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A STUDY OF OPTIMUM COWL SHAPES AND FLOW PORT LOCATIONS FOR MINIMUM DRAG WITH EFFECTIVE ENGINE COOLING - VOLUME II

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NASA Grant NSG-1584
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National Aeronautics and
Space Administration

Langley Research Center
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ABSTRACT

The successful prediction of the performance of a new or modified aircraft depends heavily on an accurate estimation of its lift and drag. This report consists of the listings, user's instructions, sample inputs, and sample outputs of two computer programs which are especially useful in obtaining an approximate solution of the viscous flow over an arbitrary non-lifting three-dimensional body. The first program performs a potential flow solution by a well-known panel method and readjusts this initial solution to account for the effects of the boundary-layer displacement thickness, a nonuniform but unidirectional onset flow field, and the presence of air intakes and exhausts. The second program is effectually a geometry package which allows the user to change or refine the shape of a body to satisfy particular needs without a significant amount of human intervention.

The report represents in part an effort to reduce the cruise drag of light aircraft through an analytical study of the contributions to the drag arising from the engine cowl shape and the forward fuselage area and also that resulting from the cooling air mass flowing through intake and exhaust sites on the nacelle. The programs may be effectively used to determine the appropriate body modifications or flow port locations to reduce the cruise drag as well as to provide sufficient air flow for cooling the engine.

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INTRODUCTION

For the past contract year a research program has been conducted for the purpose of reducing the cruise drag of light aircraft for better performance and fuel economy through studying the effects arising from modifications to body shape and the surrounding flow field. The procedures have been described [1] and coded into two FORTRAN computer programs.

The purpose of this report is to present these programs with their complete user's instructions. Sample inputs and outputs are also given to provide references for proper program executions at other computing installations.

The first program - FLOWBODY - performs a potential flow solution by the Hess low-speed panel method [1], [2], [3] and readjusts this initial solution to account for the effects of the boundary-layer displacement thickness, a nonuniform but unidirectional onset flow field, and the presence of air intakes and exhausts. The logic of the program can conveniently be described by the following steps:

(1) The surface of the isolated fuselage is represented by a sufficiently large number of quadrilaterals or four-sided panels.

(2) All four corners of the panel are moved into the same plane through a procedure which determines the direction of the normal.

(3) A nonuniform onset flow field may be superimposed onto the uniform onset flow field.

(4) A source of undetermined strength is placed on each panel, and the prescribed normal boundary condition is required to be satisfied.

(5) The resulting system of equations are solved for the source strengths from which the velocity and pressures over the body surface are calculated.

(6) The system of equations may be resolved for the source strengths to account for the presence of air intakes and exhausts.

(7) Two-dimensional, momentum-integral-type boundary layer computations are performed along the streamlines to find the local values of displacement thickness and wall shear.

(8) The wall shear is integrated over the surface to find the skin friction drag.

(9) The body shape is modified by attaching a wake-body toward the trailing edge and by accounting for the displacement thickness effects.

(10) A new set of source strengths and surface pressures corresponding to the wake-body shape is calculated.

(11) The surface pressures are integrated to find the lift and pressure drage.

(12) The total drag is determined from the sum of the skin friction drag and the pressure drag.

The second program - GRIDPLOT - is a geometry package which may be used to correct body misrepresentations, to change the body geometry, to refine the network or grid of the panels or quadrilaterals that form the surface of the body, and to plot various orthographic, perspective, and stereoscopic views of the original and the modified body. The workhorse of this program is a cubic-spline curve-fitting method coupled to a coordinate-system rotation-translation technique that is very effective in modeling body shapes with regions of high curvature or changes in slope.

The U. S. customary units used in this report reflect those most commonly used in this country by engineers and scientists in the General Aviation field. The reader may choose to use S.I. units in lieu of U. S. customary units in both FLOWBODY and GRIDPLOT programs with only one restriction in the FLOWBODY program. If locations for air intakes and exhausts are to be specified, U. S. customary units must be used throughout FLOWBODY since the constants in the derivations for internal mass flow obtain from U. S. customary units. Otherwise, S.I. units are completely permissible.

USER'S INSTRUCTIONS - FLOWBODY PROGRAM

The program is written in FORTRAN IV and is designed to execute in single precision on an IBM 370/165 computer with an average execution time of 4 minutes 40 seconds for typically large data set. An average execution requires approximately 426,000 bytes of core storage. The program accepts multiple data sets.

Given a data set describing the half-body* under consideration, the program may be instructed to calculate an approximate solution of the three-dimensional viscous flow over an arbitrary body and to estimate the body lift and drag coefficients with or without

(a) a simulated propeller slipstream, and

(b) mass flow through the body.

The orientation of the body with respect to the body reference axes for the programs is shown in Figure 1.

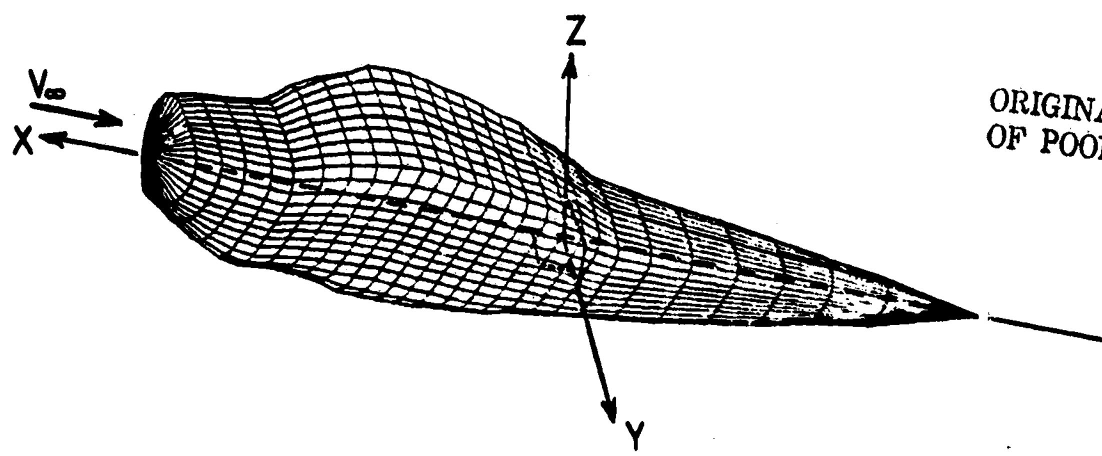

Figure 1: Orientation of the body with respect to the body reference axes

---

*Since the body is considered to be symmetrical about the X-Z plane, only half of the body is needed to describe the entire body.

The program requires the specification of the following input in the indicated order:

CARD 1:

The read unit number IDS:

IDS is a right-adjusted integer number occupying columns 1-5 and specifying that the data is to be read from cards, magnetic tape, disk, etc. The user must supply the suitable job control cards for the specific reads. The IDS parameter controls only the reading of CARD 2, CARD 7, and the Body Description cards.

CARD 2:

The title array TITLE:

The 80 characters of the array TITLE are used for identifying output. The reading of TITLE is controlled by the read unit number IDS.

** The Flow Control Variables **

CARD 3:

Columns	FORTRAN Name	Description
1-20	VINF	Reference free-stream velocity (ft/sec)
21-40	VO	Kinematic viscosity of the fluid in which the body is moving (ft^2/sec)
41-60	ROE	Density of the fluid in which the body is moving (slug/ft^3)
61-80	REFA	Reference area upon which the aerodynamic coefficients will be based (ft^2)

Parameters VINF, VO, ROE, and REFA are single-precision floating-point numbers in E20 fields.

CARD 4:

Columns	FORTRAN Name	Description
1-20	HVF	Heat of combustion of the fuel being used to develop engine power (BTU/lb_m)
21-40	SFC	Specific fuel consumption of the engine ($lb_m/ft\text{-}lb_f$)
41-60	DEP	Developed engine power or power into airstream ($ft\text{-}lb_f/sec$)
61-80	CPHA	Specific heat at constant pressure for air ($BTU/lb_m\,^\circ R$)

Parameters HVF, SFC, DEP, and CPHA are single-precision floating-point numbers in E20 fields.

CARD 5:

Columns	FORTRAN Name	Description
1-20	TINF	Reference free-stream temperature ($^\circ R$)
21-40	EOA	Effective orifice area-representative of that area seen by the cooling fluid passing through the body and about the body (ft^2)
41-45	IWRITE	Control variable which denotes the amount of output the user desires. IWRITE = 0 yields the normal maximum output ever desired by the user. IWRITE = 1 deletes information given for each input point. IWRITE = 2 deletes streamline and boundary layer information as well as input point information. IWRITE < 0 generates an enormous amount of output dealing with the streamline calculations, and therefore this option should be used with caution.
46-50	IPCH1	Control variable which denotes the punching of the input cards in a form compatible to the NCSU PLOT program of Reference 3. IPCH1 = 0 yields no punched cards, while IPCH1 = 1 produces punched cards.

CARD 5 (continued):

Columns	FORTRAN Name	Description
51-55	IPCH2	Control variable which denotes the punching of cards of the body after the addition of the wake-body in a form compatible to the NCSU PLOT program of Reference 3. IPCH2 = 0 yields no punched cards, while IPCH2 = 1 produces punched cards.
56-60	IMATCH	Control variable which denotes the matching of the simulated slipstream's power to the specified power into the airstream. With IMATCH = 0, the matching is performed. With IMATCH = 1, no matching occurs and the program utilizes the user-supplied values. Normally, IMATCH = 0 should be specified for an overall program compatibility.

Parameters TINF and EOA are single-precision floating-point numbers in E20 fields, while parameters IWRITE, IPCH1, IPCH2, and IMATCH are right-adjusted integer numbers in I5 fields.

** Conversion and Test Parameters **

CARD 6:

Columns	FORTRAN Name	Description
1-10	CF	Conversion factor to change the units of the body coordinates points to units of feet. If CF = 0.0, the program automatically sets CF = 1.0. If CF = 1.0, the program assumes that the data units are compatible.
11-15	ITEST	Control parameter which allows only sufficient information of the propeller-slipstream (or series of vortex rings) calculation to be performed for the plotting of the location and diameter of the vortex rings and the induced velocity of such an arrangement of rings. (See Figure 2). ITEST = 0 produces no plots, while ITEST = 1 does.

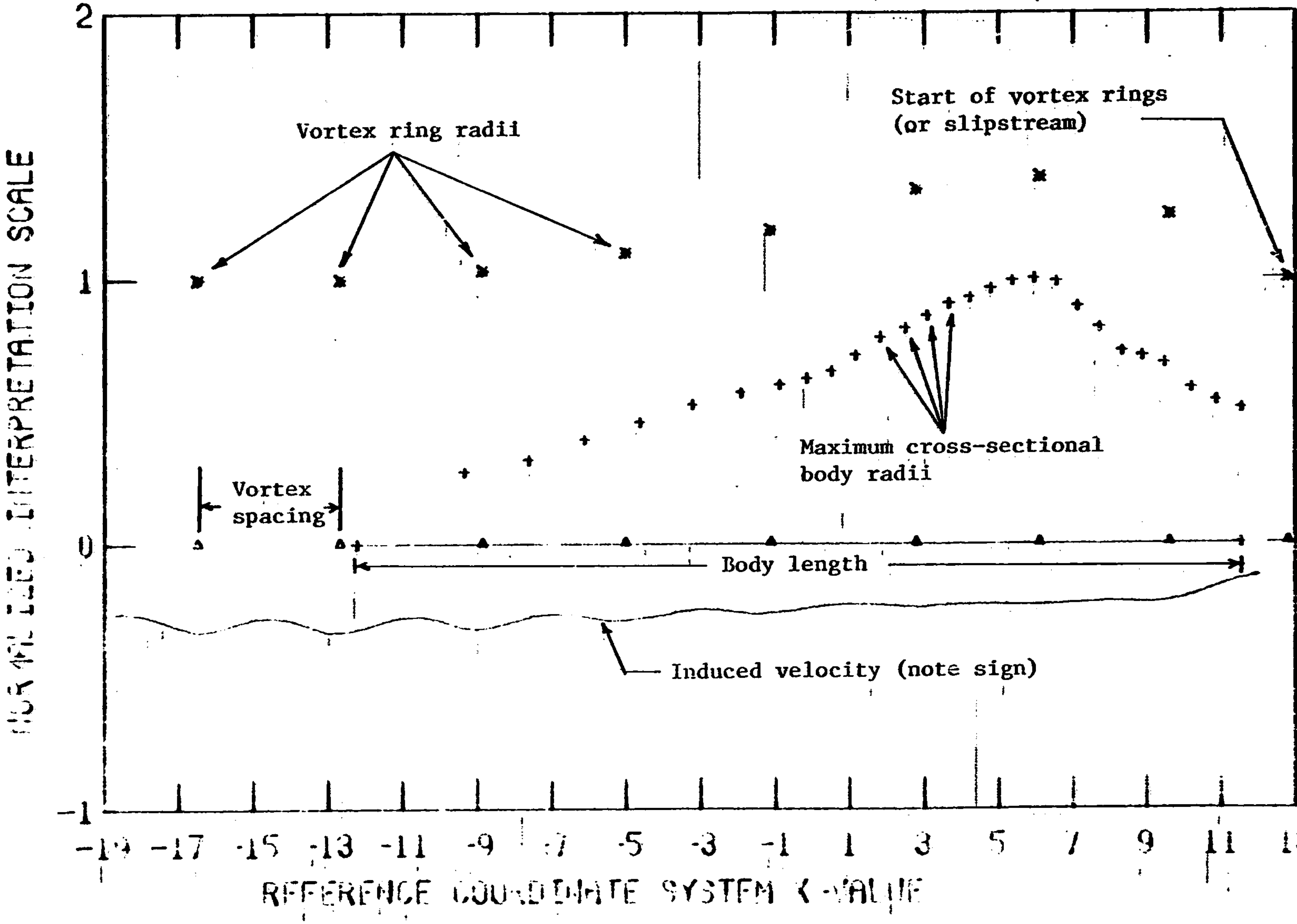

Figure 2: Typical plot of the location and radii of the vortex rings as well as the induced velocity of such an arrangement of rings

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CARD 6 (continued):

Columns	FORTRAN Name	Description
16-20	NODE	Control parameter--equal in value to the node or panel number in question--that generates additional output in that portion of the streamline calculation near the specified node or panel. NODE = 0 produces no additional output, while NODE = *"panel number"* does.

Parameter CF is a single-precision floating-point number in a F10 field.

Parameters ITEST and NODE are right-adjusted integer numbers in I5 fields.

CARD 7:

The number NQE of quadrilaterals or panels of the input half-body data:

Occupying columns 1-4 in an I4 field, NQE is a right-adjusted integer number determined by the product
(maximum MI - 1) * (maximum NI - 1)
where MI and NI are defined later. NQE should be restricted in value to approximately 600 because of the array dimensions in the program. The resulting of NQE is controlled by the read unit number IDS.

CARD 8: ** Ring Vortex Systems--Propeller Slipstream **

Columns	FORTRAN Name	Description
1-5	NSRV	Number of independent ring-vortex systems. Normally NSRV = 1 or 0.
6-10	ISPACE	Generation parameter for ring vortices. If ISPACE = 0, no automatic generation and spacing of ring vortices are performed. If NSRV > 1, ISPACE must be equal to zero. If ISPACE > 0, NSRV is set equal to 1 and the program is permitted to generate a system of ring vortices.
11-20	XCRP(1)	The approximate vortex spacing along the x-axis before the x-position of maximum body diameter (ft).

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CARD 8 (continued):

Columns	FORTRAN Name	Description
21-30	XCRP(2)	The approximate vortex spacing along the x-axis aft of the x-position of maximum body diameter (ft).
31-40	AEXP(1)	Factor in the exponential of the equation $X_i = X_{i-1} - XCRP(1)*EXP(-AEXP(1)*(R-RMX)/RMX)$ where X_i, X_{i-1} = x-locations; R = body radius at X_i; RMX = maximum body radius; for vortex spacing before the x-location of the maximum body diameter.
41-50	AEXP(2)	Factor in the exponential of the equation $X_i = X_{i-1} - XCRP(2)*EXP(-AEXP(2)*(R-RMX)/RMX)$ where X_i, X_{i-1} = x-locations; R = body radius at X_i; RMX = maximum body radius; for vortex spacing aft of the x-location of the maximum body diameter.
51-60	XRM	Limiting downstream x-location of the axially-spaced vortices (ft).

NSRV and ISPACE are right-adjusted integer numbers in I5 fields, while XCRP(1), XCRP(2), AEXP(1), AEXP(2) and XRM are single-precision floating-point numbers in F10 fields.

** Ring Vortex Parameters' Cards **

Two cards are necessary to specify the information about the location and orientation of the starting vortex (or vortices) of a generated system of vortices or an individual independent ring vortex. It should be noted that if NSRV = 0, no cards are specified under this section. If NSRV ≠ 0, the user must specify NSRV set(s) of these two cards in the order indicated in the section Circulation Variation Cards.

The first card contains

Columns	FORTRAN Name	Description
1-10	XCV	x-coordinate of the center of the vortex ring (ft).
11-20	YCV	y-coordinate of the center of the vortex ring (ft).
21-30	ZCV	z-coordinate of the center of the vortex ring (ft).
31-40	RDM	Maximum vortex radius (ft). RDM is usually considered to be the boundary of the propeller slipstream. If NSRV = 1, ISPACE > 0, and if XCV, YCV, and ZCV correspond to the propeller's center of rotation, RDM is the propeller radius.
41-50	CA	Initial central angle, degrees (See Figure 3).
51-60	PHI	Rotation angle, degrees (See Figure 3).
61-65	NCA	Central angle increment number. NCA is that number dividing 360 degrees into NCA equal parts from which NCA segments are determined to approximate the perimeter of a circle.
66-70	NVPHI	Rotation tilt parameter. NVPHI = 0: Plane of the vortex ring(s) is perpendicular to the x-axis of body (Set PHI = 90.0). NVPHI = 1: Plane of the vortex ring(s) is not perpendicular to the x-axis of the body. Parameter allows PHI to change at the same rate as CA so that initial choices of PHI and CA determine the path taken by point P of Figure 3.

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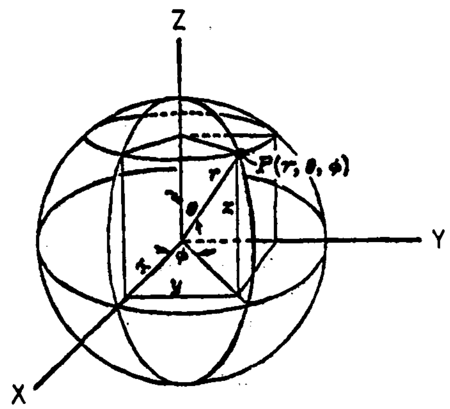
first card (continued):

Columns	FORTRAN Name	Description
71-75	NRS	Number of radial stations or concentric vortex rings.
76-80	NPTS	Number of (circulation vs. radial distance) points ($\leq$ 50).

The parameters XCV, YCV, ZCV, RDM, CA, and PHI are single-precision floating-point numbers in F10 fields. The parameters NCA, NVPHI, NRS, and NPTS are right-adjusted integer numbers in I5 fields.



CA = θ

PHI = φ

Figure 3: Definition of angles for specification of vortex ring(s) orientation (Point P described in Cartesian coordinates by $x = r \sin \theta \cos \phi$, $y = r \sin \theta \sin \phi$, and $z = r \cos \theta$)

The second card contains

Columns	FORTRAN Name	Description
1-10	GFACT	The circulation-strength scale factor. If GFACT = 0.0, the program automatically sets GFACT = 1.0. Since an arbitrary normalized circulation variation may be specified that may not be compatible to the specified DEP, GFACT provides an easy means to adjust power into the air-stream by changing the magnitude of the circulation variation. If IMATCH = 0, GFACT is automatically adjusted to match

second card (continued):

		the simulated slipstream's power to the specified power into the airstream. GFACT is a single-precision floating-point number in an F10 field.

** Circulation Variation Cards **

For each independent vortex system, a set of NPTS cards must be specified in this section. Each card of the set contains

Columns	FORTRAN Name	Description
1-10	RAD	The radius at which the circulation (or strength) of the vortex ring is to be specified (ft).
11-20	GAM	The circulation (or strength) of the vortex ring at radius RAD.

The parameters RAD and GAM are single-precision floating-point numbers in F10 fields.

Ordering of cards: For each of the NSRV vortex systems, the user must supply the two cards from the Ring-Vortex-Parameters' section first and, secondly, the NPTS cards of this section. For every independent ring-vortex system, the user must repeat this sequence.

** Body Description Cards **

Each card contains the information to specify one half-body point. Each card contains

Columns	FORTRAN Name	Description
1-12	XI	x-coordinate
13-24	YI	y-coordinate
25-36	ZI	z-coordinate

Body Description Cards (continued):

Columns	FORTRAN Name	Description
37-40	NI	N-station index (See Figure 4)
41-44	MI	M-station index (See Figure 4)
45-48	NS	Body number

XI, YI and ZI are single-precision floating-point numbers in F12 fields, while NI, MI and NS are right-adjusted integer numbers in I4 fields. The maximum value of NI or MI must be restricted to less than or equal to 30 because of the array dimensions of the program. NS should be a constant for a given data set, which must be greater than zero but no equal to 1000. A blank card must be supplied at the end of these cards to signal the end of the body description cards. The reading of the body description cards is controlled by the read unit number IDS.

** Inlet and Exhaust Panel Cards **

Each card contains the information to specify one panel or quadrilateral either as an inlet (flow into the body) panel or as an exhaust (flow out of the body) panel. Each card contains

Columns	FORTRAN Name	Description
1-5	MS1	1st reference M-station index [MS1 $\geq$ 1]
6-10	MS2	2nd reference M-station index [MS1 < MS2 $\leq$ max (MI)]
11-15	NS1	1st reference N-station index [NS1 $\geq$ 1]
16-20	NS2	2nd reference N-station index [NS1 < NS2 $\leq$ max (NI)]

Columns	FORTRAN Name	Description
21-25	IPNS	Parameter which denotes the panel enclosed by the M- and N-station indexes as an inlet or exhaust panel. If IPNS = -1, the panel is designated as an inlet panel, while the panel is designated as an exhaust panel if INPS = +1. If IPNS = 0, the panel is bypassed as being impermeable to mass flow.

The panels are designated by the order in which the data cards are encountered. It must be true--with the exception of a blank card--that

$$(MS2 - MS1) = 1$$

and

$$(NS2 - NS1) = 1$$

since only one panel specification is allowed per card. Since stagnation flows are not permitted in the program, at least one exhaust panel is required if at least one inlet panel is specified, and vice versa. MS1, MS2, NS1, NS2, and IPNS are right-adjusted integer numbers in I5 fields. A blank or zero card must be supplied to serve either of two purposes. If no inlet and exhaust panels are specified, the blank card terminates the attempt to read more cards. If inlet and exhaust panels are specified, the blank card signals the end of this information.

Specification of the cards above represent a complete set of data for a particular body. Additional data sets are programmed similarly starting again at CARD 1.

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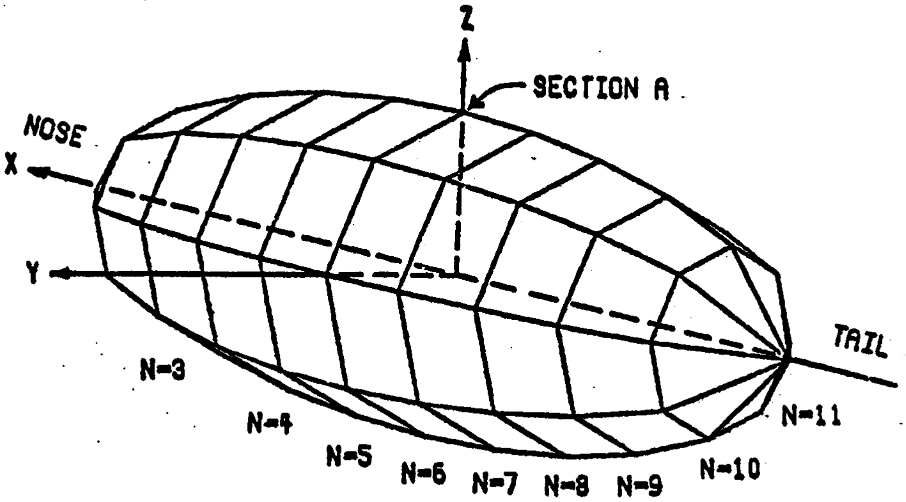

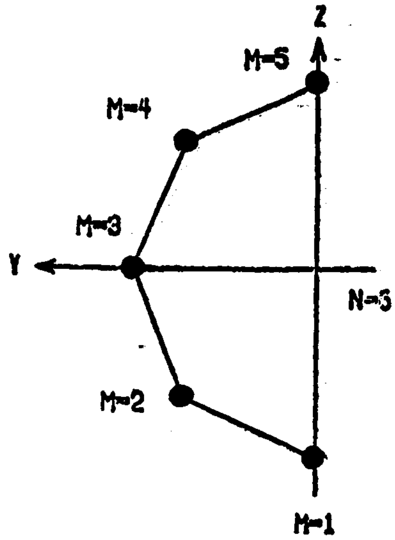

SECTION A

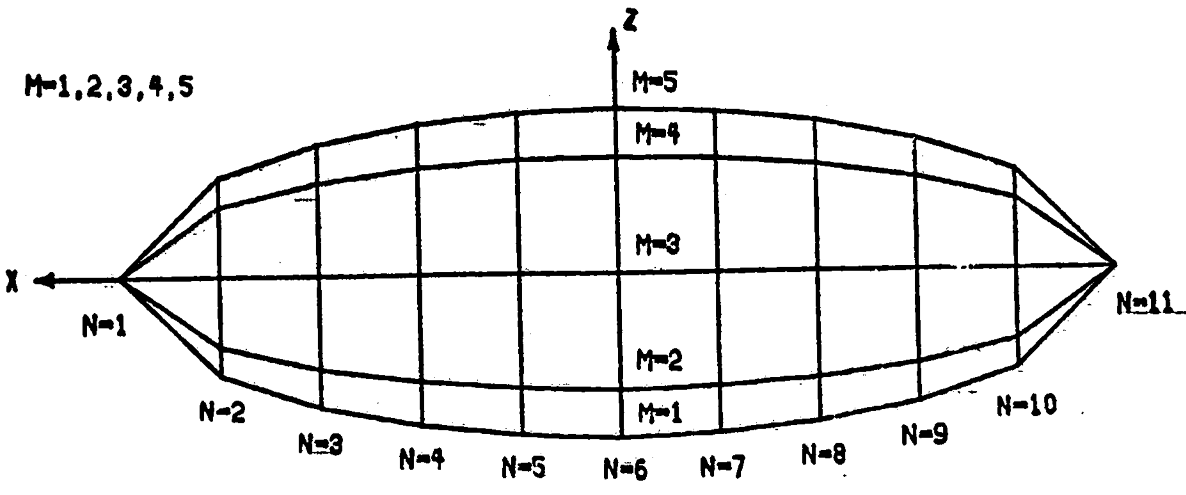

Figure 4: Schematic of indexing scheme

PROGRAM LISTING - FLOWBODY

```
C
C***  THIS BASIC PROGRAM WAS OBTAINED FROM THE NAVAL SHIP RESEARCH AND
C***  DEVELOPMENT CENTER AND WAS THEN EXTENSIVELY MODIFIED FOR USE AT
C***  N.C. STATE UNIVERSITY BY F.O. SMETANA, ET AL AND BY STAN R. FOX.
C***
C***  REFERENCES: THE XYZ POTENTIAL FLOW PROGRAM
C***              CHARLES W. DAWSON & JANET S. DEAN
C***              REPORT 3892
C***              NAVAL SHIP RESEARCH & DEVELOPMENT CENTER
C***              BETHESDA, MARYLAND  20034
C***
C***              THE NCSU BODY PROGRAM
C***              F.O. SMETANA, ET AL
C***              NASA CR-2523
C***              N.C.STATE UNIVERSITY
C***              RALEIGH, NORTH CAROLINA  27650
C***
C***
C***  ANY QUESTIONS CONCERNING THE USE OF THIS PROGRAM SHOULD BE
C***  DIRECTED TO STAN R. FOX OR F.O. SMETANA
C***              2404 BROUGHTON BLDG
C***              DEPT ME ENGRG, NCSU
C***              RALEIGH, N.C.  27650      (919/737-2374)
C***
C
C
      DIMENSION INDEX(9,3),C(9,6),D(9),CZ(9),IP(9),XP(9),YP(9),ZP(9),X(6
     150),Y(650),Z(650),ID(31,31),B(192),FF(9,1),BHOLD(192),XNEW(150),YN
     1EW(150),ZNEW(150),XK(4),RK(4),IDD(650,4),IPT(4),XS(651),YS(651),ZS
     1(651),XCV(40),YCV(40),ZCV(40),FDM(40),CA(40),PHI(40),NCA(40),NVPHI
     1(40),NFS(40),NPTS(40),RAD(50),GAM(50),SVV(31,2),XCFP(2),AEXP(2)
      DIMENSION XORD(5,200),YORD(5,200),XDUM(5,200),YDUM(5,200),KIND(5)
      EQUIVALENCE (XNEW(1),DELS(1)),(YNEW(1),CFI(1)),(ZNEW(1),THT(1)),(C
     17(1),D(1)),(D(1),FF(1,1))
      COMMON TITLE(20),XCP(650),YCP(650),ZCP(650),XNP(650),YNP(650),ZNP(
     1650),AOP(650),REFA,REBODY,NQUAD,IWRITE,NP,KNEW
      COMMON /S2V/CIRCV(40)
```

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```
      COMMON /S1K/SN(650),VNP(650),IPN(650)
      COMMON /RING/VTX(3,650)
      COMMON /VCK/HVF,SFC,DEP,CPHA,TINF,AOUT,AIN,EOA
      COMMON /BL/VOV(75),SS(75),VINF,VO,ROE,DELS(150),CFI(150),THT(150),
     1STOTAL,KKK
      COMMON /INOUT/JREAD,JWRITE,KFILE,KFILE1,KFILE2,KFILE3,KFILE4,KFILE
     15
      COMMON /CANCEL/ICANCL,NODE
      INTEGER P,P1,P2,P3,P4,PC,P5,P6,P7,P8,P9
C
C***  SET CARRIAGE CONTROL PARAMETERS FOR INSTALLATION
      JREAD=1
      JPUNCH=2
      JWRITE=3
      KFILE1=7
      KFILE2=8
      KFILE3=9
      KFILE4=10
      KFILE5=11
C***  SET INITIAL PARAMETERS
      PI=3.1415927
      IPLOT=0
      LINE=0
      MXLINE=50
C***  READ DATA CARDS
    1 READ (JREAD,2, END=173) IDS
    2 FORMAT (I5)
      ICANCL=0
      READ (IDS,3) (TITLE(I),I=1,20)
    3 FORMAT (20A4)
      WRITE (JWRITE,4)
    4 FORMAT (1H1,//,10X,105HNCSU FLOWBODY PROGRAM:  POTENTIAL FLOW + BO
     1UNDARY LAYER + NONUNIFORM SLIPSTREAM FLOW + INTERIOR MASS FLOW.//)
     1
      KFILE=KFILE1
      REWIND KFILE1
      REWIND KFILE2
      REWIND KFILE3
      REWIND KFILE4
      REWIND KFILE5
      KNEW=1
      ICK=3
```

```
      KWRITE=0                                                          PF1  80
      JHOLD=0                                                           PF1  81
      QHOLD=1.0E44                                                      PF1  82
      J=0                                                               PF1  83
      WRITE (JWRITE,5) (TITLE(I),I=1,20)                                PF1  84
    5 FORMAT (1X,20A4)                                                  PF1  85
      SA=.0                                                             PF1  86
      IMATCH=0                                                          PF1  87
      LMATCH=0                                                          PF1  88
C***  DEFINE AND READ PERTINENT GEOMETRIC & FLOW CCNTROL PARAMETERS      PF1  89
      PEAD (JREAD,6) VINF,VO,ROE,REFA,HVF,SFC,DEP,CPHA,TINF,EOA,IWRITE,I PF1  90
     1PCH1,IPCH2,IMATCH                                                 PF1  91
    6 FCRMAT (4E20.13,/,4E20.13,/,2E20.13,4I5)                          PF1  92
      READ (JREAD,7) CF,ITFST,NODE                                      PF1  93
    7 FCRMAT (F10.0,2I5)                                                PF1  94
      IF (CF.EQ.0.0E0)CF=1.0E0                                          PF1  95
      READ (IDS,8) NQE                                                  PF1  96
    8 FCRMAT (I4)                                                       PF1  97
      NSF=1                                                             PF1  98
      MIX=130                                                           PF1  99
      ISM=1                                                             PF1 100
      EPS=0.0001                                                        PF1 101
      ISP=0                                                             PF1 102
      WRITF (JWRITE,9) NQE,NSF,MIX                                      PF1 103
    9 FORMAT (17HONO. OF QUADS.   =,I4/17H NO. OF  SECTIONS=,I4/31H MAX. N PF1 104
     1O. OF ITERATIONS X FLOW ,I3)                                      PF1 105
      WRITF (JWRITE,11)) VINF,VO,ROE,REFA,HVF,SFC,DEP,CPHA,TINF,EOA,IWRIT PF1 106
     1F,IPCH1,IPCH2,IMATCH,IDS,ITEST,NODE                               PF1 107
   10 FCRMAT (//,2X,7HVINF = ,E14.7,3X,5HVO = ,E14.7,3X,6HROE = ,E14.7,3 PF1 108
     1X,7HREFA = ,F14.7,3X,6HHVF = ,F14.7,//,2X,6HSFC = ,F14.7,3X,6HDEP  PF1 109
     1= ,E14.7,3X,7HCPHA = ,E14.7,3X,7HTINF = ,E14.7,3X,6HEOA = ,E14.7,/ PF1 110
     1/,2X,9HIWRITE = ,I2,3X,8HIPCH1 = ,I2,3X,8HIPCH2 = ,I2,3X,9HIMATCH  PF1 111
     1= ,I2,3X,6HIDS = ,I2,3X,8HITEST = ,I2,3X,7HNCDE = ,I4)            PF1 112
C***  PRINT COORDINATE CCNVERSION FACTOR                                PF1 113
      WRITF (JWRITE,11) CF                                              PF1 114
   11 FCRMAT (1X,/,2X,29HCOORDINATE CONVERSION FACTOR,,1X,F12.7,/)      PF1 115
      WRITE (JWRITE,12) ISM,EPS                                         PF1 116
   12 FORMAT (1X,/,2X,I1,18H PLANE OF SYMMETRY,/,2X,22HCCNVERGENCE CRITE PF1 117
     1RIA ,,F8.5)                                                       PF1 118
      LINE=LINE+23                                                      PF1 119
      NCES=NOE                                                          PF1 120
C***  READ PERTINENT CATA FOR THE VORTEX FLOW(S)                        PF1 121
```

```
      NPMAX=650
      DO 13 LL=1,NPMAX
      DC 13 I=1,3
   13 VTX(I,LL)=0.0
C***  READ NUMBER OF VORTEX SYSTEMS
      READ (JREAD,14) NSRV,ISPACE,XCRP(1),XCRP(2),AEXP(1),AEXP(2),XRM
   14 FORMAT (2I5,5F10.0)
      IF (NSRV.LE.0)ISPACE=0
      IF (ISPACE.NE.0)NSRV=1
      ISEE=0
      IF (ISPACE.NE.0)ISEE=1
      INSRV=NSRV
      IF (NSRV.LE.0) GC TO 24
      WRITE (JWRITE,15) NSRV,ISPACE,XCRP(1),AEXP(1),XCRP(2),AEXP(2),XRM
   15 FORMAT (1X,//,2X,I2,27H VORTEX SYSTEM(S) SPECIFIED,/,31X,7HISPACE=
     1,I2,/,31X,10H   XCRP(1)=,F10.5,3X,8HAEXP(1)=,F10.5,/,31X,10H   XCRP(
     12)=,F10.5,3X,8HAEXP(2)=,F10.5,5X,4HXRM=,F10.5,//)
      LINE=LINE+6
C***  READ COORDINATES FOR VORTEX CENTER, MAXIMUM VORTEX RADIUS,   THE
C***  INITIAL CENTRAL ANGLE, ROTATION ANGLE, CENTRAL-ANGLE-INCREMENT
C***  NUMBER, ROTATION TILT PARAMETER, NUMBER OF RADIAL STATIONS FOR
C***  VORTEX SYSTEM, THE NUMBER OF POINTS OF CIRCULATION VS RADIAL
C***  DISTANCE, AND THE CIRCULATION STRENGTH SCALE FACTOR
      DO 23 LL=1,NSRV
      READ (JREAD,16) XCV(LL),YCV(LL),ZCV(LL),RDM(LL),CA(LL),PHI(LL),NCA
     1(LL),NVPHI(LL),NRS(LL),NPTS(LL),GFACT
   16 FORMAT (6F10.0,4I5,/,F10.0)
      IF (GFACT.EQ.0.0)GFACT=1.0
      IF (RDM(LL).GT.0.0) GO TO 17
      NRS(LL)=1
      NPTS(LL)=0
      ISEE=1
   17 IF ((LINE+7).LE.MXLINE) GO TO 19
      WRITE (JWRITE,18)
   18 FORMAT (1H1)
      LINE=0
   19 WRITE (JWRITE,20) LL,XCV(LL),YCV(LL),ZCV(LL),RDM(LL),CA(LL),PHI(LL
     1),NCA(LL),NVPHI(LL),NRS(LL),NPTS(LL),GFACT
   20 FORMAT (1X,'FOR VORTEX SYSTEM:',I2,/,4X,'XCV=',F10.5,'   YCV=',F10.
     15,'   ZCV=',F10.5,/,4X,'RDM=',F10.5,'   CA=',F10.5,'   PHI=',F10.5,/,
     14X,'NCA=',I5,'   NVPHI=',I5,'   NRS=',I5,'   NPTS=',I5,/,4X,'GFACT=',
     1F16.9,//)
```

```
      LINE=LINE+7
      CA(LL)=CA(LL)*PI/180.0
      PHI(LL)=PHI(LL)*PI/180.0
      IF (NPTS(LL).EQ.0) GC TO 23
C***  READ SPLINE POINTS FOR CIRCULATICNS
      MNPTS=NPTS(LL)
      DO 22 I=1,MNPTS
      READ (JREAD,21) RAD(I),GAM(I)
   21 FCRMAT (2F10.0)
      GAM(I)=GAM(I)*GFACT
   22 CONTINUE
      CALL SPLINE(MNPTS,GAM,RAD,LL)
   23 CONTINUE
   24 K=0
      IF (NSRV.FQ.1)LMATCH=1
      XMIN=0.0
      XMAX=0.0
      MM=0
      P=1
      Q=1.0
      DO 25 I=1,31
      DC 25 J=1,31
   25 ID(I,J)=0
      J=0
C***  READ INPUT POINTS--AN ODD NUMBER MUST BE USED FOR BOTH NI AND MI
      RFAD (IDS,26) XI,YI,ZI,NI,MI,NS,NE,VN
   26 FCRMAT (3F12.9,4I4,F12.9)
      MMAX=MI
      MMIN=MI
      NMAX=NI
      NMIN=NI
      NSS=NS
      PC=1
      GO TO 31
   27 READ (IDS,26) XI,YI,ZI,NI,MI,NS,ME,VN
      GO TO 30
   28 MI=MI+1
      IF (MI.LE.MMAXOD) GO TO 29
      MI=1
      NI=NI+1
      IF (NI.FQ.6)NS=3
      IF (NI.EQ.6) GO TO 35
```

```
   29 XI=XNEW(PC+1)
      YI=YNFW(PC+1)
      ZI=ZNEW(PC+1)
   30 PC=PC+1
      IF (NS.NE.NSS) GO TO 35
   31 IF (KNEW.EQ.1.AND.NE.EQ.0) GO TO 32
      IF (KNEW.NF.1.AND.NE.FQ.0) GO TO 33
      IW=NI
      NI=MI
      MI=IW
C***  CONVERT BODY COORDINATES TO COMPATIBLE UNITS
   32 XI=XI*CF
      YI=YI*CF
      ZI=ZI*CF
C***  STORE INPUT POINTS IN POINT ARRAY
   33 X(PC)=XI
      Y(PC)=YI
      Z(PC)=ZI
      IF (KNEW.NE.1) GO TO 34
      XS(PC)=X(PC)
      YS(PC)=Y(PC)
      ZS(PC)=Z(PC)
   34 ID(MI,NI)=PC
      MMAX=MAXO(MMAX,MI)
      MMIN=MINO(MMIN,MI)
      NMAX=MAXO(NMAX,NI)
      NMIN=MINO(NMIN,NI)
      IF (XMIN.GE.XI)XMIN=XI
      IF (XMAX.LE.XI)XMAX=XI
      GO TO (27,28),KNEW
   35 IF ((LINE+3).LE.MXLINE) GO TO 36
      WRITE (JWRITE,18)
      LINE=0
   36 WRITE (JWRITE,37) NSS
   37 FORMAT (/,10H0 SECTION ,I4)
      IF (ISEF.EQ.0.OR.NSRV.EQ.0) GO TO 66
      PC=PC-1
C***  DEFINE CENTERLINE OF BODY
      X21=X(PC)-X(1)
      Y21=Y(PC)-Y(1)
      Z21=Z(PC)-Z(1)
      BCDC=SQ?(X21,Y21,Z21)
```

```
      XDCS=X21/BCDC
      YDCS=Y21/BCDC
      ZDCS=Z21/BCDC
      WRITE (JWRITE,38) XDCS,YDCS,ZDCS
   38 FORMAT (1X,//,10X,35HBODY-CENTERLINE DIRECTION COSINES( ,F7.4,3H ,
     1 ,F7.4,3H , ,F7.4,2H ))
      IF (ITEST.EQ.0) GO TO 39
      XORD(2,1)=X(1)
      XORD(2,2)=X(PC)
      YORD(2,1)=0.0
      YORD(2,2)=0.0
      KIND(2)=-1
      KIND(3)=3
C***  FOR EACH N-STATION, DETERMINE CROSS-SECTIONAL AREA AND MAX RADIUS
   39 LPT=1
      XMR=X(1)
      RXMR=0.0E0
      MMAXM1=MMAX-1
      LZP=0
      DO 41 JN=NMIN,NMAX
      LZP=LZP+1
      X3=X(LPT)
      XORD(3,JN)=X3
      Y3=Y(1)+(X3-X(1))*Y21/X21
      Z3=Z(1)+(X3-X(1))*Z21/X21
      AREAS=0.0E0
      DO 40 JM=MMIN,MMAXM1
      Y4=Y(LPT)
      Z4=Z(LPT)
      IF (JM.EQ.MMIN)RMX=SQ2F(0.0,0.0,Y3,Y4,Z3,Z4)
      Y5=Y(LPT+1)
      Z5=Z(LPT+1)
      AREA=0.5E0*ABS(Y3*Z4+Z3*Y5+Z5*Y4-(Z4*Y5+Z3*Y4+Y3*Z5))
      AREAS=AREAS+2.0E0*AREA
      RMX1=SQ2F(0.0,0.0,Y3,Y5,Z3,Z5)
      IF (RMX1.GT.RMX)RMX=RMX1
      IF (RMX.LT.1.0E-06)RMX=0.0E0
      IF (RMX.GT.RXMR)RXMR=RMX
      IF (RMX.EQ.RXMR)XMR=X3
   40 LPT=LPT+1
      LPT=LPT+1
      SVV(JN,1)=AREAS
```

