(NASA-TM-104978) WIND TUNNEL MODELING SEMINAR (NASA) 410 p

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WIND TUNNEL MODELING SEMINAR

NASA LEWIS RESEARCH CENTER

MARCH 20 AND 21, 1984

Wind Tunnel Modeling Seminar

Administration Building Auditorium

Agenda

March 20, 1984

8:30- 8:35 a.m.	Welcome	Dr. J.M. Klineberg Dep. Dir., Lewis Research Center
8:35- 8:50 a.m.	Introduction	M. J. Hartmann Dir. of Aeronautics
8:50- 9:10 a.m.	AWT Project Status	R.L. Allen, Manager AWT Project Office
9:10- 9:30 a.m.	AWT Modeling Status	J.M. Abbott, Deputy Manger, AWT Res. Off.
9:30-10:15 a.m.	NTF Modeling Program	L.W. McKinney, Asst. Chief, Transonic Aerodnyamics Division (LaRC)
10:15-10:30 a.m.	Coffee Break	
10:30-11:00 a.m.	NTF Modeling Program	Continued
11:00-12:00 p.m.	4x7 M Modeling Program	Z.T. Applin Subsonic Aerodynamics Branch (LaRC)
12:00- 1:00 p.m.	Lunch	
1:00- 1:45 p.m.	AEDC Modeling Programs	R.D. Herron, Manager Test Operations and Eng. Branch (Calspan)
1:45- 2:30 p.m.	Boeing Modeling Programs	R.P. Doerzbacher, Specialist Engineer, Boeing Comm. Airplane Co.
2:30- 3:00 p.m.	40x80x120 Modeling Programs	M.D. Falarski Manager, Test Operations, 40x80x120 Wind Tunnel Project (ARC)
3:00- 3:15 p.m.	Coffee Break	

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3:15- 4:00 p.m.	40x80x120 Modeling Programs	Continued
4:00- 4:30 p.m.	40x80x120 Vane Redesign	E.R. McFarland Computional Fluid Mechanics Branch (LeRC)
4:30- 5:30 p.m.	AWT Tour	

<u>March 21, 1984</u>

8:30-10:00 a.m.	AWT Aerodynamic Design Status	M.W. Davis Lead Engineer, AWT Aerodynamics, Sverdrup Corporation
10:00-10:30 a.m.	Coffee Break - Move to Building 86,	Room 100
10:30-11:30* a.m.	AWT Circuit Aerothermo. Discussion	L. Povinelli Head, Turbine, Aerodynamics Section (LeRC)
11:30-12:30 p.m.	Lunch	
12:30- 1:15* p.m.	AWT Drive System Discussion	Lonnie Reid Head, Multistage Compressor Section (LeRC)
1:15- 2:00* p.m.	AWT Icing Discussion	J. Reinmann Head, Icing Research Section (LeRC)
2:00- 2:45* p.m.	AWT Acoustics Discussion	J.F. Groeneweg Head, Turbomachinery Noise Section (LeRC)
2:45- 3:30* p.m.	AWT Dynamics & Controls Discussion	J.R. Szuch Head, Systems Dynamics Section (LeRC)
3:30- 3:45 p.m.	Closing Remarks	J.M. Abbott
3:45 p.m.	Adjourn	

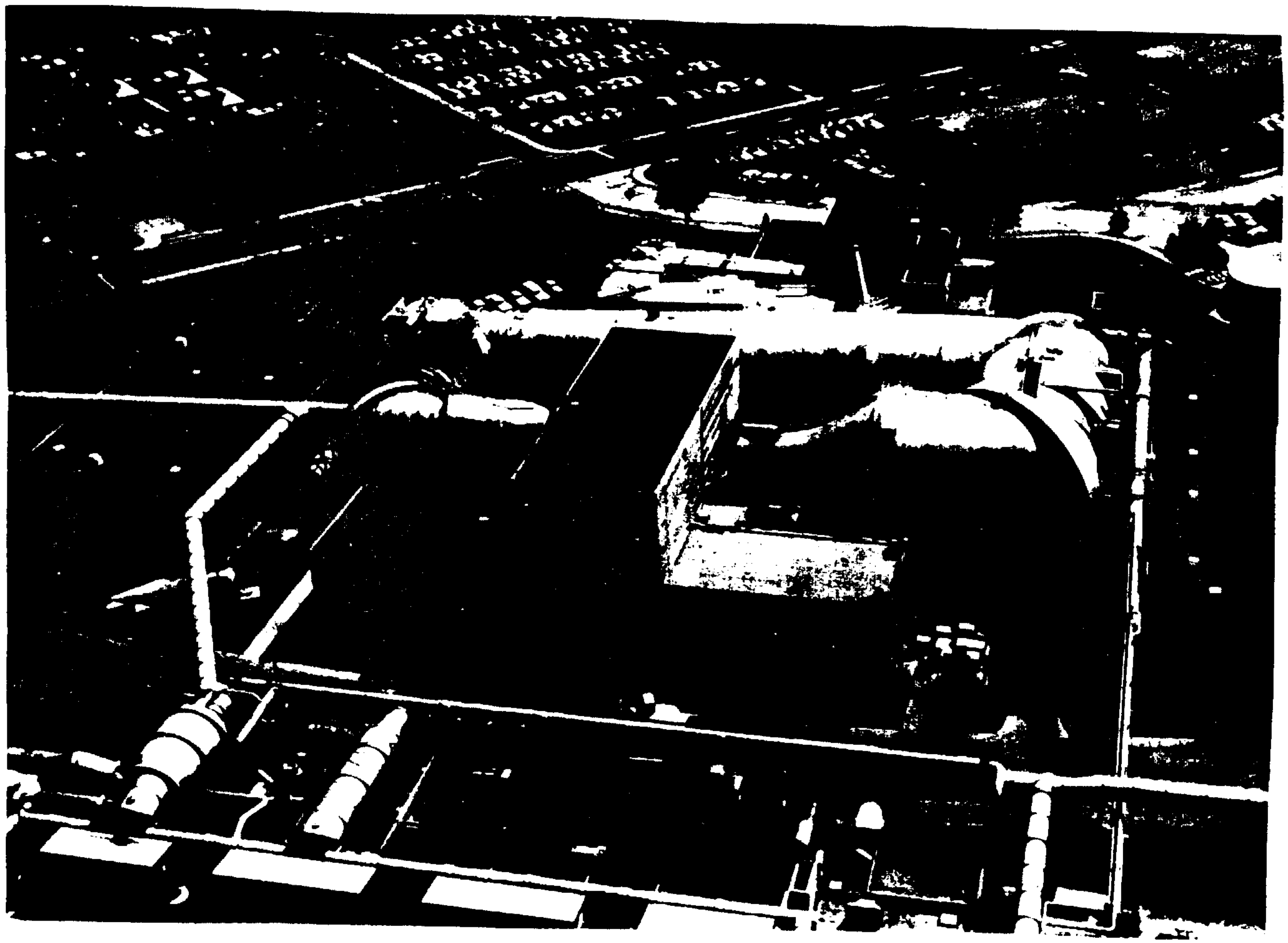
* Building 86, Room 100 (Attendance limited to about 50)

INTRODUCTION

MELVIN J. HARTMANN
DIRECTOR OF AERONAUTICS
NASA LEWIS RESEARCH CENTER

NASA

National Aeronautics and Space Administration



ALTITUDE WIND TUNNEL

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FUTURE OF AERONAUTICS

ALTITUDE WIND TUNNEL

- MAJOR ADVANCEMENTS STILL ACHIEVABLE
- SIGNIFICANT TECHNICAL CHALLENGES EXIST
- UNPRECEDENTED DEGREE OF INTEGRATION
  - INTERACTION OF PROPULSION SYSTEM COMPONENTS
  - EFFECTS OF INSTALLATION ON PROPULSION SYSTEM

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FUTURE SYSTEMS

ALTITUDE WIND TUNNEL

- HIGH SPEED TURBOPROP PROPULSION
- HIGHLY SURVIVABLE MILITARY AIRCRAFT
- V/STOL AIRCRAFT
- HIGH SPEED ROTORCRAFT
- ALL WEATHER AIRCRAFT

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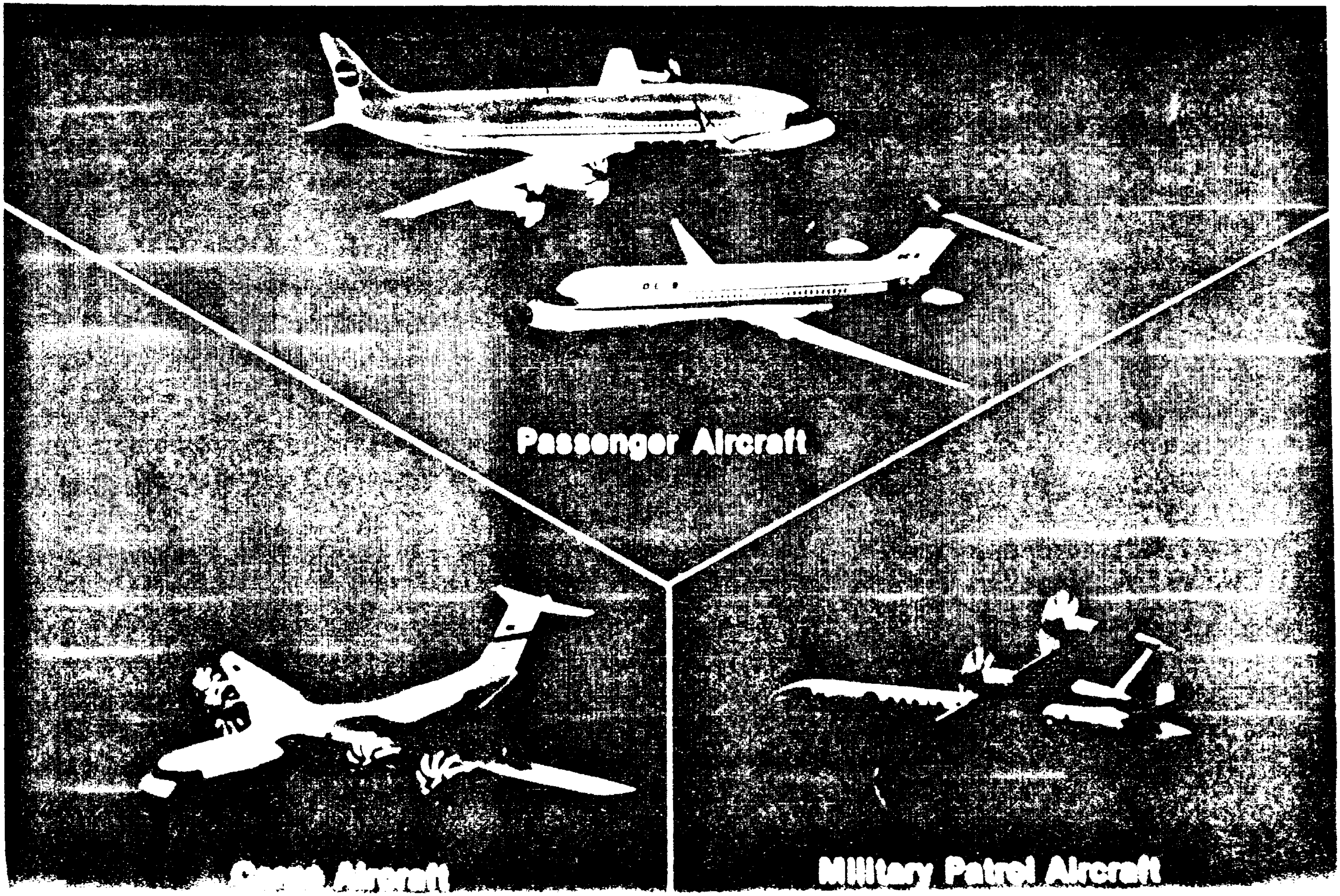
ADVANCED TURBOPROP AIRCRAFT CONCEPTS



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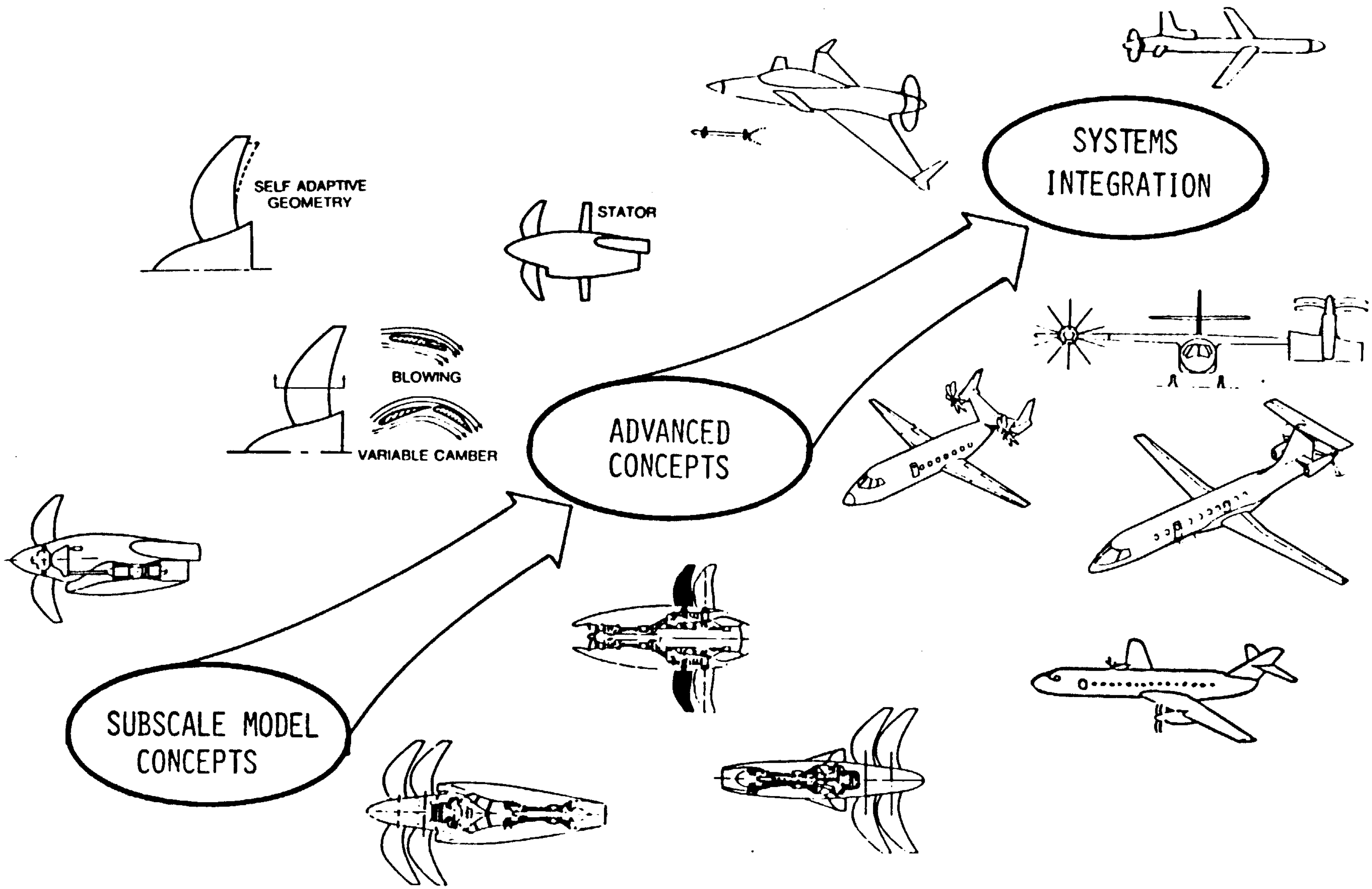
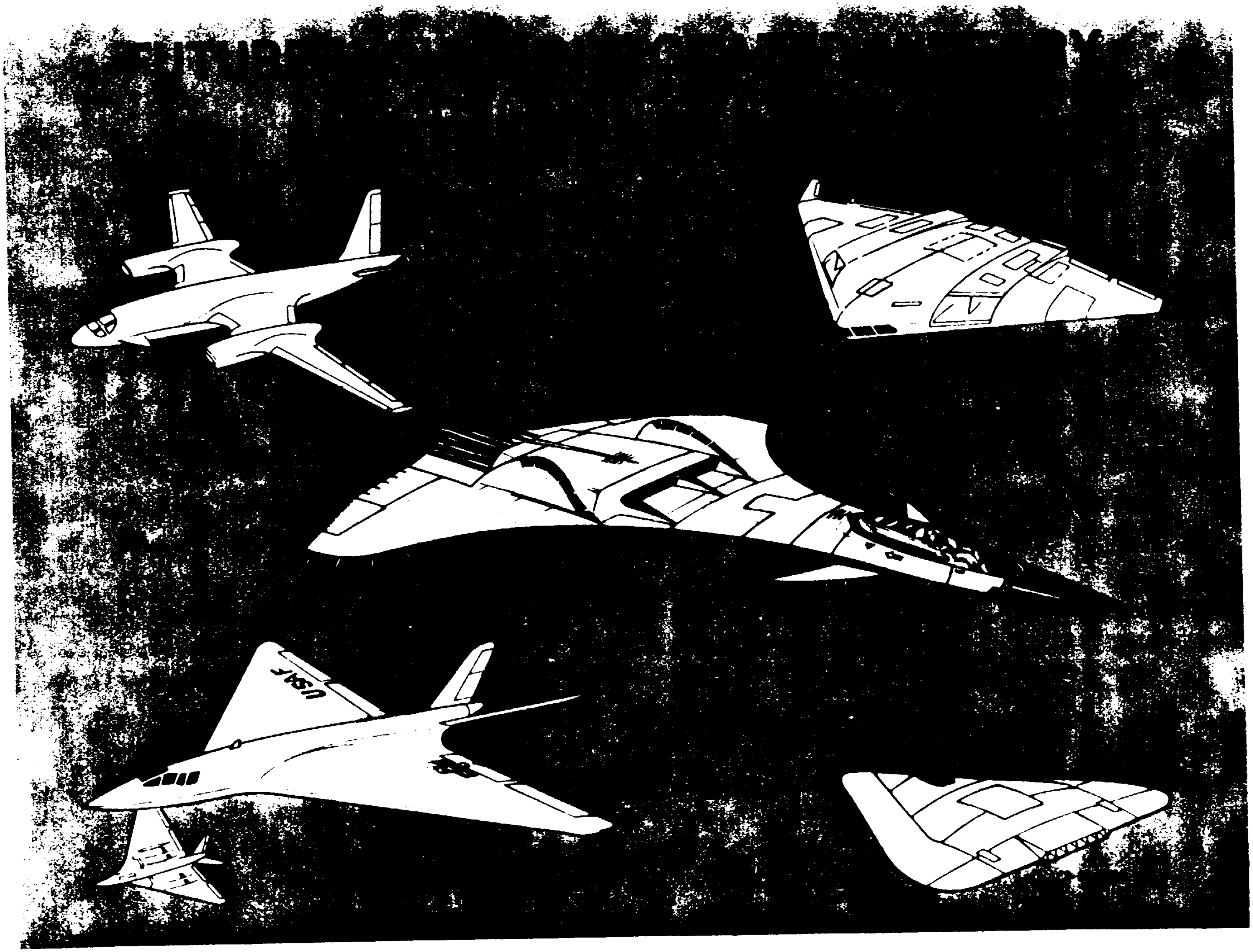
AWT ALTITUDE WIND TUNNEL

FUTURE OF ADVANCED TURBOPROP





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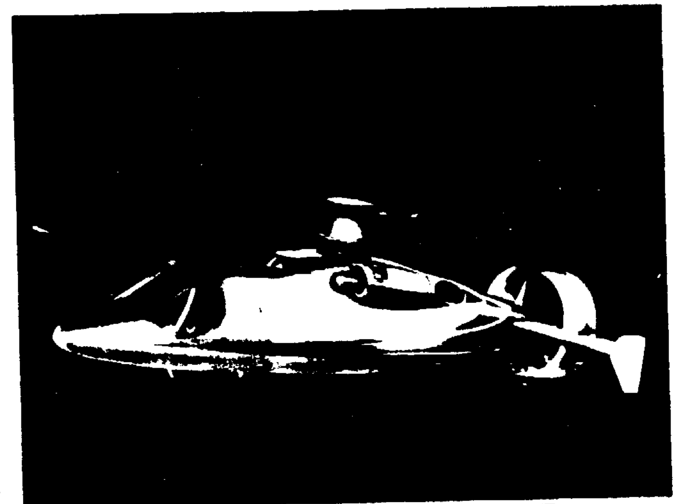
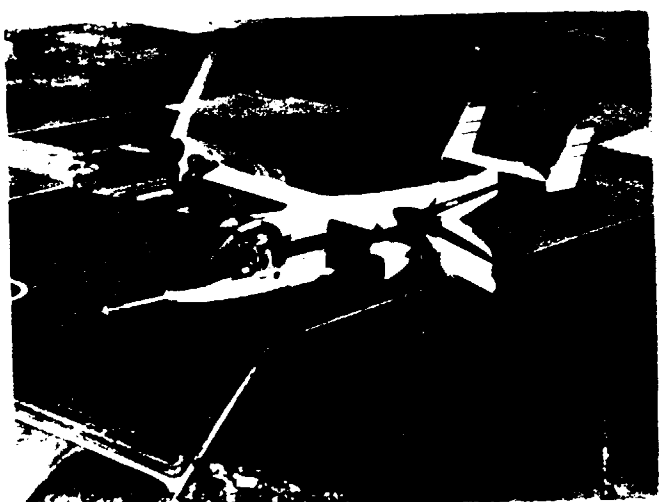
ROTORCRAFT

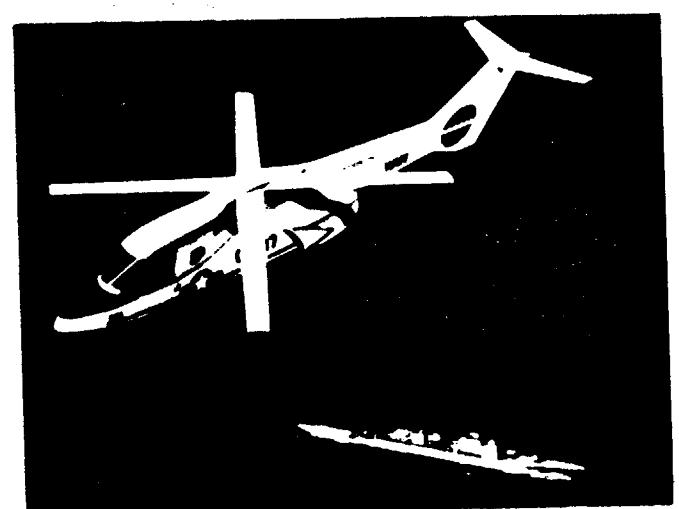
CONVENTIONAL



ADVANCING BLADE CONCEPT
'ABC'



TILT ROTOR



X-WING

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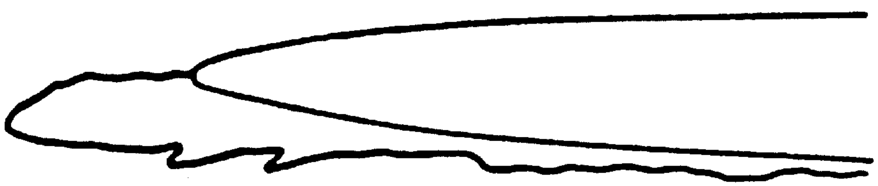
AWT ALTITUDE WIND TUNNEL

ICE ACCRETION

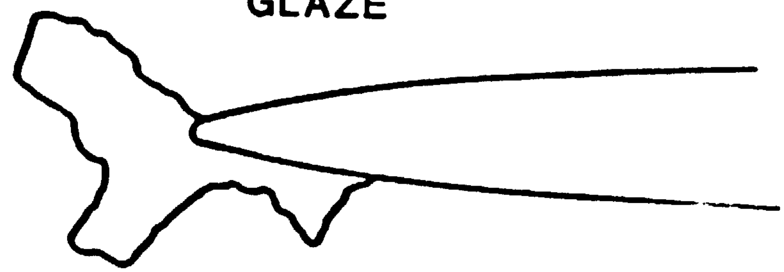
- TYPES OF ICE GROWTH

RIME



DROPS FREEZE ON IMPACT

GLAZE



DROPS DON'T FREEZE ON IMPACT

- ICE GROWTH IS A FUNCTION OF
  - VELOCITY
  - AMBIENT TEMPERATURE
  - AMBIENT PRESSURE
  - LIQUID WATER CONTENT
  - WATER DROP SIZE
  - AIRFOIL SIZE, SHAPE
  - ANGLE-OF-ATTACK

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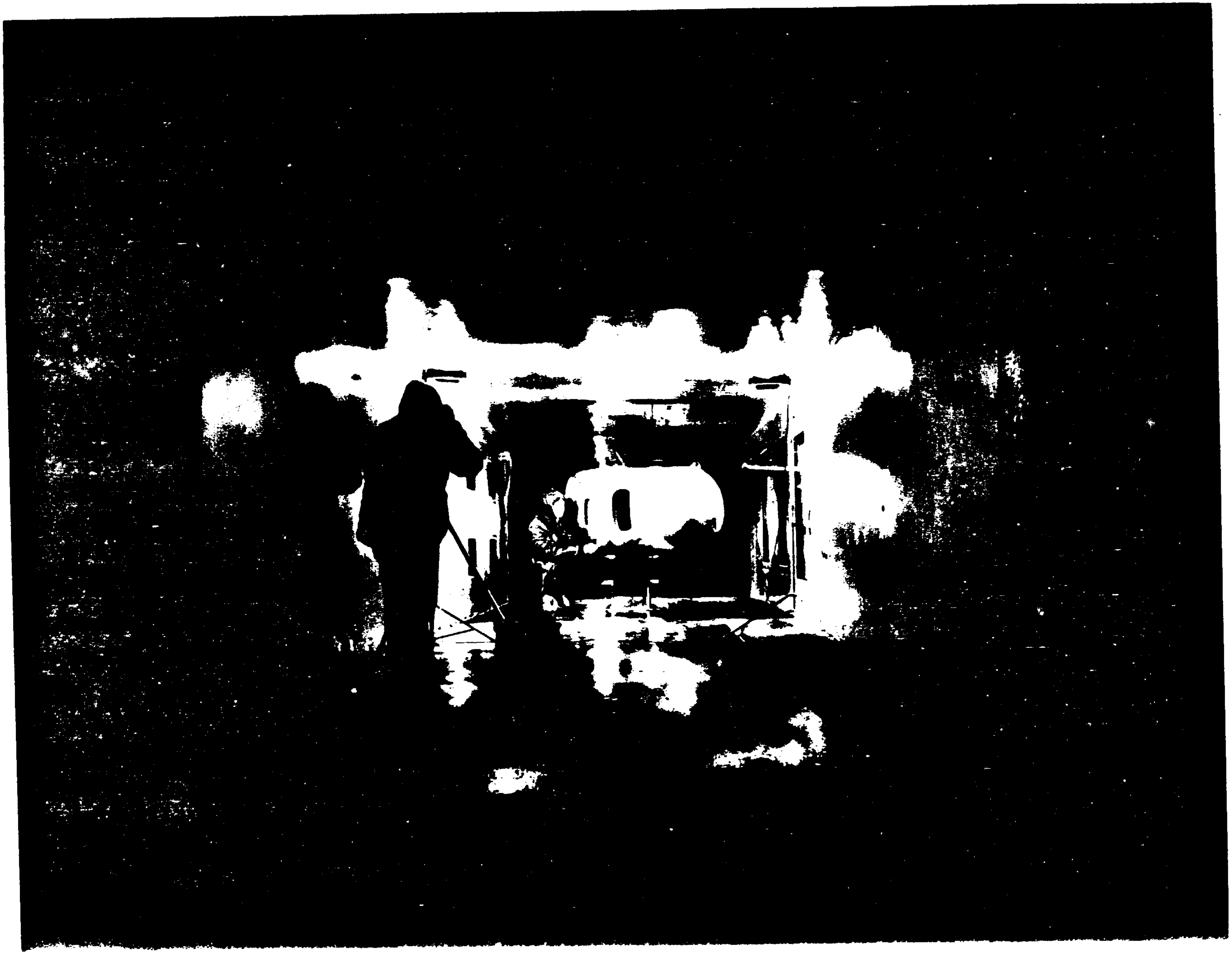

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ALTITUDE WIND TUNNEL

NEW TEST FACILITY REQUIREMENTS

- CONCURRENT PRESSURE AND TEMPERATURE SIMULATION OF ALTITUDE
- LARGE SCALE TEST ARTICLES
- FULL SUBSONIC SPEED RANGE
- WIND TUNNEL CONFIGURATION
- PROPULSION SYSTEM OPERATION/SIMULATION
- ICING, HEAVY RAIN CAPABILITY

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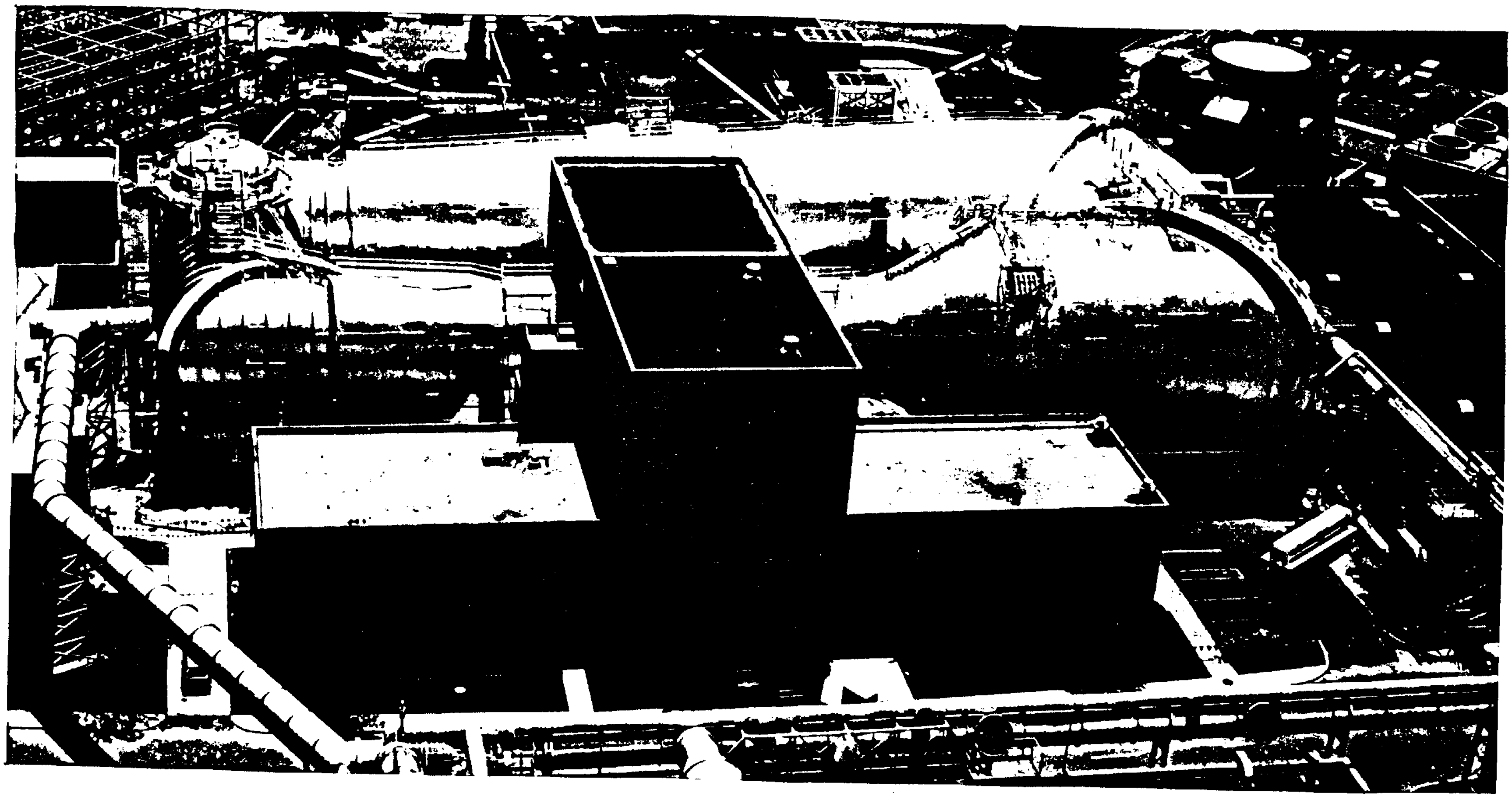
ALTITUDE WIND TUNNEL



PROVIDES NEW NATIONAL

AERONAUTICAL PROPULSION AND ICING R&D CAPABILITY

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AWT ALTITUDE WIND TUNNEL

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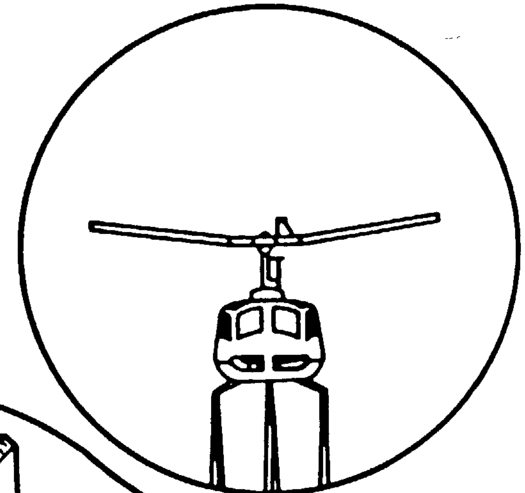
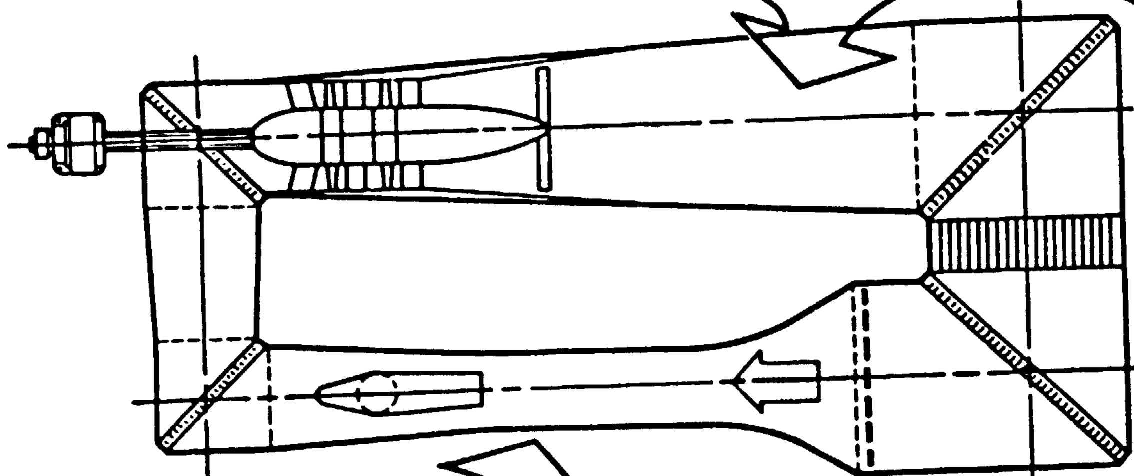
ALTITUDE WIND TUNNEL



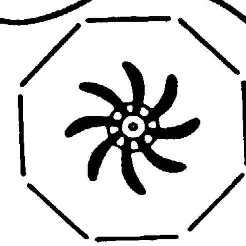
45' D. LOW-SPEED TEST SECTION

VELOCITY 0 TO 50 KNTS
ALTITUDE 0 TO 22 K ft$^+$
TEMPERATURE -10 TO 60° F



20' D. HIGH-SPEED TEST SECTION

MACH 0 TO 0.9$^+$
ALTITUDE 0 TO 55 K ft
TEMPERATURE -20 TO 60° F



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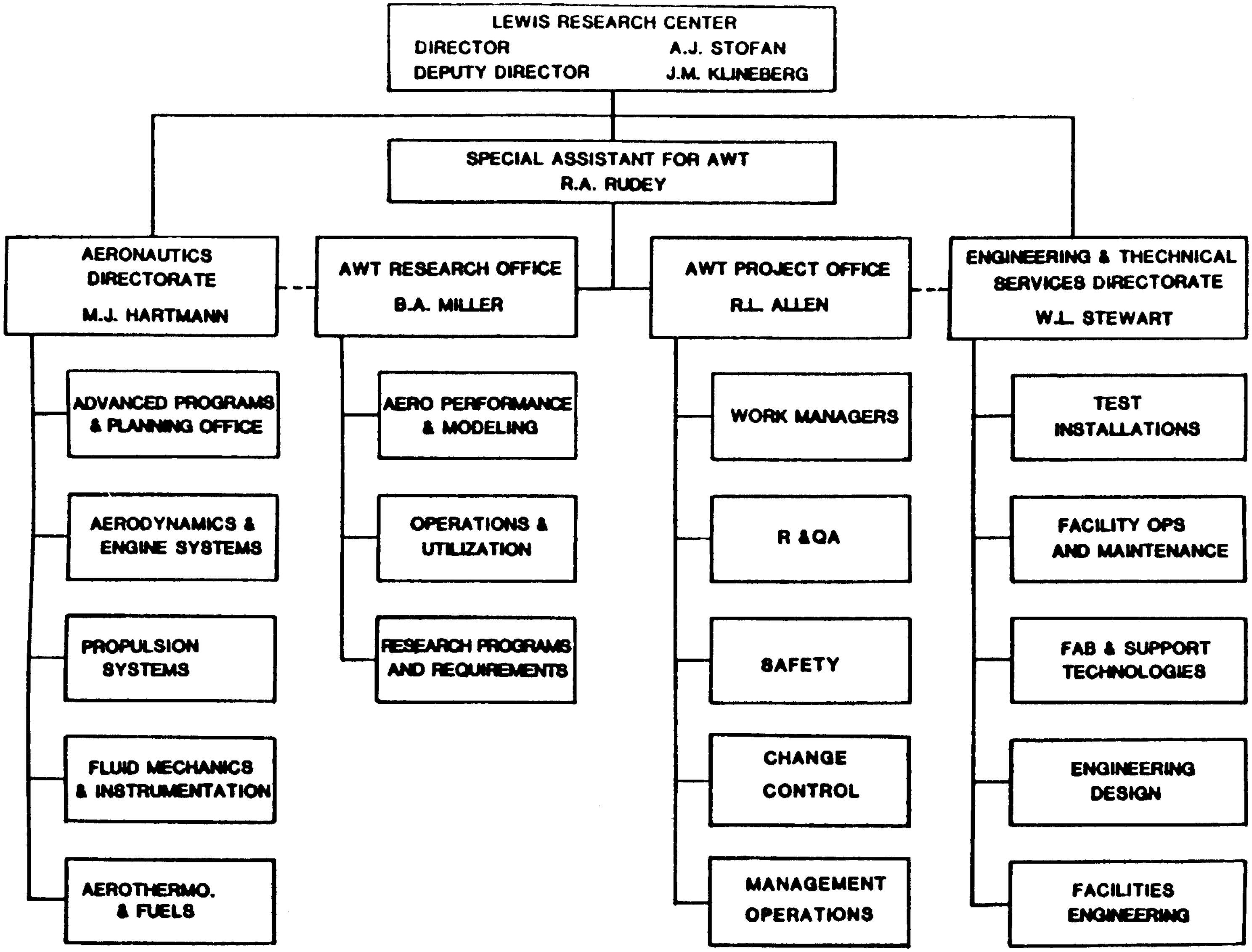
AWT ALTITUDE WIND TUNNEL



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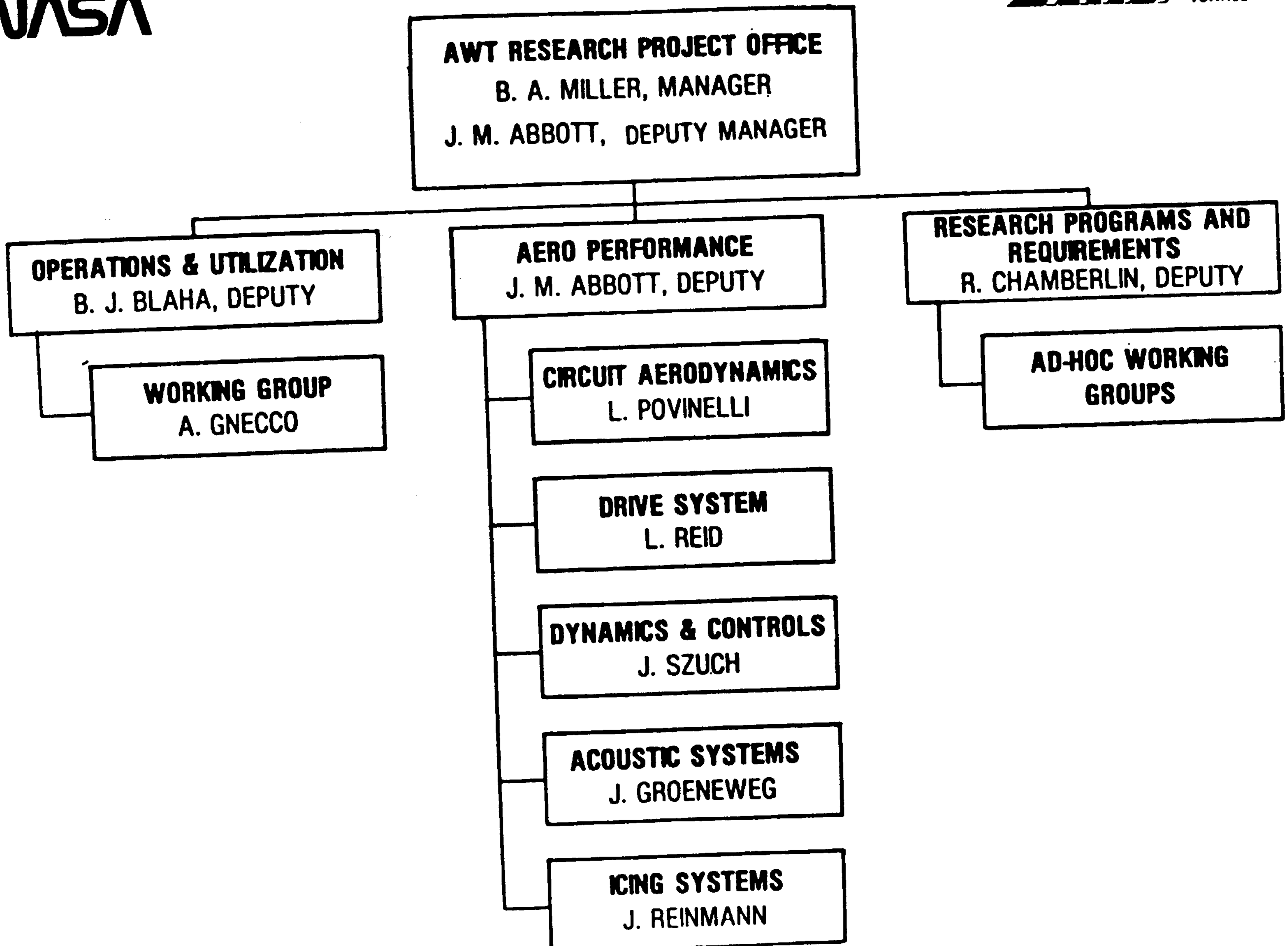

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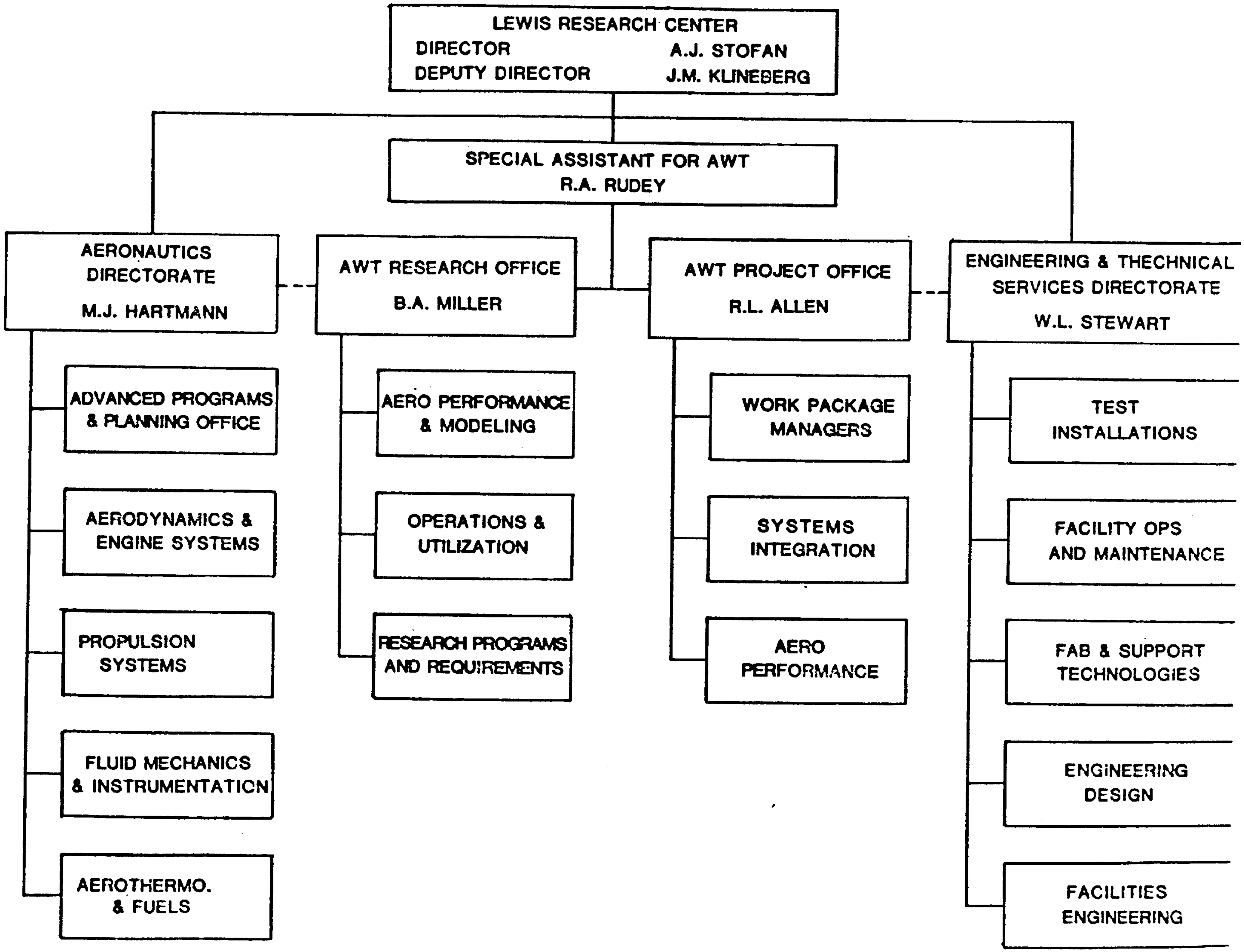
AWT PROJECT STATUS

ROBERT L. ALLEN

MANAGER, AWT PROJECT OFFICE

NASA LEWIS RESEARCH CENTER



LEWIS RESEARCH CENTER
DIRECTOR A.J. STOFAN
DEPUTY DIRECTOR J.M. KLINEBERG
SPECIAL ASSISTANT FOR AWT
R.A. RUDEY
AERONAUTICS DIRECTORATE
M.J. HARTMANN
AWT RESEARCH OFFICE
B.A. MILLER
AWT PROJECT OFFICE
R.L. ALLEN
ENGINEERING & THECHNICAL SERVICES DIRECTORATE
W.L. STEWART
ADVANCED PROGRAMS & PLANNING OFFICE
AERODYNAMICS & ENGINE SYSTEMS
PROPULSION SYSTEMS
FLUID MECHANICS & INSTRUMENTATION
AEROTHERMO. & FUELS
AERO PERFORMANCE & MODELING
OPERATIONS & UTILIZATION
RESEARCH PROGRAMS AND REQUIREMENTS
WORK PACKAGE MANAGERS
SYSTEMS INTEGRATION
AERO PERFORMANCE
TEST INSTALLATIONS
FACILITY OPS AND MAINTENANCE
FAB & SUPPORT TECHNOLOGIES
ENGINEERING DESIGN
FACILITIES ENGINEERING

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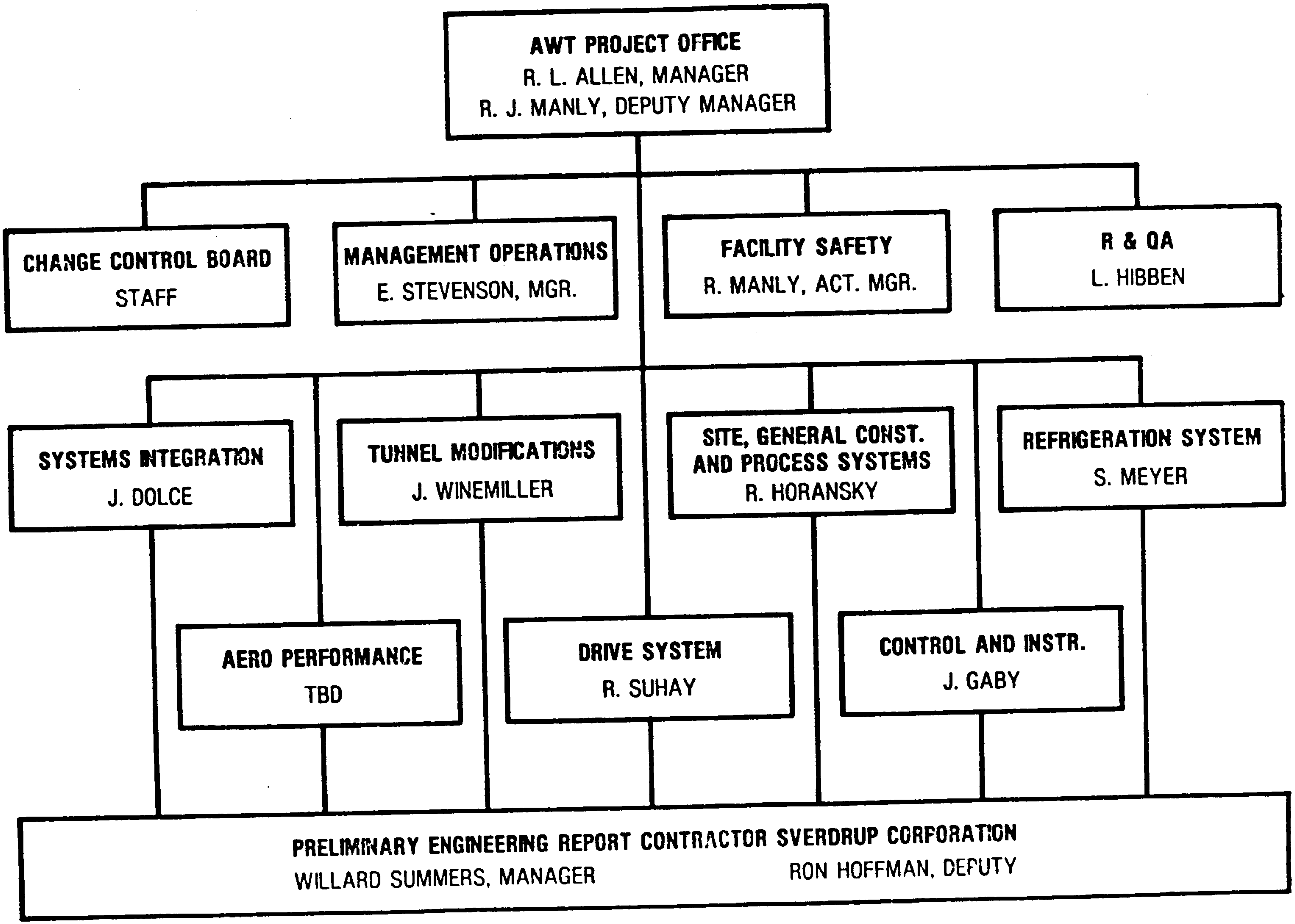
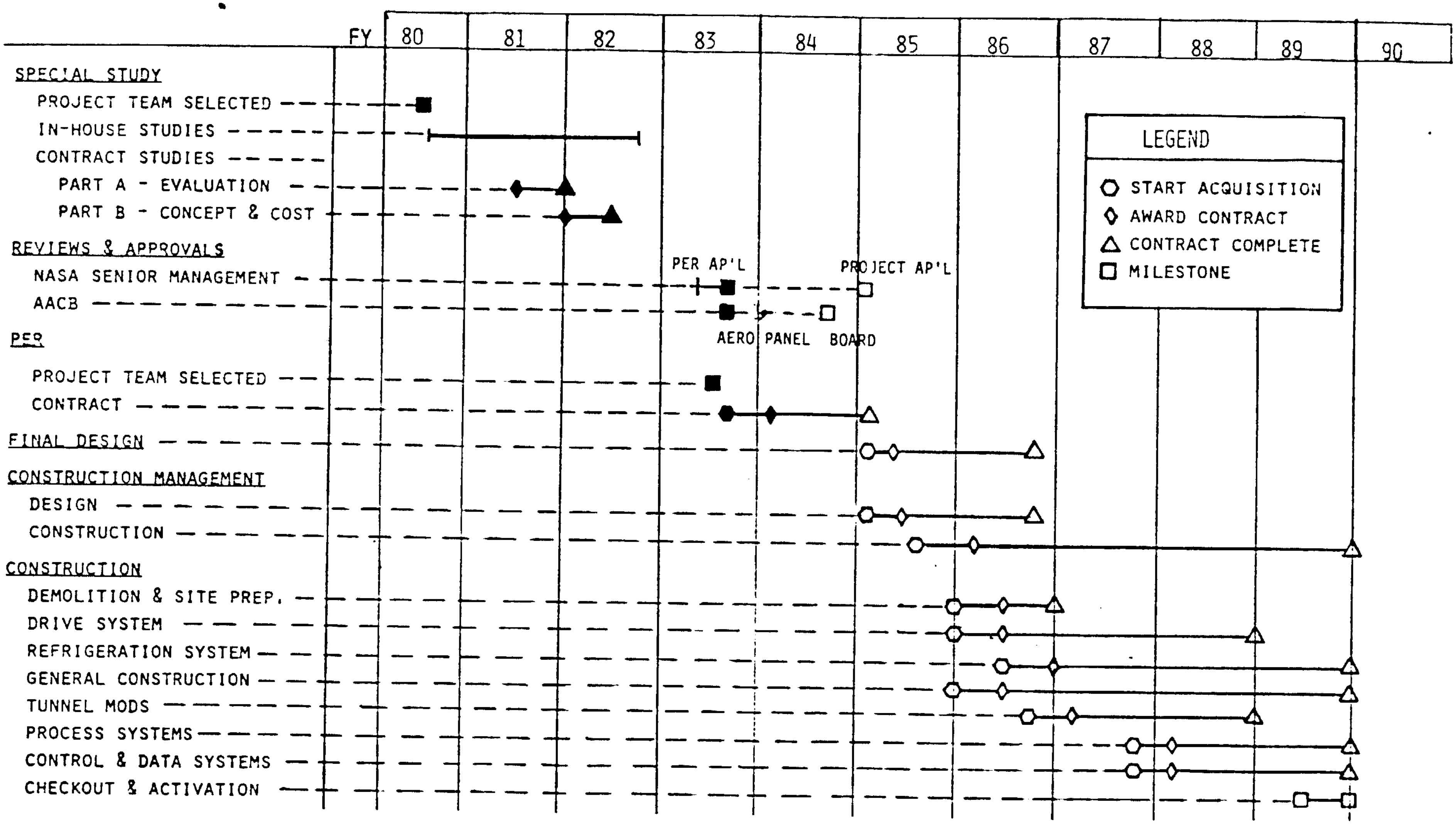
ALTITUDE WIND TUNNEL



AWT PROJECT MASTER SCHEDULE FY'86 BUDGET YEAR



ALTITUDE WIND TUNNEL PROJECT

STUDY PHASE LEVEL OF EFFORT

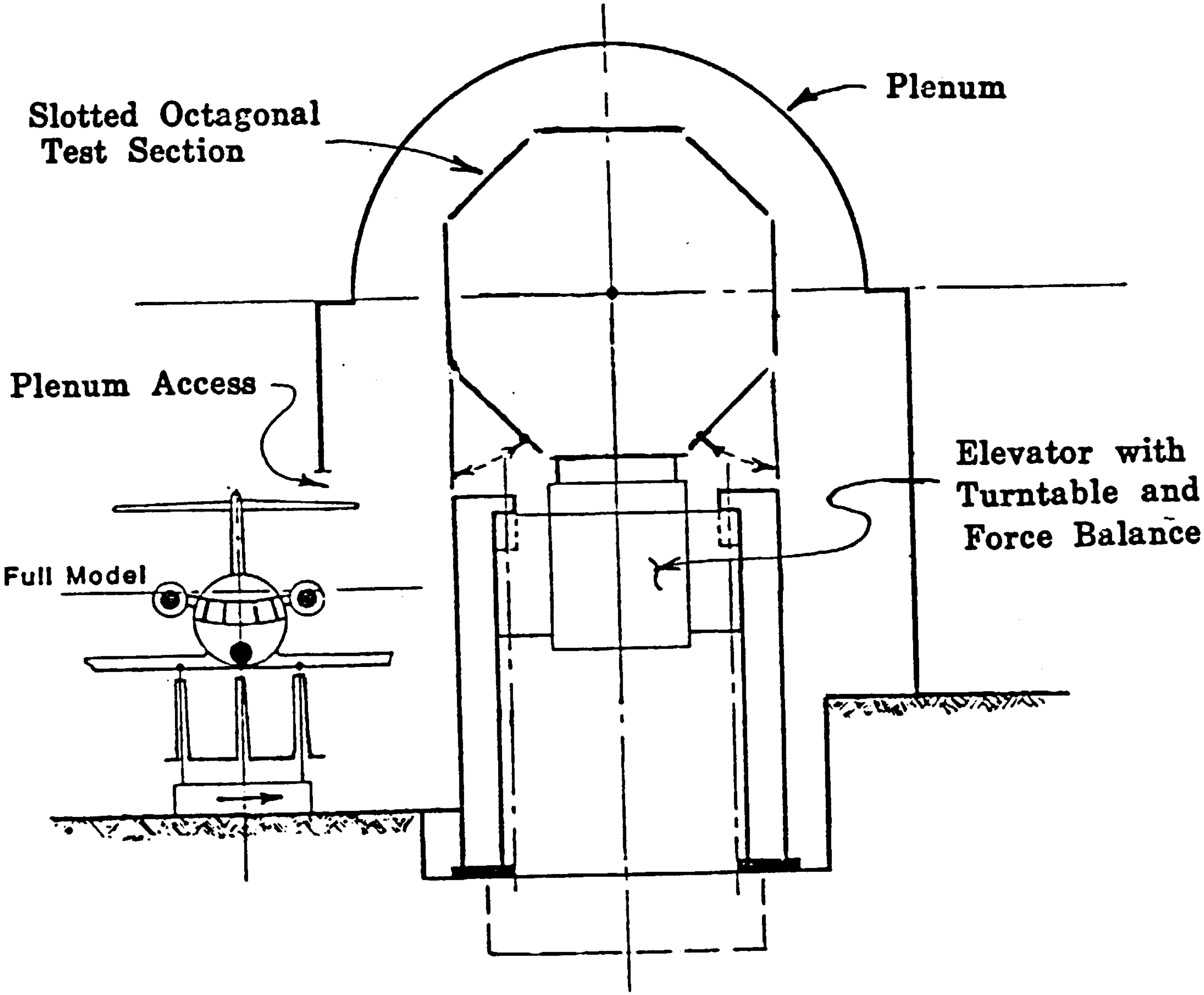
- o A/E CONTRACTOR $200K
- o SUPPORT SERVICE CONTRACTOR $115K
- o IN-HOUSE MANHOURS 27K

FINDINGS OF EVALUATION STUDY

- o STRUCTURAL
  - FOUNDATIONS ARE IN EXCELLENT SHAPE
  - TUNNEL PRESSURE SHELL
    - o NO VISIBLE CRACKS OR FLAWS
    - o RADIOGRAPHS SHOW WELDS DO NOT COMPLY WITH CURRENT CODES
    - o FATIGUE/FRACTURE ANALYSIS VERIFIES SHELL INTEGRITY
  - TUNNEL INSULATION IS IN VERY GOOD CONDITION
- o REFRIGERATION SYSTEM HAS 9 OF 14 COMPRESSORS OPERATIONAL
- o PROCESS SYSTEMS (COMPRESSED AIR, EXHAUST, AND STEAM) ARE CURRENTLY IN USE

USE OF THE EXISTING AWT SYSTEMS AS THE NUCLEUS FOR A NEW RESEARCH FACILITY IS TECHNICALLY AND ECONOMICALLY SOUND

AWT TEST SECTION BASELINE ALTERNATIVE



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ALTITUDE WIND TUNNEL PROJECT

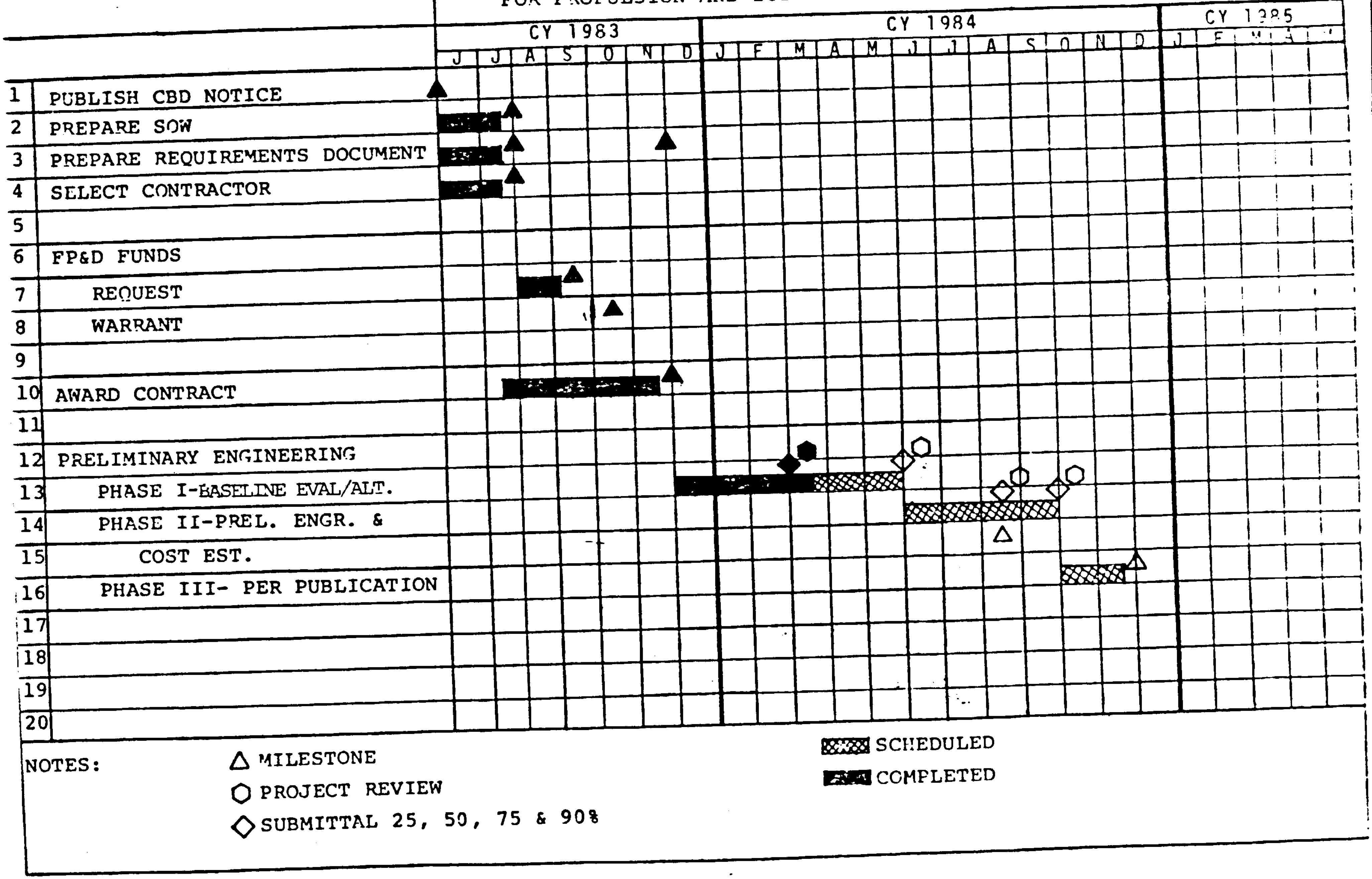
CONSTRUCTION COST ESTIMATE (FY 1986)

WORK PACKAGE	BUDGET COST $M
o DRIVE SYSTEM	34.3/48.3
o REFRIGERATION EQUIPMENT AND BUILDING	30.0/34.0
o SITE WORK, GENERAL CONSTRUCTION, TUNNEL MODS.	21.7/25.7
o PROCESS SYSTEMS, IE.	~15.5
- COOLING TOWER	
- AIR, EXHAUST, STEAM AND CO_2	
o FACILITY CONTROL AND RESEARCH DATA	~8.5
o RELOCATION OF VISITOR INFORMATION CENTER	TBD
FACILITY TOTAL	110/130

LEWIS RESEARCH CENTER

MILESTONE SCHEDULE

PRELIMINARY ENGINEERING REPORT
MODIFICATION OF ALTITUDE WIND TUNNEL
FOR PROPULSION AND ICING RESEARCH



LIST OF ATTENDEES FOR THE

PROJECT BRIEFING AND SITE SHOWING

JUNE 8, 1983 1:30 P.M.

OSBORNE ENGINEERING COMPANY
CLEVELAND, OHIO

R. E. WARNER & ASSOCIATE
LORAIN, OHIO

SVERDRUP & PARCEL & ASSOC. INC.
ST. LOUIS, MISSOURI

DSMA
ORLANDO, FLA.

FLUIDYNE
MINNEAPOLIS, MINNESOTA

BURNS & McDONNEL
KANSAS CITY, MISSOURI

NORMAN ENGINEERING
LOS ANGELES, CALIFORNIA

GENERAL ELECTRIC
CLEVELAND, OHIO

GEORGE S. RIDER CO.
ROCKY RIVER, OHIO

BURNS AND ROE
PARAMUS, NEW JERSEY

MRI METER RES. INC.
ALTADENA, CALIFORNIA

MIDDOUGH ASSOCIATES
CLEVELAND, OHIO

H. K. FERGUSON COMPANY
CLEVELAND, OHIO

A. M KINNEY INC.
CINCINNATI, OHIO

HWH ASSOCIATES
CLEVELAND, OHIO

BOEING ENG. & CONST.
SEATTLE, WASHINGTON

SWINDELL RUST
PITTSBURG, PENNSYLVANIA

RALPH M. PARSONS
PASADENA, CALIFORNIA

AWT PER
JULY 29, 1983

ALTITUDE WIND TUNNEL PROJECT
A/E SELECTION CONSIDERATIONS

- o RECENT LARGE AEROFACILITY EXPERIENCE
- o SYSTEMS INTEGRATION CAPABILITY
- o SKILL DEPTH TO SUPPORT CONTRACTED PERIOD OF PERFORMANCE
- o SKILL MIX FOR CRITICAL DESIGN AREAS
  - A. AERODYNAMICS
  - B. LARGE DRIVE SYSTEMS
  - C. SLOTTED AND ADAPTIVE WALL TEST SECTIONS
  - D. ICING
- o ALL REQUIRED SKILLS CONTAINED WITHIN A SINGLE CONTRACTOR

SOLICITATION RESPONSE

SANDERS & THOMAS
POTTSTOWN, PENNSYLVANIA

SVERDRUP CORPORATION
ST. LOUIS, MISSOURI

BE&C ENGINEERS, INC.
TUKWILA, WASHINGTON

METEOROLOGY RESEARCH, INC.
ALTADENA, CALIFORNIA

DSMA ENGINEERING CORP./DMJM
ORLANDO, FLORIDA
LOS ANGELES, CALIFORNIA

FLUIDYNE/PARSONS
MINNEAPOLIS, MINNESOTA
PASADENA, CALIFORNIA

NORMAN ENGINEERING CO.
LOS ANGELES, CALIFORNIA

O'DONNELL AND ASSOCIATES
PITTSBURGH, PENNSYLVANIA

ANT PER
JULY 29, 1983

THE ALTITUDE WIND TUNNEL INTERCENTER TECHNICAL OVERSIGHT COMMITTEE

Center	Name	Position
AEDC	Forrest B. Smith	Director for Engineering Development
ARC	Dale Compton, Chairman	Director of Engineering and Computer Systems
ARC	Frank Steinle	Assistant Chief, Experi. Investigation Bransh
KSC	James Phillips	Chief, Mechanical Engineering Division
LaRC	Hugh Clark	Assistant Director, Office for Systems Engineering and Operations
LaRC	Wayne McKinney	Assistant Chief, Transonic Aerodynamics Division
LeRC	Bob Allen, Exec. Secy.	AWT Project Manager
HQs	D/Haggai Cohen	Deputy Chief Engineer for Safety, Reliability & Quality Assurance
	NX/Dick Irwin	Deputy Director, Facilities Management
	RF/Art Henderson	OAST Facilities Manager

ALTITUDE WIND TUNNEL PROJECT
A/E MANHOUR SUMMARY

0 ESTIMATED
0 PROPOSED

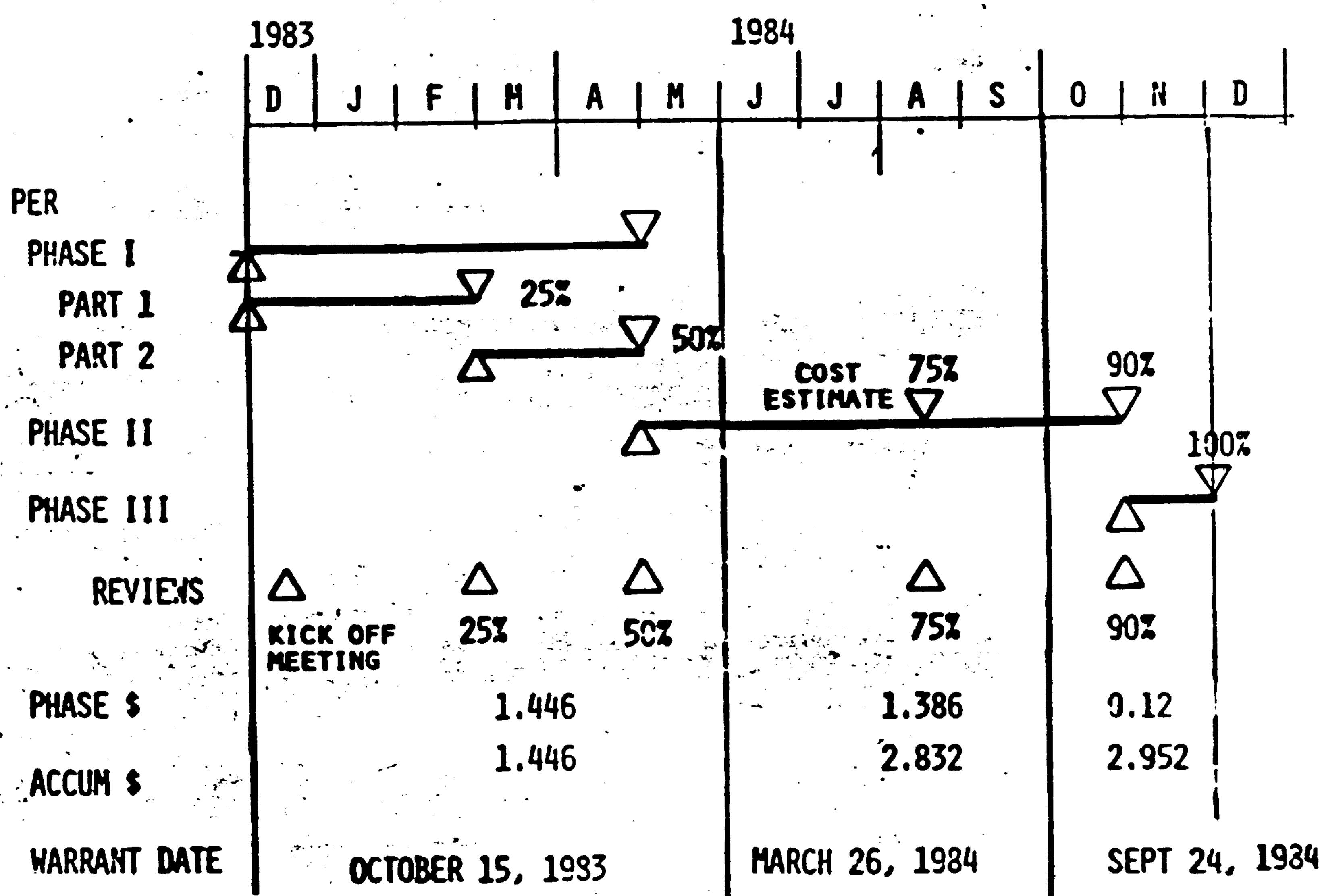
WORK PACKAGE	MANHOURS PHASE I PART 1	PHASE I PART 2	PHASE II	PHASE III	TOTAL MH
1. DRIVE SYSTEM (A)	801 / 3030	990 / 2560	3250 / 3470	169 / 690	5210 / 9750
2. REFRIGERATION (B)	1668 / 3920	1906 / 3660	2380 / 3280	256 / 240	6210 / 11100
3. SITE WORK	375 / 850	364 / 880	357 / 970	84 / 120	1180 / 2670
4. GENERAL CONSTR.	662 / 1730	1456 / 1730	2128 / 1370	54 / 160	4300 / 4990
5. TUNNEL MOD'S	3258 / 3920	2615 / 1050	6608 / 2090	799 / 410	12280 / 7470
6. PROCESS SYSTEMS	1124 / 2540	828 / 2380	2492 / 2430	246 / 260	4690 / 7630
7. CONTROL & DATA	782 / 280	1446 / 280	3350 / 7990	72 / 680	5650 / 9230
TUNNEL VERIF. (C) (D)	1598 / 2080	1658 / 1060	430 / 920	34 / 80	3720 / 4140
AERODYNAMICS	1318 / 2210	946 / 1840	684 / ---	202 / ---	3150 / 4050
PHA	130 / ---	130 / ---	260 / 1060	-- / 40	520 / 1100
PROJECT MGT.	1008 / 1040	718 / 1040	2016 / 1390	330 / 690	4072 / 4160
CLERICAL	320 / 1040	320 / 1040	600 / 1390	100 / 690	1340 / 4160
$EST, SCH, PLAN	680 / Dist.	690 / Dist.	1610 / Dist.	185 / Dist.	3165 / Dist.
TOTALS	12,724 / 22,640	14,067 / 17,490	26,165 / 26,240	2,531 / 4,080	55,487 / 70,450

SUBCONTRACTORS
(A) G.E. $50K
(B) DDN - MH'S INCL.
(C) PACKMAN $7510
(D) HERRON $36K

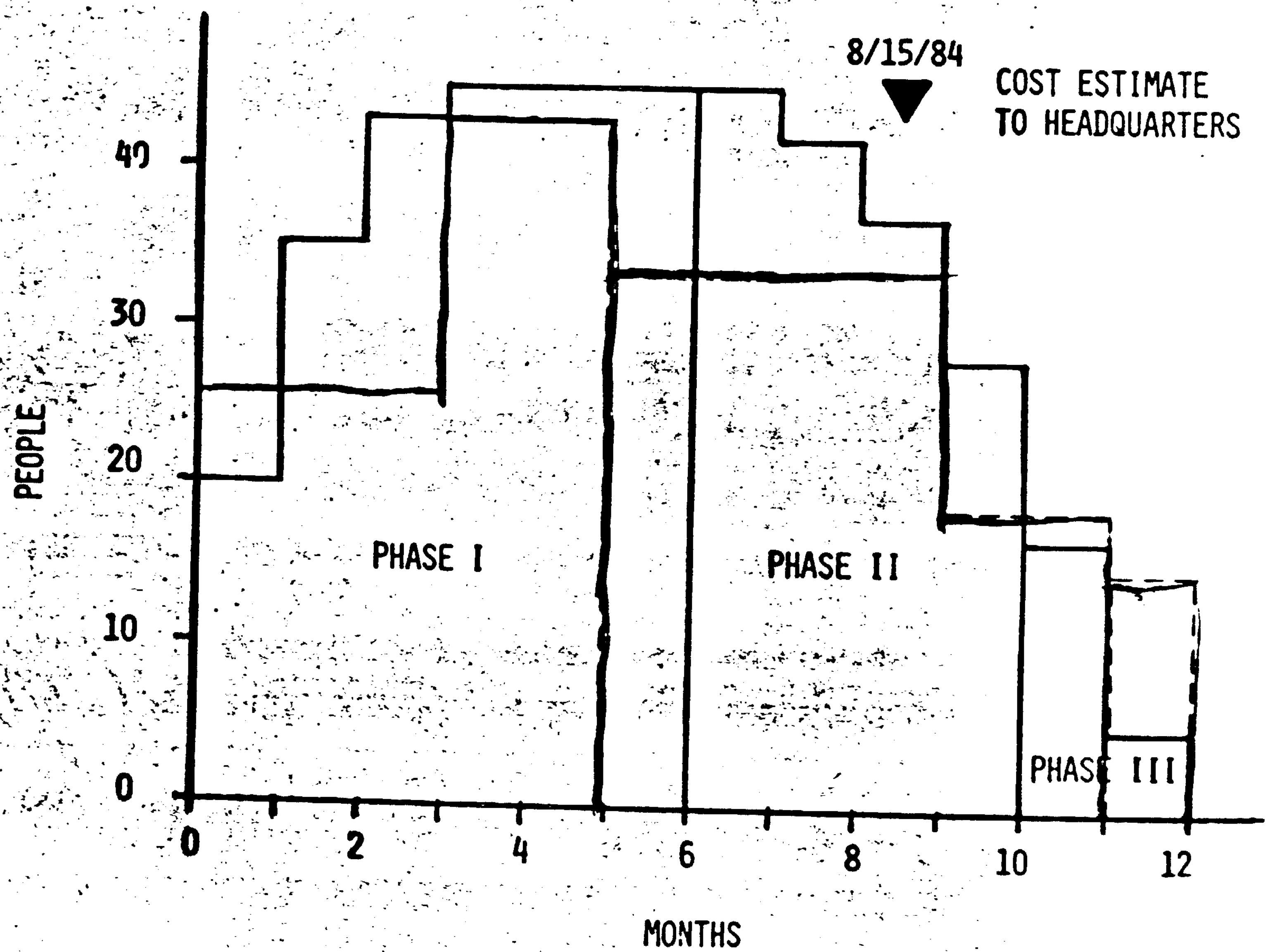
ALTITUDE WIND TUNNEL PROJECT
PER CONTRACT PHASING

	TASK DEFINITION	% EFFORT	% TOTAL EFFORT
PHASE I			
PART I	EVALUATE BASELINE CONFIGURATION PROPOSE ALTERNATIVES IN SELECTED AREAS (COST-PERFORMANCE IMPROVEMENT LIKELIHOOD IS HIGH)	25	25
PART 2	EVALUATE ALTERNATIVES AND SELECT AN UPGRADED BASELINE CONFIGURATION	25	50
PHASE II	DEVELOP BASELINE CONFIGURATION IN ADEQUATE DETAIL TO PRODUCE A 90 PERCENT CONFIDENCE LEVEL IN THE CONSTRUCTION COST ESTIMATE	40	75▼ COST ESTIMATE 90
PHASE III	DOCUMENTATION AND PUBLICATION OF THE PER (TECHNICAL RESULTS AND COST ESTIMATE)	10	100

ALTITUDE WIND TUNNEL PROJECT
FINANCIAL PLAN



MANHOUR PROFILE



AWT PROJECT

CURRENT COST ESTIMATE (FY 1986 START)

WORK PACKAGE	BUDGET COST $M	* FACTOR
o DRIVE SYSTEM	27	75%
o REFRIGERATION SYSTEM	29	50%
o SITE WORK, GENERAL CONSTRUCTION, TUNNEL MODS.	45	50%
o PROCESS SYSTEMS	14	50%
o CONTROL & DATA SYSTEM	9	50%
o RELOCATE VISITOR INFORMATION CENTER	TBD	
FACILITY TOTAL	$124	54%

* CONFIDENCE FACTOR (%) = $\frac{100 \text{ (LEAST ESTIMATED COST)}}{\text{AVERAGE ESTIMATED COST}}$

BUDGET COST = ENG'G COST + ESCALATION + SITE ADJUSTMENT + CONSTRUCTION CONTINGENCIES

ESCALATION @ ~5% PER YEAR TO CONSTRUCTION MID POINT

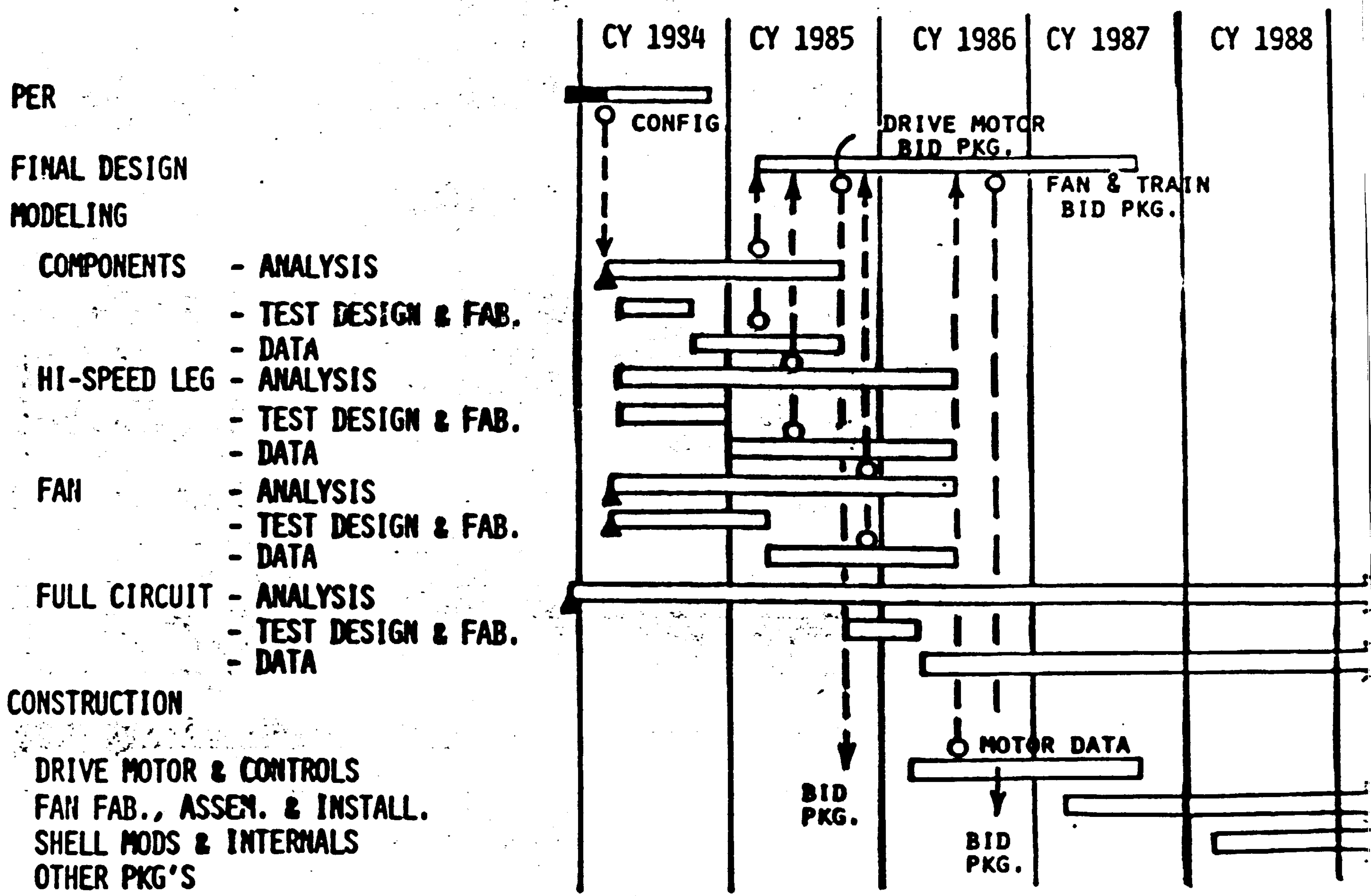
AWT PROJECT

PER CONTRACT 25 PERCENT SUMMARY

- PRELIMINARY AERODYNAMIC DEFINITION
  - MAIN CONTRACTION
  - HIGH SPEED DIFFUSER AND FINGER FLAPS
  - EXHAUST SCOOP
  - FAN
- AERODYNAMIC CIRCUIT LOSS ANALYSIS
- PLENUM EXHAUST SYSTEM EVALUATION
- BASELINE/OPTION EVALUATIONS
  - DRIVE SYSTEM
  - REFRIGERATION
  - 20' AND 45' TEST SECTIONS
  - COMPUTER CONTROL SYSTEMS
  - ICING AND DEICING SYSTEMS
- FINITE ELEMENT MODELS OF TUNNEL STRUCTURE
- BASELINE CONSTRUCTION SCHEDULE
- BASELINE COST ESTIMATE

AWT PROJECT

MODELING/DESIGN/CONSTRUCTION INTERFACES



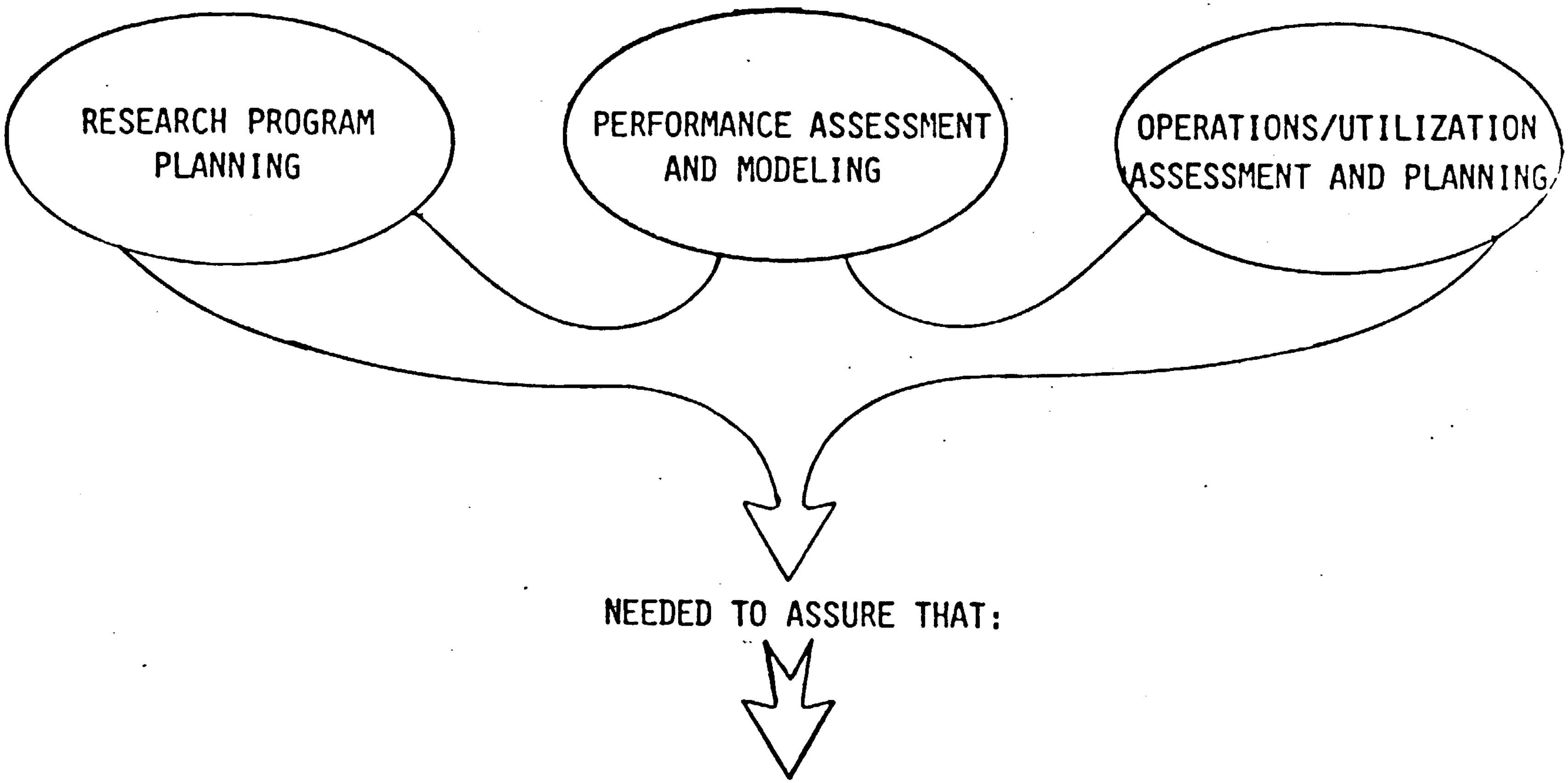
AWT MODELING STATUS

JOHN M. ABBOTT

DEPUTY MANAGER, AWT RESEARCH OFFICE

NASA LEWIS RESEARCH CENTER

AERO DIRECTORATE AWT ACTIVITIES



- o SUITABLE AWT PERFORMANCE CAPABILITIES DEFINED
- o SOUND AWT DESIGN ESTABLISHED

AWT PERFORMANCE ASSESSMENT AND MODELING

OBJECTIVES:

- O DEVELOP A TECHNICALLY SOUND AWT DESIGN THROUGH ANALYTICAL AND PHYSICAL PERFORMANCE ASSESSMENT AND MODELING
- O ADVISE THE AWT PROJECT OFFICE ON CONTRACTED DESIGN ACTIVITIES

APPROACH:

- O LEARN FROM OTHERS WHO HAVE RECENT MODELING EXPERIENCE
  - O VISITS FOR TECHNICAL DISCUSSIONS
  - O SEMINAR ON WIND TUNNEL MODELING
- O CONDUCT MODELING AND PERFORMANCE ASSESSMENT ACTIVITIES WITHIN THE AERONAUTICS DIRECTORATE
  - O AD HOC AWT PERFORMANCE WORKING GROUP
  - O PERFORMANCE ASSESSMENT AND MODELING TASK FORCE

AD HOC AWT PERFORMANCE WORKING GROUP

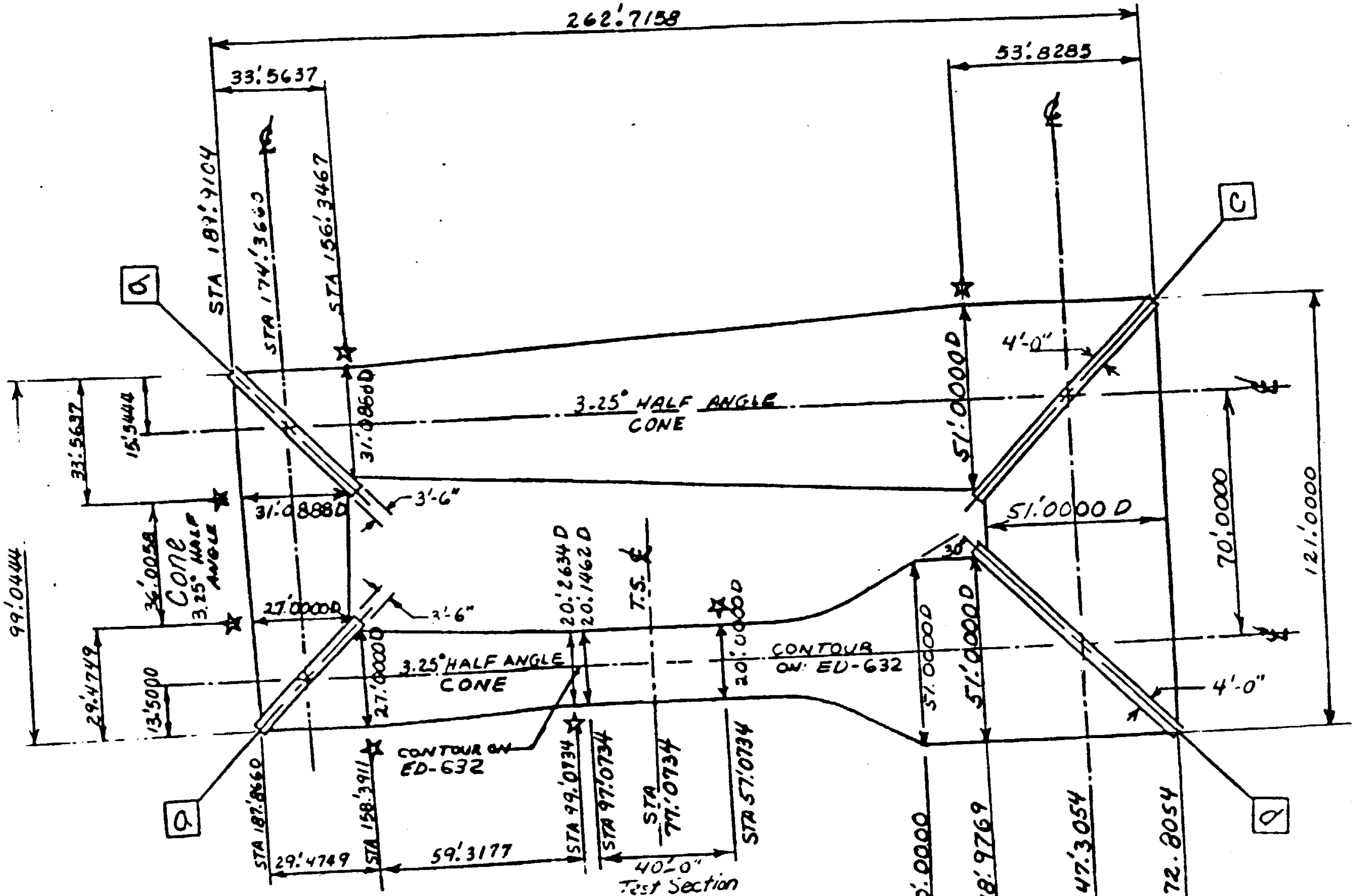
OBJECTIVE: O PULL TOGETHER A DATA PACKAGE OF INFORMATION ON AWT THAT INCLUDES:

- O CIRCUIT DIMENSIONS
- O CIRCUIT AREA DISTRIBUTION
- O CIRCUIT 1-D FLOW CHARACTERISTICS (M, P, R_E, ETC.)

STATUS:

- O GROUP ESTABLISHED JANUARY 13 (4 MEMBERS)
- O GEOMETRIC CHARACTERIZATION COMPLETE. PHYSICAL DIMENSIONS OF TUNNEL BEING VERIFIED
- O DETAILED LOOK AT COMPONENT LOSS MODELS NOW UNDERWAY - NEEDED TO DETERMINE 1-D FLOW CHARACTERISTICS
- O GROUP FUNCTION HAS BEEN ABSORBED INTO CIRCUIT AEROTHERMODYNAMICS TASK TEAM

ORIGINAL A.W.T. GEOMETRIC DIMENSIONS



Notes

Propeller location (Sta. 147'.16040)

Clear opening of T.S. door 36'-0"

✡ represents beginning or end of conic section

All linear dimensions taken from prints

1-30-84 HEN
DEN
DRB

Source: NACA Dwgs. ED-602, EX-603, ED-632 & ED-685

AWT PERFORMANCE ASSESSMENT AND MODELING TASK FORCE

OBJECTIVE:

- O ESTABLISH AND IMPLEMENT AN AWT PERFORMANCE ASSESSMENT AND MODELING PLAN TO ENSURE THE TECHNICAL SOUNDNESS OF THE AWT PROJECT
  - O ANALYTICAL MODELING REQUIREMENTS
  - O PHYSICAL MODELING REQUIREMENTS (INCLUDING FACILITIES)
  - O RESOURCE REQUIREMENTS ($'S, MY'S)
  - O SCHEDULE

APPROACH:

- O CONDUCT MODELING AND PERFORMANCE ASSESSMENT ACTIVITIES WITHIN THE AERONAUTICS DIRECTORATE VIA FIVE TASK TEAMS LED BY SECTION HEADS WITH THE APPROPRIATE BACKGROUND

STATUS:

- O KICKOFF MEETING - JANUARY 27
- O IDENTIFYING NEEDS FOR PERFORMANCE ASSESSMENT AND MODELING

NASA

AWT ALTITUDE WIND TUNNEL

ORGANIZATION FOR AWT PERFORMANCE ASSESSMENT AND MODELING

AWT PERFORMANCE ASSESSMENT AND MODELING TASK FORCE

CHAIRMAN: J. ABBOTT

MEMBERS:
- O LEADERS OF ALL TASK TEAMS
- O R. ALLEN
- O J. DIEDRICH

CIRCUIT AEROTHERMODYNAMICS TASK TEAM

LEADER - L. POVENELLI
(HEAD, TURBINE AERO. SECT.)

DRIVE SYSTEM TASK TEAM

LEADER - L. REID
(HEAD, MULTISTAGE COMPR. SECT.)

CONTROL & DYNAMIC ANALYSIS TASK TEAM

LEADER - J. SZUCH
(HEAD, SYSTEM DYNAMICS SECT.)

ICING SYSTEMS TASK TEAM

LEADER - J. REINMANN
(HEAD, ICING RESEARCH SECT.)

ACOUSTIC SYSTEMS TASK TEAM

LEADER - J. GROENEWEG
(HEAD, TURBOMACHINERY NOISE SECT.)

ISSUES/QUESTIONS BEING ADDRESSED BY TASK TEAMS

- O ASSESS CURRENT ANALYTICAL CAPABILITIES; DETERMINE ADDITIONAL NEEDS; DEVELOP NEW CAPABILITIES.
- O WHAT, AND HOW MUCH, NEEDS TO BE PHYSICALLY MODELED?
- O WHAT SIZE SHOULD THE PHYSICAL MODELS BE?
- O IN WHAT FACILITIES SHOULD THE MODELS BE TESTED? PERMANENCE IS AN ISSUE.
- O AT WHAT CONDITIONS WILL THE MODELS BE TESTED? P, T, H, RE, ETC.
- O WHAT INSTRUMENTATION IS REQUIRED?
- O WHAT ARE RESOURCE REQUIREMENTS? #'S? MY's?
- O WHAT IS THE SCHEDULE OF ACTIVITIES?

SCHEDULE OF PERFORMANCE ASSESSMENT AND MODELING ACTIVITIES

1984

ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
ESTABLISH MODELING TASK FORCE	▽											
OBTAIN ARC, LARC & BAC INPUT	▽	▽										
ESTABLISH PRELIMINARY PLAN		▽										
PRESENT TO AWT OVERSIGHT COMM.		22ND ▽										
MODELING SEMINAR			▽									
PRESENT PLANS TO DIRECT. MGMT.				▽								
MODELING - ANALYSIS/TEST	═	═	═	═	═	═	═	═	═	═	═	═⇒
PER MILESTONES		25% ▽		50% ▽				75% ▽				100% ▽

NTF MODELING PROGRAM

L. WAYNE McKINNEY

ASSISTANT CHIEF, TRANSONIC AERODYNAMICS DIVISION

NASA LANGLEY RESEARCH CENTER

NTF PERFORMANCE ESTIMATION AND MODELING

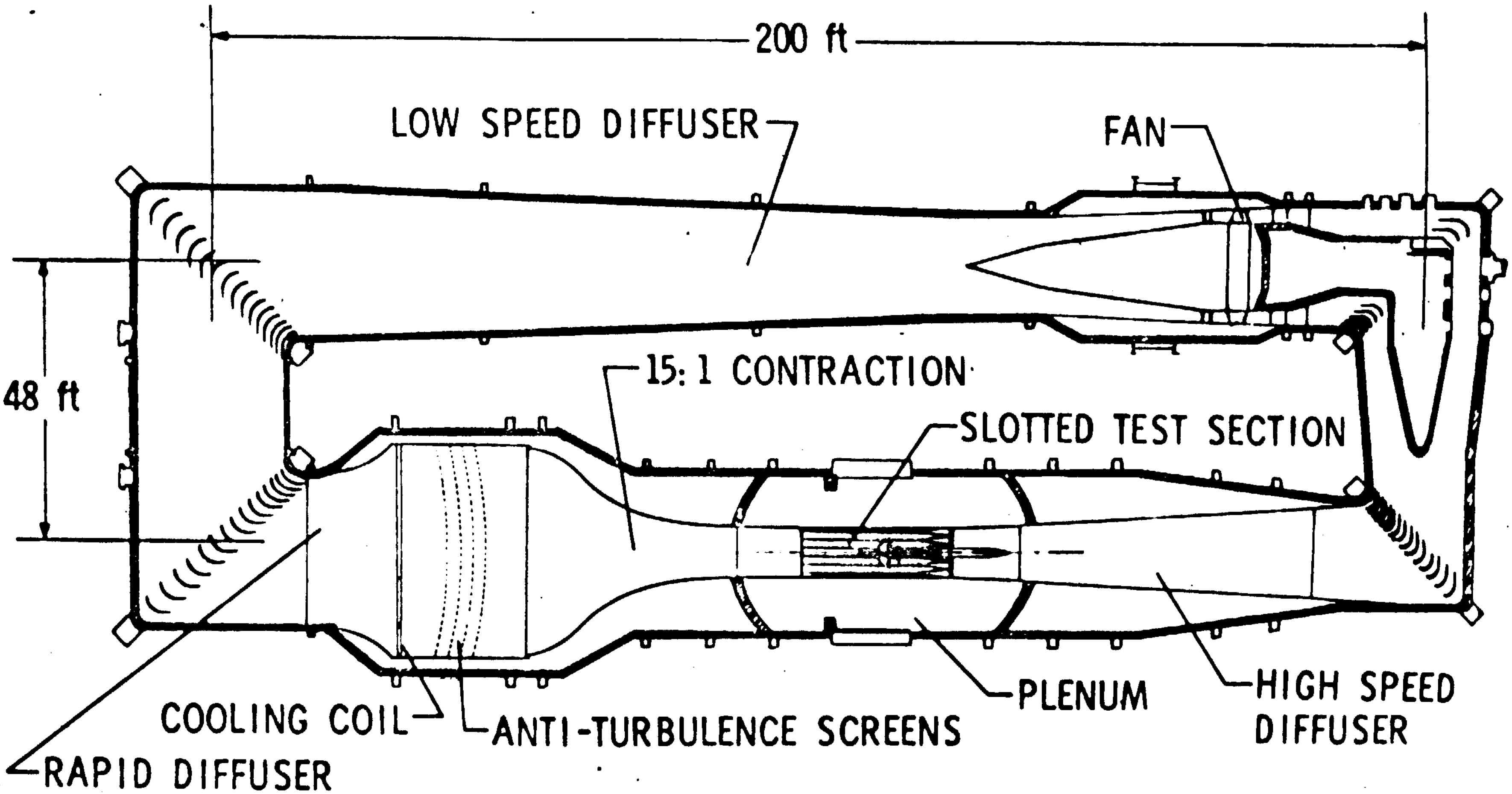
PRESENTED AT LeRC WORKSHOP ON
WIND TUNNEL MODELING
MARCH 20 AND 21, 1984

L. W. McKINNEY

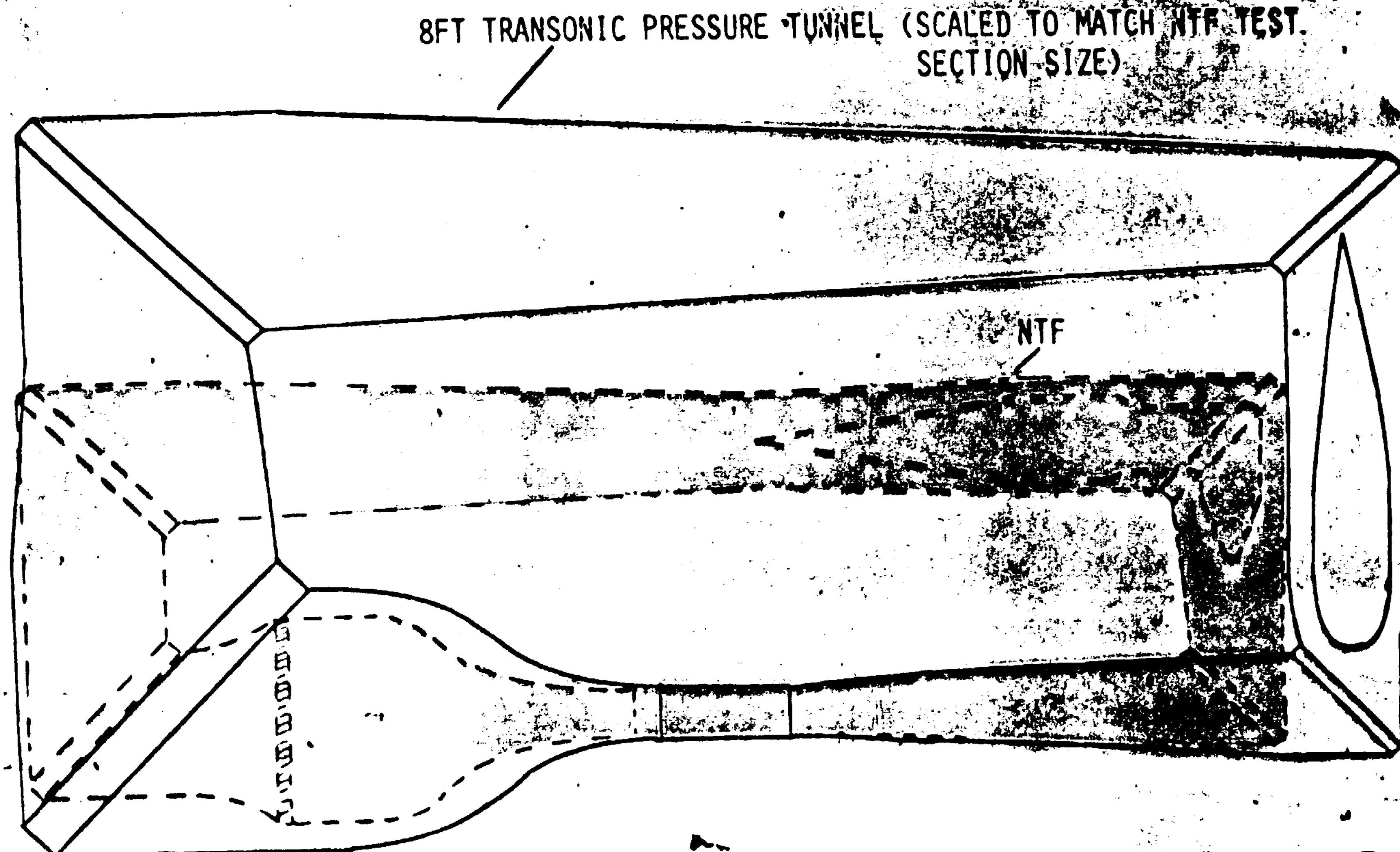
AERODYNAMIC DESIGN CRITERIA

- 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 $= 150\text{db}$
- 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

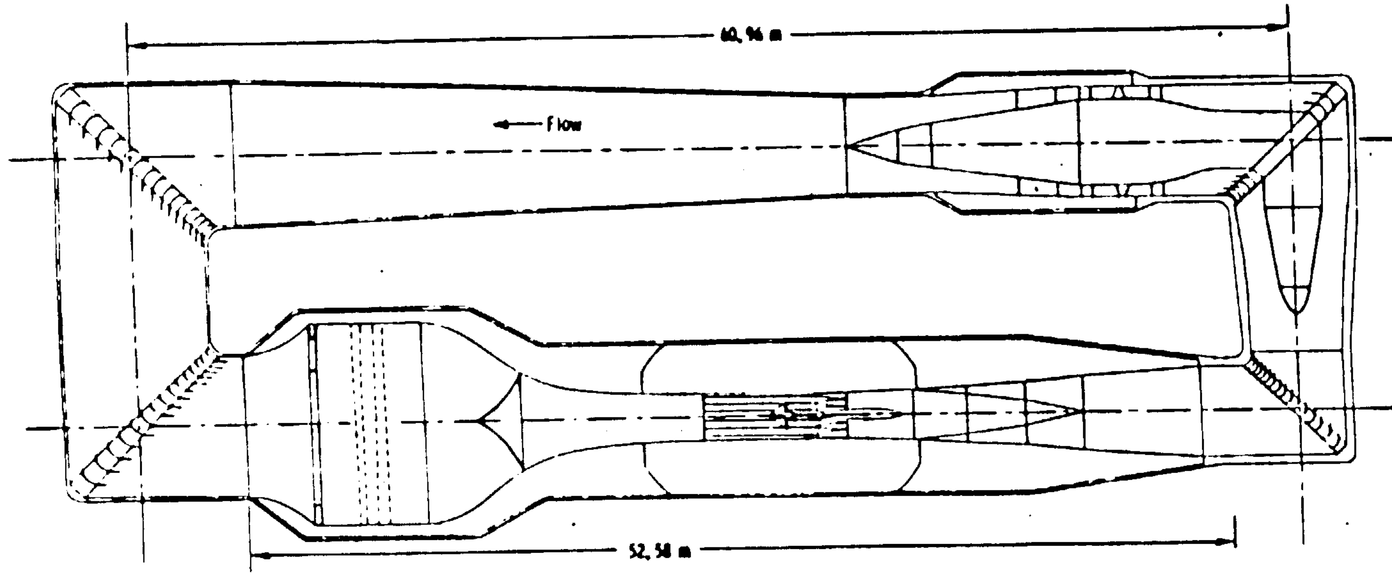
  -- TUNNEL PRESSURE RATIO
  -- AERODYNAMIC LOADS
  -- EFFECT OF PLENUM BLEED

- 1/12 SCALE COMPONENTS

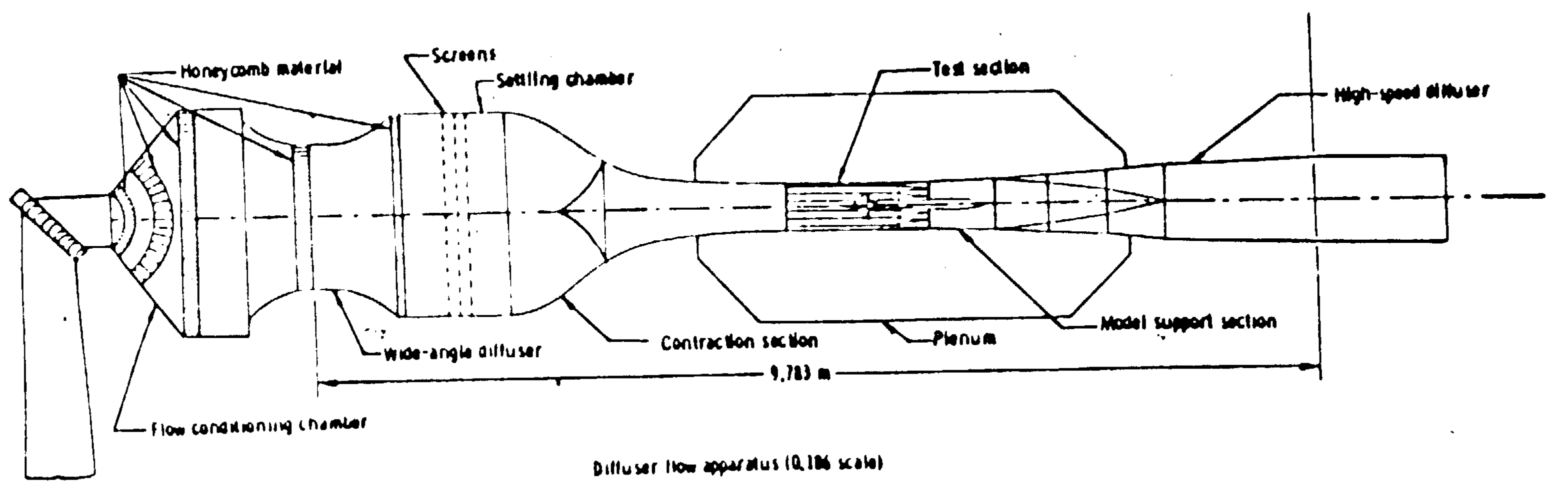
  -- SECOND TURN PERFORMANCE
  -- QUICK DIFFUSER PERFORMANCE
  -- COOLING COIL TESTS
  -- AERODYNAMIC LOADS

- 0.3-METER CRYO TUNNEL

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

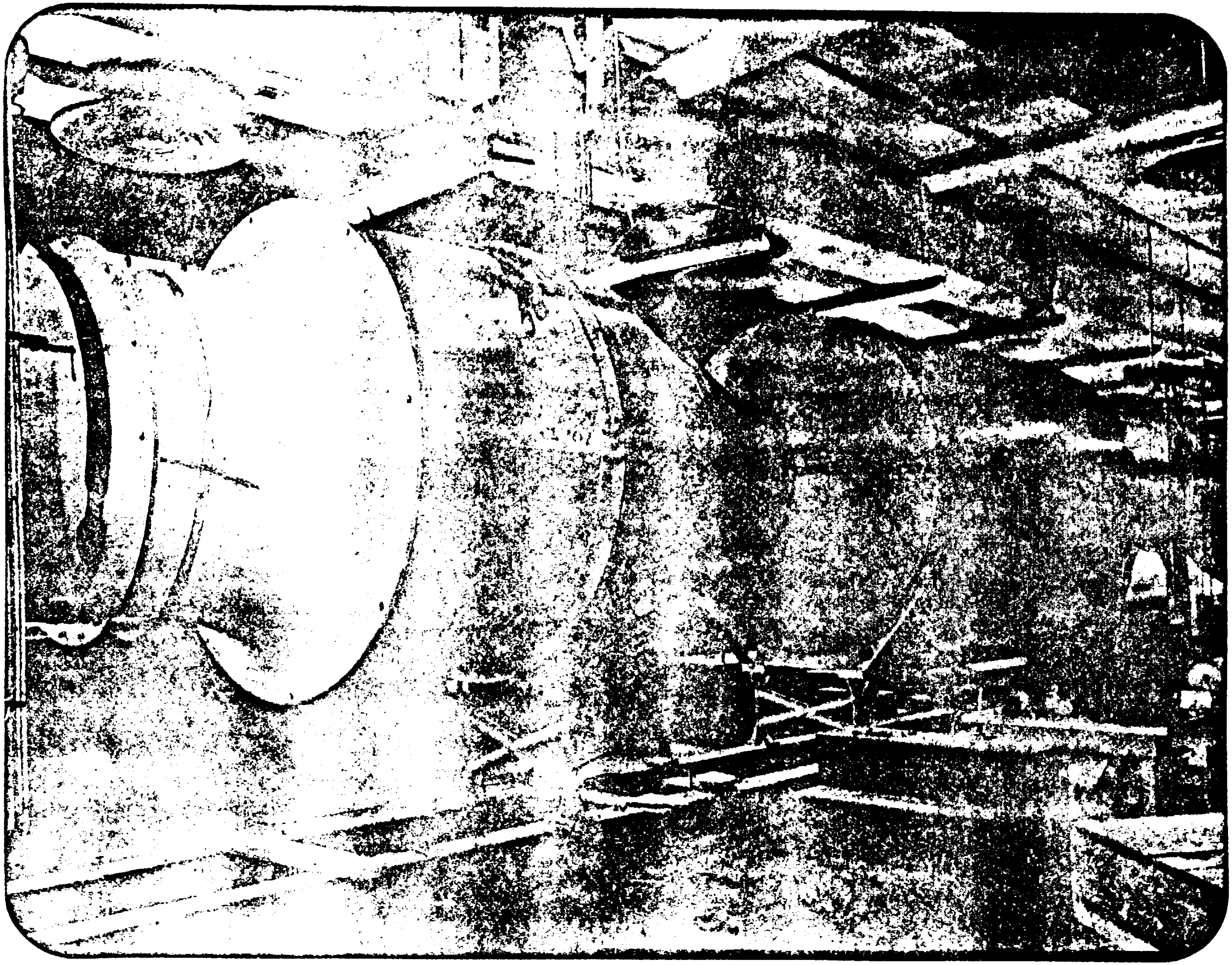


National Transonic Facility



Diffuser flow apparatus (0.186 scale)

Comparison showing extent of representation of NTF by DFA.



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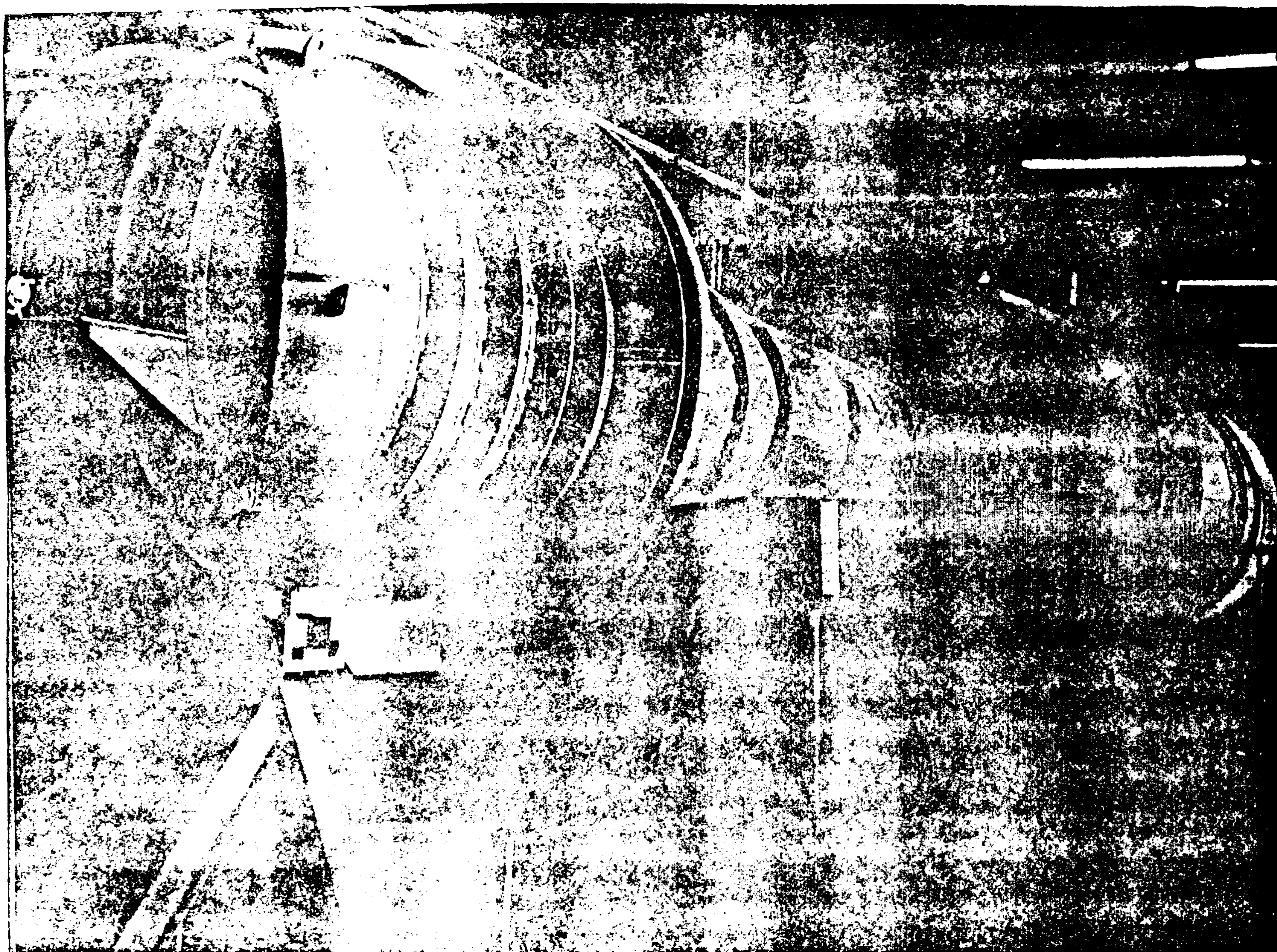
DIFFUSER TEST APPA



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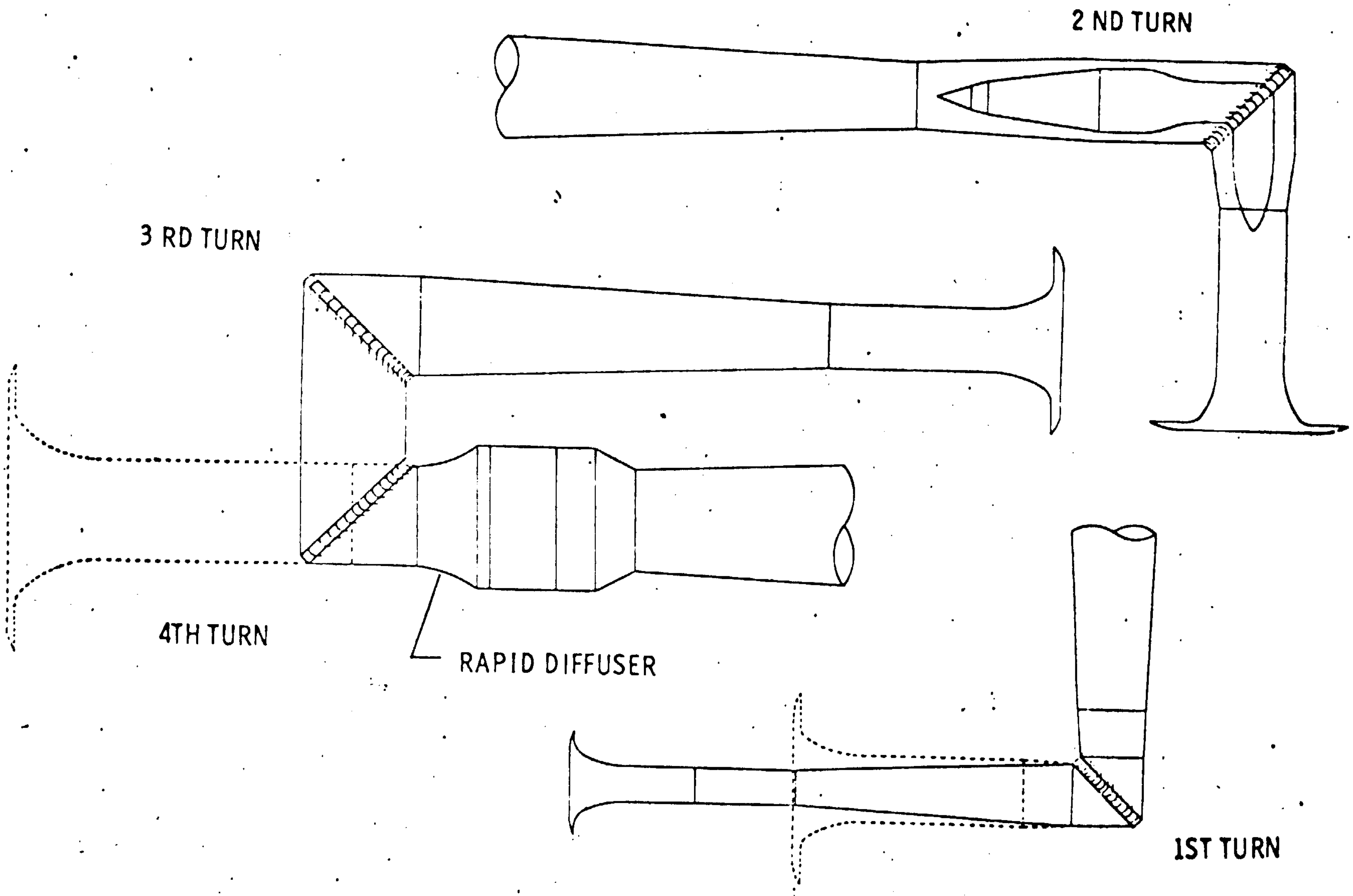
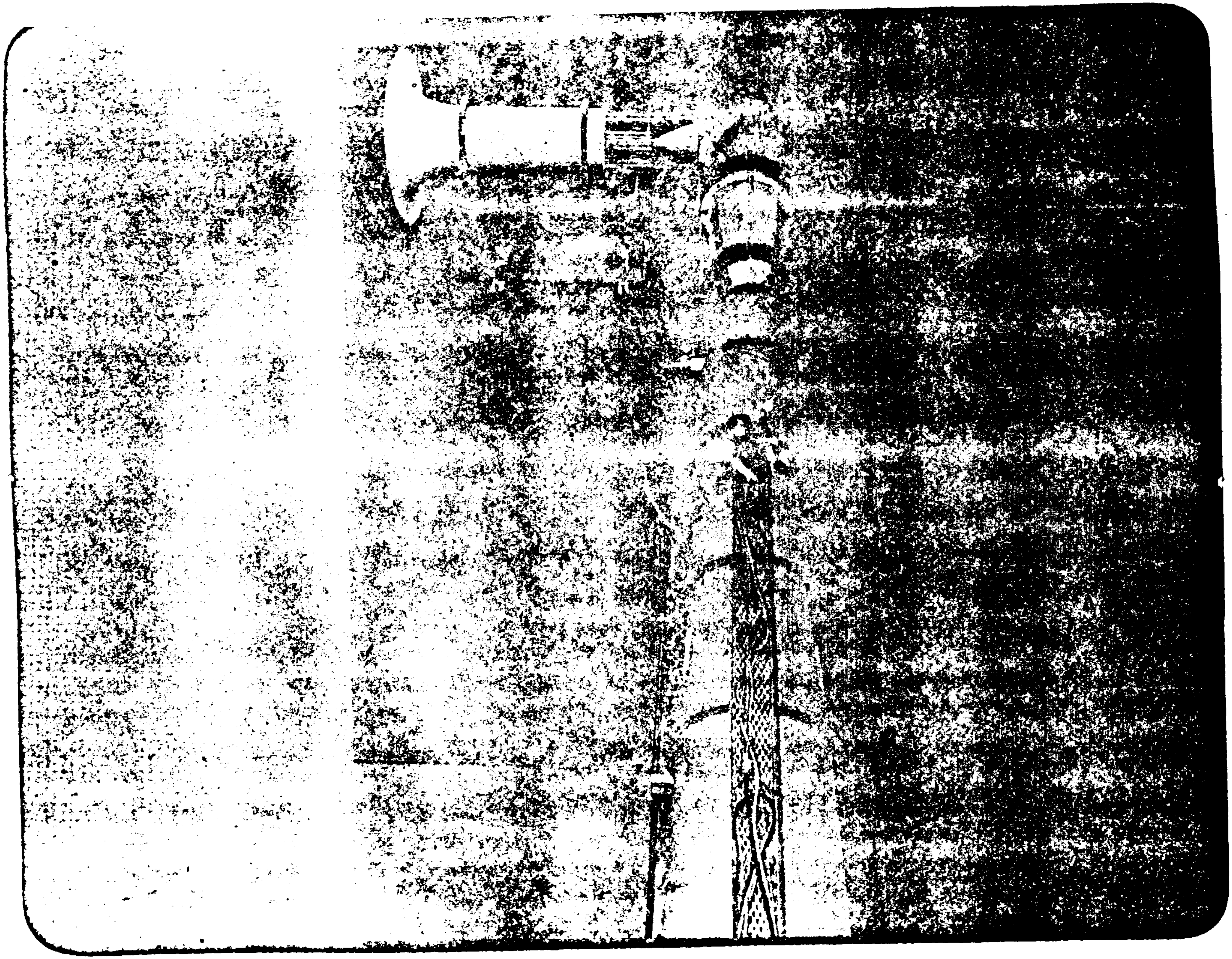
1/12 SCALE MODELS OF NTF COMPONENTS





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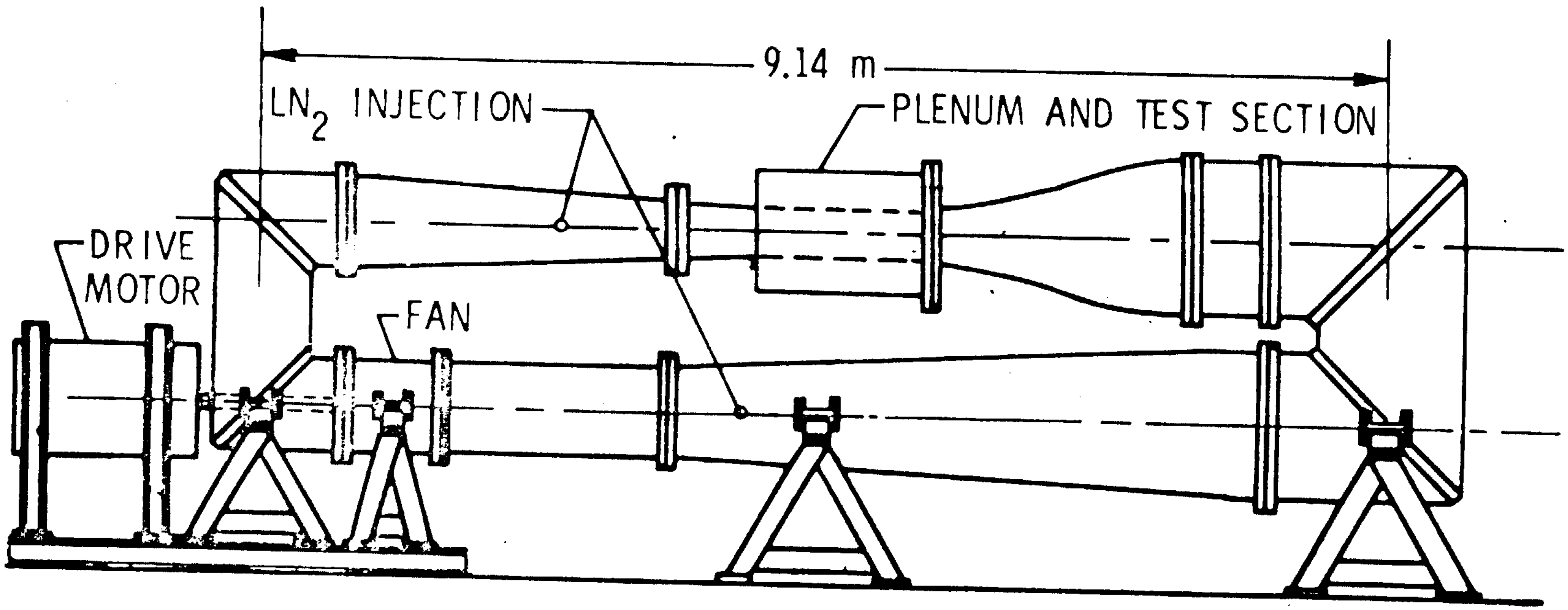
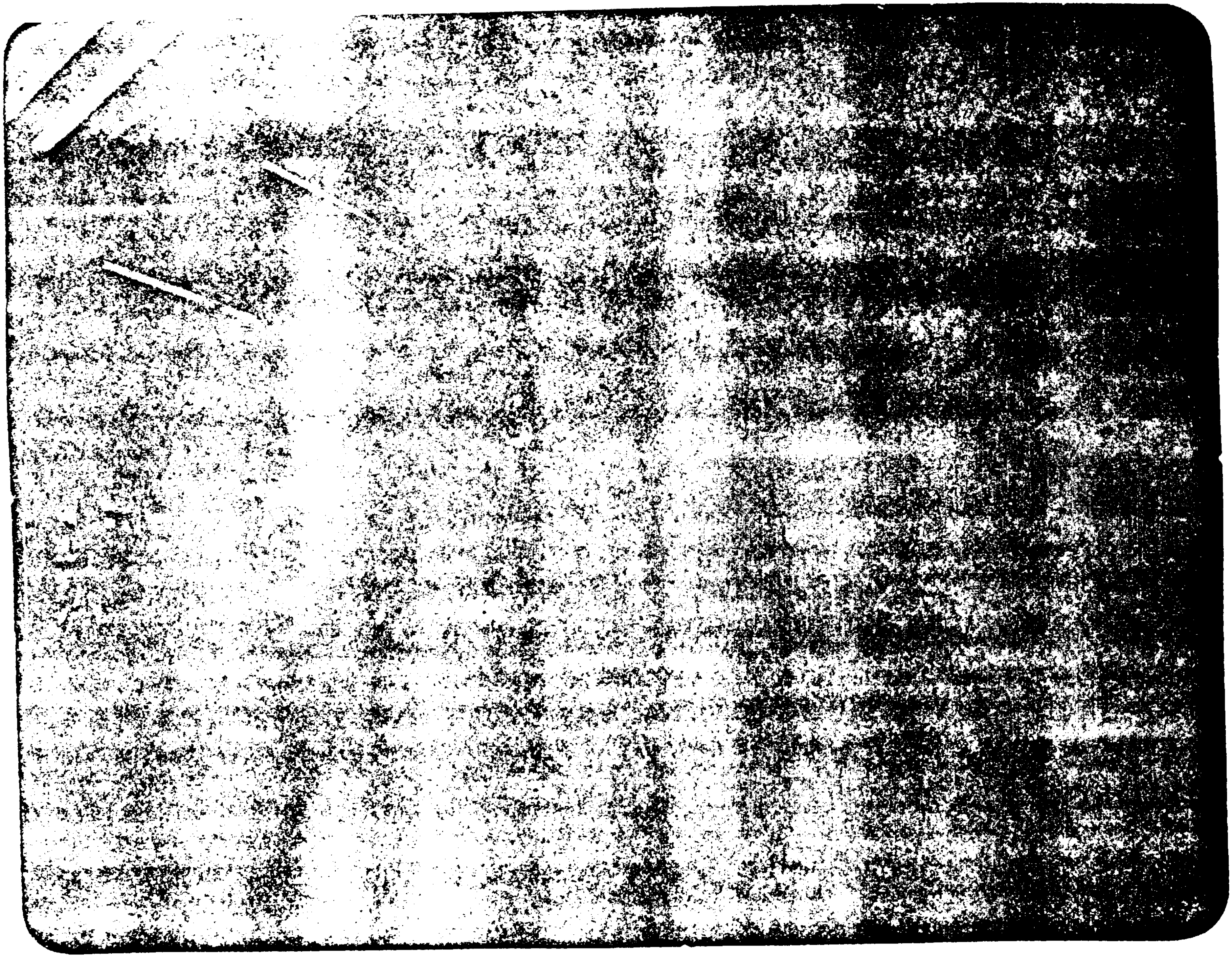
LANGLEY 34 cm (13.5") PILOT TRANSONIC CRYOGENIC TUNNEL





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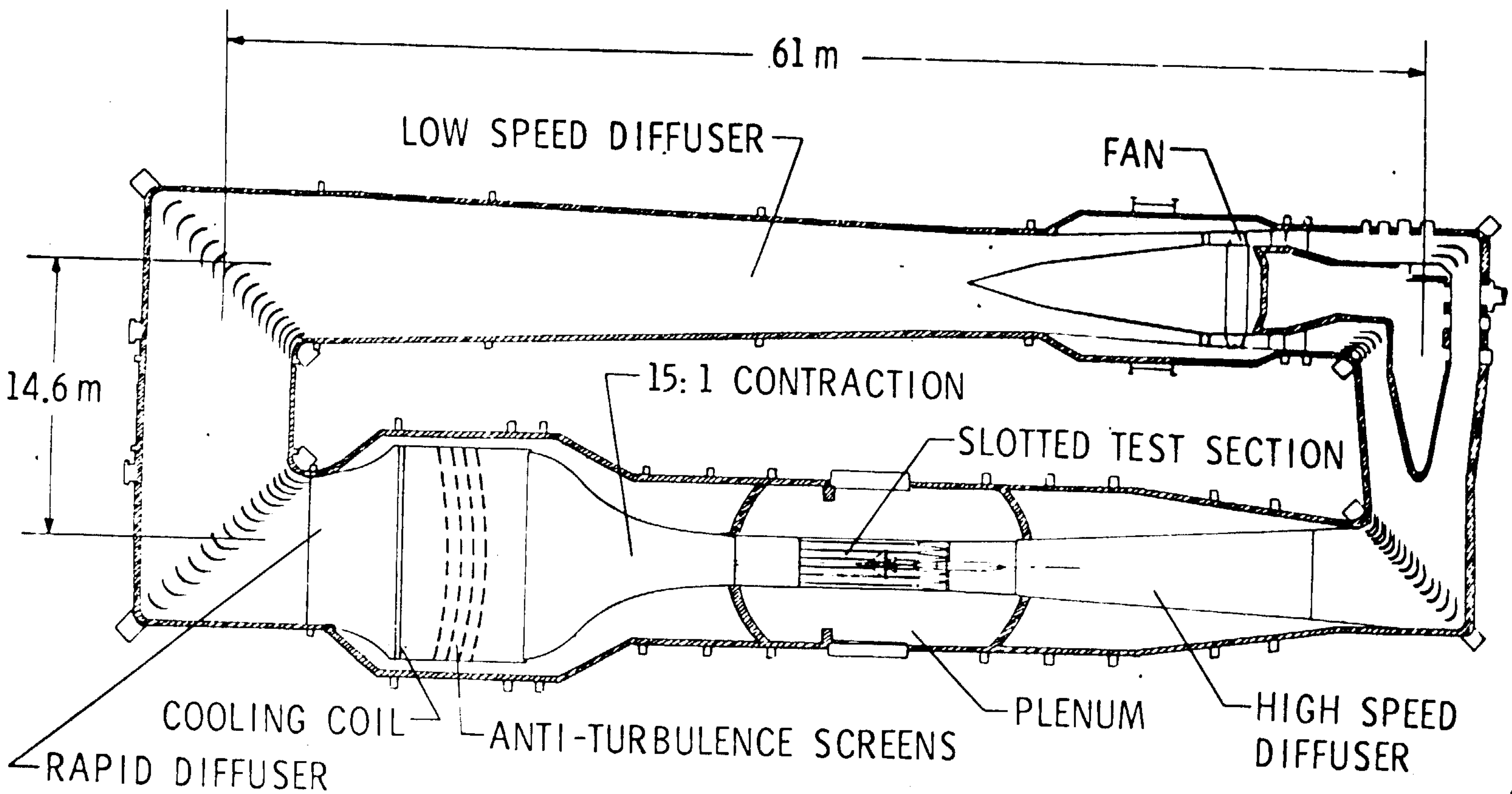
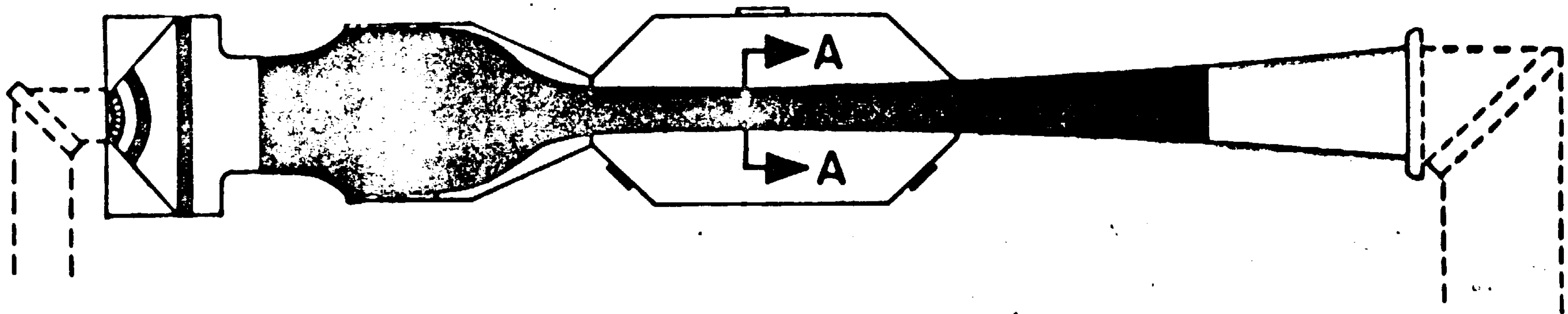
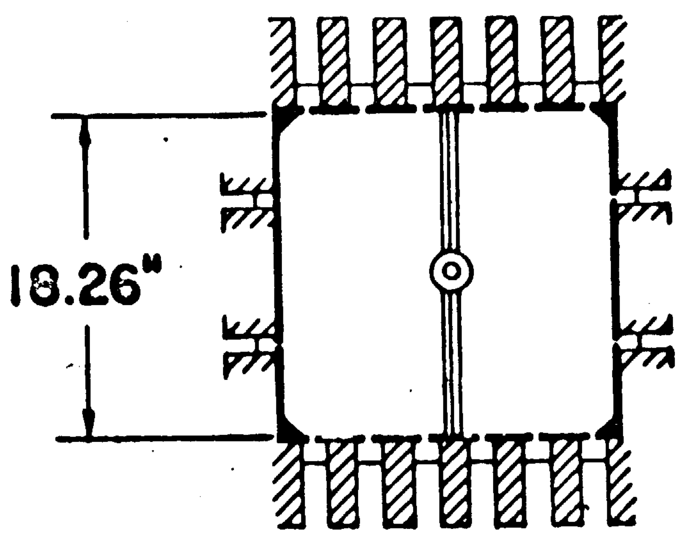
NATIONAL TRANSONIC FACILITY
PLAN OF TUNNEL CIRCUIT

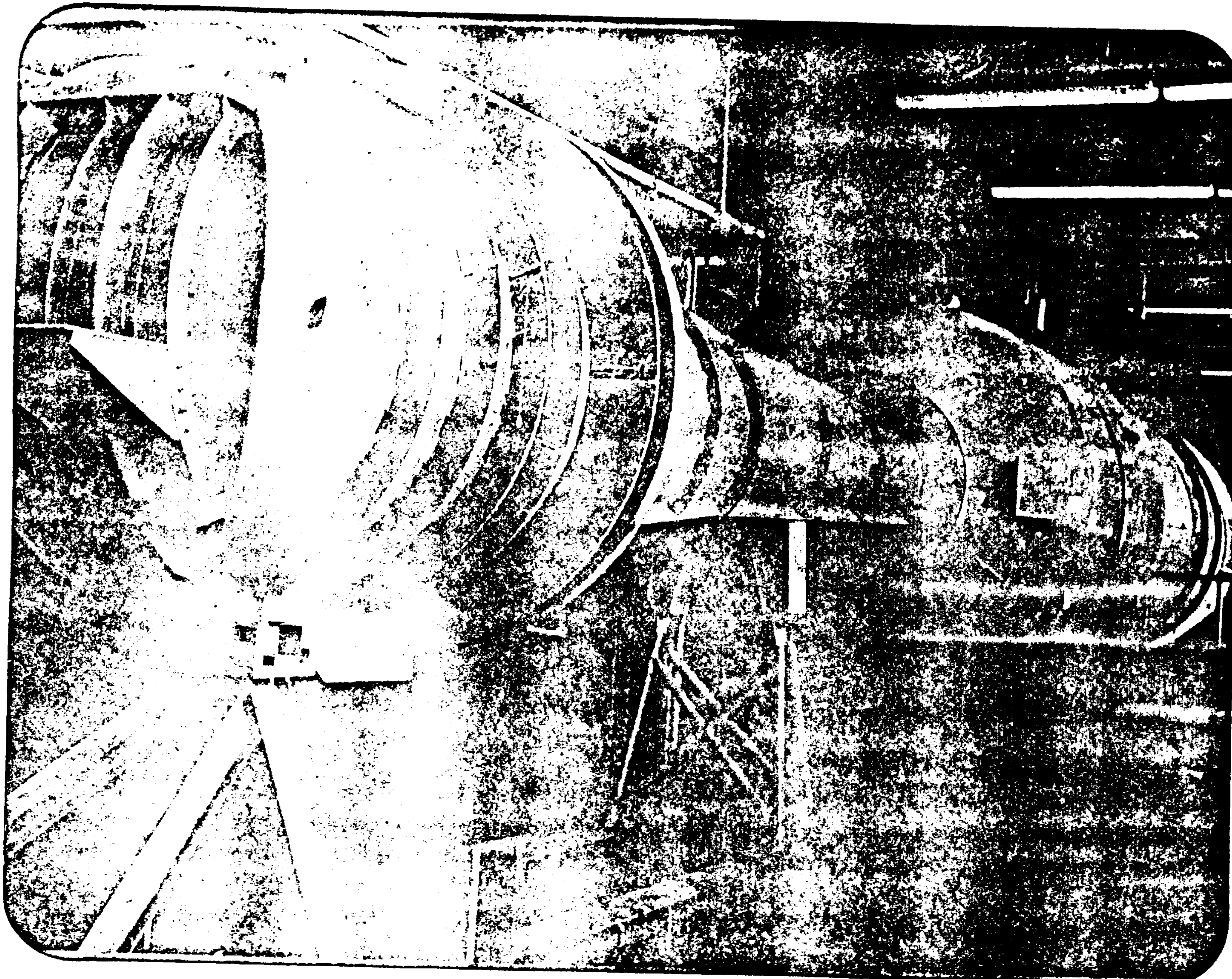


NTF PERFORMANCE MODEL





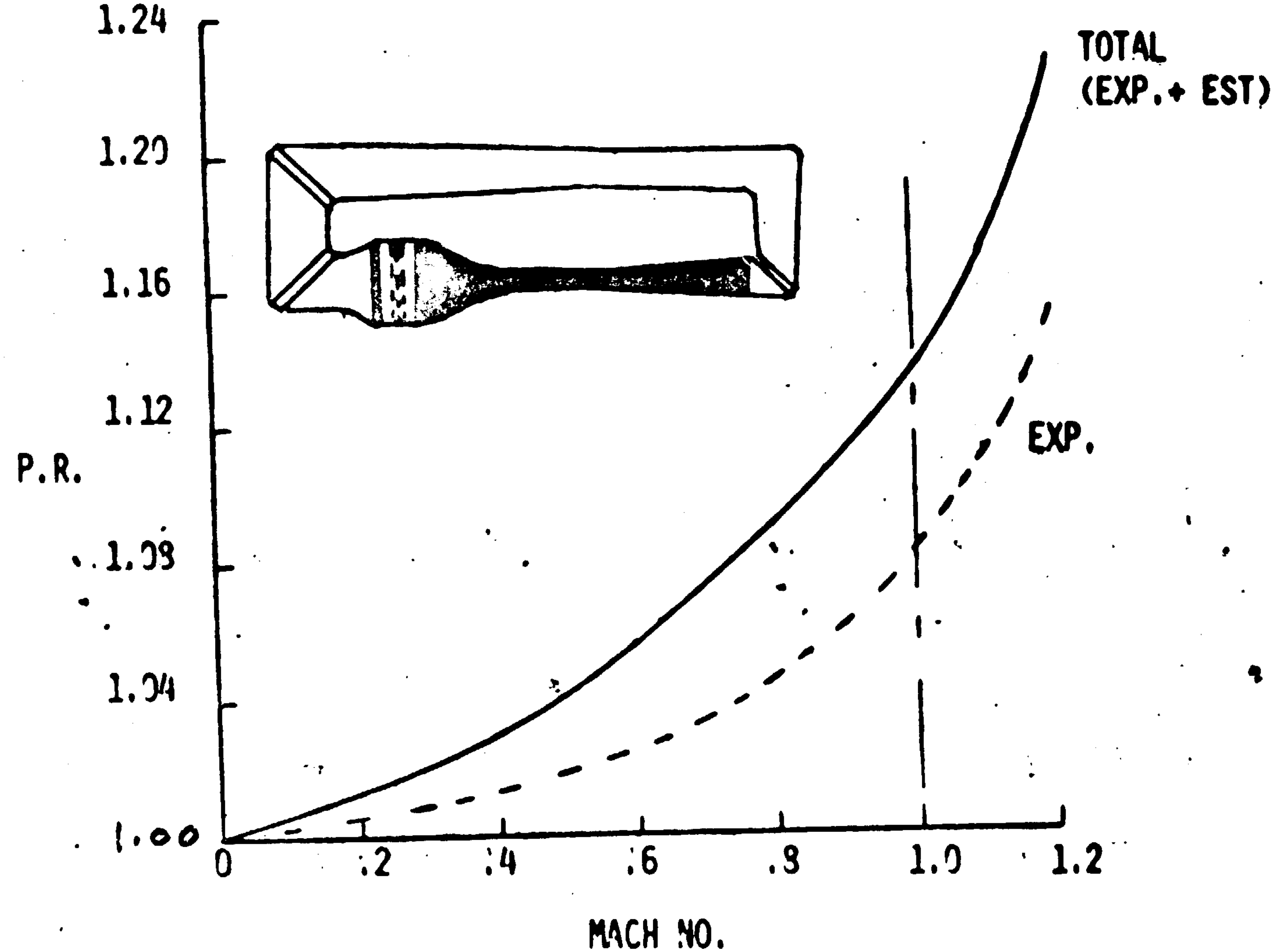
SECTION A-A

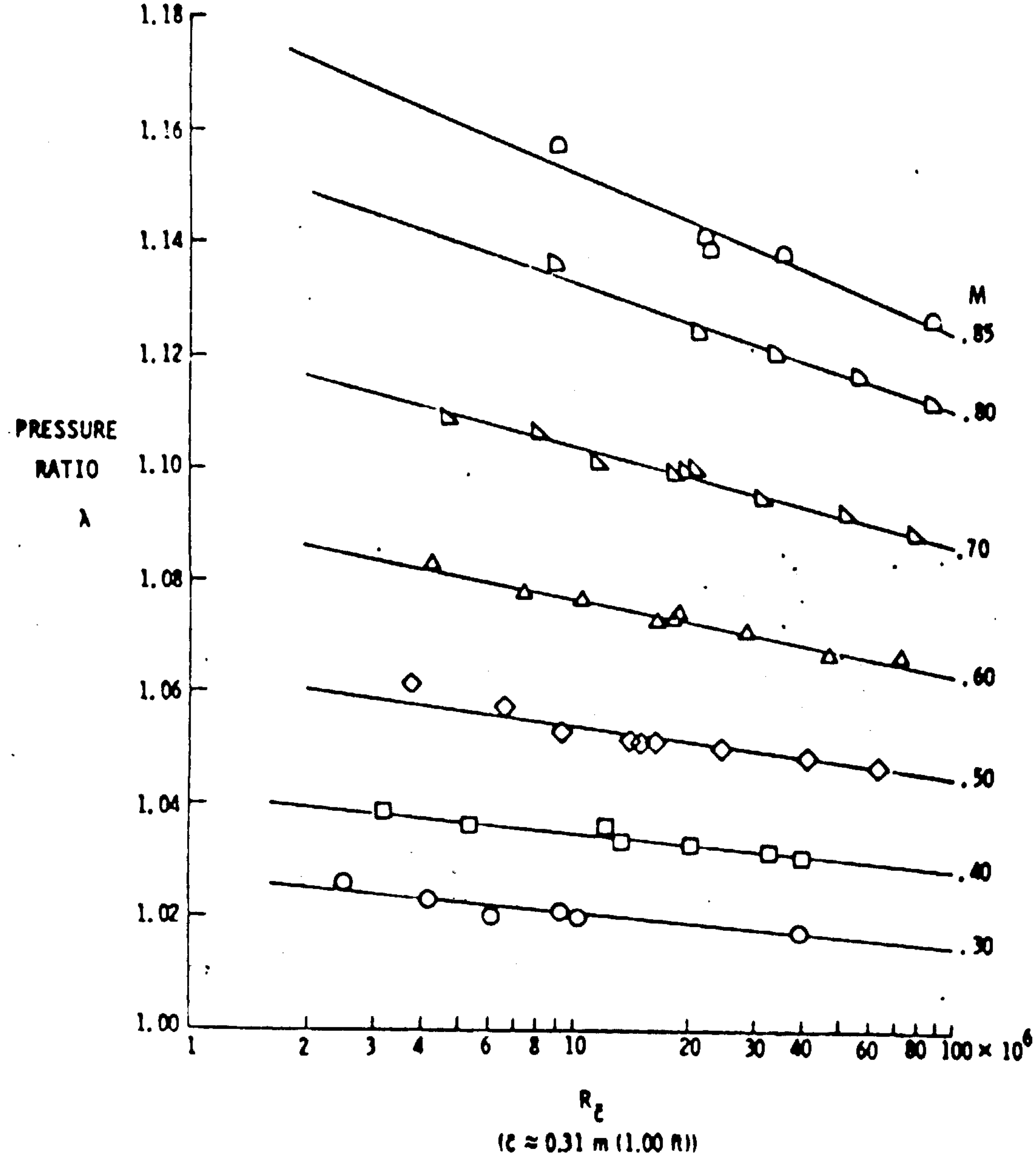


ORIGINAL PAGE IS
OF POOR QUALITY

NASA LANGLEY RESEARCH CENTER

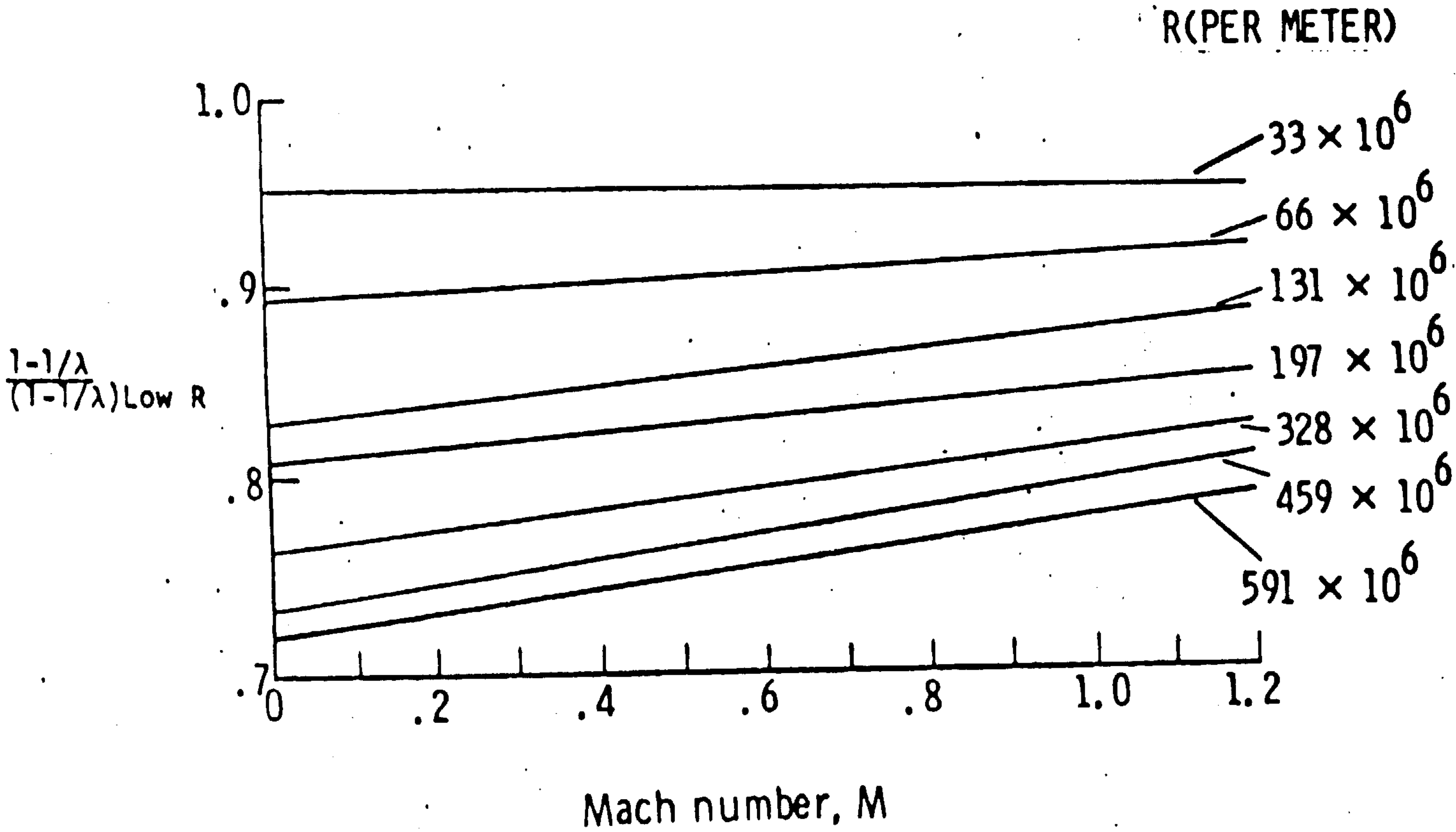
NTF FAN PRESSURE RATIO
RN = 4 X 10⁶/FT





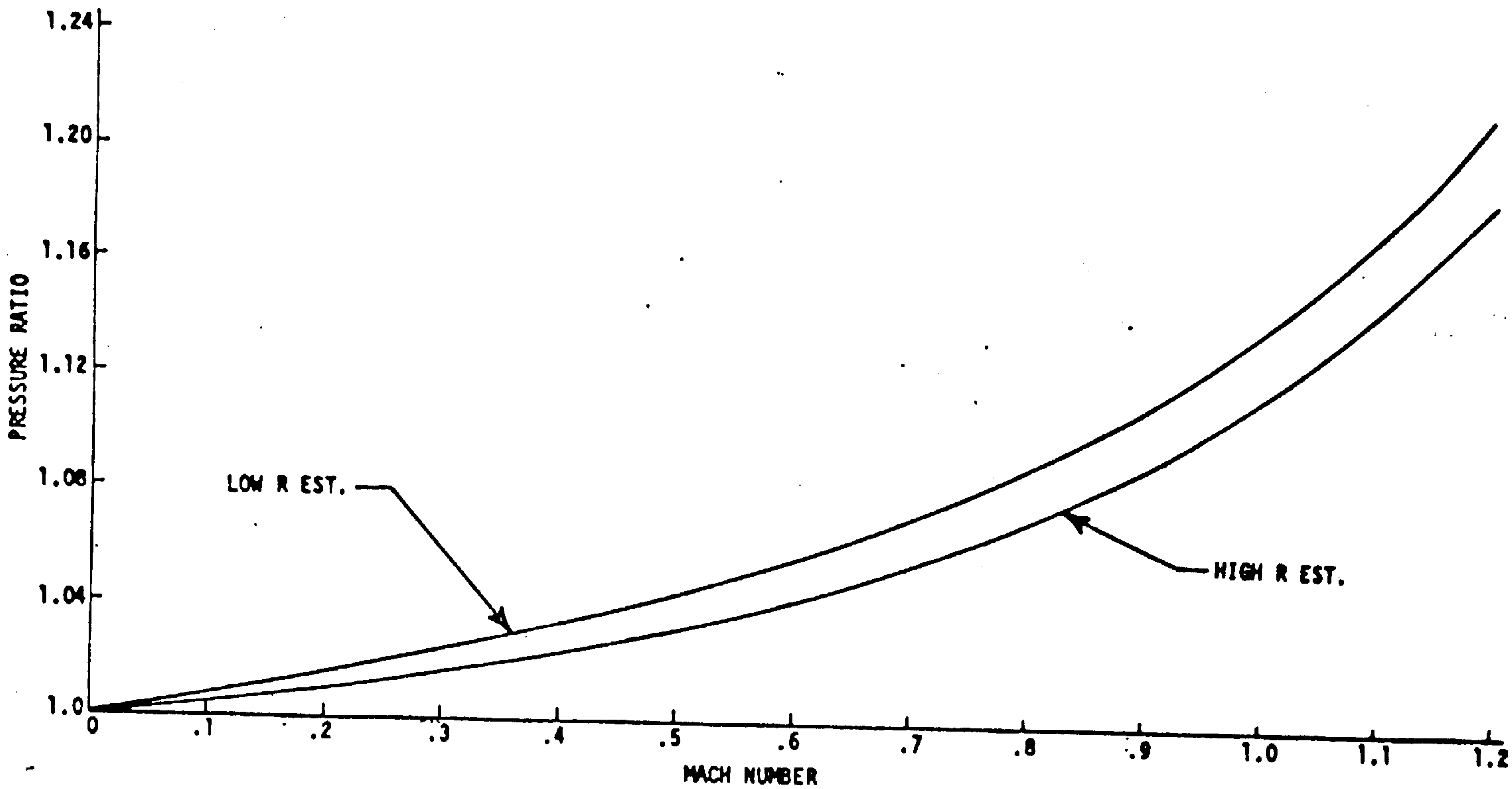
Effect of Reynolds number on tunnel pressure ratio
0.3-Meter Transonic Cryogenic Tunnel.

