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A COUPLED INTERIOR BALLISTICS-FINITE ELEMENT COMBUSTION INSTABI--ETC(U)
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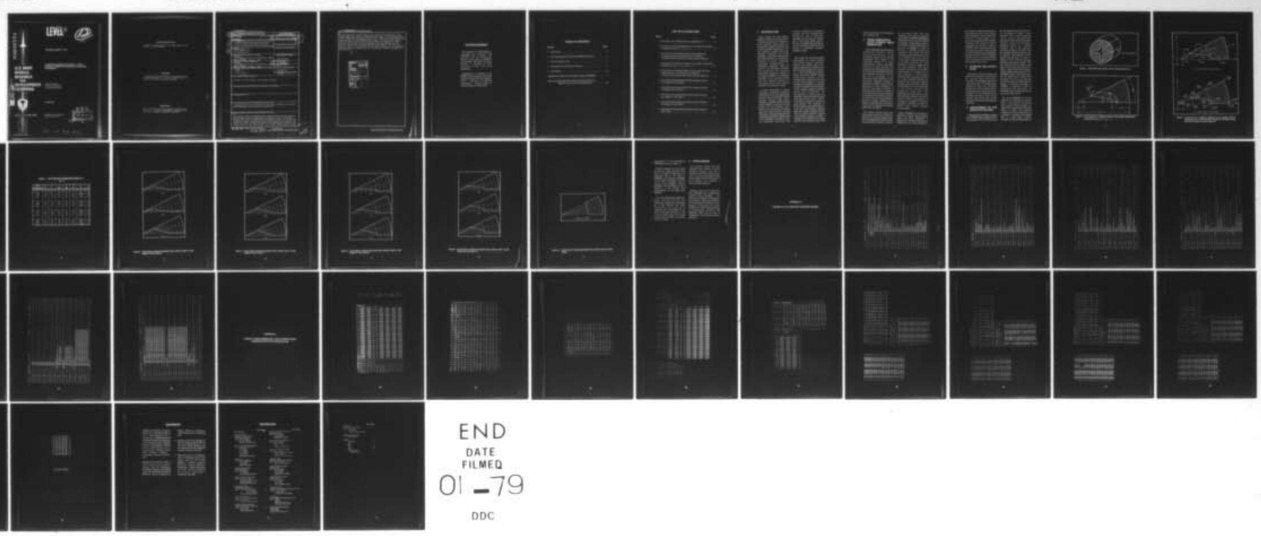

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TECHNICAL REPORT T-78-72

A COUPLED INTERIOR BALLISTICS — FINITE ELEMENT COMBUSTION INSTABILITY ANALYSIS PROCEDURE

Robert M. Hackett
Propulsion Directorate
Technology Laboratory

U.S. ARMY MISSILE RESEARCH AND DEVELOPMENT COMMAND

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An executive routine is developed which should provide the solid propellant grain designer with the capability of performing an interior ballistics analysis while, with a minimum amount of additional effort, at the same time performing a combustion instability prediction analysis of the system. The routine, in effect, couples the output of an existing solid propellant grain design evaluation code, which predicts the acoustic chamber geometry during → over

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surface regression, with the input to the existing three-dimensional finite element combustion instability prediction code, FLAP3. The three-dimensional finite element mesh and boundary conditions are generated from the grain surface regression data for the progressive burn times. The entire finite element mesh and boundary condition generation by FLESH3, the companion to FLAP3, is executed with the input of seven parameters, which are obtained from the ballistics code output or from the initial grain geometry. The use of the developed routine, in conjunction with the two existing codes, is demonstrated through a number of example cases of a star design, along with the case of a shell design.

ACKNOWLEDGMENT

The assistance of Robert Radke in developing the computer code GRNMSH and in running the numerous test cases is gratefully acknowledged. The effort of Francis Thiessen in preparing the final drawings is also very much appreciated.

Appreciation is expressed to the MIRADCOM Propulsion Directorate Redstone Arsenal, the Army Research Office - Durham, and Battelle Laboratories - Durham Office for financial support of this project.

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1. INTRODUCTION

Untii recently the term Interior Ballistics referred to the computation of head end pressure and thrust in solid propellant rocket motors by quasi-steady analysis. However, with recently developed technology[1,2], it is now possible to predict, given the necessary propellant and nozzle admittance and response parameters, the linear stability of a rocket motor subjected to small, combustion amplified, disturbances, i.e., combustion instability. With the advent of low signature constraints, this capability has assumed considerable importance because of the high probability of combustion instability in low signature motors and the attendant jeopardy to successful motor (and system) operation that instability creates.

A major shortcoming of current combustion instability prediction technology is that it is computationally divorced from conventional interior ballistic analysis. This makes instability analysis difficult because interior ballistic data must be hand loaded into the stability codes. Moreover, it has fostered a functional split, with interior ballistic analysis the domain of the grain designer while combustion instability analysis is that of the "instability specialist". Due to the difficulties associated with running combustion instability analyses and the aforementioned functional split, combustion instability has not been an integral part of the motor design process. Clearly, a successful motor design for any low signature application should include a combustion instability prediction aspect.

The remedy for this shortcoming would seem to be obvious: combine conventional interior ballistics analysis and stability codes into a single complete interior ballistics code that the motor designer can employ, i.e., a code that performs pressure, thrust, and linear stability margin versus time analyses virtually simultaneously. In this way, it is easy for the motor designer to consider combustion instability. It is with this concept in mind that the development of the computer program described herein was undertaken. Its development is based upon the utilization of the previously developed three-dimensional finite element combustion instability prediction code, FLAP3[2]. The utilization of FLAP3 requires automatic finite element mesh and boundary condition generation, and the coupling of FLAP3 with an interior ballistics analysis code, therefore, requires, in effect, a coupling of the ballistics code output with the mesh generator input. This process is the essence of a development of a combined code.

2. THREE-DIMENSIONAL FINITE ELEMENT MESH GENERATION

FLAP3 (Fluid Analysis Program, 3 Dimensions) performs a linear acousto-modal analysis of the irrotational motions of an inviscid, compressible fluid coupled to the irrotational motions of a nearly incompressible, linearly viscoelastic solid, and a linear potential flow anaylsis of the irrotational motions of an inviscid, imcompressible fluid, and then determines the effect of the flow field and of combustion on the calculated acoustic oscillations[2,3]. This combustion instability analysis is performed at different points in time, beginning at initial combustion, or time zero. The output of FLAP3 is modal frequency and an evaluation of the pressure growth/decay coefficient α for each mode of vibration analyzed. A positive net value of α indicates a growth of pressure oscillations and, therefore, instability while a negative value of α is an indication of decaying oscillations, or stability.

The FLAP3 analysis utilizes the finite element method and models the acoustic cavity and propellant grain as an assemblage of three-dimensional quasi-hexahedral elements connected at the corner nodes. The mesh generation code used in conjunction with FLAP3 is FLESH3 (Fluid Mesh, 3 Dimensions) which was developed for the purpose of generating input data for FLAP3. A detailed description of the use of FLESH3 is found in *Reference 3*. FLESH3 generates the numbered nodal points and nodal coordinates and identifies each node as to whether it lies in the acoustic cavity, on the cavity-grain interface, or in the grain; generates the quasi-hexahedral elements, designated by the eight numbered nodal points defining each element, and identifies each element as to whether it is a cavity element, a cavity element adjacent to the cavity-grain interface, or a solid propellant element; and generates the cavity-grain interface element surfaces (burning surfaces) and identifies each as to the direction of the surface normal. This information, along with a few additional input data relative to gas and propellant properties and type of acoustic mode(s) to be analyzed, is necessary and sufficient to activate a combustion instability analysis by FLAP3, given adequate computational facilities.

Input to FLESH3 is in the form of a definition of global curves, defining cavity and grain boundaries; a designation of blocks of points, as to whether they are cavity, interface or grain points; a designation of blocks to be generated, by their nodal indices; and a designation of the number and location of longitudonal cross-sections, defining the number of layers of elements. The objective is that of minimizing the amount of input to FLESH3. This can be done by the use of an executive routine which accepts as input a small number of geometrical parameters from the interior ballistics code and, in turn, activates FLESH 3. The development of this routine is the major thrust of this report.

3. INTERIOR BALLISTICS CODE

The interior ballistics analysis code used in the formulation was developed by Aerojet Solid Propulsion Company[4]. The FLESH3 geometrical input parameters are, therefore, those presented in that code, but similar parameters would be obtained from a consideration of a comparable interior ballistics code. The description of the developed executive routine will be related to the Aerojet code, but the procedure followed in the development is general.

4. DEVELOPMENT OF THE EXECUTIVE ROUTINE

A listing of the formulated computer code GRNMSH (Grain Mesh) is found in Appendix A. The code is based upon the star design found in *Reference 4* and reproduced in *Figure 1.* One computer card of input parameters (seven values) automatically generates the three-dimensional finite element mesh and boundary conditions needed for a FLAP3 analysis. Due to the dihedral symmetry provision in FLAP3, only the smallest repeating segment need be analyzed. This segment, for the general star geometry, is shown in *Figures 2 and 4*; with the necessary geometry parameters identified. The only difference between *Figure 2* and *Figure 4* is that the angle Φ is zero in *Figure 4*. This condition necessitated a slightly different internal provision in GRNMSH. *Figures 3 and 5* indicate: (a) the key global curves (others were generated, as can be seen from the included example), and (b) the key part indices. A working knowledge of FLESH3[3] is necessary in order to understand the intricacies of GRNMSH, and to modify and add to it, but not in order to use it.

The use of GRNMSH can best be understood by following an example. *Table 1*, from *Reference 4*, lists the twelve cases of the star design upon which the formulation of the executive routine is based. The generated meshes for the twelve cases are shown in *Figures 6* through *9*. The special case of a shell design (circular cylinder), for which the parameter Φ is

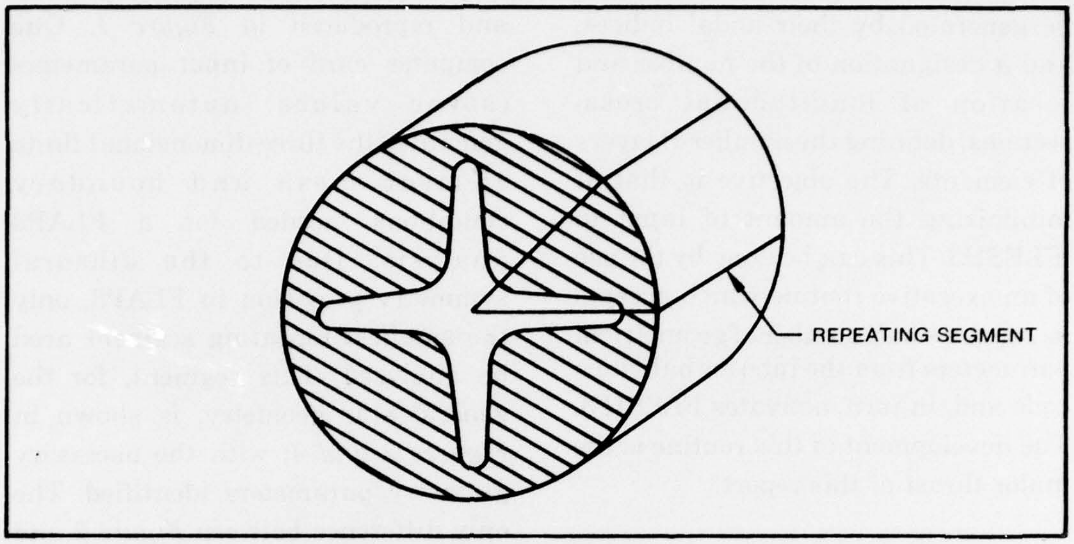


Figure 1. Star design with outside round on propellant tip; N=4

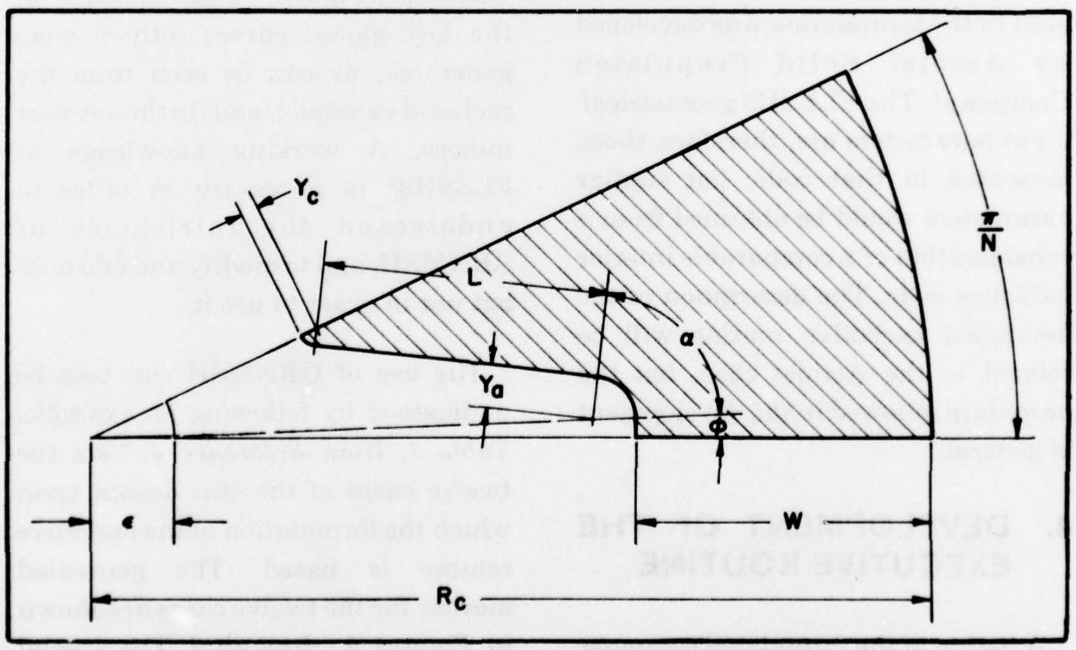


Figure 2. Cross-section of repeating segment of star design; independent parameters: N, R_c, w, Φ, Y_a, α, L

