NASA TECHNICAL NOTE



NASA TN D-8243

NASA TN D-8243

# AERODYNAMIC DESIGN GUIDELINES AND COMPUTER PROGRAM FOR ESTIMATION OF SUBSONIC WIND TUNNEL PERFORMANCE

William T. Eckert, Kenneth W. Mort, and Jean Jope Ames Research Center and U.S. Army Air Mobility R&D Laboratory Moffett Field, Calif. 94035



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION . WASHINGTON, D. C. . OCTOBER 1976

1. Report No. TN D-824:	3	2. Government Acces	ssion No.	3. Recipient's Catalog	No.
4. Title and Su AERODYNAM	Ibtitle MIC DESIGN GUIDELINES	AND COMPUTER PROGR	RAM FOR ESTIMATION	5. Report Date October 1976	·
01 50550	ATO WIND TOWNED TENTOR			6. Performing Organia	zation Code
7. Author(s)	T. Felert + Kenneth U	Most and Less L		8. Performing Organiz	ation Report No.
wiiiiam .	. Eckert, Kenneth W.	Mort, and Jean Jo		10. Work Unit No.	
9. Performing C NASA Ames	Drganization Name and Address s Research Center		•	505-06-31	
Ames Dire	and ectorate,U.S. Army Air Field CA 94035	Mobility R&D Labo	oratory	11. Contract or Grant	NO.
12 Sponsoring	Agency Name and Address		· · · · · · · · · · · · · · · · · · ·	_ 13. Type of Report ar	nd Period Covered
National	Aeronautics and Space	Administration	•	Technical Not	.e
Washingto U.S. Army	on, D. C. 20546 and y Air Mobility R&D Lab	oratory, Moffett H	Field, CA 94035	14. Sponsoring Agency	Code .
15. Supplementa	ary Notes		······································		
*Ames Din	rectorate, U.S. Army A	ir Mobility R&D La	aboratory, Moffett	Field, CA 94035	: •.
16. Abstract	<u> </u>				<u> </u>
This technique tunnels. the inlet nology, h is includ	s report brings togeth es for the aerodynamic General guidelines a ts and exits of non-re has been compiled and ded) for determining t	er and refines the design and loss p re given for the c turn tunnels. A s assembled into a c he total pressure	prediction of the c lesign of diffusers system of equations computer program ( losses. The form	components of subsc s, contractions, cc s, reflecting the c a user's manual for ilation presented i	onic wind orners, and current tech- this program s applicable
This technique tunnels. the inlet nology, h is inclue to compre tunnels. facilitie	s report brings togeth es for the aerodynamic General guidelines a ts and exits of non-re has been compiled and ded) for determining t essible flow through m A comparison of esti es produced generally	er and refines the design and loss p re given for the d turn tunnels. A s assembled into a c he total pressure ost closed- or ope mated performance good agreement.	previously scatte orediction of the c lesign of diffusers system of equations computer program ( losses. The form en-throat, single-, with that actually	components of subsc s, contractions, cc s, reflecting the c a user's manual for ilation presented i , double-, or non-r y achieved by sever	whic wind prners, and current tech- this program a applicable return wind cal existing
This technique tunnels. the inlet nology, H is inclue to compre tunnels. facilitie	s report brings togeth es for the aerodynamic General guidelines a ts and exits of non-re has been compiled and ded) for determining t essible flow through m A comparison of esti es produced generally	er and refines the design and loss p re given for the d turn tunnels. A s assembled into a c he total pressure ost closed- or ope mated performance good agreement.	prediction of the of lesign of diffusers system of equations computer program (a losses. The form en-throat, single-, with that actually	components of subsc s, contractions, cc s, reflecting the c a user's manual for ilation presented i , double-, or non-r y achieved by sever	whic wind orners, and current tech- this program s applicable return wind cal existing
This technique tunnels. the inlet nology, H is inclue to compre tunnels. facilitie	s report brings togeth es for the aerodynamic General guidelines a ts and exits of non-re has been compiled and ded) for determining t essible flow through m A comparison of esti es produced generally	er and refines the design and loss p re given for the d turn tunnels. A s assembled into a c he total pressure ost closed- or ope mated performance good agreement.	prediction of the of lesign of diffusers system of equations computer program (a losses. The formu en-throat, single-, with that actually	components of subsc s, contractions, cc s, reflecting the c a user's manual for ilation presented i , double-, or non-r y achieved by sever	onic wind orners, and current tech- this program s applicable return wind ral existing
This technique tunnels. the inlet nology, H is inclue to compre- tunnels. facilitie	s report brings togeth es for the aerodynamic General guidelines a ts and exits of non-re has been compiled and ded) for determining t essible flow through m A comparison of esti es produced generally	er and refines the design and loss p re given for the d turn tunnels. A s assembled into a d he total pressure ost closed- or ope mated performance good agreement.	prediction of the or lesign of diffusers system of equations computer program (a losses. The formu en-throat, single-, with that actually	components of subsc s, contractions, cc s, reflecting the c a user's manual for ilation presented i , double-, or non-r y achieved by sever	onic wind orners, and current tech- this program s applicable eturn wind cal existing
This technique tunnels. the inlet nology, H is inclue to compre tunnels. facilitie	s report brings togeth es for the aerodynamic General guidelines a ts and exits of non-re has been compiled and ded) for determining t essible flow through m A comparison of esti es produced generally	er and refines the design and loss p re given for the d turn tunnels. A s assembled into a c he total pressure ost closed- or ope mated performance good agreement.	prediction of the o lesign of diffusers system of equations computer program (a losses. The form en-throat, single-, with that actually	components of subsc s, contractions, cc s, reflecting the c a user's manual for ilation presented i , double-, or non-r y achieved by sever	whic wind primers, and current tech- this program is applicable return wind cal existing
This technique tunnels. the inlet nology, H is includ to compre tunnels. facilitie	s report brings togeth es for the aerodynamic General guidelines a ts and exits of non-re has been compiled and ded) for determining t essible flow through m A comparison of esti es produced generally	er and refines the design and loss p re given for the d turn tunnels. A s assembled into a d he total pressure ost closed- or ope mated performance good agreement.	prediction of the or lesign of diffusers system of equations computer program (a losses. The form en-throat, single-, with that actually	components of subsc s, contractions, cc s, reflecting the c a user's manual for ilation presented i , double-, or non-r y achieved by sever	whic wind prners, and current tech- this program is applicable return wind ral existing
This technique tunnels. the inlet nology, H is inclue to compre- tunnels. facilitie	s report brings togeth es for the aerodynamic General guidelines a ts and exits of non-re has been compiled and ded) for determining t essible flow through m A comparison of esti es produced generally	er and refines the design and loss p re given for the d turn tunnels. A s assembled into a c he total pressure ost closed- or ope mated performance good agreement.	prediction of the o lesign of diffusers system of equations computer program (a losses. The form en-throat, single-, with that actually	components of subsc s, contractions, cc s, reflecting the c a user's manual for ilation presented i , double-, or non-r y achieved by sever	whic wind briners, and current tech- this program is applicable return wind tal existing
This technique tunnels. the inlet nology, h is inclue to compre tunnels. facilitie	s report brings togeth es for the aerodynamic General guidelines a ts and exits of non-re has been compiled and ded) for determining t essible flow through m A comparison of esti es produced generally	er and refines the design and loss p re given for the d turn tunnels. A s assembled into a c he total pressure ost closed- or ope mated performance good agreement.	prediction of the of lesign of diffusers system of equations computer program (a losses. The form en-throat, single-, with that actually	components of subsc s, contractions, cc s, reflecting the c a user's manual for ilation presented i , double-, or non-r y achieved by sever	onic wind orners, and current tech- this program is applicable return wind ral existing
This technique tunnels. the inlet nology, H is inclue to compre- tunnels. facilitie	s report brings togeth es for the aerodynamic General guidelines a ts and exits of non-re has been compiled and ded) for determining t essible flow through m A comparison of esti es produced generally	er and refines the design and loss p re given for the d turn tunnels. A s assembled into a d he total pressure ost closed- or ope mated performance good agreement.	prediction of the of lesign of diffusers system of equations computer program ( losses. The form en-throat, single-, with that actually	components of subsc s, contractions, cc s, reflecting the c a user's manual for ilation presented i , double-, or non-r y achieved by sever	onic wind prners, and current tech- this program is applicable return wind cal existing
This technique tunnels. the inlet nology, H is inclue to compre tunnels. facilitie	s report brings togeth es for the aerodynamic General guidelines a ts and exits of non-re has been compiled and ded) for determining t essible flow through m A comparison of esti es produced generally	er and refines the design and loss p re given for the d turn tunnels. A s assembled into a c he total pressure ost closed- or ope mated performance good agreement.	prediction of the o lesign of diffusers system of equations computer program (a losses. The form en-throat, single-, with that actually	components of subsc s, contractions, cc s, reflecting the c a user's manual for ilation presented i , double-, or non-r y achieved by sever	nic wind prners, and current tech- this program s applicable return wind cal existing
This technique tunnels. the inlet nology, H is inclue to compre tunnels. facilitie	s report brings togeth es for the aerodynamic General guidelines a ts and exits of non-re has been compiled and ded) for determining t essible flow through m A comparison of esti es produced generally	er and refines the design and loss p re given for the d turn tunnels. A s assembled into a d he total pressure ost closed- or ope mated performance good agreement.	with that actually	components of subsc s, contractions, cc s, reflecting the c a user's manual for ilation presented i , double-, or non-r y achieved by sever	nic wind prners, and current tech- this program is applicable return wind cal existing
This technique tunnels. the inlet nology, H is inclue to compre- tunnels. facilitie	s report brings togeth es for the aerodynamic General guidelines a ts and exits of non-re has been compiled and ded) for determining t essible flow through m A comparison of esti es produced generally	er and refines the design and loss p re given for the d turn tunnels. A s assembled into a c he total pressure ost closed- or ope mated performance good agreement.	T 18 Distribution Status	components of subsc s, contractions, cc s, reflecting the c a user's manual for ilation presented i , double-, or non-r y achieved by sever	whic wind prners, and current tech- this program is applicable return wind cal existing
This technique tunnels. the inlet nology, H is inclue to compre tunnels. facilitie 17. Key Words ( Wind tune	(Suggested by Author(s)) nes for the aerodynamic General guidelines a ts and exits of non-re has been compiled and ded) for determining t essible flow through m A comparison of esti es produced generally	er and refines the design and loss p re given for the d turn tunnels. A s assembled into a c he total pressure ost closed- or ope mated performance good agreement.	<ul> <li>18. Distribution Statem Unlimited</li> </ul>	components of subsc s, contractions, cc s, reflecting the c a user's manual for ilation presented i , double-, or non-r y achieved by sever	nic wind prners, and current tech- this program is applicable return wind cal existing
This technique tunnels. the inlet nology, H is inclue to compre- tunnels. facilitie 17. Key Words ( Wind tunn Wind tunn Duct flor	(Suggested by Author(s)) (Suggested by Author(s)) nel design (subsonic)	er and refines the design and loss p re given for the d turn tunnels. A s assembled into a c he total pressure ost closed- or ope mated performance good agreement.	18. Distribution Statem	components of subsc s, contractions, cc s, reflecting the c a user's manual for ilation presented i , double-, or non-r y achieved by sever	nic wind prners, and current tech- this program is applicable return wind cal existing
This technique tunnels. the inlet nology, H is inclue to compre tunnels. facilitie <b>17. Key Words</b> Wind tunn Wind tunn Duct flow Duct flow	(Suggested by Author(s)) nel design (subsonic) Market Solution (Suggested by Author(s)) nel design (subsonic) Market Solution (Suggested by Author(s)) nel design (subsonic) Market Solution Market Solut	<pre>er and refines the design and loss p re given for the d turn tunnels. A s assembled into a c he total pressure ost closed- or ope mated performance good agreement.</pre>	<ul> <li>18. Distribution Statem Unlimited</li> </ul>	components of subsc s, contractions, cc s, reflecting the c a user's manual for ilation presented i , double-, or non-r y achieved by sever	nic wind prners, and current tech- this program is applicable return wind ral existing
This technique tunnels. the inlet nology, H is incluc to compre tunnels. facilitie 17. Key Words ( Wind tunn Wind tunn Duct flow Duct loss Wind tunn Aircraft	(Suggested by Author(s)) (Suggested by Author(s)) mel design (subsonic) mel performance ana testing	er and refines the design and loss p re given for the d turn tunnels. A s assembled into a c he total pressure ost closed- or ope mated performance good agreement.	18. Distribution Statem	components of subsc s, contractions, cc s, reflecting the c a user's manual for ilation presented i , double-, or non-r y achieved by sever achieved by sever	<pre>y - 02</pre>
This technique tunnels. the inlet nology, H is inclue to compre- tunnels. facilitie 17. Key Words ( Wind tunn Mind tunn Duct flow Duct loss Wind tunn Aircraft 19. Security Cla	(Suggested by Author(s)) nel design (subsonic) mel performance and exits of non-re has been compiled and ded) for determining t essible flow through m A comparison of esti es produced generally (Suggested by Author(s)) nel design (subsonic) nel (subsonic) W Energy ses Power nel performance ana testing ssif. (of this report)	er and refines the design and loss p re given for the d turn tunnels. A s assembled into a c he total pressure ost closed- or ope mated performance good agreement. y use analysis consumption lysis 20. Security Classif. (	18. Distribution Statem         Unlimited	ent STAR Category 21. No. of Pages	<pre>vinic wind primers, and current tech- this program is applicable return wind ral existing v - 02 22. Price*</pre>

\*For sale by the National Technical Information Service, Springfield, Virginia 22161

# TABLE OF CONTENTS

			Page
NOTATION (Engineering Symbols)	•••	•	• v
	•••	•	. 1
	•••	•	. 1
CAULIUNARI DESIGN GUIDELINES	•••	•	. 2
	• •	•	• 2
	•••	•	• 3
Non-Return Wind Tunnels	•••	•	• •
PERFORMANCE ESTIMATION	•••	•	• 4
General Approach	•••	•	. 4
Problem Restrictions			. 5
Computation Formulas			. 5
Flow-state parameters			. 5
Local conditions		•	. 5
Section pressure losses		•	. 6
COMPUTER PROGRAM DESCRIPTION		•	. 11
Method of Solution		•	. 11
Computing Equipment Required		•	. 12
Hardware and machine components	•••	•	. 12
Software	• •	•	. 13
Programming Techniques	•••	•	. 14
Source Code	•••	•	. 15
	•••	•	. 15
	•••	•	· 15
Computer system restrictions	•••	•	. 10
Optional inputs	•••	•	• 1/
Diagnostic messages	•••	•	. 18
Test Case			. 21
DISCUSSION AND APPLICATIONS			. 22
Results		•	. 23
Evaluation		•	. 24
APPENDIX A - NON-STANDARD FUNCTIONAL FORMS		•	. 26
Local Flow-State Parameters			. 26
Mach number		•	. 26
Reynolds number		•	. 27
Friction coefficient		•	. 27
Section Pressure Losses	•••	•	. 27
Corners (constant area)	•••	•	. 27
Corners (diffusing)	•••	•	. 28
Diffusers	•••	•	• 29
	•••	•	. 30
Flow straighteners: airfoil members (thick)	•••	•	. 31
Internal flow obstruction: drag item	•••	•	. 32
Vaned diffusers	•••	•	. 32
Wall proceure differential	•••	•	· 52
Input power required	•••	•	. 34
		•	

		Page
APPENDIX B - NUMERICAL FUNCTION-APPROXIMATION	IS	. 35
Corners		. 35
Diffusers		. 35
Mesh Screen	• • • • • • • • • • • •	. 38
Vaned Diffusers		. 38
APPENDIX C - COMPUTER PROGRAM FØRTRAN CODES		. 39
Notation (FØRTRAN)		. 40
PERFØRM		. 52
DATACK		<b>.</b> 79
SPEED		. 97
FRICTN		. 98
ØUTPUT		. 99
PLØTIT		. 104
APPENDIX D - INPUT AND OUTPUT FOR SAMPLE CASE	'S	. 107
REFERENCES		. 142
TABLES         . <td></td> <td>. 144</td>		. 144
FIGURES		. 153

. E

# NOTATION

# (Engineering Symbols)

Symbol	FØRTRAN <sup>1</sup> name	Description			
A	A	cross-sectional area of local section, $m^2$ (ft <sup>2</sup> )			
A <sub>F</sub>		<pre>total cross-sectional flow area at drive fan(s), m<sup>2</sup> (ft<sup>2</sup>)</pre>			
A <sub>FLOW</sub>	AL	cross-sectional area of local flow, $m^2$ (ft <sup>2</sup> )			
A <sub>o</sub>	AO	cross-sectional flow area of test section at upstream end, $m^2$ (ft <sup>2</sup> )			
A1	A1	cross-sectional flow area of section at upstream end, m <sup>2</sup> (ft <sup>2</sup> )			
A <sub>2</sub>	A2	cross-sectional flow area of section at it downstream end, m <sup>2</sup> (ft <sup>2</sup> )			
A <sub>*</sub>	ASTAR	<pre>cross-sectional area for sonic flow at     specified flow conditions, m<sup>2</sup> (ft<sup>2</sup>)</pre>			
AR	AR	<b>cross-se</b> ctional flow area ratio of upstream and downstream ends of section			
a <sub>T</sub>	AT	<pre>speed of sound in still gas, computed at total  (stagnation) conditions, m/sec (ft/sec)</pre>			
a <sub>o</sub>	ASO	<pre>speed of sound in moving flow at upstream end   of test section, m/sec (ft/sec)</pre>			
В		dummy constraint used in defining the friction term of turning vane loss function			
c <sub>D</sub>	CD	drag coefficient of flow obstructions: drag/qS			
c <sub>v</sub>	CHØRD	chord of turning vanes, m (ft)			
D	D	cross-sectional diameter of circular duct, m (ft)			
D <sub>e</sub> 1		cross-section diameter at the upstream end of an equivalent circular duct with equal area, m (ft)			

<sup>1</sup>Note that in this section, as throughout the report, all letter 0's occurring in FØRTRAN names are shown with slashes, as  $\emptyset$ ; all number zeros are shown without slashes.

v

Symbol .	FØRTRAN <u>name</u>	Description			
D <sub>e2</sub>		cross-section diameter at the downstream end of an equivalent circular duct with equal area, m (ft)			
D <sub>h</sub>	DH	hydraulic diameter: $\frac{4 \times (cross-sectional area)}{perimeter}$ , m (ft)			
ER	ER	energy ratio: ratio of energy of flow at the test section to the output energy of the fans			
f(Ø)	FKTV1 FKTV2	function defining turning vane loss parameter K <sub>TV</sub>			
К	ЕК	local total pressure loss coefficient of section: $\frac{\Delta p_T}{q}$			
K <sub>CONTRACTION</sub>	EKCNTR	local total pressure loss coefficient from cor tracting portion of thick-airfoil flow straighteners			
K <sub>DIFFUSION</sub>	EKD	local total pressure loss coefficient from diffusing portion of multi-loss-type section			
к <sub>ехр</sub>	EKEXP	net expansion loss coefficient for diffusers			
K <sub>EXP</sub> Additional	EKADD	additional diffuser expansion loss coefficient due only to more diffusion in one plane that the other			
K <sub>EXP</sub> Basic	EKBASE	basic diffuser expansion loss factor coeffi- cient for three-dimensional diffusion			
K <sub>EXP</sub> Circular	EKC	expansion loss coefficient for conical diffusers			
K <sub>EXP</sub> Rectangular	EK2DR	expansion loss coefficient for a two- dimensional, rectangular cross-section diffuser			
K <sub>EXP</sub> Square	EKS	expansion loss coefficient for three- dimensional expansion in square cross-section diffusers			
K <sub>EXP2D</sub> Average	EK2DCS	estimated expansion loss value for a two- dimensional diffuser (one with expansion in only one plane) with cross-section shape of some square/circular hybrid			

Symbo1	FØRTRAN name	Description		
K <sub>EXP2D</sub> Circular	EK2DC	estimated expansion loss value for a hypotheti- cal two-dimensional diffuser with circular sides:		
		$K_{EXP_{2D}}$ Rectangular $(K_{EXP}Square)$		
K <sub>EXP</sub> 3D <sub>Average</sub>	EKCSAV	estimated expansion loss coefficient for three- dimensional, combination circular and square cross-section diffuser		
K <sub>EXPANSION</sub>		diffuser loss coefficient due to expansion:		
		$K_{EXP} \left(\frac{AR - 1}{AR}\right)^2$		
<b>K</b> FRICTION		turning vane loss due to friction		
K <sub>FRICTION</sub> (CONICAL)		diffuser loss due to friction for the equiva- lent conical diffuser		
K <sub>MESH</sub>	EKMESH	mesh screen-type loss parameter		
K <sub>Ref</sub> . 9		diffuser loss factor presented in reference 9: $\frac{\Delta p/q}{[(AR - 1)/AR]^2}$		
к <sub>RN</sub>		mesh screen Reynolds number sensitivity factor		
KROTATION		turning vane loss coefficient due to rotation		
K <sub>TV</sub>	EKTV	turning vane loss coefficient		
к <sub>т</sub> v <sub>90</sub>	EKTV90	turning vane loss parameter for given vanes at a 90° turn		
K <sub>v</sub>	EKV	local total pressure loss coefficient for vaned diffusers		
<sup>K</sup> VANED DIFFUSER		local total pressure loss coefficient for vaned diffuser, $K_v \left(\frac{AR - 1}{AR}\right)^2$		
К <sub>о</sub>	EKO	section total pressure loss coefficient referred to test section conditions: $\frac{\Delta p_{T}}{q_{o}}$		

<b>.</b>	FØRTRAN	Decorintian			
Symbol	name	Description			
K <sub>O</sub> DRAG		flow obstruction (drag item) total pressure loss coefficient referred to test section conditions			
L	EL	centerline length of section, m (ft)			
L		characteristic dimension on which Reynolds number is based			
M	AMACH	local Mach number			
Mo	EMO	Mach number at upstream end of test section			
N	N	section assigned sequence number for order of occurrence in circuit			
P <sub>DRAG</sub>		power loss due to drag of flow obstruction, W (hp)			
PINPUT	PWRIP	tunnel drive power required to be input to flow by the fans, W (hp)			
PINPUTDRAG		power input required to overcome drag of flow obstruction, W (hp)			
PREQUIRED	PWRØP	total fan motor output power required to drive wind tunnel at specified speed, W (hp)			
p		local static pressure, $N/m^2$ (lb/ft <sup>2</sup> )			
<sup>р</sup> т	PT	<pre>tunnel total (stagnation) pressure, N/m<sup>2</sup>  (lb/ft<sup>2</sup>)</pre>			
<sup>P</sup> T <sub>ATM</sub>	PATM	atmospheric (barometric) pressure, N/m <sup>2</sup> (lb/ft <sup>2</sup> )			
PTSC		<pre>total (stagnation) pressure in the circuit   settling chamber, N/m<sup>2</sup> (lb/ft<sup>2</sup>)</pre>			
<b>q</b> .		local dynamic pressure: $\frac{\rho V^2}{2}$ , N/m <sup>2</sup> (lb/ft <sup>2</sup> )			
q <sub>o</sub>	QO	test section dynamic pressure: $\frac{\rho_0 V_0^2}{2}$ , N/m <sup>2</sup> (lb/ft <sup>2</sup> )			
R	R	gas constant, m <sup>2</sup> /sec <sup>2</sup> °K (ft <sup>2</sup> /sec <sup>2</sup> °R)			
R <sub>e</sub>		equivalent radius: $\sqrt{A/\pi}$ , m (ft)			

viii

	FØRTRAN	Description			
Symbol	name				
RN	RN	Reynolds number: $\frac{\rho V l}{\mu}$			
RN <sub>REF</sub>	RNREF	reference Reynolds number at which turning vane 90° loss parameter, K <sub>TV90</sub> , was determined			
S		drag area of flow obstruction (i.e., area for which $C_D$ is determined), $m^2$ (ft <sup>2</sup> )			
s		distance along diffuser wall, m (ft)			
s <sub>2</sub>		length of diffuser, taken along wall, m (ft)			
Т	•	tunnel temperature in moving flow, °K (°R)			
Τ <sub>T</sub>	TT	tunnel total (stagnation) temperature, °K (°R)			
V	V	local flow velocity, m/sec (ft/sec)			
V <sub>F</sub>		<pre>flow velocity at the drive fan(s), m/sec   (ft/sec)</pre>			
V <sub>SYSTEM</sub>		<pre>flow velocity in a multiple-duct section, m/sec   (ft/sec)</pre>			
V <sub>o</sub>	VO	<pre>test section upstream-end flow velocity, m/sec   (ft/sec)</pre>			
X		location of inflection point in contraction wall (distance from upstream end), m (ft)			
Ŷ	G	specific heat ratio of gas			
Δ	RUFNES	surface roughness in honeycomb cells, m (ft)			
ΔER	• •	difference between estimated and true circuit energy ratios; i.e., error in energy ratio estimate			
$\Delta p_{\mathbf{F}}$		static pressure rise across the fan(s), N/m <sup>2</sup> (1b/ft <sup>2</sup> )			
$^{\Delta p}T$		total pressure drop through a section, N/m <sup>2</sup> (1b/ft <sup>2</sup> )			
ΔPTDUCT		total pressure drop through a single duct of a multiple-duct section, N/m <sup>2</sup> (1b/ft <sup>2</sup> )			
${}^{\Delta \mathbf{p}}\mathbf{T}_{\mathbf{F}}$		total pressure rise across the fan(s), N/m <sup>2</sup> (1b/ft <sup>2</sup> )			

ix

Symbol	FØRTRAN	Description		
Δρ.		average total pressure rise across a single fan.		
TFDUCT		$N/m^2$ (lb/ft <sup>2</sup> )		
$^{\Delta p}$ tsystem		total pressure drop through a multiple-duct section, N/m <sup>2</sup> (1b/ft <sup>2</sup> )		
$^{\Delta p}T_{TOTAL}$		summation of all total pressure drops through the wind tunnel circuit, N/m <sup>2</sup> (lb/ft <sup>2</sup> )		
$^{\Delta p}W_{i}$	DELP	local pressure difference across wind tunnel wall, N/m <sup>2</sup> (1b/ft <sup>2</sup> )		
<sup>∆P</sup> required		difference between true and estimated required drive power levels for given levels of oper- ating velocity and fan efficiency; i.e., error in required power estimate, W (hp)		
ΔV <sub>o</sub>		difference between estimated and true test sec- tion operating velocity for given power and fan efficiency levels; i.e., error in oper- ating velocity estimate, m/sec (ft/sec)		
Δε		increment of flow-obstruction downstream influ- ence factor greater than unity: ε - 1 (greater than or equal to zero)		
δ <sub>s</sub>	SLR	diffuser side length ratio: ratio of change in height to change in width from upstream to downstream end, or its inverse, whichever is less than or equal to unity		
ε	EPS	flow-obstruction downstream influence coeffi- cient (greater than or equal to unity)		
n <sub>E</sub>		drive motor electrical efficiency, percent		
n <sub>F</sub>	ETAFAN	fan aerodynamic efficiency, percent		
θ	TH	diffuser half-angle, rad		
λ	SLAMDA	friction coefficient for smooth pipes		
μ	EMU	flow viscosity, N sec/m <sup>2</sup> (lb sec/ft <sup>2</sup> )		
$^{\mu}$ std	EMUSTD	standard-day value of viscosity, N sec/m <sup>2</sup> (1b sec/ft <sup>2</sup> )		
μ <sub>T</sub>	EMUT	reference viscosity at a known temperature, com- puted for still gas (stagnation conditions), N sec/m <sup>2</sup> (lb sec/ft <sup>2</sup> )		

х

Symbol	FØRTRAN	Description
ν	ENU	kinetic viscosity of gas, m <sup>2</sup> /sec (ft <sup>2</sup> /sec)
ρ	RHØS	local static density, N $\sec^2/m^4$ (lb $\sec^2/ft^4$ )
°F	RHØSF	<pre>static density at the fan(s), N sec<sup>2</sup>/m<sup>4</sup>  (lb sec<sup>2</sup>/ft<sup>4</sup>)</pre>
°τ	RHØT	density computed for total (stagnation) condi- tions, N sec <sup>2</sup> /m <sup>4</sup> (1b sec <sup>2</sup> /ft <sup>4</sup> )
ρ <sub>o</sub>	RHØSO	static density at upstream end of test section, N $\sec^2/m^4$ (lb $\sec^2/ft^4$ )
$\sum_{i=1}^{N} \kappa_{o_{i}}$	SUMEKO	summation of section total pressure losses referenced to test section conditions
$\sum_{i=1}^{N} L_{i}$	SUMEL	summation of section centerline lengths, m (ft)
φ	PHI	corner flow turning angle, deg
20	TH2	diffuser equivalent cone angle:
		$\left(\sqrt{A_{0}} - \sqrt{A_{1}}\right)$

ļ

2 tan<sup>-1</sup> 
$$\left(\frac{\sqrt{A_2} - \sqrt{A_1}}{L\sqrt{\pi}}\right)$$
, deg

#### AERODYNAMIC DESIGN GUIDELINES AND COMPUTER PROGRAM FOR ESTIMATION

#### OF SUBSONIC WIND TUNNEL PERFORMANCE

William T. Eckert, Kenneth W. Mort, and Jean Jope

Ames Research Center and Ames Directorate, U.S. Army Air Mobility R&D Laboratory

#### SUMMARY

This report brings together and refines the previously scattered and oversimplified techniques for the aerodynamic design and loss prediction of the components of subsonic wind tunnels. General guidelines are given for the design of diffusers, contractions, corners, and the inlets and exits of nonreturn tunnels. A system of equations, reflecting the current technology, has been compiled and assembled into a computer program (a user's manual for this program is included) for determining the total pressure losses. The formulation presented is applicable to compressible flow through most closed- or openthroat, single-, double-, or non-return wind tunnels. A comparison of estimated performance with that actually achieved by several existing facilities produced generally good agreement.

#### INTRODUCTION

In the past, most of the work on the design of ducts and wind tunnels and on the determination of their pressure (and power) losses has been either highly specialized, considering only one type of component, or over-simplified, covering several types of components but giving only a superficial idea of what parameters are important. However, for the recent NASA studies directed toward new and modified wind tunnel facilities, it has been necessary to do a careful job of estimating, easily and quickly, the performance of all circuit components. This report brings together, revises, and updates the techniques for the aerodynamic design and performance prediction of subsonic wind tunnels.

The basic procedures and guidelines for the aerodynamic design of critical wind tunnel components, as presented in references 1 through 3, have been revised and updated, as required. The diffuser and contraction design curves developed and suggested herein show the relative design points for several existing facilities. Also provided are recommendations derived from recent NASA studies on end treatments for non-return wind tunnels.

The method of loss analysis presented is a synthesis of theoretical and empirical techniques. Generally, the algorithms used were those substantiated by experimental results. The methods of references 4 through 11 for predicting component losses have been refined and incorporated. The performance calculations, based on user-selected flow conditions at the test section, assume that the circuit geometry has been predetermined.

The comparison of the actual and predicted performance for several existing wind tunnel facilities shows generally good agreement.

# CAUTIONARY DESIGN GUIDELINES

This report presents the means for rapidly estimating the performance of a wind tunnel circuit after its geometry has been determined. However, an improper design of any of its several components (diffusers, contractions, or corners, for example) could result in performance penalties caused by interaction with the flow in other components; such penalties cannot be predicted. In addition, improper design could cause poor test-section flow quality which would not be indicated by the performance analysis. Therefore, the purposes of this section are to point out critical areas of concern in wind tunnel design and to attempt to establish proper design criteria.

#### Diffusers

Diffusers, especially those just downstream of high-speed sections, are very sensitive to design errors which may cause flow separation. The equivalent cone angle and area ratio must be properly selected to avoid steady-state or intermittent separation of the flow from the diffuser walls. (This separation can cause vibration, oscillatory fan loading, oscillations in test section velocity, and higher losses in downstream components.) Generally, proper diffuser design requires that, for a given area ratio, the equivalent cone angle be constrained below a certain value. ("Equivalent" denotes an imaginary conical section with length and with inlet and exit areas identical to the actual section.) This cone angle should probably be held 0.5° to 1° lower for diffusers with sharp corners than for those with a rounded cross section.

Since the portion of the wind tunnel between the test section and the fans is usually the higher-loss segment, it is the most critical in affecting circuit performance. Therefore, it was used as a basis for establishing recommended design limits as a guide to diffuser selection. It was assumed that the fans serve to reenergize the boundary layer of downstream sections and that the fans and the upstream and downstream components have no interaction that affects their losses; this may or may not be true (see ref. 12). The overall area ratio and cone angle between the test section and fan contraction were examined for several wind tunnels. This analysis used the centerline lengths of all intervening components, including corners. (The actual effect of corners is unknown: they may alter the onset of separation somewhat.) Figure 1(a) compares curves for the first appreciable stall for flows with thin inlet boundary layers, from references 1 and 2, with the design points of selected existing wind tunnels. These curves were used to aid in defining the separation trend; good correlation with the symbols is not necessarily expected. Figure 1(a) shows that most of these wind tunnels were designed beyond (above) the two-dimensional stall curve but below the conical stall

curve. (Some of these diffusers are far from conical.) The recommended design region, shown in figure 1(b), was positioned with the prior knowledge that the NASA-Ames 7- by 10-Foot Wind Tunnel has a partially separated diffuser just downstream of the test section, and that the NASA-Ames 40- by 80-Foot Wind Tunnel has some local separation in the corners of the primary diffuser. The upper portion of the design region is recommended for diffusers with rounded corners, and the lower portion for diffusers with sharp corners.

# Contractions

Contracting sections are subject to separation in the same manner as diffusers; however, the penalties are usually much less severe in the contracting sections. Separation of the flow can occur if the contraction is too short for the amount of area reduction. Figure 2(a) presents the general wall shapes suggested in reference 3 and figure 2(b) shows the design boundary for these shapes in comparison with the designs of several selected wind tunnel facilities.

From this comparison it is evident that, while some facilities were designed more conservatively than others, no design severely exceeds the design boundary. Since none of the facilities considered has shown significant contraction-caused flow problems, the design boundary may be considered empirically reasonable. Further, reference 13 generally tends to support the positioning of the suggested design curve. However, the criteria of reference 13 are more conservative due to consideration of viscous effects which were neglected in the study of reference 3.

#### Corners

The corner losses in a wind tunnel can be large. To minimize them, turning vanes should be used for more efficient turning. Also, as with any other high-loss item corners should, where possible, be located in a large-area section where the flow speed is low. Corner vane losses can be minimized in two additional ways: (1) by selecting an efficient vane cross-sectional shape and adjusting it for proper alignment with the flow, and (2) by choosing the best chord-to-gap spacing.

With reference to item (1), turning vane shapes can vary from bent plates to highly-cambered airfoils. Some sources favor airfoil vanes as being more efficient (ref. 4, p. 63) while others claim that thin vanes can have lower losses (ref. 5, p. 93). But airfoil vanes with blunted leading edges may be more forgiving of misalignment with the flow. The thicker vanes may, therefore, hold some advantage.

When considering item (2), the best chord-to-gap ratio depends on the vane type. For thick vanes, a ratio of about 2.5-to-1 is recommended (ref. 4, p. 62) and for thin vanes a ratio of about 4-to-1 is suggested (ref. 5, p. 92).

# Non-Return Wind Tunnels

Non-return wind tunnels have presented some interesting problems in tunnel design. This type of wind tunnel has the advantages of less structure (and therefore lower construction costs) and of no exhaust-gas-purging or airexchange requirement. Careful design can make the non-return circuit operating power competitive with that of closed-return wind tunnels (the corner losses can be traded for inlet and exit losses). However, an area of concern for the non-return tunnel is its potential sensitivity to external winds which could affect both the required power and the test section flow quality.

A recent series of NASA studies, which dealt with wind s nsitivity problems, showed that a non-return wind tunnel should have three eatures: (1) a vertical exit system, (2) a horizontal inlet, and (3) an enclosed area of protection, with a solid roof, at the inlet. References 14 and 15 detail the development work for the end treatment considered in those studies.

Reference 16 describes an inlet geometry that was developed to reduce the effects of wind. (This reference also presents a set of test-section flowquality requirements by which the characteristics of any inlet treatment may be evaluated.) Although the end treatment designs shown in references 14 through 16 could be revised or refined for additional wind protection, any additional inlet treatment would increase the structural cost and could increase the power requirement.

#### PERFORMANCE ESTIMATION

Although the performance analysis presented in this report was systematized and automated for rapid calculation of numerous cases or iterations (by the computer program described in the following sections), the equations presented are equally amenable to manual calculation methods.

# General Approach

The equations were derived in forms that use the most common and convenient defining parameters. The equations are listed and explained below and may be used for component after component, each in turn.

The total pressure losses (proportional to power losses) of each component are calculated and summed to give the total circuit loss and operating power required. The computation technique is applicable to either closed- or non-return circuit types made up of any combination of standard wind tunnel components in any order. The flow conditions in the test section (velocity, and stagnation temperature and pressure) and the external atmospheric pressure are variable as required.

### Problem Restrictions

Three restrictions were found to be necessary in order to allow rapid solution of most cases with a minimum amount of effort. First, the crosssectional geometries were limited to the most common shapes: circular, rectangular, and flat-oval (semi-circular side walls with flat floor and ceiling). Second, air exchangers were omitted from this analysis due to lack of uniformity of configuration and a lack of definition as to the proper method of computing the losses. Finally, the drive system was assumed to be located in one or more parallel, annular ducts.

# Computation Formulas

е Л

The equations used in this performance analysis were synthesized from various sources. Some were used in their original (source) form and others were modified to make them more convenient for use in this analysis. The equations used are presented below.

Flow-state parameters- The basic flow-state parameters were determined from input information about the reference control station and the test section. These parameters were derived from standard relationships for compressible flow.

$$\rho_{\rm T} = \frac{P_{\rm T}}{RT_{\rm T}}$$
 (ref. 17, p. 8)

$$a_{T} = \sqrt{\gamma RT_{T}} \qquad (ref. 17, p. 51)$$

$$\mu_{\rm T} = \mu_{\rm STD} \left( \frac{{\rm T}_{\rm T}}{{\rm T}_{\rm STD}} \right)^{0.76}$$
 (ref. 18, p. 19)

$$a_{0} = \frac{a_{T}}{\sqrt{1 + (\frac{\gamma - 1}{2} M_{0}^{2})}}$$
 (ref. 18, p. 4)

$$\rho_{o} = \frac{\rho_{T}}{\left[1 + \left(\frac{\gamma - 1}{2} M_{o}^{2}\right)\right]^{\frac{1}{\gamma - 1}}} \qquad (ref. 18, p. 4)$$

$$A_{\star} = M_{o}A_{o} \left\{\frac{\gamma + 1}{2\left[1 + \left(\frac{\gamma - 1}{2} M_{o}^{2}\right)\right]}\right\}^{\frac{\gamma + 1}{2(\gamma - 1)}} \qquad (appendix A)$$

Local conditions- The local flow conditions were determined for each end of each section.

1. Mach number: The local Mach number was found from a Newton's-method solution of the relationship

$$M^{2} - \left[\frac{\gamma + 1}{\gamma - 1} \left(\frac{A}{A_{\star}} M\right)^{\frac{2(\gamma - 1)}{\gamma + 1}}\right] + \frac{2}{\gamma - 1} = 0 \qquad (appendix A)$$

2. Reynolds number: The Reynolds number based on the characteristic length *l*, usually the local hydraulic diameter, was determined from

$$RN = \frac{\rho_0 V_0 \ell}{\mu_T} \left(\frac{A_0}{A}\right) \left[1 + \left(\frac{\gamma - 1}{2} M^2\right)\right]^{0.76}$$
(appendix A)

3. Friction coefficient: A Newton's-method solution was used to determine the friction coefficient for smooth walls from the expression

$$[\log_{10}(\lambda RN^2) - 0.8]^{-2} - \lambda = 0$$
 (appendix A)

Section pressure losses- The loss in total pressure caused by each section was calculated in a form non-dimensionalized by local dynamic pressure:  $K = \Delta p_T/q$ . (In this study the smallest-area end of each section was used as the local reference position.) The individual losses were based on the nature of the section, local flow conditions, and input geometry and parameter information. The most appropriate loss forms for typical wind tunnel sections are catalogued on the following pages. The nonstandard formulas, those which are not directly attributable to the literature, are developed in appendix A. The precise equations, which were developed from various curve-fitting and interpolation techniques based on the plots presented in certain figures, are given in appendix B.

1. Constant-area ducts: For closed, constant-area sections the pressure loss due to friction is given by

$$K = \frac{\lambda L}{D_h}$$
 (ref. 7, p. 53)

2. Open-throat duct: The losses from an open-throat test section may be found from the expression

$$K = 0.0845 \frac{L}{D_{h}} - 0.0053 \left(\frac{L}{D_{h}}\right)^{2}$$
 (ref. 7, p. 150)

3. Contractions: In contracting sections, where the major part of the losses is due to friction, the local loss may be approximated as

$$K = 0.32 \frac{\lambda L}{D_h}$$
 (ref. 6, p. 528)

4. Corners with no net area change ("constant area"): A duct can change direction with or without the aid of flow guide vanes. For a constant-area turn employing turning vanes for efficiency, with a "normal" number of vanes (ref. 7, p. 241), and with chord-to-gap ratios between 2-to-1 and 4-to-1, the losses resulting from friction and rotation caused by the vanes are

$$K = \frac{K_{\text{TV}}}{3} \left[ 2 + \left( \frac{\log_{10} \text{RN}_{\text{REF}}}{\log_{10} \text{RN}} \right)^{2.58} \right]$$
(appendix A)

The Reynolds number used for the turning vane loss should be based on vane chord. The turning vane loss parameter  $K_{\rm TV}$  is plotted as a function of turning angle in figure 3(a), with the assumption that  $K_{\rm TV}$  = 0.15 is a reasonable value for a 90° corner. Corners without turning vanes are less efficient and the loss function may be approximated by a sixth-order polynomial as shown in figure 3(b):

$$K = 4.313761 \times 10^{-5} - 6.021515 \times 10^{-4} \phi + 1.693778 \times 10^{-4} \phi^2 - 2.755078 \times 10^{-6} \phi^3$$

+2.323170×10<sup>-7</sup> 
$$\phi^4$$
 - 3.775568×10<sup>-9</sup>  $\phi^5$  + 1.796817×10<sup>-11</sup>  $\phi^6$ 

(appendix B)

This function assumes a loss value of about K = 1.8 for a 90° turn. The foregoing losses are those associated with the turning of the flow only. The losses for a corner system (with or without vanes), with the walls of the duct to be considered as well, requires an additional term for the frictional loss of the constant-area duct based on the centerline length.

5. Corners (diffusing): Corners with diffusion may well employ longer vanes in order to improve the efficiency of the diffusion process. For this reason they were treated as vaned diffusers with the addition of the rota-tional loss term of the turning vane function:

$$K = \left\{0.3 + [0.006(2\theta - 21.5^{\circ})u(2\theta - 21.5^{\circ})]\right\} \left(\frac{AR - 1}{AR}\right)^{2} + \frac{2}{3}K_{TV}$$

(appendix A)

where  $u(2\theta - 21.5^{\circ})$  is the unit step function and the turning vane loss parameter is defined as for a constant-area corner. This loss function includes the effects of friction.

6. Diffusers: Diffusion produces both expansion and friction losses in the duct given by

$$K = \left[K_{EXP} + \left(\frac{\lambda}{8 \sin \theta} \frac{AR + 1}{AR - 1}\right)\right] \left(\frac{AR - 1}{AR}\right)^2 \qquad (appendix A)$$

where the expansion parameter values,  $K_{EXP}$ , are plotted against equivalent cone angle in figure 4 and the technique used for estimating the  $K_{EXP}$  values is described in appendix A.

(It should be noted that there are more sophisticated techniques for estimating diffuser performance than the one presented here. However, they require boundary-layer calculations; for example, see reference 19. Experience with both the simple technique described herein and more complex techniques indicates that the two produce comparable results. Generally, little is gained by the significant additional effort required to use the more complex approaches.)

7. Exit: The total pressure loss at the exit of a non-return wind tunnel, or of any expelled flow, is due to the loss of the kinetic energy of the exiting flow. This is given by

$$K = \frac{2\left\{\left[1 + \left(\frac{\gamma - 1}{2} M^2\right)\right]^{\frac{1}{\gamma - 1}} - 1\right\}}{\gamma M^2}$$
 (appendix A)

8. Fan (power) section: Fan drive sections are commonly made up of contractions, constant-area annular ducts, and diffusers. Analysis should be handled by dividing the fan section into these three component parts.

9. Flow straighteners - honeycomb (thin walls): The loss through thin flow-straightener or honeycomb systems may be expressed as

$$K = \lambda \left(3 + \frac{L}{D_h}\right) \left(\frac{A}{A_{FLOW}}\right)^2 + \left(\frac{A}{A_{FLOW}} - 1\right)^2 \quad (ref. 7, p. 478)$$

where the hydraulic diameter is that of the honeycomb cell. The friction coefficient is determined from a Reynolds number based on the surface roughness of the honeycomb:

for RN 
$$\leq 275$$
,  $\lambda = 0.375 \text{ RN}^{-0.1} \left(\frac{\Delta}{D_h}\right)^{0.4}$   
and for RN > 275,  $\lambda = 0.214 \left(\frac{\Delta}{D_h}\right)^{0.4}$ 

10. Flow straighteners - airfoil members (thick walls): Flow through adjacent airfoils will first contract and then diffuse. It was assumed that the point of minimum distance between parallel members would be at 30 percent of the straightener length back from the leading edge. The forward 30 percent was treated as a contraction and the aft 70 percent as a vaned diffuser. Thus,

$$K = 0.096 \frac{\lambda L}{D_{h}} + \left\{ 0.3 + [0.006(2\theta - 21.5^{\circ})u(2\theta - 21.5^{\circ})] \right\} \left( \frac{AR - 1}{AR} \right)^{2}$$

(appendix A)

where the hydraulic diameter is that of each cell of the flow straightener, the friction coefficient is determined from a Reynolds number based on that hydraulic diameter, the area ratio and equivalent cone angle are based on the exit and minimum flow areas, and  $u(2\theta - 21.5^{\circ})$  is the unit step function.

ll. Internal flow obstruction - drag item: The loss due to the drag of internal structure such as struts or models has the form

$$K = C_D \frac{S}{A_{FLOW}} \epsilon \qquad (appendix A)$$

12. Perforated plate: Perforated plate with sharp-edged orifices, used as protection screen or as screen around the inlet of a non-return tunnel, produces losses given by

$$K = \left\{ \left[ \sqrt{\frac{1}{2} \left( 1 - \frac{A_{FLOW}}{A} \right)} + \left( 1 - \frac{A_{FLOW}}{A} \right) \right] \frac{A}{A_{FLOW}} \right\}^2 \quad (ref. 7, p. 321)$$

13. Mesh screen: The losses produced by a mesh screen may be expressed as

$$K = K_{\rm RN} K_{\rm MESH} \left( 1 - \frac{A_{\rm FLOW}}{A} \right) + \left( \frac{A}{A_{\rm FLOW}} - 1 \right)^2 \qquad ({\rm ref. 7, p. 308})$$

where the Reynolds number influence factor,  $K_{\rm RN}$ , is plotted against Reynolds number (based on mesh diameter) in figure 5, and the mesh constant,  $K_{\rm MESH}$ , is 1.3 for average circular metal wire, 1.0 for new metal wire, and 2.1 for silk thread.

14. Sudden expansion: For a sudden expansion with ducting downstream (to allow reattachment of the flow and maximize the pressure recovery) the loss is

$$K = \left(\frac{AR - 1}{AR}\right)^2 \quad (ref. 7, p. 128)$$

15. Vaned diffusers: The pressure loss of a vaned diffuser, one in which splitter vanes are used to improve the performance of a short diffuser by decreasing the effective equivalent cone angle of each chamber, may be determined from

$$K = \left\{0.3 + [0.006(2\theta - 21.5^{\circ})u(2\theta - 21.5^{\circ})]\right\} \left(\frac{AR - 1}{AR}\right)^{2}$$

(appendix A)

where  $u(2\theta - 21.5^{\circ})$  is the unit step function. (See fig. 6.)

16. Fixed, known loss: For a fixed loss item where the pressure loss value is known, that value may be used directly by definition:

should be based on the geometry of one of the individual ducts. The loss for the system of ducts may then be determined from the loss for a single duct:

$$K = \frac{\Delta PTSYSTEM}{q} = \frac{\Delta PTDUCT}{q}$$

18. Loss value transferred to reference location: Each local loss parameter is calculated based on local conditions at the smallest-area end of each section and may then be referenced to the test section conditions by the formula

$$K_{o} = K \left[ \frac{A_{o}M}{AM_{o}} \sqrt{\frac{1 + \left(\frac{\gamma - 1}{2} M_{o}^{2}\right)}{1 + \left(\frac{\gamma - 1}{2} M^{2}\right)}} \right]$$
(appendix A)

19. Overall and summary performance: The energy ratio of the wind tunnel under consideration is given by

ER = 
$$\frac{1}{\sum_{i=1}^{N} K_{o_i}}$$
 (ref. 4, p. 69)

flow.

the

The pressure difference across the wind tunnel walls, determining the minimum required structural strength for each section, is given by

$$\Delta p_{W_{i}} = p_{T_{ATM}} - \left\{ \frac{p_{T_{SC}} - \left(q_{o} \sum_{j=1}^{i} K_{o_{j}}\right)}{\left[1 + \left(\frac{\gamma - 1}{2} M_{i}^{2}\right)\right]^{\frac{\gamma}{\gamma - 1}}} \right\}$$
(appendix A)

The power required to be input into the flow in order to drive the flow through the wind tunnel at a specified test section speed is expressed as

$$P_{\rm INPUT} = \frac{\left(\sum_{i=1}^{N} \kappa_{o_i}\right) \rho_o^2 A_o V_o^3}{2\rho_F} \qquad (appendix A)$$

The actual drive power required is dependent on the efficiency of the fan/motor system:

10

passes

losses

$$K = \frac{\Delta P_T}{q}$$



#### COMPUTER PROGRAM DESCRIPTION

The computer program was written in FØRTRAN IV language. It consists of a main program which calls five subroutines and/or six library routines, as required. Two of the subroutines are optional and may be abbreviated and simulated in order to save execution time and/or memory storage space.

#### Method of Solution

The general technique used is outlined in the computer program functional flow chart in figure 7. The program was developed in six functional units: a main program and five specialized subroutines. The main program retains general control over the computational flow and calls the subprograms as required.

In the main portion (designated PERFØRM), at first entry into the program, various section-shape geometry relationships and certain semi-empirical diffuser, turning vane, and honeycomb loss functions are defined. The case title card is read and checked for validity by specified code. The tunnel master data control card is then read, checked for validity, and checked for content of pertinent data by the data-checking subroutine. If any errors are found in either of these two preliminary cards, error messages will be printed. Although detected errors will not abort the computer run (unless a card of improper format is encountered where not expected), the case under current consideration will not be computed - only the checking of input errors will then be performed on each section card. Prior to reading the section cards, the units of measure (International System or U.S. Customary System) to be used for the particular case are read. These units of measure are used as the basis for the development of the appropriate flow parameters and test section conditions.

The section cards are read and operated on one at a time. They are checked for validity and input errors by the data-checking subroutine (called DATACK) and the input information, if sufficiently complete, is then used in the computation of the section upstream- and downstream-end geometries. Adjustments to these geometry calculations are made for any multiple-ducted sections. For diffusing sections where the expansion loss parameter was not input by the user, that parameter is generated from predefined functions. Branching of the computational flow then transfers control to the appropriate block of instructions for the remainder of the calculations which are peculiar to the particular section under consideration.

After all section cards have been read in and operated on, each in turn, a case termination card is encountered. The termination card specifies the optional summary operations to be performed. The encounter of this card signals the end of a case and triggers the final calculations. The codes contained on this card determine the printing of velocity-optimizing and circuit summary information, the plotting of the summary information, and the return to the beginning for another case.

The data-checking subroutine evaluates the master and section input cards for completeness of data (based on the requirements for the type of section). Then, if any error was detected during computation of a case or if the appropriate termination code was specified by the user, the complete set of input data is tabulated. Messages about errors, omissions, or superfluous information are included.

The subroutine SPEED computes the local Mach number based on local crosssectional area and determines the local flow velocity.

The subroutine FRICTN calculates the local Reynolds number, usually based on the local duct hydraulic diameter, and the local friction coefficient for smooth pipes.

The subroutine ØUTPUT accepts the calculated section parameters along with the section type codes describing the types of information to be output and prints the section information according to the appropriate format.

The subroutine PLØTIT plots the summary information (cummulative total pressure losses and/or wall pressure differential) versus circuit centerline length if requested. The plot is scaled for centimeter or inch plot paper, determined by whether International or U.S. Customary units are used for computation.

The program is terminated after the last operations on a case for which a no-return instruction on the termination card was given by the user.

# Computing Equipment Required

Hardware and machine components- Although this program was written for use on an IBM 360/67 with TSS Monitor, batch mode, an attempt was made to keep it compatible with any system that uses FØRTRAN IV. No magnetic tapes were used. In this version, input is made by cards and the data to be plotted are stored on a disc file for plotting at a later time in an off-line mode. However, it is possible to use a typewriter-type terminal for conversational or real-time computation, typing the data by card-image format, and plotting immediately after the computation has been completed for a case.

The total core required for compilation on the IBM 360/67 was approximately 82 000 (decimal) bytes. If necessary this figure can be reduced by eliminating two subroutines, DATACK and PLØTIT. The sizes of the main program and of each subroutine were approximately as follows:

PERFØRM	38	800	bytes
DATACK	25	700	
SPEED		800	
FRICTN		900	
ØUTPUT	12	900	
PLØTIT	2	900	

The program was executed on an IBM 360/67, writing plot data on a disc, logical unit 10. Later the data file was accessed from a 14.8 character-persecond binary-coded-decimal terminal and plotted on a Zeta plotter with 0.005-in. step increments. The plot page size was programmed not to exceed 25 by 38 cm (or 10 by 15 in.).

Software- This program was written for use on any computer with sufficient core and with a standard FØRTRAN IV compiler.

The Zeta plotter routines, with minor exceptions, are compatible with the Calcomp routines. The subroutines AXIS, FACTØR, LINE, PLØT, SCALE and SYMBØL are alike in both Calcomp and Zeta plotting.

- CALL AXIS draws the axis line and annotates the divisions at every two centimeters or each inch (depending on the units of measure specified).
- CALL FACTØR enables the user to produce normal size drawings with plotters which have either 0.01- or 0.005-in. increment size. The variable FACT must be set to 1.0 for 0.01-in. increments and to 2.0 for 0.005-in. increment plotters.
- CALL LINE plots centered squares connected by straight lines through the coordinate pairs of data values.
- CALL PLØT is used to establish a new point of origin for the pen and paper movements. Before plotting commences, the pen must be positioned where desired along the X-axis. The program will position it along the Y-axis. The plot-page size is defined by the values of YLEN and XLEN which are equated to 25 and 38 cm or 10 and 15 in., as required.
- CALL PLØTF is an alternate plotting initialization routine which is available in the Zeta but not Calcomp plot package. It is used in place of PLØTS whenever deferred plotting is desired. The first argument in the call statement indicates the speed of the terminal with which the plotter is interfaced. The second argument is the logical-device number of the plot file.
- CALL SCALE examines the data and determines the proper scaling for the given dimensions of the plotter paper, 25 by 38 cm or 10 by 15 in.
- CALL SMØDE is available only in the Zeta plot package. It permits the user to choose from extensive capabilities which affect several of the plotter routines. In this program the options have been set equal to the usage found in the Calcomp routines, and therefore, if Zeta plotter routines are not available, the call to SMØDE should be eliminated.

CALL SYMBØL - prints the input case title at the top left of each plot page as it appears in columns 2 through 80 of the title card. For reference purposes, it also draws a small plus sign at the origin of the plot.

The library routines used are standard FØRTRAN routines:

ABS - Absolute value

ALØG10 - Common logarithm, base ten

ATAN - Arctangent (result in radians)

EXP - Exponential of the natural number e

IFIX - Convert from real number to integer

SIN - Trigonometric sine (argument in radians)

SQRT - Square root

#### Programming Techniques

It was intended that this program be usable on as many different computer systems as possible. Therefore, in order to make them applicable to some machines, certain statements were forced into particular forms which would be less efficient on other systems (e.g., Hollerith instead of literals in format statements).

CØMMØN and DATA statements were used as much as possible to simplify the definition of parameter values. In the main program, arithmetic statement functions were used for three purposes: (1) for the definition of section hydraulic diameter, area, and equivalent cone angle geometry functions; (2) for the conversion function from local to reference-section pressure losses; and (3) for the definition of the least-squares-polynomial-curve-fit functions. The last group of functions includes: (1) the corner turning-loss parameters as functions of turning angle (see fig. 3); (2) the diffuser expansion loss parameters for the different cross-section shapes as functions of equivalent cone angle (see fig. 4); and (3) the mesh screen Reynolds number sensitivity factor as a function of mesh-diameter-based Reynolds number (see fig. 5).

Certain functions not easily solvable in closed form were solved iteratively (some by Newton's method) to 0.01 percent accuracy. These functions include test section Mach number, local section Mach number, and local section friction coefficient.

Numeric codes were used for specifying such things as section type, section end-shape types, and system of computational units; for decisions on requirements for inputs to each section type; and for case-termination procedures and outputs desired. The various important input codes are listed in tables 1 and 4. All sections of the multiple-ducted type were assigned high code numbers for simplicity in selecting them for special handling. The

various section types were grouped in code decades for reasonable association of section code and component function. Where possible, the second digit of the code (if that second digit is not zero) reflects the basic characteristic of the section: constant area, contracting, or diffusing.

The information input fields on the master data and section cards were arranged in three basic groups: (1) qualitative information (type and shape); (2) quantitative geometry information (number of ducts, cross-sectional end dimensions, and length); and (3) loss-related parameters. The case termination card employs the same format as the section cards so that it may be encountered at random intervals without causing a program crash. For the tabulation of the input data (for error-location and record-keeping purposes), objecttime formatting was used to compile the combination input and annotation data set for a convenient output.

Much of the output of the program was set up on a demand (i.e., optional) basis. A section-by-section performance analysis is automatically provided. A brief summary of the variation of selected parameters through the circuit, and plots of those parameters, may be selected if desired. An annotated listing of the inputs may be requested or, if errors are detected, the listing is internally forced in order to provide a simple means of error-detection and correction and/or simplified record-keeping of case data.