ORR 9/14/83 YII f

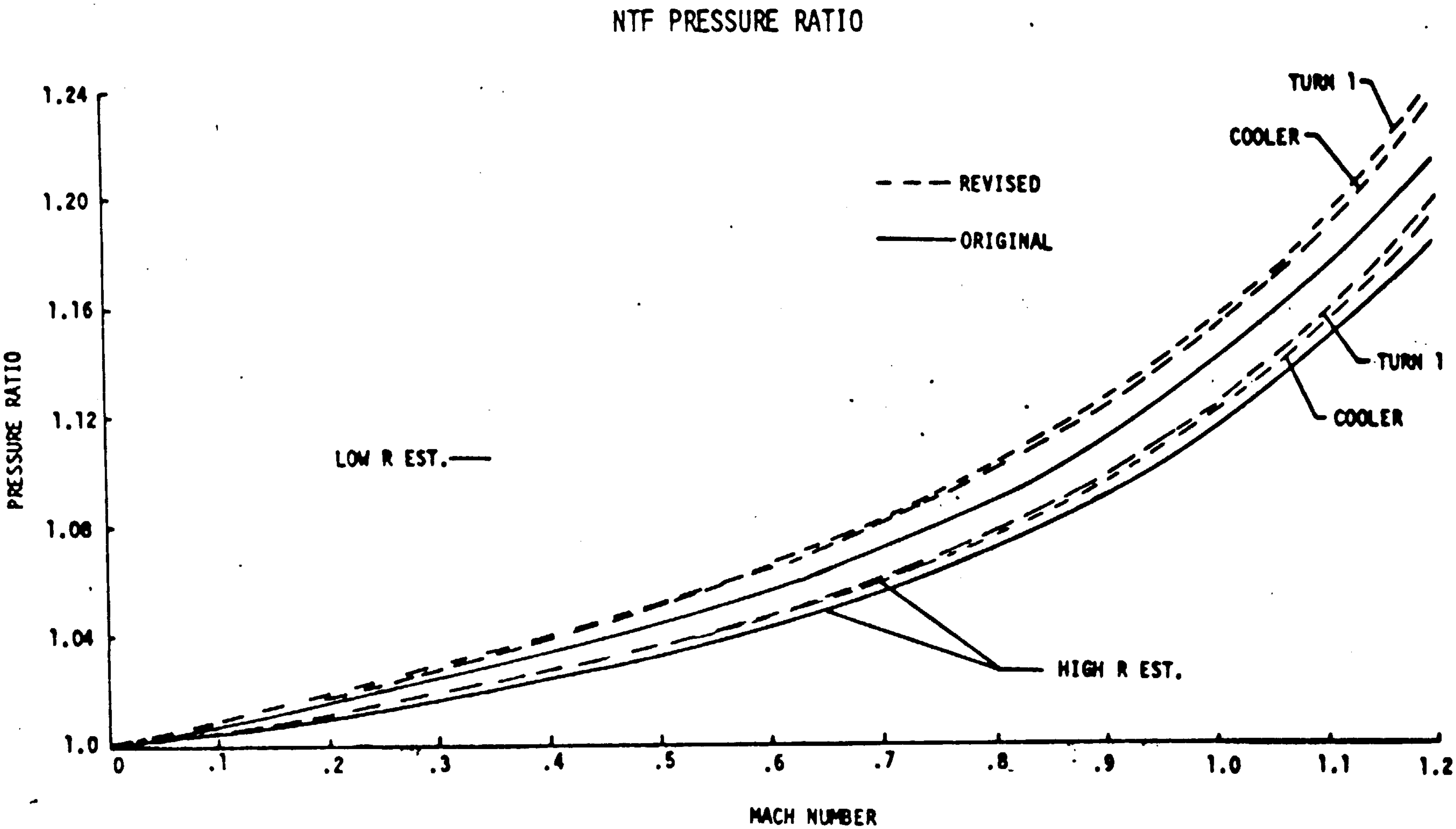


EFFECT OF REYNOLDS NUMBER ON TUNNEL PRESSURE LOSS.

NTF PRESSURE RATIO

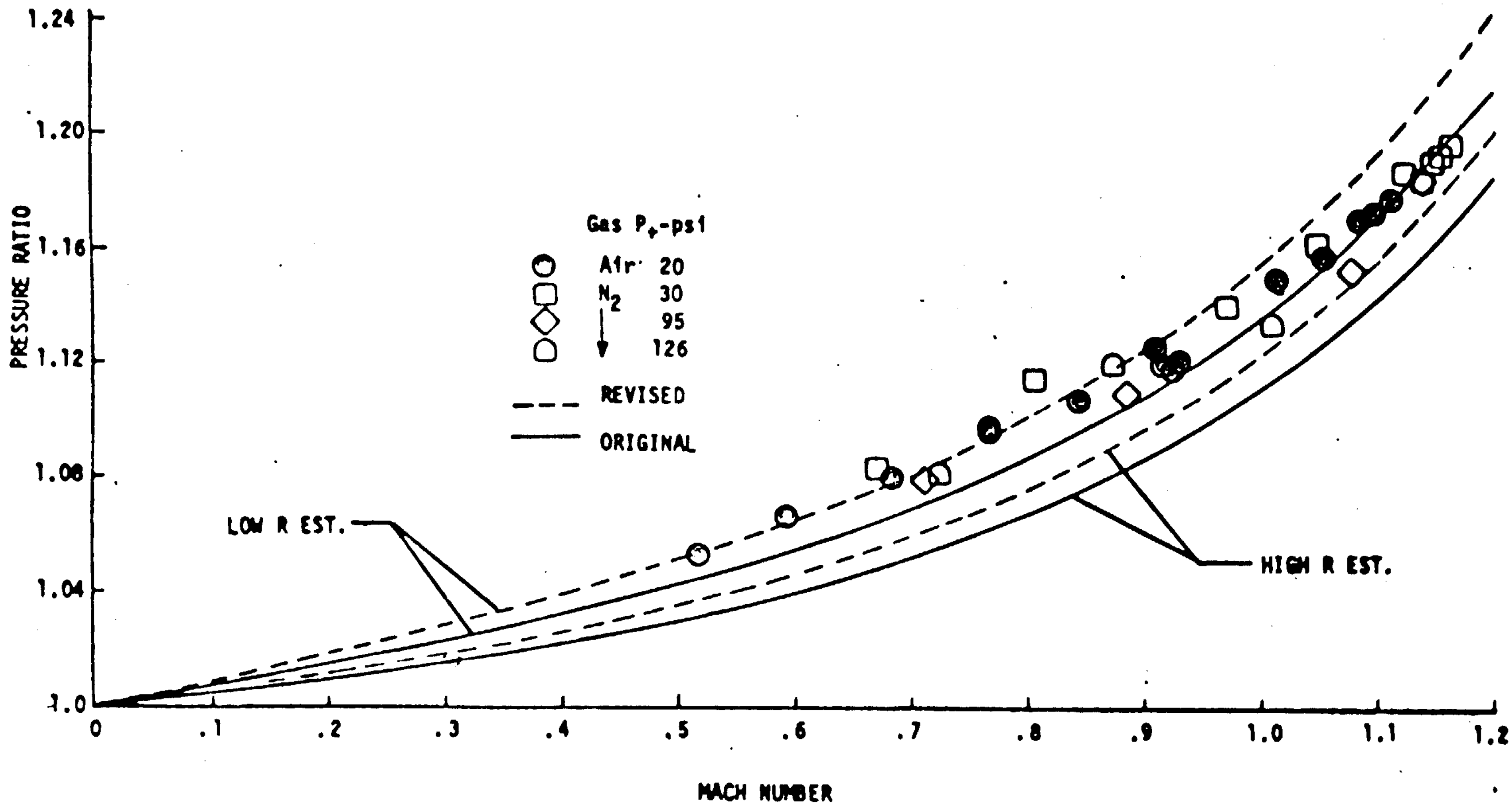


ORR 9/14/83 YTI



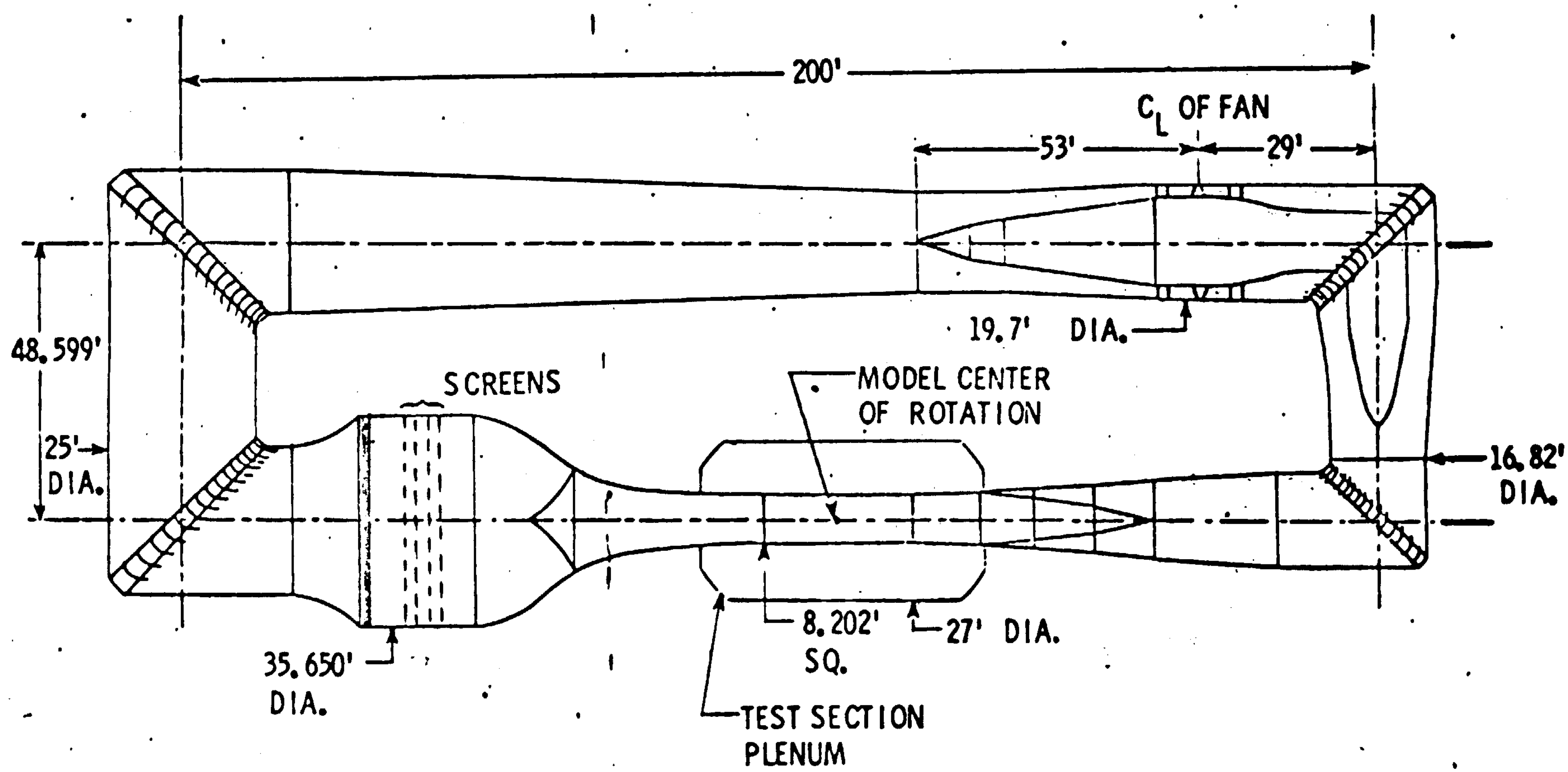
NTF PRESSURE RATIO
REVISED
ORIGINAL
TURN 1
COOLER
TURN 1
COOLER
LOW R EST.
HIGH R EST.
PRESSURE RATIO
MACH NUMBER
1.24
1.20
1.16
1.12
1.08
1.04
1.0
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
1.1
1.2

NTF PRESSURE RATIO

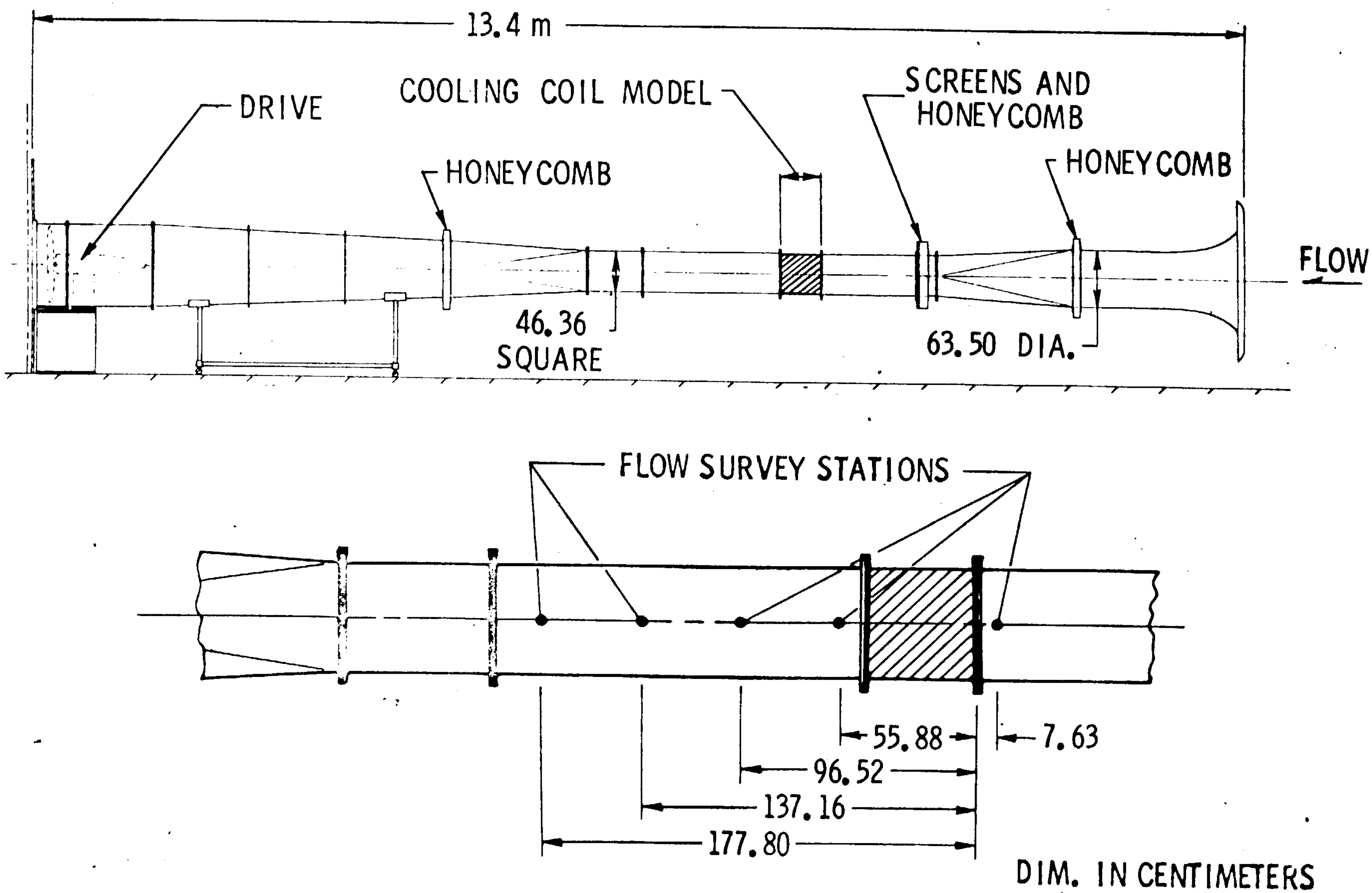


ORR 9/14/83 YII

NATIONAL TRANSONIC FACILITY

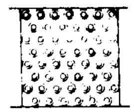
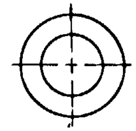
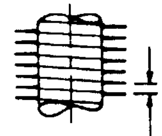
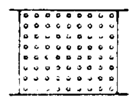
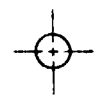
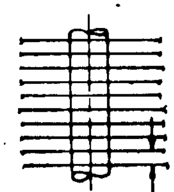
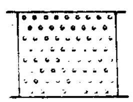
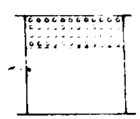
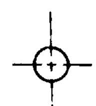
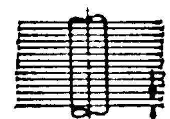


SCHEMATIC OF FLOW APPARATUS



NASA LANGLEY RESEARCH CENTER

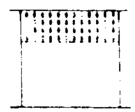
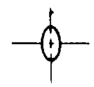
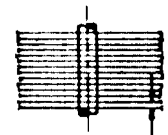
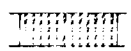
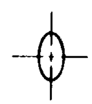
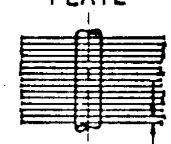
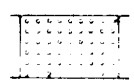
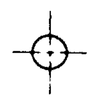
TEST MODELS

Model	Tube Geometry: Spacing*	Tube Geometry: Placement	Tube Geometry: Size*	Fin Geometry	Porosity	RN Range**	Test Facility
1	8 ROWS STAGGERED 6.05 x 6.99 ON CENTERS		2.84 O.D.  ROUND	SPIRAL  0.508	0.55	2 X 10^4 TO 3 X 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 X 10^4 TO 8 X 10^6	FLOW APPARATUS and 0.3 m TCT

* ALL DIMENSIONS IN CENTIMETERS

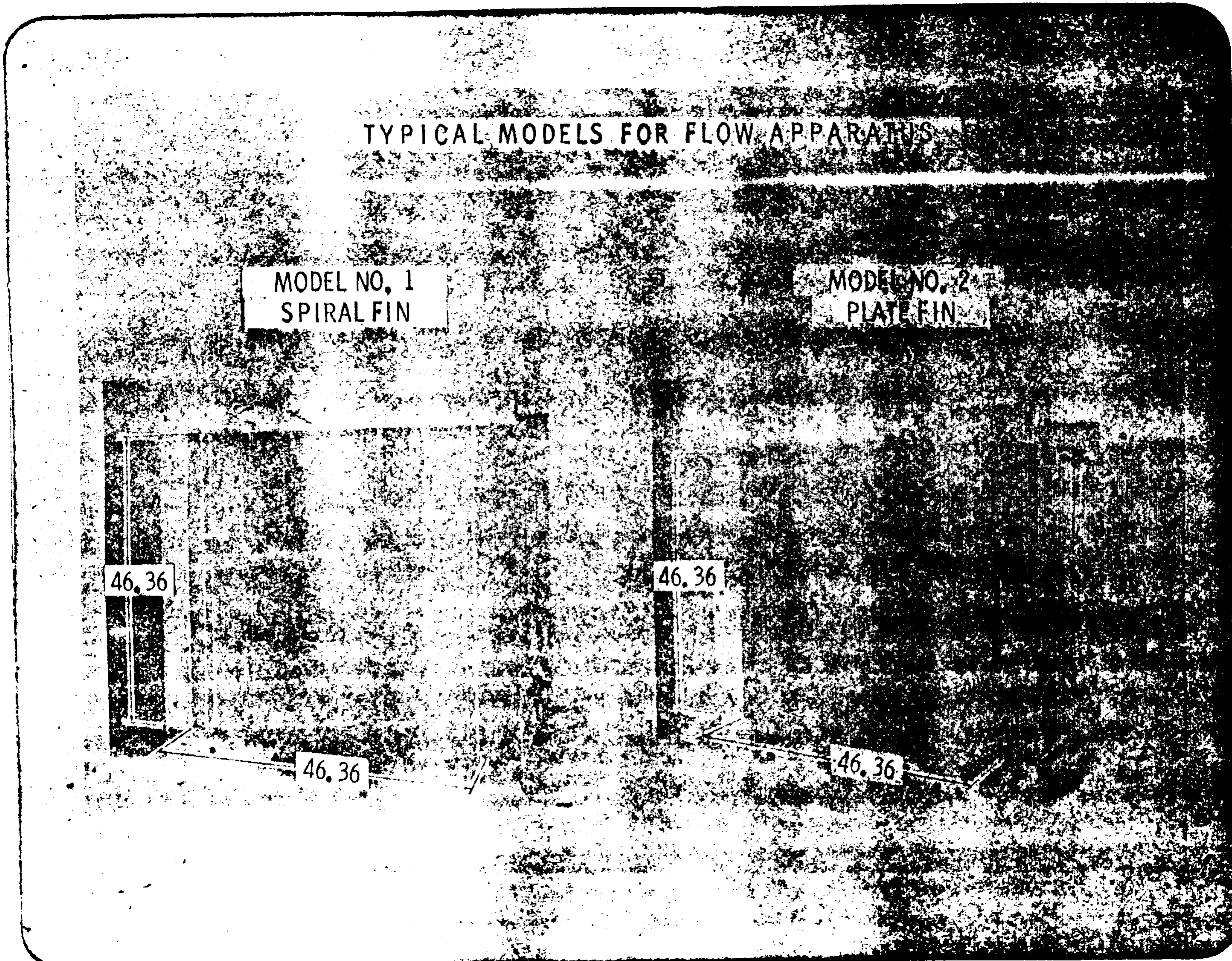
** RN PER FOOT

TEST MODELS (CONTINUED)

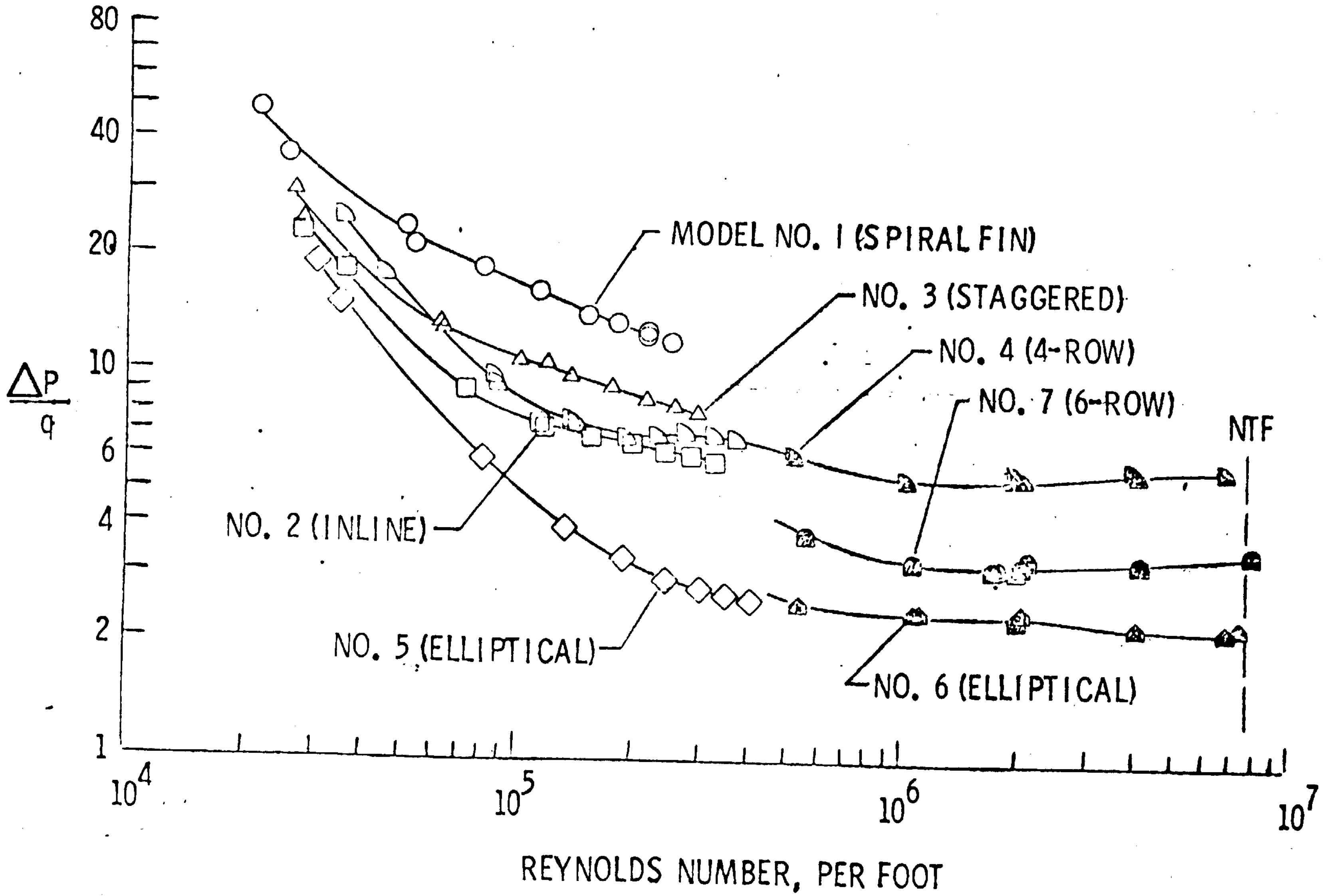
Model	Tube Geometry			Fin Geometry	Porosity	RN Range**	Test Facility
	Spacing*	Placement	Size*				
5	4 ROWS INLINE 3.81 x 3.81 ON CENTER		0.79 x 1.59  ELLIPSE	PLATE  0.25	0.71	2×10^4 TO 3×10^5	FLOW APPARATUS
6			1.14 x 2.27  ELLIPSE	PLATE  0.25	0.63	5×10^5 TO 8×10^6	0.3 m TCT
7	6 ROWS INLINE 5.08 x 5.08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

* ALL DIMENSIONS IN CENTIMETERS

** RN PER FOOT

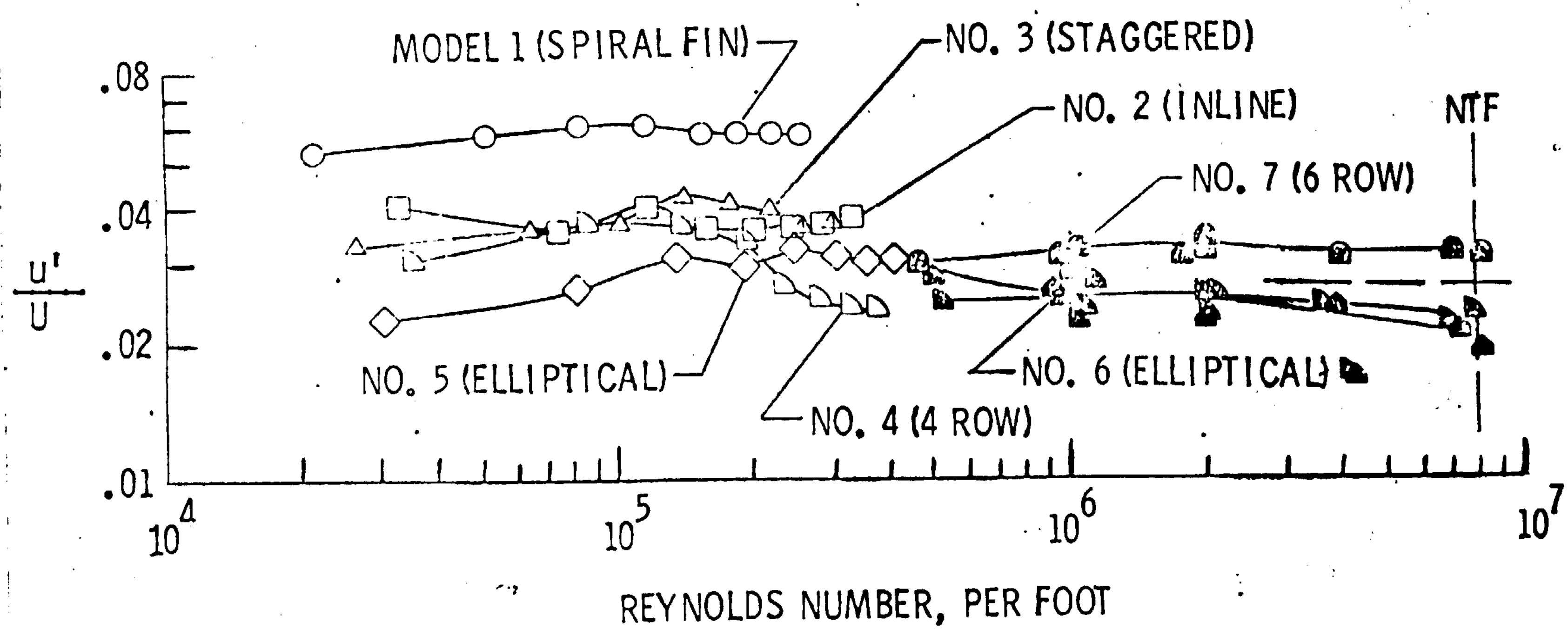

TYPICAL MODELS FOR FLOW APPARATUS
MODEL NO. 1
SPIRAL FIN
MODEL NO. 2
PLATE FIN
46.36
46.36
46.36
46.36

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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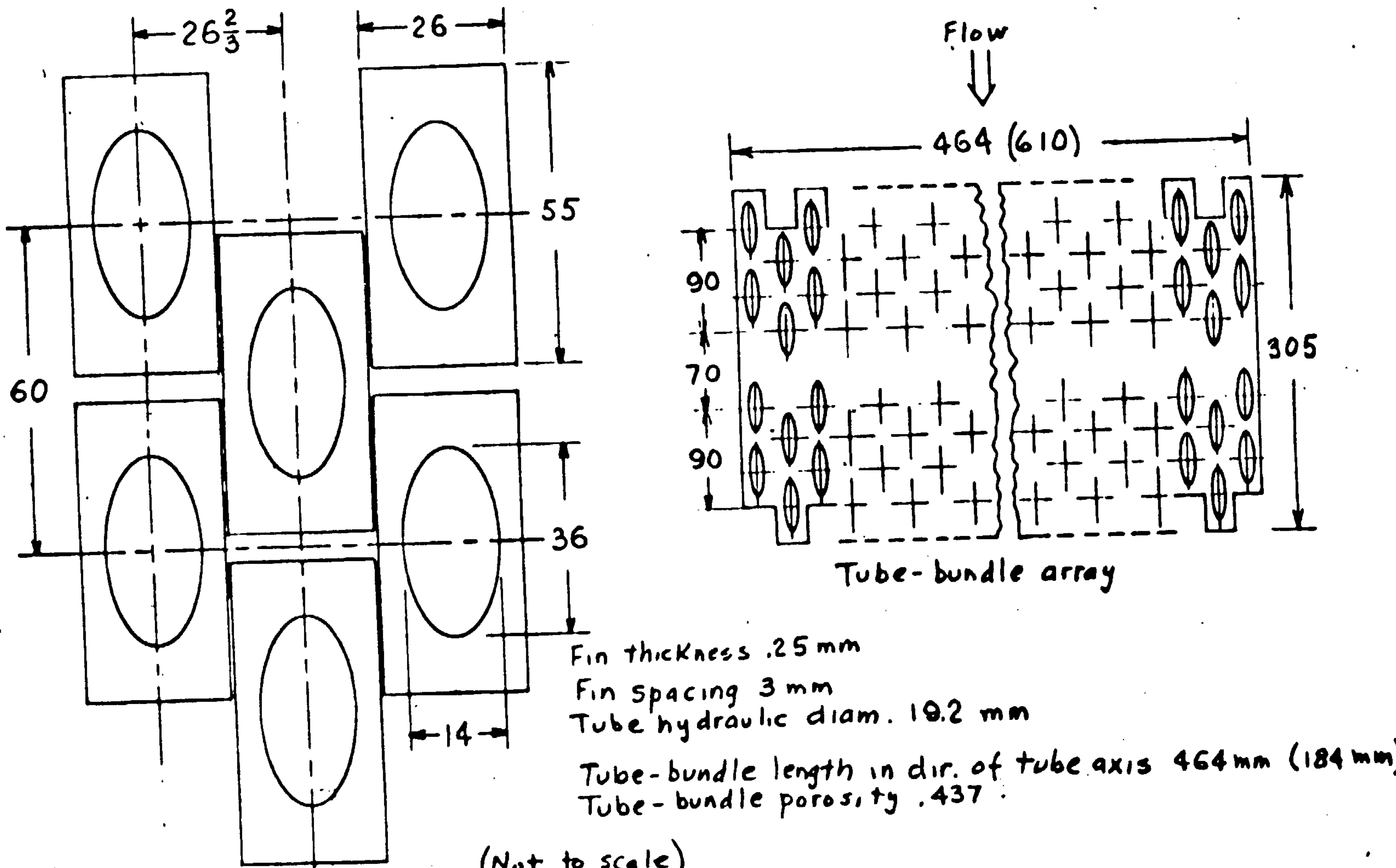
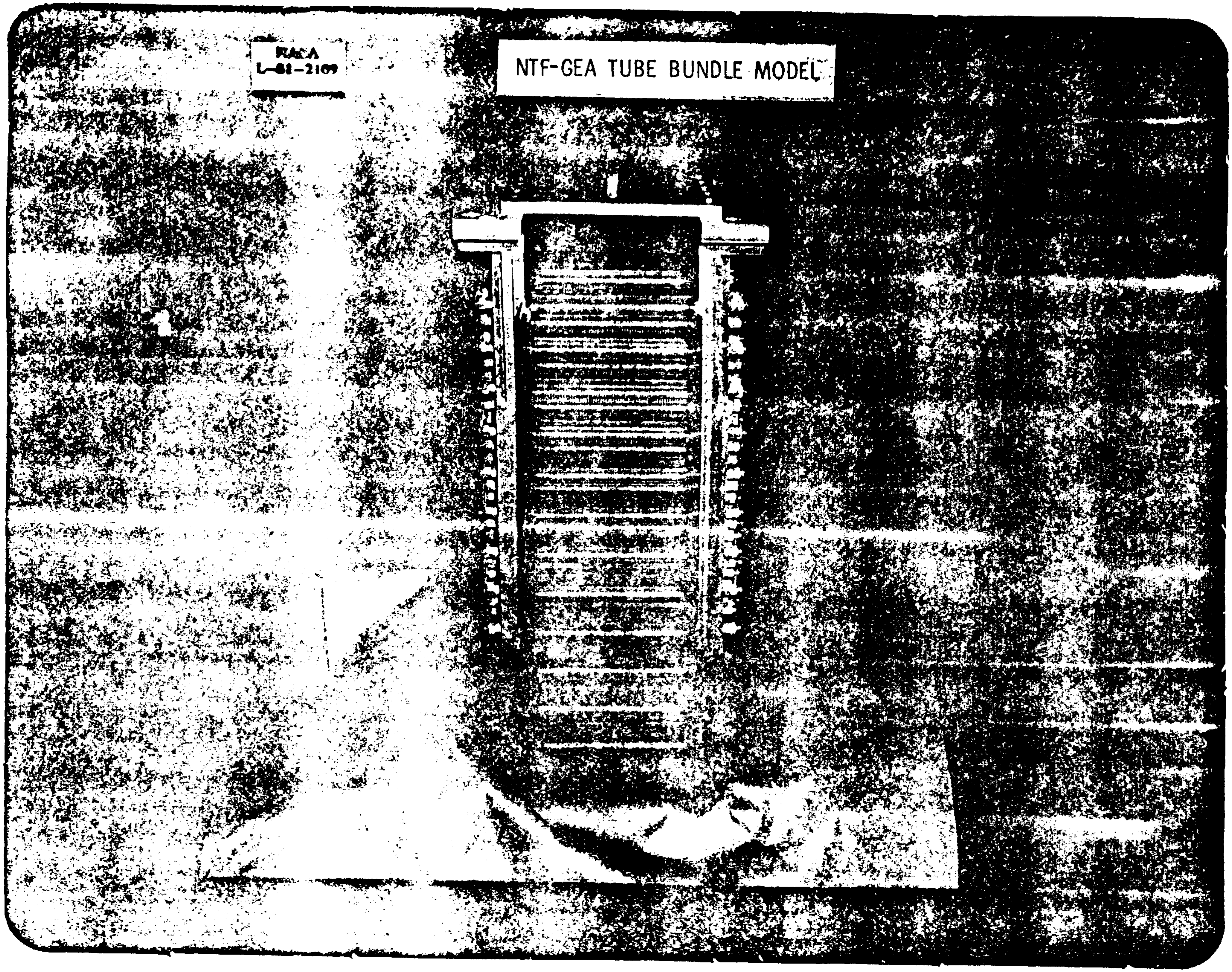
NASA-Langley, Form 92 (APR 69)

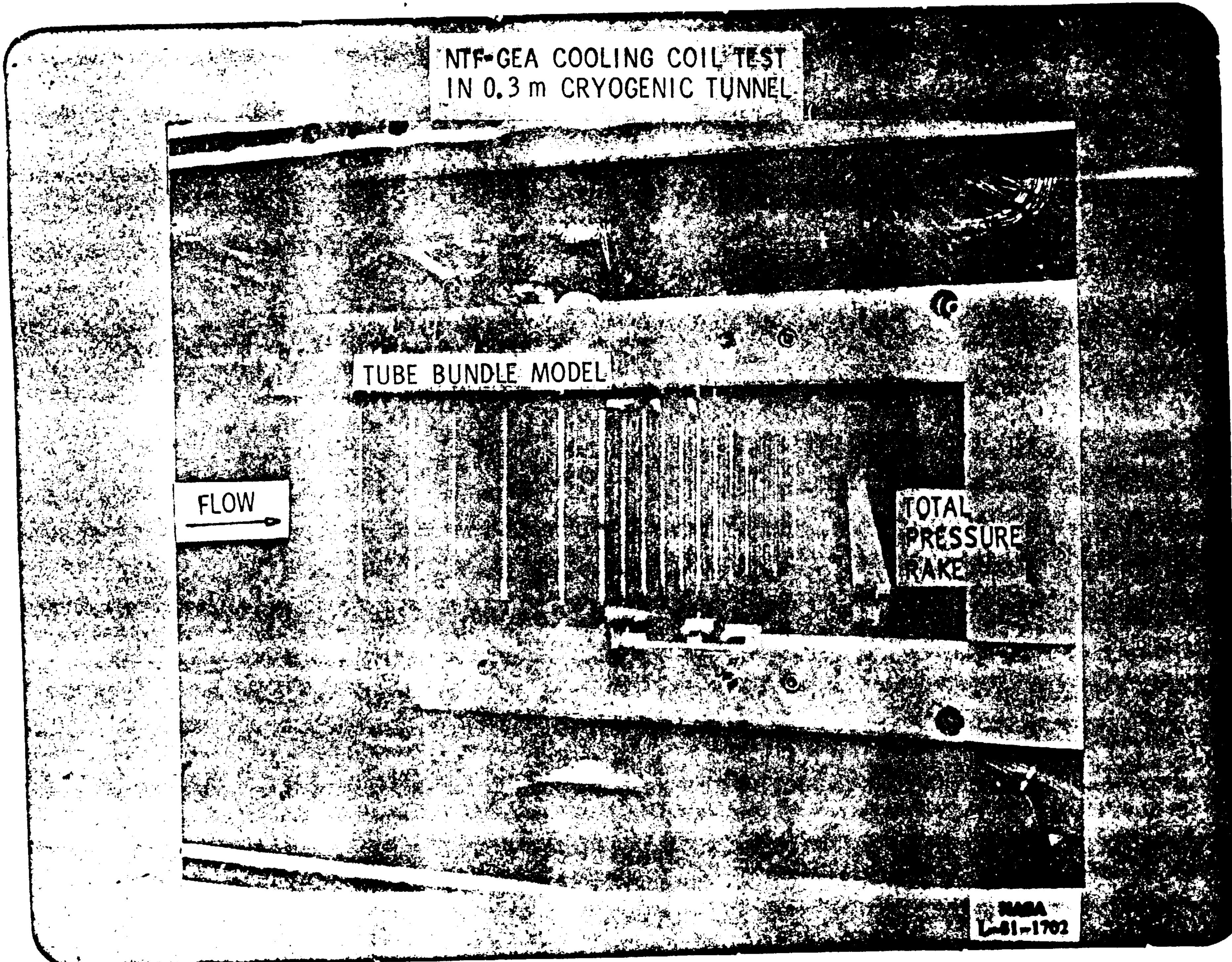
COOLING COIL AERODYNAMIC REQUIREMENTS

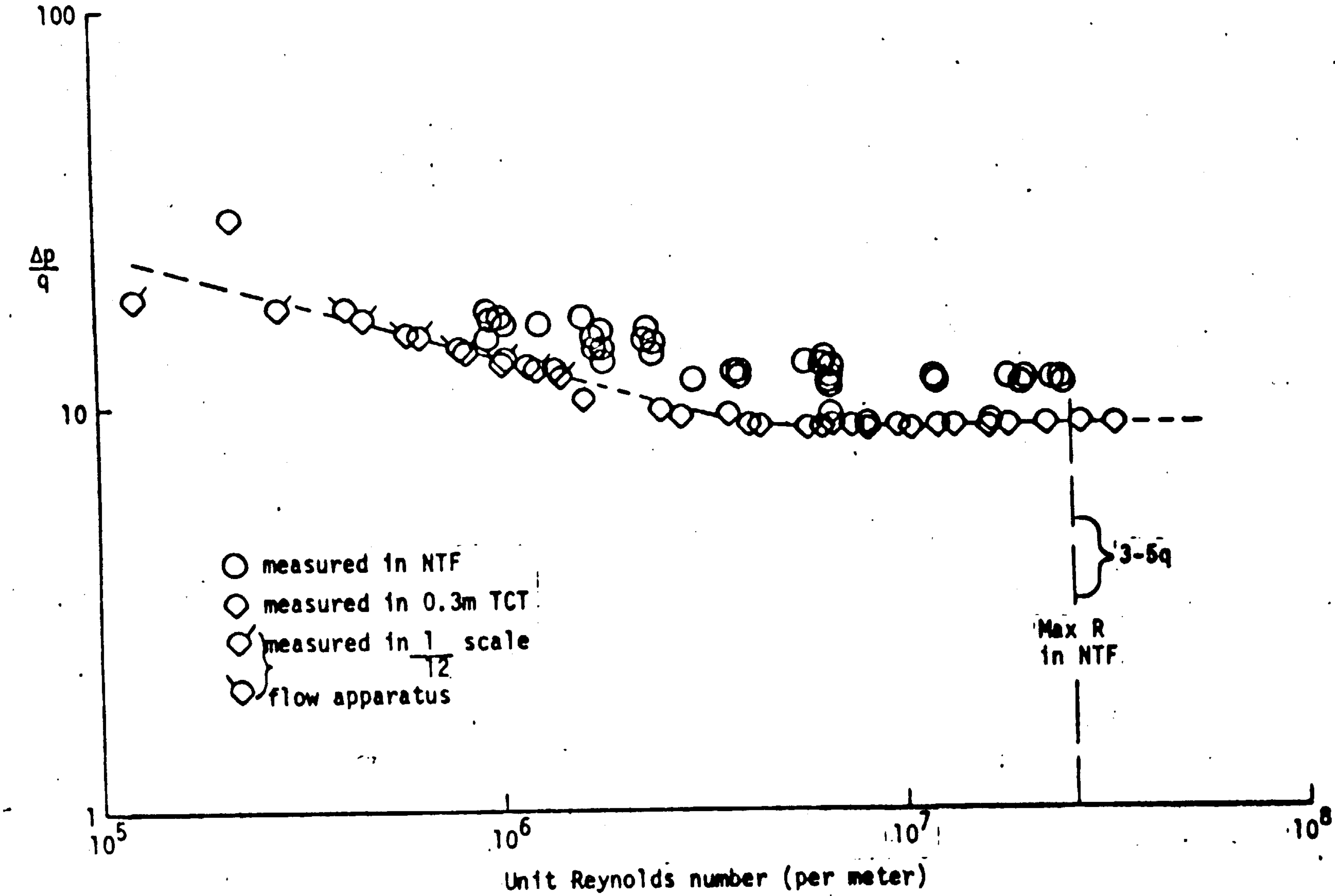
- $\frac{\Delta P_1}{q} \leqslant 5$
- DOWNSTREAM TURBULENCE $\leqslant .026$
- HEAT CAPACITY CORRESPONDING TO $M = 1.0$ @ $P_T = 2$ ATMOS.
  $T_T = 150^0F$, HP = 47,000



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

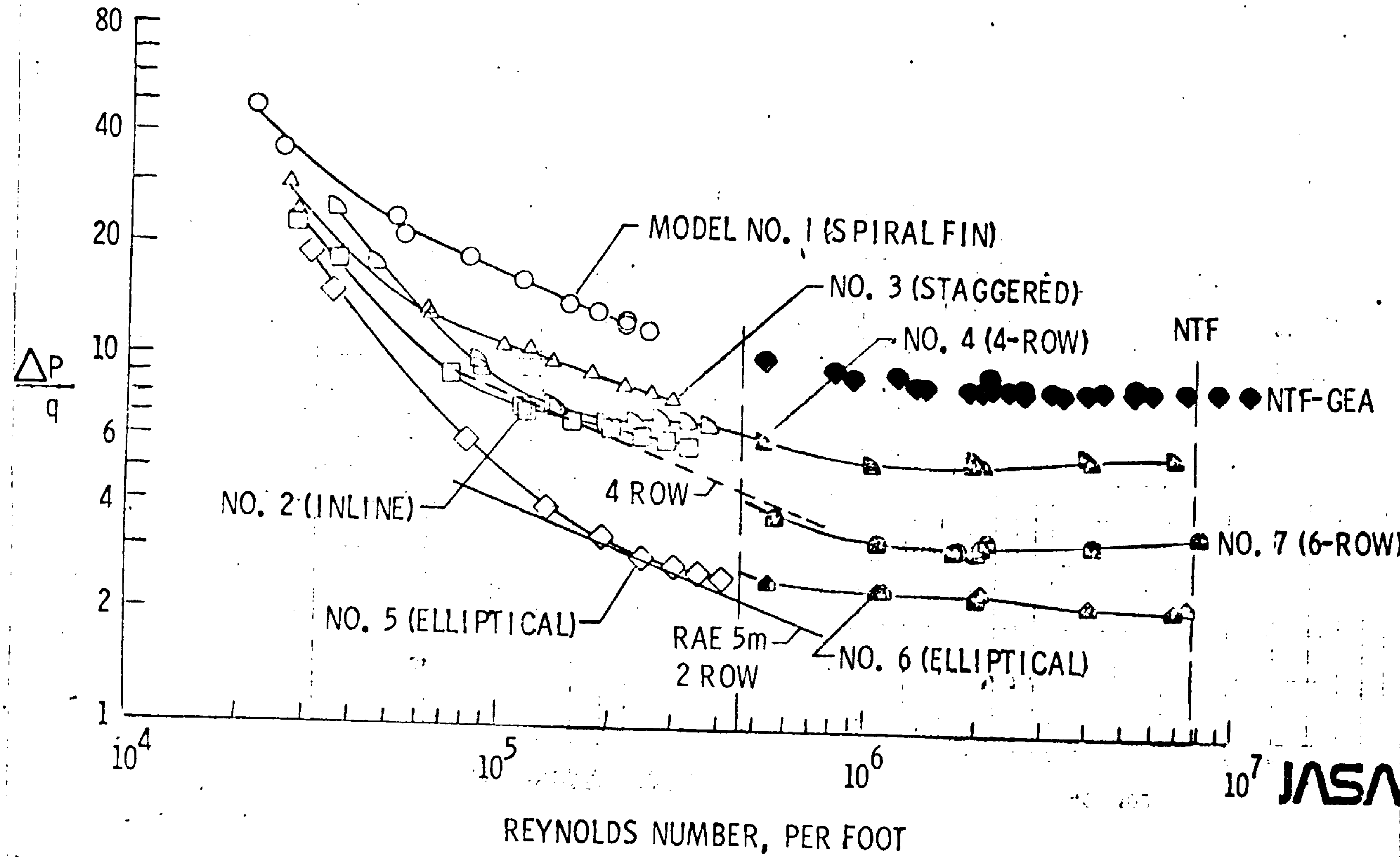

NTF-GEA TUBE BUNDLE MODEL


NTF-GEA COOLING COIL TEST
IN 0.3 m CRYOGENIC TUNNEL
TUBE BUNDLE MODEL
FLOW
TOTAL PRESSURE RAKE
NASA
L-81-1702



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

VARIATION OF PRESSURE LOSS WITH REYNOLDS NUMBER



NASA

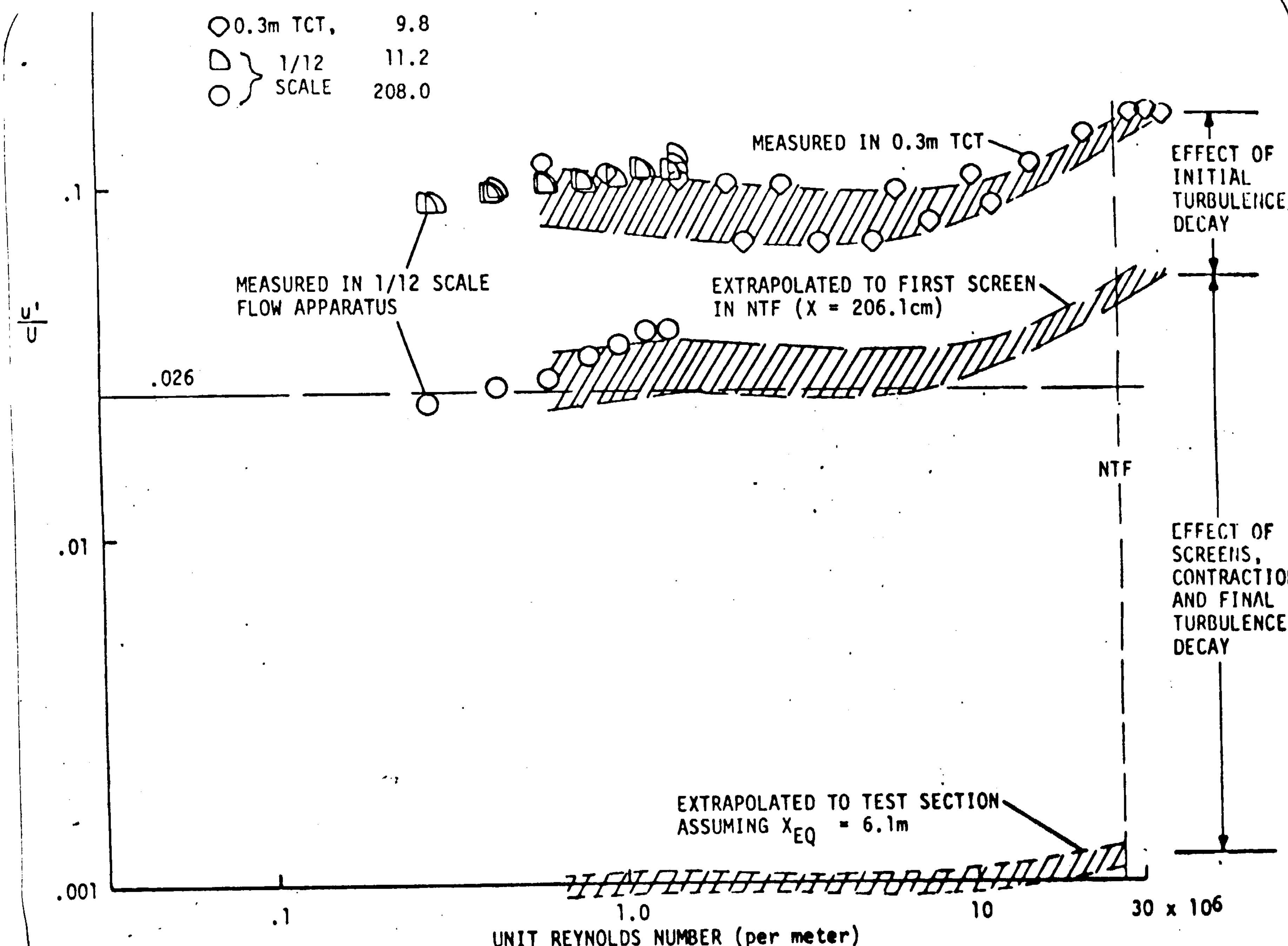
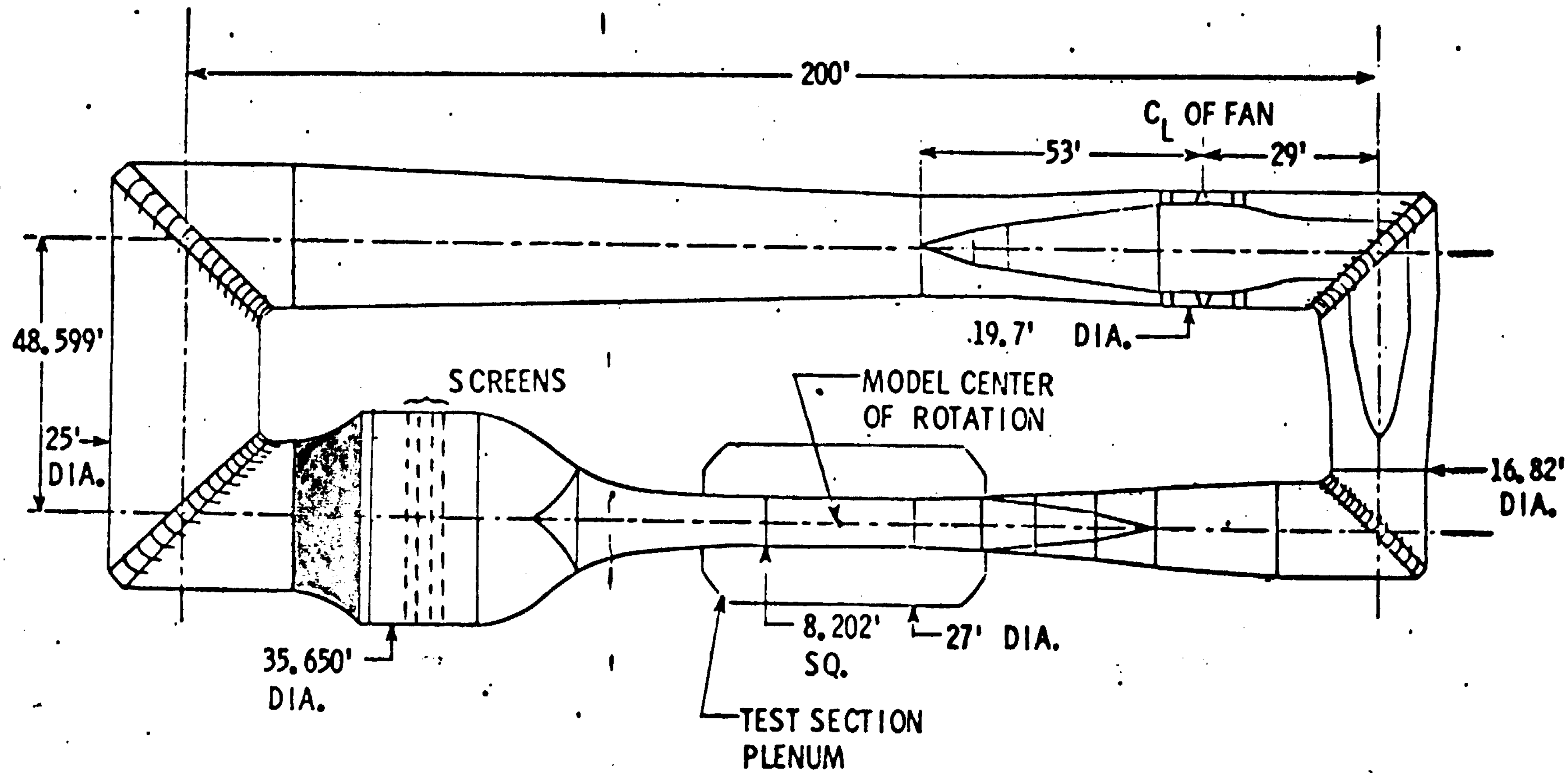
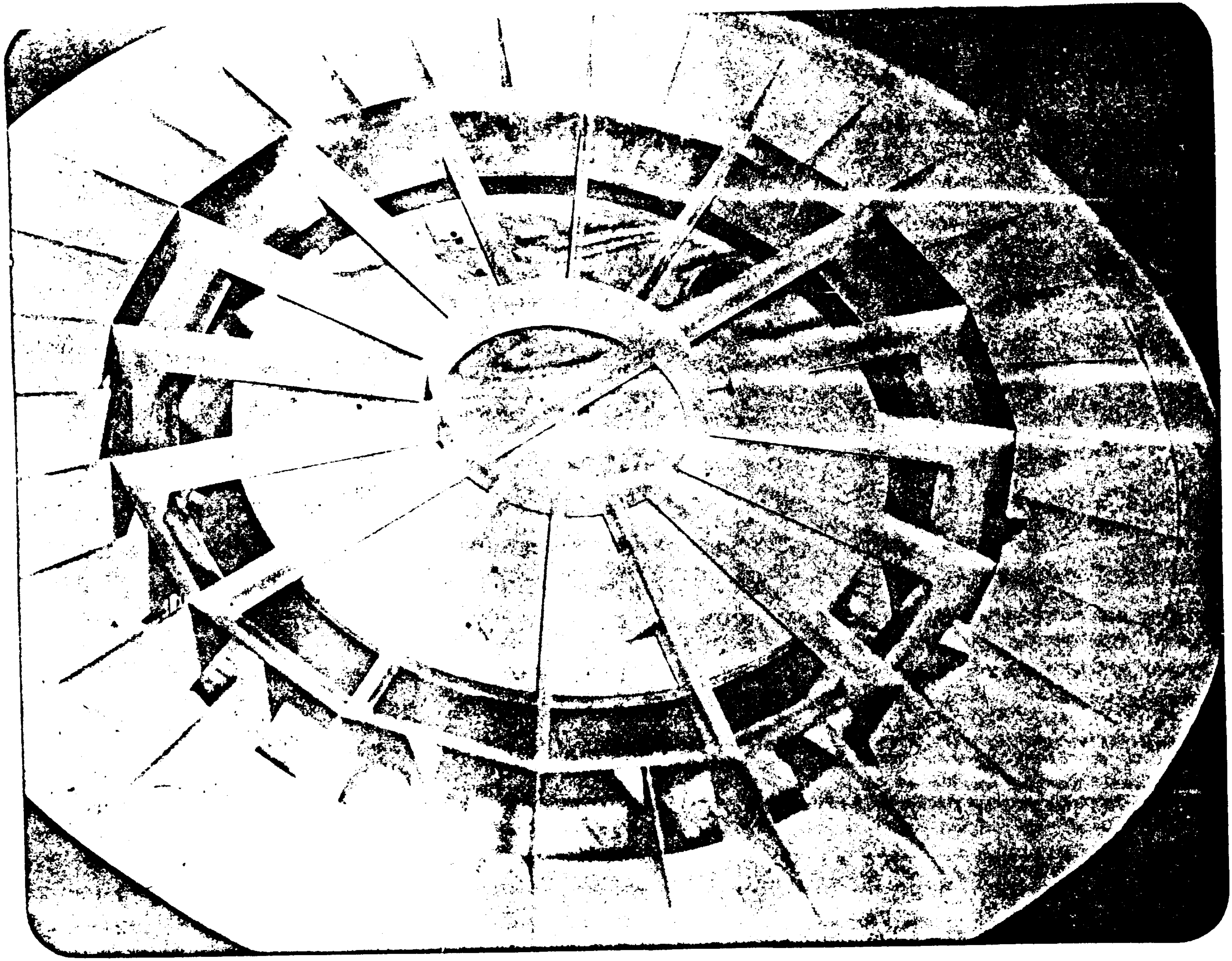


FIGURE 3: LONGITUDINAL COMPONENT OF TURBULENCE (rms) FOR THE NTF-GEA HEAT EXCHANGER.

NATIONAL TRANSONIC FACILITY





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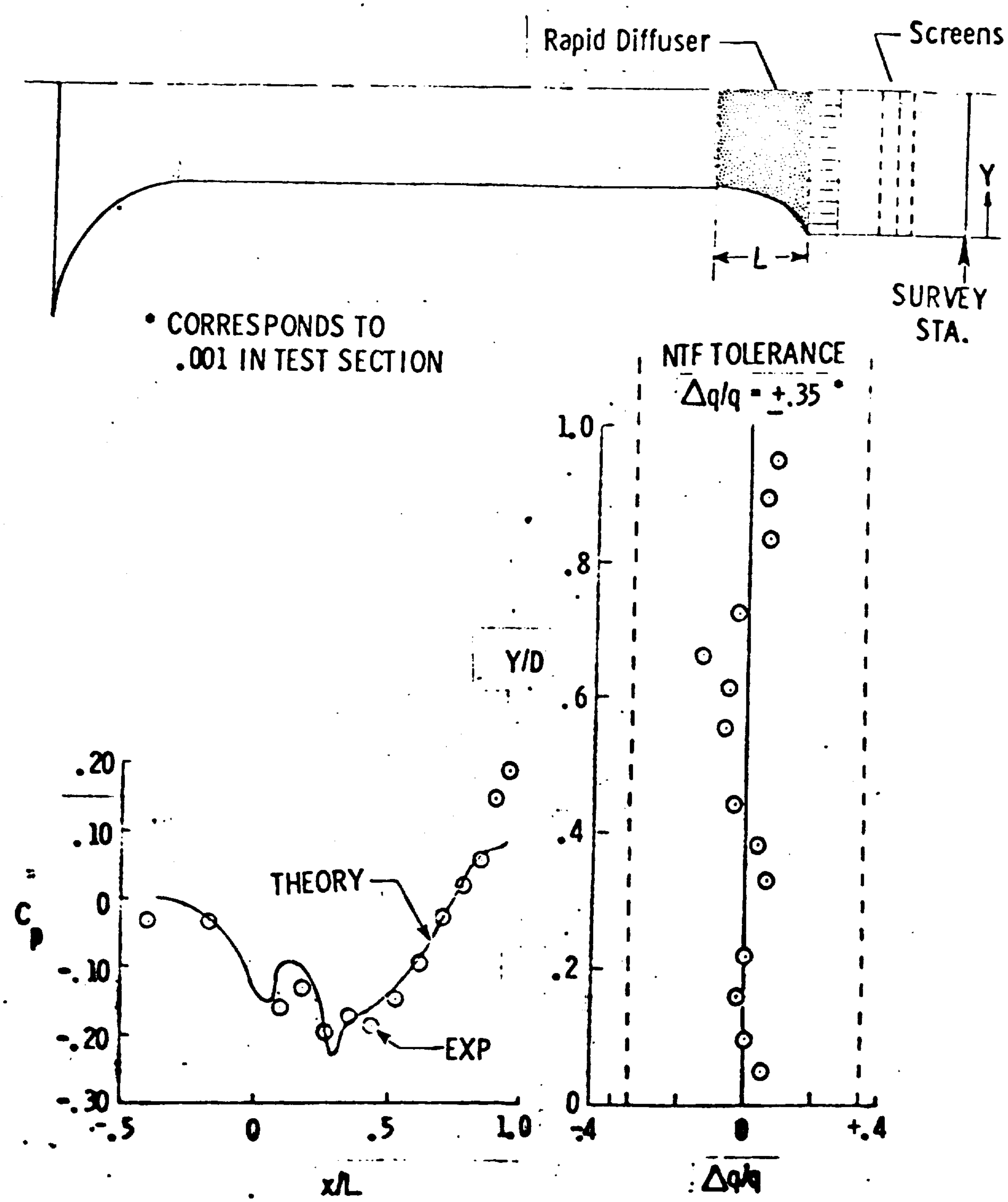
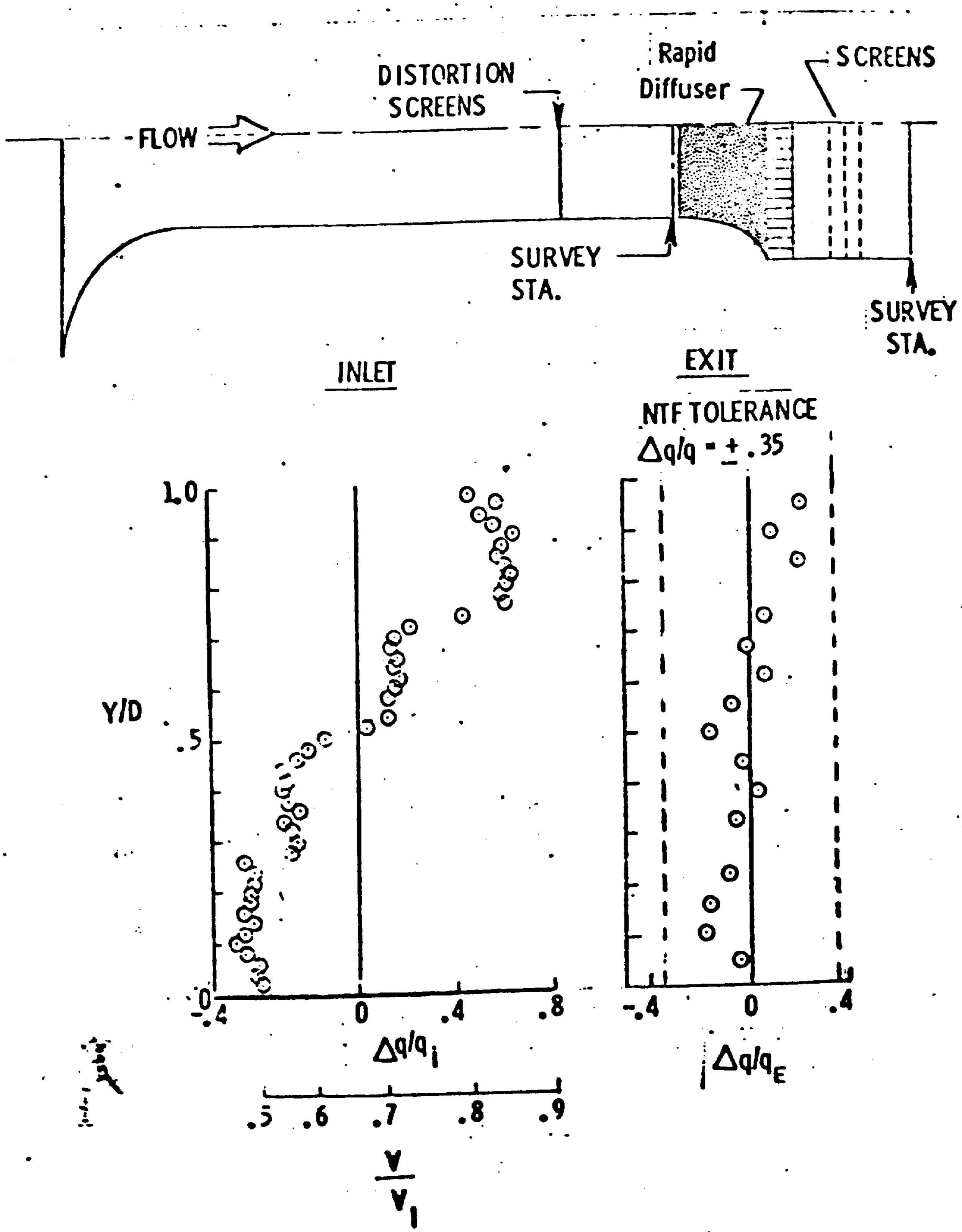
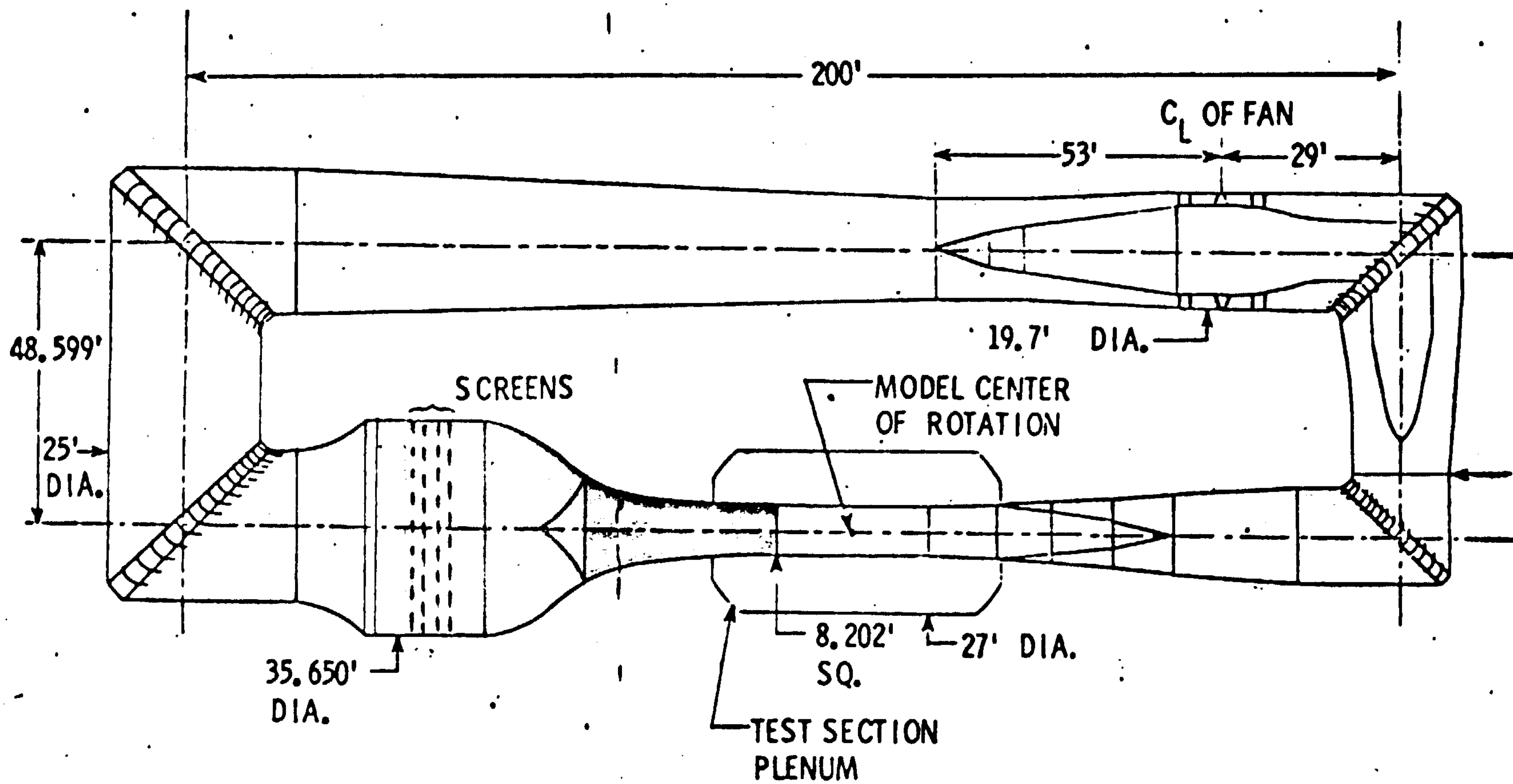
RAPID DIFFUSER PERFORMANCE (NTF)



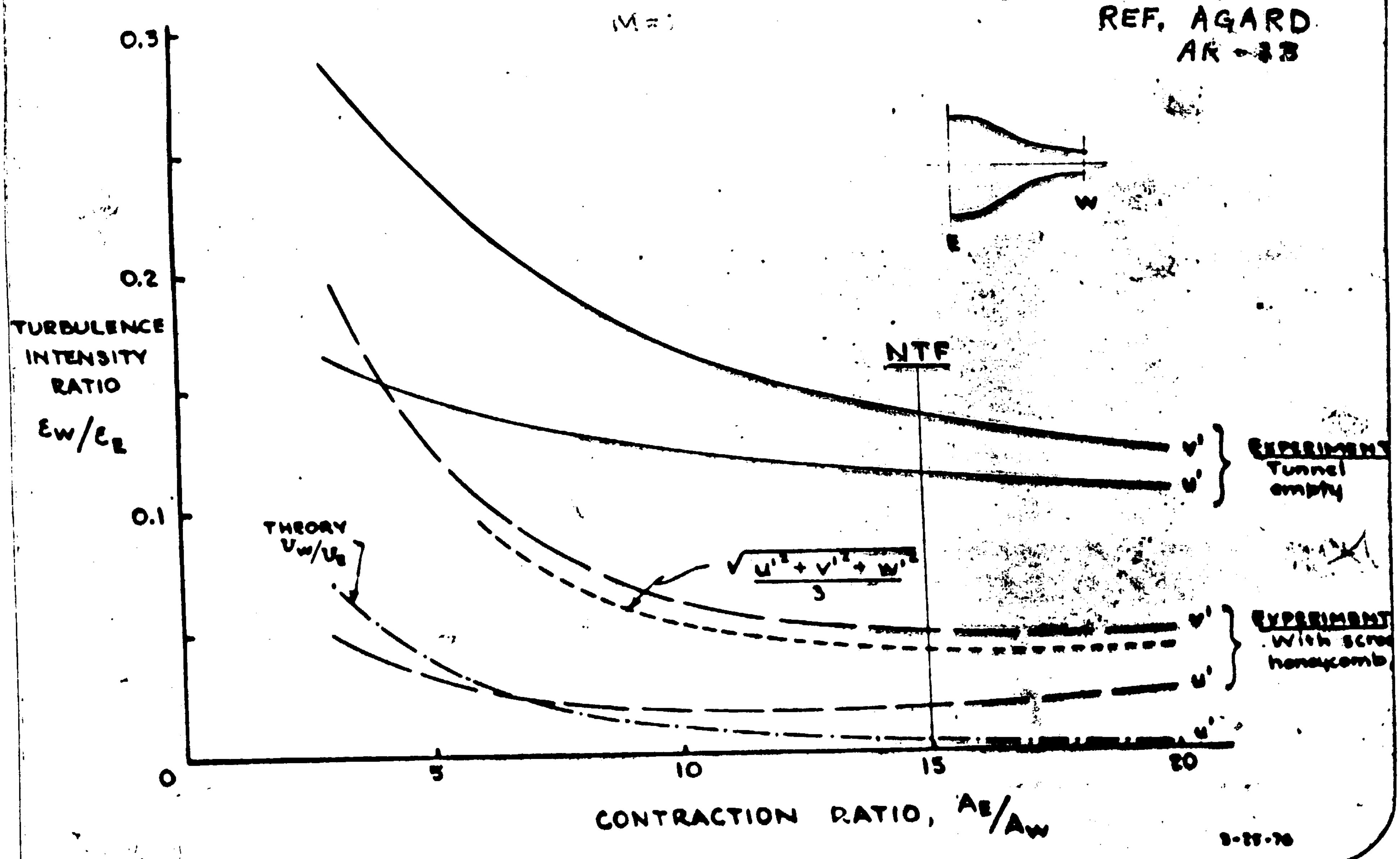
EFFECT OF DISTORTED INLET VELOCITY PROFILE ON RAPI DIFFUSER PERFORMANCE



NATIONAL TRANSONIC FACILITY

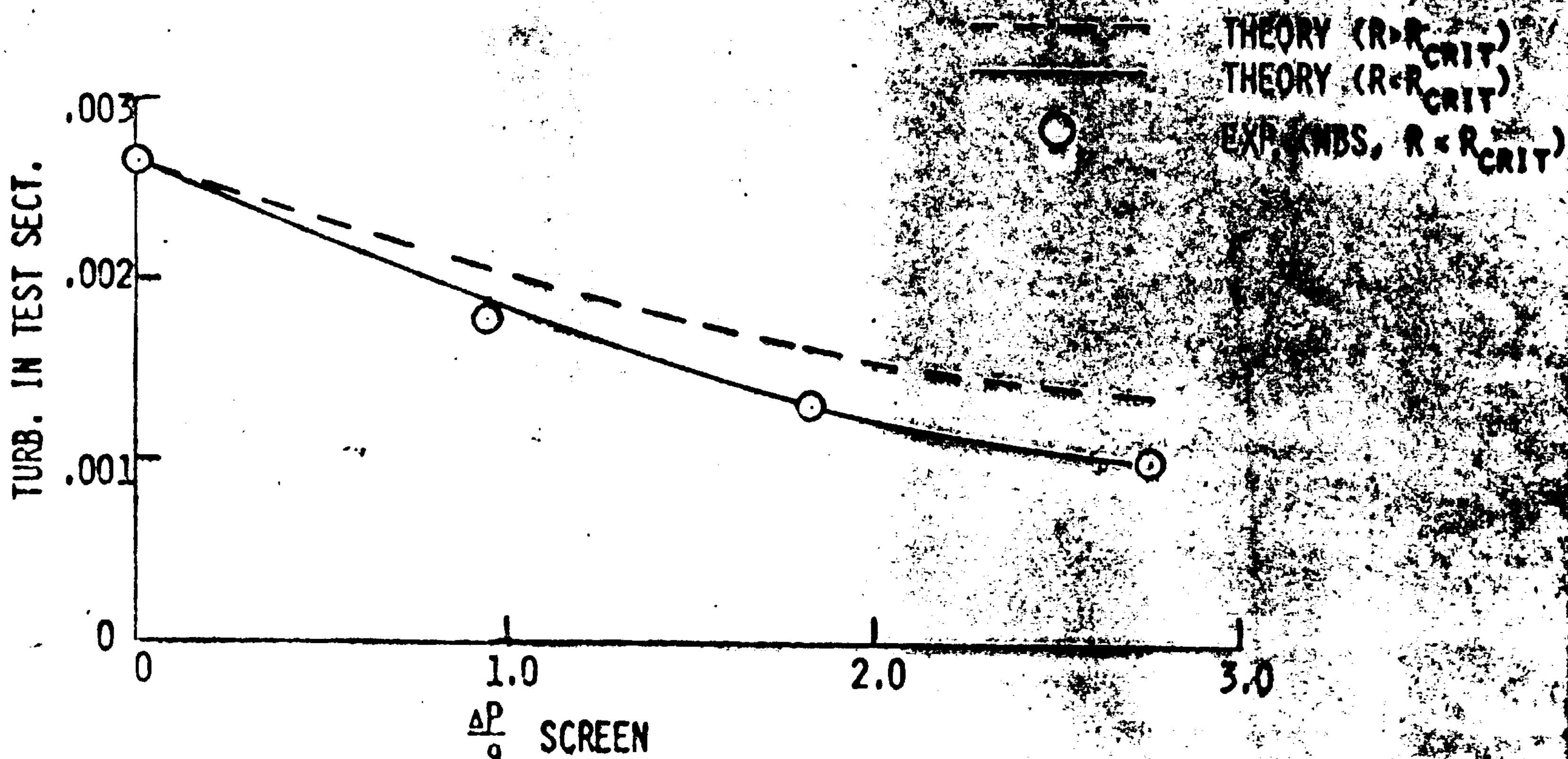


EFFECTS OF CONTRACTION RATIO

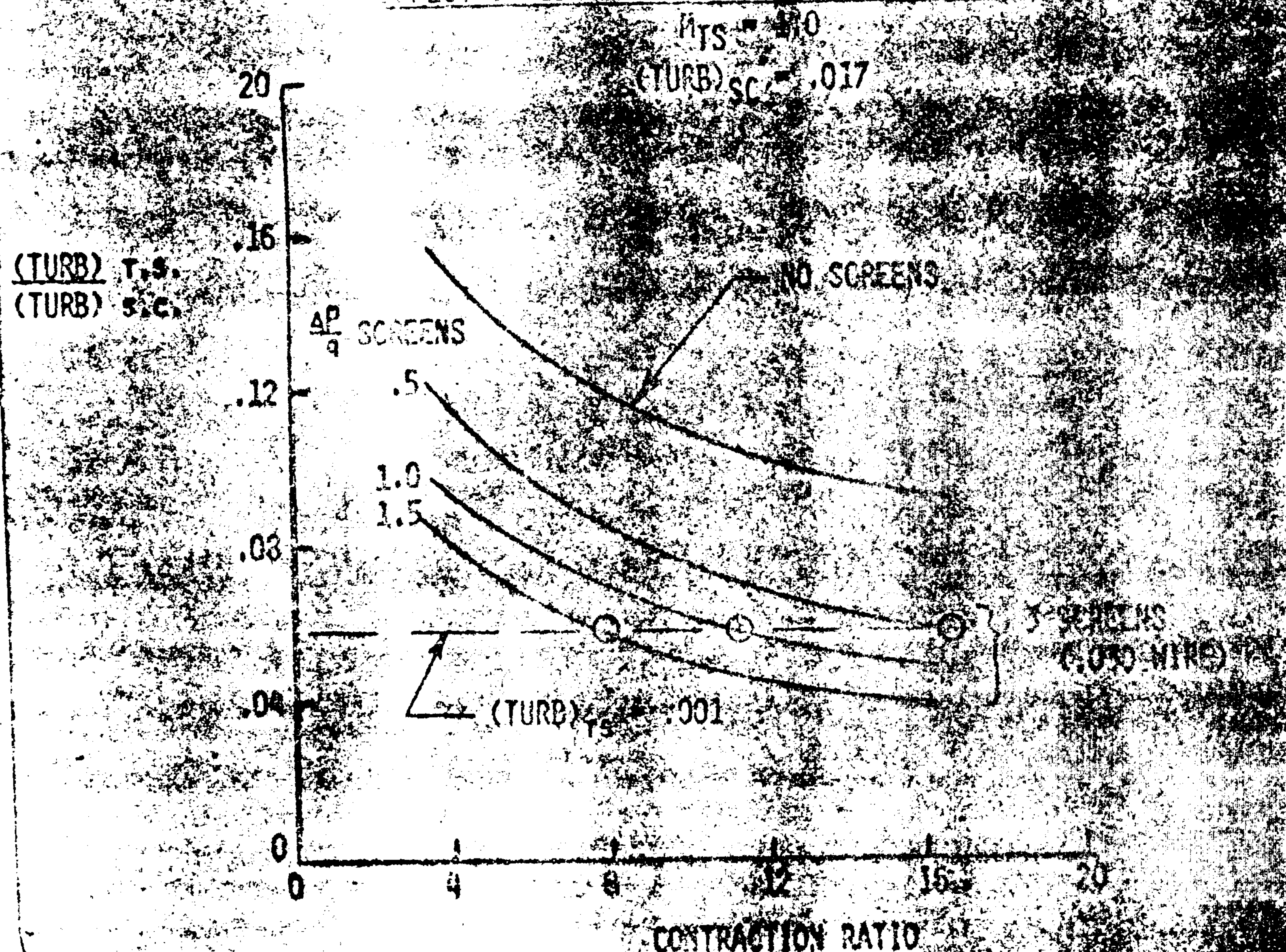


COMPARISON OF THEORY AND EXPERIMENT

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



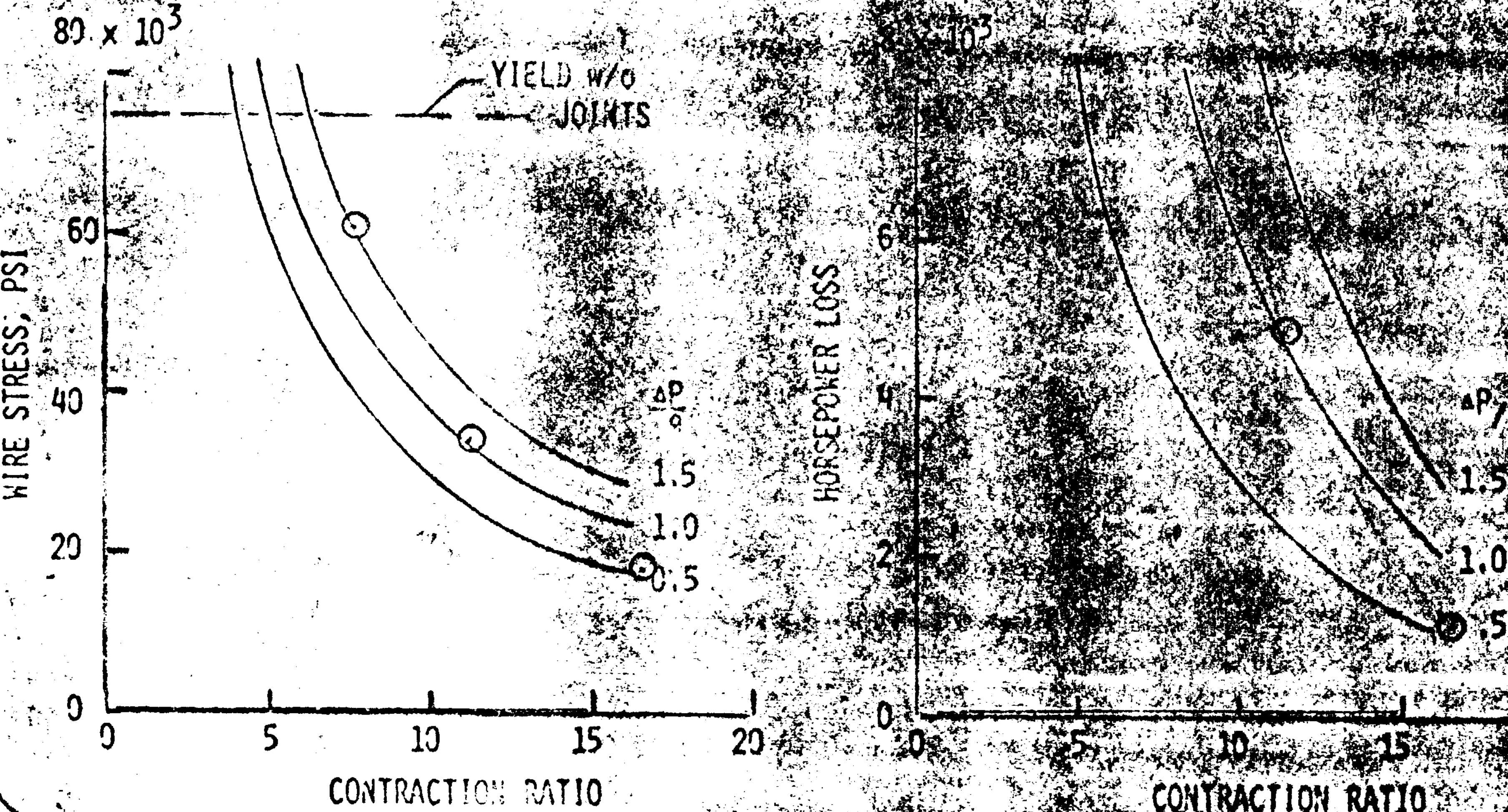
EFFECT OF CONTRACTION AND SCREENS ON TURBULENCE



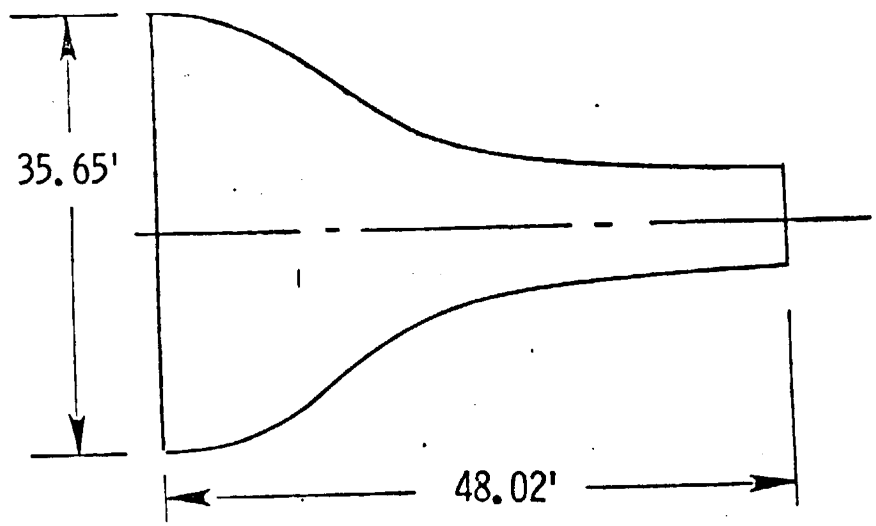
C-5

ORIGINAL PAGE IS OF POOR QUALITY

EFFECT OF C.R. ON SCREEN STRESS AND HORSEPOWER
(3 SCREENS .030 WIRE DIA. 2FT SAG)
M=1.0 P_T 130 PSIA



NTF CONTRACTION SECTION



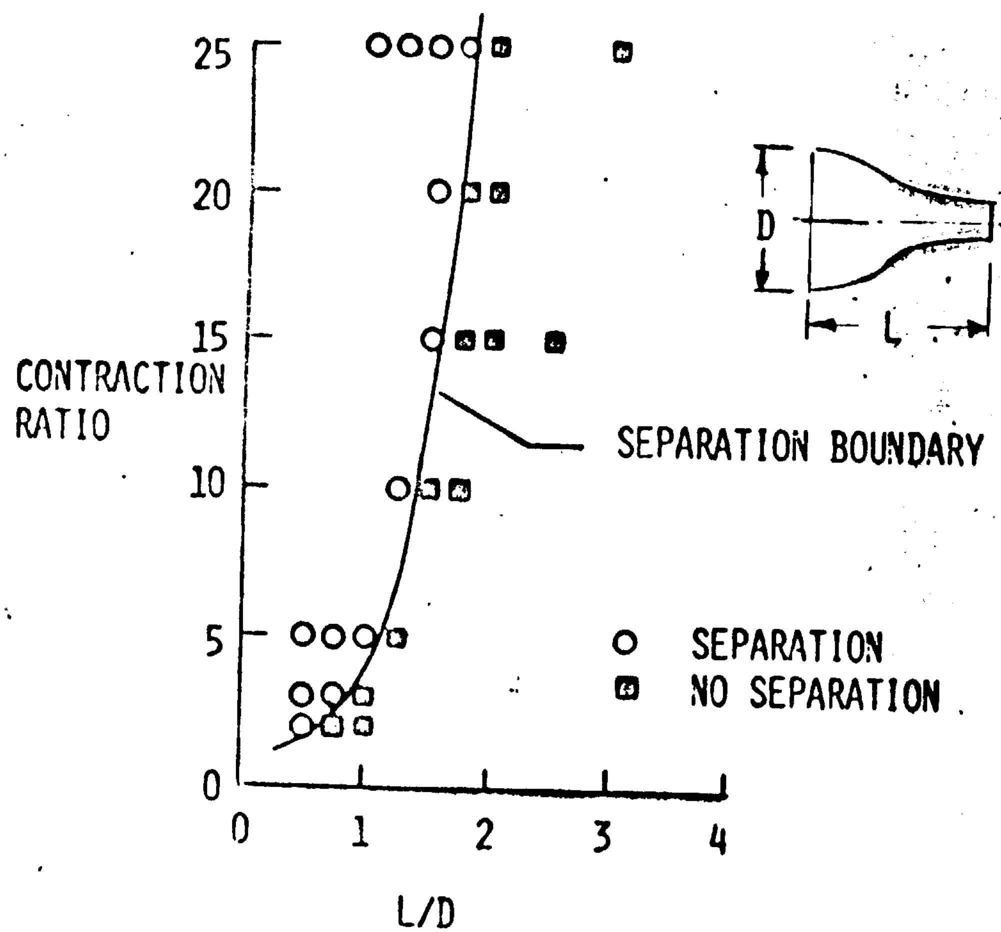
BASIS FOR DESIGN

- 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

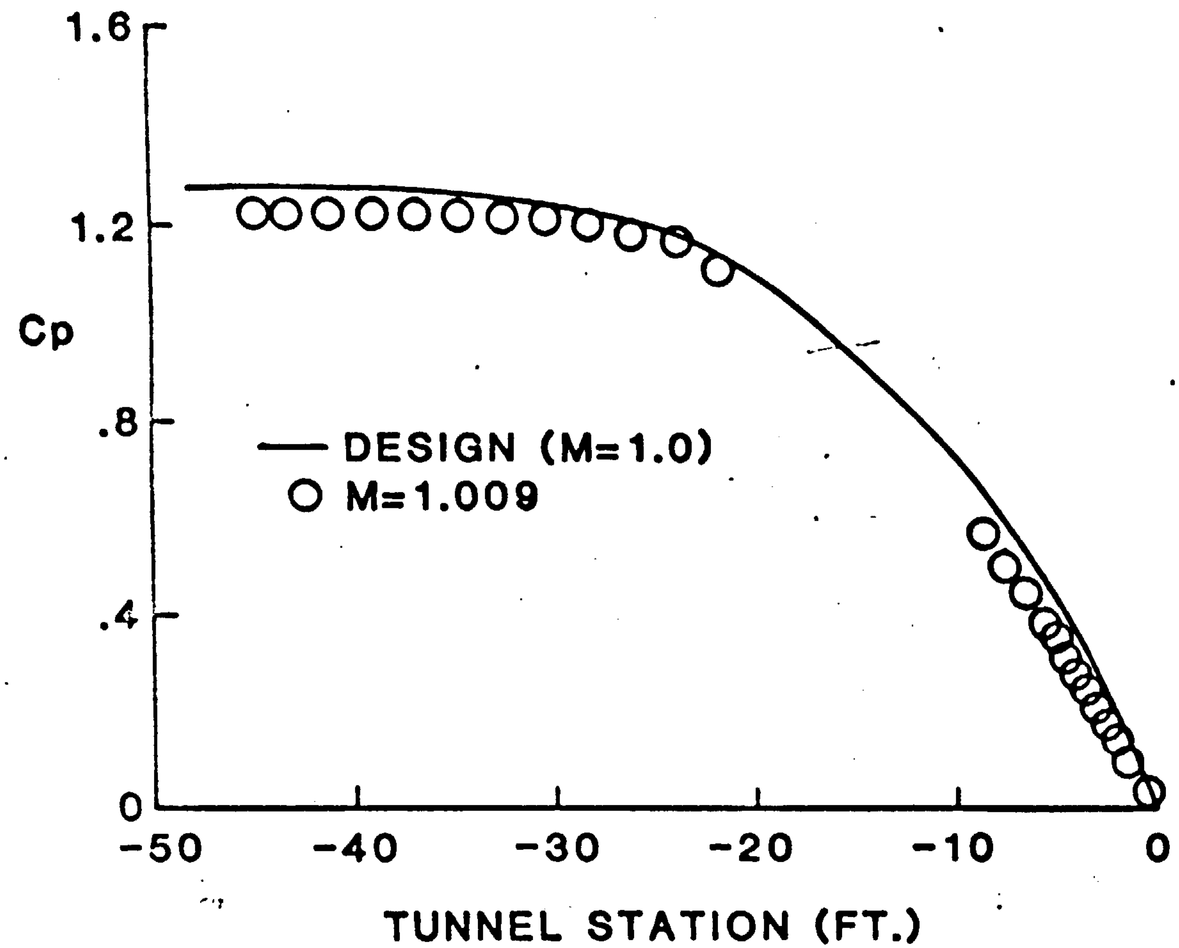
- NASA CR-112239 ~ Streamtube Curvature Analysis
- EXPERIMENTAL STUDIES
  - Flow Visualization
  - Mach No. Distributions

EFFECT OF CONTRACTION LENGTH ON SEPARATION



REF: J. ARICRAFT, AUG 74
BY CHMIELEWSKI

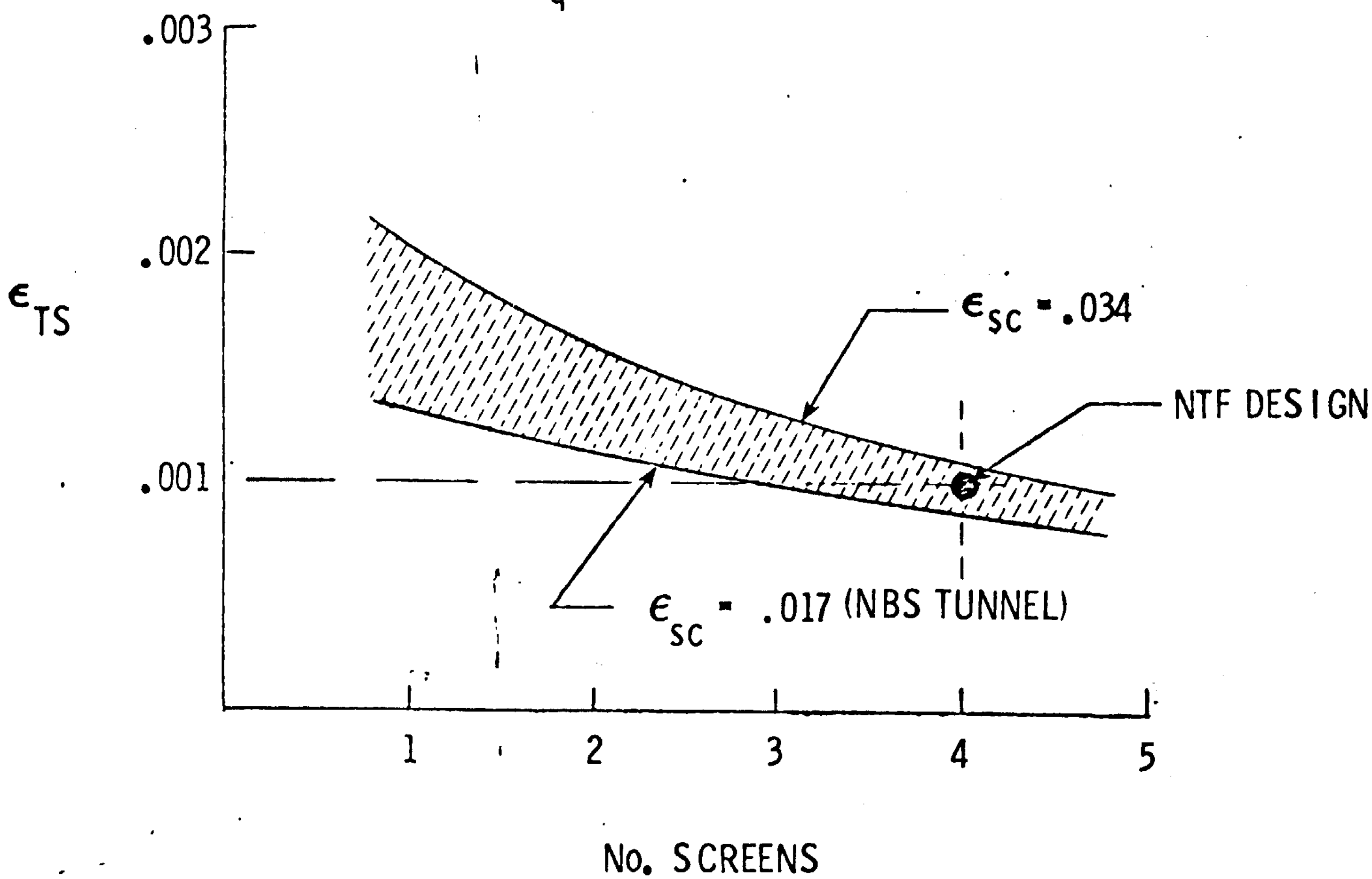
NTF CONTRACTION



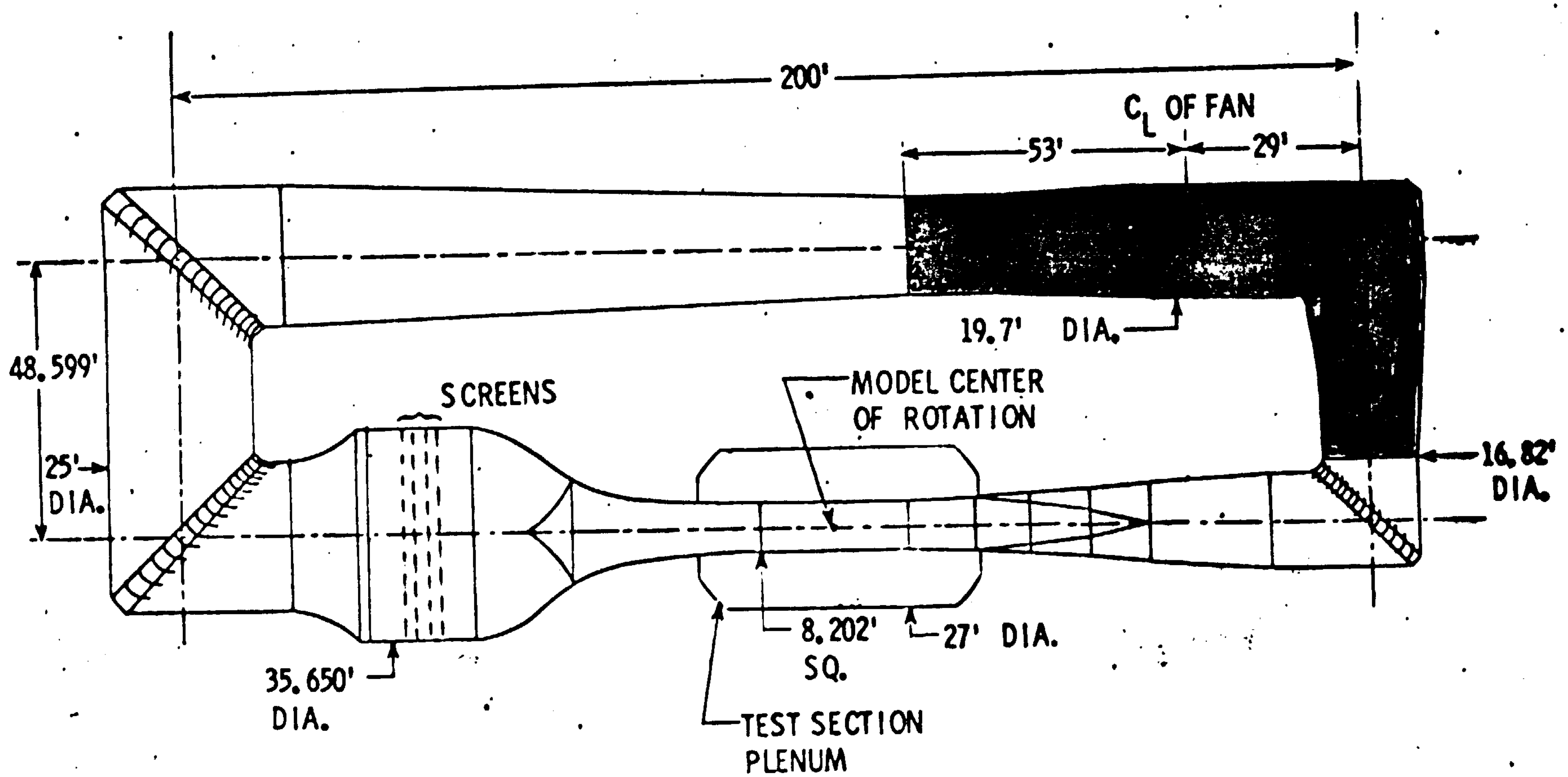
EFFECT OF NUMBER OF SCREENS

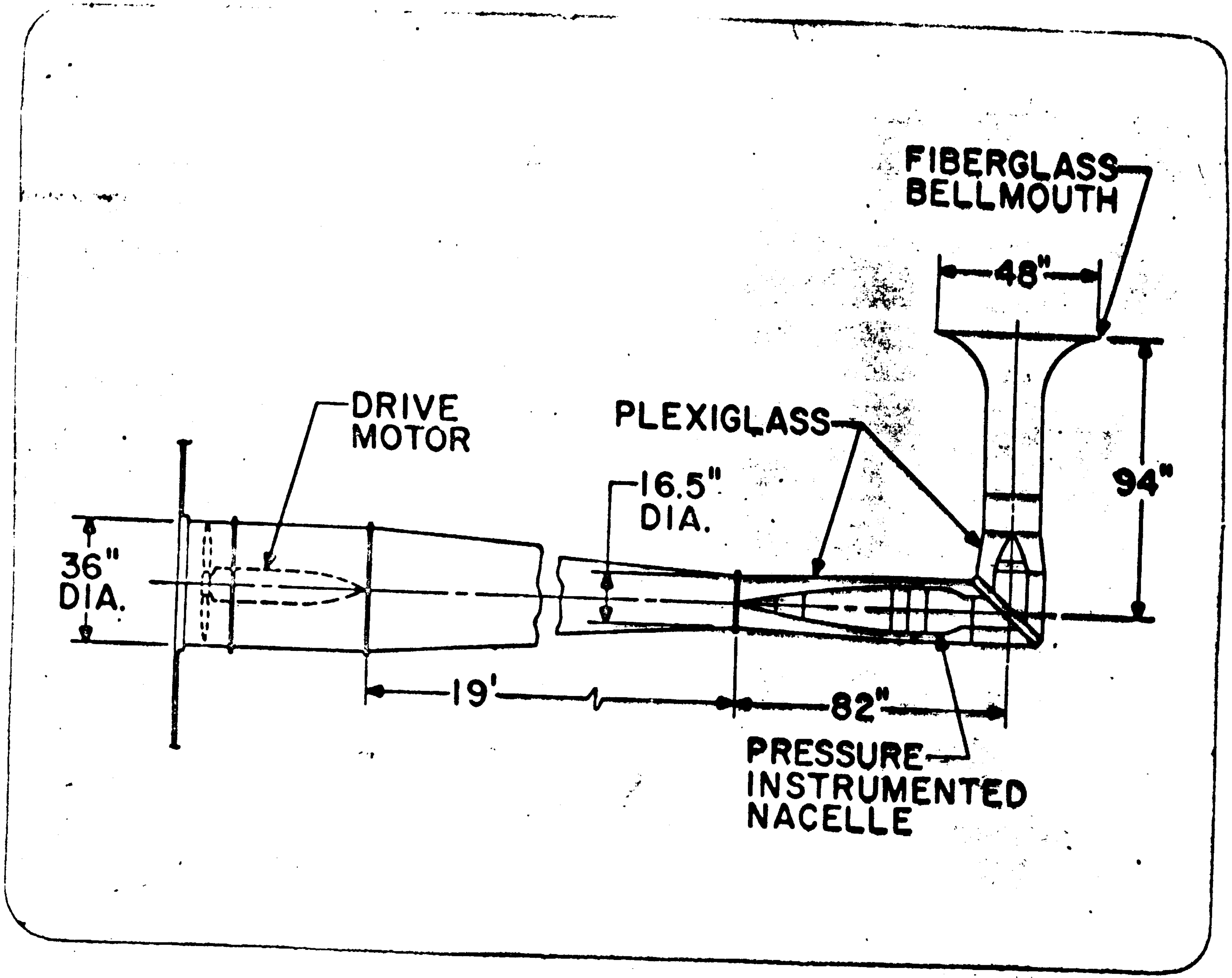
SOLIDITY = .34
(.032" wire; 6 per inch)

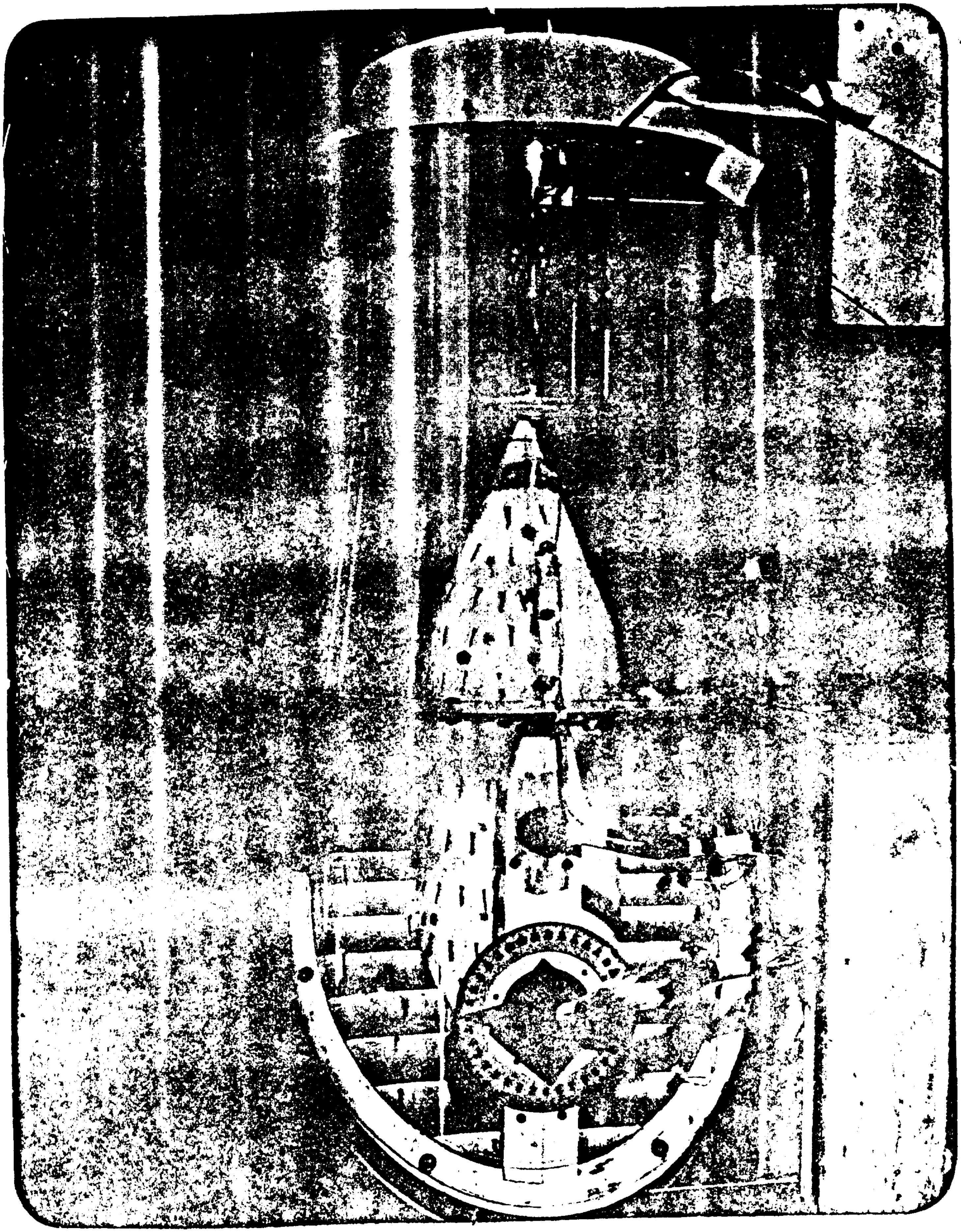
$\frac{\Delta P}{q}$ = .75 per screen



NATIONAL TRANSONIC FACILITY

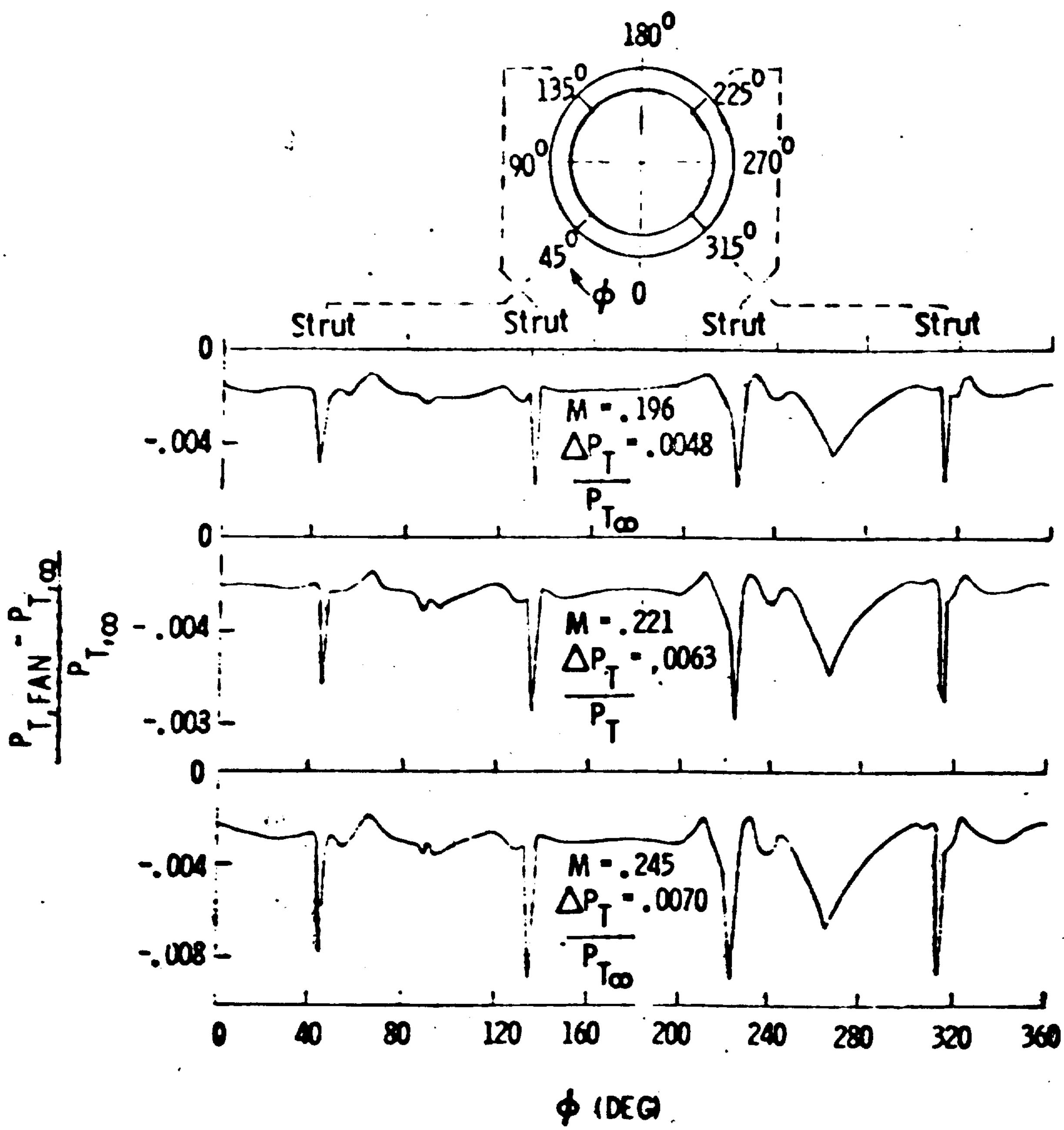



FIBERGLASS BELLMOUTH
48"
94"
DRIVE MOTOR
PLEXIGLASS
16.5" DIA.
36" DIA.
19'
82"
PRESSURE INSTRUMENTED NACELLE

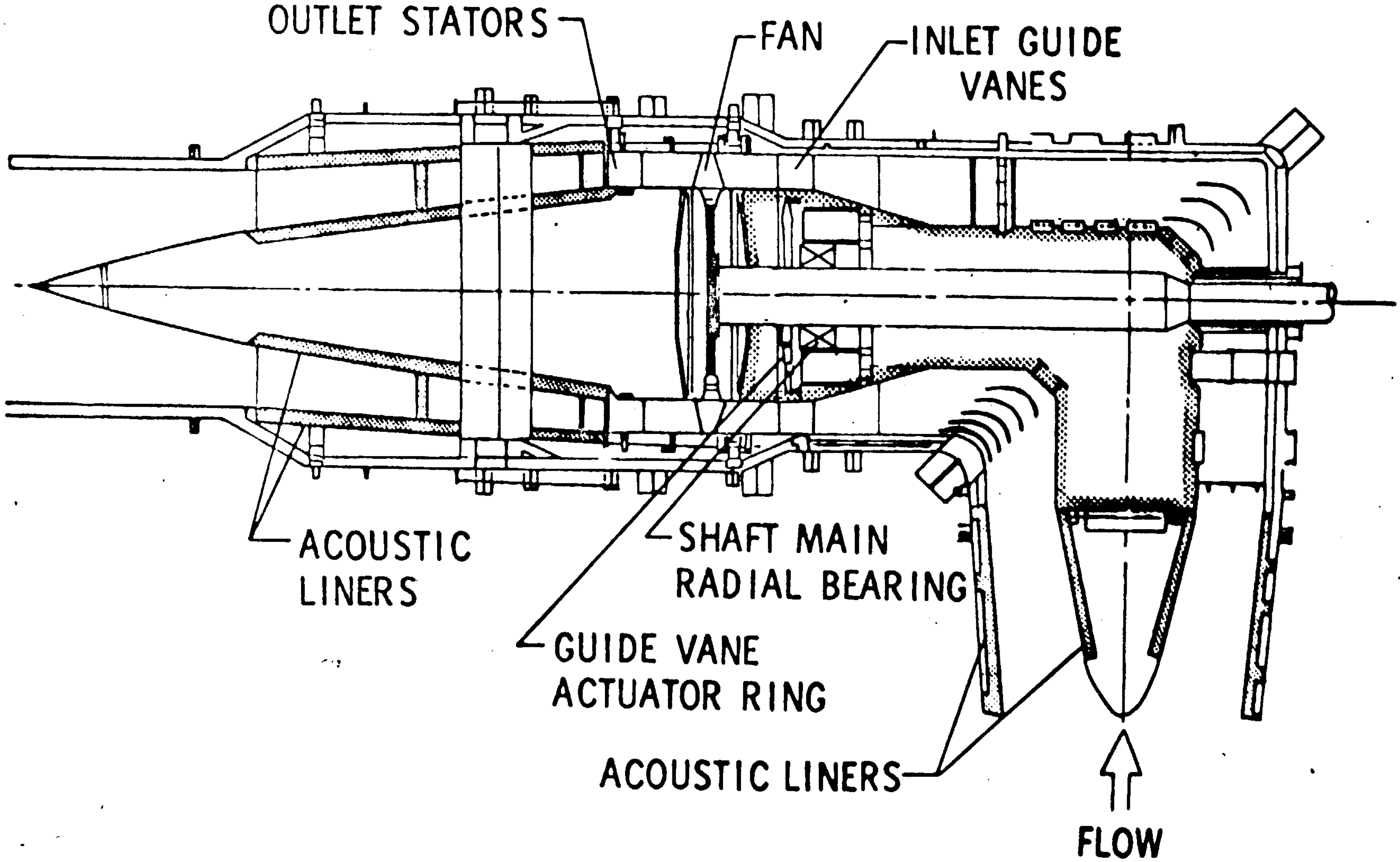


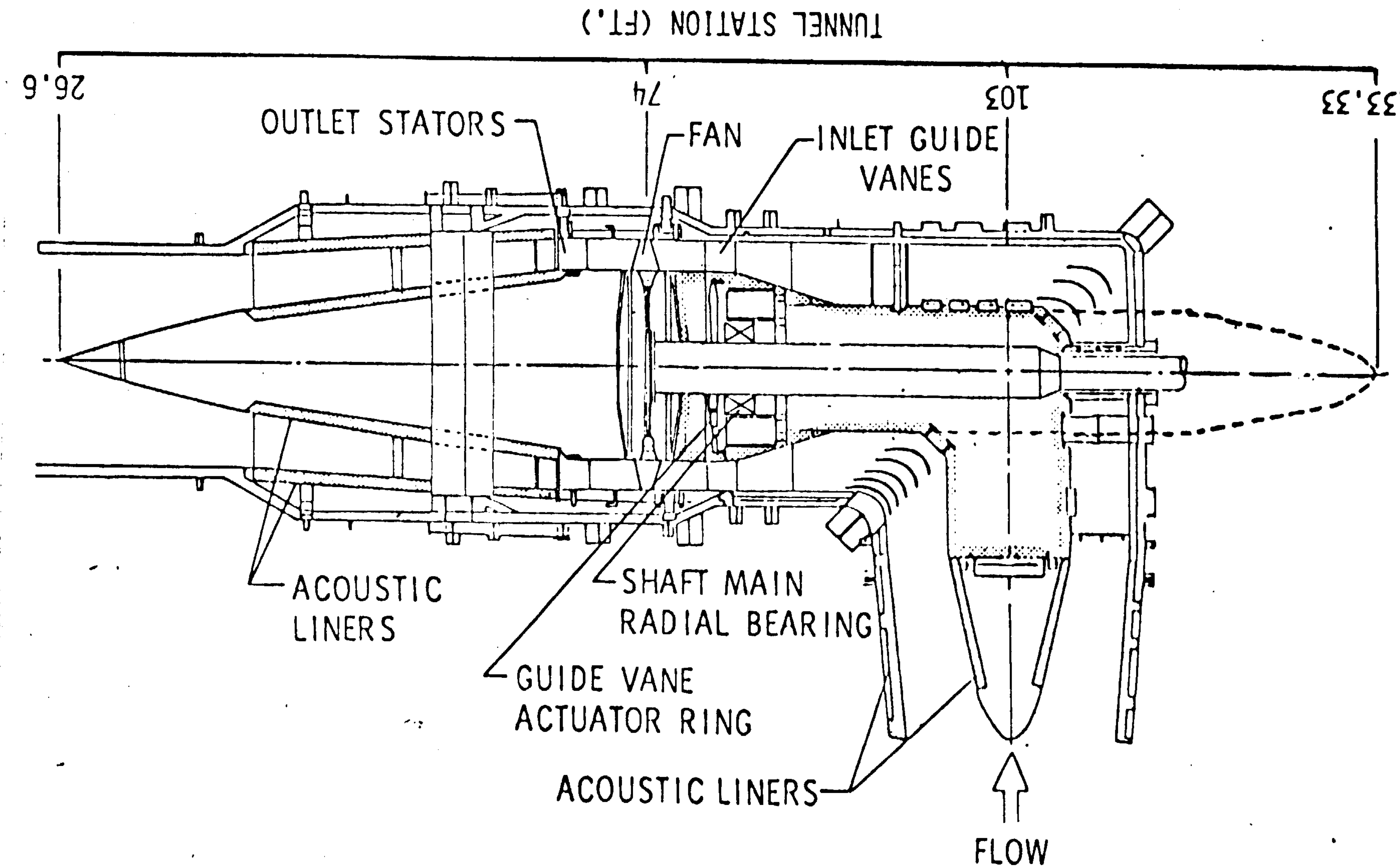
NTF FAN ANNULUS TOTAL PRESSURE DISTORTION

