

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

N 92-70489

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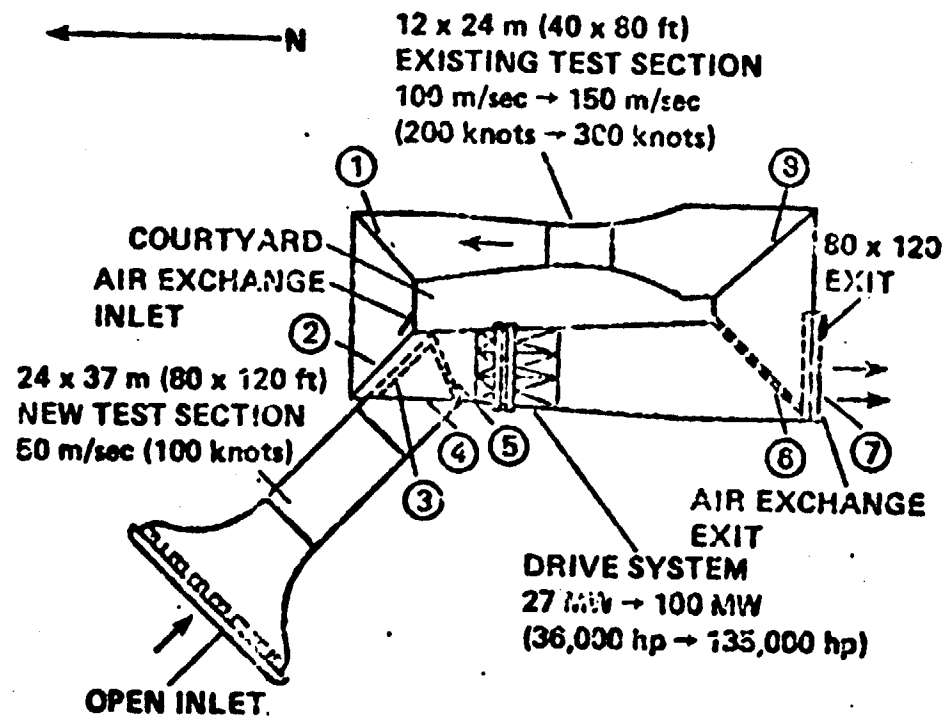
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40x80x120 WIND TUNNEL PROJECT
AERODYNAMIC PERFORMANCE CRITERIA

	<u>40x80</u>	<u>80x120</u>
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.	<u>± 0.5</u>	<u>± 0.5</u>

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SCHEMATIC OF 40x30/80x120-FOOT WIND TUNNEL AT NASA-Ames Research Center



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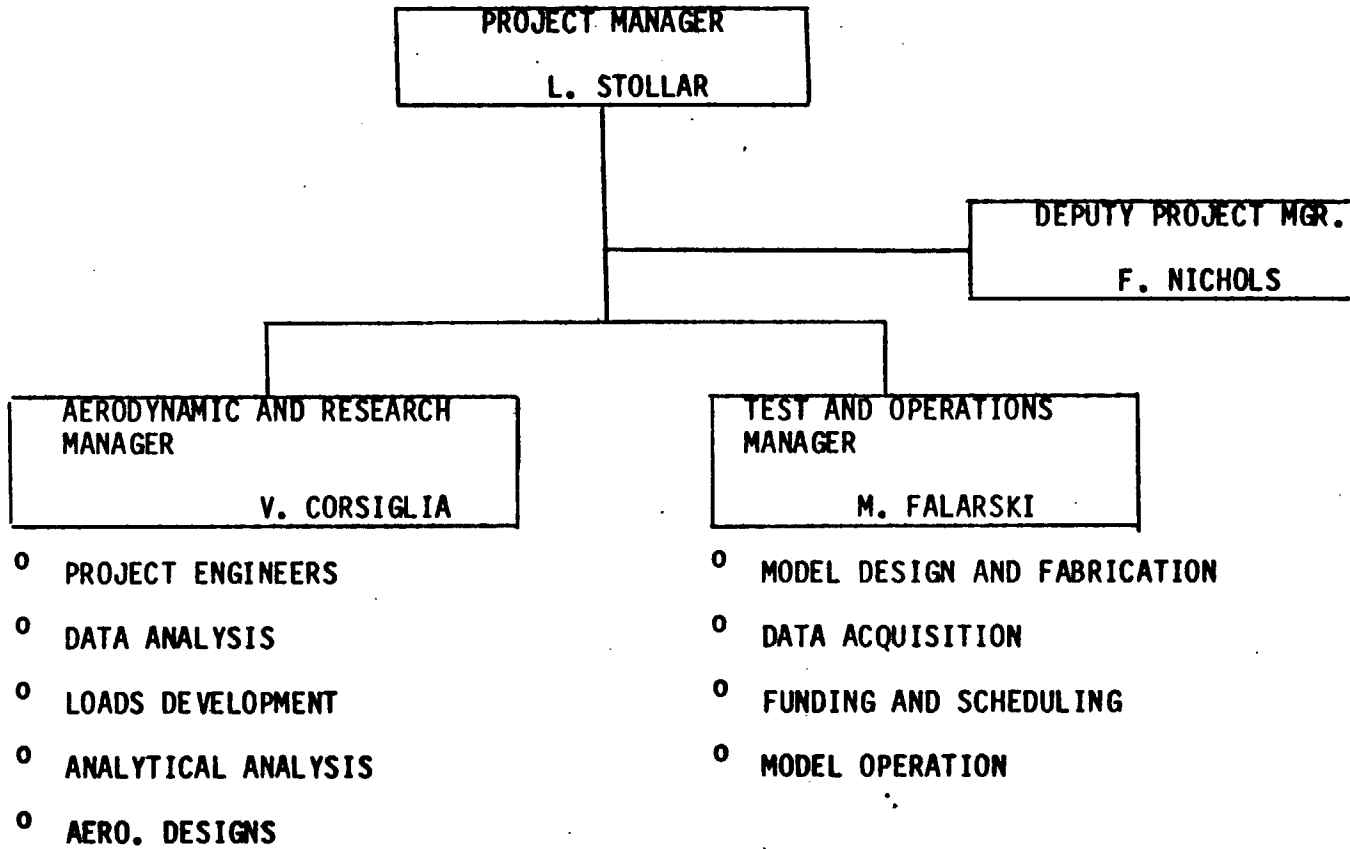
40x80x120 WIND TUNNEL PROJECT

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**

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40x80x120 WIND TUNNEL PROJECT
AERODYNAMIC VERIFICATION ORGANIZATION



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40x80x120 WIND TUNNEL PROJECT
AERODYNAMIC VERIFICATION APPROACH

- 0 REVIEW ALL EXISTING AERO. INFORMATION FROM 40x80x120 AND SIMILAR FACILITIES
- 0 ESTABLISH FACILITY PERFORMANCE CRITERIA
- 0 ESTABLISH INFORMATION REQUIRED FOR DESIGN AND OPERATION LOADS
- 0 DEVELOP RESEARCH PROGRAM USING ALL TOOLS AVAILABLE
 - ANALYTICAL METHODS
 - MODEL TESTING
 - EXPERT CONSULTANTS
- 0 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

