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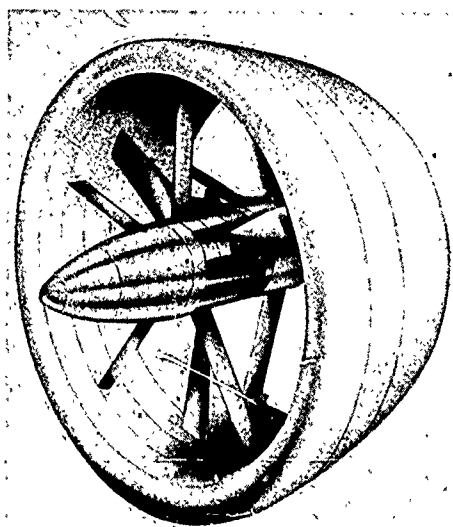
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VOLUME II OF II

ENGINEERING REPORT

SHROUDED PROPELLER TEST PROGRAM COMPUTER PROGRAM



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151

ENGINEERING REPORT

SHROUDED PROPELLER TEST PROGRAM COMPUTER PROGRAM

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1.0 INTRODUCTION

➤ Hamilton Standard computer deck numbered H193 is used to calculate shrouded propeller performance and shroud surface pressure coefficients based on the computational procedure discussed in Volume 1 of "Shrouded Propeller Test Program - Method Development". The necessary shroud thickness and camber effects are generated by Hamilton Standard Deck H194, and the pertinent centerbody information is obtained from Hamilton Standard Deck H060. Therefore, data generated by Decks H194 and H060 are used as input for Deck H193.

The computations permissible with Hamilton Standard Deck H193 are divided into the following three categories.

(1) Given Shroud and Propeller Geometry --

For a given shroud and propeller geometry, an iterative process is involved in establishing the propeller circulation for the specific operating condition. Then, the net shrouded propeller (shroud + propeller) performance is computed as well as the shroud and propeller contributions to the performance. Shroud friction drag and shroud surface pressure distributions are also calculated.

(2) Given Shroud Geometry and Propeller Circulation --

For a given shroud geometry and propeller circulation, the same output as noted above is obtained.

(3) Given Shroud Geometry (No Propeller) --

For a given shroud geometry, the shroud surface pressure coefficients, the shroud drag, and velocity induced by the shroud in any plane in the shroud are computed. () ↗

All the computer programs are coded in FORTRAN IV and have run on a Univac 1108. Flow charts showing the interaction of the main program with the subroutines and the corresponding FORTRAN IV listings are presented in the Appendix. The input format consists of integers in columns 1 through 6, which must be right justified, and eleven fields of floating point data consisting of six columns each (2I3, 11F6.0). Detailed information will be given with respect to input and output as well as sample cases.

2.0 SHROUDED PROPELLER PERFORMANCE COMPUTER PROGRAM

- A. Deck: Hamilton Standard Deck H193
- B. Title: Shrouded Propeller Performance
- C. Purpose: Compute shrouded propeller performance, shroud drag, and shroud surface pressure coefficients
- D. Analysis Method:

The computational procedure is based on the theory discussed in Volume 1. The theory defines the interaction of shroud, propeller and centerbody induced flows, represents the propeller by a finite number of blades, and includes the influence of finite shroud dimensions on induced flow and the corresponding shroud thrust. The program is restricted to propellers incorporating NACA Series 16 airfoil sections.

E. Description of Input:

The input is coded as shown on Fig. 1. For ease of discussion, the pertinent input is divided into the following six categories and is coded on the noted cards.

1. Blade Characteristics (Cards 3 thru 9)
2. Shroud Characteristics (Cards 31, 32, 33, 36, 37, 38, 39, 40)
3. Centerbody Characteristics (Cards 34, 35, 36--1, 37--1, 38--1, 39--1)
4. Type of Calculation (Card 3)
5. Operating Conditions (Card 10 & subsequent cards)
6. Print Out Options (Subsequent cards noted above & card 31)

Pertinent information will be explained for each input category.

1. Blade Characteristics (Cards 3 thru 9 on Fig. 1)

#Blades - The number of blades is limited to 2, 3, 4, 5, 6, 7, or 8.

AF - Activity Factor is included as identification only and therefore is not used in the computational procedure.

$$A. F. = \frac{100,000}{16} \int_2^1 \frac{B}{D} x^3 dx$$

C_{L1} - Integrated Design C_L is included as identification only and therefore is not used in the computational procedure.

INPUT INSTRUCTIONS FOR HAMILTON STANDARD DECK H193 (SHROUDED PROPELLER PERFORMANCE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	
1	LABEL CARDS																																																																															
2																																																																																
3	BLADE LABEL																																																																															
4	SHROUD=1. (SHROUD PROPELLER) CODE ALL INFORMATION EXCEPT T/D																																																																															
5	SHROUD=5. (SHROUD + T/D) CODE ALL INFORMATION																																																																															
6	SHROUD=1. (SHROUD ALONE) CODE ONLY T/D WHERE $H/D=0$ RATIO OF																																																																															
7	CENTERBODY RADIUS TO SHROUD INNER SURFACE RADIUS (AT																																																																															
8	SPECIFIC PLANE)																																																																															
9																																																																																
10	X/D RATIO																																																																															
11	FOR SHROUD=1., CODE X'S IN SPECIFIED PLANE																																																																															
12																																																																																
13	IF SHROUD=1. CODE THE FOLLOWING PROPELLER BLADE INFORMATION																																																																															
14	T/D RATIO CORRESPONDING THICKNESS TO CHORD RATIO																																																																															
15	B/D RATIO CORRESPONDING BLADE WIDTH TO DIAMETER RATIO																																																																															
16	T/D RATIO CORRESPONDING DESIGN LIFT COEFFICIENT																																																																															
17	C_L RATIO																																																																															
18	C_D RATIO																																																																															
19	IF SHROUD=5. CODE THE FOLLOWING																																																																															
20	T/D RATIO NON-DISTANTIAL PROPELLER CALCULATION																																																																															
21	B/D RATIO																																																																															
22	T/D RATIO																																																																															
23	IF SHROUD=6. NO FURTHER PROPELLER CHARACTERISTICS ARE REQUIRED																																																																															

FIGURE 1. (SHEET 1 OF 4)

INPUT INSTRUCTIONS FOR HAMILTON STANDARD DECK H193 (SHROUDED PROPELLER PERFORMANCE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	
34	7 CENTERBODY ELEMENT COEFFICIENTS (ELEM'S)																																																																															
35	ALL NECESSARY CENTERBODY INFORMATION CAN BE OBTAINED FROM HIS DECK H060																																																																															
36	AXIAL VELOCITIES INDUCED BY CENTERBODY IN SPECIFIED PLANE-TYPE TO SHANK																																																																															
36	IN SET IS DEFINED AS TWO CARDS MAINTAINING THE SAME NUMBERS IN COLUMNS																																																																															
36	2 AND 3 WITH THE SECOND CARD MAINTAINING A 1 IN COLUMN 6. THE FIRST																																																																															
37	CARD OF EACH SET CONTAINS THE SHROUD SECTIONAL X'S IN ASCENDING																																																																															
37	ORDER FOR PRESSURE COEFFICIENT CALCULATION. THE SECOND CARD OF																																																																															
38	EACH SET CONTAINS THE CORRESPONDING CENTERBODY INDUCED AXIAL																																																																															
38	VELOCITIES. X'S AND REL ARE REPRESENTED AS A PERCENTAGE OF CHORD																																																																															
39	AND 0.5X/S/D. WSX IS THE NUMBER OF X'S. THE MAXIMUM NUMBER OF X'S																																																																															
39	IS 40. THE X'S MUST BE CONTINUOUSLY ASCENDING FROM ONE SET TO THE																																																																															
	NEXT.																																																																															
	THERE ARE TWO OPTIONS IN REGARD TO THE SHROUD THICKNESS 2-D EFFECT																																																																															
	ON SHROUD SURFACE VELOCITIES.																																																																															
40	I) TO COMPUTE THE DATA CODE AS FOLLOWS																																																																															
40	40998																																																																															
41	II) TO INCLUDE DATA IN TABULAR FORM CODE AS FOLLOWS																																																																															
41	40999 X'S IN ASCENDING ORDER FOLLOWED BY THE CORRESPONDING 2-D																																																																															
	SHROUD THICKNESS EFFECT. MINIMUM # OF X'S IS 4 AND THE MAXIMUM IS 20.																																																																															

FIGURE 1. (SHEET 3 OF 4)

INPUT INSTRUCTIONS FOR HAMILTON STANDARD DECK H193 (SHROUDED PROPELLER PERFORMANCE)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
A1		SIGNIFIES THAT ALL PERTINENT INFORMATION HAS BEEN INCLUDED.																																																																													
		FOR SUBSEQUENT CONFIGURATIONS, THE FOLLOWING MUST BE INCLUDED																																																																													
		A. CARDS 1, 2, 3																																																																													
		B. CARDS 4 THROUGH 60 WHICH VARY FROM THE PREVIOUS CONFIGURATION.																																																																													
		IF THERE ARE ANY CHANGES MADE IN THE OPERATING CONDITIONS, CARD 10																																																																													
		AS WELL AS THE CONDITION CARDS MUST BE INCLUDED.																																																																													
		C. CARD 61																																																																													
A2		SIGNIFIES THE LAST CASE																																																																													

FIGURE 1. (SHEET 4 OF 4)

2.0 (Continued)

$$C_{L_i} = 4 \int_{HCO}^{1.0} (\text{Des } C_L) x^3 dx$$

The variables in these equations are defined in the following text.

D_{prop} - Propeller diameter in feet.

HCO = HUB X - Ratio of hub radius to propeller radius.

The propeller blade elemental characteristics are included for 10 stations along the blade defined by the following equation.

$$x_i = (1.0 - HCO) (\mu_i) + \text{mid point}$$

where

x = Ratio of propeller sectional radius to propeller tip radius and

$$\mu_1 = +.4870$$

$$\mu_6 = -.0744$$

$$\mu_2 = +.4325$$

$$\mu_7 = -.2167$$

$$\mu_3 = +.3397$$

$$\mu_8 = -.3397$$

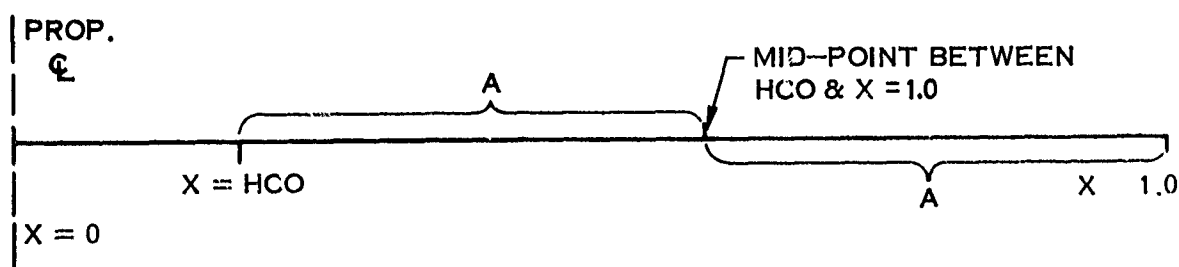
$$\mu_4 = +.2167$$

$$\mu_9 = -.4325$$

$$\mu_5 = +.0744$$

$$\mu_{10} = -.4870$$

Mid-point - Defined as shown in the following sketch.



If SHROUD on card 3 (See explanation under Paragraph 4, Type of Calculation, following) is equal to 4., signifying that the propeller geometry is defined, code the following propeller sectional properties corresponding to each of the ten x's.

2.0

(Continued)

T/B - The ratio of propeller sectional thickness to sectional width.

B/D - The ratio of blade sectional width to propeller diameter.

DES C_L - The sectional design C_L for the NACA Series 16 sectional airfoil.

$\Delta \theta$ - Propeller blade section twist. It is defined as $\theta_x - \theta_{x=3/4 \text{ radius}}$.

If SHROUD (See explanation under Type of Calculation) on card 3 is equal to 5., signifying that the sectional propeller circulation (Γ_P) is known, code the radial variation of non-dimensionalized circulation ($\bar{\Gamma}_P$) which is defined as

$$\bar{\Gamma}_P = \frac{\Gamma_P}{R_P V_\infty}$$
 where R_P is the propeller radius (ft) and V_∞ is the uniform free stream velocity (ft/sec). The corresponding propeller thrust coefficient, C_T must be coded on card 3 where $C_T = \frac{T}{\rho n^2 D^4}$. The variables in this equation are defined under paragraph 4 of output.

2. Shroud Characteristics (Cards 31, 32, 33, 36, 37, 38, 39, & 40 on Fig. 1)
Shroud I. D. # for identification purposes only.

LAMBDA - Ratio of shroud chord to shroud reference diameter. Shroud reference diameter is defined as the distance in the propeller plane measured from the centerline to the mean camber line (See Fig. 2.) $.25 \leq \lambda \leq 1.00$

XPBAR - Ratio of the distance of the propeller plane position from shroud mid-chord to the shroud chord. The value is negative upstream of mid-chord and positive downstream of mid-chord (See Fig. 2).

MU - Ratio of propeller radius to shroud reference radius (See Fig. 2).
 $.75 \leq \mu \leq .998$

For the case of calculation of shroud alone, code the shroud reference diameter in feet in the MU slot. MU will be defined internally as the ratio of shroud inner surface diameter to shroud reference diameter.

$A_0 - A_7$ - Shroud thickness coefficients defined by

$$t/c = A_0 \sqrt{x_s} + \sum_{n=1}^7 A_n (x_s)^n$$

where t = shroud thickness, c is shroud chord and x_s is the percentage of shroud chord from the leading edge. If the shroud shape is one for which the coefficients A_n are not known, they can be obtained from Hamilton Standard Deck H194, as noted in the Introduction and described in Section 3.0.

DESCRIPTION OF SHROUD PARAMETERS

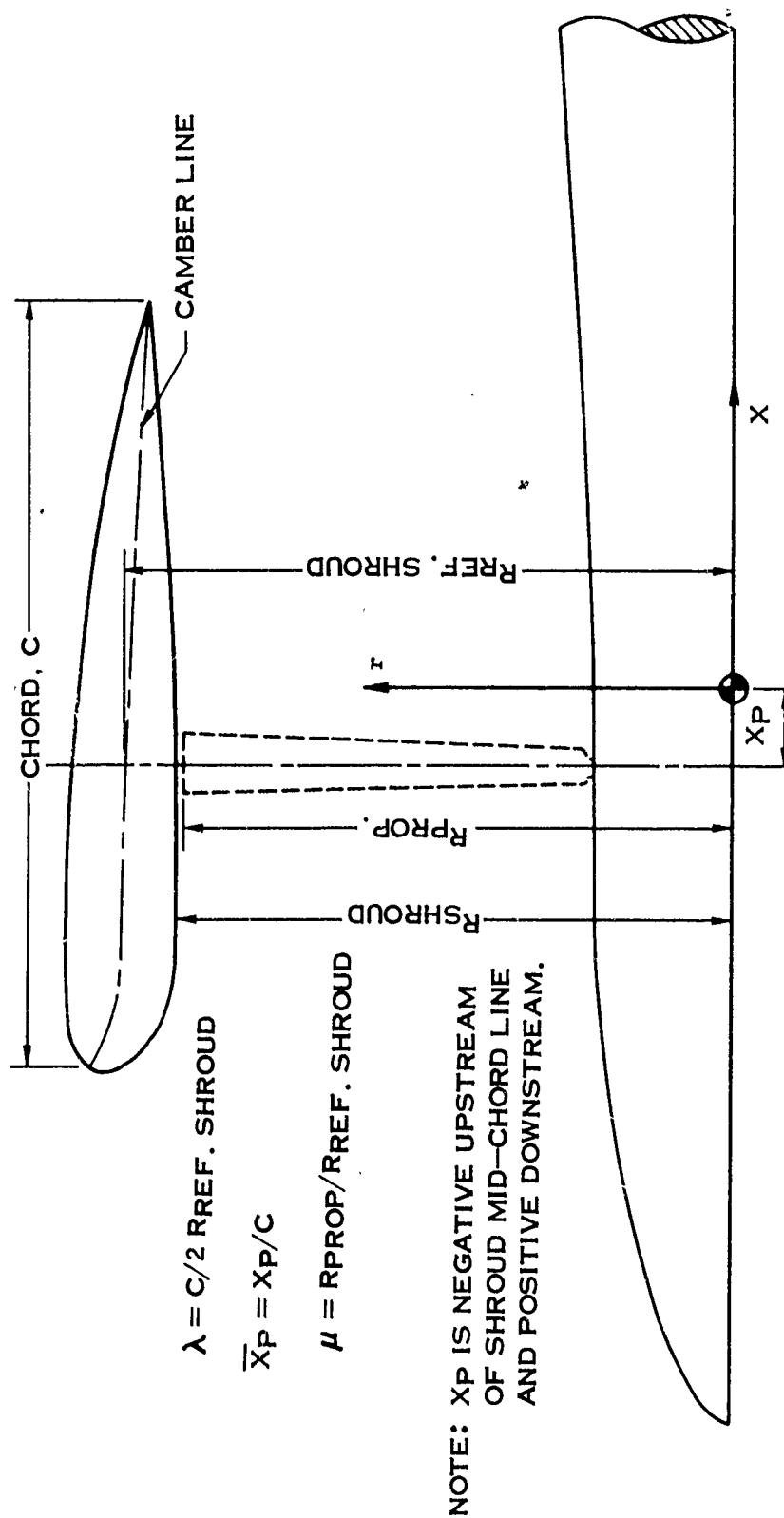


FIGURE 2.

2.0

(Continued)

Eo-E6 - Shroud camber 2-dimensional Glauert coefficients. If the shroud camber line is one for which the information is not known, use Hamilton Standard Deck H194 to obtain the pertinent data as described in Section 3.0.

T/C_{2D} - 2D shroud thickness effect on shroud surface velocity. The information is used in the computation of shroud surface pressure distribution. If the data is not available for the particular shroud, use the option of having it computed as specified on card 40 in Fig. 1.

Shroud Diameter - Defined as diameter to inner surface of shroud in the propeller plane. Note that this is always smaller than the shroud reference diameter.

A₄/A₂ - Ratio shroud open area at shroud exit to shroud open area directly ahead of propeller.

Riegels Factor Limit - The x_s corresponding to the shroud maximum thickness.

X - On card 4, for shroud alone, is defined as sectional radius/shroud inner surface radius in specified plane.

Shroud X - Ratio of shroud sectional chord to shroud chord. These are the points for which the shroud surface pressure coefficients will be computed. The shroud x_s's should be greater than 0 and less than 1.

NSX - Number of shroud x_s's for which shroud surface pressure coefficients will be computed. The maximum number is 40.

3. Centerbody Characteristics (Cards 34, 35, 36--1, 37--1, 38--1, & 39--1 on Fig. 1)

The following velocities induced by the centerbody are required.

- a) Radial velocities along shroud surface expressed as Glauert coefficients.
- b) Axial velocities induced by the centerbody in the plane of the propeller corresponding to the ten stations along the blade.
- c) Axial velocities induced by the centerbody on the shroud surface corresponding to the axial locations taken along the shroud chord.

They are obtained from Hamilton Standard Deck H060 as described in Section 4.0.

2.0

(Continued)

4. Type of Calculations (Card 3 of Fig. 1).

SHROUD - Defines which computational option is being used,
where

SHROUD = 4. specifies computations for the combination of specified
shroud and propeller geometry.

SHROUD = 5. specifies computations for the combination of a defined
shroud geometry and the propeller represented as a propeller
circulation.

SHROUD = 6. specifies computations for the shroud alone.

5. Operating Conditions (Card 10 & subsequent cards on Fig. 1)

No. Cond - Number of operating conditions to be considered with the maximum
being equal to 10.

For the given shroud and propeller geometry computation, each operating
condition is defined by the following condition cards.

J - Advance ratio where $J = v/nD$ and v is free stream velocity (ft/sec)
 n is propeller rotational speed (rev/sec) and D is propeller diameter (ft)

$\theta_{3/4}$ first - First propeller blade angle for which computation is to be made.

$\Delta \theta_{3/4}$ - Increment of $\theta_{3/4}$ by which $\theta_{3/4}$ will be changed for subsequent
computations.

$\theta_{3/4}$ - The number of $\theta_{3/4}$'s for which computations will be made. The
maximum number will be 10.

M. N. - Free stream Mach number.

For computations based on a given shroud geometry and propeller circulation,
the operating condition is defined by J and M. N.

For computations based on shroud geometry alone, the operating condition is
defined by M. N. alone.

The number of condition cards must be equal to the number of conditions spe-
cified on card 10.

6. Print Out Options (Subsequent cards as noted above & card 31 on Fig. 1)

The following options will be of use to those engaged in the detail design of
propeller and shroud. Thus, it is important that there is a complete under-
standing of the mathematics of the theory.

2.0

(Continued)

P.O. (on the condition cards) Code 1 for blade elemental print out. It permits the examination of the sectional aerodynamic components required to compute the thrust and power coefficient derivatives. The print out will be discussed in more detail under description of output.

TRIG 1 - The option permits the display of the matrices and characteristics functions used in the computation for a more detailed examination of the computational procedure. See the paragraphs dealing with output for more details.

TRIG 2 - Code 1. for the print out of the 2-dimensional Glauert coefficient content with respect to shroud camber and thickness, propeller circulation, and centerbody. These Glauert coefficients are used in defining the velocity induced by the interaction of shroud and propeller.

A sample case of input for each type of calculation is shown on Fig. 3.

F. Description of Output

The output consists of the following print outs.

1. Input
2. Type of Calculation
3. Matrices and Characteristic Functions if Option Exercised
4. Performance
5. Induced Velocity Content at Specified Plane
6. Glauert Coefficients Content if Option Exercised
7. Shroud Surface Pressure Coefficients
8. Blade Elemental Print Out if Option Exercised
9. Error Messages

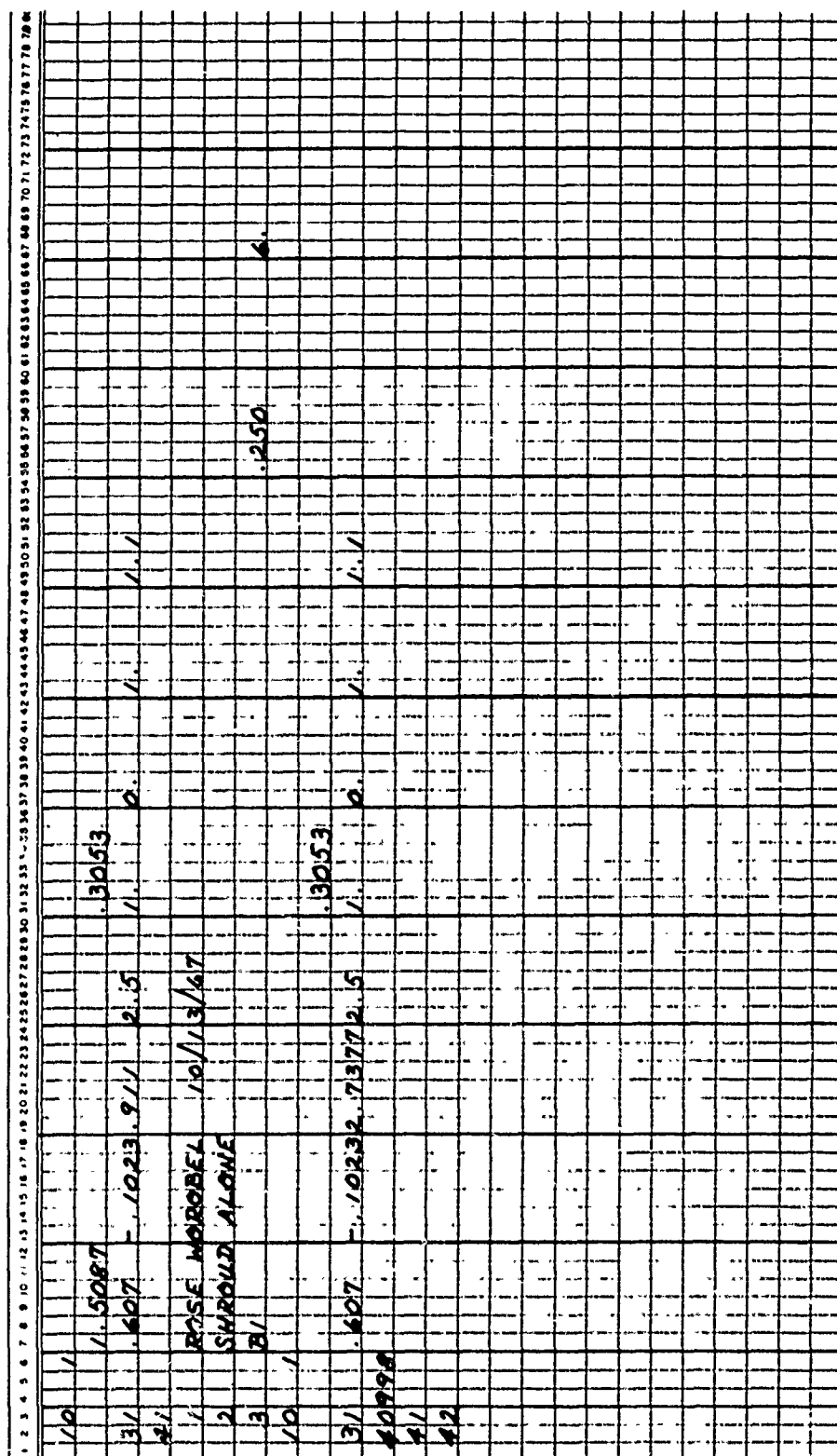
1. Input

The propeller input prints out under the section labelled "PROPELLER CHARACTERISTICS". All of the shroud input prints out under "SHROUD CHARACTERISTICS". If the 2-D thickness effect on shroud surface pressure is included as input, it will print out under "SHROUD SURFACE PRESSURE COEFFICIENTS". The 2-D Glauert coefficients due to centerbody are tabulated under "CENTERBODY CHARACTERISTICS".

SAMPLE INPUT FOR HAMILTON STANDARD DECK H193 (SHROUDED PROPELLER PERFORMANCE)

[illegible]

SAMPLE INPUT FOR HAMILTON STANDARD DECK H193 (SHROUDED PROPELLER PERFORMANCE)



2.0

(Continued)

The axial velocities induced by the centerbody on the shroud print out under "SHROUD SURFACE PRESSURE COEFFICIENTS". The centerbody axially induced velocities in the propeller plane print out under "INDUCED VELOCITY CONTENT".

2. Type of Calculation

A statement prints out specifying which of the three types of computations was made.

3. Matrices and Characteristics Functions

P(K, L) - Curvature coefficients as functions of shroud chord to diameter ratio (λ) where K and L are dummy summation indices. (Ref. 1, p 24-27).

M(K, L) - Matrix used in defining shroud thickness effect on 2-D Glauert coefficients. (Ref. 2, p 39-42).

S(K, L) - Matrix used in defining shroud vorticity distribution (continuous part) contribution to shroud pressure distribution. (Ref. 2, p 63-66).

TT(K, L) - Matrix used in defining shroud thickness (3-D part) contribution to shroud pressure distribution (Ref. 2, p 57-60).

CHI (J, NU) - Integral of the characteristic functions used in defining the propeller effect on the 2-D Glauert coefficients. (Volume I, Appendix 11.7).

VELC (NU) - Characteristic function used in defining velocities induced by shroud vorticity at the propeller plane. (Volume I, Appendix 11.6).

VELH (NU) - Characteristic functions used in defining velocities induced by shroud thickness at the propeller plane. (Volume I, Appendix 11.6).

4. Performance

For the shroud-propeller combinations, the power coefficient, and net thrust coefficient plus the breakdown to shroud and propeller thrust coefficients and shroud drag are included,

where $C_p = \frac{P}{\rho n^3 D^5}$

$$C_T = \frac{T}{\rho n^2 D^4}$$

$$C_D = \frac{F_D}{\rho n^2 D^4}$$

2.0

(Continued)

P = Power (ft-lb/sec)

ρ = Density (lb-sec²/ft⁴)

n = Propeller rotational speed (fps)

D = Propeller diameter (ft)

T = Thrust (lb)

F_D = Drag (lb)

The additional data which prints out in this section is slipstream contraction (ratio of slipstream diameter to propeller diameter), ratio of average slipstream velocity to free stream velocity, and the ratio of the average duct velocity at the propeller plane to free stream velocity. The duct velocity includes the summation of the velocities induced by the shroud, propeller, and centerbody. For the shroud alone, the shroud drag coefficient as defined below prints out

$$C_D = \frac{F_D}{q_0 \pi D_s C}$$

where

F_D = Shroud drag (lb)

q_0 = Dynamic pressure (psf)

D_s = Shroud diameter to inner surface (ft)

C = Shroud chord (ft)

5. Induced Velocity Content at Specified Plane

The increment of velocity/free stream velocity induced by the interaction of shroud and propeller (vorticity), shroud thickness effect, and centerbody are listed for each station in the specified propeller plane (XPBAR). Total and assumed velocity ratios are included since for the case of the given shroud and propeller geometry or propeller circulation, the velocity is defined by an iterative procedure. Convergence is reached when subsequent values are within .0025 of each other. Also included are the propeller induced velocity increments based on Goldstein (G) and momentum (M) theories. The Goldstein velocities are used in defining propeller performance and the momentum velocities are used in defining the net performance (shroud plus propeller). Furthermore, for the given shroud and propeller geometry combination, the swirl angle is computed. The swirl angle is defined as the angle formed by the leaving absolute velocity and the axially induced velocity.

2.0

(Continued)

For the shroud alone case, only the velocities induced by the shroud and centerbody are included.

6. Glauert Coefficients Content

If this print option is selected, the contributions to the 2-dimensional Glauert coefficients of shroud camber, shroud thickness, propeller circulation and centerbody are printed out. The 3-dimensional Glauert coefficients are also listed.

7. Shroud Surface Pressure Coefficients

Shroud surface pressure and velocity coefficients are presented as well as the following various components which define the velocity distribution.

- a. Shroud vorticity distribution (discontinuous part) due to the local shroud vorticity.
- b. Shroud thickness (2-dimensional effect) due to the local source sink distribution.
- c. Shroud vorticity distribution (continuous) due to curvature of shroud plus shroud thickness (3-dimensional effect).
- d. Propeller wake contribution due to propeller circulation.
- e. Centerbody contribution due to centerbody.

8. Blade Elemental Printout

If the blade elemental printout option is exercised, the following information is obtained for the ten stations along the blade.

THETA - Sectional blade angle

ALPHA - Angle of attack

PHI - Angle of advance plus induced angle

BETA - Propeller induced angle

PHIO - Advance angle of blade element

CL3 - Blade sectional lift coefficient

CD/CL - Drag to lift ratio

2.0

(Continued)

DCP/DX - Sectional power coefficient derivative.

DCT/DX - Sectional thrust coefficient derivative.

SECT. EFF. - Sectional Efficiency

SECT. MN - Sectional Mach Number

M/M_{CRIT} - Ratio of sectional Mach Number to sectional critical Mach Number

9. Error Messages

"Trouble in Alpha, Beta Iteration ----" - Occasionally there is trouble in the α , β propeller iteration convergence process. Rerun by changing the operating blade angle by a small amount.

"Off Airfoil Data" - The condition exceeds the angle of attack limitation of the airfoil data.

"Phi Is Greater Than 180 Degrees ----" - Usually this is an indication of α , β iteration trouble.

"Illegal Number of Blades" - Computations are limited to 2, 3, 4, 5, 6, 7 and 8 bladed propellers.

"Error in Input - Card Not Labelled and Not Covered By Cards 10 or 36 thru 40" - Check that the number of condition cards agree with "No. Cond." on card 10 and that cards 36 thru 40 are followed by only one card labeled in column 6.

"Trouble in Establishing Circulation Convergence" - Occasionally there is trouble in the circulation iteration convergence process.

"Lambda Limits Exceeded" - The λ limits are $.25 \leq \lambda \leq 1.00$.

"Mu Limit Exceeded for Characteristic Function" - The μ limits are $.75 \leq \mu \leq .998$.

The output for the sample cases are included in Fig. 4a-4c.

G. Running Time Estimates

Twenty-five performance points are computed per minute on the Univac 1108.

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SAMPLE OUTPUT FOR HAMILTON STANDARD
SAMPLE CASE FOR DEFINED SHROUD AND P

HS COMPUTER DECK H193
HS SHROUDED PROPELLER PERFORMANCE
HAMILTON STANDARD
WINDSOR LOCKS, CONN.
1967

1 ROSE WROBEL 10/13/67
2 SAMPLE INPUT FOR HS DECK H193

**** PROPELLER CHARACTERISTICS ****

3 B1-3WT

NO. OF BLADES= 3. AF= 168.0
DIAMETER FT.= 2.4940 CLI= .4000
HUB X = .2500

X=	.9903	.9493	.8797	.7875	.6807	.5693	.4626	.
T/B=	.0320	.0420	.0570	.0770	.1040	.1380	.1770	.
B/D=	.1192	.1165	.1125	.1065	.1000	.0928	.0862	.
DES CL=	.1760	.3390	.4360	.4910	.4980	.4700	.4170	.
DELTA Θ=	-5.20	-4.70	-3.50	-1.25	3.30	9.40	16.30	2.

**** SHROUD CHARACTERISTICS ****

SHROUD NO. = 1. LAMBDA= .6070
XP-BAR=-.1023 MU = .9110
SHROUD INNER SURFACE DIAMETER FT.= 2.5000
SHROUD REFERENCE DIAMETER FT.= 2.7377
RIEGELS FACTOR LIMIT = .1875
AREA RATIO = 1.1000

T/C CONTRIBUTION TO VORTICITY (THICKNESS COEFF.)= .5270 .2506 -7.
SLOPE OF MEAN CAMBER LINE (GLAUERT COEFF.)= -.5100 .4742 .

**** CENTERBODY CHARACTERISTICS ****

CONTRIBUTION TO VORTICITY (GLAUERT COEFF.)= -.0930 -.0338 .01

**** CALCULATIONS ARE BASED ON BOTH PROPELLER AND SHROUD CHARACTERISTICS

**** IN THE SUBSEQUENT MATRICES THE SUBSCRIPT L REFERS TO THE ROW AND TH

P(K,L) DATA LAMBDA= .6070
 .09336 .00000 .04670 .00000 -.00002 .00000 .00
 .18672 .11179 .00000 -.01857 .00000 .00013 .00
 .03688 .00000 .02459 .00000 -.00618 .00000 .00
 -.00009 -.00619 .00000 .00911 .00000 -.00297 .00

A.

MILTON STANDARD DECK H193 -
NED SHROUD AND PROPELLER GEOMETRY

COMPUTER DECK H193
PROPELLER PERFORMANCE PROGRAM
MILTON STANDARD
WINDSOR LOCKS, CONN.
1967

7	.5693	.4626	.3700	.3005	.2600
0	.1380	.1770	.2140	.2450	.2650
0	.0928	.0862	.0800	.0760	.0735
0	.4700	.4170	.3510	.2940	.2570
0	9.40	16.30	23.10	28.70	32.30

.5270	.2506	-7.4200	30.5670	-34.6900	73.8190	-43.2900	10.2380
-.5100	.4742	.5894	.3748	.2473	.0951	-.0456	
-.0930	-.0338	.0142	-.0007	-.0009	.0000	.0000	-.0000

SHROUD CHARACTERISTICS ****

REFERS TO THE ROW AND THE SUBSCRIPT K REFERS TO THE COLUMN ****

002	.00000	.00000
000	.00013	.00000
018	.00000	.00003
000	-.00297	.00000

FIGURE 4A.
(SHEET 1 OF 5)

B.

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**SAMPLE OUTPUT FOR HAMILTON STAND
SAMPLE CASE FOR DEFINED SHROUD AI**

-.00025	.00000	-.00309	.00000	.0047
-.00000	.00003	.00000	-.00178	.0000
.00000	.00000	.00001	.00000	-.0011

M(K,L) MATRIX LAMBDA= .6070

.77577	.42779	-.00000	.05230	-.00000
-.24243	-.00000	.08170	-.00000	.01588
.02740	.06795	-.00000	-.00439	-.00000
-.00531	-.00000	-.01624	-.00000	-.00079
.00278	.00628	-.00000	.00430	-.00000
-.00142	-.00000	-.00220	-.00000	-.00119
.00076	.00181	-.00000	.00080	-.00000
-.00051	-.00000	-.00075	-.00000	-.00028

S(K,L) DATA LAMBDA= .6070

1.34181	.67251	-.00000	-.00157	-.00000
-.63085	-.00000	-.31730	-.00000	.0019
.00633	.15863	-.00000	-.15604	-.00000
.00374	-.00000	.10401	-.00000	-.1023
.00008	-.00051	-.00000	.07676	-.00000
-.00006	-.00000	-.00019	-.00000	.0610
-.00001	-.00000	-.00000	-.00012	-.00000

TT(K,L) DATA LAMBDA= .6070

.02255	.00000	-.00781	.00000	-.0018
.07153	.04805	.00000	.00417	.00000
.01847	.00000	-.00641	.00000	-.0011
-.00088	-.00320	.00000	.00040	.00000
-.00002	.00000	-.00002	.00000	.00000
-.00009	-.00012	.00000	-.00012	.00000
.00000	.00000	.00001	.00000	.00000

**** IN THE SUBSEQUENT MATRIX THE SUBSCRIPT J REFERS

CHI(J,NU) INTEGRAL DATA LAMBDA= .607 MU= .911 XPI

.368797	-.098303	.043780	-.1
-.070586	.024980	-.011631	.1
.162295	-.071615	.037169	-.1
.043807	-.025107	.014595	-.1
-.042131	.024995	-.016077	.1
-.023317	.016541	-.011489	.1
.011405	-.009108	.005867	-.1

RAD.STA. VELC(NU) AS NU GOES FROM 0 TO 7

.9903	8.55389	5.62314	1.28969	-2.85074	-1.63158
.9493	8.00916	5.09583	1.08626	-2.29601	-1.21526
.8797	7.07703	4.29719	.80696	-1.59809	-.73598
.7875	5.87233	3.40182	.53993	-.99936	-.37977
.6807	4.58011	2.55458	.33623	-.58796	-.17831
.5693	3.39057	1.84241	.20297	-.34065	-.08217
.4626	2.41270	1.28978	.12265	-.20034	-.03940
.3700	1.68862	.89415	.07656	-.12301	-.02059
.3005	1.21798	.64189	.05152	-.08208	-.01262
.2600	.97338	.51153	.03952	-.06279	-.00916

RAD.STA. VELH(NU) AS NU GOES FROM 0 TO 7

.9903	1.60236	-.31274	-.83864	.06054	-.13508
.9493	1.40222	-.29308	-.72793	.04479	-.12216
.8797	1.10414	-.25748	-.57043	.02503	-.10112
.7875	.78950	-.20963	-.41068	.00916	-.07669
.6807	.52496	-.15820	-.27832	.00023	-.05414

A.