```
      SVV(JN,2)=RMX
   41 CONTINUE
      IROUND=0
      IF (ITEST.EQ.0) GO TO 43
      DO 42 JN=1,LZP
   42 YORD(3,JN)=SVV(JN,2)/RXMR
   43 IF (ISPACE.EQ.0) GO TO 45
C***  COMPUTE LOCATION CF VORTICES
      CALL SPACF(NSRV,SVV,XCV,NMIN,NMAX,X-MMAX,XCRP,AEXP,XRM,ISPACE,RXMR
     1,XMR)
      INSRV=NSRV
      DO 44 JV=2,NSRV
      NRS(JV)=1
      NPTS(JV)=0
      CA(JV)=CA(1)
      PHI(JV)=PHI(1)
      NCA(JV)=NCA(1)
      RDM(JV)=0.0
   44 NVPHI(JV)=NVPHI(1)
   45 IF ((LINE+25).LE.MXLINE) GO TO 46
      WRITE (JWRITE,18)
      LINE=0
   46 IF (LMATCH.NE.1) GO TO 47
      IF (IMATCH.FQ.0) GO TO 49
   47 WRITE (JWRITE,48)
   48 FCRMAT (1X,//,5X,24HRING VORTFX INFORMATION:,//,6X,6HNUMBER,9X,18H
     1CENTER COORDINATFS,8X,6HRADIUS,3X,11HCIRCULATICN,/,19X,1HX,9X,1HY,
     19X,1HZ,/)
      IROUND=1
   49 DO 60 JV=1,NSRV
      IF (JV.GT.1) GO TO 51
C***  COMPUTE A TOTAL CIRCULATICN
      PDR=RDM(JV)
      NR=NRS(JV)
      GGDR=0.0
      DO 50 MV=1,NR
      RVX=F(NR,MV,PDR,DRX)/PDR
   50 GGDR=GGDR+G(JV,RVX)/RVX
      CIRCV(JV)=GGDR
   51 IF (RDM(JV).NE.0.0.AND.JV.NE.1.AND.IMATCH.NE.0) GO TO 60
C***  CENTER VORTEX CN BODY CENTERLINE
      X3=XCV(JV)
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      IF (ITEST.EQ.0) GO TO 52
      XORD(1,JV)=XCV(JV)
      YORD(1,JV)=0.0
      KIND(1)=2
   52 YCV(JV)=Y(1)+(X3-X(1))*Y21/X21
      ZCV(JV)=Z(1)+(X3-X(1))*Z21/X21
      IF (JV.EQ.1) GO TO 56
C***  SCAN N-STATIONS FOR VORTEX LOCATION
      LPT=1
      NMAXM1=NMAX-1
      DO 53 JN=NMIN,NMAXM1
      LC1=JN
      LC2=JN+1
      IF (XCV(JV).LE.X(LPT).AND.XCV(JV).GE.X(LPT+MMAX)) GO TO 54
   53 LPT=LPT+MMAX
      RDM(JV)=RDM(1)
      GO TO 55
C***  VORTEX LOCATED, DETERMINE RADIUS
   54 RXTL=(X(LPT)-XCV(JV))/(X(LPT)-X(LPT+MMAX))
      RDM(JV)=SVV(LC1,2)+RXTL*(SVV(LC2,2)-SVV(LC1,2))
      RAV1=SQRT(SVV(LC1,1)/PI)
      RAV2=SQRT(SVV(LC2,1)/PI)
      RAV=RAV1+RXTL*(RAV2-RAV1)
      RAVD=SQRT(PDR**2+RAV**2)
      IF (RAVD.GT.RDM(JV))RDM(JV)=RAVD
   55 CIRCV(JV)=GGDR/(RDM(JV)/PDR)
   56 IF (ITEST.EQ.0) GO TO 57
      XORD(4,JV)=XCV(JV)
      YORD(4,JV)=RDM(JV)/PDR
      KIND(4)=6
   57 IF (LMATCH.NE.1) GO TO 58
      IF (IMATCH.EQ.0.AND.IROUND.EQ.0) GO TO 60
   58 WRITE (JWRITE,59) JV,XCV(JV),YCV(JV),ZCV(JV),RDM(JV),CIRCV(JV)
   59 FORMAT (8X,I2,5X,F9.5,1X,F9.5,1X,F9.5,1X,F9.5,2X,F11.7)
   60 CONTINUE
      IF (IROUND.EQ.1) GO TO 64
      IROUND=1
      CALL RGVRTX(XCV,YCV,ZCV,XCV(1),YCV(1),ZCV(1),RDM,NCA,CA,PHI,NVPHI,
     1NRS,NSRV,VX,VY,VZ,IM,NPTS)
      VI=SQ2(VX,VY,VZ)
      IF (IMATCH.NE.0.OR.LMATCH.NE.1) GO TO 64
      DELV=VINF*(1.0+VI)
```

```
      PNET=ROE*PI*(RDM(1)*VINF)**2*DELV
      GFACT=DFP/PNET
      WRITE (JWRITE,61) VI
   61 FORMAT (1X,//,5X,29HREFERENCE INDUCED VELOCITY = ,E16.9)
      WRITE (JWRITE,62) GFACT
   62 FORMAT (1X,//,5X,80HMATCHING OF AIRSTREAM POWER TO DEVELOPED ENGIN
     1E POWER(DFP) REQUIRED GFACT TO BE ,E16.9,20H TIMES THE ORIGINAL.)
      DO 63 I=1,MNPTS
   63 GAM(I)=GAM(I)*GFACT
      CALL SPLINE(MNPTS,GAM,RAD,1)
      GO TO 47
   64 WRITE (JWRITE,65)
   65 FORMAT (1X,//)
      IF (ITEST.EQ.0) GO TO 66
C***  DETERMINE PARAMETERS FOR PLOT OF EXTENT OF VORTICES
      XKEEP=ABS(X21)
      XHOLD=ABS(XRM-X(1))
      IF (XHOLD.GT.XKEEP)XKEEP=XHOLD
      IKEEP1=IFIX(XRM-1.0)
      IKEEP2=IFIX(X(1)+2.0)
      IF (((2*IKEEP1)/2).NE.IKEEP1)IKEEP1=IKEEP1+1
      IF (((2*IKEEP2)/2).NE.IKEEP2)IKEEP2=IKEEP2+1
      LTEST=IABS(IKEEP1)+IABS(IKEEP2)
      XINC=2.0
      XKEEP1=FLOAT(IKEEP1)
      XKEEP2=FLOAT(IKEEP2)
      IHLD1=IFIX(X(1))
      IHLD2=IFIX(XKEEP)
      XHLD=FLOAT(IHLD1)+1.0
      LL1=1
      LL2=2*(IABS(IHLD1)+IABS(IHLD2))+1
      GO TO 111
   66 IF (IWRITE.GT.0) GO TO 68
C***  SET LINE COUNTER
      WRITE (JWRITE,18)
      LINE=0
      WRITE (JWRITE,67)
   67 FORMAT (4H0  M,7X,2HX1,12X,2HX2,12X,2HX3,12X,2HX4,12X,2HXC,12X,2HX
     1N,12X,1HA,13X,3HCZ4/4H   N,7X,2HY1,12X,2HY2,12X,2HY3,12X,2HY4,12X,
     12HYC,12X,2HYN,12X,2HFL,12X,3HCZ5/4H    P,7X,2HZ1,12X,2HZ2,12X,2HZ3,
     112X,2HZ4,12X,2HZC,12X,2HZN,12X,4HCZ1  ,10X,3HCZ6/)
      LINE=LINE+5
```

```
   68 IF (KNEW.EQ.2) GO TO 69
      STCTAL=XMAX-XMIN
      PEBODY=VINF*STOTAL/VO
   69 MMAXQD=MMAX
      NMAXQD=NMAX
      IF (KNEW.NE.1) GO TO 70
      NMX=NMAX+2
   70 IDD=(NMAXQD-3)*(MMAXQD-1)/12
      N1=NMIN
      MM2=MMAX-MMIN
      NN2=NMAX-NMIN
      IF (MOD(MM2,2).EQ.0.AND.MOD(NN2,2).EQ.0) GO TO 71
      ISP=1
   71 MM2=MM2/2
      NN2=NN2/2
      IF ((KNEW.EQ.1.AND.IPCH1.EQ.0).OR.(KNEW.EQ.2.AND.IPCH2.EQ.0)) GO T
     1O 72
C***  PUNCH CARDS FOR PLOTTING
      CALL PUNCH(NMIN,NMX,MMIN,MMAX,XS,YS,ZS,JPUNCH,JWRITE)
C***  DC LOOPS WHICH SWEEP POINT ARRAYS & SET UP PANEL GEOMETRY
   72 DO 110 NN=1,NN2
      M1=MMIN
      DO 109 MM=1,MM2
      NQ=1
      IT=ID(M1,N1)*ID(M1+1,N1)*ID(M1+2,N1)*ID(M1,N1+1)*ID(M1+1,N1+1)*ID(
     1M1+1,N1+2)*ID(M1,N1+2)*ID(M1+1,N1+2)*ID(M1+2,N1+2)
      IF (IT.EQ.0) GO TO 109
      M2=M1+1
      DO 108 M=M1,M2
      N2=N1+1
      DC 108 N=N1,N2
      GC TO (73,74,75,76),NQ
   73 P1=ID(M,N)
      P2=ID(M+1,N)
      P3=ID(M+1,N+1)
      P4=ID(M,N+1)
      P5=ID(M+2,N)
      P6=ID(M+2,N+1)
      P7=ID(M+1,N+2)
      P8=ID(M,N+2)
      P9=P1
      IF ((X(P1).NE.X(P2).OR.Y(P1).NE.Y(P2).OR.Z(P1).NE.Z(P2)).AND.(X(P1
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     1).NE.X(P4).OR.Y(P1).NE.Y(P4).OR.Z(P1).NE.Z(P4))) GO TO 77             PF1 458
      P9=ID(M+2,N+2)                                                        PF1 459
      GO TO 77                                                              PF1 460
   74 P1=ID(M,N+1)                                                          PF1 461
      P2=ID(M,N)                                                            PF1 462
      P3=ID(M+1,N)                                                          PF1 463
      P4=ID(M+1,N+1)                                                        PF1 464
      P5=ID(M,N-1)                                                          PF1 465
      P6=ID(M+1,N-1)                                                        PF1 466
      P7=ID(M+2,N)                                                          PF1 467
      P8=ID(M+2,N+1)                                                        PF1 468
      P9=P1                                                                 PF1 469
      IF ((X(P1).NE.X(P2).OR.Y(P1).NE.Y(P2).OR.Z(P1).NE.Z(P2)).AND.(X(P1 PF1 470
     1).NE.X(P4).OR.Y(P1).NE.Y(P4).OR.Z(P1).NE.Z(P4))) GO TO 77             PF1 471
      P9=ID(M+2,N-1)                                                        PF1 472
      GC TO 77                                                              PF1 473
   75 P1=ID(M+1,N)                                                          PF1 474
      P2=ID(M+1,N+1)                                                        PF1 475
      P3=ID(M,N+1)                                                          PF1 476
      P4=ID(M,N)                                                            PF1 477
      P5=ID(M+1,N+2)                                                        PF1 478
      P6=ID(M,N+2)                                                          PF1 479
      P7=ID(M-1,N+1)                                                        PF1 480
      P8=ID(M-1,N)                                                          PF1 481
      P9=P1                                                                 PF1 482
      IF ((X(P1).NE.X(P2).OR.Y(P1).NE.Y(P2).OR.Z(P1).NE.Z(P2)).AND.(X(P1 PF1 483
     1).NE.X(P4).OR.Y(P1).NF.Y(P4).OR.Z(P1).NF.Z(P4))) GO TO 77             PF1 484
      P9=ID(M-1,N+2)                                                        PF1 485
      GC TO 77                                                              PF1 486
   76 P1=ID(M+1,N+1)                                                        PF1 487
      P2=ID(M,N+1)                                                          PF1 488
      P3=ID(M,N)                                                            PF1 489
      P4=ID(M+1,N)                                                          PF1 490
      P5=ID(M-1,N+1)                                                        PF1 491
      P6=ID(M-1,N)                                                          PF1 492
      P7=ID(M,N-1)                                                          PF1 493
      P8=ID(M+1,N-1)                                                        PF1 494
      P9=P1                                                                 PF1 495
      IF ((X(P1).NE.X(P2).OR.Y(P1).NE.Y(P2).OR.Z(P1).NE.Z(P2)).AND.(X(P1 PF1 496
     1).NF.X(P4).OR.Y(P1).NE.Y(P4).OR.Z(P1).NF.Z(P4))) GO TO 77             PF1 497
      P9=ID(M-1,N-1)                                                        PF1 498
   77 IP(1)=P1                                                              PF1 499
```

```
      IP(2)=P2
      IP(3)=P3
      IP(4)=P4
      IP(5)=P5
      IP(6)=P6
      IP(7)=P7
      IP(8)=P8
      IP(9)=P9
C***  STORE CORNER POINTS TO PANEL NUMBER
      DO 78 JX=1,4
   78 IDD(P,JX)=IP(JX)
C***  COMPUTE NORMAL VECTOR TO PANEL (IN TERMS OF REFERENCE COORDINATE
C***  SYSTEM)
      X1=X(P3)-X(P1)
      X2=X(P4)-X(P2)
      Y1=Y(P3)-Y(P1)
      Y2=Y(P4)-Y(P2)
      Z1=Z(P3)-Z(P1)
      Z2=Z(P4)-Z(P2)
      XN=Y2*Z1-Y1*Z2
      YN=X1*Z2-X2*Z1
      ZN=X2*Y1-X1*Y2
      R=SQ2(XN,YN,ZN)
      XN=XN/R
      YN=YN/R
      ZN=ZN/R
      AQ=.5*R
C***  COMPUTE PANEL CENTROID (IN TERMS OF REFERENCE COORDINATE SYSTEM)
      X1=X(P3)-X(P2)
      Y1=Y(P3)-Y(P2)
      Z1=Z(P3)-Z(P2)
      X5=Y1*Z2-Y2*Z1
      Y5=Z1*X2-Z2*X1
      Z5=X1*Y2-X2*Y1
      A1=SQ2(X5,Y5,Z5)
      A2=R-A1
      IT=1
      XC=(X(P2)+X(P4)+(A1*X(P3)+A2*X(P1))/R)/3.
      YC=(Y(P2)+Y(P4)+(A1*Y(P3)+A2*Y(P1))/R)/3.
      ZC=(Z(P2)+Z(P4)+(A1*Z(P3)+A2*Z(P1))/R)/3.
   79 X4=YN*Z1-Y1*ZN
      Y4=ZN*X1-Z1*XN
```

```
      Z4=XN*Y1-X1*YN                                                     PF1 542
      A=1./SQ2(X4,Y4,Z4)                                                 PF1 543
      X4=X4*A                                                            PF1 544
      Y4=Y4*A                                                            PF1 545
      Z4=Z4*A                                                            PF1 546
      X3=ZN*Y4-Z4*YN                                                     PF1 547
      Y3=XN*Z4-X4*ZN                                                     PF1 548
      Z3=YN*X4-Y4*XN                                                     PF1 549
C***  CCMPUTE POINTS IN QUAD SYSTEM (I.E., ELEMENT COORDINATE SYSTEM)    PF1 550
      DO 80 I=1,9                                                        PF1 551
      L=IP(I)                                                            PF1 552
      XP(I)=X3*(X(L)-XC)+Y3*(Y(L)-YC)+Z3*(Z(L)-ZC)                       PF1 553
      YP(I)=X4*(X(L)-XC)+Y4*(Y(L)-YC)+Z4*(Z(L)-ZC)                       PF1 554
   80 ZP(I)=XN*(X(L)-XC)+YN*(Y(L)-YC)+ZN*(Z(L)-ZC)                       PF1 555
C***  COMPUTE MATRIX COEFFICIENTS TO FIND LOCAL BODY SURFACE EQUATION    PF1 556
      DO 81 I=2,9                                                        PF1 557
      C(I,1)=1.                                                          PF1 558
      C(I,2)=XP(I)                                                       PF1 559
      C(I,3)=YP(I)                                                       PF1 560
      C(I,4)=XP(I)**2                                                    PF1 561
      C(I,5)=YP(I)**2                                                    PF1 562
      C(I,6)=YP(I)*XP(I)                                                 PF1 563
   81 D(I)=ZP(I)                                                         PF1 564
      DO 82 I=1,6                                                        PF1 565
      C(1,I)=C(9,I)                                                      PF1 566
      C(5,I)=C(5,I)+C(6,I)                                               PF1 567
   82 C(6,I)=C(7,I)+C(8,I)                                               PF1 568
      D(1)=D(9)                                                          PF1 569
      D(5)=D(5)+D(6)                                                     PF1 570
      D(6)=D(7)+D(8)                                                     PF1 571
C***  SCLVE MATRIX EQ.  C*CZ=D  FOR CZ                                   PF1 572
      CALL MATINS(C,9,6,FF,6,1,DETERM,IDM,INDEX)                         PF1 573
      IF (IDM.EQ.1) GO TO (84,85),IT                                     PF1 574
      WRITE (JWRITE,83)                                                  PF1 575
   83 FORMAT (33H ERROR IN INPUT - SINGULAR MATRIX)                      PF1 576
      LINE=LINE+1                                                        PF1 577
      ISP=1                                                              PF1 578
      GO TO 85                                                           PF1 579
   84 IT=2                                                               PF1 580
C***  CCMPUTE NEW NORMAL VECTORS                                          PF1 581
      XN=XN-CZ(2)*X3-CZ(3)*X4                                            PF1 582
      YN=YN-CZ(2)*Y3-CZ(3)*Y4                                            PF1 583
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```
      ZN=ZN-CZ(2)*Z3-CZ(3)*Z4
      A=1./SQ2(XN.YN.ZN)
      XN=XN*A
      YN=YN*A
      ZN=ZN*A
      GO TO 79
C***  STORE DATA IN ARRAY TO BE WRITTEN ON TAPE
   85 B(J+1)=XP(1)
      B(J+2)=YP(1)
      B(J+3)=XP(2)
      B(J+4)=YP(2)
      B(J+5)=XP(3)
      B(J+6)=XP(4)
      B(J+7)=YP(4)
      B(J+8)=X3
      B(J+9)=Y3
      B(J+10)=Z3
      B(J+11)=X4
      B(J+12)=Y4
      B(J+13)=Z4
      XCP(K+1)=XC
      YCP(K+1)=YC
      ZCP(K+1)=ZC
      XNP(K+1)=XN
      YNP(K+1)=YN
      ZNP(K+1)=ZN
      AQP(K+1)=AQ
C***  CCMPUTE QUADRUPOLE MCMENTS
      XI1=XP(1)+XP(2)
      XI2=XP(1)+XP(4)
      XI3=XP(3)+XP(2)
      XI4=XP(3)+XP(4)
      XI5=XP(2)+XP(4)
      YI1=YP(1)+YP(2)
      YI2=YP(1)+YP(4)
      YI3=YP(3)+YP(2)
      YI4=YP(3)+YP(4)
      YI5=YP(2)+YP(4)
      R1=A1/24.
      R2=A2/24.
      R3=AQ/12.
      AXX=(XI1**2+XI2**2)*R1+(XI3**2+XI4**2)*R2+XI5**2*R3
```

```
      AXY=(XI1*YI1+XI2*YI2)*R1+(XI3*YI3+XI4*YI4)*R2+XI5*YI5*R3
      AYY=(YI1**2+YI2**2)*R1+(YI3**2+YI4**2)*R2+YI5**2*R3
C***  COMPUTE BODY SOLID ANGLE
      X1=XC*X3+YC*Y3+ZC*Z3
      Y1=XC*X4+YC*Y4+ZC*Z4
      Z1=XC*XN+YC*YN+ZC*ZN
      RD=1./SQ2(X1,Y1,Z1)
      RCU=RD**3
      RSV=RCU**2*RD
      SA=SA+Z1*(AQ*RCU-((AXX*(Y1**2+Z1**2-4.*X1**2)+AYY*(X1**2+Z1**2-4.*
     1Y1**2))*1.5-15.*X1*Y1*AXY)*RSV)
      B(J+14)=AXX
      B(J+15)=AXY
      B(J+16)=AYY
C***  BODY ERROR TESTS
      D1=SQ2((XP(3)-XP(1)),(YP(3)-YP(1)),0.)
      D2=SQ2((XP(4)-XP(2)),(YP(4)-YP(2)),0.)
      FL=.5*AMAX1(D1,D2)
      CZ23=ABS(CZ(2))+ABS(CZ(3))
      IF (ABS(CZ(2))+ABS(CZ(3)).GT.FL*.001) GO TC 86
      IF (ABS(CZ(1)).LT.FL*.3) GO TO 88
   86 IF (IWRITE.GT.0) GO TO 88
      WRITE (JWRITE,87) CZ23
   87 FORMAT (29H QUESTIONABLE PCINT -POOR FIT,6E14.3)
      LINF=LINF+1
   88 IF (XP(4).LT.XP(1)) GO TO 89
      IF ((YP(4)-YP(3))*(YP(1)-YP(2)).GE.0.) GO TO 92
   89 IF (IWRITE.GT.0) GO TO 91
      WRITE (JWRITE,90) (XP(I),YP(I),I=1,4)
   90 FORMAT (30H ERROR IN INPUT - CROSSED QUAD,4(2F10.5,3X))
      LINE=LINE+1
   91 ISP=1
   92 CRCF=SQ2((XP(2)-XP(1)),(YP(2)-YP(1)),0.)+XP(3)-XP(2)+SQ2((XP(1)-XP
     1(4)),(YP(1)-YP(4)),0.)+SQ2((XP(4)-XP(3)),(YP(4)-YP(3)),0.)
      IF (36.*AQ.GT.CRCF**2) GO TO 94
      IF (IWRITE.GT.0) GO TO 104
      LINE=LINE+1
      WRITE (JWRITE,93)
   93 FCRMAT (24H WARNING LONG THIN QUAD.)
   94 IF (IWRITE.GT.0) GO TO 104
      IF (Z1.GE.0.) GO TO 96
      WRITE (JWRITE,95)
```

```
   95 FORMAT (35H QUESTIONABLE POINT - INWARD NORMAL)
      LINE=LINE+1
C***  EDIT QUADRILATERAL INFORMATION
   96 GO TO (97,98,99,100),NQ
   97 WRITE (JWRITE,101) M,X(P1),X(P2),X(P3),X(P4),XC,XN,AQ,CZ(4),N,Y(P1
     1),Y(P2),Y(P3),Y(P4),YC,YN,FL,CZ(5),P,Z(P1),Z(P2),Z(P3),Z(P4),ZC,ZN
     1,CZ(1),CZ(6)
      GO TO 102
   98 WRITE (JWRITE,101) M,X(P2),X(P3),X(P4),X(P1),XC,XN,AQ,CZ(4),N,Y(P2
     1),Y(P3),Y(P4),Y(P1),YC,YN,FL,CZ(5),P,Z(P2),Z(P3),Z(P4),Z(P1),ZC,ZN
     1,CZ(1),CZ(6)
      GO TO 102
   99 WRITE (JWRITE,101) M,X(P4),X(P1),X(P2),X(P3),XC,XN,AQ,CZ(4),N,Y(P4
     1),Y(P1),Y(P2),Y(P3),YC,YN,FL,CZ(5),P,Z(P4),Z(P1),Z(P2),Z(P3),ZC,ZN
     1,CZ(1),CZ(6)
      GC TO 102
  100 WRITE (JWRITE,101) M,X(P3),X(P4),X(P1),X(P2),XC,XN,AQ,CZ(4),N,Y(P3
     1),Y(P4),Y(P1),Y(P2),YC,YN,FL,CZ(5),P,Z(P3),Z(P4),Z(P1),Z(P2),ZC,ZN
     1,CZ(1),CZ(6)
  101 FORMAT (1H ,I3,8E14.5/1X,I3,8E14.5/1X,I3,8E14.5/)
  102 LINE=LINE+4
      IF (LINF.LT.MXLINE) GO TO 104
      WRITE (JWRITE,103)
  103 FORMAT (4H1   M,7X,2HX1,12X,2HX2,12X,2HX3,12X,2HX4,12X,2HXC,12X,2HX
     1N,12X,1HA,13X,3HCZ4/4H   N,7X,2HY1,12X,2HY2,12X,2HY3,12X,2HY4,12X,
     12HYC,12X,2HYN,12X,2HFL,12X,3HCZ5/4H   P,7X,2HZ1,12X,2HZ2,12X,2HZ3,
     112X,2HZ4,12X,2HZC,12X,2HZN,12X,4HCZ1  ,10X,3HCZ6/)
      LINF=0
  104 J=J+16
      IF (KNEW.NE.1.AND.P.LE.NQES) GO TO 105
C***  INITIALIZE ARRAYS
      VNP(P)=0.0
      IFN(P)=0
  105 I=P
      P=P+1
      NC=NQ+1
      K=K+1
C***  WRITE B ARRAY CONTAINING INFORMATION FOR 12 QUADRILATERALS
      IF (J.LT.192) GO TO 108
      IF (KNEW.EQ.1)KWRITE=KWRITE+1
      WRITE (KFILE)Q,(E(I),I=1,192)
      IF (KNFW.NF.1) GC TO 107
```

```
      IF (KWRITE.NE.IDO+1) GO TO 107
      QHCLD=Q
      DC 106 I=1,192
  106 BHOLD(I)=B(I)
  107 Q=P
      J=0
  108 CCNTINUE
  109 M1=M1+2
  110 N1=N1+2
      IF (KNEW.NE.1) GC TO 129
  111 IMESS=0
C***  READ AND TEST M AND N STATIONS TO SPECIFY NCNZERO NORMAL VELOCITY
C***  ON A QUADRILATERAL
  112 READ (JREAD,113) MS1,MS2,NS1,NS2,IPNS
  113 FCRMAT (5I5)
      IF (MS1.FQ.0.AND.IPNS.EQ.0) GO TO 129
      IF (IPNS.EQ.0) GO TO 112
      IF (((MS1.LF.0.OR.MS1.GT.MMAX).OR.(MS2.LE.0.OR.MS2.GT.MMAX)).OR.((
     1NS1.LE.0.OR.NS1.GT.NMAX).OR.(NS2.LE.0.OR.NS2.GT.NMAX)).OR.(MS2-MS1
     1).NE.1.OR.(NS2-NS1).NE.1) GO TO 116
      IF (IMESS.FQ.1) GO TO 115
      WRITE (JWRITE,114)
  114 FORMAT (1H1,///,5X,48HDFSIGNATION OF NORMAL VELOCITY ON QUADRILATE
     1RALS,/)
      LINE=6
  115 IMFSS=1
      GC TO 118
  116 WRITE (JWRITF,117) MS1,MS2,MMAX,NS1,NS2,NMAX
  117 FORMAT (1X,/,10X,36HAN ERROR IN DATA INPUT HAS OCCURRED:,/,15X,4HM
     1S1=,I3,3X,4HMS2=,I3,3X,5HMMAX=,I3,/,15X,4HNS1=,I3,3X,4HNS2=,I3,3X,
     15HNMAX=,I3,/,10X,12HCALLING EXIT,//)
      GC TO 172
  118 MC=0
      ICK=1
      LC=0
C***  LOCATE CORNER PCINTS OF NONZERC-NORMAL-VELOCITY QUADRILATERAL
      DC 120 NX=NMIN,NS2
      DC 120 MX=MMIN,MMAX
      LC=LC+1
      IF ((NX.EQ.NS1.OR.NX.FQ.NS2).AND.(MX.EQ.MS1.OR.MX.EQ.MS2)) GO TO 1
     119
      GO TO 120
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  119 MC=MC+1
      IPT(MC)=LC
      IF (NX.EQ.NS2.AND.MX.EQ.MS2) GO TO 121
  120 CONTINUE
C***  CORNER POINTS LOCATED. NOW FIND CORRESPONDING PANEL NUMBER
  121 DO 124 JX=1,NQE
      NPL=JX
      LC=0
      DO 123 MX=1,4
      DO 122 NX=1,4
      IF (IPT(MX).EQ.IDD(JX,NX))LC=LC+1
  122 CONTINUE
  123 CONTINUE
      IF (LC.EQ.4) GO TO 125
  124 CONTINUE
C***  PANEL NUMBER FOUND. STORE INDICATION OF NONZERO NORMAL VELOCITY
  125 IPN(NPL)=IFNS
      IF (IPNS.LT.0) GO TO 127
      WRITE (JWRITE,126) MS1,MS2,NS1,NS2,NPL
  126 FORMAT (2X,4(I5,1X),2X,6HPANEL ,I4,2X,75HHAS BEEN DESIGNATED TO HA
     1VE A NONZERO OUTWARD NORMAL COMPONENT OF VELOCITY.)
      LINE=LINE+1
      GO TO 112
  127 WRITE (JWRITE,128) MS1,MS2,NS1,NS2,NPL
  128 FORMAT (2X,4(I5,1X),2X,6HPANEL ,I4,2X,74HHAS BEEN DESIGNATED TO HA
     1VE A NONZERO INWARD NORMAL COMPONENT OF VELOCITY.)
      LINE=LINE+1
      GO TO 112
C***  SET UP FOR NEXT SECTION
  129 IF (ITFST.NE.0) GO TO 150
      DO 130 M=MMIN,MMAX
      DO 130 N=NMIN,NMAX
  130 ID(M,N)=0
  131 NSS=NS
      PC=1
      MMAX=MI
      MMIN=MI
      NMIN=NI
      NMAX=NI
      NE=ME
      IF (NS.GT.0) GO TO 31
      JHOLD=((NMAXQD-3)*(MMAXQD-1)-12*IDD)*16
```

```
      IF (J.EQ.192) GO TO 133
      IF (KNEW.EQ.1)KWRITE=KWRITE+1
      WRITE (KFILE)Q,(B(I),I=1,192)
      IF (KNEW.NE.1) GO TO 133
      IF (KWRITE.NE.IDO+1) GO TO 133
      QHOLD=Q
      DO 132 I=1,192
  132 BHOLD(I)=B(I)
  133 NP=K
      NQUAD=NP
      ISMP=ISM+1
      GO TO (137,136,135,134),ISMP
  134 SA=SA+SA
  135 SA=SA+SA
  136 SA=SA+SA
  137 J=1
C***  CHECK SOLID ANGLE
      IF (ABS(SA-12.566).LT..05) GO TO 138
      IF (ABS(SA).LE..05) GO TO 140
  138 WRITE (JWRITE,139) SA
  139 FORMAT (40HOPROBABLE ERROR IN INPUT - SOLIC ANGLE =,2F12.3)
  140 REWIND KFILE
C***  CHECK NO. OF QUADRILATERALS
      IF (NP.EQ.NQE) GO TO 143
      WRITE (JWRITE,141) NP,NQE
  141 FORMAT (1X,I4,27H QUADRILATERALS GIVEN, NOT ,I4)
      WRITE (JWRITE,142)
  142 FORMAT (//,1X,11HEXIT CALLED,//)
      GO TO 172
  143 IF (ISP.LE.0) GO TO 144
      WRITE (JWRITE,142)
      GO TO 172
C***  CALL REMAINING SECTIONS OF THE POTENTIAL FLOW PROGRAM
  144 CALL PFP2(ISM,K)
      IF (ICANCL.NE.0) GO TO 172
      NSRV=INSRV
  145 IF (NSRV.LE.0) GO TO 158
      LL1=1
      LL2=NP
      IF (KNEW.NE.2) GO TO 146
      LL1=LL1S
      LL2=LL2S
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146 IF (KNEW.EQ.1) WRITE (JWRITE,147)
147 FORMAT (1H1,//,1X,67HINDUCED VELOCITY BY RING VORTICES AT ORIGINAL
   1-BODY PANEL CENTROIDS:,/)
    IF (KNEW.EQ.2) WRITE (JWRITE,148)
148 FORMAT (1H1,//,1X,63HINDUCED VELOCITY BY RING VORTICES AT WAKE-BOD
   1Y PANEL CENTROIDS:,/)
    WRITE (JWRITE,149)
149 FORMAT (2X,5HPANEL,3X,10('-'),1X,23HPANEL CENTROID LOCATION,1X,11(
   1'-'),4X,12('-'),1X,19HVELOCITY COMPONENTS,1X,13('-'),/,1X,6HNUMBER
   1,9X,1HX,15X,1HY,15X,1HZ,17X,1HX,15X,1HY,15X,1HZ,/)
    LINE=0
    GO TO 153
150 WRITE (JWRITE,151)
151 FORMAT (1H1,//,1X,63HINDUCED VELOCITY BY RING VORTICES ALONG BODY-
   1CENTERLINE POINTS:,/)
    WRITE (JWRITE,152)
152 FORMAT (1X,5HPOINT,3X,15('-'),1X,14HPOINT LOCATION,1X,15('-'),4X,1
   12('-'),1X,19HVELOCITY COMPONENTS,1X,13('-'),/,1X,6HNUMBER,9X,1HX,1
   15X,1HY,15X,1HZ,17X,1HX,15X,1HY,15X,1HZ,/)
153 DO 157 LL=LL1,LL2
    IF (ITEST.EQ.0) GO TO 154
C***  FOR ITEST=1, SET AXIAL STATIONS FOR VORTEX INDUCED VELOCITIES
    YCP(LL)=0.0
    ZCP(LL)=0.0
    IF (LL.EQ.1)XCP(LL)=XHLD
    IF (LL.GT.1)XCP(LL)=XCP(LL-1)-0.5E0
    XORD(5,LL)=XCP(LL)
C***  COMPUTE INDUCED VELOCITY COMPONENTS AT PANEL CENTROIDS BY THE RING
C***  VORTICIES
154 CALL RGVRTX(XCV,YCV,ZCV,XCP(LL),YCP(LL),ZCP(LL),RDM,NCA,CA,PHI,NVP
   1HI,NRS,NSRV,VX,VY,VZ,IM,NPTS)
    VTX(1,LL)=VX
    VTX(2,LL)=VY
    VTX(3,LL)=VZ
    IF (ITEST.NE.0)YCRD(5,LL)=VTX(1,LL)
    IF ((LINE+1).LE.MXLINE) GO TO 155
    WRITE (JWRITE,18)
    IF (ITEST.EQ.0) WRITE (JWRITE,149)
    IF (ITEST.NE.0) WRITE (JWRITE,152)
    LINE=0
155 WRITE (JWRITE,156) LL,XCP(LL),YCP(LL),ZCP(LL),(VTX(IS,LL),IS=1,3)
156 FORMAT (2X,I4,3X,1H(,1PE14.7,2H, ,1PE14.7,2H, ,1PE14.7,4H)    ,1PE1
```

```
     14.7,2X,1PE14.7,2X,1PE14.7)
      LINE=LINE+1
  157 CONTINUE
      IF (ITEST.EQ.0) GO TO 158
C***  WARNING:  THE FOLLOWING PLOT CARDS MAY BE INSTALLATION-DEPENDENT.
      KIND(5)=-1
      IPLOT=1
      CALL PICSIZ(10.0,10.0)
      CALL GRAFF(7.5,XKEEP1,XKEEP2,XINC,0,'REFERENCE COORDINATE SYSTEM X
     1-VALUE_',XORD,XDUM,5.0,-1.0,2.0,1.0,0,'NORMALIZED INTERPRETATION S
     1CALE_',YORD,YDUM,1,5,5,200,NSRV,2,NMAX,NSRV,LL2,KIND,1,' _')
  158 IF (ITEST.NE.0) GO TO 172
      CALL PFP3(EPS,MIX)
      CALL PFP4(CLPA,CDPA,ICK)
C***  COMPUTE INTERIOR PRESSURE COEFFICIENT AND NORMAL VELOCITIES
      IF (ICK.EQ.1) CALL VINOUT(JWRITE,VINF,ROE,NQE,VI)
      IF (ICANCL.NE.0) GO TO 172
      NSRV=0
      ICK=ICK+1
      IF (ICK.EQ.2) GO TO 145
      IF (KNEW.NE.2) GO TO 160
C***  ON SECOND PASS THROUGH COMPUTE LIFT & DRAG COEFFICIENTS
      CL=CLPA/REFA
      CD=(CDPA+CDFA)/REFA
      WRITE (JWRITE,159) CL,CD,REFA,REBODY,STOTAL
  159 FORMAT (////,31X,23HTOTAL BODY COEFFICIENTS///,28X,29(1H*)/30X,16H
     1TOTAL BODY CL = ,F11.5,/30X,16HTOTAL BODY CD = ,F11.5,/29X,17HREFE
     1RENCE AREA = ,F11.5,/28X,18HREYNOLDS NUMBER = ,E11.4,/32X,14HBODY
     1LENGTH = ,F11.5,/28X,29(1H*),//)
      GO TO 172
  160 CALL PFP5(MMAXQD,NMAXQD,AREAAV,AVDELS,AVXCG,CDFA)
      IF (ICANCL.NE.0) GO TO 172
C***  REMAINING CARDS COMPUTE NECESSARY INFORMATION FOR WAKE-BODY
      KNEW=2
      NQFS=NQF
      MI=1
      NI=1
      NS=1000
      K=(NMAXQD-3)*(MMAXQD-1)
      MF=0
      NQE=NQE+2*(MMAXQD-1)
      LL1S=K
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      LL2S=NOE
      REWIND KFILE1
      DC 161 I=1,IDO
      READ (KFILE1)Q,(B(IJK),IJK=1,192)
      WRITE (KFILE2)Q,(B(IJK),IJK=1,192)
  161 CONTINUE
      KFILE=KFILE2
      J=JHOLD
      IF (J.EQ.0) GO TO 163
      DO 162 I=1,J
  162 B(I)=BHOLD(I)
  163 Q=QHOLD
      JP=JHOLD/16
      QADD=QHOLD+.5
      P=QADD+JP
      ISTART=(NMAXQD-3)*MMAXQD
      IST=ISTART+MMAXQD
      XHCLD1=X(ISTART+1)
      XHOLD2=X(IST+1)
C***  Y REFERENCE LINE MUST BE 0.0
      ZAV=0.0
      DC 164 I=1,MMAXQD
      XNEW(I)=X(ISTART+I)
      YNEW(I)=Y(ISTART+I)
      ZNEW(I)=Z(ISTART+I)
  164 ZAV=ZAV+ZNEW(I)
      THETA=-90.0*3.14159/180.0
      ZAV=ZAV/MMAXQD
      RAV=0.0
      DC 165 I=1,MMAXQD
      RNFW=SQRT((YNEW(I))**2+(ZNEW(I)-ZAV)**2)
  165 PAV=RAV+RNEW
      RAV=RAV/MMAXQD
      FAC=(AVXCG-XHOLD1)/(XHOLD2-XHOLD1)
      AVSLOP=0.0
      DO 166 I=1,MMAXQD
      YCG=YNEW(I)-(YNEW(I)-Y(IST+I))*FAC
      ZCG=ZNEW(I)-(ZNEW(I)-Z(IST+I))*FAC
      P1=SQRT((YNFW(I))**2+(ZNFW(I)-ZAV)**2)
      R2=SQRT((YCG)**2+(ZCG-ZAV)**2)+2.0*AVDELS
      SLOPF=(R2-R1)/(XHOLD1-AVXCG)
  166 AVSLOP=AVSLOP+SLOPE
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      AVSLOP=AVSLOP/MMAXQD
      AREAT=4.0*AREAAV*2.0*MMAXQD
      XINF=XHOLD1-AREAT/(3.14159*RAV)
C***  CHECK TO MAKE SURE BODY SLOPE IS DECREASING
      IF (AVSLOP.GE.0.)AVSLOP=-ABS(RAV/(XINF-XHOLD1))
      WRITE (JWRITE,167) AVSLOP,AREAAV,AVXCG,XINF
  167 FORMAT (1H1/50X,24HBEGIN WAKE BODY GEOMETRY///,17H AVERAGE SLOPE =
     1 ,F8.5,3X,22H AVERAGE PANEL AREA = ,F8.5,3X,22H AVERAGE X-CENTROID
     1 = ,F10.5,3X,20H END OF BODY AT X = ,F10.5)
      DELTAZ=.01
      KK=1
      XX1=XHOLD1
      ZZ2=0.0
      RR1=RAV
  168 ZZ2=ZZ2+DFLTAZ
      XX2=ZZ2*(XINF-XHOLD1)+XHOLD1
      RR2=RAV*EXP(AVSLOP*ZZ2)*(1.0-ZZ2)
      DTHETA=3.14159/(MMAXQD-1)
      AREA2=(RR2+RR1)*SIN(DTHETA/2.0)*SQRT((RR2-RR1)**2+(XX2-XX1)**2)
      IF (AREA2.LT.AREAAV) GO TO 168
      XK(KK)=XX2
      RK(KK)=RR2
      XX1=XX2
      RR1=RR2
      KK=KK+1
      IF (KK.GE.4) GO TO 169
      GO TO 168
  169 XK(4)=XINF
      RK(4)=0.0
      X1=XK(1)
      X2=XK(2)
      X3=XK(3)
      X4=XK(4)
      R1=RK(1)
      R2=RK(2)
      R3=RK(3)
      R4=RK(4)
      NSTRT1=MMAXQD
      NSTRT2=2*MMAXQD
      NSTRT3=3*MMAXQD
      NSTRT4=4*MMAXQD
      YFAC=(-Y(1))/(XINF-XHOLD1)
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      ZFAC=(ZAV-Z(1))/(XINF-XHOLD1)                                     PF11004
      DO 170 I=1,MMAXQD                                                 PF11005
      COSTHT=COS(THETA)                                                 PF11006
      SINTHT=SIN(THETA)                                                 PF11007
      XNEW(NSTRT1+I)=X1                                                 PF11008
      XNEW(NSTRT2+I)=X2                                                 PF11009
      XNEW(NSTRT3+I)=X3                                                 PF11010
      XNEW(NSTRT4+I)=X4                                                 PF11011
      YNEW(NSTRT1+I)=R1*COSTHT-(XNEW(NSTRT1+I)-XHOLD1)*YFAC             PF11012
      YNEW(NSTRT2+I)=R2*COSTHT-(XNEW(NSTRT2+I)-XHOLD1)*YFAC             PF11013
      YNEW(NSTRT3+I)=R3*COSTHT-(XNEW(NSTRT3+I)-XHOLD1)*YFAC             PF11014
      YNEW(NSTRT4+I)=R4*COSTHT-(XNEW(NSTRT4+I)-XHOLD1)*YFAC             PF11015
      ZNEW(NSTRT1+I)=R1*SINTHT+ZAV-(XNEW(NSTRT1+ I)-XHOLD1)*ZFAC        PF11016
      ZNEW(NSTRT2+I)=R2*SINTHT+ZAV-(XNEW(NSTRT2+ I)-XHOLD1)*ZFAC        PF11017
      ZNEW(NSTRT3+I)=R3*SINTHT+ZAV-(XNEW(NSTRT3+ I)-XHOLD1)*ZFAC        PF11018
      ZNEW(NSTRT4+I)=R4*SINTHT+ZAV-(XNEW(NSTRT4+ I)-XHOLD1)*ZFAC        PF11019
  170 THETA=THETA+DTHETA                                                PF11020
C***  STORE COORDINATES FOR PUNCHING                                     PF11021
      KPI=5*MMAXQD                                                      PF11022
      DO 171 I=1,KPI                                                    PF11023
      XS(ISTART+I)=XNEW(I)                                              PF11024
      YS(ISTART+I)=YNEW(I)                                              PF11025
  171 ZS(ISTART+I)=ZNEW(I)                                              PF11026
      XI=XNEW(1)                                                        PF11027
      YI=YNEW(1)                                                        PF11028
      ZI=ZNEW(1)                                                        PF11029
      GO TO 131                                                         PF11030
C***  PREPARE FOR NEXT DATA SET                                          PF11031
  172 IF (IDS.NE.JREAD) REWIND IDS                                      PF11032
      GO TO 1                                                           PF11033
C***  WARNING:  THE FOLLOWING PLOT CARD MAY BE INSTALLATION-DEPENDENT.   PF11034
  173 IF (IPLOT.NE.0) CALL PICSIZ(0.0,0.0)                              PF11035
      STOP                                                              PF11036
      END                                                               PF11037


      FUNCTION SQ2(X,Y,Z)                                               SQ2    1
C                                                                       SQ2    2
C***  FUNCTION SQ2 CALCULATES THE SQUARE ROOT OF R**2                    SQ2    3
C                                                                       SQ2    4
      RS=X**2+Y**2+Z**2                                                 SQ2    5
```

```
      SQ2=SQRT(RS)                                                      SQ2    6
      RFTURN                                                            SQ2    7
      END                                                               SQ2    8

      SUBROUTINE MATINS(A,NR,N1,B,NC,M1,DETERM,ID,INDEX)                MIN    1
C                                                                       MIN    2
C***  MATRIX INVERSION(PIVOT METHOD) WITH SIMULTANEOUS EQUATION SOLUTION MIN    3
C***  INPUT A(NR,NR),B(NR,NC),& INDEX(NR,3)--NR,NC ARE ARRAY DIMENSIONS. MIN    4
C***  DEFINITIONS: N1-THE ORDER OF A, M1-THE NUMBER OF COLUMN VECTORS IN MIN    5
C***  B(MAY BE 0), DETERM-CONTAINS DETERMINANT ON EXIT, INDEX-WORK ARRAY MIN    6
C***  ID-(ID=2--SINGULAR MATRIX,ID=1--SUCESSFUL INVERSION), A-THE INPUT  MIN    7
C***  MATRIX WHICH IS REPLACED BY A INVERSE, B-COLUMN VECTORS WHICH IS   MIN    8
C***  REPLACED BY CORRESPONDING SOLUTICN VECTORS.                        MIN    9
C                                                                       MIN   10
      DIMENSION A(9,6),B(9,1),INDEX(9,3)                                MIN   11
      FQUIVALFNCE (IROW,JROW),(ICOLUM,JCOLUM),(AMAX,T,SWAP)             MIN   12
C                                                                       MIN   13
C***  INITIALIZATION                                                    MIN   14
      N=N1                                                              MIN   15
      M=M1                                                              MIN   16
      DETFRM=1.0                                                        MIN   17
      DO 1 J=1,N                                                        MIN   18
    1 INDEX(J,3)=0                                                      MIN   19
      DO 20 I=1,N                                                       MIN   20
C***  SEARCH FOR PIVOT ELEMENT                                          MIN   21
      AMAX=0.0                                                          MIN   22
      DC 6 J=1,N                                                        MIN   23
      IF (INDEX(J,3)-1)  2,6,2                                          MIN   24
    2 DC 5 K=1,N                                                        MIN   25
      IF (INDFX(K,3)-1)  3,5,26                                         MIN   26
    3 IF (AMAX-ABS(A(J,K)))  4,5,5                                      MIN   27
    4 IRCW=J                                                            MIN   28
      ICOLUM=K                                                          MIN   29
      AMAX=ABS(A(J,K))                                                  MIN   30
    5 CCNTINUE                                                          MIN   31
    6 CCNTINUE                                                          MIN   32
      INDFX(ICOLUM,3)=INDEX(ICOLUM,3)+1                                 MIN   33
      INDEX(I,1)=IROW                                                   MIN   34
      INDFX(I,2)=ICOLUM                                                 MIN   35
C***  INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGCNAL                 MIN   36
```