- o 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

- o 3-D COMPONENT TESTS
 - 1/15 SCALE INLET MODEL*
 - 1/10 SCALE HIGH SPEED DIFFUSER MODEL*
 - 1/7 SCALE FAN STALL MODEL*

- o 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

o PURPOSE

MEASURE 2-D AERO. PERFORMANCE OF VANE CONCEPTS

o 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

o MEASUREMENT

INFLOW/OUTFLOW ANGLES SURVEY

TOTAL PRESSURE SURVEY

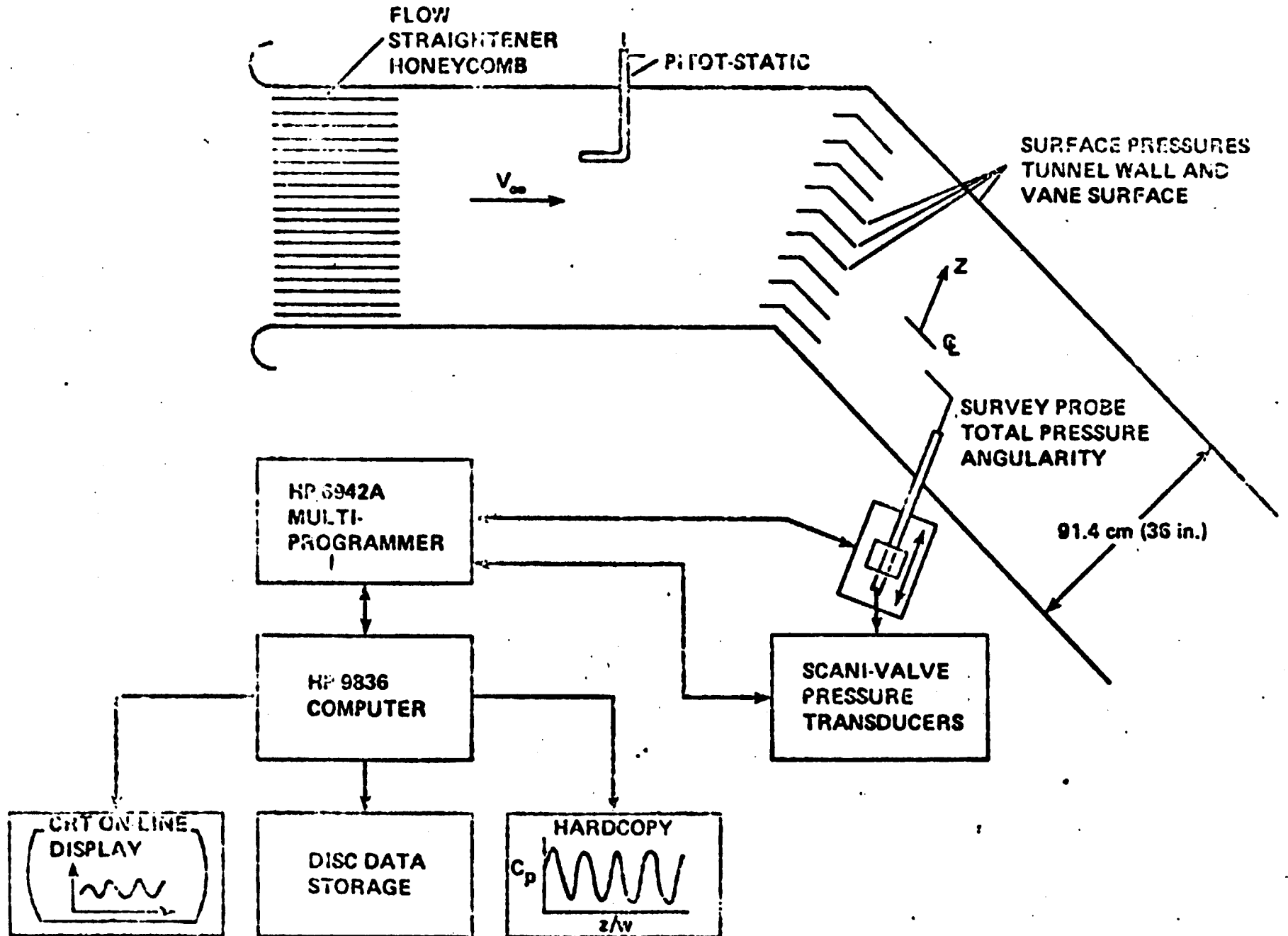
WALL/VANE SURFACE PRESSURE (STATIC & DYNAMIC)