#### Source Code

A source code listing of the performance estimation program is provided in appendix C along with the associated notation definitions. The source code includes the use of comment cards throughout the program for identification of the operations carried out by each set of instructions.

#### Operating Instructions

The basic source program deck arrangement is shown in figure 8.

Input- Sample coding forms for the four types of input cards required are presented in figure 9. The special symbols required in the first columns of the title and master data cards are included.

1. Title card: For the title labeling card, with the exception of the first column which must contain an asterisk (\*), the entire card may be used as desired. This title was programmed to appear at the top of each page of the case to which the title refers, including the plots. Only one title card per case may be used.

2. Master card: The tunnel master control data card provides sufficient information for defining conditions in the test section (which is the reference section for all calculations) and conditions of the surrounding external atmosphere. Table 2 details the inputs included on the master data card. The first column must contain a minus sign in order to identify the card as a valid master card. The remainder of the inputs should be positive, with columns 2 through 6 containing five fields of integers only (no decimal points). Columns 7 through 10 were not used on this card and should be left blank. Columns 11 through 50 should contain floating-point numbers. These columns were divided into eight parameters of five columns each, including decimal point.

3. Section cards: The individual section information cards were based on the same format as the master card, except that the section cards require no special identifying code. Table 3 details the inputs contained on the section cards. The first six columns, containing four data fields, require integer inputs. The remaining 74 columns were divided into two real number fields of two columns each (with the assumed default decimal points to the right of the second columns), and 14 real number fields of five columns each (with the assumed default decimal point between the third and fourth columns of each field).

Although the input parameter requirements vary from section to section, certain requirements are basic to all sections. These items include: (1) the section type code, (2) the section end shape codes, and (3) the section dimensions (end height(s) and width(s) and/or diameter(s) and usually length). A detailed list of the additional, specialized requirements for each section is presented in table 4.

Although not mandatory in order to obtain a correct total power estimation, it is advisable to input the section data cards in the actual section order so that the summary calculations and plots have relevance to the actual circuit.

4. Termination card: The case termination card, which signals the end of the section inputs for a particular case, is identified by the constraint of blanks in card columns 3 and 4. The numbers contained on this card are used strictly as task codes; table 5 shows the details of these codes. In the event of a request for plotted information, the code determines the type(s) of information to be presented. For all other tasks the codes dictate a simple yes/no decision.

As many cases as desired may be input in a single job submission. The same system of units need not be used in all cases. Any parameters may be changed as desired from case-to-case since there are no forced carry-overs (except the specific heat ratio,  $\gamma$ , which is fixed at the time of program compilation).

Output- Based on the foregoing input information the results may be calculated and tabulated in five different types of information groups.

1. Section performance analysis: The section performance tabulation fully describes the performance-related parameters of the wind tunnel circuit. Atmospheric and test section flow reference conditions are stated at the top of the first page. The various parameters are tabulated for each section in the order of computation with the upstream end information on the first and the downstream information on the second of the two lines for each section. The section sequence number and type (a translation of the code) and the end shapes are given first. The geometry and local velocity information are presented next, followed by the section length and calculated total pressure loss values.

2. Overall performance: If no input errors are encountered during the analysis of a case, overall performance values are presented at the end of the section performance tabulation. This includes the total circuit length, the total pressure losses and energy ratio for the circuit, and the total operating power required.

3. Summary characteristics: If requested on the termination card and barring any errors, a summary of the circuit characteristics is tabulated on a separate page. This tabulation includes section sequence numbers, Mach numbers, cumulative pressure losses, and local wall pressures, all as functions of distance through the circuit.

4. Plots: Under proper condition codes, the cumulative pressure losses and/or the wall pressure differentials will be plotted as functions of distance through the circuit (centerline length). The straight lines that appear on the plots connecting the points are for reference only and do not represent the actual distribution in a component.

5. Input data tabulation: Finally, if an input error was encountered during the analysis of the circuit, or if such information was requested by the user, the input cards are tabulated with annotations regarding missing or superfluous inputs. A careful look at this section should allow the user to discover why a given set of input data did not produce the expected type of results.

All of the foregoing types of output are shown for the test case.

Computer system restrictions- Certain restrictions and/or assumptions had to be imposed on the computer system and its methods and abilities in order to perform the performance analysis within reasonable time, effort, and money constraints.

1. Hardware: This analysis was programmed for a moderate-sized system with common components. No special hardware is required with the exception of a plotter if the plotting option is used. The output printing device is assumed to have available a minimum capacity of 120 characters per line, but the number of lines per page may be set by means of the LINEMX parameter in the main program. (Barring any special requirements, 45 lines for an 8.5-in. page or 60 lines for an 11-in. page are recommended.)

2. Software: Certain software restrictions were imposed simply as a starting point to the problem solution. The input card formats were fixed as shown in figure 9. The specific heat ratio ( $\gamma$ ) and the number of lines per output page were fixed for each compilation of the source deck, although changes can be made by altering the values of G and/or LINEMX, respectively, near the beginning of the main program.

For reasons of possible memory limitations on smaller systems, the number of wind tunnel components in each circuit case was limited to 30 sections. This limit may be changed by assigning a new value to LMTSEC in the main program and by re-dimensioning the following variables as denoted by "XX": in the main program (PERFØRM), DELP(XX+2), SEKO(XX), SEL(XX), SMACH(XX), SSUMEL(XX+2) and SSUMKO(XX+2); in the data-checking subroutine (DATACK), ENDATA(XX,20), NCHECK(XX,20) and NDATA(XX,4); and in the plotting subroutine (PLØTIT), DELP(XX+2), SSUMEL(XX+2) and SSUMKO(XX+2). If memory limitations are a severe problem and/or if computer-controlled plotting facilities are not available to the user, the data-checking and/or plotting subroutines may be "removed" by inserting dummy, one-card subroutines with the same arguments which would have no effect on the calculations. This would decrease the utility and power of the program, but would retain the basic performance estimation capabilities without crippling them altogether.

The plotting routines were written according to the requirements for a plotter with 0.005-in. increments.

Optional inputs- Certain of the parameter inputs are designated as optional and have built-in assumed default values in the event that the user knows no better values than the ones provided in the sources referenced herein. These optional parameters are shown in tables 2 through 4.

On the master card (see table 2), the units of measure should be specified and an error message will be given if they are specified erroneously (other than as type 1 or 2). However, the units code will default to 1 (the International System) and case execution will continue. The test section and atmospheric total pressures will default to one atmosphere if not specified.

On the section cards (see table 3), the number of items in the duct will default to unity if not specified. The expansion loss parameter for diffusers defaults to a value based on figure 4. (It is computed by determining the shape of each end, the extent to which the diffuser is two-dimensional in nature (i.e., changing cross-sectional size in height or width only), and the equivalent cone angle, and then interpolating between the curves of figure 4. See appendix A.) The mesh screen loss constant defaults to 1.3, the value for an average-condition metal mesh screen (ref. 6, p. 527), and the reference Reynolds number for turning vanes defaults to 0.5 million (ref. 6, p. 527). The surface roughness for honeycombs defaults to the appropriate equivalent of 0.00001 m, the value for new, commercially smooth, non-steel pipe (ref. 7, p. 62). The factor for the additional influence of a blockage on downstream sections ( $\Delta \varepsilon$ ) defaults to zero.

*Diagnostic messages*- There are a limited number of error diagnostic messages which were built in to handle many, but not all, of the potential user errors. The causes and appropriate corrections of these errors should be evident in each message.

1. Title card: If a card is in the position of a title card and does not begin with an asterisk as required, the following message will appear:

TITLE ('...(invalid title)...') IS INCORRECT OR IMPROPER AS IT EXISTS. THE FIRST CARD COLUMN MUST CONTAIN AN ASTERISK (\*) TO BE IDENTIFIED AS A VALID TITLE CARD.

2. Master card: An invalid master card is denoted by:

MASTER CONTROL DATA ('...(card image)...') IS INCORRECT OR IMPROPER AS IT EXISTS. THE FIRST TWO CARD COLUMNS MUST CONTAIN A NEGATIVE NUMBER (-1 TO -9) TO BE IDENTIFIED AS A VALID MASTER CARD. THIS CASE WILL BE SKIPPED.

A general omission from the master card of required information produces:

CRITICAL OMISSION(S) IN TUNNEL MASTER CONTROL DATA PREVENT EXECUTION OF THIS CASE. ANY SUCCEEDING CASES WILL NOT BE AFFECTED.

Two master cards, back-to-back, for a given case are identified by:

MORE THAN ONE MASTER CONTROL CARD EXISTS FOR THIS CASE OR INPUT CARDS ARE OUT OF ORDER. CHECK DECK SET-UP. THE LAST MASTER CARD ENCOUNTERED WILL BE ASSUMED AS THE CORRECT MASTER CARD FOR THE SECTION CARDS WHICH FOLLOW.

Encountering a master card where not expected (generally indicating missing case termination and title cards) causes this message:

MASTER CONTROL CARD HAS BEEN ENCOUNTERED BEFORE CASE TERMINATION AND TITLE CARDS. CHECK DECK SET-UP. ERROR-MESSAGE TITLE WILL BE GENER-ATED AND SUMMARY OUTPUT, NO-PLOT, INPUT DATA TABULATION, AND NEXT-CASE RETURN TERMINATION PARAMETERS WILL BE ASSUMED.

If an invalid test section upstream end shape geometry is specified, one which the program cannot handle, an error results:

\*\*ERROR -- INVALID TEST SECTION UPSTREAM END SHAPE CODE WAS SPECIFIED AS (code used) (SHOULD BE 1, 2 OR 3). THIS CASE CANNOT BE EXECUTED.

If an invalid units code is specified the message is:

THE UNITS OF MEASURE CODE IS IMPROPERLY SPECIFIED AS (code used), (SHOULD BE 1 OR 2). CHECK MASTER CARD (COLUMN 4). SEE THE DATA TABULATION AT THE END OF THIS CASE. THE INTERNATIONAL SYSTEM OF UNITS WILL BE ASSUMED FOR THIS CASE.

If the termination code requests power-matching but the input power value is such that the calculation would be meaningless, a diagnostic of the following form is printed:

\*\*ALTHOUGH VELOCITY-OPTIMIZING WAS REQUESTED BY TERMINATION CODE, THE INPUT POWER VALUE IS ILLEGAL (LESS THAN OR EQUAL TO ZERO). THEREFORE, NO VELOCITY-OPTIMIZING IS POSSIBLE. RECHECK INPUT VALUE ON MASTER DATA CARD. 3. Section card: A general omission of required data from a section card will cause this message:

\*\*ERROR -- CRITICAL OMISSION(S) IN SECTION INPUT DATA. SEE DATA TABULATION AT END OF OUTPUT FOR THIS CASE.\*\*

If an invalid section shape code is specified it is not possible for the program to properly compute section end geometries; as a result an error occurs:

\*\*ERROR -- INVALID SECTION SHAPE CODE WAS SPECIFIED AS (input code) (SHOULD BE 1, 2 OR 3). THIS SECTION WILL BE SKIPPED.

An error which arises during computation and causes a non-positive total pressure loss for a given section prevents completion of the case analysis and gives rise to an error message:

\*\*ERROR -- SOME INCORRECT COMBINATION OF INPUTS OR UNANTICIPATED SITUATION HAS CAUSED AN INVALID (NON-POSITIVE) TOTAL LOSS LEVEL. RECHECK SECTION (section number) INPUT DATA.

If the maximum allowable number of circuit sections written into the program is exceeded by placing too many section cards together in one case, or without termination, title, and master cards between cases, this diagnostic will appear:

MAXIMUM LIMIT ON THE NUMBER OF SECTIONS (...(maximum allowable number of section)...) HAS BEEN REACHED. EITHER A CASE TERMINATION CARD HAS BEEN OMITTED (ALONG WITH TITLE AND MASTER CARDS TO BEGIN A NEW CASE) OR THIS CASE IS TOO LONG FOR THE PROGRAMMED ALLOWABLE NUMBER OF SECTIONS. THE CASE HAS BEEN TERMINATED AT THIS POINT.

In this instance, the inputs from the group of sections for which the limit was exceeded will be tabulated and the remaining section inputs will be evaluated and tabulated. If the user fails to cause the test section blockage amounts specified on the master control card to coincide with that of the test section card, erroneous analysis may result since inconsistent flow areas would be calculated. The section card value will be used (since the discrepancy may be desired) and this notice is given:

\*\*NOTE -- TEST SECTION BLOCKAGE FROM SECTION CARD INPUT (...(section input value)...PERCENT) DOES NOT EQUAL THAT OF THE MASTER CARD INPUT (...(master input value)...PERCENT). CHECK DATA DECK. SECTION CARD VALUE WILL BE ASSUMED AS CORRECT AND EXECUTION WILL CONTINUE.

An invalid section type code will cause a section to be skipped and a message to be printed:

\*ERROR -- INPUT SECTION TYPE CODE (CARD COLUMNS 3 AND 4) CALLS INVALID SECTION TYPE. DATA CARD IGNORED.\*\*

Any input errors were deemed justifiable cause for judgment as an incomplete case. As a result, reliable overall and summary information cannot be calculated. To assist the user in locating the error(s), the input values will be forced to be tabulated and the following explanation appears:

\*\*\*DUE TO ERROR(S) IN INPUT CARD(S), VALID SUMMARY INFORMATION IS NOT AVAILABLE. REFER TO THE TABULATION OF INPUT DATA ON THE FOLLOWING PAGES. CORRECT THE ERROR(S) AND RESUBMIT THIS CASE. SUBSEQUENT CASES WILL NOT BE AFFECTED.

4. Possible errors lacking diagnostics: Certain potential problem areas remain unprotected by diagnostic and error-recovery systems.

No special provision was made for two test sections in the same circuit case. As long as the blockage values for both test sections match the one from the master card, no message will be printed. In any event, the execution will not be terminated. The test section shapes and dimensions from the master card are not checked against those of the test section card. Although a mismatch of these values could cause a mass-flow error, including and enforcing such a check could inhibit any meaningful tandem-test section cases. These problems could be avoided, however, by naming only one working section as a test section and referring to the other by general type.

Also, there was no provision for checking the specified tunnel type against the types of sections actually used (e.g., checking a non-return, or open-test-section tunnel for exit or open-throat test section input cards). This check is not critical and was left to the user.

One error-check was not included due to the program complications which would have resulted. If a case termination card is omitted at the end of a case and a computer-system control card or a title card is encountered, the error will be disastrous due to mismatched format types. Execution and calculations will be immediately aborted by the computer.

#### Test Case

The NASA-Ames Research Center 40- by 80-Foot Wind Tunnel was used as an example of a typical wind tunnel. This tunnel, illustrated in figure 10, is of the single-return, closed-test-section, continuous-running type. It has a flat-oval test section 12.2 m (40 ft) high by 24.4 m (80 ft) wide and is powered by six 12.2-m (40 ft) diameter, six-bladed fans. It has an eight-to-one overall contraction ratio and uses multiple-circular-arc type turning vanes in each of the four 90° corners.

A complete list of the test case inputs and computed information outputs are presented in figure 11. The machine computing time for this test case (without plots) was about 7 sec on an IBM 360/67.

Although this test case was not an exhaustive exercise of all possible tunnel components, it does include most of the basic section types: diffusing test section, single-duct contraction and diffuser, constant-area single duct, constant-area corner with turning vanes, and multiple-duct fan sections (contraction, constant-area annulus, and diffuser). Examples of other types of components are shown in the sample cases which follow.

# DISCUSSION AND APPLICATIONS

Wind tunnel energy ratio, required power, and operating velocity are interdependent. The energy ratio is affected by velocity through the effect of velocity on the Reynolds number. The required drive power, influenced directly by operating velocity and inversely by energy ratio, is also controlled by the fan system efficiency which is often only an estimated quantity. Any estimate of operating velocity for a given power level is, then, dependent on the basic efficiency of the circuit (energy ratio) and drive system efficiency, assuming the best power estimate available to be that delivered to the fans. This interdependency means that an error in the prediction of energy ratio (and/or in the estimation of fan efficiency) will cause corresponding errors in power and velocity estimates.

These errors resulting from an erroneous prediction of the circuit energy ratio can be found from the relationship governing required power, test section velocity, and energy ratio, assuming given motor electrical and fan efficiencies. For a fixed test section velocity,

$$\frac{\Delta P_{\text{REQUIRED}}}{P_{\text{REQUIRED}}} = \frac{1}{1 - \frac{\Delta ER}{ER}} - 1$$

and, for constant power, an error in energy ratio yields the performance penalty

$$\frac{\Delta V_{o}}{V_{o}} = 1 - \left(1 - \frac{\Delta ER}{ER}\right)^{1/3}$$

The expected true power and velocity levels can thus be obtained from the performance estimate:

$$P_{\text{REQUIRED}} = \left(\frac{1}{1 - \frac{\Delta ER}{ER}}\right) P_{\text{REQUIRED}_{\text{Estimate}}}$$

for a given set of test section conditions, and from

$$V_{o} \approx \left(1 - \frac{\Delta ER}{ER}\right)^{1/3} V_{o_{Estimate}}$$

for a given level of required power.

This adjustment of the estimated performance values is pointless for a known, existing wind tunnel, but necessary for new, or proposed facilities. Before the adjustment can be made the probable error in the energy ratio estimate must be determined. It is desirable, therefore, to consider several existing facilities of different circuit types in order to gain a degree of confidence in the performance estimation routine.

#### Results

The input parameters and output performance values for the several sample cases, other than the test case shown in figure 11, are compiled in appendix D. The estimated energy ratios for the seven sample wind tunnels are presented in table 6. The corresponding sketches for all these sample tunnel circuits are shown in figures 10 and 12.

The actual energy ratios for the first three wind tunnels presented in table 6 were estimated from the best available information on fan and electrical efficiencies from known input power levels. The actual performance of the other four facilities was taken from measured data.

The test case and first sample case was the circuit of the NASA-Ames Research Center 40- by 80-Foot Wind Tunnel as described previously in the test case discussion. The predicted energy ratio for this rather conventional tunnel was only 1 percent higher than the actual value when new.

The performance of the NASA-Ames 7- by 10-Foot Tunnel was predicted at a slightly optimistic level. However, this tunnel is one with several known problems which complicate the prediction process. With the air exchanger operating, the primary diffuser is known to have some local flow separation, having been designed at a 6° equivalent cone angle, an angle too great for its cross-sectional shape and length (see fig. 1). Also, the drive fan is stalled from the centerbody out to about 45 percent of the fan radius, causing some back-flow along the nacelle centerbody. (The impact of the stall on the fan efficiency has only been estimated; it was assumed that the fan efficiency would suffer by about an additional 10 percent.) In spite of these things, the predicted energy ratio was only about 3 percent too high relative to the original value of approximately 7.85, both values taken in the zero-airexchange configuration. This agreement may indicate that much of the abovementioned off-design performance is triggered by the air exchanger operation and is not as significant with the air exchanger closed. Although insufficient data are available to resolve this question, the fact remains that the prediction accuracy, for the stated conditions, was good.

The Lockheed-Georgia Low-Speed Wind Tunnel employs a tandem test section design. For this analysis, the larger, V/STOL test section was used as the only reference station. Because of the two area restrictions to cross sections smaller than that of the reference area (those of the smaller test section and of the fan), the tunnel efficiency would be expected to be low. (This in no way reflects on the tunnel's usefulness as a research tool or on its design or capabilities. The "low efficiency" value results only from the point of reference used in the calculations.) In other than these features the facility is basically of conventional design. The computerized performance prediction was in error by less than 2 percent from the true value of about 1.10.

The Indian Institute of Science 14- by 9-Foot Tunnel at Bangalore stands out among non-return wind tunnels as a facility with an unusually high energy ratio. Although the determination of circuit dimensions for the program input was somewhat hampered by the limitations of small drawings, the estimated energy ratio was within 1 percent of the true facility value of 6.85. It is interesting to note that the fan performance data of reference 23 would indicate a fan design efficiency of about 69 percent. The power requirement calculations based on energy ratio and test section maximum velocity, however, show that the fan efficiency must be higher than was expected; in fact, greater than 90 percent.

The Hawker Siddeley 15-Foot V/STOL Tunnel at Hatfield, England was constructed under economy constraints and is a compact, cost-effective facility. The estimated performance was about 1.6 energy ratios higher (i.e., more optimistic) than the actual value of 2.38. This is an error of about 67 percent. The primary performance difference was probably caused by the fan system. The losses of the ducting in this area are difficult to predict because the area changes are not gradual and are even difficult to define.

The University of Washington 8- by 12-Foot Double-Return Tunnel has a surprisingly high measured energy ratio of 8.3. This would indicate a very carefully designed circuit powered by carefully designed fans. The performance estimate produced by the computer program is lower than the actual energy ratio by about 13 percent, showing that the achieved performance level is higher than would normally be expected.

The NASA-Langley Research Center 30- by 60-Foot Open-Throat Tunnel is unusual in configuration, having a double-return system with the twin fans located less than two fan-diameters downstream of the test section. The location of the data point for this tunnel on the diffuser design curves of figure 1 would not indicate that any diffuser-related problems should be expected forward of the fans. The diffuser between the fans and the first corner, however, does have a rather large equivalent cone angle (more than 8°). If the fans cause or contribute to diffuser flow problems (see the Cautionary Design Guidelines for Diffusers) and if those problems lead to corner flow inefficiency in a region critical to overall performance, then the circuit energy ratio may be well below the normal estimated level. Although it is not clear whether this is the case in the NASA-Langley 30- by 60-Foot Tunnel, the performance estimate was about 27 percent higher than the actual value of about 3.71.

#### Evaluation

To summarize what may be learned from the sample cases:

1. The Ames 40- by 80-Foot and 7- by 10-Foot Tunnels and the Lockheed-Georgia Low-Speed Tunnel, although at opposite ends of the energy ratio

spectrum, are all basically standard, single return, closed-test-section facilities; the computer program estimates of actual performance were good.

2. The Indian Institute of Science Bangalore tunnel, being of the nonreturn variety, is a different and less common type of facility; the computer program closely estimated its actual performance.

3. The University of Washington double-return tunnel is a third major circuit type; the program produced a reasonably accurate prediction of its performance.

4. The Hawker Siddeley V/STOL and Langley 30- by 60-Foot Tunnels are examples of facilities which may have flow problems due to too-rapid area changes and, as a result, lower than optimum performance levels for their respective circuit types. For these tunnels, because of their flow quality and not because of their circuit types, the program provided a poor estimate of actual performance.

Based on these results one thing is immediately clear: the performance of a wind tunnel of conventional, conservative design can be evaluated accurately. On the other hand, the performance of a tunnel whose design generates or contributes to flow problems (separation or grossly non-uniform) will be overestimated by the loss equations and computer program.

Flow peculiarities and off-optimum designs, even though seemingly only slight, can cause operational performance to fall significantly below the predicted levels. Such problems can be expensive whether considered in terms of modifying the facility or in such terms as reduced testing capability and increased power costs. Judicious, iterative use of the estimation techniques presented in this report, simplified by computerized automation, can lead to the improvement of an existing facility through guidance of design changes or to the optimization of a proposed new wind tunnel design.

Ames Research Center National Aeronautics and Space Administration Moffett Field, California 94035, January 8, 1976
#### APPENDIX A

#### NON-STANDARD FUNCTIONAL FORMS

Due to the nature of this analysis, certain of the local flow-state, section loss, and summary parameter formulas were used in a form more convenient than that usually found in the literature. The relationships which were altered or derived are outlined on the following pages.

## Local Flow-State Parameters

The calculation of several local parameters was based on the local Mach number, determined from the relationship between the local area and the area for choked flow:

$$\frac{A_{\star}}{A} = \left(\frac{\gamma + 1}{2}\right)^{\frac{\gamma + 1}{2(\gamma - 1)}} M\left[1 + \left(\frac{\gamma - 1}{2} M^2\right)\right]^{-\frac{\gamma + 1}{2(\gamma - 1)}}$$
(ref. 18, p. 6)

Solving for the area for choked flow, knowing the test section area and Mach number,

$$A_{\star} = M_{o}A_{o} \left\{ \frac{\gamma + 1}{2\left[1 + \left(\frac{\gamma - 1}{2} M_{o}^{2}\right)\right]} \right\}^{\frac{\gamma + 1}{2(\gamma - 1)}}$$

Mach number- Another form of the same area relationship,

$$\left(\frac{A}{A_{\star}}\right)^{2} = \frac{1}{M^{2}} \left\{ \frac{2}{\gamma + 1} \left[ 1 + \left(\frac{\gamma - 1}{2} M^{2}\right) \right] \right\}^{\gamma - 1}$$
(ref. 17, p. 126)

can be rewritten to produce a polynomial equation in Mach number which may be solved by Newton's method if the areas are known:

$$\left[ \left( \frac{A}{A_{\star}} \right)^2 M^2 \right]^{\frac{\gamma-1}{\gamma+1}} = \frac{2}{\gamma+1} \left[ 1 + \left( \frac{\gamma-1}{2} M^2 \right) \right]$$
$$= \frac{2}{\gamma+1} + \left( \frac{\gamma-1}{\gamma+1} M^2 \right)$$

$$M^{2} - \left[\frac{\gamma + 1}{\gamma - 1} \left(\frac{A}{A_{\star}} M\right)^{\frac{2(\gamma - 1)}{\gamma + 1}}\right] + \frac{2}{\gamma - 1} = 0$$

Reynolds number- The local Reynolds number was calculated based on other, known, local conditions and from basic principles:

 $RN = \frac{\rho V \ell}{\mu}$   $\rho VA = \rho_0 A_0 V_0 \qquad (\text{conservation of mass})$   $\mu = \mu_T \left(\frac{T}{T_T}\right)^{0.76} \qquad (\text{ref. 18, p. 19})$   $\frac{T}{T_T} = \left[1 + \left(\frac{\gamma - 1}{2} M^2\right)\right]^{-1} \qquad (\text{ref. 18, p. 4})$   $RN = \frac{\rho_0 V_0 \ell}{\mu_T} \frac{A_0}{A} \left[1 + \left(\frac{\gamma - 1}{2} M^2\right)\right]^{0.76}$ 

Friction coefficient- The Reynolds number-friction coefficient function used was

$$\frac{1}{\sqrt{\lambda}} = 2 \log_{10}(RN\sqrt{\lambda}) - 0.8$$
 (ref. 6, p. 70)

A Newton's method solution was performed on a rewritten form of the equation:

$$[\log_{10}(\lambda RN^2) - 0.8]^{-2} - \lambda = 0$$

### Section Pressure Losses

The losses for some types of sections were derived in forms not found in the literature. For others, a curve-fit of data points or a simplification of analysis was performed.

Corners (constant area) - The frictional and rotational losses through turning vanes are additive:  $K = K_{FRICTION} + K_{ROTATION}$ . Also,

$$K_{\text{FRICTION}} = \frac{1}{3} K_{\text{TV}}$$
 and  $K_{\text{ROTATION}} = \frac{2}{3} K_{\text{TV}}$  (ref. 6, p. 527)

Assuming that the frictional loss value has a form similar to that for a flat plate, then at 90°:

$$K_{\text{FRICTION}} = \frac{1}{3} K_{\text{TV}_{90}} = \frac{0.455B}{(\log_{10} \text{ RN})^{2.58}}$$
 (ref. 6, p. 527)

Thus, the constant B is dependent on the turning vane loss constant and the reference Reynolds number at which that constant was determined:

$$B = \frac{\frac{1}{3} K_{TV_{90}} (\log_{10} RN_{REF})^{2.58}}{0.455}$$

Therefore,

$$K_{\text{FRICTION}} = \frac{1}{3} K_{\text{TV}_{90}} \left( \frac{\log_{10} \text{RN}_{\text{REF}}}{\log_{10} \text{RN}} \right)^{2.58}$$

Since the rotational term is assumed independent of Reynolds number,  $K_{\rm ROTATION} = (2/3)K_{\rm TV_{90}}$ . The additional complication of loss parameter variation with turning angle is presented in figure 3 for a loss parameter at 90° equal to 0.15. It was assumed that the relationship between the actual and reference loss constants is linear:

$$K_{\rm TV} = K_{\rm TV_{90}} \left[ \frac{f(\phi)}{0.15} \right]$$

where  $f(\phi)$  is the functional relationship plotted in figure 3. The complete turning vane loss function then becomes

$$K = K_{TV} \left\{ \frac{2}{3} + \left[ \frac{1}{3} \left( \frac{\log_{10} RN_{REF}}{\log_{10} RN} \right)^{2.58} \right] \right\}$$

*Corners (diffusing)*- Diffusing corners were treated as vaned diffusers with the addition of rotational losses dependent on the turning angle. The expansion and frictional losses used were those for a vaned diffuser:

$$K_{\text{VANED DIFFUSER}} = \left\{ 0.3 + [0.006(2\theta - 21.5^{\circ})u(2\theta - 21.5^{\circ})] \right\} \left( \frac{AR - 1}{AR} \right)^{2}$$

The rotational loss is as for a constant-area corner where

$$K_{\text{ROTATION}} = \frac{2}{3} K_{\text{TV}} = \frac{2}{3} K_{\text{TV}_{90}} \left[ \frac{f(\phi)}{0.15} \right]$$

The diffusing corner loss function is then

$$K = \left\{ 0.3 + [0.006(2\theta - 21.5^{\circ})u(2\theta - 21.5^{\circ})] \right\} \left( \frac{AR - 1}{AR} \right)^{2} + \frac{2}{3} K_{TV}$$

where  $u(2\theta - 21.5^{\circ})$  is the unit step function.

Diffusers- The diffuser losses are due to both friction and expansion. The friction term may be derived theoretically from

$$K_{\text{FRICTION}} = \frac{\Delta p_{\text{T}}}{q} \Big|_{\text{FRICTION}} = \int_{0}^{s_2} \frac{\lambda \rho V^2}{\rho_1 V_1^2 D_h} \, \mathrm{d}s$$

Making the simplifying assumptions that the density and the friction coefficient are approximately constant and applying conservation of mass,

$$K_{\text{FRICTION}} = \lambda A_1^2 \int_0^{s_2} \frac{ds}{D_h A^2}$$

which, for a conical diffuser, becomes

$$K_{\text{FRICTION}} = \frac{16A_1^2\lambda}{\pi^2} \int_0^{s_2} \frac{\mathrm{ds}}{D^5}$$

and transforming variables from surface to centerline distances,

$$K_{\text{FRICTION}} = \frac{16A_1^2\lambda}{\pi^2 \cos \theta} \int_0^L \frac{dx}{(D_1 + 2x \tan \theta)^5}$$

Completing this integration the friction loss becomes

$$K_{\text{FRICTION}} = \frac{\lambda}{8 \sin \theta} \left( 1 - \frac{1}{AR^2} \right)$$

The influence of the expansion term is given by

 $K = K_{\text{EXPANSION}} + K_{\text{FRICTION}}$ 

Thus, it may be rewritten:

$$K = \frac{K_{\text{EXPANSION}} + K_{\text{FRICTION}}}{\left(1 - \frac{1}{AR}\right)^2} \left(1 - \frac{1}{AR}\right)^2$$

$$K = \left\{K_{\text{EXP}} + \left[\frac{\lambda}{8 \sin \theta} \frac{\frac{AR^2 - 1}{AR^2}}{\left(\frac{AR - 1}{AR}\right)^2}\right]\right\} \left(\frac{AR - 1}{AR}\right)^2$$

$$K = \left\{K_{\text{EXP}} + \left[\frac{\lambda}{8 \sin \theta} \left(\frac{AR + 1}{AR - 1}\right)\right]\right\} \left(\frac{AR - 1}{AR}\right)^2$$

$$\kappa_{EXP} = \frac{\kappa_{EXPANSION}}{\left(\frac{AR - 1}{AR}\right)^2}$$
$$\kappa_{EXP} = \frac{\kappa - \kappa_{FRICTION}}{\left(\frac{AR - 1}{AR}\right)^2}$$

The expansion loss parameter curves shown in figure 4 were determined using the approximation

$$\kappa_{EXP} = \frac{K - K_{FRICTION(CONICAL)}}{\left(\frac{AR - 1}{AR}\right)^2}$$

$$\kappa_{EXP} = \frac{K - \left[\frac{\lambda}{8 \sin \theta} \left(1 - \frac{1}{AR^2}\right)\right]}{\left(\frac{AR - 1}{AR}\right)^2}$$

and figure 5(a) of reference 9, which shows complete diffuser losses plotted as functions of equivalent cone angle and independent of area ratio for circular, square and rectangular, and two-dimensional diffusers. (This implies an assumption that the expansion part of the losses is dependent only on crosssectional shape, the extent to which the diffusion takes place in only one direction, and the equivalent cone angle.) Thus, the complete loss for diffusers is given as

$$K = \left\{ K_{EXP} + \left[ \frac{\lambda}{8 \sin \theta} \left( \frac{AR + 1}{AR - 1} \right) \right] \right\} \left( \frac{AR - 1}{AR} \right)^2$$

using K<sub>EXP</sub> from figure 4.

*Exit*- The kinetic energy loss at an exit of a non-return wind tunnel was derived from basic compressibility relationships and with the assumptions that the exit flow static pressure is equal to the atmospheric pressure and that the exit velocity is uniform.

$$\frac{p_{T}}{p} = \left[1 - \left(\frac{\gamma - 1}{2} M^{2}\right)\right]^{\frac{\gamma}{\gamma - 1}}$$
 (rewritten  
from ref. 17, p. 53)

Rewriting, the local total pressure is

$$p_{T} = p \left[ 1 - \left( \frac{\gamma - 1}{2} M^{2} \right) \right]^{\frac{\gamma}{\gamma - 1}}$$

Also, since  $\Delta p_T = p_T - p_{TATM} = p_T - p$ , the total loss parameter is

$$K = \frac{\Delta p_{T}}{q} = \frac{p \left\{ \left[ 1 + \left( \frac{\gamma - 1}{2} M^{2} \right) \right]^{\frac{\gamma}{\gamma - 1}} - 1 \right\}}{\frac{1}{2} \gamma p M^{2}}$$

since

$$q = \frac{1}{2} \rho V^2 = \frac{1}{2} \gamma p M^2$$
 (ref. 17, p. 55)

Simplifying, the exit loss becomes

$$K = \frac{2}{\gamma M^2} \left\{ \left[ 1 + \left( \frac{\gamma - 1}{2} M^2 \right) \right]^{\frac{\gamma}{\gamma - 1}} - 1 \right\}$$

Flow straighteners: airfoil members (thick) - Thick flow straightener losses were assumed to be made up of two parts: contraction and subsequent diffusion:

$$K = K_{CONTRACTION} + K_{DIFFUSION}$$

The contraction was estimated as being about 30 percent of the length of the straighteners:

$$K_{\text{CONTRACTION}} = \frac{0.32\lambda(0.30L)}{D_{\text{h}}}$$
$$K_{\text{CONTRACTION}} = \frac{0.096\lambda L}{D_{\text{h}}}$$

The diffusion portion was based on the aft 70 percent of the length and on the exit and minimum areas for the computation of the area ratio and equivalent cone angle. As for a vaned diffuser,

$$K_{\text{DIFFUSION}} = \left\{ 0.3 + [0.006(2\theta - 21.5^{\circ})u(2\theta - 21.5^{\circ})] \right\} \left( \frac{AR - 1}{AR} \right)^{2}$$

Hence the loss for thick flow straighteners becomes

$$K = 0.096 \frac{\lambda L}{D_h} + \left\{ 0.3 + [0.006(2\theta - 21.5^\circ)u(2\theta - 21.5^\circ)] \right\} \left( \frac{AR - 1}{AR} \right)^2$$

Internal flow obstruction: drag item- The loss due to internal structure may be derived from the relationships governing power losses:

$$P_{\text{INPUT}_{\text{DRAG}}} = \frac{K_{o}_{\text{DRAG}} \rho_{o}^{2} A_{o} V_{o}^{3}}{2 \rho_{F}}$$

and  $P_{DRAG} = DV\epsilon = (1/2)\rho V^3SC_D\epsilon$ , where  $\epsilon$  is the factor accounting for additional effects on downstream sections. Since  $P_{INPUT_{DRAG}} = P_{DRAG}$ , the loss becomes

$$K_{o} = \frac{q}{q_{o}} \frac{S}{A_{o}} C_{D} \varepsilon \frac{\rho_{F} V}{\rho_{o} V_{o}}$$

and therefore

$$K = C_{D} \frac{S}{A} \epsilon \frac{\rho_{F}}{\rho} \frac{\rho VA}{\rho_{O} V_{O} A_{O}}$$
$$K = C_{D} \frac{S}{A} \epsilon \frac{\rho_{F}}{\rho}$$

Since in general the flow density at the fans is unknown at the time a given section loss is calculated, and since for incompressible flow the density ratio is unity, the ratio of the densities at the fan and the local station was assumed as unity for the analysis. (If the user prefers not to make such an assumption, an approximation of the ratio may be made by way of a change in the downstream influence factor  $\varepsilon$ .) The loss due to a flow obstruction is

$$K = C_D \frac{S}{A} \epsilon$$

Vaned diffusers- The expansion and friction losses for vaned diffusers were combined into one parameter which is reasonably independent of area ratio and is presented in figure 6. The loss curves shown were approximated by a two-segment, straight-line curve fit so that, for vaned diffusers

$$K = K_v \left(\frac{AR - 1}{AR}\right)^2$$

and

$$K = \left\{0.3 + [0.006(2\theta - 21.5^{\circ})u(2\theta - 21.5^{\circ})]\right\} \left(\frac{AR - 1}{AR}\right)^{2}$$

where  $u(2\theta - 21.5^{\circ})$  is the unit step function.

Loss value transferred to reference location- The change of reference for loss values is defined as

$$K_{o} = \frac{\Delta p_{T}}{q} \left(\frac{q}{q_{o}}\right) = K \left(\frac{q}{q_{o}}\right)$$

Using the law of conservation of mass, this may be rewritten in terms of areas and Mach numbers:

$$\rho VA = \rho_0 V_0 A_0$$

$$\frac{q}{q_0} = \frac{\frac{1}{2} \rho V^2}{\frac{1}{2} \rho_0 V_0^2} = \frac{A_0 V}{A V_0}$$

$$\frac{q}{q_0} = \frac{A_0}{A} \frac{M}{M_0} / \frac{1 + \left(\frac{\gamma - 1}{2} M_0^2\right)}{1 + \left(\frac{\gamma - 1}{2} M^2\right)}$$

and

$$K_{o} = K \left[ \frac{A_{o}}{A} \frac{M}{M_{o}} / \frac{1 + \left(\frac{\gamma - 1}{2} M_{o}^{2}\right)}{1 + \left(\frac{\gamma - 1}{2} M^{2}\right)} \right]$$

Wall pressure differential- The pressure across a section of wall was determined from the exterior atmospheric pressure, internal static pressure, and cumulative pressure losses through the circuit. Since the wall pressure differential for a given section is  $\Delta p_{W_i} = p_{T_{ATM}} - p_i$  and

$$\mathbf{p_{i}} = \frac{\mathbf{p_{T_{i}}}}{\left[1 + \left(\frac{\gamma - 1}{2} \mathbf{M_{i}}^{2}\right)\right]^{\frac{\gamma}{\gamma - 1}}}$$

and, using the test section as the reference location,

$$p_{T_i} = p_{T_{SC}} - \sum_{j=1}^{i} \kappa_{o_j}$$

The wall pressure differential may be written as

$$\Delta p_{W_{i}} = p_{T_{ATM}} - \left\{ \frac{p_{T_{SC}} - q_{o} \sum_{j=1}^{i} K_{o_{j}}}{\left[1 + \left(\frac{\gamma - 1}{2} M_{i}^{2}\right)\right]^{\frac{\gamma}{\gamma - 1}}} \right\}$$

Input power required- The power input to the flow required for operation of a wind tunnel circuit having predetermined losses was calculated from the pressure rise required at the fans, with the simplifying assumption that the static and total pressure rises across the fan are equal.

$$P_{INPUT} = \Delta P_F A_F V_F$$
$$P_{INPUT} = \Delta P_T A_F V_F \frac{\rho_F \rho_o A_o V_o}{\rho_F \rho_o A_o V_o}$$

Considering conservation of mass,

$$P_{INPUT} = \Delta p_{T_F} A_0 V_0 \frac{\rho_0}{\rho_F}$$

Also,

$$\Delta p_{T_F} = \Delta p_T = q_0 \sum_{i=1}^{N} K_{o_i}$$

Thus,

$$P_{\text{INPUT}} = \left(\sum_{i=1}^{N} \kappa_{o_i}\right) \frac{1}{2} \rho_o A_o V_o^3 \frac{\rho_o}{\rho_F}$$
$$\left(\sum_{i=1}^{N} \kappa_{o_i}\right) \rho_o^2 A_o V_o^3$$

$$P_{\text{INPUT}} = \frac{\left(\sum_{i=1}^{K_{o_i}} \rho_o^{-A_o v_o}\right)^{\rho_o - A_o v_o}}{2\rho_F}$$

#### APPENDIX B

# NUMERICAL FUNCTION-APPROXIMATIONS

The formulas that follow resulted from curve-fitting and/or interpolation techniques applied to certain functions arising from the loss analysis.

### Corners

The corner loss parameters for corners with and without turning vanes are shown in figure 3. For a corner with vanes, using least-squares polynomial curve-fitting techniques, the turning vane loss function of figure 3(a) becomes, for  $0^{\circ} \leq \emptyset \leq 30^{\circ}$ :

$$K_{TV} = 1.395066 \times 10^{-2} + 5.672649 \times 10^{-4} \phi$$
  
+7.081591×10<sup>-5</sup>  $\phi^{2}$  + 1.394685×10<sup>-6</sup>  $\phi^{3}$   
-4.885101×10<sup>-8</sup>  $\phi^{4}$  (B1)

and for  $30^{\circ} < \phi \leq 90^{\circ}$ :

$$K_{TV} = -1.605670 \times 10^{-1} + 1.446753 \times 10^{-2} \phi$$
  
-2.570748×10<sup>-4</sup>  $\phi^{2}$  + 2.066207×10<sup>-6</sup>  $\phi^{3}$   
-6.335764×10<sup>-9</sup>  $\phi^{4}$  (B2)

For a corner without turning vanes the local loss function of figure 3(b) was found using a least-squares polynomial technique and is given by

$$K = 4.313761 \times 10^{-5} - 6.021515 \times 10^{-4} \phi$$
  
+1.693778×10<sup>-4</sup>  $\phi^2 - 2.755078 \times 10^{-6} \phi^3$   
+2.323170×10<sup>-7</sup>  $\phi^4 - 3.775568 \times 10^{-9} \phi^5$   
+1.796817×10<sup>-11</sup>  $\phi^6$  (B3)

For all the above equations,  $\emptyset$  is the flow turning angle in degrees.

### Diffusers

The determination of the diffuser loss parameter is a complex operation. It depends on the cross-sectional shape and equivalent cone angle of the section. For a conical diffuser the expansion functions are, for  $3^{\circ} \leq 2\theta \leq 10^{\circ}$ :

$$K_{\text{EXP}_{\text{Circular}}} = 1.70925 \times 10^{-1} - 5.84932 \times 10^{-2} (20) +8.14936 \times 10^{-3} (20)^2 + 1.34777 \times 10^{-4} (20)^3 -5.67258 \times 10^{-5} (20)^4 - 4.15879 \times 10^{-7} (20)^5 +2.10219 \times 10^{-7} (20)^6$$
(B4)

for  $0^{\circ} < 2\theta < 3^{\circ}$ :

$$K_{EXP}Circular = 1.033395 \times 10^{-1} - 1.19465 \times 10^{-2}$$
 (20)  
and for 20 > 10°: (B5)

$$K_{EXP}_{Circular} = -9.66135 \times 10^{-2} + 2.336135 \times 10^{-2} (2\theta)$$
(B6)  
For a square cross-section diffuser the expressions are, for  $3^{\circ} \le 2\theta \le 10^{\circ}$ :

$$K_{EXP}_{Square} = 1.22156 \times 10^{-1} - 2.29480 \times 10^{-2} (20) +5.50704 \times 10^{-3} (20)^2 - 4.08644 \times 10^{-4} (20)^3 -3.84056 \times 10^{-5} (20)^4 + 8.74969 \times 10^{-6} (20)^5 -3.65217 \times 10^{-7} (20)^6$$
(B7)

for  $0^{\circ} < 2\theta < 3^{\circ}$ :

$$K_{EXP}_{Square} = 9.62274 \times 10^{-2} - 2.07582 \times 10^{-3}$$
 (20) (B8)

and for  $2\theta > 10^\circ$ :

$$K_{\text{EXP}Square} = -1.321685 \times 10^{-1} + 2.93315 \times 10^{-2}$$
 (20) (B9)

For a two-dimensional diffuser with a square upstream-end cross section the expansion loss functions are, for  $3^{\circ} \leq 2\theta \leq 9^{\circ}$ :

$$\kappa_{\text{EXP}_{2D_{\text{Rectangular}}}} = 3.23334 \times 10^{-1} - 5.82939 \times 10^{-2} (20)$$
  
-4.97151×10<sup>-2</sup> (20)<sup>2</sup> + 1.99093×10<sup>-2</sup> (20)<sup>3</sup>  
-1.98630×10<sup>-3</sup> (20)<sup>4</sup> + 2.06857×10<sup>-5</sup> (20)<sup>5</sup>  
+3.81387×10<sup>-6</sup> (20)<sup>6</sup> (B10)

for  $9^{\circ} \leq 2\theta \leq 10^{\circ}$ :

$$\kappa_{\text{EXP}_{2D}} = 5.72853 - 1.21832 (20) +7.08483 \times 10^{-2} (20)^2$$
(B11)

for  $0^{\circ} < 2\theta < 3^{\circ}$ :

$$K_{\text{EXP}_{2D}}_{\text{Rectangular}} = 1.0 \times 10^{-1} - 5.333333 \times 10^{-3} (2\theta)$$
(B12)

and for  $2\theta > 10^{\circ}$ :

$$K_{EXP_{2}D_{Rectangular}} = -1.36146 + 1.986460 \times 10^{-1} (20)$$
(B13)

Since the expansion function for a two-dimensional diffuser with circular sides was not given (and is not defined), it was assumed for computational purposes that this value would be the same fraction of that for a twodimensional rectangular diffuser as the loss of a conical is of that for a three-dimensional square diffuser:

$$K_{\text{EXP}_{2D}} = K_{\text{EXP}_{2D}} \left( \frac{K_{\text{EXP}_{Circular}}}{K_{\text{EXP}_{Square}}} \right)$$

For cross-section shapes somewhere between rectangular and circular, such as flat oval (flat ceiling and floor with semi-circular sidewalls), or for diffusers which have one end rectangular and one end either circular or flat oval, a loss value between that for circular and rectangular may be more appropriate; thus,

$$K_{\text{EXP}_{2}\text{D}_{\text{Average}}} = \frac{K_{\text{EXP}_{2}\text{D}_{\text{Rectangular}}} + K_{\text{EXP}_{2}\text{D}_{\text{Circular}}}{2}$$

and

$$K_{\text{EXP}_{3D}\text{Average}} = \frac{K_{\text{EXP}Square} + K_{\text{EXP}Circular}}{2}$$

The extent to which a diffuser is planar in nature was computed from the ratio of the changes in size of the two characteristic dimensions from end to end:

$$\delta_s$$
 = smaller of  $\frac{h_2 - h_1}{w_2 - w_1}$  or  $\frac{w_2 - w_1}{h_2 - h_1}$ 

or if the ratio is negative,

 $\delta_{e} \equiv 0$ 

Then, based on the geometries of each end, the basic loss constant,  $K_{EXP}_{Basic}$ , may be selected from  $K_{EXP}_{Circular}$ ,  $K_{EXP}_{3D}_{Average}$  or  $K_{EXP}_{Square}$  and the additional loss fact.  $K_{EXP}_{Additional}$ , may be selected from the corresponding

 $K_{EXP_{2D}Circular}$ ,  $K_{EXP_{2D}Average}$  or  $K_{EXP_{2D}Rectangular}$ . Finally, the applicable diffuser expansion loss coefficient is given by

$$K_{EXP} = K_{EXP}_{Basic} + (1 - \delta_s) \left( K_{EXP}_{Additional} - K_{EXP}_{Basic} \right)$$
(B14)

#### Mesh Screen

The mesh screen Reynolds number sensitivity factor plotted in figure 5 can be expressed in functional form as, for  $0 \le RN < 400$ :

$$K_{\rm RN} = \frac{78.5\left(1 - \frac{\rm RN}{354}\right)}{100} + 1.01 \tag{B15}$$

and for  $RN \ge 400$ :

 $K_{RN} \equiv 1.0$ 

# Vaned Diffusers

The vaned diffuser loss coefficient functions plotted in figure 6 were approximated by two line segments; for  $2\theta < 21.5^\circ$ :

 $K_{v} = 0.3$ 

and for  $21.5^{\circ} \leq 2\theta \leq 90^{\circ}$ :

$$K_{\rm rr} = 0.3 + [0.006(2\theta - 21.5^{\circ})]$$

Thus, over the entire range of equivalent cone angles of interest,

$$K_{v} = 0.3 + [0.006(2\theta - 21.5^{\circ})u(2\theta - 21.5^{\circ})]$$
(B16)

where  $u(2\theta - 21.5^{\circ})$  is the unit step function.

#### APPENDIX C

### COMPUTER PROGRAM FØRTRAN CODES

The following pages contain the FØRTRAN codes developed to implement the wind tunnel performance analysis techniques presented in this report.

The Notation section explains the variable names used in the program. (Note that in the notation sections, as throughout this report, all letter 0's occurring in FØRTRAN names are shown with slashes, as  $\emptyset$ ; all number zeros are shown unslashed.) This notation section is similar to that for engineering symbols presented in the main body of the report, but this section was changed in two respects. First, it was rearranged alphabetically by FØRTRAN variable name. Second, it was expanded to include many variable names which were not used elsewhere and which have significance only in the context of the computer program. The "titles" shown in parentheses in the first column of this notation section are column heading titles which appear on the program output pages.

Immediately following the Notation are the listings of the six actual FØRTRAN program codes: the main program (PERFØRM) and the five subroutines (DATACK, SPEED, FRICTN, ØUTPUT, AND PLØTIT). Each program routine page is titled and numbered for clarity. The last seven columns of each line on each page contain a two-letter program routine name abbreviation and a line sequence number (in ten-count increments). Thus, the user can know at a glance to which routine (and where within that routine) any given line or instruction belongs. Each instruction line in the program is uniquely identified.