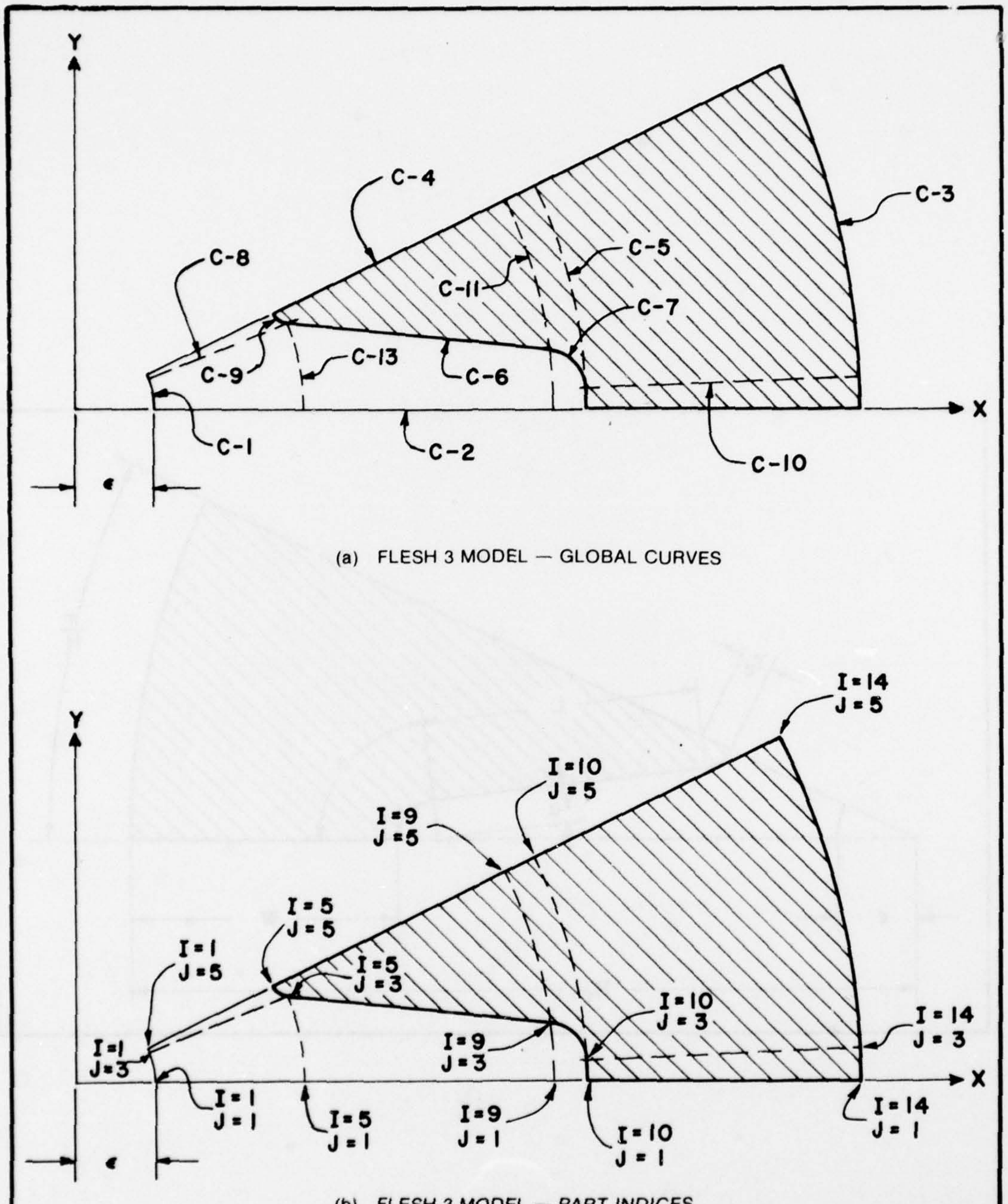


Figure 3. Cross-section of repeating segment of star design showing important input to mesh generator (FLESH 3): (a) Global curves and (b) Part indices (matches Figure 2).

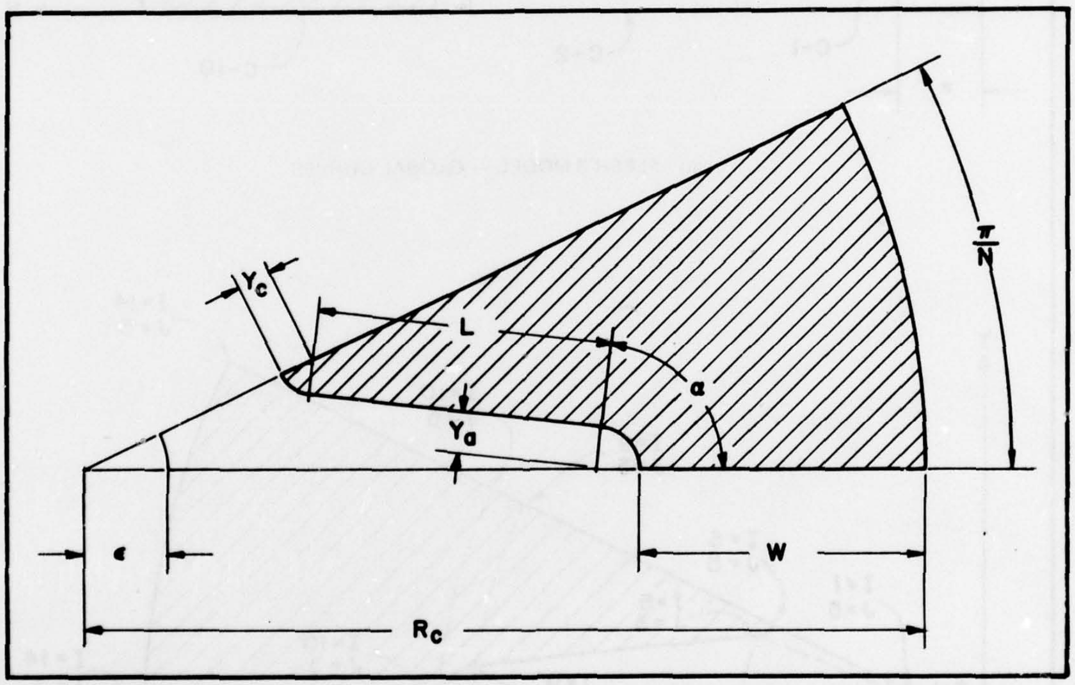
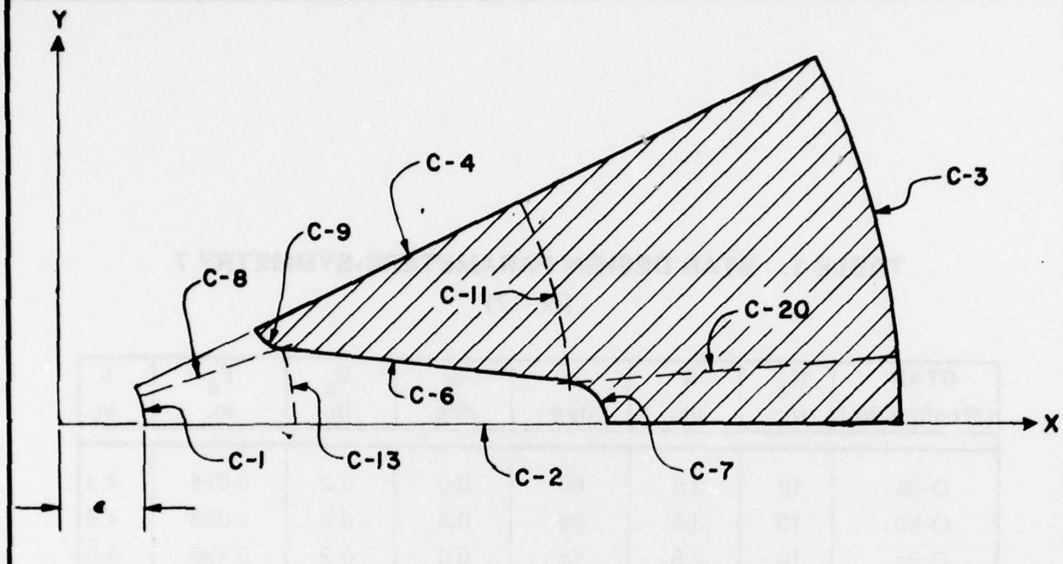
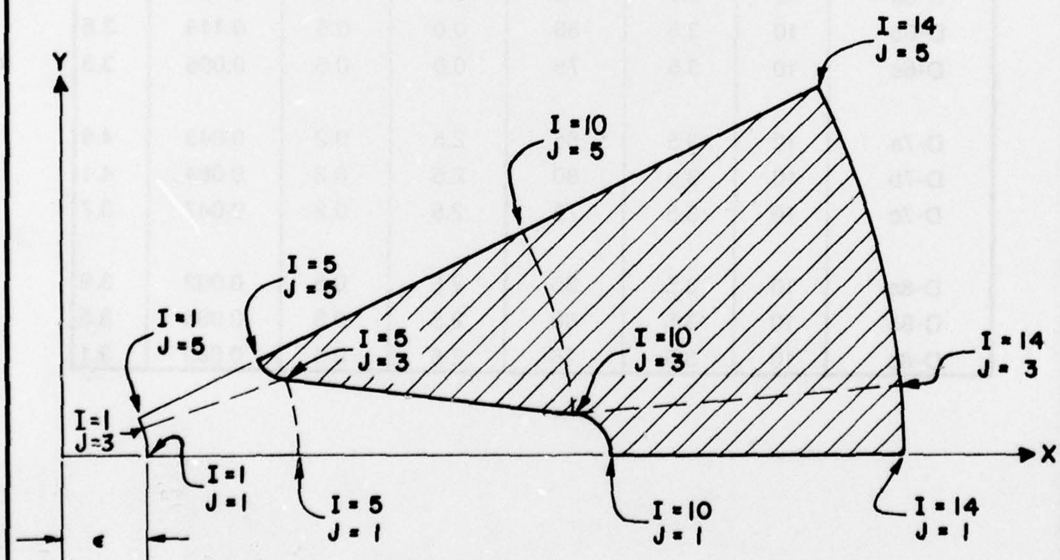


Figure 4. Cross-section of repeating segment of star design; independent parameters: N, R_c, w, Y_a, α , L; Φ = 0



(a) FLESH 3 MODEL — GLOBAL CURVES



(b) FLESH 3 MODEL — PART INDICES

Figure 5. Cross-section of repeating segment of star design showing important input to mesh generator (FLESH3): (a) Global curves and (b) Part indices (matches Figure 4).

TABLE 1. STAR DESIGN PARAMETERS-SYMMETRY 7 (N = 7)

STAR (Design No.)	R_c in.	w in.	α deg	Φ deg	Y_a in.	Y_c in.	L in.
D-5a	10	3.5	80	0.0	0.2	0.075	4.3
D-5b	10	3.5	85	0.0	0.2	0.068	4.9
D-5c	10	3.5	75	0.0	0.2	0.136	3.8
D-6a	10	3.5	85	0.0	0.5	0.092	4.1
D-6b	10	3.5	80	0.0	0.5	0.118	3.6
D-6c	10	3.5	75	0.0	0.5	0.095	3.3
D-7a	10	3.5	85	2.5	0.2	0.043	4.8
D-7b	10	3.5	80	2.5	0.2	0.084	4.1
D-7c	10	3.5	75	2.5	0.2	0.047	3.7
D-8a	10	3.5	85	2.5	0.5	0.092	3.9
D-8b	10	3.5	80	2.5	0.5	0.035	3.5
D-8c	10	3.5	75	2.5	0.5	0.069	3.1

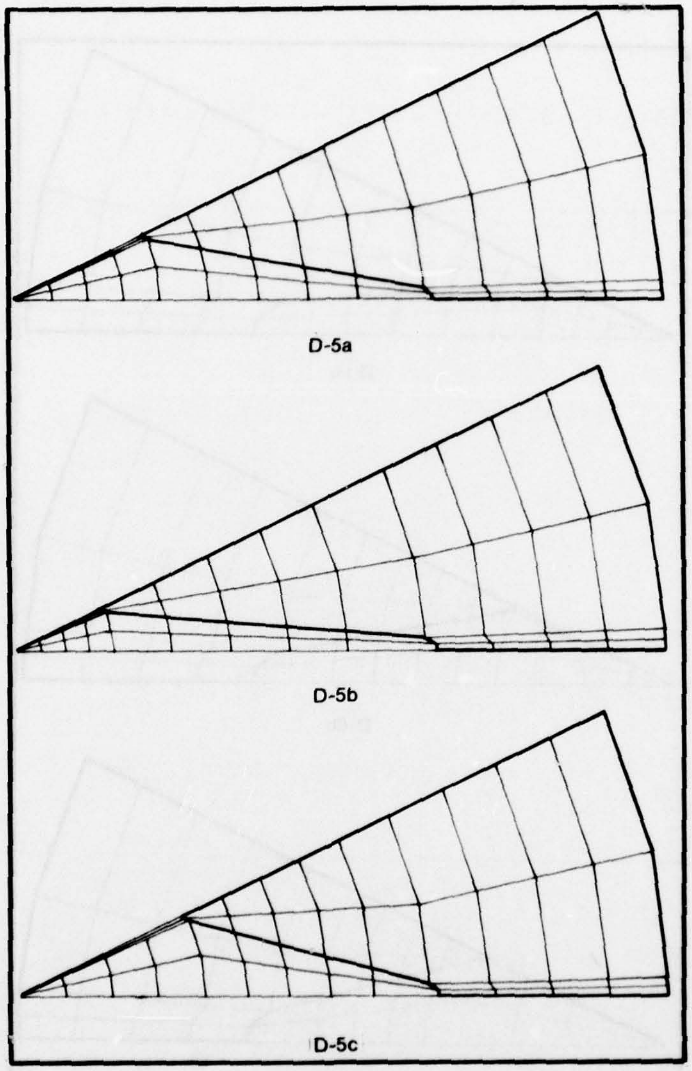


Figure 6. Cross-section showing generated finite element mesh for star design D-5 (see Table 1).

