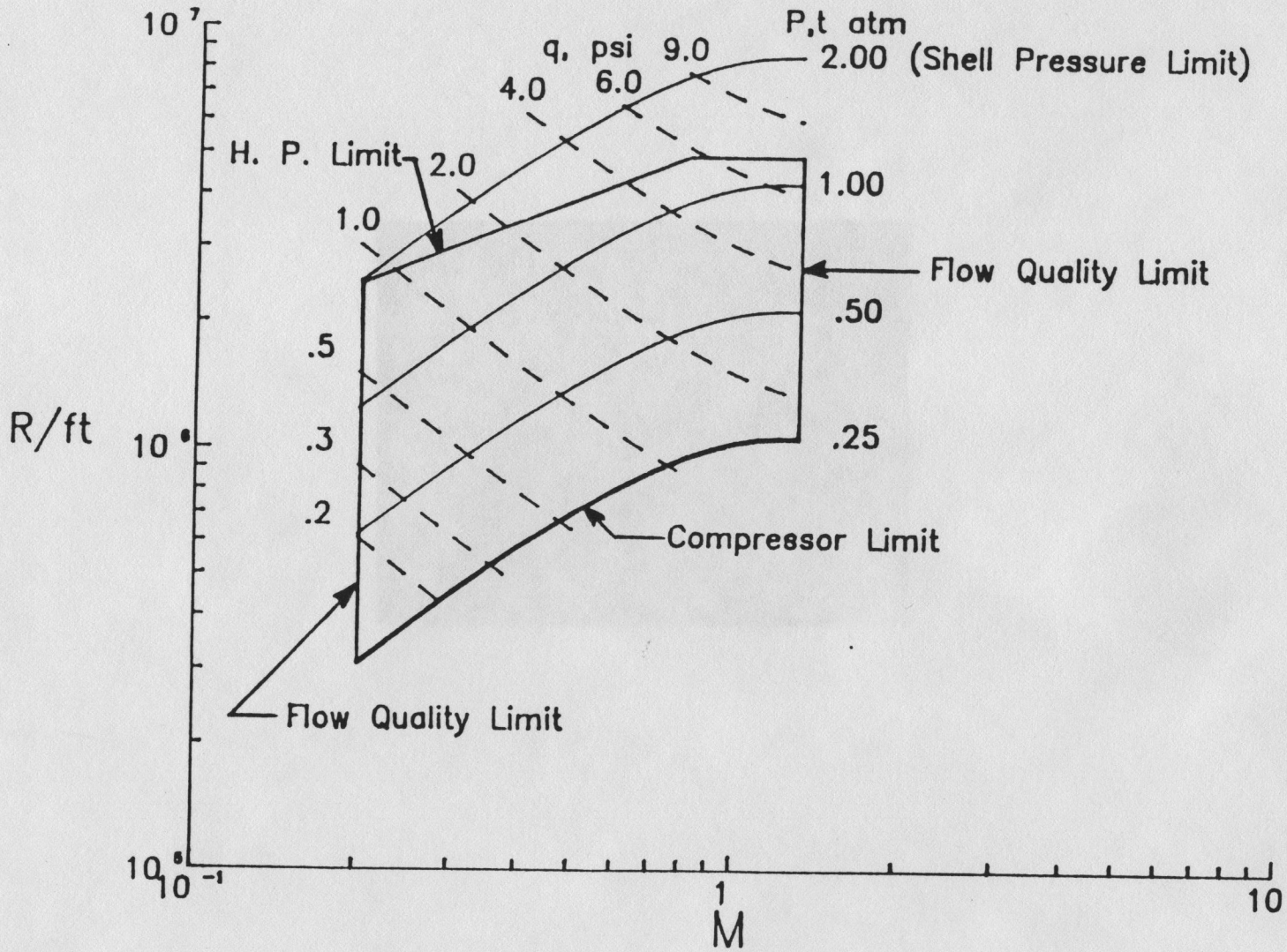
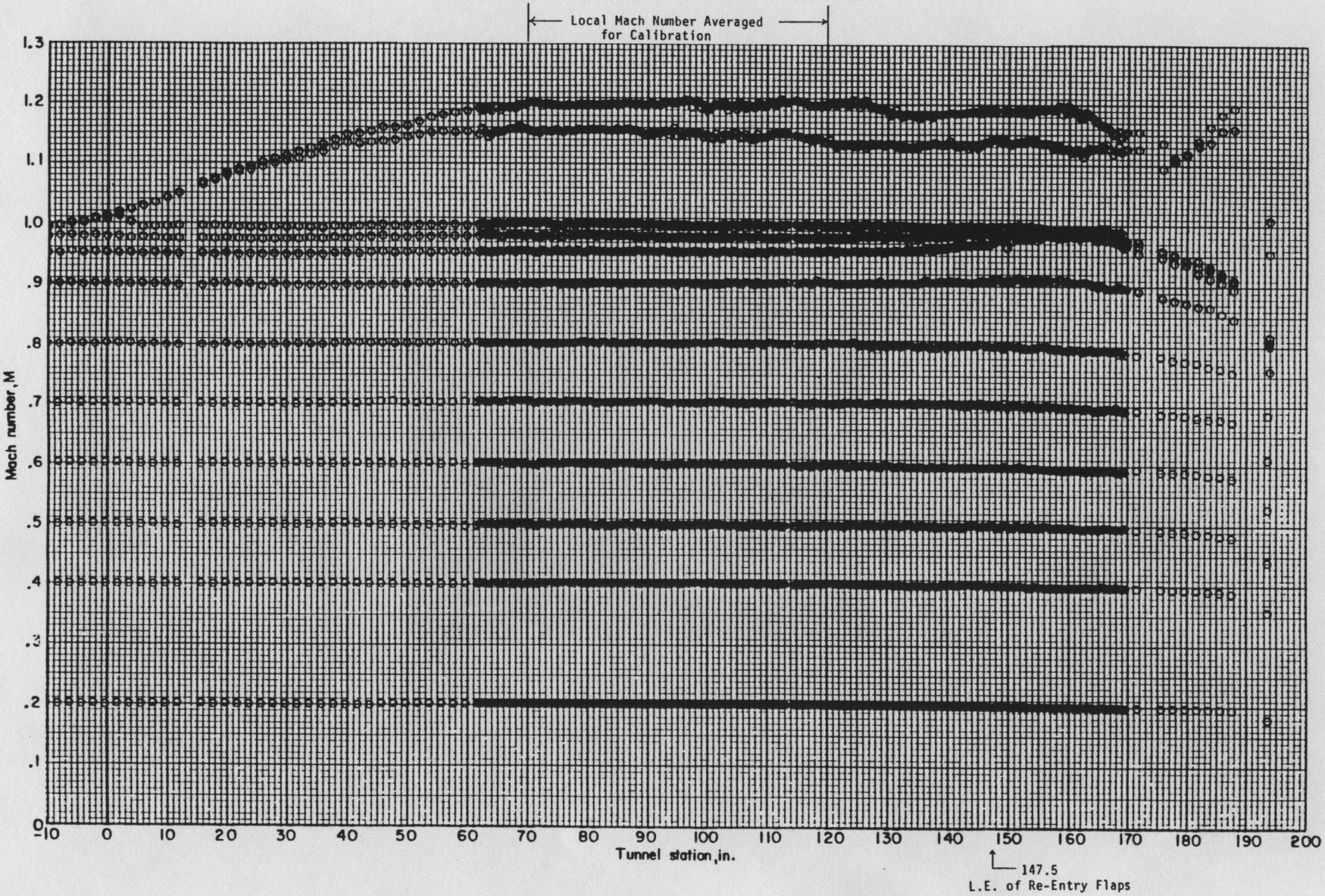

Cooling coils and turning vanes
Transition from circular to square cross section
Sta -50
Sta -22
Sta -14
Slot origin
Sta 0
Sta 25
Sta 34
Sta 39
Transition from square to circular cross section
25,000 h.p. Main drive motor
Constant-diameter section
Honeycomb
Screens 1-5
Hollow vanes for turning of stream flow and entry of compressor flow
Suction duct
Atmospheric exhaust
Air drier
70 ft
Single-stage fan
Straightening vanes
Atmospheric intake
Butterfly valve
10K CFM compressor
165 ft
Turning vanes
Turning vanes