NOTATION	(FØRTRAN)
----------	-----------

FØRTRAN name and/or (title)	Engineering symbol	Description
A	A	cross-sectional area of local section, m <sup>2</sup> (ft <sup>2</sup> )
AIl		cross-sectional area of individual duct at upstream end, m <sup>2</sup> (ft <sup>2</sup> )
AI2		cross-sectional area of individual duct at downstream end, m <sup>2</sup> (ft <sup>2</sup> )
AL	A <sub>FLOW</sub>	cross-sectional area of local flow, m <sup>2</sup> (ft <sup>2</sup> )
АМАСН	М	local Mach number
AMACH1 (MACH1)		Mach number at section upstream end
AMACH2 (MACH2)		Mach number at section downstream end
AR (AR,CR)	AR	ratio of cross-sectional areas at upstream and downstream ends of section
ASL		<pre>speed of sound in moving flow at local   section, m/sec (ft/sec)</pre>
ASTAR	A <sub>*</sub>	cross-sectional area for sonic flow at specified flow conditions, m <sup>2</sup> (ft <sup>2</sup> )
ASO	a <sub>0</sub>	speed of sound in moving flow at upstream end of test section, m/sec (ft/sec)
AT	a <sub>T</sub>	speed of sound in still gas, computed at total (stagnation) conditions, m/sec (ft/sec)
AVGPWR		average power consumed by each drive fan at specified conditions: PWRØP/ENFAN, W (hp)
AO	A <sub>o</sub>	cross-sectional flow area of test section at upstream end, m <sup>2</sup> (ft <sup>2</sup> )
Al (AREA1)	A <sub>1</sub>	cross-sectional flow area of section at upstream end, m <sup>2</sup> (ft <sup>2</sup> )

FØRTRAN name and/or (title)	Engineering symbol	Description
A1ØAO (A1/AO)		ratio of local section upstream area to test section area, m <sup>2</sup> (ft <sup>2</sup> )
A2 (AREA2)	A <sub>2</sub>	cross-sectional flow area of section at downstream end, m <sup>2</sup> (ft <sup>2</sup> )
A2ØAO (A2/AO)		ratio of local section downstream area to test section area, m <sup>2</sup> (ft <sup>2</sup> )
BLKAGE		blockage to flow in local section (at upstream end for all applicable sec- tions except fan contraction, for which it is at downstream end), fraction of local area
(BLKGE)		blockage to flow in local section (at upstream end for all applicable sec- tions except fan contraction, for which it is at downstream end), percent of local area
CD	C <sub>D</sub>	drag coefficient of flow obstruction, <u>drag</u> qS
CHØRD	c <sub>v</sub>	chord of turning vanes, m (ft)
D	D	diameter of circular duct, m (ft)
DATA		data array of master, section, and termination card floating-point inputs
DELP	^p <sub>Wi</sub>	<pre>local pressure difference across wind    tunnel wall, N/m<sup>2</sup> (lb/ft<sup>2</sup>)</pre>
(D EPS)	Δε	increment of flow-obstruction downstream influence factor greater than unity: $\varepsilon$ - 1, (greater than or equal to zero)
DFAN		drive fan diameter, m (ft)
DH	D <sub>h</sub>	hydraulic diameter: $\frac{4 \times (cross-sectional area)}{perimeter}$ , m (ft)
DHL		hydraulic diameter of single cell in flow straightener, m (ft)

FØRTRAN name and/or (title)	Engineering symbol	Description
DHUB		diameter of drive fan hub and/or spinner, m (ft)
DHO		hydraulic diameter of test section, m (ft)
DH1		hydraulic diameter of upstream end of local section, m (ft)
DH2		hydraulic diameter of downstream end of local section, m (ft)
DMESH		diameter of mesh element in woven-mesh screen, m (ft)
D1		diameter of upstream end of circular section, m (ft)
D2		diameter of downstream end of circular section, m (ft)
EK (DP/QL)	K	local total pressure loss of section: $\frac{\Delta p_T}{q}$
EKADD	K <sub>EXP</sub> Additional	additional diffuser expansion loss factor due to more diffusion in one plane than in another (i.e., partially two- dimensional diffusion)
EKBASE	K <sub>EXP</sub> Basic	basic diffuser expansion loss factor for purely three-dimensional diffusion
EKC	K <sub>EXP</sub> Circular	expansion loss value for conical diffusers
EKCNTR	K <sub>CONTRACTION</sub>	local total pressure loss from contract- ing portion of thick-airfoil flow straighteners
EKCSAV	K <sub>EXP3D</sub> Average	estimated expansion loss coefficient for three-dimensional, combination circular and square cross-section diffuser
EKD	K <sub>DIFFUSION</sub>	local total pressure loss from diffusing portion of multi-loss-type sections
EKEXP (KEXP)		net expansion loss coefficient for diffusers
42		

FØRTRAN name and/or (title)	Engineering symbols	Description
EKMESH (KMESH)	K <sub>MESH</sub>	mesh screen-type loss constant
EKS	K <sub>EXP</sub> Square	expansion loss value for three- dimensional expansion in square cross- section diffusers
EKSTRT		local total pressure loss coefficient due to strut drag in fan section
EKTE		local total pressure loss parameter for corners without turning vanes
EKTE90 (KT 90)		vaneless-corner loss parameter for given corner at a 90° turn
EKTV	ĸ <sub>tv</sub>	turning vane loss coefficient
EKTV90 (KT 90)	κ <sub>τν<sub>90</sub></sub>	turning vane loss parameter for given vanes at a 90° turn
EKV	К <sub>v</sub>	local total pressure loss coefficient for vaned diffusers
EKO (DP/QO)	к <sub>о</sub>	section total pressure loss referred to test section conditions: $\frac{\Delta p_T}{q_0}$
EK1		local total pressure loss coefficient due to diffusion and vanes in a diffusing corner
EK2		local total pressure loss coefficient due to rotational flow in a diffusiing corner
EK2DC	K <sub>EXP2D</sub> Circular	estimated expansion loss coefficient for hypothetical, two-dimensional diffusion with circular sides:
		$K_{EXP_{2D}Rectangular} \left( \frac{K_{EXP}_{Circular}}{K_{EXP}_{Square}} \right)$
EK2DCS	K <sub>EXP2D</sub> Average	estimated expansion loss coefficient for two-dimensional diffuser with cross- section shape of some square/circular hybrid

FØRTRAN name and/or (title)	Engineering symbol	Description
EK2DR	K <sub>EXP2D</sub> Rectangular	expansion loss coefficient for two- dimensional rectangular cross-section diffusers
EL (L)	L	centerline length of section, m (ft)
ELC		<pre>length of contracting portion of thick- airfoil flow straighteners, m (ft)</pre>
ELD		<pre>length of diffusing portion of thick- airfoil flow straighteners, m (ft)</pre>
ELØDH (L/DH)		length-to-hydraulic-diameter ratio of flow straightener cell
EMDATA		data array containing master-card floating-point inputs
EMF		Mach number at the fan section
EMU	μ	flow viscosity, N sec/m <sup>2</sup> (lb sec/ft <sup>2</sup> )
EMUSTD	<sup>µ</sup> std	standard-day value of viscosity, N sec/m <sup>2</sup> (1b sec/ft <sup>2</sup> )
EMUT	<sup>μ</sup> T	reference viscosity at a known tempera- ture, computed for a still gas (stagna- tion conditions), N sec/m <sup>2</sup> (lb sec/ft <sup>2</sup> )
EMWRIT		<pre>master card output array containing data     and/or annotation(s)</pre>
EMO	Mo	Mach number at upstream end of test section
ENDATA		data array containing section-card floating-point input
ENDUCT		number of ducts in multiple-duct sections
ENFAN		number of fans in fan drive section
ENITEM		number of drag or blockage items in each local duct
ENU	ν	kinematic viscosity of gas, m <sup>2</sup> /sec (ft <sup>2</sup> /sec)

FØRTRAN name and/or (title)	Engineering system	Description
ENWRIT		<pre>section-card output array containing data     and/or annotation(s)</pre>
EPS	ε	flow-obstruction downstream influence factor (greater than or equal to unity)
ER	ER	energy ratio: ratio of energy of flow at test section to the output energy of the fans
ETAFAN (ETA)	<sup>n</sup> F	fan aerodynamic efficiency, percent
ETWRIT		case termination-card output array con- taining termination request de-codings
FAC		function defining the area of sections with circular cross sections
FACT		scaling factor for plot size
FAFØ		function defining the area of sections with flat-oval cross sections (flat floor and ceiling, semi-circular walls)
FAR		function defining the area of sections with rectangular cross sections
FDHC		function defining the hydraulic diameter of sections with circular cross sections
FDHFØ		function defining the hydraulic diameter of sections with flat-oval cross sections
FDHR		function defining the hydraulic diameter of sections with rectangular cross sections
FEKC		function defining the diffuser expansion loss for three-dimensional, circular cross-section diffusers
FEKCH		<pre>function defining the diffuser expansion   loss for three-dimensional, circular   cross-section diffusers at high diffu-   sion angles (TH2 &gt; 10°)</pre>

FØRTRAN name and/or (title)	Engineering system	Description
FEKCS		<pre>function defining the diffuser expansion loss for three-dimensional, circular cross-section diffusers at small diffu- sion angles (TH2 &lt; 3°)</pre>
FEKS		function defining the diffuser expansion loss for three-dimensional, square cross-section diffusers
FEKSH		function defining the diffuser expansion loss for three-dimensional, cross- section diffusers at high diffusion angles (TH2 > 10°)
FEKSS		<pre>function defining the diffuser expansion     loss for three-dimensional, square     cross-section diffusers at small diffu-     sion angles (TH2 &lt; 3°)</pre>
FEKO		function defining the change-of-reference station for total pressure losses from local section to test section
FEK2DL		function defining "two-dimensional" (rectangular) diffuser expansion loss for low diffuser angle range (TH2 < 9°)
FEK2DU		function defining "two-dimensional" (rectangular) diffuser expansion loss for high diffuser angle range (TH2≥9°)
FKTE		<pre>function defining corner turning loss parameter EKTE for corners without turning vanes (based on a value of EKTE = 1.80 at PHI = 90°)</pre>
FKTV1	f(\$)	function defining turning vane loss param- eter EKTV (based on a value of EKTV = 0.15 at PHI = 90°) for lower turning angle range (PHI ≤ 30°)
FKTV2	f(¢)	<pre>function defining turning vane loss parameter EKTV (based on a value of EKTV = 0.15 at PHI = 90°) for upper turning angle range (30° &lt; PHI ≤ 90°)</pre>
FTH		function converting diffuser equivalent cone angle, TH2, in degrees to half- angle, TH, in radians
46		

FØRTRAN name and/or (title)	Engineering symbol	Description
FTH2		function defining diffuser equivalent cone angle, TH2
G	γ	specific heat ratio of gas
Hl	hl	height at the upstream end of a non- circular section
Н2	h <sub>2</sub>	height at the downstream end of a non- circular section
IFLAG		parameter indicating the sequence number assigned to the fan section
IPLØT		decision parameter for selecting which (if any) plots are to be plotted
IPRINT		decision parameter for requesting or omitting output of summary character- istics page
ISEC		section type-description code
ISEQ		input section sequence number
ISHAP1		section upstream-end cross-sectional shape code
ISHAP2		section downstream-end cross-sectional shape code
ITITLA		assumed case-title array in the event the title card is omitted
ITITLE		input case-title array
ITUNNL		wind tunnel circuit-type code
ITYPE		code for type of output format required for printing section information
IU		units-of-measure type code
LINEMX		maximum number of output lines per page
LMTSEC		limit for maximum number of sections in any given case

FØRTRAN name and/or (title)	Engineering system	Description
MCHECK		master-card input-requirement checking code array
MDATA		master-card integer input data array
MFØRMT		master-card output format array
MWRITE		<pre>master-card output array containing data     and/or annotation(s)</pre>
N	N	section assigned sequence number for order of occurrence in circuit
NCHECK		section-card input-requirement checking code array
NDATA		section-card integer input data array
NFØRMT		section-card output format array
NN		section type number for printing proper section title
NWRITE		<pre>section-card output array containing data     and/or annotation(s)</pre>
Ρ		input tunnel total (stagnation) pressure, standard atmospheres
PA		input atmospheric (barometric) pressure, standard atmospheres
PATM (P ATM)	<sup>PT</sup> ATM	atmospheric (barometric) pressure, N/m <sup>2</sup> (lb/ft <sup>2</sup> )
PHI	ф	corner flow turning angle, deg
PI	π	ratio of the area of a circle to the square of its radius
PRSTY		porosity of certain non-solid flow obstructions: AL/A
PT	P <sub>T</sub>	<pre>tunnel total (stagnation) pressure, N/m<sup>2</sup>   (1b/ft<sup>2</sup>)</pre>
PWRI		decision parameter for requesting or omitting the matching of power consump- tion with given input value

FØRTRAN name and/or (title)	Engineering system	Description
PWRIP		power required to be input to flow in order to drive wind tunnel at specified speed, W (hp)
PWRMCH		total power value for which the maximum test section velocity is to be deter- mined (if requested), W (hp)
PWRØP	PREQUIRED	total fan motor output power required to drive wind tunnel at specified speed, W (hp)
QO	₫ <sub>0</sub>	test section upstream-end dynamic pressure: $\frac{\rho_0 V_0^2}{2}$ , N/m <sup>2</sup> (1b/ft <sup>2</sup> )
R	R	gas constant, m <sup>2</sup> /sec <sup>2</sup> °K (ft <sup>2</sup> /sec <sup>2</sup> °R)
RHØS	ρ	local static density, N sec <sup>2</sup> /m <sup>4</sup> (1b sec <sup>2</sup> /ft <sup>4</sup> )
RHØSF	٥F	static density at the fans, N $\sec^2/m^4$ (1b $\sec^2/ft^4$ )
RHØSO	ρ <sub>ο</sub>	static density at upstream end of test section, N sec <sup>2</sup> /m <sup>4</sup> (1b sec <sup>2</sup> /ft <sup>4</sup> )
RHØT	τ <sup>α</sup>	density computed for total (stagnation) conditions, N sec <sup>2</sup> /m <sup>4</sup> (lb sec <sup>2</sup> /ft <sup>4</sup> )
RN	RN	<b>Reynolds</b> number: $\frac{\rho V \ell}{\mu}$
RNREF	RN <sub>REF</sub>	reference Reynolds number at which turn- ing vane 90°-loss constant,EKTV90,was determined
RNV		Reynolds number for turning vanes based on vane chord: $\frac{\rho V c_V}{\mu}$
RUFNES	Δ	<pre>surface roughness in honeycomb cells,   m (ft)</pre>
(RUFNES)		surface roughness in honeycomb cells, $10^{-6}$ m ( $10^{-6}$ ft)
SEKO		section total pressure loss array (refer- enced to test section conditions) used in summary calculations

FØRTRAN name and/or (title)	Engineering symbol	Description
SEL		section centerline length array used in summary calculations, m (ft)
SERRØR		section input error occurrence code
SLAMDA		friction coefficient for smooth pipes
SLMDAE		calculated friction coefficient in test section at the requested power-matching condition
SLMDA1		friction coefficient at section upstream end
SLMDA2		friction coefficient at section down- stream end
SLR	δ <sub>s</sub>	diffuser side length ratio: ratio of change in height to change in width from upstream to downstream end, or its inverse, whichever is less than or equal to unity
SMACH		section downstream-end Mach number array used in summary calculations
SØA (S/AL)		ratio of flow-obstruction drag area to local flow area
SSUMEL		summation array of total centerline length from start of circuit to end of local section
SSUMKO		summation array of total pressure losses from start of circuit to end of local section
SUMEKO	$\sum_{i=1}^{N} \kappa_{o_{i}}$	summation of all section total pressure losses referenced to test section conditions
SUMEL	$\sum_{i=1}^{N} L_{i}$	<pre>summation of all section centerline   lengths (total circuit flow length),   m (ft)</pre>
Т		<pre>tunnel total (stagnation) temperature, °C (°F)</pre>
тн	θ	diffuser half-angle, rad
50		

FØRTRAN name and/or (title)	Engineering symbol	Description
TH2 (2 THETA)	20	diffuser equivalent cone angle, deg
TLIST		case-fatal error occurrence code
TLISTI		decision parameter for requesting or omitting tabulation of input data
TRETRN		decision parameter for requesting return for additional case or final termination
TSBLKG		test section blockage used for computa- tion of basic test section conditions, percent of test section cross-sectional area
TT	Τ <sub>T</sub>	<pre>tunnel total (stagnation) temperature,</pre>
v	v	local flow velocity, m/sec (ft/sec)
VOC		calculated test section velocity at adjusted power level, m/sec (ft/sec)
VOK		test section flow velocity at input conditions, knots
V1		<pre>section upstream-end flow velocity, m/sec  (ft/sec)</pre>
V2		<pre>section downstream-end flow velocity, m/sec (ft/sec)</pre>
Wl	wı	width of upstream end of non-circular section, m (ft)
W2	w <sub>2</sub>	width of downstream end of non-circular section, m (ft)

<b>P</b> A	61	1	1
	_		 

C MAIN PROGRAM PERFORM (SEE NASA TN D=6243)	PH	10
C	PM_	20
	PM	30
C THIS PROGRAM CALCULATES THE PERFORMANCE EFFICIENCY LEVEL (ENERGY	PM	40
C RATIO, POWER REQUIREMENTS, AND VELOCITY CAPABILITIES OF WIND TUNNEL	PH	50
C CTRCUTTS OF A VARYABLE NUMBER OF INDIVIDUAL COMPONENT SECTIONS AND	PM.	60
C WITH ANY OF TA DIFFERENT TYPES OF COMPONENTS FOR SELECTED INPUTS OF	PM	70
C RECTION GEOMETRIES AND TEST SECTION FLOW CONDITIONS.	PM	80
C THIS MAIN PODGAM CALLS THE FOLLOWING PEOFOOMANCE_RELATED. VERY	PM	90
C REFCIALTER SUPPOUTINES - DATACK, REFER, FRICTN, OUTPUT, AND PLOTIT,	PM	100
C FURTHER EXPLANATION OF THE DETAILS PURPOSES APPROACH, AND	PM	110
A DESTRUCTIONS OF THIS PROGRAM ARE PRESENTED ALONG WITH AN OPERATING	PH	120
C MANUAL IN THE NASA TECHNICAL NOTE IN DES243. ENTITIED LARBODYNAMIC	PM	130
C DETEND GUIDE, THE AND COMBUTED BOGDAN FOR FETALTION OF SUBSONIC	PM	140
A WIND THINKS I BEREAMANT I BY WILLIAM T ERVERT KENNETH W. MORT. AND	PM	150
E WIND (DANEL FERFORMANCE, DI WILLIAM IN LONDY, MENETA WA MONTY WAS	DM.	160
	PM	170
	PM	180
	PM	190
COMMON AN OCKAPTOLITICAL TITLE ALL TRADE IPLOT TRATALISE. TUNNI .	PM	200
	<b>D</b> M	210
- JOYLINE OFFER ANTALISEN OFFELSIVE IN THE ANTALISEN	<b>D</b> M	220
	<b>P</b> M	230
COMMUNICUCEUF ANACHI AVACHA ARIAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA	<b>PM</b>	240
	<b>P</b> M	250
4	<b>D</b> M	260
	D M	270
· 8cc(20)18	Вм	280
C EDDON DEFAULT OMYTED-CASESTITIE APPAY	PM	290
CE CKNORDCLADEL CONTINUE AKKEL	P.H	300
DATA TTTD. TTTT. A/1He. 1He. 3H E. 4HPPOP. 4H 4HTTTL. 4HE CA. 4HPD 0.	PM	310
1 AMMITT AMEN AM AN AMANA AMANA AMANA AM	DM	320
	PM	330
	PM	340
Contraction This Fight TITLE ADDAY	PM	350
	PM	360
DATA LTITLA/4H SI.4HNGLE.4H DO.4HURLE.4H .4H NON.4H-RFT.	PM	370
1 4HUDN. 4H CLO.4HSED. 4H 0.4HDEN. 4HTEST.4H-SEC.4HTION/	PM	380
	PM	390
C. S. SECTION GEDMETRY FUNCTIONS	PM	400
	PM	410
FAC(D) # ATAN(1.)+D++2	PM	420
FARMAN A HAW	PM	430
FAFn/H.w) = ATAN/1.)+He+2+H+/W=H)	<b>P</b> M	440
	PM	450
FCHR(H+W+A) # 2.*A/(H+W)	PM	460
FOHFOIH, W. A. B. 2. +A/(WeH+2.+ATAN(1.)+H)	PM	470
FTH(TH2) = TH2+ATAN(1.)/90.	PM	480
FTH2(A2,A1,EL) = ATAN((SQRT(A2)+SQRT(A1))/(SQRT(4.+ATAN(1.))*EL))*	PM	490
1 90 (ATAN(1))	PM	500

\_

C	PM	510
CARABPRESSURE LOSS REFERENCEDSTATION TRANSFER FUNCTION	PH	520
C REKARK IN A SHO AMAGH BHORD ON THE SAMANA AND SHARAWAR	PM	530
		340
1 GARI(Kungar(1**(A41*)\R**Vuuveuske))	PE BM	220
C LOSS PARAMETER CURVENEIT FUNCTIONS	<u>— р.н.</u> Ди	.500
	- PM	580
FEKC(+H2) # 170925+, 584932E+1++H2+,814934E+2++H2++2	PM	590
1 +134777E=3+TH2++3= 567258E=4+TH2+44= 415879E=6+TH2++5	PM	600
2 +,210219E_6*TH2**6	₽M	610
FERB(TH2) = 122156+,229480E=1++H2+,550704E=2++H2++2	PM	620
1 •• <u>408644</u> <u>=</u> 3+TH2++3= <b>.</b> 384056 <u>E</u> =4+TH2++4+ <b>.</b> 874969 <u>E</u> =5+TH2++5	PM	630
2 - 3652175-647H2486	PM	640
PER2DE(TH2) = 323344,30243451,TH2,447131EU14TH2442	PM	050
	<u> </u>	690
2 4,30,3076,57,078,778,778,779 FF(,50)374,077,077,8577,172,779	19 M	6/0
	<u> </u>	690
FEK-4(142) 8 .962274E414.207882E424-H2	<b>D</b> M	700
FEK208(TH2) = .1=.533333E=2.TH2	P M	710
FEKCH(TH2) = -,966135E-1+,2336135E-1+TH2	PM	720
FEK8H(TH2) # +1321685+293315E+1+TH2	PM	730
FEK2DH(TH2) = =1,361464,1986460+TH2	PM	740
FKTE(P) = ,4313761E=4=,6021515E=3+P+,1693778E=3+P++2=	PM	750
1 _2755078E=5+p++3+_2323170E=++p++4=_3775568E=8+P++5+	PM	760
2 1796817E=10+P++6	PM	770
FRIVI(F) = ,1375086544,5778475476,7001371544#P****	<u> </u>	780
1		800
1 20662072=5-10020/004.1770/22014/5-5270/40002828282	<u>F !**</u>	<u>810</u>
	29 M	820
C. COMPLETIME PADAMETED DEFINITIONS	PM	830
	PM	840
Č	PM	850
CAA FIXED PARAMETER DEFINITIONS	PM	860
C	Рм	870
P: # 4.#ATAN(1.)	PM	880
PLOTON # 0'0	PM	890
	PM.	900
C OPTIONAL PARAMETER SELECTION	PM	910
	<u> </u>	
	PM Du	<b>73</b> 0
	 	<u></u>
	р M р M	940 940
C., THERE IS NO SETUDN TO THE PREVIOUS TNETHIETIONS	- P M	970
	₽ M	980
~***	PM	990
	PM.	1000

	PM 1010
C. TILLE CARD DERALIONS	
100 PFAD/5-7000) ITITIF	PM 1040
IPAGE # 4	PM 1050
	PM 1060
	PM 1070
SUMEL	PM 1080
TLIST # 0.0	PM 1090
<u>C</u>	PM_1100
C., TITLE CARD VALIDITY CHECK	PM 1110
<u></u>	PH_1120
IF (ITITLE(1) .EQ. ITID) GO TO 101	PM 1130
	<u>PM 1140</u>
WRITE(6,9500)	PM 1150
WRITE(6,9502) ITITLE	PM_1160
	PM 1170
C. WIND TUNNEL MASTER CUNTROL DATA GARD OPERATIONS	PM 1100
	PH 1300 PM 1100
101 READ(5,7001) ISED; ITUNN, ; 10,15 APP; 13 APE; (DATA(1),1-3,10)	
	94 1220
	PM 1210
	PM 1240
$\frac{1}{16} \left( \frac{1}{15} + \frac{1}{5} + \frac{1}{5} + \frac{1}{5} \right) = 0 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 +$	PM 1250
IF (TLIGT .GT. #3.5) TLIGT # #3.	PH 1260
WRITE(6,9503, ISEG, ITUNNL, IU, ISHAP1, ISHAP2, (DATA(I), IB3, 10)	PM 1270
GO TO 201	PM 1280
C	PH 1290
CMASTER CARD ERRORDCHECK AND BASIC PARAMETER DEFINITION	PM 1300
C	PM 1310
102 CALL DATACK(1)	PM 1320
IPAGE = 1	PM 1330
<u>N 8 0</u>	<u>PM 1340</u>
	PM 1350
SUMEL DO	PM 1300
IF (ILIST LT) =2.5) WRITE(6,9004)	PM 1370
TE (ILISI LUTA SEA AND, IU SEA, AJ HRAIE(SATUR)	FM_1300
IF (ILIGI AND, IU NITE(G,7000)	PM 1370 BM 1400
	DM 4420
IF $(P, LT, 1, F = A) P = 1$	PM 1410
T B DATAros	PM 1440
PA & DATA(10)	PM 1450
IF (PA .LT. 1.E=6) PA # 1.	PM 1460
 C	PM 1470
C BASIC DIMENSIONAL FLOW PARAMETERS DEPENDING ON UNITS-OF-MEASURE	PM 1480
C	PM 1490
IF (III .FQ. 2) GO TO 103	PM 1500

\_\_\_\_\_

C		PM 1510
<u></u>	INTERNATIONAL SYSTEM OF UNITS (SI)	PM 1520
¢		PM 1530
EMU	<u>STD # 1,7807E=5</u>	PM_1540_
PTI	P + 101325	PM 1550
PAT	* <b>B</b> PA+101325,	PM_1560_
RE	286,79	PM 1570
ŢŢ_	¥ Y+273,15	PM 1580
EMU	1 a EMUSTD+(TT/288,0)++,76	PM 1590
PWR	ACH & DATA(7)+1,E6	<u>PM_1600_</u>
GO	ro 104	PM 1610
_ <b>C</b> _++++		PM_1620_
C	U.S. CUSTOMARY UNITS	PM 1630
_ <u>C</u>		PM 1640
103 EMU	stD = 3,719E=7	PM 1650
PT	P+2116,217	<u>PM 1660</u>
PAT	1 = pA+2116,217	PM 1670
<u>R</u>	1715.0	PM 1680
TT -	n T+459,6	PM 1690
EMU	T = ExUSTD*(TT/518,4)**.76	PM 1700
PWR	ICH # DATA(7)+1,E3	PM 1710
Garagean	u	PH 1720
C.,,GENE	RAL-FORM DIMENSIONAL PARAMETERS	PM 1730
<u>C</u>		PM 1740
104 AT 1	s SQRT(G*R*TT)	PH 1750
RHO	f # PT/(R+TT)	PM 1760
C		PH 1770
CTEST	SECTION MACH NUMBER NEWTON'S METHOD ITERATION	PH 1780
C		PM 1790
<u> </u>	E DATA(6)	PM 1800
105 IF	(IU .EQ. 1) VOK # VO+1.9438	PM 1810
<u> </u>	(IU .EQ. 2) VOK # VO+.59248	PM 1820
EMO	n VOJAT	PM 1830
106 ASO	# AT/\$pRT(1.+(G=1.)/2.+EM0++2)	PH 1840
EM	B VO/ASO	PM 1850
IF	(ABS(EMO-EM)/EMO LT. 1.E-4) GO TO 107	PM 1860
EMO		PM 1870
00	<u>r0 166</u>	PH 1880
107 EMO	E EM	PM 1890
Gamma	·····	PM 1900
CMACH	NUMBER-DEPENDENT PARAMETERS	PM 1910
_C		PM 1920
EMO	5Q # 1,+(G=1,)/2,#EM0##2	PM 1930
<u>RH0</u>	SD # RHOT/EMOSOA+(1./(0+1.))	PM 1940
90	# RH050+V0++2/2.	PM 1950
<u> </u>	••	PM 1960
CTEST	SECTION THROAT SIZE AND THROAT-AREA-DEPENDENT PARAMETERS	PM 1970
_C		PM 1980
TSB	LKG = DATA(5)	PM 1990
A0	# FAR(DATA(3), DATA(4))*(1, =TSBLKG/100,)	PM 2000

		BN 3010
	IF (ISMAM) SO IN AN - FARMUDATA(S);DATA(4))#(1,0TSBLKG/100)	PM 6010
·····	F [[PHAFI <u>EUS ]] AN E FAURIE[T]]R[ISTIGLENVINN]</u>	
	TE / TEHANI - EN INO - ENDER/DATA/3),DATA/3),AAN	- PM 2030
	TE (ISHAD) EQ IL DHO - EDNE(DIALAI)ERIALEISEN	
	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	BM 2040
		PH 2070
~	SAUC - SAUGURAUNENDI	
	SESS.	DM 2000
	ICHACCELLE AVE Y21AABEN!	PH 2100
<b>L 8 8 9</b> ~	TE (TTIAN OF 1 AND TTIAN IF AN GO TO 100	-DM 2110
	TO TO THE T	DA 2120
1.58		PH 2140
• 0. •		PM 2150
109		DH 2160
• • •		PM 2170
	6 1 5 16 5 19 18 6 1 5 16 7 6 7 5 1 1 1 1 1 1 7 6 7 5 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	BM 2180
		DM 210/
	$[\mathbf{r}_{1}] = [\mathbf{r}_{2}] = [\mathbf{r}_{1}] = [$	PM 2200
	IF ITUNNI NE I AND ITUNNI NE 4. GO TO 110	PH 2240
		PM 2220
• • • •		PM 221(
	uraiucici — Liiiun(C) Co To 110	
110	IF TTUNNI NE 2 AND TTUNNI NE 51 GO TO 114	DM 224/
* 1 V	ar talonne anda e anno alonne anda of oo to sal	Du 226/
1.1		DN 2201
* * *		
112		
	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Bu 212
		DM 2344
		DM 236
	r = r = r = r = r = r = r = r = r = r =	PM 236
<b>r</b>		PM 237
	OUTDUT OF CARE DAGE 1 TITLE. HEADINGS AND DEFINING BARAMFTERS	PM 23A
- <b>* * * * *</b>	VIPUL VLIVNOLENYELILIEIDELJIKAKANAS, KUVLKELENENY LANKDERAVL	DM 230
~* <b>!!</b> 4	WRITE/6.90003 1717; E.IPAGE.; TIT: E	PM 240
a in 1947.	IF (ILL FO 1, WEITE A 9002, PA PATM P PT, T TT VO, VOK, GO	PM 2410
	TF (1) . FO. 2) WatE(6,903) A. BATM, B. OT. T. TT. VO. VOK. 00	DM 242
	ARITERS 90.4	
	TF (TU .FG. 1) WRYTF(6.9005)	BM 244
	IF ILL SG DA WEITS A GOGA	DM 2461
<b>C</b>		
	M MIND IFFINE FURTING FARTING AND FAR DERIGERS ENDINESSIONERS	n ("" 1970) Du 201
- C - E	H NEW CONDER CTUENTS	
<b>b</b> d- <b>\$</b> -\$		

56

•• •

PERFORM

****	***************	* PM 23
		PM 25
		PM 25
	MAXIMUM NUMBER OF SECTIONS PER CASE LIMITSCHECK AND MESSAG	E PM 25
		PH 25
200	IF (N .LT. LMTSEC) QO TO 201	PM 25
	IF (LINECT ,GE, (LINEMX#7)) IPAGE # IPAGE+1	PM 25
	IF (LINECT GE, (LINEMX+7)) WRITE(6:9001) ITITLE, IPAGE	PM 25
	WRITE(6,9505) LHTSEC	PM 25
	WRITE(6,9501)	PH 26
	CALL DATACK(3)	PM 26
	TLIST = _4	PM 26
	N <b>B</b> 0	PM 26
	IPAGE U IPAGEA1	PM 26
	WRITE(6,9001) ITITLE, IPAGE	PM 26
	WRITE(6,9004)	PM 26
	IF (IU .Eq. 1) WRITE(6,9005)	PM 26
	IF (IU .EO. 2) WRITE(6.9006)	PM .20
	LINECT I 9	PM 26
		PM 27
SEC	TION DATA OPERATIONS	PM 27
		PM 27
201	4EAD (5,7002) ISEN, ISEC, ISHAP1, ISHAP2, (DATA(I), 101, 16)	PM 27
	IF (ISER GE O) GO TO 204	_ PM 27
	TLIST = -2,	PM 27
	1F (N NE 0) GO TO 202	PM. 27
	WRITE(6,9504)	PH 27
	LINECT # LINECT+5	PM 27
	GD TO 102	PH 21
202	WRITE(0,9500)	PM 26
	LINECT à LINÉCT+5	PM 28
		PM 26
	ITITLE(I) = ITITLA(I)	PM 28
203	CONTINUE	<u></u>
		PM 28
	DEFINITION OF ASSUMED TERMINATION PARAMETERS FOR OMITTED	PM 26
	TERMINATION CARD	PM 28
		PM 28
·	IPRINT # 1	PM 28
	IPLOT . O	
	TLISTI = 1.	PM 29
	PWRI = 0.0	PM. 29
	TRETRN s	PH 29
	50 TO 2002	PM 29
204	IF (ISEC NE G AND TLIST LT2.5) GO TO 205	PH 24
	IF (ISEC INE 0 AND. TLIST GT. =2.5) 60 TO 206	PM 29
		PM 20
	DEFINITION OF TERMINATION TASKOREQUEST PARAMETERS	PM 21
		PM 24
	IPRINT & ISHAPS	PH _3

57

PAGE

IPLOT = IFIX(AB8(DATA(1))) TLISTI = A8S(DATA(2)) PWRI = ABS(DATA(3)) TRETRN = A6S(DATA(4)) GU TO 2002 C C CASE-SKIP SECTION CHECK C CALL DATACK(2) GO TO 200 C C NORMAL SECTION CHECK	PM PM PM PM PM PM PM PM PM PM	30 30 30 30 30 30 30 30	)10 20 30 140 )50 )60 (70 180
TLISTI # A8S(DATA(2))         PWRI # A8S(DATA(3))         TRETRN # A8S(DATA(4))         GU TO 2002         C         C         C         C         CASE=SKIP SECTION CHECK         C         CASE=SKIP SECTION CHECK         GU TO 2002         C         CALL DATACK(2)         GU TO 200         C         NORMAL SECTION CHECK	PM PM PM PM PM PM PM PM PM PM	30 30 30 30 30 30 30	20 30 140 50 160 170 180
PWRI = ABS(DATA(3))         TRETRN = ABS(DATA(4))         GU TO 2002         C         C         C         CASE-SKIP SECTION CHECK         C         CASE-SKIP SECTION CHECK         C         CALL DATACK(2)         GO TO 200         C         CALL DATACK(2)         GO TO 200         C         NORMAL SECTION CHECK	PM PM PM PM PM PM PM PM	30 30 30 30 30 30 30	30 40 50 60 70 80
TRETRN # ACS(DATA(4))         GU TO 2002         C         C         CASE-SKIP SECTION CHECK         205 N # N+1         CALL DATACK(2)         GO TO 200         C         CALL DATACK(2)         GO TO 200         C         NORMAL SECTION CHECK	PM PM PM PM PM PM PM	30 30 30 30 30	140 )50 )60 )70 180
GU TO 2002 C C CASE-SKIP SECTION CHECK C CALL DATACK(2) GO TO 200 C NORMAL SECTION CHECK	PM PM PM PM PM PM	30 30 30 30	50 60 70 80
C CASE-SKIP SECTION CHECK C CASE-SKIP SECTION CHECK C CALL DATACK(2) GO TO 200 C NORMAL SECTION CHECK	PM PM PM PM PM	30 30 30	)60 )70 180
C CASE-SKIP SECTION CHECK C 205 N = N+1 CALL DATACK(2) GO TO 200 C NORMAL SECTION CHECK	PM PM PM PM	30	70
C	PM PM PM	30	80
205 N = N+1 CALL DATACK(2) GO TO 200 C	PM PM PM	30	
CALL DATACK(2) GO TO 200 C	PM PM	41	J♥0
GO TO 200 C NORMAL SECTION CHECK	PM		0.0
C NORMAL SECTION CHECK		31	10
C NORWAL SECTION CHECK	PM	31	20.
	PM	31	30
	PM.	Ĵ1	40
	PM	31	150
CALL DATACK(2)	PM.	.31	60
IF (SERROR -1 T1.) GO TO 200	PM	31	170
EL # DATA(5)	PM	31	180
SEL(N) = EL	PM	3	90
SUMFL = SUMELAFL	PM	37	200
C	Рм	37	210
CSECTION UPSTREAM END (INLET OR END 1) GEOMETRY COMPUTATIONS	PM	32	220
	PM	37	230
BIKAGE # DATA(10)	PM	37	240
IF (ISEC .GE. 60 AND. DATA(2) .GT. 1.E-0) BI KAGE & BLKAGE*DATA(2)	PM	37	250
IF (ISEC LE. 6 AND. ABS(TSBLKG-DATA(10)) .GT. 1.E.6)	PM	37	005
1 WRYTE (6.9507) BLKAGE, TSBLKG	PM	3	270
IF (ISEC LE & AND ABS(TSBLKG_DATA(10)) .GT. 1.E.O.	PM	3	280
1 INECT = INECT+3	PM	3	290
IF (ISHAP1 EQ. 2) GO TO 207	Рм	. 32	500
IF (ISHAP1 . EQ. 3) GO TO 208	PM	3	510
DI B DATA(4)	PM	3	120
A1 # FAC(D1)	PM	3	530
IF (ISEC_EG_ 2 OR_ISEC_EG_ 4 OR_ISEC_EG_ 56 OR_	PM	3	40
1 TSEC .EQ. 96) A1 # A1*(1BLKAGE/100.)	PM	33	550
0H1 = F0HC(01,A1)	PM	3	160
GO TO 209	PM	3:	370
207 H1 = DATA(3)	PM	3	380.
HI B DATACUT	PM	3:	390
A1 = FAR(H1.W1)	PM	.3	400
IF (ISEC .EQ. 2 .OR. ISEC .EQ. 4 .DR. ISEC .EQ. 56 .OR.	PM	3	410
1 ISEC EQ. 961 AL # Aler1. +BLKAGE/100.1	PM	3	420
$DH1 = F \tilde{D} H R (H1, W1, A1)$	PM	3	430
<u>00 TO 209</u>	Рм	_3	440
208 H1 = DATA(3)	Рм	3	450
W1 B DATA(4)	PM	-3	<b>4.6</b> Q.
A1 = FAFO(H1,W1)	PM	3	470
IF (ISEC EQ 2 OR ISEC EQ 4 OR ISEC EQ 56 OR	PM	3	480
1 19EC "EQ, 96) A1 # A1*(1,-BLKAGE/100.)	PM	3	490
DH1 = FDHFO(H1, H1, A1)	_ <b>P</b> M	3	500

PERFORM

C	PM 351
CSECTION DOWNSTREAM (EXIT OR END 2) GEOMETRY COMPUTATIONS	PM_352
C	PM 353
209 IF (ISHAP2_FG, 3) GD TO 211	<u>PM_354</u>
IF (ISHAP2 "EG, 2) GO TU 210	PM 355
02 # DATA(7)	PM_ 356
A2 • FAC(D2)	PM 357
	<u> </u>
0 TO 212	PM 359
E10 H2 E DAIA(6)	<u>PM_360</u>
H2 B DATA(7)	PM 361
A2 8 FAR(H2,H2)	PM 362
DH2 B FOHR (H2, H2, A2)	PM 363
	<b>PM_364</b>
$\mathbf{C}_{11} + \mathbf{C} = \mathbf{D}_{\mathbf{A}} \mathbf{T}_{\mathbf{A}} \mathbf{C}_{\mathbf{A}}$	PM 365
	PM 366
A2 = FAFU(H2, W2)	PM 367
0H2 # FDHFD(H2, H2, A2)	<u> </u>
C	PM 369
C,,,,ALTERATIONS TO GEOMETRY DEFINITIONS DUE TO MULTIPLE DUCTING	<u>PM 370</u>
C	PM 371
212 IP (ISEC LT. 60 OR, ISEC EG. 85) GO TO 215	<u>PM_372</u>
ENDUCT = DATA(1)	PM 373
IF (ISEC .GE, 91 AND, ISEC .LE, 94, AND, ENDUCT .LT, 1.E=6)	PH 374
1 ENDUCT = 1.	PM 375
AI1 = A1	PM 376
SA R SI	PM 377
AL B AIIENDUCT	<u>PM 378</u>
IF (ISEC NE B6) AZ # AIZ+ENDUCT_	PM 379
IF (ISEC .LT. 91 .OR. ISEC .GE. 95) GO TO 215	PM 380
C	PM 381
C. FAN SECTION GEOMETRY	<u>PM 302</u>
	PM 383
DHUB = DATA(9)	PH 384
IF (ISEC NE, 91) GO TO 213	PM 385
DFAN B DATA(4)	PM_366
OH1 B DFANDHUB	PM 387
0H2 # DH1	PM 388
A1 = PI+(OFAN++2=DHUB++2)/4++(1+=BLKAGE/100+)+ENDUCT	PM 389
A2 = PI+(D2++2-OHUB++2)/4,+(1,-BLKAGE/100,)+ENDUCT	PM 390
	PM 391
213 IF (ISEC NE 92) GO TO 214	Ри 392
DFAN B DATACT)	PM 393
	<u> </u>
A2 = PI+(DFAN++2=DHUB++2)/4++ENDUCT+(1+=BLKAGE/100+)	PM 395
AI1 = A1/ENOUCT	PM 396
AI2 # AZ/ENDUCT	PM 397
<u>60 TO 215</u>	PM 398
214 DFAN & DATA(4)	PM 399
DH1 DFAN_DHUB	PM 400

. 8.

A1 = PI+(DFAN++2-DHUB++2)/4.+(1BLKAGE/100.)+ENDUCT	PM 4010
AI1 # AI/ENDUCT	PM 4020
C	PM 4030
C SECTION AREA-RATIOS, VELOCITIES AND MACH NUMBERS AT BOTH ENDS	<u>PM 4040</u>
C	PM 4050
215 A10A0 # A1/A0	PM 4060
DAVEA # DAVEA	PM 4070
AR = A2/A1	PM 4080
IF (AR LT. 1.) AR # A1/A2	PM 4090
CALL SPEED AL ANACHAVY	PM 4100
CALL FRICTNODH, AL AMACH, SLAMDAN	PM 4110
	PM 4120
	PM 4130
	ØM 4140
	0 M 4150
CALL OF ECULARYAMACTYY	BM 4160
	EFL7884 80 Å198
SHALH(N) & AMALH2	FM9190
V2 = V	
SLMDA2 SLAMDA	<u>MM_4600</u>
IF (ISEC NE 3 AND ISEC NE 4 AND ISEC NE 40 AND	PM 4810
1 ISEC NE. 54 AND. (ISEC AND. VI ADR. (AK/ALVIA) ALTA LEPP)	PH 4660
2 AND, ISEC NE, 94, GO TO 224	PM 4230
C	<u>PM_4240</u>
CDEFINITION OF DIFFUSER_ONLY PARAMETERS	PM 4250
<u>C</u>	PM 4260
TH2 # FTH2(A2,A1,EL)	PM 4270
IF (ISEC .GE. 60 AND. ISEC .NE. 85) THE # FTHE(AIE, AII, EL)	PM 4280
TH # FTH(TH2)	PM 4290
EXEXP = DATA(12)	PM 4300
IF (EKEXP _GT. 1.E=6) GO TO 224	PM 4310
C	PM 4320
C DEFAULT-CAUSED DETERMINATION OF DIFFUSER EXPANSION LOSS	PM 4330
C. PARAXETER	PM 4340
	PH 4350
	PM 4360
IF (TH2 LT, 3 ) EKC # FEKCS(TH2)	PM 4170
-F (TH2 - GT - 10.) FUC # FFUCH(TH2)	PM 4380
	9M 4190
$\frac{1}{12} \frac{1}{12} \frac$	PM 4400
TE (THE ALLS FALLERS F ERSEL/THEN.	
AF (INE SUIS IVS) END & FENDR(INE)	BM 4420
TREAT A TEREVISION - FERDERALS	DN 44=A
4F [196 gb1g 3g] EREVR = FEREVO[196]	
$\frac{17}{100} \left( \frac{100}{100} + \frac{7}{100} \right) = \frac{17}{100} \left( \frac{100}{100} + \frac{7}{100} \right) = \frac{17}{100} \left( \frac{100}{100} + \frac{100}{100} \right)$	
AF TIME (UT) IO() ENCOR # FERZUR(INC)	TE 4430
EKUSAV B (EKC+EKB)/S.	<u>PM_4400</u>
ENZUL # EKZURAEKC/EKS	PM 4470
CN2ULS # (EK2DR+EK2DC)/2	PM 4480
IF (ISHAP1 .NE. 1 .OR. ISHAP2 .NE. 1) GO TO 216	PM 4490
<u>C</u>	PM 4500

60

PERFORM

\_\_\_\_\_PAGE\_\_\_10

C	BOTH ENDS CIRCULAR	PM 4510
<u>C</u>		PH 4520
	8LR # 1.	PH 4530
	EKRASE = EKC	PM 4540
	EKADD = EK2DC	PM 4550
	GO TO 223	PM 4560
216	) IF (ISHAP1 _NE. 1 _OR_ ISHAP2 _EQ. 1) GO TO 219	PM 4570
<u>C</u>		PM 4580
C	UPSTREAM END ONLY CIRCULAR	PM 4590
£		RH 4600
	IF ((H2=D1) _GY_ 0.0 _AND. (W2=D1) _GT. 0.0) GD TO 217	PM 4610
	SLR = 0'0	PM 4620
	GO TO <b>2</b> 18	PM 4630
217	/ SLR = (M2=D1)/(W2=D1)	PM 4640
	1 (SLR .GT. 1.) SLR # 1./SLR	PM 4650
218	IF (ISHAP2 .EQ. 2) EKBASE & EKCSAV	PM 4660
	IF (ISHAP2 .EG. 2) EKADD = EK2DCs	PH 4670
	IF (ISHAP2 EQ. 3) EKBASE = EKC	PM 4680
	IF (ISHAP2 .EG. 3) EKADD = EK2DC	PM 4690
	GO TO 223	PM 4700
219	IF (ISHAP2 NE, 1) GO TO 220	PM 4710
C		PM 4720
C	DOWNSTREAM ONLY CIRCULAR	PH 4730
C		PM 4740
	8LR # 1.	PM 4750
	IF (ISHAP) _EQ. 23 EKBASE # EKCSAV	PH 4760
	TE (TSHAPI . ED. 2) EKADD = EKZDCS	PM 4770
	IF (ISHAP1 .EQ. 3) EKBASE # EKC	PM 4780
	IF (ISHAP1 -EO. 3) EKADD # EK2DC	PM 4790
	FCC 01 00	PM 4800
C		PM 4810
č	BOTH ENDS NON-CTPCHLAD	PH 4820
C		PM 4830
220	) IF ((H20H1) _FQ. (W20W1)) SIR = 1.	PM 4840
	IF ((H2+H1) - For (W2+W1)) 60 TO 222	PM 4850
	IF ((H2-H1, GT, 0.0 AND, (W2-W1, GT, 0.0, GD TO 22)	PM 4860
	SIR # 0'0	PM 4876
	GQ TQ 222	PM LAAA
221	1 SLR = (H2-H1.//H2-W1.	PM UBON
~	IF (SLR .GT. 1.) SLR # 1./SIR	PH 4900
222	2 EKBAGE # EKCOAV	PM 491A
	EKADD # EKaDrs	PM 4920
	IF (ISHAPI .EQ. 2 .AND. ISHAP2 .EQ. 2) EKBASE = #KR	PM 4930
	IF (ISHAP) FQ 2 AND ISHAP2 FQ 2) EKADD = EK2DR	PM 1910
	IF (18HAD1 .ED. 3 .AND. +SHAD2 .ED. 3) ELBARE # EKA	PM 4950
	IF (ISHAP1 FQ. 3 AND. ISHAP2 FQ. 3) FKADD = FK2DC	PM 4946
221	S EKEYP & FKRAOFA/1, uglo)+/EKADDOEKBAGEN	
6		DM 40AA
C	PAGING CHECK REFORE SECTION INFORMATION OUTPUT	DM 400A
<b>C</b>	- HAFLALAUMAN DREAM APPRENT GULANNERAN DALLAL	BM \$700
224 IF (LINECT .LT. (LINEMX-2)) GO TO 225	PM 5010 PM 5020	
--	--------------------	
ATTACE B ATACEAL		
MUTIC(O'AOOT) TITIFE'TLWAF	PM 5040	
75 (1) 55 (1) WOITEAL GODEN	PM 5050	
17 (10 stigs 1) MR12(0)70737	PM 5060	
	PM 5070	
	PM 5080	
GARAGE SALA	PM 5090	
Peesseritonelike DKanchane	PM 5100	
225 TE /TEFC ED 11 60 TO 1010	PM 5110	
IF (IRF FQ 2) GC TO 1010	PM 5120	
IF (1860 .FQ. 3) GO TO 1030	PM 5130	
1F (ISEC .FR. 4) GO TO 1030	PM 5140	
TF (18EC	PM 5150	
IF (ISEC . EQ. 6) GO TO 1050	PM 5160	
IF (ISEC .EG. 10) GO TO 1100	PM 5170	
IF (ISEC _EQ. 20) GO TO 1200	PM 5180	
IF (ISEC .EQ. 30) GO TO 1300	PM 5190	
IF (ISEC .EQ. 32, GO TO 1300	PM 5200	
IF (ISEC .E0. 33) GO TO 1330	PM 5210	
IF (ISEC EQ. 34) GO TO 1340	PM 2220	
IF (ISEC .EQ. 40) GO TO 1400	PM 7630	
IF (ISEC . EG. 45, GO TO 1450	PM 3640	
IF (ISEC .EQ. 46) GO TO 1460	PM 3230 Dw 5360	
IF (ISEC EQ. 51) GO TO 1510	<u>PM 3200</u>	
1F (18EC .EQ, 52) 60 TO 1520	PM 3270	
	FM \$290	
IF (ISEC .EQ. 54) 60 TO 1540	PM 5300	
17 (1850 60 44 60 10 1970 18 (1850 60 44 60 10 1970	PM 5320	
	PM 5330	
TE (1920 +00 -02) 50 10 1025	PM 5340	
- F (1960 FO TIN GO TO 1700	PM 5350	
17 (1860 FR 72, GO TO 1700	PM 5360	
1F (ISEC .FQ. 73) GO TO 1730	PM 5370	
1F (1SEC	PM 5380	
TE (ISEC	PM 5390	
IF (ISEC	PM 5400	
TF (18EC .EQ. 85) GO TO 1850	PM 5410	
IF (ISEC .EQ. 86) GO TO 1860	PM 5420	
1F (ISEC .EQ. 87) GO TO 1860	PM 5430	
IF (ISEC . EQ. 91, GO TO 1910	PM 5440	
IF (18EC , EQ, 92) GO TO 1920	PM 5450	
IF (ISEC	PM 5460	
IF (ISEC .E9, 96) GO TO 1960	PM 5470	
IF (ISEC , EQ, 97) GU TO 1970	PM 5480	
C	PM 5490	
C	PM 5500	

i

i

i

i

i

C		Dм	 5510
Casa	La	PM.	5520
C	TEST SECTIONS	PM	5530
_C		P.M	.5540
C		Рм	5550
_C	CLOSED, CONSTANT=AREA TEST SECTION	P.M.	5560
C		PM	5570
1010	DEK B SLMDA1+EL/DH1	<b>P</b> M_	.5580
	ERO # PEKO(EK,AO,AI,EMO,AMACH1,EMOSQ,G)	PM	5590
		<u> </u>	5600
	OVMERO B SUMERO,ERO	Рм	5610
		PM.	-5620
	LINELI E LINELIAS	PM	2030
		PM.	_2040
5.4	MOREL IN THE TEST BRATION	PM	5650
<u> </u>	TUBEL IN IDE LEAL SECTION		
- 1120		PP M	3070
		<u>PM</u> .	2000
			5040
· · · · · · · · · · · · · · · · · · ·		<u></u>	
	EKO B FEKOZEK, AO, A1, EMO, AMACH1, EMOSQ.G3	- <b>F</b> 10	5720
	SEKO(N) = SEKO(N) + FKO	C.E.	577A
	SUMERO = SUMEROJERO	<b>D</b> M	5740
	CALL DUTPUT(2.3)		5750
	LINECY & LINECHIS	P M	5760
	0 TU 200	P.11-	5770
C		PM	5780
C	CLOSED, DIFFURING TEST SECTION	PM	5790
<u> </u>		Рм	5800
I03(	0 EK = (EKEXP+SLMDA1/(B.+SIN(TH))+(AR+1.)/(AR-1.))+((AR-1.)/AR)++2	PM	5810
	IF (EK .LT. (gLMDA1+EL/DH1)) EK # gLMDA1+EL/OH1	Pm	5820
	EKO = FEKO(EK,AO,A1,EMO,AMACH1,EMOBQ,G)	Рм	5830
	SEKO(N) = EKO	P.M.	5840
	SUMERO = SUMERO+ERO	РM	5850
	CALL OUTPUT(3,2)	<u></u> PM.	
	LINECT # LINECT+3	P M	5870
	IF (ISEC	<u>P.M</u>	5680
	GU TO 1020	PM	5890
		<b>P</b> M	5900
C .	UPEN-IMRUAT TEST SECTION	PM	5910
- <u>C</u>		PM.	5920.
1030	V CD = AV8434CL/DM1=AV9338(CL/DM1)486	PM	3930
	CHU + FERVICAJALIETUJATAUNIJETUSWJU)	<u>PM</u> .	.2740
	95 NUNERO - BUNERO EKO	PM	5750
	THE O STUDIAD AL SL.	<u>PM</u> _	3400
	144 - THOS (MC)	P M	37/0
	LINECT - LINECT.I	. PM	2490
	16 /1864 50 5. CO TO 344	PM 8	2440
	······································	<b>P</b> P	. ουψυ

	GO TO 1020		РM Л	6010
Cores			27 M	LAIA
C	STRAIGHT, NON-DIFFUSING DUCTS			<b>0030</b>
<u> </u>			M.M.	9040
C			PM	0030
<u>C</u>			PM.	0000
C			PM.	0070
1100	NN 6 5		PM.	0080
	EK # BLMDA14EL/DH1		PM	0090
	EKO B FEKOZEK, AO, A1, EMO, AMACH1, EMOSQ, G)		PM	6100
	ITYPE M 1		PM	6110
	GO TO 2000		<u>P.M</u> .	6120
C			Рм	6130
č	CONTRACTION		PM	6140.
_ <del></del>			PM	6150
1200	NN 8 6		PM.	6160
	TH2 # F+H2(A1, A2, EL)		PM	6170
	EK 32-SLMDA2-EL/DH2		PM	6180
	EKO & FEKOTEK, AD. AZ. EMO. AMACHZ. EMOBG. GY		PM	6190
			PM	6200
			PH	0150
r			PM	6220
	CONFOR AND THONS		PM	6230
	CUKUCKG AND ICKAG		PM	6240
- <u><u><u></u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u></u>		-	PM	6250
L	C-NOTANT-ADEA C-PNED THONING VANES ONLY		PM	6260
<u></u>	UNNSTATEGRAA UNNOR COLLUNATION IN STATEGRA		PM	6270
			Ph	6280
1300			P u	6290
			D.M.	6100
			D M	6310
			0.4	6320
	KAKEF BUALALALALALA		<u>р</u> та 10 м.	6330
	IF (DATA(14) LITE ISCHON KREF B STAVESTO		BM	6340
	IT (EKIV90 LIA IALED) EKIVYU BAJ		800 100	6250
	IF (PHI , LE, 30) ENIV = FNIVI(PHI) + ENIVIVO(1)		D M	6360
	TH (PHI AUTA AVA) CKIY # FKIVE(PHI)#EKIY79/AD		E III	287A
	HNV H HNGUAUHUHUHAIR[] +{U@1 }/C #AMAUMIR#C]## /0		<b>D</b> w	6180
	th a third C. + (A) DULU (RNREP ) /AL DULU (RNY) JAAC, 203/ 3.		<b>6</b> 1	N300
	The light "En" 201 Ph 10 1201			- 9379 - 6866
<b>C</b>	ուն հայոր ուներում է հայունը։ Դերելու հենչին հայունը հայորը է հենչինը է Գունի տու նշենքին էլեննին էլեննին հայոններին։ Հենքին հայոններին։		r D Du	6400
С	CONSTANT-AREA CORNER WITH TURNING VANES AND WALLS			6410
C	a a second construction of the matrix of the matrix of the second construction of the second construction of the		P.W.	0420
	NN S A		M M	5430
	EK = EK,SLMDA1,EL/DH1		MW	- <b>0</b> 440 - 6020
1301	L EKO # FEKOTEK,AO,A1,EMO,AMACH1,EMOSU,G)		PM	0430
			PM	0400
	60 TO 2000		PM	6470
C			PM	6480
C	CONSTANT-AREA CORNER WITH WALLS AND WITHOUT TURNING	VANES	PM	6490
٤			PM	0000

1

Ì

; |

PE	<u>Pro</u>	RM
----	------------	----

1330	NN & P	Рм	6510
	PHI B ABS(DATA(11))	PM	6520
	EKTE90 B DATA(12)	PM	6530
	<u>IF (EKTE90 + I + 1 + F = 6) EKTE90 # 1 + 80</u>	PM	6540
	EKTE = FKTE(PHI)+EKTE90/1,80	PM	0550
	EK = EKTE+BLMDA1+EL/DH1		6560
	EKO 🛪 FEKO(EK,AO,A1,EMO,AMACH1,EMOSQ,G)	PM	6570
		PM	6580
	GO TO 2000	РM	6590
<u>_C++</u>		PM	6600
C	DIFFUSING CORNER WITH TURNING VANES AND WALLS	РМ	6610
Lino	NN B 1A		992U
1940			6030
			2040
	FUTUR = DO(UNIN(11))		0030
			0000
	1995 - VALASTA VATAD - 18	PM	0070
	$\frac{4\Gamma}{\Gamma} \frac{(\Gamma_1)^2}{2} (\Gamma_$	PM	6680
	IF (UAIA(14) LIE ISERO) KNKEF H BOWLUSKAB	PM	6690
	1 (FT1 LE 30.) EXIV # FRIVI(FHI)+ERIV40/15	PM	6700
	IN (NHI * CI* 20*) FKIN # HKINS(BHI)*FKINADN*12	PM	6710
	THE FINCIALIS	PM	6720
	KNV # KNUC+LHUHU/A1+(I++(G+1+)/2++AMACH1++2)+++76	PM	6730
	<u>EKV # 3</u>	<b>P</b> M	6740
	IF (TH2 .GE. 21.5) EKV = EKV+.006+(TH2=21.5)	PM	6750
	$E_{K1} = E_{KV} + ((A_{R} = 1_{a})/A_{R}) + A_{2}$	PM	6760
	EK2 = EKTV+2./3.	PM	6770
	CALL FRICTN(CHORD,A1,AMACH1,SLAMDA)	PM	6780
	$EK = EK_{1+}EK_{2}$	PM	6790
	EKO = FEKOTEK, AO, A1, EMO, AMACH1, EMOSQ, GY	PM	6800
	ITYPE = 3	PM	6810
	0 TU 2000	PH	6820
C		PM	6830
c	DIFFUSION	PM	6840
f		р 1 с. р м	6850
Č		е р. <b>В</b> м	6840
C	DIFFUSER	е П Ом	6870
r.		19 M	6840
1400	NN 8 11	рн 10 м	6804
	EK = (EKEXP+S) MDA1/(8.+STN(TH))+/AR+1.)/(AD-1.))+//AD-1.)/AD-1.(AD-1.)/	2 64	6040
5 • 4 • ···•	TE TERTINATIONELLARGANELLE AND AND TERTIAL AND	ь <u>г</u> е. Вч	
		19 M	- 071U - 6074
	LINDE - * TERNICKTENTERIENTELENTELENTELENGONON	<b>P</b> M	9789 - 607-
		μ	6430
• • • • • • • • • • • • • •		P M	0940
L	Ruth utherts chedow form find the	PM	0950
. <b>L</b> . <b>e</b> . e	EXIT KINETIC ENERGY FROM FLOW DUDP	PM	6960
C		PM	6970
1450	NN = 12	PM	6980
	EK = 2 + ((1++(G=1+)/2+*AMACH1**2)**(G/(G=1+))=1+)/(G*AMACH1**2)	PM	6990
	EKO E FEKO(EK, AO, A1, EMO, AMACH1, EMOSC, G)	PM	7000

		the second se		
	ITYPE # 2	PM	701	0
	<u>GO TO 2000</u>	<u>PM</u>	202	Ο.
C		PM	703	0
	SUDDEN EXPANSION	PM _	704	0
C		PM	705	0
1460	NN = 13	<u> </u>	700	Q
	TH2 = 90	PM	707	0
		PM	708	0.
	Fro = FFro/Fr.AO.A1.EMO.AMACH1.EMOSO.G1	PM	709	0
	TYDE = -	DM	710	٥
		DW.	711	6
•		B M	712	ñ
_ <u>_</u>			712	ň
C	FLOW GREEKUCTIONS		743	
_ <u>C</u>			114	.U
C		PM	[13	0
	HONEYCOMB THIN FLOW STRAIGHTENERS		.710	0.
C		PM	717	0
1510	NN <b>8 14</b>		718	0
	ELODH = DATA(R)	Рм	719	0
	PRSTY = DATA(10)	PM	720	0
	DUFNES & DATA(14)+10.++(+6)	Рм	721	0
	IF (DATA(14)	PM	722	20
	IF (DATA(14, IT 1 E-6 AND III EG. 2, RUFNES & 000032808	PM	723	0
	The stand stand	Рм	724	in.
			72	in i
	AC - POSTANIZION	D M	724	
¥ 10	CALL SPEEURAL AMACHIV		.1 4 9	10
	$RMU0 = RMU1 / (1_{2} + (Ge1_{3})/\mathcal{C}_{2} + AMAU + Cl_{2} / (Ge1_{3}))$	P 11	720	
	EMU = EMUT/(1++(G=1+)/2+AAMACHRAK)### 10	<b></b>	169	10
	ENU = EMU/RHOS	РМ	147	10
	RN = V_RUFNES/DHL/ENU	<u>PM</u>	730	10
	SLAMDA = '375+(RUFNES/DHL)++_4/RN++_1	PM	731	, 0
	IF (RN		737	20
	EK = SLAMDA_(ELUCH+3.)+(100_/PRSTY)++2+(100_/PRSTY=1+)**2	PM	733	10
	EKU = FEKOZEK, A0, A1, EMO, AMAČH1, EMOŠQ, G)	PM	734	10
	ITYPE A 1	PM	739	10
		Рм	736	0
r		PM	731	10
¥••	ATOSATI THICK FLOW ATOATGHTENEOS	PM	738	30
	ATHUNDE DISKING AN OLKERATING AND		710	30
·	A.2.1		74	50
1.264			749	10
		E CI		10
	PROIT # DATA(10)	<b>r</b> 5.	. E ¶2 ¶ A =	20
	TH (FFAUH "FE" 0"0) FFADH # 5"	P M	143	10
	ELC = .3xEL		.744	40
	ELD & ELWELC	PM	74	30
	AL = PHSTY/100, AA1	<b>P</b> M	74(	<b>b</b> 0
	AR E AZZAL	PM	74	70
	DHL . EL/ELODH	PM	.74	30
	CALL SPEED (AL, AMACH, V)	PM	74	90
	CALL FRICTN (DHL, AL, AMACH, SLANDA)	PM	75	0 0

	PERFORM		16
	EKCNTR = .32+ELC/DHL+SLAMDA	PM	751
	THE B FTHE (A2, AL, ELD)	Рм	7520
	EKV B _S	PM	752
	IF (TH2 .GF. 21.5) FKV # EKV+.006+(TH2=21.5)	9 M	754
	EKD # EKV*((AR=1.)/AR)**2	DM	755/
	EK . EKCNTRAEKD	P M	756/
	EKO # FEKO(EK, AQ, A1, EMO, AMACH1, EMOSQ, G)	PM	7570
	ITYPE s x	9 M	7581
	0005 DT 000	PFL- DM	750
<b>C</b>		р н Р м	7601
C	PERFORATED PLATE WITH SHARD-EDGED OPIFICES	. рам. Бамі	761/
r	ten dister forte all on appendix distances	P **	763/
1530	NN 8 16		7620
	PRSTY = DATA(10)		76
	Ev B ([SOPT(.5-0-2STY/200.)+1,-0-2STY/100.)+100./0-25TY)++2	<b>F</b> E	7660
	FKO = FFKO/FK, AO, AI, FMO, AMACHI, FMOSO, CA	9 Pi	7020
	TTVE = 5	. <b>F</b> M	1991
		P M	10/(
~		. PM	1000
	WAVEN HEAR AR EXA	Рм	709(
<u>Las</u>	WUVEN DESD SEBEEN		7700
1. Ban	MA - 17	PM	7710
1340		PM.	7720
	UPESH - DATA(4)	<b>P</b> M	7730
	PROIT = UATA(10)	PM	7740
	EKMESH = DATA(12)	PM	775(
	IF (EKMESH LT 1 E+6) EKMESH = 1 3	PM	7760
	R <sup>H</sup> US = R <sup>H</sup> UT/(1 <sub>4</sub> +(G=1 <sub>4</sub> )/2 <sub>4</sub> *A <sub>M</sub> ACH1**2)**(1 <sub>4</sub> /(G=1 <sub>4</sub> ))	PM	7770
	EMU = EMUT/(1++(G=1+)/2++AMACH1++2)++,76	PM	778(
	ÊNU # ÊMUZAHOS	PM	779(
	RN = V1+DMESH/ENU	PM	7800
	EK = EKMESH*(1,=PR8Ty/100,)+(100,/PRSTy=1,)++2	PM	7810
	IF (RN LT 400 AND	PM	7820
	1 EK .LT. (EK*(78,5**(1RN/354.)/100.+1.01)))	PM	7830
	1 EK = EK+(78,5**(1,=RN/354,)/100,+1.01)	PM	7840
	EKO = FEKOPEK, AU, A1, EMU, AMACH1, EMUSO, GJ	PM	7850
	ITYPE = 2	PM	786
	0 10 2000	PM	787
C		<b>D</b> M	7880
C	INTERNAL STRUCTURE (DRAG ITEM(E)) AT UPSTREAM END OF	A PM	7890
C	SFETION	- P.	9900
C	unang ang ang ang ang ang ang ang ang ang	רביים בייים ביים ביים ביים העופס	7910
1560	NN # 18		7020
	ENITEM # DATA(2)	<b>F</b> M Dv	175.U 701./
	SOA B DATA/AN		ママヨし
			7745 705-
	FPS = 1 = 0.4 TA / 16 / 100	<b>F</b> M	テママし
· ··· ··· ···	N Y E SBIVAIALLYSCANA A A ANTEMA A		1700
	AN LEVELUTITETS OF A LOCATED A LOCATED A LOCAL CONTRACTOR A LOCAL CONTRACTOR		177(
	SKA - SEVAREFORENEIEN SKA - SEVAREFORENEIEN		1400
	LIV = FERV(ER,AV,AI,ERV,AMALMI,ERV30,6)	PM	744(
		PM	9000