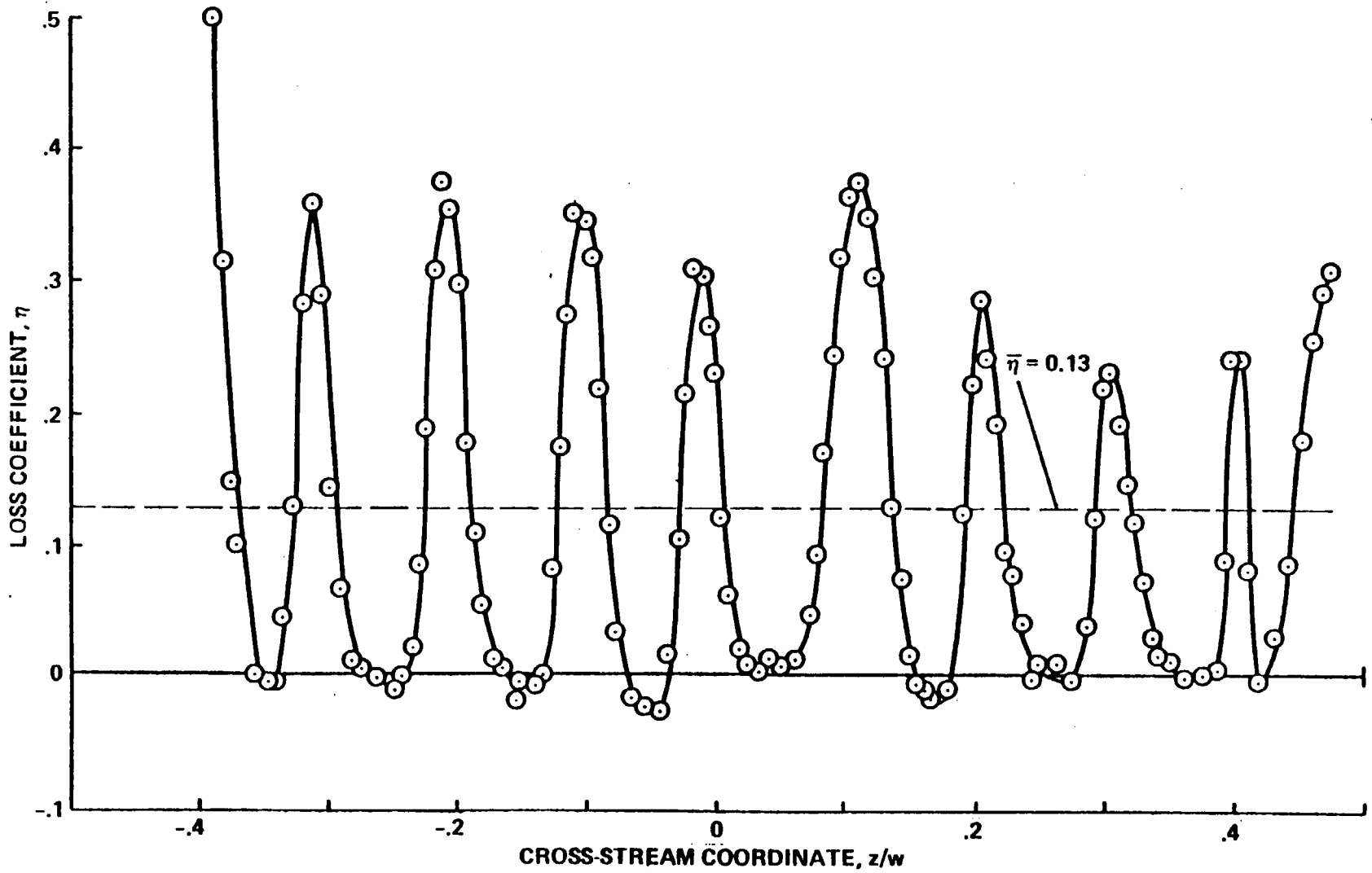
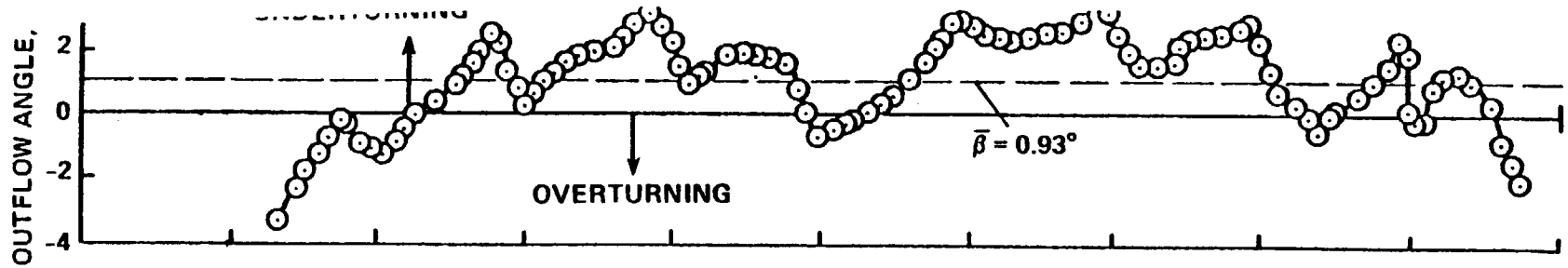
TURBULENCE

FLOW VISUALIZATION

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SCHEMATIC OF 1/10 SCALE CHANNEL FACILITY AND INSTRUMENTATION





93% → 87%

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40x80x120 WIND TUNNEL PROJECT

2-D INLET BAFFLE TEST

0 PURPOSE

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

0 TEST DESCRIPTION

2-D BAFFLE SEGMENT (1/2 SCALE)
7x10-FOOT WIND TUNNEL TEST SECTION
VELOCITY = 200 KNOTS
REYNOLDS NO. = 600,000 (FULL SCALE)

0 MEASUREMENTS

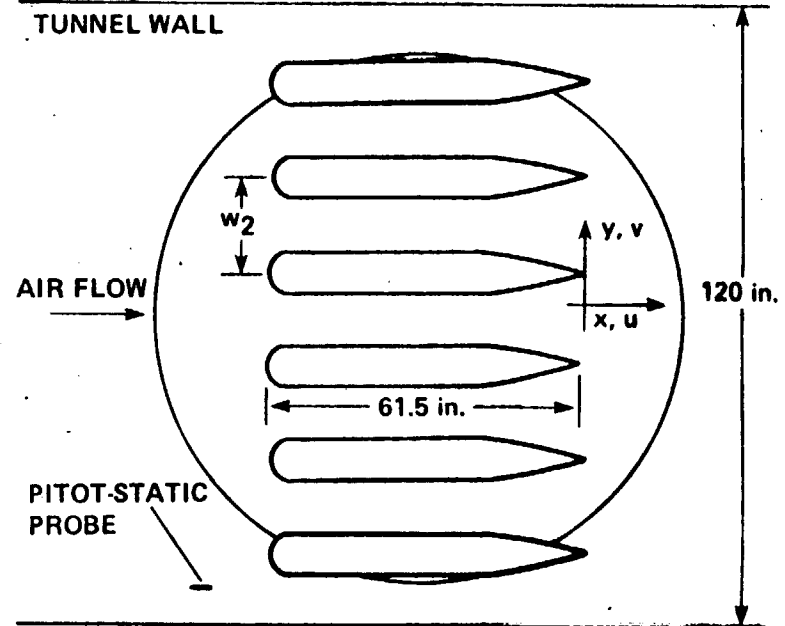
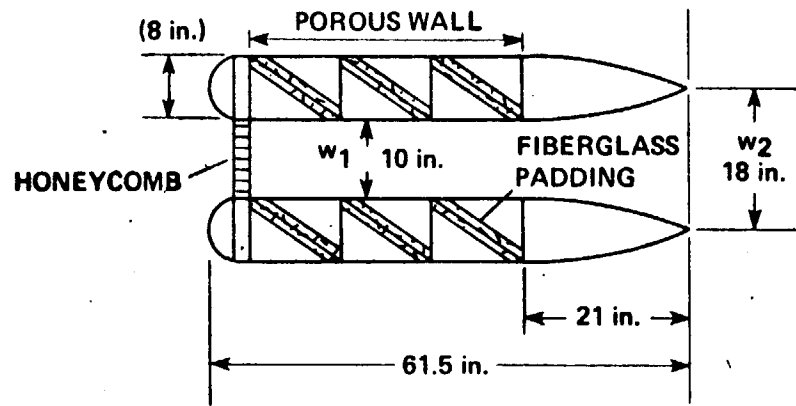
MAKE SURVEYS OF PRESSURE AND TURBULENCE
FLOW VISUALIZATION

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NAME MIKE DUDLEY

NO. _____

BASELINE MODEL

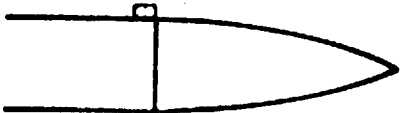
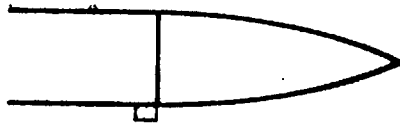