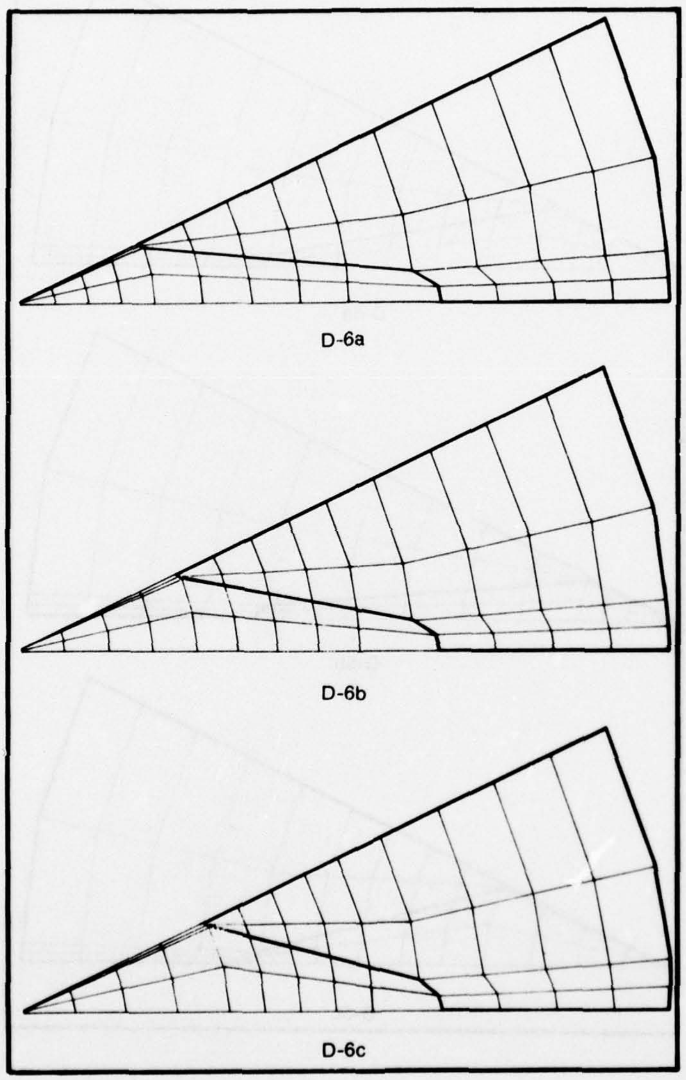


Figure 7. Cross-section showing generated finite element mesh for star design D-6 (see Table 1).

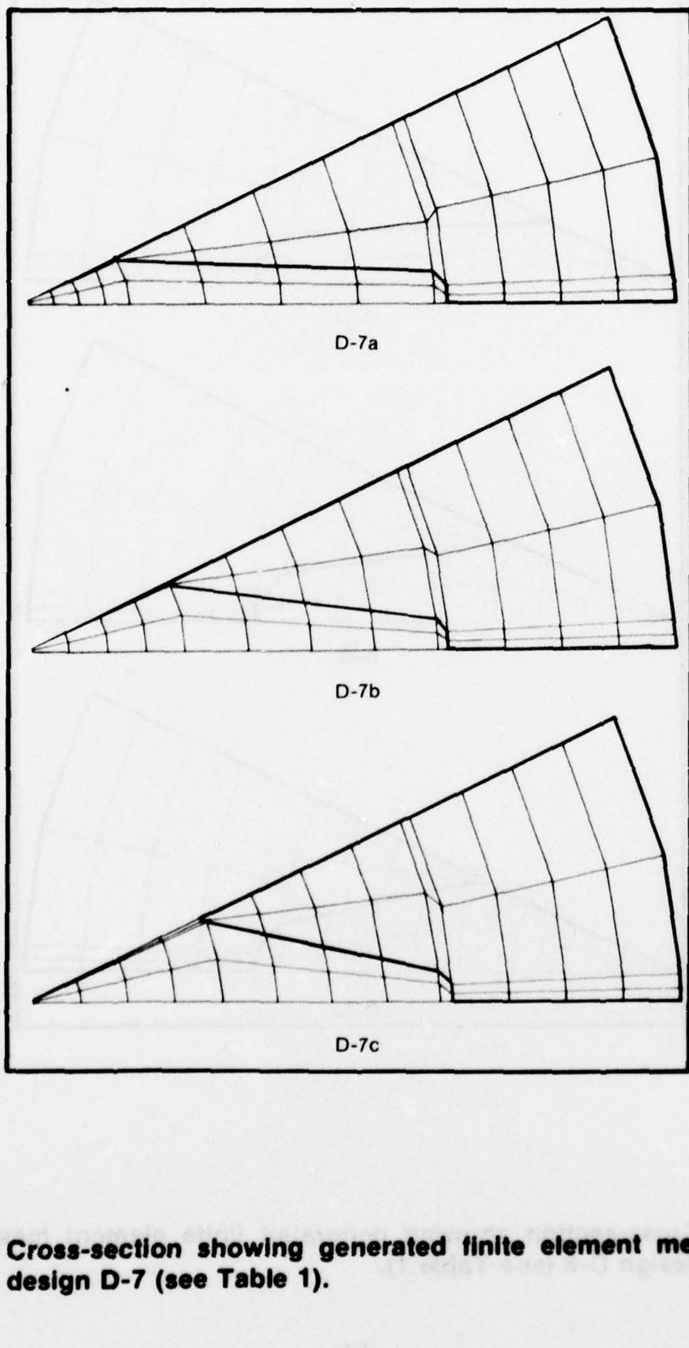


Figure 8. Cross-section showing generated finite element mesh for star design D-7 (see Table 1).

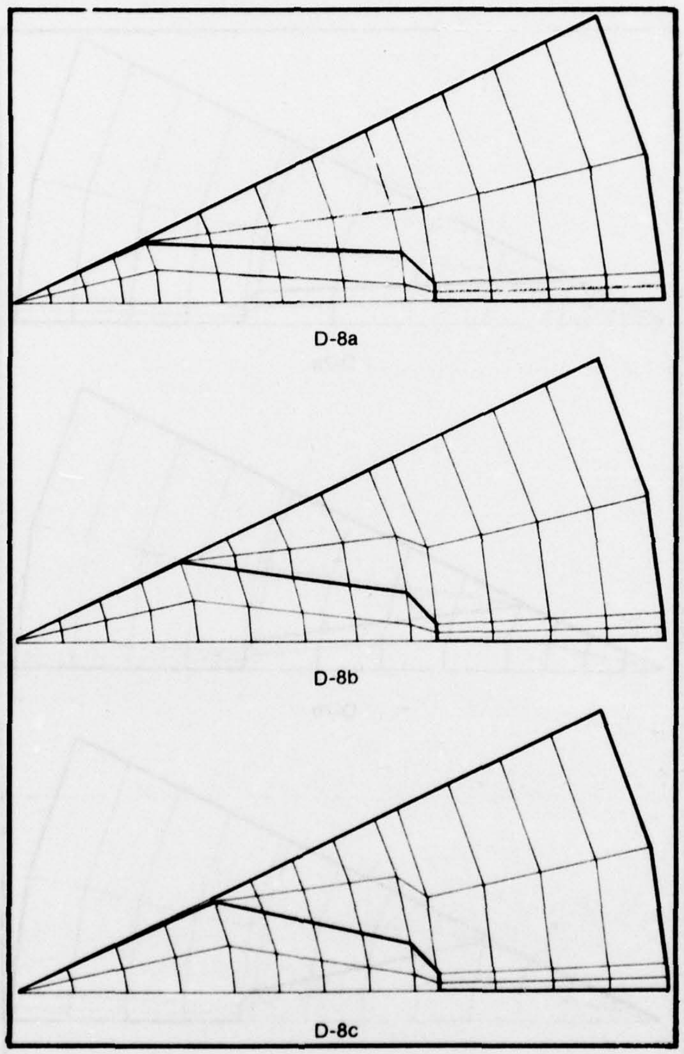


Figure 9. Cross-section showing generated finite element mesh for star design D-8 (see Table 1).

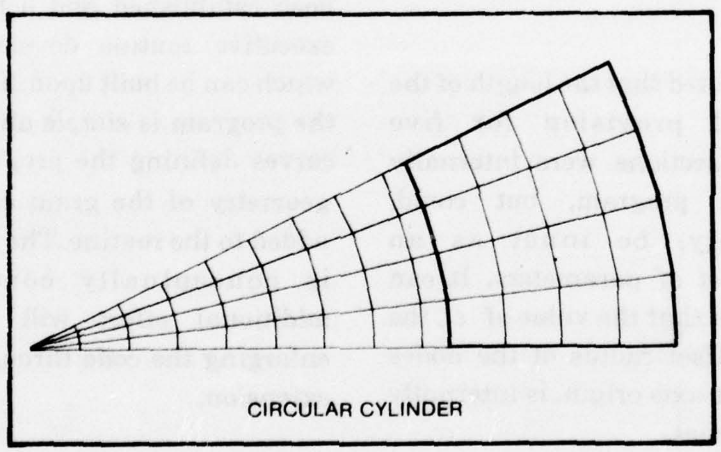


Figure 10. Cross-section showing generated finite element mesh for shell design.

input equal to π/N, as generated by GRNMSH is shown in *Figure 10.*

Sample computer input and output for the star design geometry D-5a (*Table 1*) is found in Appendix B. In sequential order is: the input to GRNMSH, the output from GRNMSH (or the input to FLESH 3), and the output from FLESH3. Again, familiarity with FLESH3, by way of *Reference 3,* will enhance one's understanding of the output from FLESH3.

It can be noted that the length of the grain, and provision for five equidistant sections were internally set in the program, but could, alternatively, be input as an additional set of parameters. It can also be noted that the value of ϵ, the necessary offset radius of the nodes closest to the axis origin, is internally set at 0.1 inches.

5. CONCLUSIONS

An executive routine has been developed which couples an interior ballistics analysis code with a combustion instability analysis code; thus, in concept, providing the rocket motor designer with the potential for a more inclusive and, therefore, a superior design approach.

Basically, the proof of concept has been established and a fundamental executive routine developed — one which can be built upon. The format of the program is simple and additional curves defining the progressive burn geometry of the grain can be easily added to the routine. The development is conceptually complete; the additional effort will be that of enlarging the code through repetitive extension.