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

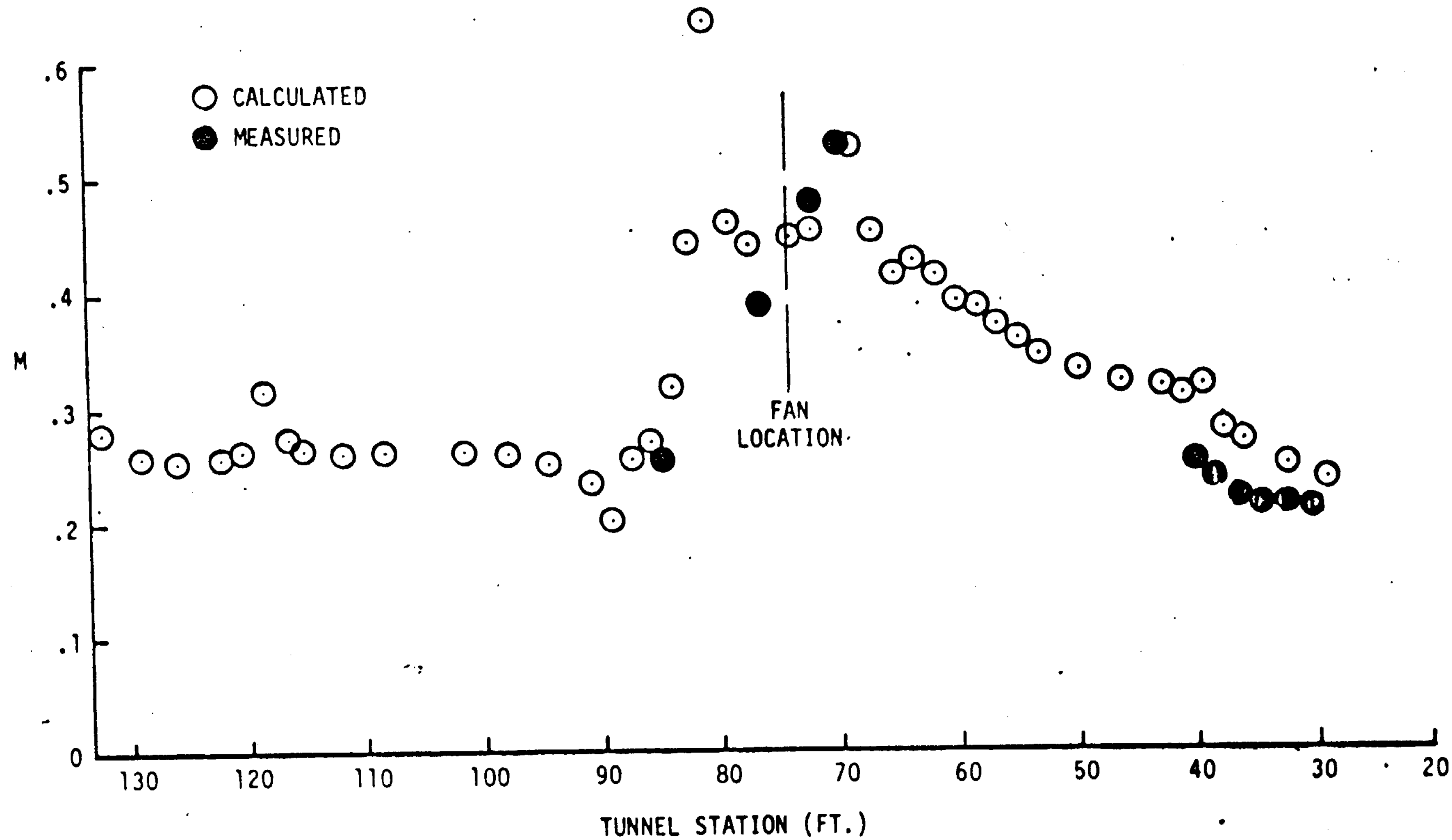


NATIONAL TRANSONIC FACILITY
FAN SECTION ASSEMBLY

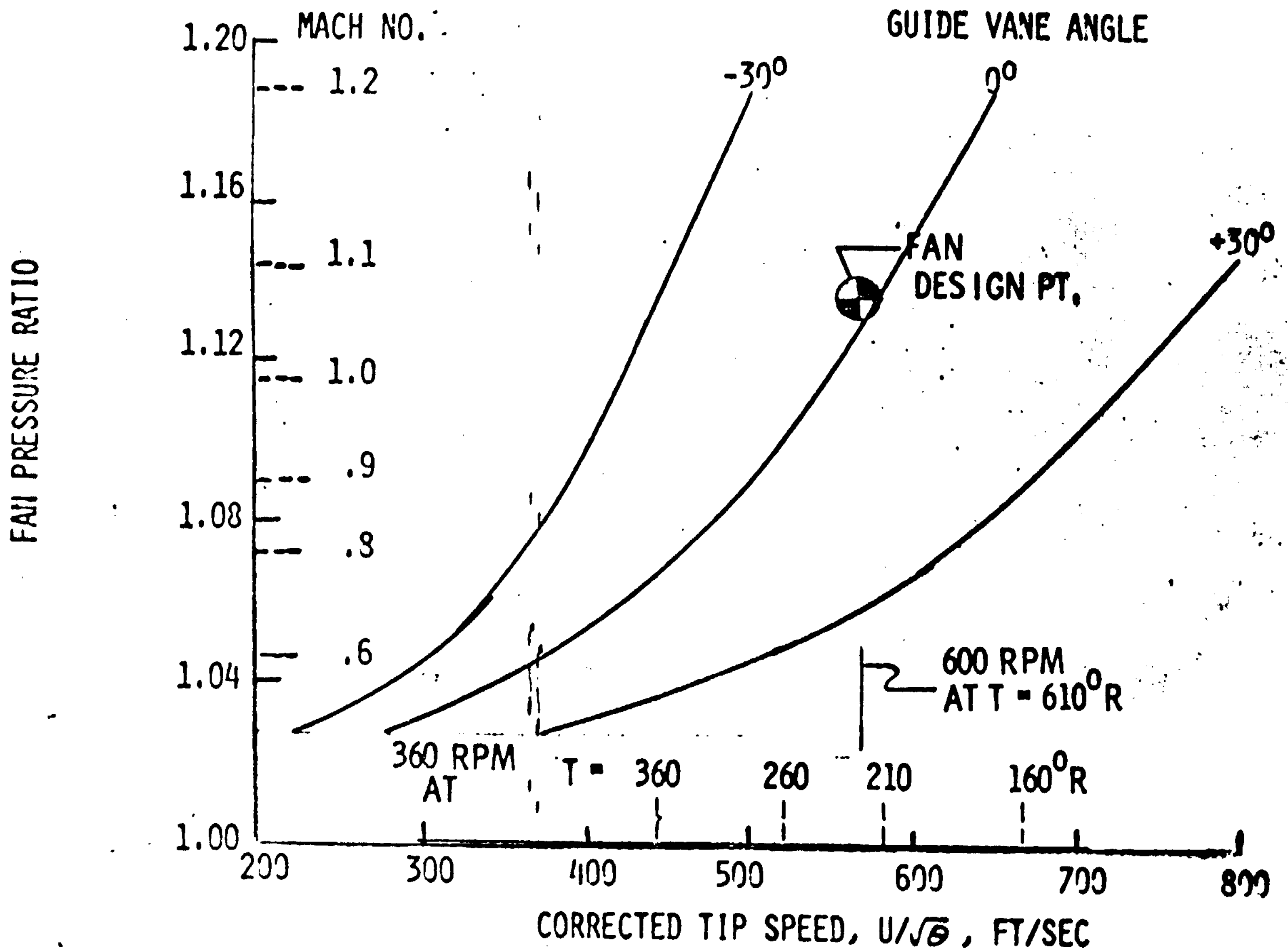



TUNNEL STATION (FT.)
26.6
74
103
133.33
OUTLET STATORS
FAN
INLET GUIDE VANES
ACOUSTIC LINERS
SHAFT MAIN RADIAL BEARING
GUIDE VANE ACTUATOR RING
ACOUSTIC LINERS
FLOW

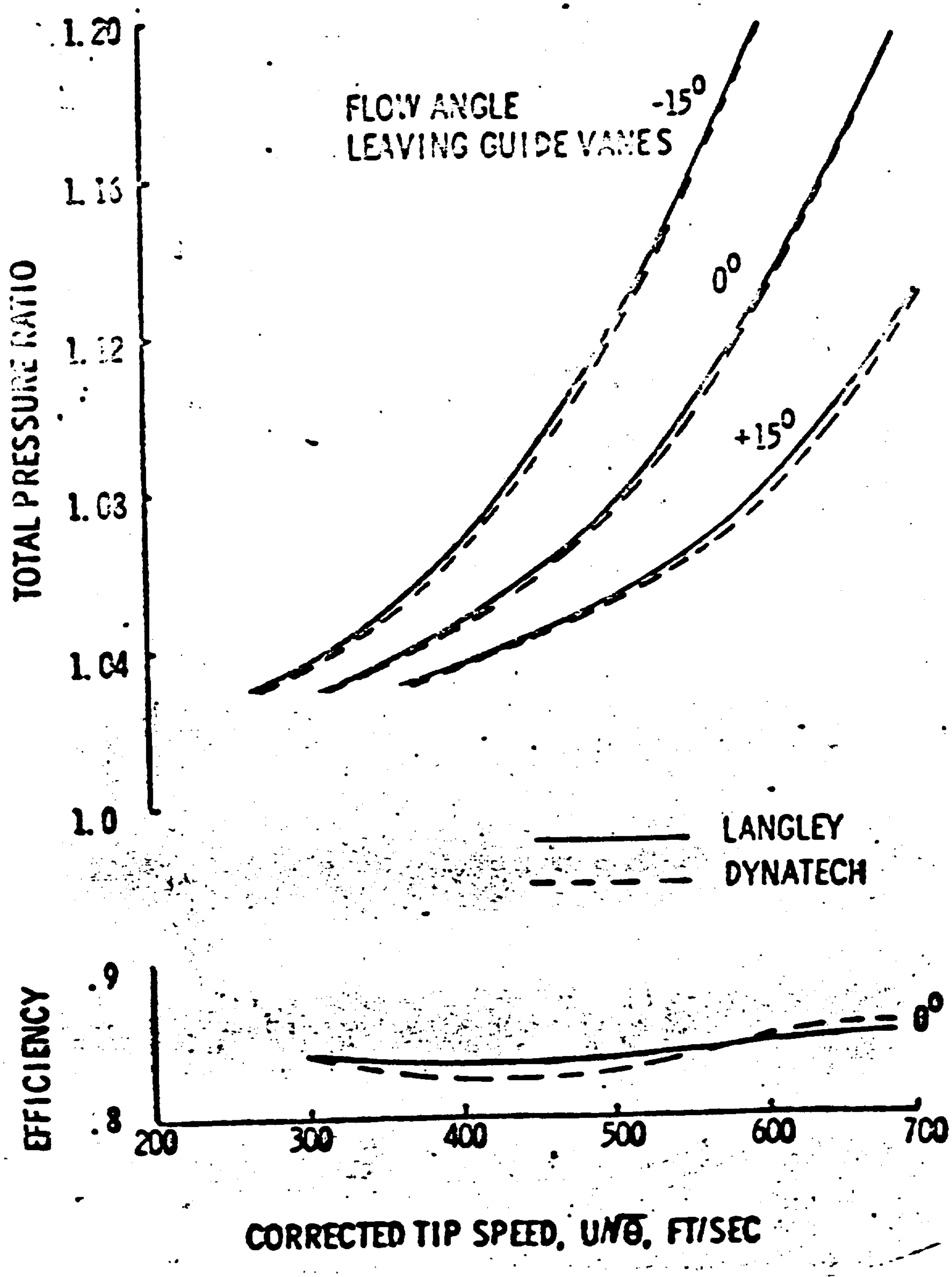
NTF FAN NACELLE



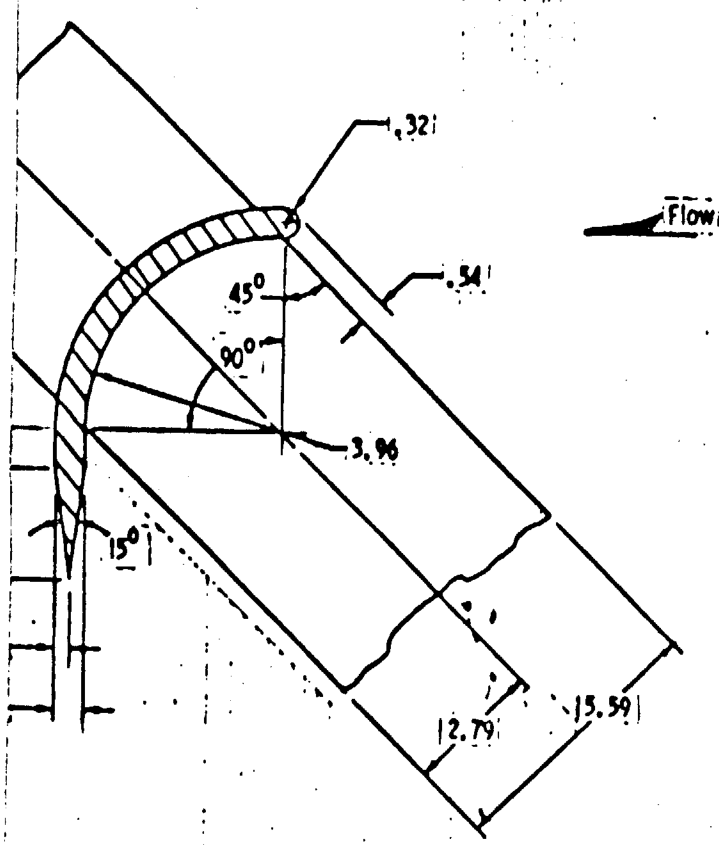
FAN - GUIDE VANE PERFORMANCE MAP



OFF-DESIGN PERFORMANCE VERIFICATION

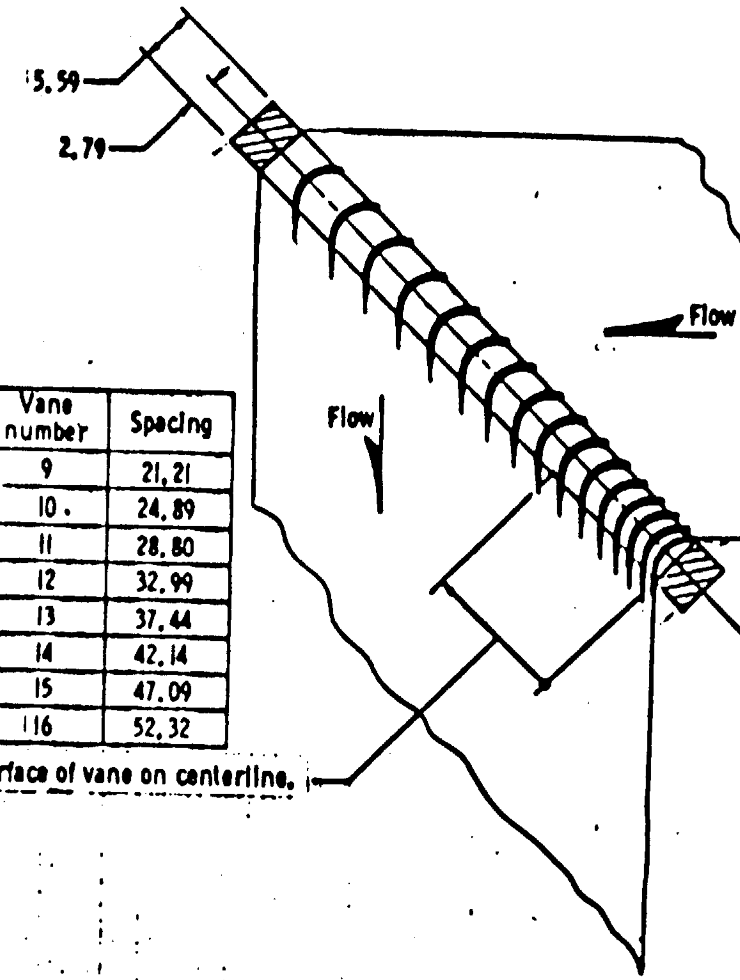


DESIGN CONDITION

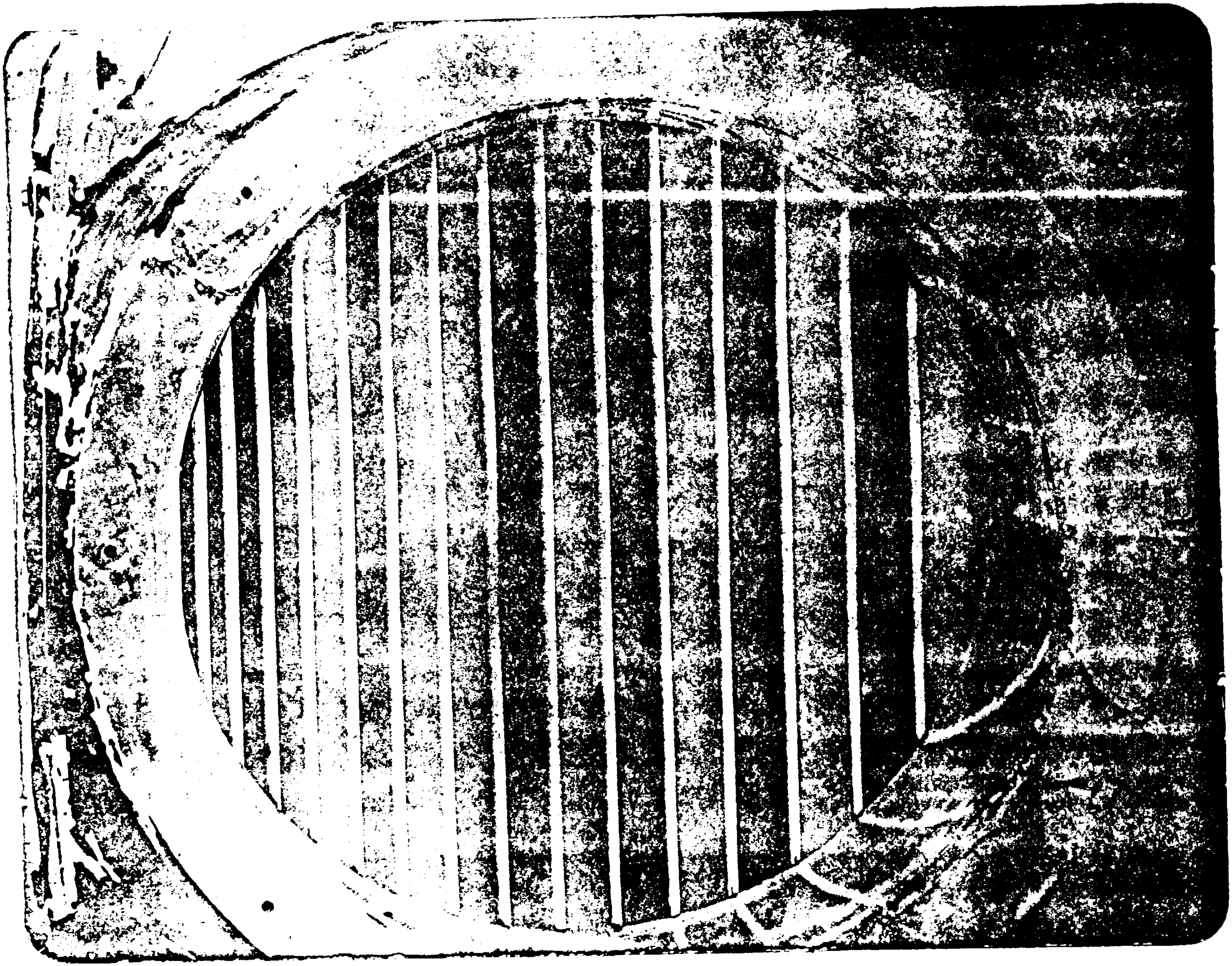


Vane number	Spacing	Vane number	Spacing
1	1.14	9	21.21
2	2.77	10	24.89
3	4.62	11	28.80
4	6.73	12	32.99
5	9.12	13	37.44
6	11.76	14	42.14
7	14.66	15	47.09
8	17.81	16	52.32

Vane spacing given to inside surface of vane on centerline.



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



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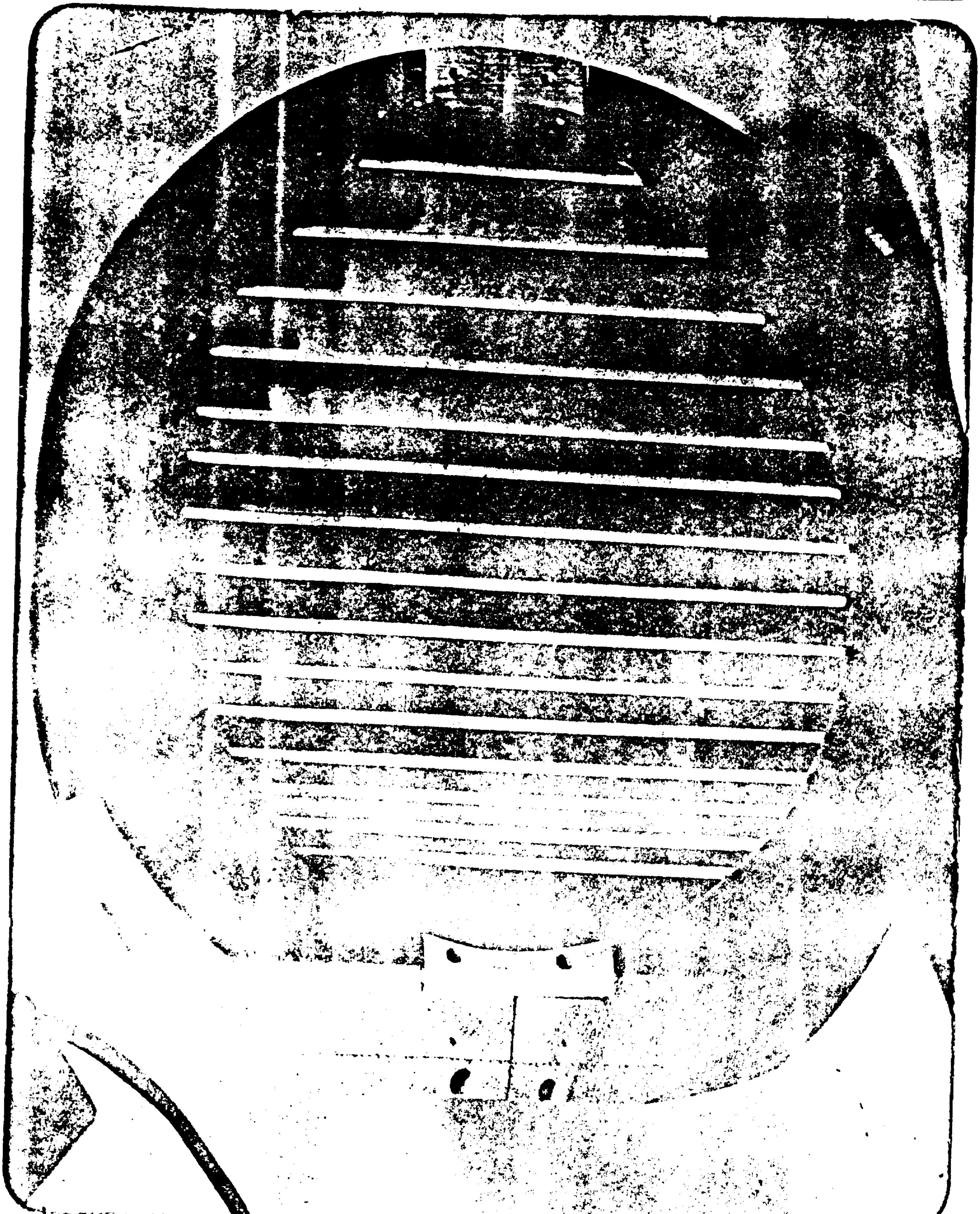
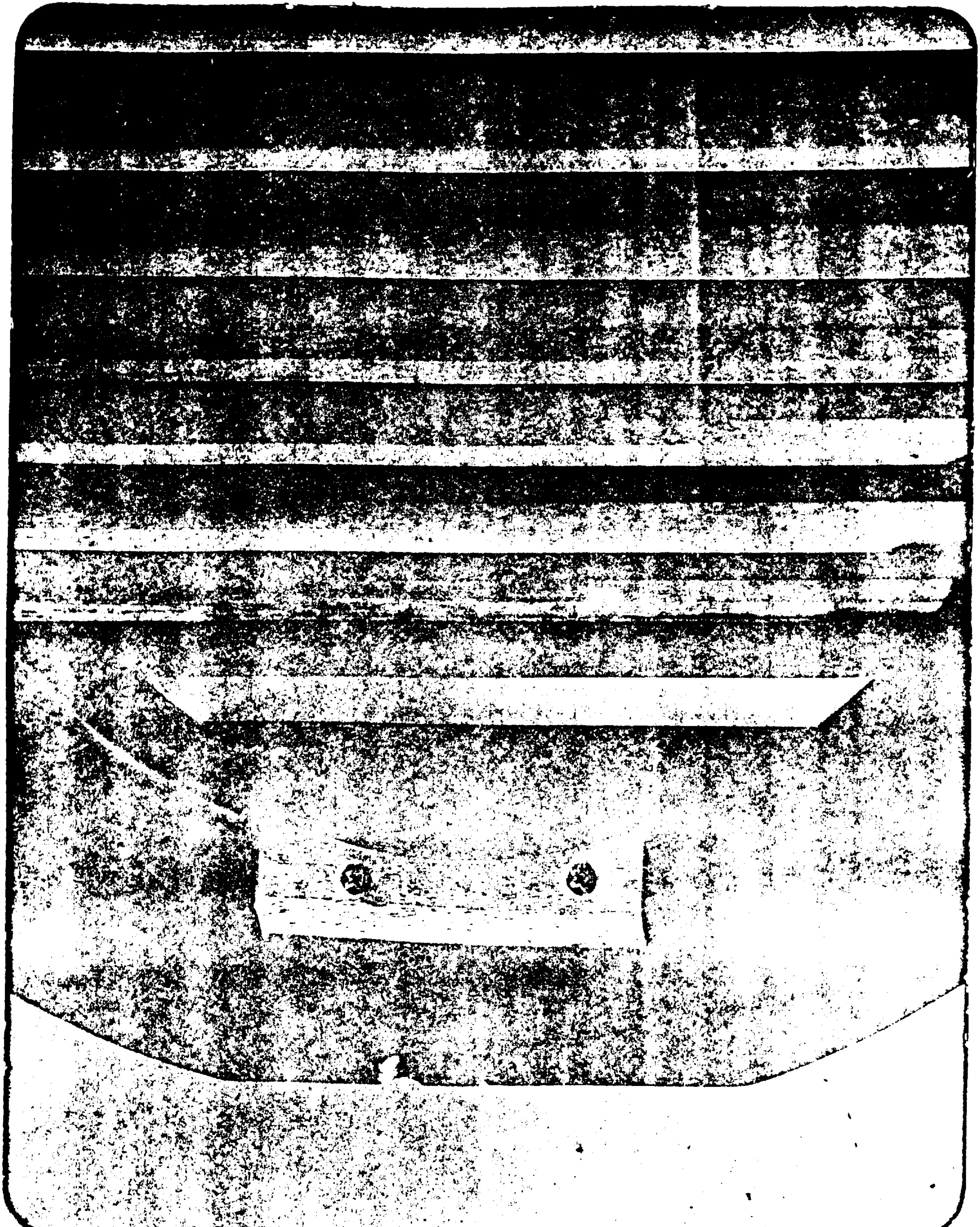
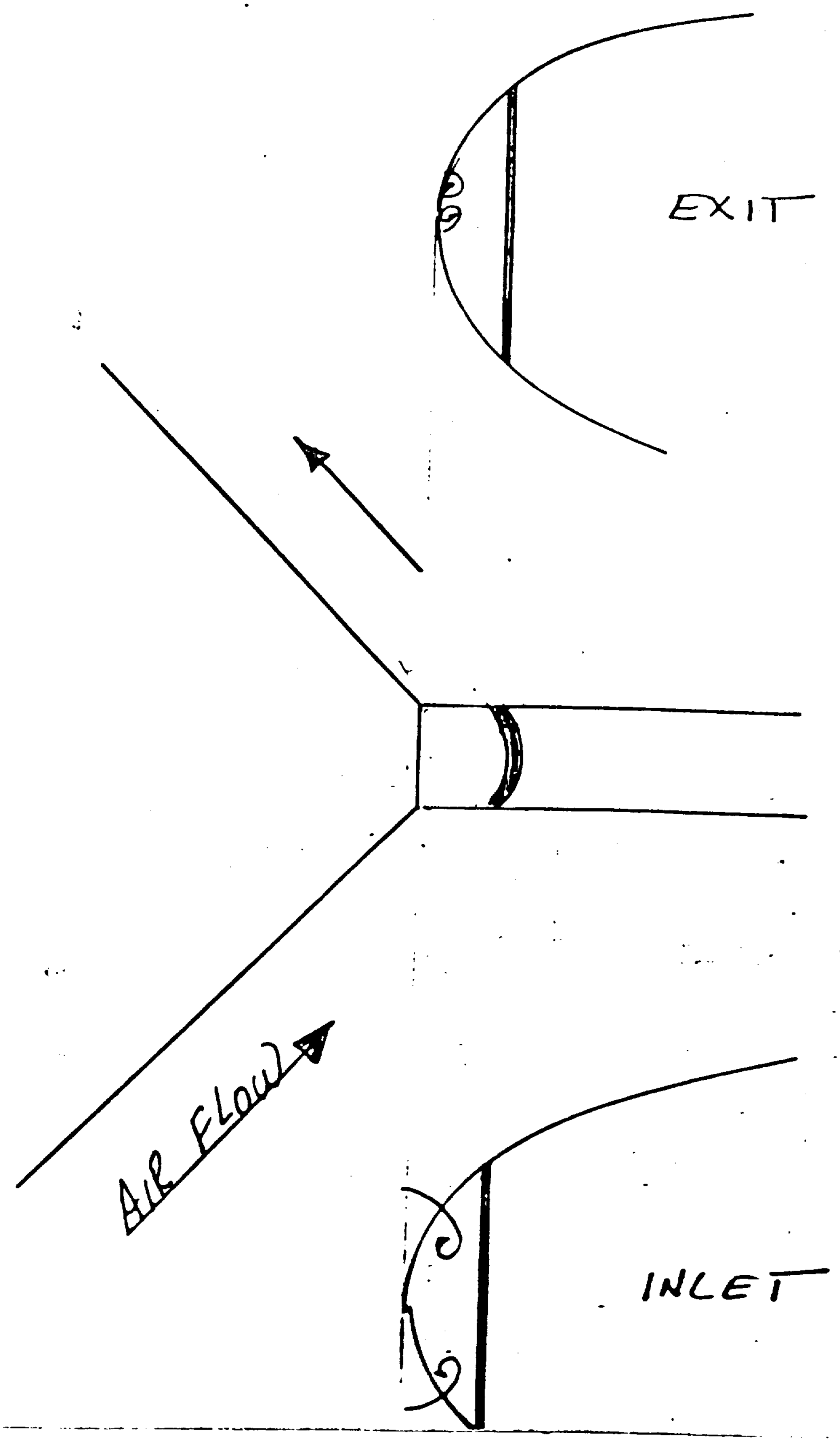
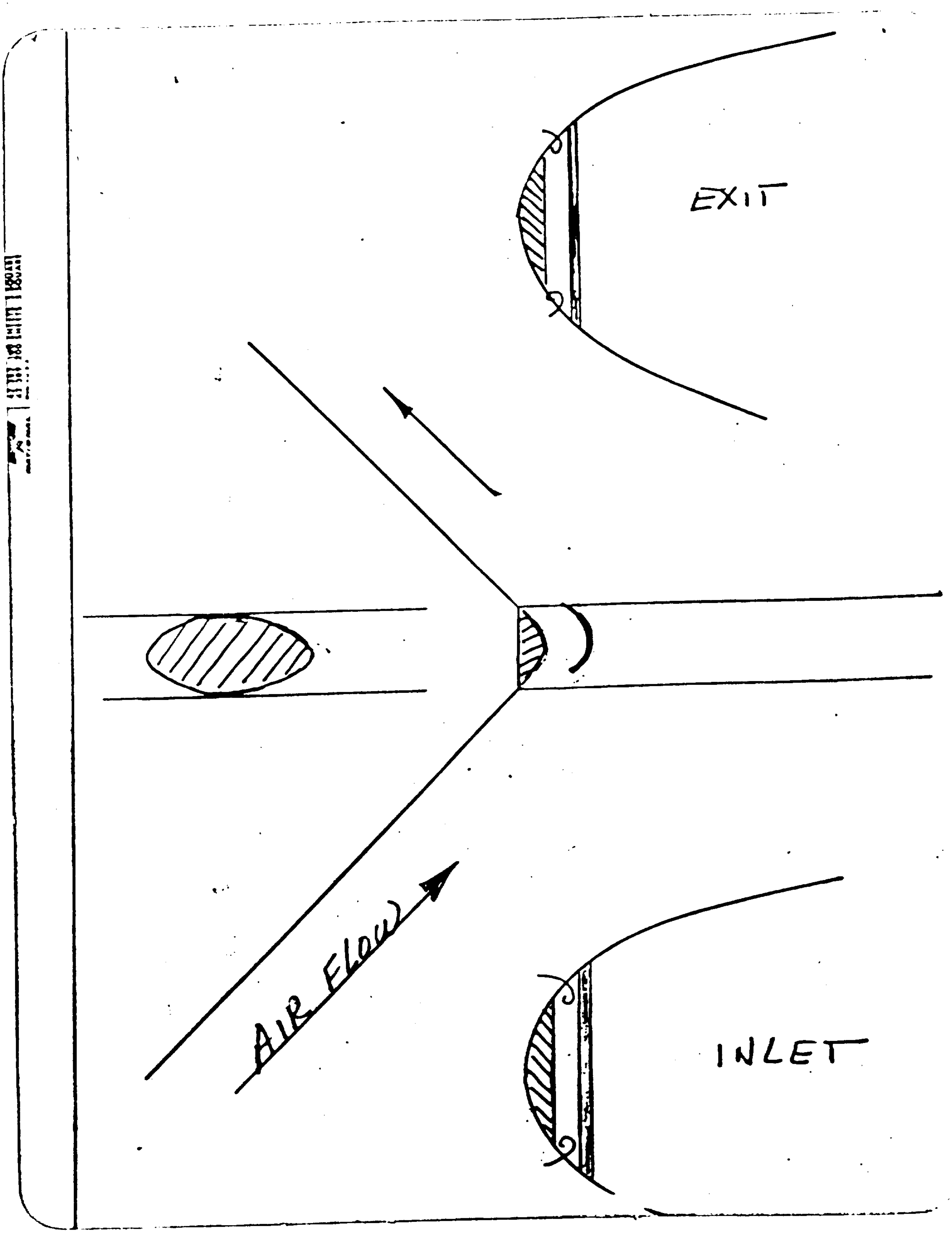
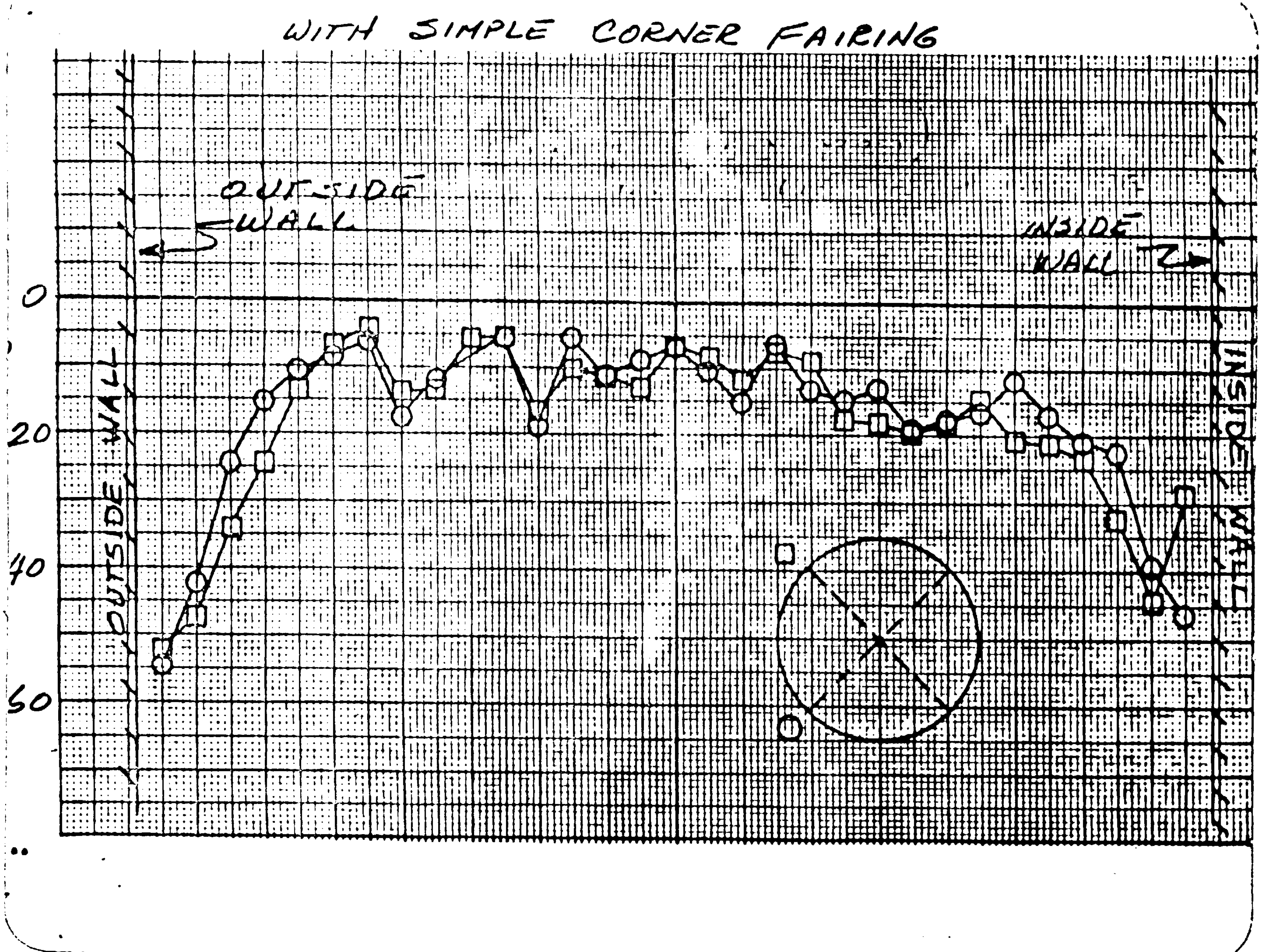




NO. 1 TURN - AS BUILT

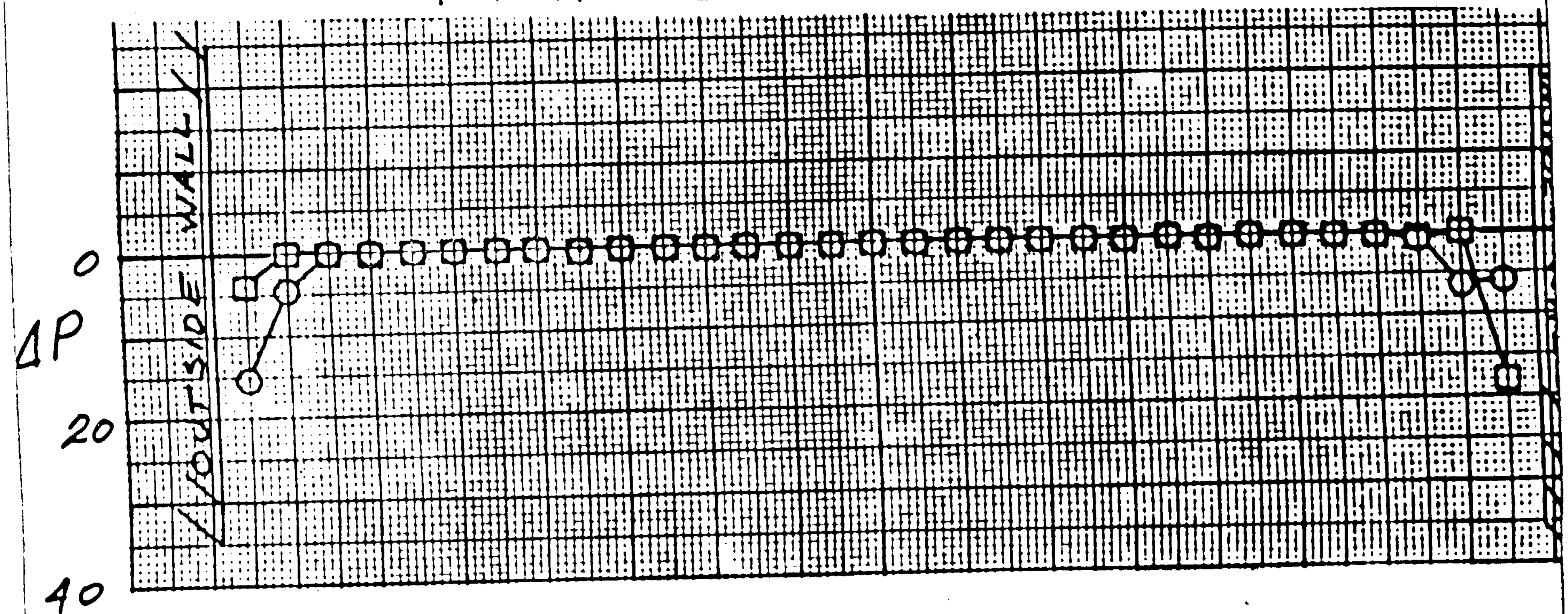


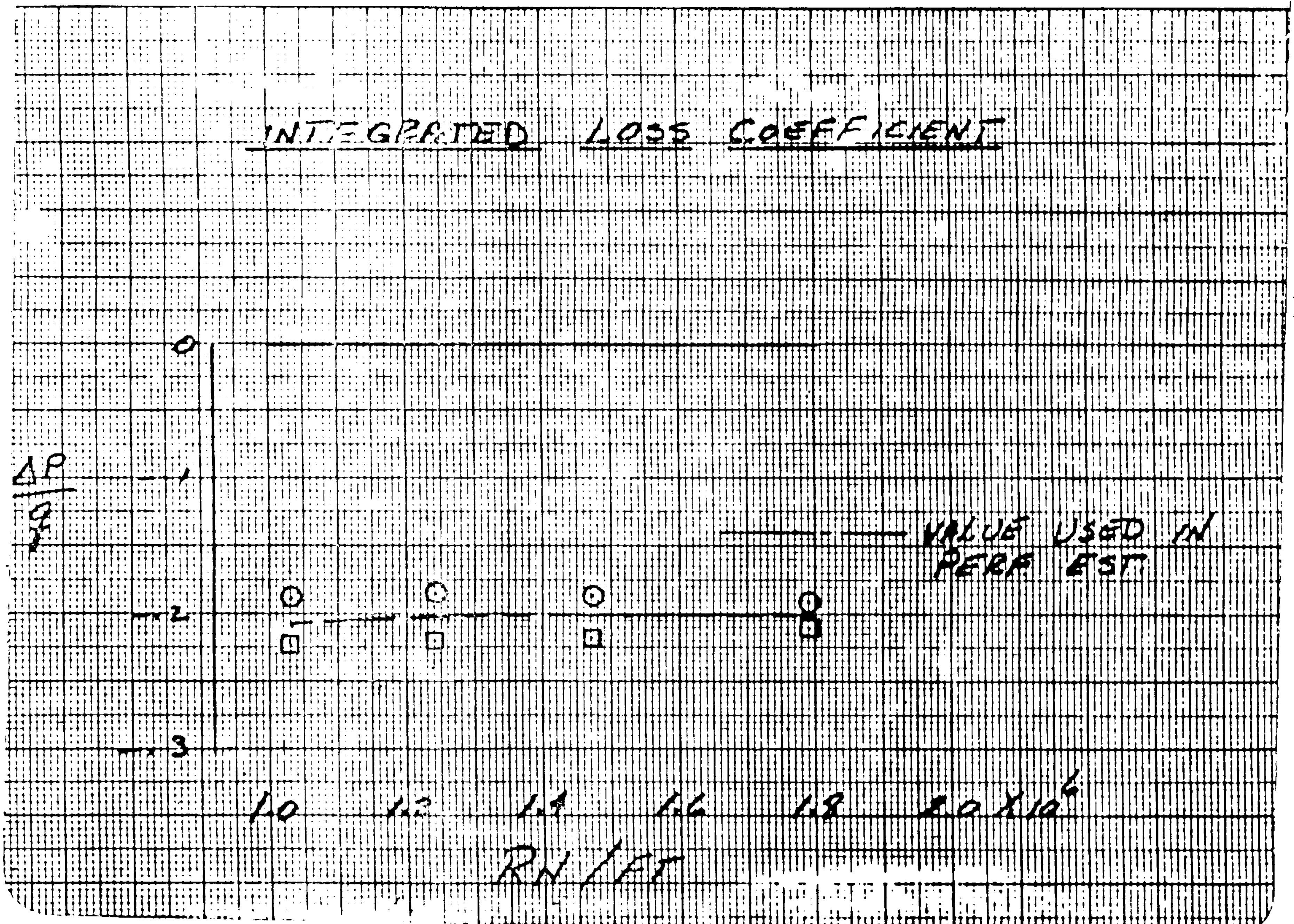

EXIT
AIR FLOW
INLET



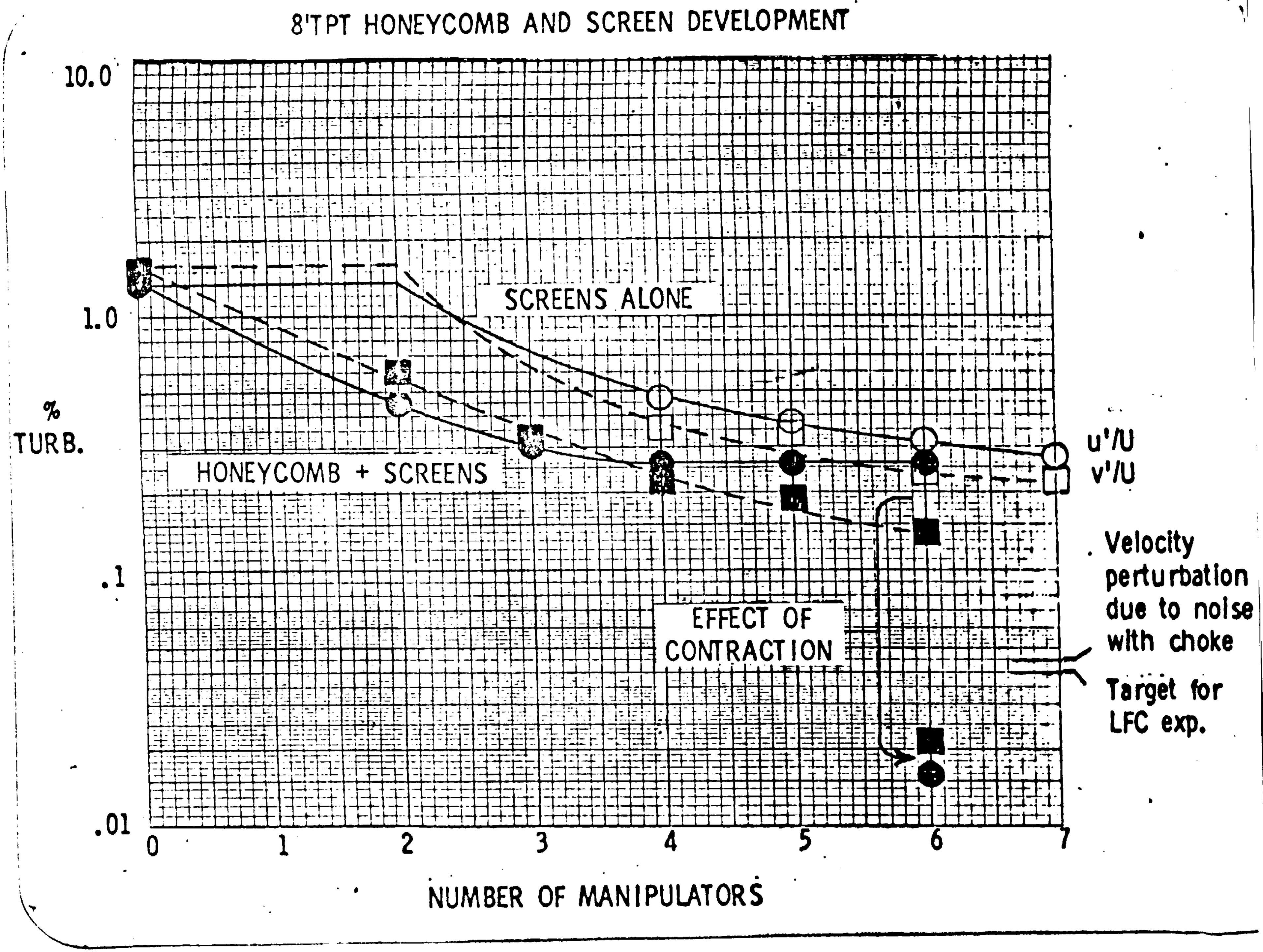
WITH SIMPLE CORNER FAIRING
OUTSIDE WALL
INSIDE WALL
OUTSIDE WALL
INSIDE WALL
0
20
40
60

INLET DISTRIBUTION





INTEGRATED LOSS COEFFICIENT
ΔP/q
0
.1
.2
.3
VALUE USED IN PERF EST
1.0
1.2
1.4
1.6
1.8
2.0 X10^6
RN/FT


8'TPT HONEYCOMB AND SCREEN DEVELOPMENT
10.0
1.0
.1
.01
%
TURB.
SCREENS ALONE
HONEYCOMB + SCREENS
EFFECT OF
CONTRACTION
u'/U
v'/U
Velocity
perturbation
due to noise
with choke
Target for
LFC exp.
0
1
2
3
4
5
6
7
NUMBER OF MANIPULATORS

4 x 7 M MODELING PROGRAM

ZACHERY T. APPLIN

SUBSONIC AERODYNAMICS BRANCH

NASA LANGLEY RESEARCH CENTER

THE USE OF SMALL-SCALE MODELING IN DEFINING FLOW IMPROVEMENTS FOR THE LANGLEY 4- BY 7-METER TUNNEL

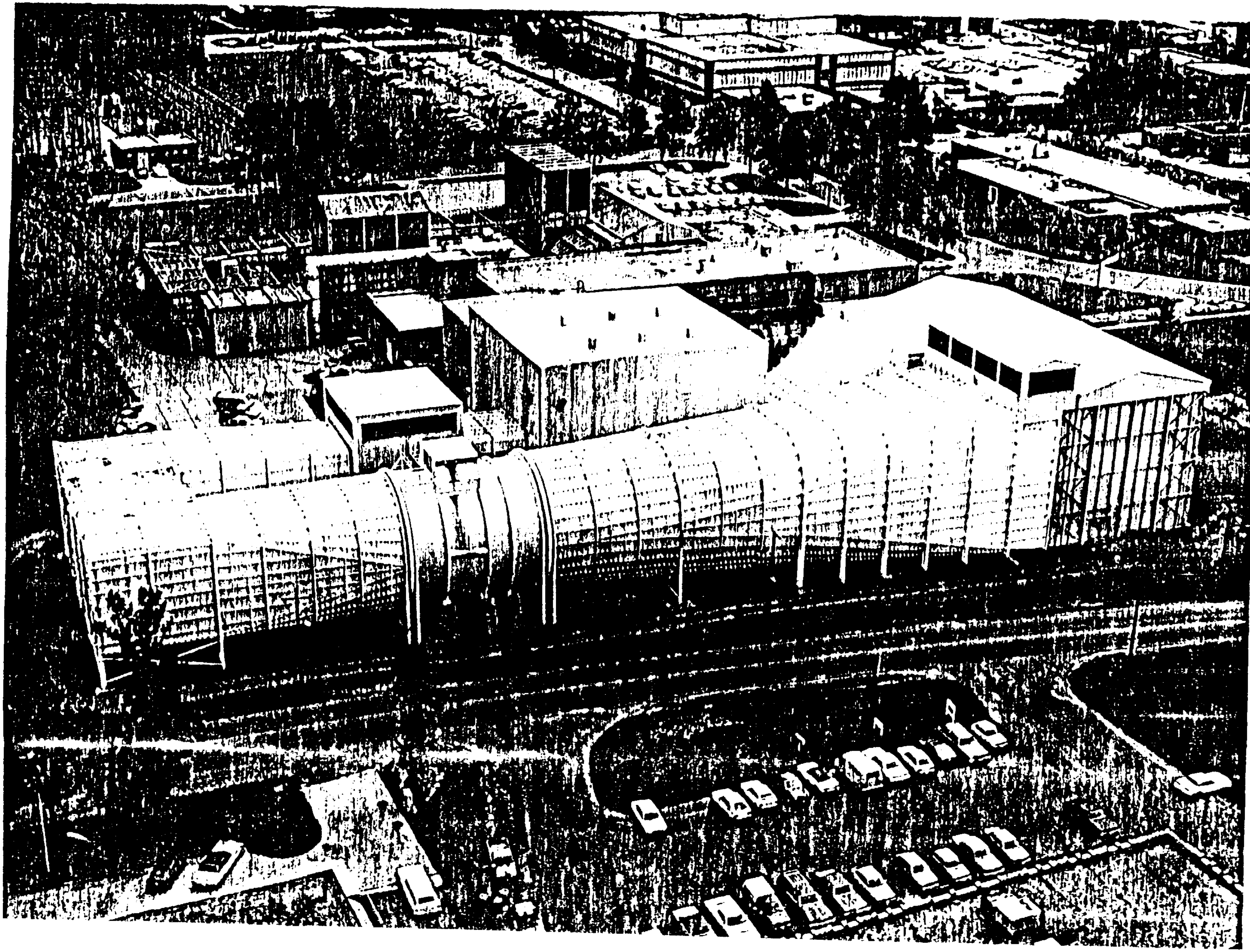
ZACHARY T. APPLIN

PRESENTED AT THE NASA LEWIS RESEARCH CENTER
WIND-TUNNEL MODELING WORKSHOP
CLEVELAND, OHIO
MARCH 20-21, 1984

OVERVIEW OF PRESENTATION

- DESCRIPTION OF THE 4- BY 7-METER TUNNEL
- DESCRIPTION OF 1/24-SCALE MODEL TUNNEL
- TUNNEL CIRCUIT FLOW CHARACTERISTICS
- OPEN TEST SECTION TURBULENCE CHARACTERISTICS
- CONCLUDING REMARKS

NASA
L-81-5962

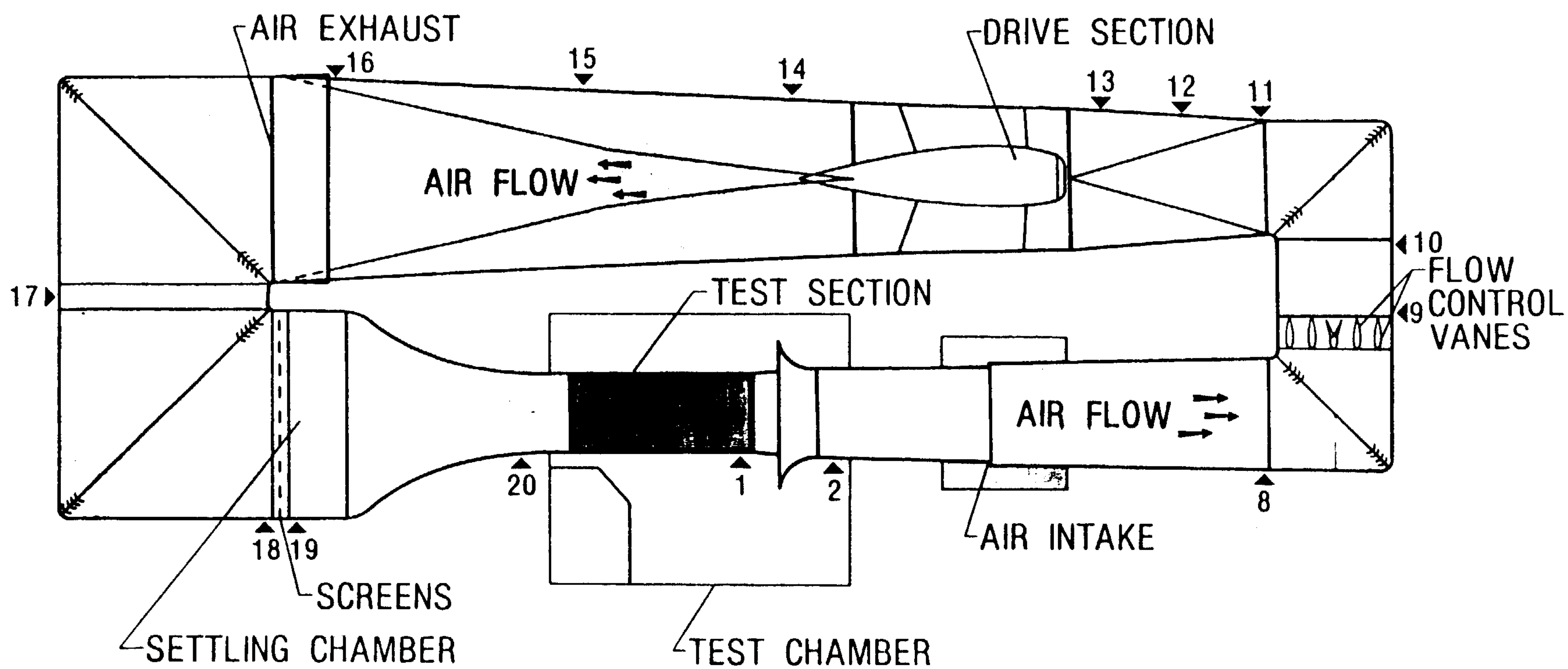


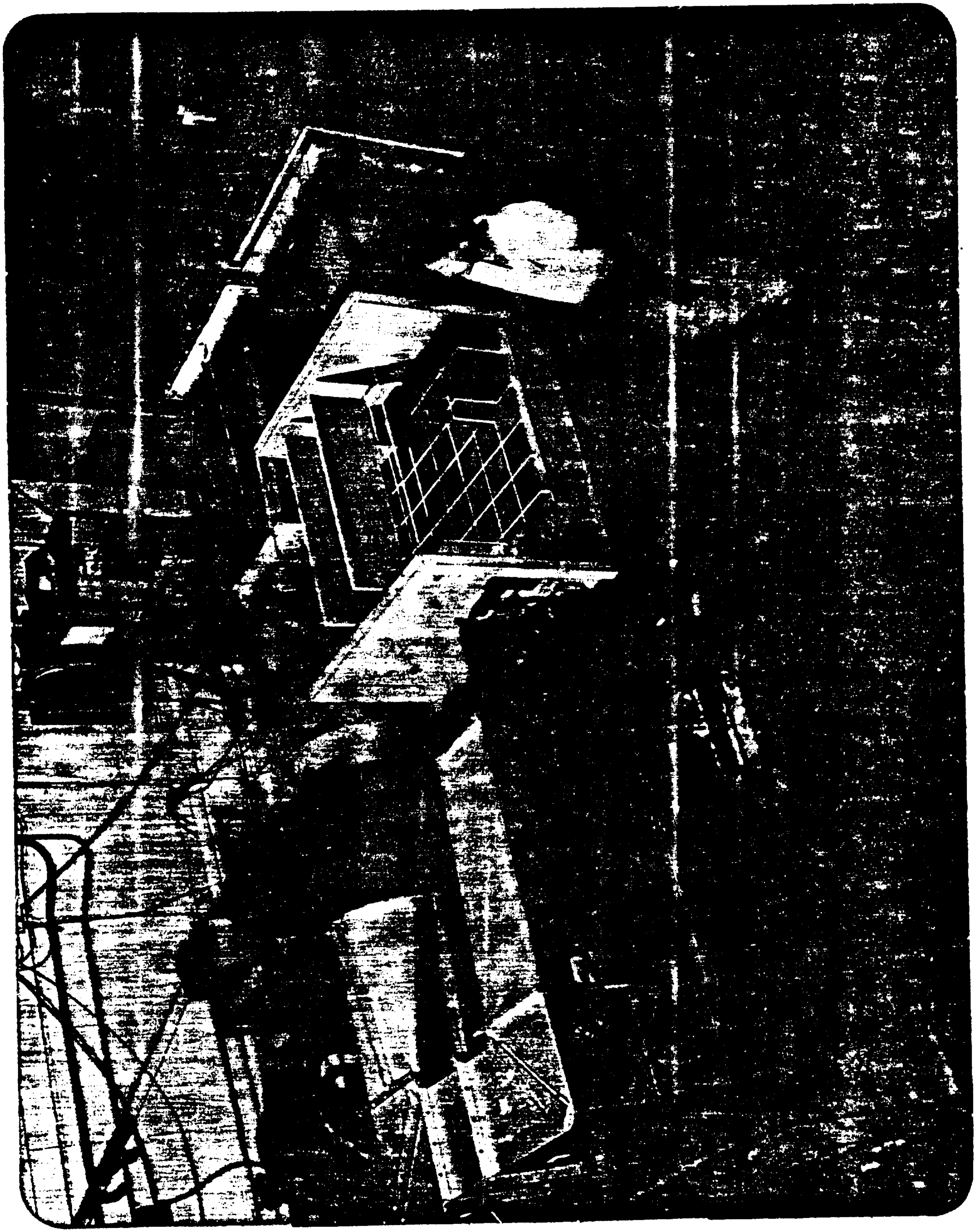
LANGLEY 4- BY 7-METER TUNNEL DESCRIPTION

- TEST SECTION: 14.5 X 21.75 FT
- SPEED CAPABILITY: 0 TO 200 KTS
- 8000 HP DRIVE MOTOR
- MULTIPLE WALL CONFIGURATION CAPABILITY: CLOSED, SLOTTED, PARTIALLY OPEN, OPEN
- ACOUSTIC TEST CAPABILITY
- TEST SECTION ENTRANCE FLOOR SUCTION AND MOVING GROUND BELT
- AUTOMATED, TWO-COMPONENT LASER-VELOCIMETER SYSTEM
- AUTOMATED HIGH-PRESSURE AIR SYSTEM AND VARIABLE FREQUENCY POWER SUPPLY FOR POWER SIMULATION
- ON-LINE DATA REDUCTION AND DISPLAY

NASA
L-83-7.552

4 × 7 METER TUNNEL ARRANGEMENT





ORIGINAL PAGE IS
OF POOR QUALITY

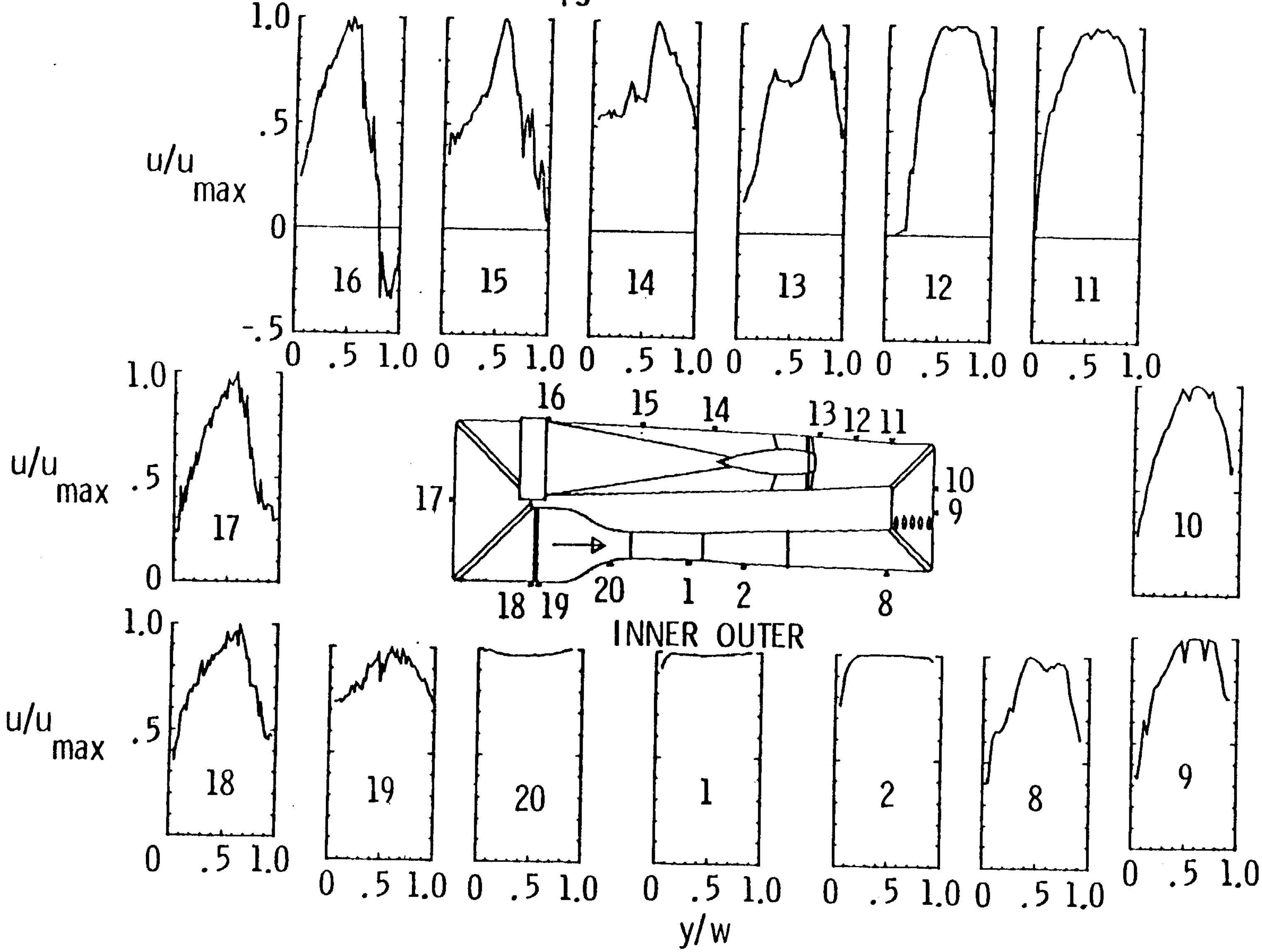
	4 X 7 TUNNEL	MODEL TUNNEL
AIR INTAKE	YES	YES
1ST CORNER VANES	55	~ 15
FLOW CONTROL VANES	YES	YES
2ND CORNER VANES	55	~15
2ND CORNER SCREEN	1/3	1/3
3RD DIFFUSER ANGLE	AS BUILT	SAME
PROP BLADES	CLOCKWISE (9)	COUNTERCLOCKWISE (8)
FLOW STRAIGHTENER VANES	YES	YES
4TH DIFFUSER ANGLE	AS BUILT	SAME
VENT	YES	YES
3RD CORNER VANES	99	~ 25
4TH CORNER VANES	202	~ 25
SETTLING CHAMBER	2 SCREENS	2 SCREENS

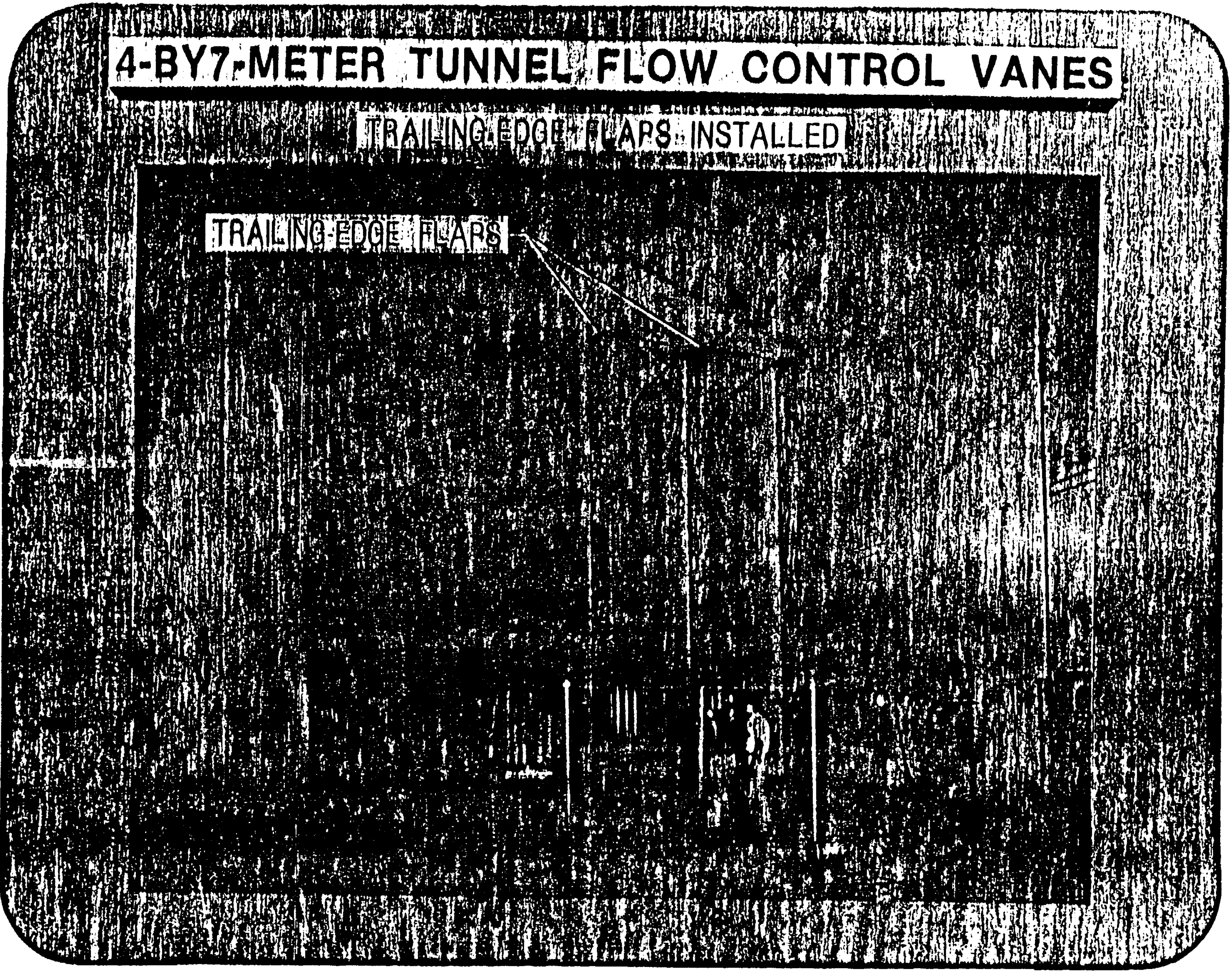
TUNNEL CIRCUIT FLOW CHARACTERISTICS

- 4- BY 7-METER TUNNEL
  - VELOCITY PROFILES MEASURED BY PROPELLER ANEMOMETER
- 1/24-SCALE MODEL TUNNEL
  - VELOCITY PROFILES MEASURED BY PITOT-STATIC TUBE
  - ATTEMPT TO MATCH 4- BY 7-METER TUNNEL CHARACTERISTICS
- CONTRACTION CONE BOUNDARY-LAYER CHARACTERISTICS

HORIZONTAL VELOCITY PROFILES-CLOSED TEST SECTION

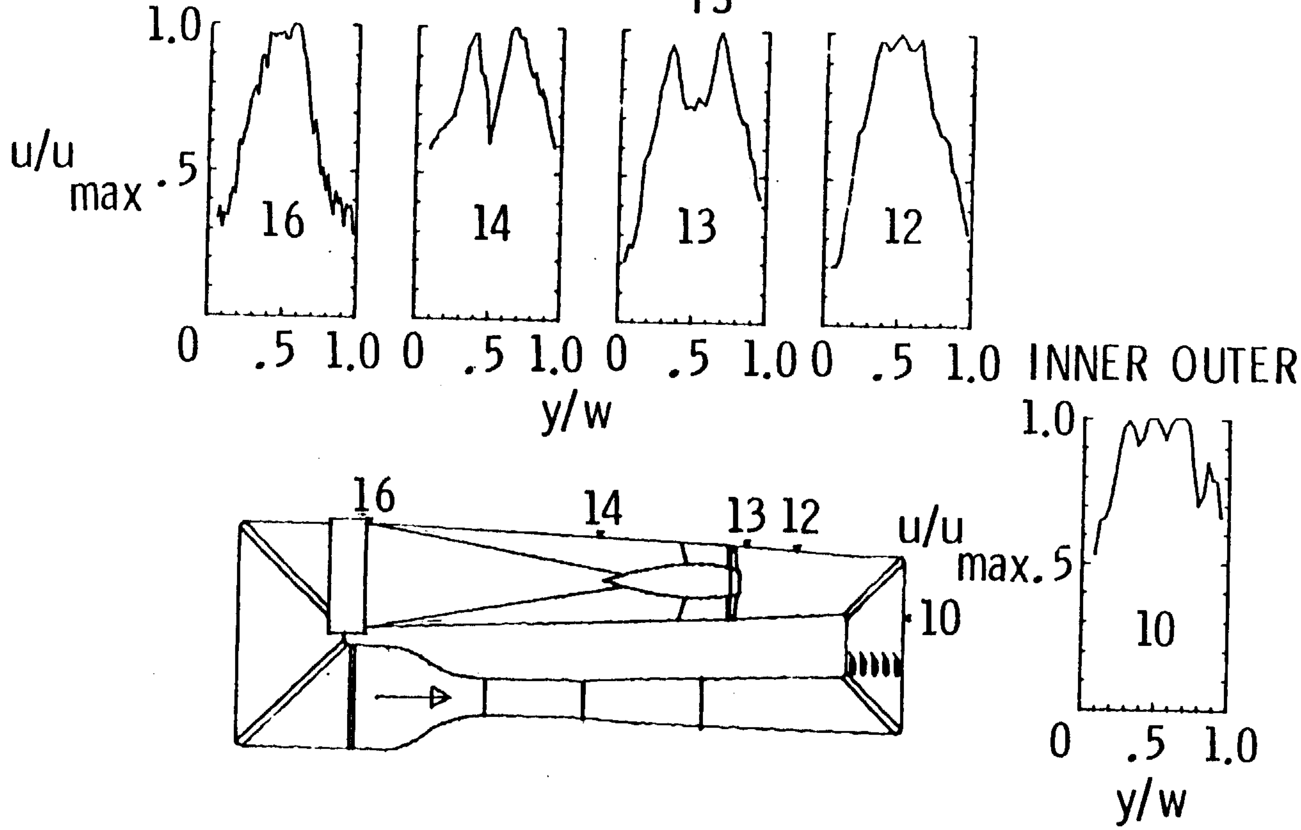
q_{TS} = 2.78 kpa (58 psf)



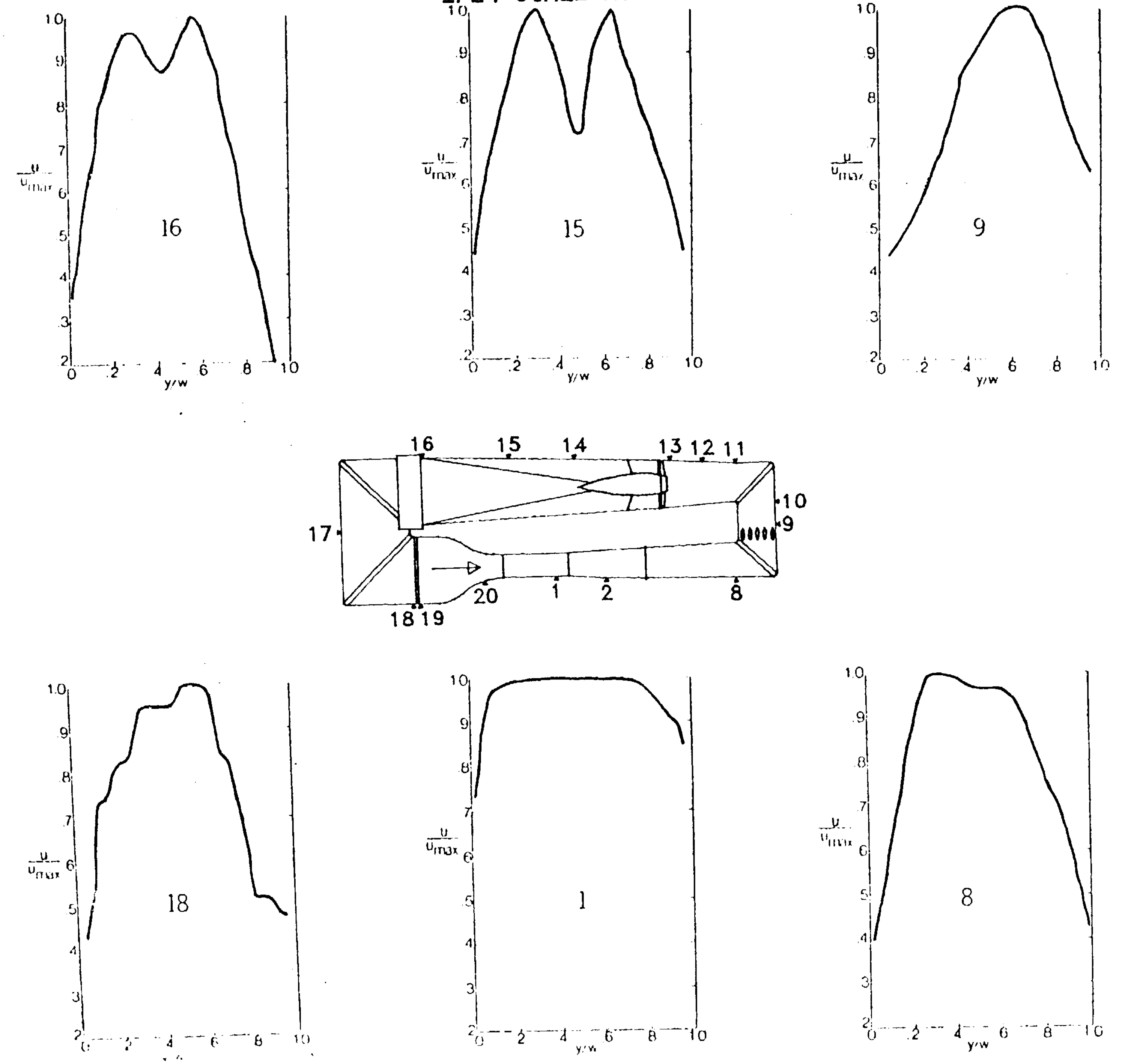

4-BY7-METER TUNNEL FLOW CONTROL VANES
TRAILING-EDGE FLAPS INSTALLED
TRAILING-EDGE FLAPS

HORIZONTAL VELOCITY PROFILES-CLOSED TEST SECTION

FCV FLAPS INSTALLED, q_{TS} = 2.78 kpa (58 psf)

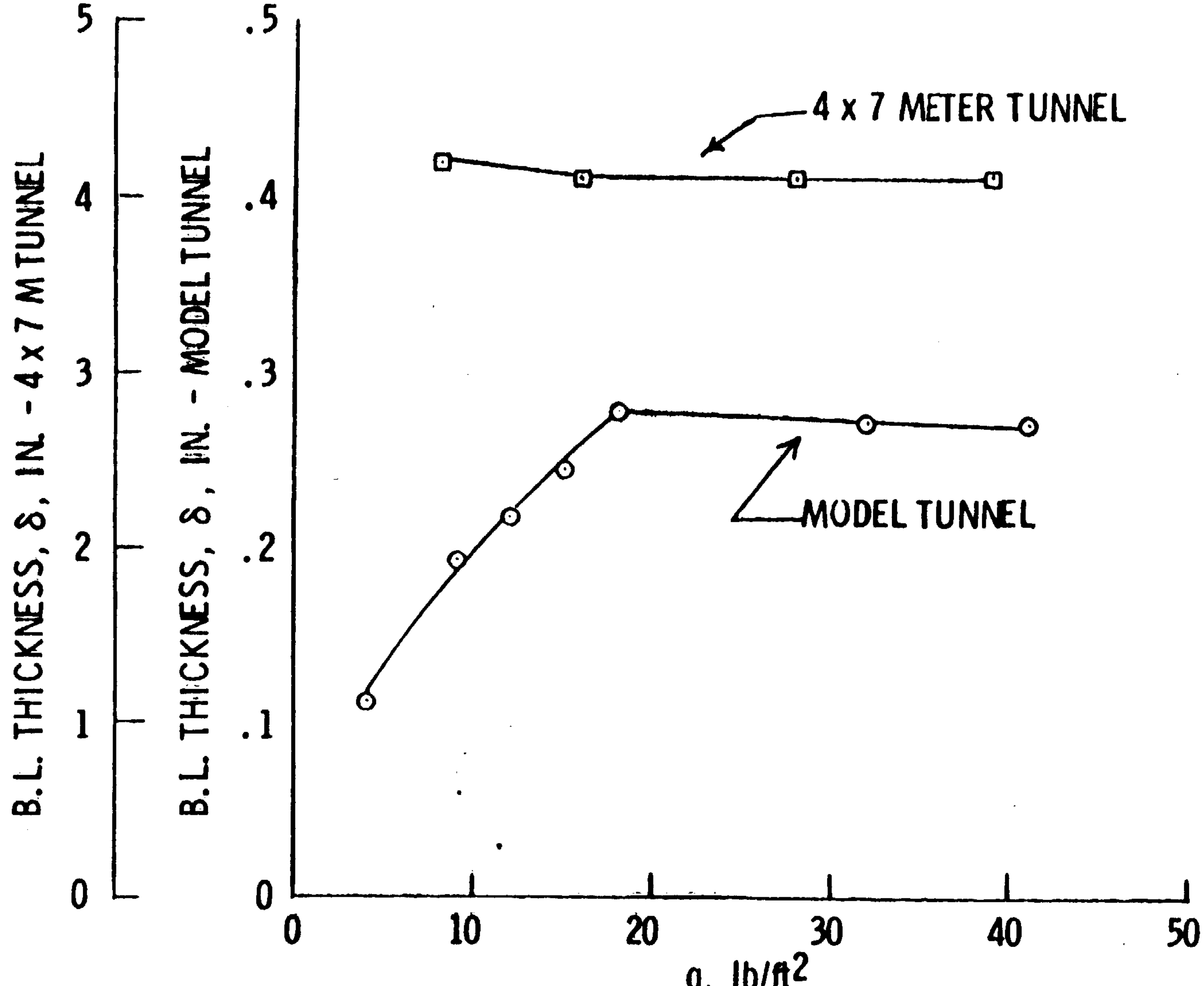


1/24-SCALE MODEL TUNNEL

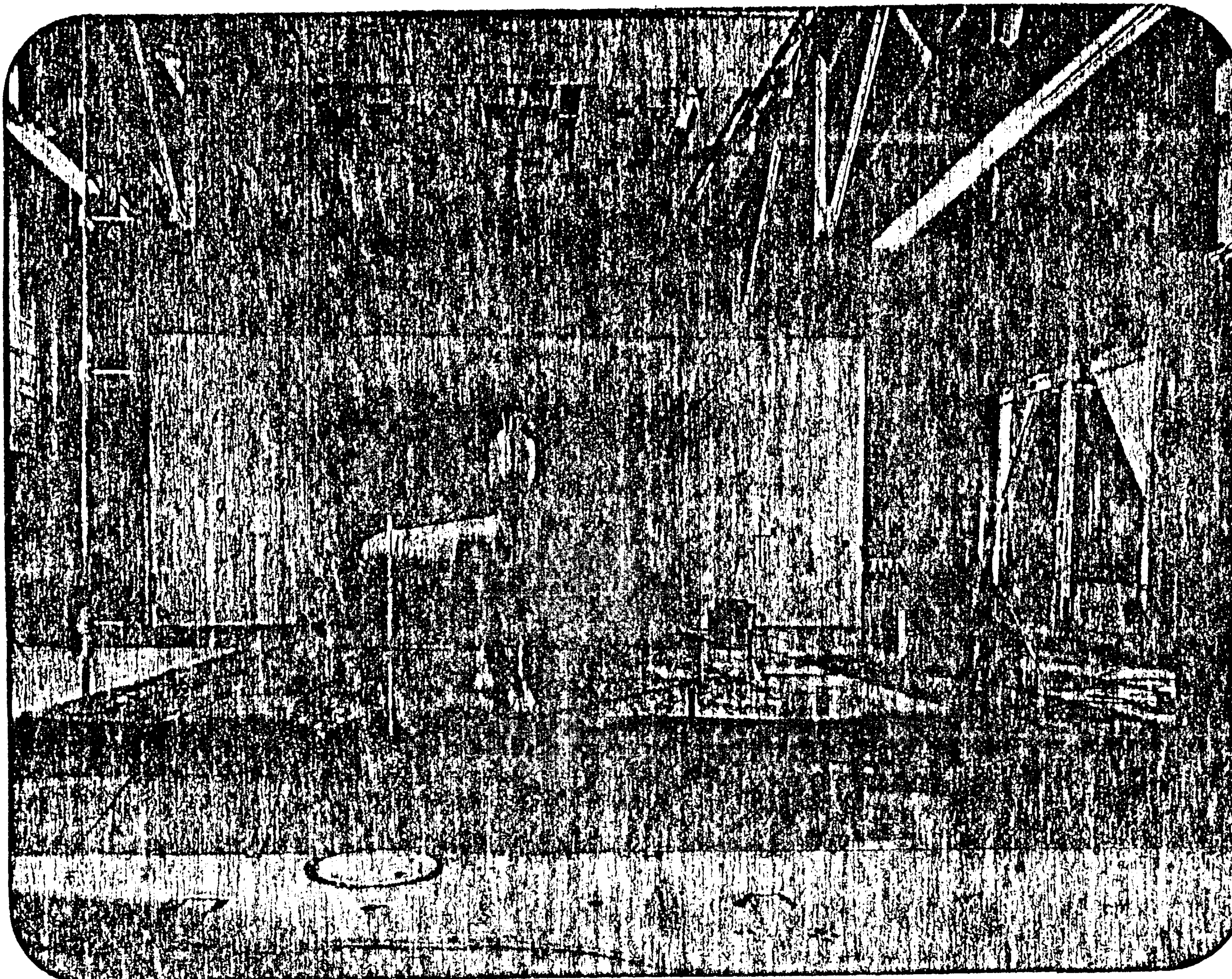


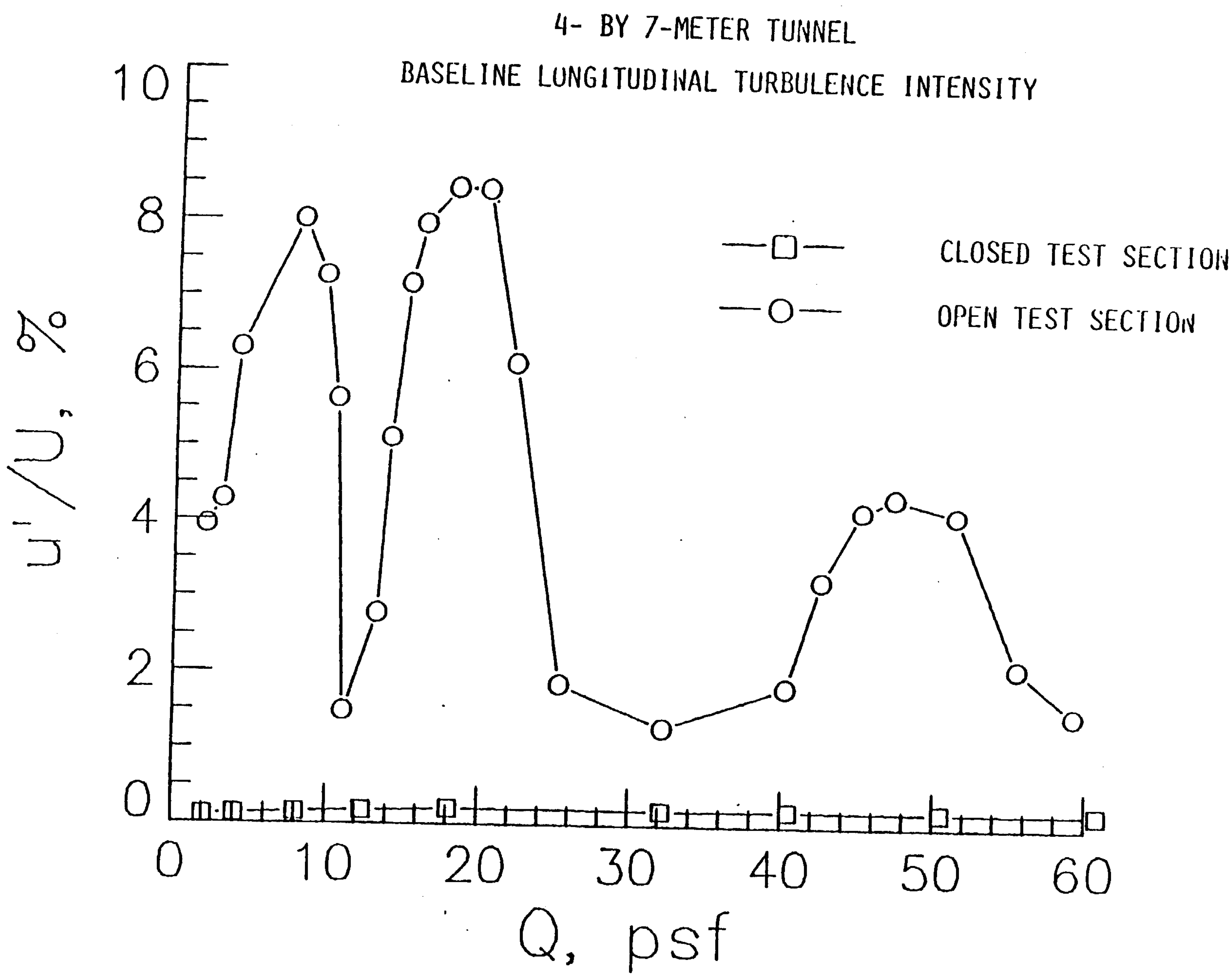
NO

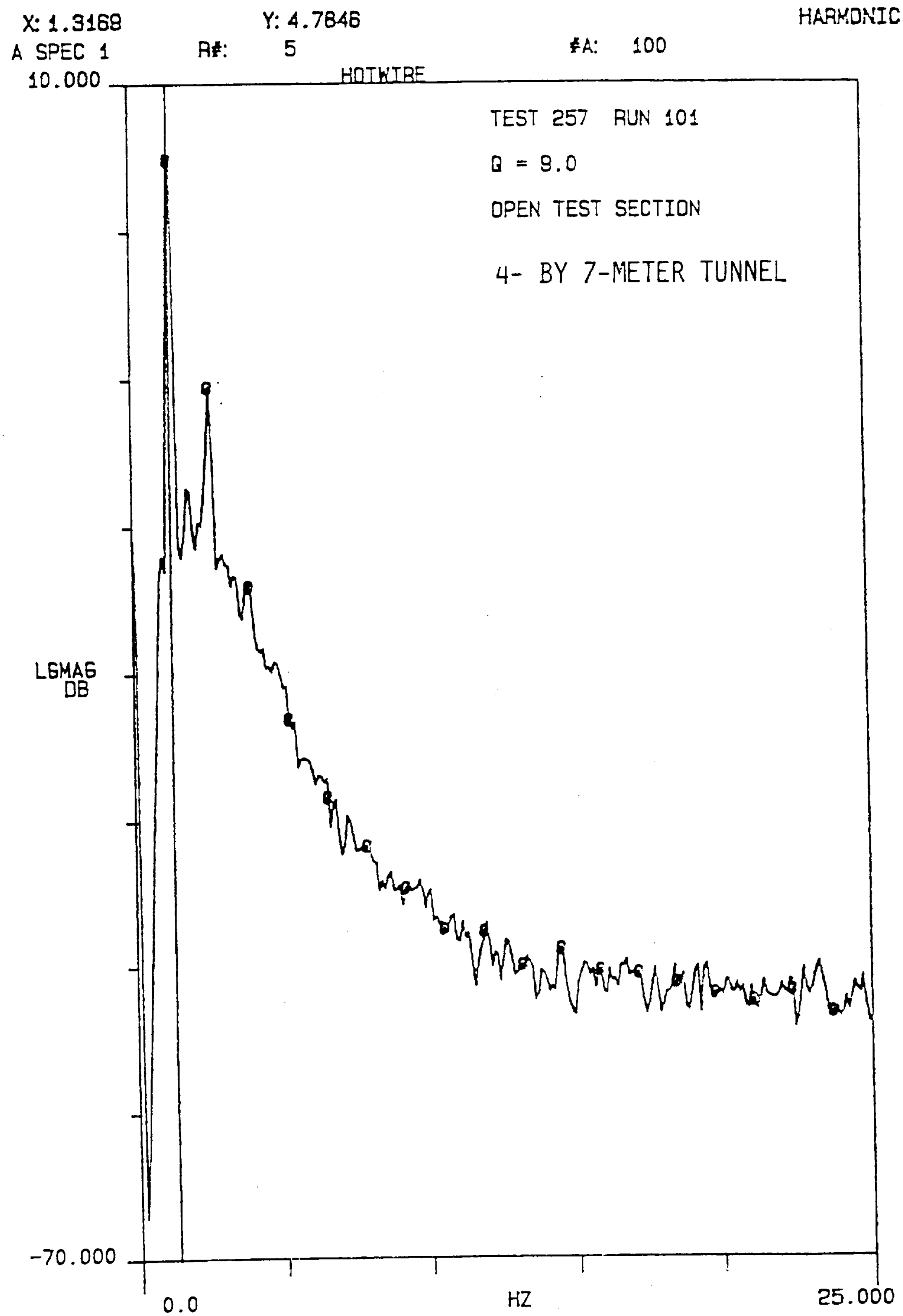
BOUNDARY-LAYER THICKNESS VS. DYNAMIC PRESSURE



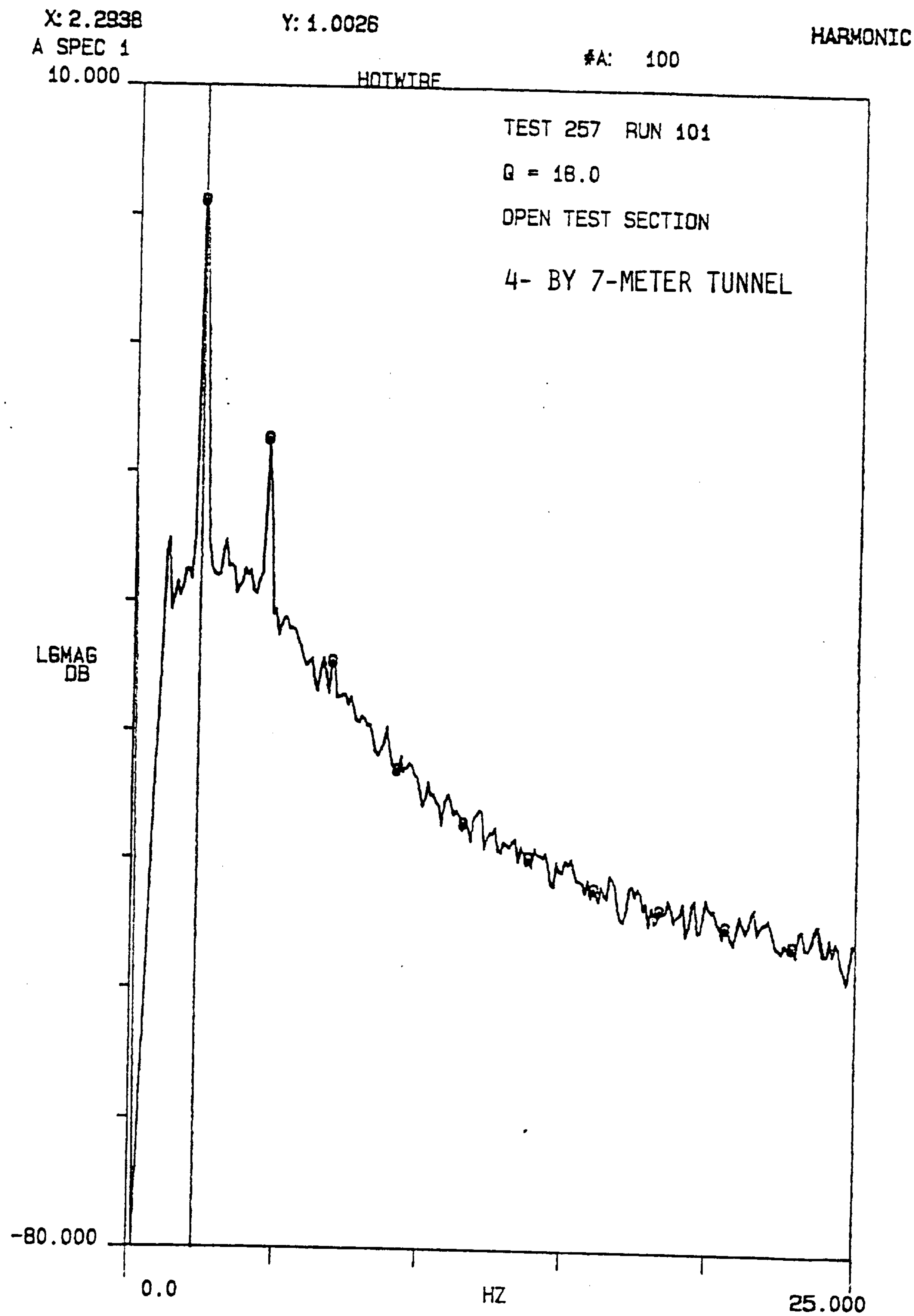
Space Administration



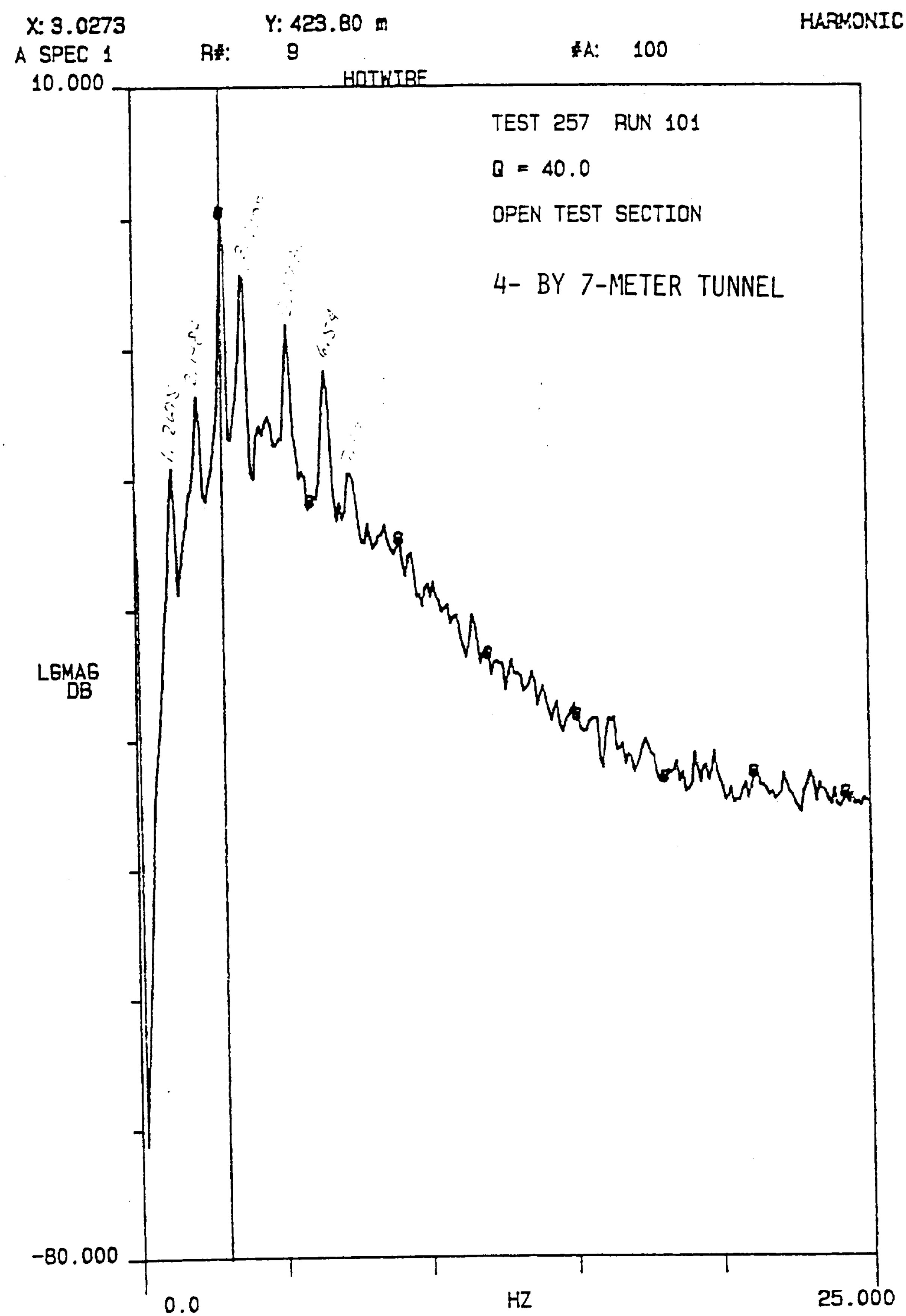

4- BY 7-METER TUNNEL
BASELINE LONGITUDINAL TURBULENCE INTENSITY
CLOSED TEST SECTION
OPEN TEST SECTION
u'/U, %
Q, psf
0
2
4
6
8
10
0
10
20
30
40
50
60



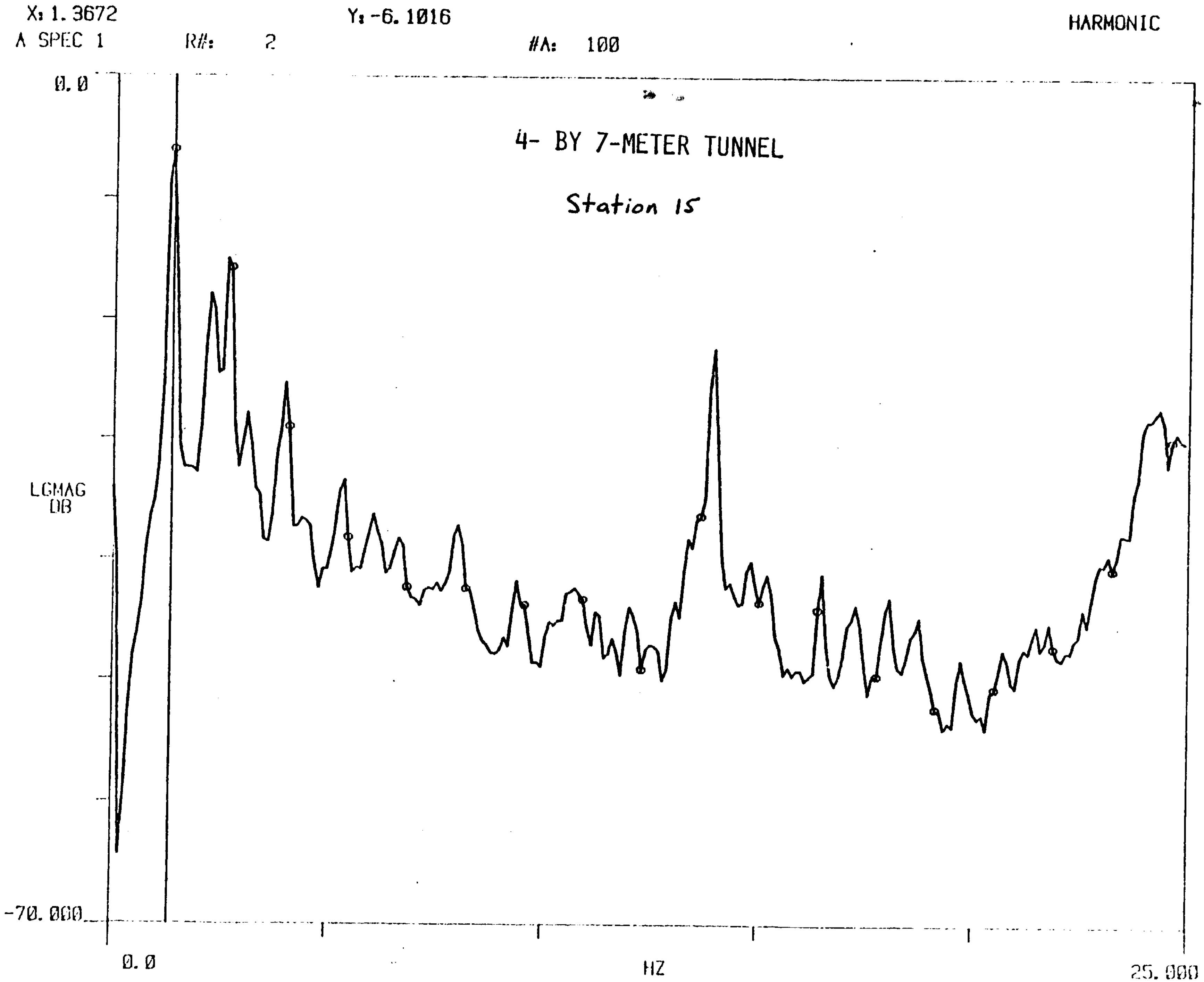
X: 1.3168
Y: 4.7846
HARMONIC
A SPEC 1
R#: 5
#A: 100
HOTWIRE
10.000
TEST 257 RUN 101
Q = 9.0
OPEN TEST SECTION
4- BY 7-METER TUNNEL
LGMAG
DB
-70.000
0.0
HZ
25.000

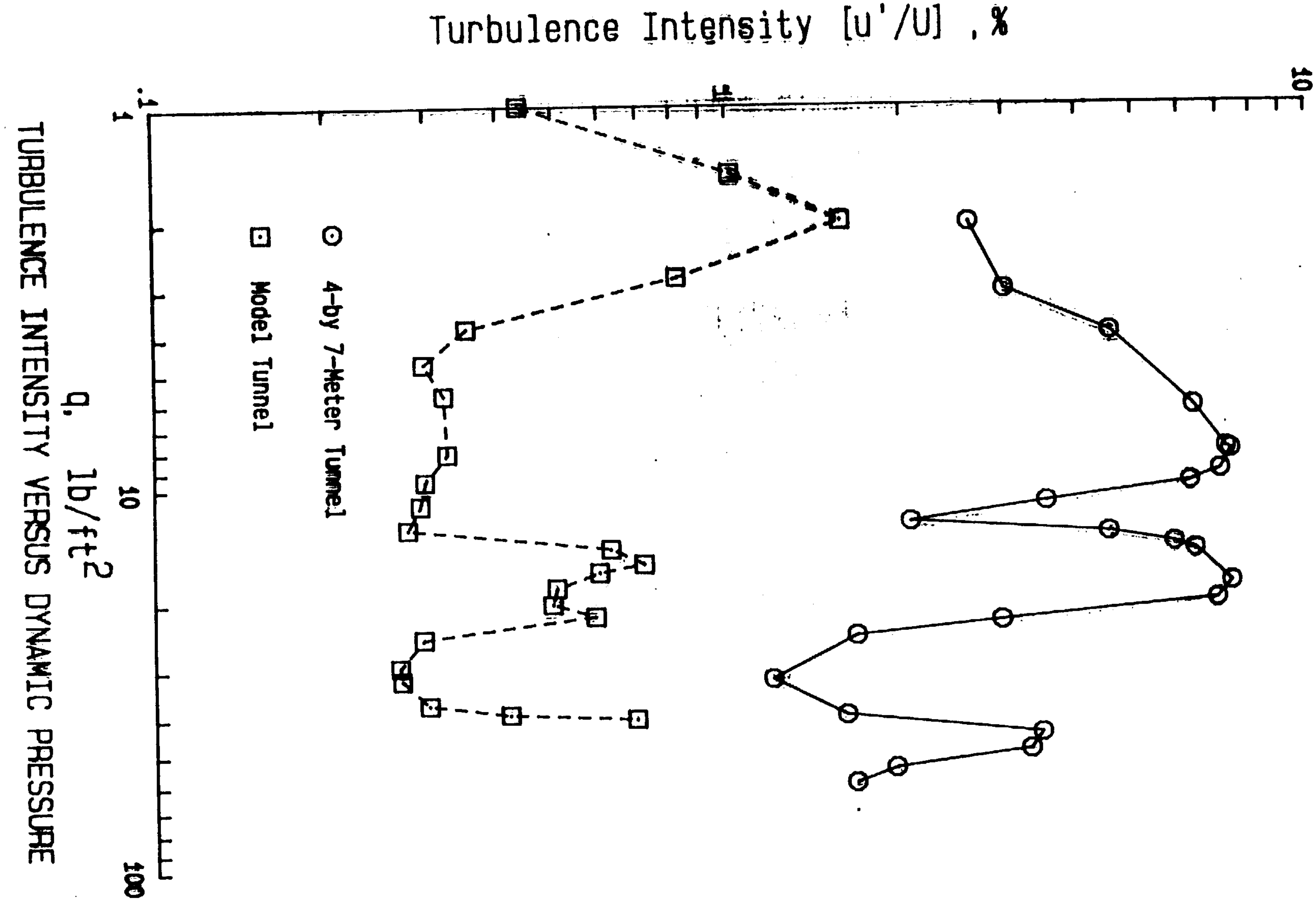


X: 2.2938
Y: 1.0026
HARMONIC
A SPEC 1
#A: 100
10.000
HOTWIRE
TEST 257 RUN 101
Q = 18.0
OPEN TEST SECTION
4- BY 7-METER TUNNEL
LGMAG
DB
-80.000
0.0
HZ
25.000

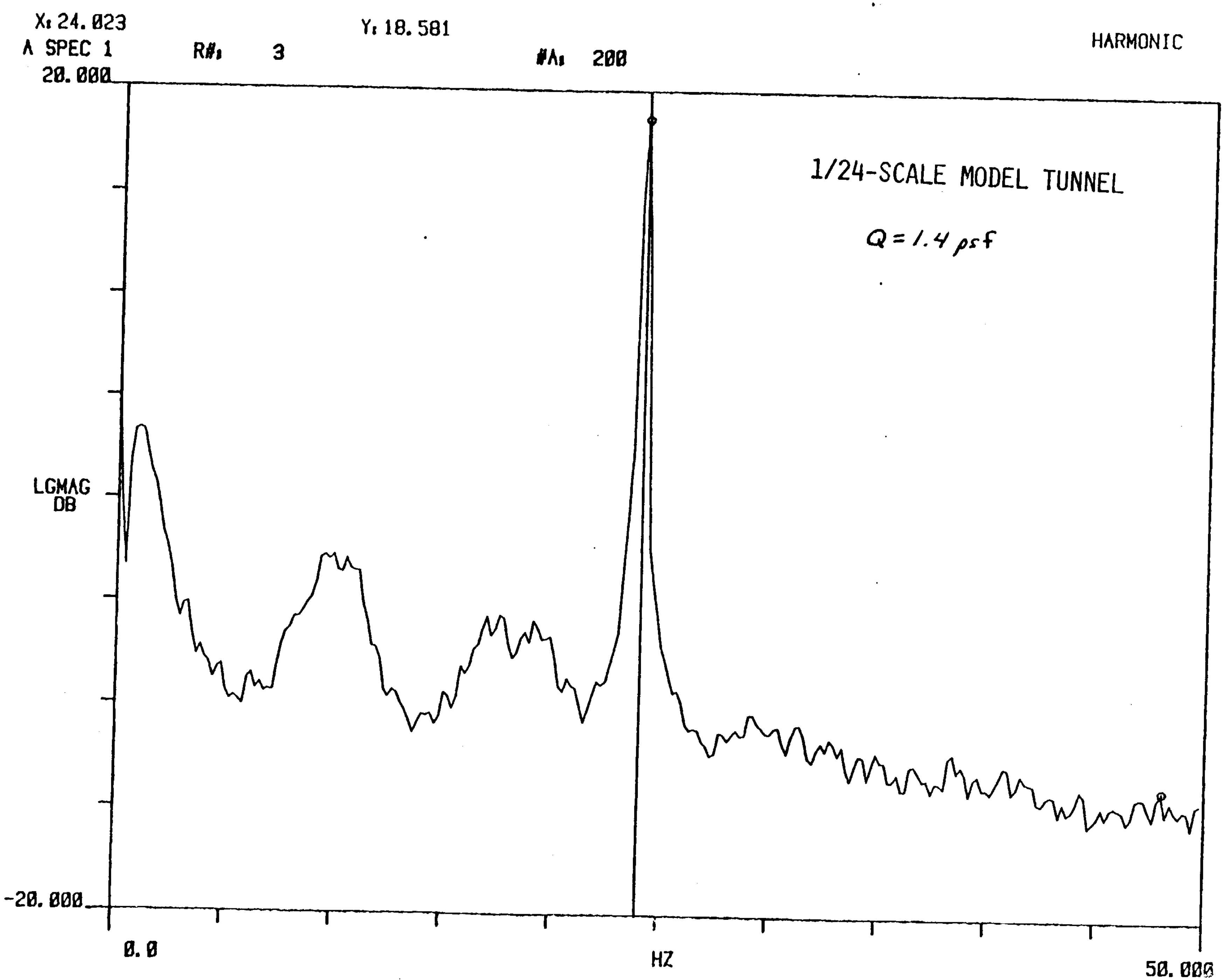

X: 3.0273
Y: 423.80 m
HARMONIC
A SPEC 1
R#: 9
#A: 100
10.000
HOTWIRE
TEST 257 RUN 101
Q = 40.0
OPEN TEST SECTION
4- BY 7-METER TUNNEL
LGMAG
DB
-80.000
0.0
HZ
25.000

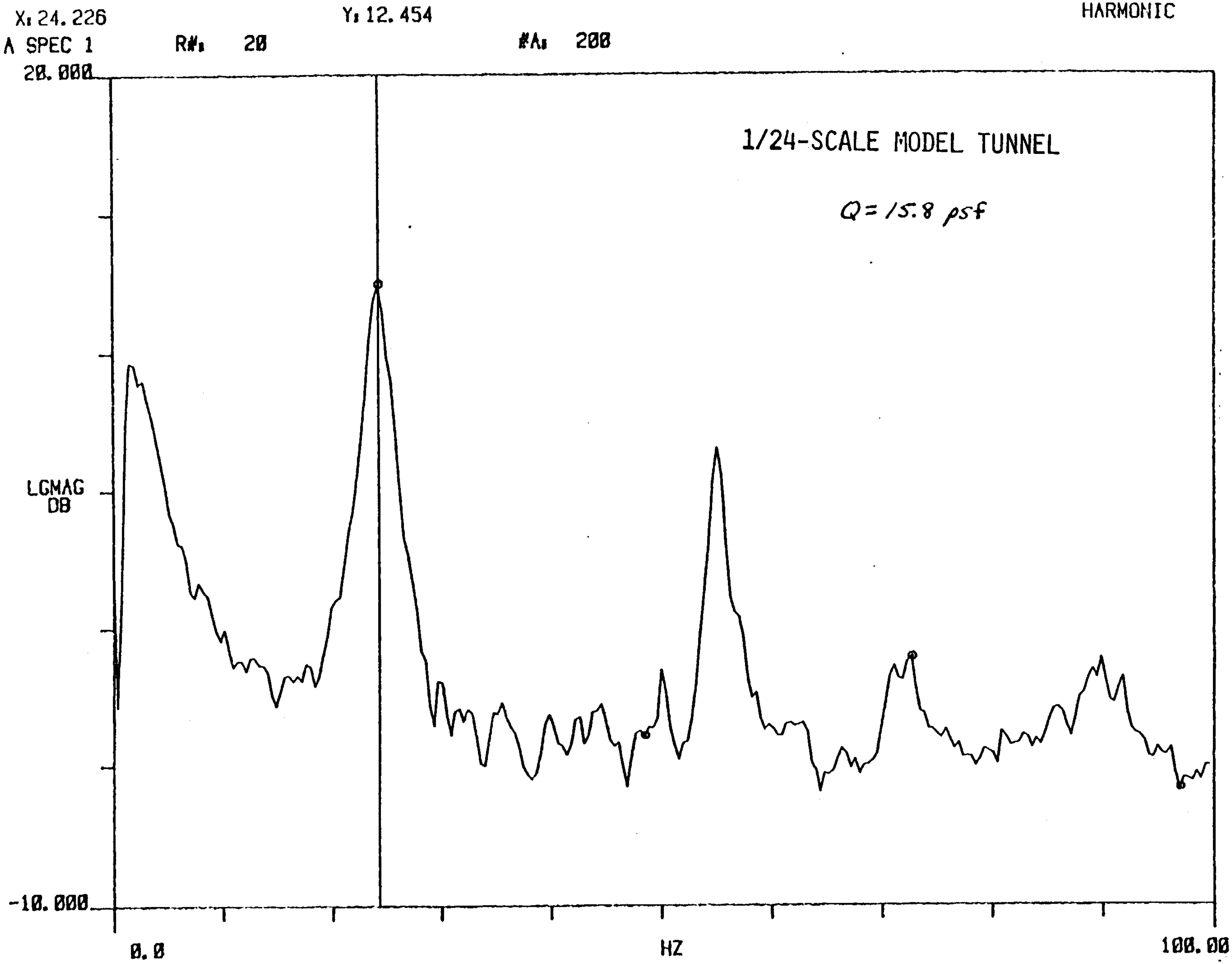
OPEN 12, FCV=10, Q=9, STA 15





TURBULENCE INTENSITY VERSUS DYNAMIC PRESSURE


X: 24.023
Y: 18.581
A SPEC 1
R#: 3
#A: 200
HARMONIC
20.000
1/24-SCALE MODEL TUNNEL
Q = 1.4 psf
LGMAG
DB
-20.000
0.0
HZ
50.000



X: 24.226
Y: 12.454
HARMONIC
A SPEC 1
R#: 20
#A: 200
20.000
1/24-SCALE MODEL TUNNEL
Q = 15.8 psf
LGMAG
DB
-10.000
0.0
HZ
100.00

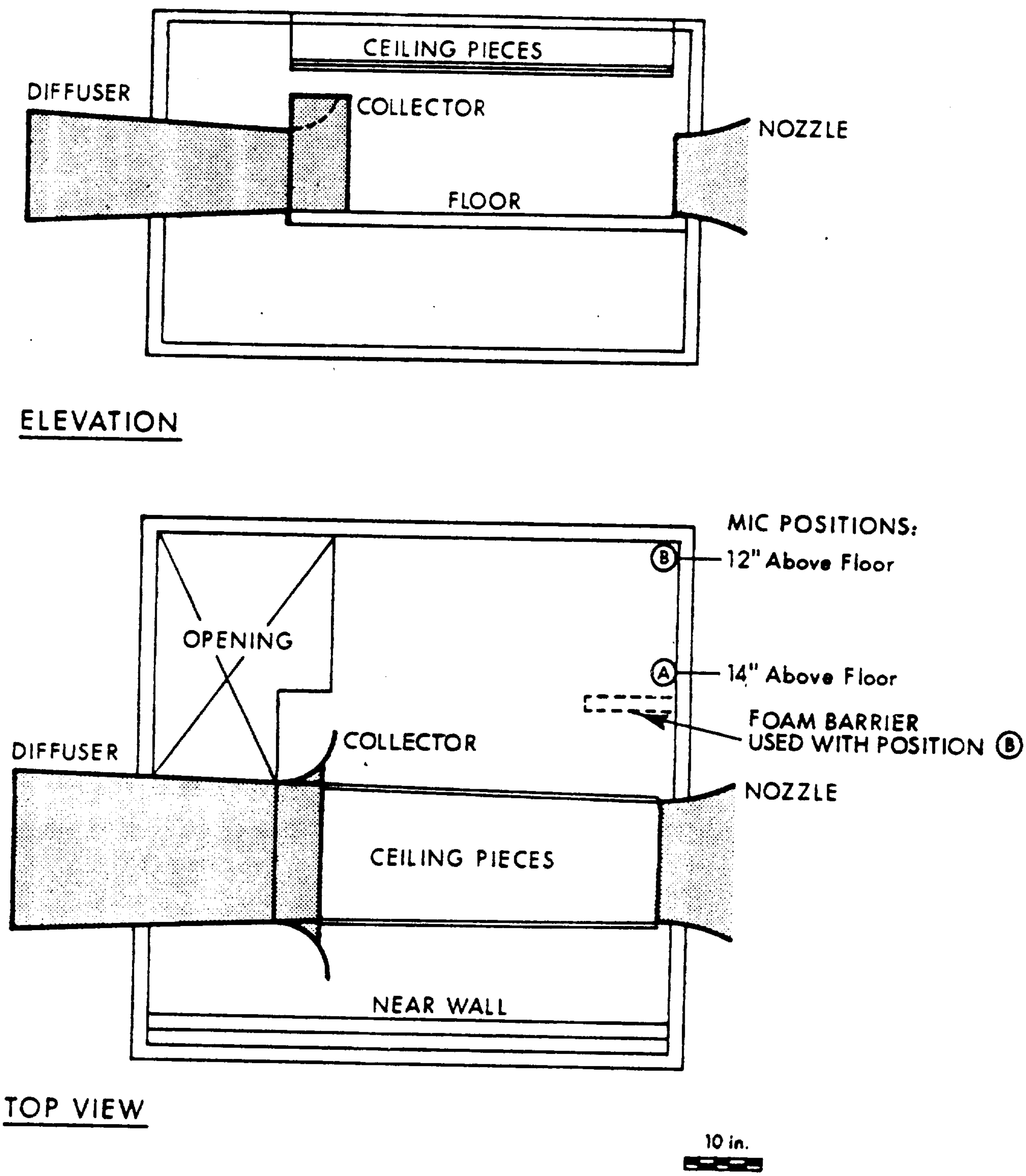


FIG. 24 AERODYNAMIC MODEL OF THE NASA LANGLEY V/STOL TUNNEL.

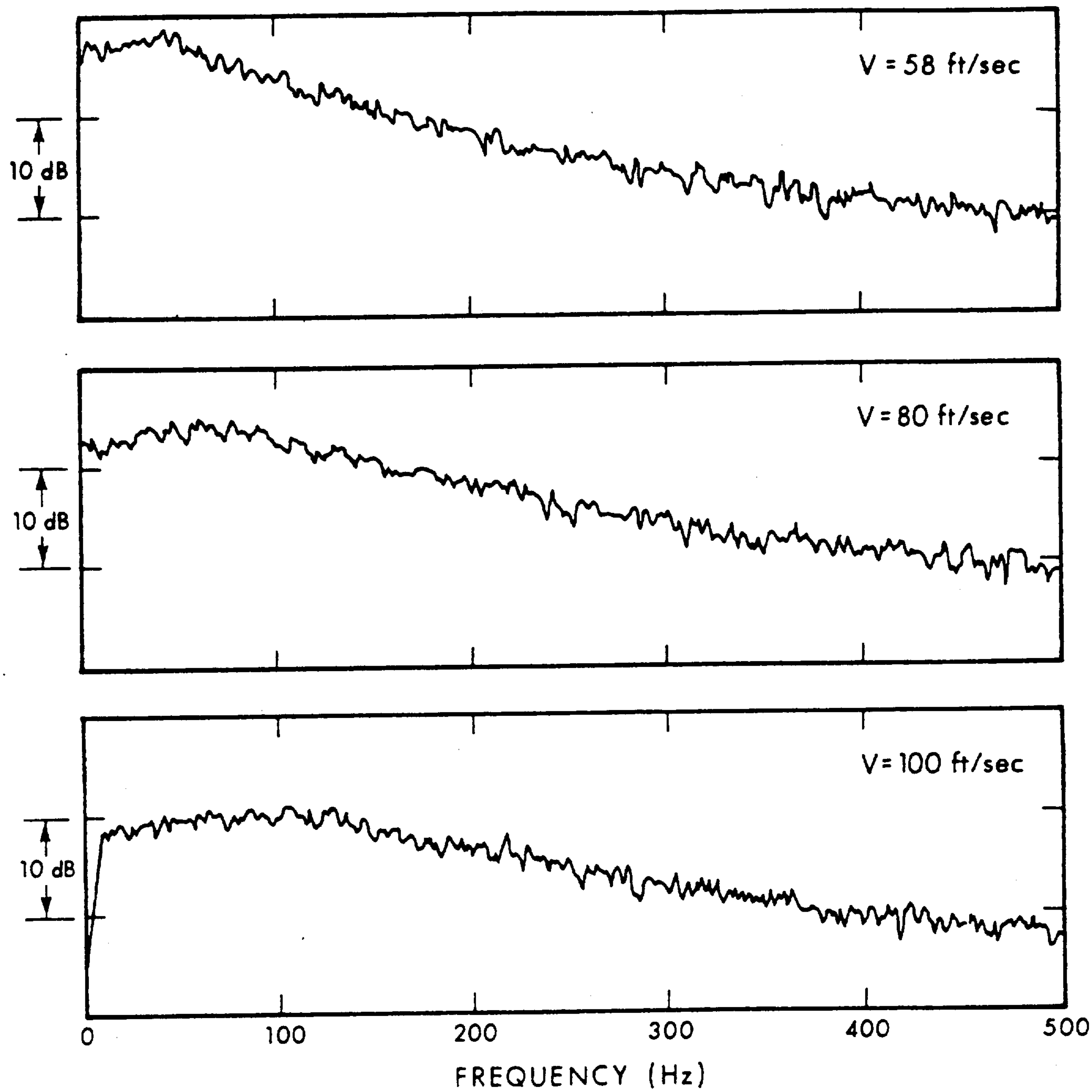
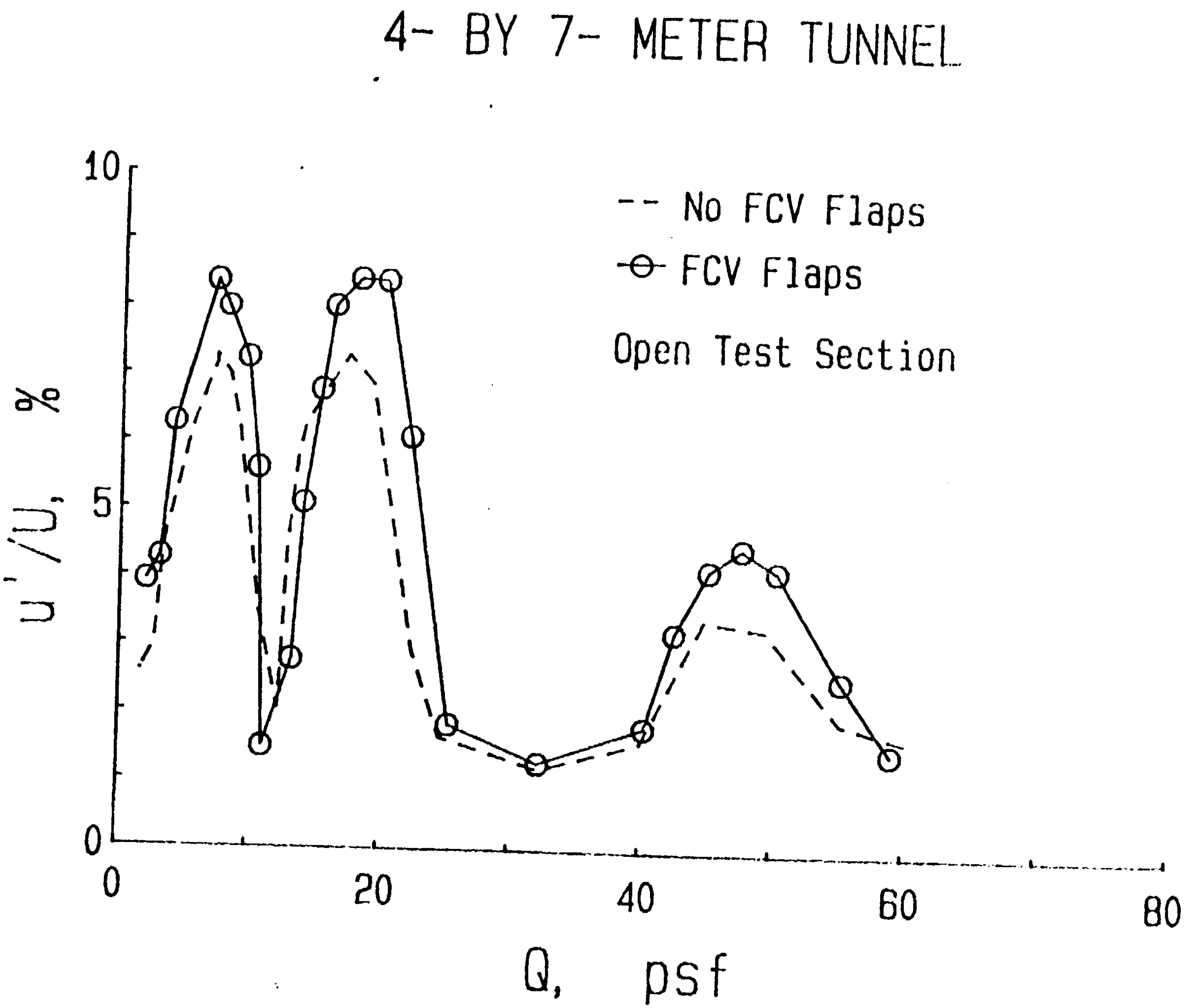
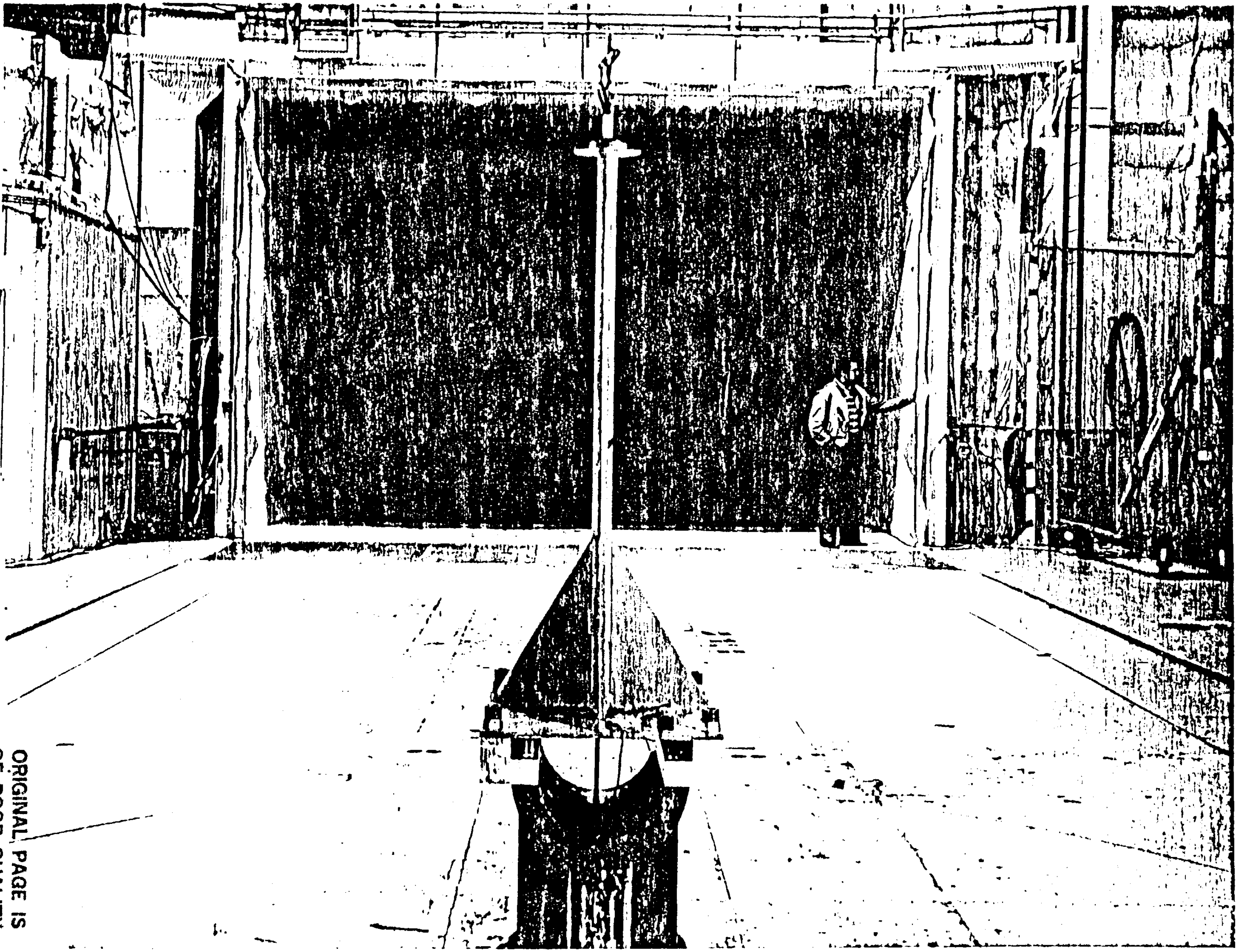


FIG. 28 TYPICAL HOT-WIRE VELOCITY SPECTRUM IN THE SHEAR LAYER.