8–FOOT TRANSONIC PRESSURE TUNNEL

Temperature = 120 deg. F

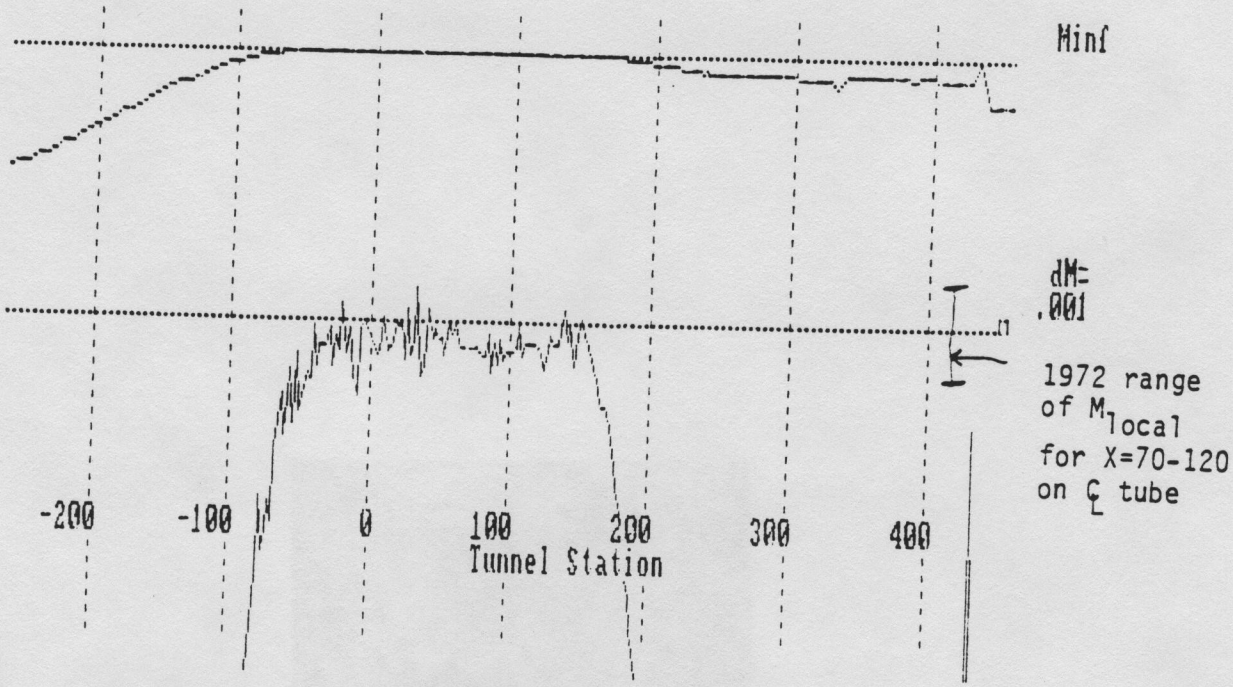


MACH NUMBER DISTRIBUTION FOR 8-Ft TRANSONIC PRESSURE TUNNEL



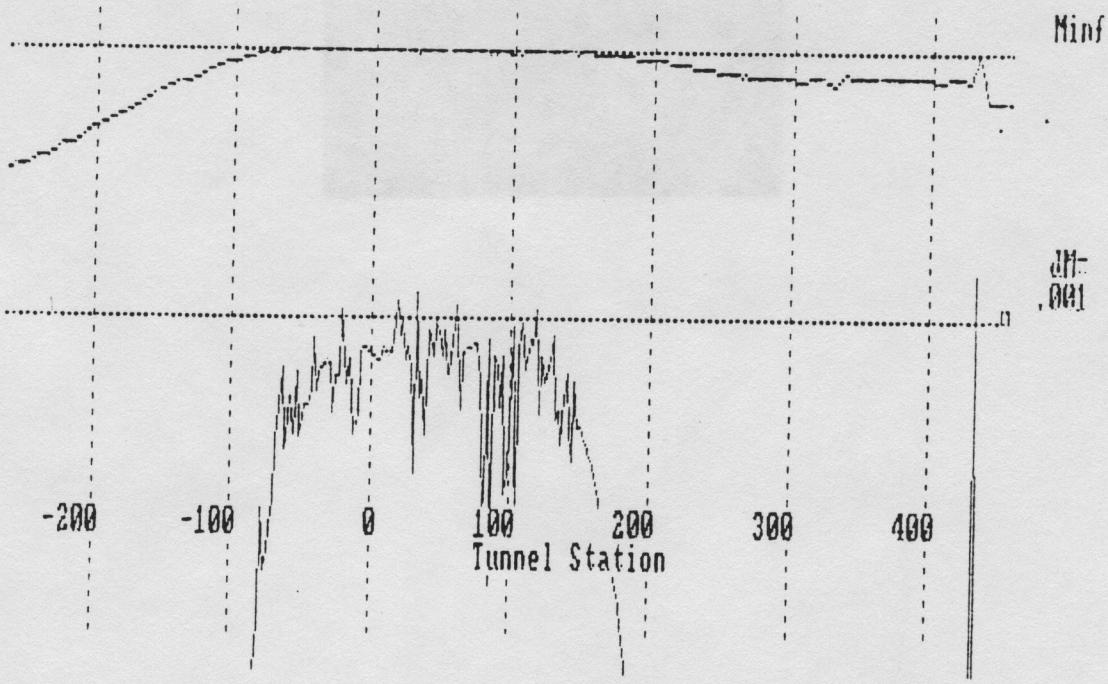
Test Run Pt Minf 8' TPT East Wall
1000 18 7 0.700

Final smoothed orifice installation

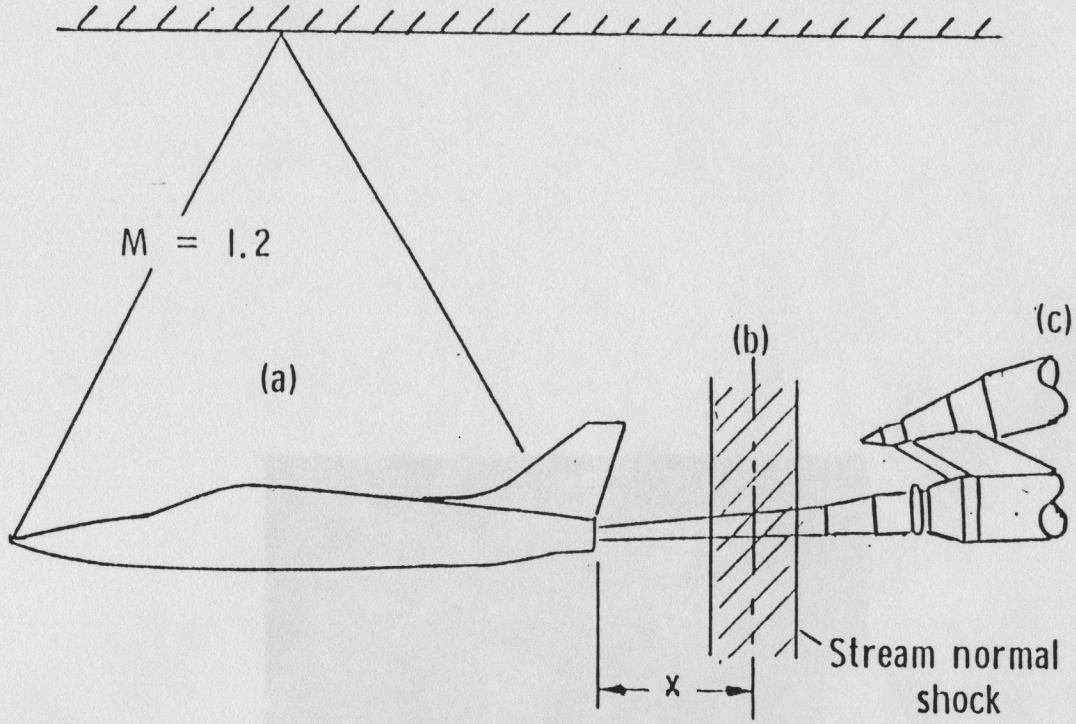


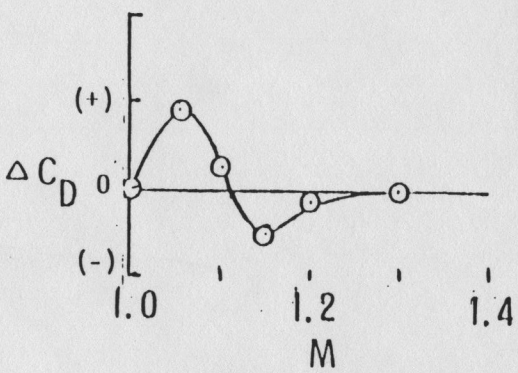
Test Run Pt Minf 8' TPT East Wall
1000 7 5 0.704

