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(UNCLASSIFIED TITLE)
INVESTIGATION OF
A HIGHLY LOADED
TWO-STAGE FAN-DRIVE TURBINE

VOLUME II. Phase II, Part 1. Preliminary Experimental Evaluation

H. Weina, D. E. Dahlberg and W. H. Heiser

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AFAPL-TR-69-92
VOLUME II

(UNCLASSIFIED TITLE)
INVESTIGATION OF
A HIGHLY LOADED
TWO-STAGE FAN-DRIVE TURBINE

VOLUME II. Phase II, Part 1. Preliminary Experimental Evaluation

H. Welna, D. E. Dahlberg and W. H. Heiser
Pratt & Whitney Aircraft
Division of United Aircraft Corporation

Technical Report
AFAPL-TR-69-92 Volume II
December 1969

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FOREWORD

(U) This Interim Technical Status Report (Contractors Reference No. PWA-3576) was prepared by Pratt & Whitney Aircraft, Division of United Aircraft Corporation, East Hartford, Connecticut, as the second Semiannual Report under United States Air Force Contract F33615-68-C-1208, Project No. 3066, Task No. 306606. This report was submitted by the Contractor on 31 December 1968, and covers the Report period from 1 July 1968 to 31 December 1968.

(U) The findings and conculsions of this report are not deemed as final by the Contractor. They are subject to verification or revision in the Final Report to be published upon the completion of this Contract.

(U) The Air Force Program Monitor is Mr. Jack Richens, APTC, Air Force Aero Propulsion Laboratory, Wright-Patterson Air Force Base, Ohio, 45433.

(U) This report contains no classified information extracted from other classified documents.

(U) Publication of this report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

Wayne Tall
Project Engineer
Air Force Aero Propulsion Laboratory

UNCLASSIFIED ABSTRACT

(U) A comprehensive three-year program is in progress to investigate methods of improving the performance of fan-drive turbines. The goals of the program are to develop turbine aerodynamic techniques and design procedures for efficient, high work, low pressure turbines by means of analytical studies and cascade testing, and to demonstrate the effectiveness of the techniques by designing and testing a two stage turbine that meets or exceeds the contract stage work and efficiency goals. The first phase effort defining the preliminary turbine design has been completed and the results have been reported. The second phase consists of a preliminary experimental evaluation which includes establishment of two-dimensional loss levels and three-dimensional flow behavior for both the baseline airfoils and airfoils utilizing boundary layer control devices. The design of the rig hardware and the baseline airfoils which will be evaluated during this second phase are presented in this report.

Distribution of this abstract is unlimited.

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TABLE OF CONTENTS

Section		Page
	LIST OF ILLUSTRATIONS	vi
	LIST OF TABLES	xi
	LIST OF SYMBOLS	xiv
I	INTRODUCTION	1
II	BACKGROUND	3
III	TWO-DIMENSIONAL DESIGN VERIFICATION (TASK IIa)	5
	1. RFP OBJECTIVE	5
	2. TASK OBJECTIVE	5
	3. AIRFOIL SECTION AND RIG DESIGN	5
IV	BASELINE AIRFOIL EVALUATION (TASK IIb)	25
	1. RFP OBJECTIVE	25
	2. TASK OBJECTIVE	25
	3. ANNULAR SEGMENT CASCADE AIRFOIL AND RIG DESIGN	25
V	PRELIMINARY DESIGN MANUAL PREPARATION (TASK IIe)	59
	1. RFP OBJECTIVE	59
	2. TASK OBJECTIVE	59
	3. STATUS	59
	APPENDIX	61
	REFERENCES	123
	DD FORM 1473	

LIST OF ILLUSTRATIONS

Figure No.	Title	Page No.
1	Medium Reaction, Normal Solidity, Final First Stage Vane Mean	7
2	Medium Reaction, Normal Solidity, Final First Stage Blade Mean	8
3	Medium Reaction, Normal Solidity, Final Second Stage Vane Root	9
4	Medium Reaction, Normal Solidity, Final Second Stage Vane Mean	10
5	Medium Reaction, Normal Solidity, Final Second Stage Blade Root	11
6	Medium Reaction, Normal Solidity, Final Second Stage Blade Mean	12
7	Plane Cascade Test Pack Assembly	14
8	1st Stage Vane, Mean Section	15
9	1st Stage Blade, Mean Section	16
10	2nd Stage Vane, Root Section	17
11	2nd Stage Vane, Mean Section	18
12	2nd Stage Blade, Root Section	19
13	2nd Stage Blade, Mean Section	20
14	Airfoil Surface Static Pressure Location	21/22
15	Schematic of Plane Cascade Test Rig	23
16	Turbine Test Airfoil Elevations	26
17	Ass'y of First Vane Cascade, Mean Section, Full Scale	27

LIST OF ILLUSTRATIONS (Cont'd)

Figure No.	Title	Page No.
18	First Blade Cascade	28
19	Ass'y of Second Vane Cascade	29
20	Second Blade Cascade	30
21	First Vane Cascade Elevation	32
22	First Vane Cascade, Required Turning Vane Exit Angle	32
23	First Vane Cascade, First Vane Inlet Angle	32
24	First Blade Cascade Elevation	33
25	First Blade Cascade Required Turning Vane Exit Angle	33
26	First Blade Cascade First Blade Inlet Angle	33
27	Second Vane Cascade Elevation	34
28	Second Vane Cascade Required Turning Vane Exit Angle	34
29	Second Vane Cascade, Second Vane Inlet Angle	34
30	Second Blade Cascade Elevation	35
31	Second Bl: e Cascade Required Turning Vane Exit Angle	35
32	Second Blade Cascade, Second Blade Inlet Angle	35
33	First Vane Cascade Turning Vane Root Section	36
34	First Vane Cascade Turning Vane 1/4R Section	36
35	First Vane Cascade Turning Vane Mean Section	37

LIST OF ILLUSTRATIONS (Cont'd)

Figure No.	Title	Page No.
36	First Vane Cascade Turning Vane 1/4T Section	37
37	First Vane Cascade Turning Vane Tip Section	38
38	First Blade Cascade Turning Vane Root Section	38
39	First Blade Cascade Turning Vane 1/8R Section	39
40	First Blade Cascade Turning Vane 1/4R Section	39
41	First Blade Cascade Turning Vane 3/8R Section	40
42	First Blade Cascade Turning Vane Mean Section	40
43	First Blade Cascade Turning Vane 1/8T Section	41
44	First Blade Cascade Turning Vane 1/4T Section	41
45	First Blade Cascade Turning Vane 3/8T Section	42
46	First Blade Cascade Turning Vane Tip Section	42
47	Second Vane Cascade Turning Vane Root Section	43
48	Second Vane Cascade Turning Vane 1/8R Section	43
49	Second Vane Cascade Turning Vane 1/4R Section	44
50	Second Vane Cascade Turning Vane 3/8R Section	44
51	Second Vane Cascade Turning Vane Mean Section	45
52	Second Vane Cascade Turning Vane 1/8T Section	45
53	Second Vane Cascade Turning Vane 1/4T Section	46
54	Second Vane Cascade Turning Vane 3/8T Section	46
55	Second Vane Cascade Turning Vane Tip Section	47
56	Second Blade Cascade Turning Vane Root Section	47

LIST OF ILLUSTRATIONS (Cont'd)

Figure No.	Title	Page No.
57	Second Blade Cascade Turning Vane 1/8R Section	48
58	Second Blade Cascade Turning Vane 1/4R Section	48
59	Second Blade Cascade Turning Vane 3/8R Section	49
60	Second Blade Cascade Turning Vane Mean Section	49
61	Second Blade Cascade Turning Vane 1/8T Section	50
62	Second Blade Cascade Turning Vane 1/4T Section	50
63	Second Blade Cascade Turning Vane 3/8T Section	51
64	Second Blade Cascade Turning Vane Tip Section	51
65	Airfoil Static Pressure Tap Locations-First Stage Vane	52
66	Traverse Probe Head, Annular Cascade	52
67	Second Stage Blade Annular Segment Cascade, Inlet Bellmouth	54
68	Second Stage Blade Annular Segment Cascade, Turning Vane Assembly	54
69	Second Stage Blade Annular Segment Cascade, Test Airfoil Assembly	55
70	Second Stage Blade Annular Segment Cascade, Inlet View of Assembled Rig	55
71	Second Stage Blade Annular Segment Cascade, Top View of Assembled Rig	56
72	Second Stage Blade Annular Segment Cascade, Side View of Assembled Rig	56
73	Installation of First Stage Vane in Annular Segment Cascade Rig, Overall View	57

LIST OF ILLUSTRATIONS (Cont'd)

Page No.	Title	Page No.
74	Installation of First Stage Vane in Annular Segment Cascade Rig, Close-up View	57

LIST OF TABLES

Table No.	Title	Page No.
I	Turbine Design Parameters	3
II	First Stage Turbine Data - Medium Reaction	4
III	Second Stage Turbine Data - Medium Reaction	4
IV	Medium-Reaction Normal-Solidity Airfoil Summary	6
V	Vane 1 Normal Solidity	61
VI	Vane 1 Normal Solidity	62
VII	Vane 1 Normal Solidity	63
VIII	Vane 1 Normal Solidity	64
IX	Vane 1 Normal Solidity	65
X	Vane 1 Normal Solidity	66
XI	Vane 1 Normal Solidity	67
XII	Vane 1 Normal Solidity	68
XIII	1st Stage Blade	69
XIV	1st Stage Blade	70
XV	1st Stage Blade	71
XVI	1st Stage Blade	72
XVII	1st Stage Blade	73
XVIII	1st Stage Blade	74
XIX	1st Stage Blade	75
XX	Vane 2 Normal Solidity	76
XXI	Vane 2 Normal Solidity	77
XXII	Vane 2 Normal Solidity	78

LIST OF TABLES (Cont'd)

Table No.	Title	Page No.
XXIII	Vane 2 Normal Solidity	79
XXIV	Vane 2 Normal Solidity	80
XXV	Vane 2 Normal Solidity	81
XXVI	Vane 2 Normal Solidity	82
XXVII	Vane 2 Normal Solidity	83
XXVIII	2nd Stage Blade	84
XXIX	2nd Stage Blade	85
XXX	2nd Stage Blade	86
XXXI	2nd Stage Blade	87
XXXII	2nd Stage Blade	88
XXXIII	2nd Stage Blade	89
XXXIV	2nd Stage Blade	90
XXXV	First Vane Cascade Turning Vane	91
XXXVI	First Vane Cascade Turning Vane	92
XXXVII	First Vane Cascade Turning Vane	93
XXXVIII	First Vane Cascade Turning Vane	94
XXXIX	First Vane Cascade Turning Vane	95
XL	First Blade Cascade Turning Vane	96
XLI	First Blade Cascade Turning Vane	97
XLII	First Blade Cascade Turning Vane	98
XLIII	First Blade Cascade Turning Vane	99
XLIV	First Blade Cascade Turning Vane	100

LIST OF TABLES (Cont'd)

Table No.	Title	Page No.
XLV	First Blade Cascade Turning Vane	101
XLVI	First Blade Cascade Turning Vane	102
XLVII	First Blade Cascade Turning Vane	103
XLVIII	First Blade Cascade Turning Vane	104
XLIX	Second Vane Cascade Turning Vane	105
L	Second Vane Cascade Turning Vane	106
LI	Second Vane Cascade Turning Vane	107
LII	Second Vane Cascade Turning Vane	108
LIII	Second Vane Cascade Turning Vane	109
LIV	Second Vane Cascade Turning Vane	110
LV	Second Vane Cascade Turning Vane	111
LVI	Second Vane Cascade Turning Vane	112
LVII	Second Vane Cascade Turning Vane	113
LVIII	Second Vane Cascade Turning Vane	114
LIX	Second Blade Cascade Turning Vane	115
LX	Second Blade Cascade Turning Vane	116
LXI	Second Blade Cascade Turning Vane	117
LXII	Second Blade Cascade Turning Vane	118
LXIII	Second Blade Cascade Turning Vane	119
LXIV	Second Blade Cascade Turning Vane	120
LXV	Second Blade Cascade Turning Vane	121
LXVI	Second Blade Cascade Turning Vane	122

LIST OF SYMBOLS

A	- area, square inches
B	- axial chord, inches
C	- absolute gas velocity, feet per second
C_F	- drag coefficient
C_L	- Zwiefel load coefficient
C_L^*	- load coefficient, $\Delta Cu/U$
E	- diffusion parameter
H	- boundary layer shape factor
ΔH	- work, Btu per pound
M	- Mach number
P	- pressure, psia
ΔP	- pressure rise from minimum to exit value on suction surface
Q	- exit dynamic head
R	- fillet radius, inches
R_C	- radius of curvature, inches
Re_θ	- Reynolds number based on boundary layer momentum thickness
S	- distance along airfoil surface, inches
T	- temperature, °R
u	- tangential velocity, feet per second
W	- relative gas velocity, feet per second
Wg	- gas flow, pounds per second
X	- axial distance, inches
Y	- tangential distance, inches
Z	- number of airfoils
α	- absolute gas angle, degrees
β	- relative gas angle degrees
δ	- boundary layer thickness, inches
δ^*	- boundary layer displacement thickness
θ	- boundary layer momentum thickness, inches
θ_b	- blade camber, degrees
θ_v	- vane camber, degrees
τ	- gap, inches
η	- efficiency, percent

Subscripts

0	inlet to first vane
1	inlet to first blade
2	exit from stage or airfoil section

LIST OF SYMBOLS (Cont'd)

G	gage point
ws	wetted surface
ms	mainstream surface
S	static
T	total

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SECTION I
INTRODUCTION

(U) Aircraft jet engine performance and optimization studies have always included a trade-off between increasing turbine efficiency and reducing the turbine weight. Recently, the bypass turbofan engine has dominated jet engine applications. For this type of engine, the economy generally increases with increasing bypass ratio. However, increased bypass ratios represent increased fan power requirements, which must be met by increased fan-drive turbine power. It is, therefore, necessary to meet these increased turbine loading requirements without penalizing the turbine efficiency.

(U) The fan-drive turbine design is constrained by certain unique requirements. The rotational speed of the turbine must be limited in order that the fan tip Mach number does not exceed the limit for reasonable losses. As the bypass ratio and, therefore, the fan diameter increase, this problem becomes even more critical. Applying conventional aerodynamics, as limiting turbine rotational speeds are approached, increased work can only be realized by increasing the number of stages and/or the turbine diameter. Reduction of the turbine diameter or solidity results in a lighter turbine, but with a sacrifice in efficiency due to losses associated with increased loading. Considerable gains can be realized by an engine if the size and weight reduction can be made with no loss in efficiency. Because of the time required between the evolution of new concepts and engine production, turbine technology must be improved now, so that the desired level of turbofan engine performance can be achieved for aircraft which will be operational in the 1975-1980 time period.

(U) The objective of the work done under this contract is to analyze and test concepts which will increase the low pressure turbine loading and maintain or increase current turbine efficiency levels. The goals of this program are to develop turbine aerodynamic techniques and design procedures for efficient high work, low pressure turbines by means of analytical studies and cascade testing, and to demonstrate the effectiveness of the techniques, by designing and testing a two-stage turbine that meets or exceeds the contract stage work and efficiency goals.

(U) The total program has been planned in four phases over a period of three years. Phase I defined the basic turbine design and an analysis of promising increased loading concepts was completed. The results of the Phase I study is reported in Reference 1 and briefly summarized in Section I of this report. Phases II and III consist of experimental testing to verify and extend the turbine aerodynamic techniques and design procedures for high loading levels. Phase IV will subject the aerodynamic techniques and design procedures to a two-stage rotating rig test.

(U) Work on this contract during the reporting period proceeded on Phase II. The design and fabrication of both the annular segment and plane cascade airfoils and test rigs has been conducted as scheduled. This report describes this effort. Sufficient test airfoil and rig design details are included for permanent record in order that this hardware can be duplicated in the future, if necessary. Testing has been initiated and the results will be reported in the next Interium Technical Report.

SECTION II
BACKGROUND

(U) The Phase I analysis of this contract has been completed and the results are described in Reference 1. The objective of Phase I was to select a preliminary turbine design that is capable of meeting the performance requirements specified in this Contract (See Table I). The final choice of the preliminary turbine configuration was based on the judgments formed from the analyses generated during Phase I. These analyses included consideration of the flow-path, reaction level, load coefficient level, and variations in work distribution for which velocity triangles were generated.

(U) Preliminary airfoil contours were defined for the velocity triangles for three levels of reaction and three levels of solidity for equal work split stages. Based on the resulting two-dimensional suction surface pressure coefficients and diffusion parameters, the following preliminary airfoils were selected for contour refinement: first vane, first blade and second vane - normal, medium and low solidity; second blade - normal and medium solidity. The selected preliminary airfoil contours were refined further to improve the pressure distribution and increase resistance to flow separation. Modifications of the contours required several iterations on each section to arrive at the desired pressure distribution. Two-dimensional boundary layer calculations were made for the final refined contours. Based on these analyses, the design system has indicated that a number of turbine configurations are capable of meeting the performance requirements of this contract. In particular, the medium reaction, normal solidity turbine promises to meet the required goals. This design was chosen for preliminary evaluation during Phases II and III. For convenience, the pertinent parameters for the chosen design are presented in Tables II and III. As part of Phase II, these baseline airfoils will be tested to determine the nature and extent of the end loss mechanism before selecting, designing, and testing appropriate boundary layer control techniques.

TABLE I

TURBINE DESIGN PARAMETERS

Number of Stages	2
Average Load Coefficient, C_L*	2.2
First Blade Tip Wheel Speed	1000 fps
First Blade Inlet Hub-Tip Diameter Ratio	≤ 0.8
Exit Swirl Angle - Without Exit Guide Vane	20°
- With Exit Guide Vane	0°
Turbine Inlet Temperature	1450°F
Airflow	≥ 50 lb/sec
Average Stage Efficiency	91%
Life	10,000 hr.

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TABLE II

FIRST STAGE TURBINE DATA - MEDIUM REACTION

Inlet Total Pressure (Pto) psia	-	105.0
Inlet Total Temperature (Tto) (°R)	-	1910.0
Gas Flow (Wg) (lbs/sec)	-	67.7
Total/total Efficiency (N_{tt})	-	90.5
Turbine Work (ΔH) (Btu/lb.)	-	67.3

[redacted]

	Root	Mean	Tip
Stage Total Pressure Ratio (P_{to}/P_{t2})	1.88	1.85	1.80
Vane Static Pressure Ratio (P_{so}/P_{s1})	1.66	1.54	1.42
Blade Static Pressure Ratio (P_{s1}/P_{s2})	1.32	1.30	1.34
Vane Inlet Gas Angle (α_o)	64.1	59.6	61.6
Vane Exit Gas Angle (α_1)	26.5	22.7	18.3
Vane Camber (θ_v)	89.4	97.7	100.1
Blade Inlet Gas Angle (β_1)	37.6	39.0	45.4
Blade Exit Gas Angle (β_2)	24.7	24.7	24.7
Blade Camber (θ_b)	117.7	116.3	109.9
Stage Exit Swirl Angle	40.2	52.1	66.4
Blade Inlet Absolute Gas Velocity (C_1)	1820.0	1654.0	1481.0
Blade Exit Absolute Gas Velocity (C_2)	1082.0	822.0	695.0
Blade Inlet Relative Gas Velocity (W_1)	1214.0	928.0	634.0
Blade Exit Relative Gas Velocity (W_2)	1699.0	1499.0	1414.0
Blade Inlet Tangential Velocity (U_1)	701.0	835.0	961.0
Blade Exit Tangential Velocity (U_2)	701.0	862.0	1005.0
Blade Reaction ($P_{s1}-P_{s2}/P_{so}-P_{s2}$)	25.9	30.1	37.3
Vane Inlet Absolute Mach Number (M_{oab})	0.345	0.290	0.279
Vane Exit Absolute Mach Number (M_{1ab})	0.949	0.854	0.770
Blade Inlet Relative Mach Number (M_{1rel})	0.622	0.469	0.317
Blade Exit Relative Mach Number (M_{2rel})	0.890	0.780	0.730
Interstage Axial Mach Number	0.371	0.320	0.296

TABLE III

SECOND STAGE TURBINE DATA - MEDIUM REACTION

Inlet Total Pressure (P_{to}) (psia)	-	56.8
Inlet Total Temperature (T_{to}) (°R)	-	1663.1
Gas Flow (W_g) (lbs/sec)	-	67.7
Total/Total Efficiency (N_{tt})	-	91.5
Turbine Work (ΔH) (Btu/lb)	-	67.2

[redacted]

	Root	Mean	Tip
Stage Total Pressure Ratio (P_{to}/P_{t2})	1.88	2.05	2.09
Vane Static Pressure Ratio (P_{so}/P_{s1})	1.37	1.50	1.4
Blade Static Pressure Ratio (P_{s1}/P_{s2})	1.32	1.51	1.61
Vane Inlet Gas Angle (α_o)	37.3	50.0	61.9
Vane Exit Gas Angle (α_1)	30.6	24.5	22.6
Vane Camber (θ_v)	112.1	105.5	95.5
Blade Inlet Gas Angle (β_1)	45.4	47.1	67.0
Blade Exit Gas Angle (β_2)	37.0	28.9	22.3
Blade Camber (θ_b)	97.6	104.0	90.7
Stage Exit Swirl Angle (α_2)	57.7	57.9	59.8
Blade Inlet Absolute Gas Velocity (C_1)	1799.0	1570.0	1355.0
Blade Exit Absolute Gas Velocity (C_2)	1178.0	917.0	711.0
Blade Inlet Relative Gas Velocity (W_1)	1242.0	824.0	506.0
Blade Exit Relative Gas Velocity (W_2)	1655.0	1591.0	1586.0
Blade Inlet Tangential Velocity (U_1)	693.0	891.0	1090.0
Blade Exit Tangential Velocity (U_2)	693.0	906.0	1112.0
Blade Reaction ($P_{s1}-P_{s2}/P_{so}-P_{s2}$)	30.3	40.8	48.5
Vane Inlet Absolute Mach Number (M_{oab})	0.554	0.365	0.292
Vane Exit Absolute Mach Number (M_{1ab})	1.003	0.869	0.765
Blade Inlet Relative Mach Number (M_{1rel})	0.696	0.446	0.269
Blade Exit Relative Mach Number (M_{2rel})	0.944	0.904	0.892
Interstage Axial Mach Number	0.568	0.435	0.337

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SECTION III

TWO-DIMENSIONAL DESIGN VERIFICATION (TASK IIa)

1. RFP OBJECTIVE

(U) Provide an experimental verification of the two-dimensional design characteristics.

2. TASK OBJECTIVE

(U) The purpose of this Task is to conduct plane cascade tests in order to verify the aerodynamic concepts applied to the turbine design during the Phase I program, and to establish the two-dimensional loss levels for the chosen turbine airfoil profiles at design conditions.

(U) The plane cascade tests will serve two, equally important, purposes. First, the measured profile losses will be compared with those contained in the computer programs to verify the existing design procedures. Second, the total pressure and flow angle profiles at the exit plane will indicate whether or not the surface boundary layer has separated. Each airfoil has been designed so that such two-dimensional separation should not occur, and these tests will constitute a verification of the separation criterion used in the airfoil design.

3. AIRFOIL SECTION AND RIG DESIGN

(U) A summary of the pertinent airfoil design parameters for the selected baseline turbine as a result of Phase I study are shown in Table IV. The six airfoil sections to be initially tested are the mean section of each airfoil row and the second vane and blade root sections. These profiles will be individually evaluated in order to verify the predicted two-dimensional losses. The cascade packs will consist of straight airfoils having the contours of their respective baseline airfoil design. The airfoil sections are shown in Figures 1 through 6. The dimensions listed in these figures and the coordinates for the airfoils (see the Appendix) show the engine size values. In order to permit a reasonable amount of surface static pressure taps to be installed on the plane cascade airfoils, scaled up airfoils were fabricated for plane cascade testing. Scale factors were 1.840, 2.012, 2.123, 1.921, 2.067, 2.066, for the first vane mean, first blade mean, second vane root, second vane mean, second blade root, second blade mean airfoils, respectively.

TABLE IV

MEDIUM-REACTION NORMAL-SOLIDITY AIRFOIL SUMMARY

First Stage Vane	No. of Foils	Exit Mach Number, M_2	$\Delta P/Q$	Max. Surface Mach Number
Root	62	0.949	0.313	1.150
1/4 Root	62	0.891	0.244	1.036
Mean	62	0.852	0.213	0.966
1/4 Tip	62	0.820	0.195	0.918
Tip	62	0.770	0.192	0.859
First Stage Blade				
Root	116	0.890	0.279	1.058
1/4 Root	116	0.849	0.296	1.020
Mean	116	0.788	0.331	0.968
1/4 Tip	116	0.738	0.294	0.883
Tip	116	0.730	0.236	0.840
Second Stage Vane				
Root	80	1.003	0.337	1.230
1/4 Root	80	0.920	0.277	1.094
Mean	80	0.870	0.227	0.999
1/4 Tip	80	0.821	0.196	0.928
Tip	80	0.765	0.203	0.865
Second Stage Blade				
Root	126	0.944	0.408	1.233
1/4 Root	126	0.922	0.324	1.136
Mean	126	0.904	0.263	1.067
1/4 Tip	126	0.897	0.236	1.040
Tip	126	0.892	0.224	1.025

