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THE COMPUTER PROGRAMS FOR
HEAT TRANSFER ANALYSIS IN A
HORIZONTAL ANNULAR POROUS
INSULATION LAYER

March 1984

Hiroaki SHIMOMURA

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The Computer Programs for Heat Transfer Analysis in
a Horizontal Annular Porous Insulation Layer

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(Received January 31, 1984)

Two computer programs have been developed to analyze natural convective heat transfer in an annular porous insulation layer which has a horizontal axis.

In the insulation layer, it is considered that the Darcy's law rules the fluid motion and the effect of density variation on natural convection is taken into account basis of Boussinesq approximation.

The boundary condition at the outer surface of insulation layer is applicable to both constant temperature and given heat transfer conditions for the energy equation. In solving the equations the successive over relaxation (SOR) method was employed for both momentum and energy equations and up-wind difference-method was also applied to the convective term of energy equation to avoid the divergence of the solutions.

The input data including some control parameters are briefly described with their formats and the output data are also explained.

Elements of the programs including the main program and the functions of subroutines are described.

The source program listing is appended.

Keywords: Hot Gas Duct, Natural Convection, Porous Media, High Temperature Thermal Insulation, Effective Thermal Conductivity, Boussinesq Approximation, SOR Method, Up-wind Difference

水平軸環状多孔質断熱層内の熱伝達解析プログラム

日本原子力研究所東海研究所高温工学部

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(1984年1月31日受理)

水平軸，環状多孔質断熱層内の自然対流熱伝達解析を行う二種類の計算機プログラムを開発した。

これらプログラム中において，断熱層内の流体運動はDarcy法則を適用し，かつ，自然対流に及ぼす密度変化の影響はBoussinesq近似を用いた。

断熱層の外面上におけるエネルギー方程式に対する境界条件は大別して，一定温度の場合と種々の熱伝達条件に対する場合の両方が適用可能である。

運動方程式及びエネルギー方程式の数値解にあたっては繰返し過緩和法（SOR法）を適用し，また，エネルギー式の非線型項（対流項）については解の発散を避けるため，風上差分を適用した。

コントロールパラメータを含む入力データの意味，フォーマット及び出力データについて簡単な説明を加えた他，プログラムの各要素とそれぞれの機能についても述べ，ソースリストを附録とした。

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1. Introduction

In the field of high temperature gas-cooled reactor technology, high temperature gas duct whose inside is composed of fibrous thermal insulation layer has become very important technology from the technological standpoint.

The heat transfer under such high pressure atmosphere is characterized as follows:

- (1) Grashof number (Gr) or Rayleigh number (Ra, a product of Grashof number and Prandtl number $Gr \cdot Pr$) increases approximately in proportion to the square of gas pressure because the kinematic viscosity and thermal diffusivity are proportional to the gas pressure.
- (2) Heat transfer by natural convection in thermal insulation layer, total heat transferred across thermal insulation layer, and variation of effective thermal conductivity increases with Rayleigh number.
- (3) Relative thermal expansion difference of insulation and a metal tube causes macroscopic gap in insulation layer. This gives rise to additional heat loss and local overheating of the pressure tube. It also affects material strength and stress of the duct.
- (4) Radiation heat transfer in insulation layer increases near the high temperature surface.
- (5) Mass transfer of gas impurities between fibrous insulation to flowing gas, and safety problems in rapid depressurization are important.

Few theoretical studies of previous problems have been published so far, because empirical thermal conduction model have been satisfactory for thermal design in atmospheric air. In empirical considerations, the "thermal conductivity" has been used not taking into account of the size of insulation layer, relative direction of the gravity force and the temperature difference across the layer. The "thermal conductivity" has been considered to be a physical property of the insulation materials.

In contrast to the studies mentioned above, present study on natural convective heat transfer in porous (fibrous) media has been carried out. Detailed theory and formulation have been already reported by the author.¹⁾ The computer program for calculating the heat transfer of a hot gas duct will be briefly described in the following sections.

2. Basic Equations

As already reported in the preceding paper¹⁾, following assumptions are applied to the momentum balance of fluid motion in the insulation layer:

- (a) Darcy's law is applicable to the relation of pressure drop and interstitial velocity of fluid.
- (b) The inertia term is negligible for the present case where a product of Rayleigh number and Darcy number, $RaDa$, is less than 10,000.
- (c) Viscous shear force $\mu \nabla^2 u$ does not appear to be a reasonable term in a macroscopic treatment of the fluid motion in the porous media.

Heat conduction in the outer tube wall is taken into account where a temperature boundary condition at outer surface is not constant temperature.

2.1 Coordinate system

As shown in Fig. 2.1, both case which has and does not have outer wall two dimensional annular insulation layer with horizontal axis are studied in the present work.

In these systems, temperature and flow fields are assumed to be symmetric about a central vertical axis of both annular spaces.

2.2 Equation of fluid motion in the fibrous media

In the fibrous insulation materials the momentum balance for the fluid can be represented by Darcy's law which describes a linear relation between pressure drop and interstitial velocity of fluid as follows:

$$\frac{v\varepsilon}{K} u = - \frac{1}{\rho_\infty} \cdot \frac{\partial p}{\partial r} + \frac{\rho}{\rho_\infty} g \cos \phi \quad (1)$$

$$\frac{v\varepsilon}{K} v = - \frac{1}{\rho_\infty r} \cdot \frac{\partial p}{\partial \phi} - \frac{\rho}{\rho_\infty} g \sin \phi \quad (2)$$

where ρ : fluid density
 g : gravity acceleration coefficient
 p : pressure of fluid
 μ : kinematic viscosity of fluid
 K : permeability of insulation layer

- u,v : interstitial velocity components in r and ϕ directions respectively
 ϵ : porosity of insulation layer

In the equations, the physical properties of fluid and insulation materials are assumed to be constant except the case where fluid density change causes buoyancy (Bousinesque approximation). This assumption is generally employed in the analysis of natural convection.

2.3 Equation of continuity

In the coordinate system mentioned above, the equation of continuity can be described as follows:

$$\frac{\partial(ru)}{\partial r} + \frac{\partial v}{\partial \phi} = 0 \quad (3)$$

- where r : radial coordinate
 ϕ : azimuthal coordinate

The compressibility of gas is neglected in the equation. This approximation can be acceptable generally for natural convection.

2.4 Equation of energy

Energy equation is described as follows:

$$u \frac{\partial T}{\partial r} + \frac{v}{r} \frac{\partial T}{\partial \phi} = a_m \left(\frac{\partial^2 T}{\partial r^2} + \frac{1}{r} \frac{\partial T}{\partial r} + \frac{1}{r^2} \frac{\partial^2 T}{\partial \phi^2} \right) \quad (4)$$

- where T : temperature
 a_m : effective thermal diffusivity of insulation layer

a_m is given by,

$$a_m = \lambda_m / (c_p \cdot \rho)_f$$

- where λ_m : thermal conductivity of insulation layer in the case where natural convection is so weak that heat is transferred by conduction only

$(c_p \cdot \rho)_f$: heat capacity of fluid except fibrous material

2.5 Equation of thermal conduction

The equation of thermal conduction in a hot gas duct pressure wall is expressed by the following equation. When the temperature of the outer surface of hot gas duct is constant, this equation of thermal conduction is not used, because heat conduction in the pressure wall is negligible, but convergence of numerical computation takes long time.

$$\frac{\partial^2 T}{\partial r^2} + \frac{1}{r} \frac{\partial T}{\partial r} + \frac{1}{r^2} \frac{\partial^2 T}{\partial \phi^2} = 0 \quad (5)$$

2.6 Boundary conditions

The boundary conditions for equation of energy or thermal conduction are given as,

$$r = r_i , \quad T = T_i \quad (0 \leq \phi \leq \pi) \quad (6)$$

$$u = 0 \quad (0 \leq \phi \leq \pi) \quad (7)$$

$$r = r_o , \quad u = 0 \quad (0 \leq \phi \leq \pi) \quad (8)$$

$$T_{in} = T_w \quad (0 \leq \phi \leq \pi) \quad (9)$$

$$\lambda_i \frac{\partial T}{\partial r} = \lambda_w \frac{\partial T_w}{\partial r} \quad (0 \leq \phi \leq \pi) \quad (10)$$

$$r = r_w , \quad - \frac{\partial T}{\partial r} = \frac{\alpha_o}{\lambda} (T - T_\infty) \quad (0 \leq \phi \leq \pi) \quad (11)$$

Flow and temperature fields are symmetrical about a vertical axis,

$$\phi = 0, \phi = \pi, \quad \frac{\partial T}{\partial \phi} = 0 \quad (r_i \leq r \leq r_w) \quad (12)$$

$$v = 0 \quad (r_i \leq r \leq r_o) \quad (13)$$

where r_i : inner radius of insulation

- r_w : outer radius of hot gas duct
- r_o : outer radius of insulation (radius of insulation and pressure wall interface)
- λ : thermal conductivity
- subscript i : insulation layer or inner radius
- w : hot gas duct wall.

Change of fluid density is given by,

$$\rho = \rho_o \{1 - \beta(T - T_o)\} \quad (14)$$

2.7 Dimensionless expression of equation

Introducing a dimensionless stream function (ψ) defined by,

$$u = \frac{a_m}{r_i R} \frac{\partial \psi}{\partial \phi} \quad (15)$$

$$v = -\frac{a_m}{r_i} \frac{\partial \psi}{\partial R} \quad (16)$$

ψ satisfies Eq. (3). Then, Eqs. (1), (2), (4) and (5) are transformed into dimensionless forms to yield :

$$- RaDa \left(\frac{\partial \theta}{\partial R} \sin \phi + \frac{1}{R} \frac{\partial \theta}{\partial \phi} \cos \phi \right) = \frac{\partial^2 \psi}{\partial R^2} + \frac{1}{R} \frac{\partial \psi}{\partial R} + \frac{1}{R^2} \frac{\partial^2 \psi}{\partial \phi^2} \quad (17)$$

$$\frac{\partial \psi}{\partial \phi} \cdot \frac{\partial \theta}{\partial R} - \frac{\partial \psi}{\partial R} \cdot \frac{\partial \theta}{\partial \phi} = R \left(\frac{\partial^2 \theta}{\partial R^2} + \frac{1}{R} \frac{\partial \theta}{\partial R} + \frac{1}{R^2} \frac{\partial^2 \theta}{\partial \phi^2} \right) \quad (18)$$

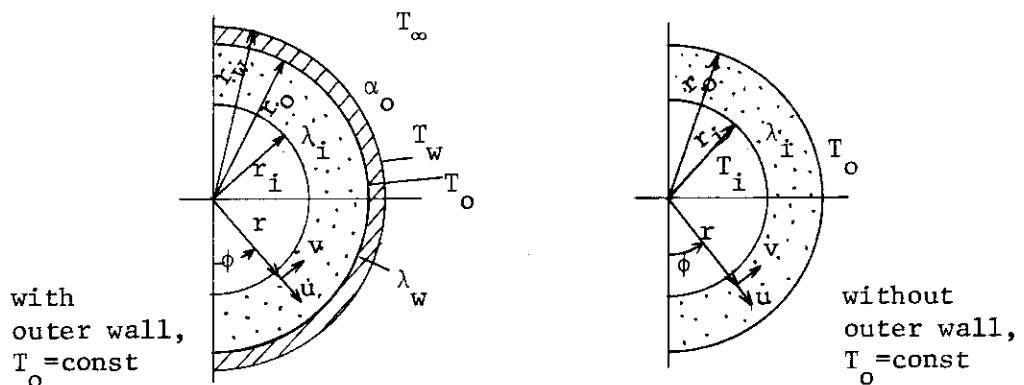


Fig. 2.1 Coordinate system

$$\frac{\partial^2 \theta}{\partial^2 R} + \frac{1}{R} \frac{\partial \theta}{\partial R} + \frac{1}{R^2} \frac{\partial^2 \theta}{\partial \phi^2} = 0 \quad (19)$$

where $R = r/r_i$
 $\theta = (T - T_o)/(T_i - T_o)$
 $R_a = g(T_i - T_o) \cdot r_i^3 / (T_o \cdot a_m \cdot v \cdot \epsilon)$
 $D_a = K/r_i^2$

Boundary conditions (6) - (13) are made dimensionless to give:

at $R = 1$,

$$\theta = 1 \quad (0 \leq \phi \leq \pi) \quad (20)$$

$$\frac{\partial \psi}{\partial \phi} = 0 \quad (0 \leq \phi \leq \pi) \quad (21)$$

at $R = r_o/r_i$,

$$\frac{\partial \psi}{\partial \phi} = 0 \quad (0 \leq \phi \leq \pi) \quad (22)$$

$$\theta_{iR=R_o} = \theta_{wR=R_o} \quad (0 \leq \phi \leq \pi) \quad (23)$$

$$\lambda_i \left(\frac{\partial \theta}{\partial R} \right)_{R=R_o} = \lambda_w \left(\frac{\partial \theta}{\partial R} \right)_{R=R_o} \quad (0 \leq \phi \leq \pi) \quad (24)$$

at $R = R_w$,

$$- \left(\frac{\partial \theta}{\partial R} \right)_{R=R_w} = Nu_w^* \theta \quad (0 \leq \phi \leq \pi) \quad (25)$$

at $\phi = 0, \pi$,

$$\frac{\partial \theta}{\partial \phi} = 0 \quad (1 < R < R_w) \quad (26)$$

$$\frac{\partial \psi}{\partial R} = 0 \quad (1 < R < R_o) \quad (27)$$

where $Nu_w^* = \frac{1}{2} Nu_o / \left(\frac{\lambda_w}{\lambda_\infty} R_w \right)$ (28)

$$Nu_o = 2 \alpha_o r_w / \lambda_\infty \quad (29)$$

$$R_o = r_o/r_i \quad , \quad R_w = r_w/r_i \quad (30)$$

It can be seen that solution of Eqs. (16) and (17) is determined uniquely by two parameters, RaDa and $R_o (= r_o/r_i)$.

Based on the logarithmic mean radius of the annular insulation layer, the relative increase of effective thermal conductivity caused by natural convection λ_e/λ (dimensionless effective thermal conductivity) is given by:

$$(\lambda_e/\lambda)_i = - (\partial\theta/\partial R)_{R=1} \ln R_o \quad (31)$$

$$(\lambda_e/\lambda)_o = - (\partial\theta/\partial R)_{R=R_o} R_o \ln R_o \quad (32)$$

The circumferential mean value of the dimensionless effective thermal conductivity $(\lambda_e/\lambda)_m$ is obtained as follows:

$$\begin{aligned} (\lambda_e/\lambda)_m &= -\frac{1}{\pi} \ln R_o \int_0^\pi \left(\frac{\partial\theta}{\partial R}\right)_{R=1} d\phi \\ &= -\frac{R_o}{\pi} \ln R_o \int_0^\pi \left(\frac{\partial\theta}{\partial R}\right)_{R=R_o} d\phi \end{aligned} \quad (33)$$

Ratio of local heat flux to its mean value (q/q_m) is given by,

$$(q/q_m)_\phi = \pi \left(\frac{\partial\theta}{\partial R}\right)_{R=1,R_o} / \int_0^\pi \left(\frac{\partial\theta}{\partial R}\right)_{R=1,R_o} d\phi \quad (34)$$

From the equation above, the dimensionless effective thermal conductivity $(\lambda_e/\lambda)_m$ is expressed by,

$$(\lambda_e/\lambda)_m = f (RaDa , R_o) \quad (35)$$

The function in Eq. (35) can be determined by solving Eqs. (17), (18) and (19) numerically under given boundary conditions.

3. Numerical Method

The flow pattern and temperature distribution in the insulation layer can be determined by solving Eqs. (17), (18) and (19) with boundary conditions (20) and (27).

Applying finite difference approximation, Eqs. (17) and (18) are transformed into (36) and (37) respectively.

In the transformation, the up-wind difference method was employed to avoid the numerical instability caused by nonlinear convection term of energy eq. (18).

$$\begin{aligned} & \frac{1}{\partial R^2} (\psi_{i-1,j} - 2\psi_{i,j} + \psi_{i+1,j}) + \frac{1}{2R_i \delta R} (\psi_{i+1,j} - \psi_{i-1,j}) \\ & + \frac{1}{(R_i \delta \phi)^2} (\psi_{i,j-1} - 2\psi_{i,j} + \psi_{i,j+1}) \\ & = - Ra Da \left[(\theta_{i+1,j} - \theta_{i-1,j}) \frac{\sin \phi_j}{2\delta R} + (\theta_{i,j+1} - \theta_{i,j-1}) \frac{\cos \phi_j}{2R_i \delta \phi} \right] \quad (36) \end{aligned}$$

$$\begin{aligned} & \left(\frac{\psi_{i,j+1} - \psi_{i,j-1}}{2\delta \phi} \right) \left(\frac{\theta_{i,j} - \theta_{i+1,j}}{\delta R} \right) - \left(\frac{\psi_{i+1,j} - \psi_{i-1,j}}{2\delta R} \right) \left(\frac{\theta_{i,j} - \theta_{i,j+1}}{\delta \phi} \right) \\ & = \frac{R_i}{\delta R^2} (\theta_{i+1,j} + \theta_{i-1,j} - 2\theta_{i,j}) + \left(\frac{\theta_{i+1,j} - \theta_{i,j}}{\delta R} \right) \\ & + \frac{1}{R_i (\delta \phi)^2} (\theta_{i,j+1} + \theta_{i,j-1} - 2\theta_{i,j}) \quad (37) \end{aligned}$$

In the left term of eq. (37), finite difference of temperature is selected between the defined point and the up-wind mesh point of velocity U or V (i.e., $\frac{\partial \psi}{\partial \phi}$ or $-\frac{\partial \psi}{\partial \phi}$).

The equation of thermal conduction in the hot gas duct wall (19) is transformed into the following forms in each region,

at the contact interface between insulation layer and pressure wall ($R = R_0$),

$$\begin{aligned} & \left(\frac{2R_k}{\delta R_i + \delta R_w} \right) \left[\frac{\theta_{k-1,j}}{\delta R_i} + \frac{\lambda_w}{\lambda_i} \cdot \frac{\theta_{k+1,j}}{\delta R_w} - \theta_{k,j} \left(\frac{\lambda_w}{\lambda_i} \cdot \frac{1}{\delta R_w} + \frac{1}{\delta R_i} \right) \right] \\ & + \frac{1}{2} \left[\theta_{k,j} \left(\frac{1}{\delta R_i} - \frac{\lambda_w}{\lambda_i} \cdot \frac{1}{\delta R_w} \right) + \frac{\lambda_w}{\lambda_i} \cdot \frac{\theta_{k+1,j}}{\delta R_w} - \frac{\theta_{k-1,j}}{\delta R_i} \right] \end{aligned}$$

$$+ \frac{\left(\frac{\delta R_i + \frac{\lambda_w}{\lambda_i} \cdot \delta R_w}{\delta R_i + \delta R_w} \right)}{R_k \cdot (\delta \phi)^2} (\theta_{k,j-1} + \theta_{k,j+1} - 2\theta_{k,j}) = 0 \quad (38)$$

at $R = R_o$ to R_w ,

$$\frac{\theta_{i+1,j} + \theta_{i-1,j} - 2\theta_{i,j}}{(\delta R_w)} + \frac{1}{R_i} \cdot \frac{\theta_{i+1,j} - \theta_{i-1,j}}{2\delta R_w} + \frac{1}{R_i^2 \cdot (\delta \phi)^2} (\theta_{i,j+1} + \theta_{i,j-1} - 2\theta_{i,j}) = 0 \quad (39)$$

at $r = r_w$,

$$\frac{\theta_{M,j} - \theta_{M+1,j}}{\delta R_w} - \left(\frac{\lambda_\infty}{\lambda_w} \right) \cdot \frac{1}{2} Nu_o \cdot \frac{\theta_{M+1,j}}{R_w} + \frac{\frac{1}{2} \delta R_w}{\left(R_w - \frac{\delta R_w}{4} \right)^2 (\delta \phi)^2} (\theta_{M+1,j+1} + \theta_{M+1,j-1} - 2\theta_{M+1,j}) = 0 \quad (40)$$

If the pressure wall is approximated in one radial mesh, Eq.(19) is written as follows:

$$\lambda_i \frac{\theta_{M,j} - \theta_{M+1,j}}{\delta R_w} - \lambda_\infty \cdot \frac{1}{2} Nu_o \cdot \frac{\theta_{M+1,j}}{R_w} + \frac{\lambda_w}{(\delta \phi)^2} (\theta_{M+1,j+1} + \theta_{M+1,j-1} - 2\theta_{M+1,j}) \frac{R_w - R_o}{\left\{ \frac{1}{2} (R_w + R_o) \right\}^2} = 0 \quad (41)$$

In the beginning of solving the equation of fluid motion (36), the values of stream function ψ_{ij} 's are initially guessed to be zero at all mesh points, and for energy equation (37) and equation of heat conduction of hot gas duct wall (38) to (40) or (41), dimensionless temperature θ_{ij} 's are guessed to be 1 to 0 linearly from the inside to the outside of the insulation layer at all azimuthal mesh points.