```
      IF (IROW-ICOLUM)  7,11,7                                          MIN  37
    7 DETERM=-DETERM                                                    MIN  38
      DO 8 L=1,N                                                        MIN  39
      SWAP=A(IROW,L)                                                    MIN  40
      A(IROW,L)=A(ICOLUM,L)                                             MIN  41
    8 A(ICOLUM,L)=SWAP                                                  MIN  42
      IF (M)  11,11,9                                                   MIN  43
    9 DO 10 L=1,M                                                       MIN  44
      SWAP=B(IROW,L)                                                    MIN  45
      B(IROW,L)=B(ICOLUM,L)                                             MIN  46
   10 B(ICOLUM,L)=SWAP                                                  MIN  47
C***  DIVIDE PIVCT ROW BY PIVOT ELEMENT                                 MIN  48
   11 PIVOT=A(ICOLUM,ICOLUM)                                            MIN  49
      DETERM=DETERM*PIVOT                                               MIN  50
      A(ICOLUM,ICOLUM)=1.0                                              MIN  51
      DO 12 L=1,N                                                       MIN  52
   12 A(ICOLUM,L)=A(ICCLUM,L)/PIVOT                                     MIN  53
      IF (M)  15,15,13                                                  MIN  54
   13 DO 14 L=1,M                                                       MIN  55
   14 B(ICOLUM,L)=B(ICOLUM,L)/PIVOT                                     MIN  56
C***  REDUCE NON-PIVOT ROWS                                             MIN  57
   15 DO 20 L1=1,N                                                      MIN  58
      IF (L1-ICOLUM)  16,20,16                                          MIN  59
   16 T=A(L1,ICOLUM)                                                    MIN  60
      A(L1,ICOLUM)=0.0                                                  MIN  61
      DO 17 L=1,N                                                       MIN  62
   17 A(L1,L)=A(L1,L)-A(ICOLUM,L)*T                                     MIN  63
      IF (M)  20,20,18                                                  MIN  64
   18 DO 19 L=1,M                                                       MIN  65
   19 B(L1,L)=B(L1,L)-B(ICCLUM,L)*T                                     MIN  66
   20 CONTINUE                                                          MIN  67
C***  INTERCHANGE CCLUMNS                                               MIN  68
      DO 23 I=1,N                                                       MIN  69
      L=N+1-I                                                           MIN  70
      IF (INDEX(L,1)-INDEX(L,2))  21,23,21                              MIN  71
   21 JROW=INDEX(L,1)                                                   MIN  72
      JCCLUM=INDEX(L,2)                                                 MIN  73
      DO 22 K=1,N                                                       MIN  74
      SWAP=A(K,JROW)                                                    MIN  75
      A(K,JROW)=A(K,JCCLUM)                                             MIN  76
      A(K,JCOLUM)=SWAP                                                  MIN  77
   22 CCNTINUE                                                          MIN  78
```

```
   23 CCNTINUE                                                          MIN   79
      DO 24 K=1,N                                                       MIN   80
      IF (INDEX(K,3)-1)  26,24,26                                       MIN   81
   24 CONTINUF                                                          MIN   82
      ID=1                                                              MIN   83
   25 RETURN                                                            MIN   84
   26 ID=2                                                              MIN   85
      GC TO 25                                                          MIN   86
      END                                                               MIN   87


      SUBROUTINF PFP2(ISM,KM)                                           PF2    1
C                                                                       PF2    2
C***  SUBROUTINE PFP2 CALCULATES THE INDUCED VELOCITIES OF EACH QUAD-   PF2    3
C***  RILATERAL ON EVERY OTHER QUADRILATERAL                            PF2    4
C                                                                       PF2    5
      DIMENSION B(193),V1(1000),C1(900),VX(8),VY(8),VZ(8)               PF2    6
      EQUIVALENCE (Y3,Y2)                                               PF2    7
      CCMMON TITLF(20),XCP(650),YCP(650),ZCP(650),XNP(650),YNP(650),ZNP( PF2    8
     1650),AQP(650),REFA,REBODY,NQUAD,IWRITE,NP,KNEW                    PF2    9
      CCMMON /INOUT/JREAD,JWRITE,KFILE,KFILE1,KFILE2,KFILE3,KFILE4,KFILE PF2   10
     15                                                                 PF2   11
      COMMON /S1K/SN(650),VNP(650),IPN(650)                             PF2   12
      COMMCN /CANCEL/ICANCL,NODE                                        PF2   13
C                                                                       PF2   14
      BLK=1.0                                                           PF2   17
      IDW=0                                                             PF2   18
C***  READ FIRST BLOCK OF B ARRAY                                       PF2   21
      READ (KFILE)(B(I),I=1,193)                                        PF2   22
      K=1                                                               PF2   23
      J=1                                                               PF2   24
      P=1                                                               PF2   25
      JC=1                                                              PF2   26
      JV=2                                                              PF2   27
      KMM=5*((NP+4)/5)+1                                                PF2   28
C***  START LCOP OVER QUADRILATERALS                                    PF2   29
      IF (B(1)-P)  68,3,68                                              PF2   30
    3 J=2                                                               PF2   31
C***  CHOOSE QUADRILATERAL AS REFERENCE POINT                           PF2   32
    4 X1=B(J)                                                           PF2   33
      Y1=B(J+1)                                                         PF2   34
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```
      X2=B(J+2)                                                        PF2  35
      Y2=B(J+3)                                                        PF2  36
      X3=B(J+4)                                                        PF2  37
      X4=B(J+5)                                                        PF2  38
      Y4=B(J+6)                                                        PF2  39
      XN=XNP(K)                                                        PF2  40
      YN=YNP(K)                                                        PF2  41
      ZN=ZNP(K)                                                        PF2  42
      XC=XCP(K)                                                        PF2  43
      YC=YCP(K)                                                        PF2  44
      ZC=ZCP(K)                                                        PF2  45
      A=AQP(K)                                                         PF2  46
      XX=B(J+7)                                                        PF2  47
      YX=B(J+8)                                                        PF2  48
      ZX=B(J+9)                                                        PF2  49
      XY=B(J+10)                                                       PF2  50
      YY=B(J+11)                                                       PF2  51
      ZY=B(J+12)                                                       PF2  52
C***  CCMPUTE LENGTH OF SIDES OF QUADRILATERAL                          PF2  53
      D12=SQ2F(X1,X2,Y1,Y2,0.,0.)                                      PF2  54
      D23=SQ2F(X2,X3,Y2,Y3,.0,.0)                                      PF2  55
      D34=SQ2F(X3,X4,Y3,Y4,.0,.0)                                      PF2  56
      D41=SQ2F(X4,X1,Y4,Y1,.0,.0)                                      PF2  57
C***  CCMPUTE SLOPE OF SIDES OF QUADRILATERAL                           PF2  58
      IF (X2-X3)  6,5,6                                                PF2  59
    5 CI23=1.                                                          PF2  60
      GC TO 7                                                          PF2  61
    6 CM23=(Y2-Y3)/(X2-X3)                                             PF2  62
      CI23=0.                                                          PF2  63
    7 IF (X3-X4)  9,8,9                                                PF2  64
    8 CI34=1.                                                          PF2  65
      GC TO 10                                                         PF2  66
    9 CM34=(Y4-Y3)/(X4-X3)                                             PF2  67
      CI34=0.                                                          PF2  68
   10 IF (X4-X1)  12,11,12                                             PF2  69
   11 CI41=1.                                                          PF2  70
      GC TO 13                                                         PF2  71
   12 CM41=(Y1-Y4)/(X1-X4)                                             PF2  72
      CI41=0.                                                          PF2  73
   13 IF (X1-X2)  15,14,15                                             PF2  74
   14 CI12=1.                                                          PF2  75
      GC TO 16                                                         PF2  76
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   15 CM12=(Y2-Y1)/(X2-X1)                                     PF2  77
      CI12=0.                                                  PF2  78
C***  DEFINE QUACRAPOLE MOMENTS                                PF2  79
   16 CIXX=B(J+13)                                             PF2  80
      CIXY=B(J+14)                                             PF2  81
      CIYY=B(J+15)                                             PF2  82
C***  INITIALIZE VARIABLES FOR SINE AND COSINE                 PF2  83
      CY12=0.0                                                 PF2  84
      CX12=0.0                                                 PF2  85
      CY23=0.0                                                 PF2  86
      CX23=0.0                                                 PF2  87
      CY34=0.0                                                 PF2  88
      CX34=0.0                                                 PF2  89
      CY41=0.0                                                 PF2  90
      CX41=0.0                                                 PF2  91
C***  CCMPUTE SINE AND COSINE OF SLOPE ANGLE FOR EACH SIDE      PF2  92
      IF (D12)  17,18,17                                       PF2  93
   17 CY12=(Y2-Y1)/D12                                         PF2  94
      CX12=(X1-X2)/D12                                         PF2  95
   18 IF (D23)  19,20,19                                       PF2  96
   19 CY23=(Y3-Y2)/D23                                         PF2  97
      CX23=(X2-X3)/D23                                         PF2  98
   20 IF (D34)  21,22,21                                       PF2  99
   21 CY34=(Y4-Y3)/D34                                         PF2 100
      CX34=(X3-X4)/D34                                         PF2 101
   22 IF (D41)  23,24,23                                       PF2 102
   23 CY41=(Y1-Y4)/D41                                         PF2 103
      CX41=(X4-X1)/D41                                         PF2 104
C***  CCMPUTE MAXIMUM LENGTH OF QUADRILATERAL                   PF2 105
   24 ST=ABS(X1-X3)                                            PF2 106
      ST2=SQ2F(X2,X4,Y2,Y4,.0,.0)                              PF2 107
      ST=AMAX1(ST,ST2,D12,D23,D34,D41)                         PF2 108
C***  START LOOP OVER CENTROID POINTS OF ALL QUADRILATERALS     PF2 109
      KC=1                                                     PF2 110
      L=1                                                      PF2 111
   25 I=KQ                                                     PF2 112
      IS=1                                                     PF2 113
      XCQ=XCP(I)                                               PF2 114
      YCQ=YCP(I)                                               PF2 115
      ZCQ=ZCP(I)                                               PF2 116
      XNQ=XNP(I)                                               PF2 117
      YNG=YNP(I)                                               PF2 118
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```
      ZNQ=ZNP(I)
C***  COMPUTE DISTANCE BETWEEN CENTROID OF REFERENCE QUADRILATERAL AND
C***  CENTROID OF ANOTHER QUADRILATERAL
   26 RPQ=SQ2F(XC,XCQ,YC,YCQ,ZC,ZCQ)
      IF (RPQ-ST*4)  27,27,39
C***  TRANSFORM POINT FROM REFFERENCE COORDINATE SYSTEM TO ELEMENT(QUAD)
C***  COORDINATE SYSTEM
   27 X=(XCQ-XC)*XX+(YCQ-YC)*YX+(ZCQ-ZC)*ZX
      Y=(XCQ-XC)*XY+(YCQ-YC)*YY+(ZCQ-ZC)*ZY
      Z=(XCQ-XC)*XN+(YCQ-YC)*YN+(ZCQ-ZC)*ZN
      IF (RPQ-ST*2.0)  28,28,37
C***  COMPUTE VELOCITY COEFFICIENTS BY EXACT METHOD (QUAD SYSTEM)
   28 R1=SQ2F(X,X1,Y,Y1,Z,0.)
      R2=SQ2F(X,X2,Y,Y2,Z,0.)
      R3=SQ2F(X,X3,Y,Y3,Z,0.)
      R4=SQ2F(X,X4,Y,Y4,Z,0.)
      IF ((R1+R2).LE.D12) GO TO 75
      IF ((R2+R3).LE.D23) GO TO 75
      IF ((R3+R4).LE.D34) GO TO 75
      IF ((R4+R1).LE.D41) GO TO 75
      CLA1=ALOG((R1+R2-D12)/(R1+R2+D12))
      CLA2=ALOG((R2+R3-D23)/(R2+R3+D23))
      CLA3=ALOG((R3+R4-D34)/(R3+R4+D34))
      CLA4=ALOG((R4+R1-D41)/(R4+R1+D41))
      TVX=CY12*CLA1+CY23*CLA2+CY34*CLA3+CY41*CLA4
      TVY=CX12*CLA1+CX23*CLA2+CX34*CLA3+CX41*CLA4
      TVZ=0.
      IF (ABS(Z/ST)-.010)  38,29,29
   29 ZSQ=Z**2
      E1=ZSQ+(X-X1)**2
      E2=ZSQ+(X-X2)**2
      F3=ZSQ+(X-X3)**2
      F4=ZSQ+(X-X4)**2
      H1=(Y-Y1)*(X-X1)
      H2=(Y-Y2)*(X-X2)
      H3=(Y-Y3)*(X-X3)
      H4=(Y-Y4)*(X-X4)
      IF (CI12)  30,30,31
   30 WS1=(CM12*F1-H1)/(Z*R1)
      WS2=(CM12*E2-H2)/(Z*R2)
      TVZ=ATAN(WS1)-ATAN(WS2)
   31 IF (CI23)  32,32,33
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```
   32 TVZ=TVZ+ATAN((CM23*E2-H2)/(Z*R2))-ATAN((CM23*E3-H3)/(Z*R3))           PF2 161
   33 IF (CI34)  34,34,35                                                   PF2 162
   34 TVZ=TVZ+ATAN((CM34*E3-H3)/(Z*R3))-ATAN((CM34*E4-H4)/(Z*R4))           PF2 163
   35 IF (CI41)  36,36,38                                                   PF2 164
   36 TVZ=TVZ+ATAN((CM41*F4-H4)/(Z*R4))-ATAN((CM41*E1-H1)/(Z*R1))           PF2 165
      GO TO 38                                                              PF2 166
C***  COMPUTE VELOCITY COEFFICIENTS BY QUADRAPOLE METHOD (QUAD SYSTEM)      PF2 167
   37 RPQ3=RPQ**3                                                           PF2 168
      RPQ7=(RPQ3**2)*RPQ                                                    PF2 169
      WS1=X/RPQ3                                                            PF2 170
      XSQ=X**2                                                              PF2 171
      YSQ=Y**2                                                              PF2 172
      ZSQ=Z**2                                                              PF2 173
      PS=YSQ+ZSQ-4.*XSQ                                                     PF2 174
      QS=XSQ+ZSQ-4.*YSQ                                                     PF2 175
      WS2=X*(9.*PS+30.*XSQ)/RPQ7                                            PF2 176
      WS3=3.*Y*PS/RPQ7                                                      PF2 177
      WS4=3.*X*QS/RPQ7                                                      PF2 178
      TVX=A*WS1-CIXY*WS3-CIXX*WS2-CIYY*WS4                                  PF2 179
      WS1=Y/RPQ3                                                            PF2 180
      WS2=Y*(9.*QS+30.*YSQ)/RPQ7                                            PF2 181
      TVY=A*WS1-CIXX*WS3-CIXY*WS4-CIYY*WS2                                  PF2 182
      TVZ=Z*(A/RPQ3-3.*(CIXX*PS-5.*CIXY*X*Y+CIYY*QS)/RPQ7)                  PF2 183
C***  TRANSFORM FROM ELEMENT TO REFERENCE COORDINATE SYSTEM                 PF2 184
   38 VX(IS)=TVX*XX+TVY*XY+TVZ*XN                                           PF2 185
      VY(IS)=TVX*YX+TVY*YY+TVZ*YN                                           PF2 186
      VZ(IS)=TVX*ZX+TVY*ZY+TVZ*ZN                                           PF2 187
      GO TO 40                                                              PF2 188
C***  COMPUTE VELOCITY COEFFICIENTS BY MONOPOLE METHOD (DIRECTLY IN THE     PF2 189
C***  REFERENCE COORDINATE SYSTEM)                                          PF2 190
   39 ARPQ3=A/(RPQ**3)                                                      PF2 191
      VX(IS)=(XCO-XC)*ARPQ3                                                 PF2 192
      VY(IS)=(YCO-YC)*ARPQ3                                                 PF2 193
      VZ(IS)=(ZCO-ZC)*ARPQ3                                                 PF2 194
C***  REFLECT CENTROID POINT IN PLANE OF SYMMETRY                           PF2 195
   40 GO TO (41,43,45,46,48,49,50,51),IS                                    PF2 196
C***  DC LOOPS SET UP TO FORCE USE OF INDEX REGISTERS                       PF2 197
   41 J1=JV                                                                 PF2 198
      J2=JC                                                                 PF2 199
      V1(J1)=VX(1)                                                          PF2 200
      V1(J1+1)=VY(1)                                                        PF2 201
      V1(J1+2)=VZ(1)                                                        PF2 202
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      IF (ISM)  54,54,42
   42 IS=2
C***  XZ SYMMETRY
      YCQ=-YCQ
      GO TO 26
   43 IF (ISM-1)  53,53,44
C***  XY SYMMETRY
   44 IS=3
      ZCQ=-ZCQ
      GO TO 26
   45 IS=4
      YCQ=-YCQ
      GO TO 26
   46 IF (ISM-2)  52,52,47
C***  YZ SYMMETRY
   47 IS=5
      XCQ=-XCQ
      GO TO 26
   48 IS=6
      YCQ=-YCQ
      GC TO 26
   49 IS=7
      ZCQ=-ZCQ
      GO TO 26
   50 IS=8
      YCQ=-YCQ
      GC TO 26
C***  ADD CONTRIBUTIONS OF ALL REFLECTIONS TO OBTAIN NET INDUCED
C***  VELOCITY CCMPONENTS IN REFERENCE COORDINATE SYSTEM
   51 V1(J1)=V1(J1)+VX(8)+VX(7)+VX(6)+VX(5)
      V1(J1+1)=V1(J1+1)-VY(8)+VY(7)+VY(6)-VY(5)
      V1(J1+2)=V1(J1+2)-VZ(8)-VZ(7)+VZ(6)+VZ(5)
   52 V1(J1)=V1(J1)+VX(4)+VX(3)
      V1(J1+1)=V1(J1+1)+VY(4)-VY(3)
      V1(J1+2)=V1(J1+2)-VZ(4)-VZ(3)
   53 V1(J1)=V1(J1)+VX(2)
      V1(J1+1)=V1(J1+1)-VY(2)
      V1(J1+2)=V1(J1+2)+VZ(2)
C***  CALCULATE THE NORMAL VELOCITY INDUCED AT THE CONTROL POINT OF THE
C***  I-TH FLEMENT BY A UNIT SOURCE DENSITY ON THE J-TH ELEMENT (STORED
C***  BY COLUMNS)
   54 C1(J2)=XNQ*V1(J1)+YNQ*V1(J1+1)+ZNQ*V1(J1+2)
```

```
      JV=JV+3
   55 JC=JC+1
C***  WRITE COEFFICIENTS ON TAPE
      IF (JV-1001)  61,56,56
   56 JV=2
      V1(1)=BLK
      IF (BLK-636.0)  57,58,59
   57 WRITE (KFILE3)BLK,V1
      GO TO 60
   58 REWIND KFILE3
   59 WRITF (KFILF5)BLK,V1
   60 BLK=BLK+1.
   61 IF (JC-901)  63,62,62
   62 IDW=IDW+1
      WRITE (KFILE4)IDW,C1
      JC=1
   63 KQ=KQ+1
      L=L+1
C***  END OF LOOP OVER CENTROIDS
      IF (KQ-KM)  25,25,64
   64 C1(JC)=0
      IF (KQ-KMM)  55,65,65
   65 P=P+1
      K=K+1
      J=J+16
      IF (K-KM)  66,66,70
C***  FND OF LOOP OVER QUADRILATERALS
C***  READ NEXT BLOCK OF B ARRAY IF NEEDED
   66 IF (J-193)  4,67,67
   67 READ (KFILE)(B(I),I=1,193)
      J=2
      IF (B(1)-P)  68,4,68
   68 WRITE (JWRITE,69) B(1),P
   69 FORMAT (28H0 POINTS OUT OF ORDER  B(1)=,1F4.0,4H  P=,1F4.0)
      ICANCL=1
      RETURN
   70 IF (BLK-636.0)  71,72,73
C***  WRITE REMAINING COEFFICIENTS ON TAPE
   71 WRITE (KFILF3)BLK,V1
      REWIND KFILE3
      GO TO 74
   72 REWIND KFILE3
```

```
   73 WRITE (KFILE5)BLK,V1
      REWIND KFILE5
   74 WRITE (KFILE4)IDW,C1
      REWIND KFILE4
      REWIND KFILE
      GO TO 77
   75 WRITE (JWRITE,76) L,P
   76 FORMAT (3H L=,I5,20X,3H P=,F5.1)
   77 RETURN
      END


      FUNCTION SQ2F(X1,X2,Y1,Y2,Z1,Z2)
C
C***  FUNCTION SQ2F CALCULATES THE DISTANCE BETWEEN TWO POINTS
C
      X=X1-X2
      Y=Y1-Y2
      Z=Z1-Z2
      RS=Z**2+Y**2+X**2
      SQ2F=SQRT(RS)
      RETURN
      END


      SUBROUTINE PFP3(EPS,MIX)
C
C***  SUBROUTINE PFP3 SOLVES FOR SOURCE DENSITY
C
      DIMENSION VIP(650),S(5,650),COEF(900),VTX(650)
      COMMON TITLE(20),XCP(650),YCP(650),ZCP(650),XNP(650),YNP(650),ZNP(
     1650),AQP(650),REFA,REFBDY,NQUAD,IWRITE,NP,KNEW
      COMMON /INOUT/JREAD,JWRITE,KFILE,KFILE1,KFILE2,KFILE3,KFILE4,KFILE
     15
      COMMON /SIK/SN(650),VNP(650),IPN(650)
      COMMON /RING/VXX(3,650)
C
      WRITE (JWRITE,1)
    1 FORMAT(1H1,///,24H0SOURCE DENSITY SOLUTION)
      WRITE (JWRITE,2) (TITLE(I),I=1,20)
```

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```
    2 FORMAT (1H0,20A4)
      K1=1
      K2=NP
C***  SET CONDITIONS FOR CNSET FLOW OF -1.0+VXX(1,K) IN X DIRECTION.
C***  ZFRO IN Y AND Z DIRECTIONS
      FX=-1.0
C***  CCMPUTE (1) DOT PRODUCT OF PANEL NORMAL TO CNSET FLOW, VIP(K).
C***  (2) DOT PRODUCT OF PANEL NORMAL TO NONUNIFORM FLOW, VTX(K).
C***  (3) INITIAL SOURCE DENSITY.  AND SET PARTIAL SUM VECTOR TO ZERO
      DO 3 K=1,NP
      VIP(K)=XNP(K)*FX
      VTX(K)=XNP(K)*VXX(1,K)
      S(5,K)=-(VIP(K)+VTX(K)-VNP(K))*.11936
    3 SN(K)=0.
      SN(NP+1)=0.
      SN(NP+2)=0.
      SN(NP+3)=0.
      SN(NP+4)=0.
      WRITE (JWPITE,30) FX
      WRITE (JWRITE,4)
    4 FORMAT (/,12X,37HITERATIVE MATRIX SOLUTION INFORMATION,/,27H0ITERA
     1TION    SUM OF CHANGES,9X,1HA,10X,2HB1,10X,2HB2)
      IT=1
      IC=5
C***  START ITEFATICN,READ FIRST BLOCK OF COEFS..START LOOP OVER QUADS.
    5 READ (KFILE4)IDW,COEF
C***  (DO LOOP 40) CALCULATES THE SUM OF THE PRODUCTS OF THE INDUCED
C***  VFLOCITIES AND THE SOURCF DENSITIES
      J=0
      DO 8 K=1,NP
C***  PICK UP SOURCE DENSITY & START LOOP OVER CENTROID POINTS
      SP=S(IC,K)
      DO 8 KP=1,NP,5
      IF (J-930)  7,6,6
    6 READ (KFILE4)IDW,COFF
      J=0
C***  CCMPUTE PARTIAL SUMS FOR NEXT 5 POINTS
    7 SN(KP)=SN(KP)+COEF(J+1)*SP
      SN(KP+1)=SN(KP+1)+COEF(J+2)*SP
      SN(KP+2)=SN(KP+2)+COEF(J+3)*SP
      SN(KP+3)=SN(KP+3)+COEF(J+4)*SP
      SN(KP+4)=SN(KP+4)+CCEF(J+5)*SP
```

```
      J=J+5
C***  END LOOP OVER CENTROID POINTS & END LOOP OVER QUADS.
    8 CCNTINUE
C***  CCMPUTE NEW SOURCE DENSITIES
      REWIND KFILE4
      PASS=1.0
      SUM=0.
      DC 9 K=K1,K2
      SN(K)=-(SN(K)+VIP(K)-VNP(K)+VTX(K))/6.28318S308
      TEST=ABS(SN(K)-S(IC,K))
      SUM=SUM+TEST
      IF (TEST.GT.EPS)PASS=-1.0
    9 CCNTINUE
      WRITE (JWRITE,29) IT,SUM
      IF (PASS.EQ.1.0) GO TC 27
      IF (IT.EQ.MIX) GC TO 27
      IT=IT+1
      IC=IC-1
      IF (IC.EQ.0) GO TO 11
      DO 10 K=K1,K2
      S(IC,K)=SN(K)
   10 SN(K)=0.
      GC TO 5
   11 A=0.
      B1=0.
      B2=0.
      DA=0.
      D1=0.
      D2=0.
      DC 17 K=K1,K2
      DS9=2*S(1,K)-SN(K)-S(2,K)
      IF (DS9.GT.0.) GO TO 12
      A=A+S(2,K)-S(1,K)
      DA=DA-DS9
      GC TO 13
   12 A=A+S(1,K)-S(2,K)
      DA=DA+DS9
   13 DS1=S(4,K)-S(3,K)
      DS2=S(3,K)-S(2,K)
      DS3=DS1-DS2
      DSS=S(2,K)-S(1,K)
      DS5=DS2-DSS
```

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      DS6=DS1-DSS                                                       PF3 100
      DS4=DS2-S(1,K)+SN(K)                                              PF3 101
      DS7=DS3*DS4-DS5*DS6                                               PF3 102
      DS8=DS6*DS5-DS4*DS3                                               PF3 103
      IF (DS7.GT.0.) GO TO 14                                           PF3 104
      B1=B1-DS1*DS4+DS2*DS6                                             PF3 105
      D1=D1-DS7                                                         PF3 106
      GC TO 15                                                          PF3 107
   14 B1=B1+DS1*DS4-DS2*DS6                                             PF3 108
      D1=D1+DS7                                                         PF3 109
   15 IF (DS8.GT.0.) GC TO 16                                           PF3 110
      B2=B2-DS1*DS5+DS2*DS3                                             PF3 111
      D2=D2-DS8                                                         PF3 112
      GO TO 17                                                          PF3 113
   16 B2=B2+DS1*DS5-DS2*DS3                                             PF3 114
      D2=D2+DS8                                                         PF3 115
   17 CONTINUF                                                          PF3 116
      A=A/DA                                                            PF3 117
      B1=B1/D1                                                          PF3 118
      B2=B2/D2                                                          PF3 119
      IF (IT.EQ.6) GO TO 23                                             PF3 120
      AA=ABS(A-AS)                                                      PF3 121
      IF (AA.GT..02) GO TO 20                                           PF3 122
      DC 18 K=K1,K2                                                     PF3 123
      S(5,K)=A*(SN(K)-S(1,K))+S(1,K)                                    PF3 124
   18 SN(K)=0.                                                          PF3 125
      WRITF (JWRITE,19)                                                 PF3 126
   19 FCRMAT (29X,17HA EXTRAPCLATION   )                                PF3 127
      GC TO 25                                                          PF3 128
   20 BB1=50.*ABS(B1-BS1)                                               PF3 129
      BB2=50.*ABS(B2-BS2)                                               PF3 130
      BBB=ABS(B1)+ABS(B2)                                               PF3 131
      IF ((BB1.GT.BBB).OR.(BB2.GT.BBB)) GO TO 23                        PF3 132
      DC 21 K=K1,K2                                                     PF3 133
      S(5,K)=S(2,K)+B1*(S(1,K)-S(2,K))+B2*(SN(K)-S(2,K))                PF3 134
   21 SN(K)=0.                                                          PF3 135
      WRITF (JWRITF,22)                                                 PF3 136
   22 FCRMAT (29X,17H3 EXTRAPOLATICN   )                                PF3 137
      GC TO 25                                                          PF3 138
   23 DO 24 K=K1,K2                                                     PF3 139
      S(5,K)=SN(K)                                                      PF3 140
   24 SN(K)=0.                                                          PF3 141
```

```
25 IC=5
   WRITE (JWRITE,26) A,B1,B2
26 FORMAT (29X,3E12.3)
   AS=A
   BS1=B1
   BS2=B2
   GC TO 5
27 DC 28 K=K1,K2
28 S(1,K)=SN(K)
29 FCRMAT (4X,I3,E18.5)
30 FORMAT (/,13H0 X VELOCITY=,F4.1,24H+VXX(1,K)     Y VELOCITY=,4H 0.0
  1,15H      Z VELOCITY=,4H 0.0)
   RETURN
   FND


   SUBROUTINE PFP4(CLPA,CDPA,ICK)
C
C***  SUBROUTINF PFP4 COMPUTES VELOCITIES AND PRESSURE COEFFICIENTS AT
C***  THE PANEL CENTROIC POINTS
C
   DIMENSION CV1(1000)
   CCMMON TITLE(20),XCP(650),YCP(650),ZCP(650),XNP(650),YNP(650),ZNP(
  1650),AQP(650),REFA,REBODY,NQUAD,IWRITE,NP,KNEW
   CCMMCN /RING/VTX(3,650)
   COMMON /S1K/S1(650),VNP(650),IPN(650)
   COMMON /VCK/HVF,SFC,DEP,CPHA,TINF,AOUT,AIN,EGA
   CCMMON /CFSX/CPS(650),CPIN,CPOUT
   COMMON /VXYZ/VX1(650),VY1(650),VZ1(650),VABS(650)
   CCMMON /HOLD/XNH(650),ZNH(650),AQPH(650)
   COMMCN /INOUT/JREAD,JWRITF,KFILE,KFILF1,KFILE2,KFILE3,KFILE4,KFILE
  15
C
   WRITF (JWRITF,1)
 1 FCRMAT (1H1,//,1X,75H COMPUTATION OF VELOCITIES AND PRESSURE COEFF
  1ICIENTS AT THE PANFL CFNTROIDS)
C***  INITIALIZE PARAMETERS
   D=-.5/3.14159265
   J=1
   K1=1
   IF (KNEW.EQ.1)KHOLD=NP
```

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```
      K2=NP
      BBR=1.0
      CD=0.0
      CL=0.0
      AREA=0.0
C***  READ FIRST BLOCK OF COEFFICIENTS
      ITAPE=KFILE3
      READ (KFILE3)BB,CV1
      IF (BB-BBR)  45,2,45
C***  CALCULATE VELOCITY CCMPONENTS DUE TO ENTIRE FLOW FIELD
    2 DO 3 I=K1,K2
      VX1(I)=-1.0+VTX(1,I)+VNP(I)*XNP(I)-S1(I)*XNP(I)/D
      VY1(I)=VTX(2,I)+VNP(I)*YNP(I)-S1(I)*YNP(I)/D
      VZ1(I)=VTX(3,I)+VNP(I)*ZNP(I)-S1(I)*ZNP(I)/D
    3 CCNTINUE
C***  SFT UP LOOP OVFR QUADS..PICK UP SOURCE,SET UP LOOP OVER CENTROIDS
C***  TO SUM THE PRODUCTS OF THE VELOCITY REFLECTIONS AND THE SOURCE
C***  DENSITIES
      JC=2
    4 S1J=S1(J)
      DO 10 JP=K1,K2
C***  COMPUTE PARTIAL SUM FOR 3 COMPONENTS OF 3 VELOCITIES
      VX1(JP)=VX1(JP)+S1J*CV1(JC)
      VY1(JP)=VY1(JP)+S1J*CV1(JC+1)
      VZ1(JP)=VZ1(JP)+S1J*CV1(JC+2)
      JC=JC+3
C***  READ MORE COEFFICIENTS IF NEEDED
      IF (JC-1000)  10,5,5
    5 JC=2
      IF (BBR-635.0)  6,7,8
    6 READ (KFILE3)BB,CV1
      GO TO 9
    7 REWIND KFILE3
    8 RFAD (KFILF5)BB,CV1
    9 BBR=BBR+1.
      IF (BBR-BB)  45,10,45
C***  END OF LOOP OVER CENTROIDS THEN END OF LOOP OVER QUADS.
   10 CCNTINUE
      J=J+1
      IF (J-NP)  4,4,11
   11 IF (BBR-635.0)  12,12,13
   12 RFWIND KFILE3
```

```
      GO TO 14
   13 REWIND KFILES
   14 IP=K1+49
C***  THE VELOCITIES AT THE CONTROL POINTS ON THE BODY SURFACE HAVE BEEN
C***  CALCULATFD
      IS=K1
      IPAGE=1
      IIN=0
      ICUT=0
      CPIN=0.0
      CPOUT=0.0
      ACUT=0.0
      AIN=0.0
   15 IF (IP-K2)  16,16,28
C***  COMPUTE PRESSURE COEFFICIENT, ABSOLUTE VALUE OF VELOCITY, CL, & CD
   16 IF (IPAGE.EQ.1) WRITE (JWRITE,17) (TITLE(I),I=1,20),IPAGE
   17 FORMAT (//,1H0,20A4,8H  PAGE =,I5)
      IF (IPAGE.NE.1) WRITE (JWRITE,18) (TITLE(I),I=1,20),IPAGE
   18 FORMAT (1H1,///////,1X,20A4,8H  PAGE =,I5)
      WRITE (JWRITE,19)
   19 FORMAT (8H0 X FLOW)
      WRITE (JWRITE,20)
   20 FORMAT (4H PT.,10X,2HXC,8X,2HYC,8X,2HZC,12X,2HVX,8X,2HVY,8X,2HVZ,9
     1X,5HABS.V,8X,2HCP,6X,6HSOURCE,5X,8HV NORMAL,5X,4HAREA)
      DO 27 I=IS,IP
      VSQ=VX1(I)**2+VY1(I)**2+VZ1(I)**2
      VM=SQRT(VSQ)
      VABS(I)=VM
      CP=1.-VSQ
      CPS(I)=CP
      VNR=VX1(I)*XNP(I)+VY1(I)*YNP(I)+VZ1(I)*ZNP(I)
      IF (KNEW.EQ.2.OR.ICK.GE.2) GO TO 23
C***  CHECK INDICATOR FOR A NONZERO NORMAL VFLOCITY SPECIFICATION
      IF (IPN(I).EQ.0) GO TO 23
      IF ((1+IPN(I)/IABS(IPN(I))).EQ.0) GO TO 21
      GO TO 22
   21 CPIN=CPIN+CP*AQP(I)
      AIN=AIN+AQP(I)
      IIN=IIN+1
      GO TO 23
   22 CPOUT=CPOUT+CP*AQP(I)
      ACUT=AOUT+AQP(I)
```

```
      ICUT=IOUT+1                                                         PF4 110
   23 IF (I.GT.KHOLD) GO TO 25                                            PF4 111
      IF (KNEW.EQ.2) GO TO 24                                             PF4 112
      CL=CL+CP*AQP(I)*ZNP(I)                                              PF4 113
      CD=CD+CP*AQP(I)*XNP(I)                                              PF4 114
      AREA=AREA+AQP(I)                                                    PF4 115
      GO TO 25                                                            PF4 116
C***  COMPUTE CL, CD, AND AREA FOR WAKE-BODY PORTICN                      PF4 117
   24 CL=CL+CP*AQPH(I)*ZNH(I)                                             PF4 118
      CD=CD+CP*AQPH(I)*XNH(I)                                             PF4 119
      AREA=AREA+AQPH(I)                                                   PF4 120
C***  WRITE CENTROID POINTS,VFLOCITIES,CP'S,CL-PRESSURE,& CD-PRESSURE      PF4 121
   25 WRITE (JWRITE,26) I,XCP(I),YCP(I),ZCP(I),VX1(I),VY1(I),VZ1(I),VM,C PF4 122
     1P,S1(I),VNR,AQP(I)                                                  PF4 123
   26 FORMAT (1X,I3,4X,3F10.5,4X,3F10.5,1F13.5,2F11.5,E12.2,2X,E10.3)     PF4 124
   27 CCNTINUE                                                            PF4 125
      IS=IS+50                                                            PF4 126
      IP=IP+50                                                            PF4 127
      IPAGE=IPAGE+1                                                       PF4 128
      IF (K2-IS)  29,28,15                                                PF4 129
   28 IP=K2                                                               PF4 130
      GC TO 16                                                            PF4 131
C***  ADJUST AND REFERENCE CL AND CD DUE TO SYMMETRY AND REFERENCE AREA    PF4 132
   29 CLPA=2.0*CL                                                         PF4 133
      CDPA=2.0*CD                                                         PF4 134
      CLP=CLPA/REFA                                                       PF4 135
      CDP=CDPA/REFA                                                       PF4 136
      WRITE (JWRITE,30) CLP,CDP,REFA,REBODY                               PF4 137
   30 FCRMAT (1H1,//////,18X,35HPRESSURE LIFT AND DRAG COEFFICIENTS,//,2 PF4 138
     11X,29(1H*),/,25X,14HPRESSURE CL = ,F11.5,/,25X,14HPRESSURE CD = ,F PF4 139
     111.5,/,22X,17HREFERENCE AREA = ,F11.5,/,21X,18HREYNOLDS NUMBER = , PF4 140
     1E11.4,/,21X,29(1H*),//)                                             PF4 141
      IF (KNEW.EQ.2) GO TO 35                                             PF4 142
      WRITE (JWRITE,31)                                                   PF4 143
   31 FORMAT (1H1,//,2X,2HPT,5X,3HXNH,6X,3HYNH,6X,3HZNH,6X,2HCP,5X,6HVX* PF4 144
     1XNH,3X,6HVY*YNH,3X,6HVZ*ZNH,5X,4HAQPH,3X,13H2*CP*AQPH*ZNH,3X,13H2* PF4 145
     1CP*AQPH*XNH,4X,2HPT,//)                                             PF4 146
      LINE=0                                                              PF4 147
      DC 34 I=1,NP                                                        PF4 148
      VXXN=VX1(I)*XNP(I)                                                  PF4 149
      VYYN=VY1(I)*YNP(I)                                                  PF4 150
      VZZN=VZ1(I)*ZNP(I)                                                  PF4 151
```

```
      CAZ=2.0*CPS(I)*AQP(I)*ZNP(I)
      CAX=2.0*CPS(I)*AQP(I)*XNP(I)
      LINE=LINE+1
      IF (LINE.LE.50) GO TO 32
      LINE=0
      WRITE (JWRITE,31)
   32 WRITE (JWRITE,33) I,XNP(I),YNP(I),ZNP(I),CPS(I),VXXN,VYYN,VZZN,AQP
     1(I),CAZ,CAX,I
   33 FORMAT (1X,I4,7F9.5,F8.3,3X,F10.7,6X,F10.7,5X,I4)
   34 CCNTINUE
      GO TO 41
   35 WRITE (JWRITE,36)
   36 FORMAT (1H1,//,2X,2HPT,5X,3HXNP,6X,3HYNP,6X,3HZNP,6X,2HCP,5X,6HVX*
     1XNP,3X,6HVY*YNP,3X,6HVZ*ZNP,5X,4HAQP  ,3X,13H2*CP*AQPH*ZNH,3X,13H2*
     1CP*AQPH*XNH,4X,2HPT,//)
      LINE=0
      DO 40 I=1,NP
      VXXN=VX1(I)*XNP(I)
      VYYN=VY1(I)*YNP(I)
      VZZN=VZ1(2)*ZNP(I)
      LINE=LINE+1
      IF (LINE.LE.50) GO TO 37
      LINE=0
      WRITE (JWRITE,36)
   37 IF (I.GT.KHOLD) GO TO 38
      CAZ=2.0*CPS(I)*AQPH(I)*ZNH(I)
      CAX=2.0*CPS(I)*AQPH(I)*XNH(I)
      WRITE (JWRITE,33) I,XNP(I),YNP(I),ZNP(I),CPS(I),VXXN,VYYN,VZZN,AQP
     1(I),CAZ,CAX,I
      GC TO 40
   38 WRITE (JWRITE,39) I,XNP(I),YNP(I),ZNP(I),CPS(I),VXXN,VYYN,VZZN,AQP
     1(I),I
   39 FCRMAT (1X,I4,7F9.5,F8.3,34X,I4)
   40 CONTINUF
   41 IF (KNEW.EQ.2.OR.ICK.GE.2) GO TO 47
C***  TEST FOR ERRORS
      IF (IIN.EQ.0.OR.IOUT.EQ.0)ICK=2
      IF (ICK.EQ.1) GO TO 44
      WRITF (JWRITE,42)
   42 FCRMAT (1X,///,1X,131HAT LEAST ONE INLET(OUTLET) WAS SPECIFIED WIT
     1HOUT AT LEAST CNE OUTLET(INLET)...ASSUMING NO INLETS OR OUTLETS...
     1EXECUTION PROCEEDING.,///)
```

```
      DO 43 I=1,NP
   43 VNP(I)=0.0
      GO TO 47
C***  CCMPUTE AVERAGE CP'S
   44 CPIN=CPIN/AIN
      CPOUT=CPOUT/AOUT
      GC TO 47
   45 WRITF (JWRITE,46) ITAPE,BBR,BB
   46 FORMAT (6H1TAPE ,I2,16H OUT OF POSITION/I4,6F6.1)
   47 RETURN
      END


      SUBROUTINE VINOUT(JWRITE,VINF,ROE,NQE,VI)
C
C***  SUBROUTINE VINOUT CALCULATES THE INTERIOR PRESSURE COEFFICIENTS
C***  AND THE NORMAL VELOCITIES ON SPECIFIED PANELS
C
      COMMON TITLE(20),XCP(650),YCP(650),ZCP(650),XNP(650),YNP(650),ZNP(
     1650),AQP(650),REFA,REBODY,NQUAD,IWRITE,NP,KNEW
      COMMON /S1K/SN(650),VNP(650),IPN(650)
      CCMMON /VCK/HVF,SFC,DEP,CPHA,TINF,AOUT,AIN,EOA
      COMMON /CPSX/CPS(650),CPIN,CPOUT
      COMMON /CANCEL/ICANCL,NODE
C
      IPASS=0
      WRITE (JWRITE,1) CPIN,AIN,CPOUT,AOUT
    1 FORMAT (1H1,//,5X,75H*** CALCULATION OF INTERIOR PRESSURE COFFFICI
     1ENTS AND NORMAL VELOCITIES ***,//,9X,29HAVERAGE CP ON INLET PANELS
     1  =,1PE16.9,3X,13HINLET AREA  =,1PE16.9,/,9X,29HAVERAGE CP CN EXHA
     1UST PANFLS=,1PE16.9,3X,13HEXHAUST AREA=,1PE16.9,/)
C***  CALCULATE PRESSURE COEFFICIENTS
    2 CPXX=(AOUT**2*CPOUT+(EOA*AIN)**2*CPIN/(AIN**2+EOA**2))*((AIN**2+EO
     1A**2)/((AOUT*AIN)**2+(AOUT**2+AIN**2)*EOA**2))
      CPX=(AIN**2*CPIN+EOA**2*CPXX)/(AIN**2+EOA**2)
      IF (CPX.GT.CPXX) GO TO 3
      IF (ABS(CPX-CPXX).LT.1.0E-05)CPXX=CPX
    3 WRITE (JWRITE,4) CPX,CPXX
    4 FORMAT (10X,5HCPX =,1PE16.9,/,10X,5HCPXX=,1PE16.9,/)
      IF (CPX.LF.CPIN.AND.CPX.GE.CPXX) GO TO 7
      WRITF (JWRITE,5)
```

```
    5 FORMAT (12X,32HCPX > CPIN OR CPX < CPXX.   STOP..///)
    6 ICANCL=1
      RETURN
    7 IF (CPXX.LE.CPX.AND.CPXX.GE.CPOUT) GO TO 9
      WRITE (JWRITE,8)
    8 FORMAT (12X,34HCPXX > CPX OR CPXX < CPOUT.   STOP..///)
      GO TO 6
C***  ADJUST EFFECTIVE ORIFICE AREA EFFECT
    9 IPASS=IPASS+1
      IF (IPASS.GT.1) GO TO 14
      PNET=DEP*(778.0*HVF*SFC-1.0)
      IF (PNET)  10,10,12
   10 WRITE (JWRITE,11) PNET
   11 FORMAT (12X,23HDEP*(778.0*HVF*SFC-1) =,1PE16.9,/)
      IF (PNET.LT.0.0) GO TO 6
      GO TO 14
   12 TR=PNET/(ROE*32.2*AIN*CPHA*778.0*TINF*VINF*SQRT(CPIN-CPX))+1.0
      TR=SQRT(1.0/TR)
      ECA=EOA*TR
      WRITE (JWRITE,13) TR,ECA
   13 FORMAT (9X,58HADJUSTMENT DUE TO HEATING OF FLOW: TEMPERATURE RATIO
     1  =,1PE16.9,/,44X,23HEFFECTIVE ORIFICE AREA=,1PE16.9,//)
      GO TO 2
C***  CALCULATE NORMAL VELOCITIES
   14 DO 24 I=1,NQE
      ITEST=3
      IF (IPN(I).EQ.0) GO TO 24
      IF ((1+IPN(I)/IABS(IPN(I))).EQ.0) GO TO 15
      GO TO 16
   15 X1=CPS(I)-CPX
      IF (X1.LT.0.0)ITEST=1
      VNP(I)=-SQRT(ABS(X1))
      GO TO 17
   16 X1=CPXX-CPS(I)
      IF (X1.LT.0.0)ITEST=2
      VNP(I)=SQRT(ABS(X1))
   17 GO TO (18,20,22),ITEST
   18 WRITE (JWRITE,19) I,VNP(I),I
   19 FORMAT (10X,24HNORMAL VELOCITY AT PANEL,I4,3H = ,E14.7,10X,11HNOTE
     1: ( CP(,I4,11H)-CPX )<0.0,/)
      GO TO 24
   20 WRITE (JWRITE,21) I,VNP(I),I
```

```
21 FORMAT (10X,24HNCRMAL VELOCITY AT PANEL,I4,3H = ,E14.7,10X,16HNOTE VNT
  1: ( CPXX-CP(,I4,6H))<0.0,/)                                        VNT
   GC TO 24                                                           VNT
22 WRITE (JWRITE,23) I,VNP(I)                                         VNT
23 FORMAT (10X,24HNORMAL VELOCITY AT PANEL,I4,3H = ,E14.7,/)          VNT
24 CONTINUE                                                           VNT
   RETURN                                                             VNT
   END                                                                VNT


      SUBROUTINE PUNCH(NMIN,NMAX,MMIN,MMAX,X,Y,Z,JPUNCH,JWRITE)       PCH
C                                                                     PCH
C***  SUBROUTINE PUNCH CONVERTS AND PUNCHES THE (BODY+WAKEBODY) DATA   PCH
C***  BACK TO A COMPATIBLE PLOT PROGRAM DATA SET FOR THE FUSELAGE      PCH
C                                                                     PCH
      DIMENSION X(651),Y(651),Z(651),XX(31,31),YY(31,31),ZZ(31,31)    PCH
C                                                                     PCH
C***  SET INITIAL PARAMETERS                                          PCH
      NS=1                                                            PCH
      L=C                                                             PCH
      LMN=1                                                           PCH
C***  CONVERT TO ORIGINAL AXIS SYSTEM                                  PCH
      ZMAX=-1000.0                                                    PCH
      ZMIN=1000.0                                                     PCH
      DO 1 N=NMIN,NMAX                                                PCH
      DC 1 M=MMIN,MMAX                                                PCH
      L=L+1                                                           PCH
      IF (M.GT.MMIN.AND.M.LT.MMAX) GO TO 1                            PCH
      IF (ZMAX.LT.Z(L))ZMAX=Z(L)                                      PCH
      IF (ZMIN.GT.Z(L))ZMIN=Z(L)                                      PCH
    1 CCNTINUE                                                        PCH
      ZORG=ABS(ZMIN)+ABS(ZMAX)                                        PCH
      L=0                                                             PCH
      DO 3 N=NMIN,NMAX                                                PCH
      XP=X(1)-X(LMN)                                                  PCH
      DC 2 M=MMIN,MMAX                                                PCH
      L=L+1                                                           PCH
      YP=Y(L)                                                         PCH
      ZP=Z(L)                                                         PCH
      XX(N,M)=XP                                                      PCH
      YY(N,M)=YP                                                      PCH
```