Original orifice installation

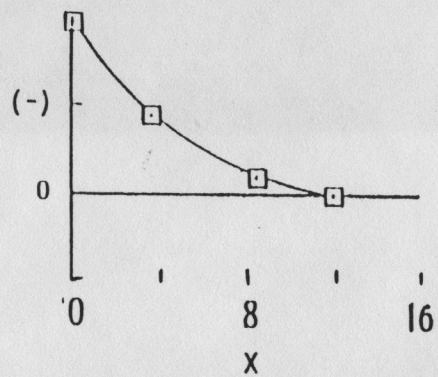


TRANSONIC TUNNEL TESTING

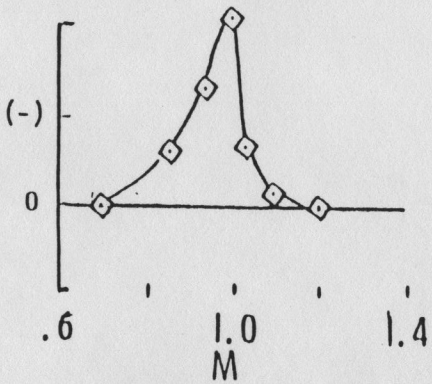




(a) SHOCK REFLECTION

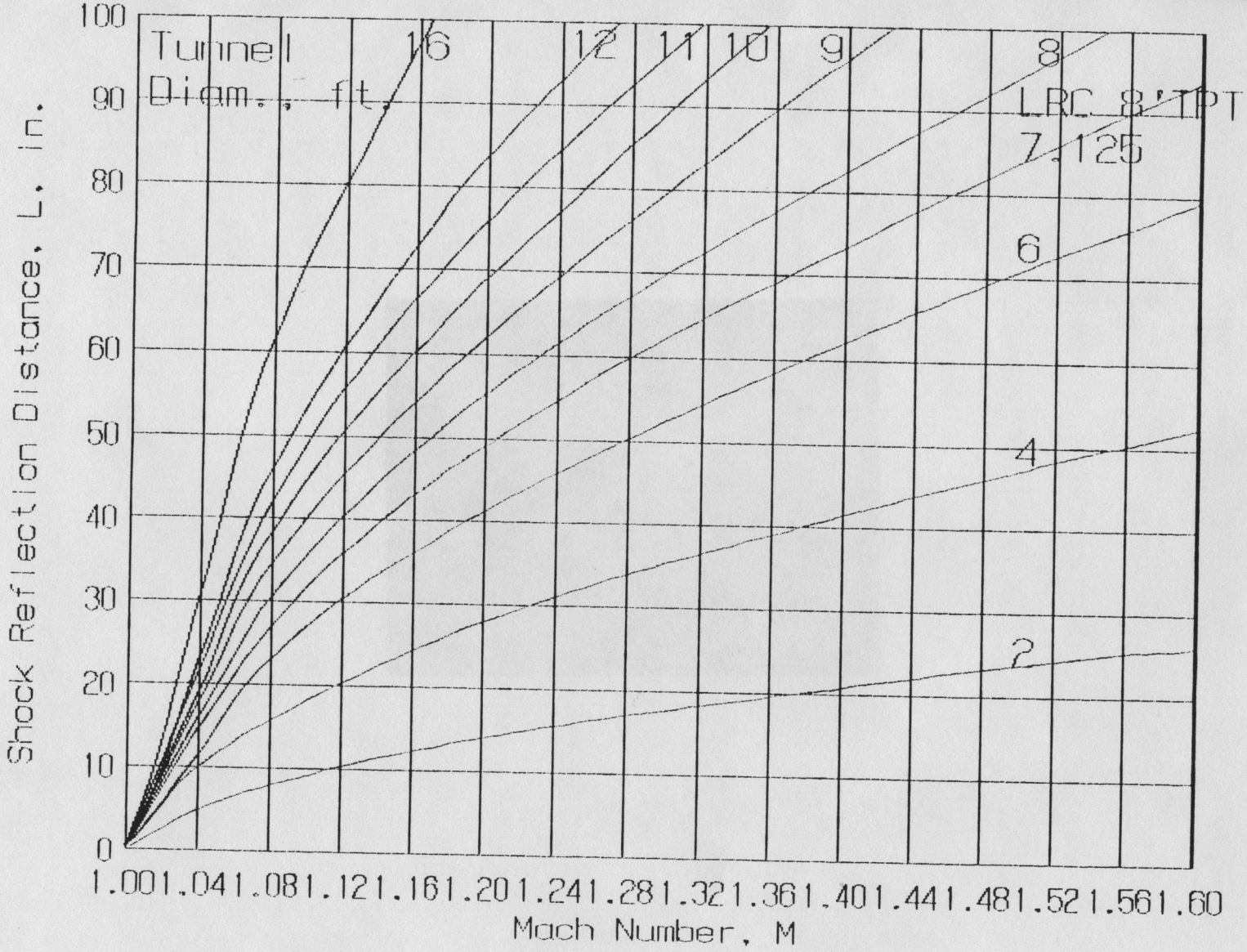


(b) NORMAL SHOCK PROXIMITY



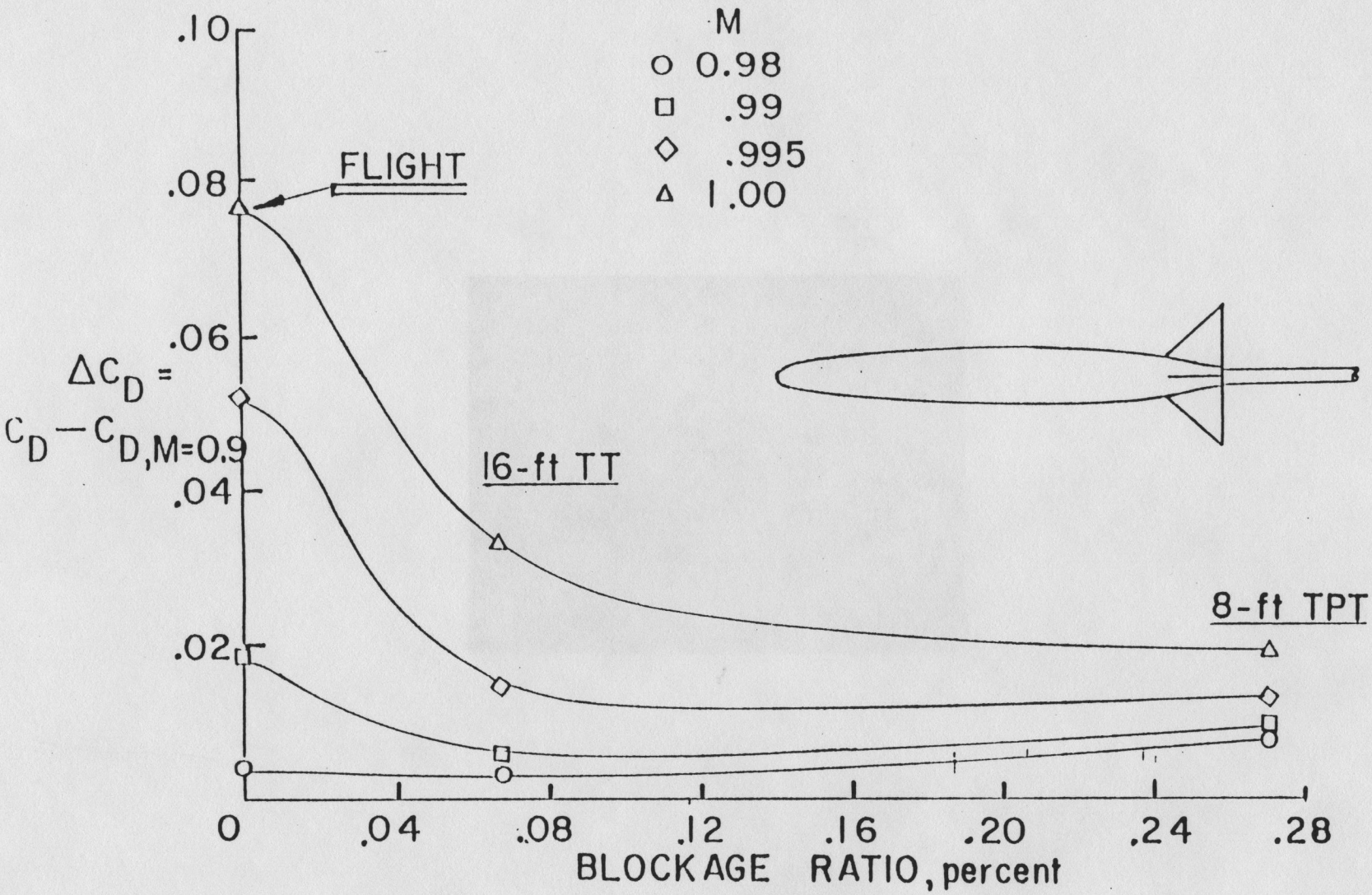
(c) INTERFERENCE CAUSED BY POORLY DESIGNED SUPPORT

SHOCK REFLECTION DISTANCE FOR VARIOUS SIZE TUNNELS



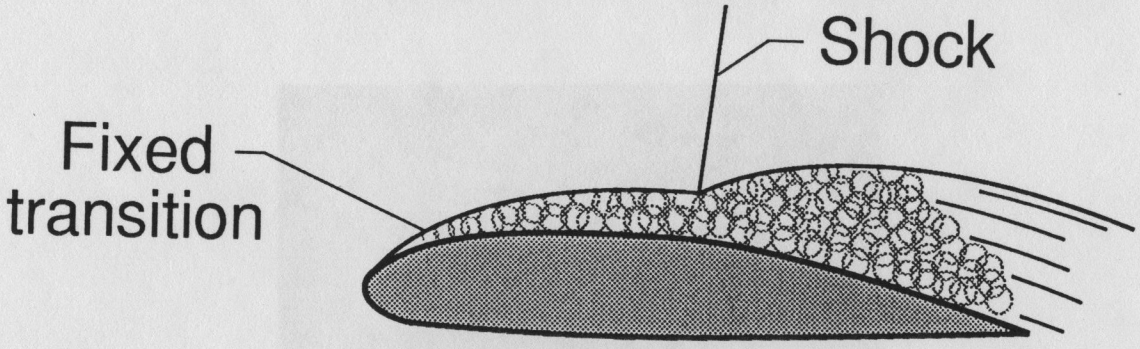
WALL INTERFERENCE

SLENDER BODY

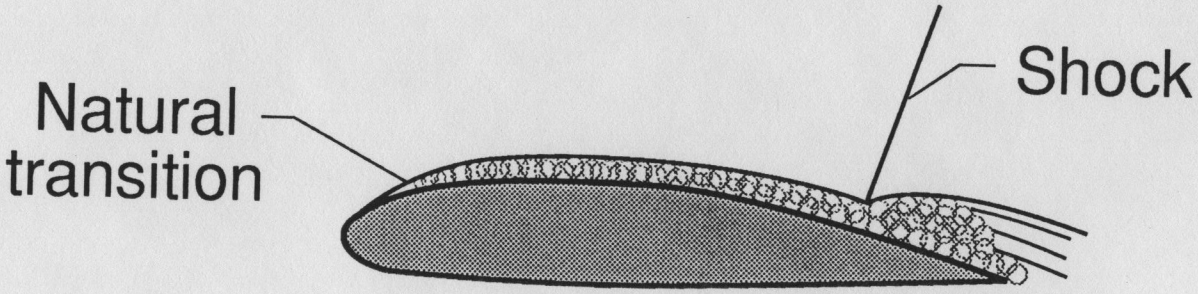


EFFECT OF BOUNDARY LAYER ON SHOCK-INDUCED SEPARATION

WIND TUNNEL
Low Reynolds Number



FLIGHT
High Reynolds Number

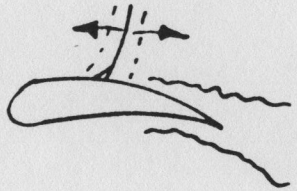


CONSEQUENCE OF TRANSONIC VISCOUS EFFECTS

INCREASE SEVERITY OF SEPARATION

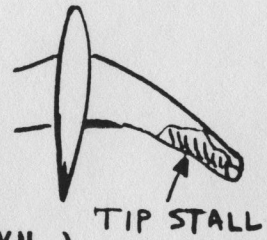
1. DEGRADES RANGE ($\sim M_\infty (L/D)$) VIA DRAG DIVERGENCE

2. CAUSES HIGH M_L BUFFET { RIDE COMFORT-HANDLING / STRUCTURAL FATIGUE



3. PRODUCES PITCHUP (PREMATURE WING TIP STALL) VARIABLE ALONG-STABILITY

   - LOSS OF LONGITUDINAL STABILITY (ONE OF "BIGGER HEADACHES" FOR TRANSPORT AERODYN.)