	GO TO 2000	рм	8010
<u> </u>	THEN VIQUES OF A STORE AN AND DE A	. PM DM	8010
<b>C</b>	FIXED, KNUWNGEULALDEUSS LIEM AF THE UPDIREAM END OF A	P M	8040
		PM	8050
1570	NN 2 19	PM	8060
		рм	8070
	EKO # FEKO / EK, AO, A1, EMO, AMACH1, EMOSQ, G1	PM	8080
	ITYPE # 2	Рм	8090
	<u>60 TO 2000</u>	. <b>P</b> M	8100
C		PM	8110
Ceeee	MULTIPLE=DUCT SECTIONS TOTAL=PRESSURE LOSSES	<b>P</b> M	0120
C		PM	8130
		PM	0140
C	STRAIGHT, NON-DIFFUSING DUCTS	P M	0120
<u>_</u>			0100
C		PM DM	8186
<u> </u>	CONSTANTAREA DULTS	. 17 El 13 M	8190
	NN # 34	P M	8200
1010		₽ M.	8210
	EKO = FEKO = FEKO, A1, EMO, AMACH1, EMOSQ.GN	PM	8220
		PM	8230
		PM	8240
		PM	8250
č	CONTRACTIONS	PM	8260
C		РМ	8270
1620	NN • 21	PM	8580
-	TH2 = FTH2(AI1,AI2,EL)	PM	8290
	EK = 32+SLMDA1+EL/DH2	Рм	8300
	EKO = FEKO(EK,AO,A2,EMO,AMACH2,EMOSQ,G)	PM	8310
		PM	0220
	GO TO 2000	M N M	0330
_ G		E M	- <b>Q34</b> 0 - B15A
C	LURNERS AND TURNS		8140
<b>6</b>		201 201	8370
G	CONSTANT ASEA COONERS - THONING VANES ON V	P.M	83An
- <b>Vaa</b>	AANG THUTTERRY" AAKNANG" ATTTERNALATTENG ANTI	PM	8390
1700	NN 8 22	PM	8400
₿ 1 ¥ ¥	CHORD = DATA(9)	PM	8410
	PHT # ABS(DATA(11))	PM	8420
	EKTV90 = DATA(12)	PM	8430
	RNREF = DATA/141410.440	PM	8440
	1F (EKTV90 .LT. 1.E=6) EKTV90 = .15	Рм	8450
	IF (DATA(14) .LT. 1.8-6) RNREF # .5+10.8+6	P M	6400
	IF (PHI LE. 30,) EKTV = FKTV1(PHI)+EKTV90/.15	Pit	8470
	IF (PHI .GT. 30.) EKTY # FKTV2(PHI)*EKTV90/.15	Рм	8480
	RNV = RNOC+CHORD/A1+(1,+(G=1,)/2,+AMACH1++2)++,76	PM	8490
	EK = EKTV#(2,+(ALOG10(HNREF)/ALOG10(RNV))**2,58)/3	PM	8500

Constant-agea CORNEq8 with Turning vanes and walls         PM 850           C.         CONSTANT-AGEA CORNEq8 with TurNing vanes and walls         PM 850           EK = EK4BLMDA1.EL/DH1         PH 850           IF (ISEC .EG, 71) NN = 23         PH 850           C.         CONSTANT-AGEA CORNERS WITH TURNING VANES AND ONLY ONE         PH 850           C.         CONSTANT-AGEA CORNERS WITH TURNING VANES AND ONLY ONE         PH 850           C.         SIDE=wall EACH         PH 860           C.         CONSTANT-AGEA CORNERS WITH TURNING VANES AND ONLY ONE         PH 860           GO TO 2000         PH 860         PH 860           C.         CONSTANT-AGEA CORNER WITH MALLS AND WITHOUT TURNING VANES PM 8600         PH 8600           C.         CONSTANT-AGEA CORNER WITH MALLS AND WITHOUT TURNING VANES PM 8600         PH 8600           C.         CONSTANT-AGEA CORNER WITH MALLS AND WITHOUT TURNING VANES PM 8600         PH 8600           C.         CONSTANT-AGEA CORNER WITH MALLS AND WITHOUT TURNING VANES PM 8600         PH 8700           C.         CONSTANT-AGEA CORNER WITH MALLS AND WITHOUT TURNING VANES PM 8600         PH 8700           C		IF (ISEC .EQ. 70) GO TO 1701	PM	8510
C.       PM 8500         PM 8500       FK = EK+8LMDA1_EL/DH1         IF (ISEC = EQ, 71) NN = 23       PH 8500         C.       CONSTANT=AREA CORNERS WITH TURNING VANES AND ONLY ONE         C.       SIDE=wall EACH         PH 8500       PH 8500         C.       SIDE=wall EACH         PH 8500       PH 8500         C.       SIDE=wall EACH         PH 8500       PH 8500         C.       SIDE=wall EACH         PH 8500       PH 8600         C.       SIDE=wall EACH         PH 8500       PH 8600         GO TO 2000       PH 8660         C.       CONSTANT=AREA CORNER WITH WALLS AND WITHOUT TURNING VANES PH 8600         C.       CONSTANT=AREA CORNER WITH WALLS AND WITHOUT TURNING VANES PH 8600         C.       CONSTANT=AREA CORNER WITH WALLS AND WITHOUT TURNING VANES PH 8600         C.       CONSTANT=AREA CORNER WITH WALLS AND WITHOUT TURNING VANES PH 8600         C.       CONSTANT=AREA CORNER WITH WALLS AND WITHOUT TURNING VANES PH 8600         FXTE PH 1, EACH 2001, EXTERO 1, 1, 1, 1, 1, 2, 1, 1, 1, 2, 1, 1, 1, 2, 1, 1, 1, 2, 1, 1, 1, 2, 1, 1, 1, 2, 1, 1, 1, 1, 2, 1, 1, 1, 2, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,	<u></u>	CONSTANT-APEA CORNERS WITH THENING VANES AND WALLS	PM Pm	8530
NN # 24       PH d550         FK #EKABMDA1_EL/DP1       PH d550         IF (ISEC _EQ, 71) NN # 23       PH d550         C       CONSTANT=AREA CORNERS HITH TURNING VANES AND ONLY ONE       PH d550         C       SIDE=ualL EACH       PH d550         C       SIDE=ualL EACH       PH d560         C       If (ISEC _EQ, 71) EK = EKA3,/4.       PH d660         T/701 EK 0 = FEKO(EK,A0,A1,EMO,A1,EMO,AMACH1,EMOSG,G)       PH d660         ITYPE = 1       PH d560       PH d660         GO TO 2000       PH d660       PH d660         C       CONSTANT=AREA CORNER WITH WALLS AND WITHOUT TURNING VANES PH d660         C       CONSTANT=AREA CORNER WITH WALLS AND WITHOUT TURNING VANES PH d660         C       CONSTANT=AREA CORNER WITH WALLS AND WITHOUT TURNING VANES PH d660         C       CONSTANT=AREA CORNER WITH WALLS AND WITHOUT TURNING VANES PH d660         C       CONSTANT=AREA CORNER WITH TURNING VANES AND WALLS PH d660         PH = ABS(DATA(II))       PH d760         EK TE SENDATAEL/EADMI       PH d760         EK TE SENDATAEL/EADM			PM	8540
EK = EKASLMDA1SEL/DH1       PH 8500         IF (ISEC ,EG, 71) NN = 23       PH 8570         C       CONSTANT=AREA CORNERS HITH TURNING VANES AND ONLY ONE       PH 8560         C       SIDE=wall EACH       PH 8660         C       If (ISEC ,EG, 71) EK = EKA3,/4.       PH 8660         1701 EKO = FEKO(EK,A0,A1,EMO,AMACH1,EMOSG,G)       PH 8660         IT701 EKO = FEKO(EK,A0,A1,EMO,AMACH1,EMOSG,G)       PH 8660         IT701 EKO = FEKO(EK,A0,A1,EMO,AMACH1,EMOSG,G)       PH 8660         IT701 EKO = AFEKO(EK,A0,A1,EMO,AMACH1,EMOSG,G)       PH 8660         C       CONSTANT=AREA CORNER WITH HALLS AND WITHOUT TURNING VANES PH 8670         PH 3       ABS(DATA(11))       PH 8660         EKTE FEKOLONAL(11)       PH 8660         PH 4       ABS(DATA(11))       PH 8700         EKTE FEKOLONAL(2)       PH 8700         IF (EKTE90 = ATA(12)       PH 8700         EKTE FEKOLONAL(2)       PH 8700 <td></td> <td>NN # 24</td> <td>PM</td> <td>8550</td>		NN # 24	PM	8550
IF (ISEC .EG, 71) NN = 23       PH 8570         C.*       CONSTANT=AREA CORNERS HITH TURNING VANES AND ONLY ONE       PH 8560         C.*       STDE=MALL EACH       PH 8560         C.*       STDE=MALL EACH       PH 8600         TOIE EKO = FERCICEX, AO, AI, EMO, AMACHI, EMOSG, G)       PH 8660         ITYPE = 1       PH 8560       PH 8660         GO TO 2000       PH 8660       PH 8660         C.*       CONSTANT=AREA CORNER, WITH MALLS AND WITHOUT TURNING VANES PH 8660       PH 8660         C.*       CONSTANT=AREA CORNER, WITH MALLS AND WITHOUT TURNING VANES PH 8660       PH 8660         C.*       CONSTANT=AREA CORNER, WITH MALLS AND WITHOUT TURNING VANES PH 8660       PH 8660         C.*       CONSTANT=AREA CORNER, WITH MALLS AND WITHOUT TURNING VANES PH 8660       PH 8660         C.*       CONSTANT=AREA CORNER, WITH MALLS AND WITHOUT TURNING VANES PH 8660       PH 8660         C.*       CONSTANT=AREA CORNER, WITH MALLS AND WITHOUT TURNING VANES AND PH 8700       PH 8670         PH 8 640       PH 8660       PH 8670       PH 8670         C.*       CONSTANT=AREA CORNERS WITH TURNING VANES AND WALLS       PH 8700         C.*       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 8700         C.*       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 8700		EK # EK+BLMDA1+EL/DH1	PM	8560
C       CONSTANT-AREA CORNERS WITH TURNING VANES AND ONLY ONE       PH 8500         C       SIDE=WALL EACH       PH 8500         C       If (ISEC _EO, 71) EK = EK=3,/4.       PH 8500         1701 EK 0 = FEKO(EK,A0,A1,EMO,AMACH1,EMOSO,G)       PH 8600         GO TO 2000       PH 8600         GO TO 2000       PH 8660         C       CONSTANT-AREA CORNER WITH MALLS AND WITHOUT TURNING VANES PM 8600         C       CONSTANT-AREA CORNER WITH MALLS AND WITHOUT TURNING VANES PM 8600         C       CONSTANT-AREA CORNER WITH MALLS AND WITHOUT TURNING VANES PM 8600         PH = ABS(DATA(111)       PH 8600         EKTES       DATA(12)         PH 6000       PH 8700         EKTESUMATION ANACH1, EMOSO,G)       PH 8700         FK SECTEPHI, EKTESO/1, 80       PH 8700         EKTESUMATION, AMACH1, EMOSO,G)       PH 8700         FK SECTEPHI, EKTESO/1, 80       PH 8700         EKTESUMATION, AMACH1, EMOSO,G)       PH 8700         FG TO 2000       PH 8700         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 8700         FG TO 2000       PH 8700       PH 8700         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 8700         FG TO 2000       PH 8700       PH		IF (ISEC ,EQ, 71) NN # 23	Рм	8570
C CONSTANT-AREA CORVERS WITH TURNING VANES AND ONLY ONE PH 8500 C SIDE=wall EACH PH 8600 C If (ISEC_EG, T1) EK = EK43,/4. PH 8600 FOR 6000 GU TO 2000 C CONSTANT-AREA CORNER WITH MALLS AND WITHOUT TURNING VANES PH 8600 FOR 6650 PH 6600 PH	<u>C</u>		PM	8580
C       SIDE=WALL FALM       PM 8610         C       IF (ISEC .EG. TI) EK = EKS3,/4.       PM 8620         1701 EKO = FEKO(EK,AO,AI,EMO,AMACHI,EMOSO,G)       PM 8630         ITYPE       PM 8630         GO TO 2000       PM 8640         C       CONSTANT=AREA CORNER WITH WALLS AND WITHOUT TURNING VANES PM 8670         C       CONSTANT=AREA CORNER WITH WALLS AND WITHOUT TURNING VANES PM 8670         C       CONSTANT=AREA CORNER WITH WALLS AND WITHOUT TURNING VANES PM 8670         PH = ABS(DATA(11))       PM 8640         EKTE90 = DATA(12)       PM 8670         EKTE90 = DATA(12)       PM 8720         EKTE90 = ALL I.E=05 EKTE90 = 1,80       PM 8720         EKTE = FKTE(PHI)=EKTE90/1.80       PM 8720         EKT = FKTE(PHI)=EKTE90/1.80       PM 8720         EKT = FKTE(SLMDALEL/DM1       PM 8720         EKT = FKTE(SLMDALEL/DM1       PM 8720         EKT = SLMOALEL/DM1       PM 8720         C       OIFFUSING CORNERS WITH	C	CONSTANT AREA CORNERS WITH TURNING VANES AND ONLY ONE	PM	8590
L:* IF (IGEC _EG, 71) EK = EK#3./4. I701 EK0 = FEK0(EK,A0,A1,EM0,AMACH1,EM0S0,G) ITYPE = 1 GO TO 2000 C C CONSTANT-AGEA CORNER WITH WALLS AND WITHOUT TURNING VANES PH 6640 PH = A8S(DATA(11)) EKTE90 = DATA(12) EKTE90 = DATA(12) EKTE = FKTEFPH1;*EKTE90/1.60 EKT = FKTEFPH1;*EKTE90/1.60 EKT = FKTEFFL;/DH1 EKT = 0 O TO 2000 C DIFFUSING CORNERS WITH TURNING VANES AND WALLS PH 670 C DIFFUSING CORNERS WITH TURNING VANES AND WALLS PH 6860 PH = A8S(DATA(11)) EKT = 1 GO TO 2000 C DIFFUSING CORNERS WITH TURNING VANES AND WALLS PH 670 C DIFFUSING CORNERS WITH TURNING VANES AND WALLS PH 6860 IF (DATA(14), LT. 1.E=0; RNREF = .5x10.**6 IF (PHI, LE: 30, 2, EKTV = FKTV1(PH1)*EKTV90/.15 PH 6860 IF (PHI, LE: 30, 2, EKTV = FKTV1(PH1)*EKTV90/.15 PH 6860 IF (PHI, GT. 30, EKTV = FKTV2(PH1)*EKTV90/.15 PH 6860 IF (PHI, GT. 30, EKTV = FKTV1(PH1)*EKTV90/.15 PH 6860 IF (PHI, EE 21, S) EKV = EKV.0000/A1*A(10) PH 6960 C DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE PH 6960 C DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE PH 6960 C DIFF	<u> </u>	SIDE WALL CACH	PM	8600
1701       EK0 # FEK0(EK, A0, A1, EM0, AMACH1, EM0S0, G)       PH       8650         ITYPE # 1       PH       8650         GU TO 2000       PH       8650         C.*       CONSTANT=AGEA CORNER WITH WALLS AND WITHOUT TURNING VANES PH       8650         1730       NN # 25       PH       8660         PH # A85(DATA(11))       PH       8660         EKTE90       DATA(12)       PH       8670         EKTE90       DATA(12)       PH       8700         EKTE90       DATA(12)       PH       8700         EKTE90       STATA(11)       PH       8700         EKTE90       STATA(12)       PH       8700         EKTE91       PH       8700       PH         EKTE95       STATEPH1; EKTE90/1.80       PH       8730         EKTEPH1; EKTEPH1; EKTE90/1.80       PH       8730       PH         EKT       STATEPH1; EKTE90/1.80       PH       8730         EKT       STATEPH1; EKTE90/1.80       PH       8700	L g g	18 /1880 EA 913 EK = 8K+3 /4	19 M	8620
ITYPE # 1       PH 8640         GO TO 2000       PH 8660         Ca.       CONSTANT-AREA CORNER WITH WALLS AND WITHOUT TURNING VANES PH 8650         Ca.       CONSTANT-AREA CORNER WITH WALLS AND WITHOUT TURNING VANES PH 8650         PHI # A85(DATA(11))       PH 8660         EKTES0 # LT 1.8=60 EXTE90 # 1.80       PH 8700         EKTES0 # LT 1.8=60 EXTE90 # 1.80       PH 8700         EKTE # FKTEFPH1;*EXTE90/1.80       PH 8720         EKTE # FKTEFPH1;*EXTE90/1.80       PH 8730         EKT # EXTESUDATA(12)       PH 8730         EKT # EXTESUDATA(12)       PH 8730         EKT # EXTESUDATA(14,1,EM0,30,G)       PH 8730         ITYPE # 1       PH 8730         GO TO 2000       PH 8730         Ca.       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 8730         PH # # A85(DATA(11))       PH 8630       PH 8630         Ca.       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 8630         Ca.       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 8630         F( CATA(14), 10,       PH 8630       PH 8630         Ca.       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 8630         F( PH 1, 11, 1.4, 10,       PH 8630       PH 8630         F( CATA(14), 11, 1.4, 10, <td>1701</td> <td>EKO # FFK0/EK.AQ.A1.EMQ.AMACH1.EMOSQ.G)</td> <td>P M</td> <td>8630</td>	1701	EKO # FFK0/EK.AQ.A1.EMQ.AMACH1.EMOSQ.G)	P M	8630
G0 TO 2000       PH 8650         C       CONSTANT-AREA CORNER WITH WALLS AND WITHOUT TURMING VANES PH 8600         1730 NN # 25       PH 8600         PHI # A85(DATA(11))       PH 8600         EKTE90 = DATA(12)       PH 8600         IF (EXTE90 + LI, 1, 1=5-5)       EXTE90 = 1,80         EKTE # FKTE(PHI, *EXTE90/1,80       PH 8730         EKT E # FKTE(PHI, *EXTE90/1,80       PH 8730         EK = EXTE+SLMDA1*EL/DH1       PH 8760         GD TO 2000       PH 8760         C       OIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 8860         FH 8050ATA(11)       PH 8860       PH 8860         C       OIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 8860         PH 1 = ABS(DATA(11))       PH 8860       PH 8860         FY40 NN # 26       DATA(12)       PH 8860       PH 8860         C       OIFFUSING CORNERS WITH TURNING VANES AND WA		ITYPE • 1	PM	8640
C       CONSTANT=AQEA CORNER WITH WALLS AND WITHOUT TURNING VANES       PH       6600         C       CONSTANT=AQEA CORNER WITH WALLS AND WITHOUT TURNING VANES       PH       6600         1730       NN = 25       PH       6600       PH       6600         PH = ABS(DATA(11))       PH       6600       PH       6600       PH       6700         EKTE90 = UIT. 1=50) EXTE90 = 1.80       PH       6700       PH       6700         EKTE STEE(PHI) = EXTESO) EXTE90 = 1.80       PH       6700       PH       6700         EKT E STEE(PHI) = EXTESO/1.80       PH       6700       PH       6700         EKT E STEE(PHI) = EXTESO/1.80       PH       6700       PH       6700         EKT E STEE(PHI) = EXTESO/1.80       PH       6700       PH       6700         EKT E STEE(PHI) = EXTESO/1.80       PH       6700       PH       6700         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH       6700         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH       6700         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH       6800         FH       #ABS(DATA(11))       PH       6800         EXT PO DATA(12)       FKTV		GO TO 2000	Рн	8650
C CONSTANT-AREA CORNER WITH MALLS AND WITHOUT TURNING VANES PM 8670 C PHI = ABS(DATA(11)) EKTE90 = DATA(12) EKTE90 = DATA(12) EKTE = FKTE(PHI, EKTE90, = 1,80 EKTE = FKTE(PHI, EKTE90/1,80 EKT = EKTE, MDA1+EL/DM1 EKT = DATA(14), EKT, EKT, EKT, EKT, EKT, EKT, EKT, EKT	_ <u>C</u>		Ph	8660
Cs.       PM 8660         1730 NN # 25       PM 8660         PHI = A85(DATA(11))       PM 8670         EKTE90 = DATA(12)       PM 8710         IF (EKTE90	C	CONSTANT-AREA CORNER WITH WALLS AND WITHOUT TURNING VANES	PM	8670
1730       NN = 25       PH = ABS(DATA(11))       PH & 86900         PH = ABS(DATA(12)       PH & 67100       PH & 67100         ExTE90 = LT1. 1.E=6) EXTE90 = 1.80       PH & 87300         ExTE = FRTE(PHI); *EXTE90/1.80       PH & 87300         Ext = ExTE+SUMDATA(12)       PH & 87300         Ext = ExTE+SUMDATA(EDH1)       PH & 87300         Ext = Ext = State       PH & 87300         PH = State       State         Ext = State       PH & 87300         Ex			PM	8680
PHI = ABS(DATA(11))       PM 8700         EKTE90 = DATA(12)       PH 8710         IF (EKTE90 ,LT : 1, E=6) EKTE90 = 1,80       PM 8730         EKTE = FKTE(PHI), EKTE90/1,80       PM 8730         EK = EKTESUMDA1*EL/DM1       PM 8730         GD TO 2000       PM 8760         C:-       DIFFUSING CORNERS WITH TUQNING VANES AND WALLS         PH 8700       PM 8700         C:-       DIFFUSING CORNERS WITH TUQNING VANES AND WALLS         PH 8610       PM 8630         C:-       DIFFUSING CORNERS WITH TUQNING VANES AND WALLS         PH 8630       PM 8630         PH 8 # 20       PM 8630         PH 8 # 20       PM 8630         F(T40 NN # 26       PM 8630         CHORD = DATA(9)       PM 8630         PH 8 # 20       PM 8630         F(T40 NN # 26       PM 8630         F(T40 NN # 26       PM 8630         F(T41 * 10, **6       FKTV1(PHI)*EKTV90/.15         F(T41 * 10, **5       FKTV1(PHI)*EKTV90/.15	1730		PM	8690
ExtEvo = Data(12)       PM 0710         IF (ExtEq0 _11, 1, E=0) ExtEq0 = 1,80       PM 0730         ExtE = FKTE(PH1) * ExtEq0/1.80       PM 0730         Ext = ExtExstendal*E/DH1       PM 0730         GD T0 2000       PM 0730         C       OIFFUSING CORNERS with TuqNING vanes and walls         PM 0700       Ext = Still         C       OIFFUSING CORNERS with TuqNING vanes and walls         PH 0830       PM 0830         PH1 = ABS(DATA(11)       PM 0830         Ext = V900 = DATA(12)       PM 0830         RNREF = DATA(14) + 10, **6       PM 0830         IF (DATA(14) + 11, I			PM	8700
Image: String		TEXTERNO IN SELAN EXALON N S 80	PM PH	8710
Ext = ExtExsumDaixE/2DHi       PM 07400         GD TO 2000       PM 07700         C       DIFFUSING CORNERS WITH TUQNING VANES AND WALLS       PM 07700         C       DIFFUSING CORNERS WITH TUQNING VANES AND WALLS       PM 07700         C       DIFFUSING CORNERS WITH TUQNING VANES AND WALLS       PM 08700         C       DIFFUSING CORNERS WITH TUQNING VANES AND WALLS       PM 08700         C       DIFFUSING CORNERS WITH TUQNING VANES AND WALLS       PM 08700         C       DIFFUSING CORNERS WITH TUQNING VANES AND WALLS       PM 08700         C       DIFFUSING CORNERS WITH TUQNING VANES AND WALLS       PM 08700         C       DIFFUSING CORNERS WITH TUQNING VANES AND WALLS       PM 08700         C       DIFFUSING CORNERS WITH TUQNING VANES AND WALLS       PM 08700         C       DIFFUSING CORNERS WITH TUQNING VANES AND WALLS       PM 08700         F       DIFFUSING CORNERS WITH TUQNING VANES AND WALLS       PM 08700         F       SIDF KINSTON       Extra Extra State		$\frac{s_1}{1 + 1 + 1} = \frac{1}{1 +$	. Г Щ.	ATTO
EKn # FEKn(EK,A0,A1,EMn,AMACH1,EM0S0,G)       PH 8750         GO TO 2000       PM 8760         Go TO 2000       PM 8760         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PM 8760         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PM 8760         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PM 8760         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PM 8760         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PM 8760         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PM 8760         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PM 8760         C       DATA(14)       PM 8760       PM 8870         C       DATA(14)       PM 8760       PM 8870         PM 800       DATA(14)       E=01       RNREF = .5x10.xx60       PM 8870         FK (PHI 4.1.1.1.5=0)       RNREF = .5x10.xx60       PM 8870       PM 8870         IF (PHI 4.1.1.5=0)       EKTV 2.0x1       FKTV2(PHI)*EKTV90/.15       PM 8870         IF (PHI 4.5.30.x00       EKTV 2.0x1       FKTV2(PHI)*EKTV90/.15       PM 8970         RN0C_CCCMORD/A1*(1.+(G=1.)/2.x4MACH1**2)**.76       PM 8970       PM 8970         EKTV 2.73 <td< td=""><td></td><td></td><td>E M</td><td>8740</td></td<>			E M	8740
ITVPE = 1       PH 0760         GO TO 2000       PH 0760         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 0760         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 0760         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 0760         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 0760         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 0760         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 0770         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 0770         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 0770         PH 0770       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PH 0810         C       DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE       PH 0930         C       DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE       PH 0930         C       DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE       PH 0930         C       DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE       PH 0930		EKA B FFKAGEKIAGIALIFMAJAMACHIJFMASQ.G)	D M	8766
GO TO 2000       PM 8770         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PM 8780         C       PM 8800       PM 8610         CHORD = DATA(9)       PM 8620       PM 8620         PHI = ABS(DATA(11))       PM 8630       PM 8630         EKTV90 = DATA(12)       PM 8630       PM 8630         RNREF = DATA(14)+10,**6       PM 8640       PM 8640         IF (DATA(14)+10,**6       PM 8640       PM 8640         IF (EKTV90 +LT, 1,E=6) EKTV90 = ,15       PM 8650       IF (PHI +LE, 30.) EKTV = FKTV1(PHI)*EKTV90/.15       PM 8650         IF (PHI +LE, 30.) EKTV = FKTV1(PHI)*EKTV90/.15       PM 8650       IF (PHI + GT, 30.) EKTV = FKTV2(PHI)*EKTV90/.15       PM 8650         IF (PHI + GT, 30.) EKTV = FKTV2(PHI)*EKTV90/.15       PM 8650       IF (EKTV90, A1.£(1.*(G=1.)/2.*AMACH1**2)**.76       PM 8650         RNV = RN0C_CHORD/A1*(1.*(G=1.)/2.*AMACH1**2)**.76       PM 8650       IF (TH2 -GE. 21.5) EKV = EKV+.006*(TH2=21.5)       PM 8630         EK1 = EKY*(AR=1.)/AR)**2       PM 8630       PM 8630       IF 6630         EK1 = EKY*(IAR=1.)/AR)**2       PM 8630       PM 8630       IF 6630         C       DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE       PM 8690       IF 6630         C       DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE       P			БM	8760
C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PM 8780         C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PM 8790         I740 NN # 20       PM 8810       PM 8810         CHORD # DATA(13)       PM 8620       PM 8630         PHI # ABS(DATA(11))       PM 8630       PM 8630         EKTV90 # DATA(12)       PM 8630       PM 8630         RNREF # DATA(14)+10,**6       PM 8630       PM 8630         IF (DATA(14) LT. 1,E=0) RNREF # .5*10,**6       PM 8630         IF (DATA(14) LT. 1,E=0) RNREF # .5*10,**6       PM 8630         IF (DATA(14) LT. 1,E=0) RNREF # .5*10,**6       PM 8630         IF (EKTV90 LT. 1,E=0) EKTV9 # .5       PM 8630         IF (PHI alts 30,) EKTV # FKTV2(PHI)*EKTV90/,15       PM 8690         IF (PHI alts 30,) EKTV # FKTV2(PHI)*EKTV90/,15       PM 8690         RNV # RN0C,CHORD/A1*(1,*(G=1,)/2,*AMACH1**2)***.76       PM 8900         RNV # RN0C,CHORD/A1*(1,*(G=1,)/2,*AMACH1**2)**.76       PM 8910         EKY # 3       IF (TH2 GE, 21.5) EKV # EKV*.006*(TH2=21.5)       PM 8920         EKY # 3       PM 8920       PM 8920         EK1 # EKY*.006*(TH2=21.5)       PM 8930       PM 8930         EK1 # EKY*.006*(TH2=21.5)       PM 8930       PM 8930         Call FRICIN(CHORO,A1*AMACH1*SLAMOA)		60 TO 2006	PM	8770
C       DIFFUSING CORNERS WITH TURNING VANES AND WALLS       PM 8690         I740       NN = 20       PM 8610         CHORD = DATA(9)       PM 8620         PHI = ABS(DATA(11))       PM 8620         EKTV90 = DATA(12)       PM 8620         RNREF = DATA(14) +10,**6       PM 8630         IF (DATA(14) +10,**6       PM 8650         IF (DATA(14) +10,**6       PM 8650         IF (DATA(14) +1,*E=0) RNREF = .5*10,**6       PM 8650         IF (PHI +1E= 30,) EKTV = FKTV90 = .15       PM 8650         IF (PHI +1E= 30,) EKTV = FKTV1(PHI)*EKTV90/.15       PM 8650         IF (PHI +1E= 30,) EKTV = FKTV2(PHI)*EKTV90/.15       PM 8650         IF (PHI +1E= 30,) EKTV = FKTV2(PHI)*EKTV90/.15       PM 8690         TH2 = FTH2(A2,A1,EL)       PM 8690         R^V = RNOC_COND/A1*(1.*(G=1,)/2.*AMACH1**2)**.76       PM 8910         EK1 = EKV*((AR=1.)/AR)**2       PM 6930         IF (TH2 -GE, 21.5) EKV = EKV+.006*(TH2=21.5)       PM 6930         EK1 = EKV*((AR=1.)/AR)**2       PM 6930         C       DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE       PM 6930         C       DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE       PM 6930         C       SIDE=WALL EACH       PM 6960       PM 6960 <td><u> </u></td> <td></td> <td>Рм</td> <td>8780</td>	<u> </u>		Рм	8780
Las     PM 8810       CHORD = DATA(9)     PM 8620       PHI = ABS(DATA(11))     PM 8620       EKTV90 = DATA(12)     PM 8830       RNREF = DATA(14)*10**6     PM 8850       IF (DATA(14)*LI***********************************	C	DIFFUSING CORNERS WITH TURNING VANES AND WALLS	PM	8790
CHORD = DATA(9)       PH 862(         PHI = ABS(DATA(11))       PM 862(         EKTV90 = DATA(12)       PM 883(         RNREF = DATA(14) + 10 + *6       PM 884(         RNREF = DATA(14) + 1 = 1 = E=6)       RNREF = .5 * 10 + *6       PM 884(         IF (DATA(14) + 1 = 1 = E=6)       RNREF = .5 * 10 + *6       PM 884(         IF (DATA(14) + 1 = E = 6)       EKTV90 = .15       PM 885(         IF (PHI = LE = 30 + EKTV = FKTV1(PHI) * EKTV90/.15       PM 886(         IF (PHI = GT = 30 + EKTV = FKTV2(PHI) * EKTV90/.15       PM 886(         IF (PHI = GT = 30 + EKTV = FKTV2(PHI) * EKTV90/.15       PM 886(         IF (PHI = GT = 30 + EKTV = FKTV2(PHI) * EKTV90/.15       PM 886(         IF (PHI = GT = 30 + EKTV = FKTV2(PHI) * EKTV90/.15       PM 896(         RN0 + EKTU = STH2(A2,A1,EL)       PM 896(         RN0 + EKTU = GT = .3/2, A1,EL)       PM 892(         EKV = _3       PM 892(         IF (TH2 = GT = .21.5)       EKV = .6006 * (TH2=21.5)         EK1 = EKV*((AR=1))/AR) **2       PM 893(         EK2 = EKTV.2./3       PM 893(         GALL FRICIN(CHORD, A1 AMACH1, SLAMDA)       PM 895(         C.       DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE       PM 896(         FT       SIDE=#ALL EACH       PM 896(       PM 896(    <	1740		- E M.	9840 8840
PHI = ABS(DATA(11))       PM 883(         EKTV9Q = DATA(12)       PM 884(         RNREF = DATA(14) + 10, **6       PM 885(         IF (DATA(14) + 1, 1, E=6) RNREF = \$\$*10, **6       PM 886(         IF (DATA(14) + 1, 1, E=6) RNREF = \$\$*10, **6       PM 886(         IF (DATA(14) + 1, 1, E=6) RNREF = \$\$*10, **6       PM 886(         IF (DATA(14) + 1, 1, E=6) RNREF = \$\$*10, **6       PM 886(         IF (PHI = LE, 30, ) EKTV = FKTV1(PHI)*EKTV90/, 15       PM 886(         IF (PHI GT, 30, ) EKTV = FKTV2(PHI)*EKTV90/, 15       PM 886(         IF (PHI GT, 30, ) EKTV = FKTV2(PHI)*EKTV90/, 15       PM 886(         IF (PHI GT, 30, ) EKTV = FKTV2(PHI)*EKTV90/, 15       PM 886(         EKTV = RNOC, CHORD/A1, (1, + (G=1, )/2, *AMACH1**2)**, 76       PM 890(         RNV = RNOC, CHORD/A1, (1, + (G=1, )/2, *AMACH1**2)**, 76       PM 891(         EKV = 3       PM 892(       PM 892(         IF (TH2, GE, 21, 5) EKV = EKV, 006*(TH2=21, 5)       PM 892(         EK1 = EKY*((AR=1,)/AR)**2       PM 893(         EK2 = EKTV, 2,/3       PM 893(         C_*       DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE       PM 896(         C_*       DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE       PM 896(         G       SIDE=WALL EACH       PM 896(	• / • /		- PM	8820
EKTV90 = DATA(12)       PM 8840         RNREF = DATA(14)+10,**6       PM 8850         IF (DATA(14) + LT. 1, E=6) RNREF = .5*10,**6       PM 8850         IF (DATA(14) + LT. 1, E=6) RNREF = .5*10,**6       PM 8860         IF (EKTV90 + LT. 1, E=6) EKTV90 = .15       PM 8860         IF (EKTV90 + LT. 1, E=6) EKTV = FKTV1(PMT)*EKTV90/.15       PM 8860         IF (PHI + LE: 30, EKTV = FKTV2(PHI)*EKTV90/.15       PM 8860         IF (PHI - GT. 30, EKTV = FKTV2(PHI)*EKTV90/.15       PM 8860         TH2 = FTH2(A2,A1,EL)       PM 8900         RNV = RNOC_CHORD/A1*(1.*+(G=1.)/2.*AMACH1**2)**.76       PM 8900         EKV = .3       PM 8910         EKV = .3       PM 8910         EK1 = EKV*((AR=1.)/AR)**2       PM 8920         EK1 = EKV*((AR=1.)/AR)**2       PM 8920         EK2 = EKTV.2./3.       PM 8930         C       DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE       PM 8960         C       DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE       PM 8960		PHT & ABS(DATA(11))	PM	8830
RNREF = DATA(14)*10***6       PH 8850         IF (DATA(14)*LT*1*E=6) RNREF = \$\$*10***6       PM 8860         IF (EKTV90*LT*1*E=6) EKTV90 = 15       PM 8870         IF (PHT*LE*30*) EKTV = FKTV1(PHT)*EKTV90/*15       PM 8880         IF (PHT*LE*30*) EKTV = FKTV2(PH1)*EKTV90/*15       PM 8880         IF (PHT*LE*30*) EKTV = FKTV2(PH1)*EKTV90/*15       PM 8890         TH2 = FTH2(A2*A1*EL)       PM 8890         RNV = RNOC*CHORD/A1*(1*+(G=1*)/2**AMACH1**2)***76       PM 8910         EKV = 3       PM 8920         IF (TH2*GE*21*5) EKV = EKV**000*(TH2*21*5)       PM 8920         EK1 = EKV**((AR=1*)/AR)**2       PM 8930         EK2 = EKTV**2./3       PM 8930         C**       DIFFUSING CORNERS HITH TURNING VANES AND ONLY ONE       PM 8930         C**       DIFFUSING CORNERS HITH TURNING VANES AND ONLY ONE       PM 8930         C**       DIFFUSING CORNERS HITH TURNING VANES AND ONLY ONE       PM 8930		EKTV90 = DATA(12)	PM	8840
IF       (DATA(14) *LT* 1*E=6) RNREF = \$\$*10***6       PM 8860         IF       (EKTV90 *LT* 1*E=6) EKTV90 = 15       PM 8870         IF       (PHT**LE**30**) EKTV = FKTV1(PHT)*EKTV90/*15       PM 8880         IF       (PHT**LE**30**) EKTV = FKTV2(PHT)*EKTV90/*15       PM 8880         IF       (PHT**LE**30**) EKTV = FKTV2(PHT)*EKTV90/*15       PM 8890         TH2       FTH2(A2*A1*EL)       PM 8890         R*V = R*0C**CHORD/A1**(1**(G=1**)/2**********************************		RNREF = DATA(14)+10.++6	PM	8850
IF (EKTV90 .LT. 1.E=6) EKTV90 = .15       PM 8870         IF (PHT .LE. 30.) EKTV = FKTV1(PMT)*EKTV90/.15       PM 8880         IF (PHI .GT. 30.) EKTV = FKTV2(PHI)*EKTV90/.15       PM 8890         TH2 = FTH2(A2,A1,EL)       PM 8900         RNV = RNOC_CHORD/A1*(1.+(G=1.)/2.*AMACH1**2)**.76       PM 8910         EKV = .3       PM 8920         IF (TH2 .GE. 21.5) EKV = EKV+.006*(TH2=21.5)       PM 8920         EK1 = EKY*((AR=1.)/AR)**2       PM 8930         EK2 = EKTV+2./3.       PM 8930         C       DIFFUSING CORNERS HITH TURNING VANES AND ONLY ONE       PM 8930         C       DIFFUSING CORNERS HITH TURNING VANES AND ONLY ONE       PM 8930		1F (DATA(14) .LT. 1.E=6) RNREF = .5+10.++6	PM	8860
IF       (PH1 aLE 30.) EKTV = FKTV1(PH1)*EKTV90/.15       PM 8880         IF       (PHI GT 30.) EKTV = FKTV2(PH1)*EKTV90/.15       PM 8890         TH2 = FTH2(A2,A1,EL)       PM 8900         RNV = RNOC_CHORD/A1*(1*+(G=1*)/2***********************************		IF (EKTV90 .LT. 1.E.6) EKTV90 = .15	Рм	8870
IF (PHI_GT_30_) EKTV = FKTV2(PHI)*EKTV90/.15       PM 889(         TH2 = FTH2(A2,A1,EL)       PM 89(         RNV = RNOC_CHORD/A1*(1*+(G=1*)/2***********************************		1F (PH1 .LE. 30.) EKTV = FKTV1(PH+)+EKTV90/.15	PM.	8880
TH2 = FTH2(A2,A1,EL)       PM 890(         RNV = RN0C_CHORD/A1+(1+(G=1)/2.*AMACH1**2)**.76       PM 891(         Ekv = 3       PM 892(         IF (TH2 .GE. 21.5) EKV = EKV+.006*(TH2=21.5)       PM 893(         Ek1 = Ekv*((AR=1.)/AR)**2       PM 893(         EK2 = EKTV+2./3.       PM 895(         Call FRICIN(CHORD,A1.AMACH1.SLAMDA)       PM 896(         C       DIFFUSING CORNERS HITH TURNING VANES AND ONLY ONE       PM 897(         C       SIDE=WALL EACH       PM 896(		IF (PHI GT. 30.) EKTV = FKTV2(PHI)+EKTV90/,15	PM	8890
REV = MNOU_COMUNU/A1+(1.+(U=1.)/C.**AMACH1**C)***76       PM 8910         EKV = 3       PM 8920         IF (TH2 .GE. 21.5) EKV = EKV+.006*(TH2=21.5)       PM 8920         EK1 = EKV+((AR=1.)/AR)**2       PM 8930         EK2 = EKTV+2./3.       PM 8950         Call FRICIN(CHORD.A1.AMACH1.SLAMDA)       PM 8960         C       DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE       PM 8960         C       SIDE=WALL EACH       PM 8960		THE # PTHE(A2, A1, EL)	<b>P</b> M.	6900
EKV #		$\frac{1}{1} = \frac{1}{2} $	P.M.	9410
EK1 = EKY+((AR=1_)/AR)++2       PM 0940         EK2 = EKTV+2_/3       PM 0940         Call FRICTN(CHORD,A1,AMACH1,SLAMDA)       PM 0950         C       DIFFUSING CORNERS HITH JURNING VANES AND ONLY ONE       PM 0960         C       SIDE=WALL EACH       PM 0960	· · .	16 / TH2 GE 21 53 5KV # 5KV. 006+/ TH2-21 53	. 2M 04	97 <b>2</b> 0
EK2 B EKTV+2./3 PM 8950 CALL FRICTN(CHORD,A1,AMACH1,SLAMQA) C C DIFFUSING CORNERS WITH JURNING VANES AND ONLY ONE PM 8960 C SIDE=WALL EACH		ar line buch effort to prive static termetar. Fut a funetiont 1/201662	р.м. р.ч.	- HOUA
C CALL FRICTN(CHORD,A1,AMACH1,SLAMDA) C DIFFUSING CORNERS WITH JURNING VANES AND ONLY ONE PH 8960 C SIDEWWALL EACH PM 8960 PM 8970 PM 8960 PM 8960 PM 8970 PM 8960 PM 8960 PM 8960 PM 8970 PM 8960 PM 89			 	8980
C DIFFUSING CORNERS WITH JURNING VANES AND ONLY ONE PM 897( C SIDEWWALL EACH PM 898(		CALL FRICTNICHORD, AL. AMACHL. SLAMDAN	PM	8960
C. DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE PH 8980 SIDEWWALL EACH PM 8980	<b>C</b>	an Thankan an an Anna Anna Anna Anna Anna Ann	PM	8970
C SIDE-WALL EACH PM 8990	Č.	DIFFUSING CORNERS WITH TURNING VANES AND ONLY ONE	PM	8980
	C	SIDE-WALL EACH	PM	8990
C PM 9001	C		PM	9000

\_ \_\_\_

	IF (ISEC .EQ. 74) EK1 = EK1=EL+SLAMDA/DH1/4.	PM	9010
	<u>IF (ISEC_EG_75) NN = 27</u>		.YUEV
	EK # EK14EK2	1717 1110	9040
	EKO S FEKO(EK.AU.AI.EMU.AMACHI.EMU.SU.G)	E.П.	U
	ITYPE = 3	P M	
C			9070
<u></u>	DIFFUSION		<u>6000</u>
C		9 M	9100
<u> </u>		DM D	9110
C	DILLASEKS	PM	9120
-C	NN = 34	PM	9130
1040	NN A EG EK - JEKEVD. EL MNATJJA - STNJTUSSIJADIT SJJAR-1 SJ4JARATSJJAR]4#2	PM	9140
	$\mathbf{F}$ = $(\mathbf{F} \mathbf{F} + \mathbf{F})$ = $(\mathbf{F} + \mathbf{F})$ = $(\mathbf{F} + \mathbf{F})$ = $(\mathbf{F} + \mathbf{F})$	PM	9150
	f = f = f = f = f = f = f = f = f = f =	PH	9160
		PM	9170
		PM.	9180
<b>C</b>		PM	9190
C	VANED DIFFUSERS	PM	9200
		PM	9210
1850	NN = 29	<u> 2 M</u>	9220
	EKV 8 . 3	PM	9230
	TH2 # FTH2(A2, A1, EL)	<b>P</b> M.	9240
	IF (TH2 .GE. 21.5) EKV # EKV+,006+(TH2=21.5)	PM	9250
	EK = EKV+((AR=1.)/AR)++2	<u></u> <u>P</u> M	9260
	$E_{40} = FE_{K0} (E_{K}) A \overline{0} A \overline{1} A \overline{1} A A A A CH1 (E_{M0} S \overline{0}) G \overline{1}$	PM	9270
1.00 · .	ITYPE = 3	<b>P</b> M	9280
	60 70 2000	PM	9290
C	SUDDEN EXPANSION FROM MULTIPLE DUCTS TO SINGLE DUCT	<u>P</u> M	4200
C		PM	9310
1860	) NN <b>= 3</b> 0		9320
	TH2 # 90	19 19 19 19 19 19 19 19 19 19 19 19 19 1	9330
	$\xi K = ((AR=1)/AR) + 2$		9340 0364
	$EK_0 = FEK_0 (EK, A0, A1, EMO, AMACH1, EMO_8, G)$	F M	933U 0360
	<u>IF (ISEC EQ 87) NN # 51</u>		730V 0770
	ITYPE H 3		- <b>73/</b> 0
	<u>cu</u> tu <b>z</b> 000	. <b>F</b> F	7300 0100
C		9 10 10 10 10 10 10 10 10 10 10 10 10 10	9390
Gaa.	DRIVEWPAN SYSTEM	0 M	0410
C		е м В м	9420
G	CAN ANNULAD DUCTION WITH MOTOD_SUDDOT STOUTIES	E M BM	941A
U.e.e	LUM BURNTTUK AATIGA ATIG AATIG AATIGAAAALLARI GIKAI(A)	е 10 Дом	9440
C:81.		D M	9450
1 7 1 0	ENTRE DATAIN	P M	9460
	- 「「本」「我」「父母」」が「我」」」、「」、「」、「」、「」、「」、「」、「」、「」、「」、「」、「」、「」、	PH	9470
	TO B DATALIN	PN	9480
	FTAFAN S DATA(15)	PM	9490
	FPe # 1.+DATA(16)/100.	p.	9500
	おとないの、世界ももの生物をあるものを見たると、 パン・ディン・ション		

\_\_\_\_

- - ---

	PERFORM	PAGE	20
	IF (ENITEM .LT. 1.E.6) ENITEM = 1.	PM	9510
	IF (ETAFAN <u>LT. 1.1-6)</u> ETAFAN B 100.	<b>P</b> M	9520
	EMP = AMACH1	PM	9530
<b>-</b>	ENPAN = ENDUCT	<b>P</b> M	9540
	IFLAD & N General Duration of the international contract the test	PM	9550
	<pre>FUD = E FUD / [1++ [9=1+]/C++AMAUP1**6)**[1+/[9=1+]]</pre>	. PM	7500
	CHU E OLFUNAIAEL/UMI Te //id/akaka. Chu k e.k. evn - fekend.simnai/ag abtu/fukaa	PM DM	<b>9370</b>
	AT ((ACTAINIA) 401A, 14000) GAV = (CACATAOLTZICOLTOLTIA)	<b>8</b> 0	730V.
	TE JERD I TE JERDALE SI MONTAEJELEN EN SI MONTAELEN.	<u>е</u> п.	9600
		E FI DM	9610
	The FKD FKSTRT	D M	9620
	EKC # FEKC/EK.AC.A1.EMC.AMACH1.EMCSQ.G.	D M	9630
	ITYPE a s	PM	9640
	IF $(A \ge A = 1, y, GT, 1, E = 6)$ ITYPE = 3	PM	9650
	50 TO 2000	. PM	9660
C		₽.M	9670
Č.	FAN CONTRACTION(S) TO ANNULAR DUCT(S) WITH MOTOR-SUPPORT	PM	9680
C	STPUT(S)	PM	9690
C		PM	9700
1950	NN = 33	PM	9710
<b>.</b> .	TH2 # FTH2(AI1, AI2,EL)	<b>P</b> M	9720
	EK = , SZASLMDAIWEL/DHZ	PM	9730
	END = PERO(EK, AD, AZ, EMO, AMACHZ, EMOSW,G)	PM	9749
		PM Du	9750
-			7/90
С <b>.</b> .	E.N. INTERISEDION FORM ANNULLO DURTION. EARL WITH TABEDING	P M	4//0
6.8.8	FAN DIFFUGERIGZ, FROM ANDLAN UUGLIGJ <u>, EAGH MAIN IAFERING</u>	. 213. DM	9794
L	CUNCESPARTO CENTERDUCY	8.4	9140
1940	NN E 14	 D M	9810
1,46	EK S JEKEXPASLMDA1/18 ASINITHXXAJARA1.X/JARA1.X)+J/ARA1.X/ARA1.X/ARA1.X/ARA4.	PM.	9820
	YF (EK , IT, (SIMDALAEI/DHI)) EK & SIMDALAEI/DHI	PM	9830
	EKO = FEKO/EK, AO, A1, EMO, AMACH1, EMOSQ.G)	PM	9840
	ITYPE # 3	PM	9850
	G0 T0 2000	PM	9860
C		PM	9870
C	FLOW DESTRUCTIONS	PM	9880.
C		PM	9890
C		<b>P</b> M_	9900
C	INTERNAL STRUCTURE (DRAG ITEM(S)) AT UPSTREAM END OF EACH	P M	9910
C	DUCT	<b>P</b> M	9920
C		PM	9930
. 1960	NN <b>I 35</b>	<u> </u>	9940
	ENTIEM # DATA(2)	PM	<b>VY50</b>
	DUA E UATA(B)	_PM	
	LU I UATA(13) EP	FM.	7770
	TE PENTTEM IT & E AN ENTTEM - 4	P.M #1.14	_7780
	47 (594)509 (19 16500) 594(50 0 16 Fu - 60400455005555754	- 14 M I	9440
	PY B AAIONVELOUENITEU		F7 7 7 7 7

	EKO = FEKO(EK,AO,A1,EMO,AMACH1,EMO80,G)	PM10010
		PM10020
e '		PH10030
- <b>Lee</b>	FIXED, KNOWNELOCALELOSS ITEM AT UPSTREAM FND OF FACH DUCT	PM10050
C	TADO, NAGAN-LUGAL-DUGG TIDE AT CEDIALAN DA OF LAGH SGA	PM10060
1970	) NN # 36	PH10070
• • • •	EK = DATA(13)	PM10080
	EKQ = FEKO(EK, AQ, A1, EMQ, AMACH1, EMOSQ, G)	PM10090
	ITYPE S 2	PM10100
C		PM10110
Casa	COMPONENT TEST-SECTION-REFERENCED LOSS SUMMATION	PM10120
C		PM10130
_2000	D SEKO(N) = EKO	PM10140
	SUMEKO = SUMEKO+EKO	PM10150
C	SECTION PERFORMANCE INFORMATION OUTPUT	PH10170
_ <u>C.</u>		PM1016(
	IP (EKU .GT. 0.0) GO TO 2001	PM10190
	WRIIE(6,9509) N	PM10201
		PM10210
	LINELI E LINELIAS	- PMIUKE
<b>3</b>		PM10230
	LICAL UDIFULITIES, NY	- FM19599
		- PELVES
e		
		PM102A
	n produce parametrica presenta ta presenta e ne n	PM1029
CC		PM1030
		PM1031
C		PH1032
Č	SUMMARY AND OVERALL PERFORMANCE CALCULATIONS	PH1033
		PM1034
C		PM1035
C	ERROR-CAUSED SKIP AND MESSAGE	PM1036
C		PM1037
2002	2 IF ((TLIST .LT. =1OR. ABS(SUMEKO) .LT. 1.E=0) .AND.	PM1.038
	1 LINECT GE, (LINEMX=1)) IPAGE = IPAGE+1	PM1039
	IF ((TLIST LT1. OR. ABS(SUMEKO) LT. 1.E.6) AND.	PH10404
	1 LINECT .GE. (LINEMX=1)) WRITE(6,9001) ITITLE, IPAGE	PM1041
	IF ((TLIST LT. 1. OR ABS(SUMEKO) LT. 1. E.O. AND.	PM1042
	1 LINECT , GE, (LINEMX=1)) WHITE(6,9004)	PM1043
	IF ((TLIST LT, 1, OR, ABS(SUMEKO) LT, 1, E.6) .AND.	PM1044
	1 LINECT .GE. (LINEMX-1) .AND. TU .EQ. 1) WRITE(6,9005)	PH1045
	IF ((TLIST LT. 1 OR. ABS(SUMEKO) .LT. 1.E.O) .AND.	PM1046
	I LINECT GE, (LINEMX-1) AND, IU EU. 2) WRITE(6,9006)	PM1047
	AF ((TLIST LT. 1. OR. ABS(SUMEKO) LT. 1. E.O) AND.	PM1048
	1 LINECT .GE, (LINEMX+1)) LINECT # 10	PM1049
	IF (ILIST LT	PM1050/

	IF (TLIST LT. 1. OR. ABS(SUMEKO) LT. 1.E.6) GO TO 2015	<u>ч</u> т <b>ү</b> д 
<b>.</b>	ENERGY RATIO	
•	to m 1 /sumfk0	
	PRESSURE DIFFERENTIAL ACRUSS SECTION WALLS (COMPUTED A	T THE
	DOWNSTREAM END OF EACH SECTION)	
þ- <u>-</u>		
	$0_0 2005 I = 1, N$	
	47 [1 _ NP _ ] . UV IV £002	
	SCHMED(1) = SEL(1)	
	GO TO 2004	
203	SSUMEL(1) # SSUMEL(1-1)+SEL(1)	
	SSUMKO(I) = SSUMKO(I-1)+SEKO(I)	
004	IF (IFLAG .EG. 1) SSUMKO(1) = SSUMKO(1)-SUMEKO	
005	DELP(I) = PATM=((PT=Q0+SSUMK0(I))/(1.+(G=1.)/2.+SMACH(I)++2)+	*
	$\frac{\left(G\left(G_{1}\right)\right)}{16} = \frac{1}{10} \frac{1}$	
	IPAGE = IPAGE11	
	WRITE (8.9001) ITITLE. IPAGE	
	LINECT = 6	
006	IF (IU .EG. 1) WRITH (6,9300) SUMFL	
	IF (IU .Eg. 2) WRITE (6,9301) SUMEL	
	LINECT = LINECT+2	
8 <b>8</b> 8.	BICTHO CHECK BITO TO DUE DUE OF SUMME A DEPENDINGE	
•	TAGINGELACK FRIDE TO OUTFUT OF SUMMADY PERFORMANCE	
♦ □		
	IF (  INECT	
	IPAGE # IPAGE+1	
a.a. 17-5	WRITE(6,9001) ITITLE, IPAGE	
_	LINECT = 6	
1007	IF (IU _EG_ 2) GO TO 2008	
	A DOWER FARENTIAL FIRME FOR ST HATTE	
•	POWER CALCULATIONS FOR SI UNITS	
•	PWRTP = A0+V0++3+SUMFK0+RH0S0++2/2./RH0SF	
	PWROP = PWRIP.100./ETAFAN	
	AVGPWR - PWROP/ENFAN	
	WRITE (6,9302) SUMEKO, ER, PWRIP, PWROP, AVGPWR, ETAFAN, ENFAN	
	LINECT E LINECT+5	
	00 TU 2009	
£		
•	POWER CALCULATIONS PUR U.S. CUSTOMARY UNITS	
1.08	PWDTP = AALVAALTEUNEKALAHASALL2/1100 /AHAE	
	一些分离了 一一一条以来来的事实,还是否的现在我们要说的以后的事实是是未来说是不是没有以后来	

\_\_\_\_\_

\_

- -

----

	AVGPWR # PWROP/ENFAN	PM11010
	WRITE(6,9303) SUMEKOJER, PWRIP, PWROP, AVGPWR, ETAPAN, ENPAN	PMILVEV
	LINECT & LINECT S	PM11030
2004	14 (PWR1 LT. 1. E-0) 60 TO 2011	PM11040
C	*****	PM11050
G	VELOCITY ADJUSTMENT CALCULATIONS FOR POWERSHATCHING WITH INPUT	PM11000_
C	POWER VALUE DETERMINES APPROXIMATE MAXIMUM TEST SECTION VELOCITY	PM11070
C	FOR THE SPECIFIED POWER LEVEL	PM11080
C		PM11090
	CALL FRICTN(DH0,A0,EM0,SLMDAC)	_PM11100_
	VOC = VO	PM11110
	VQ = VQ_(PWRMCH/PWROP)++(1./3.)	PM11120.
	EMF # EMF+V0/V0C	PM11130
		PM11140
	RHOSF = RHOT/(1.+(G=1.)/2.*EMF**2)**(1./(G=1.))	PM11150
	RH050 = RH01/(1++(G=1+)/2++EH0++2)++(1+/(G=1+))	<u>PM11160</u>
	RNOC = RHOSO+VO+A0/EMUT	PM11170
	CALL FRICTN(DH0, A0, EM0, SLMDAE)	PM11180
	IF (IU _EQ 1) PWROP # A0+V0+43+5UMEK0+5LMDAE+RHO80++2/8LMDAC+50,/	PM11190
	1 RHOSFZETAFAN	PM11200
	IF (IU _EQ 2; PWROP = A0+V0++3+SUMEK0+SLMDAE+RHOS0++2/SLMDAC/11+	PM11210
		PM11220
	IF (ABS((PWRMCH-PWROP)/PWRMCH) GT. 1, E-6) GD TO 2009	PM11230
	TF (TU .EQ. 1) VOK = VO+1.9438	PM11240
	IF (IU FG 2) VOK # VO* 59248	PH11250
	40 s RH350+V0++2/2.	PM11260
	IF (LINECT LY, (LINEMX-10)) GO TO 2010	PM11270
	IPAGE & IPAGE+1	PM11280
•	WRITE (6.9001) ITITLE. IPAGE	PM11290
2010	7 TF (TU .EQ. 1) WRITE(6,9304) PWROP, VO, VOK, EMO, QO	PM11300
	IF (14 . E. 2) WRITE (6,9305) PWROP, VO, VOK, EMO, GO	PM11310
2011	1 IF (IPRINT FR. 0) GO TO 2014	PM11320
c		PM11330
c	ČIŘČŮÍT SUMMARY CHARACTERISTICS PAGE <u>DUTPUT</u>	PM11340
Г		PM11350
~	LINECT # 100	PM11360
	D0 2013 I # 1.N	PM11370
	IF (, INECT T. , INEMX) GO TO 2012	PM11380
		PM11390
	WRITE (6.9001) ITITLE, IPAGE	PM11400
		PM11410
	TE (THE FOL 1) WETTE(6.9402)	PM11420
	IF (IU FG 2) wRITE(6.9403)	PM11430
		PM11440
2012	WRITE 6. 9400. T. SSUMEL (I., SMACH (T., SSUMKO (T., DEL P(T))	PM11450
e v 1 e		PM11460
2011	VINVI	PM11470
21.44		PM11480
~ « V 1 ~	Tet Lermert gElige. V3VV. IV.EUAP	PM1149A
- U # # # #	CIGIUIT CUMMARY CHARACTERISTICS PLOTICS	PM11500
	#AKKAA?1_9n	

•

74

i

PERFORE	P	AGE	24
C		PM1	1510
CALL PLOTITCH DELP, SSUMEL, SSUMKU, IU, IPLOT, ITITLE, TRETRN	PLOTON)	PHI	1520
	-	P#11	1530
CANNUTATED TABULATION OF INPUT DATA CARDS FOR CURRENT CAS	E	PM11	1540
- Casa - 2015 TE (TETETT OT 1.5mb or, TETET	7.1	PM1	1550
	<b>3.</b> ]	1911 1911	1300
CEND-OF-CISES OR RETURN CHECK		PHI	1580
Ç		PM1	1590
WRITE(0,9007) ITITLE		PM1	1600
IF (TRETRY GT. 1.E=6) GO TO 100		PM1	1610
IF (THETRN LT, e, 5) GO TO 102		Pn1	1620
210H 1000		Ph1	1630
		PMI	1040
		PM11	1650
C., INPUT READ FORMATS	and an appropriate the state of	PM1	1670
C		PHI	1680
7000 FURMAT (A1, 19A4, A3)		PM1	690
7001 FORMAT (12, 411, 4x, 8F5, 2)		PM1	1700
1002 FURMAT (212,211,252,0,1455,2)		PM1	1710
LESSESSESSESSESSESSESSESSESSESSESSESSESS	en aver er er er er ander	PM1	1720
C .		PM11 PM11	1730
MARA		DHI	1750
CDERFORMANCE INFORMATION LABELLING AND OUTPUT FORMATS		PM1	1760
		Pm1	1770
9000 FORMAT (1H1//20X, A1, 19A4, A3, 13X, 4HPAGE, 13//		PMI	1780
1 26x,944,24H wIND=TUNNEL PERFORMANCE/)		PM1	1790
9001 FURMAT (1H1//5x, A1, 19A4, A3, 6x, 16H, CONTINUED, 11, 6X, 4H	PAGE, 13//)	PM1	1800
SUCC FORMAL (CAN ALMOSPHERIC PRESSURE = , PO, S, 15H ATMOSPHERE	S # , +9,1,	PM1	1610
A TH TEST SECTION CONDITIONS /		PMI	1960
r 21m TOTAL PRESSURE # .F6.3.15M ATMOSPHERES # .F9.1	_	Del	1840
n - BH N/SQ M'/	• • • • • • • • • •	Pm1	1850
E 24H TOTAL TEMPERATURE = F6.2.9H DEG C . F7.2.7H	DEG K./	PM1	1860
F_15H VELOCITY = ,F7,2,9H M/SEC = ,F7,2,28H KNOTS,	DYNAMIC PRE	PM1	1870
GSSURE # , F9.218H N/SQ M, /)	·····	PM1	1880
9003 FURNAT (24H ATNOSPHERIC PRESSURE = ,F6,3,15H ATMOSPHERE	S = ,F8,2,	PM1:	1890
A 104 L9/SQ FL/	and the second sec	PM1	1900
C PIH TOTAL PRESSURE & FAIR ATMOSPHEDES & ER P		P 11	1410
D 10H LR/SQ FT /	A second seco	PHI	1930
F 24H TOTAL TEMPERATURE # .F6.2.9H DEG F # .F7.2.7H	DEG R./	PMT	1940
F 15H VELOCITY = , F7.2.10H FT/SEC = , F7.2.28H KNOTS.	DYNAMIC P	PMI	1950
GRESSURE = , F7.2, 10H L8/50 FT. /)		PH1	1960
9004 FOPMAT (120H NO, SECTION TYPE SHAPE H1 #1,0	1 AREA1	PMI	1970
A ALVAN AR, CR 2 THETA VI MACHI LENGTH DP/G	L OP/QO	PM1	1980
8 / 30x, 33H H2 +2,02 AREA2 AR/AO ,17x,		Pn1	1990
	· · · · · ·	PMI	≤000

.....