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      ZZ(N,M)=ZP+ZDRG
    2 CONTINUE
      LMN=LMN+MMAX
    3 CCNTINUE
C***  PUNCH CARDS FOR NEW FUSELAGE
      WRITE (JPUNCH,4) (XX(J,1),J=NMIN,NMAX)
    4 FORMAT (10F7.4)
      DO 5 I=NMIN,NMAX
      WRITE (JPUNCH,4) (YY(I,J),J=MMIN,MMAX)
      WRITE (JPUNCH,4) (ZZ(I,J),J=MMIN,MMAX)
    5 CCNTINUE
      RETURN
      END


      SUBROUTINE PFP5(MM,NN,AREAAV,AVDELS,AVXCG,CDFA)
C
C***  SUBROUTINE PFP5 COMPUTES ON-BODY STREAMLINES
C
      DIMENSION XC1(650),YC1(650),XC2(650),YC2(650),XC3(650),XC4(650),YC
     14(650),X3(650),Y3(650),Z3(650),X4(650),Y4(650),Z4(650),DMX(650),XL
     1(75),YL(75),ZL(75),YC3(650),SF(5),XCR(5),YCR(5),STML(75),UABS(75),
     1SKIN(650),DSTAR(650),NOTEST(5)
      EQUIVALENCE (YC3(1),YC2(1)),(XL(1),XNH(1)),(YL(1),AQPH(1)),(ZL(1),
     1ZNH(1))
      CCMMCN /HOLD/XNH(650),ZNH(650),AQPH(650)
      COMMON TITLF(20),XCP(650),YCP(650),ZCP(650),XNP(650),YNP(650),ZNP(
     1650),AQP(650),REFA,REBODY,NQUAD,IWRITE,NP,KNEW
      CCMMON /VXYZ/VX1(650),VY1(650),VZ1(650),VABS(650)
      COMMON /BL/VOV(75),SS(75),VINF,VO,ROE,DELS(150),CFI(150),THT(150),
     1STOTAL,KKK
      COMMON /INOUT/JREAD,JWRITE,KFILE,KFILE1,KFILE2,KFILE3,KFILE4,KFIL5
      CCMMON /RING/VTX(3,650)
      CCMMCN /CANCEL/ICANCL,NODE
      NAMELIST /NAM1/NP,NQ,DMX/NAM2/II,NSTART,NEND,NDEL/NAM3/LL,MID,DIRT
     1,JI/NAM4/AF,UX,UY,UZ,CP,NQ,NCP,LNQ,JSTOP,J,JL,XLT,YLT,XL,YL,ZL/NAM
     15/NQ,IQT,NR,NU,LXQ,UYQ,UZQ,UXP,UYR,UZR,UXU,UYU,UZU,UQ,VQ,CSR,UT,VT
     1,XXR,XYR,UR,YXR,YYR,VR,UU,CSU,VU,XD,YD,ZD,XT,YTT,ZT,YT,XR,YR/NAM6/
     1XD,YD,ZD,XU,YT,ZT,YU,DEN,U1,U2,V1,V2,USL,VSL,UXP,UYP,UZP,VSQD/NAM7
     1/DEN,CXY,CYY,CXX,CC,NQ,XCR,YCR,SF,TEST/NAM8/N,XM,YM,SFM,AC,BC/NAM9
     1/XNTP,YNTP,TESTP/NAM10/TEST,XNT,YNT/NAM11/UX,UY,UZ,CP,UABS/NAM12/J
```

```
     1L,J,JI,USL,VSL,UX,UY,UZ,VSQD,CORD,STML,CP,AF,LNQ/NAM13/KMOD,NTEST,
     1NQ,NQTEST,M/NAM14/M,I,TEST,DS1,DS2,DS3,DS4,XLT,YLT,ZLT,ZSQ/NAM15/T
     1EST,RC1,RC2,RC3,RC4/NAM16/TEST/NAM17/TEST/NAM18/TEST/NAM19/DIRT,JI
     1,JMIN/NAM20/JMAX,SSS,STML/NAM21/KEY,JJ,KK,JMIN/NAM22/XL,YL,ZL,UABS
     1/NAM23/KEY,KK,JJ,JMAX/NAM24/JMN,JMX,AF,L/NAM25/J,L,STML,UABS,AF,MI
     1D/NAM26/L,K,STML,UABS/NAM27/L,JMAX,JMIN,STML,XL,YL,ZL,UABS
      COMMON /S1K/SN(650),VNP(650),IPN(650)
C
      WRITE (JWRITE,1)
    1 FORMAT (1H1,///,35HOCALCULATION OF ON-BODY STREAMLINES)
      NB=(NP+11)/12
      NLIN=NQUAD
      DO 2 I=1,NB
      IFN=I*12
      IS=IFN-11
C***  READ PANEL GEOMETRY FROM TAPE
      READ (KFILE)Q,(XC1(J),YC1(J),XC2(J),YC2(J),XC3(J),XC4(J),YC4(J),X3
     1(J),Y3(J),Z3(J),X4(J),Y4(J),Z4(J),(SKIP,K=1,3),J=IS,IFN)
      NQ=Q
      IF (NQ.NE.IS) GO TO 68
    2 CONTINUE
      NOD1=NP+1
      NOD2=NOD1
      IWRTS=IWRITE
      IF (NODE.GT.NP)NODE=0
      IF (NODE.LE.0) GO TO 3
      NOD1=NODE-2
      NOD2=NODE+2
      IF (NOD1.LE.0)NOD1=1
      IF (NOD2.GT.NP)NOD2=NP
C***  FOR EACH QUAD, COMPUTE SQUARE OF THE RADIUS OF A CIRCLE ABOUT THE
C***  CENTROID WHICH ENCLOSES THE QUAD WITH 1% TO SPARE
    3 DO 4 I=1,NP
      D1=(XC1(I)**2+YC1(I)**2)*1.01
      D2=(XC2(I)**2+YC2(I)**2)*1.01
      D3=(XC3(I)**2+YC3(I)**2)*1.01
      D4=(XC4(I)**2+YC4(I)**2)*1.01
      IF (I.GT.75) GO TO 4
      XL(I)=0.0
      YL(I)=0.0
      ZL(I)=0.0
      STML(I)=0.0
```

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      UABS(I)=0.0
      VCV(I)=0.0
      SS(I)=0.0
    4 DMX(I)=AMAX1(D1,D2,D3,D4)
      IF (NODE.NE.0) WRITE (JWRITE,NAM1)
      MID=70
      MAXJ=75
      MINJ=1
      VXI=-1.0
      IF (NLIN.EQ.0) GO TO 70
      WRITF (JWRITE,5) (TITLF(I),I=1,20)
    5 FORMAT (///,1H0,20A4)
      IF (IWRITE.GT.1) GO TO 7
      WRITE (JWRITE,6) NLIN
    6 FORMAT (1X,47HFOR V INFINITY = -1.0+VXX(1,K),0.0,0.0, COMPUTE,I4,5
     ,0H STREAMLINES STARTING AT EACH PANEL CENTROID POINT)
C***  CALCULATE STREAMLINES FOR EACH PANEL CENTROID OMITTING TRIANGULAR
C***  PANELS AT ENDS. LINES FOUND FROM NOSE TO 3 PTS PAST PANEL CENTROID
    7 IUPPFR=NLIN+1-2*(MM-1)
      ILCWEF=2*(MM-1)
      NLINM1=NLIN-1
      DO 61 II=1,3
      IF (II-2)  8,9,10
    8 NSTART=2
      NEND=2*(MM-1)
      NDEL=2
      IWRTS=IWRITE
      GO TO 11
    9 NSTART=NEND+1
      NEND=(NN-3)*(MM-1)
      NDEL=1
      GO TO 11
   10 NSTART=NEND+1
      NEND=(NN-1)*(MM-1)-1
      NDEL=2
   11 IF (NODE.NE.0) WRITE (JWRITE,NAM2)
      DO 55 LL=NSTART,NEND,NDEL
      IWRITE=IWRTS
      IF (LL.LT.NOD1) GO TO 12
      IF (LL.GT.NOD2) GO TO 12
      IWRITE=-1
   12 MID=70
```

```
      DIRT=-1.
      JI=-1
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM3)
   13 AF=1.
      UX=0.
      UY=0.
      UZ=0.
      CP=0.
      STML(MID)=0.
      NQ=LL
      NCP=LL
      LNQ=NQ
      XL(MID)=XCP(LL)
      YL(MID)=YCP(LL)
      ZL(MID)=ZCP(LL)
      JSTOP=MID+3
      J=MID
      JL=J
      XLT=(XL(J)-XCP(NQ))*X3(NQ)+(YL(J)-YCP(NQ))*Y3(NQ)+(ZL(J)-ZCP(NQ))*
     1Z3(NQ)
      YLT=(XL(J)-XCP(NQ))*X4(NQ)+(YL(J)-YCP(NQ))*Y4(NQ)+(ZL(J)-ZCP(NQ))*
     1Z4(NQ)
      XL(J)=XLT*X3(NQ)+YLT*X4(NQ)+XCP(NQ)
      YL(J)=XLT*Y3(NQ)+YLT*Y4(NQ)+YCP(NQ)
      ZL(J)=XLT*Z3(NQ)+YLT*Z4(NQ)+ZCP(NQ)
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM4)
   14 IQT=MOD(NQ,4)+1
      GO TO (18,15,16,17),IQT
   15 NR=NQ+1
      NU=NQ+2
      GO TO 19
   16 NR=NQ+2
      NU=NQ-1
      GO TO 19
   17 NR=NQ-2
      NU=NQ+1
      GO TO 19
   18 NR=NQ-1
      NU=NQ-2
   19 UXQ=-(VXI*VX1(NQ))
      UYQ=-(VXI*VY1(NQ))
      UZQ=-(VXI*VZ1(NQ))
```

```
      UXR=-(VXI*VX1(NR))                                                PF5 153
      UYR=-(VXI*VY1(NR))                                                PF5 154
      UZR=-(VXI*VZ1(NR))                                                PF5 155
      UXU=-(VXI*VX1(NU))                                                PF5 156
      UYU=-(VXI*VY1(NU))                                                PF5 157
      UZU=-(VXI*VZ1(NU))                                                PF5 158
C***  TRANSFORM VELOCITIES TO QUAD. SYSTEM                              PF5 159
      UQ=UXQ*X3(NQ)+UYQ*Y3(NQ)+UZQ*Z3(NQ)                               PF5 160
      VQ=UXQ*X4(NQ)+UYG*Y4(NQ)+UZQ*Z4(NQ)                               PF5 161
      CSR=1./(XNP(NQ)*XNP(NR)+YNP(NQ)*YNP(NR)+ZNP(NG)*ZNP(NR))          PF5 162
      UT=UXR*X3(NR)+UYR*Y3(NR)+UZR*Z3(NR)                               PF5 163
      VT=(UXR*X4(NR)+LYR*Y4(NR)+UZR*Z4(NR))*CSR                         PF5 164
      XXR=(X3(NR)*X3(NQ)+Y3(NR)*Y3(NQ)+Z3(NR)*Z3(NQ))                   PF5 165
      XYR=(X4(NR)*X3(NQ)+Y4(NR)*Y3(NQ)+Z4(NR)*Z3(NQ))                   PF5 166
      UR=UT*XXR+VT*XYR                                                  PF5 167
      YXR=(X3(NR)*X4(NQ)+Y3(NR)*Y4(NQ)+Z3(NR)*Z4(NQ))                   PF5 168
      YYR=(X4(NR)*X4(NQ)+Y4(NR)*Y4(NQ)+Z4(NR)*Z4(NQ))                   PF5 169
      VR=UT*YXR+VT*YYR                                                  PF5 170
      UU=UXU*X3(NQ)+UYU*Y3(NQ)+UZU*Z3(NQ)                               PF5 171
      CSU=(XNP(NQ)*XNP(NU)+YNP(NQ)*YNP(NU)+ZNP(NQ)*ZNP(NU))             PF5 172
      VU=(UXU*X4(NQ)+UYU*Y4(NQ)+UZU*Z4(NQ))/CSU                         PF5 173
C***  FIND RELATIVE COORDINATES OF NEIGHBORING QUADS.                    PF5 174
      XD=XCP(NR)-X P(NQ)                                                PF5 175
      YD=YCP(NR)-YCP(NQ)                                                PF5 176
      ZD=ZCP(NR)-ZCP(NQ)                                                PF5 177
      XT=XD*X3(NR)+YD*Y3(NR)+ZD*Z3(NR)                                  PF5 178
      YTT=XD*X4(NR)+YD*Y4(NR)+ZD*Z4(NR)                                 PF5 179
      ZT=XD*XNP(NR)+YD*YNP(NR)+ZD*ZNP(NR)                               PF5 180
      YT=(-4.*SQRT(YTT**2+ZT**2)+YTT*CSR+YTT)*CSR*.16666667             PF5 181
      XR=XT*XXR+YT*XYR                                                  PF5 182
      YR=XT*YXR+YT*YYR                                                  PF5 183
      IF (IWRITE.LT.0) WRITE (JWRITE.NAM5)                              PF5 184
      XD=XCP(NU)-XCP(NQ)                                                PF5 185
      YD=YCP(NU)-YCP(NQ)                                                PF5 186
      ZD=ZCP(NU)-ZCP(NQ)                                                PF5 187
      XU=XD*X3(NQ)+YD*Y3(NQ)+ZD*Z3(NQ)                                  PF5 188
      YT=XD*X4(NQ)+YD*Y4(NQ)+ZD*Z4(NQ)                                  PF5 189
      ZT=XD*XNP(NQ)+YD*YNP(NQ)+ZD*ZNP(NQ)                               PF5 190
      YU=(4.*SQRT(YT**2+ZT**2)+YT/CSU+YT)*.16666667                     PF5 191
C***  FIND COEFFICIENTS OF VELOCITY FUNCTIONS                            PF5 192
      DEN=1./(XR*YU-XU*YR)                                              PF5 193
      U1=((UR-UQ)*YU-(UU-UQ)*YR)*DEN                                    PF5 194
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      U2=-((UR-UQ)*XU-(UU-UQ)*XR)*DEN
      V1=((VR-VQ)*YU-(VU-VQ)*YR)*DEN
      V2=-((VR-VQ)*XU-(VU-VQ)*XR)*DEN
C***  FIND VELOCITY AT STREAMLINE POINT
      USL=UQ+U1*XLT+U2*YLT
      VSL=VQ+V1*XLT+V2*YLT
      UXP=USL*X3(NQ)+VSL*X4(NQ)
      UYP=USL*Y3(NQ)+VSL*Y4(NQ)
      UZP=USL*Z3(NQ)+VSL*Z4(NQ)
      VSQD=USL**2+VSL**2
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM6)
      DEN=VSQD*SQRT(VSQD)
C***  FIND LOCAL STREAM FUNCTION
      CXY=(U1*VQ**2-V2*UQ**2)/VSQD
      CYY=U2-UQ*VQ*(U1+V2)/VSQD
      CXX=U2-CYY-V1
      CC=XLT*VQ-YLT*UQ-CXY*XLT*YLT-CYY*YLT**2-CXX*XLT**2
C***  FIND STREAM FUNCTION AT CORNER POINTS
      XCR(1)=XC1(NQ)
      XCR(2)=XC2(NQ)
      XCR(3)=XC3(NQ)
      XCR(4)=XC4(NQ)
      XCR(5)=XCR(1)
      YCR(1)=YC1(NQ)
      YCR(2)=YC2(NQ)
      YCR(3)=YC3(NQ)
      YCR(4)=YC4(NQ)
      YCR(5)=YCR(1)
      DO 20 N=1,4
   20 SF(N)=CO-VQ*XCR(N)+UQ*YCR(N)+CXY*XCR(N)*YCR(N)+CYY*YCR(N)**2+CXX*X
     1CR(N)**2
      SF(5)=SF(1)
      TEST=0.
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM7)
      DO 23 N=1,4
      IF (SF(N)*SF(N+1).GE.0.) GO TO 23
      XM=(XCR(N)+XCR(N+1))*.5
      YM=(YCR(N)+YCR(N+1))*.5
C***  FIND INTERSECTION WITH SIDE OF QUAD.
      SFM=CO-VQ*XM+UQ*YM+CXY*XM*YM+CYY*YM**2+CXX*XM**2
      AC=2.*(SF(N)-2.*SFM+SF(N+1))
      BC=3.*SF(N)-4.*SFM+SF(N+1)
```

```
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM8)
      IF (AC.EQ.0) GO TO 21
      SR=SQRT(BC**2-4.*AC*SF(N))
      TP=(BC+SR)/(2.*AC)
      IF (TP.LE.1..AND.TP.GE.0.) GO TO 22
      TP=(BC-SR)/(2.*AC)
      IF (TP.LE.1.0.AND.TP.GE.0.0) GO TO 22
   21 IF (BC.EQ.0) GO TO 23
      TP=SF(N)/BC
      IF (TP.GT.1.0.OR.TP.LT.0.0) GO TO 23
   22 XNTP=(1.-TP)*XCR(N)+TP*XCR(N+1)
      YNTP=(1.-TP)*YCR(N)+TP*YCR(N+1)
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM9)
      TESTP=((XNTP-XLT)*UQ+(YNTP-YLT)*VQ)*DIRT
      IF (TESTP.LE.TEST) GO TO 23
      TEST=TESTP
      XNT=XNTP
      YNT=YNTP
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM10)
   23 CONTINUE
      IF (TEST.EQ.0.) GO TO 34
C***  AVERAGE LAST VELOCITY AND CURVATURE
      UX=(UX+UXP)*AF
      UY=(UY+UYP)*AF
      UZ=(UZ+UZP)*AF
      CP=1.-(UX**2+UY**2+UZ**2)
      UABS(J)=SQRT(1.-CP)
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM11)
      IF (J.GE.JSTOP) GO TO 35
C***  COMPUTE VELOCITY AT NEXT POINT
      JL=J
      J=J+JI
      USL=UQ+XNT*U1+YNT*U2
      VSL=VQ+XNT*V1+YNT*V2
      UX=USL*X3(NQ)+VSL*X4(NQ)
      UY=USL*Y3(NQ)+VSL*Y4(NQ)
      UZ=USL*Z3(NQ)+VSL*Z4(NQ)
      VSQD=USL**2+VSL**2
      CORD=SQRT((XNT-XLT)**2+(YNT-YLT)**2)*DIRT
      STML(J)=STML(JL)+CORD
      CP=1.-VSQD
      UABS(J)=SQRT(1.-CP)
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      AF=.5
      LNQ=NQ
      IF (IWRITE.LT.C) WRITE (JWRITE,NAM12)
      XL(J)=XNT*X3(NQ)+YNT*X4(NQ)+XCP(NQ)
      YL(J)=XNT*Y3(NQ)+YNT*Y4(NQ)+YCP(NQ)
      ZL(J)=XNT*Z3(NQ)+YNT*Z4(NQ)+ZCP(NQ)
      IF (J.LE.MINJ.OR.J.GE.MAXJ) GO TO 54
C***  PROCEDURE FOR FINDING NEXT QUAD. WAS MODIFIED SO THAT, DEPENDING
C***  ON THE DIRECTION, THERE ARE ONLY 5 POSSIBLE QUADS. TO TEST
      KMOD=MOD(NQ,2)
      NTEST=5
      IF (DIRT)  26,24,29
   24 WRITE (JWRITE,25) DIRT
   25 FORMAT (1H1,1X,7HDIRT = ,F10.7,26HPROGRAM TERMINATED IN PFP5)
      ICANCL=1
      RETURN
   26 IF (KMOD)  27,28,27
C***  LAST QUAD. IS ODD & WE ARE TESTING AGAINST THE STREAM DIRECTION
   27 NQTEST(1)=NQ-2*(MM-1)+1
      NQTEST(2)=NQ+2
      NQTEST(3)=NQ-2
      NQTEST(4)=NQTEST(1)+2
      NQTEST(5)=NQTEST(1)-2
      IF (NQ.NE.NLINM1) GO TO 32
      NQTEST(2)=NQTEST(5)
      NTEST=3
      GO TO 32
C***  LAST QUAD. IS EVEN & WE ARE TESTING AGAINST THE STREAM DIRECTION
   28 NQTEST(1)=NQ-1
      NQTEST(2)=NQ+2
      NQTEST(3)=NQ-2
      NQTEST(4)=NQ+1
      NQTEST(5)=NQ-3
      IF (NQ.GT.ILOWER) GO TO 32
      NQTEST(1)=NQTEST(2)
      NQTEST(2)=NQTEST(3)
      NTEST=2
      IF (NQ.EQ.2)NTEST=1
      GO TO 32
   29 IF (KMOD)  30,31,30
C***  LAST QUAD IS ODD & WE ARE TESTING IN THE STREAM DIRECTION
   30 NQTEST(1)=NQ+1
```

```
      NQTEST(2)=NQ+2
      NQTEST(3)=NQ-2
      NQTEST(4)=NQ+3
      NQTEST(5)=NQ-1
      IF (NQ.LT.IUPPER) GO TO 32
      NTEST=2
      NQTEST(1)=NQTEST(3)
      IF (NQ.EQ.NLINM1)NTEST=1
      GO TO 32
C***  LAST QUAD IS EVEN & WE ARE TESTING IN THE STREAM DIRECTION
   31 NQTEST(1)=NQ+2*(MM-1)-1
      NQTEST(2)=NQ+2
      NQTEST(3)=NQ-2
      NQTEST(4)=NQTEST(1)+2
      NQTEST(5)=NQTEST(1)-2
      IF (NQ.NE.2) GO TO 32
      NTEST=4
      NQTEST(3)=NQTEST(5)
   32 M=1
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM13)
   33 I=NQTEST(M)
      NQ=I
      TEST=(XL(J)-XCP(I))**2+(YL(J)-YCP(I))**2+(ZL(J)-ZCP(I))**2-DMX(I)
      IF (TEST.GT.0.) GO TO 34
      DS1=(XC1(I)-XC2(I))**2+(YC1(I)-YC2(I))**2
      DS2=(XC2(I)-XC3(I))**2+(YC2(I)-YC3(I))**2
      DS3=(XC3(I)-XC4(I))**2+(YC3(I)-YC4(I))**2
      DS4=(XC4(I)-XC1(I))**2+(YC4(I)-YC1(I))**2
      XLT=(XL(J)-XCP(I))*X3(I)+(YL(J)-YCP(I))*Y3(I)+(ZL(J)-ZCP(I))*Z3(I)
      YLT=(XL(J)-XCP(I))*X4(I)+(YL(J)-YCP(I))*Y4(I)+(ZL(J)-ZCP(I))*Z4(I)
      ZLT=(XL(J)-XCP(I))*XNP(I)+(YL(J)-YCP(I))*YNP(I)+(ZL(J)-ZCP(I))*ZNP
     1(I)
      ZSQ=ZLT**2
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM14)
      TEST=ZSQ-.1*DMX(I)
      IF (TEST.GT.0.) GO TO 34
      RC1=SQRT(ZSQ+(XLT-XC1(I))**2+(YLT-YC1(I))**2)
      RC2=SQRT(ZSQ+(XLT-XC2(I))**2+(YLT-YC2(I))**2)
      RC3=SQRT(ZSQ+(XLT-XC3(I))**2+(YLT-YC3(I))**2)
      RC4=SQRT(ZSQ+(XLT-XC4(I))**2+(YLT-YC4(I))**2)
      TEST=((RC1+RC2)**2)-DS1*1.3
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM15)
```

```
      IF (TEST.LT.0.) GC TO 14
      TEST=((RC2+RC3)**2)-DS2*1.3
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM16)
      IF (TEST.LT.0.) GO TO 14
      TEST=((RC3+RC4)**2)-DS3*1.3
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM17)
      IF (TEST.LT.0.) GO TO 14
      TEST=((RC4+RC1)**2)-DS4*1.3
      IF (IWRITF.LT.0) WRITF (JWRITE,NAM18)
      IF (TEST.LT.0.) GO TO 14
   34 M=M+1
      IF (M.LE.NTEST) GO TO 33
   35 IF (DIRT.GT.0.) GC TO 36
C***  CHANGE THF DIRFCTION IN WHICH THE STREAMLINE IS TRACED
      DIRT=1.
      JI=1
      JMIN=J
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM19)
      GO TO 13
   36 JMAX=J
      SSS=STML(JMIN)
      DO 37 J=JMIN,JMAX
   37 STML(J)=STML(J)-SSS
      IF (IWRITE.LT.0) WRITE (JWRITF,NAM20)
      IF ((STML(JMIN+3)-STML(JMIN)).LT.8.*(STML(JMIN+1)-STML(JMIN))) GO
     1TO 39
      KFY=1
      JJ=JMIN
      KK=JMIN+1
      JMIN=JMIN+1
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM21)
   38 XL(KK)=(XL(JJ)+XL(KK))/2.0
      YL(KK)=(YL(JJ)+YL(KK))/2.0
      ZL(KK)=(ZL(JJ)+ZL(KK))/2.0
      UABS(KK)=(UABS(JJ)+UABS(KK))/2.0
      IF (IWRITF.LT.0) WRITE (JWRITE,NAM22)
      IF (KFY.FQ.1) GO TO 39
      GO TO 40
   39 IF ((STML(JMAX)-STML(JMAX-3)).LT.8.*(STML(JMAX)-STML(JMAX-1))) GO
     1TO 40
      KEY=2
      KK=JMAX-1
```

```
      JJ=JMAX                                                           PF5 405
      JMAX=JMAX-1                                                       PF5 406
      IF (IWRITE.LT.0) WRITF (JWRITE,NAM23)                             PF5 407
      GO TO 38                                                          PF5 408
   40 JMN=JMIN+1                                                        PF5 409
      JMX=JMAX-2                                                        PF5 410
      AF=1.                                                             PF5 411
      L=JMN                                                             PF5 412
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM24)                             PF5 413
      IF (IWRITE.GT.1) GO TO 42                                         PF5 414
      WRITF (JWPITF,41) NCP                                             PF5 415
   41 FORMAT (///,37H0 LINE PASSING THROUGH QUADRILATERAL ,I4)          PF5 416
   42 DO 46 J=JMN,JMX                                                   PF5 417
      IF ((STML(J+2)-STML(L-1)).LT.8.*(STML(J+1)-STML(L))) GO TO 45     PF5 418
      IF (IWRITE.GT.1) GO TO 44                                         PF5 419
      WRITE (JWRITF,43) XL(L),YL(L),ZL(L),XL(J+1),YL(J+1),ZL(J+1)       PF5 420
   43 FORMAT (14H POINT DELETED,10X,3F12.5,10X,3F12.5)                  PF5 421
   44 STML(L)=(AF*STML(L)+STML(J+1))/(AF+1.)                            PF5 422
      XL(L)=(AF*XL(L)+XL(J+1))/(AF+1.)                                  PF5 423
      YL(L)=(AF*YL(L)+YL(J+1))/(AF+1.)                                  PF5 424
      ZL(L)=(AF*ZL(L)+ZL(J+1))/(AF+1.)                                  PF5 425
      UABS(L)=(AF*UABS(L)+UABS(J+1))/(AF+1.0)                           PF5 426
      AF=AF+1.                                                          PF5 427
      IF (IWRITF.LT.0) WRITE (JWRITE,NAM25)                             PF5 428
      IF (L.LE.MID)MID=MID-1                                            PF5 429
      GO TO 46                                                          PF5 430
   45 AF=1.                                                             PF5 431
      L=L+1                                                             PF5 432
      K=J+1                                                             PF5 433
      STML(L)=STML(K)                                                   PF5 434
      XL(L)=XL(K)                                                       PF5 435
      YL(L)=YL(K)                                                       PF5 436
      ZL(L)=ZL(K)                                                       PF5 437
      UABS(L)=UABS(K)                                                   PF5 438
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM26)                             PF5 439
   46 CONTINUE                                                          PF5 440
      L=L+1                                                             PF5 441
      STML(L)=STML(JMAX)                                                PF5 442
      XL(L)=XL(JMAX)                                                    PF5 443
      YL(L)=YL(JMAX)                                                    PF5 444
      ZL(L)=ZL(JMAX)                                                    PF5 445
      UABS(L)=UABS(JMAX)                                                PF5 446
```

```
      IF (IWRITE.LT.0) WRITE (JWRITE,NAM27)
      JMAX=L
      IF (IWRITE.GT.1) GO TO 48
      WRITE (JWRITE,47)
   47 FORMAT (3H0 I,6X,1HX,9X,1HY,9X,1HZ,13X,2HCP,8X,2HSL,7X,4HUABS)
   48 K=0
      LOHO=0
      LOGO=0
      IF ((JMAX-JMIN).LE.4)LOGO=1
      DO 51 I=JMIN,JMAX
      K=K+1
      VOV(K)=UABS(I)
      SS(K)=STML(I)
      IF (LOGO.EQ.0) GO TO 49
      SSTEST=1000.0
      IF (K.GT.1)SSTEST=(SS(K)-SS(K-1))
      IF (SSTEST.LE.0.0)LOHO=LOHO+1
   49 IF (IWRITE.GT.1) GO TO 51
C***  WRITE POINTS,VELOCITIES,&CP'S FOR THE STREAMLINE POINTS CALCULATED
      CP=1.0-UABS(I)**2
      WRITE (JWRITE,50) K,XL(I),YL(I),ZL(I),CP,STML(I),UABS(I)
   50 FORMAT (1X,I3,3F10.5,4X,3F10.5)
   51 CONTINUE
      IF (LOHO.GT.0) GO TO 52
C***  CALL ROUTINE TO CALCULATE BOUNDARY LAYER OVER THE STREAMLINE
      CALL BLCONT(K,IWRITE)
      IF (ICANCL.NE.0) RETURN
      K2=(MID-JMIN)*KKK+1
C***  HOLD THE DISPLACEMENT THICKNESS & THE WALL SHEAR VALUES AT THE
C***  CENTROID POINT FOR WHICH THE STREAMLINE WAS CALCULATED
      SKIN(LL)=CFI(K2)
      DSTAR(LL)=DELS(K2)
      HSK=SKIN(LL)
      HDS=DSTAR(LL)
      GO TO 56
   52 SKIN(LL)=HSK
      DSTAR(LL)=HDS
      WRITE (JWRITE,53) LL
   53 FORMAT (1X,/,2X,65HVALUES OF WALL SHEAR AND DISPLACEMENT THICKNESS
     1 AT QUADRILATERAL ,I3,40H WAS SET DUE TO STREAMLINE DIFFICULTIES.,
     1/)
      GO TO 56
```

```
   54 WRITE (JWRITE,41) NCP
      WRITE (JWRITE,55)
   55 FORMAT (35H PROBABLE ERROR - LINE IS VERY LCNG)
      GC TO 35
   56 CONTINUE
      IWRITE=IWRTS
      IF (II-2)  57,61,59
   57 JEND=NEND-1
C***  ESTIMATE DSTAR & SKIN FOR TRIANGLES AT THE NOSE AND TAIL OF BODY
      DO 58 J=1,JEND,2
      DSTAR(J)=DSTAR(J+1)/3.0
   58 SKIN(J)=SKIN(J+1)/3.0
      GO TO 61
   59 JSTART=NSTART+1
      DO 60 J=JSTART,NLIN,2
      DSTAR(J)=DSTAR(J-1)
   60 SKIN(J)=SKIN(J-1)
   61 CONTINUE
C***  END OF LOOP ON PANEL CENTROIDS EXCEPT TRIANGLES
      WRITE (JWRITE,62)
   62 FORMAT (///,1X,56HSUMMARY OF BOUNDARY LAYER INFORMATION FOR QUADRI
     1LATERALS//2X,5HNQUAD,6X,1HX,9X,1HY,9X,1HZ,11X,5HDSTAR,5X,4HSKIN/)
      CDF=0.0
      AREA=0.0
C***  WRITE POINTS,DSTAR,& SKIN FOR EACH CENTROID. COMPUTE FRICTION CD
      DC 64 J=1,NLIN
      IF (SKIN(J).GT.900.0)SKIN(J)=0.0
      WRITE (JWRITE,63) J,XCP(J),YCP(J),ZCP(J),DSTAR(J),SKIN(J)
   63 FCRMAT (4X,I3,3F10.5,4X,2F10.5)
      CDF=CDF-SKIN(J)*AQP(J)*VX1(J)/(0.5*VABS(J))
      AREA=AREA+AQP(J)
   64 CCNTINUE
      AREAAV=AREA/NLIN
      CDFA=2.0*CDF
      CDF=CDFA/REFA
      WRITE (JWRITE,65) CDF,REFA,REBODY,STOTAL
   65 FCRMAT (///,15X,25HFRICTION DRAG COEFFICIENT,//,13X,29(1H*),/17X,1
     14HFRICTION CD = ,F11.5,/14X,17HREFERENCE AREA = ,F11.5,/13X,18HREY
     1NCLDS NUMBER = ,E11.4/17X,14HBODY LENGTH = ,F11.5/,13X,29(1H*),///
     1)
      REWIND KFILE3
      REWIND KFILE4
```

```
      REWIND KFILE5
      SUMA=0.0
      AVXCG=0.0
      AVAREA=0.0
      AVDELS=0.0
      NDC=NLIN-2*MM+4
C***  CALCULATE AVERAGE DSTAR,AVERAGE PANEL AREA, AND AVERAGE X-ORDINATE
C***  FOR THE THIRD STATION OF INPUT POINTS FROM THE END OF BODY.  THESE
C***  QUANTITIES ARF USED TO CALCULATF THE WAKE-BODY COORDINATES.
      DO 66 I=NDO,NLIN,2
      AVXCG=AVXCG+XCP(I-1)*AQP(I-1)
      AVDFLS=AVDELS+DSTAR(I-1)*AQP(I-1)
      AVAREA=AVAREA+AQP(I-1)
   66 SUMA=SUMA+AQP(I)
      AVDELS=AVDELS/AVAREA
      AVXCG=AVXCG/AVAREA
      SUMA=SUMA/(MM-1)
      AREAAV=SQRT(AREAAV*SUMA)
      DO 67 I=1,NLIN
      XNH(I)=XNP(I)
      ZNH(I)=ZNP(I)
   67 AQPH(I)=AQP(I)
      RETURN
   68 WRITE (JWRITE,69) IS,NQ
   69 FORMAT (14H TAPE 04 ERROR,2I4)
      REWIND KFILE
   70 RETURN
      END

      SUBROUTINE BLCONT(KNP,IWRITE)
C
C***  BOUNDARY LAYER CONTROL ROUTINE WHICH CALLS LAMINR & TURB2. THE
C***  LAMINAR AND TURBULENT ROUTINES WHICH USE MOMENTUM INTEGRAL METHOD
C
      DIMENSION V(150),S(150),DUDS(150)
      COMMON /BOUND/TAW(150),HMEAN(150),NP
      COMMON /SPLN/VCOFF(4,75)
      COMMON /BL/VOV(75),SS(75),VINF,VO,ROE,DELS(150),CFI(150),THT(150),
     1STOTAL,KKK
      COMMON /INOUT/JREAD,JWRITE,KFILE,KFILE1,KFILE2,KFILE3,KFILE4,KFILE
```

```
   15
      COMMON /CANCEL/ICANCL.NODE
C
      STRAN=.05
      NP=KNP
C***  SPLINE IS CALLED TO CURVE FIT THE STREAMLINE VALUES OF ABSOLUTE
C***  VELOCITY VERSUS SURFACE DISTANCE FROM THE NOSE OF THE BODY
      CALL SPLINE(NP.VOV.SS.0)
      M=NP-1
      SEND=SS(NP)
      KKK=2
      K=1
      S(1)=SS(1)
      V(1)=VOV(1)
      DUDS(1)=VCOEF(3.1)
      DO 1 I=1.M
      H=(SS(I+1)-SS(I))/KKK
      DO 1 J=1.KKK
      K=K+1
      S(K)=S(K-1)+H
      V(K)=((VCOEF(1.I)*S(K)+VCOEF(2.I))*S(K)+VCOEF(3.I))*S(K)+VCOEF(4.I
     1)
      DUDS(K)=(3.0D0*VCOEF(1.I)*S(K)+2.0D0*VCOEF(2.I))*S(K)+VCOEF(3.I)
      NPP=KKK*(NP-1)+1
    1 CONTINUE
      DO 2 I=1.NPP
      S(I)=S(I)/STOTAL
    2 DUDS(I)=DUDS(I)*STOTAL
      CALL LAMINR(S.V.DUDS.STRAN.II.NPP.IWRITE)
      IF (ICANCL.NE.0) RETURN
      IF (II.EQ.NPP) GO TO 3
      CALL TURB2(S.V.DUDS.SEND.II.NPP)
    3 IF (IWRITE.GT.1) GO TO 5
      WRITE (JWRITE.4)
    4 FORMAT (/.6X.1HS.13X.1HV.10X.4HDUDS.9X.5HHMEAN.8X.6HDELTAS.7X.6HTH
     1ETAS.8X.3HTAW.9X.3HCFI/)
    5 DO 6 I=1.NPP
      S(I)=S(I)*STOTAL
      V(I)=V(I)*VINF
      DUDS(I)=DUDS(I)*VINF/STOTAL
    6 DELS(I)=DELS(I)*STOTAL
      IF (IWRITE.GT.1) RETURN
```

```
      DO 7 I=1,NPP,KKK
    7 WRITE (JWRITE,8) S(I),V(I),DUDS(I),HMEAN(I),DELS(I),THT(I),TAW(I),
     1CFI(I)
    8 FORMAT (1X,8(F10.5,3X))
      RETURN
      END


      SUBROUTINE LAMINR(X,UDEL,DUDX,XTRAN,II,NPP,IWRITE)
C
C***  CALCULATES LAMINAR BOUNDARY LAYER BY MOMENTUM INTEGRAL
C
      DIMENSION X(150),UDEL(150),DUDX(150)
      COMMON /BOUND/TAW(150),HMEAN(150),NP
      COMMON /SPLN/VCOEF(4,75)
      COMMON /BL/VOV(75),SS(75),VINF,VO,ROE,DELS(150),CFI(150),THT(150),
     1STOTAL,KKK
      COMMON /INOUT/JREAD,JWRITE,KFILE,KFILE1,KFILE2,KFILE3,KFILE4,KFILE
     15
      COMMON /CANCEL/ICANCL,NODE
C
      II=1
      H=X(II+1)-X(II)
      IF (UDEL(II).LT.1.0E-06) GO TO 1
C***  STARTING CONDITIONS ASSUMING FLAT PLATE
      Z=0.0
      THT(II)=0.0
      DELS(II)=0.0
      TAW(II)=5000.0
      CFI(II)=1000.0
      HMEAN(II)=2.554
      II=2
      GO TO 4
C***  STARTING CONDITIONS ASSUMING STAGNATION POINT
    1 DUDXO=VCOEF(3,1)*STOTAL
      D2UDXC=2.0*VCOEF(2,1)*STOTAL**2
      Z=0.0770/DUDXO
      THT(II)=SQRT(Z*VO/(VINF*STOTAL))
      DELS(II)=THT(II)*2.308
      CFI(II)=0.664*UDEL(II)/(THT(II)*VINF*STOTAL/VO)
      TAW(II)=CFI(II)*0.5*ROE*VINF*VINF
```

```
      HMEAN(II)=2.308
      II=2
      GO TO 3
    2 II=II+1
      H=X(II)-X(II-1)
      GO TO 4
    3 AM1=H*(-0.0652*D2UDX0/(DUDX0**2))
      GO TO 5
    4 AKD=Z*DUDX(II-1)
      CALL FFK(AKD,FD,F1D,F2D)
      IF (ICANCL.NE.0) RETURN
      AM1=H*FD/UDEL(II-1)
    5 UDELP=0.5*(UDEL(II-1)+UDEL(II))
      DUDXP=0.5*(DUDX(II-1)+DUDX(II))
      AKD=(Z+AM1/2.0)*DUDXP
      CALL FFK(AKD,FD,F1D,F2D)
      IF (ICANCL.NE.0) RETURN
      AM2=H*FD/UDELP
      AKD=(Z+AM2/2.0)*DUDXP
      CALL FFK(AKD,FD,F1D,F2D)
      IF (ICANCL.NE.0) RETURN
      AM3=H*FD/UDELP
      AKD=(Z+AM3)*DUDX(II)
      CALL FFK(AKD,FD,F1D,F2D)
      IF (ICANCL.NE.0) RETURN
      AM4=H*FD/UDEL(II)
      Z=Z+(AM1+2.0*AM2+2.0*AM3+AM4)/6.0
      AKD=Z*DUDX(II)
      CALL FFK(AKD,FD,F1D,F2D)
      IF (ICANCL.NE.0) RETURN
      THT(II)=SQRT(Z*VO/(VINF*STOTAL))
      DELS(II)=THT(II)*F1D
      CFI(II)=2.0*F2D*UDEL(II)/(THT(II)*VINF*STOTAL/VO)
      TAW(II)=CFI(II)*0.5*ROE*VINF*VINF
      HMEAN(II)=DELS(II)/THT(II)
      IF (TAW(II).LT.0.0) GO TO 8
      IF (X(II).GE.XTRAN) GO TO 6
      IF (II.EQ.NPP) GO TO 6
      GO TO 2
    6 IF (IWRITE.GT.1) RETURN
      WRITE (JWRITE,7) X(II),II
    7 FORMAT (/1X,18HTRANSITION AT X = ,F10.5,17H FOR STEP NUMBER ,I3)
```

```
      RETURN
    8 IF (IWRITE.GT.1) RETURN
      IK=II/KKK
      WRITE (JWRITE,9) TAW(II),IK
    9 FORMAT (/,27H NEGATIVE VALUE OF TAWST = ,E14.7,21H AT OR AFTER STA
     1TION ,I3,19H ON THE STREAMLINE.,38H FOR MORE INFORMATION ON THE LO
     1CATION,/,108H OF LAMINAR SEPARATION USE IWRITE = 0 PRINT OPTION. T
     1HE TURBULENT ROUTINE IS CALLED AT THE SEPARATION POINT.)
      RETURN
      END


      SUBROUTINE FFK(AKD,FD,F1D,F2D)
C
C***  ROUTINE FOR NUMERICAL INTERPOLATION OF LAMINAR B.L. FUNCTIONS
C
      DIMENSION AK(55),F(55),F1(55),F2(55)
      COMMON /INOUT/JREAD,JWRITE,KFILE,KFILE1,KFILE2,KFILE3,KFILE4,KFILE
     15
      COMMON /CANCEL/ICANCL,NODE
      DATA AK/0.094815,0.094632,0.094083,0.093166,0.091882,0.090234,0.08
     18223,0.085855,0.083134,0.080068,0.076664,0.072930,0.068877,0.06451
     16,0.059857,0.054912,0.049697,0.044223,0.038506,0.032562,0.026405,0
     1.020054,0.013524,0.006833,0.000000,-0.006957,-0.014321,-0.021170,-
     10.028387,-0.035651,-0.042943,-0.050244,-0.057532,-0.064789,-0.0719
     195,-0.079129,-0.086171,-0.093104,-0.099906,-0.106558,-0.113043,-0.
     1119341,-0.125434,-0.131304,-0.136935,-0.142309,-0.147411,-0.152224
     1,-0.156735,-0.160927,-0.164789,-0.168307,-0.171470,-0.174267,-0.17
     16687/
      DATA F/-0.094815,-0.093915,-0.091177,-0.086542,-0.079963,-0.071400
     1,-0.060818,-0.048195,-0.033512,-0.016759,0.002068,0.022964,0.04591
     19,0.070916,0.097932,0.126938,0.157897,0.190770,0.225538,0.262060,0
     1.300369,0.340371,0.381999,0.425181,0.469841,0.515896,0.563264,0.61
     11853,0.661571,0.712321,0.764004,0.816516,0.869752,0.923601,0.97795
     12,1.032691,1.087700,1.142862,1.198055,1.253157,1.308043,1.362589,1
     1.416665,1.470145,1.522902,1.574802,1.625719,1.675522,1.724079,1.77
     11259,1.816936,1.860975,1.903251,1.943633,1.981994/
      DATA F1/2.250000,2.250686,2.252684,2.255924,2.260349,2.265904,2.27
     12545,2.280231,2.288928,2.298609,2.309248,2.320828,2.333333,2.34675
     11,2.361073,2.376291,2.392406,2.409414,2.427320,2.446130,2.465849,2
     1.486485,2.508057,2.530574,2.554053,2.578518,2.603985,2.630480,2.65
```

```
     18031,2.686666,2.716418,2.747321,2.779412,2.812734,2.847327,2.88324
     12,2.920529,2.959246,2.999447,3.041230,3.084570,3.129634,3.176471,3
     1.225166,3.275810,3.328505,3.383357,3.440479,3.499999,3.562056,3.62
     16788,3.694360,3.764940,3.838720,3.915905/
      DATA F2/0.355556,0.355293,0.354515,0.353236,0.351470,0.349229,0.34
     16528,0.343380,0.339800,0.335801,0.331397,0.326601,0.321428,0.31589
     12,0.310005,0.303782,0.297237,0.290383,0.283234,0.275804,0.268107,0
     1.260156,0.251966,0.243549,0.234921,0.226093,0.217082,0.207899,0.19
     18559,0.189077,0.179464,0.169736,0.159906,0.149987,0.139995,0.12994
     11,0.119841,0.109708,0.099555,0.089397,0.079247,0.069120,0.059028,0
     1.048985,0.039007,0.029105,0.019294,0.009588,0.000000,-0.009455,-0.
     1018765,-0.027914,-0.036890,-0.045678,-0.054266/
C
      IF (AKD.LE.AK(1)) GO TO 1
      FD=F(1)
      F1D=F1(1)
      F2D=F2(1)
      AKD=AK(1)
      RETURN
    1 IF (AKD.GT.AK(55)) GO TO 2
      FD=F(55)
      F1D=F1(55)
      F2D=F2(55)
      AKD=AK(55)
      RETURN
    2 DO 3 I=1,54
      IF (AKD.LE.AK(I).AND.AKD.GT.AK(I+1)) GO TO 5
    3 CONTINUE
      WRITE (JWRITE,4) AKD
    4 FORMAT (1X,6HAKD = ,E12.5,22H EXCEEDS ALLOWED RANGE)
      ICANCL=1
      RETURN
    5 FD=F(I)+(F(I+1)-F(I))*(AKD-AK(I))/(AK(I+1)-AK(I))
      F1D=F1(I)+(F1(I+1)-F1(I))*(AKD-AK(I))/(AK(I+1)-AK(I))
      F2D=F2(I)+(F2(I+1)-F2(I))*(AKD-AK(I))/(AK(I+1)-AK(I))
      RETURN
      END

      SUBROUTINE TURB2(SUMS,UE,DUEDX,SEND,N1,NPP)
C
```