APPENDIX A

LISTING OF THE COMPUTER PROGRAM GRNMSH

```
          PROGRAM GRNMSH
         A(INPUT,OUTPUT,PUNCH,TAPE5=INPUT,TAPE6=OUTPUT,TAPE7=PUNCH)
      COMMENT...
      COMMENT...THIS ROUTINE DEVELOPES THE INPUT FOR FLESH3
      COMMENT...STATUS-----OPERATIONAL--------10JAN78
      COMMENT...
          DIMENSION X(60), Y(60), AA(60), BB(60), THI(60), THF(60)
          DIMENSION NN(60), NP(60)
          DIMENSION IEND(3)
          DATA LUI/5/, LUO/6/, LUA/7/
          DATA IEND(1)/1HE/, IEND(2)/1HN/, IEND(3)/1HC/
          DATA PI/3.14159265/, PIO/180.0/, DEGRAD/1.745329925E-02/
          DATA ZERO/0.0/
          DATA IZERO/0/, NC/60/
          DATA ITITLE/10HGRAIN MESH/
     6111 FORMAT(A10)
          WRITE (LUA,6111) ITITLE
     5211 FORMAT(7F10.2)
          READ  (LUI,5211) XN, RC, W, PHID, YA, ALPHAD, XL
          PHI=PHID*DEGRAD
          ALPHA=ALPHAD*DEGRAD
          THETAD=PIO/XN
          THETA=THETAD*DEGRAD
          IMAX=14
          JMAX=5
          NNC=29
          IBC=3
          IF(PHI.LT.THETA) IBC=7
          SCALE=1.0
          NLAY=5
          Z=ZERO
          DZ=2.0
          ZMAX=8.0
     6211 FORMAT(4I5, F10.2,I5)
          WRITE (LUA,6211) IMAX, JMAX, NNC, IBC, SCALE, NLAY
          DO 111 I=1,NC
          X(I)=ZERO
          Y(I)=ZERO
          NN(I)=IZERO
          NP(I)=IZERO
          AA(I)=ZERO
          BB(I)=ZERO
          THI(I)=ZERO
          THF(I)=ZERO
      111 CONTINUE
          EPSLON=0.1
          RCWYA=RC-W-YA
          PINPHI=THETA-PHI
          SFPHI=SIN(PINPHI)
          CFPHI=COS(PINPHI)
          DELTA=PI*0.5+THETA-PHI-ALPHA
          SFDEL=SIN(DELTA)
          CFDEL=COS(DELTA)
          SPHI=SIN(PHI)
          CPHI=COS(PHI)
          SFAP=SIN(PHI+ALPHA)
          CFAP=COS(PHI+ALPHA)
```

```
      PROGRAM GRNMSH      74/74    OPT=1                    FTN 4.6+439        06/14/78  13.09.04        PAGE    2

            BETA=PI*0.5-PHI-ALPHA
            SBETA=SIN(BETA)
            CBETA=COS(BETA)
            APT=ALPHA*0.5+PHI*0.5+THETA
            SAPT=SIN(APT)
            CAPT=COS(APT)
            YC=(RCWYA*SFPHI-YA*CFDEL-XL*SFDEL)/SIN(ALPHA+PHI-THETA)
        201 CONTINUE
            I=1
            NN(I)=1
            NP(I)=THETAD
            AA(I)=EPSLON
            BB(I)=EPSLON
            THE(I)=THETAD
        202 CONTINUE
            I=3
            X(I)=RC
            NN(I)=2
        203 CONTINUE
            I=4
            NN(I)=3
            NP(I)=THETAD
            AA(I)=RC
            BB(I)=RC
            THE(I)=THETAD
        204 CONTINUE
            I=6
            X(I)=RC
            Y(I)=RC*TAN(THETA)
            NN(I)=4
        205 CONTINUE
            I=7
            NN(I)=5
            NP(I)=THETAD
            AA(I)=RC-W
            BB(I)=AA(I)
            THE(I)=THETAD
        206 CONTINUE
            I=8
            CC=(RCWYA*SPHI+YA*SFAP+XL*SBETA)-(RCWYA*SPHI+YA*SFAP)
            DD=(RCWYA*CPHI+YA*CFAP)-(RCWYA*CPHI+YA*CFAP-XL*CBETA)
            SLOPE1=CC/DD
            X(I)=RCWYA*CPHI+YA*CFAP-XL*CBETA-0.1
            Y(I)=RCWYA*SPHI+YA*SFAP+XL*SBETA+0.1*SLOPE1
            I=9
            X(I)=RCWYA*CPHI+YA*CFAP+0.1
            Y(I)=RCWYA*SPHI+YA*SFAP-0.1*SLOPE1
            NN(I)=6
        207 CONTINUE
            I=10
            X(I)=RCWYA*CPHI
            Y(I)=RCWYA*SPHI
            NN(I)=7
            NP(I)=ALPHAD
            AA(I)=YA
            BB(I)=YA
            THI(I)=PHID
```

```
      THE(I)=PHID+ALPHAD
  204 CONTINUE
      I=12
      GGG=RC*YA*SPHI+YA*SFAP+XL*SBETA
      HHH=RC*YA*CPHI+YA*CFAP-XL*CBETA
      SLOPE2=GGG/HHH
      X(I)=RC*YA*CPHI+YA*CFAP-XL*CBETA+0.1
      Y(I)=RC*YA*SPHI+YA*SFAP+XL*SBETA+0.1*SLOPE2
      NN(I)=8
  204 CONTINUE
      I=13
      X(I)=RC YA*CPHI+YA*CFAP-XL*CBETA+YC*SBETA
      Y(I)=RC*YA*SPHI+YA*SFAP+XL*SBETA+YC*CBETA
      NN(I)=9
      NP(I)=ALPHAD+PHID-THETAD
      AA(I)=YC
      BB(I)=YC
      THI(I)=PID+THETAD-1.0
      THE(I)=PID+PHID+ALPHAD+1.0
  210 CONTINUE
      I=15
      X(I)=RC
      Y(I)=RC*TAN(PHI)
      NN(I)=10
  211 CONTINUE
      I=16
      NN(I)=11
      NP(I)=THETAD
      AA(I)=((RC*YA*CFPHI+YA*SFDEL)**2+(RC*YA*SFPHI-YA*CFDEL)**2)**0.5
      BB(I)=AA(I)
      THE(I)=THETAD
  212 CONTINUE
      I=18
      X(I)=RC
      Y(I)=RC*TAN(THETA*0.5)
      NN(I)=12
  213 CONTINUE
      I=19
      NN(I)=13
      NP(I)=THETAD
      CCC=(RC*YA*CFPHI+YA*SFDEL-XL*CFDEL)**2
      DDD=(RC*YA*SFPHI-YA*CFDEL-XL*SFDEL)**2
      AA(I)=(CCC+DDD)**0.5
      BB(I)=AA(I)
      THE(I)=THETAD
  214 CONTINUE
      I=20
      EE=AA(19)*SIN(THETA*0.5)-AA(16)*SPHI
      FF=AA(16)*CPHI-AA(19)*COS(THETA*0.5)
      SLOPE3=EE/FF
      X(I)=AA(19)*COS(THETA*0.5)-0.1
      Y(I)=AA(19)*SIN(THETA*0.5)+0.1*SLOPE3
      I=21
      X(I)=AA(16)*CPHI+0.1
      Y(I)=AA(16)*SPHI-0.1*SLOPE3
      NN(I)=14
  215 CONTINUE
```

```
      I=22
      NN(I)=15
      VP(I)=THETAD
      AA(I)=EPSLON+(AA(19)-AA(1))*0.75
      BB(I)=AA(I)
      THE(I)=THETAD
  216 CONTINUE
      I=23
      GG=AA(16)*SPHI-AA(7)*SIN(PHI*0.5)
      HH=AA(7)*COS(PHI*0.5)-AA(16)*CPHI
      SLOPE4=GG/HH
      X(I)=AA(16)*CPHI-0.1
      Y(I)=AA(16)*SPHI+0.1*SLOPE4
      I=24
      X(I)=AA(7)*COS(PHI*0.5)+0.1
      Y(I)=AA(7)*SIN(PHI*0.5)-0.1*SLOPE4
      NN(I)=16
  217 CONTINUE
      I=25
      NN(I)=17
      VP(I)=THETAD
      AA(I)=AA(19)+(AA(16)-AA(19))*0.75
      BB(I)=AA(I)
      THE(I)=THETAD
  218 CONTINUE
      I=27
      X(I)=RC
      Y(I)=RC*TAN(PHI*0.5)
      NN(I)=18
  219 CONTINUE
  220 CONTINUE
      I=28
      VV=RC*(YA*SIN(ALPHA)/(RCWYA+YA*COS(ALPHA)))-RCWYA*SPHI+YA*SFAP
      WW=RC-RCWYA*CPHI+YA*CFAP
      SLOPE5=VV/WW
      X(I)=RCWYA*CPHI+YA*CFAP-0.1
      Y(I)=RCWYA*SPHI+YA*SFAP-0.1*SLOPE5
      I=29
      X(I)=RC
      Y(I)=RC*(YA*SIN(ALPHA)/(RCWYA+YA*COS(ALPHA)))
      NN(I)=20
  221 CONTINUE
  222 CONTINUE
      I=31
      X(I)=RC
      Y(I)=(RC*(YA*SIN(ALPHA)/(RCWYA+YA*COS(ALPHA))))*0.5
      NN(I)=22
  223 CONTINUE
  224 CONTINUE
      I=32
      UUU=Y(31)**2/(RC**2)
      WWW=(X(10)+((YA**2)*(1.0+UUU)-(X(10)**2)*UUU)**0.5)/(1.0+UUU)
      ZZZ=WWW*Y(31)/RC
      YYY=AA(19)*SIN(THETA*0.5)-ZZZ
      XXX=WWW-AA(19)*COS(THETA*0.5)
      SLOPE6=YYY/XXX
      X(I)=AA(19)*COS(THETA*0.5)-0.1
```

```
      Y(I)=AA(19)*SIN(THETA*0.5)+0.1*SLOPE6
      I=33
      X(I)=WWW+0.1
      Y(I)=ZZ7-0.1*SLOPE5
      NN(I)=24
  225 CONTINUE
  226 CONTINUE
      I=35
      SLOPE7=(Y(13)-YC*SAPT)/(X(13)-YC*CAPT)
      X(I)=X(13)-YC*CAPT+0.1
      Y(I)=Y(13)-YC*SAPT+0.1*SLOPE7
      NN(I)=26
  227 CONTINUE
  228 CONTINUE
      I=36
      X(I)=X(13)-YC*CAPT-0.1
      Y(I)=Y(13)-YC*SAPT-0.1*TAN(THETA*0.25)
      I=37
      X(I)=AA(16)
      Y(I)=Y(13)-YC*SAPT+(AA(16)-X(13)+YC*CAPT)*TAN(THETA*0.25)
      NN(I)=28
  229 CONTINUE
  230 CONTINUE
      I=38
      AD=Y(13)-YC*CAPT
      AE=Y(13)-YC*SAPT
      AF=AA(16)
      AG=TAN(THETA*0.25)
      AX=AG**2.0+1.0
      AY=2.0*(AD+AE*AG)
      AZ=AD**2.0+AE**2.0-AF**2.0
      AW=(-AY+(AY**2.0-4.0*AX*AZ)**0.5)/(2.0*AX)
      BW=AW*AG
      CW=AA(7)*SIN(THETA*0.5)-(Y(13)-YC*SAPT+BW)
      DW=AA(7)*COS(THETA*0.5)-(X(13)-YC*CAPT+AW)
      SLOPE8=CW/DW
      X(I)=X(13)-YC*CAPT+AW-0.1
      Y(I)=Y(13)-YC*SAPT+BW-0.1*SLOPE8
      I=39
      X(I)=AA(7)*COS(THETA*0.5)+0.1
      Y(I)=AA(7)*SIN(THETA*0.5)+0.1*SLOPE8
      NN(I)=30
  231 CONTINUE
  232 CONTINUE
      I=40
      X(I)=RC*0.25
      Y(I)=RC*0.25*TAN(THETA*0.5)
      I=41
      X(I)=RC
      Y(I)=RC*TAN(THETA*0.5)
      NN(I)=32
  233 CONTINUE
  234 CONTINUE
      I=43
      X(I)=RC
      Y(I)=RC*TAN(THETA*0.25)
      NN(I)=34
```

```
  235 CONTINUE
  236 CONTINUE
      I=45
      X(I)=RC
      Y(I)=RC*TAN(THETA*0.50)
      NN(I)=36
  237 CONTINUE
  238 CONTINUE
      I=47
      X(I)=RC
      Y(I)=RC*TAN(THETA*0.75)
      NN(I)=38
  239 CONTINUE
  240 CONTINUE
      I=48
      AB=AA(16)*SIN(THETA*0.5)-(Y(13)-YC*SAPT)
      AC=AA(16)*COS(THETA*0.5)-(X(13)-YC*CAPT)
      SLOPE9=AB/AC
      X(I)=X(13)-YC*CAPT-0.1
      Y(I)=Y(13)-YC*SAPT-0.1*SLOPE9
      I=49
      X(I)=AA(16)*COS(THETA*0.5)+0.1
      Y(I)=AA(16)*SIN(THETA*0.5)+0.1*SLOPE9
      NN(I)=40
  299 CONTINUE
      DO 331 I=1,49
      WRITE (LUA,6331) X(I),Y(I),NN(I),NP(I),AA(I),BB(I),THI(I),THF(I)
 331  CONTINUE
 6331 FORMAT(2F10.4,2I5,4F10.4)
      IM1=-1
      II=ZERO
      IJ=1
      IK=2
      IL=3
      IM=4
      IN=5
      IP=6
      IQ=7
      IR=8
      IS=9
      JI=10
      JJ=11
      JK=12
      JL=13
      JM=14
      JN=15
      JP=16
      JQ=17
      JR=18
      JS=19
      KI=20
      KJ=21
      KK=22
      KL=23
      KM=24
      KN=25
      KP=26
```

```
      KQ=27
      KR=28
      KS=29
      LI=30
      LJ=31
      LK=32
      LL=33
      LM=34
      LN=35
      LP=36
      LQ=37
      LR=38
      LS=39
      MI=40
      MJ=41
      MK=42
      ML=43
      MM=44
      MN=45
      MP=46
      MQ=47
      MR=48
      MS=49
  440 CONTINUE
      IF (PHI.LT.THETA) GO TO 442
 6373 FORMAT (5I5)
      WRITE (LUA,6373) IJ,IJ,IJ,IS,IN
      WRITE (LUA,6373) IK,JI,IJ,JI,IN
      WRITE (LUA,6373) IL,JJ,IJ,JM,IN
      GO TO 441
  442 CONTINUE
 6332 FORMAT(5I5)
      WRITE (LUA,6332) IJ,IJ,IJ,IM,IN
      WRITE (LUA,6332) IJ,IN,IJ,IS,IK
      WRITE (LUA,6332) IK,IN,IL,IN,IN
      WRITE (LUA,6332) IK,IP,IL,IS,IL
      WRITE (LUA,6332) IK,JI,IJ,JI,IL
      WRITE (LUA,6332) IL,IP,IM,JM,IN
      WRITE (LUA,6332) IL,JJ,IJ,JM,IL
  441 CONTINUE
      IF (PHI.LT.THETA) GO TO 443
 6443 FORMAT (14I5)
      WRITE (LUA,6443) IJ,IJ,IJ,IS,IK,IK,JJ,LM,IJ,IJ,II,II,II,II
      WRITE (LUA,6443) IK,IJ,IK,IS,IL,LM,JJ,LP,IJ,IJ,II,II,II,II
      WRITE (LUA,6443) IL,IJ,IL,IS,IM,LP,JJ,LR,IJ,IJ,II,II,II,II
      WRITE (LUA,6443) IM,IJ,IM,IS,IN,LR,JJ,IM,IJ,IJ,II,II,II,II
      WRITE (LUA,6443) IN,IS,IJ,JI,IK,IK,IN,LM,JJ,IK,II,II,II,II
      WRITE (LUA,6443) IP,IS,IK,JI,IL,LM,IN,LP,JJ,IK,II,II,II,II
      WRITE (LUA,6443) IQ,IS,IL,JI,IM,LP,IN,LR,JJ,IK,II,II,II,II
      WRITE (LUA,6443) IR,IS,IM,JI,IN,LR,IN,IM,JJ,IK,II,II,II,II
      WRITE (LUA,6443) IS,JI,IJ,JM,IK,IK,IL,LM,IN,IL,II,II,II,II
      WRITE (LUA,6443) JI,JI,IK,JM,IL,LM,IL,LP,IN,IL,II,II,II,II
      WRITE (LUA,6443) JJ,JI,IL,JM,IM,LP,IL,LR,IN,IL,II,II,II,II
      WRITE (LUA,6443) JK,JI,IM,JM,IN,LR,IL,IM,IN,IL,II,II,II,II
      WRITE (LUA,6443) IM1,II,II,II,II,II,II,II,II,II,II,II,II,II
      GO TO 445
  443 CONTINUE
```

```
      IF (PHI.EQ.0.0) GO TO 444
 6441 FORMAT(14I5)
      WRITE (LUA,6441) IJ,IJ,IJ,IN,IK,IK,JL,JK,IJ,IJ,II,II,II,II
      WRITE (LUA,6441) IK,IJ,IK,IN,IL,JK,JL,IR,IJ,IJ,II,II,II,II
      WRITE (LUA,6441) IL,IJ,IL,IM,IM,IR,JN,KP,IJ,IJ,II,II,II,II
      WRITE (LUA,6441) IM,IJ,IM,IM,IN,KP,JN,IM,IJ,IJ,II,II,II,II
      WRITE (LUA,6441) IN,IN,IJ,IS,IK,IK,JJ,JM,JL,IJ,II,II,II,II
      WRITE (LUA,6441) IP,IM,IL,IN,IM,IR,IS,KP,JN,IK,II,II,II,II
      WRITE (LUA,6441) IQ,IM,IM,IN,IN,KP,IS,IM,JN,IK,II,II,II,II
      WRITE (LUA,6441) IR,IN,IK,IS,IL,JM,JJ,IP,JL,IK,II,II,II,II
      WRITE (LUA,6441) IS,IS,IJ,JI,IK,IK,IN,JP,JJ,IK,II,II,II,II
      WRITE (LUA,6441) JI,IS,IK,JI,IL,JP,IN,IQ,JJ,IK,II,II,II,II
      WRITE (LUA,6441) JJ,IN,IL,IS,IM,IP,JJ,KR,IS,IL,II,II,II,II
      WRITE (LUA,6441) JK,IN,IM,IS,IN,KR,JJ,IM,IS,IL,II,II,II,II
      WRITE (LUA,6441) JL,IS,IL,JI,IM,IQ,IN,LI,JJ,IL,II,II,II,II
      WRITE (LUA,6441) JM,IS,IM,JI,IN,LI,IN,IM,JJ,IL,II,II,II,II
      WRITE (LUA,6442) JN,JI,IJ,JM,IK,IK,IL,JR,IN,IL,II,II,II,II
      WRITE (LUA,6441) JP,JI,IK,JM,IL,JR,IL,JI,IN,IL,II,II,II,II
      WRITE (LUA,6441) JQ,JI,IL,JM,IM,JI,IL,LK,IN,IL,II,II,II,II
      WRITE (LUA,6441) JR,JI,IM,JM,IN,LK,IL,IM,IN,IL,II,II,II,II
      WRITE (LUA,6441) IM1,II,II,II,II,II,II,II,II,II,II,II,II,II
      60 TO 445
  444 CONTINUF
 6442 FOR'AT (14I5)
      WRITE (LUA,6442) IJ,IJ,IJ,IN,IK,IK,JL,JK,IJ,IJ,II,II,II,II
      WRITE (LUA,6442) IK,IJ,IK,IN,IL,JK,JL,IR,IJ,IJ,II,II,II,II
      WRITE (LUA,6442) IL,IJ,IL,IM,IM,IR,JN,KP,IJ,IJ,II,II,II,II
      WRITE (LUA,6442) IM,IJ,IM,IM,IN,KP,JN,IM,IJ,IJ,II,II,II,II
      WRITE (LUA,6442) IN,IN,IJ,IS,IK,IK,JQ,KM,JL,IJ,II,II,II,II
      WRITE (LUA,6442) IP,IM,IL,IN,IM,IR,IS,KP,JN,IK,II,II,II,II
      WRITE (LUA,6442) IQ,IM,IM,IN,IN,KP,IS,IM,JN,IK,II,II,II,II
      WRITE (LUA,6442) IR,IN,IK,IS,IL,KM,JQ,IP,JL,IK,II,II,II,II
      WRITE (LUA,6442) IS,IS,IJ,JI,IK,IK,IQ,KM,JG,IK,II,II,II,II
      WRITE (LUA,6442) JI,IS,IK,JI,IL,KM,IQ,IP,JG,IK,II,II,II,II
      WRITE (LUA,6442) JJ,IN,IL,IS,IM,IP,JQ,MI,IS,IL,II,II,II,II
      WRITE (LUA,6442) JK,IN,IM,IS,IN,MI,JQ,IM,IS,IL,II,II,II,II
      WRITE (LUA,6442) JL,IS,IL,JI,IM,IP,JJ,MI,JG,IL,II,II,II,II
      WRITE (LUA,6442) JM,IS,IM,JI,IN,MI,JJ,IM,JG,IL,II,II,II,II
      WRITE (LUA,6442) JN,JI,IJ,JM,IK,IK,IL,KK,IG,IL,II,II,II,II
      WRITE (LUA,6442) JP,JI,IK,JM,IL,KK,IL,KI,IG,IL,II,II,II,II
      WRITE (LUA,6442) JQ,JI,IL,JM,IM,KI,IL,LK,JJ,IL,II,II,II,II
      WRITE (LUA,6442) JR,JI,IM,JM,IN,LK,IL,IM,JJ,IL,II,II,II,II
      WRITE (LUA,6442) IM1,II,II,II,II,II,II,II,II,II,II,II,II,II
  445 CONTINUE
 6444 FORMAT(F10.4)
      WRITE (LUA,6444) Z
      Z=Z+DZ
      IF (Z.LE.ZMAX) GO TO 441
 6333 FORMAT(3A1)
      WRITE (LUA,6333) (IEND(I),I=1,3)
      STOP
      END
```

