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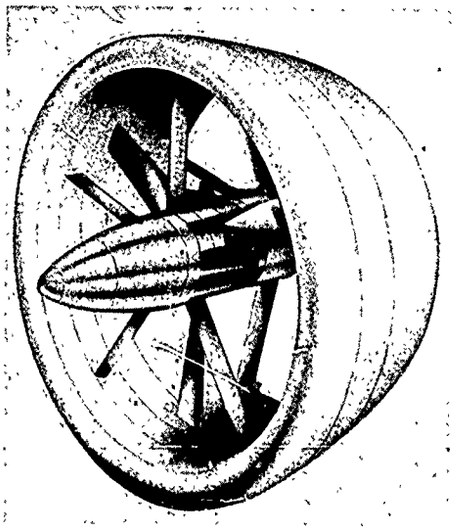
HSER 4776
VOLUME II OF II

ENGINEERING REPORT

SHROUDED PROPELLER TEST PROGRAM COMPUTER PROGRAM



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HSER 4776
VOLUME II OF II

ENGINEERING REPORT

SHROUDED PROPELLER TEST PROGRAM COMPUTER PROGRAM

PREPARED BY: Rose Worobel
R. WOROBEL – SENIOR ANALYTICAL ENGINEER

A. A. Peracchio
A. A. PERACCHIO – SENIOR ANALYTICAL ENGINEER

John H. Fidler
J. H. FIDLER – SENIOR ANALYTICAL ENGINEER

APPROVED BY: Carl Rohrbach
C. ROHRBACH – HEAD OF AERODYNAMICS & HYDRODYNAMICS

W. Fortmann
W. FORTMANN – CHIEF OF TECHNICAL STAFF

Al O. Croxall
A. D. CROXALL – CHIEF PROJECT ENGINEER

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DIVISION OF UNITED AIRCRAFT CORP

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ILLUSTRATIONS

ILLUSTRATIONS (Cont.)

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_{L_i} - 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)

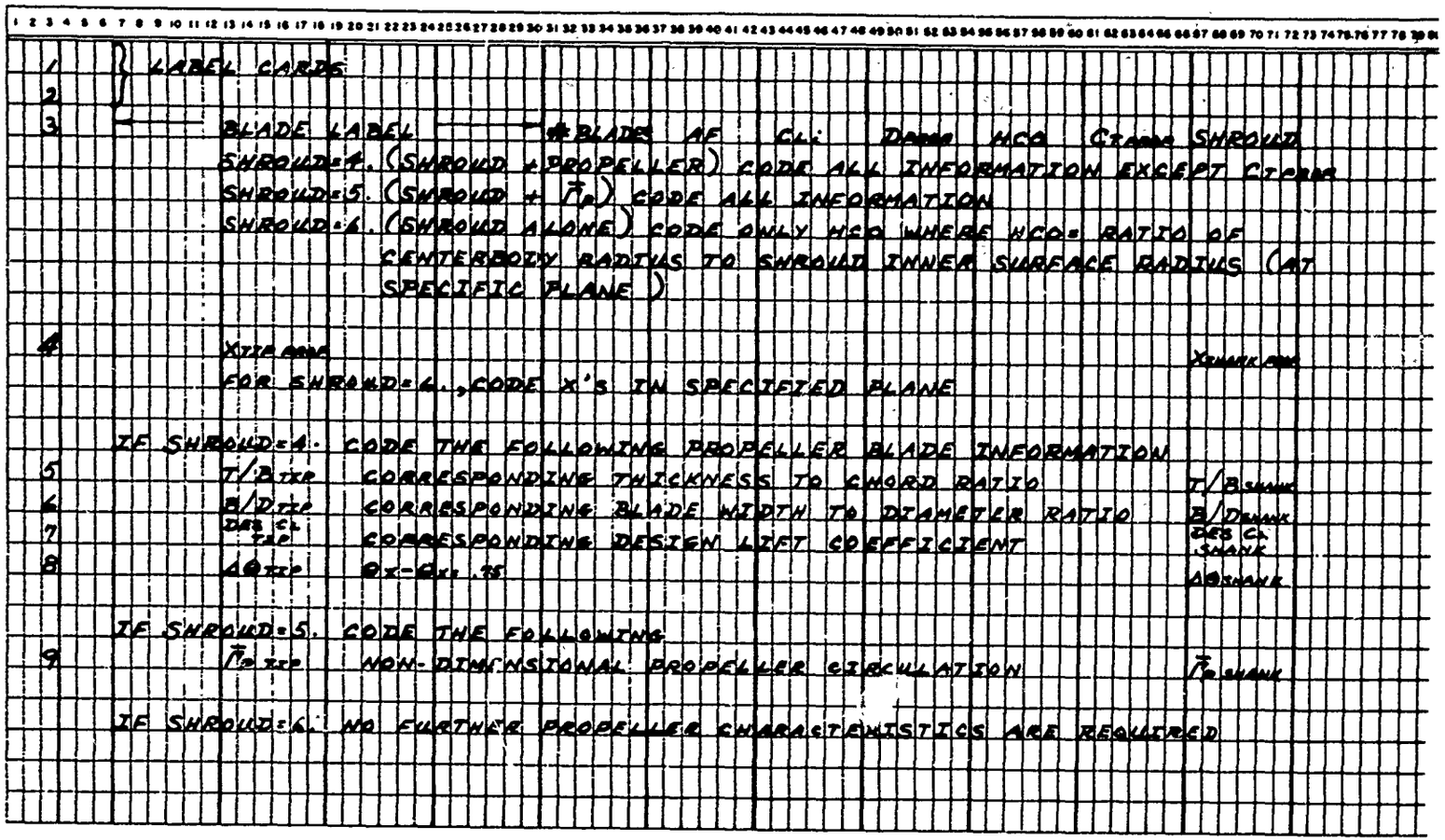
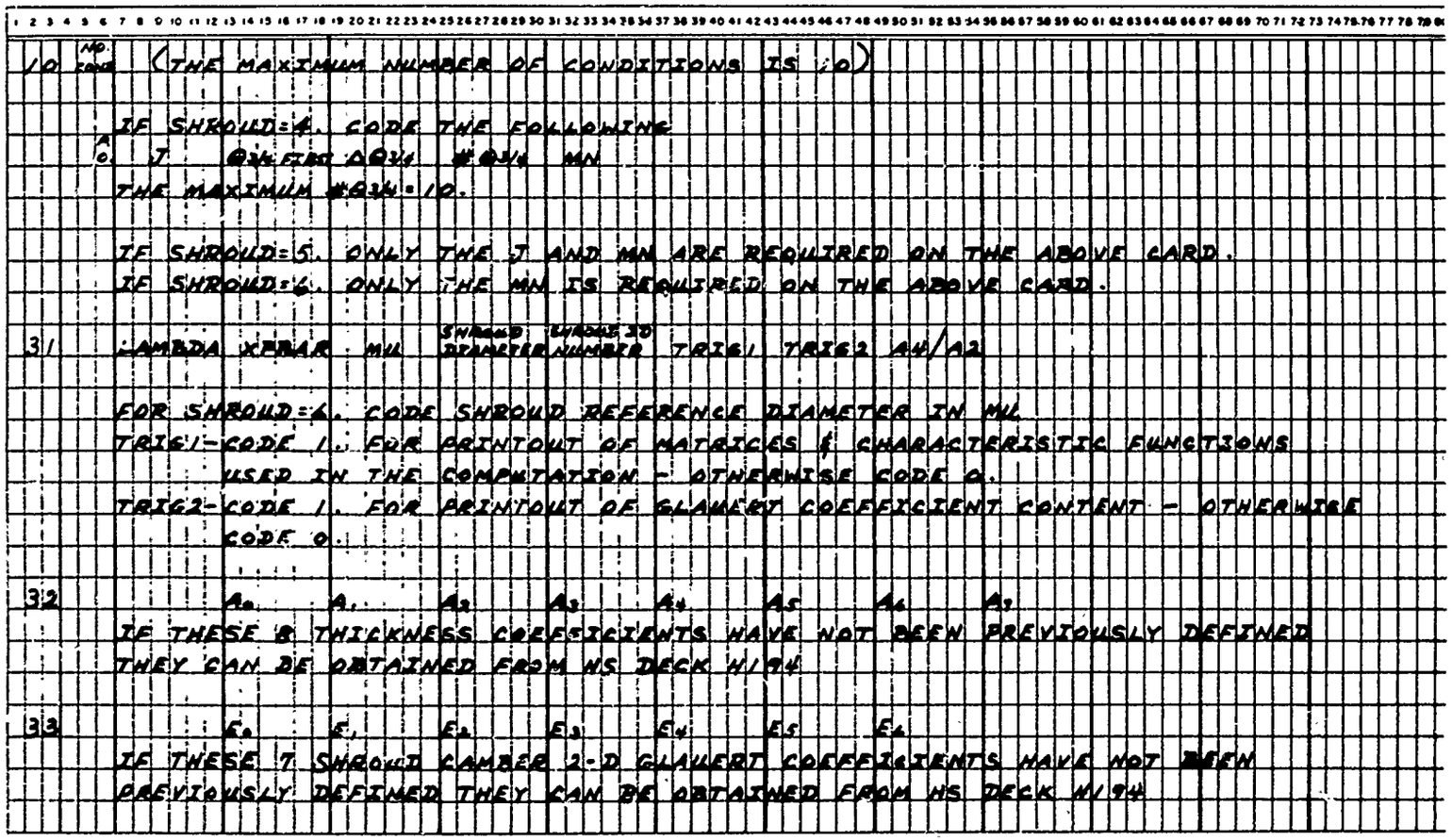


FIGURE 1. (SHEET 1 OF 4)

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



10	NO. CARDS	(THE MAXIMUM NUMBER OF CONDITIONS IS 10)
		IF SHROUD=4. CODE THE FOLLOWING
	A0.	J @M=TIP ΔQ3/4 #@3/4 MN
		THE MAXIMUM #@3/4=10.
		IF SHROUD=5. ONLY THE J AND MN ARE REQUIRED ON THE ABOVE CARD.
		IF SHROUD=6. ONLY THE MN IS REQUIRED ON THE ABOVE CARD.
31		LAMBDA XBEAR MU — SHROUD DIAMETER — CAMBER ID NUMBER — TRIG1 — TRIG2 — A4/A2
		FOR SHROUD=6. CODE SHROUD REFERENCE DIAMETER IN MU
		TRIG1-CODE 1. FOR PRINTOUT OF MATRICES & CHARACTERISTIC FUNCTIONS USED IN THE COMPUTATION - OTHERWISE CODE 0.
		TRIG2-CODE 1. FOR PRINTOUT OF GLAUERT COEFFICIENT CONTENT - OTHERWISE CODE 0.
32		A_0 A_1 A_2 A_3 A_4 A_5 A_6 A_7
		IF THESE 8 THICKNESS COEFFICIENTS HAVE NOT BEEN PREVIOUSLY DEFINED THEY CAN BE OBTAINED FROM HS DECK H194
33		E_0 E_1 E_2 E_3 E_4 E_5 E_6
		IF THESE 7 SHROUD CAMBER 2-D GLAUERT COEFFICIENTS HAVE NOT BEEN PREVIOUSLY DEFINED THEY CAN BE OBTAINED FROM HS DECK H194

FIGURE 1. (SHEET 2 OF 4)

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

```
34                  7 CENTERBODY GLAUERT COEFFICIENTS (BCB'S)
      ALL NECESSARY CENTERBODY INFORMATION CAN BE OBTAINED FROM HS DECK H060

35                  AXIAL VELOCITIES INDUCED BY CENTERBODY IN SPECIFIED PLANE-TIP TO SHANK
36  N   NUMBER      A SET IS DEFINED AS TWO CARDS HAVING THE SAME NUMBERS IN COLUMNS
36  1   OF XS'S     2 AND 3 WITH THE SECOND CARD HAVING A 1 IN COLUMN 6. THE FIRST
37                  CARD OF EACH SET CONTAINS THE SHROUD SECTIONAL XS'S IN ASCENDING
37  1               ORDER FOR PRESSURE COEFFICIENT CALCULATION. THE SECOND CARD OF
38                  EACH SET CONTAINS THE CORRESPONDING CENTERBODY INDUCED AXIAL
38  1               VELOCITIES. XS'S AND RCL ARE REPRESENTED AS A PERCENTAGE OF CHORD
39                  AND 0<XS<1.0 NSX IS THE NUMBER OF XS'S. THE MAXIMUM NUMBER OF XS'S
39  1               IS 40. THE XS'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.

I)  TO COMPUTE THE DATA CODE AS FOLLOWS
40998

II) TO INCLUDE DATA IN TABULAR FORM CODE AS FOLLOWS
40  # OF
    XS SHROUD XS'S IN ASCENDING ORDER FOLLOWED BY THE CORRESPONDING 2-D
       SHROUD THICKNESS EFFECT. MINIMUM # OF XS'S IS 4 AND THE MAXIMUM IS 20.
```

FIGURE 1. (SHEET 3 OF 4)