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```
C***  ROUTINE FOR TURBULENT BOUNDARY LAYER USING MOMENTUM INTEGRAL
C
      COMMON /BOUND/TAW(150),HMEAN(150),NP
      COMMON /BL/VOV(75),SS(75),VINF,VO,ROE,DELS(150),CFI(150),THT(150),
     1STOTAL,KKK
      DIMENSION HVMEAN(2),SUMS(150),UE(150),DUEDX(150)
C
      DO 1 L=N1,NPP
      DUEDX(L)=VINF*DUEDX(L)/STOTAL
      SUMS(L)=SUMS(L)*STOTAL
    1 UE(L)=VINF*UE(L)
      THT(N1)=THT(N1)*STOTAL
      DELS(N1)=1.45*THT(N1)
      C1=0.56
      C2=.1667
      C3=1.65
      C4=0.246
      C5=0.678
      C6=0.268
      HMEAN(N1)=1.45
      HVMEAN(1)=1.269*HMEAN(N1)/(HMEAN(N1)-.379)
      E1=3.+2.*C2
      E2=1.+C2
      E3=3.+3.*C2
      T1=0.02*C1/C3*E2
      IBEG=N1+1
      DO 7 I=IBEG,NPP
      HMEAN(I)=0.0
      HVMEAN(2)=0.0
      UETR=(UE(I-1)/UE(I))**E3
      UEINT=0.5*(SUMS(I)-SUMS(I-1))*(UE(I)**E1+UE(I-1)**E1)
      THT(I)=(THT(I-1)**E2*UETR+T1*VO**C2/(UE(I)**E3)*UEINT)**(1./E2)
      TERMA=(0.02*C1)/((UE(I)*THT(I))/VO)**C2*1.1
      T2=THT(I)/UE(I)*DUEDX(I)
      HH=HMEAN(I-1)
      HV=HVMEAN(1)
      DO 6 J=1,6
      TERMB=-HV*C4*10.0**(-C5*HH)*(UE(I)*THT(I)/VO)**(-C6)
      TERMB=TERMB/2.
      TERMC=(HH-1.1)*HV*T2
      DHVDX=(TERMA+TERMB+TERMC)/THT(I-1)
      HVITR=HVMEAN(1)+DHVDX*(SUMS(I)-SUMS(I-1))
```

```
      IF (HVITR-1.85)  3,2,2
    2 HVITR=1.85
    3 IF (HVITR-1.55)  4,4,5
    4 HVITR=1.55
    5 HITR=0.379*HVITR/(HVITR-1.269)
      HVMEAN(2)=HVMEAN(2)+HVITR
      HMEAN(I)=HMEAN(I)+HITR
      HV=HVITR
    6 HH=HITR
      HVMEAN(1)=HVMEAN(2)/6
      HMEAN(I)=HMEAN(I)/6
      DELS(I)=THT(I)*HMEAN(I)
      CFI(I)=C4*10.0**(-C5*HMEAN(I))*(UE(I)*THT(I)/VO)**(-C6)*(UE(I)/VIN
     1F)**2
      TAW(I)=CFI(I)*0.5*RDE*VINF*VINF
      IF (SEND-SUMS(I))  8,8,7
    7 CONTINUE
    8 DO 9 L=N1,NPP
      DELS(L)=DELS(L)/STOTAL
      THT(L)=THT(L)/STOTAL
      DUEDX(L)=DUEDX(L)*STOTAL/VINF
      SUMS(L)=SUMS(L)/STOTAL
    9 UE(L)=UE(L)/VINF
      RETURN
      END


      SUBROUTINE RGVRTX(XC,YC,ZC,X0,Y0,Z0,RD,NTHETA,THETA,PHI,NVPHI,NRS,
     1NSRV,VX,VY,VZ,IM,NPTS)
C
C***  SUBROUTINE RGVRTX CALCULATES THE INDUCED VELOCITIES DUE TO THE
C***  RING VORTICES
C
      DIMENSION XC(40),YC(40),ZC(40),RD(40),NTHETA(40),THETA(40),PHI(40)
     1,NVPHI(40),NRS(40),UC(360),VC(360),WC(360),TX(360),NPTS(40)
C
C***  DEFINE INITIAL PARAMETERS
      PI=3.1415927
      C=1.0/(4.0*PI)
      VXX=0.0
      VYY=0.0
```

```
      VZZ=0.0
C***  SET UP LOOP OVER SYSTEMS OF VORTICES
      DO 8 L=1,NSRV
      TINC=2.0*PI/FLOAT(NTHETA(L)-1)
      NR=NRS(L)
      ISEE=0
      IF (NPTS(L).EQ.0.AND.NRS(L).EQ.1)ISEE=1
      DO 7 M=1,NR
C***  DETERMINE RADIAL STATION AND CIRCULATION
      IF (ISEE.EQ.0) GO TO 1
      GAMMA=CIRC(L)
      R=RD(L)
      DR=R
      GO TO 2
    1 R=F(NR,M,RD(L),DR)
      XR=R/RD(L)
      GAMMA=G(L,XR)
    2 T=THETA(L)
      PHX=PHI(L)
      NTH=NTHETA(L)
C***  TEST FOR FLOW SIMPLICATION BY DOUBLET
      TEST=SQRT((X0-XC(L))**2+(Y0-YC(L))**2+(Z0-ZC(L))**2)
      FACTOR=1.5
      DISX=FACTOR*(2.0*RD(L))
      IF (TEST.LT.DISX) GO TO 3
      FACX=0.00932
C***  CALCULATE DOUBLET STRENGTH AND FLOW
      GAM=FACX*GAMMA*R**2
      CALL DBLET(NVPHI,R,T,PHX,GAM,L,X0,Y0,Z0,XC,YC,ZC,VX,VY,VZ)
      IN=1
      GO TO 6
    3 DO 5 I=1,NTH
C***  DEFINE PARAMETRIC EQNS FOR POINT ON VORTEX RING
      XI=XC(L)+R*SIN(T)*COS(PHX)
      ETA=YC(L)+R*SIN(T)*SIN(PHX)
      ZETA=ZC(L)+R*COS(T)
C***  DEFINE DERIVATIVES OF PARAMETRIC EQNS WRT T
      DXI=R*COS(T)*COS(PHX)
      DETA=R*COS(T)*SIN(PHX)
      DZETA=-R*SIN(T)
C***  INITIALIZE OR DEFINE PARAMETER
      TX(I)=T
```

```
      UC(I)=0.0
      VC(I)=0.0
      WC(I)=0.0
C***  COMPUTE DISTANCE FROM FILAMENT TO ARBITRARY POINT
      RHO=SQRT((XI-X0)**2+(ETA-Y0)**2+(ZETA-Z0)**2)
      IF (RHO.LE.1.0E-10) GO TO 4
C***  COMPUTE VELOCITY CONTRIBUTIONS AROUND THE RING VORTEX UPON AN
C***  ARBITRARY POINT
      DENOM=RHO**3*RD(L)/(C*DR)
      UC(I)=(DETA*(Z0-ZETA)-DZETA*(Y0-ETA))/DENOM*GAMMA
      VC(I)=(DZETA*(X0-XI)-DXI*(Z0-ZETA))/DENOM*GAMMA
      WC(I)=(DXI*(Y0-ETA)-DETA*(X0-XI))/DENOM*GAMMA
    4 IF (I.EQ.NTH) GO TO 5
      T=T+TINC
      IF (NVPHI(L).NE.0)PHX=PHX+TINC
    5 CONTINUE
C***  INTEGRATE TO FIND VX, VY, VZ
      IP=0
      CALL TRAP(NTH,TX,UC,VX)
      CALL TRAP(NTH,TX,VC,VY)
      CALL TRAP(NTH,TX,WC,VZ)
    6 VXX=VXX+VX
      VYY=VYY+VY
      VZZ=VZZ+VZ
    7 CONTINUE
    8 CONTINUE
C***  DEFINE TOTAL INDUCED VELOCITY COMPONENTS
      VX=VXX
      VY=VYY
      VZ=VZZ
C***  MODIFY, IF NECESSARY, FOR PRECISION PROBLEMS
      VMX=ABS(VX)
      IF (ABS(VY).GT.VMX)VMX=ABS(VY)
      IF (ABS(VZ).GT.VMX)VMX=ABS(VZ)
      FVMX=1.0E-4*VMX
      IF (ABS(VX).LT.FVMX)VX=0.0
      IF (ABS(VY).LT.FVMX)VY=0.0
      IF (ABS(VZ).LT.FVMX)VZ=0.0
      RETURN
      END
```

```
      FUNCTION F(N,M,R,RD)
C
C***  FUNCTION F CALCULATES THE RADIAL STATION OF THE VORTEX RING
C
      RD=R/FLOAT(N)
      RX=R+RD
      DO 1 I=1,M
    1 RX=RX-RD
      F=RX
      RETURN
      END


      FUNCTION G(L,R)
C
C***  FUNCTION G COMPUTES THE CIRCULATION AS A FUNCTION OF RADIAL
C***  DISTANCE FROM THE VORTEX'S CENTER
C
      CALL GAMMA(L,R,B)
      G=B
      RETURN
      END


      FUNCTION CIRC(L)
C
C***  FUNCTION CIRC SETS THE VORTEX STRENGTH
C
      COMMON /S2V/CIRCV(40)
C
      CIRC=CIRCV(L)
      RETURN
      END


      SUBROUTINE SPLINE(N,Y,X,IC)
C
C***  THIS SUBROUTINE PERFORMS A SPLINE FIT ON THE TABULATED
```

```
C***   DATA Y VS. X.  THE SPLINE FIT PROVIDES A CURVE FIT OF THE
C***   TABULATED DATA THAT HAS A CONTINUOUS FIRST DERIVATIVE.  THE
C***   FORM OF THE CURVE FIT IS
C***      Y = AA(1,I)*X**3 + AA(2,I)*X**2
C***                        + AA(3,I)*X + AA(4,I)
C***   FOR          X(I) <= X <= X(I+1).
C***      N      - NUMBER OF TABULATED DATA POINTS
C***      Y      - TABULATED FUNCTION VALUES
C***      X      - TABULATED ARGUMENT VALUES
C***      AA     - ARRAY OF COEFFICIENTS OF THE CUBIC POLYNOMIAL
C***               SPLINE FIT.  DIMENSIONS OF AA ARE 4 BY N-1.
C***   REFERENCE FOR THIS METHOD IS
C***      THE THEORY OF SPLINES AND THEIR APPLICATIONS
C***      J.H. AHLBERG, ET AL. ACADEMIC PRESS, NEW YORK . 1967
C
      DIMENSION H(75),Q(75),U(75),X(N),Y(N),CF(40,4,50)
      COMMON /SPLN/AA(4,75)
C
      NM1=N-1
      DO 1 I=1,NM1
    1 H(I)=X(I+1)-X(I)
C***  IF IC=0, SET SECOND DERIVATIVE TO ZERO FOR LEFT HAND END CONDITION
      Q(1)=0.0
      U(1)=0.0
      IF (IC.EQ.0) GO TO 2
C***  MODIFIED LEFT HAND END CONDITION THAT ALLEVIATES THE NEED
C***  TO SPECIFY THE X-DERIVATIVE OF Y AT POINT 1
      Q(1)=-31.0/32.0
      H1=H(1)
      H2=H(2)
      H3=H(3)
      U(1)=Y(1)*(32.0*H1+42.0*H2+21.0*H3)/(H1+H2)/(H1+H2+H3)-Y(2)*(11.0*
     1H1+42.0*H2+21.0*H3)/(H2+H3)/H2+Y(3)*H1*(11.0*H1+21.0*(H2+H3))/(H1+
     1H2)/H2/H3-Y(4)*H1*(11.0*H1+21.0*H2)/(H2+H3)/(H1+H2+H3)/H3
      U(1)=3.0*U(1)/H1/16.0
C***  GENERATE INTERNAL U(I) BY ALGORITHMN GIVEN BY AHLBERG
    2 HM=H(1)
      YY=Y(2)
      YM=Y(1)
      DO 3 I=2,NM1
      HP=H(I)
      YP=Y(I+1)
```

```
      D=3.0*((YP-YY)/HH-(YY-YM)/HM)/(HH+HM)
      C=0.5*HH/(HH+HM)
      A=0.5-C
      P=A*Q(I-1)+1.0
      Q(I)=-C/P
      U(I)=(D-A*U(I-1))/P
      HM=HH
      YM=YY
    3 YY=YP
C***  MODIFIED RIGHT HAND END CONDITION THAT ALLEVIATES THE NEED
C***  TO SPECIFY THE X-DERIVATIVE OF Y AT POINT N
      A=31.0/32.0
      P=A*Q(N-1)+1.0
      H1=H(NM1)
      H2=H(NM1-1)
      H3=H(NM1-2)
      D=Y(N)*(32.0*H1+42.0*H2+21.0*H3)/(H1+H2)/(H1+H2+H3)-Y(NM1)*(11.0*H
     11+42.0*H2+21.0*H3)/(H2+H3)/H2+Y(NM1-1)*H1*(11.0*H1+21.0*(H2+H3))/(
     1H1+H2)/H2/H3-Y(NM1-2)*H1*(11.0*H1+21.0*H2)/(H2+H3)/(H1+H2+H3)/H3
      D=3.0*D/H1/16.0
      U(N)=(D-A*U(N-1))/P
C***  SOLVE FOR THE SPLINE COEFFICIENTS CORRESPONDING TO AHLBERG'S
C***  M(0) TO M(N) AND STORE THEM IN THE U(I).
      DO 4 J=1,NM1
      I=N-J
    4 U(I)=Q(I)*U(I+1)+U(I)
C***  FORM THE AA(J,I) COEFFICIENTS FOR THE CONVENTIONAL FORM OF
C***  A CUBIC POLYNOMIAL FROM THE U(I)
      UU=U(1)
      XX=X(1)
      YY=Y(1)
      DO 5 I=1,NM1
      UP=U(I+1)
      XP=X(I+1)
      YP=Y(I+1)
      HH=H(I)
      AA(1,I)=(UP-UU)/HH/6.0
      AA(2,I)=0.5*(XP*UU-XX*UP)/HH
      AA(3,I)=0.5*(UP*XX*XX-UU*XP*XP)/HH+(UU-UP)*HH/6.0+(YP-YY)/HH
      AA(4,I)=(UU*XP*XP*XP-UP*XX*XX*XX)/HH/6.0+(UP*XX-UU*XP)*HH/6.0+(YY*
     1XP-YP*XX)/HH
      XX=XP
```

```
      UU=UP
    5 YY=YP
      IF (IC.EQ.0) GO TO 7
      DO 6 I=1,NM1
      DO 6 J=1,4
    6 CF(IC,J,I)=AA(J,I)
    7 RETURN
C
      ENTRY GAMMA(IC,T,Z)
      IF (T.GT.X(1)) GO TO 8
      I=1
      GO TO 10
    8 DO 9 I=1,NM1
      IF (X(I).LE.T.AND.X(I+1).GT.T) GO TO 10
    9 CONTINUE
      I=NM1
   10 Z=((CF(IC,1,I)*T+CF(IC,2,I))*T+CF(IC,3,I))*T+CF(IC,4,I)
      RETURN
      END


      SUBROUTINE TRAP(ND,X,DY,Y)
C
C***  SUBROUTINE TRAP PERFORMS TRAPEZOIDAL INTEGRATION
C
C
      DIMENSION X(ND),DY(ND)
C
C***  INITIALIZE PARAMETER
      S2=0.0
      IF (ND-1)  4,3,1
C***  INTEGRATE OVER INTERVAL AND SUM
    1 DO 2 I=2,ND
      S1=S2
      S2=S2+0.5*(X(I)-X(I-1))*(DY(I)+DY(I-1))
    2 CONTINUE
    3 Y=S2
    4 RETURN
      END
```

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```
      SUBROUTINE DBLET(N,R,T,PHX,GAM,L,X0,Y0,Z0,XC,YC,ZC,VX,VY,VZ)
C
C***  SUBROUTINE DBLET CALCULATES DOUBLET FLOW
C
      DIMENSION N(40),XC(40),YC(40),ZC(40)
C
      PI=3.1415927
C***  DETERMINE DOUBLET AXIS VECTOR
      X1=R*SIN(T)*COS(PHX)
      Y1=R*SIN(T)*SIN(PHX)
      Z1=R*COS(T)
      PI2=0.5*PI
      X2=R*SIN(T+PI2)*COS(PHX+N(L)*PI2)
      Y2=R*SIN(T+PI2)*SIN(PHX+N(L)*PI2)
      Z2=R*COS(T+PI2)
      X3=Y1*Z2-Z1*Y2
      Y3=Z1*X2-X1*Z2
      Z3=X1*Y2-Y1*X2
      RD=SQRT(X3**2+Y3**2+Z3**2)
      X3=X3/RD
      Y3=Y3/RD
      Z3=Z3/RD
C***  DETERMINE DOUBLET STRENGTH VECTOR COMPONENTS
      XMU=GAM*X3
      YMU=GAM*Y3
      ZMU=GAM*Z3
      PI4=-0.5*PI2
C***  DETERMINE DOUBLET-TO-ARBITRARY POINT VECTOR
      X1=X0-XC(L)
      Y1=Y0-YC(L)
      Z1=Z0-ZC(L)
C***  DETERMINE VELOCITY COMPONENTS
      RD=X1**2+Y1**2+Z1**2
      F=PI4/RD**1.5
      VX=F*XMU*(1.0-3.0*X1**2/RD)
      VY=F*YMU*(1.0-3.0*Y1**2/RD)
      VZ=F*ZMU*(1.0-3.0*Z1**2/RD)
      RETURN
      END
```

```
      SUBROUTINE SPACE(NSRV,SVV,XCV,NMIN,NMAX,X,MMAX,XCRP,AEXP,XRM,ISPAC
     1E,RXMR,XMR)
C
C***  SUBROUTINE SPACE CALCULATES VORTEX LOCATION VIA EXPONENTIAL
C***  FUNCTION
C
      DIMENSION SVV(31,2),XCV(40),X(650),XCRP(2),AEXP(2)
C
      MAX=(NMAX-1)*(MMAX-1)
      NMAXM1=NMAX-1
      JV=1
C***  SET MAXIMUM RADIUS
      RMX=RXMR
    1 JV=JV+1
C***  GUESS A LOCATICN
      J=1
      IF (XCV(JV-1).LT.XMR)J=2
      XCV(JV)=XCV(JV-1)-XCRP(J)
      LPT=1
C***  SCAN N-STATIONS
      DO 2 JN=NMIN,NMAXM1
      LC1=JN
      LC2=JN+1
      IF (XCV(JV).LE.X(LPT).AND.XCV(JV).GE.X(LPT+MMAX)) GO TO 3
    2 LPT=LPT+MMAX
      IF (ISPACE.EQ.2) GO TO 4
      JV=JV-1
      GC TO 5
C***  COMPUTE EXPONENTIAL LOCATION
    3 RXTL=(X(LPT)-XCV(JV))/(X(LPT)-X(LPT+MMAX))
      R=SVV(LC1,2)+RXTL*(SVV(LC2,2)-SVV(LC1,2))
      XCV(JV)=XCV(JV-1)-XCRP(J)*EXP(-AEXP(J)*(R-RMX)/RMX)
      IF (XCV(JV).LE.X(MAX).AND.ISPACE.EQ.1.OR.JV.EQ.40) GO TO 5
      GO TO 1
    4 R=0.0
      XCV(JV)=XCV(JV-1)-XCRP(J)*EXP(-AEXP(J)*(R-RMX)/RMX)
      IF (XCV(JV).GT.XRM.AND.JV.LT.40) GO TO 1
    5 NSRV=JV
      RETURN
      END
```

SAMPLE INPUT - FLOWBODY

```
  13
BEST CESSNA 182 WITH M=21 AND N=29 YIELDING 550 PANELS -- FUSELAGE ONLY
             160.00E0            0.00016E0            0.002378E0          155.0E0
          .18000E+05          .252525E-06            .110000E+06          .240E0
             520.0E0             0.50E0      2        0      0      0
1.0              0     0
560
    1      2  3.5       4.0       -0.3       -0.05      -18.0
12.8        0.00      -.4271      2.5        0.0        90.0        360     0     4    21
0.16
0.0         0.0                             CIRCULATION DISTRIBUTION
0.05        0.5
0.1         1.0
0.15        1.5
0.2         2.0
0.25        2.35
0.3         2.64
0.35        2.86
0.4         3.0
0.45        3.05
0.5         3.0
0.55        2.6
0.6         2.25
0.65        1.95
0.7         1.55
0.75        1.2
0.8         1.0
0.85        0.65
0.9         0.45
0.95        0.25
1.0         0.001
  12.2085000   0.0000000   -0.4271002   1   1   1
  12.2085000   0.0000000   -0.4271002   1   2   1
  12.2085000   0.0000000   -0.4271002   1   3   1
  12.2085000   0.0000000   -0.4271002   1   4   1
  12.2085000   0.0000000   -0.4271002   1   5   1
  12.2085000   0.0000000   -0.4271002   1   6   1
```

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12.2085000	0.0000000	-0.4271002	1	7	1
12.2085000	0.0000000	-0.4271002	1	8	1
12.2085000	0.0000000	-0.4271002	1	9	1
12.2085000	0.0000000	-0.4271002	1	10	1
12.2085000	0.0000000	-0.4271002	1	11	1
12.2085000	0.0000000	-0.4271002	1	12	1
12.2085000	0.0000000	-0.4271002	1	13	1
12.2085000	0.0000000	-0.4271002	1	14	1
12.2085000	0.0000000	-0.4271002	1	15	1
12.2085000	0.0000000	-0.4271002	1	16	1
12.2085000	0.0000000	-0.4271002	1	17	1
12.2085000	0.0000000	-0.4271002	1	18	1
12.2085000	0.0000000	-0.4271002	1	19	1
12.2085000	0.0000000	-0.4271002	1	20	1
12.2085000	0.0000000	-0.4271002	1	21	1
11.5418000	0.0000000	-1.6353990	2	1	1
11.5418000	0.1833000	-1.5978990	2	2	1
11.5418000	0.3583000	-1.5270990	2	3	1
11.5418000	0.5146000	-1.4430990	2	4	1
11.5418000	0.6708000	-1.3499990	2	5	1
11.5418000	0.8187000	-1.2520990	2	6	1
11.5418000	0.9688000	-1.1270990	2	7	1
11.5418000	1.1083000	-0.9958000	2	8	1
11.5418000	1.2645990	-0.8436995	2	9	1
11.5418000	1.4083000	-0.6520995	2	10	1
11.5418000	1.5166990	-0.4271002	2	11	1
11.5418000	1.5707990	-0.1854000	2	12	1
11.5418000	1.5625000	0.0728998	2	13	1
11.5418000	1.4917000	0.3228999	2	14	1
11.5418000	1.3291990	0.5229006	2	15	1
11.5418000	1.1062000	0.6729002	2	16	1
11.5418000	0.3833000	0.7396602	2	17	1
11.5418000	0.6667000	0.7708998	2	18	1
11.5418000	0.4437000	0.7771006	2	19	1
11.5418000	0.2167000	0.7813005	2	20	1
11.5418000	0.0000000	0.7813005	2	21	1
10.3755000	0.0000000	-1.9271000	3	1	1
10.3755000	0.2208000	-1.9229000	3	2	1
10.3755000	0.4458000	-1.8853990	3	3	1
10.3755000	0.6625000	-1.8186990	3	4	1
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19	20	5	6	1
20	21	5	6	1
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SAMPLE OUTPUT - FLOWBODY

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NEW FLOWBODY PROGRAM: POTENTIAL FLOW + BOUNDARY LAYER + NONUNIFORM SLIPSTREAM FLOW + INTERIOR MASS FLOW

TEST CESSNA 182 WITH [illegible] YIELDING [illegible] PANELS -- FUSELAGE ONLY

NO. OF QUADS. = [illegible]
NO. OF SECTIONS   1
MAX. NO. OF ITERATIONS [illegible] 100

VINF = [illegible]   VO = [illegible]   [illegible] = [illegible]   [illegible] = [illegible]   [illegible] = [illegible]

[illegible]

COORDINATE CONVERSION FACTOR,    1.0000000

1 PLANE OF SYMMETRY
CONVERGENCE CRITERIA , 0.00010

1 VORTEX SYSTEM(S) SPECIFIED
                    [illegible] 2
                    [illegible]  3.00000   [illegible]  -0.30000
                    [illegible]  4.00000   [illegible]  -0.00000    [illegible] -10.00000

FOR VORTEX SYSTEM 1
   [illegible] 12.00000  YCV   0.0     ZCV  -0.[illegible]
   [illegible]

SECTION    1

   [illegible] DIRECTION COSINES -0.9990 ,  0.0   ,  0.0[illegible] )

REFERENCE INDUCED VELOCITY = [illegible]

[illegible]

RING VORTEX INFORMATION
NUMBER      CENTER COORDINATES      RADIUS   CIRCULATION
              X       Y      Z
[illegible]

[illegible]

QUESTIONABLE POINT -POOR FIT   [illegible]
WARNING LONG THIN QUAD.
[illegible]

QUESTIONABLE POINT -POOR FIT   [illegible]
[illegible]

QUESTIONABLE POINT -POOR FIT   [illegible]
WARNING LONG THIN QUAD.
[illegible]

QUESTIONABLE POINT -POOR FIT   [illegible]
[illegible]

QUESTIONABLE POINT -POOR FIT   [illegible]
WARNING LONG THIN QUAD.
[illegible]

   .                 .                 .
   .                 .                 .
   .                 .                 .

QUESTIONABLE POINT -POOR FIT   [illegible]
WARNING LONG THIN QUAD.
[illegible]

WARNING LONG THIN QUAD.
[illegible]