APPENDIX B

EXAMPLE THREE-DIMENSIONAL FINITE ELEMENT MESH GENERATION FOR STAR DESIGN (D-5A)

7.0	10.0	3.5	0.0	0.2	80.0	4.3

GRAIN MESH

14	5	29	7	1.00	5

0.0000	0.0000	1	25	.1000	.1000	0.0000	25.7143
0.0000	0.0000	0	0	0.0000	0.0000	0.0000	0.0000
10.0000	0.0000	2	0	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	3	25	10.0000	10.0000	0.0000	25.7143
0.0000	0.0000	0	0	0.0000	0.0000	0.0000	0.0000
10.0000	4.8157	4	0	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	5	25	6.5000	6.5000	0.0000	25.7143
2.0081	.9613	0	0	0.0000	0.0000	0.0000	0.0000
6.4347	.1793	6	0	0.0000	0.0000	0.0000	0.0000
6.3000	0.0000	7	80	.2000	.2000	0.0000	80.0000
0.0000	0.0000	0	0	0.0000	0.0000	0.0000	0.0000
2.2001	.9886	8	0	0.0000	0.0000	0.0000	0.0000
2.1131	1.0176	9	54	.0751	.0751	204.7143	261.0000
0.0000	0.0000	0	0	0.0000	0.0000	0.0000	0.0000
10.0000	0.0000	10	0	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	11	25	6.3378	6.3378	0.0000	25.7143
0.0000	0.0000	0	0	0.0000	0.0000	0.0000	0.0000
10.0000	2.2824	12	0	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	13	25	2.3023	2.3023	0.0000	25.7143
2.1446	.5248	0	0	0.0000	0.0000	0.0000	0.0000
6.4378	-.0125	14	0	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	15	25	1.7517	1.7517	0.0000	25.7143
6.2378	0.0000	0	0	0.0000	0.0000	0.0000	0.0000
6.6000	0.0000	16	0	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	17	25	5.3289	5.3289	0.0000	25.7143
0.0000	0.0000	0	0	0.0000	0.0000	0.0000	0.0000
10.0000	0.0000	18	0	0.0000	0.0000	0.0000	0.0000
6.2347	.1834	0	0	0.0000	0.0000	0.0000	0.0000
10.0000	.3109	20	0	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0	0	0.0000	0.0000	0.0000	0.0000
10.0000	.1555	22	0	0.0000	0.0000	0.0000	0.0000
2.1446	.5221	0	0	0.0000	0.0000	0.0000	0.0000
6.5728	.0909	24	0	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0	0	0.0000	0.0000	0.0000	0.0000
2.1822	.9947	26	0	0.0000	0.0000	0.0000	0.0000
1.9822	.9379	0	0	0.0000	0.0000	0.0000	0.0000
6.3378	1.4286	28	0	0.0000	0.0000	0.0000	0.0000
6.0788	1.3882	0	0	0.0000	0.0000	0.0000	0.0000
6.4370	1.4689	30	0	0.0000	0.0000	0.0000	0.0000
2.5080	.5706	0	0	0.0000	0.0000	0.0000	0.0000
10.0000	2.2824	32	0	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0	0	0.0000	0.0000	0.0000	30.0000
10.0000	1.1267	34	0	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0	0	0.0000	0.0000	0.0000	0.0000
10.0000	2.2824	36	0	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0	0	0.0000	0.0000	0.0000	0.0000
10.0000	3.4992	38	0	0.0000	0.0000	0.0000	0.0000
1.9822	.9379	0	0	0.0000	0.0000	0.0000	0.0000
6.2789	1.4215	40	0	0.0000	0.0000	0.0000	0.0000

1	1	1	4	5									
2	5	1	9	2									
2	5	3	5	5									
2	6	3	9	3									
2	10	1	10	3									
3	6	4	14	5									
3	11	1	14	3									
1	1	1	5	2	2	13	12	1	1	0	0	0	0
2	1	2	5	3	12	13	8	1	1	0	0	0	0
3	1	3	4	4	8	15	26	1	1	0	0	0	0
4	1	4	4	5	26	15	4	1	1	0	0	0	0
5	5	1	9	2	2	17	24	13	1	0	0	0	0
6	4	3	5	4	8	9	26	15	2	0	0	0	0

7	4	4	5	5	26	9	4	15	2	0	0	0	0
8	5	2	9	3	24	17	6	13	2	0	0	0	0
9	9	1	10	2	2	7	24	17	2	0	0	0	0
10	9	2	10	3	24	7	6	17	2	0	0	0	0
11	5	3	9	4	6	17	40	9	3	0	0	0	0
12	5	4	9	5	40	17	4	9	3	0	0	0	0
13	9	3	10	4	6	11	40	17	3	0	0	0	0
14	9	4	10	5	40	11	4	17	3	0	0	0	0
15	10	1	14	2	2	3	22	7	3	0	0	0	0
16	10	2	14	3	22	3	20	7	3	0	0	0	0
17	10	3	14	4	20	3	32	11	3	0	0	0	0
18	10	4	14	5	32	3	4	11	3	0	0	0	0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0
8.0000													
1	1	1	5	2	2	13	12	1	1	0	0	0	0
2	1	2	5	3	12	13	8	1	1	0	0	0	0
3	1	3	4	4	8	15	26	1	1	0	0	0	0
4	1	4	4	5	26	15	4	1	1	0	0	0	0
5	5	1	9	2	2	17	24	13	1	0	0	0	0
6	4	3	5	4	8	9	26	15	2	0	0	0	0
7	4	4	5	5	26	9	4	15	2	0	0	0	0
8	5	2	9	3	24	17	6	13	2	0	0	0	0
9	9	1	10	2	2	7	24	17	2	0	0	0	0
10	9	2	10	3	24	7	6	17	2	0	0	0	0
11	5	3	9	4	6	17	40	9	3	0	0	0	0
12	5	4	9	5	40	17	4	9	3	0	0	0	0
13	9	3	10	4	6	11	40	17	3	0	0	0	0
14	9	4	10	5	40	11	4	17	3	0	0	0	0
15	10	1	14	2	2	3	22	7	3	0	0	0	0
16	10	2	14	3	22	3	20	7	3	0	0	0	0
17	10	3	14	4	20	3	32	11	3	0	0	0	0
18	10	4	14	5	32	3	4	11	3	0	0	0	0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0
2.0000													
1	1	1	5	2	2	13	12	1	1	0	0	0	0
2	1	2	5	3	12	13	8	1	1	0	0	0	0
3	1	3	4	4	8	15	26	1	1	0	0	0	0
4	1	4	4	5	26	15	4	1	1	0	0	0	0
5	5	1	9	2	2	17	24	13	1	0	0	0	0
6	4	3	5	4	8	9	26	15	2	0	0	0	0
7	4	4	5	5	26	9	4	15	2	0	9	0	0
8	5	2	9	3	24	17	6	13	2	0	0	0	0
9	9	1	10	2	2	7	24	17	2	0	0	0	0
10	9	2	10	3	24	7	6	17	2	0	0	0	0
11	5	3	9	4	6	17	40	9	3	0	0	0	0
12	5	4	9	5	40	17	4	9	3	0	0	0	0
13	9	3	10	4	6	11	40	17	3	0	0	0	0
14	9	4	10	5	40	11	4	17	3	0	0	0	0
15	10	1	14	2	2	3	22	7	3	0	0	0	0
16	10	2	14	3	22	3	20	7	3	0	0	0	0
17	10	3	14	4	20	3	32	11	3	0	0	0	0
18	10	4	14	5	32	3	4	11	3	0	0	0	0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0
4.0000													
1	1	1	5	2	2	13	12	1	1	0	0	0	0
2	1	2	5	3	12	13	8	1	1	0	0	0	0
3	1	3	4	4	8	15	26	1	1	0	0	0	0
4	1	4	4	5	26	15	4	1	1	0	0	0	0
5	5	1	9	2	2	17	24	13	1	0	0	0	0
6	4	3	5	4	8	9	26	15	2	0	0	0	0
7	4	4	5	5	26	9	4	15	2	0	0	0	0
8	5	2	9	3	24	17	6	13	2	0	0	0	0
9	9	1	10	2	2	7	24	17	2	0	0	0	0
10	9	2	10	3	24	7	6	17	2	0	0	0	0
11	5	3	9	4	6	17	40	9	3	0	0	0	0
12	5	4	9	5	40	17	4	9	3	0	0	0	0