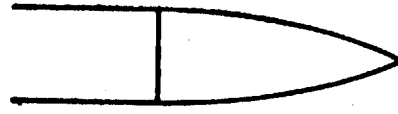
NAME MIKE DUDLEY

NO. _____

VANE MODIFICATIONS INVESTIGATED



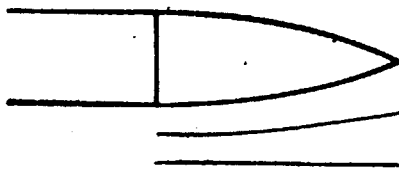
VORTEX GENERATORS



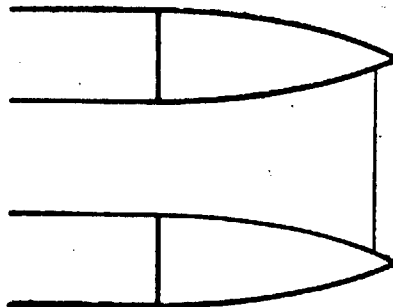
TRAILING EDGE SCREEN



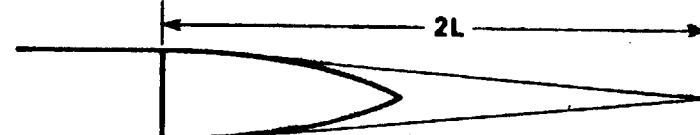
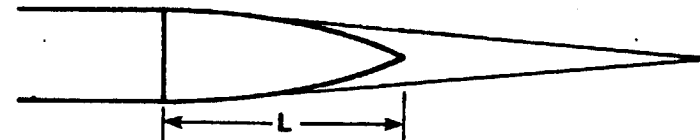
FLAT PLATE EXTENSIONS



SPLITTER VANES



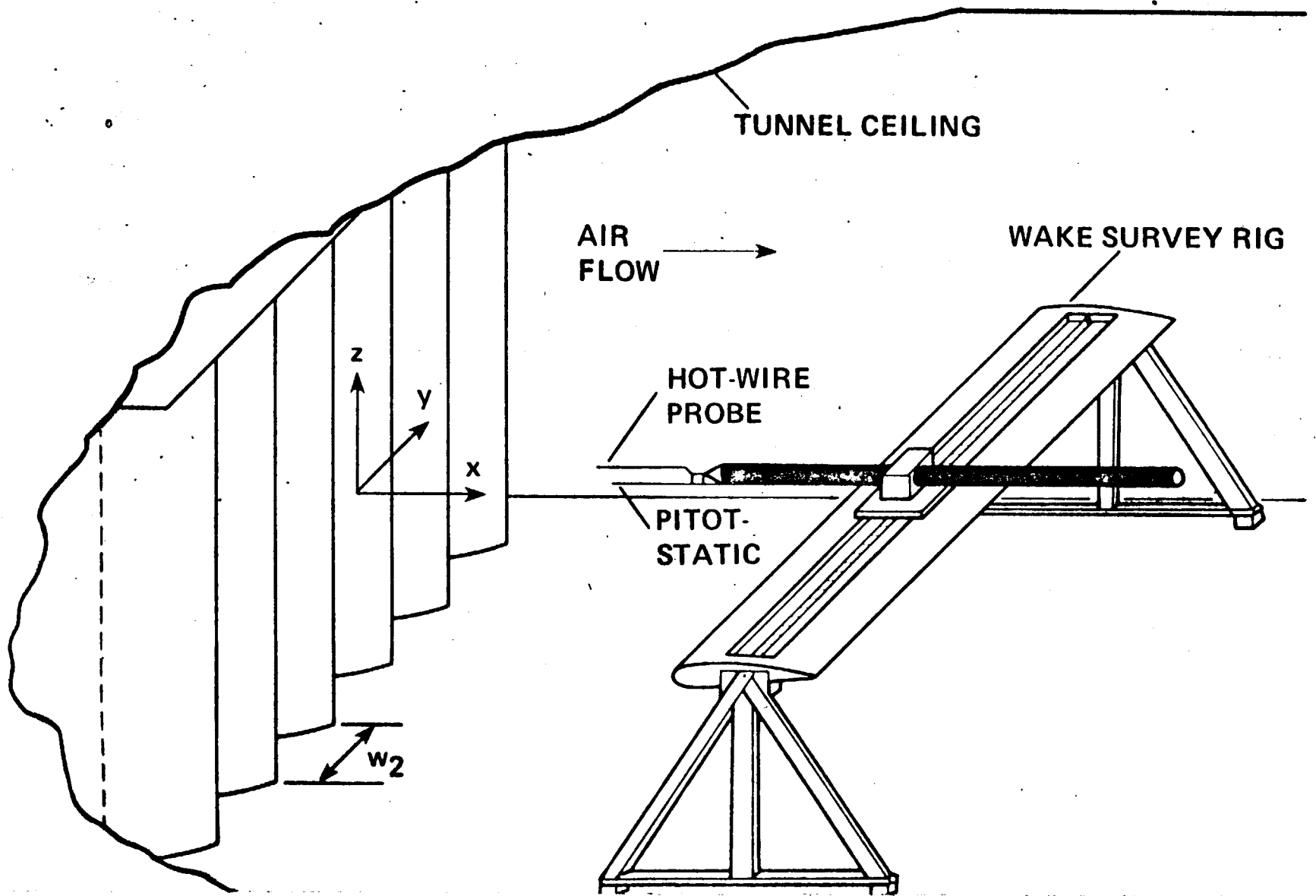
TRAILING EDGE HONEYCOMB



EXTENDED BOATTAIL

NAME MIKE DUDLEY NO. _____

WAKE SURVEY TECHNIQUE



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

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3-20-84

264

(2L)

NAME _____ NO. _____

80 by 120 INLET VANE STUDY
7% SCALE 3-D TEST (FULL SCALE VELOCITY)

0
|
STATION (FT.)

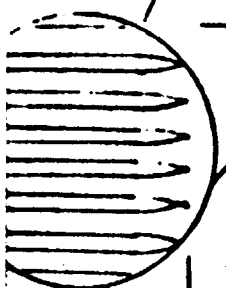
14.7

31.5

41.5

EXISTING STRUCTURE

SCALED VANE
or ACROSS
INLET



1 1/2'