QUESTIONABLE POINT -POOR FIT   [illegible]
WARNING LONG THIN QUAD.
[illegible]
```

DESIGNATION OF NORMAL VELOCITY ON QUADRILATERALS

1	2	1	2	PANEL 1 HAS BEEN DESIGNATED TO HAVE A NONZERO INWARD NORMAL COMPONENT OF VELOCITY.
3	4	1	2	PANEL 5 HAS BEEN DESIGNATED TO HAVE A NONZERO INWARD NORMAL COMPONENT OF VELOCITY.
4	5	1	2	PANEL 7 HAS BEEN DESIGNATED TO HAVE A NONZERO INWARD NORMAL COMPONENT OF VELOCITY.
5	6	1	2	PANEL 9 HAS BEEN DESIGNATED TO HAVE A NONZERO INWARD NORMAL COMPONENT OF VELOCITY.
6	7	1	2	PANEL 11 HAS BEEN DESIGNATED TO HAVE A NONZERO INWARD NORMAL COMPONENT OF VELOCITY.
7	8	1	2	PANEL 13 HAS BEEN DESIGNATED TO HAVE A NONZERO INWARD NORMAL COMPONENT OF VELOCITY.
8	9	1	2	PANEL 15 HAS BEEN DESIGNATED TO HAVE A NONZERO INWARD NORMAL COMPONENT OF VELOCITY.
18	19	5	6	PANEL 115 HAS BEEN DESIGNATED TO HAVE A NONZERO OUTWARD NORMAL COMPONENT OF VELOCITY.
19	20	5	6	PANEL 117 HAS BEEN DESIGNATED TO HAVE A NONZERO OUTWARD NORMAL COMPONENT OF VELOCITY.
20	21	5	6	PANEL 119 HAS BEEN DESIGNATED TO HAVE A NONZERO OUTWARD NORMAL COMPONENT OF VELOCITY.

PROBABLE ERROR IN INPUT - SOLID ANGLE = 12.[illegible]

INDUCED VELOCITY BY RING VORTICES AT ORIGINAL-BODY PANEL CENTROIDS:

PANEL NUMBER	PANEL CENTROID LOCATION X	Y	Z	VELOCITY COMPONENTS X	Y	Z
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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•	•	•				•
•	•	•				•
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SOURCE DENSITY SOLUTION

BEST CESSNA 182 WITH [illegible] AND [illegible] YIELDING 960 PANELS -- FUSELAGE ONLY

X VELOCITY=-1.0 Y VELOCITY= 0.0 Z VELOCITY= 0.0

ITERATIVE MATRIX SOLUTION INFORMATION

ITERATION	SUM OF CHANGES	A	B1	B2
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3	[illegible]			
4	[illegible]			
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15	[illegible]			
		A EXTRAPOLATION		
		[illegible]	[illegible]	[illegible]
16	[illegible]			

ORIGINAL PAGE IS
OF POOR QUALITY

COMPUTATION OF VELOCITIES AND PRESSURE COEFFICIENTS AT THE PANEL CENTROIDS

[illegible] CESSNA 182 WITH [illegible] AND [illegible] [illegible] PANELS — FUSELAGE ONLY PAGE = 1

X FLOW

PT.	XC	YC	ZC	VX	VY	VZ	ABS.V	CP	SOURCE	V NORMAL	AREA
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3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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458	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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460	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PRESSURE LIFT AND DRAG COEFFICIENTS

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PRESSURE CD = [illegible]
REFERENCE AREA = [illegible]
REYNOLDS NUMBER = [illegible]

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457	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	457
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460	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	460

*** CALCULATION OF INTERIOR PRESSURE COEFFICIENTS AND NORMAL VELOCITIES ***

AVERAGE CP ON INLET PANELS = [illegible] E-01 INLET AREA = [illegible] E-01
AVERAGE CP ON EXHAUST PANELS= [illegible] E-01 EXHAUST AREA= [illegible] E-01

CPI = [illegible] E-01
CPISE= [illegible] E-01

ADJUSTMENT DUE TO HEATING OF FLOW: TEMPERATURE RATIO = [illegible] E-01
EFFECTIVE ORIFICE AREA= [illegible] E-01

CPI = [illegible] E-01
CPISE= [illegible] E-01

NORMAL VELOCITY AT PANEL 1 = [illegible]
NORMAL VELOCITY AT PANEL 5 = [illegible]
NORMAL VELOCITY AT PANEL 7 = [illegible]
NORMAL VELOCITY AT PANEL 9 = [illegible]
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NORMAL VELOCITY AT PANEL 117 = [illegible]
NORMAL VELOCITY AT PANEL 119 = [illegible]

ORIGINAL PAGE IS OF POOR QUALITY

SOURCE DENSITY SOLUTION

REST CESSNA 182 WITH NOZ1 AND NOZ2 YIELDING [illegible] PANELS -- FUSELAGE ONLY

X VELOCITY=-1.0 Y VELOCITY= 0.0 Z VELOCITY= 0.0

ITERATIVE MATRIX SOLUTION INFORMATION

ITERATION	SUM OF CHANGES	A	B1	B2
1	[illegible]			
2	[illegible]			
3	[illegible]			
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16	[illegible]			

COMPUTATION OF VELOCITIES AND PRESSURE COEFFICIENTS AT THE PANEL CENTROIDS

REST CESSNA 182 WITH NOZ1 AND NOZ2 YIELDING [illegible] PANELS -- FUSELAGE ONLY PAGE 1

X FLOW

NO.	XC	YC	ZC	VX	VY	VZ	ABS.V	CP	SOURCE	V NORMAL	AREA
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3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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PRESSURE LIFT AND DRAG COEFFICIENTS

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    PRESSURE CD =     0.01796
 REFERENCE AREA =   174.00000
REYNOLDS NUMBER =  0.2379E+08
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PT	XNH	YNH	ZNH	CP	VXDXNH	VYDYNH	VZDZNH	AGPN	ZDCPDAGPNDZNH	ZDCPDAGPNDXNH	PT
1	0.77828	0.48277	-0.40022	0.00094	-0.06623	0.09140	0.09479	0.111	-0.0019792	0.0098120	1
2	0.29072	0.69001	-0.91912	-0.16790	-0.30063	0.00018	0.30036	0.149	0.0060250	-0.0190609	2
3	0.79990	0.41308	-0.22070	0.07806	-0.32112	0.27722	0.04306	0.109	-0.0201030	0.0082909	3
4	0.61108	0.10699	-0.09174	-0.12226	-0.41221	0.00991	0.00321	0.194	0.0330716	-0.0144074	4
5	0.80066	0.34590	-0.37099	0.23200	-0.77741	0.03208	0.02119	0.101	-0.0130236	0.0021096	5
6	0.64098	0.29949	-0.23473	-0.00014	-0.62014	0.03797	0.30067	0.199	0.0195230	-0.0090771	6
7	0.80229	0.42907	-0.19003	0.00087	-0.70848	0.10129	0.01200	0.106	-0.0159011	0.0024737	7
8	0.60776	0.40716	-0.77772	-0.01200	-0.42030	0.09173	-0.33686	0.166	0.0030026	-0.0010362	8
9	0.08110	-0.00096	-0.47276	0.37980	-0.07027	-0.00012	0.00467	0.161	-0.0363000	0.0076614	9
10	0.60096	0.92109	-0.60960	0.01234	-0.42343	0.16940	0.25398	0.157	-0.0027130	0.0010952	10
11	0.89080	0.13004	-0.42403	0.23013	-0.70076	0.02377	-0.00022	0.113	-0.0229905	0.0003309	11
12	0.66761	0.02924	-0.42196	-0.00008	-0.41187	0.24935	0.14042	0.160	0.0001204	-0.0000905	12
13	0.69119	-0.07861	-0.73120	0.08630	-0.41170	-0.30923	0.17300	0.112	-0.0914742	0.0002317	13
14	0.63000	0.70973	-0.18284	-0.00197	-0.39336	0.29992	0.09373	0.160	0.0079467	-0.0087784	14
15	0.67776	0.12740	-0.72785	0.43698	-0.40730	0.02068	-0.00094	0.129	-0.0019107	0.0794941	15
16	0.30928	0.74292	-0.21619	-0.00224	-0.30763	0.22798	0.03996	0.107	0.0142163	-0.0107219	16
17	0.72000	0.05112	-0.94874	0.31387	-0.24089	0.00070	0.22789	0.191	-0.0090027	0.0304322	17
18	0.22029	0.03744	-0.40062	-0.14587	-0.21947	0.33242	-0.01302	0.173	-0.0201401	-0.0161261	18
19	0.27998	0.38401	-0.29452	0.23061	-0.26488	0.07978	0.18668	0.171	-0.0470390	0.0292450	19
20	0.24667	0.02810	-0.28382	-0.10290	-0.29040	0.27985	-0.02844	0.174	0.0160911	-0.0192484	20
21	0.20174	0.40487	-0.04667	0.05418	-0.10539	0.09170	0.09358	0.183	-0.0297244	0.0058952	21
22	0.15389	0.48290	-0.10119	-0.19919	-0.14564	0.17796	-0.01259	0.171	0.0089923	-0.0104429	22
23	0.17327	0.00562	-0.77766	0.02757	-0.16612	0.12097	0.04953	0.206	-0.0110307	0.0028542	23
24	0.09996	0.00468	0.03740	-0.10374	-0.10389	0.10882	0.00347	0.178	-0.0024401	-0.2062795	24
25	0.32016	0.01098	0.25130	0.00085	-0.29443	0.38171	0.21318	0.213	0.0290313	0.0111226	25
⋮					⋮					⋮	
552	-0.14087	0.00000	0.67763	-0.29323	0.10701	-0.10587	-0.06100	0.131	-0.0309400	0.0113708	552
553	-0.10183	0.82108	0.77712	-0.41080	0.11057	-0.02087	-0.09080	0.187	-0.1193081	0.0190826	553
554	-0.16311	0.75240	0.60729	-0.29730	0.10129	-0.00329	-0.09783	0.137	-0.0260723	0.0116720	554
555	-0.08340	0.40529	0.49080	-0.41490	0.10009	-0.00304	-0.10272	0.197	-0.1059427	0.0146791	555
556	-0.13774	0.59127	0.79402	-0.30042	0.19921	-0.03914	-0.11000	0.147	-0.0791020	0.0171092	556
557	-0.07777	0.28196	0.49070	-0.41772	0.08629	0.00195	-0.08797	0.242	-0.1930087	0.0147708	557
558	-0.13102	0.40778	0.90374	-0.38318	0.14025	-0.01993	-0.13341	0.184	-0.1009907	0.0167039	558
559	-0.06080	0.07947	0.09095	-0.41021	0.07238	0.00032	-0.07230	0.220	-0.1090037	0.0114970	559
560	-0.12920	0.18300	0.47470	-0.38473	0.14522	-0.40326	-0.14203	0.178	-0.1090458	0.0137745	560

CALCULATION OF ON-BODY STREAMLINES

RPST CESSNA 182 WITH NNF1 AND NNF2 YIELDING 560 PANELS -- FUSELAGE ONLY
FOR V INFINITY=A =1.0,0.0,0.0, COMPUTE 560 STREAMLINES STARTING AT EACH PANEL CENTROID POINT

LINE PASSING THROUGH QUADRILATERAL 2

I	X	Y	Z	CP	SL	VABS
1	11.24400	0.00210	-1.63287	0.07221	0.0	0.97394
2	11.20092	0.18206	-1.77742	-0.16790	0.37033	1.08040
3	10.87201	0.09307	-1.91910	-0.37840	0.73997	1.17281
4	10.28058	0.09906	-2.11070	-0.87390	1.42024	1.22053
5	9.67033	0.09875	-2.23786	-0.08482	2.10774	1.30568

TRANSITION AT X = 0.00014 FOR STEP NUMBER 7

S.	V	EUDS	HMEAN	DELTAS	THETAS	TAU	CPI
0.0	179.78800	49.71200	2.55600	0.0	0.0	5000.00000	1000.00000
0.37039	172.01041	49.26210	2.42074	0.30000	0.00001	0.05100	0.00170
0.75997	187.60090	22.40013	2.42291	0.00107	0.00002	0.04819	-0.00197
1.69826	200.77418	13.72420	1.49000	0.00008	0.00002	0.03537	0.00116
2.16823	219.47993	40.81703	1.60000	0.00287	0.10037	0.17294	0.20070

LINE PASSING THROUGH QUADRILATERAL 4

I	X	Y	Z	CP	SL	VABS
1	11.24160	0.21309	-1.52910	0.12210	0.0	0.93003
2	11.10409	0.20290	-1.73900	-0.12230	0.38642	1.05942
3	10.07030	0.26709	-1.40773	-0.30097	0.79900	1.17770
4	10.21036	0.26000	-2.12070	-0.37008	1.49303	1.29974
5	9.90092	-0.24702	-2.14700	-0.07103	1.67432	1.29240

TRANSITION AT X = 0.00118 FOR STEP NUMBER 9

S	V	EUDS	HMEAN	DELTAS	THETAS	TAU	CPI
0.0	149.40000	40.49713	2.99680	0.0	0.0	5000.00000	1000.00000
0.38642	199.90000	94.61929	2.41073	0.30009	0.00001	0.09296	0.00192
0.79900	199.63170	39.43221	2.41277	0.30103	0.10332	0.04491	0.00190
1.49303	200.41791	14.22234	1.49000	0.30004	0.30102	0.03777	0.10176
1.67432	231.87909	-34.40470	1.64000	0.30142	0.30284	0.14980	0.33061

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LINE PASSING THROUGH QUADRILATERAL [illegible]

I	X	Y	Z	CP	S	[illegible]
1	[illegible]	[illegible]	[illegible]	[illegible]	0.0	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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TRANSITION AT X = [illegible] FOR STEP NUMBER [illegible]

S	V	DUDS	HMEAN	DELTAS	THETAS	TAU	CFI
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SUMMARY OF BOUNDARY LAYER INFORMATION FOR QUADRILATERALS

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25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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FRICTION DRAG COEFFICIENT

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ORIGINAL PAGE IS
OF POOR QUALITY

BEGIN WAKE BODY GEOMETRY

AVERAGE SLOPE = [illegible]   AVERAGE PANEL AREA = [illegible]   AVERAGE X-CENTROID = [illegible]   END OF BODY AT X = [illegible]

SECTION 1000

N	X1	X2	X3	X4	XC	XN	A	C24
N	Y1	Y2	Y3	Y4	YC	YN	PL	C25
P	Z1	Z2	Z3	Z4	ZC	ZN	C21	C26

WARNING LONG THIN QUAD.
[illegible]

WARNING LONG THIN QUAD.
[illegible]

WARNING LONG THIN QUAD.
[illegible]

WARNING LONG THIN QUAD.
[illegible]

WARNING LONG THIN QUAD.
[illegible]

N	X1	X2	X3	X4	XC	XN	A	C24
N	Y1	Y2	Y3	Y4	YC	YN	PL	C25
P	Z1	Z2	Z3	Z4	ZC	ZN	C21	C26

WARNING LONG THIN QUAD.
[illegible]

ALLOWABLE ERROR IN INPUT - SOLID ANGLE = [illegible]

INDUCED VELOCITY BY RING VERTICES AT WAKE-BODY PANEL CENTROIDS:

PANEL NUMBER	PANEL CENTROID LOCATION X	Y	Z	VELOCITY COMPONENTS X	Y	Z
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

.
.
.

PANEL NUMBER	X	Y	Z	X	Y	Z
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

SOURCE DENSITY SOLUTION

BEST CESSNA 182 WITH [illegible] AND [illegible] YIELDING [illegible] PANELS — FUSELAGE ONLY

X VELOCITY=-1.0 Y VELOCITY= 0.0 Z VELOCITY= 0.0

ITERATIVE MATRIX SOLUTION INFORMATION

ITERATION	SUM OF CHANGES	A	B1	B2
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2	[illegible]			
3	[illegible]			
4	[illegible]			
5	[illegible]			
		[illegible]	[illegible]	[illegible]
6	[illegible]			
7	[illegible]			
8	[illegible]			
9	[illegible]			
10	[illegible]			
		[illegible]	[illegible]	[illegible]
11	[illegible]			
12	[illegible]			
13	[illegible]			
14	[illegible]			
15	[illegible]			
		A EXTRAPOLATION [illegible]	[illegible]	[illegible]
16	[illegible]			
17	[illegible]			
18	[illegible]			
19	[illegible]			
20	[illegible]			
		A EXTRAPOLATION [illegible]	[illegible]	[illegible]
21	[illegible]			
22	[illegible]			
23	[illegible]			
24	[illegible]			
25	[illegible]			
		A EXTRAPOLATION [illegible]	[illegible]	[illegible]
26	[illegible]			

COMPUTATION OF VELOCITIES AND PRESSURE COEFFICIENTS AT THE PANEL CENTROIDS

BEST CESSNA 182 WITH [illegible] AND [illegible] YIELDING [illegible] PANELS -- FUSELAGE ONLY PAGE = 1

X FLOW

PT.	XC	YC	ZC	VX	VY	VZ	ABS.V	CP	SOURCE	V NORMAL	AREA
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7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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PRESSURE LIFT AND DRAG COEFFICIENTS

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     PRESSURE CD =  [illegible]
  REFERENCE AREA =  [illegible]
 REYNOLDS NUMBER =  [illegible]
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OF POOR QUALITY

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ST									ST
580	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	580
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TOTAL BODY COEFFICIENTS

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    TOTAL BODY CD =     0.02020
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USER'S INSTRUCTIONS - GRIDPLOT PROGRAM

The program is written in FORTRAN IV and is designed to execute in single precision on an IBM 370/165 computer with an average execution time of 1 minute for each data set. An average execution requires approximately 320,000 bytes of core storage. The program accepts multiple data sets.

Given a data set describing the half-body* under consideration, the program may be instructed to perform the following:

(a) Generate a properly-indexed data set with additional body (M,N) stations,

(b) Modify the input data by a simple averaging technique, a linear-interpolation technique, and/or user-specified data-point change information,

(c) Plot various orthographic, perspective, and/or stereoscopic views of the input data and/or the modified data,

(d) Refine the grid network by either an equal-line augmentation scheme or a user-specified line augmentation scheme,

(e) Punch properly-indexed data sets of the input and/or modified data set(s) for input into the NCSU PLOT program of NASA CR-2523 and/or into the FLOWBODY program of this report, and

(f) Convert the data into different units.

*Since the body is considered to be symmetrical about the X-Z plane, only half of the body is needed to describe the entire body.

The program requires the specification of the following input in the indicated order:

CARD 1:

(a) The maximum number N of N-stations present in any input data set to be tried:

N is a right-adjusted positive integer number occupying columns 1-5.

(b) The maximum number M of M-stations present in any input data set to be tried:

M is a right-adjusted positive integer number occupying columns 6-10.

(c) The maximum number NADD of additional N-stations present in any input data set to be tried:

NADD is a right-adjusted positive integer number occupying columns 11-15.

(d) The maximum number MADD of additional M-stations present in any input data set to be tried:

MADD is a right-adjusted positive integer number occupying columns 16-20.

(e) The horizontal (x-direction) length PXL of the plotting picture:

PXL is a single-precision floating-point number occupying columns 21-30 in an F10.0 field. The units of PXL must be appropriate to the installation. At NCSU, PXL must be in inches.

(f) The width (y-direction) PYL of the plotting picture:

PYL is a single-precision floating-point number occupying columns 31-40 in a F10.0 field. The units of PYL must be appropriate to the installation. At NCSU, PYL must be in inches.

Important: Only one "Card 1" is permitted per execution.

CARD 2:

(a) The read unit number IDS:

IDS is a right-adjusted integer number occupying columns 1-5 and specifying that the data is to be read from cards, magnetic tape, disk, etc. The user must supply the suitable job control cards for the tape and/or disk reads. The IDS parameter controls only the reading of CARD 3, CARD 4, and the Body Description cards.

(b) The desired number INPTM of additional interior M-stations:

INPTM is a right-adjusted integer number occupying columns 6-10. INPTM may be negative, zero, or positive. If INPTM is negative, no grid refinement of the M-station is performed. If INPTM is zero, no equal-line augmentation is performed but allows for refinement by the user-specified line-augmentation scheme. If INPTM is positive, the equal-line augmentation scheme may (to be explained later) be used with the number of additional M-stations between each two successive input M-stations equal to INPTM.

(c) The desired number INPTN of additional interior N-stations:

INPTN is a right-adjusted integer number occupying columns 11-15. INPTN may be negative, zero, or positive. If INPTN is negative, no grid refinement of the N-stations is performed. If INPTN is zero, no equal-line augmentation is performed but allows for refinement by the user-specified line-augmentation scheme. If INPTN is positive, the equal-line augmentation scheme may (to be explained later) be used with the number of additional N-stations between each two successive input M-stations equal to INPTN.

(d) The punch option IPUNCH:

IPUNCH is a right-adjusted nonnegative integer number, occupying columns 16-20, that specifies the punching of the data set with the additional body (M,N) stations. If IPUNCH = 0, no cards are punched. If IPUNCH = 1, cards are punched.

(e) The input-data plot option IPLOT1:

IPLOT1 is a right-adjusted nonnegative integer number occupying columns 21-25. If IPLOT1 = 0, no plots are produced. If IPLOT1 = 1, plots are produced.

(f) The modified-data plot option IPLOT2:

IPLOT2 is a right-adjusted nonnegative integer number occupying columns 26-30. If IPLOT2 = 0, no plots are produced. If IPLOT2 = 1, plots are produced.

(g) The input-data punch option LPCH1:

LPCH1 is a right-adjusted nonnegative integer number, occupying columns 31-35, that specifies the punching of the input data in a compatible form for the PLOT program given in NASA CR-2523 [Reference 3]. If LPCH1 = 0, no cards are punched. If LPCH1 = 1, cards are punched.

(h) The modified-data punch option LPCH2:

LPCH2 is a right-adjusted nonnegative integer number, occupying columns 36-40, that specifies the punching of the modified data in a compatible form for the PLOT program given in NASA CR-2523 [Reference 3]. If LPCH2 = 0, no cards are punched. If LPCH2 = 1, cards are punched.

(i) The write option IWRITE:

IWRITE is a right-adjusted nonnegative integer number, occupying columns 41-45, that specifies the amount of desired output. If IWRITE = 0, maximum printout is produced. If IWRITE = 2, minimum printout is produced. If IWRITE = 1, the amount of printout is between the minimum and maximum.

(j) The conversion factor CF:

CF is a single-precision floating-point number, occupying columns 51-60 in an F10.0 field, that may be used to convert the data of CARD 5 through CARD (K + 4) from one set of units to another.

CARD 3:

The title array TITLE:

The 80 characters of the array TITLE are used for identifying output. The reading of TITLE is controlled by the read unit number IDS.

CARD 4:

The number NQE of quadrilaterals of the input half-body data:

NQE is a right-adjusted integer number occupying columns 1-4. The reading of NQE is controlled by the read unit number IDS.

** Body Description Cards **

Each card contains the information to specify one half-body point. Each card contains

Columns	FORTRAN Name	Description
1-12	XI	x-coordinate
13-24	YI	y-coordinate
25-36	ZI	z-coordinate
37-40	NI	N-station index (See Figure 4)
41-44	MI	M-station index (See Figure 4)
45-48	NS	Body number

XI, YI, and ZI are single-precision floating-point numbers in F-fields. NI, MI, and NS are right-adjusted integer numbers. NS should be a constant for a given data set, which must be greater than zero but not equal to 1000. A blank card must be supplied at the end of these cards to signal the end of the body description cards. The reading of the body description cards are controlled by the read unit number IDS.

** Point Modification Cards **

1. Additional Input Point Change Information:

A single card contains the information to change one input point to the given values.

Columns	FORTRAN Name	Description
1-20	XP	New X-value at (N,M)
21-40	YP	New Y-value at (N,M)
41-60	ZP	New Z-value at (N,M)
61-65	N	Reference N-station (≤ max NI)
66-70	M	Reference M-station (≤ max MI)

XP, YP, and ZP are single-precision floating-point numbers in F-fields. N and M are right-adjusted integer numbers that denote the N and M station for the application of XP, YP, and ZP. A blank card must be supplied to serve either of two purposes. If no additional point change information is to be supplied, the blank card terminates the attempt to read more cards. If point change information is supplied, the blank card signals the end of this information.

2. Simple Averaging of Points or Linear Interpolation:

A single card contains the information to change one input point in a prescribed manner. The user may specify a two-point average, four-point average, two-point linear interpolation, or four-point linear interpolation.

Columns	FORTRAN Name	Description
1-5	M1	1st reference M-station [$0 \le M1 \le \max(MI)$]
6-10	M2	2nd reference M-station [$1 \le M2 \le \max(MI)+1$]
11-15	N1	1st reference N-station [$0 \le N1 \le \max(NI)$]
16-20	N2	2nd reference N-station [$1 \le N2 \le \max(NI)+1$]
21-25	IMETH	Method: IMETH = 0 → simple average IMETH = 1 → linear interpolation

It should be noted that points are changed by the order in which the data cards are encountered. It must be true that

$$|M2 - M1| = 0 \text{ or } 2$$

and

$$|N2 - N1| = 0 \text{ or } 2 .$$

Consider a representative (plane) portion of the grid of the original input data below. Suppose it is desired the modify the original input point (e). Three schemes of each method are available (See Figure 5):

1. Two-point scheme of the points (a) and (c): M2 = (m+1), M1 = (m-1), N2 = (n+2), N1 = (n)
2. Two-point scheme of the points (b) and (d): M2 = (m+2), M1 = (m), N2 = (n+1), N1 = (n+1)
3. Four-point scheme of the points (a), (b), (c), and (d): M2 = (m+2), M1 = (m), N2 = (n+2), N1 = (n).

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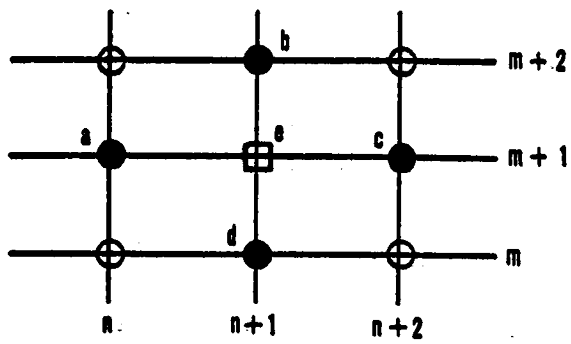


Figure 5: Illustration of points used in averaging and interpolating schemes

M2, M1, N2, and N1 are right-adjusted integer numbers. A blank card must be supplied to serve either of two purposes. If no averaging (or linear interpolation) information is to be supplied, the blank card terminates the attempt to read more cards. If averaging (or linear interpolation) information is supplied, the blank card signals the end of this information.

** Console Message LABEL Card **

The 80 characters of the array LABEL is used to provide information to the operator on the console typewriter about specific forms for plotting. Important: Only one LABEL card is permitted per execution.

** Plot Cards **

A single card contains all the necessary information for one plot. The available options and the necessary inptu for each are described in the succeeding sections. Reading of these cards are controlled by nonzero values of IPLOT1 and/or IPLOT2. Although the various plot cards, applicable to both the input and modified data, are presently discussed, only the plot card(s) pertaining to the plotting of the input data (i.e., if IPLOT1 $\neq$ 0) must be included at this time.

<u>Orthographic projections</u>. - For orthographic projections, the card should be set up as follows (See Figure 6):

Columns	FORTRAN Name	Description
1	HORZ	"X", "Y", or "Z" for horizontal axis
3	VERT	"X", "Y", or "Z" for vertical axis
5 to 7	TEST1	Word "OUT" for deletion of hidden lines; otherwise, leave blank
8 to 12	PHI	Roll angle, degrees (See Figure 7)
13 to 17	THETA	Pitch angle, degrees (See Figure 7)
18 to 22	PSI	Yaw angle, degrees (See Figure 7)
48 to 52	PLOTSZ	PLOTSZ determines the size of plot (scale factor is computed using PLOTSZ and maximum dimension of configuration)
53 to 55	TYPE	Word "ORT"
72	KODE	If KODE = 0, continue reading plot cards If KODE = 1, after processing this plot, continue with the remaining non-plotting portion of the program

An attempt is made to center the given configuration within the specified field. If the desired plot size is <u>greater</u> than 28 inches, centering is attempted within 28 inches so care must be taken in choosing the view. Minimum values are adjusted so that body axis lines with no rotation angles coincide with grid lines on the plotter paper. Therefore, the plotter pen should always be positioned exactly 1 inch from the side of the plotting space and on the intersection of heavy grid lines at the start of plotting.

<u>Plan, front, and side views (stacked)</u>. - For plan, front, and side views, the card should be set up as follows (See Figure 8):

Columns	FORTRAN Name	Description
8 to 12	PHI	y-origin on paper of plan view, inches
13 to 17	THETA	y-origin on paper of side view, inches
18 to 22	PSI	y-origin on paper of front view, inches

Columns	FORTRAN Name	Description
48 to 52	PLOTSZ	PLOTSZ determines size of plot (a scale factor is computed using PLOTSZ and maximum dimension of configuration)
53 to 55	TYPE	Word "VU3"
72	KODE	If KODE = 0, continue reading plot cards If KODE = 1, after processing this plot, continue with the remaining non-plotting portion of the program

Perspective views. - For perspective views, the card should be set up as follows (See Figure 9):

Columns	FORTRAN Name	Description
8 to 12	PHI	x of view point (location of viewer) in data coordinate system
13 to 17	THETA	y of view point in data coordinate system
18 to 22	PSI	z of view point in data coordinate system
23 to 27	XF	x of focal point (determines direction and focus) in data coordinate system
28 to 32	YF	y of focal point in data coordinate system
33 to 37	ZF	z of focal point in data coordinate system
38 to 42	DIST	Distance from eye to viewing plane, inches
43 to 47	FMAG	Viewing-plane magnification factor; it controls size of projected image
48 to 52	PLOTSZ	Diameter of viewing plane, inches; DIST and PLOTSZ together determine a cone which is field of vision; PLOTSZ value is also relative to type of viewer which is to be used.
53 to 55	TYPE	Word "PER"
72	KODE	If KODE = 0, continue reading plot cards If KODE = 1, after processing this plot, continue with the remaining non-plotting portion of the program

Stereo frames suitable for viewing in a stereoscope. - For stereo frames suitable for viewing in a stereoscope, the input is identical to that for the perspective views except that the word "STE" is used in columns 53 to 55. (See Figure 10).

IMPORTANT: If IPLOT1 ≠ 0, at least one plot card must be supplied. Similarly, if IPLOT2 ≠ 0, at least one plot card must be supplied.

** User-Specified Line-Augmentation Cards **

A single card contains the information to specify additional M-lines or N-lines between the "referenced" input M- or N-line.

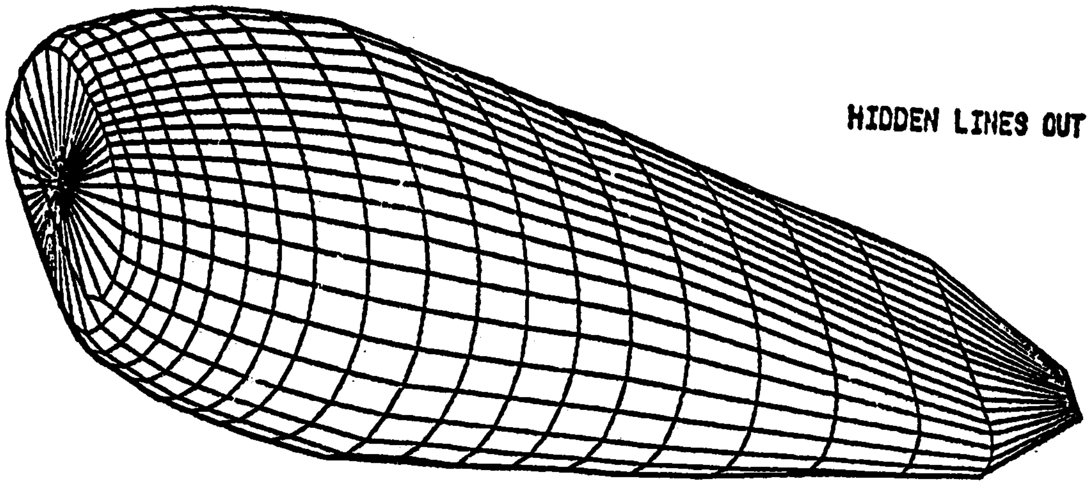
Columns	FORTRAN Name	Description
1-4	NAME	Line of reference (M or N or END)
6-10	K1	Reference line number
11-15	NL	Number of additional lines

NAME is a character array, occupying columns 1-4 in an A4 field. If NAME = M, the number NL of additional lines is supplied between M-line (K1) and M-line (K1+1). If NAME = N, the number NL of additional lines is supplied between N-line (K1) and N-line (K1+1). Cards of this type is continued until NAME = END is encountered. Since NAME is a character array, the specification of M, N, or END must be left-adjusted.

** Plot Cards for Modified Data **

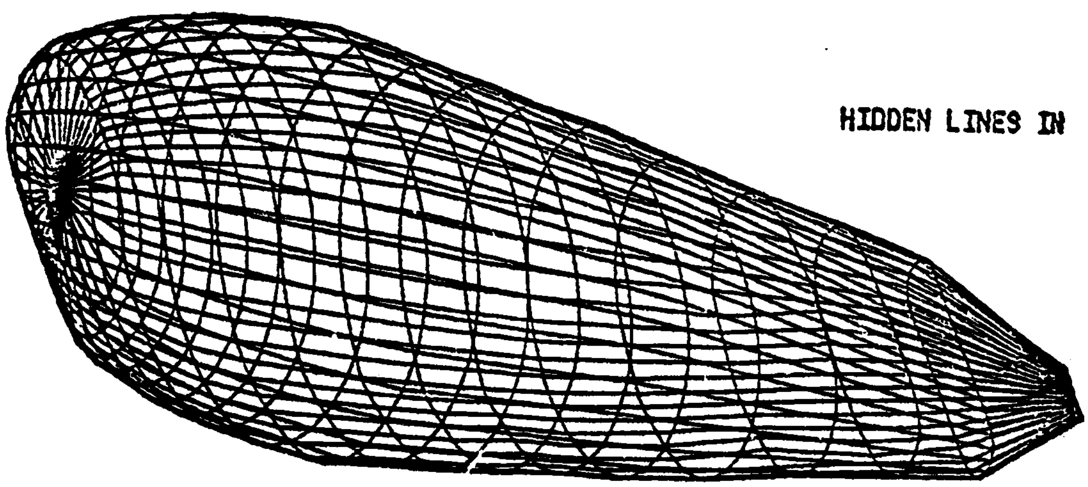
The plot cards described earlier must be now included for the plotting of the modified body, if and only if IPLOT2 ≠ 0.

Specification of the cards above represent a complete set of data for a particular body. Additional data sets are programmed similarly starting again at CARD 2. A blank card should be supplied at the end of the last data set to terminate the program.



NEW FAT NACELLE FOR LESS DRAG WITH N=21 AND M=21 YIELDING 400 PANELS —

X Z OUT 45. 10. 30. 6.0 ORT 0



NEW FAT NACELLE FOR LESS DRAG WITH N=21 AND M=21 YIELDING 400 PANELS --

X Z 45. 10. 30. 6.0 ORT 1

Figure 6: Example of orthographic projection

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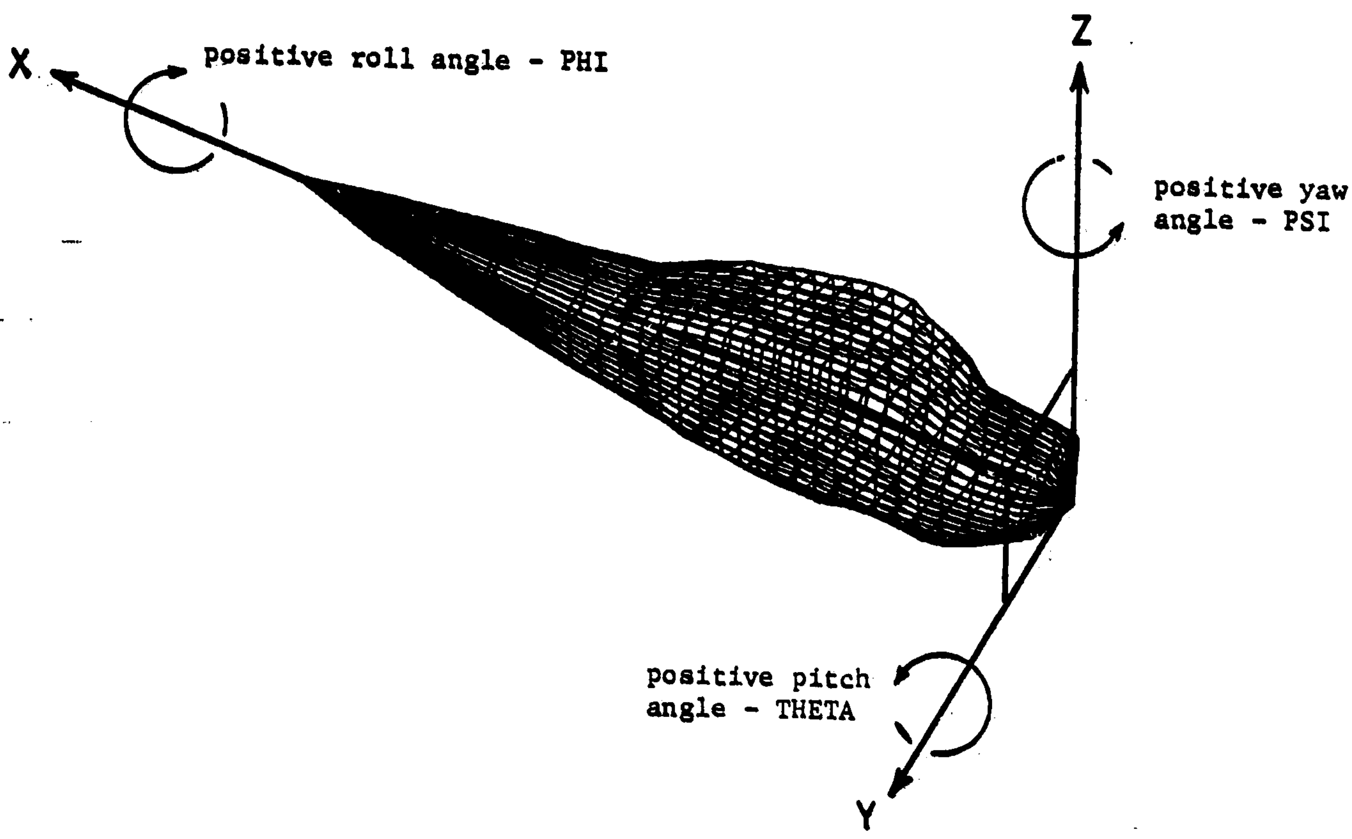


Figure 7: Orientation of body with respect to body reference axes for plotting angles

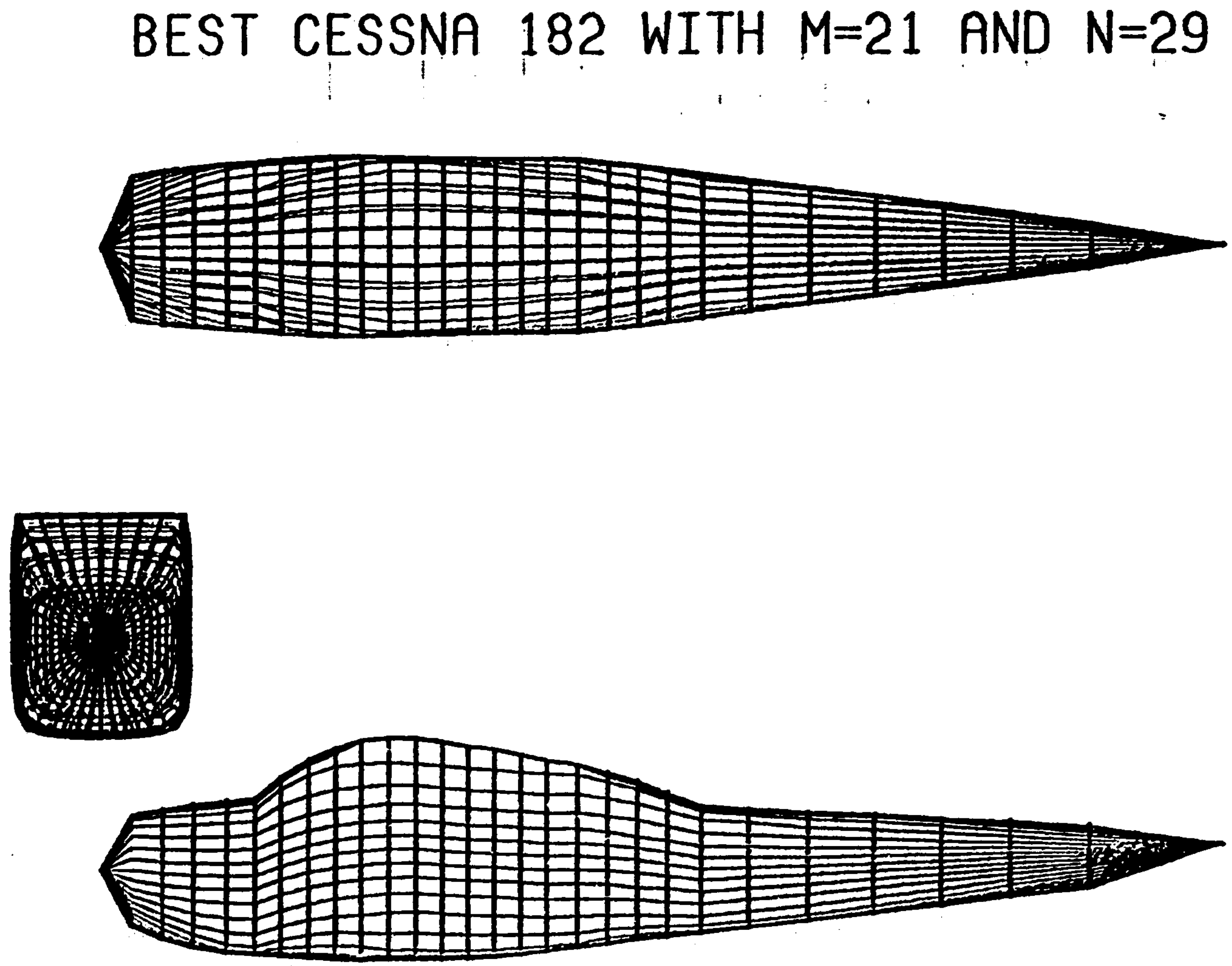
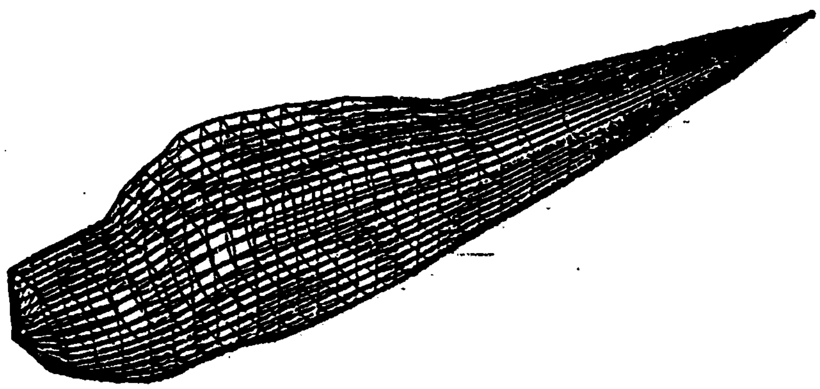


Figure 8: Example of 3-view plot



BEST CESSNA 182 WITH M=21 AND N=29 YIELDING 560 PANELS -- FUSELAGE ONLY

-20. -50. 50. 12. 0.0 0.0 14. 1.0 8.0 PER 1

Figure 9: Example of perspective view

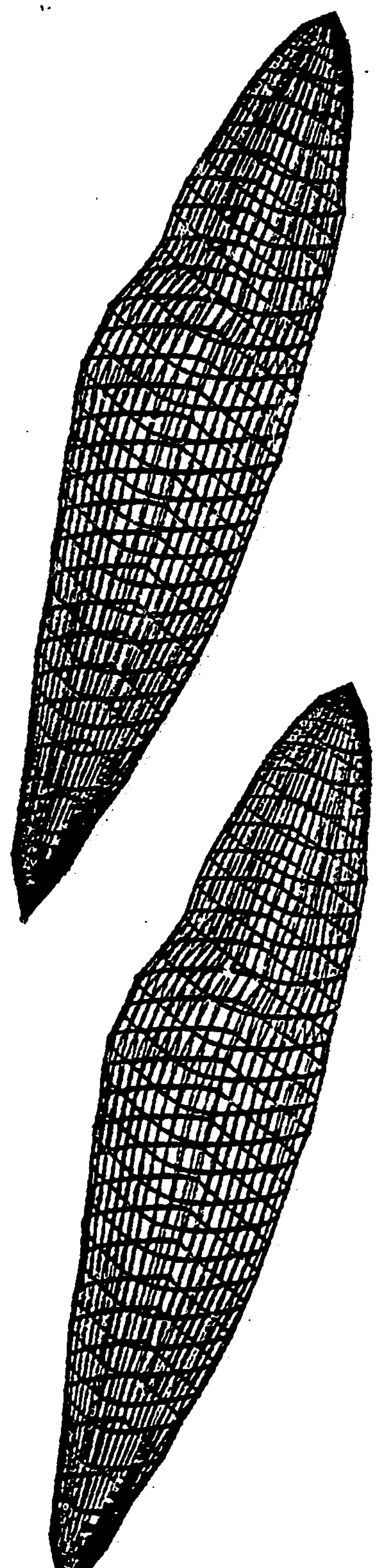


Figure 10: Example of stereo frames of stereoscopic view

PROGRAM LISTING - GRIDPLOT

```
C       PROGRAMMER:          STAN R. FOX
C                            2406 BROUGHTON BDLG
C                            DEPT ME ENGRG. NCSU
C                            RALEIGH, N.C.  27650
C                            PHONE: 919/737-2374
C
C
C       FOR A COMPLETE DESCRIPTION OF NECESSARY INPUT AND THE AVAILABLE
C       OPTIONS. CONSULT THF USFR'S INSTRUCTIONS.
C
C
        DIMENSION P(29,21,3),X(29),Y(29),Z(29),XN(89),YN(89),Q(29,81,3),R(
       189,81,3),XFUS(89),SFUS(89,81,2),BS(2,81,3),C(4,29),D(29),DIAG(29),
       1MP(21,2),NP(29,2)
        DIMENSION XAME1(4),XAME2(4),LABEL(80)
        COMMON /INOUT/JREAD,JWRITE,JPUNCH,KFILE1,KFILE2,KFILE3,KFILE4,IWRI
       1TE
        COMMON /TRANS/TITLE(20)
        COMMON /CODE/ICODE,IBP1,IBP2
        COMMON /PCODE/LCODE
        DATA XAME1/4HINPU,4HT PL,4HOT D,4HATA /,XAME2/4HNEW ,4HPLOT,4H DAT
       1,4HA   /
C
        JREAD=1
        JPUNCH=2
        JWRITE=3
        KFILE1=4
        KFILE2=5
        KFILE3=6
        KFILE4=7
        NCOUNT=1
C***    READ DATA CARDS
        READ (JREAD,1) N,M,NADD,MADD,PXL,PYL
      1 FORMAT (4I5,2F10.0)
        J1=M
        J2=N
        N1=N+IABS(NADD)
        M1=M+IABS(MADD)
        J3=MAX0(N1,M1)
        J4=MAX0(N,M)
      2 READ (JREAD,3) IDS,INPTM,INPTN,IPUNCH,IPLOT1,IPLOT2,LPCH1,LPCH2,IW
       1RITE,CF
```

```
    3 FORMAT (9I5,5X,F10.5)
      ICAN=0
      IF (CF.EQ.0.0E0)CF=1.0E0
      IF ((IDS.GT.0.AND.IDS.NE.JPUNCH).AND.(IDS.NE.JWRITE.AND.IDS.NE.KFI
     1L1).AND.(IDS.NE.KFILE2.AND.IDS.NE.KFILE3).AND.IDS.NE.KFILE4) GO TO
     1 5
      IF (IDS.LE.0) GO TO 97
      WRITE (JWRITE,4)
    4 FORMAT (1X,///,3X,28HERROR IN IDS ... TERMINATING,//)
      GO TO 97
    5 INPTN=IABS(INPTN)
      INPTM=IABS(INPTM)
      INPTNS=INPTN
      INPTMS=INPTM
      READ (IDS,6) (TITLE(I),I=1,20)
    6 FORMAT (20A4)
      WRITE (JWRITE,7) (TITLE(I),I=1,20)
    7 FORMAT (1H1,//,5X,8HINPUT***,//,10X,20A4,/)
      WRITE (JWRITE,8) IDS,INPTM,INPTN,IPUNCH,IPLOT1,IPLOT2,LPCH1,LPCH2,
     1IWRITE,CF
    8 FORMAT (1X,/,10X,4HIDS=,I3,3X,6HINPTM=,I3,4X,6HINPTN=,I3,4X,7HIPUN
     1CH=,I3,4X,7HIPLOT1=,I3,3X,7HIPLOT2=,I3,/,10X,6HLPCH1=,I3,2X,6HLPCH
     12=,I3,3X,7HIWRITE=,I3,3X,3HCF=,E16.9,/)
      READ (IDS,9) NQE
    9 FORMAT (I4)
      WRITE (JWRITE,10) NQE
   10 FORMAT (10X,25HNUMBER OF QUADRILATERALS.,I4,//)
      IF (IWRITE.EQ.0) WRITE (JWRITE,11)
   11 FORMAT (15X,2HXI,12X,2HYI,12X,2HZI,8X,2HNI,5X,2HMI,5X,2HNS,/)
      READ (IDS,12) XI,YI,ZI,NI,MI,NS
   12 FORMAT (3F12.8,3I4)
      MMAX=MI
      MMIN=MI
      NMAX=NI
      NMIN=NI
      NSS=NS
      L=1
      GO TO 14
   13 READ (IDS,12) XI,YI,ZI,NI,MI,NS
      IF (NS.NE.NSS) GO TO 16
      L=L+1
   14 IF (IWRITE.EQ.0) WRITE (JWRITE,15) XI,YI,ZI,NI,MI,NS
```

```
   15 FORMAT (10X,3(F12.8,2X),3(I5,2X))
      P(NI,MI,1)=XI*CF
      P(NI,MI,2)=YI*CF
      P(NI,MI,3)=ZI*CF
      MMAX=MAX0(MMAX,MI)
      MMIN=MIN0(MMIN,MI)
      NMAX=MAX0(NMAX,NI)
      NMIN=MIN0(NMIN,NI)
      GO TO 13
   16 NQ=(MMAX-MMIN)*(NMAX-NMIN)
      IF (NQ.EQ.NQE) GO TO 18
      WRITE (JWRITE,17) NQ,NQE
   17 FORMAT (1X,///,5X,30HNUMBER OF QUADRILATERALS READ(,I4,56H) DOES N
     1OT EQUAL THE NUMBER OF SPECIFIED QUADRILATERALS(,I4,1H))
      ICAN=1
      GO TO 96
C***  INPUT READING COMPLETED, CHECK FOR ERRORS
   18 IF (((MMAX.EQ.(2*(MMAX/2)).OR.MMAX.LT.4).OR.(MMIN.EQ.(2*(MMIN/2)).
     1OR.MMIN.NE.1)).OR.((NMAX.EQ.(2*(NMAX/2)).OR.NMAX.LT.4).OR.(NMIN.EQ
     1.(2*(NMIN/2)).OR.NMIN.NE.1))) GO TO 19
      GO TO 21
   19 WRITE (JWRITE,20) MMAX,MMIN,NMAX,NMIN
   20 FORMAT (1X,//,5X,23HERROR DETECTED IN INPUT,3X,6HMMAX =,I3,3X,6HMM
     1IN =,I3,/,31X,6HNMAX =,I3,3X,6HNMIN =,I3)
      ICAN=1
      GO TO 96
C***  ENACT POINT MODIFICATIONS
   21 CALL PNT1(J1,J2,P,JREAD,JWRITE,CF)
      CALL PNT2(J1,J2,P,JREAD,JWRITE,MMAX,NMAX)
      IF (NCOUNT.NE.1) GO TO 23
      IF (IPLOT1.EQ.0.AND.IPLOT2.EQ.0) GO TO 23
      CALL PICSIZ(PXL,PYL)
      READ (JREAD,22) (LABEL(NN),NN=1,80)
   22 FORMAT (80A1)
      CALL PENMSG(LABEL)
   23 IF (IPLOT1.EQ.0.AND.LPCH1.EQ.0) GO TO 38
      LCODE=1
C***  CONVERT TO PLOT AXIS SYSTEM
      ZMAX=-1000.0
      ZMIN=1000.0
      DO 24 NN=1,NMAX
      XFUS(NN)=P(1,1,1)-P(NN,1,1)
```

```
      DO 24 MM=1,MMAX
      IF (MM.GT.1.AND.MM.LT.MMAX) GO TO 24
      IF (ZMAX.LT.P(NN,MM,3))ZMAX=P(NN,MM,3)
      IF (ZMIN.GT.P(NN,MM,3))ZMIN=P(NN,MM,3)
   24 CONTINUE
      ZORG=ABS(ZMIN)+ABS(ZMAX)
      DO 25 NN=1,NMAX
      DC 25 MM=1,MMAX
   25 P(NN,MM,3)=P(NN,MM,3)+ZORG
C***  INPUT DATA
      IF (LPCH1.EQ.0) GO TC 33
      WRITE (JPUNCH,26) (XAME1(I),I=1,4)
   26 FORMAT (4A4)
      WRITE (JPUNCH,27) (XFUS(NN),NN=1,NMAX)
   27 FORMAT (10F7.4)
      DO 28 NN=1,NMAX
      WRITE (JPUNCH,27) (P(NN,MM,2),MM=1,MMAX)
   28 WRITE (JPUNCH,27) (P(NN,MM,3),MM=1,MMAX)
      IF (IWRITE.GT.1) GO TO 33
      WRITE (JWRITE,29)
   29 FORMAT (1X,///,10X,16HINPUT PLCT DATA:,//)
      WRITE (JWRITE,30) (XFUS(NN),NN=1,NMAX)
   30 FORMAT (10X,F7.4,1X,F7.4,1X,F7.4,1X,F7.4,1X,F7.4,1X,F7.4,1X,F7.4,1
     1X,F7.4,1X,F7.4,1X,F7.4)
      WRITE (JWRITE,31)
   31 FORMAT (1X)
      DO 32 NN=1,NMAX
      WRITE (JWRITE,30) (P(NN,MM,2),MM=1,MMAX)
      WRITE (JWRITE,31)
      WRITE (JWRITE,30) (P(NN,MM,3),MM=1,MMAX)
   32 WRITE (JWRITE,31)
   33 IF (IPLOT1.EQ.0) GO TO 36
      REWIND KFILE1
      WRITE (KFILE1)(XFUS(NN),NN=1,NMAX)
      DO 34 NN=1,NMAX
      WRITE (KFILE1)(P(NN,MM,2),MM=1,MMAX)
   34 WRITE (KFILE1)(P(NN,MM,3),MM=1,MMAX)
      WRITE (JWRITE,35)
   35 FORMAT (1X,//,1X,127('-'))
      CALL XYZPLT(MMAX,NMAX,XFUS,SFUS)
   36 DO 37 NN=1,NMAX
      DO 37 MM=1,MMAX
```

```
   37 P(NN,MM,3)=P(NN,MM,3)-ZORG                                        GRD 206
   38 IF (INPTM.LT.0.AND.INPTN.LT.0.AND.IPLOT2.EQ.0.AND.LPCH2.EQ.0) GO T GRD 207
     1O 96                                                              GRD 208
      CALL TEST(MAC1,MAC2,MP,NP,J1,J2,KM1,KM2,KN1,KN2,MMAX,NMAX)        GRD 209
      KN=NMAX                                                           GRD 210
      IF ((INPTM.EQ.0.AND.INPTN.EQ.0).AND.(MAC1.EQ.0.AND.MAC2.EQ.0)) GO GRD 211
     1TO 79                                                             GRD 212
C***  FOR EACH N-STATION, CURVE FIT THE M-STATIONS                      GRD 213
      IBP1=0                                                            GRD 214
      IBP2=0                                                            GRD 215
      K=0                                                               GRD 216
      DO 54 N=1,NMAX                                                    GRD 217
      IF (N.EQ.1.OR.N.EQ.NMAX) GO TO 39                                 GRD 218
      GO TO 46                                                          GRD 219
   39 IF (MAC1.NE.0) GO TO 40                                           GRD 220
      NPTS=MMAX+(MMAX-1)*INPTM                                          GRD 221
      GO TO 41                                                          GRD 222
   40 NPTS=MAC1                                                         GRD 223
C***  FOR FIRST AND LAST N-STATIONS                                     GRD 224
   41 DO 42 M=1,NPTS                                                    GRD 225
   42 Q(N,M,1)=P(N,1,1)                                                 GRD 226
      IQ=1                                                              GRD 227
      IP=1                                                              GRD 228
      Q(N,IQ,2)=P(N,IP,2)                                               GRD 229
      Q(N,IQ,3)=P(N,IP,3)                                               GRD 230
   43 IQMX=IQ+1+INPTM                                                   GRD 231
      IP=IP+1                                                           GRD 232
      IF (IP.GT.MMAX) GO TO 54                                          GRD 233
      IF (MAC1.EQ.0) GO TO 44                                           GRD 234
      ICODE=0                                                           GRD 235
      IF ((IP-1).GE.KM1)ICODE=1                                         GRD 236
      IF (ICODE.EQ.0)INPTM=MP(IP-1,1)                                   GRD 237
      IF (ICODE.EQ.1)INPTM=MP(IP-KM1,2)                                 GRD 238
      IF (ICODE.EQ.0)IBP1=IBP1+INPTM                                    GRD 239
      IF (ICODE.EQ.1)IBP2=IBP2+INPTM                                    GRD 240
      IQMX=IQ+1+INPTM                                                   GRD 241
   44 X1=(P(N,IP,2)-P(N,IP-1,2))/FLOAT(INPTM+1)                         GRD 242
      X2=(P(N,IP,3)-P(N,IP-1,3))/FLOAT(INPTM+1)                         GRD 243
      IQP1=IQ+1                                                         GRD 244
      DO 45 ML=IQP1,IQMX                                                GRD 245
      Q(N,ML,2)=Q(N,ML-1,2)+X1                                          GRD 246
   45 Q(N,ML,3)=Q(N,ML-1,3)+X2                                          GRD 247
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```
      IQ=IQMX
      GO TO 43
   46 MID=(MMAX+1)/2
      IF (MMAX.LT.7)MID=MMAX
      KNS=MID+(MID-1)*INPTMS
      SLP1=P(N,1,2)/P(N,1,3)
      SLP2=(P(N,MID,2)-P(N,1,2))/(P(N,MID,3)-P(N,1,3))
      A=ATAN((SLP2-SLP1)/(1.0+SLP1*SLP2))
      M1=1
      M2=MID
      ICODE=0
      MADD=0
      MD=0
      Y0=P(N,MID,2)
      Z0=P(N,MID,3)
   47 DO 48 M=M1,M2
      Z(M+MADD)=(P(N,M,3)-Z0)*COS(A)+(P(N,M,2)-Y0)*SIN(A)
      Y(M+MADD)=(P(N,M,2)-Y0)*COS(A)-(P(N,M,3)-Z0)*SIN(A)
   48 CONTINUE
      IF (MAC1.EQ.0) GO TO 49
      KNS=KM2+IBP2
      IF (ICODE.EQ.0)KNS=KM1+IBP1
   49 CALL PCS(MID,Y,Z,XN,YN,INPTM,KN,C,D,DIAG,JWRITE,J4,J3,MAC1,MP,J1,K
     11)
      IF (KN.NE.KNS) GO TO 50
      GO TO 52
   50 WRITE (JWRITE,51) N,ICODE,KN,KNS
   51 FORMAT (1X,52HPCS DID NOT FIND CORRECT NO. OF POINTS AT N-STATION
     1,I3,12H WITH ICODE=,I2,/,1X,6HFOUND ,I3,18H POINTS(SHOULD BE ,I3,1
     1H))
      GO TO 96
   52 DO 53 M=1,KN
      Q(N,M+MD,1)=P(N,1,1)
      Q(N,M+MD,2)=XN(M)*SIN(A)+YN(M)*COS(A)+Y0
      Q(N,M+MD,3)=XN(M)*COS(A)-YN(M)*SIN(A)+Z0
   53 CONTINUE
      IF (ICODE.NE.0.OR.MID.EQ.MMAX) GO TO 54
      SLP1=P(N,MMAX,2)/P(N,MMAX,3)
      SLP2=(P(N,MMAX,2)-P(N,MID,2))/(P(N,MMAX,3)-P(N,MID,3))
      A=ATAN((SLP2-SLP1)/(1.0+SLP1*SLP2))
      ICODE=1
      M1=MID
```