4- BY 7- METER TUNNEL
-- No FCV Flaps
-o- FCV Flaps
Open Test Section
u'/U, %
10
5
0
0
20
40
60
80
Q, psf

NASA
L-82-10,890



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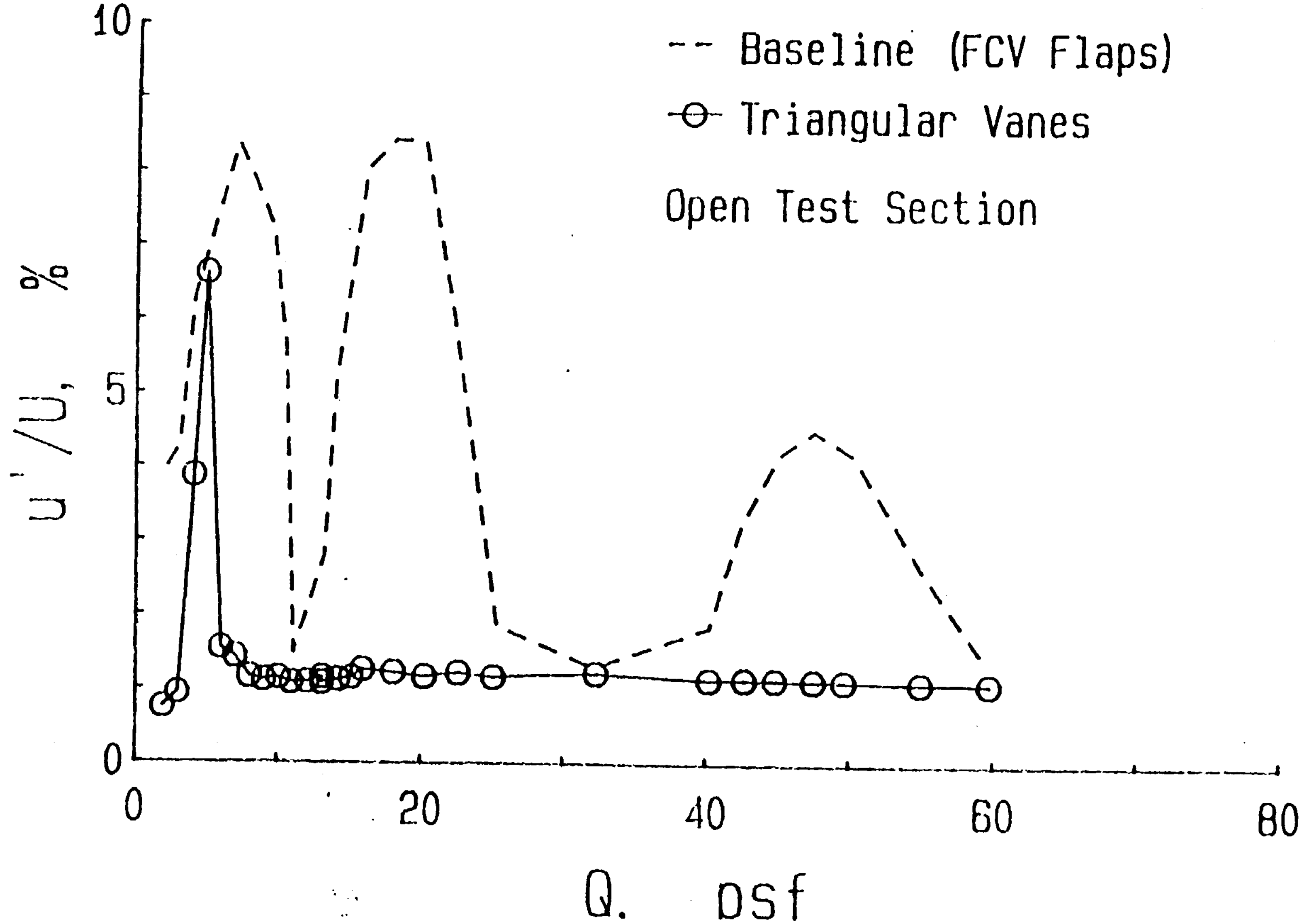
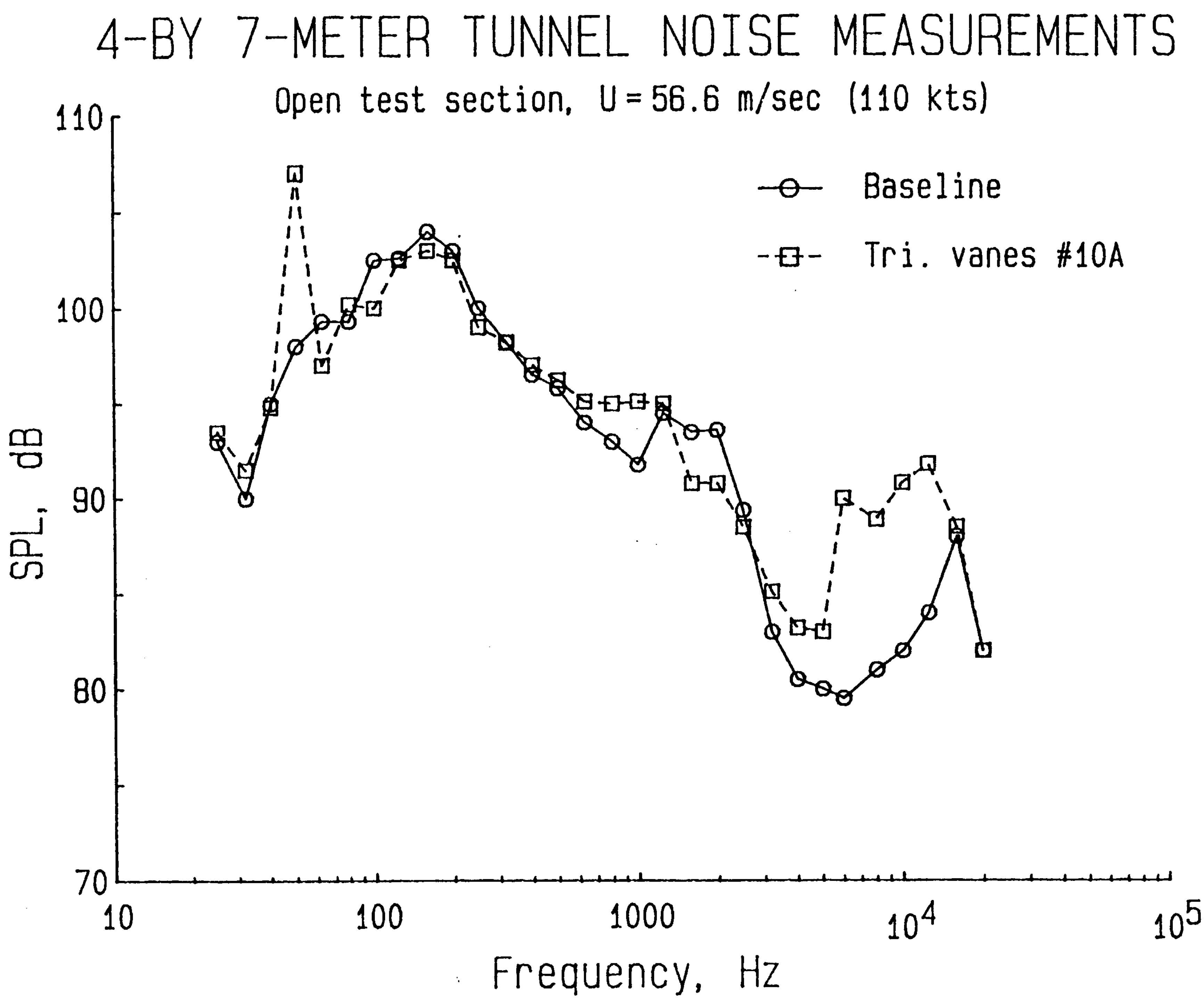
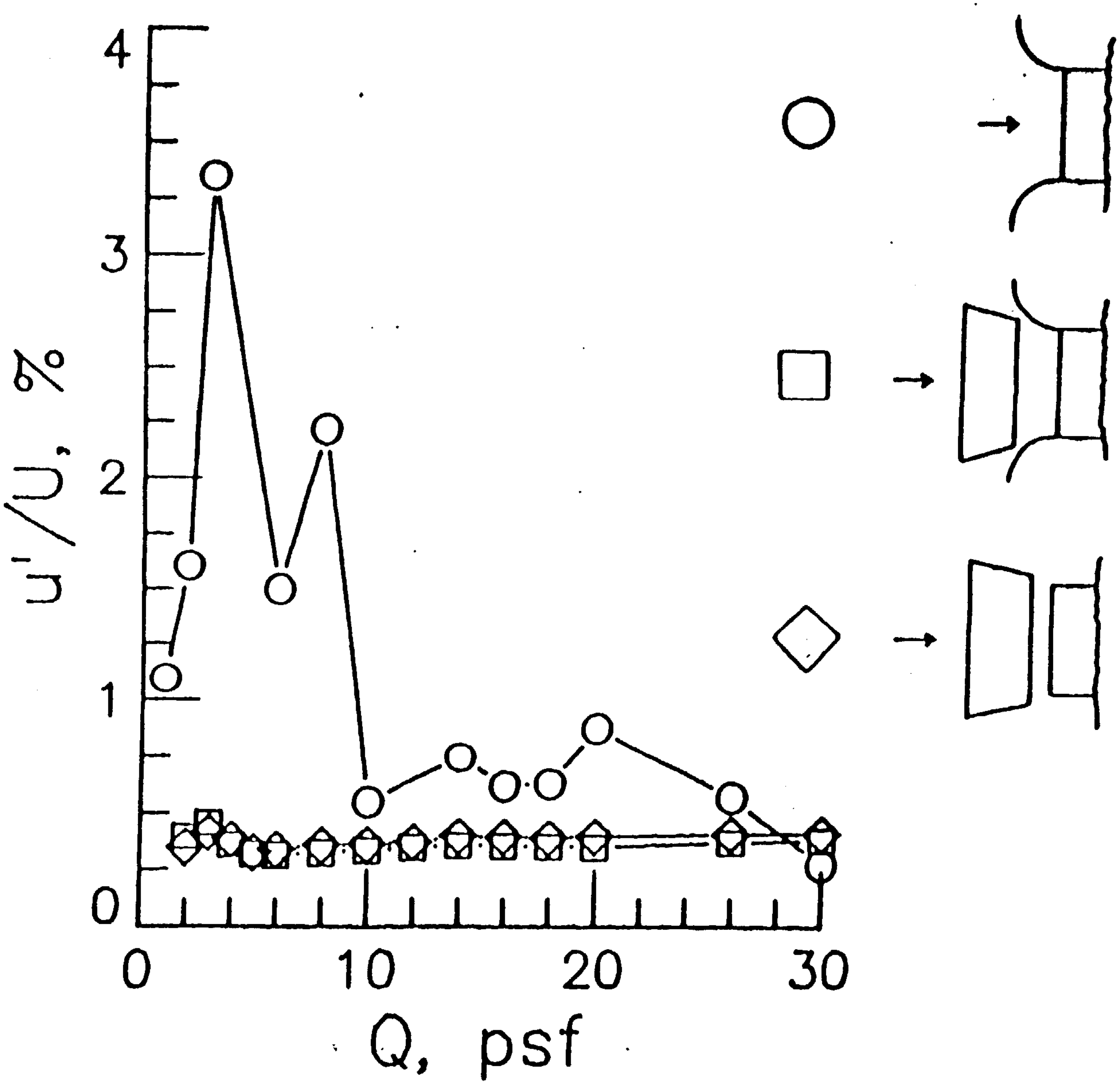
4- BY 7- METER TUNNEL





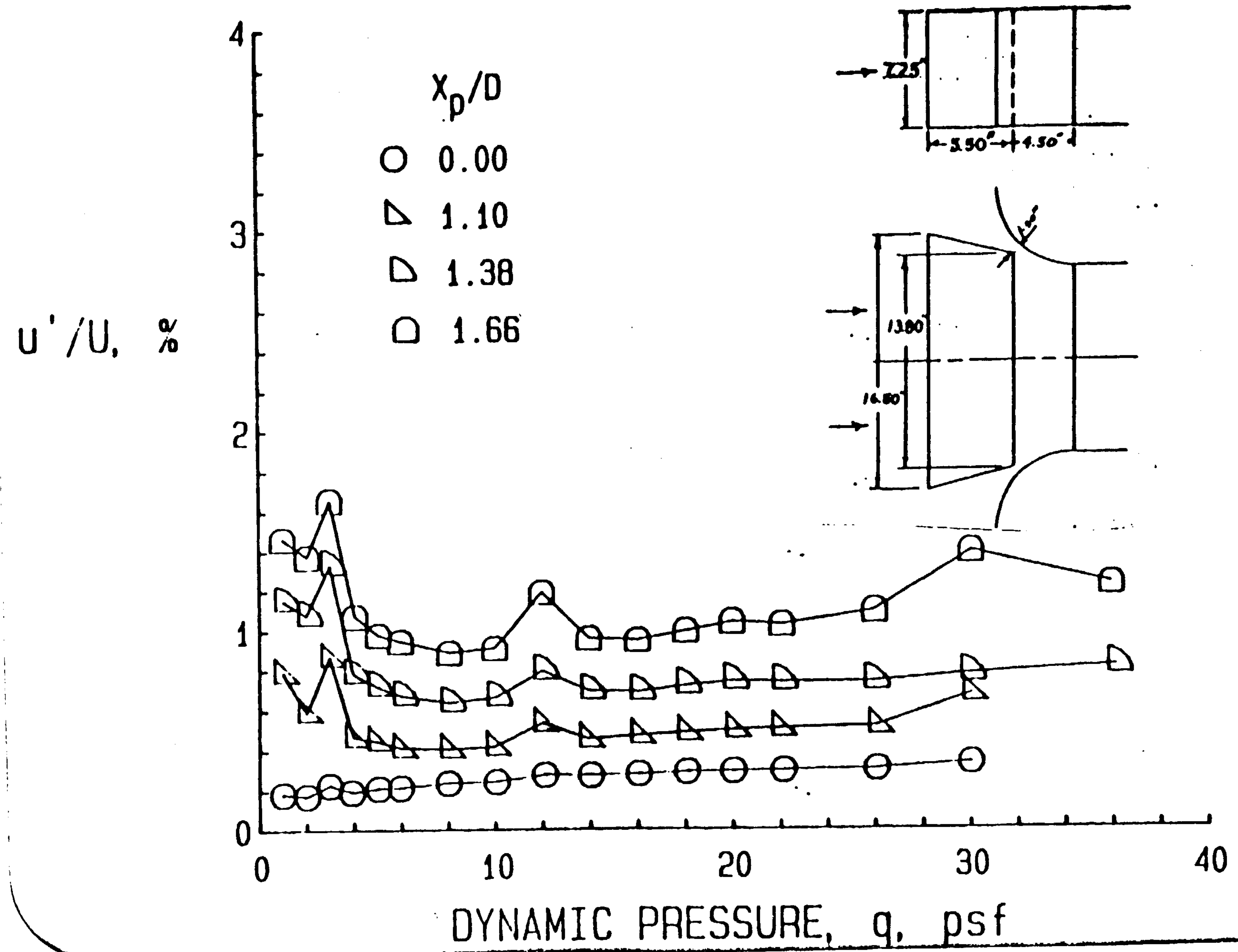
4-BY 7-METER TUNNEL NOISE MEASUREMENTS
Open test section, U = 56.6 m/sec (110 kts)
Baseline
Tri. vanes #10A
SPL, dB
110
100
90
80
70
10
100
1000
10^4
10^5
Frequency, Hz

TURBULENCE MEASUREMENTS IN MODEL TUNNEL

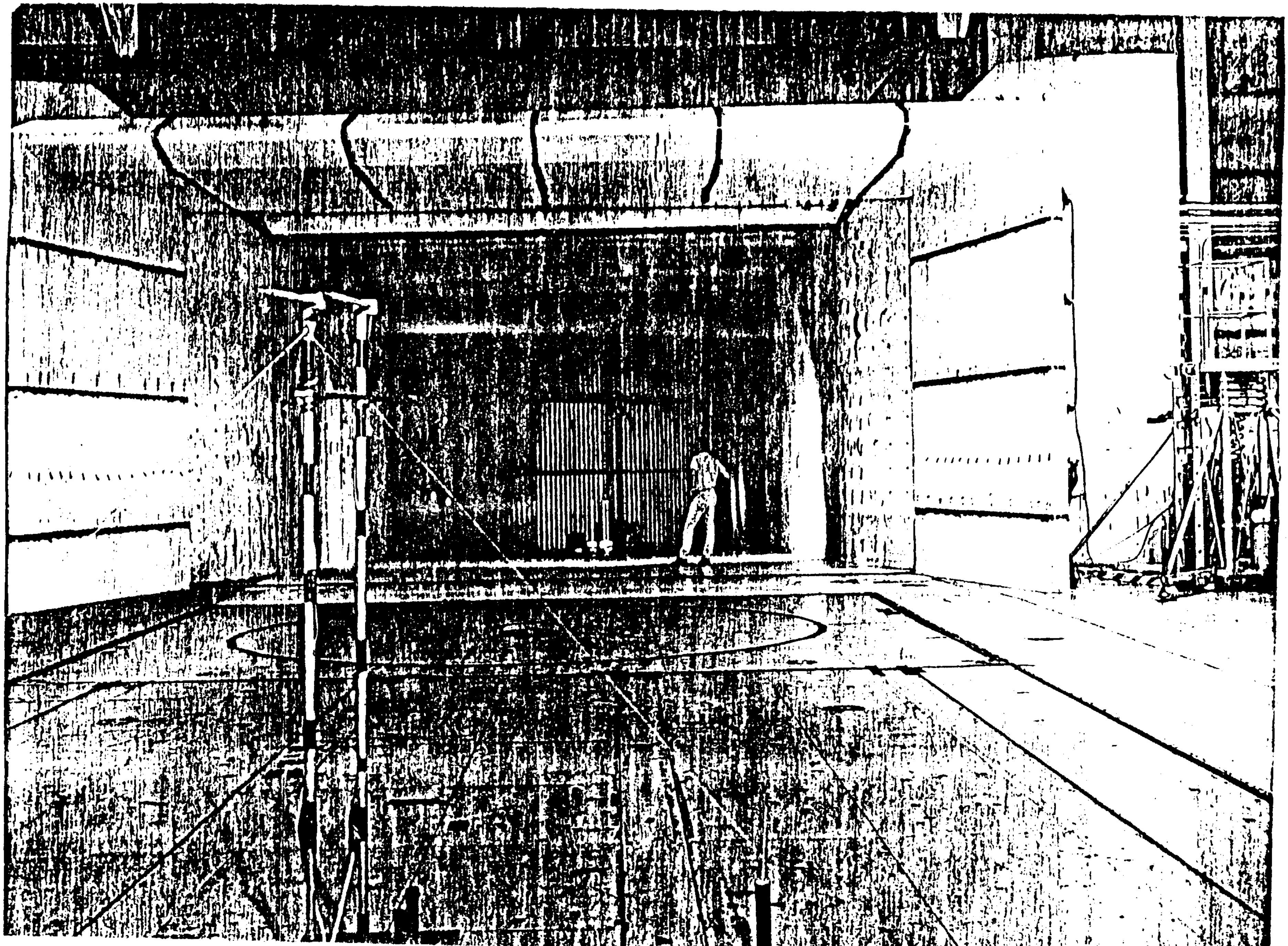


EFFECT OF AXIAL LOCATION ON VELOCITY FLUCTUATIONS

COLLECTOR CONFIGURATION #7 - 1/D = 2.21



NASA
L-83-8,073



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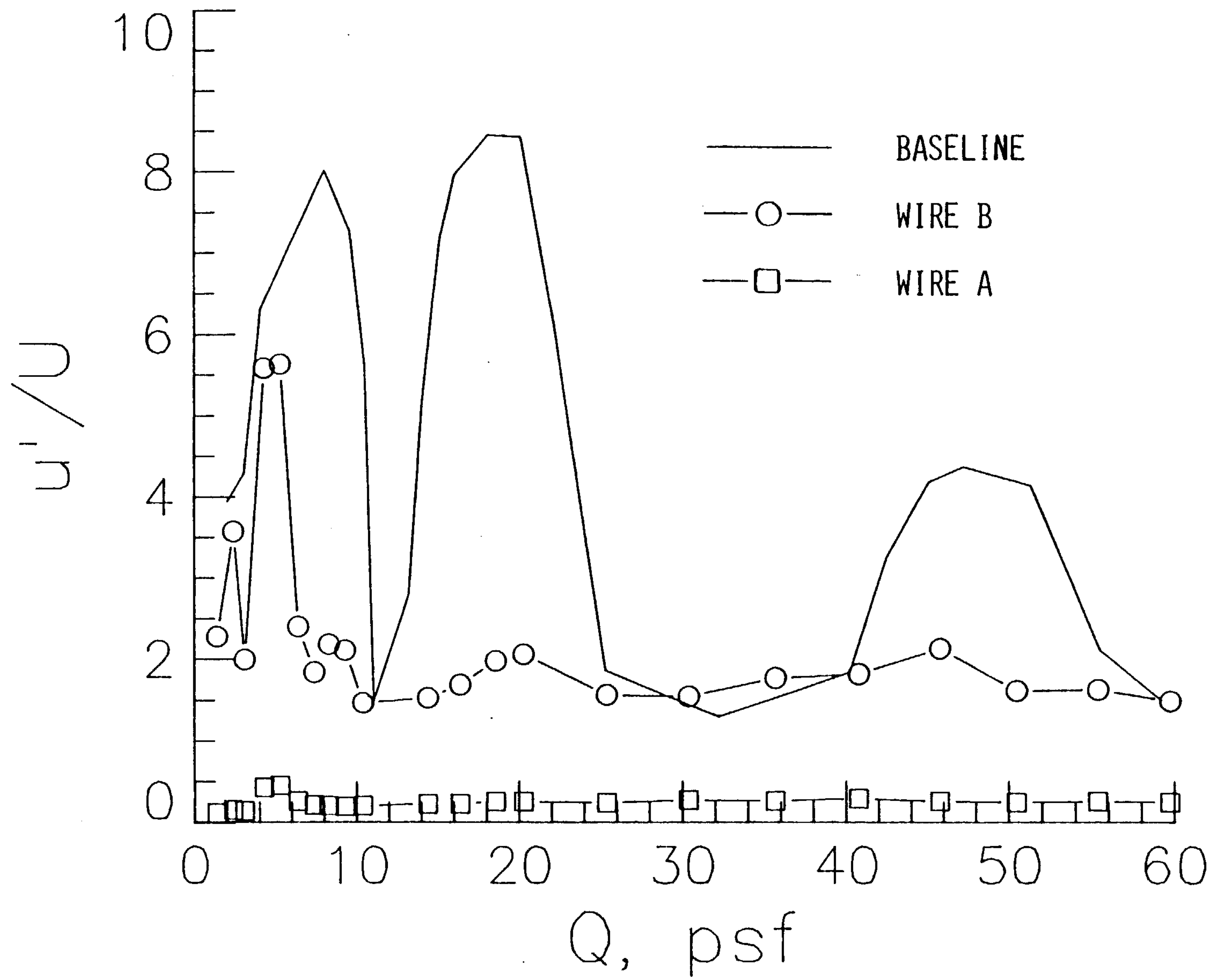
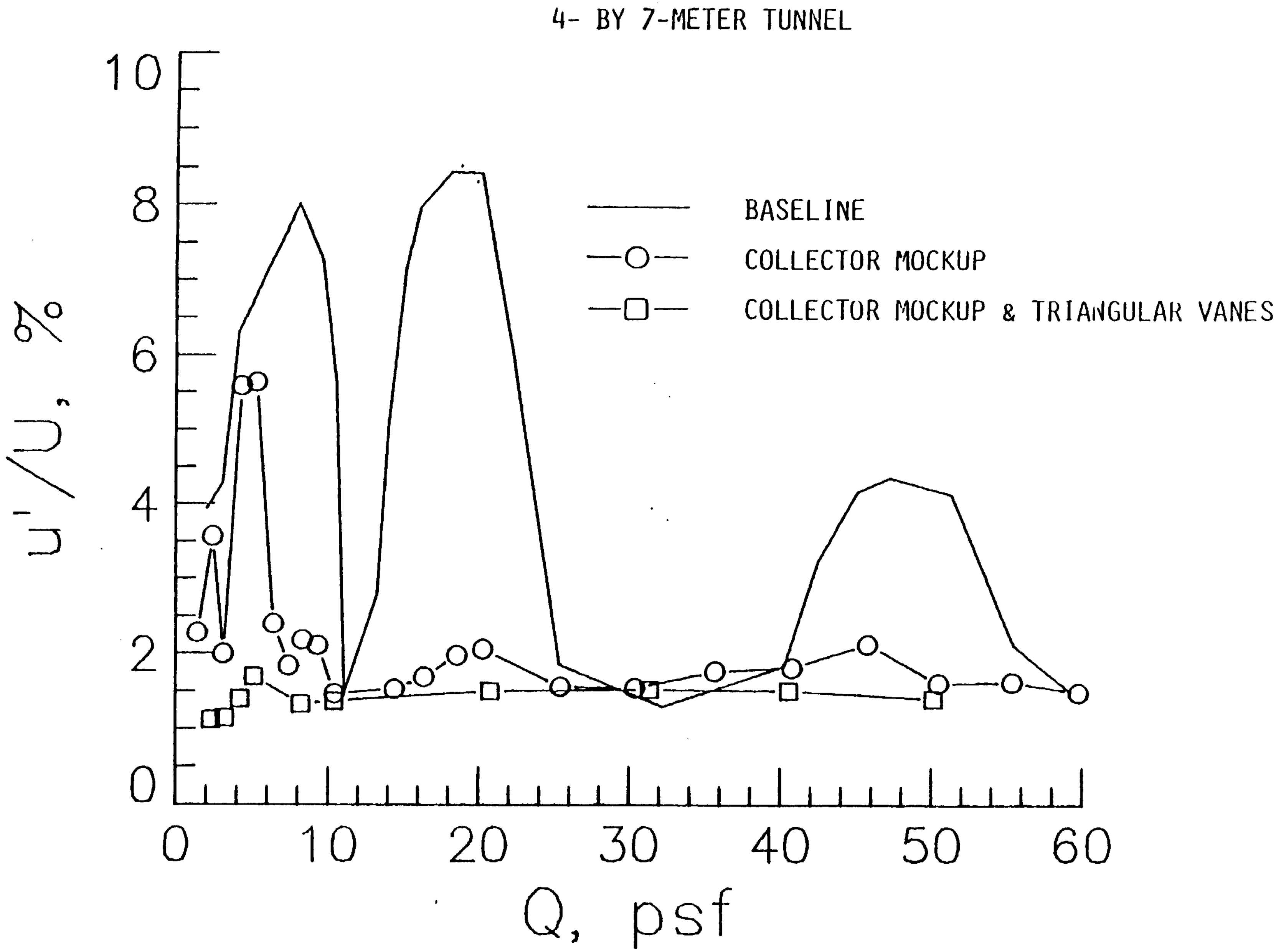
4- BY 7-METER TUNNEL

EFFECT OF COLLECTOR MOCKUP





4- BY 7-METER TUNNEL
BASELINE
COLLECTOR MOCKUP
COLLECTOR MOCKUP & TRIANGULAR VANES
u'/U, %
Q, psf
0
2
4
6
8
10
0
10
20
30
40
50
60

CONCLUDING REMARKS

- UNSUCCESSFUL IN MODELING VELOCITY PROFILES IN THE CIRCUIT OF THE 4- BY 7-METER TUNNEL. MODEL TUNNEL IS NOT AN ACCURATE DUPLICATE AND IS PROBABLY TOO SMALL

- MODEL TUNNEL HAS OPEN TEST SECTION TRENDS THAT ARE VERY SIMILAR TO THE 4-BY 7-METER TUNNEL

  - NO OBVIOUS SCALING FOR TURBULENCE INTENSITIES

  - FREQUENCIES SCALE APPROXIMATELY WITH THE GEOMETRIC RATIO

- COMPLETE CIRCUIT HAS A SIGNIFICANT EFFECT ON FLOW PULSATIONS

CONCERNS

- ACCURATE MODEL TUNNEL SIMULATION IS DIFFICULT AT BEST

- REYNOLDS NUMBER MATCHING MAY BE IMPORTANT IN DETERMINING FLOW SEPARATION ZONES

MAKE YOUR MODEL TUNNEL AS BIG AS POSSIBLE AND PROVIDE FOR REYNOLDS NUMBER SIMULATION

AEDC MODELING PROGRAMS

R. DEAN HERRON

MANAGER, TEST OPERATIONS AND ENGINEERING BRANCH (CALSPAN)

ARNOLD ENGINEERING AND DEVELOPMENT CENTER

WIND TUNNEL MODELING AT AEDC

DEAN HERRON
ARVIN/CALSPAN FIELD SERVICES

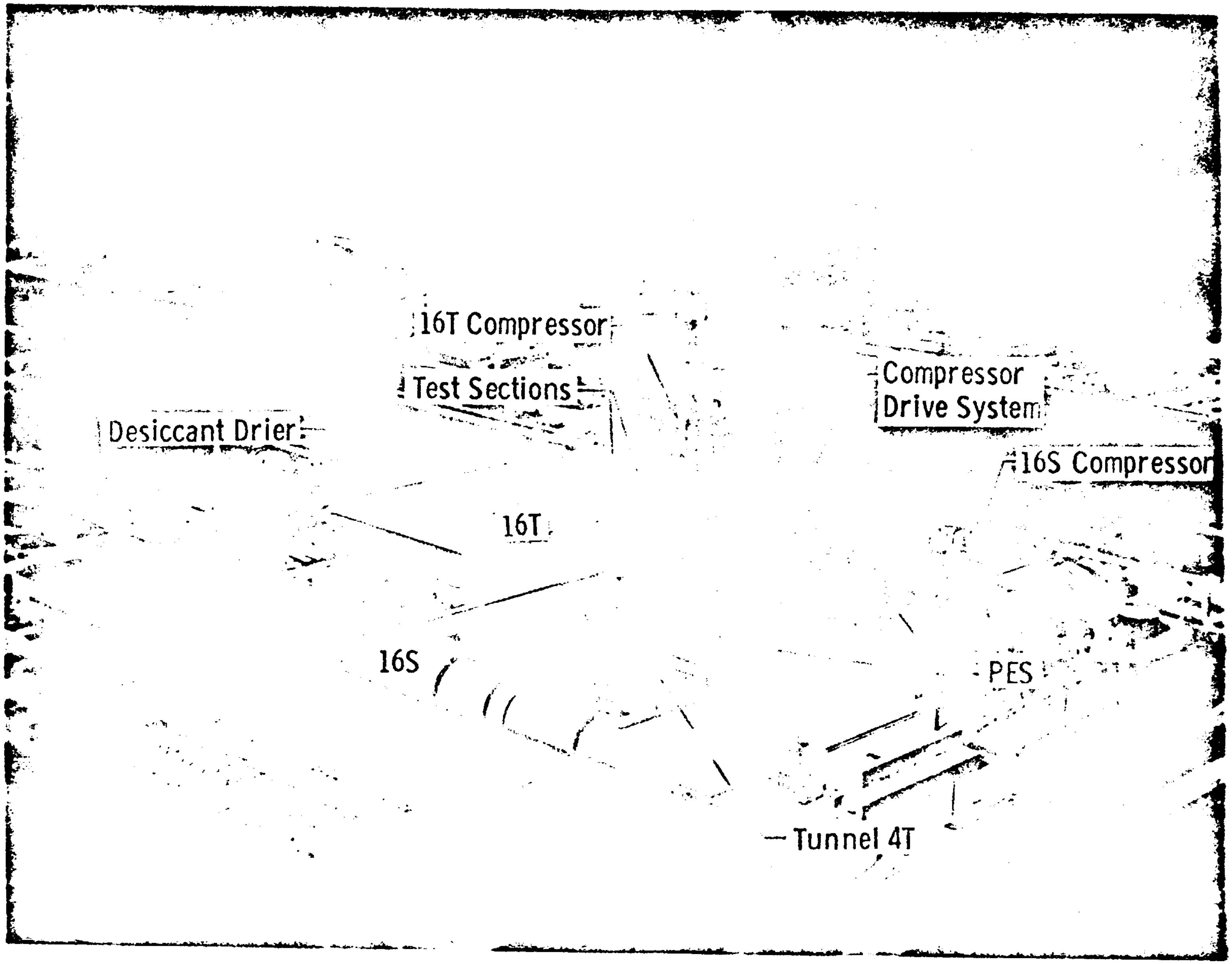
ARNOLD ENGINEERING DEVELOPMENT CENTER
AIR FORCE SYSTEMS COMMAND

PROPULSION WIND TUNNEL FACILITY

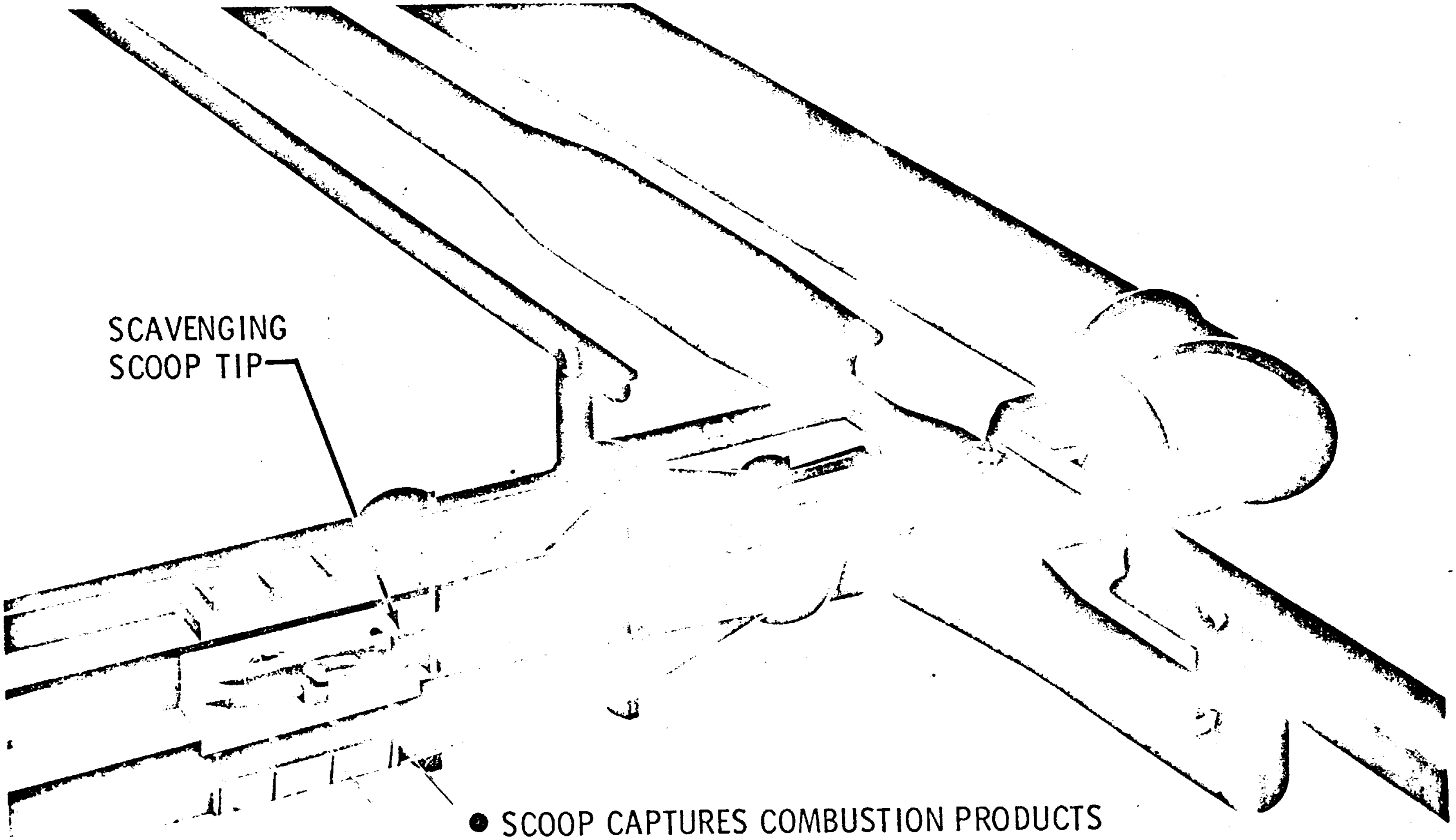
- 16T
- 16S
- 4T

VON KARMAN GAS DYNAMICS FACILITY

- APTU - AERODYNAMIC AND PROPULSION TEST UNIT

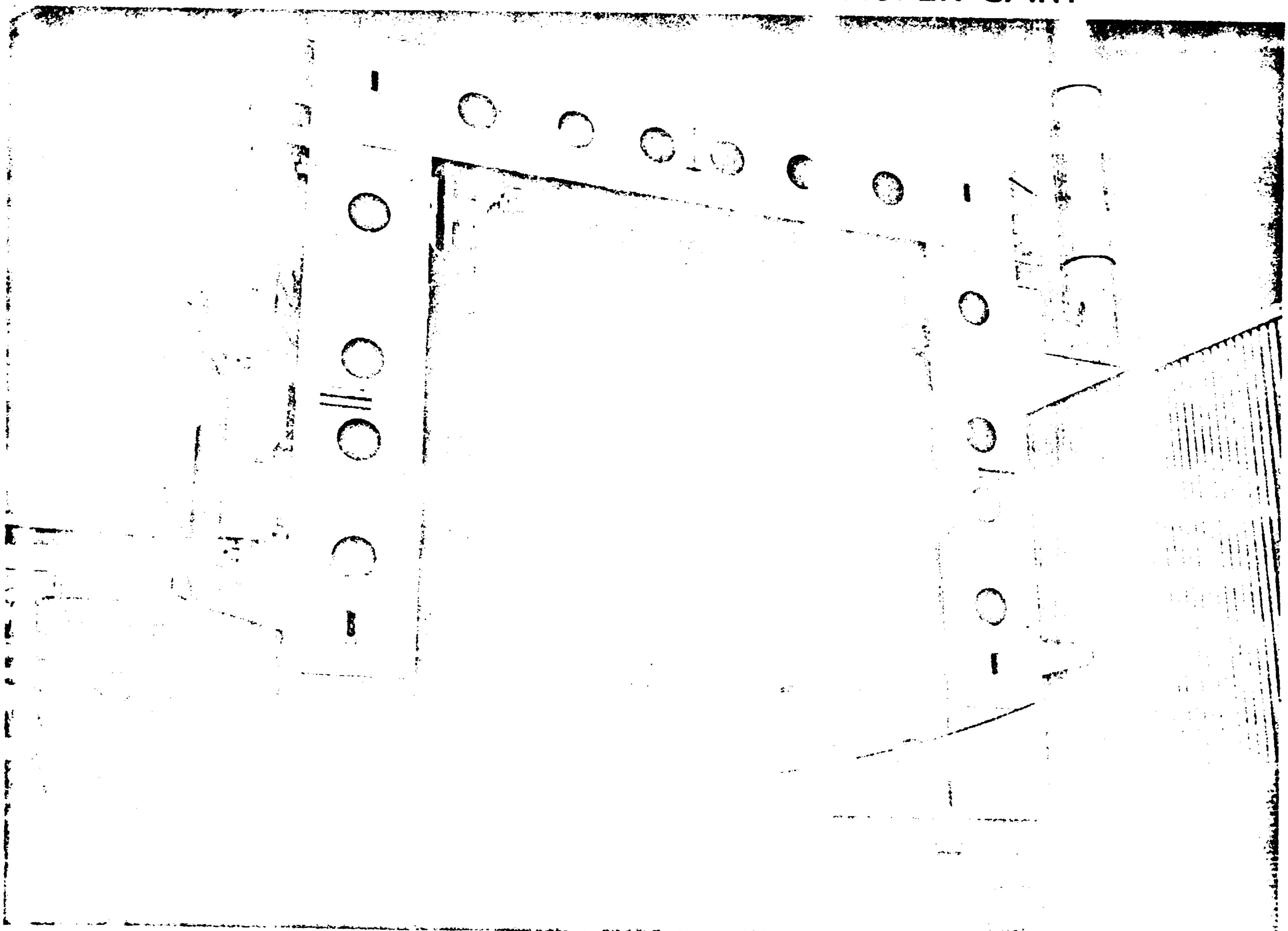

16T Compressor
Test Sections
Desiccant Drier
Compressor Drive System
16S Compressor
16T
16S
PES
Tunnel 4T

TUNNEL 16T SCAVENGING SYSTEM

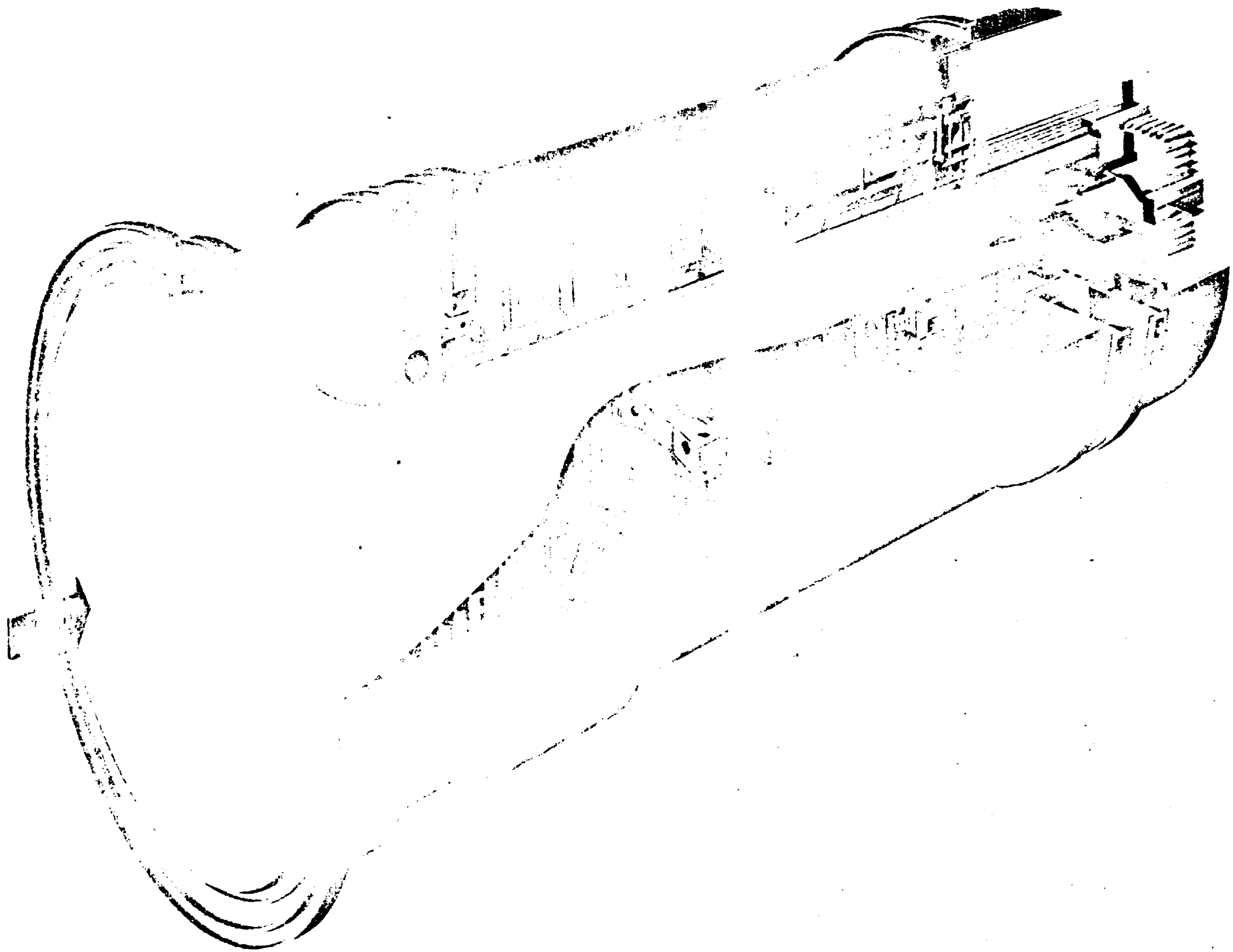


- SCOOP CAPTURES COMBUSTION PRODUCTS
- SCOOP PITCHES TO FOLLOW EXHAUST PLUME
- VARIABLE SCOOP GEOMETRIES AVAILABLE

TUNNEL 16T TEST SECTION TRANSFER CART



TUNNEL 16T VARIABLE GEOMETRY NOZZLE



COMPRESSOR PROTECTIVE SCREEN IN THE TUNNEL 16T DIFFUSER

HISTORY

DEVELOPMENT AND MODELING OF PWT-16T AND 16S

- DESIGN CRITERIA FOR PWT-16T AND 16S WERE LARGELY DETERMINED FROM COMPONENT STUDIES AT OTHER FACILITIES
- NATIONAL TRANSONIC PANEL - REVIEWED WORK
  NACA, WRIGHT FIELD, BOEING, S&P, OTHERS
- FINAL DESIGN BY SVERDRUP AND PARCEL, ST. LOUIS
- SOME DESIGN CONFIRMATION AND MANY LATER MODIFICATIONS DEVELOPED IN AEDC 1-FT TUNNELS

16T COOLER

- o PROBABLY MOST USEFUL OF ALL MODEL TESTS - PINDZOLA
- o MODEL IN GA TECH WIND TUNNEL (9-FT.)
- o AERODYNAMICS AND STRUCTURAL DESIGN
- o REVEALED MANY DEFICIENCIES
- o SOME FIXES IDENTIFIED WERE NOT INCORPORATED - COSTS/CONTRACTOR
- o SECTION TESTED AT UAC FOR SIMPLER FIXES
- o HEAT TRANSFER OF FINNED TUBES - PURDUE UNIVERSITY
- o NOW TRYING TO OBTAIN BETTER FIXES

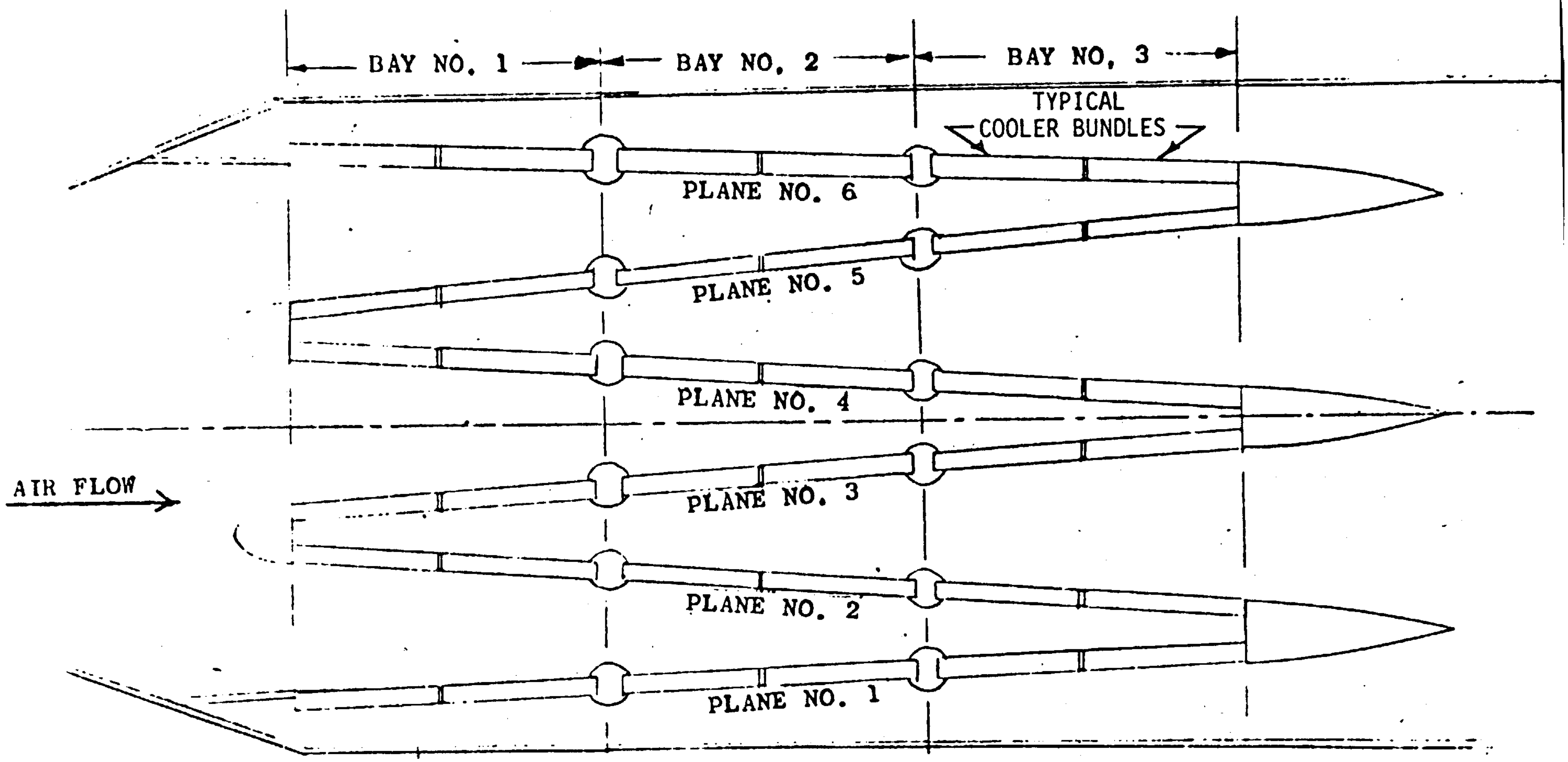


FIG. 2. 16T COOLER

SECTION VIEW, LOOKING NORTH.

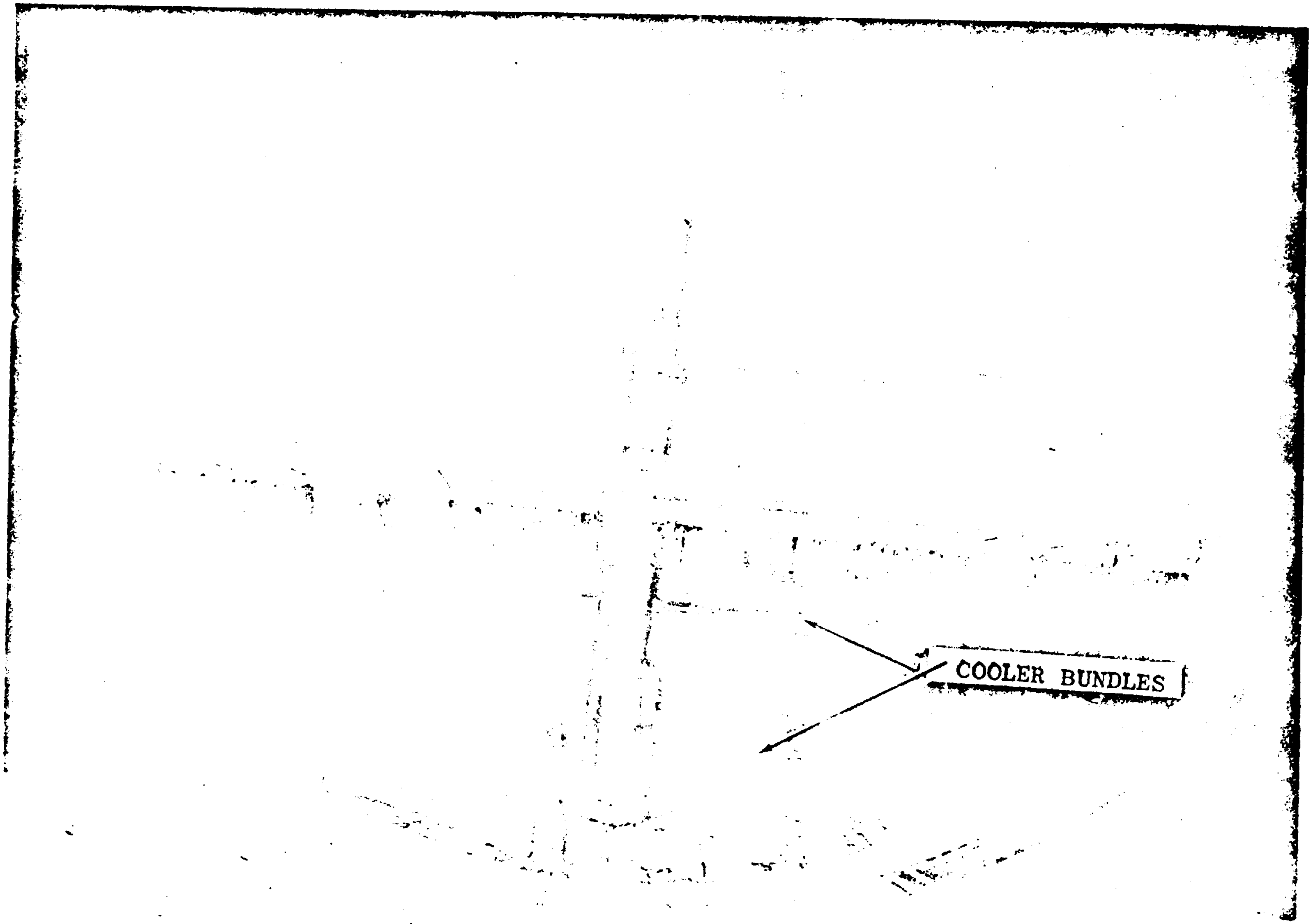


FIG. 1. VIEW OF THE COOLER ENTRANCE.

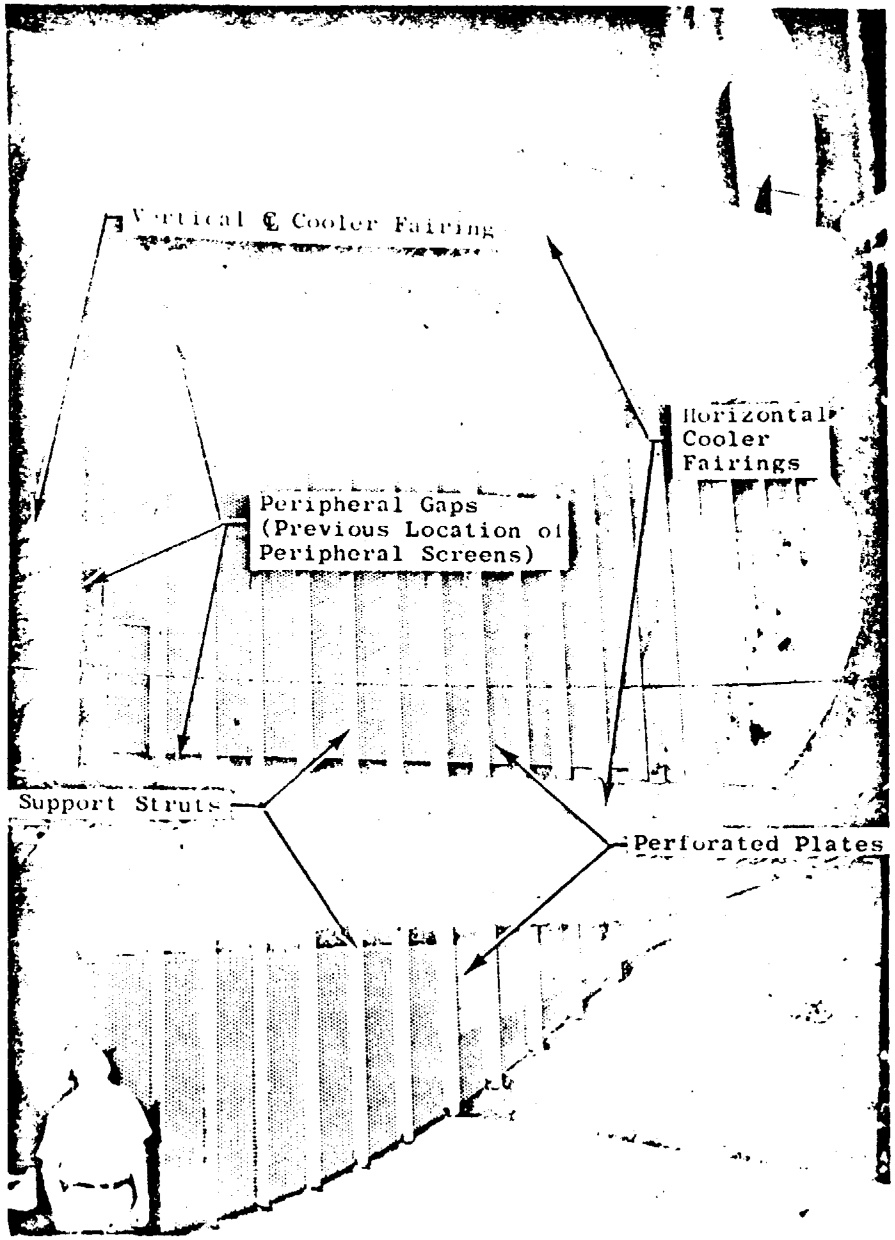


FIG. 3. VIEW OF COOLER EXIT SHOWING COOLER FAIRINGS AND PERFORATED PLATES.

16T AND 16S COMPRESSORS

- MODELS TESTED BY WESTINGHOUSE ELECTRIC
- 16T - LOW SPEED
  (VECTOR TRIANGLE SIMILITUDE, INCOMPRESSIBLE)
- 16S - HIGH-SPEED
  (1/16-SCALE, MACH-SCALED)
- MANY MECHANICAL PROBLEMS WITH 9600 RPM 16S MODEL
- LIMITED USEFULNESS - PINDZOLA'S RECOLLECTION
- REPORTS ARE BELIEVED TO EXIST

DIFFUSER/SCAVENGING SCOOP -16T AND 16S

- UNIVERSITY OF MINNESOTA - PRIMARY STUDIES
- APPROXIMATE 6-INCH TUNNEL
- SOME WORK AT UNIVERSITY OF TEXAS (?)
- DIFFUSER, SCAVENGING SCOOP, AIR REMOVAL/RETURN STUDIES
- DESIGN REFINED AT AEDC

WALL CONFIGURATIONS

- o WALL DEVELOPMENT EFFORTS

  UAC - 22% POROUS, NORMAL HOLE CONFIGURATION
  CORNELL - VARIOUS POROUS STUDIES
  WRIGHT FIELD - SLOTTED WALL STUDIES

- o OHIO STATE - PWT CONFIGURATION DEVELOPMENT
  1-FT BLOWDOWN TUNNEL

- o INITIAL PWT CONFIGURATIONS - 20% POROUS, NORMAL HOLE

- o AEDC 1-FT TRANSONIC MODEL TUNNEL (TMT) LATER PATTERNED AFTER OSU, EXCEPT CONTINUOUS

- o 16T WALLS RECONFIGURED (1957) TO 6% POROUS, INCLINED HOLE BASED ON TMT TESTS

MODELING STUDIES

COMPONENT MODELING FACILITIES

- 1T (TMT) - 1 FT CONTINUOUS TUNNEL - VERY HEAVY USE
  APPROXIMATE MODEL OF 16T TEST SECTION AND DIFFUSER/SCOOP

- 1S (SMT) - 1 FT CONTINUOUS TUNNEL - DISMANTLED
  APPROXIMATE MODEL OF 16S NOZZLE, TEST SECTION, AND DIFFUSER/SCOOP

- ART (ACOUSTIC RESEARCH TUNNEL) - 6 INCH CONTINUOUS TUNNEL
  ATMOSPHERE IN-DRAFT TUNNEL FOR "QUIET" WALL DEVELOPMENT, VARIOUS DUCTING, SCREEN/HONEYCOMB STUDIES

AEDC'S GENERAL APPROACH

- COMPONENT STUDIES PLUS ANALYTIC PREDICTIONS AND COMBINATIONS
- PRESENT TREND - HEAVIER RELIANCE ON ANALYTIC PREDICTIONS, ESPECIALLY MATH MODELS
- COMPONENTS

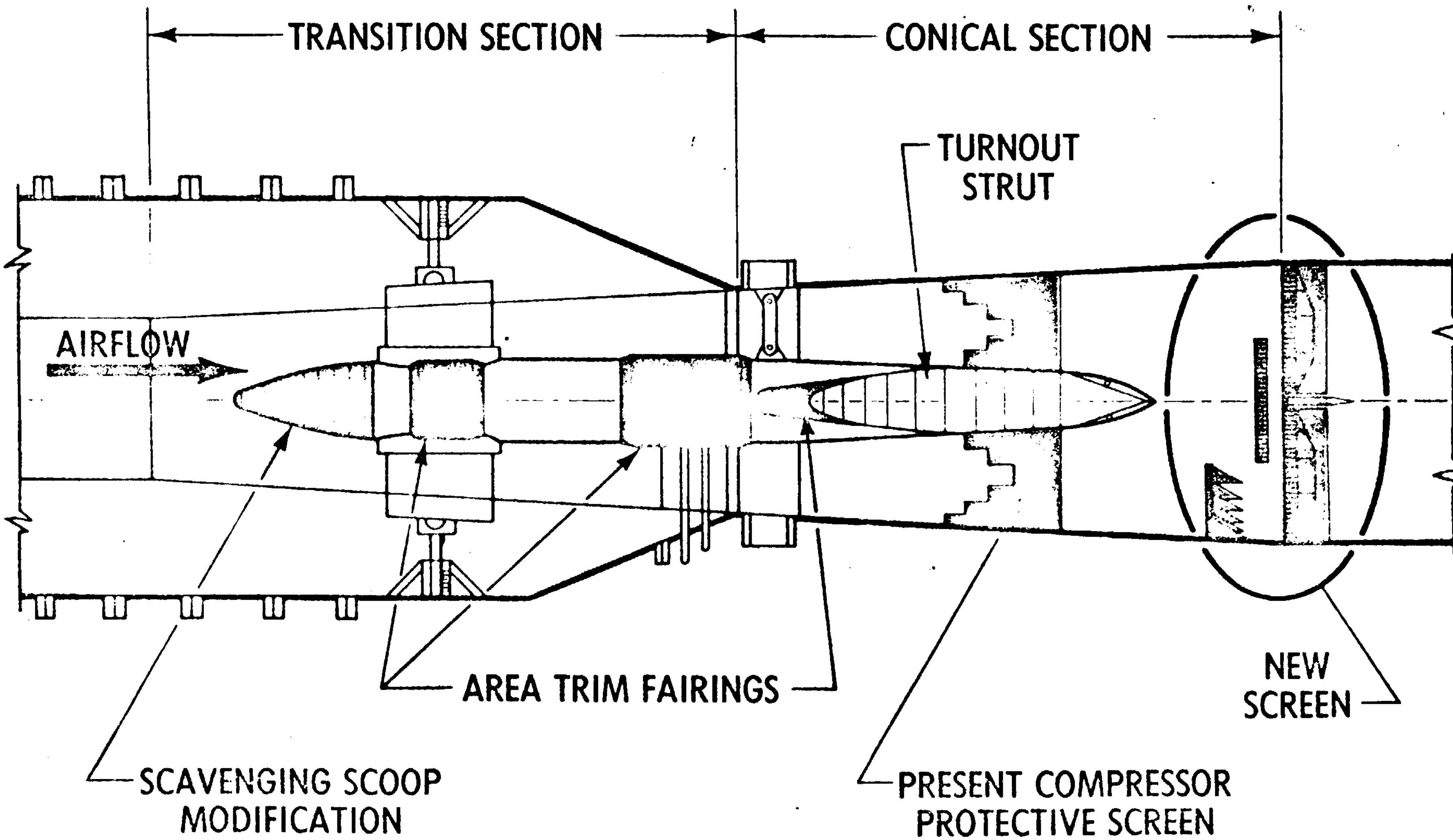
  SCALED-TEST SECTION, DIFFUSERS, MODEL SUPPORT SYSTEMS

  FULL SCALE-SCREENS/HONEYCOMB
- ANALYTIC

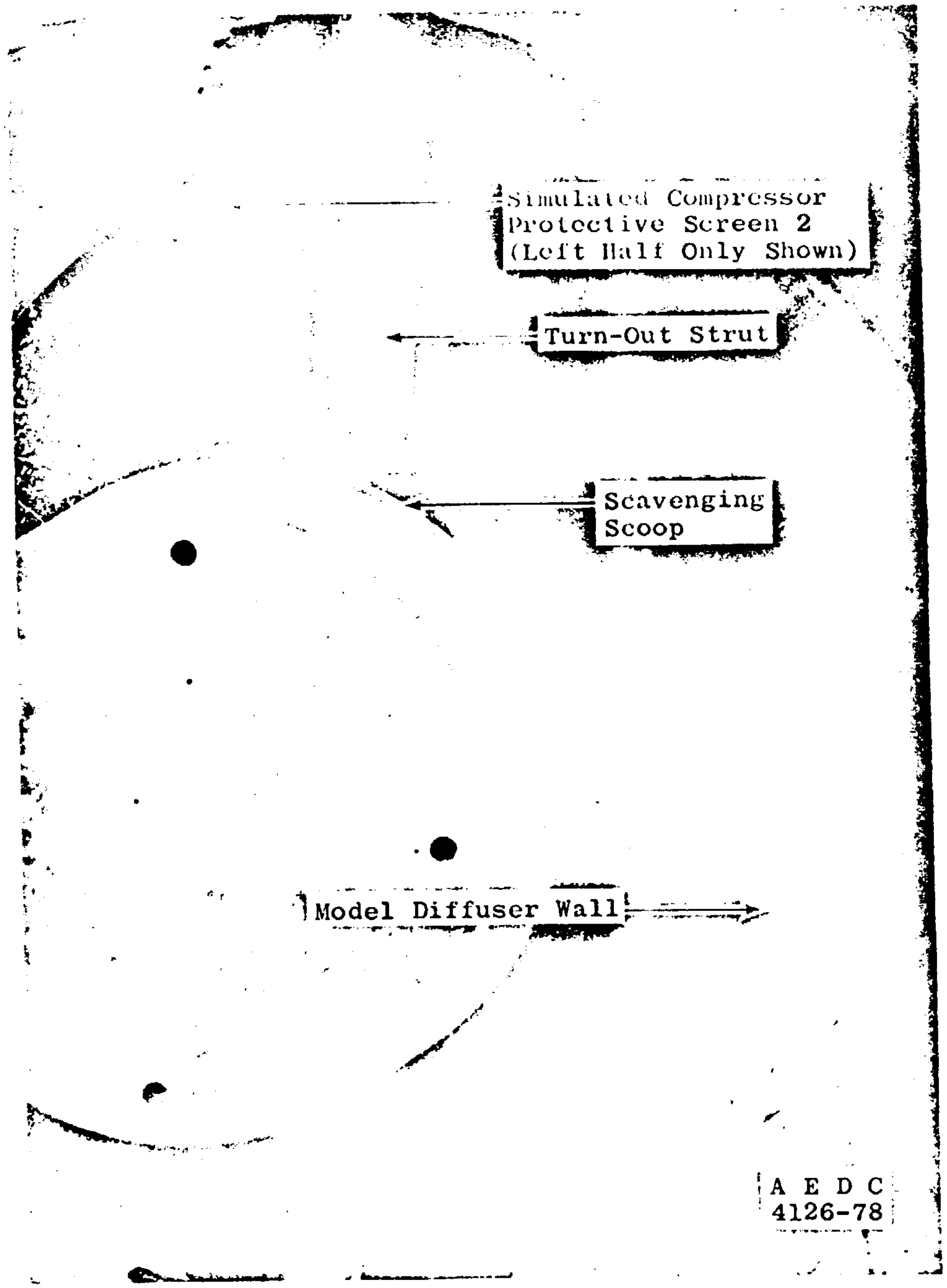
  SEMI-EMPIRICAL MODELS

  "MATH MODELS"

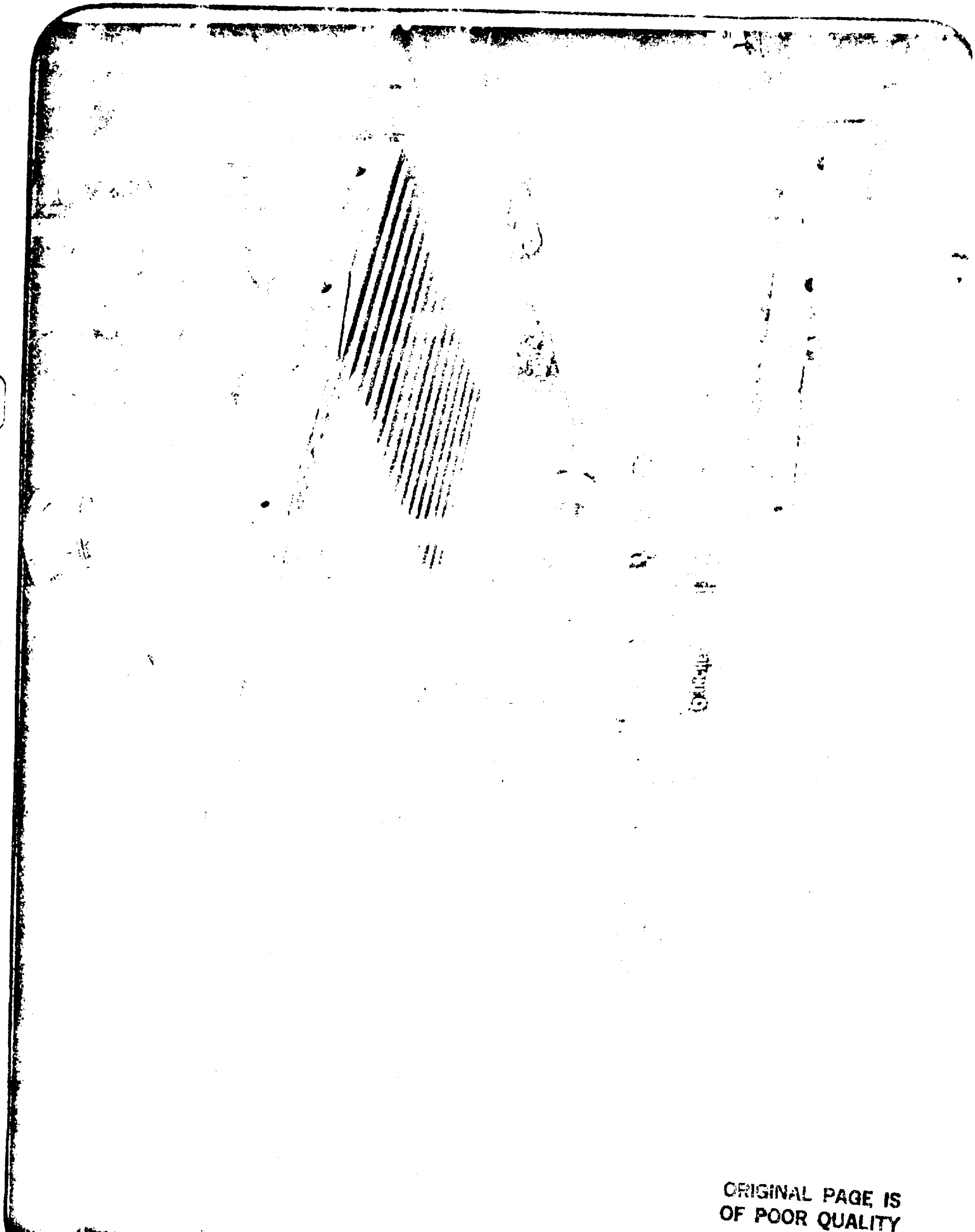
PWT-16T DIFFUSER IMPROVEMENTS



C-84-82



b. Installation
Figure 7. Concluded



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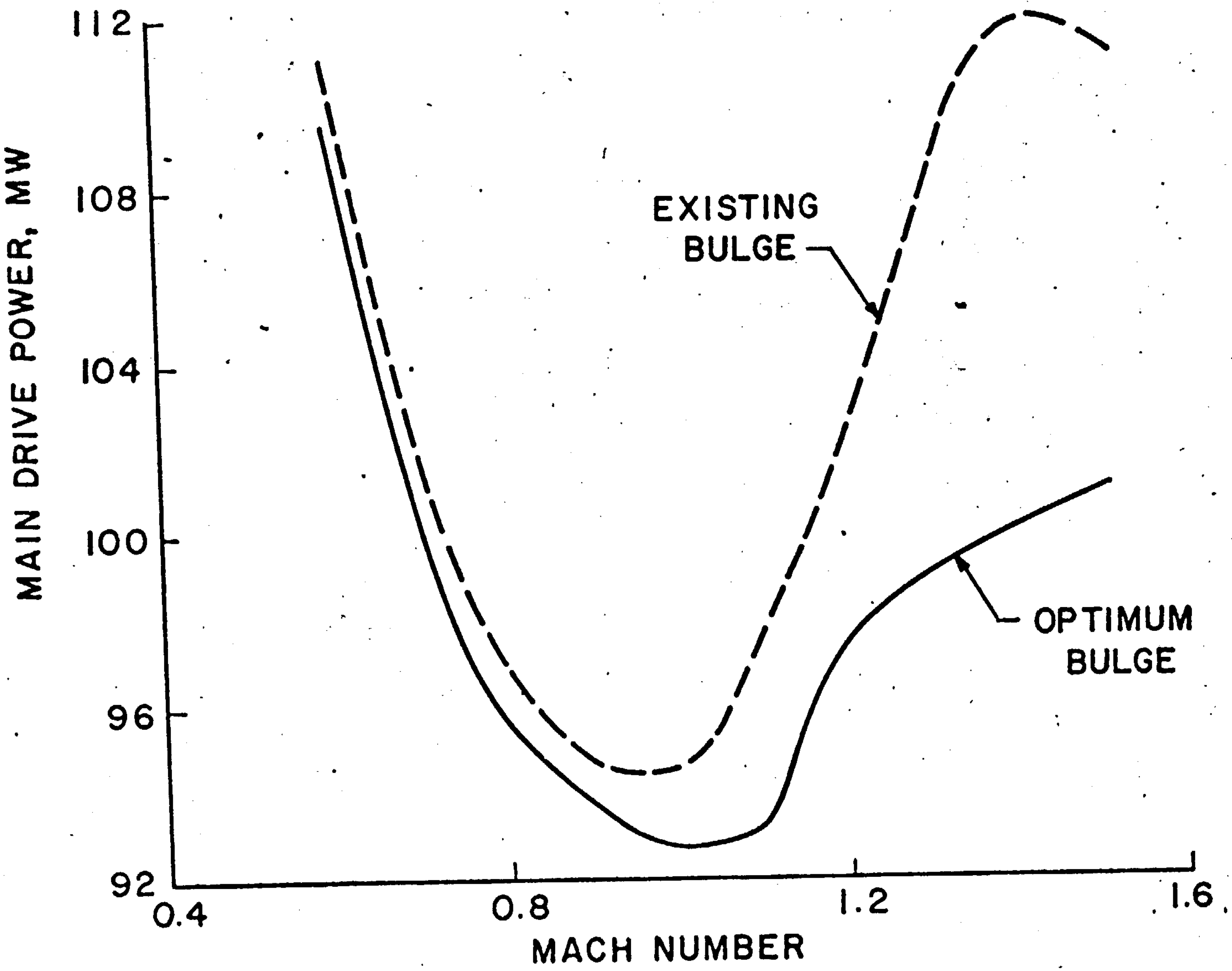
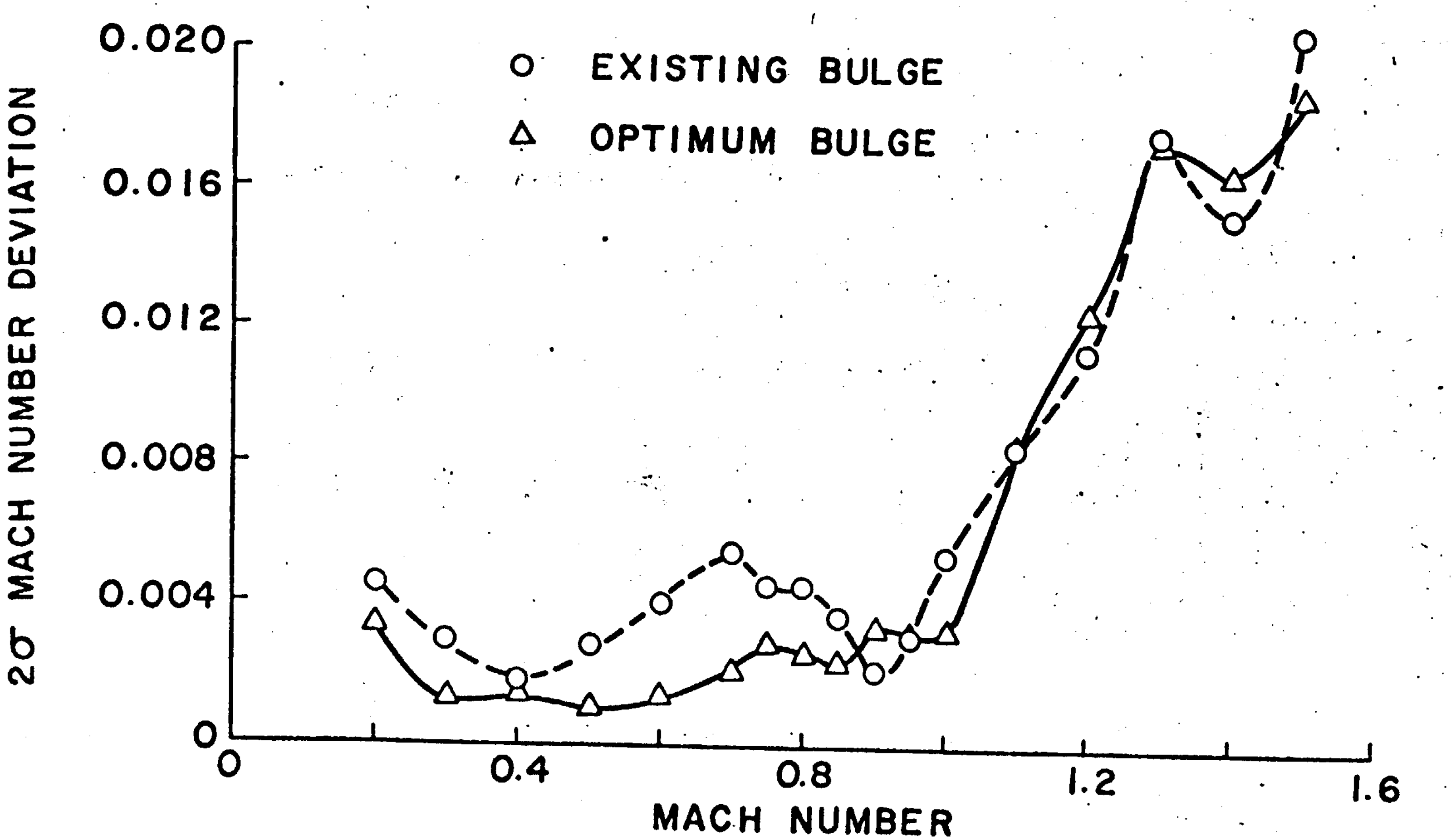
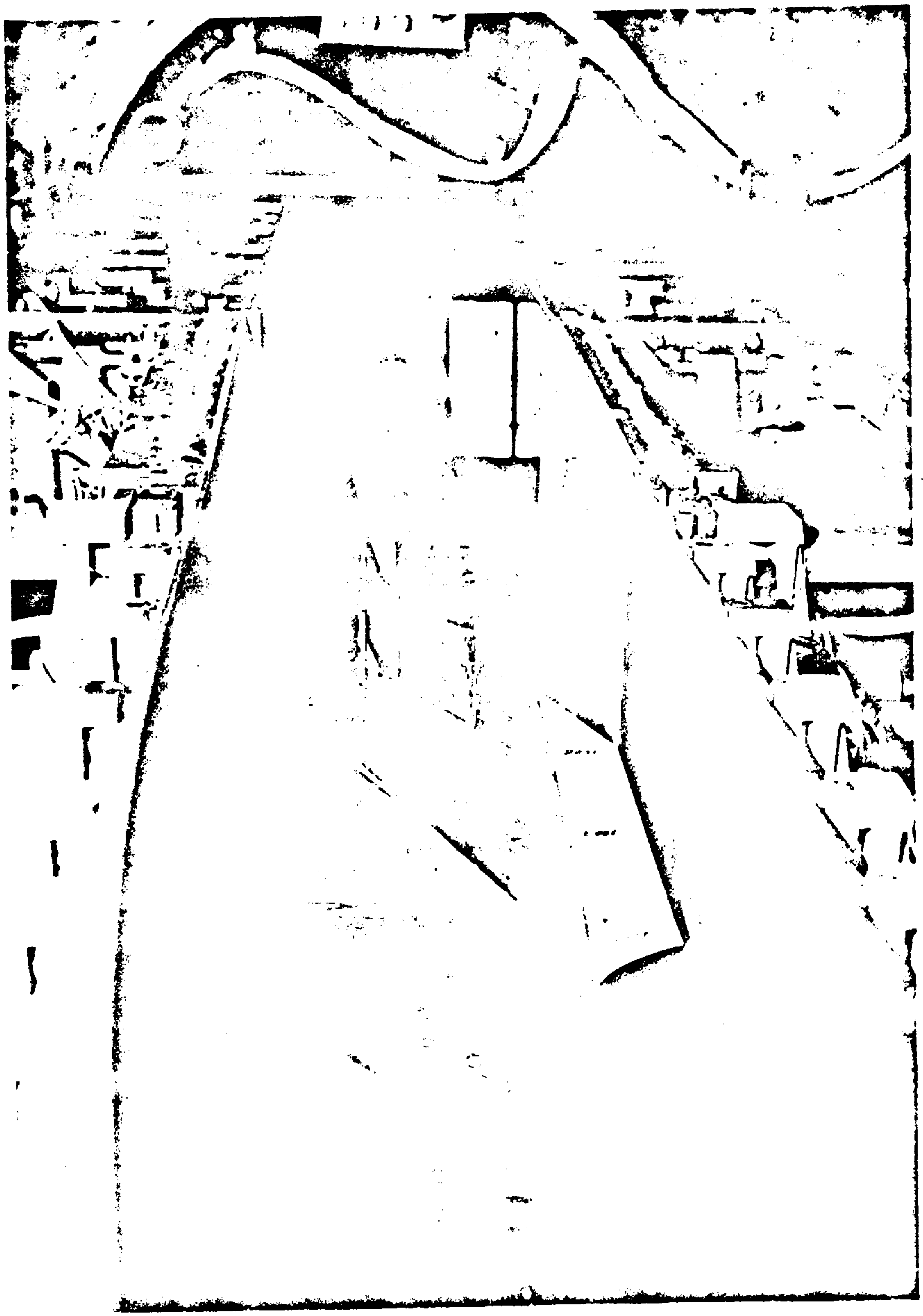
ESTIMATED POWER SAVINGS

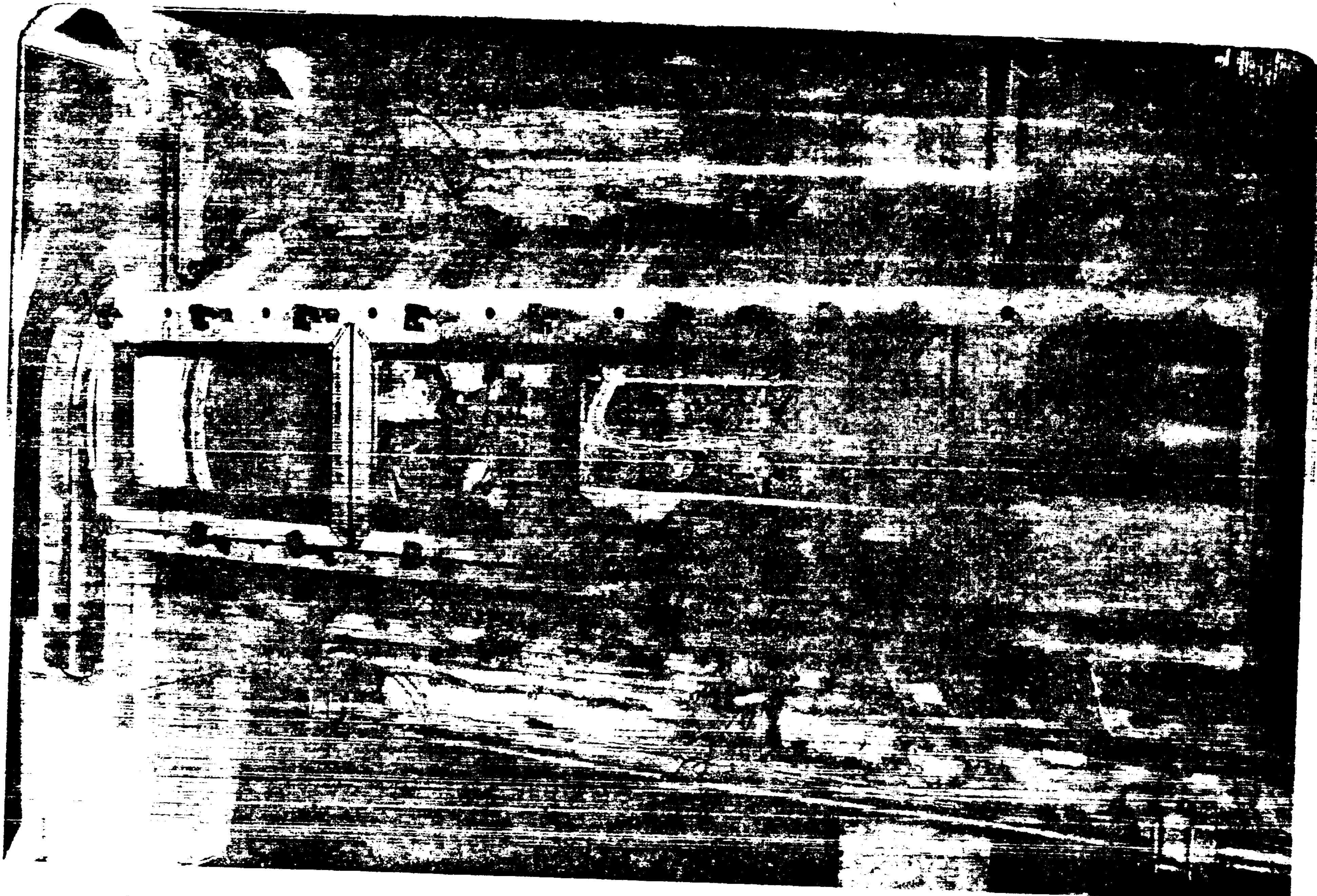
$128,000 ANNUAL SAVING
1.4 YEARS TO PAY BACK



TUNNEL 1T MACH NUMBER DEVIATIONS

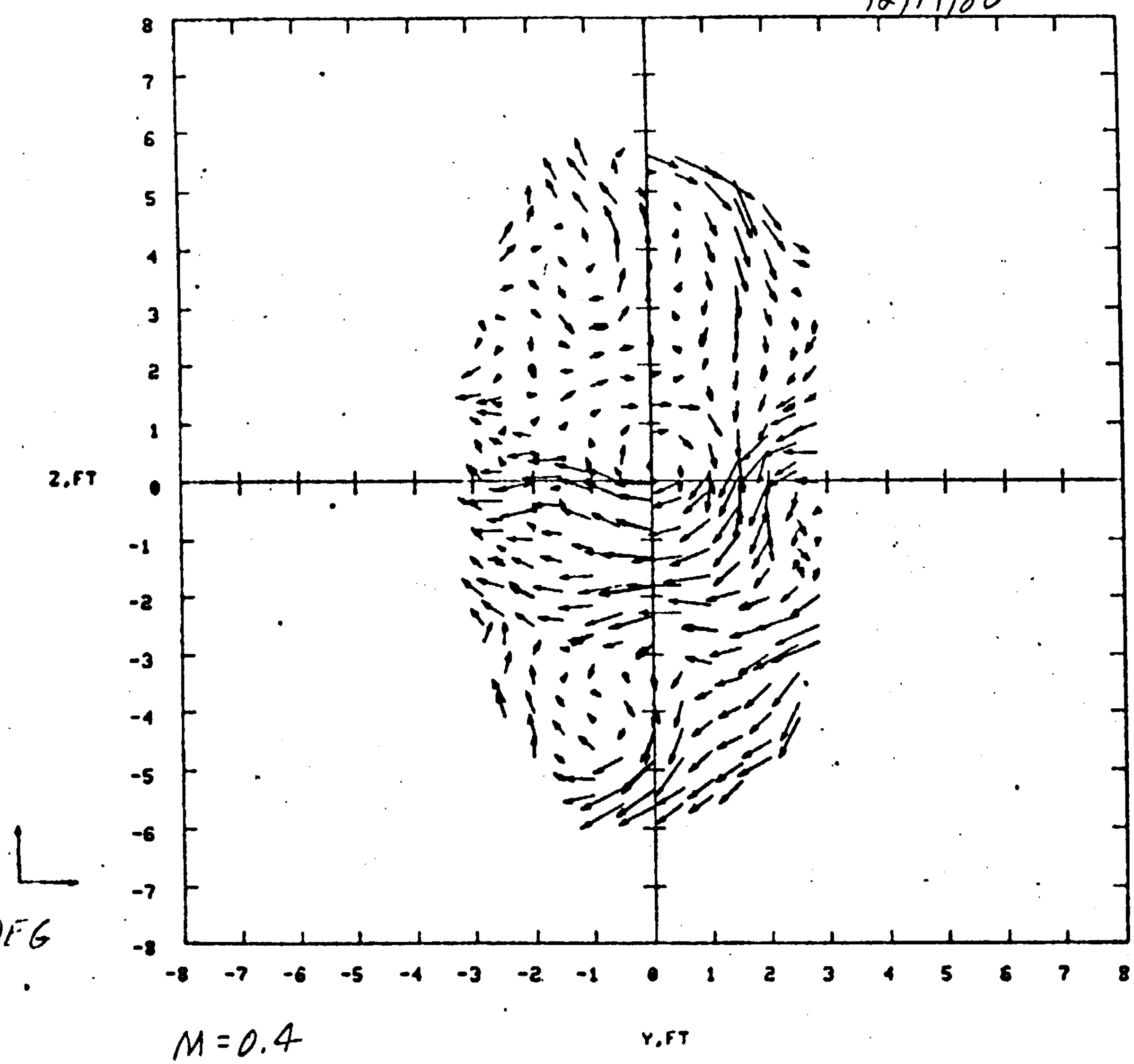






ADAPTIVE WALL TEST SECTION OF AEDC TUNNEL 1T

12/19/80



1-DFG

M=0.4

BEFORE TURNING VANE ADJUSTMENT - 16T

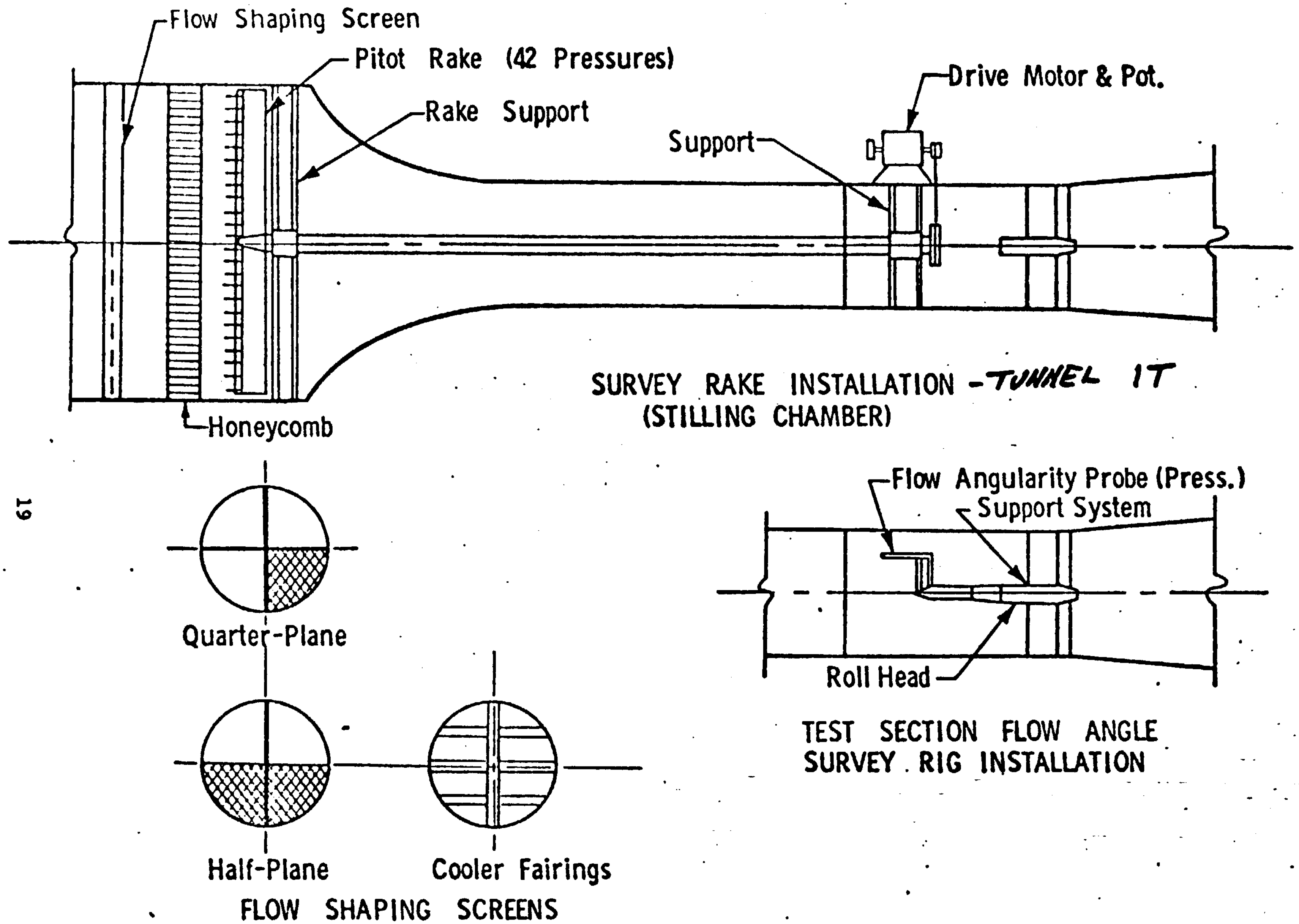


Figure 2. Schematic of Test Installation

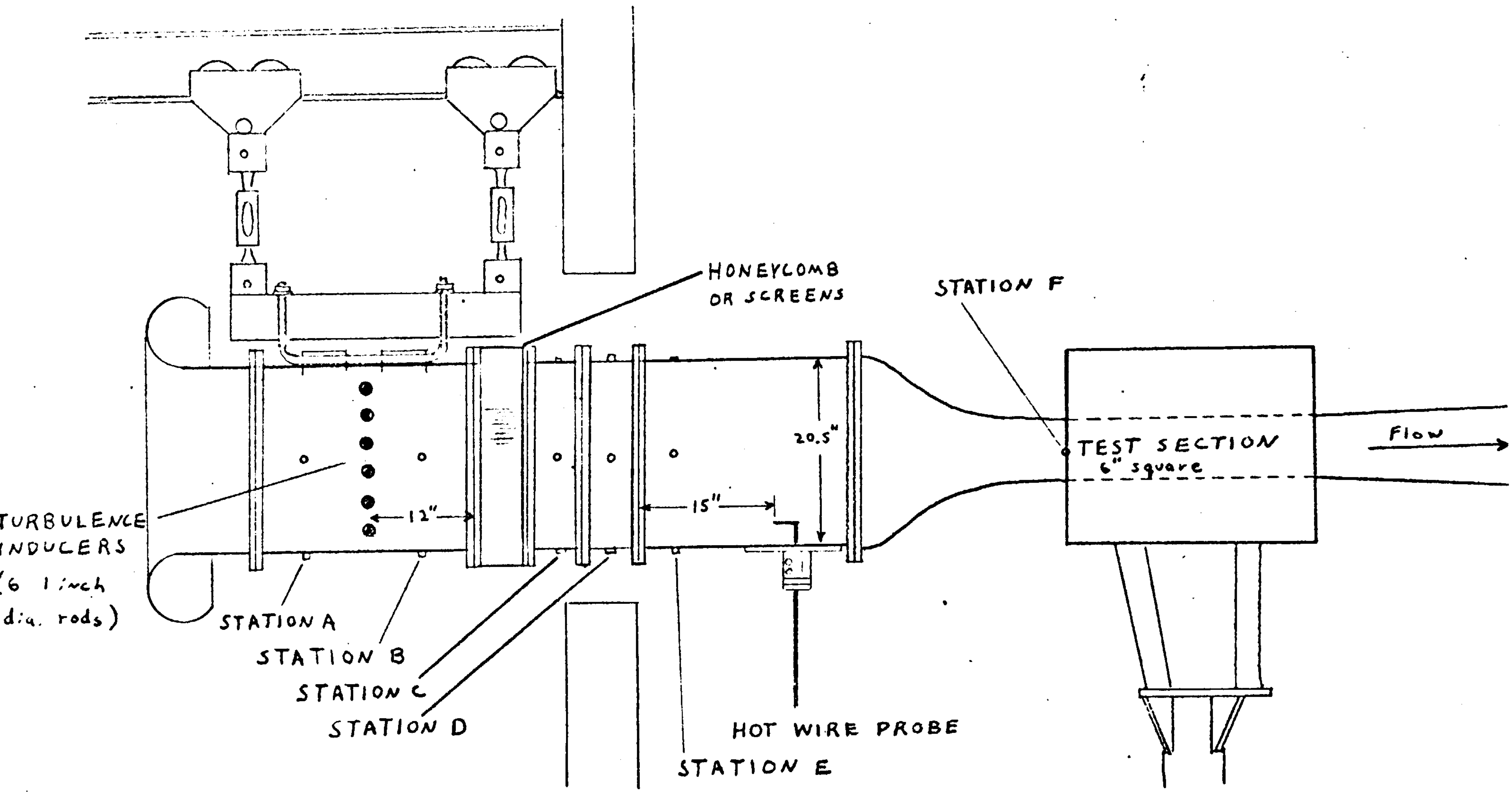


FIG. 1 ART PRESSURE ORIFICES

HONEYCOMB/SCREEN TESTS

- TO BE ADDED TO PWT-16T IN FY 86
- REDUCE FLOW ANGLE NON-UNIFORMITIES
- REDUCE FLOW TURBULENCE LEVEL
- MINIMUM POWER INCREASE DESIRED
- INITIAL CONFIGURATION SAME AS LANGLEY 8-FT
- LARGE SIZE (55 FT.) REQUIRED ADDITION OF 1-MESH BACKUP SCREEN
- EFFECT OF BACKUP SCREEN WAS MAJOR CONCERN
- COMPONENT TESTS IN ART (6-INCH ACOUSTIC RESEARCH TUNNEL)

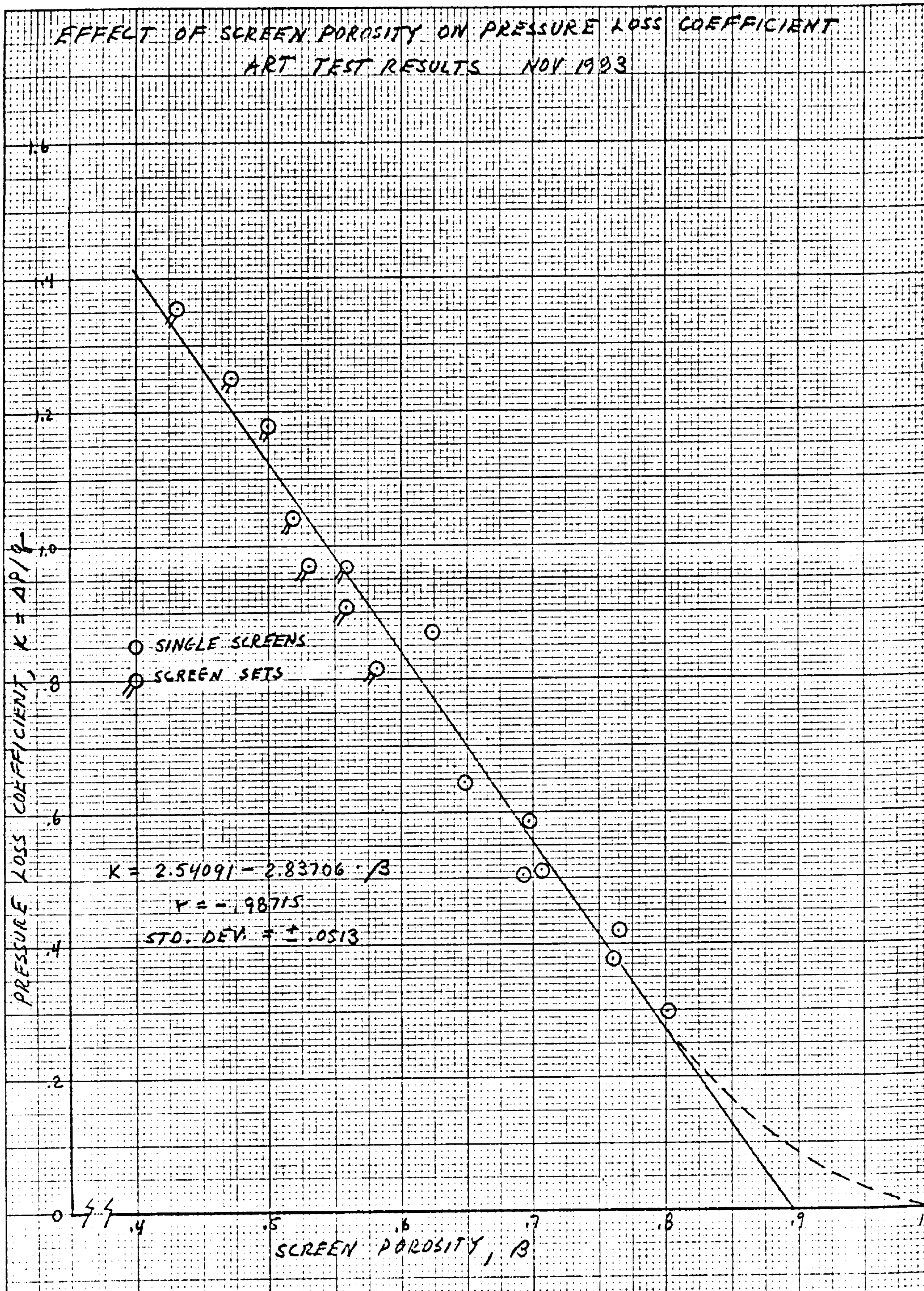


Figure 5 Relationship Between Screen Porosity and Pressure Losses

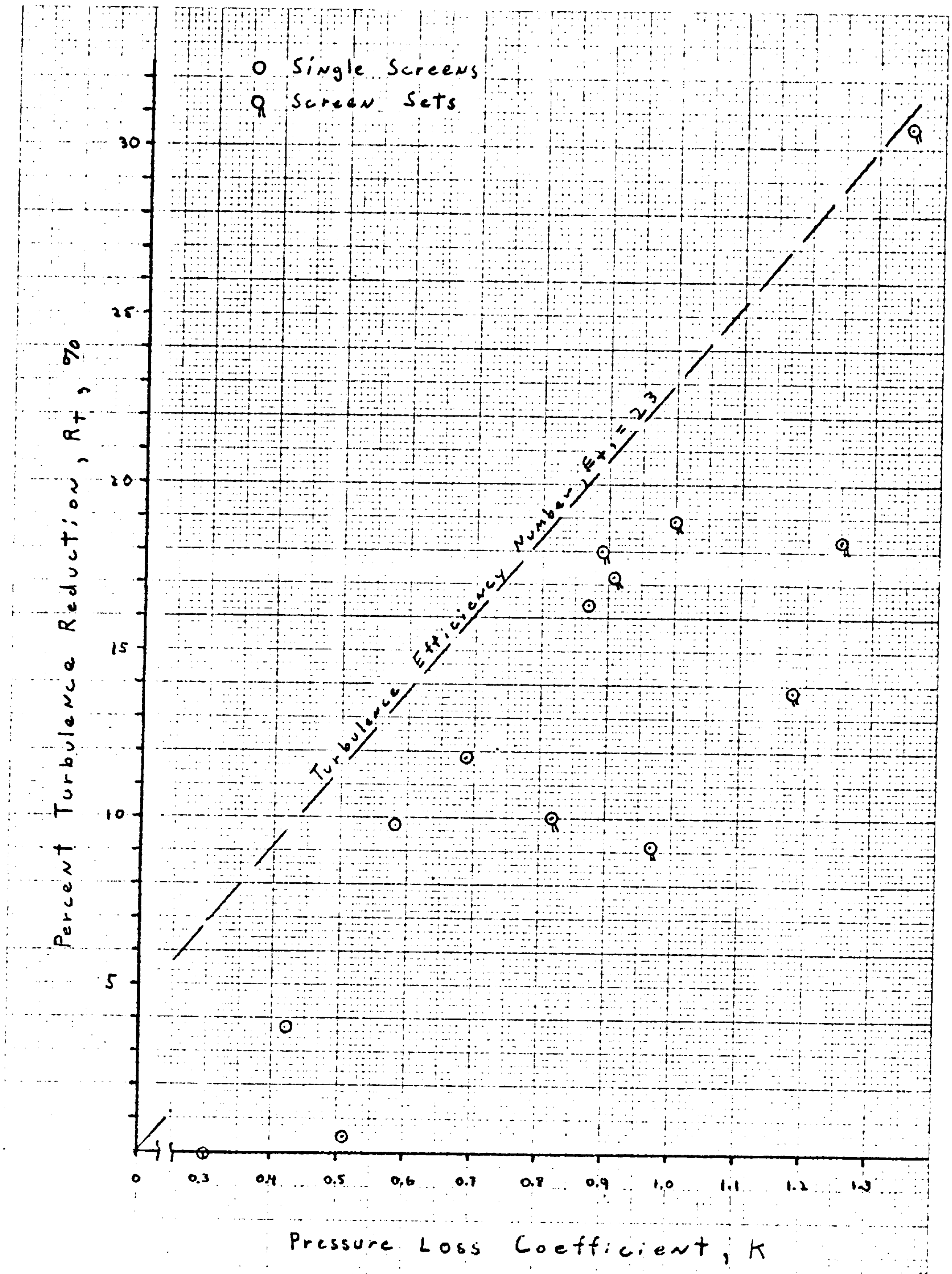


Figure 6 Turbulence Reduction of Screens and Screen Sets

RESULTS

- PRESSURE DROP AND TURBULENCE REDUCTION MEASURED FOR 25 CONFIGURATIONS
- EFFECT OF BACKUP SCREENS
  - PRESSURE DROP PROPORTIONAL TO "COMBINED" POROSITY
  - ADDING BACKUP IMPROVES TURBULENCE REDUCTION
- OTHER RESULTS
  - HONEYCOMB EFFECTIVE IN REDUCING TURBULENCE
  - HONEYCOMB/SCREEN COMBINATIONS MORE EFFECTIVE THAN PREDICTED FROM COMPONENTS
  - SCREEN SETS REDUCED FROM 4 TO 2

OTHER MODELING STUDIES

- TEST INSTALLATIONS

  NUMEROUS STUDIES OF GENERAL AND SPECIFIC TEST INSTALLATIONS TO DETERMINE/MINIMIZE SUPPORT SYSTEM INTERFERENCE.

- "QUIET" WALL RESEARCH

  WALL CONFIGURATIONS WITH "LOWER ACOUSTIC NOISE" LEVELS

- EFFECT OF WINDOWS, OTHER SOLID PLATES (ALSO HOLES) ON THE TUNNEL FLOW

C-3

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ANALYTIC MODELS

STATIC

- DUCT FLOW
- 16T TUNNEL
- 16T AND 16S COMPRESSOR

DYNAMIC

- APTU
- 16T (WORK IN PROGRESS)

DUCT FLOW MODELS

JACKSON - AEDC-CW-01-6-76

- ONE-DIMENSIONAL COMPRESSIBLE PIPE-TYPE FLOW
- APPLIED TO MODELING ENTIRE WIND TUNNEL
- EXTENSIVE COLLECTION OF EMPIRICAL LOSS DATA
- INCLUDES COOLERS, SCREENS, HONEYCOMBS, TURNING VANES, ETC.
- ADAPTED TO HP9830 DESK COMPUTER
- COMPARISONS GOOD WITH PWT-16T AND LANGLEY TDT

GUNN, KRAFT, POOLE - AEDC COMPUTER PROGRAM SEP00058

- PRECEEDED JACKSON, ABOVE, AND SIMILAR
- USED ON LARGER COMPUTERS

PWT - 16T STATIC MATH MODEL

DAVID AND JACKSON - AEDC-TMR-79-P5

STICH - UNIVERSITY OF TENN. THESIS, MARCH 1984

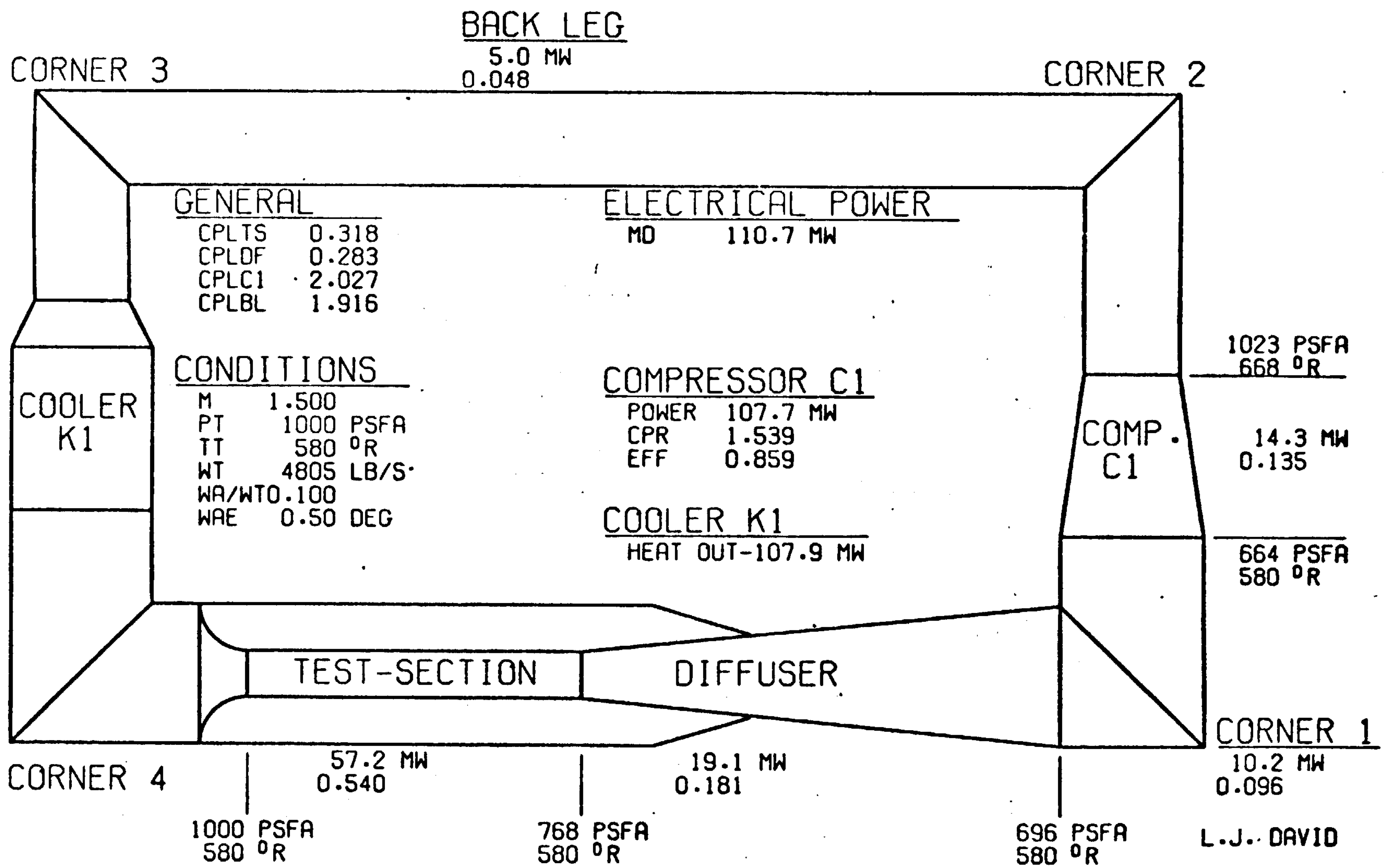
- o HISTORICAL PROGRAM - FROM HISTORICAL DATA BASE

  TUNNEL DIVIDED INTO 8 COMPONENTS, AND LOSSES MEASURED

- o ANALYTICAL PROGRAM

  COMPONENT LOSS FROM HISTORICAL PROGRAM

  EVALUATE IMPROVEMENTS



TUNNEL 16T-MODEL NO.2-ANALYTIC

WIND TUNNEL COMPRESSOR MATH MODELING

- o 16T C1 MATH MODEL COMPLETED FY 81

  PWT "CALIBRATED" COCODEC CODE (UNION CARBIDE - ERDA)

  ADEQUATELY MODELS PERFORMANCE

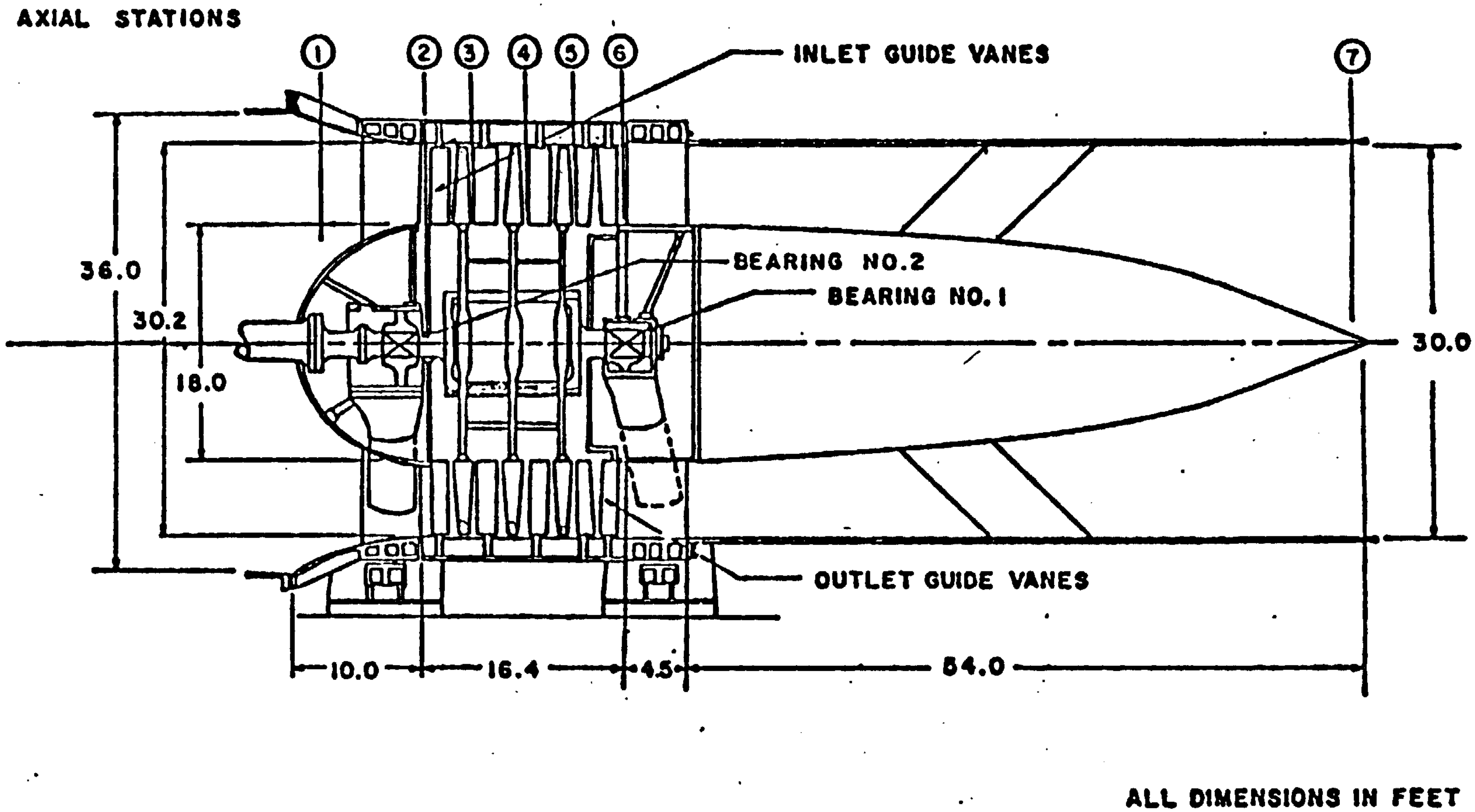
  DOES NOT ADEQUATELY PREDICT STALL

- o 16S C2345 MATH MODEL WORK STOPPED

  C2 HAS BEEN MODELED

  GENERALLY GOOD RESULTS

  FURTHER DEVELOPMENTS REQUIRED FOR 3 OR 4 BARREL CONFIGURATIONS

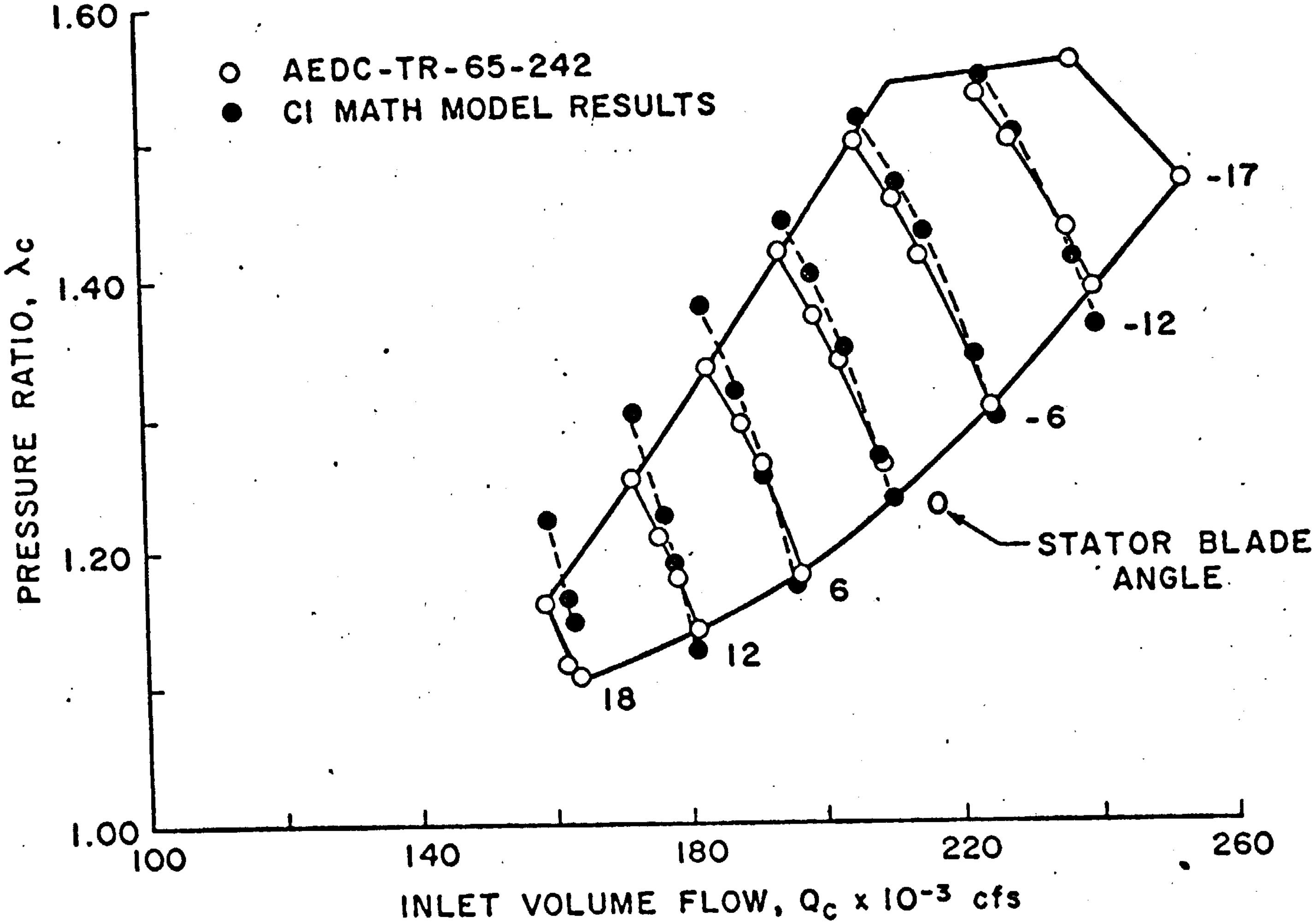


Design Conditions

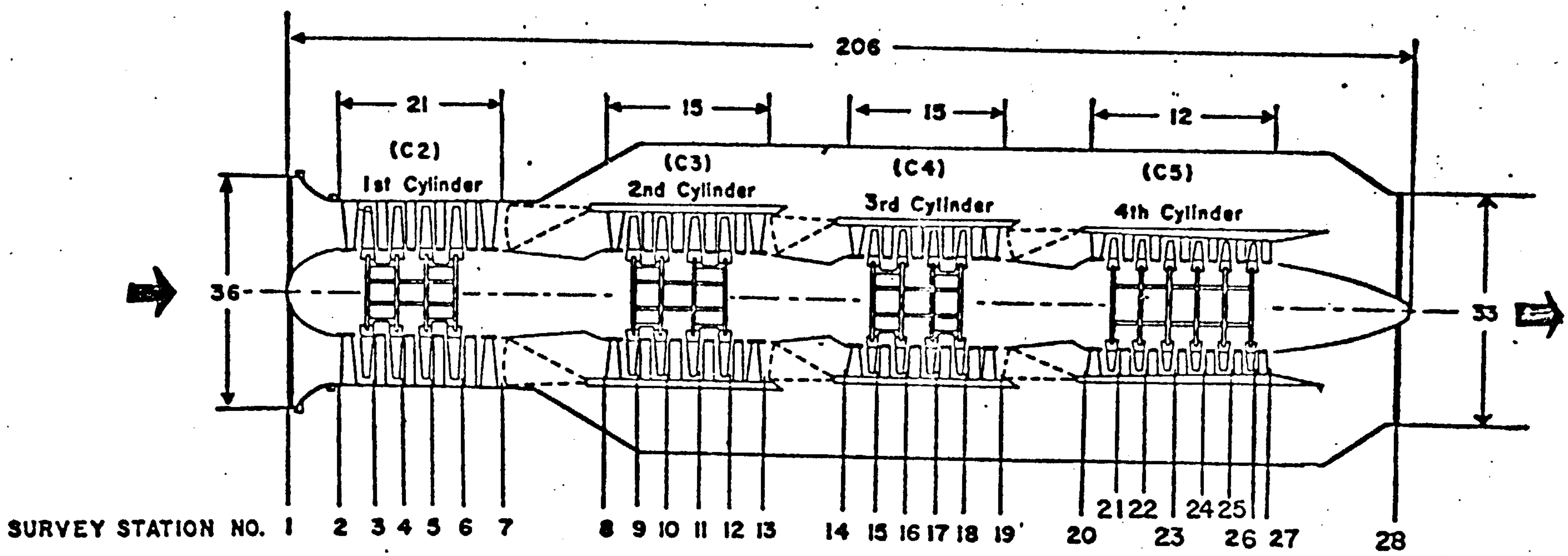
Tip Speed, 942 ft/sec (Absolute)
Hub Speed, 565 ft/sec (Absolute)
Design Pressure Ratio, 1.385
Design Inlet Volume Flow, 200,000 cfs
Flow Coefficient, 0.47
Work Coefficient, 0.308
Inlet Axial Velocity, 442 ft/sec

Figure 1. Tunnel 16T Compressor C1 Layout

COMPARISON OF TUNNEL 16T PERFORMANCE WITH CODE



TUNNEL 16S COMPRESSOR



All Dimensions In Feet
Not to Scale

Open Symbols: Data of Ref. 5

Solid Symbols: Present Calculations (COCODEC)

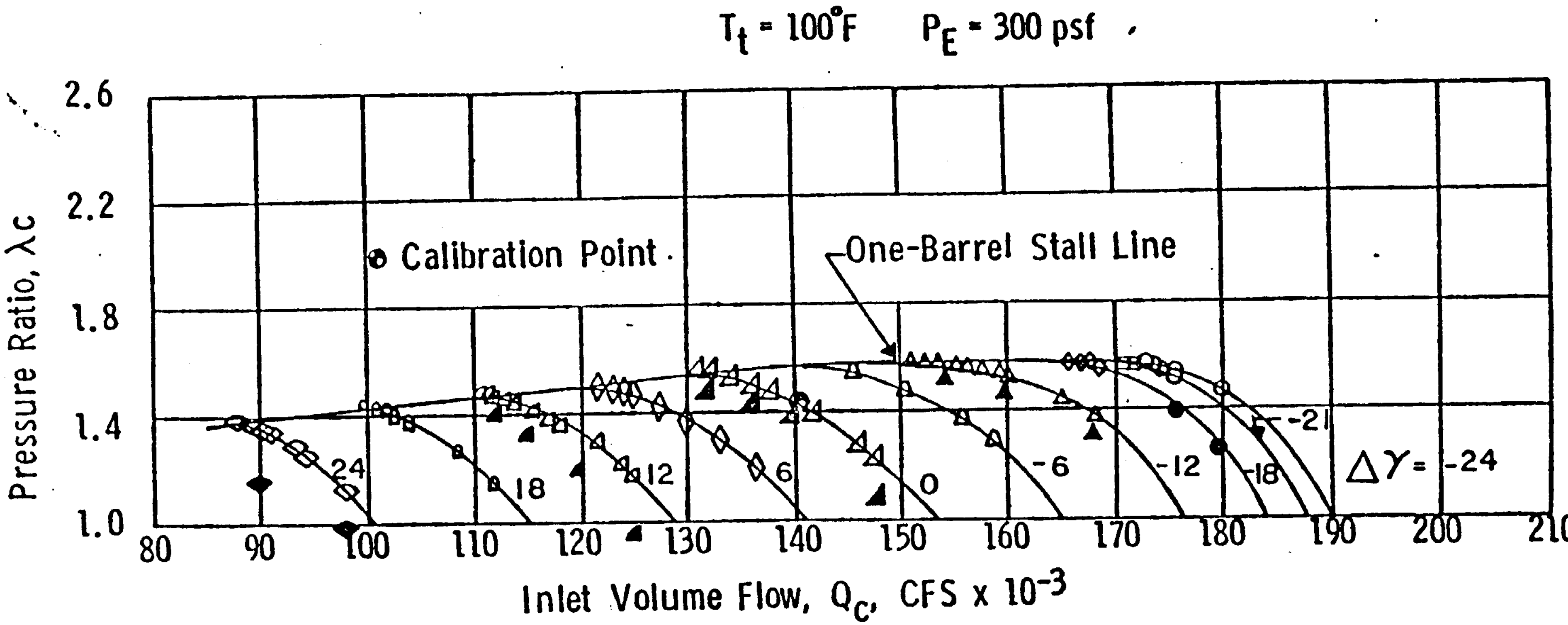
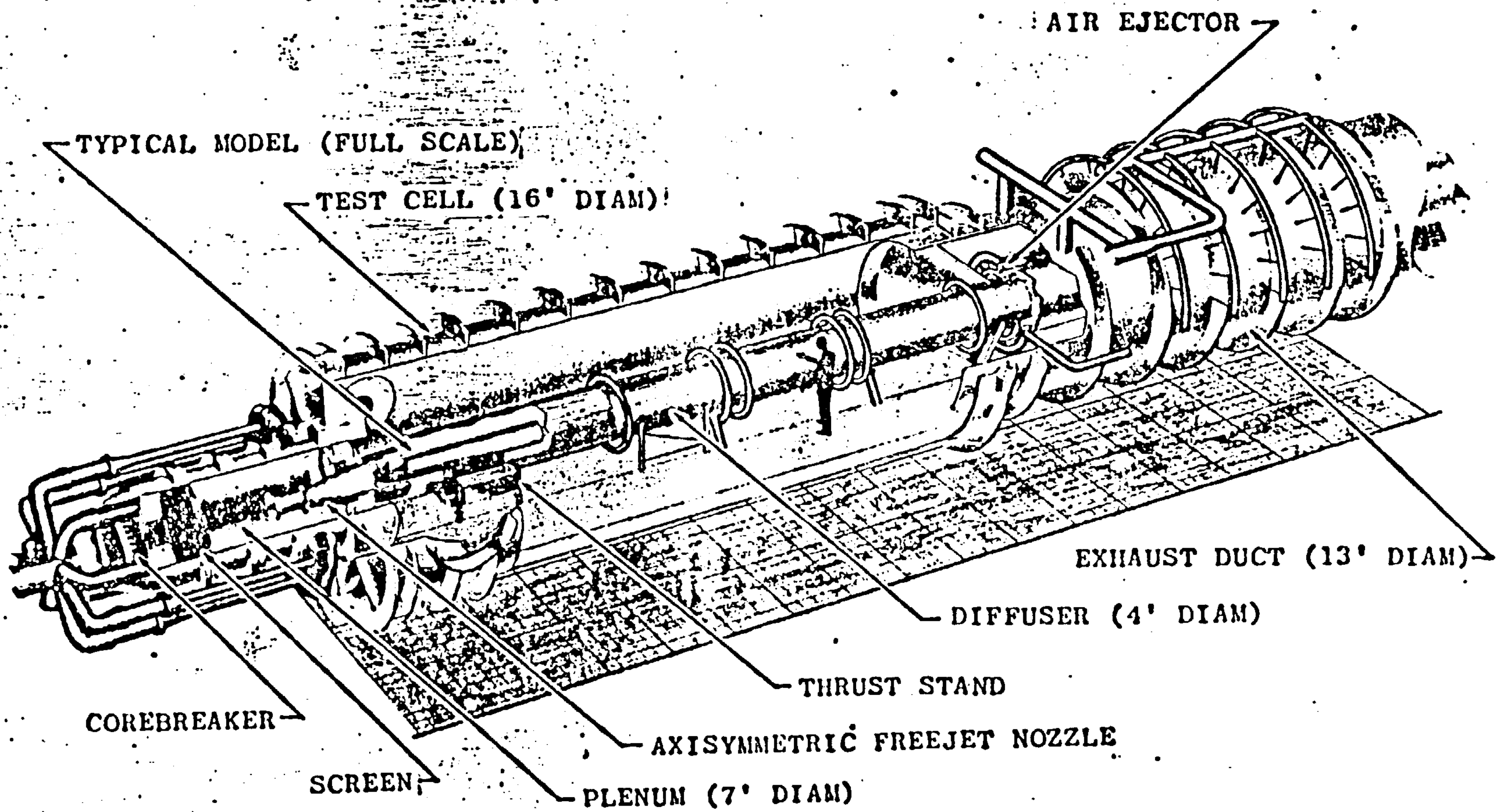


Fig. 9 Comparison of COCODEC Calculations for Compressor C2 with Measurements of Ref. 5.

AUTOMATION AND MATH MODELING IN THE APTU FACILITY AT AEDC

- BLOW-DOWN FACILITY
- PRIMARILY FOR RAMJET PROPULSION SYSTEM TESTING
- TRUE TEMPERATURE AERODYNAMIC TESTS
- HIGH TEMPERATURE TESTS.

AERODYNAMIC AND PROPULSION TEST UNIT (APTU)
TYPICAL FREEJET INSTALLATION



A. TYPICAL TEST INSTALLATION

FIGURE 1. AERODYNAMIC AND PROPULSION TEST UNIT (APTU)

APTU TEST CAPABILITIES

- Mach number range 2.0 to 4.5 (current nozzles)
- Stagnation pressure up to 300 psia (depending on Mach number)
- Vitiated air heater provides stagnation temperatures between 700 and 2000°R
- Cell pressure control
- Oxygen depletion replacement
- Run times to approximately 10 minutes.

MATH MODEL

- ACCURATE MATH MODEL OF THE PROCESS
- MODEL INCLUDES PROCESS, VALVES AND INSTRUMENTATION
- RUNS IN REAL TIME WITH CONTROLS SOFTWARE
- USED BEFORE ALL TEST RUNS TO CHECK OUT HARDWARE AND CONSTANTS.

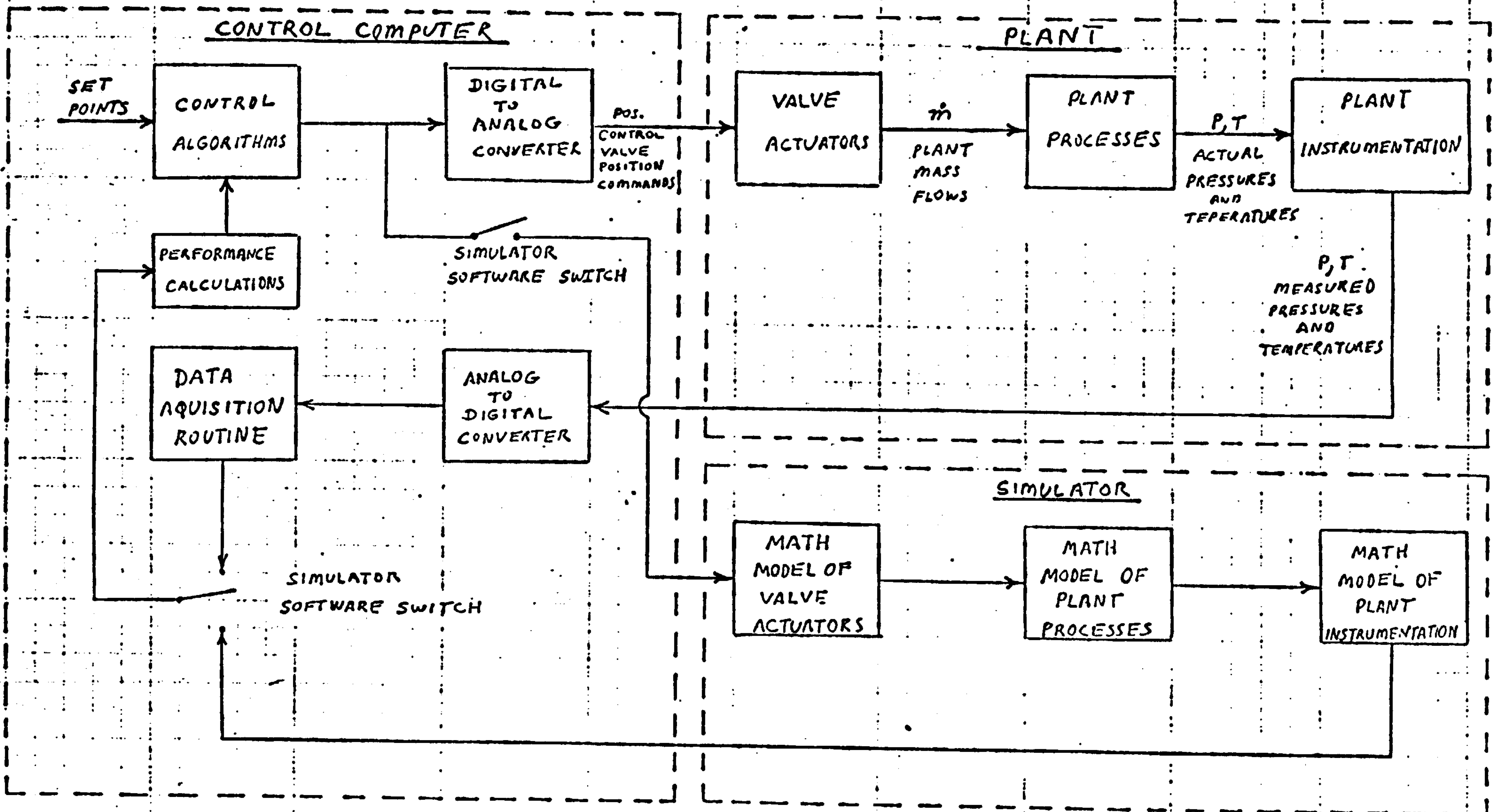
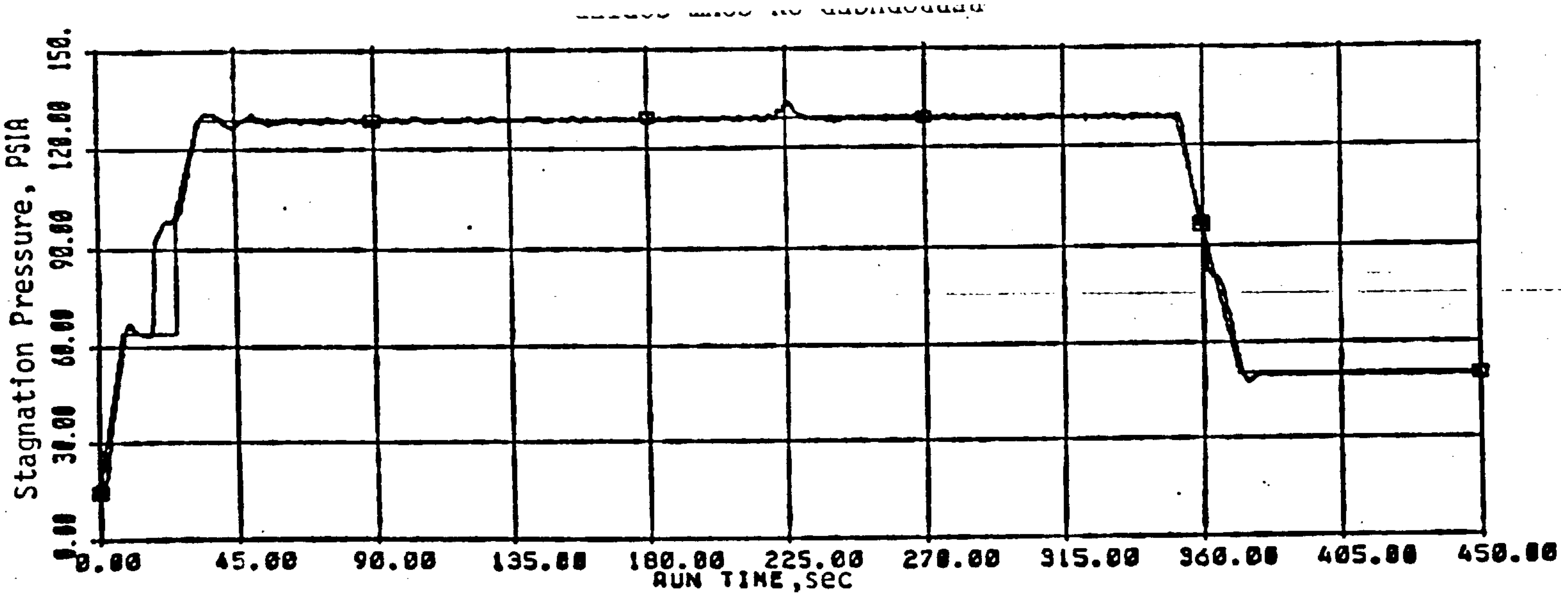
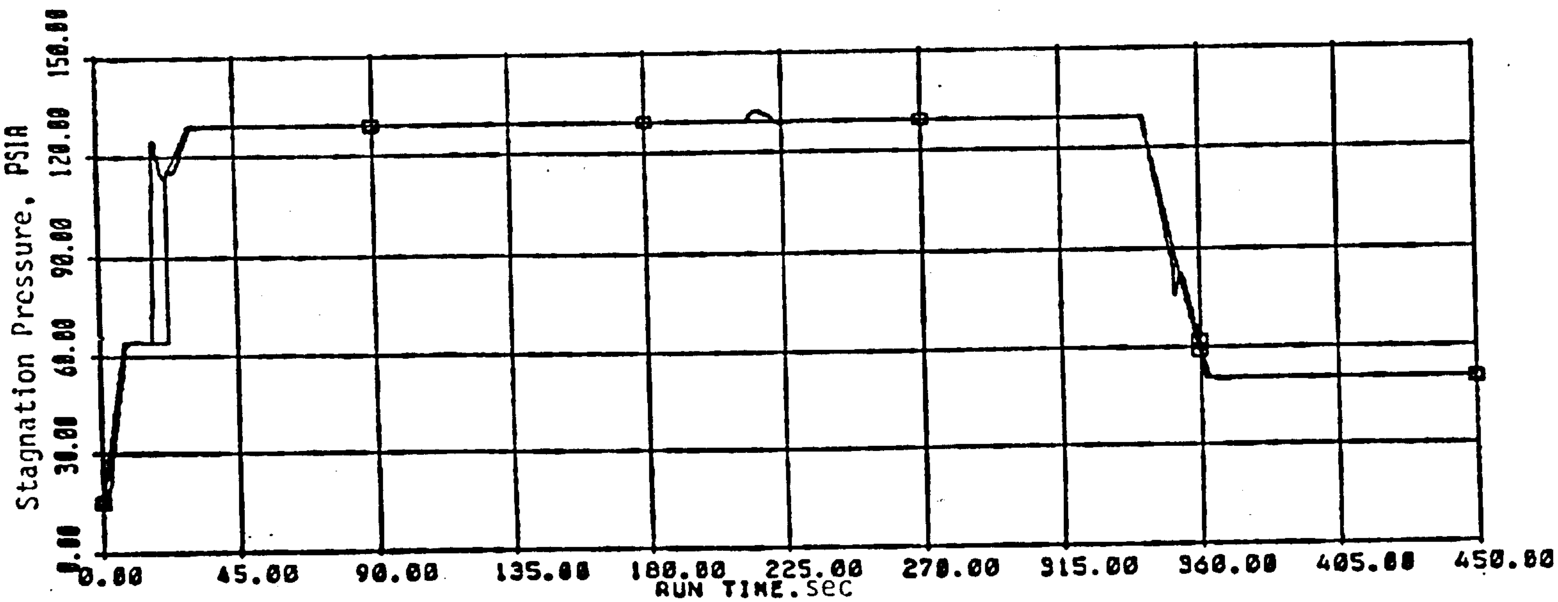


Figure 4 Block Diagram of the MFC Controls Software, APTU Plant System and MFC Simulator

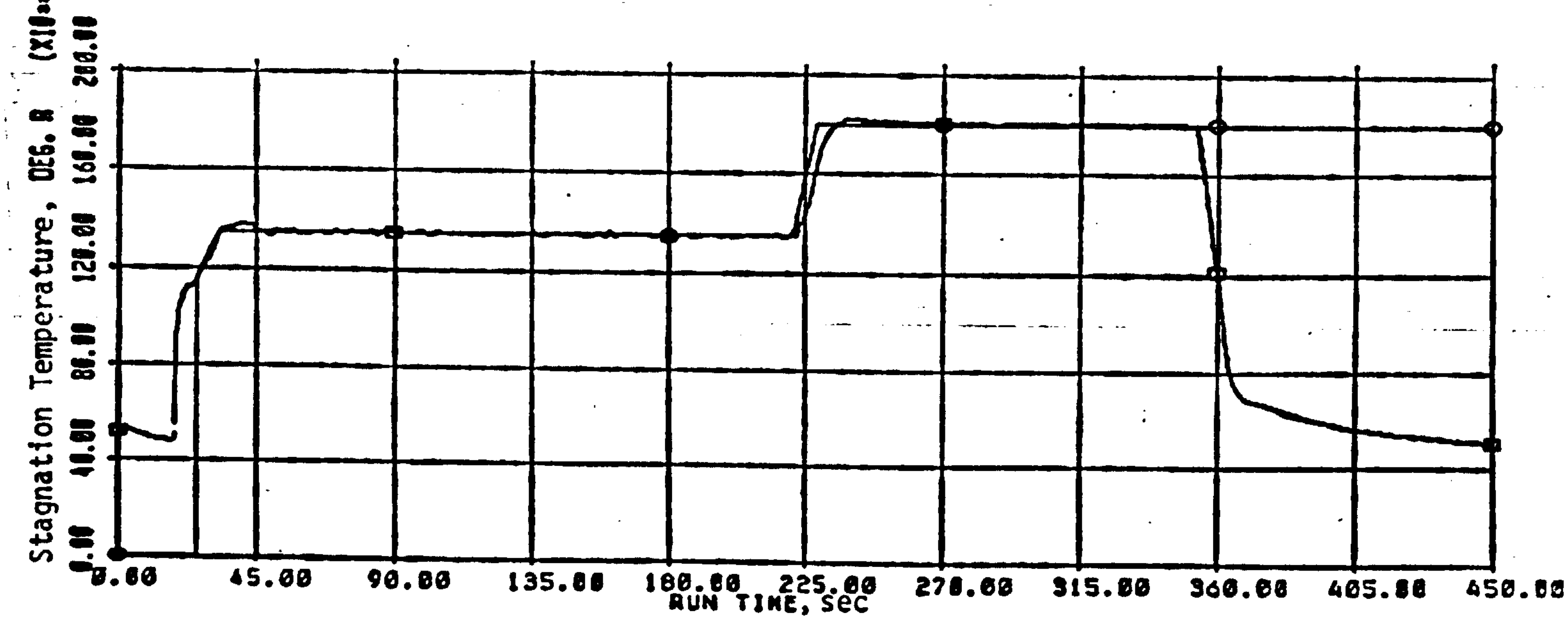


Actual Test Data

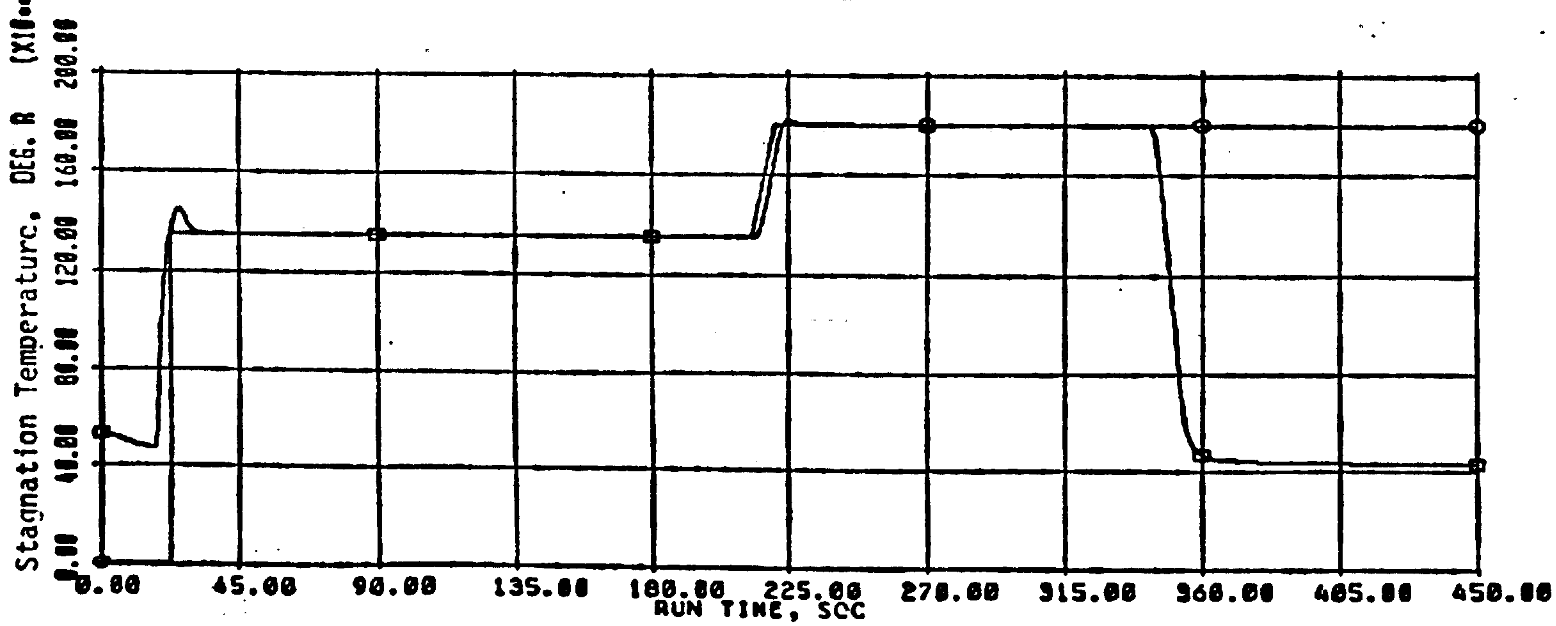


Math Model Simulation
a. Stagnation Pressure

Fig. 5 Comparison of APTU Math Model Simulation with Test Data



Actual Test Data



Math Model Run

b. Stagnation Temperature

Fig. 5 (continued)

KEY FACTORS IN SUCCESS

- MOVES MADE BY RAMPS
- ACCURATE MATH MODEL USED TO CHECK OUT SOFTWARE AND CONTROL STRATEGY DURING DEVELOPMENT AND ON-LINE OPERATIONS
- OPTIMUM CONTROL AT ALL CONDITIONS
- LINEARIZED CONTROL ELEMENT OUTPUTS
- MODERN SOFTWARE DEVELOPMENT TECHNIQUES.