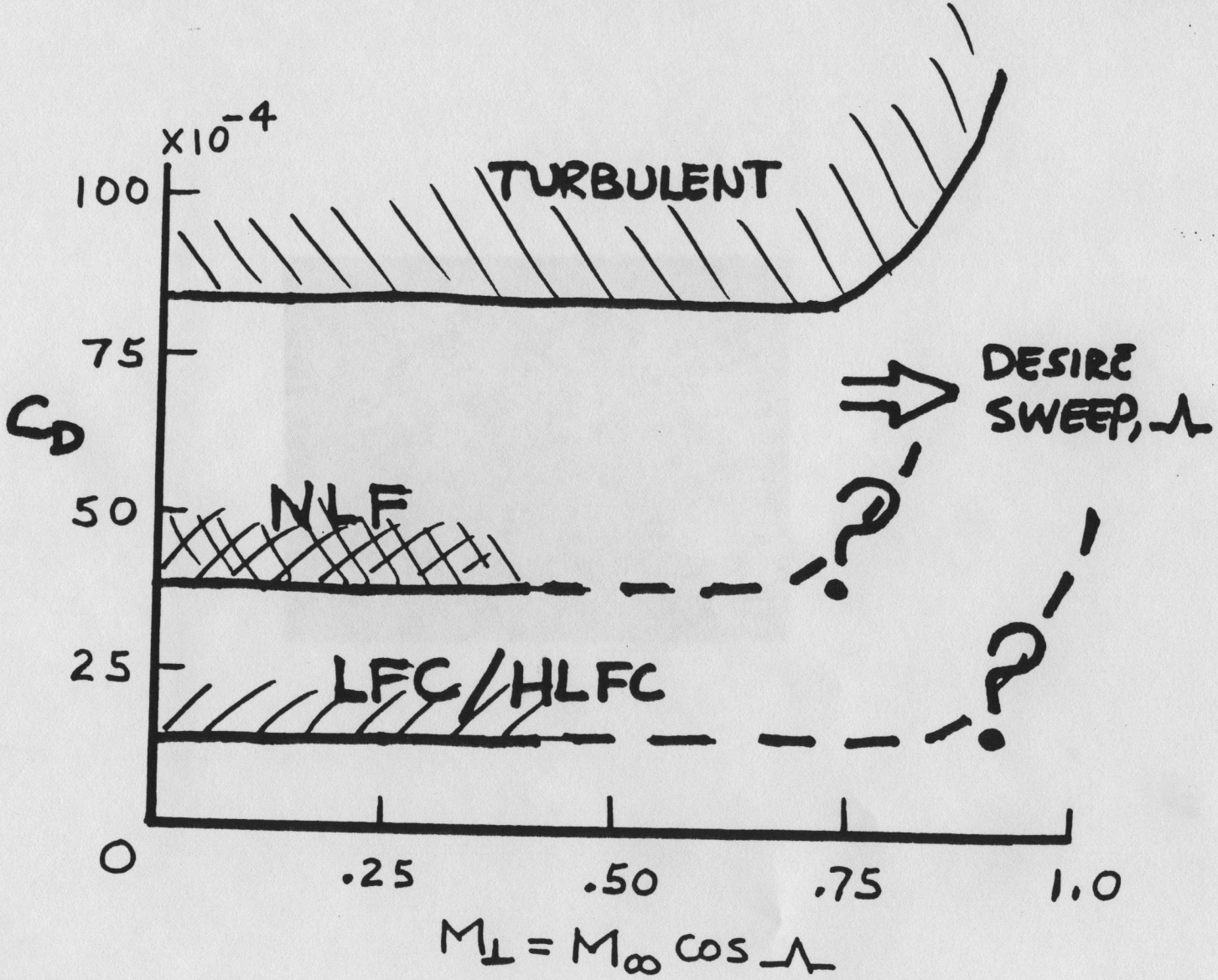


   - LOSS OF OUTBOARD CONTROLS

4. DEGRADATION OF LATERAL STABILITY (MILITARY FIGHTERS) WING ROCK, ETC.

5. COMPARABLE CONSEQUENCES IN INTERNAL AERO, COMPRESSOR DESIGN, HELICOPTER, ETC.

POTENTIAL DRAG REDUCTION ON WINGS WITH/WITHOUT LAMINAR FLOW



LANGLEY 8-FT. TRANSONIC PRESSURE TUNNEL

Recent And Current Utilization

1983–1986

UTILIZATION: Dedicated to supercritical Laminar Flow Control (LFC) research since 1980

PURPOSE: Support NASA/Industry Energy Efficiency Technology Program

OBJECTIVES:
* Validate prediction techniques
* Establish technology base for future transport designs.
* Establish compatibility of LFC with supercritical technology.
* Evaluate Slotted/Porous suction surface concepts.

OPERATING SHIFTS: 1 shift per day

RESULTS: Completed Slotted–surface LFC model demonstrating full–chord LFC and compatibility with supercritical technology and low drag.
Currently testing porous surface concept.

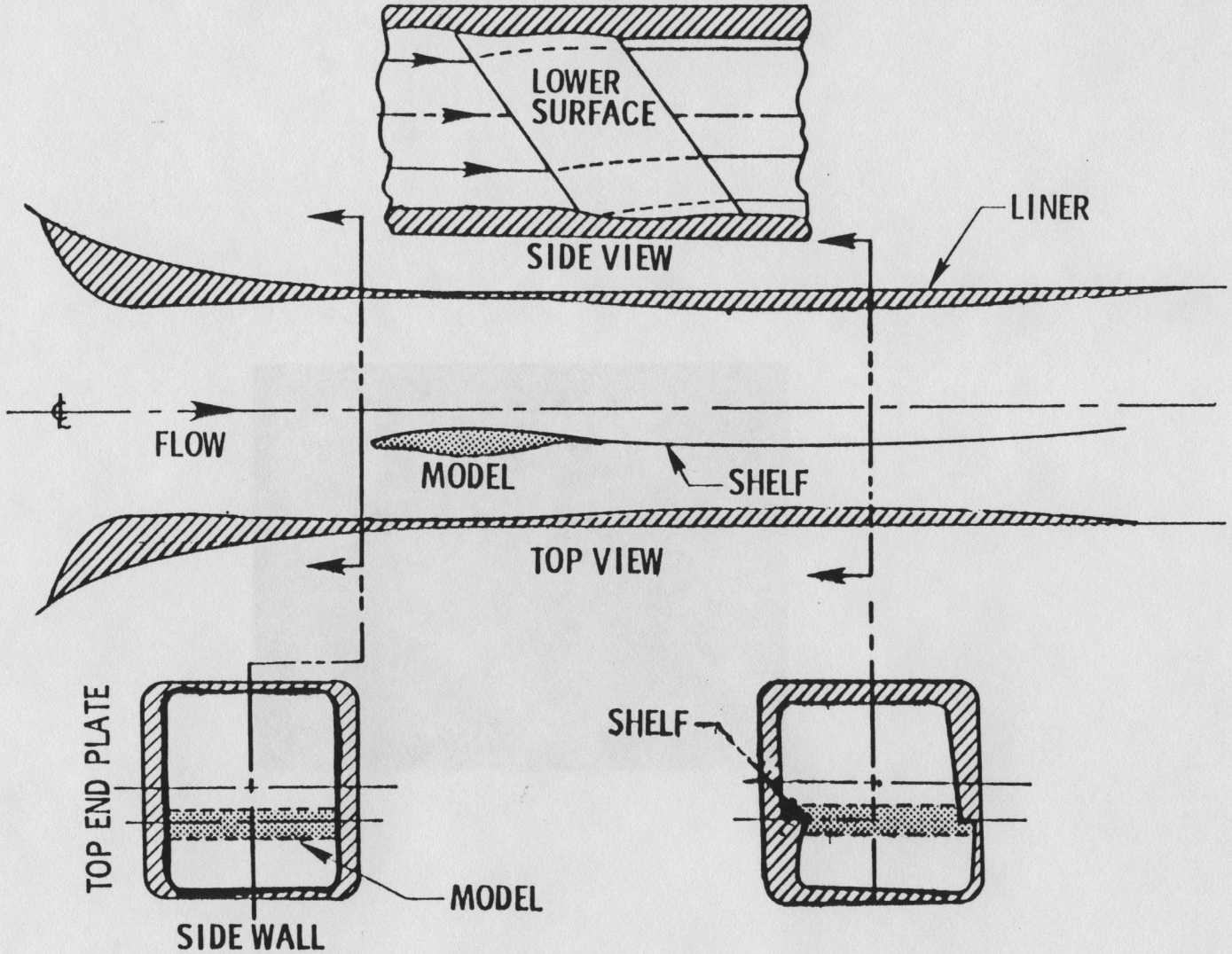
LFC EXPERIMENT REQUIREMENTS

- DESIGN 2-D SWEPT SUPERCRITICAL LFC AIRFOIL WITH HIGH PERFORMANCE COMPARABLE TO TURBULENT AIRFOIL, SIMULATION OF FLIGHT CONDITIONS AND SCALE EFFECTS

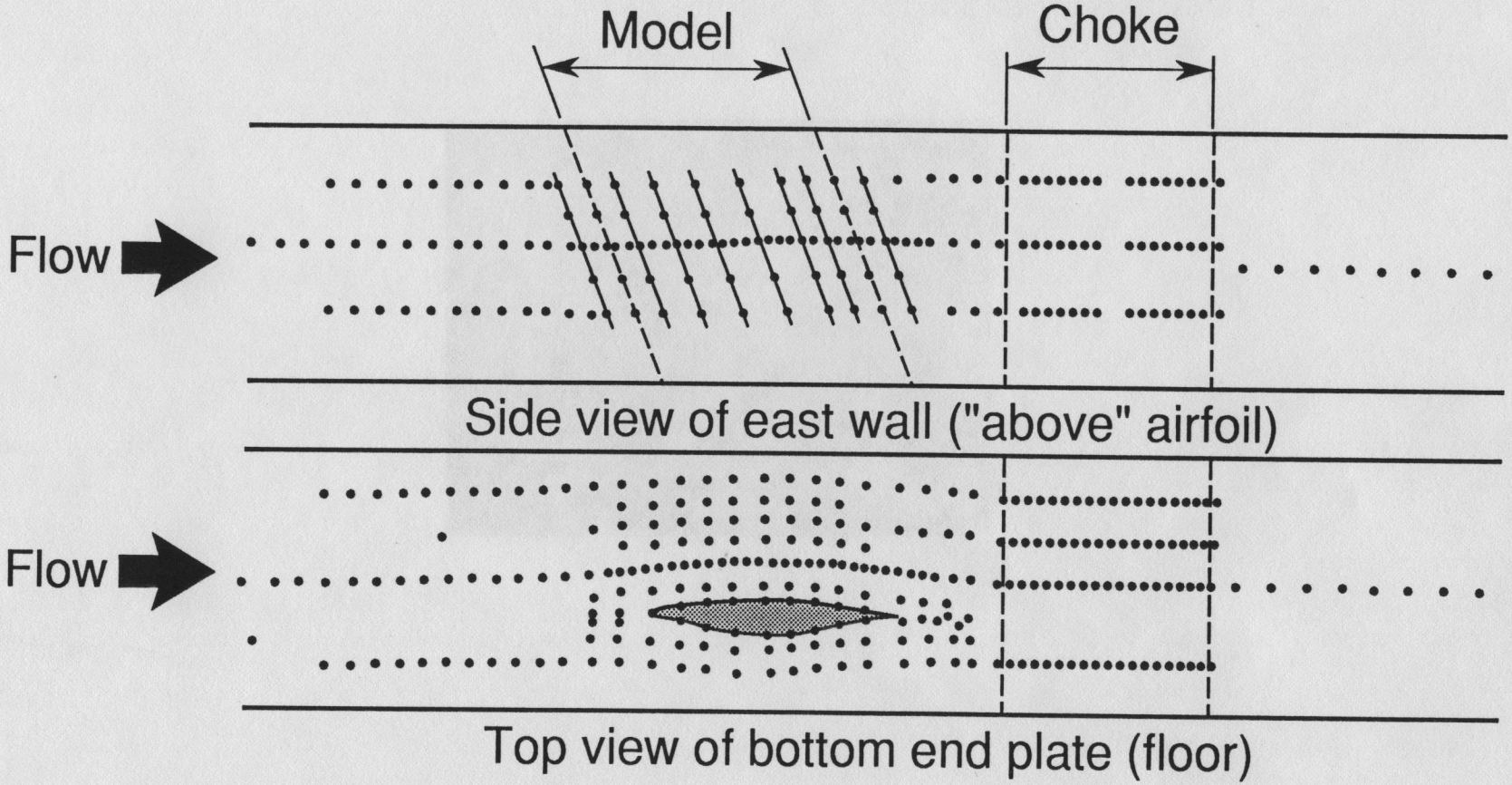
- MODIFY 8-FT TPT FOR IMPROVED FLOW QUALITY AT TRANSONIC SPEEDS

- CONTOUR ALL NON-POROUS TUNNEL WALLS TO PROVIDE FREE-AIR FLOW ABOUT YAWED AIRFOIL INCLUDING MODEL-WALL JUNCTURE SUCTION FOR BLC

