NTF MODELING PROGRAM

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NASA LANGLEY RESEARCH CENTER

NTF PERFORMANCE ESTIMATION AND MODELING

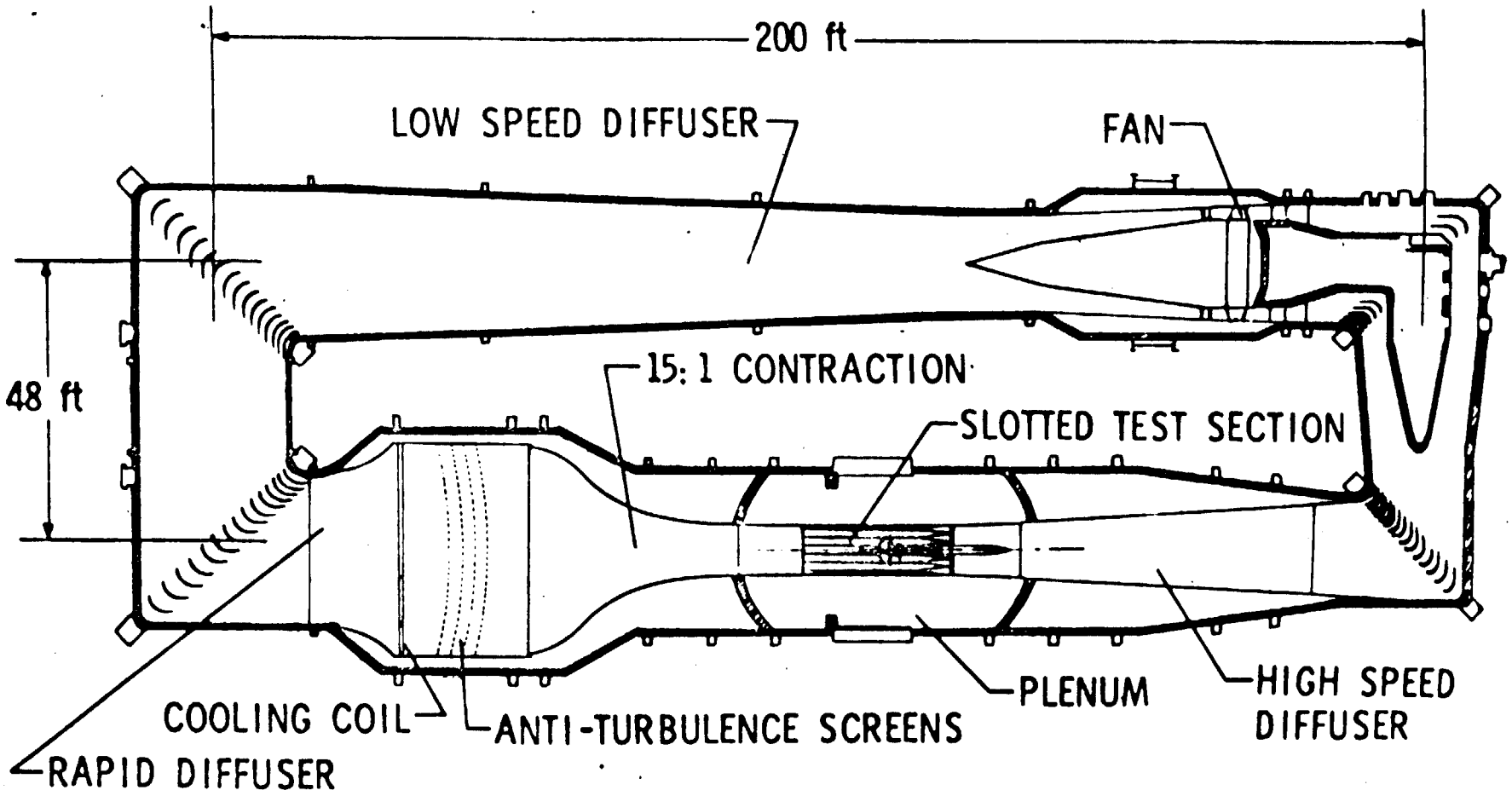
PRESENTED AT LERC WORKSHOP ON
WIND TUNNEL MODELING
MARCH 20 AND 21, 1984

L. W. McKINNEY

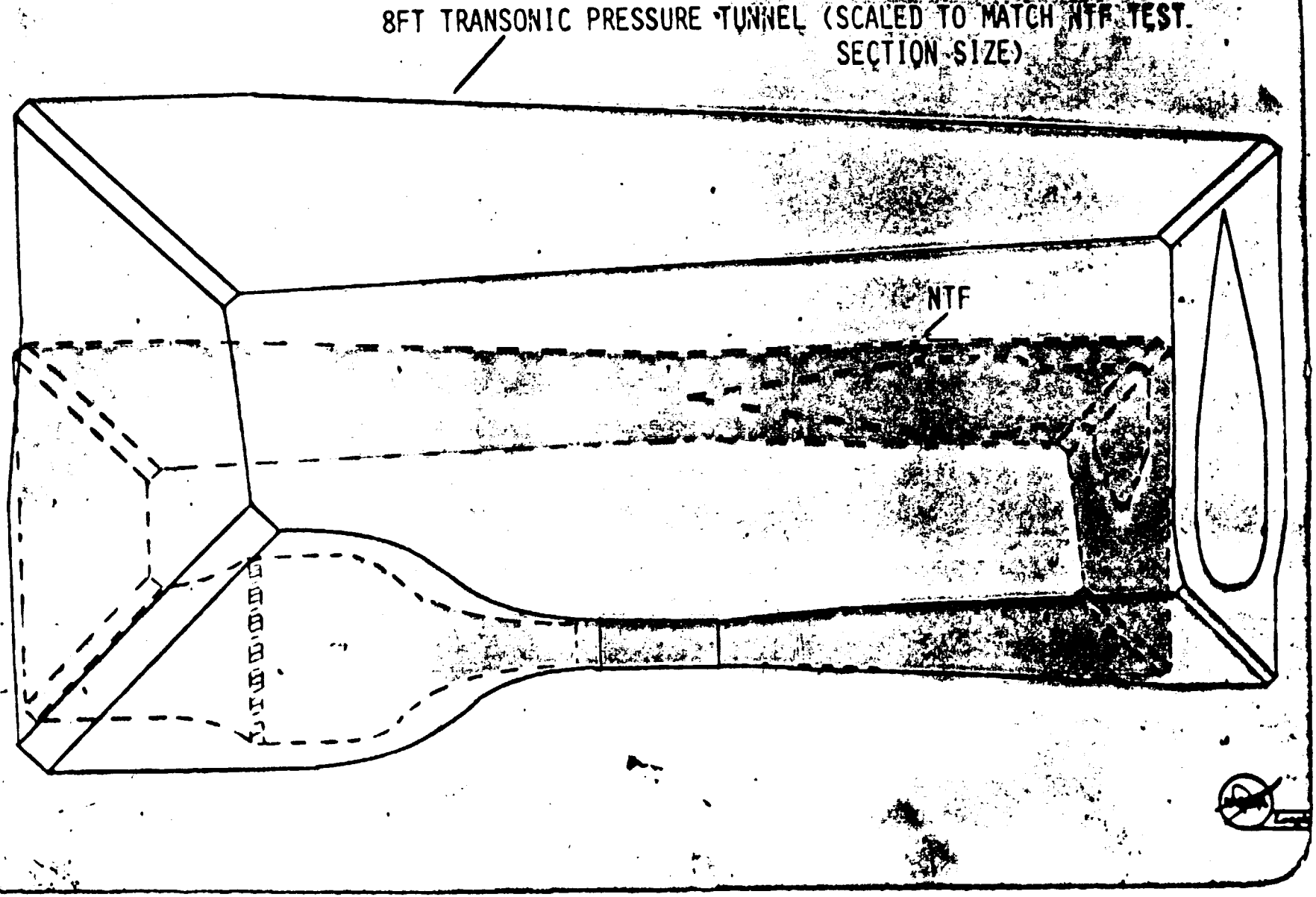
AERODYNAMIC DESIGN CRITERIA

- TEST SECTION SIZE: (2.5 METERS SQUARE)
- FLOW QUALITY IN TEST SECTION
  - TURBULENCE INTENSITY $T_I = \pm .001$
  - FLUCTUATING STATIC PRESSURE $\Delta C_p = \pm .002$
  - FLOW UNIFORMITY $\frac{\Delta q}{q} = \pm .001$
  - NOISE, SPL = 150db
- MINIMIZE OPERATING COSTS

NATIONAL TRANSONIC FACILITY
PLAN OF TUNNEL CIRCUIT



COMPARISON OF THE NTF AND THE 8FT. TRANSONIC PRESSURE TUNNEL



AERODYNAMIC VALIDATION MODELS

- 1/5.4 SCALE PERFORMANCE MODEL

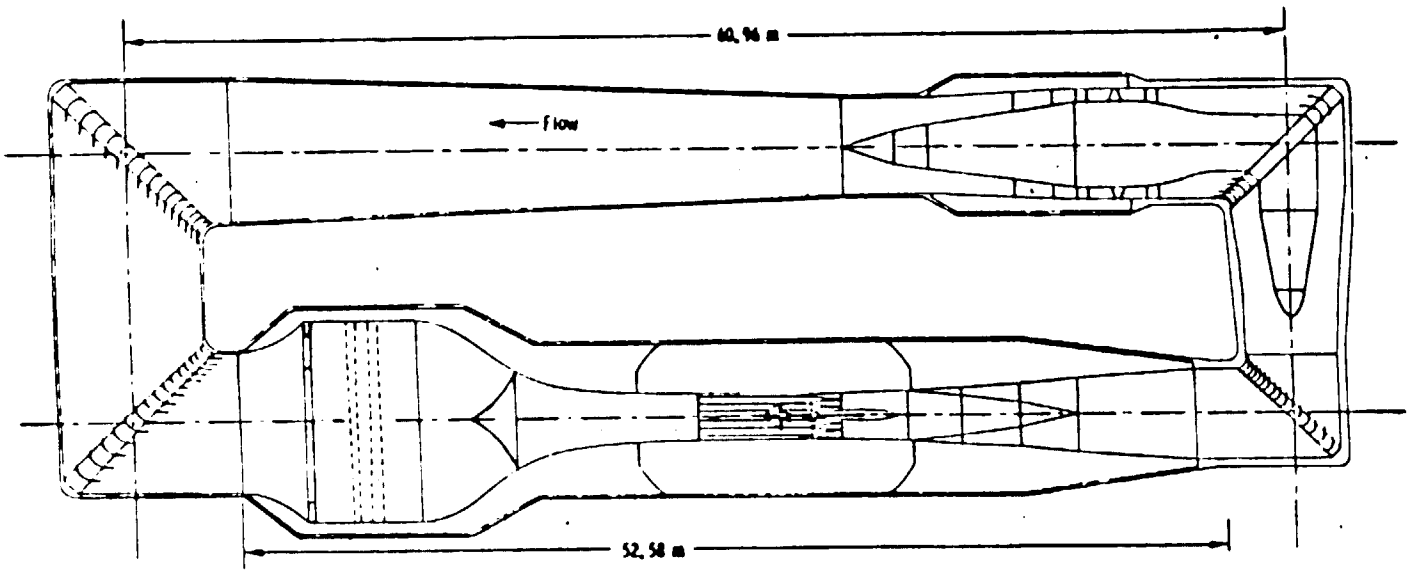
  -- TUNNEL PRESSURE RATIO
  -- AERODYNAMIC LOADS
  -- EFFECT OF PLENUM BLEED

- 1/12 SCALE COMPONENTS

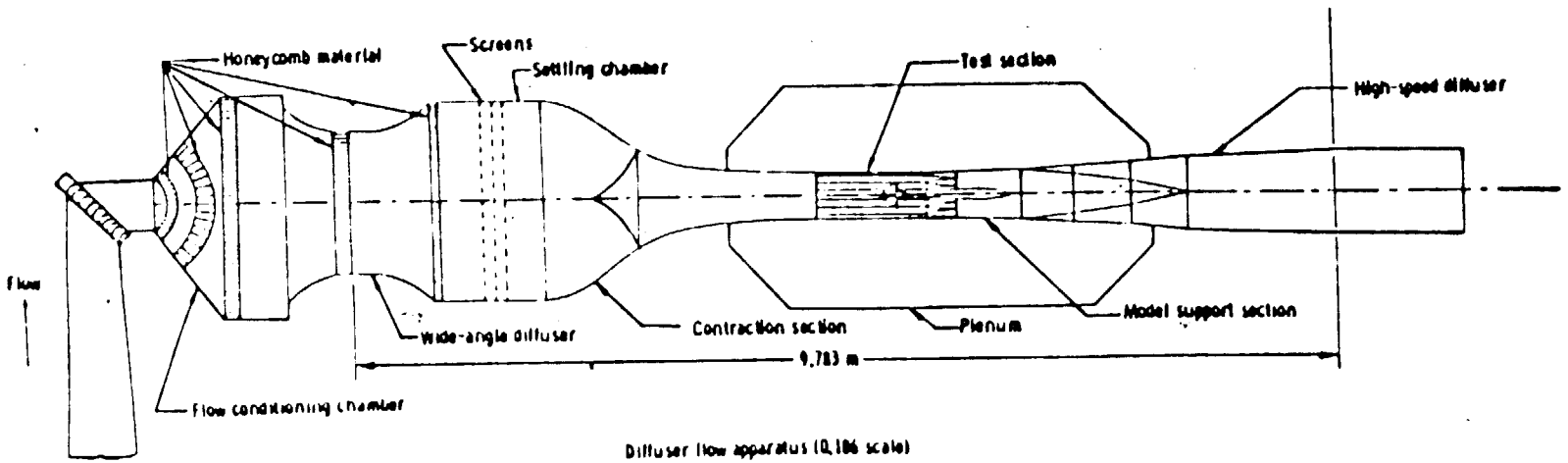
  -- SECOND TURN PERFORMANCE
  -- QUICK DIFFUSER PERFORMANCE
  -- COOLING COIL TESTS
  -- AERODYNAMIC LOADS

- 0.3-METER CRYO TUNNEL

  -- REYNOLDS NUMBER EXTRAPOLATIONS
  -- COOLING COIL TEST AT FULL SCALE REYNOLDS NUMBER



National Transonic Facility



Diffuser flow apparatus (0,186 scale)

Comparison showing extent of representation of NTF by DFA.

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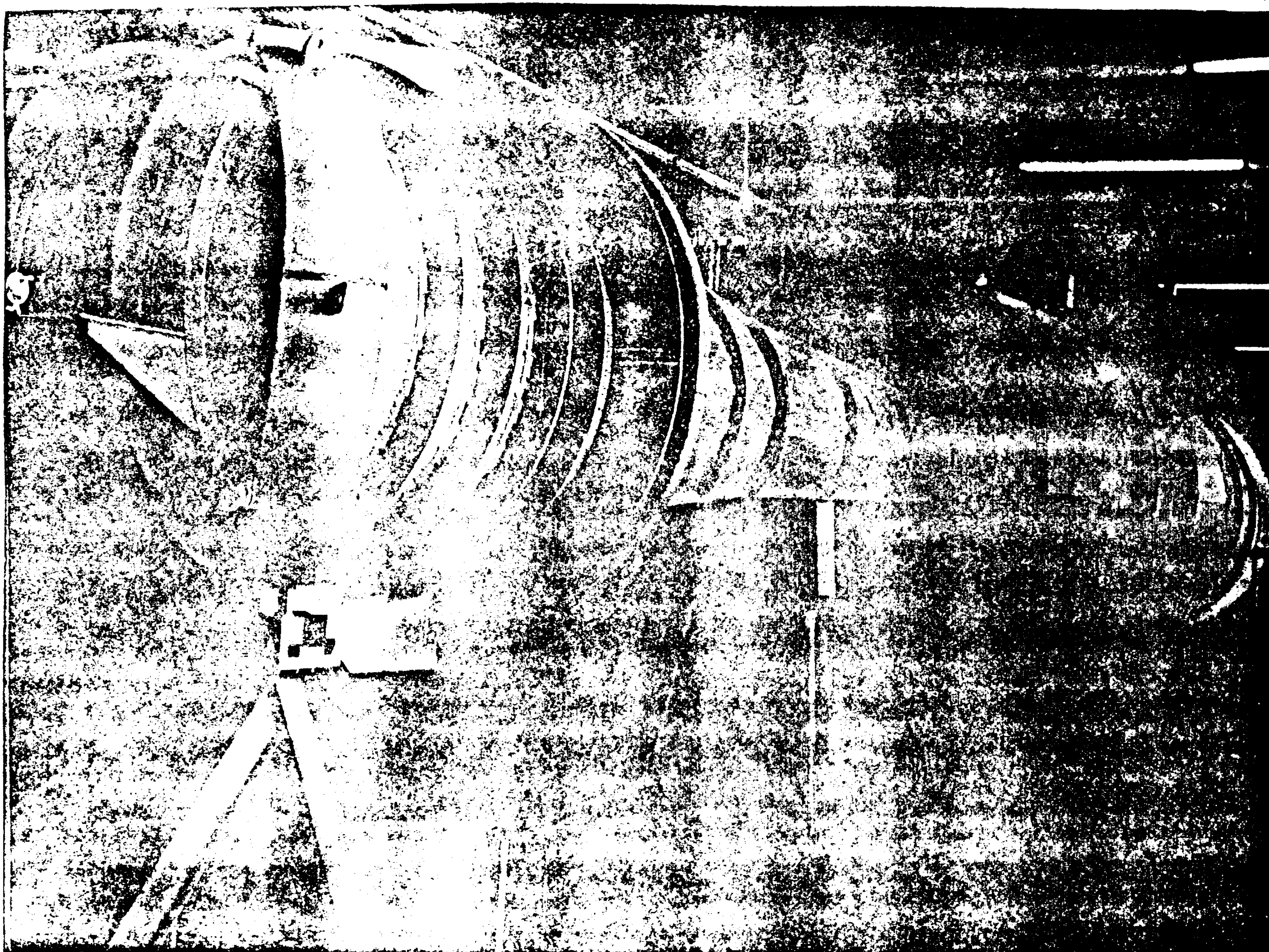

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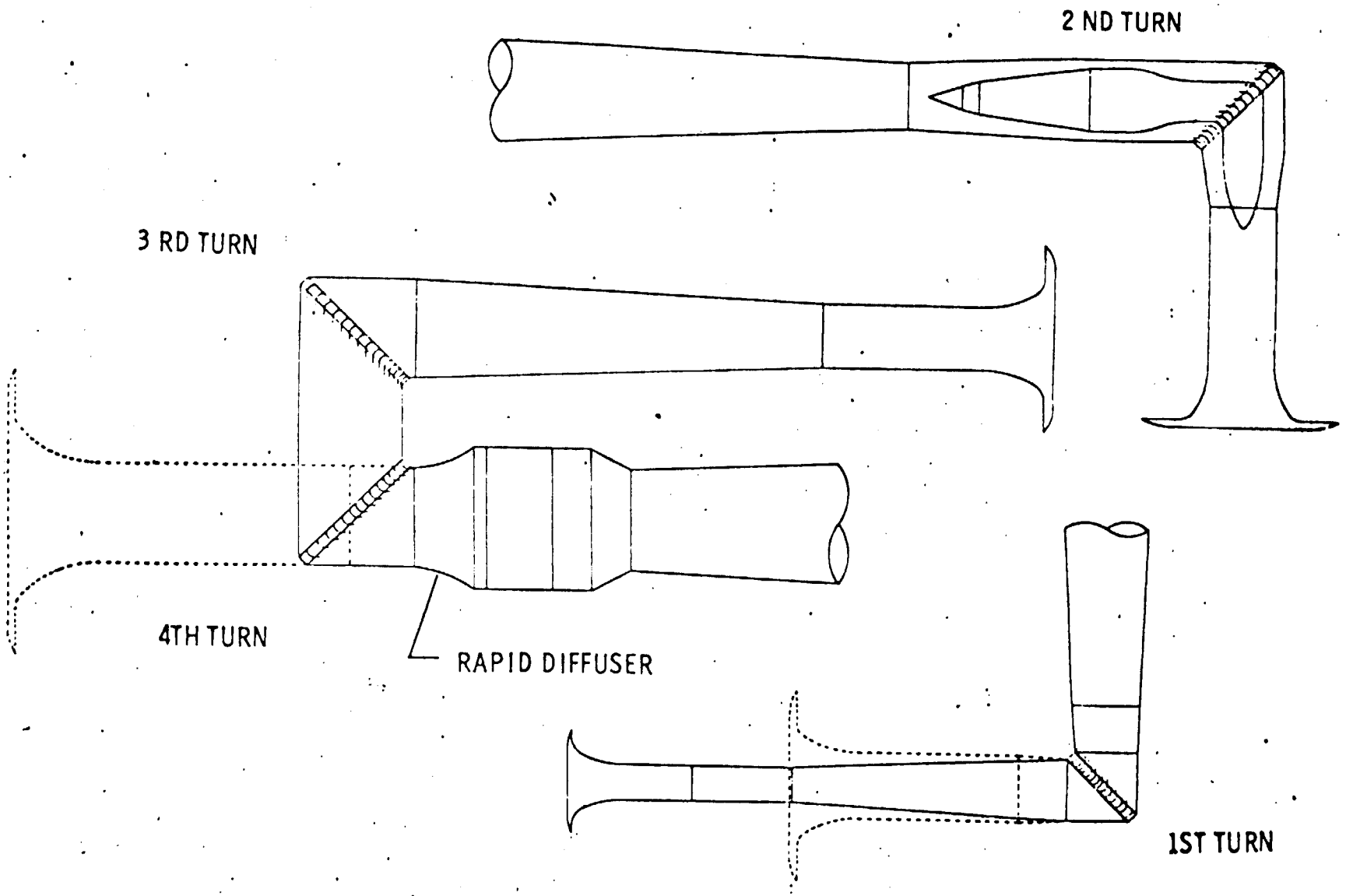
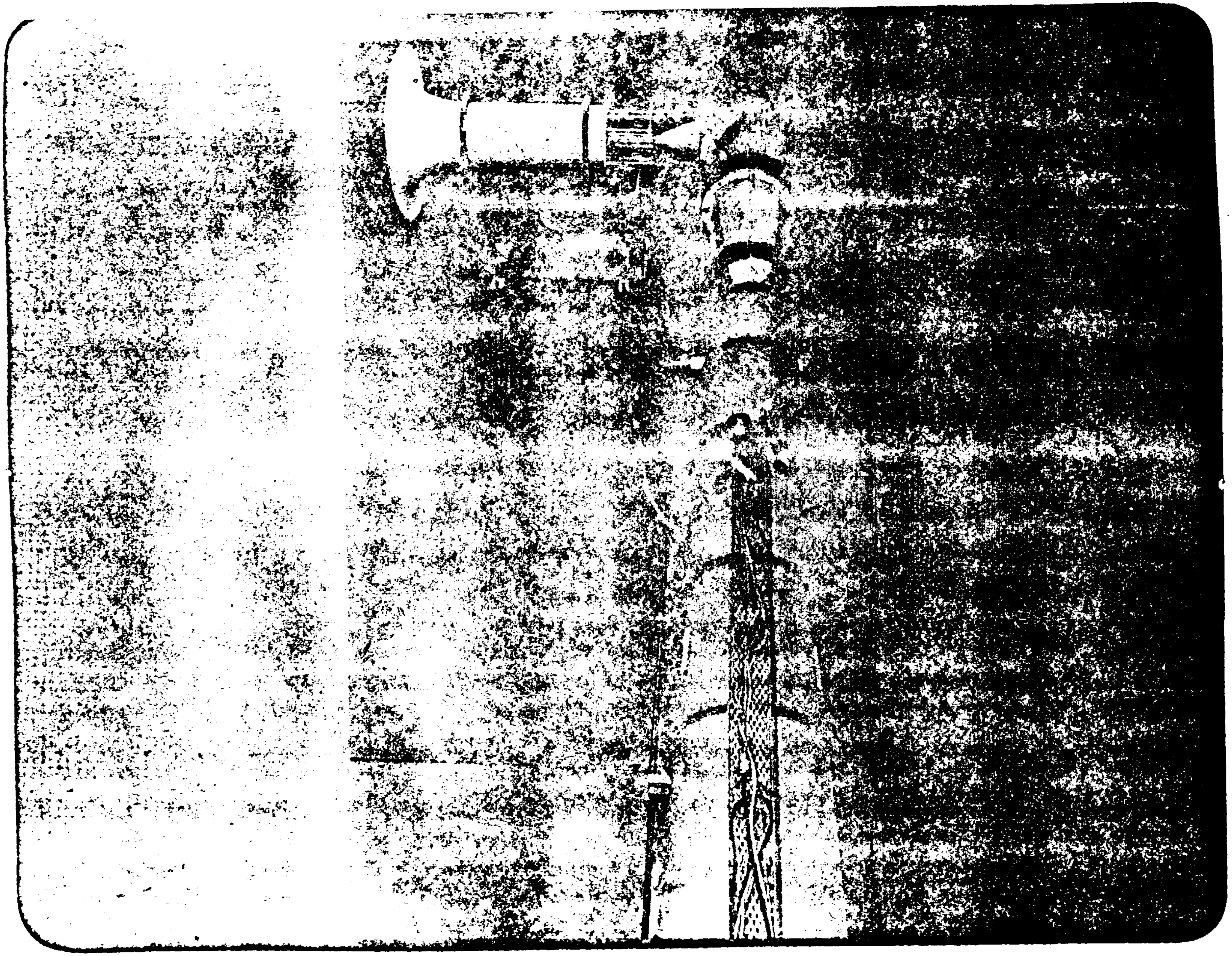
1/12 SCALE MODELS OF NTF COMPONENTS