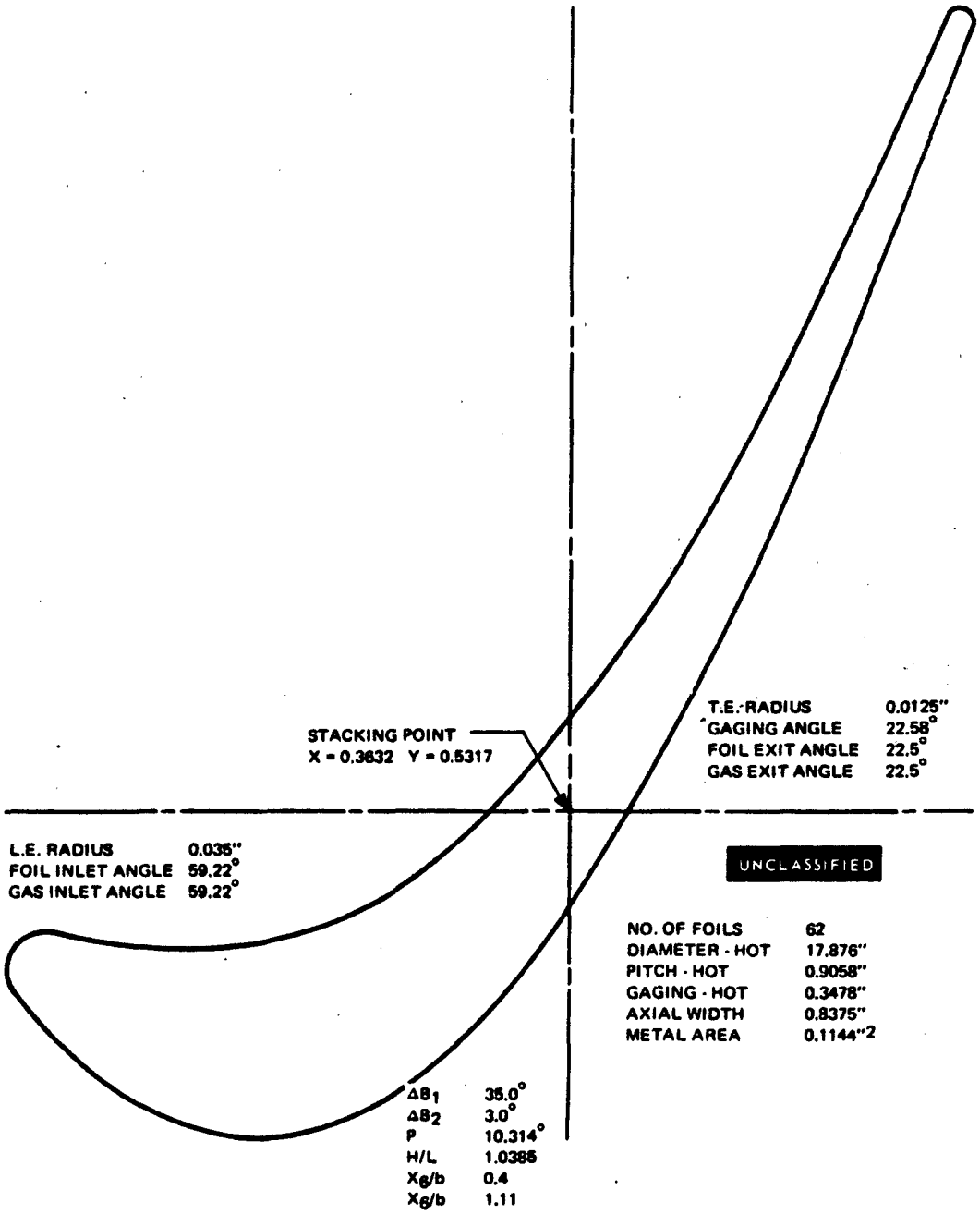

Figure 1 Medium Reaction, Normal Solidity, Final First Stage Vane Mean

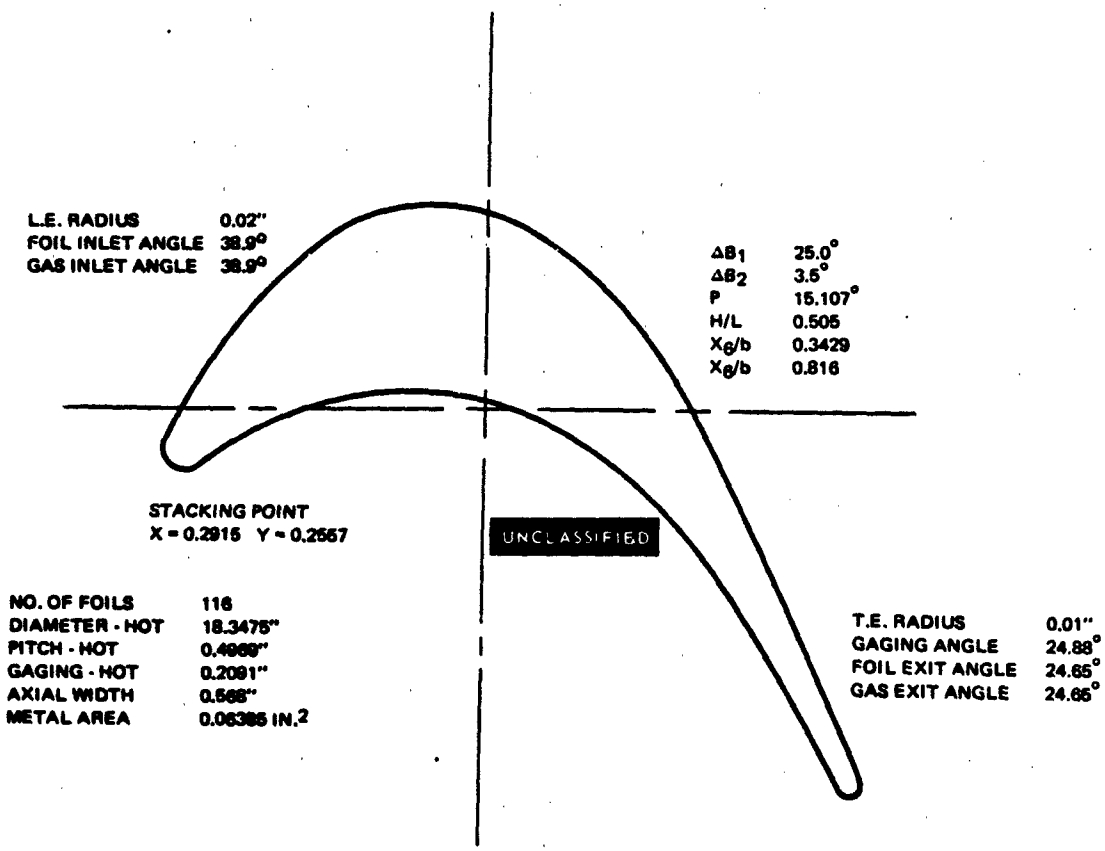

Figure 2 Medium Reaction, Normal Solidity, Final First Stage Blade Mean

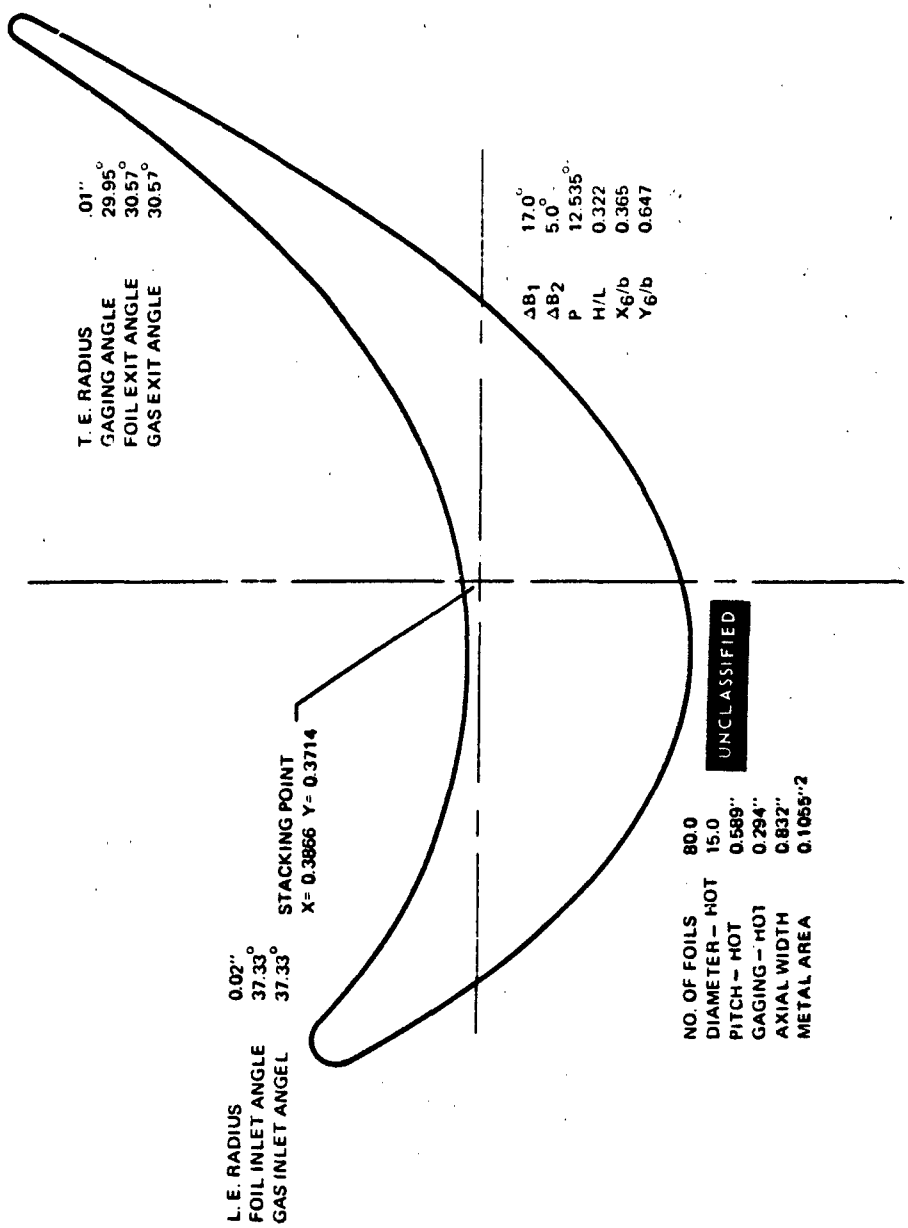

Figure 3 Medium Reaction, Normal Solidity, Final Second Stage Vane Root

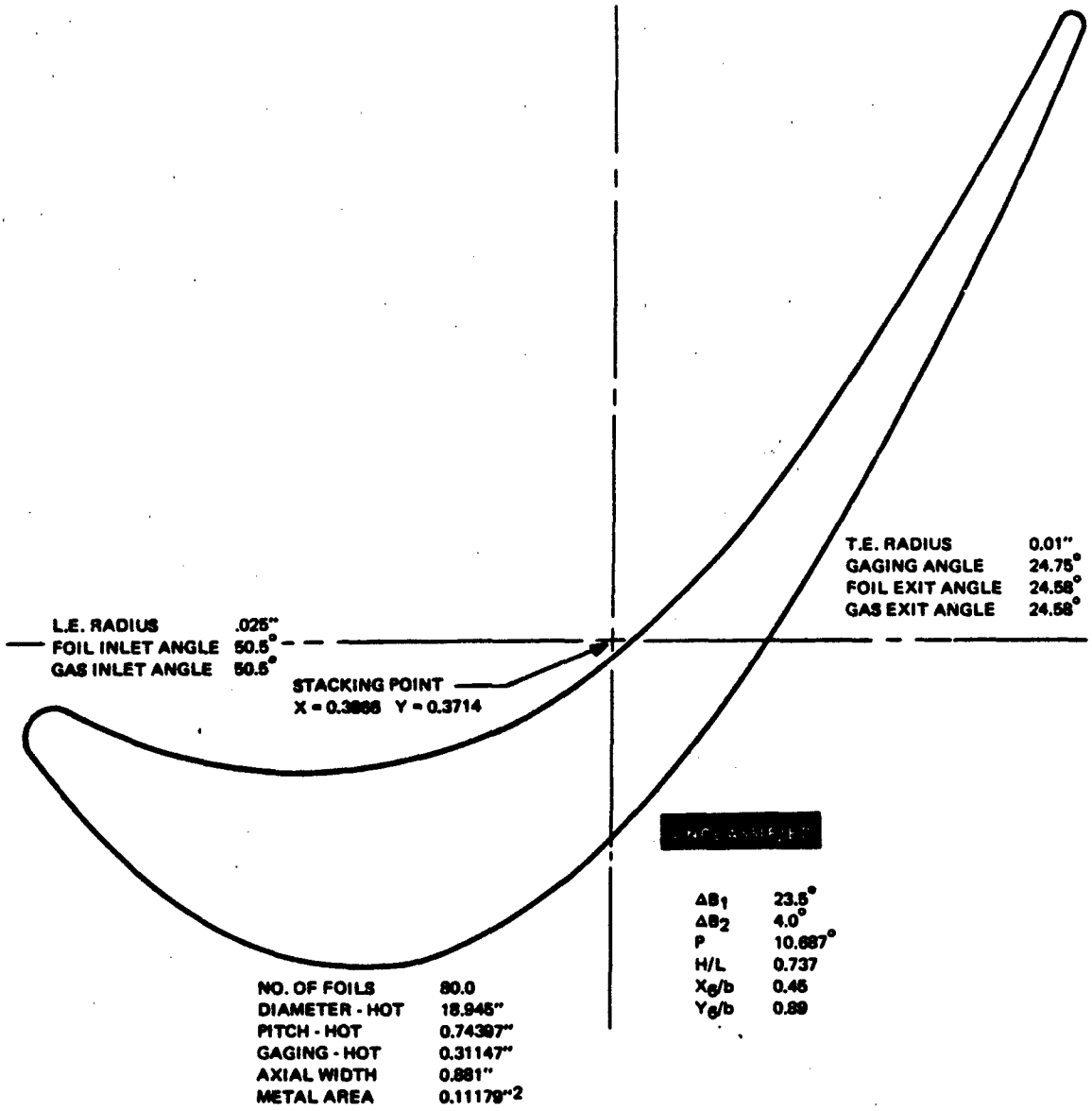

Figure 4 Medium Reaction, Normal Solidity, Final Second Stage Vane Mean

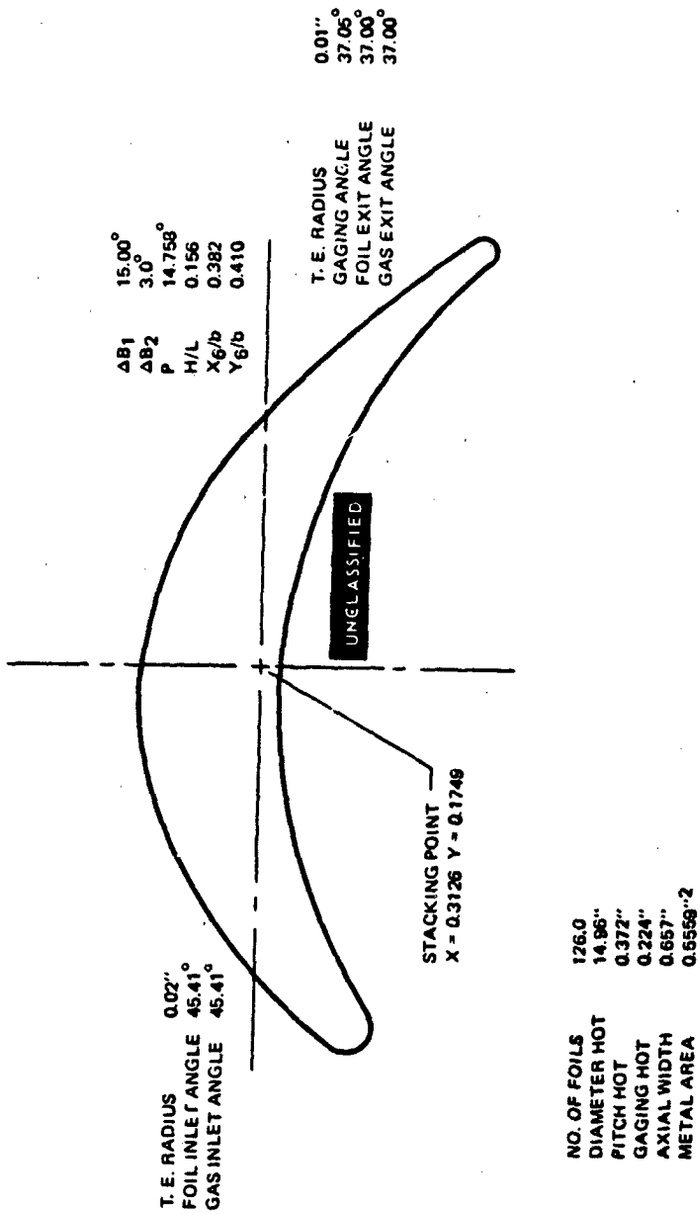

Figure 5 Medium Reaction, Normal Solidity, Final Second Stage Blade Root

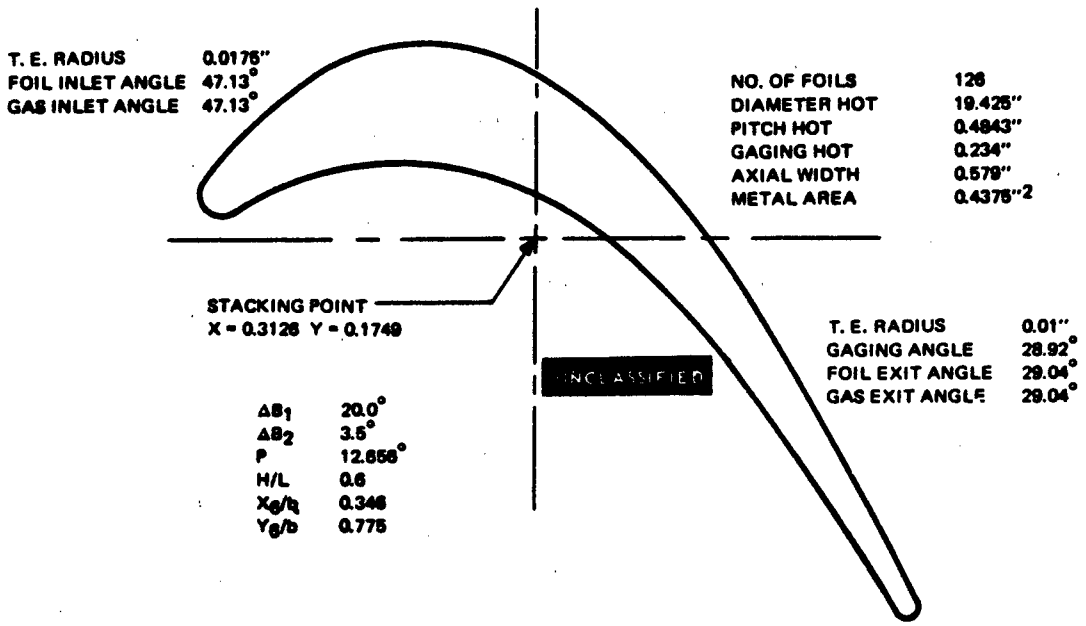

Figure 6 Medium Reaction, Normal Solidity, Final Second Stage Blade Mean

(U) The method of assembly of the cascade test packs is shown in Figure 7 and sketches of each of the individual test packs are shown in Figures 8 thru 13. All packs have airfoils with a span of 7.0 inches. The axial chords are 1.54, 1.14, 1.76, 1.69, 1.35, and 1.19 inches for the first vane mean, first blade mean, second vane root, second vane mean, second blade root and second blade mean airfoils, respectively. The gaps, the stagger angles, and the number of airfoils for each pack are also shown on the assembly sketch, Figure 7. Locations of the exit static taps are also shown for each pack, as well as the airfoil which will have surface static pressure taps, in Figures 8 thru 13. The method of installing of the airfoil surface static pressure taps and their locations for each of the test packs are shown in Figure 14. A total of 25, 20, 15, 16, 17 and 13 surface taps are installed in the first vane mean, first blade mean, second vane root, second vane mean, second blade root and second blade mean airfoils, respectively. The number of surface taps depended on the fabrication limitations imposed by each airfoil chord size.

(U) The design of the plane cascade rig and the location of the test section on the test stand are shown in Figure 15. Inlet static pressure taps will be installed on the test rig rather than on each test cascade as in the case of the exit static taps. The test section will have a variable inlet and exit flow path in order that all six cascades can be evaluated using basically the same hardware. The variable geometry rig design will permit each cascade to be tested at its respective design incidence angle. Both inlet and exit pressures can be independently controlled, as well as the inlet temperature level, allowing the correct simulation of inlet and exit Mach numbers, as well as the design Reynolds number. The cascade pack exit total pressure and exit flow angle profiles will be measured. Based on these measurements, profile loss coefficients will be determined for the midspan of the instrumented airfoil in the cascade. Local and integrated loss coefficients will be calculated for the test passage width. These midspan profile losses will be compared with the turbine mean line loss as predicted by the design system. The root section profile loss will be compared with the two-dimensional design prediction, verifying its characteristics without the end wall influences.

	1ST VANE MEAN	1ST BLADE MEAN	2ND VANE ROOT	2ND VANE MEAN	2ND BLADE ROOT	2ND BLADE MEAN
A	1.930	1.535	2.170	2.093	1.768	1.594
B	2.321	1.365	1.331	2.011	.963	1.483
C	1.501	1.108	1.759	1.657	1.393	1.182
D	12.508	11.559	11.567	12.205	11.231	11.709
E	.100	.100	.100	.100	.100	.100
F	.745	.745	.745	.745	.745	.745
T	1.667	1.000	1.250	1.429	.769	1.000
No. of Foils	7	11	9	8	14	11
θ	45° 0′	74° 15′	67° 15′	45° 30′	88° 0′	59° 40′

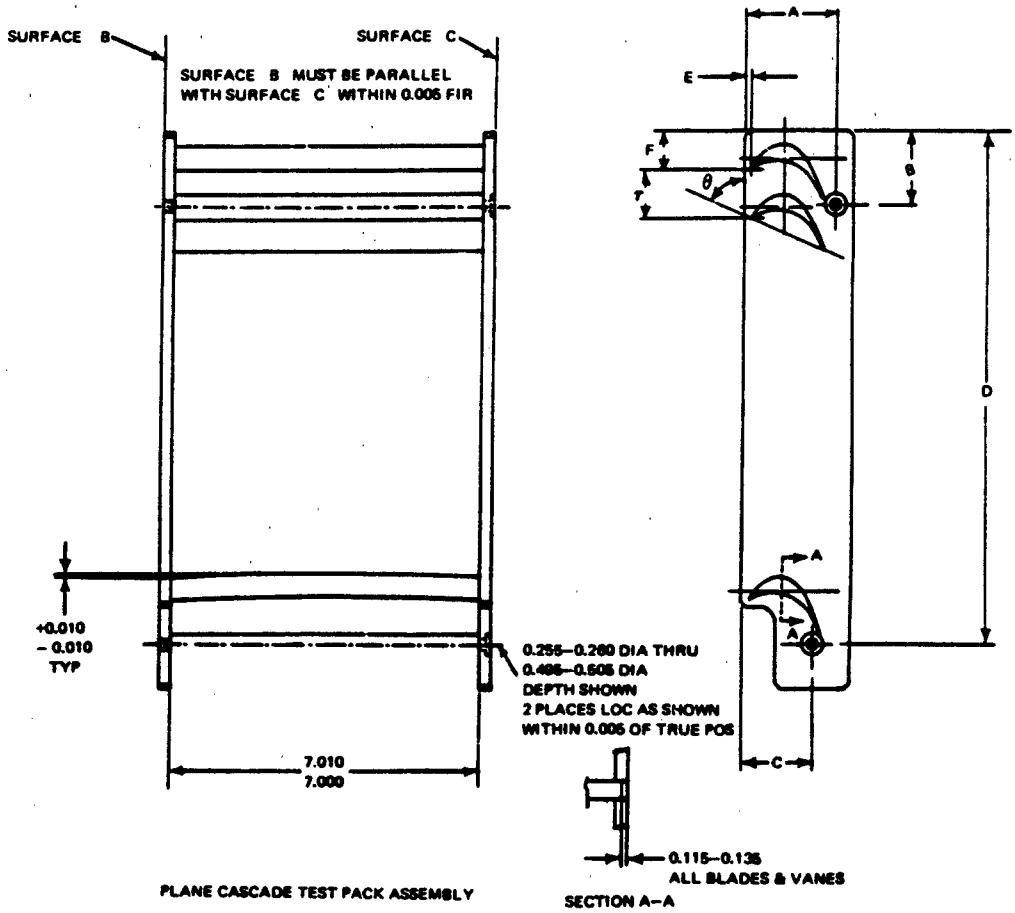

Figure 7 Plane Cascade Test Pack Assembly

[redacted]

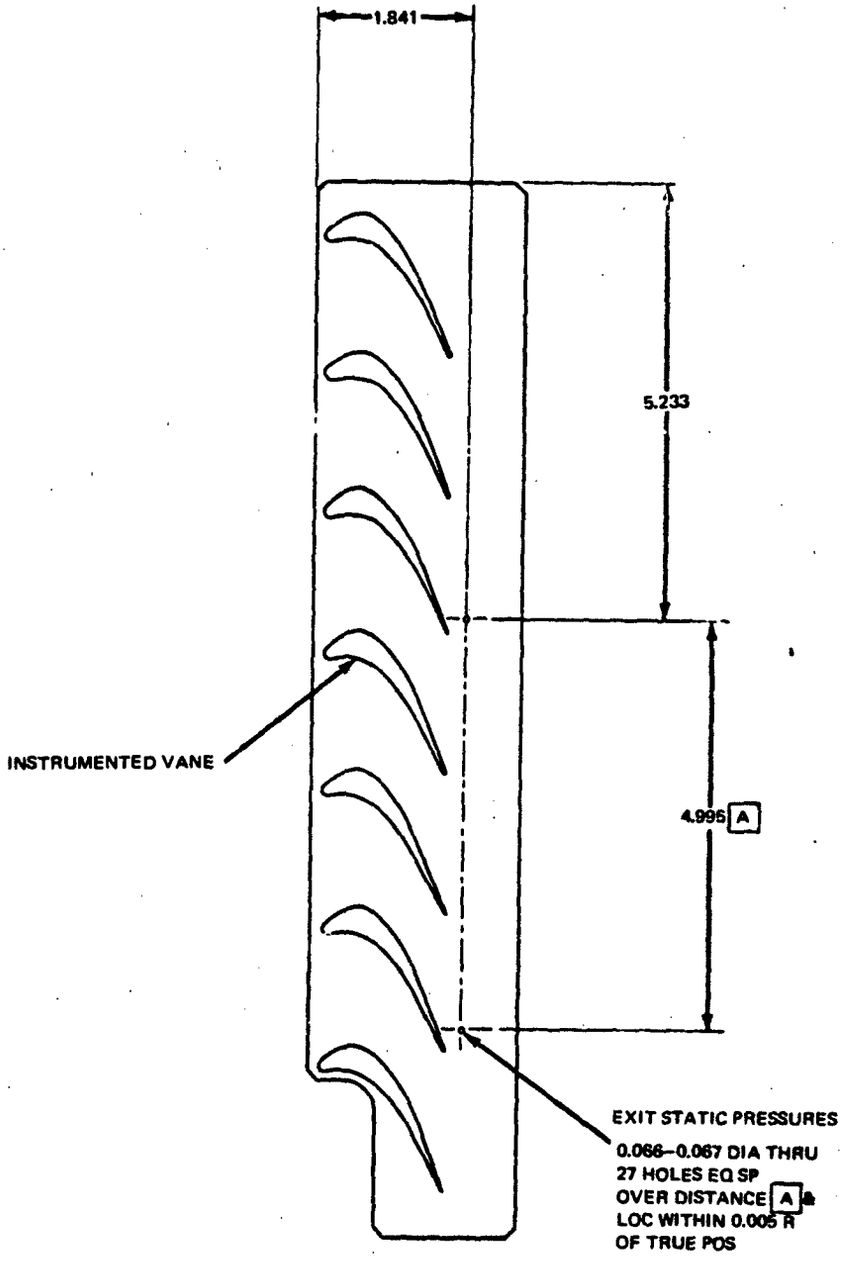

Figure 8 1st Stage Vane, Mean Section

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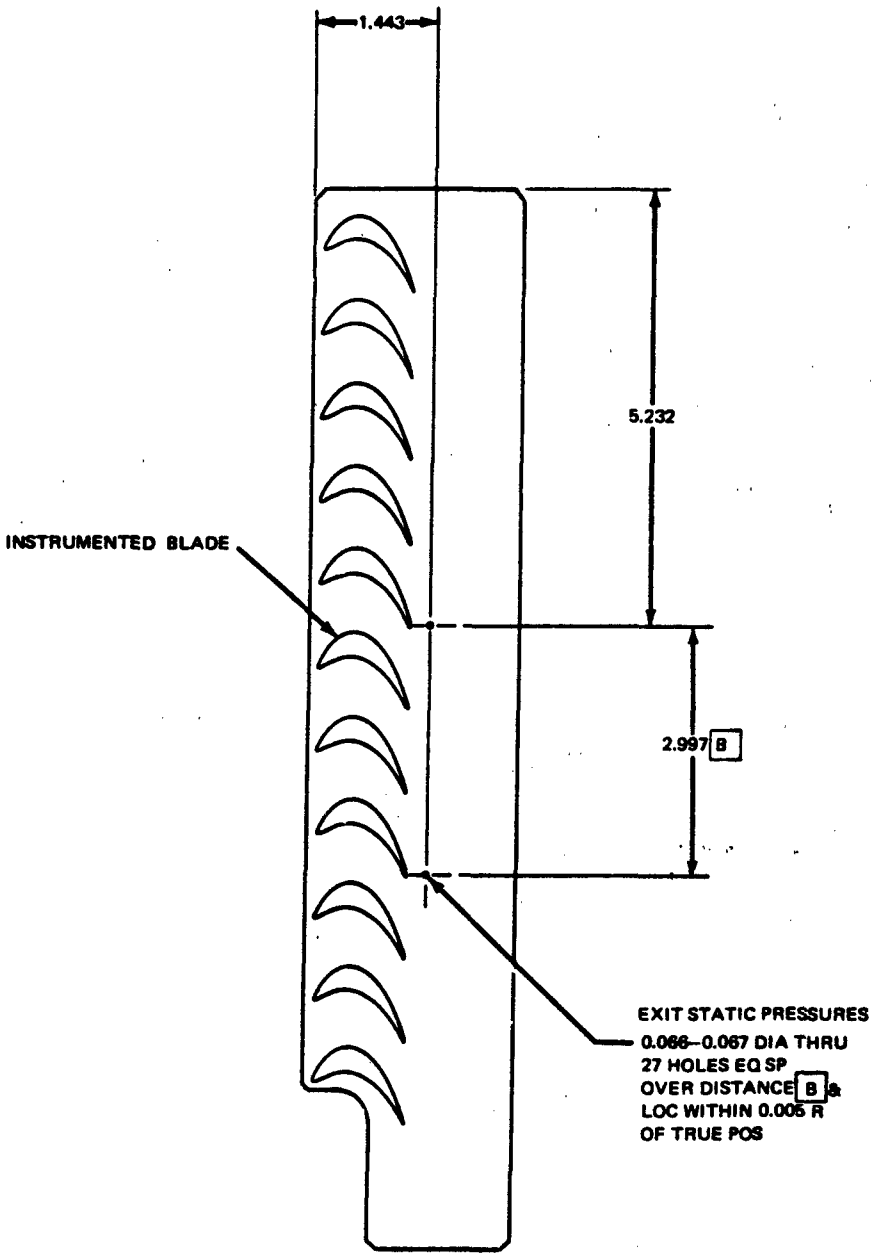

Figure 9 1st Stage Blade, Mean Section

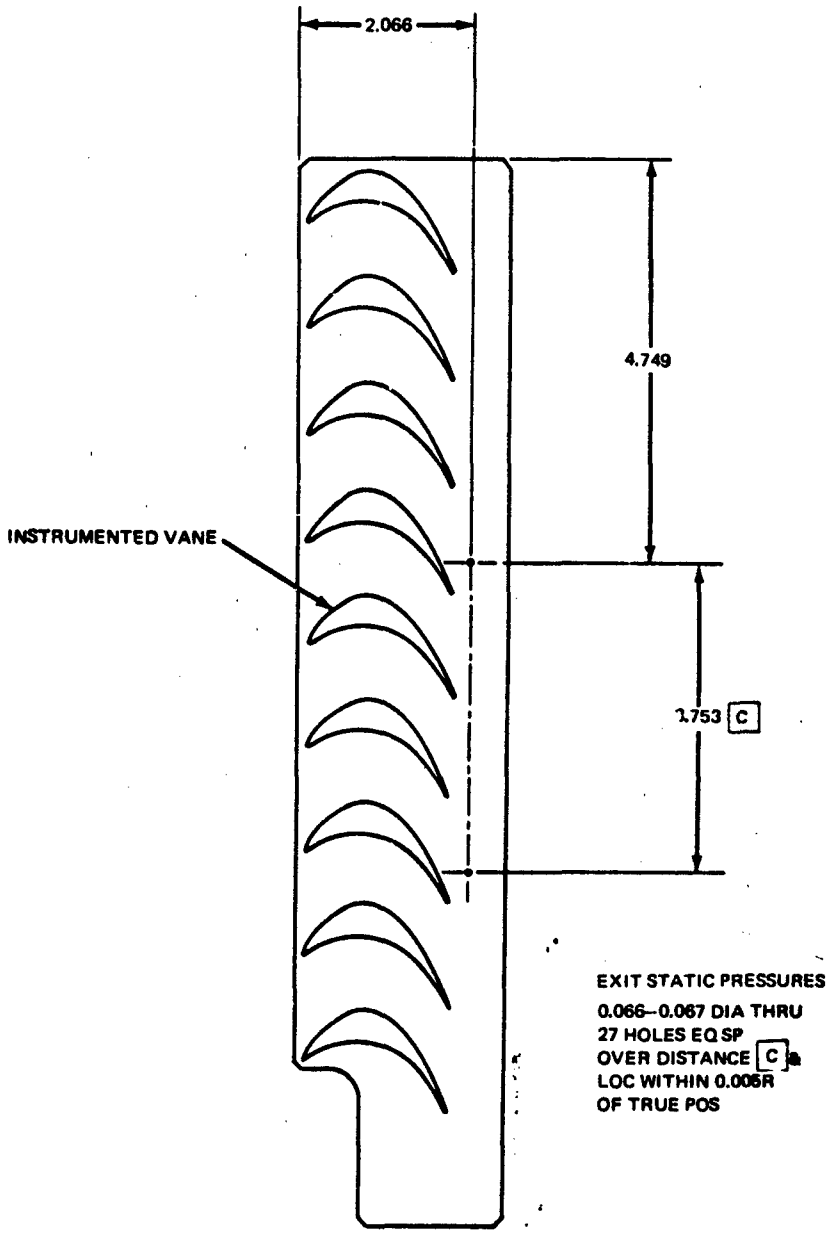

Figure 10 2nd Stage Vane, Root Section

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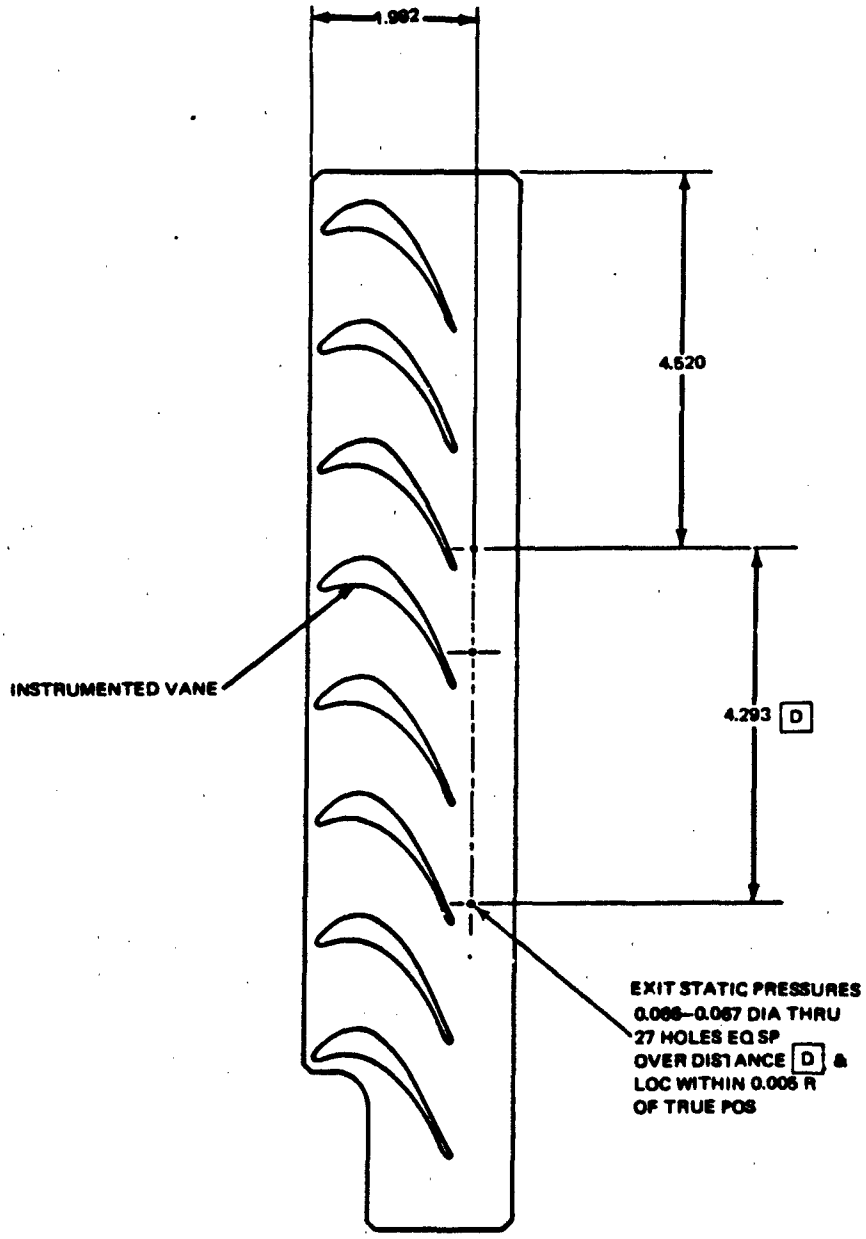

Figure 11 2nd Stage Vane, Mean Section [redacted]

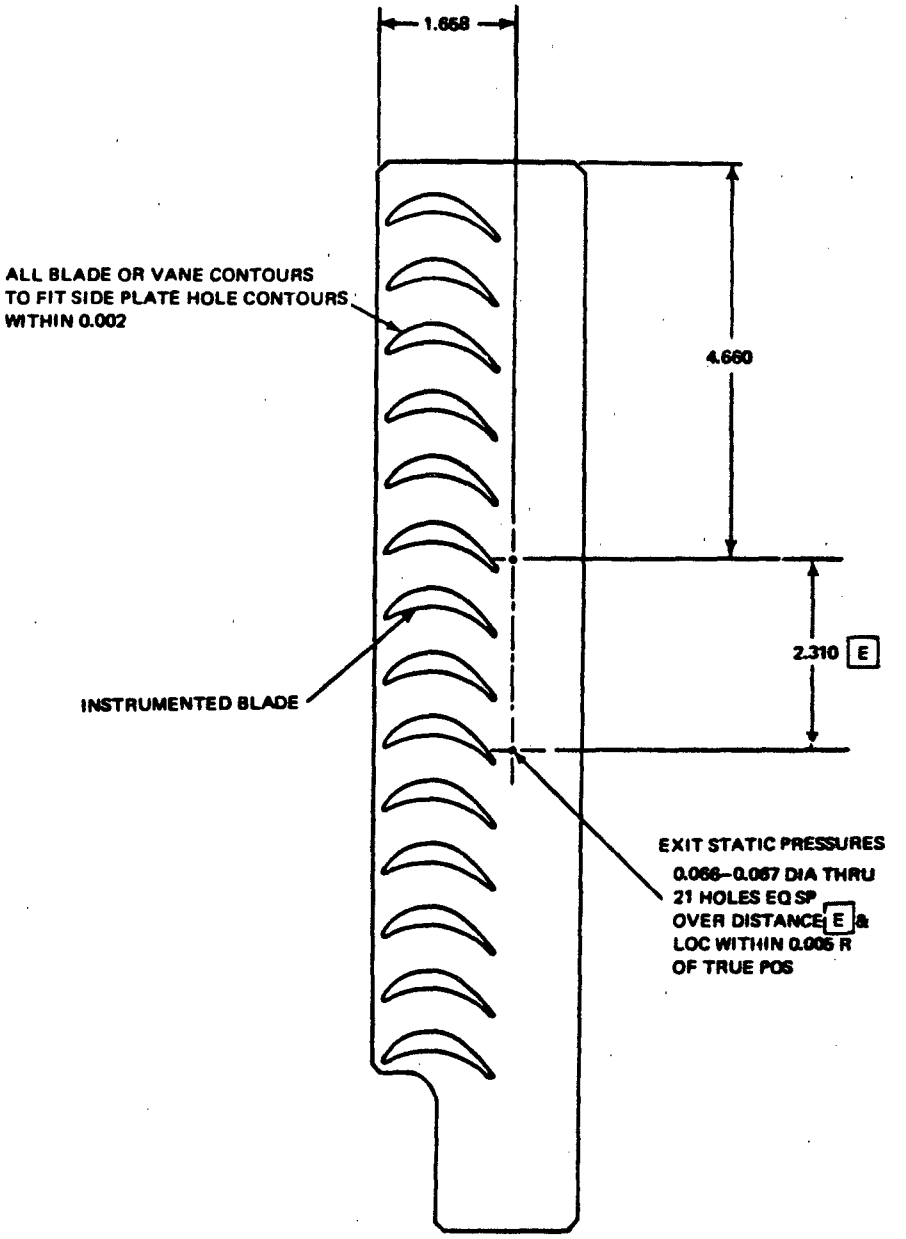

Figure 12 2nd Stage Blade, Root Section

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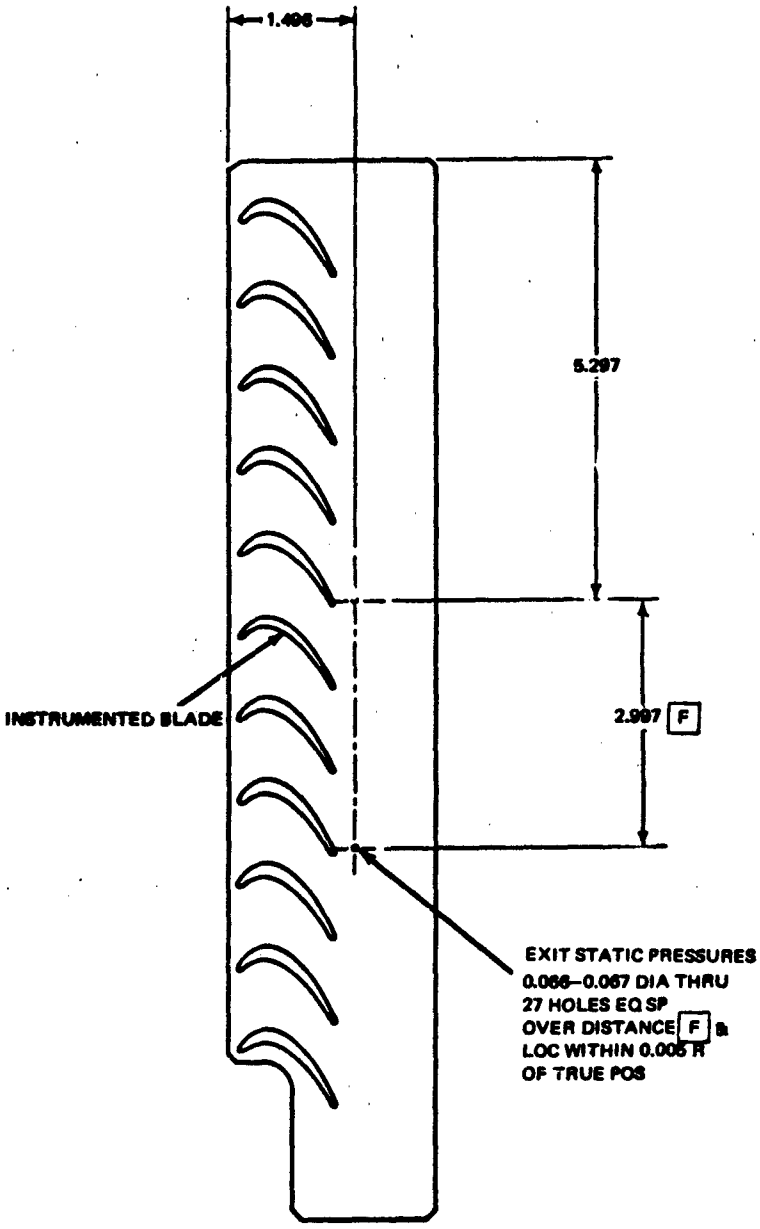
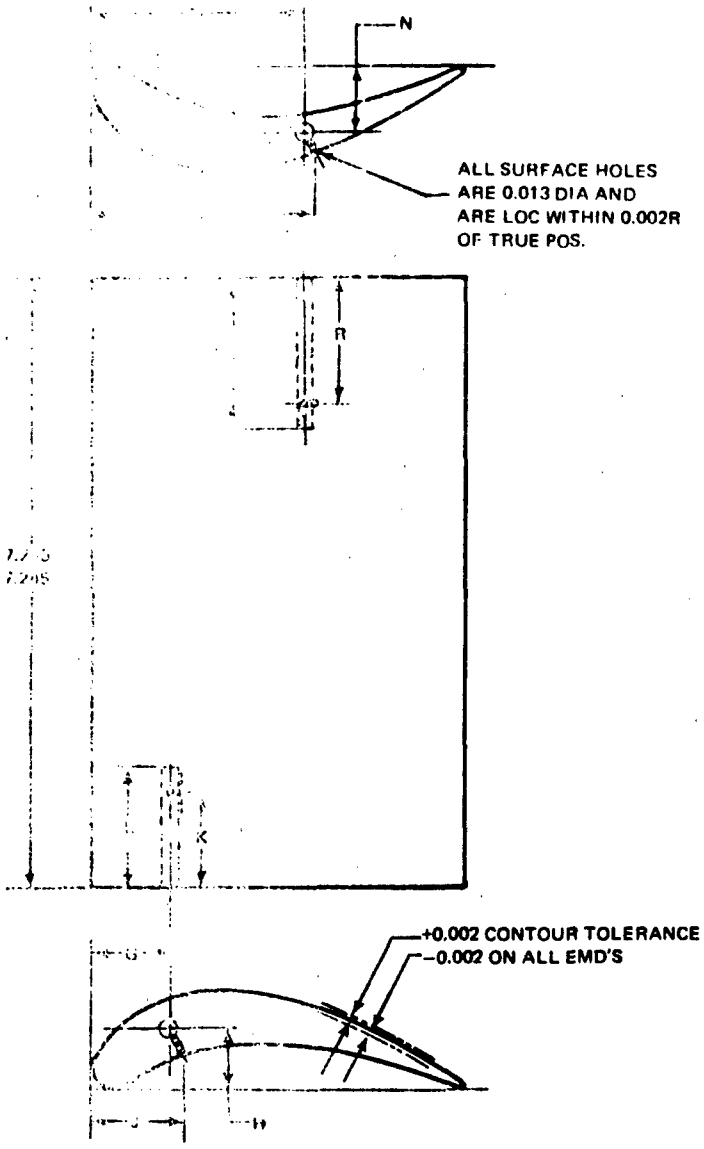


Figure 13 2nd Stage Blade, Mean Section



FIRST STAGE VANE MEAN SECTION ALL TAP

TAP No	G	H	J	K	L	M
1	044	094	001	2.765	2.890	
2	060	030	051	2.734	2.859	
3	097	051	121	2.713	2.838	
4	536	434	552	2.563	2.688	
5	1.000	455	990	2.445	2.570	
6	1.590	251	1.577	2.282	2.407	
7	2.098	053	2.084	2.138	2.263	
8	2.118	035	2.189	2.125	2.250	
9			100			082
10			012			042
11						088
12						129
13						266
14						269
15						352
16						522
17						762
18						883
19						1.063
20						1.408
21						1.783
22						1.884
23						1.976
24						2.059
25						2.138

FIRST STAGE BLADE MEAN SECTION ALL TA

TAP No	G	H	J	K	L	M
1	040	040	062	2.511	2.636	
2	073	096	107	2.487	2.612	
3	351	184	381	2.393	2.518	
4	632	393	624	2.327	2.452	
5	949	250	931	2.239	2.363	
6	628	044	1.214	2.149	2.274	
7	1.239	034	1.273	2.125	2.250	
8			031			.040
9						045
10						076
11						.111
12						.185
13						.280
14						.418
15						.593
16						.817
17						.923
18						1.034
19						1.148
20						1.206

SECOND STAGE VANE – ROOT SECTION – ALL TAP

TAP NO.	G	H	J	K	L	M
1	.032	.065	.091	2.675	2.800	
2	.486	.472	.451	2.542	2.667	
3	.993	.562	.980	2.397	2.522	
4	1.425	.363	.397	2.276	2.401	
5	1.739	.109	1.753	2.259	2.384	
6	1.020	.071	1.032	2.125	2.250	
7			.058			.041
8						106
9						.317
10						.549
11						.753
12						1.109
13						1.561
14						1.700
15						1.820

MEAN SECTION ALL TAPS NORMAL TO SURFACE

	K	L	M	N	P	R	S	
01	2.765	2.890						
51	2.734	2.859						
21	2.713	2.838						
52	2.563	2.688						
00	2.645	2.570						
77	2.282	2.407						
04	2.138	2.263						
09	2.125	2.250						
00			.082	.036		2.86[illegible]	[illegible]	
12			.042	.048		2.842	[illegible]	
			.088	.147	.000	2.80[illegible]	[illegible]	
			.129	.146	.043	2.741	[illegible]	
			.266	.388	.162	2.69[illegible]	[illegible]	
			.269	.489	.223	2.6[illegible]	[illegible]	
			.352	.444	.317	2.66[illegible]	[illegible]	
			.522	.533	.525	[illegible]	[illegible]	
			.762	.485	.780	[illegible]	[illegible]	
			.883	.472	.903	[illegible]	[illegible]	
			1.063	.422	1.084	2.4[illegible]	[illegible]	
			1.408	.318	1.428	2.1[illegible]	[illegible]	
			1.783	.178	1.798	[illegible]	[illegible]	
			1.884	.138	1.896	[illegible]	[illegible]	
			1.976	.101	1.987	[illegible]	[illegible]	
			2.059	.067	2.070	2.4[illegible]	[illegible]	.025
			2.138	.036	2.148	2.1[illegible]	[illegible]	.025

DE MEAN SECTION ALL TAPS NORMAL TO SURFACE

	K	L	M	N	P	R	S	HOLE SIZE
2	2.511	2.636						[illegible]
7	2.487	2.612						[illegible]
1	2.393	2.518						[illegible]
4	2.327	2.452						[illegible]
1	2.239	2.363						
6	2.149	2.274						
3	2.125	2.250						[illegible]
1			.040	.040		2.63[illegible]	[illegible]	
			.045	.093	.002	2.609	[illegible]	[illegible]
			.076	.145	.006	2.593	[illegible]	[illegible]
			.111	.230	.022	2.566	[illegible]	.043
			.185	.407	.110	2.511	2.636	.062
			.280	.485	.247	2.457	2.582	.062
			.418	.491	.432	2.407	2.532	[illegible]
			.593	.458	.627	2.353	2.478	[illegible]
			.817	.335	.852	2.281	2.406	.043
			.923	.270	.952	2.247	2.372	[illegible]
			1.034	.193	1.056	2.211	2.336	.031
			1.148	.107	1.165	2.172	2.297	.025
			1.206	.062	1.221	2.151	2.276	.025

E – ROOT SECTION – ALL TAPS NORMAL TO SURFACE

	K	L	M	N	P	R	S	HOLE SIZE
	2.675	2.800						[illegible]
	2.542	2.667						[illegible]
	2.397	2.522						.062
	2.276	2.401						[illegible]
	2.259	2.384						[illegible]
	2.125	2.250						.025
			.041	.041		2.845	2.970	[illegible]
			.106	.193	.040	2.768	2.893	[illegible]
			.317	.558	.237	2.655	2.780	.062
			.549	.664	.503	2.568	2.693	[illegible]
			.753	.695	.777	2.494	2.619	.062
			1.109	.580	1.155	2.383	2.508	.062
			1.561	.259	1.591	2.231	2.356	.031
			1.700	.143	1.722	2.183	2.308	.025
			1.820	.071	1.799	2.153	2.278	.025