SCHEMATIC OF CONTOURED LINER FOR LRC/8' TPT



8-FT LFC LINER WALL PRESSURE ORIFICE LOCATIONS



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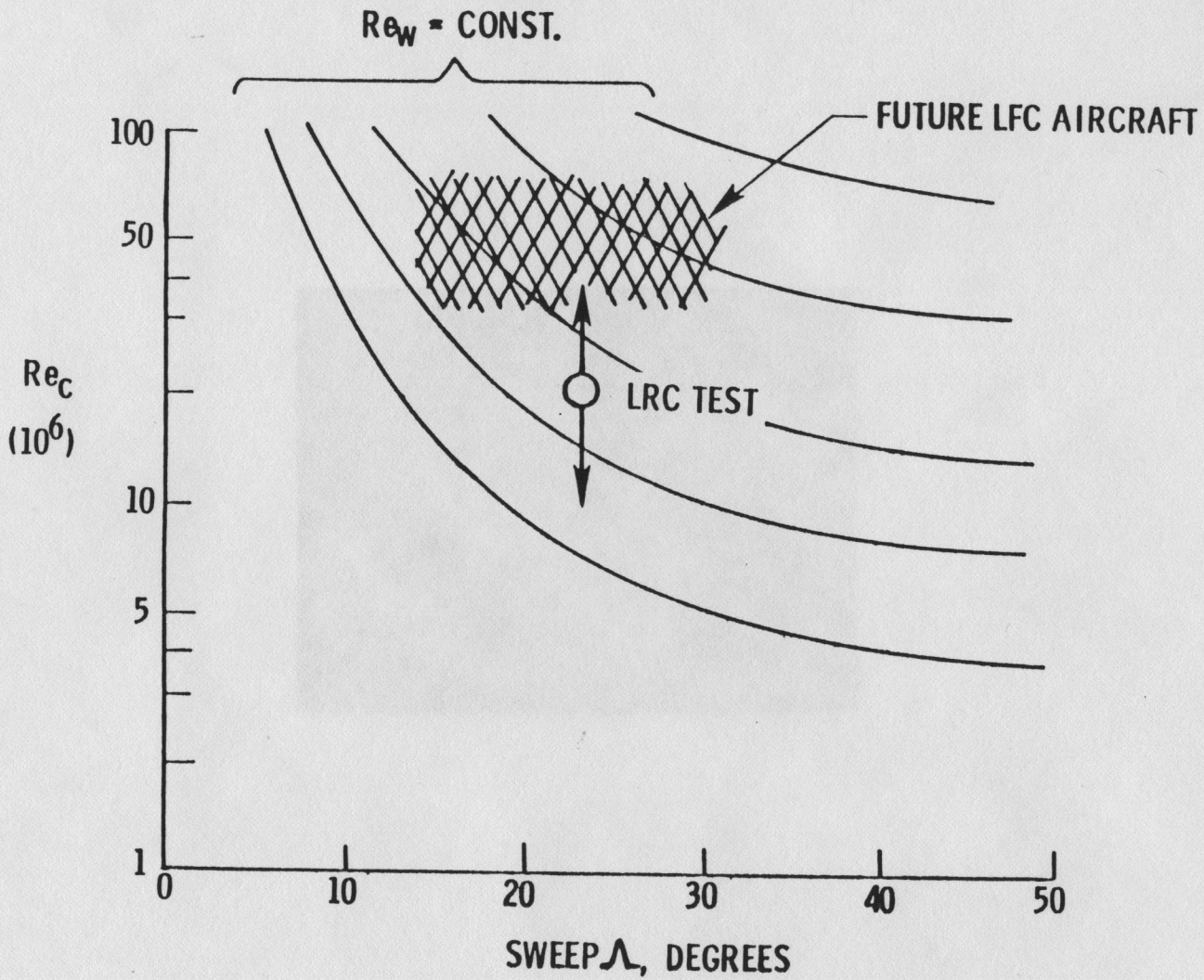
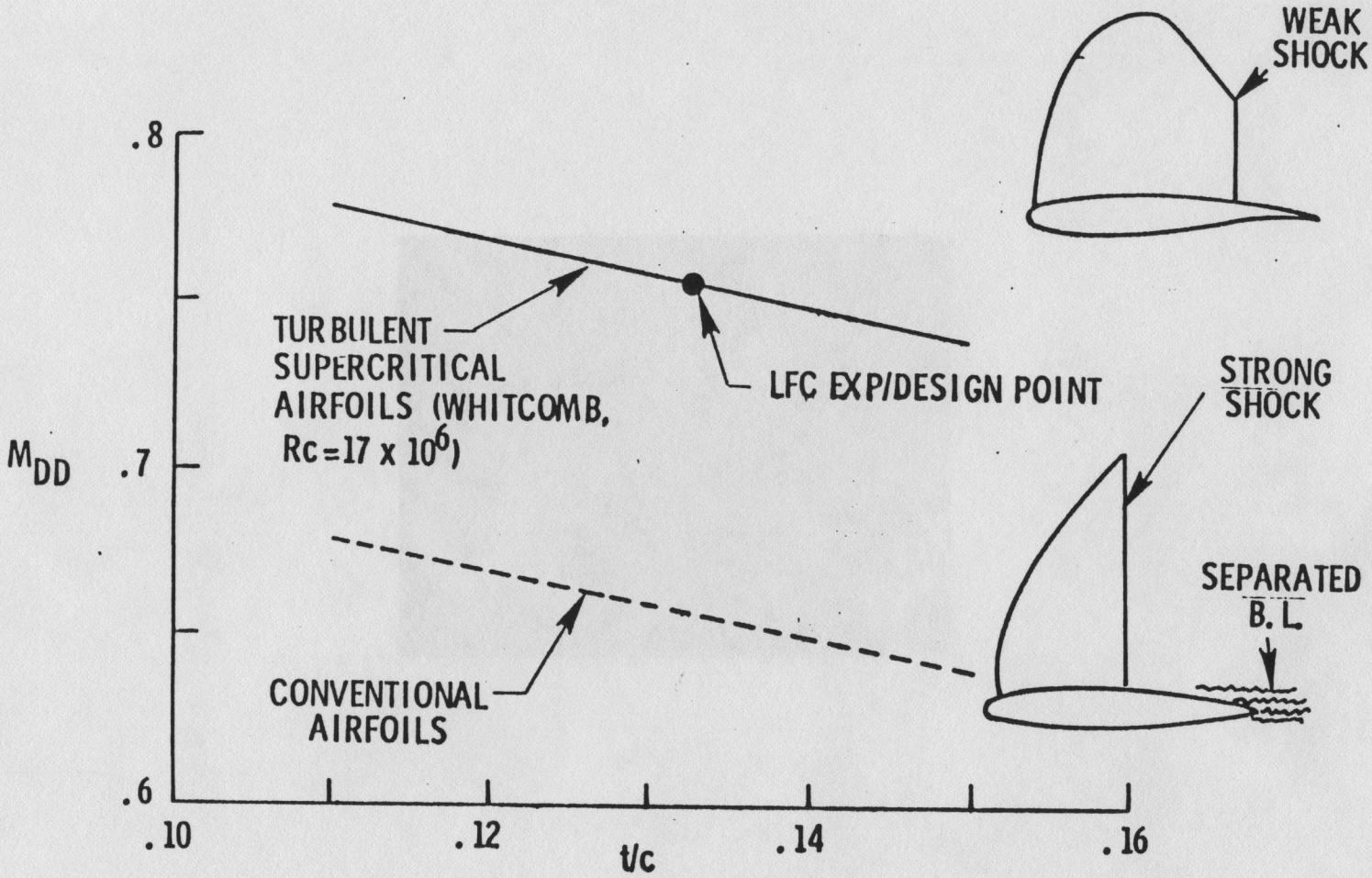
CROSSFLOW REYNOLDS NUMBER (Rew) SIMULATION