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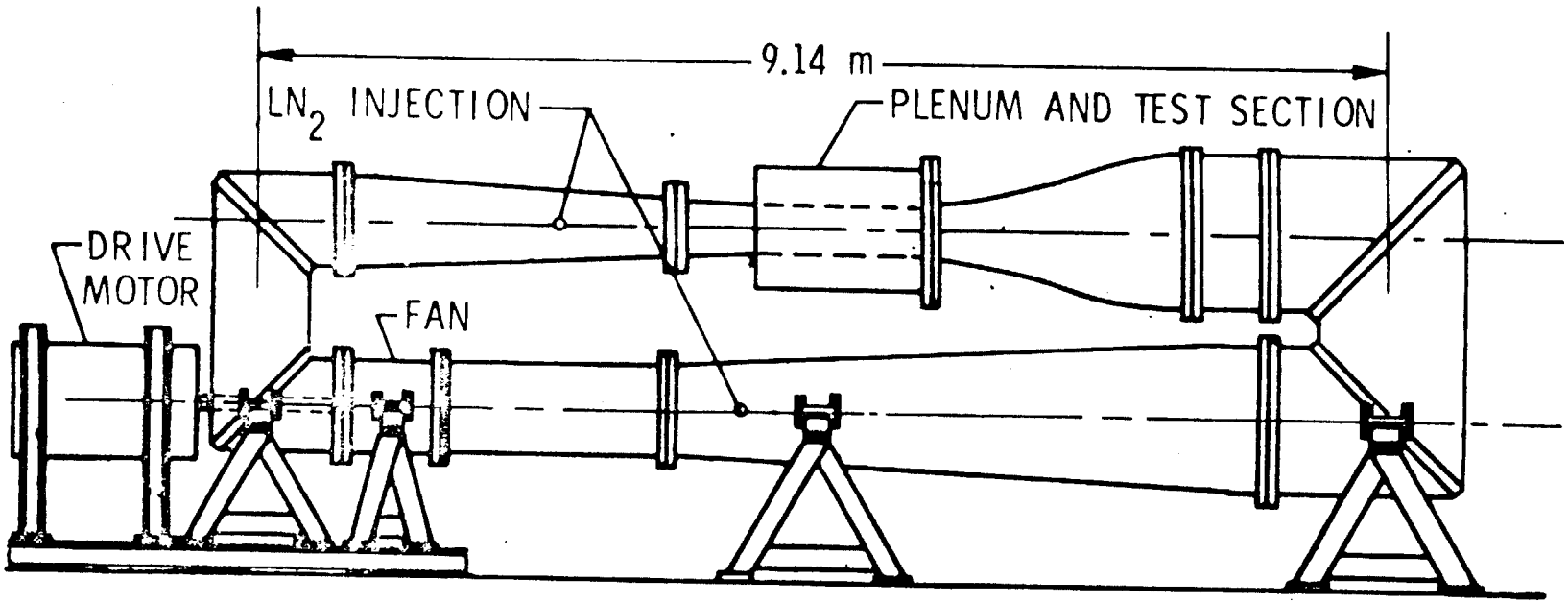
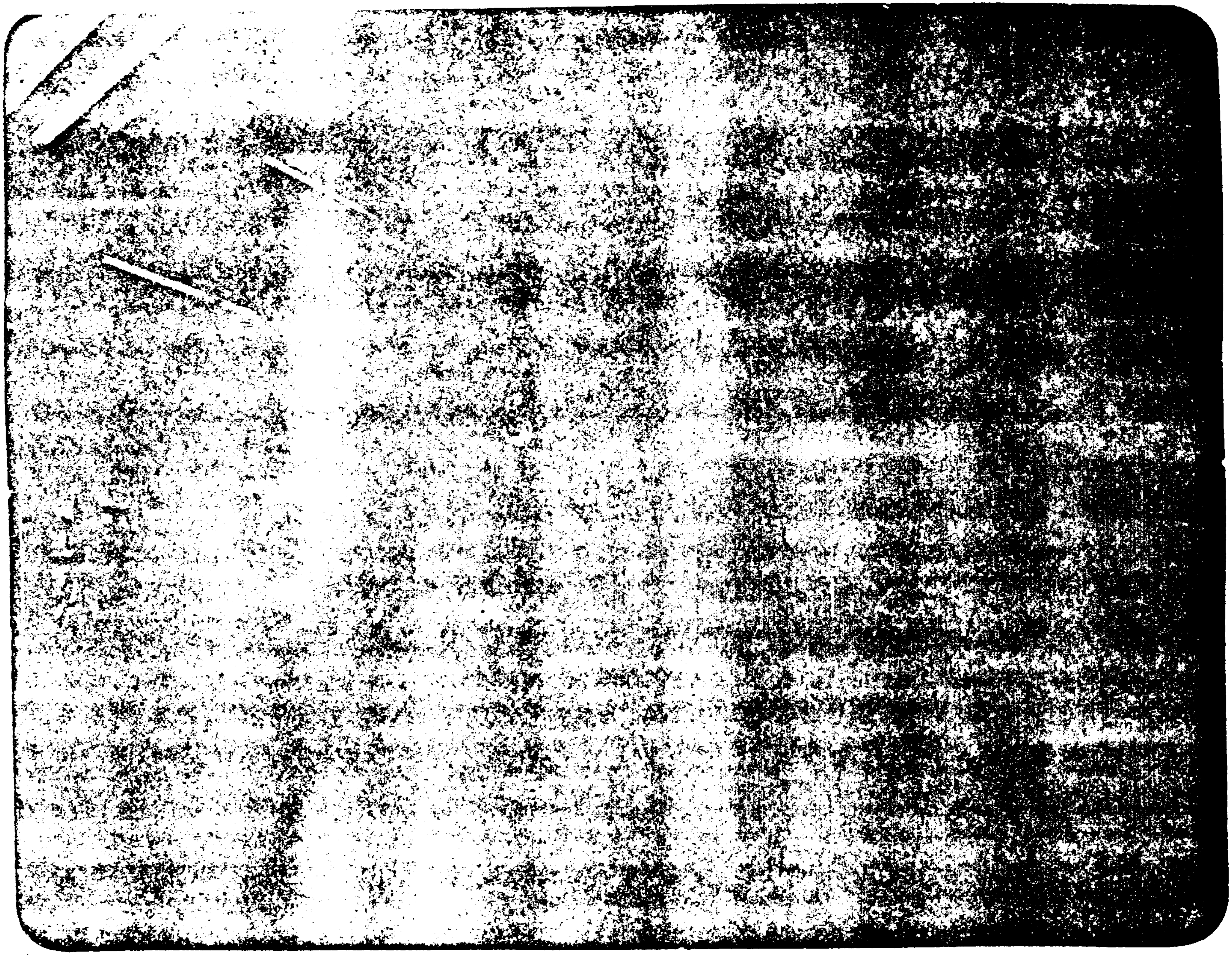
LANGLEY 34 cm (13.5") PILOT TRANSONIC CRYOGENIC TUNNEL





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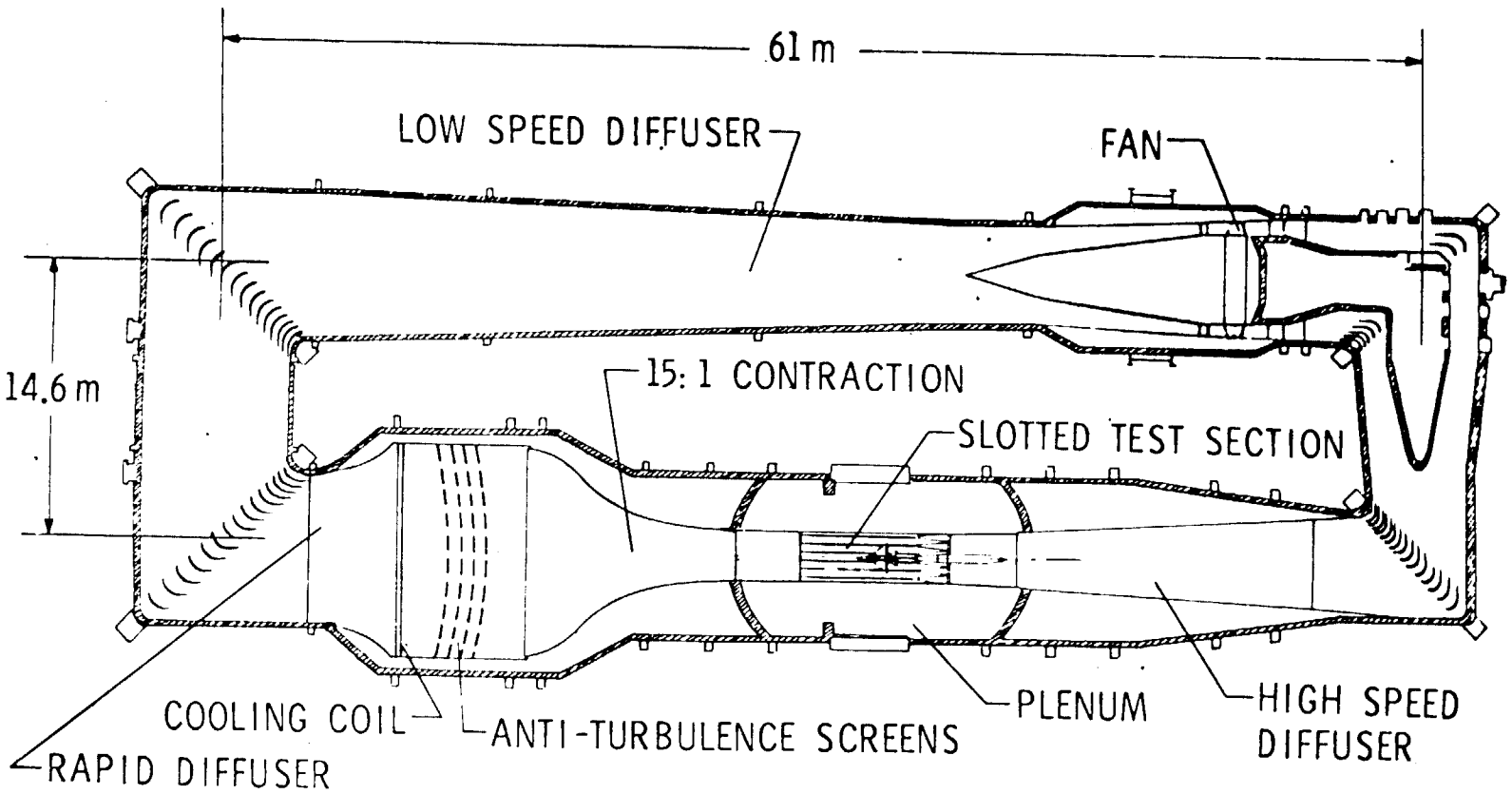
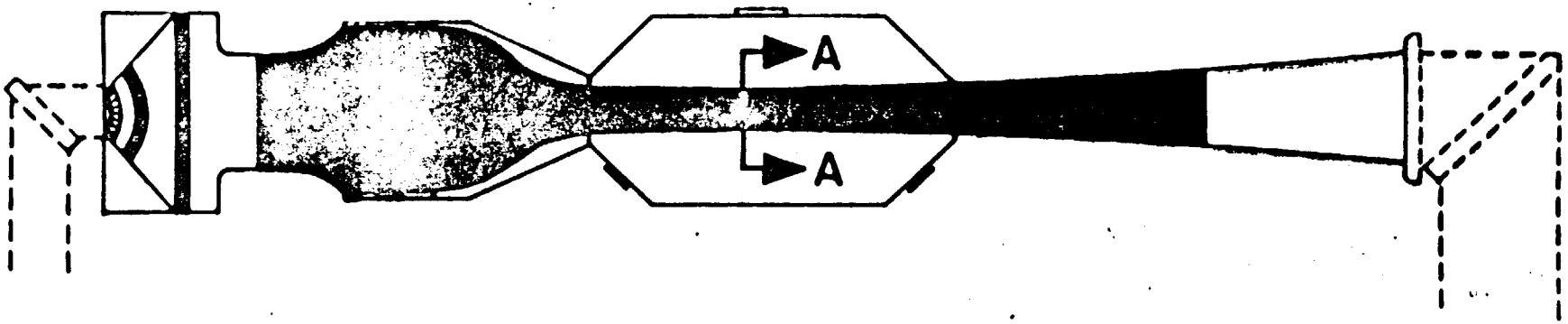
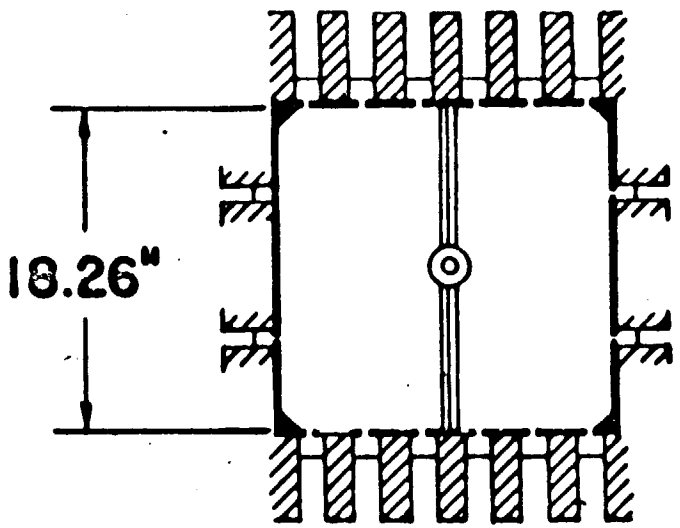
NATIONAL TRANSONIC FACILITY
PLAN OF TUNNEL CIRCUIT

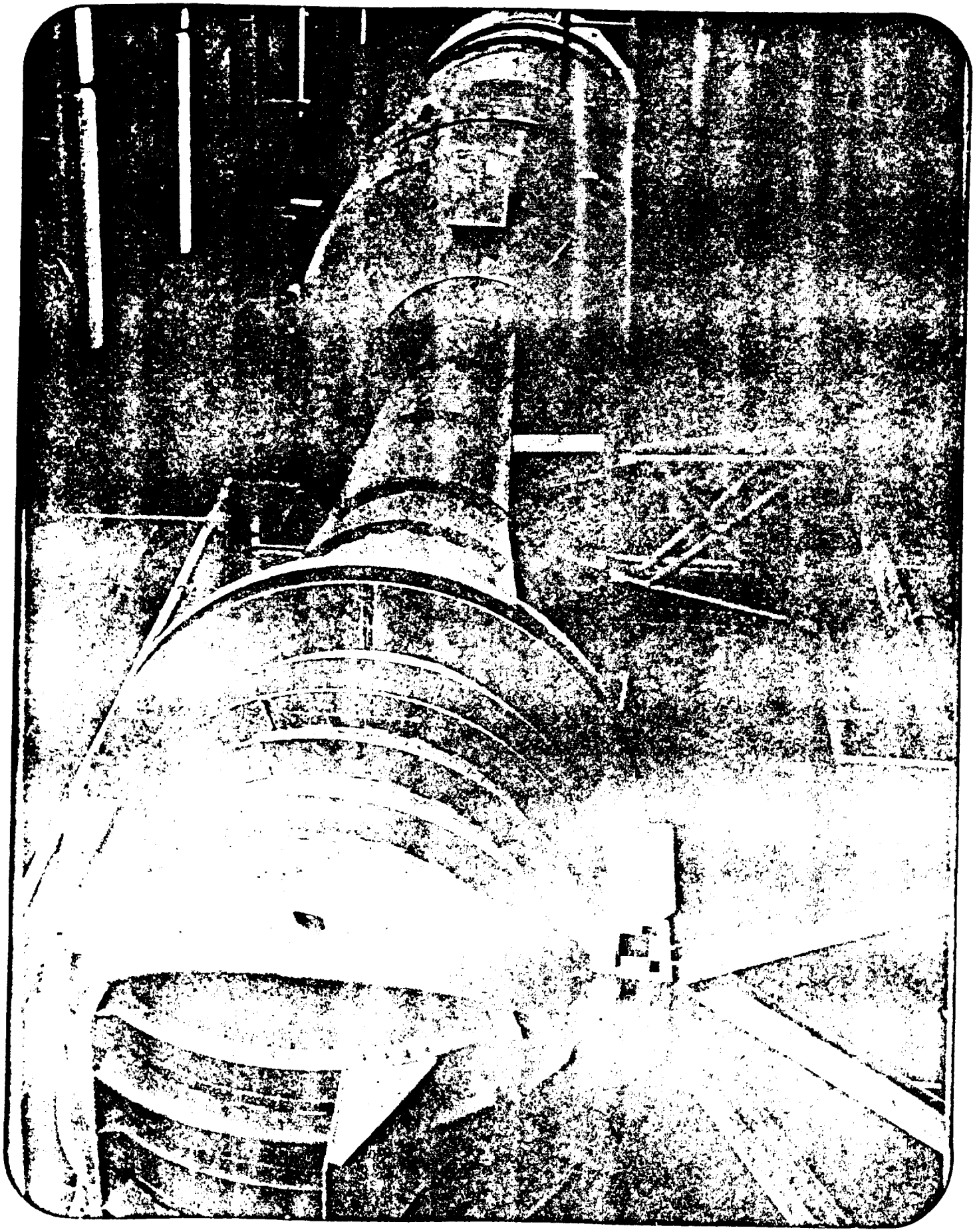


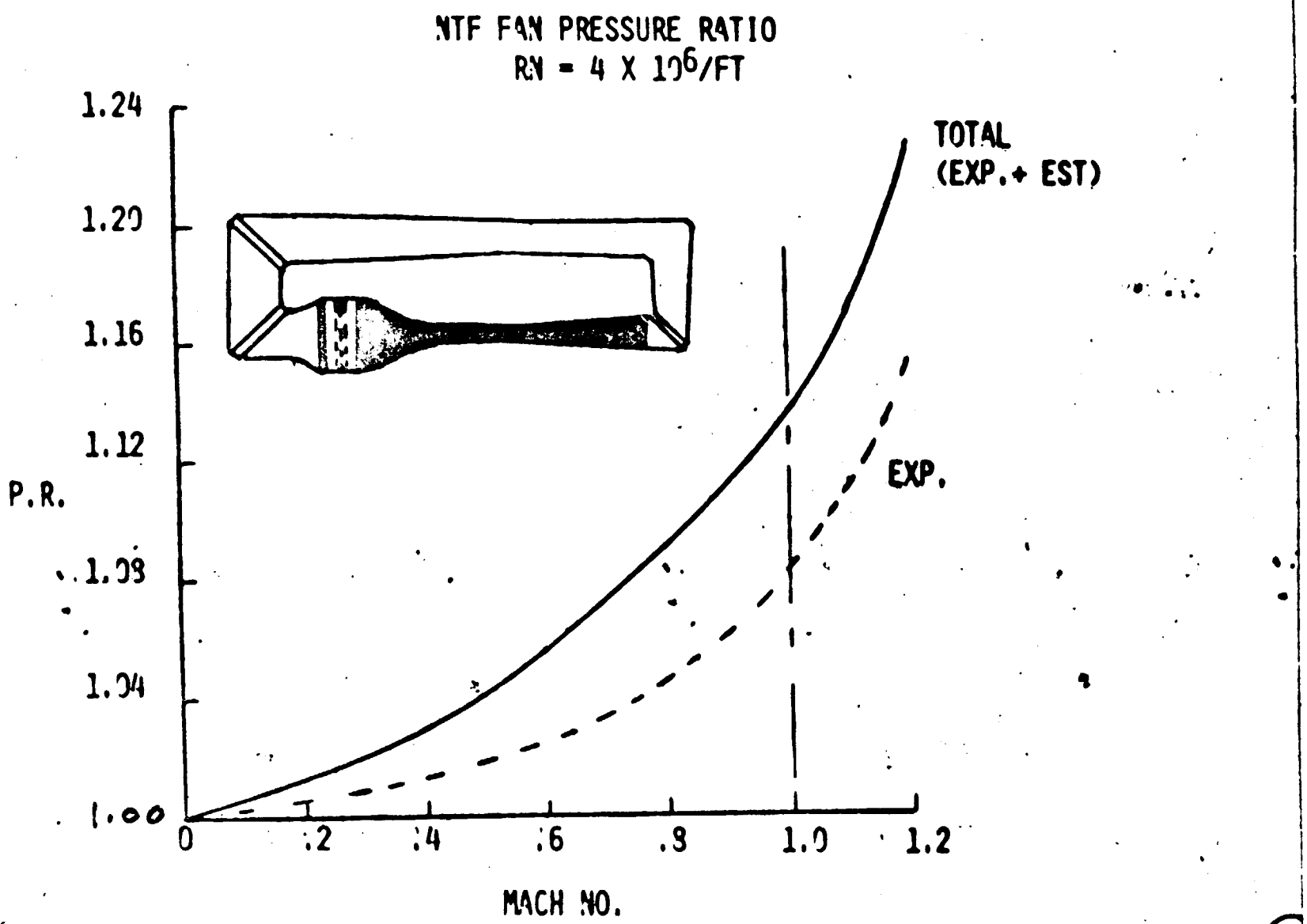
NTF PERFORMANCE MODEL

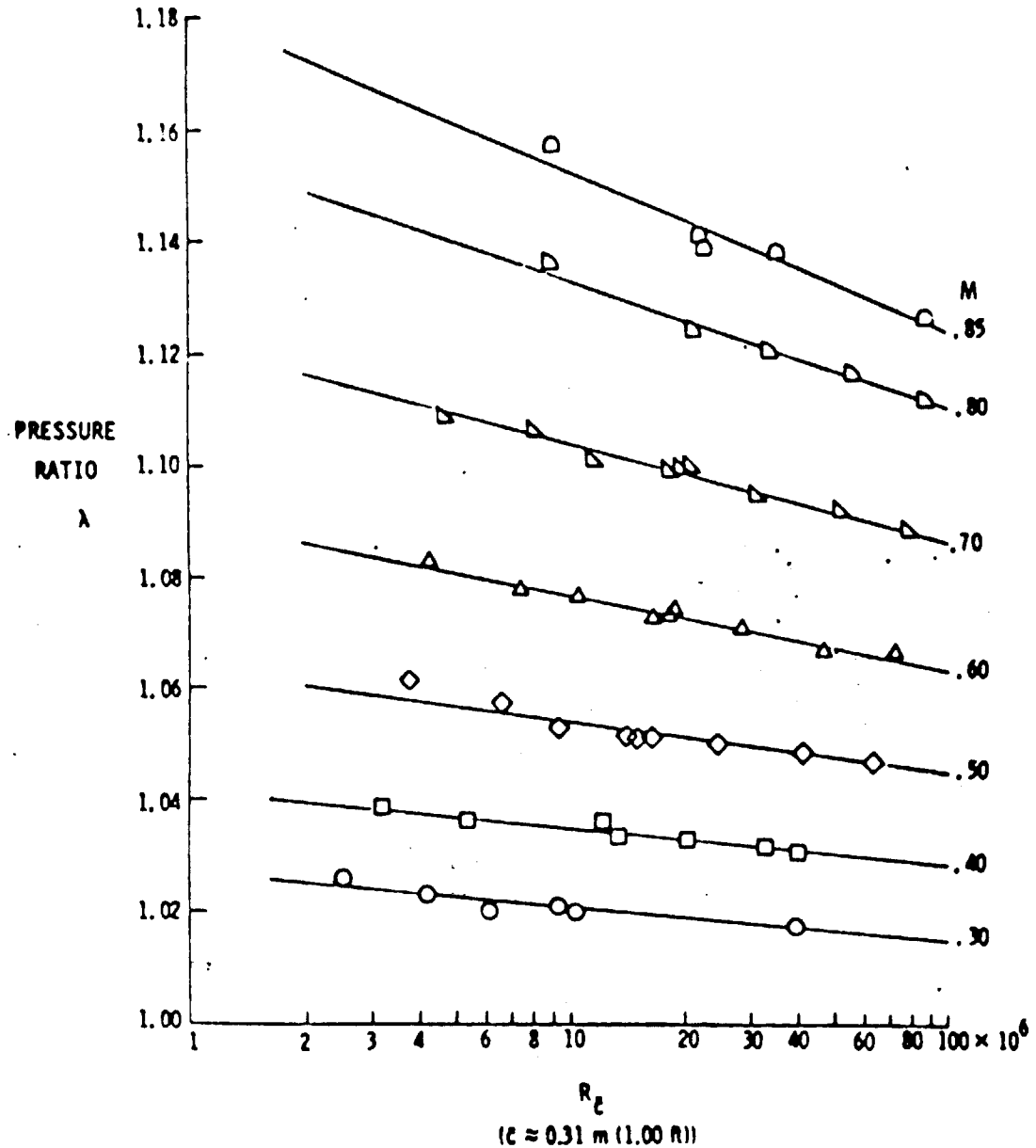




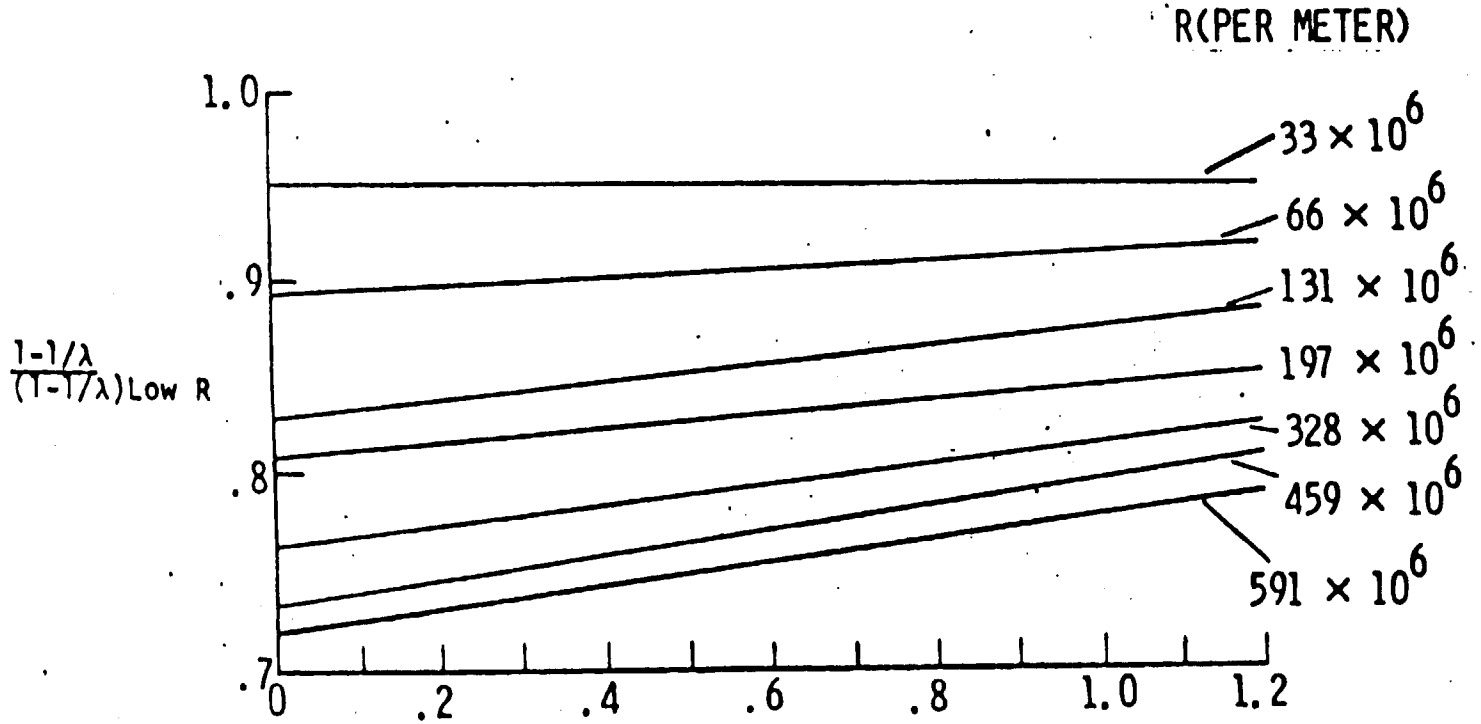
SECTION A-A




NTF FAN PRESSURE RATIO
RN = 4 X 10^6/FT
1.24
1.20
1.16
1.12
1.08
1.04
1.00
P.R.
TOTAL
(EXP.+ EST)
EXP.
0
.2
.4
.6
.8
1.0
1.2
MACH NO.

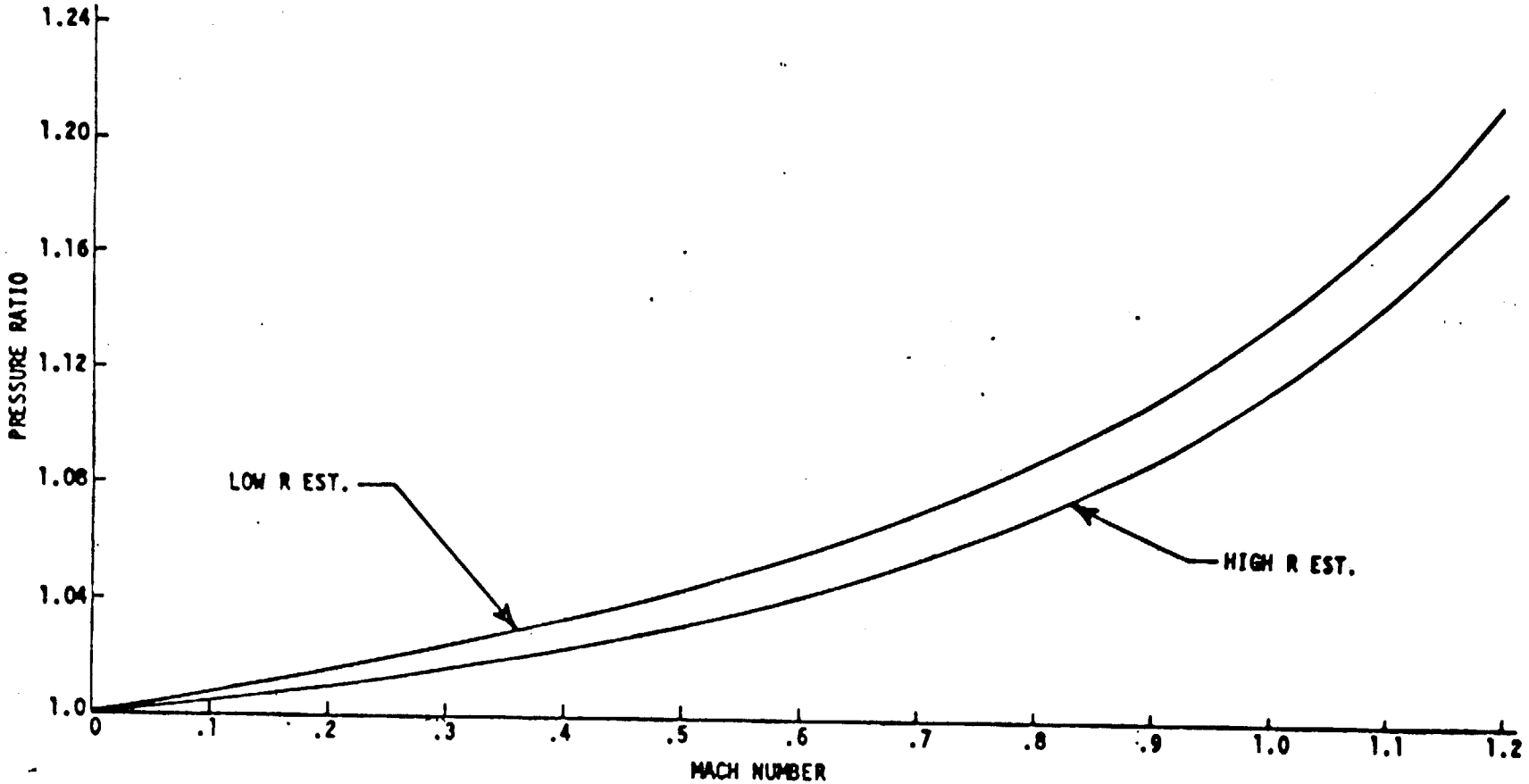


Effect of Reynolds number on tunnel pressure ratio
0.3-Meter Transonic Cryogenic Tunnel.