MILTON STANDARD DECK H193 —
MED SHROUD AND PROPELLER GEOMETRY

.00000	.00472	.00000	-.00176
.00178	.00000	.00292	.00000
.00000	-.00116	.00000	.00199

80	-.00000	.00910	-.00000	-.00100
80	.01588	-.00000	.00058	-.00000
89	-.00000	-.00125	-.00000	.00089
90	-.00079	-.00000	.00003	-.00000
90	-.00000	.00042	-.00000	-.00012
90	-.00119	-.00000	-.00003	-.00000
90	-.00000	.00029	-.00000	-.00014
90	-.00028	-.00000	-.00001	-.00000

.00157	-.00000	-.00001	-.00000
.00000	.00193	-.00000	-.00000
.15604	-.00000	.00051	-.00000
.00000	-.10232	-.00000	.00019
.07676	-.00000	-.07637	-.00000
.00000	.06103	-.00000	-.06093
.00012	-.00000	.05079	-.00000

.00000	-.00185	.00000	-.00041
.00417	.00000	.00093	.00000
.00000	-.00114	.00000	.00011
.00040	.00000	-.00004	.00000
.00000	.00001	.00000	.00001
.00012	.00000	.00004	.00000
.00000	.00003	.00000	-.00002

SCRIPT J REFERS TO THE ROW AND THE SUBSCRIPT NU REFERS TO THE COLUMN ****

607 MU= .911 XPB= -.10230				
.043780	-.024433	.015646	-.010819	.007970
-.011631	.006482	-.004140	.002873	-.002080
.037169	-.022480	.014742	-.010497	.007697
.014595	-.009236	.006222	-.004451	.003320
-.016077	.010445	-.007399	.005321	-.004095
-.011489	.007988	-.005775	.004285	-.003307
.005867	-.004348	.003083	-.002396	.001816

FROM 0 TO 7				
.85074	-1.63158	1.48951	1.56171	-.61415
.29601	-1.21526	1.06647	1.03086	-.39701
.59809	-.73598	.61247	.51115	-.19412
.99936	-.37977	.30118	.20465	-.07843
.58796	-.17831	.13677	.07286	-.02874
.34065	-.08217	.06184	.02566	-.01048
.20034	-.03940	.02936	.00969	-.00408
.12301	-.02059	.01527	.00423	-.00184
.08208	-.01262	.00930	.00210	-.00100
.06279	-.00916	.00684	.00175	-.00075

FROM 0 TO 7				
.04054	-.13508	.01172	-.03064	.00276
.04479	-.12216	.00960	-.02816	.00235
.02503	-.10112	.00637	-.02385	.00166
.00916	-.07669	.00319	-.01852	.00091
.00023	-.05414	.00101	-.01333	.00035

FIGURE 4A.
(SHEET 2 OF 5)

B.

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✓
**SAMPLE OUTPUT FOR HAMILTON STAND/
SAMPLE CASE FOR DEFINED SHROUD AN**

.5693	.33604	-.11248	-.18255	-.00312	-.036
.4626	.21298	-.07698	-.11832	-.00357	-.024
.3700	.13749	-.05222	-.07763	-.00299	-.016
.3005	.09433	-.03698	-.05390	-.00236	-.011
.2600	.07369	-.02932	-.04232	-.00196	-.004

A.

MILTON STANDARD DECK H193 —
HED SHROUD AND PROPELLER GEOMETRY

55	-.00312	-.03654	-.00005	-.00913	.00006
32	-.00357	-.02413	-.00039	-.00608	-.00006
63	-.00299	-.01601	-.00042	-.00406	-.00008
90	-.00236	-.01119	-.00036	-.00285	-.00007
32	-.00196	-.00881	-.00031	-.00225	-.00007

FIGURE 4A.
(SHEET 3 OF 5)

B.

SAMPLE OUTPUT FOR HAMILTON STANDARD
SAMPLE CASE FOR DEFINED SHROUD AND PI

*** PERFORMANCE ***

CONDITION J= 1.5087 THETA 3/4=42.000 MN= .3053 CP= .4292

NET THRUST COEFF. (SHROUD + PROPELLER) = .2102
SHROUD THRUST COEFFICIENT = -.0148
SHROUD FRICTION DRAG COEFFICIENT = .0216
PROPELLER THRUST COEFFICIENT = .2250

SLIPSTREAM CONTRACTION= .95

RATIO OF AVERAGE DUCT VEL./FREE STREAM VEL.= 1.0957

RATIO OF AVERAGE SLIPSTREAM VEL./FREE STREAM VEL.= 1.1317

**** INDUCED VELOCITY CONTENT ****

PROP. X	=	.9903	.9493	.8797	.7875	.6807	.5693
CENTERBODY DV/V0=		-.0084	-.0086	-.0089	-.0092	-.0092	-.0084
SHROUD T/C DV/V0=		.1316	.1255	.1152	.1023	.0891	.0780
VORTICITY DV/V0=		-.0712	-.0680	-.0646	-.0621	-.0605	-.0592
TOTAL V/V0=		1.0520	1.0489	1.0417	1.0310	1.0194	1.0104
ASSUMED V/V0=		1.0514	1.0484	1.0414	1.0308	1.0196	1.0107
PROP. IND. G. VP/V=		.1940	.1662	.1363	.1074	.0873	.0685
PROP. IND. M. VP/V=		.0740	.0880	.0888	.0813	.0738	.0628
SWIRL ANGLE	=	3.6107	4.2513	4.3162	4.6163	3.7084	3.2153

**** GLAUERT COEFFICIENTS CONTENT ****

NU	SHROUD CAMBER	SHROUD T/C	PROP. CIRC.	CENTER -BODY	TOTAL 2-D	3-D
-0	-.5100	-.0770	.0814	-.0930	-.3676	-.3719
1	.4742	-.0245	-.0176	-.0338	.4719	.4449
2	.5694	.0001	.0467	.0142	.6501	.6509
3	.3748	-.0009	.0152	-.0007	.3911	.3917
4	.2473	.0081	-.0156	-.0009	.2470	.2463
5	.0951	-.0054	-.0103	.0000	.0956	.0952
6	-.0456	.0055	.0054	.0000	-.0293	-.0296

**** SHROUD SURFACE VELOCITIES AND PRESSURE COEFFICIENTS ****

SHROUD X	VORT. DIS.	VELOCITY COMPONENTS		PROP WAKE	CB EFF
		2-D THICK.	3-D THICK. + VORT. CONT.		
0					
.00010	9.27679	.19128	-.03645	.01551	-.00
.00500	1.16724	.37954	-.03476	.01560	-.00
.01250	.60794	.43680	-.03238	.01573	-.00
.02500	.29398	.47207	-.02889	.01596	-.00
.05000	.05831	.47070	-.02350	.01641	-.00

A.

TON STANDARD DECK H193 —
SHROUD AND PROPELLER GEOMETRY

HSER 4776
Volume II

053 CP= .4292

957

1.1317

.6807	.5693	.4626	.3700	.3005	.2600
-.0092	-.0084	-.0067	-.0039	-.0005	.0021
.0891	.0780	.0698	.0644	.0613	.0599
-.0605	-.0592	-.0581	-.0573	-.0568	-.0566
1.0194	1.0104	1.0050	1.0032	1.0040	1.0055
1.0196	1.0107	1.0054	1.0036	1.0044	1.0059
.0873	.0685	.0497	.0340	.0231	.0174
.0738	.0628	.0495	.0365	.0269	.0216
3.7084	3.2153	2.5809	1.9296	1.4356	1.1585

0
0719
0449
0509
0917
0463
0952
0296

ICIENTS ****

TOP WAKE	CB EFF.	OUTER SURFACE		INNER SURFACE	
		V/VINF	CPRESS	V/VINF	CPRESS
.01551	-.00530	.9492	.0990	-.8568	.2659
.01560	-.00530	1.3318	-.7737	-.7374	.4563
.01573	-.00530	1.4280	-1.0393	.0992	.9902
.01596	-.00530	1.4596	-1.1303	.5697	.6755
.01641	-.00520	1.4248	-1.0300	.9686	.0619
				1.3152	-.7299

FIGURE 4A.
(SHEET 4 OF 5)

B,

SAMPLE OUTPUT FOR HAMILTON STANDAR
SAMPLE CASE FOR DEFINED SHROUD AND

.07500	-.03427	.43353	-.01987	.01686
.10000	-.07184	.38498	-.01761	.01731
.15000	-.07519	.28996	-.01601	.01814
.20000	-.04174	.21918	-.01672	.01876
.25000	-.00226	.17644	-.01840	.01885
.30000	.03024	.15560	-.02027	.01771
.40000	.06032	.14512	-.02316	.00406
.50000	.05587	.13347	-.02466	-.01566
.60000	.04725	.10324	-.02552	-.01891
.70000	.05566	.06518	-.02618	-.01785
.80000	.07476	.03178	-.02604	-.01607
.90000	.06859	-.01239	-.02383	-.01433
.95000	.04324	-.06159	-.02171	-.01352

**** BLADE ELEMENTAL PRINTOUT ****

J= 1.5087 THETA 3/4= 42.00 FREE STREAM M.N.= .3053

X=	.9903	.9493	.8797	.7875	.6807	.50
THETA=	36.80	37.30	38.50	40.75	45.30	51
ALPHA=	4.07	4.28	4.40	4.66	5.86	7
PHI=	32.73	33.02	34.10	36.09	39.44	43
BETA=	5.72	5.08	4.48	3.93	3.71	3
PHI 0=	27.02	27.94	29.62	32.15	35.73	40
CL3=	.5699	.7147	.7875	.8193	.8684	.8
CD/CL=	.0446	.0296	.0182	.0162	.0172	.0
DCP/DX=	1.1067	1.1997	1.0619	.8285	.6241	.4
DCT/DX=	.5027	.5806	.5459	.4442	.3427	.2
SECT.EFF.=	.6853	.7301	.7756	.8088	.8283	.8
SECT.MN=	.7032	.6804	.6413	.5899	.5319	.4
M/MCRIT=	.7738	.7989	.7089	.7587	.7193	.7

A.

ON STANDARD DECK H193 —
THROUD AND PROPELLER GEOMETRY

.01686	-.00520	1.3605	-.8510	1.4275	-1.0379
.01731	-.00530	1.2981	-.6852	1.4408	-1.0759
.01814	-.00540	1.2111	-.4667	1.3614	-.8535
.01876	-.00570	1.1738	-.3777	1.2573	-.5807
.01885	-.00610	1.1685	-.3655	1.1731	-.3760
.01771	-.00660	1.1767	-.3845	1.1162	-.2459
.00406	-.00780	1.1785	-.3890	1.0579	-.1192
-.01566	-.00910	1.1399	-.2994	1.0282	-.0572
-.01891	-.01050	1.0956	-.2002	1.0011	-.0021
-.01785	-.01170	1.0651	-.1345	.9538	.0903
-.01607	-.01250	1.0519	-.1065	.9024	.1857
-.01433	-.01280	1.0052	-.0105	.8681	.2465
-.01352	-.01270	.9337	.1282	.8472	.2822

.3053

.6807	.5693	.4626	.3700	.3005	.2600
45.30	51.40	58.30	65.10	70.70	74.30
5.86	7.45	8.93	9.92	10.36	10.62
39.44	43.95	49.37	55.18	60.34	63.68
3.71	3.50	3.14	2.69	2.26	1.97
35.73	40.45	46.23	52.49	58.08	61.71
.8684	.8844	.8351	.7282	.6048	.5215
.0172	.0189	.0277	.0400	.0577	.0747
.6241	.4288	.2682	.1558	.0930	.0647
.3427	.2394	.1497	.0855	.0488	.0321
.8283	.8424	.8421	.8278	.7920	.7480
.5319	.4747	.4245	.3859	.3610	.3485
.7193	.7086	.7196	.7050	.6082	.6085

FIGURE 4A.
(SHEET 5 OF 5)

B.

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SAMPLE OUTPUT FOR HAMILTON STANDARD
SAMPLE CASE FOR DEFINED SHROUD AND PF

HS COMPUTER DECK H193
HS SHROUDED PROPELLER PERFORMANCE
HAMILTON STANDARD
WINDSOR LOCKS, CONN.
1967

1 ROSE WROBEL 10/13/67
2 GIVEN PROPELLER CIRCULATION

**** PROPELLER CHARACTERISTICS ****

3 B1-3WT

NO. OF BLADES = 3. AF = 168.0
DIAMETER FT. = 2.4940 CL = .4000
HUB X = .2500

X =	.9903	.9493	.8797	.7875	.6807	.5693	.4626
CIRCULATION =	.1489	.1769	.1788	.1632	.1484	.1262	.0995

**** SHROUD CHARACTERISTICS ****

SHROUD NO. = 1. LAMBDA = .6070
XP-BAR = -.1023 MU = .9110
SHROUD INNER SURFACE DIAMETER FT. = 2.5000
SHROUD REFERENCE DIAMETER FT. = 2.7377
RIEGELS FACTOR LIMIT = .1875
AREA RATIO = 1.1000

T/C CONTRIBUTION TO VORTICITY (THICKNESS COEFF.) =	.5270	.2506	-
SLOPE OF MEAN CAMBER LINE (GLAUERT COEFF.) =	-.5100	.4742	-

**** CENTERBODY CHARACTERISTICS ****

CONTRIBUTION TO VORTICITY (GLAUERT COEFF.) =	-.0930	-.0338	.
--	--------	--------	---

**** CALCULATIONS ARE BASED ON SHROUD CHARACTERISTICS AND GIVEN PROPEL

A.

DETON STANDARD DECK H193 —
RO SHROUD AND PROPELLER CIRCULATION

MPUTER DECK H193
PELLER PERFORMANCE PROGRAM
CE P HILTON STANDARD
SOR LOCKS, CONN.
1967

.3 .5693 .4626 .3700 .3005 .2600
.0 .1262 .0995 .0734 .0540 .0435

-7. .5270 .2506 -7.4200 30.5670 -64.6900 73.8190 -43.2900 10.2380
. -5100 .4742 .5894 .3748 .2473 .0951 -.0456

.01 .0930 -.0338 .0142 -.0007 -.0009 .0000 .0000 -.0000

LLER S AND GIVEN PROPELLER CIRCULATION ****

FIGURE 4B.
(SHEET 1 OF 3)

SAMPLE OUTPUT FOR HAMILTON STANDARD
SAMPLE CASE FOR DEFINED SHROUD AND F

*** PERFORMANCE ***

CONDITION J= 1.5087 MN= .3053

NET THRUST COEFF.(SHROUD + PROPELLER) = .2102
SHROUD THRUST COEFFICIENT = -.0148
SHROUD FRICTION DRAG COEFFICIENT = .0216
PROPELLER THRUST COEFFICIENT = .2250

SLIPSTREAM CONTRACTION= .95

RATIO OF AVERAGE DUCT VEL./FREE STREAM VEL.= 1.0957

RATIO OF AVERAGE SLIPSTREAM VEL./FREE STREAM VEL.= 1.1317

**** INDUCED VELOCITY CONTENT ****

PROP. X	=	.9903	.9493	.8797	.7875	.6807	.56
CENTERBODY DV/V0=	-.0084	-.0086	-.0089	-.0092	-.0092	-.0092	-.00
SHROUD T/C DV/V0=	.1316	.1255	.1152	.1023	.0891	.07	
VORTICITY DV/V0=	-.0712	-.0680	-.0646	-.0621	-.0605	-.05	
TOTAL V/V0=	1.0520	1.0489	1.0417	1.0309	1.0194	1.01	

**** GLAUERT COEFFICIENTS CONTENT ****

NU	SHROUD CAMBER	SHROUD T/C	PROP. CIRC.	CENTER BODY	TOTAL 2-D	3-D
-0	-.5100	-.0770	.0814	-.0930	-.3676	-.3719
1	.4742	-.0245	-.0176	-.0338	.4719	.4449
2	.5894	.0001	.0466	.0142	.6501	.6509
3	.3748	-.0009	.0152	-.0007	.3911	.3917
4	.2473	-.0041	-.0156	-.0009	.2470	.2463
5	.0951	-.0054	-.0103	.0000	.0956	.0952
6	-.0456	-.0055	.0054	.0000	-.0293	-.0296

**** SHROUD SURFACE VELOCITIES AND PRESSURE COEFFICIENTS ****

SHROUD X	VORT.DIS.	VELOCITY COMPONENTS			PROP WAKE
		2-D THICK.	3-D THICK.+	VORT.CONT.	
.00010	9.27720	.19128	-.03645	.01550	
.00500	1.16730	.37954	-.03477	.01559	
.01250	.60797	.43680	-.03238	.01572	
.02500	.29401	.47207	-.02889	.01595	
.05000	.05833	.47070	-.02350	.01640	
.07500	-.03426	.43353	-.01987	.01685	
.10000	-.07182	.38498	-.01762	.01730	
.15000	-.07518	.28996	-.01602	.01813	
.20000	-.04173	.21918	-.01672	.01875	

A.

MILTON STANDARD DECK H193
SHROUD AND PROPELLER CIRCULATION

2102
0148
0216
0250

1.0957
VEL.= 1.1317

7875	.6807	.5693	.4626	.3700	.3005	.2600
0092	-.0092	-.0084	-.0067	-.0039	-.0005	.0021
1023	.0891	.0780	.0698	.0644	.0613	.0599
0621	-.0605	-.0592	-.0582	-.0573	-.0568	-.0566
0309	1.0194	1.0104	1.0050	1.0032	1.0040	1.0055

3-0
76 -.3719
19 .4449
01 .6509
11 .3917
70 .2463
66 .0952
93 -.0296

COEFFICIENTS ****

ST.	PROP WAKE	CB EFF.	OUTER SURFACE		INNER SURFACE	
			V/VINF	CPRESS	V/VINF	CPRESS
645	.01550	-.00530	.9492	.0990	-.8568	.2659
677	.01559	-.00530	1.3318	-.7738	-.7374	.4562
638	.01572	-.00530	1.4281	-1.0394	.0991	.9902
689	.01595	-.00530	1.4596	-1.1304	.5696	.6755
650	.01640	-.00520	1.4248	-1.0301	.9685	.0619
687	.01685	-.00520	1.3605	-.8510	1.3152	-.7298
762	.01730	-.00530	1.2982	-.6852	1.4275	-1.0378
602	.01813	-.00540	1.2111	-.4667	1.4408	-1.0758
672	.01875	-.00570	1.1738	-.3777	1.3614	-.8534
					1.2572	-.5807

FIGURE 4B.
(SHEET 2 OF 3)

B.

SAMPLE OUTPUT FOR HAMILTON STANDARD
SAMPLE CASE FOR DEFINED SHROUD AND PR

.25000	-.00225	.17644	-.01841	.01884	-.0
.30000	.03024	.15560	-.02028	.01770	-.0
.40000	.06032	.14512	-.02317	.00406	-.0
.50000	.05587	.13347	-.02466	-.01566	-.0
.60000	.04725	.10324	-.02552	-.01890	-.0
.70000	.05566	.06518	-.02618	-.01784	-.0
.80000	.07476	.03178	-.02604	-.01607	-.0
.90000	.06859	-.01239	-.02383	-.01432	-.0
.95000	.04324	-.06159	-.02171	-.01351	-.0

A.

ETON STANDARD DECK H193 —
D SHROUD AND PROPELLER CIRCULATION

.01884	-.00610	1.1685	-.3655	1.1730	-.3760
.01770	-.00660	1.1767	-.3845	1.1162	-.2459
.00406	-.00780	1.1785	-.3890	1.0579	-.1191
-.01566	-.00910	1.1399	-.2994	1.0282	-.0572
-.01890	-.01050	1.0956	-.2003	1.0011	-.0021
-.01784	-.01170	1.0651	-.1345	.9538	.0903
-.01607	-.01250	1.0519	-.1066	.9024	.1856
-.01432	-.01280	1.0053	-.0105	.8681	.2465
-.01351	-.01270	.9337	.1281	.8472	.2822

FIGURE 4B.
(SHEET 3 OF 3)

B.

Hamilton
Standard

DIVISION OF UNITED AIRCRAFT CORPORATION

U
A®

SAMPLE OUTPUT FOR HAI
SAMPLE CASE FOR SHROU

HS COMPUTER DECK H19
HS SHROUDED PROPELLER PERFORMANCE
HAMILTON STANDARD
WINDSOR LOCKS, CONN.
1967

1 ROSE WOROBEL 10/13/67
2 SHROUD ALONE
3 B1

**** SHROUD CHARACTERISTICS ****

SHROUD NO. = 1. LAMBDA = .6070
XP-BAR = -.1023 MU = .9132
SHROUD INNER SURFACE DIAMETER FT. = 2.5000
SHROUD REFERENCE DIAMETER FT. = 2.7377
RIEGELS FACTOR LIMIT = .1875
AREA RATIO = 1.1000
CENTERBODY X IN SPECIFIED PLANE = .2500

T/C CONTRIBUTION TO VORTICITY (THICKNESS COEFF.) = .5270 .2506
SLOPE OF MEAN CAMBER LINE (GLAUERT COEFF.) = -.5100 .4742

**** CENTERBODY CHARACTERISTICS ****

CONTRIBUTION TO VORTICITY (GLAUERT COEFF.) = -.0930 -.0338

**** CALCULATIONS ARE BASED ON THE SHROUD ALONE ****

A.

INPUT FOR HAMILTON STANDARD DECK H193 —
USE FOR SHROUD ALONE

COMPUTER DECK H193
SPELLER PERFORMANCE PROGRAM
HAMILTON STANDARD
DOR LOCKS, CONN.
1967

.5270	.2506	-7.4200	30.5670	-64.6900	73.8190	-43.2900	10.2380
-.5100	.4742	.5894	.3748	.2473	.0951	-.0456	
.0930	-.0338	.0142	-.0007	-.0009	.0000	.0000	-.0000

FIGURE 4C.
(SHEET 1 OF 3)

SAMPLE OUTPUT FOR HA
SAMPLE CASE FOR SHRO

*** PERFORMANCE ***

CONDITION MN= .3053

SHROUD FRICTION DRAG COEFFICIENT = .0079

SLIPSTREAM CONTRACTION= .96

RATIO OF AVERAGE DUCT VEL./FREE STREAM VEL.= .9825

**** INDUCED VELOCITY CONTENT ****

PROP. X	=	.9903	.9493	.8797	.7875	.6807	.565
CENTERBODY DV/V0=		-.0084	-.0086	-.0089	-.0092	-.0092	-.001
SHROUD T/C DV/V0=		.1319	.1258	.1155	.1025	.0893	.071
VORTICITY DV/V0=		-.1181	-.1145	-.1102	-.1065	-.1032	-.101
TOTAL V/V0=		1.0054	1.0027	.9964	.9869	.9769	.965

**** GLAUERT COEFFICIENTS CONTENT ****

NU	SHROUD CAMBER	SHROUD T/C	PROP. CIRC.	CENTER -BODY	TOTAL 2-D	3-D
-0	-.5100	-.0770	.0000	-.0930	-.4490	-.4644
1	.4742	-.0245	.0000	-.0338	.4895	.4456
2	.5894	.0001	.0000	.0142	.6034	.5994
3	.3748	-.0009	.0000	-.0007	.3759	.3763
4	.2473	-.0081	.0000	-.0009	.2626	.2622
5	.0951	-.0054	.0000	.0000	.1059	.1055
6	-.0456	-.0055	.0000	.0000	-.0347	-.0350

**** SHROUD SURFACE VELOCITIES AND PRESSURE COEFFICIENTS ****

----- VELOCITY COMPONENTS -----

SHROUD X	VORT.DIS.	2-D THICK.	3-D THICK.+ VORT.CONT.	PROP WAKE	CB
.0					
.00010	11.58799	.19128	-.06053	.00000	
.00500	1.49560	.37954	-.05881	.00000	
.01250	.81715	.43680	-.05636	.00000	
.02500	.44391	.47207	-.05276	.00000	
.05000	.16751	.47070	-.04719	.00000	
.07500	.05778	.43353	-.04337	.00000	
.10000	.01049	.38498	-.04091	.00000	
.15000	-.00410	.28996	-.03879	.00000	
.20000	.02185	.21918	-.03879	.00000	
.25000	.05443	.17644	-.03958	.00000	
.30000	.07956	.15560	-.04037	.00000	
.40000	.09309	.14512	-.04072	.00000	
.50000	.07239	.13347	-.03955	.00000	
.60000	.05223	.10324	-.03802	.00000	

A.

OUTPUT FOR HAMILTON STANDARD DECK H193 —
CASE FOR SHROUD ALONE

0079

.9825

7875	.6807	.5693	.4626	.3700	.3005	.2600
0092	-.0092	-.0084	-.0067	-.0039	-.0005	.0021
1025	.0893	.0781	.0699	.0645	.0613	.0599
1065	-.1032	-.1004	-.0980	-.0963	-.0951	-.0946
9869	.9769	.9693	.9652	.9643	.9657	.9675

3-D

-.4644
.4456
.5994
.3763
.2622
.1055
-.0350

COEFFICIENTS ****

	PROP WAKE	CB EFF.	OUTER SURFACE		INNER SURFACE	
			V/VINF	CPRESS	V/VINF	CPRESS
					-1.0697	-.1443
3	.00000	-.00530	1.1557	-.3356	-.9511	.0954
1	.00000	-.00530	1.4843	-1.2030	-.0951	.9910
6	.00000	-.00530	1.5477	-1.3954	.3939	.8448
6	.00000	-.00530	1.5515	-1.4071	.8101	.3437
9	.00000	-.00520	1.4897	-1.2192	1.1750	-.3806
7	.00000	-.00520	1.4111	-.9911	1.2980	-.6849
1	.00000	-.00530	1.3396	-.7945	1.3187	-.7391
9	.00000	-.00540	1.2413	-.5407	1.2494	-.5611
9	.00000	-.00570	1.1965	-.4317	1.1528	-.3290
8	.00000	-.00610	1.1852	-.4047	1.0763	-.1585
7	.00000	-.00660	1.1882	-.4118	1.0291	-.0590
2	.00000	-.00780	1.1897	-.4154	1.0035	-.0070
5	.00000	-.00910	1.1572	-.3391	1.0124	-.0250
2	.00000	-.01050	1.1070	-.2253	1.0025	-.0050

FIGURE 4C.
(SHEET 2 OF 3)

B.

SAMPLE OUTPUT FOR HAMILTON ST
SAMPLE CASE FOR SHROUD ALONE

.70000	.05633	.06518	-.03679	.00000	-.0117
.80000	.07651	.03178	-.03523	.00000	-.0125
.90000	.07068	-.01239	-.03188	.00000	-.0128
.95000	.04343	-.06159	-.02921	.00000	-.0127

A.

OR HAMILTON STANDARD DECK H193 —
SHROUD ALONE

.00000	-.01170	1.0730	-.1514	.9604	.0777
.00000	-.01250	1.0606	-.1248	.9075	.1764
.00000	-.01280	1.0136	-.0274	.8723	.2392
.00000	-.01270	.9399	-.1165	.8531	.2723

FIGURE 4C.
(SHEET 3 OF 3)

B.

3.0 SHROUD GEOMETRY COMPUTER PROGRAM

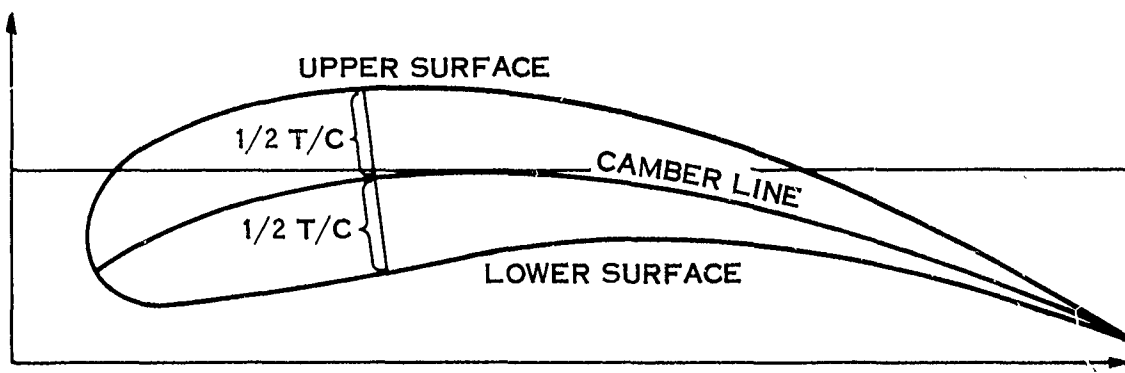
A. Deck: Hamilton Standard Deck H194

B. Title: Shroud Geometry Program

C. Purpose: Shroud camber two dimensional Glauert coefficients E_n and shroud thickness coefficients A_n are computed for the given shroud geometry. The results are included as input for Hamilton Standard Deck H193 to compute shrouded propeller performance.

D. Analysis Method

Given the shroud geometry and its orientation relative to the shroud center line, the mean camber line and thickness ratio are defined as discussed below. The mean camber line is defined as the locus of points equidistant from the upper and lower surfaces of the shroud. The distance from the camber line to the shroud surface is measured along a normal to the camber line as shown in the sketch below.



1. Shroud Camber 2-D Glauert Coefficients are defined as

$$b_{0\nu(\nu)}^{c.B.} = \frac{-4}{\pi} \int_0^{\pi} 2\epsilon (\text{CONST}) d\phi_s$$

where ϵ = slope of the shroud camber line relative to the shroud center line.

3.0 (Continued)

$$\text{const.} = \begin{cases} -1/2 & \text{for } \nu = 0 \\ \cos(\nu \phi_s) & \text{for } \nu = 1 \text{ to } 6 \end{cases}$$

$$\phi_s = \cos^{-1}(-x_s/\lambda)$$

x_s = Percentage shroud chord from leading edge.

($x_s = 0$ at leading edge and $x_s = 1.0$ at exit)

λ = Ratio of shroud chord to shroud reference diameter (diameter to shroud camber line in propeller plane).

2. Shroud Thickness Coefficients

$$T/C = A_0 \sqrt{x_s} + \sum_{n=1}^7 A_n (x_s)^n$$

where

$$A_0 = 2 \sqrt{\frac{2R_{LE}}{C}}$$

R_{LE} = Leading edge radius

C = Shroud chord

T/C = Shroud thickness to chord ratio

x_s = Percentage chord from leading edge radius

A_n = Shroud thickness coefficients

E. Description of Input

The input is coded as specified on Fig. 5.

The slope of the shroud camber line is represented by a table. Small intervals of x_s should be selected where the slope changes rapidly.

From the many cases run, the following x_s 's appear to well define the shroud T/C

$$x_s(1) = 1.00$$

INPUT INSTRUCTIONS FOR HAMILTON STANDARD DECK H194 (SHROUD GEOMETRY PROGRAM)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	
1	LABEL CARD																																																																															
2	CARDS 2 THROUGH 7 DEFINE THE TABLE OF THE SLOPE OF THE SHROUD CAMBER LINE																																																																															
3	X'S FOLLOWED BY X'S THEMSELVES IN ASCENDING ORDER FOLLOWED BY THE																																																																															
4	CORRESPONDING SLOPES OF THE CAMBER LINE. THE MAXIMUM NUMBER OF X'S=32.																																																																															
5	USE ONLY THE NUMBER OF CARDS NECESSARY.																																																																															
6																																																																																
7																																																																																
8	CARDS 8 & 9 DEFINE THE SHROUD THICKNESS, T/C																																																																															
9	X'S(11) T X'S SELECTED TO DEFINE T/C X'S(11)																																																																															
10	T/C(1) CORRESPONDING T/C'S T/C(11)																																																																															
11	A. (DEFINED IN TEXT)																																																																															
12	OPTION TABLE																																																																															
13	WHERE OPTION=1. COMPUTES T/C AND CAMBER LINE COEFFICIENTS (INCLUDE CARDS																																																																															
14	1 THROUGH 11)																																																																															
15	OPTION=1. COMPUTES CAMBER LINE COEFFICIENTS ONLY (INCLUDE CARDS																																																																															
16	1 THROUGH 7 & 11)																																																																															
17	OPTION=2. COMPUTES T/C COEFFICIENTS ONLY (INCLUDE CARDS 1 &																																																																															
18	8 THROUGH 11)																																																																															

FIGURE 5. (SHEET 1 OF 2)

INPUT INSTRUCTIONS FOR HAMILTON STANDARD DECK H194 (SHROUD GEOMETRY PROGRAM)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
IF MORE CASES ARE TO FOLLOW																																																																															
FOR LAST CASE																																																																															
FOR SUBSEQUENT CASES, THE FOLLOWING MUST BE INCLUDED																																																																															
A. CARD 1																																																																															
H. CARDS 2 THROUGH 10 THAT VARY FROM THE PREVIOUS CASE. IF ANY																																																																															
CHANGE IS MADE ON CARDS 2 THROUGH 7 THE ENTIRE SET MUST BE																																																																															
INCLUDED.																																																																															
C. CARD 11																																																																															

FIGURE 5. (SHEET 2 OF 2)

3.0

(Continued)

$$x_S (2) = .925$$

$$x_S (3) = .8$$

$$x_S (4) = .6$$

$$x_S (5) = .4$$

$$x_S (6) = .2$$

$$x_S (7) = .1$$

A sample case of input is shown in Fig. 6.

F. Description of Output

The output for the sample case is shown on Fig. 7. The comment card and the input camberline table are listed. Then, for the 81 intervals used in numerical integration, the interpolated slopes are listed. It is advisable to plot this data to be certain that the camberline is properly represented. Fig. 8 shows such a comparison for the sample case. The listed shroud camber 2-D Glauert coefficient are used as input to Hamilton Standard Deck H193.

The shroud thickness input prints out as well as the shroud thickness coefficients (Input to Deck H193) and a table of x_S versus T/C based on the polynomial fit. The data in this table should be plotted to assure that the shroud thickness is properly represented. Fig. 9 shows the comparison for the sample case.

An error message, "MATRIX IS SINGULAR", means that the internal solution of a set of simultaneous equations has yielded zeros for all coefficients. Check the input for errors.

G. Estimated Running Time

On the Univac 1108, the running time is 10 cases per minute.

SAMPLE INPUT FOR HAMILTON STANDARD DECK H194 (SHROUD GEOMETRY PROGRAM)

[illegible]

SAMPLE OUTPUT FOR SHROUD GEOMET

HS COMPUTER DECK H194
SHROUD GEOMETRY PROGRAM
HAMILTON STANDARD
WINDSOR LOCKS, CONN.
1967

1 JOHN FIDLER B1 CAMBER AND THICKNESS 10-17-67

**** CALCULATION OF SHROUD CAMBER 2-D GLAUERT COEFFICIENTS ****

AXIAL LOC.	INPUT SLOPE	AXIAL LOC.	INPUT SLOPE
.00000	-.52500	.10000	-.13400
.01000	-.50000	.12500	-.05000
.02000	-.47400	.15000	-.01700
.03000	-.44100	.17500	-.00200
.04000	-.41300	.20000	.00000
.05000	-.37900	.22500	.00000
.06000	-.34100	.25000	.00000
.07000	-.30100	.27500	-.00600
.08000	-.25500	.30000	-.01200
.09000	-.20000	.35000	-.02750

AXIAL LOC.	INT. SLOPE	AXIAL LOC.	INT. SLOPE
-.00000	-.52500	.25569	-.00105
.00039	-.52398	.27300	-.00544
.00154	-.52097	.29067	-.00971
.00347	-.51607	.30866	-.01444
.00616	-.50940	.32694	-.02001
.00961	-.50096	.34549	-.02602
.01382	-.49052	.36428	-.03227
.01877	-.47745	.38328	-.03830
.02447	-.45939	.40245	-.04341
.03090	-.43843	.42178	-.04567
.03806	-.41856	.44123	-.04645
.04593	-.39344	.46077	-.04599
.05450	-.36229	.48037	-.04457
.06375	-.32644	.50000	-.04250
.07368	-.28493	.51963	-.04050
.08427	-.23276	.53923	-.03833
.09549	-.16386	.55877	-.03617
.10734	-.09927	.57822	-.03422
.11980	-.06060	.59754	-.03266
.13284	-.03572	.61672	-.03239
.14645	-.01983	.63572	-.03279
.16060	-.00873	.65451	-.03370
.17528	-.00193	.67306	-.03511
.19045	.00007	.69134	-.03696
.20611	.00011	.70933	-.03933
.22221	.00004	.72700	-.04215
.23875	.00038	.74431	-.04526

**** SHROUD CAMBER 2-D GLAUERT COEFFICIENTS --- E0 THRU E6 ****
-.50999 .47422 .58942 .37482 .24726 .09510 -.045

**** CALCULATION OF SHROUD THICKNESS COEFFICIENTS ****

AXIAL LOCATION =	1.0000	.9250	.8000	.6000	.4000	.2000	.1000
INPUT T/C =	.0000	.0268	.0639	.1130	.1419	.1510	.1423

**** SHROUD THICKNESS COEFFICIENTS --- A0 THRU A7 ****
.5270 .2506 -7.4202 30.5666 -64.6876 73.8186 -43.2923 10.2375

AXIAL LOC. CALC.T/C

A.

FOR SHROUD GEOMETRY PROGRAM

COMPUTER DECK H194
SHROUD GEOMETRY PROGRAM
HAMILTON STANDARD
INDSOR LOCKS & CONN.
1967

57

EFFICIENTS ****

AL LOC.	INPUT SLOPE	AXIAL LOC.	INPUT SLOPE
.10000	-.13400	.40000	-.04300
.12500	-.05000	.50000	-.04250
.15000	-.01700	.60000	-.03250
.17500	-.00200	.70000	-.03800
.20000	.00000	.80000	-.05700
.22500	.00000	.90000	-.08100
.25000	.00000	.95000	-.09100
.27500	-.00600	1.00000	-.10100
.30000	-.01200		
.35000	-.02750		

AL LOC.	INT. SLOPE	AXIAL LOC.	INT. SLOPE
.25569	-.00105	.76125	-.04858
.27300	-.00544	.77778	-.05205
.29067	-.00971	.79389	-.05561
.30866	-.01444	.80955	-.05927
.32694	-.02001	.82472	-.06295
.34549	-.02602	.83940	-.06655
.36428	-.03227	.85355	-.07002
.38328	-.03830	.86716	-.07333
.40245	-.04341	.88020	-.07644
.42178	-.04567	.89266	-.07934
.44123	-.04645	.90451	-.08193
.46077	-.04599	.91573	-.08421
.48037	-.04457	.92632	-.08633
.50000	-.04250	.93625	-.08829
.51963	-.04050	.94550	-.09012
.53923	-.03833	.95407	-.09180
.55877	-.03617	.96194	-.09335
.57822	-.03422	.96910	-.09476
.59754	-.03266	.97553	-.09604
.61672	-.03239	.98123	-.09718
.63572	-.03279	.98618	-.09818
.65451	-.03370	.99039	-.09903
.67306	-.03511	.99384	-.09974
.69134	-.03696	.99653	-.10029
.70933	-.03933	.99846	-.10068
.72700	-.04215	.99961	-.10092
.74431	-.04526	1.00000	-.10100

THRU E6 ****
726 .09510 -.04560

.4000 .2000 .1000
.1419 .1510 .1423

06 -43.2923 10.2375

FIGURE 7.
(SHEET 1 OF 2)

B.

Hamilton
Standard

U
A[®]
DIVISION OF UNITED AIRCRAFT CORPORATION

SAMPLE OUTPUT FOR SHROUD GE

.000000	.000000
.050000	.115257
.100000	.142300
.150000	.150280
.200000	.151000
.250000	.149437
.300000	.147384
.350000	.145033
.400000	.141900
.450000	.137387
.500000	.131083
.550000	.122888
.600000	.113000
.650000	.101804
.700000	.089725
.750000	.077069
.800000	.063900
.850000	.049996
.900000	.034920
.950000	.016249
1.000000	-.000001

A.