```
      M2=MMAX
      MADD=1-MID
      MD=KN-1
      GO TO 47
   54 INPTM=INPTMS
C***  SET INITIAL AND FINAL VALUES
      DO 55 LL=1,2
      N=1
      IF (LL.EQ.2)N=NMAX
      DO 55 M=1,NPTS
      DO 55 JJ=1,3
   55 BS(LL,M,JJ)=Q(N,M,JJ)
      MMAX=NPTS
C***  FOR EACH M-STATION, CURVE FIT EACH SET OF N-STATIONS
      MID=(NMAX+1)/2
      IF (NMAX.LT.7)MID=NMAX
      KNS=MID+(MID-1)*INPTN
      KS=NMAX+(NMAX-1)*INPTN
      IF (MAC2.EQ.0) GO TO 57
      K=1
      IBP1=0
      IBP2=0
      JD2=NMAX
      IF (NMAX.GE.7)JD2=(NMAX+1)/2
      DO 56 J=1,NMAX
      IF (J.LT.JD2)IBP1=IBP1+NP(J,1)
      IF (J.GE.JD2)IBP2=IBP2+NP(J-JD2+1,2)
   56 CONTINUE
   57 DO 64 M=1,MMAX
      X0=Q(MID,M,1)
      Y0=Q(MID,M,2)
      Z0=Q(MID,M,3)
      SAX=0.0
      ICODE=0
      M1=1
      M2=MID
      MADD=0
      MD=0
   58 SLP1=(Q(M1,M,2)-Q(M2,M,2))/(Q(M1,M,1)-Q(M2,M,1))
      SLP2=(Q(M1,M,3)-Q(M2,M,3))/(Q(M1,M,1)-Q(M2,M,1))
      ALP1=ATAN((SLP1-SAX)/(1.0+SAX*SLP1))
      ALP2=ATAN((SLP2-SAX)/(1.0+SAX*SLP2))
```

```
      DO 59 N=M1,M2
      IP=M2+M1-N
      X(N+MADD)=(Q(IP,M,1)-X0)*COS(ALP1)+(Q(IP,M,2)-Y0)*SIN(ALP1)
      Y(N+MADD)=(Q(IP,M,2)-Y0)*COS(ALP1)-(Q(IP,M,1)-X0)*SIN(ALP1)
   59 CONTINUE
      IF (MAC2.EQ.0) GO TO 60
      KNS=KN2+IBP2
      IF (ICODE.EQ.0)KNS=KN1+IBP1
   60 CALL PCS(MID,Y,X,XN,YN,INPTN,KN,C,D,DIAG,JWRITE,J4,J3,MAC2,NP,J2,K
     1)
      IF (KN.NE.KNS) GO TO 77
      DO 61 N=1,KN
      IP=KN+1-N+MD
      R(IP,M,1)=XN(N)*COS(ALP1)-YN(N)*SIN(ALP1)+X0
   61 R(IP,M,2)=XN(N)*SIN(ALP1)+YN(N)*COS(ALP1)+Y0
      DO 62 N=M1,M2
      IP=M2+M1-N
      X(N+MADD)=(Q(IP,M,1)-X0)*COS(ALP2)+(Q(IP,M,3)-Z0)*SIN(ALP2)
      Z(N+MADD)=(Q(IP,M,3)-Z0)*COS(ALP2)-(Q(IP,M,1)-X0)*SIN(ALP2)
   62 CONTINUE
      CALL PCS(MID,Z,X,XN,YN,INPTN,KN,C,D,DIAG,JWRITE,J4,J3,MAC2,NP,J2,K
     1)
      IF (KN.NE.KNS) GO TO 77
      DO 63 N=1,KN
      IP=KN+1-N+MD
      R(IP,M,3)=XN(N)*SIN(ALP2)+YN(N)*COS(ALP2)+Z0
   63 CONTINUE
      IF (ICODE.EQ.1.OR.MID.EQ.NMAX) GO TO 64
      ICODE=1
      M1=MID
      M2=NMAX
      MADD=1-MID
      MD=KN-1
      GO TO 58
   64 CONTINUE
      KN=KS
      IF (MAC2.EQ.0) GO TO 65
      KN=MAC2
   65 DO 67 LL=1,2
      N=1
      IF (LL.EQ.2)N=KN
      DO 66 M=1,MMAX
```

```
      DO 66 JJ=1,3
   66 R(N,M,JJ)=BS(LL,M,JJ)
   67 CONTINUE
      DO 76 N=1,KN
      X0=0.0
      DO 68 M=1,MMAX
      X0=X0+R(N,M,1)
   68 CONTINUE
      X0=X0/FLOAT(MMAX)
      IF (N.EQ.1) GO TO 70
      IF (X0.LT.R(N-1,1,1)) GO TO 70
      X0=0.0
      LK=0
      DO 69 M=1,MMAX
      IF (R(N,M,1).GT.R(N-1,1,1)) GO TO 69
      LK=LK+1
      X0=X0+R(N,M,1)
   69 CONTINUE
      IF (LK.EQ.0)ICAN=1
      IF (ICAN.EQ.1) GO TO 72
      X0=X0/FLOAT(LK)
   70 DO 71 M=1,MMAX
   71 R(N,M,1)=X0
      IF (N.EQ.1) GO TO 76
      IF (X0.GT.R(N-1,1,1)) GO TO 72
      GO TO 76
   72 NM1=N-1
      IF (ICAN.EQ.1) GO TO 74
      WRITE (JWRITE,73) N,NM1
   73 FORMAT (1X,///,10X,29HAVERAGE X-VALUE AT N-STATION ,I2,46H IS GREA
     1TER THAN AVERAGE X-VALUE AT N-STATION ,I2,38H.  MUST BE LESS THAN
     1OR EXACTLY EQUAL.,//)
      GO TO 96
   74 WRITE (JWRITE,75) N,NM1
   75 FORMAT (1X,///,10X,35HALL COMPUTED X-VALUES AT N-STATION ,I2,51H A
     1RE GREATER THAN THE AVERAGE X-VALUE AT N-STATION ,I2,//)
      GO TO 96
   76 CONTINUE
      GO TO 81
   77 WRITE (JWRITE,78) M,ICODE,KN,KNS
   78 FORMAT (1X,52HPCS DID NOT FIND CORRECT NO. OF POINTS AT M-STATION
     1,I3,12H WITH ICODE=,I2,/,1X,6HFOUND ,I3,18H POINTS(SHOULD BE ,I3,1
```

```
     1H))
      ICAN=1
      GO TO 96
   79 DO 80 N=1,KN
      DO 80 M=1,MMAX
      DO 80 J=1,3
   80 R(N,M,J)=P(N,M,J)
C***  NOW PRINT RESULTS
   81 NNQE=(MMAX-1)*(KN-1)
      IF (IWRITE.NE.2) WRITE (JWRITE,82) MMAX,KN,NNQE
   82 FORMAT (1H1,//,5X,11HNEW DATA***,//,5X,6HMMAX =,I3,3X,6HNMAX =,I3,
     12X,5H---->,I5,15H QUADRILATERALS,//,15X,2HXI,12X,2HYI,12X,2HZI,8X,
     12HNI,5X,2HMI,5X,2HNS,/)
      IF (IPUNCH.NE.0) WRITE (JPUNCH,83) NNQE
   83 FORMAT (I4)
      NS=1
      DO 85 N=1,KN
      DO 85 M=1,MMAX
      DO 84 J=1,3
   84 IF (ABS(R(N,M,J)).LT.1.0E-04)R(N,M,J)=0.0E0
      IF (IWRITE.NE.2) WRITE (JWRITE,15) (R(N,M,J),J=1,3),N,M,NS
      IF (IPUNCH.NE.0) WRITE (JPUNCH,12) (R(N,M,J),J=1,3),N,M,NS
   85 CONTINUE
      IF (IPLOT2.EQ.0.AND.LPCH2.EQ.0) GO TO 96
      LCODE=2
C***  CONVERT TO PLOT AXIS SYSTEM
      ZMAX=-1000.0
      ZMIN=1000.0
      DO 87 NN=1,KN
      XFUS(NN)=R(1,1,1)-R(NN,1,1)
      DO 86 MM=1,MMAX
      IF (MM.GT.1.AND.MM.LT.MMAX) GO TO 86
      IF (ZMAX.LT.R(NN,MM,3))ZMAX=R(NN,MM,3)
      IF (ZMIN.GT.R(NN,MM,3))ZMIN=R(NN,MM,3)
   86 CONTINUE
   87 CONTINUE
      ZORG=ABS(ZMIN)+ABS(ZMAX)
      DO 88 NN=1,KN
      DO 88 MM=1,MMAX
   88 R(NN,MM,3)=R(NN,MM,3)+ZORG
C***  NEW DATA
      IF (LPCH2.EQ.0) GO TO 92
```

```
      WRITE (JPUNCH,26) (XAME2(I),I=1,4)                                GRD 458
      WRITE (JPUNCH,27) (XFUS(NN),NN=1,KN)                              GRD 459
      DO 89 NN=1,KN                                                     GRD 460
      WRITE (JPUNCH,27) (R(NN,MM,2),MM=1,MMAX)                          GRD 461
   89 WRITE (JPUNCH,27) (R(NN,MM,3),MM=1,MMAX)                          GRD 462
      IF (IWRITE.GT.1) GO TO 92                                         GRD 463
      WRITE (JWRITF,90)                                                 GRD 464
   90 FORMAT (1X,///,10X,14HNEW PLOT DATA:,//)                          GRD 465
      WRITE (JWRITE,30) (XFUS(NN),NN=1,KN)                              GRD 466
      WRITE (JWRITE,31)                                                 GRD 467
      DO 91 NN=1,KN                                                     GRD 468
      WRITE (JWRITE,30) (R(NN,MM,2),MM=1,MMAX)                          GRD 469
      WRITE (JWRITE,31)                                                 GRD 470
      WRITE (JWRITE,30) (R(NN,MM,3),MM=1,MMAX)                          GRD 471
   91 WRITE (JWRITE,31)                                                 GRD 472
   92 IF (IPLOT2.EQ.0) GO TO 94                                         GRD 473
      REWIND KFILE4                                                     GRD 474
      WRITE (KFILE4)(XFUS(NN),NN=1,KN)                                  GRD 475
      DO 93 NN=1,KN                                                     GRD 476
      WRITE (KFILE4)(R(NN,MM,2),MM=1,MMAX)                              GRD 477
   93 WRITE (KFILE4)(R(NN,MM,3),MM=1,MMAX)                              GRD 478
      WRITE (JWRITF,35)                                                 GRD 479
      CALL XYZPLT(MMAX,KN,XFUS,SFUS)                                    GRD 480
C***  RESET Z-VALUES                                                    GRD 481
   94 DO 95 NN=1,KN                                                     GRD 482
      DO 95 MM=1,MMAX                                                   GRD 483
   95 R(NN,MM,3)=R(NN,MM,3)-ZCRG                                        GRD 484
   96 IF (IPLOT1.NE.0.OR.IPLOT2.NE.0)NCOUNT=NCOUNT+1                    GRD 485
      IF (IDS.NE.JREAD) REWIND IDS                                      GRD 486
      GO TO 2                                                           GRD 487
      NCOUNT=NCOUNT+1                                                   GRD 488
   97 IF (NCOUNT.GT.1) CALL PICSIZ(0.0,0.0)                             GRD 489
      STOP                                                              GRD 490
      END                                                               GRD 491

      SUBROUTINE PNT1(J2,J1,R,JREAD,JWRITF,CF)                          PNS   1
C                                                                       PNS   2
C***  POINT MODIFICATION BY ADDITIONAL INPUT POINT CHANGE INFORMATION    PNS   3
C                                                                       PNS   4
      DIMENSION R(J1,J2,3)                                              PNS   5
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C
      K=0
    1 READ (JREAD,2) XP,YP,ZP,N,M
    2 FORMAT (3F20.0,2I5)
      IF (N.LE.0.OR.M.LE.0) GO TO 5
      K=K+1
      IF (K.EQ.1) WRITE (JWRITE,3)
    3 FORMAT (1X,///,5X,63HPOINT MODIFICATION BY ADDITIONAL INPUT POINT
     1CHANGE INFORMATION,//,15X,2HXI,12X,2HYI,12X,2HZI,8X,2HNI,5X,2HMI,/
     1)
      WRITE (JWRITE,4) XP,YP,ZP,N,M
    4 FORMAT (10X,3(F12.8,2X),2(I5,2X))
      R(N,M,1)=XP*CF
      R(N,M,2)=YP*CF
      R(N,M,3)=ZP*CF
      GO TO 1
    5 RETURN
      END

      SUBROUTINE PNT2(J2,J1,R,JREAD,JWRITE,MMAX,NMAX)
C
C***  POINT MODIFICATION BY SIMPLE AVERAGE OR LINEAR INTERPOLATION
C
      DIMENSION R(J1,J2,3)
C
      K=0
      ICODE1=0
      ICODE2=0
    1 READ (JREAD,2) M1,M2,N1,N2,IMETH
    2 FORMAT (5I5)
      IF ((M1.LE.0.AND.M2.LE.0).AND.(N1.LE.0.AND.N2.LE.0)) GO TO 31
      IF ((M1.LE.0.AND.M2.LE.0).OR.(N1.LE.0.OR.N2.LE.0)) GO TO 1
      IF ((M1.LE.0.OR.M2.LE.0).OR.(N1.LE.0.OR.N2.LE.0))
      K=K+1
      IF (K.EQ.1) WRITE (JWRITE,3)
    3 FORMAT (1X,///,5X,38HPOINT MODIFICATION BY SPECIFIED METHOD)
      JS=M2
      IF (M1.LE.M2) GO TO 4
      M2=M1
      M1=JS
    4 JS=N2
```

```
      IF (N1.LE.N2) GO TO 5                                             PNT   22
      N2=N1                                                             PNT   23
      N1=JS                                                             PNT   24
    5 L1=M2-M1                                                          PNT   25
      L2=N2-N1                                                          PNT   26
      IF (M2-MMAX-1)  6,6,1                                             PNT   27
    6 IF (1-M1)  7,7,1                                                  PNT   28
    7 IF (N2-NMAX-1)  8,8,1                                             PNT   29
    8 IF (1-N1)  9,9,1                                                  PNT   30
    9 IF (((L1.EQ.1.OR.L1.GT.2).OR.(L2.EQ.1.OR.L2.GT.2)).OR.(L1.EQ.0.AND PNT   31
     1.L2.EQ.0)) GO TO 1                                                PNT   32
      IF (IMETH.LT.0)IMETH=0                                            PNT   33
      IF (IMETH.GT.1)IMETH=1                                            PNT   34
      AYN=0.0E0                                                         PNT   35
      AZN=0.0E0                                                         PNT   36
      AYM=0.0E0                                                         PNT   37
      AZM=0.0E0                                                         PNT   38
      IM=IMETH+1                                                        PNT   39
      IF (L1.NE.0.AND.L2.NE.0) GO TO 19                                 PNT   40
      IF (L1.EQ.0.AND.L2.NE.0) GO TO 13                                 PNT   41
      IF (M2.GT.MMAX) GO TO 10                                          PNT   42
      IF (M1.LT.1) GO TO 11                                             PNT   43
      AYM=(R(N1,M1,2)+R(N1,M2,2))/2.0E0                                 PNT   44
      AZM=(R(N1,M1,3)+R(N1,M2,3))/2.0E0                                 PNT   45
      GO TO 12                                                          PNT   46
   10 AYM=R(N1,M1+1,2)                                                  PNT   47
      AZM=R(N1,M1,3)                                                    PNT   48
      GO TO 12                                                          PNT   49
   11 AYM=R(N1,M2-1,2)                                                  PNT   50
      AZM=R(N1,M2,3)                                                    PNT   51
   12 N=N1                                                              PNT   52
      M=M1+1                                                            PNT   53
      D=1.0E0                                                           PNT   54
      GO TO 28                                                          PNT   55
   13 GO TO (14,15),IM                                                  PNT   56
   14 AYN=(R(N1,M1,2)+R(N2,M1,2))/2.0E0                                 PNT   57
      AZN=(R(N1,M1,3)+R(N2,M1,3))/2.0E0                                 PNT   58
      GO TO 18                                                          PNT   59
   15 IF (N2.GT.NMAX) GO TO 16                                          PNT   60
      IF (N1.LT.1) GO TO 17                                             PNT   61
      A=(R(N1,M1,2)-R(N2,M1,2))/(R(N1,M1,1)-R(N2,M1,1))                 PNT   62
      B=R(N1,M1,2)-A*R(N1,M1,1)                                         PNT   63
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      AYN=A*R(N1+1,M1,1)+B
      A=(R(N1,M1,3)-R(N2,M1,3))/(R(N1,M1,1)-R(N2,M1,1))
      B=R(N1,M1,3)-A*R(N1,M1,1)
      AZN=A*R(N1+1,M1,1)+B
      GO TO 18
   16 AYN=R(N1,M1,2)
      AZN=R(N1,M1,3)
      ICODE1=1
      GO TO 18
   17 AYN=R(N2,M1,2)
      AZN=R(N2,M1,3)
      ICODE2=1
   18 N=N1+1
      M=M1
      D=1.0E0
      GO TO 28
   19 IF (M2.GT.MMAX) GO TO 20
      IF (M1.LT.1) GO TO 21
      AYM=(R(N1+1,M1,2)+R(N1+1,M2,2))/2.0E0
      AZM=(R(N1+1,M1,3)+R(N1+1,M2,3))/2.0E0
      GO TO 22
   20 AYM=R(N1+1,M1+1,2)
      AZM=R(N1+1,M1,3)
      GO TO 22
   21 AYM=R(N1+1,M2-1,2)
      AZM=R(N1+1,M2,3)
   22 GO TO (23,24),IM
   23 IF (N2.GT.NMAX) GO TO 25
      IF (N1.LT.1) GO TO 26
      AYN=(R(N1,M1+1,2)+R(N2,M1+1,2))/2.0E0
      AZN=(R(N1,M1+1,3)+R(N2,M1+1,3))/2.0E0
      GO TO 27
   24 IF (N2.GT.NMAX) GO TO 25
      IF (N1.LT.1) GO TO 26
      A=(R(N1,M1+1,2)-R(N2,M1+1,2))/(R(N1,M1+1,1)-R(N2,M1+1,1))
      B=R(N1,M1+1,2)-A*R(N1,M1+1,1)
      AYN=A*R(N1+1,M1+1,1)+B
      A=(R(N1,M1+1,3)-R(N2,M1+1,3))/(R(N1,M1+1,1)-R(N2,M1+1,1))
      B=R(N1,M1+1,3)-A*R(N1,M1+1,1)
      AZN=A*R(N1+1,M1+1,1)+B
      GO TO 27
   25 AYN=R(N1,M1+1,2)
```

```
      AZN=R(N1,M1+1,3)
      ICODE1=1
      GO TO 27
   26 AYN=R(N2,M1+1,2)
      AZN=R(N2,M1+1,3)
      ICODE2=1
   27 N=N1+1
      M=M1+1
      D=2.0E0
   28 AVY=(AYM+AYN)/D
      AVZ=(AZM+AZN)/D
      IF (IMETH.EQ.0) WRITE (JWRITE,29) N,M,R(N,M,2),AVY,R(N,M,3),AVZ
   29 FORMAT (1X,/,5X,'POINT(N=',I2,',M=',I2,') Y=',1PE14.7,' -->',1PE14
     1.7,/,22X,'Z=',1PE14.7,' -->',1PE14.7,5X,14HSIMPLE AVERAGE)
      IF (IMETH.EQ.1) WRITE (JWRITE,30) N,M,R(N,M,2),AVY,R(N,M,3),AVZ
   30 FORMAT (1X,/,5X,'POINT(N=',I2,',M=',I2,') Y=',1PE14.7,' -->',1PE14
     1.7,/,22X,'Z=',1PE14.7,' -->',1PE14.7,5X,20HLINEAR INTERPOLATION)
      R(N,M,2)=AVY
      R(N,M,3)=AVZ
      GO TO 1
   31 IF (ICODE2.NE.0) WRITE (JWRITE,32)
   32 FORMAT (1X,///,5X,67HWARNING...DATA NOT COMPATIBLE AS INPUT TO 'FL
     1OWBODY' PROGRAM DUE TO,/,15X,39HPOINT MODIFICATION(S) AT FRONT OF
     1BODY.)
      IF (ICODE1.NE.0) WRITE (JWRITE,33)
   33 FORMAT (1X,///,5X,67HWARNING...DATA NOT COMPATIBLE AS INPUT TO 'FL
     1OWBODY' PROGRAM DUE TO,/,15X,38HPOINT MODIFICATION(S) AT REAR OF B
     1ODY.)
      RETURN
      END


      SUBROUTINE TEST(M1,M2,MF,NP,J1,J2,KM1,KM2,KN1,KN2,MX,NX)
C
C***  SUBROUTINE TEST ALLOWS THE SPECIFICATION OF ARBITRARY ADDITIONAL
C***  STATIONS
C
      DIMENSION MP(J1,2),NP(J2,2)
      COMMON /INOUT/JREAD,JWRITE,JPUNCH,KK(5)
      DATA M/4HM   /,N/4HN   /,MN/4HEND /
C
```

```
C***  INITIALIZE PARAMETERS                                             TST  10
      M1=0                                                              TST  11
      M2=0                                                              TST  12
      KM1=0                                                             TST  13
      KM2=0                                                             TST  14
      KN1=0                                                             TST  15
      KN2=0                                                             TST  16
      L1=0                                                              TST  17
      L2=0                                                              TST  18
      WRITE (JWRITE,1)                                                  TST  19
    1 FORMAT (1H1,///,13X,43HADDITIONAL ARBITRARY STATION SPECIFICATIONS TST  20
     1,//,10X,48HREFERENCE|___ M-STATIONS ___|___ N-STATIONS ___|,/,11X, TST  21
     19HSTATION |,18X,1H|,18X,1H|,/,19X,39H|1ST HALF  2ND HALF|1ST HALF  TST  22
     1 2ND HALF|,/)                                                     TST  23
      DO 2 J=1,J1                                                       TST  24
      MP(J,1)=0                                                         TST  25
    2 MP(J,2)=0                                                         TST  26
      DO 3 J=1,J2                                                       TST  27
      NP(J,1)=0                                                         TST  28
    3 NP(J,2)=0                                                         TST  29
      IF (MX.GE.7) GO TO 4                                              TST  30
      KM1=MX                                                            TST  31
    4 IF (NX.GE.7) GO TO 5                                              TST  32
      KN1=NX                                                            TST  33
    5 IF (MX.LT.7) GO TO 6                                              TST  34
      KM1=(MX+1)/2                                                      TST  35
      KM2=KM1                                                           TST  36
    6 IF (NX.LT.7) GO TO 7                                              TST  37
      KN1=(NX+1)/2                                                      TST  38
      KN2=KN1                                                           TST  39
C***  READ DATA CARDS                                                   TST  40
    7 READ (JREAD,8) NAME,K1,NL                                         TST  41
    8 FORMAT (A4,1X,2I5)                                                TST  42
      IF (NAME.EQ.MN) GO TO 11                                          TST  43
      IF (NAME.EQ.M) GO TO 9                                            TST  44
      IF (NAME.EQ.N) GO TO 10                                           TST  45
      GO TO 12                                                          TST  46
    9 IF (K1.LE.0.OR.K1.GE.MX) GO TO 7                                  TST  47
      IF (K1.LT.KM1)MP(K1,1)=IABS(NL)                                   TST  48
      IF (K1.GE.KM1)MP(K1-KM1+1,2)=IABS(NL)                             TST  49
      L1=L1+IABS(NL)                                                    TST  50
      GO TO 7                                                           TST  51
```

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```
10 IF (K1.LE.0.OR.K1.GE.NX) GO TO 7                                  TST  52
   IF (K1.LT.KN1)NP(K1,1)=IABS(NL)                                   TST  53
   IF (K1.GE.KN1)NP(K1-KN1+1,2)=IABS(NL)                             TST  54
   L2=L2+IABS(NL)                                                    TST  55
   GO TO 7                                                           TST  56
11 M1=MX+L1                                                          TST  57
   M2=NX+L2                                                          TST  58
   IF ((2*(M1/2)).EQ.M1.OR.(2*(M2/2)).EQ.M2) GO TO 14                TST  59
   GO TO 16                                                          TST  60
12 WRITE (JWRITE,13)                                                 TST  61
13 FORMAT (1X,///,1X,57HERROR... DATA CARD IN TEST ROUTINE HAS NO DIR TST  62
  1ECTION LABEL,///)                                                 TST  63
   CALL EXIT                                                         TST  64
   RETURN                                                            TST  65
14 WRITE (JWRITE,15) M1,M2                                           TST  66
15 FORMAT (1X,///,1X,38HWARNING... TOTAL NUMBER OF M-STATIONS(,I3,16H TST  67
  1) OR N-STATIONS(,I3,22H) IS NOT AN ODD NUMBER,//)                 TST  68
16 IF (M1.EQ.MX)M1=0                                                 TST  69
   IF (M2.EQ.NX)M2=0                                                 TST  70
   K=KM1                                                             TST  71
   IF (KN1.GT.K)K=KN1                                                TST  72
   DO 23 J=1,K                                                       TST  73
   IF (J.LE.KM1.AND.J.LE.KN1) GO TO 17                               TST  74
   IF (J.LE.KM1.AND.J.GT.KN1) GO TO 19                               TST  75
   IF (J.GT.KM1.AND.J.LE.KN1) GO TO 21                               TST  76
17 WRITE (JWRITE,18) J,MP(J,1),MP(J,2),NP(J,1),NP(J,2)               TST  77
18 FORMAT (12X,I3,7X,I3,7X,I3,6X,I3,7X,I3)                           TST  78
   GO TO 23                                                          TST  79
19 WRITE (JWRITE,20) J,MP(J,1),MP(J,2)                               TST  80
20 FORMAT (12X,I3,7X,I3,7X,I3)                                       TST  81
   GO TO 23                                                          TST  82
21 WRITE (JWRITE,22) J,NP(J,1),NP(J,2)                               TST  83
22 FORMAT (12X,I3,26X,I3,7X,I3)                                      TST  84
23 CONTINUE                                                          TST  85
   WRITE (JWRITE,24)                                                 TST  86
24 FORMAT (1X,////)                                                  TST  87
   RETURN                                                            TST  88
   END                                                               TST  89


   SUBROUTINE PCS(K,F,X,XY,Y,INPIS,KN,C,D,DIAG,JWRITE,J4,J3,M1,N,J,KK PCS   1
```

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```
     1)
C
C***  CONTROL ROUTINE FOR PIECEWISE CUBIC SPLINE
C
      DIMENSION F(J4),X(J4),XY(J3),Y(J3),C(4,J4),D(J4),DIAG(J4),N(J,2)
      COMMON /CODE/ICODE,IBP1,IBP2
C
      KN=K+(K-1)*INPTS
      JP1D2=K
      IF (M1.EQ.0) GO TO 1
      IF (ICODE.EQ.0)KN=JP1D2+IBP1
      IF (ICODE.EQ.1)KN=JP1D2+IBP2
    1 IF (KN.EQ.K) GO TO 2
      DF=1.0E-4
      GO TO 4
    2 DO 3 I=1,K
      Y(I)=F(I)
    3 XY(I)=X(I)
      GO TO 9
    4 C(2,1)=(F(2)-F(1))/(X(2)-X(1))
      C(2,K)=(F(K)-F(K-1))/(X(K)-X(K-1))
      DO 5 I=1,K
    5 C(1,I)=F(I)
      CALL SPLINE(K,X,C,D,DIAG,J4)
      XX=X(1)
      XXH=X(K)
      XINC=0.0E0
      M=0
      L=1
    6 M=M+1
      IF (M.GT.KN) GO TO 10
      XX=XX+XINC
      IF (ABS(XX-XXH).LT.DF)XX=XXH
      IF (XX.EQ.XXH) GO TO 7
      IF (ABS(XX-X(L)).LT.DF)XX=X(L)
      IF (ABS(XX-X(L+1)).LT.DF)XX=X(L+1)
      IF (XX.EQ.X(L+1).AND.XX.NE.X(K))L=L+1
    7 XY(M)=XX
      Y(M)=PCUBIC(XX,X,C,K,J4)
      IF (XX.EQ.XXH) GO TO 9
      IF (M1.EQ.0) GO TO 8
      IF (KK.EQ.0)INPTS=N(L,ICODE+1)
```

```
      IF (KK.EQ.1.AND.(JP1D2-L).NE.0)INPTS=N(JP1D2-L,ICODE+1)
    8 IF (L.LT.K)XINC=(X(L+1)-X(L))/(INPTS+1)
      GO TO 6
    9 RETURN
   10 WRITE (JWRITE,11) M,KN
   11 FORMAT (3X,16HERROR IN PCS: M=,I4,6H > KN=,I4)
      CALL EXIT
      RETURN
      END

      SUBROUTINE SPLINE(NP1,XI,C,D,DIAG,J)
C
C***  PIECEWISE CUBIC SPLINE
C
      DIMENSION XI(J),C(4,J),D(J),DIAG(J)
C
      D(1)=0.0E0
      DIAG(1)=1.0E0
      N=NP1-1
      DO 1 M=2,NP1
      D(M)=XI(M)-XI(M-1)
    1 DIAG(M)=(C(1,M)-C(1,M-1))/D(M)
      DO 2 M=2,N
      C(2,M)=3.0E0*(D(M)*DIAG(M+1)+D(M+1)*DIAG(M))
    2 DIAG(M)=2.0E0*(D(M)+D(M+1))
      DO 3 M=2,N
      G=-D(M+1)/DIAG(M-1)
      DIAG(M)=DIAG(M)+G*D(M-1)
    3 C(2,M)=C(2,M)+G*C(2,M-1)
      NJ=NP1
      DO 4 M=2,N
      NJ=NJ-1
    4 C(2,NJ)=(C(2,NJ)-D(NJ)*C(2,NJ+1))/DIAG(NJ)
      DO 5 I=1,N
      DX=XI(I+1)-XI(I)
      DF1=(C(1,I+1)-C(1,I))/DX
      DF3=C(2,I)+C(2,I+1)-2.0E0*DF1
      C(3,I)=(DF1-C(2,I)-DF3)/DX
    5 C(4,I)=DF3/DX/DX
      RETURN
```

```
      END

      FUNCTION PCUBIC(XBAR,XI,C,NP1,J)
C
C***  FUNCTION EVALUATION OF PIECEWISE CUBIC SPLINE
C
      DIMENSION XI(J),C(4,J)
C
      I=1
      DX=XBAR-XI(I)
      IF (DX) 1,4,3
    1 IF (I.EQ.1) GO TO 4
      I=I-1
      DX=XBAR-XI(I)
      IF (DX) 1,4,4
    2 I=I+1
      DX=DDX
    3 IF (I.EQ.(NP1-1)) GO TO 4
      DDX=XBAR-XI(I+1)
      IF (DDX) 4,2,2
    4 PCUBIC=C(1,I)+DX*(C(2,I)+DX*(C(3,I)+DX*C(4,I)))
      RETURN
      END

      SUBROUTINE XYZPLT(M,N,XFUS,SFUS)
C
C***  CONTROL ROUTINE FOR CONFIGURATION PLOTS
C
      DIMENSION FIRST(7),XFUS(N),SFUS(N,M,2)
      COMMON /PASS/ABC(20),ABCDE(20),HORZ,VERT,TEST1,PHI,THETA,PSI,XF,YF
     1,ZF,DIST,FMAG,PLOTSZ,TYPF,XMIN,XMAX,YMIN,YMAX,ZMIN,ZMAX,XMID,YMID,
     1ZMID,BIGD,KODE,ISP
      COMMON /INOUT/JREAD,JWRITE,JPUNCH,KFILE1,KFILE2,KFILE3,KFILE4,IWRI
     1TE
      COMMON /PCODE/LCODE
      COMMON /TRANS/TITLE(20)
      DATA FIRST/4HNEW ,4HBODY,4H WIT,4HH IM,4HPRCV,4HED G,4HRID /,TAME/
     14H    /
```

```
C                                                                        XYZ  15
      DO 1 I=1,20                                                        XYZ  16
      IF (LCCDE.EQ.1)ABC(I)=TITLE(I)                                     XYZ  17
      IF (LCODE.FQ.2.AND.I.LE.7)ABC(I)=FIRST(I)                          XYZ  18
    1 IF (LCODE.EQ.2.AND.I.GT.7)ABC(I)=TAME                              XYZ  19
      WRITE (JWRITE,2) (ABC(I),I=1,20)                                   XYZ  20
    2 FORMAT (28X25HCONFIGURATION DESCRIPTION//1X20A4/)                  XYZ  21
C***  INPUT CONFIGURATION DESCRIPTION AND INITIALIZE                     XYZ  22
      CALL CBC10(M,N,XFUS,SFUS)                                          XYZ  23
C***  PLOT CONFIGURATION                                                 XYZ  24
      WRITE (JWRITE,3)                                                   XYZ  25
    3 FORMAT (//36X9HPLOT DATA//)                                        XYZ  26
    4 READ (JREAD,5) (ABCDE(I),I=1,20)                                   XYZ  27
    5 FORMAT (20A4)                                                      XYZ  28
      WRITE (KFILE3,5) (ABCDE(I),I=1,20)                                 XYZ  29
      REWIND KFILE3                                                      XYZ  30
      READ (KFILE3,6) HORZ,VERT,TEST1,PHI,THETA,PSI,XF,YF,ZF,DIST,FMAG,P XYZ  31
     1LOTSZ,TYPE,KODE                                                    XYZ  32
      REWIND KFILE3                                                      XYZ  33
    6 FORMAT (2A2,A3,9F5.3,A3,16X,I1)                                    XYZ  34
      WRITE (JWRITE,7) HORZ,VERT,TEST1,PHI,THETA,PSI,XF,YF,ZF,DIST,FMAG, XYZ  35
     1PLOTSZ,TYPE,KODE                                                   XYZ  36
    7 FORMAT (1X,2A2,A3,9(1X,F10.5),A3,16X,I1)                           XYZ  37
      CALL CBC20(M,N)                                                    XYZ  38
      IF (KODE.EQ.0) GO TO 4                                             XYZ  39
      WRITE (JWRITE,8)                                                   XYZ  40
    8 FORMAT (1X,//,1X,127('-'))                                         XYZ  41
      RETURN                                                             XYZ  42
      END                                                                XYZ  43


      SUBROUTINE CBC10(NRADX,NFORX,XFUS,SFUS)                            C10   1
C                                                                        C10   2
C***  INPUTS AND INITIALIZES CONFIGURATION DESCRIPTION                   C10   3
C                                                                        C10   4
      COMMON /PASS/ABC(20),ABCDE(20),HORZ,VERT,TEST1,PHI,THETA,PSI,XF,YF C10   5
     1,ZF,DIST,FMAG,PLOTSZ,TYPE,XMIN,XMAX,YMIN,YMAX,ZMIN,ZMAX,XMID,YMID, C10   6
     1ZMID,BIGD,KODE,ISP                                                 C10   7
      COMMON /INOUT/JREAD,JWRITE,JPUNCH,KFILE1,KFILE2,KFILE3,KFILE4,IWRI C10   8
     1TE                                                                 C10   9
      DIMENSION XFUS(NFORX),SFUS(NFORX,NRADX,2)                          C10  10
```

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```
      COMMON /AV/ALRT(212,3,2),VECRT(211,3)
      COMMON /PCODE/LCODE
C
      REWIND KFILE1
      REWIND KFILE2
      REWIND KFILE4
      LREAD=KFILE1
      IF (LCODE.NE.1)LREAD=KFILE4
      NRAD=NRADX
      NFUSOR=NFORX
      N=NFUSOR
      READ (LREAD)(XFUS(I),I=1,N)
      IF (IWRITE.EQ.0) WRITE (JWRITE,1) (XFUS(I),I=1,N)
    1 FORMAT (1X,F10.5,1X,F10.5,1X,F10.5,1X,F10.5,1X,F10.5,1X,F10.5,1X,F
     110.5,1X,F10.5,1X,F10.5,1X,F10.5)
      IF (IWRITE.EQ.0) WRITE (JWRITE,2)
    2 FORMAT (1X,/)
      DO 4 NN=1,N
      DO 3 K=1,2
      READ (LREAD)(SFUS(NN,MM,K),MM=1,NRAD)
      IF (IWRITE.EQ.0) WRITE (JWRITE,1) (SFUS(NN,MM,K),MM=1,NRAD)
    3 CONTINUE
      IF (IWRITE.EQ.0) WRITE (JWRITE,2)
    4 CONTINUE
      XMIN=XFUS(1)
      XMAX=XFUS(1)
      YMAX=SFUS(1,1,1)
      ZMIN=SFUS(1,1,2)
      ZMAX=SFUS(1,1,2)
      XMIN=AMIN1(XMIN,XFUS(1))
      XMAX=AMAX1(XMAX,XFUS(NFUSOR))
      DO 5 NN=1,NFUSOR
      DO 5 NR=1,NRAD
      YMAX=AMAX1(YMAX,SFUS(NN,NR,1))
      ZMIN=AMIN1(ZMIN,SFUS(NN,NR,2))
    5 ZMAX=AMAX1(ZMAX,SFUS(NN,NR,2))
C***  SETUP 1ST LINE IN STREAMWISE DIRECTION
      NL1=NFUSOR-1
      NAN=NRAD
      DO 6 N=1,NFUSOR
      ALRT(N,1,2)=XFUS(N)
      ALRT(N,2,2)=SFUS(N,1,1)
```

```
    6 ALRT(N,3,2)=SFUS(N,1,2)
      WRITE (KFILE2)((ALRT(N,N3,2),N=1,NFUSOR),N3=1,3)
      DO 9 NN=2,NAN
      DO 7 N=1,NFUSOR
      DO 7 N3=1,3
      ALRT(N,N3,1)=ALRT(N,N3,2)
    7 CONTINUE
      DO 8 N=1,NFUSOR
      ALRT(N,2,2)=SFUS(N,NN,1)
    8 ALRT(N,3,2)=SFUS(N,NN,2)
      CALL SURCL(NFUSOR)
      WRITE (KFILE2)((VECRT(N,N3),N=1,NL1),N3=1,3)
      WRITE (KFILE2)((ALRT(N,N3,2),N=1,NFUSOR),N3=1,3)
    9 CONTINUE
C***  SETUP 1ST LINE AROUND BODY
      NL1=NAN-1
      DO 10 N=1,NAN
      ALRT(N,1,2)=XFUS(1)
      ALRT(N,2,2)=SFUS(1,N,1)
   10 ALRT(N,3,2)=SFUS(1,N,2)
      WRITE (KFILE2)((ALRT(N,N3,2),N=1,NAN),N3=1,3)
      DO 13 NN=2,NFUSOR
      DO 11 N=1,NAN
      DO 11 N3=1,3
      ALRT(N,N3,1)=ALRT(N,N3,2)
   11 CONTINUE
      DO 12 N=1,NAN
      ALRT(N,1,2)=XFUS(NN)
      ALRT(N,2,2)=SFUS(NN,N,1)
   12 ALRT(N,3,2)=SFUS(NN,N,2)
      CALL SURCC(NAN)
      WRITE (KFILE2)((VECRT(N,N3),N=1,NL1),N3=1,3)
      WRITE (KFILE2)((ALRT(N,N3,2),N=1,NAN),N3=1,3)
   13 CONTINUE
C***  FIND MAXIMUM DISTANCE AND MIDPOINT
      YMIN=-YMAX
      XDIS=XMAX-XMIN
      YDIS=YMAX-YMIN
      ZDIS=ZMAX-ZMIN
      BIGD=AMAX1(XDIS,YDIS,ZDIS)
      XMID=.5*(XMAX-XMIN)+XMIN
      YMID=0.
```

```
      ZMID=.5*(ZMAX-ZMIN)+ZMIN                                          C10  95
      RETURN                                                            C10  96
      END                                                               C10  97


      SUBROUTINE SURCL(NPT)                                             SCL   1
C                                                                       SCL   2
C***  COMPUTES SURFACE UNIT NORMALS                                     SCL   3
C                                                                       SCL   4
      COMMON /AV/FLINE(212,3,2),FVEC(211,3)                             SCL   5
C                                                                       SCL   6
      DO 2 N=2,NPT                                                      SCL   7
      T1X=FLINE(N,1,2)-FLINE(N-1,1,1)                                   SCL   8
      T2X=FLINE(N-1,1,2)-FLINE(N,1,1)                                   SCL   9
      T1Y=FLINE(N,2,2)-FLINE(N-1,2,1)                                   SCL  10
      T2Y=FLINE(N-1,2,2)-FLINE(N,2,1)                                   SCL  11
      T1Z=FLINE(N,3,2)-FLINE(N-1,3,1)                                   SCL  12
      T2Z=FLINE(N-1,3,2)-FLINE(N,3,1)                                   SCL  13
      XNX=T2Y*T1Z-T1Y*T2Z                                               SCL  14
      YNY=T1X*T2Z-T2X*T1Z                                               SCL  15
      ZNZ=T2X*T1Y-T1X*T2Y                                               SCL  16
      FN=SQRT(XNX**2+YNY**2+ZNZ**2)                                     SCL  17
      IF (FN.EQ.0.) GO TO 1                                             SCL  18
      FVEC(N-1,1)=XNX/FN                                                SCL  19
      FVEC(N-1,2)=YNY/FN                                                SCL  20
      FVEC(N-1,3)=ZNZ/FN                                                SCL  21
      GO TO 2                                                           SCL  22
    1 FVEC(N-1,1)=0.                                                    SCL  23
      FVEC(N-1,2)=0.                                                    SCL  24
      FVEC(N-1,3)=0.                                                    SCL  25
    2 CONTINUE                                                          SCL  26
      RETURN                                                            SCL  27
      END                                                               SCL  28


      SUBROUTINE SURCC(NPT)                                             SCC   1
C                                                                       SCC   2
C***  COMPUTES SURFACE UNIT NORMALS                                     SCC   3
C                                                                       SCC   4
      COMMON /AV/FLINE(212,3,2),FVEC(211,3)                             SCC   5
```

```
C                                                          SCC   6
      DO 2 N=2,NPT                                         SCC   7
      T1X=FLINE(N,1,2)-FLINE(N-1,1,1)                      SCC   8
      T2X=FLINE(N,1,1)-FLINE(N-1,1,2)                      SCC   9
      T1Y=FLINE(N,2,2)-FLINE(N-1,2,1)                      SCC  10
      T2Y=FLINE(N,2,1)-FLINE(N-1,2,2)                      SCC  11
      T1Z=FLINE(N,3,2)-FLINE(N-1,3,1)                      SCC  12
      T2Z=FLINE(N,3,1)-FLINE(N-1,3,2)                      SCC  13
      XNX=T2Y*T1Z-T1Y*T2Z                                  SCC  14
      YNY=T1X*T2Z-T2X*T1Z                                  SCC  15
      ZNZ=T2X*T1Y-T1X*T2Y                                  SCC  16
      FN=SQRT(XNX**2+YNY**2+ZNZ**2)                        SCC  17
      IF (FN.EQ.0.) GO TO 1                                SCC  18
      FVEC(N-1,1)=XNX/FN                                   SCC  19
      FVEC(N-1,2)=YNY/FN                                   SCC  20
      FVEC(N-1,3)=ZNZ/FN                                   SCC  21
      GO TO 2                                              SCC  22
    1 FVEC(N-1,1)=0.                                       SCC  23
      FVEC(N-1,2)=0.                                       SCC  24
      FVEC(N-1,3)=0.                                       SCC  25
    2 CONTINUE                                             SCC  26
      RETURN                                               SCC  27
      END                                                  SCC  28

      SUBROUTINE CBC20(NRADX,NFORX)                        C20   1
C                                                          C20   2
C***  CONTROL ROUTINE FOR VARIOUS TYPES OF PLOTS OF A BODY  C20   3
C                                                          C20   4
      COMMON /PASS/ABC(20),ABCDE(20),HORZ,VERT,TEST1,PHI,THETA,PSI,XF,YF C20 5
     1,ZF,DIST,FMAG,PLOTSZ,TYPE,XMIN,XMAX,YMIN,YMAX,ZMIN,ZMAX,XMID,YMID, C20 6
     1ZMID,BIGD,KODF,ISP                                   C20   7
      COMMON /INOUT/JREAD,JWRITE,JPUNCH,KFILE1,KFILE2,KFILE3,KFILE4,IWRI C20 8
     1TE                                                   C20   9
      DIMENSION ORG(3)                                     C20  10
      DATA TYPEP/3HPER/,TYPES/3HSTE/,TYPEV/3HVU3/          C20  11
      DATA X1/1HX/,Y1/1HY/,Z1/1HZ/                         C20  12
C                                                          C20  13
      REWIND KFILE2                                        C20  14
C***  SAVE MIN AND MAX                                     C20  15
      XSAV=XMIN                                            C20  16
```