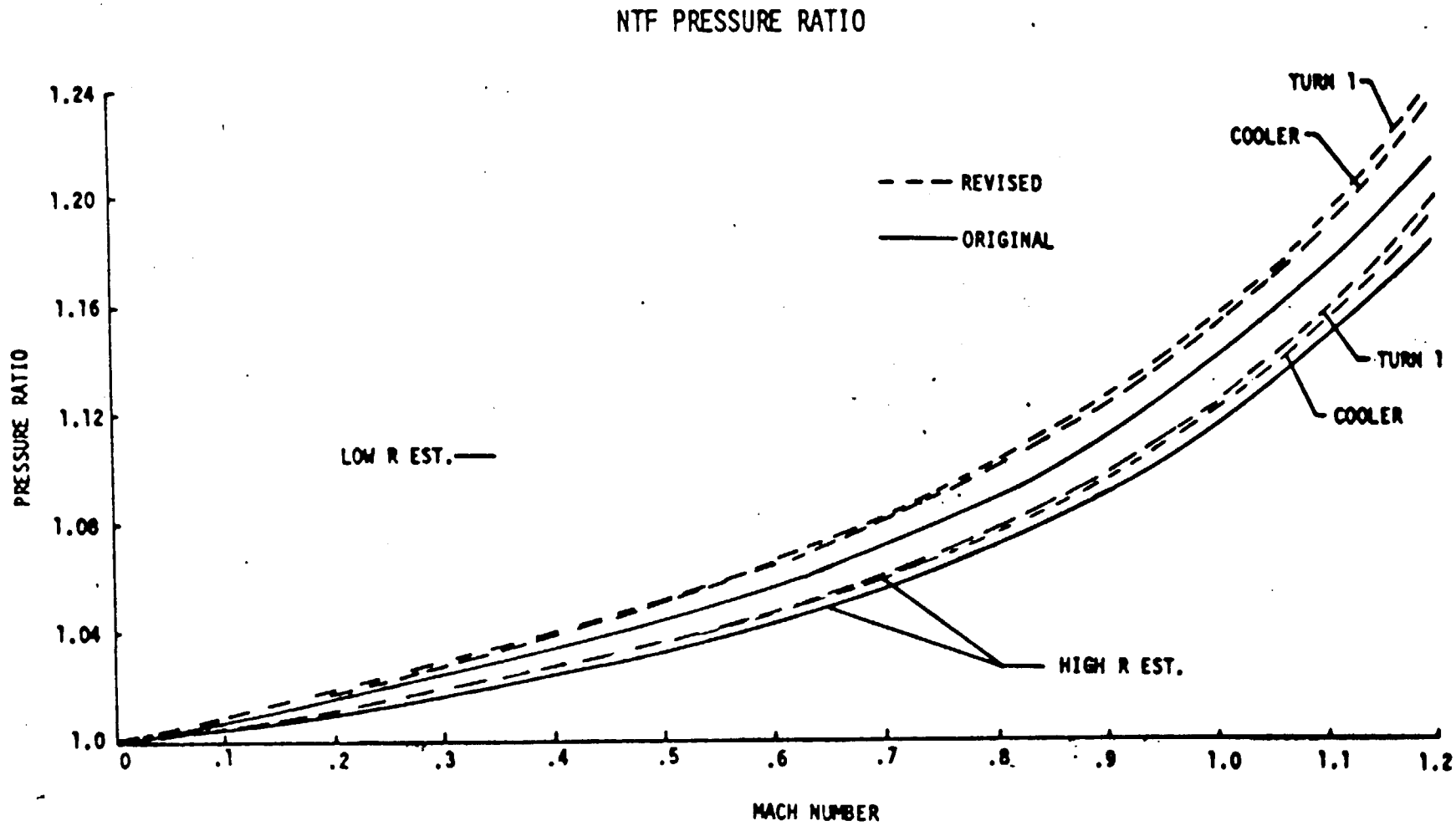


EFFECT OF REYNOLDS NUMBER ON TUNNEL PRESSURE LOSS.

NTF PRESSURE RATIO



ORR 9/14/83 XII



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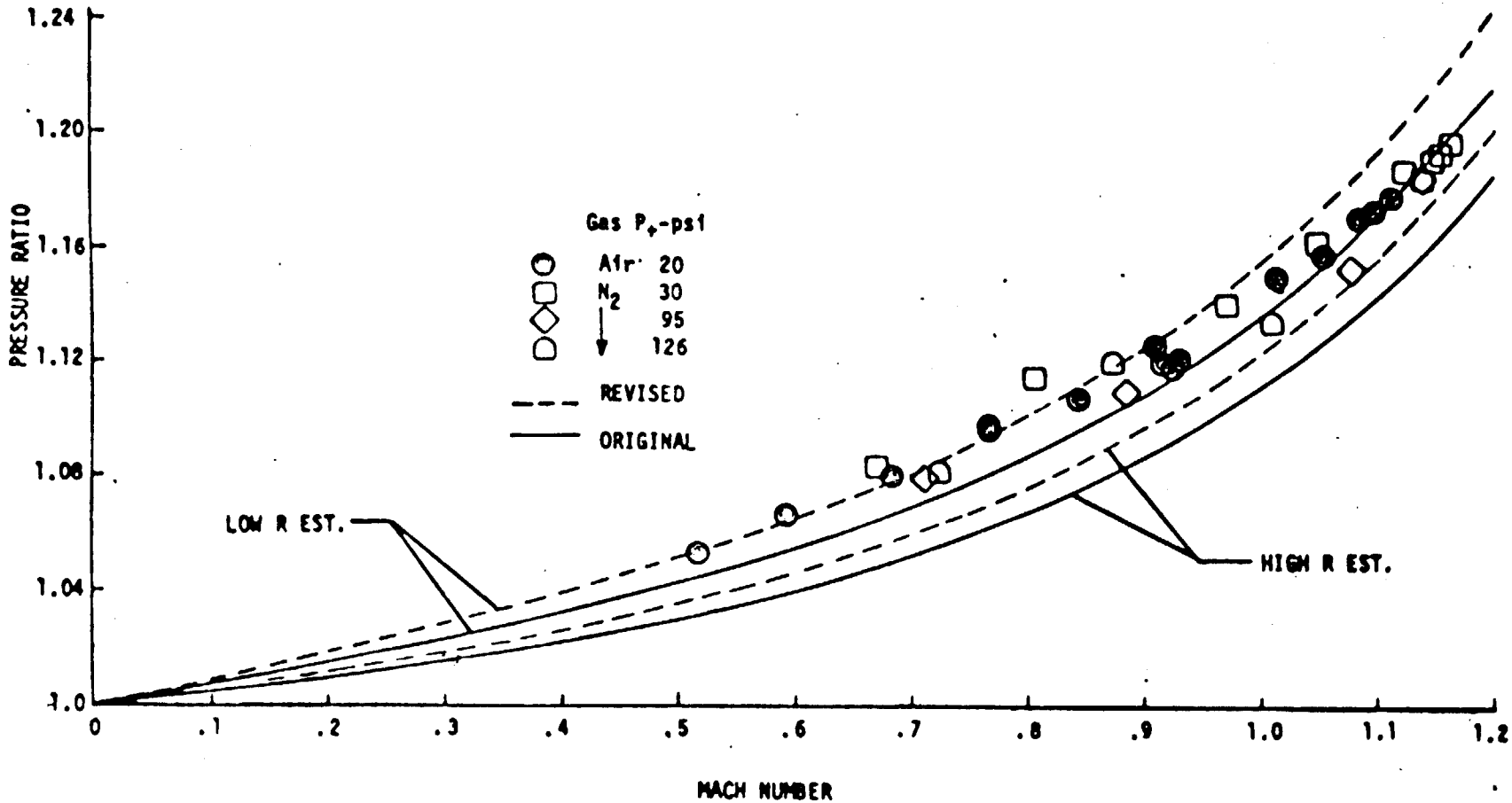
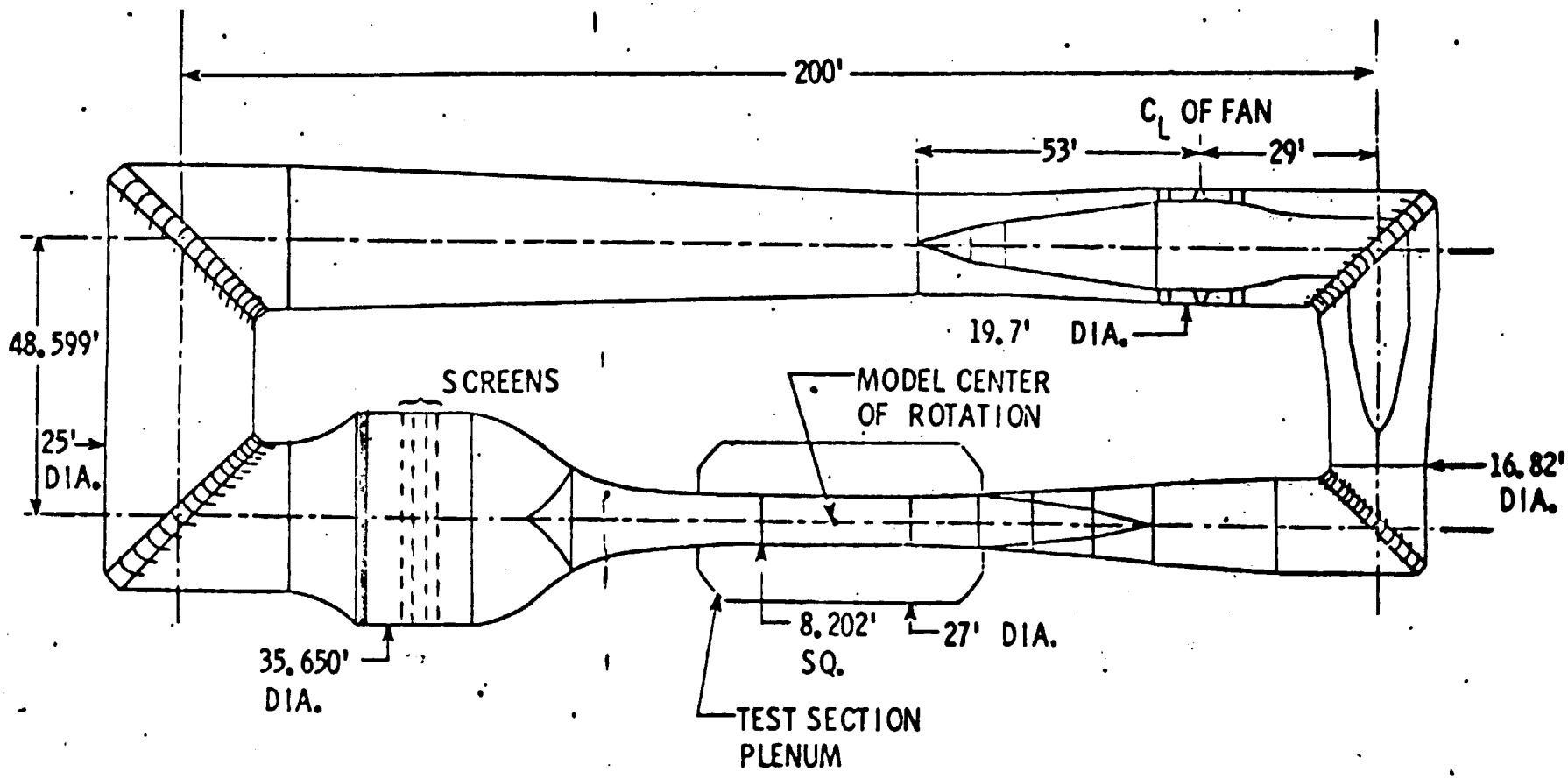
NTF PRESSURE RATIO

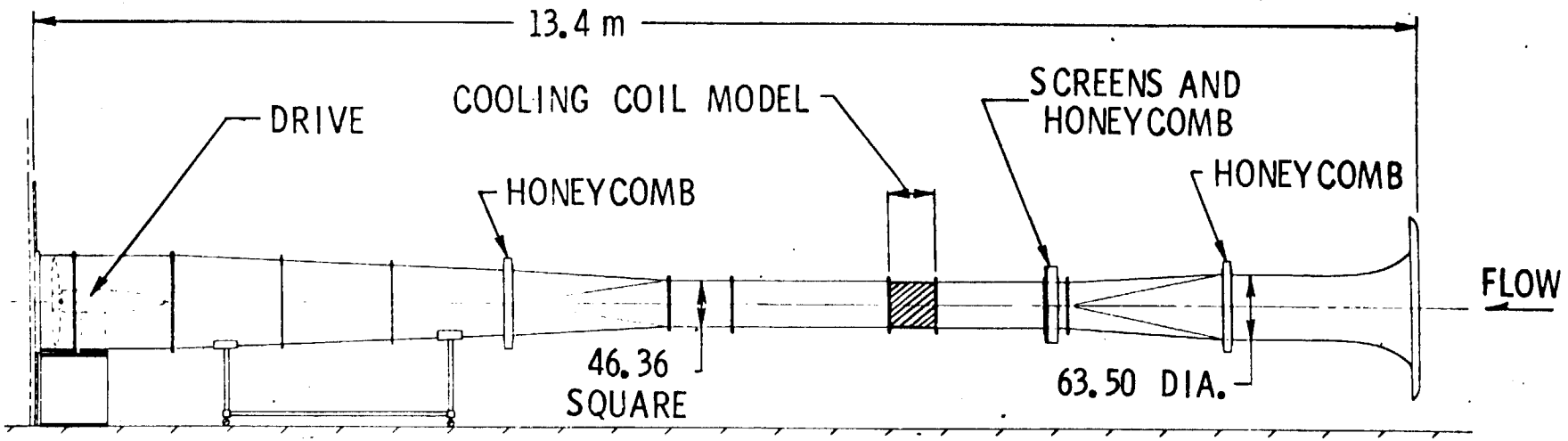


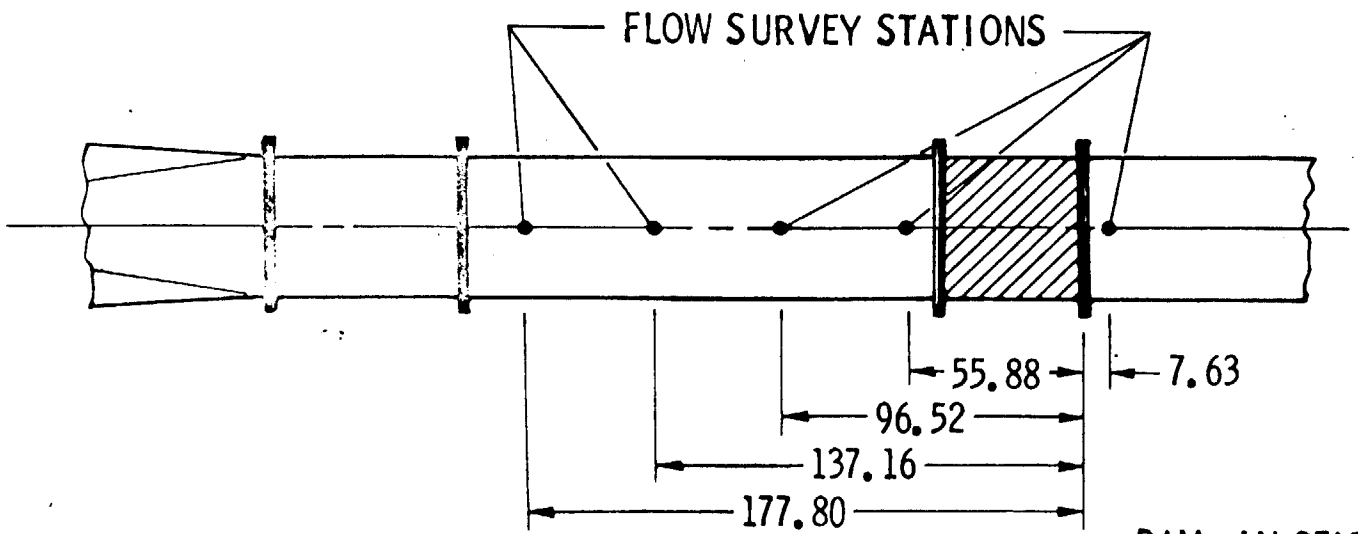
ORR 9/14/83 VII

NATIONAL TRANSONIC FACILITY



SCHEMATIC OF FLOW APPARATUS





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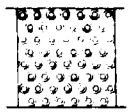
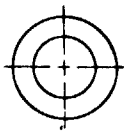
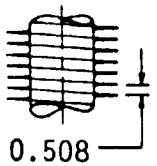
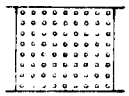
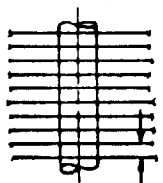
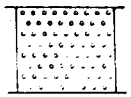
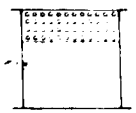
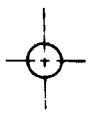
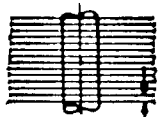
TEST MODELS

Model	Tube Geometry			Fin Geometry	Porosity	RN Range**	Test Facility
	Spacing*	Placement	Size*				
1	8 ROWS STAGGERED 6.05 x 6.99 ON CENTERS		2.84 O.D.  ROUND	SPIRAL  0.508	0.55	2×10^4 TO 3×10^5	FLOW APPARATUS
2	8 ROWS INLINE 5.08 x 5.08 ON CENTERS		1.59 O.D.  ROUND	PLATE  0.64	0.65		
3	8 ROWS STAGGERED 5.08 x 5.08 ON CENTERS						
4	4 ROWS INLINE 3.81 x 3.81 ON CENTERS		1.59 O.D.  ROUND	PLATE  0.25	0.53	2×10^4 TO 8×10^6	FLOW APPARATUS and 0.3 m TCT

* ALL DIMENSIONS IN CENTIMETERS

** RN PER FOOT

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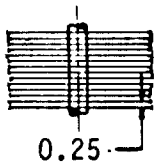
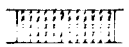
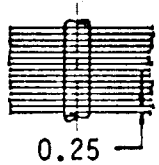
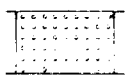
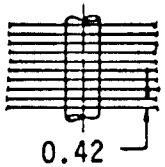
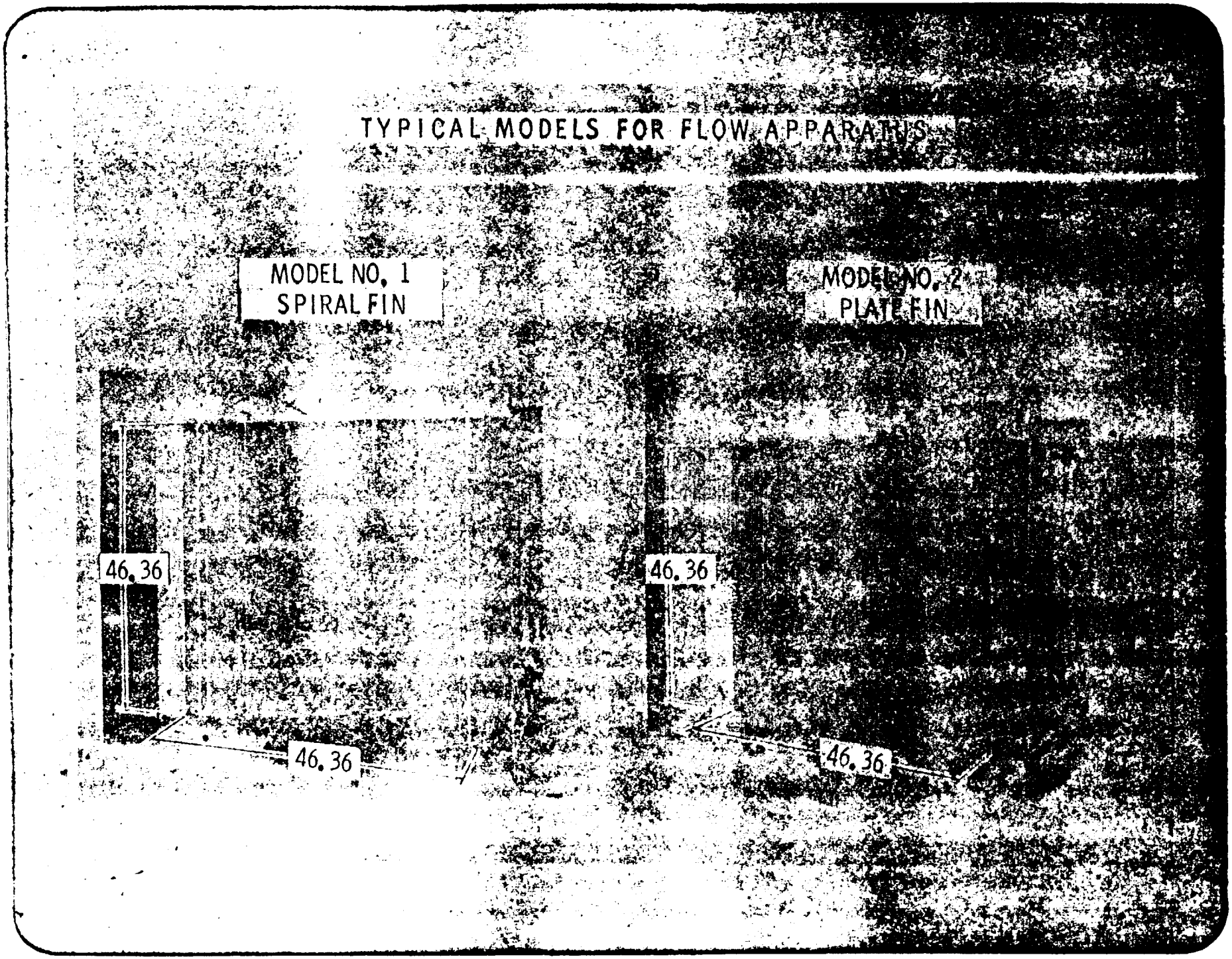
TEST MODELS (CONTINUED)

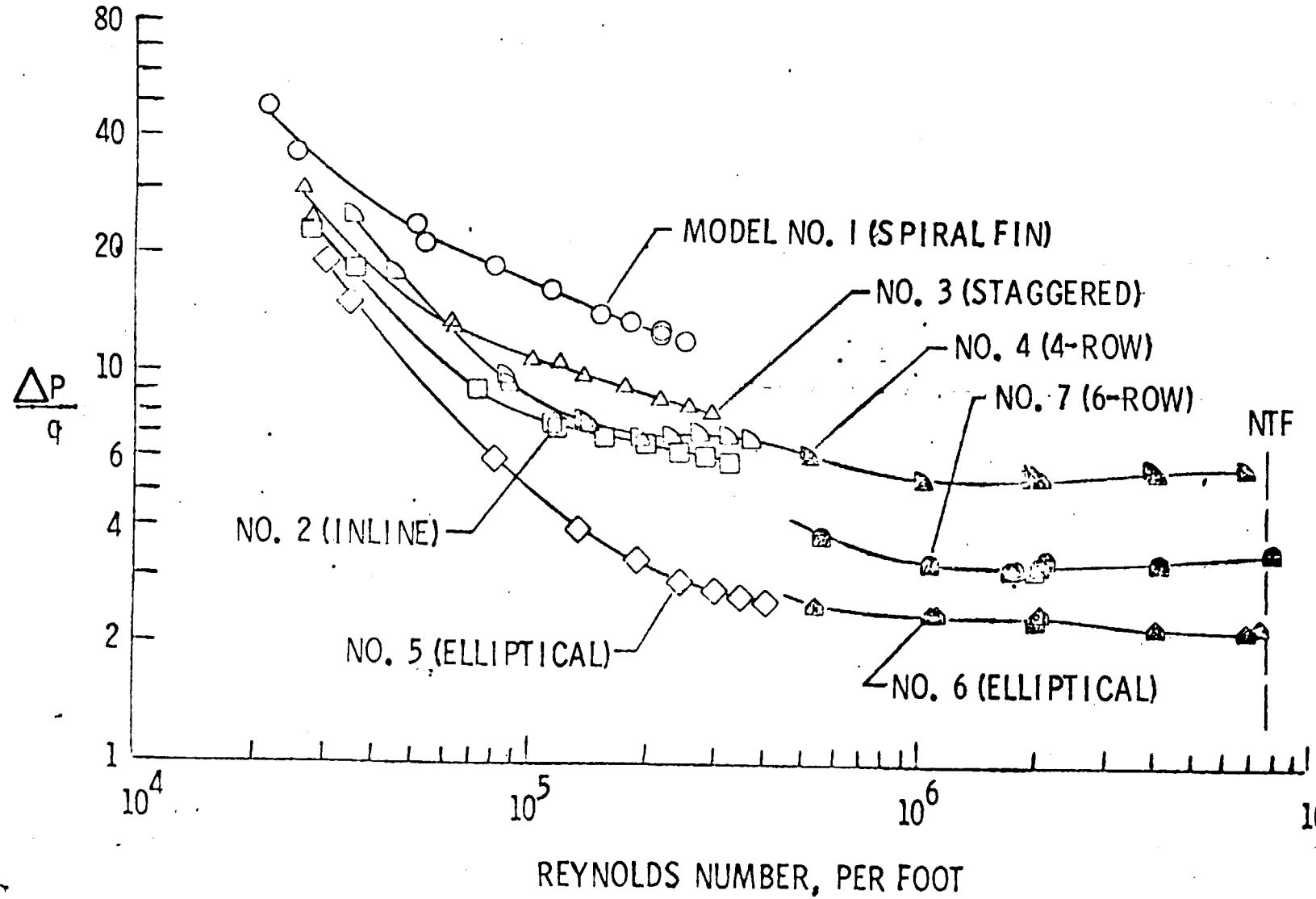
Model	Tube Geometry			Fin Geometry	Porosity	RN Range**	Test Facility
	Spacing*	Placement	Size*				
5	4 ROWS INLINE 3.81 x 3.81 ON CENTER		0.79 x 1.59  ELLIPSE	PLATE  0.25	0.71	2×10^4 TO 3×10^5	FLOW APPARATUS
6			1.14 x 2.27  ELLIPSE	PLATE  0.25	0.63	5×10^5 TO 8×10^6	0.3 m TCT
7	6 ROWS INLINE 5.08 x 5.08 ON CENTER		1.59 O.D.  ROUND	PLATE  0.42			

* ALL DIMENSIONS IN CENTIMETERS

** RN PER FOOT

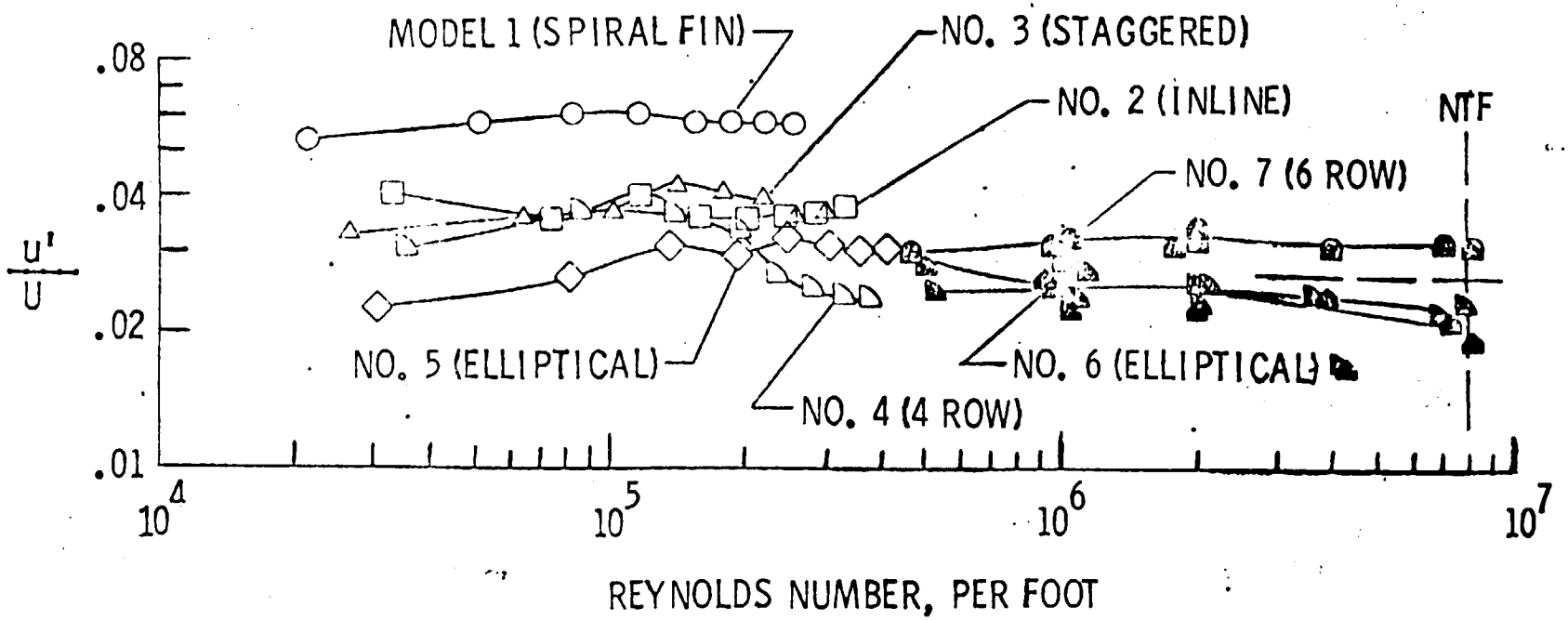


VARIATION OF PRESSURE LOSS WITH REYNOLDS NUMBER



VARIATION OF LONGITUDINAL TURBULENCE COMPONENT WITH REYNOLDS NUMBER

(177.8 CM DOWNSTREAM OF MODEL FACE)



