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A TWO-DIMENSIONAL FINITE-DIFFERENCE SOLUTION FOR THE TEMPERATURE DISTRIBUTION IN A RADIAL GAS TURBINE GUIDE VANE BLADE

BY

W.M. HOSNY AND W. TABAKOFF

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16. Abstract

A two-dimensional finite-difference numerical technique is presented to determine the temperature distribution in a solid blade of a radial turbine guide vane.

A computer program is written in Fortran IV for IBM 370/165 computer. The computer results obtained from these programs have a similar behavior and trend as those obtained by experimental results.

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SUMMARY

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A computer program is written in Fortran IV for IBM 370/165 computer. The computer results obtained from these programs have a similar behavior and trend as these obtained by experimental results.

INTRODUCTION

The power output of a radial gas turbine is directly proportional to the inlet temperature of the combustion gases. Generally, higher inlet temperatures are desired in order to achieve higher power outputs. Due to the limitations on the material strength, the operating temperature is limited for the safe operation of the blading without failure. One way of ensuring the safe operation of gas turbine blades is to provide adequate cooling for the blades. The cooling of the blades helps the safe operation of an engine by reducing the temperature level in the blade material and by equalizing the temperature differences throughout the blade sections. By determining the temperature distribution in the blades of a gas turbine, the critical stress areas could be located and hence could be provided with sufficient cooling mechanisms. Kuhl[1] reported the temperature measurements that were taken in the rotor blades of a gas turbine. He used the analogy between the heat flux and the electric current within a three-dimensional model to determine the heat flow in a complete blade.

Calculating the temperature distribution at a cross section of a gas turbine blading using analytical methods poses some problems due to the irregular shape of the boundary of the blade and the fact that the temperature and the velocity of the gas around the blade surface are variable from one point to another. The variable gas velocity around the blade results in a variable heat transfer coefficient. Due to these circumstances, it is necessary to resort to numerical techniques using a finite-difference or a finite element method of solution. In the present study, a computer program is written using a two-dimensional finite-difference numerical technique to determine the temperature distribution at a cross section of a solid blade. Data concerning the geometry of the blade surface is given as an input in the form of the coordinates of the points intersection of the mesh lines of

Figure 1 with the boundary of the blade. The gas temperatures and the corresponding heat transfer coefficients at these blade boundary points are also given in the input data.

This computer program determines the two-dimensional temperature distribution in the cross section of a blade without cavities. It can be modified however to handle the case of a hollow blade utilizing internal cooling as in Reference [2]. It is assumed that the thermal conductivity of the blade material is the same everywhere since the variations in the conductivity will not be significant except for very large temperature differences within the blade. A subroutine can be added to the program however if it is desired to take into account the local variation of the thermal conductivity with temperature. The second order derivatives in the partial differential equation governing the temperature distribution in the blade are expressed in terms of second order accurate finite-differences and the resulting algebraic equation in the mesh point temperatures are solved using the Gauss-Seidel iteration technique. Over-relaxation factors are used to accelerate the convergence process.

GOVERNING EQUATIONS

In plane rectangular coordinate system, the differential equation governing the temperature distribution in the turbine blade is given by:

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = 0 \tag{1}$$

In the above equation it is assumed that there is no heat generation in the blade body and that the thermal conductivity of the material is constant.

The boundary condition at any point on the blade surface can be expressed as:

$$K \frac{\partial T}{\partial n} = h(T_g - T_s) \tag{2}$$

Where K is the thermal conductivity of the blade material

n is the normal to the blade surface at a given point

T_g is the gas temperature at the surface of the blade

and T_s is the blade surface temperature at the particular point in question

The turbine blade and the grid network used in the present case is shown in Figure 1. The particulars of the blade are given in Table 1. The grid spacings in the x-direction, DX, are uniform as well as the spacing DY in the y-direction.

Referring to Figure 2, the partial differential Equation (1) can be written in a finite-difference form at any mesh point P(i,j) inside the blade surface in terms of the temperatures at the neighboring points A, B, C and D as follows:

$$\frac{T_{i-1,j} - 2T_{i,j} + T_{i+1,j}}{DX^2} + \frac{T_{i,j-1} - 2T_{i,j} + T_{i,j+1}}{DY^2} = 0$$

or

$$T_{i,j} = \frac{1}{2(DX^2 + DY^2)} [DY^2 (T_{i+1,j} + T_{i-1,j}) + DX^2 (T_{i,j+1} + T_{i,j-1})] \tag{3}$$

Equation (3) is second order accurate, and is valid at all interior points whose four closest neighboring points happen to be at regular mesh locations. For points near the boundary of the blade, in Figure 3, the neighboring points A, B, C and D do not occupy normal mesh locations and hence the expression given by Equation (3) has to be modified to take into account the nonsymmetrical locations of the neighboring mesh points. In a general case such as in Figure 4, where points A and C are located at ζ_1 and ζ_2 fractions of DX and points B and D are at δ_1 and δ_2 fractions of DY relative to P, the difference Equation (4) will be used. This equation is arrived at by expressing the temperatures at A, B, C and D in terms of Taylor series expansions at P, and then eliminating the first order derivatives between these expressions to obtain the following equation:

$$\frac{2}{DX^2(\zeta_1+\zeta_2)} \left[\frac{T_{i-1,j}}{\zeta_1} - T_{i,j} \left(\frac{1}{\zeta_1} + \frac{1}{\zeta_2}\right) + \frac{T_{i+1,j}}{\zeta_2}\right]$$

$$+ \frac{2}{D^2(\delta_1+\delta_2)} \left[\frac{T_{i,j-1}}{\delta_1} - T_{i,j} \left(\frac{1}{\delta_1} + \frac{1}{\delta_2}\right) + \frac{T_{i,j+1}}{\delta_2}\right] = 0 \quad (4)$$

Equation (4) can be written in a more convenient form as follows:

$$T_{i,j} = \frac{1}{E} \left[\frac{T_{i-1,j}}{\zeta_1(\zeta_1+\zeta_2)} + \frac{T_{i,j+1}}{\zeta_2(\zeta_1+\zeta_2)} + \left(\frac{DX}{DY}\right)^2 \left\{\frac{T_{i,j-1}}{\delta_1(\delta_1+\delta_2)} + \frac{T_{i,j+1}}{\delta_2(\delta_1+\delta_2)}\right\}\right] \quad (5)$$

Where

$$E = \left[\frac{1}{\zeta_1\zeta_2} + \left(\frac{DX}{DY}\right)^2 \frac{1}{\delta_1\delta_2}\right] \quad (6)$$

The above equations are second order accurate when $\delta_1 \simeq \delta_2$ and $\zeta_1 \simeq \zeta_2$. For equally spaced grid lines, the factors ζ_1, ζ_2, δ_1 and δ_2 will all be equal to 1.0 and Equations (5) and (6) will ultimately reduce to Equation (3). Equation (5) is used instead of Equation (3) at grid locations next to the boundary of the blade such as at the point P in Figure 3. At the blade boundary points such as C or D in Figure 3, the convective boundary condition given by Equation (2) has to be used to evaluate the surface temperature of the blade. In order to apply Equation (2), the normal gradient of the temperature normal to the boundary point has to be expressed in a finite difference form. Referring to Figure 3, if NDN' is the normal to the blade surface at the boundary point D, then the temperature gradient D is approximated by:

$$\frac{\partial T}{\partial n} = \frac{T_D - T_N}{DN} = \frac{h_D}{K} (T_g - T_D) \quad (7)$$

Rearranging Equation (7), the temperature at the boundary point D is given by:

$$T_D = \frac{[T_N + \frac{h_D \, DN}{K} T_g]}{[1 + \frac{h_D \, DN}{K}]} \qquad (8)$$

The solution of Equation (3) at the interior points, (5) at the points next to the boundary, along with Equation (8) at the boundary points will give the temperature distribution in the blade.

COMPUTER PROGRAM

The details of the input to the computer program are given in Appendix A. From the blade boundary points, the program calculates ζ_1, ζ_2, δ_1 and δ_2 from the data concerning the mesh structure and the boundary point coordinates. As an initial guess the temperature matrix T is set to any convenient value. The Gauss-Seidel method of iteration then starts with the interior points of the blade. The computations giving new temperatures of mesh points on each I line proceed in the x direction. Equation (3) is used for all points which do not lie next to a boundary and Equation (5) is used for all the points which lie next to a boundary. Once this is completed, the temperatures on the blade surface are evaluated using the convective boundary condition expressed by the finite-difference Equation (8). The normal to the boundary at any point is determined by fitting a least squares parabolic curve through the three boundary points consisting of the one under consideration and the two adjacent points on both its sides. From the parabolic equation of the curve, the slope of the tangent to the surface at the point can be found and hence the slope of the normal to the curve at the required. The coordinates of the intersection of the normal with the closest mesh line inside the blade, point N in Figure 3, can thus be found. The temperature at the intersection point, N, is determined by linear interpolation from the temperatures of the neighboring points A and P of Figure 3. The length DN is determined from the coordinates of N and D which are known from previous steps. In each iteration, the boundary temperatures are first evaluated at points on the I lines and then the temperatures at the boundary points on the J lines are determined in a similar fashion. This iteration process is repeated until the sum of the squares of the differences between two successive iterations is less than a prescribed small quantity.

$$\text{i.e.} \quad \sum_{\text{all points}} (T_n - T_{n-1})^2 \leq \varepsilon \tag{9}$$

Where T_n is the temperature after n^{th} iteration

T_{n-1} is the temperature after (n-1)th iteration

and ε is the prescribed error limit.

The process of convergence could be accelerated by using an over-relaxation factor, ω, thus:

$$T_n = \omega\, T_n^{'} + (1 - \omega) T_{n-1} \tag{10}$$

Where T_{n-1} is the temperature after (n-1) iterations

$T_n^{'}$ is the temperature computed after n iterations

ω is the over-relaxation factor

T_n is the temperature used for the $(n+1)^{st}$ iteration.

After the final iteration, all the grid temperatures are printed and the locations for isothermals are found by linear interpolation.

COMPUTATION PROCEDURE AND DISCUSSION

To use the program for determining the temperature distribution, the input data has to be prepared. The details of input parameters required are given in Appendix A. Defining the blade boundaries can be most easily done graphically as shown in Figure 1. To find the gas temperatures and heat transfer coefficients around the blade, the flow behavior around the blade should be obtained first.

The velocities on a radial gas turbine blade are determined from the computer program given by Dastanis[3]. This can be used to determine the flow properties on a blade-to-blade surface in a turbomachine. The solution is obtained using a velocity gradient method; which uses information obtained from a finite-difference stream function solution at a reduced weight flow. From the velocity distribution, the temperature of gas around the blade can be determined. A typical velocity distribution for the case used in this investigation is shown in Figure 5. For convenience, the blade surface flow velocities are plotted as a function of surface distance; which are measured from the point, S_o in Figure 1. The temperature distribution is computed using the energy equation and is shown in Figure 6 as a function of the blade surface distance from the leading edge. The heat transfer coefficient is determined from the Reynold's Analogy and the boundary layer characteristics.

The boundary layer solution is determined using the computer program written by Herring and Mellor[4]. The velocity distribution of Figure 5 is used as input for the boundary layer computations. The details of the program input and method of solution are given in Reference (4). This program can be used for both laminar and turbulent boundary layers over two-dimensional or axi-symmetric bodies. The program also takes into consideration the effects of pressure gradients, Reynolds Number, wall transpiration and surface roughness. This program solves the boundary layer equations numerically by using Crank-Nicolson method in combination with a fourth order Runge-Kutta solution scheme. In its output, the program gives the boundary layer parameters on the blade surface, such as the displacement thickness, the momentum thickness, the friction coefficient, and the energy thickness. Knowing the friction coefficient along the surface from the boundary layer computations, the heat transfer coefficient is determined using Reynold's Analogy. The convection heat transfer coefficient shown in Figure 7 is calculated using the gas velocity and temperature distributions of Figures 5 and 6. The temperature and the heat transfer coefficients around the stagnation point are not expected to be accurate, however, since the velocity distribution calculated using the method of Reference (3) is not accurate in this region.

The present conduction heat transfer program uses a 40 x 12 mesh point with DX = 1.27 mm and DY = 0.635 mm. The over-relaxation factor for faster convergence is determined by trial and error. Figure 8 gives the variation of the number of iterations needed for a certain convergence with the relaxation factor, ω. Three different error limits, $\varepsilon = 0.1$, 0.05, and 0.02 were considered for convergence. With an error of $\varepsilon \leq 1$, the minimum number of iterations occurs at $\omega = 1.75$. Similar behavior was observed with the other error limits, with the minimum number of iterations being obtained with $\omega = 1.7$ and 1.6 for $\varepsilon \leq 0.05$ and 0.02 respectively. The solution was found to oscillate at higher values of the over relaxation factor ω.

The program written in FORTRAN IV for an IBM 370/165 computer, is given in Appendix B. The computation time was 14 cpu seconds for 280 iterations. An explanation of the program input and its preparation is given in Appendix A while in Appendix C, a sample output is given. Figure 9 shows some of isothermals for the blade profile considered. From Figures 6 and 9 it can be observed that the upper surface of the blade is generally at a higher temperature than the lower surface. The isothermal lines, which are obtained using the present numerical methods are found to have similar behavior and trends as those found experimentally by Kuhl[1].

CONCLUSIONS

The computer program presented here gives a two-dimensional theoretical temperature distribution for a radial turbine guide vane blade. The temperature distribution agrees with the experimental results obtained by other investigators.

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4. Herring, H.J., and Mellor, G.L., "A Computer Program to Calculate Incompressible Laminar and Turbulent Boundary Layer Development," NASA-CR-1564, March 1970.

5. Schneider, P.J., Conduction Heat Transfer, Addison-Wesley Publishing Co., Cambridge, Massachusetts, 1955.

LIST OF SYMBOLS

A,B,C,D	Points indicated in Figure 2
DN	Distance along normal to surface of blade (Figure 3)
DX	Grid spacing in x direction (m)
DY	Grid spacing in y direction (m)
E	Constant defined by Equation (6)
h	Heat transfer coefficient $\left(\frac{J}{hr\ m^2\ {}^\circ K}\right)$
I	Grid line numbers in x direction
J	Grid line numbers in y direction
K	Thermal conductivity of material of the blade $\left(\frac{J}{hr\ m\ {}^\circ K}\right)$
n	Normal direction to the blade surface
P	A point of grid structure as in Figure 2
T	Temperature
X	X-coordinate
Y	y-coordinate
δ_1	Fraction of grid spacing for point B in Figure 4
δ_2	Fraction of grid spacing for point D in Figure 4
ζ_1	Fraction of grid spacing for point A in Figure 4
ζ_2	Fraction of grid spacing for point C in Figure 4
ε	Error term as defined in Equation (9)

Subscripts:

D	Corresponds to boundary point in Figure 3

g	Corresponds to gas
i,j	Mesh line numbers in x and y directions
N	Corresponds to the point where normal NN′ to the boundary at D cuts the mesh line AP (Figure 3)
S	Surface

TABLE I

PARTICULARS OF RADIAL TURBINE NOZZLE BLADE:

Leading edge Radius = 2.07 mm

Trailing edge Radius = 0.40 mm

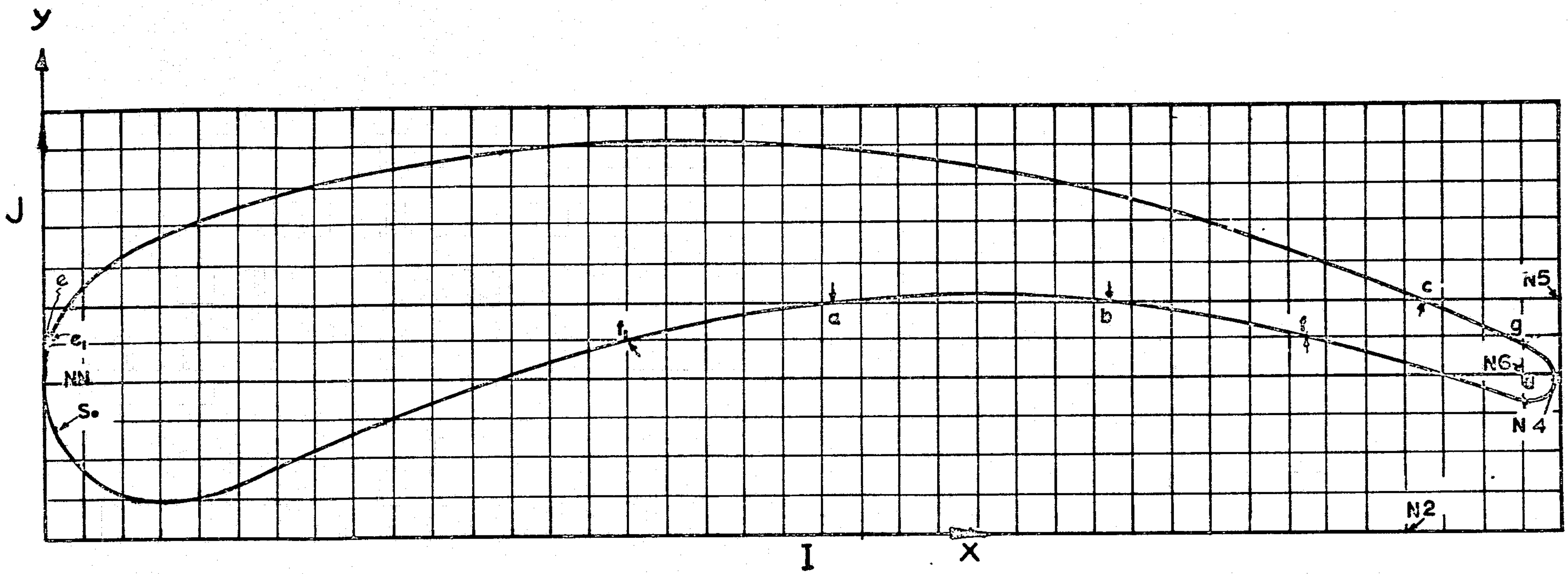
c = 49.3 mm

Thermal conductivity = $0.7476 \times 10^5 \frac{J}{hr\ m\ °K}$

Boundary points:

X mm	Y (Lower) mm	Y (Upper) mm
0.0	2.54	2.54
2.54	0.71	4.57
5.08	0.63	5.16
10.16	1.73	5.92
15.24	2.67	6.32
20.32	3.38	6.48
25.40	3.76	6.35
30.48	3.94	6.04
35.56	3.73	5.46
40.64	3.22	4.65
45.72	2.54	3.63
49.27	2.54	2.54

DX = 1.27 mm ; DY = 0.635 mm.



ee_1 = X3(6)

ef_1 = X4 (6)

ef = X5(6)

eg = X6(6)

SURFACE DIST. OF So FROM NN = 1.016 mm

DX = 1.27 mm

DY = 0.635 mm

FIGURE 1. TURBINE BLADE WITH MESH LINES

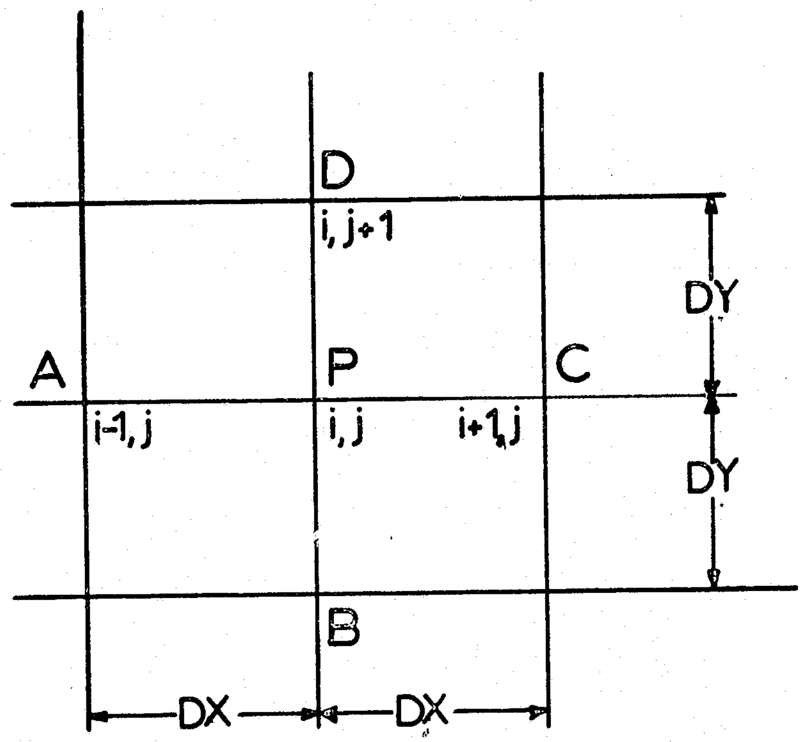


FIGURE 2 GRID STRUCTURE FOR INTERIOR POINTS

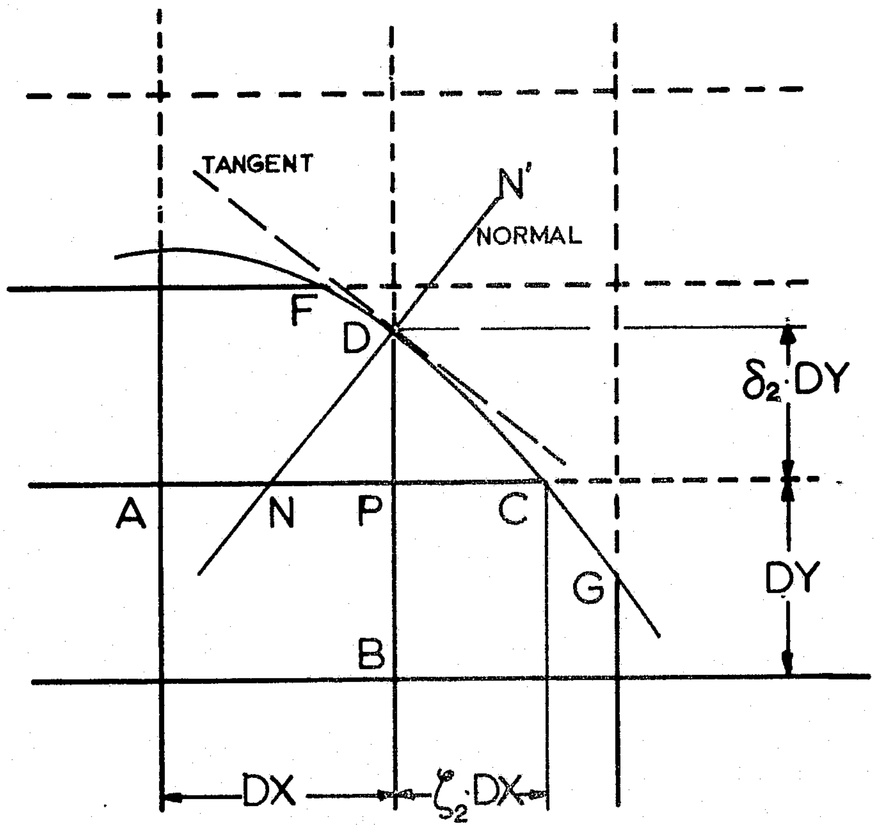


FIGURE 3. POINTS NEAR A BOUNDARY

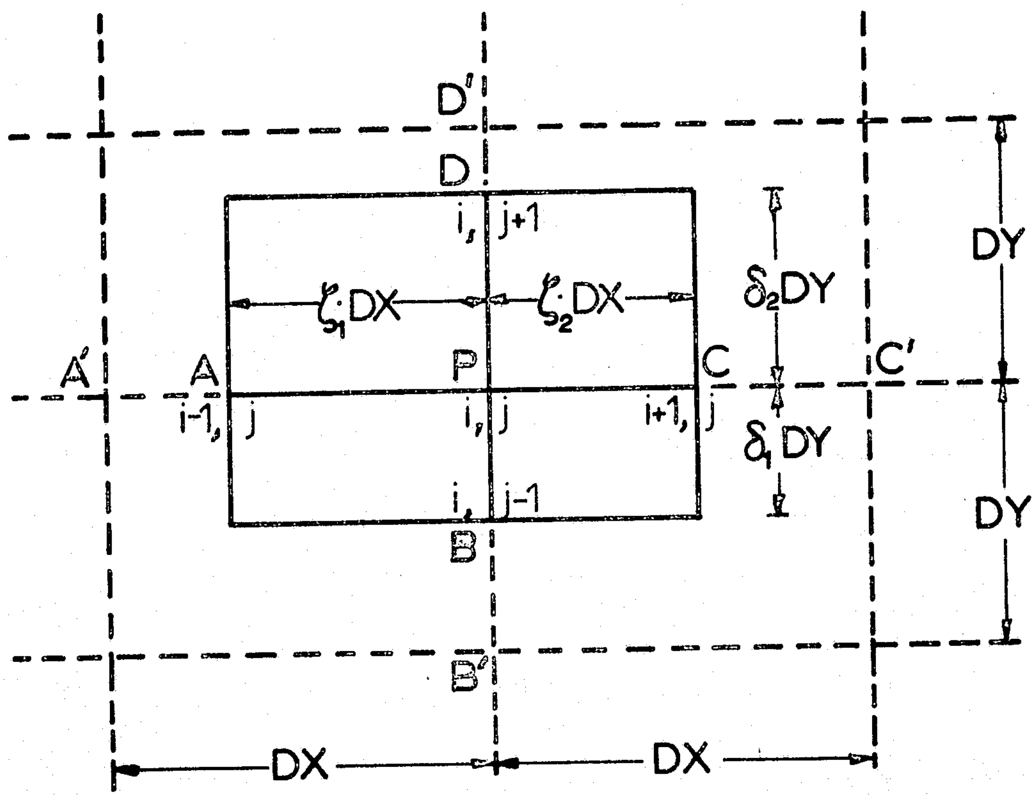


FIGURE 4 GENERAL GRID POINT WITH UNEQUAL SPACINGS

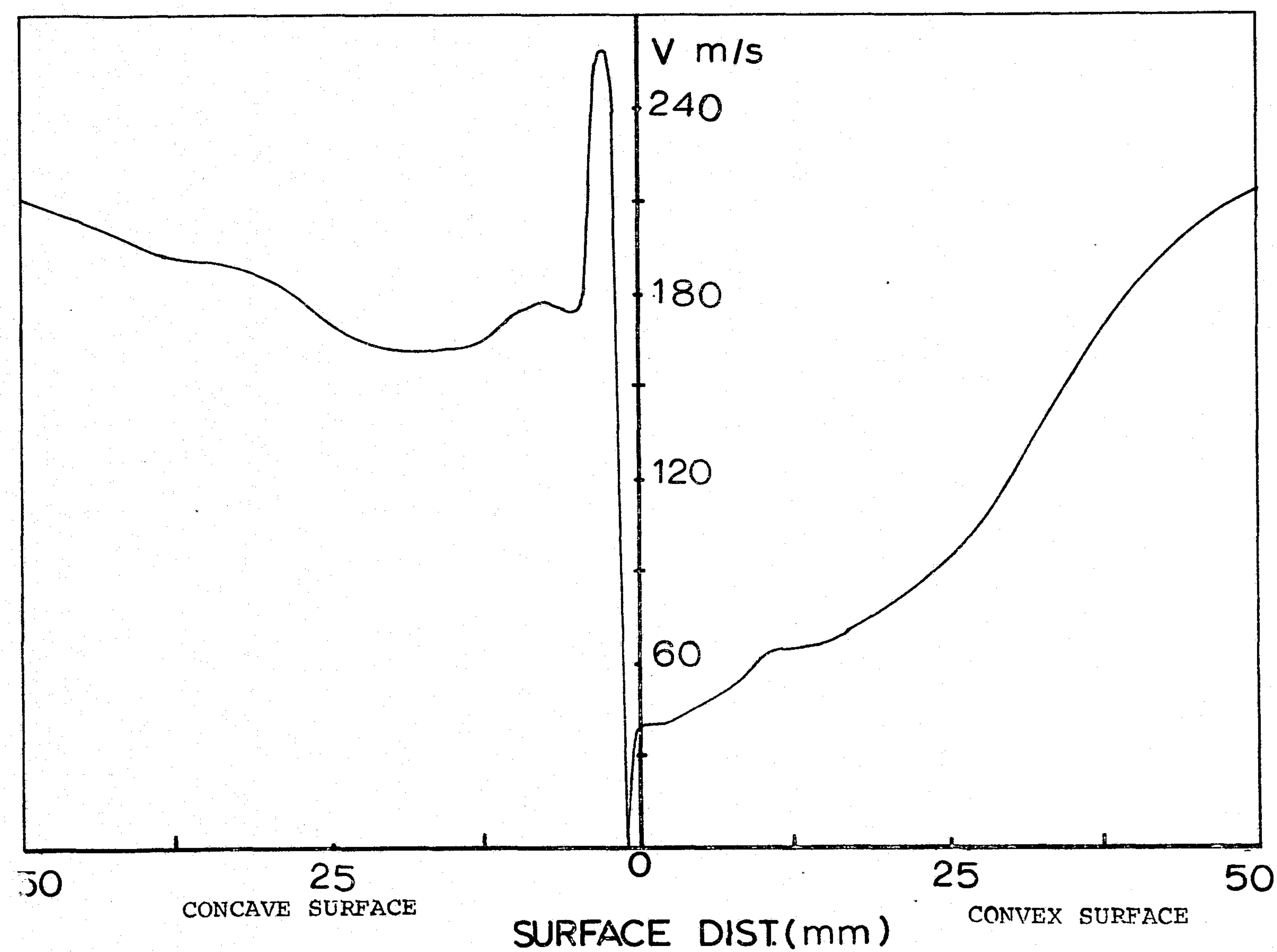


FIGURE 5. VELOCITY DIST. AROUND THE BLADE

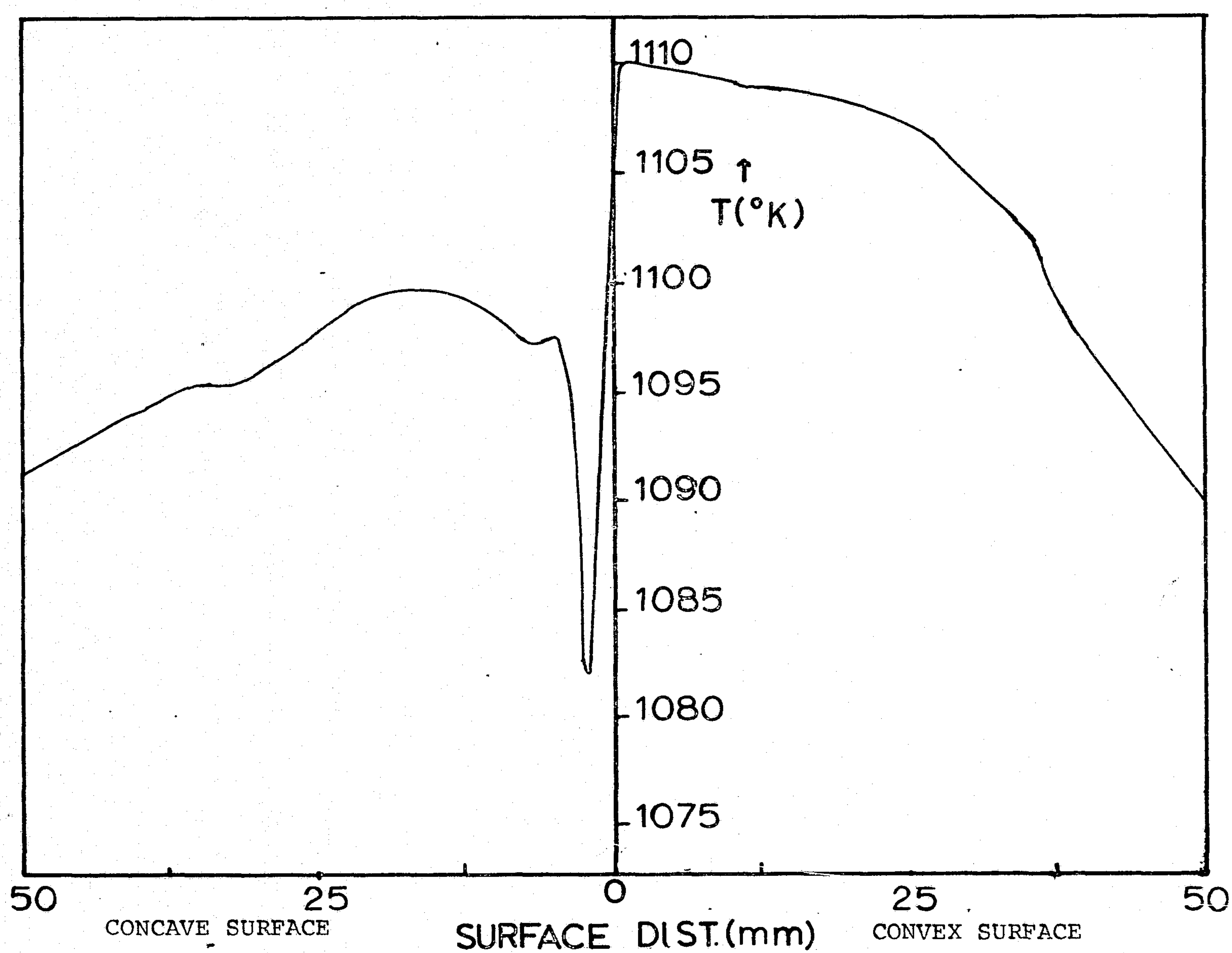


FIGURE 6 TEMPERATURE DIST. AROUND THE BLADE

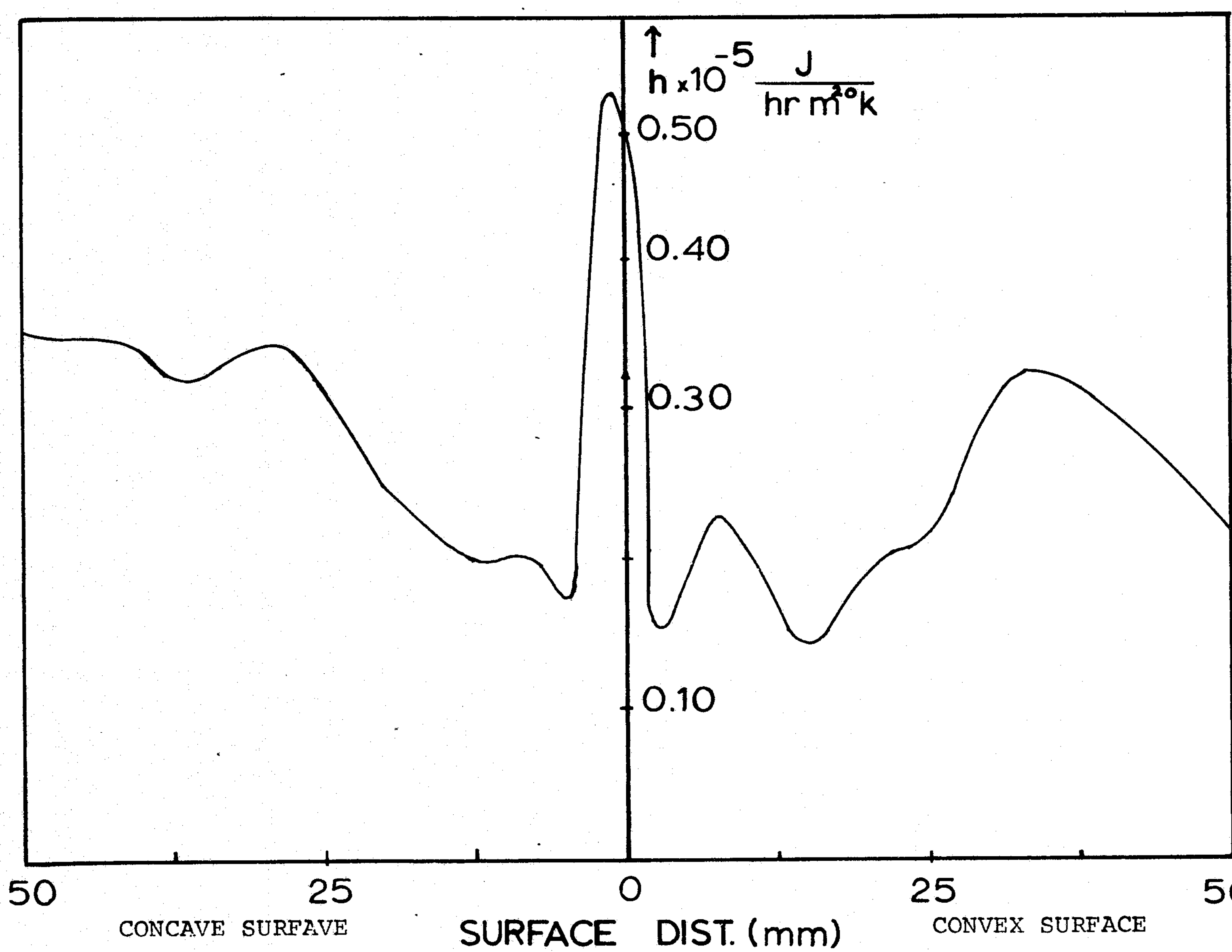


FIGURE 7 HEAT TRANSFER COEFF. AROUND THE BLADE

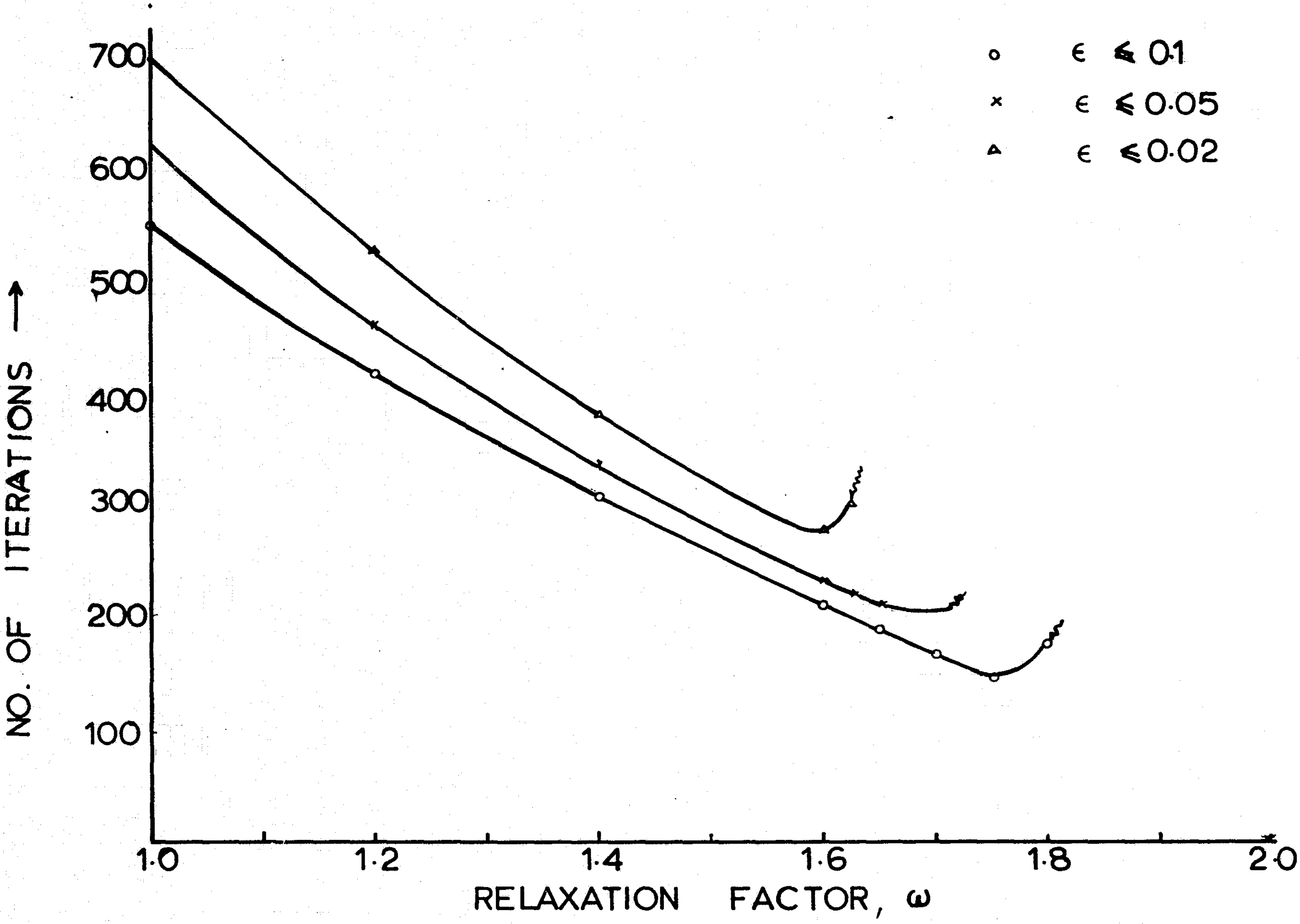


FIG. 8 VARIATION OF NO. OF ITERATIONS WITH ω

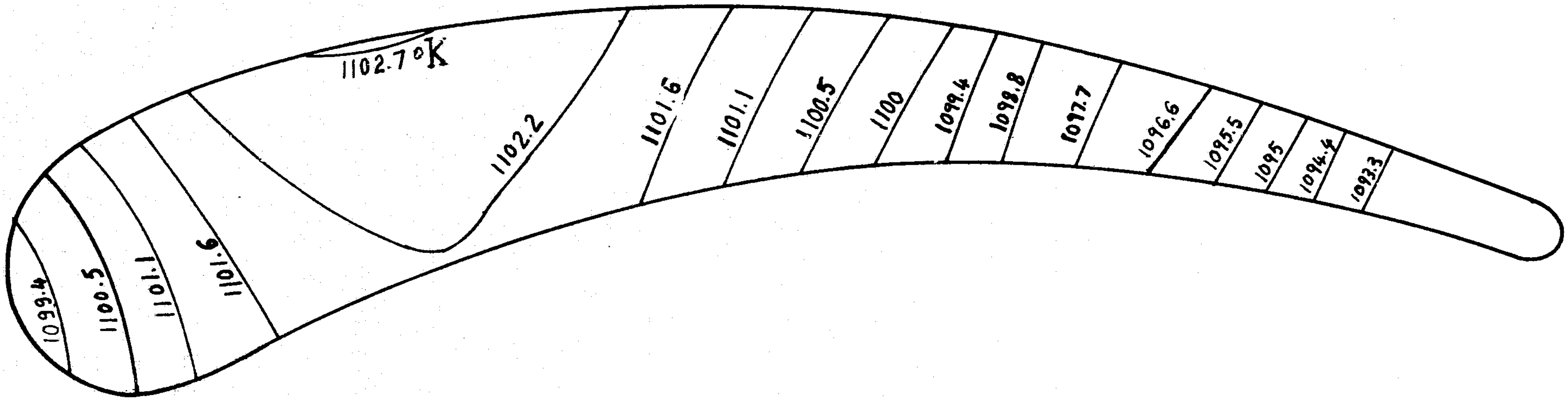


FIGURE 9. ISOTHERMALS IN THE BLADE

APPENDIX A

Input for the computer Program:

The input to the computer program consists of the following parts:

1. Physical parameters for the grid system, blade material properties, allowable error, and number of iterations.
2. Blade geometry.
3. Convection heat transfer coefficients around the blade at the mesh line intersections.
4. The gas temperatures around the blade at the mesh line intersections.

The first part consists of the following items: DX, DY, XK, ØME, NX, NY, SUMM, NITE, NTE, N4, N5, NN, N1, N2, N6. These items are specified according to the Format 4F5.3, 2I2, F6.3, 2I3, 6I2.

DX: The grid spacing in the x-direction (m).

DY: The grid spacing in the y-direction (m).

XK: Thermal conductivity of the material of the blade $(\frac{J}{hr\ m\ °K})$.

ØME: Relaxation Factor (If not known give a value of 0.0), and the program would assume a value of 1.0).

NX: The number of grid lines in the x-direction ($\leq$ 40).

NY: The number of grid lines in y-direction ($\leq$ 20).

SUMM: Maximum allowable error, ε, which is the sum of the squares of temperature differences between two successive iterations.

NITE: Maximum number of iterations. This would terminate the computations if the required convergence is not achieved at or below the specified number of iterations.

NTE: Print out of temperature required at every NTE iteration.

N4: The first J line that intersects the blade in more than two points. Specify N4 = 99 if the above phenomenon does not occur. (In the example of Figure 1, N4 = 5).

N5: Final J line that intersects the blade in four points. When N4 = 99, N5 represents the J line which differentiates the top and bottom portions of the blade near the trailing edge of the blade. In the example of Figure 1, N5 = 7.

NN: This corresponds to the J mesh line which differentiates the top and bottom portions of the blade near the front end of the blade. In Figure 1, NN = 5.

N1: This corresponds to the I mesh line, which separates the two points 'a' and 'b' on the bottom blade surface intersected by the J line: N5. (If N4 = 99, take N1 = NX). In Figure 1, N1 can be any number between 22 and 27.