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

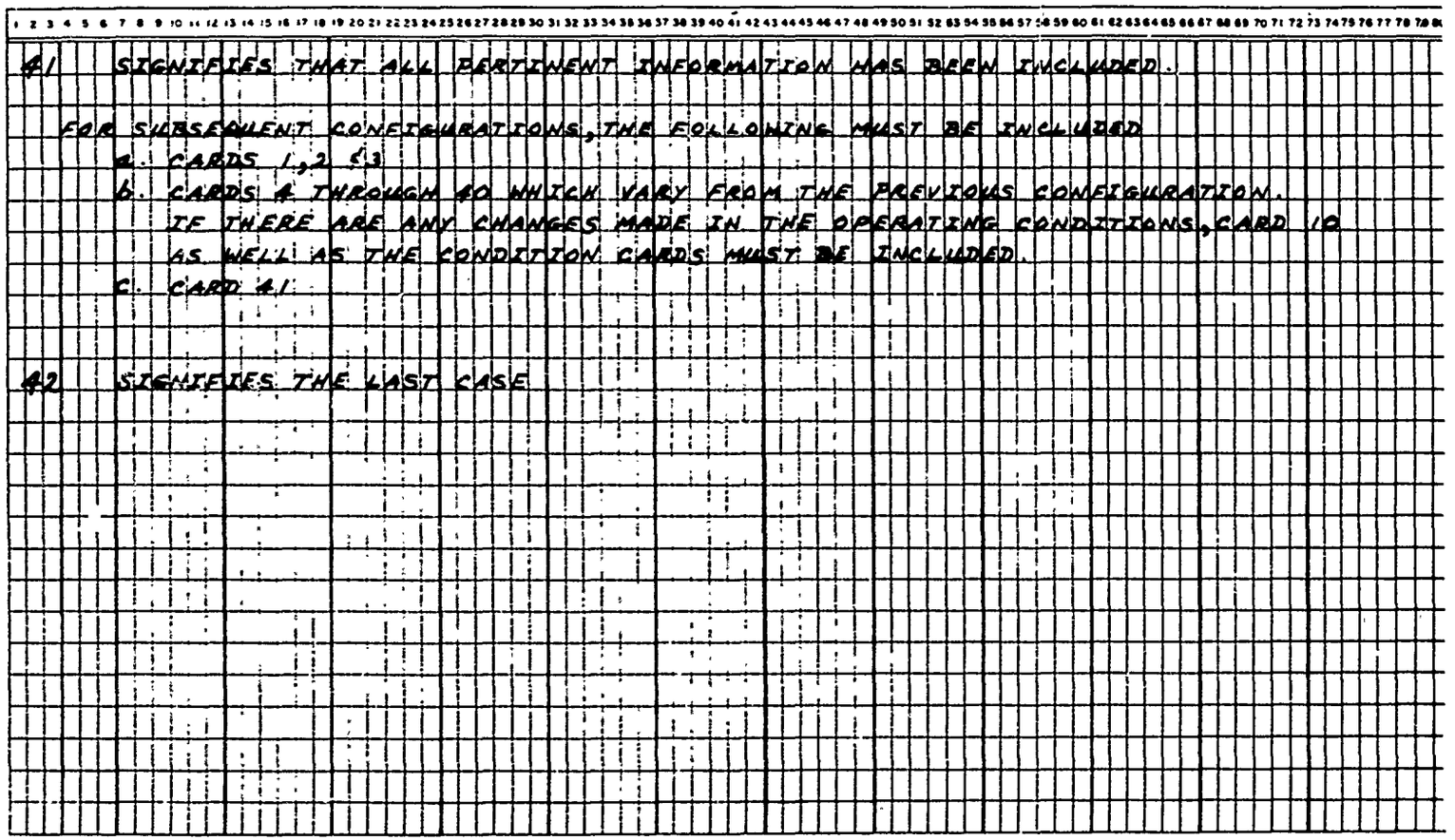


FIGURE 1. (SHEET 4 OF 4)

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.

Dprop - 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

$\mu_1 = +.4870$ $\quad$ $\mu_6 = -.0744$

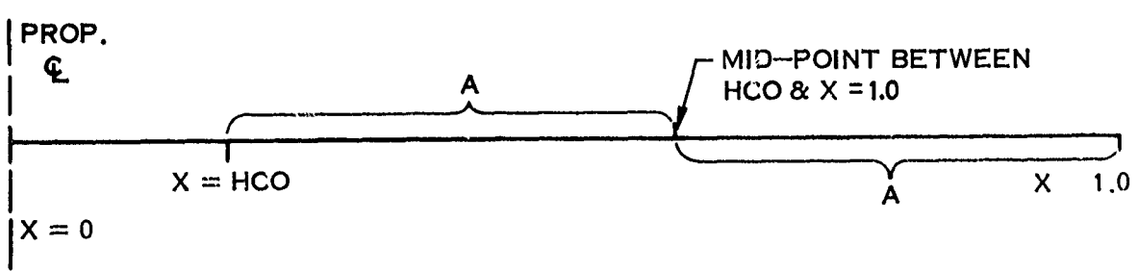
$\mu_2 = +.4325$ $\quad$ $\mu_7 = -.2167$

$\mu_3 = +.3397$ $\quad$ $\mu_8 = -.3397$

$\mu_4 = +.2167$ $\quad$ $\mu_9 = -.4325$

$\mu_5 = +.0744$ $\quad$ $\mu_{10} = -.4870$

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.

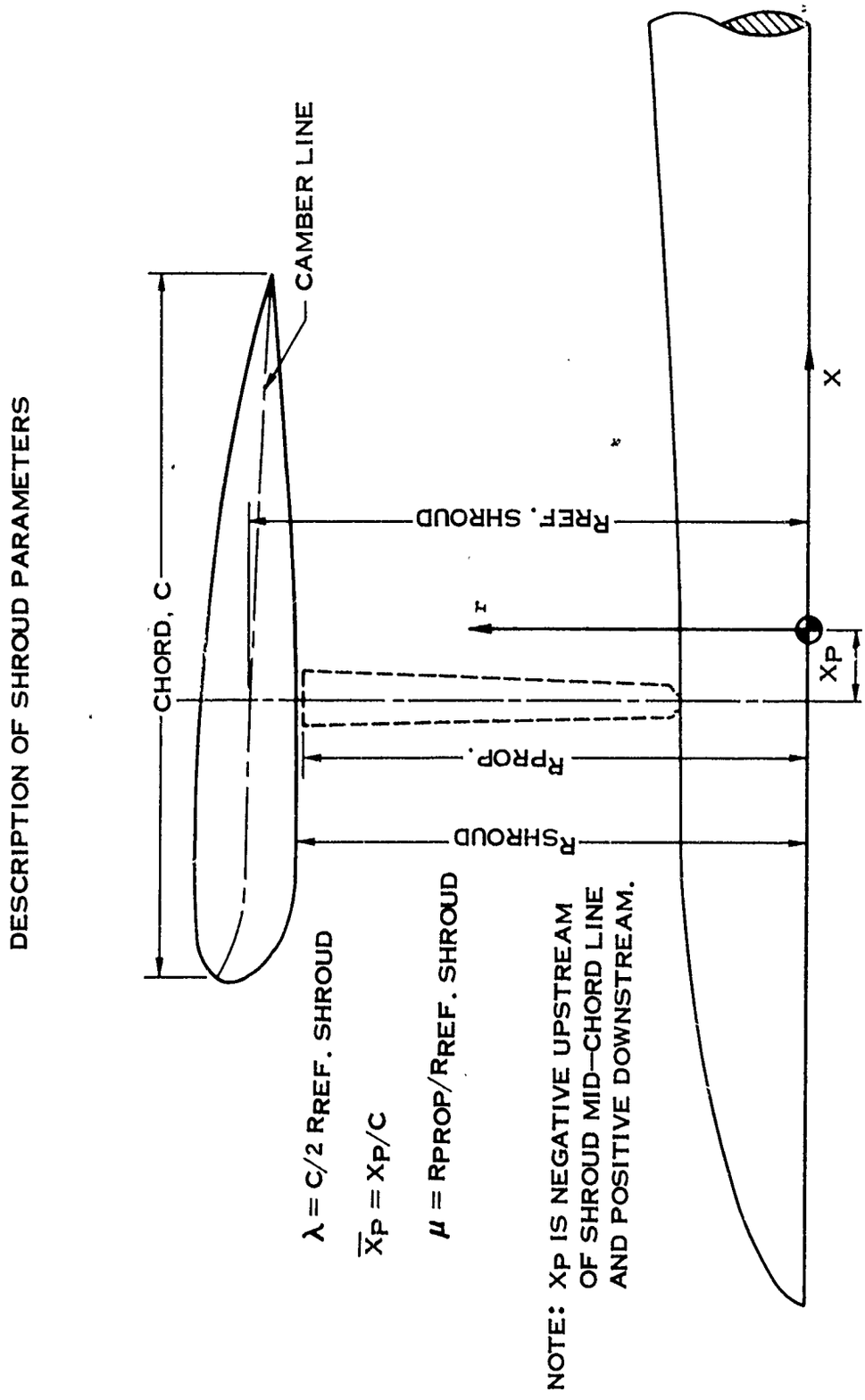

DESCRIPTION OF SHROUD PARAMETERS
CAMBER LINE
CHORD, C
X
R
REF. SHROUD
XP
RPROP.
RSHROUD
λ = C/2 RREF. SHROUD
X̄P = XP/C
μ = RPROP/RREF. SHROUD
NOTE: XP IS NEGATIVE UPSTREAM OF SHROUD MID-CHORD LINE AND POSITIVE DOWNSTREAM.

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.

A_4/A_2 - 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 specified 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 understanding 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)

Card	Cols 6–10	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
1	ROSE WOROBEL 10/13/67										
2	SAMPLE INPUT FOR HS DECK H193										
3	B1-3WT				3.	168.0	.400	2.494	.250		4.
4		.9903	.9493	.8197	.7875	.6807	.5693	.4626	.3700	.3005	.2600
5		.032	.042	.057	.077	.104	.158	.177	.214	.245	.265
6		.1192	.1165	.1125	.1065	.1000	.0928	.0862	.0800	.0760	.0735
7		.176	.339	.436	.491	.498	.470	.417	.351	.294	.257
8		-5.2	-4.7	-3.5	-1.25	3.3	9.4	16.3	23.1	28.7	52.3
10	1										
11	1.5087	42.00	0.	1.	.3053						
31	.607	-.1023	.9111	2.5	1.	1.	1.	1.1			
32		.527	.2506	-7.420	30.567	-64.69	73.819	-43.29	10.238		
33		-.510	.49422	.58942	.37482	.24726	.09510	-.0456			
34		-.0930	-.0338	.01421	-.0007	-.0009	.00004	0			
35		-.0084	-.0086	-.0089	-.0092	-.0092	-.0084	-.0067	-.0039	-.0005	.00215
36	18 .1875	.0001	.005	.0125	.025	.05	.075	.1	.15	.20	.25
		-.0053	-.0053	-.0053	-.0053	-.0052	-.0052	-.0053	-.0054	-.0057	-.0061
37		.3	.4	.5	.6	.7	.8	.9	.95		
		-.0066	-.0078	-.0091	-.0105	-.0117	-.0125	-.0128	-.0127		
40998											
41											
1	ROSE WOROBEL 10/13/67										
2	GIVEN PROPELLER CIRCULATION										
3	B1-3WT				3.	168.0	.400	2.494	.250	.225	5.
9		.1489	.1769	.1788	.1632	.1484	.1262	.0995	.0734	.0540	.0435

FIGURE 3. (SHEET 1 OF 2)

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

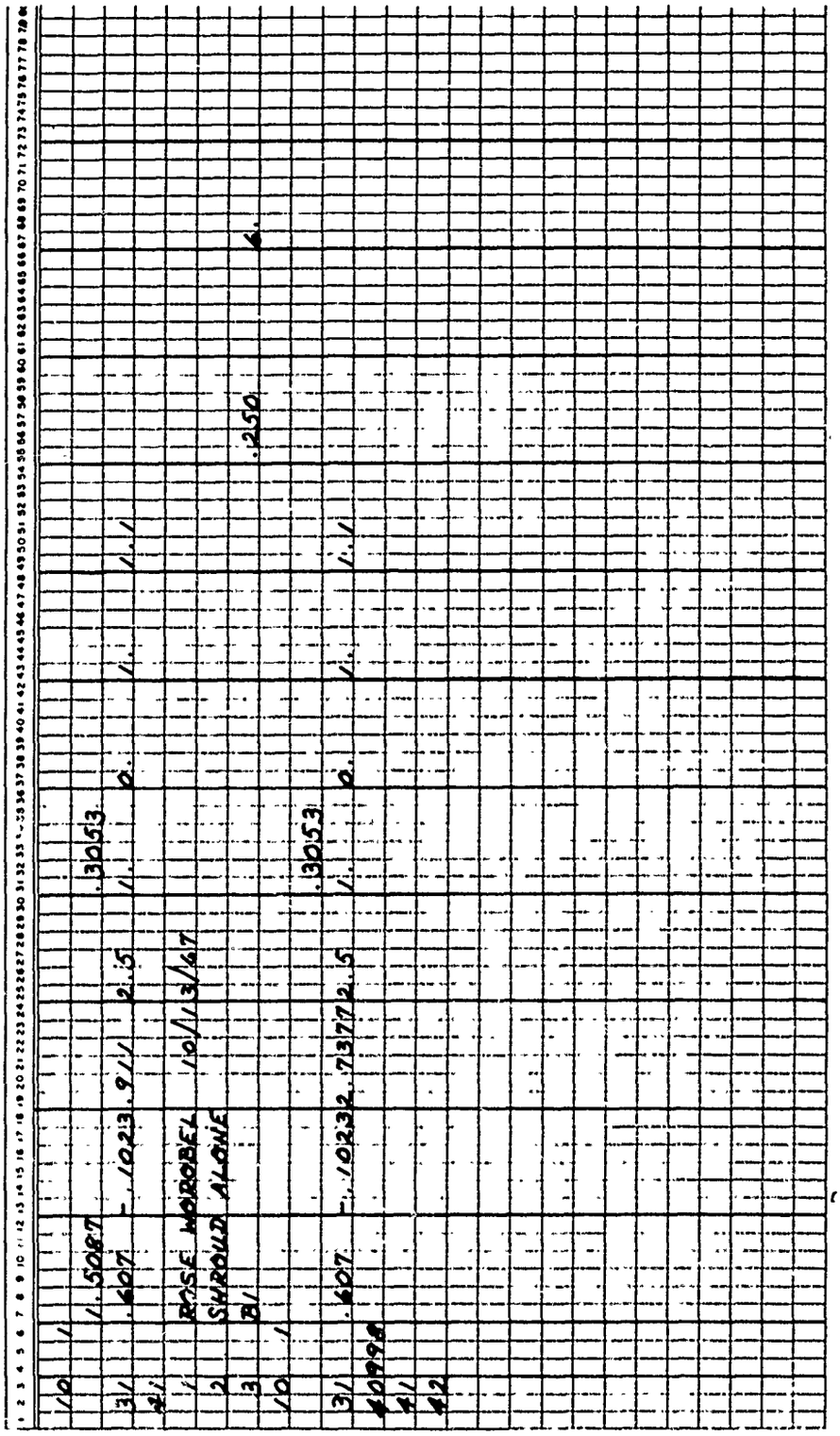


FIGURE 3. (SHEET 2 OF 2)

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-sec^2/ft^4)

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

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

where

F_D = Shroud drag (lb)

q_o = 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.