SECOND STAGE VANE MEAN SECTION ALL TAPS NORMAL TO SURFACE

TAP NO	G	H	J	K	L	M	N	P	R	S	HOLE SIZE
	.047	.048	.950	2.727	2.852						.031
	.059	.158	.146	2.699	2.824						.043
3	.733	.573	.741	2.515	2.640						.062
4	1.233	.441	1.215	2.385	2.510						.043
5	1.956	.068	2.094	2.125	2.250						.025
6			.072			.047	.048		2.879	3.004	.031
						.080	.154	.010	2.817	2.942	.043
8						.130	.259	.030	2.784	2.809	.062
9						.257	.468	.148	2.703	2.828	.062
10						.402	.554	.359	2.636	2.761	.062
11						.550	.581	.552	2.583	2.708	.062
						.762	.582	.790	2.519	2.644	.062
						1.048	.507	1.078	2.438	2.563	.062
						1.528	.310	1.550	2.298	2.423	.031
						1.893	.121	1.906	2.187	2.312	.025
						1.986	.068	1.998	2.158	2.283	.025

SECOND STAGE BLADE ROOT SECTION ALL TAPS NORMAL TO SURFACE

TAP NO	G	H	J	K	L	M	N	P	R	S	HOLE SIZE
	.040	.042	.074	2.506	2.631						.031
	.089	.112	.134	2.484	2.609						.043
	.155	.163	.197	2.463	2.588						.043
	.225	.218	.240	2.443	2.568						.043
5	.655	.366	.659	2.333	2.458						.062
6	1.102	.223	1.082	2.217	2.342						.043
7	1.247	.121	1.230	2.171	2.296						.025
8	1.320	.056	1.374	2.125	2.250						.025
9			.045			.040	.042		2.607	2.732	.031
10						.100	.112	.046	2.557	2.682	.043
11						.159	.178	.113	2.531	2.656	.043
12						.462	.343	.424	2.427	2.552	.062
13						.742	.361	.766	2.335	2.460	.062
14						.953	.305	.996	2.267	2.392	.062
15						1.102	.223	1.138	2.219	2.344	.043
16						1.277	.096	1.296	2.161	2.286	.025
17						1.320	.056	1.336	2.146	2.271	.025

SECOND STAGE BLADE MEAN SECTION ALL TAPS NORMAL TO SURFACE

TAP NO	G	H	J	K	L	M	N	P	R	S	HOLE SIZE
1	.036	.037	.072	2.520	2.645						.031
2	.067	.109	.107	2.503	2.648						.043
3	.531	.371	.532	2.370	2.495						.043
4	1.042	.200	1.028	2.230	2.355						.031
5	1.317	.051	1.387	2.125	2.250						.025
6			.054			.036	.037		2.615	2.740	.031
7						.067	.109	.014	2.672	2.797	.043
8						.210	.305	.142	2.497	2.622	.062
9						.570	.370	.590	2.370	2.495	.043
10						.668	.352	.690	2.343	2.498	.043
11						.938	.254	.957	2.263	2.388	.031
12						1.261	.084	1.274	2.166	2.298	.025
13						1.371	.051	1.330	2.147	2.272	.025

Figure 14 Airfoil Surface Static Pressure Location

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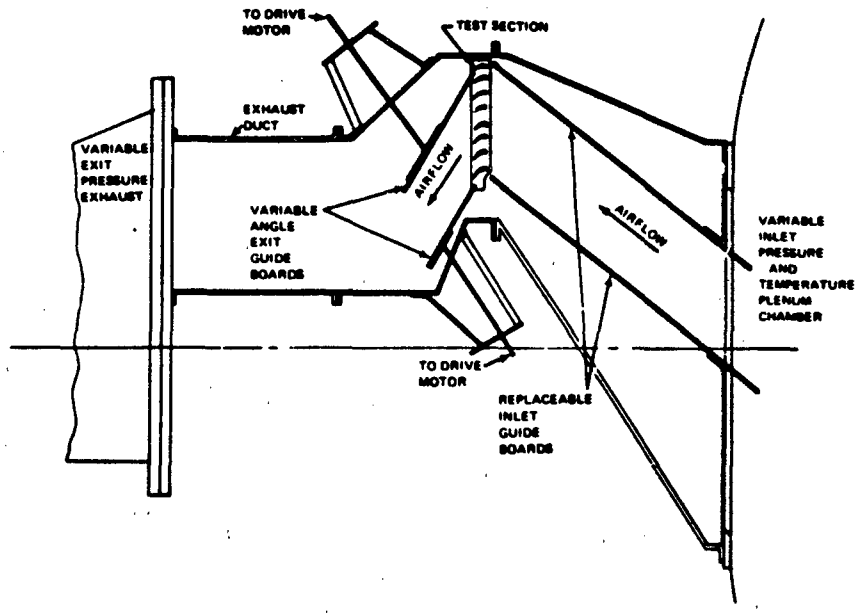


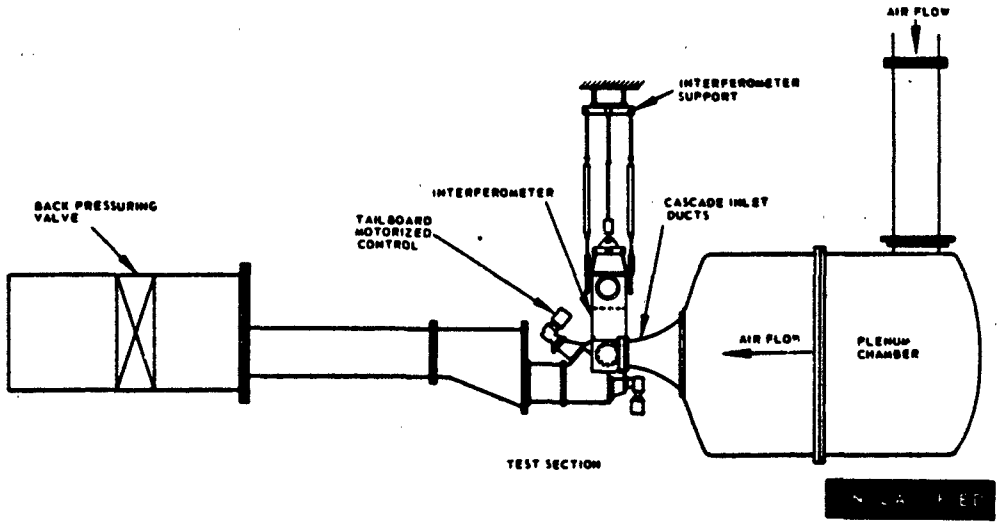


Figure 15 Schematic of Plane Cascade Test Rig

SECTION IV

BASELINE AIRFOIL EVALUATION (TASK IIb)

1. RFP OBJECTIVE

(U) Determine the design point performance of the baseline turbine airfoils and the need for corner boundary layer control.

2. TASK OBJECTIVE

(U) Each of the baseline airfoil designs as determined by the Phase I portion of this Contract will be evaluated in an annular segment cascade, where the correct three-dimensional flow behavior will be closely reproduced. The purpose of these tests is to evaluate the average losses, so that by subtracting out the plane cascade two-dimensional losses, the net effects of secondary losses can be evaluated for comparison with the present design system secondary loss correlations. Location and severity of losses due to airfoil and/or corner boundary layer separation will be found if they occur. When separation does occur, simple flow visualization techniques will be employed in order to locate the beginning of the region of separation. This information will be required in the following Task where boundary layer control techniques will be applied, since the most effective techniques are those which are applied upstream of the existing point of separation. Furthermore, surface static pressure distributions will be measured on the airfoils in order to verify the aerodynamic concepts used in their design. These static pressure distributions will also assist in determining the location and extent of any regions of separation.

3. ANNULAR SEGMENT CASCADE AIRFOIL AND RIG DESIGN

(U) The elevations of the first stage vane and blade as well as the second stage vane and blade which were determined as a result of the Phase I study are shown in Figure 16. The airfoil sections for the chosen medium reaction, normal solidity design were presented in the Phase I report, Reference 1. The fabrication coordinates for each of the sections indicated in Figure 16 are tabulated, in the Appendix, for the first vane in Tables V through XII, the first blade in Table XIII through XIX, the second vane in Table XX through XXVII, and for the second blade in Tables XXVIII through XXXIV. Additional airfoil information as airfoil angles, gaging distance, airfoil area, axial chord, uncovered turning are also tabulated. These airfoils have been fabricated for evaluation in the annular segment cascade rig.

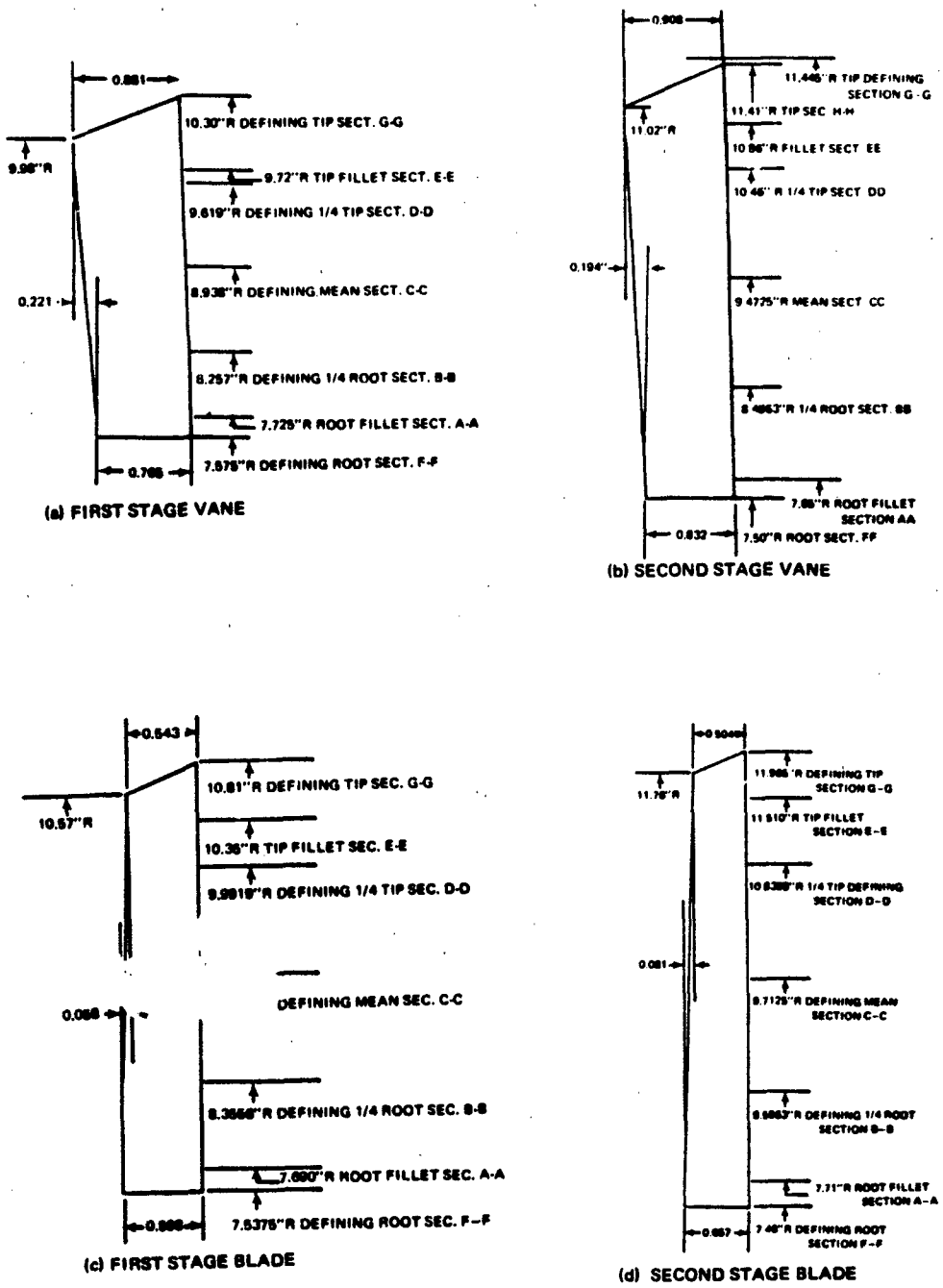


Figure 16 Turbine Test Airfoil Elevations [redacted]

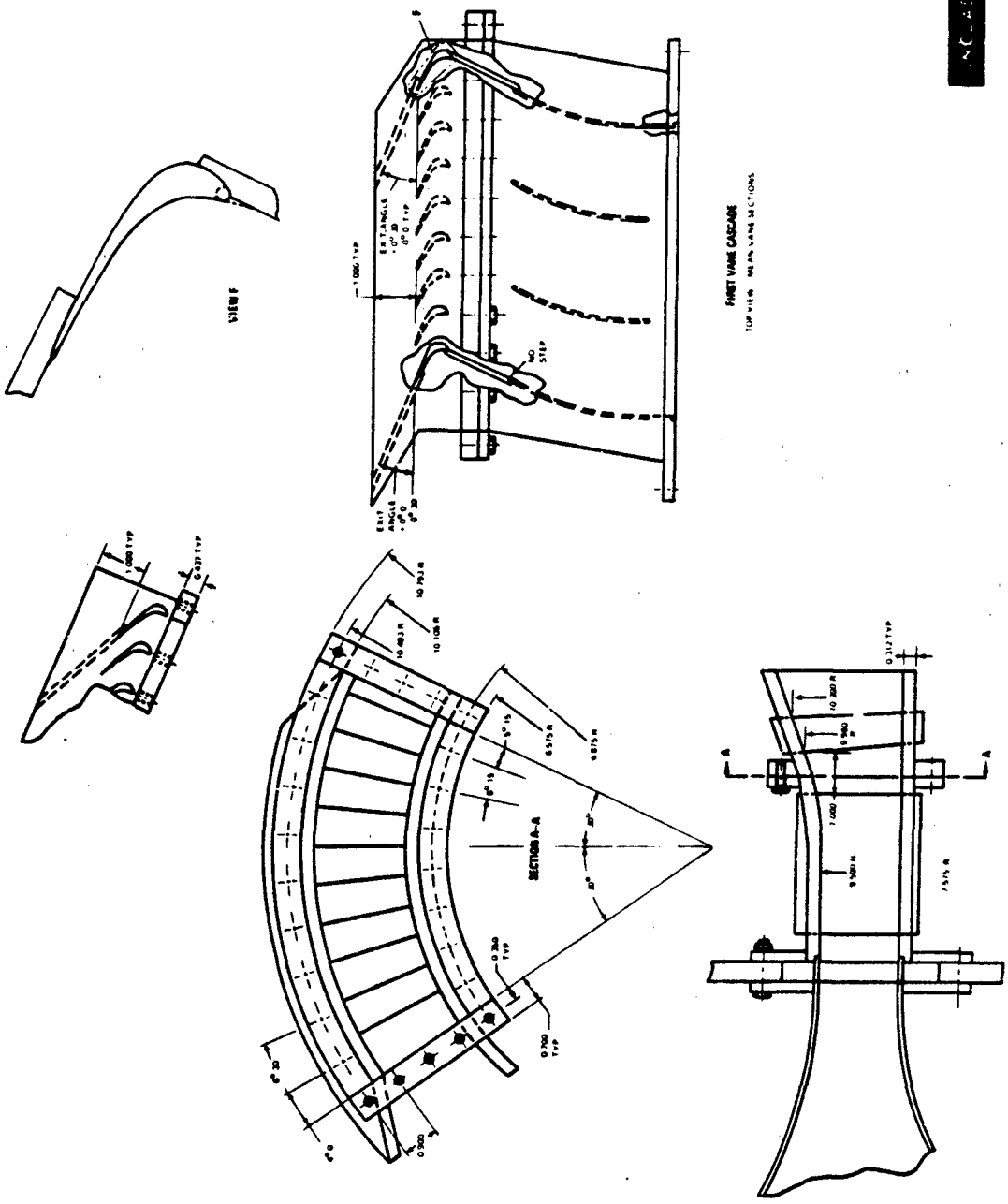


Figure 17 Ass'y of First Vane Cascade, Mean Section, Full Scale

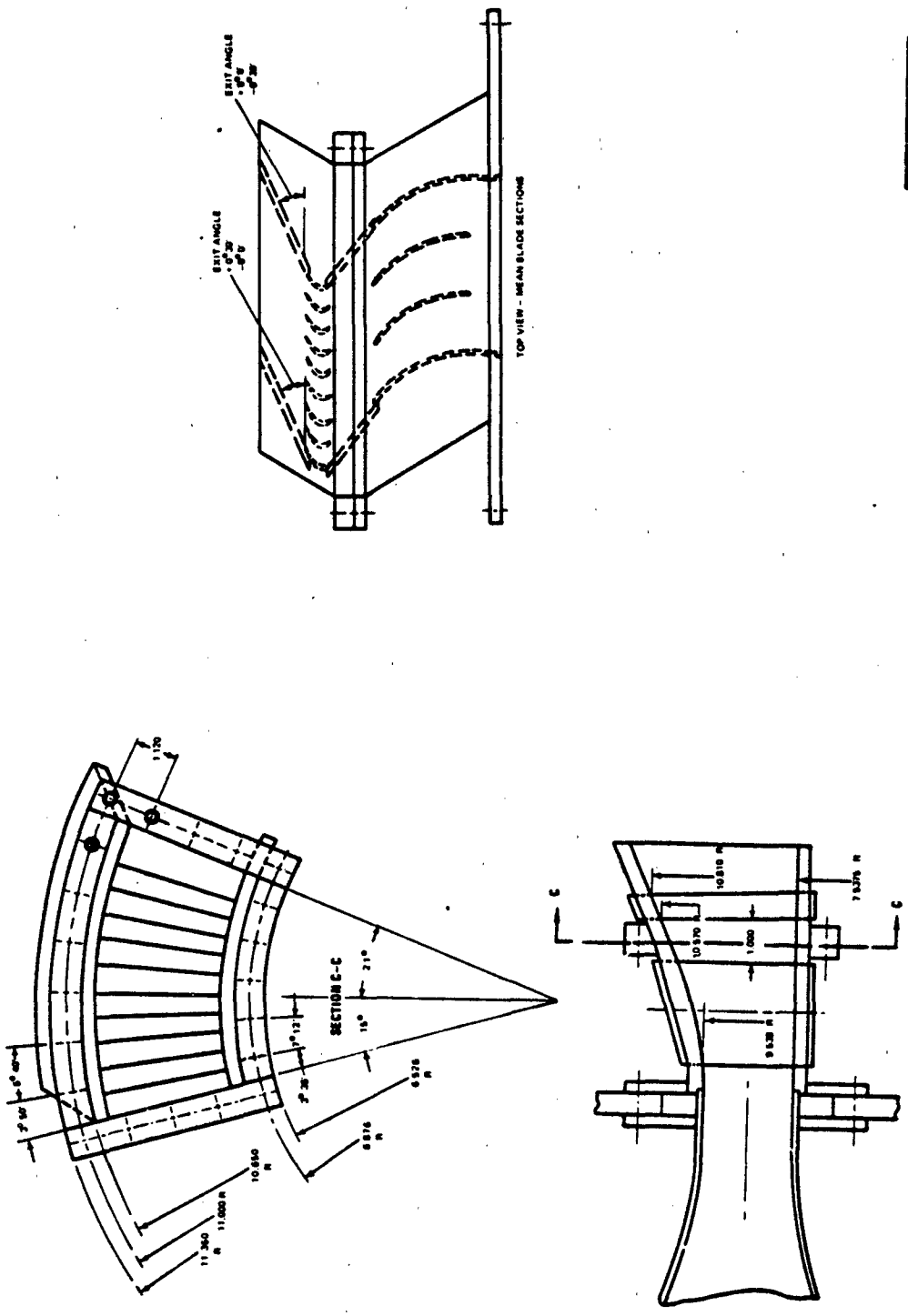


Figure 18 First Blade Cascade

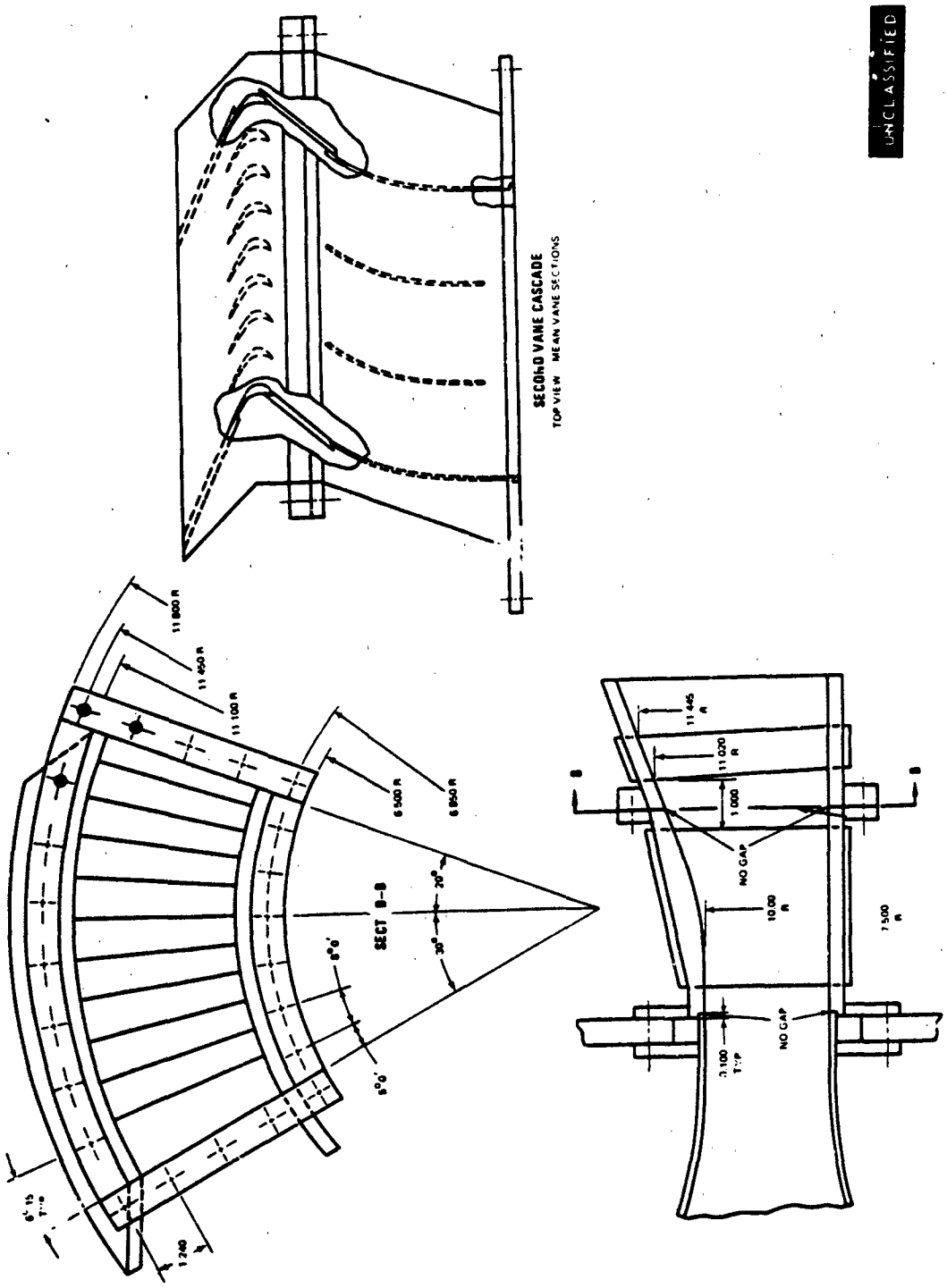


Figure 19 Ass'y of Second Vane Cascade

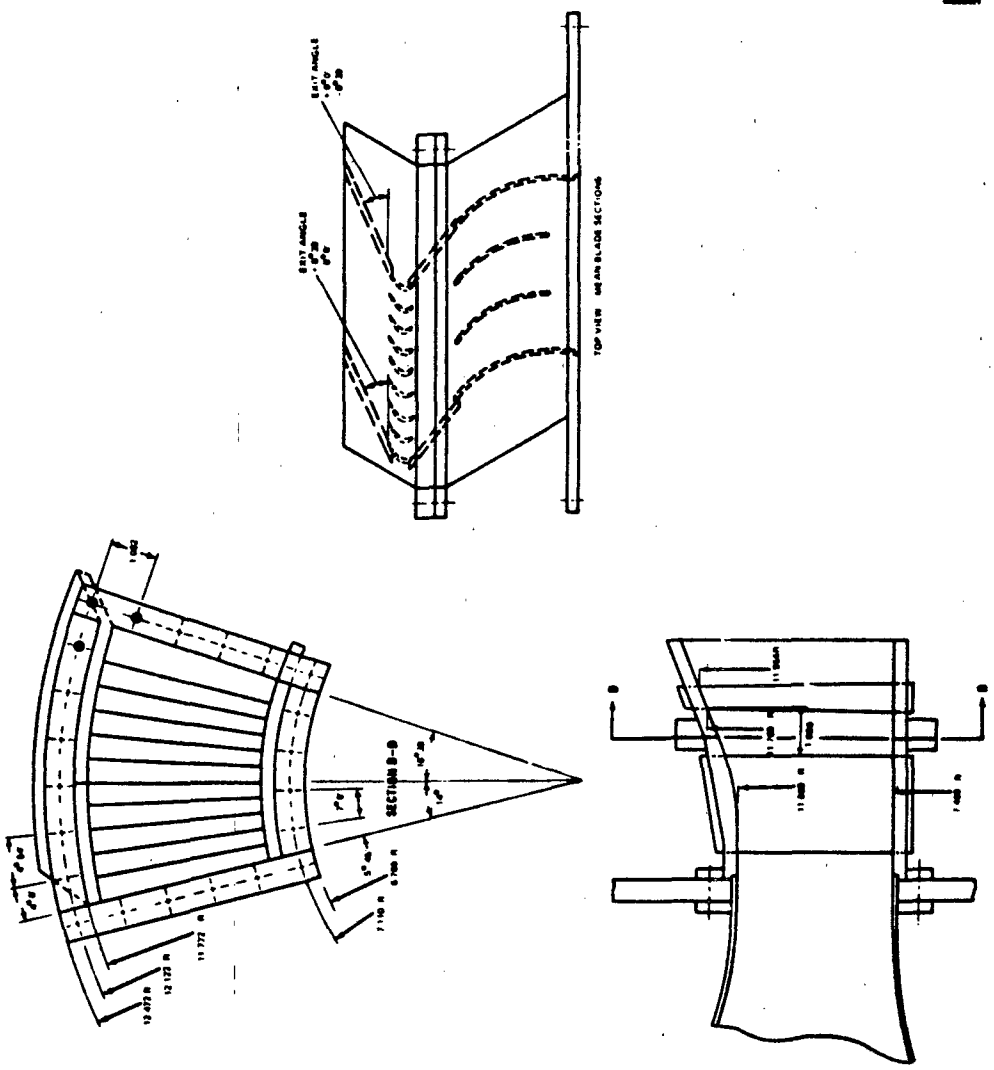


Figure 20 Second Blade Cascade

(U) The test sections for each of the four airfoils to be evaluated in the annular segment cascade are shown in Figures 17 through 20. The inlet to each cascade consists of a bellmouth transition section followed by a turning vane which aligns the flow with its design angle. The turning vanes are followed by the test airfoils. In each case seven airfoils are used. These test airfoils then are followed by exit wall extensions.

(U) The turning vane design was generated by applying the turbine streamline analysis program in order to provide proper inlet flow angles over the entire span of the test airfoils. Two long chord guide vanes are used in each cascade unit. The turning vane sector endwalls conform to the turning vane contours providing three uniform flow passages before the test cascades. The central three test airfoils will be between the turning vanes and entirely free of wake disturbances. The elevations, required turning vane exit angle and required test airfoil inlet angles are shown in Figure 21 through 32. The turning vane cross sections are shown in Figures 33 through 64, and the coordinates for these sections are shown in Tables XXXV through LXVI of the Appendix.

(U) Analyses were also made to determine if potential problems of flow separation exist on the inside end wall extensions downstream of the test airfoils. If such separation occurs, it may trigger separation on the test airfoils and thus produce false indications of airfoil performance. The results of the analyses, fortunately, indicate that the end wall extension is sufficiently long to maintain a small enough pressure gradient to prevent separation.

(U) Sufficient instrumentation is installed on the rig, on the flow path walls and airfoil surfaces to determine the loss coefficients and exit flow deviations for these cascades. Surface static pressure tap locations were installed on all four of the baseline airfoils as shown in Figure 65. The method of installing the taps is also indicated in this Figure. A total of 30 static taps were installed on each test channel. Static taps will be located at the midspan section as well as near the root and tip sections to obtain data in the end wall regions.

(U) A single cone probe as shown in Figure 66 was chosen for the exit plane total and static pressure and angle traverse requirements. This probe will be positioned parallel to the midspan streamline. The resulting pitch angles with respect to the cascade end walls were analytically estimated. The probe was also calibrated to determine total and static pressure errors due to pitch angle over the test Mach number range. Based on these probe calibrations, corrections for pitch angle were added to the data reduction program.

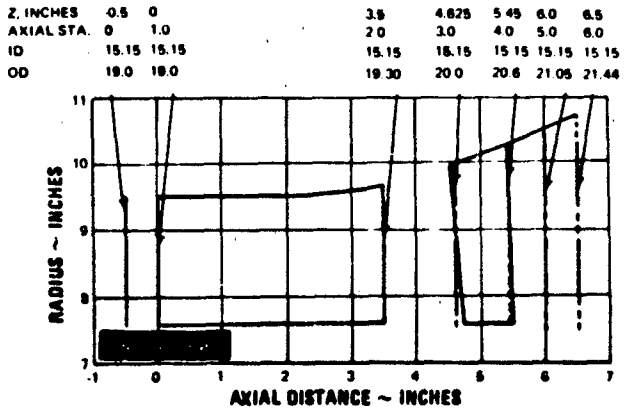


Figure 21 First Vane Cascade Elevation

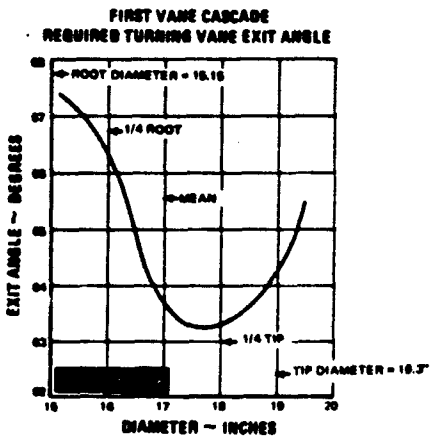


Figure 22 First Vane Cascade, Required Turning Vane Exit Angle

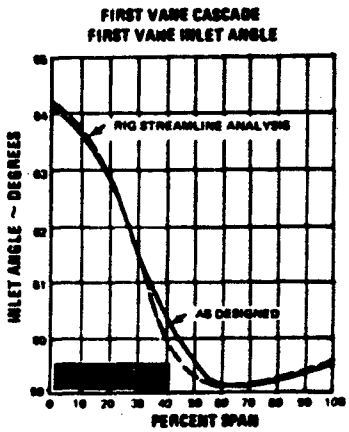


Figure 23 First Vane Cascade, First Vane Inlet Angle

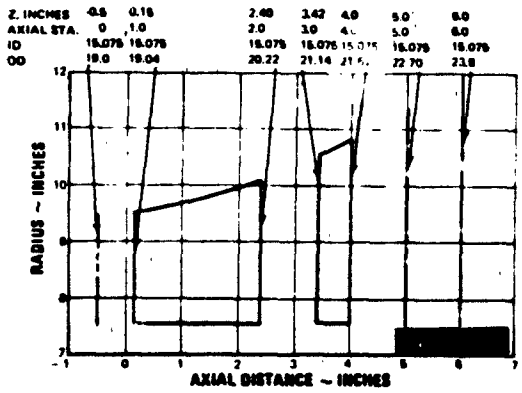


Figure 24 First Blade Cascade Elevation

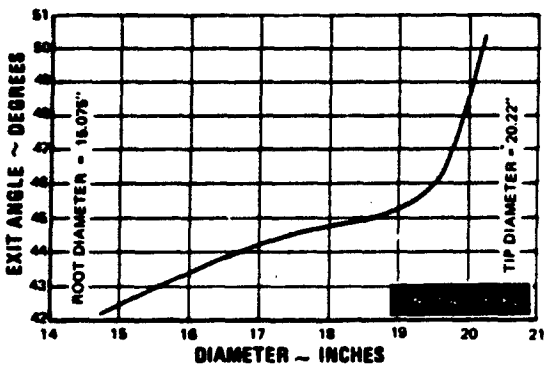


Figure 25 First Blade Cascade Required Turning Vane Exit Angle

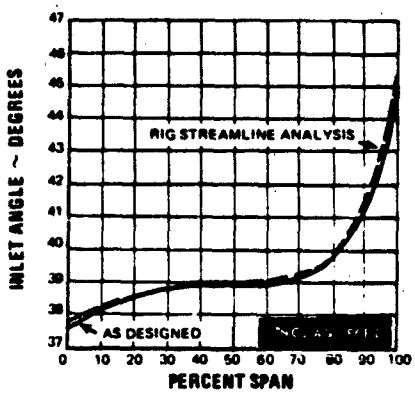


Figure 26 First Blade Cascade First Blade Inlet Angle

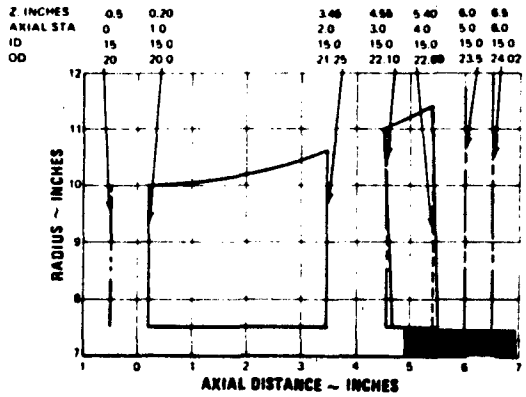


Figure 27 Second Vane Cascade Elevation

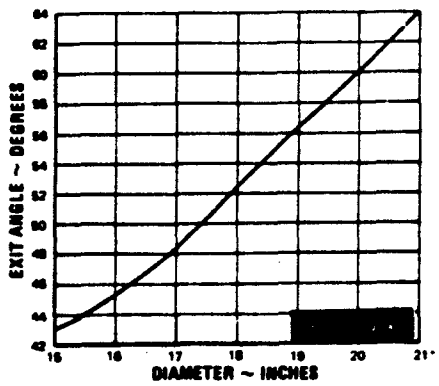


Figure 28 Second Vane Cascade Required Turning Vane Exit Angle

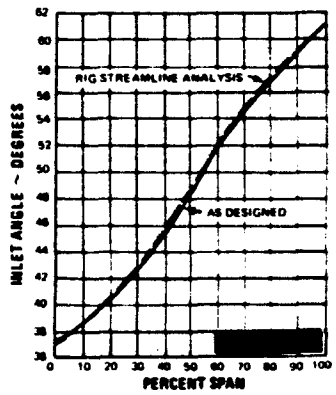


Figure 29 Second Vane Cascade, Second Vane Inlet Angle

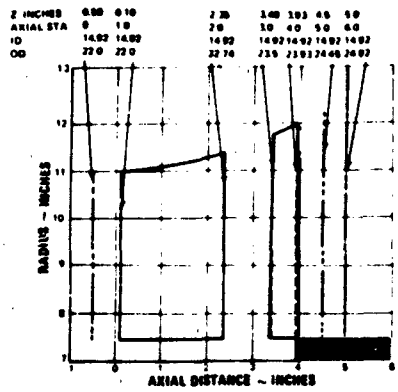


Figure 30 Second Blade Cascade Elevation

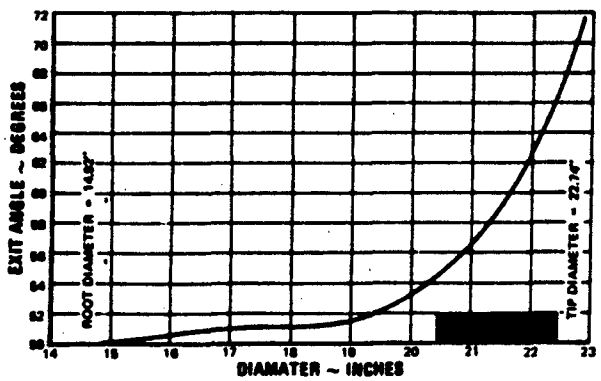


Figure 31 Second Blade Cascade Required Turning Vane Exit Angle

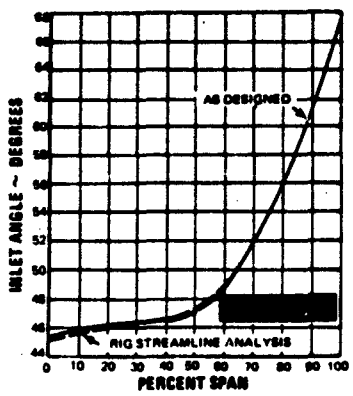
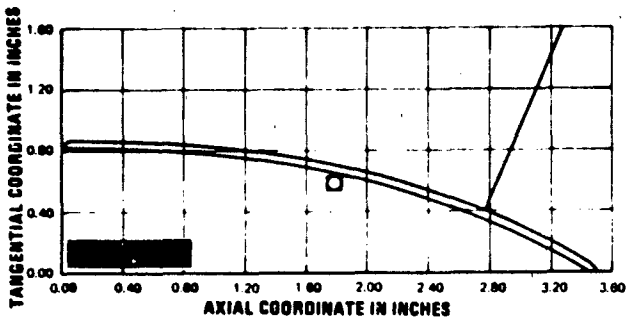


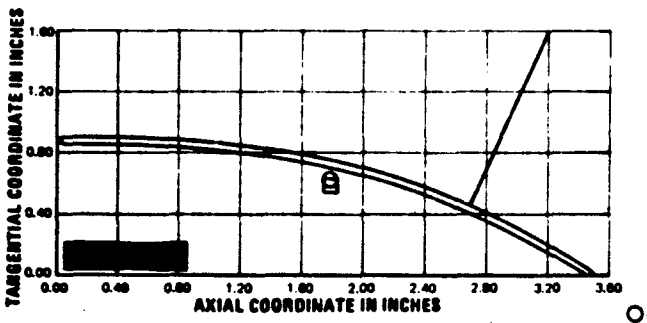
Figure 32 Second Blade Cascade, Second Blade Inlet Angle



NUMBER OF BLADES	4.0	
DIAMETER (HOT)	15.1500	IN
GAGING (HOT)	1.7000	IN
PITCH (HOT)	2.0480	IN
AXIAL WIDTH	3.5000	IN
BLADE INLET ANGLE	90	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	50.90	DEG
GAS EXIT ANGLE	67.30	DEG
GAGING ANGLE	60.60	DEG
UNCOVERED TURNING	7.03	DEG
PRINCIPAL AXIS	0.00	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1745	IN^2

	X	Y
○ C.G	1.7928	0.5946
□ RADIAL REF.	1.7929	0.5946
GAGE	2.7715	0.4943

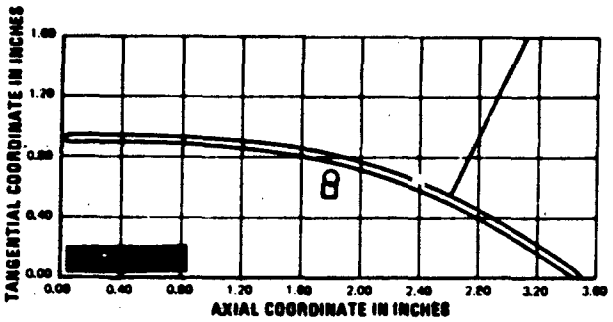
Figure 33 First Vane Cascade Turning Vane Root Section