N2: This corresponds to the I mesh line upstream of the point C in Figure 1, which is the last point on the top surface intersected by the N5 mesh line. If N4 = 99, N2 will be equal to NX.

N6: Corresponds to the J value at the point d of Figure 1, which is the center of the trailing edge radius.

The second part consists of three items. The first set of cards contain the y coordinates where each I mesh line intersects the blade. The first coordinate, Y1(I), refers to the lower surface of the blade and Y2(I) refers to the upper surface of the blade, both are given in inches according to the Format 12F6.3. These values are given in pairs of coordinates corresponding to the bottom and top boundaries at each I mesh line. If the I line does not intersect the blade, give the two coordinates as (NY-1)DY. The program reads in NX pairs of numbers with 6 pairs to a card, with a total cards read = NX/6 or the next whole number if NX is not of multiple of six.

The next set of cards contain the x-coordinates where each J grid line intersects the blade surface where X3(J) refers to the point closer to the Y axis and X4(J) refers to the next intersection further from the Y axis. Both are given in inches according to the same Format, the 12F6.3 as before. The program reads in NY pairs of numbers with 6 pairs to a card with a total of NY/6 cards read. If N4 is not equal to 99, the third set of cards are given, which specify the other pair of x-coordinates for the mesh lines J = N4 to N5. These x-coordinates are given as X5(J) and X6(J) in inches and according to the same Format 12F6.3. If N4 = 99, the third set of cards does not exist. The various parameters are shown in Figure 1.

The third part of the input is the convection heat transfer coefficients in $J/hr\ m^2\ °K$. These values are given in three sets of cards. The Format used here is 12F6.3. The first set of cards contain all H(I) values (for I=1, NX) corresponding to the top surface. The computer program stores the bottom surface coefficients in locations H(I,1) and top surface coefficients in the locations H(I,2). The second set of cards corresponds to all HX(J) values (for J=1, NY) corresponding to to the nearer surface and then all the HX(J) values corresponding to X4(J) points. These values are given in the same units and according to the same Format as before. The computer program stores these coefficients in the locations HX(1,J) and HX(2,J). If N4 is 99, the third set of cards are omitted. Otherwise the third set of cards are given corresponding to HX1(J) values and HX1(J) values for J = N4 to N5. The HXL(J) corresponds to X5(J) point and HX1(J) to X6(J).

The fourth part of the program input gives the gas temperature values in °K. These values are given in three sets of cards similar to part three. These are given according to the Format 10F8.2 with 10 values to a card. The first set of cards contain all TG(I) values corresponding to bottom surface and then all TG(I) values. These values are stored in the computer in locations TG(I,1) and TG(I,2). These two correspond to H(I,1) and H(I,2) respectively. The second set contain all TGX(1,J) values and then all TGX(2,J) values corresponding to X3(J) and X4(J) points respectively. Finally, if N4 is not equal to 99, the third set of cards are given containing TGX1(1,J) values for J = N4 to N5. This set is omitted if N4 = 99.