Hamilton Standard — DIVISION OF UNITED AIRCRAFT CORPORATION — UA®

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 WGROBEL 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
ROPELLER PERFORMANCE PROGRAM
AMILTON STANDARD
NDSOR 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 ****

FERS 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.

Hamilton Standard
DIVISION OF UNITED AIRCRAFT CORPORATION
UA®

SAMPLE OUTPUT FOR HAMILTON STANI
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    -.0000
   -.63085    -.00000    -.31730    -.00000     .0019
    .00633     .15863    -.00000    -.15604    -.0000
    .00374    -.00000     .10401    -.00000    -.1023
    .00008    -.00051    -.00000     .07676    -.0000
   -.00006    -.00000    -.00019    -.00000     .0610
   -.00001    -.00000    -.00000    -.00012    -.0000

TT(K,L) DATA LAMBDA=  .6070
    .02255     .00000    -.00781     .00000    -.0018
    .07153     .04805     .00000     .00417     .0000
    .01847     .00000    -.00641     .00000    -.0011
   -.00088    -.00320     .00000     .00040     .0000
   -.00002     .00000    -.00002     .00000     .0000
   -.00009    -.00012     .00000    -.00012     .0000
    .00000     .00000     .00001     .00000     .0000

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

 CHI(J,NU) INTEGRAL DATA   LAMBDA=  .607 MU=  .911 XP
                .368797    -.098303     .043780    -.
               -.070586     .024980    -.011631     .
                .162295    -.071615     .037169    -.
                .043807    -.025107     .014595    -.
               -.042131     .024995    -.016077     .
               -.023317     .016541    -.011489     .
                .011405    -.009108     .005867    -.

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   .64169   .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 —
ED SHROUD AND PROPELLER GEOMETRY

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

00   -.00000    .00910   -.00000   -.00100
00    .01588   -.00000    .00058   -.00000
99   -.00000   -.00125   -.00000    .00089
00   -.00079   -.00000    .00003   -.00000
00   -.00000    .00042   -.00000   -.00012
00   -.00119   -.00000   -.00003   -.00000
00   -.00000    .00029   -.00000   -.00014
00   -.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    -.06095
.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 ****

```
07 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

ROM 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


ROM 0 TO 7
06054  -.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.

Hamilton Standard
DIVISION OF UNITED AIRCRAFT CORPORATION
UA®

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

.5693	.33604	-.11248	-.18255	-.00312	-.03(
.4626	.21298	-.07698	-.11832	-.00357	-.02(
.3700	.13749	-.05222	-.07763	-.00299	-.01(
.3005	.09433	-.03698	-.05390	-.00236	-.01(
.2600	.07369	-.02932	-.04232	-.00196	-.00(

A.

MILTON STANDARD DECK H193 —
IED 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
82	-.00196	-.00881	-.00031	-.00225	-.00007

FIGURE 4A.
(SHEET 3 OF 5)

B.

Hamilton Standard
DIVISION OF UNITED AIRCRAFT CORPORATION
UA®

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	4.0163	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	.5894	.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 ****

	VELOCITY COMPONENTS				
SHROUD X	VORT.DIS.	2-D THICK.	3-D THICK.+ VORT.CONT.	PROP WAKE	CB EFF
.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

053 CP= .4292

057

= 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
9449
5809
3917
2463
0952
0296

ICIENTS ****

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

FIGURE 4A.
(SHEET 4 OF 5)

B1

Hamilton Standard
DIVISION OF UNITED AIRCRAFT CORPORATION
UA®

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	.5
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 –
HROUD 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.

Hamilton Standard
DIVISION OF UNITED AIRCRAFT CORPORATION
UA®

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

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

```
1   ROSE WOROBEL  10/13/67
2   GIVEN PROPELLER CIRCULATION

**** 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
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
```

TON STANDARD DECK H193 —
SHROUD AND PROPELLER CIRCULATION

MPUTER DECK H193
PELLER PERFORMANCE PROGRAM
ILTON STANDARD
SOR LOCKS, CONN.
1967

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

.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

S AND GIVEN PROPELLER CIRCULATION ****

FIGURE 4B.
(SHEET 1 OF 3)

B.

Hamilton Standard
DIVISION OF UNITED AIRCRAFT CORPORATION
U A®

SAMPLE OUTPUT FOR HAMILTON STANDARI
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	-.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	-.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 ****

	-------- VELOCITY COMPONENTS --------				
SHROUD X/	VORT.DIS.	2-D THICK.	3-D THICK.+ VORT.CONT.	PROP WAKE	C
.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.

LTON STANDARD DECK H193
D SHROUD AND PROPELLER CIRCULATION

.2102
-.0148
.0216
.2250

= 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-D
76 -.3719
19 .4449
01 .6509
11 .3917
70 .2463
56 .0952
03 -.0296

COEFFICIENTS ****

S ---------

.+			OUTER SURFACE		INNER SURFACE	
T.	PROP WAKE	CB EFF.	V/VINF	CPRESS	V/VINF	CPRESS
					-.8568	.2659
645	.01550	-.00530	.9492	.0990	-.7374	.4562
477	.01559	-.00530	1.3318	-.7738	.0991	.9902
238	.01572	-.00530	1.4281	-1.0394	.5696	.6755
889	.01595	-.00530	1.4596	-1.1304	.9685	.0619
350	.01640	-.00520	1.4248	-1.0301	1.3152	-.7298
987	.01685	-.00520	1.3605	-.8510	1.4275	-1.0378
762	.01730	-.00530	1.2982	-.6852	1.4408	-1.0758
602	.01813	-.00540	1.2111	-.4667	1.3614	-.8534
672	.01875	-.00570	1.1738	-.3777	1.2572	-.5807

FIGURE 4B.
(SHEET 2 OF 3)

B.

Hamilton Standard
DIVISION OF UNITED AIRCRAFT CORPORATION
UA®

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

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

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

SAMPLE OUTPUT FOR HAI
SAMPLE CASE FOR SHROU

HS COMPUTER DECK H19
HS SHROUDED PROPELLER PERFORMA
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.

TPUT FOR HAMILTON STANDARD DECK H193 —
SE FOR SHROUD ALONE

```
MPUTER DECK H193
PELLER PERFORMANCE PROGRAM
ILTON STANDARD
SOR 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)

B.

Hamilton Standard
DIVISION OF UNITED AIRCRAFT CORPORATION
UA®

SAMPLE OUTPUT FOR HA
SAMPLE CASE FOR SHRC

*** 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	.56
CENTERBODY DV/V0=	-.0084	-.0086	-.0089	-.0092	-.0092	-.00
SHROUD T/C DV/V0=	.1319	.1258	.1155	.1025	.0893	.07
VORTICITY DV/V0=	-.1181	-.1145	-.1102	-.1065	-.1032	-.10
TOTAL V/V0=	1.0054	1.0027	.9964	.9869	.9769	.96

**** 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	-.0031	.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	

A1

OUTPUT FOR HAMILTON STANDARD DECK H193 —
CASE FOR SHROUD ALONE

.0079

.9825

875	.6807	.5693	.4626	.3700	.3005	.2600
092	-.0092	-.0084	-.0067	-.0039	-.0005	.0021
025	.0893	.0781	.0699	.0645	.0613	.0599
065	-.1032	-.1004	-.0980	-.0963	-.0951	-.0946
869	.9769	.9693	.9652	.9643	.9657	.9675

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

OEFFICIENTS ****

	PROP WAKE	CB EFF.	OUTER SURFACE V/VINF	OUTER SURFACE CPRESS	INNER SURFACE V/VINF	INNER SURFACE CPRESS
					-1.0697	-.1443
53	.00000	-.00530	1.1557	-.3356	-.9511	.0954
51	.00000	-.00530	1.4843	-1.2030	-.0951	.9910
56	.00000	-.00530	1.5477	-1.3954	.3939	.8448
76	.00000	-.00530	1.5515	-1.4071	.8101	.3437
19	.00000	-.00520	1.4897	-1.2192	1.1750	-.3806
17	.00000	-.00520	1.4111	-.9911	1.2980	-.6849
91	.00000	-.00530	1.3396	-.7945	1.3187	-.7391
79	.00000	-.00540	1.2413	-.5407	1.2494	-.5611
79	.00000	-.00570	1.1965	-.4317	1.1528	-.3290
58	.00000	-.00610	1.1852	-.4047	1.0763	-.1585
37	.00000	-.00660	1.1882	-.4118	1.0291	-.0590
72	.00000	-.00780	1.1897	-.4154	1.0035	-.0070
55	.00000	-.00910	1.1572	-.3391	1.0124	-.0250
32	.00000	-.01050	1.1070	-.2253	1.0025	-.0050

FIGURE 4C.
(SHEET 2 OF 3)

B.

Hamilton Standard
DIVISION OF UNITED AIRCRAFT CORPORATION

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

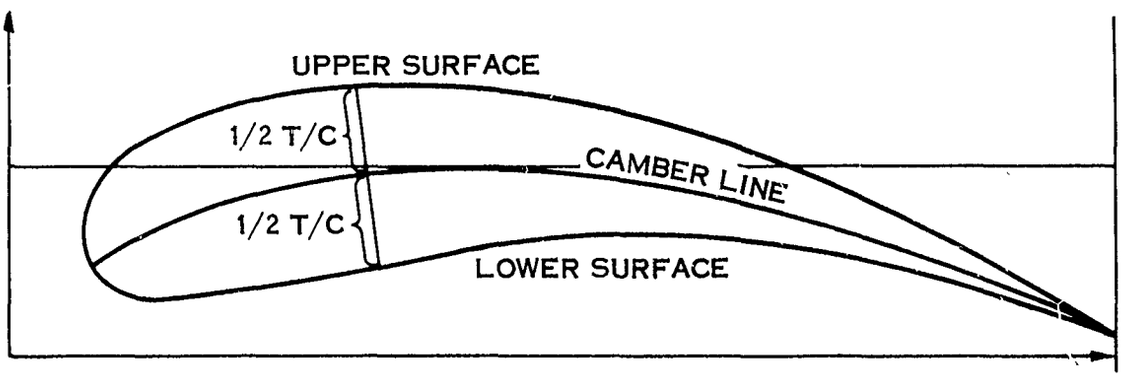
A. Deck: Hamilton Standard Deck H194

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

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

where

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

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	LABEL CARD
2	CARDS 2 THROUGH 7 DEFINE THE TABLE OF THE SLOPE OF THE SHROUD CAMBER LINE.
3	#X_s'S FOLLOWED BY X_s'S THEMSELVES IN ASCENDING ORDER FOLLOWED BY THE
4	CORRESPONDING SLOPES OF THE CAMBER LINE. THE MAXIMUM NUMBER OF X_s'S = 32.
5	USE ONLY THE NUMBER OF CARDS NECESSARY.
6	
7	
	CARDS 8 & 9 DEFINE THE SHROUD THICKNESS, T/C
8	$X_s(1)$ 7 X_s'S SELECTED TO DEFINE T/C $X_s(7)$
9	T/C(i) CORRESPONDING T/C'S T/C(7)
10	A_0 (DEFINED IN TEXT)
11	OPTION, TRIG

WHERE OPTION=0. COMPUTES T/C AND CAMBER LINE COEFFICIENTS (INCLUDE CARDS 1 THROUGH 11)
OPTION=1. COMPUTES CAMBER LINE COEFFICIENTS ONLY (INCLUDE CARDS 1 THROUGH 7 & 11)
OPTION=2. COMPUTES T/C COEFFICIENTS ONLY (INCLUDE CARDS 1 & 8 THROUGH 11)