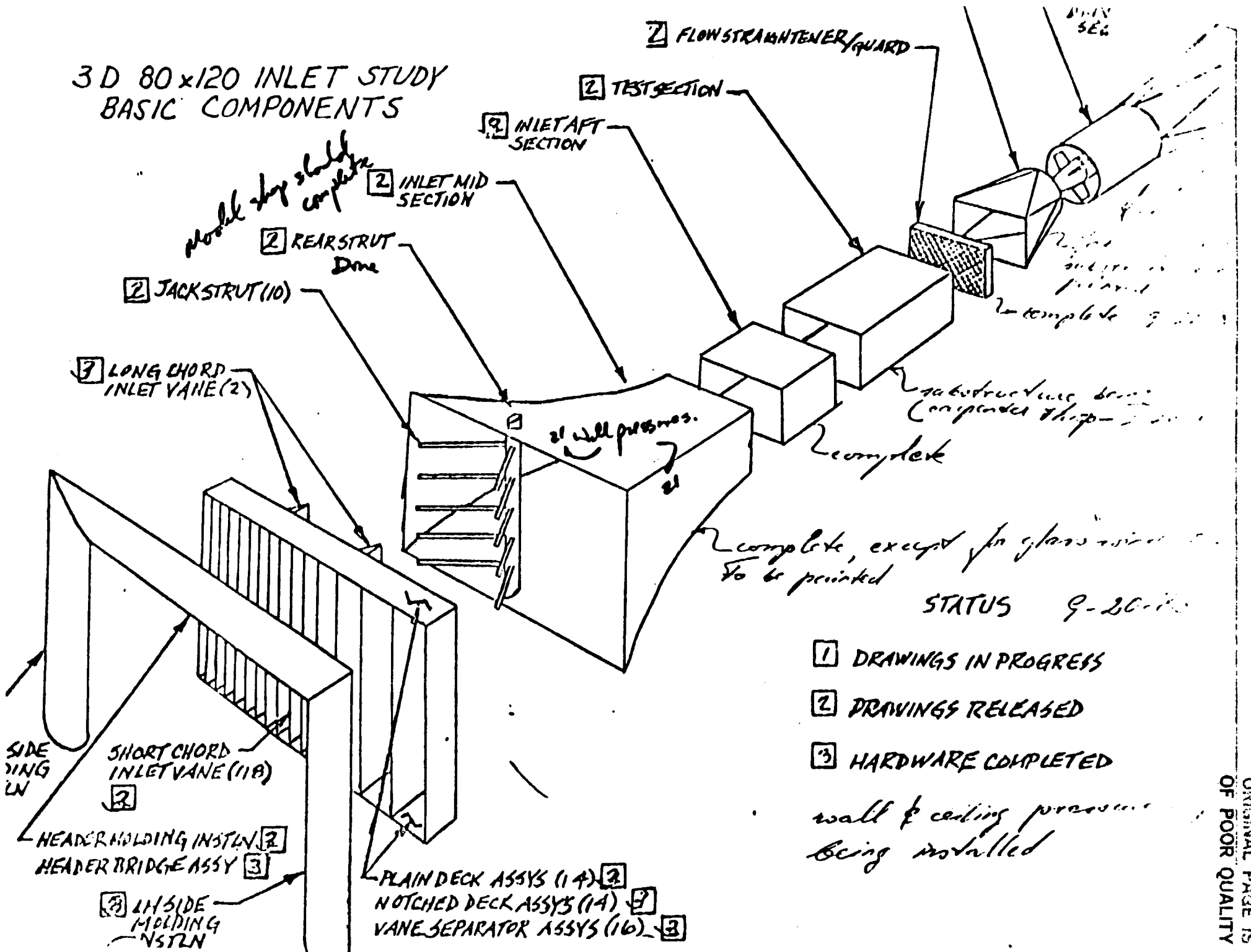
NEW STRUCTURE

9

ROUND

TOP VERTICAL

3D 80x120 INLET STUDY BASIC COMPONENTS



40x80x120 WIND TUNNEL PROJECT

1/10 SCALE DIFFUSER MODEL

0 PURPOSE

DEVELOP VORTEX GENERATOR CONFIGURATION TO IMPROVE FLOW IN
40x80 HIGH SPEED DIFFUSER

0 MODEL DESCRIPTION

1/15 SCALE INLET

6' DIA. FAN DRIVE SYSTEM

1/10 SCALE 40x80 TEST SECTION AND DIFFUSER

SCREEN SIMULATION OF CORNER

0 MEASUREMENTS

FLOW VISUALIZATION

FLOW SURVEYS (P_t , LASER)

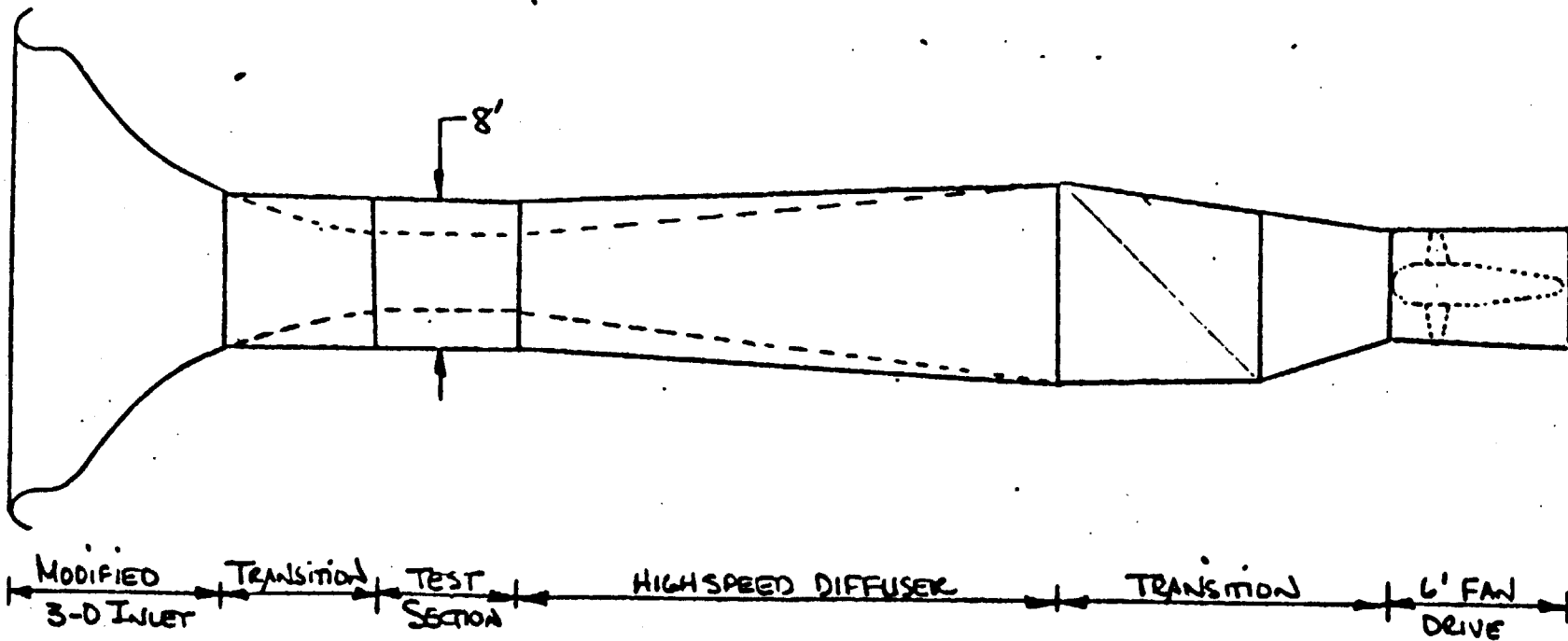
WALL STATIC PRESSURE

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1/10 SCALE 4x80 DIFFUSER MODEL

OVERALL MODEL LENGTH = 105'