FOR SHROUD GEOMETRY PROGRAM

FIGURE 7.
(SHEET 2 OF 2)

COMPARISON OF ACTUAL SHROUD CAMBER LINE SLOPE DISTRIBUTION WITH
COMPUTER PROGRAM REPRESENTATION

B1-3WT

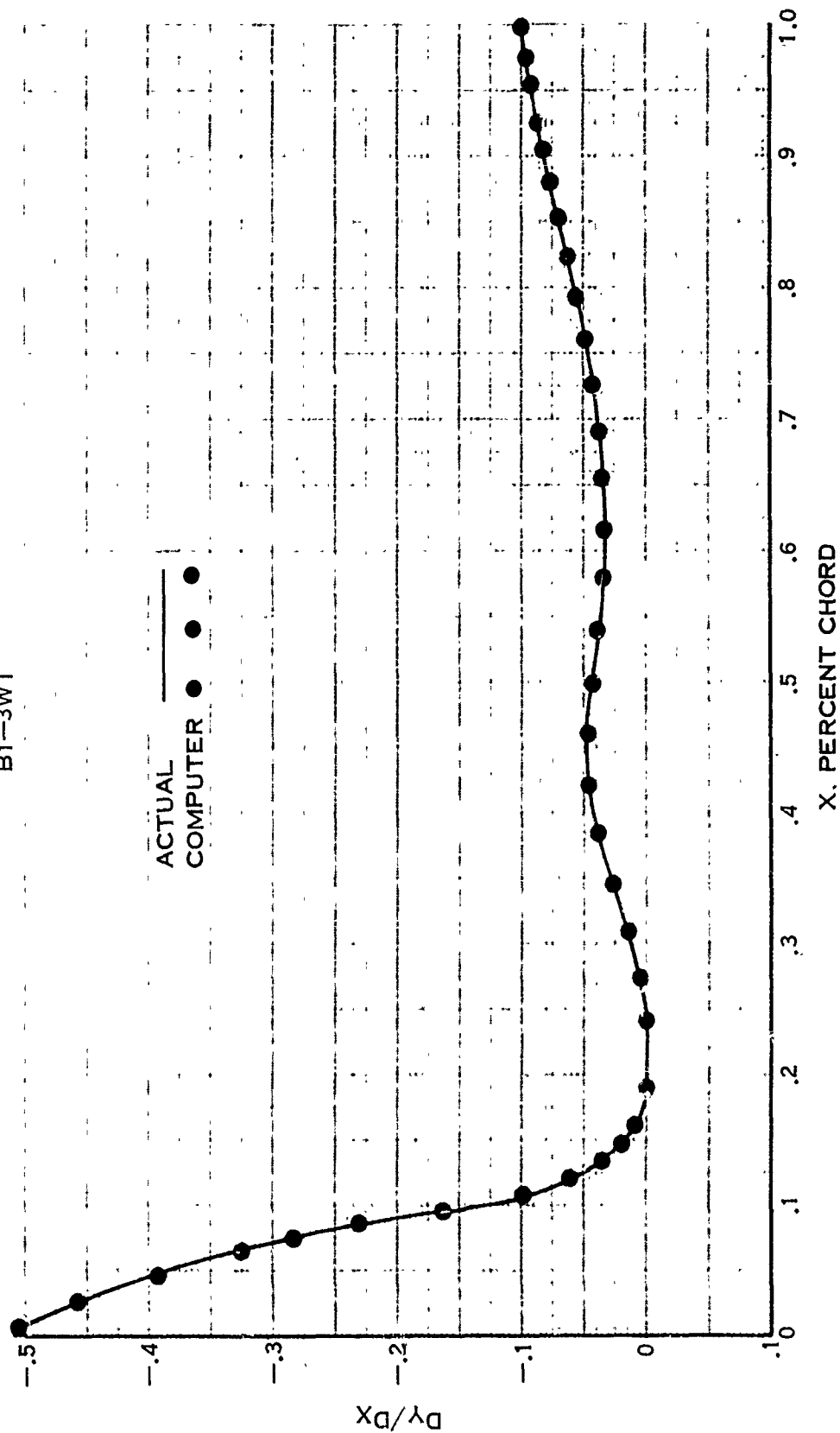


FIGURE 8.

COMPARISON OF ACTUAL SHROUD THICKNESS RATIO DISTRIBUTION WITH
CALCULATIONS BASED ON SHROUD THICKNESS COEFFICIENTS

B1-3WT

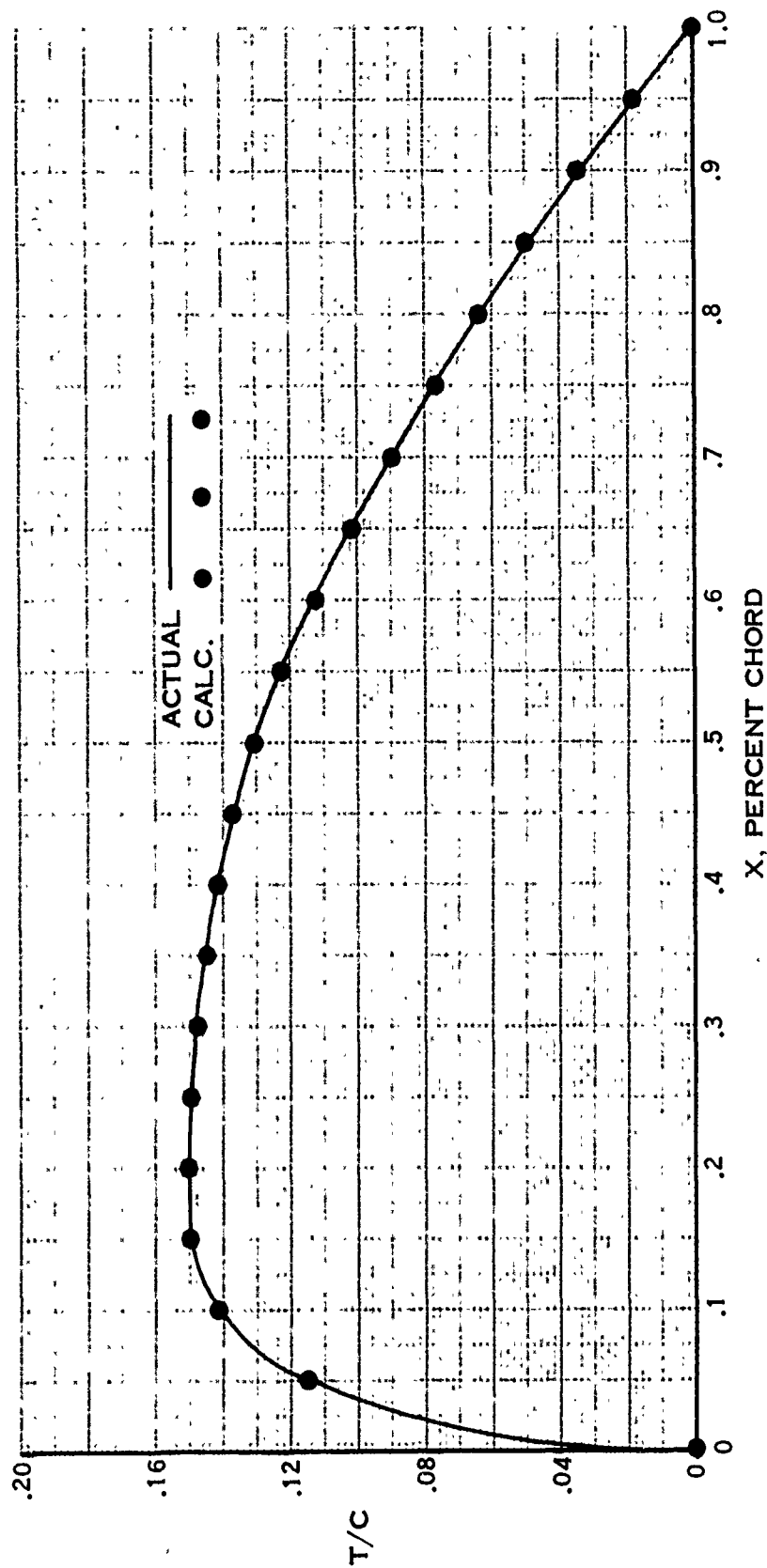


FIGURE 9.

4.0 CENTERBODY COMPUTER PROGRAM

- A. Deck: Hamilton Standard Deck H060
- B. Title: Centerbody Induced Velocities
- C. Purpose: This program computes the ratios of the velocities induced by the centerbody on the shroud surface and in the plane of the propeller to the free stream velocity.
- D. Analysis Method

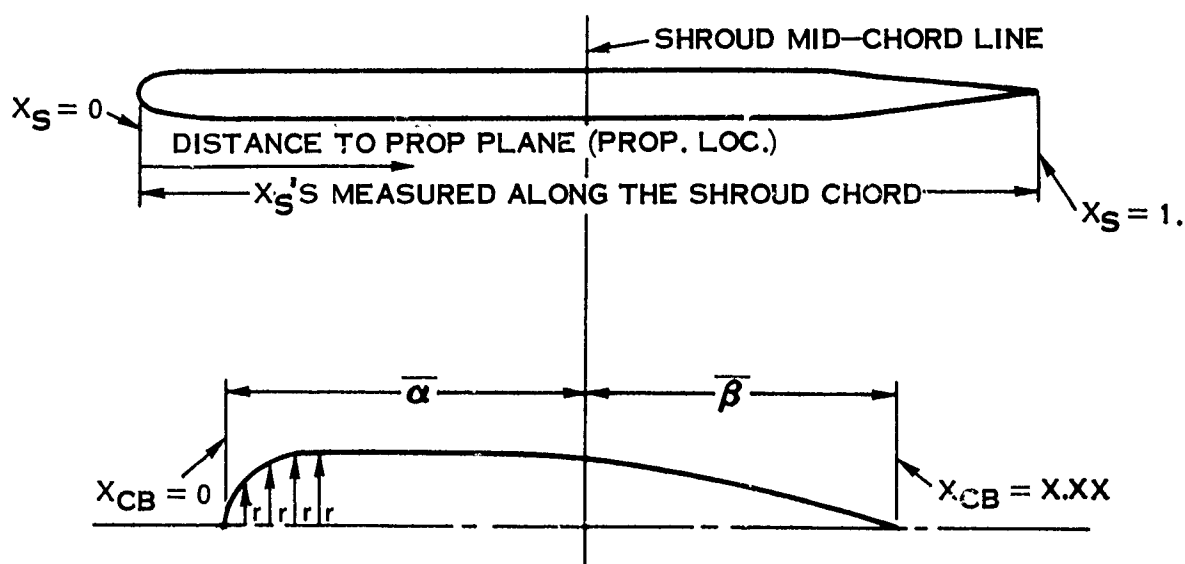
The method of sources and sinks has been employed to approximate the desired body shape. The method of least squares has been used to calculate a seventh order polynomial representative of the source-sink distribution. This distribution is employed to calculate the radial and axial velocity ratios induced by the centerbody. This analysis method is explained in detail in Appendix 11.1 of Volume I.

F. Restrictions

The analysis is limited to centerbodies with a large length to diameter ratio and with the trailing edge tapering gradually to zero. For bodies with blunt trailing edges, it is essential that the trailing edge be extended to meet the restriction.

G. Description of Input

The following illustration defines the co-ordinate system used for obtaining the necessary input parameters.



4.0

(Continued)

The input is included as shown on Fig. 10 where:

LAMBDA - Ratio of shroud chord to shroud reference diameter. The shroud reference diameter is measured at the plane of the propeller out to the shroud camber line.

ALPHABAR - Distance from shroud mid-chord to centerbody leading edge divided by the shroud reference radius. $\bar{\alpha}$ is positive if the leading edge of the centerbody is forward of the shroud mid-chord line and negative if the leading edge of the centerbody is aft of the shroud mid-chord line.

BETABAR - Distance from shroud mid-chord to centerbody trailing edge divided by the shroud reference radius. $\bar{\beta}$ is positive if the trailing edge of the centerbody is aft of the shroud mid-chord line and negative if the trailing edge of the centerbody is forward of the shroud mid-chord line.

AZERO - The value of the source-sink distribution at the centerbody leading edge = $R_{LE}/2R_S$ where R_S is the shroud reference radius and R_{LE} is the centerbody leading edge radius.

PROP LOC - Ratio of the propeller plane location (measured from the shroud leading edge) to the shroud reference radius.

MU - Ratio of propeller radius to shroud reference radius.

TRIG - Code 1. for last case and 0. for all other cases.

Xp - Ratio of propeller sectional radius to propeller radius. These ten locations in the propeller plane correspond to the locations used in Deck H193 for which the axial velocities induced by the centerbody are required.

#XCB's - The number of points which will be used in the least squares representation of the centerbody by the seventh order polynomial.

X_{CB} - The ratio of the sectional centerbody length along centerline to the shroud reference radius. These points should be spaced so that a greater number of points are taken in the areas where there is a substantial amount of curvature.

RBAR - The ratio of the centerbody radius (See previous illustration) to the shroud reference radius (r/R_S). The centerbody is represented in the program in the form of a table where the **X_{CB}'s** are listed in ascending order followed by the corresponding **RBAR's**.

#X_S's - The number of points along the shroud for which the axial velocities are to be computed. The maximum number = 40.

X_S - Ratio of a point on the shroud chord line to the shroud chord. The $X_S = 0.$ at the leading edge and $X_S = 1.0$ at the trailing edge.

INPUT INSTRUCTIONS FOR HAMILTON STANDARD DECK H060 (CENTERBODY PROGRAM)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	
1	LABEL CARD																																																																															
2	SEE TRMT FOR DEFINITION OF DATA REQUIRED FOR CARDS 2 THROUGH 6																																																																															
3	LAMBDA ALPHA SET A ZERO PROLOC MM TRIG																																																																															
4	TRIG=1. FOR LAST CASE AND 0. FOR ALL OTHERS																																																																															
5	Xp(1) Xp(2) Xp(3) Xp(4) Xp(5) Xp(6) Xp(7) Xp(8) Xp(9) Xp(10)																																																																															
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FIGURE 10.

4.0 (Continued)

A sample case of input is shown in Fig. 11.

H. Description of Output

The output for the sample case is shown on Fig. 12. All the input is printed. The calculated RBAR's are printed so that a check can be made to be certain that the seventh order polynominal adequately defines the centerbody. Fig. 13 shows the comparison for the sample case. If the fit is not adequate, select the points to better define the shape.

The coefficients of the power series are listed as well as the centerbody axial and radial induced velocities on the shroud reference cylinder and the centerbody axial induced velocities on the propeller. The Glauert coefficients are generated from the radial induced velocities. The Glauert coefficients and axial induced velocities are inputs to Hamilton Standard Deck H193.

I. Estimated Running Time

On the Univac 1108, the running time is 6 cases per minute.

SAMPLE INPUT FOR HAMILTON STANDARD DECK H060 (CENTERBODY PROGRAM)

[illegible]

FIGURE 11. (SHEET 1 OF 2)

SAMPLE INPUT FOR HAMILTON STANDARD DECK H060 (CENTERBODY PROGRAM)

[illegible]

FIGURE 11. (SHEET 2 OF 2)

SAMPLE OUTPUT FOR HAMILTON STANDARD DECK

HS COMPUTER DECK H060
CENTERBODY INDUCED VELOCITIES
HAMILTON STANDARD
WINDSOR LOCKS, CONN.
1967

1 JOHN FIDLER B1-ADJ.PTR L.E.=.656 10-17-67

**** INPUT ****

SHROUD CHORD TO DIAMETER RATIO = .6070
ALPHA BAK = 1.1594
BETA BAR = 4.8089
A ZERO = .01998
NON-DIMENSIONAL DOWNSTREAM PROP LOCATION = .4826
PROP DIAMETER/SHROUD REFERENCE DIAMETER = .9110

AXIAL LOC.	INPUT RBAR	CALC.RBAR	AXIAL LOC.	INPUT RBAR	CAI
.00000	.00000	.00000	1.36300	.24080	
.00880	.02378	.02683	1.38100	.24200	
.01203	.02740	.03150	1.40100	.24330	
.01761	.03360	.03837	1.41100	.24400	
.02105	.03690	.04212	1.42200	.24570	
.02635	.04170	.04741	1.44100	.24700	
.03105	.04610	.05174	1.46200	.24780	
.03520	.04910	.05533	1.47800	.24920	
.03910	.05210	.05855	1.49400	.25050	
.04400	.05560	.06242	1.51000	.25180	
.06010	.06650	.07406	1.52300	.25300	
.08800	.08250	.09163	1.54000	.25350	
.11030	.10030	.10410	1.55300	.25400	
.13210	.10360	.11531	1.57000	.25520	
.15030	.11540	.12406	1.58300	.25600	
.17600	.12050	.13558	1.60000	.25610	
.19040	.12630	.14167	1.61300	.25620	
.22000	.13540	.15340	1.63000	.25625	
.23050	.13940	.15733	1.64400	.25640	
.24050	.14140	.16097	1.66000	.25780	
.25050	.14500	.16450	1.67300	.25850	
.26350	.14850	.16895	1.69000	.25950	
.27700	.15100	.17340	1.70500	.26000	
.28080	.15350	.17462	1.72000	.26020	
.29400	.15700	.17876	1.73200	.26050	
.30800	.16020	.18298	1.75000	.26100	
.31400	.16280	.18473	1.76400	.26150	
.32100	.16550	.18674	1.78000	.26200	
.33600	.16800	.19091	1.79500	.26250	
.35200	.17100	.19515	1.81000	.26350	
.36150	.17380	.19757	1.82500	.26450	
.37100	.17640	.19992	1.85400	.26520	
.38400	.17840	.20302	1.88400	.26600	
.39700	.18050	.20599	1.91400	.26720	
.40900	.18240	.20862	1.94500	.26780	
.42100	.18450	.21115	1.96400	.26820	
.43000	.18700	.21297	1.98500	.26860	
.44000	.18910	.21493	2.03000	.27120	
.48400	.19610	.22275	2.07000	.27380	
.52750	.20320	.22923	2.08000	.27520	
.57200	.20900	.23466	2.09200	.27650	
.61600	.21430	.23892	2.11000	.27800	
.66000	.21840	.24216	2.13000	.28000	

A.

STANDARD DECK H060 (CENTERBODY PROGRAM)

COMPUTER DECK H060
INDUCED VELOCITIES PROGRAM
MILTON STANDARD
DESIGN LOCKS, CONN.
1967

C.	INPUT RBAR	CALC. RBAR	AXIAL LOC.	INPUT RBAR	CALC. RBAR
	.24080	.22215	2.64500	.42400	.44328
	.24200	.22169	2.67800	.43600	.45129
	.24330	.22129	2.71300	.44700	.45967
	.24400	.22113	2.74500	.45750	.46719
	.24570	.22100	2.77200	.46900	.47344
	.24700	.22088	2.80000	.48100	.47981
	.24780	.22088	2.83200	.49000	.48695
	.24920	.22100	2.86600	.49900	.49437
	.25050	.22122	2.90000	.50900	.50160
	.25180	.22154	2.92500	.51700	.50680
	.25300	.22188	2.95800	.52700	.51349
	.25350	.22242	2.98500	.53600	.51882
	.25400	.22293	3.01500	.54400	.52459
	.25520	.22369	3.04000	.55100	.52926
	.25600	.22436	3.07300	.55700	.53525
	.25610	.22535	3.10000	.56200	.53999
	.25620	.22620	3.13500	.56800	.54591
	.25625	.22742	3.17000	.57250	.55157
	.25640	.22852	3.22500	.58000	.55995
	.25780	.22989	3.28600	.58700	.56846
	.25850	.23108	3.35000	.59000	.57649
	.25950	.23276	3.41000	.59300	.58316
	.26000	.23434	3.47000	.59200	.58898
	.26020	.23602	3.53000	.59100	.59393
	.26050	.23744	3.59000	.58950	.59801
	.26100	.23968	3.65000	.58750	.60120
	.26150	.24152	3.71500	.58600	.60365
	.26200	.24372	3.78000	.58500	.60505
	.26250	.24538	3.84000	.58100	.60541
	.26350	.24812	3.90000	.57800	.60487
	.26450	.25046	3.96000	.57500	.60344
	.26520	.25521	4.02000	.57200	.60111
	.26600	.26044	4.08000	.56800	.59791
	.26720	.26598	4.14000	.56200	.59382
	.26780	.27200	4.20000	.55700	.58887
	.26820	.27583	4.26000	.55100	.58306
	.26860	.28018	4.32000	.54400	.57640
	.27120	.28988	4.39000	.53600	.56757
	.27380	.29889	4.45000	.53000	.55912
	.27520	.30119	4.51000	.52300	.54985
	.27650	.30398	4.57000	.51700	.53979
	.27800	.30821	4.63000	.51100	.52896
	.28000	.31298	4.69000	.50000	.51735

FIGURE 12,
(SHEET 1 OF 3)

B.

SAMPLE OUTPUT FOR HAMILTON STANDARD DECK

.70400	.22240	.24444	2.14000	.28150	.31
.74800	.22500	.24586	2.15500	.28250	.31
.79200	.22730	.24648	2.17000	.28410	.32
.83500	.22800	.24640	2.19000	.28600	.32
.88000	.22850	.24566	2.20000	.28800	.33
.92700	.22850	.24428	2.20500	.29080	.33
.97500	.22850	.24234	2.23000	.29300	.33
1.01400	.22850	.24044	2.25000	.29550	.34
1.05300	.22850	.23833	2.27200	.30000	.34
1.07600	.22850	.23701	2.29500	.30450	.35
1.09600	.22850	.23583	2.30100	.30600	.35
1.13000	.22950	.23379	2.31200	.30720	.35
1.16300	.23050	.23180	2.32000	.31400	.36
1.19000	.23100	.23019	2.33500	.32080	.36
1.21800	.23150	.22859	2.35800	.32250	.37
1.23600	.23200	.22759	2.37500	.32470	.37
1.25300	.23300	.22669	2.40000	.33300	.38
1.26800	.23400	.22593	2.43200	.34100	.38
1.28000	.23450	.22535	2.46000	.35100	.39
1.29100	.23600	.22484	2.49000	.36000	.40
1.30400	.23750	.22427	2.52000	.37200	.41
1.32100	.23800	.22357	2.55500	.38400	.42
1.34000	.23850	.22287	2.58500	.39750	.42
1.35100	.23950	.22251	2.61500	.41100	.43

COEFFICIENTS OF POWER SERIES REPRESENTATION OF SOURCE SINK DISTRIBUTION

-.006969

.005256

.070331

-.014053

-.026911

.0

AXIAL LOC.	VR/UI	AXIAL LOC.	VR/UI	AXIAL LOC.	VR/UI
.00000	.01795	.25566	.01753	.76118	.02596
.00039	.01795	.27297	.01756	.77772	.02652
.00154	.01795	.29063	.01760	.79383	.02708
.00347	.01794	.30862	.01766	.80943	.02764
.00615	.01794	.32690	.01774	.82466	.02819
.00961	.01793	.34545	.01783	.83934	.02873
.01381	.01792	.36423	.01795	.85349	.02927
.01877	.01791	.38323	.01809	.86710	.02979
.02447	.01790	.40240	.01825	.88014	.03030
.03090	.01788	.42173	.01844	.89260	.03079
.03805	.01786	.44118	.01865	.90445	.03126
.04592	.01784	.46072	.01889	.91568	.03171
.05449	.01782	.48031	.01916	.92627	.03214
.06374	.01780	.49994	.01945	.93620	.03255
.07367	.01777	.51957	.01978	.94546	.03293
.08425	.01774	.53917	.02012	.95403	.03328
.09548	.01771	.55871	.02050	.96190	.03361
.10733	.01768	.57815	.02090	.96906	.03390
.11978	.01765	.59748	.02133	.97550	.03417
.13282	.01762	.61666	.02178	.98120	.03441
.14643	.01760	.63565	.02225	.98616	.03462
.16058	.01757	.65444	.02273	.99037	.03480
.17525	.01755	.67299	.02324	.99383	.03494
.19043	.01753	.69127	.02376	.99652	.03506
.20608	.01752	.70926	.02430	.99845	.03514
.22218	.01751	.72693	.02484	.99961	.03519
.23872	.01752	.74424	.02540	1.00000	.03520

GLAUERT COEFFICIENTS FOR CENTERBODY EFFECT

-.092950

-.033763

.014213

-.000735

-.000857

.000036

PROP.X

VA/UI

.99030

-.008393

A

STANDARD DECK H060 (CENTERBODY PROGRAM)

.26150	.31538	4.75000	.49900	.50498
.28250	.31902	4.81000	.47800	.49186
.28410	.32268	4.87000	.46700	.47802
.28600	.32761	4.93000	.45800	.46344
.28800	.33010	4.99000	.44900	.44813
.29080	.33134	5.05000	.43300	.43210
.29300	.33760	5.11000	.41700	.41534
.29550	.34265	5.17000	.40000	.39782
.30000	.34824	5.23000	.38300	.37958
.30450	.35412	5.30000	.36500	.35731
.30600	.35566	5.36000	.34700	.33732
.30720	.35848	5.42000	.32700	.31650
.31400	.36054	5.48000	.30750	.29472
.32080	.36440	5.54000	.28050	.27194
.32250	.37033	5.60000	.26000	.24794
.32470	.37472	5.65000	.22300	.22690
.33300	.38118	5.71000	.19400	.20012
.34100	.38944	5.78000	.15600	.16616
.35100	.39665	5.84000	.11470	.13330
.36000	.40436	5.86000	.10030	.12122
.37200	.41202	5.89000	.07520	.10137
.38400	.42089	5.91000	.05560	.08641
.39750	.42843	5.96830	.00000	.00352
.41100	.43589			

SOURCE SINK DISTRIBUTION ****
 -.026911 .013632 -.002388 .000147

VR/UI

- .02596
- .02652
- .02708
- .02764
- .02819
- .02873
- .02927
- .02979
- .03030
- .03079
- .03126
- .03171
- .03214
- .03255
- .03293
- .03328
- .03361
- .03390
- .03417
- .03441
- .03462
- .03480
- .03494
- .03506
- .03514
- .03519
- .03520

.000857 .000036 -.000000 .000023

FIGURE 12.
(SHEET 2 OF 3)

B.

SAMPLE OUTPUT FOR HAMILTON STANDARD DEC

.94930	-.008619
.87970	-.008943
.78750	-.009209
.68070	-.009151
.56930	-.008419
.46260	-.006680
.37000	-.003862
.30050	-.000509
.26000	.002152

AXIAL LOC.	VA/UI
.00010	-.005309
.00500	-.005296
.01250	-.005279
.02500	-.005255
.05000	-.005228
.07500	-.005230
.10000	-.005262
.15000	-.005415
.20000	-.005686
.25000	-.006068
.30000	-.006550
.40000	-.007755
.50000	-.009146
.60000	-.010538
.70000	-.011732
.80000	-.012539
.90000	-.012794
.95000	-.012671

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Volume II

STANDARD DECK H060 (CENTERBODY PROGRAM)

FIGURE 12.
(SHEET 3 OF 3)

B.

COMPARISON OF ACTUAL CENTERBODY SHAPE WITH COMPUTER
REPRESENTATION

— ACTUAL
o o o SEVENTH ORDER POLYNOMIAL REPRESENTATION

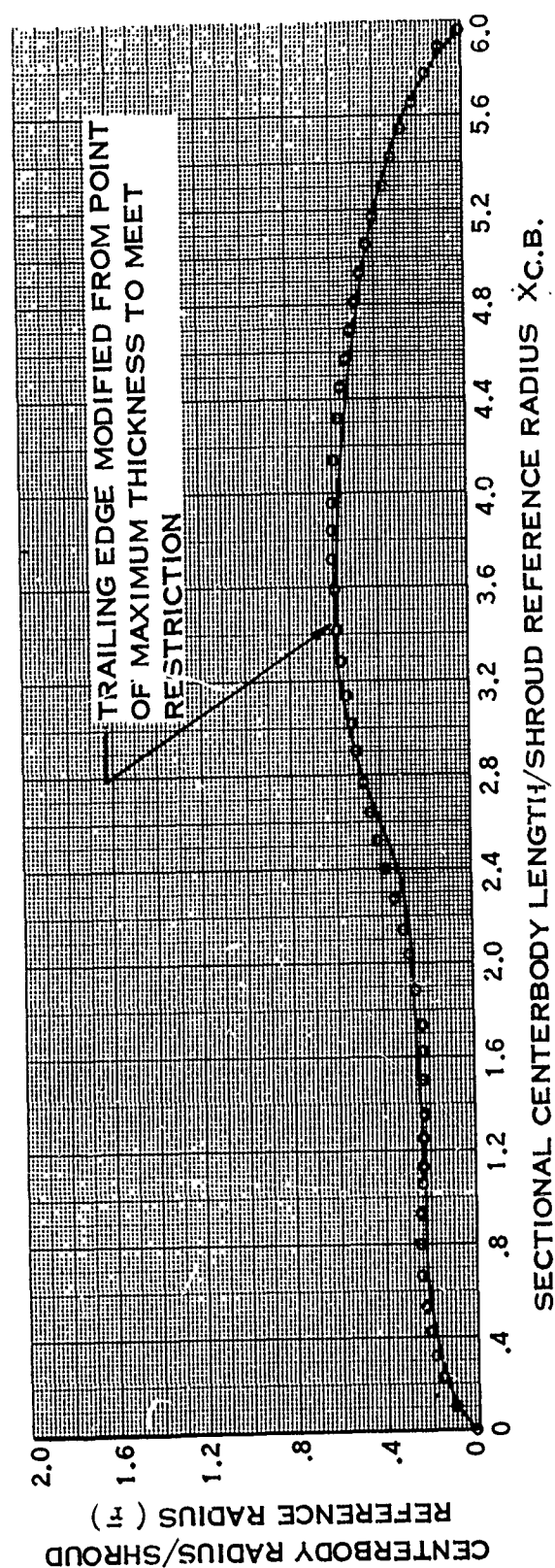


FIGURE 13.

5.0 REFERENCES

1. Ordway, D. E. and Greenberg, M. D., "General Harmonic Solutions for the Ducted Propeller", Therm Advanced Research Report TAR-TR613, August 1961.
2. Hough, G. R., "The Aerodynamic Loading on Streamlined Ducted Bodies," Therm Advanced Research Report TAR-TR625, December 1962.

6.0 APPENDICES

6.1 FLOW CHART, SUBROUTINE LIST, AND FORTRAN IV LISTINGS FOR HAMILTON
STANDARD DECK H193

Figures 14, 15, and 16 contain the pertinent data for Hamilton Standard Deck H193. It is the computer deck which permits shrouded propeller performance and shroud surface pressure distribution computations.

FLOW CHART FOR HAMILTON STANDARD DECK H193
SHROUDED PROPELLER PERFORMANCE

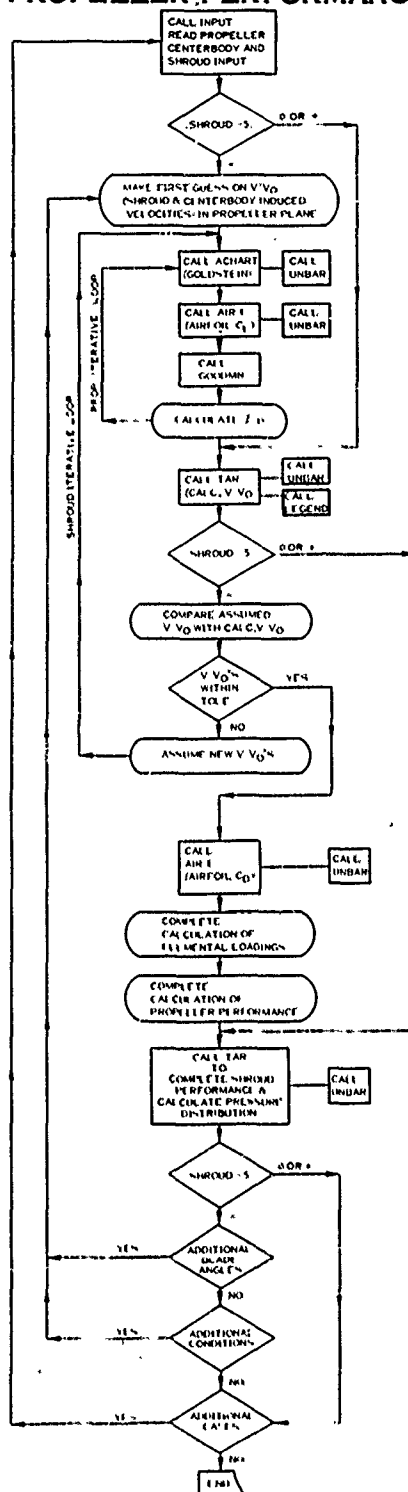


FIGURE 14.

6.1 (Continued)

LIST OF SUBROUTINES

HAMILTON STANDARD DECK H193

SHROUDED PROPELLER PERFORMANCE

MNH193
ACHART
AIR1
 DUMEY
 DUMAY
GOODMN
INPUT
LEGEND
TAR
 DATUM
 DATAM
 DATOM
UNBAR

Figure 15

FORTTRAN IV LISTINGS FOR HAMILTON STANDARD DECK H193

```

C   MAIN PROGRAM FOR HS DECK H193
      DIMENSION AA(8),AKA(10),ALPH(10),APBET(10,7),BCB(8),BETA(10),
      1BOD(10),C(10),CDOCL(10),CL3(10),COCLN(10),CTAC(10),DCPAP(10,6),
      2DCPIN(10,6),DCTAP(10,6),DCTIN(10,6),DECL(10),DELTH(10),DTHET(10),
      3EFFS(10),EINT(7),FT(10),G(10),GIR(10),HOB(10),IPR(10),PHI(10),
      4PHI0(10),PXI(10),SM(10),SR(10),S1(10),S2(10),S3(10),S4(10),
      5TABLE2(43),THET(10),THET34(10),TTHERM(50),TX(50),VACB(10),
      6VOV(10,10),X(10),X1(11),ZJ(10),ZM(10),ZMCRT(10),ZMCROM(10),
      7ZMMCR(10),ZMN(10),ZNMN(10),Z5(10),CLA0(10),THETN(10),MSUB(3)
      8,GOOD(10),CD(10),DCDCL(10)
      DIMENSION ZMM(10),SDCTAP(10,6),ZJ2(10)
      COMMON A      , AA      , ABOVE , AF      , AKA      , ALCHT
      COMMON ALPH    , AMBDA , APBET , APLUS , ASHRD , A4A2
      COMMON BCB     , BELOW , BETA  , BLADN , BOD      ,
      COMMON C       , CDOCL , CHOICE , CLA0  , CLI     , CL1
      COMMON CL2     , CL3   , COBET , COCLN , COPHI  , COUNT
      COMMON CPA     , CTA   , CTAC  , CD
      COMMON D       , DCD   , DCPAP , DCPIN , DCTAP  , DCTIN
      COMMON DECL    , DEGCV , DELA  , DELTAC , DELTH  , DSHRD
      COMMON DTHET   , DMCRT , DCDCL
      COMMON EFFA    , EFFS  , EINT
      COMMON FAKE    , FT
      COMMON G       , GIR   , GOOD
      COMMON HOB     , HOBSUB
      COMMON I       , IB    , IC    , IDL    , IERROR , IHOLD
      COMMON IOFF    , IP    , IPR   , ISET   , ISET1  , ISET2
      COMMON IT      , INCON
      COMMON JV
      COMMON KOUNT
      COMMON L
      COMMON M       , MFIND , MSUB  , M6     , M8
      COMMON N       , NMN   , NOF   , NRECN , NSIZE  , NSS
      COMMON PHI     , PHI0  , PI    , PXI
      COMMON RADCV   , RFL
      COMMON SBETA1  , SBETA2 , SCO   , SHRDNO , SHROD  , SIPHI
      COMMON SM      , SR    , STHET1 , STHET2 , SUM   , S1
      COMMON S2      , S3    , S4    , S5
      COMMON TABLE2 , THET  , THETN , THET34 , TRIG1  , TRIG2
      COMMON TTHERM  , TX
      COMMON VACB    , VOV   , V1    , V2
      COMMON X       , X1    , XNSS  , XPB
      COMMON Y1      , Y2
      COMMON ZIPI    , ZJ    , ZJI   , ZM    , ZMCRT  , ZMCROM
      COMMON ZMMCR   , ZMN   , ZMS   , ZMU   , ZNMN   , Z5
C
C   IC IS VARIABLE WHICH CONTROLS WHICH OF A POSSIBLE 10 CONDITIONS IS
C   BEING CALCULATED
C
      GIR(1)=.03333
      GIR(2)=.07472
      GIR(3)=.10954
      GIR(4)=.13463
      GIR(5)=.14776
      GIR(6)=GIR(5)
      GIR(7)=GIR(4)
      GIR(8)=GIR(3)
      GIR(9)=GIR(2)
      GIR(10)=GIR(1)
      1 WRITE (6,10)
      10 FORMAT (1H1,47X,22H HS COMPUTER DECK H193/38X,42H HS SHROUDED PROP

```

FIGURE 16. (SHEET 1 OF 57)

```

1ELLER PERFORMANCE PROGRAM /50X.18H HAMILTON STANDARD /49X.20H WIND
2SOR LOCKS.CONN. /57X.5H 1967 )
20 IC=1
  CALL INPUT
  KOUNT=0
  IK=0
  LI=1
  IOFF=1
  CALL TAR
  IOFF=0
  IF (SHROD-5.)30,30,25
25 DO 28 I=1,10
  S(I)=0.0
28 CONTINUE
  ZMS=ZMN(IC)
  GO TO 802

C
C AT BEGINNING OF MAIN ROUTINE CHECK FOR COMPLETION OF COND.CALC.
C
30 K=1
  IP=1
  IF (IC-NOF)200,200,1
200 ZJ1=ZJ(IC)
  ZM1=ZMN(IC)
  DO 204 I=1,10
  VOV(I,1)=1.0
204 CONTINUE
  JV=1
  IF (SHROD-5.)206,802,802
206 DO 210 I=1,10
210 THET34(I)=S1(I)

C
C CALCULATES PH10,G,AND SECTIONAL M.N.
C
320 DO 326 I=1,10
326 ZJ2(I)=ZJ1
327 DO 430 IF=1,10
340 ABOVE=ZJ2(IF)*VOV(IF,JV)
  BELOW=PI*X(IF)
358 PH10(IF)=DEGCV*ATAN(ABOVE/BELOW)
  IF(ABOVE)362,368,368
362 IF (PH10(IF))365,365,370
365 PH10(IF)=360.0+PH10(IF)
  GO TO 380
368 IF(PH10(IF))370,380,380
370 PH10(IF)=180.0+PH10(IF)
380 SR(IF)=ABOVE**2+BELOW**2
390 G(IF)=BLADN*SR(IF)/4.0
  ZMM(IF)=ZMS*SQR(SR(IF))/ZJ1
430 CONTINUE

C
C LOOP FOR ALPHA BETA ITERATION FOR 10 STATIONS
C
440 DO 800 I=1,10
  GO TO 445
490 IERROR=0.0
540 THET34(IC)=THET34(IC)+DELTH(IC)
  IF(KOUNT)550,550,560
550 IAKE=1.0
560 IOFF=0