$Re_W \sim \sin 2\Lambda \sqrt{Re_C} = \text{CONST.}$



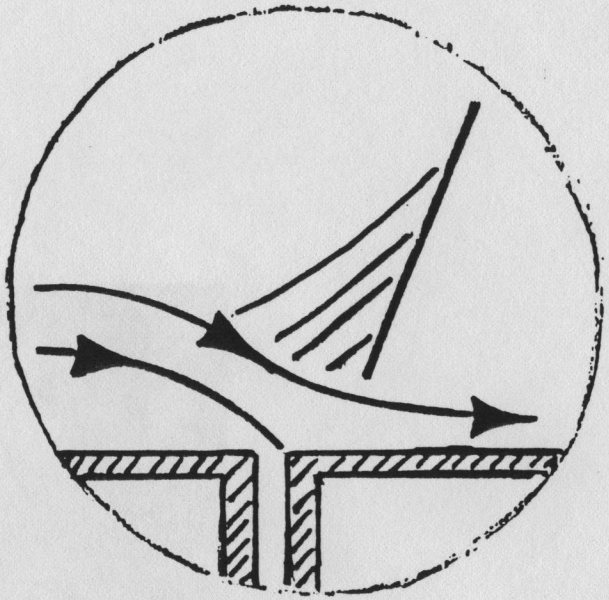
AIRFOIL DRAG DIVERGENCE WITH THICKNESS

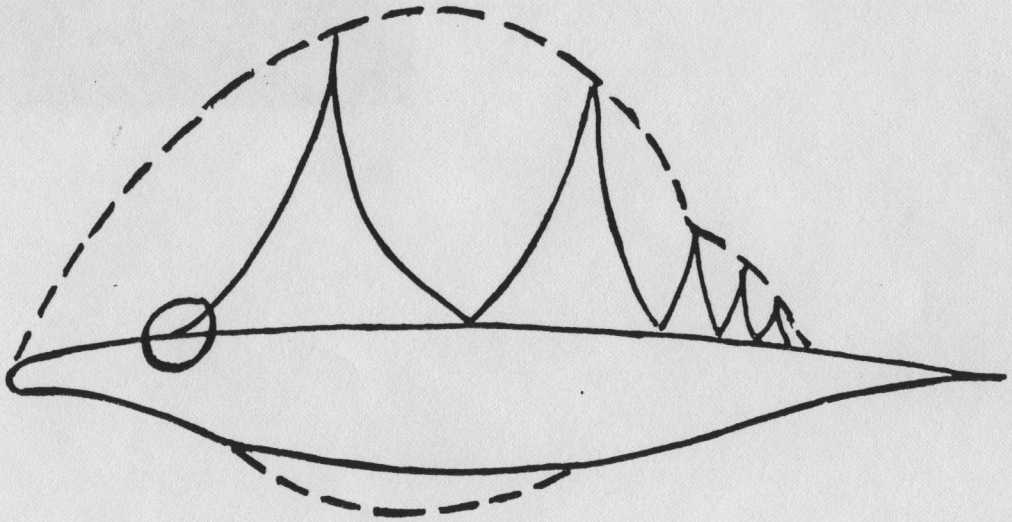
$C_L = 0.55$

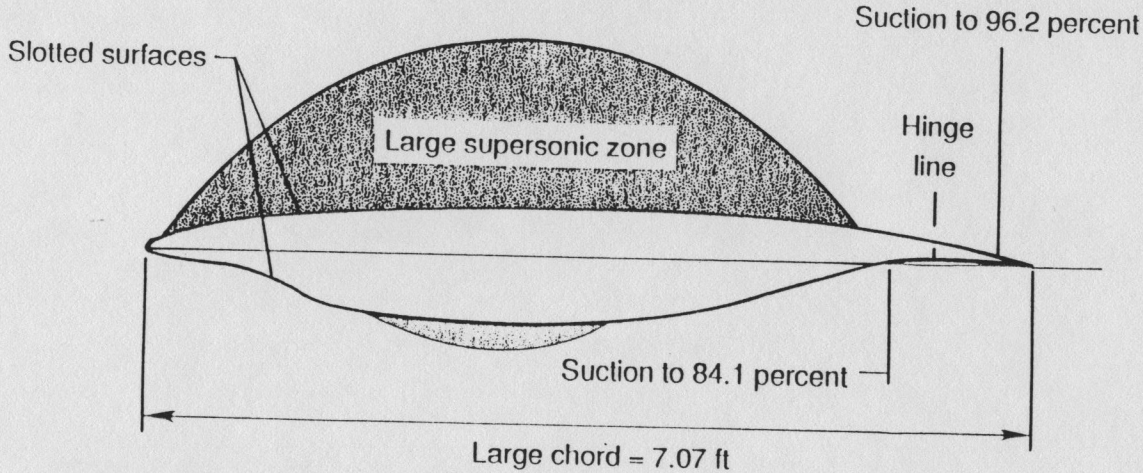


LFC AIRFOIL BOUNDARY LAYER/FLOW FIELD

- SLOT GENERATED DISTURBANCES
- SONIC LINE WAVE REFLECTION
- BACKFLOW IN SUCTION PLENUM
- SHOCK-B.L. INTERACTION
- B.L. GROWTH ACROSS SLOTS