APPENDIX B

PROGRAM LISTING

In the following pages 27 to 39 is a listing of the main program and the subroutines SLO and BUN.

```
      DIMENSION T(40,20),TX(2,20),TX1(2,20),H(40,2),HX(2,20),HX1(2,20),T
     1G(40,2),TGX(2,20),TGX1(2,20),S1(40,2),S2(40,2),D1(40,2),D2(40,2),Y
     21(40),Y2(40),X3(20),X4(20),X5(20),X6(20),IN(2,40),IM(2,20),IM1(2,2
     30)
      DIMENSION SI(20)
      CALL UNDFLW
      WRITE(6,451)
  451 FORMAT(//,40X,'TEMPERATURE DISTRIBUTION IN A TURBINE BLADE',///)
      READ(5,1) DX,DY,XK,OME,NX,NY,SUMM,NITE,NTE,N4,N5,NN,N1,N2,N6
    1 FORMAT(4F5.3,2I2,F6.3,2I3,6I2)
C   READS IN INPUT DATA  BOUD. PTS., ETC.
      IF(OME.EQ.0.) OME=1.0
      IF(NX.GT.40.OR.NY.GT.20) GO TO 505
      WRITE(6,3) DX,DY,OME,XK,NX,NY,SUMM
    3 FORMAT(//,5X,'DX =',F8.4,5X,'DY =',F8.4,4X,'OMEGA =',F6.3,4X,'THER
     1M. COND. =',F8.4/,5X,'NX =',I8,5X,'NY =',I8,4X,'MAX. ERR.=',F8.4/)
      NX1=NX-1
      NY1=NY-1
      READ(5,5) (Y1(I),Y2(I),I=1,NX)
    5 FORMAT((12F6.3))
      READ(5,5) (X3(J),X4(J),J=1,NY)
      IF(N4.EQ.99) GO TO 26
      READ(5,5) (X5(J),X6(J),J=N4,N5)
   26 CONTINUE
      DO 6 I=1,NX1
      XM=(Y1(I)+0.0001)/DY
      LM=XM
      S1(I,1)=1.
      S2(I,1)=1.
      S1(I,2)=1.
      S2(I,2)=1.
      D2(I,1)=1.
      D1(I,1)=FLOAT(LM+1)-Y1(I)/DY
      IN(1,I)=LM+2
      XM=(Y2(I)+0.0001)/DY
      LM=XM
      D1(I,2)=1.
      IN(2,I)=LM+1
      IF(ABS(Y2(I)-FLOAT(LM)*DY).LT.0.0001) IN(2,I)=LM
      D2(I,2)=Y2(I)/DY-FLOAT(IN(2,I)-1)
    6 CONTINUE
   30 FORMAT(5X,I3,2(I5,F10.4))
      DO 7 J=2,NY1
      XM=(X3(J)+0.0001)/DX
      LM=XM
      IM(1,J)=LM+2
      JJ=IM(1,J)
      S1(JJ,1)=FLOAT(LM+1)-X3(J)/DX
      IF(J.GT.NN) S1(JJ,2)=S1(JJ,1)
      IF(J.GT.NN) S1(JJ,1)=1.
      XM=(X4(J)+0.0001)/DX
      LM=XM
      IM(2,J)=LM+1
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      IF(ABS(X4(J)-FLOAT(LM)*DX).LT.0.0001) IM(2,J)=LM
      JJJ=IM(2,J)
      S2(JJJ,1)=X4(J)/DX-FLOAT(JJJ-1)
      IF(J.GT.N5) S2(JJJ,2)=S2(JJJ,1)
      IF(J.GT.N5) S2(JJJ,1)=1.
 7    CONTINUE
 35    FORMAT(5X,I5,2(I5,2F10.4))
      S1(2,1)=1.-X3(IN(1,2))/DX
      IA=IN(1,2)+1
      IB=IN(2,2)-1
      DO 9 I=IA,IB
 9    SI(I-IA+1)=1.-X3(IA)/DX
      IF(N4.EQ.99) GO TO 12
      DO 8 J=N4,N5
      XM=(X5(J)+0.00001)/DX
      LM=XM
      IM1(1,J)=LM+2
      JJ=IM1(1,J)
      S1(JJ,1)=FLOAT(LM+1)-X5(J)/DX
      XM=(X6(J)+0.00001)/DX
      LM=XM
      IM1(2,J)=LM+1
      IF(X6(J).EQ.FLOAT(LM)*DX) IM1(2,J)=LM
      JJJ=IM1(2,J)
      S2(JJJ,2)=X6(J)/DX-FLOAT(JJJ-1)
 8    CONTINUE
 12   CONTINUE
 10   FORMAT(40I2)
 15   FORMAT(16F5.3)
      READ(5,20) ((H(I,J),I=1,NX),J=1,2)
 20   FORMAT(12F6.3)
      READ(5,20) ((HX(I,J),J=1,NY),I=1,2)
      IF(N4.EQ.99) GO TO 33
      READ(5,20) ((HX1(I,J),J=N4,N5),I=1,2)
 33   CONTINUE
      READ(5,25) ((TG(I,J),I=1,NX),J=1,2)
 25   FORMAT(10F8.2)
      READ(5,25) ((TGX(I,J),J=1,NY),I=1,2)
      IF(N4.EQ.99) GO TO 34
      READ(5,25) ((TGX1(I,J),J=N4,N5),I=1,2)
 34   CONTINUE
C   SETS INITIAL VALUES AND BOUNDARY POINTS
      DXY=DX*DX/DY/DY
      DO 100 I=2,NX1
      IA=IN(1,I)-1
      IB=IN(2,I)+1
      DO 100 II=IA,IB
 100   T(I,II)=1900.
      DO 110 J=2,NY1
      TX(1,J)=1900.
 110  TX(2,J)=1900.
      IF(N4.EQ.99) GO TO 36
      DO 115 J=N4,N5
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      TX1(1,J)=1900.
  115 TX1(2,J)=1900.
  36  CONTINUE
      DO 120 I=1,NX
      IA=IN(1,I)-2
      IB=IN(2,I)+2
      DO 120 J=1,NY
      IF(J.GT.IA.AND.J.LT.IB) GO TO 120
      IF(J.LE.IA) T(I,J)=TG(I,1)
       IF(J.GE.IB) T(I,J)=TG(I,2)
  120  CONTINUE
      WRITE(6,458)
  458 FORMAT(1H1)
      WRITE(6,455)
  455 FORMAT(/,5X,'TEMPERATURE AT GRID POINTS',//,4X,'J=',5X,'1',9X,'2',
     19X,'3',9X,'4',9X,'5',9X,'6',9X,'7',9X,'8',8X,'9',8X,'10',8X,'11',8
     2X,'12'/,4X,'I'/)
      DO 124 I=1,NX
  124 WRITE(6,440) I,(T(I,J),J=1,NY)
C   ITERATIONS... LOWER, MIDDLE AND TOP POINTS
      WRITE(6,456)
  456 FORMAT(//,5X,'(B2,C2) IS THE POINT ON THE BOUNDARY AND (B1,C1),(B3
     1,C3) ARE THE SURROUNDING POINTS ON BLADE',/,5X,' A,B,C ARE THE COE
     2FFICIENTS OF THE PARABOLIC CURVE Y=A+B*X+C*X*X'/)
      SUM=0.
      ITER=1
  125  CONTINUE
      AL=H(1,1)/XK
      T(1,5)=(DX*AL*TG(1,1)+T(2,5))/(1.+AL*DX)
      DO 150 I=2,NX1
      IA=IN(1,I)+1
      IB=IN(2,I)-1
      A=1./(S1(I,1)*S2(I,1))+4./(D1(I,1)*D2(I,1))
      A1=T(I-1,IA-1)/S1(I,1)/(S1(I,1)+S2(I,1))
      A2=T(I+1,IA-1)/S2(I,1)/(S1(I,1)+S2(I,1))
      IF(I.GT.N1) GO TO 130
      IF(S1(I,1).NE.1.) A1=TX(1,IA-1)/S1(I,1)/(S1(I,1)+S2(I,1))
      IF(S2(I,1).NE.1.) A2=TX(2,IA-1)/S2(I,1)/(S1(I,1)+S2(I,1))
      GO TO 135
  130  CONTINUE
      IF(S1(I,1).NE.1.) A1=TX1(1,IA-1)/S1(I,1)/(S1(I,1)+S2(I,1))
      IF(S2(I,1).NE.1.) A2=TX1(2,IA-1)/S2(I,1)/(S1(I,1)+S2(I,1))
  135  A3=T(I,IA-2)/D1(I,1)/(D1(I,1)+D2(I,1))
      A4=T(I,IA)/D2(I,1)/(D1(I,1)+D2(I,1))
      TNEW=(A1+A2+DXY*(A3+A4))/A
      TNEW=(1.-OME)*T(I,IA-1)+OME*TNEW
      SUM=SUM+(T(I,IA-1)-TNEW)*(T(I,IA-1)-TNEW)
      T(I,IA-1)=TNEW
      IF(IA.GT.IB) GO TO 142
      DO 140 J=IA,IB
      IF(I.EQ.2) GO TO 138
      TNEW=0.5*(T(I-1,J)+T(I+1,J)+DXY*(T(I,J-1)+T(I,J+1)))/(1.+DXY)
       TNEW=(1.-OME)*T(I,J)+OME*TNEW
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      SUM=SUM+(T(I,J)-TNEW)*(T(I,J)-TNEW)
      T(I,J)=TNEW
      GO TO 140
  138 CONTINUE
      S=SI(J-IA+1)
       TNEW=(1.-OME)*T(I,J)+OME*TNEW
      TNEW=S*(TX(1,J)/(S*(1.+S))+T(I+1,J)/(1.+S)+0.5*DXY*(T(I,J-1)+T(I,J
     1+1)))/(1.+S*DXY)
      SUM=SUM+(T(I,J)-TNEW)*(T(I,J)-TNEW)
      T(I,J)=TNEW
  140  CONTINUE
  142 A=1./(S1(I,2)*S2(I,2))+DXY/(D1(I,2)*D2(I,2))
      A1=T(I-1,IB+1)/S1(I,2)/(S1(I,2)+S2(I,2))
      A2=T(I+1,IB+1)/S2(I,2)/(S1(I,2)+S2(I,2))
      IF(I.GE.N2) GO TO 145
      IF(S1(I,2).NE.1.) A1=TX(1,IB+1)/S1(I,2)/(S1(I,2)+S2(I,2))
      IF(S2(I,2).NE.1.) A2=TX(2,IB+1)/S2(I,2)/(S1(I,2)+S2(I,2))
      GO TO 146
  145 IF(S1(I,2).NE.1.) A1=TX1(1,IB+1)/S1(I,2)/(S1(I,2)+S2(I,2))
      IF(S2(I,2).NE.1.) A2=TX1(2,IB+1)/S2(I,2)/(S1(I,2)+S2(I,2))
  146 CONTINUE
      A3=T(I,IB)/D1(I,2)/(D1(I,2)+D2(I,2))
      A4=T(I,IB+2)/D2(I,2)/(D1(I,2)+D2(I,2))
      TNEW=(A1+A2+DXY*(A3+A4))/A
      TNEW=(1.-OME)*T(I,IB+1)+OME*TNEW
      SUM=SUM+(T(I,IB+1)-TNEW)*(T(I,IB+1)-TNEW)
      T(I,IB+1)=TNEW
  150  CONTINUE
C   BOUND. POINTS   LINES PARLL. TO Y AXIS .. LOWER AND TOP
      IF(ITER.EQ.1) WRITE(6,457)
  457 FORMAT(/,7X,'I',7X,'B1',8X,'C1',8X,'B2',8X,'C2',8X,'B3',8X,'C3',9X
     1,'A',9X,'B',9X,'C',/ )
      DO 200 I=2,NX1
      XI=I-1
      B2=XI*DX
C     LOWER
      C2=Y1(I)
      XM=(C2+0.0001)/DY
      M=XM+2
      DM=X3(M)
      IF(I.GT.N1) DM=X5(M)
      IF(ABS(B2-DM).LT.DX) GO TO 155
      B1=B2-DX
      C1=Y1(I-1)
      GO TO 156
  155  B1=DM
      C1=(FLOAT(M)-1.)*DY
  156 CONTINUE
      DM=X4(M)
      IF(I.GT.N1) DM=X6(M)
      IF(ABS(B2-DM).LT.DX) GO TO 160
      B3=B2+DX
      C3=Y1(I+1)
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      GO TO 161
160   CONTINUE
      B3=DM
      C3=FLOAT(M-1)*DY
161   CALL SLO(B1,C1,B2,C2,B3,C3,A,B,C)
      IF(ITER.EQ.1) WRITE(6,490)I,B1,C1,B2,C2,B3,C3,A,B,C
      XMN=B+2.*C*B2
      XT=FLOAT(M-1)*DY
      IF(ABS(XMN).LE.0.015) GO TO 170
      X=(C2-XT)*XMN+B2
      IF(X.LE.B2) GO TO 165
      TTT=T(I,M)+(T(I+1,M)-T(I,M))*(X-B2)/DX
      GO TO 166
165    TTT=T(I,M)-(T(I,M)-T(I-1,M))*(B2-X)/DX
166   XNL=(X-B2)*(X-B2)+(Y1(I)-XT)*(Y1(I)-XT)
      XNL=SQRT(XNL)
      GO TO 171
170    TTT=T(I,M)
      XNL=XT-Y1(I)
171    AL=H(I,1)/XK
      TNEW=(XNL*AL*TG(I,1)+TTT)/(1.+XNL*AL)
      TNEW=(1.-OME)*T(I,IN(1,I)-1)+OME*TNEW
      SUM=SUM+(T(I,IN(1,I)-1)-TNEW)*(T(I,IN(1,I)-1)-TNEW)
      T(I,IN(1,I)-1)=TNEW
C     UPPER POINTS
      C2=Y2(I)
      XM=(C2+0.0001)/DY
      M=XM+1
      DM=X3(M)
      IF(I.GE.N2) DM=X5(M)
      IF(ABS(B2-DM).LT.0.0001) GO TO 174
      IF(ABS(B2-DM).LT.DX) GO TO 175
174   B1=B2-DX
      C1=Y2(I-1)
      GO TO 176
175   B1=DM
      C1=FLOAT(M-1)*DY
176    DM=X4(M)
      IF(I.GE.N2) DM=X6(M)
      IF(ABS(B2-DM).LT.0.0001) GO TO 179
      IF(ABS(B2-DM).LT.DX) GO TO 180
179   B3=B2+DX
      C3=Y2(I+1)
      GO TO 181
180   B3=DM
      C3=FLOAT(M-1)*DY
      IF(I.EQ.NX1) B3=X6(IN(2,I)+1)
      IF(I.EQ.NX1) C3=FLOAT(IN(2,I))*DY
181   CALL SLO(B1,C1,B2,C2,B3,C3,A,B,C)
      IF(ITER.EQ.1) WRITE(6,490)I,B1,C1,B2,C2,B3,C3,A,B,C
490   FORMAT(5X,I3,2X,9F10.6)
      XMN=B+2.*C*B2
      IF(D2(I,2).EQ.1.) GO TO 192
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      XT=FLOAT(M-1)*DY
      IF(ABS(XMN).LE.0.015) GO TO 190
      X=(C2-XT)*XMN+B2
      IF(X.LE.B2) GO TO 185
      TTT=T(I,M)+(T(I+1,M)-T(I,M))*(X-B2)/DX
      GO TO 186
  185 TTT=T(I,M)-(T(I,M)-T(I-1,M))*(B2-X)/DX
  186 XNL=(X-B2)*(X-B2)+(Y2(I)-XT)*(Y2(I)-XT)
      XNL=SQRT(XNL)
      GO TO 191