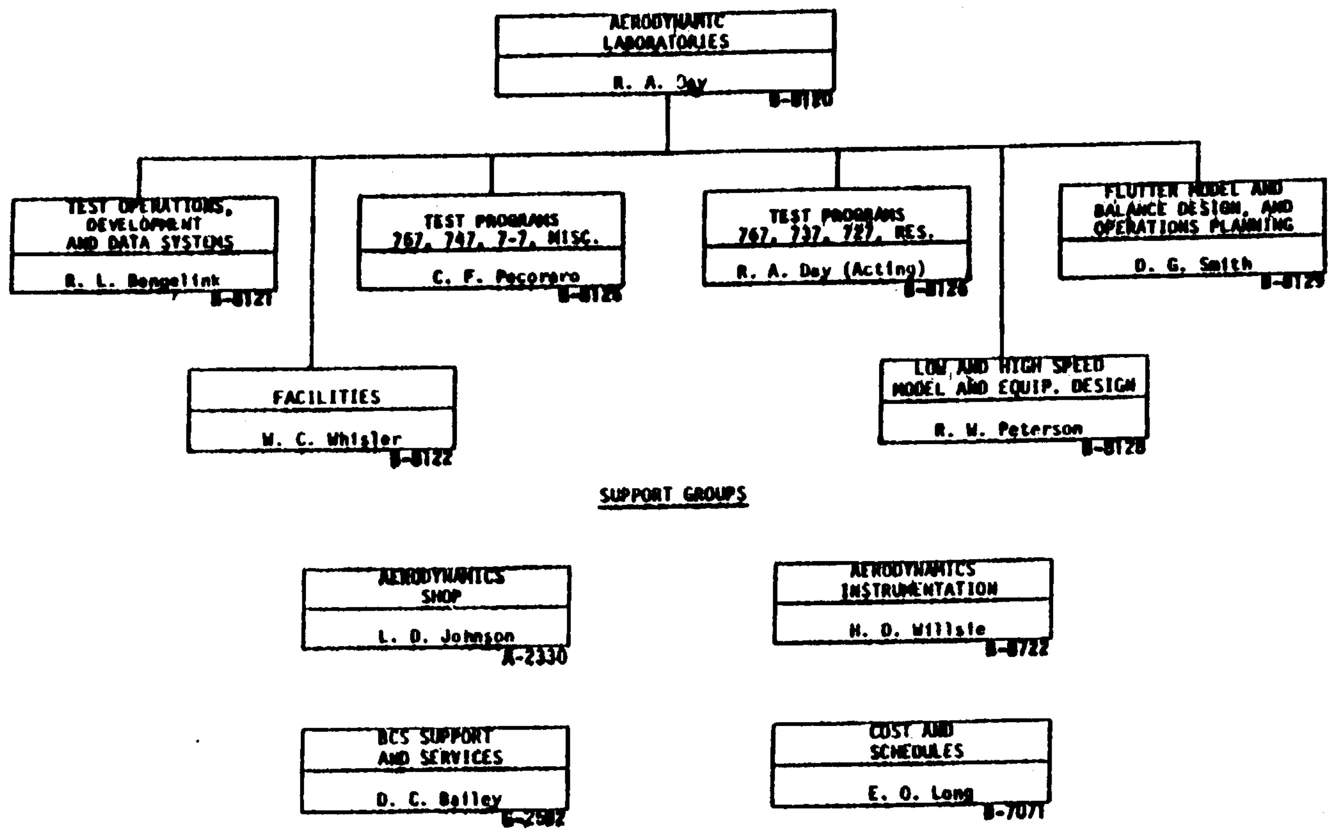
BOEING MODELING PROGRAMS

ROBERT P. DOERZBACHER

SPECIALIST ENGINEER

BOEING COMMERCIAL AIRPLANE COMPANY

January 9, 1984



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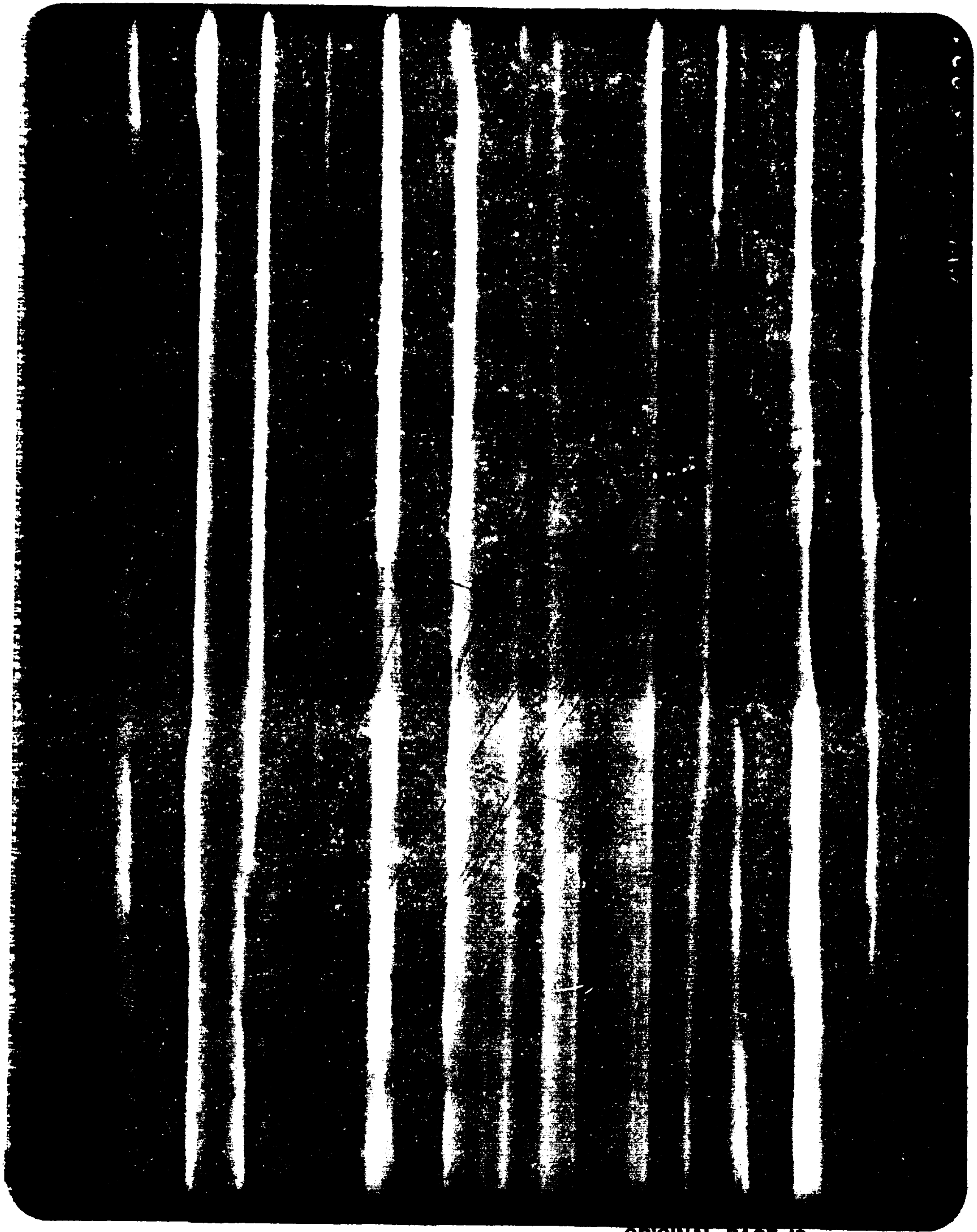
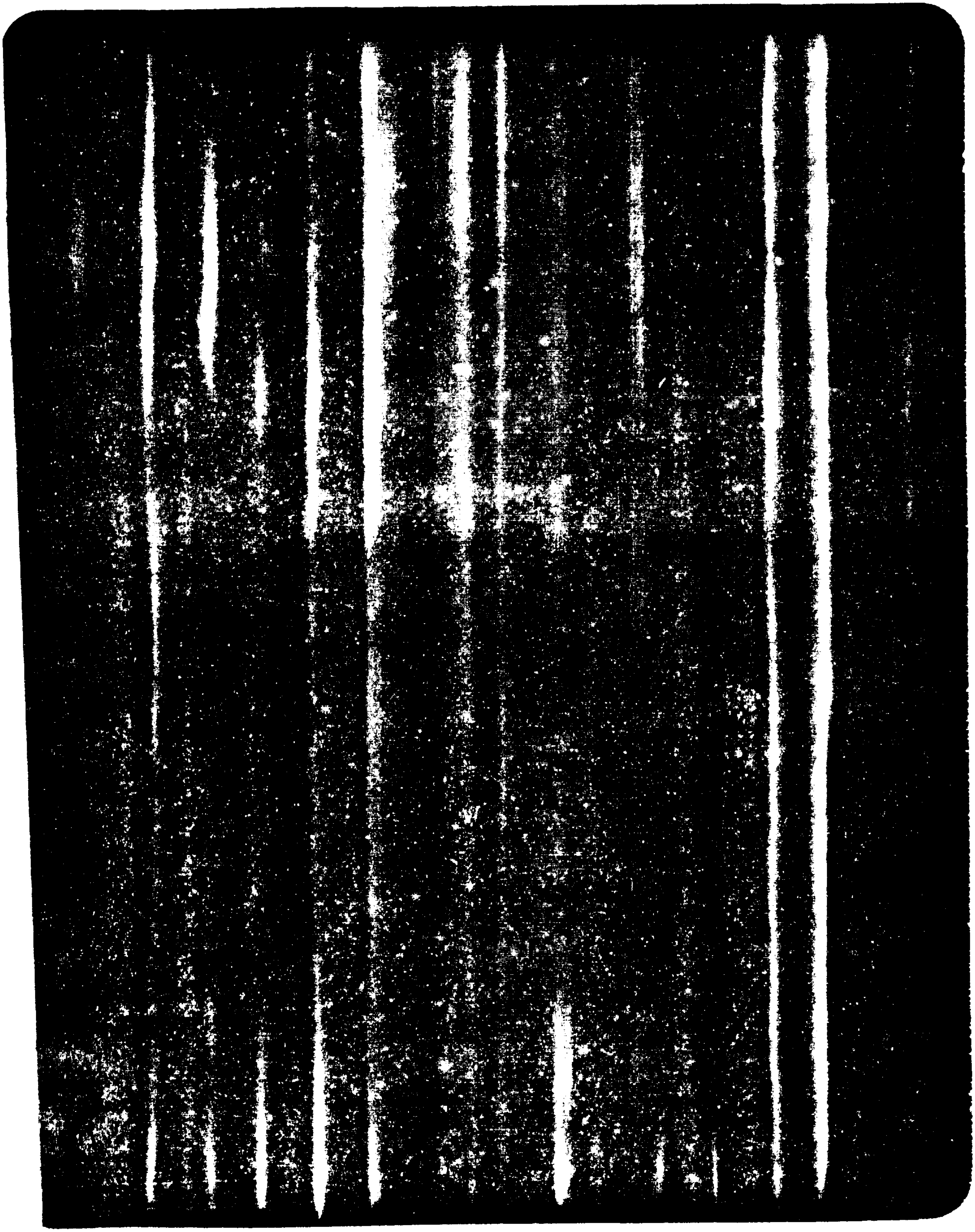
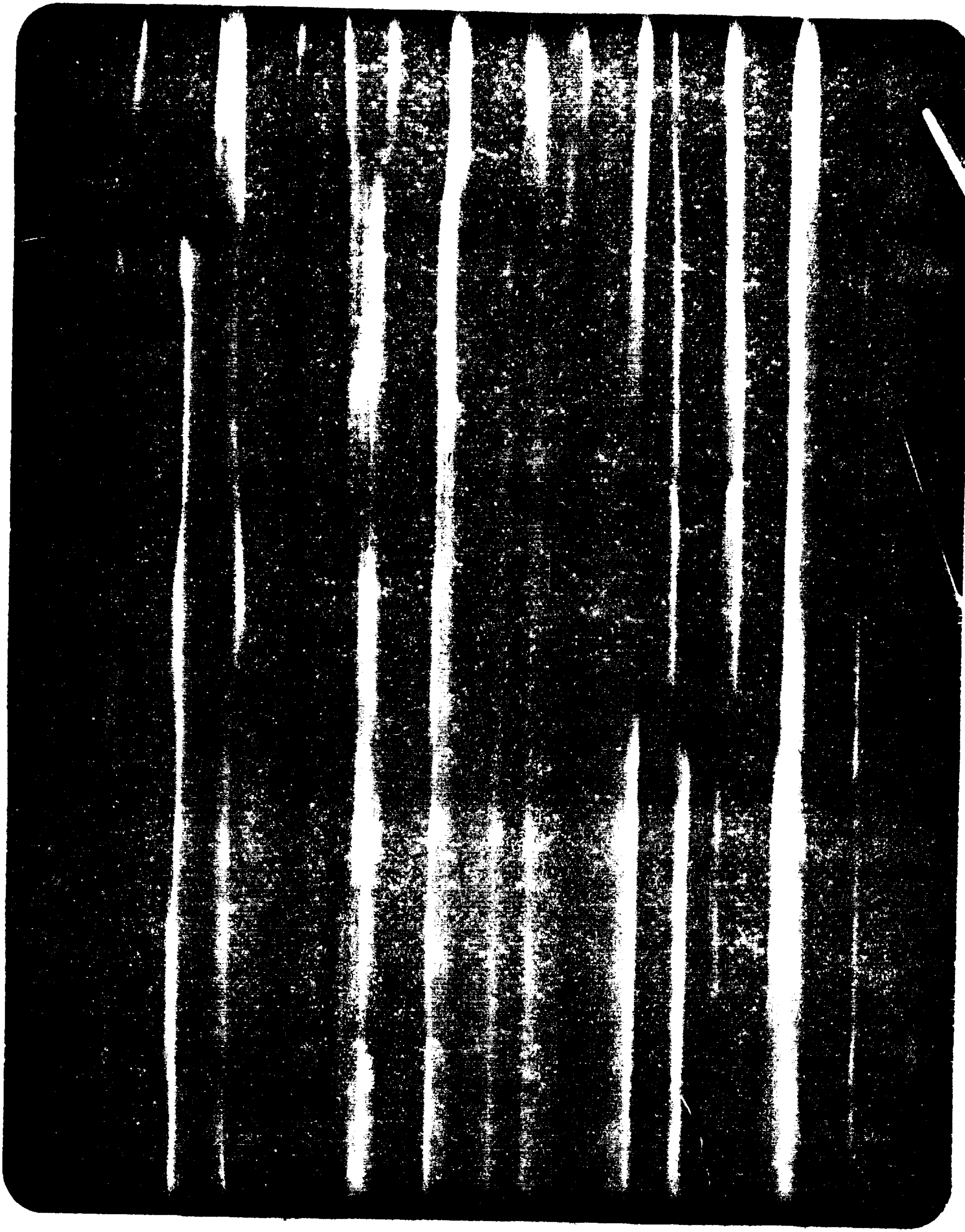
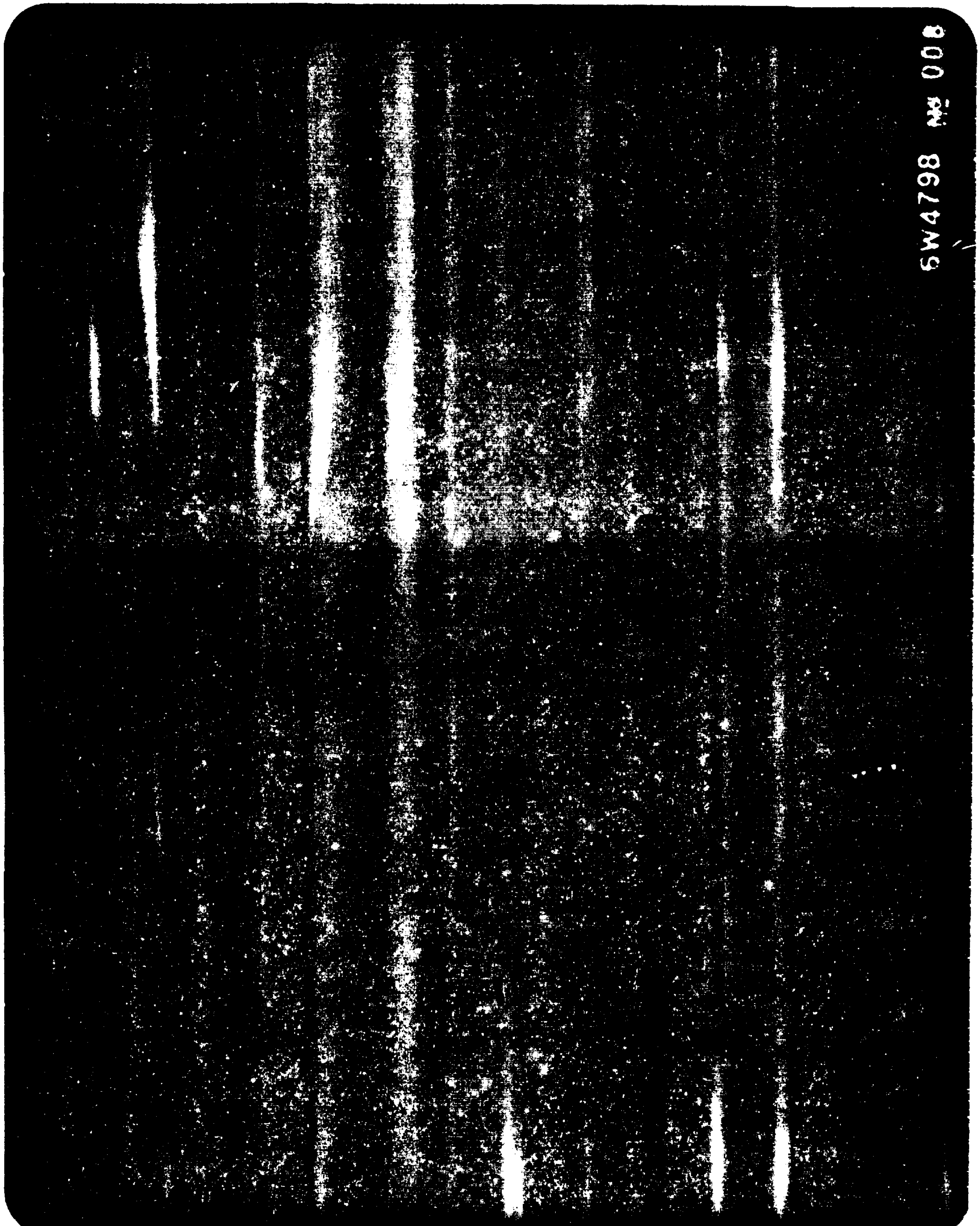
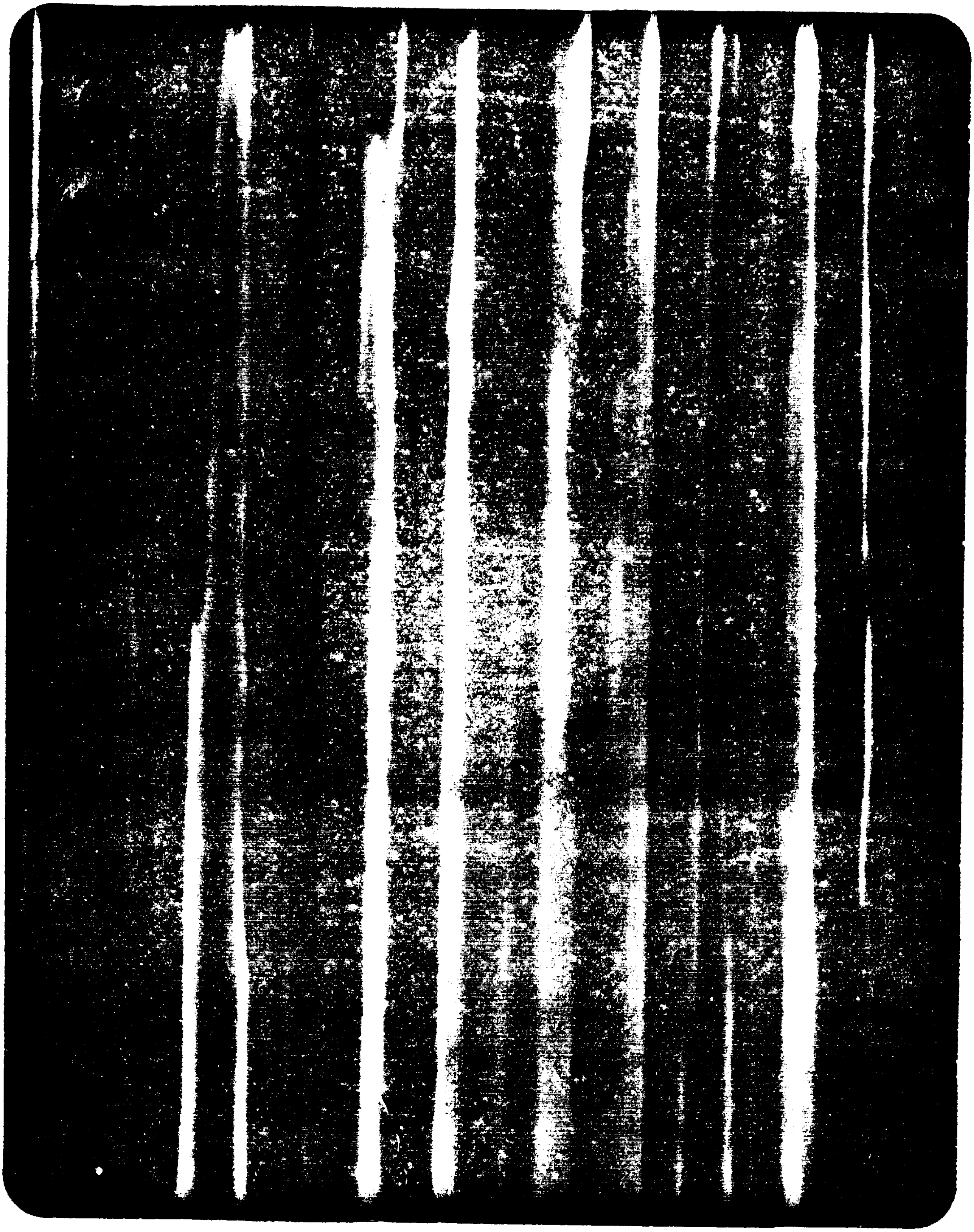
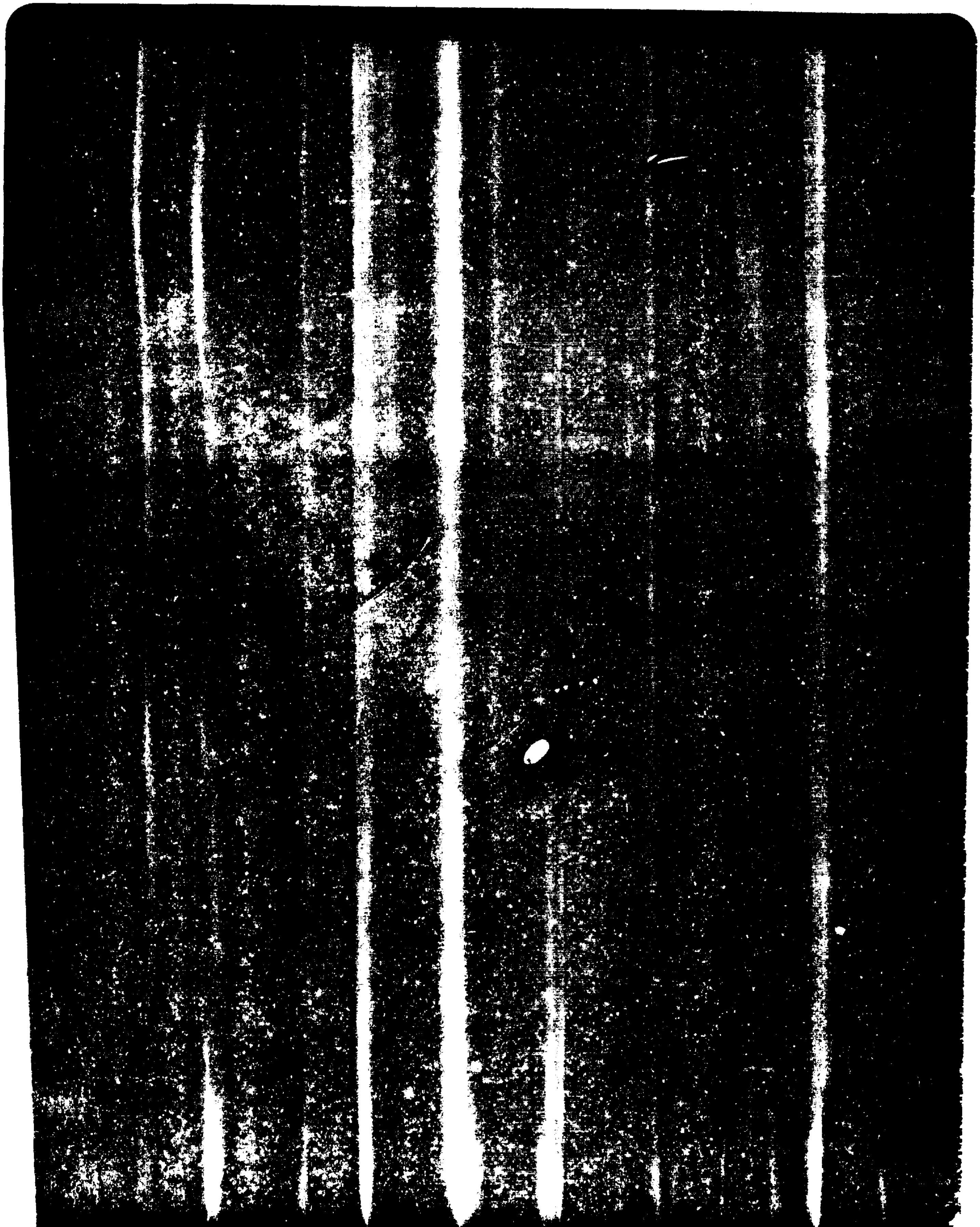


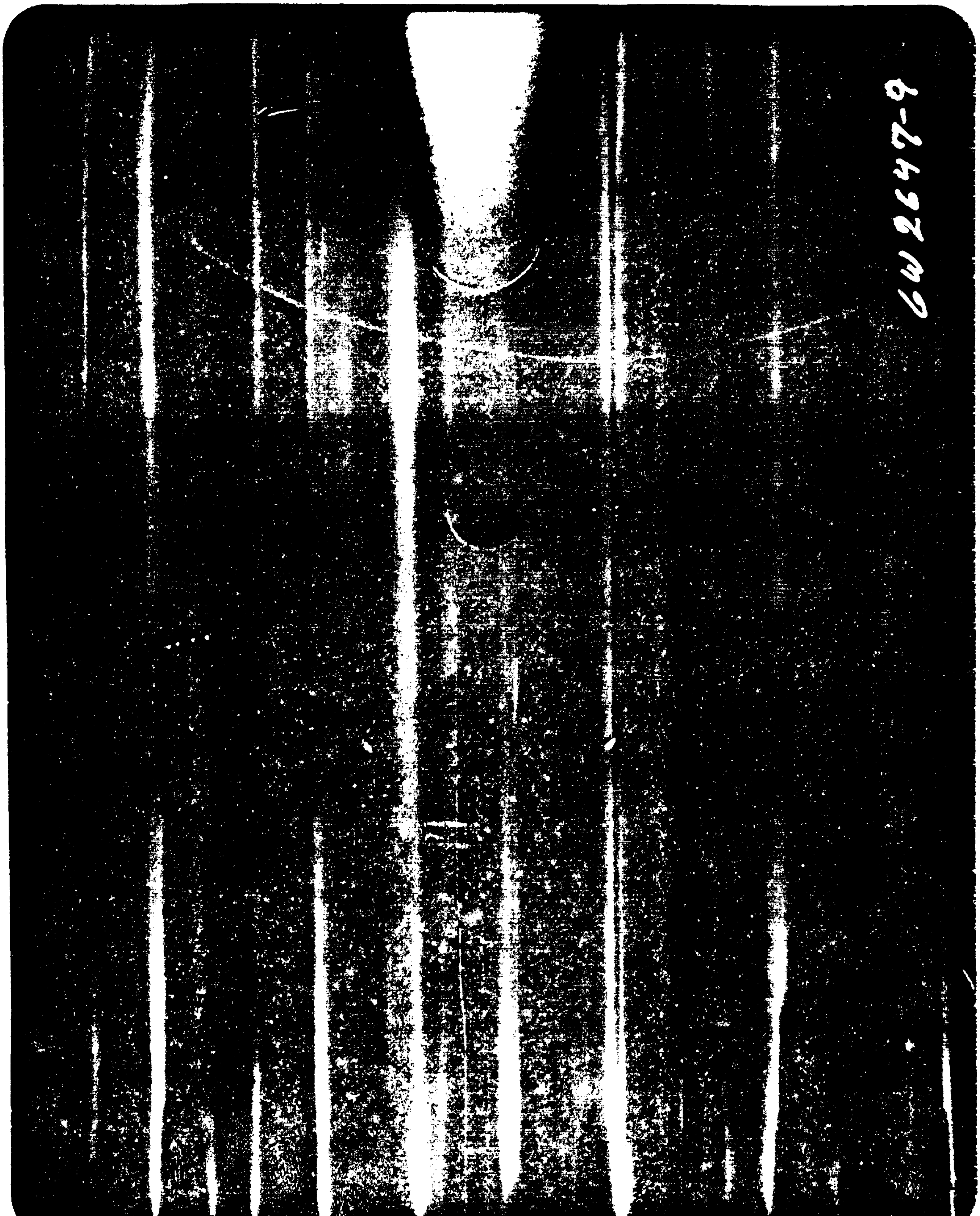


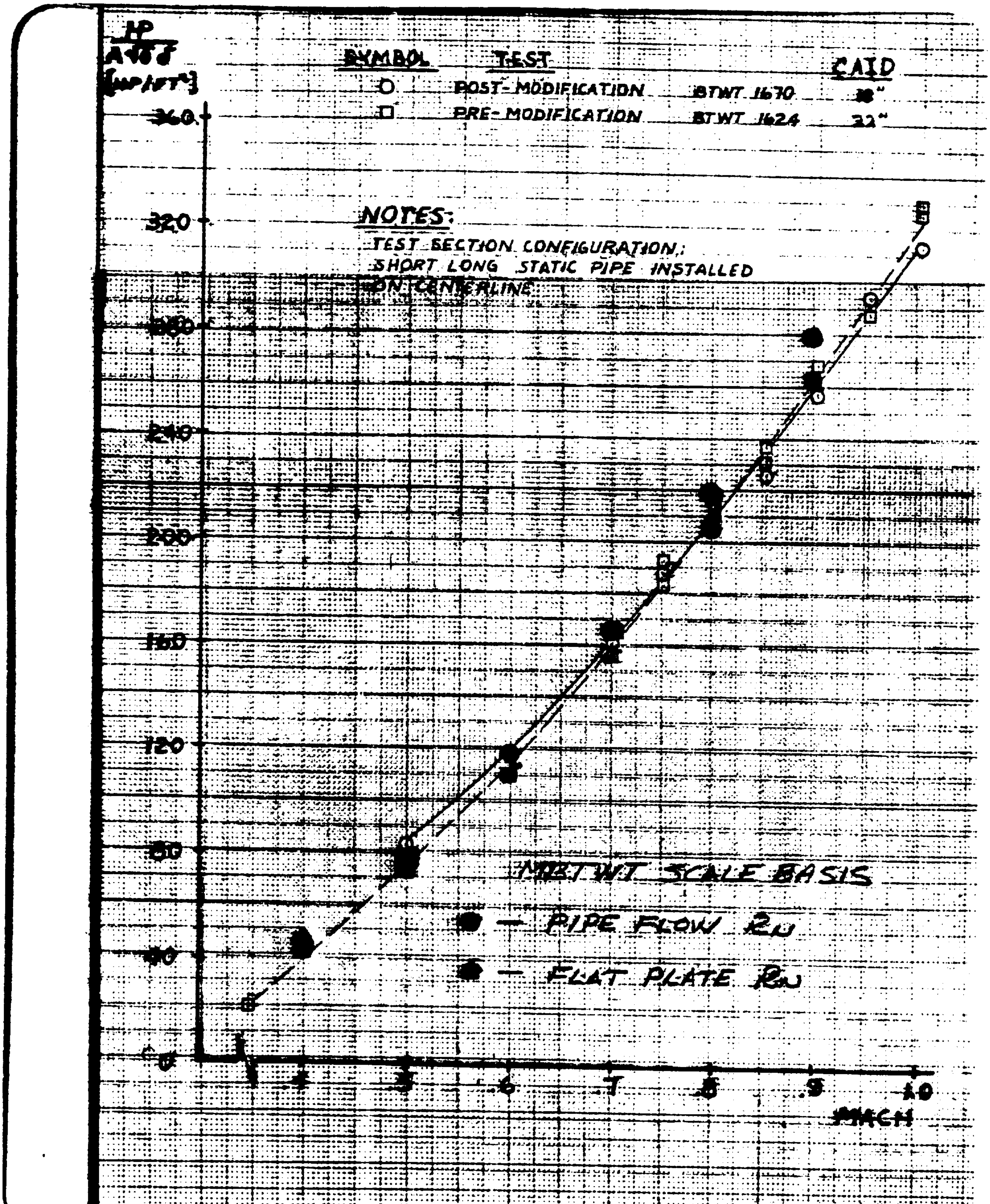



SW4798 № 008

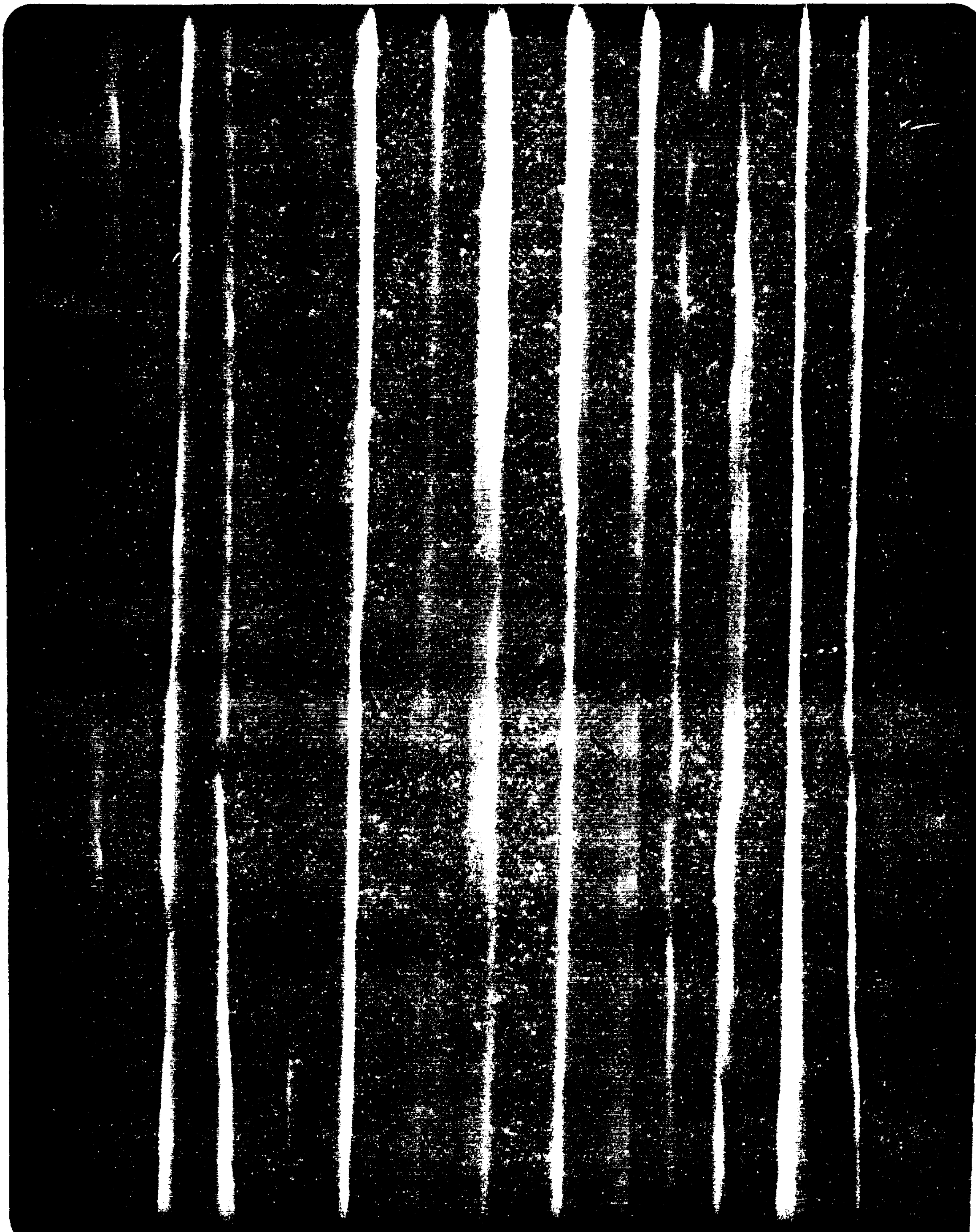


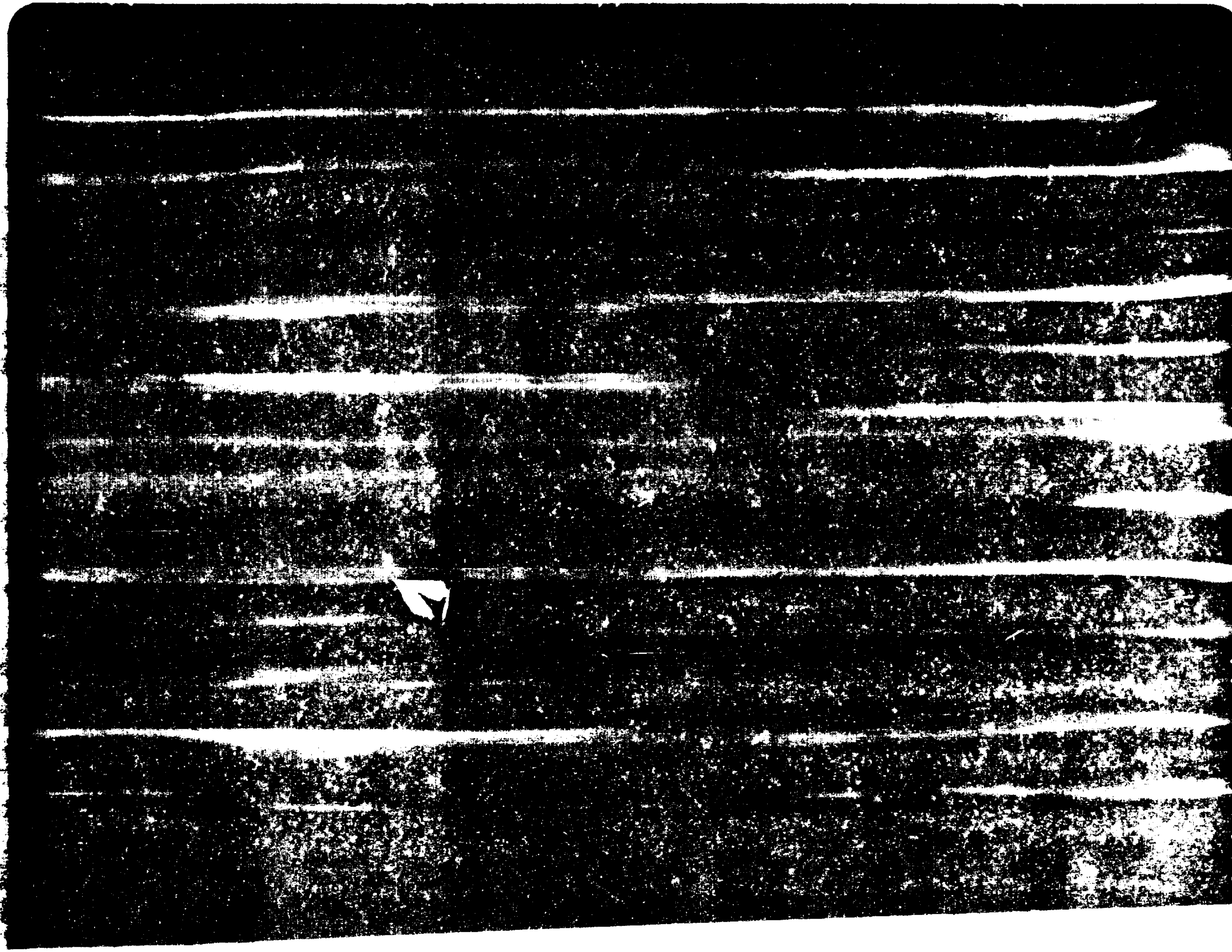


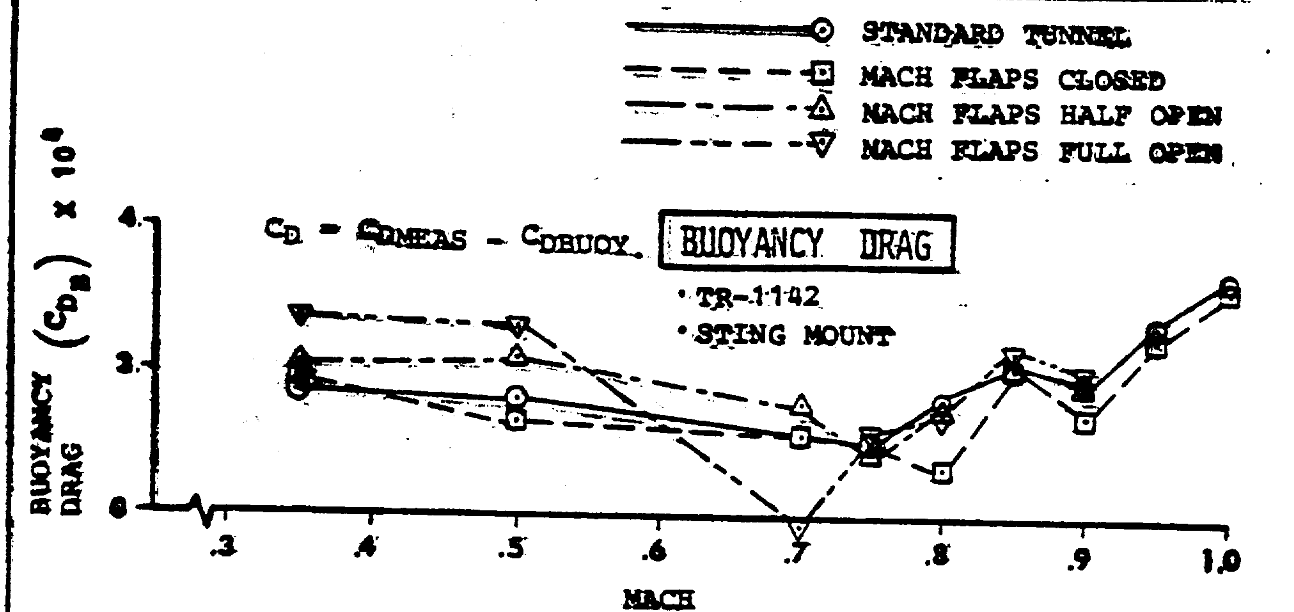


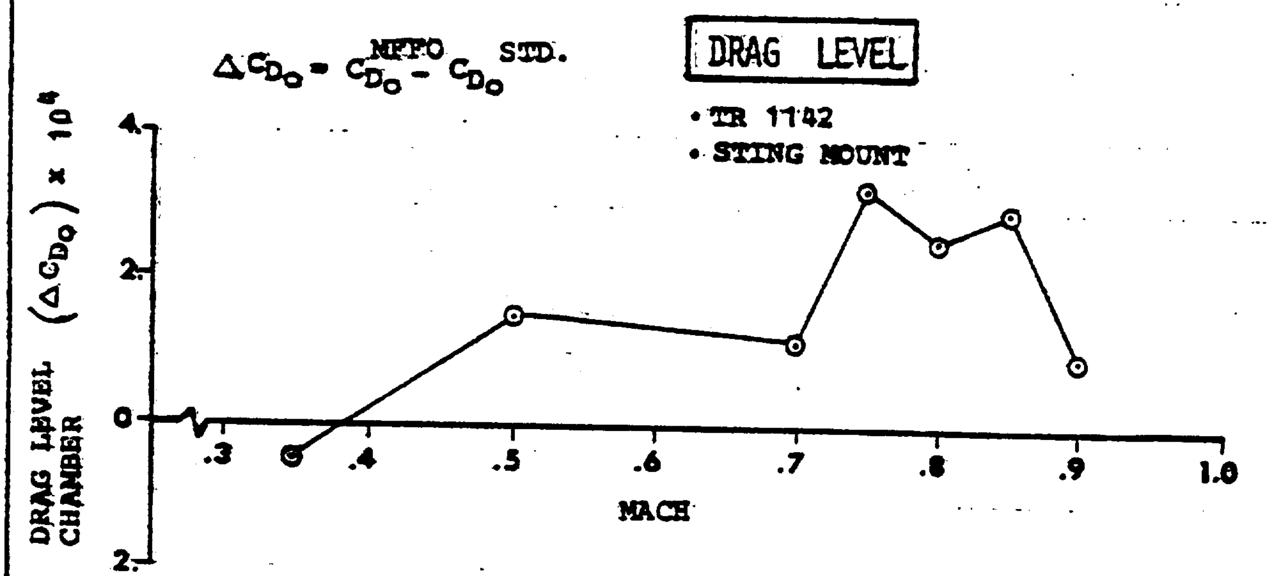


CALC | AKRYNYTSKY | 3/10/79

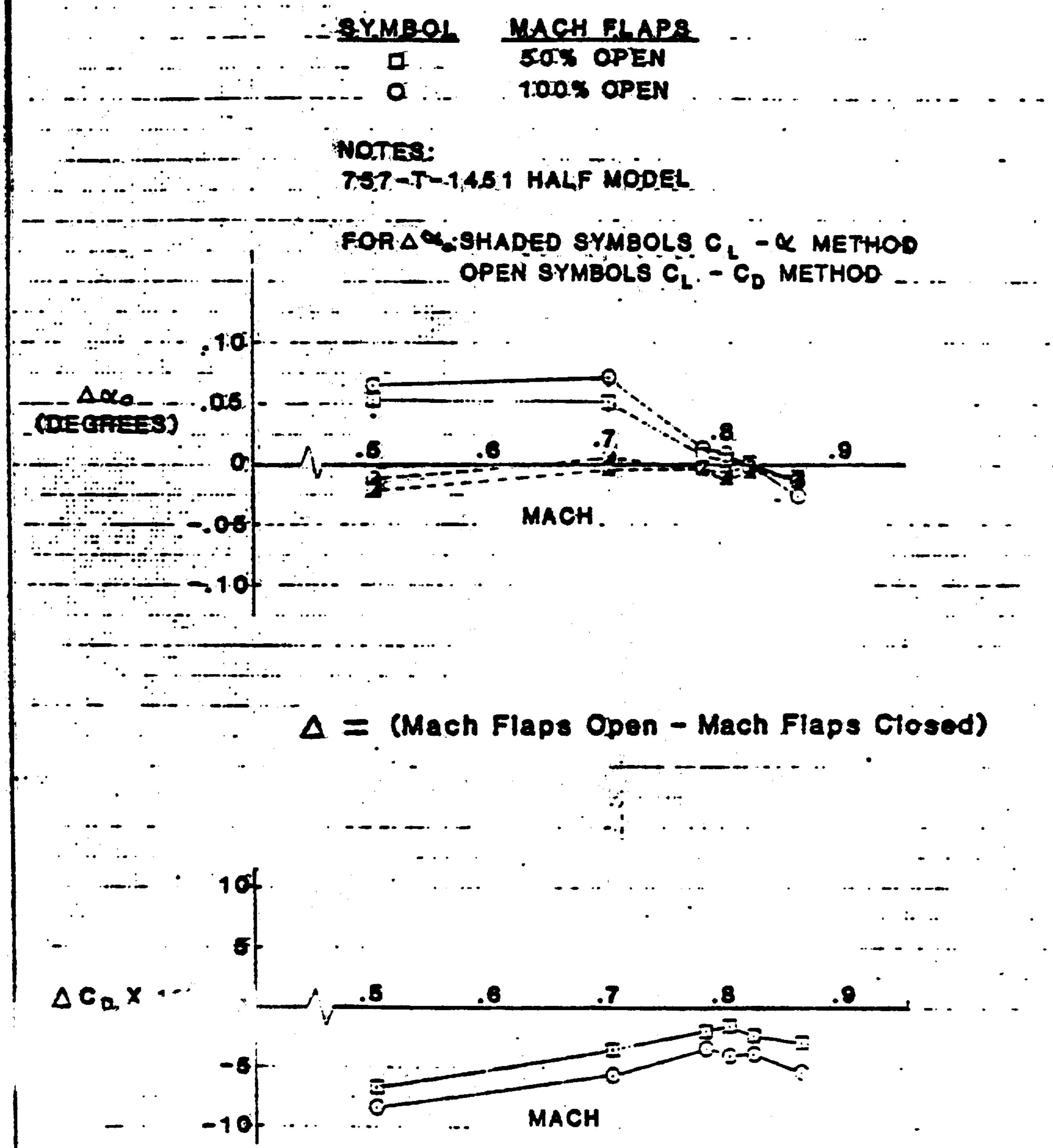








ORIG	J.M.SMYTH	5/10	REVISED	DATE	BTWT MACH CONTROL FLAPS DRAG EFFECTS	CTR-67
CHECK		78				FIGURE
APP						



CALC	MCN	4/5/79	REVISED	DATE
CHECK				
APR				

EFFECT OF MACH CONTROL FLAPS ON MODEL UPFLOW AND C_D SHIFTS OF THE 757-T-1451 HALF MODEL

BTWT 1684

Fig. '

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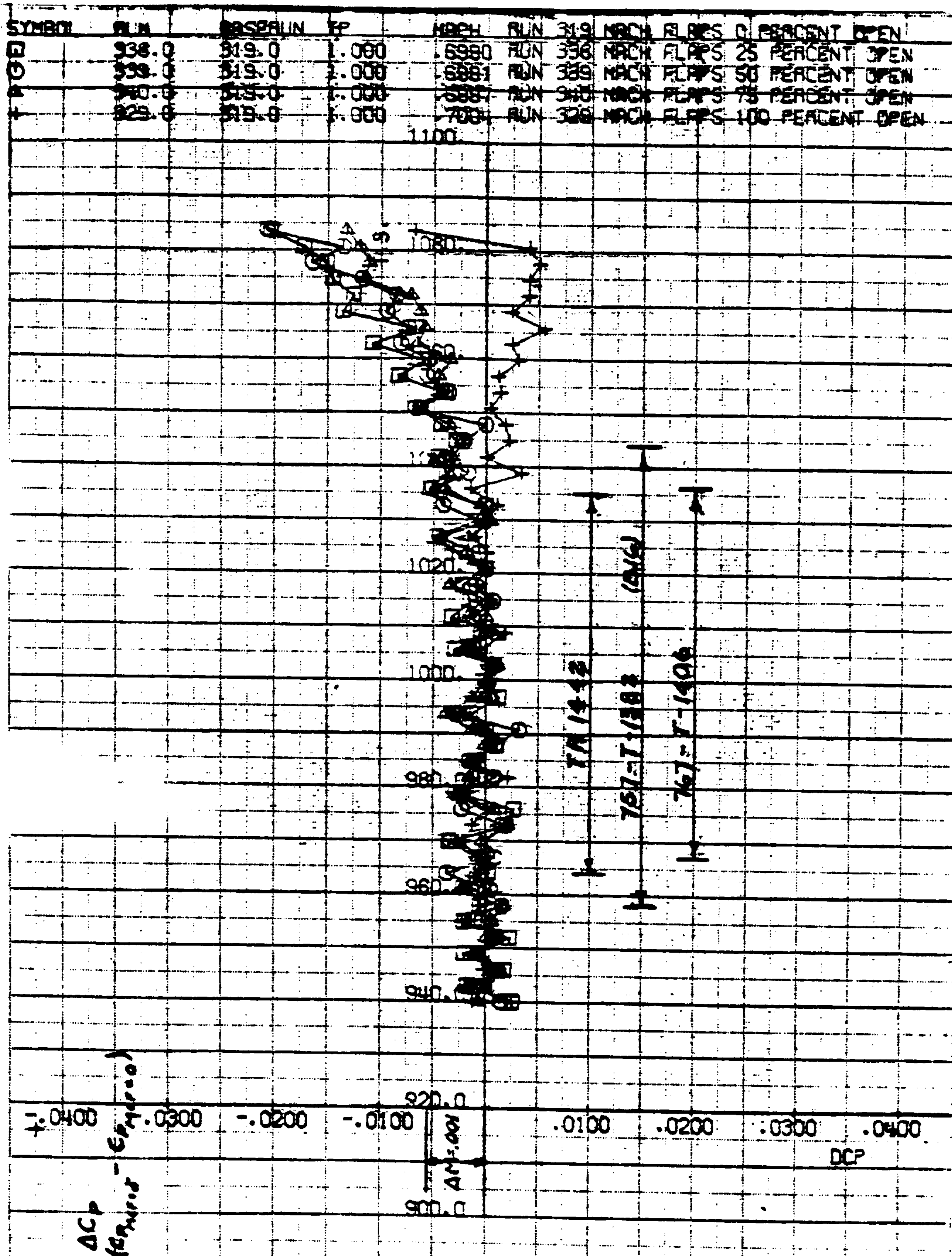

CALC	A.J.K.		REVISED	03/08/79	BTWT 1670	WT-T-69
CHECK	[redacted]				CENTERLINE STATIC PRESSURE	

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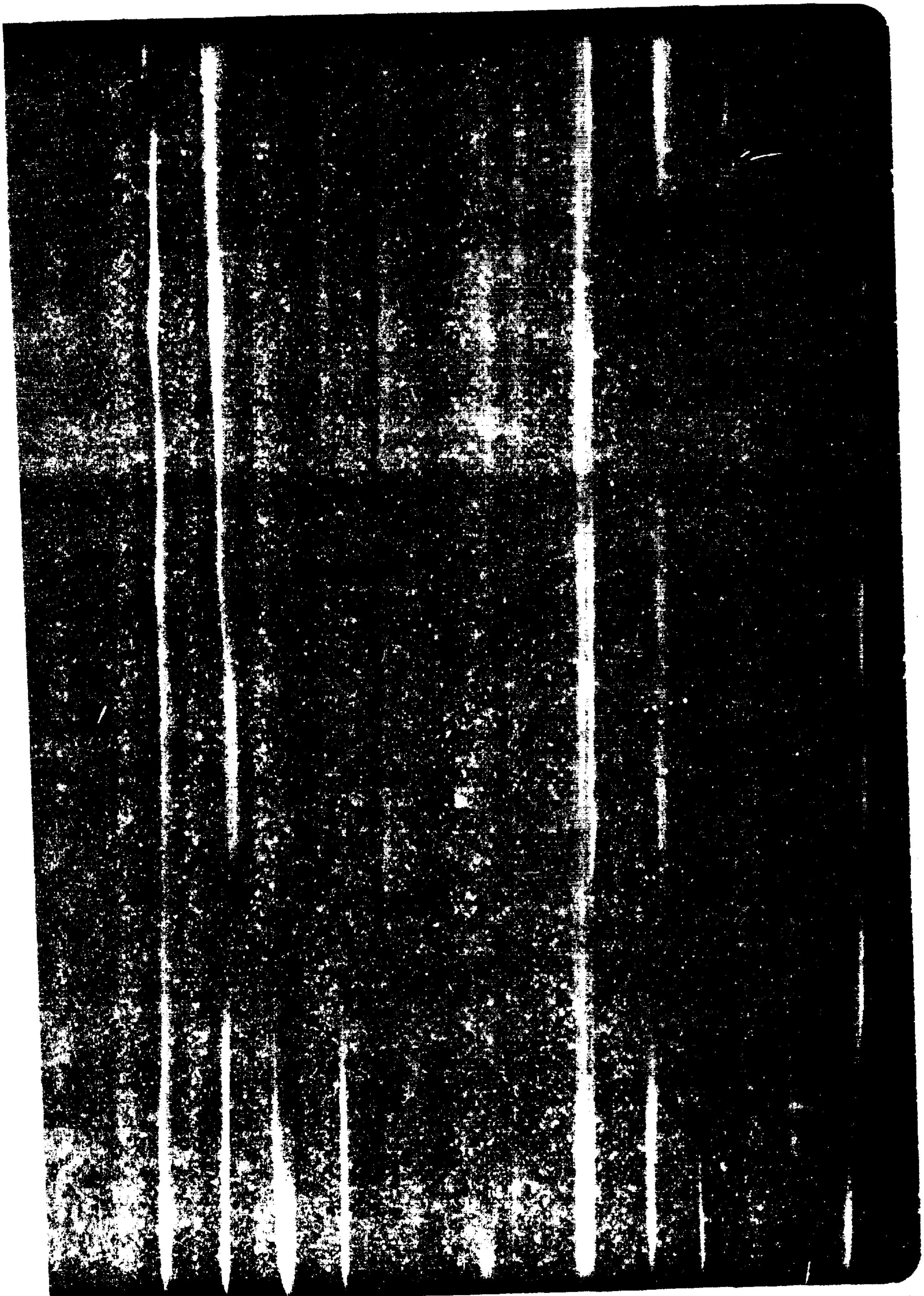
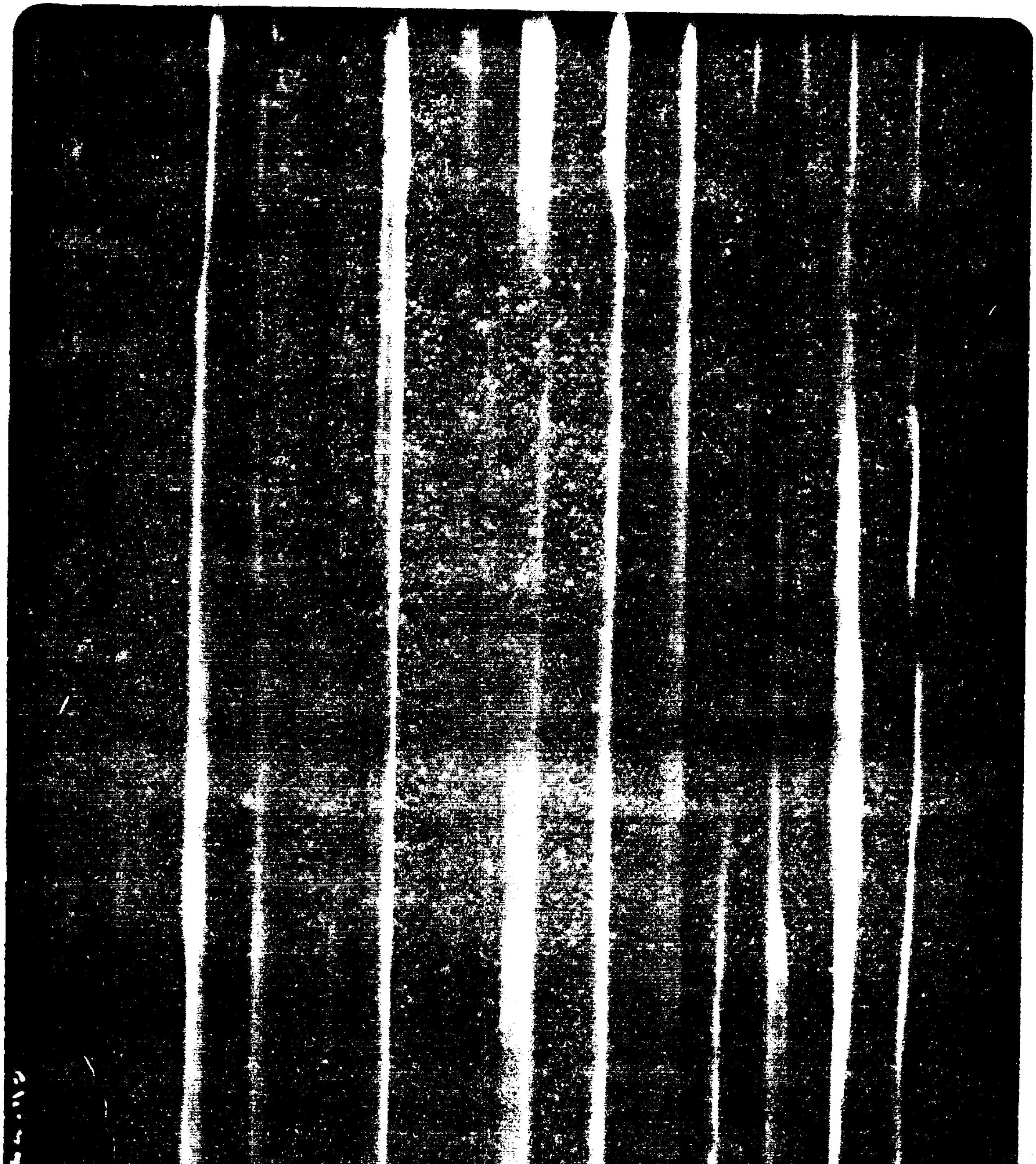
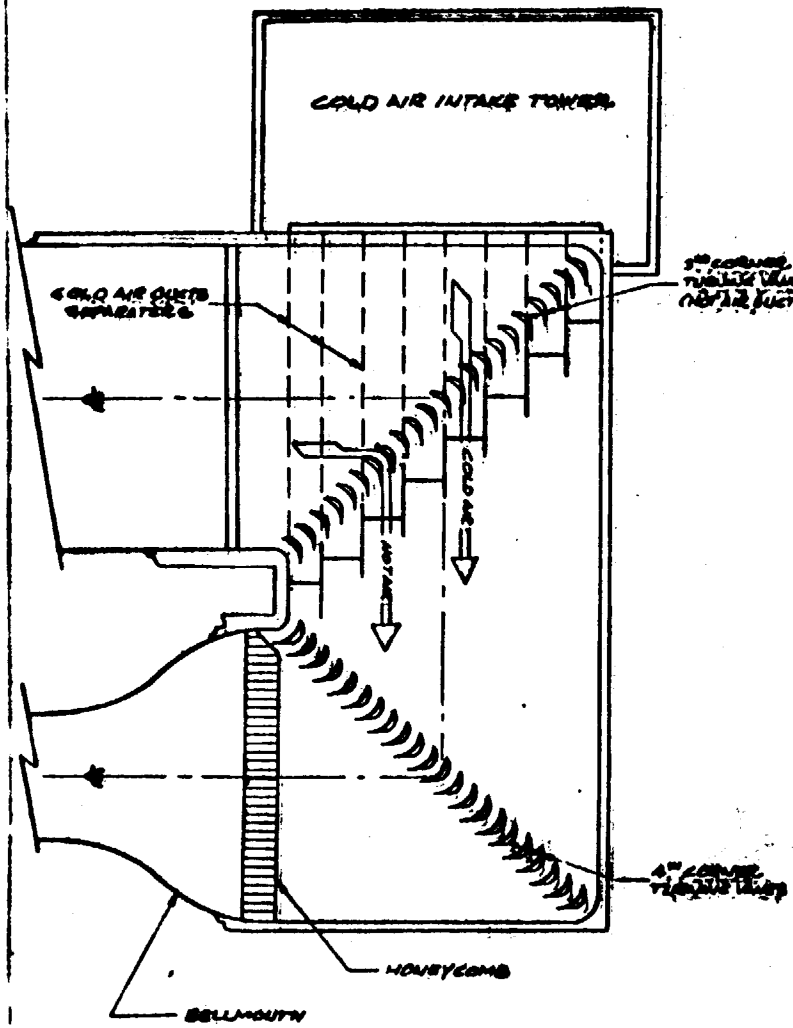
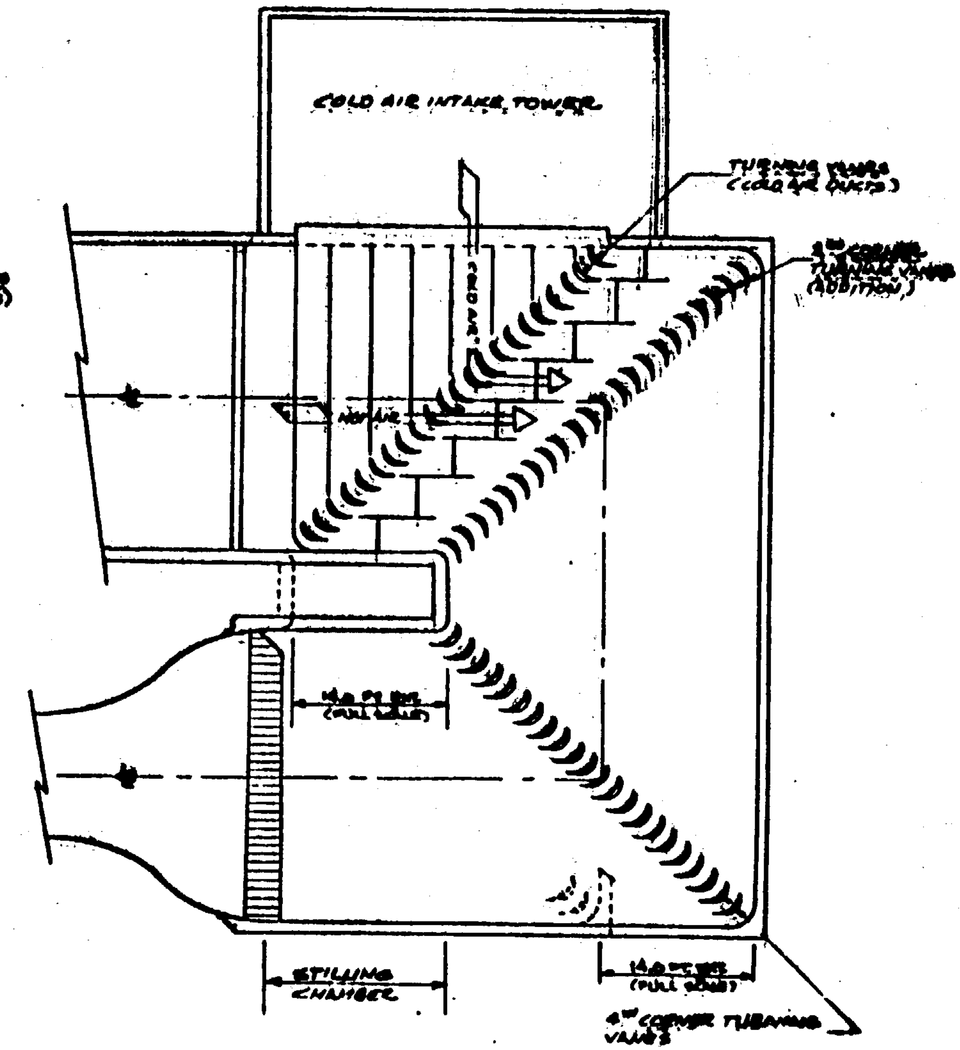


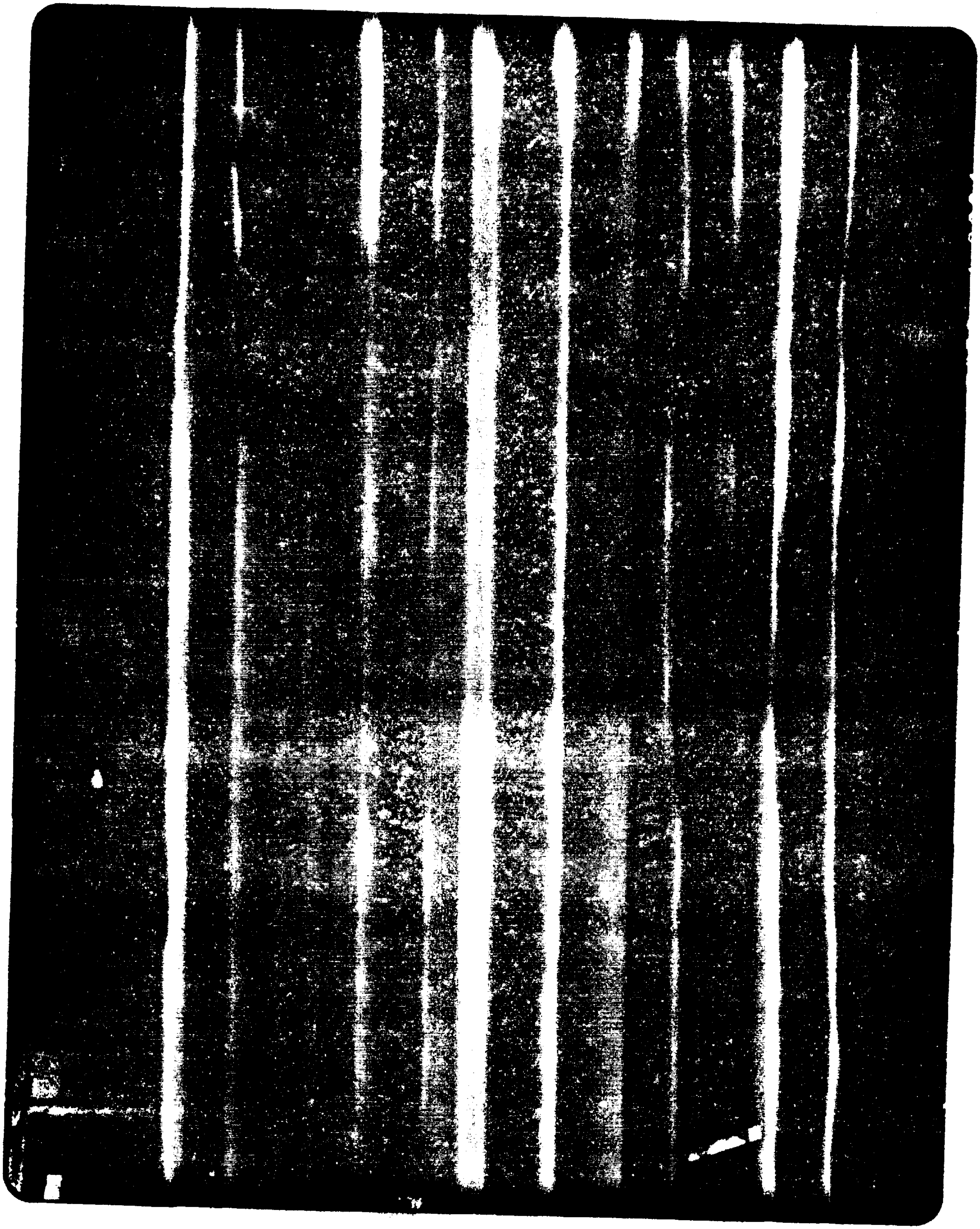


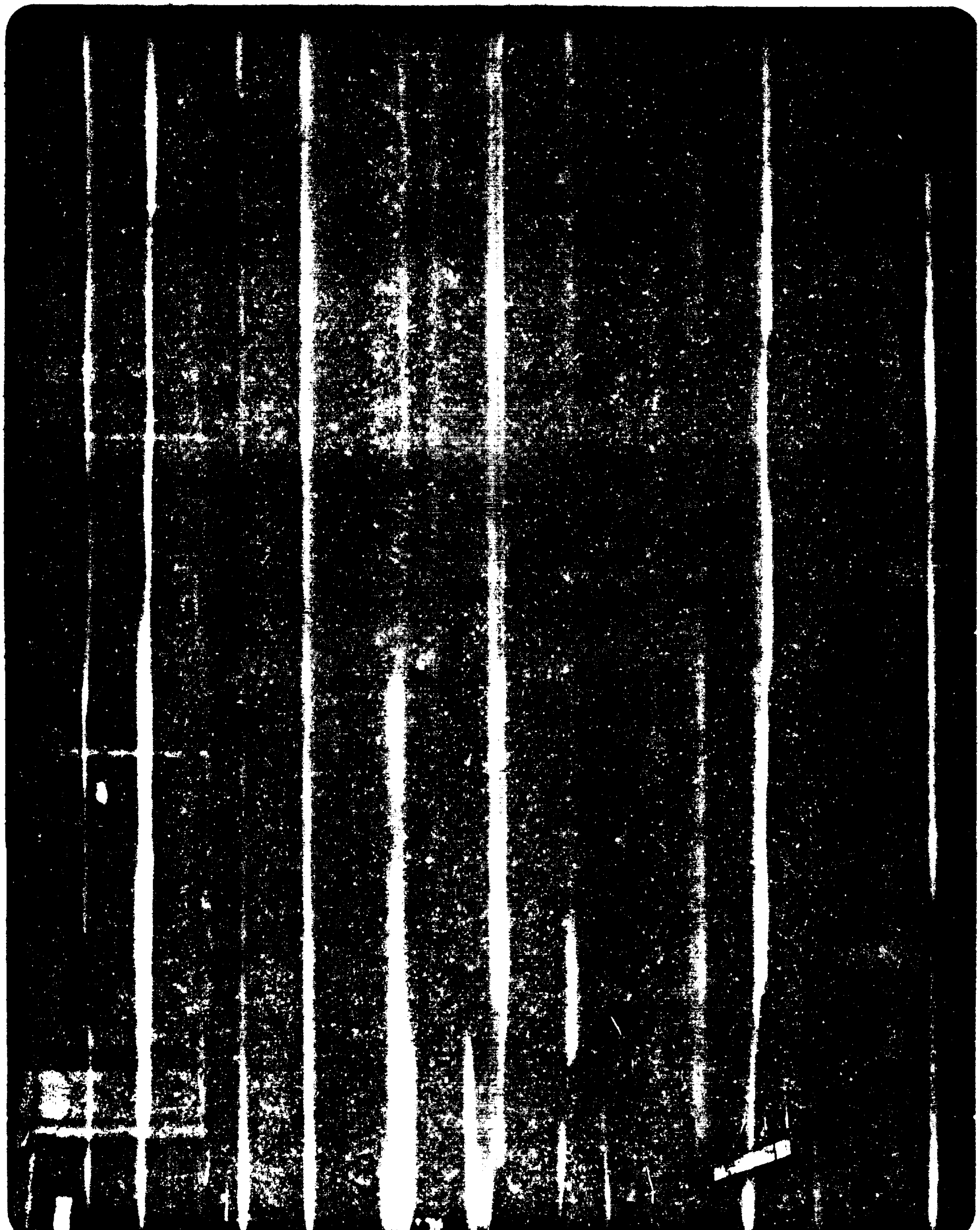


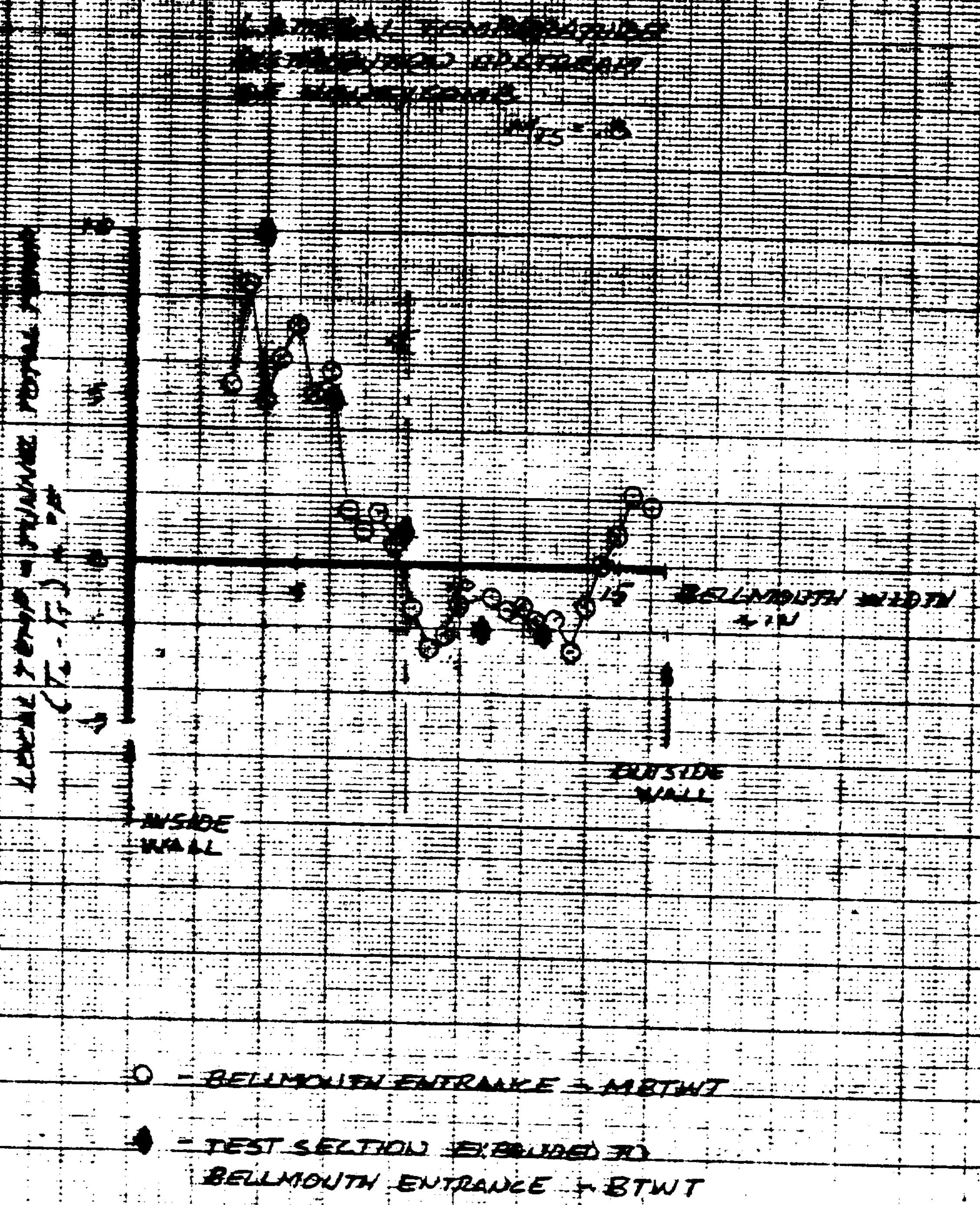
EXISTING CIRCUIT
- PLAN VIEW -



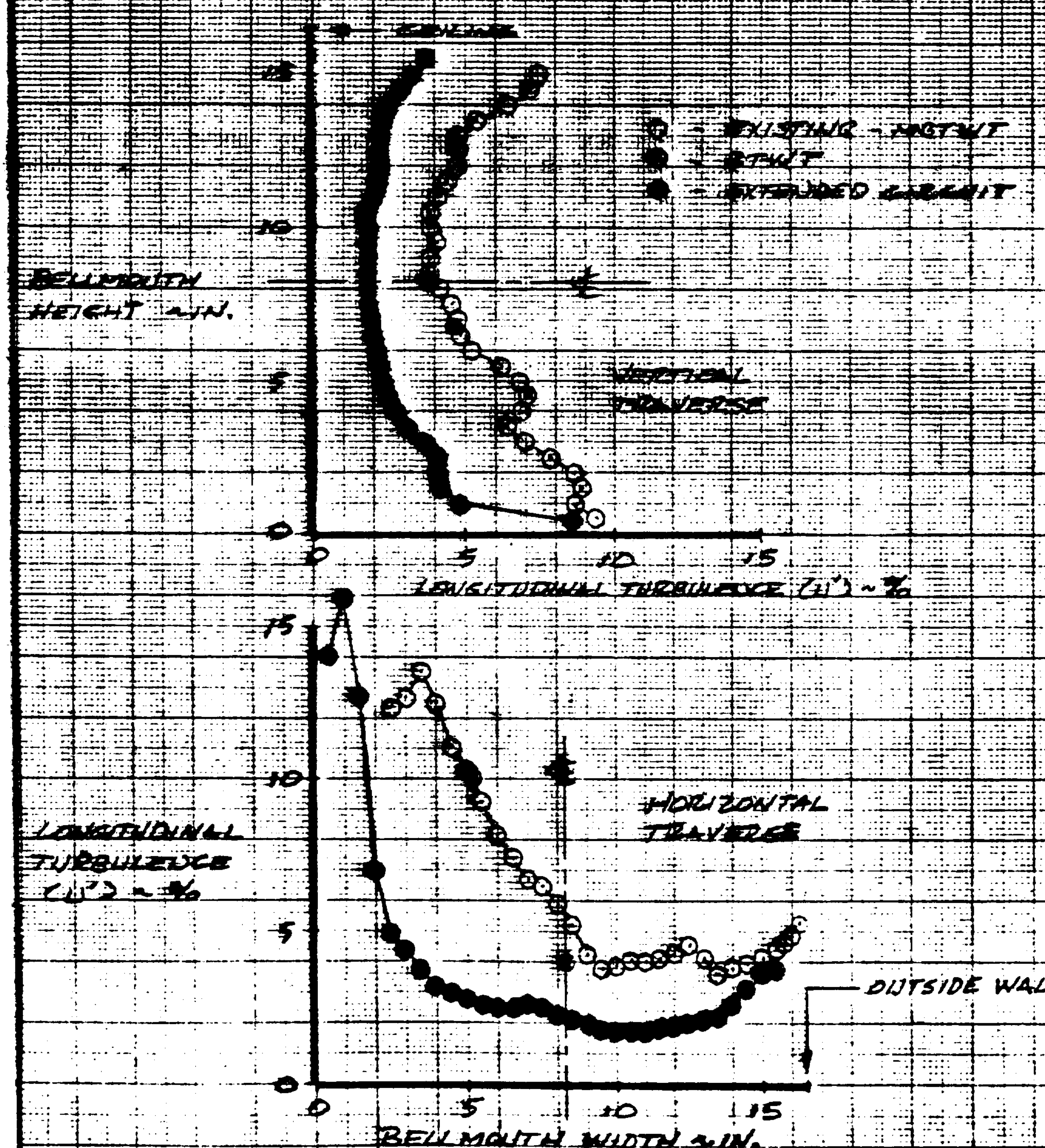
EXTENDED CIRCUIT
(AS TESTED)



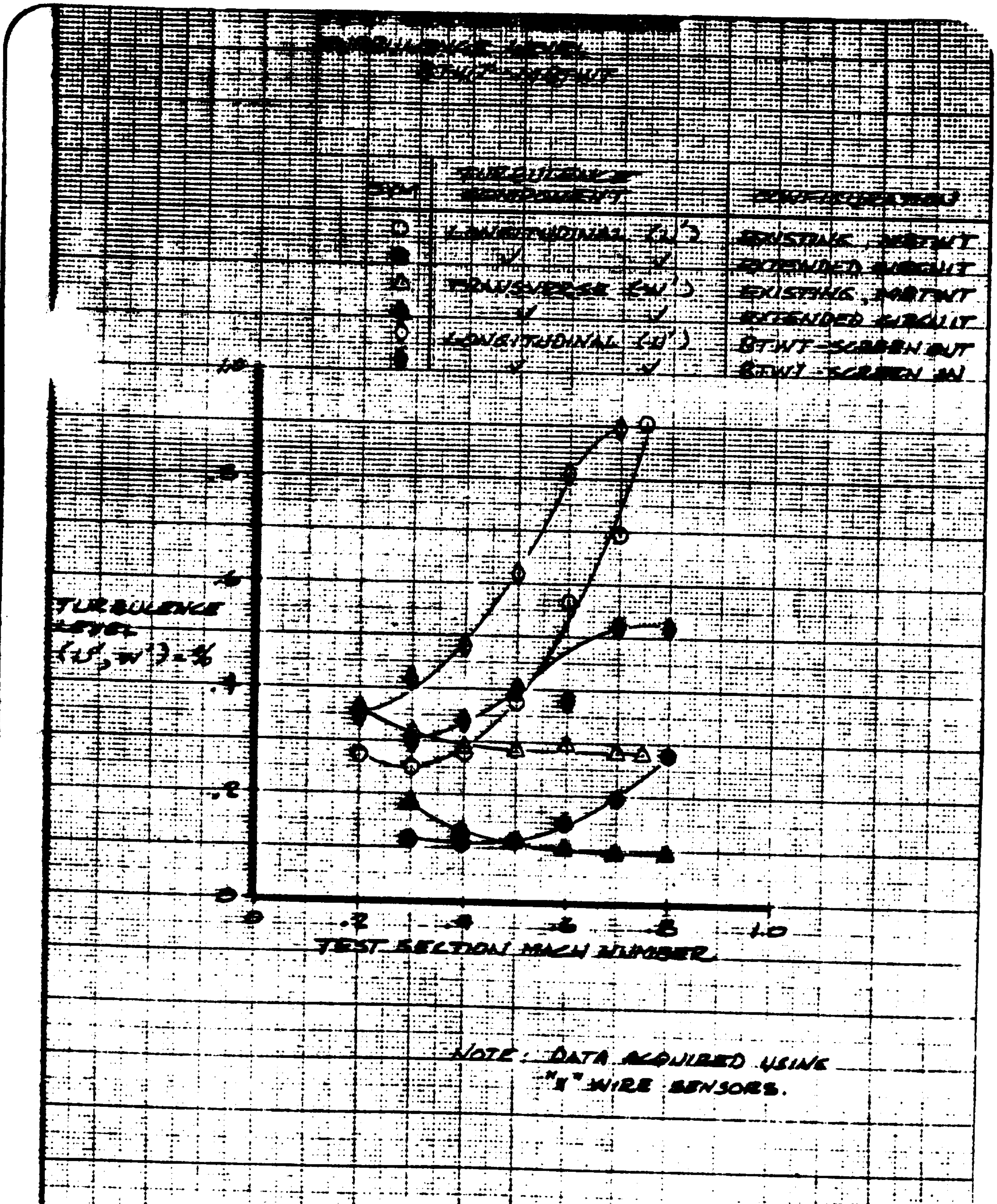




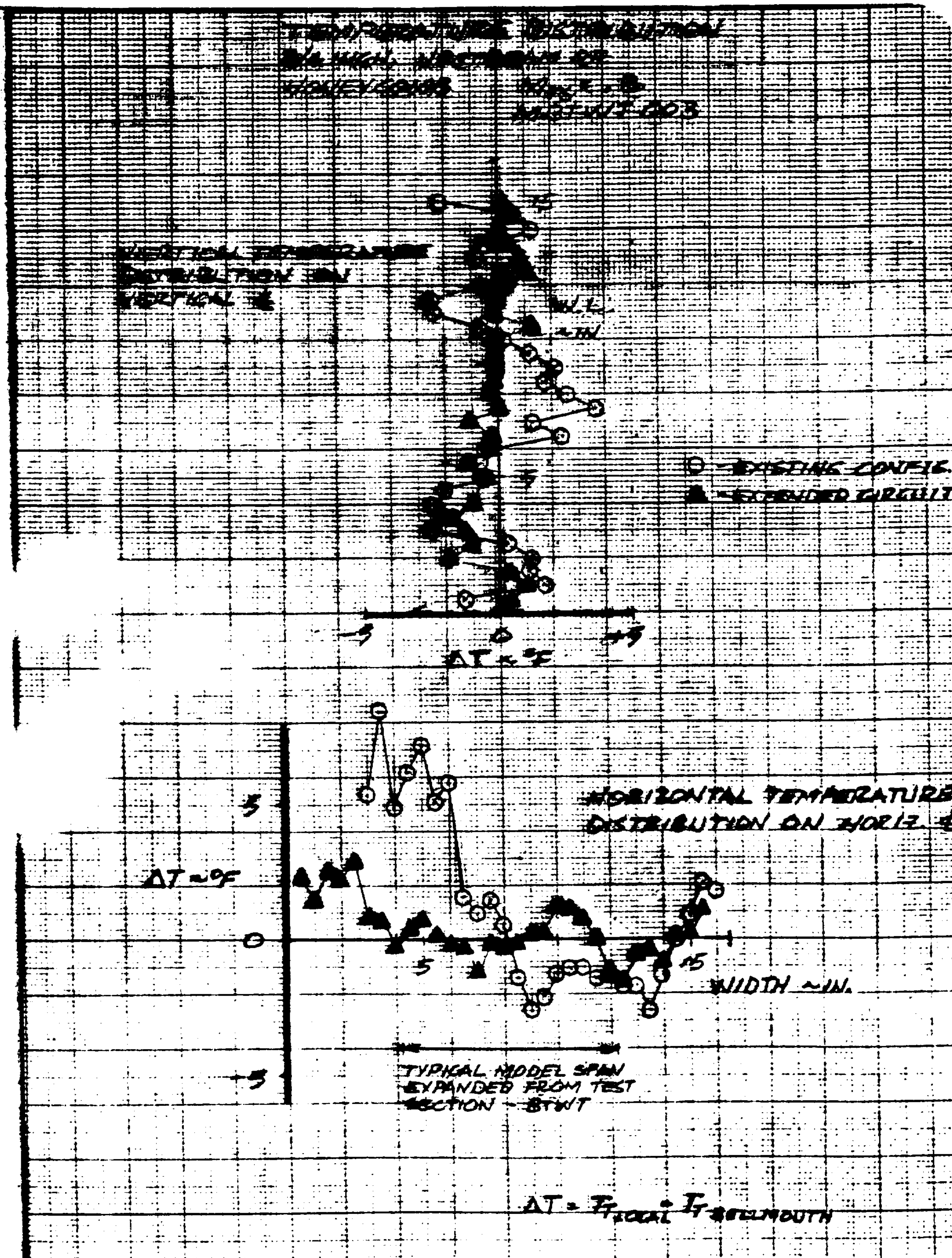
CALC	RPD		REVISED	DATE	LATERAL TEMPERATURE	FIG. 1



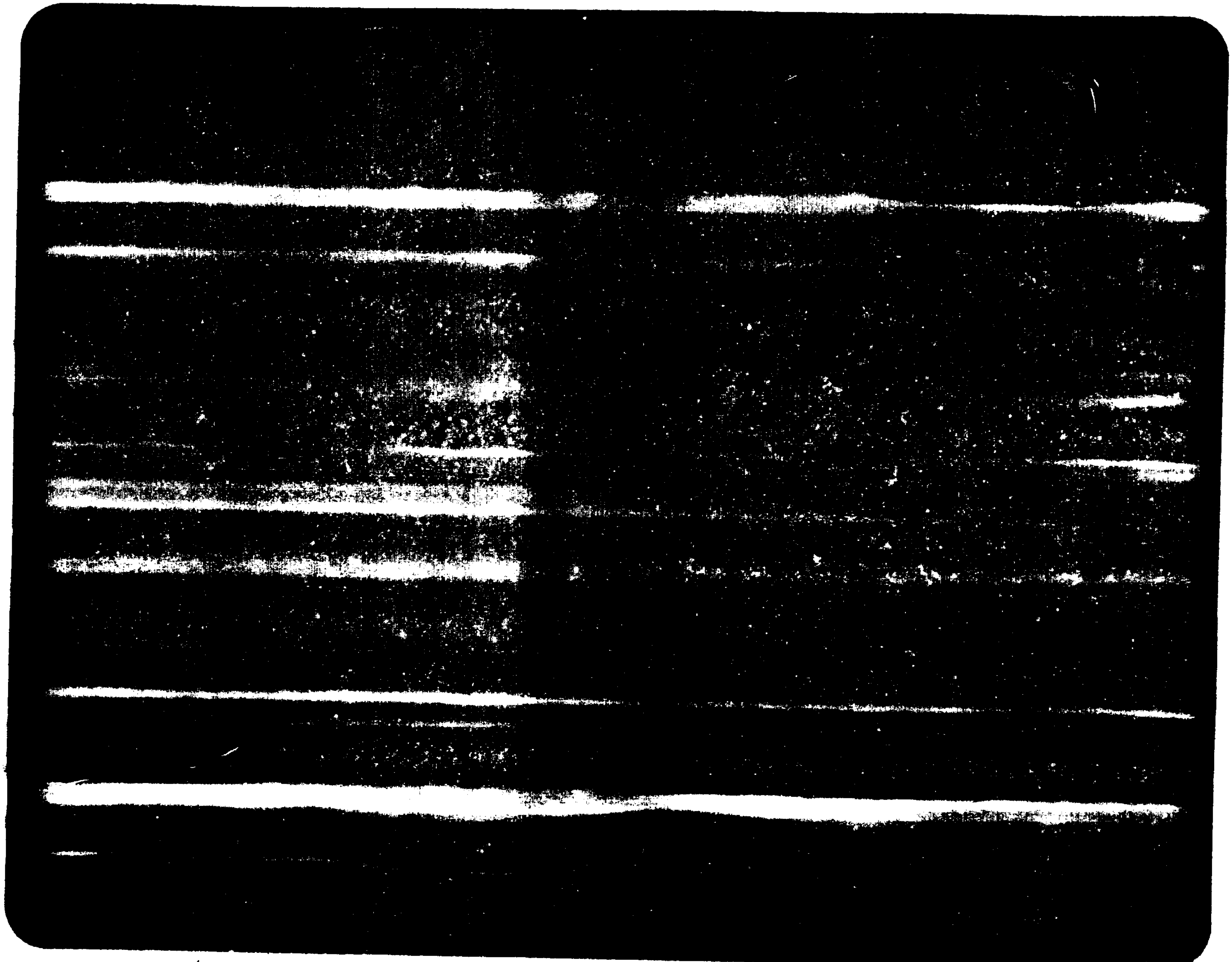
CALC	RPD		REVISED	DATE	FLOW TURBULENCE	FI-



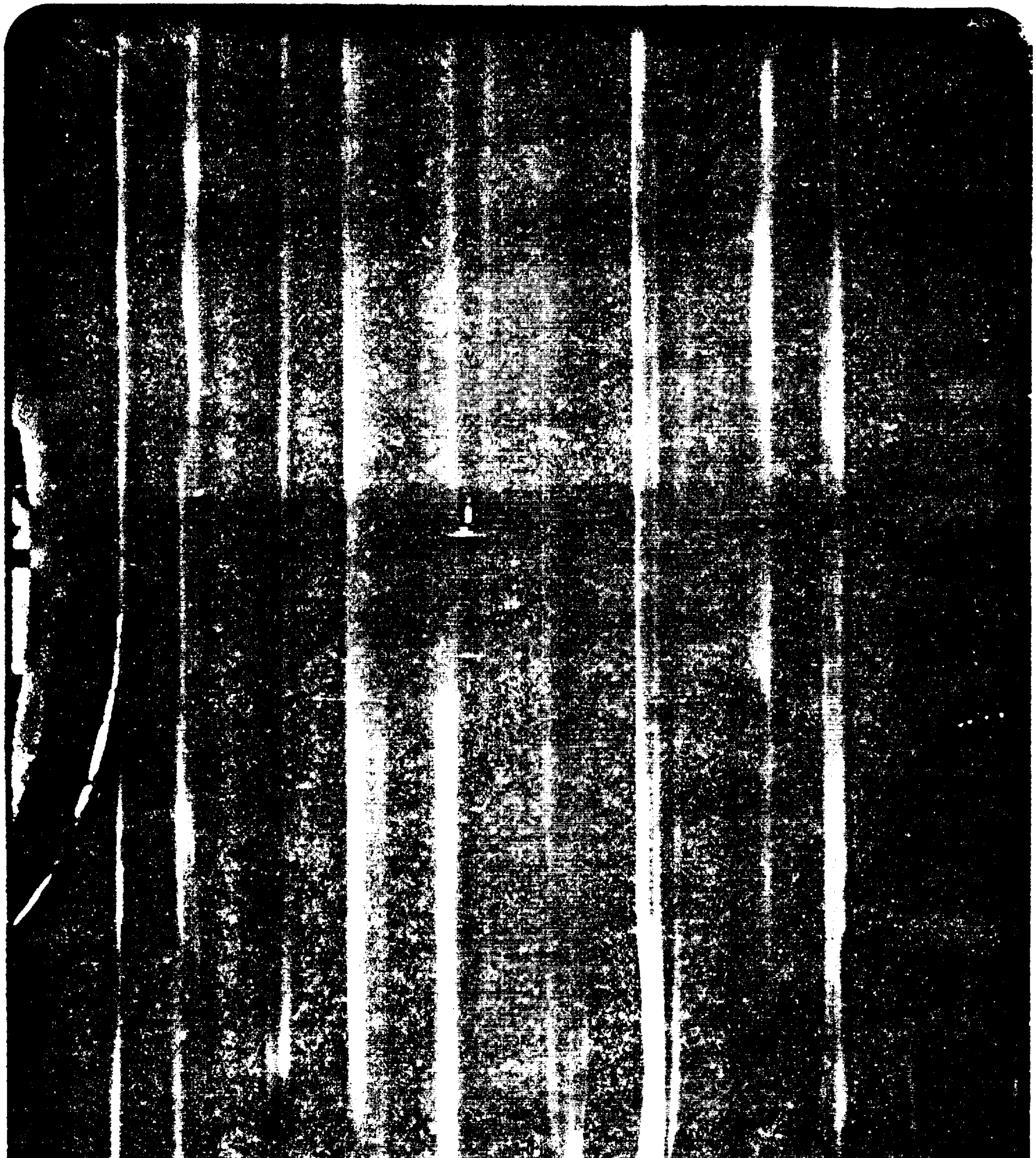
CALC	ZPD		REVISED	DATE	TEST SECTION TURBULENCE	FIG. 14
CHECK						

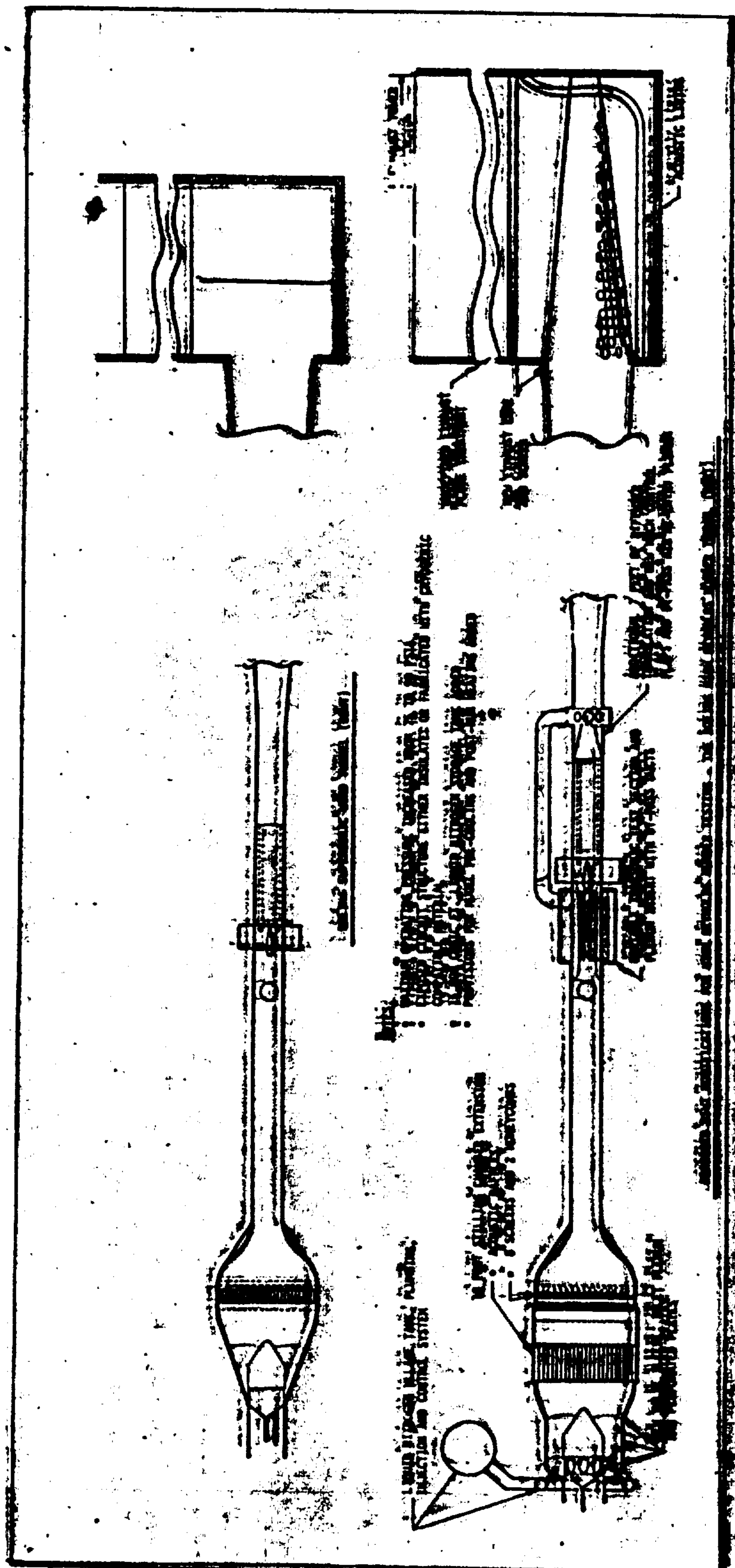


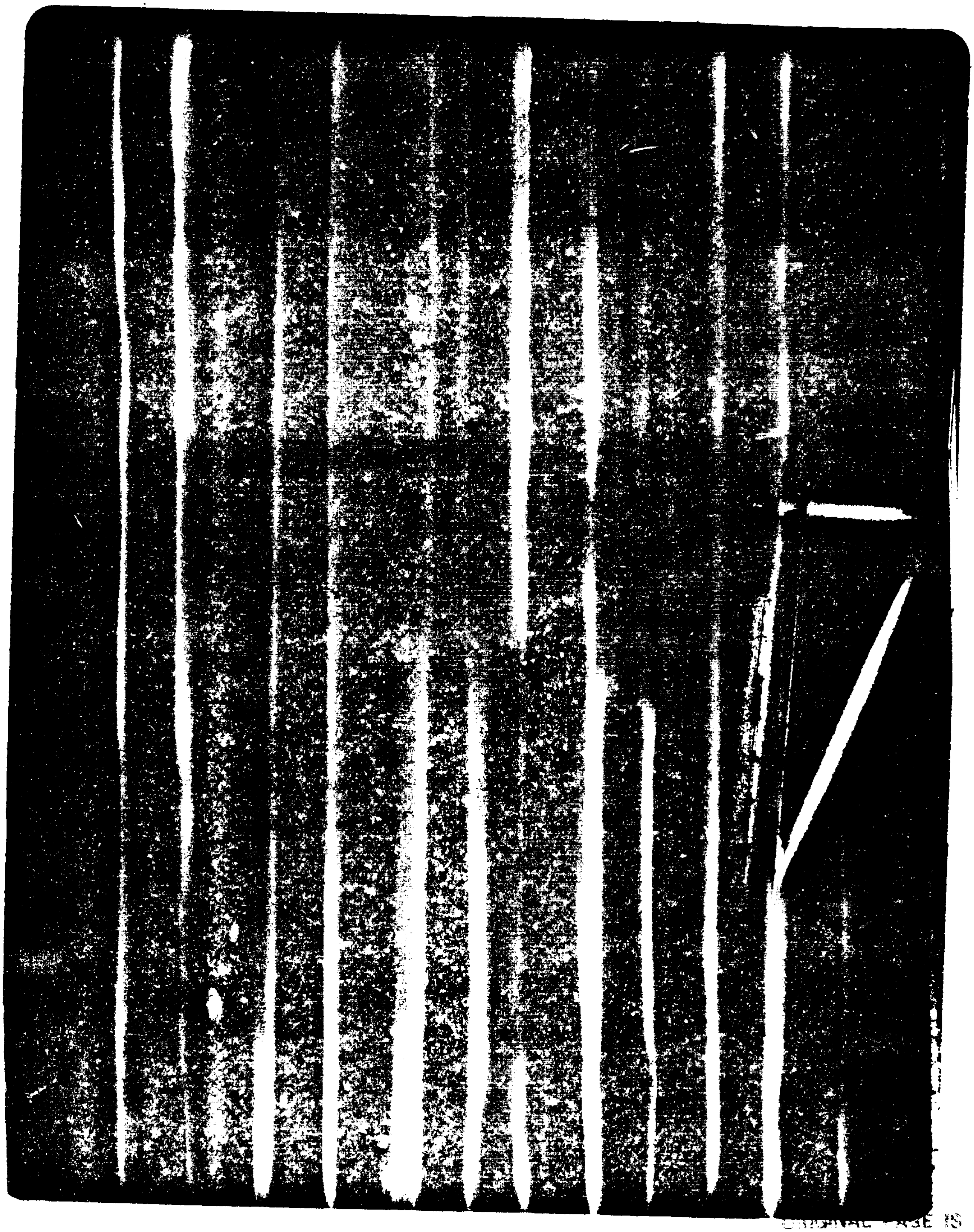
CALC	RPD	10/27/81	REVISED	DATE	TEMPERATURE DISTRIBUTION	FIG



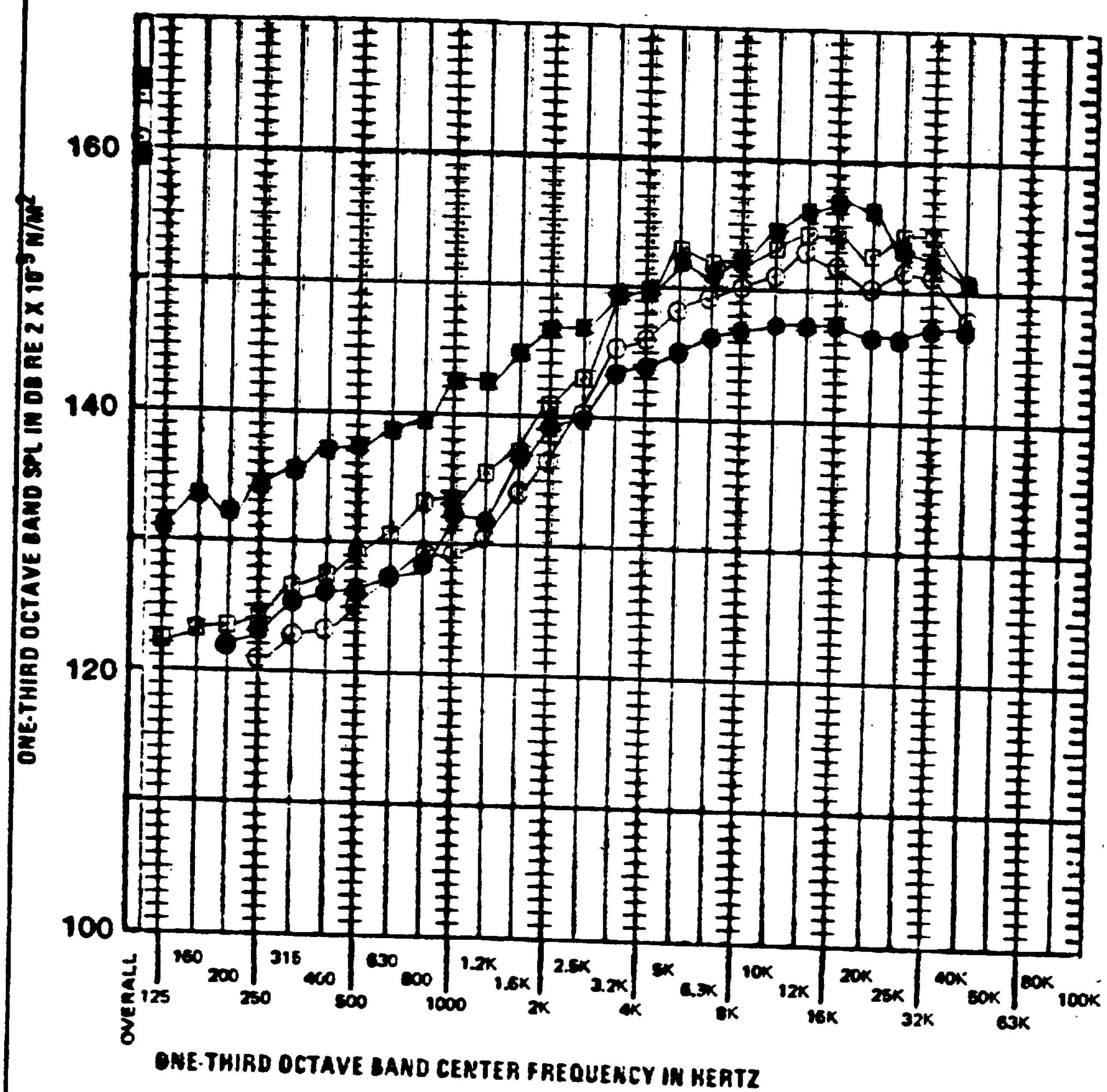
1/10 SCALE SUPERSONIC TUNNEL







TEST SECTION ACOUSTICS
COMPARISON OF BSWT AND MSWT



SYM.	FACILITY	MACH	WEIGHT FLOW(#/SEC
○	MSWT	0.95	9.17
●	BSWT	0.85	1000
□	MSWT	0.95	16.05
■	BSWT	0.85	1712

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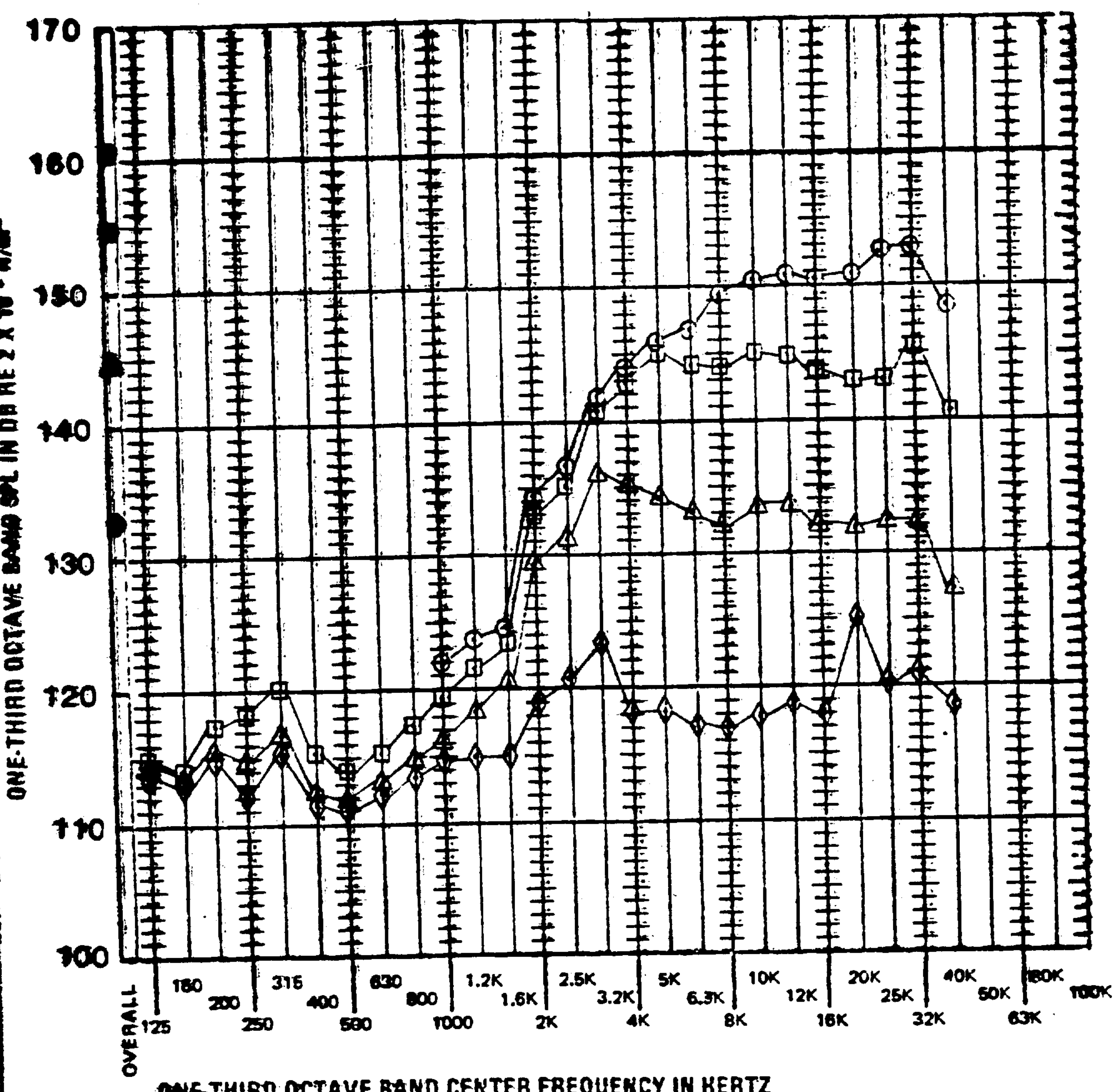
EFFECT OF VALVE PRESSURE RATIO ON TEST SECTION ACOUSTIC LEVEL



SYM	VALVE PRESSURE RATIO
●	7.0
■	2.7
▲	1.45
◆	1.10

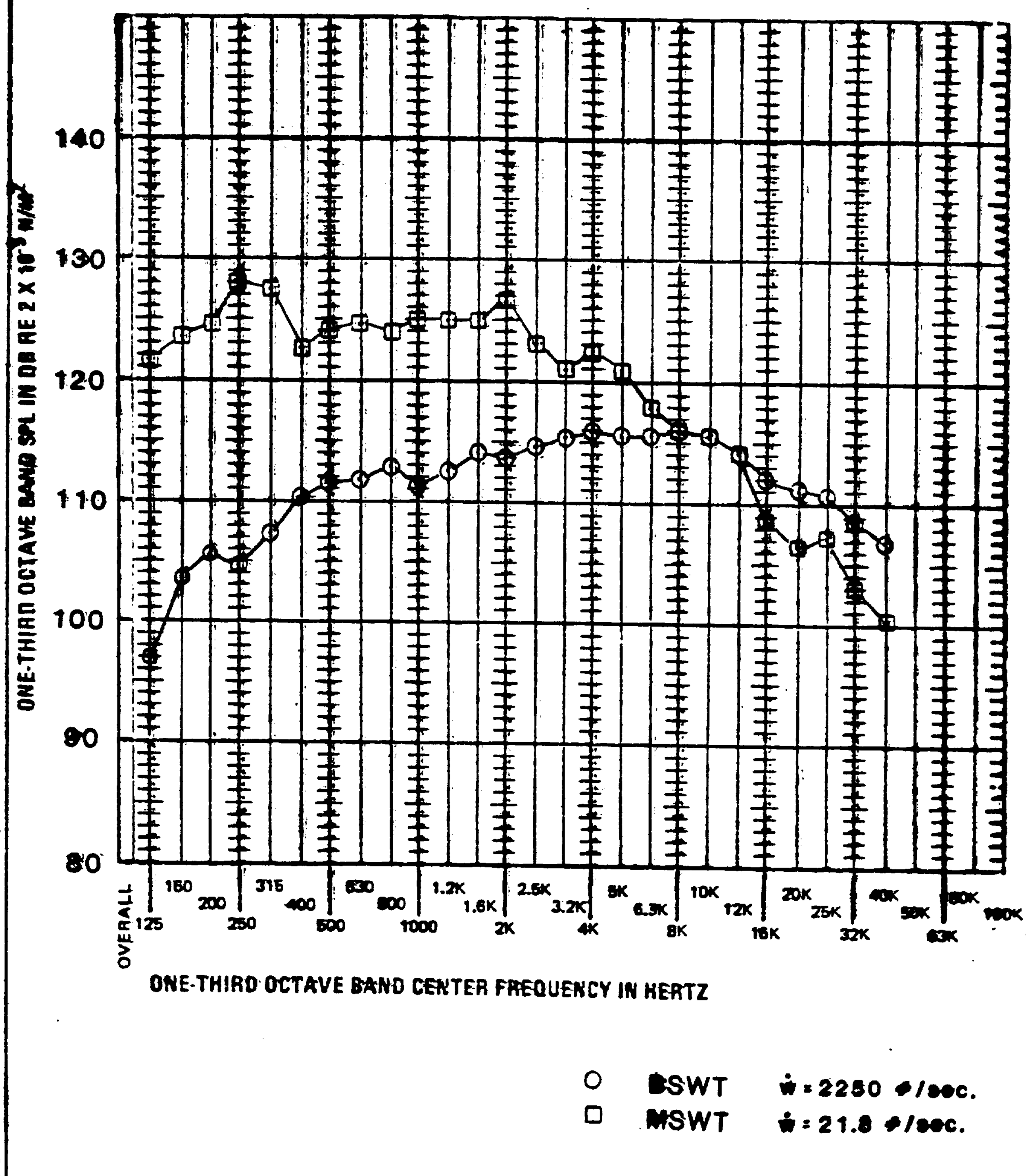
MACH=0.3

PT=20 PSIA

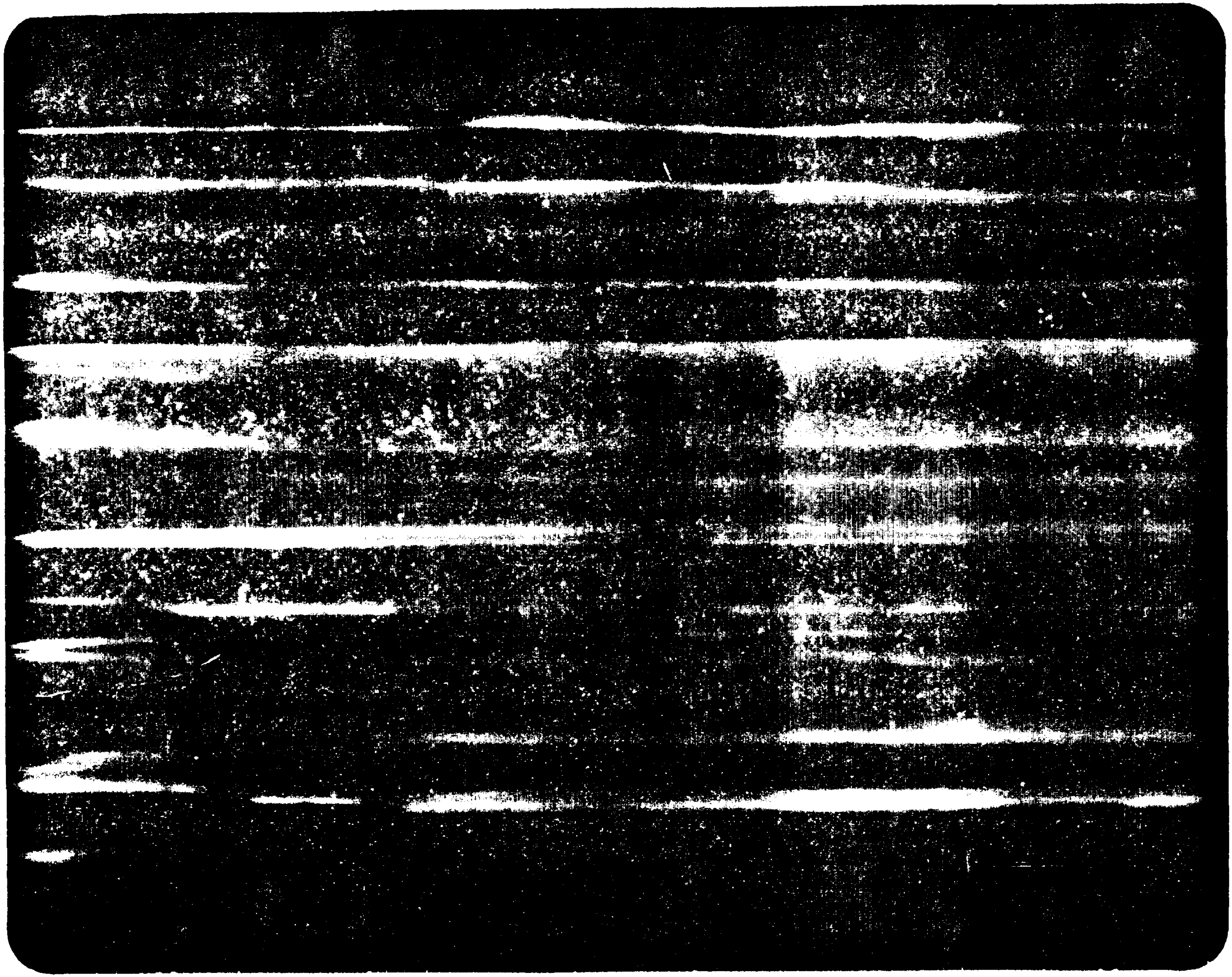
WEIGHT FLOW=4.86 #/SEC

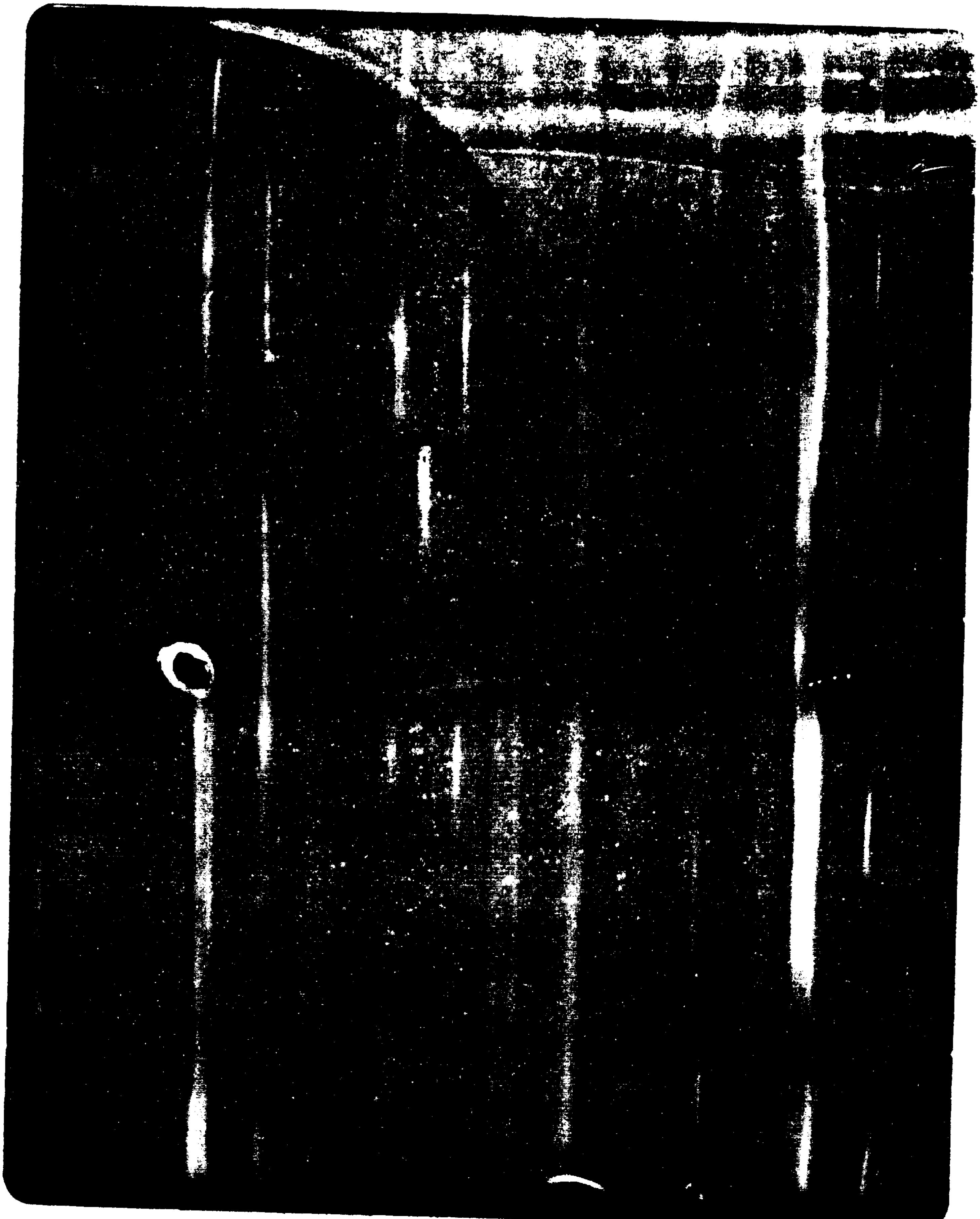
4 00 7740 ORIG.3/71

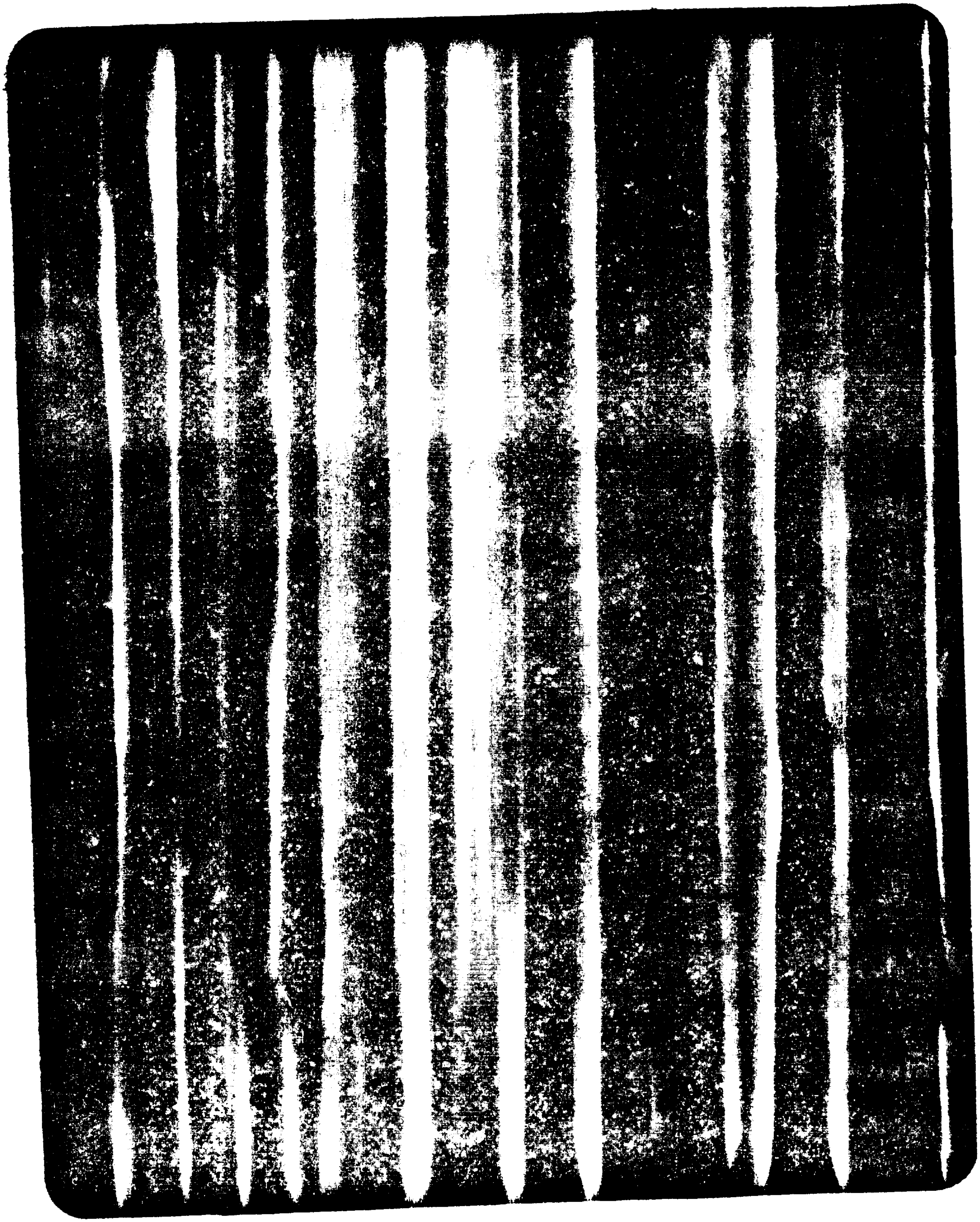
SOUND TOWER EXIT NOISE SPECTRUM
COMPARISON BSWT - MSWT



Note: BSWT data shifted in frequency by a factor of 10







40 x 80 x 120 MODELING PROGRAMS

MICHAEL D. FALARSKI

MANAGER, TEST OPERATIONS, 40 x 80 x 120 WIND TUNNEL PROJECT

NASA AMES RESEARCH CENTER

AWT WIND TUNNEL MODELING SEMINAR

WIND TUNNEL MODELING AND PERFORMANCE ASSESSMENT

OF

AMES 40x80x120-FOOT WIND TUNNEL

by

MICHAEL FALARSKI

40x80x120 WIND TUNNEL PROJECT, TEST & OPERATIONS MANAGER

40x80x120 WIND TUNNEL PROJECT

PROJECT SCOPE

- INCREASE SPEED OF 40x80 CLOSED CIRCUIT TO 300 KNOTS TO EXPAND ROTORCRAFT RESEARCH CAPABILITY
- ADD 80x120 OPEN CIRCUIT WITH 100 KNOT MAX SPEED TO EXPAND V/STOL RESEARCH CAPABILITY

PROJECT COST: $111.5M

SCHEDULE ACTIVATION DATE; DECEMBER, 1985

FALARSKI
3-20-84

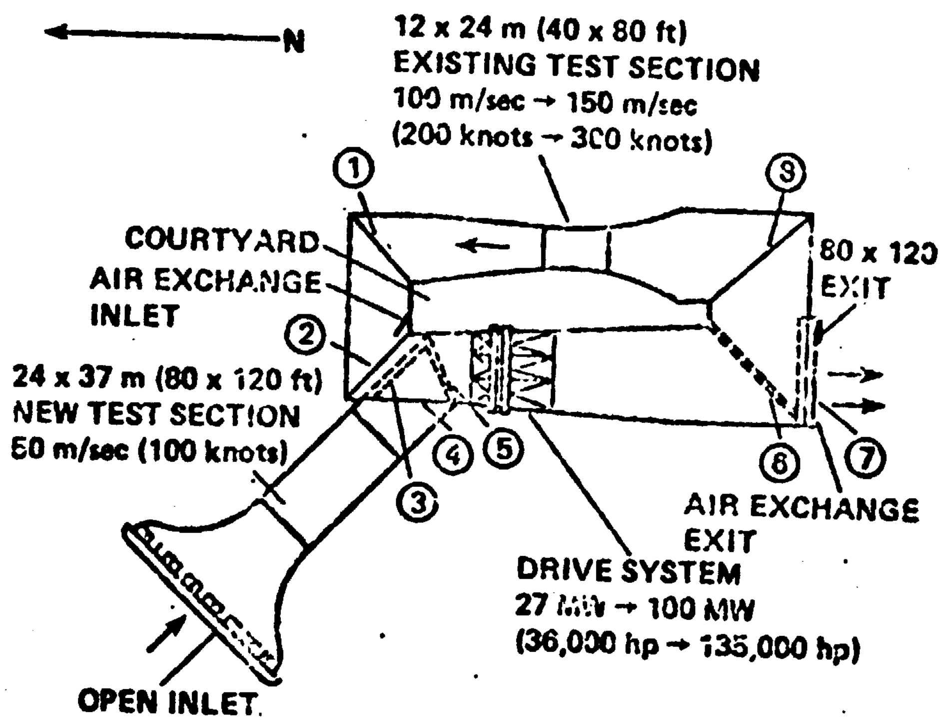
40x80x120 WIND TUNNEL PROJECT

AERODYNAMIC PERFORMANCE CRITERIA

	40x80	80x120
MAX. SPEED, KTS	300	100
CIRCUIT PRESSURE	ATMOSPHERIC	ATMOSPHERIC
TEMPERATURE, °F	40-130	AMBIENT
RESULTANT TURBULENCE, %	0.7	1.0
MAX. POWER, MEGAWATTS	100	100
MAX. FLOW ANGULARITY, DEG.	± 0.5	± 0.5

FALARSKI
3-20-84

SCHEMATIC OF 40x80/80x120-FOOT WIND TUNNEL AT NASA–Ames Research Center



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40x80x120 WIND TUNNEL PROJECT

AERODYNAMIC VERIFICATION

- VERIFY FACILITY AERODYNAMIC PERFORMANCE REQUIREMENTS
- DEVELOP AERODYNAMIC CRITERIA FOR DESIGN
    - AIR EXCHANGE
    - VANES
    - INLETS
    - FAN BLADES
- COMPUTE AERODYNAMIC DESIGN AND OPERATING LOADS
- REVIEW ENGINEERING DESIGNS
- DEVELOP INSTRUMENTATION FOR VERIFICATION OF AERODYNAMIC CHARACTERISTICS DURING INTEGRATED SYSTEMS TEST

FALARSKI
3-20-84

40x80x120 WIND TUNNEL PROJECT

AERODYNAMIC VERIFICATION ORGANIZATION

PROJECT MANAGER
L. STOLLAR

DEPUTY PROJECT MGR.
F. NICHOLS

AERODYNAMIC AND RESEARCH MANAGER
V. CORSIGLIA

- PROJECT ENGINEERS
- DATA ANALYSIS
- LOADS DEVELOPMENT
- ANALYTICAL ANALYSIS
- AERO. DESIGNS

TEST AND OPERATIONS MANAGER
M. FALARSKI

- MODEL DESIGN AND FABRICATION
- DATA ACQUISITION
- FUNDING AND SCHEDULING
- MODEL OPERATION

FALARSKI
3-20-84

40x80x120 WIND TUNNEL PROJECT

AERODYNAMIC VERIFICATION APPROACH

- REVIEW ALL EXISTING AERO. INFORMATION FROM 40x80x120 AND SIMILAR FACILITIES
- ESTABLISH FACILITY PERFORMANCE CRITERIA
- ESTABLISH INFORMATION REQUIRED FOR DESIGN AND OPERATION LOADS
- DEVELOP RESEARCH PROGRAM USING ALL TOOLS AVAILABLE
    - ANALYTICAL METHODS
    - MODEL TESTING
    - EXPERT CONSULTANTS
- ESTABLISH REVIEW MECHANISM WITH DESIGN STAFF TO PRODUCE MOST EFFECT DESIGN

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40x80x120 WIND TUNNEL PROJECT

TESTING APPROACH

- USE ANALYTICAL METHODS TO DEVELOP AERODYNAMIC CONCEPTS
- PERFORM 2-D COMPONENT TEST OF PROMISING CONCEPTS

  MEASURE BOTH ON AND OFF-DESIGN PERFORMANCE
- PERFORM 3-D COMPONENT OR MODEL WIND TUNNEL TEST OF OPTIMUM CONCEPT

  MEASURE CIRCUIT PERFORMANCE AND INSTALLATION EFFECTS

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40x80x120 WIND TUNNEL PROJECT

TEST MODELS

- 2-D COMPONENT TESTS

  1/10 SCALE COMPONENT TESTER*
  7x10 INLET BAFFLE TEST*
  OHIO STATE FAN BLADE SECTION TEST
  CAL POLY INLET BAFFLE TEST
  ACOUSTIC LINING FAIRING

- 3-D COMPONENT TESTS

  1/15 SCALE INLET MODEL*
  1/10 SCALE HIGH SPEED DIFFUSER MODEL*
  1/7 SCALE FAN STALL MODEL*

- MODEL WIND TUNNEL TESTS

  80x120 MODEL/COMMUNITY NOISE
  LANGLEY VSTOL WIND TUNNEL
  ARMY 7- by 10-FOOT WIND TUNNEL
  1/50 SCALE 40x80x120 WIND TUNNEL MODEL*

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40x80x120 WIND TUNNEL PROJECT

1/10 SCALE COMPONENT TESTER

- PURPOSE

  MEASURE 2-D AERO. PERFORMANCE OF VANE CONCEPTS

- MODEL DESCRIPTION

  CHANNEL SIZE = 3' x 3'

  POWER SYSTEM = 4' DUCTED PROP/800 HP ELECTRIC MOTOR

  FLOW ANGLES = 5 to 95°

  FLOW VELOCITY = 80 KNOTS

  REYNOLDS NUMBER = 500,000

- MEASUREMENT

  INFLOW/OUTFLOW ANGLES SURVEY

  TOTAL PRESSURE SURVEY

  WALL/VANE SURFACE PRESSURE (STATIC & DYNAMIC)

  TURBULENCE

  FLOW VISUALIZATION

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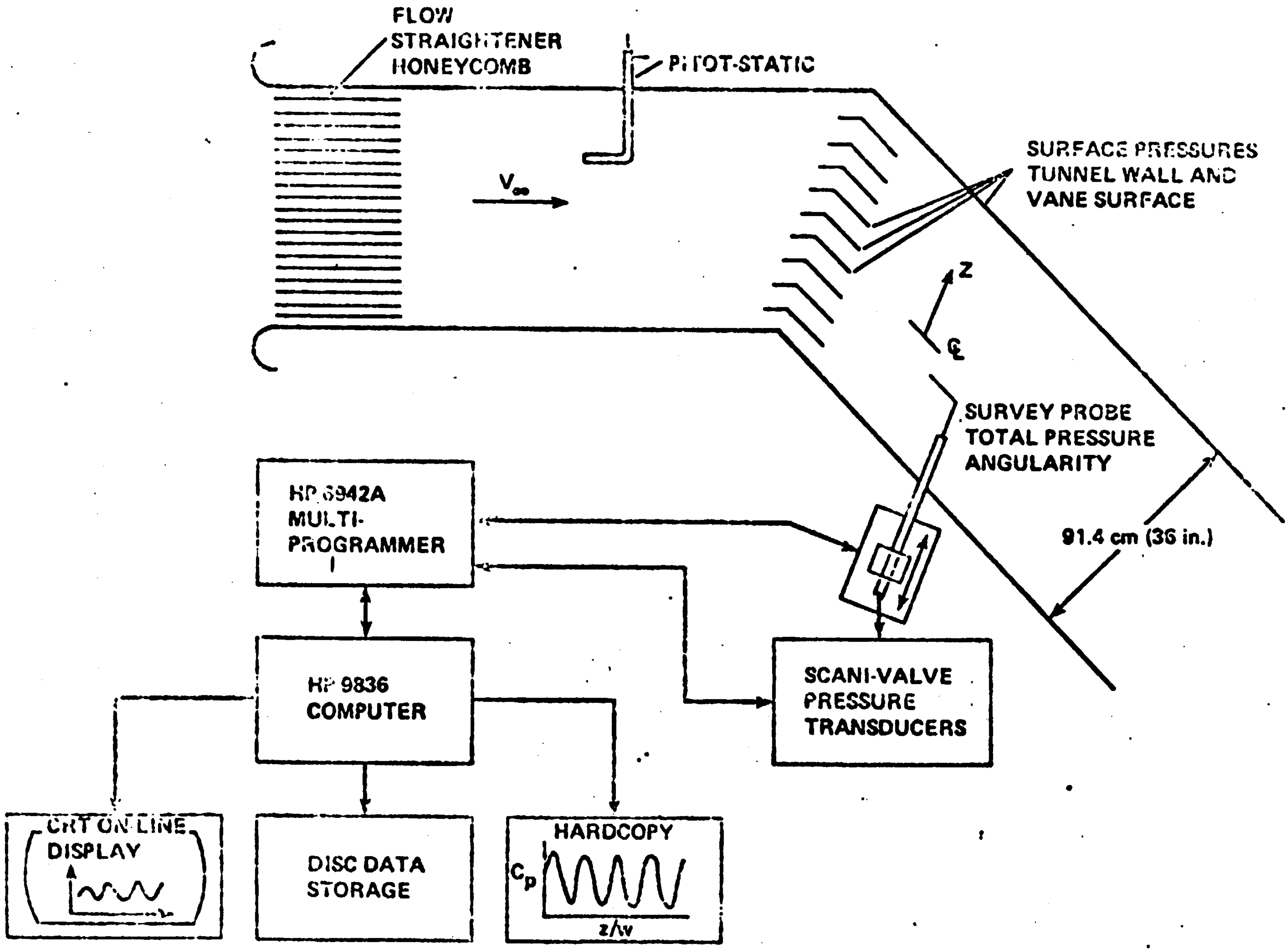
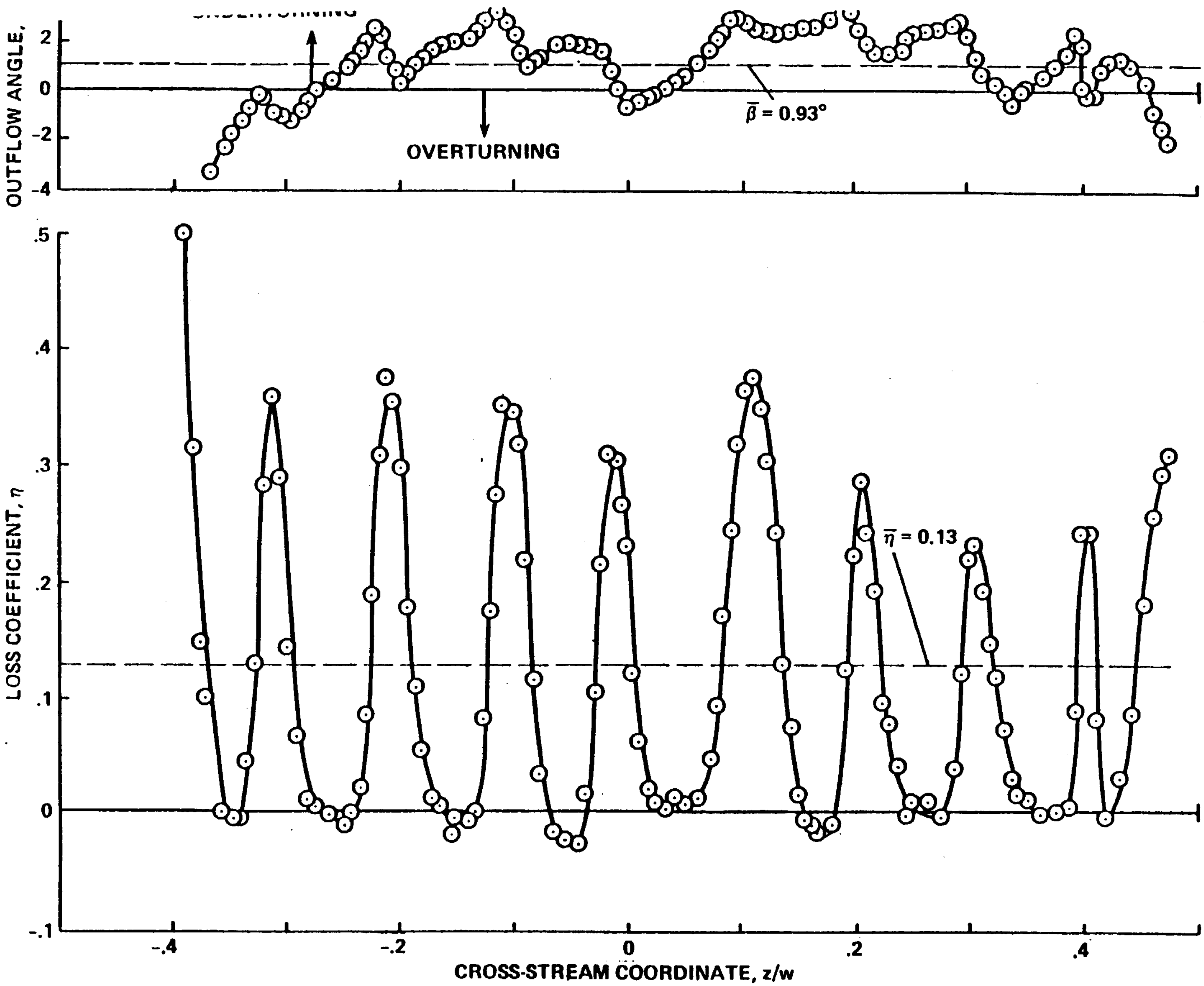
3-20-84

SCHEMATIC OF 1/10 SCALE CHANNEL FACILITY AND INSTRUMENTATION




UNDERTURNING
OVERTURNING
$\bar{\beta}$ = 0.93°
OUTFLOW ANGLE,
2
0
-2
-4
$\bar{\eta}$ = 0.13
LOSS COEFFICIENT, η
.5
.4
.3
.2
.1
0
-.1
-.4
-.2
0
.2
.4
CROSS-STREAM COORDINATE, z/w

9% → 8%   #5

40x80x120 WIND TUNNEL PROJECT

2-D INLET BAFFLE TEST

- PURPOSE

  MINIMIZE FLOW SEPARATION AND WAKE TURBULENCE OF 80x120 INLET ACOUSTIC BAFFLES

- TEST DESCRIPTION

  2-D BAFFLE SEGMENT (1/2 SCALE)

  7x10-FOOT WIND TUNNEL TEST SECTION

  VELOCITY = 200 KNOTS

  REYNOLDS NO. = 600,000 (FULL SCALE)

- MEASUREMENTS

  MAKE SURVEYS OF PRESSURE AND TURBULENCE
  FLOW VISUALIZATION

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3-20-84

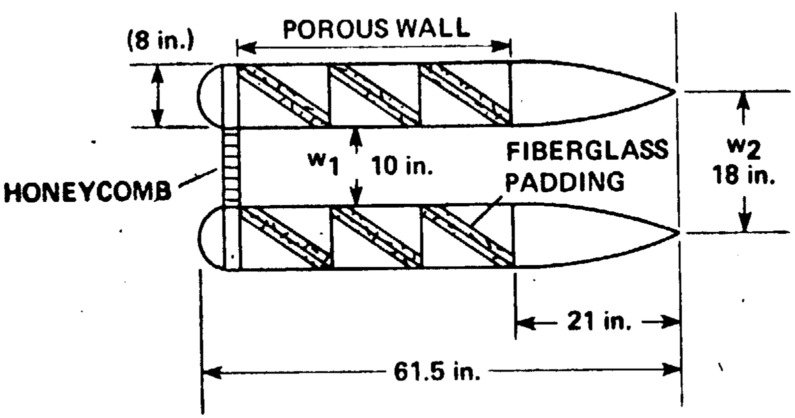
Space
Administration

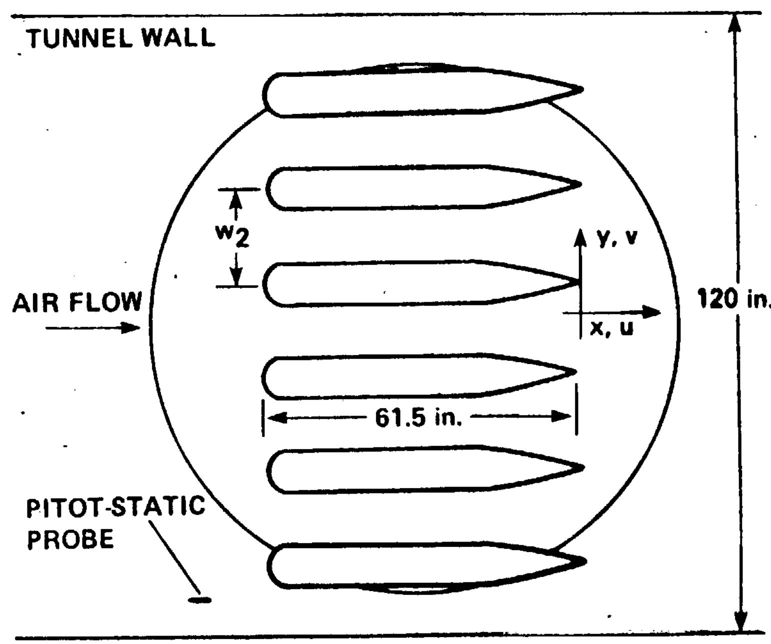
NASA

Ames Research Center
Moffett Field, California 94035

NAME MIKE DUDLEY NO.