```

FIGURE 16. (SHEET 2 OF 57)

```
KOUNT=KOUNT+1
IF (KOUNT-IFIX(THETN(IC)))440,2140,2140
445 I=1
THET(I)=THET34(IC)+DTHET(I)
IB=BLADN
460 APBET(I,IP)=THET(I)-PHI0(I)
ALPH(I)=.25*APBET(I,IP)
BETA(I)=APBET(I,IP)-ALPH(I)
SBETA1=BETA(I)
470 DO 770 IT=1,20
PHI(I)=PHI0(I)+BETA(I)
IDL=1
480 CALL ACHART
IF(1ERROR)500,500,390
500 ZM(I)=ZMM(I)*COS(BETA(I)*RADCV)
520 CALL AIRI
INCON=INCON
C
C      IOFF IS SET EQUAL TO ONE WHEN OFF AIRFOILS
C
      IF (IOFF)600,600,582
582 IF (IT-20)584,540,540
584 IOFF=0.0
600 RBET=BETA(I)*RADCV
COBET=COS(RBET)
SIBET=SIN(RBET)
HOLD=(A/(.01745*BOD(I)))
620 CL1=HOLD*SIBET/COBET
700 Y1=Y2
705 TEMJ2=ZJ2(I)*VOV(I,JV)
CALL GOODMN (TEMJ2,X(I),BLADN,D,DSHRD,CL1)
708 Y2=CL1-CL2
IF(ABS(Y2)-.004)790,790,710
710 IF(IT-2)720,750,750
720 IF(Y2)730,730,740
730 BETA(I)=BETA(I)+4.0
GO TO 760
740 BETA(I)=BETA(I)-4.0
GO TO 760
750 BETA(I)=(SBETA2-Y1*(SBETA1-SBETA2))/(Y2-Y1)
IF(ABS(BETA(I))-90.0)754,754,751
751 IF(Y2)753,753,752
752 BETA(I)=SBETA1-5.0
GO TO 754
753 BETA(I)=SBETA1+5.0
754 ALPH(I)=APBET(I,IP)-BETA(I)
IF(ALPH(I)+16.0)756,760,755
755 IF(ALPH(I)-8.0)760,760,756
756 IF(ALPH(I))757,760,759
757 IF(BETA(I))760,760,758
758 BETA(I)=0.0
GO TO 760
759 IF(BETA(I))758,760,760
760 ALPH(I)=APBET(I,IP)-BETA(I)
SBETA2=SBETA1
SBETA1=BETA(I)
770 CONTINUE
WRITE (6,780)ZJ1,THET34(IC),X(I),ALPH(I)
780 FORMAT (68H0TROUBLE IN ALPHA, BETA ITERATION      ZJ1      THET34
IX          ALPHA      /F43.4,F7.2,2F10.4 )
```

FIGURE 16. (SHEET 3 OF 57)

```
GO TO 490
790 CL3(I)=(CL1+CL2)*.5
    IF (IOFF)800,800,792
792 IOFF=0
    WRITE (6,795)ZJI,THET34(IC),X(I),ALPH(I)
795 FORMAT (50HCOFF AIRFOIL DATA      J      03/4      X      ALPHA
    IF28.4,F8.3,F7.4,F7.2 )
800 CONTINUE
802 CALL TAR
    IF (IOFF-1)320,803,804
803 IF (SHROD-5.0)805,2090,2090
804 IF (SHROD-5.0)540,2140,2140
805 IOFF=0
C
C   CALCULATES CD,DCTDX,DCPDX
C
    IDL=2
8080 CALL AIR1
820 DO 860 I=1,10
    CDCL(I)=CD(I)/CL3(I)
    SIPHI=SIN(PHI(I)*RADCV)
    COPHI=COS(PHI(I)*RADCV)
    COBET=COS(BETA(I)*RADCV)
830 CONS=COBET**2
    DCTIN(I,IP)=BOD(I)*CL3(I)*G(I)*COPHI*CONS
    DCPIN(I,IP)=DCTIN(I,IP)*SIPHI*PI*X(I)/COPHI
    DCTAP(I,IP)=DCTIN(I,IP)-BOD(I)*G(I)*CONS*CD(I)*SIPHI
    DCPAP(I,IP)=DCPIN(I,IP)+BOD(I)*G(I)*CONS*PI*X(I)*CD(I)*COPHI
860 CONTINUE
    INCON=INCON
1010 CPA=0.0
    DO 2000 I=1,10
    CPA=CPA+GIR(I)*DCPAP(I,I)
2000 CONTINUE
    CPA=CPA*(1.0-SCO)
    GO TO (2002,2004),INCON
2002 IDL=3
    CALL AIR1
    GO TO 2008
2004 DO 2006 I=1,10
    DCDCL(I)=0.0
2006 CONTINUE
2008 DO 2010 I=1,10
    COCLN(I)=CDOCL(I)+DCDCL(I)
    CORCD=CD(I)+ABS(DCDCL(I)*CL3(I))
    SDCTAP(I,I)=DCTIN(I,I)+(DCTAP(I,I)-DCTIN(I,I))*CORCD/CD(I)
    EFFS(I)=(SDCTAP(I,I)/DCPAP(I,I))*ZJ2(I)
2010 CONTINUE
    CTAC(I)=0.0
    CTA=0.0
    DO 2020 I=1,10
    CTA=CTA+GIR(I)*DCTAP(I,I)
    CTAC(I)=CTAC(I)+GIR(I)*SDCTAP(I,I)
2020 CONTINUE
    CTA=CTA*(1.0-SCO)
    CTAC(I)=CTAC(I)*(1.0-SCO)
    FT(I)=CTAC(I)/CTA
2050 KOUNT=KOUNT+1
2090 IOFF=2
    CALL TAR
```

FIGURE 16. (SHEET 4 OF 57)

```

      IF (SHROD-5.0)2120,2140,2140
2120 IF (IPR(IC))2125,2125,2060
2060 WRITE (6,2070)ZJ1,THET34(IC),ZMS
2070 FORMAT (37H0 **** BLADE ELEMENTAL PRINTOUT **** //4H J=F7.4,12H
      XTHETA 3/4=F6.2,20H FREE STREAM M,N.=F6.4 )
      WRITE (6,2080)(X(I),I=1,10),(THET(I),I=1,10),(ALPH(I),I=1,10),
      X(PHI(I),I=1,10),(BETA(I),I=1,10),(PHIC(I),I=1,10),(CL3(I),I=1,10),
      X(COCLN(I),I=1,10),(DCPAP(I,1),I=1,10),(SDCTAP(I,1),I=1,10),
      X(EFFS(I),I=1,10),(ZM(I),I=1,10),(ZMMCR(I),I=1,10)
2080 FORMAT (1H0,15X,2HX=10F8.4/12X,6HTHETA=10F8.2/12X,6H4ALPHA=10F8.2/
      X14X,4H4PHI=10F8.2/13X,5H4BETA=10F8.2/12X,6H4PHI 0=10F8.2/14X,4H4CL3=
      X10F8.4/12X,6H4DCP/CL=10F8.4/11X,7H4DCP/DX=10F8.4/11X,7H4DCT/DX=10F8.4/
      X8X,10HSECT.EFF.=10F8.4/10X,8HSECT.MN=10F8.4/10X,8H4M/MCRIT=10F8.4 )
2125 IF (KOUNT-IFIX(THETN(IC)))2130,2140,2140
2130 THET34(IC)=THET34(IC)+DELTH(IC)
      GO TO 440
2140 KOUNT=0
      IC=IC+1
      GO TO 30
      END

```

FIGURE 16. (SHEET 5 CF 57)

```

SUBROUTINE ACHART
  DIMENSION AA(8),AKA(10),ALPH(10),APBET(10,7),BCB(8),BETA(10),
  1BOD(10),C(10),CDOCL(10),CL3(10),COCLN(10),CTAC(10),DCPAP(10,6),
  2DCPIN(10,6),DCTAP(10,6),DCTIN(10,6),DECL(10),DELTH(10),DTHET(10),
  3EFFF(10),EINT(7),FT(10),G(10),GIR(10),HOB(10),IPR(10),PHI(10),
  4PHI0(10),PXI(10),SM(10),SR(10),S1(10),S2(10),S3(10),S4(10),
  5TABLE2(43),THET(10),THET34(10),TTHERM(50),TX(50),VACB(10),
  6VOV(10,10),X(10),XI(11),ZJ(10),ZM(10),ZMCRT(10),ZMCROM(10),
  7ZMMCR(10),ZMN(10),ZNMN(10),Z5(10),CLAO(10),THETN(10),MSUB(7)
  8,GOOD(10),CD(10),DCDCL(10)
  DIMENSION CURVE(1386)
  COMMON A , AA , ABOVE , AF , AKA , ALCHT
  COMMON ALPH , AMBDA , APBET , APLUS , ASHRD , A4A2
  COMMON BCB , BELOW , BETA , BLADN , BOD
  COMMON C , CDOCL , CHOICE , CLAO , CLI , CL1
  COMMON CL2 , CL3 , COBET , COCLN , COPHI , COUNT
  COMMON CPA , CTA , CTAC , CD
  COMMON D , DCD , DCPAP , DCPIN , DCTAP , DCTIN
  COMMON DECL , DEGCV , DELA , DELTAC , DELTH , DSHRD
  COMMON DTHET , DMCRIT , DCDCL
  COMMON EFFA , EFFF , EINT
  COMMON FAKE , FT
  COMMON G , GIR , GOOD
  COMMON HOB , HOB SUB
  COMMON I , IB , IC , IDL , IERROR , IHOLD
  COMMON IOFF , IP , IPR , ISET , ISET1 , ISET2
  COMMON IT , INCON
  COMMON JV
  COMMON KOUNT
  COMMON L
  COMMON M , MFIN , MSUB , M6 , M8
  COMMON N , NMN , NOF , NREC , NSIZE , NSS
  COMMON PHI , PHI0 , PI , PXI
  COMMON RADCV , RFL
  COMMON SBETA1 , SBETA2 , SCO , SHRDNO , SHROD , SIPHI
  COMMON SM , SR , STHET1 , STHET2 , SUM , S1
  COMMON S2 , S3 , S4 , S5
  COMMON TABLE2 , THET , THETN , THET34 , TRIG1 , TRIG2
  COMMON TTHERM , TX
  COMMON VACB , VOV , V1 , V2
  COMMON X , XI , XNSS , XPB
  COMMON Y1 , Y2
  COMMON ZIP1 , ZJ , ZJ1 , ZM , ZMCRT , ZMCROM
  COMMON ZMMCR , ZMN , ZMS , ZMU , ZNMN , Z5
  DATA (CURVE (I) , I = 1 , 133 ) /
  X 3.,13.,13.
  X 0.,5.,10.,15.,20.,25.,30.,40.,50.,60.,70.,80.,90.
  X 0.,10.,175.,25.,35.,45.,55.,65.,75.,85.,95.,9875,1.
  X 0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.
  X 0.,.00098.,.0017.,.0024.,.00335.,.0043.,.00525.,.00615.,.00695.,.0073
  X .,00565.,.00505,0.
  X 0.,.0019.,.0033.,.0047.,.0066.,.0085.,.0103.,.0118.,.0127.,.01185
  X .,0062.,.00590,0.
  X 0.,.0028.,.0049.,.0069.,.0097.,.0124.,.0146.,.0160.,.01635.,.01455
  X .,00925.,.00615,0.
  X 0.,.0037.,.0064.,.00905.,.0126.,.0157.,.0179.,.0190.,.0186.,.0159
  X .,0097.,.00631,0.
  X 0.,.0047.,.0080.,.0111.,.0151.,.01945.,.02065.,.0209.,.020.,.0166
  X .,010.,.00647,0.
  X 0.,.0057.,.0096.,.0131.,.0175.,.0208.,.0226.,.0224.,.0206.,.0170

```

FIGURE 16. (SHEET 6 OF 57)

X,.0102,.00660,0.
X,0...0082,.0131,.0173,.0215,.02405,.02495,.0242,.0217,.0178
X,.0107,.00698,0.
X/
DATA (CURVE (1) , I = 134 ,266)/
X 0...0101,.01685,.021,.02485,.0263,.0266,.0257,.0228,.0184
X,.0108,.00725,0.
X,0...0133,.02045,.0247,.0277,.0284,.0279,.0260,.0230,.01855
X,.0113,.00750,0.
X,.0...0167,.0241,.0279,.0297,.0296,.0286,.0264,.0232,.0186
X,.0114,.00770,0.
X,0...0197,.0273,.0306,.0314,.0306,.0290,.02635,.02335,.0187
X,.0115,.00778,0.
X,0...0226,.0301,.0326,.0327,.0312,.0292,.0266,.0234,.0188
X,.0116,.00778,0.
X,4,.13,.13.
X,0,.5,.10,.15,.20,.25,.30,.40,.50,.60,.70,.80,.90.
X,0...10,.175,.25,.35,.45,.55,.65,.75,.85,.95,.9875,1.
X,0,.0,.0,.0,.0,.0,.0,.0,.0,.0,.0.
X,0...00065,.0011,.0016,.00224,.0029,.00352,.00412,.00472
X,.00512,.00435,.00342,0.
X,0...0013,.00219,.00316,.00441,.0057,.0069,.00808,.0091,.00916
X,.0066,.00463,0.
X/
DATA (CURVE (1) , I = 267 ,383)/
X 0...00188,.00325,.0047,.00625,.0084,.01015,.0117,.01255,.0118
X,.0080,.00541,0.
X,0...00242,.00429,.00615,.0086,.0110,.0130,.0145,.0150,.01355
X,.00882,.00589,0.
X,0...00298,.00529,.0076,.01055,.0134,.0154,.0168,.0167,.0146
X,.0093,.00613,0.
X,0...00357,.00629,.00893,.0123,.0154,.0175,.01845,.0179,.0152
X,.00955,.00625,0.
X,0...00477,.00825,.0116,.0156,.0189,.0205,.0209,.0195,.0160
X,.00983,.00625,0.
X,0...0064,.01025,.0145,.0186,.0216,.0227,.0224,.0203,.0165
X,.0101,.00625,0.
X,0...0083,.01315,.01735,.0214,.0237,.0244,.0235,.0209,.01685
X,.0101,.00625,0.
X,0...0107,.0160,.02015,.0237,.02555,.0257,.0242,.02135,.0172
X,.0101,.00625,0.
X,0...0132,.0187,.02255,.02555,.0267,.02635,.02455,.0216,.0173
X,.0101,.00625,0.
X/
DATA (CURVE (1) , I = 384 ,516)/
X 0...0156,.0210,.0246,.0269,.0273,.0266,.02475,.0216,.0174
X,.0101,.00625,0.
X,5,.13,.13.
X,0,.5,.10,.15,.20,.25,.30,.40,.50,.60,.70,.80,.90.
X,0...10,.175,.25,.35,.45,.55,.65,.75,.85,.95,.9875,1.
X,0,.0,.0,.0,.0,.0,.0,.0,.0,.0,.0.
X,0...00048,.00085,.00118,.00166,.00215,.00265,.00312,.00362
X,.00395,.00365,.00256,0.
X,0...00095,.00165,.00235,.00328,.00428,.00522,.00612,.00702
X,.00732,.00568,.00380,0.
X,0...0014,.00245,.0035,.0049,.0063,.0077,.00898,.0099,.0098
X,.00695,.00472,0.
X,0...00186,.00325,.00462,.00645,.00832,.0100,.0116,.0124,.0116
X,.00782,.00532,0.
X,0...00228,.0040,.0057,.00795,.0102,.0122,.0136,.0141,.0127

FIGURE 16. (SHEET 7 OF 57)

X..00835..00571.0.
X.0...0027..0047..00672..00938..0119..0140..0152..01535..01355
X..00865..00595.0.
X/
DATA (CURVE (1) , I = 517 .649)/
X 0...00348..00608..00865..0120..0150..0170..0178..0171..0146
X..0091..00653.0.
X.0...00458..00788..0103..0145..0173..0189..0192..0182..0153
X..0096..00672.0.
X.0...0058..0097..0132..0170..0196..02065..02045..01905..0157
X..0099..00680.0.
X.0...0076..0120..01565..0190..02105..0219..02125..0193..0158
X..0099..00680.0.
X.0...00958..0142..01775..0206..0220..0225..02145..0196..0159
X..0099..00680.0.
X.0...0118..0161..0192..02165..0226..0226..0216..0197..0161
X..0099..00680.0.
X.6..13..13.
X.0..5..10..15..20..25..30..40..50..60..70..80..90.
X.0...10..175..25..35..45..55..65..75..85..95..9875.1.
X.0..0..0..0..0..0..0..0..0..0..0..0..0..0.
X.0...00039..00069..00097..00135..00173..00214..00253..00292
X..00326..00324..00265.0.
X/
DATA (CURVE (1) , I = 650 .766)/
X 0...000778..00135..00192..002675..00348..00426..005..00573
X..00612..00516..00392.0.
X.0...00115..002011..00287..00401..00514..00629..00736..00924
X..0084..00633..00486.0.
X.0...00152..00266..00379..0053..00679..00823..00956..01043
X..01009..00721..00529.0.
X.0...001866..00327..00466..00656..00836..01009..01145..01206
X..01116..00785..00602.0.
X.0...0022..00385..0055..0077..00979..01165..01298..01340
X..01208..00824..0063.0.
X.0...00285..00499..00708..00985..01229..01438..01547..01529
X..01334..00875..00651.0.
X.0...00363..00629..00863..01202..01432..01629..01693..01638
X..01401..00907..00673.0.
X.0...00449..00765..01064..01401..01653..01785..01806..01711
X..01439..00929..00688.0.
X.0...00556..00918..01238..01575..018..019..01887..01753
X..01458..00941..00711.0.
X/
DATA (CURVE (1) , I = 767 .899)/
X 0...00691..01088..01412..01711..01896..01969..01920..01783
X..01468..0094..00699.0.
X.0...00807..01197..01513..01792..01915..01969..01924..01785
X..01467..00913..00673.0.
X.7..13..13.
X.0..5..10..15..20..25..30..40..50..60..70..80..90.
X.0..1..175..25..35..45..55..65..75..85..95..985.1.
X.0..0..0..0..0..0..0..0..0..0..0..0..0..0.
X.0..000319..000559..0008..0011..00141..00175..00207..00238
X..0027..00283..00246..00195
X.0..000635..00111..00158..0022..00285..0035..00412..00473
X..00516..00465..00358..00296
X.0..000948..00166..00236..0033..00424..00518..00609..00692
X..00725..00575..00440..00376
X.0..001252..00219..00313..00438..00556..00683..00796..00885

FIGURE 16. (SHEET 8 OF 57)

X..00885..0066..00502..00432
X..0..00154..00269..00385..00544..00691..00841..00970..0104
X..0099..0073..0055..00481
X/
DATA (CURVE (1) , I = 900 ,1032)/
X .0..001811..00317..00454..00637..00813..00977..01115..01175
X..01085..00773..00578..00503
X..0..002355..00412..00585..00816..0102..01225..0135..0137
X..01225..0083..00581..00483
X..0..00292..00508..00725..0100..012..0141..015..0148..01295
X..00854..00603..00505
X..0..00353..00611..00864..0116..014..0155..01605..0155..01335
X..00873..00635..00549
X..0..00412..00712..0099..0131..0154..01655..01685..0160..0136
X..00894..00655..00561
X..0..005..00839..0113..01425..0163..01725..01725..0163..0137
X..00894..00641..00559
X..0..00549..00895..0120..01485..0163..01725..01725..0163..0136
X..00860..00607..00512
X.8..13..13.
X.0..5..10..15..20..25..30..40..50..60..70..80..90.
X.0..10..175..25..35..45..55..65..75..85..95..9875..1.00
X.0..0..0..0..0..0..0..0..0..0..0..0..0..0..0..0
X/
DATA (CURVE (1) , I = 1033 ,1149)/
X 0..000266..000460..000670..000921..001183..001469..001736
X..001996..002270..002430..001994..0.
X.0..000538..000930..001330..001855..002400..002950..003480
X..004010..004430..004140..002780..0.
X.0..000800..001396..001985..002790..003590..004390..005180
X..005930..006340..005230..003340..0.
X.0..001050..001844..002640..003710..004740..005790..006800
X..007600..007880..006000..003790..0.
X.0..001301..002260..003260..004600..005850..007160..008360
X..009120..008920..006690..004150..0.
X.0..001538..002670..003850..005410..006910..008380..009710
X..010400..009850..007140..004390..0.
X.0..002010..003480..004960..006930..008740..010620..011900
X..012330..011310..007760..004420..0.
X.0..002450..004250..006160..008450..010350..012320..013410
X..013480..012120..008030..004630..0.
X.0..002910..005070..007070..009770..012020..013610..014410
X..01421..01258..00824..00491..0.
X/
DATA (CURVE (1) , I = 1150 ,1282)/
X 0..003280..005820..008210..011050..013240..014550..015190
X..014730..012850..008470..005110..0.
X.0..003840..006720..009290..012020..014030..015200..015600
X..015000..012970..008530..005050..0.
X.0..004050..007040..009800..012460..014050..015270..015640
X..015040..012890..008310..004840..0.
X.9..13..13.
X.0..5..10..15..20..25..30..40..50..60..70..80..90.
X.0..1..175..25..35..45..55..65..75..85..95..9875..1.
X.0..0..0..0..0..0..0..0..0..0..0..0..0..0..0..0
X.0..00023..00039..00058..00081..00105..00130..00153..00177
X..00198..00204..00125..0.
X.0..00047..00081..00117..00164..00213..00260..00307..00358
X..00394..00364..00152..0.
X.0..00070..00122..00174..00246..00320..00390..00462..00528

FIGURE 16. (SHEET 9 OF 57)

```
X,.00567,.00475,.00169,0.
X,0...00092,.00162,.00233,.00327,.00421,.00512,.00609,.00687
X,.00717,.00540,.00185,0.
X/
  DATA (CURVE      (1) , I = 1283 ,1386 )/
X 0...00115,.00199,.00290,.00403,.00519,.00633,.00743,.00822
X,.00821,.00603,.00198,0.
X,0...00138,.00235,.00343,.00480,.00614,.00746,.00867,.00936
X,.00909,.00645,.00212,0.
X,0...00181,.00306,.00440,.00617,.00791,.00948,.01067,.01117
X,.01053,.00713,.00235,0.
X,0...00222,.00379,.00537,.00737,.00937,.01095,.01217,.01240
X,.01153,.00752,.00252,0.
X,0...00263,.00454,.00632,.00852,.01058,.01217,.01315,.01323
X,.01207,.00780,.00267,0.
X,0...00305,.00529,.00730,.00959,.01152,.01301,.01388,.01370
X,.01233,.00800,.00279,0.
X,0...00343,.00587,.00809,.01043,.01214,.01352,.01425,.01393
X,.01249,.00817,.00291,0.
X,0...00375,.00625,.00853,.01073,.01240,.01375,.01440,.01407
X,.01255,.00827,.00302,0.
X/
  I=I
302 PHIPOS=ABS(PHI(I))
  IF(90.0-PHIPOS)1,3,3
  1 IF(180.0-PHIPOS)200,2,2
  2 PHIPOS=180.0-PHIPOS
  3 IB=IB
  IF(IB-8)4,4,220
  4 GO TO (220,20,30,40,50,60,70,80),IB
20 KOEFF=1
  GO TO 90
30 KOEFF=199
  GO TO 90
40 KOEFF=397
  GO TO 90
50 KOEFF=595
  GO TO 90
60 KOEFF=793
  GO TO 90
70 KOEFF=991
  GO TO 90
80 KOEFF=1189
90 CALL UNBAR (CURVE(1),KOEFF,PHIPOS,X(1),A,LIMIT)
  GO TO 300
200 WRITE (6,210)ZJ1,THET34(IC),X(1)
210 FORMAT(35HOPHI IS GREATER THAN 180 DEGREES J=F8.4,6H 03/4=F9.2,
  13H X=F5.4)
  IERROR=1
  GO TO 300
220 WRITE (6,230)
230 FORMAT(23H0 ILLEGAL NO. OF BLADES )
  IERROR=1
300 RETURN
END
```

FIGURE 16. (SHEET 10 OF 57)

```
SUBROUTINE AIR1
  DIMENSION AA(8),AKA(10),ALPH(10),APBET(10,7),BCB(8),BETA(10),
  1BOD(10),C(10),CDOCL(10),CL3(10),COCLN(10),CTAC(10),DCPAP(10,6),
  2DCPIN(10,6),DCTAP(10,6),DCTIN(10,6),DECL(10),DELTH(10),DTHET(10),
  3EFFS(10),EINT(7),FT(10),G(10),GIR(10),HOB(10),IPR(10),PHI(10),
  4PHI0(10),PXI(10),SM(10),SR(10),S1(10),S2(10),S3(10),S4(10),
  5TABLE2(43),THET(10),THET34(10),TTHERM(50),TX(50),VACB(10),
  6VOV(10,10),X(10),XI(11),ZJ(10),ZM(10),ZMCRT(10),ZMCROM(10),
  7ZMMCR(10),ZMN(10),ZNMN(10),Z5(10),CLA0(10),THEIN(10),MSUB(3)
  8,GOOD(10),CD(10),DCDCL(10)
  DIMENSION CMCRT(123),DMCRT(23),CLAZRO(156)
  DIMENSION DUMMY(1977)
  COMMON A , AA , ABOVE , AF , AKA , ALCHT
  COMMON ALPH , AMBDA , APBET , APLUS , ASHRD , A4A2
  COMMON BCB , BELOW , BETA , BLADN , BOD
  COMMON C , CDOCL , CHOICE , CLA0 , CL1 , CL1
  COMMON CL2 , CL3 , COBET , COCLN , COPHI , COUNT
  COMMON CPA , CTA , CTAC , CD
  COMMON D , DCD , DCPAP , DCPIN , DCTAP , DCTIN
  COMMON DECL , DEGCV , DELA , DELTAC , DELTH , DSHRD
  COMMON DTHET , DMCRT , DCDCL
  COMMON EFA , EFFS , EINT
  COMMON FAKE , FT
  COMMON G , GIR , GOOD
  COMMON HOB , HOBSUB
  COMMON I , IB , IC , IDL , IERROR , Ihold
  COMMON IOFF , IP , IPR , ISET , ISET1 , ISET2
  COMMON IT , INCON
  COMMON JV
  COMMON KOUNT
  COMMON L
  COMMON M , MFIN , MSUB , M6 , M8
  COMMON N , NMN , NOF , NREC , Nsize , NSS
  COMMON PHI , PHI0 , PI , PXI
  COMMON RADCV , RFL
  COMMON SBETA1 , SBETA2 , SCO , SHRDNO , SHROD , SIPHI
  COMMON SM , SR , STHET1 , STHET2 , SUM , S1
  COMMON S2 , S3 , S4 , S5
  COMMON TABLE2 , THET , THETN , THET34 , TRIG1 , TRIG2
  COMMON TTHERM , TX
  COMMON VACB , VOV , V1 , V2
  COMMON X , XI , XNSS , XPB
  COMMON Y1 , Y2
  COMMON ZIP1 , ZJ , ZJ1 , ZM , ZMCRT , ZMCROM
  COMMON ZMMCR , ZMN , ZMS , ZMU , ZNMN , Z5
  COMMON/DUM/DUMMY
  DATA (CMCRT(I),I=1,123)/
  X 1.,10.,10.
  X 0.0.,02.,04.,07.,11.,16.,22.,29.,35.,60
  X 0.0.,10.,20.,30.,40.,55.,70.,85.,1.0,1.2
  X 1.0.,90.,851.,807.,776.,736.,704.,672.,645.,605
  X .897.,853.,8135.,782.,757.,723.,693.,663.,634.,595
  X .841.,8125.,784.,760.,7375.,71.,681.,652.,622.,584
  X .781.,763.,748.,73.,7125.,687.,661.,6335.,6035.,567
  X .7215.,713.,701.,69.,675.,654.,631.,604.,577.,539
  X .661.,657.,649.,639.,63.,611.,5905.,564.,538.,503
  X .5985.,596.,5905.,5835.,576.,559.,5395.,515.,490.,459
  X .530.,528.,523.,518.,511.,497.,480.,458.,36.,408
  X .472.,469.,466.,462.,455.,443.,428.,410.,390.,363
  X .226.,2245.,222.,219.,216.,211.,205.,197.,196.,179
```

FIGURE 16. (SHEET 11 OF 57)

```
X/
  DATA (DMCRIT(I),I=1,23)/
X 2.,10.,0.
X 0.,1.,2.,3.,4.,5.,5.,7.,8.,5.,10.,15.
X.,1108.,0896.,07.,0535.,0398.,0248.,015.,008.,0037.,001
X/
  DATA (CLAZRO(I),I=1,156)/
X 3.,13.,10.
X 0.,04.,06.,10.,14.,16.,18.,20.,21.,219.,24.,3.,6
X 0.,1.,2.,3.,42.,54.,68.,86.,1.,1.2
X 0.,15.,266.,38.,515.,641.,781.,887.,930.,988
X 0.,135.,248.,364.,502.,63.,769.,892.,945.,1.002
X 0.,120.,233.,345.,481.,606.,745.,872.,939.,996
X 0.,088.,186.,283.,406.,520.,648.,777.,857.,921
X 0.,049.,122.,193.,283.,367.,464.,571.,659.,755
X 0.,033.,087.,138.,200.,255.,320.,383.,438.,519
X 0.,013.,053.,083.,117.,145.,168.,195.,218.,243
X 0.,005.,023.,038.,048.,058.,068.,074.,078.,083
X 0.,0.,01.,015.,018.,022.,027.,03.,033.,035
X 0.,-002.,-002.,-003.,-003.,-004.,-004.,-005.,-005.,-006
X 0.,-01.,-011.,-012.,-013.,-015.,-017.,-018.,-019.,-02
X 0.,-03.,-035.,-04.,-042.,-045.,-047.,-05.,-05.,-055
X 0.,-086.,-1.,-11.,-12.,-127.,-133.,-137.,-141.,-145
X/

C
C   SERIES 16 INCOMPRESSIBLE
C
      I=1
      IC=IC
      INCON=1
102 GO TO (21,22,23),IDL

C
C   LIFT PORTION OF AIRFOIL CALCULATION
C
21 APLUS=ABS(ALPH(I))
   IF(APLUS -90.0)1,1.2
2  IOFF=1
   1 CALL UNBAR (DUMMY(I),1,APLUS,HOB(I),CL2,LIMIT)
     CL2=SIGN(CL2,ALPH(I))
   4 CALL UNBAR (DUMMY(I),577,ALPH(I),HOB(I),DELTAC,LIMIT)
28 DELTAC= DELTAC*DECL(I)/.7
26 CL2= CL2+DELTAC

C
C   CENTRIFUGAL PUMPING EFFECT PROVISION FOR SERIES 16
C
      CALL UNBAR(DUMMY(I),1898,HOB(I),UNVAR,CLMCO,LIMIT)
      CALL UNBAR(DUMMY(I),1915,HOB(I),UNVAR,DMAXCL,LIMIT)
      CALL UNBAR(DUMMY(I),1932,HOB(I),UNVAR,SLOPE,LIMIT)
      CALL UNBAR(DUMMY(I),1955,HOB(I),UNVAR,AMAX,LIMIT)
      IF(APLUS-40.0)5000,5020,5020
5000 IF(APLUS-AMAX)5020,5020,5010
5010 CL2=ALPH(I)*SLOPE+DELTAC
5020 CLMAX=DMAXCL*(DECL(I)**2)/1.4+CLMCO
5025 IF (ABS(CL2)-CLMAX)5032,5032,5030
5030 CL2=SIGN(CLMAX,CL2)
5032 IF (IC-1)5035,5035,25
5035 IF (IT-1)5040,5040,25
5040 CALL UNBAR (CMCRIT,1,HOB(I),DECL(I),ANS,LIMIT)
      XIN=.5*(1.0-X(I))/ROD(I)
      CALL UNBAR (DMCRIT,1,XIN,0.0,ANS1,LIMIT)
```

FIGURE 16. (SHEET 12 OF 57)

```
      ZMCRT(I)=ANS+ANSI
      CALL UNBAR (CLAZRO,1,HOB(I),DECL(I),CLAO(I),LIMIT)
5045  FORMAT (1H0,3F10.5 )
      GO TO 25
C
C      DRAG
C
      22 DO 99 I=1,10
          APLUS=ABS(ALPH(I))
          IF(HOB(I) -.04) 7,8,8
      7  HOBSUB =.04
          GO TO 500
      8  HOBSUB=HOB(I)
500  CALL UNBAR (DUMMY(1),789,APLUS,HOBSUB,CD(I),LIMIT)
          IF(ALPH(I)) 9,9,10
      10  DELA= -64.5*HOBSUB +3.8
          GO TO 18
      9  IF(HOBSUB-.07) 17,17,16
      17  DELA=0.0
          GO TO 18
      16  DELA=      50.7*HOBSUB-3.5
      18  ALCHT= ALPH(I)+DELA
          IF(ALCHT*ALPH(I))14,14,15
      14  ALCHT=0.0
      15  CALL UNBAR (DUMMY(1),1181,ALCHT,DECL(I),DCD,LIMIT)
          CD(I)=CD(I)+DCD
      99  CONTINUE
          GO TO 25
C
C      CALCULATION FOR COMPRESSIBILITY LOSSES
C
      23 DO 100 I=1,10
          IF(I-9) 47,48,48
      47  Z5(I)=CL3(I)-CLAO(I)
          IF(Z5(I)+.237)4020,4020,4021
      4020  DMCRT=.15*(Z5(I)+.3)-.006
          GO TO 4022
      4021  IF(Z5(I)-.44) 4023,4023,4024
      4023  DMCRT=-.0133*(Z5(I)+.1)+.002
          GO TO 4022
      48  DMCRT=0.0
          GO TO 4022
      4024  DMCRT=-.265*(Z5(I)-.5)-.02
      4022  ZMCROM(I)=ZMCRT(I)+DMCRT
          ZMMCR (I) = ZM(I)/ZMCROM(I)
C
C      ROUTINE FOR K AS A FUNCTION OF CL3
C
          IF(ZMMCR(I)-1.0) 200,200,82
      32  IF(ABS(CL3(I))- .450)4027,4027,4028
      4027  AKA(I)=-1.525*ABS(CL3(I))+1.680
          GO TO 4029
      4028  IF(ABS(CL3(I))- .6)4030,4030,4031
      4030  AKA(I)=-1.33*ABS(CL3(I)-.45)+1.0
          GO TO 4029
      4031  IF(ABS(CL3(I))- .820)4032,4032,4033
      4032  AKA(I)=-1.13*(ABS(CL3(I))- .5)+.8
          GO TO 4029
      4033  AKA(I)=-1.061*(ABS(CL3(I))- .82)+.55
      4029  DCDCL(I)= AKA(I)*(ZMMCR(I)-1.0)
```

FIGURE 16. (SHEET 13 OF 57)

```
      IF (DCDCL(1)*CDOCL(1)) 203,203,100
200 DCDCL(1)=0.0
    GO TO 100
203 DCDCL(1)=-DCDCL(1)
100 CONTINUE
25  RETURN
    END
```

FIGURE 16. (SHEET 14 OF 57)

```

C  DUMEY
   BLOCK DATA
   COMMON/DUM/DUMMY
   DIMENSION DUMMY(1977)
   DATA (DUMMY (I) , I = 1 , 160 ) /
X 10.,40.,13.
X 0.,1.,3.,5.,4.,4.,5.,6.,5.,7.,7.,7.,8.,3.,9.,2.,10.,2.,11.,5.,12.,4.,13.,3.,14.,2
X 15.,4.,16.,2.,17.,17.,9.,18.,7.,19.,5.,20.,7.,21.,5.,22.,5.,23.,5.,24.,5.,25.,5
X 26.,5.,28.,5.,31.,5.,36.,41.,45.,49.,59.,60.,5.,72.,85.,0.,87.,5.,90.
X 0.,03.,06.,09.,12.,15.,18.,21.,24.,27.,30.,33.,36
X 0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.
X 107.,104.,100.,092.,085.,073.,065.,062.,055.,045.,040.,033
X 030
X 373.,367.,362.,332.,297.,261.,227.,202.,174.,142.,121.,102
X 091
X 425.,422.,413.,380.,340.,295.,260.,227.,195.,158.,133.,112
X 099
X 475.,47.,452.,417.,38.,33.,29.,25.,213.,173.,144.,12.,106
X 679.,669.,642.,593.,537.,471.,409.,342.,28.,22.,172.,143.,12
X 732.,717.,692.,638.,580.,508.,441.,366.,298.,232.,179.,148
X 123
X 773.,773.,755.,701.,636.,562.,486.,404.,326.,252.,191.,156
X 127
X /
   DATA (DUMMY (I) , I = 161 , 290 ) /
X 785.,795.,775.,751.,685.,607.,525.,439.,354.,273.,205.,163
X 132
X 790.,809.,836.,810.,755.,678.,590.,496.,400.,31.,235.,180
X 141
X 788.,808.,850.,852.,817.,749.,660.,560.,458.,356.,277.,209
X 159
X 778.,792.,841.,876.,876.,826.,742.,640.,531.,425.,335.,254
X 191
X 770.,780.,82.,876.,898.,867.,797.,698.,584.,474.,379.,289
X 218
X 77.,772.,8.,865.,908.,9.,846.,755.,634.,521.,421.,325.,246
X 773.,77.,783.,841.,906.,925.,893.,81.,685.,57.,465.,363.,277
X 781.,774.,770.,812.,89.,943.,936.,874.,755.,635.,523.,417
X 319
X 789.,778.,766.,794.,872.,94.,953.,908.,798.,678.,563.,453
X 349
X 796.,785.,767.,780.,852.,93.,96.,933.,834.,721.,601.,488
X 378
X /
   DATA (DUMMY (I) , I = 291 , 433 ) /
X 808.,794.,773.,771.,832.,878.,958.,952.,871.,768.,645.,526
X 411
X 819.,805.,782.,77.,816.,883.,95.,958.,9.,807.,685.,56.,44
X 831.,817.,792.,773.,802.,861.,934.,957.,918.,836.,721.,591
X 470
X 853.,84.,813.,782.,785.,829.,892.,937.,928.,863.,762.,636
X 514
X 870.,855.,829.,792.,78.,809.,863.,916.,924.,87.,78.,665.,542
X 89.,877.,85.,808.,778.,789.,828.,881.,907.,867.,789.,694
X 580
X 912.,9.,873.,827.,785.,776.,8.,84.,876.,853.,792.,713.,613
X 936.,925.,898.,846.,796.,775.,775.,802.,835.,829.,789.,724
X 64
X 962.,95.,925.,87.,816.,779.,757.,768.,791.,798.,777.,73.,661
X 987.,976.,952.,896.,839.,792.,756.,745.,751.,765.,761.,728

```

FIGURE 16. (SHEET 15 OF 57)

```
X,.676  
X,.104,.1027,.1003,.953,.893,.837,.78,.748,.725,.713,.716,.713  
X,.692  
X/  
DATA (DUMMY      (I) , I = 434    .563   )/  
X .1.115.1.1.1.075.1.033..975..913..849..806..767..735..707..69  
X..695  
X.1.206.1.188.1.167.1.128.1.073.1.01.95..897..852..805..767  
X..732..705  
X.1.258.1.245.1.225.1.189.1.14.1.08.1.02..963..912..865..819  
X..777..741  
X.1.246.1.237.1.218.1.185.1.144.1.089.1.03..974..92..873..828  
X..787..756  
X.1.198.1.189.1.174.1.146.1.11.1.065.1.015..96..91..865..82  
X..78..749  
X.1.005..997..987..971..947..91..866..824..786..749..713..682  
X..650  
X..97..962..953..937..914..876..833..795..759..723..691..66..63  
X..639..631..625..617..595..564..54..519..5..478..457..438..421  
X..178..176..173..171..168..158..152..147..144..14..134..128  
X..123  
X..089..087..084..082..079..077..075..073..071..069..067..065  
X..063  
X/  
DATA (DUMMY      (I) , I = 564    .697   )/  
X .0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.  
X.11..14..13.  
X.-18..-10..-6..-4..-2..0..4..6..8..10..12..15..18..22.  
X..0..03..06..09..12..15..18..21..24..27..30..33..36  
X..521..516..500..478..448..419..393..366..331..280..230..177  
X..128  
X..553..548..532..510..468..417..375..340..298..253..203..149  
X..094  
X..577..572..556..533..480..415..361..312..253..209..157..106  
X..062  
X..586..584..567..54..483..417..357..296..24..184..132..083  
X..038  
X..590..587..574..547..486..422..357..292..227..168..112..059  
X..008  
X..591..587..573..546..491..427..365..302..235..172..110..045  
X..01  
X..569..564..549..527..492..455..417..378..332..267..189..103  
X..011  
X/  
DATA (DUMMY      (I) , I = 698    .832   )/  
X .549..541..528..510..486..462..437..407..375..324..231..144  
X..048  
X..526..516..504..489..472..453..432..411..382..345..276..194  
X..112  
X..502..492..481..469..452..439..420..399..375..342..295..245  
X..197  
X..480..471..461..448..436..421..403..382..362..337..307..275  
X..240  
X..455..447..437..425..412..397..382..365..350..334..314..295  
X..272  
X..437..430..420..410..396..384..373..356..342..330..317..303  
X..284  
X..423..414..406..395..388..377..367..356..344..330..317..302  
X..284  
X.12..29..12.
```