PERFORM

9005	FORM	AT (28	X,26H M	ETERS	METERS	SQ M,	17×, 32	HDEGREES	MISEC
ş	3	+==+	<u></u>	• • • • • •	• • • • • • • • • •			******	*****
			_ <u>,</u>	· · ·				· · · · · · · · · · · · · · · · · · ·	
06	FORM	AT (3	0X, 26H	FEET	FEET	SQ FT	, 15	X,31HDEG	REES FT/
	SEC		FE	ET /1	20H ++			*****	****
ş	****		+===+	*****	+===+ +	******	****	****	+ +
ا تر م	50-1	• •	••••• ) 64		A / AT T/L		MOLESEN	OD TEDNT	
107	F UR*	TAT (/		1141114	A4, A3, 347	II LASE LU	THETED	OR TERMI	NATEU: **
<b>.</b>	•								
	50 M M A	RY PE	RFORMAN	CE LABE	I ING AND	OUTPUT F	ORMATS		
							<b></b> , <b>.</b>		
ē0	FORM	AT (9	4×,8+++	/	68X,26H 1	TOTAL CENT	ER INE L	ENGTH #	F8.2.
1	A 7+	METE	RS)		-	-	-		_
101	FORM	AT (9	4X, 8H==		68X,26H 1	TOTAL CENT	ERLINE L	ENGTH .	<u>F8,2,</u>
	4 61	FEET	)						
C 2.	P URN	1AT (2	SHOPERF	UNMANCE	SUMMARY		E LU +1	LENEDOW	
	4 J) - F1	(, 3VM) 	IVIAL P	HE 33URE	C038 (DP	-/QVJ =, PO	*310X114	TENERWY	
{	zΓ.Ι 	1447		WER					
í	1	DH	INP	UT TO F		DUTPUT REQ	UIRED	AVERAG	E PER FAN
		FAN	EFFICI	ENCY	TOTAL	NUMBER OF	FANS	angenera film to Malaine to Ma	/
9	F Fj	5.0.6	H WATTS	F13.0.	6H WATTS	F14.0.6H	WATTS FI	1,2,94	PERCENT,
(	G F1	6.01		,,		• • •	•		-
03	FORM	1AT (2	3HOPERF	ORMANCE	SUMMARY				
1	a 3)	(,30H	TOTAL P	RESSURE	LOSS (DF	₽/Qoy <b>#,</b> F8	<b>.</b> 5,6×,14	HENERGY	RATIO =,
!	<u> </u>	.3/	0						
		(,14MT	UTAL PU	/WER ==/	1.0	AUTOUT DEG	UITOES	AVERAC	
_	5		FFFTAT	ENCY		NUMBED OF	FANG	AVENAG	LIFER FAN
		15 0 4	H HP S	15 0 4H	HP F16	AUMBER OF	F13 2 0	- PERCEN	T.F16.01
504	FORM	IAT C	1135X.5	OHMAXIM	UM VELOC	TY FOR A	SPECIFI	D POWER	CONSUMPTI
	ON A	1146H	THE MAX	IMUM TE	ST SECTIO	ON FLOW AC	HIEVABL	E.WITH.F1	0.0.
	B 56	5H #AT	TS OF P	OWER AV	AILABLE :	IS APPROXI	MATELY	S FOLLOW	S ==/
. 1	C 15	5×,13H	VELOCI	TY	F8.2.8H !	M/SEC .F8	2,6H KI	OTS/	
1	D 11	5X,16H	MACH	UMBER .	+ ,F5,2/				
	<u> </u>	5X 21H	DYNAMI	C PRESS	URE .	F9 2 7H N/	SQ M		
202	PURF	"AT (/	//358,2	OHMAXIM	UM VELUC	ITT FUR A	SPECIFI	D PUNER	CONSUMPTI
		<u>746</u> 14 HO-	BEPOWE-	AVATLA	ALF TA A	PPONYTMA+5	LY AN E	1110WS	• V.4
	0 J4	57 NVR	VEL OF	7 MVAIGA 77 mm -	FALL IS AT	FT/SEC ± F	NT AS P		•
		5x.16H	MACH N	UMBER -	• . #5.2/	<u>, , , , , , , , , , , , , , , , , , , </u>	- <b></b>	132 <b>.M</b> . 1. <b>M</b> . <b>I</b>	• · · · • • • • • • • • • • • • • • • •
	E 1	5X 21H	DYNAMI	C PRESS	URE	7.2.9H LE	180 FT1		
		····							
L	<u>c î r ci</u>	JIT SU	MMARY J	NEORMAT	ION PAGE	EURMATS			
00	FOR	AT CZ	5x,15,1	17,2,F1	4.3,F15.	5,F17.1)			
01	FORM	MAT (3	8X,44H	WIND-TU	INNEL CIRI	CUIT CHARA	CTERIST	ICS SUMMA	RY/
	<u>A 4(</u>	0X,40H	TAKEN	AT DOWN	STREAM E	ND OF EACH	LSECTIO	11	

PAGE 26

					and the second second
	25x,71H SECTION	CUMULATIVE	MACH	CUMULATIVE	PM12510
	WALL PRESSURE/				PM12520
r	D 25X,71HASSIGNED	CIRCUIT	NUMBER	PRESSURE	PM12530
	DIFFERENTIAL/				<u>PM12540</u>
F	7 25X,71HSEQUENCE	LENGTH		LOSS	PM12550
(	G (ATMOSPHERIC				PM12560
ł	4 69X,27H(DP/Q0)	INTERNAL)	)		PH12570
9402	FORMAT (25X,70H	METER	\$		PM12580
	N/SQ H /				PM12590
!	<u>8 25x,71H+=====+</u>	*********	<u> </u>	<u>+======+++</u>	<u>PM12600</u>
(					PM12610
9403	FORMAT (25x,70H	FEET			PM12620
1	LB/SO FT /				PM12630
	3 25x,71H+====++	<u>+#########</u>	<u> </u>		<u>PM12640</u>
(	C +========++/)				PM12650
.C			·····		<u>PM12660</u>
C !	ERROR=DIAGN <sub>O</sub> STIC MESSA	GES AND FORMATS	l .		PM12670
Ç					PM12680.
9500	FORMAT (1H1)				PM12690
9501	FUHMAT (/118H +++ DUE	TO ERRORIS, IN	INPUT CARD	(3), VALID SUMMARY	<u>PM12700</u>
	AINFURMATION IS NOT AN	ATLADLE, HEFEN	TO THE TABL	JLATION OF INPUT	/ PM12710
	B LEOM DATA UN I	HE PULLUNING MA	GES CURRET	T THE ERRORISS AN	<u>D_PELCICO</u>
	L RESUBRIT THIS LASE	SUBSEQUENT LAS	DES WILL NUT	DE AFPEUTEU,)	PM16/30
2005	FURMAT C//IOH TITLE	(1,41,1944,43,2	(///) 13 INCO	DRREET UN IMPRUPER	<u>Z. MM14749</u>
	A LEOP AS LI EXISIS,	THE FIRST CAR	CU CULUMN MU	ST CUNTAIN AN AOTE	R PM12/30
	RISK (+) TO BE IVENIL	TED AS A VALID	TITLE CARD,	/	MICLOU
05.7	C Sou Luis Case Mili	SE SKIPPED /)		THE D LININ TO TH	PM12//0
4203	FURMAI CZZEM MASIE	CUNIRUL DATA		<u>(F346+9171) 18 IN</u>	C.MALELON.
	AURRELT OR TMPROPER AN		TTVE NUMBER	(ARU/ (-1 TO -8) TO BE T	D 8412800
	CENTIETED AS A VALID	LUNIAIN A NEGAL	TE CLER WT.	DE ONTODED /	DHISBIA
65 - //	EUDWAT YYYYAH WUBE	THAN ONE MARTER	10 CASE #111	L DE UNIFFEURY) Da éviete end tuig	- PM12820
<b>A</b> 20 M	A CASE OF AUDIT CAPOS	APE OUT OF OPDE	P CHEC. DI	FOR SET-UD	/ PH12830
	S CASE ON INFUT CARDO	TER CARD ENCOUNT	TEDEN WILL D	ELA GETHUP; F Arrined ar the f	0 PM12840
	CUPERT MISTER FIRM FOI	P THE SECTION CA	PAS WHICH B		DULE DULE CONDU
05.5	FORMAT ///H MAYTMU	M LIMIT ON THE N	NUMBER OF SFI	CTIONS (.II.69H) H	A PM12260
7202	AS REEN REACHED' FT	THED & CARE TEDA	ATNATION CAR	D HAS REEN DATTED	A PM12870
	C 120H FALONG WITH	TITLE AND MASTER	R CARDS TO B	FGIN A NEW CASEL O	R PH12880
	D THIS CASE IS TOO LO	NG FOR THE PROGE	RANMED ALLOW	ARLE NUMBER /	PM12890
	F SOH OF SECTIONS	THE CASE HAS BE	EEN TERMINATI	ED AT THIS POINT /	1 PM12900
9500	FORMAT CALLAH MASTE	R CONTROL CARD	AS BEEN ENC	DUNTERED REFORE CA	S PM12910
·• • •	AE TERMINATION AND TH	TIE CARDS CHEC	W DECK SET		/ PM12920
	A 120H ERROR-MESSAG	E TITLE WILL BE	GENERATED A	ND SUMMARY OUTPUT.	PM12930
	CNO-PLOT, INPUT DATA	TABULATION AND	NEXT-CASE R	ETURN /	PM12940
	D 41H TERMINATION P	ARAMETERS WILL I	BE ASSUMED /	/)	PM12950
95n7	FORMAT (/60H ** NOT	E . TEST SECTIO	ON BLOCKAGE	FROM SECTION CARD	1. PM12960
	ANPUT C.FS. 3.49H PERC	ENTY DOES NOT	EQUAL THAT O	F THE MASTER CARDA	PM12970
	B BH INPUT C.FS. 3.10	OH PERCENT	HECK DATA DE	CK. SECTION CARD	V PM12980
	CALUE WILL BE ASSUMED	AS CORRECT AND	EXECUTION W	ILL CONTINUE.	) PM12990
95n8	FURMAT (/117H AL	THOUGH VELOCITY.	OPTIMIZATIO	N WAS REQUESTED BY	PM13000
		and a second			

ATERMINAT	ION CODE, THE INP	UT POWER VALUE IS ILLEGA	L (LESS THAN OR / PHIJO10
B 120H	EQUAL TO ZEROY	THEREFORE, NO VELOCITY	-OPTIMIZING 18 PO PM13020
CSSIBLE.	RECHECK INPUT VA	LUE ON MASTER DATA CARD.	) PM13030
9509 FORMAT (	/115H ++ ERROR -	SOME INCORRECT COMMINAT	ION OF INPUTS OR PMIJ040
AUNANTTCT	PATED STTUATTON H	AS CAUSED AN INVALID INC	N-POSITIVE) / PM13050
B 39H	TOTAL LOSS LEVE	L RECHECK SECTION 11.1	2H INPUT DATA./1 PM13060
END			PM13070

**1 1 1** 

é s i

DA	T A	ĈK.

PAGE 1

SUGROUTINE DATACK(NLIST)	DK	10
	OK.	20
		<u>6.</u> ¥.
Сказаварияния и выправляющих на видения в ракания и воловия и в раской в стали в сор		30
L 1949 ROUTINE, A GOROUTINE UP THE PAIN PROBAM PERFURM, CHELKA FUR	DR_	40
C ERRORS IN INPUTS OF MASTER CONTROL CARD AND SECTION CARDS, AND, IF	DK	50
C REQUESTED, IT CONTROLS THE ASSEMBLY AND PRINTING OF THE ANNOTATED	DK_	60
C TABULATION OF THE INPUT INFORMATION	DK	70
· · · · · · · · · · · · · · · · · · ·	DK	80
C ************************************	DK	00
COMMON/BLOCKA/ISEQ ISHAPI ISHAP2 N	n K	100
COMMON / BLOCKS / DATA / IAN TTTLE / 21, TPACE TOLOT TODANT TREA TTUNNI	 	
. THE I NEAR I THEN OWDE ANDONE TITET TEATS THAT.		114
1 IVALINECIALINERAAFWALAGENUNAILABIALABIALABIA	_DK	120
UIMENSION EMDATA(IJJ,EMWRIT(20),ENDATA(JU,EU),ENWRIT(40),	DK	130
<u>1 ETWRIT(12), MCHECK(13), MDATA(5), MFURMT(30), MWRITE(12),</u>	DK	140
2 NCHECK(30,20),NDATA(30,4),NFORMT(42),NWRITE(8)	DK	150
<u> </u>	DK	160
CÓBJECT_TIME FORMATTING ARRAYS	DK	170
	DK	180
DATA MLEFT NEEPT IAPLD2 IAFLD4 TIFLD5 TELDA TEFLD6 TEFLD6 TEFLD6 TEFLD6	DK.	100
TEFLDA TEFLDA TCOMMA TSPACE TSPACA TPICATA	o K	200
	<u></u>	240
<pre>6 = T([7], y = ( ) = A = ( ) = T(J) = T(T) = U, = T(J) = T(J</pre>	Un	610
	DK.	_620 .
	DK	230
C INPUT TABULATION ANNOTATION MESSAGE ARRAY (INTEGER VALUES)	DK	240
C	DK	250
DATA IBLNK2, IBLNK4, IMBG1, IMBG2, IMBG3, IMBG4, IMBG5, IMBG6, IMBG7,	DK	260
1 IMSG8/2H 4H 2H E 4HXTRA 2H E 4HRROR 2H D 4HPTIN 2H E	DK	270
2 4HMPTY/	nK.	280
	DK	201
C INPUT TABULATION ANNOTATION MESSAGE ARRAY PLOATING POINT VALUES	ňk.	300
P	<u></u>	 1 4 A
VIII		310
A DERAS AN AN AN AN AN AN ANALY AND ANALY ANALY AND ANALY AND ANALY ANA	DA_	
1 MOGOZEN , 4H , 2H E, 4HXIKA, 2H E, 4HKKUK, 2H U, 4HPIIN, 2H E,	DK	330
	DK.	340
	DK	350
CARA IERMINATION CARD PARAMETER TRANSLATION ARRAY	DK	360
	DK	370
DATA TMSG1, TMSG2, TMSG3, TMSG4, TMSG5, TMSG6A, TMSG6B, TMSG7, TMSG8,	DK	380
1 TM8G9, TM8B10, TM8G11, TM8G12, TM8G13/	DK	390
2 4HYES ,4H NO ,4HNONE,4HPRES.4HS L.4HOSS ,4HOSS ,4H WAL AHL PR.	DK	400
3 4HESS. 4H/CHO. 4HSEN). 4H/FOP. 4HCED)/	DK	410
	n¥.	424
C. TRANSFER TO ADDITCARLE SECTION OF RUSPOUTINE		<u></u>
C BIDT 4 STITEMENT 4AAA FOO MISTER CANTON CHECK AND	0h	770 445
BAR ANTI COLLEMENT 1000 FUN MAGIEN CONTROL LAND CHELKOUT	<u>un</u>	<u></u>
L. PART 2 (STATEMENT 2000) PUR SECTION CARD CHECK-OUT	DK.	450
CARDS PARI 3 (STATEMENT 4000) FOR DUTPUT TABULATION OF INPUT CARDS	DK	460
	DK	470
<u>GO TO (1000,2000,4000), NLIST</u>	DK_	480
	DK	490
	DK.	500

04	T	۸	Ĉ	ĸ	

C	DK	510
C CODE 101 INDICATES INPUT WHICH IS NOT REQ	UIRED FOR ANY DK	530
C PURPOSE AND WHICH MAY BE OMITTED	FROM INPUT CARD DK	.540
C CODE 111 INDICATES MANDATORY INPUT	DK	550
CODE 121 INDICATES OPTIONAL INPUT WITH DE	FAULT PROVISION DK	
C CODE (3) INDICATES NON-REDUIRED, CONVENTE OBTIONIL INDUT WHICH NIM OF CODD	NCE INPUT OR DR	570
C UPILUNAL INFUT MALLE MAT BE LURR		500
	DK	600
CINTEGER DATA	DK	610
C	OK	- 620
ÍÖÖO MDATA(1) # TSEQ	DK	630
MDATA(2) = ITUNNL	DK	640
MDATA(3) # IU	DK	050
MDATA(4) @ ISMAP1		000
WANTHIDJ # 180APC		680
CFLOATING POINT DATA	DK	690
	DN.	700
DO 1001 I = 6.13	DK	710
EMDATA(I) # DATA(I-3)	DK	720
1001 CONTINUE	DK DK	730
C	¥DK	740
CINPUT REQUIREMENT DEFINITIONS	× DK	750
C	DK	760
DU 1002 I I 1,13	DK DK	770
		700
1004 LUNTINUC Memfék, 20 m 9		800
MCHECK( 5) # 3		810
IF (ISHAP) .FQ. IN MCHECK/ AN # 0	DK	820
MCHECK ( 8) # 3	DK	830
MCHECK(10) B 3	OK	840
MCHECK(11) = 2	DK	850
MCHECK (12) = 3	DK	860
MCHECK(13) = 2	DK	870
	DK	
Cassa INIEGEN INPUT ENNUMACHECK	DK	0¥0
TE MCHECK.TN NE O AND MDATA.TN EQ O AN	ID. TETST GT. 4.51 DK	920
1 TLTET R R	<del></del>	930
IF (MCHECK/I) EQ. 1 AND. MDATA/I) EQ. ON TH	18T # #3DK	940
1003 CONTINUE	DK	950
	DK	. 960
C UNITS-OF-MEASURE ERRAR DETECTION	DH	( 970
C	DK	980
EMERR = 0.0	DH	990
JF (((IU=1)+(IU=2)) .EQ. 0, GU TO 1004	DM	1000

DATACK

. . . . . . . . . . . . . . . . . . .

WRITE(0,8000) ITITLE, IPAGE	DK	1010
	DK	1020
LINEGT B B	DK	1050
	_DK	1040
CHERR B 3	DK	1050
1004 17 (((30AP101)#(130AP102)#(130AP103)) .EU. 0) 50 10 1006	_DK.	1060
IF (EMERK	DK	1070
TILE(0,0000) ITILE, IMAGE	DK.	1080
LINELT # 4	DK	1040
AAR WOTTA GAAA TAMADA	<u>рк</u>	1100
1003 PRIIC(0,0001) 10HAP1	DK.	1110
		1120
$[b_1]$ if $a_3$ , $b_4$ , $b_4$ , $b_4$ , $b_5$ , $b_4$ , $b_5$ , $b_6$ , $b_7$ , $b_7$ , $b_8$ , b_8, $b_8$ , $b_8$ , $b_8$ , $b_8$ , $b_8$ , $b_8$ , b_8, $b_8$ , $b_8$ , $b_8$ , b_8, $b_8$ , b_8, $b_8$ , b_8, $b_8$ , b_8, b_8, $b_8$ , b_8, $b_8$ , b_8, b	DK	1130
TUUD IF (([IJHAPED]]#[IJHAPED]]*[IJHAPED]] NE. U) TLIBI	QN	1140.
	DN	1150
Cassar COALING POINT INPUT ERRORSCHEER	. <u>A</u> R	1190.
	DK	1170
	DK.	1100
IF (MCHECK(I) +NE+ U +AND+ AB8(ENDATA(I)) +LT+ 1+E+6 +AND+	DK	1190
	<u>_DK</u> _	.1400.
IL (MCHECK(I) FERE I SANDE ROS(EMURIA(I)) FEE (SEBO) (FISL # AS	DN	1410
	. <u>DK</u> _	1220
The (Provide of the state of th	DN	1230
TE (ECODUU)	N	1240.
AF LEMERK ALIA ESJJ HKAIELOJOVOJ AIALESAPAGE Te semedo Af s R. Italet — Italetsa		1240
TE (CHCDN JUL C.) LINE D CINCULM	DA-	1394
er (chenn gerg Egg) kunch Dethou	Un .	1300
REJURN	_Dn	1200
	DA DA	1200
	DI	
CARADIGESSESSESSESSESSESSESSESSESSESSESSESSESS	0n nK	1320
CODE 14. THOTATES THOUS WERE TO TRANSPORTED FOR ANY	DK	1320
	DX DX	1340
C CODE 441 INDICATES MANDATORY INPUT	 	1360
CODE 121 INDICATES OPTIONAL INPUT WITH DEFAULT PROVISION	DK UN	1340
C CODE 131 INDICATES NON-REQUIRED. CONVENTENCE INPUT OF	nK.	1370
C. OPTIONAL INPUT WHICH MAY BE CORRECT AS 75PO	DK.	1340
маан	nK.	1300
2000 SERRUR B 0 0	nK	1400
	nK.	1410
CINTEGER DATA	nK.	1420
Casa	nK	1410
NDATA(N.1) # ISEQ	nK.	1446
NDATAIN.2) E ISEC	DK.	1450
NDATA(N.3) # ISHAP	DK	1440
NDATA(N.4) = ISHAD2	DK	1470
ренин сулурии — нуслев. Саваалаа	DK.	1480
CFLOATING POINT DATA	DK.	1490
	nK.	1500

P		ĠE	•	4
_	-	-	_	 

Dn 2001 I = 5,20	DK 1510
ENDATA(N,I) = DATA(I=4)	DK 1520
2001 CONTINUE	DK 1530
C	DN 1330
	UN 1370
	OK 1500
COOC CUNTINUE	DK 1940
NCHELK(N) ZJ W 1 Newber, N yr m 4	NK 1620
	DK 1630
TE JAHARI NE IN NCHECKIN TY E I	DK 1640
	DK 1650
NCHECKIN, Q3 R 4	NK 1660
IF (ISHAR2	DK 1670
NCHECK/N.11) = 1	OK 1680
C	DK 1690
C SECTION TYPE BRANCHING	DK 1700
C	DK 1710
IF (ISEC .EG. 1) GO TO 3000	DK 1720
IF (ISEC .E. 2) GO TO 2020	DK 1730
IF (ISEC	DK 1740
IF (ISEC . EQ. 4) GO TO 2040	DK 1750
IF (ISEC EQ 5) GO TO 3000	<u> </u>
IF (ISEC . E4 6) GO TO 2060	DK 1770
IF (18EC .EQ. 10) GO TO 3000	DK 1780
IF (18EC , EQ. 20) 60 TO 3000	DK 1790
IF (18EC . EQ. 30) GO TO 2300	DK 1800
IF (ISEC .EG. 32) GO TO 2300	DK 1810
IF (18EC , EQ. 33, GO TO 2330	DK_1820
IF (ISEC , EQ, 34) GO TO 2340	DK 1830
IF (18EC .EQ. 40) GO TO 2400	DK 1840.
IF (18EC , EQ, 45) 60 TO 2450	DK 1850
IF (ISEC , EQ, 46) GO TO 2460	DK 1860
IF (ISEC ,EG, 51) GO TO 2510	DK 1870
<u>IP (ISEC EQ 52) GO TO 2520</u>	DK 1080
TE (1960 E0, 53) GO TO 2330	DK 1890
<u>IF (1886 EW, 34) GU IO 2340</u>	DK 1900-
IF (1920,20, 50) 60 TO 2000	UN 1410
	<u>DR 1780</u>
101500 (1) 31 5 1 15 1950 50 41 00 70 700	PK 1974
18 1950 50 43, 00 TO 7000	
15 (1950 50 70) 00 10 3000 15 (1950 50 70) 00 10 3700	NK 1074 DV 1430
IF 11-50 50 71 60 0 3700	
4' (4550 804 73) 00 TO 2700	DK 1980
17 (18FC EQ 93) 60 TO 5730	DK 1990
15 (1850 50%) 733 00 10 <i>2130</i> 15 (1850 50 74) 60 70 2740	OK 2000
▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁▁ <mark>ਸ਼</mark> ▁ਸ਼ <u>ਸ਼ਸ਼ਸ਼ਸ਼ਸ਼ਸ਼ਸ਼ਸ਼ਸ਼ਸ਼ਸ਼ਸ਼ਸ਼</u>	

DATACK	PAGE 5
16 (1050 °50° 41) CO 10 5840 11 (1050 °50° 12) CO 10 5840	NK 2010
IF TREE FO AEN ON TO TOON	DR 2020
IF (ISEC	UN 2040
IF (ISEC .FQ. 87) GO TO 2860	
IF (ISEC .FG. 91) GO TO 2910	DK 2060
IF (ISEC .EQ. 92) GO TO 2920	DK 2070
IF (ISEC .EQ. 94) GO TO 2940	DK 2080
IF (ISEC .EQ. 96) GO TO 2960	DK 2090
IF (ISEC .EQ. 97) GO TO 2970	DK 2100
G,,,,,	DK 2110
C. INVALID SECTION TYPE=CODE MESSAGE	DK 2120
C.,	DK 2130
IF (LINECT LT. (LINEMX-2)) GO TO 2003	DK 2140
IFAGE # IPAGE+1	DK 2150
WRITE(6,6111) ITITLE, IPAGE	DK_2160
LINECT # 5	DK 2170
2003 WHITE(6,8004) N	DK_2180
LINECT # LINECT+3	DK 2190
	<u>DK_2200</u>
60 10 3003	DK KKIO
A STARTS - DUPT COFFIA, TTED TUDIT PEOUTOF, FATE OFFT, STYONG	DR CCCC
C'SESSCHOLCHOOL CHECTALITED THEN REDITERNED DELIVITING	DN 6630
	DK 2250
	DK 2240
	nK 2270
	DK 2280
C., CONSTANT-AREA TEST SECTION WITH MODEL	DK 2290
C.,	DK 2300
2020 NCHECK(N,12) = 1	DK 2310
NCHECK(N, 14) = 3	DK 2320
NCHECK(N, 17) = 1	DK 2330
NCHECK(N, 20) # 3	DK 2340
GU TU 3000	DK 2350
	DK 2360
nte Otland ical acciinn ee sukia	DK 2370
ZATA NCHECKIN 141 B 3	DA 2300
20 TO	UN 634(
	DR 2447
C DIFFUSING TEST SECTION WITH MONEL	DK 2434
	DK 243/
2040 NCHECK/N.12) # 1	DK 2447
NCHECK(N.14) = 3	DK 2450
NCHECK(N, 16) 8 2	DK 2460
NCHECK(N, 17) # 1	DK 2470
NCHECK(N, 20) # 3	DK 2480
GD TO 3000	DK 2490
	DK 2500

	PAC	E	
--	-----	---	--

C	OPEN-THROAT TEST SECTION WITH MODEL	DK	2510
		OK.	2520
5090	NCHECK(N, 12) = 1	DK	2530
		OK	2540_
	NUNCUN (NJ 17) # 1 Nemfekan, dan bit	DK DK	2220
	GO TO 3000	µn	2570
C		DK	2580
C	CORNERS AND TURNS	DK	2590
_ <u>C</u>		DK_	2600
C		DK	2610
<u> </u>	CUNSIANIGAREA IURN HAIH VANES	DA.	2670
2300	NCHECKAN (S) B (		2640
	NCHECK/N.15) # 1	DK	2650
	NCHECK(N, 16) # 2	DK	.2660 -
	NCHECK(N, 18) = 2	DK	2670
	<u>GU TU 1000</u>	DK	2680
C	CONSTANT APPA THRE WITHOUT VANER	DK	2700
Č.	CONSTANT ANEA TONN RETHOUT VANED	Un.	2710
2330	NCHECK(N, 15) = 1	DK	2720
	NCHECK(N,16) = 2	DK	2730
	GO TO 3000	DK.	2740
C	•	DK	2750
<u> </u>	ATERUSTIC ADNED	<u>DK</u> .	.2760
C	DILLOGING CORNER	0 M	2784
2340	NCHECK/N. 131 B 1		2790
	NCHECK (N. 15) .	DK	2800
	NCHECK (N, 16) # 2	ŋκ.	2810
	NCHECK(N, 18) = 2	_ DK	2820
~	GU TO 3000	DK	2830
. haaaa	A	. DK	2450
C		OK	2860
C		DK	2870
_ <u>C</u> ,,	DIFFUSER	DK	2880
C		DK	2890
			29.00
r	SU IU 3000 Sytt_siow kingtia Ensrgy		2920
Č		DK	2930
2450	NCHECK(N, 9) = 0	DK	2940
	GO TO 3000	DK	2950
<b>C</b>		_DK	2960
C	SUDDEN EXPANSION	DK	2970
54AD	NCHECKIN. ON B O	DK NK	2000
	GO TO BANA	D K	3000
		· · •	

DATACK

PAGE 7

Casasa FLOW OBSTRUCTIONS	DK 3010 DK 3020
C.,	DK 3030
	DK_3040
C HONEYCOMB THIN PLOW STRAIGHTENERS	DK 3050
2510 NCHECK(N.12) B 1	DK 3080
NCHECK (N, 14) # 1	DK 3080
NCHECK(N, 18) = 2	DK 3090
<u>GO TO 3000</u>	DK_3100
	DK 3110
C AIRFOIL THICK FLOW STRAIGHTENERS	DK 3120
550 NCHECKAN 100 m 0	OK 3130
	06 3190
	DK 3160
C	DK 3170
C PERFORATED PLATE	DK 3180
C.,	DK 3190
2530 NCHECK(N, 9) # 0	DK 3200
NCHECK(N,14) # 1	OK 3510
<u>GO TO 3000</u>	DK 3220
	DK 3230
	DK 2640
2540 NCHECKAN, ON E O	DK 3260
NCHECK/N.13) # 1	DK 3270
NCHECK(N, 14) # 1	DK 3280
NCHECK(N, 16) # 2	DK 3290
GD TO 3000	DK 3300
Cae	DK 3310
C. INTERNAL STRUCTURE	DK 3320
	DK 533(
	DN 2340
	DK 3360
NCHECK (N. 14) = 3	DK 3370
NCHECK(N, 17) # 1	DK 3380
NCHECK(N, 20) = 3	DK 3390
GO TO 3000	DK 3400
C	DK 3410
C FIXED, KNOWN LOCAL LOSS	DK 3420
	DK 343(
<u> </u>	DA_344(
CO TO \$000	()N 243( NK 1444
C	DK 3471
CMULTIPLE-DUCT SPECIALIZED INPUT REQUIREMENTS DEFINITIONS	DK 3480
Ç.,,	DK 3490
<u>C</u>	DK 3500

PAGE 8

C	CORNERS AND TURNS	OK 3510
<u> </u>		DK 3520
C		DK 3530
_C	CONSTANT-AREA CORNERS WITH VANES	<u>DK 3540</u>
C		DK 3550
2700 NC	HECK(N, 13) # 1	DK 3560
NC	CHECK(N, 15) # 1	DK <b>357</b> 0
NC	HECK(N, 16) # 2	DK 3580
NC	HECK(N.18) # 2	DK <b>359</b> 0
GÖ	1 10 3000	DK 3600
e		OK 3610
č**	CONSTANT_AREA CORNERS WITHOUT VANES	DK 3620
~ <del>~~~</del>		NK 3630
2730 NC	HERKIN, LEN	DK 3640
NC	NERVIN 445 5 5	DK 3650
	, TO 3000	DK 1440
61		
C.	ATERIETNO ACONSOS	17 3070 Re 1424
		DR 3050
		UK 3040
2140 N		DK 3700
N	HELK (N, 13) # 1	DA 3710
NC	HECK(N, 10) # 2	<u>DN_3/20</u>
N	HECK(N,18) = 2	DK 3750
GC	J TO 3000	<u>DK 3740</u>
C		DK 3750
_ <u>C</u>	DIFFUSION	<u>DK 3760</u>
C		DK 3770
		DK3780
С.,	DIFFUSERS	DK 3790
_C.+		DK 3800
2840 N	CHECK(N,16) • 2	DK 3810
G	0 TO 3000	DK 3820
C		DK 3830
	BUDDEN EXPANSION	DK 3840
C		DK 3850
2860 N	CHECK (N, 9) = 0	DK 3860
G	0 TO 3000	DK 3870
C		DK 3880
C	DRIVE_FAN SYSTEM	DK 3890
<b>C</b> • •	n na materia de la constante	DK 3900
····¥.#.#		DK 301A
	FAN ANNULAR DUCTION	NK 1924
	TAT ANTAPHI AAPITAT	NY 1024
3940	CHÉCKA, EN e D	
	$\frac{\nabla F_{\text{L}}}{\nabla F_{\text{L}}} = \frac{\nabla F_{\text{L}}}{\nabla F_{\text{L}}}$	UN 3740
N	uncun[n] = 2	UN 3430
<u>N</u>	UNCUN(N, 12) # 1	DK \$960
N	CHECK(N,13) # 1	DK 3970
N	CHECK(N,14) # 3	DK 1980
N	CHECK(N,17) # 1	DK 3990
N	CHECK(N, 19) = 2	DK_4000

DATACK	PAGE 9
NCHECK(N,20) = 3	DK 4010
GO TO 3000	DK 4020
C. FAN CONTRACTION(S)	DK 4030
<u>C.</u>	DK. 4040
2920 NCHECK(N, 5) = 2	DK 4050
NCHECK(N, 6) = 2	DK 4060
NCHECK(N,13) a 1	DK 4070
NCHECK (N, 14) = 3	DK 4080
GU TU 3000	DK 4090
Cae FAN DIFFUSER(S)	DK_4100
	DK 4110
	DK 4120
NUTELA (N, C) E Z	OK 4130
	DN_9190-
967668(N)14) # 3 Nouserstan 142 = 3	DK 4150
	<u>DR_4190</u> .
	DN 4170
	Dh 4100
Car Fow Deptholitons	OK 4200
	DK 4210
C INTERNAL STRUCTURE	DK 4220
A TENNAL VINY INTE	
2940 NCHECKIN, AN E 2	NK 4240
	OK 4250
NCHECK(No.12) = 1	DK 4260
NCHECK(N.14) # 3	DK 4270
NCHECK(N.17) # 1	DK 4280
NCHECK(N, 20) = 3	DK 4290
GO TU 3000	DK 4300
C • •	DK 4310
C FIXED, KNOWN LOSS	DK 4320
C	DK 4330
2970 NCHECK(N, 9) = 0	DK 4340
NCHECK(N,17) = 1	DK 4350
C	DK 4360
C, INTEGER INPUT ERROR-CHECK AND SETTING OF ERROR FLAG	DK 4370
	DK 4380
3000 00 3001 1 =1,4	DK 4390
IP (NCHECK(N, I) NE 0 AND NDATA(N, I) EQ. 0 AND	DK 4400
1 BERRUR GI, +,5) SERRUR 8 +,5	DK 4410
TOAL CONTINUE	DR 4420
SAGT CONITINE	DR 4430
C FLATTING DATING THREE SPRAD AMERICAN ARTITING OF PRODA PLAC	<u>DR 4440</u> NK 1/12A
e A <sup>8888</sup> leautadolatat talat cuunworlden van gentum al cukak LTVP	UR 4430 AV 1144A
	UNUNUNUNUNUNUN
TE INCHECKIN TO NE DI AND ARGIENDATAINITAL LE CELLA AN	D DK 4480
1 SERROR .GT	NK 4400
IF INCHERKININ EQ. 1 AND. ABSIENDATAINATIN IT. 1.5=AN	DK 4500

1 SERROR # =2.	DK	4510	)
3002 CONTINUE	DK	4520	L
Course Thurst an erection such a curry and measure	DK	4530	1
LOO INVALID SELIJUN SHAPE LHECK AND HESSAGE	<u>.08</u>	<u></u>	<u>.</u>
Cas 3003 TF (((TSHADINI)))/TSHADIN2)/TSHADINI), FA. 0. CO TO 3005	DK	4330	) 1
T = (1 T N E A T + 1 T + 1 T N E M T = 2 T + 2 T = 2 T + 2	nx.	4570	
IPAGE # IDAGF-1	DK	4580	
WRITE (6.8111) ITITLE, IPAGE	<b>ŇK</b>	4590	1
WRITE(6.8007)	-OK	4600	
IF (IU .EG. 1) WRITE(6.8008)	DK	4610	)
IF (10 EQ. 2) WRITE(6,8009)	DK.	4620	_
LINECT = 9	DK	4630	)
3004 WRITE(6,8003) N.ISHAP1	DK.	4640	L
LINECT # LINECT-3	DK	4650	)
SERROR = -2.	DK.	.4660	L.,
3005 IF (((ISHAP2-1)+(ISHAP2-2)+(ISHAP2-3)) .EQ. 0) GO TO 3007	ĎK	4670	)
IF (LINECT LT (LINEMX_2)) GO TO 3006	DK	4680	<b>.</b>
IPAGE B IPAGE+I	DK	4690	)
WRITE(6,8111) ITITLE, IPAGE	DK	. 47.0.0	L
WRITE(6,8007)	DK	4710	)
<u>IF (IU _EQ 1) WRITE(6,8008)</u>	DK.	4720	Ł
IF (IU .EG. 2) WRITE(6,8009)	DK	4730	)
LINECT = Q	DK	4740	1
3006 WRITE(6,8003) N,ISHAP2	0K	4750	)
LINECT # LINECT+3	DK.	47.6.0	L
SERROR # 2.	DK	4770	)
3007 IP (SERROR GT1.) GU TU 3009	.05.	4780	L.,
IF (LINECT LT (LINEMX=3)) GU TU 5008	DK	-4790 -2800	)
	.00	4900	£ .
MATIC(D9M111) 111160/17806	Dr	- 4010 - 4010	2
		- 496U - 6977	į.,
IF (IU 250 I) WAIE(0,0000)	Un	- <b>403</b> 0	
	-01	494U 4854	
LINEUT - 9	0 h	4030	2
		4000	
BANGUI W BINGUIAJ 1009 IR VIITAK GR ABADADA VIIER A AFADADA	- 10 M	4880	,
Dertion	UN.	4000	/ \
	DK	4901	Ś
	DK	4910	5
	DK	492(	)
C. PRINTED TABULATION OF INPUT DATA WITH ANNOTATIONS AS REQUIRED	DK	4931	١
<u>C</u>	DK	4940	2
C	DK	495(	)
GARALABELLING OF MASTER AND TERMINATION DATA PAGE	DK	496(	)
	DK	497(	)
4000 LMAGE B IPAGEA1	DK	498(	)
WRITE(0,0100) ITITLE, IPAGE	DK	499(	)
<u>RELIC(0,0101)</u>	<b>₽</b> K		J

DATACK	PAGE	11
IF (IU .E0. 1) WRITE(6,8102)	DK	5010
IF (IU .EQ. 2) WRITE(6,8103)		5020
""""""""""""""""""""""""""""""""""""""	DK	5030
C. DEFINITION OF MASTER DATA INFORMATION AND FORMAT ARRAYS		5050
	DK	5060
C	DK	5070
C. INTEGER INFORMATION	DK.	5080
	DK	5090
MEURMICIII & MLEFI MEODMIC 33 - TOOMAA	<u>DK</u> -	5100
MFORMT/ILS = ISPACI	DN DK	5120
MFORMT(3n) = IRIGHT	nK	5110
	DK	5140
10F # 3	DK.	5150
Do 4007 I = 1,5	DK	5160
IF (MCHECK(I) NE, 0) GO TO 4001	DK	5170
	DK	2100
TE LUDATALTA FO DA GO TO 4005	DN	5240
MWRITF/IOV) = IMSG1	<u>0K</u>	5210
HWRITE(IOV+1) # 148G2	DK	5220
GD TO 4005	DK	5230
4001 IF (MCHECK(I) EQ. 0 OR. MDATA(I) EQ. 0) GO TO 4002	DK	5240
MWRITE(IOV) = MOATA(I)	DK	5250
	DK.	2200
MENEMT(LOF) B LIFLOG MENEMT(LOFL) _ +SPACC	DN	5284
SD TO HONG	DK	520
4002 IF (MCHECK/I) NE. 1 OR. MDATA/I) NE. 01 GO TO 4003	DK	5300
MWRITE(IOV) = IM8G3	DK	5310
HWRITE(IOV+1) = IM8G4		5320
GD TO 4005	DK	5330
4005 IF (MCHECK(I) NE C OR MDATA(I) NE 0) GO TO 4004	DK	534(
MARTERTOVIE TWOCE	DN	7330 6144
		5270
4004 HWRITE/IOV) = IMSG7	DK	5380
MWRITE(IOV+1) # IMSG8	DK	5390
4005 10V = 10V+2	DK	5400
MFORMT(IOF) = IAFLD2	DK.	5410
MFORMT(IOF+1) B IAFLD4	DK	5420
HOOD LUF W LUFAZ	DK	543(
TOP & TOPLI	<u>DK</u>	.744( 5451
	טית הג	9436 8461
IQVR . IQVI+1	DK	5470
£	DK	5480
C FLOATING-POINT INFORMATION	DK	5490
<u></u>	DK.	.5500

DATACK

	DD 4014 I = 6,13	DK T	5510
	IF (MCHECK(I) NE. 0) GO TO 4008	DK	5520
	EMWRIT(IOV) = ŘBLŇK2	DK 1	5530
	EMWRITCIOV+1) = RBLNK4	<u>pk</u>	5540
	IF (ABS(EMDATA(I)) .LT. 1.E=6) GO TO 4012	DK 5	<b>55</b> 50
	EMWRIT ( IOV) RMSG1	<u>DK_</u> f	<b>556</b> 0
	EMWRIT(IOV+1) = RMSG2	DK 1	5 <b>57</b> 0
	<u>90 TO 4012</u>	DK_	5580
4008	IF (MCHECK(I) .EQ, 0 .OR, ABS(EMDATA(I)) .LT, 1.E=6) GO TO 4009	DK 1	5590
	EMWRIT(IDV) _ EMDATA(I)	DK!	1600
	10V = 10V+1	DK	5610
<u></u>		DK	5620
C	DATA-MAGNITUDE-CONTROLLED FORMATTING	DK 5	5630
C		OK	5640
	MFURMT(IOF) # IFFLDO	DK	5650
	IF (EMDATA(I) LT. 1000.) MFORMT(IOF) _ IFELD1	DK	5660
	IF (EMDATA(I) LT. 100.) MFORMT(IOF) = IFFLD2	DK	5670
	IF (EMDATA/I) LT. 10.3 HFORMT, 10F) = IFFLD3	DK_	5680
	IF (EMDATA(I) (LT. 1) MFORMT(IOF) # IFFLD4	DK 1	5690
	MFORMT, TOF-1) = ICOMMA	DK	57.00.
	GO TO 4013	DK 1	5710
4009	IF (MCHECK(I) .NE. 1 .DR. ABS(EMDATA(I)) .GT. 1.E=6) GO TO 4010	<u> </u>	<u>5720.</u>
	EMWRIT(IOV) = RMSG3	DK S	5730
	EMWRIT(IOV+1) = RM8G4	DK !	5740
	GO TO 4012	DK !	5750
4010	IF (MCHECK(I) NE_ 2 OR ABS(EMDATA(I)) GT. 1.E=6) GO TO 4011	DK !	5760
	EMWRIT(IOV) # RMSG5	DK	5770
	EMWRIT(10V+1) = RM366	OK!	5780.
	GO TO 4012	DK	5790
4011	EMARITCIOV) = RMSG7	<u>DK</u>	5800
	EMWRIT(IOV+1) = RMSG8	DK	2910
4012		DK	5820
	MFORMT(IOF) = IAFLD2	DK	5830
	MFORMTCIOF+1) = IAFLD4	DK	5840.
4013	i IOF = IOF+2	ĎК	5850
4014		DK	5860.
	10V <b>s</b> 10V-1	DK	5870
	WRITE(6,MFORMT) (MWRITE(I),I = 1,IOVI),(EMWRIT(I),I = IOVR,IOV)	DK	5880.
C		DK	>890
Ceses	DEFINITION OF TERMINATION CONTROL CODES	DK	2900
C		DK	5910
£		DK	5920
C.,	SUMMARY INFORMATION PRINT	DK	5430
_ <u>C</u>		DK .	3940.
	ETWRIT( 1) = TMSG2	DK	3950
	IE (IPRINT NE. 0) ETHRIT( 1) a TMSG1	<u>_OK</u> _	3760
C		DK	3970
	SUMMARY PLOIS	DK	3480
C		DK	3990
	IF (IPLOT NE, 0) GO TO 4015	DK .	0000

90

		PAGE	13
ETM	RIT( 2) = R8LNK4	DK	6010
ETH	RIT( 3) = TMSG3	DK	6020
ETH	RIT( 4) = RBLNK4	DK	5030
<u>60</u>	TO 4017	DK.	0040
4015 IF	(IPLDT NE, 1 AND, IPLOT NE, 3) GO TO 4016	DK	6050
ETH	PIT(2) = TMBG4	DK .	6060
ETH	RIT( 3) = TMSG5	DK	<b>607</b> 0
	RIT( 4) B TMSG6A	DK	6080
47	$(1FLUI _{0}UI_{0} Z) EIWRII(4) = IMOGOD$	DK	6090
4016 STu	$ U, 901\rangle$	DK	6100
- 4010 EIN 674	×11( ζ) ■ 1°367 ΩΤΤ, 15 ■ Τναρα	DK	0110
	NII 21 - INDUO	DK	2160
4017 15	VIPLOT GT 3. CO TO 4019	OK DK	6130
00		un	9140
4018 ET.	RIT(T) = RBINKU	04	2120
Gn	To 4020	Un	8170 6170
4019 ET#	RITAIDA E TMAG7	DK	6180
ETW	RIT(11) # THSG8	BK	6100
ETH	HIT(12) = TMSG9	DK	6200
C		DK.	6210
<u>C.</u>	ANNUTATED TABULATION OF INPUT DATA	DK	6220
C		DK	6230
4020 ETH	RIT( 5) = TMSG1	DK	6240
IF	(TLIST ,GT,6) GO TO 4021	DK	6250
ETM	RIT( 6) STMSG12	DK	0850
ETA	RIT( 7) # TM9G13	DK	6270
<u> </u>	10 4022	DK	0050
4021 ET.	RIT( 6) = TMSG10	0 K	9540
EIV	RIT( 7) # TMSG11	DK	6300
4020 614	RIT( 8) # THSG2	DK	6310
Ç.s.s.s.s		DK	6350
C	PUWER_MATCHING AND VELUCITY_UPTIMIZATION REQUEST	DK	6330
<u>. 5. a. a.</u>		<u> </u>	6340
1 F 6 Tu	(LANT PRI TERNI COMMINICO) M (MORT	DK	0.550
<u> </u>	HILL AT . IMDUC	DK	0300
×****	NEXT CARE RETHON OF TERMINATION DECHERT	DK	6370
<u>v.s.</u>	MEATELADCENTIONN ON TEAPINATION REDUEST		<u>9399</u>
UHH IF	TRETEN OT I FAST STUDITY ON A THROU		0340
WR1	TELO ALOS A	<u>un</u>	6410
WRI	TF/6.81065 FTWRTT	nk hu	6420
C		0n	2369. 6420
C. HEAD	INGS FOR LISTING OF SECTION DATA INPUTS	DK DK	6440
C		DK	6450
1PA	GE B IPAGF+1	0K	5460
WR1	TE(6,8100) ITITLE, IPAGE	DK	6470
WR	TE(6,8107)	DK	6480
IF	(IU ,EQ, 1) WRITE (6,8108)	DK	6490
IF	(IU .EQ. 2) WRITE (6.8109)	DK	6500

WRITE(6,8110)	DK	6510
LINECT # 27	DK	6520
00 4039 I = 1 N	DK	6530
IF (LINECT LT. (LINEMXWII) GO TO 4023	OK	6540
IPAGE B IPAGE+1	DK	6550
WRITE (D, BIII) ITITLE, IPAGE	DK	0200
WRITE(6,8107)	DK	6570
IF (IU .EQ. 1) WRITE (6,8108)	DK	0580
IF (IU .EQ. 2) WRITE (6,8109)	DK	6590
WRITE(6,8110)	DK	
LINEGT = 19	DK	6610
CARACTERISTON OF REALING DATE INFORM. TON AND FORMER AD		U
C DEFINITION OF SECTION DATA INFORMATION AND FORMAT AR	HATO UN	6640
4033 NEORMTA IN A NIFET		6650
NEORMT(42) = TRICHT		6660
	DK	6670
	DK	6680
	DK	6600
C. INTEGED INFORMATION	DK	6700
C.	DK	6710
DO 4030 J = 1.4	DK	6720
IF (NCHECK (I.J) .NE. 0) GO TO 4024	DK	6730
NARITE (IOV) = IBLNK2	DK	6740
NWRITE(IOV+1) = IBLNK4	DK	6750
IF (NDATA(I.J) .En. 0) GO TO 4028	DK	6760
NWRITF/IOV) . IMSGI		6770
NWRITF(TOV+1) = IMSG2	DK	6780
GO TO 4028	DK	6790
4024 IF (NCHECK/I, J) EQ. 0 OR NDATA/I, J) EQ. 0) GO T	0 4025 DH	6800
NWRITE(IOV) = NDATA(I,J)	DH	6810
Inv # Inv+1	Ū.K	6820
NFURMT(IOF) = IIFLD5	DK	6830
NFORMT(IOF+1) = ISPACC	01	6840
GO TO 4029	۲۵	6850
4025 IF (NCHECK(I,J) NE. 1 OR. NDATA(I,J) NE. 0) GO T	0 4026 DF	6860
NWRITE(IOV) = IMSG3	DH	6870
NWRITE(IUV+1) # IMAG4		6880
GU TU 4028	DH	( 6890
4026 IF (NCHECK(I,J) NE. 2 OR. NDATA(I,J) NE. 01 GO T	0 4027 DF	6900
NWRITE(IDV) # IMSG5	DH	6910
NHRITE(IUV+1) = IMSG6	0	6920
GO TO 402A	10	6930
4027 NWRITE(IOV) + IMEG7	D*	6940
NWRITE(IOV+1) = IMSG8	DH	6950
4028 IOV # 10V.2	Ď!	6960
NFORMT(IOF) = IAFLD2	10	6970
NFORMT (IOF+1) # IAFLD4	Dr	6980
4029 10F # 10F+2	10	6990
4030 CONTINUE	f	K 7000

n	A	т	۸	C	ĸ
<b>.</b>		_			4.1

P.A	GE_	Í	5
-----	-----	---	---

Ĭ	OVI = 10V-1	DK	7010
<b>I</b>		DK	7020
C		DK.	7030
<u></u>	FLOATING-POINT_INFORMATION	DK.	1040
C		DK	7050
0		DK	1060
1	F (NCHECK(1,J) .NE. 0) GU TO 4031	DK.	7070
£	NWRIT(IOV) = RBLNKZ	DK	7080
E	NWRIT(IOV+1) # RBLNK4	DK	7090
	P (ABS(ENDATA(I,J)) ,LT, 1,E=0) GO TO 4030	QK.	7100
٤	NWRIT(IOV) # RMSG1	DK	7110
E	NWRIT(IOV+1) = RMSG2	DK.	7120
G	0 TO 4036	DK	7130
4031 I	F (NCHECK(I,J) _EQ, O _OR, ABS(ENDATA(I,J)) _LT, 1,E=6)	DK	7140
1	GO TO 4933	DK	7150
Ē	NWRIT(IOV) = ENDATA(I,J)	DK.	.7160
1	OV # 10V+1	DK	7170
1	F (J NE S AND J NE 6) GO TO 4032	DK	7180
N	FORMT(IOF) # IFLOO	DK	7190
N	FORMT(TOF+1) = TSPACC	DK	7200
G	0 TO 4037	DK	7210
C		DK	.7220
C	DATA_MAGNITUDE_CONTROLLED FORMATTING	DK	7230
C		DK	7240
4032 N	FORMT(IDF) = IFFLDO	DK.	7250
	F (ENDATA(+.1) .IT. 1000.) NFORMT(+0F) = +FFIDE	DK	7260
	F (ENDATA(1.J) LT. 100.) NFORMT/ 10F1 # IFFLD2	nK	7270
	F (ENDATA(+.1) .IT. 10.) NFORMT(TOF) # VFFIDS	DK	7280
1	F (ENDATA) J. LT. 1.) NEORMT (OF) = IFFLD4	DK	7290
Ň	FORMT/TOFALL - TCOMMA	DK.	7300
6	0 TO 4037	n K	7310
4033 1	F NCHECK/I.J. NE 1 OR ABB/ENDATA/I.J.N. GF. 1.F=6.	D K	7320
4		N	711
·	GUIDING ANDA		7340
¥		 N	7360
		01	784
4014 1	F INHERKAT IN NE 2 OR ABS/ENDATAAT IN OF 1 E-6.	UA	7170
	CO TO HARE - INC. E BORE ROULENCERTR(1707) BUEL 18200)	20	- 7 3 7 V - 7 1 8 A
¥	NWRIT, TOUL _ DARCE	UA	7204
5	NWDITETNILL BURGES		7270
		UN	- <u>1,900</u>
4076 C	NWD17,10N, _ DM204	DA DA	7410
<u> </u>	NUDIT (104) B RM307	<u>DK</u>	1460
1096 1	10/ m 10/ m 10/ m 10/ m KW909	DK	7430
- 4030 I		<u>DK</u>	7440
	AFURMI (LUF) B IAFUDZ	DK	7450
	VPURMICIUFAL) NIAFLU4	DK	7460
4037	rok # Tok*5	DK	7470
4038 (	UNTINUE	<u> </u>	7480
1	IUV B IOV-1	DK	7490
¥	<u>HRITE(6,NFORMT) (NWRITE(J),J = 1,IOVI),(ENWRIT(J),J = IOVR,IOV)</u>	OK	7500