FIGURE 5. (SHEET 1 OF 2)

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

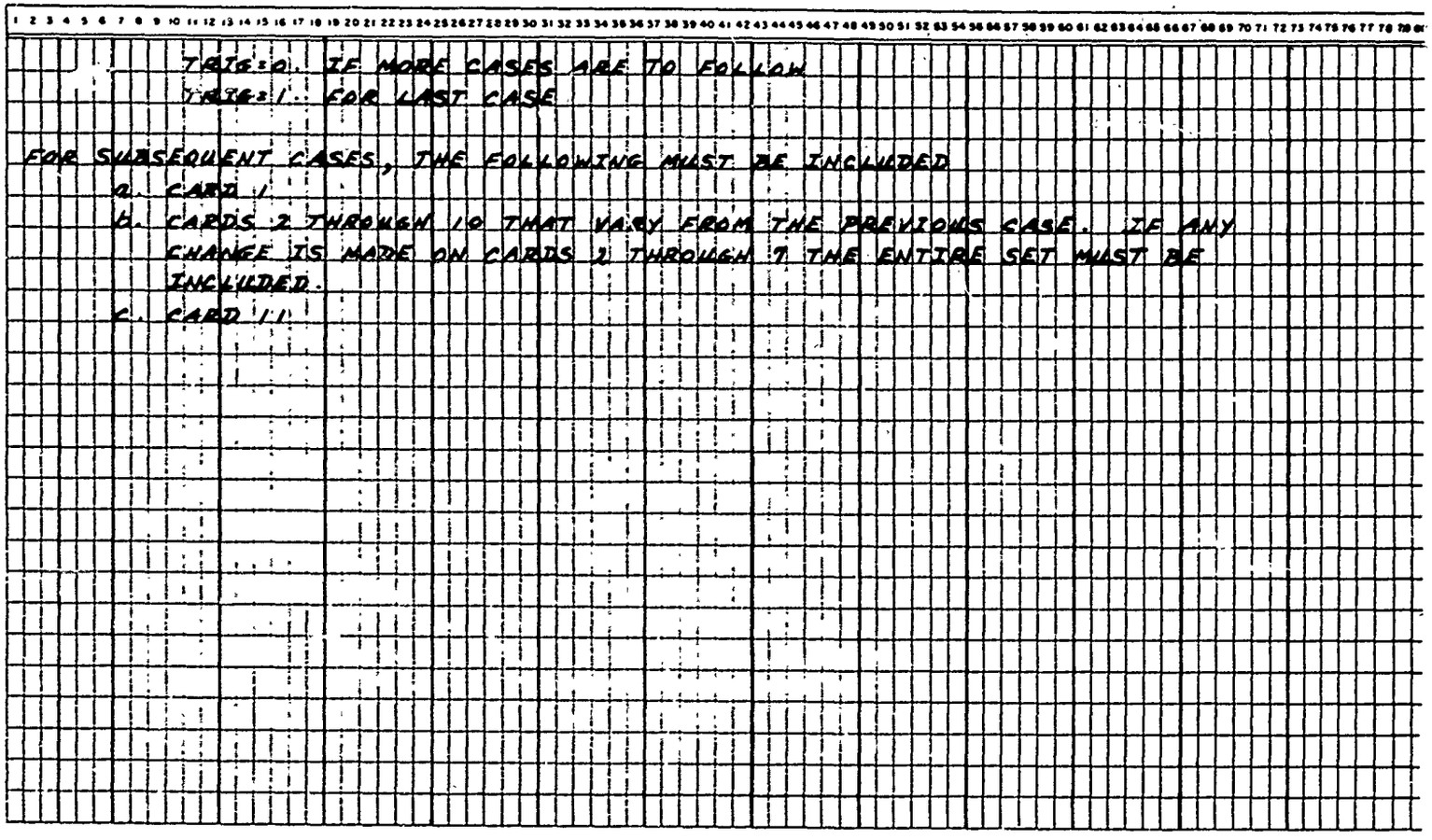


FIGURE 5. (SHEET 2 OF 2)

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 adviseable 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)

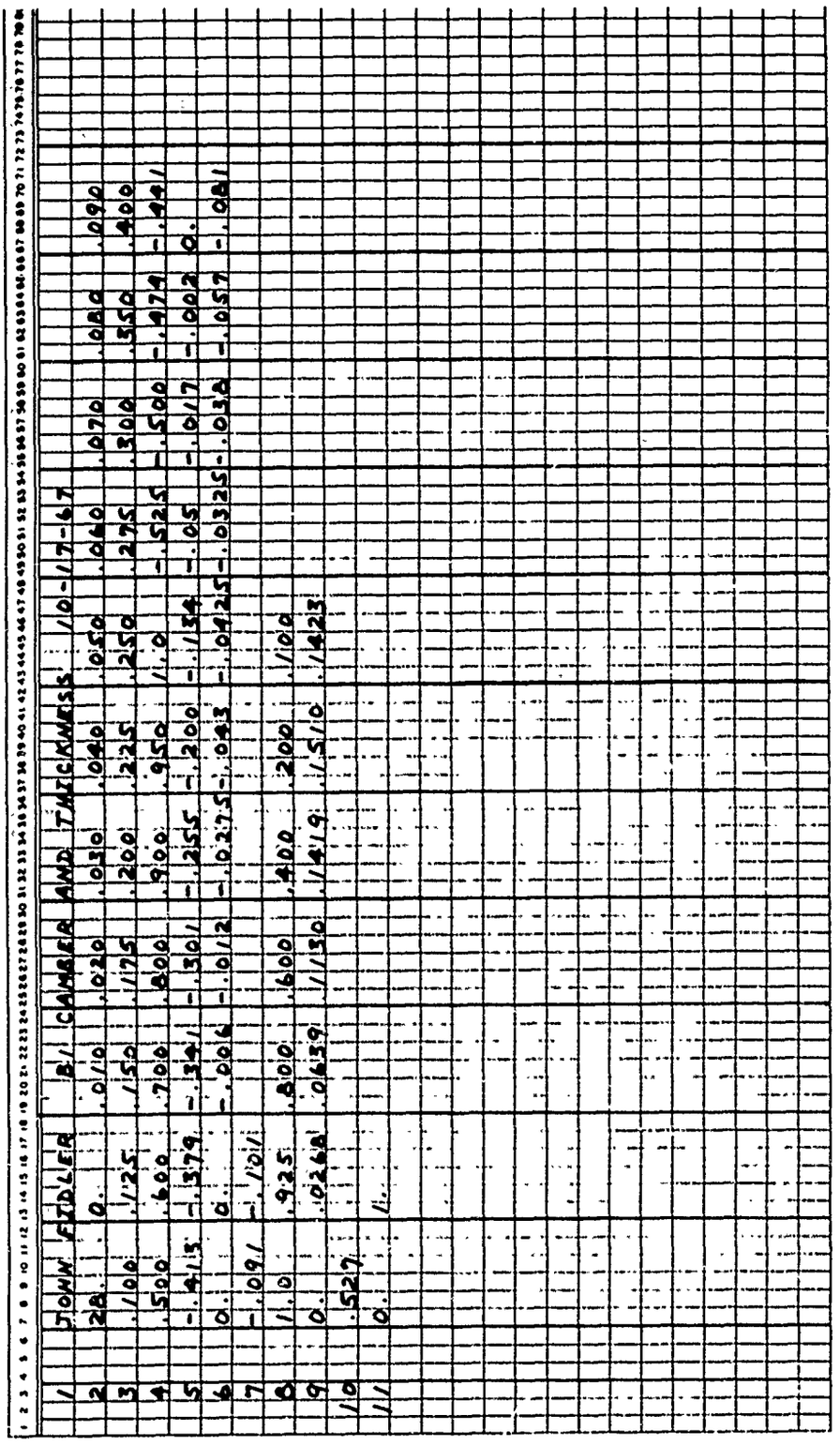


FIGURE 6.

Hamilton Standard — DIVISION OF UNITED AIRCRAFT CORPORATION

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
OUD GEOMETRY PROGRAM
AMILTON STANDARD
NDSOR LOCKS, CONN.
      1967
7