BASELINE MODEL





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National
Aeronautics and
Space
Administration

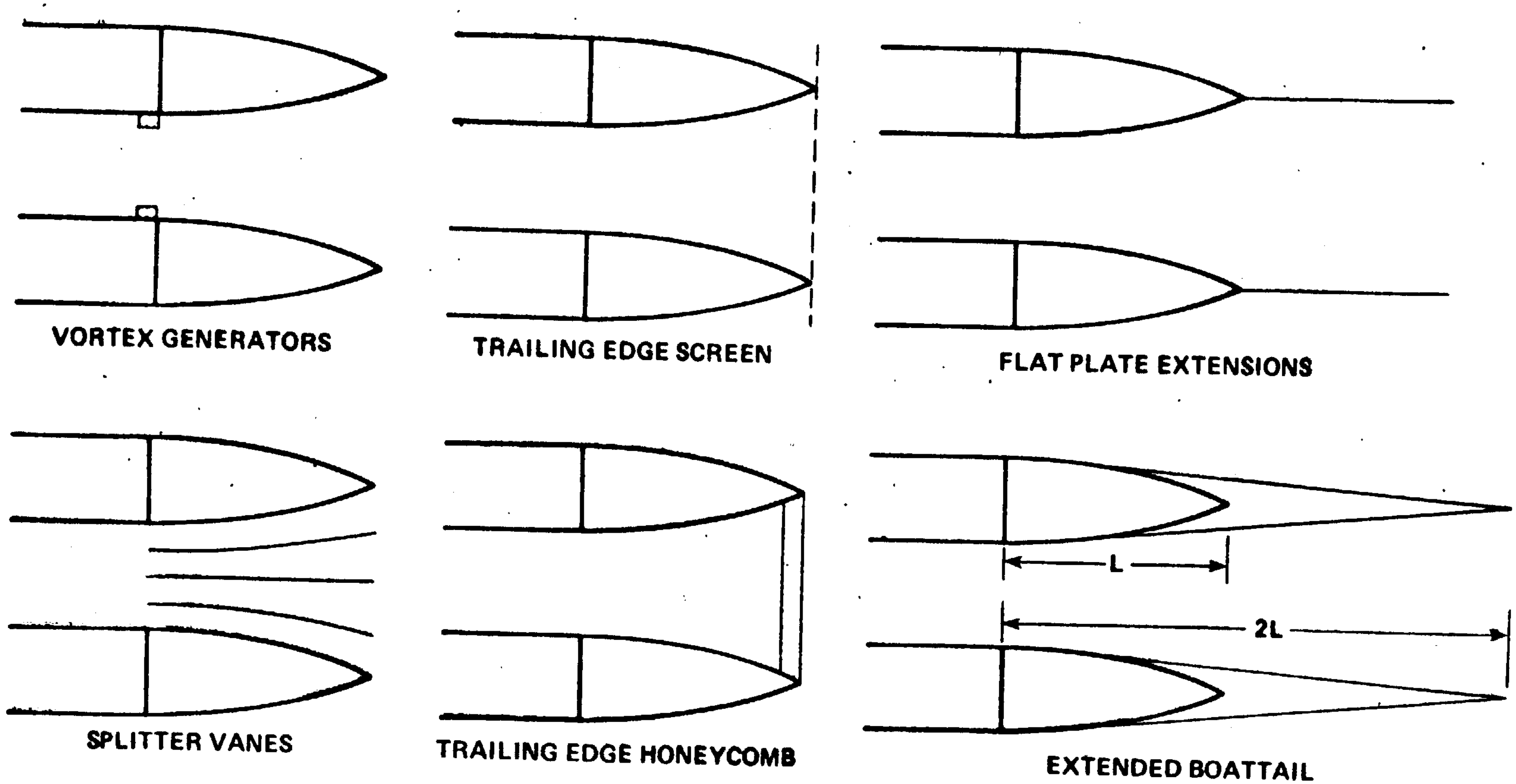
TOP HORIZONTAL

Ames Research Center
Moffett Field, California 94035

NASA

NAME MIKE DUDLEY NO.

VANE MODIFICATIONS INVESTIGATED



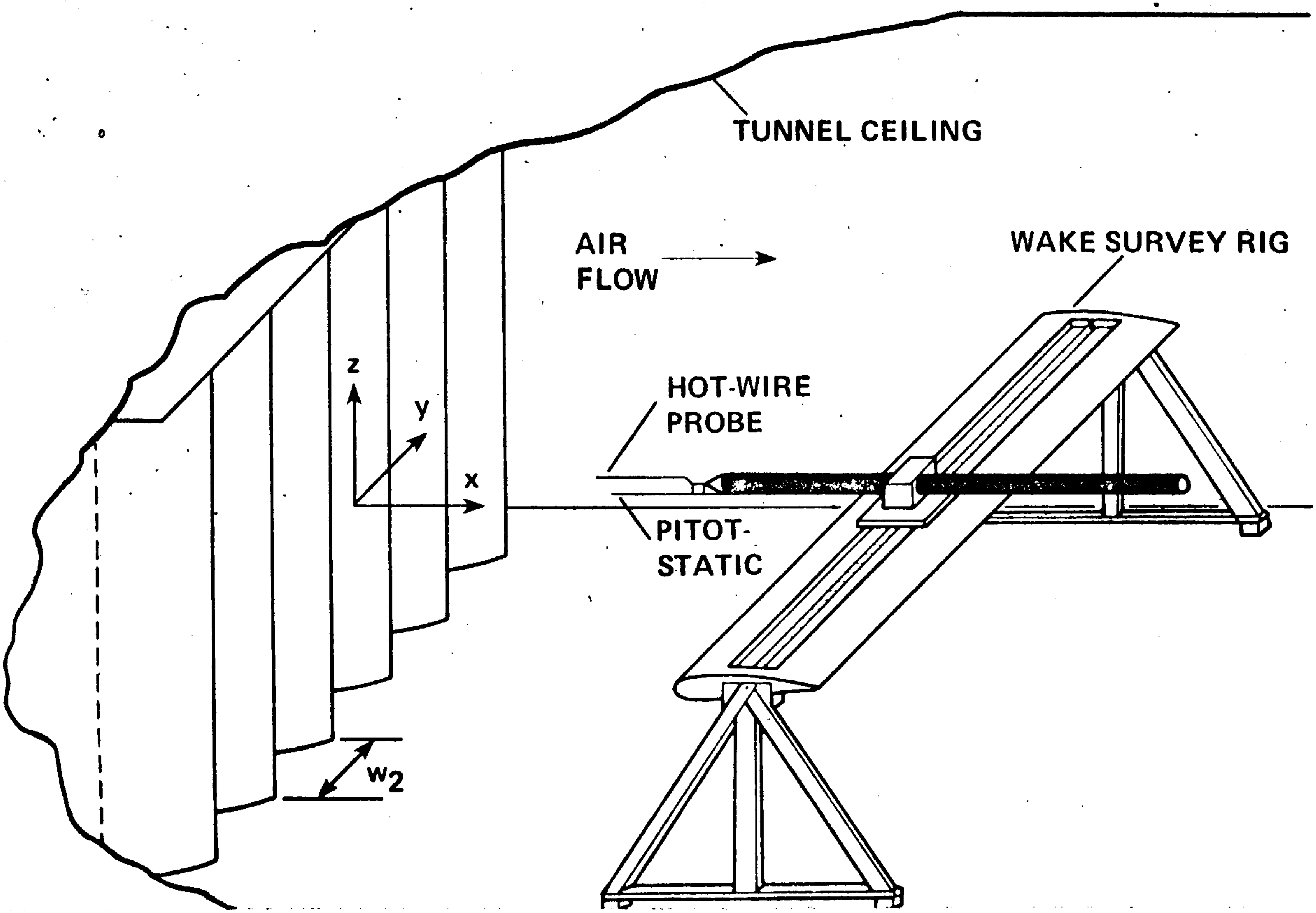
Space
Administration

NASA

Ames Research Center
Moffett Field, California 94035

NAME MIKE DUDLEY NO.______

WAKE SURVEY TECHNIQUE



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40x80x120 WIND TUNNEL PROJECT

1/15 SCALE INLET MODEL

- PURPOSE

  DEVELOP 80x120 INLET MODIFICATIONS TO IMPROVE TEST SECTION FLOW QUALITY

- MODEL DESCRIPTION

  1/15 SCALE INLET, CONTRACTION AND TEST SECTION

  6' DIA. SINGLE STAGE FAN DRIVE POWERED BY 1500 HP MOTOR

  AS-BUILT AND MODIFIED CONFIGURATIONS

  TEST SECTION VELOCITY = 100 KNOTS

- MEASUREMENTS

  FLOW VISUALIZATION (SMOKE, TUFTS)

  TEST SECTION SURVEY (P_t, TURBULENCE, ANGULARITY)

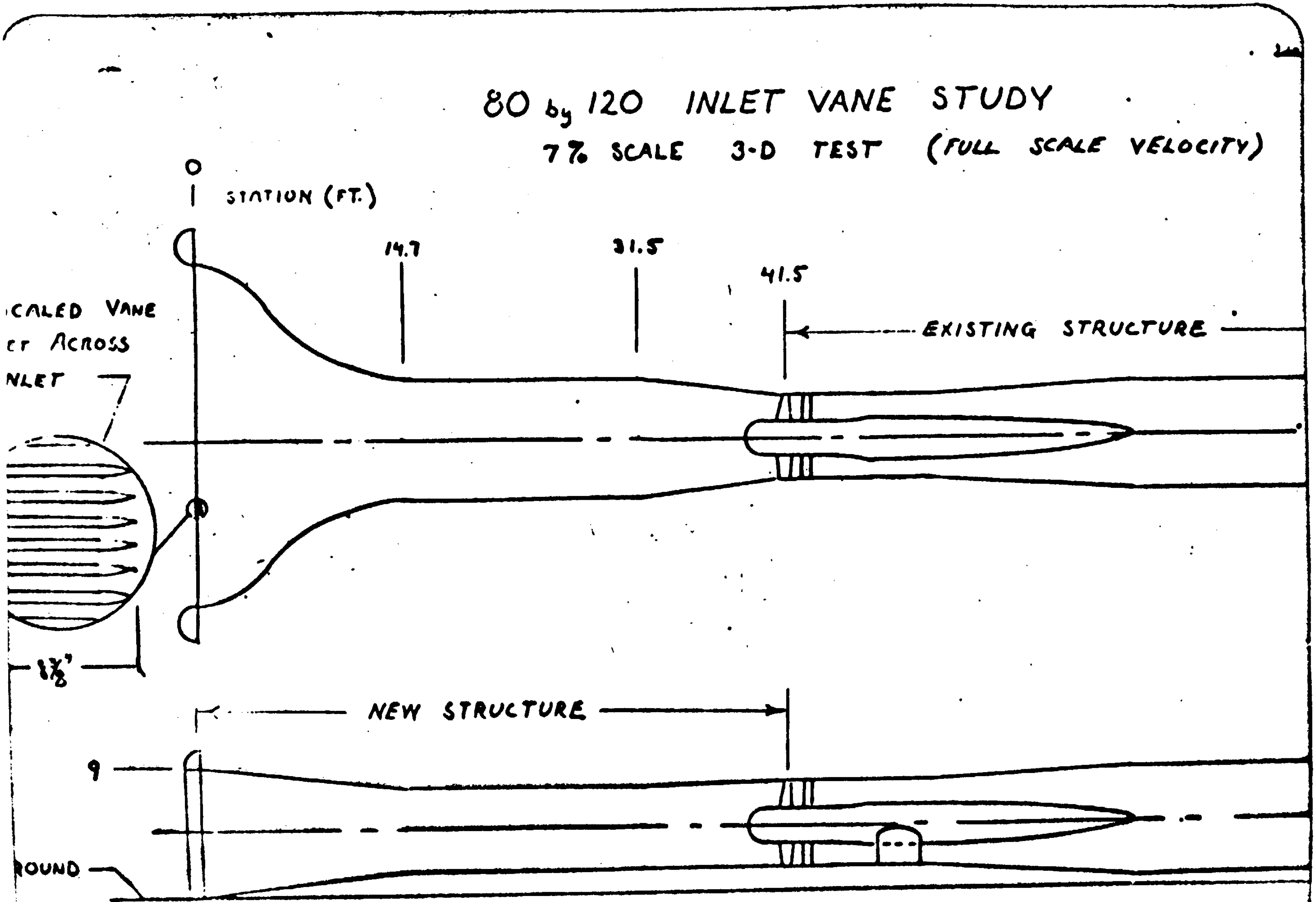
  FLOW SURVEYS UPSTREAM WITH LASER

FLARASKI
3-20-84

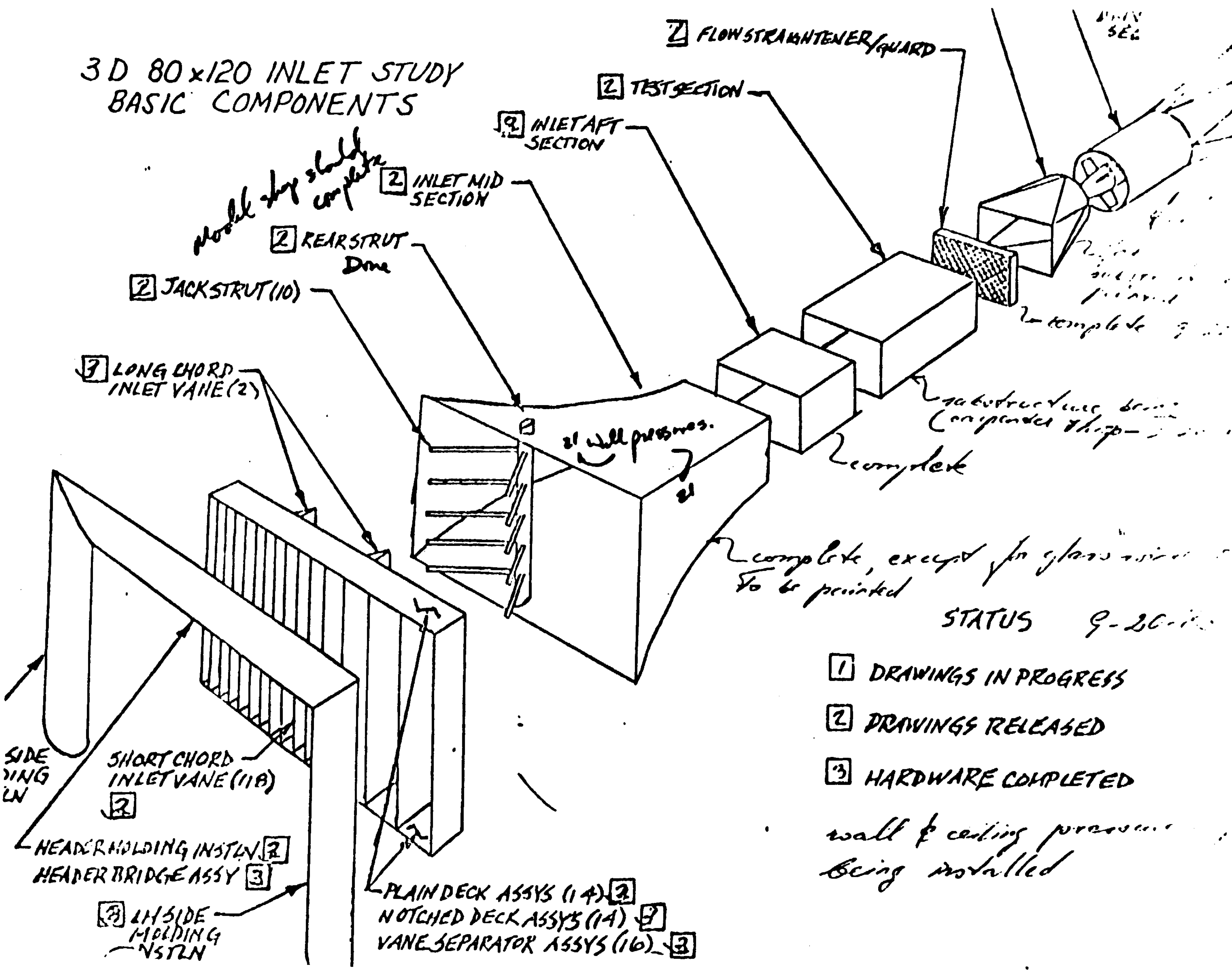
National Aeronautics and Space Administration
NASA
Ames Research Center
Moffett Field, California 94035

TOP HORIZONTAL

NAME ______________________ NO. ________



TOP VERTICAL


3 D 80 x 120 INLET STUDY
BASIC COMPONENTS
2 FLOW STRAIGHTENER/GUARD
2 TEST SECTION
2 INLET AFT SECTION
2 INLET MID SECTION
2 REAR STRUT
Done
2 JACK STRUT (10)
3 LONG CHORD INLET VANE (2)
21 wall pressures.
21
complete
complete, except for glass
to be painted
STATUS 9-20
1 DRAWINGS IN PROGRESS
2 DRAWINGS RELEASED
3 HARDWARE COMPLETED
wall & ceiling pressure
being installed
SHORT CHORD INLET VANE (118)
2
HEADER HOLDING INSTLN 2
HEADER BRIDGE ASSY 3
3 INSIDE HOLDING INSTLN
PLAIN DECK ASSYS (14) 3
NOTCHED DECK ASSYS (14) 3
VANE SEPARATOR ASSYS (16) 3

40x80x120 WIND TUNNEL PROJECT

1/10 SCALE DIFFUSER MODEL

- PURPOSE

  DEVELOP VORTEX GENERATOR CONFIGURATION TO IMPROVE FLOW IN

  40x80 HIGH SPEED DIFFUSER

- MODEL DESCRIPTION

  1/15 SCALE INLET

  6' DIA. FAN DRIVE SYSTEM

  1/10 SCALE 40x80 TEST SECTION AND DIFFUSER

  SCREEN SIMULATION OF CORNER

- MEASUREMENTS

  FLOW VISUALIZATION

  FLOW SURVEYS (P_t, LASER)

  WALL STATIC PRESSURE

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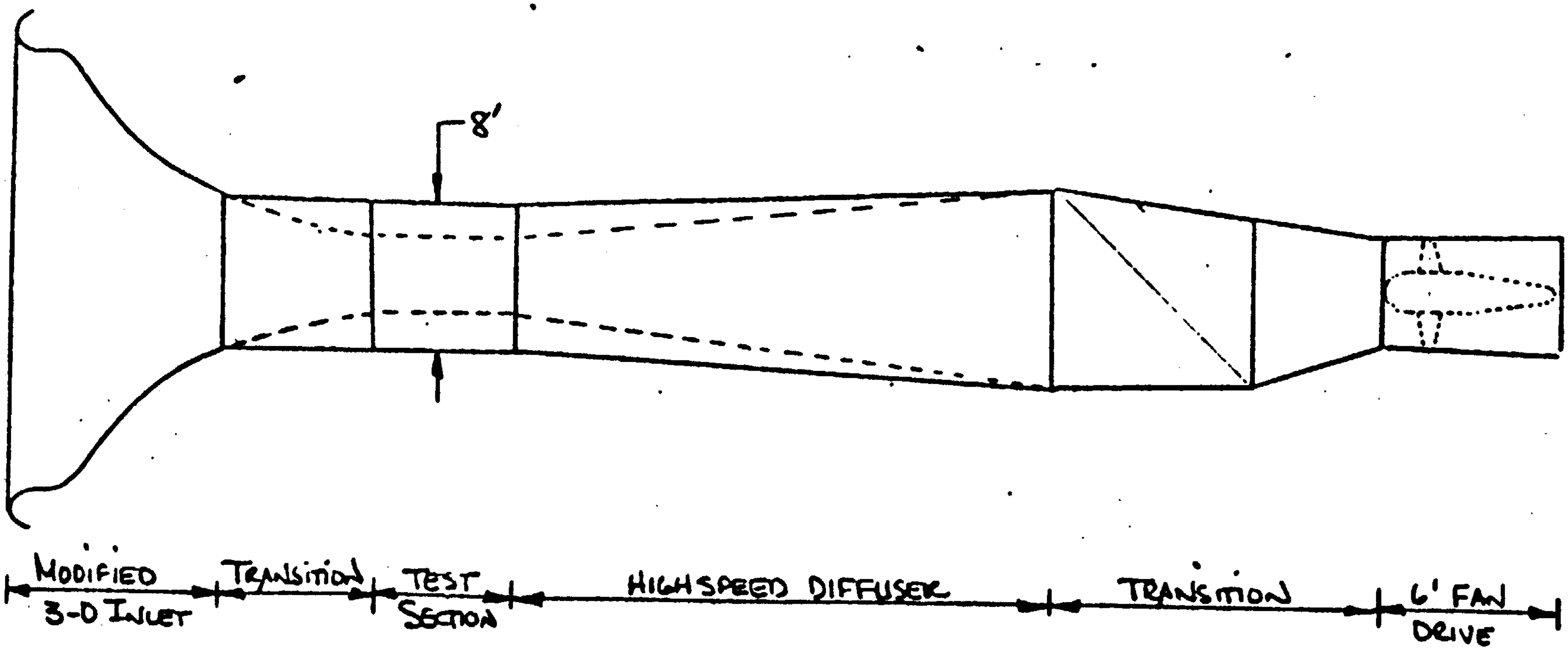
3-20-84

1/10 Scale 40x80 Diffuser Model

Overall model length = 105'



MDF 11/30/83

269

40x80x120 WIND TUNNEL PROJECT

1/7 SCALE FAN DRIVE MODEL

- PURPOSE
  - MEASURE FAN DRIVE PERFORMANCE WITH MODIFIED BLADE CONTOUR
  - INCLUDING STALL MARGIN

- MODEL DESCRIPTION
  - 1/15 SCALE INLET AND TEST SECTION
  - 6' DIA. FAN DRIVE
  - VARIABLE AREA EXHAUST

- MEASUREMENTS
  - INFLOW DISTORTION
  - STATOR AND EXIT SURVEYS
  - WALL PRESSURES

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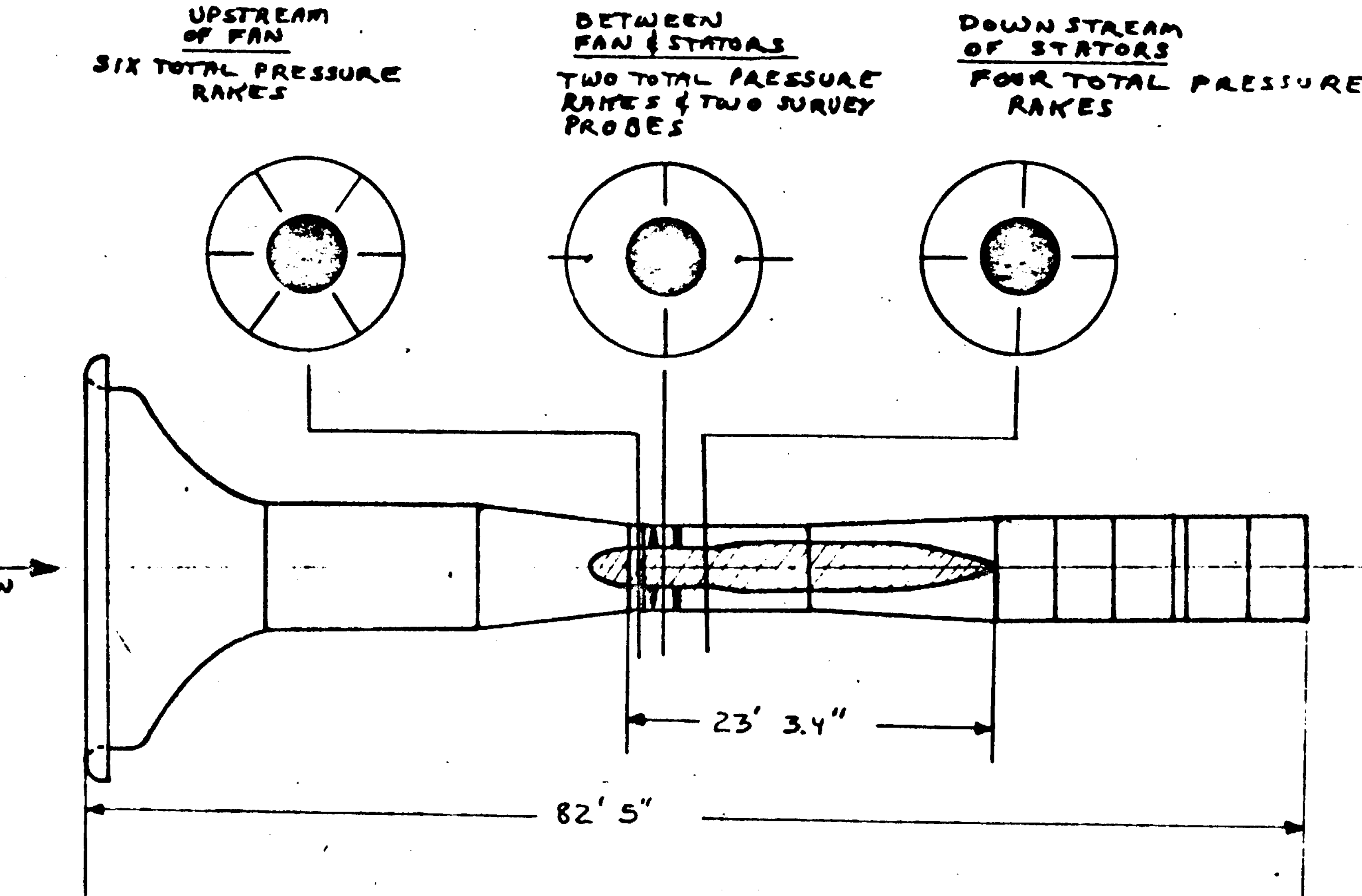


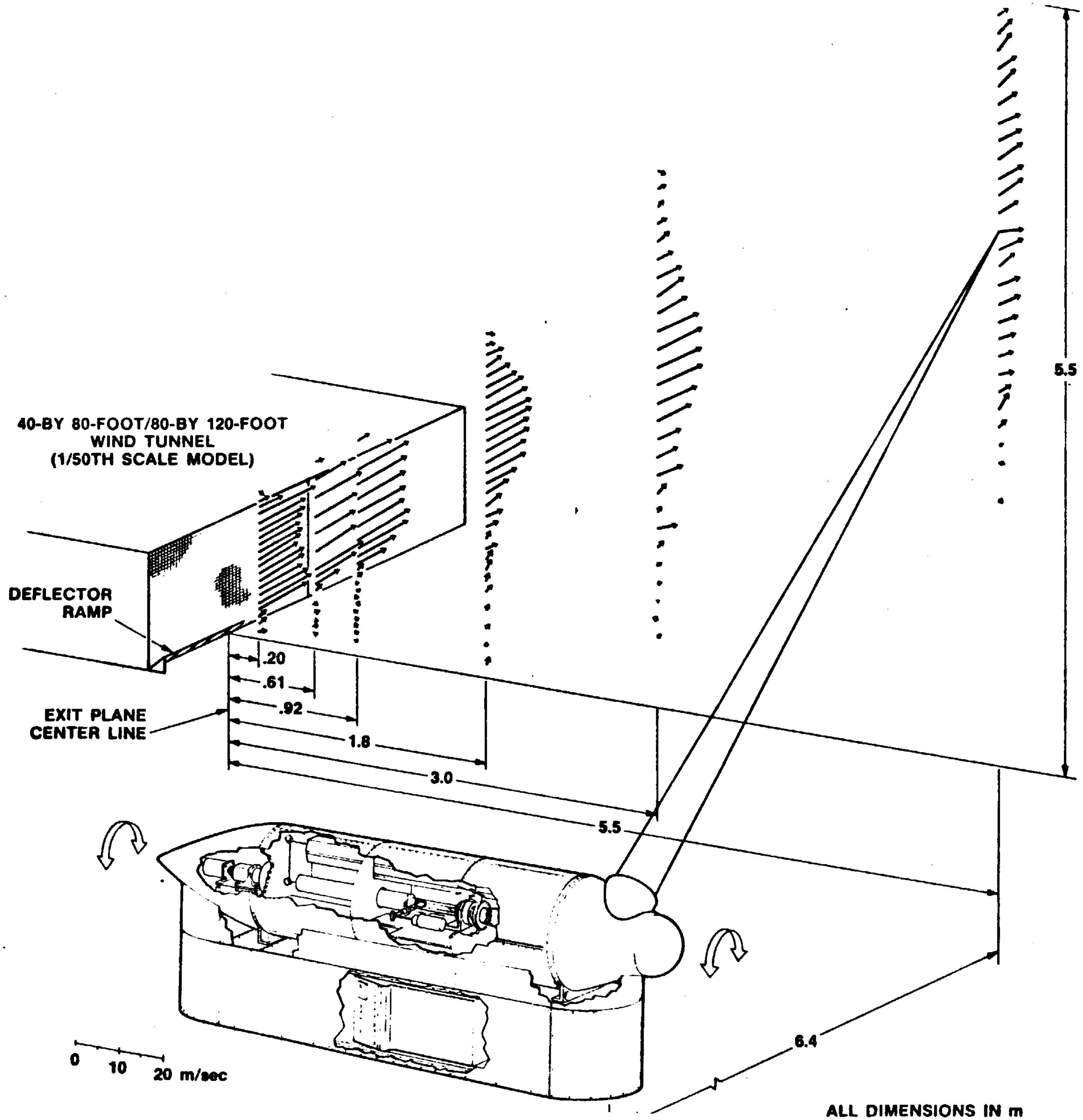
15% SCALE FAN STALL TEST
3/32" = 1'

40x80x120 WIND TUNNEL PROJECT

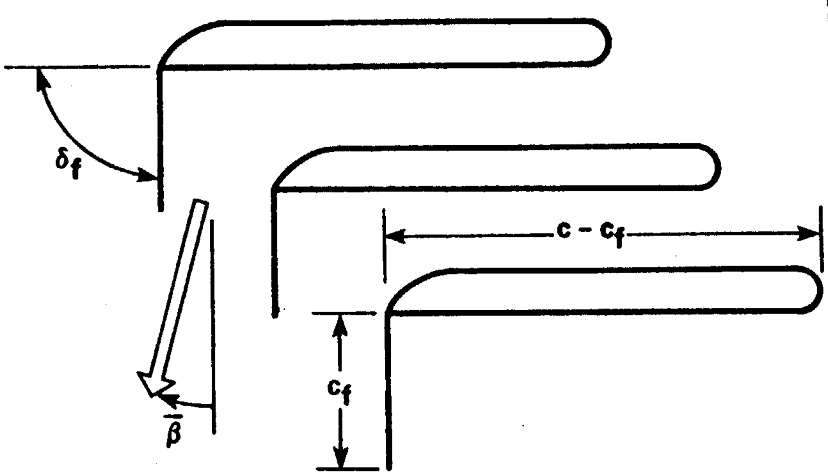
1/50 SCALE WIND TUNNEL MODEL

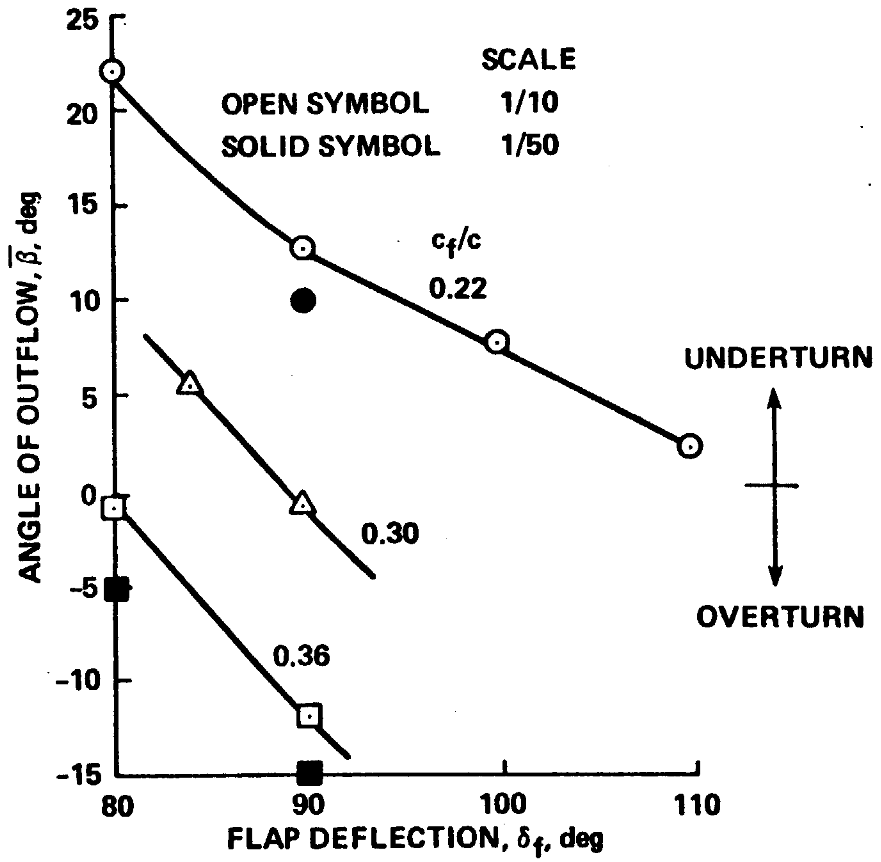
- PURPOSE
  - MEASURE CIRCUIT PERFORMANCE
  - MEASURE COMPONENT INSTALLATION EFFECTS
  - DEVELOP AIR EXCHANGE SYSTEM
- MODEL DESCRIPTION
  - COMPLETE 1/50 SCALE MODEL OF BOTH CIRCUITS
  - POWERED BY 6 FIX-PITCH VARIABLE SPEED FANS
  - 50% FULL SCALE VELOCITY
- MEASUREMENTS
  - VERTICAL & HORIZONTAL SURVEYS
  - WALL STATIC PRESSURES
  - FLOW VISUALIZATION
  - EXHAUST PLUME LASER SURVEY

FALARSKI
3-20-84

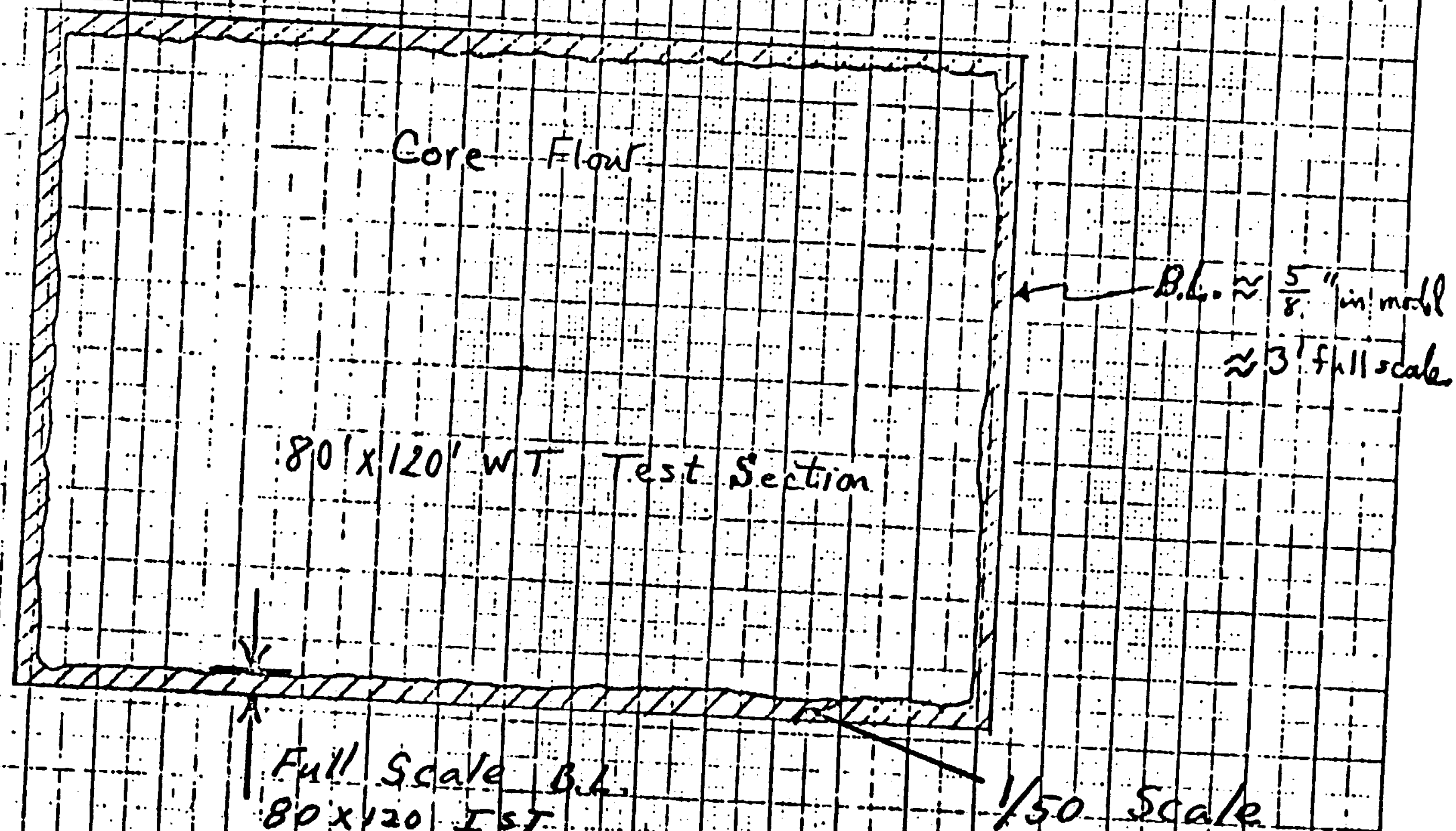

40-BY 80-FOOT/80-BY 120-FOOT
WIND TUNNEL
(1/50TH SCALE MODEL)
DEFLECTOR
RAMP
EXIT PLANE
CENTER LINE
.20
.61
.92
1.8
3.0
5.5
5.5
6.4
0
10
20 m/sec
ALL DIMENSIONS IN m

ANGLE OF OUTFLOW vs. FLAP DEFLECTION AND CHORD





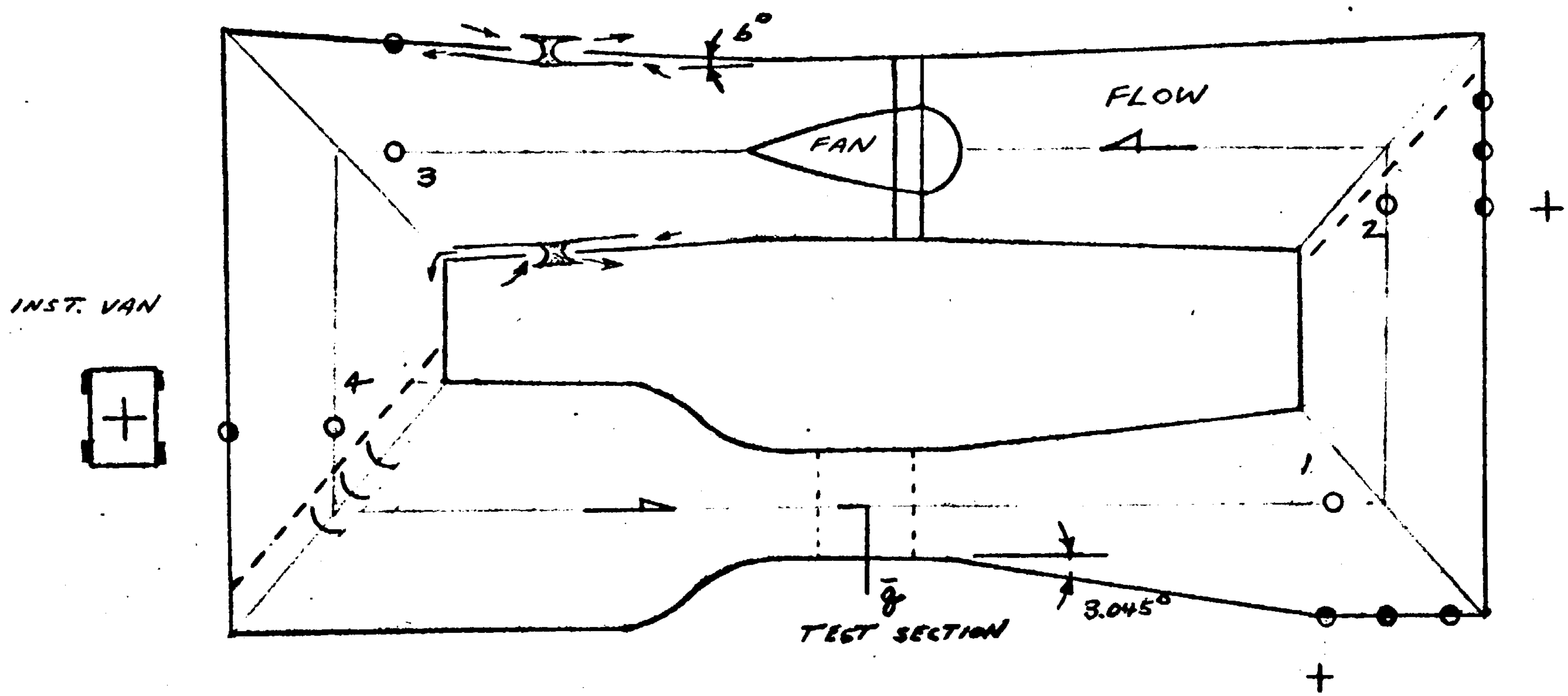
Results of Total Head (H) Surveys in 80'x120' WT Test Section.



Data taken 3/22/83 (40)

N

7x10 #2



c = 14:1

○ { $u'/U \rightarrow E(\omega)$; $\tilde{p}$ ℄ ; $\bar{q}$ ℄ }

● $\tilde{p}_1 \rightarrow G(\omega)$ WALL

$\tilde{p}_2$ "

$\tilde{q}_4$ "

40x80x120 WIND TUNNEL PROJECT

AERODYNAMIC VERIFICATION COST

DATA ACQUISITION EQUIPMENT *	$ 40,000
MODEL FABRICATION	$ 600,000
COMPUTER OPERATION	$ 80,000
CONTRACT SUPPORT +	$ 300,000
MISCELLANEOUS	$ 20,000
TOTAL	$1,040,000

* MOST EQUIPMENT EXISTING COST FOR SPECIAL ITEMS

\+ EXPERT CONSULTANTS, SUPPORT TESTING AT OTHER FACILITIES

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3-20-84

40x80x120 WIND TUNNEL PROJECT

AERODYNAMIC VERIFICATION RESOURSES

FUNDING		$1,000,000
MANPOWER (IN-HOUSE)		
	ENGINEERING	20 MAN YEARS
	SUPPORT	10 MAN YEARS
CALENDAR TIME		1-1/2 YEARS

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3-20-84

40 x 80 x 120 VANE REDESIGN

ERIC R. McFARLAND

COMPUTATIONAL FLUID MECHANICS BRANCH

NASA LEWIS RESEARCH CENTER

AMES 40 x 80/80 x 120 FOOT WIND TUNNEL

TURNING VANES DESIGN

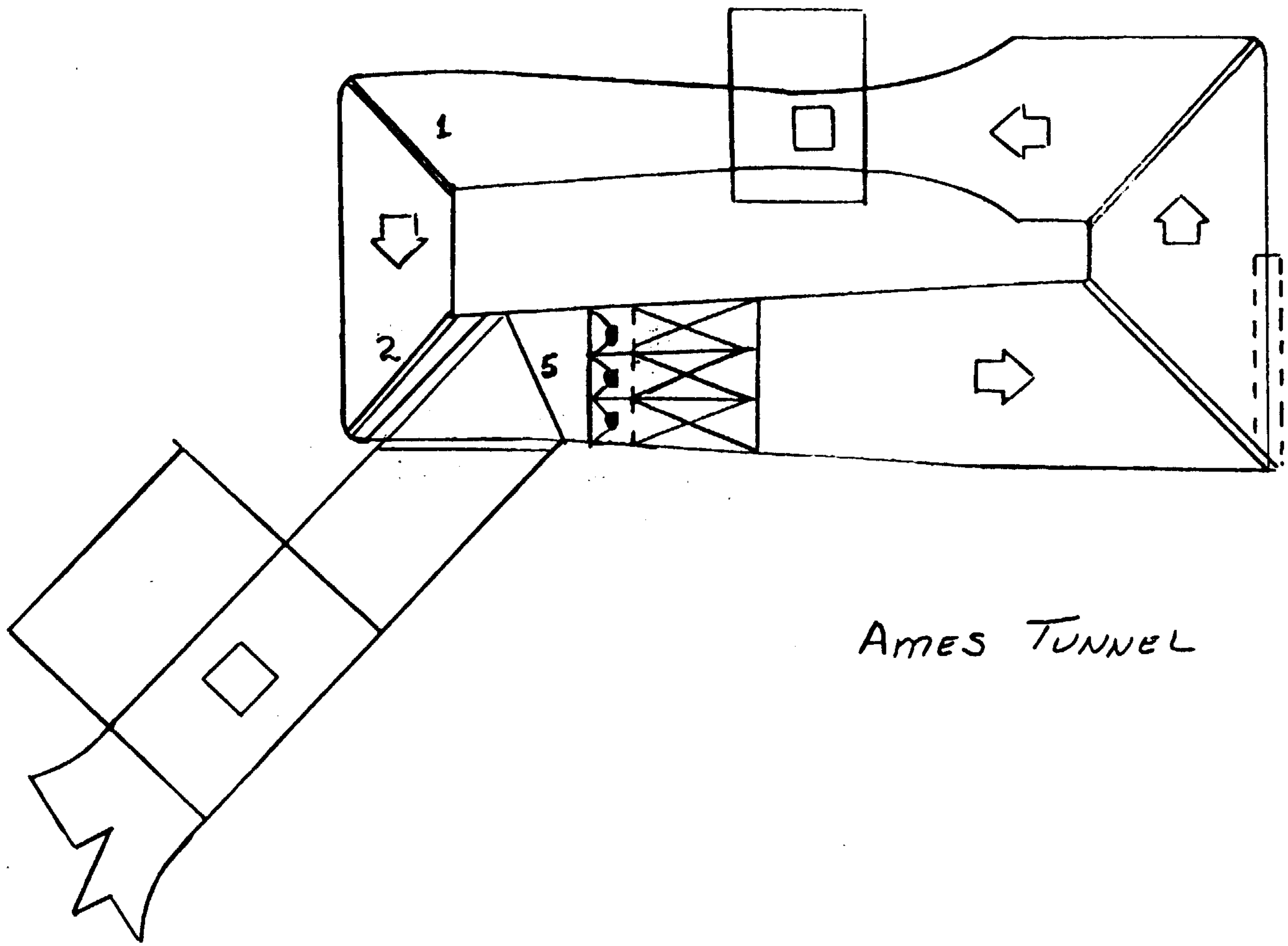
J. SANZ

E. McFARLAND

N. SANGER

T. GELDER

R. CAVICCHI



AMES TUNNEL

COMPUTATIONAL DESIGN TOOLS

- o DESIGN CODE - SANZ

  HODOGRAPH SOLUTION

  BOUNDARY LAYER CORRECTION

- o ANALYSIS CODE - McFARLAND

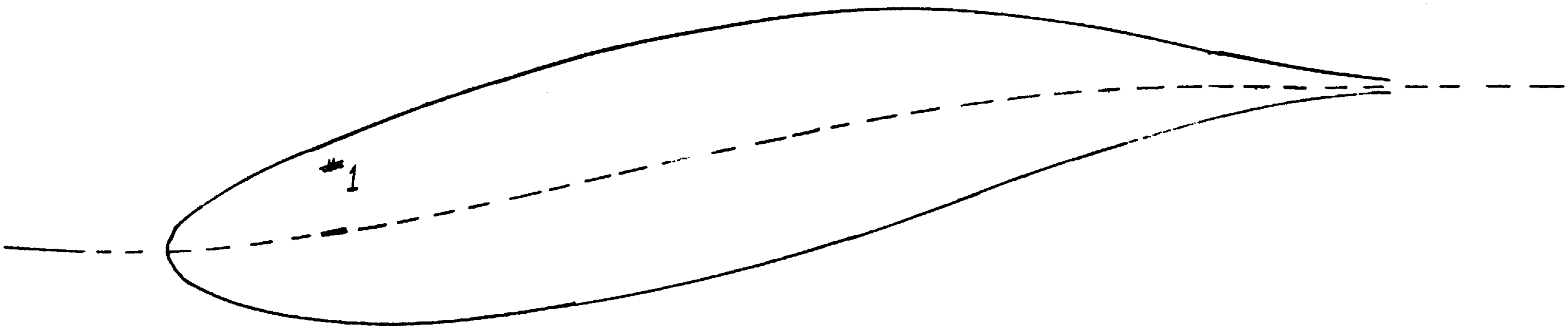
  PANEL METHOD

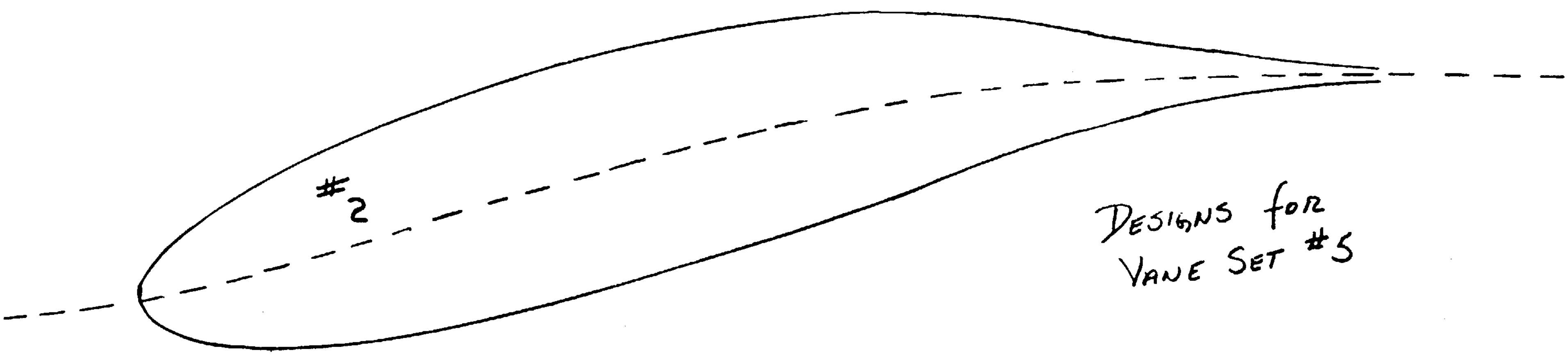
- o BOUNDARY LAYER - McNALLY

  INTEGRAL METHOD

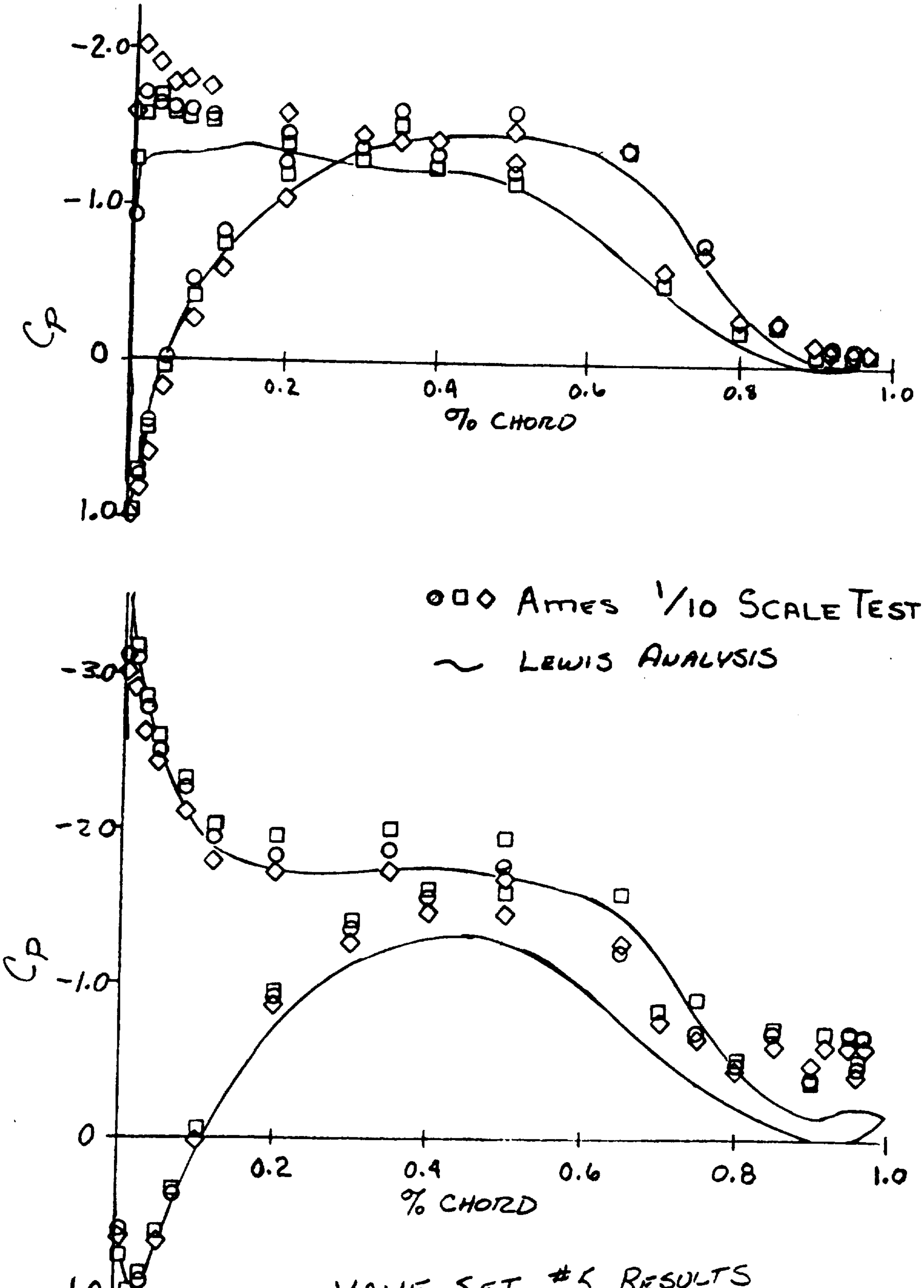
VANE SET 5 DESIGN CONSTRAINTS

- TWO MODES OF OPERATION
- LOW LOSS - ZERO TURNING
- 45 DEGREES TURNING - HIGHER LOSS ACCEPTABLE

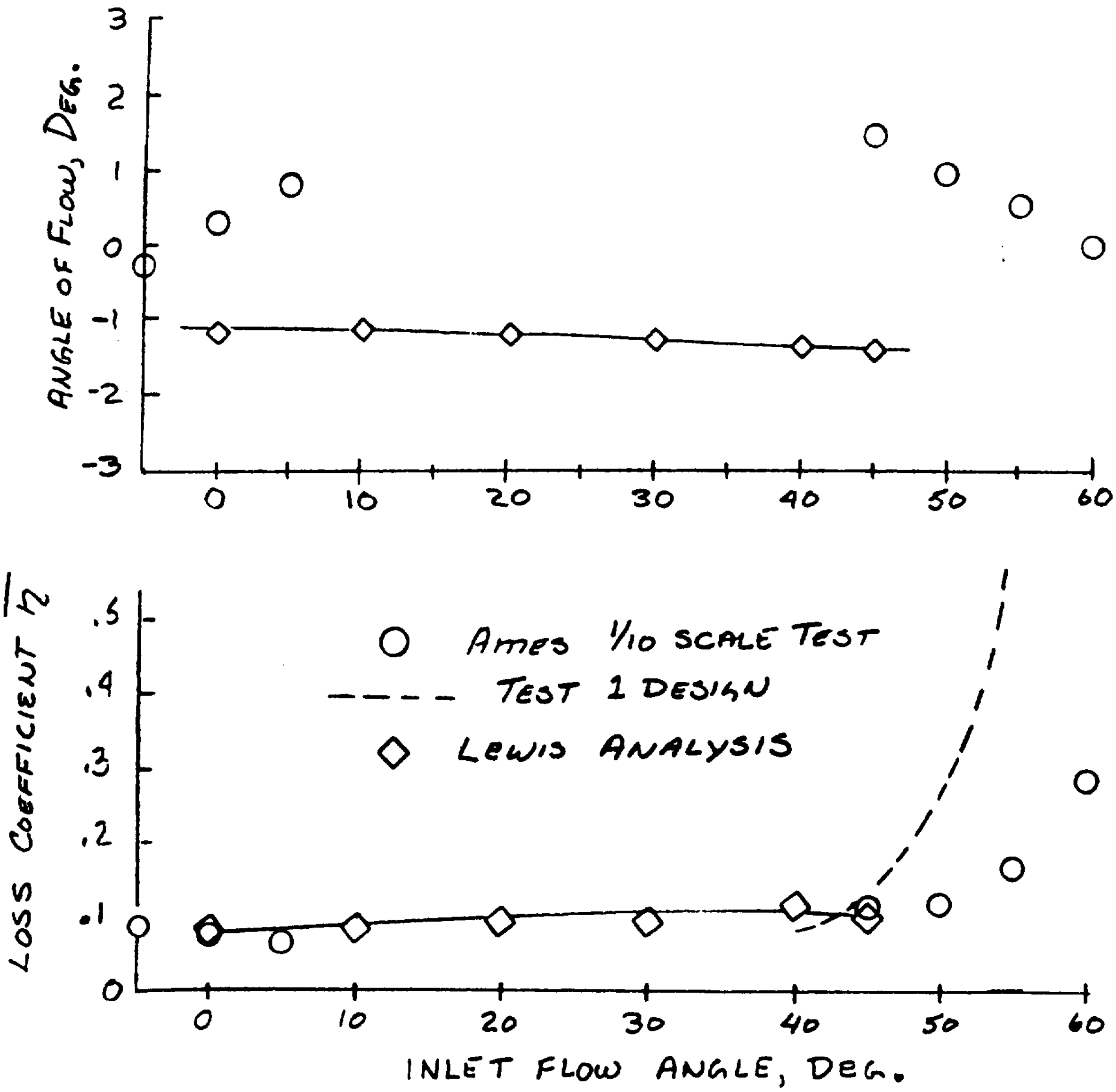




DESIGNS FOR
VANE SET #5



VANE SET #5 RESULTS



LOSS AND TURNING VANE SET #5

VANE SETS 1 AND 2 DESIGN CONSTRAINTS

- o SINGLE MODE OF OPERATION

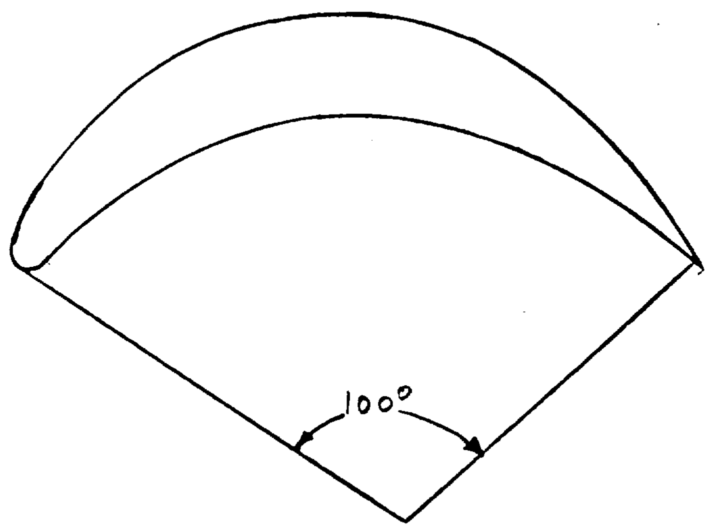
  90 DEGREES OF TURNING - LOW LOSS

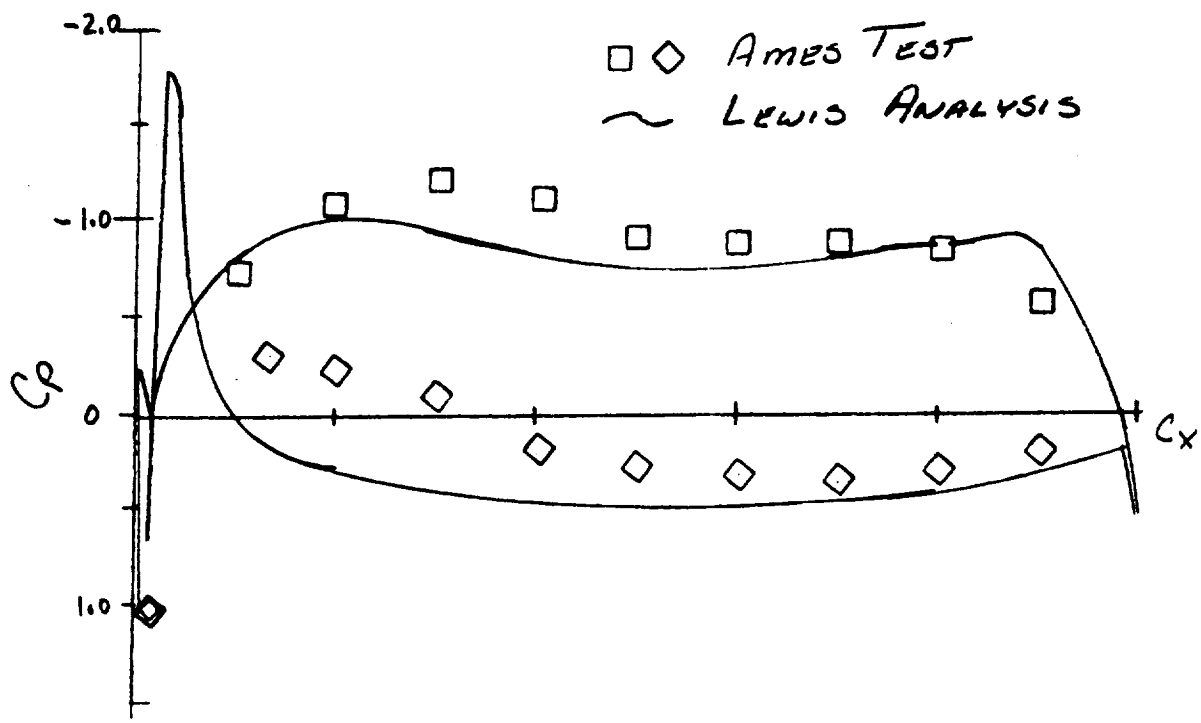
- o CONSTRUCTION

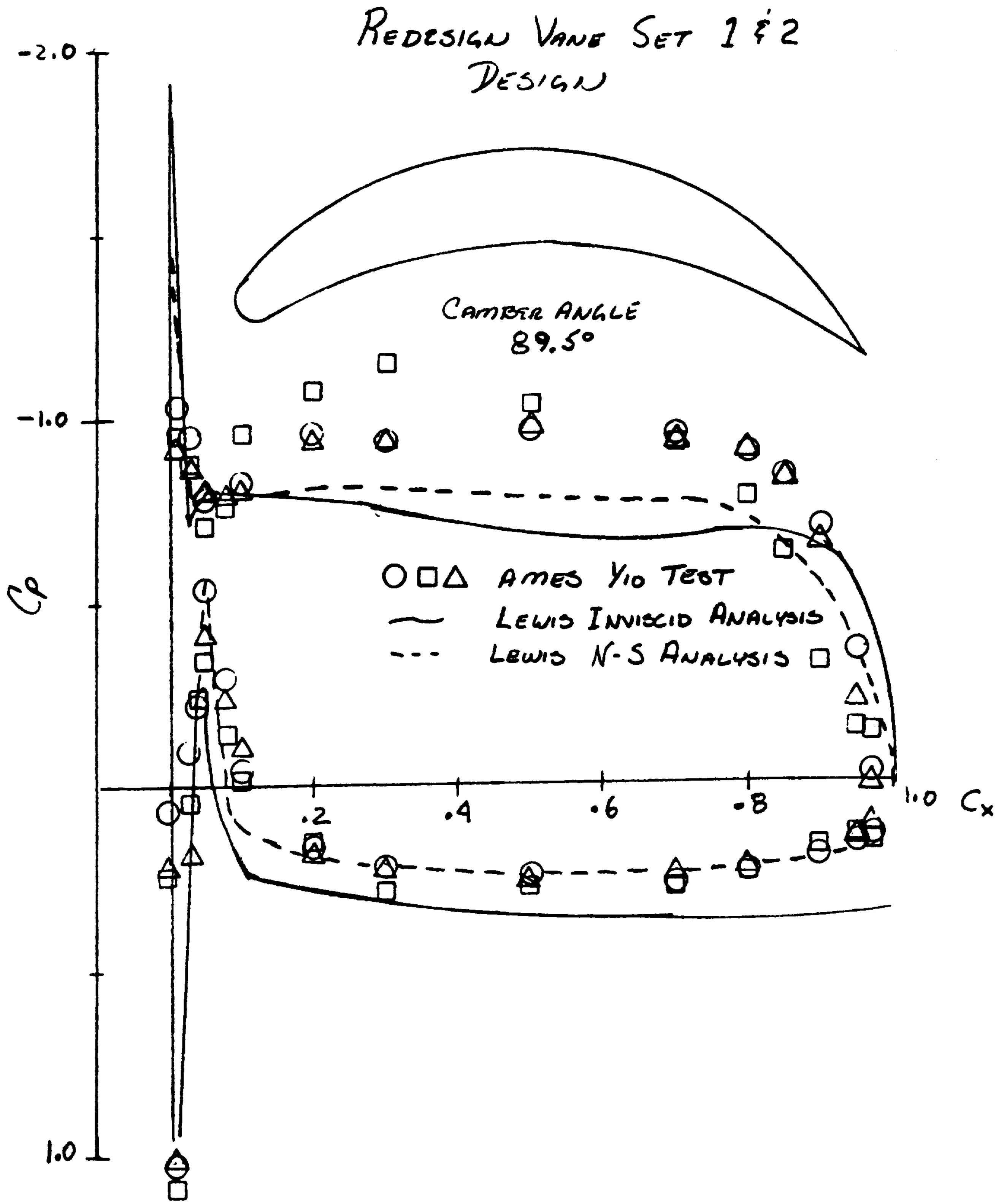
  CIRCULAR TUBE FOR LEADING EDGE

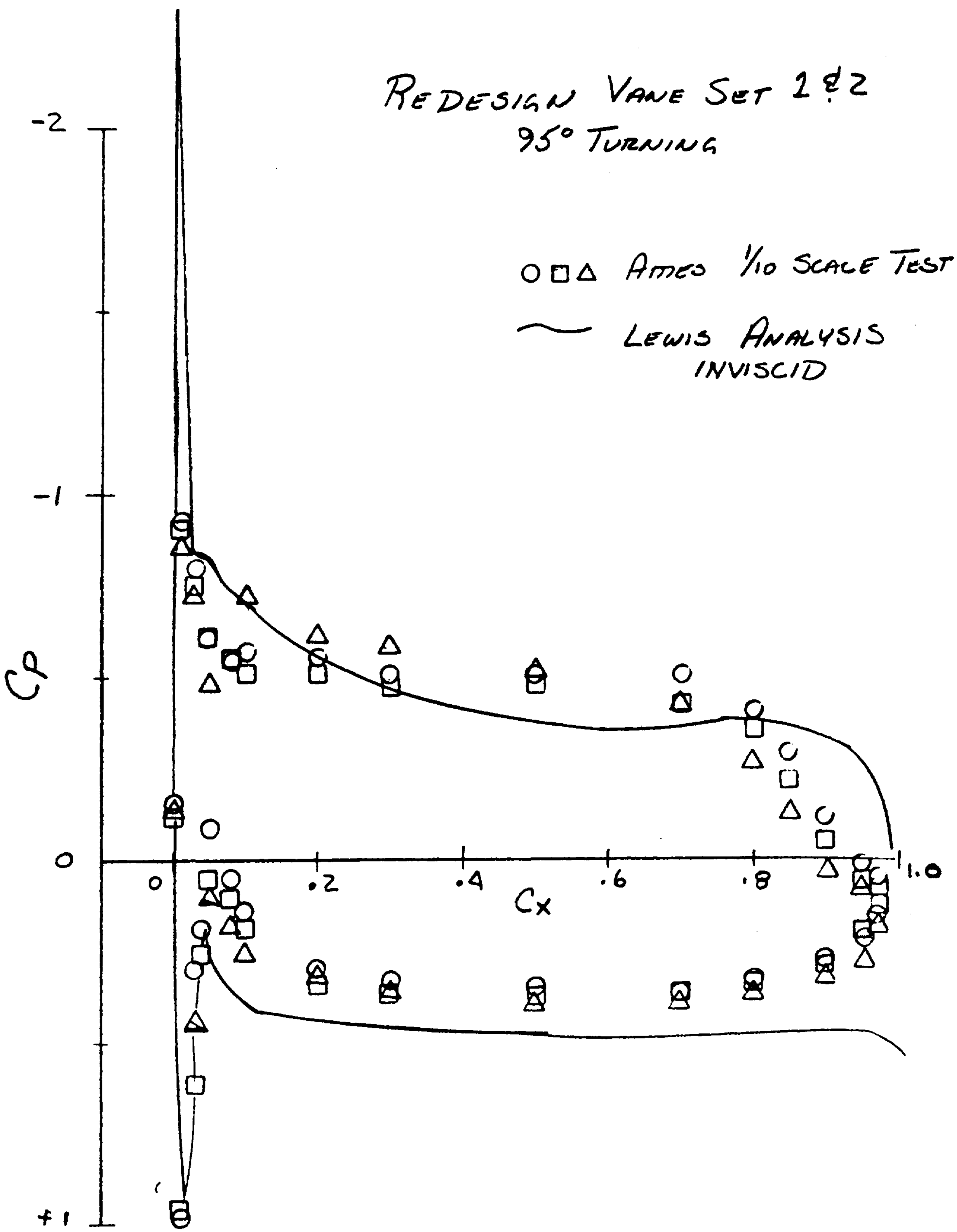
  CIRCULAR ARCS FOR THE SUCTION AND PRESSURE SURFACES

ORIGINAL VANE SET 1 & 2

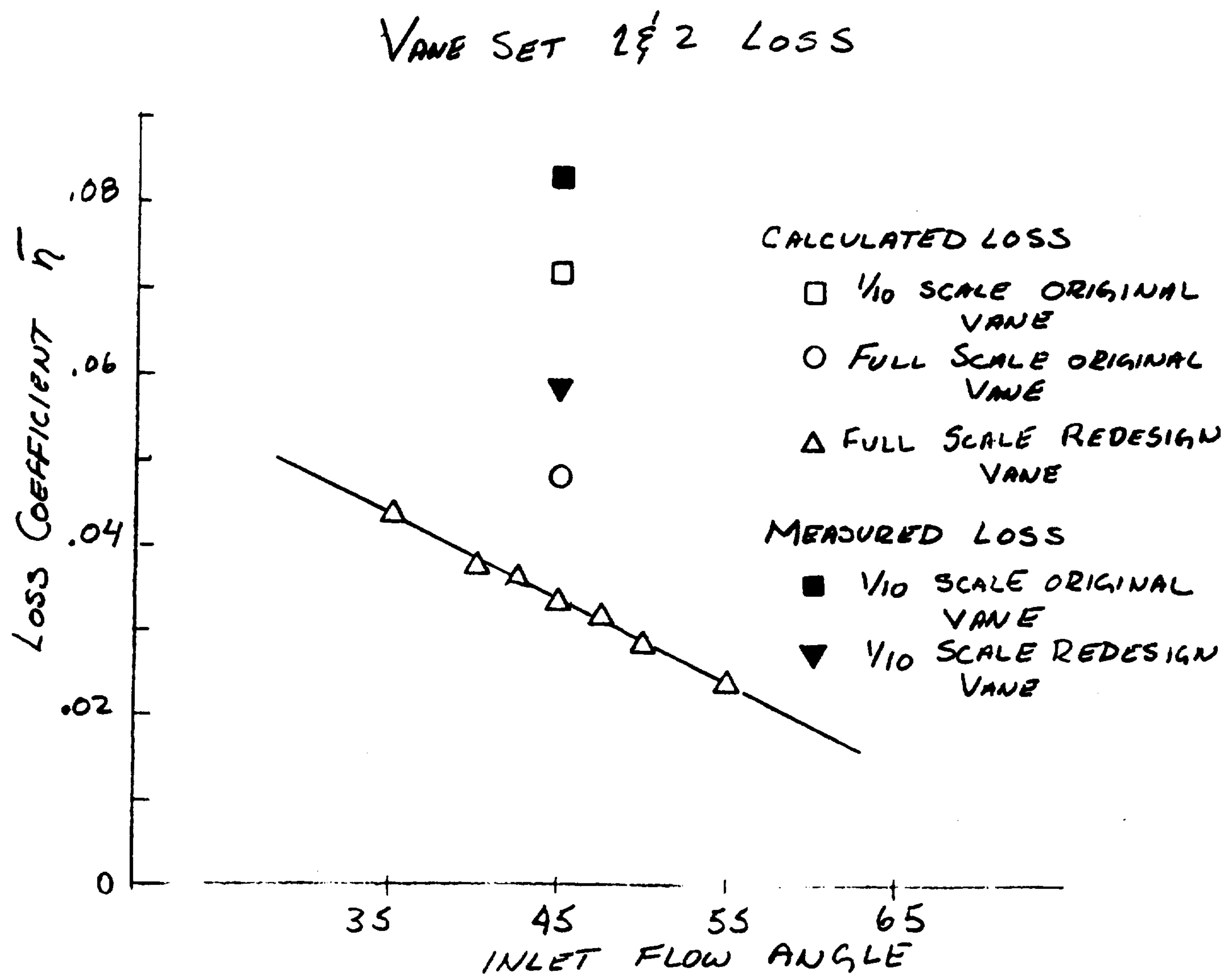




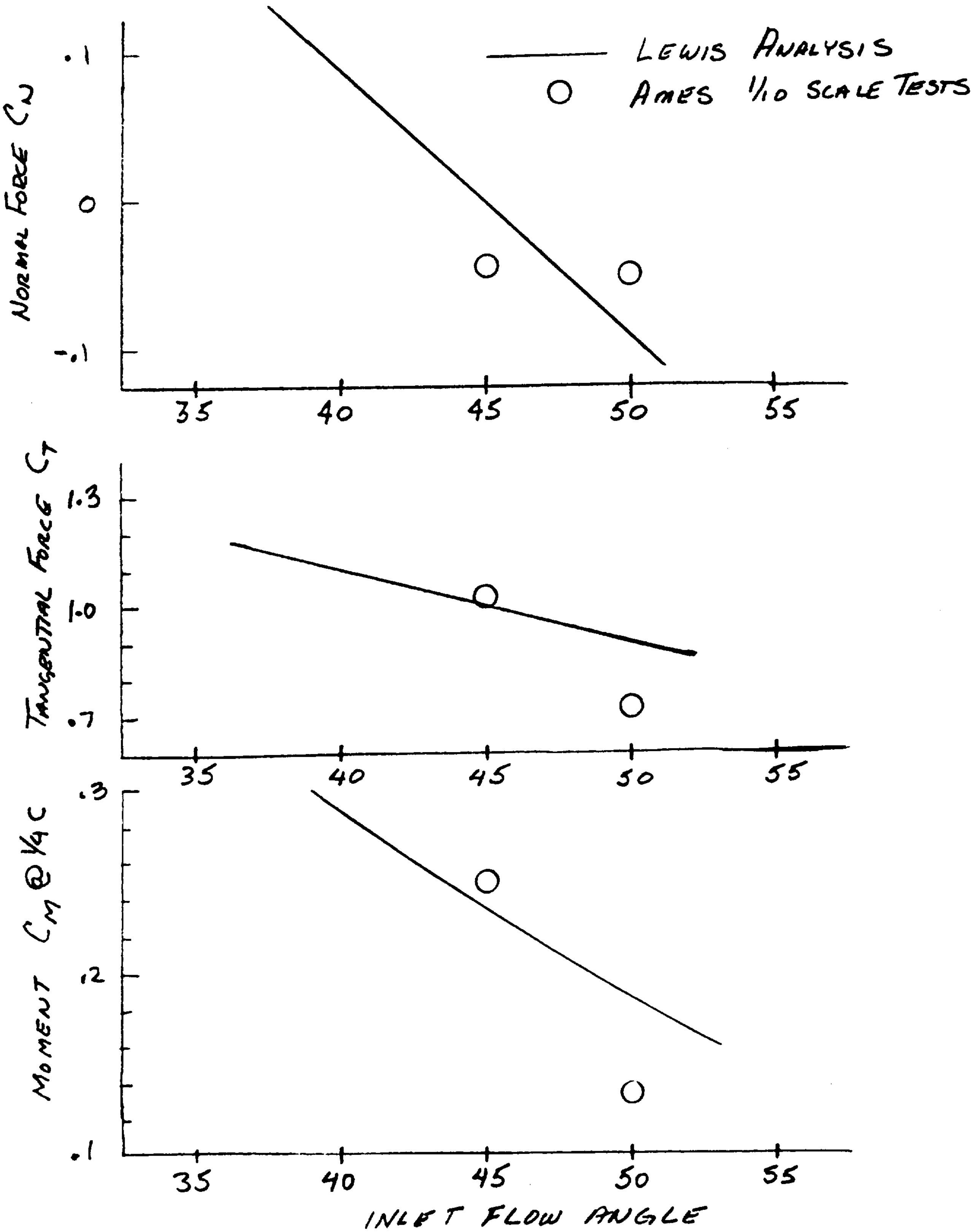

Redesign Vane Set 1 & 2
Design
Camber Angle
89.5°
Ames 1/10 Test
Lewis Inviscid Analysis
Lewis N-S Analysis
Cp
-2.0
-1.0
1.0
.2
.4
.6
.8
1.0 Cx

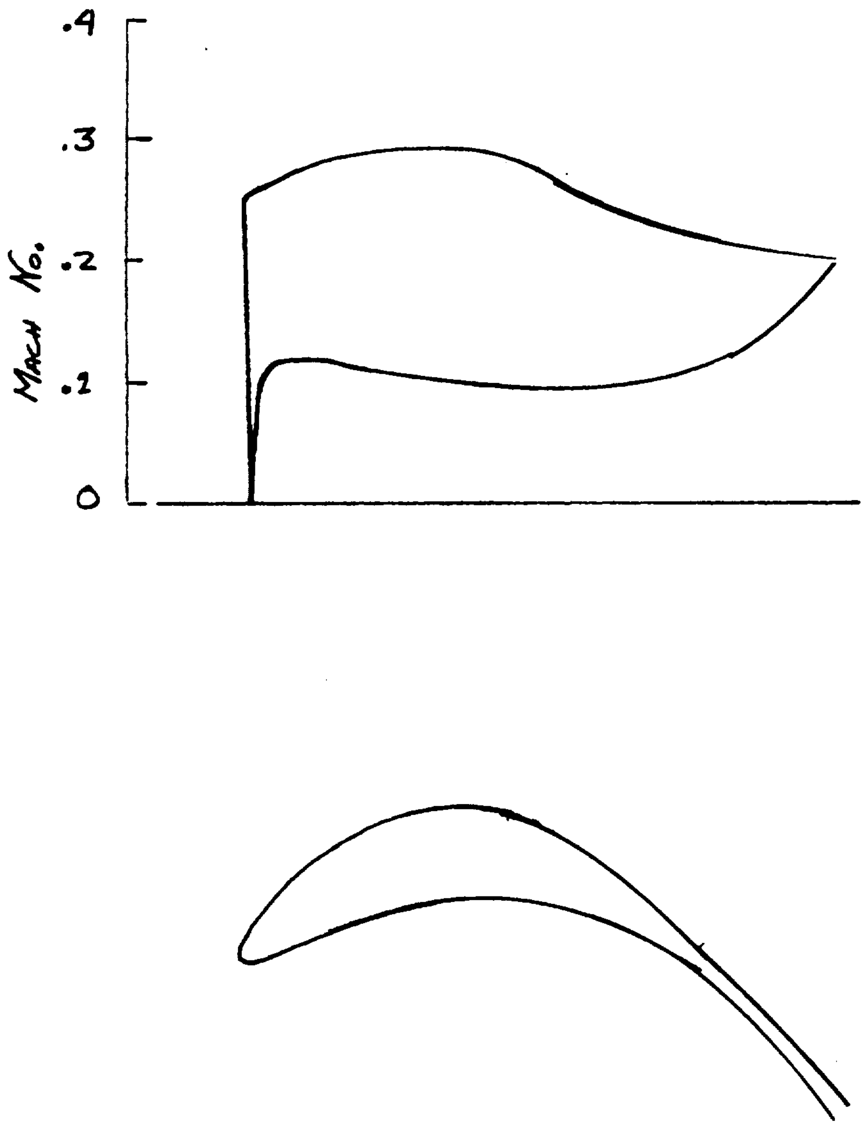


REDESIGN VANE SET 1 & 2
95° TURNING
○□△ AMES 1/10 SCALE TEST
LEWIS ANALYSIS INVISCID
-2
-1
0
+1
Cp
0
.2
.4
.6
.8
1.0
Cx


VANE SET 1 & 2 LOSS
LOSS COEFFICIENT η
.08
.06
.04
.02
0
35
45
55
65
INLET FLOW ANGLE
CALCULATED LOSS
□ 1/10 SCALE ORIGINAL VANE
○ FULL SCALE ORIGINAL VANE
△ FULL SCALE REDESIGN VANE
MEASURED LOSS
■ 1/10 SCALE ORIGINAL VANE
▼ 1/10 SCALE REDESIGN VANE

REDESIGN FORCE COEFFICIENTS





Controlled Diffusion 90° Turning Vane

AWT AERODYNAMIC DESIGN STATUS

MILT W. DAVIS

LEAD ENGINEER, AWT AERODYNAMICS

SVERDRUP CORPORATION

ALTITUDE WIND TUNNEL
FOR PROPULSION AND ICING RESEARCH

NASA LEWIS RESEARCH CENTER, CLEVELAND, OHIO

PRELIMINARY ENGINEERING REPORT
SECTION 2

TUNNEL AERODYNAMICS, PERFORMANCE
AND OPERATING COST

PREPARED BY
SVERDRUP CORPORATION
St. Louis, Missouri

FOR
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LEWIS RESEARCH CENTER
CLEVELAND, OHIO
NAS3-24024-AE

FEBRUARY 13, 1984

The Team

Milt Davis

Jim Reed

Dave Boylan

Mike Varner

Bill Moger

Tom Barton

Bill Martindale

Grant Patterson

Keith Bailey

Wanda Floyd

Barbara Pennington

Bill Crouch, et al

25-PERCENT REVIEW, AWT AERODYNAMICS

MAIN ACTIVITIES

- ANALYSIS OF AN INDEPENDENT PLENUM EVACUATION SYSTEM (PES)
- AIRLINE DEFINITION AND PRESSURE LOSS CODE DEVELOPMENT WITH EMPHASIS ON THE DEVELOPMENT OF ALTERNATE COOLER AND BASELINE SCAVENGING SCOOP DESIGNS
- CONTRACTION GEOMETRY AND CODE ANALYSIS
- AERODYNAMIC DESIGN OF THE TWO-STAGE FAN USING THE REF. 1 DEFINED PRESSURE RATIO REQUIREMENTS
- COORDINATION AND COMMUNICATION

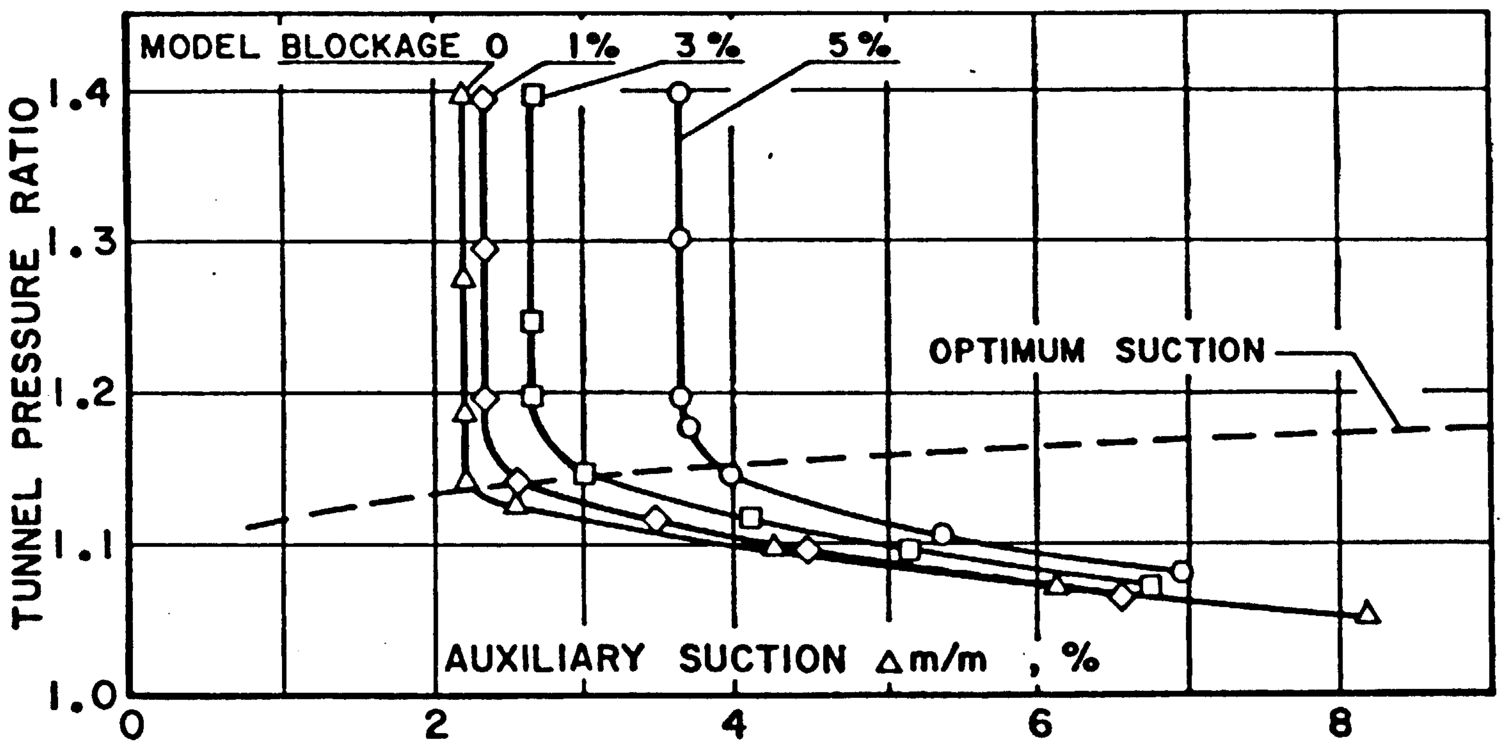
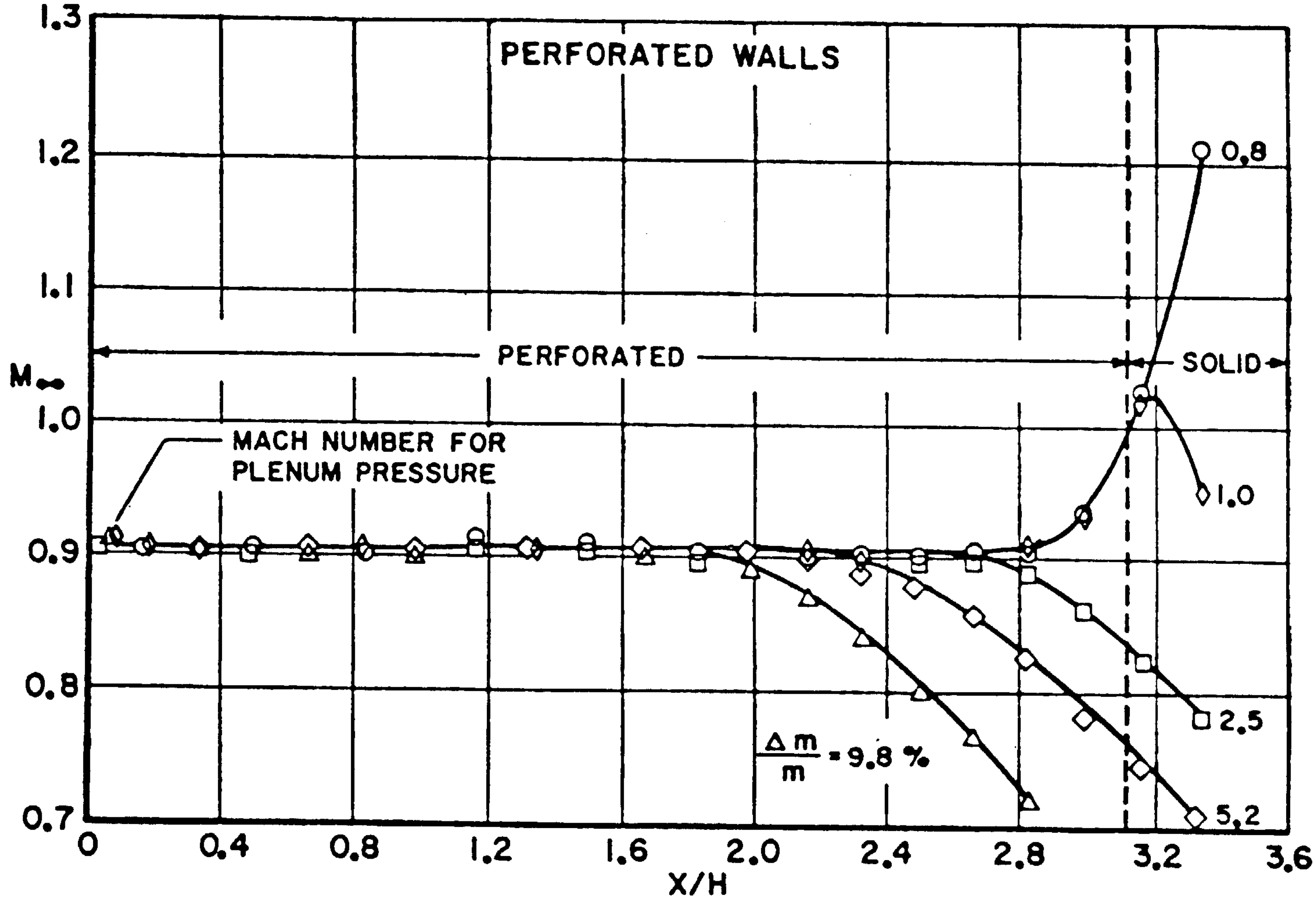


FIG. 14.13. *Influence of model size on pressure ratio and suction requirements of perforated wind tunnel at* $M = 1.0$ *(22.5 per cent open walls,* $\frac{1}{4}$ *in. holes, parallel walls) (AEDC 1 ft transonic model tunnel*[4]*).*

MACH NUMBER DISTRIBUTIONS FOR PERFORATED TEST SECTION WITH PARALLEL WALLS FOR VARIOUS PLENUM CHAMBER SUCTION QUANTITIES



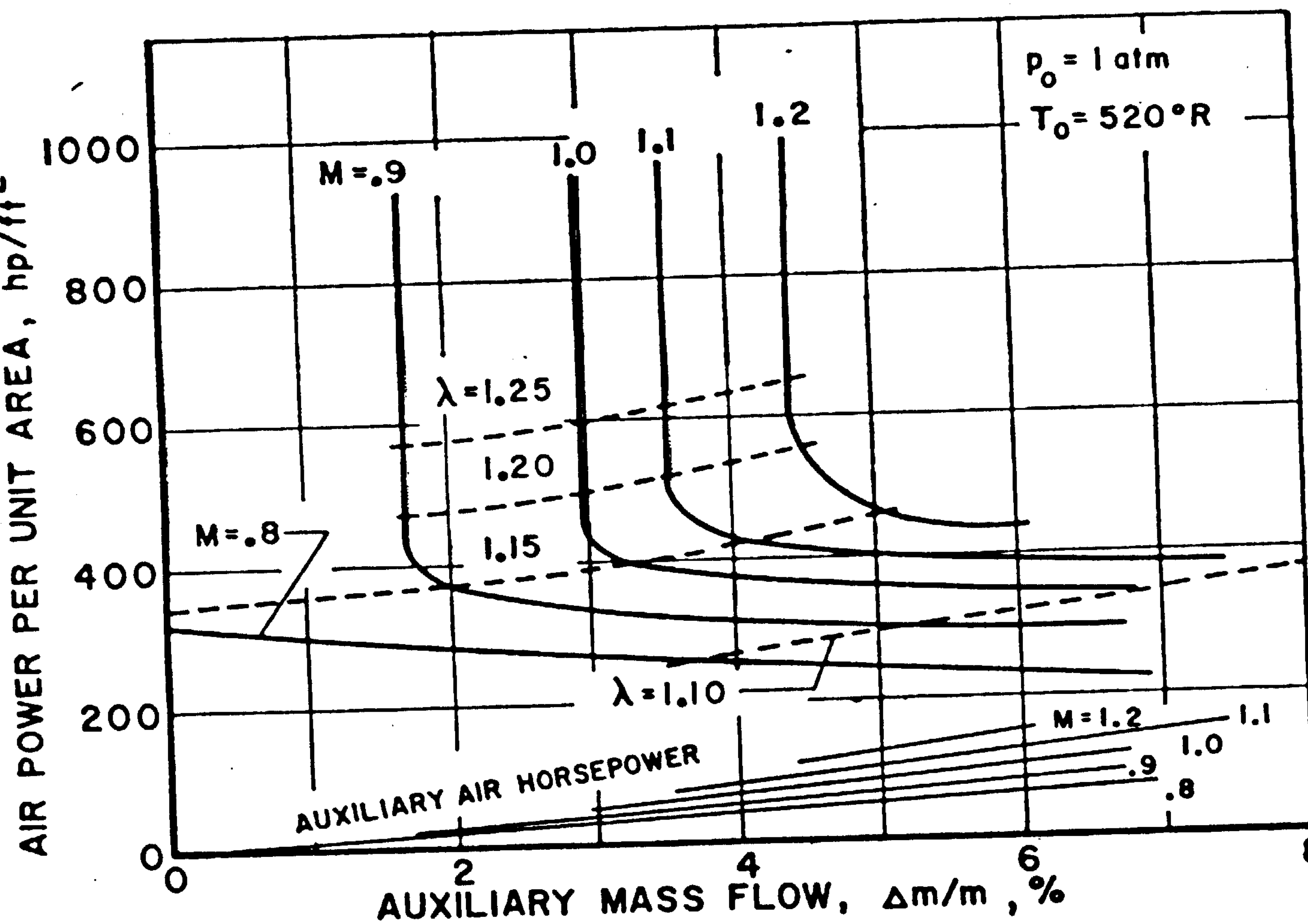


Fig. 14.16. *Power requirements and auxiliary mass flow of slotted test section for various Mach numbers (sixteen slots, 11 per cent open, diffuser flaps closed) (AEDC 1 ft transonic model tunnel[5]).*

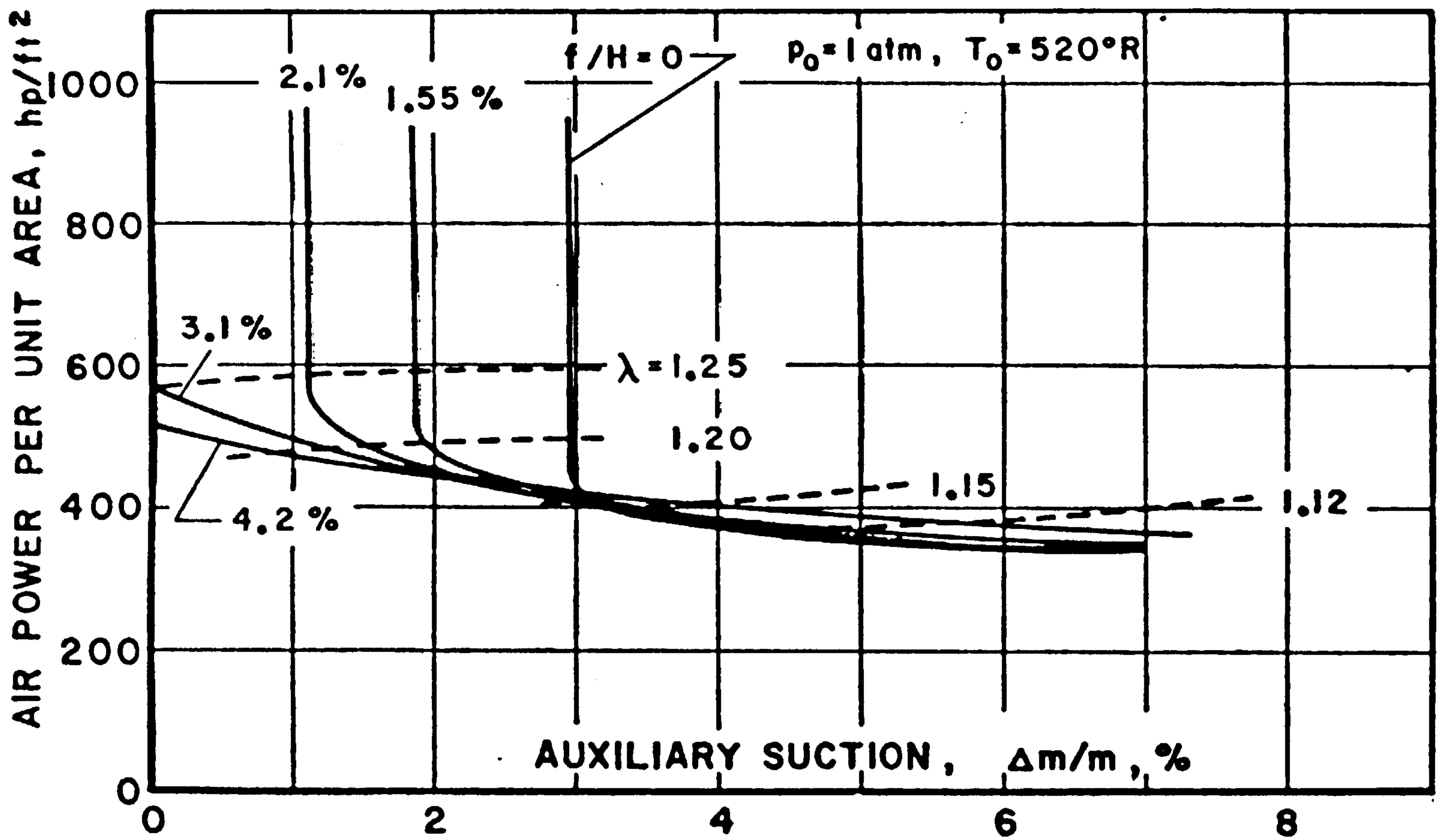


FIG. 14.17. *Influence of diffuser flap opening on power requirements of slotted test section at $M = 1.0$ (sixteen slots, 11 per cent open, parallel walls) (AEDC 1 ft transonic model tunnel[5]).*

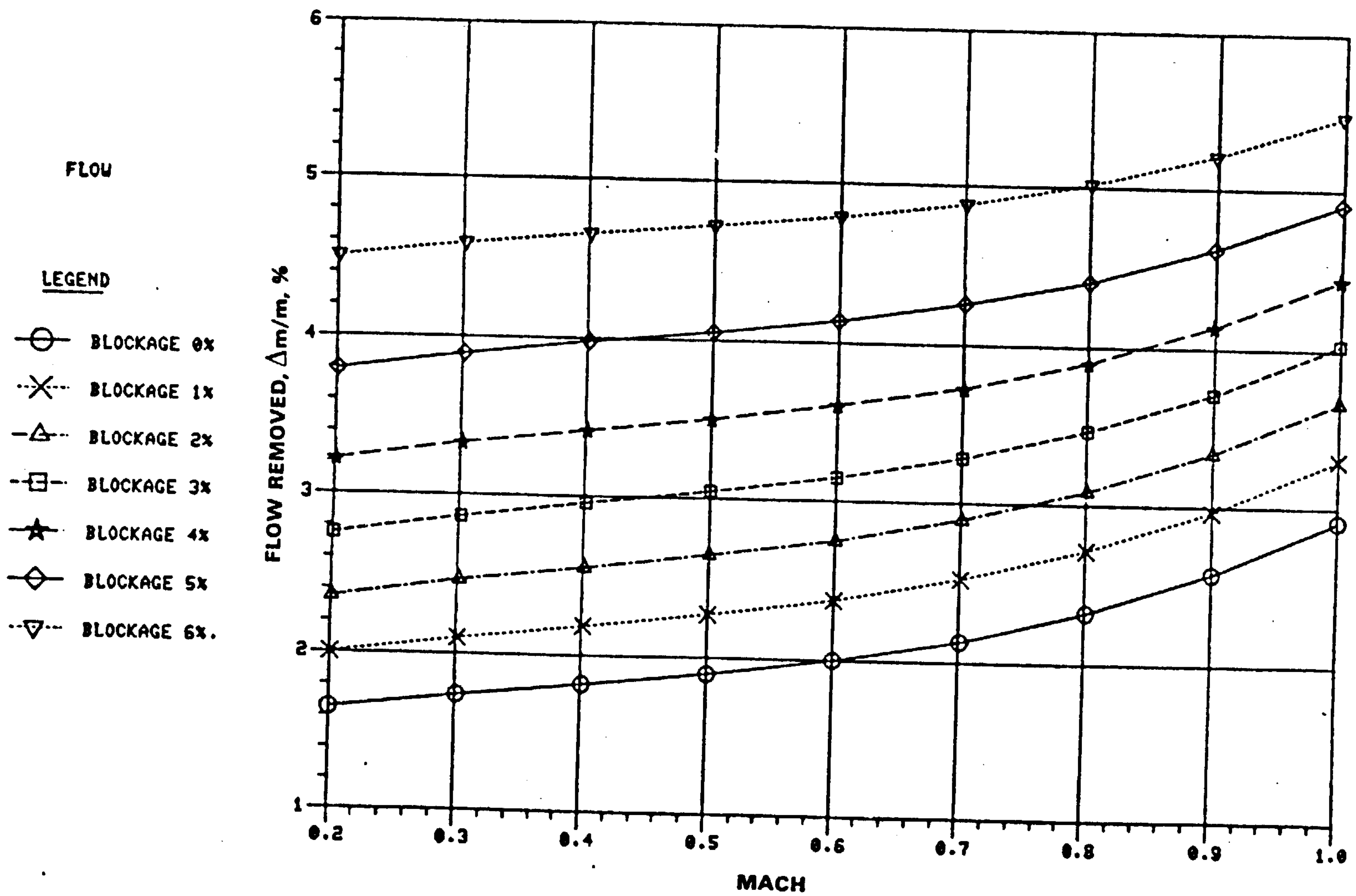


FIGURE 2. PLENUM FLOW REMOVAL REQUIREMENTS FOR AWT

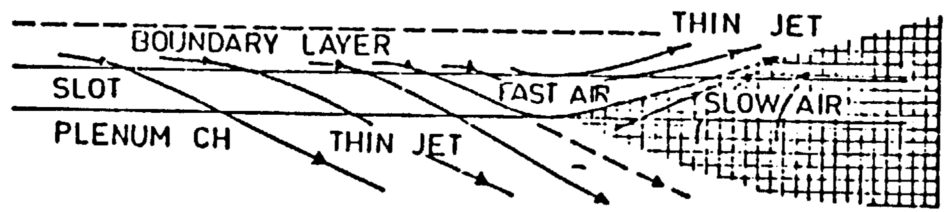
THE FIRST DIFFUSER ALGORITHM

Baseline Tunnel

$$B_t = B_{t,o} + \left(\frac{\Delta m}{m} \right), \%$$

PES Tunnel

$$B_t = B_{t,o}, \%$$



NYBERG'S SLOT FLOW MODEL

$$B_{t,o} = \left[1 - \frac{[A_{660}]e}{45,726.4} \right] 100, \%$$

$$[A_{660}]e = (233.68 - 2\delta^*_{ex})^2 (0.429705) + (236.24 - 2\delta^*_{e})^2 (0.39889), \text{ in}^2$$

$$\delta^*_{ex} = 10.38275 \left[\frac{R_e}{\ell} \right]^{-1/5}, \text{ in}$$

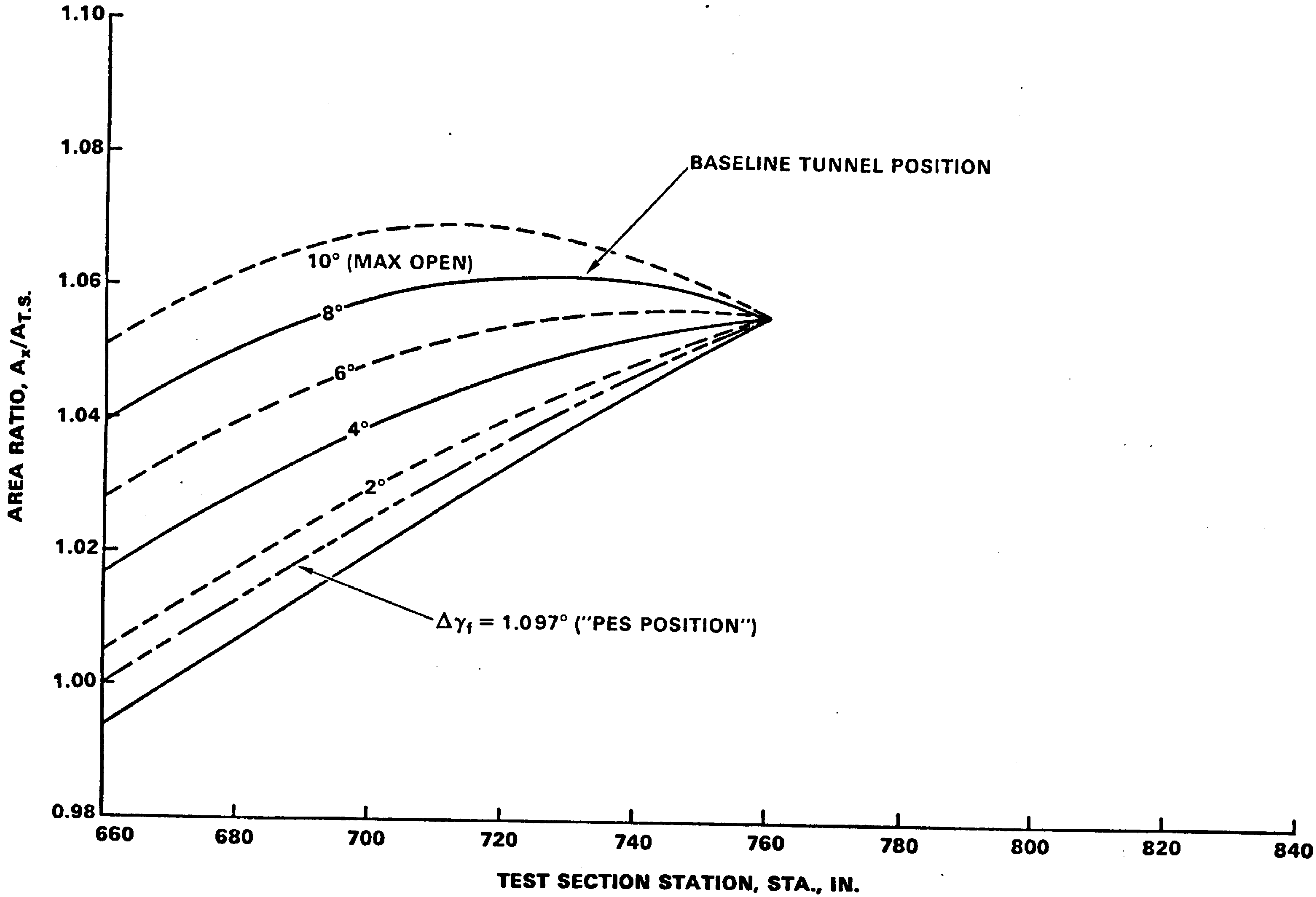


FIGURE 1. EFFECT OF EJECTOR FLAP OPENING ON DIFFUSER GEOMETRIC AREA DISTRIBUTION

CROSS-LEG DIFFUSER ALGORITHM & TEST LEG PRESSURE RATIO

- VARNER'S CODE FOR FIRST DIFFUSER DEFINES DIFFUSER EXIT BOUNDARY-LAYER BLOCKAGE

- THIS BLOCKAGE IS USED AS AN ARGUMENT FOR A CROSS-LEG DIFFUSER CALCULATION FURTHER ACCENTUATING THE INFLUENCE OF AN INDEPENDENT PES

- FOR CALCULATION AROUND THE MATCHED-ALTITUDE ENVELOPE (FIG. 5), THE PES-TUNNEL IS ALSO GIVEN THE ADVANTAGE THAT THE $\Delta m/m$ MASS FLOW DEFICIT REDUCES THE DIFFUSER ENTRANCE AND CORNER 1 MACH NUMBER (FIG. 6)

- THE RESULTING REDUCTION IN THE TEST LEG PRESSURE RATIO IS SHOWN IN (FIG. 7)

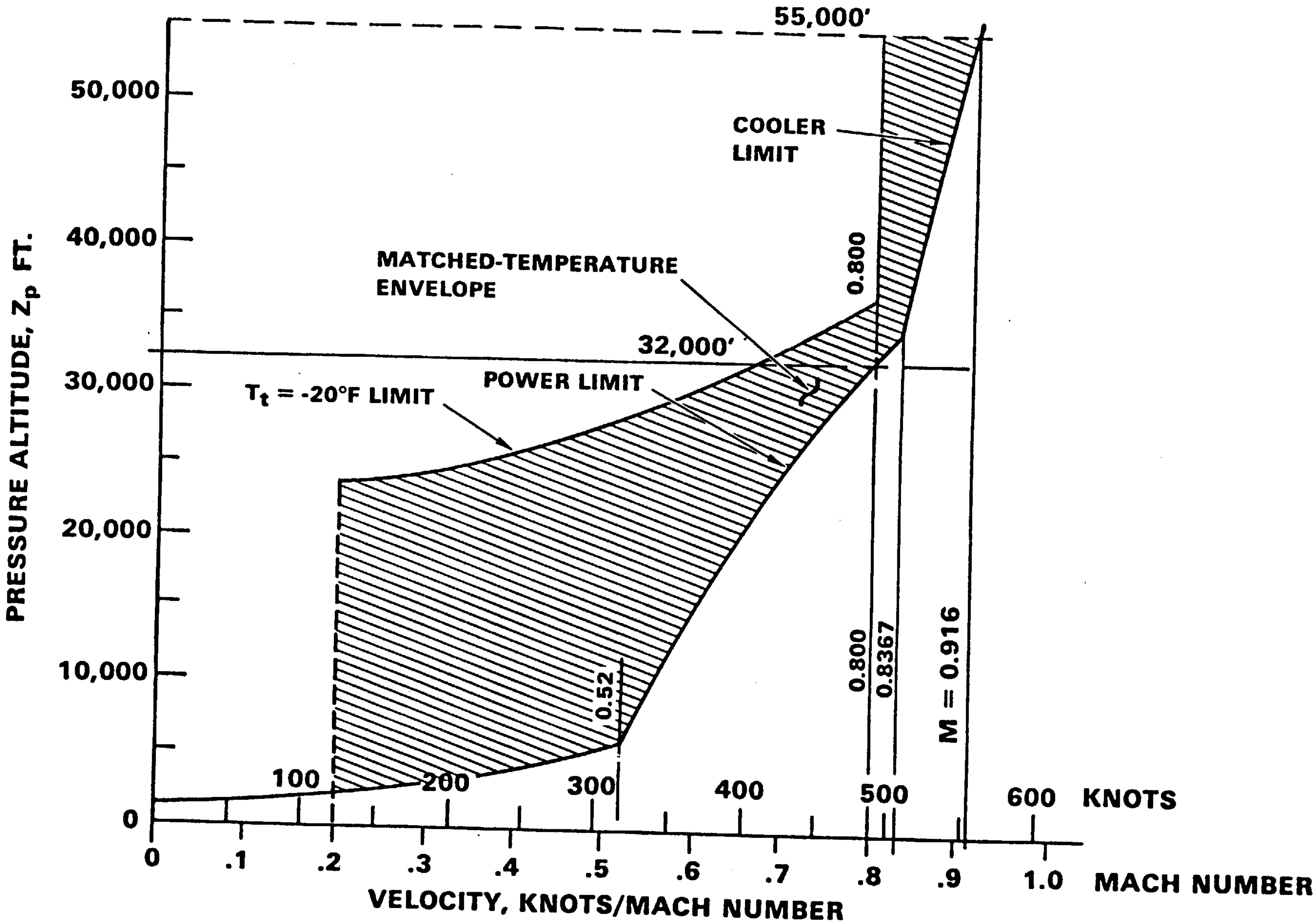


FIGURE 5. AWT PERFORMANCE 20' TEST SECTION

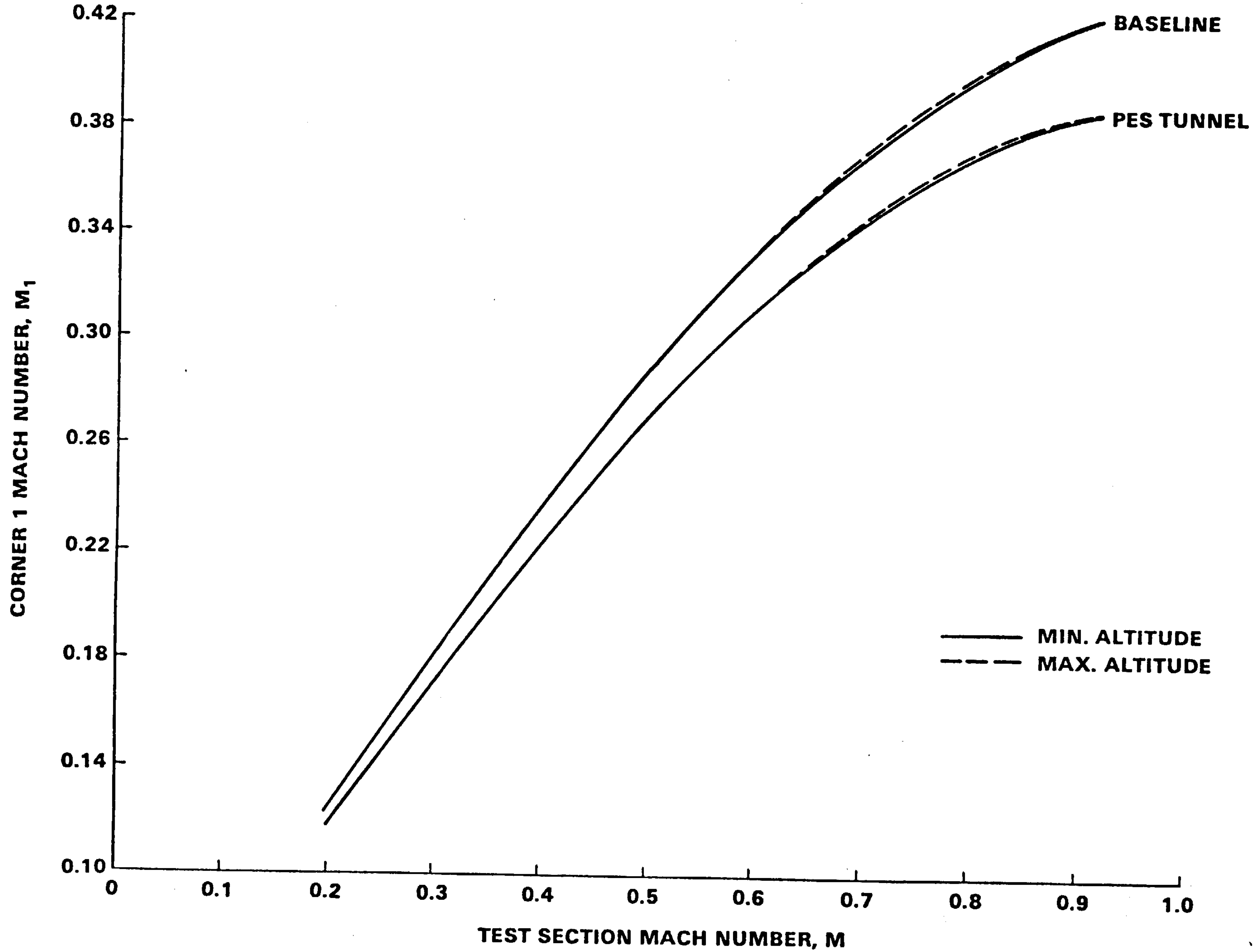


FIGURE 6. EFFECT OF PES SCHEME ON FIRST CORNER ENTRANCE MACH NUMBER, 6% MODEL CW

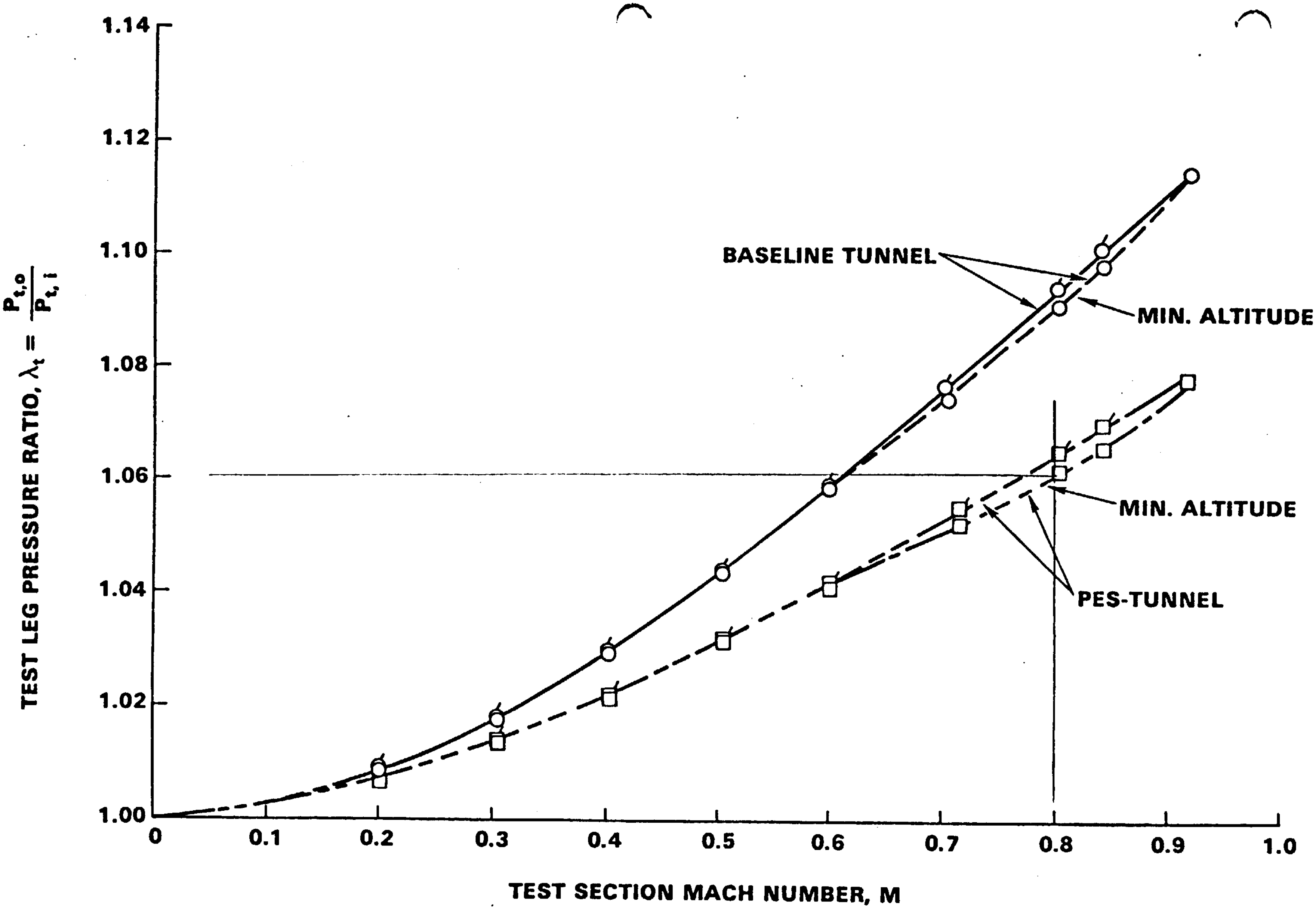
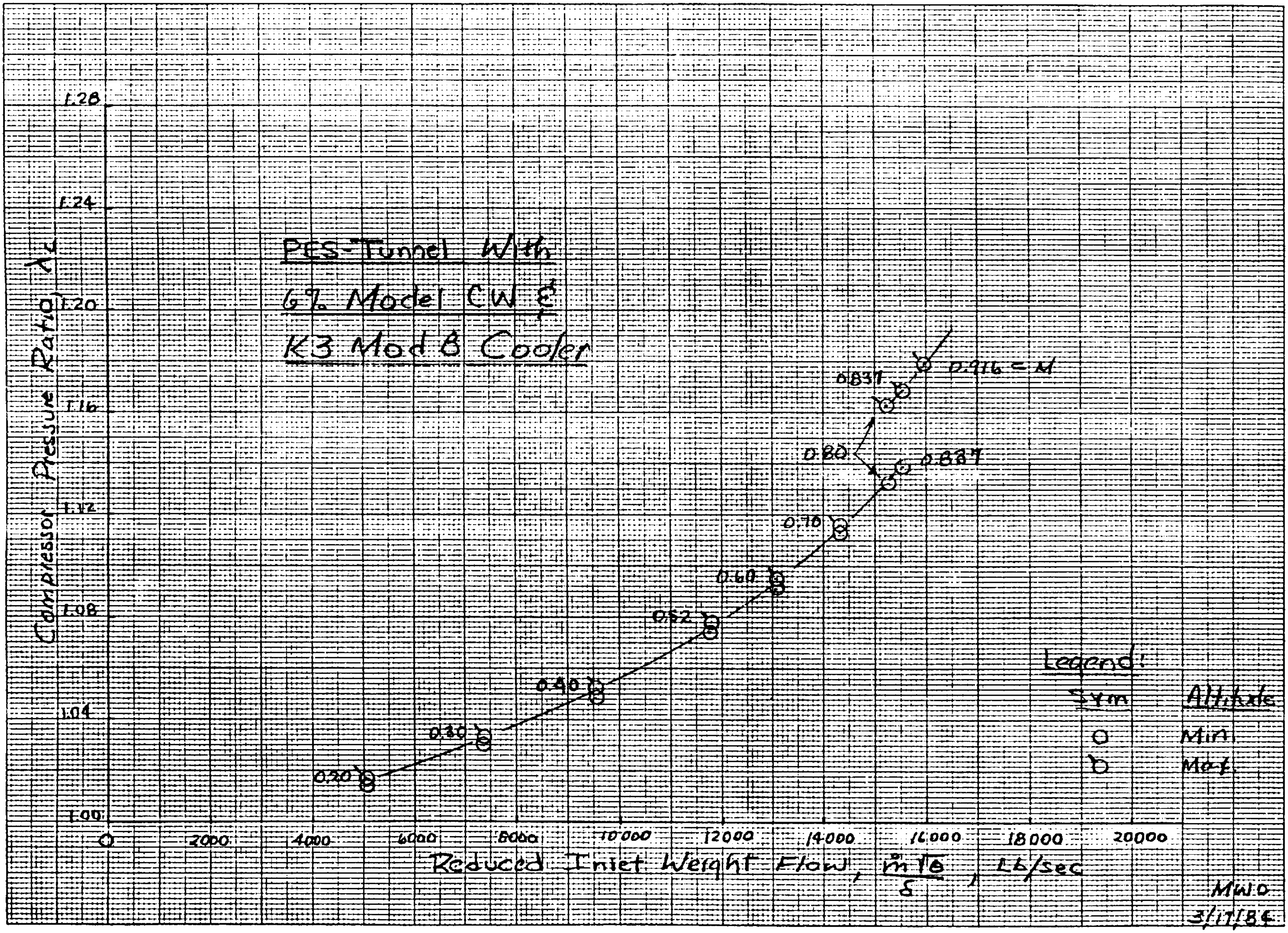
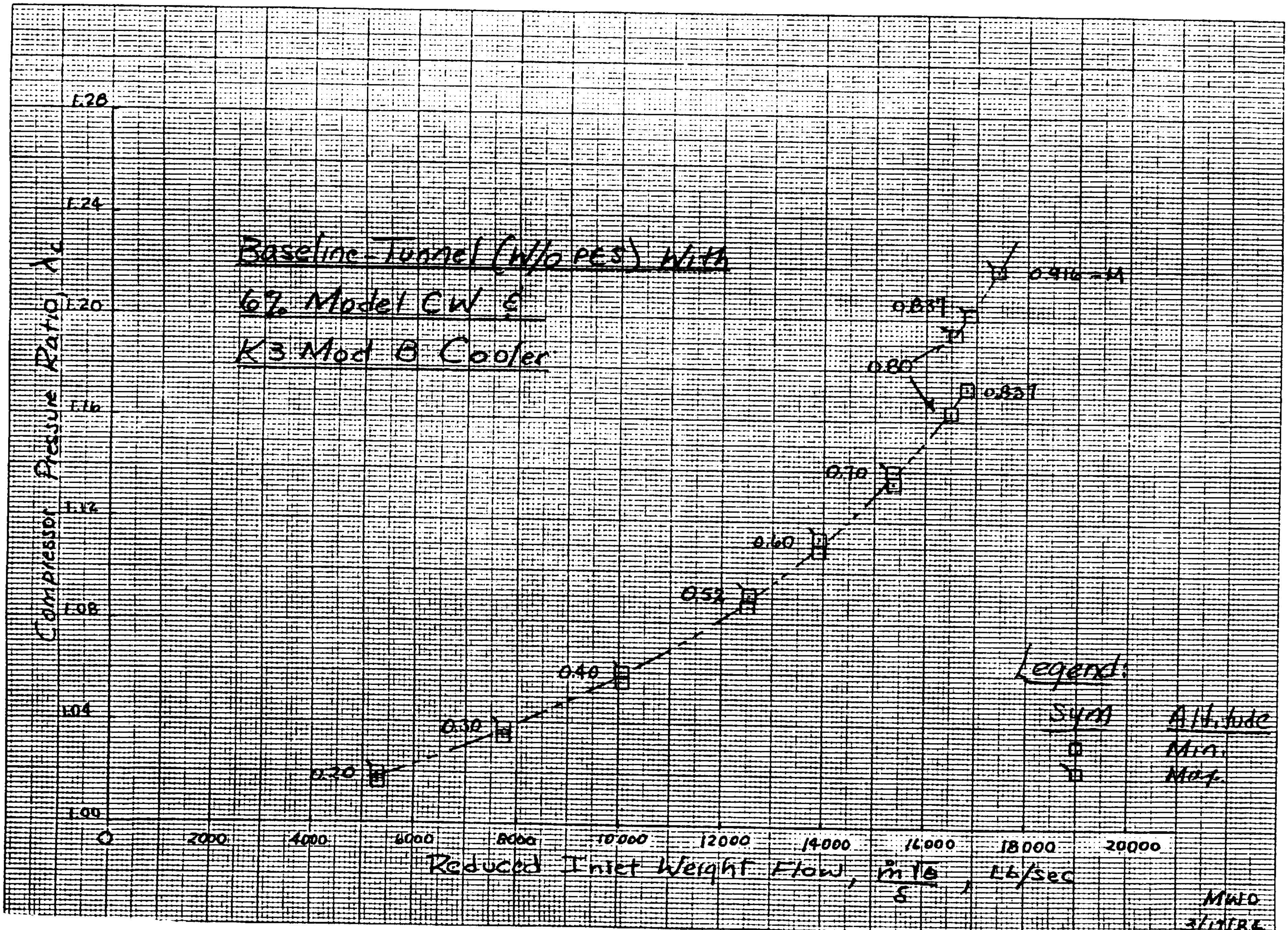
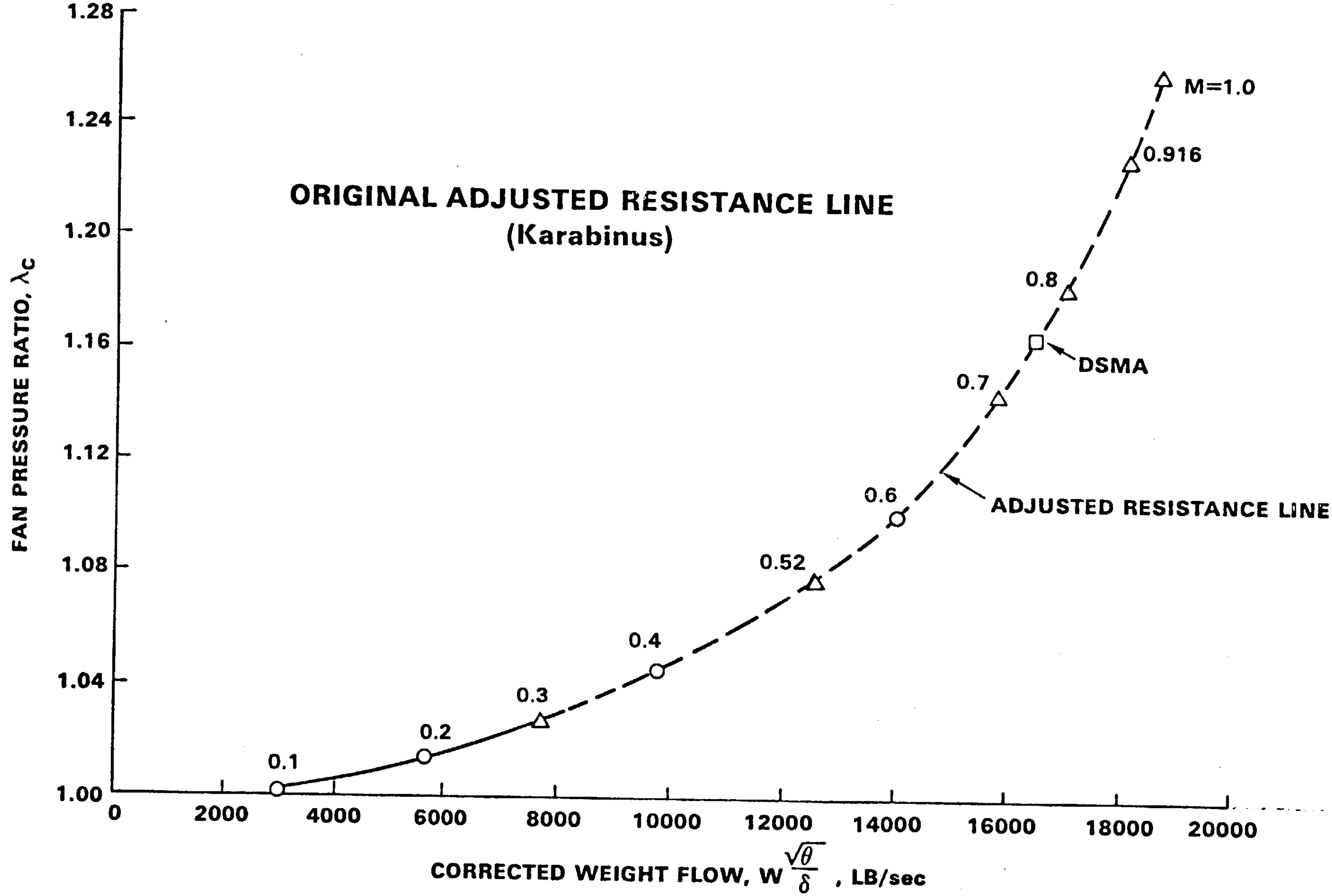