FIGURE 16. (SHEET 16 OF 57)

X,0.,1.,2.,3.,4.,5.,7.,8.,5.,10.,12.,5.,14.,5.,15.,5.,16.,5.,17.,5.,18.,5.,19.,5
X,21.,5.,23.,0.,25.,5.,30.,35.,40.,45.,55.,60.,65.,75.,80.,85.,90.
X,.04.,.06.,.09.,.12.,.15.,.18.,.21.,.24.,.27.,.30.,.33.,.36
X/
DATA (DUMMY (I) , I = 833 .940)/
X .0030.,.0039.,.0051.,.0071.,.0100.,.0131.,.0168.,.0216.,.0262.,.0330
X,.0400.,.0470
X,.0042.,.0042.,.0051.,.0072.,.0100.,.0137.,.0171.,.0219.,.0268.,.0330
X,.0400.,.0470
X,.0069.,.0057.,.0058.,.0079.,.0102.,.0140.,.0178.,.0220.,.0270.,.0332
X,.0401.,.0472
X,.0143.,.0088.,.0068.,.0081.,.0110.,.0147.,.0183.,.0224.,.0279.,.0339
X,.0403.,.0479
X,.0372.,.0228.,.0129.,.0098.,.0121.,.0159.,.0198.,.0239.,.0290.,.0350
X,.0413.,.0487
X,.0893.,.0668.,.0350.,.0193.,.0152.,.0188.,.0228.,.0269.,.0322.,.0381
X,.0442.,.0509
X,.1233.,.1022.,.0595.,.0300.,.0198.,.0217.,.0250.,.0293.,.0349.,.0409
X,.0469.,.0530
X,.150.,.140.,.0935.,.0478.,.0269.,.0257.,.0282.,.0327.,.0380.,.0441
X,.0500.,.0560
X,.213.,.201.,.164.,.1005.,.0480.,.0352.,.0361.,.0400.,.0448.,.0502
X,.0567.,.0628
X/
END

FIGURE 16. (SHEET 17 OF 57)

C DUMAY
BLOCK DATA
COMMON/DUM/DUMMY
DIMENSION DUMMY(1977)
DATA (DUMMY (I) , I = 941 ,1060)/
X .260,.249,.218,.163,.0873,.0518,.0459,.0479,.0520,.0578
X .0630,.0689
X .282,.271,.241,.191,.1147,.0673,.0530,.0525,.0564,.062,.067
X .0724
X .307,.294,.263,.218,.1465,.0886,.0647,.0588,.0613,.067,.0717
X .0768
X .331,.319,.289,.242,.178,.1172,.0802,.0673,.0673,.0721,.0765
X .0810
X .360,.341,.312,.269,.208,.151,.1018,.0798,.0744,.0778,.0818
X .0858
X .388,.370,.338,.292,.238,.187,.129,.0960,.0839,.0838,.0876
X .0903
X .448,.427,.392,.349,.297,.252,.199,.1489,.1121,.1021,.1010
X .1019
X .497,.472,.438,.393,.341,.298,.248,.198,.149,.1232,.1157
X .1140
X .576,.551,.513,.470,.416,.372,.328,.278,.233,.188,.158,.145
X .730,.704,.663,.611,.559,.516,.470,.427,.388,.347,.304,.276
X/
DATA (DUMMY (I) , I = 1061 ,1180)/
X .922,.895,.848,.782,.731,.682,.641,.601,.555,.512,.470,.442
X .111,1.083,1.032,.968,.911,.858,.812,.769,.717,.670,.627,.598
X .128,1.255,1.207,1.143,1.089,1.028,.972,.923,.867,.819,.773
X .740
X .1558,1.54,1.502,1.444,1.379,1.310,1.250,1.190,1.133,1.086
X .1041,1.
X .1661,1.642,1.61,1.552,1.487,1.418,1.363,1.302,1.250,1.200
X .1159,1.119
X .1738,1.718,1.683,1.629,1.567,1.513,1.462,1.403,1.352,1.303
X .1265,1.229
X .1832,1.819,1.778,1.731,1.679,1.640,1.600,1.554,1.511,1.469
X .1428,1.397
X .1864,1.850,1.810,1.768,1.719,1.680,1.648,1.601,1.560,1.527
X .1487,1.452
X .188,1.87,1.83,1.789,1.739,1.705,1.671,1.628,1.594,1.560
X .1530,1.499
X .1889,1.88,1.84,1.791,1.747,1.713,1.68,1.642,1.610,1.581
X .1556,1.527
X/
DATA (DUMMY (I) , I = 1181 ,1321)/
X 13,.54,.12.
X -.18,-.165,-.15,-.14,-.125,-.11,-.97,-9,-.84,-8,-.77,-7.2
X -.69,-.67,-.64,-.62,-.59,-.53,-.45,-.38,-.3,-.2,-.1,.5,2,.3.
X .4,.45,5,.55,6,.65,7,.8,.9,5,10,.10,5,11,5,12,2,12.8,13.8
X .14,3,14.8,15,.15,7,16.2,16.6,16.9,17.3,17.8,18.5,19.5,21,.22.
X .0,.1,.2,.3,.4,.5,.6,.7,.8,.9,1,.15
X .0,-.005,-.01,-.015,-.02,-.025,-.0305,-.0365,-.0425,-.0469
X -.0508,-.0614
X .0,-.005,-.01,-.0149,-.02,-.025,-.0303,-.0362,-.0418,-.0459
X -.0499,-.061
X .0,-.0034,-.0093,-.0147,-.0192,-.0242,-.0291,-.0348,-.0400
X -.0439,-.0479,-.0600
X .0,-.0022,-.0076,-.0131,-.0173,-.0222,-.0269,-.0328,-.0376
X -.0416,-.0454,-.0581
X .0,.0028,-.0019,-.0068,-.0110,-.0161,-.0215,-.0276,-.0315

FIGURE 16. (SHEET 18 OF 57)

X,-.0354,-.0385,-.0522
X,0,...0067,.0090,.0057,0,-.0056,-.0114,-.0178,-.0212,-.0244
X,-.0272,-.0388
X/
DATA (DUMMY (I) , I = 1322 ,1429)/
X 0,...0080,.0160,.0176,.0127,.0076,.0022,-.0041,-.0074,-.0099
X,-.0124,-.0184
X,0,...0080,.0170,.0221,.0217,.0170,.0122,.0065,.0037,.0012
X,-.0012,-.0052
X,0,...0078,.0166,.0230,.0264,.0251,.0213,.0177,.0148,.0132
X,.0116,.0073
X,0,...0076,.0158,.0229,.0274,.0292,.0274,.0247,.0221,.0203
X,.0192,.0147
X,0,...0073,.0152,.0222,.0275,.0307,.0310,.0289,.0263,.0250
X,.0239,.0202
X,0,...0068,.0136,.0200,.0267,.0311,.0336,.0337,.0322,.0308
X,.0301,.0272
X,0,...0069,.0124,.0186,.0250,.0309,.0336,.0346,.0343,.0331
X,.0323,.0302
X,0,...0062,.0117,.0175,.0237,.0302,.0333,.0347,.0352,.0341
X,.0334,.0315
X,0,...0057,.0105,.0159,.0217,.0287,.0321,.0342,.0354,.0355
X,.0347,.0334
X/
DATA (DUMMY (I) , I = 1430 ,1537)/
X 0,...0052,.0097,.0148,.0202,.0270,.0310,.0334,.0352,.0359
X,.0352,.0342
X,0,...0047,.0086,.0131,.0182,.0237,.0286,.0315,.0341,.0354
X,.0357,.0348
X,0,...0035,.0064,.0097,.0137,.0177,.0217,.0251,.0291,.0317
X,.0339,.0348
X,0,...0018,.0038,.0061,.0086,.0115,.0140,.0171,.0198,.0225
X,.0258,.0312
X,0,...0009,.0021,.0037,.0055,.0072,.0091,.0114,.0131,.0151
X,.0178,.0238
X,0,...0002,.0010,.0018,.0029,.0041,.0055,.0069,.0082,.0096
X,.0111,.0151
X,0,0,0,...0005,.0012,.0020,.0024,.0041,.0048,.0057,.0070
X,.0099
X,0,...0001,.0003,.0005,.0009,.0012,.0017,.0025,.0033,.0042
X,.005,.0084
X,0,0,0,...0002,.0004,.0007,.001,.0014,.0018,.0027,.0035,.0045
X,.0076
X/
DATA (DUMMY (I) , I = 1538 ,1654)/
X 0,0,0,0,...0001,.0002,.0004,.0006,.0014,.002,.0027,.0034,.0062
X,0,0,0,...0006,-.0016,-.0024,-.0024,-.0017,-.0008,-.0003,.0006
X,.0013,.0041
X,0,-.0007,-.0021,-.0041,-.0058,-.0063,-.0064,-.0064,-.0058
X,-.0043,-.0032,-.0007
X,0,-.0012,-.0032,-.0058,-.008,-.0096,-.0096,-.0096,-.0087
X,-.0076,-.0065,-.0041
X,0,-.0016,-.0043,-.0076,-.0105,-.0126,-.0138,-.0135,-.0126
X,-.0117,-.0107,-.0084
X,0,-.0021,-.0053,-.0094,-.013,-.0164,-.0172,-.0179,-.0166
X,-.0164,-.0155,-.0136
X,0,-.0028,-.0063,-.011,-.0154,-.0197,-.0211,-.0232,-.0221
X,-.0221,-.021,-.0194
X,0,-.0034,-.0073,-.0124,-.0176,-.0225,-.0252,-.0286,-.0287
X,-.0286,-.0279,-.0259

FIGURE 16. (SHEET 19 OF 57)

```

X..0,-.004,-.0084,-.0139,-.0195,-.0249,-.0292,-.034,-.0345
X,-.035,-.0351,-.033
X..0,-.004,-.0095,-.0158,-.0225,-.0288,-.0354,-.0423,-.0451
X/
  DATA (DUMMY (I) , I = 1655 ,1763 )/
X -.0468,-.0482,-.0489
X..0,.0006,-.0066,-.0148,-.0231,-.0312,-.041,-.0497,-.0547
X,-.058,-.0612,-.0652
X..0,.0028,-.0036,-.0124,-.0212, .0309,-.0412,-.0505,-.0550
X,-.0590,-.0624,-.0689
X..0,.0046,.0002,-.0095,-.0182,-.0289,-.0399,-.0499,-.0549
X,-.0587,-.0624,-.0689
X..0,.007,.0087,.0022,-.0081,-.0182,-.0291,-.0405,-.0462
X,-.0501,-.0540,-.0640
X..0,.0078,.0122,.0118,.0027,-.0082,-.0182,-.0279,-.0342,-.0382
X,-.043,-.0544
X..0,.008,.0135,.0169,.0122,.0028,-.008,-.0171,-.0228,-.0267
X,-.0322,-.0445
X..0,.0077,.0142,.0204,.0228,.0199,.0098,.001,-.0032,-.0074
X,-.012,-.0243
X..0,.0073,.0141,.0207,.0244,.0252,.0178,.0094,.0657,.0024
X,-.0014,-.0142
X..0,.0067,.0137,.0204,.0247,.0277,.0255,.0179,.0148,.0114
X/
  DATA (DUMMY (I) , I = 1764 ,1871 )/
X .0097,-.0025
X..0,.0065,.0135,.0201,.0246,.028,.0276,.0211,.0178,.0146
X,.0128,.0021
X..0,.0056,.0121,.0186,.0235,.0276,.0314,.0306,.0287,.0258
X,.0235,.0153
X..0,.0049,.0107,.017,.0222,.0265,.0314,.0334,.0329,.0317
X,.0294,.0227
X..0,.0044,.0097,.0156,.0208,.0254,.0305,.0372,.0341,.0342
X,.0331,.0274
X..0,.004,.0089,.0144,.0196,.0242,.0294,.0328,.034,.0348,.0346
X,.0304
X..0,.0034,.0079,.013,.018,.0224,.0278,.0315,.0334,.0344,.0351
X,.0341
X..0,.0028,.0067,.0114,.0161,.0202,.0255,.0291,.0312,.0327
X,.0339,.0359
X..0,.002,.0052,.0094,.0135,.0175,.0219,.0255,.0274,.029,.0306
X,.0349
X..0,.0014,.0039,.0073,.0109,.0143,.0181,.0215,.0232,.0246
X/
  DATA ( DUMMY (I) , I = 1872 , 1977)/
X .0257,.0302
X..0,.001,.0032,.0061,.0093,.0125,.0157,.0185,.0202,.0217
X,.0225,.0252
X..0,.001,.0032,.0057,.009,.0122,.0154,.0181,.0198,.0213,.022
X,.024
X,.14,.7,.0.
X..0,.06,.12,.18,.24,.30,.36
X,.258,1.225,1.144,1.030,.920,.828,.756
X,.15,.7,.0.
X..0,.06,.12,.18,.24,.30,.36
X,.538,.500,.443,.390,.342,.308,.284
X,.16,.10,.0.
X..0,.04,.08,.12,.16,.20,.24,.28,.32,.36
X,.1046,.0997,.0891,.0776,.0672,.0580,.0487,.0401,.0324,.0259
X,.17,.10,.0.

```

FIGURE 16. (SHEET 20 OF 57)

X..0..04..08..12..16..20..24..28..32..36
X.7..7.7.9.1.11.2.13.6.15.8.18.0.19.9.21.6.22.8
X/
END

FIGURE 16. (SHEET 21 OF 57)

```
SUBROUTINE GOODMN (ZJ2,X,B,DP,DS,CL)
  DIMENSION DUMMY ( 291 )
  DATA (DUMMY(I),I= 1, 98 )/
  X1.,7.,11.
  X.,65.,70.,75.,80.,85.,E7.5,90.
  X.,70.,72.,74.,76.,78.,80.,82.,84.,86.,88.,90.
  X.,1.41993,1.43365,1.44684,1.45927,1.47073,1.48098,1.48977,1.4969
  X.,1.50215,1.50537,1.50645
  X.,1.59590,1.61661,1.63693,1.65651,1.67495,1.69181,1.70658,1.71876
  X.,1.72786,1.73350,1.73541
  X.,1.79268,1.82402,1.85566,1.88713,1.91779,1.94682,1.97316,1.99562
  X.,2.01290,2.02384,2.02758
  X.,2.01192,2.05903,2.10843,2.15978,2.21243,2.26527,2.31643,2.36313
  X.,2.40153,2.42718,2.43624
  X.,2.25177,2.32070,2.39615,2.47892,2.56980,2.66935,2.77736,2.89146
  X.,3.00370,3.09448,3.13130
  X.,2.375,2.460,2.550,2.655,2.770,2.900,3.058,3.218,3.445,3.640,3.8
  X.,2.50455,2.59981,2.70806,2.83267,2.97856,3.15338,3.36986,3.65185
  X.,4.05275,4.74271,5.8 /
  DATA (DUMMY(I),I= 99 ,121 )/
  X2.,10.,0.
  X.,70.,72.,74.,76.,78.,80.,82.,84.,86.,88.
  X.,2.50455,2.59981,2.70806,2.83267,2.97856,3.15338,3.36986,3.65185
  X.,4.05275,4.74271 /
  DATA (DUMMY(I),I= 122,291 )/
  X3.,11.,13.
  X.,.05.,10.,20.,40.,60.,80.,1.2,1.6,2.2,2.9,3.6
  X.,.002.,.005.,.015.,.025.,.05.,.1.,.2.,.3.,.4.,.6,1.0,1.4,1.8
  X.,.525.,.460.,.390.,.350.,.309.,.261.,.230.,.222.,.219.,.215.,.210.,.204.,.198
  X.,.605.,.555.,.485.,.445.,.411.,.364.,.315.,.304.,.302.,.300.,.294.,.288.,.283
  X.,.694.,.655.,.595.,.565.,.522.,.475.,.434.,.421.,.413.,.404.,.400.,.394.,.390
  X.,.785.,.759.,.712.,.692.,.658.,.615.,.576.,.563.,.554.,.544.,.540.,.536.,.531
  X.,.837.,.818.,.783.,.763.,.735.,.700.,.671.,.661.,.653.,.643.,.637.,.633.,.630
  X.,.874.,.855.,.830.,.811.,.792.,.767.,.739.,.730.,.725.,.717.,.709.,.707.,.705
  X.,.918.,.908.,.890.,.878.,.867.,.850.,.829.,.820.,.814.,.812.,.810.,.809.,.807
  X.,.950.,.940.,.928.,.922.,.913.,.900.,.886.,.881.,.879.,.875.,.874.,.873.,.872
  X.,.973.,.970.,.964.,.959.,.953.,.947.,.941.,.939.,.936.,.933.,.932.,.931.,.930
  X.,.985.,.984.,.983.,.981.,.978.,.973.,.968.,.967.,.966.,.965.,.964.,.963.,.962
  X.,.993.,.992.,.991.,.990.,.989.,.988.,.987.,.9865.,.986.,.9855.,.985.,.9845
  X.,.984 /
  PI=3.14159265
  DEGCV=180./PI
  AMBDA=ZJ2/PI
  ZMU=B*SQRT(1.0+AMBDA**2)/(2.0*AMBDA)
  F=ZMU*(1.0-X)
  G=ZMU*(-1.0+DS/DP)
  IF (F-.05)10,10,90
10  COSHG=1.0+G**2/2.0+G**4/24.0
  ALPHA=ASIN(1.0/COSHG)*DEGCV
  FG=F+G
  COSHFG=1.0+FG**2/2.0+FG**4/24.0
  PHI=ASIN(COSHG/COSHFG)*DEGCV
  IF (ALPHA-88.)?0,20,30
20  CALL UNBAR (DUMMY, 99 ,ALPHA,0.0,SK,LIMIT)
  GO TO 40
30  SK=.5*ALOG(16./(1.0-(1.0/COSHG)**2))
40  IF (PHI-85.0)50,60,60
50  CALL UNBAR (DUMMY, 1 ,PHI,ALPHA,FONE,LIMIT)
  GO TO 80
60  IF (ALPHA-86.)50,70,70
```

FIGURE 16. (SHEET 22 OF 57)

```
70 TWOPHI=ATAN(1.0/SQRT(COSHFG**2-1.0))  
   PHIONE=.5*(TWOPHI+PHI/DEGCV)  
   FONE=ALOG(SIN(PI/4.0+PHIONE/2.0)/COS(PI/4.0+PHIONE/2.0))/(1.0/SQRT  
   X(1.0/COSHG))  
80 FTWO=1.0-FONE/SK  
   GO TO 110  
90 CALL UNBAR (DUMMY, 122,F,G,FTWO,LIMIT)  
110 FINF=2.0*ATAN(SQRT(EXP(2.0*F)-1.0))/PI  
   FTWO=FTWO/FINF  
120 CL=CL*FTWO  
   RETURN  
   END
```

FIGURE 16. (SHEET 23 OF 57)

SUBROUTINE INPUT

```

DIMENSION AA(8),AKA(10),ALPH(10),APBET(10,7),BCB(8),BETA(10),
1BOD(10),C(10),CDOCL(10),CL3(10),COCLN(10),CTAC(10),DCPAP(10,6),
2DCPIN(10,6),DCTAP(10,6),DCTIN(10,6),DECL(10),DELTH(10),DTHET(10),
3EFFS(10),EINT(7),FT(10),G(10),GIR(10),HOB(10),IPR(10),PHI(10),
4PHIO(10),PXI(10),SM(10),SR(10),S1(10),S2(10),S3(10),S4(10),
5TABLE2(43),THET(10),THET34(10),TTHERM(50),TX(50),VACB(10),
6VOV(10,10),X(10),XI(11),ZJ(10),ZM(10),ZMCRT(10),ZMCROM(10),
7ZMMCR(10),ZMN(10),ZNMN(10),Z5(10),CLAO(10),THETN(10),MSUB(3)
8,GOOD(10),CD(10),DCDCL(10)
DIMENSION CBAR(11),HOL(5)
COMMON A      , AA      , ABOVE  , AF      , AKA      , ALCHT
COMMON ALPH    , AMBDA  , APBET  , APLUS  , ASHRD  , A4A2
COMMON BCB     , BELOW  , BETA   , BLADN  , BOD
COMMON C       , CDOCL  , CHOICE , CLAO   , CLI     , CL1
COMMON CL2     , CL3    , COBET  , COCLN  , COPHI   , COUNT
COMMON CPA     , CTA    , CTAC   , CD
COMMON D       , DCD    , DCPAP  , DCPIN  , DCTAP   , DCTIN
COMMON DECL    , DEGCV  , DELA   , DELTAC , DELTH   , DSHRD
COMMON DTHET   , DMCRIT , DCDCL
COMMON EFFA    , EFFS   , EINT
COMMON FAKE    , FT
COMMON G       , GIR    , GOOD
COMMON HOB     , HOB SUB
COMMON I       , IB     , IC     , IDL    , IERROR  , IHOLD
COMMON IOFF    , IP     , IPR    , ISET   , ISET1   , ISET2
COMMON IT      , INCON
COMMON JV
COMMON KOUNT
COMMON L
COMMON M       , MFINO  , MSUB   , M6     , M8
COMMON N       , NMN    , NOF    , NRECN  , NSIZE   , NSS
COMMON PHI     , PHIO   , PI     , PXI
COMMON RADCV   , RFL
COMMON SBETA1  , SBETA2 , SCO    , SHRDNO , SHROD   , SIPHI
COMMON SM      , SR     , STHET1 , STHET2 , SUM     , S1
COMMON S2      , S3     , S4     , S5
COMMON TABLE2 , THET   , THETN  , THET34 , TRIG1   , TRIG2
COMMON TTHERM  , TX
COMMON VACB    , VGV    , V1     , V2
COMMON X       , XI     , XNSS   , XPR
COMMON Y1      , Y2
COMMON ZIP1    , ZJ     , ZJI    , ZM     , ZMCRT   , ZMCROM
COMMON ZMMCR   , ZMN    , ZMS     , ZMU    , ZNMN    , Z5
KTJT=-1
PI=3.14159265
RADCV=PI/180.
DEGCV=180./PI
10 READ (5,20)I
20 FORMAT (13,69H
X
)
C
C   TEST FOR LAST CASE
C
IF (1-42)30,630,30
30 WRITE (6,20)I
READ (5,20)I
WRITE (6,20)I
READ (5,40)HOL,BLADN,AF,CLI,D,SCO,CTAC(1),SHROD
40 FORMAT (5A6,7F6.0)

```

FIGURE 16. (SHEET 24 OF 57)

```
      IF (SHROD-5.)42,42,44
42 WRITE (6,50)HOL,BLADN,AF,D,CL1,SCO
50 FORMAT (37H0 **** PROPELLER CHARACTERISTICS ****//5A6//15H0 NO.OF
1BLADES=F4.0,10X,3HAF=F6.1/15H DIAMETER FT.=F8.4,5X,4HCL1=F6.4/15H
2      HUB X      =F6.4 )
      GO TO 60
44 WRITE (6,46)HOL
46 FORMAT (5A6)
60 READ (5,70)I,K,(XI(J),J=1,11)
70 FORMAT (2I3,11F6.0)
      IF (I-3)72,72,76
72 WRITE (6,74)
74 FORMAT (79H0 ERROR IN INPUT -- CARD NOT LABELLED AND NOT COVERED B
1Y CARDS 10 OR 36 THRU 40 )
      GO TO 60
76 IF (I-41)80,420,80
80 IF (I-30)90,240,240
90 IK=I-3
      GO TO (100,120,140,160,180,200,220),IK
100 DO 110 J=1,10
110 X(J)=XI(J+1)
      GO TO 60
120 DO 130 J=1,10
130 HOB(J)=XI(J+1)
      GO TO 60
140 DO 150 J=1,10
150 BOD(J)=XI(J+1)
      GO TO 60
160 DO 170 J=1,10
170 DECL(J)=XI(J+1)
      GO TO 60
180 DO 190 J=1,10
190 DTHET(J)=XI(J+1)
      GO TO 60
200 DO 210 J=1,10
210 C(J)=XI(J+1)
      GO TO 60
220 NOF=K
      READ (5,230)(IPR(I),ZJ(I),S1(I),DELTH(I),THETN(I),ZMN(I),I=1,NOF)
230 FORMAT (16,5F6.0)
      GO TO 60
240 IK=I-30
      GO TO (250,260,280,300,320,340,350,350,370,420),IK
C
C      SHROUD CHARACTERISTICS
C
250 AMBDA=XI(1)
      XPB=XI(2)
      ZMU=XI(3)
      DSHRD=XI(4)
      IF (SHROD-5.)254,254,252
252 SHRDNO=ZMU
      ZMU=DSHRD/SHRDNO
254 ASHRD=XI(5)
      TRIG1=XI(6)
      TRIG2=XI(7)
      A4A2=XI(8)
      GO TO 60
260 DO 270 JT=1,8
270 AA(JT)=XI(JT+1)
```

FIGURE 16. (SHEET 25 OF 57)

```
GO TO 60
280 DO 290 JT=1,7
290 EINT(JT)=XI(JT+1)
GO TO 60
300 DO 310 JT=1,8
310 BCB(JT)=XI(JT+1)
GO TO 60
320 DO 330 JT=1,10
330 VACB(JT)=XI(JT+1)
GO TO 60
340 NSS=K
XNSS=NSS
RFL=XI(1)
350 READ (5,70)I,KL,(CBAR(JT),JT=1,11)
DO 360 JT=2,11
JJT=KTJT+JT
TX(JJT)=XI(JT)
360 TTHERM(JJT)=CBAR(JT)
KTJT=KTJT+10
GO TO 60
370 TABLE2(2)=K
ZIP1=0.0
IF (TABLE2(2)-998.0)380,60,380
380 DO 390 JT=1,11
390 TABLE2(JT+3)=XI(JT)
TABLE2(1)=20.0
TABLE2(3)=0.0
IF (TABLE2(2)-5.0)60,60,400
400 ITTAB2=TABLE2(2)*2.0+3.0
READ (5,410)(TABLE2(JT),JT=15,ITTAB2)
410 FORMAT (F12.0,10F6.0)
GO TO 60
420 IF (SHROD-5.0)430,430,490
430 WRITE (6,440)(X(I),I=1,10)
440 FORMAT (1H0,10X,2HX=10F8.4)
IF (SHROD-5.0)450,470,490
450 WRITE (6,460)(HOB(I),I=1,10),(BJD(I),I=1,10),(DECL(I),I=1,10),
X(DTHET(I),I=1,10)
460 FORMAT (9X,4HT/B=10F8.4/9X,4HE/D=10F8.4/6X,7HDES CL=10F8.4/5X,8HDE
XLTA 0=/1H+,10X,2H- ,10F8.2)
GO TO 490
470 WRITE (6,480)(C(I),I=1,10)
480 FORMAT (13H CIRCULATION=10F8.4 )
490 IF (SHROD-5.0)492,492,494
492 DR=D/ZMU
GO TO 496
494 DR=SHRDNO
496 WRITE (6,500)ASHRD,AMBDA,XPB,ZMU,DSHRD,DR,RFL,A4A2
500 FORMAT (///34H0 **** SHROUD CHARACTERISTICS ****///15H0 SHROUD NO.
1 =F4.0,6X,7HLAMBDA=F6.4/8X,7HXP-BAR=F6.4,4X,7HMU =F6.4 /35H SH
2ROUD INNER SURFACE DIAMETER FT.=F8.4 /5X,30HSHROUD REFERENCE DIAME
3TER FT.=F8.4 /13X,22HRIEGELS FACTOR LIMIT =F8.4 /23X,12HAREA RATIO
4 =F8.4 )
IF (SHROD-5.0)508,508,505
505 WRITE (6,506)SCO
506 FORMAT (34H CENTERBODY X IN SPECIFIED PLANE =F6.4 )
508 WRITE (6,510)(AA(I),I=1,8),(EINT(I),I=1,7)
510 FORMAT (51H0 T/C CONTRIBUTION TO VORTICITY (THICKNESS COEFF.)=8F9.
X4/51H SLOPE OF MEAN CAMBER LINE (GLAUERT COEFF.)=7F9.4 )
IF (TABLE2(2)-998.0)520,540,520
```

FIGURE 16. (SHEET 26 OF 57)

```

520 WRITE (6,530)(TABLE2(I),I=1,1TTAB2)
530 FORMAT (63H0 TABLE OF 2-D T/C CONTRIBUTION TO SHROUD PRESSURE COEF
      XFICIENTS//(10F9.4))
540 WRITE (6,550)(BCB(I),I=1,8)
550 FORMAT (38H0 **** CENTERBODY CHARACTERISTICS ****//49H CONTRIBUTI
      XON TO VORTICITY      (GLAUERT COEFF.)=8F9.4 )
      IF (SHROD=5.0)560,580,600
560 WRITE (6,570)
570 FORMAT (////79H **** CALCULATIONS ARE BASED ON BOTH PROPELLER AND
      1 SHROUD CHARACTERISTICS **** //// )
      GO TO 620
580 WRITE (6,590)
590 FORMAT (////92H **** CALCULATIONS ARE BASED ON SHROUD CHARACTERIS
      ITICS AND GIVEN PROPELLER CIRCULATION **** //// )
      GO TO 620
600 WRITE (6,610)
610 FORMAT (////54H **** CALCULATIONS ARE BASED ON THE SHROUD ALONE *
      1*** //// )
620 S5=0.0
      RETURN
630 CALL EXIT
      END

```

FIGURE 16. (SHEET 27 OF 57)

```
SUBROUTINE LEGEND (ARGL,FPOS,FNEG,DPOS,DDNEG)
PI=3.14159265
ZAV2=ARGL-1.0
ZAV3=ALOG(ZAV2)
ZAV4=1.0/(ARGL+1.0)
ZAV5=.5*ZAV4/ZAV2
ZAV6=ZAV4**2
ZAV7=SQRT(ZAV4)
ZAV9=ZAV6**2
ZAV10=ZAV2**2
4010 IF (ARGL-2.3) 4020,4020,4030
4020 FPOS=-.267.32+ZAV2*(.5248255-.040988359*ZAV2+.95135319E-02*ZAV10)+
1   ZAV3*(-.5-.1875*ZAV2+.029296875*ZAV10-.85449219E-02*ZAV2*ZAV10)
2   +ZAV10**2*(-.29774364E-02+.30040741E-02*ZAV3)
3   +ZAV10**2*ZAV2*(.001068207-.11565672E-02*ZAV3)
   FNEG=1.732868+ZAV2*(-.0916085+.199061765E-01*ZAV2-.60980647E-02*ZAV10)+ZAV3*(-.5+.0625*ZAV2-.017578125*ZAV10+.61035157E-02*ZAV2*ZAV10)
   GO TO 4050
4030 FPOS=(.125+.1875*ZAV4+.29296875*ZAV6+.47851562*ZAV4*ZAV6+.80749511
1*ZAV9+.1.395813*ZAV4*ZAV9+2.4572124*ZAV6*ZAV9+4.3878793*ZAV4*ZAV6*
2ZAV9)*PI*.414214*ZAV4*ZAV7
   FNEG=(1.0+.5*ZAV4+.5625*ZAV6+.78125*ZAV4*ZAV6+.1.196289*ZAV9+.1.9379
1883*ZAV4*ZAV9)*PI*ZAV7/.414214
4050 DPOS=(ARGL*FPOS-FNEG)*ZAV5
   DDNEG=(FPOS-ARGL*FNEG)*ZAV5
   RETURN
   END
```

FIGURE 16. (SHEET 28 OF 57)

SUBROUTINE TAR

```
DIMENSION AA(8),AKA(10),ALPH(10),APBET(10,7),BCB(8),BETA(10),
1BOD(10),C(10),CDOCL(10),CL3(10),COCLN(10),CTAC(10),DCPAP(10,6),
2DCPIN(10,6),DCTAP(10,6),DCTIN(10,6),DECL(10),DELTH(10),DTHET(10),
3EFFS(10),EINT(7),FT(10),G(10),GIR(10),HOB(10),IPR(10),PHI(10),
4PHI0(10),PXI(10),SM(10),SR(10),S1(10),S2(10),S3(10),S4(10),
5T/ELE2(43),THET(10),THET34(10),THERM(50),TX(50),VACB(10),
6VOV(10,10),X(10),XI(11),ZJ(10),ZM(10),ZMCRT(10),ZMCROM(10),
7ZMMCR(10),ZMN(10),ZNMN(10),Z5(10),CLAO(10),THETN(10),MSUR(3)
8,GOOD(10),CD(10),DCDCL(10)
DIMENSION CBAR(8),CC(25),CHI(81,7),CHII(7,7),CIRFT(7),CONS2(7),
1COSC(81,7),DNEG(81),DUMMY(938),DXPB(81),P(7,7),POR(81),PKL(28,7),
2SA(8),SBO(7),SBO1(7),SBO2(7),SINC(81,7),THM(8),TM(8,8),TMT(32,8),
3TVOV1(10),TVOV2(10),TVOVS(10,2),VFLC(10,8),VFLH(10,8),DATA(2980),
4AVOV(10,10),DELVOV(10,10),VPOV(10),TOTAL(10),UQUIN(10),SWANG(10),
5SKL(28,7),TKL(28,7),S(7,7),TT(7,7),PWKE(40),
6DCB(8,8),PM(7),TCPU(40),TCPL(40),FTHRM(40),DXA(7),SX(40),
7FCTRAL(9),SCONS2(7),SUM1(10)
DIMENSION PCU(40),PCL(40),CT(40),SVSH(40),VRATU(40),VRATL(40),
XSTHERM(40)
COMMON A      , AA      , ABOVE  , AF      , AKA      , ALCHT
COMMON ALPH   , AMBDA   , APBET   , APLUS   , ASHRD   , A4A2
COMMON BCB    , BELOW   , BETA    , BLADN   , BOD
COMMON C      , CDOCL   , CHOICE  , CLAO    , CL1      , CL1
COMMON CL2    , CL3     , COBET   , COCLN   , COPHI    , COUNT
COMMON CPA    , CTA     , CTAC    , CD
COMMON D      , DCD     , DCPAP   , DCPIN   , DCTAP    , DCTIN
COMMON DECL   , DEGCV   , DELA   , DELTAC  , DELTH    , DSHRD
COMMON DTHET  , DMCRT   , DCDCL
COMMON EFFA   , EFFS    , EINT
COMMON FAKE   , FT
COMMON G      , GIR     , GOOD
COMMON HOB    , HOB SUB
COMMON I      , IB      , IC      , IDL     , IERROR   , I HOLD
COMMON IOFF   , IP      , IPR     , ISET    , ISET1    , ISET2
COMMON IT     , INCON
COMMON JV
COMMON KOUNT
COMMON L
COMMON M      , M FIND   , MSUB   , M6      , M8
COMMON N      , NMN     , NOF    , NREC   , NSIZE   , NSS
COMMON PHI    , PHI0    , PI     , PXI
COMMON RADCV  , RFL
COMMON SBETA1 , SBETA2   , SCO    , SHRDNO  , SHROD   , SIPHI
COMMON SM     , SR      , STHET1 , STHET2  , SUM     , S1
COMMON S2     , S3      , S4      , S5
COMMON TABLE2, THET    , THETN   , THET34  , TRIG1   , TRIG2
COMMON THERM  , TX
COMMON VACB   , VOV     , V1      , V2
COMMON X      , XI      , XNSS    , XPB
COMMON Y1     , Y2
COMMON ZIP1   , ZJ      , ZJ1     , ZM      , ZMCRT   , ZMCROM
COMMON ZMMCR  , ZMN     , ZMS     , ZMU     , ZNMN    , Z5
COMMON/DAT/DA
EQUIVALENCE (DNEG(1),DXPB(1))
EQUIVALENCE (DATA(1),PKL(1)),(DATA(197),TMT(1)),(DATA(453),COSC(1))
1,(DATA(1020),SINC(1)),(DATA(1587),DUMMY(1))
1,(DATA(2525),SKL(1)),(DATA(2721),TKL(1)),(DATA(2917),DCB(1))
DATA (FCTRAL(1),1=1.9)/1.0,1.0,2.0,6.0,24.0,120.0,720.0,5040.0,
X40320.0 /
```

FIGURE 16. (SHEET 29 OF 57)

```

IF (10FF-1)229,3100,2810
C
C      P(7,7),M(8,8),S(7,7), AND TT(7,7)MATRIX INTERPOLATION
C
3100 IF(SAMBDA-AMBDA)3120,3110,3120
3110 IF(SSMBDA-AMBDA)3120,3500,3120
3120 SAMBDA=AMBDA
      IF(AMBDA-.25)3220,3130,3140
3130 CATEG=3.0
      GO TO 3320
3140 IF(AMBDA-.50)3160,3150,3170
3150 CATEG=4.0
      GO TO 3320
3160 CATEG=1.0
      GO TO 3240
3170 IF(AMBDA-.75)3190,3180,3200
3180 CATEG=5.0
      GO TO 3320
3190 CATEG=2.0
      GO TO 3240
3200 IF(AMBDA-1.0)3190,3210,3220
3210 CATEG=6.0
      GO TO 3320
3220 WRITE (6,3230)
3230 FORMAT(23HOLAMBDA LIMITS EXCEEDED)
      GO TO 2900
3240 DO 3310 LK=1,8
      LL=LK
      LLL=LK
      LLLL=LK
      ML=LK
      MLL=LK
      MLLL=LK
      DO 3300 KL=1,8
      IF(CATEG-1.0)3260,3250,3260
3250 AMB1=.25
      KK=KL
      KKK=7+KL
      KKKK=14+KL
      MK=KL
      MKK=8+KL
      MKKK=16+KL
      GO TO 3270
3260 AMB1=.50
      KK=7+KL
      KKK=14+KL
      KKKK=21+KL
      MK=8+KL
      MKK=16+KL
      MKKK=24+KL
3270 IF(LK-8)3280,3290,3290
3280 IF(KL-8)3285,3290,3290
3285 P(KL,LK)=
1      ((2.0*(PKL(KKK,LLL)-PKL(KK,LL))-0.5*(PKL(KKKK,LLLL)-PKL(KK,L
2L)))+(2.0*(PKL(KKKK,LLLL)-PKL(KK,LL))-4.0*(PKL(KKK,LLL)-PKL(KK,LL)
3))*(AMBDA-AMB1))*(AMBDA-AMB1)/.25+PKL(KK,LL)
      S(KL,LK)=((2.0*(SKL(KKK,LLL)-SKL(KK,LL))-0.5*(SKL(KKKK,LLLL)-SKL(KK
1,LL)))+(2.0*(SKL(KKKK,LLLL)-SKL(KK,LL))-4.0*(SKL(KKK,LLL)-SKL(KK,L
2L)))*(AMBDA-AMB1))*(AMBDA-AMB1)/.25+SKL(KK,LL)
      TT(KL,LK)=((2.0*(TKL(KKK,LLL)-TKL(KK,LL))-0.5*(TKL(KKKK,LLLL)-TKL(K