FFICIENTS ****

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

****
6 -43.2923  10.2375
```

FIGURE 7.
(SHEET 1 OF 2)

B.

Hamilton Standard
DIVISION OF UNITED AIRCRAFT CORPORATION
UA®

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	.101604
.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)

B.

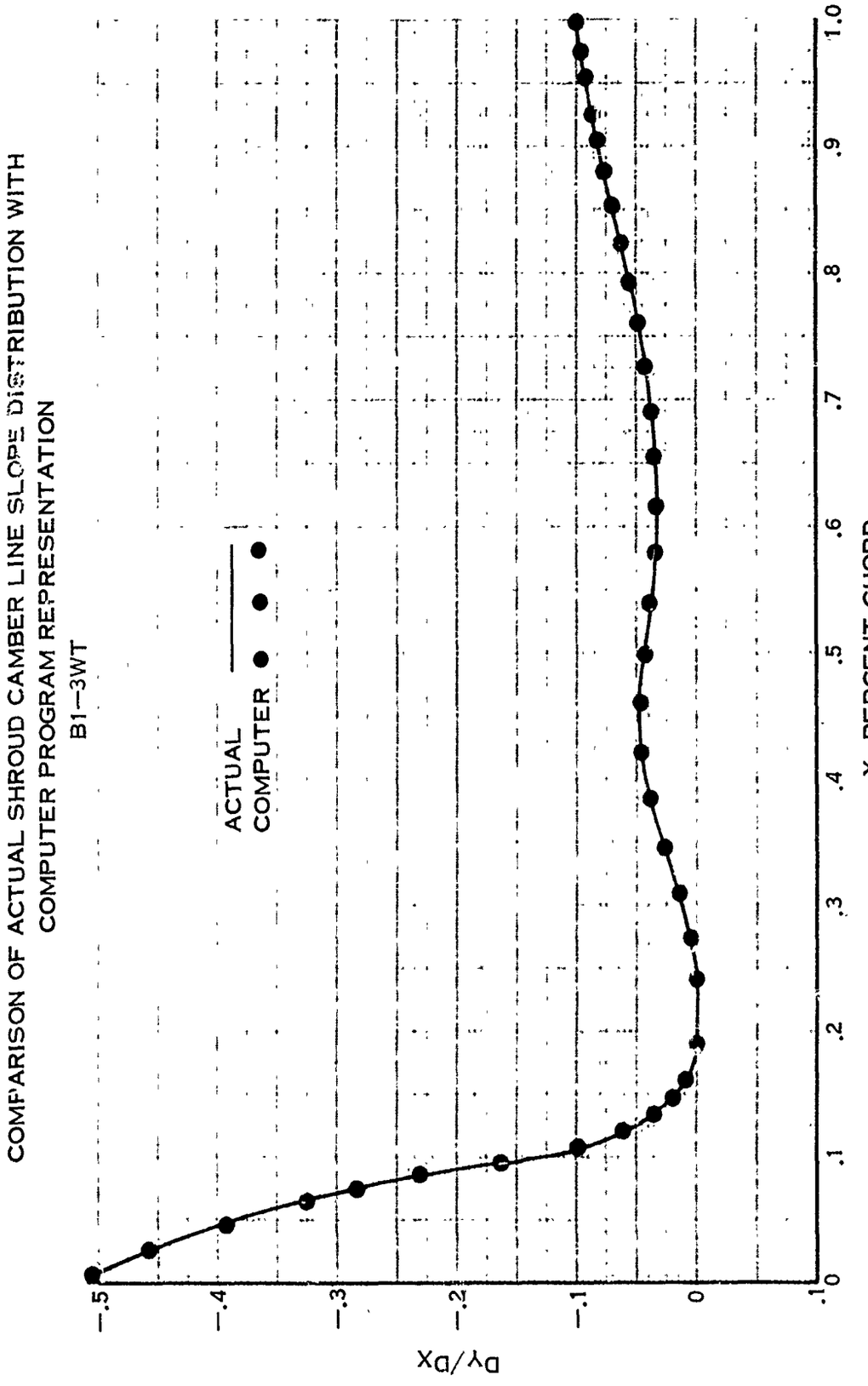

COMPARISON OF ACTUAL SHROUD CAMBER LINE SLOPE DISTRIBUTION WITH COMPUTER PROGRAM REPRESENTATION
B1—3WT
ACTUAL
COMPUTER
dy/dx
X, PERCENT CHORD
-.5
-.4
-.3
-.2
-.1
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIGURE 8.

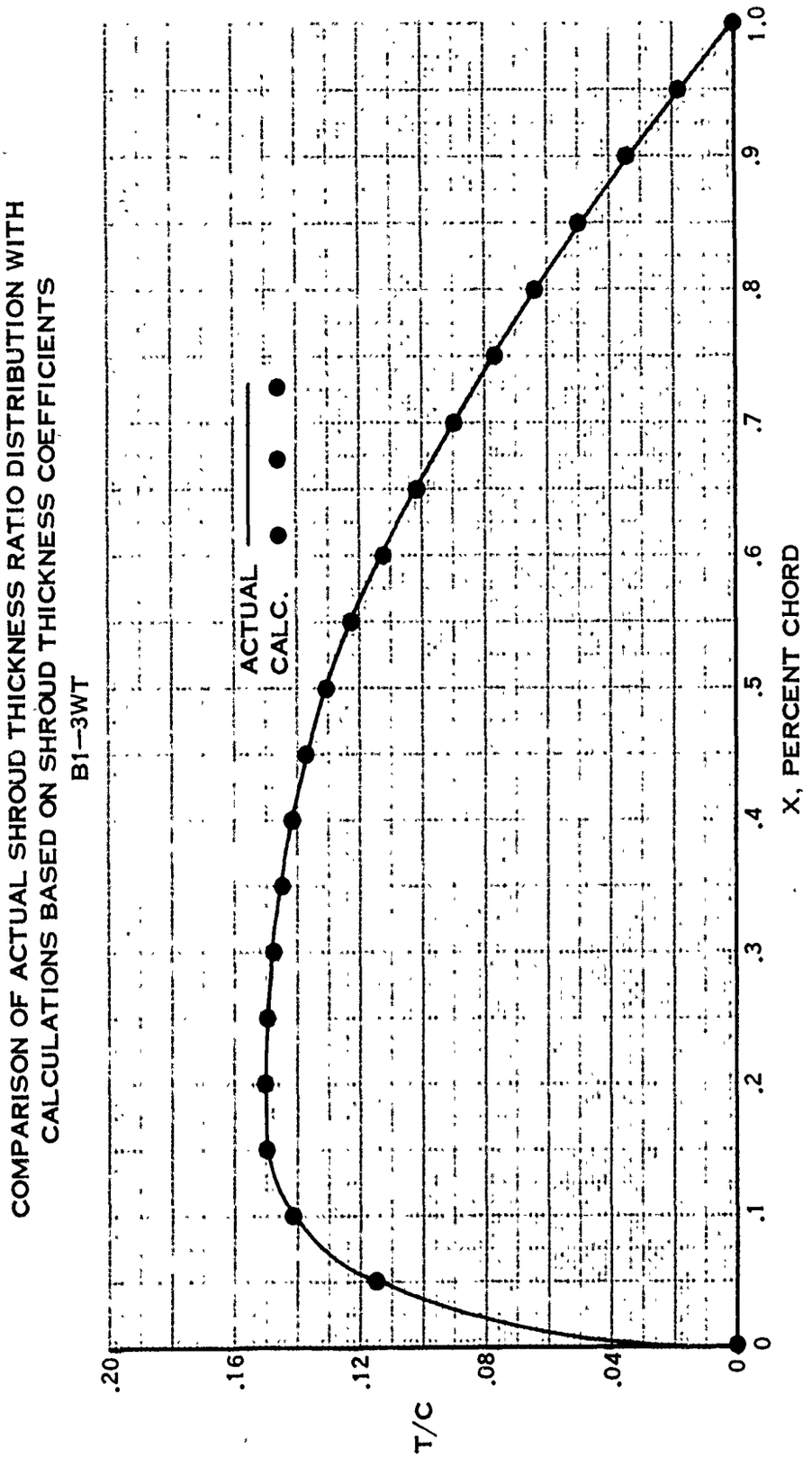

COMPARISON OF ACTUAL SHROUD THICKNESS RATIO DISTRIBUTION WITH CALCULATIONS BASED ON SHROUD THICKNESS COEFFICIENTS
B1—3WT
ACTUAL
CALC.
T/C
.20
.16
.12
.08
.04
0
X, PERCENT CHORD
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

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

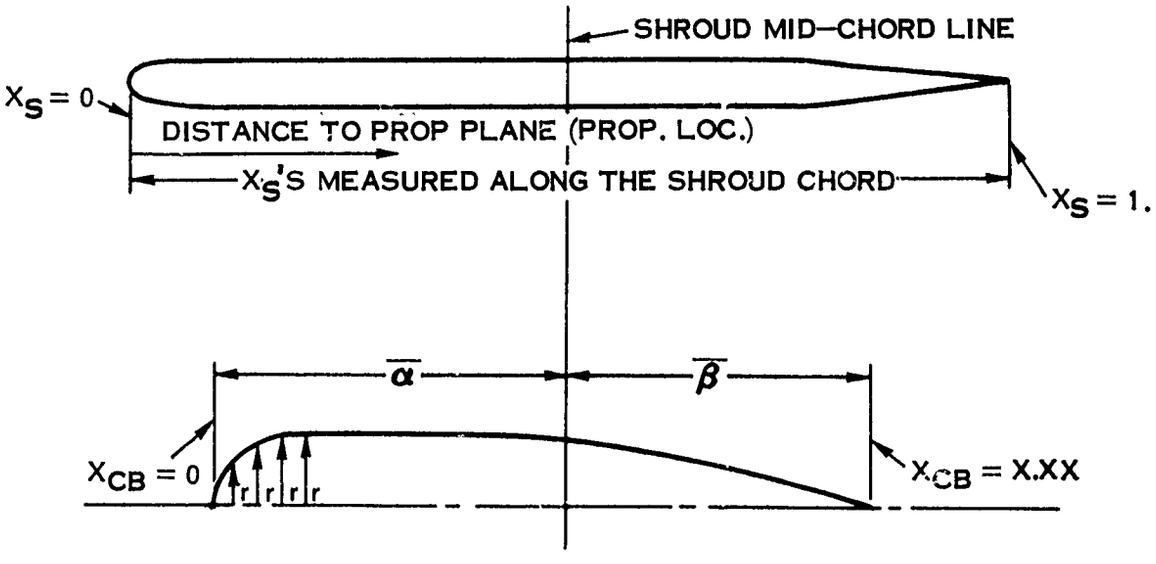
The method of sources and sinks has been employed to approximate the desired body shape. The method of least squares has been used to calculate a seventh order polynominal representative of the source-sink distribution. This distribution is employed to calculate the radial and axial velocity ratios induced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

#X_{CB}'s - The number of points which will be used in the least squares representation of the centerbody by the seventh order polynominal.

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)

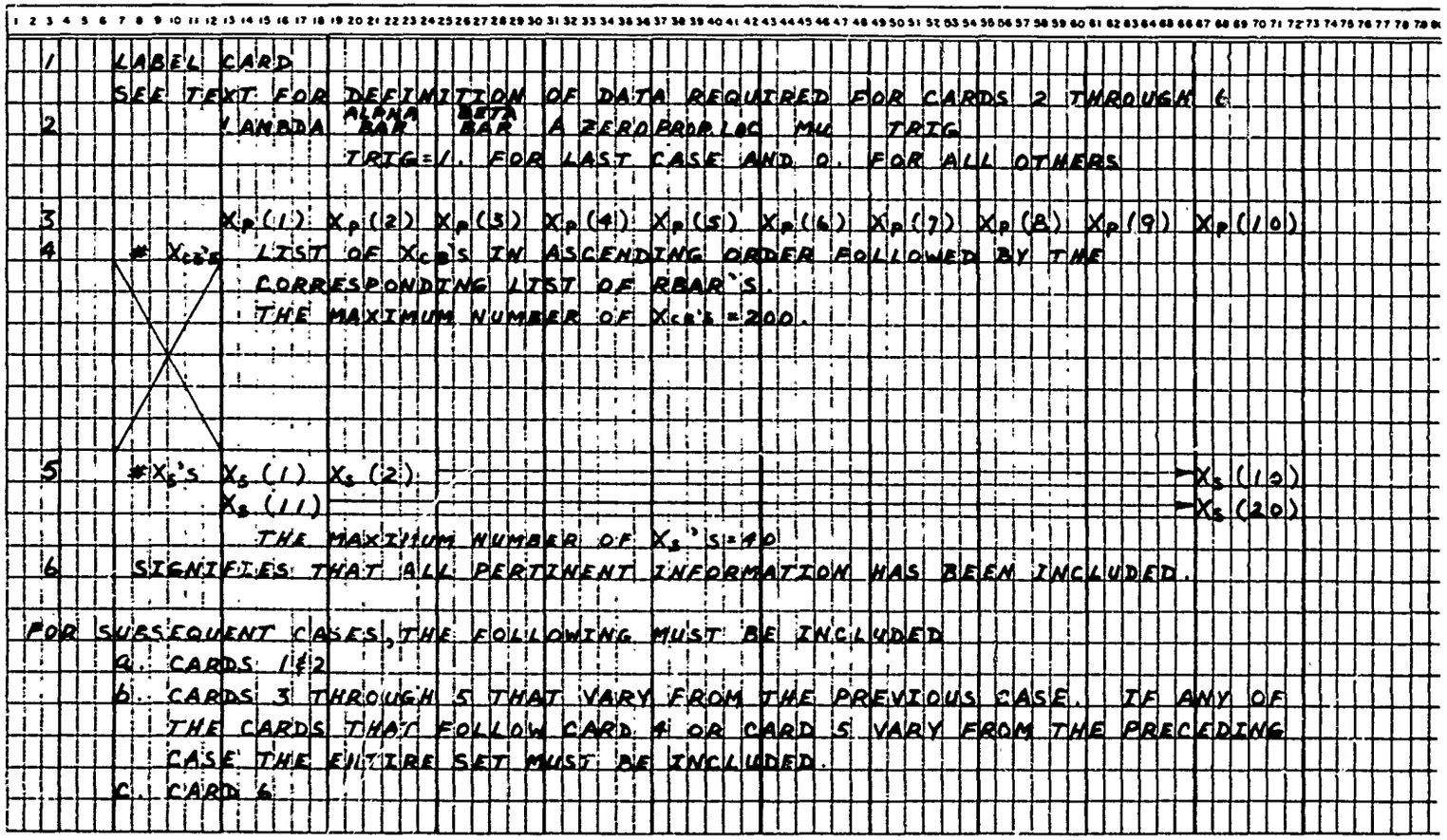


FIGURE 10.

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)

1		JOHN FIDLER	BI-ADJ. PTR	L.E. = .656	10-17-67						
2		.607	1.15944	.8089	.01998	.48264	.911	1.			
3		.9903	.9493	.8797	.7875	.6807	.5693	.4626	.3700	.3005	.2600
4	200.	0.	.0088	.01205	.01761	.02105	.02635	.03105	.0352	.0391	.044
		.0601	.0880	.1103	.1321	.1503	.1760	.1904	.2200	.2305	.2405
		.2505	.2635	.2770	.2808	.2940	.3080	.3140	.3210	.3360	.3520
		.3615	.3710	.3840	.3970	.4090	.4210	.4300	.4400	.4840	.5275
		.572	.616	.660	.704	.748	.792	.835	.880	.927	.975
		1.014	1.053	1.076	1.096	1.130	1.163	1.190	1.218	1.236	1.253
		1.268	1.280	1.291	1.304	1.321	1.340	1.351	1.363	1.381	1.401
		1.411	1.422	1.441	1.462	1.478	1.494	1.510	1.523	1.540	1.553
		1.570	1.583	1.600	1.613	1.630	1.644	1.660	1.673	1.690	1.705
		1.720	1.732	1.750	1.764	1.780	1.795	1.810	1.825	1.854	1.884
		1.914	1.945	1.964	1.985	2.030	2.070	2.080	2.092	2.110	2.130
		2.140	2.155	2.170	2.190	2.200	2.205	2.230	2.250	2.272	2.295
		2.301	2.312	2.320	2.335	2.358	2.375	2.400	2.432	2.460	2.490
		2.520	2.555	2.585	2.615	2.645	2.678	2.713	2.745	2.772	2.800
		2.832	2.866	2.900	2.925	2.958	2.985	3.015	3.040	3.073	3.100
		3.135	3.170	3.225	3.286	3.350	3.410	3.470	3.530	3.590	3.650
		3.715	3.780	3.840	3.900	3.960	4.020	4.080	4.140	4.200	4.260
		4.320	4.390	4.450	4.510	4.570	4.630	4.690	4.750	4.810	4.870
		4.930	4.990	5.050	5.110	5.170	5.230	5.300	5.360	5.420	5.480
		5.540	5.600	5.650	5.710	5.780	5.840	5.860	5.890	5.910	5.9683
		0.	.02378	.0274	.0336	.0369	.0417	.0461	.0491	.0521	.0556
		.0665	.0825	.1003	.1036	.1154	.1205	.1263	.1354	.1394	.1414

FIGURE 11. (SHEET 1 OF 2)

SAMPLE INPUT FOR HAMILTON STANDARD DECK H060 (CENTERBODY PROGRAM)