NUMBER OF BLADES	4.0	
DIAMETER (HOT)	16.1000	IN
GAGING (HOT)	1.6000	IN
PITCH (HOT)	2.1000	IN
AXIAL WIDTH	3.5000	IN
BLADE INLET ANGLE	90.	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	50.62	DEG
GAS EXIT ANGLE	65.67	DEG
GAGING ANGLE	59.64	DEG
UNCOVERED TURNING	7.29	DEG
PRINCIPAL AXIS	0.00	DEG
L.E. RADIUS	0.0200	IN
T.E. RADIUS	0.0246	IN
METAL AREA	0.1722	IN^2

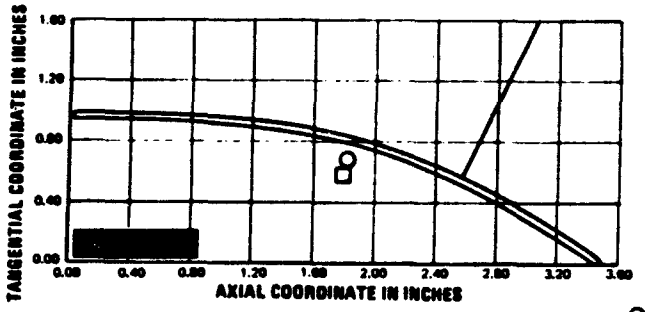
	X	Y
○ C.G.	1.7832	0.6371
□ RADIAL REF.	1.7929	0.5946
GAGE	2.6887	0.4886

Figure 34 First Vane Cascade Turning Vane 1/4R Section



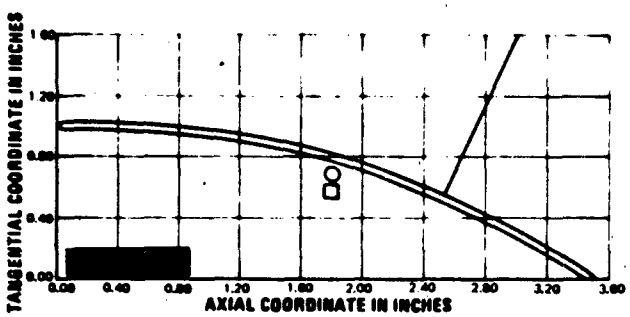
NUMBER OF BLADES	4.0	
DIAMETER (HOT)	17.2260	IN
GAGING (HOT)	1.9704	IN
PITCH (HOT)	2.3288	IN
AXIAL WIDTH	3.5000	IN
BLADE INLET ANGLE	90.	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	56.51	DEG
GAS EXIT ANGLE	63.42	DEG
GAGING ANGLE	57.80	DEG
UNCOVERED TURNING	7.90	DEG
PRINCIPAL AXIS	0.00	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0249	IN
METAL AREA	0.1775	IN^2
	X	Y
○ C.G.	1.8061	0.6784
□ RADIAL REF.	1.7929	0.5946
GAGE	2.6151	0.5629

Figure 35 First Vane Cascade Turning Vane Mean Section



NUMBER OF BLADES	4.0	
DIAMETER (HOT)	18.2624	IN
GAGING (HOT)	2.0986	IN
PITCH (HOT)	2.4687	IN
AXIAL WIDTH	3.5000	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	56.52	DEG
GAS EXIT ANGLE	63.42	DEG
GAGING ANGLE	58.13	DEG
UNCOVERED TURNING	8.11	DEG
PRINCIPAL AXIS	0.00	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1723	IN^2
	X	Y
○ C.G.	1.8227	0.6818
□ RADIAL REF.	1.7929	0.5946
GAGE	2.5710	0.5746

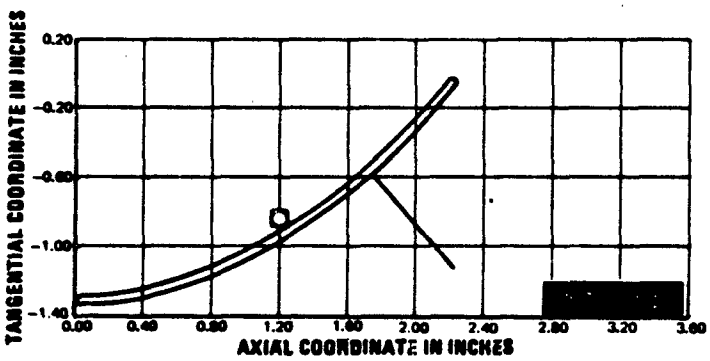
Figure 36 First Vane Cascade Turning Vane 1/4T Section



NUMBER OF BLADES	4.0	
DIAMETER (HOT	19.3080	IN
GAGING (HOT)	2.2440	IN
PITCH (HOT)	2.6080	IN
AXIAL WIDTH	3.5000	IN
BLADE INLET ANGLE	90	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	57.79	DEG
GAS EXIT ANGLE	64.89	DEG
GAGING ANGLE	58.33	DEG
UNCOVERED TURNING	7.50	DEG
PRINCIPAL AXIS	0.00	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0254	IN
METAL AREA	0.1835	IN^2

	X	Y
C.G.	1.7997	0.7008
RADIAL REF.	1.7978	0.5846
GAGE	2.5372	0.5882

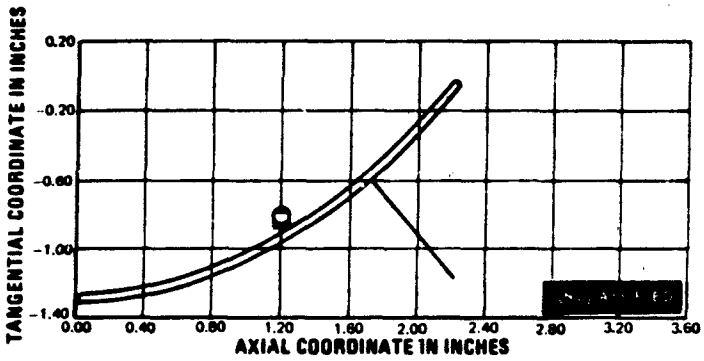
Figure 37 First Vane Cascade Turning Vane Tip Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	15.0750	IN
GAGING (HOT)	0.7011	IN
PITCH (HOT)	1.0887	IN
AXIAL WIDTH	2.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	38.62	DEG
GAS EXIT ANGLE	42.38	DEG
GAGING ANGLE	40.18	DEG
UNCOVERED TURNING	10.10	DEG
PRINCIPAL AXIS	-30.97	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1237	IN^2

	X	Y
C. G.	1.2088	-0.8246
RADIAL REF.	1.2088	-0.8246
GAGE	1.7480	-0.5880

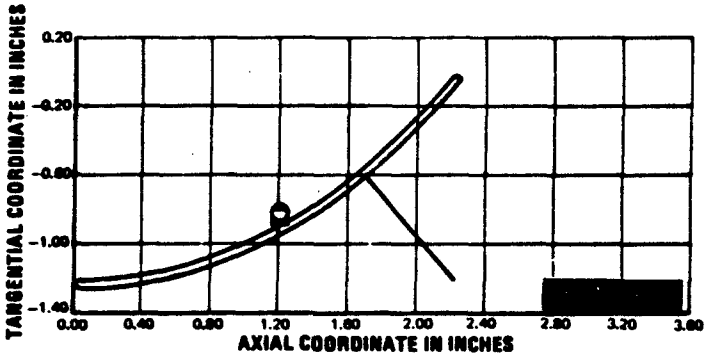
Figure 38 First Blade Cascade Turning Vane Root Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	15.7181	IN
GAGING (HOT)	0.7398	IN
PITCH (HOT)	1.1331	IN
AXIAL WIDTH	2.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	39.09	DEG
GAS EXIT ANGLE	43.20	DEG
GAGING ANGLE	40.75	DEG
UNCOVERED TURNING	10.27	DEG
PRINCIPAL AXIS	30.08	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1299	IN^2

	X	Y
C. G.	1.2032	-0.8107
RADIAL REF.	1.2058	-0.8246
GAGE	1.7273	-0.5776

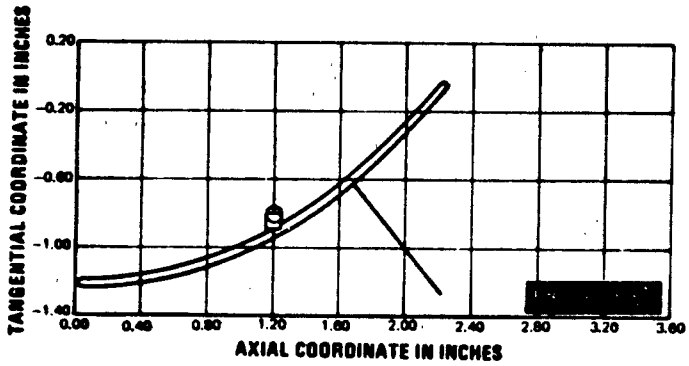
Figure 39 First Blade Cascade Turning Vane 1/8R Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	16.3612	IN
GAGING (HOT)	0.7784	IN
PITCH (HOT)	1.1794	IN
AXIAL WIDTH	2.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	39.61	DEG
GAS EXIT ANGLE	43.75	DEG
GAGING ANGLE	41.30	DEG
UNCOVERED TURNING	10.28	DEG
PRINCIPAL AXIS	-29.40	DEG
L. E. RADIUS	0.0250	IN
T. E. RADIUS	0.0250	IN
METAL AREA	0.1292	IN^2

	X	Y
C. G.	1.2074	-0.7949
RADIAL REF.	1.2058	-0.8246
GAGE	1.7079	-0.5896

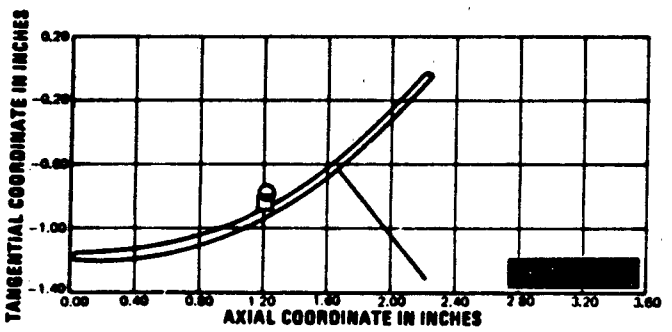
Figure 40 First Blade Cascade Turning Vane 1/4R Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	17.0043	IN
GAGING (HOT)	0.8173	IN
PITCH (HOT)	1.2258	IN
AXIAL WIDTH	2.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	40.11	DEG
GAS EXIT ANGLE	44.25	DEG
GAGING ANGLE	41.81	DEG
UNCOVERED TURNING	10.21	DEG
PRINCIPAL AXIS	-28.86	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1307	IN^2

	X	Y
○ C. G.	1.2137	-0.7801
□ RADIAL REF.	1.2068	-0.8246
GAGE	1.6870	-0.6027

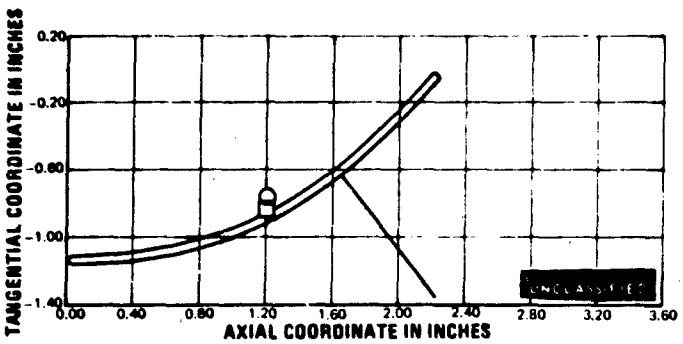
Figure 41 First Blade Cascade Turning Vane 3/8R Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	17.6476	IN
GAGING (HOT)	0.8664	IN
PITCH (HOT)	1.2722	IN
AXIAL WIDTH	2.2600	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	40.38	DEG
GAS EXIT ANGLE	44.62	DEG
GAGING ANGLE	42.25	DEG
UNCOVERED TURNING	10.49	DEG
PRINCIPAL AXIS	-28.22	DEG
L.E. RADIUS	0.0250	IN
T. E. RADIUS	0.0250	IN
METAL AREA	0.1331	IN^2

	X	Y
○ C. G.	1.2171	-0.7883
□ RADIAL REF.	1.2068	-0.8246
GAGE	1.6880	-0.6145

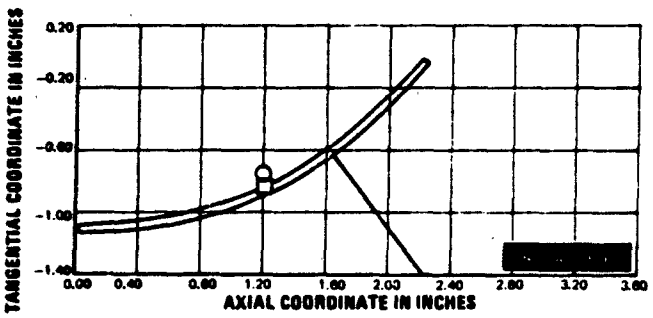
Figure 42 First Blade Cascade Turning Vane Mean Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	18.2905	IN
GAGING (HOT)	0.8939	IN
PITCH (HOT)	1.3185	IN
AXIAL WIDTH	2.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	40.40	DEG
GAS EXIT ANGLE	44.90	DEG
GAGING ANGLE	42.68	DEG
UNCOVERED TURNING	11.39	DEG
PRINCIPAL AXIS	-27.22	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1344	IN^2

	X	Y
○ C.G.	1.2099	-0.7545
□ RADIAL REF.	1.2058	-0.8246
GAGE	1.6566	-0.6216

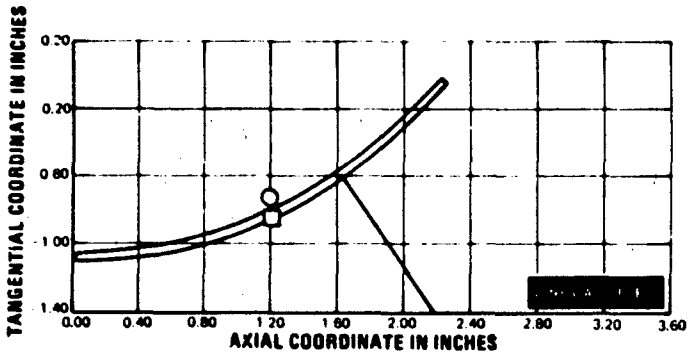
Figure 43 First Blade Cascade Turning Vane 1/8T Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	18.9336	IN
GAGING (HOT)	0.9408	IN
PITCH (HOT)	1.3649	IN
AXIAL WIDTH	2.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	40.90	DEG
GAS EXIT ANGLE	46.25	DEG
GAGING ANGLE	43.58	DEG
UNCOVERED TURNING	12.25	DEG
PRINCIPAL AXIS	-26.12	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1341	IN^2

	X	Y
○ C.G.	1.1980	-0.7380
□ RADIAL REF.	1.2058	-0.8246
GAGE	1.6463	-0.6166

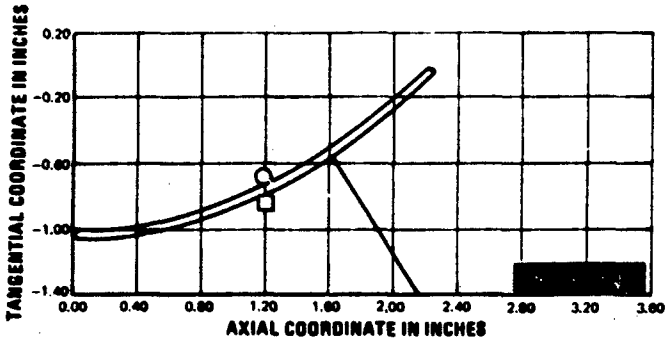
Figure 44 First Blade Cascade Turning Vane 1/4T Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	19.5768	IN
GAGING (HOT)	1.0052	IN
PITCH (HOT)	1.4113	IN
AXIAL WIDTH	2.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	42.62	DEG
GAS EXIT ANGLE	46.20	DEG
GAGING ANGLE	45.42	DEG
UNCOVERED TURNING	12.38	DEG
PRINCIPAL AXIS	25.34	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0251	IN
METAL AREA	0.1325	IN^2

	X	Y
○ C.G.	1.1913	-0.7088
□ RADIAL REF.	1.2058	-0.8246
GAGE	1.6341	-0.5921

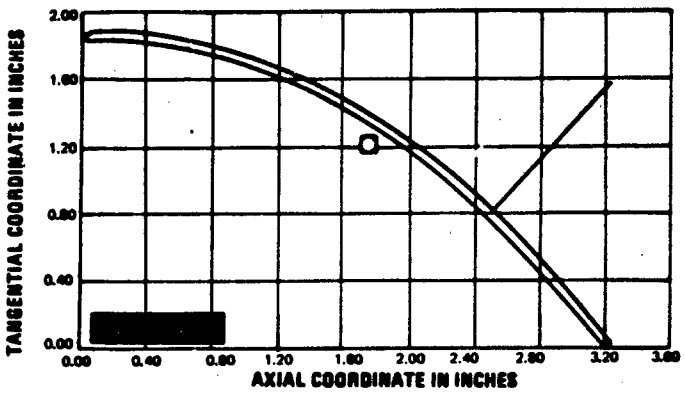
Figure 45 First Blade Cascade Turning Vane 3/8T Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	20.2200	IN
GAGING (HOT)	1.0801	IN
PITCH (HOT)	1.4676	IN
AXIAL WIDTH	2.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	46.39	DEG
GAS EXIT ANGLE	50.50	DEG
GAGING ANGLE	48.40	DEG
UNCOVERED TURNING	11.77	DEG
PRINCIPAL AXIS	-24.92	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1293	IN^2

	X	Y
○ C.G.	1.1881	-0.6672
□ RADIAL REF.	1.2058	-0.8246
GAGE	1.6200	-0.5460

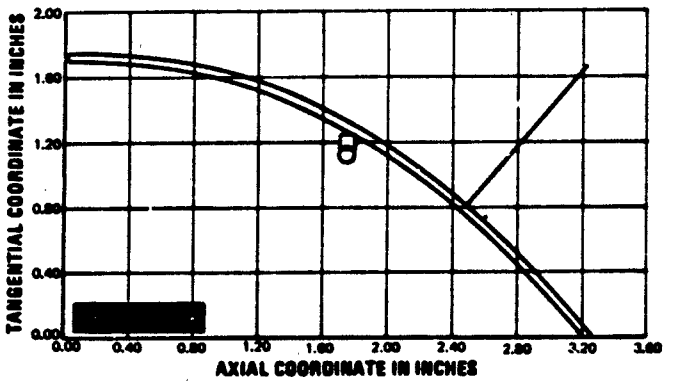
Figure 46 First Blade Cascade Turning Vane Tip Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	15.0000	IN
GAGING (HOT)	1.0214	IN
PITCH (HOT)	1.5708	IN
AXIAL WIDTH	3.2500	IN
BLADE INLET ANGLE	90.01	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	39.06	DEG
GAS EXIT ANGLE	43.06	DEG
GAGING ANGLE	40.56	DEG
UNCOVERED TURNING	8.19	DEG
PRINCIPAL AXIS	−31.10	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1968	IN^2

	X	Y
○ C. G.	1.7484	1.2099
□ RADIAL REF.	1.7484	1.2099
GAGE	2.5142	0.8279

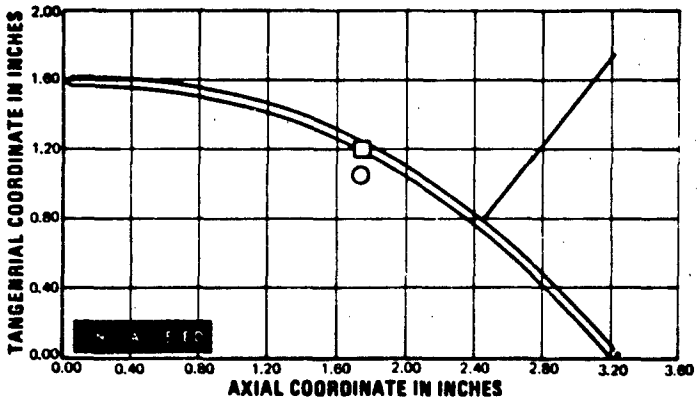
Figure 47 Second Vane Cascade Turning Vane Root Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	15.7810	IN
GAGING (HOT)	1.1088	IN
PITCH (HOT)	1.6526	IN
AXIAL WIDTH	3.2500	IN
BLADE INLET ANGLE	90.01	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	40.29	DEG
GAS EXIT ANGLE	44.70	DEG
GAGING ANGLE	42.14	DEG
UNCOVERED TURNING	8.78	DEG
PRINCIPAL AXIS	−28.94	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0249	IN
METAL AREA	0.1917	IN^2

	X	Y
○ C. G.	1.7482	1.1346
□ RADIAL REF.	1.7484	1.2099
GAGE	2.4823	0.8210

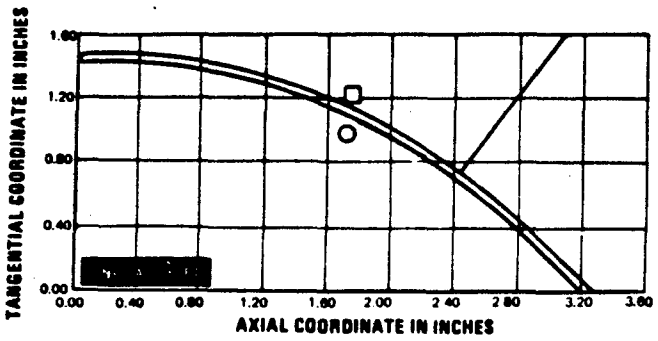
Figure 48 Second Vane Cascade Turning Vane 1/8R Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	16.5620	IN
GAGING (HOT)	1.2103	IN
PITCH (HOT)	1.7344	IN
AXIAL WIDTH	3.2500	IN
BLADE INLET ANGLE	90.01	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	42.29	DEG
GAS EXIT ANGLE	46.90	DEG
GAGING ANGLE	44.25	DEG
UNCOVERED TURNING	9.06	DEG
PRINCIPAL AXIS	-26.77	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1854	IN^2

	X	Y
○ C. G.	1.7350	1.0801
□ RADIAL REF.	1.7484	1.2099
GAGE	2.4640	0.7943

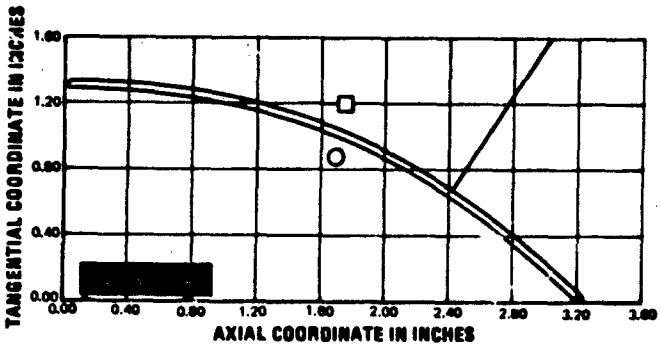
Figure 49 Second Vane Cascade Turning Vane 1/4R Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	17.3430	IN
GAGING (HOT)	1.3263	IN
PITCH (HOT)	1.8162	IN
AXIAL WIDTH	3.2500	IN
BLADE INLET ANGLE	90.08	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	44.83	DEG
GAS EXIT ANGLE	48.80	DEG
GAGING ANGLE	46.91	DEG
UNCOVERED TURNING	9.24	DEG
PRINCIPAL AXIS	-24.64	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1790	IN^2

	X	Y
○ C. G.	1.7164	0.9806
□ RADIAL REF.	1.7484	1.2099
GAGE	2.4329	0.7464

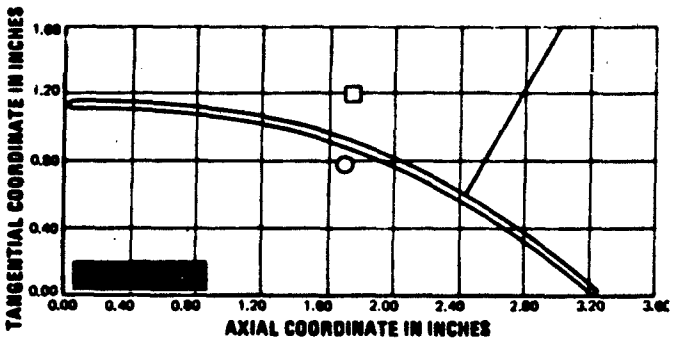
Figure 50 Second Vane Cascade Turning Vane 3/8R Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	18.1250	IN
GAGING (HOT)	1.4615	IN
PITCH (HOT)	1.8660	IN
AXIAL WIDTH	3.2500	IN
BLADE INLET ANGLE	90.01	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	47.51	DEG
GAS EXIT ANGLE	53.00	DEG
GAGING ANGLE	49.88	DEG
UNCOVERED TURNING	9.66	DEG
PRINCIPAL AXIS	−22.22	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0249	IN
METAL AREA	0.1738	IN^2

	X	Y
○ C. G.	1.7002	0.8902
□ RADIAL REF.	1.7484	1.2088
GAGE	2.4267	0.6817

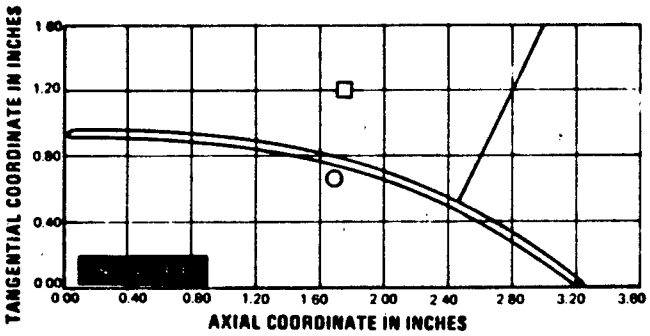
Figure 51 Second Vane Cascade Turning Vane Mean Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	18.9062	IN
GAGING (HOT)	1.5786	IN
PITCH (HOT)	1.9799	IN
AXIAL WIDTH	3.2500	IN
BLADE INLET ANGLE	90.06	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	50.10	DEG
GAS EXIT ANGLE	56.10	DEG
GAGING ANGLE	52.88	DEG
UNCOVERED TURNING	10.43	DEG
PRINCIPAL AXIS	−19.09	DEG
L.E. RADIUS	0.0249	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1703	IN^2

	X	Y
○ C. G.	1.6906	0.7875
□ RADIAL REF.	1.7484	1.2088
GAGE	2.4360	0.6088

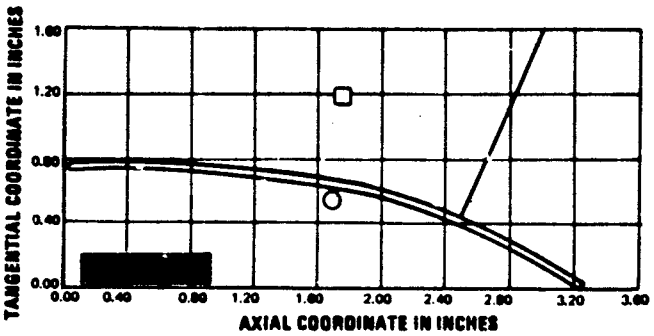
Figure 52 Second Vane Cascade Turning Vane 1/8T Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	19.6874	IN
GAGING (HOT)	1.7071	IN
PITCH (HOT)	2.0671	IN
AXIAL WIDTH	3.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	52.65	DEG
GAS EXIT ANGLE	58.90	DEG
GAGING ANGLE	55.90	DEG
UNCOVERED TURNING	11.25	DEG
PRINCIPAL AXIS	15.61	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1686	IN^2

	X	Y
○ C.G.	1.6888	0.6754
□ RADIAL REF.	1.7484	1.2099
GAGE	2.4622	0.5315

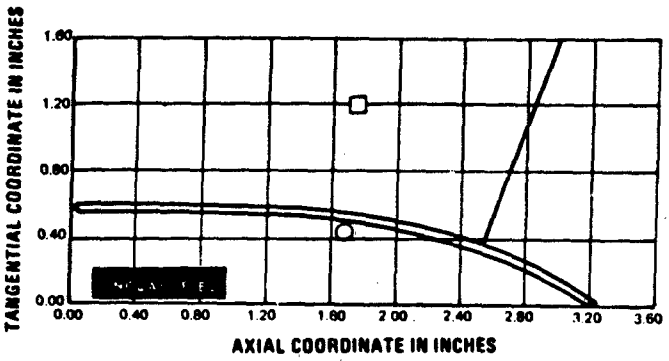
Figure 53 Second Vane Cascade Turning Vane 1/4T Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	20.4687	IN
GAGING (HOT)	1.8386	IN
PITCH (HOT)	2.1438	IN
AXIAL WIDTH	3.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	58.22	DEG
GAS EXIT ANGLE	61.80	DEG
GAGING ANGLE	60.00	DEG
UNCOVERED TURNING	11.81	DEG
PRINCIPAL AXIS	−12.00	DEG
L.E. RADIUS	0.0200	IN
T.E. RADIUS	0.0251	IN
METAL AREA	0.1660	IN^2

	X	Y
○ C.G.	1.6829	0.5640
□ RADIAL REF.	1.7484	1.2099
GAGE	2.4870	0.4630

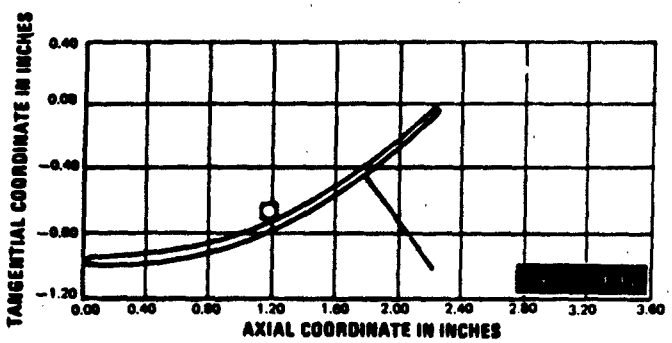
Figure 54 Second Vane Cascade Turning Vane 3/8T Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	21.2500	IN
GAGING (HOT)	1.9724	IN
PITCH (HOT)	2.2253	IN
AXIAL WIDTH	3.2500	IN
BLADE INLET ANGLE	90.02	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	57.79	DEG
GAS EXIT ANGLE	64.89	DEG
GAGING ANGLE	62.42	DEG
UNCOVERED TURNING	12.14	DEG
PRINCIPAL AXIS	-8.67	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1657	IN^2

	X	Y
○ C.G.	1.6755	0.4536
□ RADIAL REF.	1.7484	1.2099
GAGE	2.5401	0.3739

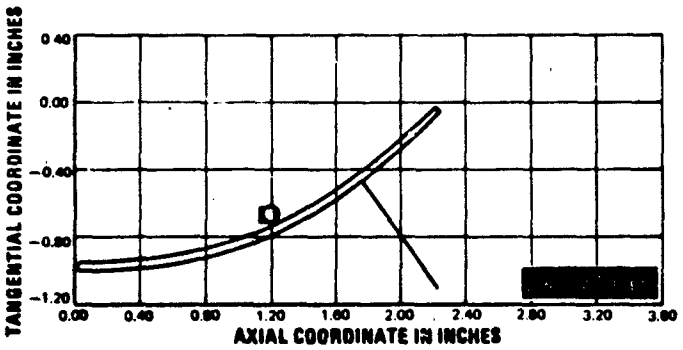
Figure 55 Second Vane Cascade Turning Vane Tip Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	14.9200	IN
GAGING (HOT)	0.7008	IN
PITCH (HOT)	0.9920	IN
AXIAL WIDTH	2.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	46.16	DEG
GAS EXIT ANGLE	50.14	DEG
GAGING ANGLE	44.92	DEG
UNCOVERED TURNING	8.23	DEG
PRINCIPAL AXIS	-22.87	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1267	IN^2

	X	Y
○ C.G.	1.1744	-0.6546
□ RADIAL REF.	1.1744	-0.6546
GAGE	1.7921	-0.4349

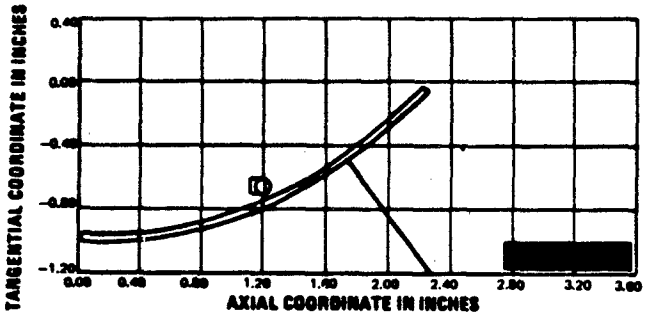
Figure 56 Second Blade Cascade Turning Vane Root Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	15.8975	IN
GAGING (HOT)	0.7548	IN
PITCH (HOT)	1.0570	IN
AXIAL WIDTH	2.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	45.61	DEG
GAS EXIT ANGLE	50.75	DEG
GAGING ANGLE	46.57	DEG
UNCOVERED TURNING	8.31	DEG
PRINCIPAL AXIS	−23.25	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1273	IN^2

	X	Y
C. G.	1.1909	−0.6490
RADIAL REF.	1.1744	−0.6546
GAGE	1.7857	−0.4619

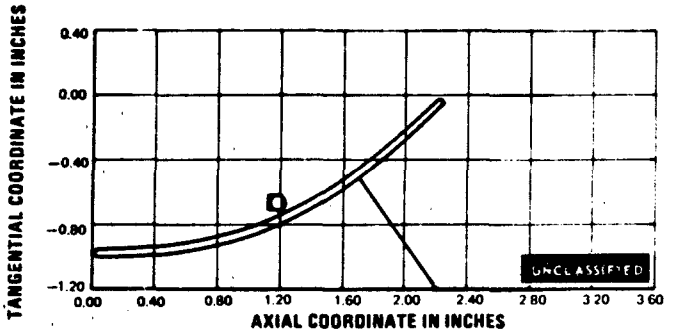
Figure 57 Second Blade Cascade Turning Vane 1/8R Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	16.8750	IN
GAGING (HOT)	0.8071	IN
PITCH (HOT)	1.1220	IN
AXIAL WIDTH	2.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	46.84	DEG
GAS EXIT ANGLE	51.00	DEG
GAGING ANGLE	46.00	DEG
UNCOVERED TURNING	8.27	DEG
PRINCIPAL AXIS	−23.50	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1270	IN^2

	X	Y
C. G.	1.1933	−0.6515
RADIAL REF.	1.1744	−0.6546
GAGE	1.7374	−0.4727

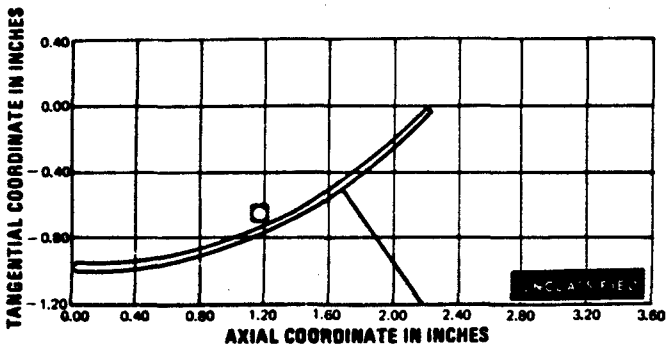
Figure 58 Second Blade Cascade Turning Vane 1/4R Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	17.8525	IN
GAGING (HOT)	0.8587	IN
PITCH (HOT)	1.1870	IN
AXIAL WIDTH	2.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	45.94	DEG
GAS EXIT ANGLE	51.50	DEG
GAGING ANGLE	46.34	DEG
UNCOVERED TURNING	8.30	DEG
PRINCIPAL AXIS	-23.59	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1252	IN^2

	X	Y
○ C.G.	1.1846	-0.6586
□ RADIAL REF.	1.1744	-0.6545
GAGE	1.7080	-0.4953

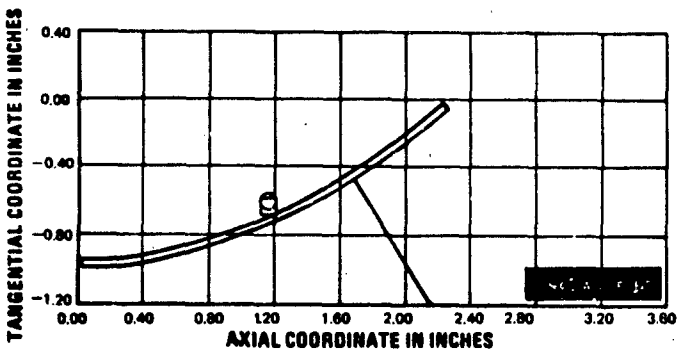
Figure 59 Second Blade Cascade Turning Vane 3/8R Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	18.8300	IN
GAGING (HOT)	0.9194	IN
PITCH (HOT)	1.2520	IN
AXIAL WIDTH	2.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	46.22	DEG
GAS EXIT ANGLE	51.40	DEG
GAGING ANGLE	47.25	DEG
UNCOVERED TURNING	9.30	DEG
PRINCIPAL AXIS	-23.48	DEG
L.E. RADIUS	0.0250	IN
T. E. RADIUS	0.0250	IN
METAL AREA	0.1235	IN^2

	X	Y
○ C. G.	1.1761	-0.6543
□ RADIAL REF.	1.1744	-0.6545
GAGE	1.6902	-0.4987

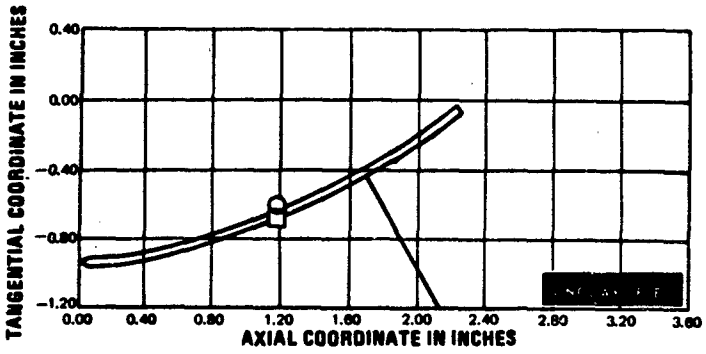
Figure 60 Second Blade Cascade Turning Vane Mean Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	19.8075	IN
GAGING (HOT)	0.9991	IN
PITCH (HOT)	1.3170	IN
AXIAL WIDTH	2.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	47.19	DEG
GAS EXIT ANGLE	52.25	DEG
GAGING ANGLE	49.34	DEG
UNCOVERED TURNING	11.62	DEG
PRINCIPAL AXIS	-23.12	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1233	IN^2

	X	Y
○ C.G.	1.1774	−0.6263
□ RADIAL REF.	1.1744	−0.6545
GAGE	1.6826	−0.4673

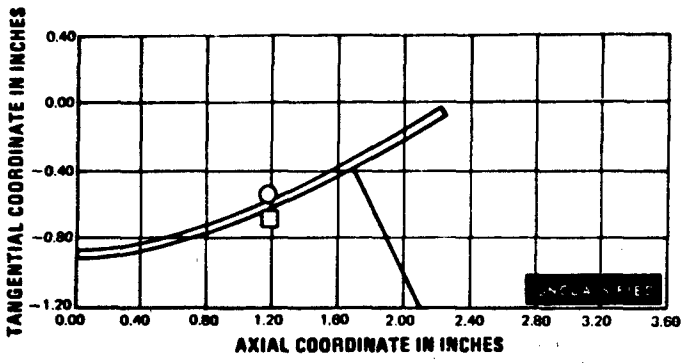
Figure 61 Second Blade Cascade Turning Vane 1/8T Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	20.7850	IN
GAGING (HOT)	1.0916	IN
PITCH (HOT)	1.3820	IN
AXIAL WIDTH	2.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	49.80	DEG
GAS EXIT ANGLE	56.60	DEG
GAGING ANGLE	52.18	DEG
UNCOVERED TURNING	12.47	DEG
PRINCIPAL AXIS	−22.55	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0250	IN
METAL AREA	0.1233	IN^2