After the initial guess, the stream function ψ_{ij} 's at all mesh points of equation (36) are calculated iteratively for a given temperatures distribution by the successive overrelaxation method (SOR). The iteration is continued until the convergence is achieved.

The dimensionless temperature θ_{ij} 's are calculated from the previously calculated stream function ψ_{ij} 's by the same way as the calculation of stream function.

These iterative calculation cycles of stream function and temperature are repeated alternatively until the stream function ψ_{ij} and temperature θ_{ij} of all mesh points satisfy the following conditions.

$$\left. \begin{aligned} & \left| \frac{\sum_{ij} (\psi_{ij})_n - \sum_{ij} (\psi_{ij})_{n-1}}{\sum_{ij} (\psi_{ij})_n} \right| \leq E_1 & (a) \\ & \left| \frac{\sum_{ij} |(\theta_{ij})_n| - \sum_{ij} |(\theta_{ij})_{n-1}|}{\sum_{ij} (\theta_{ij})_n} \right| \leq E_1 & (b) \\ & \frac{1}{n+1} \sum_j \left| \frac{|(\theta_{M+1,j})_{n-1}| - |(\theta_{M+1,j})_n|}{|(\theta_{M+1,j})_n|} \right| \leq E_1 & (c) \end{aligned} \right\} (42)$$

- where n : present iteration cycle
- $n-1$: last iteration cycle
- E_1 : allowable convergence error
- $M+1$: radial mesh number at outer surface

When the boundary condition that the outer surface is cooled under a definite heat transfer coefficient is used, amendments of temperature in the iteration cycles become significantly large at the region near the outer surface. Therefore, Eq. (42)(c) becomes a convergence criteria of temperature for this boundary condition.

4. Outline of the Programs

Two computer programs are prepared to analyze the heat transfer characteristics of the thermal insulation layer mentioned in the preceding sections. The difference of these programs mainly lies in the boundary condition at the outer surface of the layer. In the first program, the boundary condition of constant temperature is taken, on the other hand, in the second one, the boundary conditions of constant temperature and heat transfer is taken, as shown in Table 5.1.

In the second program, thermal conduction in the outer wall (pressure tube) is taken into account.

5. Functions and Input Data of the Programs

Basically each program solves the same equations: An equation of energy in annular porous media with horizontal axis and an equation of motion, simultaneously in the same system.

Boundary conditions are applicable to each program in Table 5.1.

Table 5.1 Program names and boundary conditions

program name (file name)	boundary conditions on the outer surface of hot gas duct
NAPHAS3	uniform constant temperature. (heat transfer coefficient on the outer surface of the hot gas duct is large enough to establish uniform constant temperature.)
WALNAPH	a) uniform constant temperature. (results will be the same as those of NAPHAS3) b) given heat transfer conditions. * given uniform heat transfer coefficient. * given nonuniform heat transfer coefficient. * natural convective cooling by a given Rayleigh number.

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(A) NAPHAS3

(A-1) 1st card (5I10)

1	1011	2021	3031	4041	50
M	N	ITEL	MPRINT	NPRINT	

- M : Number of radial mesh division. (M = 40 is recommended)
 N : Number of circumferential mesh division. (N = 40 is recommended)
 ITEL : Limit number of the maximum iteration cycle. (1000 to 5000 is recommended)
 MPRINT : Number of radial mesh for output data. (10 to 20)
 NPRINT : Number of azimuthal mesh for output data. (10 to 20)

(A-2) 2nd card (5F5.0)

1	56	1011	1516	2021	25
RMAX	RADA	ERROR	EXOMEG	OMPSI	

- RMAX : Ratio of outer to inner radius of insulation layer (r_o/r_i)
 RADA : Product of Rayleigh number and Darcy number.
 $(g(T_i - T_o)r_i K / T_o a_m \cdot v \cdot \epsilon)$
 where g : acceleration of gravity force. (9.8 m/s²)
 T_i : temperature at inner surface of layer. (deg.-K)
 T_o : temperature at outer surface of layer. (deg.-K)
 r_i : inner radius of layer. (m)
 r_o : outer radius of layer. (m)
 K : permeability of layer. (m²)
 a_m : thermal diffusivity of layer. (m²/S)
 $(=\lambda_m / (cp \cdot \rho)_f)$
 λ_m : thermal conductivity of layer in the case where natural convection is very weak. (Kcal/m.hr.deg.)
 $(cp \cdot \rho)_f$: heat capacity of fluid. (Kcal/m³.deg.)
 v : kinematic viscosity of fluid. (m²/S)
 ε : porosity of layer. (-)
 ERROR : Allowable convergence error for dimensionless temperature.
 (1.0 × 10⁻⁶ to 1.0 × 10⁻⁵)

EXOMEG : Relaxation factor given externally for calculation of energy equation. (1.0 to 1.8)

OMPSI : Relaxation factor for calculation of momentum equation. (1.0 to 1.8)

(A-3) 3rd card (20A1, A4, 6X, A4)

1	2021	2425	2930	33
CONT(1)-----CONT(20)	OPT	6X	(BCOUT)	

CONT(1): control datum, if CONT(1) = "A", relaxation factor (EXOMEG in 2nd card) is used. If CONT(1) = "A", (blank datum) the factor is conventionally decided in the program. ("A" is recommended)

CONT(2): If "A" is used, interpolated dimensionless temperature distribution at the designated mesh points by MPRINT and NPRINT in 1st card is printed.

CONT(3): If "A" is used, the stream function at the designated mesh points are printed in the same manner as above.

CONT(4): If "A" is used, the temperature distribution is displayed graphically in a rectangular space of the printing paper. If library function "IBTOD" is not available at the computer center, it is impossible. (In this case, blank datum should be used.)

CONT(5): If "A" is used, the flow pattern is displayed in the same manner.

CONT(6): } "A" is usable only at JAERI's computer center, it must be
CONT(7): } blank. (see page 23, (12))

CONT(8): When "A" is given, the vorticity pattern is displayed in the same manner as CONT(4).

CONT(9): If "A" is used, the relative inertia force patterns are displayed in the same manner.

OPT : If "A" is given for any one of CONT(4) to CONT(9), the string data "SIMA" should be given.

BCOUT : not used

(B) WALNAPH

(B-1) 1st card (3I10)

1	1011	2021	30
M	N	ITEL	

- M :: Number of radial mesh divisions. (M = 40 is recommended)
- N :: Number of circumferential mesh divisions
(N = 40 is recommended)
- ITEL : Limit number of maximum iteration cycles. (1000 to 5000 is recommended)

(B-2) 2nd card (7F5.0)

1	56	1011	1516	2021	2526	3031	35
RO	RADA	ERROR	ERRORP	EXOMEG	OMPSI	DOMMIN	

- RO : Ratio of outer to inner radius of insulation layer. (r_0/r_1)
- RADA : Product of Rayleigh number and Darcy number (see A-2)
- ERROR : Allowable convergence error for dimensionless temperature.
(recommended value = 1×10^{-5} to 1×10^{-6})
- ERRORP : Allowable convergence error for calculation of stream function at every iteration cycle. (the same order as ERROR is recommended)
- EXOMEG : Relaxation factor given externally for energy equation calculation. (1.0 to 1.8)
- OMPSI : Relaxation factor for momentum equation calculation. (the same as above)
- DOMMIN : Minimum adjusting width of relaxation factor, when automatic adjustment of relaxation factor is employed. (blank datum is recommended)

- TCWBYO : Ratio of the thermal conductivity of pressure tube to that of air. (λ_w/λ_{air})
- MW : Number of radial mesh divisions in pressure tube wall.
(MW = 1 is recommended)
- DIST : Heat transfer condition at the outer surface of pressure tube.
(see Table 5.1, b)

If "CONS" is used, constant heat transfer coefficient is defined and the value of the Nusselt number (Nu_0) must be given by next card. If a blank datum is used, heat transfer coefficient of natural convection is defined, the value of Rayleigh number (Ra_0) must be given by the next card. In this case, heat transfer coefficient around the pressure tube is not uniform.

where $Nu_0 = \alpha_0 D_w / \lambda_{air}$

$$Ra_0 = g(T_w - T_{air}) D_w^3 / (T_{air} \cdot a_{air} \cdot \nu_{air})$$

α_0 : heat transfer coefficient around pressure tube
(kcal/m²·hr·deg.)

D_w : outer diameter of hot gas duct pressure tube (m)

λ_{air} : thermal conductivity of air (kcal/m·hr·deg.)

g : acceleration factor of gravity force (9.8 m/s²)

T_w : temperature of hot duct pressure tube surface
(deg-K) (must be assumed)

T_{air} : temperature of surrounding air (deg-K)

a_{air} : thermal diffusivity of air (m²/s)

ν_{air} : kinematic viscosity of air (m²/s)

(B-5) 5th card (F10.0)

1 10

RAO	
-----	--

or

1 10

AVNU	
------	--

- RAO : Rayleigh number (Ra_0) defined in the preceding section, it must be given when a blank datum is used as "DIST" in the previous card.
- AVNU : Nusselt number must be given, when "CONS" is used as "DIST" (constant heat transfer coefficient) in the previous card.

6. Output Data

Output data of the two programs are given in the almost same format, and are classified into six criteria as follows:

- (a) input data
- (b) information of iteration cycles and conditions of final convergence
- (c) converged dimensionless temperature and stream function
- (d) another data obtained from (c)
- (e) summarized data
- (f) graphical display

The important data in these criteria are briefly described in the following subsections.

6.1 Input data

The input data given from the cards previously described are printed in the same format. After calling a library subroutine DATAON, input data are printed when READ statement is executed.

In the case when the library subroutine DATAON is not available at the computer center, CALL DATAON statement preceded by READ statement must be deleted.

6.2 Information of iteration cycles

At the end of every iteration cycle of energy equation calculation, the following information is printed out.

- ITER : Iteration number for energy equation.
- ITEP : Iteration number for momentum equation at every one iteration cycle of energy equation calculation.
- APS : Temperature variation error of all mesh points between the cycle and preceding one.

- RAO : Rayleigh number (Ra_0) defined in the preceding section, it must be given when a blank datum is used as "DIST" in the previous card.
- AVNU : Nusselt number must be given, when "CONS" is used as "DIST" (constant heat transfer coefficient) in the previous card.

6. Output Data

Output data of the two programs are given in the almost same format, and are classified into six criteria as follows:

- (a) input data
- (b) information of iteration cycles and conditions of final convergence
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6.2 Information of iteration cycles

At the end of every iteration cycle of energy equation calculation, the following information is printed out.

- ITER : Iteration number for energy equation.
- Itep : Iteration number for momentum equation at every one iteration cycle of energy equation calculation.
- APS : Temperature variation error of all mesh points between the cycle and preceding one.

ERRPSI : Error at the time when momentum equation is converged.
 OMEGA : Relaxation factor for energy equation calculation.
 OMPST : Relaxation factor for momentum equation calculation.
 EPSTW : Temperature variation error of outer surface mesh of the hot
 gas duct between adjoining iteration cycles.

6.3 Converged dimensionless temperature and stream function

The numerical solutions of energy and momentum equation, namely dimensionless temperature and stream function at all mesh points defined by I, J are printed.

The mesh numbers I and J define the position in the coordinates shown in Fig. 6.1.

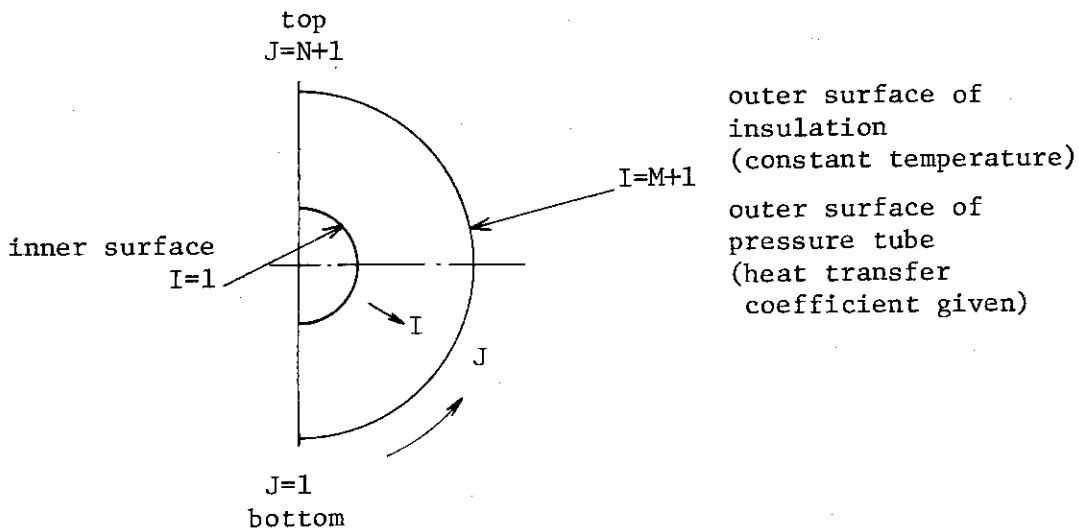


Fig. 6.1 Mesh numbers in the coordinate system

The reduced printing mesh number is applicable to avoid complication from numerous mesh points. (only for NAPHAS3)

6.4 Another data

Dimensionless radial (U) and azimuthal (V) velocity components are obtained from the stream function data. U and V are defined by,

$$u = (a_m/r_i R) \cdot U$$

$$v = (a_m/r_i) \cdot V$$

where u : absolute radial velocity component (m/s)
 v : absolute azimuthal velocity component (m/s)

The vorticity and inertia data are also obtained from the stream function data.

6.5 Summarized data

The relative thermal conductivities ($\lambda_e(\phi)/\lambda_0$) and relative heat fluxes along the inner and outer surfaces are summarized from the data of dimensionless temperature. Data captions are defined as,

$$KE/K : \lambda_e(\phi)/\lambda_0$$

$$AVNUSS : (\lambda_e(\phi)/\lambda_0)_{\text{mean}} \text{ at inner surface}$$

$$AVNUSO : (\lambda_e(\phi)/\lambda_0)_{\text{mean}} \text{ at outer surface}$$

$$Q(J)/QM : q(\phi)/q_m$$

where $\lambda_e(\phi)$: effective thermal conductivity at azimuth ϕ in the case where natural convection is taken into account.

λ_0 : thermal conductivity in the case where natural convection is negligible.

$$(\lambda_e(\phi)/\lambda_0)_{\text{mean}} = \frac{1}{\pi \cdot \lambda_0} \int_0^\pi \lambda_e(\phi) d\phi$$

$q(\phi)$: local heat flux at azimuth ϕ

q_m : average heat flux $(= \frac{1}{\pi} \int_0^\pi q(\phi) d\phi)$

6.6 Graphical display

Temperature distribution and the other data are to be shown graphically. The coordinate system is depicted in a rectangular form as shown in Fig. 6.2.

The input data must be set up specially for the library subroutine IBTOD. (see CONT(3), (4), (5), (8), (8) of NAPHAS 3 and CONT(5), (6)

of WALNAPH) If this subroutine is not available at the computer center, it is impossible to display the results.

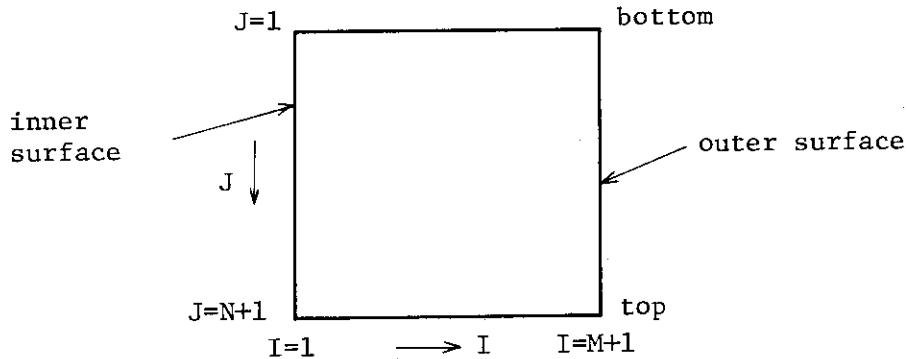


Fig. 6.2 Graphical coordinate system

7. Elements of the Programs

7.1 Main program

Basically, the main programs of the both programs are to control input data and arrange some subroutines which solve equations and output the results on a printer or magnetic disks.

7.2 Subroutines

(1) DATAON

This subroutine does not include in the source program but in the system library.

This subroutine has a simple function to print all input data after READ statement is executed. Therefore, if this subroutine is not available in the system, "CALL DATAON" must be deleted.

(2) VELOCI

This subroutine calculates for printing and solving the energy equation by the up-wind methods to get radial and circumferential velocity components U and V.

Both velocity components U and V are simply calculated by the following equation:

of WALNAPH) If this subroutine is not available at the computer center, it is impossible to display the results.

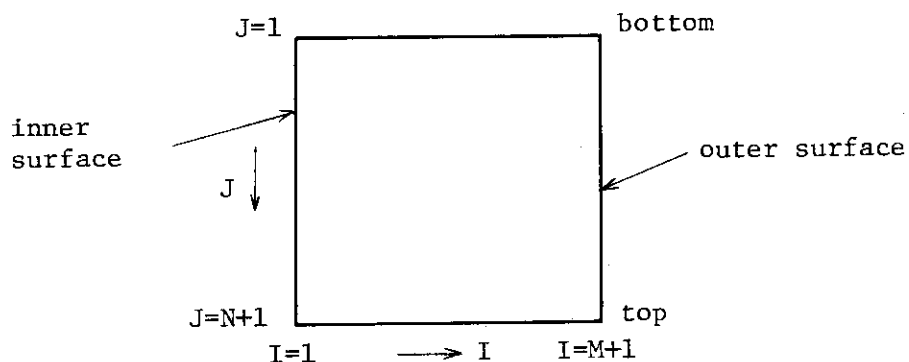


Fig. 6.2 Graphical coordinate system

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(2) VELOCI

This subroutine calculates for printing and solving the energy equation by the up-wind methods to get radial and circumferential velocity components U and V.

Both velocity components U and V are simply calculated by the following equation:

$$U = \frac{1}{R} \frac{\partial \psi}{\partial R} \quad (43)$$

$$V = - \frac{\partial \psi}{\partial R} \quad (44)$$

where R : dimensionless radial coordinate ($= r/r_{in}$) dimensionless
 ψ : stream function (PSI)

This subroutine is called in the subroutine SIMSOL.

(3) PSISOL

This subroutine is called in the subroutine SIMSOL and uses SOR method to solve equation of natural convection motion of gas in the system.

Iteration cycles are continued until the convergence is achieved. If number of iteration cycles over a certain limit (ITEL, this value is given from input data), the calculation will be stopped and a message "PSI DOES NOT CONVERGE IN PSISOL" will be printed out. If

$$\frac{\sum_i (\psi_i)_{new} - \sum_i (\psi_i)_{old}}{\sum_i (\psi_i)_{new}} < \text{ERRORP} \quad (45)$$

is achieved, calculation returns to a subroutine SIMSOL.

(4) SIMSOL

The equation of energy and fluid motion in the system are solved simultaneously by this subroutine. At the first step of this subroutine, the equation of motion is solved for a given temperature distribution by calling a subroutine PSISOL, and then velocity components are calculated to solve the energy equation by SOR method by the up-wind technique.

Various boundary conditions for the energy equation can be treated in this subroutine. Thermal conduction in the outer wall (pressure tube) is also computed in this subroutine when the input data are given. In this subroutine, iteration cycles are continued until the convergence is achieved. At the end of every ten iteration cycles, some information on convergence is printed. (IAERA, ITEP ----- etc.)