WDF 11/30/83

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1/7 SCALE FAN DRIVE MODEL

0 PURPOSE

MEASURE FAN DRIVE PERFORMANCE WITH MODIFIED BLADE CONTOUR
INCLUDING STALL MARGIN

0 MODEL DESCRIPTION

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

0 MEASUREMENTS

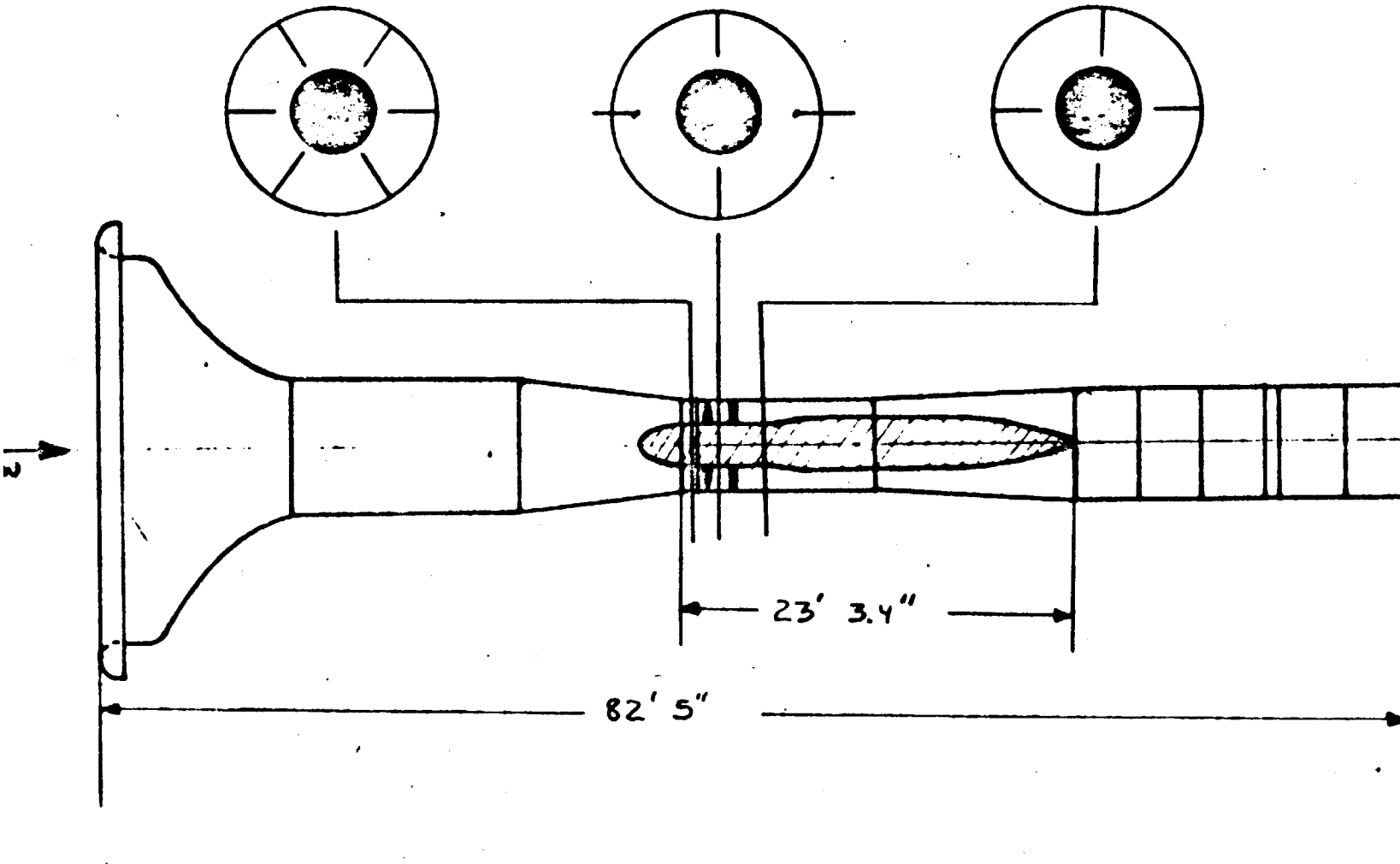
INFLOW DISTORTION
STATOR AND EXIT SURVEYS
WALL PRESSURES

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UPSTREAM
OF FAN
SIX TOTAL PRESSURE
RAKES

BETWEEN
FAN & STATORS
TWO TOTAL PRESSURE
RAKES & TWO SURVEY
PROBES

DOWN STREAM
OF STATORS
FOUR TOTAL PRESSURE
RAKES



15% SCALE FAN STALL TEST
 $\frac{7}{32}'' = 1'$

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

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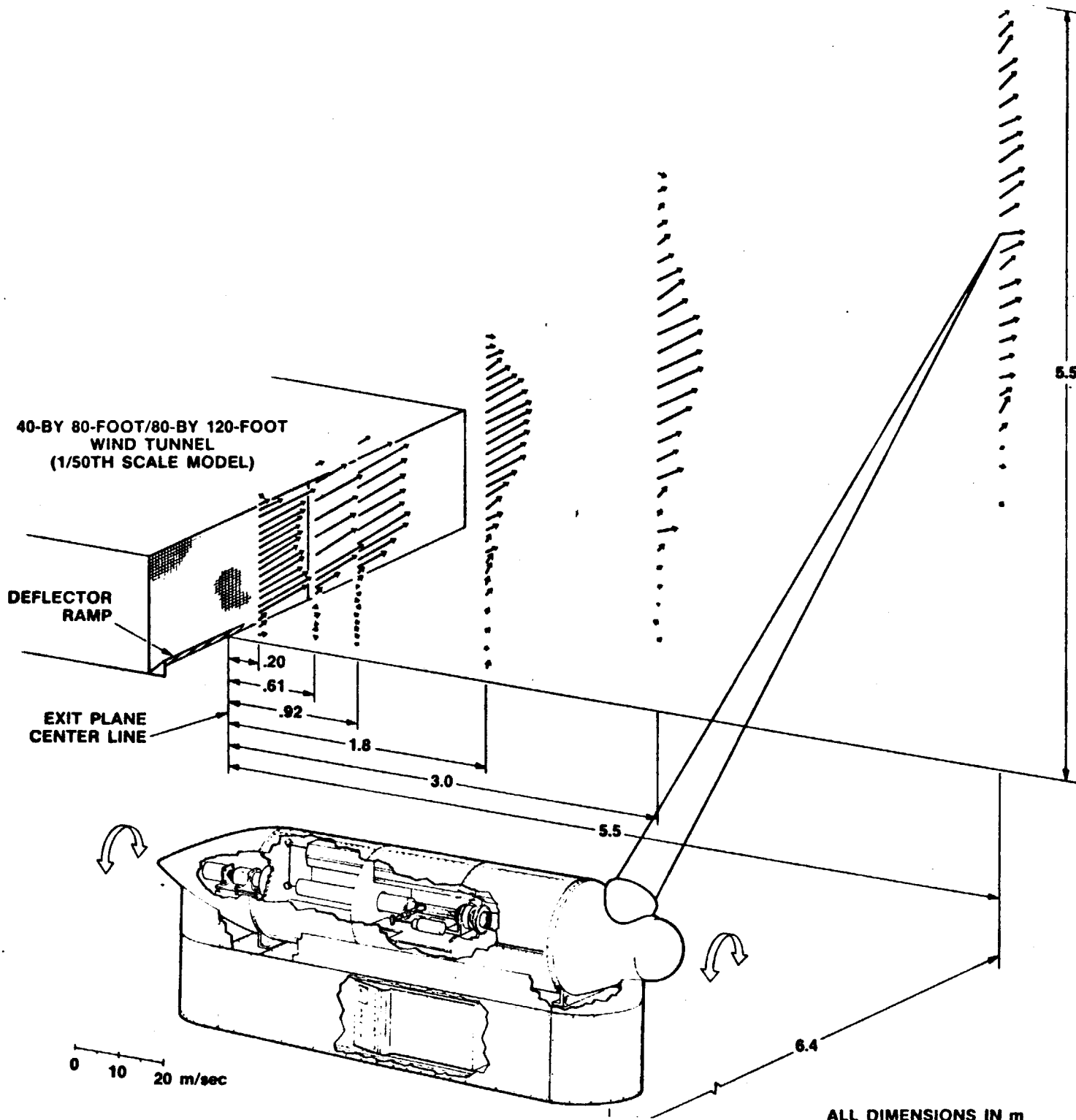
40-BY 80-FOOT/80-BY 120-FOOT
WIND TUNNEL
(1/50TH SCALE MODEL)