LINECT = LINECT+2	DK	7510
4039 CONTINUE	DK	7520
_ RETURN	DK	7530
	<u>px</u>	7040
CONDATA LAROR MESSAGE PORMATS	DK	7550
ANA FORMAT // LAY SHEPTTEAL ONTERTONIES TH THINKEL MARTER CONTROL DA		7570
A PREVENT EXECUTION OF THIS CASE VIA ANALY SUCCEDING CASES WILL	N DK	7570
ROT BE AFECTED. /)	DK	7500
8001 FORMAT (/10X.73HAA ERROR - INVALID TEST SECTION UPSTREAM END SH	AP DK	7600
AE CODE WAS SECTIFIED AS, 12,23H (SHOULD BE 1, 2 OR 3)./	DK	7610
B 13X 29HTHIS CASE CANNOT BE EXECUTED / 1	ŐK	7620
8002 FORMAT (/54H THE UNITS OF MEASURE CODE IS IMPROPERLY SPECIFIED	AS DK	7630
A, I2, 54H (SHOULD RE 1 OR 2). CHECK MASTER CARD (COLUMN 4).	DK	7640
R 120H SEE THE DATA TABULATION AT THE END OF THIS CASE. THE IN	TE DK	7650
CRNATIONAL SYSTEM OF UNITS WILL BE ASSUMED FOR THIS CASE. /)	DK	7660
8003 FURMAT (/I3,2X,55H++ ERROR INVALID SECTION SHAPE CODE WAS SPE	LI DK	7670
AFIED ASITZISH (SHOULD BE 1, 2 OR 3). THIS SECTION WILL BE SKIP	PE OK	7080
		7090
ANS I AND ALLS INVALO SECTION TYPE DATA CADD TROPED ++/3	OK OK	7710
BOOS FORMAT (/I 3.2X. 11) ++ FROR ++ CRITICAL OMISSION(S) IN SECTION	NP DE	7720
AUT DATA. SEE DATA TABULATION AT END OF DUTPUT FOR THIS CASE. **	IL DK	7730
8006 FORMAT (1H1//5X, A1, 19A4, A3, 28X, 4HPAGE, 13)	DK	7740
8007 FORMAT (120H ND. SECTION TYPE SHAPE HI WI.DI ' ARE	A1 DK	7750
A ALVAN AR, CR 2 THETA VI MACHI LENGTH DP/DL DP/O	0 DK	7760
H / 30x, 33H H2 W2.02 AQEA2 A2/A0 ,17x,	DK	7770
	DK	.7780
BUOB FORMAT (28X,26H METERS METERS BQ M, 17X, 32HDEGREES M/SE	C DK	7790
<u>A METERS /120H ++ +=====+ +===+ +===+ +===+</u> +====	+. DK	7800
A tugat toost tugant turnary turnary toost turnary turnary	+ DK	7810
	. DK	7020
DUDY FURMAL (SDX, CONFEEL FEEL SW PL , 15X, 3100 UREED F		78/0
	-# DK	7860
		7860
	DK	7870
C. ANNOTATED TABULATION LABELLING AND DATA FORMATS		7880
L g # a	DK	7890
8100 FORMAT (1H1//5x, A1, 19A4, A3, 6x, 16H CONTINUED6x, 4HPAGE, 13//		7890 7900
BIOU FORMAT (1H1//5x, A1, 19A4, A3, 6x, 16HCONTINUED6x, 4HPAGE, I3// A 44x, 32H ANNOTATED INPUT DATA TABULATION//		7890 7900 7910
A 44X 32H ANNOTATED INPUT DATA TABULATION// B 120H (EMPTY) INDICATES OPTIONAL, NON-REQUIRED INPUT PARAMETER	H DK	7890 7900 7910 7920
<u>6100 FORMAT (1H1//5x, A1, 19A4, A3, 5x, 16H, CONTINUED, A, 6x, 4HPAGE, I3//</u> A 44x, 32H ANNOTATED INPUT DATA TABULATION// <u>B 120H (EMPTY) INDICATES OPTIONAL, NON-REQUIRED INPUT PARAMETER</u> CAS BEEN OMITTED OR PARAMETER MAY BE INTENDED AS ZERO, /		7890 7900 7910 7920 7930
BIO0       FORMAT       (1H1//5X, A1, 19A4, A3, 5X, 16HCONTINUED6X, 4HPAGE, I3//         A       44X, 32H       ANNOTATED       INPUT       DATA       TABULATION//         B       120H       IEMPTY:       INDICATES       OPTIONAL,       NON-REQUIRED       INPUT       PARAMETER         CAS       BEEN       OMITTED       OR       PARAMETER       MAY       BE       INTENDED       AS       ZERO,       /	DK DK DK H DK DK TT DK	7890 7900 7910 7920 7930 7940
BIOU       FORMAT       (1H1//5X,A1,19A4,A3,6X,16HCONTINUED6X,4HPAGE,I3//         A       44X,32H       ANNOTATED       INPUT       DATA       TABULATION//         B       120H       1EMPTY:       INDICATES       OPTIONAL,       NON-REQUIRED       INPUT       PARAMETER         CAS       BEEN       OMITTED       OR       PARAMETER       MAY       BE       INTENDED       AS       ZFRO,       /         120H       IEROR!       INDICATES       MANDATORY       INPUT       PARAMETER       MAS       BEEN       OMI         EED,       THIS       MUST       RE       CORRECTED       DEFORE       COMPUTATION       IS       POSSIBLE,       /		7890 7900 7910 7920 7930 7930 7940 7950
BIOU       FORMAT       (1H1//5X,A1,19A4,A3,6X,16HCONTINUED6X,4HPAGE,I3//         A       44X,32H       ANNOTATED       INPUT       DATA       TABULATION//         B       120H       (EMPTY)       INDICATES       OPTIONAL, NON-REQUIRED       INPUT       PARAMETER         CAS       BEEN       OMITTED       OR       PARAMETER       MAY       BE       INTENDED       AS       ZFRO,       /         120H       IERORI       INDICATES       MANDATORY       INPUT       PARAMETER       MAS       BEEN       OMI         EED       THIS       MUST       RE       CORRECTED       BEFORE       COMPUTATION       IS       POSSIBLE, /         F       120H       IEXTRAI       INDICATES       SUPERFLUOUS       INPUT       PARAMETER       HAS       BEEN       DMI	DK DK DK DK DK TT DK DK	7890 7900 7910 7920 7930 7930 7940 7950 7960
BIOU       FORMAT       (1H1//5X,A1,19A4,A3,6X,16HCONTINUED6X,4HPAGE,I3//         A       44X,32H       ANNOTATED       INPUT       DATA       TABULATION//         B       120H       1EMPTY:       INDICATES       OPTIONAL,       NON-REQUIRED       INPUT       PARAMETER         CAS       BEEN       OMITTED       OR       PARAMETER       MAY       BE       INTENDED       AS       ZFRO,       /         CAS       BEEN       OMITTED       OR       PARAMETER       MAY       BE       INTENDED       AS       ZFRO,       /         CAS       BEEN       OMITTED       OR       PARAMETER       MAY       BE       INTENDED       AS       ZFRO,       /         CAS       BEEN       OMITTED       OR       PARAMETER       MAY       BE       INTENDED       AS       ZFRO,       /         CAS       BEEN       OMITTED       OR       NOATORY       INPUT       PARAMETER       HAS       BEEN       OMITTED         CAS       HERORI       INDICATES       MANDATORY       INPUT       PARAMETER       HAS       BEEN       OMITTED         EED       THIS       MUST       BE       SUPERFLUCUS       INPUT	DK DK DK DK DK DK DK DK DK	7890 7900 7910 7920 7930 7930 7950 7950 7950 7950
BIOU       FORMAT       (1H1//5X,A1,19A4,A3,6X,16HCONTINUED6X,4HPAGE,I3//         A       44X,32H       ANNOTATED       INPUT       DATA       TABULATION//         B       120H       1EMPTY:       INDICATES       OPTIONAL,       NON_REQUIRED       INPUT       PARAMETER         CAS       BEEN       OMITTED       OR       PARAMETER       MAY       BE       INTENDED       AS       ZFRO,       /         CAS       BEEN       OMITTED       OR       PARAMETER       MAY       BE       INTENDED       AS       ZFRO,       /         CAS       BEEN       OMITTED       OR       PARAMETER       MAY       BE       INTENDED       AS       ZFRO,       /         CAS       BEEN       OMITTED       OR       PARAMETER       MAY       BE       INTENDED       AS       ZFRO,       /         CAS       BEEN       OMITTED       OMITTED       MANDATORY       INPUT       PARAMETER       HAS       BEEN       OMITTED         CAS       H       ISCH       INDICATES       SUPERFLUOUS       INPUT       PARAMETER       HAS       BEEN       L         EED       THIS       MUST       INPUT       INPUT		7890 7900 7910 7920 7930 7930 7950 7950 7950 7950 7950 7950 7950 795
BIOU       FORMAT       (1H1//5X,A1,19A4,A3,6X,16HCONTINUED6X,4HPAGE,I3//         A       44X,32H       ANNOTATED       INPUT       DATA       TABULATION//         B       120H       1EMPTY.       INDICATES       OPTIONAL,       NON-REQUIRED       INPUT       PARAMETER         CAS       BEEN       OMITTED       OR       PARAMETER       MAY       BE       INTENDED       AS       ZERO,       /         CAS       BEEN       OMITTED       OR       PARAMETER       MAY       BE       INTENDED       AS       ZERO,       /         CAS       BEEN       OMITTED       OR       PARAMETER       MAY       BE       INTENDED       AS       ZERO,       /         CAS       BEEN       OMITTED       OR       PARAMETER       MAY       BE       INPUT       PARAMETER       HAS       BEEN       OMIT         EED,       THIS       MUST       RE       CORRECTED       BEFORE       COMPUTATION       IS       POSSIBLE,       /         F       120H       IEXTRAI       INDICATES       SUPERFLUOUS       INPUT       PARAMETER       HAS       BEEN       /         GECESSARILY       INCLUDED       ON       INP	DK DK DK DK DK DK DK DK DK ND DK DK DK	7890 7900 7910 7920 7930 7930 7950 7950 7950 7950 7950 7950 7950 7970 7980 7990

\_\_\_\_

DATACK

\_\_\_\_\_PAGE\_\_\_17.

A 20%,78H CASE TUNNEL UNITS SECT, SECT, HI WI MODEL VO PO	DK	8010
	DK.	8020
C 20x, 61H SEQ, TYPE INLET EXIT D1 BLKGE LE	DK	8030
	<u>0</u> K . 1	8040
A SOX 47M M M CENT MAREC WATTR ATM DEC C ATM N	DK I	8050 8040
8103 FORMAT (21X,4H NO., 13X,12H SHAPE SHAPE, 13X,17H PER. FT/ 10(3)/	DK I	8070
A SOX, 47H FEET FEET CENT SEC HP ATH DEG F ATH )	DK	6080
8104 FURMAT (18H DATA FTELD BEGINS/	DK	8090
<u>A 18H IN CARD COLUMN ==, 78H 1 3 4 5 6 11</u>	DK_	6100.
	DK	8110
	DK	
8105 FORMAT ///44X.32HCASE TERMINATION CONDITIONS DATA//	DK I	8140
A 27X,06H CASE TERMINATION OCCURRED (DUE TO BLANKS IN CARD COLUMNS	DK	B150
B 3 AND 4)/	DK.	140-
C 25x, 6H AFTER, I3, 61H INPUT SECTIONS, AND ACCORDING TO THE FOLLOWI	DK	8170
DNG CONDITIONS//	DK I	8180
E EUX, CIN SUMMARY PLOTTING AS INPUT V	DK	5190
G 20X AIHCHADACTERISTICS A FUNCTION DATA OF	DK	1600
HTIMIZATION FOR NEXT /	BK I	951U 8770
I 20X, BIH OUTPUT OF LENGTH TABULATION (FI	DK	8230
JXED POWER) CASE	DK	8240
K 17H TERMINATION-CODE/	DK	8250
L 14H DATA FIELD IS/13H CONTAINED IN/	DK I	8260
	1	
M 16H CARD COLUMNS, 10X, 74H5+6 7+8 9+	DK	8270
M 16H CARD COLUMNS ==,10X,74H5=6 7=8 9= N10 11=15 16=20/		8270 8280 8280
M         16H         CARD         COLUMNS         ==         10x,74H5=6         7=8         9=           N10         11=15         16=20/ </td <td>DK DK DK</td> <td>8270 8280 8290 8300</td>	DK DK DK	8270 8280 8290 8300
M     16H     CARD     COLUMNS     ==     10x,74H5=6     7=8     9=       N10     11=15     16=20/     16=20/     16=20/     16=20/     16=20/       0     20x,61H+=========+     +======+     +======+     +======+     +======+       0     20x,61H+==========+     +======+     +======+     +======+       0     20x,61H+=========+     +=======+     +========+       0     20x,61H+=========+     +========+     +========+       0     20x,61H+==========+     +==========+     +==========+       0     50RMAT     (26x,A4,10X,3A4,5X,3A4,10X,A4,13X,A4/40X,3A4)     +===========	DK DK DK DK	8270 8280 8290 8300 8310
M 16H CARD COLUMNS ==,10X,74H5=6 N10 0 20x,81H+======= P======================= P========	DK DK DK DK DK	8270 8280 8290 8300 8310 8310
M 16H CARD COLUMNS, 10X, 74H5=6 N10 0 20x, 61H+	DK DK DK DK DK DK	8270 8280 8300 8300 8310 8320 8320
M 16H CARD COLUMNS, 10X, 74H5=6 N10 20x, 51H++++++++++++++++++++++++++++++++++++	DK DK DK DK DK DK DK	8270 8280 8300 8310 8320 8320 8320
M 16H CARD COLUMNS ==,10X,74H5=6 N10 20x,81H+======= P======= P======== P======== P========	DK DK DK DK DK DK DK DK	8270 8280 8300 8310 8320 8320 8320 8350
M 16H CARD COLUMNS ==,10X,74H5=6 N10 20x,81H+======= P======= P======= P======= P======= P===== P==== P==== P==== P==== P==== P==== P==== P==== P==== P==== P==== P==== P==== P=== P=== P=== P=== P=== P=== P=== P=== P=== P	DK DK DK DK DK DK DK DK DK	5270 5260 5300 5310 5320 5320 5320 5320 5320 5350 5340 5350 5360
M 16H CARD COLUMNS ==,10X,74H5=6 N10 20x,81H P======= 11=15 0 20x,81H P====== 10 11=15 16=20/ 0 20x,81H P====== / 8106 FORMAT (26x,A4,10x,3A4,5x,3A4,10x,A4,13x,A4/40x,3A4) 8107 FORMAT (26x,A4,10x,3A4,5x,3A4,10x,A4,13x,A4/40x,3A4) 8106 FORMAT (26x,A4,10x,3A4,5x,3A4,10x,A4,13x,A4/40x,3A4) 8106 FORMAT (26x,A4,10x,3A4,5x,3A4,10x,A4,13x,A4/40x,3A4) 8107 FORMAT (26x,A4,10x,3A4,5x,3A4,10x,A4,13x,A4/40x,3A4) 8106 FORMAT (26x,A4,10x,3A4,5x,3A4,10x,A4,13x,A4/40x,3A4) 8106 FORMAT (26x,A4,10x,3A4,5x,3A4,10x,A4,13x,A4/40x,3A4) 8107 FORMAT (26x,A4,10x,3A4,5x,3A4,10x,A4,10x,A4,13x,A4/40x,3A4) 8107 FORMAT (26x,A4,10x,3A4,5x,3A4,10x,A4,10x,A4,13x,A4/40x,3A4) 8107 FORMAT (26x,A4,10x,3A4,5x,3A4,10x,A4,13x,A4/40x,3A4) 8107 FORMAT (26x,A4,10x,3A4,5x,3A4,10x,A4,10x,A4,13x,A4/40x,3A4) 8107 FORMAT (26x,A4,10x,3A4,5x,3A4,10x,A4,10x,A4,13x,A4/40x,3A4) 8107 FORMAT (26x,A4,10x,24HSET EVENT TOTAL ITEMS H1 H1 H1 H1 H1 H1 8 H2 L/DH SEQ TYPE INLET EXIT NO PFR D1 D D2 S/AL DHUB PRSTY KMESH K RUFNES F DMESH KT 90 C DMESH	DK DK DK DK DK DK DK DK DK DK	5270 5260 5290 5310 5310 5320 5330 5340 5350 5360 5370 5380
M       16H CARD COLUMNS ==,10X,74H5=6       7=8       9=         N10       11=15       16=20/       7=8       9=         D       20x,81H++++++++++++++++++++++++++++++++++++	DK DK DK DK DK DK DK DK DK DK DK	5270 5260 5300 5310 5320 5330 5340 5350 5360 5360 5360 5390
M       16H CARD COLUMNS ==,10X,74H5=6       7=8       9=         N10       11=15       16=20/       16=20/         0       20x,81H+       ************************************	0K 0K 0K 0K 0K 0K 0K 0K 0K 0K	5270 5260 5300 5310 5320 5330 5350 5360 5360 5360 5360 5360 536
M       16H CARD COLUMNS ==,10X,74H5=6       7=8       9=         N10       11=15       16=20/	DK DK DK DK DK DK DK DK DK DK	5270 5260 5300 5310 5320 5330 5350 5350 5360 5360 5370 5360 5370 5360 5390 5400 5410
M       16H CARD COLUMNS ==,10X,74H5=6       7=8       9=         N10       11=15       16=20/	DK	5270 5260 5300 5310 5320 5330 5330 5350 5350 5360 5360 5370 5360 5370 5380 5390 5400
M       16H CARD COLUMNS ==,10X,74H5=6       7=8       9=         N10       11=15       16=20/	DK	5270 5260 5300 5310 5320 5320 5320 5320 5320 5350 5350 5350 5360 5370 5360 5370 5360 5370 5360 5370 5340 5370 5340 5370 5340 5320 5340 5340 54400 54400 54400 54400 54400 5440000000000
M       16H CARD COLUMNS ==,10x,74H5=6       7=8       9=         N10       11=15       16=20/       7=8       9=         0       20x,81H+========       /1       16=20/       7=8       9=         0       20x,81H+=======       /1       16=20/       7=8       9=         0       20x,81H+=======       /1       16=20/       7=8       9=         0       20x,81H+======       /1       16=20/       7=8       9=         0       20x,81H+======       /1       16=20/       7=8       9=         0       20x,81H+======       /1       7=8       7=8       9=         8106       FORMAT (20x,84,10x,344,10x,84,13x,A4/40x,384)       8107       8107       FORMAT (20x,84,52,384,52,384,52,384,52,384,52,384,52,424       10         10       20M SECT       SECT       SECT       SECT       SECT       SECT       10(10)         10       D2       S/AL       DHUB PRSTY       KMESH       K       RUFNES       /         10       D2       S/AL       DHUB PRSTY       KMESH       K RUFNES       /       /         10       D2       S/AL       DHUB PRSTY       KMESH       K RUFNES       /       / <td></td> <td>5270 5260 5300 5310 5320 5340 5340 54400 5440 54400 54400 54400 54400 54400 54400 54400 5440</td>		5270 5260 5300 5310 5320 5340 5340 54400 5440 54400 54400 54400 54400 54400 54400 54400 5440
M       16H CARD COLUMNS ==,10x,74H5=6       7=8       9=         N10       11=15       16=20/         O       20x,61H+	DK	5270 5260 5300 5310 5320 5330 5320 5330 5340 5350 5360 5360 5360 5360 5360 5360 536
M       16H CARD COLUMNS, 10X, 74H5-6       7=8       9=         N10       11=15       16=20/	DK	5270 5260 5300 5310 5320 5330 5330 5340 5350 5360 5360 5360 5360 5360 5360 5360 5360 5360 5360 5360 5370 5360 5370 5370 5370 5370 5370 5370 5370 5370 5370 5370 5370 5440 5470
M       16H CARD COLUMNS ==,10x,74H5=6       7=8       9=         N10       11=15       16=20/       0         O       20x,61H+======++++++++++++++++++++++++++++++	DK	5270 5260 5300 5310 5310 5320 5330 5350 5350 5350 5360 5360 5360 5360 5360 5360 5360 5360 5360 5360 5370 5360 5360 5370 5360 5360 5360 5370 5360 5360 5360 5370 5360 5370 5360 5370 5360 5370 5360 5370 5440 5470
M       16H CARD COLUMNS ==,10x,74H5=6       7=8       9=         N10       11=15       16=20/         O       20x,61H,=========+/1       +=======+/1         B106 FORMAT (26x,A4,10x,344,5x,3A4,10x,A4,13x,A4/40x,3A4)       +=======+/1         B106 FORMAT (26x,A4,10x,3A4,5x,3A4,10x,A4,13x,A4/40x,3A4)       +=======+/1         B106 FORMAT (26x,A4,10x,3A4,5x,3A4,10x,A4,13x,A4/40x,3A4)       +=======+/1         B106 FORMAT (26x,A4,10x,3A4,5x,3A4,5x,3A4,10x,A4,13x,A4/40x,3A4)       +=======+/1         A       120H SECT SECT, SECT, SECT, TOTAL ITEMS H1 H1 H1 H2       H2         B       #2 L/OH, CHORD BLKGE PHI KEXP CD RNREF, ETA D EPS/       C         C       120H SEG' TYPE INLET EXIT ND PFR D1       D1         D       D2 \$/AL DHUB PRSTY KMESH K RUFNES       /         E       120H INPUT SHAPE SHAPE DUCTS DUCT       -         F       DMESH       KT 90       )         8108 FORMAT (67x,42H M/M,       10(e0) PER= PER=/       -         B       24x,96H NO, NO, M M M M M M SG M M C       -         CENT DEG       METER8 CENT CENT )       10(e0), /         A       67x,53H8Q FT/ PER_       10/=60) PER= PER=/         B       24x,96H NO, NO, FEET FEET FEET FEET FEET FEET FEET C       -         CENT DEG       PER_       210	DK           DK	5270 5260 5300 5310 5310 5320 5330 5340 5350 5360 5360 5360 5360 5360 5360 5360 5360 5360 5370 5360 5370 5360 5370 5360 5370 5360 5370 5360 5370 5440 5400

.

95 8:2

D	120H	++	++	•	+	++	++	+==+	+===+	+==+	+==+	DK 8510
E	+++++	++									12	DK 8520
8111	FORMAT	(141//5	X, A1, 1	944,43	, 6×, 1	6HC	ONTINU	JED.	. 6X, 4+	PAGE,	13/15	DK 8530
	END				- 					······		DK 8540

ş,

· •

----

ì

SUBROUTINE SPEED(A, AMACH, V)	<b>8</b> D	10
C*********	80	20
C*************************************		30
C THIS ROUTINE, A SUBROUTINE OF THE MAIN PROGRAM PERFORM. COMPUTES THE	80	40
C LOCAL MACH NUMBERS AND VELOCITIES	80	50
C*************************************	80	60
C+************************************		70
COMMON/BLOCKC/ ASTAR.AT.G	80	80
C	•D	9 A
C. NEWTON'S METHOD ITERATION FOR MACH NUMBER		100
É	• D	110
EMT a 1	aD.	120
1 EMN & EMT_(ASTAR/A*(2,/(G+1'))+*((G+1))/2,/(G-1)))*	80	130
1 (1.+(G=1.)/2.+EMT++2)++((G+1.)/2./(G=1.))=Fut)/	e.)	140
2 (ASTAR/A+EMT+(2-//G+1-))++//3-=G1/2-//G=1-))+		150
3 (1.+(G-1.)/2.+EMT++2)++(3G)/2./(G-1.))-1.)	80	140
IF (ABS(EMNVENT)/EMN ALT. 1.FP4) GC TO 2		170
EMT - EMN		180
60 10 1	-0¥-	100
2 AMACH 5 EMN	80	200
C	• •	210
		220
	- <u>av</u> _	210
ASL & AT/SORT/1.4/Ge1.3/2.+AMACH++23	8V 8D	240
V = AMACHAASI		284
	80 80	264
FNO	<u>au</u>	27A
	8V	<b>#</b> 70
SUBROUTINE FRICTN(DH, A, AMACH, SLAMDA)	#N	10
--	---	-------
<u>C+++**********************************</u>	PN_	20
C#####################################	FN	30
C THIS HOUTINE, A SUBROUTINE OF THE MAIN PROGRAM PERFORM, COMPUTES THE	<u>FN</u>	40
C LUCAL REYNOLDS NUMBERS AND SMOOTH-FIPE FRICTION COEFFICIENTS.	FN	50
<u> </u>	_EN_	60
C+++++++++++++++++++++++++++++++++++++	<b>FN</b>	70
COMMON/BLOCKC/ ASTAR, AT, G	<b>FN</b>	
COMMON/RLOCKD/ RNOC	FN	90
	<u>N</u>	-100-
C. REYNOLDS NUMBER BASED ON THE CHARACTERISTIC DIMENSION DH (USUALLY BUT	<b>FN</b>	110
C. NUT ALWAYS THE HYDRAULIC DIAMETER OF THE LUCAL DUCY)	N	120
	EN	130
HN B HNUL+DH/A+(1++(U=1+)/6+AHAUHR+6)R++/0		140.
IF (RN ,GE, 4,E3) GU TO 1	F N	190
		-100
C. FRICIUM COEFFICIENT	F N	170
	N	100
$C_{aba}$ (as a state of the contraction of the co	<b>FN</b>	140
CARRENULUS NUMBERS LESS THAN 4000	FN	
		234
		210
C FOR DEVNOL DE MINDERS I ESS THAN 2000	P N #N	2/10
LASS FOR REINULUS NOMBERS LEGS THAN EUUD	<u> </u>	284
Less TE JON 17 DET SLAMOA E 4/1 JON	e N	240
	E (1 at N	214
	ar hi	200
A STATUTE STATE ST	SN .	291
C NUMBERS OFFICE THAN OF FOUL TO AAA	# N	100
C C	n an the states of the states	
SIAMT = 005	#N	120
2 SIAMN E SIAMTA//1.//ALOGIO/SIAMTARNAA21	E.M.	330
	<b>P</b> N	340
IF (ABS(6) AMNOS) ANT/CIAMA - IT. 1.504 AD - 0.3	EN.	150
SLAMT = SLAMN	EN N	360
	# N	370
T SIAMN	EN.	380
	TN .	390
F NO	S N	400

OUTPUT	PAGE	
	····	
SUBROUTINE OUTPUT(ITYPE, NN)	nΤ	10
<u>C</u> ************************************		
【表示大学者来来来来来来来来来来来来来来来来来来来来来来来来来来来来来来来来来来来来	OT	30
L THIS ROYLING, A SUBROYLING UF THE MAIN FRUGRAM PERFUHM, HANDLES THE		
C OUTON FORMATTING OF CALCULATED SECTION PERFORMANCE INFORMATION,		50
	 AT	<u>40</u>
COMON/ALOCKA/ISED ISHAP1 ISHAP2 N	01 6T	9.4
COMMON/BLOCKE, AMACHI, AMACH2, AR, AI, AIDAA, A2, A2DAD, DI, D2, FK, FKO, FL	. <u>U.I</u> NT	00. 
1 H1. H2. TH2. V1. V2. W1. W2	07	100
DIMENSION NSECT (180), NSHAPE (3)	nt	110
C	٥Î.	120
CSECTION-TYPE NAME DEFINITIONS	ÖŤ	130
	OT	140.
DATA NSECT( 1), NSECT( 2), NSECT( 3), NSECT( 4), NSECT( 5)/	ŌT	150
<u>1 4HTEST, 4H SEC, 4HT, C, 4HONST, 2H A/</u>	0	160
DATA NSECT( 6), NSECT( 7), NSECT( 8), NSECT( 9), NSECT( 10)/	OT	170
	_01	180
DATA NSECT, 11), NSECT, 12), NSECT, 13), NSECT, 14), NSECT, 15)/	OŢ	190
1 4HOURE, 4HL IN, 4H IES, 4HI SE, 2HI J.	_01	200
WATA NSELT ( 10), NSECT ( 1/), NSECT ( 10), NSECT ( 14), NSECT ( 20)/		210
NATA NEET, 200100, 40241, 201 25, 2017		210
1 AHEONS AHTANT AH ARE AHA DU DHETA	01	240
DATA NSECT( 36), NSECT( 37), NSECT( 38), NSECT( 39), NSECT( 30)/	nT	2=0
1 4HCONT. 4HRACT. 4HN, S. 4HINGI. ZHE /	07	260
DATA NSECT, 311, NSECT, 321, NSECT, 331, NSECT, 341, NSECT, 35)/	oT	270
4 4HTURN, AHTNG, AHVANE, AHS 2H	_01	280
DATA NSECT: 36), NSECT: 37), NSECT: 38), NSECT: 39), NSECT: 40)/	٥T	290
1 4HCORN, 4HER A, 4HITH, 4HVANE, 2HS /		300
DATA NSECT( 41), NSECT( 42), NSECT( 43), NSECT( 44), NSECT( 45)/	OT	310
1 4HCORNS 4HERS , 4HNO V. 4HANES, 2H /	<u></u>	320
DATA NSECT ( 40), NECT ( 47), NSECT ( 40), NSECT ( 49), NSECT ( 50)/	DT	330
DATA SEFT ELL AFON & AN ANY ZHEST ELL SECTORES		340
A MARTER ANNERD AN AN SUIT SUINSELL SUINS	01	330
DATA USECTI S6) ABECTI 57) ABECTI 58) ABECTI S01 ABECTI 601	0T	370
1 AHEXIT, AH KIN, AHETIC, AH ENR, ƏHGYA	nT	SAN
DATA NSECT( 61), NSECT( 62), NSECT( 61), NSECT( 64), NSECT( 64)/	01	300
1 4HSUDD, 4HEN E. 4HXPAN, 4HSIDN, 2H /	٥ï	400
DATA NSECT( 66), NSECT( 67), NSECT( 68), NSECT( 69), NSECT( 70)/	OŤ	410
1 4HHONE, 4HYCON, 4HB FL, 4HOW S, 2HTR/	01	420
DATA NSECT( 71), NSECT( 72), NSECT( 73), NSECT( 74), NSECT( 75)/	01	430
1 4HAIRF, 4HOIL, 4HFLOW, 4H STR, 2H /	01	440
UAIA NSECT( 76),NSECT( 77),NSECT( 78),NSECT( 79),NSECT( 80)/	OI	450
DATA NEET, ON NEET, ON NEET, ON NEET, AN NEET, ON		460
AND NOEUT ( BIJINGELT ( BZJINGELT ( BJJINGELT ( B4))NSECT ( B5)/ 1. Amerika - Amerika Amerika an aka ommu a		470
DATA NSECT/ ANT. NSECT/ ATT. NSECT/ RAT. NSECT/ ANT. NSECT/ ANT.	<u></u>	<u></u>
AHINTE, AHRNAL, AH STR. AHUCTU, ONREA	01	800
······································	· · · · · · · · · · · · · · · · · · ·	

NUTPUT	
--------	--

DATA NSECT ( 91), NSECT ( 92), NSECT ( 93), NSECT ( 94), NSECT ( 95)/	10	510
1 4HSING, 4HLE F. 4HIXED, 4H LOS. 2HS	_n	520
DATA NSECT ( 96), NSECT ( 97), NSECT ( 98), NSECT ( 99), NSECT ( 100) /	ñŤ	530
A HMELT, AH DUC, AHTS, AHCNST, 2H AZ	o T	540
DATA NEETIIAI), NEETIIAE), NEETIIAE), NEETIIAE), NEETIIAE), NEETIIAE)	0Ť	550
	0 <del>-</del>	560
LATA NEETIAN'S NEETIAN'S NEETIAN'S DELL'ARS NEETIANS NEETIANS		574
A AUNTA AND AND AND AND AND AND AND AND AND AN	01	SEA.
NATA NOTE AND A REAL AND AREAL AND REAL AND REALAND AREALAND		20 A
A A A A A A A A A A A A A A A A A A A		370
ATTOLL OF UL HATTAL, OL OF ANN ACCILLAN ACCILLAN	 0 T	
DATA NSECT(116), NSECT(117), NSECT(110), NSECT(114), NSECT(140)/	01	810
1 4HMULT, 4H D 2, 4HEWAL, 4HL CR. 2HNR	<b>0</b> Ţ	
DATA NSECT(121), NSECT(122), NSECT(123), NSECT(124), NSECT(125)/	01	0.50
1 4HM D, 4H CRN, 4HR, N, 4HO VA, ZHNEZ	O	640
DATA NSECT(126),NSECT(127),NSECT(128),NSECT(129),NSECT(130)/	OT	650
1 4HM D, 4H10HA, 4HLL D, 4HIF C, 2HNR /	<u></u>	660
DATA NSECT(131), NSECT(132), NSECT(133), NSECT(134), NSECT(135)/	DT	670
1 4HM D , 4H2=KA, 4H11 D, 4HIF C, 2HNR /	01	680
NATA NSECT(136), NSECT(137), NSECT(138), NSECT(139), NSECT(140)/	οT	690
1 4HMULT, 4H DUC, 4HT DI, 4HFFUS, 2HER/	O.T_	700
DATA NSECT(141), NSECT(142), NSECT(143), NSECT(144), NSECT(145)/	01	710
1 4HVANE, 4HD DI, 4HFFUS, 4HER . 2H /		720
DATA NSECT(,46), NSECT(,47), NSECT(,46), NSECT(,49), NSECT(150)/	OT	730
1 4HSUD . 4HEXP . 4HM D . 4H- SN. 2HGI/	01	740
UATA NSECT(151), NSECT(152), NSECT(153), NSECT(154), NSECT(155)/	ΛT	750
1 AHSUD AHEXP AHM D AHA M 2HD /	o T	760
DATA NSECT (, EA) NSECT (, EY) NSECT (, EA) NSECT (, EQ) NSECT (140) /		770
A AREAN ARDIT AR & S. ARTRIT SHE /		780
TATA NECTIAN NECTIAN NECTIAN NECTIAN NECTIAN NECTIAN	01	790
		800
DATA SCHUMI, CORTILAT SCHUM SCH SCHUMANNER SCHUMAN		
A AND THE AND THE AND A SHOW AND A		830
1 497 AN & 4991173, 4986 N. 4918 A. A. MARCALLAR AND	.0.1	. 920
UAIA NOELI (171), NOELI (172), NOELI (173), NOELI (174), NOELI (173)		0.00
1 4HOLI, 4H INI, 4HENL, 4HSIRC, 2HIRZ		
DATA NSECT (176), NSECT (177), NSECT (176), NSECT (174), NSECT (160)/	01	050
1 4HMULT, 4HIPL, 4HPIXE, 4HD LO, 4HSS/	.01	. 000
C	<u> 01</u>	870
CARAGEUTIUN ENDAGHAPE NAME DEFINITIONS	0T	660
C	01	890
DATA NSHAPE(1), NSHAPE(2), NSHAPE(3)/ 4HCIRC, 4HRECT, 4HEL Q/	01	900
N1 = NN+5=4	01	910
N5 = N1+4	oT	920
IF (ISHAP1 .NE, 1 .OR, ISHAP2 .NE, 1) GO TO 1	07	930
C	01	940
C, WRITE STATEMENTS FOR SECTIONS WHICH HAVE CIRCULAR CROSS-SECTIONS	01	950
C. AT BOTH ENDS	۵T	960
	0T	970
IF (ITYPE .EQ. 1)	ŌŤ	980
1 WRITE(6,9111) N, (NSECT(1), I=N1, N5), NSHAPE(ISHAP1), D1, A1, A10AU,	OT	990
2. VI. AMACHI, EL. EK. EKO, NSHAPE (ISHAP2) DZ. AZ. AZOAO. VZ. AMACH2	ΩT	1000

0	u	T	P	U	T
_	_	•		-	

......

\_

.

and the second se	
IF (ITYPE EQ. 2)	0T 1/
WEITERS, DISTANCE TATA THE NEAR NEW ADDITED AND A ALL ALGAD	01 1
1 - HATELOFTIZIZ, NECHAGO CITETATIAN DIFINARA ELIQUARIJEVIALERUANE	
2 VI;AMACH1;EK;EKO;NSHAPE(ISHAP2);D2;A2;A20A0;V2;AMACH2	07 10
IF VITYPE EQ 3.	of 1/
● 1 【 ● 1 15 Line ( 東部)建築 wind James Construction ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) (	
1 WRITE(6,9131) N/(NSECT(I)/IEN1/NS)/NSHAPE(ISHAPI)/UI/AI/AIUAU/	01 1
2 AR.TH2.V1.AMACH1.EL.EK.EKO.NSHAPE(ISHAP2).D2.42.A2040.V2.AMACH2	OT 10
	- 0 F 🕂
1 WAITE(6,9132) N, (NRECY(I), I=N1, N5), NRHAPE(ISHAP1), 01, A1, A10A0,	OT 10
A AR THOLY, AMACHA FL NSHARE/ISHAPOL D. AD. AD.AD.VD. AMACHO EK EKO	01 1/
5 WEILISIALIANACHITELMOBRECTONELSINSIKSIKSUKOIAEIKUKUKIENIEN	01 41
	0T.1
1 IF (ISHAP1 FO 1 OR ISHAPƏ FO 1) CO TO Ə	07 1
****	011
CWRITE STATEMENTS FOR SECTIONS WHICH HAVE NON-CIRCULAR CROSS-SECTIONS	01 1
AT ROTH ENDE	AT 1
FRAT DOTT CIVES	
	- OT 11
IF (ITYPE FO. 1)	nT 1
RT - LE FLIND BURGE A LA STANDER CONTRACTOR STANDER STANDARD STANDARD STANDARD STANDARD STANDARD STANDARD STAND	A
I MUTIC(D)AI411 N)[NSCI(T))THAI)NSINSHWE(TSUNDI)NI)MI'AI)	01 1
2 A10A0.V1.AMACH1.EL.EK.EK0.NSHAPE(ISHAP2).H2.W2.A2.A20A0.V2.	01 1
	<b>d</b> T1
WRITE(A.9.51) N. (NSECT(I). TEN. NS). NSHAPE(ISHAP1). H1. W1. A1.	n1 1
i = 1 = 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 1	
<pre>4 1049,91,AMAUDIJENJENJENJELISMATELISMATELISMATELAEJAGDAV,92,AMAUDE</pre>	
IF (ITYPE LEG. X)	01 1
1 4017F/6,01411	AT 1
· · · · · · · · · · · · · · · · · · ·	
<pre>c = aluau, ar, the, vl, amach1, tl, ek, eku, nShape(IShape), H2, W2, A2, A20A0,</pre>	OT 1/
3 V2. AMACH2	07 1
	01 1
1 NRITE(6,9162) N. (NSECT(I), IPN1, NS), NSHAPE(ISHAP1), H1, W1, A1,	<u>. 07 1</u>
2 ALDAN AR THR. V. AMACHA FLANSHARE(ISHARR) AR HA AZ AZIAO VZ	AT 1
E alouding in Stalter and technology Stalter behavior	
3 AMACHZIRKIEKO	<u>0</u> ¥
GO TO 4	07.1
E IT (IONATI NE 1 UN IONATE EW 1) UU IU 3	<b>1</b>
	- nT 1
C. WRITE STATEMENTS FOR SECTIONS WHICH HAVE A CIRCULAR CROSS-SECTION AT	01 1
THE HOLTDER FREINE AND VERAMM TERMINER BERGER GAUGENER UND STREETAN. AL	
L, THE PROTREAM END AND A NUNGERCULAR URUSSISECTION AT THE DOWNSTREAM	01 1
	nT 1
	01 1
IF (ITYPE .EQ. 1)	1
1 WRITE 6. 9171 N. NSFET T. TENI NEL NEL PETEHADIL DI AL ALDAD.	OT 1
<u>C VI, AMACMI, EL, EK, EKU, NSHAPE (ISHAPE), HZ, WZ, AZ, AZAO, VZ, AMACHZ</u>	DT . 1
IF (ITYPE FG. 2)	<b>NT 1</b>
1 MATIC (0, VIOL) N, (NOCCI (1), IENI, NOTAPE (10MAPI), DIAAI, ALUAU,	
Z V1,AMACH1,EK,EKO,NSHAPE(ISHAPZ),H2,W2,AZ,Á20A0.V2,AMACH2	OT 1
IE (ITVDE ED TA	
1 WRITE(6,9191) N# (NSECT(I)#I#N1,N5)#NSHAPE(ISHAP1);D1;A1;A1DA0.	OT 1
2 AR. TH2. VI. AMACHI. FL. FK. FKO. NRMAPFITRHAPSI. 43. 43. 42. 42040 43	01 1
······································	····
3 AMACH2	- ÚL 1
IF (ITYPE EQ. 4)	<b>NT 1</b>
1 WDITEL 0103 A ANGERTATY TONG NES NEULDEATEMANTS OF AL ALOAD	
1 HUTICLOBATART WACADERICTATINGTANDALECTONAMITATATATAA	011
) ARTH2,VI,AMACHI,EL,NSHAPE/ISHAP),H2,W2,A3,A20A0,V2,AMACH2.	nt 1

OUTPUT

4

3 EK, EKO	OT	1510
C	01	1530
C. AT THE UPSTREAM END AND A CIRCULAR CROSS-SECTION AT THE DOWNSTREAM	OT	1550
	oT	1570
1 WRITE(6,9201) N, (NSECT(I), ION1, N5), NSHAPE, ISHAP1), H1, W1, A1,	OT	1590
IF (ITYPE (EQ. 2)	OT	1610
2 A10A0,V1,AMACH1,EK,EK0,NSHAPE(ISHAP2),D2,A2,A20A0,V2,AMACH2	01	1630
IF (ITYPE EQ. 3) 1 WRITE(6,921) N, (NSECT(I), INN1, N5), NSHAPE(ISHAP1), M1, W1, A1,	<u>-07</u> 01	1640
2 A10A0, AR, TH2, V1, AMACH1, EL, EK, EK0, NSHAPE(ISHAP2), D2, AZ, A20A0, V2, 3 AMACH2	07	<u>1660</u> 1670
IF (ITYPE EQ. 4) 1 WRITE(6,9222) No (NSECT(I), IEN1, N5), NSHAPE(ISHAP1), H1, W1, A1,	ŌŤ OT	1680
2 A10A0, AR, TH2, V1, AMACH1, EL, NSHAPE (ISHAP2), D2, A2, A20A0, V2, AMACH2,		1700
4 RETURN	<u>oj</u>	1720.
C. SECTION PERFORMANCE CALCULATION OUTPUT WRITE FORMATS	ŏŢ.	1740
9111 FORMAT (/13,1x,4A4,A2,1x,A4,8x,F9,2,F11,2,F7,2,16x,F8,1,F7.3,	_01	1760
9121 FORMAT (/13,1X,4A4,A2,1X,A4,8X,F9,2,F11,2,F7,2,16X,F8,1,F7,3,	01.	1780.
9131 FORMAT (/13,12,444,42,12,444,82,F9,22,F11,2,247,2,F9,2,F8,1,F7,3,	. OT	1800
A F9.2,2F9.5/23x,A4,8x,F9.2,F11.2,F7.2,16x,F8.1,F7.3) 9132 FURMAT (/I3,1x,4A4,A2,1x,A4,8x,F9.2,F11.2,2F7.2,F9.2,F8.1,F7.3,	0T _0T	1810
A F9 2/23X, A4, 8X, F9 2, F11 2, F7 2, 16X, F8 1, F7 3, 9X, 2F9 5) 9141 FORMAT (/I3, 1X, 4A4, A2, 1X, A4, F8, 2, F9, 2, F11, 2, F7, 2, 16X, F8, 1, F7, 3,	01 . 01	1830
A F9.2,2F9.5/23x,A4,F8.2,F9.2,F11.2,F7.2,16x,F8.1,F7.3) 9151 FURMAT //I3.1X,4A4,A2,1X,A4,F8.2,F9.2,F11.2,F7.2,16x,F8.1,F7.3,	DT.	1850 1860
A 9χ,2F9,5/23χ,A4,F8,2,F9,2,F11,2,F7,2,16χ,F8,1,F7,3) 9161 FORMAT (/I3,1Χ,4Α4,Α2,1Χ,Α4,F8,2,F9,2,F11,2,2F7,2,F9,2,F8,1,F7,3,	nT DI	1870
A F9 2,2F9 5/23X, A4, F8 2, F9 2, F11 2, F7 2, 16X, F8, 1, F7, 3) 9162 FORMAT (/13, 1X, 4A4, A2, 1X, A4, F8, 2, F9, 2, F11, 2, 2F7, 2, F9, 2, F8, 1, F7, 3.	01 01	1890 1900
A F9.2/23x, A4, F8.2, F9.2, F11.2, F7.2, 16x, F8.1, F7.3, 9x, 2F9.51 9171 FDRMAT // T3.1x, 4A4, A2.1x, A4, BX, F9.2, F11.2, F7.2, 16x, F8.1, F7.3, F9.2.	DT DT	1910
A 2F9,5/23,44,F8,2,F9,2,F11,2,F7,2,16%,F8,1,F7,3) 9181 F0MAT //13.1v.444,42.1v.44,8v.F9.2,F11,2,F7,2,16%,F8,1,F7,3,9v.	01	1930
$\begin{array}{c} \underline{1} \\ A \\ 2F9' 5/23x, A4, F8 \\ 2,F9 \\ 2,F11 \\ 2,F7 \\ 2,16x, F8 \\ 1,F7 \\ 3) \\ \hline \\ B101 \\ F0 \\ 2,F1 \\ 1,F7 \\ 3) \\ \hline \\ B101 \\ F0 \\ 2,F1 \\$		1950
		1970
A F9.2/23X, A4, F8.2, F9.2, F11.2, F7.2, 10X, F8.1, F7.3, 9X, 2F9.5)	01 01	1990
9201 FURMAT (/I3+1X+4A4+A2+1X+A4+F8+2+F9+2+F1++2+F7+2+16X+F8+1+F7+3+	01	2000

l

i.

OUTPUT	PAGE.	
A F9.2,2F9.5/23x,A4,8x,F9.2,F11.2,F7.2,16x,F8.1,F7.3)	0T 2	010
9213 FURMAT (/13,12,444,46,12,44,F0,6,F7,6,F7,6,F7,6,10,F0,1,F7,3, A 2F9,5/232,A4,82,F9,2,F11,2,F7,2,162,F8,1,F7,3) 9221 FURMAT (/13,12,444,42,12,A4,F8,2,F9,2,F11,2,2F7,2,F9,2,F8,1,F7,3)		020. 1030 1040
A F9.2,2F9.5/23x,A4,8x,F9.2,F11.2,F7.2,16x,F8.1,F7.3) 9222 FORMAT (/13,1x,4A4,A2,1x,A4,F8.2,F9.2,F11.2,2F7.2,F9.2,F8.1,F7.3,	2 10 07 2	050
A F9.2/23x, 44,8x,F9.2,F11.2,F7.2,16x,F8.1,F7.3,9X,2F9.5) END	5 TO 5 TO	070

.

SUBROUTINE PLOTIT(N, DELP, SSUMEL, SSUMKO, IU, IPLOT, ITITLE, TRETRN,	PT	10
	 n†	
	5t	40
C THIS POUTINE, A SUBROUTINE OF THE MAIN PROGRAM PERFORM. PLOTS WALL	PT	50
PRESSURE DIFFERENTIAL AND/OR CUMMULATIVE. NONDIMENSIONAL PRESSURE	PT	60
C LOSSES AGAINST CUMMULATIVE CIRCUIT CENTERLINE LENGTH. THIS PLOT	PT	70
C SUBROUTINE WAS WRITTEN FOR A ZETA PLOTTER WITH 0.005-INCH INCREMENTS.	PL	80
C NOTE WHEN PLOTTING IN SI UNITS, CENTIMETER SCALES WILL RESULT.	PT	90
<u>Cathanananananananananananananananananana</u>	<u>.</u>	<u>    100</u> .
C+++++++++++++++++++++++++++++++++++++	PŢ	110
<u>DIMENSION DELP(32), ITITE(21), SSUMEL(32), SSUMEC(32)</u>	<u></u>	_120
DIMENSION IX(6),IXN(6),IXNM(6),IY(6),IYN(6),IYNM(6)		1.30
	_¥ n¶	150
Cee PLUI AAIG GADELG ARRAIG	aT	140
DAVA TYNELLATYNER TYNER TYNER TYNER TYNER TYNER AHCIRC. AHUIT	PT	170
ANLENG, ANTH ( ANFET AN)	PT	_180
DATA IXNM(1), IXNM(2), IXNM(3), IXNM(4), IXNM(5), IXNM(6)/ 4HCIRC,	PT	190
1 4HUIT AHLENG ANTH ( 4HMETE 4HR\$ )	PT	200
DATA TYN(1),TYN(2),TYN(3),TYN(4),TYN(5),TYN(6)/ 4HWALL,4H PRE,	PT	210
1 4H8\$UR, 4HE (L, 4HB/80, 4H PT)/	PI	550
DATA IYNM(1),IYNM(2),IYNM(3),IYNM(4),IYNM(5),IYNM(6)/ 4HWALL,	PT	230
1 4H PRE, 4H8SUR, 4HE (N, 4H/SQ , 4HM) /	- <u>PI</u>	
	PI	240
GARAGREAUTING OF THE PLOTTER AND ESTADLABHMENT OF THE DRAGIN	<u></u>	270
0	5t	280
	PT	290
C DEFINITION OF PLOTTED PADAMETEDS IN STANDADD PLOTTER UNITS (INCHES)	PT	300
C	PT	310
N1 # N+1	. <b>R.T</b> .	
N2 = N+2	PT	330
FACT = 2	RI	
XLEN = 15.	PT	350
	<u>R.</u> I.	
	81 61	3/U 1a1
	⊭: ∎†	100
THAY = 11.	PT	400
YNARG B . S	PT	410
Canaa	P1	420
C DEFINITION OF AXIS LABELS	PT	430
	_PI	440
Do 50 I = 1,6	PŢ	450
IY(I) = IYN(I)	<u> </u>	460
IX(I) # IXN(I)	PT	470
50 CUNTINUE	<u>P.</u> ]. 	
		500
LAGADIWELFIR IFE UP UNAIS	<b></b>	

PLOTIT		• • •	PAGE	
--------	--	-------	------	--

C IF (LU .NE. 2) GO TO 3000	PT PT	510 520
C	PT.	530
CASSIGNMENT OF DESIGNATED SCALE FACTOR AND PLOTTING OF A SMALL	+ AT PT	.540
C <sub>PROD</sub> THE ORIGIN	PT	550
	<u> </u>	- 560
1000 CUNITNE	PT	570
	<u>PI</u>	580
CALL BUDE(V)I)	PT	390
	<u>P.I.</u>	
$CALL  SYMBOL \left( \begin{array}{c} 0 \\ 0 \end{array}, \begin{array}{c} 0 \\ 0 \\ 0 \\ 0 \end{array}, \begin{array}{c} 0 \\ 0 \\ 0 \\ 0 \end{array}, \begin{array}{c} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{array}, \begin{array}{c} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{array}, \begin{array}{c} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 $	P1	430
		610
CDETERMINATION OF SCALE FOR CIRCUIT LENGTH ON Y AXTS	et	640
C	DT	.650
CALL SCALE (SSUMEL, XLEN, N. 1)		660
C	PT	670
Cas TRANSFER IF DRESSURE-LOSS DLOT ONLY	PT	
C	PT	690
IF (IPLOT , EG, 2) GO TO 2000	PT	
C	PŢ	710
C. WALL PRESSURE DIFFERENTIAL PLOTTED AGAINST CIRCUIT LENGTH	PI	
	1/ <b>9</b> T	730
CALL AXIS(UAUFVEU) IX/ = CALENI VEU/SSUMEL(NI), SSUMEL(NZ))	<u>11PT</u>	740
CALL STADULIUSSTERDISISIIILESUSUSIYY)	, PT.	,750
CALL AVERIA 0.0.1 HOREFUR . OR 13 OV. K. DO REUMAANIA		7.60
- CE ANISCONTRACTOR LUSSIFIEN, TO SOURCO (AL),	T M	. 770
		700
	P	790
	سنال#	818
CDEFINITION OF LOCATION OF ODIGIN FOD NEW PLOT	aŤ	820
C		830
CALL PLOT(0.0, - YMAX, -3)	p T	840
CALL PLOT(0.0, YMARG,=3)	PT	850
CALL PLOT(XNEXT,0,0,-3)	PT	660
CALL SYMBOL(0.0,0,0,001,3,0,0,0,01)	PT	870
<u>C</u>		
CCUMMULATIVE PRESSURE LOSS PLOTTED AGAINST CIRCUIT LENGTH	PŤ	890
2000 CONTINUE	₽Ť	910
CALL AXIG(0.0.0.0.1X, UZ4, XLEN, 0.0.55UMEL(N1), SSUMEL(N2))	PT.	
CALL STMBUL(, S, YLAB, 1, ITITLE, 0, 0, 79)	PŢ	930
CALL DEALE (DELMAYLENANA)	PI.	
CALL I THE CREWER HEL HELP A 4 4 AA CALL I THE CREWER HELP ALL ALL ALL ALL ALL ALL ALL ALL ALL A	Tq	950
C C C C C C C C C C C C C C C C C C C	PI	460
VEREFEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE	P1	470
C	P.[	
2500 CONTINUE		1000
	·····¥4	

CALL PLOT(0,0,-YMAX,-3)	PT 1010
CALL PLOT(XNEXT,0.0,=3)	pt 1030
CARACTER CARE CONTROL REPHANENTLY TAKEN FROM DIOTTER	PT 1050
C IF (ABS(TOFTON) LT. 1.Fm6) CALL DIDT(0.0.0.0.998)	PT 1070 PT 1080
	PT 1090 PT 1100
GPARAMETER CONVERSION TO SI UNITS	PT 1110 PT 1120
3000 CONTINUE FACT # 2./1.26999	PT 1130 PT 1140
XLEN = 15 +1 26999 YLEN = 10 +1 2699	PT 1150 PT 1160
YLAB # YLEN+,1 XNEXT # 17 +1 26999	PT 1170 PT 1180
YMAX = 11.+1.26999 YMARG = 5+1.26999	PT 1190 PT 1200
Do 3500 I = 1,6 IV(I) = IVNM(I)	PT 1210 PT 1220
3500 IX(I) = IXNH(I) G0 T0 1000	PT 1230 PT 1240
END	PT 1250

## APPENDIX D

## INPUT AND OUTPUT FOR SAMPLE CASES

Six wind tunnels were used, in addition to the test case (fig. 11), as sample cases to establish the reliability and accuracy of the computer program analysis technique for the various types of duct components and wind tunnel circuits. Each case included here is titled with the appropriate wind tunnel name and its pages are numbered. The performance analyses are presented on the first two to three pages of each case. The summary characteristics tabulations and the plotted information were omitted. The annotated tabulations of the input data were included for reference.

The results of the performance analyses are summarized in table 6. They are discussed and critiqued in the Results and Evaluation sections of this report.

- 1 k ... 1 ... 1 <u>1 k</u> ...

PAGE 1				06/40	+	•0000 <b>•</b>	0.01213	0.01322	0.00096	0.00244	0.07838	0.00799	0.00076	0.00448
				0P/QL	++	0.00560	0.01213	0.01322	66000*0	0.00224	0.08292	0.15748	0-01500	0.16035
*				LENGTH METERS	++	6•10	13.11	4.57	0.34		28.96	6.21	9.14	7.04
				MACH1 MACH2	++	0.026 0.026	0.026 0.397	0.397 0.391	0.391 0.385	0.416 0.385	0.385	0.085 0.085	0.085 0.063	0.063
TUNNEL	DRMANCE			VI V2 M/SFC	+	8.7 8.7	8.7 133.0	133.0 131.0	<u>131.0</u> 129.0	139•2 129•0	129.0 28.9	28 9 28 9	28•9 21•4	21.4
UUT WIND	NËL PERFC		0.16 N/S	2 THETA	++		33.71	0.24	3 • 69		6 <b>•</b> 00		5 • 58	
BY 10-F	AIND-TUN		= 1003	AR, CK	++		14.14	101	1.01		4.17		1.35	
NTER 7-	ECTION V	/SQ M. M.	RESSURE	A1/A0 A2/A0	++	14•14 14•14	14.14 1.00	1.01	1.03 1.03	0.96 1.03	1.03 4.28	4 • 28 4 • 28	4.28 5.76	5.76 5.76
SEARCH CE	EC-TEST-S	01325.0 N	DEG K.	AREAL AREA2 So M	++	66•16 66•16	91•99 6•50	<u>6.50</u> 6.59	6.59 6.67	6.26 6.67	6.67 27.82	27.82 27.82	27.82 37.47	37.47
SA-AMES RE	TURN, CLOS	HERES = 1 ES = 1013	= 288.00 3 KACTS.	W1,01 W2,02 Meteos	++	10.06 10.06	10.06 3.05	3.05	3.09 3.11	3.09	3.11 5.75	5.75	5.75 6.60	6 • 60 6 • 6 0
NA	I NGLE-RE	O ATMOSP TMOSPHER	5 DEG C = 258.5	H1 H2 H2	++	9.14 9.14	9.14 2.13	2.13 2.13	2.13	2 <b>•13</b> 2 <b>•15</b>	2.15 4.84	4• 84 4• 84	4.84 5.68	5 • 68 5 • 68
	S	= 1.00 NS	= 14.6 M/SEC	SHAPE	+  +  +	RECT	RECT RECT	RÉCT RÉCT	RECT RECT	RECT	RECT	RÉCT RÉCT	RECI-	RECT
		ATMOSPHERIC PRESSURE TEST SECTION CUNDITIO	TOTAL TEMPERATURE VELCCITY = 133.00	NO. SFCTICN TYPE	++ ++	A CONSTANT AREA WUCT	2 CONTRACTN. SINGLE	3 TEST SECT. LIFSN	4 DIFEUSEP	5 INTERNAL STRUCTURE	6 DLFFUSER			9 CORNER WITH VANES.