In general, acceleration parameter or relaxation factor (OMEGA) in SOR method is very important and the appropriate selection of factors

is rather difficult.

The most conservative value for acceleration parameter is 1.00.

(5) SIMPSN

This subroutine integrates local effective thermal conductivities of thermal insulation in both inner and outer walls of the hot gas duct by means of Simpson's method. After integrating these values, they are averaged through the circumference of inner or outer wall.

(6) HERMAN

The natural convective heat transfer coefficient of the horizontal cylinder which has uniform temperature was obtained by Hermann²⁾ and improved by Spallow³⁾.

This subroutine calculates heat transfer coefficient distribution around the hot gas duct using the above results.

Exactly speaking, this method of calculation is applicable only for a horizontal cylinder with uniform temperature, but the actual temperature distribution of hot gas duct outer wall is not always uniform.

For a practical use, however, the temperature distribution of hot gas duct can be taken as uniform, because the temperature variation on the actual hot gas duct surface is generally not so large.

This subroutine is applicable to the case when a hot gas duct surface is cooled by natural convection of air, and the average heat transfer coefficient around a hot gas duct is calculated by the following formula,

$$\text{Nu} = 0.399 (\text{Gr} \cdot \text{Pr})^{0.25} \quad (46)$$

The outer diameter of the hot gas duct must be taken as a hydraulic diameter.

(7) VISUAL

This subroutine is prepared to print out the two dimensional matrix data (3 dimensional data) to get information on the calculated results.

(8) INTPL2

This subroutine interpolates one-dimensional array data by a second order interpolation, and is used in the subroutine D2ITPL.

(9) D2ITPL

This subroutine interpolates two-dimensional array data by the INTPL2. This is used in the subroutine VISUAL to transform the calculated data into the desired matrix size.

(10) OPTOM

The basic idea of this subroutine is that if divergence is occurred in the SOR iteration process, the value of an acceleration factor is decreased by a given step width. On the contrary, if not occurred, the factor is increased.

The adjusting step width is decreased step by step and the final value is used hereafter.

(11) PTSNGL

Double precision values are transformed into single precision value by this subroutine. It is only used to print out the result briefly.

(12) PLDATA

This subroutine transforms the Cartesian coordinate system into the polar coordinate one, normalizes the value and writes the data in a disk file which provides to plot contour line (iso-thermal line, stream line, etc.) by means of a contour line plotting program prepared in JAERI's program library (JGPCP). If the contour line plotting program is not provided in a computer library, this subroutine must not be called in the main program by using blank control data. (see page 13, 15)

(13) TABLE

This subroutine prints out two-dimensional matrix data with some titles on a line printer. Parameter in this subroutine "XLETER" is character data to be printed. Each element of the dimension (A(1), A(2)) allows 4 characters maximum, if hoped.

8. Conclusions

The following conclusions have derived from executions of the programs.

- (1) Convergence of numerical solutions and stability of the computations were successfully obtained when the relaxation factor (acceleration

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8. Conclusions

The following conclusions have derived from executions of the programs.

(1) Convergence of numerical solutions and stability of the computations were successfully obtained when the relaxation factor (acceleration

factor) for the energy equation ranges from 1.0 to 1.1 to any practical value of RaDa.

(2) Using the value of relaxation factor from 1.0 to 1.8, convergence of the computations were so rapid when the value of RaDa does not exceed certain value and ratio of outer to inner radius lies from 1.2 to 2.0.

(3) Allowable value of convergence judgement E_1 in eq. (42) is recommended as less than 1×10^{-6} .

(4) The appropriateness of the boundary conditions on the basis of symmetry against vertical axis for the temperature and flow pattern shown by eqs. (26) and (27) respectively is open to the further study.

When the natural convection is strong, symmetry of temperature and flow patterns against vertical axis may be not always maintained.

The author wishes to express cordial appreciation to Prof. T. Masuoka, Kyushu Institute of Technology, and also to Dr. H. Kawamura, Dr. K. Sanokawa and Dr. Y. Okamoto for their helpful advice and suggestion.

9. Literatures

- 1) Shimomura, H., et al.; Heat Transf. Japanese Research 8, 2, pp.1 - 11 (1979).
- 2) Hermann, R.; VDI Forschungsheft, 379, B-7, pp.1 - 24 (1936).
- 3) Spallow, E.M. and Tsou, F.K.; Phys. Fluids, 8, 8 pp.1559 - 1561 (1965).

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Appendix

Source Program Listing

(1) WALNAPH

(2) NAPHAS3

(1) FACOM DSIV/F4 FORTRAN IV (HE) V04L18

DATE 83.01.26 TIME 14.48.59

SPECIFIED OPTIONS: NONAME,FLAG(I),BYNAME,GOSTMT,NOSTATIS,ISN(D),NOMAP,ELM(*)

C	WALNAPH	JUL. 1977	BY H.SHIMOMURA	00000100
C	THIS PROGRAM COMPUTES THERMAL AND FLUID-DYNAMIC PERFORMANCES IN			00000200
C	HORIZONTAL ANNULAR POROUS SPACES IN GRAVITATIONAL FIELD.			00000300
C				00000400
C	REFERECE DOCUMENTATION	JAERI-M-		00000500
C				00000600
C	VARIABLES DEFINITION			00000700
C				00000800
C	RADA	RAYLEIGH NUMBER * DARCY NUMBER		00000900
C	AVNU	AVERAGE NUSSELT NUMBER AROUND WALL		00001000
C	WNU(J)	LOCAL NUSSELT NUMBER AROUND WALL		00001100
C	RAO	RAYLEIGH NUMBER AROUND WALL OUT SIDE		00001200
C	TCWBYI	THERMAL CONDUCTIVITY RATIO OF WALL TO INSULATION		00001300
C	TCWBYO	THERMAL CONDUCTIVITY RATIO OF WALL TO OUTER GAS		00001400
C	RO	D-LESS OUTER RADIUS OF INSULATION LAYER		00001500
C	RW	D-LESS OUTER RADIUS OF WALL		00001600
C	PHMAX	MAX.ANGULAR ARGUMENT FROM BOTTOM CENTER (=3.14..)		00001700
C	RI(I)	D-LESS RADIAL ARGUMENT (INNER RADIUS =1)		00001800
C	PHI(J)	ANGULAR ARGUMENT		00001900
C	DR	ACTUAL RADIAL MESH WIDTH IN COMPUTATION		00002000
C	DRI	RADIAL MESH WIDTH FOR WALLED BC IN INS. =(RO-1)/KW-1		00002100
C	DRW	RADIAL MESH WIDTH FOR WALLED BC IN WALL =(RW-RO)/MW		00002200
C	DRT	RADIAL MESH WIDTH FOR T=CONST BC =(RO-1)/M		00002300
C	DPH	ANGULAR MESH WIDTH		00002400
C	M	NUMBER OF RADIAL DIVISION		00002500
C	N	NUMBER OF ANGULAR DIVISION		00002600
C	MCAL	M+1		00002700
C	NCAL	N+1		00002800
C	MW	NUMBER OF RADIAL DIVISION IN WALL		00002900
C	KW	RADIAL MESH POINT AT INSULATION-WALL CONTACT		00003000
C				00003100
C				00003200
C	TN(I,J)	D-LESS TEMPERATURE AT ITERATION CYCLE ITERA		00003300
C	PSI(I,J)	D-LESS STREAM FUNCTION AT ITERATION CYCLE ITERA		00003400
C	U(I,J)	D-LESS RADIAL VELOCITY		00003500
C	V(I,J)	D-LESS ANGULAR VELOCITY		00003600
C	DTDRI(J)	D-LESS RADIAL TEMP. GRADIENT AT R=1.0		00003700
C	DTDRO(J)	D-LESS RADIAL TEMP. GRADIENT AT R=RO		00003800
C	EKBYK(J)	RATIO OF EFFECTIVE AND MOLEC. T.CONDUCT. AT R=1.0		00003900
C	EKBYKO(J)	RATIO OF EFFECTIVE AND MOLEC. T.CONDUCT. AT R=RO		00004000
C	AVNUSS	AVERAGE NUSSELT NUMBER AT R=1.0		00004100
C	AVNUSO	AVERAGE NUSSELT NUMBER AT R=RO		00004200
C	QIBYQM(J)	RELATIVE LOCAL HEAT FLUX AT INNER WALL(HEAT T COEFF)		00004300
C		= ((KE/K)LOCAL)/((KE/K)AV.) AT R=1.0		00004400
C	QOBYQM(J)	RELATIVE LOCAL HEAT FLUX AT OUTER WALL(HEAT.T COEFF)		00004500
C		= ((KE/K)LOCAL)/((KE/K)AV.) AT R=RO		00004600
C	ITERA	NUMBER OF ITERATION CYCLE		00004700
C	ITEL	LIMITED NUMBER OF ITERATION		00004800
C	OMEGA	RELAXATION FACTOR FOR ENERGY EQ.		00004900
C	EXOMEG	RELAXATION FACTOR GIVEN EXTERNALLY FOR ENERGY EQ.		00005000
C	OMPSI	RELAXATION FACTOR FOR EQ. OF MOTION		00005100
C	SNEW	SUMMATION OF TN(I,J) AT ITERATION CYCLE=N		00005200
C	SOLD	SUMMATION OF TN(I,J) AT ITERATION CYCLE=N-1		00005300
C	APS	SUMMATION OF ALL GRID POINTS RELATIVE TEMP. CHANGE		00005400
C	EPSTW	SUMMATION OF RELATIVE WALL TEMP. CHANGE		00005500
C	ERROR	ALLOWABLE CALCULATION ERROR FOR TN(I,J)		00005600

```

C      ERRORP      ALLOWABLE CALCULATION ERROR FOR PSI(I,J)      00005700
C      KALP,BCOUT  IF BCOU.EQ.ALPHBC(='ALPH') KALP=1, THEN DATA CARD 00005800
C      FOR (RW,TCWBYI,TCWBYO,AVNU,MW,DIST) MUST BE GIVEN      00005900
C      DIST        IF DIST.EQ.CONST ('CONS'),WNU(J)=AVNU,KDIST=0 00006000
C      IF DIST.NE.CONST, HERMAN'S THEORY IS APPLIED FOR      00006100
C      WNU(J), KDIST=1      00006200
C      CONT(I)     OPTION CONTROLLER (I=1,2, ...,20)      00006300
C      CONT(1) = 'A';EXTERNAL OMEGA IS USED, IF CONT(1).NE.'A',AUTOMATIC. 00006400
C      CONT(2).NE.'A':PSI(I,J) PRINTING OMITTED      00006500
C      CONT(3).NE.'A':U(I,J) PRINTING OMITTED      00006600
C      CONT(4).NE.'A':V(I,J) PRINTING OMITTED      00006700
C      CONT(5) = 'A';GRAPHIC TEMPERATUR DISTRIBUTION IS PRINTED 00006800
C      CONT(6) = 'A';GRAPHIC FLOW PATTERN IS PRINTED 00006900
C      CONT(7) = 'A';DATA FOR ISO-THERMAL LINE PLOTTING ARE OUTPUT IN 00007000
C      DISK FILE. (CONTROL CARDS ARE NECESSARY)      00007100
C      CONT(8) = 'A';DATA FOR STREAM LINE PLOTTING ARE OUTPUT IN 00007200
C      DISK FILE. (CONTROL CARDS ARE NECESSARY)      00007300
C      00007400
C      00007500
C      00007600
ISN 00001 COMMON/INDEP/ RI(41),PHI(41),DR,DRT,DRI,DRW,DPH      00007700
ISN 00002 COMMON/TPUVC/ TN(41,41),PSI(41,41),U(41,41),V(41,41)      00007800
ISN 00003 COMMON/PARAC/ RO,RW,PHIMAX,RADA      00007900
ISN 00004 COMMON/INTEC/ M,N,MCAL,NCAL,MW,KW,KALP,KDIST      00008000
ISN 00005 COMMON/SORCO/ OMEGA,OMPSI,ITERA,ITEL,ITEP,ERROR,ERRPSI,EPS,APS,      00008100
          ERRORP      00008200
ISN 00006 1 COMMON/SORCA/ SNEW,SOLD,EPSTW      00008300
ISN 00007 COMMON/WALLC/ WNU(41),AVNU,TCWBYI,TCWBYO,RAO      00008400
ISN 00008 COMMON/SCOMM/ TNS(41,41),PSIS(41,41)      00008500
ISN 00009 COMMON/CONCO/ CONT(80)      00008600
ISN 00010 COMMON/COMOPT/ IOMEGA,DOM,NSIGN,TOLD(41,41),TRACER,DOMMIN      00008700
C      00008800
ISN 00011 C      DIMENSION XX(50),YY(50),ZZ(50,50),ZYJ(41),ZIIJ(50,41),ZII(41),      00008900
          1      EKBYK(41),DTDRO(41),EKBYKO(41),DTDRI(41),KZ(50,50),      00009000
          2      QIBYQM(41),QOBYQM(41),TWPHI(41)      00009100
ISN 00012 DIMENSION TLETER(2),PLETER(2),ULETER(2),VLETER(2)      00009200
ISN 00013 DIMENSION TOPHI(41)      00009300
C      00009400
ISN 00014 DOUBLE PRECISION TN,PSI      00009500
ISN 00015 DOUBLE PRECISION TOLD      00009600
ISN 00016 DATA CONS,CP,CN,ALPHBC/'CONS','A',' ','ALPH'/      00009700
ISN 00017 DATA (TLETER(I),I=1,2)/' TEM','P.'/      00009800
ISN 00018 DATA (PLETER(I),I=1,2)/' PS','I.'/      00009900
ISN 00019 DATA (ULETER(I),I=1,2)/'U(I','J)'/      00010000
ISN 00020 DATA (VLETER(I),I=1,2)/'V(I','J)'/      00010100
ISN 00021 PHMAX = 3.1415926      00010200
          ***** INITIALIZATION *****      00010300
C      00010400
ISN 00022 KW = 1      00010400
ISN 00023 DRI = 1.      00010410
ISN 00024 DRW = 1.      00010500
ISN 00025 CALL DATAON      00010600
C      00010700
ISN 00026 READ (5,1) M,N,ITEL      00010800
ISN 00027 MCAL = M+1      00010900
ISN 00028 NCAL = N+1      00011000
ISN 00029 READ (5,2) RO,RADA,ERROR,ERRORP,EXOMEG,OMPSI,DOMMIN      00011100
ISN 00030 READ (5,3) (CONT(K),K=1,20),BCOUT      00011200
C      00011300
ISN 00031 IF (BCOUT.EQ.ALPHBC) GO TO 10
    
```

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ISN 00032      KALP=0                      00011400
ISN 00033      GO TO 520                    00011500
ISN 00034      10 KALP=1                    00011600
ISN 00035      READ (5,11) RW,TCWBYI,TCWBYO,MW,DIST 00011700
ISN 00036      IF(RW.LE.RO) GO TO 900        00011800
ISN 00037      IF((MW.GT.M).OR.(MW.LT.O)) GO TO 950 00011900
ISN 00038      KW =M+1-MW                   00012000
ISN 00039      IF (DIST.EQ.CONST) GO TO 510  00012100
C              VARIABLE NUSSELT              00012200
ISN 00040      KDIST = 1                     00012300
ISN 00041      READ (5,12) RAO               00012400
ISN 00042      GO TO 520                      00012500
C                                              00012600
C              CONSTANT NUSSELT              00012700
ISN 00043      510 READ (5,12) AVNU           00012800
ISN 00044      KDIST = 0                     00012900
ISN 00045      DO 515 J=1,N+1                00013000
ISN 00046      515 WNU(J) = AVNU             00013100
C                                              00013200
ISN 00047      520 IF (CONT(1).EQ.CP) OMEGA = EXOMEG 00013300
C                                              00013400
C              MESH SIZE                     00013500
ISN 00048      DPH = PHMAX/N                  00013600
C                                              00013700
C              OUTER BOUNDARY CONDITION DETECTION 00013800
ISN 00049      IF (BCOUT.EQ.ALPHBC) GO TO 6   00013900
ISN 00050      DRT = (RO-1.0)/M              00014000
ISN 00051      DO 540 I=1,M+1                00014100
ISN 00052      540 RI(I) = DRT*(I-1)+1.0     00014200
ISN 00053      GO TO 550                      00014300
ISN 00054      6 DRI = (RO-1.0)/(KW-1)       00014400
ISN 00055      IF (MW.GE.1) DRW = (RW-RO)/MW 00014500
ISN 00056      IF (MW.EQ.0) DRW = RW-RO     00014600
C                                              00014700
ISN 00057      RI(1) = 1.0                   00014800
ISN 00058      DO 8 I=2,M+1                   00014900
ISN 00059      IF (I.GT.KW) GO TO 7           00015000
ISN 00060      DR = DRI                       00015100
ISN 00061      GO TO 8                        00015200
ISN 00062      7 DR = DRW                     00015300
ISN 00063      8 RI(I) = RI(I-1)+DR          00015400
C                                              00015500
C              ,                              00015600
ISN 00064      550 DO 560 J=1,N+1             00015700
ISN 00065      560 PHI(J) = DPH*(J-1)        00015800
ISN 00066      ITERA = 0                      00015900
ISN 00067      ITERB = 0                      00016000
ISN 00068      IF (KALP.EQ.1.AND.KDIST.EQ.1) CALL HERMAN 00016100
C              INITIAL SET AND BOUNDARY CONDITIONS 00016200
ISN 00069      IF (KALP.EQ.1) GO TO 564      00016300
C              INITIAL SET FOR T = CONSTANT  00016400
ISN 00070      DO 562 J=1,N+1                 00016500
ISN 00071      DO 562 I=1,M+1                 00016600
ISN 00072      562 TN(I,J) = (RO-RI(I))/(RO-1.0) 00016700
ISN 00073      GO TO 571                      00016800
C              INITIAL SET FOR WALLED        00016900
ISN 00074      564 DO 570 J=1,N+1             00017000
ISN 00075      WNUST1 = 0.5*WNU(J)*TCWBYI/(RW*TCWBYO) 00017100

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ISN 00076      WNUST2 = 0.5*WNU(J)/(RW*TCWBYO)
ISN 00077      REX1 = RO+(RW-RO)/TCWBYI+1.0/WNUST1
ISN 00078      REX2 = RW+1.0/WNUST2
ISN 00079      DO 570 I=1,M+1
ISN 00080      IF (I.GT.KW) GO TO 566
                C      R . LE . RO
ISN 00081      TN(I,J) = (REX1-RI(I))/(REX1-1.0)
ISN 00082      GO TO 570
                C      R . GT . RO
ISN 00083      566 TN(I,J) = TN(KW,J)*(REX2-RI(I))/(REX2-RO)
ISN 00084      570 CONTINUE
ISN 00085      571 DO 572 J=1,N+1
ISN 00086      DO 572 I=1,M+1
ISN 00087      572 PSI(I,J) = 0.0
ISN 00088      IOMEGA = 0
                C
ISN 00089      40 SOLD = 0.
ISN 00090      SNEW = 0.
ISN 00091      EPSTW = 0.
ISN 00092      IF (CONT(1).EQ.CP) GO TO 50
                C      OMEGA OPTIMIZATION
ISN 00093      CALL OPTOM
                C
ISN 00094      50 CALL SIMSOL
ISN 00095      IF((NSIGN.EQ.-1).AND.(CONT(1).EQ.CP)) GO TO 1000
ISN 00096      IF(NSIGN.EQ.-1) GO TO 40
                C
ISN 00097      ESP=(SNEW-SOLD)/SNEW
ISN 00098      APS = ABS(ESP)
ISN 00099      IF (KALP.EQ.1) GO TO 55
ISN 00100      IF(APS.LE.ERROR) GO TO 75
ISN 00101      GO TO 60
ISN 00102      55 IF (APS.LE.ERROR.AND.EPSTW.LE.ERROR) GO TO 75
ISN 00103      60 IF (ITERA.LE.ITEL) GO TO 70
                C      *** LATEST DATA OUTPUT ***
ISN 00104      PRINT 65, ITERA,OMEGA,EPS
ISN 00105      GO TO 80
                C
ISN 00106      70 ITERA = ITERA+1
ISN 00107      ITERB = ITERB+1
ISN 00108      IF (ITERB.LT.10) GO TO 40
ISN 00109      PRINT 240, ITERA,ITEP,EPS,ERRPSI,OMEGA,DMPSI
ISN 00110      IF (KALP.EQ.1) PRINT 245,EPSTW
ISN 00111      ITERB = 0
ISN 00112      GO TO 40
                C
                C
ISN 00113      75 PRINT 230, ITERA,ITEP,EPS,ERRPSI
ISN 00114      80 IF (KALP.EQ.1) PRINT 235, EPSTW
ISN 00115      CALL VELOCI
ISN 00116      CALL PTSNGL
                C
ISN 00117      CALL TABLE(TNS,TLETER)
ISN 00118      IF(CONT(2).NE.CP) GO TO 81
ISN 00119      CALL TABLE(P SIS,PLETER)
                C      U(I,J) PRINT OUT
                C
ISN 00120      81 IF(CONT(3).NE.CP) GO TO 83
    