DEFLECTOR
RAMP

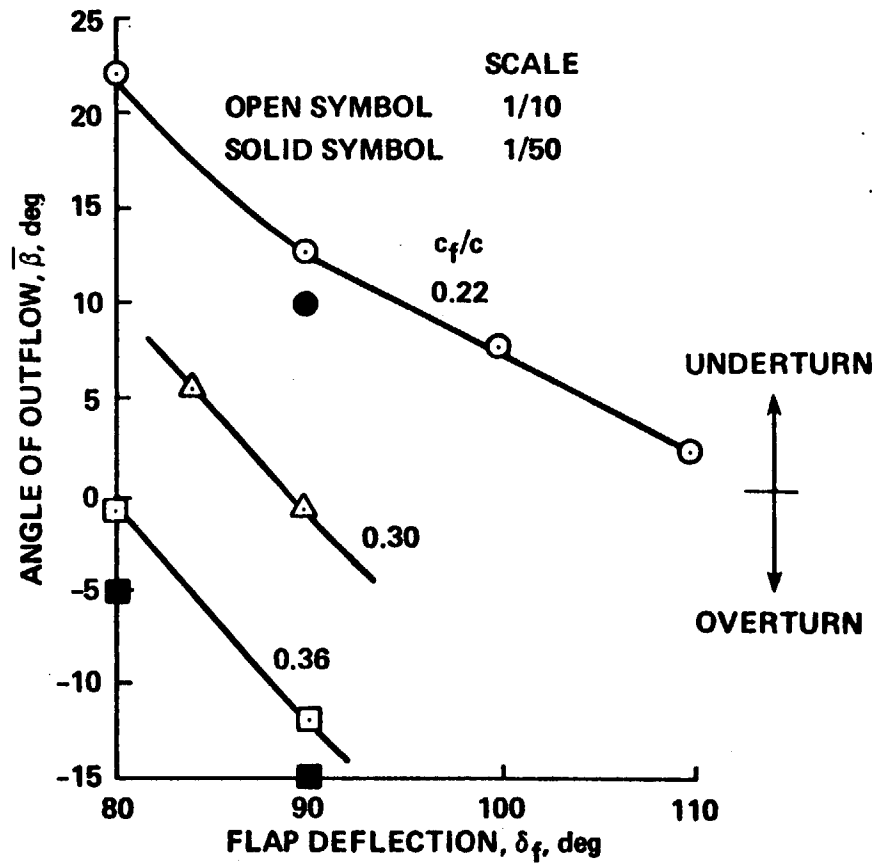
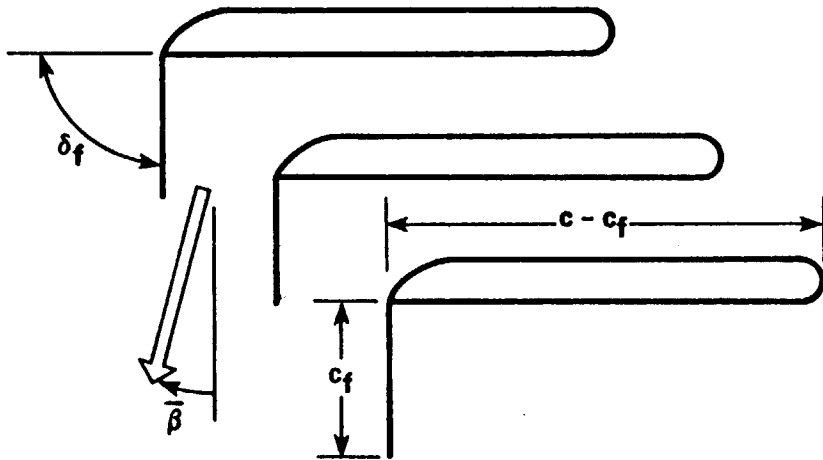
EXIT PLANE
CENTER LINE