  192  X=DY*XMN+B2
      XNL=SQRT(DY*DY+(B2-X)*(B2-X))
      IF(X.LE.B2) GO TO 193
      TTT=T(I,M-1)+(T(I+1,M-1)-T(I,M-1))*(X-B2)/DX
      GO TO 191
  193  TTT=T(I,M-1)+(T(I,M-1)-T(I-1,M-1))*(B2-X)/DX
      GO TO 191
  190 TTT=T(I,M)
      XNL=Y2(I)-XT
  191  AL=H(I,2)/XK
      TNEW=(XNL*AL*TG(I,2)+TTT)/(1.+XNL*AL)
      TNEW=(1.-CME)*T(I,IN(2,I)+1)+CME*TNEW
      SUM=SUM+(T(I,IN(2,I)+1)-TNEW)*(T(I,IN(2,I)+1)-TNEW)
      T(I,IN(2,I)+1)=TNEW
  200 CONTINUE
C    BOUND. POINTS.. NEARER AND FARTHER POINTS.
C    POINTS ON LINES PARLL. TO X AXIS
      DO 300 J=2,NY1
      YJ=J-1
      B2=X3(J)
C     NEARER
      C2=YJ*DY
      XN=(X3(J)+0.0001)/DX
      N=XN+2
      IF((Y2(N)-C2).LT.(C2-Y1(N))) GO TO 220
      IF(ABS(C2-Y1(N)).LT.ABS(C2-FLOAT(J-2)*DY)) GO TO 206
      B1=X3(J-1)
      C1=FLOAT(J-2)*DY
      GO TO 208
  206 B1=FLOAT(N-1)*DX
      C1=Y1(N)
  208 IF(ABS(B2-FLOAT(N-2)*DX).LE.0.0001) N=N-1
      IF(ABS(C2-FLOAT(J)*DY).LT.ABS(C2-Y1(N-1))) GO TO 210
      B3=FLOAT(N-2)*DX
      C3=Y1(N-1)
      GO TO 240
  210 B3=X3(J+1)
      C3=FLOAT(J)*DY
      GO TO 240
  220 IF(ABS(C2-Y2(N)).LT.ABS(C2-FLOAT(J)*DY)) GO TO 225
      B1=X3(J+1)
      C1=FLOAT(J)*DY
      GO TO 226
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 225  B1=FLOAT(N-1)*DX
      C1=Y2(N)
 226  IF(ABS(B2-FLOAT(N-2)*DX).LT.0.0001) N=N-1
      IF(ABS(C2-FLOAT(J-2)*DY).LT.ABS(C2-Y2(N-1))) GO TO 230
      B3=FLOAT(N-2)*DX
      C3=Y2(N-1)
      GO TO 240
 230  B3=X3(J-1)
      C3=FLOAT(J-2)*DY
      GO TO 240
 240  CALL SLO(B1,C1,B2,C2,B3,C3,A,B,C)
      IF(ITER.EQ.1) WRITE(6,490)J,B1,C1,B2,C2,B3,C3,A,B,C
      XMN=B+2.*C*B2
      YT=FLOAT(N-1)*DX
      IF(ABS(XMN).GE.60.) GO TO 250
      Y=C2-(YT-B2)/XMN
      IF(Y.LE.C2) GO TO 245
      TTT=T(N,J)+(T(N,J+1)-T(N,J))*(Y-C2)/DY
      GO TO 246
 245    TTT=T(N,J)-(T(N,J)-T(N,J-1))*(C2-Y)/DY
 246   XNL=(YT-B2)*(YT-B2)+(Y-C2)*(Y-C2)
      XNL=SQRT(XNL)
      GO TO 251
 250   TTT=T(N,J)
      XNL=YT-B2
 251  AL=HX(1,J)/XK
      TNEW=(TTT+AL*XNL*TGX(1,J))/(1.+XNL*AL)
      TNEW=(1.-OME)*TX(1,J)+OME*TNEW
      SUM=SUM+(TNEW-TX(1,J))*(TNEW-TX(1,J))
      TX(1,J)=TNEW
C     FARTHER
      B2=X4(J)
      XN=(X4(J)+0.0001)/DX
      N=XN+1
      IF(ABS(B2-FLOAT(N-1)*DX).LT.0.0001) N=N-1
      IF((Y2(N)-C2).LT.(C2-Y1(N))) GO TO 290
      IF(ABS(B2-FLOAT(N-1)*DX).LT.ABS(B2-X4(J-1))) GO TO 282
      B1=X4(J-1)
      C1=FLOAT(J-2)*DY
      GO TO 283
 282  B1=FLOAT(N-1)*DX
      C1=Y1(N)
 283  IF(ABS(B2-FLOAT(N)*DX).LT.0.0001) N=N+1
      IF(ABS(B2-FLOAT(N)*DX).LT.ABS(B2-X4(J+1))) GO TO 284
      B3=X4(J+1)
      C3=FLOAT(J)*DY
      GO TO 261
 284  B3=FLOAT(N)*DX
      C3=Y1(N+1)
      GO TO 261
 290  IF(ABS(B2-FLOAT(N-1)*DX).LT.ABS(B2-X4(J+1))) GO TO 292
      B1=X4(J+1)
      C1=FLOAT(J)*DY
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      GO TO 293
292   B1=FLOAT(N-1)*DX
      C1=Y2(N)
293   IF(ABS(B2-FLOAT(N)*DX).LT.0.0001) N=N+1
      IF(ABS(B2-FLOAT(N)*DX).LT.ABS(B2-X4(J-1))) GO TO 295
      B3=X4(J-1)
      C3=FLOAT(J-2)*DY
       GO TO 261
295   B3=FLOAT(N)*DX
      C3=Y2(N+1)
261   CALL SLO(B1,C1,B2,C2,B3,C3,A,B,C)
      IF(ITER.EQ.1) WRITE(6,490)J,B1,C1,B2,C2,B3,C3,A,B,C
      XMN=B+2.*C*B2
      YT=FLOAT(N-1)*DX
      IF(ABS(XMN).GE.60.) GO TO 270
      Y=C2-(YT-B2)/XMN
      IF(Y.LE.C2) GO TO 265
      TTT=T(N,J)+(T(N,J+1)-T(N,J))*(Y-C2)/DY
      GO TO 266
265   TTT=T(N,J)-(T(N,J)-T(N,J-1))*(C2-Y)/DY
266   XNL=(YT-B2)*(YT-B2)+(Y-C2)*(Y-C2)
      XNL=SQRT(XNL)
      GO TO 271
270    TTT=T(N,J)
      XNL=B2-YT
271   AL=HX(2,J)/XK
      TNEW=(TTT+AL*XNL*TGX(2,J))/(1.+XNL*AL)
      TNEW=(1.-OME)*TX(2,J)+OME*TNEW
      SUM=SUM+(TNEW-TX(2,J))*(TNEW-TX(2,J))
300   TX(2,J)=TNEW
C     BOUNDARY POINTS FOR J=N4 TO N5
      IF(N4.EQ.99) GO TO 351
      DO 350 J=N4,N5
      YJ=J-1
      B2=X5(J)
      C2=YJ*DY
      XN=(X5(J)+0.0001)/DX
      N=XN+2
      B1=FLOAT(N-1)*DX
      C1=Y1(N)
      B3=B1-DX
      C3=Y1(N-1)
      IF(B3.EQ.B2) B3=B3-DX
      IF(C3.EQ.C2) C3=Y1(N-2)
      CALL SLO(B1,C1,B2,C2,B3,C3,A,B,C)
      XMN=B+2.*C*B2
      IF(ABS(XMN).GE.60.) GO TO 320
      YT=FLOAT(J)*DY
      X=B2+(C2-YT)*XMN
      IND=X/DX
      IN1=IND+1
      TTT=T(IND,J+1)+(T(IN1,J+1)-T(IND,J+1))*(X-FLOAT(IND-1)*DX)/DX
      XNL=(X-B2)*(X-B2)+(YT-C2)*(YT-C2)
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      XNL=SQRT(XNL)
      GO TO 322
320    TTT=T(N,J)
      XNL=FLOAT(N-1)*DX-X5(J)
322   AL=HX1(1,J)/XK
      TNEW=(TTT+AL*XNL*TGX1(1,J))/(1.+AL*XNL)
      TNEW=(1.-OME)*TX1(1,J)+OME*TNEW
      SUM=SUM+(TX1(1,J)-TNEW)*(TX1(1,J)-TNEW)
      TX1(1,J)=TNEW
      B2=X6(J)
      XN=(X6(J)+0.0001)/DX
      N=XN+1
      IF(FLOAT(N)*DX.EQ.B2) N=N-1
      IF(ABS(Y1(N)-C2).LT.DY) GO TO 325
      IF(ABS(FLOAT(N)*DX-B2).LT.0.0001) GO TO 324
      IF(N.GE.NX) GO TO 327
      B1=FLOAT(N)*DX
      C1=Y2(N+1)
      GO TO 323
327    B3=X6(J-1)
      C3=FLOAT(J-2)*DY
      GO TO 323
324   B1=FLOAT(N+1)*DX
      C1=Y2(N+2)
      GO TO 323
325    B1=FLOAT(N-1)*DX
      C1=Y1(N)
323    IF(ABS(Y2(N)-C2).LT.DY) GO TO 326
      B3=X6(J+1)
      IF((J+1).GT.N5) B3=X4(J+1)
      C3=FLOAT(J)*DY
      GO TO 328
326    B3=FLOAT(N-1)*DX
      C3=Y2(N)
328   CONTINUE
      CALL SLO(B1,C1,B2,C2,B3,C3,A,B,C)
      XMN=B+2.*C*B2
       IF(J.EQ.N6) GO TO 335
      XT=B3
      Y=C2-(XT-B2)/XMN
      TTT=T(N-1,J)-(T(N-1,J)-T(N-1,J-1))*(C2-Y)/DY
      XNL=(C2-J)*(C2-J)+(B2-B3)*(B2-B3)
      XNL=SQRT(XNL)
      GO TO 336
335   TTT=T(NX1,N6)
      XNL=B2-FLOAT(NX-2)*DX
336   AL=HX1(2,J)/XK
      TNEW=(TTT+AL*XNL*TGX1(2,J))/(1.+AL*XNL)
      SUM=SUM+(TX1(2,J)-TNEW)*(TX1(2,J)-TNEW)
      TNEW=(1.-OME)*TX1(2,J)+OME*TNEW
      TX1(2,J)=TNEW
350    CONTINUE
351    CONTINUE
```

```
      T(1,4)=TX(1,4)
      T(1,6)=TX(1,6)
      T(40,4)=1982.
      T(40,5)=TX1(2,5)
      T(40,6)=1982.
      WRITE(6,420) ITER,SUM
  420 FORMAT(4X,'ITERATION =',I3,4X,'SUM=',E12.5)
      IF(SUM.LE.SUMM) GO TO 400
      IF(ITER/NTE*NTE.EQ.ITER) GO TO 400
      SUM=0.
      ITER=ITER+1
      GO TO 125
  400 CONTINUE
      WRITE(6,458)
      IF(SUM.LE.SUMM) WRITE(6,461)
  461 FORMAT(/,20X,'THE FINAL ITERATIVE' )
  440 FORMAT(3X,I2,12F10.3/)
      WRITE(6,455)
      DO 450 I=1,NX
      WRITE(6,440) I,(T(I,J),J=1,NY)
  450 CONTINUE
      IF(SUM.LE.SUMM) GO TO 410
      IF(ITER.GE.NITE) GO TO 410
  415 CONTINUE
      ITER=ITER+1
      SUM=0.
      GO TO 125
  410 CONTINUE
      WRITE(6,460)
  460 FORMAT(1H1,38X,'ISOTHERMAL LINE LOCATIONS '/,9X,'I',4X,'J',3X,'T',
     14X,'T-LOW',6X,'T-HIGH',8X,'FRAC',/)
      DO 500 I=2,NX1
      IA=IN(1,I)-1
      IB=IN(2,I)
      IT1=T(I,IA)
      IT2=T(I,IB+1)
      IF(IT1.GE.IT2) GO TO 470
      IL=IT1
      IH=IT2
      GO TO 471
  470 IL=IT2
      IH=IT1
  471 CONTINUE
      DO 482 II=IL,IH
      DO 480 J=IA,IB
      IF(T(I,J).LT.FLOAT(II).AND.T(I,J+1).GT.FLOAT(II)) GO TO 481
      IF(T(I,J).GT.FLOAT(II).AND.T(I,J+1).LT.FLOAT(II)) GO TO 483
      GO TO 480
  481 RX=(FLOAT(II)-T(I,J))/(T(I,J+1)-T(I,J))
      GO TO 484
  483 RX=(T(I,J)-FLOAT(II))/(T(I,J)-T(I,J+1))
  484  CONTINUE
      WRITE(6,485) I,J,II,T(I,J),T(I,J+1),RX
```

```
 485  FORMAT(5X,3I5,3F11.4)
 480  CONTINUE
 482  CONTINUE
 500  CONTINUE
      CALL BUN(T,NX,NY)
 505  CONTINUE
      STOP
      END
```

```
      SUBROUTINE SLO(X1,Y1,X2,Y2,X3,Y3,A,B,C)
C   FINDS EQUATION THRU THREE POINTS AS Y=A+B$X+C*X*X
      CALL UNDFLW
      IF(ABS(X1-X2).LE.0.001.AND.ABS(X2-X3).LE.0.001) GO TO 10
      XS3=X3*X3
      XS2=X2*X2
      XS1=X1*X1
      D1=X2*XS3-X3*XS2
      D2=X1*XS3-X3*XS1
      D3=X1*XS2-X2*XS1
      D=D1-D2+D3
       IF(ABS(D).LE.0.000001) GO TO 10
      A1=Y1*(X2*XS3-X3*XS2)
      A2=Y2*(X1*XS3-X3*XS1)
      A3=Y3*(X1*XS2-X2*XS1)
      A=(A1-A2+A3)/D
      B1=Y2*XS3-Y3*XS2
      B2=Y1*XS3-Y3*XS1
      B3=Y1*XS2-Y2*XS1
      B=(B1-B2+B3)/D
      C1=X2*Y3-X3*Y2
      C2=X1*Y3-X3*Y1
      C3=X1*Y2-X2*Y1
      C=(C1-C2+C3)/D
      RETURN
   10 A=100.
      B=100.
      C=100.
       RETURN
      END
```

```
      SUBROUTINE BUN(T,NX,NY)
      DIMENSION T(40,20)
      LOGICAL*1 KP(60),LIT(15)/'0','1','2','3','4','5','6','7','8','9','
     1.','?','+','$','*'/
      TMA=T(1,1)
      TMI=T(1,1)
      DO 10 I=1,NX
      DO 10 J=1,NY
      IF(T(I,J).GT.TMA) TMA=T(I,J)
      IF(T(I,J).LT.TMI) TMI=T(I,J)
   10 CONTINUE
      WRITE(6,20) TMA,TMI
   20 FORMAT(1H1,5X,'MAX=',F12.5,2X,'MIN=',F12.5/,5X,'TEMP. INCREASES AS
     1 : 0-1-2-3-4-5-6-7-8-9-.-?-+-$-*', 5(/))
      WRITE(6,5)
    5 FORMAT(35X,'PICTORIAL VIEW OF TEMPERATURE',15(/))
      RC=14.99999/(TMA-TMI)
      DO 30 JX=1,NY
      J=NY+1-JX
      DO 29 I=1,NX
      S=RC*(T(I,J)-TMI)
   29 KP(I)=LIT(1+IFIX(S))
      WRITE(6,35) (KP(I),I=1,NX)
   30 CONTINUE
   35 FORMAT(1H ,'.',25X,50(A1,1X))
      RETURN
      END
```