```

00017200
00017300
00017400
00017500
00017600
00017700
00017800
00017900
00018000
00018100
00018200
00018300
00018400
00018500
00018600
00018700
00018800
00018900
00019000
00019100
00019200
00019300
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00020000
00020100
00020200
00020300
00020400
00020500
00020600
00020700
00020800
00020900
00021000
00021100
00021200
00021300
00021400
00021500
00021600
00021700
00021800
00021900
00022000
00022100
00022200
00022300
00022310
00022400
00022410
00022420
00022500
00022600

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ISN 00121      CALL TABLE(U,VLETER)                                00022610
C                                                       00022620
C                                                       00022630
ISN 00122      83 IF (CONT(4).NE.CP) GO TO 85                    00022640
ISN 00123      CALL TABLE(V,VLETER)                              00022650
C                                                       00022700
C                                                       00022800
C                                                       00022900
C                                                       00023000
C                                                       00023100
C                                                       00023200
C                                                       00023300
ISN 00124      85 CONTINUE                                        00023400
C                                                       00023500
C                                                       00023600
C               MEAN WALL T. AND T. DIFFERENCE
ISN 00125      IF (KALP.EQ.0) GO TO 320                          00023700
ISN 00126      300 DO 310 J=1,N+1                                00023800
ISN 00127      310 TOPHI(J) = TN(KW,J)                          00023900
ISN 00128      CALL SIMPSN (N+1,DPH,TO PHI,TROM,IEE)           00024000
ISN 00129      TROM = TROM/PHMAX                                00024100
ISN 00130      DTOIN = 1.0-TROM                                00024200
ISN 00131      GO TO 330                                        00024300
ISN 00132      320 DTOIN = 1.0                                  00024400
ISN 00133      330 CONTINUE                                    00024500
C                                                       00024600
C               EFFECTIVE AND MOLECULAR CONDUCTIVITY RATIO
C                                                       00024700
ISN 00134      DO 90 J=1,N+1                                    00024800
ISN 00135      DTDRI(J) = (-25.*TN(1,J)+48.*TN(2,J)-36.*TN(3,J)+16.*TN(4,J)
1              -3.*TN(5,J))/(12.*DR)                          00024900
ISN 00136      EKBYK(J) = -DTDRI(J)*ALOG(RO)/DTOIN             00025000
ISN 00137      IF (KALP.EQ.1) GO TO 360                        00025100
C               CONSTANT TEMPERATURE
ISN 00138      MO = M                                          00025400
ISN 00139      DR = DRT                                        00025500
ISN 00140      GO TO 370                                        00025600
C               H.T. COEFF B.C. (WALLED)
ISN 00141      360 MO = KW-1                                    00025800
ISN 00142      DR = DRI                                        00025900
C                                                       00026000
ISN 00143      370 DTDRO(J) = (25.0*TN(MO+1,J)-48.0*TN(MO,J)+36.0*TN(MO-1,J)
1              -16.0*TN(MO-2,J)+3.0*TN(MO-3,J))/(12.0*DR)     00026100
ISN 00144      90 EKBYKO(J) = -DTDRO(J)*RO*ALOG(RO)/DTOIN     00026300
ISN 00145      CALL SIMPSN (N+1,DPH,EKBYK,SEKBYK,IER1)        00026400
ISN 00146      CALL SIMPSN (N+1,DPH,EKBYKO,SEKBKO,IER)        00026500
ISN 00147      AVNUSS = SEKBYK/3.1415926                      00026600
ISN 00148      AVNUSO = SEKBKO/3.1415926                      00026700
C                                                       00026800
ISN 00149      PRINT 111, AVNUSS,RADA, RO                      00026900
ISN 00150      PRINT 121, (J,EKBYK(J), J=1,N+1)                00027000
C                                                       00027100
C                                                       00027200
ISN 00151      PRINT 115, AVNUSO,RADA,RO                       00027300
ISN 00152      PRINT 121, (J,EKBYKO(J), J=1,N+1)              00027400
C               RELATIVE LOCAL HEAT FLUX
C                                                       00027500
C                                                       00027600
ISN 00153      DO 98 J=1,N+1                                    00027700
ISN 00154      QIBYQM(J) = EKBYK(J) /AVNUSS                    00027800
ISN 00155      98 QOBYQM(J) = EKBYKO(J) /AVNUSO              00027900
C

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ISN 00156          PRINT 122                                00028000
ISN 00157          PRINT 121, (J,QIBYQM(J), J=1,N+1)        00028100
ISN 00158          PRINT 123                                00028200
ISN 00159          PRINT 121, (J,QOBYQM(J), J=1,N+1)        00028300
C
ISN 00160          IF (KALP.EQ.1) GO TO 100                  00028400
ISN 00161          GO TO 130                                00028500
ISN 00162          100 DO 91 J=1,N+1                          00028600
ISN 00163          91 TWPHI(J) = TN(M+1,J)                  00028700
ISN 00164          CALL SIMPSN (N+1,DPH,TWPHI,STW,IER)      00028800
ISN 00165          TWM = STW/3.1415926                      00028900
ISN 00166          PRINT 400, AVNU,TWM                       00029000
ISN 00167          IF (KDIST.EQ.0) GO TO 120                00029100
C
ISN 00168          PRINT 410                                 00029200
ISN 00169          PRINT 430, (J,WNU(J),J=1,N+1)            00029300
C
ISN 00170          120 PRINT 420                              00029400
ISN 00171          PRINT 430, (J, TN(M+1,J), J=1,N+1)      00029500
ISN 00172          PRINT 440, TROM                           00029600
ISN 00173          PRINT 430, (J, TOPHI(J), J=1,N+1)        00029700
ISN 00174          130 CONTINUE                              00029800
ISN 00175          IF (CONT(5).NE.CP) GO TO 241             00029900
ISN 00176          CALL VISUAL (RI,PHI,TNS,M+1,N+1,XX,YY,ZZ,ZYJ,ZIIJ,ZII,KZ) 00030000
ISN 00177          PRINT 250                                 00030100
ISN 00178          241 CONTINUE                              00030200
ISN 00179          IF (CONT(6).NE.CP) GO TO 243             00030300
C
ISN 00180          CALL VISUAL (RI,PHI,PSIS,M+1,N+1,XX,YY,ZZ,ZYJ,ZIIJ,ZII,KZ) 00030400
ISN 00181          PRINT 260                                 00030500
ISN 00182          243 CONTINUE                              00030600
ISN 00183          IF (CONT(7).NE.CP) GO TO 270             00030700
ISN 00184          RR = RO                                   00030800
ISN 00185          IF (KALP.EQ.1) RR=RW                     00030900
ISN 00186          CALL PLDATA (RI,PHI, TNS,M+1,N+1,RR)    00031000
ISN 00187          270 CONTINUE                              00031100
C
ISN 00188          IF (CONT(8).NE.CP) GO TO 280             00031200
ISN 00189          RR = RO                                   00031300
ISN 00190          IF (KALP.EQ.1) RR=RW                     00031400
ISN 00191          CALL PLDATA (RI,PHI,PSIS,M+1,N+1,RR)    00031500
ISN 00192          280 CONTINUE                              00031600
C
ISN 00193          INPUT FORMATS                             00031700
ISN 00194          1 FORMAT (3I10)                           00031800
ISN 00195          2 FORMAT ( 7F5.0 )                        00031900
ISN 00196          3 FORMAT (20A1,A4)                        00032000
C
ISN 00196          11 FORMAT (3F5.0,I5,A4)                  00032100
ISN 00197          12 FORMAT ( F10.0 )                       00032200
C
ISN 00198          ALARM MESSAGES                           00032300
ISN 00198          65 FORMAT ('1', // T20, 'CONVERGENCE OF TN(I,J) ARE NOT ACHIEVED' / 00032400
ISN 00198          1 T20, ' NUMBER OF ITERATION(ITERA) =', I6, / 00032500
ISN 00198          2 T20, ' RESULTS AFTER LATEST ITERATION ARE AS FLLOWS' 00032600
ISN 00198          3 '/T20, ' OMEGA =', 1PE13.4/ T20, ' EPS =', 1PE13.4 /) 00032700
C
ISN 00199          OUTPUT FORMATS                           00032800
ISN 00199          111 FORMAT ( '1' // T47, 'EFFECTIVE CONDUCTIVITY ON INNER WALL' 00032900
ISN 00199          A // T20, 'AVNUSS = ', 1PE15.3, T50, 'RADA = ', 1PE15.3, 00033000

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      1          T80, 'RO = ', 1PE15.3 // T5, 9( 'J',4X,'KE/K',      00033800
      2          5X ) / )      00033900
ISN 00200 115 FORMAT (   /// T47, 'EFFECTIVE CONDUCTIVITY ON OUTER SURFACE (RO) 00034000
      A',          // T20, 'AVNUSO = ', 1PE15.3, T50, 'RADA = ', 1PE15.3, 00034100
      1          T80, 'RO = ', 1PE15.3 // T5, 9( 'J',4X,'KE/K',      00034200
      2          5X ) / )      00034300
C
ISN 00201 121 FORMAT ( 9(I6,      F8.4 ) / )      00034400
ISN 00202 122 FORMAT ( /// T46, 'RELATIVE LOCAL HEAT FLUX AT INNER WALL' //      00034500
      1          T5, 9( 'J', 3X, 'Q(J)/QM', 3X ) / )      00034600
ISN 00203 123 FORMAT ( /// T46, 'RELATIVE LOCAL HEAT FLUX AT OUTER WALL' //      00034700
      1          T5, 9( 'J', 3X, 'Q(J)/QM', 3X ) / )      00034800
ISN 00204 230 FORMAT ( '1' /// T20, ' TN(I,J) AND PSI(I,J) ARE CONVERGED.', //      00034900
      1          T20, ' ITERA = ', 14, T50, '(TEMP-LOOP)',      00035000
      2          / T20, ' ITEP = ', 14, T50, '(PSI-LOOP)',      00035100
      3          / T20, ' EPS = ', 1PE13.4, T50, '(TEMP ERROR)',      00035200
      4          / T20, ' ERRPSI = ', 1PE13.4, T50, '(PSI-ERROR)' / )      00035300
ISN 00205 235 FORMAT ( T20, ' EPSTW = ', 1PE13.4, T50, '(T-WALL ERROR)' )      00035400
ISN 00206 240 FORMAT ( T2, ' ITERA = ', 14, T16, ' ITEP = ', 14, T29,      00035500
      1          ' EPS = ', 1PE11.4, T49, ' ERRPSI = ', 1PE11.4,      00035600
      2          T71, ' OMEGA = ', 1PE11.4, T93, ' OMPSI = ', 1PE11.4 )      00035700
ISN 00207 245 FORMAT ( '+', T114, ' EPSTW = ', 1PE11.3      00035800
      )      00035900
C
ISN 00208 250 FORMAT ( /// T47, ' NORMALIZED TEMPERATURE DISTRIBUTION ' )      00036000
ISN 00209 260 FORMAT ( /// T45, ' NORMALIZED STREAM FUNCTION DISTRIBUTION ' )      00036100
C
ISN 00210 400 FORMAT ( '1', /// T20, 'OUT SIDE NUSSELT NO (AVNU) = ', 1PE11.3,      00036200
      1          /// T20, 'D-LESS MEAN WALL TEMP (TWM) = ', 1PE11.3 // )      00036300
ISN 00211 410 FORMAT ( /// T45, 'NUSSELT NUMBER AROUND WALL OUT SIDE', //      00036400
      1          T5, 9( 'J', 3X, 'WNU(J)', 3X ) / )      00036500
ISN 00212 420 FORMAT ( /// T37, 'D-LESS TEMPERATURE DISTRIBUTION AROUND WALL OUT SID      00036600
      1E' // T5, 9( 'J', 2X, 'TN(M+1,J)', 2X ) / )      00036700
ISN 00213 430 FORMAT ( 9( I6, F8.4 ) / )      00036800
C
ISN 00214 440 FORMAT (   /// T20, 'AVERAGE CONTACT SURFACE TEMP. (TROM) =',      00036900
      1 1PE11.4 /// T37, 'D-LESS TEMPERATURE DISTRIBUTION AROUND CONTACT SURFAC      00037000
      2T SURFACE', // T5, 9( 'J', 2X, 'TOPHI(J)', 3X ) / )      00037100
ISN 00215 900 WRITE(6,460)      00037200
ISN 00216 460 FORMAT(' ***RW (WALL OUTER R. ) IS TOO SMALL ***')      00037300
ISN 00217 GO TO 1100      00037400
ISN 00218 950 WRITE(6,470)      00037500
ISN 00219 470 FORMAT(' *** MW (RADIAL DIY. OF WALL ) ERROR ***** ' )      00037510
ISN 00220 GO TO 1100      00037520
ISN 00221 1000 WRITE(6,480)      00037530
ISN 00222 480 FORMAT(' TN(I,J) ABNORMAL *****' )      00037540
ISN 00223 1100 STOP      00037550
ISN 00224 END      00037560
      00037570
      00037580
      00037700

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DATE 83.01.26 TIME 14.49.01

SPECIFIED OPTIONS: NONAME, FLAG(I), BYNAME, GOSTMT, NOSTATIS, ISN(D), NOMAP, ELM(*)

ISN 00001		SUBROUTINE VELOCI	00037710
	C		00037720
	C		00037730
	C		00037740
ISN 00002		COMMON/INDEP/ RI(41),PHI(41),DR,DRT,DRI,DRW,DPH	00037750
ISN 00003		COMMON/TPUVC/ TN(41,41),PSI(41,41),U(41,41),V(41,41)	00037760
ISN 00004		COMMON/INTEC/ M,N,MCAL,NCAL,MW,KW,KALP,KDIST	00037770
ISN 00005		DOUBLE PRECISION TN,PSI	00037780
	C		00037790
ISN 00006		DR = DRT	00037800
ISN 00007		IF (KALP.EQ.1) DR = DRI	00037810
	C		00037820
ISN 00008		DO 10 J=1,N+1	00037830
ISN 00009		DO 10 I=1,M+1	00037840
ISN 00010		IF (J.EQ.1) GO TO 1	00037850
ISN 00011		IF (J.EQ.N+1) GO TO 2	00037860
ISN 00012		U(I,J) = (PSI(I,J+1)-PSI(I,J-1)) / (2.0*RI(I)*DPH)	00037870
ISN 00013		GO TO 3	00037880
	C		00037890
ISN 00014		1 U(I,J) = (PSI(I,J+1)-PSI(I,J)) / (RI(I)*DPH)	00037900
ISN 00015		GO TO 3	00037910
	C		00037920
ISN 00016		2 U(I,J) = (PSI(I,J)-PSI(I,J-1)) / (RI(I)*DPH)	00037930
	C		00037940
ISN 00017		3 IF (I.EQ.1) GO TO 4	00037950
ISN 00018		IF (I.EQ.M+1) GO TO 5	00037960
ISN 00019		V(I,J) = (PSI(I-1,J)-PSI(I+1,J)) / (2.0*DR)	00037970
ISN 00020		GO TO 10	00037980
	C		00037990
ISN 00021		4 V(I,J) = (PSI(I,J)-PSI(I+1,J)) / DR	00038000
ISN 00022		GO TO 10	00038010
ISN 00023		5 V(I,J) = (PSI(I-1,J)-PSI(I,J)) / DR	00038020
ISN 00024		10 CONTINUE	00038030
ISN 00025		RETURN	00038040
ISN 00026		END	00038050

SPECIFIED OPTIONS: NONAME,FLAG(I),BYNAME,GOSTMT,NOSTATIS,ISN(D),NOMAP,ELM(*)

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ISN 00001      SUBROUTINE PSISOL                                00038060
C                                                       00038070
C   THIS ROUTINE SOLVES EQ. OF MOTION IN HORIZONTAL ANNULAR POROUS 00038080
C   MEDIA BY EXTRAPOLATED LIEBMANN METHOD                        00038090
C                                                       REVISD ON MARCH 1978 00038100
C   TN           DIMENSIONLESS TEMPERATURE AT MESH POINTS (I,J) 00038110
C   PSI          DIMENSIONLESS STREAM FUNCTION AT MESH POINTS (I,J) 00038120
C   OMPSI        RELAXATION FACTOR                               00038130
C                                                       00038140
ISN 00002      COMMON/INTEC/ M,N,MCAL,NCAL,MW,KW,KALP,KDIST      00038150
ISN 00003      COMMON/SORCO/ OMEGA,OMPSI,ITERA,ITEL,ITEP,ERROR,ERRPSI,EPS,APS, 00038160
1              ERRORP                                           00038170
ISN 00004      COMMON/PARAC/ RO,RW,PHIMAX,RADA                    00038180
ISN 00005      COMMON/TPUVC/ TN(41,41),PSI(41,41),U(41,41),V(41,41) 00038190
ISN 00006      COMMON/INDEP/ RI(41),PHI(41),DR,DRT,DRI,DRW,DPH    00038200
ISN 00007      DOUBLE PRECISION TN,PSI                          00038210
C                                                       00038220
C                                                       00038230
ISN 00008      IF (KALP.EQ.1) GO TO 2                            00038240
C               T = CONSTANT                                    00038250
ISN 00009      MSOL = M                                          00038260
ISN 00010      DR = DRT                                          00038270
ISN 00011      GO TO 3                                          00038280
C                                                       00038290
C               WALLED                                         00038300
ISN 00012      2 MSOL = KW-1                                     00038310
ISN 00013      DR = DRI                                         00038320
C                                                       00038330
C                                                       00038340
ISN 00014      3 ITEP = 0                                        00038350
C                                                       00038360
C                                                       00038370
ISN 00015      5 SPSI = 0.                                       00038380
ISN 00016      SPSIO = 0.                                       00038390
C                                                       00038400
ISN 00017      DO 10 J=2,N                                         00038410
ISN 00018      DO 10 I=2,MSOL                                       00038420
ISN 00019      A = 2.0/DR**2 + 2.0/(RI(I)*DPH)**2                00038430
ISN 00020      B = (PSI(I+1,J)+PSI(I-1,J))/DR**2                00038440
ISN 00021      C = (PSI(I+1,J) - PSI(I-1,J))/(2.0*RI(I)*DR)    00038450
ISN 00022      D = (PSI(I,J+1)+PSI(I,J-1))/(RI(I)*DPH)**2      00038460
ISN 00023      E = (TN(I+1,J)-TN(I-1,J))/(2.0*DR)*SIN(PHI(J))  00038470
ISN 00024      F = (TN(I,J+1)-TN(I,J-1))/(2.0*RI(I)*DPH)*COS(PHI(J)) 00038480
C                                                       00038490
ISN 00025      SPSIO = SPSIO+PSI(I,J)                              00038500
ISN 00026      PSI(I,J) = (1.0-OMPSI)*PSI(I,J)+OMPSI/A*(B+C+D+RADA*(E+F)) 00038510
ISN 00027      10 SPSI = SPSI + PSI(I,J)                          00038520
C                                                       00038530
ISN 00028      ITEP = ITEP+1                                       00038540
ISN 00029      ERRPSI = ABS((SPSI-SPSIO)/SPSI)                   00038550
ISN 00030      IF (ITEP.GT.ITEL) GO TO 20                         00038560
ISN 00031      IF (ERRPSI.LT.ERRORP) GO TO 30                     00038570
C                                                       00038580
ISN 00032      GO TO 5                                             00038590
C                                                       00038600
ISN 00033      20 PRINT 100, ITERA,ITEP,ERRPSI,EPS              00038610
    
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FACOM OSIV/F4 FORTRAN IV (HE) V04L18 PSISOL DATE 83.01.26 TIME 14.49.01

	C		00038620
	C		00038630
ISN 00034		STOP	00038640
ISN 00035		30 RETURN	00038650
	C		00038660
ISN 00036		100 FORMAT ('1' // T20, ' PSI DOES NOT CONVERGE IN PSISOL ' //	00038670
	1	T20, ' ITERA= ', I4, T50, '(TEMP-LOOP)'	00038680
	2	/ T20, ' ITEMP = ', I4, T50, '(PSI-LOOP) '	00038690
	3	/ T20, ' ERRPSI= ', 1PE13.4, T50, '(PSI-ERROR)'	00038700
	4	/ T20, ' EPS = ', 1PE13.4, T50, '(TEMP-ERROR)'/)	00038710
	C		00038720
ISN 00037		END	00038730

FACOM OSIV/F4 FORTRAN IV (HE) VO4L18 DATE 83.01.26 TIME 14.49.03

SPECIFIED OPTIONS: NONAME,FLAG(I),BYNAME,GOSTMT,NOSTATIS,ISN(D),NOMAP,ELM(*)

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ISN 00001      SUBROUTINE SIMSOL                                00038740
C                                                       00038750
C   THIS ROUTINE SOLVES ENERGY AND MOTIONAL EQ. SIMULTANEOUSLY IN 00038760
C   HORIZONTAL ANNULAR POROUS MEDIA BY SUCCESSIVE OVER RELAXATION 00038770
C   METHOD WITH UPPER STREAM DIFFERENTIAL TECHNIQUE.           00038780
C                                                       00038790
C   TN      DIMENSIONLESS TEMPERATURE AT MESH POINTS (I,J)    00038800
C   PSI     DIMENSIONLESS STREAM FUNCTION AT MESH POINTS (I,J) 00038810
C   OMEGA   RELAXATION FACTOR                                  00038820
C   U       DIMENSIONLESS RADIAL VELOCITY COMPONENT AT (I,J)  00038830
C   V       DIMENSIONLESS CIRCUMFERENTIAL VELOCITY COMPONENTS 00038840
C           AT (I,J)                                           00038850
C   RO      D-LESS RADIUS FOR INSULATION-WALL CONTACT RO=RI(KW) 00038860
C   RW      D-LESS RADIUS FOR WALL OUTER SURFACE RW=RI(M+1)    00038870
C   RI(I)   D-LESS RADIUS I=1,...,KW,...,M,M+1                 00038880
C   PHI(J)  ANGLE FROM BOTTOM CENTER J=1,...,N,N+1 (RAD)       00038890
C   DR      RADIAL MESH WIDTH AT RI(I)                         00038900
C   DRT     RADIAL MESH WIDTH IN INSULATION FOR T=CONST B.C.   00038910
C           DRT=(RO-1.0)/M                                       00038920
C   DRI     RADIAL MESH WIDTH IN INSULATION FOR WALLED B.C.    00038930
C           DRI=(RO-1.0)/(KW-1)                                   00038940
C   DRW     RADIAL MESH WIDTH IN WALL FOR WALLED B.C.         00038950
C           DRW=(RW-RO)/MW                                       00038960
C   DPH     ANGULAR MESH WIDTH DPH=3.14.../N                  00038970
C   KW      RADIAL MESH POINT NUMBER FOR INS.-WALL CONTACT    00038980
C   MW      NUMBER OF RADIAL DIVISION IN WALL                 00038990
C   M       NUMBER OF RADIAL DIVISION IN INSULATION AND WALL  00039000
C   N       NUMBER OF ANGULAR DIVISION ( DPH=3.14.../N )     00039010
C   TCWBYI  RATIO OF WALL TO INS. T-CONDUCTIVITY             00039020
C   TCWBYO  RATIO OF WALL TO WALL OUT SIDE GAS T-CONDUCTIVITY 00039030
C   WNU(J)  NUSSLETT NUMBER AROUND WALL OUT SIDE J=1,...,N+1 00039040
C   KALP    KEY FOR OUT SIDE BOUNDARY CONDITION KALP=0; T=CONST 00039050
C           KALP=1; WALLED                                       00039060
C                                                       00039070
ISN 00002      COMMON/INTEC/ M,N,MCAL,NCAL,MW,KW,KALP,KDIST    00039080
ISN 00003      COMMON/SORCO/ OMEGA,OMPSI,ITERA,ITEL,ITEP,ERROR,ERRPSI,EPS,APS, 00039090
1              ERRORP                                           00039100
ISN 00004      COMMON/SORCA/ SNEW,SOLD,EPSTW                   00039110
ISN 00005      COMMON/PARAC/ RO,RW,PHIMAX,RADA                00039120
ISN 00006      COMMON/TPUVC/ TN(41,41),PSI(41,41),U(41,41),V(41,41) 00039130
ISN 00007      COMMON/INDEP/ RI(41),PHI(41),DR,DRT,DRI,DRW,DPH 00039140
ISN 00008      COMMON/WALLC/ WNU(41),AVNU,TCWBYI,TCWBYO,RAO   00039150
ISN 00009      COMMON/COMOPT/ IOMEGA,DOM,NSIGN,TOLD(41,41),TRACER,DOMMIN 00039160
ISN 00010      DOUBLE PRECISION TOLD                          00039170
ISN 00011      DOUBLE PRECISION TN,PSI                        00039180
C                                                       00039190
ISN 00012      CALL PSISOL                                     00039200
C           DIMENSIONLESS VELOCITY                             00039210
ISN 00013      CALL VELOCI                                    00039220
C                                                       00039230
ISN 00014      IF (KALP.EQ.1) GO TO 2                         00039240
ISN 00015      MLAST = M                                       00039250
ISN 00016      DR = DRT                                          00039260
ISN 00017      GO TO 3                                          00039270
ISN 00018      2 DR = DRI                                        00039280
ISN 00019      AA = 2*RO/(DRI+DRW)*(TCWBYI/DRW+1.0/DRI)     00039290
    
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ISN 00020      BB = 0.5*(TCWBYI/DRW-1.0/DRI)
ISN 00021      A1 = (DRI+TCWBYI*DRW)/(DRI+DRW)
ISN 00022      CC = 2*A1/(RO*DPH**2)
ISN 00023      MLAST = M+1
ISN 00024      TNW1 = 2.0*TN(M+1,2)
ISN 00025      TNWN = 2.0*TN(M+1,N)
ISN 00026      RMW = 0.5*(RO+RW)
ISN 00027      CONST1 = TCWBYI*(RW-RO)/RMW**2.
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C
ISN 00028      3 DO 91 J=1,N+1
ISN 00029      IF (KALP.EQ.1) TWOLD = TN(M+1,J)
ISN 00030      DO 90 I=2,MLAST
ISN 00031      SOLD = SOLD + TN(I,J)
ISN 00032      TO=TN(I,J)
ISN 00033      IF (KALP.EQ.0) GO TO 5
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C
C      WALLED OUTER SURFACE
ISN 00034      4 IF (I.EQ.M+1) GO TO 71
ISN 00035      IF (I.GE.KW+1) GO TO 11
ISN 00036      IF (I.EQ.KW) GO TO 72
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C
C      GO TO 5
ISN 00037      GO TO 5
ISN 00038      11 CONTINUE
ISN 00039      A = 2.0*RI(I)/DRW**2 + 2.0/(RI(I)*DPH**2)
ISN 00040      B = RI(I)*(TN(I+1,J) + TN(I-1,J))/DRW**2
ISN 00041      C = (TN(I+1,J)-TN(I-1,J))/(2.0*DRW)
ISN 00042      IF (J.GT.1.AND.J.LT.N+1) D=(TN(I,J+1)+TN(I,J-1))/(RI(I)*DPH**2)
ISN 00043      IF (J.EQ.1) D = TN(I,2)/(RI(I)*DPH**2)*2
ISN 00044      IF (J.EQ.N+1) D = TN(I,N)/(RI(I)*DPH**2)*2
ISN 00045      E = 0.0
ISN 00046      F = 0.0
ISN 00047      GO TO 25
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C
C      CONSTANT T. OR WALLED (I.NE.KW, I.NE.KW+1, I.NE.M+1)
ISN 00048      5 CONTINUE
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C
ISN 00049      IF (U(I,J).GT.0.0) GO TO 10
ISN 00050      A = -U(I,J)/DR*RI(I)
ISN 00051      E = -U(I,J)*TN(I+1,J)/DR*RI(I)
ISN 00052      GO TO 20
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C
ISN 00053      10 A = U(I,J)/DR*RI(I)
ISN 00054      E = U(I,J)*TN(I-1,J)/DR*RI(I)
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C
ISN 00055      20 IF (V(I,J).GT.0.0) GO TO 30
ISN 00056      A = A - V(I,J)/DPH
ISN 00057      IF (J.GT.1.AND.J.LT.N+1) F = -V(I,J)*TN(I,J+1)/DPH
ISN 00058      GO TO 40
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C
ISN 00059      30 A = A + V(I,J)/DPH
ISN 00060      IF (J.GT.1.AND.J.LT.N+1) F = V(I,J)*TN(I,J-1)/DPH
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C
ISN 00061      40 A = A + 2.0*RI(I)/DR**2 + 1.0/DR + 2.0/(RI(I)*DPH**2)
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C
ISN 00062      B = RI(I)*(TN(I+1,J)+TN(I-1,J))/DR**2
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C
ISN 00063      C = TN(I+1,J)/DR
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C
ISN 00064      IF (J.EQ.1) GO TO 50
ISN 00065      IF (J.EQ.N+1) GO TO 60
ISN 00066      D = (TN(I,J+1)+TN(I,J-1))/(RI(I)*DPH**2)
ISN 00067      GO TO 70
C
ISN 00068      50 D = 2.0*TN(I,2)/(RI(I)*DPH**2)
ISN 00069      GO TO 70
C
ISN 00070      60 D = 2.0*TN(I,N)/(RI(I)*DPH**2)
C
ISN 00071      70 IF (J.EQ.1.OR.J.EQ.N+1) F = 0.0
C
ISN 00072      25 TN(I,J) = (1.0-OMEGA)*TN(I,J) + OMEGA/A*(B+C+D+E+F)
C
ISN 00073      GO TO 85
C
C              TEMP AT R=RW ( I=M+1 )
ISN 00074      71 IF (MW.EQ.0) GO TO 1000
ISN 00075      IF (J.GT.1.AND.J.LT.N+1) TNJJ=TN(M+1,J+1)+TN(M+1,J-1)
ISN 00076      IF (J.EQ.1) TNJJ=TNW1
ISN 00077      IF (J.EQ.N+1) TNJJ=TNWN
C
ISN 00078      TN(M+1,J) = TN(M,J)/DRW+0.5*TNJJ*DRW/((RW-DRW/4)*DPH)**2
ISN 00079      TN(M+1,J) = TN(M+1,J)/(1.0/DRW + 0.5*WNU(J)/(TCWBYO*RW)
1              + DRW/((RW-DRW/4)*DPH)**2)
ISN 00080      GO TO 85
C
C              SINGLE WALL LAYER MODEL ( MW = 0 )
ISN 00081      1000 IF (J.GT.1.AND.J.LT.N+1) TNJJ=TN(M+1,J+1) + TN(M+1,J-1)
ISN 00082      IF (J.EQ.1) TNJJ=TNW1
ISN 00083      IF (J.EQ.N+1) TNJJ=TNWN
ISN 00084      WNUSTI = 0.5*WNU(J)*TCWBYI/(RW*TCWBYO)
ISN 00085      TN(M+1,J) = (TN(M,J)/DRI + CONST1*TNJJ/DPH**2) /
1              (1.0/DRI + WNUSTI + 2.0*CONST1/DPH**2)
ISN 00086      GO TO 85
C
C              TEMP AT R=RO ( I=KW )
ISN 00087      72 DD = 2*RO/(DRI+DRW)*(TN(KW-1,J)/DRI+TCWBYI*TN(KW+1,J)/DRW)
ISN 00088      EE = 0.5*(TCWBYI*TN(KW+1,J)/DRW-TN(KW-1,J)/DRI)
ISN 00089      IF (J.EQ.1) GO TO 73
ISN 00090      IF (J.EQ.N+1) GO TO 74
ISN 00091      FF = A1*(TN(KW,J+1)+TN(KW,J-1))/(RO*DPH**2)
ISN 00092      GO TO 75
C
C              J = 1
ISN 00093      73 FF = 2*A1*TN(KW,2)/(RO*DPH**2)
ISN 00094      GO TO 75
C
C              J = N+1
ISN 00095      74 FF = 2*A1*TN(KW,N)/(RO*DPH**2)
ISN 00096      75 TN(KW,J) = (1.0-OMEGA)*TN(KW,J) + OMEGA/(AA+BB+CC)*(DD+EE+FF)
ISN 00097      GO TO 85
C
ISN 00098      85 IF (TN(I,J).LT.0.0) GO TO 86
ISN 00099      GO TO 90
C
C              ABNORMAL TEMPERATURE INFORMATION
C

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FACOM OSIV/F4 FORTRAN IV (HE) VO4L18 SIMSOL DATE 83.01.26 TIME 14.49.03

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ISN 00100      86 IF (KALP.EQ.1.AND.I.EQ.KW) GO TO 87      00040460
ISN 00101      PRINT 100, I,J,TN(I,J),A,B,C,D,E,F      00040470
ISN 00102      X=TO*(1.0-OMEGA)      00040480
ISN 00103      Y=OMEGA/A*(B+C+D+E+F)      00040490
ISN 00104      PRINT 200, X,Y,TO,ITERA      00040500
ISN 00105      GO TO 88      00040510
ISN 00106      87 AB1 = (1.-OMEGA)*TO      00040520
ISN 00107      AB2 = OMEGA/(AA+BB+CC)*(DD+EE+FF)      00040530
ISN 00108      PRINT 300,I,J,TN(KW-1,J),TO,TN(KW,J),TN(KW+1,J),AA,BB,CC,DD,EE,      00040540
ISN 00108      1      FF,AB1,AB2      00040550
ISN 00109      88 NSIGN = -1      00040560
ISN 00110      RETURN      00040570
C
ISN 00111      90 SNEW = SNEW + TN(I,J)      00040580
ISN 00112      IF (KALP.EQ.1) EPSTW = DABS((TWOLD-TN(M+1,J))/TN(M+1,J))+EPSTW      00040590
ISN 00113      91 CONTINUE      00040600
ISN 00114      NSIGN = 1      00040610
ISN 00115      IF (KALP.EQ.1) EPSTW = EPSTW/(N+1)      00040620
ISN 00116      RETURN      00040630
C
ISN 00117      INFORMATION FORMATS      00040640
ISN 00117      100 FORMAT ( / T8, 'I=', I2, ' J=', I2, ' TN=', 1PD11.3, ' A=',      00040650
ISN 00117      1      1PD11.3, ' B=', 1PD11.3, ' C=', 1PD11.3, ' D=', 1PD11.3,      00040660
ISN 00117      2      ' E=', 1PD11.3, ' F=', 1PD11.3 )      00040670
C
ISN 00118      200 FORMAT ( T8, '(1.0-OMEGA)*TO = ', 1PE13.3, T50, 'OMEGA/A*(B+C+D+E+F)      00040680
ISN 00118      1 = ', 1PE13.3, T90, 'TO = ', 1PE13.3, T110, 'ITERA=', I3 )      00040690
C
ISN 00119      300 FORMAT ( / T5, 'I=', I3, 5X, 'J=', I3, 5X, 'TN(KW-1,J) =', 1PE13.3,      00040700
ISN 00119      1      5X, 'TO(KW,J) =', 1PE13.3, 5X, 'TN(KW,J) =', 1PE13.3, 5X,      00040710
ISN 00119      2      'TN(KW+1,J) =', 1PE13.3, //T10, 'AA', T21, 'BB', T32, 'CC',      00040720
ISN 00119      3      T43, 'DD', T54, 'EE', T65, 'FF' /1P6E13.3//      00040730
ISN 00119      4      T5, '(1.-OMEGA)*TO(KW,J) =', 1PE13.3, 5X, 'OMEGA/(AA+BB+CC) *      00040740
ISN 00119      5(DD+EE+FF) =', 1PE13.3 //)      00040750
C

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FACOM OSIV/F4 FORTRAN IV (HE) V04L18

DATE 83.01.26 TIME 14.49.06

SPECIFIED OPTIONS: NONAME, FLAG(I), BYNAME, GOSTMT, NOSTATIS, ISN(D), NOMAP, ELM(*)