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```
      YSAV=YMIN
      ZSAV=ZMIN
      XMSAV=XMAX
      YMSAV=YMAX
      ZMSAV=ZMAX
      IF (TYPE.NE.TYPEV) GO TO 5
      SCALF=BIGD/PLOTSZ
      ORG(1)=PHI
      ORG(2)=THETA
      ORG(3)=PSI
      PHI=0.
      THETA=0.
      PSI=0.
      YBIG=ORG(1)
      YORG=FLOAT(IFIX(YMAX/SCALE))+ORG(1)
      IF (YBIG.GT.ORG(2)) GO TO 1
      YBIG=ORG(2)
      YORG=FLOAT(IFIX(ZMAX/SCALE))+ORG(2)
    1 IF (YBIG.GT.ORG(3)) GO TO 2
      YBIG=ORG(3)
      YORG=FLOAT(IFIX(ZMAX/SCALE))+ORG(3)
    2 CALL CALPLT(2.0,YORG,-3)
C***  NOTATE ON 3VIEW PLOTS
      NCHAR=IFIX(6.*PLOTSZ)
      IF (NCHAR.GT.80) GO TO 3
      X=0.
      GO TO 4
    3 NDIF=(NCHAR-8))/2
      X=FLOAT(NDIF)/6.
      NCHAR=80
    4 CALL NOTATE(X,0.,.2,ABC,0.,NCHAR)
      XMIN=0.
      YMIN=0.
      ZMIN=0.
      HORZ=X1
      VERT=Y1
      YORG=ORG(1)-YORG-1
      CALL CALPLT(0.,YORG,-3)
      CALL CBC21(NRADX,NFORX)
      REWIND KFILE2
      VERT=Z1
      YORG=ORG(2)-ORG(1)
```

```
      CALL CALPLT(0.,YORG,-3)
      CALL CBC21(NRADX,NFORX)
      REWIND KFILE2
      HORZ=Y1
      YORG=ORG(3)-ORG(2)
      YMIN=FLOAT(IFIX(YSAV/SCALE))*SCALE
      CALL CALPLT(0.,YORG,-3)
      CALL CBC21(NRADX,NFORX)
      X=FLOAT(IFIX(PLOTSZ+6.))
      Y=1.-ORG(3)
      GO TC 9
    5 IF (TYPE.EQ.TYPES) GO TO 7
C***  NOTATE ID CN PLOT
      X=0.
      NCHAR=IFIX(11.*PLOTSZ)+3
      IF (NCHAR.LE.80) GO TO 6
      NDIF=(NCHAR-80)/2
      X=FLOAT(NDIF)/11.
      NCHAR=80
    6 CALL NOTATE(X,.5,.1,ABC,0.,NCHAR)
      CALL NOTATE(X,0.,.1,ABCDE,0.,NCHAR)
    7 CALL CALPLT(0.,0.,-3)
      IF (TYPE.EQ.TYPEP.OR.TYPE.EQ.TYPES) GO TO 8
C***  ORTHOGRAPHIC
      CALL CBC21(NRADX,NFORX)
      X=FLOAT(IFIX(PLOTSZ+2.))
      Y=-0.
      GO TO 9
    8 ISP=1
      IF (TYPE.EQ.TYPES)ISP=2
C***  PERSPECTIVE OR STEREO
      CALL CBC22(NRADX,NFORX)
      X=PLOTSZ+2.
      IF (TYPE.EQ.TYPES)X=X+PLOTSZ
      Y=-0.
C***  END CF CCMPLETE PLOT
    9 CALL CALPLT(X,Y,-3)
C***  RESTORE MIN AND MAX
      XMIN=XSAV
      YMIN=YSAV
      ZMIN=ZSAV
      XMAX=XMSAV
```

```
      YMAX=YMSAV
      ZMAX=ZMSAV
      RETURN
      END

      SUBROUTINE CBC21(NRADX,NFORX)
C
C***  CONTROL ROUTINE FOR ORTHOGRAPHIC PROJECTIONS
C
      COMMON /PASS/ABC(20),ABCDE(20),HORZ,VERT,TEST1,PHI,THETA,PSI,XF,YF
     1,ZF,DIST,FMAG,PLOTSZ,TYPE,XMIN,XMAX,YMIN,YMAX,ZMIN,ZMAX,XMID,YMID,
     1ZMID,BIGD,KCDE,ISP
      DIMENSION C(3)
      COMMON /DPLT/ALINE(212,3),RLINE(212,2),RVEC(211,2),PLINE(212,2),A(
     12,3),NNUM(10)
      DATA XSEE/2HX /,YSEE/2HY /,XINTST/3HOUT/,CCNV/.017453293/
      DATA HVU3/3HVU3/
C
C***  INITIALIZE
      ITEST1=1
      DMAX=BIGD
      ITEST2=1
      IF (XINTST.NE.TEST1)ITEST1=0
      IF (PSI.EQ.0..AND.THETA.EQ.0..AND.PHI.EQ.0.)ITEST2=0
      SCALF=DMAX/PLOTSZ
      PHI=CONV*PHI
      THETA=CCNV*THETA
      PSI=CONV*PSI
      IF (TYPE.EQ.HVU3) GO TO 1
      XDIS=XMAX-XMIN
      YDIS=YMAX-YMIN
      ZDIS=ZMAX-ZMIN
      XFIX=.5*(DMAX-XDIS)
      XMIN=XMIN-XFIX
      XMAX=XMAX+XFIX
      YFIX=.5*(DMAX-YDIS)
      YMIN=YMIN-YFIX
      YMAX=YMAX+YFIX
      ZFIX=.5*(DMAX-ZDIS)
      ZMIN=ZMIN-ZFIX
```

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      ZMAX=ZMAX+ZFIX
C***  ADJUST MINIMUMS FOR GRID LINES
      XMIN=FLOAT(IFIX(XMIN/SCALE))*SCALE
      YMIN=FLOAT(IFIX(YMIN/SCALE))*SCALE
      ZMIN=FLOAT(IFIX(ZMIN/SCALE))*SCALE
C***  SETUP AXIS
    1 SINPSI=SIN(PSI)
      SINTHE=SIN(THETA)
      SINPHI=SIN(PHI)
      CCSPSI=CCS(PSI)
      COSTHE=COS(THETA)
      COSPHI=COS(PHI)
      IF (XSEE.NE.HORZ) GO TO 3
C***  USE X FOR HORIZONTAL VARIABLE
      IF (ITEST2.EQ.0) GO TO 2
      A(1,1)=COSTHE*COSPSI
      A(1,2)=-SINPSI*COSPHI+SINTHE*COSPSI*SINPHI
      A(1,3)=SINPSI*SINPHI+SINTHE*COSPSI*COSPHI
    2 HMIN=XMIN
      HMAX=XMAX
      HMID=XMID
      IHORZ=1
      GO TO 7
    3 IF (YSEE.NE.HORZ) GO TO 5
C***  USE Y FOR HORIZONTAL VARIABLE
      IF (ITEST2.EQ.0) GO TO 4
      A(1,1)=COSTHE*SINPSI
      A(1,2)=COSPSI*COSPHI+SINTHE*SINPSI*SINPHI
      A(1,3)=-COSPSI*SINPHI+SINTHE*SINPSI*COSPHI
    4 HMIN=YMIN
      HMAX=YMAX
      HMID=YMID
      IHORZ=2
      GO TO 7
C***  USE Z FOR HORIZONTAL VARIABLE
    5 IF (ITEST2.EQ.0) GO TO 6
      A(1,1)=-SINTHE
      A(1,2)=COSTHE*SINPHI
      A(1,3)=COSTHE*COSPHI
    6 HMIN=ZMIN
      HMAX=ZMAX
      HMID=ZMID
```

```
      IHORZ=3
    7 IF (XSEE.NE.VERT) GO TO 9
C***  USE X FOR VERTICAL VARIABLE
      IF (ITEST2.EQ.0) GO TO 8
      A(2,1)=COSTHE*COSPSI
      A(2,2)=-SINPSI*COSPHI+SINTHE*COSPSI*SINPHI
      A(2,3)=SINPSI*SINPHI+SINTHE*COSPSI*COSPHI
    8 VMIN=XMIN
      VMAX=XMAX
      VMID=XMID
      IVERT=1
      GO TO 13
    9 IF (YSEE.NE.VERT) GO TO 11
C***  USE Y FOR VERTICAL VARIABLE
      IF (ITEST2.EQ.0) GO TO 10
      A(2,1)=COSTHE*SINPSI
      A(2,2)=COSPSI*COSPHI+SINTHE*SINPSI*SINPHI
      A(2,3)=-COSPSI*SINPHI+SINTHE*SINPSI*COSPHI
   10 VMIN=YMIN
      VMAX=YMAX
      VMID=YMID
      IVERT=2
      GO TO 13
C***  USE Z FOR VERTICAL VARIABLE
   11 IF (ITEST2.EQ.0) GO TO 12
      A(2,1)=-SINTHE
      A(2,2)=COSTHE*SINPHI
      A(2,3)=COSTHE*COSPHI
   12 VMIN=ZMIN
      VMAX=ZMAX
      VMID=ZMID
      IVERT=3
C***  CHECK PAPER PLANE
   13 IF (.NOT.((IHORZ.EQ.1.AND.IVERT.EQ.2).OR.(IVERT.EQ.1.AND.IHORZ.EQ.
     12))) GO TO 14
      ITEST=3
      C(1)=-SINTHE
      C(2)=COSTHE*SINPHI
      C(3)=COSTHE*COSPHI
      GO TO 16
   14 IF (.NOT.((IHORZ.EQ.1.AND.IVERT.EQ.3).OR.(IVERT.EQ.1.AND.IHORZ.EQ.
     13))) GO TO 15
```

```
      ITEST=2
      C(1)=COSTHE*SINPSI
      C(2)=COSPSI*COSPHI+SINTHE*SINPSI*SINPHI
      C(3)=-COSPSI*SINPHI+SINTHE*SINPSI*COSPHI
      GO TO 16
   15 ITEST=1
      C(1)=COSTHE*COSPSI
      C(2)=-SINPSI*COSPHI+SINTHE*COSPSI*SINPHI
      C(3)=SINPSI*SINPHI+SINTHE*COSPSI*COSPHI
C***  CENTER WITHIN PAGE SIZE IF  SIZE GREATER THAN 28 INCHES
   16 IF (PLOTSZ.GT.28..AND.TYPE.NE.HVU3)VMIN=-13.*SCALE+FLOAT(IFIX(VMID
     1/SCALE))*SCALE
C***  ROTATE MIDPOINT TO PLACE ROTATED VIEW CORRECTLY
      IF (ITEST2.EQ.0) GO TO 17
      AMID1=A(1,1)*XMID+A(1,2)*YMID+A(1,3)*ZMID
      AMID2=A(2,1)*XMID+A(2,2)*YMID+A(2,3)*ZMID
      HMIN=HMIN-HMID+AMID1
      VMIN=VMIN-VMID+AMID2
C***  BEGIN PLOTTING LINES
   17 CALL PLOTIT(NRADX,NFORX,ITEST,ITEST1,ITEST2,IHORZ,IVERT,HMIN,VMIN,
     1SCALE,C)
      CALL PLOTIT(NFORX,NRADX,ITEST,ITEST1,ITEST2,IHORZ,IVERT,HMIN,VMIN,
     1SCALE,C)
      RETURN
      END


      SUBROUTINE PLOTIT(NL,NPT,ITEST,ITEST1,ITEST2,IHORZ,IVERT,HMIN,VMIN
     1,SCALE,C)
C
C***  READS LINES OF POINTS DEFINING A SURFACE FROM DISK, MANIPULATES IN
C***  SPECIFIED MANNER, AND PLOTS
C
      COMMON /INOUT/JREAD,JWRITE,JPUNCH,KFILE1,KFILE2,KFILE3,KFILE4,IWRI
     1TE
      DIMENSION VECRT(211,3,2),VECLF(211,3,2),XLINE(214,2),C(3)
      COMMON /DPLT/ALINF(212,3),RLINF(212,2),RVFC(211,2),PLINE(212,2),A(
     12,3),NNUM(10)
C
      NVFC=NPT-1
      DO 31 N=1,NL
```

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      IF (N.GT.1) GO TO 1                                               PLT  15
      KODE=3                                                            PLT  16
      K1=2                                                              PLT  17
      K2=2                                                              PLT  18
      GO TO 4                                                           PLT  19
    1 KODE=1                                                            PLT  20
      K1=1                                                              PLT  21
      K2=2                                                              PLT  22
      DO 3 NV=1,NVEC                                                    PLT  23
      DO 2 N3=1,3                                                       PLT  24
      VECRT(NV,N3,1)=VECRT(NV,N3,2)                                     PLT  25
      VECLF(NV,N3,1)=VECLF(NV,N3,2)                                     PLT  26
    2 CONTINUE                                                          PLT  27
    3 CONTINUE                                                          PLT  28
    4 READ (KFILE2)((ALINE(NN,N3),NN=1,NPT),N3=1,3)                     PLT  29
      IF (N.NE.NL) GO TO 5                                              PLT  30
      KODE=2                                                            PLT  31
      K1=1                                                              PLT  32
      K2=1                                                              PLT  33
      GO TO 7                                                           PLT  34
    5 READ (KFILE2)((VECRT(NN,N3,2),NN=1,NVEC),N3=1,3)                  PLT  35
      DO 6 NN=1,NVEC                                                    PLT  36
      VECLF(NN,1,2)=VECRT(NN,1,2)                                       PLT  37
      VECLF(NN,2,2)=-VECRT(NN,2,2)                                      PLT  38
    6 VECLF(NN,3,2)=VECRT(NN,3,2)                                       PLT  39
    7 DO 30 NN2=1,2                                                     PLT  40
C***  LOOP FOR RIGHT AND LEFT SIDE OF BODY                              PLT  41
      IF (NN2.EQ.1) GO TO 9                                             PLT  42
      DO 8 NN=1,NPT                                                     PLT  43
    8 ALINE(NN,2)=-ALINE(NN,2)                                          PLT  44
    9 IF (ITEST1.EQ.1) GO TO 14                                         PLT  45
      IF (ITEST2.EQ.1) GO TO 11                                         PLT  46
C***  NO ROTATION OR VISIBILITY TEST                                    PLT  47
      DO 10 NN=1,NPT                                                    PLT  48
      XLINE(NN,1)=ALINE(NN,IHORZ)                                       PLT  49
   10 XLINE(NN,2)=ALINE(NN,IVERT)                                       PLT  50
      GO TO 13                                                          PLT  51
C***  ROTATE BUT NO VISIBILITY TEST                                     PLT  52
   11 CALL PTROT(NPT)                                                   PLT  53
      DO 12 NN=1,NPT                                                    PLT  54
      DO 12 N2=1,2                                                      PLT  55
      XLINE(NN,N2)=RLINE(NN,N2)                                         PLT  56
```

```
   12 CONTINUE
C***  SCALE AND PLOT
   13 XLINE(NPT+1,1)=HMIN
      XLINE(NPT+1,2)=VMIN
      XLINE(NPT+2,1)=SCALE
      XLINE(NPT+2,2)=SCALE
      CALL LINE(XLINE(1,1),XLINE(1,2),NPT,1,0,0,0)
      GO TO 30
   14 IF (ITEST2.EQ.1) GO TO 19
C***  CHECK VISIBILITY BUT NO ROTATION
      DO 15 NN=1,NPT
      RLINE(NN,1)=ALINE(NN,IHORZ)
      RLINE(NN,2)=ALINE(NN,IVERT)
   15 CONTINUE
      DO 18 NN=1,NVEC
      DO 17 N2=1,2
      IF (NN2.EQ.2) GO TO 16
      RVEC(NN,N2)=VECRT(NN,ITEST,N2)
      GO TO 17
   16 RVEC(NN,N2)=VECLF(NN,ITEST,N2)
   17 CONTINUE
   18 CONTINUE
      GO TO 23
C***  ROTATE AND CHECK VISIBILITY
   19 CALL PTROT(NPT)
      IF (NN2.EQ.2) GO TO 21
      DO 20 N2=K1,K2
      CALL VECROT(NVEC,C,VECRT(1,1,N2),RVEC(1,N2))
   20 CONTINUE
      GO TO 23
   21 DO 22 N2=K1,K2
      CALL VECROT(NVEC,C,VECLF(1,1,N2),RVEC(1,N2))
   22 CONTINUE
C***  FIND VISIBLE LINES
   23 IF (ITEST.NE.2) GO TO 25
      DO 24 N2=K1,K2
      DO 24 M=1,NVEC
   24 RVEC(M,N2)=-RVEC(M,N2)
   25 CALL VISTST(KODF,NPT,NSET)
      IF (ITEST.NE.2) GO TO 27
      DO 26 N2=K1,K2
      DO 26 M=1,NVEC
```

```
   26 RVEC(M,N2)=-RVEC(M,N2)                                           PLT  99
   27 IF (NSET.EQ.0) GO TO 30                                          PLT 100
C***  SCALE AND PLOT                                                   PLT 101
      NIT=0                                                            PLT 102
      DO 29 N1=1,NSET                                                  PLT 103
      NN=NNUM(N1)                                                      PLT 104
      DO 28 NN1=1,NN                                                   PLT 105
      NIT=NIT+1                                                        PLT 106
      XLINE(NN1,1)=PLINE(NIT,1)                                        PLT 107
      XLINE(NN1,2)=PLINE(NIT,2)                                        PLT 108
   28 CONTINUE                                                         PLT 109
      XLINE(NN+1,1)=HMIN                                               PLT 110
      XLINE(NN+1,2)=VMIN                                               PLT 111
      XLINE(NN+2,1)=SCALE                                              PLT 112
      XLINE(NN+2,2)=SCALE                                              PLT 113
      CALL LINE(XLINE(1,1),XLINE(1,2),NN,1,0,0,0)                      PLT 114
   29 CONTINUE                                                         PLT 115
   30 CONTINUE                                                         PLT 116
   31 CONTINUE                                                         PLT 117
      RETURN                                                           PLT 118
      END                                                              PLT 119


      SUBROUTINE VISTST(KODE,NPT,NSET)                                 VIS   1
C                                                                      VIS   2
C***  TESTS A LINE OF POINTS FOR VISIBILITY                            VIS   3
C                                                                      VIS   4
      COMMON /DPLT/ALINE(212,3),RLINE(212,2),RVEC(211,2),PLINE(212,2),A(VIS   5
     12,3),NNUM(10)                                                    VIS   6
C                                                                      VIS   7
      IWRITE=0                                                         VIS   8
      IF (NPT.EQ.81.OR.NPT.EQ.85)IWRITE=1                              VIS   9
      NVEC=NPT-1                                                       VIS  10
      NPLT=0                                                           VIS  11
      NSET=0                                                           VIS  12
      ICOUNT=0                                                         VIS  13
      GO TO (1,2,3),KODE                                               VIS  14
    1 N1=1                                                             VIS  15
      N2=2                                                             VIS  16
      GO TO 4                                                          VIS  17
    2 N1=1                                                             VIS  18
```

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```
      N2=1
      GO TO 4
    3 N1=2
      N2=2
    4 DO 13 N=1,NPT
      IF (N.EQ.1) GO TO 6
      IF (N.EQ.NPT) GO TO 8
      DO 5 NN=N1,N2
      IF ((RVEC(N-1,NN).GT.0.).OR.(RVEC(N,NN).GT.0.)) GO TO 12
    5 CONTINUE
      GO TO 10
    6 DO 7 NN=N1,N2
      IF (RVEC(1,NN).GT.0.) GO TO 12
    7 CONTINUE
      GO TO 10
    8 DO 9 NN=N1,N2
      IF (RVEC(NVEC,NN).GT.0.) GO TO 12
    9 CONTINUE
C***  POINT NOT VISIBLE
   10 IF (ICOUNT.LE.1) GO TO 11
      NSET=NSET+1
      NNUM(NSET)=ICOUNT
   11 ICOUNT=0
      GO TO 13
C***  POINT IS VISIBLE
   12 NPLT=NPLT+1
      ICOUNT=ICOUNT+1
      PLINE(NPLT,1)=RLINE(N,1)
      PLINE(NPLT,2)=RLINE(N,2)
   13 CONTINUE
      IF (ICOUNT.LE.1) GO TO 14
      NSET=NSET+1
      NNUM(NSET)=ICOUNT
   14 RETURN
      END

      SUBROUTINE PTROT(NPT)
C
C***  ROTATES AND PROJECTS A SET OF 3-D POINTS
C
```

```
      COMMON /DPLT/ALINE(212,3),RLINE(212,2),RVEC(211,2),PLINE(212,2),A(
     12,3),NNUM(10)
C
      DO 2 N=1,NPT
      RLINE(N,1)=0.
      RLINE(N,2)=0.
      DO 1 I=1,2
      DO 1 J=1,3
      RLINE(N,I)=RLINE(N,I)+A(I,J)*ALINE(N,J)
    1 CONTINUE
    2 CONTINUE
      RETURN
      END


      SUBROUTINE VECROT(NVEC,C,FVEC,RVEC)
C
C***  TRANSFORMS VECTORS
C
      DIMENSION C(3),FVEC(211,3),RVEC(211)
C
      DO 2 N=1,NVEC
      SUM=0.
      DO 1 NN=1,3
    1 SUM=SUM+C(NN)*FVEC(N,NN)
    2 RVEC(N)=SUM
      RETURN
      END


      SUBROUTINE CBC22(NRADX,NFORX)
C
C***  CONTROL ROUTINE FOR PERSPECTIVE AND STEREO
C
      COMMON /PASS/ABC(20),ABCDF(20),HORZ,VERT,TEST1,PHI,THETA,PSI,XF,YF
     1,ZF,DIST,FMAG,PLOTSZ,TYPE,XMIN,XMAX,YMIN,YMAX,ZMIN,ZMAX,XMID,YMID,
     1ZMID,BIGD,KODE,ISP
      COMMON /INOUT/JREAD,JWRITE,JPUNCH,KFILE1,KFILE2,KFILE3,KFILE4,IWRI
     1TE
      DIMENSION XINIT(2),YINIT(2),ZINIT(2)
```

```
C
      XINIT(1)=PHI
      XINIT(2)=XF
      YINIT(1)=THETA
      YINIT(2)=YF
      ZINIT(1)=PSI
      ZINIT(2)=ZF
      CALL STERPT(XINIT,YINIT,ZINIT,0,1,0,3,PLOTSZ,DIST,FMAG)
C***  LOOP FOR RIGHT AND LEFT FRAMES
      DO 1 IC=1,ISP
      REWIND KFILE2
      NCI=-IC
C***  BEGIN PLOTTING LINES
      CALL PLTIT3(NRADX,NFORX,PHI,THETA,PSI,XF,YF,ZF,PLOTSZ,DIST,FMAG,NC
     1I)
      CALL PLTIT3(NFORX,NRADX,PHI,THETA,PSI,XF,YF,ZF,PLOTSZ,DIST,FMAG,NC
     1I)
    1 CONTINUE
      RETURN
      END


      SUBROUTINE STERPT(X,Y,Z,N,K,NC,IP,PAG,PLA,XPR)
C
C***  PLOTS STEREO        (PROGRAMMER - GEORGE C. SALLEY)
C
      DIMENSION VP(3),TRAN(3),SANG(3),CANG(3),ADJ(3),PT(4),XLP(2),ZLP(2)
      DIMENSION X(1),Y(1),Z(1)
      DIMENSION PLX(4),PLY(4),PLZ(2)
      DIMENSION PIX(4),PIY(4),PIZ(2)
      DIMENSION ILP(4),IPL(4)
      DATA PI,PI2,PI32,PI42/3.1415926,1.5707963,4.7123889,6.2831952/
      DATA PAP/1.125/
      DATA NPG/0/
      DATA NPT/1/
      DATA FRAME/9.80/
      DATA TURN/11.01/
C
      NC=1
      KK=K
      II=IP
```

```
      IF (NC)  16,1,22
    1 NP=N*K+1
      NR=NP+K
      PLIM=PAG/2.
      SF=XPR
      VPL=PLA
      DO 2 I=1,4
      PLX(I)=0.
      PLY(I)=0.
      PIX(I)=0.
      PIY(I)=0.
      IPL(I)=0
    2 ILP(I)=0
      DO 3 I=1,2
      PLZ(I)=0.
    3 PIZ(I)=0.
      VPX=X(NP)
      VPY=Y(NP)
      VPZ=Z(NP)
      FPX=X(NR)
      FPY=Y(NR)
      FPZ=Z(NR)
      VX=VPX-FPX
      VY=VPY-FPY
      VZ=VPZ-FPZ
      VP(2)=SQRT((VX**2)+(VY**2))
      VP(3)=SQRT((VZ**2)+(VP(2)**2))
      TRAN(1)=VPX-(VPL*(VX/VP(2)))
      TRAN(2)=VPY-(VPL*(VY/VP(2)))
      TRAN(3)=VPZ-(VPL*(VZ/VP(3)))
      VANG=ATAN((PAR/VP(3)))
      IF (VX)  11,4,7
    4 IF (VY)  6,6,5
    5 PANG=PI2
      GO TO 15
    6 PANG=PI32
      GO TO 15
    7 IF (VY)  10,8,9
    8 PANG=0.
      GO TO 15
    9 PANG=ATAN((VY/VX))
      GO TO 15
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10 PANG=PI42-ATAN(((ABS(VY))/VX))
   GO TO 15
11 IF (VY)  14,12,13
12 PANG=PI
   GO TO 15
13 PANG=PI-ATAN((VY/(ABS(VX))))
   GO TO 15
14 PANG=PI+ATAN(((ABS(VY))/(ABS(VX))))
15 PANG=PI32-PANG
   UANG=PANG-VANG
   RANG=UANG+(2.*VANG)
   SANG(1)=SIN(UANG)
   SANG(2)=SIN(RANG)
   CANG(1)=COS(UANG)
   CANG(2)=COS(RANG)
   SANG(3)=VZ/VP(3)
   CANG(3)=VP(2)/VP(3)
   VP(3)=VPL
   XLP(1)=0.
   ZLP(1)=0.
   XLP(2)=FRAME
   ZLP(2)=0.
   ADJ(1)=PLIM
   ADJ(2)=PLIM
   ADJ(3)=ADJ(2)+FRAME
   IF (N)  60,60,22
16 M=IABS(NC)
   L=M
   IF (NPG+NC)  23,17,23
17 IF (2+NC)  60,19,18
18 NPG=2
   GO TO 20
19 NPG=1
20 DO 21 I=1,L
   CALL CALPLT(TURN,0.,-3)
21 CONTINUE
   CALL CALPLT(XLP(M),ZLP(M),3)
22 M=1
   L=2
23 DO 59 I=M,L
   IF (NPG)  60,24,30
24 IF (NC)  25,29,29
```

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25 IF (NPT+NC)  30,26,30                                    STE 104
26 IF (2+NC)  60,28,27                                      STE 105
27 NPT=2                                                    STE 106
   GO TO 29                                                 STE 107
28 NPT=1                                                    STE 108
29 CALL CALPLT(XLP(I),ZLP(I),3)                             STE 109
30 DO 58 J=1,N                                              STE 110
   PT(1)=((X(NO)-TRAN(1))*CANG(I))-((Y(NO)-TRAN(2))*SANG(I))    STE 111
   PT(4)=((X(NO)-TRAN(1))*SANG(I))+((Y(NO)-TRAN(2))*CANG(I))    STE 112
   PT(2)=((PT(4)*CANG(3))-((Z(NO)-TRAN(3))*SANG(3)))        STE 113
   PT(3)=((PT(4)*SANG(3))+((Z(NO)-TRAN(3))*CANG(3)))        STE 114
   IF (PT(2))  31,36,36                                     STE 115
31 IF (ILP(I))  60,32,35                                    STE 116
32 IF (II-3)  33,34,60                                      STE 117
33 VX=PLX(I)-PT(1)                                          STE 118
   VY=PLY(I)-PT(2)                                          STE 119
   VZ=PLZ(I)-PT(3)                                          STE 120
   VP(1)=SQRT((VX**2)+(VY**2))                              STE 121
   VP(2)=SQRT((VZ**2)+(VP(1)**2))                           STE 122
   VPL=PLY(I)/(VY/VP(1))                                    STE 123
   PT(4)=PLX(I)-((VX/VP(1))*VPL)                            STE 124
   PLX(I)=PT(1)                                             STE 125
   PT(1)=PT(4)                                              STE 126
   PLY(I)=PT(2)                                             STE 127
   PT(2)=0.                                                 STE 128
   PT(4)=PLZ(I)-((VZ/VP(2))*VPL)                            STE 129
   PLZ(I)=PT(3)                                             STE 130
   PT(3)=PT(4)                                              STE 131
   ILP(I)=1                                                 STE 132
   GO TO 41                                                 STE 133
34 ILP(I)=1                                                 STE 134
35 PLX(I)=PT(1)                                             STE 135
   PLY(I)=PT(2)                                             STE 136
   PLZ(I)=PT(3)                                             STE 137
   GO TO 54                                                 STE 138
36 IF (ILP(I))  60,40,37                                    STE 139
37 IF (II-3)  38,39,60                                      STE 140
38 II=3                                                     STE 141
   IPL(I)=1                                                 STE 142
   PIX(I)=PT(1)                                             STE 143
   PIY(I)=PT(2)                                             STE 144
   PIZ(I)=PT(3)                                             STE 145
```

```
      VX=PT(1)-PLX(I)                                                   STE 146
      VY=PT(2)-PLY(I)                                                   STE 147
      VZ=PT(3)-PLZ(I)                                                   STE 148
      VP(1)=SQRT((VX**2)+(VY**2))                                       STE 149
      VP(2)=SQRT((VZ**2)+(VP(1)**2))                                    STE 150
      VPL=PT(2)/(VY/VP(1))                                              STE 151
      PT(2)=0.                                                          STE 152
      PT(1)=PT(1)-((VX/VP(1))*VPL)                                      STE 153
      PT(3)=PT(3)-((VZ/VP(2))*VPL)                                      STE 154
   39 ILP(I)=0                                                          STE 155
   40 PLX(I)=PT(1)                                                      STE 156
      PLY(I)=PT(2)                                                      STE 157
      PLZ(I)=PT(3)                                                      STE 158
   41 XP=(PT(1)+(PT(2)*(-PT(1))/(PT(2)+VP(3))))*SF                      STE 159
      ZP=(PT(3)+(PT(2)*(-PT(3))/(PT(2)+VP(3))))*SF                      STE 160
      VPL=SQRT((XP**2)+(ZP**2))                                         STE 161
      IF (VPL-PLIM)  47,47,42                                           STE 162
   42 IF (ILP(I+2))  60,43,46                                           STE 163
   43 IF (II-3)  44,45,60                                               STE 164
   44 PLX(I+2)=XP                                                       STE 165
      PLY(I+2)=ZP                                                       STE 166
      XP=PLIM*(XP/VPL)                                                  STE 167
      ZP=PLIM*(ZP/VPL)                                                  STE 168
      ILP(I+2)=1                                                        STE 169
      GO TO 53                                                          STE 170
   45 ILP(I+2)=1                                                        STE 171
   46 PLX(I+2)=XP                                                       STE 172
      PLY(I+2)=ZP                                                       STE 173
      GO TO 54                                                          STE 174
   47 IF (ILP(I+2))  60,51,48                                           STE 175
   48 IF (II-3)  49,50,60                                               STE 176
   49 II=3                                                              STE 177
      IPL(I+2)=1                                                        STE 178
      PIX(I+2)=XP                                                       STE 179
      PIY(I+2)=ZP                                                       STE 180
      VPL=SQRT((PLX(I+2)**2)+(PLY(I+2)**2))                             STE 181
      XP=PLIM*(PLX(I+2)/VPL)                                            STE 182
      ZP=PLIM*(PLY(I+2)/VPL)                                            STE 183
   50 ILP(I+2)=0                                                        STE 184
      GO TO 52                                                          STE 185
   51 IF ((SQRT(((PLX(I+2))**2)+((PLY(I+2))**2)))-PLIM)  52,52,48       STE 186
   52 PLX(I+2)=XP                                                       STE 187
```

```
      PLY(I+2)=ZP                                                       STE 188
   53 XPT=XP+ADJ(I+1)                                                   STE 189
      YPT=ZP+ADJ(1)                                                     STE 190
      CALL CALPLT(XPT,YPT,II)                                           STE 191
   54 II=2                                                              STE 192
      IF (IPL(I+2)) 60,56,55                                            STE 193
   55 IPL(I+2)=0                                                        STE 194
      XP=PIX(I+2)                                                       STE 195
      ZP=PIY(I+2)                                                       STE 196
      GO TO 51                                                          STE 197
   56 IF (IPL(I)) 60,58,57                                              STE 198
   57 IPL(I)=0                                                          STE 199
      PT(1)=PIX(I)                                                      STE 200
      PT(2)=PIY(I)                                                      STE 201
      PT(3)=PIZ(I)                                                      STE 202
      GO TO 40                                                          STE 203
   58 NC=NC+KK                                                          STE 204
      XLP(I)=XPT                                                        STE 205
      ZLP(I)=YPT                                                        STE 206
      NO=1                                                              STE 207
   59 II=IP                                                             STE 208
   60 RETURN                                                            STE 209
      END                                                               STE 210

      SUBROUTINE PLTIT3(NL,NPT,PHI,THETA,PSI,XF,YF,ZF,PLOTSZ,DIST,FMAG,N PL3    1
     1CI)                                                               PL3    2
C                                                                       PL3    3
C***  READS LINES OF POINTS DEFINING A SURFACE FROM DISK                 PL3    4
C                                                                       PL3    5
      COMMON /INOUT/JREAD,JWRITE,JPUNCH,KFILE1,KFILE2,KFILE3,KFILE4,IWRI PL3    6
     1TE                                                                PL3    7
      DIMENSION ALINE(214,3)                                            PL3    8
C                                                                       PL3    9
      ALINE(NPT+1,1)=PHI                                                PL3   10
      ALINE(NPT+2,1)=XF                                                 PL3   11
      ALINE(NPT+1,2)=THETA                                              PL3   12
      ALINE(NPT+2,2)=YF                                                 PL3   13
      ALINE(NPT+1,3)=PSI                                                PL3   14
      ALINE(NPT+2,3)=ZF                                                 PL3   15
      DO 5 N=1,NL                                                       PL3   16
```

```
      READ (KFILE2)((ALINE(NN,N3),NN=1,NPT),N3=1,3)                      PL3
      IF (N.EQ.NL) GO TO 1                                               PL3
C***  SKIP VECTORS                                                       PL3
      READ (KFILE2)VEC                                                   PL3
C***  LOOP FOR RIGHT AND LEFT SIDE OF BODY                               PL3
    1 DO 4 NN2=1,2                                                       PL3
      IF (NN2.EQ.1) GO TO 3                                              PL3
      DO 2 NN=1,NPT                                                      PL3
    2 ALINE(NN,2)=-ALINE(NN,2)                                           PL3
    3 CALL STERPT(ALINE(1,1),ALINE(1,2),ALINE(1,3),NPT,1,NCI,3,PLOTSZ,DI PL3
     1ST,FMAG)                                                           PL3
    4 CONTINUE                                                           PL3
    5 CONTINUE                                                           PL3
      RETURN                                                             PL3
      END                                                                PL3


      SUBROUTINE CALPLT(A,B,I)                                           CAL
C                                                                        CAL
C***  IMPORTANT???                                                       CAL
C***                                                                     CAL
C***  THIS SUBROUTINE USES THE PLOTTER SOFTWARE AVAILABLE AT N. C. STATE CAL
C***  UNIVERSITY (SUBROUTINES PLOT AND ORIGIN) TO REPRODUCE THE ACTIONS  CAL
C***  OF THE CALCOMP SOFTWARE SUBROUTINE CALPLT.                         CAL
C***                                                                     CAL
C***  IF THE USER DOES NOT HAVE THE ORIGINAL CALCOMP ROUTINE CALPLT      CAL
C***  AVAILABLE TO HIM, HE MUST WRITE A DUMMY SUBROUTINE, USING THE      CAL
C***  PLOTTER SOFTWARE AVAILABLE AT HIS INSTALLATION, WHICH WILL         CAL
C***  REPRODUCE THE ACTION OF CALPLT.                                    CAL
C                                                                        CAL
      DIMENSION A(1),B(1)                                                CAL
C                                                                        CAL
      IF (I.LT.0) GO TO 1                                                CAL
      J=I-2                                                              CAL
      CALL PLOT(A,B,J)                                                   CAL
      RETURN                                                             CAL
    1 J=IABS(I)                                                          CAL
      J=J-2                                                              CAL
      CALL PLOT(A,B,J)                                                   CAL
      CALL ORIGIN(A,B,1.0)                                               CAL
      RETURN                                                             CAL
```

```
      END
      SUBROUTINE NOTATE(A,B,C,D,E,I)
C
C***  IMPORTANT???
C***
C***  THIS SUBROUTINE USES THE PLOTTER SOFTWARE AVAILABLE AT N. C. STATE
C***  UNIVERSITY (SUBROUTINE SYMBOL) TO REPRODUCE THE ACTIONS OF THE
C***  CALCOMP SOFTWARE SUBROUTINE NOTATE.
C***
C***  IF THE USER DOES NOT HAVE THE ORIGINAL CALCOMP ROUTINE NOTATE
C***  AVAILABLE TO HIM, HE MUST WRITE A DUMMY SUBROUTINE, USING THE
C***  PLOTTER SOFTWARE AVAILABLE AT HIS INSTALLATION, WHICH WILL
C***  REPRODUCE THE ACTION OF NOTATE.
C
      DIMENSION D(1),DD(21)
      DATA STOP/4H   _/
C
      J=I/4
      XI=I
      XR=XI/4
      IF ((XR-J).GT.0.1)J=J+1
      DO 1 K=1,J
    1 DD(K)=D(K)
      DD(J+1)=STOP
      CALL SYMBOL(A,B,C,DD,E)
      RETURN
      END
      SUBROUTINE LINE(A,B,I,J,K,L,S)
C
C***  IMPORTANT???
C***
C***  THIS SUBROUTINE USES THE PLOTTER SOFTWARE AVAILABLE AT N. C. STATE
C***  UNIVERSITY (SUBROUTINE PLOT) TO REPRODUCE THE ACTIONS OF THE
C***  CALCOMP SOFTWARE SUBROUTINE LINE.
C***
C***  IF THE USER DOES NOT HAVE THE ORIGINAL CALCOMP ROUTINE LINE
```

```
C***   AVAILABLE TO HIM, HE MUST WRITE A DUMMY SUBROUTINE, USING THE
C***   PLOTTER SOFTWARE AVAILABLE AT HIS INSTALLATION, WHICH WILL
C***   REPRODUCE THE ACTION OF LINE.
C
       DIMENSION A(1),B(1),X(212),Y(212)
C
       XMIN=A(I+1)
       XSCALE=A(I+2)
       YMIN=B(I+1)
       YSCALE=B(I+2)
       DO 1 II=1,I
       X(II)=(A(II)-XMIN)/XSCALE
     1 Y(II)=(B(II)-YMIN)/YSCALE
       CALL PLOT(X,Y,I)
       RETURN
       END
```

SAMPLE INPUT - GRIDPLOT

```
    29     21     60     60      599.0       11.5
    11      1      0      0     1      1    0    0      0     1.0
CESSNA  182 FUSELAGE   (N=29, M=21)  POINT  MODIFIED
 560
 12.20849609   0.0              -0.42710018     1   1    1
 12.20849609   0.0              -0.42710018     1   2    1
 12.20849609   0.0              -0.42710018     1   3    1
 12.20849609   0.0              -0.42710018     1   4    1
 12.20849609   0.0              -0.42710018     1   5    1
 12.20849609   0.0              -0.42710018     1   6    1
 12.20849609   0.0              -0.42710018     1   7    1
 12.20849609   0.0              -0.42710018     1   8    1
 12.20849609   0.0              -0.42710018     1   9    1
 12.20849609   0.0              -0.42710018     1  10    1
 12.20849609   0.0              -0.42710018     1  11    1
 12.20849609   0.0              -0.42710018     1  12    1
 12.20849609   0.0              -0.42710018     1  13    1
 12.20849609   0.0              -0.42710018     1  14    1
 12.20849609   0.0              -0.42710018     1  15    1
 12.20849609   0.0              -0.42710018     1  16    1
 12.20849609   0.0              -0.42710018     1  17    1
 12.20849609   0.0              -0.42710018     1  18    1
 12.20849609   0.0              -0.42710018     1  19    1
 12.20849609   0.0              -0.42710018     1  20    1
 12.20849609   0.0              -0.42710018     1  21    1
 11.54179382   0.0              -1.63539696     2   1    1
 11.54179382   0.13330997       -1.59789753     2   2    1
 11.54179382   0.35830218       -1.52709770     2   3    1
 11.54179382   0.51460171       -1.44369793     2   4    1
 11.54179382   0.67080063       -1.34999657     2   5    1
 11.54179382   0.81869990       -1.25209613     2   6    1
 11.54179382   0.96880031       -1.12709713     2   7    1
 11.54179382   1.10829830       -0.99579996     2   8    1
 11.54179382   1.26459789       -0.84369946     2   9    1
 11.54179382   1.40829754       -0.65209943     2  10    1
 11.54179382   1.51659788       -0.42710018     2  11    1
 11.54179382   1.57079792       -0.18540013     2  12    1
```

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11.54179382	1.56249905	0.07289881	2	13	1
11.54179382	1.49169731	0.32289863	2	14	1
11.54179382	1.32919884	0.52289993	2	15	1
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11.54179382	0.88330030	0.73960114	2	17	1
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8.87548828	1.82979393	-0.46509069	6	11	1
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C-3

-3.20848370	1.25000000	0.01039386	24	13	1
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    0     0     0     0     0
OPERATOR - PLEASE USE PLOTTING FORMS 0120 -
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X Z OUT     0.     0.     0.                       6.5   ORT                  1
N           1      2
N           4      1
N           5      3
END
X Z OUT    45.    10.    30.                       6.5   ORT                  0
X Z OUT     0.     0.     0.                       6.5   ORT                  1
     0      0      0      0      0      0      0      0          TERMINATION CARD
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SAMPLE OUTPUT - GRIDPLOT

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ADDITIONAL ARBITRARY STATION SPECIFICATIONS

DEPENDENT STATION	N-STATIONS 1ST HALF	N-STATIONS 2ND HALF	N-STATIONS 1ST HALF	N-STATIONS 2ND HALF
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2	0	0	0	0
3	0	0	0	0
4	0	0	1	0
5	0	0	3	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12			0	0
13			0	0
14			0	0
15			0	0

NEW DATASET

NMAX = 41, MMAX = 35 ----> 1360 QUADRILATERALS

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12.20020040	0.0	-0.42710010	1	8	1
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12.20020040	0.0	-0.42710010	1	10	1
12.20020040	0.0	-0.42710010	1	11	1
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12.20020040	0.0	-0.42710010	1	41	1
•		•			•
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•		•			•
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CONFIGURATION DESCRIPTION

NEW BODY WITH IMPROVED GRID

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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					
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0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									
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[illegible]									

0.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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0.0									
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[illegible]									

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0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									
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PLOT DATA

X Z OUT	[illegible]	[illegible]	[illegible]	0.0	0.0	0.0	0.0	0.0	[illegible]	[illegible]
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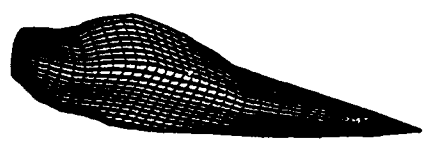
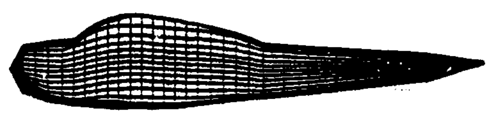


CESSNA 182 FUSELAGE (N=20, M=21) POINT MODIFIED

X Z OUT 45. 10. 30. 6.5 ORT



CESSNA 182 FUSELAGE (N=20, M=21) POINT MODIFIED

X Z OUT 0. 0. 0. 6.5 ORT 1

NEW BODY WITH IMPROVED GRID

X Z OUT 45. 10. 30. 6.5 ORT

NEW BODY WITH IMPROVED GRID

X Z OUT 0. 0. 0. 6.5 ORT 1

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