	X	Y
○ C. G.	1.1799	−0.5841
□ RADIAL REF.	1.1744	−0.6546
GAGE	1.7063	−0.4182

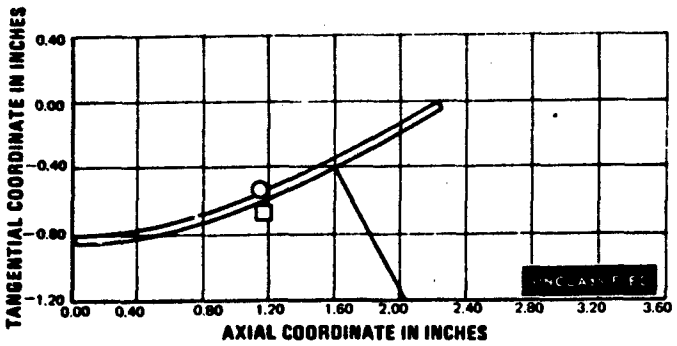
Figure 62 Second Blade Cascade Turning Vane 1/4T Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	21.7624	IN
GAGING (HOT)	1.1889	IN
PITCH (HOT)	1.4470	IN
AXIAL WIDTH	2.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	54.08	DEG
GAS EXIT ANGLE	61.50	DEG
GAGING ANGLE	55.25	DEG
UNCOVERED TURNING	9.39	DEG
PRINCIPAL AXIS	-21.86	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	0.0247	IN
METAL AREA	0.1219	IN^2

	X	Y
○ C.G.	1.1722	-0.5467
□ RADIAL REF.	1.1744	-0.6546
GAGE	1.6938	-0.3812

Figure 63 Second Blade Cascade Turning Vane 3/8T Section



NUMBER OF BLADES	4	
DIAMETER (HOT)	22.740	IN
GAGING (HOT)	1.2864	IN
PITCH (HOT)	1.5120	IN
AXIAL WIDTH	2.2500	IN
BLADE INLET ANGLE	90.00	DEG
GAS INLET ANGLE	90.00	DEG
BLADE EXIT ANGLE	62.2	DEG
GAS EXIT ANGLE	70.08	DEG
GAGING ANGLE	62.2	DEG
UNCOVERED TURNING	1.45	DEG
PRINCIPAL AXIS	−21.05	DEG
L.E. RADIUS	0.0250	IN
T.E. RADIUS	.025	IN
METAL AREA	0.1190	IN^2

	X	Y
○ C.G.	1.1513	−0.5166
□ RADIAL REF.	1.1744	−0.6545
GAGE	1.6053	−0.3846

Figure 64 Second Blade Cascade Turning Vane Tip Section

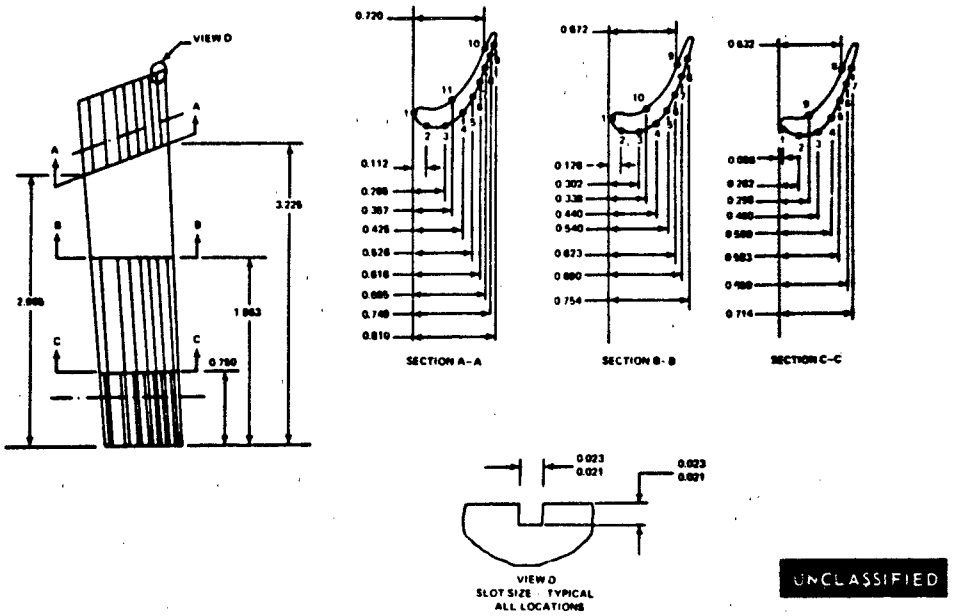


Figure 65 Airfoil Static Pressure Tap Locations-First Stage Vane

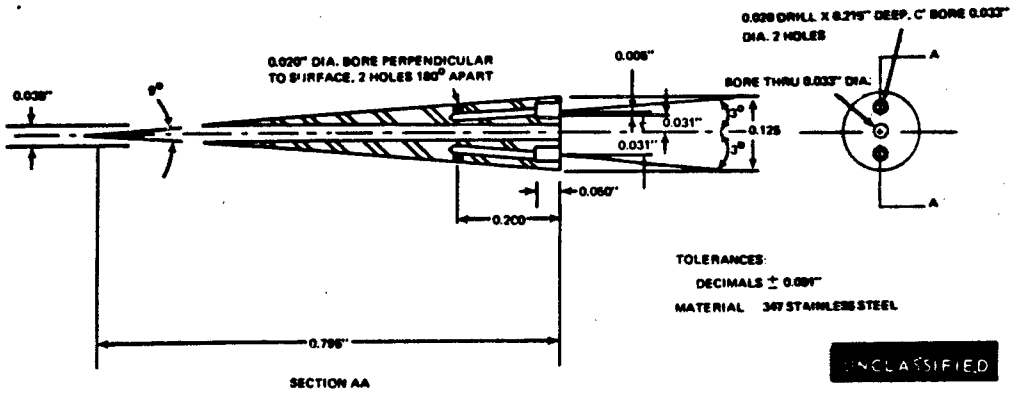
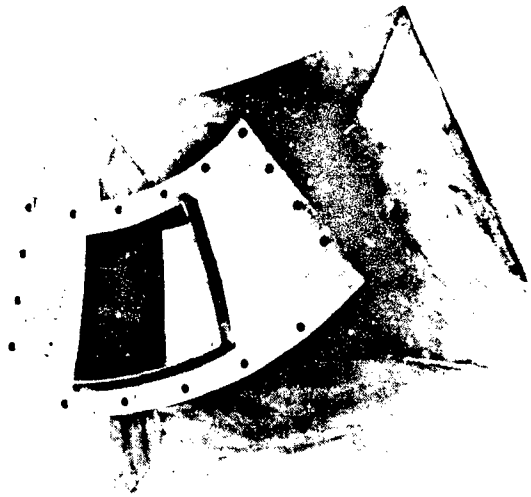


Figure 66 Traverse Probe Head, Annular Cascade

(U) A traversing probe was also installed just upstream of the test airfoils in order to measure the losses due to the turning vane, and to measure the actual inlet flow angle seen by the test airfoils. Turning vane losses will be accounted for in the data reduction program used to calculate the test airfoil performance.

(U) The completed annular segment cascade test sections have been received from fabricators. One of these is shown in Figure 67 to 72. The first vane cascade was installed in the test rig (Figures 73 and 74) and checkout runs have been completed.

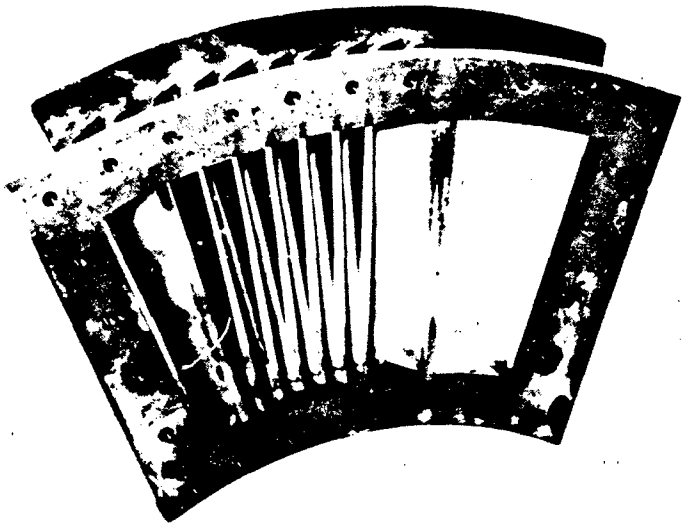


[redacted]

Figure 67 Second Stage Blade Annular Segment Cascade, Inlet Bellmouth

[redacted]

Figure 68 Second Stage Blade Annular Segment Cascade, Turning Vane Assembly



[redacted]

Figure 69 Second Stage Blade Annular Segment Cascade, Test Airfoil Assembly

[redacted]

Figure 70 Second Stage Blade Annular Segment Cascade, Inlet View of Assembled Rig

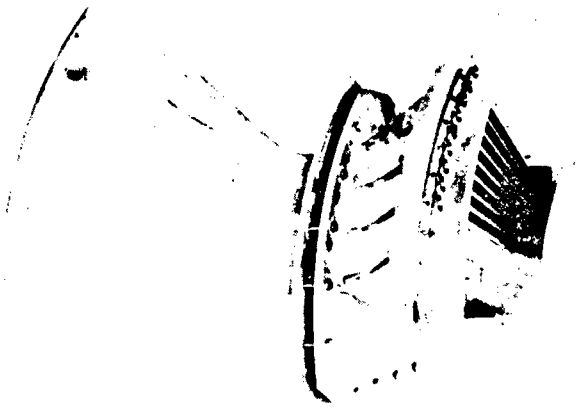


Figure 71 Second Stage Blade Annular Segment Cascade, Top View of Assembled Rig

Figure 72 Second Stage Blade Annular Segment Cascade, Side View of Assembled Rig

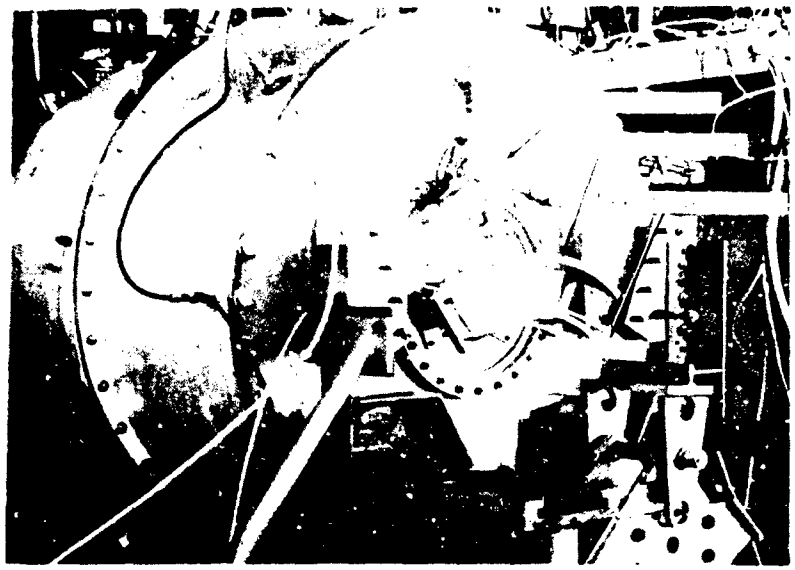


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Figure 73 Installation of First Stage Vane in Annular Segment Cascade Rig, Overall View

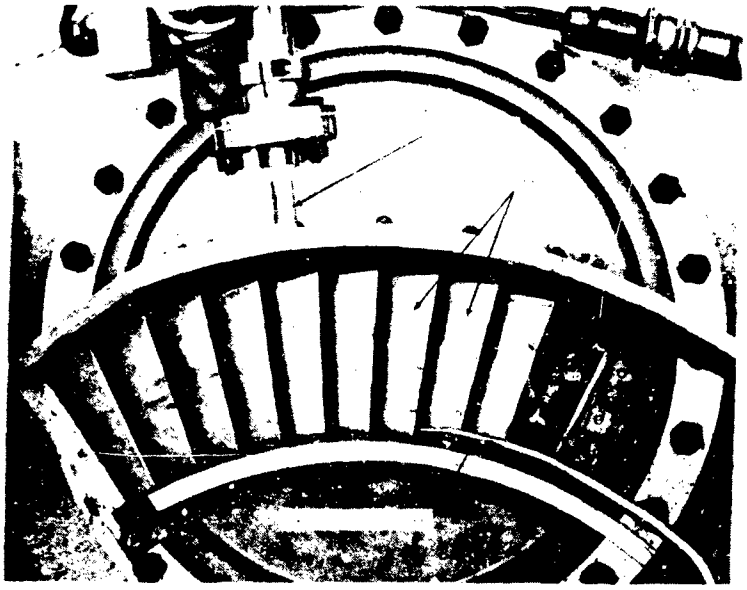

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Figure 74 Installation of First Stage Vane in Annular Segment Cascade Rig, Close-up View

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SECTION V

PRELIMINARY DESIGN MANUAL PREPARATION (TASK IIe)

1. RFP OBJECTIVE
   (U) Prepare the preliminary draft of the Turbine Design Procedure Manual.

2. TASK OBJECTIVE
   (U) The purpose of this task is to prepare and deliver a Turbine Design Procedure Manual. This manual will contain, for each computer program used to design the contract turbine, the following information: a flow diagram; a listing for all input and output items and their definitions; a list of definitions for each term used in the computer code; a writeup of the pertinent engineering equations; listing of the computer code in Fortran IV; a copy of the computer program deck in Fortran IV; any necessary test cases for deck checkout.

3. STATUS
   (U) Work is in progress on the following computer programs:
   - (a) Turbine Mean Line Design Program
   - (b) Turbine Stage Off Design Program
   - (c) Turbine Streamline Analysis Program
   - (d) Airfoil Pressure Distribution Program
   - (e) Airfoil Boundary Layer Program
   - (f) Turbine Airfoil Design and Section Properties Program
   - (g) Airfoil Curved Line Fairing Program
   - (h) Airfoil Straight Line Fairing Program

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TABLE V

VANE 1 NORMAL SOLIDITY

Section AA AT R = 7.72500

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	-.01374	.66617	.65336	.61682	.65336
.01	-.00601	.67382	.67367	.61837	.63306
.02	.00172	.68115		.61984	.62681
.03	.00945	.68816		.62122	.62373
.04	.01718	.69486		.62252	.62283
.05	.02491	.70123		.62373	
.10	.06356	.72832		.62831	
.15	.10221	.74744		.63014	
.20	.14085	.75860		.62873	
.25	.17950	.76184		.62355	
.30	.21815	.75725		.61400	
.35	.25680	.74493		.59951	
.40	.29545	.72500		.57957	
.45	.33410	.69763		.55376	
.50	.37275	.66297		.52191	
.55	.41140	.62123		.48402	
.60	.45005	.57260		.44035	
.65	.48869	.51729		.39132	
.70	.52734	.45561		.33746	
.75	.56599	.38808		.27935	
.80	.60464	.31538		.21752	
.85	.64329	.23817		.15249	
.90	.68194	.15713		.08468	
.95	.72059	.07282		.01446	
.98	.74378	.02087		-.02870	-.02538
.99	.75151	.00335		-.04325	-.02642
1.00	.75924	-.01427	-.01643	-0.5787	-.01643

LE Center	(.01679,	.65336)	R = .03053
TE Center	(.74892,	-.01643)	R = .01032
Center of Gravity	(.35251,	.53249)	
Radial Reference	(.36300,	.53208)	
Gaging =	.34537		
Nose Point	(-.00961,	.63802)	
Tail Point	(.75339,	-.02573)	

LE Tangency Points	Top	(-.00422,	.67552)	Bottom	(.02150,	.62320)
TE Tangency Points	Top	(.75837,	-.01229)	Bottom	(.73982,	-.02129)

Inlet Angle =	63.82050
Exit Angle =	25.90222
No. of Blades =	62
Pitch =	.78286
Tolerance =	-.00000
Gaging =	.34537
Uncovered Turning =	12.05888
Gaging Angle =	26.17782
Area =	.08706
Axial Chord =	.77298

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TABLE VI

VANE 1 NORMAL SOLIDITY

Section BB AT R = 8.25650

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	-.06249	.66860	.65560	.61532	.65560
.01	-.05448	.67705	.67697	.61721	.63423
.02	-.04646	.68518		.61903	.62758
.03	-.03845	.69299		.62076	.62422
.04	-.03044	.70048		.62240	.62310
.05	-.02243	.70764		.62396	
.10	.01764	.73850		.63031	
.15	.05770	.76099		.63390	
.20	.09776	.77496		.63418	
.25	.13782	.78029		.63051	
.30	.17789	.77691		.62217	
.35	.21795	.76483		.60839	
.40	.25801	.74410		.58846	
.45	.29807	.71481		.56175	
.50	.33814	.67712		.52790	
.55	.37820	.63121		.48682	
.60	.41826	.57732		.43875	
.65	.45832	.51569		.38419	
.70	.49839	.44676		.32379	
.75	.53845	.37130		.25828	
.80	.57851	.29026		.18837	
.85	.61857	.20460		.11469	
.90	.65864	.11516		.03781	
.95	.69870	.02263		-.04184	
.98	.72274	-.03416		-.09080	-.08500
.99	.73075	-.05328		-.10730	-.08555
1.00	.73876	-.07248	-.07474	-.12389	-.07474

LE Center	(-.02999,	.65560)	R = .03250
TE Center	(.72747,	-.07474)	R = .01130
Center of Gravity	(.31526,	.53317)	
Radial Reference	(.36300,	.53208)	
Gaging =	.34823		
Nose Point	(-.05745,	.63822)	
Tail Point	(.73209,	-.08505)	

LE Tangency Points	Top	(-.05314,	.67841)	Bottom	(-.02379,	.62370)
TE Tangency Points	Top	(.73789,	-.07039)	Bottom	(.71732,	-.07970)

Inlet Angle =	61.78913
Exit Angle =	24.33544
No. of Blades =	62
Pitch =	.83673
Tolerance =	-.00000
Gaging =	.34823
Uncovered Turning =	11.20821
Gaging Angle =	24.59364
Area =	.09610
Axial Chord =	.80125

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TABLE VII

VANE 1 NORMAL SOLIDITY

Section CC AT R = 8.93800

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	-.12500	.68689	.67373	.62805	.67373
.01	-.11662	.69648	.69646	.63052	.65100
.02	-.10825	.70574		.63289	.64384
.03	-.09987	.71466		.63516	.64012
.04	-.09150	.72325		.63732	.63873
.05	-.08312	.73149		.63937	.63937
.10	-.04125	.76748		.64782	
.15	.00063	.79442		.65288	
.20	.04250	.81196		.65394	
.25	.08438	.81978		.65029	
.30	.12625	.81764		.64118	
.35	.16813	.80544		.62585	
.40	.21000	.78311		.60354	
.45	.25188	.75075		.57364	
.50	.29375	.70849		.53576	
.55	.33563	.65661		.48977	
.60	.37750	.59541		.43583	
.65	.41938	.52527		.37439	
.70	.46125	.44675		.30606	
.75	.50313	.36072		.23157	
.80	.54500	.26824		.15165	
.85	.58688	.17038		.06700	
.90	.62875	.06805		-.02179	
.95	.67063	-.03800		-.11419	
.98	.69575	-.10318		-.17119	-.16133
.99	.70413	-.12514		-.19043	-.16134
1.00	.71250	-.14721	-.14951	-.20980	-.14951

LE Center	(-.08996,	.67373)	R = .03503
TE Center	(.69996,	-.14951)	R = .01255
Center of Gravity	(.27240,	.53977)	
Radial Reference	(.36300,	.53208)	
Gaging =	.34627		
Nose Point	(-.11858,	.65352)	
Tail Point	(.70467,	-.16114)	

LE Tangency Points	Top	(-.11594,	.69723)	Bottom	(-.08303,	.63939)
TE Tangency Points	Top	(.71169,	-.14506)	Bottom	(.68846,	-.15454)

Inlet Angle =	60.36023
Exit Angle =	22.21311
No. of Blades =	62
Pitch =	.90579
Tolerance =	-.00000
Gaging =	.34627
Uncovered Turning =	10.49118
Gaging Angle =	22.47510
Area =	.11466
Axial Chord =	.83750

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TABLE VIII

VANE 1 NORMAL SOLIDITY

Section DD AT R = 9.61900

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	-.18749	.72178	.70763	.65812	.70763
.01	-.17875	.73176	.73172	.66091	.68354
.02	-.17001	.74141		.66354	.67588
.03	-.16127	.75071		.66603	.67181
.04	-.15254	.75967		.66836	.67014
.05	-.14380	.76829		.67054	.67055
.10	-.10011	.80601		.67891	
.15	-.05642	.83446		.68272	
.20	-.01274	.85319		.68145	
.25	.03095	.86182		.67451	
.30	.07464	.85999		.66134	
.35	.11833	.84746		.64138	
.40	.16201	.82404		.61414	
.45	.20570	.78965		.57922	
.50	.24939	.74433		.53632	
.55	.29308	.68819		.48532	
.60	.33676	.62144		.42623	
.65	.38045	.54438		.35923	
.70	.42414	.45742		.28465	
.75	.46783	.36131		.20288	
.80	.51151	.25703		.11439	
.85	.55520	.14565		.01967	
.90	.59889	.02817		-.08081	
.95	.64258	-.09459		-.18662	
.98	.66879	-.17049		-.25250	-.23752
.99	.67753	-.19614		-.27485	-.23706
1.00	.68626	-.22195	-.22423	-.29738	-.22423

LE Center	(-.14991,	.70763)	R = .03758
TE Center	(.67247,	-.22423)	R = .01380
Center of Gravity	(.23699,	.54262)	
Radial Reference	(.36300,	.53208)	
Gaging =	.34133		
Nose Point	(-.18055,	.68587)	
Tail Point	(.67717,	-.23720)	

LE Tangency Points	Top	(-.17776,	.73286)	Bottom	(-.14284,	.67072)
TE Tangency Points	Top	(.68554,	-.21980)	Bottom	(.65965,	-.22933)

Inlet Angle =	60.66503
Exit Angle =	20.19620
No. of Blades -	62
Pitch =	.97481
Tolerance =	-.00000
Gaging =	.34133
Uncovered Turning =	10.58125
Gaging Angle =	20.49633
Area =	.13955
Axial Chord	.87375

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TABLE IX

VANE 1 NORMAL SOLIDITY

Section EE AT R = 9.7200

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	-.19675	.72701	.71259	.66288	.71259
.01	-.18796	.73694	.73688	.66563	.68830
.02	-.17917	.74654		.66823	.68057
.03	-.17038	.75581		.67068	.67644
.04	-.16159	.76473		.67297	.67474
.05	-.15280	.77332		.67510	.67511
.10	-.10884	.81094		.68323	
.15	-.06489	.83941		.68675	
.20	-.02093	.85824		.68513	
.25	.02303	.86701		.67781	
.30	.06698	.86535		.66423	
.35	.11094	.85296		.64384	
.40	.15490	.82962		.61616	
.45	.19885	.79520		.58077	
.50	.24281	.74970		.53737	
.55	.28677	.69318		.48580	
.60	.33072	.62583		.42604	
.65	.37468	.54792		.35824	
.70	.41863	.45984		.28266	
.75	.46259	.36230		.19967	
.80	.50655	.25627		.10971	
.85	.55050	.14281		.01326	
.90	.59446	.02291		-.08923	
.95	.63842	-.10260		-.19731	
.98	.66479	-.18031		-.26468	-.24882
.99	.67358	-.20659		-.28755	-.24829
1.00	.68237	-.23304	-.23531	-.31061	-.23531

LE Center	(-.15880,	.71259)	R = .03796
TE Center	(.66839,	-.23531)	R = .01398
Center of Gravity	(.23193,	.54275)	
Radial Reference	(.36300,	.53208)	
Gaging =	.34040		
Nose Point	(-.18988,	.69081)	
Tail Point	(.67308,	-.24848)	

LE Tangency Points	Top	(-.18679,	.73822)	Bottom	(-.15190,	.67527)
TE Tangency Points	Top	(.68166,	-.23090)	Bottom	(.65536,	-.24040)

Inlet Angle =	61.00703
Exit Angle =	19.87875
No. of Blades =	62
Pitch =	.98504
Tolerance =	-.00000
Gaging =	.34040
Uncovered Turning =	10.64472
Gaging Angle =	20.21659
Area =	.14300
Axial Chord =	.87913

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TABLE X

VANE 1 NORMAL SOLIDITY

Section FF AT R = 7.57500

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	.00002	.66720	.65449	.61888	.65449
.01	.00767	.67466	.67450	.62035	.63448
.02	.01532	.68180		.62175	.62835
.03	.02297	.68863		.62305	.62534
.04	.03062	.69513		.62427	.62451
.05	.03827	.70132		.62540	
.10	.07652	.72751		.62952	
.15	.11477	.74580		.63083	
.20	.15302	.75626		.62887	
.25	.19127	.75897		.62310	
.30	.22952	.75404		.61302	
.35	.26777	.74161		.59810	
.40	.30602	.72183		.57791	
.45	.34427	.69487		.55216	
.50	.38252	.66093		.52070	
.55	.42077	.62022		.48360	
.60	.45902	.57293		.44111	
.65	.49727	.51928		.39363	
.70	.53552	.45957		.34161	
.75	.57377	.39421		.28557	
.80	.61202	.32375		.22600	
.85	.65027	.24876		.16335	
.90	.68852	.16982		.09802	
.95	.72677	.08746		.03034	
.98	.74972	.03660		-.01127	-.00853
.99	.75737	.01943		-.02529	-.00973
1.00	.76502	.00215	.00003	-.03939	.00003

LE Center	(.03000,	.65449)	R = .02999			
TE Center	(.75497,	.00003)	R = .01004			
Center of Gravity	(.36346,	.53338)				
Radial Reference	(.36300,	.53208)				
Gaging =	.34367					
Nose Point	(.00395,	.63964)				
Tail Point	(.75938,	-.00900)				
LE Tangency Points	Top	(.00954,	.67641)	Bottom	(.03437,	.62482)
TE Tangency Points	Top	(.76416,	.00409)	Bottom	(.74617,	-.00480)
Inlet Angle =	64.30344					
Exit Angle =	26.31242					
No. of Blades =	62					
Pitch =	.76766					
Tolerance =	-.00000					
Gaging =	.34367					
Uncovered Turning =	12.36423					
Gaging Angle =	26.59496					
Area =	.08528					
Axial Chord =	.76500					

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TABLE XI

VANE 1 NORMAL SOLIDITY

Section GG AT R = 10.30000

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	-.24997	.75347	.73671	.68817	.73671
.01	-.24087	.76249	.76211	.69019	.71130
.02	-.23177	.77125		.69209	.70316
.03	-.22267	.77975		.69388	.69876
.04	-.21357	.78798		.69553	.69685
.05	-.20447	.79593		.69706	
.10	-.15897	.83141		.70261	
.15	-.11347	.85922		.70432	
.20	-.06797	.87865		.70162	
.25	-.02247	.88898		.69385	
.30	.02303	.88948		.68032	
.35	.06853	.87946		.66025	
.40	.11403	.85828		.63288	
.45	.15953	.82542		.59744	
.50	.20503	.78048		.55326	
.55	.25053	.72322		.49982	
.60	.29603	.65359		.43677	
.65	.34153	.57170		.36400	
.70	.38703	.47782		.28165	
.75	.43253	.37251		.19003	
.80	.47803	.25652		.08963	
.85	.52353	.13075		-.01896	
.90	.56903	-.00390		-.13514	
.95	.61453	-.14661		-.25832	
.98	.64183	-.23584		-.33536	-.31365
.99	.65093	-.26615		-.36153	-.31276
1.00	.66003	-.29675	-.29894	-.38795	-.29894

LE Center	(-.20995,	.73671)	R = .04002
TE Center	(.64498,	-.29894)	R = .01505

Center of Gravity	(.20327,	.54248)
Radial Reference	(.36300,	.53208)

Gaging = .33409

Nose Point	(-.24442,	.71636)
Tail Point	(.64957,	-.31327)

LE Tangency Points	Top	(-.23771,	.76553)	Bottom	(-.20511,	.69698)
TE Tangency Points	Top	(.65940,	-.29465)	Bottom	(.63079,	-.30396)

Inlet Angle = 64.56346
Exit Angle = 18.03789

No. of Blades = 62
Pitch = 1.04382

Tolerance = -.00000
Gaging = .33409

Uncovered Turning = 11.20890
Gaging Angle = 18.66710

Area = .15902
Axial Chord = .91000

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TABLE XII

VANE 1 NORMAL SOLIDITY

Section HH AT R - 10.26000

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	-.24630	.75184	.73529	.68653	.73529
.01	-.23723	.76096	.76062	.68864	.70995
.02	-.22815	.76981		.69061	.70184
.03	-.21907	.77839		.69247	.69746
.04	-.20999	.78669		.69419	.69556
.05	-.20091	.79472		.69578	
.10	-.15552	.83043		.70157	
.15	-.11012	.85832		.70341	
.20	-.06473	.87771		.70073	
.25	-.01934	.88789		.69290	
.30	.02606	.88818		.67924	
.35	.07145	.87791		.65900	
.40	.11684	.85649		.63144	
.45	.16224	.82343		.59586	
.50	.20763	.77836		.55163	
.55	.25303	.72108		.49824	
.60	.29842	.65154		.43538	
.65	.34381	.56987		.36298	
.70	.38921	.47636		.28115	
.75	.43460	.37156		.19021	
.80	.47999	.25625		.09065	
.85	.52539	.13135		-.01699	
.90	.57078	-.00223		-.13211	
.95	.61617	-.14369		-.25413	
.98	.64341	-.23205		-.33044	-.30919
.99	.65249	-.26207		-.35637	-.30832
1.00	.66157	-.29235	-.29455	-.38254	-.29455

LE Center	(-.20641,	.73529)	R = .03989
TE Center	(.64659,	-.29455)	R = .01498

Center of Gravity	(.20520,	.54257)
Radial Reference	(.36300,	.53208)

Gaging = .33459

Nose Point	(-.24061,	.71475)
Tail Point	(.65120,	-.30880)

LE Tangency Points	Top	(-.23426,	.76385)	Bottom	(-.20137,	.69572)
TE Tangency Points	Top	(.66094,	-.29025)	Bottom	(.63248,	-.29958)

Inlet Angle = 64.22730
Exit Angle = 18.16416

No. of Blades = 62
Pitch = 1.03977

Tolerance = -.00000
Gaging = .33459

Uncovered Turning = 11.17851
Gaging Angle = 18.77116

Area = .15813
Axial Chord = .90787

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TABLE XIII

1ST STAGE BLADE

Section A-A AT R = 7.69000

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	.00289	.17492	.16995	.12020	.16995
.01	.00884	.18623		.12728	.15567
.02	.01479	.19709		.13395	.15160
.03	.02075	.20752		.14025	.14997
.04	.02670	.21754		.14622	.15019
.05	.03265	.22717		.15188	.15232
.10	.06241	.27003		.17619	
.15	.09217	.30515		.19507	
.20	.12193	.33357		.20961	
.25	.15169	.35600		.22042	
.30	.18145	.37289		.22793	
.35	.21121	.38454		.23236	
.40	.24097	.39113		.23388	
.45	.27073	.39270		.23254	
.50	.30049	.38922		.22834	
.55	.33025	.38055		.22120	
.60	.36001	.36640		.21095	
.65	.38977	.34635		.19735	
.70	.41953	.31976		.18010	
.75	.44929	.28563		.15876	
.80	.47905	.24270		.13262	
.85	.50881	.19073		.10067	
.90	.53857	.13122		.06138	
.95	.56833	.06633		.01235	
.98	.58619	.02560		-.02348	-.01421
.99	.59214	.01179		-.03684	-.01345
1.00	.59809	-.00212	-.00421	-.05105	-.00421

LE Center	(.02299,	.16995)	R = .02010
TE Center	(.58793,	-.00421)	R = .01016
Center of Gravity	(.29215,	.25746)	
Radial Reference	(.29145,	.25568)	
Gaging =	.17723		
Nose Point	(.01169,	.15333)	
Tail Point	(.59203,	-.01350)	

LE Tangency Points	Top	(.00520,	.17931)	Bottom	(.03571,	.15438)
TE Tangency Points	Top	(.59727,	-.00021)	Bottom	(.57884,	-.00874)

Inlet Angle =	39.25663
Exit Angle =	24.82772
No. of Blades =	116
Pitch =	.41653
Tolerance =	.00000
Gaging =	.17723
Uncovered Turning =	16.20657
Gaging Angle =	25.18208
Area =	.07117
Axial Chord =	.59520

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TABLE XIV

1ST STAGE BLADE

Section B-B AT R = 8.35560

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	.01550	.19956	.19463	.14702	.19463
.01	.02133	.21073		.15355	.18047
.02	.02716	.22145		.15971	.17638
.03	.03299	.23175		.16552	.17469
.04	.03882	.24163		.17102	.17478
.05	.04465	.25113		.17623	.17667
.10	.07380	.29324		.19851	
.15	.10295	.32742		.21564	
.20	.13210	.35465		.22859	
.25	.16125	.37560		.23793	
.30	.19040	.39072		.24403	
.35	.21955	.40030		.24708	
.40	.24870	.40452		.24718	
.45	.27785	.40342		.24436	
.50	.30700	.39697		.23853	
.55	.33615	.38502		.22956	
.60	.36530	.36729		.21720	
.65	.39445	.34336		.20110	
.70	.42360	.31260		.18081	
.75	.45275	.27407		.15575	
.80	.48190	.22716		.12528	
.85	.51105	.17258		.08864	
.90	.54020	.11207		.04502	
.95	.56935	.04737		-.00654	
.98	.58684	.00713		-.04177	-.03219
.99	.59267	-.00648		-.05430	-.03137
1.0	.59850	-.02016	-.02222	-.06723	-.02222

LE Center (.03561, .19463) R = .02011
TE Center (.58840, -.02222) R = .01010

Center of Gravity (.29528, .26554)
Radial Reference (.29145, .25568)

Gaging = .19201

Nose Point (.02418, .17808)
Tail Point (.59253, -.03143)

LE Tangency Points Top (.01778, .20393) Bottom (.04782, .17865)
TE Tangency Points Top (.59769, -.01826) Bottom (.57936, -.02671)

Inlet Angle = 40.08727
Exit Angle = 24.74051

No. of Blades = 116
Pitch = .45258

Tolerance = .00000
Gaging = .19201

Uncovered Turning = 15.75148
Gaging Angle = 25.10380

Area = .06843
Axial Chord = .58300

[redacted]

TABLE XV

1ST STAGE BLADE

Section C-C AT R = 9.17380

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	.03100	.23102	.22627	.17999	.22627
.01	.03668	.24239		.18616	.21226
.02	.04236	.25325		.19196	.20815
.03	.04804	.26362		.19741	.20638
.04	.05372	.27353		.20256	.20631
.05	.05940	.28301		.20741	.20793
.10	.08780	.32438		.22800	
.15	.11620	.35701		.24353	
.20	.14460	.38208		.25492	
.25	.17300	.40040		.26273	
.30	.20140	.41250		.26727	
.35	.22980	.41873		.26872	
.40	.25820	.41930		.26712	
.45	.28660	.41429		.26242	
.50	.31500	.40368		.25446	
.55	.34340	.38733		.24294	
.60	.37180	.36499		.22741	
.65	.40020	.33621		.20724	
.70	.42860	.30036		.18172	
.75	.45700	.25679		.15037	
.80	.48540	.20584		.11313	
.85	.51380	.14886		.07025	
.90	.54220	.08749		.02206	
.95	.57060	.02307		-.03116	
.98	.58764	-.01664		-.06542	-.05545
.99	.59332	-.03001		-.07722	-.05454
1.00	.59900	-.04345	-.04549	-.08921	-.04549

LE Center	(.05113,	.22627)	R = .02012
TE Center	(.58395,	-.04549)	R = .01005
Center of Gravity	(.29953,	.27541)	
Radial Reference	(.29145,	.25568)	
Gaging =	.20887		
Nose Point	(.03981,	.20963)	
Tail Point	(.59309,	-.05464)	

LE Tangency Points	Top	(.03312,	.23526)	Bottom	(.06294,	.20998)
TE Tangency Points	Top	(.59821,	-.04157)	Bottom	(.57995,	-.04996)

Inlet Angle =	40.29964
Exit Angle =	24.68013
No. of Blades =	116
Pitch =	.49690
Tolerance =	.00000
Gaging =	.20887
Uncovered Turning =	15.25190
Gaging Angle =	24.85676
Area =	.06385
Axial Chord =	.56800

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TABLE XVI

1ST STAGE BLADE

Section D-D AT R = 9.99190

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	.04650	.27190	.26721	.22290	.26721
.01	.05203	.28314		.22859	.25335
.02	.05756	.29384		.23392	.24924
.03	.06309	.30402		.23891	.24739
.04	.06862	.31371		.24361	.24717
.05	.07415	.32293		.24802	.24853
.10	.10180	.36262		.26647	
.15	.12945	.39292		.27992	
.20	.15710	.41509		.28928	
.25	.18475	.42998		.29502	
.30	.21240	.43819		.29741	
.35	.24005	.44011		.29655	
.40	.26770	.43599		.29241	
.45	.29535	.42595		.28480	
.50	.32300	.41003		.27337	
.55	.35065	.38812		.25749	
.60	.37830	.36002		.23619	
.65	.40595	.32539		.20848	
.70	.43360	.28378		.17442	
.75	.46125	.23534		.13504	
.80	.48890	.18107		.09139	
.85	.51655	.12233		.04419	
.90	.54420	.06036		-.00607	
.95	.57185	-.00390		-.05906	
.98	.58844	-.04327		-.09204	-.08176
.99	.59397	-.05650		-.10323	-.08075
1.00	.59950	-.06978	-.07179	-.11451	-.07179

LE Center	(.06664,	.26721)	R = .02014
TE Center	(.58947,	-.07179)	R = .01003
Center of Gravity	(.30623,	.28525)	
Radial Reference	(.29145,	.25568)	
Gaging =	.22316		
Nose Point	(.05524,	.25061)	
Tail Point	(.59361,	-.08092)	

LE Tangency Points	Top	(.04857,	.27610)	Bottom	(.07781,	.25046)
TE Tangency Points	Top	(.59873,	-.06793)	Bottom	(.58052,	-.07629)

Inlet Angle =	41.24153
Exit Angle =	24.65380
No. of Blades =	116
Pitch =	.54122
Tolerance =	.00000
Gaging =	.22316
Uncovered Turning =	14.16920
Gaging Angle =	24.35155
Area =	.05927
Axial Chord =	.55300

[redacted]