```

ISN 00001      SUBROUTINE SIMPSN (M,H,F,S,IER)                00040810
C                                                       00040820
C      THIS ROUTINE INTEGRATES GIVEN FUNCTION F(1),F(2),...F(M) BY 00040830
C      SIMPSON METHOD.                                         00040840
C                                                       00040850
C      M      NUMBER OF MESH POINTS (M MUST BE ODD NUMBER)    00040860
C      H      MESH WIDTH OF INDEPENDENT VARIABLES (EQ-SPACES) 00040870
C      F(I)    DIMENSION OF GIVEN FUNCTION I=1,2,...,M         00040880
C      S      INTEGRATED VALUE OF FUNCTION                    00040890
C      IER     ERRDR CODE   =0  NORMAL                          00040900
C               =1  ABNORMAL, S IS SET FOR S = 0.0            00040910
C                                                       00040920
C                                                       00040930
C                                                       00040940
ISN 00002      DIMENSION F(M)                                00040950
C                                                       00040960
ISN 00003      MM = (M-1)/2*2                                00040970
ISN 00004      IF (MM.EQ.M-1) GO TO 10                       00040980
ISN 00005      IER = 1                                       00040990
ISN 00006      S = 0.0                                       00041000
ISN 00007      PRINT 100, IER,M                             00041010
ISN 00008      RETURN                                        00041020
C                                                       00041030
ISN 00009      10 N = (M-1)/2                                00041040
ISN 00010      S2 = 0.0                                       00041050
ISN 00011      S4 = 0.0                                       00041060
C                                                       00041070
ISN 00012      DO 20 I=1,N                                    00041080
ISN 00013      IF (I.EQ.N) GO TO 15                          00041090
ISN 00014      K2 = 2*I+1                                    00041100
ISN 00015      S2 = S2+F(K2)                                 00041110
ISN 00016      15 K4 = 2*I                                   00041120
ISN 00017      20 S4 = S4+F(K4)                              00041130
C                                                       00041140
ISN 00018      S = H*(F(1)+F(M)+4.0*S4+2.0*S2)/3.0          00041150
ISN 00019      IER = 0                                       00041160
ISN 00020      RETURN                                        00041170
ISN 00021      100 FORMAT (/// T10, 10('*'), ' ERROR IN SUBROUTINE-SIMPSN ',10('*'), 00041180
1          / T10, 'M MUST BE ODD NUMBER IER =',I2, ' M =', I4 ) 00041190
C                                                       00041200
ISN 00022      END

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FACOM OSIV/F4 FORTRAN IV (HE) V04L18