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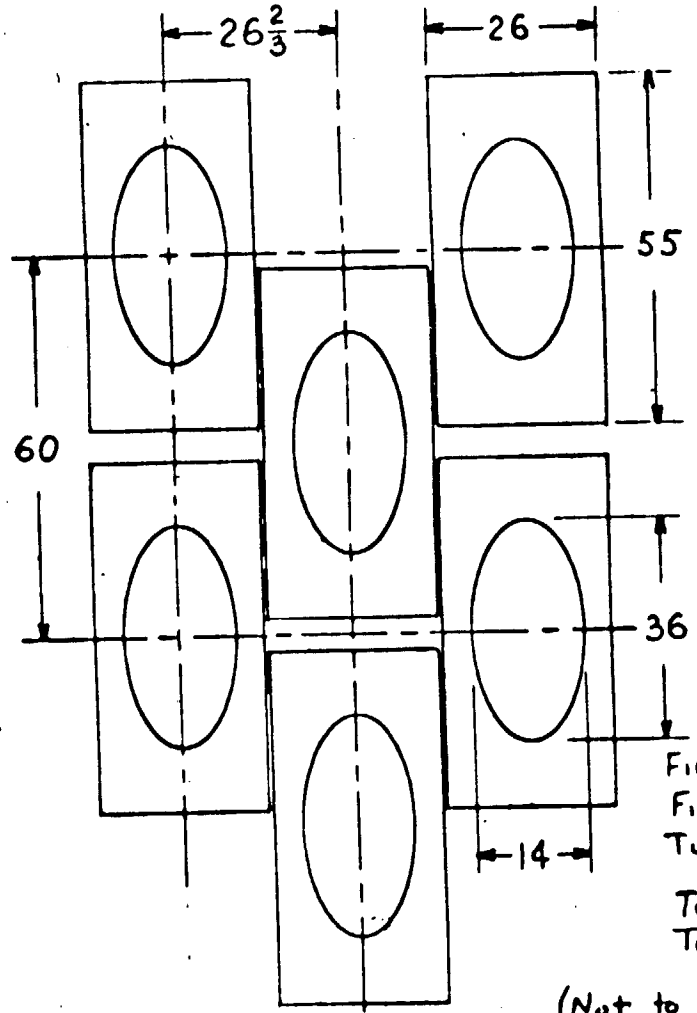
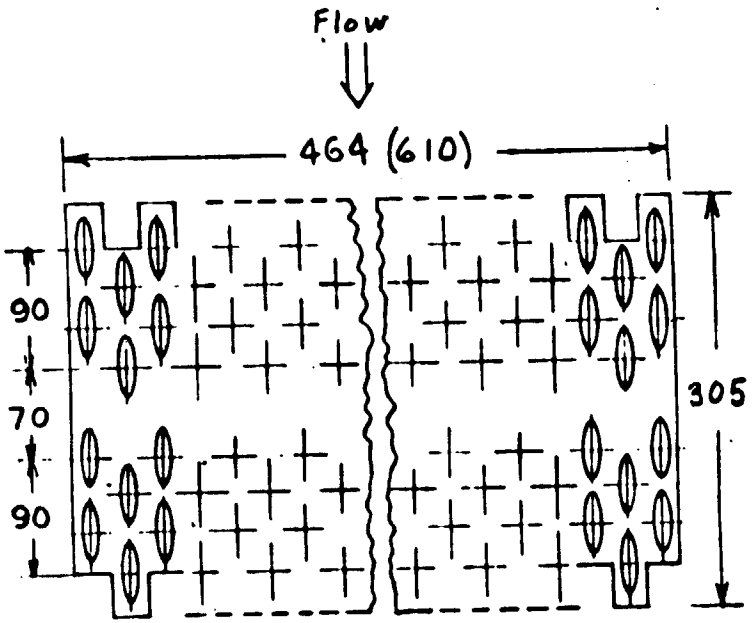
COOLING COIL AERODYNAMIC REQUIREMENTS

- $\frac{\Delta P_1}{q} \leq 5$
- DOWNSTREAM TURBULENCE $\leq .026$
- HEAT CAPACITY CORRESPONDING TO M = 1.0 @ P_T = 2 ATMOS.
  $T_T = 150^0$F, HP = 47,000





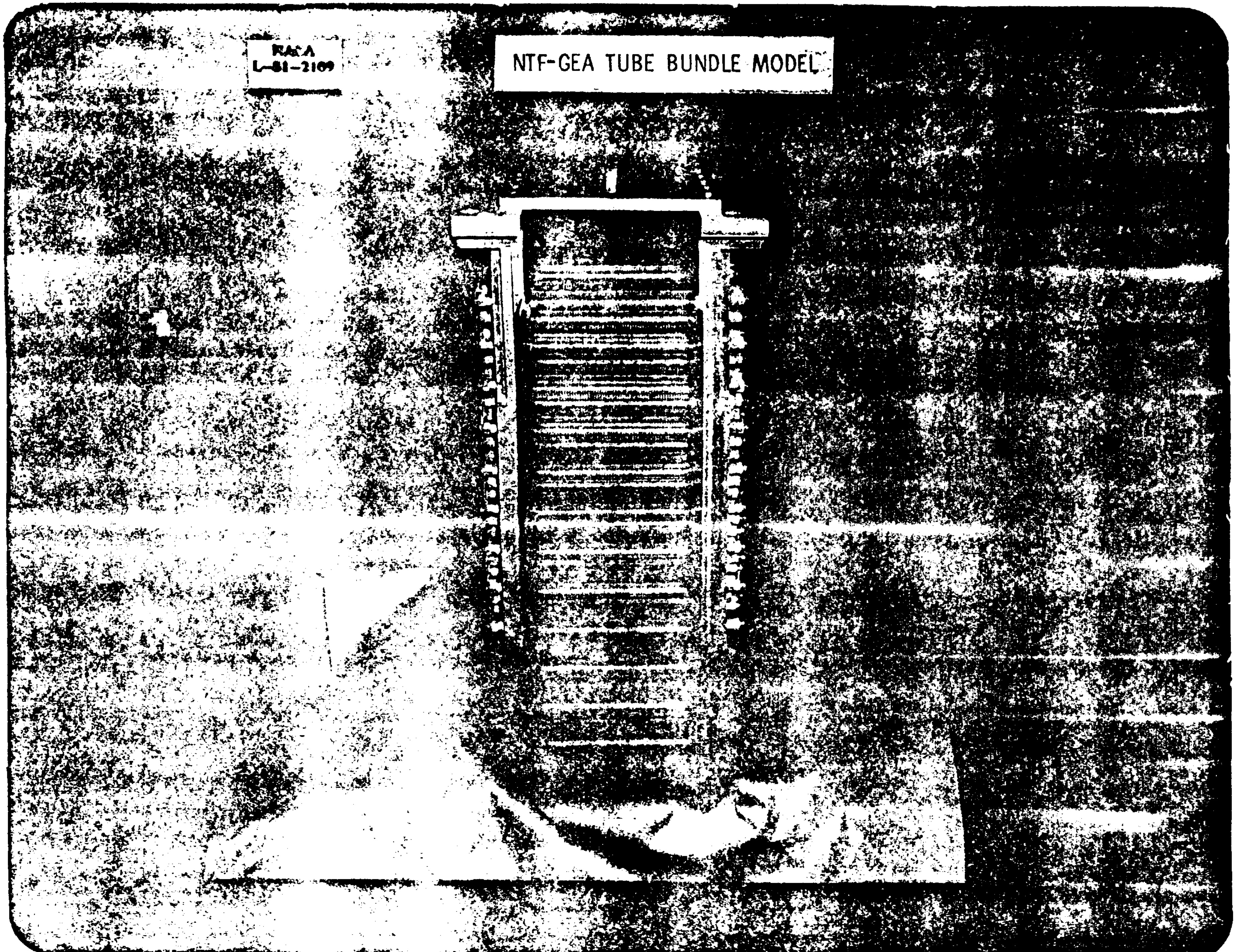
Tube-bundle array

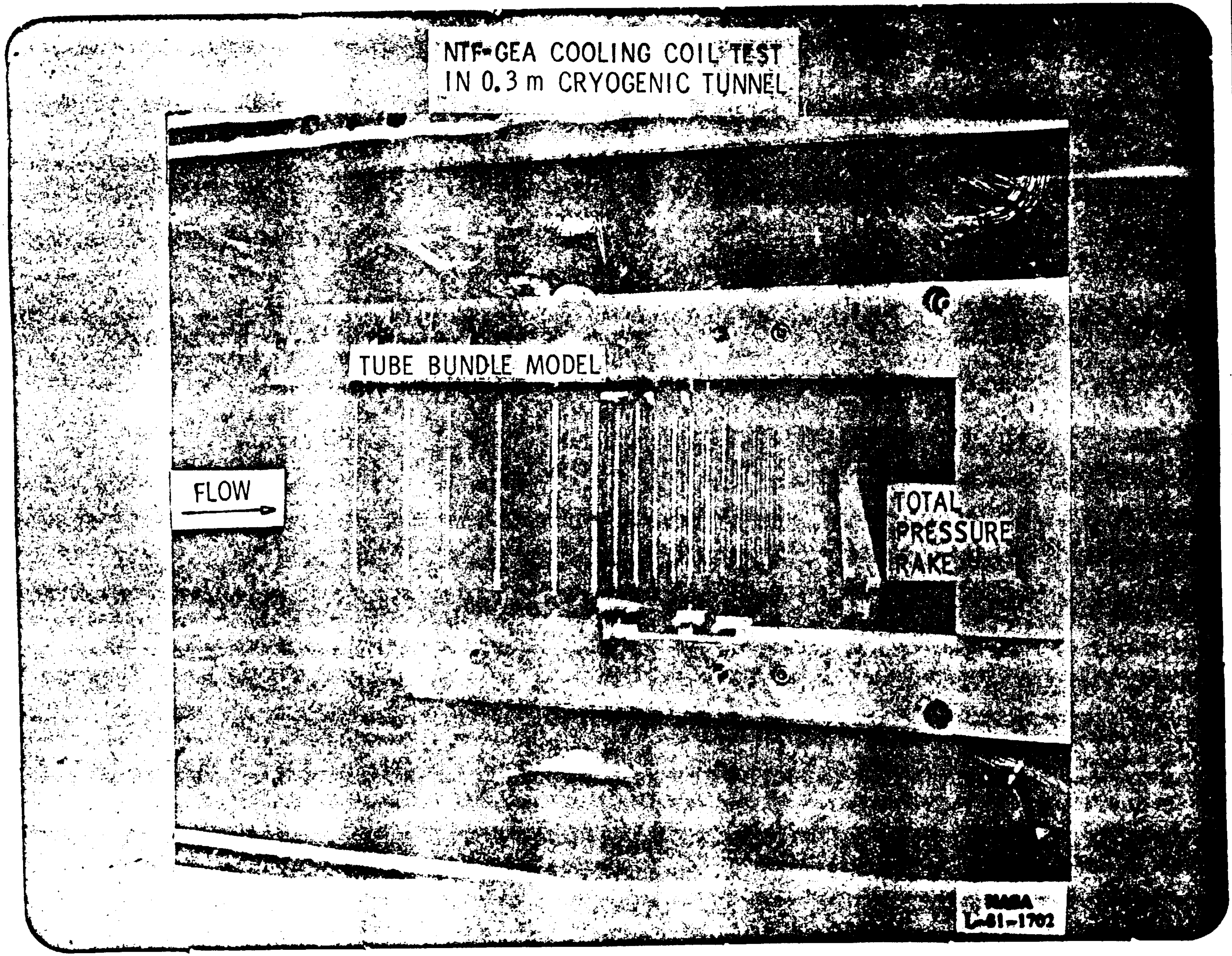
Fin thickness .25 mm
Fin spacing 3 mm
Tube hydraulic diam. 19.2 mm

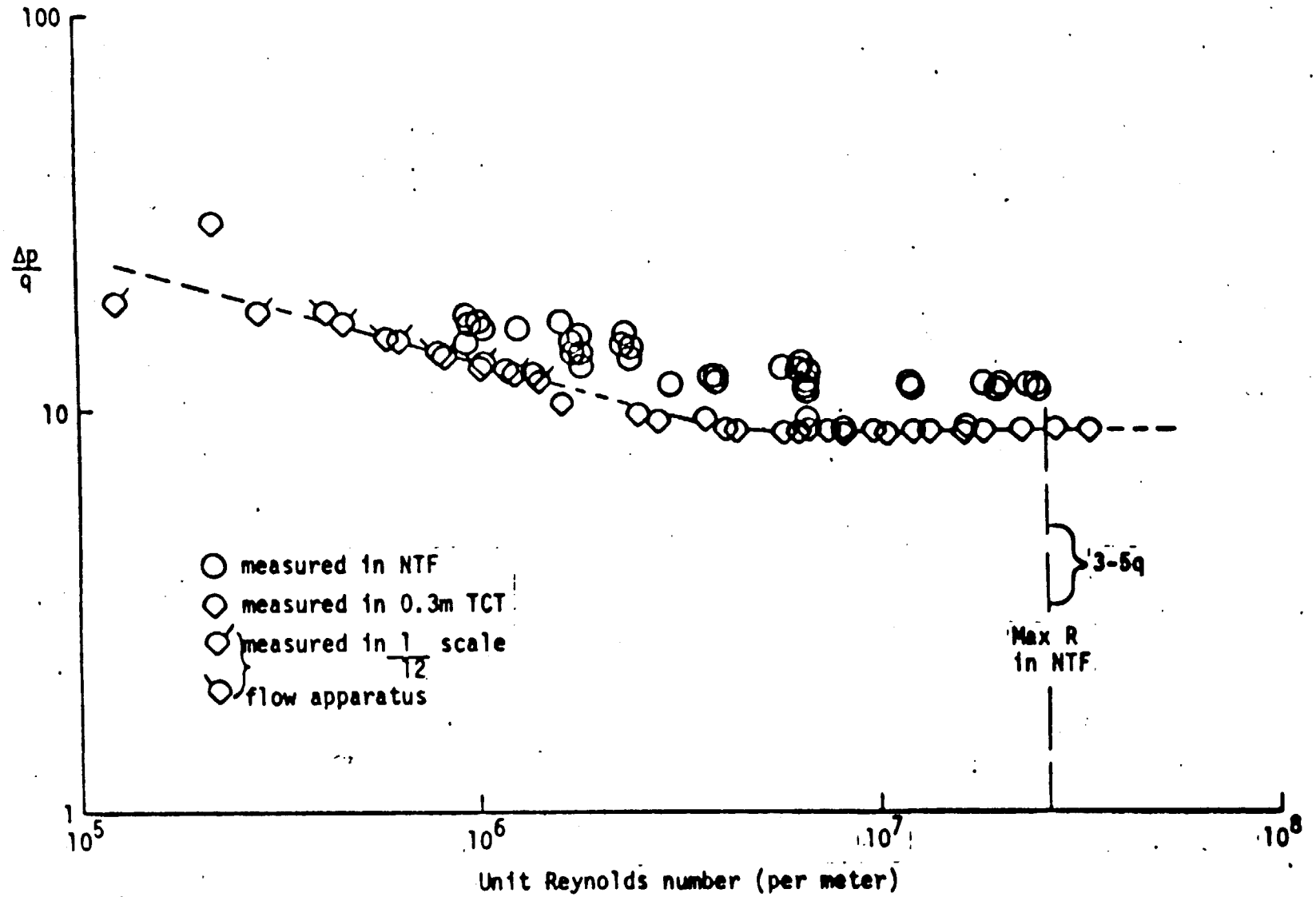
Tube-bundle length in dir. of tube axis 464 mm (184 mm)
Tube-bundle porosity .437

(Not to scale)

Geometry of tube-bundle model for ambient temperature flow apparatus. Dimensions in parentheses apply to 0.3 m TCT model. All dimens. in mm

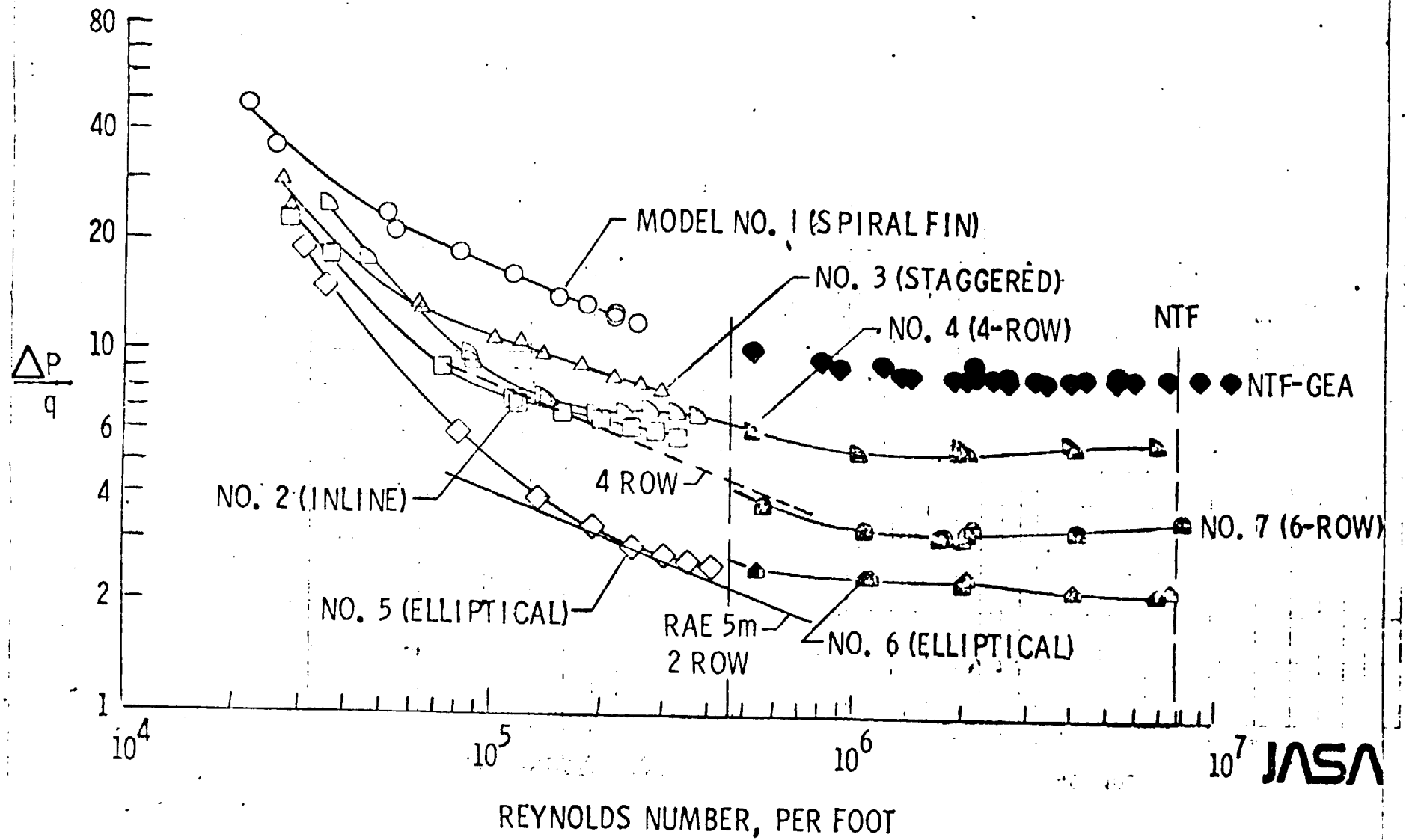






Pressure loss coefficient vs. unit Reynolds number for the NTF-GEA heat exchanger.

VARIATION OF PRESSURE LOSS WITH REYNOLDS NUMBER



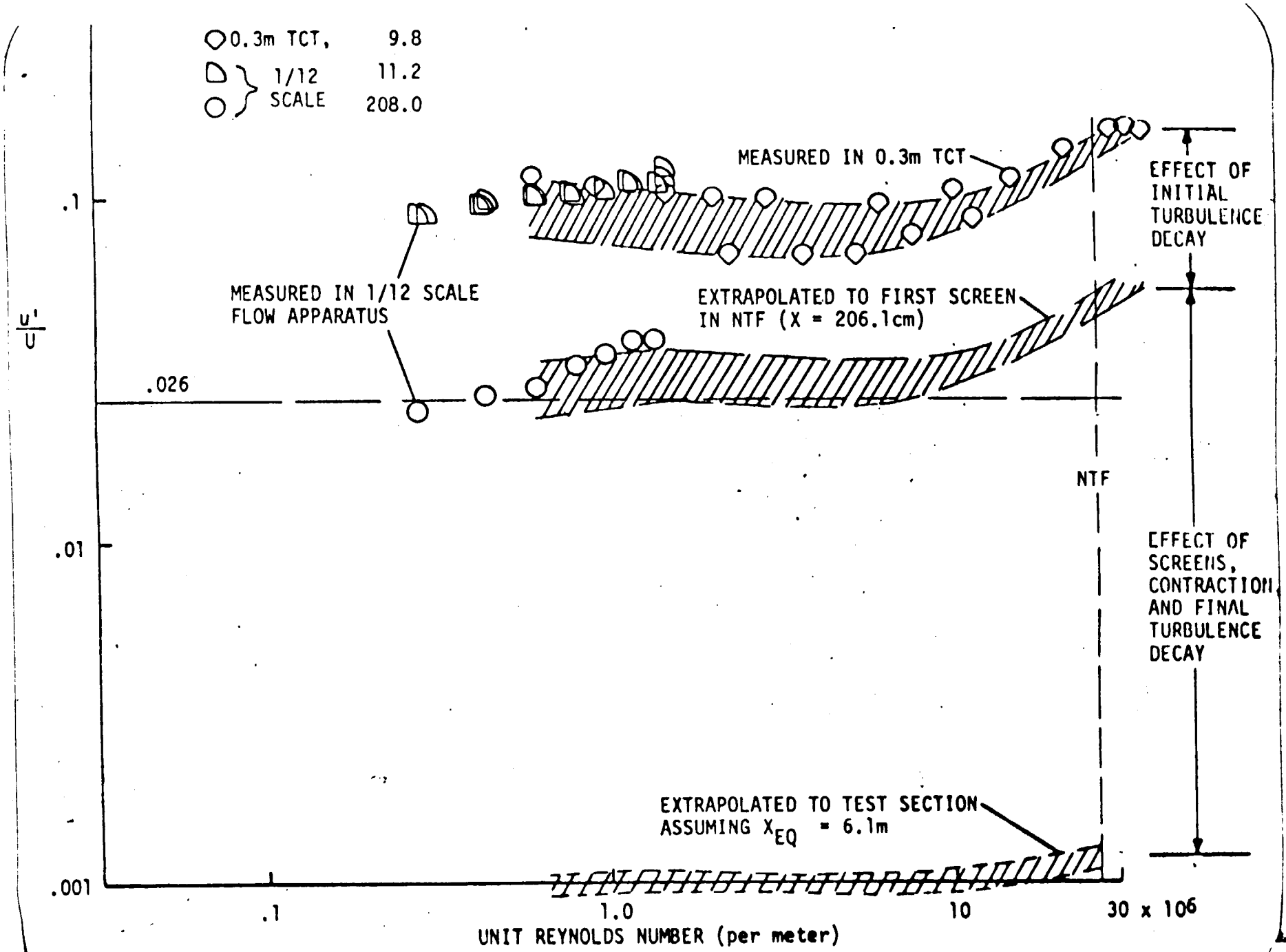


FIGURE 3: LONGITUDINAL COMPONENT OF TURBULENCE (rms) FOR THE NTF-GEA HEAT EXCHANGER.