```

FIGURE 16. (SHEET 30 OF 57)

```
1K,LL)))+(2.0*(TKL(KKKK,LLLL)-TKL(KK,LL))-4.0*(TKL(KKK,LLL)-TKL(KK,
2LL)))*(AMBDA-AMB1))*(AMBDA-AMB1)/.25+TKL(KK,LL)
3290 TM(KL,LK)=
1 ((2.0*(TMT(MKK,MLL)-TMT(MK,ML))-5*(TMT(MKKK,MLLL)-TMT(MK,
2ML)))+(2.0*(TMT(MKKK,MLLL)-TMT(MK,ML))-4.0*(TMT(MKK,MLL)-TMT(MK,ML
3)))*(AMBDA-AMB1))*(AMBDA-AMB1)/.25+TMT(MK,ML)
3300 CONTINUE
3310 CONTINUE
GO TO 3450
3320 DO 3440 LK=1.8
LL=LK
ML=LK
DO 3430 KL=1.8
IF(CATEG-3.0)3220,3330,3340
3330 KK=KL
MK=KL
GO TO 3400
3340 IF(CATEG-4.0)3220,3350,3360
3350 KK=KL+7
MK=KL+8
GO TO 3400
3360 IF(CATEG-5.0)3220,3370,3380
3370 KK=KL+14
MK=KL+16
GO TO 3400
3380 IF(CATEG-6.0)3220,3390,3400
3390 KK=KL+21
MK=KL+24
3400 IF(LK-7)3410,3410,3430
3410 IF(KL-7)3420,3420,3430
3420 P(KL,LK)=PKL(KK,LL)
S(KL,LK)=SKL(KK,LL)
TT(KL,LK)=TKL(KK,LL)
3430 TM(KL,LK)=TMT(MK,ML)
3440 CONTINUE
3450 CONTINUE
3500 IF (TRIG1)3528,3528,3502
3502 WRITE (6,3504)
3504 FORMAT (113H0 **** IN THE SUBSEQUENT MATRICES THE SUBSCRIPT L REFE
XRS TO THE ROW AND THE SUBSCRIPT K REFERS TO THE COLUMN **** // )
3505 WRITE (6,3510)AMBDA,((P(KL,LK),LK=1.7),KL=1.7)
3510 FORMAT ( 20HOP(K,L) DATA LAMBDA=F7.4/(7F11.5))
WRITE (6,3520)AMBDA,((TM(KL,LK),LK=1.8),KL=1.8)
3520 FORMAT ( 23H0 M(K,L) MATRIX LAMBDA=F7.4/(8F10.5))
WRITE (6,3523)AMBDA,((S(KL,LK),LK=1.7),KL=1.7)
3523 FORMAT(20HOS(K,L) DATA LAMBDA=F7.4/(7F11.5))
WRITE (6,3527)AMBDA,((TT(KL,LK),LK=1.7),KL=1.7)
3527 FORMAT(21HOTT(K,L) DATA LAMBDA=F7.4/(7F11.5))
C
C SHROUD THICKNESS EFFECT MATRIX M * MATRIX SA
C
3528 SA(1)=SORT(AMBDA/2.0)*AA(1)
SA(2)=AA(2)+AA(3)+.75*AA(4)+.5*AA(5)+.3125*AA(6)+.1875*AA(7)+
1.109375*AA(8)
SA(3)=(1.0/AMBDA)*(AA(3)+1.5*AA(4)+1.5*AA(5)+1.25*AA(6)+.9375*AA(7
1)+.65625*AA(8))
SA(4)=(1.0/(AMBDA**2))*(.75*AA(4)+1.5*AA(5)+1.875*AA(6)+1.875*AA(7
1)+1.640625*AA(8))
SA(5)=(1.0/(AMBDA**3))*(.5*AA(5)+1.25*AA(6)+1.875*AA(7)+2.1875*
1 AA(8))
```

FIGURE 16. (SHEET 31 OF 57)

```
SA(6)=(1.0/(AMBDA**4))*(.3125*AA(6)+.9375*AA(7)+1.640625*AA(8))
SA(7)=(1.0/(AMBDA**5))*(.1875*AA(7)+.65625*AA(8))
SA(8)=(1.0/(AMBDA**6))*(.109375 *AA(8))
DO 3540 JR=1,8
THM(JR)=0.0
DO 3530 JC=1,8
THM(JR)=TM(JR,JC)*SA(JC)+THM(JR)
3530 CONTINUE
3540 CONTINUE
3550 CONTINUE
JOUNT=0
SAMBDA=AMBDA
SSMBDA=AMBDA
C
C CHI INTEGRAL FOR PROPER LAMBDA,MU, AND XP BAR
C
IF (SHROD-5.)3560,3560,3949
3560 IF (ZMU-.75)3600,3700,3570
3570 IF(ZMU-.998)3700,3700,3600
3600 WRITE (6,3650)
3650 FORMAT(48H0 MU LIMIT EXCEEDED FOR CHARACTERISTICS FUNCTION)
GO TO 2900
3700 IF(SZMU-ZMU)3730,3710,3730
3710 IF(SBMBDA-AMBDA)3730,3720,3730
3720 IF(SxPB-xPB)3730,3940,3730
3730 DO 3740 I=1,81
3740 DXPB(I)=AMBDA*(-xPB/AMBDA-COSC(I,1))
DO 3815 JT1=1,7
DO 3810 I=1,81
GO TO (3750,3760,3770,3780,3790,3792,3794),JT1
3750 KOEFE=1
GO TO 3800
3760 KOEFE=135
GO TO 3800
3770 KOEFE=269
GO TO 3800
3780 KOEFE=403
GO TO 3800
3790 KOEFE=537
GO TO 3800
3792 KOEFE=671
GO TO 3800
3794 KOEFE=805
3800 HOLD=ABS(DXPB(I))
CALL UNBAR(DUMMY(I),KOEFE,HOLD,ZMU,CHI(I,JT1),LIMIT)
3810 CONTINUE
3815 CONTINUE
3818 DO 3910 NU=1,7
TEMP=0.0
DO 3900 JT1=1,7
CHI1(JT1,NU)=0.0
SIMP=1.0
DO 3890 I=1,81
IF(NU-1)3820,3820,3830
3820 CONST=-.5
GO TO 3840
3830 II=NU-1
CONST=COSC(I,II)
3840 CHI1(JT1,NU)=CHI(I,JT1)*CONST*SIMP+CHI1(JT1,NU)
IF(I-80)3860,3850,3850
```

FIGURE 16. (SHEET 32 OF 57)

```
3850 SIMP=1.0
      GO TO 3890
3860 IF(TEMP-0.0)3870,3870,3880
3870 SIMP=4.0
      TEMP=1.0
      GO TO 3890
3880 SIMP=2.0
      TEMP=0.0
      GO TO 3890
3890 CONTINUE
      CH11(JT1,NU)=CH11(JT1,NU)*.013083
3900 CONTINUE
3910 CONTINUE
3920 CONTINUE
3940 IF (TRIG1)3948,3948,3942
3942 WRITE (6,3945)AMBDA,ZMU,XPB
3945 FORMAT (112H0 **** IN THE SUBSEQUENT MATRIX THE SUBSCRIPT J REFERS
      X TO THE ROW AND THE SUBSCRIPT NU REFERS TO THE COLUMN **** //
      X35H0 CHI(J,NU) INTEGRAL DATA  LAMBDA=F6.3,4H MU=F6.3,5H XPB=F8.5)
      WRITE (6,3947)((CH11(JT1,NU),JT1=1,7),NU=1,7)
3947 FORMAT (F24.6,6F12.6)
3948 SZMU=ZMU
      SCMBDA=AMBDA
      SXPB=XPB
C
C      CALCULATION OF CHARACTERISTIC FUNCTIONS FOR VELOCITY PARAMETERS
C
3949 IF (SCMBDA-AMBDA)4360,4310,4360
4310 IF(SSXPB-XPB)4360,4320,4360
4320 IF (SSCO-SCO)4360,4325,4360
4325 IF (SSZMU-ZMU)4360,4330,4360
4330 IF(SCMBDA-AMBDA)4360,4340,4360
4340 IF(SSSXPB-XPB)4360,4350,4360
4350 IF (SSSCO-SCO)4360,4355,4360
4355 IF (SSSZMU-ZMU)4360,4280,4360
4360 DO 4366 IZ1=1,10
      DO 4363 IZ2=1,8
      VELC(IZ1,IZ2)=0.0
      VELH(IZ1,IZ2)=0.0
4363 CONTINUE
4366 CONTINUE
      DO 4180 IZ1=1,10
      DO 4170 IZ2=1,8
      DO 4160 IZ3=1,81
      IF(IZ2-1)4000,4000,4060
4000 ZAV1=(XPB+AMBDA*COSC(IZ3,1))*2
      ZAVB=AMBDA*(3.0/2.0)
      ZCONS4=1.0
      ARGL=1.0+((1.0/(X(IZ1)*ZMU))*(1.0+ZAV1)+X(IZ1)*ZMU-2.0)/2.0
      CALL LEGEND (ARGL,FPOS,FNEG,DPOS,DDNEG)
      DNEG(IZ3)=DDNEG
      POR(IZ3)=X(IZ1)*ZMU*DPOS-DNEG(IZ3)
4060 IF(IZ3-1)4080,4080,4070
4070 IF(IZ3-81)4090,4080,4080
4080 ZCONS1=.01308997
      ZEST=1.0
      GO TO 4120
4090 IF(ZEST)4110,4110,4100
4100 ZCONS1=.052359878
      ZEST=0.0
```

FIGURE 16. (SHEET 33 OF 57)

```
GO TO 4120
4110 ZCONS1=.026179939
      ZEST=1.0
4120 IF (IZ2-1)4130,4130,4140
4130 ZCONS2=1.0+COSC(IZ3,1)
      ZCONS3=ZAV8*SQRT(ZCONS2)
      GO TO 4150
4140 ZCONS2=SINC(IZ3,1)*SINC(IZ3,IZ2-1)
      ZCONS3=-COSC(IZ3,1)**(IZ2-2)*SINC(IZ3,1)*AMBDA**(IZ2)*ZCONS4
4150 VELC(IZ1,IZ2)=VELC(IZ1,IZ2)+POR(IZ3)*ZCONS2*ZCONS1
      VELH(IZ1,IZ2)=VELH(IZ1,IZ2)+DNEG(IZ3)*ZCONS3*ZCONS1*(-COSC(IZ3,1)-
      1XPB/AMBDA)
4160 CONTINUE
      ZCONS4=-ZCONS4
4170 CONTINUE
4180 CONTINUE
4280 DO 4184 IT=1,10
      THONT1=1.0/(2.0*PI*((X(IT)*ZMU)**1.5))
      SUM1(1)=0.0
      DO 4182 JT=2,8
      SUM1(1)=SUM1(1)+SA(JT)*VELH(IT,JT)
4182 CONTINUE
      TVOV2(IT)=THONT1*(SA(1)*VELH(IT,1)+SUM1(1))
4184 CONTINUE
      SCMBDA=AMBDA
      SSXPB=XPB
      SSCO=SCO
      SSZMU=ZMU
      SDMBDA=AMBDA
      SSSXPB=XPB
      SSSCO=SCO
      SSSZMU=ZMU
      IF (TRIG1)2999,2999,4285
4285 WRITE (6,4290)(X(IZ4),(VELC(IZ4,IZ5),IZ5=1,8),IZ4=1,10)
      WRITE (6,4300)(X(IZ4),(VELH(IZ4,IZ5),IZ5=1,8),IZ4=1,10)
4290 FORMAT(9HORAD,STA,9X,31HVELC(NU) AS NU GOES FROM 0 TO 7/10(F8.4,BF
      19.5/))
4300 FORMAT(/9H RAD,STA,9X,31HVELH(NU) AS NU GOES FROM 0 TO 7/10(F8.4,B
      1F9.5/))
      GO TO 2999

C
C      COMPUTATION OF CIRCULATION/CIRC.MAX AND CIRCULATION MAX
C
229 IF (SHROD-S.)230,230,397
230 CC(1)=100.0
      CC(2)=10.0
      CC(3)=0.0
      DO 300 IT=1,10
      IF (SHROD-S.)232,234,234
232 C(IT)=COS(BETA(IT)*RADCV)*CL3(IT)*BOD(IT)/SIN(PHI0(IT)*RADCV)
234 JT=14-IT
      KT=24-IT
      CC(JT)=X(IT)
300 CC(KT)=C(IT)
      CBARM=0.0
      CHAR(1)=0.0
      CBAR(81)=0.0
      XX=0.0
304 VAVG1=0.0
      DO 305 IT=1,10
```

FIGURE 16. (SHEET 34 OF 57)

```
105 VAVGI=VAVGI+2.0*X(IT)*GIR(IT)*(VOV(IT,JV)+BLADN*C(IT)/(4.0*ZJ))
VAVGI=VAVGI/(1.0+SCO)
307 DO 390 IT=2,80
XX=XX+.0125
IF(XX-X(1))320,330,310
310 CBAR(IT)=C(1)*(XX-1.0)/(X(1)-1.0)
GO TO 370
320 IF(XX-X(10))340,330,330
330 CALL UNBAR (CC(1),1,XX,.0,CBAR(IT),LIMIT)
GO TO 370
340 IF(XX-SCO)350,350,360
350 CBAR(IT)=0.0
GO TO 375
360 CBAR(IT)=C(10)*(XX-SCO)/(X(10)-SCO)
370 IF(CBARM)375,372,375
372 CBARM=CBAR(IT)
375 IF(CBAR(IT)-CBARM)390,390,380
380 CBARM=CBAR(IT)
390 CONTINUE
393 DO 395 IT=1,81
395 CBAR(IT)=CBAR(IT)/CBARM
LOUNT=0
C
C   CALCULATION OF CIRCULATION FACTOR
C
397 XVI=0.0
C
C   SETS UP SUMMATION INDEX FOR GLAUERT JV1
C
DO 2500 JV1=1,7
XJ=0.0
XV1=XV1+1.0
C
C   SETS UP INTEGRATION NO. AND DUMMY INDEX J
C
IF (SHROD-5.)398,398,1020
398 DO 1000 JT=1,7
XJ=XJ+1.0
IF(JT-LOUNT)470,470,400
400 CIRFT(JT)=0.0
TRIGD=0.0
DO 440 IT=2,81
408 IF(TRIGD-0.0)420,410,420
410 SIMP=4.0
TRIGD=1.0
GO TO 430
420 SIMP=2.0
TRIGD=0.0
430 CIRFT(JT)=CIRFT(JT)+2.0*CBAR(IT)*SINC(IT,JT)*SIMP
440 CONTINUE
CIRFT(JT)=CIRFT(JT)/240.0
LOUNT=JT
450 TCON1=0.0
TCON2=0.0
470 IF(JT-1)550,550,560
550 HOLD=0.0
GO TO 580
560 HOLD=CONS2(JT-1)
580 CONS2(JT)=2.0*BLADN*SORT(ZMU)*CBARM*XJ*CIRFT(JT)*CHI1(JT,JV1)/(PI*
1ZJ1*VAVGI)+HOLD
C
```

FIGURE 16. (SHEET 35 OF 57)

```

C      BRANCH TO COMPUTE MORE THAN 1 JT TERM
C
C      THICKNESS EFFECT ON SRO
C
    600 SBO(JV1)=EINT(JV1)+CONS2(JT)-2.0*THM(JV1)+RCB(JV1)
    1000 CONTINUE
    1005 SCONS2(JV1)=CONS2(7)
    1010 IF (JV1-7)2500,1100,1100
    1020 CONS2(JV1)=0.0
    1021 SCONS2(JV1)=0.0
        SBO(JV1)=EINT(JV1)-2.0*THM(JV1)+RCB(JV1)
        GO TO 1010
C
C      START OF MATRIX MANIPULATION  END OF J LOOP
C
    1100 DO 1150 IT=1,JV1
    1150 SRO1(IT)=SRO(IT)
        TTRIG=0.0
        DO 1300 IT=1,7
        TTRIG=0.0
        TEMPT=0.0
        DO 1280 KT=1,JV1
        XMATM=0.0
        IF (TEMPT-1.0)1160,1170,1170
    1160 TEMPT=1.0
        NST=3
        GO TO 1180
    1170 TEMPT=0.0
        NST=2
    1180 DO 1220 LT=NST,JV1,2
    1220 XMATM=P(KT,LT)*SRO1(LT)+XMATM
        SRO2(KT)=SBO(KT)+XMATM+SRO1(1)*P(KT,1)
        IF (ABS(SRO2(KT)-SRO1(KT))-0.0005)1280,1280,1230
    1230 TTRIG=1.0
    1280 CONTINUE
        DO 1285 LT=1,JV1
    1285 SBO1(LT)=SRO2(LT)
    1300 CONTINUE
C
C      VELOCITY DISTRIBUTION CALCULATION
C
    2000 THONST=AMBDA/(4.0*PI)
        TVOVC=0.0
        VCNVG=0.0
        DO 2400 IT=1,10
        SUM=0.0
        TVOVC=0.0
        DO 2100 JT=1,JV1
        TVOVC=0.0
        SUM=SUM+SBO1(JT)*VELC(IT,JT)
        IF (JT-2)2010,2020,2020
    2010 SUM1(1)=SUM
        GO TO 2100
    2020 IF (ABS((SUM-SUM1(1))/SUM)-0.030)2050,2050,2040
    2040 TVOVC=1.0
    2050 SUM1(1)=SUM
    2100 CONTINUE
        IF (TVOVC)2120,2120,2110
    2110 VCNVG=1.0

```

FIGURE 16. (SHEET 36 OF 57)

```
2120 TVOV1(IT)=THONST*SUM/((X(IT)*ZMU)**1.5)
      TVOVS(IT,2)=TVOV1(IT)+TVOV2(IT)+VACB(IT)
      TOTAL(IT)=TVOVS(IT,2)+1.0
2400 CONTINUE
2500 CONTINUE
2555 JV1=7
C
C      TRANSFER VECTOR IOFF=0 ASSUME ANOTHER V/VO AND GO BACK FOR NEW CL3
C      IOFF=1 GO TO COMPUTE SHROUD PARAMETERS AND
C      COMPLETE STRIP ANALYSIS
C      IOFF=2 SOME PROBLEM ENCOUNTERED-MESSAGE PRINTED
C      OUT,GOES TO NEXT CASE
C
2600 IF (SHROD-5.0)2610,2610,2800
2610 DO 2700 IT=1,10
2620 TOL=0.0025
2680 IF (ABS(VOV(IT,JV)-1.0-TVOVS(IT,2))-TOL)2700,2700,2740
2700 CONTINUE
      LOUNT=0
      JOUNT=0
      GO TO 2800
2740 JOUNT=JOUNT+1
      IOFF=0
      IF (JOUNT-3)2760,2745,2745
2745 IF (JOUNT-10)2780,2780,2750
2750 WRITE (6,2755)
2755 FORMAT(48HOUTROUBLE IN ESTABLISHING CIRCULATION CONVERGENCE)
      GO TO 2900
2760 DO 2770 IT=1,10
      DELVOV(IT,JOUNT)=VOV(IT,JV)-1.0-TVOVS(IT,2)
      VOV(IT,JV)=(1.0+TVOVS(IT,2)-VOV(IT,JV))*0.85+VOV(IT,JV)
2770 AVOV(IT,JOUNT)=VOV(IT,JV)
      IF (SHROD-5.0)2999,230,2999
2780 DO 2790 IT=1,10
      DELVOV(IT,JOUNT)=VOV(IT,JV)-1.0-TVOVS(IT,2)
      VOV(IT,JV)=AVOV(IT,JOUNT-2)+(AVOV(IT,JOUNT-1)-AVOV(IT,JOUNT-2))*
      1 DELVOV(IT,JOUNT-1)/(DELVOV(IT,JOUNT-1)-DELVOV(IT,JOUNT))
2790 AVOV(IT,JOUNT)=VOV(IT,JV)
      IF (SHROD-5.0)2999,230,2999
2800 IOFF=1
      GO TO 2999
2810 DO 2820 IT=1,10
      IF (SHROD-5.0)2814,2812,2812
2812 VPOV(IT)=0.0
      GO TO 2816
2814 VPOV(IT)=SIN(BETA(IT)*RADCV)*COS(PHI(IT)*RADCV)*VOV(IT,JV)/SIN(PHI
      10(IT)*RADCV)
2816 TOTAL(IT)=TVOVS(IT,2)+1.0
      IF (SHROD-5.0)2813,2818,2817
2817 UOUI(IT)=0.0
      GO TO 2820
2818 UOUI(IT)=BLADN*C(IT)/(4.0*ZJ1)
      SWANG(IT)=DEGCV*ATAN(2.0*ZJ1*BLADN*C(IT)/(PI*(BLADN*C(IT)+4.0*ZJ1*
      1 TOTAL(IT))))
2820 CONTINUE
      VAVG1=0.0
      VAVG11=0.0
      VAVG21=0.0
      VAVG31=0.0
      DO 5000 IT=1,10
```

FIGURE 16. (SHEET 37 OF 57)

```

      PHOLD=TVOV1(IT)+TVOV2(IT)+VACB(IT)
      VAVG1=VAVG1+2.0*X(IT)*(PHOLD+UOUIIN(IT))*GIR(IT)
      VAVG21=VAVG21+2.0*X(IT)*PHOLD*GIR(IT)
      VAVG11=VAVG11+2.0*X(IT)*UOUIIN(IT)*GIR(IT)
5000 CONTINUE
      VAVG1=VAVG1/(1.0+SC0)
      VAVG21=VAVG21/(1.0+SC0)
      VAVG11=VAVG11*(1.0-SC0)
      DO 5010 IT=1,10
      VAVG31=VAVG31+X(IT)*(UOUIIN(IT)-VAVG11)**2*GIR(IT)
5010 CONTINUE
      VAVG31=VAVG31*(1.0-SC0)
      RJORO=SQRT((1.0-SC0**2)*(1.0+VAVG1)/(2.0*VAVG11+1.0))
      VBARI=1.0+VAVG1
      VJET=2.0*VAVG11+1.0
C
C      SHROUD PRESSURE COEFFICIENT COMPUTATION
C
      ZIP=0.0
      DO 6100 IT=1,NSS
      THOLD=-2.0*(TX(IT)-.500)
      IF(THOLD)5399,5398,5399
5398 XPT=1.5707963
      GO TO 5410
5399 XPT=ATAN(SQRT(1.0-THOLD**2)/ABS(THOLD))
      IF(THOLD)5400,5410,5410
5400 XPT=3.14159265-XPT
C
C      COMPUTES SHROUD VORTICITY(DISC) AND PHI MATRIX
C
5410 PM(1)=.5
      CT(IT)=-SRO1(1)*COS(XPT/2.0)/(4.0*SIN(XPT/2.0))
      DO 5420 IIT=2,JV1
      XJVI=IIT-1
      PM(IIT)=-.5*COS(XJVI*XPT)
5420 CT(IIT)=CT(IT)-SRO1(IIT)*SIN(XJVI*XPT)/4.0
C
C      COMPUTES SHROUD VORTICITY(CONT) AND SHROUD THICKNESS 3-D
C
      SVSH(IT)=0.0
      DO 5440 IIT=1,JV1
      SV=0.0
      DO 5430 IJT=1,JV1
5430 SV=S(IIT,IJT)*SB01(IJT)/2.0+TT(IIT,IJT)*SA(IJT)+SV
      SVSH(IT)=SVSH(IT)+.5*PM(IIT)*SV
5440 CONTINUE
C
C      PROP WAKE CONTRIBUTION
C
      DXX=.0125*ZMU
      XX=0.0
      PWKE(IT)=0.0
      IF (SHROD-5.)5445,5445,5482
5445 TRIGD=0.0
      DO 5480 IIT=2,80
      XX=XX+DXX
      ARG1=((XPR+AMBDA*COS(XPT))**2+1.0+XX**2)/(2.0*XX)
      CALL LEGEND (ARG1,FPOS,FNEG,DPOS,DDNEG)
      DNEG(IIT)=DDNEG
      IF (TRIGD-0.0)5460,5460,5460

```

FIGURE 16. (SHEET 38 OF 57)

```

5450 SIMP=4.0
      TRIGD=1.0
      GO TO 5470
5460 SIMP=2.0
      TRIGD=0.0
5470 PWKE(IT)=PWKE(IT)+CRAR(IIT)*DNEG(IIT)/SORT(XX)*SIMP
5480 CONTINUE
      PWKE(IT)=RLADN*(XPR+AMBDA*COS(XPT))*PWKE(IT)*CBARM/(480.0*PI*ZJI)
      1*ZMU=-.5
C
C   INCLUDE SHROUD THICKNESS 2-D-OPTION ALSO*****
C
5482 IF (ZIP1)5800,5485,5800
5485 IF (ZIP)5496,5496,5498
5496 IF (TABLE2(2)-998.0)5700,5497,5700
5497 ZIP=1.0
5498 SX(IT)=2.0*AMBDA*(TX(IT)-.500)
      DXA(1)=-2.0*AMBDA
      DXA(2)=-4.0*SX(IT)*AMBDA
      DXA(3)=-6.0*SX(IT)**2*AMBDA-2.0*AMBDA**3
      DXA(4)=-8.0*SX(IT)**3*AMBDA-8.0*SX(IT)*AMBDA**3
      DXA(5)=-10.0*SX(IT)**4*AMBDA-20.0*SX(IT)**2*AMBDA**3-2.0*AMBDA**5
      DXA(6)=-12.0*SX(IT)**5*AMBDA-40.0*SX(IT)**3*AMBDA**3-12.0*SX(IT)*
      1 AMBDA**5
      TSU=0.0
      DO 5500 NTH=2,7
      TSUM=0.0
      NNTH=NTH-1
      DO 5490 MTH=1,NNTH
      XMTH=MTH
      MTH1=NNTH-MTH
5490 TSUM=TSUM+SX(IT)**MTH1*DGR(NNTH,MTH+1)*(-1.0)**MTH*DXA(MTH)/XMTH
      TSU=SA(NTH+1)*(SX(IT)**(NNTH)*ALOG(ARS((SX(IT)-AMBDA)/(SX(IT)+
      1 AMBDA)))+TSUM)+TSU
5500 CONTINUE
      TONE=SORT(2.0*AMBDA)
      TTWO=SORT(AMBDA+SX(IT))
      FTHRM(IT)=ALOG(ARS((TONE-TTWO)/(TONE+TTWO)))*SA(1)/(PI*TTWO)+(SA(2)
      1)/PI)*ALOG(ARS((SX(IT)-AMBDA)/(SX(IT)+AMBDA)))+TSU/PI
      FTHRM(IT)=-.5*FTHRM(IT)
5600 CONTINUE
      GO TO 5800
5700 CALL UNBAR (TABLE2(1),1,TX(IT),1.0,FTHRM(IT),LIMIT)
C
C   INCLUDE CENTERBODY EFFECT *****
C
5800 THOLD=FTHRM(IT)+SVSH(IT)+PWKE(IT)+TTHERM(IT)
      TCPU(IT)=-2.0*(THOLD+CT(IT))
      TCPL(IT)=-2.0*(THOLD-CT(IT))
C
C   CONVERSION OF THERM PRESS. COEFF. TO ACTUAL PRESS. COEFF.
C
      DZDX=0.0
      IF (TX(IT)-RFL)5810,5810,5860
5810 DO 5850 IPCC=2,8
      DZDX=DZDX+SA(IPCC)*SX(IT)**(IPCC-2)
5850 CONTINUE
      DZDX=(DZDX+SA(1)/SORT(SX(IT)+AMBDA))/(4.0*AMBDA)
5860 VRATU(IT)=(1.0-.5*TCPU(IT))/SORT(1.0+DZDX**2)
      VRATL(IT)=(1.0-.5*TCPL(IT))/SORT(1.0+DZDX**2)

```

FIGURE 16. (SHEET 39 OF 57)

```
PCU(IT)=1.0-VRATU(IT)**2
PCL(IT)=1.0-VRATL(IT)**2
STHERM(IT)=-2.0*TTHERM(IT)
6100 CONTINUE
C
C   SHROUD DRAG COMPUTATION
C
  IF (SHROD-5.)7100,7100,7110
7100 CRD=D*AMBDA/ZMU
  CTOTN=.25*PI*ZJI**2*VBARI*((1.0-SCO**2)*(SQRT(1.0+8.0*CTAC(1)/(PI*
  1ZJI**2*(1.0-SCO**2)))-1.0)
  SDRAG1=.0015799*PI*DSHRD*CRD**0.8*ZJI**2/(D**2*ZMS**0.2)*((1.0+A4A2
  X**1.8*(1.0+8.0*D**2*CTAC(1)/(PI*(1.0-SCO**2)*ZJI**2*DSHRD**2)))
  CTNET=CTOTN-SDRAG1
  CTS1=CTNET-CTAC(1)
  GO TO 7120
7110 CRD=AMBDA*SHRDNO
  SDRAG1=.003165*(1.0+A4A2**1.8)/(ZMS*CRD)**0.2
7120 VRATL=SB011)*AMBDA*SQRT(2.0*AMBDA)/SA(1)
  PCLE=1.0-VRATL**2
  ZIP1=1.0
  WRITE (6,7350)
7350 FORMAT (1H1)
  IF (SHROD-5.)7400,7410,7430
7400 WRITE (6,7490)ZJI,THET34(IC),ZMS,CPA
7490 FORMAT (20H0*** PERFORMANCE ***//11H0 CONDITION,7X,2HJ=F7.4,11H THE
  XTA 3/4=F6.3,4H MN=F6.4,4H CP=F7.4 )
  GO TO 7450
7410 WRITE (6,7420)ZJI,ZMS
7420 FORMAT (21H0 *** PERFORMANCE ***//11H0 CONDITION,7X,2HJ=F7.4,4H MN=
  XF6.4 )
  GO TO 7450
7430 WRITE (6,7440)ZMS
7440 FORMAT (21H0 *** PERFORMANCE ***//11H0 CONDITION,7X,4H MN=F6.4 )
7450 CONTINUE
  IF (SHROD-5.)7500,7500,7520
7500 WRITE (6,7540)CTNET,CTS1,SDRAG1,CTAC(1)
7540 FORMAT (43H0 NET THRUST COEFF.(SHROUD + PROPELLER) =F8.4 /
  115X,28H SHROUD THRUST COEFFICIENT =F8.4 /8X,35H SHROUD FRICTION DR
  2AG COEFFICIENT =F8.4 /12X,31H PROPELLER THRUST COEFFICIENT =F8.4 )
  GO TO 7550
7520 WRITE (6,7530)SDRAG1
7530 FORMAT (11H0,7X,35H SHROUD FRICTION DRAG COEFFICIENT =F8.4 )
7550 WRITE (6,5035)RJORO,VBARI
5035 FORMAT (25H0 SLIPSTREAM CONTRACTION=F6.2 /46H0 RATIO OF AVERAGE DU
  XCT VEL./FREE STREAM VEL.=F8.4 )
  IF (SHROD-5.)5036,5036,5038
5036 WRITE (6,5037)VJET
5037 FORMAT (52H0 RATIO OF AVERAGE SLIPSTREAM VEL./FREE STREAM VEL.=F8.
  14 )
5038 WRITE (6,2830)(X(IT),IT=1,10),(VAGR(IT),IT=1,10),(TVOV2(IT),IT=1,1
  10),(TVOV1(IT),IT=1,10),(TOTAL(IT),IT=1,10)
2830 FORMAT (//36H0 **** INDUCED VELOCITY CONTENT **** //18H0PROP. X
  1 =10F8.4/18H CENTERBODY DV/V0=10F8.4/18H SHROUD T/C DV/V0=10F
  28.4/18H VORTICITY DV/V0=10F8.4/18H TOTAL V/V0=10F8.4 )
  IF (SHROD-5.0)2832,2836,2836
2832 WRITE (6,2834)(VOV(IT,1),IT=1,10),(VPOV(IT),IT=1,10),(UOUIN(IT),IT
  1=1,10),(SWANG(IT),IT=1,10)
2834 FORMAT (18H ASSUMED V/V0=10F8.4/18H PROP.IND.G. VP/V=10F8.4/
  118H PROP.IND.M. VP/V=10F8.4/18H SWIRL ANGLE =10F8.4 )
```

FIGURE 16. (SHEET 40 OF 57)

```

2836 IF (TRIG2)2802,5900,2802
2802 WRITE (6,2520)
      DO 2804 JT=1,7
      IT=JT-1
      WRITE (6,2530)IT,EINT(JT),THM(JT),SCONS2(JT),BCB(JT),SBO(JT),SBO1(
      XJT)
2804 CONTINUE
2530 FORMAT (1H 16,6F8.4)
2520 FORMAT (//40H0 **** GLAUERT COEFFICIENTS CONTENT **** //)
      X46H          SHROUD SHROUD PROP.  CENTER TOTAL /53H  NU  CAM
      XBER  T/C  CIRC.  -BODY  2-D  3-D )
5900 WRITE (6,5905)VRATLE,PCLE
5905 FORMAT (//63H0 **** SHROUD SURFACE VELOCITIES AND PRESSURE COEFFIC
      XIENTS **** //16X,41H ----- VFLOCITY COMPONENTS ----- /
      X36X,11H3-D THICK.+.27X,31HOUTER SURFACE  INNER SURFACE /106H S
      XHROUD X  VORT.DIS.  2-D THICK. VORT.CONT.  PROP WAKE  CB EFF
      X.  V/VINF  CPRESS  V/VINF  CPRESS /6X,2H.0,82X,2F9.4 )
      WRITE (6,6000)(TX(IT),CT(IT),FTHRM(IT),SVSH(IT),PWKF(IT),TTHFRM(IT
      X),VRATU(IT),PCU(IT),VRATL(IT),PCL(IT),IT=1,NS)
6000 FORMAT (6F12.5,4F9.4)
5300 IOFF=0
      GO TO 2999
2900 IOFF=2
      LOUNT=0
      JOUNT=0
2999 RETURN
      END

```

FIGURE 16. (SHEET 41 OF 57)

C DATUM
BLOCK DATA
COMMON/DAT/DATA
DIMENSION DATA(2980)
DATA (DATA (I) , I = 1 ,126)/
X .02683,.05366,.00608,-.00005,-.00001,.0,.0
X,.07281,.14561,.02491,-.00016,-.00013,.0,.0
X,.11925,.23849,.05488,.00071,-.00042,-.00005,.0
X,.16016,.32032,.09186,.00402,-.00072,-.00025,-.00003
X,.0,.02987,.0,-.00101,.0,.0,.0
X,.0,.08526,.0,-.00417,.0,.00002,.0
X,.0,.14668,.0,-.00922,.0,.00005,.0
X,.0,.20609,.0,-.01544,.0,.00008,.0
X,.01343,.0,.00403,.0,-.00049,.0,.0
X,.03644,.0,.01655,.0,-.00206,.0,.00001
X,.05945,.0,.03702,.0,-.00482,.0,.00002
X,.07907,.0,.06338,.0,-.00883,.0,.00006
X,.0,-.00304,.0,.00148,.0,-.00029,.0
X,.0,-.01252,.0,.00609,.0,-.00120,.0
X,.0,-.02765,.0,.01418,.0,-.00278,.0
X,.0,-.04629,.0,.02592,.0,-.00512,.0
X,-.00001,.0,-.00099,.0,.00079,.0,-.00020
X,-.00004,.0,-.00411,.0,.00318,.0,-.00078
X/
DATA (DATA (I) , I = 127 ,260)/
X .00019,.0,-.00965,.0,.00732,.0,-.00181
X,.00107,.0,-.01766,.0,.01338,.0,-.00330
X,.0,.0,.0,-.00049,.0,.00049,.0
X,.0,.00006,.0,-.00200,.0,.00197,.0
X,.0,.00021,.0,-.00463,.0,.00450,.0
X,.0,.00035,.0,-.00855,.0,.00814,.0
X,.0,.0,.0,-.00029,.0,.00034
X,.0,.0,.00002,.0,-.00119,.0,.00134
X,-.00001,.0,.00007,.0,-.00272,.0,.00306
X,-.00006,.0,.00020,.0,-.00495,.0,.00550
X,.70643,-.15269,.01671,-.00413,.00178,-.00091,.00052,-.00033
X,.76981,-.21965,.02518,-.00520,.00250,-.00129,.00074,-.00047
X,.77835,-.26932,.02891,-.00543,.00323,-.00157,.00082,-.00057
X,.76809,-.30655,.02752,-.00559,.00426,-.00177,.00101,-.00066
X,.24991,.0,.02721,.0,.00264,.0,.00076,.0
X,.38538,.0,.05573,.0,.00521,.0,.00151,.0
X,.47698,.0,.08349,.0,.00774,.0,.00222,.0
X,.54241,.0,.10848,.0,.01041,.0,.00300,.0
X/
DATA (DATA (I) , I = 261 ,404)/
X .0,.01351,.0,-.00267,.0,-.00038,.0,-.00013
X,.0,.05507,.0,-.01090,.0,-.00150,.0,-.00051
X,.0,.12435,.0,-.02519,.0,-.00334,.0,-.00114
X,.0,.21832,.0,-.04583,.0,-.00587,.0,-.00202
X,.00520,.0,-.00032,.0,.00031,.0,.00006,.0
X,.03203,.0,-.00256,.0,.00248,.0,.00047,.0
X,.08932,.0,-.00911,.0,.00845,.0,.00154,.0
X,.18136,.0,-.02359,.0,.02040,.0,.00364,.0
X,.0,.00051,.0,-.00002,.0,-.00004,.0,-.00001
X,.0,.00824,.0,-.00041,.0,-.00063,.0,-.00015
X,.0,.04182,.0,-.00226,.0,-.00320,.0,-.00075
X,.0,.13037,.0,-.00749,.0,-.01016,.0,-.00237
X,.00019,.0,-.00003,.0,.00001,.0,.00001,.0
X,.00480,.0,-.00085,.0,.00027,.0,.00018,.0
X,.03013,.0,-.00664,.0,.00210,.0,.00133,.0

FIGURE 16. (SHEET 42 OF 57)

```

X..10893..0..-.02938..0..00908..0..00560..0
X..0..00002..0..0..0..0..0..0
X..0..00147..0..00005..0..-.00011..0..-.00005
X/
  DATA (DATA      (1) , I = 405      .519      )/
X .0..01677..0..00048..0..-.00122..0..-.00059
X..0..09287..0..00256..0..-.00687..0..-.00332
X..00001..0..0..0..0..0..0..0
X..00086..0..-.00020..0..00002..0..00004..0
X..01210..0..-.00346..0..00042..0..00064..0
X..07785..0..-.02699..0..00334..0..00478..0
X..1..99922903..99691733..99306845..98768834..98078528
X..97236992..96245523..95105651..93819134..92387953..90814318
X..89100652..87249601..85264017..83146962..80901700..78531694
X..76040597..73432252..70710679..67880076..64944806..61909396
X..58778526..55557025..52249866..48862126..45399052..41865977
X..38268347..34611711..30901705..27144051..23344544..19509040
X..15643456..11753750..07845920..03925993..0..-.03925978
X..-.07845905..-.11753734..-.15643440..-.19509025..-.23344528
X..-.27144036..-.30901690..-.34611696..-.38268333..-.41865963
X..-.45399038..-.48862112..-.52249852..-.55557019..-.58778520
X..-.61909389..-.64944799..-.67880068..-.70710671..-.73432244
X..-.76040589..-.78531686..-.80901692..-.83146954..-.85264009
X/
  DATA (DATA      (1) , I = 520      .614      )/
X -.87249598..-.89100649..-.90814314..-.92387950..-.93819130
X..-.95105648..-.96245521..-.97236989..-.98078525..-.98768832
X..-.99306844..-.99691732..-.99922903..-1.
X..1..99691733..98768834..97236992..95105651..92387953
X..89100652..85264017..80901700..76040597..70710679..64944806
X..58778526..52249866..45399052..38268347..30901705..23344544
X..15643456..07845920..0..-.07845905..-.15643440..-.23344528
X..-.30901690..-.38268333..-.45399038..-.52249852..-.58778520
X..-.64944799..-.70710671..-.76040589..-.80901692..-.85264009
X..-.89100640..-.92387950..-.95105648..-.97236989..-.98768832
X..-.99691732..-1..-.99691734..-.98768835..-.97236994..-.95105655
X..-.92387958..-.89100659..-.85264020..-.80901704..-.76040603
X..-.70710686..-.64944815..-.58778537..-.52249870..-.45399057
X..-.38268352..-.30901710..-.23344549..-.15643461..-.07845925
X..0..07845899..15643435..23344523..30901685..38268328
X..45399033..52249848..58778516..64944795..70710667..76040586
X..80901680..85264006..89100647..92387948..95105647..97236988
X..98768831..99691731..1.
X/
  DATA (DATA      (1) , I = 615      .712      )/
X 1.0..99306845..97236992..93819134..89100652..83146962
X..76040597..67880076..58778526..48862126..38268347..27144051
X..15643456..03925993..-.07845905..-.19509025..-.30901690
X..-.41865963..-.52249852..-.61909389..-.70710671..-.78531686
X..-.85264009..-.90814314..-.95105648..-.98078525..-.99691732
X..-.99922903..-.98768835..-.96245526..-.92387958..-.87249608
X..-.80901704..-.73432258..-.64944815..-.55557036..-.45399057
X..-.34611715..-.23344549..-.11753755..0..11753729..23344523
X..34611691..45399033..55557014..64944795..73432240..80901689
X..87249595..92387948..96245519..98768831..99922902..99691734
X..98078531..95105657..90814325..85264023..78531702..70710690
X..61909410..52249875..41865986..30901715..19509051..07845931
X..-.03925967..-.15643430..-.27144026..-.38268323..-.48862103
X..-.58778512..-.67880060..-.76040582..-.83146943..-.89100645
X..-.93819127..-.97236987..-.99306843..-1.