TABLE XVII

1ST STAGE BLADE

Section E-E AT R = 10.35000

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	.05328	.31086	.30581	.26449	.30581
.01	.05875	.32111		.26952	.29200
.02	.06421	.33085		.27422	.28787
.03	.06968	.34012		.27862	.28598
.04	.07514	.34893		.28274	.28569
.05	.08061	.35729		.28660	.28692
.10	.10793	.39300		.30249	
.15	.13525	.41961		.31360	
.20	.16257	.43820		.32067	
.25	.18989	.44955		.32409	
.30	.21721	.45419		.32401	
.35	.24454	.45250		.32040	
.40	.27186	.44473		.31304	
.45	.29918	.43103		.30142	
.50	.32650	.41147		.28487	
.55	.35382	.38600		.26319	
.60	.38114	.35451		.23619	
.65	.40847	.31677		.20346	
.70	.43579	.27257		.16537	
.75	.46311	.22233		.12308	
.80	.49043	.16712		.07760	
.85	.51775	.10810		.02956	
.90	.54507	.04631		-.02068	
.95	.57240	-.01750		-.07288	
.98	.58879	-.05651		-.10505	-.09474
.99	.59425	-.06961		-.11591	-.09369
1.00	.59972	-.08277	-.08476	-.12683	-.08476

LE Center	(.07348,	.30581)	R = .02019
TE Center	(.58970,	-.08476)	R = .01002

Center of Gravity	(.31311,	.29070)
Radial Reference	(.29145,	.25568)

Gaging = .22960

Nose Point	(.06135,	.28967)
Tail Point	(.59385,	-.09388)

LE Tangency Points	Top	(.05566,	.31531)	Bottom	(.08363,	.28836)
TE Tangency Points	Top	(.59895,	-.08092)	Bottom	(.58077,	-.08931)

Inlet Angle = 43.93851
Exit Angle = 24.78400

No. of Blades = 116
Pitch = .56061

Tolerance = .00000
Gaging = .22960

Uncovered Turning = 13.29798
Gaging Angle = 24.17658

Area = .05559
Axial Chord = .54643

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TABLE XVIII

1ST STAGE BLADE

Section F-F AT R = 7.53750

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	.00000	.16961	.16465	.11426	.16465
.01	.00598	.18100		.12150	.15035
.02	.01196	.19192		.12832	.14627
.03	.01794	.20240		.13477	.14466
.04	.02392	.21246		.14087	.14491
.05	.02990	.22213		.14665	.14709
.10	.05980	.26514		.17150	
.15	.08970	.30039		.19085	
.20	.11960	.32897		.20578	
.25	.14950	.35160		.21695	
.30	.17940	.36877		.22478	
.35	.20930	.38078		.22953	
.40	.23920	.38780		.23135	
.45	.26910	.38990		.23032	
.50	.29900	.38705		.22644	
.55	.32890	.37909		.21965	
.60	.35880	.36575		.20982	
.65	.38870	.34661		.19674	
.70	.41860	.32100		.18010	
.75	.44850	.28793		.15945	
.80	.47840	.24601		.13412	
.85	.50830	.19473		.10314	
.90	.53820	.13551		.06488	
.95	.56810	.07060		.01657	
.98	.58604	.02975		-.01938	-.01018
.99	.59202	.01589		-.03295	-.00943
1.00	.59800	.00193	-.00015	-.04753	-.00015

LE Center	(.02011,	.16465)	R = .02011			
TE Center	(.58782,	-.00015)	R = .01018			
Center of Gravity	(.29147,	.25565)				
Radial Reference	(.29145,	.25568)				
Gaging =	.17374					
Nose Point	(.00886,	.14799)				
Tail Point	(.59191,	-.00947)				
LE Tangency Points	Top	(.00231,	.17400)	Bottom	(.03296,	.14919)
TE Tangency Points	Top	(.59718,	.00385)	Bottom	(.57871,	-.00470)
Inlet Angle =	38.98929					
Exit Angle =	24.85609					
No. of Blades =	116					
Pitch =	.40827					
Tolerance =	.00000					
Gaging =	.17374					
Uncovered Turning =	16.32820					
Gaging Angle =	25.18580					
Area =	.07158					
Axial Chord =	.59800					

[redacted]

TABLE XIX

1ST STAGE BLADE

Section G-G AT R = 10.81000

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	.06200	.38628	.38006	.34537	.38006
.01	.06738	.39413		.34901	.36639
.02	.07276	.40158		.35240	.36229
.03	.07814	.40867		.35555	.36039
.04	.08352	.41538		.35848	.36005
.05	.08890	.42174		.36119	.36120
.10	.11580	.44834		.37184	
.15	.14270	.46692		.37819	
.20	.16960	.47810		.38064	
.25	.19650	.48239		.37936	
.30	.22340	.48018		.37426	
.35	.25030	.47178		.36503	
.40	.27720	.45743		.35099	
.45	.30410	.43732		.33088	
.50	.33100	.41158		.30339	
.55	.35790	.38030		.26960	
.60	.38480	.34350		.23164	
.65	.41170	.30120		.19074	
.70	.43860	.25368		.14755	
.75	.46550	.20156		.10249	
.80	.49240	.14570		.05579	
.85	.51930	.08691		.00769	
.90	.54620	.02588		-.04169	
.95	.57310	-.03685		-.09222	
.98	.58924	-.07513		-.12305	-.11287
.99	.59462	-.08798		-.13341	-.11176
1.00	.60000	-.10088	-.10288	-.14381	-.10288

LE Center	(.08206,	.38006)	R = .02006			
TE Center	(.58998,	-.10288)	R = .01001			
Center of Gravity	(.32762,	.29499)				
Radial Reference	(.29145,	.25568)				
Gaging =	.23790					
Nose Point	(.06802,	.36573)				
Tail Point	(.59419,	-.11197)				
LE Tangency Points	Top	(.06551,	.39141)	Bottom	(.08945,	.36141)
TE Tangency Points	Top	(.59923,	-.09903)	Bottom	(.58111,	-.10753)
Inlet Angle =	51.41446					
Exit Angle =	25.14093					
No. of Blades =	116					
Pitch =	.58553					
Tolerance =	.00000					
Gaging =	.23790					
Uncovered Turning =	11.60881					
Gaging Angle =	23.97302					
Area =	.04878					
Axial Chord =	.53800					

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TABLE XX

VANE 2 NORMAL SOLIDITY

Section AA AT R = 7.65000

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	-.00825	.27803	.27272	.22125	.27272
.01	.00010	.29295		.23104	.25628
.02	.00846	.30733		.24024	.25270
.03	.01682	.32120		.24892	.25293
.04	.02518	.33457		.25711	.25714
.05	.03353	.34745		.26485	
.10	.07532	.40483		.29785	
.15	.11711	.45137		.32315	
.20	.15889	.48800		.34225	
.25	.20068	.51543		.35605	
.30	.24246	.53419		.36509	
.35	.28425	.54470		.36969	
.40	.32604	.54724		.37000	
.45	.36782	.54203		.36602	
.50	.40961	.52916		.35763	
.55	.45140	.50867		.34455	
.60	.49318	.48049		.32631	
.65	.53497	.44448		.30218	
.70	.57675	.40038		.27135	
.75	.61854	.34789		.23334	
.80	.66033	.28719		.18831	
.85	.70211	.21953		.13700	
.90	.74390	.14656		.08024	
.95	.78569	.06980		.01872	
.98	.81076	.02238		-.02024	-.01956
.99	.81912	.00640		-.03355	-.02200
1.00	.82747	-.00968	-.01212	-.04702	-.01212

LE Center	(.01209,	.27272)	R = .02035			
TE Center	(.81746,	-.01212)	R = .01001			
Center of Gravity	(.38024,	.37616)				
Radial Reference	(.38657,	.37155)				
Gaging =	.29534					
Nose Point	(.00042,	.25606)				
Tail Point	(.82240,	-.02083)				
LE Tangency Points	Top	(-.00566,	.28266)	Bottom	(.02592,	.25779)
TE Tangency Points	Top	(.82634,	-.00750)	Bottom	(.80901,	-.01749)
Inlet Angle =	38.22600					
Exit Angle =	29.95553					
No. of Blades =	80					
Pitch =	.60083					
Tolerance =	-.00000					
Gaging =	.29534					
Uncovered Turning =	12.68384					
Gaging Angle =	29.44311					
Area =	.10554					
Axial Chord =	.83573					

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TABLE XXI

VANE 2 NORMAL SOLIDITY

Section BB AT R = 8.48630

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	-.05433	.36436	.35790	.30836	.35790
.01	-.04577	.37804		.31659	.34024
.02	-.03720	.39122		.32436	.33606
.03	-.02864	.40393		.33168	.33565
.04	-.02007	.41617		.33860	.33874
.05	-.01151	.42795		.34514	
.10	.03132	.48019		.37282	
.15	.07414	.52188		.39347	
.20	.11697	.55368		.40824	
.25	.15979	.57609		.41777	
.30	.20262	.58949		.42246	
.35	.24544	.59421		.42247	
.40	.28827	.59045		.41780	
.45	.33109	.57840		.40830	
.50	.37392	.55813		.39360	
.55	.41674	.52970		.37310	
.60	.45957	.49307		.34592	
.65	.50239	.44816		.31105	
.70	.54522	.39481		.26804	
.75	.58804	.33283		.21744	
.80	.63087	.26256		.16030	
.85	.67369	.18506		.09754	
.90	.71652	.10171		.02986	
.95	.75934	.01384		-.04224	
.98	.78504	-.04061		-.08747	-.08675
.99	.79360	-.05900		-.10286	-.08962
1.00	.80217	-.07751	-.07971	-.11842	-.07971

LE Center	(-.03185,	.35790)	R = .02249
TE Center	(.79216,	-.07971)	R = .01001
Center of Gravity	(.34599,	.40263)	
Radial Reference	(.38657,	.37155)	
Gaging =	.30273		
Nose Point	(-.04599,	.34042)	
Tail Point	(.79667,	-.08865)	

LE Tangency Points	Top	(-.05090,	.36984)	Bottom	(-.01820,	.34003)
TE Tangency Points	Top	(.80124,	-.07551)	Bottom	(.78344,	-.08462)

Inlet Angle =	42.35586
Exit Angle =	27.08955
No. of Blades =	80
Pitch =	.66651
Tolerance =	-.00000
Gaging =	.30273
Uncovered Turning =	12.14270
Gaging Angle =	27.01327
Area =	.10714
Axial Chord =	.85650

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TABLE XXII

VANE 2 NORMAL SOLIDITY

Section CC AT R = 9.47250

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	-.10867	.47405	.46529	.42136	.46529
.01	-.09986	.48508		.42709	.44623
.02	-.09105	.49579		.43249	.44139
.03	-.08224	.50619		.42760	.44032
.04	-.07343	.51626		.44242	.44247
.05	-.06462	.52602		.44697	
.10	-.02057	.56987		.46588	
.15	.02348	.60524		.47904	
.20	.06753	.63184		.48702	
.25	.11158	.64940		.49012	
.30	.15563	.65771		.48845	
.35	.19968	.65662		.48195	
.40	.24373	.64604		.47039	
.45	.28778	.62596		.45332	
.50	.33183	.59643		.43002	
.55	.37588	.55755		.39942	
.60	.41993	.50951		.36040	
.65	.46398	.45252		.31251	
.70	.50803	.38685		.25644	
.75	.55208	.31283		.19330	
.80	.59613	.23104		.12407	
.85	.64018	.14225		.04946	
.90	.68423	.04734		-.03006	
.95	.72828	-.05281		-.11409	
.98	.75471	-.11509		-.16657	-.16591
.99	.76352	-.13618		-.18440	-.16936
1.00	.77233	-.15743	-.15942	-.20239	-.15942

LE Center	(-.08366,	.46529)	R = .02501
TE Center	(.76232,	-.15942	R = .01001
Center of Gravity	(.30809,	.43300)	
Radial Reference	(.38657,	.37155)	
Gaging =	.31081		
Nose Point	(-.10204,	.44832)	
Tail Point	(.76643,	-.16855)	

LE Tangency Points	Top	(-.10320,	.48090)	Bottom	(-.07220,	.44306)
TE Tangency Points	Top	(.77157,	-.15559)	Bottom	(.75337,	-.16389)

Inlet Angle =	50.66591
Exit Angle =	24.51642
No. of Blades =	80
Pitch =	.74397
Tolerance =	-.00000
Gaging =	.31081
Uncovered Turning =	10.76521
Gaging Angle =	24.69407
Area =	.11199
Axial Chord =	.88100

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TABLE XXIII

VANE 2 NORMAL SOLIDITY

Section DD AT R = 10.45880

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	-.16301	.53978	.52875	.48815	.52875
.01	-.15396	.54925		.49213	.50835
.02	-.14490	.55844		.49588	.50290
.03	-.13585	.56735		.49938	.50125
.04	-.12679	.57597		.50266	.50266
.05	-.11774	.58430		.50572	
.10	-.07246	.62145		.51779	
.15	-.02719	.65071		.52482	
.20	.01809	.67158		.52706	
.25	.06336	.68360		.52457	
.30	.10864	.68637		.51729	
.35	.15391	.67956		.50495	
.40	.19919	.66293		.48711	
.45	.24446	.63636		.46304	
.50	.28974	.59981		.43171	
.55	.33501	.55338		.39192	
.60	.38029	.49726		.34307	
.65	.42556	.43173		.28569	
.70	.47084	.35717		.22082	
.75	.51611	.27409		.14947	
.80	.56139	.18330		.07241	
.85	.60666	.08580		-.00984	
.90	.65194	-.01739		-.09689	
.95	.69721	-.12534		-.18841	
.98	.72438	-.19204		-.24540	-.24500
.99	.73343	-.21456		-.26473	-.24910
1.00	.74249	-.23721	-.23914	-.28422	-.23914

LE Center	(-.13551,	.52875)	R = .02750			
TE Center	(.73248,	-.23914)	R = .01000			
Center of Gravity	(.26862,	.43211				
Radial Reference	(.38657,	.37155)				
Gaging =	.32995					
Nose Point	(-.15780,	.51263)				
Tail Point	(.73644,	-.24833)				
LE Tangency Points	Top	(-.15539,	.54776)	Bottom	(-.12672,	.50269)
TE Tangency Points	Top	(.74177,	-.23542)	Bottom	(.72344,	-.24341)
Inlet Angle =	57.53765					
Exit Angle =	23.53890					
No. of Blades =	80					
Pitch =	.82143					
Tolerance =	-.00000					
Gaging =	.32995					
Uncovered Turning =	9.87775					
Gaging Angle =	23.68281					
Area =	.11685					
Axial Chord =	.90550					

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TABLE XXIV

VANE 2 NORMAL SOLIDITY

Section EE AT R = 10.86000

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	-.18512	.54432	.53241	.49290	.53241
.01	-.17596	.55336		.49623	.51147
.02	-.16681	.56215		.49937	.50578
.03	-.15765	.57066		.50231	.50391
.04	-.14850	.57891		.50506	
.05	-.13934	.58689		.50763	
.10	-.09357	.62255		.51774	
.15	-.04780	.65077		.52341	
.20	-.00202	.67099		.52465	
.25	.04375	.68267		.52135	
.30	.08952	.68529		.51325	
.35	.13530	.67839		.49994	
.40	.18107	.66157		.48087	
.45	.22684	.63456		.45527	
.50	.27262	.59720		.42213	
.55	.31839	.54947		.38045	
.60	.36416	.49149		.32978	
.65	.40994	.42350		.27067	
.70	.45571	.34589		.20399	
.75	.50148	.25926		.13056	
.80	.54725	.16466		.05108	
.85	.59303	.06333		-.03390	
.90	.63880	-.04350		-.12391	
.95	.68457	-.15479		-.21854	
.98	.71204	-.22333		-.27743	-.27713
.99	.72119	-.24644		-.29739	-.28153
1.00	.73035	-.26966	-.27156	-.31752	-.27156

LE Center	(-.15660,	.53241)	R = .02852
TE Center	(.72035,	-.27156)	R = .01000
Center of Gravity	(.25247,	.42380)	
Radial Reference	(.38657,	.37155)	
Gaging =	.33710		
Nose Point	(-.18040,	.51670)	
Tail Point	(.72424,	-.28077)	

LE Tangency Points	Top	(-.17664,	.55270)	Bottom	(-.14890,	.50495)
TE Tangency Points	Top	(.72965,	-.26789)	Bottom	(.71127,	-.27576)

Inlet Angle = 59.84638
Exit Angle = 23.16488

No. of Blades = 80
Pitch = .85294

Tolerance = -.00000
Gaging = .33710

Uncovered Turning = 9.69143
Gaging Angle = 23.27951

Area = .12135
Axial Chord = .91547

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TABLE XXV

VANE 2 NORMAL SOLIDITY

Section FF AT R = 7.50000

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	.00001	.26416	.25899	.20756	.25899
.01	.00833	.27915		.21753	.24278
.02	.01665	.29362		.22691	.23931
.03	.02497	.30758		.23574	.23967
.04	.03329	.32104		.24408	.24412
.05	.04161	.33402		.25196	
.10	.08321	.39206		.28562	
.15	.12481	.43944		.31152	
.20	.16641	.47704		.33122	
.25	.20801	.50555		.34565	
.30	.24961	.52546		.35535	
.35	.29121	.53717		.36067	
.40	.33281	.54093		.36177	
.45	.37441	.53696		.35868	
.50	.41601	.52534		.35131	
.55	.45761	.50611		.33944	
.60	.49921	.47923		.32265	
.65	.54081	.44455		.30036	
.70	.58241	.40188		.27176	
.75	.62401	.35091		.23616	
.80	.66561	.29183		.19344	
.85	.70721	.22589		.14424	
.90	.74881	.15476		.08942	
.95	.79041	.07994		.02973	
.98	.81537	.03373		-.00817	-.00750
.99	.82369	.01816		-.02114	-.00987
1.00	.83201	.00250	.00000	-.03426	.00000

LE Center	(.01997,	.25899)	R = .01996
TE Center	(.82200,	.00000)	R = .01001
Center of Gravity	(.38670,	.37210)	
Radial Reference	(.38657,	.37155)	
Gaging =	.29359		
Nose Point	(.00863,	.24257)	
Tail Point	(.82702,	-.00866)	

LE Tangency Points	Top	(.00252,	.26868)	Bottom	(.03410,	.24489)
TE Tangency Points	Top	(.83084,	.00470)	Bottom	(.81360,	-.00545)

Inlet Angle =	36.98468
Exit Angle =	30.50032
No. of Blades =	80
Pitch =	.58905
Tolerance =	-.00000
Gaging =	.29359
Uncovered Turning =	12.64424
Gaging Angle =	29.89479
Area =	.10561
Axial Chord =	.83200

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TABLE XXVI

VANE 2 NORMAL SOLIDITY

Section GG AT R = 11.44500

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	-.21735	.52544	.51223	.47443	.51223
.01	-.20805	.53395	.53393	.47674	.49052
.02	-.19875	.54226		.47896	.48449
.03	-.18945	.55036		.48109	.48232
.04	-.18015	.55825		.48312	
.05	-.17085	.56593		.48505	
.10	-.12435	.60091		.49311	
.15	-.07785	.62969		.49817	
.20	-.03135	.65155		.49973	
.25	.01515	.66568		.49719	
.30	.06165	.67128		.48989	
.35	.10815	.66753		.47711	
.40	.15465	.65368		.45807	
.45	.20115	.62905		.43203	
.50	.24765	.59315		.39830	
.55	.29415	.54567		.35636	
.60	.34065	.48652		.30590	
.65	.38715	.41584		.24688	
.70	.43365	.33402		.17953	
.75	.48015	.24191		.10430	
.80	.52665	.14110		.02183	
.85	.57315	.03337		-.06719	
.90	.61965	-.07968		-.16202	
.95	.66615	-.19679		-.26198	
.98	.69405	-.26859		-.32413	-.32396
.99	.70335	-.29274		-.34518	-.32882
1.00	.71265	-.31699	-.31884	-.36640	-.31884

LE Center	(-.18737,	.51223)	R = .02998			
TE Center	(.70265,	-.31884)	R = .01000			
Center of Gravity	(.22900,	.40506)				
Radial Reference	(.38657,	.37155)				
Gaging =	.34502					
Nose Point	(-.21338,	.49731)				
Tail Point	(.70644,	-.32810)				
LE Tangency Points	Top	(-.20734,	.53458)	Bottom	(-.18098,	.48294)
TE Tangency Points	Top	(.71199,	-.31526)	Bottom	(.69351,	-.32291)
Inlet Angle =	62.95352					
Exit Angle =	22.48960					
No. of Blades =	80					
Pitch =	.89889					
Tolerance =	-.00000					
Gaging =	.34502					
Uncovered Turning =	9.65333					
Gaging Angle =	22.57141					
Area =	.13190					
Axial Chord =	.93000					

TABLE XXVII

VANE 2 NORMAL SOLIDITY

Section HH AT R = 11.41000

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	-.21542	.52742	.51428	.47638	.51428
.01	-.20613	.53596	.53594	.47876	.49262
.02	-.19684	.54429		.48103	.48661
.03	-.18755	.55241		.48321	.48446
.04	-.17826	.56032		.48528	
.05	-.16897	.56801		.48725	
.10	-.12251	.60298		.49540	
.15	-.07605	.63166		.50046	
.20	-.02960	.65333		.50193	
.25	.01686	.66722		.49929	
.30	.06332	.67253		.49187	
.35	.10977	.66849		.47899	
.40	.15623	.65435		.45990	
.45	.20269	.62948		.43382	
.50	.24914	.59340		.40006	
.55	.29560	.54583		.35805	
.60	.34206	.48670		.30748	
.65	.38851	.41616		.24837	
.70	.43497	.33457		.18099	
.75	.48143	.24281		.10583	
.80	.52788	.14239		.02352	
.85	.57434	.03507		-.06526	
.90	.62080	-.07758		-.15979	
.95	.66725	-.19431		-.25939	
.98	.69513	-.26589		-.32134	-.32116
.99	.70442	-.28997		-.34232	-.32599
1.00	.71371	-.31416	-.31602	-.36346	-.31602

LE Center	(-.18553,	.51428)	R = .02989
TE Center	(.70371,	-.31602)	R = .01000
Center of Gravity	(.23041,	.40640)	
Radial Reference	(.38657,	.37155)	
Gaging =	.34463		
Nose Point	(-.21140,	.49931)	
Tail Point	(.70751,	-.32527)	

LE Tangency Points	Top	(-.20549,	.53654)	Bottom	(-.17902,	.48511)
TE Tangency Points	Top	(.71304,	-.31243)	Bottom	(.69457,	-.32009)

Inlet Angle =	62.77019
Exit Angle =	22.53380
No. of Blades =	80
Pitch =	.89614
Tolerance =	-.00000
Gaging =	.34463
Uncovered Turning =	9.63787
Gaging Angle =	22.61714
Area =	.13113
Axial Chord =	.92913

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TABLE XXVIII

2ND STAGE BLADE

Section A-A AT R = 7.71000

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	.00469	.11660	.10985	.06764	.10985
.01	.01118	.12496		.07364	.09524
.02	.01766	.13302		.07933	.09133
.03	.02414	.14079		.08473	.09014
.04	.03063	.14829		.08986	.09115
.05	.03711	.15552		.09475	
.10	.06952	.18789		.11589	
.15	.10194	.21453		.13245	
.20	.13435	.23600		.14521	
.25	.16677	.25269		.15470	
.30	.19918	.26489		.16123	
.35	.23160	.27280		.16503	
.40	.26401	.27657		.16625	
.45	.29642	.27626		.16498	
.50	.32884	.27192		.16126	
.55	.36125	.26350		.15513	
.60	.39367	.25094		.14655	
.65	.42608	.23410		.13539	
.70	.45850	.21276		.12143	
.75	.49091	.18658		.10441	
.80	.52333	.15517		.08396	
.85	.55574	.11857		.05961	
.90	.58815	.07763		.03065	
.95	.62057	.03353		-.00408	
.98	.64002	.00596		-.02854	-.02560
.99	.64650	-.00337		-.03747	-.02535
1.00	.65298	-.01277	-.01592	-.04686	-.01592

LE Center	(.02440,	.10985)	R = .01971		
TE Center	(.64288,	-.01592)	R = .01010		
Center of Gravity	(.31188,	.17693)			
Radial Reference	(.31261,	.17488)			
Gaging =	.22692				
Nose Point	(.01090,	.09549)			
Tail Point	(.64873,	-.02416)			
LE Tangency Points	Top	(.00883,	.12193) Bottom	(.03626,	.09411)
TE Tangency Points	Top	(.65120,	-.01018) Bottom	(.63498,	-.02220)
Inlet Angle =	45.40499				
Exit Angle=	36.54155				
No. of Blades =	126				
Pitch =	.38447				
Tolerance =	-.00000				
Gaging =	.22692				
Uncovered Turning =	14.50464				
Gaging Angle =	36.17168				
Area =	.05416				
Axial Chord =	.64829				

[redacted]

TABLE XXIX

2ND STAGE BLADE

Section B-B AT R = 8.58630

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	.02115	.15901	.15268	.11388	.15268
.01	.02733	.16711		.11929	.13877
.03	.03350	.17492		.12442	.13506
.03	.03968	.18244		.12929	.13394
.04	.04586	.18969		.13392	.13491
.05	.05204	.19666		.13832	
.10	.08292	.22760		.15717	
.15	.11381	.25238		.17152	
.20	.14470	.27143		.18198	
.25	.17559	.28511		.18896	
.30	.20647	.29366		.19270	
.35	.23736	.29731		.19333	
.40	.26825	.29621		.19092	
.45	.29914	.29046		.18547	
.50	.33002	.28014		.17695	
.55	.36091	.26528		.16527	
.60	.39180	.24588		.15034	
.65	.42269	.22190		.13207	
.70	.45357	.19328		.11035	
.75	.48446	.15989		.08506	
.80	.51535	.12187		.05609	
.85	.54624	.07975		.02332	
.90	.57712	.03429		-.01341	
.95	.60801	-.01377		-.05428	
.98	.62654	-.04357		-.08088	-.07638
.99	.63272	-.05364		-.09011	-.07587
1.00	.63890	-.06377	-.06660	-.09952	-.06660

LE Center	(.03989,	.15268)	R = .01874
TE Center	(.62885,	-.06660)	R = .01005
Center of Gravity	(.31234,	.18537)	
Radial Reference	(.31261,	.17488)	
Gaging =	.23291		
Nose Point	(.02699,	.13909)	
Tail Point	(.63427,	-.07507)	

LE Tangency Points	Top	(.02499,	.16404)	Bottom	(.05076,	.13740)
TE Tangency Points	Top	(.63743,	-.06136)	Bottom	(.62060,	-.07234)

Inlet Angle =	45.94590
Exit Angle =	33.11900
No. of Blades =	126
Pitch =	.42817
Tolerance =	-.00000
Gaging =	.23291
Uncovered Turning =	13.27063
Gaging Angle =	32.95342
Area =	.04913
Axial Chord =	.61775

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TABLE XXX

2ND STAGE BLADE

Section C-C AT R = 9.71250

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	.04230	.21675	.21090	.17605	.21090
.01	.04808	.22443		.18087	.19790
.02	.05387	.23180		.18541	.19444
.03	.05965	.23886		.18967	.19340
.04	.06544	.24562		.19369	.19434
.05	.07122	.25209		.19747	
.10	.10015	.28019		.21319	
.15	.12907	.30162		.22435	
.20	.15800	.31683		.23159	
.25	.18692	.32618		.23525	
.30	.21585	.32996		.23549	
.35	.24477	.32839		.23233	
.40	.27370	.32166		.22565	
.45	.30262	.30990		.21520	
.50	.33155	.29321		.20065	
.55	.36047	.27166		.18164	
.60	.38940	.24527		.15805	
.65	.41832	.21404		.13011	
.70	.44725	.17795		.09823	
.75	.47617	.13713		.06285	
.80	.50510	.09203		.02431	
.85	.53402	.04336		-.01710	
.90	.56295	-.00817		-.06118	
.95	.59187	-.06194		-.10776	
.98	.60923	-.09505		-.13685	-.12976
.99	.61501	-.10620		-.14673	-.12894
1.00	.62080	-.11742	-.11985	-.15670	-.11985

LE Center	(.05979)	.21090)	R = .01750			
TE Center	(.61077,	-.11985)	R = .01003			
Center of Gravity	(.31975,	.19589)				
Radial Reference	(.31261,	.17488)				
Gaging =	.23405					
Nose Point	(.04765,	.19831)				
Tail Point	(.61560,	-.12864)				
LE Tangency Points	Top	(.04582,	.22143)	Bottom	(.06936,	.19625)
TE Tangency Points	Top	(.61968,	-.11525)	Bottom	(.60215,	-.12499)
Inlet Angle =	46.92461					
Exit Angle =	29.05572					
No. of Blades =	126					
Pitch =	.48433					
Tolerance =	-.00000					
Gaging =	.23405					
Uncovered Turning =	12.73546					
Gaging Angle -	28.89695					
Area =	.04379					
Axial Chord =	.57850					

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TABLE XXXI

2ND STAGE BLADE

Section D-D AT R = 10.83880

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	.06345	.28704	.28052	.25413	.28052
.01	.06884	.29268		.25716	.26842
.02	.07423	.29814		.25999	.26521
.03	.07962	.30342		.26264	.26426
.04	.08502	.30853		.26511	.26515
.05	.09041	.31345		.26740	
.10	.11737	.33520		.27641	
.15	.14433	.35198		.28171	
.20	.17130	.36352		.28356	
.25	.19826	.36956		.28205	
.30	.22522	.36994		.27712	
.35	.25218	.36454		.26853	
.40	.27915	.35333		.25588	
.45	.30611	.33638		.23862	
.50	.33307	.31380		.21635	
.55	.36003	.28580		.18919	
.60	.38700	.25263		.15772	
.65	.41396	.21458		.12258	
.70	.44092	.17199		.08423	
.75	.46788	.12529		.04304	
.80	.49485	.07493		-.00073	
.85	.52181	.02135		-.04690	
.90	.54877	-.03502		-.09530	
.95	.57573	-.09380		-.14581	
.98	.59191	-.13008		-.17709	-.16673
.99	.59730	-.14232		-.18767	-.16563
1.00	.60270	-.15464	-.15674	-.19834	-.15674

LE Center	(.07971,	.28052)	R = .01626
TE Center	(.59267,	-.15674)	R = .01002
Center of Gravity	(.33241,	.20643)	
Radial Reference	(.31261,	.17488)	
Gaging =	.23332		
Nose Point	(.06686,	.27055)	
Tail Point	(.59695,	-.16580)	

LE Tangency Points	Top	(.06796,	.29176)	Bottom	(.08606,	.26555)
TE Tangency Points	Top	(.60186,	-.15272)	Bottom	(.58377,	-.16134)

Inlet Angle =	55.35787
Exit Angle =	25.49415
No. of Blades =	126
Pitch =	.54049
Tolerance =	-.00000
Gaging =	.23332
Uncovered Turning =	12.34394
Gaging Angle =	25.57425
Area =	.04196
Axial Chord =	.53925

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TABLE XXXII

2ND STAGE BLADE

Section E-E AT R = 11.51000

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	.07605	.33627	.32878	.30786	.32878
.01	.08121	.34041	.34036	.30961	.31721
.02	.08637	.34444		.31122	.31413
.03	.09153	.34836		.31268	.31322
.04	.09669	.35217		.31401	
.05	.10184	.35585		.31520	
.10	.12764	.37233		.31922	
.15	.15343	.38512		.32007	
.20	.17922	.39368		.31781	
.25	.20502	.39746		.31233	
.30	.23081	.39598		.30340	
.35	.25660	.38879		.29059	
.40	.28239	.37559		.27333	
.45	.30819	.35622		.25115	
.50	.33398	.33073		.22398	
.55	.35977	.29933		.19231	
.60	.38557	.26241		.15685	
.65	.41136	.22048		.11820	
.70	.43715	.17406		.07675	
.75	.46294	.12369		.03278	
.80	.48874	.06982		-.01354	
.85	.51453	.01286		-.06208	
.90	.54032	-.04685		-.11271	
.95	.56612	-.10898		-.16535	
.98	.58159	-.14730		-.19787	-.18518
.99	.58675	-.16024		-.20886	-.18393
1.00	.59191	-.17325	-.17517	-.21992	-.17517

LE Center	(.09162,	.32878)	R = .01557
TE Center	(.58189,	-.17517)	R = .01002
Center of Gravity	(.34076,	.21272)	
Radial Reference	(.31261,	.17488)	
Gaging =	.22895		
Nose Point	(.07798,	.32128)	
Tail Point	(.58585,	-.18437)	

LE Tangency Points	Top	(.08203,	.34105)	Bottom	(.09550,	.31371)
TE Tangency Points	Top	(.59120'	-.17147)	Bottom	(.57284,	-.17947)

Inlet Angle =	63.77058
Exit Angle =	23.53731
No. of Blades =	126
Pitch =	.57396
Tolerance =	-.00000
Gaging =	.22895
Uncovered Turning =	11.95900
Gaging Angle =	23.50865
Area =	.04204
Axial Chord =	.51586

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TABLE XXXIII

2ND STAGE BLADE

Section F-F AT R = 7.46000

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	.00000	.10463	.09779	.05435	.09779
.01	.00657	.11311		.06059	.08298
.02	.01314	.12128		.06650	.07902
.03	.01971	.12915		.07210	.07781
.04	.02628	.13674		.07742	.07883
.05	.03285	.14405		.08248	
.10	.06570	.17680		.10438	
.15	.09855	.20385		.12161	
.20	.13140	.22586		.13507	
.25	.16425	.24329		.14531	
.30	.19710	.25645		.15272	
.35	.22995	.26558		.15752	
.40	.26280	.27080		.15990	
.45	.29565	.27218		.15993	
.50	.32850	.26974		.15768	
.55	.36135	.26343		.15314	
.60	.39420	.25311		.14626	
.65	.42705	.23860		.13695	
.70	.45990	.21961		.12504	
.75	.49275	.19570		.11029	
.80	.52560	.16632		.09232	
.85	.55845	.13131		.07057	
.90	.59130	.09157		.04413	
.95	.62415	.04844		.01143	
.98	.64386	.02143		-.01239	-.00983
.99	.65043	.01228		-.02128	-.00964
1.00	.65700	.00307	-.00017	-.03075	-.00017

LE Center	(.01998,	.09779)	R = .01998
TE Center	(.64688,	-.00017)	R = .01012
Center of Gravity	(.31263,	.17484)	
Radial Reference	(.31261,	.17488)	
Gaging =	.22381		
Nose Point	(.00637,	.08317)	
Tail Point	(.65283,	-.00835)	

LE Tangency Points	Top	(.00419,	.11003)	Bottom	(.03218,	.08196)
TE Tangency Points	Top	(.65512,	.00571)	Bottom	(.63908,	-.00662)

Inlet Angle =	45.08702
Exit Angle =	37.54949
No. of Blades =	126
Pitch =	.37200
Tolerance =	-.00000
Gaging =	.22381
Uncovered Turning =	14.88048
Gaging Angle =	36.98783
Area =	.05564
Axial Chord =	.65700

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TABLE XXXIV

2ND STAGE BLADE

SECTION G-G AT R = 11.96500

Percent X	X	Y (Top)	(Circle)	Y (Bot)	(Circle)
.00	.08460	.37280	.36441	.34706	.36441
.01	.08960	.37591	.37560	.34792	.35323
.02	.09460	.37893		.34867	.35026
.03	.09960	.38187		.34931	.34939
.04	.10460	.38472		.34983	
.05	.10960	.38749		.35024	
.10	.13460	.39981		.35059	
.15	.15960	.40929		.34813	
.20	.18460	.41535		.34275	
.25	.20960	.41734		.33424	
.30	.23460	.41456		.32222	
.35	.25960	.40633		.30613	
.40	.28460	.39207		.28532	
.45	.30960	.37141		.25947	
.50	.33460	.34426		.22898	
.55	.35960	.31082		.19451	
.60	.38460	.27156		.15666	
.65	.40960	.22710		.11585	
.70	.43460	.17805		.07240	
.75	.45960	.12498		.02655	
.80	.48460	.06840		-.02154	
.85	.50960	.00875		-.07172	
.90	.53460	-.05359		-.12389	
.95	.55960	-.11829		-.17796	
.98	.57460	-.15811		-.21130	-.19686
.99	.57960	-.17154		-.22255	-.19551
1.00	.58460	-.18505	-.18684	-.23388	-.18684

LE Center	(.09962,	.36441)	R = .01502
TE Center	(.57458,	-.18684)	R = .01002
Center of Gravity	(.34632,	.21697)	
Radial Reference	(.31261,	.17488)	
Gaging =	.22417		
Nose Point	(.08558,	.35907)	
Tail Point	(.57834,	-.19613)	

LE Tangency Points	Top	(.09184,	.37727)	Bottom	(.10117,	.34948)
TE Tangency Points	Top	(.58397,	-.18336)	Bottom	(.56544,	-.19095)

Inlet Angle =	71.43985
Exit Angle =	22.27146
No. of Blades =	126
Pitch =	.59665
Tolerance =	-.00000
Gaging =	.22417
Uncovered Turning =	11.69901
Gaging Angle =	22.06786
Area =	.04245
Axial Chord =	.50000

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TABLE XXXV

FIRST VANE CASCADE TURNING VANE

Radius of Root Section = 7.5750 | Axial Chord = 3.5000 | Actual Chord = 3.5925
Pitch = 2.0480 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	0.8710	0.8460
0.01	0.0350	0.8710	0.8710
0.02	0.0700	0.8709	0.8709
0.03	0.1050	0.8707	0.8707
0.04	0.1400	0.8705	0.8705
0.05	0.1750	0.8701	0.8701
0.10	0.3500	0.8670	0.8670
0.15	0.5250	0.8612	0.8612
0.20	0.7000	0.8526	0.8526
0.25	0.8750	0.8407	0.8407
0.30	1.0500	0.8253	0.8253
0.35	1.2250	0.8060	0.8060
0.40	1.4000	0.7823	0.7823
0.45	1.5750	0.7539	0.7539
0.50	1.7500	0.7205	0.7205
0.55	1.9250	0.6814	0.6814
0.60	2.1000	0.6365	0.6365
0.65	2.2750	0.5854	0.5854
0.70	2.4500	0.5277	0.5277
0.75	2.6250	0.4634	0.4634
0.80	2.8000	0.3922	0.3922
0.85	2.9750	0.3141	0.3141
0.90	3.1500	0.2293	0.2293
0.95	3.3250	0.1377	0.1377
0.98	3.4300	0.0795	0.0795
0.99	3.4650	0.0595	0.0595
1.00	3.5000	0.0394	0.0249

Foil L.E. Circle	X = 0.0250,	Y = 0.8460,	R = 0.0250
Foil T.E. Circle	X = 3.4750,	Y = 0.0249,	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0251,	Y = 0.8710	
Foil L.E. Tangency Pt. (Bot)	X = 0.0500,	Y = 0.8460	
Foil T.E. Tangency Pt. (Top)	X = 3.4874,	Y = 0.0466	
Foil T.E. Tangency Pt. (Bot)	X = 3.4626,	Y = 0.0033	
Foil Nose Point	X = 0.0007,	Y = 0.8399	
Foil Tail Point	X = 3.4967,	Y = 0.0125	

Foil Area (Less Core) = 0.1745

Gaging	LAMBDA = 1.7859,	X = 2.7715,	Y = 0.4043
Gaging Angle	= 60.695		
Center of Gravity	X = 1.7929,	Y = 0.5946	
Radial Reference	X = 1.7929,	Y = 0.5946	
Inlet Angle	= 90.		
Exit Angle	= 59.98		
Uncovered Turning	= 7.029		