DATE 83.01.26 TIME 14.49.07

SPECIFIED OPTIONS: NONAME, FLAG(I), BYNAME, GOSTMT, NOSTATIS, ISN(D), NOMAP, ELM(*)

```

ISN 00001      SUBROUTINE HERMAN                                00041210
C                                                       00041220
C           THIS ROUTINE CALCULATES AVERAGE AND LOCAL NUSSELT NUMBERS 00041230
C           AROUND HORIZONTAL CYLINDER WITH HERMANN-SPARROW,S THEORY FOR 00041240
C           ISO-THERMAL CONDITION.                                00041250
C           RAO           RAYLEIGH NUMBER AROUND OUTER WALL      00041260
C           AVNU          AVERAGE NUSSELT NUMBER                00041270
C           WNU(J)        LOCAL NUSSELT NUMBER                  00041280
C                                                       00041290
ISN 00002      COMMON/WALLC/ WNU(41),AVNU,TCWBYI,TCWBYD,RAO      00041300
ISN 00003      COMMON/INTEC/ M,N,MCAL,NCAL,MW,KW,KALP,KDIST      00041310
ISN 00004      COMMON/INDEP/ RI(41),PHI(41),DR,DRT,DRI,DRW,DPH    00041320
C                                                       00041330
ISN 00005      DIMENSION COH(10)                                00041340
C                                                       00041350
ISN 00006      DATA ( COH(I),I=1,10 ) / 1.239,0.13682,-1.0866, 2.3380, -1.9872, 00041360
1           0.10608, 0.88092, -0.57811, 0.15075, -0.01454 /    00041370
C                                                       00041380
ISN 00007      AVNU = 0.399*RAO**0.25                          00041390
C                                                       00041400
ISN 00008      DO 20 J=1,N+1                                    00041410
ISN 00009      IF (PHI(J).EQ.0.0) GO TO 2                       00041420
ISN 00010      WNU(J) = 0.0                                     00041430
ISN 00011      GO TO 5                                         00041440
ISN 00012      2 WNU(J) = COH(1)                                00041450
ISN 00013      GO TO 20                                        00041460
ISN 00014      5 DO 10 I=1,10                                  00041470
ISN 00015      10 WNU(J) = WNU(J)+COH(I)*PHI(J)**(I-1)        00041480
ISN 00016      20 WNU(J) = AVNU*WNU(J)                        00041490
ISN 00017      PRINT 100, RAO,AVNU,WNU(1),WNU(N+1)            00041500
ISN 00018      100 FORMAT ( /// T18, 37('*'), ' SUBROUTINE HERMAN ', 37('*') /// 00041510
1           T29, 'RAYLEIGH NO', T50, 'AVERAGE NU', T72, 'MAX NU', T92, 00041520
2           'MIN NU', / T32, '(RAO)', T51, '(AVNU)', T70, '(WNU(1))', 00041530
3           T90, '(WNU(N+1))' // T20, 1P4E20.4 // T18, 94('*') // ) 00041540
ISN 00019      RETURN                                          00041550
ISN 00020      END                                             00041560

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FACOM OSIV/F4 FORTRAN IV (HE) V04L18

DATE 83.01.26 TIME 14.49.08

SPECIFIED OPTIONS: NONAME,FLAG(I),BYNAME,GOSTMT,NOSTATIS,ISN(D),NOMAP,ELM(*)

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ISN 00001      SUBROUTINE VISUAL ( X,Y,Z,M,N,XA,YA,ZA,ZYJ,ZIIJ,ZII,KZ)      00041570
C                                                     00041580
C   THIS ROUTINE VISUALIZE 3-DIMENSIONAL ARRAYS BY EASY METHOD.      00041590
C                                                     00041600
C   X(I)   X-COORDINATE OF Z(I,J)   I=1,2, ... ,M      00041610
C   Y(J)   Y-COORDINATE OF Z(I,J)   J=1,2, ... ,N      00041620
C   Z(I,J) FUNCTION OF X(I),Y(J)   (VISUALIZING VALUES)      00041630
C                                                     00041640
C   **REMARKS**                                                     00041650
C   (1) X AND Y MUST BE MONOTONIC CHANGE AND EQ.-SPACES      00041660
C   (2) VISUALIZING PLANE IS 50 X 50 CHARACTERS      00041670
C   (3) X AND Y DIRECTION ARE HORIZONTAL AND VERTICAL RESPECTI-      00041680
C       VLY      00041690
C   (4) THIS ROUTINE NEEDS SUBROUTINE 'D2ITPL' AND 'INTPL2'      00041700
C                                                     00041710
ISN 00002      DIMENSION X(M),Y(N),Z(M,N),XA(50),YA(50),ZA(50,50),ZYJ(M),ZII(N),      00041720
1              ZIIJ(50,N),KZ(50,50)      00041730
C                                                     00041740
ISN 00003      DATA KBLANK,KA / ' ','A' /      00041750
C                                                     00041760
ISN 00004      CALL D2ITPL (X,Y,Z,M,N,XA,YA,ZA,50,50,IERR,ZYJ,ZIIJ,ZII)      00041770
ISN 00005      IF (IERR.EQ.0) GO TO 10      00041780
ISN 00006      PRINT 1000      00041790
ISN 00007      STOP      00041800
C                                                     00041810
ISN 00008      10 XAMAX = XA(1)      00041820
ISN 00009      XAMIN = XA(1)      00041830
ISN 00010      YAMAX = YA(1)      00041840
ISN 00011      YAMIN = YA(1)      00041850
ISN 00012      ZAMAX = ZA(1,1)      00041860
ISN 00013      ZAMIN = ZA(1,1)      00041870
C                                                     00041880
C                                                     00041890
ISN 00014      DO 20 I=2,50      00041900
ISN 00015      IF (XA(I).GT.XAMAX) XAMAX = XA(I)      00041910
ISN 00016      IF (XA(I).LT.XAMIN) XAMIN = XA(I)      00041920
ISN 00017      20 CONTINUE      00041930
C                                                     00041940
ISN 00018      DO 30 J=2,50      00041950
ISN 00019      IF (YA(J).GT.YAMAX) YAMAX = YA(J)      00041960
ISN 00020      IF (YA(J).LT.YAMIN) YAMIN = YA(J)      00041970
ISN 00021      30 CONTINUE      00041980
C                                                     00041990
ISN 00022      DO 40 J=1,50      00042000
ISN 00023      DO 40 I=1,50      00042010
ISN 00024      IF (ZA(I,J).GT.ZAMAX) ZAMAX = ZA(I,J)      00042020
ISN 00025      IF (ZA(I,J).LT.ZAMIN) ZAMIN = ZA(I,J)      00042030
ISN 00026      40 CONTINUE      00042040
C                                                     00042050
C                                                     00042060
C                                                     00042070
C               NORMALIZATION OF Z(I,J)
ISN 00027      DO 50 J=1,50      00042080
ISN 00028      DO 50 I=1,50      00042090
C      ZA(I,J) = (ZA(I,J)-ZAMIN)/(ZAMAX-ZAMIN)*1.1      00042100
C      IF (ZA(I,J).GE.1.1) ZA(I,J) = 1.0      00042110
ISN 00029      ZA(I,J) = ZA(I,J)*10.0      00042120

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FACOM OSIV/F4 FORTRAN IV (HE) V04L18 VISUAL DATE 83.01.26 TIME 14.49.08

ISN 00030	KZ(I,J) = ZA(I,J) + 1	00042130
ISN 00031	KZ(I,J) = KZ(I,J)*1000	00042140
ISN 00032	KZA = KZ(I,J)/2000*2000	00042150
ISN 00033	IF (KZA.EQ.KZ(I,J)) GO TO 45	00042160
ISN 00034	IF (KZ(I,J).EQ.11000) GO TO 41	00042170
ISN 00035	KZ(I,J) = IBTOD(KZ(I,J))	00042180
ISN 00036	GO TO 50	00042190
ISN 00037	41 KZ(I,J) = KA	00042200
ISN 00038	GO TO 50	00042210
ISN 00039	45 KZ(I,J) = KBLANK	00042220
ISN 00040	50 CONTINUE	00042230
	C	00042240
ISN 00041	PRINT 1010, XAMAX,XAMIN	00042250
ISN 00042	PRINT 1020, YAMAX,YAMIN	00042260
ISN 00043	PRINT 1030, ZAMAX,ZAMIN	00042270
	C	00042280
ISN 00044	DO 60 J=1,50	00042290
ISN 00045	60 PRINT 1040, (KZ(I,J), I=1,50)	00042300
	C	00042310
	C	00042320
ISN 00046	RETURN	00042330
	C	00042340
	C	00042350
ISN 00047	1000 FORMAT ('1 ERROR HAPPENED IN SUBROUTINE VISUAL ')	00042360
	C	00042370
ISN 00048	1010 FORMAT('1' // T10, 'XMAX =',1PE13.4 / T10, 'XMIN =',1PE13.4)	00042380
	C	00042390
ISN 00049	1020 FORMAT (T10, 'YMAX =',1PE13.4 / T10, 'YMIN =',1PE13.4)	00042400
ISN 00050	1030 FORMAT (T10, 'ZMAX =',1PE13.4 / T10, 'ZMIN =',1PE13.4 /)	00042410
	C	00042420
ISN 00051	1040 FORMAT (T40, 50A1)	00042430
	C	00042440
ISN 00052	END	00042450

SPECIFIED OPTIONS: NONAME,FLAG(I),BYNAME,GOSTMT,NOSTATIS,ISN(D),NOMAP,ELM(*)

```

ISN 00001      SUBROUTINE INTPL2( A, B, X, Y, N, IERR )      00042460
C                                                     00042470
C   THIS ROUTINE INTERPOLATES THE Y-VALUE TO THE X-VALUE BY SECOND 00042480
C   ORDER INTERPOLATION.                                         00042490
C                                                     00042500
C   A(N)      TABLE OF X(I),(I=1,2, , , N)                    00042510
C   B(N)      TABLE OF Y(I),(I=1,2, , , N)  B(I)=FUNC(A(I))   00042520
C   X         GIVEN X                                           00042530
C   Y         Y-VALUE FOR X (CALCULATED VALUE)                  00042540
C   N         NUMBER(SIZE) OF POINTS IN TABLE                 00042550
C   IERR      ERROR CODE                                         00042560
C                                                     00042570
C   IERR=0    NORMAL CONDITION                                   00042580
C   =2       VALUE OF X IS OUT-SIDE OF A(N) (MUST BE INSIDE)   00042590
C   =3       A IS NOT UNIQUE                                     00042600
C                                                     00042610
ISN 00002      DIMENSION A(N),B(N)                               00042620
C                                                     00042630
ISN 00003      DO 10 K=1,N                                       00042640
ISN 00004      IF ( A(K).NE.X ) GO TO 10                          00042650
ISN 00005      Y=B(K)                                             00042660
ISN 00006      IERR=0                                             00042670
ISN 00007      RETURN                                             00042680
ISN 00008      10 CONTINUE                                         00042690
C                                                     00042700
ISN 00009      IF ( N .GE. 3 ) GO TO 11                           00042710
ISN 00010      IERR = 1                                           00042720
ISN 00011      RETURN                                             00042730
C                                                     00042740
ISN 00012      11 IERR = 0                                         00042750
ISN 00013      OX = A(1)                                           00042760
ISN 00014      IF ( A(N)-OX ) 31,12,21                            00042770
ISN 00015      12 IERR = 3                                         00042780
ISN 00016      RETURN                                             00042790
C                                                     00042800
ISN 00017      21 IF ( X .LT. OX ) GO TO 19                         00042810
C                                                     00042820
ISN 00018      DO 23 K=2,N                                         00042830
ISN 00019      IF ( A(K) .LE. OX ) GO TO 12                       00042840
ISN 00020      OX = A(K)                                           00042850
ISN 00021      IF ( X .LE. OX ) GO TO 100                         00042860
ISN 00022      23 CONTINUE                                         00042870
C                                                     00042880
ISN 00023      19 IERR = 2                                         00042890
ISN 00024      RETURN                                             00042900
C                                                     00042910
ISN 00025      31 IF ( X .GT. OX ) GO TO 19                         00042920
ISN 00026      DO 33 K=2,N                                         00042930
ISN 00027      IF ( A(K) .GE. OX ) GO TO 12                       00042940
ISN 00028      OX = A(K)                                           00042950
ISN 00029      IF ( X .GE. OX ) GO TO 100                         00042960
ISN 00030      33 CONTINUE                                         00042970
ISN 00031      GO TO 19                                           00042980
C                                                     00042990
ISN 00032      100 DX = OX - A(K-1)                                00043000
ISN 00033      IF ( K .GT. 2 ) K=K-1                              00043010

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FACOM OSIV/F4 FORTRAN IV (HE) V04L18 INTPL2 DATE 83.01.26 TIME 14.49.08

ISN 00034	P = (X-A(K)) / DX	00043020
ISN 00035	Y = P*(1.+P)/2.*B(K+1) + (1.+P)*(1.-P)*B(K) - P*(1.-P)/2.*B(K-1)	00043030
ISN 00036	RETURN	00043040
ISN 00037	END	00043050

SPECIFIED OPTIONS: NONAME,FLAG(I),BYNAME,GOSTMT,NOSTATIS,ISN(D),NOMAP,ELM(*)

```

ISN 00001      SUBROUTINE D2ITPL( X,Y,Z,M,N,XX,YY,ZZ,MM,NN,IERR,ZYJ,ZIIJ,ZII ) 00043060
C                                                     00043070
C      THIS ROUTINE TRANSFORMES 2-DIMENSIONAL ARRAY Z( X(I),Y(J) ) 00043080
C      TO ZZ( XX(II),YY(JJ) ) IN THE SAME PLANE BY 2ND-ORDER INTERPOLA- 00043090
C      TION.
C      WHERE, I=1,2,,, ,M      (M.GE.3) 00043100
C              J=1,2,,, ,N      (N.GE.3) 00043120
C              II=1,2,,, ,MM 00043130
C              JJ=1,2,,, ,NN 00043140
C      X(I),Y(J),XX(II) AND YY(JJ) MUST BE PLACED IN SAME SPACES. 00043150
C      ** THIS ROUTINE NEEDS SUBROUTINE INTPL2 00043160
C      Z( X(I),Y(J) )      OLD 2-D ARRAY (INPUT ARRAY) 00043170
C      ZZ(XX(II),YY(JJ))   NEW 2-D ARRAY (OUTPUT ARRAY) 00043180
C      IERR                ERROR CODE      IERR=0  NORMAL CONDITION 00043190
C                               IERR=1  ABNORMAL CONDITION 00043200
C      ZYJ(I)              AUX ARRAY 00043210
C      ZIIJ(II,J)         00043220
C      ZII(J)             00043230
ISN 00002      DIMENSION X(M),Y(N),Z(M,N),XX(MM),YY(NN),ZZ(MM,NN),ZYJ(M), 00043240
C      1 ZIIJ(MM,N),ZII(N) 00043250
C      MESH POINTS TRANSFORMATION 00043260
ISN 00003      XL=X(M)-X(1) 00043270
ISN 00004      YL=Y(N)-Y(1) 00043280
ISN 00005      DO 10 II=1,MM 00043290
ISN 00006      10 XX(II)=X(1)+XL*(II-1)/(MM-1) 00043300
ISN 00007      DO 20 JJ=1,NN 00043310
ISN 00008      20 YY(JJ)=Y(1)+YL*(JJ-1)/(NN-1) 00043320
C                                                     00043330
C      X-COORDINATE PITCH TRANSFORMATION (INTERPOLATION) 00043340
ISN 00009      DO 30 J=1,N 00043350
ISN 00010      DO 25 I=1,M 00043360
ISN 00011      25 ZYJ(I)=Z(I,J) 00043370
ISN 00012      DO 30 II=1,MM 00043380
ISN 00013      CALL INTPL2( X, ZYJ, XX(II), ZIIJ(II,J), M, IER1 ) 00043390
ISN 00014      IF (IER1.EQ.0) GO TO 30 00043400
ISN 00015      PRINT 100 00043410
ISN 00016      IERR=1 00043420
ISN 00017      RETURN 00043430
ISN 00018      30 CONTINUE 00043440
C      Y-COORDINATE PITCH TRANSFORMATION 00043450
ISN 00019      DO 40 II=1,MM 00043460
ISN 00020      DO 35 J=1,N 00043470
ISN 00021      35 ZII(J)=ZIIJ(II,J) 00043480
ISN 00022      DO 40 JJ=1,NN 00043490
ISN 00023      CALL INTPL2( Y, ZII, YY(JJ), ZZ(II,JJ), N, IER2 ) 00043500
ISN 00024      IF (IER2.EQ.0) GO TO 40 00043510
ISN 00025      PRINT 200,IER2,II,JJ 00043520
ISN 00026      IERR=1 00043530
ISN 00027      RETURN 00043540
ISN 00028      40 CONTINUE 00043550
ISN 00029      IERR=0 00043560
ISN 00030      100 FORMAT ( /// T20,'ERROR HAPPEND IN SUBROUTINE D2ITPL (X-PITCH INT 00043570
C      2 1ERPOLATION)',/T20,'ERROR CODE =',I5, T40,'REFER ITPL2' / 00043580
C      2 T20,' J =',I5, / 00043590
C      3 T20,' II =',I5 // ) 00043600
C                                                     00043610

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FACOM OSIV/F4 FORTRAN IV (HE) V04L18 D2ITPL DATE 83.01.26 TIME 14.49.08

ISN 00031	200	FORMAT (///	T20,'ERROR HAPPEND IN SUBROUTINE D2ITPL (Y-PITCH INTO00043620	
		1ERPOLATION)'	//T20,'ERROR CODE =',I5, T40,'REFER ITPL2' /	00043630
	2	T20,	'II =',I5, /	00043640
	3	T20,	'JJ =',I5 //)	00043650
				00043660
				00043670
ISN 00032		RETURN		00043680
ISN 00033		END		

FACOM OSIV/F4 FORTRAN IV (HE) V04L18

DATE 83.01.26 TIME 14.49.09

SPECIFIED OPTIONS: NONAME,FLAG(I),BYNAME,GOSTMT,NOSTATIS,ISN(D),NOMAP,ELM(*)

```

ISN 00001      SUBROUTINE OPTOM                                00043690
C                                                       00043700
C           THIS ROUTINE OPTIMIZES RELAXATION FACTOR(OMEGA) FOR S.O.R. 00043710
C           AUTOMATICALLY.                                00043720
C           UPPER AND LOWER LIMIT OF OMEGA IS LIMITED BY DATA STATEMENT. 00043730
C                                                       00043740
C           IOMEGA      COUNT FOR OMEGA ADJUSTING CYCLE      00043750
C           TRACER      CODE FOR OMEGA ADJUSTING; '+' : INCREASING 00043760
C                                                       '-' : DECREASING 00043770
C                                                       '0' : NO ADJUSTING 00043780
C           OMEGA      RELAXATION FACTOR                    00043790
C           DOM        OMEGA ADJUSTING WIDTH                00043800
C           NSIGN      SIGN FROM S.O.R. ROUTINE; 1: NORMAL    00043810
C                                                       -1: OMEGA TOO LARGE 00043820
C           TN(I,J)    GRID DATA IN S.O.R. ROUTINE         00043830
C           TOLD(I,J)  RESERVED TN(I,J)                     00043840
C           WHERE      I=1,2,... M+1  J=1,2,... N+1          00043850
C                                                       00043860
C           SPECIAL COMMON FOR THIS ROUTINE                 00043870
ISN 00002      COMMON/COMOPT/ IOMEGA,DOM,NSIGN,TOLD(41,41),TRACER,DOMMIN 00043880
C           GENERAL COMMON TO LINK TN(I,J) AND OMEGA ETC., 00043890
ISN 00003      COMMON/TPUVC/ TN(41,41),PSI(41,41),U(41,41),V(41,41) 00043900
ISN 00004      COMMON/INTEC/ M,N,MCAL,NCAL,MW,KW,KALP,KDIST 00043910
ISN 00005      COMMON/SORCO/ OMEGA,OMPSI,ITERA,ITEL,ITEP,ERROR,ERRPSI,EPS,APS, 00043920
1              ERRORP 00043930
C                                                       00043940
ISN 00006      DOUBLE PRECISION TN,PSI 00043950
ISN 00007      DOUBLE PRECISION TOLD 00043960
ISN 00008      DATA OMMAX,OMMIN /1.860,1.00 / 00043970
ISN 00009      DATA UP,ZERO,DOWN/ '+','0','-'/ 00043980
C                                                       00043990
ISN 00010      IF (IOMEGA.EQ.0.OR.IOMEGA.EQ.1) GO TO 5 00044000
ISN 00011      IF (TRACER.EQ.UP.OR.TRACER.EQ.DOWN) GO TO 5 00044010
ISN 00012      GO TO 6 00044020
C                                                       00044030
ISN 00013      5 IOMEGA = IOMEGA + 1 00044040
ISN 00014      6 IF (IOMEGA.EQ.1) GO TO 10 00044050
C                                                       00044060
ISN 00015      IF (NSIGN.EQ.1) GO TO 20 00044070
ISN 00016      IF (NSIGN.EQ.-1) GO TO 100 00044080
C                                                       00044090
C           NSIGN IS NOT DEFINED 00044100
C           PRINT 1000 00044110
ISN 00017      WRITE(6,500) 00044120
ISN 00018      500 FORMAT('      NSIGN NOT DEFINED      ') 00044130
ISN 00019      STOP 00044140
ISN 00020      C                                                       00044150
ISN 00021      10 OMEGA = OMMAX 00044160
ISN 00022      DOM = 0.1*(OMMAX-OMMIN) 00044170
C                                                       00044180
C           RESERVATION OF TN(I,J) 00044190
ISN 00023      20 DO 30 J=1,N+1 00044200
ISN 00024      DO 30 I=1,M+1 00044210
ISN 00025      30 TOLD(I,J) = TN(I,J) 00044220
C                                                       00044230
ISN 00026      IF (IOMEGA.EQ.1) GO TO 40 00044240