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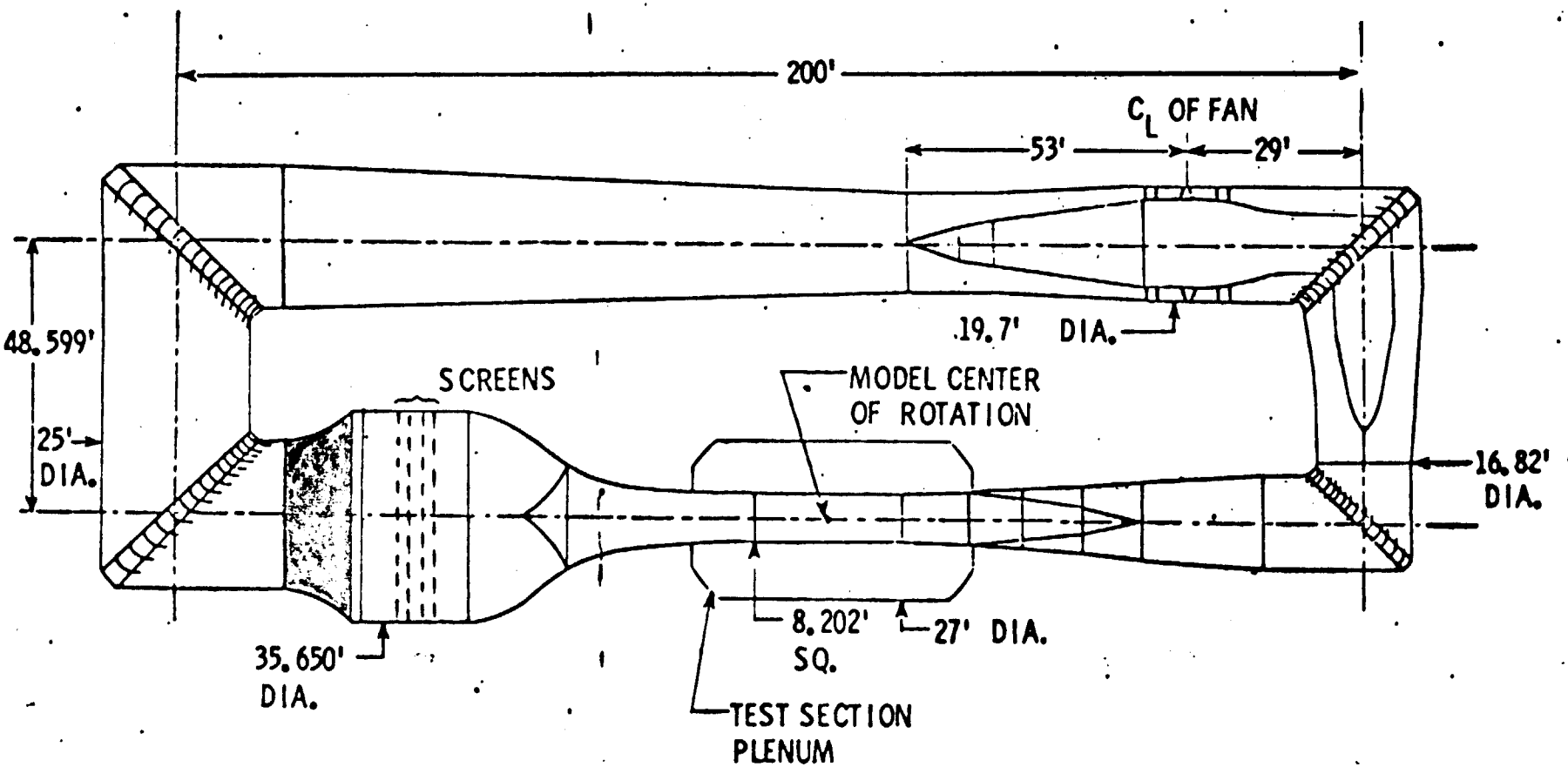

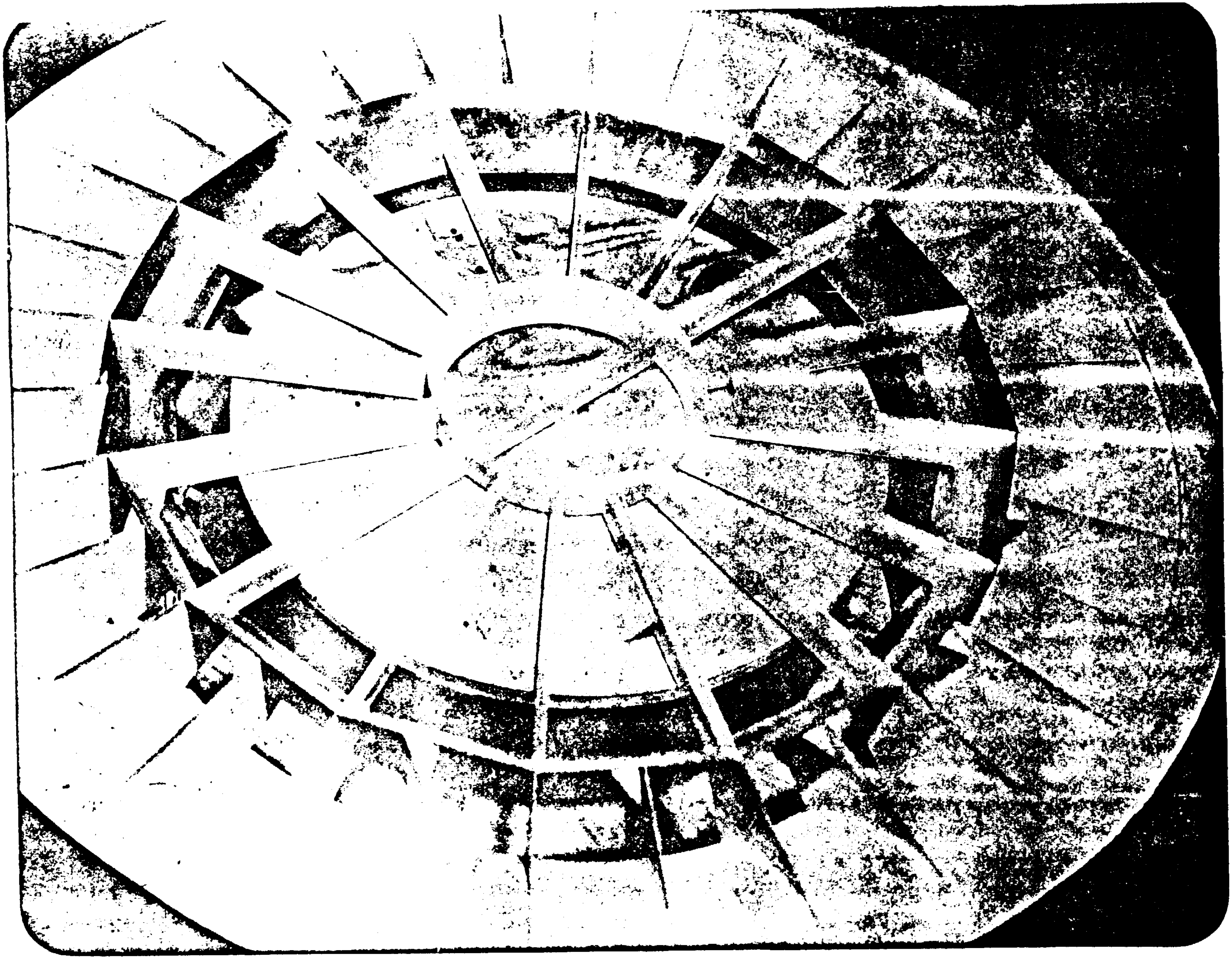

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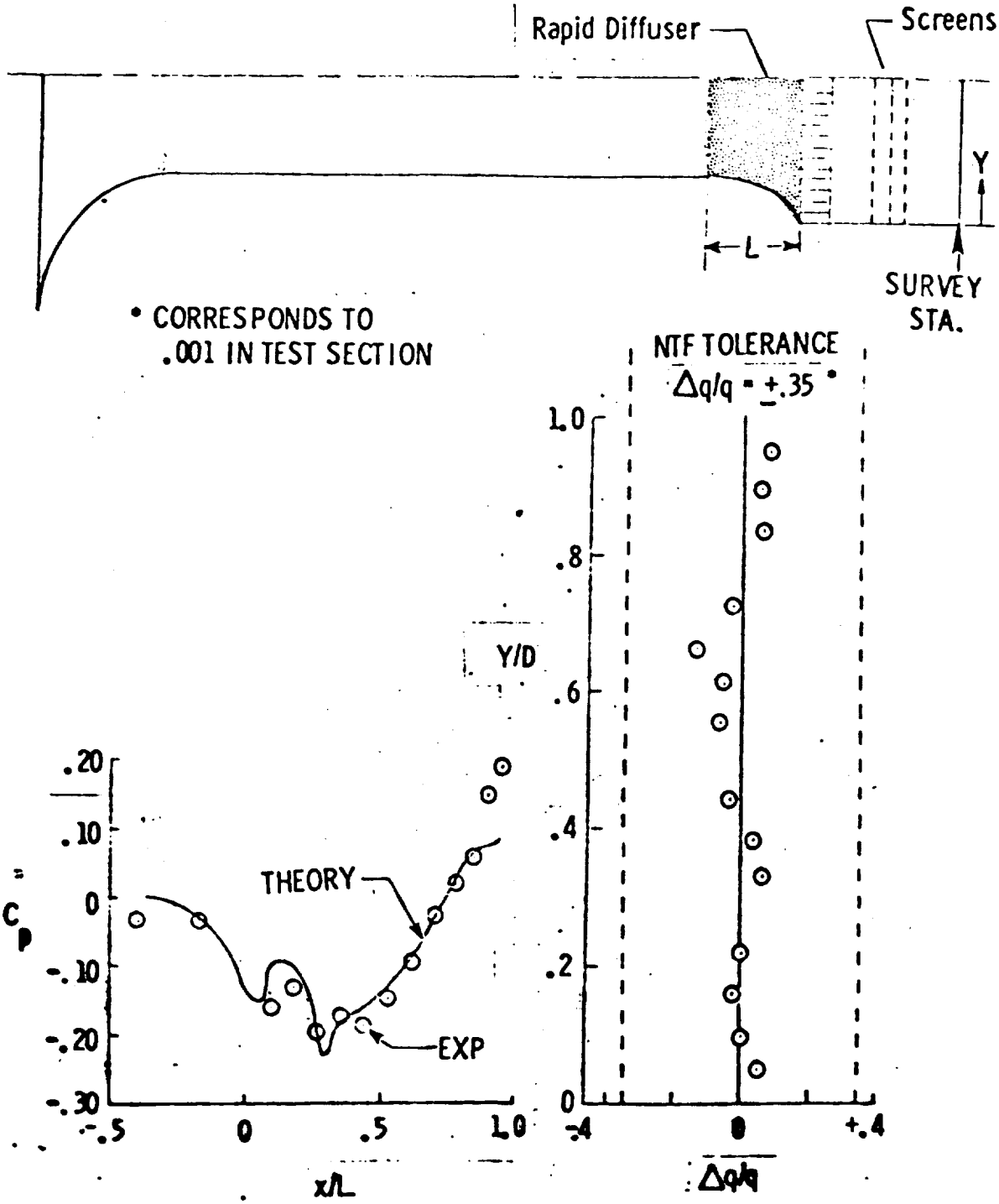
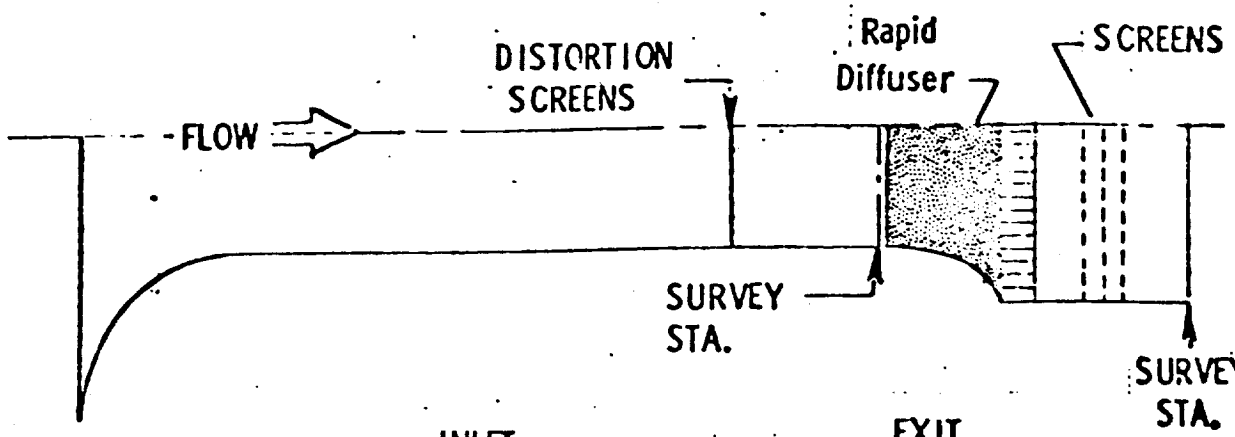
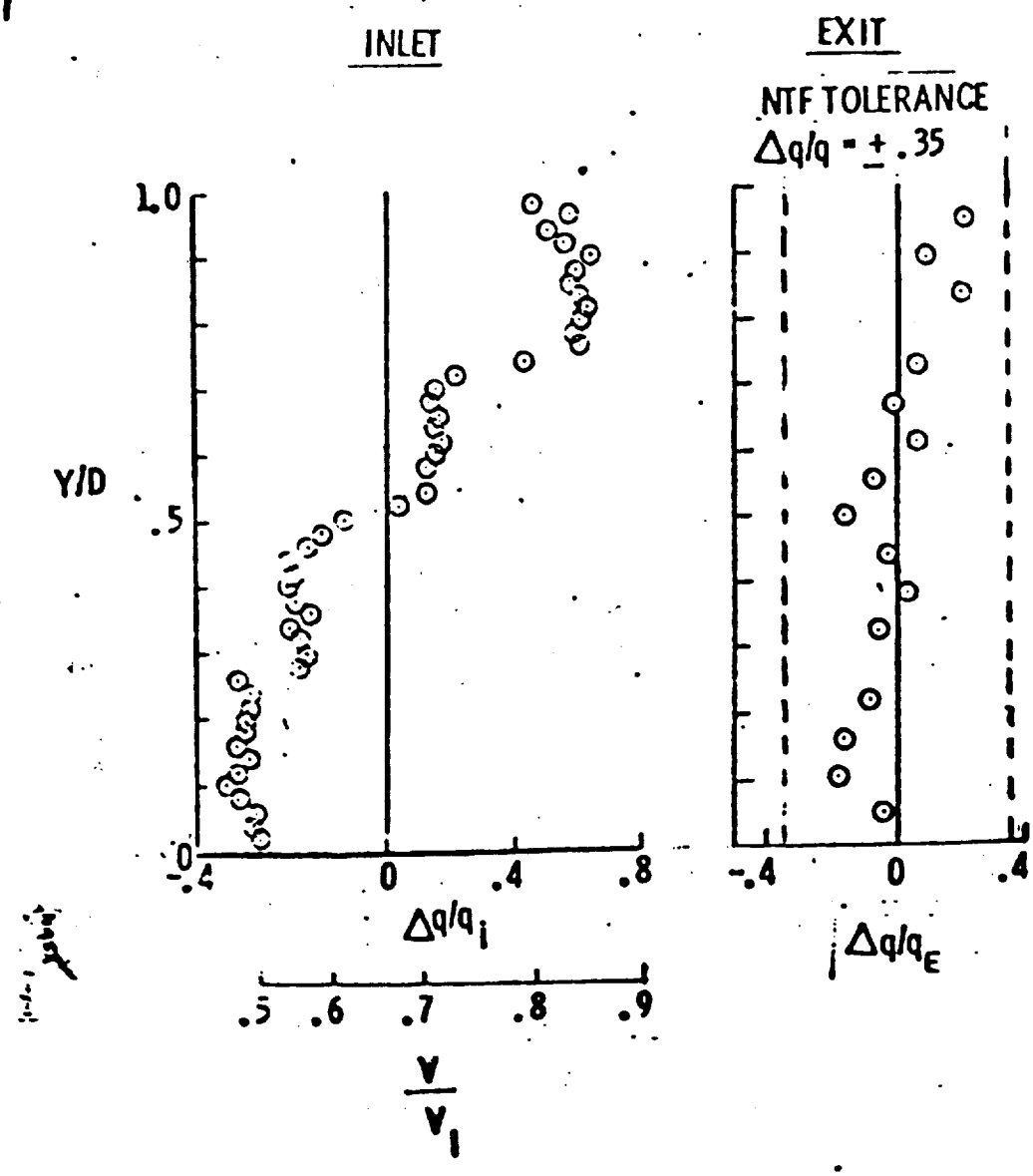
RAPID DIFFUSER PERFORMANCE (NTF)



EFFECT OF DISTORTED INLET VELOCITY PROFILE ON RAPI DIFFUSER PERFORMANCE





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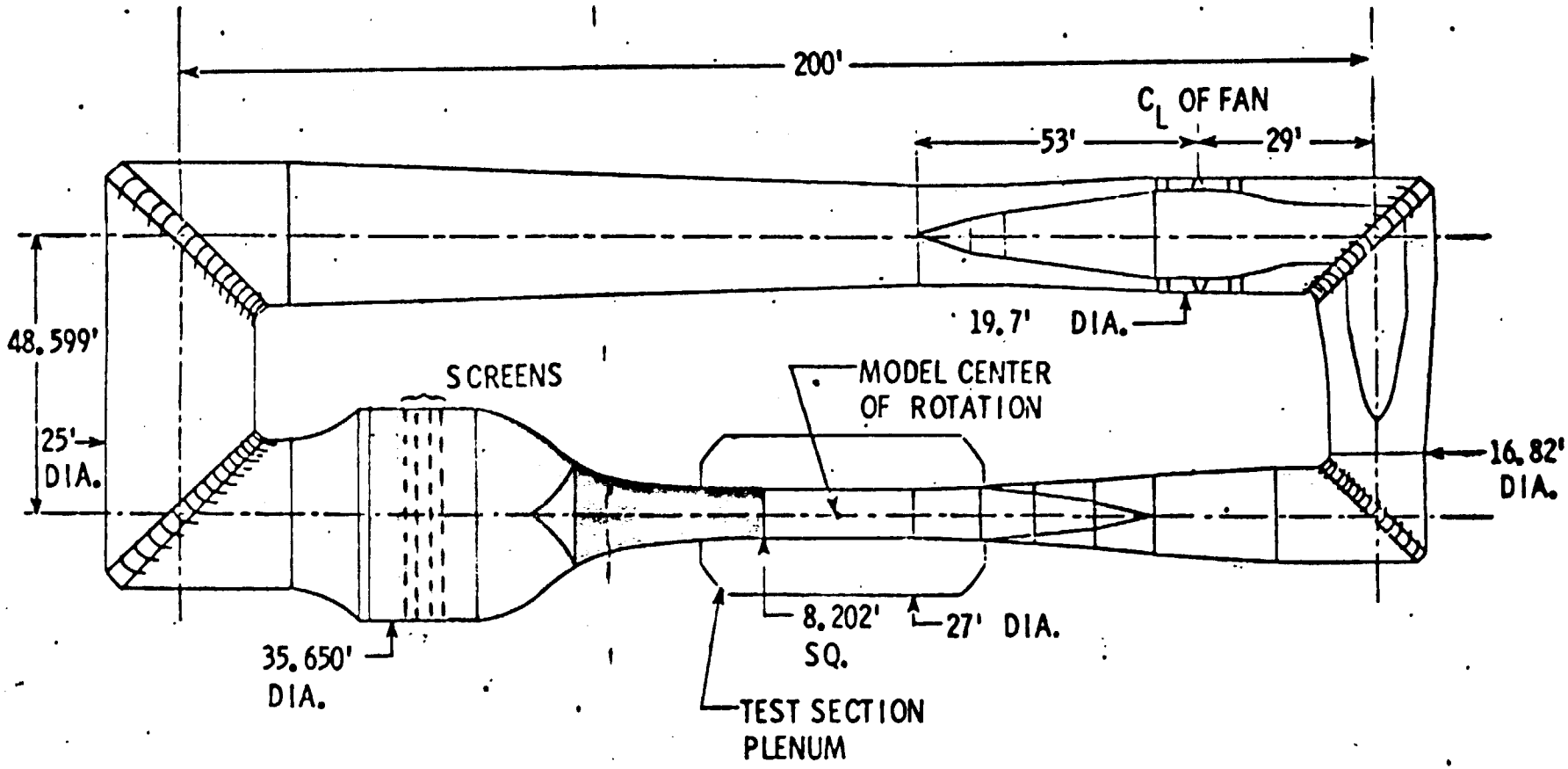
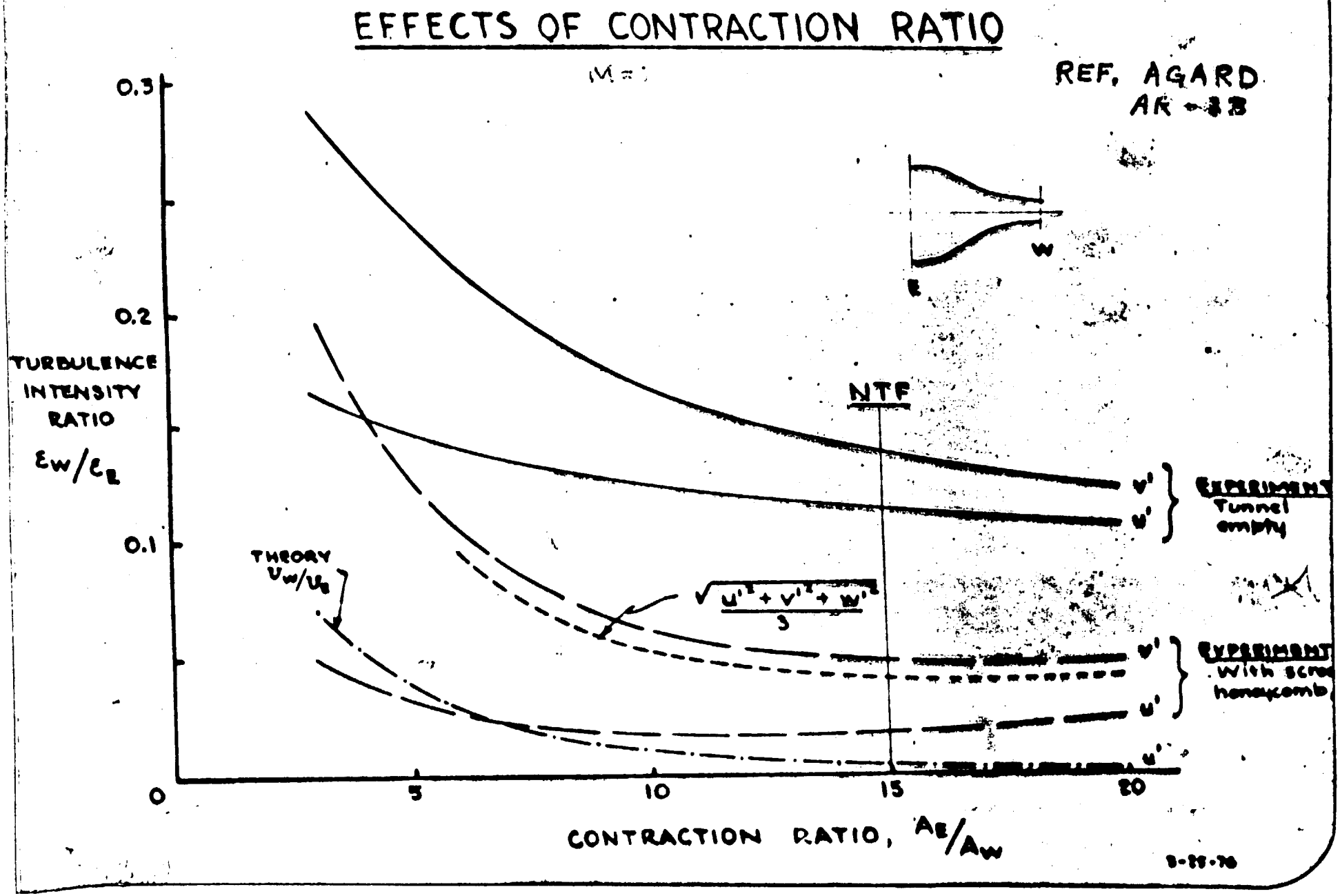
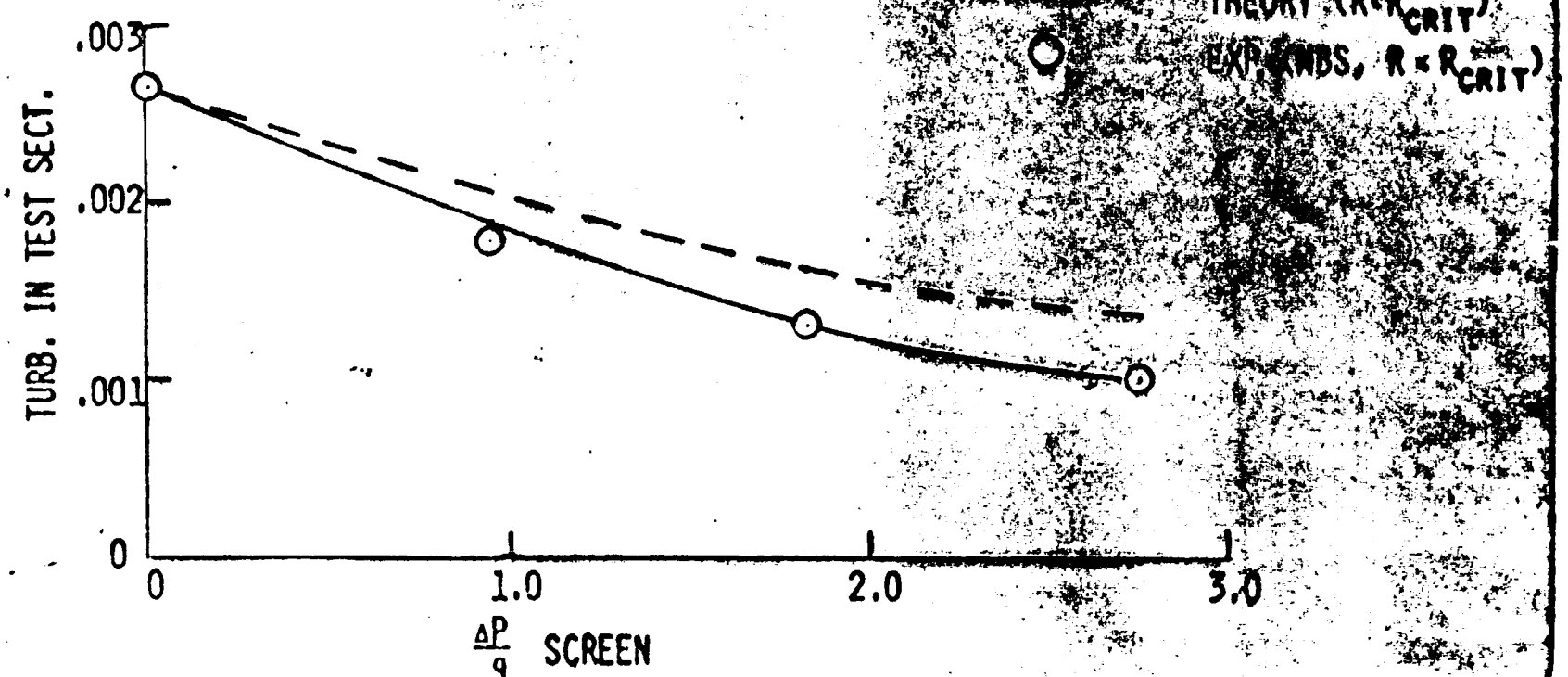
NATIONAL TRANSONIC FACILITY

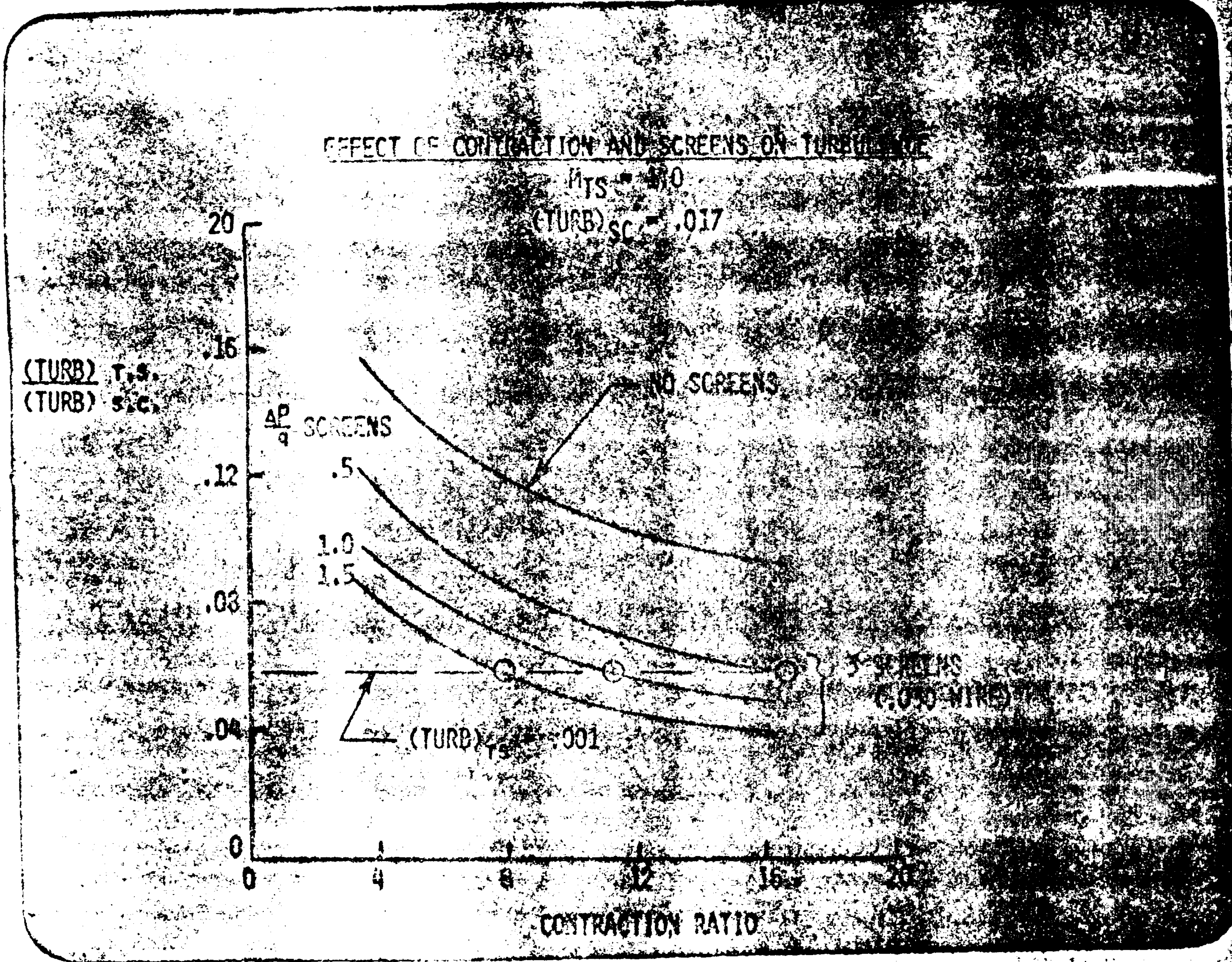




COMPARISON OF THEORY AND EXPERIMENT

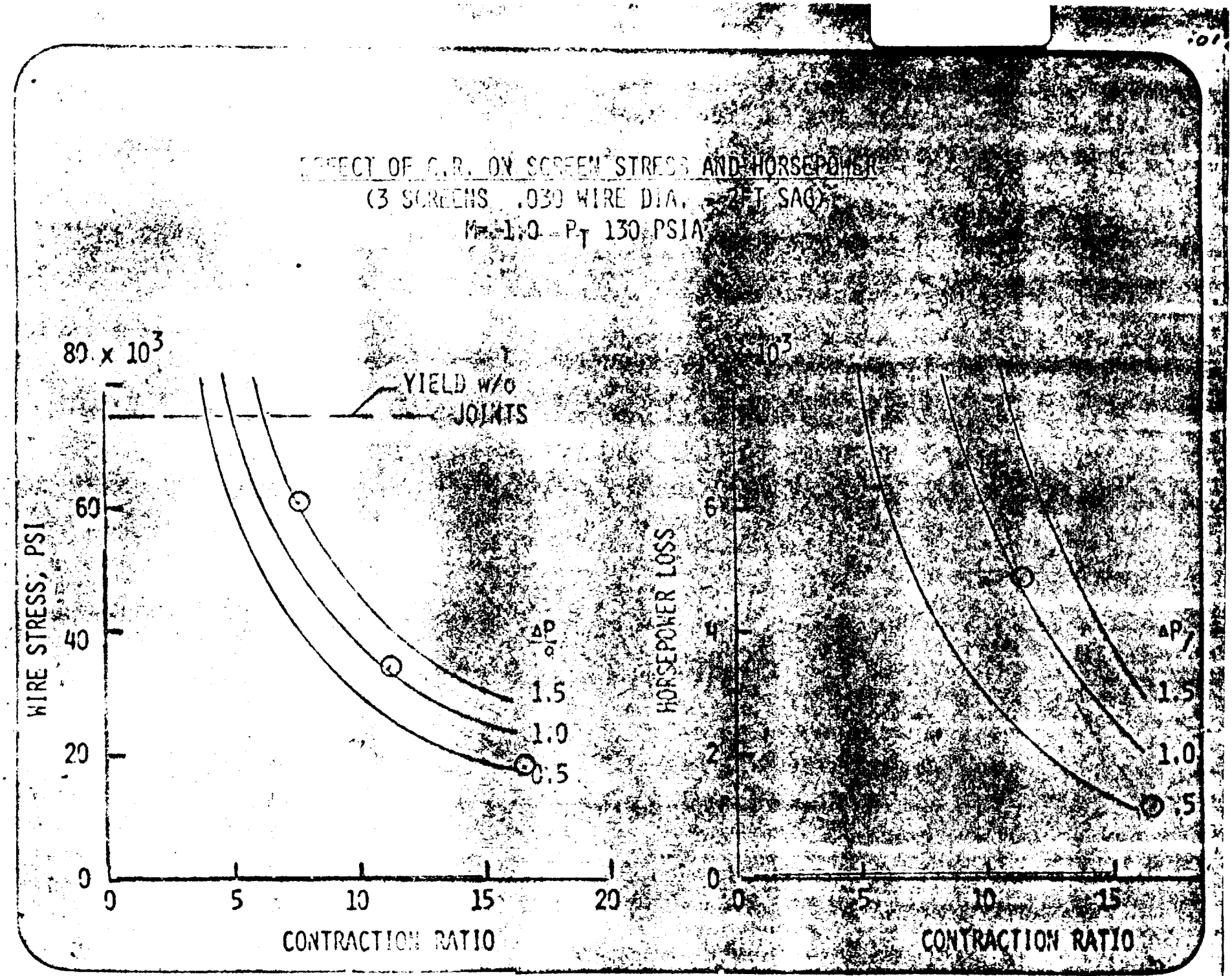
$(TURB)_{SC}$ = .017, C.R. = 6.6, WIRE DIA. = .011 INCH