APPENDIX C

SAMPLE PROGRAM OUTPUT

The program output includes the boundary point coordinates which can be used to check the program input parameters. The program also prints out, ε, for every iteration and this allows monitoring of the convergence process. After the final iteration, the grid temperatures are printed as well as the isothermal lines locations. A sample of the program output is given in the pages 41 through 56.

TEMPERATURE DISTRIBUTION IN A TURBINE BLADE

```
DX =   0.0500       DY =   0.0250     OMEGA = 1.600     THERM. COND. =   1.0000
NX =       40       NY =       12     MAX. ERR.=  0.0200
```

ORIGINAL PAGE
OF POOR QUAL

(B2,C2) IS THE POINT ON THE BOUNDARY AND (B1,C1),(B3,C3) ARE THE SURROUNDING POINTS ON BLADE
A,B,C ARE THE COEFFICIENTS OF THE PARABOLIC CURVE Y=A+B*X+C*X*X

I	B1	C1	B2	C2	B3	C3	A	B	C
2	0.040000	0.050000	0.050000	0.045000	0.100000	0.028000	0.075333	-0.739998	2.666591
2	0.028000	0.150000	0.050000	0.163000	0.100000	0.180000	0.128576	0.862729	-3.484890
3	0.050000	0.045000	0.100000	0.028000	0.150000	0.021000	0.072000	-0.640001	1.999998
3	0.080000	0.175000	0.100000	0.180000	0.150000	0.193000	0.156143	0.224286	0.142838
4	0.120000	0.025000	0.150000	0.021000	0.200000	0.025000	0.088998	-0.853307	2.666578
4	0.100000	0.180000	0.150000	0.193000	0.200000	0.203000	0.145001	0.409988	-0.599987
5	0.150000	0.021000	0.200000	0.025000	0.250000	0.035000	0.045000	-0.339995	1.199980
5	0.185000	0.200000	0.200000	0.203000	0.250000	0.211000	0.140232	0.436956	-0.615390
6	0.200000	0.025000	0.250000	0.035000	0.300000	0.045000	-0.014999	0.199996	0.000015
6	0.200000	0.203000	0.250000	0.211000	0.300000	0.220000	0.180999	0.069991	0.200048
7	0.250000	0.035000	0.300000	0.045000	0.320000	0.050000	0.038572	-0.192872	0.714225
7	0.250000	0.211000	0.300000	0.220000	0.350000	0.227000	0.136001	0.399985	-0.400119
8	0.300000	0.045000	0.350000	0.055000	0.400000	0.068000	0.047999	-0.190004	0.599994
8	0.340000	0.225000	0.350000	0.227000	0.400000	0.233000	-0.001676	1.120079	-1.333167
9	0.350000	0.055000	0.400000	0.069000	0.440000	0.075000	-0.168126	0.967934	-0.944040
9	0.350000	0.227000	0.400000	0.233000	0.450000	0.238000	0.156997	0.270025	-0.200045
10	0.400000	0.068000	0.450000	0.077000	0.500000	0.086000	-0.004005	0.180019	0.0
10	0.400000	0.233000	0.450000	0.238000	0.500000	0.243000	0.193003	0.100009	0.000238
11	0.450000	0.077000	0.500000	0.086000	0.550000	0.095000	-0.003984	0.179961	0.0
11	0.450000	0.238000	0.500000	0.243000	0.550000	0.245000	0.058038	0.670009	-0.600000
12	0.500000	0.086000	0.550000	0.095000	0.575000	0.100000	0.069342	-0.099905	0.266479
12	0.500000	0.243000	0.550000	0.245000	0.600000	0.249000	0.333022	-0.380336	0.400429
13	0.550000	0.095000	0.600000	0.105000	0.650000	0.113000	-0.146953	0.659878	-0.400060
13	0.550000	0.245000	0.600000	0.249000	0.650000	0.251000	0.069040	0.539928	-0.400000
14	0.600000	0.105000	0.650000	0.113000	0.700000	0.120000	-0.069015	0.410035	-0.200048
14	0.630000	0.250000	0.650000	0.251000	0.700000	0.254000	0.276955	-0.131915	0.142979
15	0.650000	0.113000	0.700000	0.120000	0.735000	0.125000	0.037314	0.094226	0.034054
15	0.650000	0.251000	0.700000	0.254000	0.750000	0.255000	0.030036	0.600000	-0.400000
16	0.700000	0.120000	0.750000	0.128000	0.800000	0.133000	-0.307027	1.030043	-0.600381
16	0.700000	0.254000	0.750000	0.255000	0.800000	0.255000	0.134984	0.309967	-0.199809
17	0.750000	0.128000	0.800000	0.133000	0.850000	0.138000	0.052992	0.099905	-0.000238
17	0.750000	0.255000	0.800000	0.255000	0.850000	0.255000	0.254992	0.0	0.0
18	0.800000	0.133000	0.850000	0.138000	0.900000	0.143000	0.052977	0.099905	-0.000238
18	0.800000	0.255000	0.850000	0.255000	0.900000	0.254000	0.118979	0.329995	-0.200286
19	0.850000	0.138000	0.900000	0.143000	0.950000	0.145000	-0.406026	1.150214	-0.600143
19	0.850000	0.255000	0.900000	0.254000	0.950000	0.251000	-0.034022	0.680257	-0.400095
20	0.900000	0.143000	0.950000	0.145000	1.000000	0.148000	0.277950	-0.329917	0.200000
20	0.900000	0.254000	0.950000	0.251000	1.000000	0.250000	0.649940	-0.799762	0.399762
21	0.950000	0.145000	1.000000	0.148000	1.040000	0.150000	-0.016815	0.275305	-0.110452
21	0.950000	0.251000	1.000000	0.250000	1.049999	0.248000	0.080087	0.370026	-0.200143
22	0.999999	0.148000	1.049999	0.151000	1.099998	0.154000	0.087965	0.059876	-0.000239
22	0.999999	0.250000	1.049999	0.248000	1.099998	0.245000	0.079914	0.370229	-0.200143
23	1.049999	0.151000	1.099999	0.154000	1.149999	0.155000	-0.372297	0.916825	-0.398764
23	1.049999	0.248000	1.099999	0.245000	1.149999	0.242000	0.310792	-0.059886	-0.000238
24	1.099999	0.154000	1.150000	0.155000	1.199999	0.155000	-0.120099	0.468631	-0.199144
24	1.099999	0.245000	1.150000	0.242000	1.199999	0.238000	0.058564	0.388783	-0.199144
25	1.150000	0.155000	1.200000	0.155000	1.249999	0.155000	0.154988	0.0	0.0
25	1.150000	0.242000	1.200000	0.238000	1.249999	0.232000	-0.216537	0.857414	-0.398527
26	1.199999	0.155000	1.249999	0.155000	1.299998	0.154000	-0.145172	0.490219	-0.200143
26	1.199999	0.238000	1.249999	0.232000	1.299998	0.228000	0.982362	-1.100429	0.400286
27	1.249999	0.155000	1.299999	0.154000	1.349998	0.151000	-0.468007	0.996911	-0.398764
27	1.249999	0.232000	1.299999	0.228000	1.325000	0.225000	-0.529217	1.271464	-0.529040
28	1.299999	0.154000	1.349999	0.151000	1.399999	0.147000	-0.118138	0.468631	-0.199620
28	1.299999	0.228000	1.349999	0.222000	1.399999	0.215000	0.033582	0.408745	-0.199382
29	1.349999	0.151000	1.400000	0.147000	1.449999	0.142000	-0.119170	0.470420	-0.200143
29	1.349999	0.222000	1.400000	0.215000	1.449999	0.208000	0.411051	-0.140267	0.0
30	1.400000	0.147000	1.450000	0.142000	1.499999	0.138000	0.691154	-0.667538	0.199144
30	1.400000	0.215000	1.450000	0.208000	1.499999	0.200000	0.005629	0.428945	-0.199144
31	1.449999	0.142000	1.499999	0.138000	1.549998	0.133000	-0.177242	0.510496	-0.199905
31	1.449999	0.208000	1.499999	0.200000	1.549998	0.193000	0.875194	-0.750000	0.200143
32	1.499999	0.138000	1.549999	0.133000	1.599998	0.127000	-0.176034	0.508317	-0.199144
32	1.499999	0.200000	1.549999	0.193000	1.599998	0.183000	-0.981226	1.684173	-0.598384
33	1.549999	0.133000	1.599999	0.127000	1.649999	0.123000	1.311604	-1.380725	0.400048
33	1.549999	0.193000	1.599999	0.183000	1.645000	0.175000	1.083652	-0.937500	0.234096
34	1.625000	0.125000	1.650000	0.123000	1.699999	0.115000	-2.585740	3.389520	-1.058712
34	1.599999	0.183000	1.650000	0.174000	1.699999	0.165000	0.471091	-0.180105	-0.000239
35	1.650000	0.123000	1.700000	0.115000	1.749999	0.108000	0.948414	-0.830153	0.199905
35	1.650000	0.174000	1.700000	0.165000	1.749999	0.153000	-1.212815	1.831106	-0.600429
36	1.699999	0.115000	1.749999	0.108000	1.799998	0.100000	-0.242292	0.550334	-0.200143
36	1.699999	0.165000	1.749999	0.153000	1.770000	0.150000	4.363598	-4.637669	1.275337
37	1.749999	0.108000	1.799999	0.100000	1.849998	0.097000	3.526705	-3.698194	0.996673
37	1.749999	0.153000	1.799999	0.143000	1.849998	0.133000	0.501708	-0.199144	-0.000238
38	1.799999	0.100000	1.849999	0.097000	1.899999	0.085000	-5.789301	6.513358	-1.801049
38	1.799999	0.143000	1.849999	0.133000	1.884999	0.125000	-0.616411	1.026842	-0.335737
39	1.849999	0.097000	1.900000	0.085000	1.940000	0.100000	24.526886	-25.830017	6.824074
39	1.849999	0.133000	1.900000	0.120000	1.884999	0.125000	-6.883969	7.743055	-2.134259
2	0.150000	0.021000	0.120000	0.025000	0.100000	0.028000	0.047001	-0.223317	0.333261
2	0.150000	0.021000	0.200000	0.025000	0.250000	0.035000	0.045000	-0.339995	1.199980
3	0.050000	0.045000	0.040000	0.050000	0.010000	0.075000	0.086667	-1.249997	8.333333
3	0.300000	0.045000	0.320000	0.050000	0.350000	0.055000	-0.190000	1.283372	-1.666832
4	0.040000	0.050000	0.010000	0.075000	0.0	0.100000	0.100000	-2.916664	41.666534
4	0.400000	0.068000	0.440000	0.075000	0.450000	0.077000	0.085938	-0.243880	0.497774
5	0.010000	0.075000	0.0	0.100000	0.005000	0.125000	100.000000	100.000000	100.000000
5	0.550000	0.095000	0.575000	0.100000	0.600000	0.105000	-0.014836	0.199643	0.000119
6	0.028000	0.150000	0.005000	0.125000	0.0	0.100000	0.100000	5.698756	**********
6	0.700000	0.120000	0.735000	0.125000	0.750000	0.128000	0.606264	-1.492646	1.138008
7	0.050000	0.163000	0.028000	0.150000	0.005000	0.125000	0.118022	1.450722	-11.023401
7	1.000000	0.148000	1.040000	0.150000	1.049999	0.151000	1.136719	-1.988094	1.000000
8	0.100000	0.180000	0.080000	0.175000	0.050000	0.163000	0.130999	0.790001	-3.000001
8	1.599999	0.183000	1.645000	0.175000	1.650000	0.174000	-0.766335	1.357954	-0.471591
9	0.200000	0.203000	0.185000	0.200000	0.150000	0.193000	0.163001	0.200255	-0.000142
9	1.450000	0.208000	1.500000	0.200000	1.549999	0.193000	0.877814	-0.753113	0.200670
10	0.350000	0.227000	0.340000	0.225000	0.300000	0.270000	0.335491	-0.834979	1.498975
10	1.299999	0.228000	1.325000	0.225000	1.349999	0.222000	0.382813	-0.117424	0.001894
11	0.650000	0.251000	0.630000	0.250000	0.600000	0.249000	0.355166	-0.377734	0.333996
11	0.950000	0.251000	1.000000	0.250000	1.049999	0.248000	0.080157	0.369700	-0.199857

```
ITERATION =  1     SUM= 0.17129E 05
ITERATION =  2     SUM= 0.10122E 05
ITERATION =  3     SUM= 0.47786E 04
ITERATION =  4     SUM= 0.23836E 04
ITERATION =  5     SUM= 0.20500E 04
ITERATION =  6     SUM= 0.16037E 04
ITERATION =  7     SUM= 0.14074E 04
ITERATION =  8     SUM= 0.11516E 04
ITERATION =  9     SUM= 0.11413E 04
ITERATION = 10     SUM= 0.96032E 03
ITERATION = 11     SUM= 0.91320E 03
ITERATION = 12     SUM= 0.81725E 03
ITERATION = 13     SUM= 0.75635E 03
ITERATION = 14     SUM= 0.69111E 03
ITERATION = 15     SUM= 0.64236E 03
ITERATION = 16     SUM= 0.58774E 03
ITERATION = 17     SUM= 0.54829E 03
ITERATION = 18     SUM= 0.50517E 03
ITERATION = 19     SUM= 0.46995E 03
ITERATION = 20     SUM= 0.43643E 03
ITERATION = 21     SUM= 0.40629E 03
ITERATION = 22     SUM= 0.37849E 03
ITERATION = 23     SUM= 0.35362E 03
ITERATION = 24     SUM= 0.32970E 03
ITERATION = 25     SUM= 0.30914E 03
ITERATION = 26     SUM= 0.28921E 03
ITERATION = 27     SUM= 0.27139E 03
ITERATION = 28     SUM= 0.25468E 03
ITERATION = 29     SUM= 0.24000E 03
ITERATION = 30     SUM= 0.22515E 03
ITERATION = 31     SUM= 0.21254E 03
ITERATION = 32     SUM= 0.19997E 03
ITERATION = 33     SUM= 0.18928E 03
ITERATION = 34     SUM= 0.17848E 03
ITERATION = 35     SUM= 0.16879E 03
ITERATION = 36     SUM= 0.15971E 03
ITERATION = 37     SUM= 0.15140E 03
ITERATION = 38     SUM= 0.14321E 03
ITERATION = 39     SUM= 0.13610E 03
ITERATION = 40     SUM= 0.12889E 03
ITERATION = 41     SUM= 0.12272E 03
ITERATION = 42     SUM= 0.11644E 03
ITERATION = 43     SUM= 0.11079E 03
ITERATION = 44     SUM= 0.10526E 03
ITERATION = 45     SUM= 0.10031E 03
ITERATION = 46     SUM= 0.95471E 02
ITERATION = 47     SUM= 0.90899E 02
ITERATION = 48     SUM= 0.86741E 02
ITERATION = 49     SUM= 0.82651E 02
ITERATION = 50     SUM= 0.78813E 02
```

TEMPERATURE AT GRID POINTS

I \ J=	1	2	3	4	5	6	7	8	9	10	11	12
1	1961.000	1961.000	1961.000	1953.493	1952.895	1954.163	1961.000	1961.000	1961.000	1961.000	1961.000	1961.000
2	1966.000	1952.318	1951.977	1952.025	1952.434	1953.486	1955.266	1956.594	1998.500	1998.500	1998.500	1998.500
3	1975.500	1952.739	1952.077	1952.193	1952.566	1953.208	1954.050	1954.897	1955.272	1998.500	1998.500	1998.500
4	1952.426	1952.111	1952.009	1952.098	1952.386	1952.874	1953.543	1954.387	1955.243	1998.350	1998.350	1998.350
5	1975.200	1952.773	1951.976	1951.994	1952.198	1952.575	1953.105	1953.743	1954.423	1954.785	1998.200	1998.200
6	1976.200	1952.551	1951.949	1951.958	1952.125	1952.468	1952.997	1953.723	1954.665	1955.395	1998.150	1998.150
7	1977.200	1952.642	1952.284	1952.112	1952.157	1952.414	1952.885	1953.593	1954.582	1955.737	1998.100	1998.100
8	1977.900	1977.900	1952.967	1952.223	1952.177	1952.309	1952.622	1953.097	1953.693	1954.304	1954.637	1997.500
9	1978.600	1978.600	1952.995	1952.574	1952.313	1952.306	1952.518	1952.933	1953.536	1954.320	1954.898	1996.900
10	1978.800	1978.800	1978.800	1953.180	1952.294	1952.243	1952.423	1952.819	1953.433	1954.263	1954.990	1996.700
11	1979.000	1979.000	1979.000	1952.812	1952.145	1952.106	1952.271	1952.646	1953.234	1954.039	1954.877	1996.500
12	1979.000	1979.000	1979.000	1952.298	1952.050	1951.992	1952.105	1952.419	1952.948	1953.706	1954.576	1996.500
13	1979.000	1979.000	1979.000	1979.000	1952.889	1952.037	1951.971	1952.136	1952.532	1953.184	1954.134	1996.500
14	1978.900	1978.900	1978.900	1978.900	1952.518	1951.881	1951.754	1951.762	1951.905	1952.154	1952.434	1952.719
15	1978.800	1978.800	1978.800	1978.800	1952.616	1952.211	1951.858	1951.700	1951.705	1951.843	1952.070	1952.472
16	1978.400	1978.400	1978.400	1978.400	1978.400	1953.045	1952.056	1951.847	1951.840	1952.027	1952.410	1952.858
17	1978.000	1978.000	1978.000	1978.000	1978.000	1953.102	1952.256	1952.057	1952.065	1952.276	1952.701	1953.158
18	1976.900	1976.900	1976.900	1976.900	1976.900	1953.136	1952.462	1952.313	1952.324	1952.507	1952.911	1953.372
19	1975.800	1975.800	1975.800	1975.800	1975.800	1953.324	1952.832	1952.803	1952.748	1952.700	1952.781	1953.206
20	1974.850	1974.850	1974.850	1974.850	1974.850	1954.561	1954.164	1954.240	1953.993	1953.241	1951.490	1951.804
21	1973.900	1973.900	1973.900	1973.900	1973.900	1957.775	1957.516	1957.746	1958.091	1958.703	1959.905	1993.500
22	1973.050	1973.050	1973.050	1973.050	1973.050	1973.050	1961.964	1961.430	1961.720	1962.350	1963.259	1992.500
23	1972.200	1972.200	1972.200	1972.200	1972.200	1972.200	1964.589	1964.200	1964.502	1965.118	1965.892	1991.500
24	1971.700	1971.700	1971.700	1971.700	1971.700	1971.700	1966.511	1966.190	1966.494	1967.083	1967.724	1990.050
25	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1967.716	1967.465	1967.779	1968.332	1968.830	1988.600
26	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1968.448	1968.229	1968.516	1968.977	1969.291	1986.900
27	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1968.870	1968.667	1968.955	1969.393	1969.587	1985.200
28	1970.900	1970.900	1970.900	1970.900	1970.900	1970.900	1968.947	1968.775	1969.177	1969.767	1983.350	1983.350
29	1970.600	1970.600	1970.600	1970.600	1970.600	1967.701	1967.559	1968.160	1968.719	1969.154	1981.500	1981.500
30	1969.650	1969.650	1969.650	1969.650	1969.650	1967.812	1967.677	1968.029	1968.427	1968.678	1979.550	1979.550
31	1968.700	1968.700	1968.700	1968.700	1968.700	1967.801	1967.692	1968.010	1968.461	1977.600	1977.600	1977.600
32	1968.350	1968.350	1968.350	1968.350	1968.350	1967.504	1967.411	1967.693	1968.015	1975.800	1975.800	1975.800
33	1968.000	1968.000	1968.000	1968.000	1968.000	1966.953	1966.863	1967.124	1967.305	1974.000	1974.000	1974.000
34	1967.250	1967.250	1967.250	1967.250	1965.681	1965.583	1966.057	1966.424	1972.500	1972.500	1972.500	1972.500
35	1966.500	1966.500	1966.500	1966.500	1965.678	1965.598	1965.867	1966.046	1970.500	1970.500	1970.500	1970.500
36	1965.750	1965.750	1965.750	1965.750	1965.290	1965.337	1966.127	1966.188	1969.000	1969.000	1969.000	1969.000
37	1965.000	1965.000	1965.000	1965.000	1963.041	1962.869	1963.242	1967.500	1967.500	1967.500	1967.500	1967.500
38	1964.250	1964.250	1964.250	1962.083	1961.991	1962.668	1962.783	1965.850	1965.850	1965.850	1965.850	1965.850
39	1963.500	1963.500	1963.500	1961.049	1960.837	1961.189	1964.200	1964.200	1964.200	1964.200	1964.200	1964.200
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2	1966.000	1969.377	1969.282	1969.435	1969.778	1970.541	1971.797	1972.674	1998.500	1998.500	1998.500	1998.500
3	1975.500	1970.565	1970.328	1970.461	1970.771	1971.261	1971.891	1972.538	1972.720	1998.500	1998.500	1998.500
4	1970.979	1970.880	1970.904	1971.048	1971.313	1971.694	1972.173	1972.729	1973.219	1998.350	1998.350	1998.350
5	1975.200	1971.438	1971.289	1971.440	1971.681	1972.007	1972.409	1972.869	1973.360	1973.519	1998.200	1998.200
6	1976.200	1971.759	1971.627	1971.777	1971.998	1972.302	1972.691	1973.169	1973.742	1974.115	1998.150	1998.150
7	1977.200	1972.153	1972.052	1972.121	1972.288	1972.545	1972.899	1973.357	1973.939	1974.554	1998.100	1998.100
8	1977.900	1977.900	1972.562	1972.390	1972.508	1972.706	1972.985	1973.336	1973.749	1974.186	1974.324	1997.500
9	1978.600	1978.600	1972.821	1972.699	1972.717	1972.844	1973.063	1973.370	1973.757	1974.219	1974.488	1996.900
10	1978.800	1978.800	1978.800	1973.033	1972.808	1972.908	1973.102	1973.384	1973.753	1974.209	1974.557	1996.700
11	1979.000	1979.000	1979.000	1973.002	1972.817	1972.911	1973.086	1973.346	1973.689	1974.117	1974.522	1996.500
12	1979.000	1979.000	1979.000	1972.936	1972.846	1972.903	1973.042	1973.265	1973.577	1973.979	1974.400	1996.500
13	1979.000	1979.000	1979.000	1979.000	1973.107	1972.878	1972.961	1973.134	1973.396	1973.755	1974.220	1996.500
14	1978.900	1978.900	1978.900	1978.900	1972.948	1972.766	1972.835	1972.956	1973.129	1973.345	1973.575	1973.684
15	1978.800	1978.800	1978.800	1978.800	1972.953	1972.829	1972.817	1972.880	1973.009	1973.191	1973.409	1973.576
16	1978.400	1978.400	1978.400	1978.400	1978.400	1973.055	1972.807	1972.859	1972.991	1973.198	1973.482	1973.672
17	1978.000	1978.000	1978.000	1978.000	1978.000	1972.971	1972.760	1972.825	1972.973	1973.201	1973.510	1973.702
18	1976.900	1976.900	1976.900	1976.900	1976.900	1972.824	1972.662	1972.766	1972.932	1973.164	1973.478	1973.669
19	1975.800	1975.800	1975.800	1975.800	1975.800	1972.699	1972.583	1972.748	1972.909	1973.079	1973.299	1973.470
20	1974.850	1974.850	1974.850	1974.850	1974.850	1972.896	1972.806	1973.015	1973.125	1973.077	1972.710	1972.817
21	1973.900	1973.900	1973.900	1973.900	1973.900	1973.716	1973.653	1973.925	1974.233	1974.627	1975.210	1993.500
22	1973.050	1973.050	1973.050	1973.050	1973.050	1973.050	1974.827	1974.873	1975.176	1975.587	1976.073	1992.500
23	1972.200	1972.200	1972.200	1972.200	1972.200	1972.200	1975.423	1975.508	1975.821	1976.237	1976.658	1991.500
24	1971.700	1971.700	1971.700	1971.700	1971.700	1971.700	1975.765	1975.867	1976.182	1976.586	1976.932	1990.050
25	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1975.843	1975.967	1976.278	1976.669	1976.929	1988.600
26	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1975.728	1975.852	1976.141	1976.495	1976.635	1986.900
27	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1975.397	1975.529	1975.808	1976.154	1976.220	1985.200
28	1970.900	1970.900	1970.900	1970.900	1970.900	1970.900	1974.817	1974.981	1975.272	1975.597	1983.350	1983.350
29	1970.600	1970.600	1970.600	1970.600	1970.600	1973.882	1973.888	1974.164	1974.470	1974.684	1981.500	1981.500
30	1969.650	1969.650	1969.650	1969.650	1969.650	1972.992	1973.039	1973.278	1973.542	1973.649	1979.550	1979.550
31	1968.700	1968.700	1968.700	1968.700	1968.700	1972.068	1972.145	1972.330	1972.470	1977.600	1977.600	1977.600
32	1968.350	1968.350	1968.350	1968.350	1968.350	1971.282	1971.391	1971.592	1971.758	1975.800	1975.800	1975.800
33	1968.000	1968.000	1968.000	1968.000	1968.000	1970.461	1970.593	1970.774	1970.843	1974.000	1974.000	1974.000
34	1967.250	1967.250	1967.250	1967.250	1969.544	1969.548	1969.733	1969.905	1972.500	1972.500	1972.500	1972.500
35	1966.500	1966.500	1966.500	1966.500	1968.696	1968.752	1968.920	1969.009	1970.500	1970.500	1970.500	1970.500
36	1965.750	1965.750	1965.750	1965.750	1967.903	1968.015	1968.267	1968.281	1969.000	1969.000	1969.000	1969.000
37	1965.000	1965.000	1965.000	1965.000	1966.843	1966.975	1967.066	1967.500	1967.500	1967.500	1967.500	1967.500
38	1964.250	1964.250	1964.250	1965.884	1965.890	1965.944	1965.984	1965.850	1965.850	1965.850	1965.850	1965.850
39	1963.500	1963.500	1963.500	1965.565	1965.605	1965.618	1964.200	1964.200	1964.200	1964.200	1964.200	1964.200
40	1963.000	1963.000	1963.000	1982.000	1965.501	1982.000	1963.000	1963.000	1963.000	1963.000	1963.000	1963.000