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FACOM OSIV/F4 FORTRAN IV (HE) V04L18 OPTOM DATE 83.01.26 TIME 14.49.09

ISN 00027		GO TO 45		00044250
	C		INITIAL OMEGA CYCLE	00044260
ISN 00028		40 TRACER = ZERO		00044270
ISN 00029		RETURN		00044280
	C			00044290
ISN 00030		45 IF (DOM.GT.DOMMIN) GO TO 50		00044300
	C			00044310
	C		SATURATED OMEGA	00044320
ISN 00031		TRACER = ZERO		00044330
ISN 00032		RETURN		00044340
	C			00044350
ISN 00033		50 IF (TRACER.EQ.DOWN.AND.ITERA.GT.1) DOM = 0.1*DOM		00044360
ISN 00034		TRACER = UP		00044370
	C			00044380
	C		OMEGA INCREASING	00044390
ISN 00035		OMEGA = OMEGA + DOM		00044400
	C			00044410
ISN 00036		PRINT 1200, IOMEGA,OMEGA,DOM,NSIGN,TRACER		00044420
ISN 00037		RETURN		00044430
	C			00044440
	C		OMEGA DECREASING LOOP	00044450
ISN 00038		100 TRACER = DOWN		00044460
	C			00044470
	C		TN(I,J) RESET	00044480
ISN 00039		DO 110 J=1,N+1		00044490
ISN 00040		DO 110 I=1,M+1		00044500
ISN 00041		110 TN(I,J) = TOLD(I,J)		00044510
	C			00044520
	C		OMEGA DECREASING	00044530
ISN 00042		OMEGA = OMEGA - DOM		00044540
	C			00044550
ISN 00043		PRINT 1200, IOMEGA,OMEGA,DOM,NSIGN,TRACER		00044560
ISN 00044		RETURN		00044570
	C			00044580
	C		ALARM MESSAGE FORMATS	00044590
ISN 00045		1000 FORMAT (// T10, 'NSIGN SHOULD BE DEFINED IN S.O.R. ROUTINE',		00044600
		1 / T10, 'NSIGN SHOULD BE INCLUDE IN COMMON STATEMENT'//)		00044610
	C			00044620
	C		MESSAGE FORMAT	00044630
ISN 00046		1200 FORMAT(T2,10('*'),2X,'IOMEGA =',I4, 5X, 'OMEGA =', F7.4, 5X,		00044640
		1 'DOM =', 1PE13.3, 5X, 'NSIGN = ', I2, 5X, 'TRACER =',A1,		00044650
		2 5X, 10('*'))		00044660
	C			00044670

FACOM OSIV/F4 FORTRAN IV (HE) V04L18 DATE 83.01.26 TIME 14.49.10

SPECIFIED OPTIONS: NONAME,FLAG(I),BYNAME,GOSTMT,NOSTATIS,ISN(D),NOMAP,ELM(*)

	C		00044690
	C		00044700
	C		00044710
ISN 00001		SUBROUTINE PTSNGL	00044720
	C		00044730
	C		00044740
	C		00044750
ISN 00002		COMMON/INTEC/M,N,MCAL,NCAL,MW,KW,KALP,KDIST	00044760
ISN 00003		COMMON/TPUVC/TN(41,41),PSI(41,41),U(41,41),V(41,41)	00044770
ISN 00004		COMMON/SCOMM/TNS(41,41),PSIS(41,41)	00044780
ISN 00005		DOUBLE PRECISION TN,PSI	00044790
ISN 00006		DO 10 IR = 1,MCAL	00044800
ISN 00007		DO 10 JP = 1,NCAL	00044810
ISN 00008		TNS(IR,JP)=TN(IR,JP)	00044820
ISN 00009	10	PSIS(IR,JP) = PSI(IR,JP)	00044830
ISN 00010		RETURN	00044840
ISN 00011		END	00044850

SPECIFIED OPTIONS: NONAME, FLAG(I), BYNAME, GOSTMT, NOSTATIS, ISN(D), NOMAP, ELM(*)

```

C
C
C
ISN 00001      SUBROUTINE TABLE(Z,XLETER)
C
C
ISN 00002      COMMON/INTEC/M,N,MCAL,NCAL,MW,KW,KALP,KDIST
ISN 00003      COMMON/PARAC/RO,RW,PHIMAX,RADA
ISN 00004      COMMON/SORCO/OMEGA,OMPSI,ITERA,ITEL,ITEP,ERROR,ERRPSI,EPS,APS,
1              ERRORP
ISN 00005      COMMON/WALLC/WNU(41),AVNU,TCWBYI,TCWBYO,RAD
C
C
C
ISN 00006      DIMENSION Z(MCAL,NCAL),XLETER(2)
C
C
ISN 00007      DO 70 L=1,M,11
ISN 00008      IF(L+10.GT.M+1) GO TO 20
ISN 00009      LL = L+10
ISN 00010      GO TO 30
ISN 00011      20 LL = M+1
C
C
ISN 00012      30 JLINE = 0
ISN 00013      DO 70 J= 1,N+1
ISN 00014      IF(JLINE.GT.0) GO TO 60
C
ISN 00015      PRINT 100,RADA,RO,M,N,OMEGA,ITERA,ERROR
ISN 00016      IF(KALP.EQ.1) GO TO 40
ISN 00017      GO TO 50
ISN 00018      40 PRINT 110,AVNU,RW,MW,KW,TCWBYI,TCWBYO
ISN 00019      IF(KDIST.EQ.1) GO TO 42
ISN 00020      GO TO 44
ISN 00021      42 PRINT 150
ISN 00022      GO TO 50
ISN 00023      44 PRINT 160
ISN 00024      50 PRINT 120,(XLETER(I),I=1,2)
ISN 00025      PRINT 130,((I),I=L,LL)
C
C
ISN 00026      60 PRINT 140,J,(Z(I,J),I=L,LL)
ISN 00027      JLINE=JLINE+1
ISN 00028      IF(JLINE.EQ.24) JLINE=0
ISN 00029      70 CONTINUE
C
C
C
ISN 00030      RETURN
C
C
C
C
C
C
C

```

00045370
00045380
00045390
00045400
00045410
00045420
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00045720
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00045900
00045910
00045920

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FACOM OSIV/F4 FORTRAN IV (HE) V04L18      TABLE DATE 83.01.26 TIME 14.49.10
ISN 00031      100 FORMAT('1'///T7,'RADA =',1PE9.2,T27,' RO =',0PF6.2,T43,      .00045930
                1      'M =',I3,T55,' N =',I3,T67,'OMEGA =',1PE11.4,T91,      00045940
                2      'ITERA. =',I4,T113,'ERROR =',1PE10.3)      00045950
C      00045960
ISN 00032      110 FORMAT(/T7,'AVNU =',1PE9.2,T27,' RW =',0PF6.2,T43,      00045970
                1      'MW =',I3,T55,' KW =',I3,T67,'TCWBYI=',1PE11.4,      00045980
                2      T91,'TCWBYO=',1PE11.4)      00045990
C      00046000
C      00046010
ISN 00033      120 FORMAT(/T50,'DIMENSION LESS ',A4,A2,' DISTRIBUTION '/T50,      00046020
                1      34('-'))      00046030
C      00046040
C      00046050
C      00046060
ISN 00034      130 FORMAT(/T13,10('I =',I3,5X))      00046070
ISN 00035      140 FORMAT(/T3,'J =',I3,T10,1P11E11.3)      00046080
ISN 00036      150 FORMAT('+',T113,'WNU(J)=VARIABLE')      00046090
ISN 00037      160 FORMAT('+',T113,'WNU(J)=CONSTANT')      00046100
C      00046110
C      00046120
C      00046130
C      00046140
C      00046150
ISN 00038      END

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(2) FACOM OSIV/F4 FORTRAN IV (HE) V04L18

DATE 83.01.17 TIME 14.02.20

SPECIFIED OPTIONS: NONAME, FLAG(I), BYNAME, GDSTMT, NOSTATIS, ISN(D), NOMAP, ELM(*)

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C      NAPHAS3          NOV. 1976          BY H.SHIMOMURA          00000100
C      THIS PROGRAM COMPUTES THERMAL AND FLUID-DYNAMIC PERFORMANCES IN 00000200
C      HORIZONTAL ANNULAR POROUS SPACES IN GRAVITATIONAL FIELD.          00000300
C      REFERENCE DOCUMENTATION JAERI-M-          00000400
C      REFERENCE DOCUMENTATION JAERI-M-          00000500
C      REFERENCE DOCUMENTATION JAERI-M-          00000600
C      VARIABLES DEFINITION          00000700
C      VARIABLES DEFINITION          00000800
C      TN(I,J)          D-LESS TEMPERATURE AT ITERATION CYCLE ITERA          00000900
C      RI(I)           D-LESS RADIAL ARGUMENT (INNER RADIUS =1)          00001000
C      PHI(J)          ANGULAR ARGUMENT          00001100
C      RMIN            MINIMUM D-LESS RADIUS FOR CALCULATION (RMIN=1)          00001200
C      RMAX            MAXIMUM D-LESS RADIUS FOR CALC.(=OUTER R./INNER R.) 00001300
C      PHMIN           MINIMUM ANG.ARG. FROM BOTTOM CENTER (=0.0)          00001400
C      PHMAX           MAXIMUM ANG.ARG. FROM BOTTOM CENTER (=3.14... )          00001500
C      M               NUMBER OF RADIAL MESH FOR CALCULATION          00001600
C      N               NUMBER OF CIRCUMFERENTIAL MESH FOR CALC.          00001700
C      DR              RADIAL MESH WIDTH FOR CALC.          00001800
C      DPH             ANGULAR MESH WIDTH FOR CALC.          00001900
C      EXOMEGA         RELAXATION FACTOR GIVEN EXTERNALLY FOR ENERGY EQ. 00002000
C      ITERA           NUMBER OF ITERATION CYCLE          00002100
C      ITEL            LIMITED NUMBER OF ITERATION          00002200
C      SOLD            SUMMATION OF TO(I,J)          00002300
C      SNEW            SUMMATION OF TN(I,J)          00002400
C      OMEGA           RELAXATION FACTOR FOR ENERGY EQ.          00002500
C      OMPSI           RELAXATION FACTOR FOR EQ. OF MOTION          00002600
C      ERROR           ALLOWABLE CALCULATION ERROR FOR TN(I,J) AND PSI(I,J) 00002700
C      PSI(I,J)        D-LESS STREAM FUNCTION AT ITERATION CYCLE ITERA          00002800
C      DTDRO(J)        D-LESS RADIAL TEMP. GRADIENT AT R=RO/RI          00002900
C      DTDRI(J)        D-LESS RADIAL TEMP. GRADIENT AT R=1.0          00003000
C      U(I,J)          D-LESS RADIAL VELOCITY          00003100
C      V(I,J)          D-LESS ANGULAR VELOCITY          00003200
C      AVNUSO          AVERAGE NUSSELT NUMBER AT R=RO/RI          00003300
C      AVNUSS          AVERAGE NUSSELT NUMBER AT R=1.0          00003400
C      QIBYQM(J)       RELATIVE LOCAL HEAT FLUX AT INNER WALL(HEAT T COEFF) 00003500
C                     = ((KE/K)LOCAL)/((KE/K)AV.) AT R=1.0          00003600
C      QOBYQM(J)       RELATIVE LOCAL HEAT FLUX AT OUTER WALL(HEAT.T COEFF) 00003700
C                     = ((KE/K)LOCAL)/((KE/K)AV.) AT R=RO/RI          00003800
C      EKBYK(J)        RATIO OF EFFECTIVE AND MOLEC. T.CONDUCT. AT R=1.0 00003900
C      EKBYKO(J)       RATIO OF EFFECTIVE AND MOLEC. T.CONDUCT. AT R=RO/RI 00004000
C      CONT(I)         OPTION CONTROLLER (I=1,2, ...20)          00004100
C      CONT(1) = 'A'; EXTERNAL OMEGA IS USED, IF CONT(1).NE.'A', AUTOMATIC. 00004200
C      CONT(2) = 'A'; INTERPOLATED TEMPERATUR TABLES ARE PRINTED          00004300
C      CONT(3) = 'A'; INTERPOLATED STREAM FUNCTION TABLES ARE PRINTED          00004400
C      CONT(4) = 'A'; GRAPHIC TEMPERATUR DISTRIBUTION IS PRINTED          00004500
C      CONT(5) = 'A'; GRAPHIC FLOW PATTERN IS PRINTED          00004600
C      CONT(6) = 'A'; DATA FOR ISO-THERMAL LINE PLOTTING ARE OUTPUT IN          00004700
C                     DISK FILE. (CONTROL CARDS ARE NECESSARY)          00004800
C      CONT(7) = 'A'; DATA FOR STREAM LINE PLOTTING ARE OUTPUT IN          00004900
C                     DISK FILE. (CONTROL CARDS ARE NECESSARY)          00005000
C      CONT(8) = 'A'; GRAPHIC VORTICITY PATTERN IS PRINTED          00005100
C      CONT(9) = 'A'; GRAPHIC INERTIA PATTERN IS PRINTED          00005200
C      OPT             GRAPHIC OPTION CONTROLLER, IF OPT='SIMA', STRIPED          00005300
C                     GRAPHIC-PATTERNS ARE PRINTED          00005400
C      RADA            RAYLEIGH NUMBER * DARCY NUMBER          00005500
C                     RAYLEIGH NUMBER * DARCY NUMBER          00005600

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C
ISN 00001 COMMON/VELCO/ U( 41, 41),V( 41, 41) 00005700
ISN 00002 COMMON/INDEP/ RI( 41),PHI( 41),DR,DPH 00005800
ISN 00003 COMMON/TNPSI/ TN( 41, 41),PSI( 41, 41),RADA 00005900
ISN 00004 COMMON/SIGMA/ SNEW,SOLD,SPSI,SPSID 00006000
ISN 00005 COMMON/RPHIC/ RMIN,RMAX,PHMIN,PHMAX 00006100
ISN 00006 COMMON/INTEC/ M,N,MCAL,NCAL 00006200
ISN 00007 COMMON/SORCO/ OMEGA,ITERA,ITEL,ITEP,ERROR,ERRPSI,EPS,APS,OMPSI 00006300
ISN 00008 COMMON/CONCO/ CONT(80) 00006400
ISN 00009 COMMON/INERC/ SAHEN(41,41),UHEN(41,41),SBYU(41,41) 00006500
ISN 00010 DOUBLE PRECISION TN,OMEGA,DR,RI,DPH,RADA,PHI,PSI,OMPSI 00006600
ISN 00011 DOUBLE PRECISION U,V 00006700
ISN 00012 DIMENSION TNS(41,41), RIS(41), PHIS(41), XX( 50), YY( 50), 00006800
1 ZZ( 50, 50), ZYJ(41), ZIIJ( 50,41), ZII(41), 00006900
2 PSIS(41,41), XXP( 50), YYP( 50), ZZP( 50, 50), ZYJP(41), 00007000
3 ZIIJP( 50,41), ZIIP(41),EKBYK( 41),DTDRO( 41), 00007100
4 EKBYKO( 41),DTDRI( 41) 00007200
ISN 00013 DIMENSION ZETA( 41, 41) 00007300
ISN 00014 DIMENSION KZ(50,50),NZ(50,50) 00007400
ISN 00015 DIMENSION QIBYQM( 41),GOBYQM( 41) 00007500
C
ISN 00016 DATA CP, CN / 'A', ' ' / 00007600
ISN 00017 DATA ALPHBC/'ALPH'/ 00007700
ISN 00018 RMIN = 1. 00007800
ISN 00019 PHMIN = 0. 00007900
ISN 00020 PHMAX = 3.1415926 00008000
ISN 00021 CALL DATAON 00008100
C
ISN 00022 READ (5,1) M,N,ITEL,MPRINT,NPRINT 00008200
ISN 00023 MCAL = M+1 00008300
ISN 00024 NCAL = N+1 00008400
ISN 00025 READ (5,2) RMAX,RADA,ERROR,EXOMEG,OMPSI 00008500
ISN 00026 READ (5,3) (CONT(K),K=1,20),OPT,BCOUT 00008600
C
ISN 00027 IF (CONT(1).NE.CP) GO TO 4 00008700
ISN 00028 OMEGA=EXOMEG 00008800
ISN 00029 GO TO 5 00008900
C
CALCULATION OF OPTIMUM OMEGA
ISN 00030 4 A=3.1415926/M 00009000
ISN 00031 B=3.1415926/N 00009100
ISN 00032 TXY=COS(A)+COS(B) 00009200
ISN 00033 OMEGA=4.0-TXY**2.0 00009300
ISN 00034 OMEGA=DSQRT(OMEGA) 00009400
ISN 00035 OMEGA=(8.0-4.0*OMEGA)/TXY**2.0 00009500
C
MESH SIZE
ISN 00036 5 DR=(RMAX-RMIN)/M 00009600
ISN 00037 DPH=(PHMAX-PHMIN)/N 00009700
C
DO 10 I=1,M+1
ISN 00038 10 RI(I)=1.0+(I-1)*DR 00009800
ISN 00039
C
DO 20 J=1,N+1
ISN 00040 20 PHI(J)=PHMIN+(J-1)*DPH 00009900
ISN 00041
C
ITERA=0
ISN 00042
C
DO 30 J=1,N+1
ISN 00043

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FACOM OSIV/F4 FORTRAN IV (HE) V04L18		MAIN DATE 83.01.17	TIME 14.02.20
ISN 00044	DO 30 I=1,M+1		00011500
ISN 00045	TN(I,J)=(RMAX-RI(1))/(RMAX-RMIN)		00011600
	C		00011700
	C		00011800
ISN 00046	30 PSI(I,J) = 0.0		00011900
	C		00012000
ISN 00047	40 CONTINUE		00012100
	C		00012200
ISN 00048	SOLD=0.0		00012300
ISN 00049	SNEW=0.0		00012400
	C		00012500
ISN 00050	CALL SIMSOL		00012600
	C		00012700
	C		00012800
	C		00012900
ISN 00051	EPS=(SNEW-SOLD)/SNEW		00013000
ISN 00052	APS = ABS(EPS)		00013100
ISN 00053	IF(APS.LE.ERROR) GO TO 75		00013200
ISN 00054	IF(ITERA.LE.ITEL) GO TO 70		00013300
	C		00013400
	LATEST DATA OUTPUT		00013500
ISN 00055	PRINT 65, ITERA,OMEGA,EPS		00013600
ISN 00056	GO TO 80		00013700
	C		00013800
ISN 00057	70 ITERA = ITERA+1		00013900
ISN 00058	PRINT 240, ITERA,ITEP,APS,ERRPSI,OMEGA,DMPSI		00014000
	C		00014100
ISN 00059	GO TO 40		00014200
	C		00014300
ISN 00060	75 CONTINUE		00014400
ISN 00061	PRINT 230, ITERA,ITEP,EPS,ERRPSI		00014500
ISN 00062	80 CALL VELOCI		00014600
ISN 00063	CALL PTSNGL (TN,PSI,RI,PHI,TNS,PSIS,RIS,PHIS,MCAL,NCAL)		00014700
	C		00014800
ISN 00064	CALL VORTIC (RADA,TNS,DR,RI,PHI,DPH,MCAL,NCAL,ZETA)		00014900
ISN 00065	DO 76 L=1,M,11		00015000
ISN 00066	IF (L+10.GT.M+1) GO TO 81		00015100
ISN 00067	LL = L+10		00015200
ISN 00068	GO TO 82		00015300
ISN 00069	81 LL = M+1		00015400
ISN 00070	82 CONTINUE		00015500
ISN 00071	PRINT 101, RADA,RMAX,M,N,OMEGA,ERROR,ITERA,ITEP,OMPSI		00015600
ISN 00072	PRINT 100, (I, I=L,LL)		00015700
ISN 00073	DO 76 J=1,N+1		00015800
ISN 00074	76 PRINT 110, J, (TN(I,J),I=L,LL)		00015900
ISN 00075	IF (CONT(2).NE.CP) GO TO 77		00016000
ISN 00076	CALL TNOUT (MPRINT,NPRINT,MCAL,NCAL,TNS,RIS,PHIS,XX,YY,ZZ,ZYJ, 1 ZIIJ,ZII)		00016100
ISN 00077	77 CONTINUE		00016200
ISN 00078	DO 95 L=1,M,11		00016300
ISN 00079	IF (L+10.GT.M+1) GO TO 78		00016400
ISN 00080	LL = L+10		00016500
ISN 00081	GO TO 79		00016600
ISN 00082	78 LL = M+1		00016700
ISN 00083	79 CONTINUE		00016800
ISN 00084	PRINT 101, RADA,RMAX,M,N,OMEGA,ERROR,ITERA,ITEP,OMPSI		00016900
ISN 00085	PRINT 200, (I,I=L,LL)		00017000
ISN 00086	DO 95 J=1,N+1		00017100
ISN 00087	95 PRINT 210, J, (PSI(I,J),I=L,LL)		00017200