FIGURE 7. EFFECT OF PES SCHEME ON TEST LEG PRESSURE RATIO WITH 6% MODEL CW

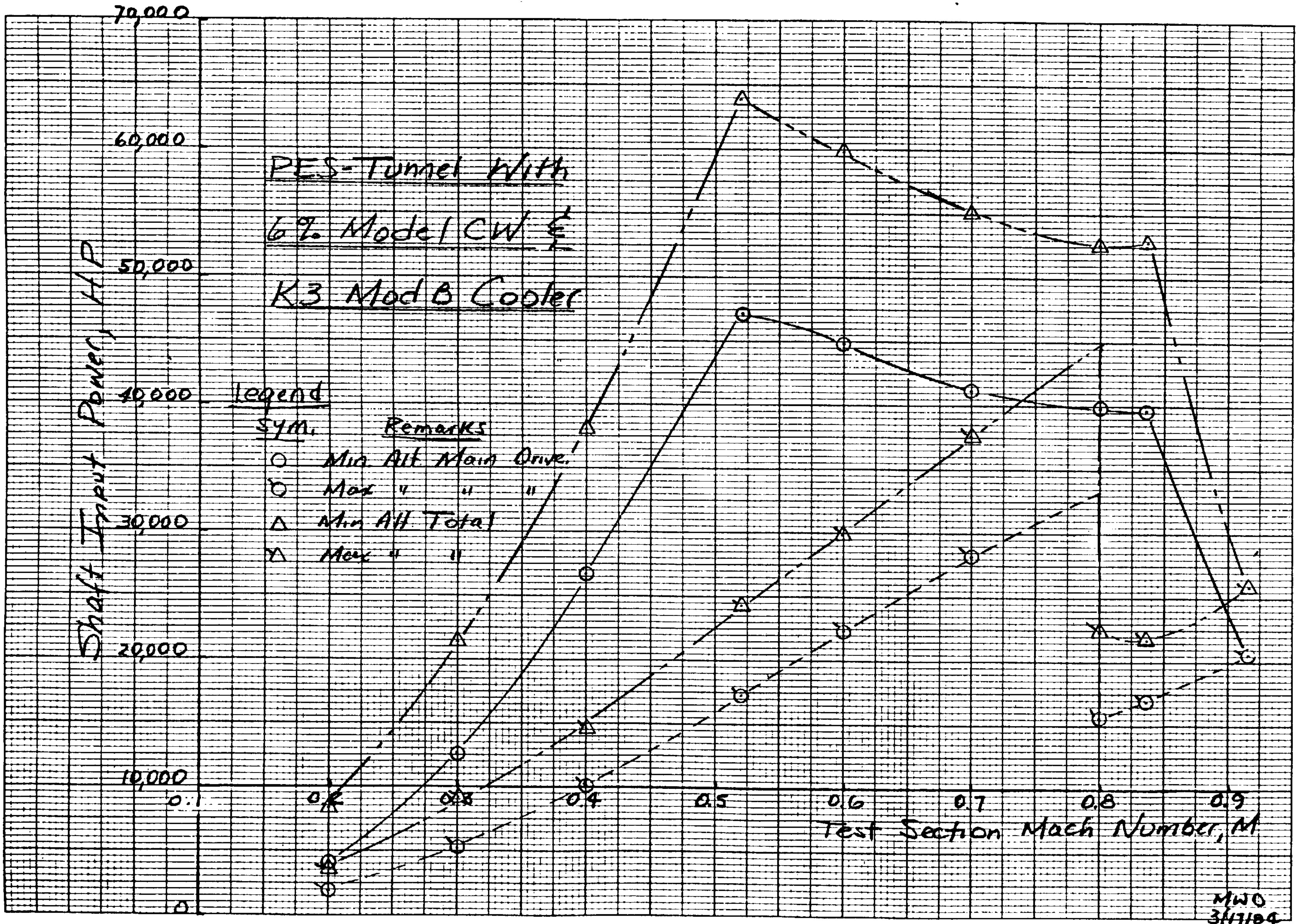

PES-Tunnel With
6% Model CW &
K3 Mod B Cooler
Compressor Pressure Ratio, π_c
1.28
1.24
1.20
1.16
1.12
1.08
1.04
1.00
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
Reduced Inlet Weight Flow, $\frac{\dot{m}\sqrt{\theta}}{\delta}$, Lb/sec
0.20
0.30
0.40
0.52
0.60
0.70
0.80
0.837
0.837
0.916 = M
Legend:
Sym
Altitude
Min.
Max.
MWO
3/17/84

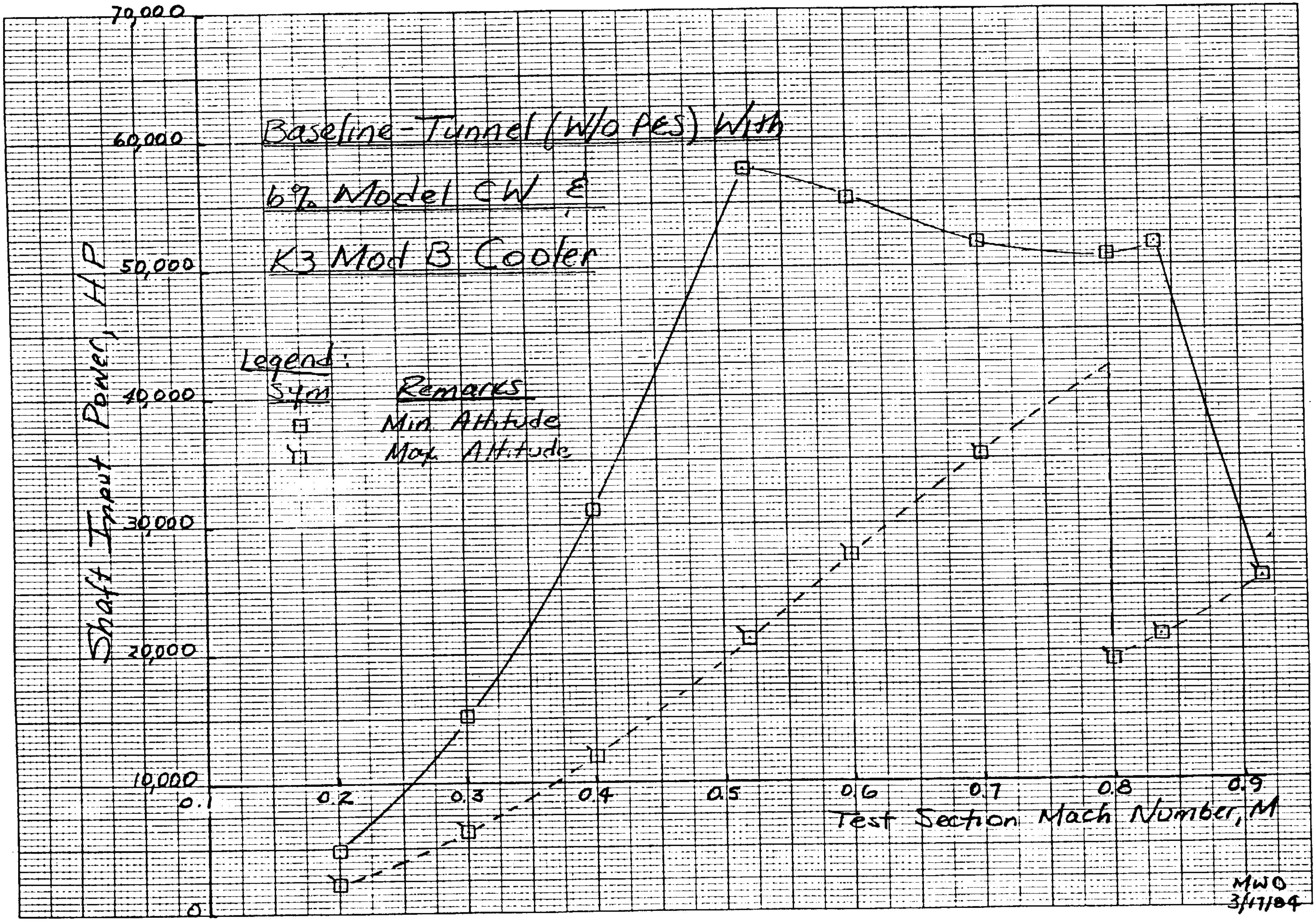

Baseline Tunnel (W/o PES) With
6% Model CW &
K3 Mod B Cooler
Compressor Pressure Ratio, π_c
1.28
1.24
1.20
1.16
1.12
1.08
1.04
1.00
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
Reduced Inlet Weight Flow, $\frac{\dot{m}\sqrt{\theta}}{\delta}$, Lb/sec
0.20
0.30
0.40
0.52
0.60
0.70
0.80
0.837
0.837
0.916 = M
Legend:
Sym
Altitude
Min.
Max.
MWO
3/17/84

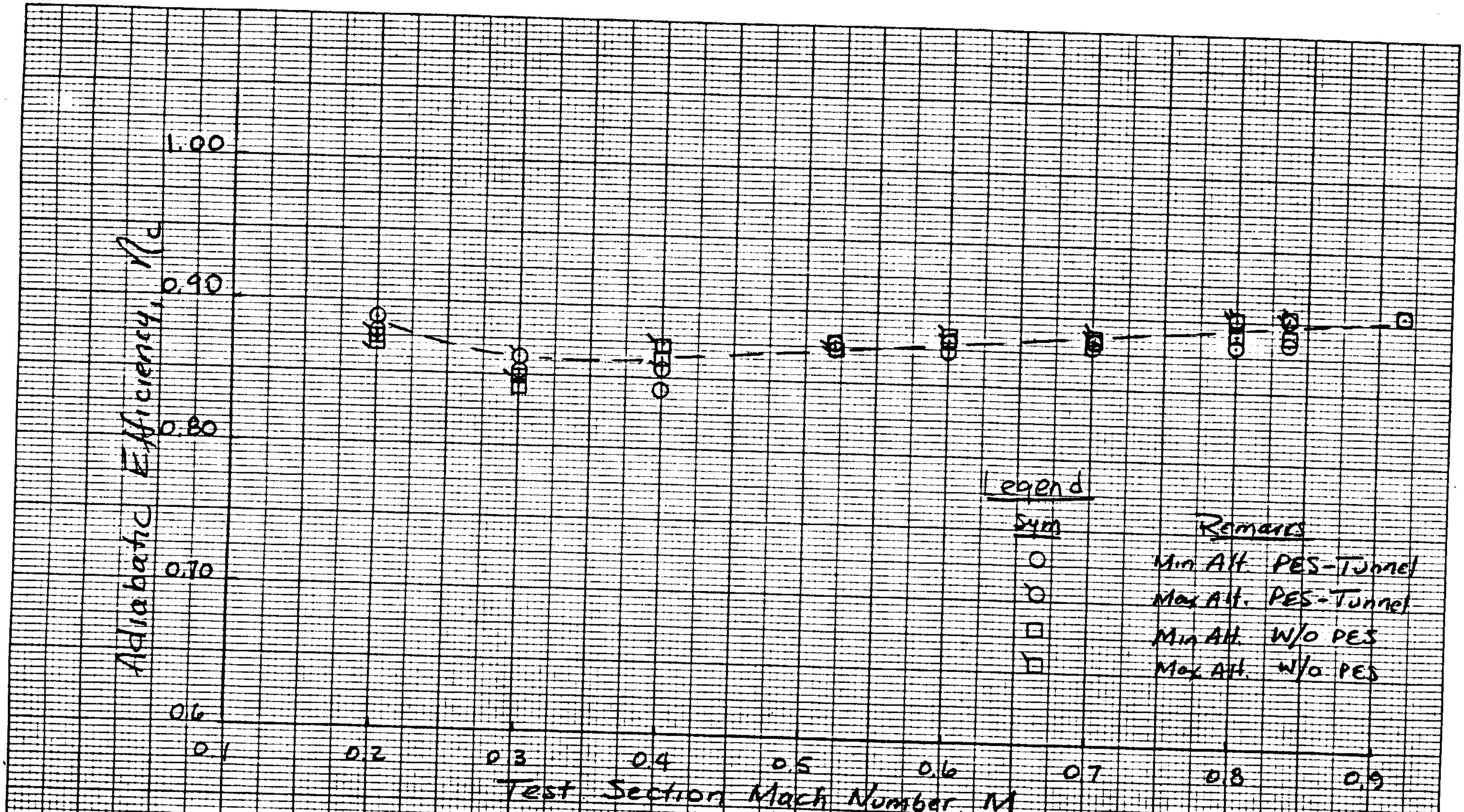
14C



ORIGINAL ADJUSTED RESISTANCE LINE
(Karabinus)
FAN PRESSURE RATIO, λ_C
1.28
1.24
1.20
1.16
1.12
1.08
1.04
1.00
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
CORRECTED WEIGHT FLOW, $W\frac{\sqrt{\theta}}{\delta}$, LB/sec
M=1.0
0.916
0.8
DSMA
0.7
ADJUSTED RESISTANCE LINE
0.6
0.52
0.4
0.3
0.2
0.1


PES-Tunnel With
6% Model CW &
K3 Mod B Cooler
Legend
Sym. Remarks
Min Alt Main Drive
Max " " "
Min Alt Total
Max " "
Shaft Input Power, HP
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Test Section Mach Number, M
MWO
3/17/84

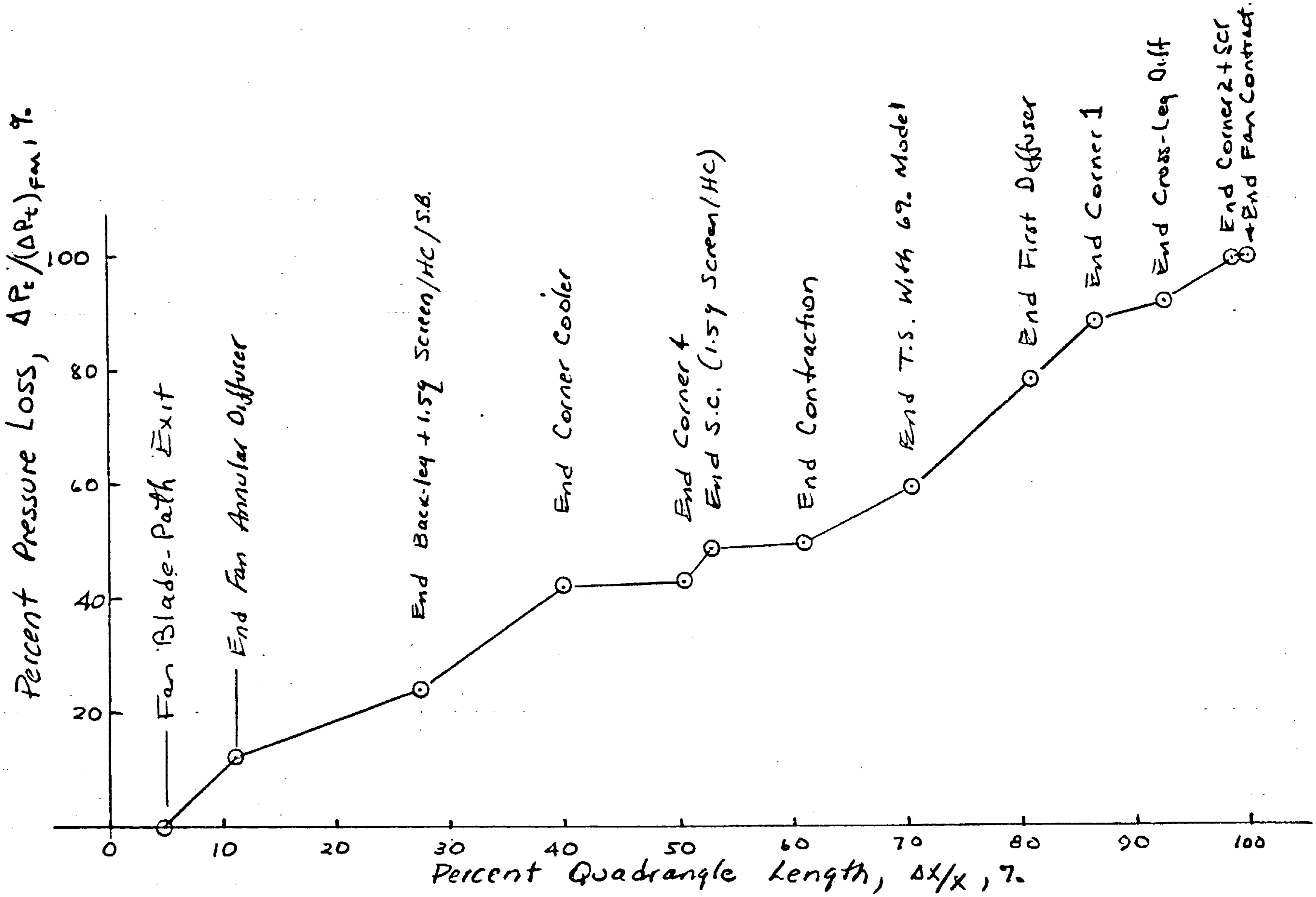

Baseline-Tunnel (W/o PES) With
6% Model CW E
K3 Mod B Cooler
Legend:
Sym
Remarks
Min Altitude
Max Altitude
Shaft Input Power, HP
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Test Section Mach Number, M
MWO
3/17/84



Adiabatic Efficiency Locii For Two Tunnels

(Main Drive Compressor Match)

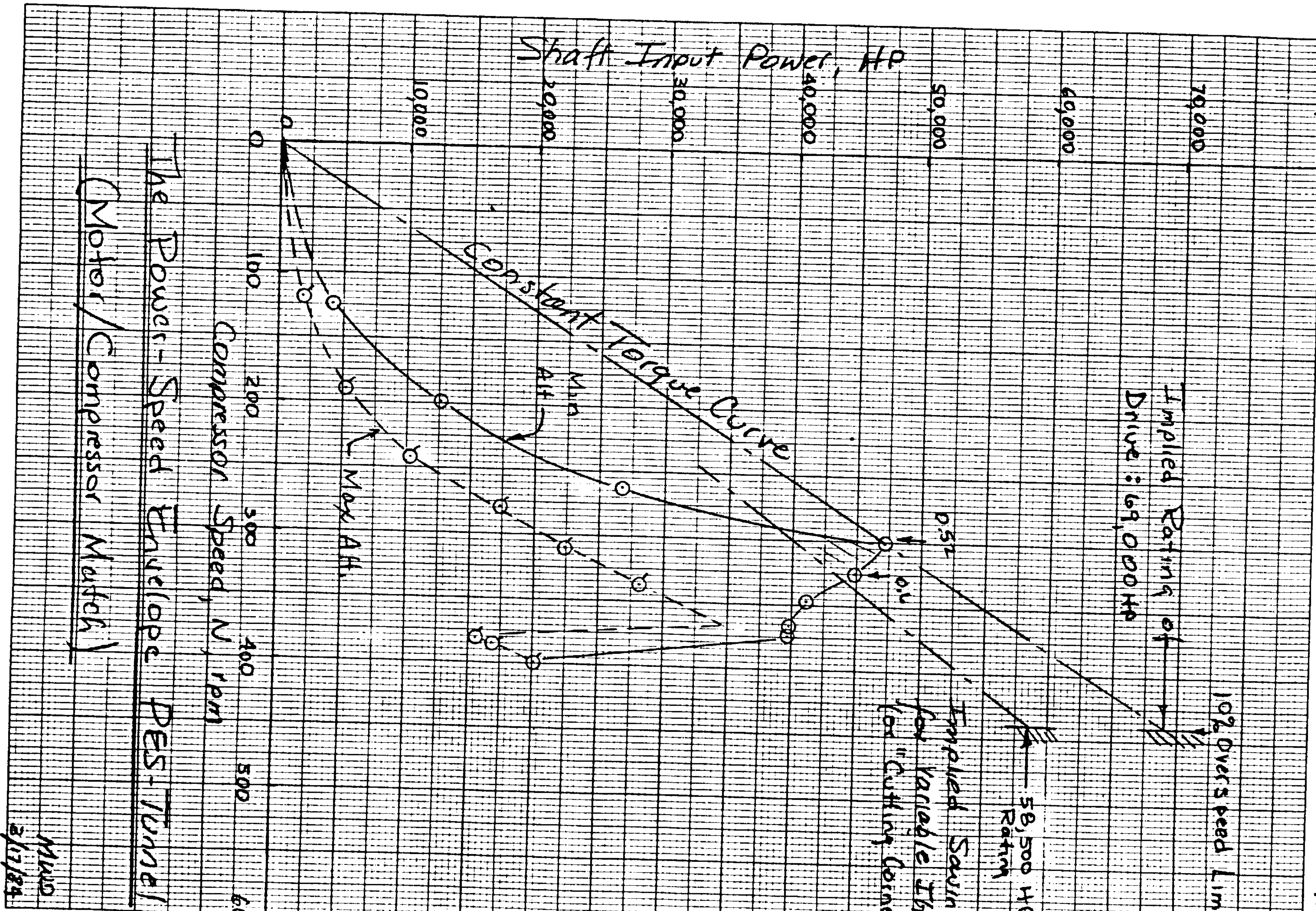
MWD
3/17/84



PES-Tunnel, M=0.8, Z_p = 32,000 ft

Ducting Pressure Loss Build-Up. With K3 Mod B Cooler & Alternate ¢ Scoop With Tip

MWD
3/19/84



Shaft Input Power, HP
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
Constant Torque Curve
Min Alt.
Max Alt.
0.52
.61
Implied Rating of Drive: 69,000 HP
10% Overspeed Limit
58,500 HP Rating
Implied Saving for Variable IGV; (or "Cutting Corners")
0
100
200
300
400
500
600
Compressor Speed, N, rpm
The Power-Speed Envelope PES-Tunnel
(Motor/Compressor Match)
MWD
2/17/84

314

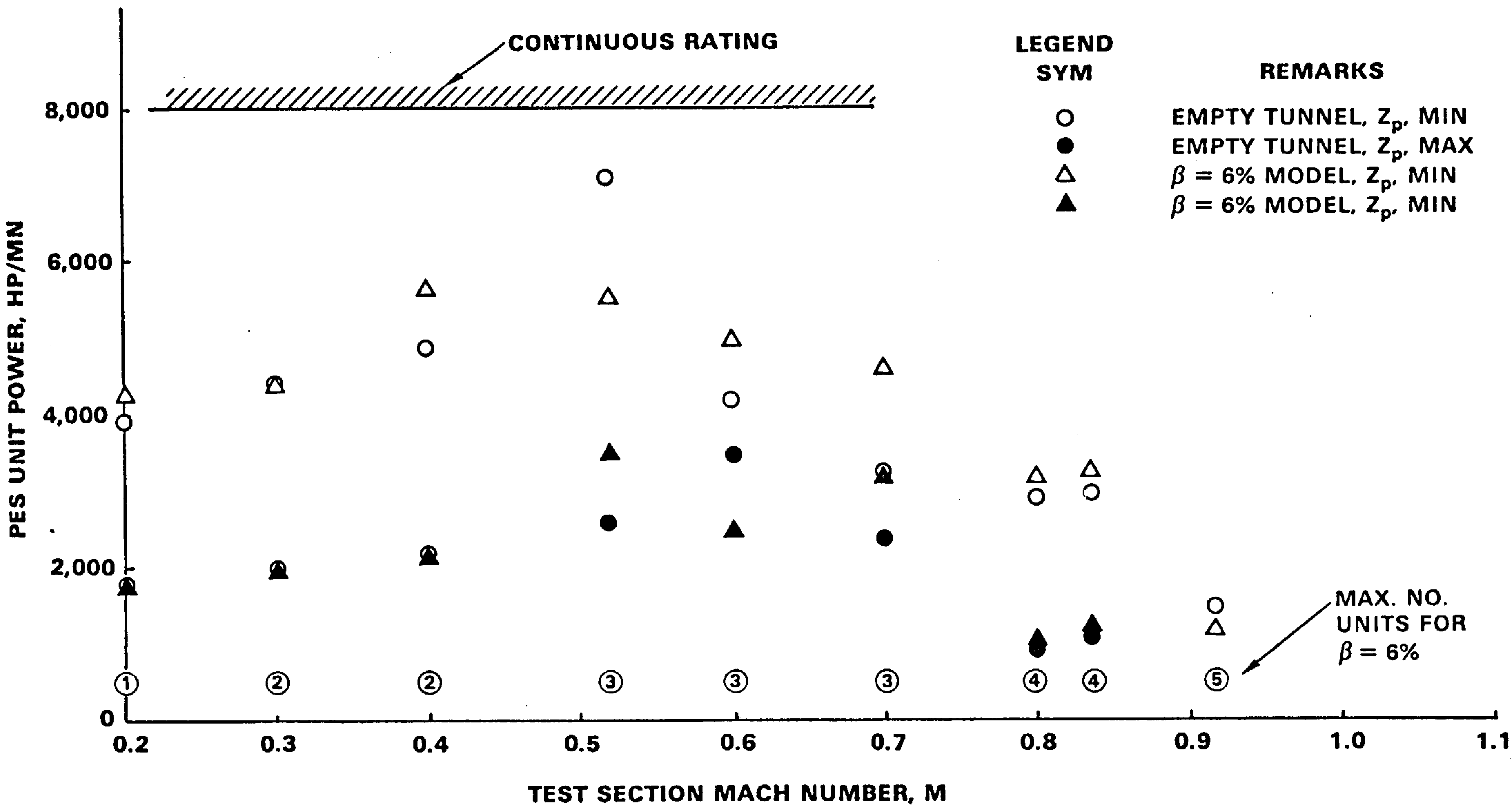


FIGURE 3. AWT-PES UNIT COMPRESSOR POWER FOR VARIOUS TEST CONDITIONS, DRY AIR W/O INLET HEATING

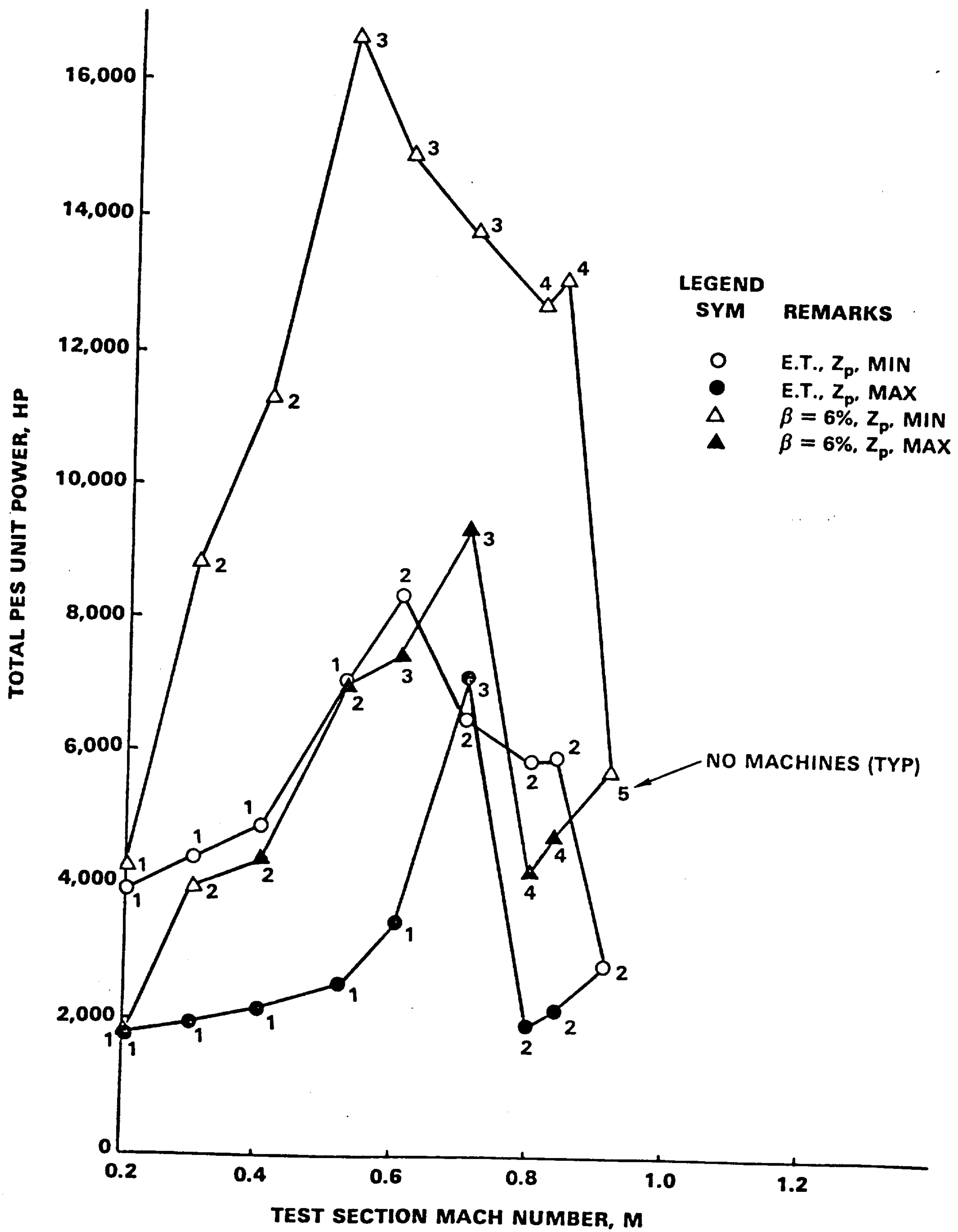
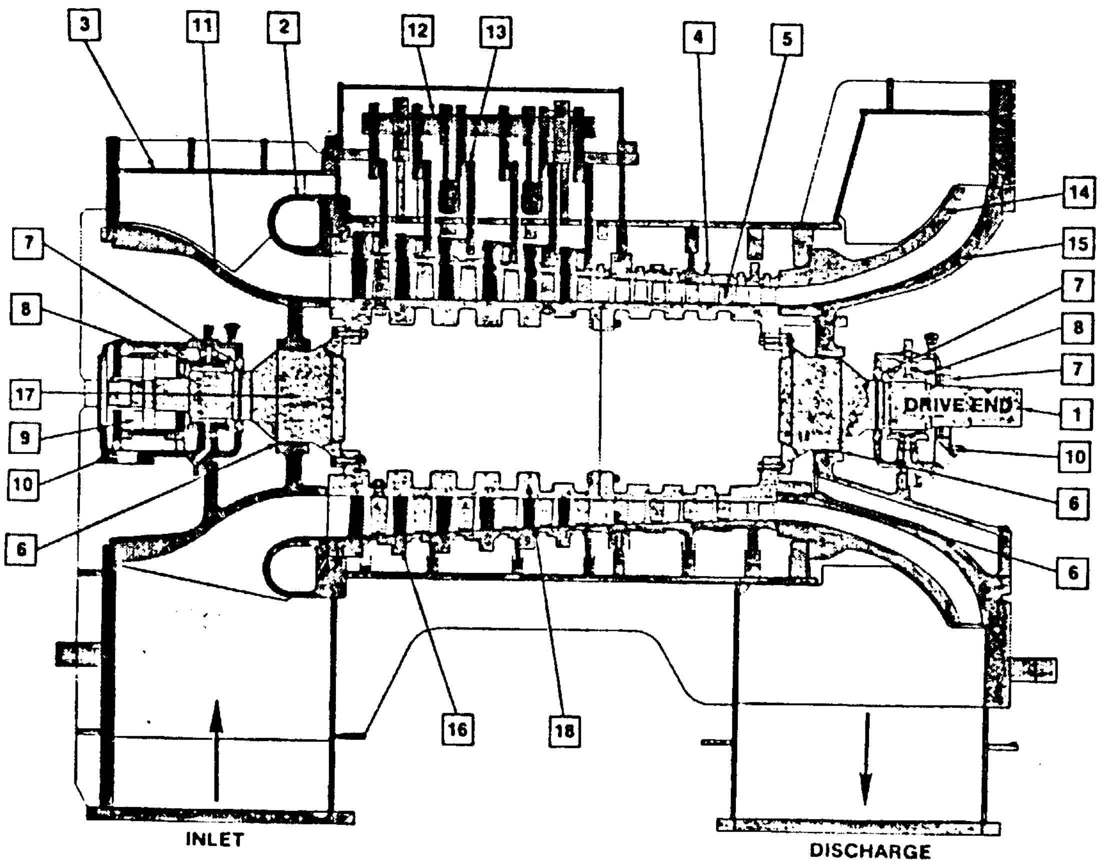


FIGURE 4. AWT-PES TOTAL COMPRESSOR POWER FOR VARIOUS TEST CONDITIONS, DRY AIR

construction features



1. Compressor Rotor Assembly
2. Fairing Ring
3. Casing
4. Stator Blading
5. Rotor Blading
6. Shaft Sealing "J-Strips"
7. Oil Baffle
8. Load Bearing
9. Thrust Bearing
10. Bearing Housing
11. Inlet End Bell
12. Operating Shaft
13. Movable Guide Vane Mech.
14. Diffuser
15. Disch. End Bell
16. Stator
17. Rotor Stub
18. Rotor Body

FIGURE 9. CONSTRUCTION FEATURES OF AN ALLIS-CHAMBERS 1410

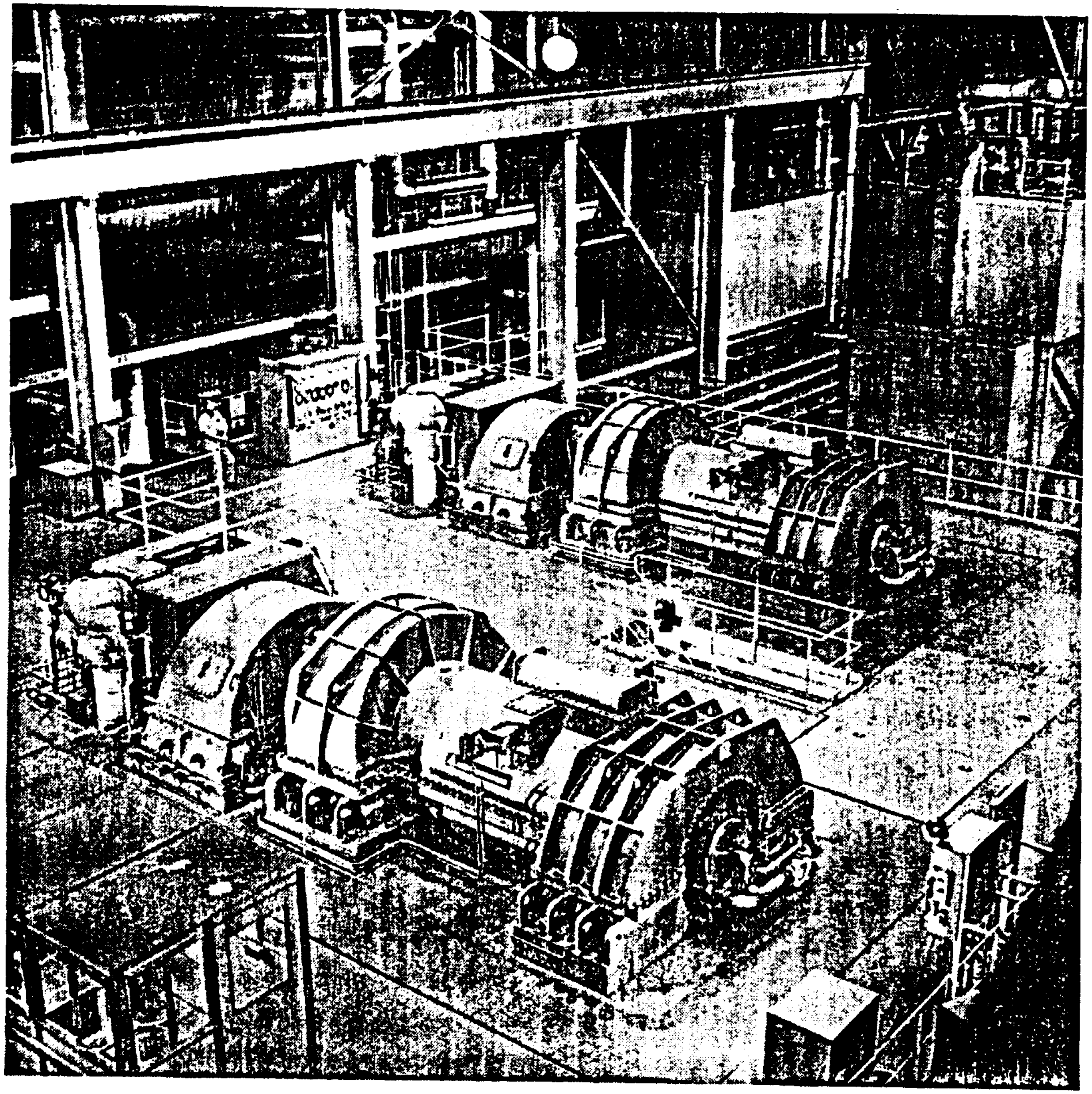


FIGURE 10. THE MAINTENANCE ADVANTAGE FOR A MEZZANINE LAYOUT OF AC 1410 MACHINES

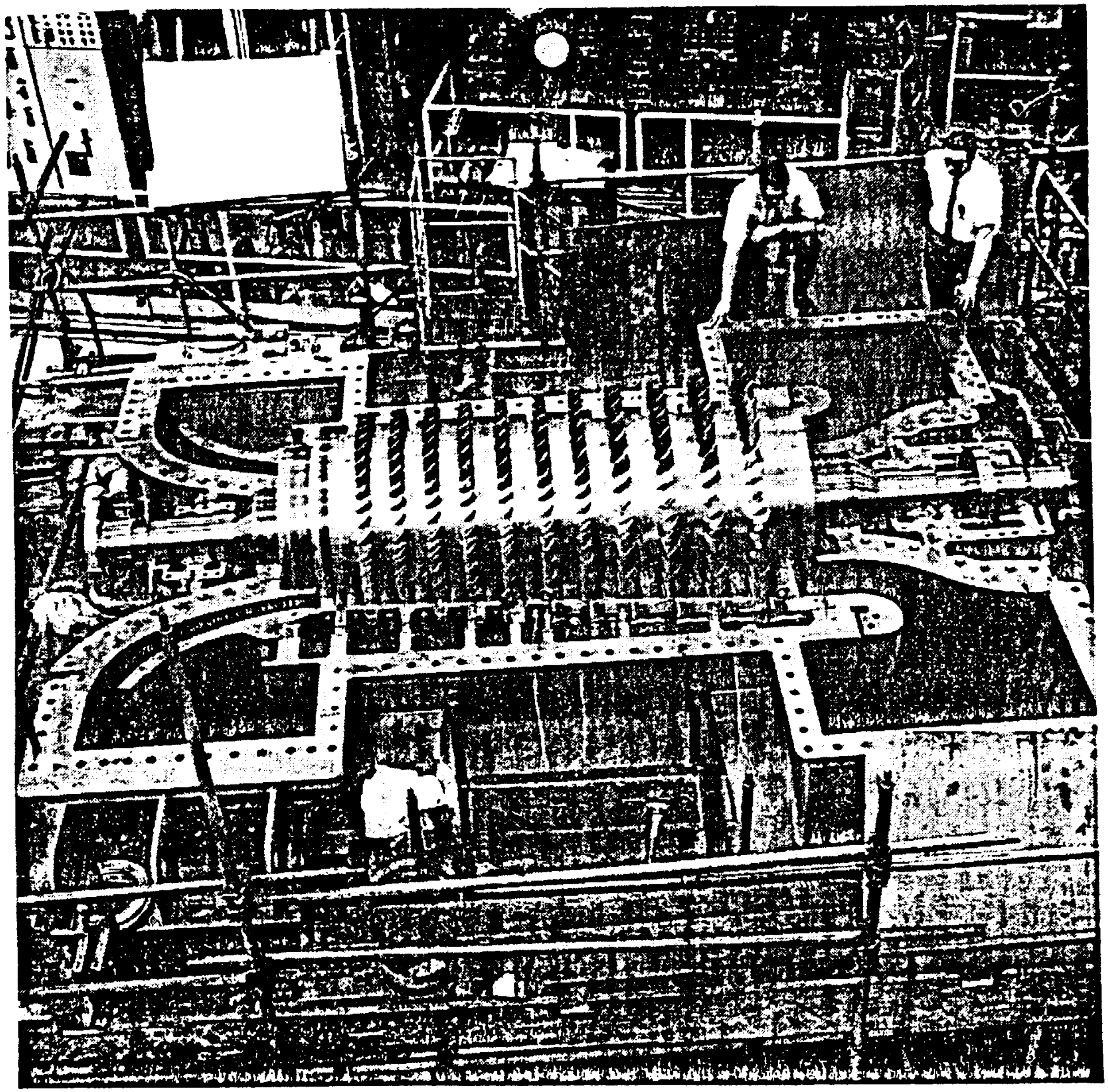
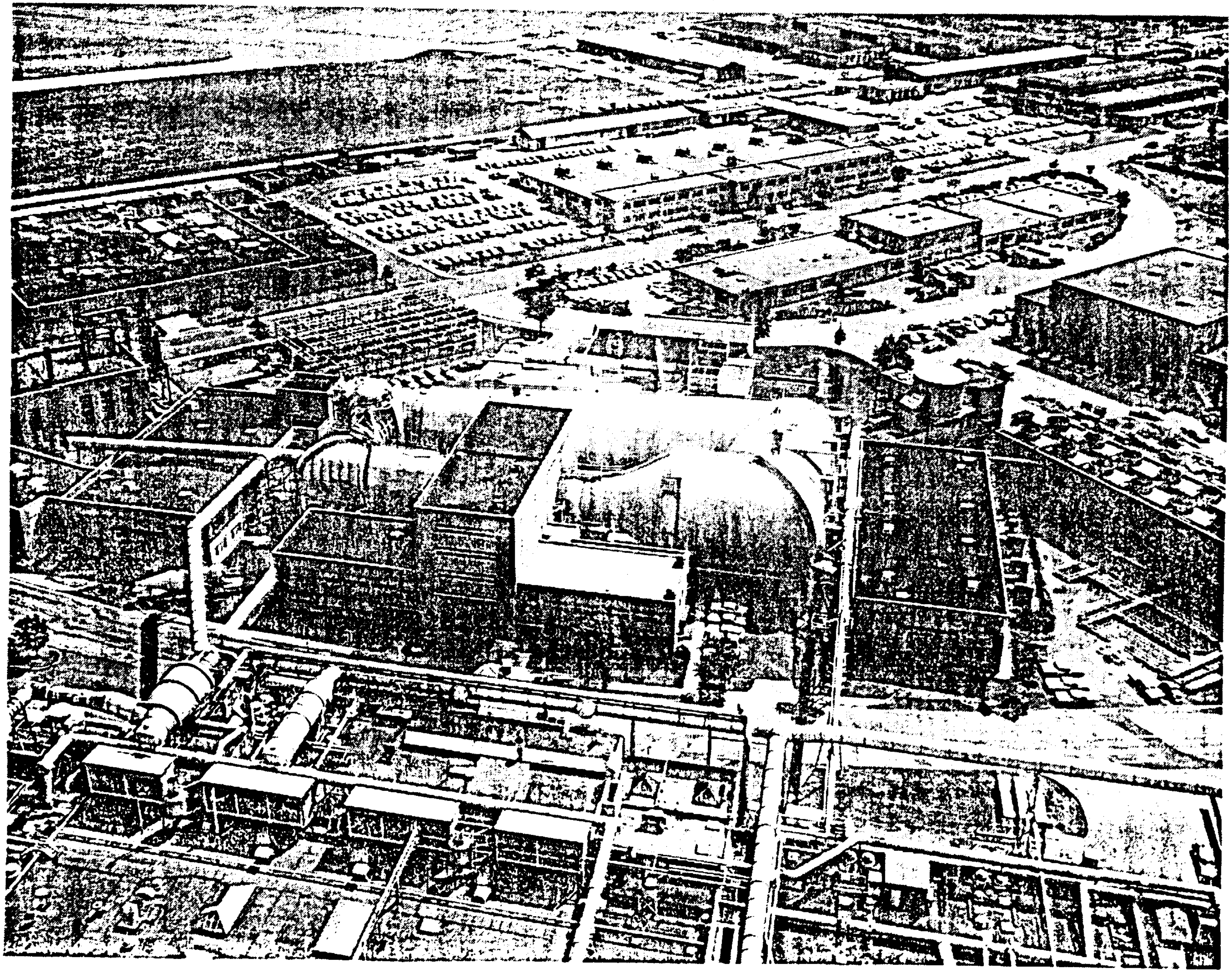
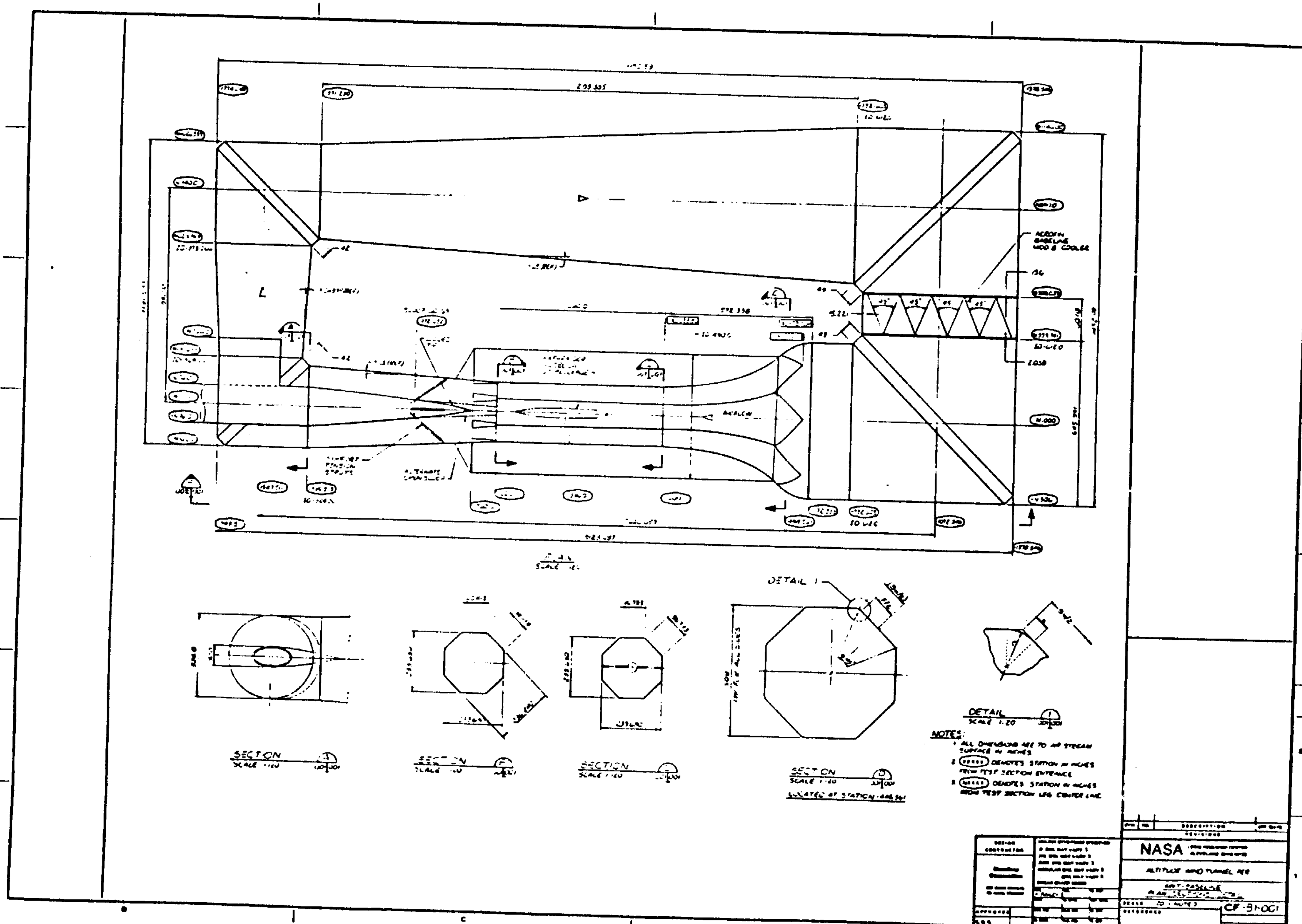


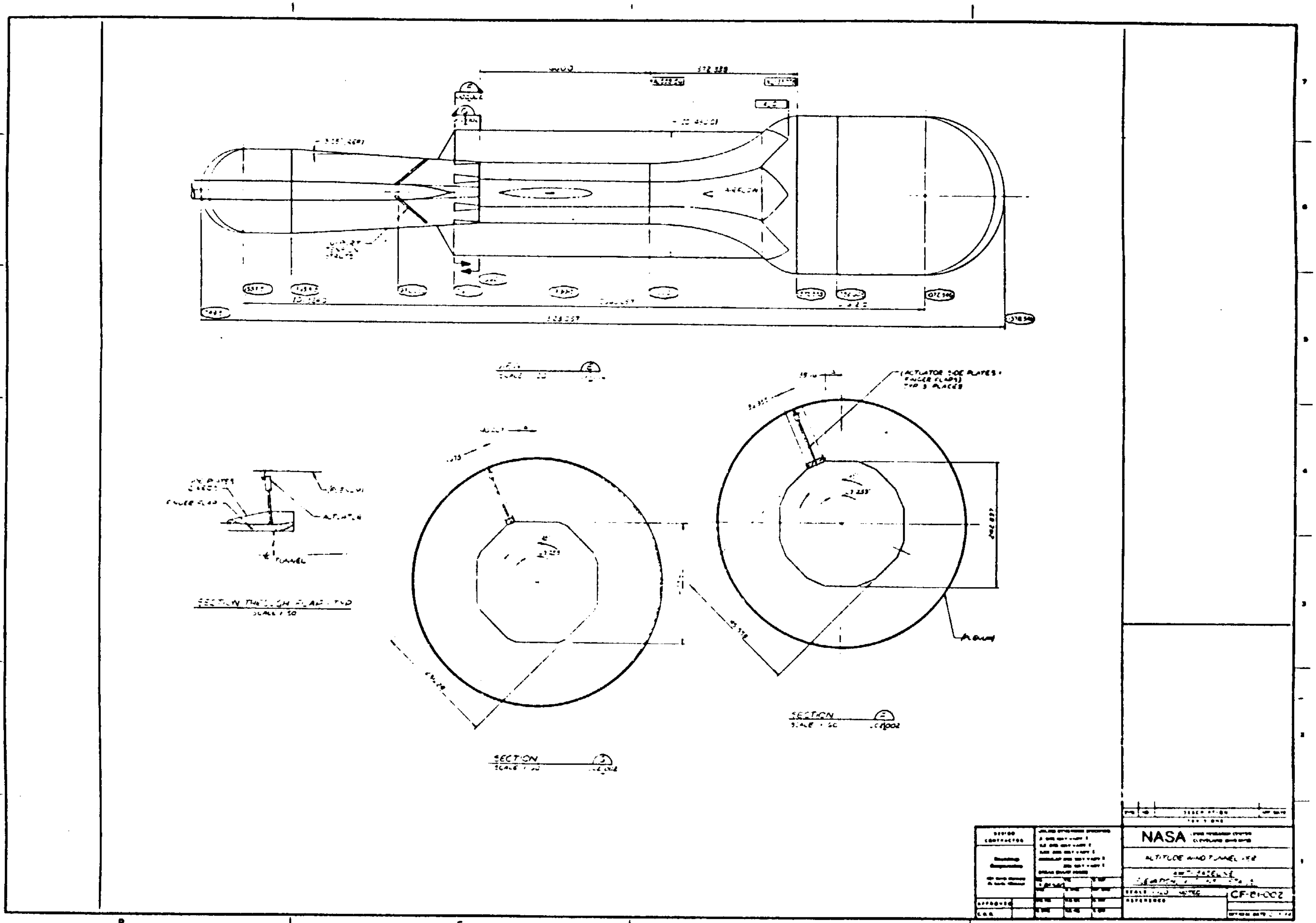
FIGURE 11. THE MAINTENANCE ADVANTAGE FOR A CASING WITH A HORIZONTAL SPLIT

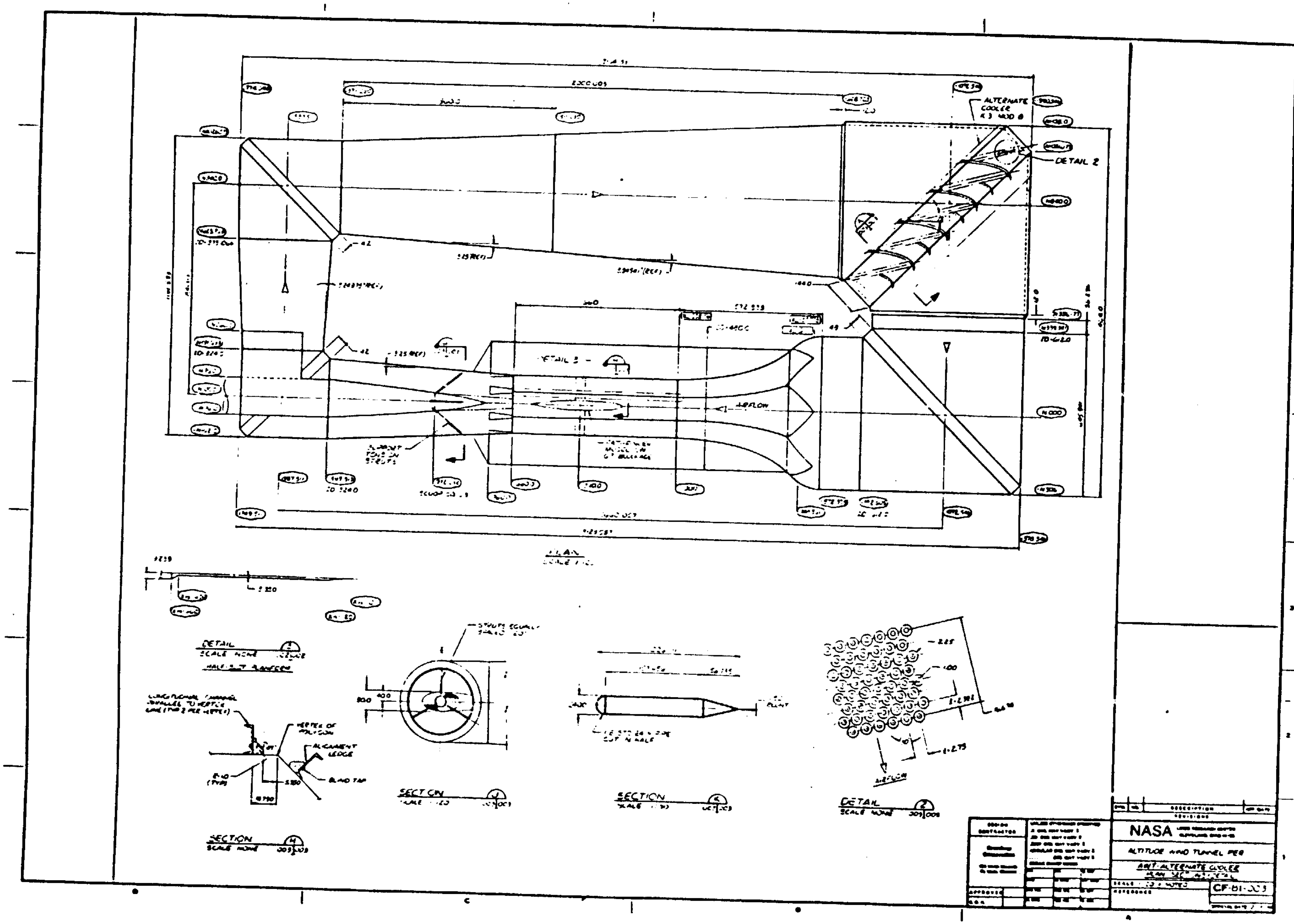
AIRLINE DEFINITION

- BASELINE SCAVENGING SCOOP
- AEROFIN BASELINE MOD B COOLER
- K3, MOD B COOLER




AIRFLOW
DETAIL 1
SECTION
SECTION
SECTION
SECTION
DETAIL
SCALE 1:20
NOTES:
1 ALL DIMENSIONS ARE TO AIR STREAM SURFACE IN INCHES
2 DENOTES STATION IN INCHES FROM TEST SECTION ENTRANCE
3 DENOTES STATION IN INCHES FROM TEST SECTION LEG CENTER LINE
NASA
ALTITUDE WIND TUNNEL
CF-91-001


AIRFLOW
(ACTUATOR SIDE PLATES + FINGER FLAPS) TYP 3 PLACES
FINGER FLAP
ACTUATOR
TUNNEL
SECTION THROUGH FLAPS - TYP
SECTION
SECTION
AIRFLOW
NASA
ALTITUDE WIND TUNNEL
CF-81-002



ALTERNATE COOLER
DETAIL 2
DETAIL 3
AIRFLOW
PLAN
DETAIL
SCALE NONE
SECTION
SECTION
SECTION
DETAIL
SCALE NONE
NASA
ALTITUDE WIND TUNNEL PEB
AWT-ALTERNATE COOLER
CF-81-303

CONTRACTION GEOMETRY AND CODE ANALYSIS

TWO CONTRACTIONS WERE DESIGNED FOR AWT USING THE "MODIFIED SINE-LAW" APPROACH WITH BOUNDARY CONDITIONS, AS FOLLOWS:

- MOD A WAS CHOSEN TO BE 9.3786 FT. SHORTER THAN THE ORIGINAL AWT CONTRACTION
- MOD B WAS CHOSEN TO BE 15.0074 FT. SHORTER THAN THE ORIGINAL AWT CONTRACTION
- VNAP CODE RESULTS

MOD A. (9.3786 FT. SHORTER THAN ORIGINAL)

LAST HONEYCOMB/SCREEN, $\Delta X/D_{H,I}$	0.25		0.175		0.100	
	VEL fps.	% DEV.	VEL fps.	% DEV.	VEL fps.	% DEV.
WALL	793.97	+1.11	796.67	+1.24	796.37	+1.44
℄	780.27	-0.53	781.61	-0.68	778.93	-0.78
AVG.	785.25		786.95		785.07	
TOTAL DEV		1.74		1.92		2.22

MOD B. (15.0074 FT. SHORTER THAN ORIGINAL)

LAST HONEYCOMB/SCREEN, $\Delta X/D_{H,i}$	0.25		0.174		0.100	
	VEL fps.	% DEV.	VEL fps.	% DEV.	VEL fps.	% DEV.
WALL	800.58	+1.34	788.10	+0.55	794.95	+1.25
℄	791.94	+0.25	773.76	-1.18	779.03	-0.78
℄ + 30	779.94	-1.27				
AVG.	789.99		782.96		795.15	
TOTAL DEV		2.61		1.84		2.03

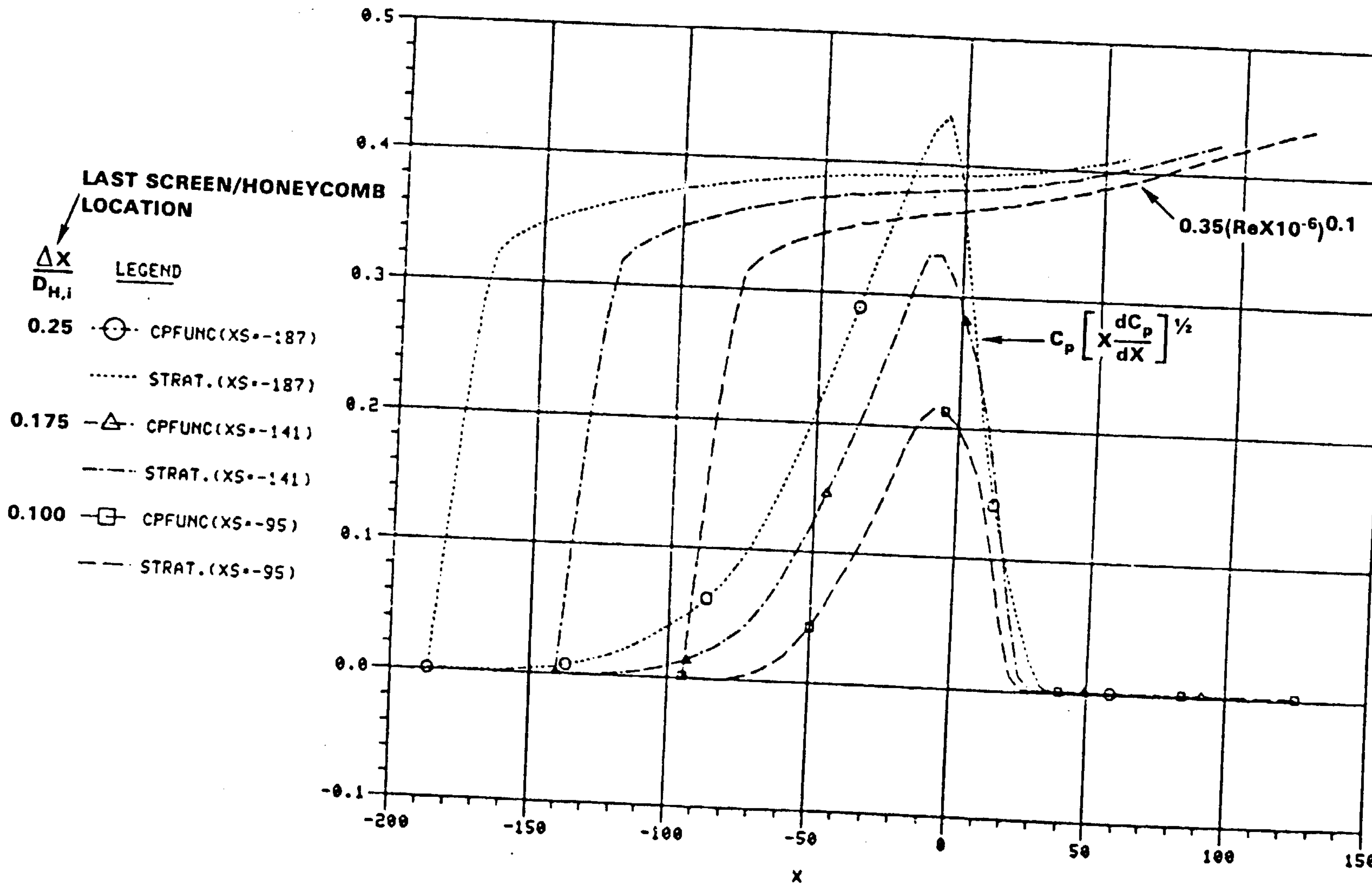


FIGURE 1. CHECK OF MOD A CONTRACTION FOR INLET FLOW SEPARATION (CONTRACTION 9.3786 FT. SHORTER)

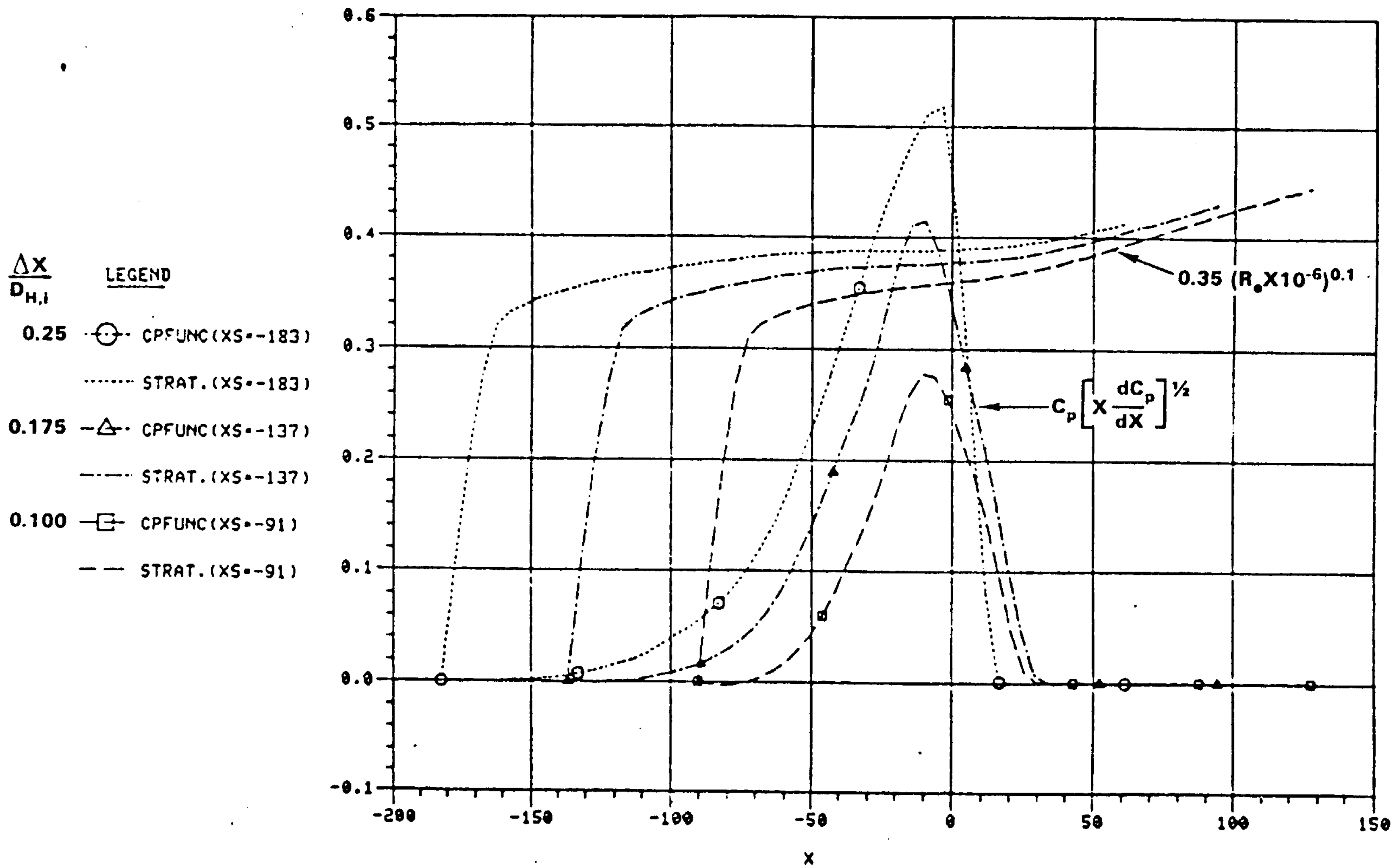


FIGURE 2. CHECK OF MOD B CONTRACTION FOR INLET FLOW SEPARATION (CONTRACTION 15.0074 FT. SHORTER)

CONTRACTION ANALYSIS (Concluded)

- INCOMPRESSIBLE FLOW CODE RESULTS

MOD A (9.3796 FT. SHORTER THAN ORIGINAL)

	V/V_{sc}	% DEV.	WITH 10-FT. EXTENSION V/V_{sc}	% DEV.
WALL	6.556	+0.82	6.504	+0.02
℄	6.437	-1.01	6.500	-0.05
AVG.	6.503		6.503	
TOTAL DEV.		1.83		0.07

MOD B (15,0074 FT. SHORTER THAN ORIGINAL)

	V/V_{sc}	% DEV.	V/V_{sc}	% DEV.
WALL	6.580	1.18	6.504	+0.02
℄	6.414	-1.37	6.499	-0.06
AVG.	6.503		6.503	
TOTAL DEV.		2.55		0.08

- RECOMMEND MOD A WITH REMOVABLE SCREEN/HONEYCOMB SECTION

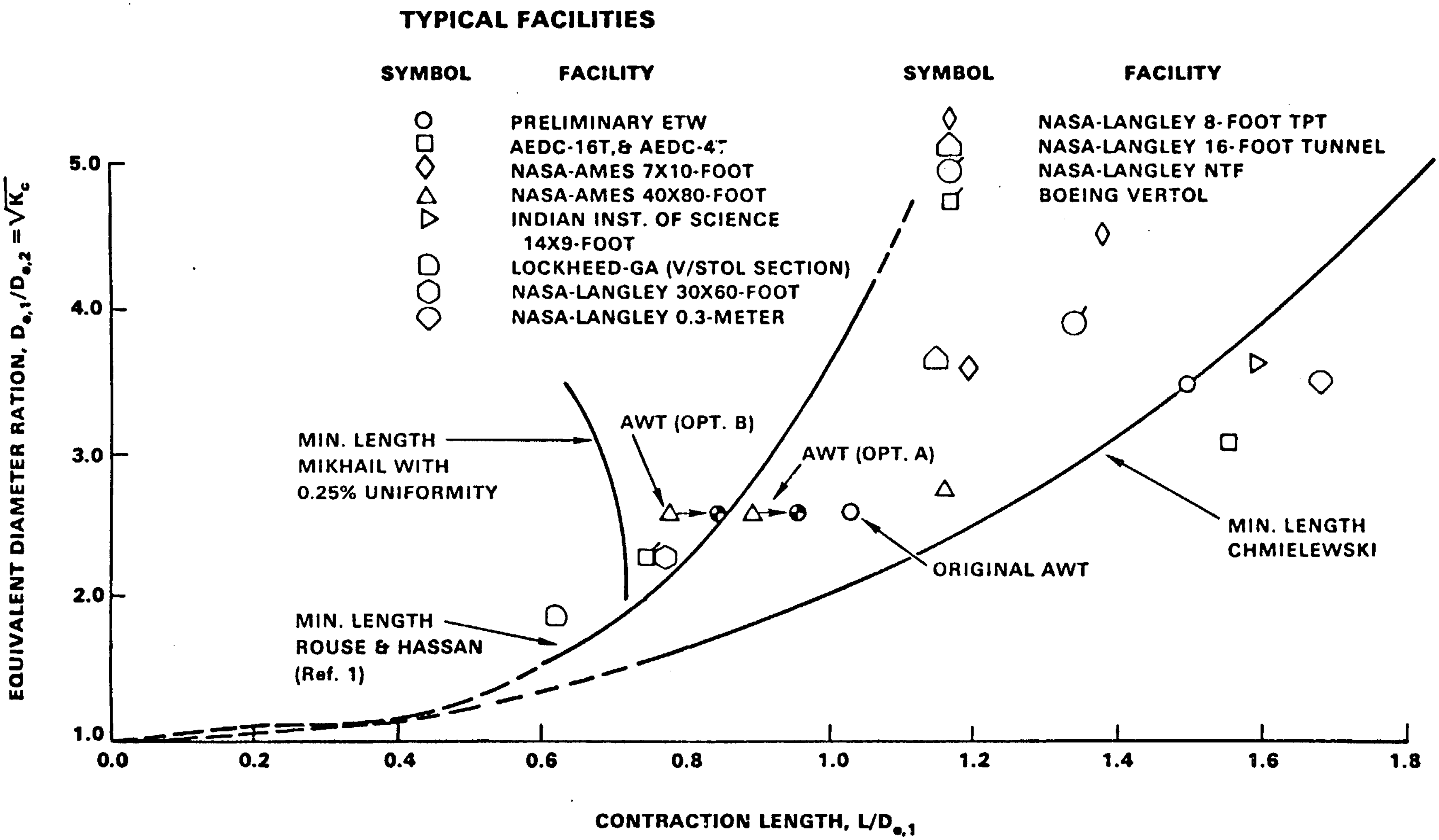


FIGURE 3. SIMPLIFIED CONTRACTION LENGTH DESIGN CURVES COMPARED TO SOME TYPICAL FACILITIES

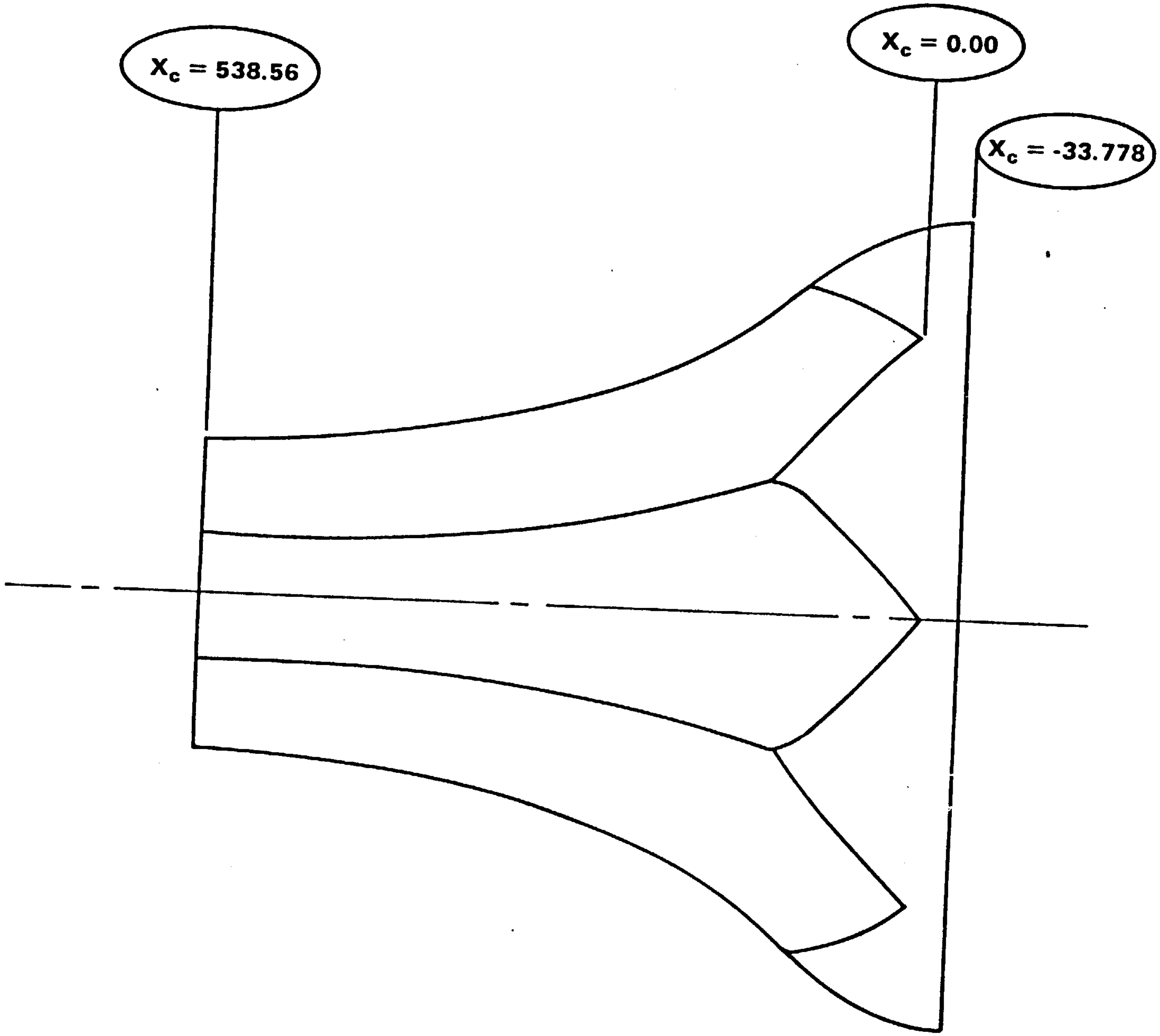
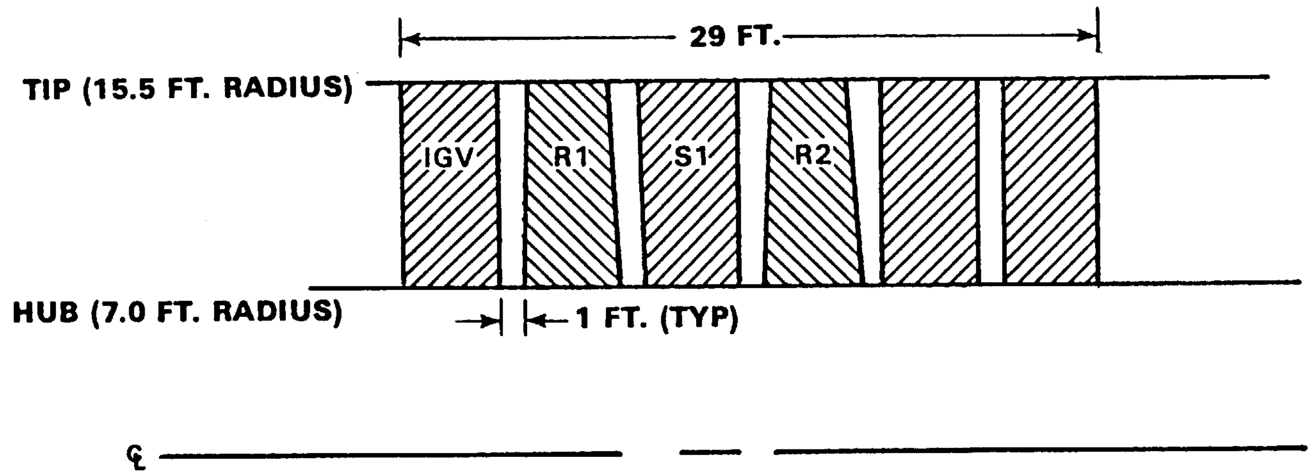


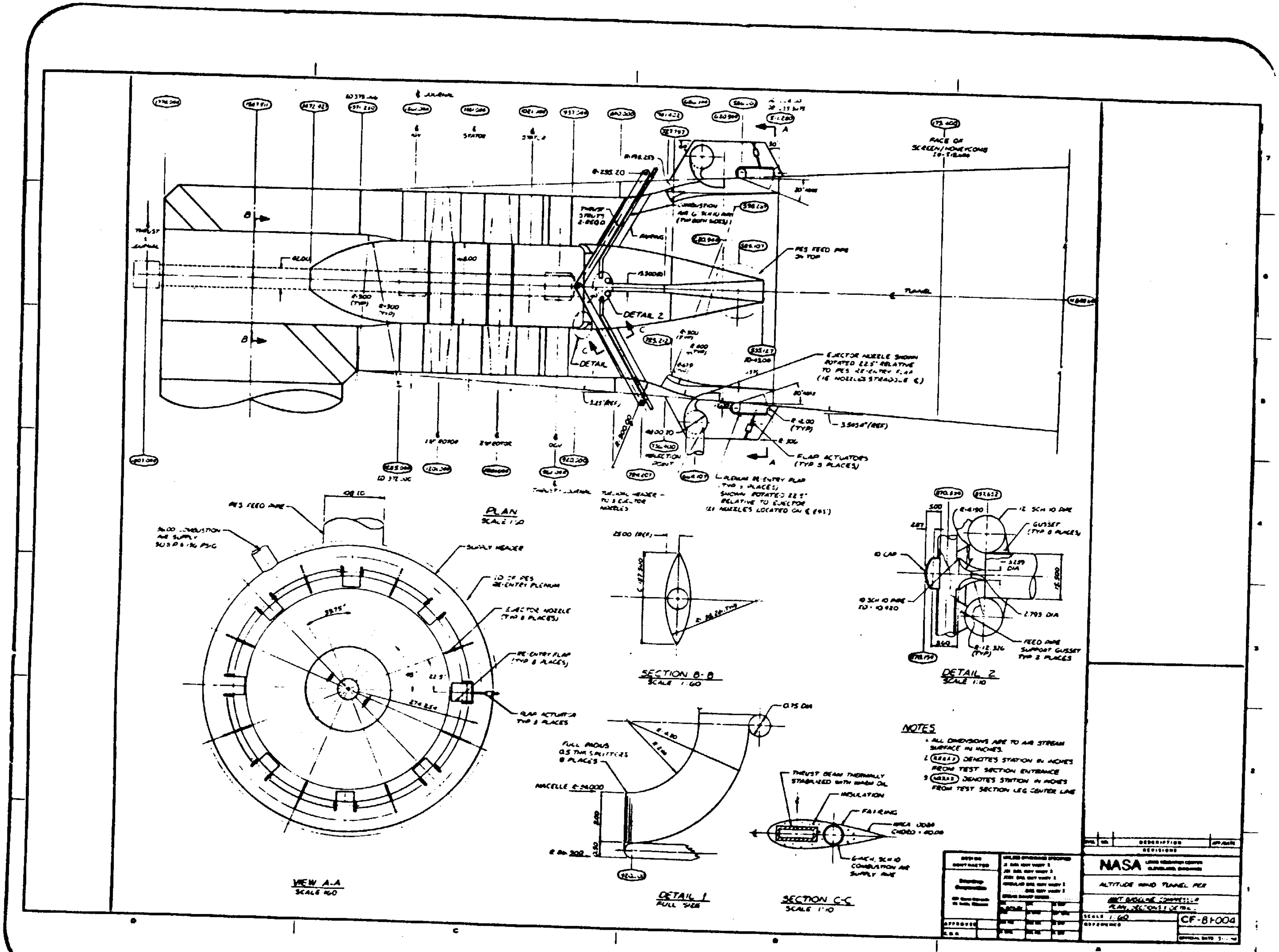
FIGURE 4. SCALE ELEVATION OF MOD A, AWT CONTRACTION

TABLE 1. AWT COMPRESSOR BLADE PATH BASELINE SPATIAL GEOMETRY

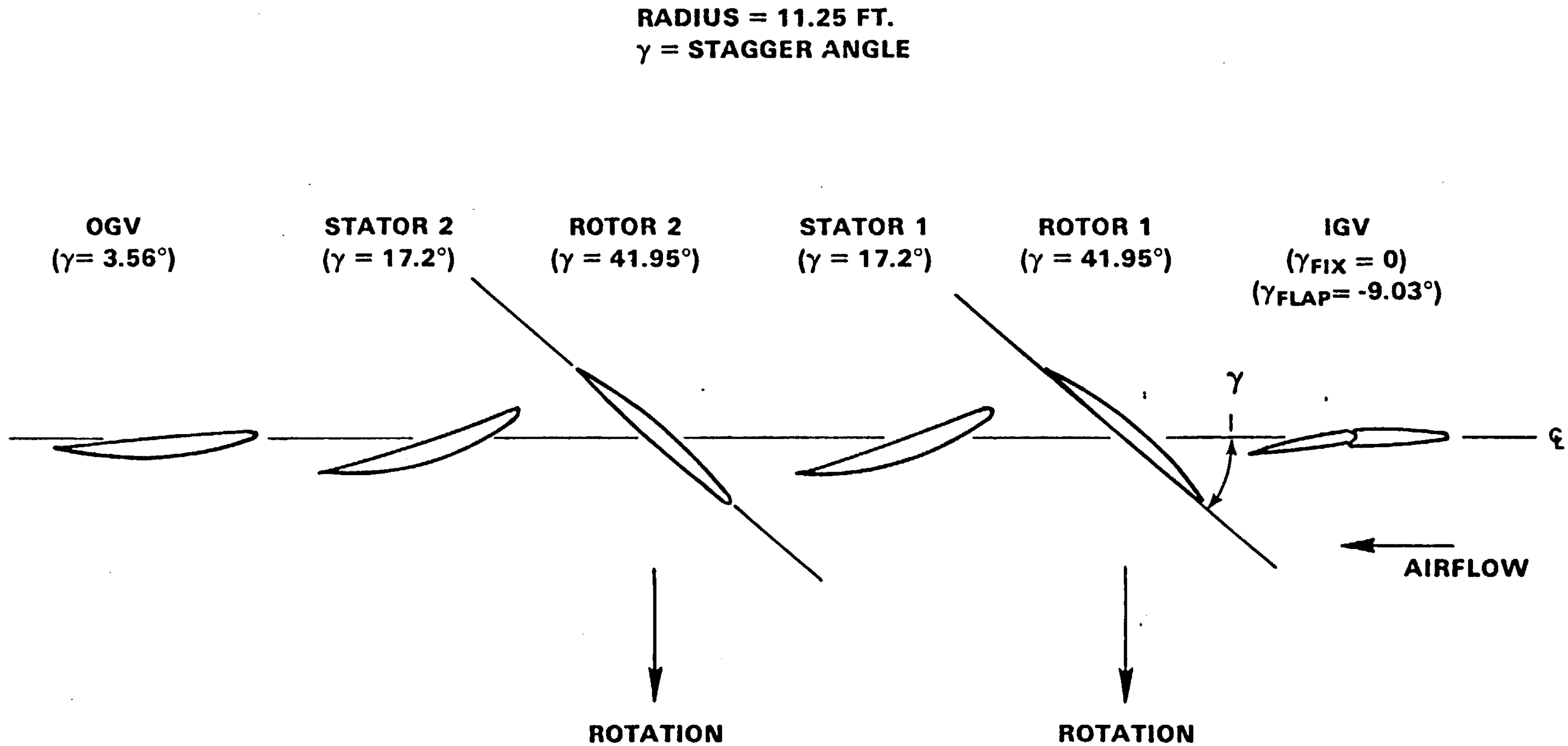
CHORD	ROTOR	IGV, STATORS, OGV
HUB	4.0 FT	4.0 FT
TIP	3.0 FT	4.0 FT

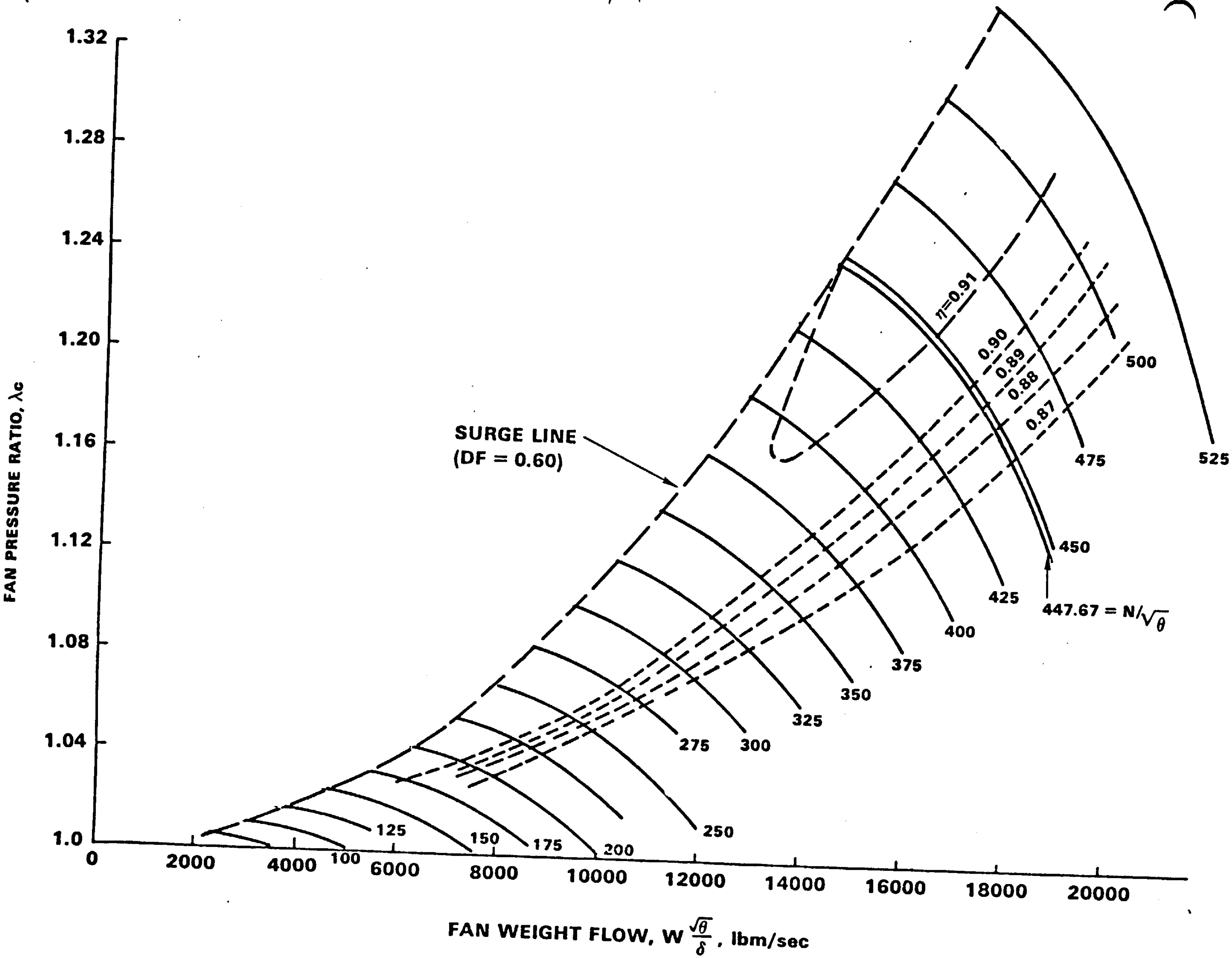


BLADE ROW	NO. OF BLADES	BLADE AIRFOIL SECIONS (CIRCULAR ARC MEANLINE)	
IGV	12	HUB: SvT MOD 65A010	TIP: SvT MOD 65A010
R1	17	SvT MOD 65A012	SvT MOD 65A006
S1	24	SvT MOD 65A010	SvT MOD 65A010
R1	17	SvT MOD 65A012	SvT MOD 65A006
S1	24	SvT MOD 65A010	SvT MOD 65A010
OGV	24	SvT MOD 65A010	SvT MOD 65A010


PLAN
SCALE 1:60
PES FEED PIPE
SUPPLY HEADER
EJECTOR NOZZLE (TYP 8 PLACES)
RE-ENTRY FLAP (TYP 8 PLACES)
FLAP ACTUATORS (TYP 3 PLACES)
DETAIL 2
SECTION B-B
SCALE 1:60
DETAIL 2
SCALE 1:10
VIEW A-A
SCALE 1:60
DETAIL 1
FULL SIZE
SECTION C-C
SCALE 1:10
FAIRING
INSULATION
NOTES
1. ALL DIMENSIONS ARE TO AIR STREAM SURFACE IN INCHES.
2. DENOTES STATION IN INCHES FROM TEST SECTION ENTRANCE
3. DENOTES STATION IN INCHES FROM TEST SECTION LEG CENTER LINE
NASA
ALTITUDE WIND TUNNEL PER
SCALE 1:60
CF-81-004

FAN BLADE PATH





1.32
1.28
1.24
1.20
1.16
1.12
1.08
1.04
1.0
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
FAN PRESSURE RATIO, λc
FAN WEIGHT FLOW, W √θ/δ, lbm/sec
SURGE LINE
(DF = 0.60)
η=0.91
0.90
0.89
0.88
0.87
100
125
150
175
200
250
275
300
325
350
375
400
425
450
447.67 = N/√θ
475
500
525

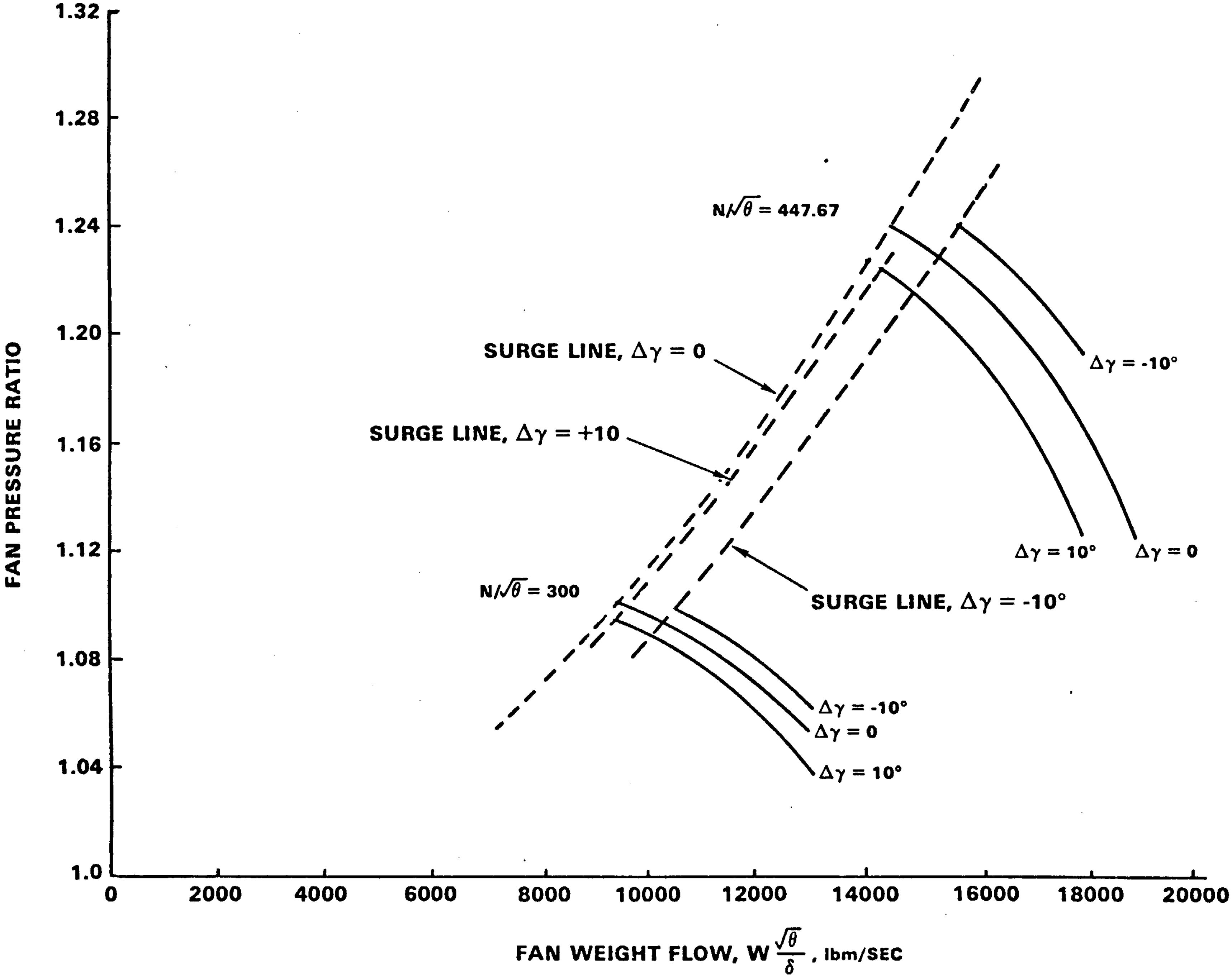


FIGURE 2. THE BASELINE AWT COMPRESSOR VARIABLE IGV CHARACTERICTICS

FAN ACOUSTIC PREDICTION METHOD

- BASED ON NASA TMX-71763
- CONSIDERS 1/3 OCTAVE BAND SPL
  - BROADBAND
  - DISCRETE TONE
  - COMBINATION TONE
- MODIFIED BOEING-AMES METHOD
- TONE CUT-OFF CRITERION INCLUDED
- CHARACTERISTIC 1/3 OCTAVE BAND SPL FOR SINGLE FAN STAGE:

$$L_c = F\left(\frac{\Delta T}{\Delta T_o}, \frac{\dot{m}}{\dot{m}_o}, M_{TR}, M_{TR_D}, RSS\right)$$

- SPL SPECTRUM:

$$SPL\ (f) = L_c + F\left(\frac{f}{f_b}\right)$$

- CORRECTION FOR INLET GUIDE VANES
- BASED ON DATA FOR 8 FULL-SCALE SINGLE-STAGE NASA-LEWIS FANS

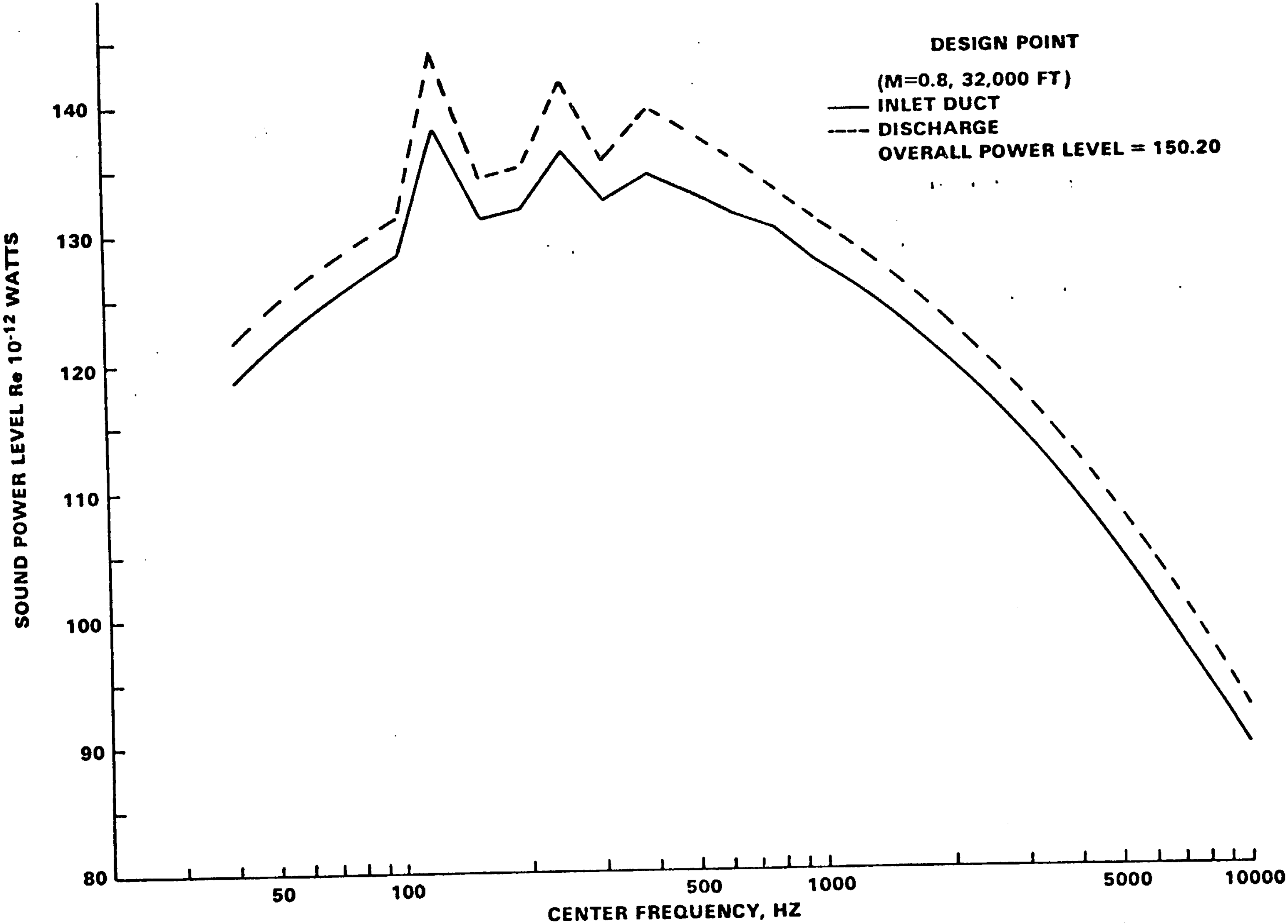


FIGURE 3. BASELINE AWT COMPRESSOR SOUND POWER SPECTRA
FOR THE DESIGN POINT

42

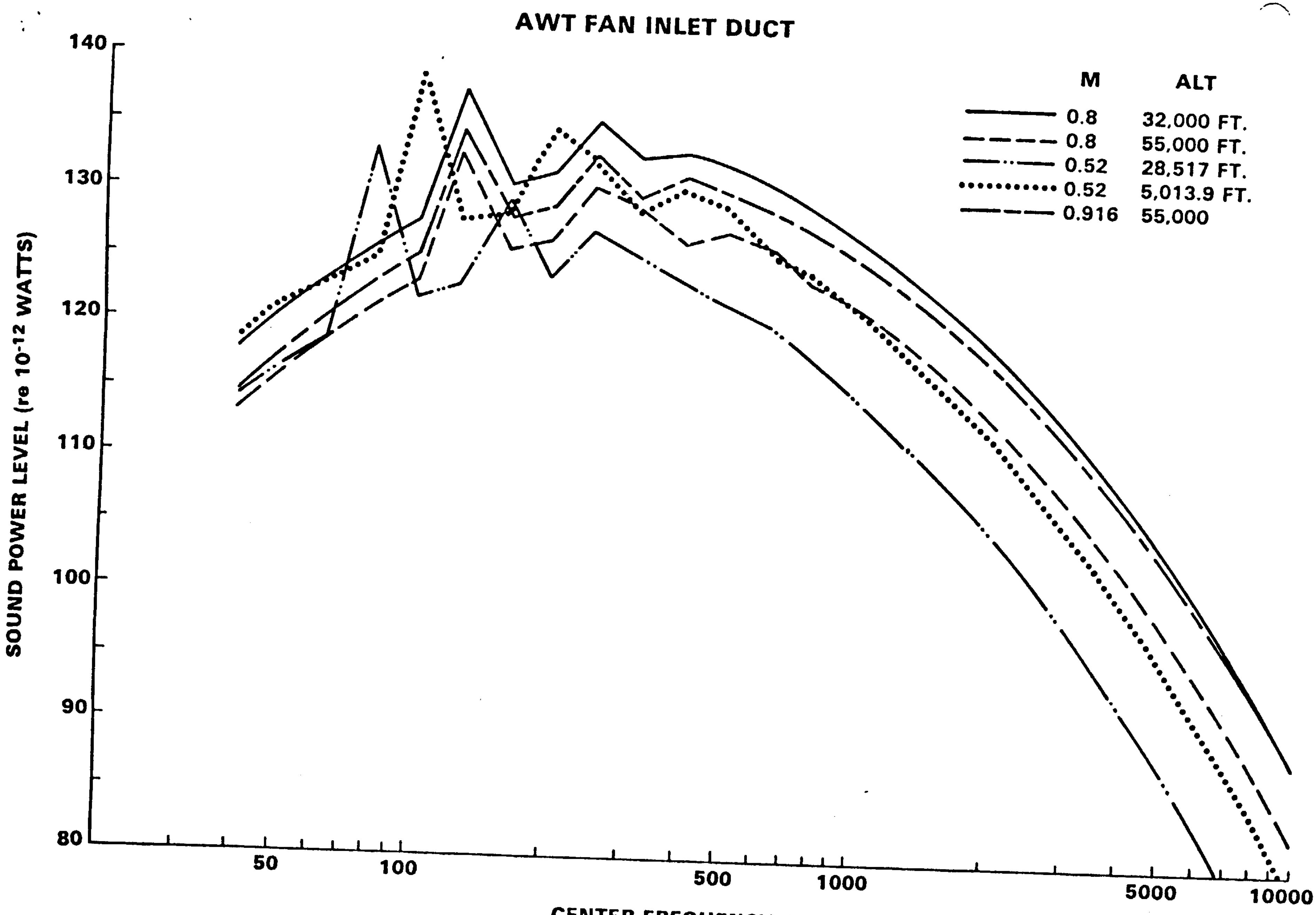


FIGURE 4. BASELINE AWT COMPRESSOR SOUND POWER SPECTRA AT THE MACHINE INLET FOR REPRESENTATIVE TEST CONDITIONS

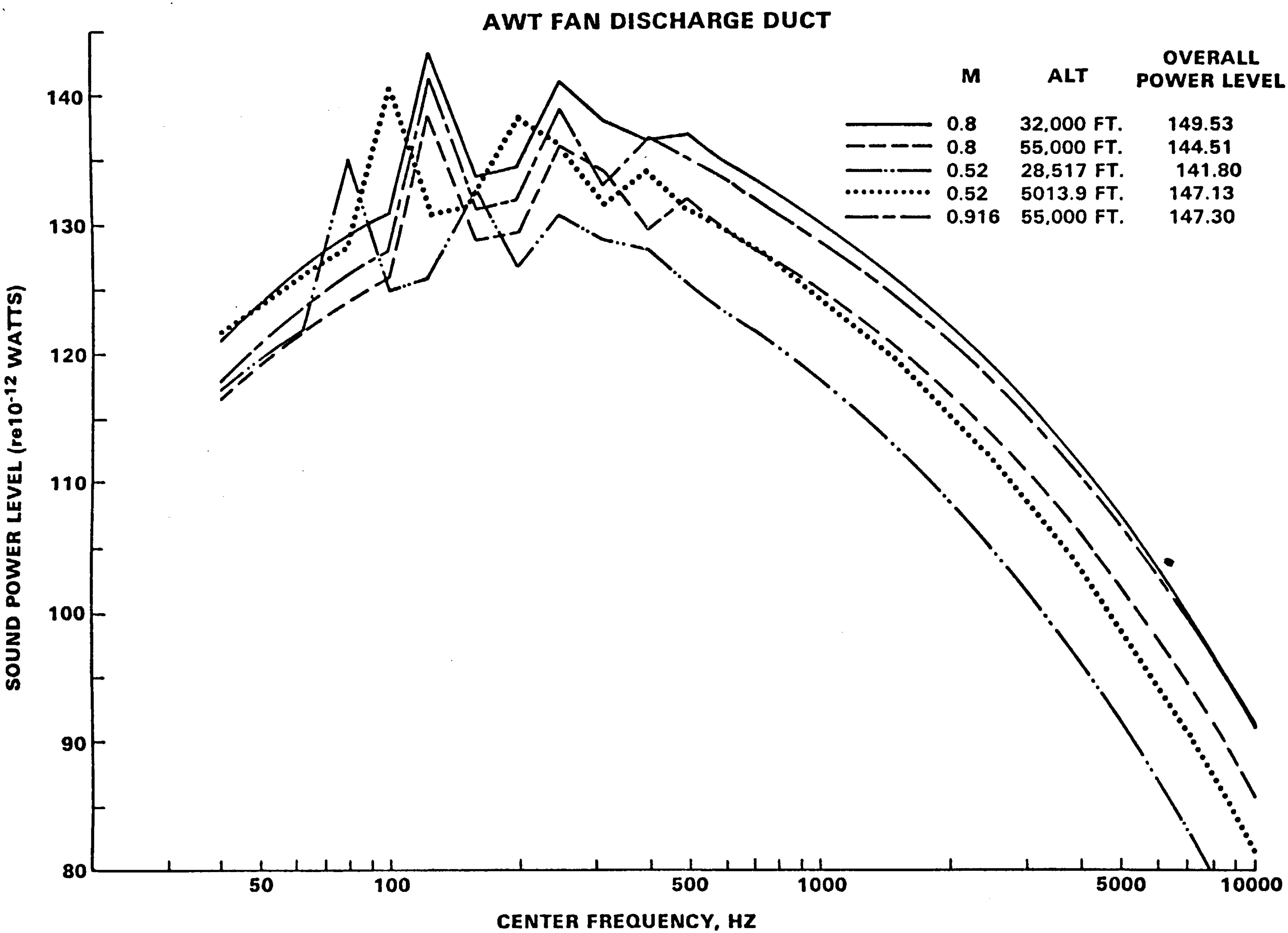
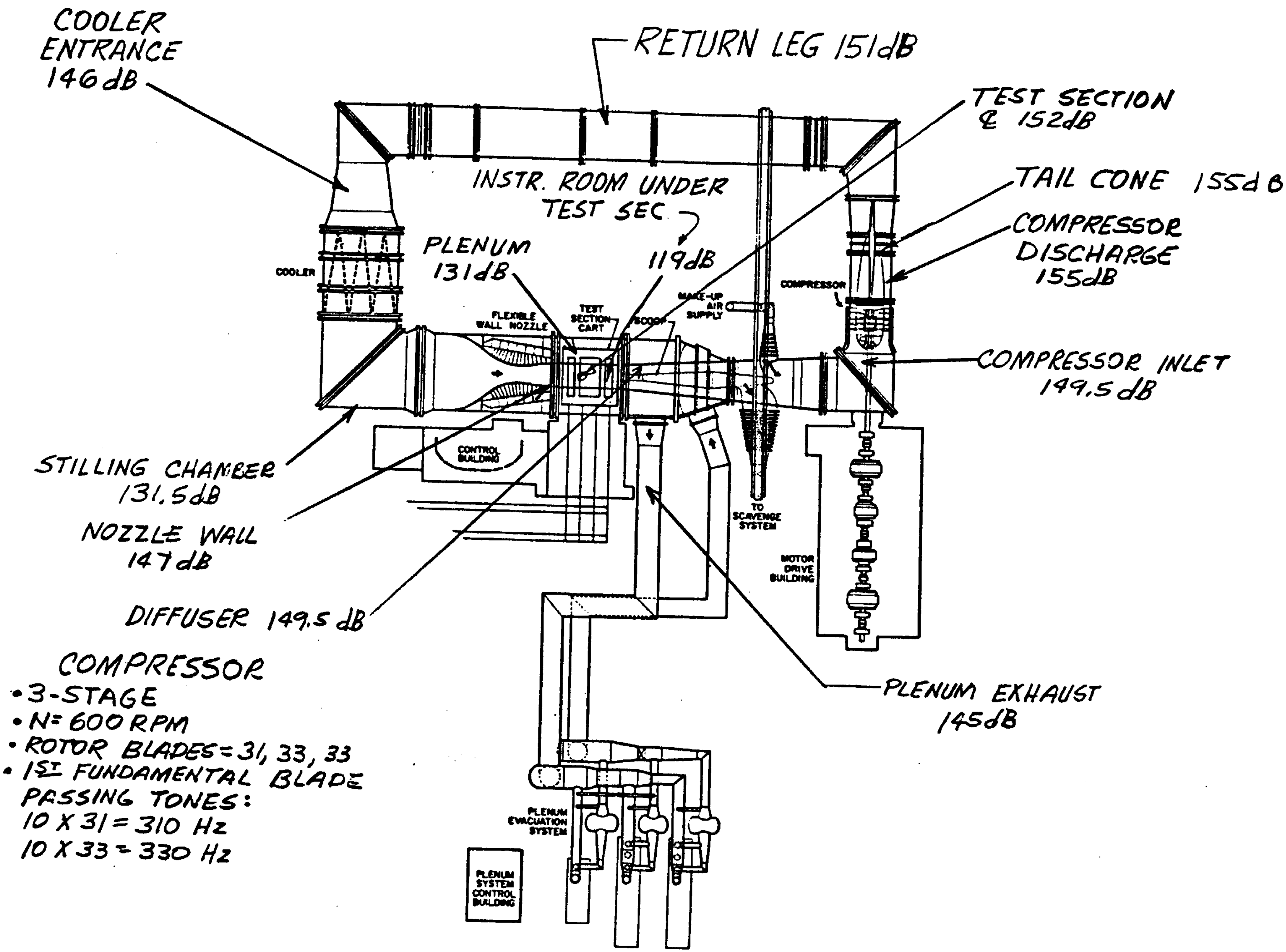


FIGURE 5. BASELINE AWT COMPRESSOR SOUND POWER SPECTRA AT THE MACHINE EXIT FOR REPRESENTATIVE TEST CONDITIONS



INTERNAL OVERALL SOUND POWER LEVELS IN TUNNEL 16T

(M = 0.75 AND P_t = 3100 PSFA)

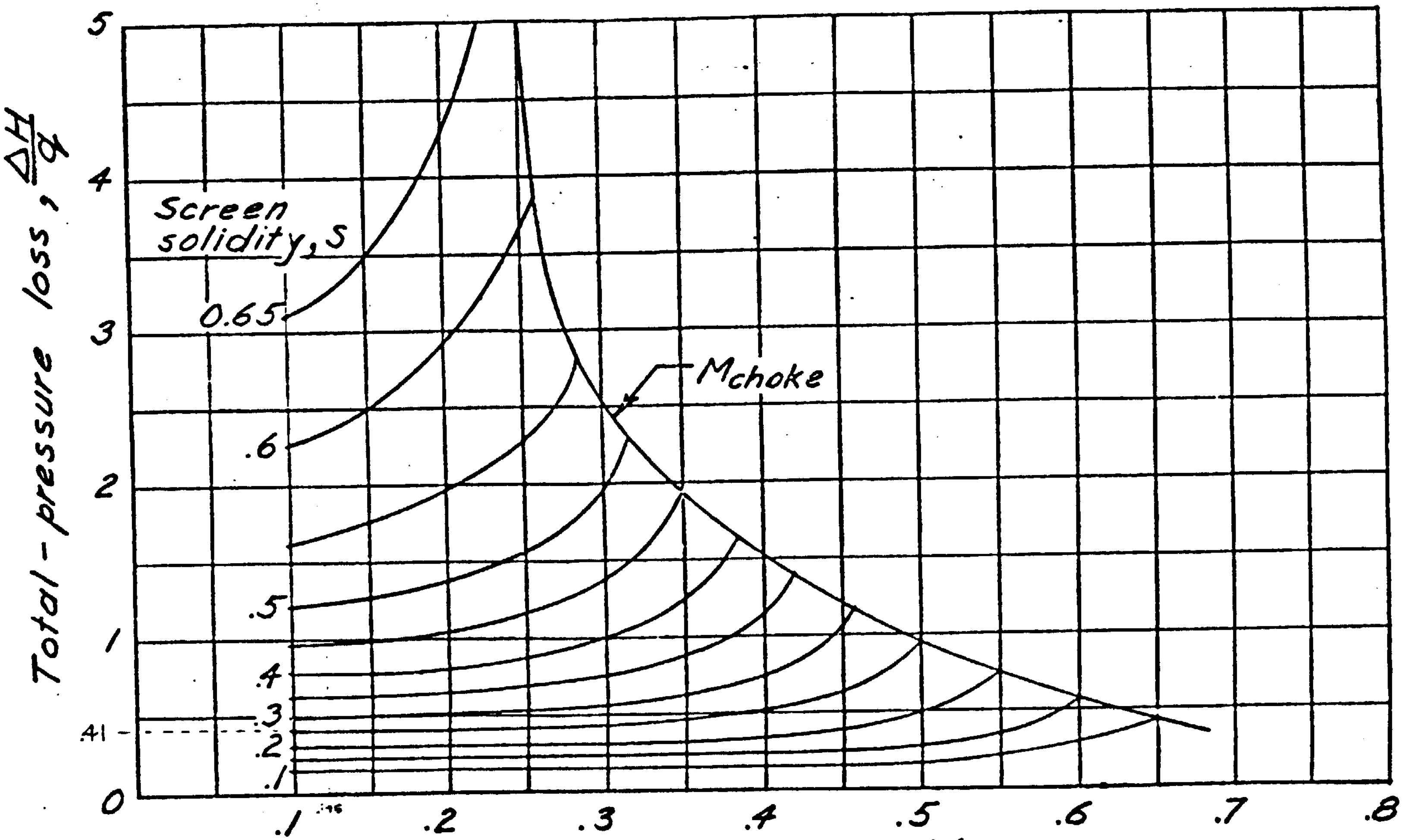


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Figure 5.- Effect of compressibility on the total-pressure loss through screens of various solidities.

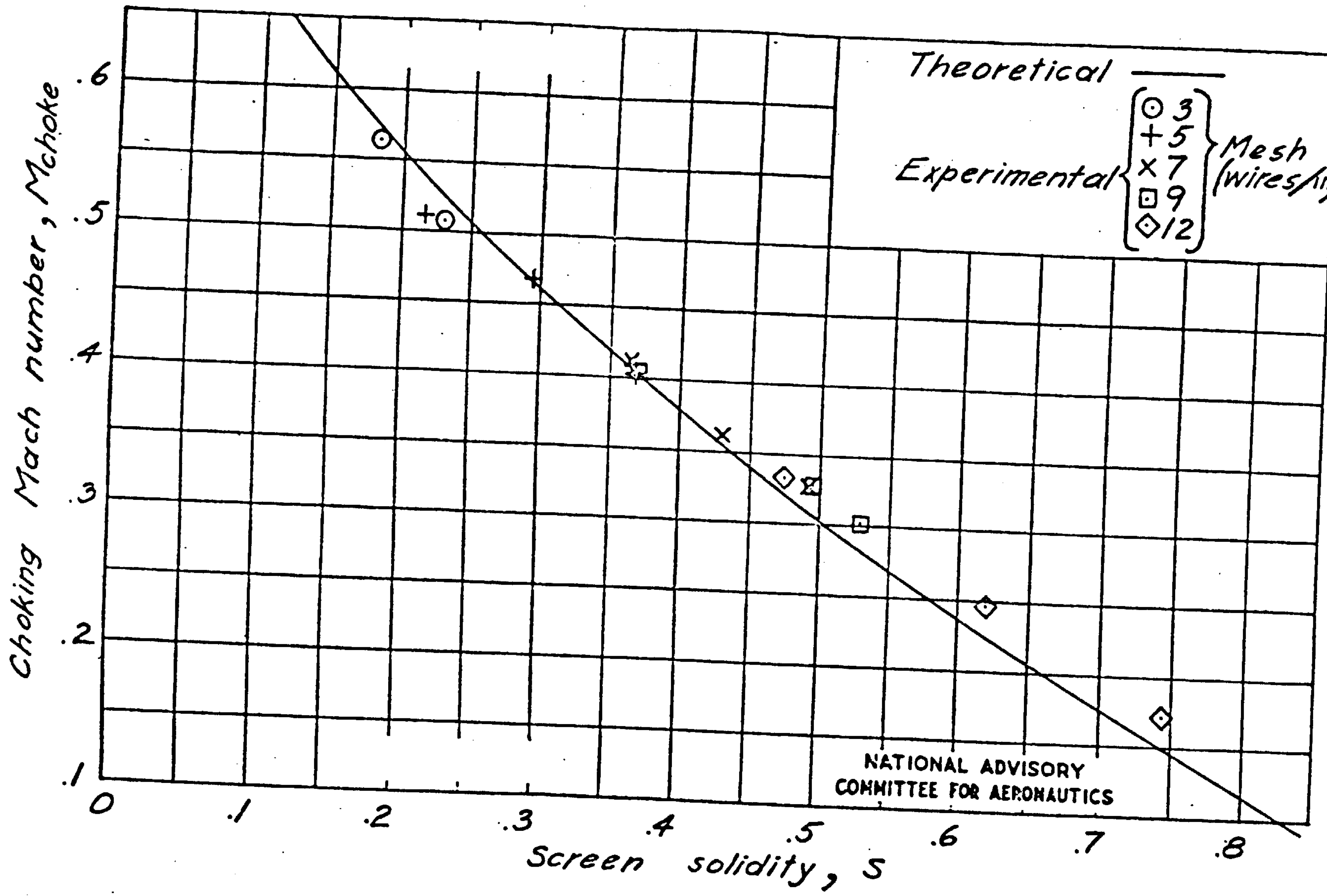


Figure 8. - Variation of choking Mach number with screen solidity.

AWT CIRCUIT AEROTHERMODYNAMICS DISCUSSION

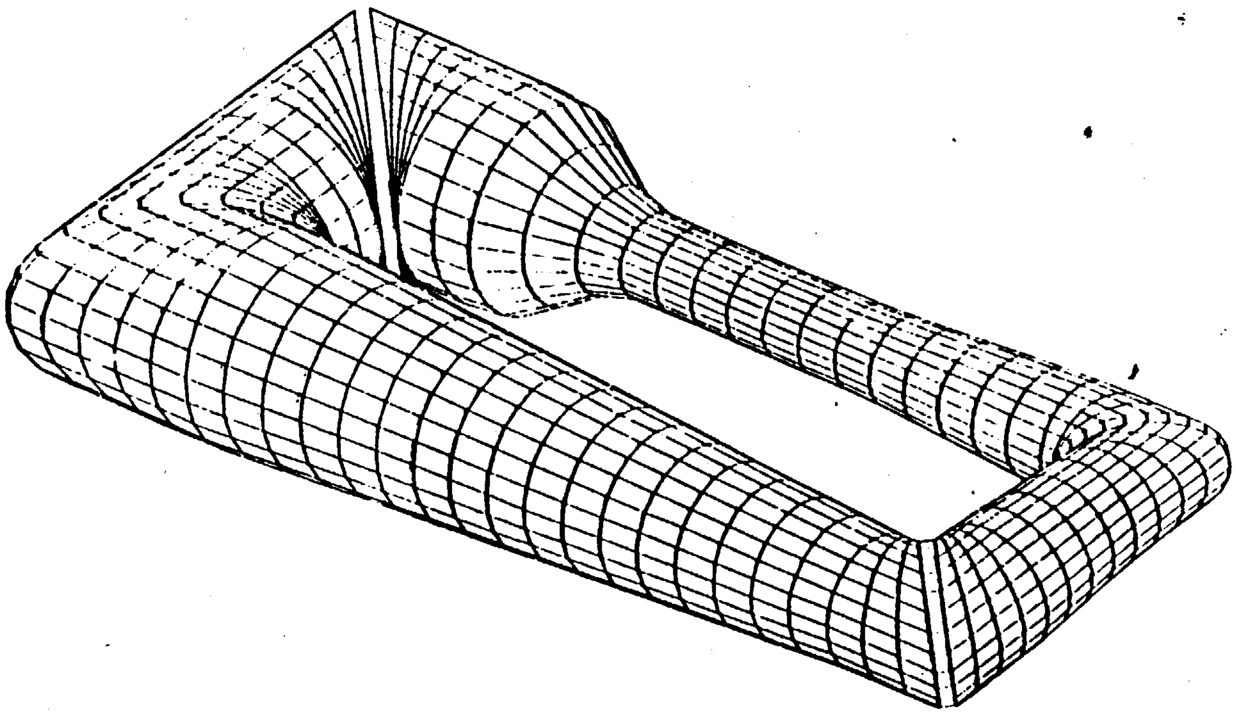
LOUIS A. POVINELLI

HEAD, TURBINE AERODYNAMICS SECTION

NASA LEWIS RESEARCH CENTER

LEWIS RESEARCH CENTER

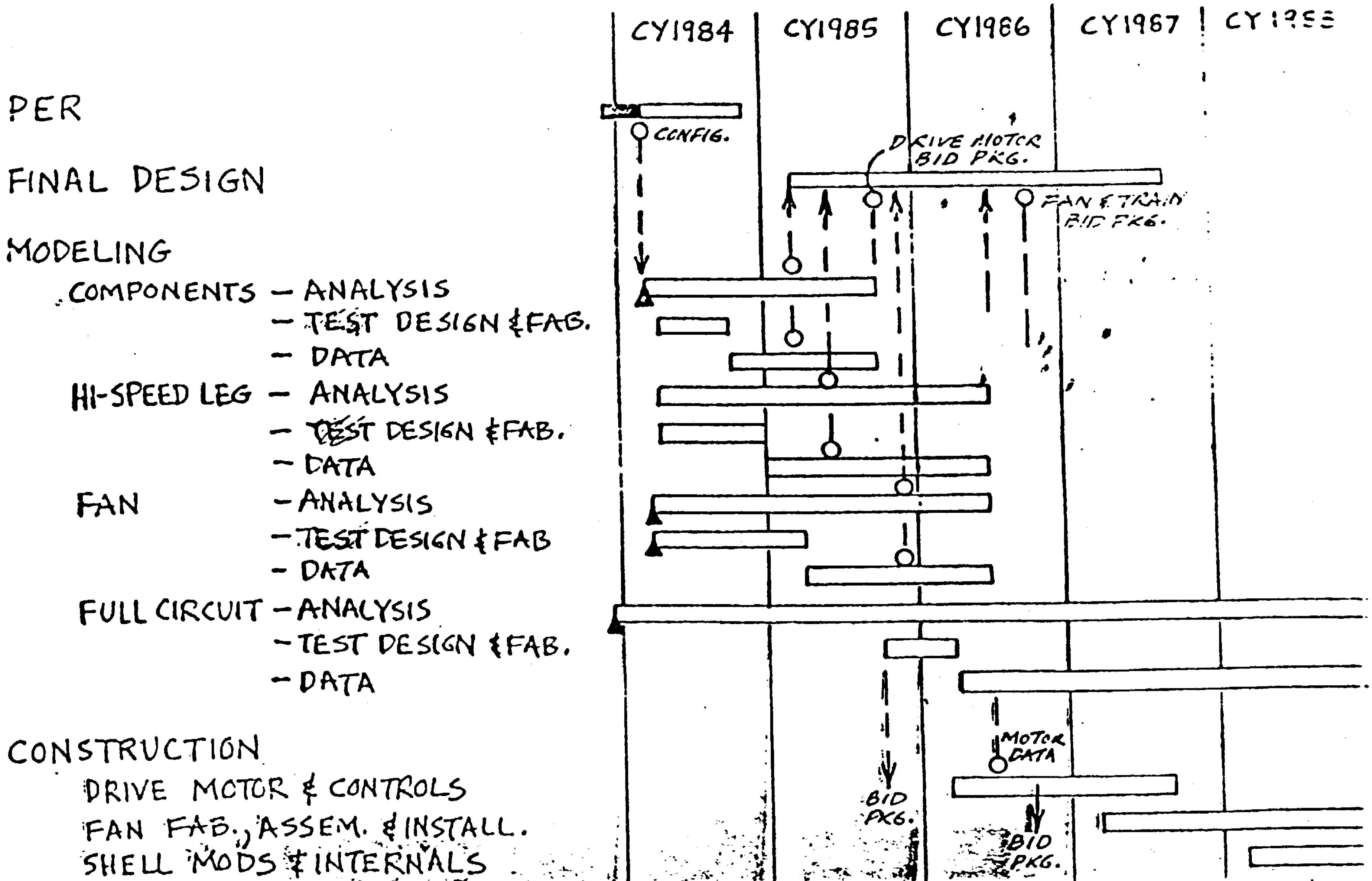
ALTITUDE WIND TUNNEL PROJECT



PERFORMANCE ASSESSMENT AND MODELING TASK FORCE

CIRCUIT AEROTHERMODYNAMICS TASK TEAM

AWT PROJECT
MODELING/DESIGN/CONSTRUCTION INTERFACES



ALTITUDE WIND TUNNEL PROJECT

CIRCUIT AEROTHERMODYNAMICS TASK TEAM

Objective: To assess the aerothermodynamic performance of the baseline (PER) design and to define proper component and system configurations to insure desired tunnel flow quality

Approach: Utilize existing or modified computer codes to assess aerothermodynamic performance

Verify aerothermodynamic performance through experimental model testing of components, coupled components, complete circuit, and research models.