Free-stream design conditions

$M_\infty = 0.82$

$\Lambda = 23°$

$c = 7.07$ ft

$R_c = 20 \times 10^6$

$c_l = 0.47$

Design conditions normal to leading edge

$M_N = 0.755$

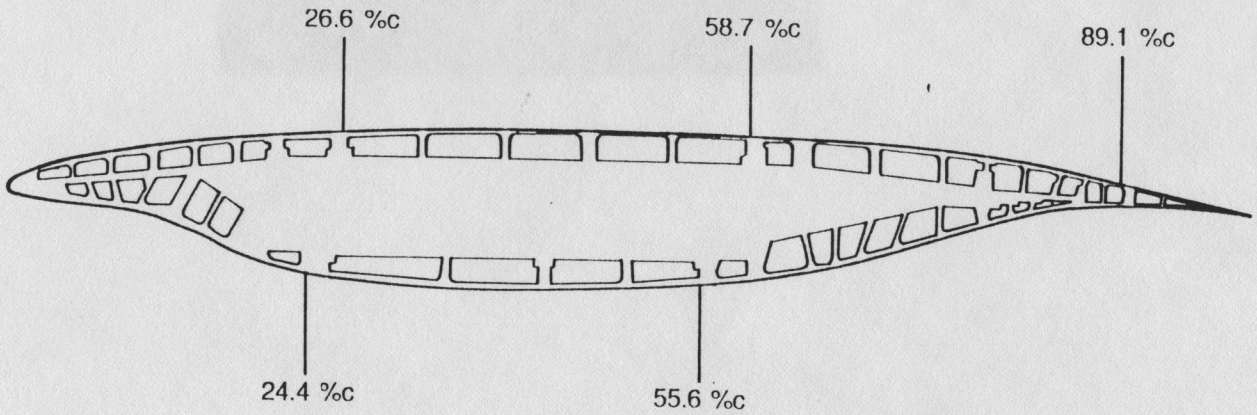
$c_N = 6.508$ ft

$R_{c,N} = 16.9 \times 10^6$

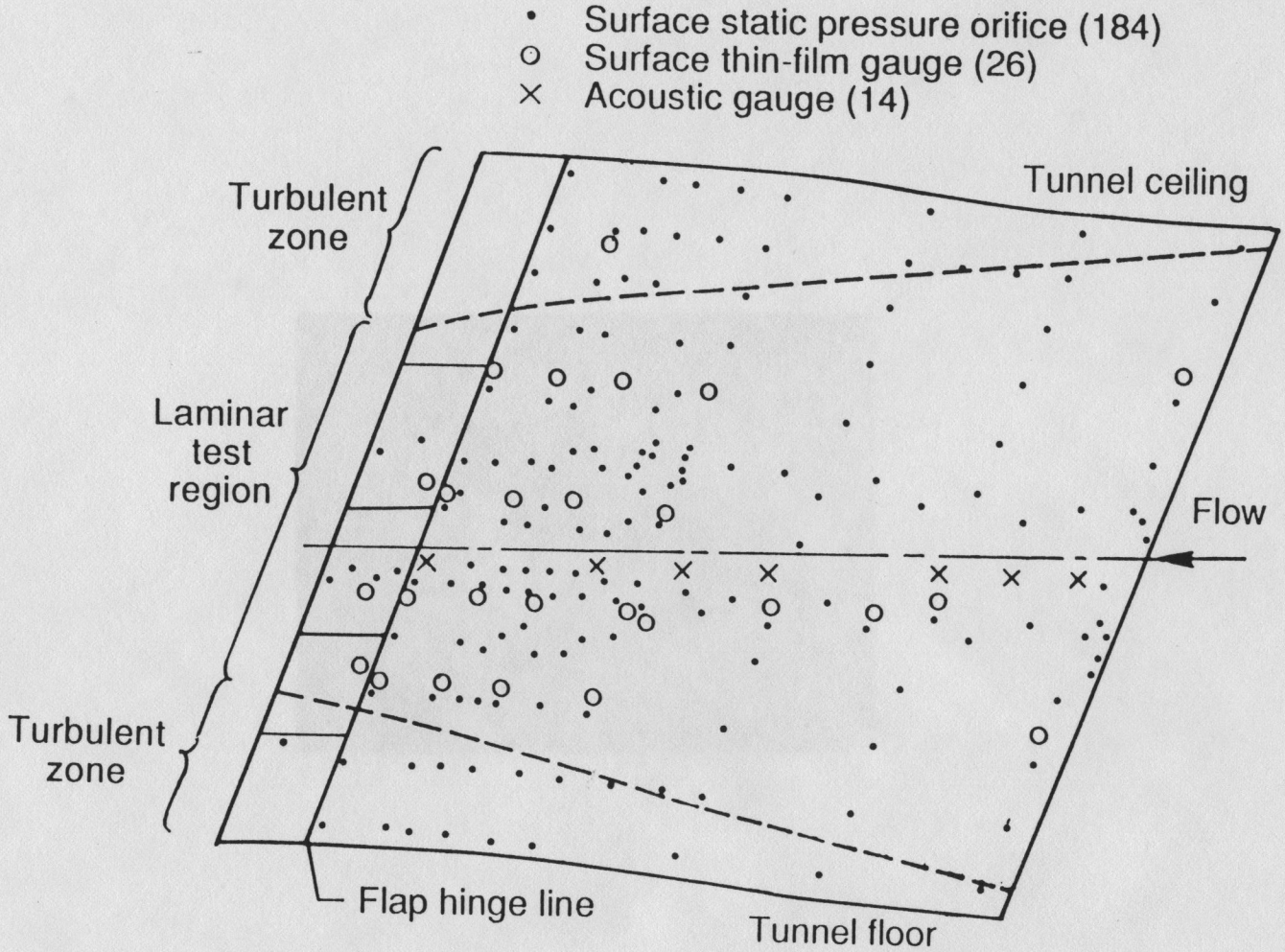
$(t/c)_N = 13.0$ percent

$c_{l,N} = 0.55$

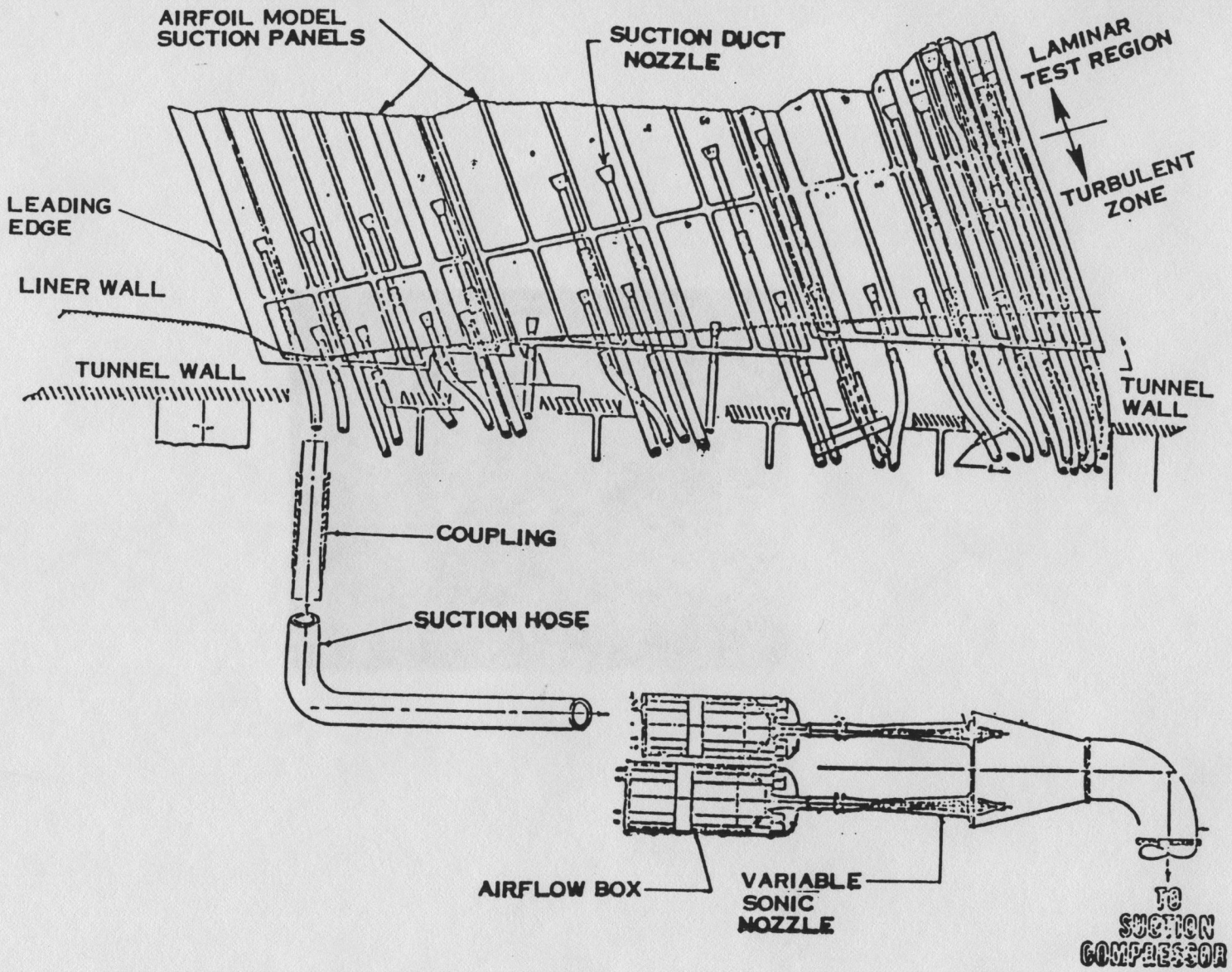
Airfoil design parameters.



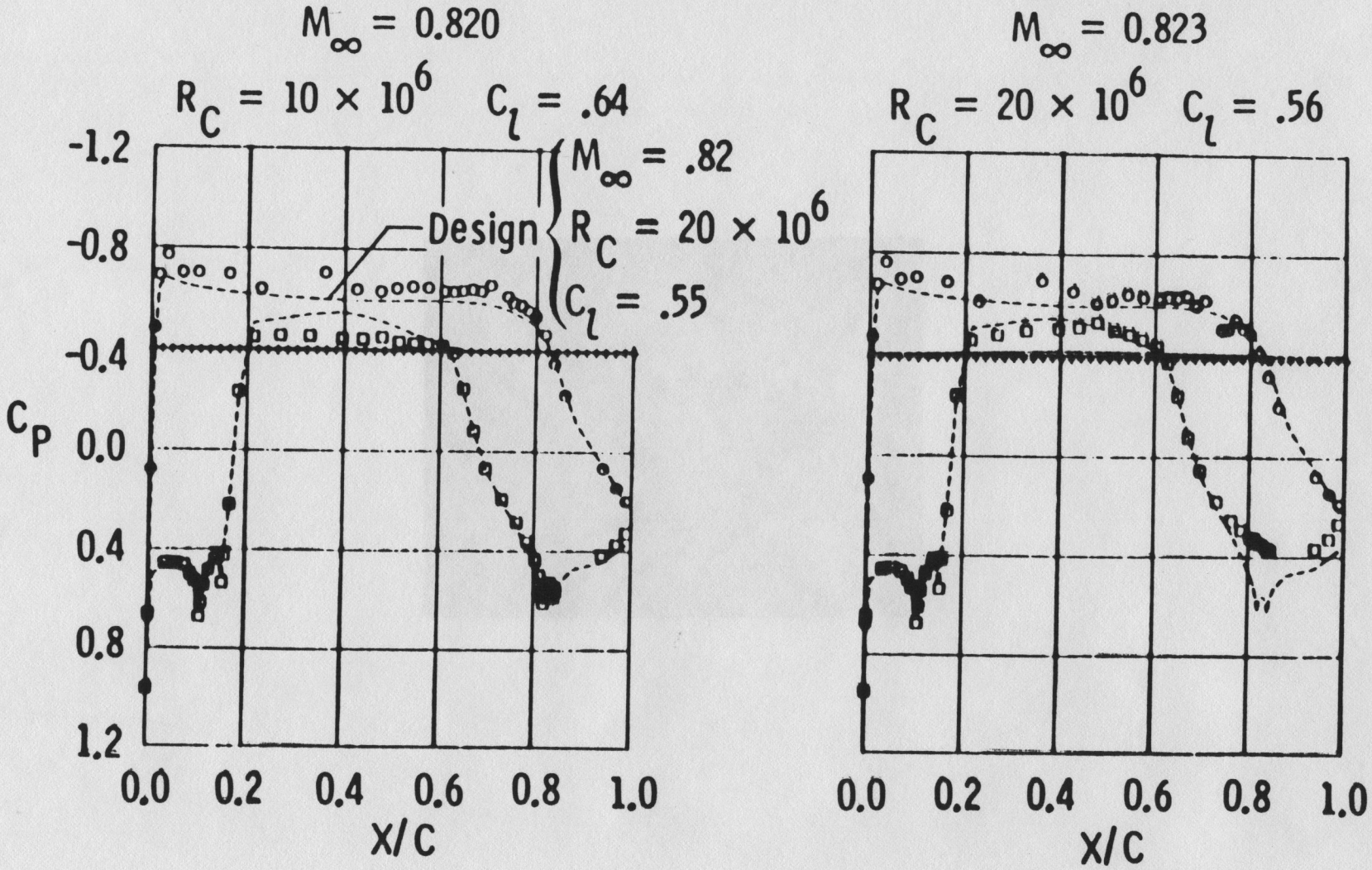
Duct arrangement.


Surface static pressure orifice (184)
Surface thin-film gauge (26)
Acoustic gauge (14)
Turbulent zone
Laminar test region
Turbulent zone
Tunnel ceiling
Flow
Flap hinge line
Tunnel floor