0 10 20 m/sec

ALL DIMENSIONS IN m

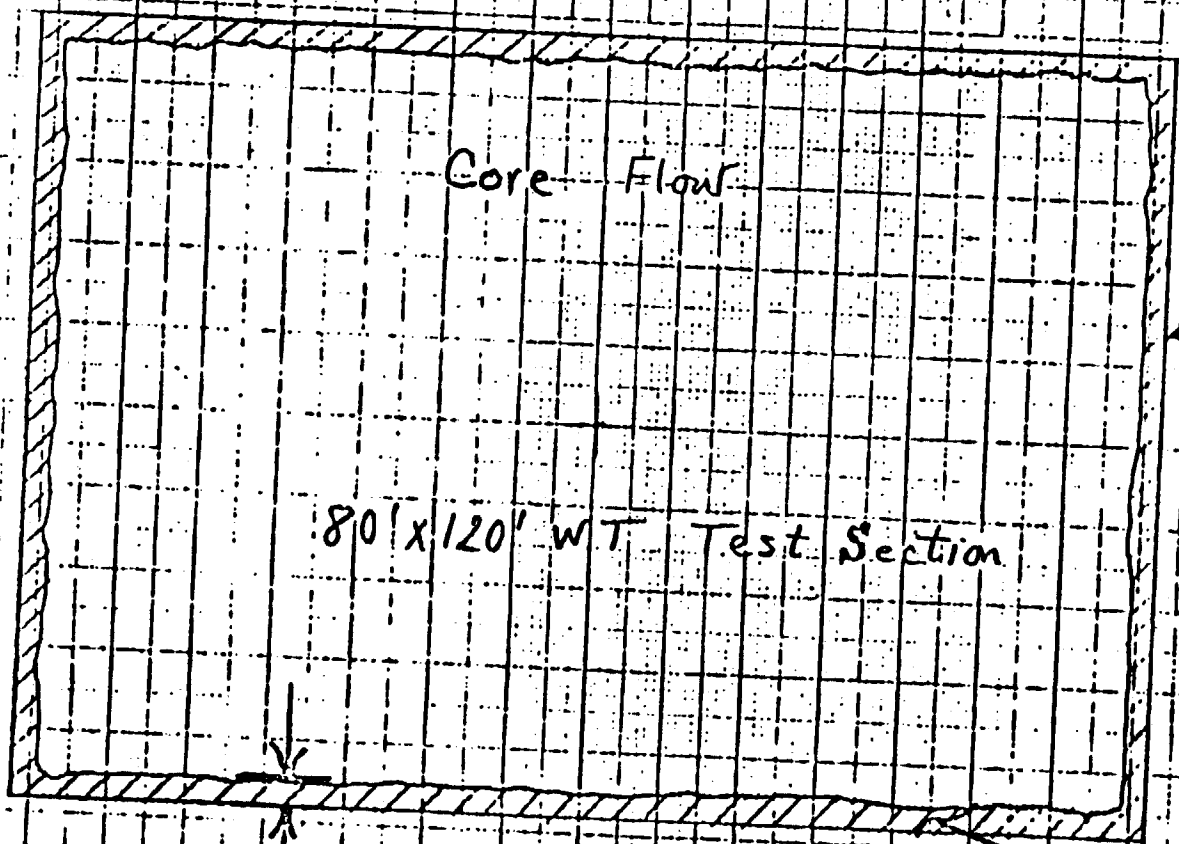


ANGLE OF OUTFLOW vs. FLAP DEFLECTION AND CHORD



RESULTS - 1st SECTION 19 1/2"

Results of Total Head (H) Surveys in 80' x 120' WT Test Section



Core Flow

80' x 120' WT Test Section

B.L. $\approx \frac{5}{8}$ " in model
 $\approx 3'$ full scale

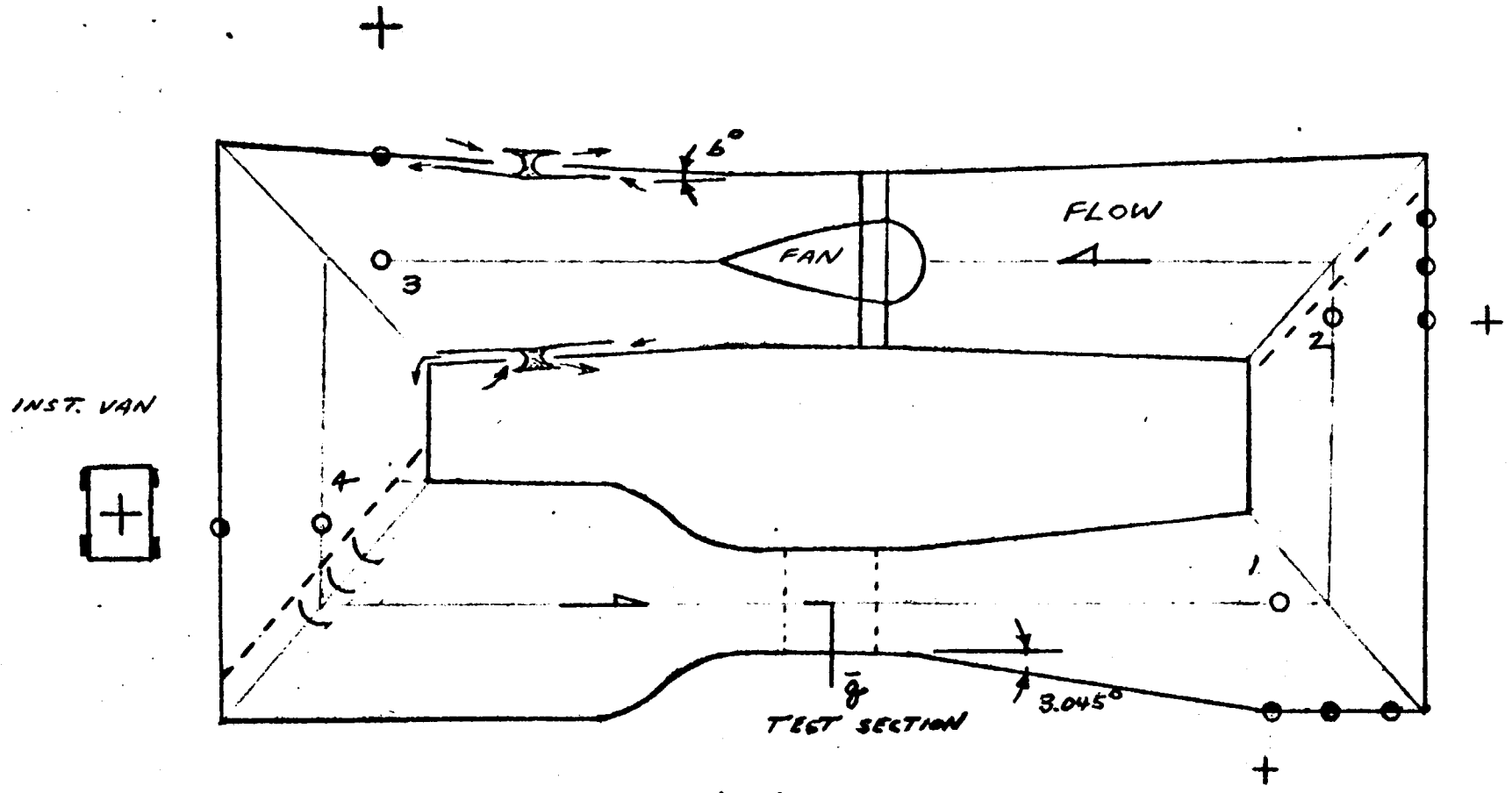
Full Scale B.L.
80' x 120' WT

1/50 Scale

JAMES RESEARCH

4²⁰

7X10 #2



INST. VAN



C = 14:1

○ $\begin{cases} u'/U \rightarrow E(w) \\ \tilde{p} & \text{E} \\ \bar{q} & \text{E} \end{cases}$

● $\begin{cases} \tilde{p}_1 \rightarrow G(w) \text{ WALL} \\ \tilde{p}_2 & \text{"} \\ \bar{q}_4 & \text{"} \end{cases}$

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	<hr/> \$1,040,000

* MOST EQUIPMENT EXISTING COST FOR SPECIAL ITEMS

+ EXPERT CONSULTANTS, SUPPORT TESTING AT OTHER FACILITIES

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40x80x120 WIND TUNNEL PROJECT
AERODYNAMIC VERIFICATION RESOURCES

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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40 x 80 x 120 VANE REDESIGN

ERIC R. McFARLAND

COMPUTATIONAL FLUID MECHANICS BRANCH

NASA LEWIS RESEARCH CENTER