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TABLE XXXVI

FIRST VANE CASCADE TURNING VANE

Radius of 1/4R Section = 8.0930 | Axial Chord = 3.5000 | Actual Chord = 3.6020
Pitch = 2.1880 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	0.9125	0.8875
0.01	0.0350	0.9125	0.9125
0.02	0.0700	0.9124	0.9124
0.03	0.1050	0.9123	0.9123
0.04	0.1400	0.9121	0.9121
0.05	0.1750	0.9119	0.9119
0.10	0.3500	0.9094	0.9094
0.15	0.5250	0.9046	0.9046
0.20	0.7000	0.8974	0.8974
0.25	0.8750	0.8872	0.8872
0.30	1.0500	0.8735	0.8735
0.35	1.2250	0.8559	0.8559
0.40	1.4000	0.8336	0.8336
0.45	1.5750	0.8061	0.8061
0.50	1.7500	0.7727	0.7727
0.55	1.9250	0.7327	0.7327
0.60	2.1000	0.6855	0.6855
0.65	2.2750	0.6307	0.6307
0.70	2.4500	0.5680	0.5680
0.75	2.6250	0.4975	0.4975
0.80	2.8000	0.4193	0.4193
0.85	2.9750	0.3340	0.3340
0.90	3.1500	0.2418	0.2418
0.95	3.3250	0.1433	0.1433
0.98	3.4300	0.0814	0.0814
0.99	3.4650	0.0603	0.0603
1.00	3.5000	0.0390	0.0252

Foil L.E. Circle	X = 0.0250,	Y = 0.8875,	R = 0.0250
Foil T.E. Circle	X = 3.4755,	Y = 0.0252,	R = 0.0245
Foil L.E. Tangency Pt. (Top)	X = 0.0251,	Y = 0.9125	
Foil L.E. Tangency Pt. (Bot)	X = 0.0500,	Y = 0.8875	
Foil T.E. Tangency Pt. (Top)	X = 3.4882,	Y = 0.0461	
Foil T.E. Tangency Pt. (Bot)	X = 3.4623,	Y = 0.0045	
Foil Nose Point	X = 0.0007,	Y = 0.8814	
Foil Tail Point	X = 3.4963,	Y = 0.0122	

Foil Area (Less Core) = 0.1722

Gaging	LAMBDA = 1.8880,	X = 2.6987,	Y = 0.4655
Gaging Angle	= 59.643		
Center of Gravity	X = 1.7832,	Y = 0.6371	
Radial Reference	X = 1.7929,	Y = 0.5946	
Inlet Angle	= 90.		
Exit Angle	= 58.62		
Uncovered Turning	= 7.288		

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TABLE XXXVII

FIRST VANE CASCADE TURNING VANE

Radius of Mean Section = 8.6125
Pitch = 2.3285

Axial Chord = 3.5000
No. of Foils = 4

Actual Chord = 3.6151

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	0.9539	0.9289
0.01	0.0350	0.9539	0.9518
0.02	0.0700	0.9539	0.9539
0.03	0.1050	0.9538	0.9538
0.04	0.1400	0.9537	0.9537
0.05	0.1750	0.9535	0.9535
0.10	0.3500	0.9519	0.9519
0.15	0.5250	0.9489	0.9489
0.20	0.7000	0.9440	0.9440
0.25	0.8750	0.9369	0.9369
0.30	1.0500	0.9269	0.9269
0.35	1.2250	0.9135	0.9135
0.40	1.4000	0.8955	0.8955
0.45	1.5750	0.8720	0.8720
0.50	1.7500	0.8417	0.8417
0.55	1.9250	0.8031	0.8031
0.60	2.1000	0.7549	0.7549
0.65	2.2750	0.6964	0.6964
0.70	2.4500	0.6274	0.6274
0.75	2.6250	0.5482	0.5482
0.80	2.8000	0.4600	0.4600
0.85	2.9750	0.3639	0.3639
0.90	3.1500	0.2610	0.2610
0.95	3.3250	0.1522	0.1522
0.98	3.4300	0.0845	0.0845
0.99	3.4650	0.0615	0.0615
1.00	3.5000	0.0384	0.0250
Foil L.E. Circle	X = 0.0250	Y = 0.9289	R = 0.0250
Foil T.E. Circle	X = 3.4751	Y = 0.0250	R = 0.0249
Foil L.E. Tangency PT. (Top)	X = 0.0500	Y = 0.9289	
Foil L.E. Tangency Pt. (Bot)	X = 0.0239	Y = 0.9039	
Foil T.E. Tangency Pt. (Top)	X = 3.4888	Y = 0.0458	
Foil T.E. Tangency Pt. (Bot)	X = 3.4613	Y - 0.0042	
Foil Nose Point	X = 0.0007	Y = 0.9350	
Foil Tail Point	X = 3.4959	Y = 0.0112	
Foil Area (Less Core)	0.1775		
Gaging	LAMBDA = 1.9704	X = 2.6151	Y = 0.5529
Gaging Angle	= 57.805		
Center of Gravity	X = 1.8051	Y = 0.6794	
Radial Reference	X = 1.7929	Y = 0.5946	
Inlet Angle	= 90.00		
Exit Angle	= 56.521		
Uncovered Turning	= 7.897		

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TABLE XXXVIII

FIRST VANE CASCADE TURNING VANE

Radius of 1/4T Section = 9.1312 | Axial Chord = 3.5000 | Actual Chord = 3.6266
Pitch = 2.4687 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	0.9977	0.9727
0.01	0.0350	0.9977	0.9956
0.02	0.0700	0.9977	0.9977
0.03	0.1050	0.9976	0.9976
0.04	0.1400	0.9974	0.9974
0.05	0.1750	0.9972	0.9972
0.10	0.3500	0.9951	0.9951
0.15	0.5250	0.9910	0.9910
0.20	0.7000	0.9846	0.9846
0.25	0.8750	0.9753	0.9753
0.30	1.0500	0.9626	0.9626
0.35	1.2250	0.9456	0.9456
0.40	1.4000	0.9235	0.9235
0.45	1.5750	0.8953	0.8953
0.50	1.7500	0.8599	0.8599
0.55	1.9250	0.8162	0.8162
0.60	2.1000	0.7634	0.7634
0.65	2.2750	0.7012	0.7012
0.70	2.4500	0.6294	0.6294
0.75	2.6250	0.5487	0.5487
0.80	2.8000	0.4597	0.4597
0.85	2.9750	0.3635	0.3635
0.90	3.1500	0.2607	0.2607
0.95	3.3250	0.1521	0.1521
0.98	3.4300	0.0845	0.0845
0.99	3.4650	0.0616	0.0616
1.00	3.5000	0.0385	0.0250

Foil L.E. Circle	X = 0.0250	Y = 0.9727	R = 0.0250
Foil T.E. Circle	X = 3.4750	Y = 0.0250	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0500	Y = 0.9727	
Foil L.E. Tangency Pt. (Bot)	X = 0.0263	Y = 0.9478	
Foil T.E. Tangency Pt. (Top)	X = 3.4887	Y = 0.0459	
Foil T.E. Tangency Pt. (Bot)	X = 3.4612	Y = 0.0042	
Foil Nose Point	X = 0.0007	Y = 0.9787	
Foil Tail Point	X = 3.4959	Y = 0.0113	

Foil Area (Less core) = 0.1723

Gaging	LAMBDA = 2.0965	X = 2.5710	Y = 0.5745
Gaging Angle	= 58.128		
Center of Gravity	X = 1.8227	Y = 0.6918	
Radial Reference	X = 1.7929	Y = 0.5946	
Inlet Angle	= 90.00		
Exit Angle	= 56.527		
Uncovered Turning	= 8.114		

TABLE XXXIX

FIRST VANE CASCADE TURNING VANE

Radius of Tip Section = 9.6500 | Axial Chord = 3.5000 | Actual Chord = 3.6378
Pitch = 2.6090 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	1.0415	1.0165
0.01	0.0350	1.0414	1.0414
0.02	0.0700	1.0410	1.0410
0.03	0.1050	1.0408	1.0408
0.04	0.1400	1.0407	1.0407
0.05	0.1750	1.0406	1.0406
0.10	0.3500	1.0369	1.0369
0.15	0.5250	1.0301	1.0301
0.20	0.7000	1.0197	1.0197
0.25	0.8750	1.0051	1.0051
0.30	1.0500	0.9860	0.9860
0.35	1.2250	0.9616	0.9616
0.40	1.4000	0.9314	0.9314
0.45	1.5750	0.8950	0.8950
0.50	1.7500	0.8517	0.8517
0.55	1.9250	0.8013	0.8013
0.60	2.1000	0.7436	0.7436
0.65	2.2750	0.6784	0.6784
0.70	2.4500	0.6059	0.6059
0.75	2.6250	0.5260	0.5260
0.80	2.8000	0.4404	0.4404
0.85	2.9750	0.3482	0.3482
0.90	3.1500	0.2503	0.2503
0.95	3.3250	0.1470	0.1470
0.98	3.4300	0.0826	0.0826
0.99	3.4650	0.0608	0.0608
1.00	3.5000	0.0388	0.0247

Foil L.E. Circle	X = 0.0250	Y = 1.0165	R = 0.0250
Foil L.E. Circle	X = 3.4746	Y = 0.0247	R = 0.0254
Foil L.E. Tangency Pt. (Top)	X = 0.0253	Y = 1.0415	
Foil L.E. Tangency Pt. (Bot)	X = 0.0242	Y = 0.9915	
Foil T.E. Tangency Pt. (Top)	X = 3.4881	Y = 0.0463	
Foil T.E. Tangency Pt. (Bot)	X = 3.4614	Y = 0.0030	
Foil Nose Point	X = -0.0000	Y = 1.0165	
Foil Tail Point	X = 3.4962	Y = 0.0114	

Foil Area (Less Core) = 0.1835

Gaging	LAMBDA = 2.2440	X = 2.5322	Y = 0.5692
Gaging Angle	= 59.330		
Center of Gravity	X = 1.7997	Y = 0.7008	
Radial Reference	X = 1.7929	Y = 0.5946	
Inlet Angle	= 90.00		
Exit Angle	= 57.79		
Uncovered Turning	= 7.497		

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TABLE XL

FIRST BLADE CASCADE TURNING VANE

Radius of Root Section = 7.5375 | Axial Chord = 2.2500 | Actual Chord = 2.5894
Pitch = 1.0867 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-1.3284	-1.3034
0.01	0.0225	-1.3284	-1.3283
0.02	0.0450	-1.3282	-1.3282
0.03	0.0675	-1.3278	-1.3278
0.04	0.0900	-1.3270	-1.3270
0.05	0.1125	-1.3260	-1.3260
0.10	0.2250	-1.3161	-1.3161
0.15	0.3375	-1.2993	-1.2993
0.20	0.4500	-1.2757	-1.2757
0.25	0.5625	-1.2458	-1.2458
0.30	0.6750	-1.2098	-1.2098
0.35	0.7875	-1.1679	-1.1679
0.40	0.9000	-1.1200	-1.1200
0.45	1.0125	-1.0663	-1.0663
0.50	1.1250	-1.0068	-1.0068
0.55	1.2375	-0.9414	-0.9414
0.60	1.3500	-0.8699	-0.8699
0.65	1.4625	-0.7921	-0.7921
0.70	1.5750	-0.7077	-0.7077
0.75	1.6875	-0.6164	-0.6164
0.80	1.8000	-0.5176	-0.5176
0.85	1.9125	-0.4107	-0.4107
0.90	2.0250	-0.2950	-0.2950
0.95	2.1375	-0.1696	-0.1696
0.98	2.2050	-0.0896	-0.0896
0.99	2.2275	-0.0620	-0.0620
1.00	2.2500	-0.0337	-0.0250

Foil L.E. Circle	X = 0.0250,	Y = -1.3034,	R = 0.0250
Foil T.E. Circle	X = 2.2250,	Y = -0.0250,	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = -1,3284	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = -1.2784	
Foil T.E. Tangency Pt. (Top)	X = 2.2445,	Y = -0.0405	
Foil T.E. Tangency Pt. (Bot)	X = 2.2055,	Y = -0.0094	
Foil Nose Point	X = 0.0,	Y = -1.3034	
Foil Tail Point	X = 2.2406,	Y = -0.0054	

Foil Area (Less Core) = 0.1337

Gaging	LAMBDA = 0.7011,	X = 1.7450,	Y = -0.5669
Gaging Angle	= 40.179		
Center of Gravity	X = 1.2058,	Y = -0.8246	
Radial Reference	X = 1.2058,	Y = -0.8246	
Inlet Angle	= 90.000		
Exit Angle	= 38.618		
Uncovered Turning	= 10.100		

Constant Section Thickness = .050

UNCLASSIFIED

TABLE XLI

FIRST BLADE CASCADE TURNING VANE

Radius of 1/BR Section = 7.8591 | Axial Chord = 2.2500 | Actual Chord = 2.5722
Pitch = 1.1331 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-1.2936	-1.2686
0.01	0.0225	-1.2936	-1.2935
0.02	0.0450	-1.2935	-1.2935
0.03	0.0675	-1.2931	-1.2931
0.04	0.0900	-1.2924	-1.2924
0.05	0.1125	-1.2915	-1.2915
0.10	0.2250	-1.2829	-1.2829
0.15	0.3375	-1.2678	-1.2678
0.20	0.4500	-1.2464	-1.2464
0.25	0.5625	-1.2190	-1.2190
0.30	0.6750	-1.1855	-1.1855
0.35	0.7875	-1.1461	-1.1461
0.40	0.9000	-1.1009	-1.1009
0.45	1.0125	-1.0497	-1.0497
0.50	1.1250	-0.9926	-0.9926
0.55	1.2375	-0.9294	-0.9294
0.60	1.3500	-0.8600	-0.8600
0.65	1.4625	-0.7841	-0.7841
0.70	1.5750	-0.7013	-0.7013
0.75	1.6875	-0.6113	-0.6113
0.80	1.8000	-0.5135	-0.5135
0.85	1.9125	-0.4074	-0.4074
0.90	2.0250	-0.2923	-0.2923
0.95	2.1375	-0.1679	-0.1679
0.98	2.2050	-0.0842	-0.0842
0.99	2.2275	-0.0522	-0.0522
1.00	2.2500	-0.0339	-0.0250

Foil L.E. Circle	X = 0.0250	Y = -1.2686	R = 0.0250
Foil T.E. Circle	X = 2.2250	Y = -0.0250	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250	Y = - 1.2936	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250	Y = - 1.2436	
Foil T.E. Tangency Pt. (Top)	X = 2.2444	Y = - 0.0408	
Foil T.E. Tangency Pt. (Bot)	X = 2.2056	Y = 0.0092	
Foil Nose Point	X = 0.0	Y = -1.2686	
Foil Tail Point	X = 2.2408	Y = -0.0056	

Foil Area (Less Core) = 0.1299

Gaging	LAMBDA = 0.7396	X = 1.7273	Y = -0.5776
Gaging Angle	= 40.747		
Center of Gravity	X = 1.2032	Y = -0.8107	
Radial Reference	X = 1.2058	Y = -0.8246	

Inlet Angle = 90.000
Exit Angle = 39.088
Uncovered Turning = 10.268
Constant Section Thickness = .050

UNCLASSIFIED

TABLE XLII

FIRST BLADE CASCADE TURNING VANE

Radius of 1/4R Section = 8.1806 | Axial Chord = 2.2500 | Actual Chord = 2.5554
Pitch = 1.1794 | No. of Foils = 4

Percent X	Foil	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-1.2589	-1.2339
0.01	0.0225	-1.2589	-1.2588
0.02	0.0450	-1.2588	-1.2588
0.03	0.0675	-1.2585	-1.2585
0.04	0.0900	-1.2579	-1.2579
0.05	0.1125	-1.2572	-1.2572
0.10	0.2250	-1.2499	-1.2499
0.15	0.3375	-1.2369	-1.2369
0.20	0.4500	-1.2181	-1.2181
0.25	0.5625	-1.1936	-1.1936
0.30	0.6750	-1.1633	-1.1633
0.35	0.7875	-1.1270	-1.1270
0.40	0.9000	-1.0848	-1.0848
0.45	1.0125	-1.0363	-1.0363
0.50	1.1250	-0.9817	-0.9817
0.55	1.2375	-0.9205	-0.9205
0.60	1.3500	-0.8527	-0.8527
0.65	1.4625	-0.7780	-0.7780
0.70	1.5750	-0.6960	-0.6960
0.75	1.6875	-0.6066	-0.6066
0.80	1.8000	-0.5092	-0.5092
0.85	1.9125	-0.4035	-0.4035
0.90	2.0250	-0.2892	-0.2892
0.95	2.1375	-0.1660	-0.1660
0.98	2.2050	-0.0828	-0.0828
0.99	2.2275	-0.0554	-0.0554
1.00	2.2500	-0.0340	-0.0250

Foil L.E. Circle	X = 0.0250,	Y = -1.2339,	R = 0.0250
Foil T.E. Circle	X = 2.2250,	Y = -0.0250,	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = -1.2589	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = -1.2089	
Foil T.E. Tangency Pt. (Top)	X = 2.2443,	Y = -0.0409	
Foil T.E. Tangency Pt. (Bot)	X = 2.2057,	Y = -0.0091	
Foil Nose Point	X = 0.0,	Y = -1.2339	
Foil Tail Point	X = 2.2409,	Y = -0.0057	

Foil Area (Less Core) = 0.1292

Gaging	LAMBDA = 0.7784,	X = 1.7079,	Y = -0.5895
Gaging Angle	= 41.299		
Center of Gravity	X = 1.2074,	Y = -0.7949	
Radial Reference	X = 1.2058,	Y = -0.8246	
Inlet Angle	= 90.000		
Exit Angle	= 39.608		
Uncovered Turning	= 10.281		

Constant Section Thickness = .050

UNCLASSIFIED

TABLE XLIII

FIRST BLADE CASCADE TURNING VANE

Radius of 3/8R Section = 8.5022 | Axial Chord = 2.2500 | Actual Chord = 2.5391
Pitch = 1.2258 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-1.2243	-1.1993
0.01	0.0225	-1.2243	-1.2241
0.02	0.0450	-1.2242	-1.2242
0.03	0.0675	-1.2239	-1.2239
0.04	0.0900	-1.2235	-1.2235
0.05	0.1125	-1.2229	-1.2229
0.10	0.2250	-1.2170	-1.2170
0.15	0.3375	-1.2063	-1.2063
0.20	0.4500	-1.1904	-1.1904
0.25	0.5625	-1.1692	-1.1692
0.30	0.6750	-1.1424	-1.1424
0.35	0.7875	-1.1097	-1.1097
0.40	0.9000	-1.0708	-1.0708
0.45	1.0125	-1.0253	-1.0253
0.50	1.1250	-0.9732	-0.9732
0.55	1.2375	-0.9139	-0.9139
0.60	1.3500	-0.8474	-0.8474
0.65	1.4625	-0.7734	-0.7734
0.70	1.5750	-0.6918	-0.6918
0.75	1.6875	-0.6023	-0.6023
0.80	1.8000	-0.5049	-0.5049
0.85	1.9125	-0.3995	-0.3995
0.90	2.0250	-0.2859	-0.2859
0.95	2.1375	-0.1641	-0.1641
0.98	2.2050	-0.0843	-0.0843
0.99	2.2275	-0.0535	-0.0535
1.00	2.2500	-0.0341	-0.0250

Foil L.E. Circle	X = 0.0250,	Y = -1.1993,	[illegible] = 0.0250
Foil T.E. Circle	X = 2.2250,	Y = -0.0250,	[illegible] 0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = -1.2243	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = -1.1743	
Foil T.E. Tangency Pt. (Top)	X = 2.2441,	Y = -0.0411	
Foil T.E. Tangency Pt. (Bot)	X = 2.2059,	Y = -0.0089	
Foil Nose Point	X = 0.0,	Y = 1.1993	
Foil Tail Point	X = 2.2411,	Y = -0.0058	

[illegible] (Less Core) = 0.1307

Gaging	LAMBDA = 0.8173,	X = 1.6870,	Y = -0.6027
Gaging Angle	= 41.814		
Center of Gravity	X = 1.2137,	Y = -0.7801	
Radial Reference	X = 1.2058,	Y = -0.8246	
Inlet Angle	= 90.000		
Exit Angle	= 40.109		
Uncovered Turning	= 10.214		

Constant Section Thickness = .050

UNCLASSIFIED

TABLE XLIV

FIRST BLADE CASCADE TURNING VANE

Radius of Mean Section = 8.8237 | Axial Chord = 2.2500 | Actual Chord = 2.5230
Pitch = 1.2722 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-1.1896	-1.1646
0.01	0.0225	-1.1896	-1.1895
0.02	0.0450	-1.1895	-1.1895
0.03	0.0675	-1.1893	-1.1893
0.04	0.0900	-1.1890	-1.1890
0.05	0.1125	-1.1885	-1.1885
0.10	0.2250	-1.1838	-1.1838
0.15	0.3375	-1.1749	-1.1749
0.20	0.4500	-1.1616	-1.1616
0.25	0.5625	-1.1433	-1.1433
0.30	0.6750	-1.1197	-1.1197
0.35	0.7875	-1.0903	-1.0903
0.40	0.9000	-1.0547	-1.0547
0.45	1.0125	-1.0123	-1.0123
0.50	1.1250	-0.9630	-0.9630
0.55	1.2375	-0.9061	-0.9061
0.60	1.3500	-0.8415	-0.8415
0.65	1.4625	-0.7690	-0.7690
0.70	1.5750	-0.6882	-0.6882
0.75	1.6875	-0.5994	-0.5994
0.80	1.8000	-0.5023	-0.5023
0.85	1.9125	-0.3973	-0.3973
0.90	2.0250	-0.2841	-0.2841
0.95	2.1375	-0.1631	-0.1631
0.98	2.2050	-0.0853	-0.0853
0.99	2.2275	-0.0605	-0.0605
1.00	2.2500	-0.0341	-0.0250

Foil L.E. Circle	X = 0.0250,	Y = -1.1646,	R = 0.0250
Foil T.E. Circle	X = 2.2250,	Y = -0.0250,	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = -1.1896	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = -1.1396	
Foil T.E. Tangency Pt. (Top)	X = 2.2441,	Y = -0.0411	
Foil T.E. Tangency Pt. (Bot)	X = 2.2060,	Y = -0.0088	
Foil Nose Point	X = 0.0,	Y = -1.1646	
Foil Tail Point	X = 2.2412,	Y = -0.0059	

Foil Area (Less Core) = 0.1331

Gaging	LAMBDA = 0.8554,	X = 1.6690,	Y = -0.6145
Gaging Angle	= 42.250		
Center of Gravity	X = 1.2171,	Y = -0.7663	
Radial Reference	X = 1.2058,	Y = -0.8246	
Inlet Angle	= 90.000		
Exit Angle	= 40.381		
Uncovered Turning	= 10.494		

Constant Section Thickness = .050

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TABLE XLV

FIRST BLADE CASCADE TURNING VANE

Radius of 1/8T Section = 9.1453
Pitch = 1.3185

Axial Chord = 2.2500
No. of Foils = 4

Actual Chord = 2.5072

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-1.1548	-1.1298
0.01	0.0225	-1.1548	-1.1547
0.02	0.0450	-1.1548	-1.1548
0.03	0.0675	-1.1546	-1.1546
0.04	0.0900	-1.1543	-1.1543
0.05	0.1125	-1.1539	-1.1539
0.10	0.2250	-1.1497	-1.1497
0.15	0.3375	-1.1418	-1.1418
0.20	0.4500	-1.1298	-1.1298
0.25	0.5625	-1.1132	-1.1132
0.30	0.6750	-1.0917	-1.0917
0.35	0.7875	-1.0647	-1.0647
0.40	0.9000	-1.0318	-1.0318
0.45	1.0125	-0.9924	-0.9924
0.50	1.1250	-0.9462	-0.9462
0.55	1.2375	-0.8925	-0.8925
0.60	1.3500	-0.8311	-0.8311
0.65	1.4625	-0.7616	-0.7616
0.70	1.5750	-0.6836	-0.6836
0.75	1.6875	-0.5969	-0.5969
0.80	1.8000	-0.5013	-0.5013
0.85	1.9125	-0.3970	-0.3970
0.90	2.0250	-0.2841	-0.2841
0.95	2.1375	-0.1630	-0.1630
0.98	2.2050	-0.0847	-0.0847
0.99	2.2275	-0.0583	-0.0583
1.00	2.2500	-0.0342	-0.0250

Foil L.E. Circle	X = 0.0250,	Y = -1.1298,	R = 0.0250
Foil T.E. Circle	X = 2.2250,	Y = -0.0250,	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = -1.1548	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = -1.1048	
Foil T.E. Tangency Pt. (Top)	X = 2.2440,	Y = -0.0412	
Foil T.E. Tangency Pt. (Bot)	X = 2.2060,	Y = -0.0088	
Foil Nose Point	X = 0.0,	Y = -1.1298	
Foil Tail Point	X = 2.2412,	Y = -0.0060	

Foil Area (Less Core) = 0.1344

Gaging	LAMBDA = 0.8939,	X = 1.6566,	Y = -0.6216
Gaging Angle	= 42.683		
Center of Gravity	X = 1.2099,	Y = -0.7545	
Radial Reference	X = 1.2058,	Y = -0.8246	
Inlet Angle	= 90.000		
Exit Angle	= 40.399		
Uncovered Turning	= 11.389		

Constant Section Thickness = .050

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TABLE XLVI

FIRST BLADE CASCADE TURNING VANE

Radius of 1/4T Section = 9.4668 | Axial Chord = 2.2500 | Actual Chord = 2.4920
Pitch = 1.3649 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-1.1203	-1.0953
0.01	0.0225	-1.1203	-1.1202
0.02	0.0450	-1.1202	-1.1202
0.03	0.0675	-1.1201	-1.1201
0.04	0.0900	-1.1198	-1.1198
0.05	0.1125	-1.1193	-1.1193
0.10	0.2250	-1.1150	-1.1150
0.15	0.3375	-1.1069	-1.1069
0.20	0.4500	-1.0948	-1.0948
0.25	0.5625	-1.0783	-1.0783
0.30	0.6750	-1.0572	-1.0572
0.35	0.7875	-1.0309	-1.0309
0.40	0.9000	-0.9992	-0.9992
0.45	1.0125	-0.9616	-0.9616
0.50	1.1250	-0.9176	-0.9176
0.55	1.2375	-0.8667	-0.8667
0.60	1.3500	-0.8085	-0.8085
0.65	1.4625	-0.7425	-0.7425
0.70	1.5750	-0.6682	-0.6682
0.75	1.6875	-0.5850	-0.5850
0.80	1.8000	-0.4927	-0.4927
0.85	1.9125	-0.3910	-0.3910
0.90	2.0250	-0.2803	-0.2803
0.95	2.1375	-0.1611	-0.1611
0.98	2.2050	-0.0818	-0.0818
0.99	2.2275	-0.0522	-0.0522
1.00	2.2500	-0.0344	-0.0250

Foil L.E. Circle	X = 0.0250,	Y = -1.0953,	R = 0.0250
Foil T.E. Circle	X = 2.2250,	Y = -0.0250,	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = -1.1203	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = -1.0703	
Foil T.E. Tangency Pt. (Top)	X = 2.2439,	Y = -0.0414	
Foil T.E. Tangency Pt. (Bot)	X = 2.2061,	Y = -0.0086	
Foil Nose Point	X = 0.0,	Y = -1.0953	
Foil Tail Point	X = 2.2414,	Y = -0.0061	

Foil Area (Less Core) = 0.1341

Gaging	LAMBDA = 0.9409,	X = 1.6463,	Y = -0.6165
Gaging Angle	= 43.579		
Center of Gravity	X = 1.1980,	Y = -0.7380	
Radial Reference	X = 1.2058,	Y = -0.8246	
Inlet Angle	= 90.000		
Exit Angle	= 40.903		
Uncovered Turning	= 12.248		

Constant Section Thickness = .050

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TABLE XLVII

FIRST BLADE CASCADE TURNING VANE

Radius of 3/8T Section = 9.7884 | Axial Chord = 2.2500 | Actual Chord = 2.4776
Pitch = 1.4113 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-1.0863	-1.0613
0.01	0.0225	-1.0863	-1.0861
0.02	0.0450	-1.0862	-1.0862
0.03	0.0675	-1.0860	-1.0860
0.04	0.0900	-1.0856	-1.0856
0.05	0.1125	-1.0850	-1.0850
0.10	0.2250	-1.0798	-1.0798
0.15	0.3375	-1.0704	-1.0704
0.20	0.4500	-1.0567	-1.0567
0.25	0.5625	-1.0385	-1.0385
0.30	0.6750	-1.0156	-1.0156
0.35	0.7875	-0.9879	-0.9879
0.40	0.9000	-0.9551	-0.9551
0.45	1.0125	-0.9169	-0.9169
0.50	1.1250	-0.8729	-0.8729
0.55	1.2375	-0.8229	-0.8229
0.60	1.3500	-0.7665	-0.7665
0.65	1.4625	-0.7031	-0.7031
0.70	1.5750	-0.6324	-0.6324
0.75	1.6875	-0.5538	-0.5538
0.80	1.8000	-0.4668	-0.4668
0.85	1.9125	-0.3712	-0.3712
0.90	2.0250	-0.2670	-0.2670
0.95	2.1375	-0.1546	-0.1546
0.98	2.2050	-0.0809	-0.0809
0.99	2.2275	-0.0535	-0.0535
1.00	2.2500	-0.0348	-0.0250

Foil L.E. Circle	X = 0.0250,	Y = -1.0613,	R = 0.0250
Foil T.E. Circle	X = 2.2249,	Y = -0.0250,	R = 0.0251
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = -1.0863	
Foil L.E. Tangency Pt. (Bot)	X = 0.02[illegible]0,	Y = -1.0363	
Foil T.E. Tangency Pt. (Top)	X = 2.2434,	Y = -0.0420	
Foil T.E. Tangency Pt. (Bot)	X = 2.2064,	Y = -0.0080	
Foil Nose Point	X = 0.0,	Y = -1.0613	
Foil Tail Point	X = 2.2419,	Y = -0.0065	

Foil Area (Less Core) = 0.1325

Gaging	LAMBDA = 1.0052,	X = 1.6341,	Y = -0.5921
Gaging Angle	= 45.419		
Center of Gravity	X = 1.1913,	Y = -0.7088	
Radial Reference	X = 1.2058,	Y = -0.8246	
Inlet Angle	= 90.000		
Exit Angle	= 42.620		
Uncovered Turning	= 12.378		

Constant Section Thickness = .050

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TABLE XLVIII

FIRST BLADE CASCADE TURNING VANE

Radius of Tip Section = 10.1100 | Axial Chord = 2.2500 | Actual Chord = 2.4640
Pitch = 1.4576 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-1.0528	-1.0278
0.01	0.0225	-1.0528	-1.0527
0.02	0.0450	-1.0527	-1.0527
0.03	0.0675	-1.0524	-1.0524
0.04	0.0900	-1.0519	-1.0519
0.05	0.1125	-1.0512	-1.0512
0.10	0.2250	-1.0444	-1.0444
0.15	0.3375	-1.0325	-1.0325
0.20	0.4500	-1.0155	-1.0155
0.25	0.5625	-0.9937	-0.9937
0.30	0.6750	-0.9669	-0.9669
0.35	0.7875	-0.9354	-0.9354
0.40	0.9000	-0.8990	-0.8990
0.45	1.0125	-0.8577	-0.8577
0.50	1.1250	-0.8115	-0.8115
0.55	1.2375	-0.7602	-0.7602
0.60	1.3500	-0.7038	-0.7038
0.65	1.4625	-0.6420	-0.6420
0.70	1.5750	-0.5746	-0.5746
0.75	1.6875	-0.5014	-0.5014
0.80	1.8000	-0.4219	-0.4219
0.85	1.9125	-0.3360	-0.3360
0.90	2.0250	-0.2431	-0.2431
0.95	2.1375	-0.1430	-0.1430
0.98	2.2050	-0.0794	-0.0794
0.99	2.2275	-0.0576	-0.0576
1.00	2.2500	-0.0355	-0.0250

Foil L.E. Circle	X = 0.0250,	Y = -1.0278,	R = 0.0250
Foil T.E. Circle	X = 2.2250,	Y = -0.0250,	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = -1.0528	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = -1.0028	
Foil T.E. Tangency Pt. (Top)	X = 2.2426,	Y = -0.0428	
Foil T.E. Tangency Pt. (Bot)	X = 2.2075,	Y = -0.0073	
Foil Nose Point	X = 0.0,	Y = -1.0278	
Foil Tail Point	X = 2.2428,	Y = -0.0075	

Foil Area (Less Core) = 0.1293

Gaging	LAMBDA = 1.0901,	X = 1.6200,	Y = -0.5460
Gaging Angle	= 48.403		
Center of Gravity	X = 1.1891,	Y = -0.6672	
Radial Reference	X = 1.2058,	Y = -0.8246	
Inlet Angle	= 90.000		
Exit Angle	= 45.388		
Uncovered Turning	= 11.766		

Constant Section Thickness = .050

TABLE XLIX

SECOND VANE CASCADE TURNING VANE

Radius of Root Section = 7.5000 | Axial Chord = 3.2500 | Actual Chord = 3.7443
Pitch = 1.5708 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	1.9060	1.8810
0.01	0.0325	1.9060	1.9060
0.02	0.0650	1.9058	1.9058
0.03	0.0975	1.9052	1.9052
0.04	0.1300	1.9044	1.9044
0.05	0.1625	1.9032	1.9032
0.10	0.3250	1.8926	1.8926
0.15	0.4875	1.8737	1.8737
0.20	0.6500	1.8462	1.8462
0.25	0.8125	1.8098	1.8098
0.30	0.9750	1.7642	1.7642
0.35	1.1375	1.7091	1.7091
0.40	1.3000	1.6443	1.6443
0.45	1.4625	1.5694	1.5694
0.50	1.6250	1.4842	1.4842
0.55	1.7875	1.3885	1.3885
0.60	1.9500	1.2822	1.2822
0.65	2.1125	1.1649	1.1649
0.70	2.2750	1.0367	1.0367
0.75	2.4375	0.8975	0.8975
0.80	2.6000	0.7470	0.7470
0.85	2.7625	0.5854	0.5854
0.90	2.9250	0.4127	0.4127
0.95	3.0875	0.2289	0.2289
0.98	3.1850	0.1101	0.1101
0.99	3.2175	0.0725	0.0725
1.00	3.2500	0.0339	0.0250

Foil L.E. Circle	X = 0.0250,	Y = 1.8810,	R = 0.0250
Foil T.E. Circle	X = 3.2250,	Y = 0.0250,	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = 1.9060	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = 1.8560	
Foil T.E. Tangency Pt. (Top)	X = 3.2444,	Y = 0.0408	
Foil T.E. Tangency Pt. (Bot)	X = 3.2056,	Y = 0.0093	
Foil Nose Point	X = 0.0,	Y = 1.8810	
Foil Tail Point	X = 3.2407,	Y = 0.0056	

Foil Area (Less Core) = 0.1968

Gaging	LAMBDA = 1.0214,	X = 2.5142,	Y = 0.8279
Gaging Angle	= 40.560		
Center of Gravity	X = 1.7484,	Y = 1.2099	
Radial Reference	X = 1.7484,	Y = 1.2099	
Inlet Angle	= 90.009		
Exit Angle	= 39.063		
Uncovered Turning	= 8.194		

Constant Section Thickness = .050

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TABLE L

SECOND VANE CASCADE TURNING VANE

Radius of 1/8R Section = 7.8905 | Axial Chord = 3.2500 | Actual Chord = 3.6746
Pitch = 1.6526 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	1.7623	1.7373
0.01	0.0325	1.7623	1.7623
0.02	0.0650	1.7621	1.7621
0.03	0.0975	1.7617	1.7617
0.04	0.1300	1.7611	1.7611
0.05	0.1625	1.7602	1.7602
0.10	0.3250	1.7521	1.7521
0.15	0.4875	1.7375	1.7375
0.20	0.6500	1.7157	1.7157
0.25	0.8125	1.6864	1.6864
0.30	0.9750	1.6489	1.6489
0.35	1.1375	1.6026	1.6026
0.40	1.3000	1.5469	1.5469
0.45	1.4625	1.4815	1.4815
0.50	1.6250	1.4056	1.4056
0.55	1.7875	1.3190	1.3190
0.60	1.9500	1.2212	1.2212
0.65	2.1125	1.1121	1.1121
0.70	2.2750	0.9915	0.9915
0.75	2.4375	0.8594	0.8594
0.80	2.6000	0.7161	0.7161
0.85	2.7625	0.5616	0.5616
0.90	2.9250	0.3963	0.3963
0.95	3.0875	0.2204	0.2204
0.98	3.1850	0.1096	0.1096
0.99	3.2175	0.0703	0.0703
1.00	3.2500	0.0342	0.0250

Foil L.E. Circle	X = 0.0250,	Y = 1.7373,	R = 0.0250
Foil T.E. Circle	X = 3.2251,	Y = 0.0250,	R = 0.0249
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = 1.7623	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = 1.7123	
Foil T.E. Tangency Pt. (Top)	X = 3.2441,	Y = 0.0412	
Foil T.E. Tangency Pt. (Bot)	X = 3.2060,	Y = 0.0089	
Foil Nose Point	X = 0.0,	Y = 1.7373	
Foil Tail Point	X = 3.2412,	Y = 0.0060	

Foil Area (Less Core) = 0.1917

Gaging	LAMBDA = 1.1088,	X = 2.4823,	Y = 0.8210
Gaging Angle	= 42.143		
Center of Gravity	X = 1.7482,	Y = 1.1345	
Radial Reference	X = 1.7484,	Y = 1.2099	
Inlet Angle	= 90.010		
Exit Angle	= 40.292		
Uncovered Turning	= 8.782		

Constant Section Thickness = .050

UNCLASSIFIED

TABLE LI

SECOND VANE CASCADE TURNING VANE

Radius of 1/4R Section = 8.2810
Pitch = 1.7344

Axial Chord = 3.2500
No. of Foils = 4

Actual Chord = 3.6127

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	1.6260	1.6010
0.01	0.0325	1.6260	1.6260
0.02	0.0650	1.6259	1.6259
0.03	0.0975	1.6255	1.6255
0.04	0.1300	1.6250	1.6250
0.05	0.1625	1.6243	1.6243
0.10	0.3250	1.6177	1.6177
0.15	0.4875	1.6055	1.6055
0.20	0.6500	1.5872	1.5872
0.25	0.8125	1.5621	1.5621
0.30	0.9750	1.5296	1.5296
0.35	1.1375	1.4891	1.4891
0.40	1.3000	1.4398	1.4398
0.45	1.4625	1.3812	1.3812
0.50	1.6250	1.3126	1.3126
0.55	1.7875	1.2336	1.2336
0.60	1.9500	1.1437	1.1437
0.65	2.1125	1.0428	1.0428
0.70	2.2750	0.9307	0.9307
0.75	2.4375	0.8074	0.8074
0.80	2.6000	0.6733	0.6733
0.85	2.7625	0.5286	0.5286
0.90	2.9250	0.3738	0.3738
0.95	3.0875	0.2090	0.2090
0.98	3.1850	0.1038	0.1038
0.99	3.2175	0.0671	0.0671
1.00	3.2500	0.0347	0.0250

Foil L.E. Circle	X = 0.0250,	Y = 1.6010,	R = 0.0250
Foil T.E. Circle	X = 3.2250,	Y = 0.0250,	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = 1.6260	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = 1.5760	
Foil T.E. Tangency Pt. (Top)	X = 3.2435,	Y = 0.0418	
Foil T.E. Tangency Pt. (Bot)	X = 3.2065,	Y = 0.0082	
Foil Nose Point	X = 0.0,	Y = 1.6010	
Foil Tail Point	X = 3.2418,	Y = 0.0065	