```

FIGURE 16. (SHEET 43 OF 57)

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X.1...98768834..95105652..89100653..80901701..70710681
X..58778529..45399061..30901705..15643456..0..15643430
X..30901690..45399038..58778512..70710664..80901692
X/
DATA (DATA      (I) , I = 713      .811      )/
X -.89100645..95105645..98768830..-1..98768837
X..95105658..89100663..80901710..70710693..58778545
X..45399075..30901720..15643471..0..15643415..30901675
X..45399025..58778500..70710653..80901683..89100638..95105641
X..98768828..1..98768839..95105663..89100670..80901719
X..70710704..58778557..45399089..30901734..15643486..0
X..15643400..30901661..45399011..58778487..70710642
X..80901674..89100631..95105636..98768825..-1..98768841
X..95105667..89100677..80901728..70710757..58778586
X..45399173..30901796..15643511..0..15643355..30901646
X..45398944..58778459..70710575..80901635..89100619..95105609
X..98768818..1.
X.1.0..98078528..92387953..83146962..70710679..55557025
X..38268347..19509040..0..19509025..38268333..55557019
X..70710671..83146954..92387950..98078525..-1..98078529
X..92387958..83146965..70710686..55557036..38268352
X..19509045..0..19509020..38268328..55557014..70710667
X..83146950..92387948..98078524..1..98078531..92387960
X/
DATA (DATA      (I) , I = 812      .913      )/
X .83146968..70710690..55557041..38268357..19509051..0
X..19509015..38268323..55557010..70710664..83146948
X..92387946..98078523..-1..98078532..92387962..83146993
X..70710757..55557078..38268362..19509105..0..19508950
X..38268308..55556947..70710646..83146906..92387932..98078507
X.1...98078550..92387980..83146974..70710733..55557050
X..38268422..19509071..0..19508984..38268248..55556976
X..70710600..83146925..92387907..98078513..-1.
X.1.0..97236992..89100653..76040599..58778529..38268356
X..15643456..07845895..30901690..52249844..70710664
X..85264009..95105645..99691731..98768837..92387962
X..80901710..64944822..45399075..23344558..0..23344504
X..45399025..64944779..80901683..92387940..98768828..99691736
X..95105663..85264038..70710704..52249892..30901734..07845951
X..15643400..38268304..58778487..76040563..89100631
X..97236980..-1..97237004..89100677..76040681..58778586
X..38268454..15643511..07845799..30901646..52249770
X..70710575..85263969..95105609..99691727..98768853..92387980
X/
END

```

FIGURE 16. (SHEET 44 OF 57)

C DATAM
 BLOCK DATA
 COMMON/DAT/ DATA
 DIMENSION DATA(2980)
 DATA (DATA (I) , I = 914 ,1009) /
X .80901766,.64944926,.45399143,.23344681,0,.-.23344401
X,.-.45398975,.-.64944706,.-.80901656,.-.92387907,.-.98768808
X,.-.99691741,.-.95105699,.-.85264067,.-.70710779,.-.52249931
X,.-.30901825,.-.07846086,.15643325,.38268188,.58778434
X,.76040494,.89100605,.97236957,1.0
X,1.0,.96245523,.85264017,.67880076,.45399052,.19509040
X,.-.07845905,.-.34611696,.-.58778520,.-.78531686,.-.92387950
X,.-.99306844,.-.98768835,.-.90814323,.-.76040603,.-.55557036
X,.-.30901710,.-.03925998,.23344523,.48862107,.70710667,.87249590
X,.97236988,.99922904,.95105657,.83146974,.64944819,.41865996
X,.15643466,.-.11753714,.-.38268323,.-.61909373,.-.80901686
X,.-.93819123,.-.99691731,.-.98078534,.-.89100664,.-.73432333
X,.-.52249905,.-.27144134,0,.-.27143982,.52249770,.73432226
X,.89100619,.98078507,.99691736,.93819161,.80901766,.61909434
X,.38268422,.11753860,.-.15643389,.-.41865889,.-.64944706
X,.-.83146925,.-.95105620,.-.99922898,.-.97237008,.-.87249653
X,.-.70710708,.-.48862192,.-.23344647,.03925931,.30901617
X,.55556922,.76040559,.90814278,.98768813,.99306853,.92387991
X/
 DATA (DATA (I) , I = 1010 ,1112) /
X .78531777,.58778583,.34611806,.07846052,.-.19508954
X,.-.45398947,.-.67879964,.-.85263971,.-.96245490,.-1.0
X,0,.-.03925981,.07845909,.11753739,.15643446,.19509031
X,.23344535,.27144044,.30901698,.34611704,.38268342,.41865972
X,.45399049,.48862122,.52249855,.55557022,.58778524,.61909393
X,.64944803,.67880073,.70710677,.73432249,.76040595,.78531692
X,.80901698,.83146959,.85264010,.87249599,.89100651,.90814315
X,.92387951,.93819131,.95105649,.96245521,.97236990,.98078526
X,.98768832,.99306844,.99691732,.99922903,1.0,.99922903
X,.99691733,.99306846,.98768835,.98078529,.97236993,.96245525
X,.95105654,.93819137,.92387957,.90814322,.89100658,.87249607
X,.85264018,.83146964,.80901702,.78531697,.76040601,.73432256
X,.70710684,.67880081,.64944813,.61909404,.58778535,.55557034
X,.52249868,.48862128,.45399055,.41865979,.38268349,.34611713
X,.30901708,.27144054,.23344546,.19509043,.15643458,.11753752
X,.07845923,.03925996,0.
X,0,.-.07845909,.15643446,.23344535,.30901698,.38268342
X,.45399049,.52249855,.58778524,.64944803,.70710677,.76040595
X/
 DATA (DATA (I) , I = 1113 ,1210) /
X .80901698,.85264010,.89100651,.92387951,.95105649,.97236990
X,.98768832,.99691732,1.0,.99691733,.98768835,.97236993
X,.95105654,.92387957,.89100658,.85264018,.80901702,.76040601
X,.70710684,.64944813,.58778535,.52249868,.45399055,.38268349
X,.30901708,.23344546,.15643458,.07845923,0,.-.07845902
X,.-.15643438,.-.23344526,.-.30901688,.-.38268330,.-.45399036
X,.-.52249850,.-.58778518,.-.64944797,.-.70710669,.-.76040588
X,.-.80901690,.-.85264007,.-.89100648,.-.92387949,.-.95105648
X,.-.97236989,.-.98768831,.-.99691732,.-1.0,.-.99691734,.-.98768835
X,.-.97236995,.-.95105656,.-.92387959,.-.89100660,.-.85264021
X,.-.80901706,.-.76040604,.-.70710688,.-.64944817,.-.58778539
X,.-.52249872,.-.45399059,.-.38268354,.-.30901712,.-.23344551
X,.-.15643463,.-.07845928,0.
X,0,.-.11753739,.23344535,.34611704,.45399049,.55557022
X,.64944803,.73432249,.80901698,.87249599,.92387951,.96245521

FIGURE 16. (SHEET 45 OF 57)

```

X..98768832..99922903..99691733..98078529..95105654..90814322
X..85264018..78531697..70710684..61909404..52249868..41865979
X..30901708..19509043..07845923..0392775..15643438
X/
DATA (DATA      (I) , I = 1211 ,1308 )/
X -.27144034, -.38268330, -.48862110, -.58778518, -.67880066
X -.76040588, -.83146952, -.89100648, -.93819130, -.97236939
X -.99306844, -1.0, -.99306847, -.97236995, -.93819139, -.89100660
X -.83146967, -.76040604, -.67880085, -.58778539, -.48862133
X -.38268354, -.27144059, -.15643463, -.03926001, .07845897
X .19509017, .30901682, .41865955, .52249846, .61909383, .70710666
X .78531681, .85264005, .90814311, .95105646, .98078524, .99691731
X .99922904, .98768836, .96245528, .92387961, .87249612, .80901709
X .73432264, .64944821, .55557043, .45399064, .34611723, .23344557
X .11753763, 0.
X 0...15643445, .30901697, .45399047, .58778522, .70710675
X .80901696, .89100646, .95105649, .98768832, 1.0, .98768836
X .95105654, .89100658, .80901708, .70710691, .58778535, .45399064
X .30901717, .15643468, 0, -.15643428, -.30901678, -.45399027
X -.58778510, -.70710662, -.80901684, -.89100639, -.95105645
X -.98768830, -1.0, -.98768839, -.95105659, -.89100665, -.80901717
X -.70710702, -.58778547, -.45399077, -.30901731, -.15643483
X 0...15643412, .30901663, .45399013, .58778497, .70710651
X/
DATA (DATA      (I) , I = 1309 ,1408 )/
X .80901675, .89100632, .95105640, .98768827, 1.0, .98768841
X .95105664, .89100672, .80901726, .70710713, .58778560, .45399091
X .30901746, .15643498, 0, -.15643397, -.30901649, -.45399000
X -.58778485, -.70710598, -.80901655, -.89100589, -.95105620
X -.98768823, -1.0, -.98768848, -.95105668, -.89100716, -.80901747
X -.70710780, -.58778612, -.45399113, -.30901827, -.15643543
X 0.
X 0...19509031, .38268342, .55557022, .70710677, .83146959
X .92387951, .98078526, 1.0, .98078529, .92387957, .83146964
X .70710684, .55557034, .38268349, .19509043, 0, -.19509023
X -.38268330, -.55557017, -.70710669, -.83146952, -.92387949
X -.98078525, -1.0, -.98078530, -.92387959, -.83146967, -.70710688
X -.55557038, -.38268354, -.19509048, 0, .19509017, .38268325
X .55557012, .70710666, .83146949, .92387947, .98078524, 1.0
X .98078531, .92387961, .83146970, .70710692, .55557043, .38268359
X .19509053, 0, -.19509012, -.38268320, -.55556974, -.70710598
X -.83146924, -.92387945, -.98078513, -1.0, -.98078544, -.92387967
X -.83147011, -.70710710, -.55557105, -.38268392, -.19509137, 0.
X/
DATA (DATA      (I) , I = 1409 ,1505 )/
X .19508918, .38268278, .55557003, .70710623, .83146943, .92387920
X .98078520, 1.0, .98078537, .92387992, .83146992, .70710756
X .55557077, .38268453, .19509103, 0.
X 0...23344534, .45399047, .64944802, .80901696, .92387947
X .98768832, .99691734, .95105654, .85264024, .70710691, .52249868
X .30901717, .07845933, -.15643428, -.38268321, -.58778510
X -.76040581, -.89100639, -.97236986, -1.0, -.97236999, -.89100665
X -.76040617, -.58778547, -.38268373, -.15643483, .07845877
X .30901663, .52249820, .70710651, .85263994, .95105640, .99691730
X .98768841, .92387969, .80901726, .64944844, .45399091, .23344586
X 0, -.23344486, -.45399000, -.64944705, -.80901655, -.92387907
X -.98768823, -.99691742, -.95105668, -.85264068, -.70710780
X -.52249933, -.30901827, -.07845989, .15643323, .38268278
X .58778432, .76040493, .89100605, .97236957, 1.0, .97237024
X .89100590, .76040580, .58778585, .38268453, .15643608, -.07845801

```

FIGURE 16. (SHEET 46 OF 57)

```

X,-.30901553,-.52249772,-.70710576,-.85263970,-.95105610
X,-.99691719,-.98768853,-.92388017,-.80901765,-.64944924
X,-.45399141,-.23344679.0.
X/
  DATA (DATA      (I) , I = 1506 ,1610 )/
X 0.,.27144044,.52249855,.73432249,.89100651,.98078526
X,.99691733,.93819137,.80901702,.61909404,.38268349,.11753752
X,-.15643438,-.41865960,-.64944797,-.83146952,-.95105648
X,-.99922903,-.97236995,-.87249609,-.70710688,-.48862141
X,-.23344551,.03925959,.30901682,.55557004,.76040584,.90814307
X,.98768831,.99306848,.92387961,.78531710,.58778543,.34611733
X,.07845934,-.19509002,-.45399027,-.67879985,-.85263986
X,-.96245498,-1.0,-.96245541,-.85264068,-.67880100,-.45399113
X,-.19509137,.07845866,.34611631,.58778432,.78531662,.92387920
X,.99306831,.98768843,.90814356,.76040680,.55557077,.30901794
X,.03926117,-.23344466,-.48862030,-.70710647,-.87249562
X,-.97236965,-.99922905,-.95105678,-.83147028,-.64944848
X,-.41866058,-.15643573,.11753675,.38268250,.61909288,.80901657
X,.93819096,.99691722,.98078543,.89100704,.73432353,.52249929
X,.27144162.0.
X.1.,.21.,.5.
X,.0.,.05.,.10.,.15.,.20.,.25.,.30.,.35.,.40.,.45.,.50.,.55.,.60.,.65.,.70
X,.75.,.80.,.85.,.90.,.95.,1.00
X/
  DATA (DATA      (I) , I = 1611 ,1659 )/
X .75.,.90.,.95.,.99.,.998
X,-.25560,-.39179,-.46299,-.55041
X,-.58074
X,-.25317,-.38341,-.44552,-.50412
X,-.51610
X,-.24639,-.36257,-.41050,-.44968
X,-.45719
X,-.23614,-.33623,-.37306,-.40135
X,-.40668
X,-.22356,-.30873,-.33766,-.35920
X,-.36322
X,-.20972,-.28215,-.30543,-.32248
X,-.32565
X,-.19543,-.25734,-.27652,-.29043
X,-.29301
X,-.18126,-.23461,-.25071,-.26236
X,-.26452
X,-.16758,-.21396,-.22773,-.23768
X/
  DATA (DATA      (I) , I = 1660 ,1704 )/
X -.23952
X,-.15462,-.19529,-.20725,-.21590
X,-.21750
X,-.14248,-.17845,-.18898,-.19661
X,-.19802
X,-.13121,-.16328,-.17264,-.17945
X,-.18072
X,-.12081,-.14960,-.15801,-.16415
X,-.16530
X,-.11126,-.13727,-.14488,-.15046
X,-.15151
X,-.10249,-.12612,-.13307,-.13818
X,-.13914
X,-.09447,-.11605,-.12241,-.12712
X,-.12802

```

FIGURE 16. (SHEET 47 OF 57)

X,-.08714,-.10693,-.11279,-.11715
X,-.11798
X,-.08044,-.09865,-.10408,-.10813
X/
END

FIGURE 16. (SHEET 48 OF 57)

C DATUM
 BLOCK DATA
 COMMON/DAT/DATA
 DIMENSION DATA(2980)
 DATA (DATA (I) , I = 1705 .1768)/
X -.10891
X -.07433, -.09114, -.09618, -.09996
X -.10069
X -.06874, -.08431, -.08900, -.09253
X -.09322
X -.06363, -.07809, -.08247, -.08578
X -.08643
X .2 .21 .5.
X .0 .05 .10 .15 .20 .25 .30 .35 .40 .45 .50 .55 .60 .65 .70
X .75 .80 .85 .90 .95 .1.00
X .75 .90 .95 .99 .998
X .08093 .14562 .18750 .24839
X .27298
X .07963 .13947 .17310 .20640
X .21302
X .07602 .12492 .14641 .16277
X .16555
X .07077 .10797 .12091 .12906
X/
 DATA (DATA (I) , I = 1769 .1813)/
X .13026
X .06464 .09194 .09956 .10346
X .10391
X .05831 .07800 .08238 .08400
X .08407
X .05219 .06632 .06874 .06913
X .06902
X .04654 .05671 .05795 .05740
X .05740
X .04147 .04885 .04939 .04881
X .04857
X .03700 .04243 .04256 .04185
X .04160
X .03308 .03716 .03707 .03633
X .03609
X .02968 .03282 .03262 .03191
X .03169
X .02673 .02921 .02898 .02832
X/
 DATA (DATA (I) , I = 1814 .1857)/
X .02812
X .02416 .02620 .02596 .02538
X .02520
X .02192 .02365 .02344 .02293
X .02278
X .01996 .02149 .02131 .02088
X .02075
X .01824 .01962 .01948 .01913
X .01902
X .01673 .01800 .01751 .01762
X .01753
X .01538 .01659 .01654 .01631
X .01623
X .01418 .01535 .01533 .01516
X .01510

FIGURE 16. (SHEET 49 OF 57)

```

X,.01311,.01424,.01426,.01413
X,.01409
X,3,.21,.5.
X/
  DATA (DATA      (I) , I = 1858 ,1922 )/
X ,.0,.05,.10,.15,.20,.25,.30,.35,.40,.45,.50,.55,.60,.65,.70
X,.75,.80,.85,.90,.95,1.00
X,.75,.90,.95,.99,.998
X,-.03917,-.07773,-.10654,-.15401
X,-.17542
X,-.03837,-.07305,-.09451,-.11589
X,-.11984
X,-.03619,-.06246,-.07381,-.08094
X,-.08177
X,-.03309,-.05100,-.05605,-.05748
X,-.05733
X,-.02962,-.04107,-.04279,-.04198
X,-.04151
X,-.02617,-.03318,-.03326,-.03166
X,-.03113
X,-.02299,-.02713,-.02647,-.02471
X,-.02422
X,-.02018,-.02254,-.02161,-.01995
X/
  DATA (DATA      (I) , I = 1923 ,1967 )/
X -.01952
X,-.01775,-.01906,-.01809,-.01662
X,-.01626
X,-.01569,-.01639,-.01548,-.01423
X,-.01392
X,-.01395,-.01431,-.01351,-.01246
X,-.01221
X,-.01247,-.01266,-.01198,-.01111
X,-.01091
X,-.01121,-.01133,-.01076,-.01005
X,-.00989
X,-.01013,-.01024,-.00977,-.00920
X,-.00906
X,-.00920,-.00933,-.00895,-.00848
X,-.00837
X,-.00840,-.00855,-.00825,-.00788
X,-.00778
X,-.00769,-.00788,-.00765,-.00735
X/
  DATA (DATA      (I) , I = 1968 ,2031 )/
X -.00727
X,-.00707,-.00729,-.00712,-.00688
X,-.00681
X,-.00652,-.00678,-.00664,-.00646
X,-.00640
X,-.00602,-.00631,-.00622,-.00607
X,-.00602
X,-.00558,-.00589,-.00583,-.00572
X,-.00568
X,4,.21,.5.
X,.0,.05,.10,.15,.20,.25,.30,.35,.40,.45,.50,.55,.60,.65,.70
X,.75,.80,.85,.90,.95,1.0
X,.75,.90,.95,.99,.998
X,.02296,.04866,.07000,.10893
X,.12817

```

FIGURE 16. (SHEET 50 OF 57)

X..02242..04499..05980..07423
X..07658
X..02098..03701..04347..04614
X/
DATA (DATA (1) , 1 = 2032 ,2076)/
X .04603
X,.01897,.02892,.03078,.02973
X..02910
X..01678..02241..02225..02025
X..01958
X..01467..01760..01669..01468
X..01411
X..01277..01415..01306..01132
X..01087
X..01114..01167..01064..00921
X..00886
X..00976..00988..00898..00783
X..00757
X..00861..00853..00779..00689
X..00667
X..00765..00751..00690..00619
X..00602
X..00684..00670..00621..00565
X/
DATA (DATA (1) , 1 = 2077 ,2121)/
X .00552
X..00616..00604..00565..00521
X..00511
X..00557..00550..00519..00484
X..00476
X..00507..00504..00480..00452
X..00446
X..00463..00464..00445..00423
X..00419
X..00425..00430..00415..00398
X..00394
X..00391..00399..00388..00374
X..00372
X..00361..00372..00364..00353
X..00351
X..00334..00347..00341..00333
X..00331
X..00310..00325..00321..00315
X/
DATA (DATA (1) , 1 = 2122 ,2185)/
X .00312
X.5..21..5.
X..0..05..10..15..20..25..30..35..40..45..50..55..60..65..70
X..75..80..85..90..95..1.0
X..75..90..95..99..998
X..01503..03338..04994..08285
X..10046
X..01466..03044..04120..05118
X..05249
X..01364..02426..02810..02850
X..02795
X..01224..01834..01882..01693
X..01619
X..01075..01386..01314..01105
X..01042

FIGURE 16. (SHEET 51 OF 57)

```

X,-.00934,-.01073,-.00972,-.00796
X,-.00749
X,-.00810,-.00859,-.00762,-.00625
X/
  DATA (DATA      (I) , I = 2186 ,2230 )/
X -.00590
X,-.00705,-.00710,-.00628,-.00523
X,-.00498
X,-.00617,-.00604,-.00537,-.00457
X,-.00439
X,-.00544,-.00525,-.00472,-.00412
X,-.00397
X,-.00483,-.00465,-.00423,-.00376
X,-.00365
X,-.00433,-.00417,-.00384,-.00348
X,-.00339
X,-.00390,-.00378,-.00352,-.00324
X,-.00317
X,-.00353,-.00345,-.00325,-.00303
X,-.00297
X,-.00321,-.00317,-.00302,-.00284
X,-.00279
X,-.00294,-.00293,-.00281,-.00267
X/
  DATA (DATA      (I) , I = 2231 ,2300 )/
X -.00264
X,-.00270,-.00272,-.00262,-.00251
X,-.00249
X,-.00248,-.00253,-.00245,-.00237
X,-.00236
X,-.00229,-.00236,-.00230,-.00224
X,-.00223
X,-.00212,-.00220,-.00216,-.00211
X,-.00211
X,-.00197,-.00206,-.00204,-.00200
X,-.00200
X,.6,.71,.5.
X,.0,.05,.10,.15,.20,.25,.30,.35,.40,.45,.50,.55,.60,.65,.70
X,.75,.80,.85,.90,.95,1.0
X,.75,.90,.95,.99,.998
X,.01060,.02434,.03759,.06605,.08231
X,.01032,.02194,.03003,.03702,.03764
X,.00957,.01704,.01938,.01861,.01787
X/
  DATA (DATA      (I) , I = 2301 ,2390 )/
X .00856,.01257,.01245,.01038,.00968
X,.00747,.00935,.00852,.00667,.00615
X,.00646,.00721,.00631,.00490,.00454
X,.00560,.00578,.00500,.00397,.00372
X,.00485,.00480,.00418,.00342,.00325
X,.00424,.00410,.00367,.00306,.00293
X,.00373,.00359,.00321,.00279,.00270
X,.00331,.00318,.00289,.00257,.00250
X,.00295,.00286,.00263,.00239,.00233
X,.00265,.00258,.00242,.00223,.00218
X,.00240,.00235,.00222,.00209,.00205
X,.00220,.00215,.00205,.00194,.00191
X,.00203,.00198,.00190,.00182,.00180
X,.00189,.00184,.00177,.00170,.00168
X,.00176,.00171,.00166,.00160,.00158

```

FIGURE 16. (SHEET 52 OF 57)

```

X..00164..00161..00156..00151..00149
X..00151..00153..00148..00144..00142
X..00138..00147..00141..00138..00136
X/
  DATA (DATA      (1) , I = 2391 ,2489 )/
X 7..21..5.
X 0..05..10..15..20..25..30..35..40..45..50..55..60..65..70
X..75..80..85..90..95..100
X..75..90..95..99..998
X..-00786..-01850..-02936..-05432..-06951
X..-00765..-01650..-02277..-02768..-02782
X..-00707..-01254..-01399..-01265..-01186
X..-00630..-00908..-00870..-00675..-00612
X..-00550..-00670..-00590..-00436..-00394
X..-00476..-00514..-00439..-00329..-00301
X..-00411..-00414..-00353..-00274..-00256
X..-00358..-00344..-00297..-00241..-00228
X..-00314..-00297..-00259..-00218..-00209
X..-00277..-00260..-00232..-00201..-00194
X..-00247..-00233..-00211..-00187..-00182
X..-00220..-00210..-00193..-00174..-00171
X..-00197..-00192..-00179..-00164..-00161
X..-00177..-00176..-00166..-00154..-00152
X/
  DATA (DATA      (1) , I = 2490 ,2601 )/
X -00159..-00162..-00155..-00146..-00144
X..-00144..-00150..-00143..-00138..-00136
X..-00132..-00137..-00134..-00129..-00128
X..-00123..-00125..-00124..-00120..-00121
X..-00117..-00115..-00114..-00111..-00112
X..-00113..-00107..-00105..-00103..-00104
X..-00106..-00102..-00098..-00096..-00096
X..784500..-02544..001800..000300..000000..000000..000000
X..1.20880..-0.51770..005700..002100..000000..000000..000000
X..1.49710..-0.77770..004000..006100..000500..000000..000000
X..1.70680..-1.0224..-0.00880..010700..002100..000500..000100
X..392700..000000..063700..000000..000000..000000..000000
X..625800..000000..130000..000000..-00030..000000..000000
X..749600..000000..195900..000000..-00080..000000..000000
X..851200..000000..258300..000000..-00130..000000..000000
X..000000..-1.2730..000000..041900..000000..000000..000000
X..000000..-0.25990..000000..084900..000000..-00010..000000
X..000000..-0.39190..000000..130000..000000..-00040..000000
X/
  DATA (DATA      (1) , I = 2602 ,2727 )/
X .000000..-0.51650..000000..176700..000000..-00100..000000
X..-00050..000000..-0.06280..000000..031300..000000..000000
X..-00140..000000..-1.2740..000000..063000..000000..-00010
X..-00090..000000..-1.9500..000000..095500..000000..-00020
X..002700..000000..-0.26500..000000..129200..000000..-00050
X..000000..000100..000000..-0.04170..000000..025000..000000
X..000000..001100..000000..-0.08400..000000..050200..000000
X..000000..003100..000000..-1.2730..000000..075700..000000
X..000000..005300..000000..-1.7210..000000..101900..000000
X..000000..000000..000000..000000..-0.3130..000000..020800
X..000000..000000..000300..000000..-0.06280..000000..041800
X..-00010..000000..001000..000000..-0.09470..000000..062900
X..-00050..000000..002400..000000..-1.2730..000000..084300
X..000000..000000..000000..000000..000000..-0.02500..000000
X..000000..000000..000000..000100..000000..-0.05010..000000

```

FIGURE 16. (SHEET 53 OF 57)

```
X,.000000,.000000,.000000,.000400,.000000,-.07550,.000000
X,.000000,.000000,.000000,.201000,.000000,-.10110,.000000
X,.015000,.046000,.004800,-.00030,.001000,.000000,.000100
X/
DATA (DATA      (1) , I = 2728 ,2853 )/
X .022400,.070200,.014000,-.00090,.000000,.000000,.000000
X,.021200,.068500,.023900,-.00020,.000000,-.00020,.000000
X,.014600,.050000,.031900,.002800,.000200,-.00040,.000000
X,.000000,.017700,.000000,-.00050,.000000,.000000,.000000
X,.000000,.040800,.000000,-.00220,.000000,-.00010,.000000
X,.000000,.054000,.000000,-.00430,.000000,-.00020,.000000
X,.000000,.054100,.000000,-.00560,.000000,-.00050,.000000
X,-.00130,.000000,-.00040,.000000,.000000,.000000,.000000
X,-.00560,.000000,-.00360,.000000,.000000,.000000,.000000
X,-.00960,.000000,-.01150,.000000,-.00020,.000000,-.00010
X,-.00950,.000000,-.02410,.000000,-.00090,.000000,-.00060
X,.000000,.000300,.000000,.000000,.000000,.000000,.000000
X,.000000,.002400,.000000,.000200,.000000,-.00010,.000000
X,.000000,.005600,.000000,.001400,.000000,-.00030,.000000
X,.000000,.005500,.000000,.005200,.000000,-.00100,.000000
X,.000000,.000000,.000000,.000000,.000000,.000000,.000000
X,-.00080,.000000,-.00060,.000000,.000000,.000000,.000000
X,-.00330,.000000,-.00400,.000000,.000000,.000000,.000100
X/
DATA (DATA      (1) , I = 2854 ,2980 )/
X -.00600,.000000,-.01490,.000000,-.00010,.000000,.000300
X,.000000,.000000,.000000,.000000,.000000,.000000,.000000
X,.000000,.000300,.000000,.000000,.000000,.000000,.000000
X,.000000,.001200,.000000,.000700,.000000,.000000,.000000
X,.000000,.000100,.000000,.004200,.000000,-.00030,.000000
X,.000000,.000000,.000000,.000000,.000000,.000000,.000000
X,-.00020,.000000,-.00010,.000000,.000000,.000000,.000000
X,-.00130,.000000,-.00150,.000000,-.00010,.000000,.000000
X,-.00450,.000000,-.00950,.000000,-.00060,.000000,.000200
X,1.,1.,1.,1.,1.,1.,1.,1.
X,1.,2.,3.,4.,5.,6.,7.,8.
X,0.,1.,3.,6.,10.,15.,21.,28.
X,0.,0.,1.,4.,10.,20.,35.,56.
X,0.,0.,0.,1.,5.,15.,35.,70.
X,0.,0.,0.,0.,1.,6.,21.,56.
X,0.,0.,0.,0.,0.,1.,7.,28.
X,0.,0.,0.,0.,0.,0.,1.,8.
X/
END
```

FIGURE 16. (SHEET 54 OF 57)

```
X,.000000,.000000,.000000,.000400,.000000,-.07550,.000000
X,.000000,.000000,.000000,.001030,.000000,-.10110,.000000
X,.015000,.046000,.004800,-.00030,.001000,.000000,.000100
X/
DATA (DATA      (I) , I = 2728 ,2853 )/
X .022400,.070200,.014000,-.00090,.000000,.000000,.000000
X,.021200,.068500,.023900,-.00020,.000000,-.00020,.000000
X,.014600,.050000,.031900,.002800,.000200,-.00040,.000000
X,.000000,.017700,.000000,-.00050,.000000,.000000,.000000
X,.000000,.040800,.000000,-.00220,.000000,-.00010,.000000
X,.000000,.054000,.000000,-.00430,.000000,-.00020,.000000
X,.000000,.054100,.000000,-.00560,.000000,-.00050,.000000
X,-.00130,.000000,-.00040,.000000,.000000,.000000,.000000
X,-.00560,.000000,-.00360,.000000,.000000,.000000,.000000
X,-.00960,.000000,-.01150,.000000,-.00020,.000000,-.00010
X,-.00950,.000000,-.02410,.000000,-.00090,.000000,-.00060
X,.000000,.000300,.000000,.000000,.000000,.000000,.000000
X,.000000,.002400,.000000,.000200,.000000,-.00010,.000000
X,.000000,.005600,.000000,.001400,.000000,-.00030,.000000
X,.000000,.005500,.000000,.005200,.000000,-.00100,.000000
X,.000000,.000000,.000000,.000000,.000000,.000000,.000000
X,-.00080,.000000,-.00060,.000000,.000000,.000000,.000000
X,-.00330,.000000,-.00400,.000000,.000000,.000000,.000100
X/
DATA (DATA      (I) , I = 2854 ,2980 )/
X -.00600,.000000,-.01490,.000000,-.00010,.000000,.000300
X,.000000,.000000,.000000,.000000,.000000,.000000,.000000
X,.000000,.000300,.000000,.000000,.000000,.000000,.000000
X,.000000,.001200,.000000,.000700,.000000,.000000,.000000
X,.000000,.000100,.000000,.004200,.000000,-.00030,.000000
X,.000000,.000000,.000000,.000000,.000000,.000000,.000000
X,-.00020,.000000,-.00010,.000000,.000000,.000000,.000000
X,-.00130,.000000,-.00150,.000000,-.00010,.000000,.000000
X,-.00450,.000000,-.00950,.000000,-.00060,.000000,.000200
X.1.1.1.1.1.1.1.1.1.1.
X.1.2.3.4.5.6.7.8.
X.0.1.3.6.10.15.21.28.
X.0.0.1.4.10.20.35.56.
X.0.0.0.1.5.15.35.70.
X.0.0.0.0.1.6.21.56.
X.0.0.0.0.0.1.7.28.
X.0.0.0.0.0.0.1.8.
X/
END
```

FIGURE 16. (SHEET 54 OF 57)

```
      SUBROUTINE UNBAR(T,IK,XIN,YIN,ZZ,KK)
      DIMENSION T(1),X(6),Y(6),A(6)
C ----- MARCH 4, 1961 -----
      II = IK+1
      N = 3
      N2 = 2
      IF (T(II)-3.) 700,701,702
700      IF (T(II)+0.) 60,701,704
704      IF (T(II)-2.) 705,706,701
705      N = 1
           GO TO 707
706      N = 2
707      N2 = 1
701      II = II+1
702      N1 = N+1
           DO 50 L = II,II
           IF (T(L) + 0.) 60,60,51
60      KK = -1
           ZZ = 0.
           GO TO 9999
51      NX = T(L)
           IF (T(L+1) + 0.) 60,52,50
52      NY = 0
           GO TO 53
50      NY = T(L+1)
53      CONTINUE
           KK = 0
           KY = 0
           XX = XIN
           J1 = II+2
           J2 = NX+II+1
           IF (XX-T(J1)) 301,306,400
400      DO 302 J=J1,J2
           IF (XX-T(J)) 304,304,302
302      CONTINUE
309      KK = 2
           XX = T(J2)
308      JX1 = J2-N
           GO TO 305
301      KK = 1
           XX = T(J1)
306      JX1 = J1
           GO TO 305
304      IF (J-J1-1) 301,306,307
307      IF (J-J2) 303,308,309
303      JX1 = J-N2
305      CONTINUE
           XINT = XX
           IF (NY) 1500, 1500, 3000
1500      DO 1599 L=1,N1
           X(L) = T(JX1)
           LY = JX1 + NX
           Y(L) = T(LY)
1599      JX1 = JX1+1
           I = 1
           GO TO 54
3000      J1 = J1+NX
           J2 = J2+NY
           YY = YIN
           IF (YY-T(J1)) 311,316,401
```

FIGURE 16. (SHEET 55 OF 57)

```
401      DO 312 J=J1,J2
          IF (YY-T(J)) 314,314,312
312      CONTINUE
319      KY = 6
          YY = T(J2)
318      JY1 = J2-N
          GO TO 315
311      KY = 3
          YY = T(J1)
316      JY1 = J1
          GO TO 315
314      IF (J-J1-1) 311,316,317
317      IF (J-J2) 313,318,319
313      JY1 = J-N2
315      CONTINUE
          JX2 = JX1
          LY = JY1 + NY*(JX2-I1-1)
          LY1 = LY
          DO 3099 L=1,N1
              X(L) = T(JX2)
              Y(L) = T(LY1)
              LY1 = LY1+NY
3099      JX2 = JX2+1
          I = 0
          GO TO 54
3098      Y(1) = ZZ
          DO 4400 I=1,N
              LY1 = LY+I
              Y(I+1) = 0.
              DO 4050 MM=1,N1
                  Y(I+1) = Y(I+1) + T(LY1)*X(MM)
4050      LY1 = LY1+NY
4400      CONTINUE
          DO 4199 L=1,N1
              X(L) = T(JY1)
4199      JY1 = JY1+1
          XINT = YY
          I = 1
54      D = 1.
          X(N+2) = X(1)
          X(N+3) = X(2)
          DO 55 J=1,N1
              A(J+1) = X(J+1) - X(J)
              TPAL1 = XINT - X(J)
              IF ( TPAL1 ) 57,58,57
58      ZZ = Y (J)
          X(1) = 0.
          X(2) = 0.
          X(3) = 0.
          X(4) = 0.
          X(J) = 1.0
          GO TO 59
57      D = D * TPAL1
          GO TO (711,712,713) ,N
711      X(J) = TPAL1/A(J+1)
          GO TO 55
712      X(J) = -TPAL1
          GO TO 55
713      X(J) = (X(J+2)-X(J))*TPAL1
55      CONTINUE
```

FIGURE 16. (SHEET 56 OF 57)