```
                                .1450  .1485  .1510  .1535  .1570  .1602  .1626  .1655  .1680  .1710
                                .1738  .1764  .1784  .1805  .1824  .1845  .1870  .1891  .1961  .2032
                                .2090  .2143  .2184  .2224  .2250  .2273  .2280  .2285  .2285  .2285
                                .2285  .2285  .2285  .2285  .2295  .2305  .2310  .2315  .2320  .2330
                                .2540  .2345  .2360  .2375  .2580  .2385  .2395  .2408  .2420  .2435
                                .2440  .2457  .2470  .2478  .2492  .2505  .2518  .2530  .2535  .2540
                                .2552  .2560  .2561  .2562  .25625 .2564  .2570  .2585  .2595  .2600
                                .2602  .2605  .2610  .2615  .2620  .2625  .2635  .2645  .2652  .2660
                                .2672  .2678  .2682  .2686  .2712  .2738  .2752  .2765  .2780  .2800
                                .2815  .2825  .2841  .2860  .2880  .2908  .2930  .2955  .3000  .3045
                                .3060  .3072  .3140  .5208  .3225  .3247  .3330  .3410  .3510  .3600
                                .3720  .3840  .3975  .4110  .4240  .4360  .4470  .4575  .4690  .4810
                                .4900  .4990  .5090  .5170  .5270  .5360  .5440  .5510  .5570  .5620
                                .5680  .5725  .5800  .5870  .5900  .5930  .5920  .5910  .5895  .5875
                                .5860  .5850  .5810  .5780  .5750  .5720  .5680  .5620  .5570  .5510
                                .5440  .5360  .5300  .5230  .5170  .5110  .5000  .4900  .4780  .4670
                                .4580  .4490  .4530  .4170  .4000  .3830  .3650  .3470  .3270  .3075
                                .2805  .2600  .2230  .1948  .1560  .1147  .1003  .0752  .0556  0.
  5     18                      .0001  .005   .0125  .025   .050   .075   .100   .150   .200   .250
                                .3     .4     .5     .6     .7     .8     .9     .95
  6
```

FIGURE 11. (SHEET 2 OF 2)

Hamilton Standard
DIVISION OF UNITED AIRCRAFT CORPORATION
U A®

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 BAR = 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	CAL
.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)

OMPUTER DECK H060
NDUCED VELOCITIES PROGRAM
MILTON STANDARD
DSOR 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	.24598	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.

Hamilton Standard
DIVISION OF UNITED AIRCRAFT CORPORATION
U A®

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 DISTRIBU

-.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)

.28150	.31538	4.75000	.49000	.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	.19480	.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.

Hamilton Standard
DIVISION OF UNITED AIRCRAFT CORPORATION
UA®

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

A.

STANDARD DECK H060 (CENTERBODY PROGRAM)

FIGURE 12.
(SHEET 3 OF 3)

B.

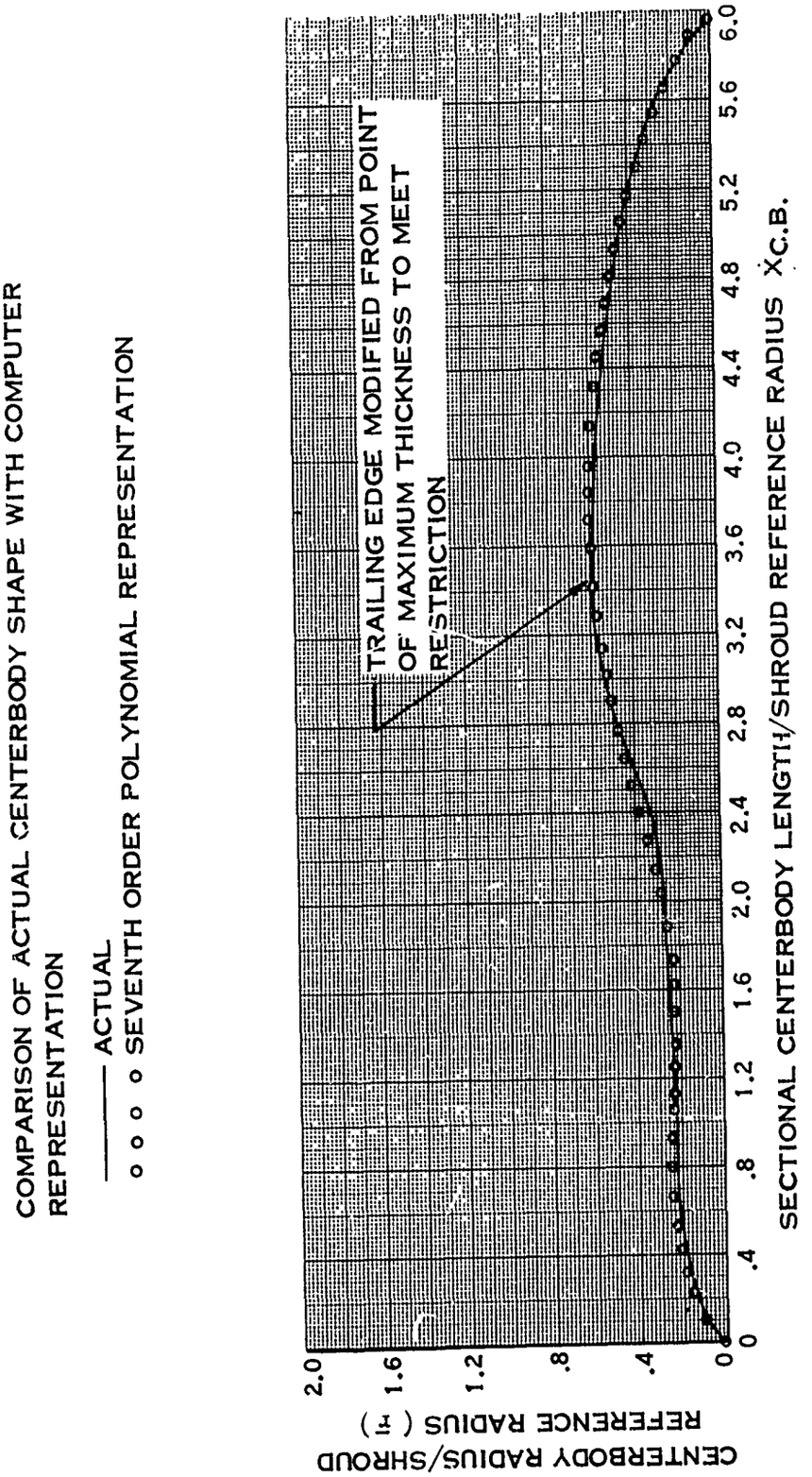

COMPARISON OF ACTUAL CENTERBODY SHAPE WITH COMPUTER REPRESENTATION
ACTUAL
o o o o SEVENTH ORDER POLYNOMIAL REPRESENTATION
TRAILING EDGE MODIFIED FROM POINT OF MAXIMUM THICKNESS TO MEET RESTRICTION
CENTERBODY RADIUS/SHROUD REFERENCE RADIUS (r/r)
SECTIONAL CENTERBODY LENGTH/SHROUD REFERENCE RADIUS Xc.B.
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
4.0
4.4
4.8
5.2
5.6
6.0

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

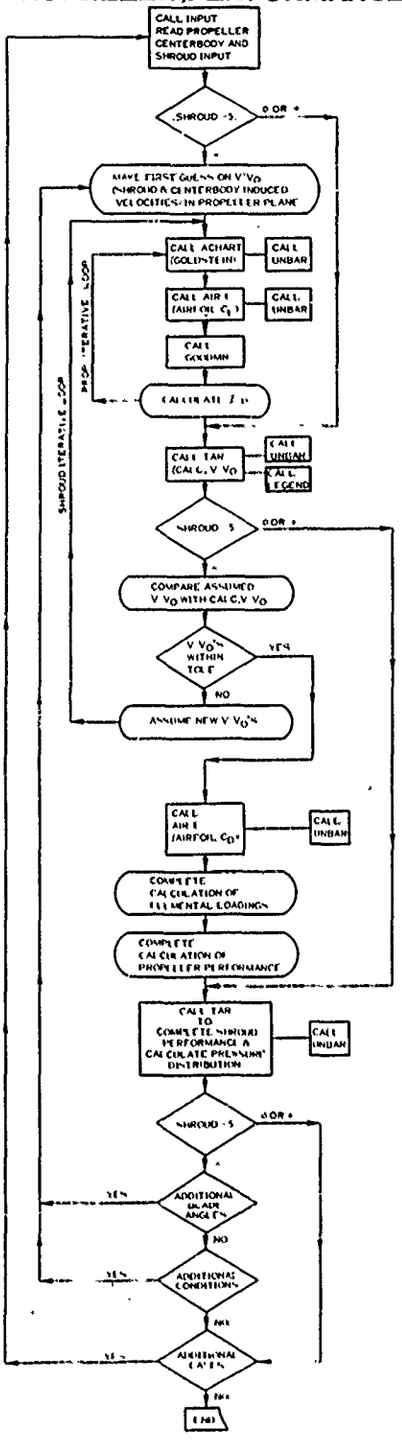


FIGURE 14.

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

FORTRAN 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(10,5),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),ZMCRIT(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    , 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     , 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       , XI      , XNSS    , XPB
      COMMON Y1      , Y2
      COMMON ZIP1    , ZJ      , ZJ1     , ZM      , ZMCRIT  , 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
     L1=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 ZJI=ZJ(IC)
     ZMS=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 PHI0,G,AND SECTIONAL M.N.
C
 320 DO 326 I=1,10
 326 ZJ2(I)=ZJI
 327 DO 430 IF=1,10
 340 ABOVE=ZJ2(IF)*VOV(IF,JV)
     BELOW=PI*X(IF)
 358 PHI0(IF)=DEGCV*ATAN(ABOVE/BELOW)
     IF(ABOVE)362,368,368
 362 IF (PHI0(IF))365,365,370
 365 PHI0(IF)=360.0+PHI0(IF)
     GO TO 380
 368 IF(PHI0(IF))370,380,380
 370 PHI0(IF)=180.0+PHI0(IF)
 380 SR(IF)=ABOVE**2+BELOW**2
 390 G(IF)=BLADN*SR(IF)/4.0
     ZMM(IF)=ZMS*SQRT(SR(IF))/ZJI
 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 FAKE=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)-PHIO(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)=PHIO(I)+BETA(I)
      IDL=1
  480 CALL ACHART
      IF(IERROR)500,500,490
  500 ZM(I)=ZMM(I)*COS(BETA(I)*RADCV)
  520 CALL AIR1
      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)ZJI,THET34(IC),X(I),ALPH(I)
  780 FORMAT (68HOTROUBLE IN ALPHA, BETA ITERATION    ZJI      THET34
     1X        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 (50HOOFF AIRFOIL DATA         J      03/4     X     ALPHA
     1F28.4,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
      CDOCL(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,1)
 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,1)=DCTIN(I,1)+(DCTAP(I,1)-DCTIN(I,1))*CORCD/CD(I)
      EFFS(I)=(SDCTAP(I,1)/DCPAP(I,1))*ZJ2(I)
 2010 CONTINUE
      CTAC(1)=0.0
      CTA=0.0
      DO 2020 I=1,10
      CTA=CTA+GIR(I)*DCTAP(I,1)
      CTAC(1)=CTAC(1)+GIR(I)*SDCTAP(I,1)
 2020 CONTINUE
      CTA=CTA*(1.0-SCO)
      CTAC(1)=CTAC(1)*(1.0-SCO)
      FT(1)=CTAC(1)/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)ZJI,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,6HALPHA=10F8.2/
     X14X,4HPHI=10F8.2/13X,5HBETA=10F8.2/12X,6HPHI 0=10F8.2/14X,4HCL3=
     X10F8.4/12X,6HCD/CL=10F8.4/11X,7HDCP/DX=10F8.4/11X,7HDCT/DX=10F8.4/
     X8X,10HSECT.EFF.=10F8.4/10X,8HSECT.MN=10F8.4/10X,8HM/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 OF 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),
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),ZMCRIT(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 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  , 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 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       , XI      , XNSS    , XPB
 COMMON Y1      , Y2
 COMMON ZIP1    , ZJ      , ZJ1     , ZM      , ZMCRIT  , 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,
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,,01845,,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      (I) , 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,,02655,,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,,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      (I) , 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      (I) , 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,,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      (I) , 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      (I) , 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,,00824
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      (I) , 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
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,,0056,,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      (I) , 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
X/
 DATA (CURVE      (I) , 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,,007020,,009770,,012020,,013610,,014410
X,,01421,,01258,,00824,,00491,0,
X/
 DATA (CURVE      (I) , 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,
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      (I) , 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(I),A,LIMIT)
       GO TO 300
 200 WRITE (6,210)ZJI,THET34(IC),X(I)
 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(23HO 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),ZMCRIT(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 CMCRIT(123),DMCRIT(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    , 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       , XI      , XNSS    , XPB
      COMMON Y1      , Y2
      COMMON ZIP1    , ZJ      , ZJ1     , ZM      , ZMCRIT  , ZMCROM
      COMMON ZMMCR   , ZMN     , ZMS     , ZMU     , ZNMN    , Z5
      COMMON/DUM/DUMMY
      DATA (CMCRIT(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,.436,.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(1),1,APLUS,HOB(I),CL2,LIMIT)
       CL2=SIGN(CL2,ALPH(I))
    4  CALL UNBAR (DUMMY(1),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(1),1898,HOB(I),UNVAR,CLMC0,LIMIT)
       CALL UNBAR(DUMMY(1),1915,HOB(I),UNVAR,DMAXCL,LIMIT)
       CALL UNBAR(DUMMY(1),1932,HOB(I),UNVAR,SLOPE,LIMIT)
       CALL UNBAR(DUMMY(1),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+CLMC0
 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))/BOD(I)
       CALL UNBAR (DMCRIT,1,XIN,0.0,ANS1,LIMIT)
```