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TEMPERATURE AT GRID POINTS

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2	1960.000	1975.403	1975.392	1975.583	1975.901	1976.566	1977.641	1978.361	1998.500	1998.500	1998.500	1998.500
3	1975.500	1976.879	1976.789	1976.929	1977.218	1977.656	1978.212	1978.791	1978.908	1998.500	1998.500	1998.500
4	1977.564	1977.541	1977.612	1977.777	1978.035	1978.378	1978.790	1979.248	1979.610	1998.350	1998.350	1998.350
5	1975.200	1978.079	1978.160	1978.363	1978.617	1978.927	1979.286	1979.683	1980.110	1980.198	1998.200	1998.200
6	1976.200	1978.611	1978.647	1978.849	1979.093	1979.384	1979.725	1980.115	1980.560	1980.806	1998.150	1998.150
7	1977.200	1979.132	1979.123	1979.282	1979.491	1979.751	1980.065	1980.436	1980.874	1981.297	1998.100	1998.100
8	1977.900	1977.900	1979.587	1979.623	1979.799	1980.019	1980.284	1980.594	1980.945	1981.323	1981.390	1997.500
9	1978.600	1978.600	1979.930	1979.919	1980.039	1980.213	1980.437	1980.706	1981.011	1981.356	1981.512	1996.900
10	1978.800	1978.800	1978.800	1980.163	1980.177	1980.327	1980.522	1980.762	1981.041	1981.360	1981.569	1996.700
11	1979.000	1979.000	1979.000	1980.248	1980.238	1980.375	1980.548	1980.762	1981.015	1981.306	1981.554	1996.500
12	1979.000	1979.000	1979.000	1980.326	1980.295	1980.386	1980.527	1980.714	1980.944	1981.215	1981.473	1996.500
13	1979.000	1979.000	1979.000	1979.000	1980.312	1980.305	1980.435	1980.605	1980.814	1981.065	1981.353	1996.500
14	1978.900	1978.900	1978.900	1978.900	1980.184	1980.166	1980.293	1980.447	1980.628	1980.832	1981.045	1981.089
15	1978.800	1978.800	1976.800	1978.800	1980.088	1980.064	1980.158	1980.294	1980.463	1980.660	1980.879	1980.959
16	1978.400	1978.400	1978.400	1978.400	1978.400	1979.976	1979.981	1980.116	1980.275	1980.510	1980.765	1980.862
17	1978.000	1978.000	1978.000	1978.000	1978.000	1979.730	1979.733	1979.882	1980.075	1980.306	1980.578	1980.678
18	1976.900	1976.900	1976.900	1976.900	1976.900	1979.395	1979.403	1979.582	1979.794	1980.041	1980.325	1980.427
19	1975.800	1975.800	1975.800	1975.800	1975.800	1979.022	1979.029	1979.252	1979.479	1979.718	1979.979	1980.067
20	1974.850	1974.850	1974.850	1974.850	1974.850	1978.732	1978.738	1978.991	1979.213	1979.386	1979.458	1979.501
21	1973.900	1973.900	1973.900	1973.900	1973.900	1978.658	1978.653	1978.937	1979.234	1979.563	1979.954	1993.500
22	1973.050	1973.050	1973.050	1973.050	1973.050	1973.050	1978.673	1978.885	1979.195	1979.548	1979.915	1992.500
23	1972.200	1972.200	1972.200	1972.200	1972.200	1972.200	1978.500	1978.709	1979.035	1979.403	1979.734	1991.500
24	1971.700	1971.700	1971.700	1971.700	1971.700	1971.700	1978.214	1978.423	1978.750	1979.116	1979.394	1990.050
25	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1977.810	1978.020	1978.344	1978.705	1978.919	1986.600
26	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1977.311	1977.503	1977.805	1978.144	1978.256	1986.900
27	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1976.651	1976.844	1977.130	1977.460	1977.508	1985.200
28	1970.900	1970.900	1970.900	1970.900	1970.900	1970.900	1975.802	1976.022	1976.309	1976.602	1983.350	1983.350
29	1970.600	1970.600	1970.600	1970.600	1970.600	1974.740	1974.762	1975.024	1975.312	1975.504	1981.500	1981.500
30	1969.650	1969.650	1969.650	1969.650	1969.650	1973.633	1973.700	1973.937	1974.190	1974.285	1979.550	1979.550
31	1968.700	1968.700	1968.700	1968.700	1968.700	1972.529	1972.626	1972.800	1972.903	1977.600	1977.600	1977.600
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33	1968.000	1968.000	1968.000	1968.000	1968.000	1970.758	1970.908	1971.088	1971.152	1974.000	1974.000	1974.000
34	1967.250	1967.250	1967.250	1967.250	1969.822	1969.833	1970.005	1970.166	1972.500	1972.500	1972.500	1972.500
35	1966.500	1966.500	1966.500	1966.500	1968.905	1968.971	1969.134	1969.216	1970.500	1970.500	1970.500	1970.500
36	1965.750	1965.750	1965.750	1965.750	1968.063	1968.181	1968.398	1968.411	1969.000	1969.000	1969.000	1969.000
37	1965.000	1965.000	1965.000	1965.000	1967.063	1967.212	1967.288	1967.500	1967.500	1967.500	1967.500	1967.500
38	1964.250	1964.250	1964.250	1966.106	1966.116	1966.131	1966.167	1965.850	1965.850	1965.850	1965.850	1965.850
39	1963.500	1963.500	1963.500	1965.821	1965.874	1965.870	1964.200	1964.200	1964.200	1964.200	1964.200	1964.200
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ITERATION =197      SUM= 0.16794E 00
ITERATION =198      SUM= 0.15877E 00
ITERATION =199      SUM= 0.14928E 00
ITERATION =200      SUM= 0.14393E 00
```

TEMPERATURE AT GRID POINTS

J= / I	1	2	3	4	5	6	7	8	9	10	11	12
1	1961.000	1961.000	1961.000	1976.419	1976.123	1976.750	1961.000	1961.000	1961.000	1961.000	1961.000	1961.000
2	1966.000	1977.541	1977.560	1977.765	1978.075	1978.706	1979.716	1980.380	1998.500	1998.500	1998.500	1998.500
3	1975.500	1979.118	1979.082	1979.224	1979.505	1979.926	1980.456	1981.010	1981.103	1998.500	1998.500	1998.500
4	1979.900	1979.905	1979.991	1980.165	1980.420	1980.750	1981.138	1981.560	1981.877	1998.350	1998.350	1998.350
5	1975.200	1980.433	1980.595	1980.816	1981.076	1981.379	1981.721	1982.097	1982.499	1982.559	1998.200	1998.200
6	1976.200	1981.034	1981.130	1981.351	1981.604	1981.889	1982.211	1982.571	1982.969	1983.169	1998.150	1998.150
7	1977.200	1981.597	1981.619	1981.809	1982.034	1982.295	1982.594	1982.934	1983.319	1983.673	1998.100	1998.100
8	1977.900	1977.900	1982.061	1982.169	1982.365	1982.593	1982.856	1983.151	1983.479	1983.636	1983.875	1997.500
9	1978.600	1978.600	1982.433	1982.459	1982.613	1982.804	1983.027	1983.280	1983.561	1983.865	1983.982	1996.900
10	1978.800	1978.800	1978.800	1982.659	1982.757	1982.926	1983.122	1983.345	1983.592	1983.863	1984.023	1996.700
11	1979.000	1979.000	1979.000	1982.779	1982.830	1982.981	1983.152	1983.348	1983.570	1983.812	1984.003	1996.500
12	1979.000	1979.000	1979.000	1982.899	1982.888	1982.989	1983.129	1983.302	1983.502	1983.726	1983.926	1996.500
13	1979.000	1979.000	1979.000	1979.000	1982.807	1982.876	1983.020	1983.186	1983.375	1983.587	1983.814	1996.500
14	1978.900	1978.900	1978.900	1978.900	1982.674	1982.712	1982.856	1983.019	1983.201	1983.400	1983.611	1983.631
15	1978.800	1978.800	1978.800	1978.800	1982.524	1982.536	1982.667	1982.823	1983.004	1983.205	1983.423	1983.475
16	1978.400	1978.400	1978.400	1978.400	1978.400	1982.320	1982.412	1982.575	1982.767	1982.983	1983.228	1983.295
17	1978.000	1978.000	1978.000	1978.000	1978.000	1982.004	1982.079	1982.254	1982.460	1982.692	1982.952	1983.021
18	1976.900	1976.900	1976.900	1976.900	1976.900	1981.589	1981.653	1981.857	1982.083	1982.333	1982.608	1982.679
19	1975.800	1975.800	1975.800	1975.800	1975.800	1981.116	1981.163	1981.404	1981.652	1981.911	1982.188	1982.249
20	1974.850	1974.850	1974.850	1974.850	1974.850	1980.649	1980.687	1980.955	1981.212	1981.456	1981.666	1981.689
21	1973.900	1973.900	1973.900	1973.900	1973.900	1980.273	1980.287	1980.574	1980.868	1981.176	1981.505	1993.500
22	1973.050	1973.050	1973.050	1973.050	1973.050	1973.050	1979.923	1980.187	1980.499	1980.832	1981.160	1992.500
23	1972.200	1972.200	1972.200	1972.200	1972.200	1972.200	1979.489	1979.739	1980.068	1980.419	1980.721	1991.500
24	1971.700	1971.700	1971.700	1971.700	1971.700	1971.700	1978.988	1979.230	1979.563	1979.918	1980.175	1990.050
25	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1978.422	1978.658	1978.985	1979.340	1979.540	1988.600
26	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1977.792	1978.004	1978.307	1978.643	1978.746	1986.900
27	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1977.017	1977.228	1977.518	1977.847	1977.892	1985.200
28	1970.900	1970.900	1970.900	1970.900	1970.900	1970.900	1976.075	1976.310	1976.598	1976.884	1983.350	1983.350
29	1970.600	1970.600	1970.600	1970.600	1970.600	1974.963	1974.986	1975.248	1975.532	1975.720	1981.500	1981.500
	1969.650	1969.650	1969.650	1969.650	1969.650	1973.791	1973.861	1974.101	1974.352	1974.445	1979.550	1979.550
31	1968.700	1968.700	1968.700	1968.700	1968.700	1972.636	1972.737	1972.909	1973.001	1977.600	1977.600	1977.600
32	1968.350	1968.350	1968.350	1968.350	1968.350	1971.723	1971.855	1972.054	1972.207	1975.800	1975.800	1975.800
33	1968.000	1968.000	1968.000	1968.000	1968.000	1970.818	1970.972	1971.153	1971.215	1974.000	1974.000	1974.000
34	1967.250	1967.250	1967.250	1967.250	1969.879	1969.890	1970.060	1970.219	1972.500	1972.500	1972.500	1972.500
35	1966.500	1966.500	1966.500	1966.500	1968.943	1969.011	1969.173	1969.256	1970.500	1970.500	1970.500	1970.500
36	1965.750	1965.750	1965.750	1965.750	1968.087	1968.206	1968.424	1968.436	1969.000	1969.000	1969.000	1969.000
37	1965.000	1965.000	1965.000	1965.000	1967.080	1967.230	1967.307	1967.500	1967.500	1967.500	1967.500	1967.500
38	1964.250	1964.250	1964.250	1966.108	1966.119	1966.138	1966.174	1965.850	1965.850	1965.850	1965.850	1965.850
39	1963.500	1963.500	1963.500	1965.825	1965.880	1965.875	1964.200	1964.200	1964.200	1964.200	1964.200	1964.200
40	1963.000	1963.000	1963.000	1982.000	1965.759	1982.000	1963.000	1963.000	1963.000	1963.000	1963.000	1963.000