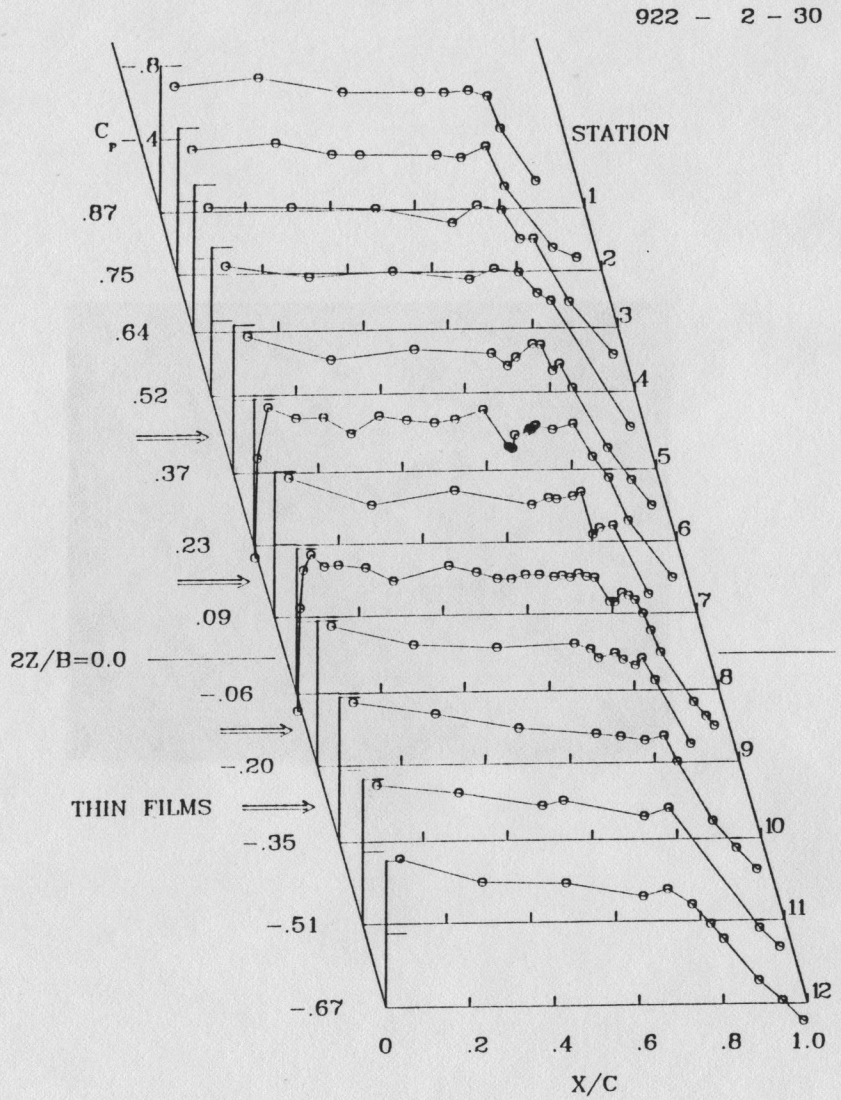
SKETCH OF LFC AIRFOIL SUCTION DUCTS AND NOZZLES



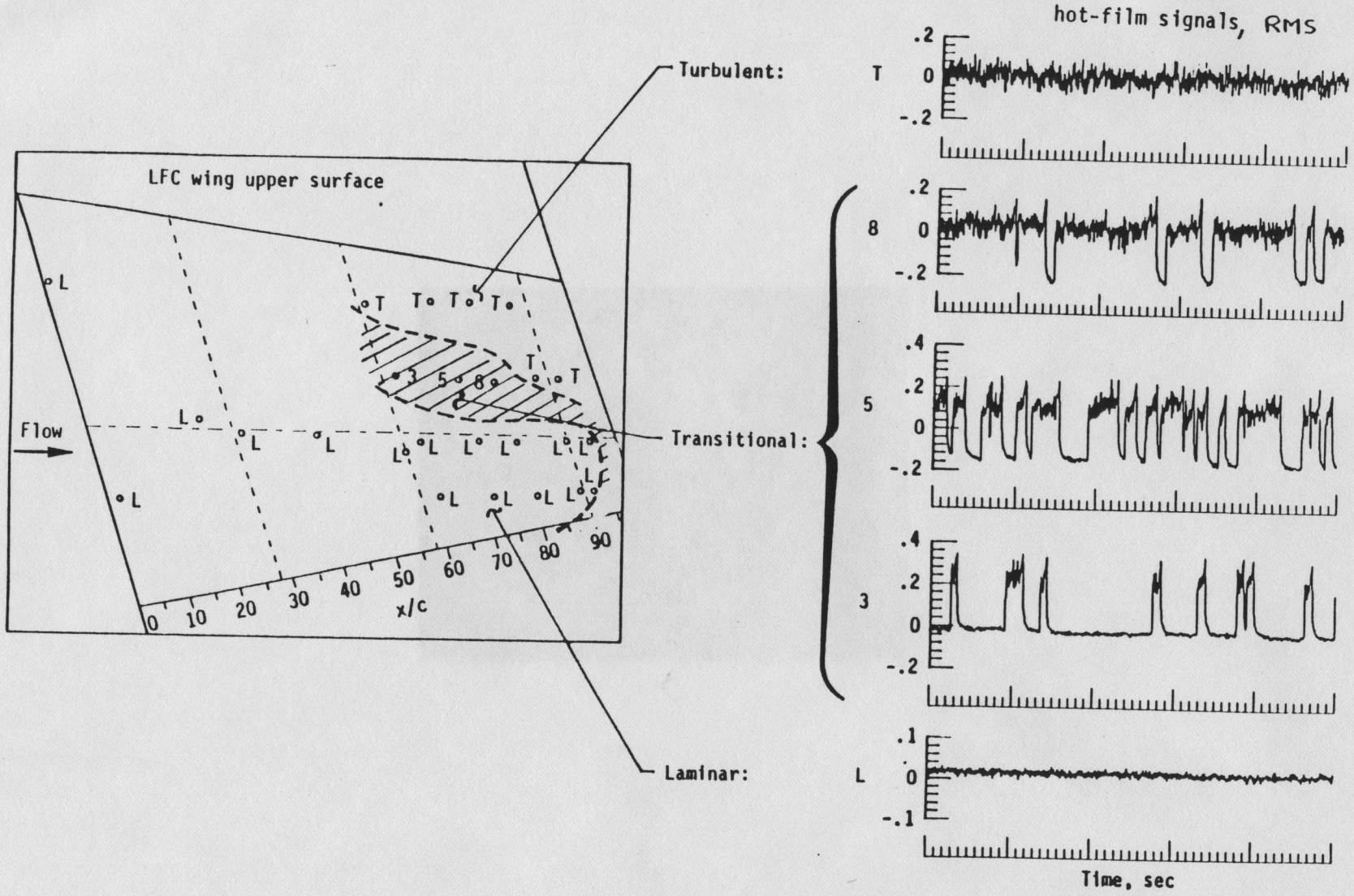
MEASURED AND DESIGN PRESSURE DISTRIBUTION



SPANWISE PRESSURE DISTRIBUTIONS, M_∞=0.82

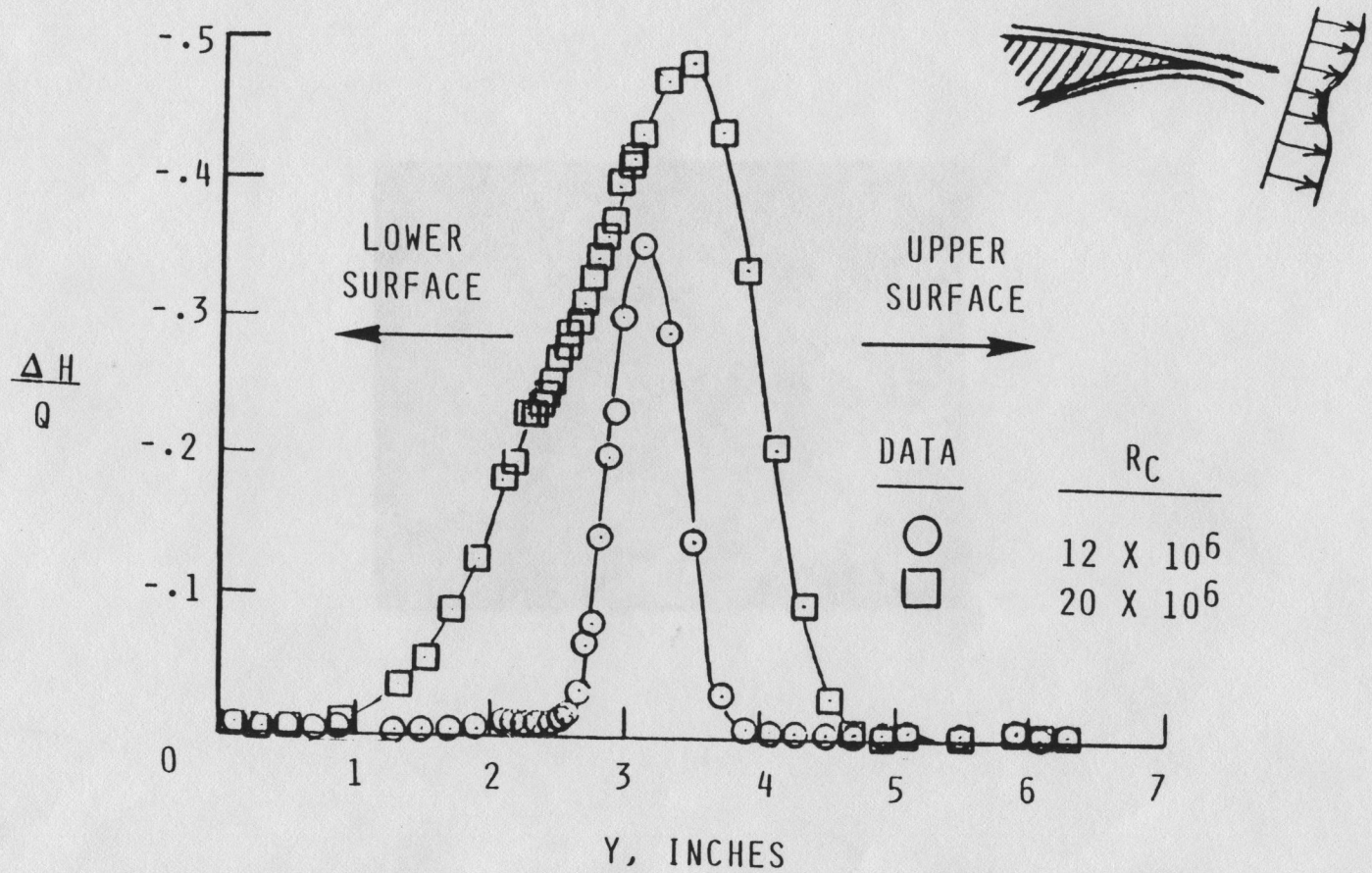


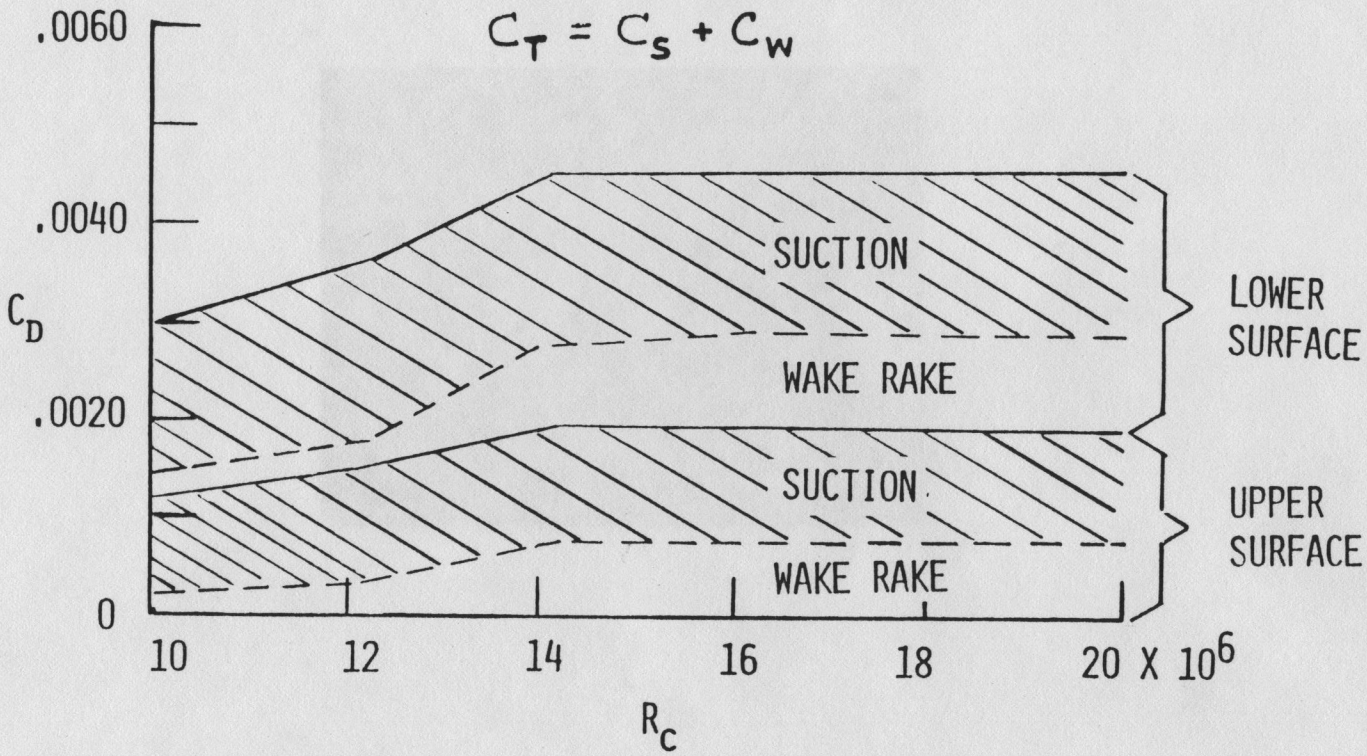
LAMINAR PATTERN AND THIN FILM LOCATIONS/EXAMPLE



SC LFC AIRFOIL WAKE RAKE PROFILE

$M_\infty \simeq .82$



MEASURED VARIATION OF DRAG WITH R_c/SWEPT LFC AIRFOIL

$M_\infty = .6$