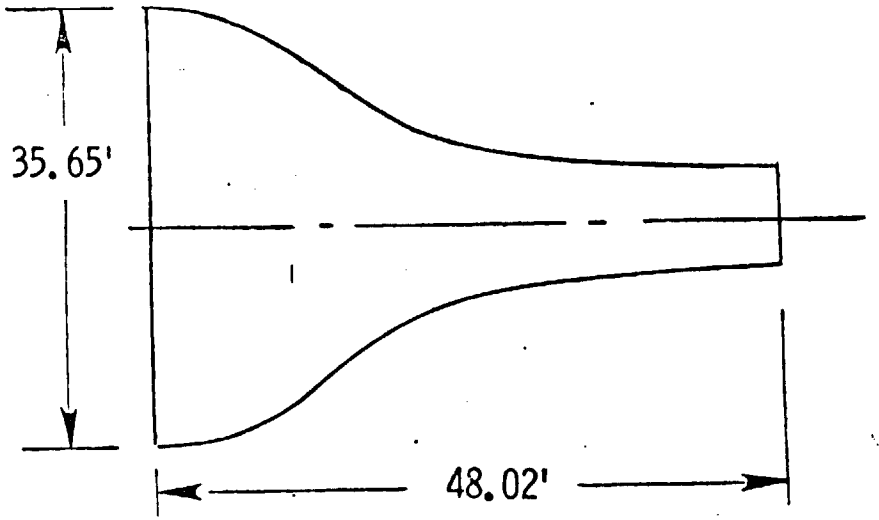


C-5

ORIGINAL PAGE IS
OF POOR QUALITY



NTF CONTRACTION SECTION



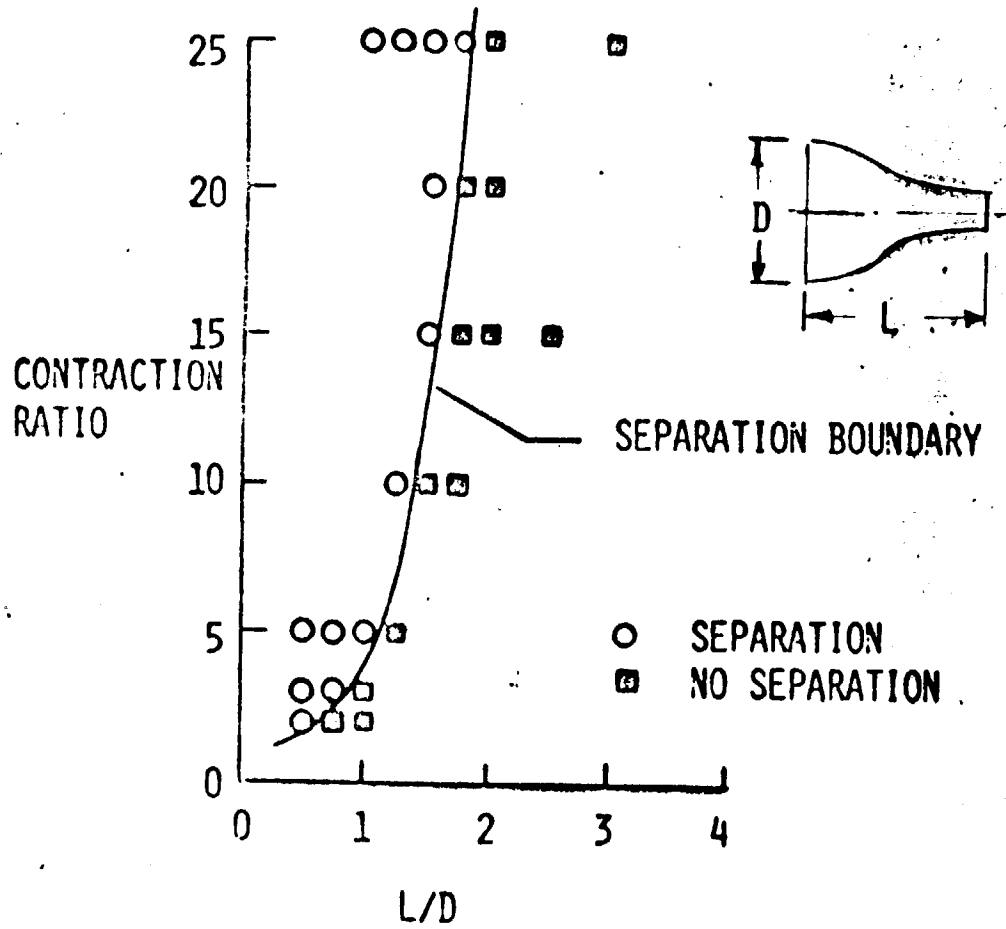
BASIS FOR DESIGN

- NASA TN D 7368
  - Streamline Curvature Method for Axisymmetric Flow
  - Compressible Flow
  - Inviscid
- DESIGN CONDITIONS
  - Minimum Length
  - Weak Adverse Pressure Gradients at Start of Contraction
  - Uniform Mach No. Distribution at Throat

VERIFICATION

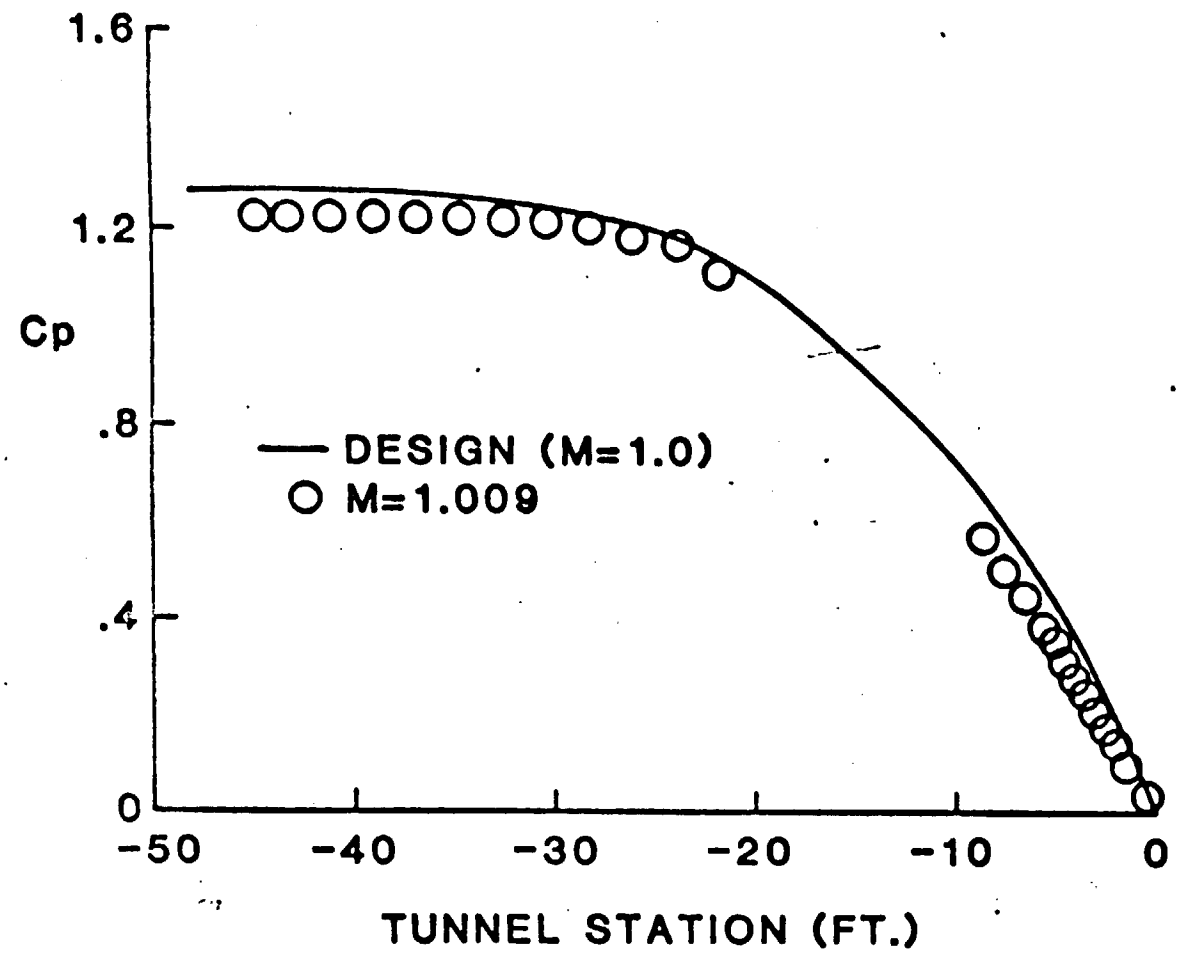
- NASA CR-112239 - Streamtube Curvature Analysis
- EXPERIMENTAL STUDIES
  - Flow Visualization
  - Mach No. Distributions

EFFECT OF CONTRACTION LENGTH ON SEPARATION



REF: J. ARICRAFT, AUG 74
BY CHMIELEWSKI

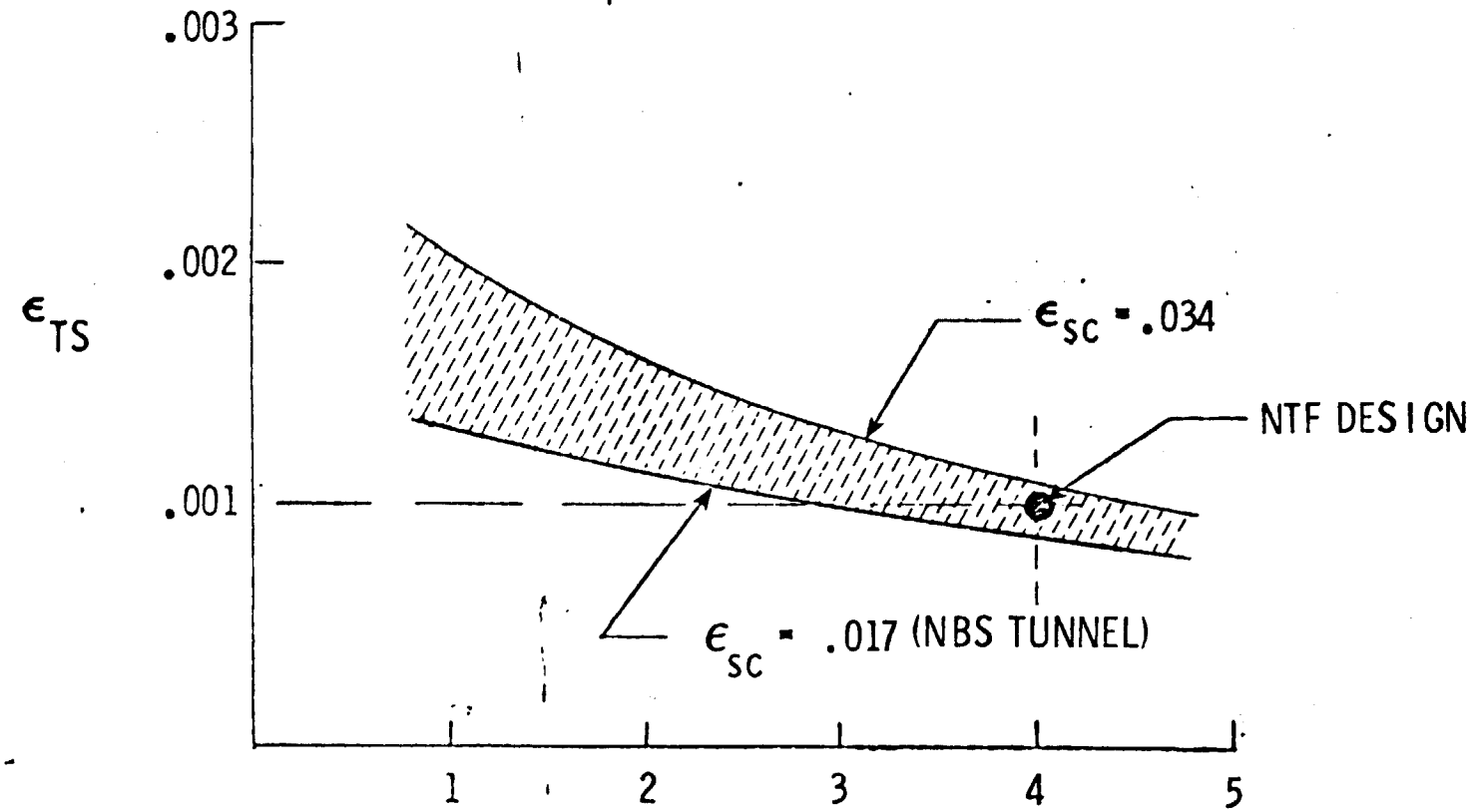
NTF CONTRACTION



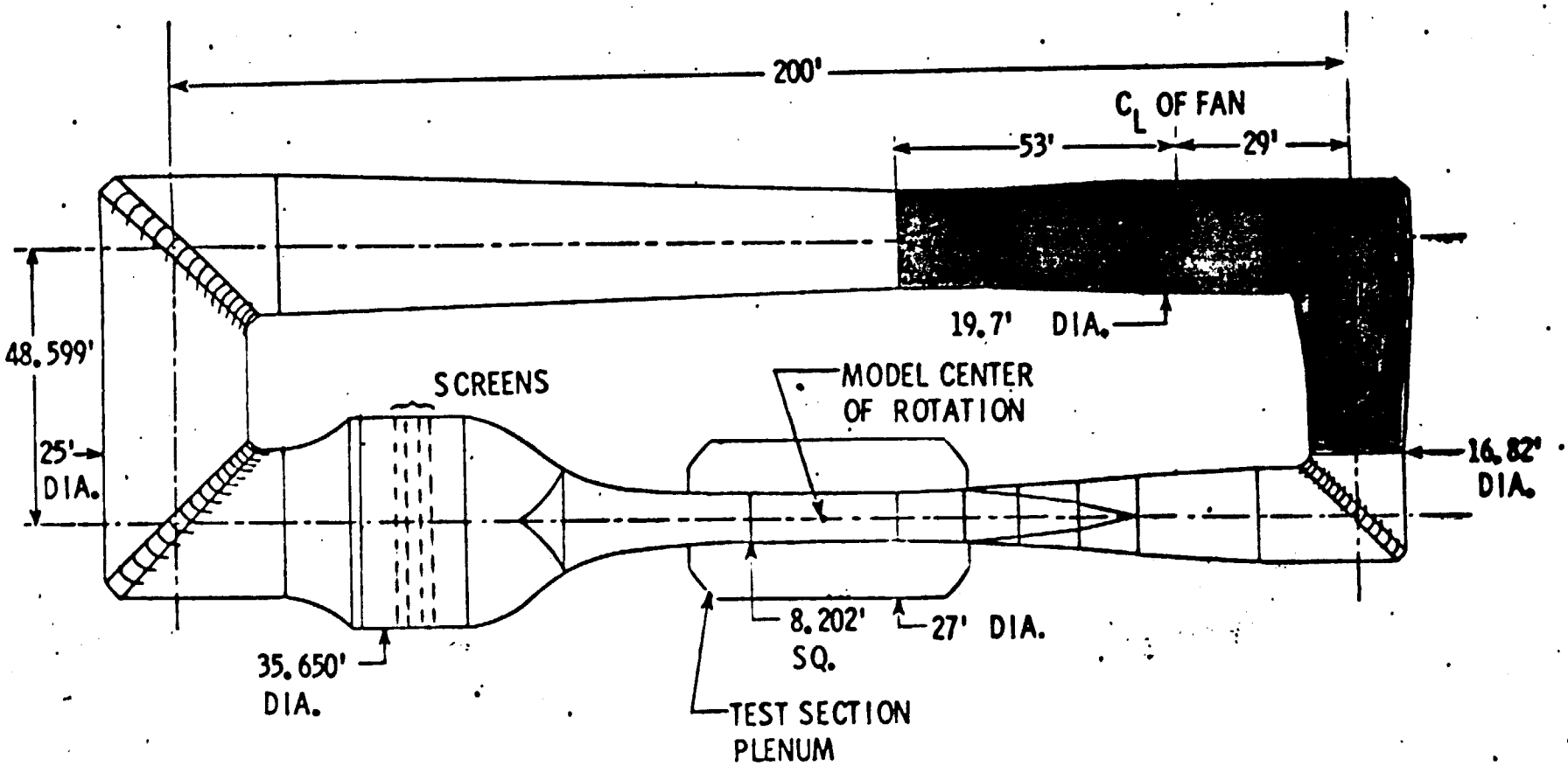
EFFECT OF NUMBER OF SCREENS

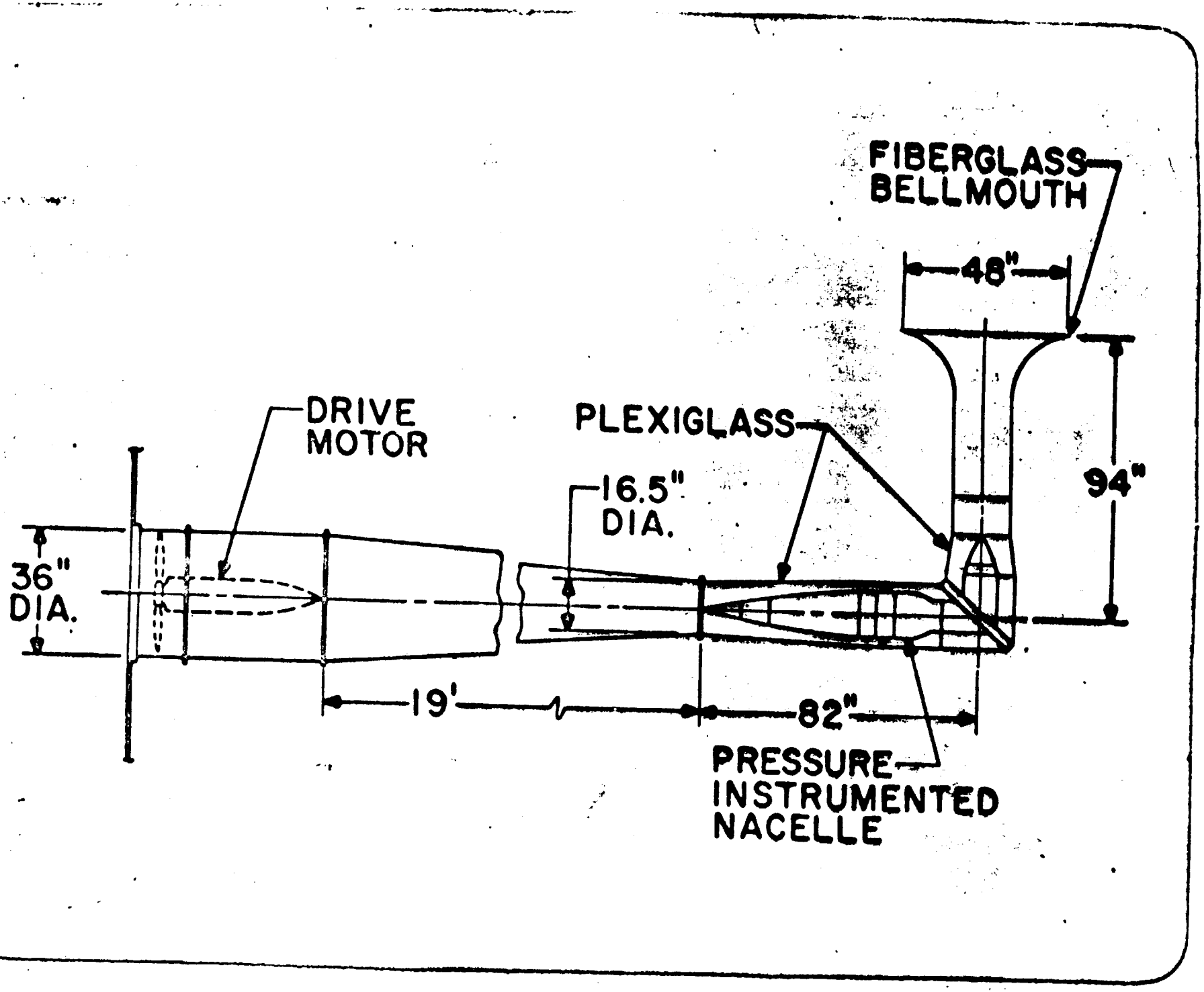
SOLIDITY = .34
(.032" wire; 6 per inch)