```
A(1) = A(N+2)
ZZ = 0.
DO 56 J=1,N1
  X(J) = D/(A(J)*A(J+1)* X(J))
  ZZ = ZZ + Y(J)* X(J)
56  CONTINUE
59  IF (1) 3098,3098,9999
9999 KK = KK+KY
      RETURN
      END
```

FIGURE 16. (SHEET 57 OF 57)

6.2 FLOW CHARTS, SUBROUTINE LIST, AND FORTRAN IV LISTINGS FOR HAMILTON STANDARD DECK H194

Figures 17, 18, and 19 contain the pertinent data for Hamilton Standard Deck H194. It is the computer deck which calculates shroud camber 2-dimensional Glauert coefficients and shroud thickness coefficients. These data are used as input for Hamilton Standard Deck H193.

FLOW CHART FOR HAMILTON STANDARD DECK H194
SHROUD GEOMETRY PROGRAM

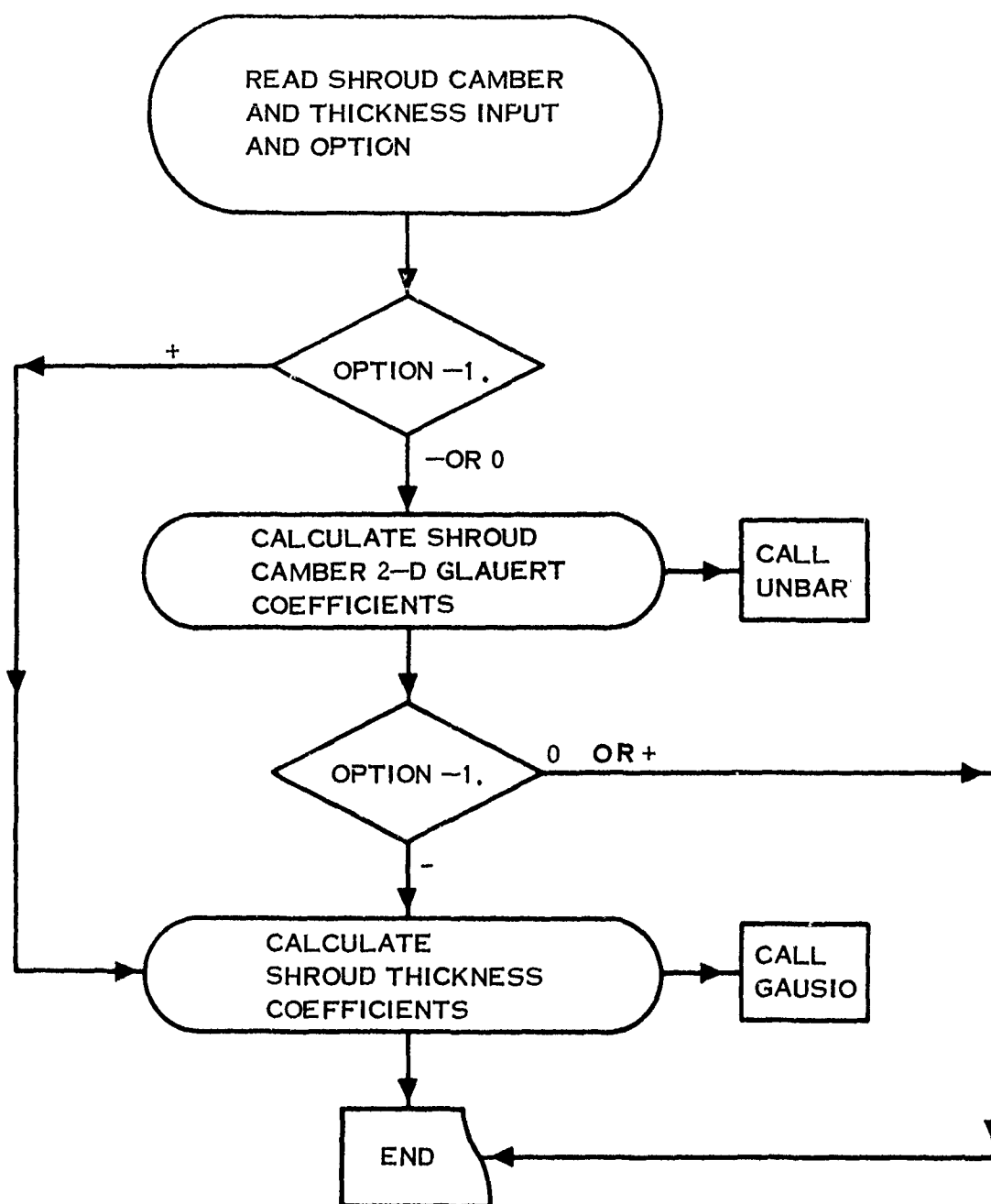


FIGURE 17.

6.2

(Continued)

LIST OF SUBROUTINES

HAMILTON STANDARD DECK H194

SHROUD GEOMETRY

MNH194

GAUSIO

UNBAR (See listing under Appendix 6.1)

Figure 18

FORTRAN IV LISTING FOR HAMILTON STANDARD DECK H194

```
C      MAIN PROGRAM FOR HS DECK H194
      DIMENSION TAB(68),FINT(7),XI(11),EEE(81),X(7),HOB(7),VECTOR(7),
      XZM(10,11),TH(21),Y(22),XBS(81)
100 WRITE (6,105)
105 FORMAT (1H1,47X,22H HS COMPUTER DECK H194/47X,24H SHROUD GEOMETRY
      1PROGRAM /50X,18H HAMILTON STANDARD /49X,20H WINDSOR LOCKS,CONN. /
      257X,5H 1967 )
      READ (5,110)
110 FORMAT (72H
      . X
      WRITE (6,110)
120 READ (5,130)I,KL,(XI(JT),JT=1,11)
130 FORMAT (2I3,1:F6.0)
      IK=I-1
      GO TO (140,160,180,200,220,240,260,280,300,310),IK
140 DO 150 JT=2,11
150 TAB(JT+2)=XI(JT)
      TAB(1)=1.0
      TAB(2)=XI(1)
      TAB(3)=0.0
      GO TO 120
160 DO 170 JT=1,11
170 TAB(JT+13)=XI(JT)
      GO TO 120
180 DO 190 JT=1,11
190 TAB(JT+24)=XI(JT)
      GO TO 120
200 DO 210 JT=1,11
210 TAB(JT+35)=XI(JT)
      GO TO 120
220 DO 230 JT=1,11
230 TAB(JT+46)=XI(JT)
      GO TO 120
240 DO 250 JT=1,11
250 TAB(JT+57)=XI(JT)
      GO TO 120
260 DO 270 JT=1,7
270 X(JT)=XI(JT)
      GO TO 120
280 DO 290 JT=1,7
290 HOB(JT)=XI(JT)
      GO TO 120
300 AZERO=XI(1)
      GO TO 120
310 OPT=XI(1)
      TRIG=XI(2)
      IF (OPT-1.0)320,320,440
C
C      CALCULATION OF SHROUD CAMBER INTEGRAL
C
320 PI=3.14159265
      WRITE (6,322)
322 FORMAT (65H0 **** CALCULATION OF SHROUD CAMBER 2-D GLAUERT COEFFIC
      XIENTS **** //1H,11X,10HAXIAL LOC.,5X,11HINPUT SLOPE,10X,10HAXIAL
      XLOC.,5X,11HINPUT SLOPE,10X,10HAXIAL LOC.,5X,11HINPUT SLOPE )
      NP=TAB(2)+.0000C5
      I=NP/3
      J=I*3
      K=NP-J
      IF (K-1)325,326,326
```

FIGURE 19. (SHEET 1 OF 5)

```
325 L=1
    GO TO 327
326 L=L+1
327 I=NP+3
    DO 331 N=1,L
        J=N+2*L
        IF (J-NP)329,329,328
328 J=J-1
329 WRITE (6,414)(TAB(M+3),TAB(M+11),M=N,J,L)
331 CONTINUE
    DO 410 NU=1,7
        EINT(NU)=0.0
        SIMP=1.0
        TEMP=0.0
        DELA=PI/80.
        ANGLE=-DELA
        DO 400 I=1,81
            ANGLE=ANGLE+DELA
            IF (NU-1)332,332,340
332 XBS(I)=-COS(ANGLE)/2.0+.5
            CALL UNBAR (TAB,I,XBS(I),1.0,EEE(I),LIMIT)
            COST=-.5
            GO TO 350
340 I=NU-1
            ALL=I
            CONST=COS(ANGLE*ALL)
350 EINT(NU)=EEE(I)*CONST*SIMP+EINT(NU)
            IF (I-80)370,360,400
360 SIMP=1.0
            TEMP=0.0
            GO TO 400
370 IF (TEMP)380,380,390
380 SIMP=4.0
            TEMP=1.0
            GO TO 400
390 SIMP=2.0
            TEMP=0.0
400 CONTINUE
            EINT(NU)=-EINT(NU)/70.
410 CONTINUE
            WRITE (6,412)
412 FORMAT (1H0,11X,10HAXIAL LOC.,6X,10HINT. SLOPE,10X,10HAXIAL LOC.,
           X6X,10HINT. SLOPE,10X,10HAXIAL LOC.,6X,10HINT. SLOPE )
            DO 416 I=1,27
                J=I+54
                WRITE (6,414)(XBS(L),EEE(L),L=I,J,27 )
414 FORMAT (1H ,3(4X,2F16.5))
416 CONTINUE
                WRITE (6,430)(EINT(I),I=1,7)
430 FORMAT (65H0 **** SHROUD CAMBER 2-D GLAUERT COEFFICIENTS --- E0 TH
           XRU E6 **** /7F11.5)
                IF (OPT-1.0)440,900,440
C
C . CALCULATION OF SHROUD THICKNESS COEFFICIENTS
C
440 WRITE (6,442)
442 FORMAT (57H0 **** CALCULATION OF SHROUD THICKNESS COEFFICIENTS ***
           X* )
            WRITE (6,445)(X(I),I=1,7),(HOR(I),I=1,7)
445 FORMAT (18H0 AXIAL LOCATION = 7F8.4 /7X,11HINPUT T/C = 7F8.4)
```

FIGURE 19. (SHEET 2 OF 5)

```
DO 450 I=1,7
450 VECTOR(I)=HOB(I)-AZERO*SQRT(X(I))
DO 500 I=1,7
  ZM(I,1)=X(I)
DO 460 J=2,7
460 ZM(I,J)=ZM(I,J-1)*X(I)
500 CONTINUE
  CALL GAUS10 (7,ZM,VECTOR,DET,IDET,L)
  IF (L-1)550,530,550
530 WRITE (6,535)
535 FORMAT (19H MATRIX IS SINGULAR )
  GO TO 900
550 WRITE (6,575)AZERO,(VECTOR(I),I=1,7)
575 FORMAT (56H0 **** SHROUD THICKNESS COEFFICIENTS --- A0 THRU A7 ***
  X* /8F9.4 )
  WRITE (6,580)
580 FORMAT (24H0 AXIAL LOC. CALC.T/C )
  Y(1)=0.
DO 800 I=1,21
  TH(I)=0.
  Z=1.
DO 600 J=1,7
  TH(I)=TH(I)+VECTOR(J)*Z*Y(I)
600 Z=Z*Y(I)
  TH(I)=AZERO*SQRT(Y(I))+TH(I)
  WRITE (6,700)Y(I),TH(I)
700 FORMAT (2F12.6)
800 Y(I+1)=Y(I)+.05
900 IF (TRIG)960,960,1000
960 WRITE (6,970)
970 FORMAT (1H1)
  GO TO 100
1000 CALL EXIT
  END
```

FIGURE 19. (SHEET 3 OF 5)

```
      SUBROUTINE GAUS10 (N,A,B,DET,IDET,LSING )
      DIMENSION A(10,11), B(10), IROW(10)
C      * *ROW AND COLUMN INTERCHANGES ARE MADE TO PUT LARGEST
C      * * ELEMENT IN THE PIVOTAL SLOT
      LSING = 0
      DET = 1.
      IDET = 0
C      NUMBER OF COL.
      NC = N+1
C      MOVE THE B VECTOR INTO COLUMN N+1 AND SET UP ARRAY IROW
      DO 2 I=1,N
      IROW(I) = 1
2      A(I,NC) = B(I)
C
C      START OF OVERALL LOOP
      NI = N-1
      DO 100 L = 1,NI
      BIG = 0.
      DO 10 J = L,N
      DO 10 I = L,N
      IF (BIG-ABS ( A(I,J) ))6, 6, 10
6      BIG = ABS ( A(I,J) )
      J1 = J
      I1 = I
10      CONTINUE
C      MOVE ROW I1 TO L START WITH COL (L) SINCE 1 TO (L-1) ARE = 0.
      IF(I1-L) 12,14,12
12      DET=-DET
      DO 16 K = L,NC
      S = A(L,K)
      A(L,K) = A(I1,K)
16      A(I1,K) = S
C      MOVE COLUMN J1 TO L
14      IF(J1-L) 17,20,17
17      DET=-DET
      DO 18 K = 1,N
      S = A(K,L)
      A(K,L) = A(K,J1)
18      A(K,J1) = S
      M = IROW(L)
      IROW(L) = IROW(J1)
      IROW(J1) = M
C      REDUCE SET OF EQ. BY 1
20      L1 = L+1
C      TEST FOR SINGULAR MATRIX
      IF ( A(L,L) ) 40, 35, 40
40      DO 50 I=L1,N
      AM = A(I,L)/A(L,L)
      DO 50 J=L,NC
50      A(I,J) = A(I,J) -AM*A(L,J)
100      CONTINUE
C      TEST FOR SINGULAR ON THE LAST REDUCTION
      IF (A(N,N) ) 150, 35, 150
C      MOVE THE B VECTOR BACK INTO B
150      DO 202 I = 1,N
202      B(I) = A(I,NC)
C      SUBSTITUTE BACKWARD
      M = N-1
      K = N
      B(N) = B(N)/A(N,N)
```

FIGURE 19. (SHEET 4 OF 5)

```
210 DO 220 I = 1,M
220 B(I) = B(I) - A(I,K)*B(K)
    B(M) = B(M)/A(M,M)
    K = K-1
    M = M-1
    IF (M) 210, 230, 210
C   REPLACE ROOTS IN ORIGINAL ORDER
230 DO 400 I = 1,N
    DO 350 L = 1,N
    IF (IROW(I) - 1) 320,400,320
320 K = IROW(I)
    IROW(I) = IROW(K)
    IROW(K) = K
    S = B(I)
    B(I) = B(K)
350 B(K) = S
400 CONTINUE
C   CALCULATE THE VALUE OF THE DETERMINANT
    DO 450 L = 1,N
    DET = DET*A(L,L)
C   PROTECTION AGAINST VALUE OF DET BEING ZERO DUE TO UNDERFLOW
    IF (DET) 5001,35,5001
5001 IF (ABS (DET)-1.E10) 5540,5541,5541
5541 IDET = IDET+10
    DET = DET/1.E10
    GO TO 5001
5540 IF (ABS (DET)-1.E-10) 5543,5543, 450
5543 IDET = IDET-10
    DET = DET*1.E10
    GO TO 5540
450 CONTINUE
500 RETURN
35 DET = 0.
    LSING = 1
    GO TO 500
END
```

FIGURE 19. (SHEET 5 OF 5)

6.3 FLOW CHARTS, SUBROUTINE LIST, AND FORTRAN IV LISTINGS FOR HAMILTON STANDARD DECK H060

Figures 20, 21, and 22 contain the pertinent data for Hamilton Standard Deck H060. It is the computer deck which computes the pertinent centerbody data required for input to Hamilton Standard Deck H193.

FLOW CHART
CENTERBODY INDUCED VELOCITIES
HAMILTON STANDARD DECK H060

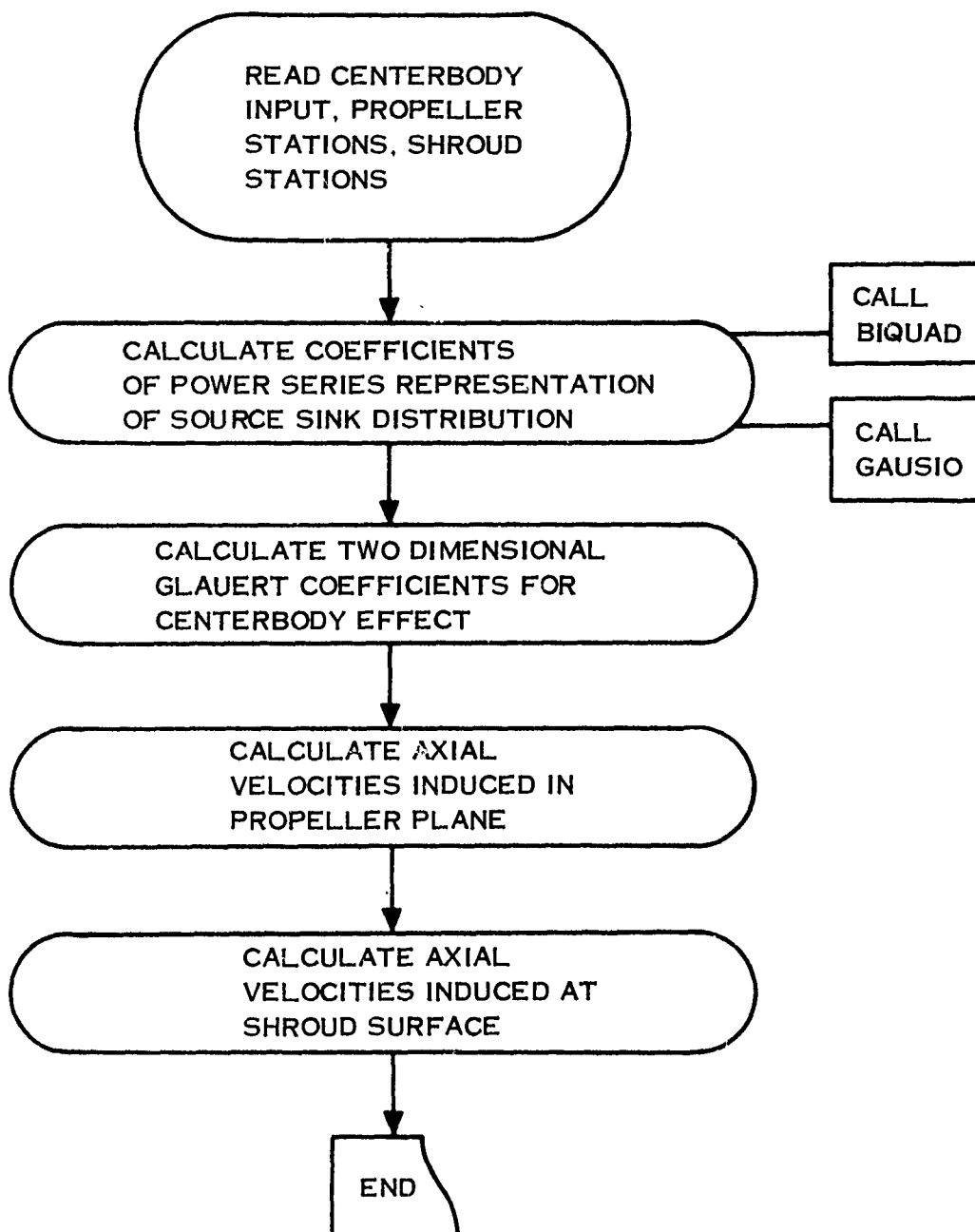


FIGURE 20.

6.3

(Continued)

LIST OF SUBROUTINES

HAMILTON STANDARD DECK H060

CENTERBODY INDUCED VELOCITIES

MNH060

BIQUAD

GAUSIO (See listing under Appendix 6.2)

Figure 21

FORTRAN IV LISTINGS FOR HAMILTON STANDARD DECK H060

```
C      MAIN PROGRAM FOR HS DECK H060
      DIMENSION COEFF(10,11),CONSUM(6),TABLE(403),BSUM(10),A(8),ANORM(8)
      1,ANCB(8),ZAV99(200),RCB(8),SUMCB(8),ZICB(81,8),ZLCB(8),DCB(8,8),
      2RBAR(10),TX(40),DATA(64),VRAD(81),XPRINT(81),RCBC(200),XI(11)
      EQUIVALENCE (DATA(1),DCB)
      DATA (DATA(1),I=1,64)/ 1.,0.,0.,0.,0.,0.,0.,0.,0.,0.,1.,1.,0.,0.,0.,
      X,0.,0.,0.,1.,2.,1.,0.,0.,0.,0.,0.,0.,0.,1.,3.,3.,1.,0.,0.,0.,0.,1.,4.,
      X,6.,4.,1.,0.,0.,0.,1.,5.,10.,10.,5.,1.,0.,0.,1.,6.,15.,20.,15.,
      X,6.,1.,0.,1.,7.,21.,35.,35.,21.,7.,1./
      1 WRITE (6,2)
      2 FORMAT (1H1,47X,22H HS COMPUTER DECK H060/40X,38H CENTERBODY INDUC
      1ED VELOCITIES PROGRAM /50X,18H HAMILTON STANDARD /49X,20H WINDSOR
      2LOCKS,CONN. /57X,5H 1967 )
      READ (5,4)
      WRITE (6,4)
      4 FORMAT (72H
      X
      )
      500 READ (5,510)I,KL,(XI(JT),JT=1,11)
      510 FORMAT (2I3,11F6.0)
      IF (I-5)520,600,630
      520 GO TO (500,530,540,560),I
      530 AMBDA=XI(2)
      ZALPCB=XI(3)
      ZBETCB=XI(4)
      AZERO=XI(5)
      XLOC=XI(6)
      ZMU=XI(7)
      TRIG=XI(8)
      GO TO 500
      540 DO 550 IT=1,10
      RBAR(IT)=XI(IT+1)
      550 CONTINUE
      GO TO 500
      560 TABLE(1)=1.0
      TABLE(2)=XI(1)
      TABLE(3)=0.0
      DO 570 IT=1,10
      TABLE(IT+3)=XI(IT+1)
      570 CONTINUE
      NPT=2.0*TABLE(2)+3.1
      IF (NPT-13)500,500,580
      580 READ (5,590)(TABLE(IT),IT=14,NPT)
      590 FORMAT (12X,10F6.0)
      GO TO 500
      600 TNX=XI(1)
      NPT=XI(1)+.1
      DO 610 IT=1,10
      TX(IT)=XI(IT+1)
      610 CONTINUE
      IF (NPT-10)500,500,620
      620 READ (5,590)(TX(IT),IT=11,NPT)
      GO TO 500
      630 WRITE (6,640)
      640 FORMAT (17H0 **** INPUT **** // )
      WRITE (6,5)AMBDA,ZALPCB,ZBETCB,AZERO,XLOC,ZMU
      5 FORMAT (33H0SHROUD CHORD TO DIAMETER RATIO =F7.4/12H ALPHA BAR =
      1F8.4 /11H BETA BAR=F8.4 /9H A ZERO =F9.5 /43H NON-DIMENSIONAL DOW
      2NSTREAM PROP LOCATION =F7.4 /43H PROP DIAMETER/SHROUD REFERENCE D
      3DIAMETER =F7.4 )
      Z1=2.0/(ZALPCB+ZBETCB)
```

FIGURE 22. (SHEET 1 OF 8)

```

XLOC=XLOC-AMBDA
NP=TABLE(2)
SUM=0.0
SUM1=0.0
DO 20 L=1,6
CONSUM(L)=0.0
DO 10 N=1,6
COEFT(L,N)=0.0
10 CONTINUE
20 CONTINUE
DO 90 L=1,6
J=L+2
JK=L+1
ZJ=0
DO 80 M=1,NP
I=M+NP+3
XNORM=TABLE(M+3)*Z1-1.0
HOLD=-1.0-XNORM
TEMP=-HOLD*(-1.0)**JK+.5*HOLD*(1.0-(-1.0)**J)/ZJ+XNORM**JK-(-1.0)*
1*JK
IF(L-1)23,23,63
23 XINT=TABLE(M+3)+.001
CALL BIQUAD (TABLE(1),1,XINT,0.0,SAVE1,LIMIT)
XINT=TABLE(M+3)-.001
CALL BIQUAD (TABLE(1),1,XINT,0.0,SAVE2,LIMIT)
IF(M-1)30,30,40
30 SLOPE=(SAVE1-SAVE2)/.001
GO TO 60
40 IF(M-NP)50,30,50
50 SLOPE=(SAVE1-SAVE2)/.002
60 ZAV99(M)=TABLE(1)*SLOPE/2.0
63 CONSUM(L)=CONSUM(L)+TEMP*(AZERO+AZERO*HOLD-ZAV99(M))
68 DO 70 N=1,6
J1=N+2
JK1=N+1
ZJ1=J1
COEFT(L,N)=COEFT(L,N)+TEMP*(-HOLD*(-1.0)**JK1+.5*(1.0-(-1.0)**J1)*
1 HOLD/ZJ1+XNORM**JK1-(-1.0)**JK1)
70 CONTINUE
80 CONTINUE
90 CONTINUE
DO 100 N=1,6
BSUM(N)=-CONSUM(N)
100 CONTINUE
CALL GAUSS10 (6,COEFT,BSUM,D,ID,L)
C
C BSUM NOW CONTAINS NORMALIZED COEFFICIENTS
C
DO 110 N=2,7
ZN=N+1
SUM=SUM+BSUM(N-1)*(-1.0)**N
SUM1=SUM1+BSUM(N-1)*.5*(1.0-(-1.0)**(N+1))/ZN
110 CONTINUE
ANORM(2)=-AZERO+SUM-SUM1
ANORM(1)=AZERO-SUM+ANORM(2)
DO 140 I=1,8
A(I)=0.0
140 CONTINUE
DO 142 I=3,8
ANORM(I) = BSUM(I-2)

```

FIGURE 22. (SHEET 2 OF 8)

```
142 CONTINUE
Z4=-Z1
DO 150 N=1,8
PN=N
Z5=(-1.0)**(N-1)
Z6=ANORM(N)*Z5
A(1)=A(1)+Z6
A(2)=A(2)+(PN-1.0)*Z6*Z4
A(3)=A(3)+(PN-2.0)*(PN-1.0)*Z6*Z4**2/2.0
A(4)=A(4)+(PN-3.0)*(PN-2.0)*(PN-1.0)*Z6*Z4**3/6.0
A(5)=A(5)+(PN-4.0)*(PN-3.0)*(PN-2.0)*(PN-1.0)*Z6*Z4**4/24.0
150 CONTINUE
A(6)=(-21.0*ANORM(8)+6.0*ANORM(7)-ANORM(6))*Z4**5
A(7)=(-7.0*ANORM(8)+ANORM(7))*Z4**6
A(8)=-ANORM(8)*Z4**7
DO 154 I=1,NP
RCBC(I)=0.0
DO 152 J=1,8
K=J
DEN=J
RCBC(I)=RCBC(I)+A(J)*TABLE(I+3)**K/DEN
152 CONTINUE
IF (RCBC(I))1400,154,1410
1400 RCBC(I)=-RCBC(I)
1410 RCBC(I)=2.0*SQRT(RCBC(I))
154 CONTINUE
WRITE (6,156)
156 FORMAT (117H0      AXIAL LOC.  INPUT RBAR  CALC.RBAR      AXIAL LOC
X, INPUT RBAR  CALC.RBAR      AXIAL LOC.  INPUT RBAR  CALC.RBAR )
I=NP/3
J=I*3
K=NP-J
IF (K-1)1500,1510,1510
1500 L=I
GO TO 1520
1510 L=I+1
1520 II=NP+3
DO 1560 N=1,L
J=N+2*L
IF (J-NP)1540,1540,1530
1530 J=J-1
1540 WRITE (6,1550)(TABLE(M+3),TABLE(M+11),RCBC(M),M=N,J,L )
1550 FORMAT (2X,3F12.5,3X,3F12.5,3X,3F12.5 )
1560 CONTINUE
DO 165 I=1,8
ANCB(I)=0.0
165 CONTINUE
Z9=ZALPCR
DO 170 I=1,8
PN=I
ANCB(1)=ANCB(1)+A(1)*Z9**(I-1)
ANCB(2)=ANCB(2)+A(1)*(PN-1.0)*Z9**(I-2)
ANCB(3)=ANCB(3)+A(1)*(PN-2.0)*(PN-1.0)*Z9**(I-3)/2.0
170 CONTINUE
ANCB(4)=A(4)+4.0*A(5)*Z9+10.0*A(6)*Z9**2+20.0*A(7)*Z9**3+35.0*A(8)
1*Z9 **4
ANCB(5)=A(5)+5.0*A(6)*Z9+15.0*A(7)*Z9**2+35.0*A(8)*Z9**3
ANCB(6)=A(6)+6.0*A(7)*Z9+21.0*A(8)*Z9**2
ANCB(7)=A(7)+7.0*A(8)*Z9
ANCB(8)=A(8)
```

FIGURE 22. (SHEET 3 OF 8)

```
WRITE (6,175)(ANCB(I),I=1,8)
175 FORMAT (84H0 **** COEFFICIENTS OF POWER SERIES REPRESENTATION OF S
SOURCE SINK DISTRIBUTION **** /1H ,8F13.6 )
WRITE (6,177)
177 FORMAT (63H0 AXIAL LOC. VR/UI AXIAL LOC. VR/UI AXIAL LOC.
X VR/UI )
DO 7080 ICB=1,8
BCB(ICB)=0.0
PHI=-.039267
DO 7060 JCB=1,81
PHI=PHI+.039267
XICB=ICB-1
COSC=COS(PHI)
COSCB=COS(XICB*PHI)
IF(ICB-1)7000,7000,7040
7000 IF(JCB-1)7010,7010,7022
7010 DO 7020 KCB=1,8
SUMCB(KCB)=0.0
7020 CONTINUE
7022 DO 7025 LCB=1,8
ZICB(JCB,LCB)=0.0
7025 CONTINUE
ZXCB=-AMBDA*COSC
ZNCB=ZBETCB-ZXCB
ZMCB=-ZALPCB-ZXCB
ZYCB=SQRT(ZNCR**2+1.0)
ZZCB=SQRT(ZMCB**2+1.0)
ZLCB(1)=ZNCB/ZYCB-ZMCB/ZZCB
ZLCB(2)=1.0/ZZCB-1.0/ZYCB
ZLCB(3)=ALOG((ZNCB+ZYCB)/(ZMCB+ZZCB))+ZMCB/ZZCB-ZNCB/ZYCB
ZLCB(4)=ZYCB-ZZCB+1.0/ZYCB-1.0/ZZCB
ZLCB(5)=.5*(ZNCB*ZYCB-ZMCB*ZZCB)+ZNCB/ZYCB-ZMCB/ZZCB+1.5*ALOG((
ZMCB+ZZCB)/(ZNCB+ZYCB))
ZLCB(6)=(ZYCB**3-ZZCB**3)/3.0+2.0*(ZZCB-ZYCB)+1.0/ZZCB-1.0/ZYCB
ZLCB(7)=(ZNCR**5-2.5*ZNCR**3-7.5*ZNCR)/(4.0*ZYCB)-(ZMCB**5-2.5*ZMC
B**3-7.5*ZMCB)/(4.0*ZZCB)+1.875*ALOG((ZNCB+ZYCB)/(ZMCB+ZZCB))
ZLCB(8)=ZYCB*(.2*ZYCB**4-ZYCB**2+3.0)+1.0/ZYCB-ZZCB*(.2*ZZCB**4-Z
CB**2+3.0)-1.0/ZZCB
M99=1
VRAD(JCB)=0.0
DO 7034 I99=1,8
DO 7032 J99=1,M99
N99=M99-J99
ZICB(JCB,I99)=ZICB(JCB,I99)+ZXCB**N99*DCB(J99,I99)*ZLCB(J99)
7032 CONTINUE
VRAD(JCB)=VRAD(JCB)+ANCB(I99)*ZICB(JCB,I99)
M99=M99+1
7034 CONTINUE
XPRINT(JCB)=.5*(1.0-COSC)
7040 IF(JCB-1)7042,7042,7041
7041 IF(JCB-81)7043,7042,7042
7042 CONSCB=.01308997
ZESTCB=1.0
GO TO 7046
7043 IF(ZESTCB)7045,7045,7044
7044 CONSCB=.052359878
ZESTCB=0.0
GO TO 7046
7045 CONSCB=.026179939
ZESTCB=1.0
```

FIGURE 22. (SHEET 4 OF 8)

```

7046 DO 7050 KCB=1,8
      IF( ICB-1) 7048,7047,7048
7047 SUMCB(KCB)=SUMCB(KCB)+ZICB(JCB,KCB)*CONSCB
      GO TO 7050
7048 SUMCB(KCB)=SUMCB(KCB)+ZICB(JCB,KCB)*CONSCB*COSCB
7050 CONTINUE
7060 CONTINUE
      DO 7070 KCB=1,8
      IF( ICB-1) 7066,7064,7066
7064 BCB( ICB)=BCB( ICB)-1.274*ANCB(KCB)*SUMCB(KCB)
      SUMCB(KCB)=0.0
      GO TO 7070
7066 BCB( ICB)=BCB( ICB)+2.548*ANCB(KCB)*SUMCB(KCB)
      SUMCB(KCB)=0.0
7070 CONTINUE
7080 CONTINUE
      DO 7084 KCB=1,27
      I=KCB+54
      WRITE ( 6,7082) (XPRINT(K),VRAD(K),K=KCB,1,27 )
7082 FORMAT (1H ,3(F11.5,F10.5))
7084 CONTINUE
      WRITE ( 6,7085) (BCB(KCB),KCB=1,8)
7085 FORMAT (55H0 **** GLAUERT COEFFICIENTS FOR CENTERBODY EFFECT ****
1/1H ,8F12.6 )
      DO 7450 I=1,2
      IF( I-1) 7300,7300,7310
7300 M88=10
      N88=1
      WRITE ( 6,7301)
7301 FORMAT (19H0 PROP.X VA/UI)
      GO TO 7320
7310 M88=1
      N88=TNX
      WRITE ( 6,7312)
7312 FORMAT (19H0AXIAL LOC. VA/UI)
7320 DO 7440 J=1,M88
      IF( I-1) 7330,7330,7340
7330 R=REAR(J)*ZMU
      GO TO 7350
7340 R=1.0
7350 DO 7430 K=1,N88
      V=0.0
      IF( I-1) 7360,7360,7370
7360 X=XLOC
      GO TO 7380
7370 X=2.0*AMBDA*(TX(X)-.5)
7380 R2=R**2
      R4=R2**2
      ZN=ZBETCB-X
      ZM=-ZALPCB-X
      ZY=SQRT(ZN**2+R2)
      ZZ=SQRT(ZM**2+R2)
      ZLCB(1)=1.0/ZZ-1.0/ZY
      ZLCB(2)=ALOG((ZN+ZY)/(ZM+ZZ))+ZM/ZZ-ZN/ZY
      ZLCB(3)=ZY+R2/ZY-ZZ-R2/ZZ
      ZLCB(4)=.5*(ZN*ZY-ZM*ZZ)+ZN*R2/ZY-ZM*R2/ZZ+1.5*R2*ALOG((ZM+ZZ)/
1(ZN+ZY))
      ZLCB(5)=(ZY**3-ZZ**3)/3.0+2.0*R2*(ZZ-ZY)+R4/ZZ-R4/ZY
      ZLCB(6)=(ZN**5-2.5*ZN**3*R2-7.5*ZN*R4)/(4.0*ZY)-(ZM**5-2.5*ZM**3*R
12-7.5*ZM*R4)/(4.0*ZZ)+1.875*R4*ALOG((ZN+ZY)/(ZM+ZZ))

```

FIGURE 22. (SHEET 5 OF 8)

```

ZLCB(7)=ZY*(.2*ZY**4-ZY**2*R2+3.0*R4)+R4*R2/ZY-ZZ*(.2*ZZ**4-ZZ**2*
1 R2+3.0*R4)-R4*R2/ZZ
ZLCB(8)=ZM**7/ZZ-ZN**7/ZY+1.1666667*(ZY*ZN**5-ZZ*ZM**5-1.25*R2*(ZY
1*
2ZN**3-ZZ*ZM**3))+.43725*R4*5.0*(ZN*ZY-ZM*ZZ+R2*ALOG((ZM+ZZ)/(ZN+ZY
3)))
M99=1
DO 7395 I99=1,8
DO 7390 J99=1,M99
N99=M99-J99
IF (N99)7382,7384,7382
7382 V=V-X**N99*DCB(J99,I99)*ZLCB(J99)*ANCB(I99)
GO TO 7390
7384 V=V-DCB(J99,I99)*ZLCB(J99)*ANCB(I99)
7390 CONTINUE
M99=M99+1
7395 CONTINUE
IF(I-1)7400,7400,7420
7400 WRITE (6,7410)RBAR(J),V
7410 FORMAT(1H F8.5,3X,F9.6)
GO TO 7430
7420 WRITE (6,7410)TX(K),V
7430 CONTINUE
7440 CONTINUE
7450 CONTINUE
IF(1RIG)1,1,7460
7460 CALL EXIT
END

```

FIGURE 22. (SHEET 6 OF 8)

```

SUBROUTINE BIQUAD (T, I, XI, YI, Z, K)
C
C   THIS ROUTINE INTERPOLATES OVER A 4 POINT INTERVAL USING A
C   VARIATION OF 2ND DEGREE INTERPOLATION TO PRODUCE A CONTINUITY
C   OF SLOPE BETWEEN ADJACENT INTERVALS.
C   DIMENSION T(1),XC(4), D(4), P(5), Y(4),C(4)
C
C   EQUIVALENCE (XC(1), D(1))
C
C   TABLE SET UP
C   T(1)      = TABLE NUMBER
C   T(1+1)    = NUMBER OF (X) VALUES
C   T(1+2)    = NUMBER OF (Y) VALUES (0* FOR UNIVARIATE TABLE)
C   T(1+3)    = VALUES OF (X) IN ASCENDING ORDER
C   NX = T(1+1)
C   NY = T(1+2)
C   J1 = 1+3
C   J2 = J1 + NX - 1
C   X = XI
C   SEARCH IN X SENSE
C   L = 0
C   GO TO 1000
C   RETURN HERE FROM SEARCH OF X
100  K = KX
C   JX = JX1
C   THE FOLLOWING CODE PUTS X AND/OR Y VALUES IN XC BLOCK
105  DO 110 J=1,4
C   XC(J) = T(JX1)
110  JX1 = JX1+1
C   GET COEFF. IN X SENSE
C   GO TO 2000
C   RETURN HERE WITH COEFF. TEST FOR UNIVARE OR BIVARIATE
200  IF (NY) 300,210,300
210  Z=0.
C   JY = JX+NX
C   DO 220 J=1,4
C   Z = Z + C(J)*T(JY)
220  JY = JY+1
C   GO TO 9999
C
C   BIVARIATE TABLE
300  L=1
C   X = YI
C   J1 = J2+1
C   J2 = J1+NY-1
C   SEARCH IN Y SENSE JX1 = SUBSCRIPT OF 1ST Y
C   GO TO 1000
500  K = K+3*KX
C   INTERPOLATE IN X SENSE
C   SUBSCRIPT - BASE NO. OF COL. NO. OF YS
C   JY = J2+1 + (JX-1-3)*NY + JX1-J1
C   DO 550 M=1,4
C   JX = JY
C   Y(M) = 0.
C   DO 520 J=1,4
C   Y(M) = Y(M) + C(J)*T(JX)
520  JX = JX+NY
550  JY = JY+1
C
C   GET COEFF. IN Y SENSE

```

FIGURE 22. (SHEET 7 OF 8)

```
GO TO 105
600  Z = 0.
      DO 700 J=1,4
700  Z = Z + C(J)*Y(J)
9999 RETURN
C
C SEARCH ROUTINE - INPUT J1,J2,X
C                      -OUTPUT RA,RS,KX,JX1
1000 KX = 0
      DO 1010 J=J1,J2
      IF (T(J)-X) 1010,1050,1050
1010 CONTINUE
C OFF HIGH END
      X = T(J2)
      KX = 2
C USE LAST 4 POINTS AND CURVE B
1020 JX1 = J2-3
      RA = 0.
      GO TO 1600
C TEST FOR - - OFF LOW END, FIRST INTERVAL, OTHER
1050 IF(J-J1-1) 1080 , 1090 , 1100
1080 IF(T(J)-X) 1082,1090,1082
1082 KX = 1
      X = T(J1)
1090 JX1 = J1
      RA = 1.
      GO TO 1600
C TEST FOR LAST INTERVAL NO, YES, NO
1100 IF (J - J2) 1500,1020,1500
1500 JX1 = J-2
      RA = (T(J) - X)/(T(J) - T(J-1))
1600 RB = 1. - RA
C
C RETURN BACK TO MAIN BODY
      IF (L) 500, 100, 500
C
C COEFFICIENT ROUTINE - INPUT X, X1, X2, X3, X4, RA, RB
2000 DO 2010 J=1,3
2010 P(J) = XC(J+1)-XC(J)
      P(4)=P(1)+P(2)
      P(5)=P(2)+P(3)
      DO 2020 J=1,4
2020 D(J) = X-XC(J)
      C(1)=(RA/P(1))*(D(2)/P(4))*D(3)
      C(2)=(-RA/P(1))*(D(1)/P(2))*D(3)+(RB/P(2))*(D(3)/P(5))*D(4)
      C(3)=(RA/P(2))*(D(1)/P(4))*D(2)-(RB/P(2))*(D(2)/P(3))*D(4)
      C(4)=(RB/P(5))*(D(2)/P(3))*D(3)
C RETURN TO MAIN BODY
      IF (L) 600,200,600
      END
```

FIGURE 22. (SHEET 8 OF 8)