PAGE 2			++	0 • 00066	10000.0	0-00017	0.00021	0.00071	10000*0	0.00002	0.00003	0.00001	0.00019	0.00002	0.00084
•			++	0.02364	0+00066	0.00914	0.01129	0.05617	12100.0	0.00306	0• 005 65	0*00140	0.17085	0.00494	0.18071
CUNT INUED			+	17.16	1.51	0.61		18.14	5.33	3.05	5.33	1.52	10.52	5.38	10.29
:		MACH2	+	0•063 0•040	0.040 0.051	0.051 0.051	U.U51 0.038	0.042 0.026	0.026 0.032	0.032 0.029	0. U29 0.026	0.026 0.026	0.026 0.026	0.026 0.026	0.026 0.026
*	3	V1 V2 H / S = C		21.4	13.5	17.4 17.4	17.4 13.0	14.3	8.7 10.7	10.7 10.0	10.0 8.7	8.7 8.7	8.7 8.7	8.7 8.7	8.7 8.7
_		2 INEIA		6.01	38.48			7.54	11.51	é.93	7.58				
D TUNNE		AK, LK	++	1.59	1.29			l.65	1.23	1.08	1.14				
NIM LOO		A 1/ PU A 2/ A0	+	5.76 9.16	9.16 7.08	7.08 7.08	7.09	8 • 59 14 • 14	14.14 11.47	11.47 12.36	12.36 14.14	14 • 14 14 • 14	14.14 14.14	14.14 14.14	14.14 14.14
7- BY 10-F		AREA2 AREA2	E +	37.47 59.56	59.56 46.04	46 •04 46 • 04	46.13 61.75	55 •84 91 •99	91.99 74.61	74.61 80.37	60.37 91.99	91 <b>.</b> 99	91 <b>.</b> 99	66°16 61°66	91.99 91.99
H CENTER		W2,02	AC 16K0	6.60 8.71	8.71 8.87	8.87 8.87	8.87 8.87	8.87 10.06	10.06 9.11	9.11 9.43	9.43 10.06	10.06 10.06	10.06 10.06	10.06 10.06	10.06 10.06
RES EARC		H2 H2	ME I E KO	5.68				9.14	9.14 8.19	8.19 8.52	8.52 9.14	9.14 9.14	9.14 9.14	9.14 9.14	9.14 9.14
SA-AMES		SHAFE	+	RECT CIRC	CIRC CIRC	CIRC CIRC	CIRC	CIRC	RECT RECT	RECT RECT	RECT	RECT	RECT RECT	RECT RECT	RECT RECT
* *		NU. SECTIUN LYPE	++ ++	10 DIFFUSEP.	II FAN CCNTRACTIUN	IZ FAN DUCT & STRUTS	13 MULT INTRNL STRCTR	14 FAN DIFSR&CNTR BDY	15 CONTRACTN, SINGLE	16 DIFFUSER	17 DIFFUSER	18 CONSTANT AREA DUCT	19 CORNER WITH VANES	ZO CONSTANT AREA DUCT	21 CORNER WITH VANES

* NA SI	A-AME S RESEAKCH CENTI	ER 7- BY 10-FOOT WI	ND TUNNEL	* •••CONTINUED••••	PAGE 3
			TUTAL CENTERLIN	E LENGTH = 154.32 METERS	
PERFUPPANCE SUMMARY					
TOTAL PPESSURE LOSS	(DP/G0) = 0.12387	ENERGY RATIO =	8. J73		
TUTAL POWER Inplited Flow	UUT PUT REQUIRED	AVERAGE PER FAN	FAN EFFICIENCY	TOTAL NUMBER OF FANS	
996651. AATTS	1172530. WATTS	1172530. WATTS	85.00 PERCENT	1	
an ann ann an ann ann ann an an an ann ann ann ann an a					
	MUMIXUM	VELOCITY FUR A SPEC	IFIED PUWER CONSUMPTIO	Z	
THE MAXIMLN TEST SECTION VELUCITY	ON FLOW ACHIEVABLE W Y 130.33 M/SEC = Mber 0.39	ITH 1110000. WATTS = 253.34 KNDTS	G PUWER AVAILABLE IS	APPRUXIMATELY AS FOLLOWS	
DYNAMIC	PRESSURE 9669.	53 N/ SQ M			

*		NA SA-AN	IE S RES	EARCH	CENTER	7- 81	10-F0	IT WIN	ID TUNN	E L		*	•	••CUNT	INUED	PAGE
						ANNCTA	TED IN	PUT DA	TAB	ULAT I	N					
• EMPTY• • ERP.OR •	INDI CATES INDI CATES	MANDATC	AL, NON	-REQUI	RED IN Ameter	PUT PA	RAMETE Een um	R HAS	BEEN O This	MITTEL	D OR P BE CO	AR AMET RRECTE	ER MAY D Bëfo	BE IN Re Com	NTENDED AS ZERC PUTATION IS PC	). JSSIBLE.
• EXTRA•	INCICATES INDICATES	SUPERFL OPTIONA	NL INPU	NPUT P	ARAMET HAS B	ER HAS EEN UM	BEEN ITTED	UNNECE AND TH	ISSARIL	V INC	HILL	<u>ON INP</u> DEFAUL	UT CAR T TO A	D AND PREDE	MAV BE REMOVED TERMINED VALUE	
						TUNN	EL MAS	TER CU	INTROL	DATA						
		CASE 1 SEU.	TYPE	UNI TS	SECT. INLET SHAPE	SECT. EXIT SHAPE	Ŧ	11	MODEL BLKGE PER-	9	POWER LEVEL Mega-	ΡŢ	11	P ATM	-	
DATA FIEL	C BEGINS						τ	Ŧ	CENT	M/SEC	WATTS	ATH	DEGC	ATM		
IN LAKU L		++	n+	+	+	•	+		++	++	1	00				
		-2	4	T	2	2	2.134	3.048	EMPTY	133.0	1.110	1.000	14.85	1.000		
	in a in an internet and a second s															
					J	ASE TE	RM INAT	I ON CU	DILION	INS DA	TA					
		A	CASE FTER 2	LERMIN I INPU	ATION T SECT	OCCURR.	ED (DU	<u>E TO B</u> Cordin	C TU T	IN CAL	LOWIN	G CUND	AND 4			
			MARY	0	PLOT	TING A	S	ZI	PUT		VELO	CI TY-		RETU	IKN	
TFRMINATT	L'N+CCF		ITPUT	3	50	LENGT	2 I	TABUL	ATION	-		POWER	2 -	CAS	E E	
DATA FIEL Contained Card Cclu	D IS IN MNS	5	9-			7-8		6	01		1	-15		16-	20	
		•		+			+		+				•		+	
			NO		Z	ONE		YES (C	HOSEN		>	ES		ΥË	S	

•

111

 $1.38 \times 10^{-1}$ 

5		س			EPS	ER- ENT		t					γTq		Ì		
PAGE		S IBL			A D	<b>⊾</b> ∪   ⊢	76	2					Ν. U				
		FR0.	VED.		H	PER CER	12										
		45 Z1	VAI		REF .	(6). (-6) FERS	·	t							N		N
0		110) 110)	BE I		RUN	HE1	ΥΥ ΥΥ	3					•		9		90
INUE		ITENC IPUTA	HAY TERM		9×								0100				
CONT		С Ш Ш	AND R F D F		HS HS			+  +			z	z	o	z.	z	z	z
:		AY B	ARD A P		X X X		, Y				LdO	do		IdO	1 d0	LdO	90 Q
		ER M	110		IHd	DEG									0.00		00.00
*		AMET Ecte	FAUL		GE TY	1 I I	u	+					54				
		PAR CURR	9 1 1		BLK PRS		44						4•3				-
	CN	D CR BE			HORD DHUB DHUB	Σ	-								3046		3048
ب	וראזו	ITTE MUST	INC INC	TA	н. Н. Н. Н.	ÉÈE		+					71		ò		0
UNNC	TABU	N N N	ARAM	NDA	S/A	E G G	72				_		0.11			•	
L GN	A TA	855 T	HE P	PTIO	#2 D2	Σ	-		0.06	840	.086	.106	1.106	. 752	. 752	. 596	• 596
IM I	UT D	TTEU	INNEC	SCRI	Ţ2	-		+	44 ]	34 3	134 3	49	149	158	37.5	581 6	183
101-	INP	IETER I OMI	NUL	DE DE			36	3	9.	2.1	2.1	7 2.1	2•1	4.	4.6	5	5.6
V 10	ATED	ARAN Been	NI 11	SCT 10		T		-1	960-0	13.11	.572	3447		28.96	<u>. 209</u>	9.144	1.045
7- B	TUNN	UT P HAS	ENG	S	= =			+	06	06 1	48 4	0880	88	06	52 6	152 9	96
ITER	4	TER	NETE S BE			2		<b>1</b>	10.	10.		Э. (	3.(	3.1	1.5.1	5.1	Ç.
CEN		I RED K AME	PARA A HA		Ŧ	Σ	-	-	.144	. 144	.134	. 134	.134	.149	. 83	.837	68] • 68]
ARCH		RE CU	DAT		R R F T			- +	6	0*		~	•		1	4	
RESE			NP U1		PE	ž											
MES		AL, CRY	LUOU AL I		DT AL NO.	ON N	r	- +									
SA-A		TION	日 日 い い		1 1 1 1	ן נ ן נ		0+	N	N	2	- N	N	2	2	2	2
AN		S UP	s su s op		SEC EXI												
		CATE CATE CATE	CATE CATE		ECT.	i I	GINS N	n +	~	2	V	*	N	2	2	2	2
		IUNI	IQNI		E I S		D BE	+	5	c C	e.	0	¢	J	2	c	2
		т <u>ү</u>	44	1	SFČ TYP			n +	1	2		4	ŝ	4	5	4	ິ ທີ
*		I C MD	EXT IDT		ECT. SFQ.		ATA N CA	- <b>‡</b>	-	~	ŝ	4	ŝ	9	Ч	8	0
1		:			S F	ч,	o H	1			i –	ļ		t t			l

*			NASA-	-AMES +	RESEARC	CH CENT	r ER 7-	BY 10-	FOOT	IL DNI	INNE L		*		CON	TINUED	•	PAC	Е 6
							v	SECTION.		101101									
SECT.	SEC T.	SECT.	SECT.	TOTAL	ITEMS	Η			H2	23	L/DH,	CHORD	BLKGE	IHd	K II X P	0.5	RNREF.	ETA (	) EPS
	1 A F E	INLEI	EXII	- NO-	тн Т		10			27	SIAL	ADHU -	PKS IY		KMUSH	¥	KULNES		
TUQNI		SHAPE	SHAPE	DUCTS	DUCT							DMESH			KT 90				
											M/M,					-	10(6),		
											SQ M/		PER-				10(-9)	PER-	PER-
				<b>.</b> 00	NO.	Σ	Σ	E.	£	Σ	SUM	Σ	CENT	DēG			METERS	CENT	CENT
DATA F	TELC	BEGINS																	
IN CAR		VWD																	
-1	ŝ	ŝ	Q	7	6	11	16	21	26	31	36	41	46	51	56 E	51	66 7		16
‡	<b>+</b> +	+	+	‡	<b>‡</b>	++	++	++	†	+	+ +	++	+	+	- + 	+	+++++++	+	+
01	40		-			5.681	6-596	17.16		8.708					NITON				
•		ł	•												:				
11	92	1	-	۱.	2.		8.708	1.507		8.667		2.743	8.780						
12	15	-4	-	۱.	2.		8-8670	• 6096		8 • 86 70	•4149	2.743	8.760		0	.0100	89	5.00 E	MP TY
13	96	1	1	1.	9.		8.867			8.3670	.1254		2.811		0	0010		u	A L d W
14	94	٦	2	ι.	Nº 1 40		8.867	18.14	9•144	10.06		2.743	EMPTY		N. 140				
15	20	7	N			9.144	10.06	5.334	8.193	9.107									
16	40	2	2			8.193	101.9	3.048	8.519	9.434					N . 140				
17	40	2	~			8.519	9.434	5.334	9.144	10.05				-	N+ 140				
18	10	2	7			9.144	10.06	1.524	9.144	10.06									
19	32	2	2			9•144	90 01	10.52	9•144	10.06	0	• 3048		00-06	Nº 1 dO		Nº 1 d'I		
20	10	2	2			9 • 144	10.06	5.377	9.144	10.06									
21	32	7	2			9.144	10. 66	10.29	9.144	10.06	0	.1524	0,	00-06	0PT•N	-	N• 140		
* *			NASA	-AME S	RE SEAR	CH CEN	TER 7-	BY 10	-F00T	T ON IM	UNNEL			E CAS	E COMPL	ETED C	DR TERM	INATED	*

113

*		LOCKHE	ED-GEURGIA	LOW-SPEE	O MI NO	TUNNEL,	V/STGL T	EST SECT	ION	*		PAGE 1
	-	SINGLE-RE	TURN, CLOS	EC-TEST-SI	ECTION	ND-TU	NNEL PERFI	DRMANCE				
; H 2	1.0	00 ATMOSP	HERES = 1	01325.0 N	/SQ M.							
é – i	510	A TMO SPHER	ES = 1032	50.1 N/SU	.Ε							
#	14. M/SEC	85 DEG C = 101.6	= 288.00 0 KNCTS.	DEG K. Dynamic Pi	RESSURE	= 16	87.59 N/S	Я				
	SHAPE	H1 H2 Meteos	W1,D1 W2,02 M57505	AREAL Areaz So M	A 1/A0 A 2/A0	AR ,CR	2 THETA	V1 V2 M/SFC	MACH1 MACH2	LENGTH Meters	DP/40	00/40
	++	++	++	+	+	++	++	++	+	++	++	++
	RECT	15.70 15.70	15.70 15.70	246.49 246.49	3.40			15.2 15.2	0 • 0 45 0 • 0 45	6.10	0.00292	0.00025
	RECT RECT	15.70 9.14	15.70 7.92	246.45 72.47	3.40	3 • 40	40.57	15.2 52.3	0.045 0.154	10.97	0.00286	0.00286
	RECT	3.14 9.14	7.92 8.12	72.47 74.22	1.00	1.02	0.35	52.3 51.0	0.154 0.150	19.20	0.01565	0.01565
	RECT RECT	5• 14 4• 95	8.12 7.09	74.22 35.10	1.02	2.11	24.44	51.0 112.7	0.150 0.335	1.01	0.00254	0.01130
	RECT	4.95	7.21	35.10 35.74	0.48	1 • 02	0.26	112.7 110.5	0.335 0.328	13.11	0.01483	0-06602
	RECT	<u>4.95</u> 8.69	7.21 8.69	35.74 75.46	0.49	2.11	5 • 87	110.5 50.1	0.328 0.148	29.79	0.06272	0 • 26884
	RECT	8•69 8•69	8•69 8•69	75.46	1.04			50.1 50.1	0.148 0.148	9.75	0.14222	0.13102
	RECT	8•69 9•15	8.69 9.75	75.46	1.04	1.25	6.51	50 <b>•1</b> 39 <b>•</b> 6	0.148 0.117	10.59	0.0000	0.00912
	RECT RECT	9•75 9•75	9.75 9.75	95.14 95.14	1.31 1.31			39•6 39•6	0.117	10.82	0•14366	0.08292

* FOCKHI	E <u>EU-GF</u>	RGIA LOW-	-SPEED WIND	TUNNEL .	V/STOL	TEST SE	C TLON	*	J	UNT INUED	••••	PAGE 2
NO. SECTION TYPE	SHAPE	H	M1,01	AREAL	A1/A0	AR,CR	2 THETA	٨١	MACHI	LENGTH	06/01	00/40
		H2 METERS	W2+D2 METERS	AREA2 SQ M	A2/A0		DEGREES	V2 M/SEC	MACH2	METERS		
	<b>*</b>	++	+	+	<b>†</b>	+	++	+ +	++	+	+ +	+
10 SCREEN, WIRE MESH	RECT RECT	9.75 9.75	9.75 9.75	95.14 95.14	1.31 1.31			39.6 39.6	0.117		0.06777	0.03912
11 DIFFUSFR	RECT CIRC	6.75	9.75 11.58	95.14 105.32	1.31 1.45	1.11	8.57	39.6 35.7	0.105	3•83	0•00327	0•00189
12 FAN CONTRACTION	CIRC CIRC		11.58 11.89	105.32 69.62	1•45 0•96	1.51	15.75	35.7 54.5	0.105 0.161	7.83	0.00244	0.00265
13 FAN DUCT & STRUTS	CIRC CIRC		11.89 11.89	69 62 69 62	0.96 0.96			54•5 54•5	0.161 0.161	5.64	0.02219	0.02407
14 FAN DIFSR&CNTR BDY	CIRC CIRC		11.69 11.89	69.62 111.03	0.96 1.53	I.59	11.18	54•5 33•9	0.161 0.100	12.65	0.02837	0• 03077
15 DIFFUSFR	CIRC RECT	15.70	11.89 15.70	111.03 246.49	1.53 3.40	2•27	6.04	33.9 15.2	0.1 UO 0.045	55.17	0.03921	0.01659
16 CCRNFR WITH VANES	RECT KECT	15.70 15.70	15.70 15.70	240•49 246•49	3.40 3.40			15•2 15•2	U. U45 0.045	17.53	0.14696	0-01257
17 CONSTANT AREA DUCT	RECT	15.70 15.70	15.70 15.70	246.49 246.49	3 40 3 40			15.2 15.2	0.045 0.045	3•35	0.00161	0.00014
18 CCPAEP WITH VANES	RECT	15•70 15•70	15.70 15.70	246.49 246.49	3.40 3.40			15.2 15.2	0.045 0.045	17.53	0.14096	0.01257
19 SCREFN, MIRE MESH	RECT RECT	15.70 15.70	15.70 15.70	246.49 246.49	3.40 3.40			15.2 15.2	0.045 0.045		1•96061	0 • 16763
						<b>T</b> 0	ITAL CENTE	RLINË LE	ENGTH =	240.87	METERS	

\_

- + LUCKHEED-(	GEORGIA LOW-SPEED V	WIND TUNNEL, V/STOL	TEST SECTION	* •••CONTINUED••••	PAGE 3
0 E Ĥ Ď Å Å Å Å F E - S LI WM ÄRV					
TOTAL PRESSURE LOSS (E TOTAL PRESSURE LOSS (E	UP/GU) = 0.89596	ENERGY RATIO =	1.116		:
INPUT TE FLUM	OUTPUT REQUIRED	AVERAGE PER FAN	FAN EFFICIENCY	TOTAL NUMBER OF FANS	
5733046. WATTS	6034785. WATTS	6034785. WATTS	95.UU PERCENT	1.	
	V AUA IXW	VELCCITY FOR A SPECI	FIED PUWER CONSUMPT	10%	
IF MAXIMUM TEST SECTION VELOCITY -	FLGW ACHIEVABLE W	ITH 6058999. WATTS = 101.74 KNUTS	OF POWER AVAILABLE	IS APPROXIMATELY AS FOLLOWS	
RACH NUMBE DYNAMIC PR	ER 0.15 RESSURE 1692.(	08 N/SQ M			

LOCKHEED-GEORGIA LOW-SPEED WIND TUNNEL, V/STCL TEST SECTION *	ATES OPTIONAL, NON-REQUIRED INPUT PARAMETER HAS BEEN UMITTED OR PARAMETER MAY BE INTENDED AS ZERD. Dies Mandatory input parameter has been umitted. This must be corrected before computation is possible. Vies superflucus input parameter has been unnecessarily included on input card and may be removed. Dies optional input data has been omitted and the parameter will default to a predetermined value.	TUNNEL MASTER CONTROL DATA	CASE TUNNEL UNITS SECT. SECT. HI WI MODEL VO POWER PT TT PATM Sev. Type inlet exit di blkge level No. Shape Shape Per- mega-	NS A F A II I A SEC WATTS ATM DEG C ATM	+ + + + + + + + + + + + + + + + + + +	-3 1 1 2 2 9.144 7.925 EMPTY 52.27 6.059 1.019 14.85 1.000	CASE TERMINATION CONDITIONS DATA	CASE TERMINATION DCCURRED (DUE TO BLANKS IN CARD COLUMNS 3 AND 4) AFTER 19 INPUT SECTIONS, AND ACCORDING TO THE FOLLOWING CONDITIONS	SUMMARYPLOTTING ASINPUTVELOCITY-RETURNCHARACTERISTICSA FUNCTIONDATAOPTIMIZATIONFUR NEXTDUTPUT0F IENGTHTABULATIONCASECASE	E 5-6 7-8 9-10 11-15 16-20	++ ++ ++ ++	NU VES (CHOSEN) YES YES
	• EMPTY• IND • FRRIR• IND • EXTR.• IND • OPT• A• IND			DATA FIELC BE In CARD COLUM						TERMINATION-C Data Field is Contained in Card Columns		

- ----

-

PAGE 5	). )SSIBLE. ).		ETA D EPS	ER- PEP- ENT CENT	76									
	ED AS ZERG TIDN IS PO BE REMOVED INED VALUE		RNREF, RUFNE S	10(6), 10(-6) PI METERS C	66 71							N.L.O		N. 140
ONTINUE	IN TENDE COMPUTAT ND MAV I EDETERM		9 X 0		61			z		z	z	z	z	z
•••	AY BE FORE ARD A		KEX KMES KT 9		56			0PT•		0PT	140	140 0	1d0	1 d O 0
	ETER M TED BE NPUT C ULT TO		ІНЧ	DEG	51							90.0		0.06
	PARAMI ORREC		BLKGE PRSTY	PER- CENT	46									
N	I CN ED OR T BE C CLUDED R WILL		CHORD DHUB DMESH	X	<u>+1</u> ++							1.067		1.067
SE CT1	IABULAT M OM ITT 11 S MUS TLY IN ARAMETE	N DATA	L/DH. S/AL	N/H. Se H/ Se M	36									
L TESI	DATA 1 S BEEN D. TH	10110	M2 D2	Σ	31	15.70	7.925	8.117	7.087	7.215	8.687	8.687	9.754	9.754
V/ 510	INPUT TER HA UMITTE N UNNE	L DESCP	Н2	Σ	26	15.70	9•144	9.144	4.953	4.953	8.687	8.687	9.754	6.754
UNNEL.	PARAME PARAME BEEN LAS BEEN DMITTE	SECTION	-	Σ	21	6• C 56	10.97	19.20	7.010	13.11	29.79	9.754	10.59	10.82
T UNIN	ANNU I NPUT ER HAS BEEN		141	τ	16	15.70	15.70	7.925	8.117	7.087	7.215	8.687	6.687	5.754
SPEED	UIRED ARAMET PARAM TA HAS		H	Σ	11	15.70	15.70	9.144	9.144	4.953	4.953	8.687	8.687	5. 754
A LOW-S	CN-RE ON NPUT PI INPUT PUT DA		ITEMS PER	N0.	6	:								
GEURGI	NAL, N TURY I FLUDUS NAL IN		TOTAL NO.	NO.	7	;								
(HEED-	0PT10 MANDA SUPER 0PT10		SECT.	SHAPE	ę	+ °	2	7	~~~~	2	2	2	N	2
LOCK	I CATES I CATES I CATES I CATES		SECT.	SHAPE	AN	+ °	7	2	2	N,	~	7	7	7
	10NI - 1		SECT.	-	TELC B C CCLU 3	+ (		Ē	20	4 C	40	32	40	32
44   	ЕМРТУ • FRR08 • EXTR /		SECT.	ININI	OATA F IN CAR	‡ <sup>-</sup>	7 ~	ŝ	4	ıc.	Ŷ	7	. 60	o,

PAGE 6		EF, ETA D EPS Nes	6) + 	ERS CENT CENT	++ ++ +-				95.00 EMPTY			Z		2		FRMINATED **
CONT INUED		KP CD RNR SH K RUF	101	METI	61 66 + ++ +	Z	z		0.0100	z	z	N OPT		N UPT	z	MPLETED OR 1
*		PHI KE	X	DEG	51 56	0010	- 140	_		- T90	UPT •	140 00°06		•T40 00.09	140	* CASE CO
ION		CHORD BLKGE DHUB PRSTY	DME SH DFR-	M CENT	41 46 ++ ++	0.030 95.00		4.724 5.110	4.724 5.110	4.724 5.110		1.829		1.829	.0015 47.00	NO 1 .
JL TEST SECT	I PTI ON DATA	W2 L/DH. D2 S/AL	. H/H.	A 50 H	31 36	9.754	11.58	11.89	11-890-3329	11.89	15.70	15.70	15.70	15.70	15.70 0	OL TEST SECT
UNNEL, V/STO	ECTION DE SCF	L H2		Σ	21 26	9-754	.831	1.827	• 639	L2.65	55.17 15.70	1.53 15.70	1.353 15.70	1.53 15.70	15.70	UNNEL, V/ST
PEED WIND T	Ø	HI WI DI		T	I 16 + ++	. 754 9.754	.754 9.754	11.58	11.89	11.89	11.89	5.70 15.70	5.70 15.70	5.70 15.70 1	5.70 15.70	SPEED WIND 1
IGIA LOW-S		L ITEMS	s puct	•ON	1 + 6 +	6	6	5.	5.	5.		1	1	I	1	RGIA LOW-
HE ED-GEOR		ECT. TCTA XIT NO.	HAPE DUCT	•UN	++ +	~	T	1 1.	1 1.	1 1.	2	2	2	7	2	KHEED-GED
<b>L</b> OCK		• SECT. S Inlet e	SHAPE S	BEGINS Luma	vî +	2	2	Ţ	<b></b>	1	I	2	2	2	2	LUCI
*		SECT. SECI SEQ. TYPE	INPUT	DATA FIELC In Care CC	1 3 ++	10 54	11 40	12 52	13 91	14 94	15 40	16 32	17 10	18 32	19 54	** **

PAGE 1					0P/40	+	0.00124		0.00124		0.00124		0.00124		0.00124		10200 0	1 0500-0	C 000E	100000	0.01241		0.06953	
					06/df	++	0.25621		0.25621		0.25621		0.25621		0.25621			14600.0		10500.0	0.01241		0.08077	
*					LENGTH METERS	++											17.86		5.49		6.10		36.85	
SALORE					MACHI MACH2	+	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.160	0.160	0.286	0.286	0.264	0.264	0•069
AT BANG	RMANCE			- E	V1 V2 M/SEC	++	6 <b>.</b> 6	6 • 6	6.6	<b>6</b> •6	6.6	<b>9</b> • 9	6.6	6 <b>.</b> 6	6.6	6 • 6	6.6	54•3	54.3	96•3	56.3	89.1	89.1	23.5
ND TUNNEL	NEL PERFO			5.13 N/SQ	2 THETA DEGREFS	+											28.11		11.96		1.26		5.40	
F00T WI	II ND-TUN			* 546	AR, CR	+ +											8.17		1.73		1.07		3.67	
- BY 9-	ECTION W	/SQ M.	÷	RESSURE	A1/A0 A2/A0	•	14.10	14.10	14.10	14.10	14.10	14.10	14.10	14.10	14.10	14.10	14.10	1.73	1.73	1.00	1.00	1.07	1.07	3.9
SCIENCE 14	EC-TEST-SE	01325+0 N	25.0 N/50	DYNAMIC PI	AREAL Areaz		148-62	148.62	148.62	148.62	148 •62	148.62	148.62	148.62	148 • 62	148.62	148.62	18.19	18.19	10.54	10.54	11.33	11-33	41.53
LI TUTE OF	rurn, clos	HERES = 1	ES = 1013	- 288.00 3 KNOTS.	W1,D1 W2,D2	++	24.38	24.38	24.38	24.38	24.38	24.38	24.38	24.38	24.38	24.38	24.38	5, 99	5.99	4•34	4.34	4.47	4.47	9 <b>•</b> 80
DIAN INS	NON-RE	0 ATMOSPI	TMOSPHER	5 DEG C = = 187.2	HL H2 H2		6.10	6.10	6.10	6.10	6.10	6.10	6.10	6.10	6.10	6.10	6.10	3.47	3.47	2.82	2.82	2• 55	2.95	4.72
NI		= 1.00 NS	1-000 A	# 14.8 M/SEC	SHAPE	+	R LC T	RECT	RECT	RECT	RFCT	RECT	RÉCT	RECT	RECT	RECT	RECT	FL 0	FL 0	FL 0	510	FL 0	FL Q	FL 0
**		ATMOSPHEPIC PRESSURE TEST SECTICA CONDITIO	TOTAL PRESSURE =	TOTAL TEMPERATURE VELCCITY = 96.32	NO. SECTION TYPE	++ ++	I CCOEEN, UTDE NECH	T STATESTE MENTE THESE	2 SCREEN. WIRE MESH		A SCREEN, MIRE WEAH		4 SCRFFN. MIRE MESH		A CREEN. WIRE WESH		A CONTRACTN. SINGLE		7 CONTRACTN. SINGLE		NYEL ( LECK		O DI FENSER	7 NILLENGED

PAGE

* INDIAN INS	TI TUTE	OF SCIEN	CE 14- 8Y	9-F00T WI	ND TUNN	EL AT B	ANGAL ORE	*		CONT INUED		PAGE 2
NU. SECTION TYPE	SHAPE	HI	MI .DI	AREAL	A1/ A0	AR, CR	2 THETA	۲۱	MACHI	LENGTH	DP/QL	00/40
		HZ METERS	WZ,02	AREA2	A2/A0			72	MACH2			
++					•		DEGREES	M/SEC		<b>NE TE RS</b>		
			*	•		+	+	+	+	++	+	++
10 FAN CCNTRACTION	FL O	4.72	5.41	41.54	3-94	1-28	11.11	23.5	0,040	30 5		
	CIRC		4.88	32.51	3.08			30.1	0.089		0.00238	0-00024
I FAN DICT & STRUTS	100		90 Y									
	CIRC		4.88	32.51	3.08			30.1	0.089 0.089	0.61	0.00626	0.00063
12 FAN DIFSRECNTR BDY	CIRC		4.88	34,00	50 ° E	1.62	07 61	0 00	900			
	FL 0	5.26	6.39	55.29	5.24		· · · · ·	17.7	0.052		4995T*N	68710°0
13 SHU FXP W F - SNG	с 1	5. 76	20	66 30	2	-						
	RECT	5.26	11.51	60.52	5.74	F-04	00.00	1 - 1 1	0.052	0.0	0.00747	0.00026
14 CORNER, NO VANES	RECT	5.26	11.51	60.52	5.74			16.1	0.047	6.10	0.60893	0-01777
	RECT	6.32	11.58	73.24	6.95			13.3	0.039			
15 EXIT KINETIC ENRGY	RECT	6.32	11.58	79.24	4.05			c c t				
	RECT	6.32	11.58	73.24	6.95			13.5	V.020		24666.0	16610*0
						TO	ITAL CENTE	RLINE LE	ENGTH =	81.38	HETERS	
PERFORMANCE SUMMARY												
TOTAL PCHER	S (0P/G	0) = 0.14	644	ENERGY RAT	9 = 01	• 829						
INPUT TO FLOW	0016	UT REQUIF	RED AV	RAGE PER	FAN	FANE	FFICIENCY	10	TAL NUM	BER OF FI	NC	
783658. WATTS	113	15735. HAT	15	567868• WA	17TS	69•00	PERCENT	1	2	•	2	
		MAX	I MIM VET UC	TTY FOR A	SDECTE	1 E.D. 0.0 U	ED CONSUM	01100				
								NOTI				
THE MAXIMUM TEST SECT	ION FLO	W ACHIEVA 87.50 M	NBLE WITH	862800. 10.08 KNDT	WATTS 0	F POWER	AVAILABL	E IS APP	ROXIMAT	ELY AS FC	SMOTTO	
MACH NI DYNAMIC	UMBER -	- 0.26 URE	4541.55 N	SQ M								

PTY INCICATES ROR' INDICATES	OPTIONAL, NON-REQUI MANDATURY INPUT PAR	RED INPUT PARAMET Ameter has been o	ER HAS BEEN OMITI MITTED. THIS MUS	TED OR PARAMETER MA 57 be corrected bef	Y BE INTENDED AS ZERO. Dre computation is possible.
TRA' INCICATES T.N. INDICATES	SUPERFLUOUS INPUT P OPTIUNAL INPUT DATA	ARAMETER HAS BEEN Has been omitted	UNNECESSARILY IN AND THE PARAMETE	VCLUDED UN INPUI CA Er mill default to	A PREDETERMINED VALUE.
		TUNNEL MA	STER CONTROL DAT	-	
	CASE TUNNEL UNITS SEQ. TYPE	SECT. SECT. HI Inlet exit suade shade	WI MODEL V DI BLKGE PER-	S POWER PT TY LEVEL MEGA-	P ATH
	NC.		H CENT M/SI	EC WATTS ATM DEG	C ATM
FIELD BEGINS ARD CCLUMN	4 5 1	5 6 11	16 21 26	31 36 41	+ ++
	• •	3 3 2 821	4.343 EMPTY 96.	320.8628 1.000 14.0	5 1.000
		CASE TERMINA	TION CONDITIONS	DATA	
	CASE TERMIN AFTER 15 INPL	ATION OCCURRED (C	UE TO BLANKS IN CCORDING TO THE	CARD COLUMNS 3 AND FOLLOWING CONDITION	4)  5
	V GA MAILO	PLUTTING AS	INPUT	VELOCI TY-	RETURN
	CHARACTERISTICS OUTPUT	A FUNCTION OF LENGTH	DATA TABULATI ON	OPTIMIZATION (Fixed Power)	FOR NEXT CASE
PINATICN-CCDE					
AJNEC IN	5-6	7-8	9-10	11-15	16-20
CLEURAS	+	++	++	+	+ =====++
	ÛN	NONE	<b>BES (CHOSEN)</b>	YES	YES

* •••CONTINUED•••• PAGE 4		ARAMETER MAY BE INTENDED AS ZERO. RRECTED BEFORE COMPUTATION IS POSSIBLE. ON INPUT CARD AND MAY BE REMOVED.	VERAULI IN A PREDETERMINED VALUE.	LKGE PHI KEXP CD RNREF, ETA D EPS 15TY KMESH K RUFNES	10(6), 10(-6) PER- PER-	LENT DEG METERS CENT CENT	<u>51 56 61 66 71 76</u>	•12 OPT•N	.12 OPT 'N	-12 OPT • N	•12 OPT •N	.12 OPT .N			N • 140	OPTIN	
TO LUTTEL AT DANGALOKE	VPUT DATA TABULATION	ER HAS BEEN OMITTED OR P MITTED. THIS MUST BE CO UNNECESSARILY INCLUDED AND THE PARAMETER UTLU	SCRIPTION DATA	HZ WZ L/UH, CHORD BI D2 S/AL DHUB PI DMFSH	A/A,		<u>-+ ++ ++ ++ +-</u>	<u>096 24.38 0.0C05 84</u>	196 24 <b>.</b> 38 0.0005 84	<u> 196 24.38 0.0005 84</u>	<u> 96 24.38 0.0005 84</u>	196 24.38 U. 0005 84	69 5.989	21 4.343	50 4.474	24 9.805	
	ANNUTATED IN	N-REQUIRED INPUT PARAMETE PUT PARAMETER HAS BEEN ON INPUT PARAMETER HAS BEEN INPUT PARAMETER HAS BEEN JI DATA HAS BEEN OMITTED	SECT ION D	EMS H1 W1 L FR D1 UCT D1	I I I I I I I I I I I I I I I I I I I		9 11 16 21 26 ++ ++ ++ ++ +	6.096 24.38 6.(	6•096 24•38 6•0	6.096 24.38 6.0	<b>6.096 24.38</b> 6.0	6•096 24•38	6.096 24.38 17.86 3.4	3.469 5.989 5.486 2.8	2 <b>.</b> 821 4.343 6.096 2.9	2.950 4.474 36.85 4.7	
		INULATES UPTIONAL, NON INCICATES MANDATORY INP INDICATES SUPERFLUOUS I INDICATES OPTIONAL INPU		CT. SECT. SECT. TOTAL IT DE INLET EXIT NO. PI SHAPE SHAPE DUCTS DU	NO.	DLUMN	+ + + + + +	4 2 2	4 2 2	4 2 2	4 2 2	4 2 2	0 2 3	6 6 0	3 3	E E (	
		ERROR		SECT. SEC SEQ. TYF INFUT		UATA FIEL	++ 3	1 5	2 5	n,	4	เกิ	6 21	7 21	6) 60	94	

---- -

,

123

Vanry

•

...CONTINUED....

¥

INDIAN INSTITUTE OF SCIENCE 14- BY 9-FOOT WIND TUNNEL AT BANGALORE

¥

ĺ

•• PAGE 5			REF, ETA D EPS FNES	1.51	(-6) PER- PER-	TERS CENT CENI		of 17			69.00 EMPTY					TERMINATED. **
CONT INUED			XP CD RN SH K RU	06	10	W		61 66 -+ ++ +-			0.0100	Z • 1		N . 1		COMPLETED OF
:			PHI KE	КĪ		DE G		51 56				40		50.00 UP		3041
JRE *			ORD BLKGE HUB PRSTY	E SH	PER-	M CENT		46	****	463 2.186	463 2.186	463 EMPTY				
AT BANGALC		NUALA	L/UH, CHI S/AL DI	IMO	M/M. S0 M/	SQ M		36 41	* * *	1.	0.2369 1.	1.				
) TUNNEL A			H2 ₩2 D2			T		31	++ +	4.877	4.877	258 6.386	258 11.51	325 11.58	325 11.58	
-FOOT WINC		SECTION DE	- -			x		21 26	+++++++++++++++++++++++++++++++++++++++	3.048	C. 6096	5-334 5.	5.	6.096 6.	ę.	
14- BY 9-				1		T		16	++ +	724 5.410	4.877	4.877	258 6.386	258 11.51	325 11.58	
SCIENCE	3615105		ITEMS H	DUCT		NO.		9 11	+ +	2. 4.	2.	QPT•N	5.	5.	<b>6</b> .	
11110 06			. TCTAL	F DUCTS		ND.		1	‡	2.	2.	2.	۲.			
1 1 1 1 1 1 1	ICNT NE		L. SECT	SE SHAPI			4S	9	+	3 1	1	1 3	3 2	2 2	2	
	1111		T. SECT				C REGIN		+	12		7	36	13	10	
-	ł		SECT. SEC	SEQ. TYP			DATA FIFL	IN LAKL C	• + • +	10 5	6	12 5	13 8	14 3	15 4	

PAGE 1							00/40		ţ	0.04672			0*00005	0.00103			0.00493	0.00410		0.01232		0.00410		0.00308		0.04021	
							DP/40			20.66628			0•00222	0.02985		00100	U. UU493	0.00410		0.01232		0.00410		0.00308		0.04015	
*							LENGTH	METERS				9.14		16 • 0		9.14		2.44		7.31		2.44		1.83		16.76	
TF IELD							MACHI MACHZ			0.006		0.006	770-0	0.025		0-135		0.135		0.135		0.135		0.135	cc1•0	0.135 0.062	
EL AT HA	FORMANCE				SQ M.		V1 V2	M/SEC		2.2	, ,	2.2		8.5		45-7		45.7		45.7	1	45.7		45.7 45.8		45.8	
IND TUNN	NNEL PER				70-61 N/						20 25	60.00			47.17											8.15	
V/STOL H	WI ND-TU				= 12	AD CO		++			2.03				6•49											2.14	
15-F00T	-SEC TI ON	N/SQ M.	N O		PRESSURE	V / V	A2/A0	++	20.54	20.94	20.94	6 . 49	5, 36	5.36	6•49	1.00	5	1.00	1.00	1.00	1.00	1.00	-	1.00	-	2.14	
IR CRAFT	SED-TEST-	101325.0	325-0 N/S	DEG K.	D YNAMIC	AREAL	AREA2 So M	++	437.63	437.63	437.63	135.67	111.97	111.97	135.67	20.90	20.90	20.90	20.90	20.90	20.90	20.90	20.00	20.89	00 00	44.70	
SIDDELEY A	ETURN, CLO	PHERES =	RES = 101	= 288.00	87 KNOTS.	IQ, IN	W2,D2 METERS	++	39.32	39.32	39.32	12.19	10.06	10.06	12.19	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	5.16	5.16	7.54	
HAWKER	NON-R	OO ATMOS	A TMOS PHE	85 DEG C	= 88.	TΗ	H2 METERS	++	11.13	11.13	11.13	11.13	11.13	11.13	11.13	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57				
•		JRE = 1.0	= 1.000	RE = 14.	.72 M/SEC	SHAPE			ATE RECT	KEU	E RECT	RECT	TR RECT	RECT	E RECT	KELI	CT RECT	RECT	A RECT	KECI	CT RECT	RECT	CT RECT	CIRC	CIRC	CIRC	
		USPFERIC PRESSU	TOTAL PRESSURE	VEL TEMPERATU	AELLUIT = 45	SECTION TYPE		+	SCREEN, PERF PL		CONTRACTN, SING		HONEYCOMB FLOW S		CONTRACTA, SINGL		ONSTANT AREA DU		EST SECT, CONST		ONSTANT AREA DU		<b>DNSTANT AREA DU</b>		I FFUSER		
		A T				0v			-		~		e		4		5		\$		-		8		0 6		

PAGE 2	0P/Q0	++	0.00704		7 0.00021	0 0.01221	7 0.01230		1 0.00028		16 0.04018		6 0.03723		0.02585						
	00/d1	+	0.03243		0.0005	0.0590	0 0504		0.0024		0.3399		1.8136		1 0000	••••		HE IEVS		FANS	
ONTINUED	LENGTH	METERS	205	0.0	0.46	1.52		00°0	2.59		00-00		0 75	<b>CI-C</b>				= 67.50		UMBER OF	٦.
	MACHI	MACH2		0.046	0.046 0.081	0.061		0.046	940.0	0.046	0-046	0.019	010 0	0.022		0.022		LENGTH :		TOTAL N	
*	11	V2 M/SEC		21.2	15.7 27.6	20.7	- • • • •	20.7		15.7	15 7	6.5		6.5 7.3		7.3		T ERL INE		2	L L
ATFIELD	2 THETA	DEGREES		22.94	82.97			00*06				00-06						TOTAL CEN		10.000	00 PERCE
EL AT H	AR.CR		•	1.35	1.75			1.32				2.40							3.971		FAN 95.
ND T UNN	04/14	A2/A0	+	2.14 2.90	2.88 1.65	2.19	2.19	2.19	7 7	2•90 2-90		2.90		6.95	0.00	6.20	0.20		RATIO =		ER FAN WATTS
V/STOL WI	10200	AREA2 SQ M	+	44.70 60.56	60.23 34.40	45.78	45.78	45.79	90.00	60.56 60.56	••••	60.56	147.62	145.2	12.621	129.5(	129.90		FAFRGY		AVERAGE P 45660.
T 15-F00T		WI, DI W2, D2 METERS	+	7.54 8.78	3.31 3.05	3.05	3.05	2.89	8.78	8°-78	8.10	8.78	14.02	14.02	12.50	12.50	12.50		26194	00107	U IRED HATTS
AIRCRAF		H1 H2 MFTERS	+										10.36	10.36	10.36	10.36	10.36				FPUT REQ 319620.
1 DOE LEY		SHAPE	ţ	CIRC	CIRC		CIRC	, CIRC	CIRC	T CIRC	CIRC	CIRC	RECT	RECT	RECT	Y RECT	RECT		1	155 (DP/	00
HAWKFR S		SECTION TYPE	++	FFUSER	A CONTRACTION	CTUITS STOLES	IN LUCI & SINUIS			JASTANT AREA DUCT		JCCEN EXPANSION		TRAFE NO VANES		VIT VINETIC ENRG			OR MANCE SUMMARY	DTAL PRESSURE LO	OTAL PCHER
•		•0N	:	10 61	11 FA		12 FA	13 61		14 CC		15 SL			ذ ٦				PERF	F	

	1		1. 1. (1997)	
- SMOTTC				
ISUMPTION Able is Approximately as fo				
/ELOCITY FOR A SPECIFIED POWER CON Th 522200, Watts of Power Avail 104.89 KNOTS 10 N/SQ M				
MAXIMUM V EVABLE WI 5 M/SEC = 5 1763.8			• · · ·	
EST SECTION F VELOCITY		• •		
FHE MAXIMUM T				
			127	
	THE MAXIMUM TEST SECTION FLOM ACHIEVABLE WITH SZZZOO, WATTS OF POWER CONSUMPTION Velocity 53.96 m/sec = 104.89 knots of power available is Approximately as follows Vach Number 0.16 Dynamic Pressure 1763.80 n/sq m	HAXIMUM TEST SECTION FLOM ACHIEVABLE WITH SZ200, WATTS OF POWER CONSUMPTION VELOCITY 53.96 M/SEC = 104.89 KNDTS Pach Number 0.16 Dynamic Pressure 1763.80 N/SQ M	HAXINUM TEST SECTION FLOM ACHEVABLE MITH SECIFIED POWER CONSUMPTION THE MAXINUM TEST SECTION FLOM ACHIEVABLE MITH S22200. WATTS OF POWER AVAILABLE IS APPROXIMATELY AS FOLLOWS VELOCITY 53.96 M/SEC = 104.89 KNOTS ACH NUMBER 0.16 DYMMIC PRESSURE 1703.80 N/SQ M	Image: state

•••CONTINUED•••• PAGE 4	AY BE INTENDED AS ZERO. Fore computation is possible. Ard and may be removed. A predetermined value.	T P ATM C ATM	46 -+ ++ .85 1.000	0 4) DNS RETURN FOR NEXT CASE	16-20 ++ YES
UNNEL AT HATFIELD •	UNIN TROUCHTED OR PARAMETER M HAS BEEN OMITTED OR PARAMETER M FED. THIS MUST BE CORRECTED BE TECESSARILY INCLUDED ON INPUT C THE PARAMETER WILL DEFAULT TO	R CONTROL DATA MI MODEL VO POMER PT T Di Blkge Level Mer- Nega- Atm Deg	21 26 31 36 41 + ++ ++ ++ ++ + 572 EMPTY 45.720.5222 1.000 14.	IN CONDITIONS DATA TO BLANKS IN CARD COLUMNS 3 AN JRDING TO THE FOLLOWING CONDITI INPUT VELOCITY- INPUT OPTIMIZATION DATA OPTIMIZATION FABULATION (FIXED POWER)	9-10 11-15 ++ ++ ES (CHOSEN) YES
AIRCRAFT 15-FOOT V/STOL WIND 1	ANNOTATED INPU NCN-RE GUIRED INPUT PARAMETER INPUT PARAMETER HAS BEEN OMIT JUS INPUT PARAMETER HAS BEEN UN INPUT DATA HAS BEEN OMITTED AN	TUNNEL MASTE VNEL UNITS SECT. SECT. H1 PE INLET EXIT SHAPE SHAPE M	3 4 5 6 11 16   + + + + + + +   3 1 2 2 4.572 4.	CASE TERMINATION CASE TERMINATION CASE TERMINATION OCCURRED (DUE TER 17 INPUT SECTIONS, AND ACC ARY PLOTTING AS ARY A FUNCTION RISTICS A FUNCTION PUT OF LENGTH	-6 7-8 -0 NONE Y
* HAWKER SICDELEY	• EMPTY' INDICATES UPTIONAL • ERROR' INCICATES UPTIONAL • ERROR' INCICATES SUPERFLUC • EXTRA' INCICATES SUPERFLUC • OPT• N• INDICATES OPTIONAL	CASE TUN SEQ. TY NG.	DATA FIELD BEGINS IN CARE CELUMA 1 ++ -5	AF SUMM CHARACTE OUT	TERMINATION-CODE DATA FIELD IS CONTAINED IN CARD CCLUMNS +

PAGE 4

* •••CUNTINUED•••• PAGE 5		ETER MAY BE INTENDED AS ZERC. Ted before computation is possible. NPUT card and may be removed. ULT to a predetermined value.		PHI KEXP CD RNREF, ETA D EPS Kmesh k Rufnes	10(6),	DEG NETERS CENT CENT	<u>51 56 61 66 71 76</u>			00114						0PT•N	
CART I 23-FUUL V/STOL WIND TUNNEL AT HATFIELD	ANNCTATED INPUT DATA TABULATION	REQUIRED INPUT PARAMETER HAS BEEN UMITTED OR PARAM It Parameter has been omitted. This must be correc Put Parameter has been unnecessarily included on t Data has been omitted and the parameter will defa	SECTION DESCRIPTION DATA	MS HI WI L HZ W2 L/DH, CHORD BLKGE R DI L H2 D2 S/AL DHUB PRSTY GT DMFSH	RA SQ R/ PER-	· · · · · · · · · · · · · · · · · · ·	<u>11 16 21 26 31 36 41 46</u> + ++ ++ ++ ++ ++ ++ ++	11•13 39•32 11•13 39•32 28°79	11°13 39°32 9°144 11°13 12°19	11-13 10-060-9144 11-13 10-06 1-200 90-00	11.13 12.19 9.144 4.572 4.572	4.572 4.572 2.438 4.572 4.572	4.572 4.572 7.315 4.572 4.572	<u>4.572</u> 4.572 2.438 4.572 4.572	4.572 4.572 1.829 5.157	5.157 16.76 7.544	
		• ERPIT INDICATES OPTIONAL, NON- • ERROR' INDICATES MANDATORY INPU • EXTRA' INDICATES SUPERFLUOUS IN • OPT• N• INDICATES OPTIONAL INPUT		SECT. SECT. SECT. SECT. TUTAL ITE SEQ. TYPE INLET EXIT NO. PEI INPUT SHAPE SHAPE DUCTS DU		DATA FIELC BEGINS IN CARD CCLUMN	++ ++ + ++ ++ ++	1 53 2 2	2 20 2 2	3 51 2 2	<u>4 20 2 2</u>	5 10 2 2	6 1 2 2	7 10 2 2	8 10 2 1	9 40 1 1	

HAWKER SIDDELEY AIRCRAFT 15-FOOT V/STOL WIND TUNNEL AT HATFIELD

\*

129

PAGE 6	ETA D EPS		PER- PER-		++ ++			OF OD EMPTY							RMINATED. **
NUE D	CO DAD CE	K RUFNES	10(6), 10(-6)		1 66			00.0	0010						LETED OR TE
CONT1		HI KEXP KMESH KT 90		9	56 6	ODT 0 N			5			Not co	0.00 UP 140		CASE COMP
*		RD BLKGE PH	PER-	CENT DI	46 51			016-9-900	C96 3.316				6		tero *
AT HATFIEL	UN DATA	S/AL DH	M/M. SO M/	SQ M	36 41	+++++++++++++++++++++++++++++++++++++++	18	48 0.6	<b>14</b> 8 2.6530.6	.81	781	.02	.50	•50	NEL AT HATE
MIND TUNNEL	ON DESCRIPTI	H2 W		X	26 31	+ ++ +-	48 8.1	72 3.0	24 3.(	8.1	-B B.	10.36 14	154 10.36 12	10.36 12	TOL WIND TUN
-F 00T V/ST0L	SECT I	M1 L D1		T	16 21	+++++++++++++++++++++++++++++++++++++++	7.544 3.0	3.3100.45	3.048 1.5	2.886	8.781 2.5	8.781	36 14.02 9.1	36 12.50	15-F00T V/S
AIRCRAFT 15-		ITEMS H1	DUCT	NO. M	0	+ + + +		9.	2.				10.	10.	EY AIRCRAFT
R SIDDELEN		SECT. TOTAL	SHAPE DUCTS	- DN	ŗ	- <b>*</b> 0 <b>+</b>	1	1 7.	1 7.	1 7.	T	2	2	2	KER STUDEL
HAWKE		ECT. SECT.	SHAPE SHAPE		IELD BEGINS	n + + n	40 1	c.2 l	91 I	eć 1	1 01	46 1	33 2	45 2	H
*		SECT. S	INPUT		DATA F		10	-		13		15	16	11	**

i

0.00187
0-01595
6.71
0.116 0.116 0.088
39.3 39.3 29.8
16**
1.31
2.84 3.73
24•15 24•15 31•75
3.05
3.96
USER RECT CIRC
MULT DUCT DIFF

. ....

¥

UNIVERSITY OF WASHINGTON 8- BY 12-FOOT WIND TUNNEL

ĺ

PAGE 2	0P/40	+	0.00003	0.00044	0-00029	10100	BATAN •A	0.00084		0,00003		0-00277		00000		0.00270				
	DP/QL	ţ	0.00034	0.005 C6	40500 0		0.01563	0-02002		0 100 0	0.00167	201110	60011•N	10000 0	16000.0	0.11319		METEKS		FANS
ONT INUED.	LENGTH	METERS	0.46	1.22		P. 1	6.40	10.50	67.01		0/•0		00.4	1	16.0	4.50		• 74•18		UMBER OF 2.
	MACHI	MACH2	0.088	0.100	0.100	0.088	0-088		0.052		0.052		0.052		0.052	0.052		LENGTH		TOTAL N
*	١٨	V2 M/SEC	29.8 33.9	33.9	33.9	31.1	29.8		23•3 17•6		17-6		17.6 17.6		17.6	17.6	7.07	rerline		NT
	2 THETA	DEGREES	33.80			3.21	5.16		4.11									TOTAL CENI		LEFFICIEN
TUNNEL	AR , CR	++	1.14			1.04	1.27		ł.•32										7.197	FAN 95.
DT WIND	04/14	A2/A0	3.73	3.29	3.29	3.58 3.73	3.73	4.76	4.76	0. 67	6.29	6.0	6.29	0.67	6.29 6.29	6.29	6.29		(AT10 =	R FAN WATTS
BY 12-FO	AD C A 1	AREA2 SQ M	31.75	27.95	27.95	30.44 31.75	31-75	40.43	40 •43	64.66	53.45	53.45	53 .45	53.42	53 45 53 45	53.45	53.45		ENERGY F	AVERAGE PE 553523•
11 NGTON 8-		WI,UL W2,D2 METERS	4.50	4.50	4.50 4.50	4.50 4.50	4.50	4.50	4.50	4.50	4 .50	4.50	4.50	4.50	4.50	4.50	4.50		13895	J IR ED 4ATT S
Y OF WASH		H1 H2 METERS						4.50	4.50	5.94	5.94	5.94	5.94	5. 54	5.94	40.3	5.94		0 = 00	TPUT REGU
IVERSIT		SHAPE	+	CIRC	CIRC CIRC	CIRC	C L D C	RECT	A RECT	RECT	A RECT	RECT	R RECT	RECT	A RECT	KEVI	RECT		 	100
NN		CTION TYPE	+	UN IKAC ITON	DUCT & STRUTS	JIF SRECNTR BDY			DIFFUSER		TON'T STOLD	חררוסי בוחח	D 1-LAIL CRN		DUCTS, CNST		T D 1-MALL CKN		MANCE SUMMARY	AL POWER
	*	ND. SE	+ +	IO FAN C	II FAN C	12 FAN (		13 MUL1		14 100		15 MUL			17 MULT		18 MUL		PERFOR	LOL

	MAXIMUM VELOCITY FOR A SPECIFIED POWER CONSUMPTION														
THE MAXIMUM 1	TEST SECTION FLOW ACHIEVABLE WITH 1076999. WATTS OF POWER AVAILABLE IS APPROXIMATELY AS FOLLOWS Velocity 116.54 M/SEC = 226.53 KNOTS Pach Number 0.35 Pach number 0.35														
	DYNAMIC PRESSURE 7849.53 N/SQ M														
:															
133															
ERSITY OF WASHINGTON 8- BY 12-FOGT WIND TUNNEL *CONTINUED PAGE 4 Annotated input data tabulation	DNAL, NCN-REQUIRED INPUT PARAMETER HAS BEEN OM ITTED OR PARAMETER MAY BE INTENDED AS ZERO. MTORY INPUT PARAMETER HAS BEEN OMITTED. THIS MUST BE CORRECTED BEFORE COMPUTATION IS POSSIBLE. Reluous input parameter has been unnecessarily included on input card and may be removed. Onal input data has been omitted and the parameter will default to a predetermined value.	TUNNEL MASTER CONTROL DATA	ETUNNEL UNITS SECT. SECT. HI MI MODEL VO POWER PT TT PATM . TYPE INLET EXIT DI BLKGE LEVEL SHADF SHADF	H M CENT M/SEC WATTS ATM DEG C ATM	3 4 5 6 11 16 21 26 31 36 41 46	2 1 2 2.380 3.572 EMPTY 117.7 1.077 1.000 14.85 1.000	CASE TERMINATION CONDITIONS DATA	CASE TERMINATION OCCURRED (DUE TO BLANKS IN CARD COLUMNS 3 AND 4)	AFTER 18 INPUT SECTIONS, AND ACCURCING TO THE FULLOWING CONDITIONS	AFTER 18 INPUT SECTIONS, AND ACCURLING TO THE FULLOWING CONDITIONS RETURN SUMMARY PLOTTING AS INPUT VELOCITY- RETURN	AFTER 18 INPUT SECTIONS; AND ACCURLING TO THE FULLOWING CONDITIONS SUMMARY PLOTTING AS INPUT VELOCITY- RETURN ACTERISTICS A FUNCTION DATA OPTIMIZATION FUR NEXT OUTPUT OF LENGTH TABULATION (FIXED POWER) CASE	AFTER 18 INPUT SECTIONS; AND ACCURLING TO THE FULLOWING CONDITIONS - SUMMARY PLOTTING AS INPUT VELOCITY- RETURN ACTERISTICS A FUNCTION DATA OPTIMIZATION FUR NEXT OUTPUT OF LENGTH TABULATION (FIXED POWER) CASE	AFTER 18 INPUT SECTIONS; AND ACCURLING TO THE FULLOWING CONDITIONS         SUMMARY       PLOTTING AS       INPUT       VELOCITY-       RETURN         SUMMARY       PLOTTING       OPTIMIZATION       FILE       CASE         OF LENGTH       TABULATION       (FIXED POWER)       CASE         Sumput       7-8       9-10       IL-15       I6-20	AFTER 18 INPUT SECTIONS, AND ACCURLING TO THE FULLOWING CONDITIONS -         SUMMARY       PLOTTING AS       INPUT       VELOCITY-       RETURN         SUMMARY       PLOTTING AS       INPUT       VELOCITY-       RETURN         SUMMARY       PLOTTING AS       INPUT       VELOCITY-       RETURN         ACTERISTICS       A FUNCTION       DATA       OPTIMIZATION       FUR KAT         OUTPUT       OF LENGTH       TABULATION       (FIXED POWER)       CASE         S-6       7-8       9-10       11-15       16-20         S-6       ************************************	AFTER 18 INPUT SECTIONS, AND ALCUKLING TO THE FULLOWING CONDITIONS         SUMMARY       PLOTTING AS       INPUT       VELOCITY-       RETURN         OUTPUT       OF LENGTH       TABULATION       (FIXED POWER)       CASE         S-6       7-8       9-10       11-15       16-20         S-6       7-8       9-10       11-15       16-20         NO       NONE       YES (CHOSEN)       YES       YES
---	--	----------------------------	--	------------------------------------	---------------------------------	---	----------------------------------	---	--	---	---	---	--	---	--
	ITES DPTICNAL, NCN-REGU TES MANDATCRY INPUT PA TTES SUPERFLUCUS INPUT 1 TTES OPTICNAL INPUT DAT		CASE TUNNEL UNITS SEQ. TYPE NO.	-04	1 3 4	++ ++ -6 2 +		CASE TERMI AFTER 18 INP		SUMMARY	SUMMARY CHARACTERISTICS OUTPUT	SUMMARY CHARAC TERI STICS OUT PUT	SUMMARY CHARACTERISTICS OUTPUT DE 5-6	SUMMARY CHARACTERISTICS OUTPUT E . 5-6	SUMMARY CHARACTERISTICS OUTPUT DE 001PUT 001PUT 00 01PUT 00
*	• EMPTY* INDICA • ERROR* INDICA • EXTRA* INDICA • OPT*A* INDICA			CATA ETELD BEGT	IN CARC COLUMN							TERMINATICN-CCD DATA FIELD IS CONTAINED IN	TERMINATICN-CCD DATA FIELD IS CONTAINED IN CARD CCLUMNS	TERMINATICN-CCDI DATA FIELT IS CONTAINED IN CARD CCLUMNS	TERMINATICN-CCDI Data FIELD IS Contained In Card Cclumns

	BLE.		O E P S	PER- CENT	76	+									
	POSSI POSSI VED.		ETA	PER- CENT		İ									
	D AS ZE Ion IS E Remov Ved Val		RNREF . RUFNES	1016), 101-6) 4ETERS	9	+						Nild		N.140	
	ITENDE( IPUTATI May Be Termin		CO K			+			1					J	
	BE IN IRE COM D AND		KE XP ME SH T 90		ہ   ہو	+					N • Id	N • 1d	PT . N	N.I.d	PT•N
	ER MAY D BEFO UT CAR T TO A		Y Y IHd	DEG		+					0	0.00.0		0.00	
	ARAMET RRECTE UN INP DEFAUL		LKGE RSTY	PER- CENT	ہ   ہ	+ + 1						6		6	
NO	D CR P BE CO HILL		HORD B DHUB P MF SH	Σ	+   +	+						9144		9144	
BULATI	DMITTE S MUST LV INCI AMETER	DATA	/DH, CI /AL D	2 2 3.	t 4	+						••		•	
ATA TA	BEEN • THI ESSARI HE PAR	PTION	W2 L D2 S	τ. Σ	m I	+	. 992	.615	.572	.572	161.	• 896	.048	•048	•496
NPUT D	ER HAS MITTED UNNEC AND T	DESCRI	H2	Ξ	n v	+	.944 8	.409 3	.380 3	.380 3	.962 5	.962 2	.962 3	•962 3	4
ATED I	ARAMETI BEEN OI S BEEN MITTED	CTION		Σ	2	+	7620 5	020 2	524 2	353 2	6.31 3	896 3	896 3	.048 3	. 706
ANNCT	VPUT PV R HAS ( TER HA) BEEN OF	SEC	M1 D1	Σ	2	+	.9920.	9 266	572 1	572 3.	572 10	896 2	.896 2	048 3	048 6.
	RED IN Ameter Paramet A has e		Π	Σ	1	+	944 8.	544 8.	380 3.	380 3.	380 3.	962 2.	562 24	962 3.	962 3.
	H-REQUI		EMS DER DUCT	0	6	+ +	5,	5.	5	3,	5	3	3,	M	'n
	NL, NUN NRY INF UDUS 1 NL INPL		ITAL IT 10. F			++						2.	2.	2.	2•
	IPT ION/ ANDATO SUPERFI		LT TI		, v	+	2	8	2	2	7	2	2	2	1
	ATES C ATES N ATES N ATES S ATES C		CT. SE	, ) ,	SINS 5	+	2	2	5	2	2	2	2	2	2
	INDI (		PE IN SE		CCLUMA	++	01	20	10		40	11	84	11	84
	EMPTY ERROR EXTRA		ECT. SE EQ. 11		ITA FIE CARC	+	-	2	m	4	5	9	7	80	σ
1			line series		101										

۰.