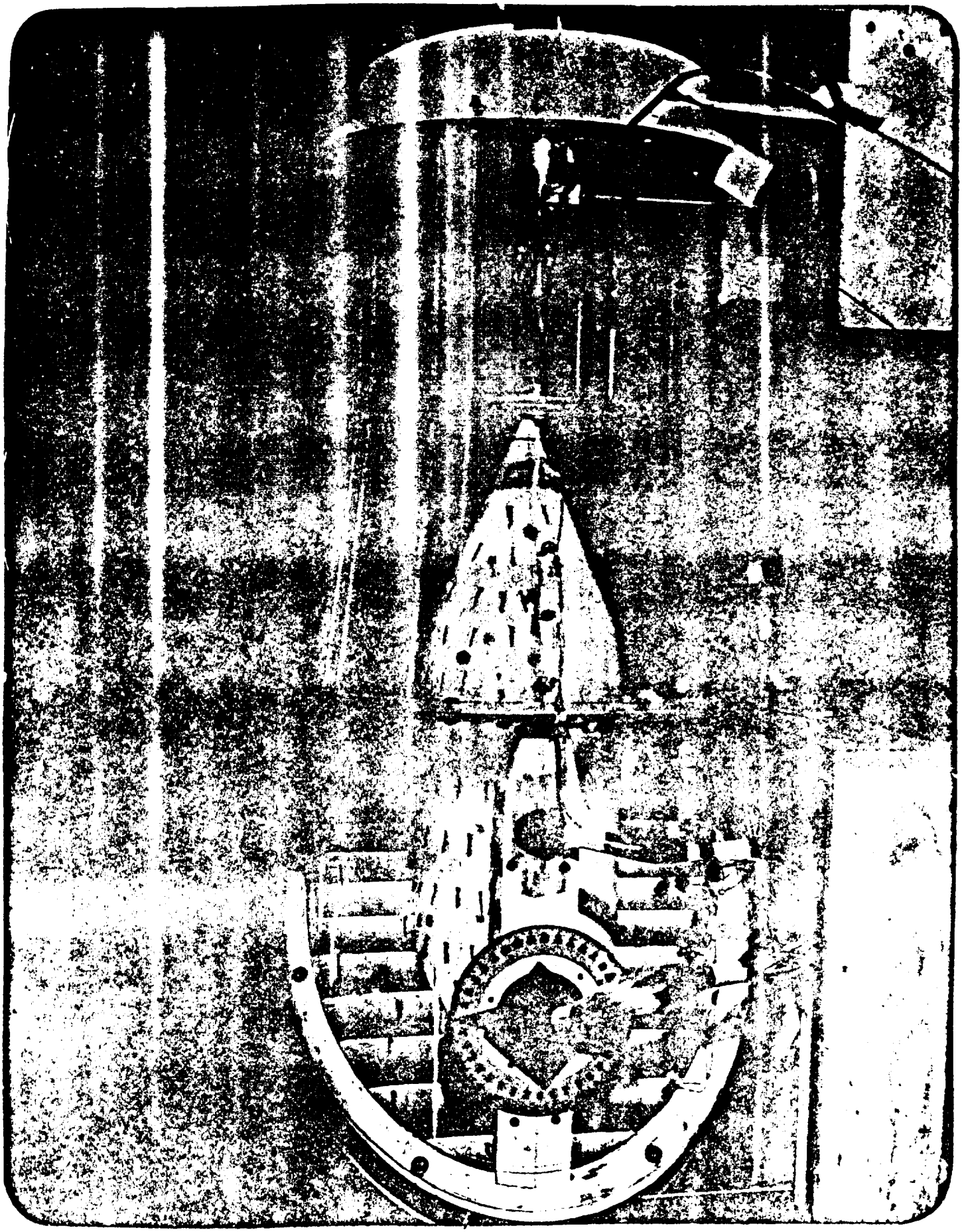
$\frac{\Delta P}{q}$ = .75 per screen



NATIONAL TRANSONIC FACILITY

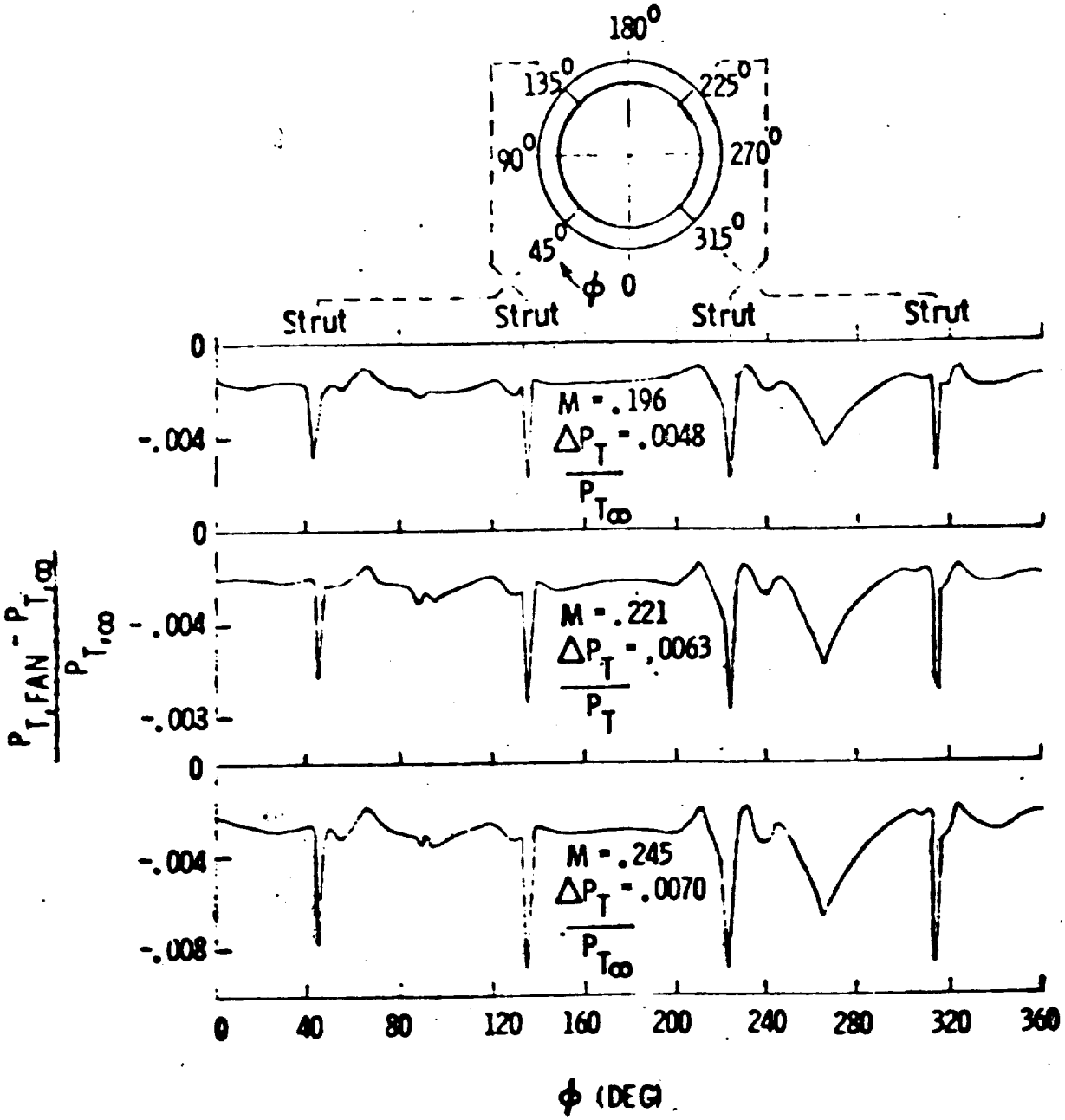



FIBERGLASS
BELLMOUTH
48"
DRIVE
MOTOR
PLEXIGLASS
16.5"
DIA.
94"
36"
DIA.
19'
82"
PRESSURE
INSTRUMENTED
NACELLE

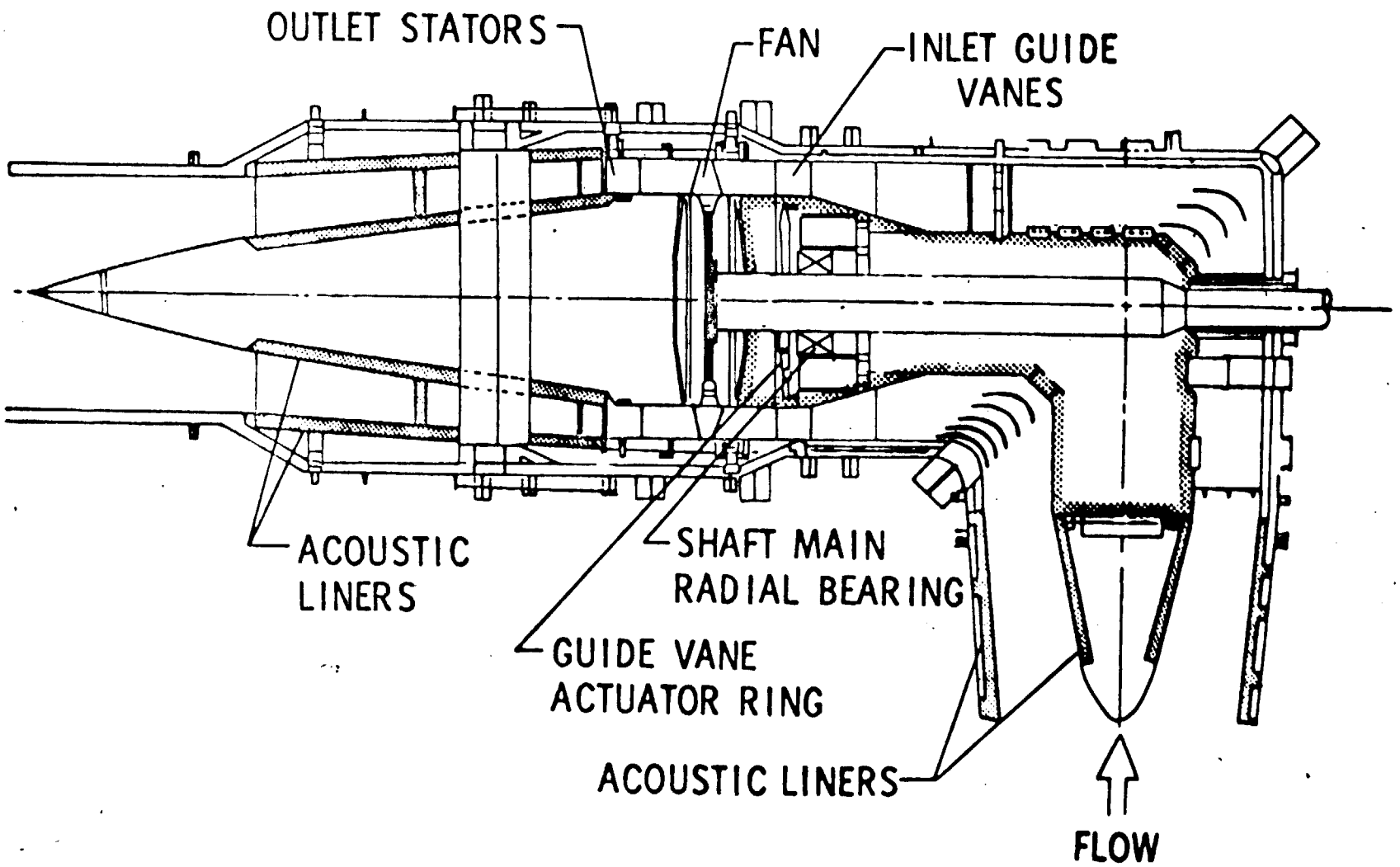


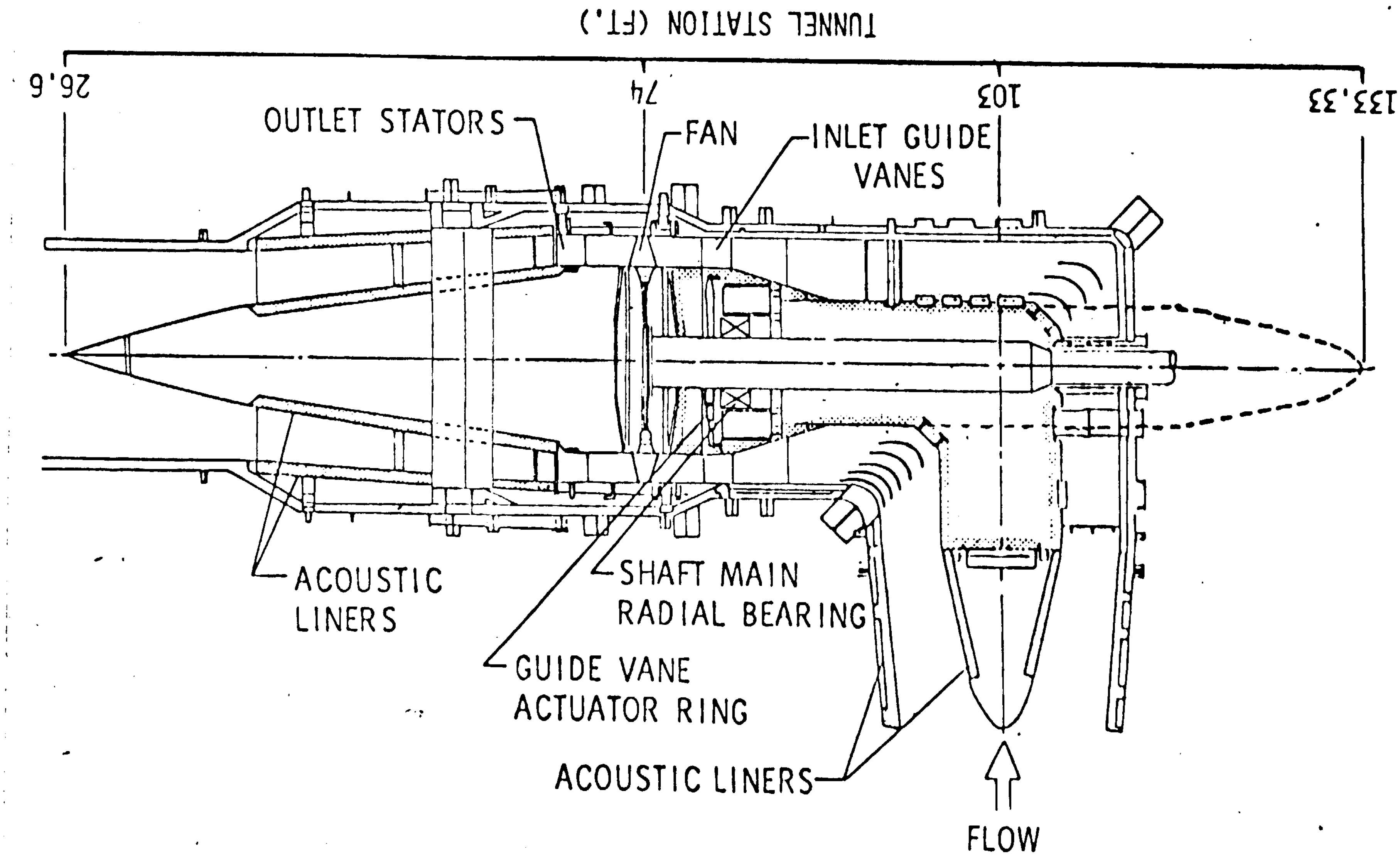
NTF FAN ANNULUS TOTAL PRESSURE DISTORTION

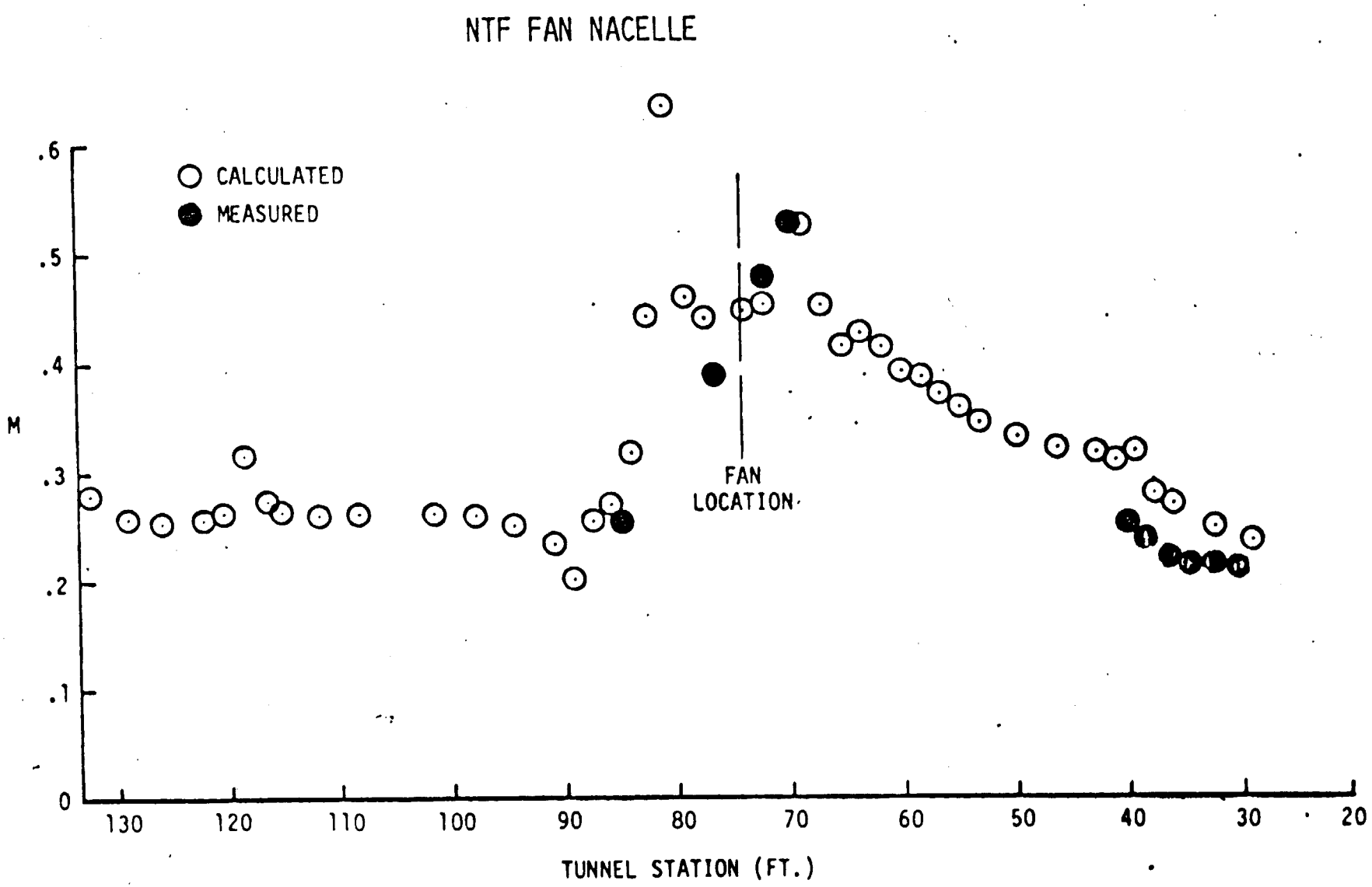
$$\Delta P_T = (P_{T,MAX} - P_{T,MIN})_{FAN}$$

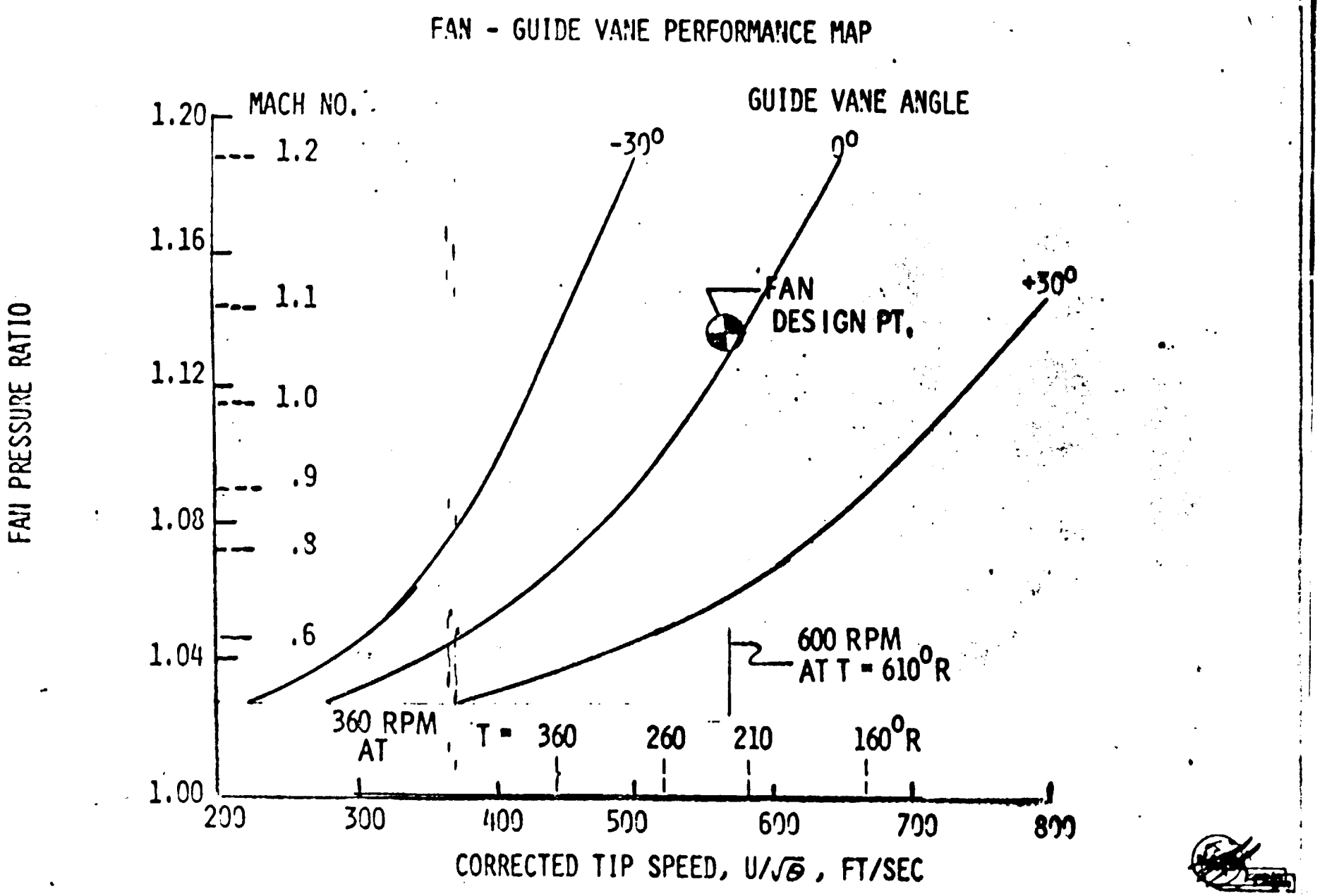


NATIONAL TRANSONIC FACILITY
FAN SECTION ASSEMBLY

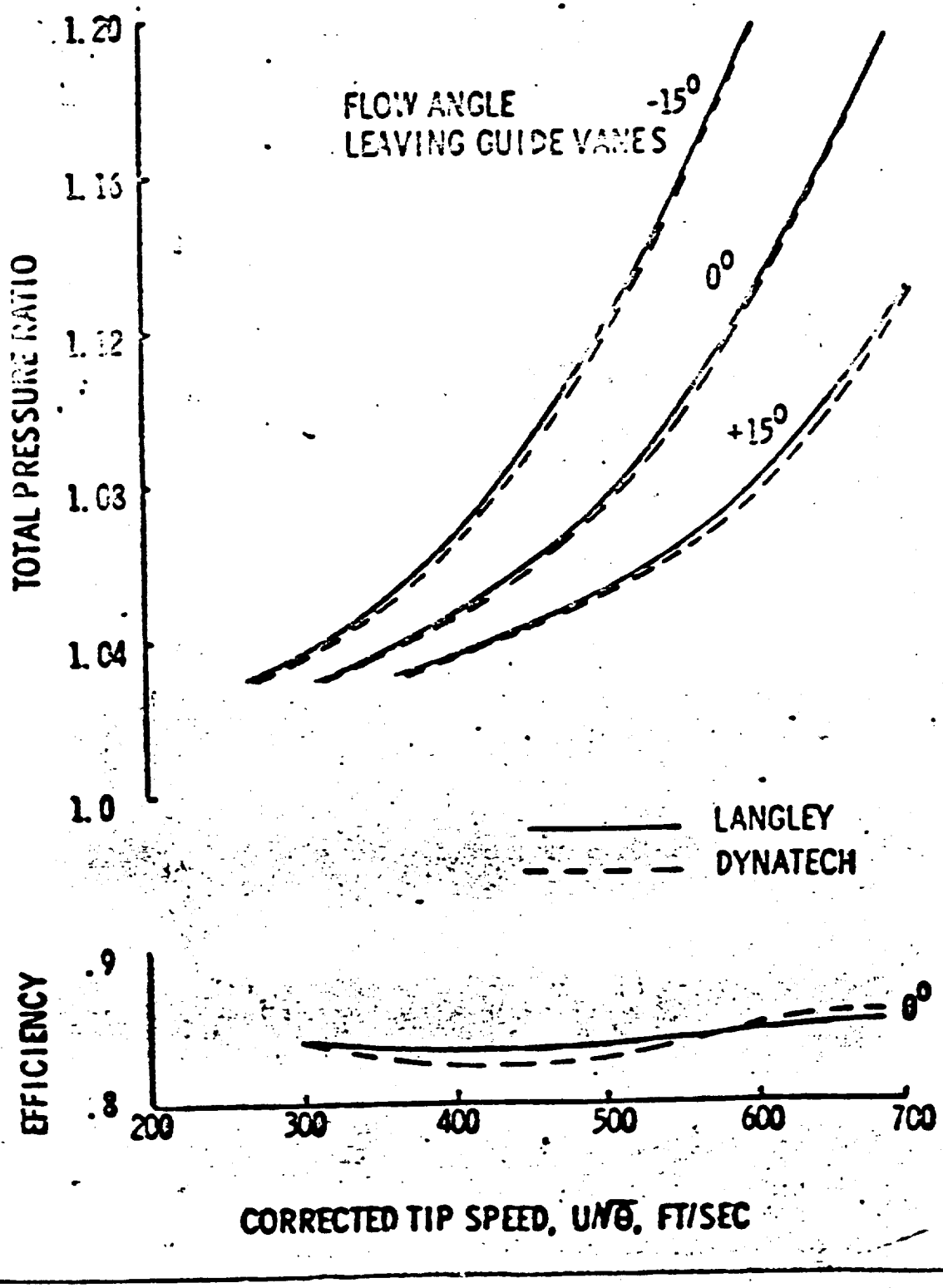



TUNNEL STATION (FT.)
26.6
74
103
133.33
OUTLET STATORS
FAN
INLET GUIDE VANES
ACOUSTIC LINERS
SHAFT MAIN RADIAL BEARING
GUIDE VANE ACTUATOR RING
ACOUSTIC LINERS
FLOW

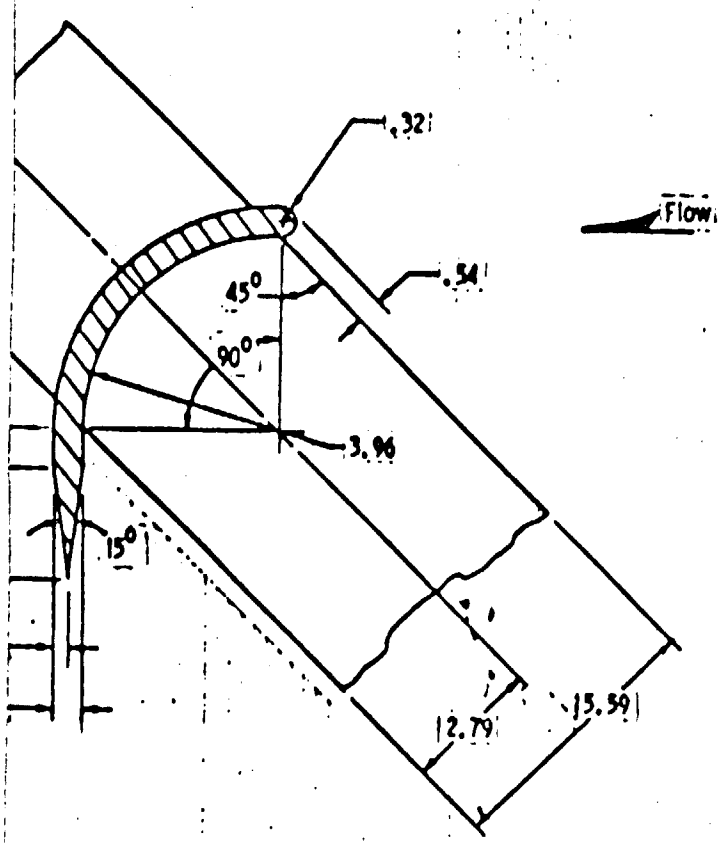

NTF FAN NACELLE
CALCULATED
MEASURED
M
.6
.5
.4
.3
.2
.1
0
FAN
LOCATION
130
120
110
100
90
80
70
60
50
40
30
20
TUNNEL STATION (FT.)

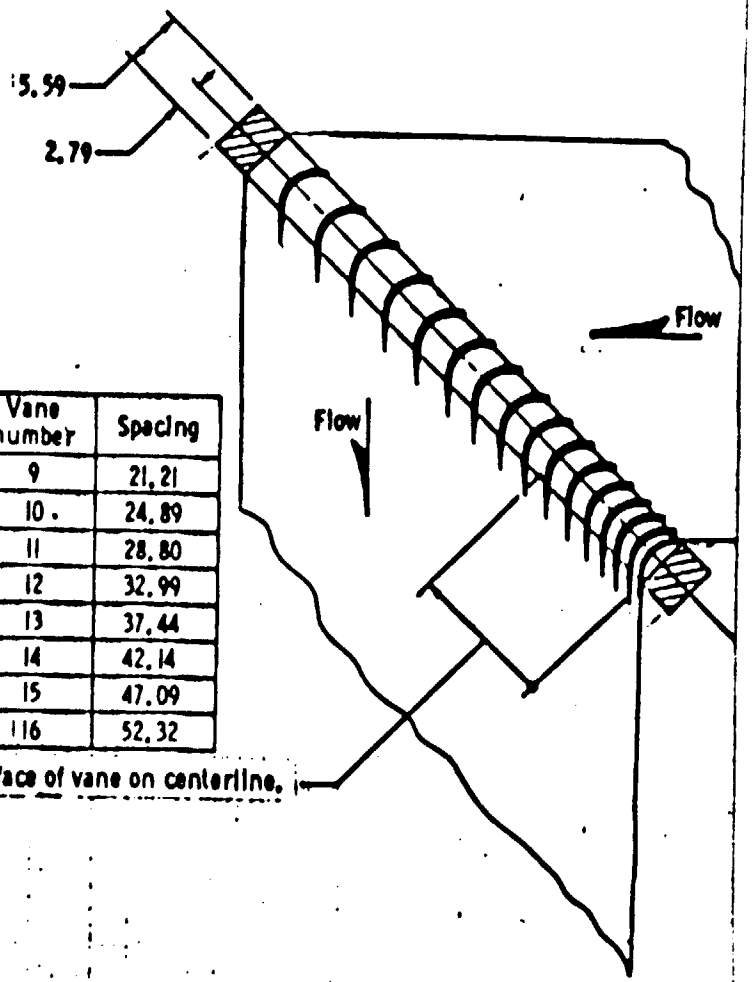

FAN - GUIDE VANE PERFORMANCE MAP
FAN PRESSURE RATIO
MACH NO.
1.2
1.1
1.0
.9
.8
.6
GUIDE VANE ANGLE
-30°
0°
+30°
FAN DESIGN PT.
600 RPM AT T = 610°R
360 RPM AT
T = 360
260
210
160°R
1.20
1.16
1.12
1.08
1.04
1.00
200
300
400
500
600
700
800
CORRECTED TIP SPEED, U/√θ , FT/SEC