FIGURE 16. (SHEET 12 OF 57)

```
      ZMCRIT(I)=ANS+ANS1
      CALL UNBAR (CLAZRO,1,HOB(I),DECL(I),CLA0(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)-CLA0(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)=ZMCRIT(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
   82 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(I)*CDOCL(I))    203,203,100
  200 DCDCL(I)=0.0
      GO TO 100
  203 DCDCL(I)=-DCDCL(I)
  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.
     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,1.04,1.027,1.003,,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,
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,,188,,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,1.11,1.083,1.032,.968,.911,.858,.812,.769,.717,.670,.627,.598
     X,1.28,1.255,1.207,1.143,1.089,1.028,.972,.923,.867,.819,.773
     X,.740
     X,1.558,1.54,1.502,1.444,1.379,1.310,1.250,1.190,1.133,1.086
     X,1.041,1.
     X,1.661,1.642,1.61,1.552,1.487,1.418,1.363,1.302,1.250,1.200
     X,1.159,1.119
     X,1.738,1.718,1.683,1.629,1.567,1.513,1.462,1.403,1.352,1.303
     X,1.265,1.229
     X,1.832,1.819,1.778,1.731,1.679,1.640,1.600,1.554,1.511,1.469
     X,1.428,1.397
     X,1.864,1.850,1.810,1.768,1.719,1.680,1.648,1.601,1.560,1.527
     X,1.487,1.452
     X,1.88,1.87,1.83,1.789,1.739,1.705,1.671,1.628,1.594,1.560
     X,1.530,1.499
     X,1.889,1.88,1.84,1.791,1.747,1.713,1.68,1.642,1.610,1.581
     X,1.556,1.527
     X/
      DATA (DUMMY      (I) , I = 1181   ,1321   )/
     X 13.,54.,12.
     X,-18.,-16.5,-15.,-14.,-12.5,-11.,-9.7,-9.,-8.4,-8.,-7.7,-7.2
     X,-6.9,-6.7,-6.4,-6.2,-5.9,-5.3,-4.5,-3.8,-3.,-2.,-1.,.5,2.,3.
     X,4.,4.5,5.,5.5,6.,6.5,7.,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.,1.5
     X,.0,-.005,-.01,-.015,-.02,-.0251,-.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,-.C 99
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,,.0308,,.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,,.004 ,,.0048,,.0057,,.0070
X,,.0099
X,,0,,.0001,,.0003,,.0005,,.0009,,.0012,,.0017,,.0025,,.0033,,.0042
X,,.005,,.0084
X,,0,,0,,.0002,,.0004,,.0007,,.001,,.0014,,.0018,,.0027,,.0035,,.0045
X,,.0076
X/
 DATA (DUMMY      (I) , I = 1538  ,1654  )/
X ,0,,,0,,,0,,.0001,,.0002,,.0004,,.0006,,.0014,,.002,,.0027,,.0034,,.0062
X,,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,.0057,.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,.0332,.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,1.258,1.225,1.144,1.030,.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.,87.5,90.
     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.)20,20,30
   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),
      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),
      6V0V(10,10),X(10),XI(11),ZJ(10),ZM(10),ZMCRIT(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 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  , 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    , V0V     , V1      , V2
       COMMON X       , XI      , XNSS    , XPB
       COMMON Y1      , Y2
       COMMON ZIP1    , ZJ      , ZJI     , ZM      , ZMCRIT  , 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 (I3,69H
      X                    )
C
C      TEST FOR LAST CASE
C
       IF (I-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,CLI,SCO
   50 FORMAT (37H0 **** PROPELLER CHARACTERISTICS ****//5A6//15H0 NO.OF
     1BLADES=F4.0,10X,3HAF=F6.1/15H  DIAMETER FT.=F8.4,5X,4HCLI=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 (213,11F6.0)
      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 (I6,5F6.0)
      GO TO 60
  240 IK=I-30
      GO TO (250,260,280,300,320,340,350,350,350,370,420),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),(BOD(I),I=1,10),(DECL(I),I=1,10),
     X(DTHET(I),I=1,10)
  460 FORMAT (9X,4HT/B=10F8.4/9X,4HR/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.)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.)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,ITTAB2)
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
   1TICS 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-.60980647F-02*ZA
     1V10)+ZAV3*(-.5+.0625*ZAV2-.017578125*ZAV10+.61035157E-02*ZAV2*ZAV1
     20)
      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*1.414214*ZAV4*ZAV7
      FNEG=(1.0+.5*ZAV4+.5625*ZAV6+.78125*ZAV4*ZAV6+1.196289*ZAV9+1.9379
     1883*ZAV4*ZAV9)*PI*ZAV7/1.414214
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),
 5TABLE2(43),THET(10),THET34(10),TTHERM(50),TX(50),VACB(10),
 6VOV(10,10),X(10),XI(11),ZJ(10),ZM(10),ZMCRIT(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 CBAR(81),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),UOUIN(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  , 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 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       , XI      , XNSS    , XPB
  COMMON Y1      , Y2
  COMMON ZIP1    , ZJ      , ZJ1     , ZM      , ZMCRIT  , ZMCROM
  COMMON ZMMCR   , ZMN     , ZMS     , ZMU     , ZNMN    , Z5
  COMMON/DAT/DATA
  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(I),I=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 (IOFF-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(23H0LAMBDA 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))-.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))-.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))-.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 ( 20H0P(K,L) DATA LAMBDA=F7.4/(7F11.5))
     WRITE (6,3520)AMBDA,((TM(KL,LK),LK=1,8),KL=1,8)
3520 FORMAT ( 23HO M(K,L) MATRIX LAMBDA=F7.4/(8F10.5))
     WRITE (6,3523)AMBDA,((S(KL,LK),LK=1,7),KL=1,7)
3523 FORMAT(20H0S(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)=SQRT(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(1),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
      CHII(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 CHII(JT1,NU)=CHI(I,JT1)*CONST*SIMP+CHII(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
      CHII(JT1,NU)=CHII(JT1,NU)*.013083
 3900 CONTINUE
 3910 CONTINUE
 3920 CONTINUE
 3940 IF (TRIG1)3948,3948,3942
 3942 WRITE (6,3945)AMBDA,ZMU,XPB
 3945 FORMAT (1H2H0 **** 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)((CHII(JT1,NU),JT1=1,7),NU=1,7)
 3947 FORMAT (F24.6,6F12.6)
 3948 SZMU=ZMU
      SBMBDA=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(SDMBDA-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
      ZAV8=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(F8.4,8F
     19.5/))
 4300 FORMAT(/9H RAD,STA,9X,31HVELH(NU) AS NU GOES FROM 0 TO 7/10(F8.4,8
     1F9.5/))
      GO TO 2999
C
C     COMPUTATION OF CIRCULATION/CIRC.MAX AND CIRCULATION MAX
C
  229 IF (SHROD-5.)230,230,397
  230 CC(1)=100.0
      CC(2)=10.0
      CC(3)=0.0
      DO 300 IT=1,10
      IF (SHROD-5.)232,234,234
  232 C(IT)=COS(BETA(IT)*RADCV)*CL3(IT)*BOD(IT)/SIN(PHIO(IT)*RADCV)
  234 JT=14-IT
      KT=24-IT
      CC(JT)=X(IT)
  300 CC(KT)=C(IT)
      CBARM=0.0
      CBAR(1)=0.0
      CBAR(81)=0.0
      XX=0.0
  304 VAVGI=0.0
      DO 305 IT=1,10
```

FIGURE 16. (SHEET 34 OF 57)

```
  305 VAVGI=VAVGI+2.0*X(IT)*GIR(IT)*(VOV(IT,JV)+BLADN*C(IT)/(4.0*ZJI))
      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 XV1=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
      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*SQRT(ZMU)*CBARM*XJ*CIRFT(JT)*CHII(JT,JV1)/(PI*
     1ZJI*VAVGI)+HOLD
C
```

FIGURE 16. (SHEET 35 OF 57)

```
C       BRANCH TO COMPUTE MORE THAN 1 JT TERM
C
C
C       THICKNESS EFFECT ON SBO
C
  600 SBO(JV1)=EINT(JV1)+CONS2(JT)-2.0*THM(JV1)+BCB(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)+BCB(JV1)
      GO TO 1010
C
C       START OF MATRIX MANIPULATION  END OF J LOOP
C
 1100 DO 1150 IT=1,JV1
 1150 SBO1(IT)=SBO(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)*SBO1(LT)+XMATM
      SBO2(KT)=SBO(KT)+XMATM+SBO1(1)*P(KT,1)
      IF (ABS(SBO2(KT)-SBO1(KT))-.0005)1280,1280,1230
 1230 TTRIG=1.0
 1280 CONTINUE
      DO 1285 LT=1,JV1
 1285 SBO1(LT)=SBO2(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)-.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 TOLE=.0025
 2680 IF(ABS(VOV(IT,JV)-1.0-TVOVS(IT,2))-TOLE)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(48H0TROUBLE 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))*.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))*
     1DELVOV(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.)2813,2818,2817
 2817 UOUIN(IT)=0.0
      GO TO 2820
 2818 UOUIN(IT)=BLADN*C(IT)/(4.0*ZJI)
      SWANG(IT)=DEGCV*ATAN(2.0*ZJI*BLADN*C(IT)/(PI*(BLADN*C(IT)+4.0*ZJI*
     1 TOTAL(IT))))
 2820 CONTINUE
      VAVGI=0.0
      VAVG1I=0.0
      VAVG2I=0.0
      VAVG3I=0.0
      DO 5000 IT=1,10
```

FIGURE 16. (SHEET 37 OF 57)

```
      PHOLD=TVOV1(IT)+TVOV2(IT)+VACB(IT)
      VAVGI=VAVGI+2.0*X(IT)*(PHOLD+U0UIN(IT))*GIR(IT)
      VAVG2I=VAVG2I+2.0*X(IT)*PHOLD*GIR(IT)
      VAVG1I=VAVG1I+2.0*X(IT)*U0UIN(IT)*GIR(IT)
 5000 CONTINUE
      VAVGI=VAVGI/(1.0+SCO)
      VAVG2I=VAVG2I/(1.0+SCO)
      VAVG1I=VAVG1I*(1.0-SCO)
      DO 5010 IT=1,10
      VAVG3I=VAVG3I+X(IT)*(U0UIN(IT)-VAVG1I)**2*GIR(IT)
 5010 CONTINUE
      VAVG3I=VAVG3I*(1.0-SCO)
      RJORO=SQRT((1.0-SCO**2)*(1.0+VAVGI)/(2.0*VAVG1I+1.0))
      VBARI=1.0+VAVGI
      VJET=2.0*VAVG1I+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)=-SBO1(1)*COS(XPT/2.0)/(4.0*SIN(XPT/2.0))
      DO 5420 IIT=2,JV1
      XJV1=IIT-1
      PM(IIT)=-.5*COS(XJV1*XPT)
 5420 CT(IT)=CT(IT)-SBO1(IIT)*SIN(XJV1*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)*SBO1(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
      ARGL=((XPB+AMBDA*COS(XPT))**2+1.0+XX**2)/(2.0*XX)
      CALL LEGEND (ARGL,FPOS,FNEG,DPOS,DDNEG)
      DNEG(IIT)=DDNEG
      IF(TRIGD-0.0)5460,5450,5460
```

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)+CBAR(IIT)*DNEG(IIT)/SQRT(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 (ZIP)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*DCR(NNTH,MTH+1)*(-1.0)**MTH*DXA(MTH)/XMTH
      TSU=SA(NTH+1)*(SX(IT)**(NNTH)*ALOG(ABS((SX(IT)-AMBDA)/(SX(IT)+    A
     1MBDA)))+TSUM) +TSU
 5500 CONTINUE
      TONE=SQRT(2.0*AMBDA)
      TTWO=SQRT(AMBDA+SX(IT))
      FTHRM(IT)=ALOG(ABS((TONE-TTWO)/(TONE+TTWO)))*SA(1)/(PI*TTWO)+(SA(2
     1)/PI)*ALOG(ABS((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)/SQRT(SX(IT)+AMBDA))/(4.0*AMBDA)
 5860 VRATU(IT)=(1.0-.5*TCPU(IT))/SQRT(1.0+DZDX**2)
      VRATL(IT)=(1.0-.5*TCPL(IT))/SQRT(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 VRATLE=SBO1(1)*AMBDA*SQRT(2.0*AMBDA)/SA(1)
      PCLE=1.0-VRATLE**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 (1H0,7X,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),(VACB(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),SB0(JT),SB01(
    XJT)
2804 CONTINUE
2530 FORMAT (1H I6,6F8.4)
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 --------- VELOCITY 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),TTHERM(IT
    X),VRATU(IT),PCU(IT),VRATL(IT),PCL(IT),IT=1,NS1)
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,.03604,.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,.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
X,,0,,00147,,0,,00005,,0,-,00011,,0,-,00005
X/
 DATA (DATA       (I) , 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
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       (I) , 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       (I) , 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)

```
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,.,9510564 1
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,-.039[illegible]975,-.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,.89100690,.76040680,.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     DATOM
      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,.05769
     X,.05749
     X,.04147,.04885,.04939,.04861
     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,.01791,.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,,15,0,20,,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       (I) , I = 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       (I) , I = 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       (I) , I = 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,,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,,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       (I) , I = 2391   ,2489   )/
X 7,.21,.5,
X,0,.,.05,.10,.15,.20,.25,.30,.35,.40,.45,.5( ,.55,.60,.65,.70
X,.75,.80,.85,.90,.95,1.0
X,.75,.90,.95,.99,.998
X,-.00786,-.01850,-.02936,-.05432,-.06951
X,-.00765,-.01650,-.02277,-.02768,-.02782
X,-.00707,-.01254,-.01399,-.01266,-.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       (I) , 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,-.51770,.005700,.002100,.000000,.000000,.000000
X,1.49710,-.77770,.004000,.006100,.000500,.000000,.000000
X,1.70680,-1.0224,-.00880,.010700,.002100,.000500,.000100
X,.392700,.000000,.063700,.000000,.000000,.000000,.000000
X,.605800,.000000,.130000,.000000,-.00030,.000000,.000000
X,.749600,.000000,.195900,.000000,-.00080,.000000,.000000
X,.851200,.000000,.258300,.000000,-.00130,.000000,.000000
X,.000000,-.12730,.000000,.041900,.000000,.000000,.000000
X,.000000,-.25990,.000000,.084900,.000000,-.00010,.000000
X,.000000,-.39190,.000000,.130000,.000000,-.00040,.000000
X/
 DATA (DATA       (I) , I = 2602   ,2727   )/
X .000000,-.51650,.000000,.176700,.000000,-.00100,.000000
X,-.00050,.000000,-.06280,.000000,.031300,.000000,.000000
X,-.00140,.000000,-.12740,.000000,.063000,.000000,-.00010
X,-.00090,.000000,-.19500,.000000,.095500,.000000,-.00020
X,.002700,.000000,-.26500,.000000,.129200,.000000,-.00050
X,.000000,.000100,.000000,-.04170,.000000,.025000,.000000
X,.000000,.001100,.000000,-.08400,.000000,.050200,.000000
X,.000000,.003100,.000000,-.12730,.000000,.075700,.000000
X,.000000,.005300,.000000,-.17230,.000000,.101900,.000000
X,.000000,.000000,.000000,.000000,-.03130,.000000,.020800
X,.000000,.000000,.000300,.000000,-.06280,.000000,.041800
X,-.00010,.000000,.001000,.000000,-.09470,.000000,.062900
X,-.00050,.000000,.002400,.000000,-.12730,.000000,.084300
X,.000000,.000000,.000000,.000000,.000000,-.02500,.000000
X,.000000,.000000,.000000,.000100,.000000,-.05010,.000000
```