13	9	3	10	4	6	11	40	17	3	0	0	0	0
14	9	4	10	5	40	11	4	17	3	0	0	0	0
15	10	1	14	2	2	3	22	7	3	0	0	0	0
16	10	2	14	3	22	3	20	7	3	0	0	0	0
17	10	3	14	4	20	3	32	11	3	0	0	0	0
18	10	4	14	5	32	3	4	11	3	0	0	0	0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0
6.0000													
1	1	1	5	2	2	13	12	1	1	0	0	0	0
2	1	2	5	3	12	13	8	1	1	0	0	0	0
3	1	3	4	4	8	15	26	1	1	0	0	0	0
4	1	4	4	5	26	15	4	1	1	0	0	0	0
5	5	1	9	2	2	17	24	13	1	0	0	0	0
6	4	3	5	4	8	9	26	15	2	0	0	0	0
7	4	4	5	5	26	9	4	15	2	0	0	0	0
8	5	2	9	3	24	17	6	13	2	0	0	0	0
9	9	1	10	2	2	7	24	17	2	0	0	0	0
10	9	2	10	3	24	7	6	17	2	0	0	0	0
11	5	3	9	4	6	17	40	9	3	0	0	0	0
12	5	4	9	5	40	17	4	9	3	0	0	0	0
13	9	3	10	4	6	11	40	17	3	0	0	0	0
14	9	4	10	5	40	11	4	17	3	0	0	0	0
15	10	1	14	2	2	3	22	7	3	0	0	0	0
16	10	2	14	3	22	3	20	7	3	0	0	0	0
17	10	3	14	4	20	3	32	11	3	0	0	0	0
18	10	4	14	5	32	3	4	11	3	0	0	0	0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0
8.0000													
END													

CARD I. TITLE.

GRAIN MESH

CARD II. CONTROL.

IMAX	JMAX	NNC	IBC	SCALE	NLAY
14	5	39	7	1.	5

CARD III. PART BOUNDARY CURVE.

X - COORD	Y - COORD	NN	NP	A X-AXIS	B Y-AXIS	THETAI	THETAF
0.000	0.000	1	25	.10000	.10000	0.00000	25.71430
0.000	0.000	0	0	0.00000	0.00000	0.00000	0.00000
10.000	0.000	2	0	0.00000	0.00000	0.00000	0.00000
0.000	0.000	3	25	10.00000	10.00000	0.00000	25.71430
0.000	0.000	0	0	0.00000	0.00000	0.00000	0.00000
10.000	4.416	4	0	0.00000	0.00000	0.00000	0.00000
0.000	0.000	5	25	6.50000	6.50000	0.00000	25.71430
2.000	.361	0	0	0.00000	0.00000	0.00000	0.00000
6.435	.179	6	0	0.00000	0.00000	0.00000	0.00000
6.300	0.000	7	80	.20000	.20000	0.00000	80.00000
0.000	0.000	0	0	0.00000	0.00000	0.00000	0.00000
2.200	.949	8	0	0.00000	0.00000	0.00000	0.00000
2.113	1.012	9	54	.07510	.07510	204.71430	261.00000
0.000	0.000	0	0	0.00000	0.00000	0.00000	0.00000
10.000	0.000	10	0	0.00000	0.00000	0.00000	0.00000
0.000	0.000	11	25	6.33780	6.33780	0.00000	25.71430
0.000	0.000	0	0	0.00000	0.00000	0.00000	0.00000
10.000	2.282	12	0	0.00000	0.00000	0.00000	0.00000
0.000	0.000	13	25	2.30230	2.30230	0.00000	25.71430
2.145	.525	0	0	0.00000	0.00000	0.00000	0.00000
6.438	-.013	14	0	0.00000	0.00000	0.00000	0.00000
0.000	0.000	15	25	1.75170	1.75170	0.00000	25.71430
6.238	0.000	0	0	0.00000	0.00000	0.00000	0.00000
6.600	0.000	16	0	0.00000	0.00000	0.00000	0.00000
0.000	0.000	17	25	5.32890	5.32890	0.00000	25.71430
0.000	0.000	0	0	0.00000	0.00000	0.00000	0.00000
10.000	0.000	18	0	0.00000	0.00000	0.00000	0.00000
6.235	.183	0	0	0.00000	0.00000	0.00000	0.00000
10.000	.311	20	0	0.00000	0.00000	0.00000	0.00000
0.000	0.000	0	0	0.00000	0.00000	0.00000	0.00000
10.000	.156	22	0	0.00000	0.00000	0.00000	0.00000
2.145	.522	0	0	0.00000	0.00000	0.00000	0.00000
6.573	.031	24	0	0.00000	0.00000	0.00000	0.00000
0.000	0.000	0	0	0.00000	0.00000	0.00000	0.00000
2.182	.295	26	0	0.00000	0.00000	0.00000	0.00000
1.982	.938	0	0	0.00000	0.00000	0.00000	0.00000
6.338	1.429	28	0	0.00000	0.00000	0.00000	0.00000
6.079	1.388	0	0	0.00000	0.00000	0.00000	0.00000
6.437	1.469	30	0	0.00000	0.00000	0.00000	0.00000
2.500	.571	0	0	0.00000	0.00000	0.00000	0.00000
10.000	2.282	32	0	0.00000	0.00000	0.00000	0.00000
0.000	0.000	0	0	0.00000	0.00000	0.00000	0.00000
10.000	1.127	34	0	0.00000	0.00000	0.00000	0.00000
0.000	0.000	0	0	0.00000	0.00000	0.00000	0.00000
10.000	2.282	36	0	0.00000	0.00000	0.00000	0.00000
0.000	0.000	0	0	0.00000	0.00000	0.00000	0.00000
10.000	3.499	38	0	0.00000	0.00000	0.00000	0.00000
1.982	.938	0	0	0.00000	0.00000	0.00000	0.00000
6.279	1.422	40	0	0.00000	0.00000	0.00000	0.00000

CARD IV. NODE CODE SEQUENCE.

IC	I1	J1	I2	J2
1	1	1	4	5
1	5	1	9	2
2	5	3	5	5
[illegible]	5	3	9	3
[illegible]	10	1	10	3
3	6	4	14	5
[illegible]	11	1	14	3

CARD V. PART DEFINITION.

NP	I1	J1	I2	J2	L1	L2	L3	L4	MT	NN	I3	J3	IK
1	1	1	5	2	2	13	12	1	1	0	0	0	0
2	1	2	5	3	12	13	8	1	1	0	0	0	0
3	1	3	4	4	8	15	26	1	1	0	0	0	0
4	1	4	4	5	26	15	4	1	1	0	0	0	0
5	5	1	9	2	2	17	24	13	1	0	0	0	0
6	4	3	5	4	8	9	26	15	2	0	0	0	0
7	4	4	5	5	26	9	4	15	2	0	0	0	0
8	5	2	9	3	24	17	6	13	2	0	0	0	0
9	9	1	10	2	2	7	24	17	2	0	0	0	0
10	9	2	10	3	24	7	6	17	2	0	0	0	0
11	5	3	9	4	6	17	40	9	3	0	0	0	0
12	5	4	9	5	40	17	4	9	3	0	0	0	0
13	9	3	10	4	6	11	40	17	3	0	0	0	0
14	9	4	10	5	40	11	4	17	3	0	0	0	0
15	10	1	14	2	2	3	22	7	3	0	0	0	0
16	10	2	14	3	22	3	20	7	3	0	0	0	0
17	10	3	14	4	20	3	32	11	3	0	0	0	0
18	10	4	14	5	32	3	4	11	3	0	0	0	0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0

CARD VI. SECTION LOCATION.

Z - COORD

0.000

N	X	Y	Z	MT
1	.10000	0.00000	0.00000	1
2	.65057	0.00000	0.00000	1
3	1.20115	0.00000	0.00000	1
4	1.75173	0.00000	0.00000	1
5	2.30230	0.00000	0.00000	1
6	3.05895	0.00000	0.00000	1
7	3.81560	0.00000	0.00000	1
8	4.57225	0.00000	0.00000	1
9	5.32890	0.00000	0.00000	1
10	6.50000	0.00000	0.00000	2
11	7.37500	0.00000	0.00000	3
12	8.25000	0.00000	0.00000	3
13	9.12500	0.00000	0.00000	3
14	10.00000	0.00000	0.00000	3
15	.09749	.02225	0.00000	1
16	.63424	.14476	0.00000	1
17	1.17099	.26727	0.00000	1
18	1.70774	.38977	0.00000	1
19	2.24447	.51238	0.00000	1
20	3.01448	.43739	0.00000	1
21	3.78443	.36241	0.00000	1
22	4.55450	.28743	0.00000	1
23	5.32452	.21245	0.00000	1
24	6.47282	.10065	0.00000	2
25	7.35427	.11436	0.00000	3
26	8.23572	.12807	0.00000	3
27	9.11716	.14177	0.00000	3
28	9.99860	.15548	0.00000	3
29	.09121	.04098	0.00000	1
30	.59340	.26664	0.00000	1
31	1.09558	.49229	0.00000	1

32	1.59774	.71793	0.00000	1
33	2.09802	.94483	0.00000	2
34	2.90392	.80952	0.00000	2
35	3.70779	.66017	0.00000	2
36	4.51166	.51841	0.00000	2
37	5.31552	.37666	0.00000	2
38	6.33481	.18679	0.00000	2
39	7.25294	.21788	0.00000	3
40	8.16691	.24883	0.00000	3
41	9.08088	.27978	0.00000	3
42	9.99485	.31073	0.00000	3
43	.09099	.04148	0.00000	1
44	.59195	.26983	0.00000	1
45	1.09292	.49818	0.00000	1
46	1.59388	.72653	0.00000	1
47	2.08220	.94916	0.00000	2
48	2.85382	1.03600	0.00000	3
49	3.62541	1.12285	0.00000	3
50	4.39700	1.20969	0.00000	3
51	5.16856	1.29653	0.00000	3
52	6.17865	1.41022	0.00000	3
53	7.07121	1.61393	0.00000	3
54	7.96377	1.81765	0.00000	3
55	8.85633	2.02137	0.00000	3
56	9.74989	2.22509	0.00000	3
57	.09010	.04339	0.00000	1
58	.58614	.28227	0.00000	1
59	1.08219	.52115	0.00000	1
60	1.57823	.76003	0.00000	1
61	2.04544	.98502	0.00000	2
62	2.73437	1.31679	0.00000	3
63	3.42331	1.64856	0.00000	3
64	4.11224	1.98033	0.00000	3
65	4.90113	2.31210	0.00000	3
66	5.71017	2.74985	0.00000	3
67	6.53535	3.14709	0.00000	3
68	7.35994	3.54433	0.00000	3
69	8.18482	3.94156	0.00000	3
70	9.00370	4.33880	0.00000	3

CARD V. PART DEFINITION.

NP	I1	J1	I2	J2	L1	L2	L3	L4	MT	NN	I3	J3	IR
1	1	1	5	2	2	13	12	1	1	0	0	0	0
2	1	2	5	3	12	13	8	1	1	0	0	0	0
3	1	3	4	4	8	15	26	1	1	0	0	0	0
4	1	4	4	5	26	15	4	1	1	0	0	0	0
5	5	1	9	2	2	17	24	13	1	0	0	0	0
6	4	3	5	4	8	9	26	15	2	0	0	0	0
7	4	4	5	5	26	9	4	15	2	0	0	0	0
8	5	2	9	3	24	17	6	13	2	0	0	0	0
9	9	1	10	2	2	7	24	17	2	0	0	0	0
10	9	2	10	3	24	7	6	17	2	0	0	0	0
11	5	3	9	4	6	17	40	9	3	0	0	0	0
12	5	4	9	5	40	17	4	9	3	0	0	0	0
13	9	3	10	4	6	11	40	17	3	0	0	0	0
14	9	4	10	5	40	11	4	17	3	0	0	0	0
15	10	1	14	2	2	3	22	7	3	0	0	0	0
16	10	2	14	3	22	3	20	7	3	0	0	0	0
17	10	3	14	4	20	3	32	11	3	0	0	0	0
18	10	4	14	5	32	3	4	11	3	0	0	0	0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0

CARD VI. SECTION LOCATION.