OFF-DESIGN PERFORMANCE VERIFICATION



DESIGN CONDITION

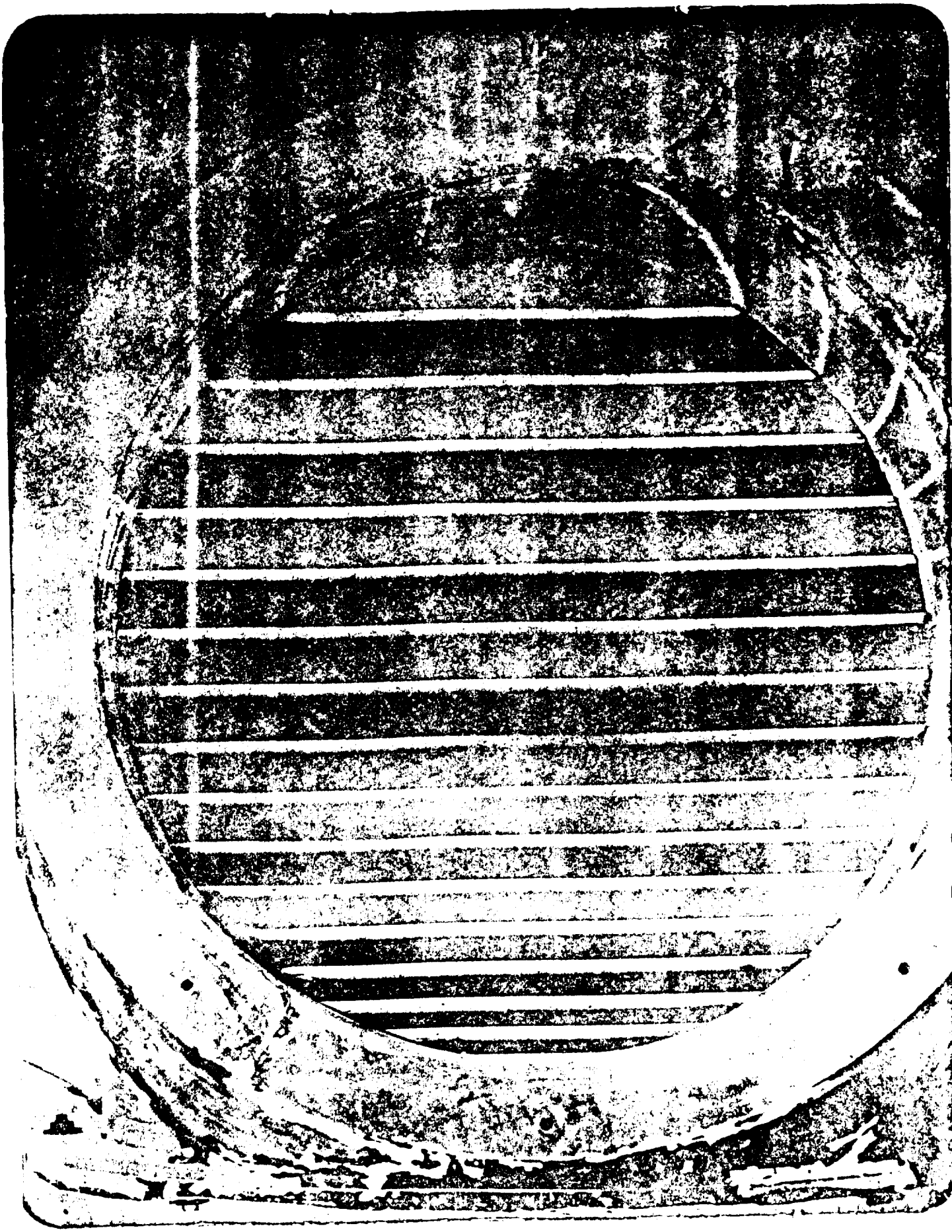




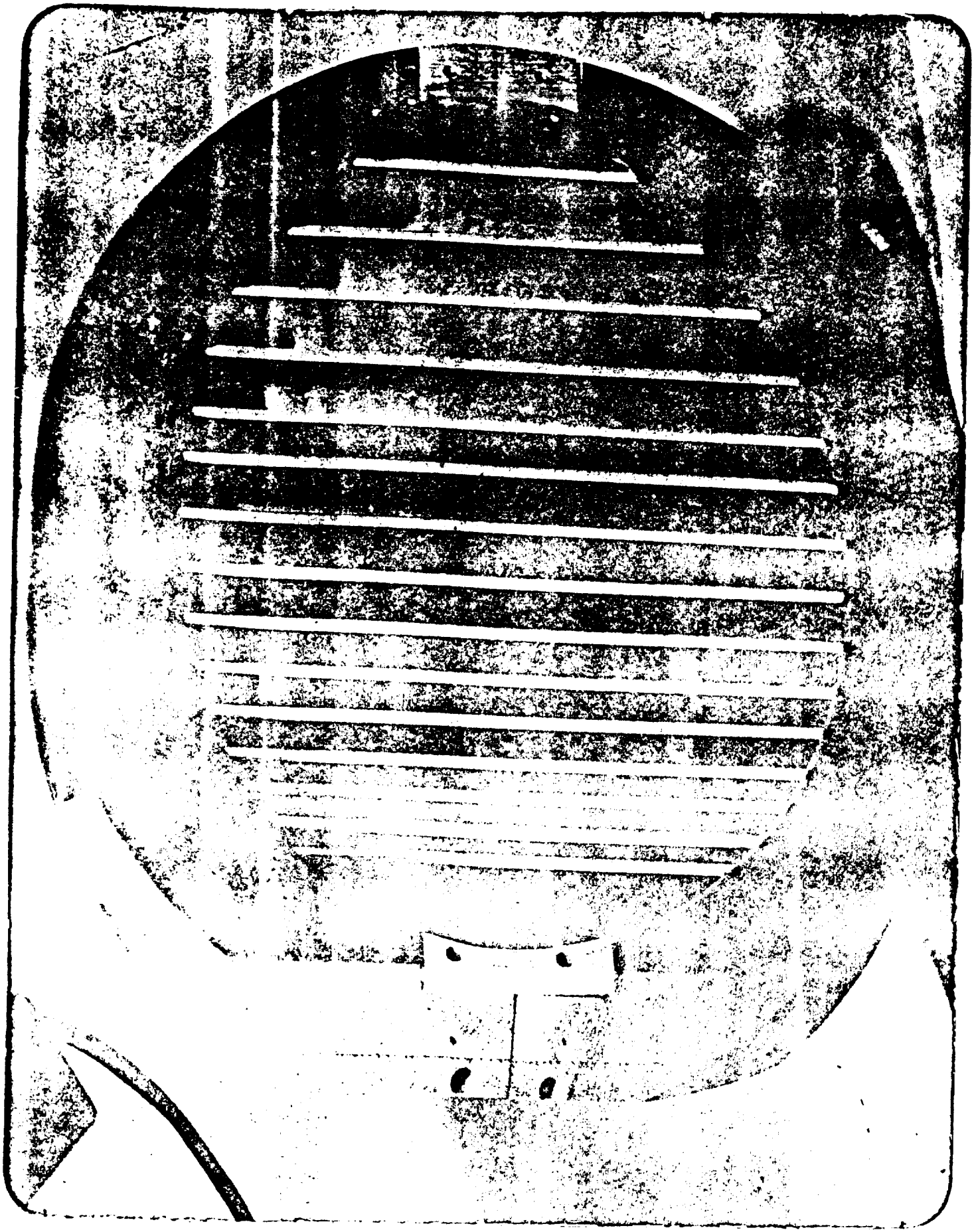
Vane number	Spacing	Vane number	Spacing
1	1.14	9	21.21
2	2.77	10	24.89
3	4.62	11	28.80
4	6.73	12	32.99
5	9.12	13	37.44
6	11.76	14	42.14
7	14.66	15	47.09
8	17.81	16	52.32

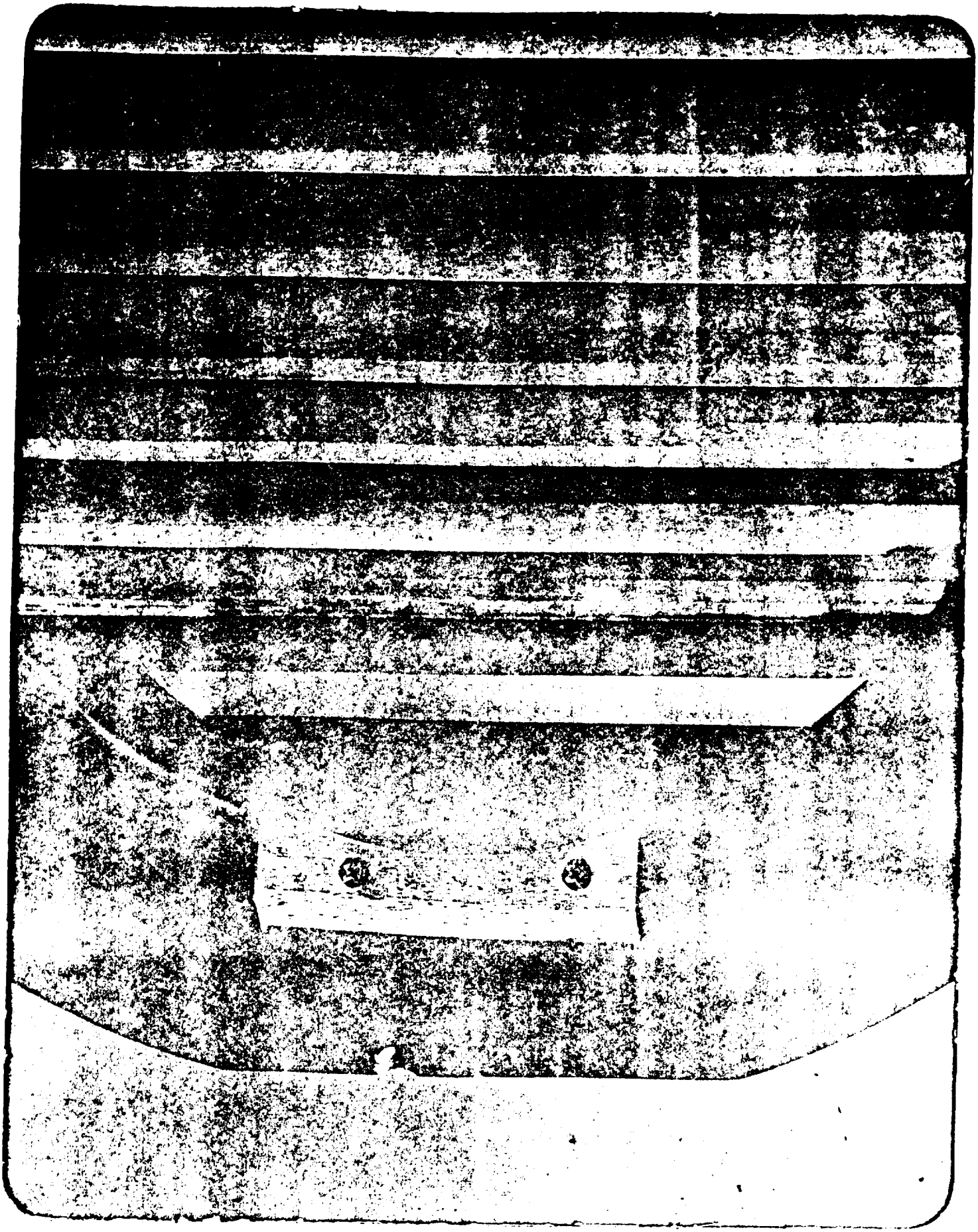
Vane spacing given to inside surface of vane on centerline.

ure . - Details of Turn 1 turning vane assembly. All dimensions are given in centimeters.

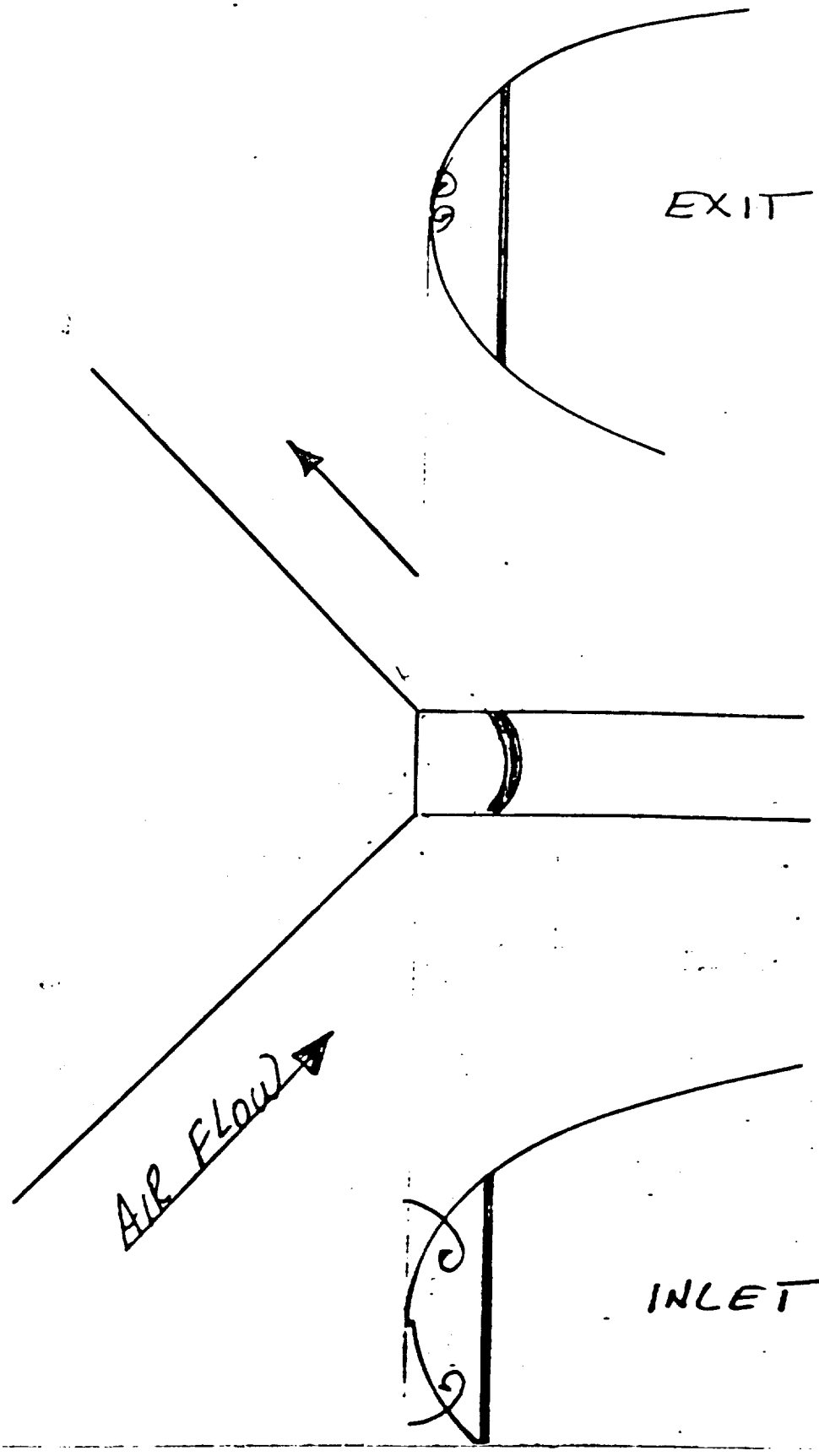


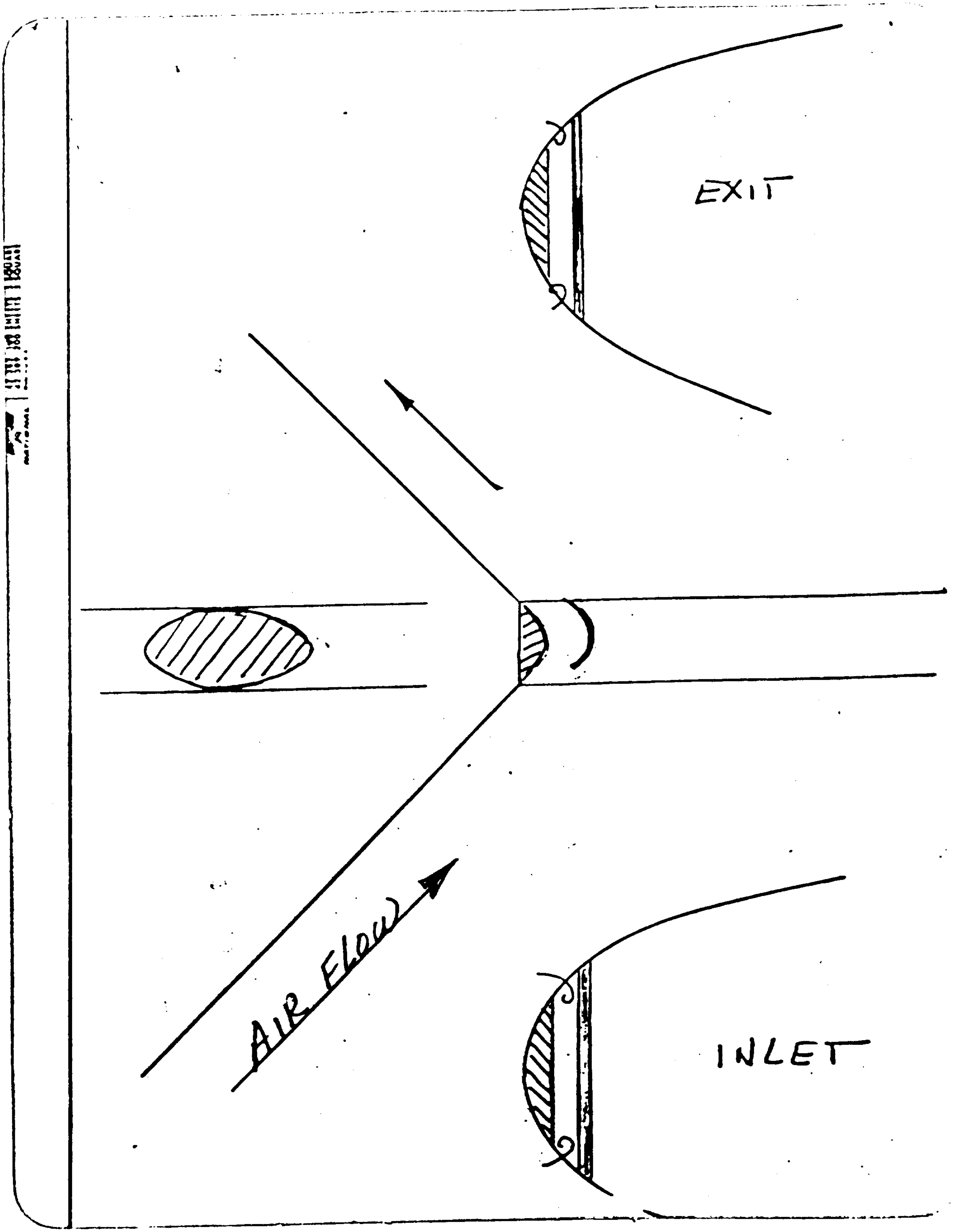
NASA LANGLEY RESEARCH CENTER

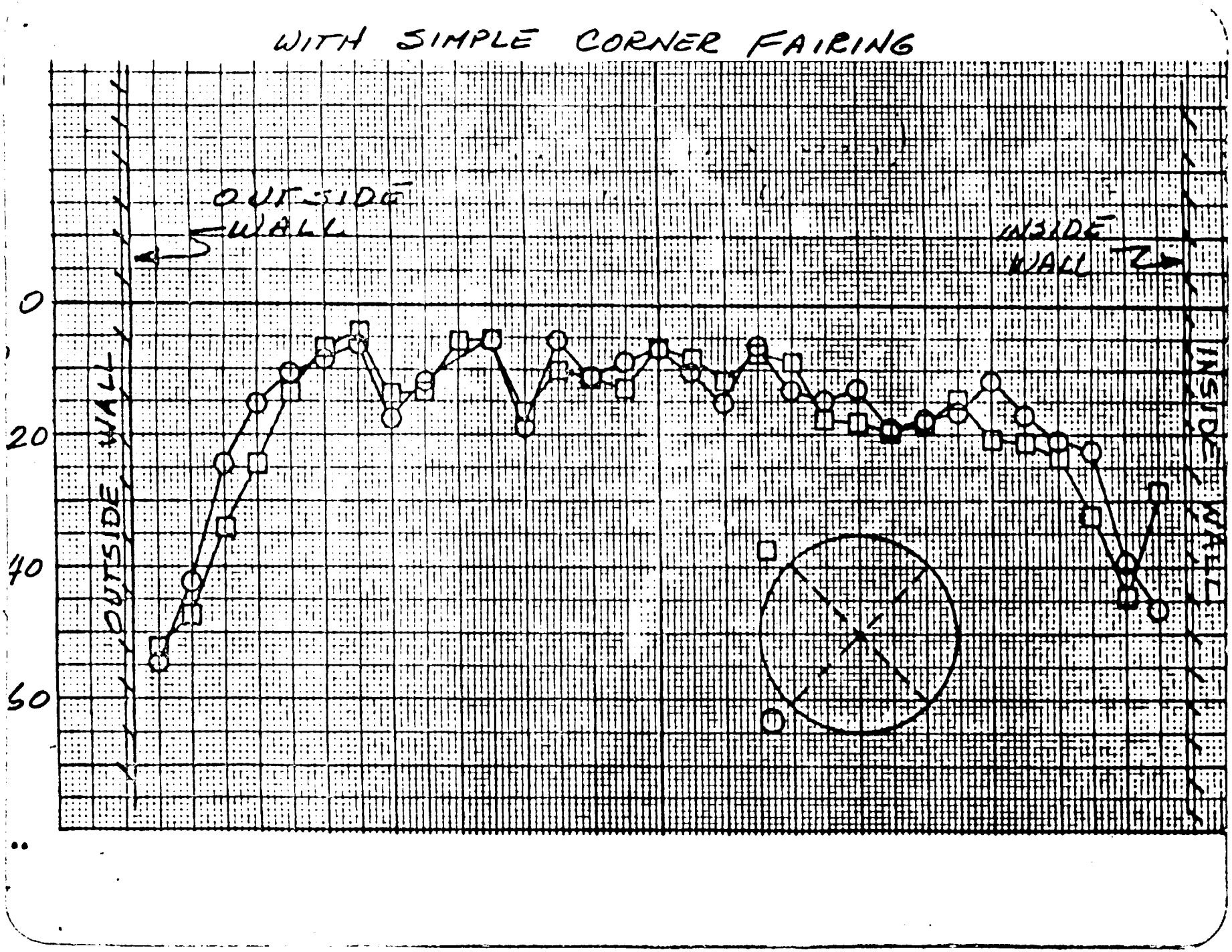




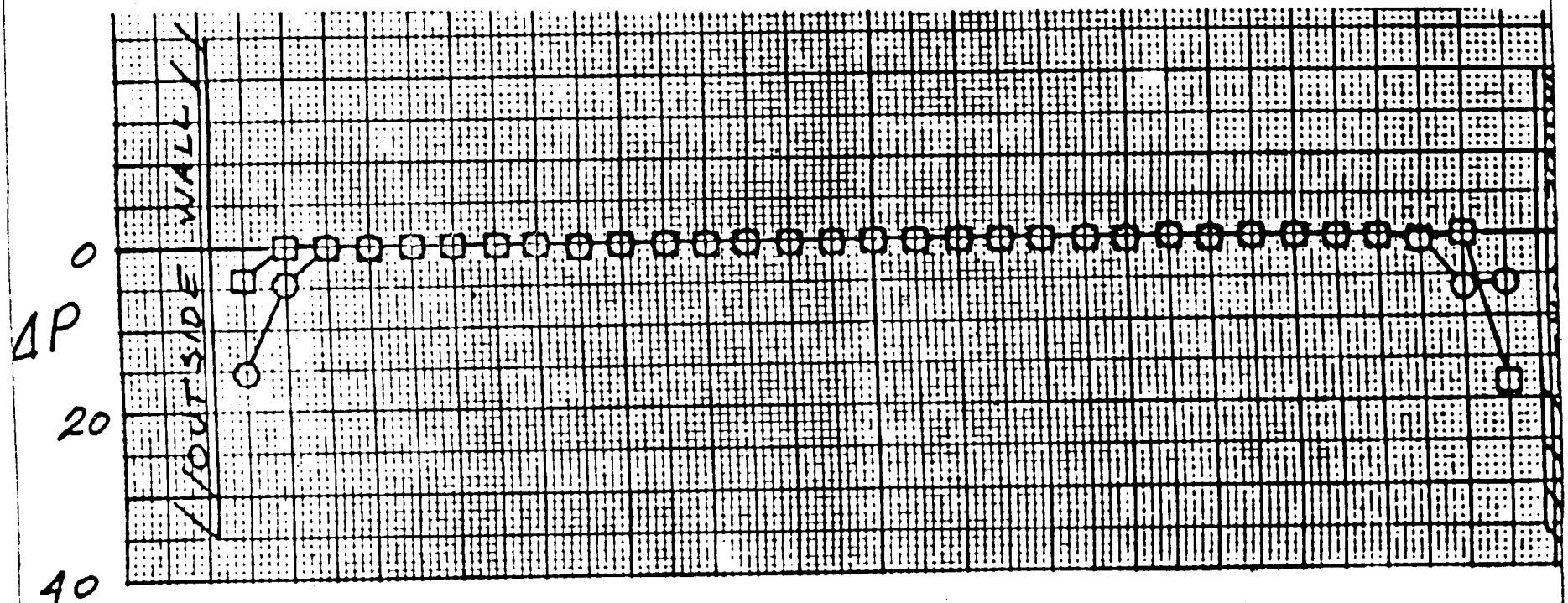
NO. 1 TURN -AS BUILT

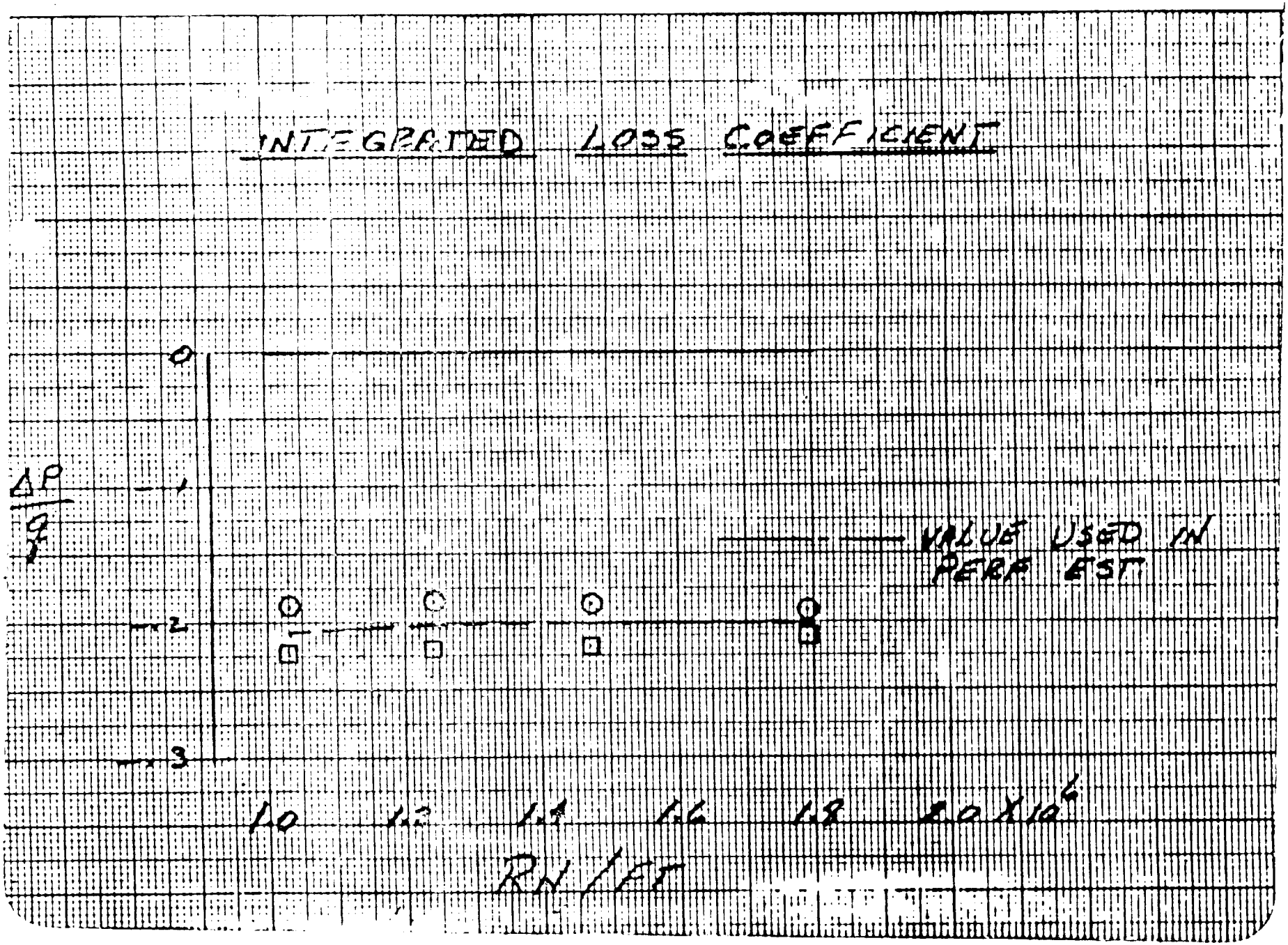



EXIT
AIR FLOW
INLET


WITH SIMPLE CORNER FAIRING
OUT-SIDE WALL
INSIDE WALL
0
20
40
60
OUTSIDE WALL
INSIDE WALL

INLET DISTRIBUTION




INTEGRATED LOSS COEFFICIENT
ΔP/q
0
-.1
-.2
-.3
VALUE USED IN PERF TEST
1.0
1.2
1.4
1.6
1.8
2.0 X 10^6
RN/FT

8'TPT HONEYCOMB AND SCREEN DEVELOPMENT