¥

UNIVERSITY OF WASHINGTON 8- BY 12-FOOT WIND TUNNEL

¥

PAGE

5

...CUNTINUED....

			VINU	ERSITY	OF WA	SHINGTC	8 -8 NC	N 12-F	00T M 1	IND TUP	UNEL		•		···CON	TI NUED		PA	<u>6</u> E 6
								ECT ION	I DESCR	UPTIO	V DATA								
SECT. SE	CT.	SECT.	SECT.	TOTAL	I TEMS	1H	12	-	Н2	32	L/DH.	CHORD	BLKGE PRSTY	рні	K E X P KME SH	θ, <del>π</del>	RNREF.	ETA	D EPS
INPUT	J L	INLET SHAPE	SHAPE	DUCT			10				л и, SQ И,	DHESH	PER-		KT 90		10(6), 10(-6)	PER-	PER-
				ND.	NO.	T	Ŧ	T	Ξ	I	SQ M	Ξ	CENT	DEG			METERS	CENT	
DATA FIE		SEGINS															,,	16	4
I LANU	3	5	9	2	6	11	16	21	26	31	36	41 + + 1 + + 1	4 Q	21 1 2 1 2	s †	1			
\$	‡	+	+	\$	\$	+					•								
10	92	-	-	2.	4.		4.496	0.4572		4.496		0.9144	2.045						
=	6	1	T	2.	4		4.496	1.219		4.496	0.0556	0.9144	2.045		0	• 0100		95.00	EMPTY
1 2	46	• •	-	2.	0P T • A	-	4•496	1.676		4.496		0.9144	EMPTY		Nº 140				
13	84	1	2	2.			4.496	6.401	4.496	4.496					N.140				
71	84	2	2	2.		4.496	4.496	10.59	5.944	4.496		1			OPT • N				
15	61	2	2	~		5.944	4.496	0.7620	5.944	4.496	_								
16	11	2	2	2.		5.944	4.496	4.496	5.944	4.496		0. 5486		90.00	N.140		0PT • N		
17	61	2	2	2.		5. 544	4.496	0.5715	5.944	4.496									
18	7	2	2	2•		5.944	4.496	4.496	5.944	4.496		0.8534		90.00	0PT•N		0PT•N		
: :			CN	IVERSI	TY OF	MASHING	TON 8-	BY 12	-F001	NIND 1	UNNEL			*• CV	ISE COM	PLETED	OR TE	RMINAT	ED. **

			06/40	+	0.00382	0.10399	0 • 00060	0.01296	0.00258	0.01545	0.00885	0.02008	0.01433
			DP/QL	++	0.00382	0.10399	0.00013	0.01578	0.00285	0.01708	0.01019	0.03618	0.10037
			LENGTH Meters	++	23.11	17.07	4.57	5.18	9•45	3.81	5.77	31.55	15.39
			MACH1 MACH2	++	0.031 0.155	0.155 0.083	0.083	0.141 0.120	0.120 0.148	0.148 0.148	0.115	0.115 0.058	0.058 0.056
DRMANCE			V1 V2 M / SEC	++	10.6	52.7 28.4	28.4	47.7 40.9	40.9 50.1	50.1 50.1	49.1 39.2	39.2 19.8	19.8 19.0
INEL PERF		15.05 N/S	2 THETA	++	39,99	16.45	45.83	12.61	6.35		11.74	8.23	1.79
NUD-TUN		= 168	AR, CR	++	4.93	1.84	1.67	1.16	1.22	ť	1.25	1.97	1.04
EC TI ON	/SQ M. M.	RESSURE	A1/A0 A2/A0	++	4 • 53 1 • 00	1.00	1.84	1.10 1.28	1.28 1.05	1.05	1.07	1.34 2.63	2.63
PEN-TEST-S	101325.0 N 325.0 N/SQ	DEG K. D YNAMIC P	AREAL Area2 So M	++	735.76 149.30	149.30 275.30	275.30 164.56	164.56 191.63	191.52 156.89	156.89 156.89	160.02 199.87	199.87	393.12 410.23
ETURN, DI	HERES = tes = 101	= 288.00 0 KNOTS.	W1,D1 W2,D2 MFTFRS	+	33.52 18.29	18.29 23.01	23.01 19.20	19.20 20.96	11.57 10.80	10.80 10.80	10.80 11.28	11.2E 14.02	14.02 14.63
JOUBL E-RE	OO ATMOSF Atmospher	35 DEG C = 102.5	H1 H2 Meters	++	21.95 9.14	9.14 13.72	13.72 9.60	9.60 10.21	10.21			14.02	14.02
-	= 1.0( NS 1.000 /	= 14.8	SHAPE	++	RECT FL 0	FL 0	FL 0	FL 0	FL 0 CIRC	CIRC	CIRC	CIRC	RECT
	ATMOSPHERIC PRESSURE Test section condition Total Pressure =	TOTAL TEMPERATURE Velocity = 52.73	NO. SECTION TYPE	++ ++	I CONTRACTN, SINGLE	2 OPEN-THROAT T SECI	3 CONTRACTN, SINGLE	4 DIFFUSER	5 FAN CONTRACTION	6 FAN DUCT & STRUTS	7 FAN DIFSRECNTR BDY	8 MULT DLCT DIFFUSER	9 M D 2-WALL CIF CNF

PAGE 1

¥

NASA-LANGLEY RESEARCH CENTER 30- BY 60-FOOT WIND TUNNEL

•

* NASA	A-LANGLI	EY RESEAR	CH CENTER	30- BY 60	-F00T W	IND TUN	NEL	*	J	ONTINUED	•	PAGE 2
NO. SECTION TYPE	SHAPE	Η	MI,DI	AREAL	A 1 / A0	AR, CR	2 THETA	VI	MACHI	LENG TH	DP/QL	00/40
		H2	W2,D2	AREA2	A2/A0			٧2	MACHZ			
		METERS	METERS	SO H	•	•	DEGREES	M/SEC		METERS		
++ ++	<b>†</b>	+	•	•		+	++					
10 MULT DUCTS, CNST A	A RECT	14.02	14.63	410.23	2. 75			19.0	0.056	2.59	0.00134	0.00018
	RECT	14.02	14.63	410.23	2.75			19.0	0.056			
11 M D 2-WALL CIF CNR	R RECT	14.02	14.63	410.23	2.75	1.04	1.69	19.0	0.056	16.00	0.10033	0.01315
	RECT	14.02	15.24	427.33	2.86			18.2	0.054			
12 MULT DUCT CIFFUSER	RECT	14.02	15.24	427.33	2.86	1.57	2.36	18.2	0.054	100.60	0.05122	0.00619
	RECT	21.95	15-24	669.04	4.48			11.6	0.034			
13 M D 2-WALL EIF CNR	RECT	21.95	15.24	669-04	4.48	1.05	2.55	11 •6	0.034	16.15	0.10053	0.00495
	RECT	21.95	16.00	702.40	4.70			11.1	0.033			
I T MILT VIICTS, CNST	A RECT	21.95	16.00	702-40	4.70			11.1	0.033	0.53	0.00022	0.0000
	RECT	21.95	16.00	702.40	4.70			11.1	0.033			
IS M DI-MAIL LIE CND	DECT	21.95	16.00	702.40	4-70	1-05	2.38	11.11	0.033	16.92	0.09771	0.00436
	RECT	21.95	16.76	735.76	4.93			10.6	0.031			
									•			
						-	DTAL CENT	ERLINE L	ENGTH =	268.70	METERS	
PERFORMANCE SUMMARY -	!											
TOTAL PRESSLAE LOS Total Power	5S (DP/	q0) = 0.2	1149	ENERGY RA	* 011	4.728						
INPUT TC FLOW 2802290. WATTS	0UT 31	PUT REQUI 13654. WA	RED A	VERAGE PER 1556827. M	FAN ATTS	FAN 90.0	EFFICIENC 0 PERCEN	~ _	DTAL NUM	IBER OF F	ANS	n 
		MA	XIMUM VEL	OCITY FDR	A SPECI	FIED PO	WER CONSUL	NOI 14				
THE MAXIMUM TEST SECT VELOCI	TION FL	DW ACHIEV 65.66	ABLE WITH M/SEC =	5967994. 127.63 KND	WAT TS TS	OF POWE	R AVAILABI	E IS AP	PROXIMAT	ELY AS F	DLLOWS	
DYNAM	NUMBER	0.19 SURE	2595.44	N/SQ M								

	44Y BE INTENDED AS ZERC. EFORE COMPUTATION IS POSSIBLE. ZARD AND MAY BE REMOVED. D A PREDETERMINED VALUE.		T P ATM	3 C ATM		.85 OPT'N		) 4) NS	KETURN	FUR NEXT CASE	16-20	+==+++++++++++++++++++++++++++++++++++	YES
ATION	TTED CR PARAMETER N UST BE CORRECTED BE INCLUDED DN INPUT C TER WILL DEFAULT TO	TA	VO POWER PT T Level Mega-	SEC WATTS ATM DEC 31 36 41	+ ++ ++ +	.73 5.968 1.000 14.	DATA	CARD COLUMNS 3 AND FOLLOWING CONDITIO	VELOCI TY-	OPTIMIZATION (Fixed Power)	11-15	+	YES
D INPUT DATA TABUL	METER HAS BEEN OMI N Omitted. This m Een Unnecessarily Ted and the parame	MASTER CONTROL DA	HI WI MODEL DI BLKGE PER-	M M CENT M/ 16 21 26	-+ ++ ++ +	144 18.29 EMPTY 52	INATION CONDITIONS	(DUE TO BLANKS IN D ACCORDING TO THE	INPUT	DATA	01-6	++	YES (CHOSEN)
ANNCTATE	EQUIRED INPUT PARA Parameter Has Bee Ut Parameter Has B Ut Parameter Has B Data Has Been Umit	T UNNEL	ITS SECT. SECT. INLET EXIT SHAPE SHAPE	4 5 6 11	+ +	1 3 3 9.	CASE TERM	RMINATION OCCURRED INPUT SECTIONS, AN	PLOTTING AS	A FUNCTION OF LENGTH	7-8	+	NONE
	ES DPTIONAL, NON-RI ES MANDATORY INPUT ES SUPERFLUOUS INPUT ES OPTIONAL INPUT		CASE TUNNEL UN SEQ. TYPE NC.	1 3	+ + +	-7 5		CASE TE	SUMMARY	CHARACTERISTICS DUTPUT	5-6	+	ON
	• EMPTY• INCICATE • FRROR• INDICATE • EXTRA• INDICATE • OPT• № INDICATE			DATA FIELC BEGINS In Card Column						TERMINATION-CCDE	DATA FIELD IS Contained in Card Cclumns		

¥

PAGE 3

...CONTINUED....

¥

NASA-LANGLEY RESEARCH CENTER 30- BY 60-FODT WIND TUNNEL

4		•		Sdi	R- NT		t						τy	I		1
AGE		1919		0	<b>a</b> 3	76	ļ						EMP			
1		RD. POSS	•	ETA	PER- CENT		Ī						0.00			
		S 2E IS EMOV		EF. Ne S	61. -61 ERS	-	+ + +						6			z
		ED A TION BE R		RUF	10( 10(	<b>6</b> 6	ļ									140
INUE		TEND PUTA HAY		e ×		<b>-</b>	t						0010			
CONT				4X HS 00		ه	+				z		•	z	z	z
•		AY B FORE ARD	E I	X X X X X X X X X X X X X X X X X X X		56	ł				0PT			Ido	140	140
		D BE	-	ІНА	DEG		Ť			l						00.0
*		AMET ECTE TNP		1 CE		5	+			1		10	10	51		6
		PAR CORR D ON	2	PRS	E P P	4 6	ļ					2.3	2.3	1.3		
	S			HORD DHUB MESH	x	-						•453	.453	•453		.134
NEL	LATI	MUST	TA	н, с	Î Ì I	4	+++++++++++++++++++++++++++++++++++++++					en	6 66			2
3I	TABU	N OM HIS RILY		L/D S/A	x 3 a s	36 36	ļ					-	0.66			
MIND	ATA	BEE BEE	PTIC	M2 D2	Σ	1	Ì	.8.29	10°E	9.20	0.96	0.80	0.80	1.28	4.02	4.63
100	11	A HAS	SCRI	12	-		+	44 ]	72 2	101	21 2	-			02 1	02 1
60-6	IN C				-	26	ļ	L 9.	1 13.	9.6	10	•			5 14.	9 14
ΒY	<b>LATE</b>	BEEN BEEN AS BE		-	Ξ	12		23.11	17.07	•-57	.182	9•440	.810		31.55	15.3
90-	ANNO	PUT I HAS		17	-		1	52	29 ]	10.	20	51	80	80	28	02
ENTE		D INI ETER AMETI			-	16	ļ	5 33.	÷ 18.	2 23.	19,	11	10.	10,	11	2 14.
U U U U		UI REI ARAMI PAR		IH	Σ	1		21.9	9.141	13.7	9-60	10.2]				14.0
SEAR				ENS ER UC T			+		•				2.			
Y RE		NCN I ND			Z											1
NGLE		NAL. TORY FLUO	NAL	TOTA NO.	ON N	-	+					2.	2.	~	2.	2.
A-LA		PT10		CT.		, o	+	۳	e	e	m		-		2	2
NAS		ES B	ם   נו	- SE SH		<u>s</u> i						_				
		DI CAT	1111	SECT INLE		SEGIA MN -	+	2	(T)	(n)	m	m)			-	
		INC	Ž			COLU COLU	+	20	N)	20	40	55	16	45	84	15
*		PTY ROR		- S - T		ARC										
			5	SECT		DATA IN C	Ŧ		τ <b>Ν</b>	l.	4	ŝ	6		30	b,

5		PS	i de la como de la com	IN I		ţ							*
AGE		0	6	3	76	Ļ							E0.
ā		ETA	PER-	CENT	11	+							MINAT
•		UFNEE .	0(6),	IE TERS	Q.	+		N. 14		N.Id		N • 1 d	IR TER
JED.		~ ~		Σ	Ŷ	+ +						0	0.0
NTIN		5-			61								PLETE
		KE XP KMESH	KT 90		56	+		N 1 10	0PT I N	0PT • N		N.140	SE COM
*		Іна		DEG	51	† 		90.06		90.00		00 <b>•</b> 06	*• CA
		BLKGE PRSTY	PER-	CENT	46	†   							
		CHORD DHUB	DMESH	I	41	+		2.134		1.067		1 • 067	<u>ب</u>
TUNNEL	I DATA	L/DH, S/AL	А/H, Su н,	S.D. R	36	+							TUNNE
<b>DNIM</b>	I PTI ON	N2 02		Σ	31	ţ	14.63	15.24	15.24	16.00	16.00	16.76	T WIND
0-F001	DE SCR	НZ		Σ	26	+	14.02	14.02	21.95	21.95	21.95	21.95	6 0- FOD
Η BY 6	ECTION		-	Σ	21	++	2.591	16.00	100.6	16.15	. 5334	16.92	<u>е</u> Вү
TER 30	0	1M 10		I	16	<b>†</b>	14.63	14.63	15.24	15.24	16.000	16.00	NTER 3
CH CEN		14		Σ	11	+ +	14.02	14.02	14.02	21.95	21.95	21.95	RCH CE
RESEAR		I TEMS PER	DUCT	NO.	6	‡							RESEA
NGLEY		TOTAL ND.	DUCTS	•0N	1	<b>‡</b>	2.	2.	2.	2.	-2.	2.	ANGLEY
AS A-LA		SECT.	SHAPE		¢	+	2	~	2	2	2	2	VASA-L
ĨN		SECT.	SHAPE	EGINS	5	•	2	2	7	2	2	2	-
		SEC T .			9	‡	61	75	84	75	61	74	
*		SECT.	INFUT	DATA F IN CARI	1	:	10	T	12	13	14	15	* • * *

- McDonald, Alan T.; and Fox, Robert W.: Incompressible Flow in Conical Diffusers. Tech. Rep. No. 1, Army Research Office (Durham), Project No. 4332, 1964. (Available from Armed Services Technical Information Agency, U.S. Department of Defense.)
- Reneau, L. R.; Johnston, J. P.; and Kline, S. J.: Performance and Design of Straight, Two-Dimensional Diffusers. Trans. ASME, Journal of Basic Engineering, Vol. 89, March 1967, pp. 141-150.
- 3. Rouse, Hunter; and Hassan, M. M.: Cavitation-Free Inlets and Contractions. Mechanical Engineering, Vol. 71, March 1949, pp. 213-216.
- 4. Pope, Alan; and Harper, John J.: Low-Speed Wind Tunnel Testing. John Wiley & Sons, Inc., N. Y., 1966.
- 5. Pankhurst, R. C.; and Holder, D. W.: Wind-Tunnel Technique. Sir Isaac Pitman & Sons Ltd., 1952.

- Wattendorf, Frank L.: Factors Influencing the Energy Ratio of Return Flow Wind Tunnels. Fifth International Congress for Applied Mechanics, Cambridge, 1938, pp. 526-530.
- 7. Idel'chik, I. E.: Handbook of Hydraulic Resistance. AEC-TR-6630, The Israel Program for Scientific Translations Ltd., 1966. (Available from Clearinghouse for Federal Scientific and Technical Information, U.S. Department of Commerce.)
- 8. Kröber, G.; (translated by Dwight M. Miner): Guide Vanes for Deflecting Fluid Currents With Small Loss of Energy. NACA TM-722, 1933. (Transl. into Engligh of "Schaufelgitter zur Umlenkung von Flüssigkeitsstromungen mit geringem Energieverlust," Ingenieur-Arkiv, Vol. 3, 1932, pp. 516-541.)
- 9. Henry, John R.; Wood, Charles C.; and Wilbur, Stafford W.: Summary of Subsonic-Diffuser Data. NACA RM L56F05, 1956.
- 10. Moore, Carl A., Jr.; and Kline, Stephen J.: Some Effects of Vanes and of Turbulence in Two-Dimensional Wide-Angle Subsonic Diffusers. NACA TN 4080, 1958.
- Cochran, D. L.; and Kline, S. J.: Use of Short Flat Vanes for Producing Efficient Wide-Angle Two-Dimensional Subsonic Diffusers. NASA TN 4309, 1958.
- 12. Wallis, R. A.: Axial Flow Fans. Academic Press, N. Y., 1961.
- Chmielewski, G. E.: Boundary-Layer Considerations in the Design of Aerodynamic Contractions. J. of Aircraft, Vol. 11, No. 8, Aug. 1974, pp. 435-438.

- Eckert, William T.; Mort, Kenneth W.; and Piazza, J. E.: Wind-Sensitivity Studies of a Non-Return Wind Tunnel With a 216- by 432-mm (8.5- by 17.0-in.) Test Section - Phase I. NASA TM X-62,171, 1972.
- Eckert, William T.; Mort, Kenneth W.; and Piazza, J. E.: Wind-Sensitivity Studies of a Non-Return Wind Tunnel With a 216- by 432-mm (8.5- by 17.0-in.) Test Section - Phase II. NASA TM X-62,307, 1973.
- 16. Mort, K. W.; Eckert, W. T.; and Kelly, M. W.: The Steady-State Flow Quality of an Open Return Wind Tunnel Model. Canadian Aeronautics and Space Journal, Vol. 18, No. 9, Nov. 1972, pp. 285-289. (Also NASA TM X-62,170, 1972.)
- 17. Liepmann, H. W.; and Roshko, A.: Elements of Gasdynamics. John Wiley & Sons, Inc., N. Y., 1957.
- Staff of Ames Research Center: Equations, Tables, and Charts for Compressible Flow. NACA Report 1135, 1953.
- Sovran, Gino; and Klomp, Edward D.: Experimentally Determined Optimum Geometries for Rectilinear Diffusers with Rectangular, Conical or Annular Cross-Section. Fluid Mechanics of Internal Flow, Gino Sovran, ed., Elsevier Publishing Co., Amsterdam, 1967, pp. 270-319.
- 20. Annon: Low-Speed Wind Tunnel User Manual. Lockheed-Georgia Company, ER-11,000, 1970.
- 21. Krishnaswamy, T. N.; Ramachandra, S. M.; and Krishnamoorthy, V.: Design and Characteristics of the 14' × 9' Open Circuit Wind Tunnel. Proc. of the 11th Seminar on Aeronautical Sciences, National Aeronautics Lab., Bangalore, 1961, pp. 417-434.
- 22. Krishnaswamy, T. N.: Selection of the Electric Drive for the 14' × 9' Wind Tunnel. Journal of the Aeronautical Society of India, Vol. 7, No. 2, May 1955, pp. 19-28.
- 23. Krishnaswamy, T. N.; and Ramachandra, S. M.: Fan System of the 14' × 9' Open Circuit Wind Tunnel of the Indian Institute of Science. Journal of the Aeronautical Society of India, Vol. 18, No. 2, May 1966, pp. 47-61.
- 24. Kirk, J. A.: Experience With a V/STOL Tunnel. Journal of the Royal Aeronautical Society, Vol. 71, Sept. 1967, pp. 606-622.
- DeFrance, Smith J.: The N.A.C.A. Full-Scale Wind Tunnel. NACA Report 459, 1933.

Code type	Code value	Description of code meaning
Tunnel type	1	Closed test section, single-return tunnel
	2	Closed test section, double-return tunnel
	3	Closed test section, non-return tunnel
	4	Open-throat, single-return tunnel
	5	Open-throat, double-return tunnel
↓ ◆	6	Open-throat, non-return tunnel
Units of measure	1	International System of Units (SI)
↓ ↓	2	U.S. Customary Units
Section shape	1	Circular cross section
1 1	2	Rectangular cross section
	3	Flat oval cross section (ceiling and floor
↓		parallel with semicircular sidewalls)
Section type		(See table 4)
Plot type	<u>≤</u> 0.0	No plots
	1.0	Cummulative pressure losses vs circuit length
	2.0	Wall pressure differential vs circuit length
	>2.0	Cummulative pressure losses and wall pressure differential vs circuit length (on separate plots)

#### TABLE 1.- NUMERIC INPUT CODE DEFINITIONS

TABLE 2.- TUNNEL MASTER CONTROL INPUT DATA DESCRIPTIONS

Units			1					m or ft		m or ft			% of	test	section	area	m/sec	or	ft/sec	10 <sup>6</sup> W	or	10 <sup>3</sup> hp	ATM		°C or	ч Р	ATM	
Description(s)	Master card identifier	Arbitrary user case number	Tunnel type code (see table 1)	Units of measure code (see table 1)	Test section upstream end shape code	(see table 1)	Test section downstream end shape	Coue (see table 1) Height of rectangular or flat oval	test section at upstream end	Width of rectangular or flat oval, or	diameter of circular test section	at upstream end	Blockage factor of the model in the	test section (if model is to be	included)	- *	Test section velocity for which	power calculation is to be made		Power for which maximum attainable	velocity is to be calculated (if	velocity-optimizing is requested)	Test section total (stagnation)	pressure	Test section total (stagnation)	temperature	External atmospheric pressure	
Input type	Minus sign	Integer	Integer	Integer	Integer		Integer	Real		Real			Real				Real			Real			Real		Real		Real	
Requirement? <sup>a</sup>	Required	Optional	<b>Optional</b>	<pre>Default(1)</pre>	Required	•	Uptional	Geom. Dep.		Required			Optional				Required		<u></u>	Optional			Default(1.0)		Required		Default(1.0)	
Field title(s)	UAS ASV	- Date 360.	TUNNEL TYPE	STINU	SECT. INLET	SHAPE	SECT. EXIT	SHAFE H1		W1, D1			MODEL BLKGE				0Λ			POWER LEVEL			PT		TT		P ATM	
Card column(s)	1	7	e	4	Ś		Q	11-15		16-20			21-25				26-30			31-35			36-40		41-45		46-50	

"Default(X)" indicates the input is optional and defaults to X if omitted. "Geom. Dep." indicates the input requirement is dependent on section geometry. "Optional" indicates the input may be selected and included as desired. "Required" indicates the input must be non-zero and included for all cases or the case will terminate

due to input error.

TABLE 3.- SECTION INPUT DATA DESCRIPTIONS

Units	1					1				n or ft	ŭ	n or ft			n or ft	n or ft		m or ft			n/m or	ft/ft,	n <sup>2</sup> /m <sup>2</sup>	or, or	ft <sup>z</sup> /ft <sup>z</sup>	n or ft		
Description(s)	Arbitrary section order number	Section type code (see table 4)	Section upstream end shape code	(see table 1)	Section downstream end shape code	Number of multiple ducts	Number of individual, flow	obstruction, drag loss items in	local duct	Height of upstream end of non-	circular section	Width of non-circular, or diameter	of circular section at upstream	end	Centerline length of section	Height of downstream end of non-	circular section	Width of non-circular, or diameter	of circular section at downstream	end	Length-to-hydraulic diameter, ratio	of flow straightener cells, or	drag-area-to-local-duct-flow-area	ratio for each flow obstruction	drag item	Hub diameter of fan-drive section,	or turning vane chord length, or	mesh screen wire diameter
Input type	Integer	Integer	Integer		Integer	Real	Real			Real	1	Real			Real	Real		Real			Real					Real		
Requirement? <sup>a</sup>	Optional	Required	Required		Required	Default(1.0)	Default(1.0)			Geom. Dep.		Required			Sect. Dep.	Geom. Dep.		Required			Sect. Dep.					Sect. Dep.		
Field title(s)	SECT. SEQ.	SECT. TYPE	SECT. INLET	SHAPE	SECT. EXIT	TOTAL NO.	DUCTS TTEMS PER	DUCT		HI		Wl, Dl			l	H2		W2, D2			L/DH,	S/AL				DHUB, CHORD,	DMESH	
Card column(s)	1-2	3-4	Ŝ		9	7-8	9-10			11-15		16-20			21-25	26-30		31-35	-		36-40					41-45		

TABLE 3.- SECTION INPUT DATA DESCRIPTIONS - Concluded.

Units	each % of % or local	s, area angle, deg	er		of too	lue lue	hich $10^6$ , n, or $10^{-6}$ m	or 10 <sup>-6</sup> ft	% % over	or 100%	an internally-
Description(s)	Local flow area blockage due to obstruction in the local duct	porosity of 110W straigntener screen, perforated plate Corner flow centerline turning $0^{\circ} < \phi < 90^{\circ}$	Diffuser expansion loss paramet (see fig. 4), or	mesh screen loss constant, or turning vane loss parameter a $\phi = 90^{\circ}$	empty corner loss parameter a $\phi = 90^{\circ}$	Drag coefficient of flow obstru- or fixed, known local loss va	Reference Reynolds number for w 90° corner loss value is give	surface roughness of flow straightener material	Efficiency of fan drive system Additional (amount over 100%)	downstream influence factor f flow obstruction items	section type, which defaults to
Input type	Real	Real	Real			кеал	Real		Real Real		dependent on
Requirement? <sup>a</sup>	Sect. Dep.	Sect. Dep.	<pre>Default(INT) Default(1.3)</pre>	Default(0.15)		Sect. Dep.	Default(0.5) Default(.0001m)		Default(100.0) Sect. Dep.		optional input.
Field title(s)	BLKGE PRSTY	IHd	KEXP KMESH	KT 90	Ę	R CD	RNREF, RUFNESS		ETA D EPS		T)" indicates
Card column(s)	46-50	51-55	56-60		Ľ	C9-T9	66-70		71-75 76-80		a"Default(TN

generated, geometry-dependent value if omitted. "Default(X)" indicates optional input, dependent on section type, which defaults to X if omitted.

"Geom. Dep." indicates the input requirement is dependent on section geometry.

"Optional" indicates the input may be selected and included as desired.

"Required" indicates the input must be non-zero and included for all sections or section will be skipped and case terminated due to input error.

"Sect. Dep." indicates the input requirement is dependent on section type.

# TABLE 4.- ADDITIONAL, SECTION-DEPENDENT INPUT REQUIREMENTS

Section		Additional		Card column(s)
Type description		input title(s)	Requirement? <sup>a</sup>	
Single ducts: Test section, closed, constant area, empty	01			
Test section, closed, constant area with model	02	S/AL BLKGE CD D EPS	Required Optional Required Optional	36-40 46-50 61-65 76-80
Test section, closed, diffusing, empty	03	KEXP	Default	56-60
Test section, closed diffusing,with model	04	S/AL BLKGE KEXP CD D EPS	Required Optional Default Required Optional	36-40 46-50 56-60 61-65 76-80
Test section, open-throat, empty	05		-	
Test section, open-throat, with model	06	S/AL BLKGE CD D EPS	Required Optional Required Optional	36-40 46-50 61-65 76-80
Constant-area duct	10			
Corner, constant-area, turning vanes only	30	CHORD PHI KT 90 RNREF	Required Required Default Default	41-45 51-55 56-60 66-70
Corner, constant-area, with turning vanes and walls	32	CHORD PHI KT 90 RNREF	Required Required Default Default	41-45 51-55 56-60 66-70
Corner, constant-area, with walls and without turning vanes	33	PHI KT 90	Required Default	51-55 56-60
Corner, diffusing, with turning vanes and walls	34	CHORD PHI KT 90 RNREF	Required Required Default Default	41-45 51-55 56-60 66-70
Diffuser Exit kinetic energy from flow	40 45	KEXP	Default	56-60
dump Sudden expansion	46			

TABLE 4.- ADDITIONAL, SECTION-DEPENDENT INPUT REQUIREMENTS - Continued.

Section		Additional		
Type description	Type code	input title(s)	Requirement? <sup>a</sup>	Card column(s)
Flow straighteners, thin honeycomb		L/DH PRSTY BUENESS	Required Required	36-40 46-50 66-70
Flow straighteners, thick	52	L/DH PRSTY	Default	36-40
Perforated plate with sharp- edged orifices	53	PRSTY	Required	46-50
Woven mesh screen	54	DMESH PRSTY KMESH	Required Required Default	41-45 46-50 56-60
Internal structure (drag item(s)) at upstream end of section	56	ITEMS S/AL BLKGE CD	Default Required Optional Required	9-10 36-40 46-50 61-65
Fixed, known local loss item at upstream end of section	57	D EPS K	Optional Required	75-80 61-65
<u>Multiple ducts</u> : Constant-area ducts Contractions Corners, constant-area; turning vanes only	61 62 70	DUCTS DUCTS DUCTS CHORD	Required Required Required Required	7-8 7-8 7-8 41-45
Corners, constant-area, with turning vanes and only one side-wall each	71	PHI KT 90 RNREF DUCTS CHORD PHI KT 90	Required Default Default Required Required Required Default	51-55 56-60 66-70 7-8 41-45 51-55 56-60
Corners, constant-area, with turning vanes and walls	72	RNREF DUCTS CHORD PHI KT 90	Default Required Required Required Default	66-70 7-8 41-45 51-55 56-60
Corners, constant-area, with walls and without turning vanes Corners, diffusing, with turning vanes and only one side-wall each	73	KNREF DUCTS PHI KT 90 DUCTS CHORD PHI KT 90 RNREF	Default Required Default Required Required Required Default Default	66-70 7-8 51-55 56-60 7-8 41-45 51-55 56-60 66-70

TABLE 4.- ADDITIONAL, SECTION-DEPENDENT INPUT REQUIREMENTS - Concluded.

Section		Additional		
Type description	Type code	input title(s)	Requirement? <sup>a</sup>	Card column(s)
Corners, diffusing, with turning vanes and walls	75	DUCTS CHORD PHI KT 90 RNREF	Required Required Required Default Default	7-8 41-45 51-55 56-60 66-70
Diffusers	84	DUCTS KEXP	Required Default	7-8 56-60
Vaned diffuser	85			
Sudden expansion from multiple ducts to single duct	86	DUCTS	Required	7-8
Sudden expansion from multiple ducts to multiple ducts	87	DUCTS	Required	7-8
Fan, constant-area annular	91	DUCTS	Default	7-8
duct(s) with motor-support	ļ	ITEMS	Default	9-10
strut(s)		S/AL	Required	36-40
	Į	DHUB	Required	41-45
		BLKGE	Optional	46-50
		CD	Required	61-65
		ETA	Default	71-75
	]	D EPS	Optional	75-80
Fan contraction(s) to annular	92	DUCTS	Default	7-8
duct(s) with motor-support		ITEMS	Default	9-10
strut(s)		DHUB	Required	41-45
		BLKGE	Optional	46-50
Fan diffuser(s) from annular	94	DUCTS	Default	7-8
duct(s), each with tapering,		DHUB	Required	41-45
cone-shaped centerbody		BLKGE	Optional	46-50
		KEXP	Default	56-60
Internal structure (drag	96	DUCTS	Required	/-8
item(s)) at upstream end of		TTEMS	Default	9-10
each duct		S/AL	Required	36-40
		BLKGE		40-50
			Required	75 00
	07	DEPS	Optional	
Fixed, known local loss item	9/		Required	/-8
at upstream end of each duct	1	ĸ	Kequirea	C0-T0

<sup>a</sup>"Default" indicates the input is optional and has a default value if omitted (see table 3).

"Optional" indicates the input may be selected and included as desired. "Required" indicates the input must be non-zero and included for all sections of the specified type or the section will be skipped and the case not completed due to input error.

### TABLE 5.- CASE TERMINATION TASK DESCRIPTIONS

Card column(s)	Input type	Input value	. Task description
3-4	Blanks	Blanks	Case termination card identification
O	Integer	0	Non-print
		<b>≠</b> 0	Print
7-8	Real		Plotting of summary information as a function of distance through circuit:
		_≤0.0	No plots
1	ļ	1.	Cummulative pressure loss
	1	2.	Wall pressure differential
		>2.	Cummulative pressure loss and wall pressure differential
9–10	Real		Complete, annotated tabulation of input
		0.0	No print unless internally forced by omission of required inputs
	ļ	≠0.0	"Chosen" tabulation
11-15	Real		Power-matching (optimizing velocity for a specified power level):
		0.0	No velocity optimization
1	}	≠0.0	Velocity optimization
16-20	Real		Return to beginning for evaluation of another case:
		0.0	No return, program termination
		<b>≠0.0</b>	Return

TABLE 6.- COMPARISON OF PREDICTED WITH ACTUAL PERFORMANCE LEVELS FOR SEVERAL EXISTING WIND TUNNEL FACILITIES

Error, -0.3 66.8 -13.3 27.4 1.0 2.8 1.8 The energy ratios of some facilities have dropped over the years 24 Energy ratio Estimated computer program 6.83 3.97 7.20 4.73 7.96 8.07 1.12 Ъу 6.85 (ref.21) Actual<sup>a</sup> 2.38 1.10 7.88 7.85 3.71 8.3 Measured (ref.24) Measured Circuit losses 1 Basis of actual energy ratio Estimated Estimated Estimated Estimated n<sub>F</sub> = 90% η<sub>F</sub> = 95% output  $n_{\rm F} = 97$ motor losses n<sub>F</sub> = 85% assumed assumed assumed assumed Fan 1 from from from from motor losses output (fan input) Estimated n<sub>E</sub> = 852 Estimated Estimated Measured Estimated  $n_{\rm E} = 95\%$ Drive power measured measured assumed Motor assumed -from from from from Measured Measured Measured Motor input ł  $^{\rm T}{\rm The}$  quoted energy ratios are the best available and best achieved for each facility. due to deterioration, leaks, soot build-up, etc. Reference condition Test section velocity, 133.0 52.3 107.3 96.3 45.7 117.7 52.7 m/sec some dimensions for the Luosed/ Surprisingly high rectangular measured energy ratio multiple circular-arc multiple-circular-arc off of small drawings The larger of two tandem test sections was considered; test estimate were scaled High diffusion rates Conventional tunnel; exchanger available Some dimensions for rectangular the estimate were with corner scaled off of small effective facility; Some separation in partial fan stall; turning vanes; air in some important Basically a costprimary diffuser; Comments section vented turning vanes components drawings Closed/ rectangular rectangular rectangular Open/flat oval Wind tunnel description cross-section type/shape Closed/ flat oval section fillets fillets Closed/ Closed/ Closed/ Test rectangular and circular Non-return/ flat oval rectangular rectangular Hawker Siddeley Aviation Non-return/ type/basic rectangular rectangular rectangular circuit Return shape Double, closed/ Single, closed/ Single, closed/ Single, closed/ University of Washington Double, 8- by 12-Foot closed/ NASA-Langley Research Lockheed-Georgia Low-Speed (V/STOL Test Section) (ref. 20) 15-Foot V/STOL (at Indian Institute of NASA-Ames Research NASA-Ames Research Hatfield) (ref. 24) by 60-Foot 40- by 80-Foot 14- by 9-Foot (at Bangalore) 7- by 10-Foot (refs. 21-23) (ref. 25) Facility Sclence Center Center Center ģ



Figure 1.- Diffuser design parameters.

(a) Several existing facilities









Figure 2.- Contraction design criteria.

2.0 0.6 0.5 (X/L)max 0.4 1.8 0.3 1.6 0.2 interview of the set o 1.4 Wind tunnel facilities 1.0 3.0 2.6 1.8 2.2 1.4 4.2 3.8 3.4 

(b) Contraction design curves from reference 3.

Figure 2.- Concluded.







Figure 3.- Concluded.





KEXP = KRef. 9 - 8 sin 0 (AR -









#### Main Program (PERFØRM)





Figure 7.- Basic functional flow chart.



}

Figure 7.- Continued.

>



(b) Data-checking subroutine.

Figure 7.- Continued.

Local Speed Subroutine (SPEED)







(c) Local speed and Reynolds number/friction coefficient subroutines.





## (d) Section information output and plotting subroutines.

Figure 7.- Concluded.





i








ł																		
											95.00							
											.0100		•0100					
	00					<b>00</b> •06		90.00		76	26.		65		00.06		- 0 <b>0</b> -	
	1.014.851.0					1.848	and the system with the state of the system of the system of the system.	1.848		4.2671.7	+3204-2671-7	4.267	1027 5.3		• 9906	. An old statement of the	• 9066 •	,
	07.326.86	0.3952.58	2.1924.380	2.2824.47	0.9033.10	0.9033.10	0.9233.10	0.9033.10	5.3237.52	12.19	12.19.4	4.7413.89	4.7413.89.	0.3952.58	0.3952.58	0.3952.58	0.3952.58	
	124.38 1	152.5815.344	152.5845.721	124.3824.381	324.4791.442	33.1036.802	33.1036.022	133.1036.802	133.1041.152	12.508.992	12.196.501	12.1927.181	12.19 1	341.6693.064	352.5854.414	752.5816.544	352.5854.414	
•	12.15	40.35	40.35	12.19	12.28	20.90	20.92	20.90	20.90	5 212.66	52	Ś	6 3 2	29.48	40.35	40.35	40.35	3 1 1
•	-11133	11022	22023	3 333	44032	53222	61022	73222	84022	99221	109111	119412	129612 (	134022	143222	151022	163222	-

(a) Listing of input data cards.

Figure 11.- Test case information details.

L L				/ 40	t	6000	1050	0835	4514	1995	0123	5661	1610	050
PAG				00	ļ	0.0	0*0	0*0	0.0	0.0	0.0	0.01	0.00	0•00
				DP/QL	++	0.00224	0.00501	0.00835	0-04616	0.14170	0.00875	0.14170	0.01359	0.00259
*				LENGTH	++	15-34	45.72	24.38	<b>471</b>	36.80	36.02	36.80	41.15	8.99
				MACHI MACH2	++	0 <u>.038</u> 0.038	0.038 0.319	0.319	0.315	0.116 0.116	0.116 0.116	0.116 0.116	0.116 0.084	0.084
TUNNEL	ORMANCE		т С	V1 V2 M/SFC	+	12 • 8 12 • 8	12.8 107.3	107.3 106.0	106.0 39.4	39 • 4 39 • 4	39 <b>.4</b> 39 <b>.4</b>	39.4 39.4	39 • 4 28 • 6	28•6 46•1
FOUT WIND	NNEL PERF		15.71 N/S	2 THETA DFGREFS	+		40.37	0.23	10-7				7.09	18.84
<u>87 80-</u>	WIND-TU		= 67	AR,CR	++		8 <b>•</b> 00	10.1	2.58				1.37	1.60
ITER 40-	ECTION	1/50 М. Р. М.	RESSURE	A 1/A0 A 2/A0	++	8 • 00 8 • 00	8.00 1.00	1.00	1.01	2.61 2.61	2•61 2•61	2.61 2.61	2•61 3•58	3. 58 2. 23
SEARCH CEN	SED-TEST-S	101325.0 h 325.0 N/SC DEG K.	DYNAMIC P	AREA1 AREA2 So M	++	2123.71 2123.71	2123.71 265.30	265.30 268.13	268.13 691.79	621.79 691.79	692.45 692.45	62.123 67.123	691.79 950.01	949 • 50 592 • 36
A-AMES RE	TURN, CLO	HERES = (ES = 101 = 288.00	17 KNGTS.	W1,D1 W2,D2 MFTFRS	++	52.58 52.58	52.58 24.38	24.38 24.47	24.47 33.10	33.10 33.10	33.10 33.10	33.10 33.10	33.10 37.52	12.50
NAS	SINGLE-RE	DO ATMOSP Atmospher 35 deg C	= 208.5	H1 H2 Meters	++	40.35 40.39	40.39 12.19	12.19 12.28	12.28 20.90	20.90 20.90	20.92 20.92	20•90 20•90	20.90 25.32	12.66
	•	= 1.00 NS 1.000 /	M/SEC	SHAPE	1	RECT	RECT FL 0	FLO	FL 0 RECT	RECT RECT	RECT RECT	RECT RECT	RECT RECT	RECT CIRC
*		ATMOSPHERIC PRESSURE TEST SECTION CONDITION TOTAL PRESSURE = TOTAL TEMPERATURE	VFLCCITY = 107.3(	NO. SECTION TYPE	++ ++	1 CONSTANT AREA DUCI	2 CONTRACTN, SINGLE	3 TEST SECT, CIFSN	4 DIFFUSEP	5 CORNFR WITH VANES	6 CONSTANT AREA DUCI	7 CORNER WITH VANES	8 DIFFUSER	9 FAN CONTRACTION

(b) Wind tunnel section and overall performance information.

Figure 11.- Continued.

4GE 2	0P/90	+	.00279	.01431	.00060	•00123	.00227	•0000•	.00227			
đ	/gL [	•	1448 0.	8002 0,	03.08 0,	2774 0	5269 0	0242 0	5269 0	κs		
	DP /	Ļ	to•0	0.0	0.00	0.02	0.15	0-00	0.15	METER		ANS
ONT INUED	LENGTH	ME TE RS	6.50	27.18		93.06	54.41	16.54	54.41	588.74		4BER OF F
)•••	MACHI	MACH2 ++	0.136 0.136	0.131 0.065	0.137 0.065	0.065 0.038	0.038 0.038	0.038 0.038	0.038 0.038	ENGTH =		OTAL NUI
*	LV VI	V2 M/SEC	46.1 46.1	44.4 22.1	46 <b>•5</b> 22•1	22.1 12.8	12.8 12.8	12.8 12.8	12.8 12.8	ERLINE L		
	2 THETA	DEGREES		9.94		7.66				UTAL CENTE		ZFFI CIENCY
D TUNNE	AK,CR			2.00		1.73				Ŧ	7.962	FAN 95.0
OOT WIN	A1/A0	A2/A0	2.23 2.23	2.32 4.63	2•21 4•63	4.63 8.00	8 • 00 8 • 00	8 • 00 8 • 00	в. CO 8.00		- 110 =	R FAN 14TTS
40- BY 80-F	AREAL	AREA2 SQ M	592.36 592.36	614.44 1228.43	587.54 1228.43	1228-14 2123-71	2123.71 2123.71	2123.71 2123.71	2123.71 2123.71		ENERGY RA	AVERAGE PER 4042853.
I CENTER 4	10-1M	W2,02 METERS	12.19 12.19	12.19 13.89	12•19 13•89	41.66 52.58	52.58 52.58	52.58 52.58	52.58 52.58		12555	IRED ATTS
RESEARCI	Ŧ	H2 METERS		14。74	14.74	29.48 40.39	40.39 40.39	40.39 40.39	40.39 40.39		20) = 0.	PUT REQU 57120. W
A-AMES	CHAPF		CIRC	CIRC RECT	CI RC RECT	RECT RECT	RECT	RECT	RECT		- 	0UT 242
* NAS.	D SECTION TYPE		O FAN DUCT & STRUTS	I FAN DIFSRECNTR BDY	2 MULT INTRNL STRCTR	3 DIFFUSFR	4 CORNER WITH VANES	S CONSTANT AREA DUCT	6 CORNER WITH VANES		DERFORMANCE SLMMARY - TOTAL PRESSURE LUS	1000 10 10 10 10 10 10 10 10 10 10 10 10

Figure 11.- Continued.

(b) Wind tunnel section and overall performance information - Concluded.

ŝ	I				1
PAGE					
•••CUNTINUED••••			PROXIMATELY AS FOLLOWS		
*		TON	IS AP		
● NASA-AMES RESEARCH CENTER 40- BY 80-FODT WIND TUNNEL		MAXIMUM VELOCITY FUR A SPECIFIED PUWER CONSUMPT	THE MAXIMUM TEST SECTION FLOW ACHIEVABLE WITH 26860000. WATTS OF POWER AVAILABLE Velocity II1.26 M/SEC = 216.27 KNOTS	MACH NUMBER 0.33 DYNAMIC PRESSURE 7193.57 N/SU M	actions for the former of the

(c) Velocity optimization information.

Figure 11.- Continued.

MIND-TUNNE TAKEN AT				
	L CIRCUIT CHARA DOWNSTREAM END	CTERISTICS SUMMAN	RY	
CUMULATIVE	MACH	CUMULAT I VE	WALL PRESSURE	
CIRCUIT LENGTH	NUMBER	PRESSURE LOSS	DIFFERENTIAL (ATMOSPHERIC - INTERNALI	
METERS			N/SD M	
+	++	+ +	++	
15.34	0.038	0.0003	100.0	
61.06	0.315	0.00505	6919.4	
85.44	0.315	0.01340	6815.3	
176.88	0.116	0.05854	1338.2	
213,68	0.116	0.07850	1470.9	
249.70	0.116	0.07972	1477.1	
286.50	0.116	0. 09968	1611.9	
327.65	0.084	0.10159	1179.6	
336.64	0.136	0.10209	1975.6	
343.14	0.136	-0.02072	1161.5	
370.32	0.065	-0.00641	255.9	
370.32	0.065	-0.00580	260.0	
463.38	0.038	-0.00457	69.1	
517.79	0.038	-0.00230	84.3	
534.33	0.038	-0.00227	84.6	
588.74	0.038	00000	99.8	

(d) Section summary characteristics information.

Figure 11.- Continued.

Figure 11.- Continued.

(e) Summary information plots







•••CONTINUED•••• PAGE 5	AY BE INTENDED AS ZERO. FORE COMPUTATION IS POSSIBLE.	ARD AND MAY BE REMOVED. A PREDETERMINED VALUE.		P ATM	C ATM 46	++	35 1.000		4)	45	RETURN FOR NEXT CASE	16-20	+====+	DN
*	AIIUN TTED OR PARAMETER MU UST BE CORRECTED BEF	INCLUGED ON INPUT CA TER WILL DEFAULT TO	ТА	VO POWER PT TI Level Mega-	SEC WATTS ATM DEG 31 36 41		7.3 26.86 1.000 14.8		CARD CULUMNS 3 AND	FULLOWING CONDITION	VELOCITY- OPTIMIZATION	11-15	+	YES
0-FOOT WIND TUNNEL	<u>d input data tabul</u> Meter Has been umi N omitted. This M	EEN UNNECESSARILY TED AND THE PARAME	MASTER CONTROL DA	HI WI MODEL DI BLKGE PER-	M M CENT M/		•19 24.38 EMPTY 10		INATION CUNUTIONS (DUE TO BLANKS IN	D ACCORDING TO THE	INPUT DATA TABUTATION	-10	++	YES (CHOSEN)
CH CENTER 40- BY 8	ANNCTATE EQUIRED INPUT PARA PARAMETER HAS BEF	UT PARAMETER HAS B Data has been omit	T UNNE L	ITS SECT. SECT. INLET EXIT Shape shape	5 5 11	+ + +	1 3 3 12	5 ( L L 9 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	CASE TERM	INPUT SECTIONS, AN	PLOTTING AS A FUNCTION		+	PRESS. LUSS. WALL PRESS.
NASA-AMES RESEARC	S OPTIONAL, NON-RE S MANDATORY INPUT	S SUPERFLUOUS INPU S OPTIONAL INPUT [		CASE TUNNEL UNI SE4. TYPE NG.	3	+ +			CASE TER	AFTER 16	SUMMARY CHARACTERISTICS		++	YES
*	• EMPTY INDICATE	• EXTRA• INCICATE • OPT• Nº INDICATE			DATA FIELD BEGINS In Carl Column							TERMINATICN-CCDE Data Field is Contained in Cadd Climms		

Figure 11.- Continued.

(f) Annotated tabulation of input data.

PAGE 6		SIBLE.		A D EPS	- PER-	76	++ +										
•		D AS ZERO. ION IS POS E REMOVED.		RNREF, ET RUFNES	10(6), 10(-6) PER- Meters Cen	66 71	++					0PT•N		N. 1 d0			
• CONTINUED		BE INTENDE RE COMPUTAT 7 AND MAY B PREDETERMI		KEXP CD HESH K 1 90		61	++ +			No Le	VI IN	N = 1 :		NII	N • 1 c		
*		AMETER MAY ECTED BEFOR INPUT CARE		SE PHI K	k- 4T DEG	51 56	+ ++ +-			90	9	90 00 OF		90.00 OP	40	16	inued.
	TI CN	TED OR PARI ST BE CORRE NCLUDED ON		CHORD BLKC DHUB PRS1 DMESH	R CEF	41 46	+++++++++++++++++++++++++++++++++++++++					1.848		1.848		4.267 1.79	ta - Cont
ID TUNNËL	TA TABULA	BEEN UMIT	TION DATA	W2 L/DH, D2 S/AL	M 20 M	36	+++	2.58	•38	••47	1.10	10	1.10		1.52	.19	input da
IO-FOUT WIN	D INPUT DI	METER HAS IN OMITTED	ICON DESCRIP	H2	Σ	26 3		14 40.39 5	2 12.19 24	8 12-28 24	4 20.90 3	0 20.90 33	12 20.92 3	30 20°90 33	5 25-32 31	2 13	ation of
R 40- BY 8	ANNOTATE	INPUT PARA Er has bee Eter has e Been om 1	SECT ]	M1 L D1 L	I I	17 91	++	52.58 15.3	52 <b>.</b> 58 45.7	24.38 24.3	24.47 91.4	33•10 36•8	33.10 36.0	33•10 36•8	33.10 41.1	12.50 8.99	ed tabula
ARCH CENTE		-REGUIRED JT PARAMET NPUT PARAMET T DATA HAS		EMS H1 ER UCT	Σ	7	++	56.04	5E•0+	12.19	12.28	20.90	20.92	20.90	20.90	2. 12.66	Annotat
-AMES RESE		CONAL, NCN- DATORY INPU ERFLUOUS I		ND. PI ND. PI DUCTS DI	N N	-	+									<b>6</b> .	(f)
NAS A-		CATES OPTI CATES MANE CATES SUPE		ECT. SECT. WLET EXIT HAPE SHAPE		GINS N	> + + +	2 2	3	Э. Э.	3 2	5	2 2	2 2	2 2	2 1	
*		MPTY' INDI RROR' INDI XTRA' INDI		T. SECT. S Q. TYPE I UT S		A FIELD BE Care colum 3	*	1 10	2 20	3 3	4 40	5 32	6 10	7 32	8 40	9 92	
1	-			SEC		DAT IN	•										

Figure 11.- Continued.

1		C EPS	PER-		16		EMPT		EMPTY					** •0
PAG		ETA (	PER-				95.00							MINATE
		RUFNES	10(6), 10(-6)	HE ICKS							Nº 140		N. LdO	OR TER
IT I NUED		₽×				10	0.0100		0.100					PLETED
		KE XP KMESH	KT 90			0		0PT • N		N . LdO	N. 140		Nº 140	ISE COM
		IHd		DEG		16					00-06		00 • 06	13 14
		BLKGE PRSTY	PER-	CENT		•	1.797	EMPTY	5•365					
		CHORD DHUB	DMESH	£		4 I ++	4.267	4.267			0.9906		9066 •0	
UNNEL	N DATA	L/DH, S/AL	м/н, SQ	Su M		36	0.4320		0.1027			-		TUNNET
I ONIN	RIPTIO	#2 D2		X		31	12.19	13.89	13.89	52.58	52.58	52.58	52.58	ON IM
-F001	N DE SCI	H2		£		26		14.74	14.74	40.39	40.39	40.39	40•39	0-F0C1
BY 80-	SECT 101	ب		Ŧ		21	6.501	27.18		93.06	54.41	16.54	54.41	<u>- 878</u>
R 40-	•	14		I		16	12.19	12.19	12.19	41.66	52.58	52.58	52.58	TER 40
I CENTE		H		x						29.48	40.35	40•39	40.39	CH CEN
S EARCH		I TEMS PER	DUCT	NO.		o ‡	2.	0PT•N	З.					RE SEAR
MES RE		TOTAL ND.	DUCTS	N0.		-:	<b>.</b> 9	<b>.</b> 0	<b>6</b> .					-AME S
NAS A-A		SECT.	SHAPE			• +	-	2	2	2	2	2	2	NASA
		SECT.	SHAPE	LEC INC		<b>4</b> ک	-	-	1	2	2	2	2	
		SECT.			C CCLI	m +	16	94	96	40	32	10	32	*
*		SECT.	TUPUT		IN CAF	- ‡	10	11	12	13	14	15	16	++

Figure 11.- Concluded.

(f) Annotated tabulation of input data - Concluded.









Figure 12.- Continued.

(b) Lockheed-Georgia Low-Speed Wind Tunnel.





Figure 12.- Continued.







Figure 12.- Continued.



Figure 12.- Concluded.

\*U.S. GOVERNMENT PRINTING OFFICE: 1976 - 635-275/120