CIRCUIT AEROTHERMODYNAMICS TASK TEAM

Leader – Lou Povinelli

Don Boldman	Bob Friedman
Tom Gelder	Joe Gladden
Doug Harrington	John Marek
Pete Meitner	Eric McFarland
Harvey Neumann	Charles Towne

Jim Van Fossen

CIRCUIT AEROTHERMODYNAMICS
MODELING PROGRAM

WORK BREAKDOWN STRUCTURE

2.1 CIRCUIT AEROTHERMODYNAMICS
- 2.1.1 ANALYTICAL MODELING
- 2.1.2 DESIGN AND FABRICATION
- 2.1.3 PHYSICAL MODELING
  - 2.1.3.1 TURNING VANE #3/#4 MODEL
  - 2.1.3.2 TURNING VANE #1 MODEL
  - 2.1.3.3 HIGH SPEED LEG MODEL
    - 2.1.3.3.1 HIGH SPEED LEG & #1 & #4 CORNER MODEL
    - 2.1.3.3.2 HIGH SPEED LEG & #1, #3, #4, & HEAT EXCHANGER MODEL
  - 2.1.3.4 HEAT EXCHANGER MODEL
  - 2.1.3.5 CIRCUIT OR COMPLETE LOOP MODEL

CIRCUIT AEROTHERMODYNAMICS TASK TEAM

AERODYNAMIC MODELING

SECTION	CODES	COMMENTS
BELLMOUTH	VISTA, NAP	AXISYMMETRIC FLOW
	PEPSIG*	TRANSITION TO OCTAGON
TEST SECTION	VISTA, ADD	AXISYMMETRIC FLOW, UNIFORM BLEED
	PAMPER	AS ABOVE, + EMPIRICAL PROP EFFECTS
	NASPROP - E*	INVISCID, CIRCULAR CROSS-SECTION, UNIFORM BLEED
	PEPSIG*	SLOTS, CIRCULAR CROSS-SECTION
	PEPSIG*	SLOTS, OCTAGONAL CROSS-SECTION
	PEPSIG*	FLOW IN PLENUM
MAIN DIFFUSER	VISTA, ADD, PEPSIM	AXISYMMETRIC FLOW, SWIRL
	PEPSIG*	TRANSITION FROM OCTAGON, VORTEX GENERATORS

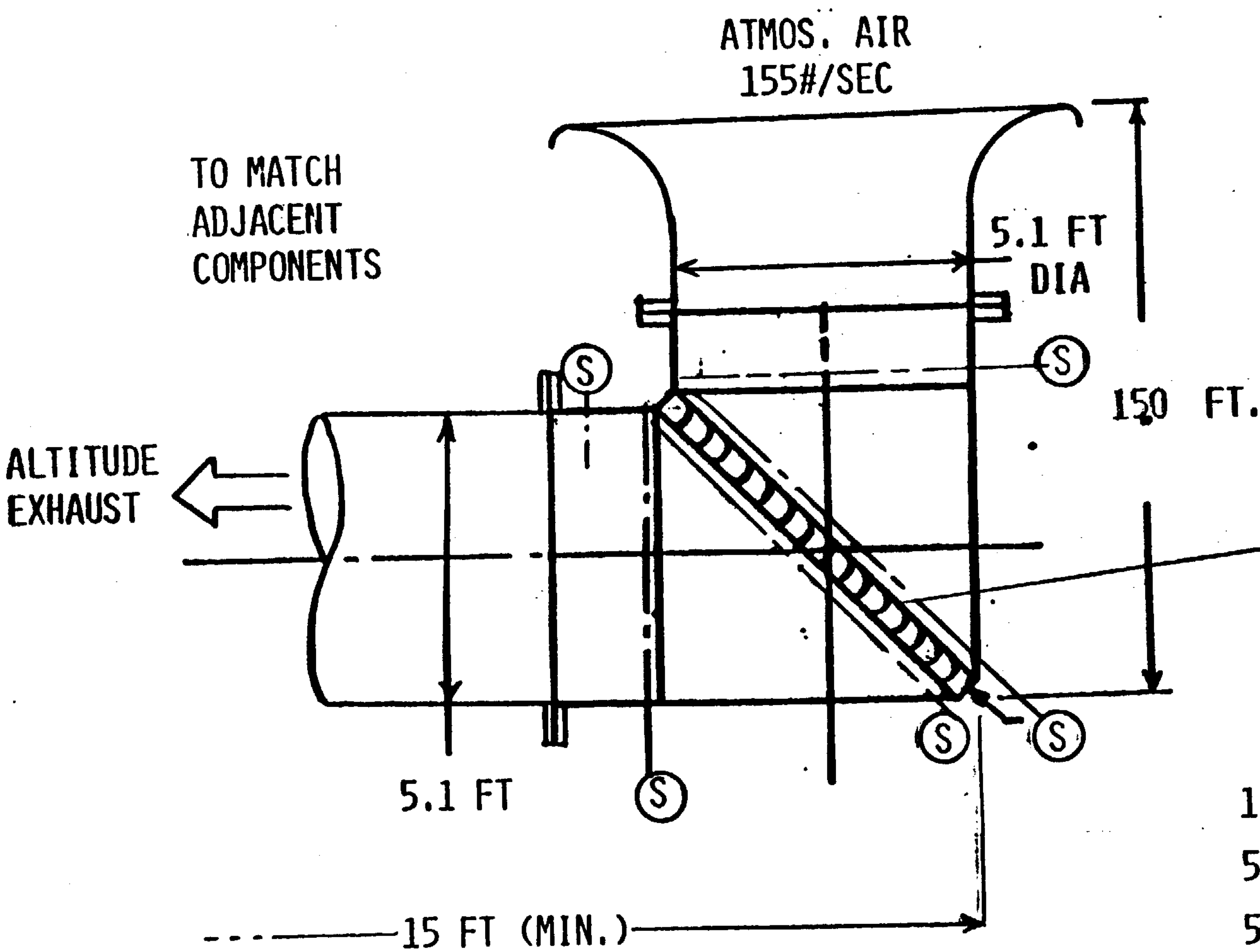
CIRCUIT AEROTHERMODYNAMICS TASK TEAM

CORNERS	PEPSIG	NO VANES, GENTLER BEND, NO FAN HARDWARE
	PANEL	QUASI 3-D CASCADE, 2-D POTENTIAL GLOW PANEL METHOD
	ROTOR VISC	2-D CASCADE, NAVIER-STOKES
	MINT	2-D CASCADE, NAVIER-STOKES
	PEPSIG*	VANES REPRESENTED BY BODY FORCES FROM NAVIER-STOKES RUN
BACK LEG	VISTA, ADD, PEPSIM	AXISYMMETRIC FLOW, SWIRL, TAIL CONE FAIRING
SIDE LEGS	VISTA, ADD	AXISYMMETRIC FLOW
	PEPSIG*	3-D INITIAL PROFILES

*REQUIRES CODE MODIFICATION

2.1.3.1 TURNING VANE MODEL # 3 AND # 4

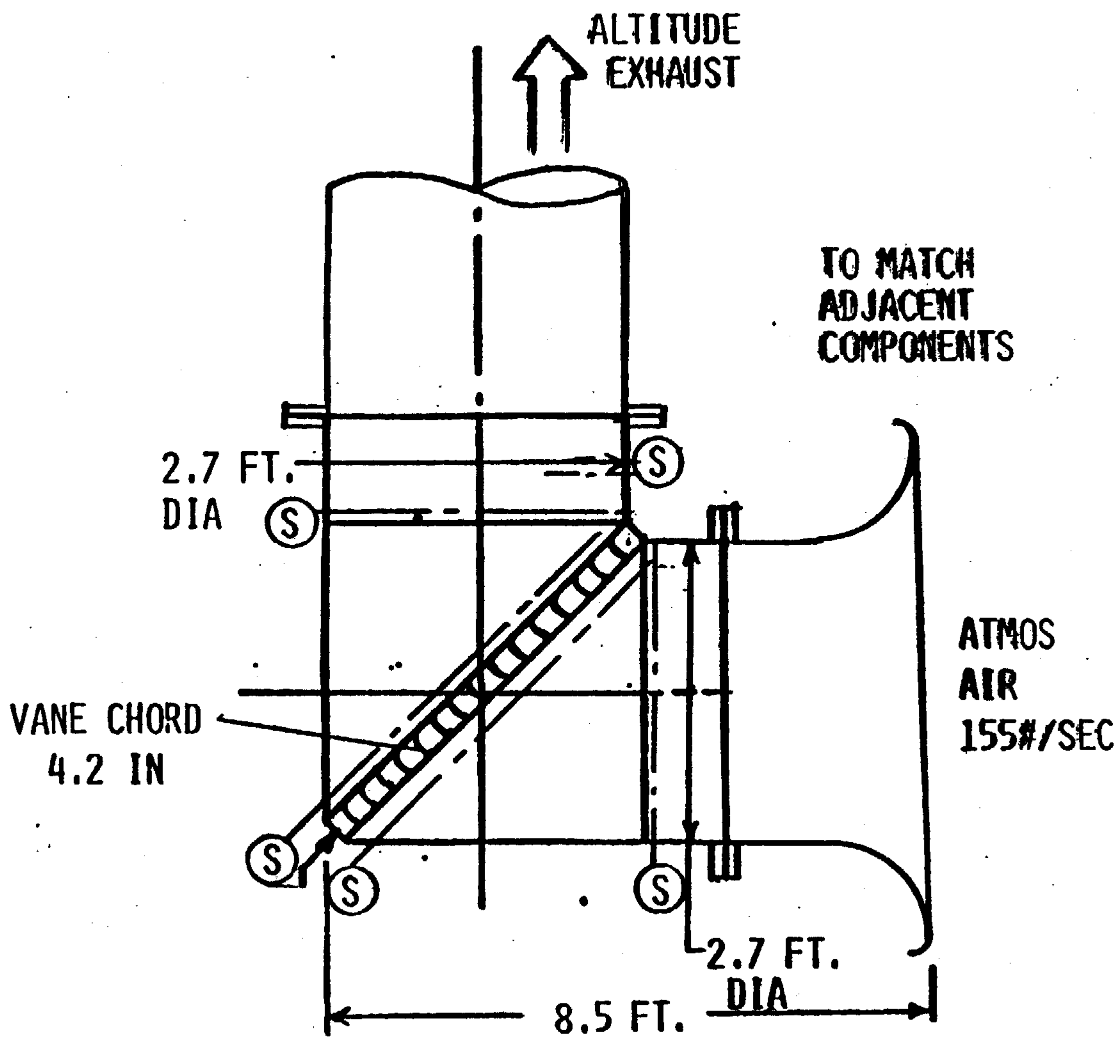
(2 REQUIRED)



MEASUREMENTS

1. TOTAL TEMP. SURVEY
5. TOTAL PRESS. SURVEYS
5. HOT WIRE SURVEYS
5. ANGULARITY SURVEYS
75. STATIC WALL TAPS
(S) SURVEY LOCATION

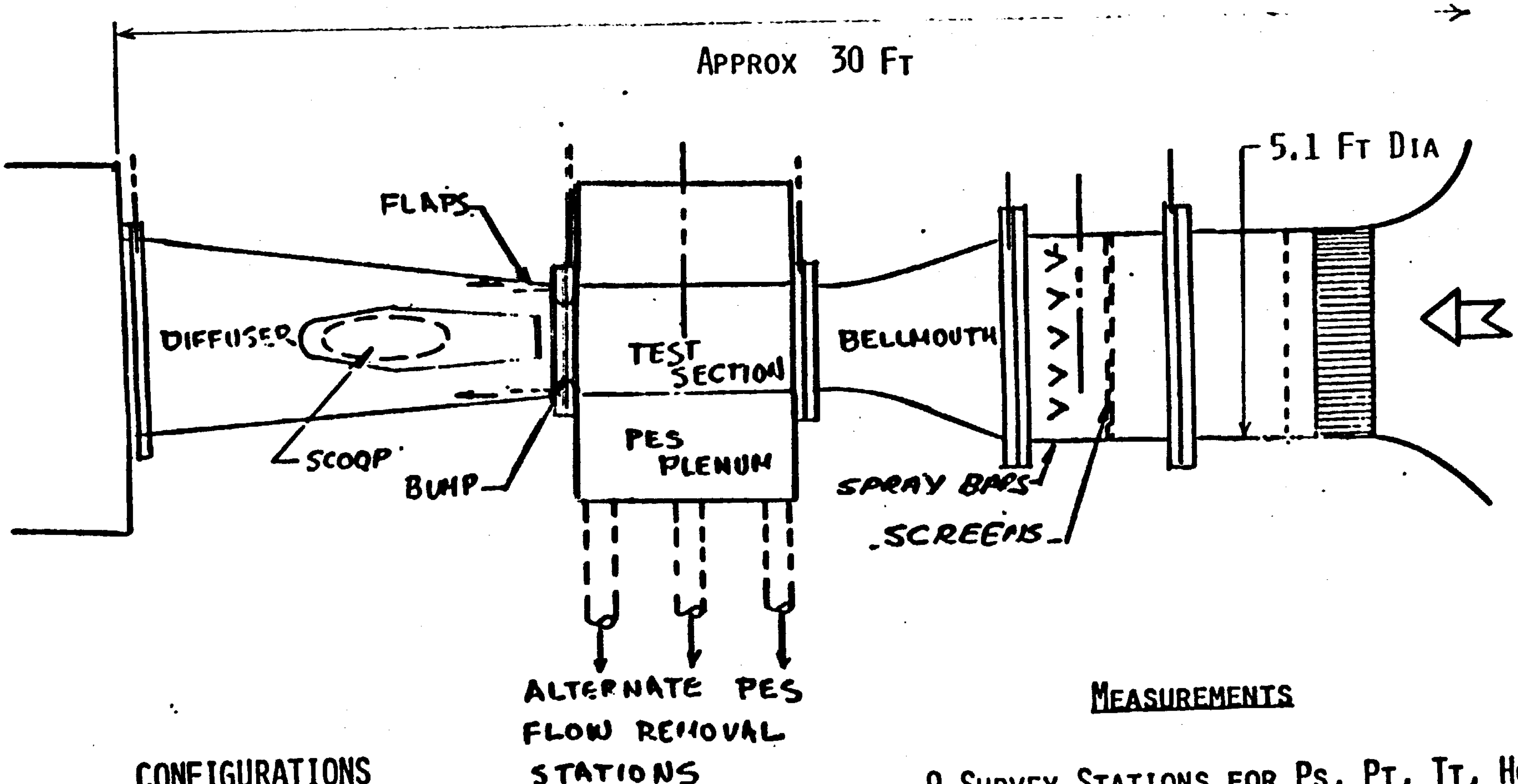
2.1.3.2 TURNING VANE MODEL # 1



MEASUREMENTS

1. TOTAL TEMP. SURVEY
5. TOTAL PRESS. SURVEYS
5. HOT WIRE SURVEYS
5. ANGULARITY SURVEYS
75 STATIC WALL TAPS

2.1.3.3 HIGH SPEED LEG MODEL



CONFIGURATIONS

8 BELLMOUTHS, SCREENS, & SPRAYS
3 TEST SECTION P.E.S.
4 SLOTS 2 FLAPS
2 SCOOPS 1 CHOKE DEVICE
1 PARTRIDGE-IN-A-PEARTREE

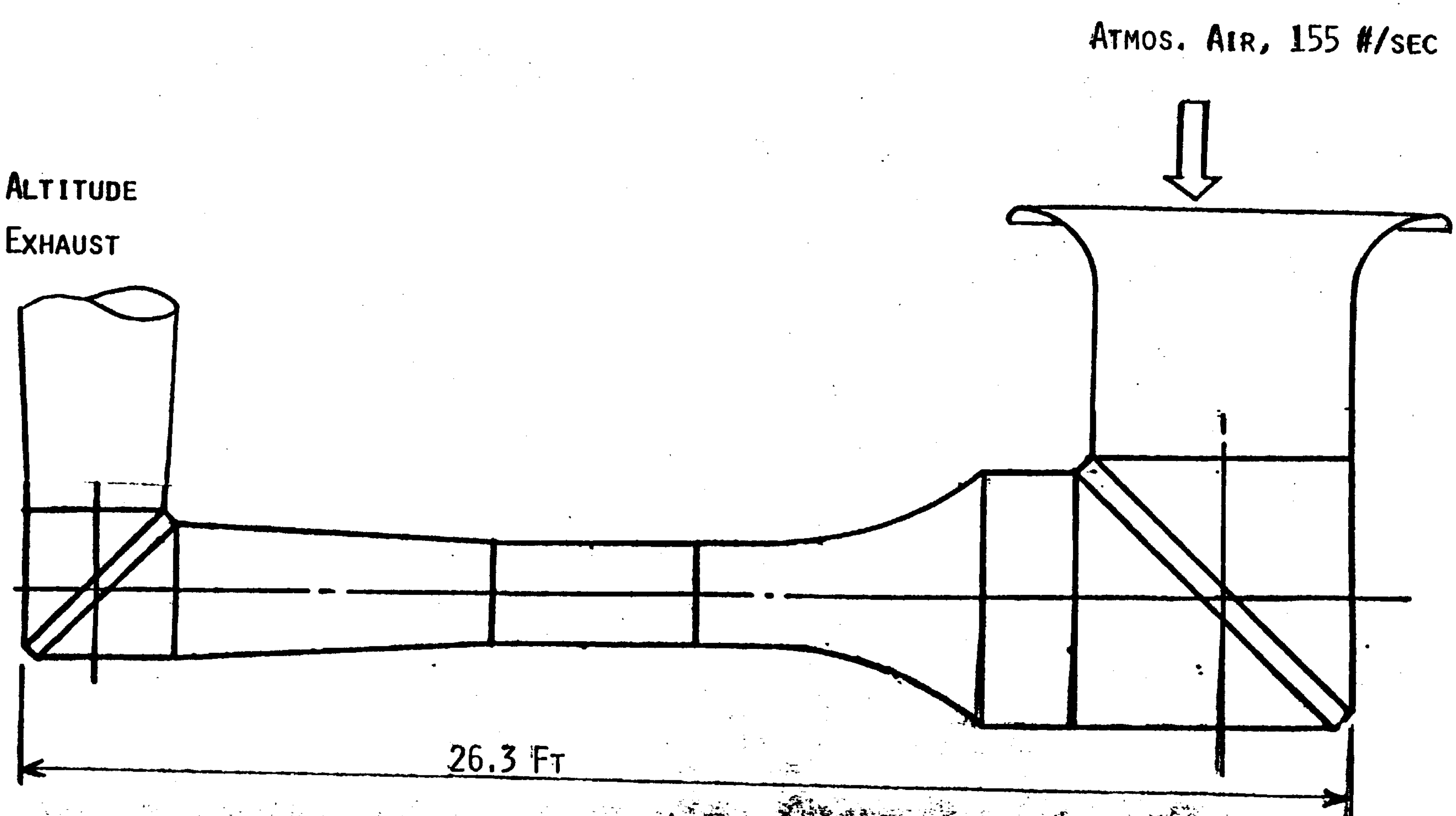
MEASUREMENTS

9 SURVEY STATIONS FOR PS, PT, TT, HOT WIRE, AND ANGULARITY
10 TOTAL PRESSURE
555 WALL STATIC PRESSURES

2.1.3.3.1 HIGH SPEED LEG, #1, AND #4 TURNING VANE MODEL

MEASUREMENTS

SAME AS COMPONENT MODELS

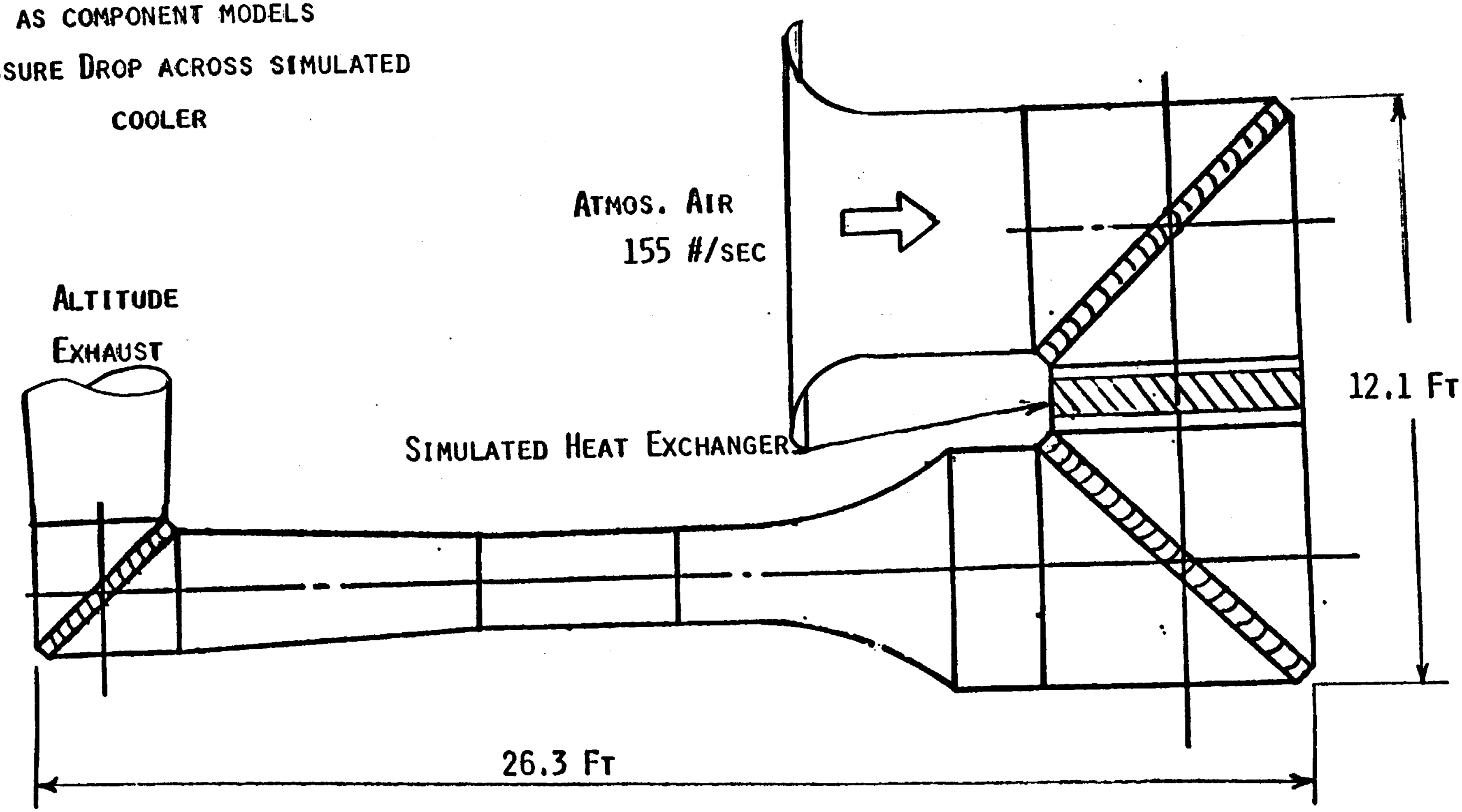


2.1.3.3.2 HIGH SPEED LEG, #3, #4, AND COOLER MODEL

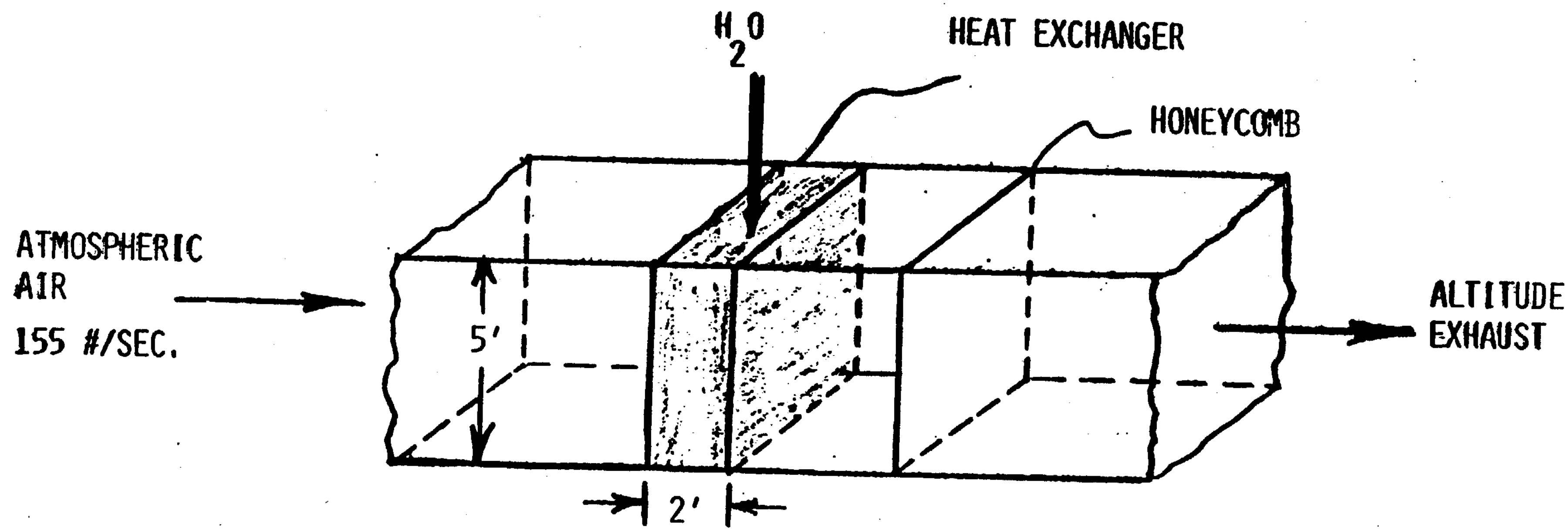
MEASUREMENTS

SAME AS COMPONENT MODELS

PRESSURE DROP ACROSS SIMULATED COOLER



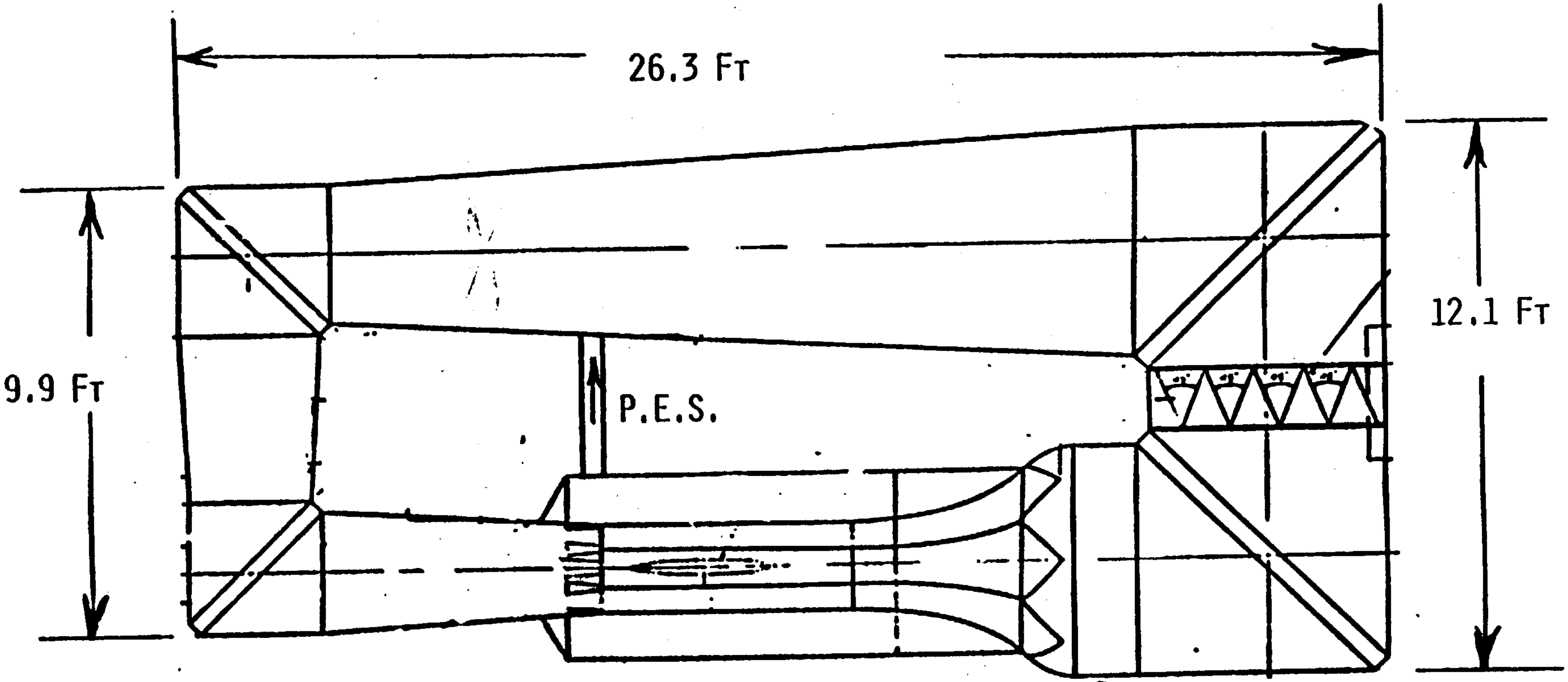
2.1.3.4 HEAT EXCHANGER MODEL



MEASUREMENTS

3 PRESSURE SURVEY STATIONS
2 TEMPERATURE " "
3 ANGULARITY " "
3 HOT WIRE " "
100 STATIC PRESSURES

2.1.3.5 CIRCUIT MODEL



MEASUREMENTS

SAME AS COMPONENTS

PES FLOW RATE

PES PRESSURE DROP

AWT DRIVE SYSTEM DISCUSSION

LONNIE REID

HEAD, MULTISTAGE COMPRESSOR SECTION

NASA LEWIS RESEARCH CENTER

DRIVE SYSTEM TASK TEAM
LEADER L. REID

OBJECTIVE: DEVELOP A PHYSICAL MODEL OF THE AWT FAN DRIVE THAT WILL PRODUCE THE DESIRED PERFORMANCE IN THE AWT ENVIRONMENT

APPROACH:

- O SELECT KEY PERSONNEL
- O IDENTIFY CRITICAL ASPECTS OF PROBLEM
- O ANALYTICAL MODELING
- O PHYSICAL MODELING

DRIVE SYSTEM TASK TEAM MEMBERS
LEADER L. REID

SANDERCOCK, D. M.	CONSULTANT	(2420)
SCHMIDT, J. F.	FAN AERO. DESIGN	(2421)
STEINKE, R. J.	FAN AERO. DESIGN	(2423)
STEVANS, W.	MECH. DESIGN AND OPERATIONS	(2452)
URASEK, D. C.	MECH. DESIGN AND OPERATIONS	(2423)
BOLDMAN, D. R.	DIFFUSER/TURNING VANES PERFORMANCE ASSESSMENT AND TASK TEAM LIAISON PERSON	(2423)
MOORE, R. D.	FAN AND PERFORMANCE	(2422)
HATHAWAY, M.D.	FUNDAMENTAL RESEARCH PROGRAM	(0300)

DRIVE SYSTEM

CRITICAL ASPECTS:

- O MUST QUANTIFY FAN INLET FLOW FIELD
- O MODELING EFFORTS TO ASSESS FAN INLET FLOW CONDITIONS AND TURNING VANES PERFORMANCE MUST BE CLOSELY INTEGRATED
- O MUST ANALYZE FAN DESIGN WITH APPROPRIATE FLOW PATH GEOMETRY

DRIVE SYSTEM

PHYSICAL MODELING: 0.10 SCALE

- O MODEL FLOW PATH WITH ELBOW, TURNING VANES, SHAFT AND CENTER-BODY TO ASSESS FAN INLET CONDITIONS
- O TEST MODEL FAN WITH CLEAN INLET FLOW TO ASSESS DESIGN PERFORMANCE
- O TEST MODEL FAN WITH UPSTREAM ELBOW AND TURNING VANES
- O CANDIDATE FACILITIES -
  - W1 - FOR ELBOW, TURNING VANES AND CENTER-BODY MODEL
  - W2 - FOR FAN MODEL TESTING

2.2 DRIVE SYSTEM

2.2.1 ANALYTICAL MODELING

2.2.1.1 BASELINE (PER) DESIGN

2.2.1.2 ALTERNATE DESIGNS

2.2.2 AERODYNAMIC DESIGN OF BLADE AND VANE AIRFOILS

2.2.2.1 TURNING VANES (CORNER 2)

2.2.2.2 ROTOR BLADES

2.2.2.3 IGV, STATORS AND OGV

2.2.3 MECHANICAL DESIGN AND FABRICATION

2.2.3.1 BLADE ROWS

2.2.3.2 ROTATING HARDWARE

2.2.3.3 CASING HARDWARE

2.2.3.4 SIGHT PREPARATION

2.2.4 PHYSICAL MODELING

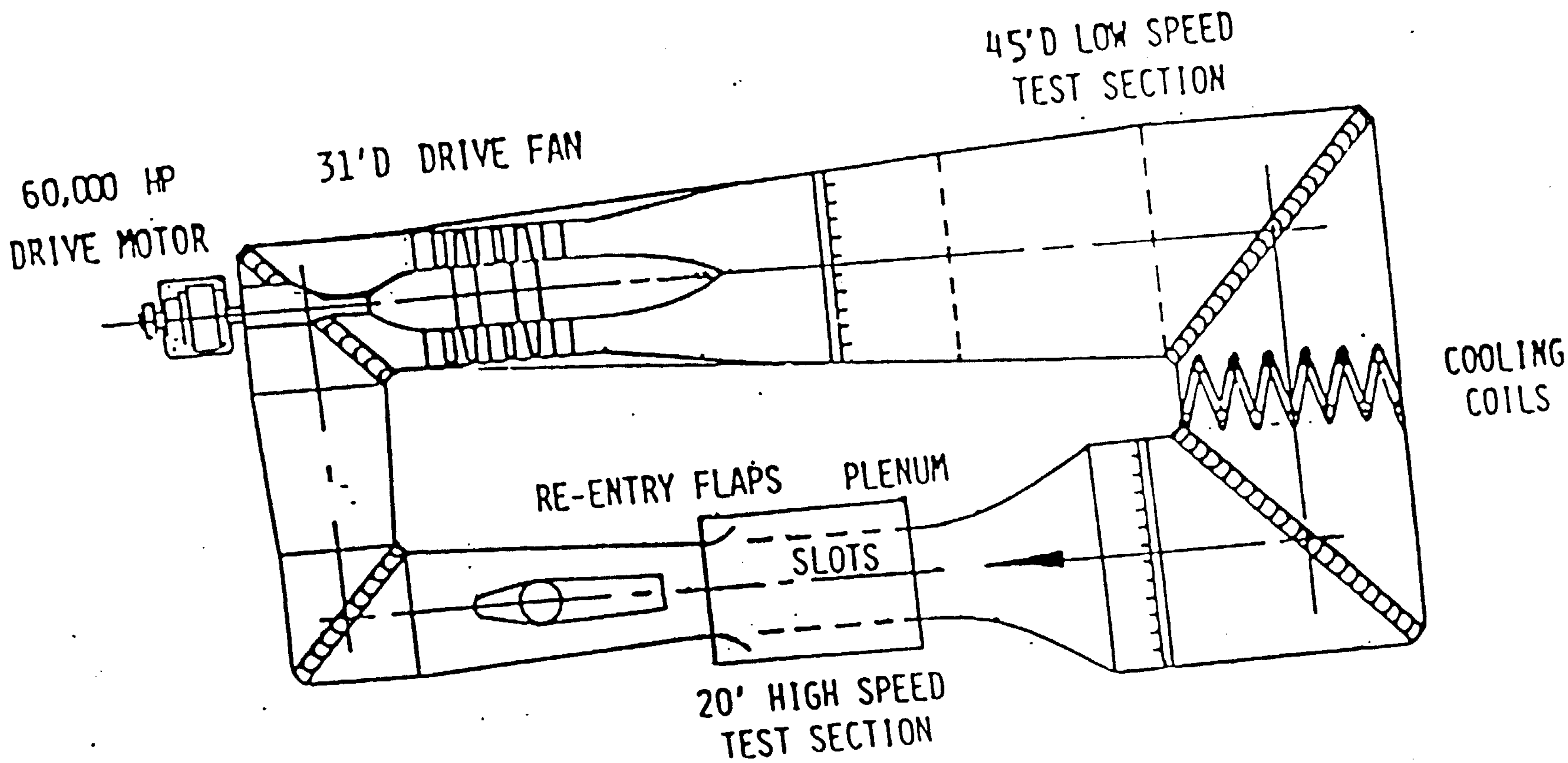
2.2.4.1 FAN FLOWPATH WITH TV, IGV AND CENTERBODY

2.2.4.2 FAN WITH BELLMOUTH INLET AND LS-TEST SECTION

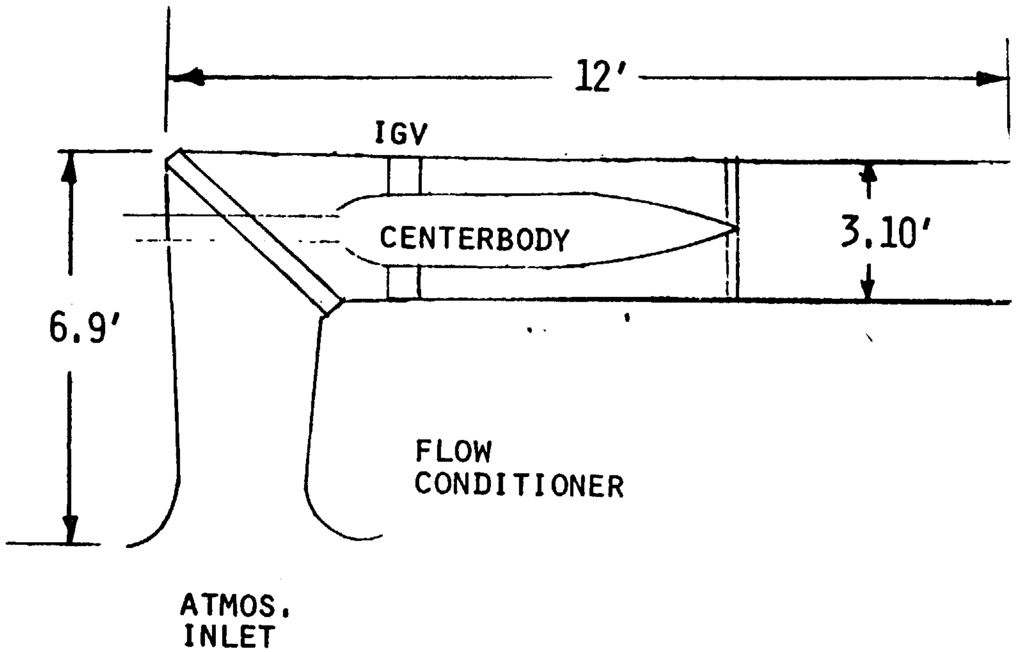
2.2.4.3 FAN WITH CORNER #2, & LS-TEST SECTION

2.2.4.4 FAN WITH CORNERS #1 AND 2 AND LS-TEST SECTION

AWT FLOW CIRCUIT



FAN FLOWPATH WITH #2 CORNER-TV, IGV & CENTERBODY

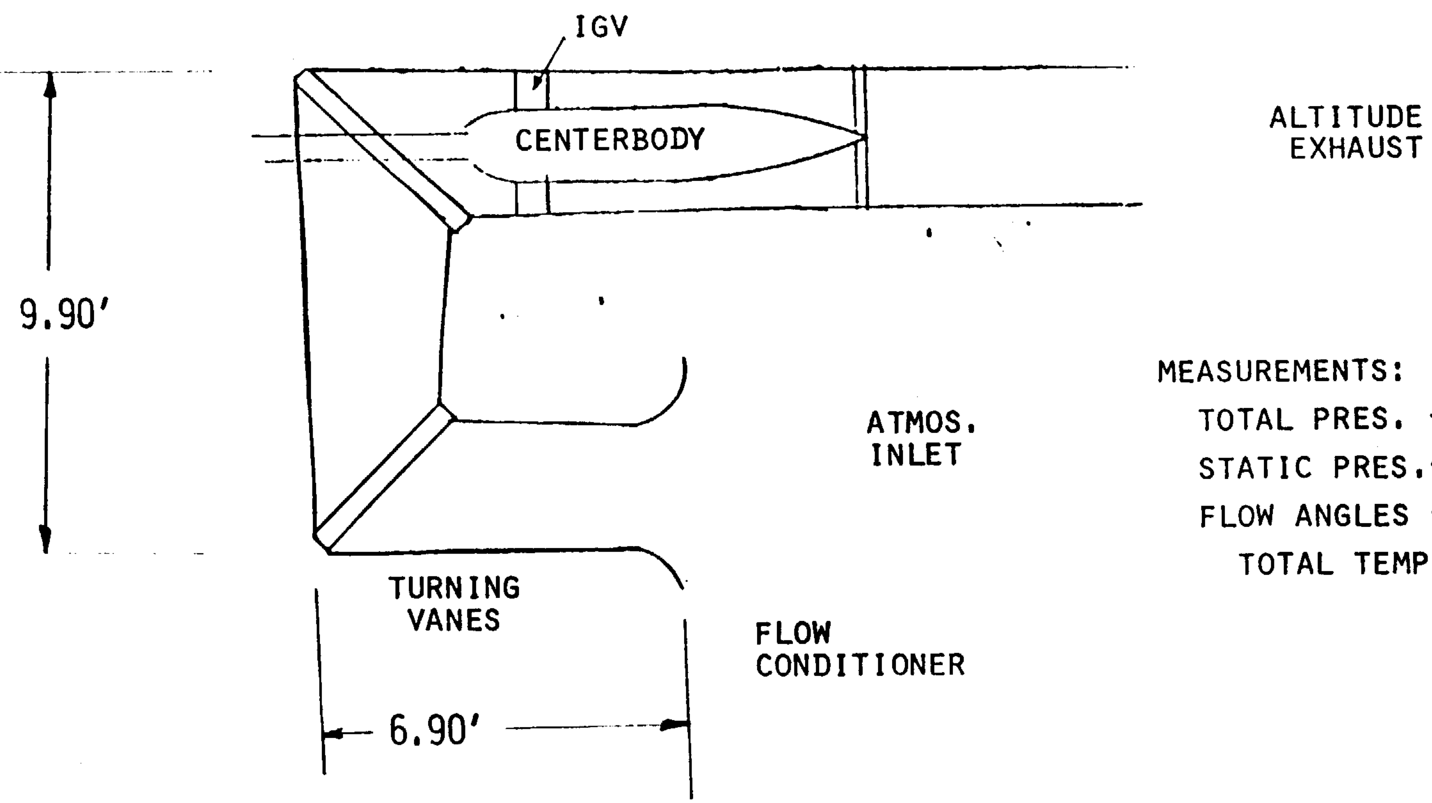


FLOW: 155 LBM/SEC

MEASUREMENTS:

TOTAL PRES. - - -	68
STATIC PRES. - -	260
FLOW ANGLES - - -	14
TOTAL TEMP. - - -	2

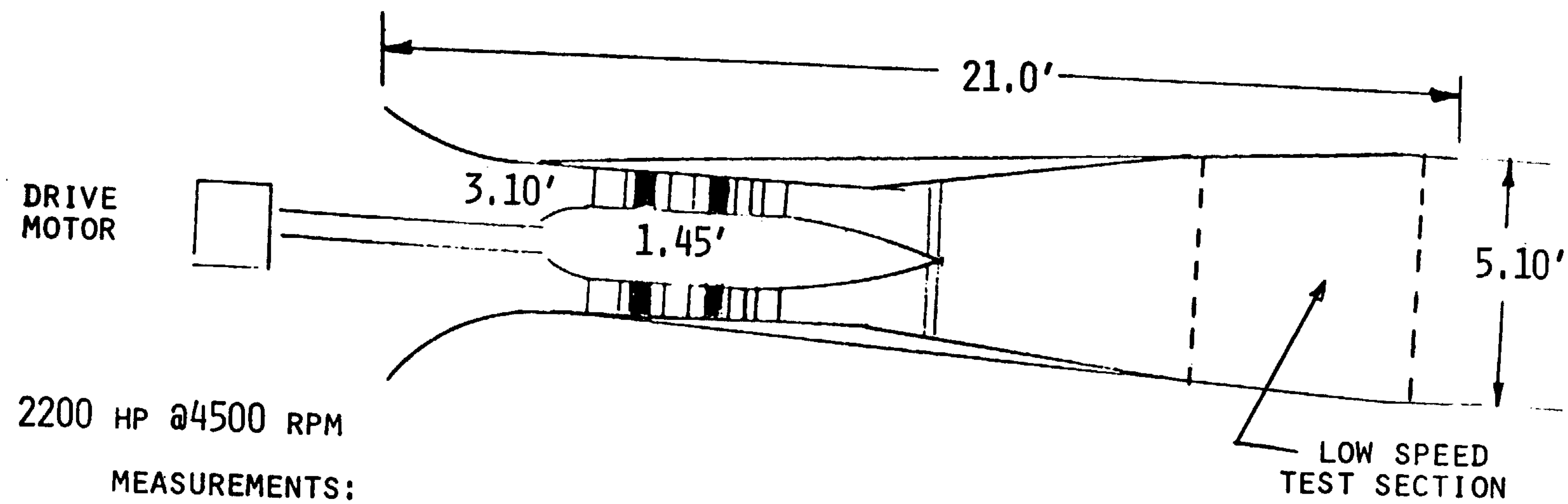
FAN FLOWPATH WITH CORNERS #1, 2-TV, IGV & CENTERBODY



MEASUREMENTS:

TOTAL PRES. - -	75
STATIC PRES.- -	300
FLOW ANGLES - -	20
TOTAL TEMP. -	2

FAN WITH BELLMOUTH AND LOW SPEED TEST SECTION

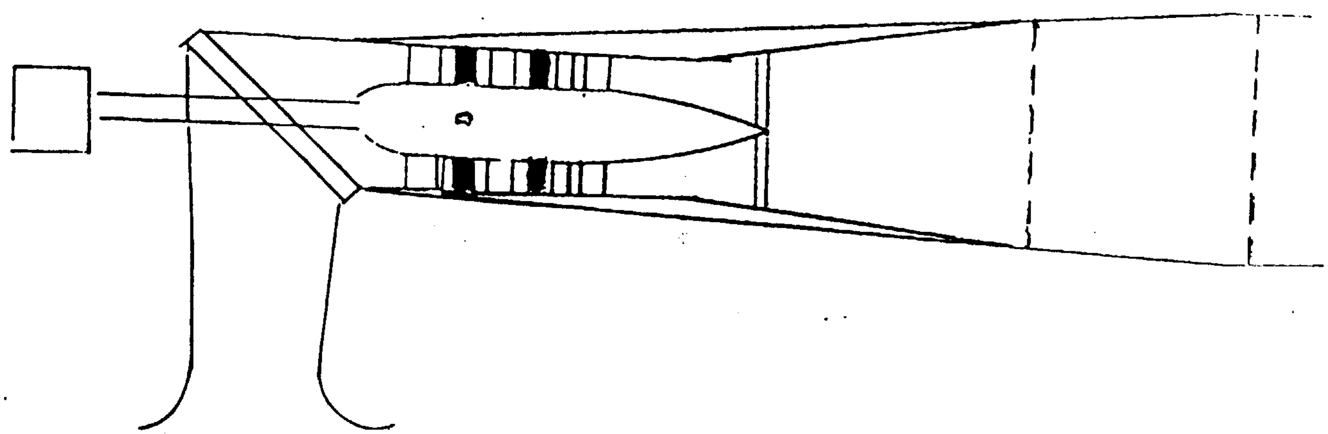


2200 HP @4500 RPM

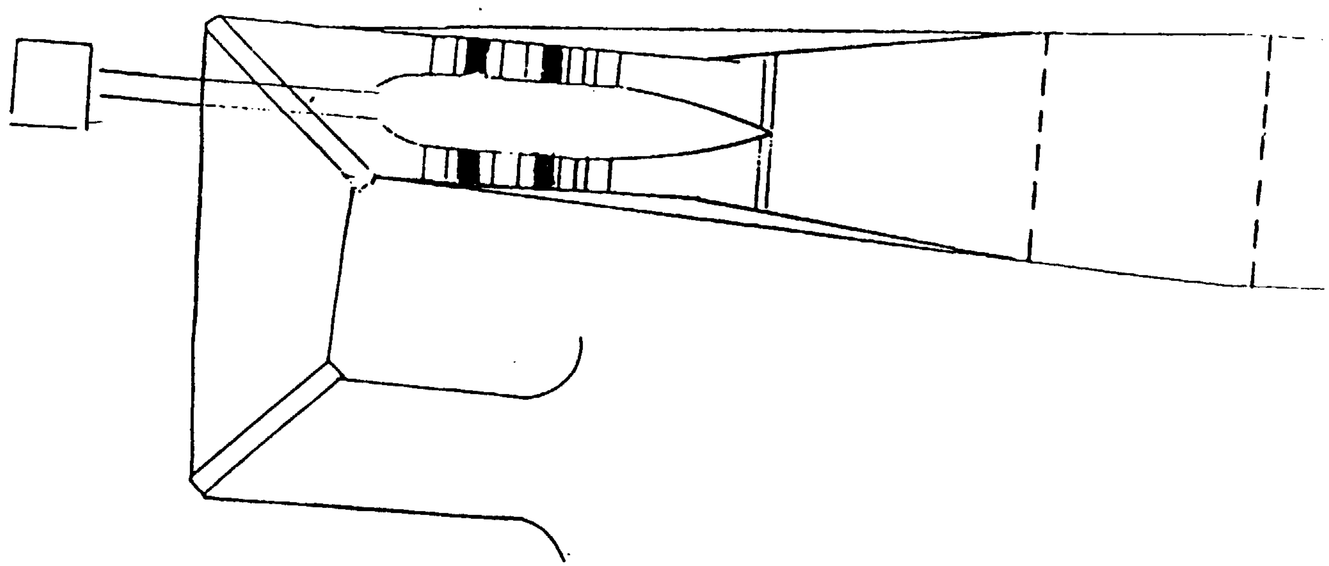
MEASUREMENTS:

- TOTAL PRES. - - 32
- STATIC PRES. - - 32
- WALL STATIC TAPS - - 100
- TOTAL TEMP - - - - 32
- FLOW ANGLES - - - - 32

FAN WITH #2 CORNER-TV AND LOW SPEED TEST SECTION



FAN WITH CORNERS #1,2-TV, & LOW SPEED TEST SECTION



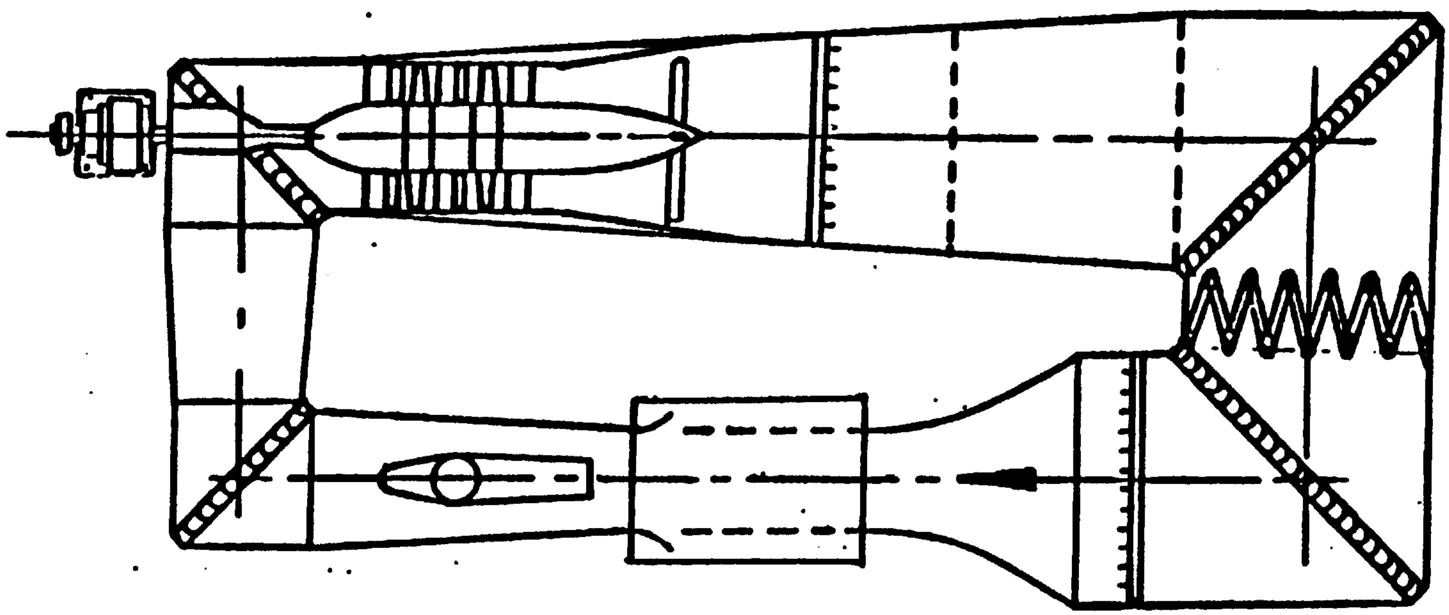
AWT ICING DISCUSSION

JOHN J. REINMANN

HEAD, ICING RESEARCH SECTION

NASA LEWIS RESEARCH CENTER

AWT ICING SYSTEMS TASK TEAM



OBJECTIVES

- o PROVIDE AN ICING AND SEVERE WEATHER CAPABILITY FOR THE AWT IN BOTH THE HIGH AND LOW SPEED TEST SECTIONS
- o ENSURE THAT ALL AWT COMPONENTS ARE DESIGNED TO PERFORM IN THE SEVERE WEATHER ENVIRONMENT WITH MINIMUM IMPACT ON PERFORMANCE AND WITH HIGH RELIABILITY

ICING SYSTEMS TASK TEAM

KEY PROBLEMS TO BE ADDRESSED

NOZZLES

- o SUPERCOOLED CLOUDS
  - WIDE LWC RANGE
  - SMALL DROPLETS
  - ACCURATE CONTROL

- o HEAVY RAIN/FREEZING RAIN
  - LARGE DROPLETS
  - VERY WIDE LWC RANGE

- o SNOW
  - SNOW FLAKE GROWTH RATE VERY SLOW
  - SIMULATE WITH FROZEN DROPLETS?

INSTRUMENTATION

- o CALIBRATION STANDARDS NEEDED FOR LWC AND PARTICLE SIZING
- o CURRENT INSTRUMENTS LIMITED TO ONLY LOW SPEEDS

ICING SYSTEMS TASK TEAM

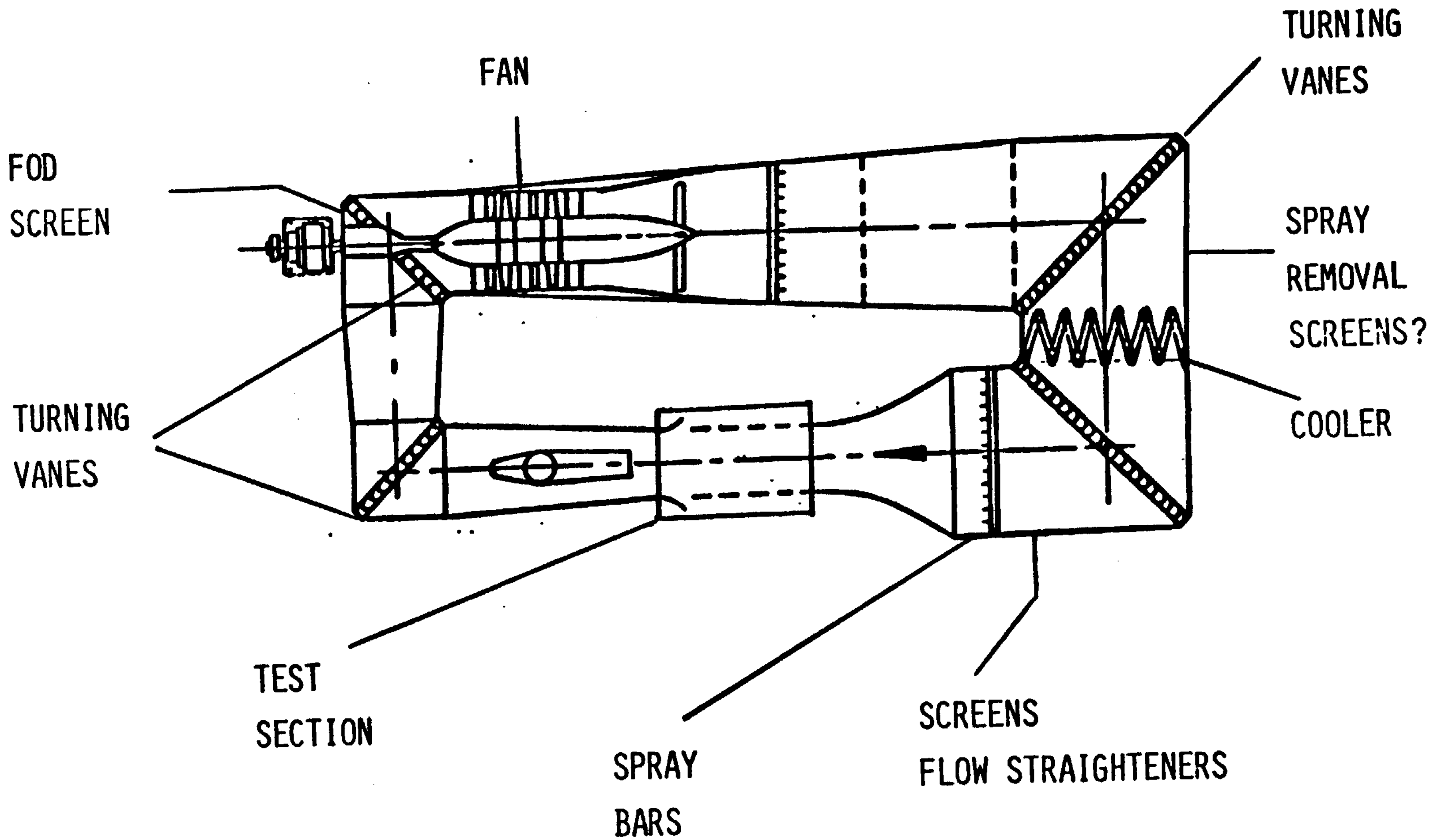
KEY PROBLEMS TO BE ADDRESSED (CONT'D)

SPRAY CLOUD

- o SIZE AND UNIFORMITY
  - SCALING OF SPRAY MIXING PROCESS
  - EFFECT OF BELLMOUTH FLOW DISTORTION AND SECONDARY FLOWS
  - UNIFORM CLOUD AT LOW LWC'S
  - HIGH LWC AT HIGH SPEEDS
- o CLOUD CHARACTERISTICS
  - DROPLET SIZE CHANGE DUE TO EVAPORATION
  - SUPERCOOLING/FREEZE-OUT
- o RAIN
  - DROPLET BREAK-UP AT HIGH SPEEDS
  - DROPLET TRAJECTORY/SPRAY BAR PLACEMENT

AWT ICING SYSTEMS TASK TEAM

KEY COMPONENTS AFFECTED BY ICING



ICING SYSTEM TASK TEAM

APPROACH

NOZZLES

- o TEST CURRENT DESIGNS
- o DESIGN AND EVALUATE NEW DESIGNS
- o CANDIDATE FACILITIES
  - IN-HOUSE SINGLE NOZZLE RIGS
  - AEDC

CLOUD INSTRUMENTATION

- o USE IN-HOUSE INSTRUMENTATION WHERE AVAILABLE
- o PURCHASE EXISTING INSTRUMENTATION AND MODIFY AS NEEDED
- o DEVELOP CALIBRATION PROCEDURES AND STANDARDS
- o CONTRACT FOR HIGH SPEED INSTRUMENTATION

SPRAY CLOUD

- o ANALYTICAL MODELING
  - SPRAY MIXING PROCESS
  - FLOW FIELDS AND PARTICLE TRAJECTORIES

- o EXPERIMENTAL MODELING CANIDATE FACILITIES
  - PSL 3/4 (10 TO 15% SCALE)
  - AWT PILOT WIND TUNNEL (~15% SCALE)
  - ICING RESEARCH TUNNEL (6 FT. X 9 FT.)

SINGLE NOZZLE TEST RIG

NOZZLE SERVICES:

WATER:

FLOW RATE 0 TO 0.5 GPM (FREEZING RAIN, HEAVY RAIN--MUCH HIGHER)

PRESSURE 10 TO 500 PSIG

TEMPERATURE 70 TO 200 F

AIR:

FLOW RATE 0 TO 0.4 LB/SEC

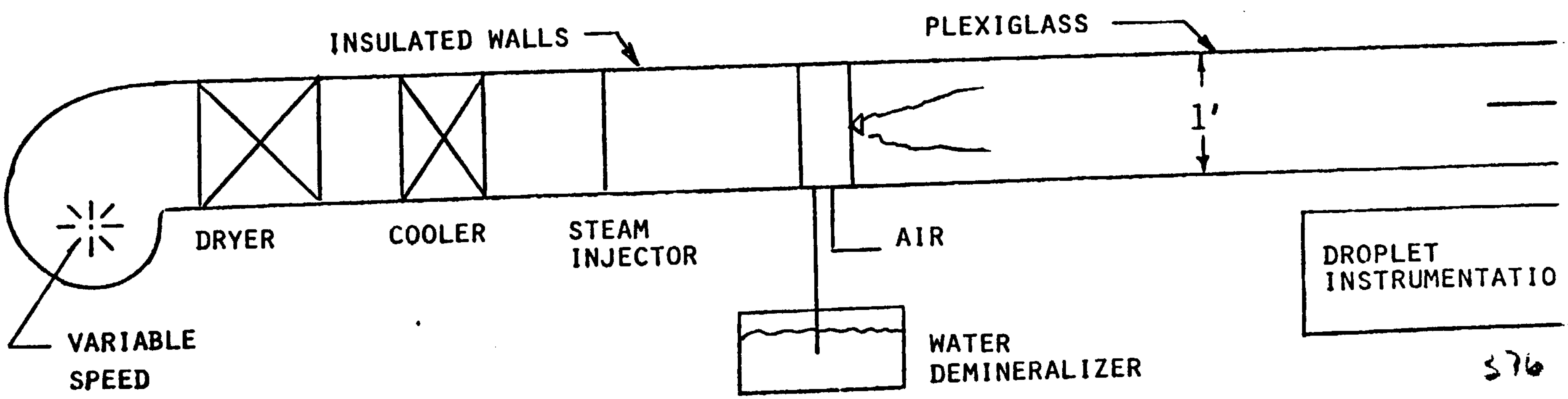
PRESSURE 10 TO 400 PSIG

TEMPERATURE 70 TO 200 F

PRESSURE MEASUREMENT ACCURACY: ± 1% OF READING FOR AIR PRESSURE AND DIFFERENTIAL PRESSURE ($P_{WATER}-P_{AIR}$)

SECONDARY AIR:

PRESSURE	1 ATM
SPEED	0 TO 75 MPH
TEMP	-20 TO 70°F
HUMIDITY	20 TO 100%



HIGH SPEED/HIGH ALTITUDE ICING TEST FACILITY

TUNNEL

MACH NO	0 TO 0.8
ALTITUDE	S.L. TO 22,000 FT
TOTAL TEMP	-20 TO 70°F
FLOW RATE	0 TO 140 LB/SEC
RELATIVE HUMIDITY	20 TO 100%

STEAM 85 PSIG, 2 INCH LINE

INSTRUMENTATION

- DROPLET SIZING SYSTEM
- HEATED WAKE SURVEY PROBE
- WALL PRESSURE TAPS
- VIDEO CAMERA AND LIGHTING

SUPERCOOLED CLOUD SPRAY BARS

WATER:

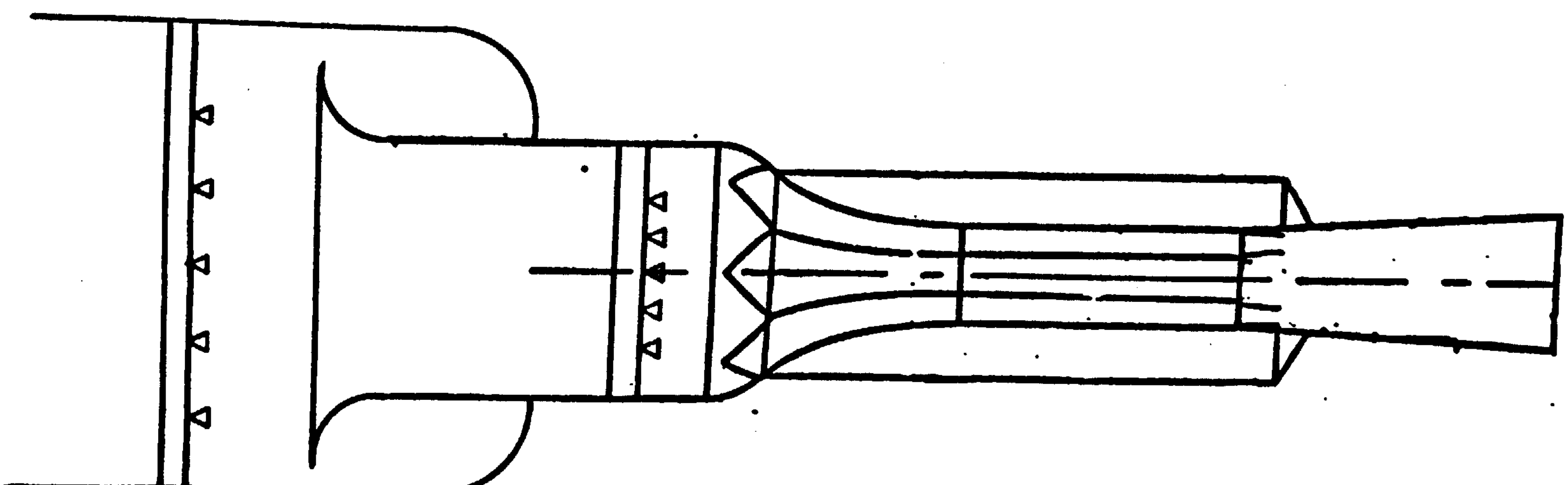
FLOW RATE	0 TO 20 GPM
TEMP	70 TO 200°F
PRESS	10 TO 500 PSIG
DEMINERALIZED	

AIR:

FLOW RATE	0 TO 12 LB/SEC
TEMP	70 TO 200°F
PRESS	10 TO 400 PSIG

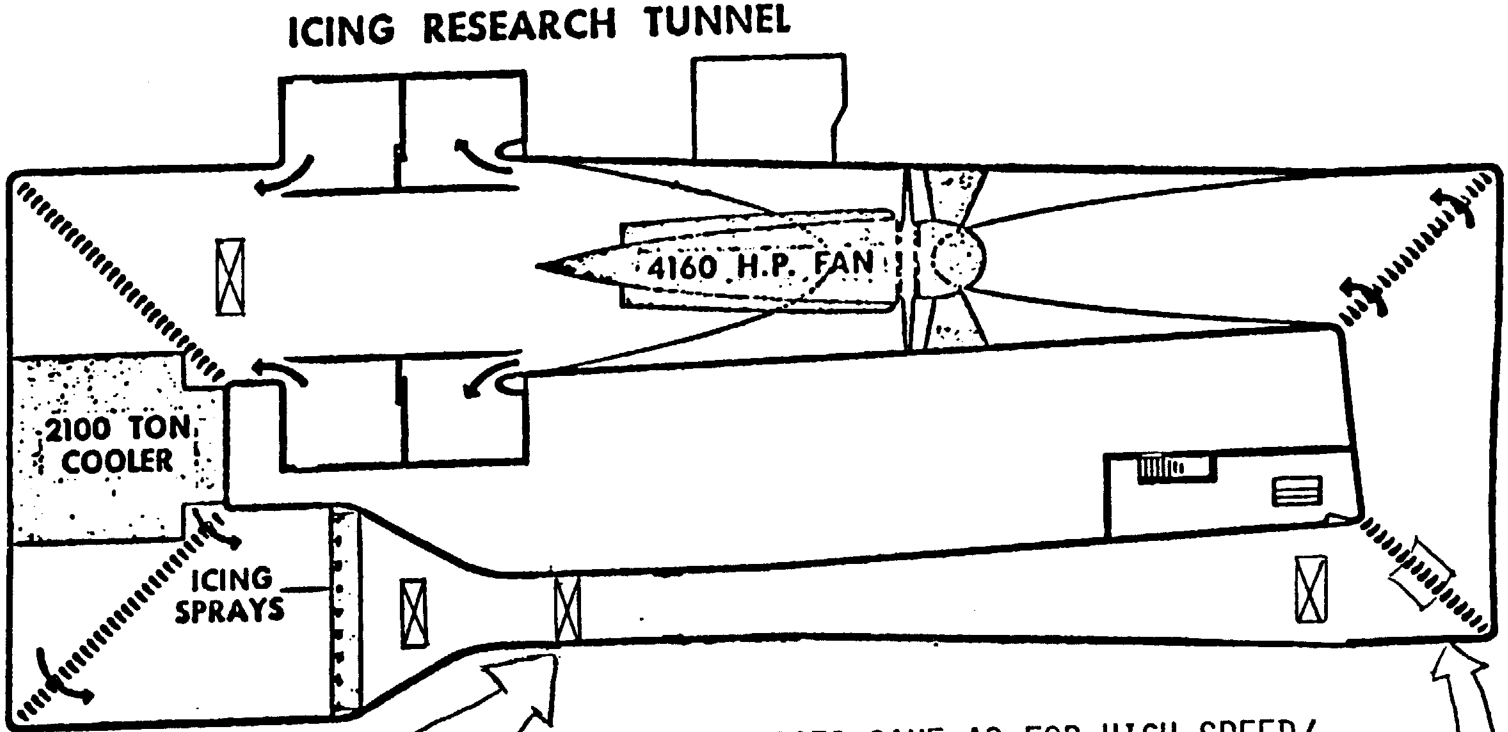
FREEZING & HEAVY RAIN SPRAY BARS

WATER:



1/10 SCALE MODEL OF HIGH SPEED LTS IN ENGINE TEST CELL

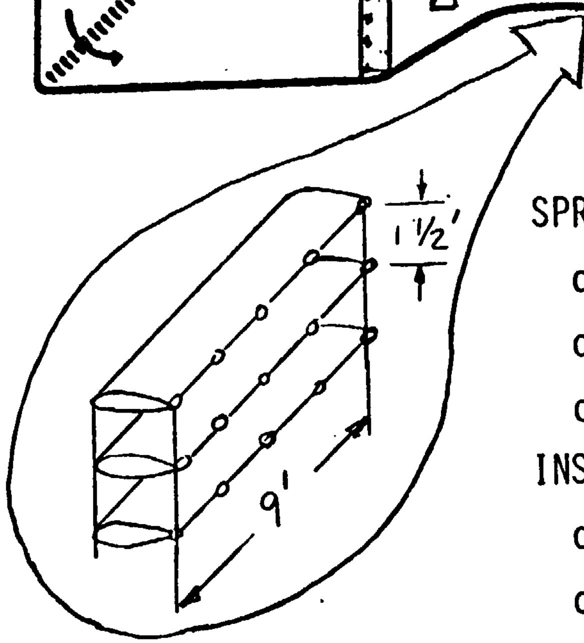
IRT TEST SUPPORT FOR AWT



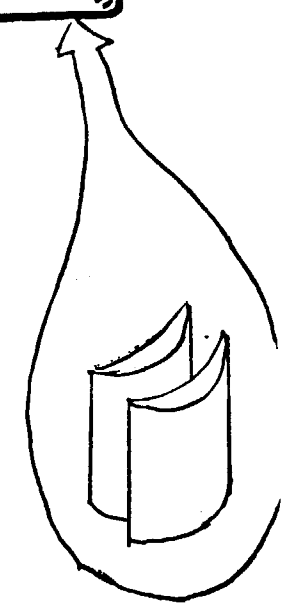
NOZZLE SERVICES SAME AS FOR HIGH SPEED/
HIGH ALTITUDE FACILITY

SPRAY BARS:
- o SUPERCOOLED CLOUDS
- o FREEZING RAIN
- o HEAVY RAIN

INSTRUMENTATION:
- o CLOUD INSTRUMENTS
- o VERTICAL WAKE SURVEY PROBES
- o HOT WIRE SYSTEM



PORTABLE AWT SPRAY BAR ASSEMBLY



AWT TURNING VANES

AWT ACOUSTICS DISCUSSION

JOHN F. GROENEWEG

HEAD, TURBOMACHINERY NOISE SECTION

NASA LEWIS RESEARCH CENTER

AWT ACOUSTIC SYSTEMS TASK TEAM

OBJECTIVE:

TO DETERMINE THE AWT FEATURES REQUIRED TO PRODUCE TEST SECTION ACOUSTIC PROPERTIES WHICH ALLOW THE ACOUSTIC SIGNATURES OF PROPULSION SYSTEMS TO BE MEASURED.

APPROACH:

A COMBINATION OF ANALYSES AND EXPERIMENTS WILL BE USED TO:

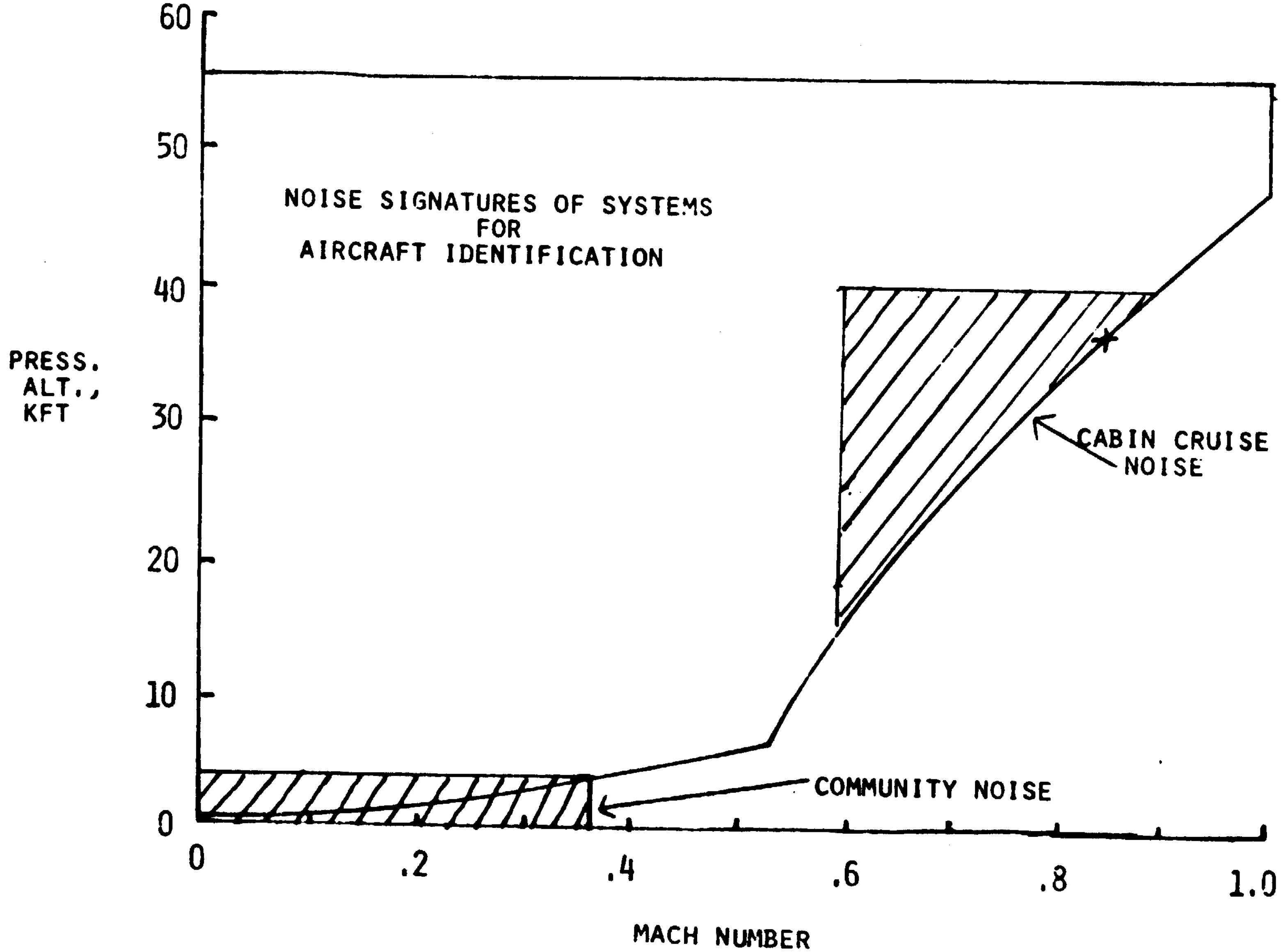
- ASSURE AN ANECHOIC TEST SECTION COMPATIBLE WITH THE SOURCE SPECTRA OF THE MOST PROBABLE PROPULSION SYSTEM TEST CANDIDATES.
- DEFINE ACCEPTABLE LEVELS OF TEST SECTION BACKGROUND NOISE AND TURBULENCE.
- IDENTIFY SOURCES OF BACKGROUND NOISE AND REQUIRED NOISE REDUCTION DESIGN FEATURES/ ACOUSTIC TREATMENT.
- CRITIQUE ALL TUNNEL DESIGN FEATURES FOR COMPATIBILITY WITH ACOUSTIC REQUIREMENTS.

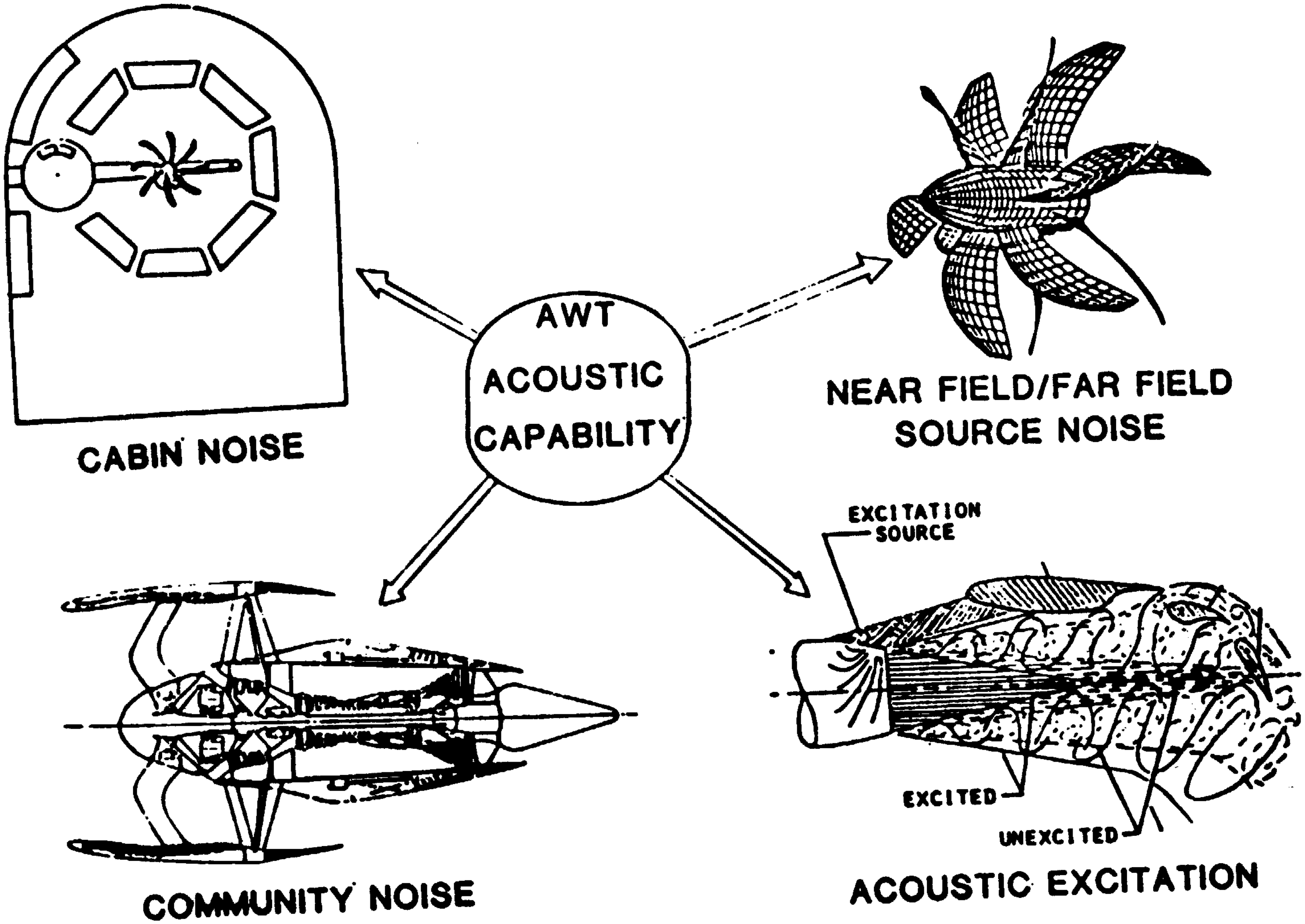
AWT ACOUSTIC SYSTEMS TASK TEAM

JOHN F. GROENEWEG - LEADER

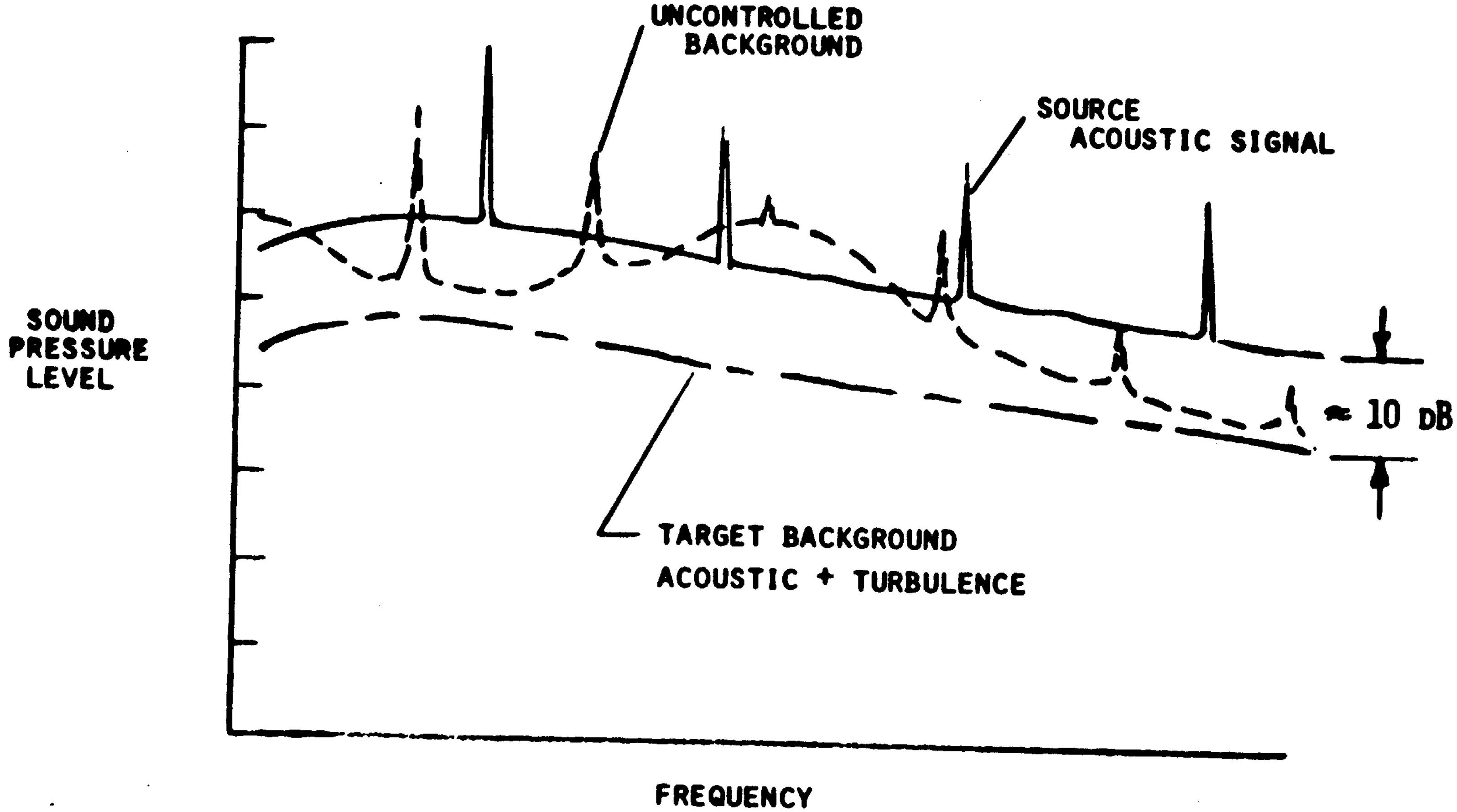
MEMBERS	PRIMARY FUNCTION
EDWARD J. RICE	ACOUSTIC TREATMENT DESIGN
KENNETH J. BAUMEISTER	COMPUTATIONAL AEROACOUSTICS
MILO D. DAHL	ACOUSTIC TREATMENT PERFORMANCE MEASUREMENT
BRUCE J. CLARK	NOISE SOURCE ANALYSIS
LEONARD HOMYAK	COMPONENT NOISE MEASUREMENT
FREDERICK W. GLASER	ACOUSTIC TREATMENT INTEGRITY/ ICING COMPATIBILITY
WILLIAM STEVANS	EXPERIMENTAL OPERATIONS

AWT TEST SECTION OPERATING ENVELOPE SHOWING REGIONS AND TYPES OF NOISE MEASUREMENTS

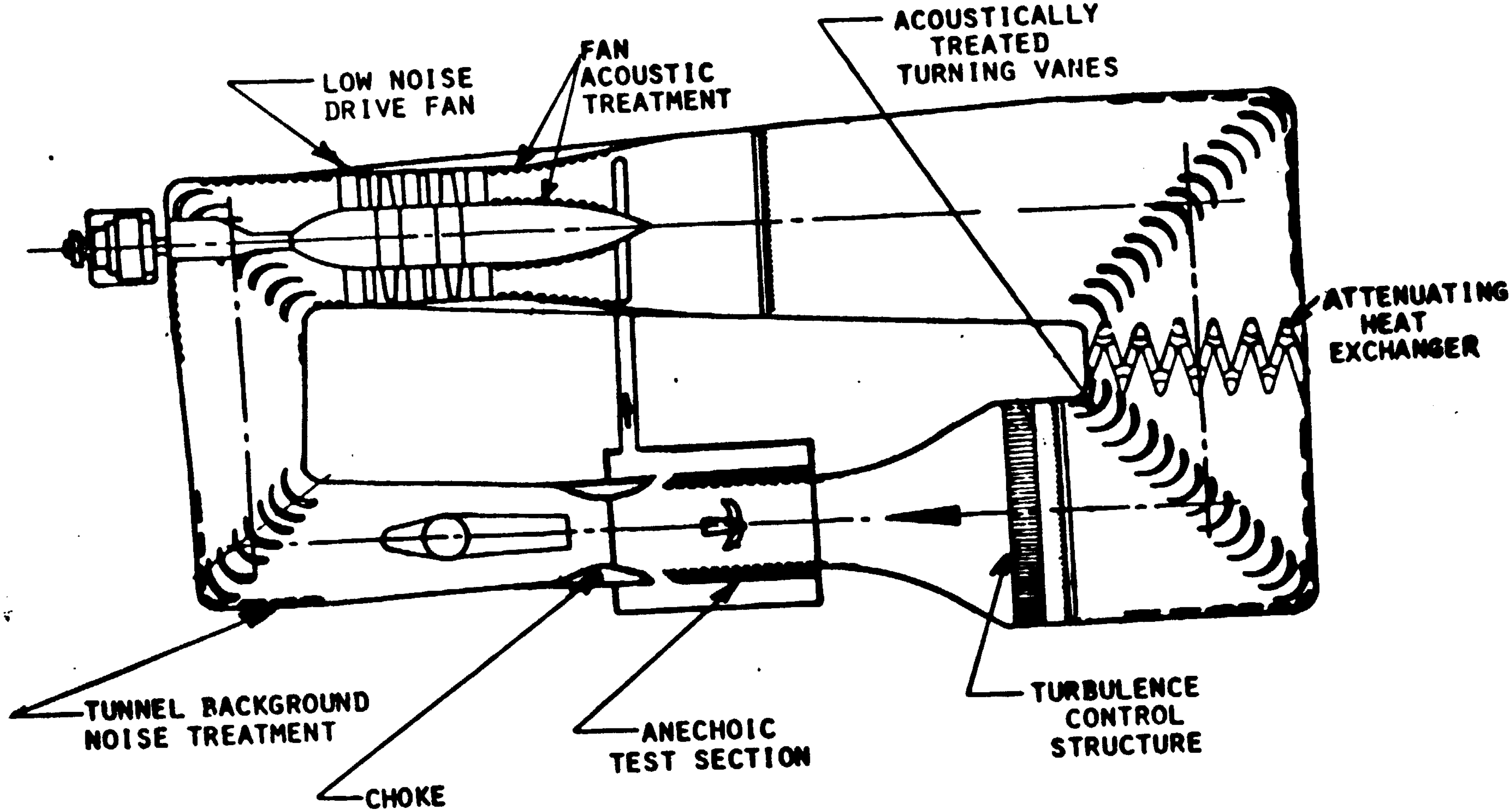



AWT
ACOUSTIC
CAPABILITY
CABIN NOISE
NEAR FIELD/FAR FIELD
SOURCE NOISE
COMMUNITY NOISE
EXCITATION
SOURCE
EXCITED
UNEXCITED
ACOUSTIC EXCITATION

TEST SECTION SPECTRAL PROPERTIES



POTENTIAL AWT ACOUSTIC FEATURES



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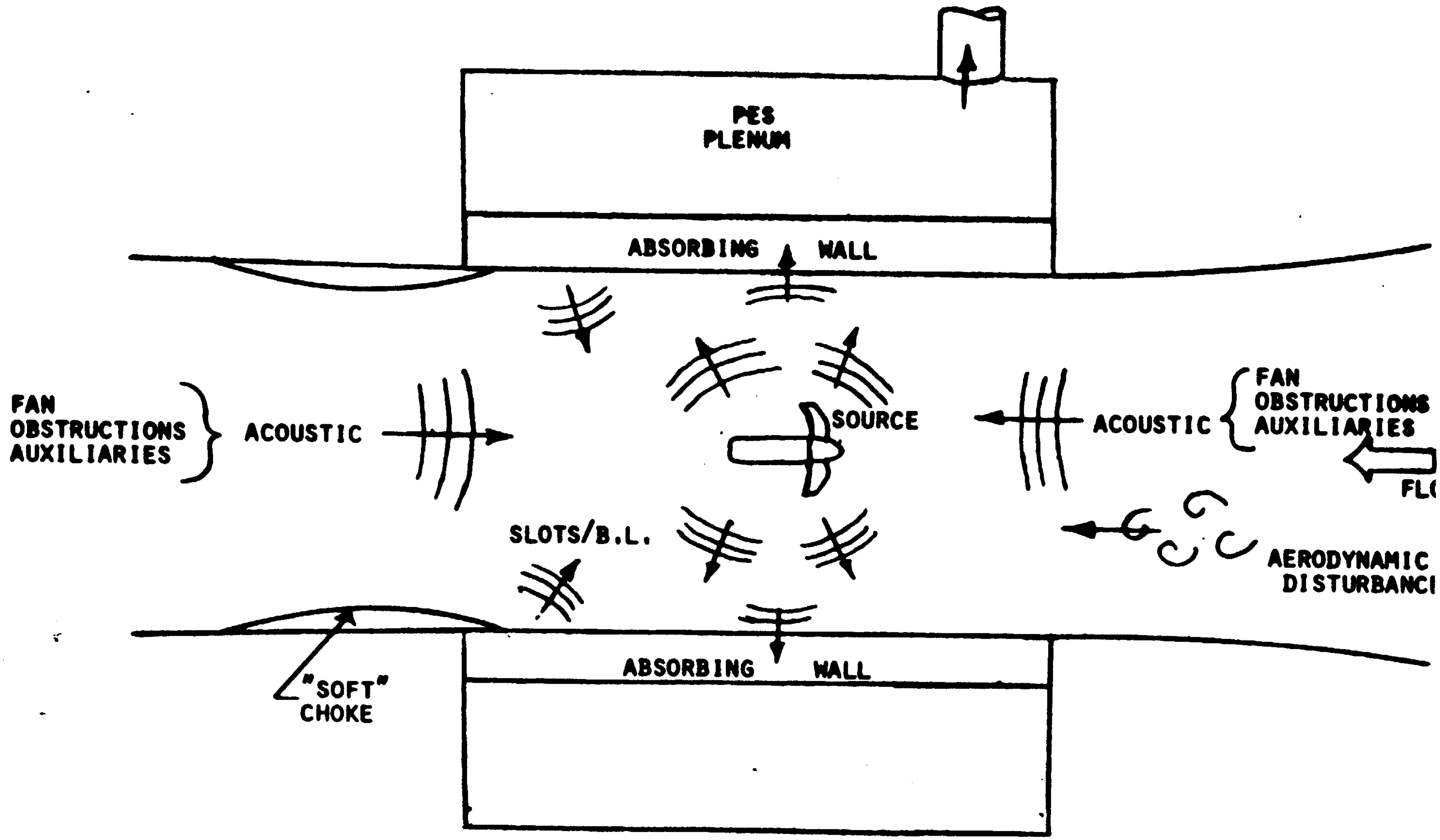
TEST SECTION PRESSURE FLUCTUATIONS

SOURCES AND SINKS



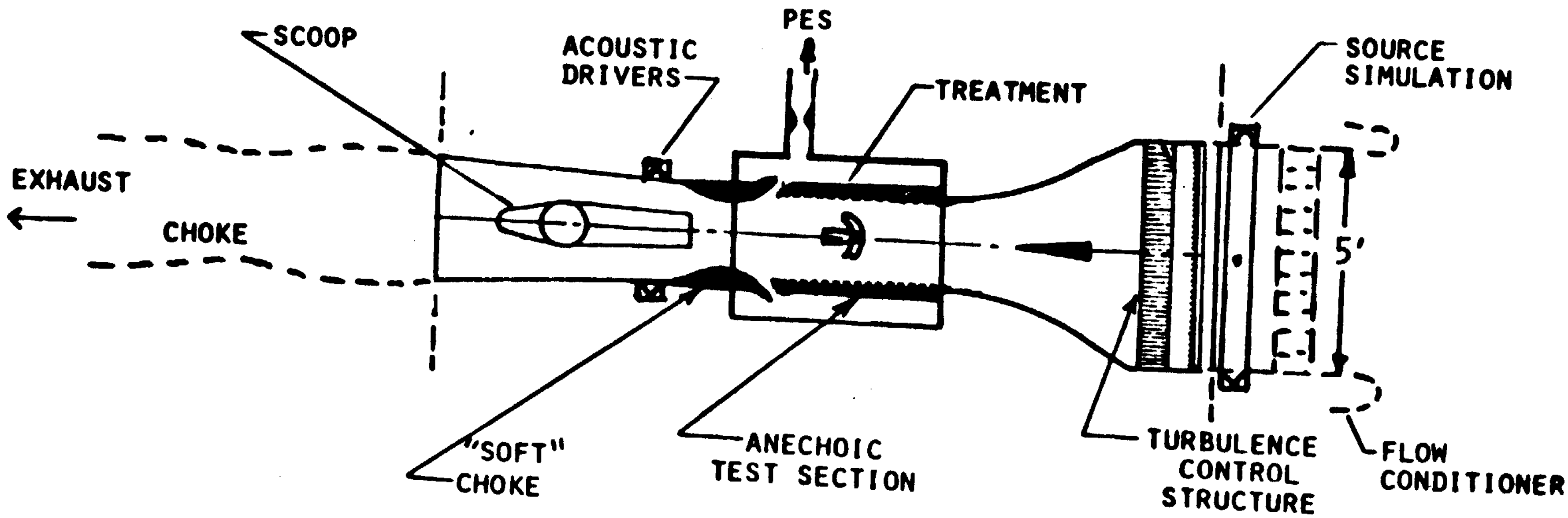
AWT ACOUSTIC SYSTEMS
MODELING
WORK BREAKDOWN STRUCTURE

2.5 ACOUSTICS

- 2.5.1 ANALYTICAL MODELING
- 2.5.2 DESIGN AND FABRICATION
- 2.5.3 PHYSICAL MODELING
  - 2.5.3.1 MODEL SCALE: 5% - 20%, 10% NOMINAL
    - 2.5.3.1.1 HIGH SPEED LEG
    - 2.5.3.1.2 LOW SPEED LEG
    - 2.5.3.1.3 HEAT EXCHANGER/TURNING VANES
    - 2.5.3.1.4 TUNNEL LOOP
  - 2.5.3.2 FULL SCALE: ≥ 50%
    - 2.5.3.2.1 TEST SECTION ACOUSTIC TREATMENT
    - 2.5.3.2.2 HEAT EXCHANGER
    - 2.5.3.2.3 TREATED TURNING VANES

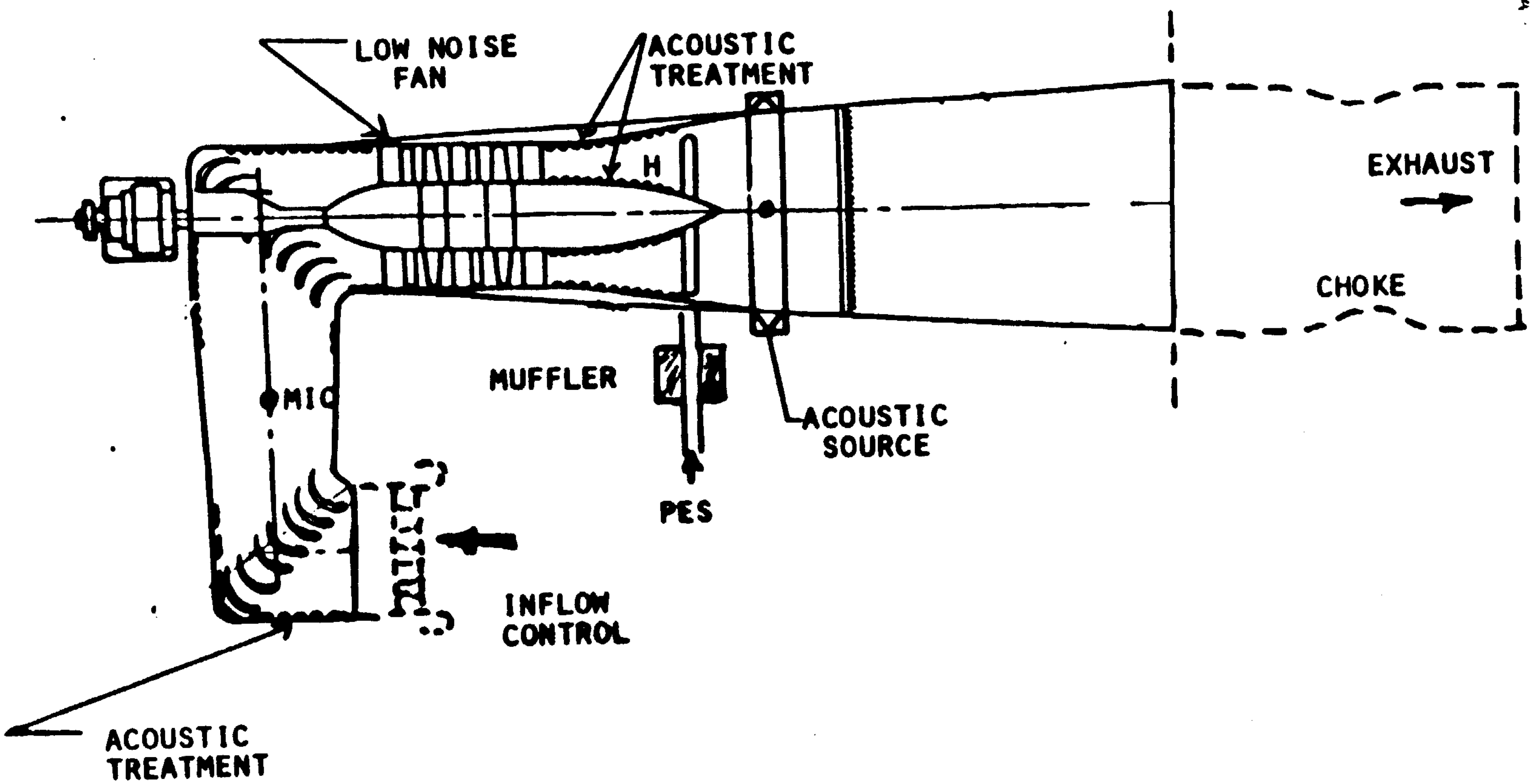
2.5.3.1.1. HIGH SPEED LEG

NOMINAL 10% SCALE



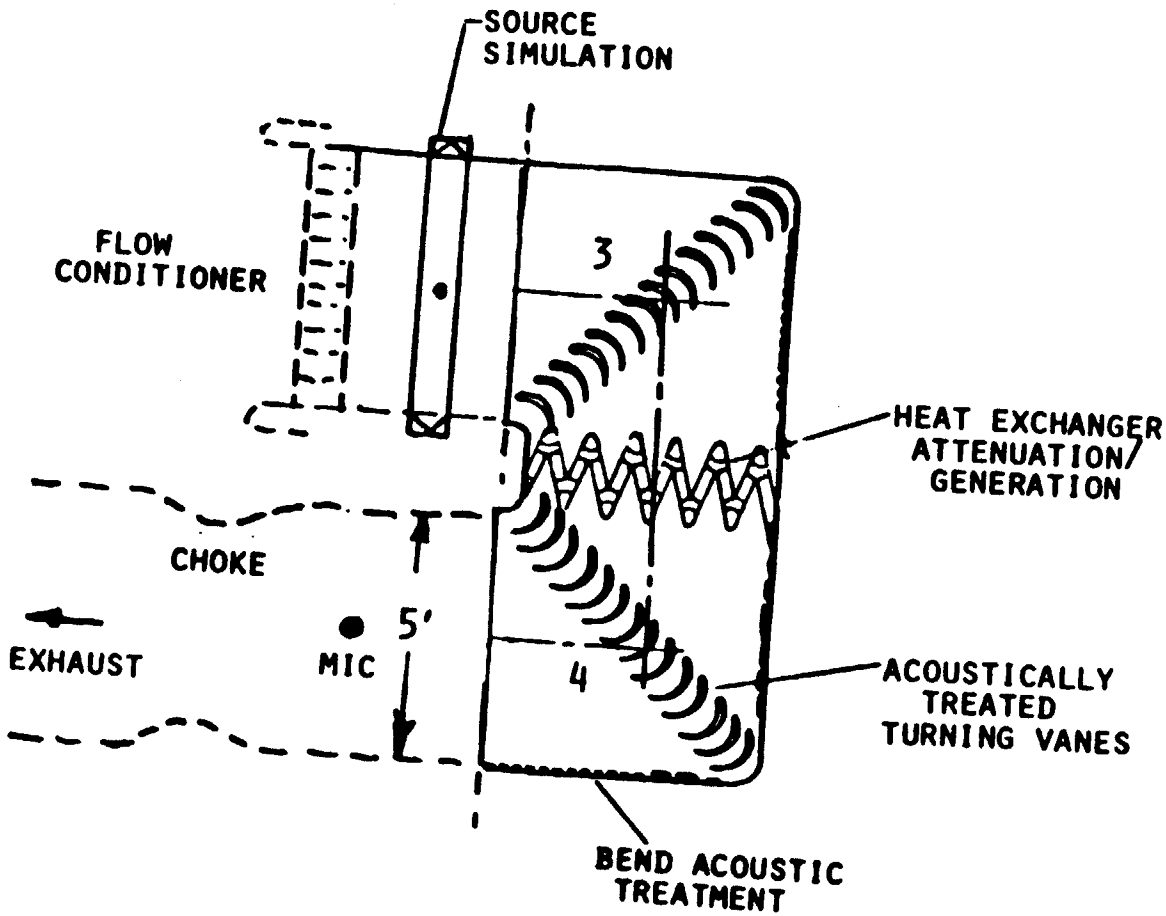
2.5.3.1.2 LOW SPEED LEG

NOMINAL 10% SCALE



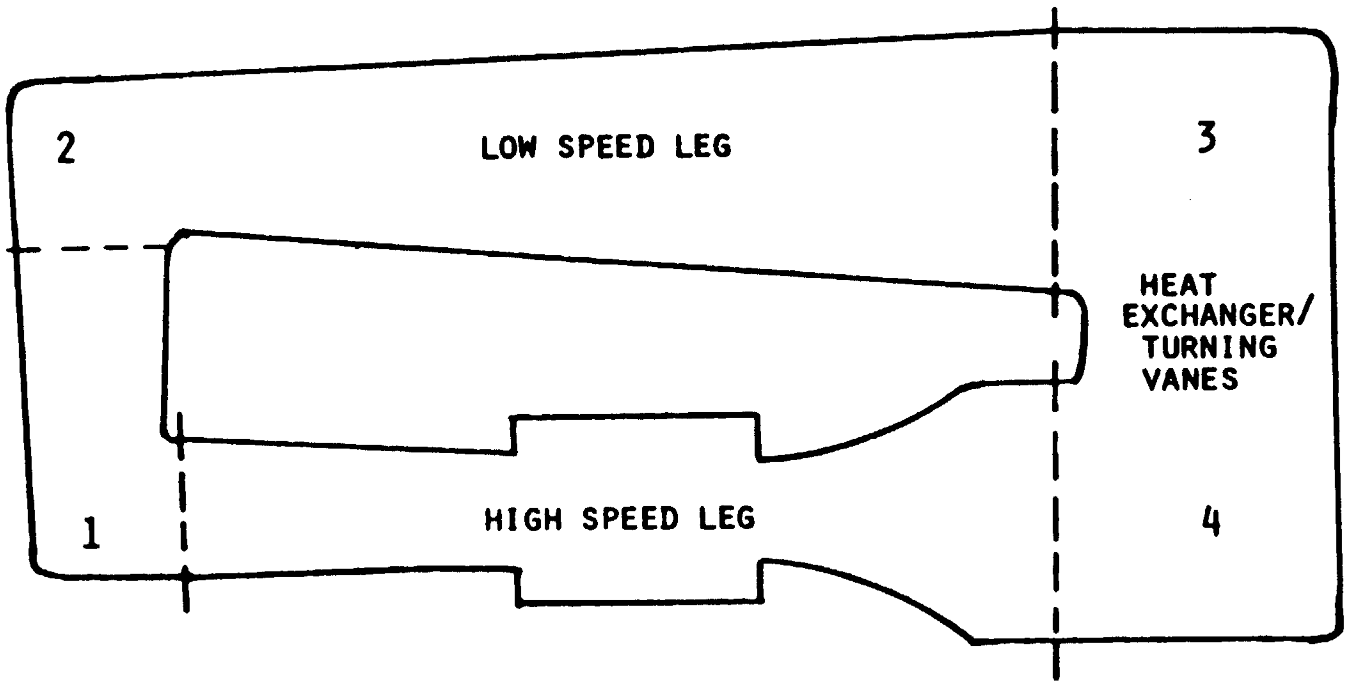
2.5.3.1.3 HEAT EXCHANGER/TURNING VANES

NOMINAL 10% SCALE



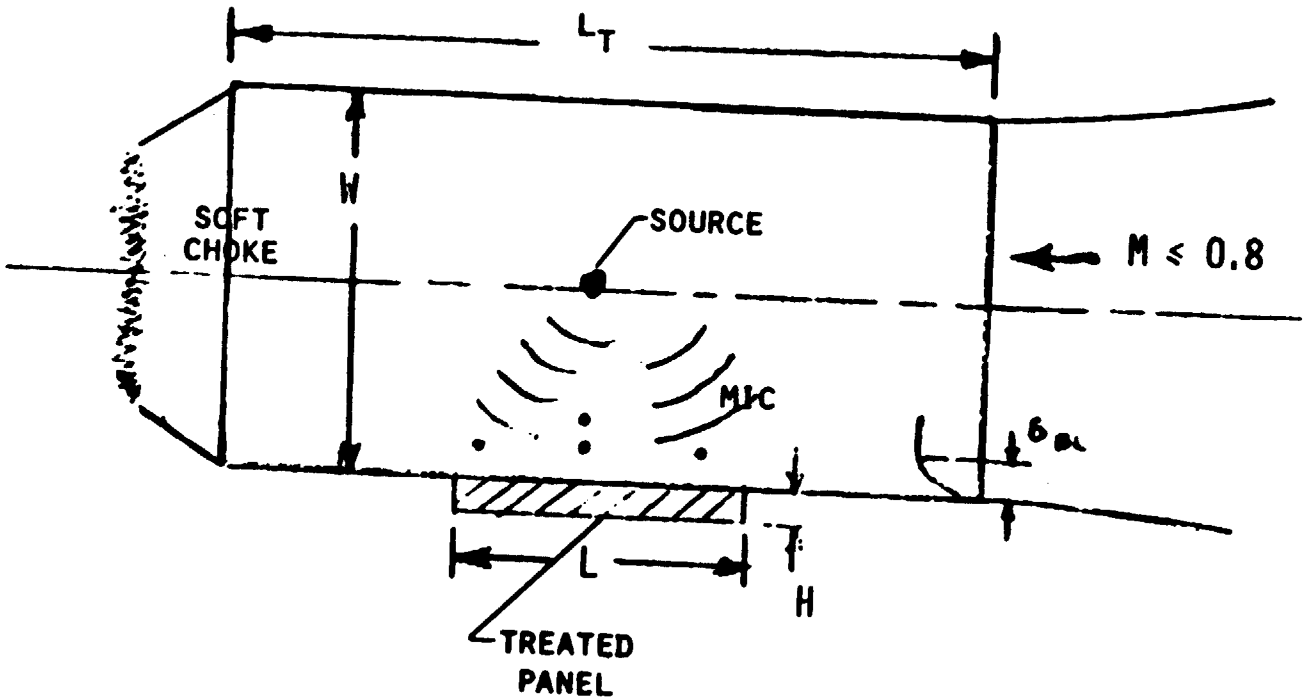
2.5.3.1.4 <u>TUNNEL LOOP</u>

NOMINAL SCALE 10%



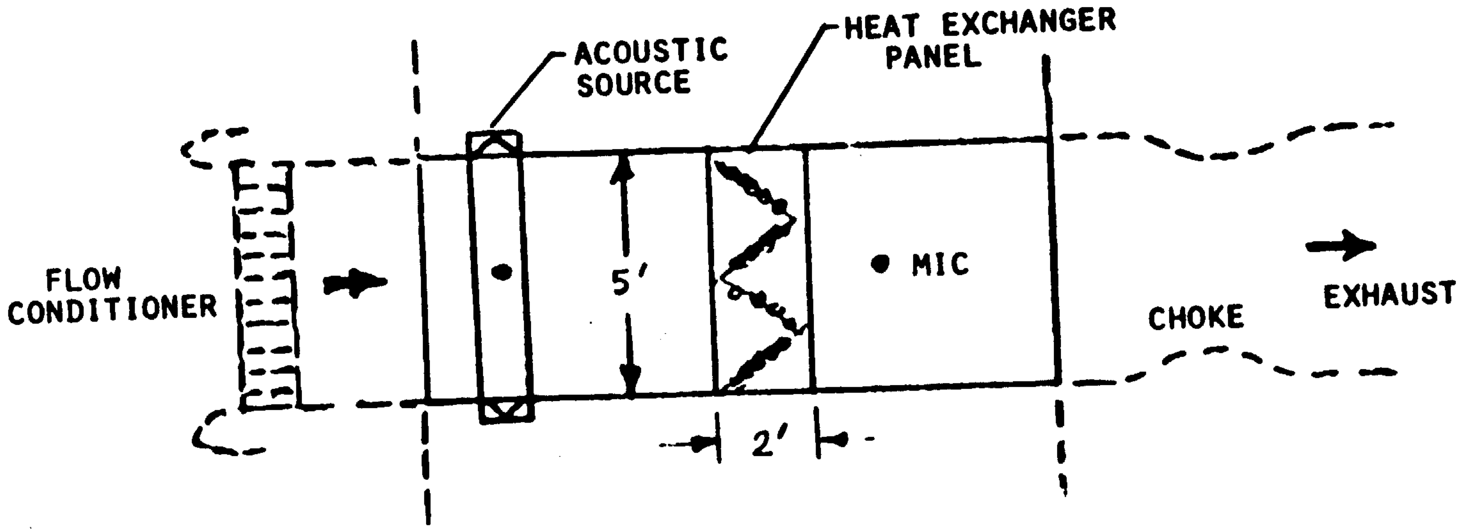
2.5.3.2.1 ACOUSTIC TREATMENT

FULL SCALE SEGMENT
IN WIND TUNNEL



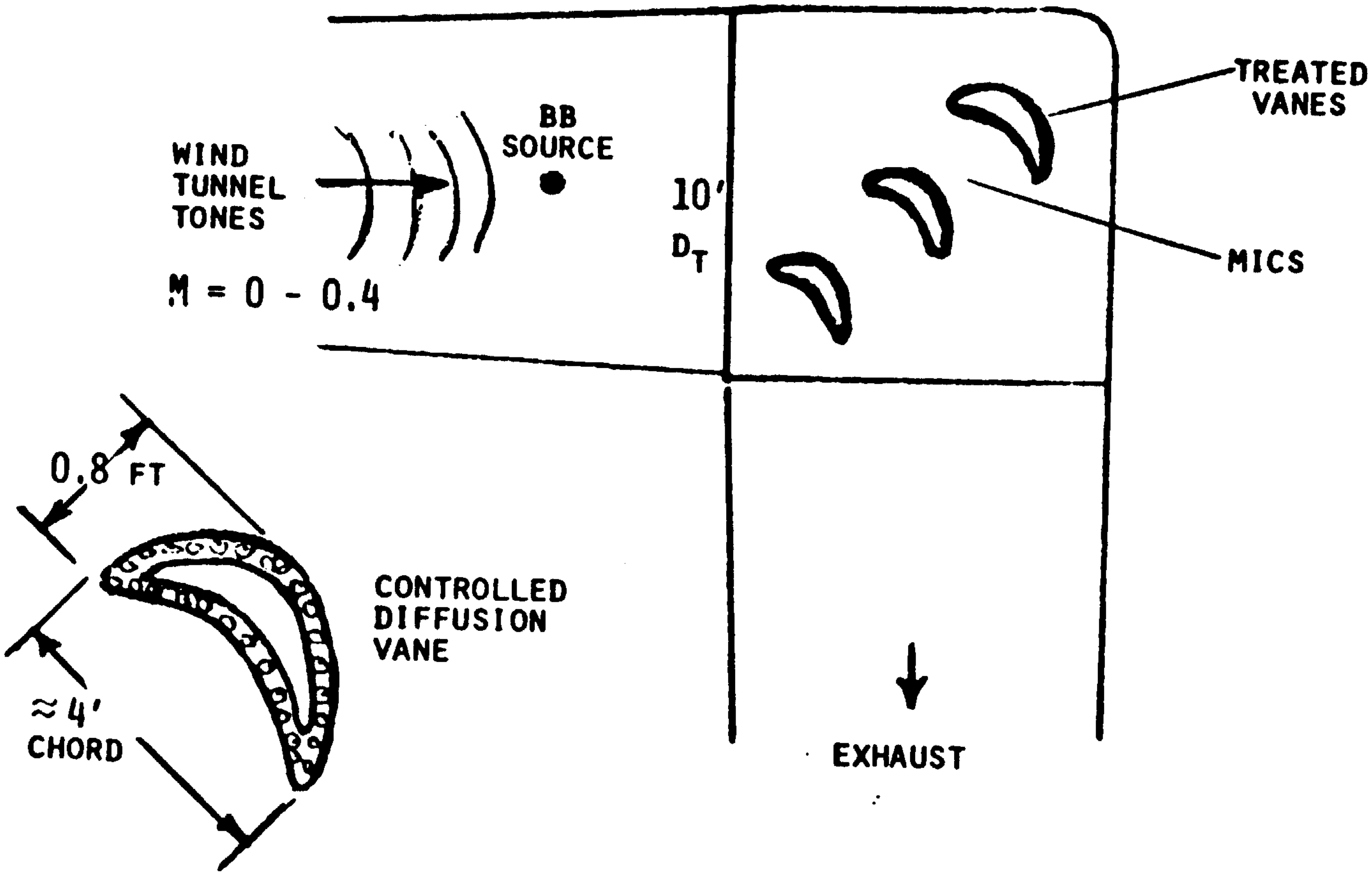
2.5.3.2.2 HEAT EXCHANGER

FULL SCALE SEGMENT

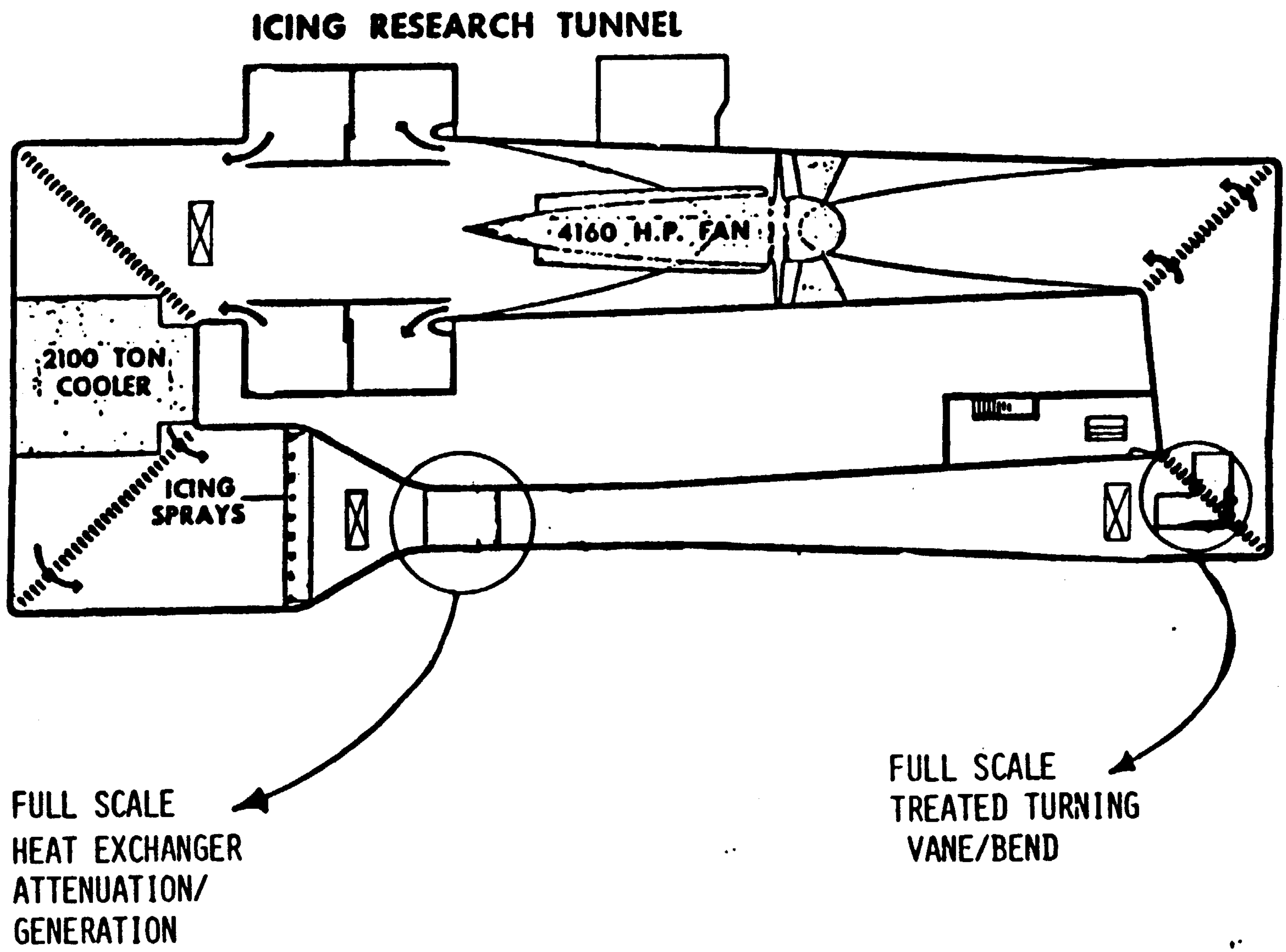


2.5.3.2.3 TREATED TURNING VANES

FULL SCALE SEGMENT



FULL SCALE HEAT EXCHANGER AND TURNING VANE ACOUSTIC TESTS



KEY TECHNICAL ISSUES IDENTIFIED

ACOUSTIC TREATMENT

- o HIGH ABSORPTION AT HIGH MACH NUMBER WITH A WALL BOUNDARY LAYER
- o LOW FREQUENCY ABSORPTION WITH MINIMUM TREATMENT THICKNESS
- o ICING COMPATIBILITY/PERMANENT INSTALLATION

BACKGROUND NOISE

- o FAN TONE REDUCTION
- o INTERDEPENDENCE OF NOISE AND FLOW QUALITY

AWT DYNAMICS AND CONTROLS DISCUSSION

JOHN R. SZUCH

HEAD, SYSTEMS DYNAMICS SECTION

NASA LEWIS RESEARCH CENTER

AWT DYNAMICS AND CONTROLS TASK TEAM

JOHN SZUCH

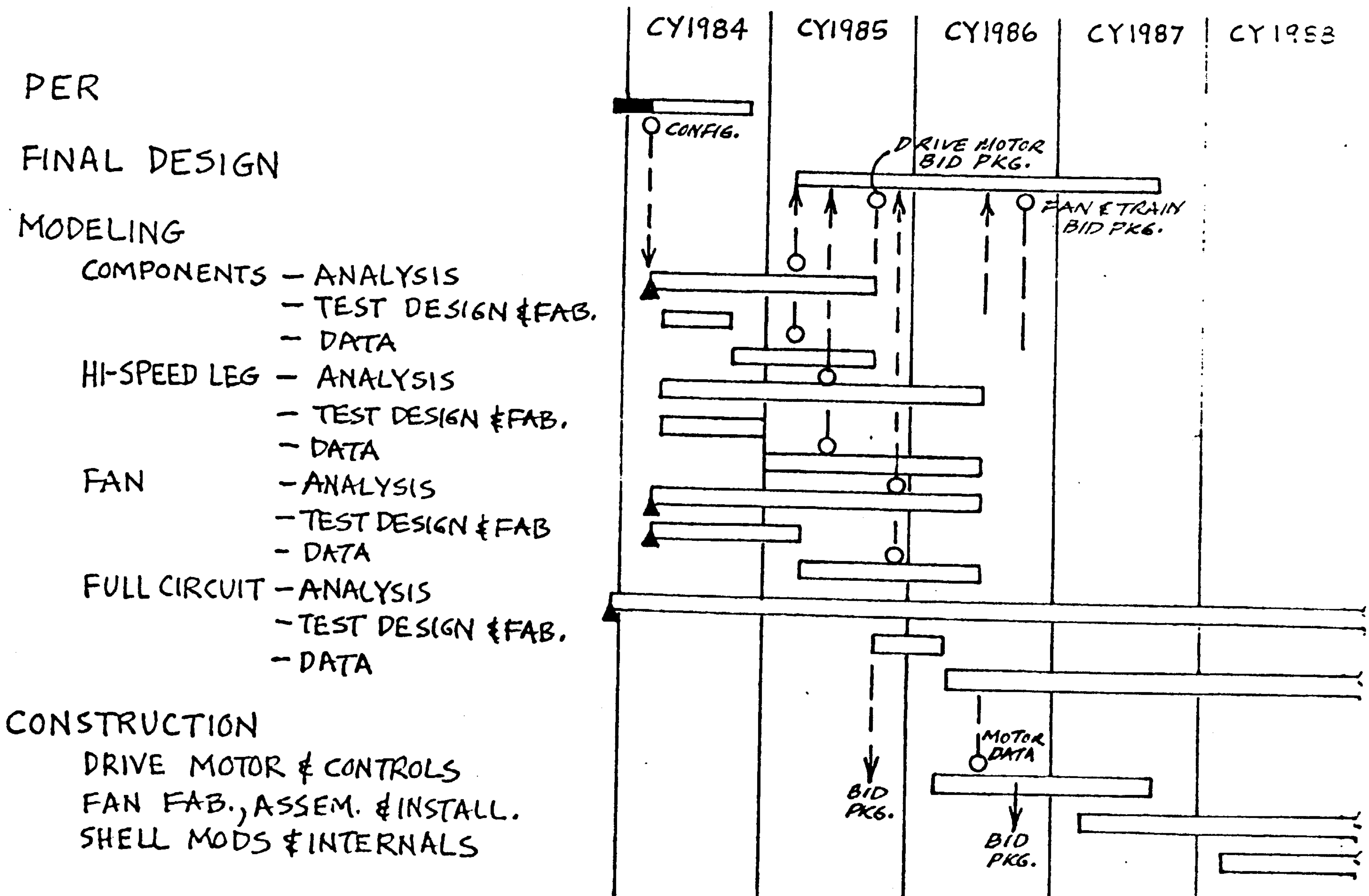
HEAD, SYSTEM DYNAMICS SECT.

AWT DYNAMICS AND CONTROLS

TASK TEAM MEMBERS

JOHN SZUCH, LEADER	DYNAMICS AND CONTROLS BRANCH
ROBERT SEIDEL	DYNAMICS AND CONTROLS BRANCH
JOSEPH GABY	AWT PROJECT OFFICE
JAMES DOLCE	AWT PROJECT OFFICE
ART KIEFFER	SYSTEMS ENGINEERING AND CONTROLS BRANCH
SUSAN KROSEL	DYNAMICS AND CONTROLS BRANCH
OTHERS	T.B.D.

AWT PROJECT
MODELING/DESIGN/CONSTRUCTION INTERFACES



AWT DYNAMICS AND CONTROLS

OBJECTIVES

- o DEVELOP AN UNDERSTANDING OF THE AWT PROCESS DYNAMICS AND INTERACTIONS
- o ASSESS AND VERIFY PROPOSED CLOSED-LOOP CONTROL CONCEPTS
- o CONSIDER AND EVALUATE ALTERNATIVE CONTROL CONCEPTS THAT MAY OFFER IMPROVED PERFORMANCE AND/OR RELIABILITY

AWT DYNAMICS AND CONTROLS

LANGLEY DISCUSSIONS INDICATED

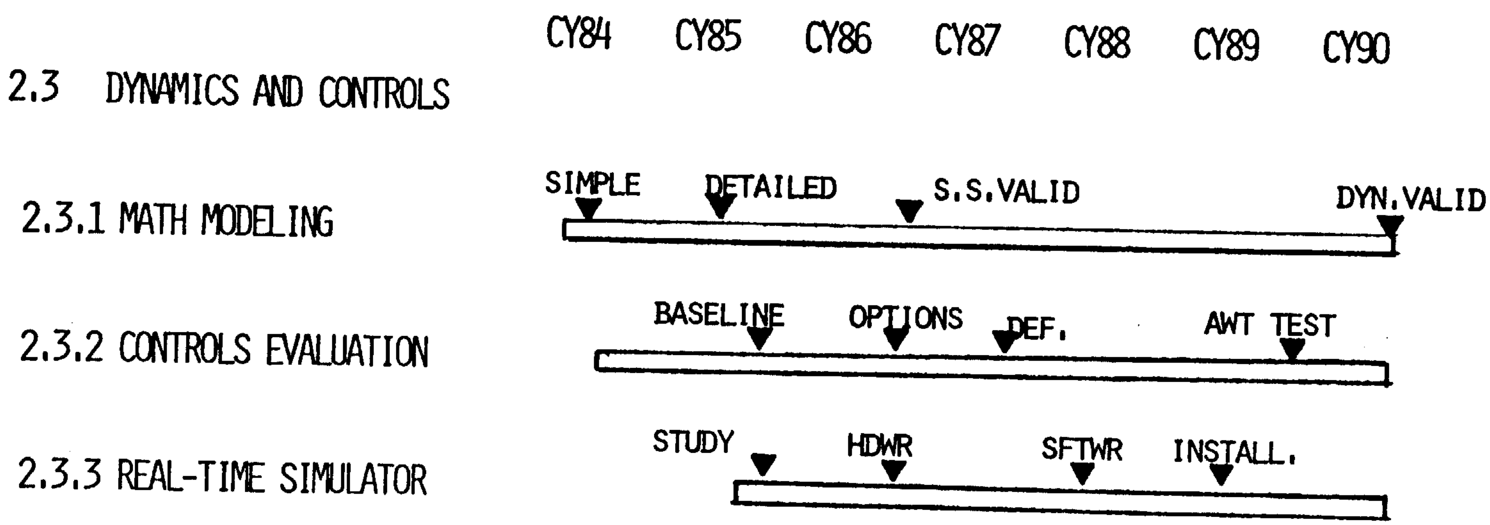
- HIGH DEGREE OF CONFIDENCE IN 1-D, 15-VOLUME MODEL OF NTF AND CONTROL ALGORITHMS DEVELOPED WITH IT
- QUALITATIVE AGREEMENT BETWEEN MODEL RESULTS AND AVAILABLE DATA
- POSSIBILITY OF CONTRACTING FOR MODELING AND CONTROLS DESIGN (E.G. DR. GUMAS OF PENN STATE)
- LOW PRIORITY PLACED ON SUB-SCALE PHYSICAL MODEL TESTS FOR MODEL VERIFICATION AND CONTROLS ASSESSMENT
- NEED FOR A REAL-TIME SIMULATOR FOR CONTROLS CHECKOUT

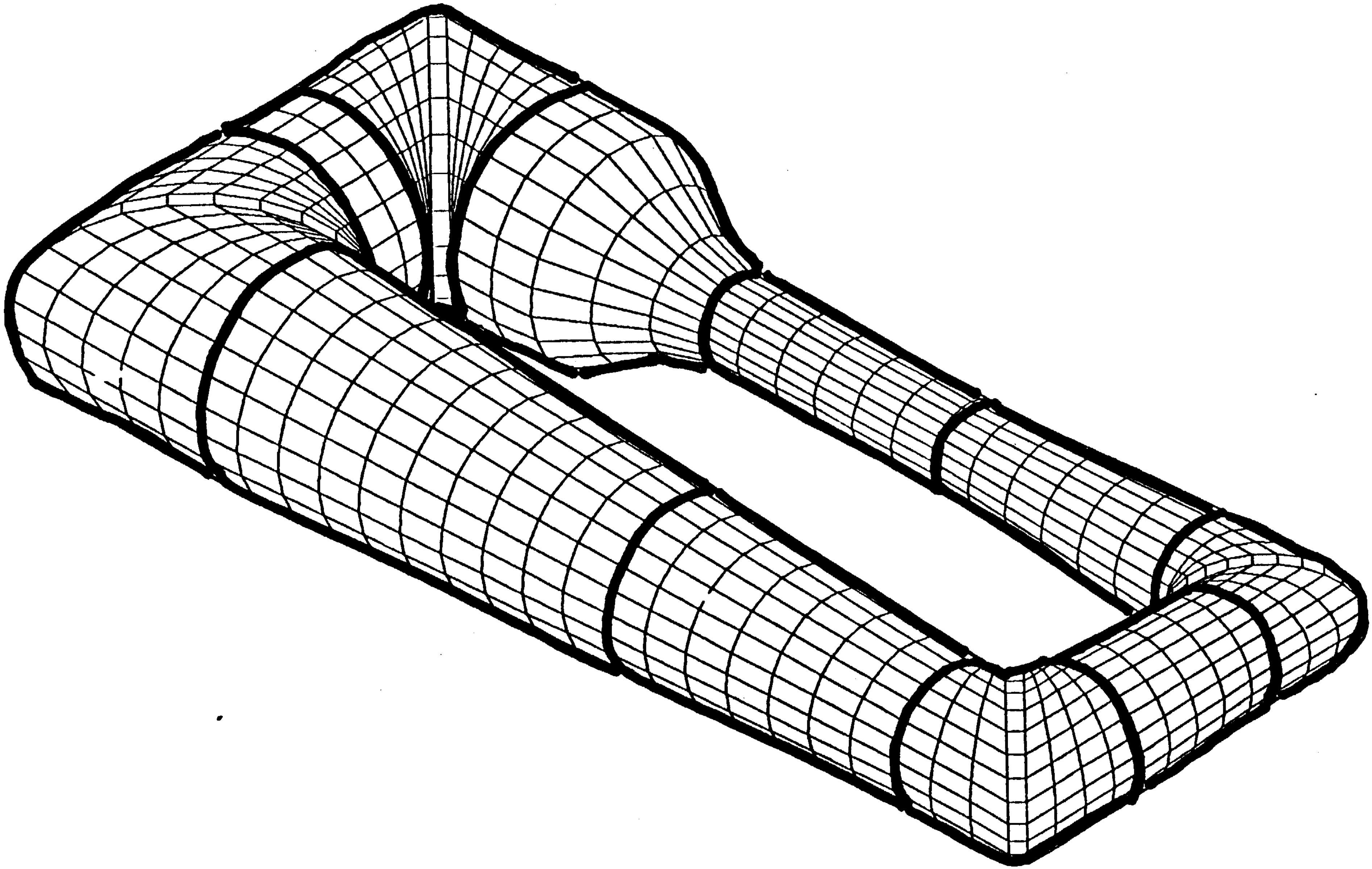
AWT DYNAMICS AND CONTROLS

APPROACH

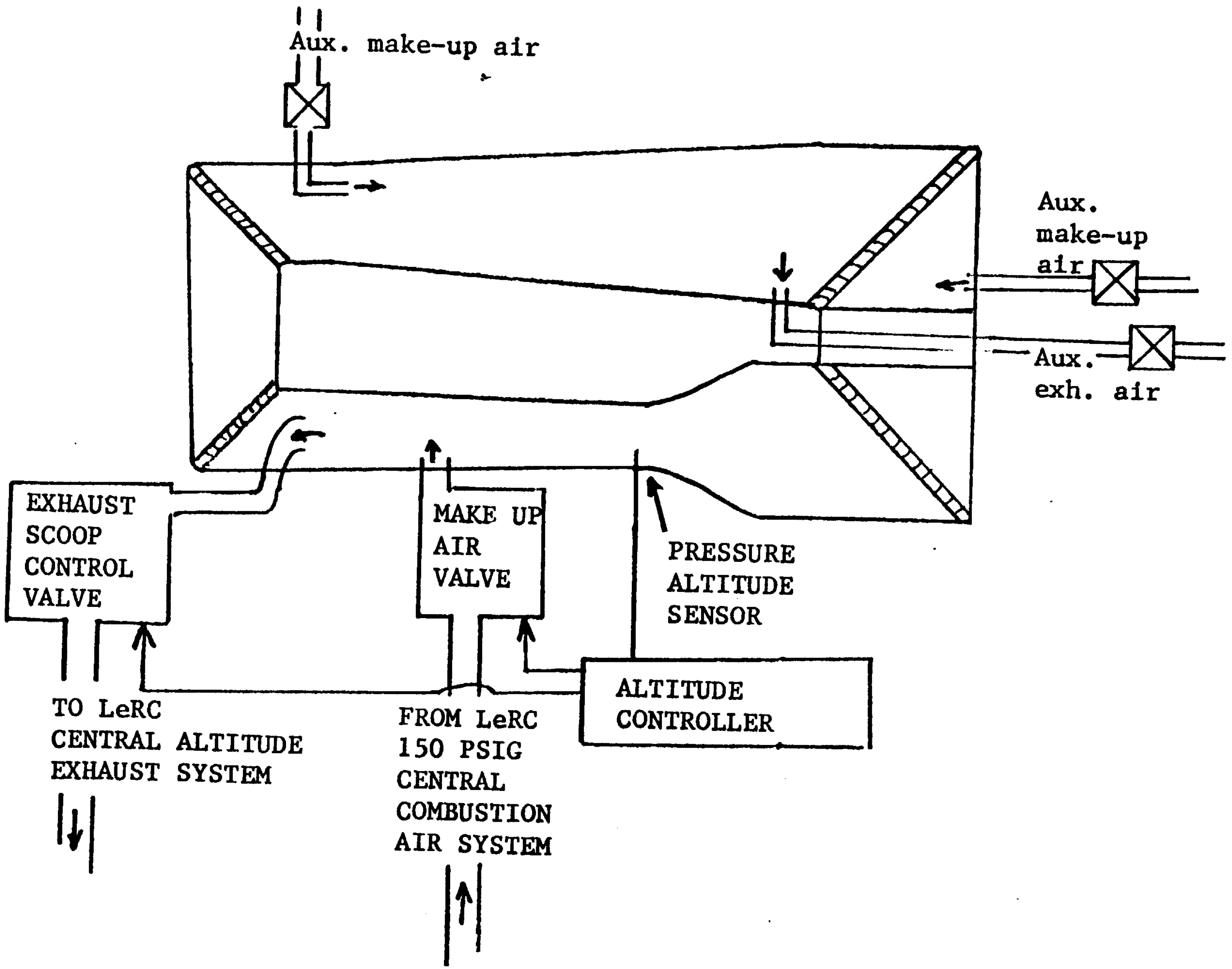
- o FOCUS ON THE IN-HOUSE DEVELOPMENT OF A 1-D, LUMPED PARAMETER MODEL
- o CONTRACT FOR INDEPENDENT DEVELOPMENT OF A "STATE-OF-THE-ART" MODEL
- o USE THE MATH MODEL(S) AS A TEST-BED TO
  - DETERMINE SYSTEM DYNAMICS
  - ANSWER "WHAT IF..." QUESTIONS
  - EVALUATE CONTROL CONCEPTS
  - ESTABLISH AN ANALYTICAL BASIS FOR SUB-SCALE AND FULL-SCALE TESTS
- o DETERMINE COSTS/BENEFITS OF DEVELOPING A REAL-TIME AWT SIMULATOR

AWT DYNAMICS AND CONTROLS

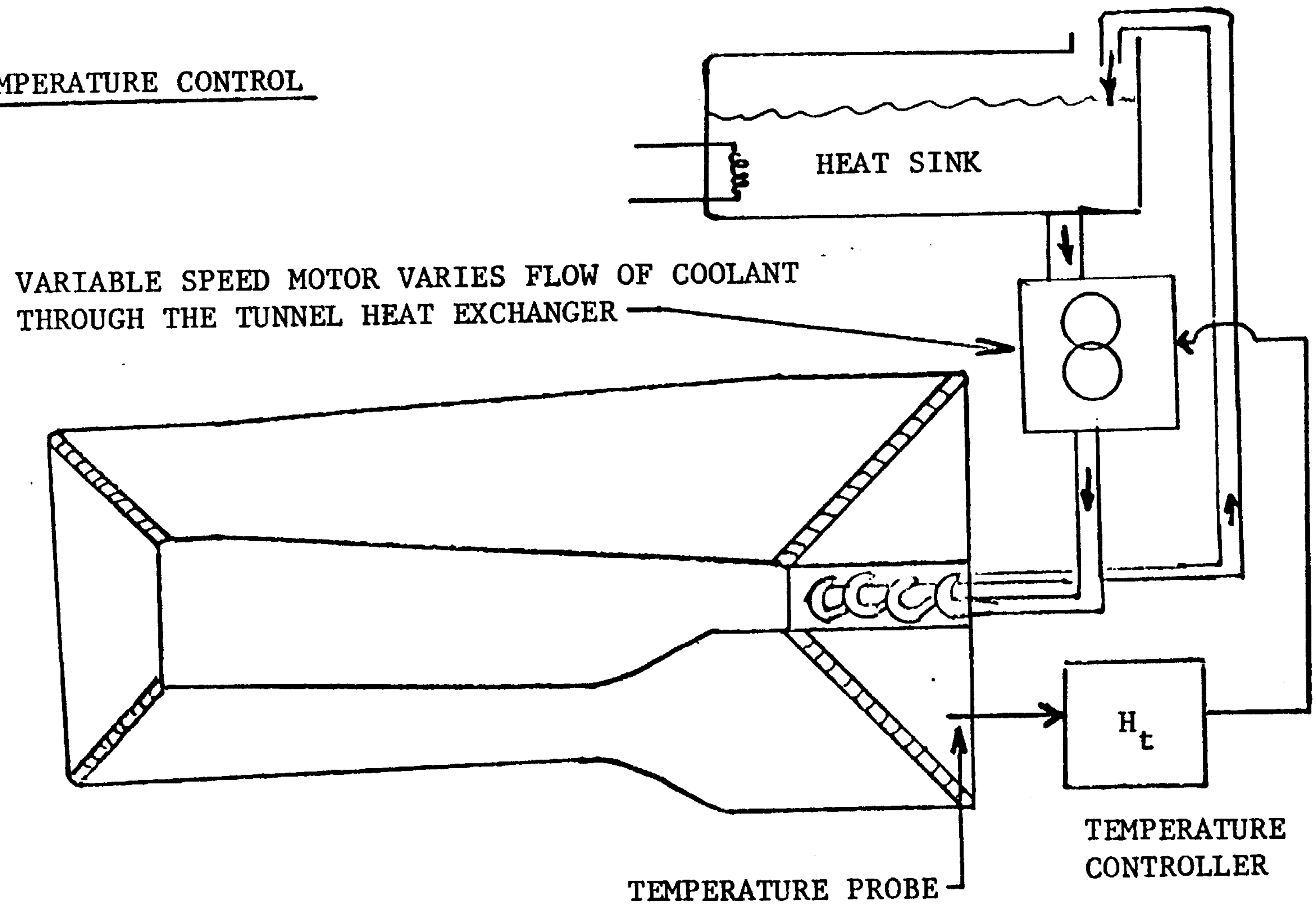




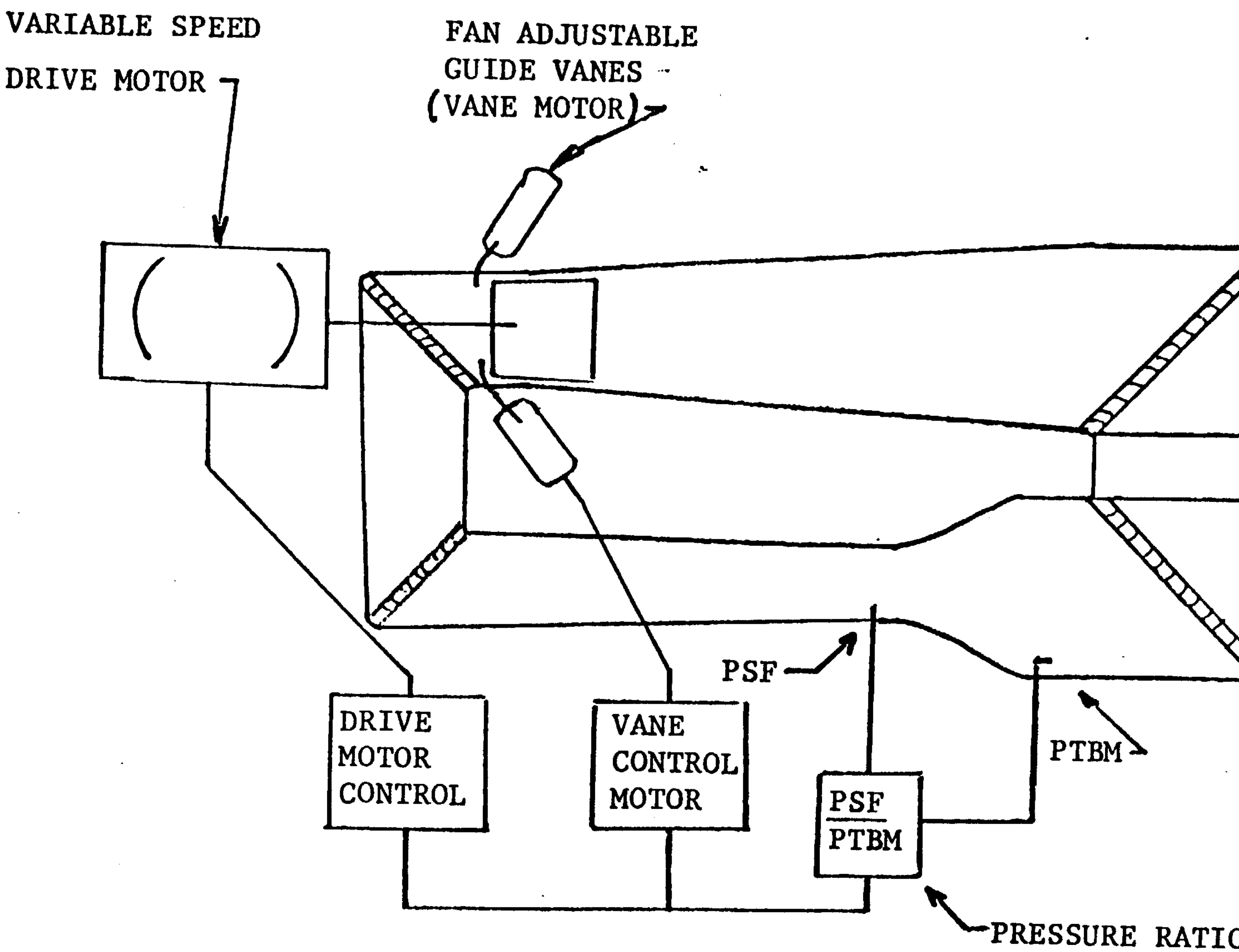
PRESSURE ALTITUDE CONTROL



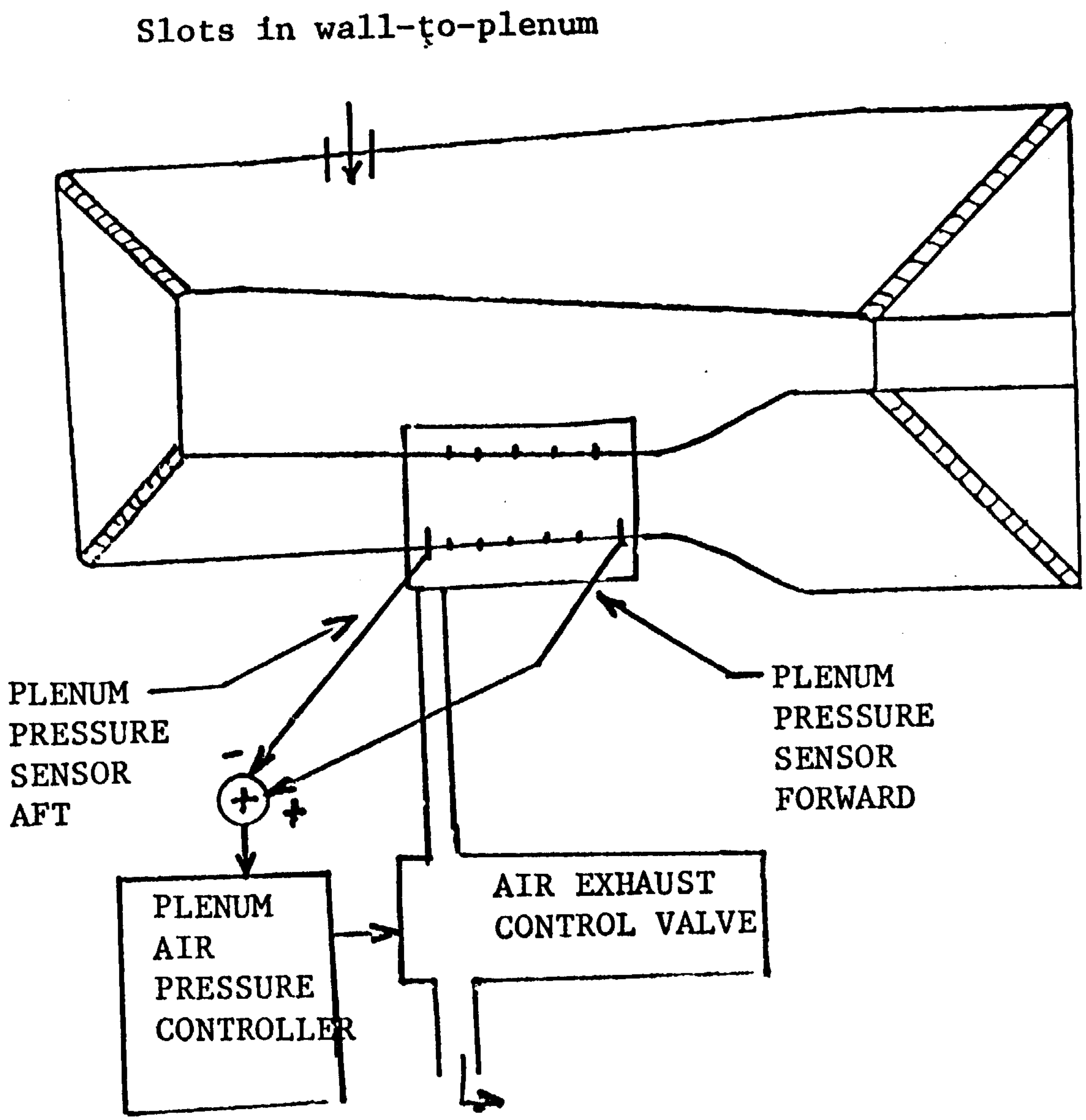
TEMPERATURE CONTROL



MACH NUMBER CONTROL



PLENUM EVACUATION CONTROL



AWT DYNAMICS AND CONTROLS

ISSUES TO DISCUSS

- o HOW ACCURATE OR DETAILED A MODEL IS NEEDED FOR CONTROLS DESIGN AND EVALUATION? IS A DISTRIBUTED (500 LUMPS) MODEL NEEDED?
- o SHOULD AN INTEGRATED SIMULATION/CONTROLS PACKAGE LIKE EASY5 BE USED EXCLUSIVELY?
- o CAN SUB-SCALE PHYSICAL MODEL TESTS GIVE USEFUL DYNAMIC PERFORMANCE AND CONTROLS INFORMATION? ARE THEY NEEDED?
- o WILL MODERN (I.E. OPTIMAL) CONTROLS BE NEEDED FOR EFFICIENT OPERATION OF THE AWT?
- o SHOULD WE DEVELOP A REAL-TIME SIMULATOR? WHAT SHOULD THE REAL-TIME MODEL LOOK LIKE?