Foil Area (Less Core) = 0.1854

Gaging	LAMBDA = 1.2103,	X = 2.4540,	Y = 0.7943
Gaging Angle	= 44.251		
Center of Gravity	X = 1.7350,	Y = 1.0601	
Radial Reference	X = 1.7484,	Y = 1.2099	
Inlet Angle	= 90.008		
Exit Angle	= 42.295		
Uncovered Turning	= 9.065		

Constant Section Thickness = .050

UNCLASSIFIED

TABLE LII

SECOND VANE CASCADE TURNING VANE

Radius of 3/8R Section = 8.6715
Pitch = 1.8162

Axial Chord - 3.2500
No. of Foils = 4

Actual Chord = 3.5566

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	1.4934	1.4684
0.01	0.0325	1.4933	1.4933
0.02	0.0650	1.4932	1.4932
0.03	0.0975	1.4929	1.4929
0.04	0.1300	1.4925	1.4925
0.05	0.1625	1.4918	1.4918
0.10	0.3250	1.4857	1.4857
0.15	0.4875	1.4745	1.4745
0.20	0.6500	1.4577	1.4577
0.25	0.8125	1.4347	1.4347
0.30	0.9750	1.4048	1.4048
0.35	1.1375	1.3676	1.3676
0.40	1.3000	1.3224	1.3224
0.45	1.4625	1.2686	1.2686
0.50	1.6250	1.2057	1.2057
0.55	1.7875	1.1332	1.1332
0.60	1.9500	1.0510	1.0510
0.65	2.1125	0.9585	0.9585
0.70	2.2750	0.8559	0.8559
0.75	2.4375	0.7431	0.7431
0.80	2.6000	0.6203	0.6203
0.85	2.7625	0.4877	0.4877
0.90	2.9250	0.3459	0.3459
0.95	3.0875	0.1950	0.1950
0.98	3.1850	0.1028	0.1028
0.99	3.2175	0.0674	0.0674
1.00	3.2500	0.0353	0.0250

Foil L.E. Circle	X = 0.0250,	Y = 1.4684,	R = 0.0250
Foil T.E. Circle	X = 3.2250,	Y = 0.0250,	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = 1.4934	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = 1.4434	
Foil T.E. Tangency Pt. (Top)	X = 3.2427,	Y = 0.0426	
Foil T.E. Tangency Pt. (Bot)	X = 3.2073,	Y = 0.0074	
Foil Nose Point	X = 0.0000,	Y = 1.4684	
Foil Tail Point	X = 3.2426,	Y = 0.0072	

Foil Area (Less Core) = 0.1790

Gaging	LAMBDA = 1.3263,	X = 2.4329,	Y = 0.7464
Gaging Angle	= 46.908		
Center of Gravity	X = 1.7164,	Y = 0.9806	
Radial Reference	X = 1.7484,	Y = 1.2099	
Inlet Angle	= 90.081		
Exit Angle	= 44.835		
Uncovered Turning	= 9.241		

Constant Section Thickness = .050

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TABLE LIII

SECOND VANE CASCADE TURNING VANE

Radius of Mean Section = 9.0625
Pitch = 1.8980

Axial Chord = 3.2500
No. of Foils = 4

Actual Chord = 3.4991

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	1.3460	1.3210
0.01	0.0325	1.3460	1.3460
0.02	0.0650	1.3459	1.3459
0.03	0.0975	1.3456	1.3456
0.04	0.1300	1.3452	1.3452
0.05	0.1625	1.3446	1.3446
0.10	0.3250	1.3390	1.3390
0.15	0.4875	1.3287	1.3287
0.20	0.6500	1.3133	1.3133
0.25	0.8125	1.2924	1.2924
0.30	0.9750	1.2654	1.2654
0.35	1.1375	1.2319	1.2319
0.40	1.3000	1.1913	1.1913
0.45	1.4625	1.1431	1.1431
0.50	1.6250	1.0869	1.0869
0.55	1.7875	1.0223	1.0223
0.60	1.9500	0.9489	0.9489
0.65	2.1125	0.8665	0.8665
0.70	2.2750	0.7749	0.7749
0.75	2.4375	0.6741	0.6741
0.80	2.6000	0.5641	0.5641
0.85	2.7625	0.4451	0.4451
0.90	2.9250	0.3173	0.3173
0.95	3.0875	0.1809	0.1809
0.98	3.1850	0.0977	0.0977
0.99	3.2175	0.0752	0.0752
1.00	3.2500	0.0360	0.0250

Foil L.E. Circle	X = 0.0250,	Y = 1.3210	R = 0.0250
Foil T.E. Circle	X = 3.2251,	Y = 0.0250,	R = 0.0249
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = 1.3460	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = 1.2960	
Foil T.E. Tangency Pt. (Top)	X = 3.2419,	Y = 0.0434	
Foil T.E. Tangency Pt. (Bot)	X = 3.2082,	Y = 0.0066	
Foil Nose Point	X = 0.0,	Y = 1.3210	
Foil Tail Point	X = 3.2434,	Y = 0.0082	

Foil Area (Less Core) = 0.1738

Gaging	LAMBDA = 1.4515,	X = 2.4257,	Y = 0.6817
Gaging Angle	= 49.884		
Center of Gravity	X = 1.7002,	Y = 0.8902	
Radial Reference	X = 1.7484,	Y = 1.2099	
Inlet Angle	= 90.008		
Exit Angle	= 47.507		
Uncovered Turning	= 9.646		

Constant Section Thickness = .050

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TABLE LIV

SECOND VANE CASCADE TURNING VANE

Radius of 1/8T Section = 9.4531
Pitch = 1.9799

Axial Chord - 3.2500
No. of Foils = 4

Actual Chord = 3.4371

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	1.1693	1.1443
0.01	0.0325	1.1693	1.1693
0.02	0.0650	1.1692	1.1692
0.03	0.0975	1.1690	1.1690
0.04	0.1300	1.1687	1.1687
0.05	0.1625	1.1682	1.1682
0.10	0.3250	1.1638	1.1638
0.15	0.4875	1.1559	1.1559
0.20	0.6500	1.1437	1.1437
0.25	0.8125	1.1271	1.1271
0.30	0.9750	1.1055	1.1055
0.35	1.1375	1.0785	1.0785
0.40	1.3000	1.0456	1.0456
0.45	1.4625	1.0062	1.0062
0.50	1.6250	0.9598	0.9598
0.55	1.7875	0.9059	0.9059
0.60	1.9500	0.8441	0.8441
0.65	2.1125	0.7740	0.7740
0.70	2.2750	0.6954	0.6954
0.75	2.4375	0.6080	0.6080
0.80	2.6000	0.5117	0.5117
0.85	2.7625	0.4063	0.4063
0.90	2.9250	0.2919	0.2919
0.95	3.0875	0.1686	0.1686
0.98	3.1850	0.0923	0.0923
0.99	3.2175	0.0635	0.0635
1.00	3.2500	0.0367	0.0250

Foil L.E. Circle	X = 0.0249,	Y = 1.1443,	R = 0.0249
Foil T.E. Circle	X = 3.2250,	Y = 0.0250	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = 1.1693	
Foil L.E. Tangency Pt. (Bot)	X = 0.0249,	Y = 1.1194	
Foil T.E. Tangency Pt. (Top)	X = 3.2410,	Y = 0.0442	
Foil T.E. Tangency Pt. (Bot)	X = 3.2090,	Y = 0.0059	
Foil Nose Point	X = 0.0000,	Y = 1.1444	
Foil Tail Point	X = 3.2442,	Y = 0.0090	

Foil Area (Less Core) = 0.1703

Gaging	LAMBDA = 1.5786,	X = 2.4360,	Y = 0.6089
Gaging Angle	= 52.876		
Center of Gravity	X = 1.6905,	Y = 0.7876	
Radial Reference	X = 1.7484,	Y = 1.2099	
Inlet Angle	= 90.054		
Exit Angle	= 50.098		
Uncovered Turning	= 10.425		

Constant Section Thickness = .050

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TABLE LV

SECOND VANE CASCADE TURNING VANE

Radius of 1/4T Section = 9.8437 | Axial Chord = 3.2500 | Actual Chord = 3.3792
Pitch = 2.0617 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	0.9780	0.9530
0.01	0.0325	0.9780	0.9780
0.02	0.0650	0.9779	0.9779
0.03	0.0975	0.9778	0.9778
0.04	0.1300	0.9776	0.9776
0.05	0.1625	0.9773	0.9773
0.10	0.3250	0.9744	0.9744
0.15	0.4875	0.9692	0.9692
0.20	0.6500	0.9611	0.9611
0.25	0.8125	0.9499	0.9499
0.30	0.9750	0.9351	0.9351
0.35	1.1375	0.9161	0.9161
0.40	1.3000	0.8925	0.8925
0.45	1.4625	0.8637	0.8637
0.50	1.6250	0.8288	0.8288
0.55	1.7875	0.7874	0.7874
0.60	1.9500	0.7388	0.7388
0.65	2.1125	0.6822	0.6822
0.70	2.2750	0.6172	0.6172
0.75	2.4375	0.5435	0.5435
0.80	2.6000	0.4607	0.4607
0.85	2.7625	0.3688	0.3688
0.90	2.9250	0.2677	0.2677
0.95	3.0875	0.1573	0.1573
0.98	3.1850	0.0850	0.0850
0.99	3.2175	0.0601	0.0601
1.00	3.2500	0.0374	0.0250

Foil L.E. Circle	X = 0.0250,	Y = 0.9530,	R = 0.0250
Foil T.E. Circle	X = 3.2250,	Y = 0.0250,	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = 0.9780	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = 0.9280	
Foil T.E. Tangency Pt. (Top)	X = 3.2401,	Y = 0.0449	
Foil T.E. Tangency Pt. (Bot)	X = 3.2098,	Y = 0.0051	
Foil Nose Point	X = 0.0,	Y = 0.9530	
Foil Tail Point	X = 3.2449,	Y = 0.0098	

Foil Area (Less Core) = 0.1686

Gaging	LAMBDA = 1.7071,	X = 2.4622,	Y = 0.5315
Gaging Angle	= 55.898		
Center of Gravity	X = 1.6898,	Y = 0.6754	
Radial Reference	X = 1.7484,	Y = 1.2099	
Inlet Angle	= 90.00		
Exit Angle	= 52.647		
Uncovered Turning	= 11.247		

Constant Section Thickness = .050

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TABLE LVI

SECOND VANE CASCADE TURNING VANE

Radius of 3/8T Section = 10.2344 | Axial Chord = 3.2500 | Actual Chord = 3.3321
Pitch = 2.1435 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	0.7902	0.7652
0.01	0.0325	0.7902	0.7902
0.02	0.0650	0.7902	0.7902
0.03	0.0975	0.7901	0.7901
0.04	0.1300	0.7900	0.7900
0.05	0.1625	0.7898	0.7898
0.10	0.3250	0.7883	0.7883
0.15	0.4875	0.7855	0.7855
0.20	0.6500	0.7810	0.7810
0.25	0.8125	0.7747	0.7747
0.30	0.9750	0.7661	0.7661
0.35	1.1375	0.7547	0.7547
0.40	1.3000	0.7401	0.7401
0.45	1.4625	0.7216	0.7216
0.50	1.6250	0.6984	0.6984
0.55	1.7875	0.6695	0.6695
0.60	1.9500	0.6340	0.6340
0.65	2.1125	0.5906	0.5906
0.70	2.2750	0.5387	0.5387
0.75	2.4375	0.4776	0.4776
0.80	2.6000	0.4076	0.4076
0.85	2.7625	0.3289	0.3289
0.90	2.9250	0.2417	0.2417
0.95	3.0875	0.1453	0.1453
0.98	3.1850	0.0818	0.0818
0.99	3.2175	0.0566	0.0566
1.00	3.2500	0.0381	0.0250

Foil L.E. Circle	X = 0.0250,	Y = 0.7652,	R = 0.0250
Foil T.E. Circle	X = 3.2249,	Y = 0.0250,	R = 0.0251
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = 0.7902	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = 0.7402	
Foil T.E. Tangency Pt. (Top)	X = 3.2392,	Y = 0.0456	
Foil T.E. Tangency Pt. (Bot)	X = 3.2106,	Y = 0.0044	
Foil Nose Point	X = 0.0,	Y = 0.7652	
Foil Tail Point	X = 3.2455,	Y = 0.0107	

Foil Area (Less Core) = 0.1668

Gaging	LAMBDA = 1.8385,	X = 2.4970,	Y = 0.4530
Gaging Angle	= 59.060		
Center of Gravity	X = 1.6829,	Y = 0.5648	
Radial Reference	X = 1.7484,	Y = 1.2099	
Inlet Angle	= 90.004		
Exit Angle	= 55.224		
Uncovered Turning	= 11.814		

Constant Section Thickness = .050

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TABLE LVII

SECOND VANE CASCADE TURNING VANE

Radius of Tip Section = 10.6250
Pitch = 2.2253

Axial Chord = 3.2500
No. of Foils = 4

Actual Chord = 3.2963

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	0.6097	0.5847
0.01	0.0325	0.6097	0.6097
0.02	0.0650	0.6097	0.6097
0.03	0.0975	0.6097	0.6097
0.04	0.1300	0.6096	0.6096
0.05	0.1625	0.6096	0.6096
0.10	0.3250	0.6091	0.6091
0.15	0.4875	0.6081	0.6081
0.20	0.6500	0.6065	0.6065
0.25	0.8125	0.6042	0.6042
0.30	0.9750	0.6009	0.6009
0.35	1.1375	0.5963	0.5963
0.40	1.3000	0.5900	0.5900
0.45	1.4625	0.5812	0.5812
0.50	1.6250	0.5692	0.5692
0.55	1.7875	0.5526	0.5526
0.60	1.9500	0.5299	0.5299
0.65	2.1125	0.4993	0.4993
0.70	2.2750	0.4594	0.4594
0.75	2.4375	0.4098	0.4098
0.80	2.6000	0.3516	0.3516
0.85	2.7625	0.2859	0.2859
0.90	2.9250	0.2132	0.2132
0.95	3.0875	0.1324	0.1324
0.98	3.1850	0.0759	0.0759
0.99	3.2175	0.0559	0.0559
1.00	3.2500	0.0388	0.0250

Foil L.E. Circle	X = 0.0250,	Y = 0.5847,	R = 0.0250
Foil T.E. Circle	X = 3.2250,	Y = 0.0250,	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = 0.6097	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = 0.5597	
Foil T.E. Tangency Pt. (Top)	X = 3.2383,	Y = 0.0462	
Foil T.E. Tangency Pt. (Bot)	X = 3.2116,	Y = 0.0038	
Foil Nose Point	X = 0.0,	Y = 0.5847	
Foil Tail Point	X = 3.2461,	Y = 0.0117	

Foil Area (Less Core) = 0.1657

Gaging	LAMBDA = 1.9724,	X = 2.5401,	Y = 0.3739
Gaging Angle	= 62.419		
Center of Gravity	X = 1.6755,	Y = 0.4536	
Radial Reference	X = 1.7484,	Y = 1.2099	
Inlet Angle	= 90.018		
Exit Angle	= 57.792		
Uncovered Turning	= 12.138		

Constant Section Thickness = .050

[redacted]

TABLE LVIII

SECOND VANE CASCADE TURNING VANE

Radius of Root Section = 7.4600 Axial Chord = 2.2500 Actual Chord = 2.4356
Pitch = 0.9920 No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-0.9822	-0.9572
0.01	0.0225	-0.9822	-0.9821
0.02	0.0450	-0.9822	-0.9822
0.03	0.0675	-0.9820	-0.9820
0.04	0.0900	-0.9818	-0.9818
0.05	0.1125	-0.9814	-0.9814
0.10	0.2250	-0.9778	-0.9778
0.15	0.3375	-0.9710	-0.9710
0.20	0.4500	-0.9607	-0.9607
0.25	0.5625	-0.9466	-0.9466
0.30	0.6750	-0.9283	-0.9283
0.35	0.7875	-0.9054	-0.9054
0.40	0.9000	-0.8775	-0.8775
0.45	1.0125	-0.8441	-0.8441
0.50	1.1250	-0.8049	-0.8049
0.55	1.2375	-0.7595	-0.7595
0.60	1.3500	-0.7075	-0.7075
0.65	1.4625	-0.6486	-0.6486
0.70	1.5750	-0.5827	-0.5827
0.75	1.6875	-0.5094	-0.5094
0.80	1.8000	-0.4290	-0.4290
0.85	1.9125	-0.3412	-0.3412
0.90	2.0250	-0.2463	-0.2463
0.95	2.1375	-0.1443	-0.1443
0.98	2.2050	-0.0799	-0.0799
0.99	2.2275	-0.0577	-0.0577
1.00	2.2500	-0.0353	-0.0250

Foil L.E. Circle	X = 0.0250,	Y = -0.9572,	R = 0.0250
Foil T.E. Circle	X = 2.2250,	Y = -0.0250,	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = -0.9822	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = -0.9322	
Foil T.E. Tangency Pt. (Top)	X = 2.2426,	Y = -0.0427	
Foil T.E. Tangency Pt. (Bot)	X = 2.2074,	Y = -0.0073	
Foil Nose Point	X = 0.0,	Y = -0.9572	
Foil Tail Point	X = 2.2427,	Y = -0.0074	

Foil Area (Less Core) = 0.1257

Gaging	LAMBDA = 0.7005,	X - 1.7921	Y = -0.4349
Gaging Angle	= 44.921		
Center of Gravity	X = 1.1744,	Y = -0.6545	
Radial Reference	X = 1.1744,	Y = -0.6545	
Inlet Angle	= 90.000		
Exit Angle	= 45.154		
Uncovered Turning	= 8.232		

Constant Section Thickness = .050

[redacted]

TABLE LIX

SECOND BLADE CASCADE TURNING VANE

Radius of 1/8R Section = 7.9487
Pitch = 1.0570

Axial Chord = 2.2500
No. of Foils = 4

Actual Chord = 2.4378

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-0.9878	-0.9628
0.01	0.0225	-0.9878	-0.9876
0.02	0.0450	-0.9877	-0.9877
0.03	0.0675	-0.9876	-0.9876
0.04	0.0900	-0.9873	-0.9873
0.05	0.1125	-0.9870	-0.9870
0.10	0.2250	-0.9833	-0.9833
0.15	0.3375	-0.9764	-0.9764
0.20	0.4500	-0.9659	-0.9659
0.25	0.5625	-0.9514	-0.9514
0.30	0.6750	-0.9327	-0.9327
0.35	0.7875	-0.9094	-0.9094
0.40	0.9000	-0.8808	-0.8808
0.45	1.0125	-0.8465	-0.8465
0.50	1.1250	-0.8066	-0.8066
0.55	1.2375	-0.7601	-0.7601
0.60	1.3500	-0.7072	-0.7072
0.65	1.4625	-0.6475	-0.6475
0.70	1.5750	-0.5809	-0.5809
0.75	1.6875	-0.5072	-0.5072
0.80	1.8000	-0.4266	-0.4266
0.85	1.9125	-0.3389	-0.3389
0.90	2.0250	-0.2443	-0.2443
0.95	2.1375	-0.1433	-0.1433
0.98	2.2050	-0.0796	-0.0796
0.99	2.2275	-0.0577	-0.0577
1.00	2.2500	-0.0355	-0.0250

Foil L.E. Circle	X = 0.0250,	Y = -0.9628,	R = 0.0250
Foil T.E. Circle	X = 2.2250,	Y = 0.0250,	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = -0.9878	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = -0.9378	
Foil T.E. Tangency Pt. (Top)	X = 2.2425,	Y = -0.0428	
Foil T.E. Tangency Pt. (Bot)	X = 2.2076,	Y = -0.0071	
Foil Nose Point	X = 0.0,	Y = -0.9628	
Foil Tail Point	X = 2.2429,	Y = -0.0075	

Foil Area (Less Core) = 0.1273

Gaging	LAMBDA = 0.7548	X = 1.7657,	Y = -0.4519
Gaging Angle	= 45.567		
Center of Gravity	X = 1.1909,	Y = -0.6490	
Radial Reference	X = 1.1744,	Y = -0.6545	
Inlet Angle	= 90.000		
Exit Angle	= 45.608		
Uncovered Turning	= 8.306		

Constant Section Thickness = .050

TABLE LX

SECOND BLADE CASCADE TURNING VANE

Radius of 1/4R Section = 8.4375 | Axial Chord = 2.2500 | Actual Chord = 2.4402
Pitch = 1.1220 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-0.9936	-0.9686
0.01	0.0225	-0.9936	-0.9935
0.02	0.0450	-0.9935	-0.9935
0.03	0.0675	-0.9934	-0.9934
0.04	0.0900	-0.9931	-0.9931
0.05	0.1125	-0.9928	-0.9928
0.10	0.2250	-0.9892	-0.9892
0.15	0.3375	-0.9825	-0.9825
0.20	0.4500	-0.9722	-0.9722
0.25	0.5625	-0.9580	-0.9580
0.30	0.6750	-0.9394	-0.9394
0.35	0.7875	-0.9160	-0.9160
0.40	0.9000	-0.8874	-0.8874
0.45	1.0125	-0.8530	-0.8530
0.50	1.1250	-0.8125	-0.8125
0.55	1.2375	-0.7655	-0.7655
0.60	1.3500	-0.7117	-0.7117
0.65	1.4625	-0.6509	-0.6509
0.70	1.5750	-0.5830	-0.5830
0.75	1.6875	-0.5082	-0.5082
0.80	1.8000	-0.4264	-0.4264
0.85	1.9125	-0.3380	-0.3380
0.90	2.0250	-0.2432	-0.2432
0.95	2.1375	-0.1423	-0.1423
0.98	2.2050	-0.0790	-0.0790
0.99	2.2275	-0.0574	-0.0574
1.00	2.2500	-0.0355	-0.0250

Foil L.E. Circle	X = 0.0250,	Y = -0.9686,	R = 0.0250
Foil T.E. Circle	X = 2.2250,	Y = -0.0250,	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250,	Y = -0.9936	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250,	Y = -0.9436	
Foil T.E. Tangency Pt. (Top)	X = 2.2424,	Y = -0.0429	
Foil T.E. Tangency Pt. (Bot)	X = 2.2077,	Y = -0.0071	
Foil Nose Point	X = 0.0,	Y = -0.9686	
Foil Tail Point	X = 2.2429,	Y = -0.0076	

Foil Area (Less Core) = 0.1270

Gaging	LAMBDA = 0.8071,	X = 1.7374	Y = -0.4727
Gaging Angle	= 46.003		
Center of Gravity	X = 1.1933,	Y = -0.6515	
Radial Reference	X = 1.1744,	Y = -0.6545	
Inlet Angle	= 90.000		
Exit Angle	= 45.841		
Uncovered Turning	= 8.275		

Constant Section Thickness = .050

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TABLE LXI

SECOND BLADE CASCADE TURNING VANE

Radius of 3/8R Section = 8.9263
Pitch = 1.1870

Axial Chord = 2.2500
No. of Foils = 4

Actual Chord = 2.4421

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-0.9985	-0.9735
0.01	0.0225	-0.9985	-0.9983
0.02	0.0450	-0.9984	-0.9984
0.03	0.0675	-0.9982	-0.9982
0.04	0.0900	-0.9980	-0.9980
0.05	0.1125	-0.9976	-0.9976
0.10	0.2250	-0.9941	-0.9941
0.15	0.3375	-0.9876	-0.9876
0.20	0.4500	-0.9776	-0.9776
0.25	0.5625	-0.9369	-0.9639
0.30	0.6750	-0.9456	-0.9456
0.35	0.7875	-0.9222	-0.9222
0.40	0.9000	-0.8936	-0.8936
0.45	1.0125	-0.8595	-0.8595
0.50	1.1250	-0.8186	-0.8186
0.55	1.2375	-0.7713	-0.7713
0.60	1.3500	-0.7169	-0.7169
0.65	1.4625	-0.6551	-0.6551
0.70	1.5750	-0.5861	-0.5861
0.75	1.6875	-0.5099	-0.5099
0.80	1.8000	-0.4269	-0.4269
0.85	1.9125	-0.3377	-0.3377
0.90	2.0250	-0.2425	-0.2425
0.95	2.1375	-0.1415	-0.1415
0.98	2.2050	-0.0782	-0.0782
0.99	2.2275	-0.0570	-0.0570
1.00	2.2500	-0.0355	-0.0250

Foil L.E. Circle	X = 0.0250	Y = -0.9735	R = 0.0250
Foil T.E. Circle	X = 2.2250	Y = -0.0250	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250	Y = -0.9985	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250	Y = -0.9485	
Foil L.E. Tangency Pt. (Top)	X = 2.2424	Y = -0.0429	
Foil T.E. Tangency Pt. (Bot)	X = 2.2076	Y = -0.0070	
Foil Nose Point	X = 0.0	Y = -0.9735	
Foil Tail Point	X = 2.2430	Y = -0.0076	
Foil Area (Less Core)	= 0.1252		
Gaging	LAMBDA = 0.8587	X = 1.7080	Y = -0.4953
Gaging Angle	= 46.340		
Center of Gravity	X = 1.1846	Y = -0.6586	
Radial Reference	X = 1.1744	Y = -0.6545	
Inlet Angle	= 90.000		
Exit Angle	= 45.940		
Uncovered Turning	= 8.303		
Constant Section Thickness	= .050		

[redacted]

TABLE LXII

SECOND BLADE CASCADE TURNING VANE

Radius of Mean Section = 9.4150 | Axial Chord = 2.2500 | Actual Chord = 2.4412
Pitch = 1.2520 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-0.9960	-0.9710
0.01	0.0225	-0.9960	-0.9959
0.02	0.0450	-0.9959	-0.9959
0.03	0.0675	-0.9958	-0.9958
0.04	0.0900	-0.9955	-0.9955
0.05	0.1125	-0.9951	-0.9951
0.10	0.2250	-0.9910	-0.9910
0.15	0.3375	-0.9835	-0.9835
0.20	0.4500	-0.9721	-0.9721
0.25	0.5625	-0.9566	-0.9566
0.30	0.6750	-0.9365	-0.9365
0.35	0.7875	-0.9115	-0.9115
0.40	0.9000	-0.8814	-0.8814
0.45	1.0125	-0.8457	-0.8457
0.50	1.1250	-0.8041	-0.8041
0.55	1.2375	-0.7563	-0.7563
0.60	1.3500	-0.7022	-0.7022
0.65	1.4625	-0.6416	-0.6416
0.70	1.5750	-0.5743	-0.5743
0.75	1.6875	-0.5005	-0.5005
0.80	1.8000	-0.4201	-0.4201
0.85	1.9125	-0.3333	-0.3333
0.90	2.0250	-0.2402	-0.2402
0.95	2.1375	-0.1410	-0.1410
0.98	2.2050	-0.0785	-0.0785
0.99	2.2275	-0.0572	-0.0572
1.00	2.2500	-0.0356	-0.0250

Foil L.E. Circle	X = 0.0250	Y = -0.9710	R = 0.0250
Foil T.E. Circle	X = 2.2250	Y = -0.0250	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250	Y = -0.9960	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250	Y = -0.9460	
Foil T.E. Tangency Pt. (Top)	X = 2.2423	Y = -0.0430	
Foil T.E. Tangency Pt. (Bot)	X = 2.2077	Y = -0.0069	
Foil Nose Point	X = 0.0	Y = -0.9710	
Foil Tail Point	X = 2.2431	Y = -0.0077	
Foil Area (Less Core)	= 0.1235		
Gaging	LAMBDA = 0.9194	X = 1.6902	Y = -0.4987
Gaging Angle	= 47.251		
Center of Gravity	X = 1.1761	Y = -0.6543	
Radial Reference	X = 1.1744	Y = -0.6545	
Inlet Angle	= 90.000		
Exit Angle	= 46.216		
Uncovered Turning	= 9.301		

Constant Section Thickness = .050

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TABLE LXIII

SECOND BLADE CASCADE TURNING VANE

Radius of 1/8T Section = 9.9038
Pitch = 1.3170

Axial Chord = 2.2500
No. of Foils = 4

Actual Chord = 2.4350

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-0.9800	-0.9550
0.01	0.0225	-0.9800	-0.9799
0.02	0.0450	-0.9801	-0.9801
0.03	0.0675	-0.9798	-0.9798
0.04	0.0900	-0.9793	-0.9793
0.05	0.1125	-0.9791	-0.9791
0.10	0.2250	-0.9731	-0.9731
0.15	0.3375	-0.9628	-0.9628
0.20	0.4500	-0.9471	-0.9471
0.25	0.5625	-0.9257	-0.9257
0.30	0.6750	-0.9007	-0.9007
0.35	0.7875	-0.8717	-0.8717
0.40	0.9000	-0.8371	-0.8371
0.45	1.0125	-0.7966	-0.7966
0.50	1.1250	-0.7538	-0.7538
0.55	1.2375	-0.7048	-0.7048
0.60	1.3500	-0.6526	-0.6526
0.65	1.4625	-0.5966	-0.5966
0.70	1.5750	-0.5359	-0.5359
0.75	1.6875	-0.4704	-0.4704
0.80	1.8000	-0.3991	-0.3991
0.85	1.9125	-0.3205	-0.3205
0.90	2.0250	-0.2338	-0.2338
0.95	2.1375	-0.1400	-0.1400
0.98	2.2050	-0.0804	-0.0804
0.99	2.2275	-0.0585	-0.0585
1.00	2.2500	-0.0359	-0.0250

Foil L.E. Circle	X = 0.0250	Y = -0.9550	R = 0.0250
Foil T.E. Circle	X = 2.2250	Y = -0.0250	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250	Y = -0.9800	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250	Y = -0.9300	
Foil T.E. Tangency Pt. (Top)	X = 2.2420	Y = -0.0433	
Foil T.E. Tangency Pt. (Bot)	X = 2.2081	Y = -0.0067	
Foil Nose Point	X = 0.0	Y = -0.9550	
Foil Tail Point	X = 2.2434	Y = -0.0081	

Foil Area (Less Core) = 0.1233

Gaging	LAMBDA = 0.9991	X = 1.69[illegible]	Y = -0.4673
Gaging Angle	= 49.341		
Center of Gravity	X = 1.1774	Y = -0.6253	
Radial Reference	X = 1.1744	Y = -0.6545	
Inlet Angle	= 90.000		
Exit Angle	= 47.193		
Uncovered Turning	= 11.621		

Constant Section Thickness = .050

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TABLE LXIV

SECOND BLADE CASCADE TURNING VANE

Radius of 1/4T Section = 10.3925
Pitch = 1.3820

Axial Chord = 2.2500
No. of Foils = 4

Actual Chord = 2.4239

Percent	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-0.9500	-0.9250
0.01	0.0225	-0.9500	-0.9499
0.02	0.0450	-0.9500	-0.9500
0.03	0.0675	-0.9497	-0.9497
0.04	0.0900	-0.9490	-0.9490
0.05	0.1125	-0.9490	-0.9490
0.10	0.2250	-0.9410	-0.9410
0.15	0.3375	-0.9280	-0.9280
0.20	0.4500	-0.9080	-0.9080
0.25	0.5625	-0.8810	-0.8810
0.30	0.6750	-0.8510	-0.8510
0.35	0.7875	-0.8180	-0.8180
0.40	0.9000	-0.7790	-0.7790
0.45	1.0125	-0.7340	-0.7340
0.50	1.1250	-0.6900	-0.6900
0.55	1.2375	-0.6400	-0.6400
0.60	1.3500	-0.5900	-0.5900
0.65	1.4625	-0.5390	-0.5390
0.70	1.5750	-0.4850	-0.4850
0.75	1.6875	-0.4280	-0.4280
0.80	1.8000	-0.3670	-0.3670
0.85	1.9125	-0.2980	-0.2980
0.90	2.0250	-0.2200	-0.2200
0.95	2.1375	-0.1350	-0.1350
0.98	2.2050	-0.0807	-0.0807
0.99	2.2275	-0.0590	-0.0590
1.00	2.2500	-0.0366	-0.0250

Foil L.E. Circle	X = 0.0250	Y = -0.9250	R = 0.0250
Foil T.E. Circle	X = 2.2250	Y = -0.0250	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250	Y = -0.9500	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250	Y = -0.9000	
Foil T.E. Tangency Pt. (Top)	X = 2.2411	Y = -0.0441	
Foil T.E. Tangency Pt. (Bot)	X = 2.2089	Y = -0.0059	
Foil Nose Point	X = 0.0	Y = -0.9250	
Foil Tail Point	X = 2.2441	Y = -0.0089	
Foil Area (Less Core)	= 0.1233		
Gaging	LAMBDA = 1.0916	X = 1.7063	Y = -0.4182
Gaging Angle	= 52.175		
Center of Gravity	X = 1.1799	Y = -0.5841	
Radial Reference	X = 1.1744	Y = -0.6545	
Inlet Angle	= 90.000		
Exit Angle	= 49.803		
Uncovered Turning	= 12.472		

Constant Section Thickness = .050

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TABLE LXV

SECOND BLADE CASCADE TURNING VANE

Radius of 3/8T Section = 10.8812 | Axial Chord = 2.2500 | Axial Chord = 2.4083
Pitch = 1.4470 | No. of Foils = 4

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-0.9066	-0.8816
0.01	0.0225	-0.9066	-0.9065
0.02	0.0450	-0.9063	-0.9063
0.03	0.0675	-0.9060	-0.9060
0.04	0.0900	-0.9052	-0.9052
0.05	0.1125	-0.9053	-0.9053
0.10	0.2250	-0.8965	-0.8965
0.15	0.3375	-0.8831	-0.8831
0.20	0.4500	-0.8618	-0.8618
0.25	0.5625	-0.8346	-0.8346
0.30	0.6750	-0.8031	-0.8031
0.35	0.7875	-0.7692	-0.7692
0.40	0.9000	-0.7292	-0.7292
0.45	1.0125	-0.6837	-0.6837
0.50	1.1250	-0.6396	-0.6396
0.55	1.2375	-0.5899	-0.5899
0.60	1.3500	-0.5407	-0.5407
0.65	1.4625	-0.4913	-0.4913
0.70	1.5750	-0.4389	-0.4389
0.75	1.6875	-0.3842	-0.3842
0.80	1.8000	-0.3283	-0.3283
0.85	1.9125	-0.2655	-0.2655
0.90	2.0250	-0.1963	-0.1963
0.95	2.1375	-0.1222	-0.1222
0.98	2.2050	-0.0763	-0.0763
0.99	2.2275	-0.0570	-0.0570
1.00	2.2500	-0.0379	-0.0252

Foil L.E. Circle	X = 0.0250	Y = -0.8816	R = 0.0250
Foil T.E. Circle	X = 2.2253	Y = -0.0252	R = 0.0247
Foil L.E. Tangency Pt. (Top)	X = 0.0250	Y = -0.9066	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250	Y = -0.8566	
Foil T.E. Tangency Pt. (Top)	X = 2.2396	Y = -0.0453	
Foil T.E. Tangency Pt. (Bot)	X = 2.2106	Y = -0.0053	
Foil Nose Point	X = 0.0	Y = -0.8816	
Foil Tail Point	X = 2.2453	Y = -0.0107	
Foil Area (Less Core)	= 0.1219		
Gaging LAMBDA	= 1.1889	X = 1.6936	Y = -0.3812
Gaging Angle	= 55.250		
Center of Gravity	X = 1.17[illegible]	Y = -0.5467	
Radial Reference	X = 1.1744	Y = -0.6545	
Inlet Angle	= 90.000		
Exit Angle	= 54.084		
Uncovered Turning	= 9.389		

Constant Section Thickness = .050

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TABLE LXVI

SECOND BLADE CASCADE TURNING VANE

Radius of Tip Section = 11.3700
Pitch = 1.5120

Axial Chord = 2.2500
No. of Foils = 4

Actual Chord = 2.3885

Percent X	Foil X	Foil Y (Top)	Foil Y (Circle)
0.0	0.0	-0.8500	-0.8250
0.01	0.0225	-0.8500	-0.8499
0.02	0.0450	-0.8490	-0.8490
0.03	0.0675	-0.8489	-0.8489
0.04	0.0900	-0.8480	-0.8480
0.05	0.1125	-0.8480	-0.8480
0.10	0.2250	-0.8400	-0.8400
0.15	0.3375	-0.8290	-0.8290
0.20	0.4500	-0.8100	-0.8100
0.25	0.5625	-0.7890	-0.7890
0.30	0.6750	-0.7600	-0.7600
0.35	0.7875	-0.7290	-0.7290
0.40	0.9000	-0.6920	-0.6920
0.45	1.0125	-0.6510	-0.6510
0.50	1.1250	-0.6080	-0.6080
0.55	1.2375	-0.5600	-0.5600
0.60	1.3500	-0.5100	-0.5100
0.65	1.4625	-0.4580	-0.4580
0.70	1.5750	-0.4010	-0.4010
0.75	1.6875	-0.3410	-0.3410
0.80	1.8000	-0.2840	-0.2840
0.85	1.9125	-0.2230	-0.2230
0.90	2.0250	-0.1620	-0.162[illegible]
0.95	2.1375	-0.1010	-0.1010
0.98	2.2050	-0.0647	-0.0647
0.99	2.2275	-0.0520	-0.0520
1.00	2.2500	-0.0400	-0.0263

Foil L.E. Circle	X = 0.0250	Y = -0.8250	R = 0.0250
Foil T.E. Circle	X = 2.2264	Y = -0.0263	R = 0.0250
Foil L.E. Tangency Pt. (Top)	X = 0.0250	Y = -0.8500	
Foil L.E. Tangency Pt. (Bot)	X = 0.0250	Y = -0.8000	
Foil T.E. Tangency Pt. (Top)	X = 2.2381	Y = -0.0468	
Foil T.E. Tangency Pt. (Bot)	X = 2.2136	Y = -0.0064	
Foil Nose Point	X = 0.0	Y = -0.8250	
Foil Tail Point	X = 2.2466	Y = -0.0140	
Foil Area (Less Core)	= 0.1190		
Gaging LAMBDA	= 1.2864	X = 1.6053	Y = -0.3848
Gaging Angle	= 62.0		
Center of Gravity	X = 1.1513	Y = -0.5165	
Radial Reference	X = 1.1744	Y = -0.6545	
Inlet Angle	= 90.000		
Exit Angle	= 62.0		
Uncovered Turning	= 1.452		
Constant Section Thickness	= .050		

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REFERENCES

1. H. Weina, D.E. Dahlberg and W.H. Heiser; (Unclassified) Investigation of a Highly Loaded Two-Stage Fan-Drive Turbine; Interim Technical Status Report; Pratt & Whitney Aircraft Division of United Aircraft Corporation; 28 June 1968; Confidential

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(U) A comprehensive three-year program is in progress to investigate methods of improving the performance of fan-drive turbines. The goals of the program are to develop turbine aerodynamic techniques and design procedures for efficient, high work, low pressure turbines by means of analytical studies and cascade testing, and to demonstrate the effectiveness of the techniques by designing and testing a two stage turbine that meets or exceeds the contract stage work and efficiency goals. The first phase effort defining the preliminary turbine design has been completed and the results have been reported. The second phase consists of a preliminary experimental evaluation which includes establishment of two-dimensional loss levels and three-dimensional flow behavior for both the baseline airfoils and airfoils utilizing boundary layer control devices. The design of the rig hardware and the baseline airfoils which will be evaluated during this second phase are presented in this report.

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