Z - COORD

2.000

	X	Y	Z	MT
71	.10000	0.00000	2.00000	1
72	.65057	0.00000	2.00000	1
73	1.20115	0.00000	2.00000	1
74	1.75173	0.00000	2.00000	1
75	2.30230	0.00000	2.00000	1
76	3.05835	0.00000	2.00000	1
77	3.81560	0.00000	2.00000	1
78	4.57225	0.00000	2.00000	1
79	5.32890	0.00000	2.00000	1
80	6.50000	0.00000	2.00000	2
81	7.37500	0.00000	2.00000	3
82	8.25000	0.00000	2.00000	3
83	9.12500	0.00000	2.00000	3
84	10.00000	0.00000	2.00000	3
85	.09749	.02225	2.00000	1
86	.63424	.14476	2.00000	1
87	1.17099	.26727	2.00000	1
88	1.70774	.38977	2.00000	1
89	2.24447	.51238	2.00000	1
90	3.01448	.43739	2.00000	1
91	3.78449	.36241	2.00000	1
92	4.55450	.28743	2.00000	1
93	5.32452	-.21245	2.00000	1
94	6.47282	.10065	2.00000	2
95	7.35427	.11436	2.00000	3
96	8.23572	.12807	2.00000	3
97	9.11716	.14177	2.00000	3
98	9.99860	.15548	2.00000	3
99	.09121	.04098	2.00000	1
100	.59340	.26664	2.00000	1
101	1.09559	.49227	2.00000	1

102	1.59774	.71793	2.00000	1
103	2.09802	.94403	2.00000	2
104	2.50392	.90132	2.00000	2
105	3.70773	.66017	2.00000	2
106	4.51166	.51441	2.00000	2
107	5.31552	.37666	2.00000	2
108	6.33481	.19673	2.00000	2
109	7.25294	.21788	2.00000	3
110	8.16691	.24483	2.00000	3
111	9.08068	.27274	2.00000	3
112	9.99425	.31073	2.00000	3
113	.09693	.04140	2.00000	1
114	.59195	.26983	2.00000	1
115	1.09242	.49819	2.00000	1
116	1.5[illegible]	.72653	2.00000	1
117	2.26220	.94315	2.00000	2
118	2.85382	1.03600	2.00000	3
119	3.62541	1.12285	2.00000	3
120	4.39710	1.20969	2.00000	3
121	5.16458	1.29653	2.00000	3
122	6.17365	1.41022	2.00000	3
123	7.07121	1.61395	2.00000	3
124	7.96877	1.81705	2.00000	3
125	[illegible]	2.02137	2.00000	3
126	9.74497	2.22509	2.00000	3
127	.23210	.04339	2.00000	1
128	.58614	.26227	2.00000	1
129	1.08210	.52115	2.00000	1
130	1.57923	.76003	2.00000	1
131	2.04546	.93592	2.00000	2
132	2.73437	1.31679	2.00000	3
133	3.42331	1.64356	2.00000	3
134	4.11224	1.98033	2.00000	3
135	4.80118	2.31210	2.00000	3
136	5.71017	2.74385	2.00000	3
137	6.55[illegible]	3.14707	2.00000	3
138	7.35994	3.54433	2.00000	3
139	8.18492	3.94156	2.00000	3
140	9.00973	4.33980	2.00000	3

CARD V. PART DEFINITION.

NP	I1	J1	I2	J2	L1	L2	L3	L4	MT	NN	I5	J5	I6
1	1	1	5	2	2	17	12	1	1	0	0	0	0
2	1	2	5	3	12	17	8	1	1	0	0	0	0
3	1	3	4	4	9	15	26	1	1	0	0	0	0
4	1	4	4	5	26	15	4	1	1	0	0	0	0
5	5	1	9	2	2	17	24	13	1	0	0	0	0
6	4	3	5	4	[illegible]	9	26	15	2	0	0	0	0
7	4	4	5	5	26	3	4	15	2	0	0	0	0
8	5	2	9	3	24	17	6	13	2	0	0	0	0
9	9	1	10	2	2	7	24	17	2	0	0	0	0
10	9	2	10	3	24	7	6	17	2	0	0	0	0
11	5	3	9	4	6	17	40	9	3	0	0	0	0
12	5	4	9	5	40	17	4	9	3	0	0	0	0
13	9	3	10	4	6	11	40	17	3	0	0	0	0
14	9	4	10	5	40	11	4	17	3	0	0	0	0
15	10	1	14	2	2	3	22	7	3	0	0	0	0
16	10	2	14	3	22	3	20	7	3	0	0	0	0
17	10	3	14	4	20	3	32	11	3	0	0	0	0
18	10	4	14	5	32	3	4	11	3	0	0	0	0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0

CARD VI. SECTION LOCATION.

Z - COORD

4.000

N	X	Y	Z	MT
141	.10000	0.00000	4.00000	1
142	.65057	0.00000	4.00000	1
143	1.20115	0.00000	4.00000	1
144	1.75173	0.00000	4.00000	1
145	2.30230	0.00000	4.00000	1
146	3.05895	0.00000	4.00000	1
147	3.81560	0.00000	4.00000	1
148	4.57225	0.00000	4.00000	1
149	5.32890	0.00000	4.00000	1
150	6.50000	0.00000	4.00000	2
151	7.37500	0.00000	4.00000	3
152	8.25000	0.00000	4.00000	3
153	9.12500	0.00000	4.00000	3
154	10.00000	0.00000	4.00000	3
155	.09749	.02225	4.00000	1
156	.63424	.14476	4.00000	1
157	1.17099	.26727	4.00000	1
158	1.70774	.38977	4.00000	1
159	2.24447	.51238	4.00000	1
160	3.01448	.43739	4.00000	1
161	3.78449	.36241	4.00000	1
162	4.55450	.28743	4.00000	1
163	5.32452	.21245	4.00000	1
164	6.47282	.10065	4.00000	2
[illegible]5	7.35427	.11436	4.00000	3
[illegible]	8.23572	.12807	4.00000	3
167	9.11716	.14177	4.00000	3
168	9.99860	.15548	4.00000	3
169	.09121	.04098	4.00000	1
170	.59340	.26664	4.00000	1
171	1.09558	.49229	4.00000	1

172	1.59774	.71793	4.00000	1
173	2.09802	.94403	4.00000	2
174	2.90392	.80192	4.00000	2
175	3.70779	.66017	4.00000	2
176	4.51166	.51841	4.00000	2
177	5.31552	.37666	4.00000	2
178	6.33481	.1[illegible]79	4.00000	2
179	7.25294	.2[illegible]	4.00000	3
180	8.16691	.24[illegible]	4.00000	3
181	9.08088	.2747[illegible]	4.00000	3
182	9.99485	.31073	4.00000	3
183	.09099	.04148	4.00000	1
184	.59195	.26983	4.00000	1
185	1.09292	.49818	4.00000	1
186	1.59388	.72653	4.00000	1
187	2.08220	.94916	4.00000	2
188	2.85382	1.03600	4.00000	3
189	3.62541	1.12285	4.00000	3
190	4.39700	1.20969	4.00000	3
191	5.16858	1.29653	4.00000	3
192	6.17865	1.41022	4.00000	3
193	7.07121	1.61393	4.00000	3
194	7.96377	1.81765	4.00000	3
195	8.85633	2.02137	4.00000	3
196	9.74889	2.22509	4.00000	3
197	.09010	.04339	4.00000	1
198	.58614	.28227	4.00000	1
199	1.08219	.52115	4.00000	1
200	1.57823	.76003	4.00000	1
201	2.04544	.98502	4.00000	2
202	2.73437	1.31679	4.00000	3
203	3.42331	1.64856	4.00000	3
204	4.11224	1.98033	4.00000	3
205	4.80118	2.31210	4.00000	3
206	5.71017	2.74985	4.00000	3
207	6.53505	3.14709	4.00000	3
208	7.35994	3.54433	4.00000	3
209	8.18482	3.94156	4.00000	3
210	9.00970	4.33880	4.00000	3

CARD V. PART DEFINITION.

NP	I1	J1	I2	J2	L1	L2	L3	L4	MT	NN	I3	J3	IR
1	1	1	5	2	2	13	12	1	1	0	0	0	0
2	1	2	5	3	12	13	8	1	1	0	0	0	0
3	1	3	4	4	8	15	26	1	1	0	0	0	0
4	1	4	4	5	26	15	4	1	1	0	0	0	0
5	5	1	9	2	2	17	24	13	1	0	0	0	0
6	4	3	5	4	8	9	26	15	2	0	0	0	0
7	4	4	5	5	26	9	4	15	2	0	0	0	0
8	5	2	9	3	24	17	6	13	2	0	0	0	0
9	9	1	10	2	2	7	24	17	2	0	0	0	0
10	9	2	10	3	24	7	6	17	2	0	0	0	0
11	5	3	9	4	6	17	40	9	3	0	0	0	0
12	5	4	9	5	40	17	4	9	3	0	0	0	0
13	9	3	10	4	6	11	40	17	3	0	0	0	0
14	9	4	10	5	40	11	4	17	3	0	0	0	0
15	10	1	14	2	2	3	22	7	3	0	0	0	0
16	10	2	14	3	22	3	20	7	3	0	0	0	0
17	10	3	14	4	20	3	32	11	3	0	0	0	0
18	10	4	14	5	32	3	4	11	3	0	0	0	0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0

CARD VI. SECTION LOCATION.

Z - COORD

6.000

	X	Y	Z	MT
211	.10000	0.00000	6.00000	1
212	.65057	0.00000	6.00000	1
213	1.20115	0.00000	6.00000	1
214	1.75173	0.00000	6.00000	1
215	2.30230	0.00000	6.00000	1
216	3.05895	0.00000	6.00000	1
217	3.81560	0.00000	6.00000	1
218	4.57225	0.00000	6.00000	1
219	5.32890	0.00000	6.00000	1
220	6.50000	0.00000	6.00000	2
221	7.37500	0.00000	6.00000	3
222	8.25000	0.00000	6.00000	3
223	9.12500	0.00000	6.00000	3
224	10.00000	0.00000	6.00000	3
225	.09743	.02225	6.00000	1
226	.63424	.14476	6.00000	1
227	1.17099	.26727	6.00000	1
228	1.70774	.38977	6.00000	1
229	2.24447	.51236	6.00000	1
230	3.01448	.43739	6.00000	1
231	3.78449	.36241	6.00000	1
232	4.55450	.28743	6.00000	1
233	5.32452	.21245	6.00000	1
234	6.47292	.10065	6.00000	2
235	7.35427	.11436	6.00000	3
236	8.23572	.12807	6.00000	3
237	9.11716	.14177	6.00000	3
238	9.99860	.15548	6.00000	3
239	.09121	.04098	6.00000	1
240	.59340	.26664	6.00000	1
241	1.09558	.49229	6.00000	1

242	1.59774	.71793	6.00000	1
243	2.29802	.84403	6.00000	2
244	2.90392	.80192	6.00000	2
245	3.70772	.66017	6.00000	2
246	4.51166	.51941	6.00000	2
247	5.31552	.37666	6.00000	2
248	6.33481	.18679	6.00000	2
249	7.25294	.21788	6.00000	3
250	8.16691	.24883	6.00000	3
251	9.08088	.27978	6.00000	3
252	9.99485	.31073	6.00000	3
253	.09099	.04148	6.00000	1
254	.59195	.26383	6.00000	1
255	1.09292	.47913	6.00000	1
256	1.59388	.72653	6.00000	1
257	2.08220	.94316	6.00000	2
258	2.85382	1.03680	6.00000	3
259	3.62541	1.12285	6.00000	3
260	4.39700	1.20963	6.00000	3
261	5.16858	1.29653	6.00000	3
262	6.17865	1.41022	6.00000	3
263	7.07121	1.61393	6.00000	3
264	7.96377	1.81765	6.00000	3
265	8.85633	2.02137	6.00000	3
266	9.74889	2.22509	6.00000	3
267	.09010	.04339	6.00000	1
268	.58614	.28227	6.00000	1
269	1.08219	.52115	6.00000	1
270	1.57823	.76003	6.00000	1
271	2.04544	.98502	6.00000	2
272	2.73437	1.31679	6.00000	3
273	3.42331	1.64856	6.00000	3
274	4.11224	1.98033	6.00000	3
275	4.80118	2.31210	6.00000	3
276	5.71017	2.74985	6.00000	3
277	6.53505	3.14709	6.00000	3
278	7.35994	3.54433	6.00000	3
279	8.18482	3.94156	6.00000	3
280	9.00970	4.33880	6.00000	3

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CARD V. PART DEFINITION.

NP	I1	J1	I2	J2	L1	L2	L3	L4	MT	NN	I3	J3	IT
1	1	1	5	2	7	13	12	1	1	0	0	0	0
2	1	2	5	3	12	13	8	1	1	0	0	0	0
3	1	3	4	4	8	15	26	1	1	0	0	0	0
4	1	4	4	5	26	15	4	1	1	0	0	0	0
5	5	1	9	2	2	17	24	13	1	0	0	0	0
6	4	3	5	4	8	9	26	15	2	0	0	0	0
7	4	4	5	5	26	9	4	15	2	0	0	0	0
8	5	2	9	3	24	17	6	13	2	0	0	0	0
9	9	1	10	2	2	7	24	17	2	0	0	0	0
10	9	2	10	3	24	7	6	17	2	0	0	0	0
11	5	3	9	4	6	17	40	9	3	0	0	0	0
12	5	4	9	5	42	17	4	9	3	0	0	0	0
13	9	3	10	4	6	11	40	17	3	0	0	0	0
14	9	4	10	5	40	11	4	17	3	0	0	0	0
15	10	1	14	2	2	3	22	7	3	0	0	0	0
16	12	2	14	3	22	3	20	7	3	0	0	0	0
17	10	3	14	4	20	3	32	11	3	0	0	0	0
18	10	4	14	5	32	3	4	11	3	0	0	0	0
-1	0	0	0	0	0	0	0	0	0	0	0	0	0

15

CARD VI. SECTION LOCATION.