```
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ITERATION =202    SUM= 0.13276E 00
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ITERATION =204    SUM= 0.13148E 00
ITERATION =205    SUM= 0.12049E 00
ITERATION =206    SUM= 0.12342E 00
ITERATION =207    SUM= 0.11000E 00
ITERATION =208    SUM= 0.10766E 00
ITERATION =209    SUM= 0.10171E 00
ITERATION =210    SUM= 0.10161E 00
ITERATION =211    SUM= 0.91683E-01
ITERATION =212    SUM= 0.90595E-01
ITERATION =213    SUM= 0.84856E-01
ITERATION =214    SUM= 0.87407E-01
ITERATION =215    SUM= 0.81052E-01
ITERATION =216    SUM= 0.84283E-01
ITERATION =217    SUM= 0.80870E-01
ITERATION =218    SUM= 0.73778E-01
ITERATION =219    SUM= 0.74146E-01
ITERATION =220    SUM= 0.70855E-01
ITERATION =221    SUM= 0.66330E-01
ITERATION =222    SUM= 0.64120E-01
ITERATION =223    SUM= 0.61972E-01
ITERATION =224    SUM= 0.61971E-01
ITERATION =225    SUM= 0.65674E-01
ITERATION =226    SUM= 0.57977E-01
ITERATION =227    SUM= 0.56381E-01
ITERATION =228    SUM= 0.52466E-01
ITERATION =229    SUM= 0.51962E-01
ITERATION =230    SUM= 0.53538E-01
ITERATION =231    SUM= 0.54815E-01
ITERATION =232    SUM= 0.56712E-01
ITERATION =233    SUM= 0.56410E-01
ITERATION =234    SUM= 0.53056E-01
ITERATION =235    SUM= 0.48655E-01
ITERATION =236    SUM= 0.43210E-01
ITERATION =237    SUM= 0.46932E-01
ITERATION =238    SUM= 0.53584E-01
ITERATION =239    SUM= 0.46352E-01
ITERATION =240    SUM= 0.43471E-01
ITERATION =241    SUM= 0.41423E-01
ITERATION =242    SUM= 0.43828E-01
ITERATION =243    SUM= 0.37151E-01
ITERATION =244    SUM= 0.36863E-01
ITERATION =245    SUM= 0.40620E-01
ITERATION =246    SUM= 0.42971E-01
ITERATION =247    SUM= 0.44084E-01
ITERATION =248    SUM= 0.37393E-01
ITERATION =249    SUM= 0.37546E-01
ITERATION =250    SUM= 0.37300E-01
```

TEMPERATURE AT GRID POINTS

J= / I	1	2	3	4	5	6	7	8	9	10	11	12
1	1961.000	1961.000	1961.000	1977.104	1976.817	1977.423	1961.000	1961.000	1961.000	1961.000	1961.000	1961.000
2	1966.000	1978.295	1978.325	1978.535	1978.841	1979.458	1980.444	1981.089	1998.500	1998.500	1998.500	1998.500
3	1975.500	1979.904	1979.887	1980.031	1980.309	1980.722	1981.243	1981.786	1981.870	1998.500	1998.500	1998.500
4	1980.716	1980.730	1980.823	1980.999	1981.252	1981.577	1981.958	1982.367	1982.668	1998.350	1998.350	1998.350
5	1975.200	1981.255	1981.446	1981.673	1981.934	1982.235	1982.573	1982.939	1983.335	1983.388	1998.200	1998.200
6	1976.200	1981.882	1981.999	1982.226	1982.478	1982.762	1983.079	1983.426	1983.806	1983.990	1998.150	1998.150
7	1977.200	1982.456	1982.491	1982.691	1982.921	1983.181	1983.474	1983.802	1984.169	1984.499	1998.100	1998.100
8	1977.900	1977.900	1982.922	1983.055	1983.258	1983.490	1983.749	1984.039	1984.357	1984.710	1984.743	1997.500
9	1978.600	1978.600	1983.305	1983.344	1983.508	1983.703	1983.925	1984.175	1984.447	1984.739	1984.841	1996.900
10	1978.800	1978.800	1978.800	1983.527	1983.652	1983.825	1984.020	1984.239	1984.475	1984.730	1984.873	1996.700
11	1979.000	1979.000	1979.000	1983.651	1983.723	1983.877	1984.049	1984.240	1984.449	1984.674	1984.847	1996.500
12	1979.000	1979.000	1979.000	1983.778	1983.775	1983.880	1984.020	1984.188	1984.377	1984.585	1984.765	1996.500
13	1979.000	1979.000	1979.000	1979.000	1983.655	1983.751	1983.900	1984.068	1984.251	1984.448	1984.654	1996.500
14	1978.900	1978.900	1978.900	1978.900	1983.523	1983.579	1983.732	1983.897	1984.080	1984.277	1984.484	1984.497
15	1978.800	1978.800	1978.800	1978.800	1983.355	1983.377	1983.519	1983.684	1983.869	1984.073	1984.293	1984.335
16	1978.400	1978.400	1978.400	1978.400	1978.400	1983.117	1983.236	1983.407	1983.603	1983.823	1984.064	1984.120
17	1978.000	1978.000	1978.000	1978.000	1978.000	1982.771	1982.871	1983.054	1983.264	1983.498	1983.753	1983.812
18	1976.900	1976.900	1976.900	1976.900	1976.900	1982.326	1982.409	1982.620	1982.852	1983.103	1983.375	1963.436
19	1975.800	1975.800	1975.800	1975.800	1975.800	1981.817	1981.877	1982.124	1982.380	1982.645	1982.926	1982.979
20	1974.850	1974.850	1974.850	1974.850	1974.850	1981.291	1981.338	1981.609	1981.880	1982.147	1982.403	1982.419
21	1973.900	1973.900	1973.900	1973.900	1973.900	1980.810	1980.830	1981.118	1981.411	1981.711	1982.020	1993.500
22	1973.050	1973.050	1973.050	1973.050	1973.050	1973.050	1980.336	1980.618	1980.932	1981.259	1981.575	1992.500
23	1972.200	1972.200	1972.200	1972.200	1972.200	1972.200	1979.813	1980.075	1980.407	1980.755	1981.049	1991.500
24	1971.700	1971.700	1971.700	1971.700	1971.700	1971.700	1979.240	1979.493	1979.827	1980.178	1980.428	1990.050
25	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1978.618	1978.863	1979.190	1979.542	1979.737	1988.600
26	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1977.943	1978.161	1978.466	1978.800	1978.902	1986.900
27	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1977.133	1977.347	1977.639	1977.967	1978.010	1985.200
28	1970.900	1970.900	1970.900	1970.900	1970.900	1970.900	1976.156	1976.395	1976.685	1976.969	1983.350	1983.350
29	1970.600	1970.600	1970.600	1970.600	1970.600	1975.008	1975.035	1975.303	1975.591	1975.777	1981.500	1981.500
30	1969.650	1969.650	1969.650	1969.650	1969.650	1973.827	1973.898	1974.140	1974.392	1974.485	1979.550	1979.550
31	1968.700	1968.700	1968.700	1968.700	1968.700	1972.657	1972.758	1972.932	1973.022	1977.600	1977.600	1977.600
32	1968.350	1968.350	1968.350	1968.350	1968.350	1971.738	1971.870	1972.071	1972.224	1975.800	1975.800	1975.800
33	1968.000	1968.000	1968.000	1968.000	1968.000	1970.826	1970.982	1971.162	1971.224	1974.000	1974.000	1974.000
34	1967.250	1967.250	1967.250	1967.250	1969.881	1969.892	1970.062	1970.222	1972.500	1972.500	1972.500	1972.500
35	1966.500	1966.500	1966.500	1966.500	1968.944	1969.010	1969.174	1969.257	1970.500	1970.500	1970.500	1970.500
36	1965.750	1965.750	1965.750	1965.750	1960.093	1968.213	1968.428	1968.438	1969.000	1969.000	1969.000	1969.000
37	1965.000	1965.000	1965.000	1965.000	1967.085	1967.237	1967.313	1967.500	1967.500	1967.500	1967.500	1967.500
38	1964.250	1964.250	1964.250	1966.113	1966.124	1966.142	1966.177	1965.850	1965.850	1965.850	1965.850	1965.850
39	1963.500	1963.500	1963.500	1965.833	1965.887	1965.882	1964.200	1964.200	1964.200	1964.200	1964.200	1964.200
40	1963.000	1963.000	1963.000	1982.000	1965.766	1982.000	1963.000	1963.000	1963.000	1963.000	1963.000	1963.000

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ITERATION =252	SUM= 0.35360E-01
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ITERATION =271	SUM= 0.21331E-01
ITERATION =272	SUM= 0.22153E-01
ITERATION =273	SUM= 0.21594E-01
ITERATION =274	SUM= 0.23230E-01
ITERATION =275	SUM= 0.25258E-01
ITERATION =276	SUM= 0.27588E-01
ITERATION =277	SUM= 0.24965E-01
ITERATION =278	SUM= 0.19849E-01

THE FINAL ITERATIVE

TEMPERATURE AT GRID POINTS

J= / I	1	2	3	4	5	6	7	8	9	10	11	12
1	1961.000	1961.000	1961.000	1977.264	1976.979	1977.580	1961.000	1961.000	1961.000	1961.000	1961.000	1961.000
2	1966.000	1978.469	1978.503	1978.715	1979.020	1979.634	1980.615	1981.255	1998.500	1998.500	1998.500	1998.500
3	1975.500	1980.090	1980.077	1980.219	1980.498	1980.910	1981.427	1981.971	1982.055	1998.500	1998.500	1998.500
4	1980.912	1980.928	1981.021	1981.197	1981.451	1981.774	1982.151	1982.558	1982.856	1998.350	1998.350	1998.350
5	1975.200	1981.451	1981.649	1981.876	1982.138	1982.437	1982.773	1983.140	1983.532	1983.583	1998.200	1998.200
6	1976.200	1982.083	1982.204	1982.432	1982.687	1982.969	1983.284	1983.629	1984.007	1984.188	1998.150	1998.150
7	1977.200	1982.662	1982.698	1982.900	1983.132	1983.392	1983.683	1984.009	1984.371	1984.695	1998.100	1998.100
8	1977.900	1977.900	1983.129	1983.267	1983.471	1983.703	1983.962	1984.250	1984.565	1984.914	1984.944	1997.500
9	1978.600	1978.600	1983.510	1983.552	1983.720	1983.916	1984.139	1984.385	1984.693	1984.940	1985.041	1996.900
10	1978.800	1978.800	1978.800	1983.730	1983.863	1984.037	1984.232	1984.447	1984.681	1964.932	1985.071	1996.700
11	1979.000	1979.000	1979.000	1983.857	1983.933	1984.089	1984.259	1984.449	1984.655	1984.876	1985.043	1996.500
12	1979.000	1979.000	1979.000	1983.987	1983.986	1984.089	1984.230	1984.396	1984.583	1984.787	1984.962	1996.500
13	1979.000	1979.000	1979.000	1979.000	1983.657	1983.958	1984.108	1984.273	1984.455	1984.651	1984.850	1996.500
14	1978.900	1978.900	1978.900	1978.900	1983.721	1983.782	1983.935	1984.102	1984.284	1984.481	1984.690	1984.701
15	1978.800	1978.800	1978.800	1978.800	1983.550	1983.575	1983.719	1983.885	1984.070	1984.272	1984.490	1984.530
16	1978.400	1978.400	1978.400	1978.400	1978.400	1983.303	1983.429	1983.602	1983.797	1984.016	1984.254	1984.307
17	1978.000	1978.000	1978.000	1978.000	1978.000	1982.949	1983.055	1983.243	1983.453	1983.687	1983.941	1983.996
18	1976.900	1976.900	1976.900	1976.900	1976.900	1982.496	1982.584	1982.797	1983.032	1983.284	1983.555	1983.614
19	1975.800	1975.800	1975.800	1975.800	1975.800	1981.982	1982.043	1982.292	1982.550	1982.817	1963.099	1983.149
20	1974.850	1974.850	1974.850	1974.850	1974.850	1981.438	1981.488	1981.760	1982.034	1982.304	1982.567	1982.581
21	1973.900	1973.900	1973.900	1973.900	1973.900	1980.929	1980.950	1981.241	1981.535	1981.834	1982.136	1993.500
22	1973.050	1973.050	1973.050	1973.050	1973.050	1973.050	1980.429	1980.716	1981.030	1981.357	1981.670	1992.500
23	1972.200	1972.200	1972.200	1972.200	1972.200	1972.200	1979.888	1980.155	1980.487	1980.833	1981.124	1991.500
24	1971.700	1971.700	1971.700	1971.700	1971.700	1971.700	1979.302	1979.557	1979.892	1980.242	1980.490	1990.050
25	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1978.667	1978.914	1979.242	1979.594	1979.788	1988.600
26	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1977.982	1978.203	1978.507	1978.841	1978.942	1986.900
27	1971.200	1971.200	1971.200	1971.200	1971.200	1971.200	1977.162	1977.379	1977.672	1977.997	1978.038	1985.200
28	1970.900	1970.900	1970.900	1970.900	1970.900	1970.900	1976.185	1976.426	1976.713	1976.996	1983.350	1983.350
29	1970.600	1970.600	1970.600	1970.600	1970.600	1975.046	1975.073	1975.335	1975.620	1975.806	1981.500	1981.500
30	1969.650	1969.650	1969.650	1969.650	1969.650	1973.847	1973.920	1974.161	1974.414	1974.507	1979.550	1979.550
31	1968.700	1968.700	1968.700	1968.700	1968.700	1972.669	1972.769	1972.944	1973.033	1977.600	1977.600	1977.600
32	1968.350	1968.350	1968.350	1968.350	1968.350	1971.743	1971.876	1972.077	1972.231	1975.800	1975.800	1975.800
33	1968.000	1968.000	1968.000	1968.000	1968.000	1970.830	1970.986	1971.167	1971.229	1974.000	1974.000	1974.000
34	1967.250	1967.250	1967.250	1967.250	1969.881	1969.892	1970.064	1970.224	1972.500	1972.500	1972.500	1972.500
35	1966.500	1966.500	1966.500	1966.500	1968.941	1969.008	1969.173	1969.257	1970.500	1970.500	1970.500	1970.500
36	1965.750	1965.750	1965.750	1965.750	1968.093	1968.212	1968.431	1968.442	1969.000	1969.000	1969.000	1969.000
37	1965.000	1965.000	1965.000	1965.000	1967.084	1967.235	1967.312	1967.500	1967.500	1967.500	1967.500	1967.500
38	1964.250	1964.250	1964.250	1966.113	1966.124	1966.142	1966.177	1965.850	1965.850	1965.850	1965.850	1965.850
39	1963.500	1963.500	1963.500	1965.833	1965.887	1965.883	1964.200	1964.200	1964.200	1964.200	1964.200	1964.200
40	1963.000	1963.000	1963.000	1982.000	1965.767	1982.000	1963.000	1963.000	1963.000	1963.000	1963.000	1963.000

ISOTHERMAL LINE LOCATIONS

I	J	T	T-LOW	T-HIGH	FRAC
2	4	1979	1978.7146	1979.0198	0.9352
2	6	1980	1979.6335	1980.6155	0.3732
2	7	1981	1980.6155	1981.2554	0.6009
3	6	1981	1980.9097	1981.4275	0.1744
3	8	1982	1981.9712	1982.0547	0.3450
4	2	1981	1980.9280	1981.0215	0.7702
4	6	1982	1981.7742	1982.1509	0.5995
5	4	1982	1981.8760	1982.1379	0.4734
5	7	1983	1982.7734	1983.1401	0.6178
6	6	1983	1982.9695	1983.2837	0.0971
6	8	1984	1983.6292	1984.0066	0.9825
7	4	1983	1982.9004	1983.1318	0.4304
7	7	1984	1983.6831	1984.0093	0.9716
8	7	1984	1983.9622	1984.2495	0.1317
9	6	1984	1983.9160	1984.1392	0.3764
9	10	1985	1984.9402	1985.0405	0.5961
10	5	1984	1983.8633	1984.0369	0.7876
10	10	1985	1984.9324	1985.0713	0.4868
11	5	1984	1983.9333	1984.0886	0.4292
11	10	1985	1984.8757	1985.0435	0.7409
12	5	1984	1983.9861	1984.0894	0.1348
13	6	1984	1983.9583	1984.1084	0.2780
14	7	1984	1983.9353	1984.1018	0.3886
15	8	1984	1983.8845	1984.0696	0.6240
16	9	1984	1983.7971	1984.0156	0.9285
17	6	1983	1982.9492	1983.0552	0.4793
18	8	1983	1982.7974	1983.0322	0.8628
19	6	1982	1981.9819	1982.0435	0.2937
19	10	1983	1982.8171	1983.0991	0.6485
20	8	1982	1981.7603	1982.0337	0.8768
21	7	1981	1980.9497	1981.2412	0.1725
21	10	1982	1981.8337	1982.1360	0.5501
22	8	1981	1980.7156	1981.0295	0.9059
23	7	1980	1979.8884	1980.1545	0.4193
23	10	1981	1980.8328	1981.1240	0.5742
24	9	1980	1979.8916	1980.2419	0.3094
25	8	1979	1978.9136	1979.2422	0.2630
26	7	1978	1977.9819	1978.2026	0.0819
27	10	1978	1977.9971	1978.0378	0.0719
30	7	1974	1973.9197	1974.1611	0.3327
31	8	1973	1972.9436	1973.0330	0.6311
32	7	1972	1971.8765	1972.0774	0.6148
33	7	1971	1970.9861	1971.1670	0.0769
34	6	1970	1969.8923	1970.0642	0.6264
35	5	1969	1968.9409	1969.0083	0.8768

MAX= 1998.50000 MIN= 1961.00000
TEMP. INCREASES AS : 0-1-2-3-4-5-6-7-8-9-.-?-+-$-*

PICTORIAL VIEW OF TEMPERATURE

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6 7 7 8 8 8 6 8 9 9 9 9 9 9 9 6 6 6 5 5 5 4 4 4 4 4 4 3 3 3 3 2 2 3 3 2 2 2 1 1
6 7 7 8 8 8 8 8 9 9 9 9 7 7 7 6 6 6 5 5 5 4 4 4 4 4 4 3 3 3 3 2 2 2 2 1 1 2 1 8
0 7 7 8 8 8 8 8 9 7 7 7 7 7 7 6 6 6 5 5 5 4 4 4 4 4 4 3 3 3 3 2 2 2 2 1 1 1 0 0
0 6 7 7 8 8 8 6 7 7 7 7 7 7 7 6 6 6 5 5 5 4 4 4 4 4 4 3 3 3 3 2 2 2 2 1 1 1 0 0
0 1 5 7 5 6 6 6 7 7 7 7 7 7 7 6 6 6 5 5 5 4 4 4 4 4 4 3 3 3 3 2 2 2 2 1 1 1 0 0
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