FIGURE 16. (SHEET 53 OF 57)

```
X,.000000,.000000,.000000,.000400,.000000,-.07550,.000000
X,.000000,.000000,.000000,.001000,.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.
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.
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-II-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 (I) 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

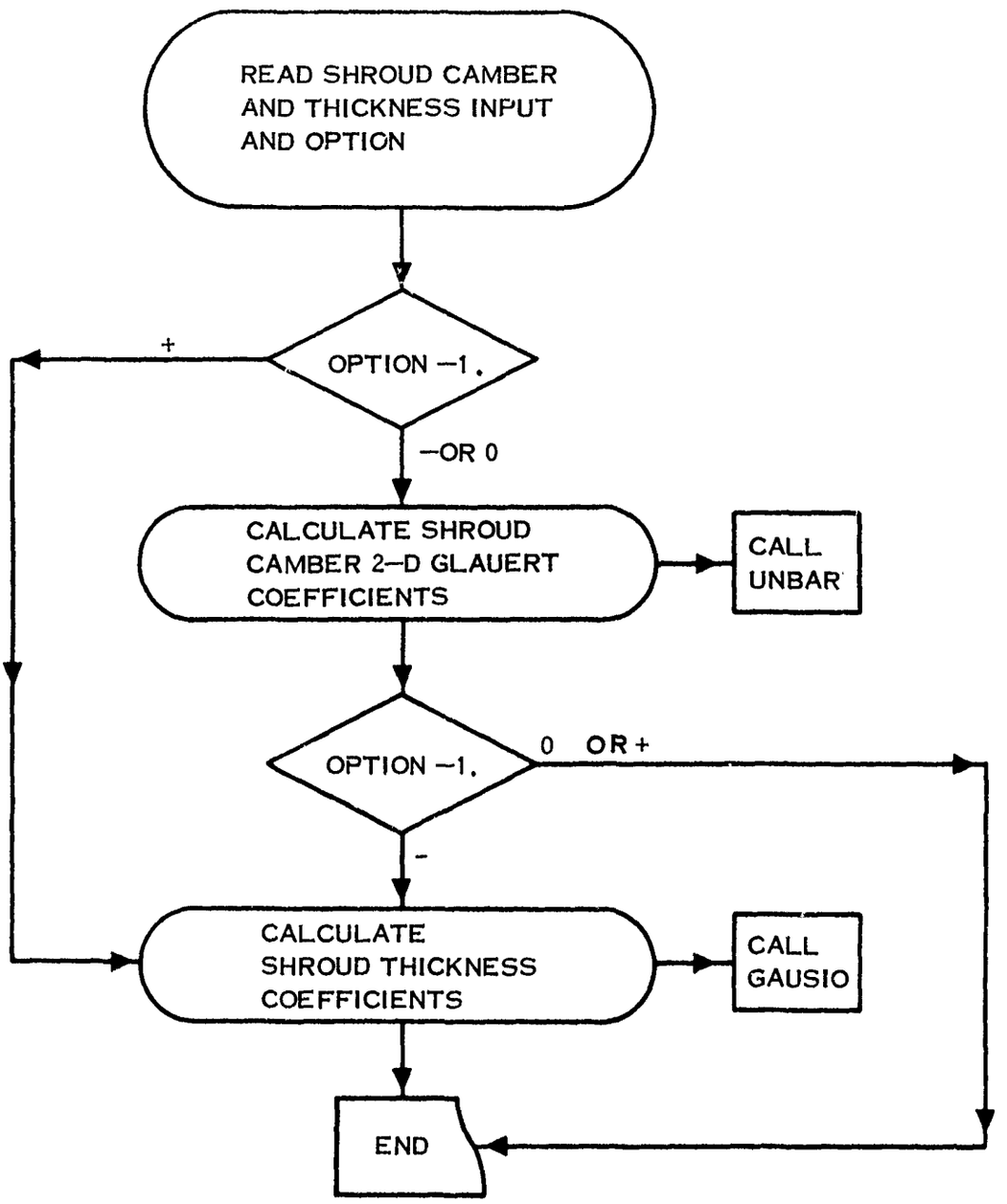


FIGURE 17.

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 (2I3,11F6.0)
        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)+.000005
        I=NP/3
        J=I*3
        K=NP-J
        IF (K-1)325,326,326
```

FIGURE 19. (SHEET 1 OF 5)

```
  325 L=I
      GO TO 327
  326 L=I+1
  327 II=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+II),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,1,XBS(I),1.0,EEE(I),LIMIT)
      CONST=-.5
      GO TO 350
  340 II=NU-1
      AII=II
      CONST=COS(ANGLE*AII)
  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)/80.
  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),(HOB(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 GAUSIO (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) = I
 2    A(I,NC) = B(I)
C
C     START OF OVERALL. LOOP
       N1 = N-1
        DO 100 L = 1,N1
       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) - I) 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

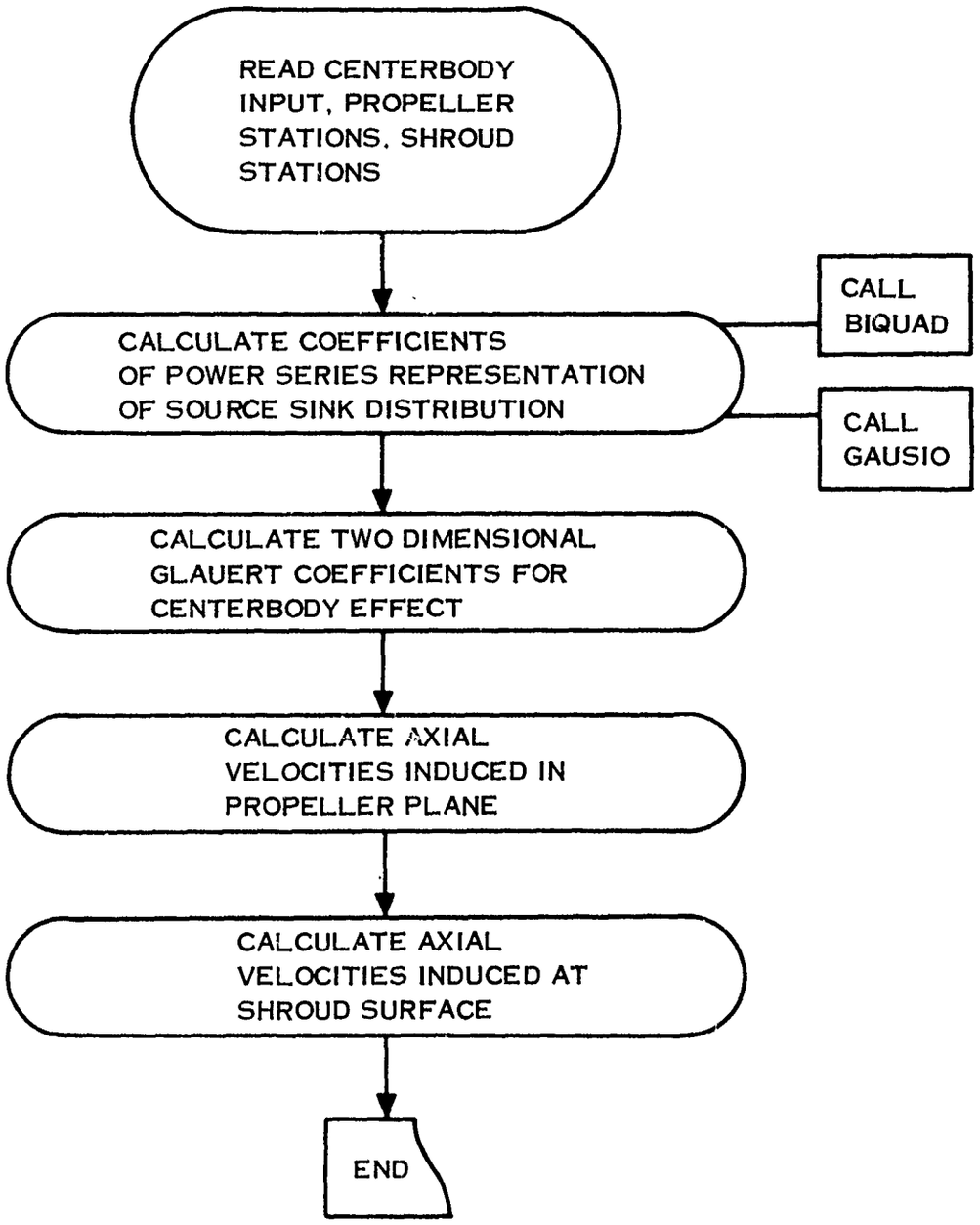


FIGURE 20.

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 COEFT(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(I),I=1,64)/   1.,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.,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
       3IAMETER =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=J
      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(I)*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 GAUS10 (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.   .NPUT 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+II),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(I)*Z9**(I-1)
      ANCB(2)=ANCB(2)+A(I)*(PN-1.0)*Z9**(I-2)
      ANCB(3)=ANCB(3)+A(I)*(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
     1OURCE 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(ZNCB**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((
     1ZMCB+ZZCB)/(ZNCB+ZYCB))
      ZLCB(6)=(ZYCB**3-ZZCB**3)/3.0+2.0*(ZZCB-ZYCB)+1.0/ZZCB-1.0/ZYCB
      ZLCB(7)=(ZNCB**5-2.5*ZNCB**3-7.5*ZNCB)/(4.0*ZYCB)-(ZMCB**5-2.5*ZMC
     1B**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-ZZ
     1CB**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
7(   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,I,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=RSAR(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(K)-.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(TRIG)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.
      DIMENSION T(1),XC(4), D(4), P(5), Y(4),C(4)
C
      EQUIVALENCE (XC(1), D(1))
C
C     TABLE SET UP
C        T(I)     = TABLE NUMBER
C        T(I+1)   = NUMBER OF (X) VALUES
C        T(I+2)   = NUMBER OF (Y) VALUES  (0. FOR UNIVARIATE TABLE)
C        T(I+3)   = VALUES OF (X) IN ASCENDING ORDER
       NX = T(I+1)
       NY = T(I+2)
       J1 = I+3
       J2 = J1 + NX - 1
       X = XI
C     SEARCH IN X SENSE
       L = 0
         GO TO 1000
C     RETURN HERE FROM SEARCH OF X
 100   K = KX
       JX= JX1
C     THE FOLLOWING CODE PUTS X AND/OR Y VALUES IN XC BLOCK
 105     DO 110 J=1,4
       XC(J) = T(JX1)
 110   JX1 = JX1+1
C     GET COEFF. IN  X SENSE
         GO TO 2000
C     RETURN HERE WITH COEFF.  TEST FOR UNIVARE OR BIVARIATE
 200     IF (NY)  300,210,300
 210   Z=0.
       JY = JX+NX
          DO 220 J=1,4
       Z= Z + C(J)*T(JY)
 220   JY = JY+1
       GO TO 9999
C
C     BIVARIATE TABLE
 300     L=1
       X = YI
       J1 = J2+1
       J2 = J1+NY-1
C     SEARCH IN  Y SENSE  JX1 = SUBSCRIPT OF 1ST Y
         GO TO 1000
 500   K = K+3*KX
C     INTERPOLATE IN X SENSE
C     SUBSCRIPT - BASE   NO. OF COL.    NO. OF YS
       JY  =    J2+1   + (JX-I-3)*NY  + JX1-J1
         DO 550 M=1,4
       JX  = JY
       Y(M) = 0.
         DO  520 J=1,4
       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,RB,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       COEFFICINT 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)