Z - CHORD

8.000

	X	Y	Z	MT
281	.10000	0.00000	8.00000	1
282	.65057	0.00000	8.00000	1
283	1.20115	0.00000	8.00000	1
284	1.75173	0.00000	8.00000	1
285	2.30230	0.00000	8.00000	1
286	3.05445	0.00000	8.00000	1
287	3.81560	0.00000	8.00000	1
288	4.57225	0.00000	8.00000	1
289	5.32890	0.00000	8.00000	1
290	6.50000	0.00000	8.00000	2
291	7.37500	0.00000	8.00000	3
292	8.25000	0.00000	8.00000	3
293	9.12500	0.00000	8.00000	3
294	10.00000	0.00000	8.00000	3
295	.09743	.02225	8.00000	1
296	.63424	.14476	8.00000	1
297	1.17099	.26727	8.00000	1
298	1.70774	.38977	8.00000	1
299	2.24447	.51238	8.00000	1
300	3.01448	.43739	8.00000	1
301	3.78443	.36241	8.00000	1
302	4.55450	.28743	8.00000	1
303	5.32452	.21245	8.00000	1
304	6.47282	.10065	8.00000	2
305	7.35427	.11436	8.00000	3
306	8.23572	.12807	8.00000	3
307	9.11716	.14177	8.00000	3
308	9.99860	.15548	8.00000	3
309	.09121	.04098	8.00000	1
310	.59340	.26664	8.00000	1
311	1.09558	.49229	8.00000	1

312	1.59774	.71795	8.00000	1
313	2.09802	.34405	8.00000	2
314	2.90392	.40192	8.00000	2
315	3.70779	.55017	8.00000	2
316	4.51166	.51341	8.00000	2
317	5.31552	.37666	8.00000	2
318	6.73481	.18679	8.00000	2
319	7.25294	.21788	8.00000	3
320	8.16691	.24883	8.00000	3
321	9.08088	.27978	8.00000	3
322	9.99485	.31073	8.00000	3
323	.09059	.04143	8.00000	1
324	.59195	.26983	8.00000	1
325	1.09292	.49818	8.00000	1
326	1.59388	.72653	8.00000	1
327	2.08221	.94916	8.00000	[illegible]
328	2.85582	1.03600	8.00000	3
329	3.62541	1.12285	8.00000	3
330	4.39730	1.20969	8.00000	3
331	5.16358	1.29653	8.00000	3
332	6.17965	1.41022	8.00000	3
333	7.07121	1.61377	8.00000	3
334	7.96377	1.81765	8.00000	3
335	8.85633	2.02137	8.00000	3
336	9.74889	2.22509	8.00000	3
337	.09013	.04339	8.00000	1
338	.59614	.28227	8.00000	1
339	1.08219	.52115	8.00000	1
340	1.57823	.76003	8.00000	1
341	2.04544	.98502	8.00000	2
342	2.73437	1.31679	8.00000	3
343	3.42331	1.64856	8.00000	3
344	4.11224	1.98033	8.00000	3
345	4.80118	2.31210	8.00000	3
346	5.71017	2.74985	8.00000	3
347	6.55505	3.14703	8.00000	3
348	7.35954	4.54433	8.00000	3
349	8.18482	3.94156	8.00000	3
350	9.00870	4.33880	8.00000	3

1	1	2	16	15	71	72	86	85	1
2	2	3	17	16	72	73	87	86	1
3	3	4	18	17	73	74	88	87	1
4	4	5	19	18	74	75	89	88	1
5	5	6	20	19	75	76	90	89	1
6	6	7	21	20	76	77	91	90	1
7	7	8	22	21	77	78	92	91	1
8	8	9	23	22	78	79	93	92	1
9	9	10	24	23	79	80	94	93	2
10	15	16	30	29	85	86	100	99	1
11	16	17	31	30	86	87	101	100	1
12	17	18	32	31	87	88	102	101	1
13	18	19	33	32	88	89	103	102	1
14	19	20	34	33	89	90	104	103	2
15	20	21	35	34	90	91	105	104	2
16	21	22	36	35	91	92	106	105	2
17	22	23	37	36	92	93	107	106	2
18	23	24	38	37	93	94	108	107	2
19	29	30	44	43	99	100	114	113	1
20	30	31	45	44	100	101	115	114	1
21	31	32	46	45	101	102	116	115	1
22	32	33	47	46	102	103	117	116	2
23	43	44	58	57	113	114	128	127	1
24	44	45	59	58	114	115	129	128	1
25	45	46	60	59	115	116	130	129	1
26	46	47	61	60	116	117	131	130	2
27	71	72	86	85	141	142	156	155	1

28	72	73	87	86	142	143	157	156	1
29	73	74	88	87	143	144	158	157	1
30	74	75	89	88	144	145	159	158	1
31	75	76	90	89	145	146	160	159	1
32	76	77	91	90	146	147	161	160	1
33	77	78	92	91	147	148	162	161	1
34	78	79	93	92	148	149	163	162	1
35	79	80	94	93	149	150	164	163	2
36	85	86	100	99	155	156	170	169	1
37	86	87	101	100	156	157	171	170	1
38	87	88	102	101	157	158	172	171	1
39	88	89	103	102	158	159	173	172	1
40	89	90	104	103	159	160	174	173	2
41	90	91	105	104	160	161	175	174	2
42	91	92	106	105	161	162	176	175	2
43	92	93	107	106	162	163	177	176	2
44	93	94	108	107	163	164	178	177	2
45	99	100	114	113	169	170	184	183	1
46	100	101	115	114	170	171	185	184	1
47	101	102	116	115	171	172	186	185	1
48	102	103	117	116	172	173	187	186	2
49	113	114	128	127	183	184	198	197	1
50	114	115	129	128	184	185	199	198	1
51	115	116	130	129	185	186	200	199	1
52	116	117	131	130	186	187	201	200	2
53	141	142	156	155	211	212	226	225	1
54	142	143	157	156	212	213	227	226	1
55	143	144	158	157	213	214	228	227	1
56	144	145	159	158	214	215	229	228	1
57	145	146	160	159	215	216	230	229	1
58	146	147	161	160	216	217	231	230	1
59	147	148	162	161	217	218	232	231	1
60	148	149	163	162	218	219	233	232	1
61	149	150	164	163	219	220	234	233	2
62	155	156	170	169	225	226	240	239	1
63	156	157	171	170	226	227	241	240	1
64	157	158	172	171	227	228	242	241	1
65	158	159	173	172	228	229	243	242	1
66	159	160	174	173	229	230	244	243	2
67	160	161	175	174	230	231	245	244	2
68	161	162	176	175	231	232	246	245	2
69	162	163	177	176	232	233	247	246	2
70	163	164	178	177	233	234	248	247	2
71	169	170	184	183	239	240	254	253	1
72	170	171	185	184	240	241	255	254	1
73	171	172	186	185	241	242	256	255	1
74	172	173	187	186	242	243	257	256	2
75	183	184	198	197	253	254	268	267	1
76	184	185	199	198	254	255	269	268	1
77	185	186	200	199	255	256	270	269	1
78	186	187	201	200	256	257	271	270	2
79	211	212	226	225	281	282	296	295	1
80	212	213	227	226	282	283	297	296	1
81	213	214	228	227	283	284	298	297	1
82	214	215	229	228	284	285	299	298	1
83	215	216	230	229	285	286	300	299	1
84	216	217	231	230	286	287	301	300	1
85	217	218	232	231	287	288	302	301	1
86	218	219	233	232	288	289	303	302	1
87	219	220	234	233	289	290	304	303	2
88	225	226	240	239	295	296	310	309	1
89	226	227	241	240	296	297	311	310	1
90	227	228	242	241	297	298	312	311	1
91	228	229	243	242	298	299	313	312	1
92	229	230	244	243	299	300	314	313	2
93	230	231	245	244	300	301	315	314	2

94	231	232	246	245	301	302	316	315	2
95	232	233	247	246	302	303	317	316	2
96	233	234	248	247	303	304	318	317	2
97	239	240	254	253	309	310	324	323	1
98	240	241	255	254	310	311	325	324	1
99	241	242	256	255	311	312	326	325	1
100	242	243	257	256	312	313	327	326	2
101	253	254	268	267	323	324	338	337	1
102	254	255	269	268	324	325	339	338	1
103	255	256	270	269	325	326	340	339	1
104	256	257	271	270	326	327	341	340	2
105	10	11	25	24	80	81	95	94	3
106	11	12	26	25	81	82	96	95	3
107	12	13	27	26	82	83	97	96	3
108	13	14	28	27	83	84	98	97	3
109	24	25	39	38	94	95	109	108	3
110	25	26	40	39	95	96	110	109	3
111	26	27	41	40	96	97	111	110	3
112	27	28	42	41	97	98	112	111	3
113	33	34	48	47	103	104	118	117	3
114	34	35	49	48	104	105	119	118	3
115	35	36	50	49	105	106	120	119	3
116	36	37	51	50	106	107	121	120	3
117	37	38	52	51	107	108	122	121	3
118	38	39	53	52	108	109	123	122	3
119	39	40	54	53	109	110	124	123	3
120	40	41	55	54	110	111	125	124	3
121	41	42	56	55	111	112	126	125	3
122	47	48	62	61	117	118	132	131	3
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124	49	50	64	63	119	120	134	133	3
125	50	51	65	64	120	121	135	134	3
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127	52	53	67	66	122	123	137	136	3
128	53	54	68	67	123	124	138	137	3
129	54	55	69	68	124	125	139	138	3
130	55	56	70	69	125	126	140	139	3
131	80	81	95	94	150	151	165	164	3
132	81	82	96	95	151	152	166	165	3
133	82	83	97	96	152	153	167	166	3
134	83	84	98	97	153	154	168	167	3
135	94	95	109	108	164	165	179	178	3
136	95	96	110	109	165	166	180	179	3
137	96	97	111	110	166	167	181	180	3
138	97	98	112	111	167	168	182	181	3
139	103	104	118	117	173	174	188	187	3
140	104	105	119	118	174	175	189	188	3
141	105	106	120	119	175	176	190	189	3
142	106	107	121	120	176	177	191	190	3
143	107	108	122	121	177	178	192	191	3
144	108	109	123	122	178	179	193	192	3
145	109	110	124	123	179	180	194	193	3
146	110	111	125	124	180	181	195	194	3
147	111	112	126	125	181	182	196	195	3
148	117	118	132	131	187	188	202	201	3
149	118	119	133	132	188	189	203	202	3
150	119	120	134	133	189	190	204	203	3
151	120	121	135	134	190	191	205	204	3
152	121	122	136	135	191	192	206	205	3
153	122	123	137	136	192	193	207	206	3
154	123	124	138	137	193	194	208	207	3
155	124	125	139	138	194	195	209	208	3
156	125	126	140	139	195	196	210	209	3
157	150	151	165	164	220	221	235	234	3
158	151	152	166	165	221	222	236	235	3
159	152	153	167	166	222	223	237	236	3

160	153	154	168	167	223	224	238	237	3
161	164	165	179	178	234	235	249	248	3
162	165	166	180	179	235	236	250	249	3
163	166	167	181	180	236	237	251	250	3
164	167	168	182	181	237	238	252	251	3
165	173	174	188	187	243	244	258	257	3
166	174	175	189	188	244	245	259	258	3
167	175	176	190	189	245	246	260	259	3
168	176	177	191	190	246	247	261	260	3
169	177	178	192	191	247	248	262	261	3
170	178	179	193	192	248	249	263	262	3
171	179	180	194	193	249	250	264	263	3
172	180	181	195	194	250	251	265	264	3
173	181	182	196	195	251	252	266	265	3
174	187	188	202	201	257	258	272	271	3
175	188	189	203	202	258	259	273	272	3
176	189	190	204	203	259	260	274	273	3
177	190	191	205	204	260	261	275	274	3
178	191	192	206	205	261	262	276	275	3
179	192	193	207	206	262	263	277	276	3
180	193	194	208	207	263	264	278	277	3
181	194	195	209	208	264	265	279	278	3
182	195	196	210	209	265	266	280	279	3
183	220	221	235	234	290	291	305	304	3
184	221	222	236	235	291	292	306	305	3
185	222	223	237	236	292	293	307	306	3
186	223	224	238	237	293	294	308	307	3
187	234	235	249	248	304	305	319	318	3
188	235	236	250	249	305	306	320	319	3
189	236	237	251	250	306	307	321	320	3
190	237	238	252	251	307	308	322	321	3
191	243	244	258	257	313	314	328	327	3
192	244	245	259	258	314	315	329	328	3
193	245	246	260	259	315	316	330	329	3
194	246	247	261	260	316	317	331	330	3
195	247	248	262	261	317	318	332	331	3
196	248	249	263	262	318	319	333	332	3
197	249	250	264	263	319	320	334	333	3
198	250	251	265	264	320	321	335	334	3
199	251	252	266	265	321	322	336	335	3
200	257	258	272	271	327	328	342	341	3
201	258	259	273	272	328	329	343	342	3
202	259	260	274	273	329	330	344	343	3
203	260	261	275	274	330	331	345	344	3
204	261	262	276	275	331	332	346	345	3
205	262	263	277	276	332	333	347	346	3
206	263	264	278	277	333	334	348	347	3
207	264	265	279	278	334	335	349	348	3
208	265	266	280	279	335	336	350	349	3

1	10	24	94	80	1
2	34	33	103	104	1
3	35	34	104	105	1
4	36	35	105	106	1
5	37	36	106	107	1
6	38	37	107	108	1
7	33	47	117	103	1
8	47	61	131	117	1
9	80	94	164	150	1
10	104	103	173	174	1
11	105	104	174	175	1
12	106	105	175	176	1
13	107	106	176	177	1
14	108	107	177	178	1
15	103	117	187	173	1
16	117	131	201	187	1
17	150	164	234	220	1

19

18	174	173	243	244	1
19	175	174	244	245	1
20	176	175	245	246	1
21	177	176	246	247	1
22	178	177	247	248	1
23	173	187	257	243	1
24	187	201	271	257	1
25	220	234	304	290	1
26	244	243	313	314	1
27	245	244	314	315	1
28	246	245	315	316	1
29	247	246	316	317	1
30	248	247	317	318	1
31	243	257	327	313	1
32	257	271	341	327	1
33	24	38	108	94	1
34	94	108	178	164	1
35	164	178	248	234	1
36	234	248	318	304	1

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