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FACOM OSIV/F4 FORTRAN IV (HE) V04L18      MAIN DATE 83.01.17 TIME 14.02.20

ISN 00088      IF (CONT(3).NE.CP) GO TO 96      00017300
ISN 00089      CALL PSIOUT (MPRINT,NPRINT,MCAL,NCAL,PSIS,RIS,PHIS,XXP,YYP,      00017400
1              ZZP,ZYJP, ZIIJP,ZIIP )          00017500
ISN 00090      96 CONTINUE                      00017600
C              U(I,J) PRINT OUT                00017700
ISN 00091      DO 320 L=1,M,11                  00017800
ISN 00092      IF (L+10.GT.M+1) GO TO 300      00017900
ISN 00093      LL = L+10                       00018000
ISN 00094      GO TO 310                       00018100
ISN 00095      300 LL = M+1                    00018200
ISN 00096      310 CONTINUE                    00018300
ISN 00097      PRINT 101, RADA,RMAX,M,N,OMEGA,ERROR,ITERA,ITEP,OMPSI      00018400
ISN 00098      PRINT 400                      00018500
ISN 00099      PRINT 410, (I,I=L,LL)          00018600
C                                                  00018700
ISN 00100      DO 320 J=1,N+1                  00018800
ISN 00101      320 PRINT 110, J, (U(I,J),I=L,LL) 00018900
C                                                  00019000
C              V(I,J) PRINT OUT                00019100
ISN 00102      DO 350 L=1,M,11                  00019200
ISN 00103      IF (L+10.GT.M+1) GO TO 330      00019300
ISN 00104      LL = L+10                       00019400
ISN 00105      GO TO 340                       00019500
ISN 00106      330 LL = M+1                    00019600
ISN 00107      340 CONTINUE                    00019700
ISN 00108      PRINT 101, RADA,RMAX,M,N,OMEGA,ERROR,ITERA,ITEP,OMPSI      00019800
ISN 00109      PRINT 420                      00019900
ISN 00110      PRINT 410, (I,I=L,LL)          00020000
C                                                  00020100
ISN 00111      DO 350 J=1,N+1                  00020200
ISN 00112      350 PRINT 110, J, (V(I,J),I=L,LL) 00020300
C              CALCULATION OF INERTIA          00020400
ISN 00113      CALL INERTA                     00020500
C                                                  00020600
C              SBYU(I,J) PRINT OUT            00020700
ISN 00114      DO 450 L=1,M,11                  00020800
ISN 00115      IF (L+10.GT.M+1) GO TO 430      00020900
ISN 00116      LL = L+10                       00021000
ISN 00117      GO TO 440                       00021100
ISN 00118      430 LL = M+1                    00021200
ISN 00119      440 CONTINUE                    00021300
ISN 00120      PRINT 101, RADA,RMAX,M,N,OMEGA,ERROR,ITERA,ITEP,OMPSI      00021400
ISN 00121      PRINT 500                      00021500
ISN 00122      PRINT 410, (I,I=L,LL)          00021600
C                                                  00021700
ISN 00123      DO 450 J=1,N+1                  00021800
ISN 00124      450 PRINT 110, J, (SBYU(I,J), I=L,LL) 00021900
C                                                  00022000
C              EFFECTIVE AND MOLECULAR CONDUCTIVITY RATIO 00022100
C              00022200
C              00022300
C              00022400
ISN 00125      DO 90 J=1,N+1                   00022500
ISN 00126      DTDRI(J) = (-25.*TN(1,J)+48.*TN(2,J)-36.*TN(3,J)+16.*TN(4,J)      00022600
1              -3.*TN(5,J))/(12.*DR)          00022700
ISN 00127      EKBYK(J) = -DTDRI(J)*ALOG(RMAX) 00022800
ISN 00128      DTDRO(J) = (25.*TN(M+1,J)-48.*TN(M,J)+36.*TN(M-1,J)-16.*TN(M-2,J)      00022900
1              +3.*TN(M-3,J))/(12.*DR)        00023000
ISN 00129      EKBYKO(J) = -DTDRO(J)*RMAX*ALOG(RMAX)

```



```

C
C          OUTPUT FORMATS
ISN 00173 100 FORMAT ( //T45, 'SOLUTION OF D-LESS TEMPERATUR DISTRIBUTION ' /
1          // T13, 11( 'I =', I3, 5X ) )
ISN 00174 101 FORMAT ('1' / T2, 'RADA =', 1PE8.1, T18, 'RO/RI =', 0PF5.2, T32, 'M =', I3,
1          T40, 'N =', I3, T48, 'OMEGA =', 1PE11.4, T68, 'ERROR =', 1PE10.3,
2          T87, 'ITERA =', I4, T101, 'ITEP =', I4, T113, 'OMPSI =', 1PE11.4 )
C
ISN 00175 110 FORMAT ( / T3, 'J =', I3, T10, 1P11D11.3 )
C
ISN 00176 111 FORMAT ( '1' // T47, 'EFFECTIVE CONDUCTIVITY ON INNER WALL'
A          // T20, 'AVNUSS = ', 1PE15.3, T50, 'RADA = ', 1PE15.3,
1          T80, 'RMAX = ', 1PE15.3, // T5, 9( 'J', 4X, 'KE/K',
2          5X ) / )
ISN 00177 115 FORMAT ( /// T47, 'EFFECTIVE CONDUCTIVITY ON OUTER WALL'
A          // T20, 'AVNUSO = ', 1PE15.3, T50, 'RADA = ', 1PE15.3,
1          T80, 'RMAX = ', 1PE15.3, // T5, 9( 'J', 4X, 'KE/K',
2          5X ) / )
C
ISN 00178 121 FORMAT ( 9(I6, F8.4 ) / )
ISN 00179 122 FORMAT ( // T46, 'RELATIVE LOCAL HEAT FLUX AT INNER WALL' //
1          T5, 9( 'J', 3X, 'Q(J)/QM', 3X ) / )
ISN 00180 123 FORMAT ( // T46, 'RELATIVE LOCAL HEAT FLUX AT OUTER WALL' //
1          T5, 9( 'J', 3X, 'Q(J)/QM', 3X ) / )
ISN 00181 200 FORMAT ( //T45, 'SOLUTION OF D-LESS STREAM FUNCTION' ///
1          T13, 11( 'I =', I3, 5X ) )
C
ISN 00182 210 FORMAT ( / T3, 'J =', I3, T10, 1P11D11.3 )
ISN 00183 230 FORMAT ( '1' // T20, ' TN(I,J) AND PSI(I,J) ARE CONVERGED.', //
1          T20, ' ITERA = ', I4, T50, '(TEMP-LOOP)',
2          / T20, ' ITEP = ', I4, T50, '(PSI-LOOP)',
3          / T20, ' EPS = ', 1PE13.4, T50, '(TEMP ERROR)',
4          / T20, ' ERRPSI = ', 1PE13.4, T50, '(PSI-ERROR)' / )
ISN 00184 240 FORMAT ( T10, 'ITERA =', I4, T24, 'ITEP =', I4, T37,
1          'APS =', 1PE13.4, T61, 'ERRPSI =', 1PE13.4,
2          T85, 'OMEGA =', 1PE13.4, T110, 'OMPSI =', 1PE13.4 )
C
C
ISN 00185 250 FORMAT ( ///T47, ' NORMALIZED TEMPERATURE DISTRIBUTION ' )
ISN 00186 260 FORMAT ( ///T45, ' NORMALIZED STREAM FUNCTION DISTRIBUTION ' )
ISN 00187 265 FORMAT ( ///T57, ' VORTICITY ' )
ISN 00188 266 FORMAT ( ///T59, ' INERTIA ' )
C
ISN 00189 400 FORMAT ( // T48, 'DIMENSIONLESS RADIAL VELOCITY U(I,J)' )
ISN 00190 410 FORMAT ( /// T13, 11( 'I =', I3, 5X ) )
ISN 00191 420 FORMAT ( // T43, 'DIMENSIONLESS CIRCUMFERENTIAL VELOCITY V(I,J)')
ISN 00192 500 FORMAT ( // T46, 'DIMENSIONLESS INERTIA SBYU(I,J)*(PR)/(DA) ' )
C
ISN 00193 STOP
ISN 00194 END

```

FACOM DSIV/F4 FORTRAN IV (HE) V04L18

DATE 83.01.17 TIME 14.02.21

SPECIFIED OPTIONS: NONAME, FLAG(I), BYNAME, GOSTMT, NOSTATIS, ISN(D), NOMAP, ELM(*)

ISN 00001	SUBROUTINE PTSNGL(TN,PSI,RI,PHI,TNS,PSIS,RIS,PHIS,MCAL,NCAL)	00033900
ISN 00002	DOUBLE PRECISION TN,PSI,RI,PHI	00034000
ISN 00003	DIMENSION TN(41,41),PSI(41,41),RI(41),PHI(41),TNS(MCAL,NCAL),	00034100
	1 PSIS(MCAL,NCAL),RIS(MCAL),PHIS(NCAL)	00034200
	DO 10 IR=1,MCAL	00034300
ISN 00004	DO 10 JP=1,NCAL	00034400
ISN 00005	TNS(IR,JP)=TN(IR,JP)	00034500
ISN 00006	PSIS(IR,JP)=PSI(IR,JP)	00034600
ISN 00007	RIS(IR)=RI(IR)	00034700
ISN 00008	10 PHIS(JP)=PHI(JP)	00034800
ISN 00009	RETURN	00034900
ISN 00010	END	00035000
ISN 00011		

FACOM OSIV/F4 FORTRAN IV (HE) V04L18 DATE 83.01.17 TIME 14.02.21
 SPECIFIED OPTIONS: NONAME,FLAG(I),BYNAME,GOSTMT,NOSTATIS,ISN(D),NOMAP,ELM(*)

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ISN 00001      SUBROUTINE TNOUT (MM,NN,MCAL,NCAL,TNS,RIS,PHIS,XX,YY,ZZ,ZYJ,ZIIJ, 00035100
                1          ZII ) 00035200
                C 00035300
                C 00035400
ISN 00002      COMMON/SORCO/ OMEGA,ITERA,ITEL,ITEP,ERROR,ERRPSI,EPS,APS,OMPSI 00035500
ISN 00003      COMMON/TNPSI/ TN( 41, 41),PSI( 41, 41),RADA 00035600
ISN 00004      COMMON/RPHIC/ RMIN,RMAX,PHMIN,PHMAX 00035700
                C 00035800
ISN 00005      DOUBLE PRECISION TN,OMEGA,DR,RI,DPH,RADA,PHI,PSI 00035900
ISN 00006      DOUBLE PRECISION OMPSI 00036000
                C 00036100
                C 00036200
ISN 00007      DIMENSION TNS(MCAL,NCAL),RIS(MCAL), PHIS(NCAL), XX(MM), YY(NN), 00036300
                1          ZZ(MM,NN), ZYJ(MCAL), ZIIJ(MM,NCAL), ZII(NCAL) 00036400
                C 00036500
ISN 00008      CALL D2ITPL( RIS,PHIS,TNS,MCAL,NCAL,XX,YY,ZZ,MM,NN,IERO,ZYJ,ZIIJ, 00036600
                1          ZII ) 00036700
ISN 00009      IF ( IERO.EQ.0 ) GO TO 20 00036800
ISN 00010      PRINT 100 00036900
ISN 00011      STOP 00037000
ISN 00012      20 CONTINUE 00037100
ISN 00013      DO 40 L=1,MM,11 00037200
ISN 00014      IF ( L+11.GT.MM ) GO TO 25 00037300
ISN 00015      LL = L+10 00037400
ISN 00016      GO TO 30 00037500
                C 00037600
ISN 00017      25 LL = MM 00037700
ISN 00018      30 CONTINUE 00037800
                C 00037900
                C 00038000
ISN 00019      PRINT 150,RADA,RMAX,RMIN,PHMAX,PHMIN,MCAL,NCAL,ITERA,EPS 00038100
ISN 00020      PRINT 160 00038200
ISN 00021      PRINT 200,( XX(IR), IR=L,LL) 00038300
ISN 00022      DO 40 JP=1,NN 00038400
ISN 00023      YYDEG = YY(JP)*180./3.1415926 00038500
ISN 00024      40 PRINT 300, YY(JP),YYDEG,(ZZ(IR,JP),IR=L,LL) 00038600
ISN 00025      RETURN 00038700
                C 00038800
                C 00038900
ISN 00026      ERROR MESSAGE 00039000
                100 FORMAT ( // T20, 'ERROR HAPPENED IN TNOUT (D2ITPL) ' // ) 00039100
                C 00039200
                C 00039300
ISN 00027      OUTPUT FORMAT 00039400
                150 FORMAT ( '1', // T10, 'RADA = ', 1P10.3, T30, 'RMAX = ', 1PE10.3, 00039500
                1          T50, 'RMIN = ', 1PE10.3, T70, 'PHMAX = ', 1PE10.3, T90, 00039600
                2          'PHMIN = ', 1PE10.3 // T10, 'MCAL =', I4, '(R-MESH)', 00039700
                3          T30, 'NCAL =', I4, '(PHI-MESH)', T70, 'ITERA =', I8, 00039800
                4          T90, 'EPS = ', 1PE10.3 / ) 00039900
ISN 00028      160 FORMAT (T46, 'TABLE OF INTERPOLATED TEMPERATURE DISTRIBUTION' / 00040000
                1          T46, 46(' ') // 00040100
                2          T5, '(YY)', T11, 11(7X,'(XX)') / 00040200
                3          T5, 'PHI(DEG)', T19, 'R =', T22, 10(8X, 'R =') ) 00040300
ISN 00029      200 FORMAT ( T15, 1P11E11.3 / ) 00040400
ISN 00030      300 FORMAT ( / T2,F5.3, '( ', F5.1, ' )', T15,1P11E11.3 )
                C
    
```


FACOM OSIV/F4 FORTRAN IV (HE) V04L18 DATE 83.01.17 TIME 14.02.21

SPECIFIED OPTIONS: NONAME, FLAG(I), BYNAME, GOSTMT, NOSTATIS, ISN(D), NOMAP, ELM(*)

```

ISN 00001      SUBROUTINE PSIOUT (MM,NN,MCAL,NCAL,PSIS,RIS,PHIS,XXP,YYP,ZZP,      00040600
                1      ZYJP, ZIIJP,ZIIP )      00040700
                C      00040800
                C      00040900
                C      00041000
                C      00041100
ISN 00002      COMMON/RPHIC/ RMIN,RMAX,PHMIN,PHMAX      00041200
ISN 00003      COMMON/TNPSI/ TN( 41, 41),PSI( 41, 41),RADA      00041300
ISN 00004      COMMON/SORCO/ OMEGA,ITERA,ITEL,ITEP,ERROR,ERRPSI,EPS,APS,OMPSI      00041400
ISN 00005      DOUBLE PRECISION TN,OMEGA,DR,RI,DPH,RADA,PHI,PSI      00041500
ISN 00006      DOUBLE PRECISION OMPSI      00041600
ISN 00007      DIMENSION PSIS(MCAL,NCAL), RIS(MCAL), PHIS(NCAL), XXP(MM), YYP(NN)00041700
                1,      ZZP(MM,NN), ZYJP(MCAL), ZIIJP(MM,NCAL), ZIIP(NCAL)      00041800
                C      00041900
ISN 00008      CALL D2ITPL (RIS,PHIS,PSIS,MCAL,NCAL,XXP,YYP,ZZP,MM,NN,IERP,ZYJP,      00042000
                1      ZIIJP,ZIIP )      00042100
ISN 00009      IF ( IERP.EQ.0 ) GO TO 20      00042200
ISN 00010      PRINT 100      00042300
ISN 00011      STOP      00042400
ISN 00012      20 CONTINUE      00042500
ISN 00013      DO 40 L=1,MM,11      00042600
ISN 00014      IF ( L+11.GT.MM ) GO TO 25      00042700
ISN 00015      LL = L+10      00042800
ISN 00016      GO TO 30      00042900
                C      00043000
ISN 00017      25 LL = MM      00043100
ISN 00018      30 CONTINUE      00043200
                C      00043300
ISN 00019      PRINT 150, RADA,RMAX,RMIN,PHMAX,PHMIN,MCAL,NCAL,ITERA,ERRPSI      00043400
ISN 00020      PRINT 160      00043500
ISN 00021      PRINT 200, (XXP(IR), IR=L,LL )      00043600
                C      00043700
ISN 00022      DO 40 JP=1,NN      00043800
ISN 00023      YYDEG =      YYP(JP)*180.0/3.1415926      00043900
ISN 00024      40 PRINT 300, YYP(JP),YYDEG,(ZZP(IR,JP),IR=L,LL)      00044000
ISN 00025      RETURN      00044100
                C      00044200
ISN 00026      ERROR MESSAGE      00044300
                100 FORMAT ( // T20, 'ERROR HAPPENED IN PSIOUT (D2ITPL) ' // )      00044400
                C      00044500
                C      00044600
ISN 00027      OUTPUT FORMATS      00044700
                150 FORMAT ( '1' // T10, 'RADA = ', 1PD10.3, T30, 'RMAX = ', 1PE10.3,      00044800
                1      T50,'RMIN = ', 1PE10.3,T70, 'PHMAX = ', 1PE10.3, T90,      00044900
                2      'PHMIN = ', 1PE10.3, // T10, 'MCAL = ', I4, '(R-MESH)',      00045000
                3      T30, 'NCAL = ', I4, '(PHI-MESH)', T70, 'ITERA = ', I8,      00045100
                4      T90, 'ERRPSI = ', 1PE10.3 // )      00045200
ISN 00028      160 FORMAT ( / T50, 'TABLE OF INTERPOLATED STREAM FUNCTION' / T50,      00045300
                1 37('-')//T5,'(YYP)', T11, 11( 6X, '(XXP)') / T5, 'PHI(DEG)',      00045400
                2      T19, 'R = ', T22, 10( 8X, 'R = ' )      00045500
ISN 00029      200 FORMAT ( T15, 1P11E11.3 / )      00045600
ISN 00030      300 FORMAT (/T2, F5.3, '( ', F5.1, ' )', T15, 1P11E11.3 )
                C
    
```

FACOM OSIV/F4 FORTRAN IV (HE) VO4L18

DATE 83.01.17 TIME 14.02.22

SPECIFIED OPTIONS: NONAME, FLAG(I), BYNAME, GOSTMT, NOSTATIS, ISN(D), NOMAP, ELM(*)

ISN 00001	SUBROUTINE VELOCI	00045800
ISN 00002	COMMON/INTEC/ M,N,MCAL,NCAL	00045900
ISN 00003	COMMON/TNPSI/ TN(41, 41),PSI(41, 41),RADA	00046000
ISN 00004	COMMON/VELCO/ U(41, 41),V(41, 41)	00046100
ISN 00005	COMMON/INDEP/ RI(41),PHI(41),DR,DPH	00046200
ISN 00006	DOUBLE PRECISION PSI,RI,DR,DPH,TN,RADA,PHI	00046300
ISN 00007	DOUBLE PRECISION U,V	00046400
ISN 00008	DO 10 J=1,N+1	00046500
ISN 00009	DO 10 I=1,M+1	00046600
ISN 00010	IF (J.EQ.1) GO TO 1	00046700
ISN 00011	IF (J.EQ.N+1) GO TO 2	00046800
ISN 00012	U(I,J) = (PSI(I,J+1)-PSI(I,J-1)) / (2.0*RI(I)*DPH)	00046900
ISN 00013	GO TO 3	00047000
	C	00047100
ISN 00014	1 U(I,J) = (PSI(I,J+1)-PSI(I,J)) / (RI(I)*DPH)	00047200
ISN 00015	GO TO 3	00047300
	C	00047400
ISN 00016	2 U(I,J) = (PSI(I,J)-PSI(I,J-1)) / (RI(I)*DPH)	00047500
	C	00047600
ISN 00017	3 IF (I.EQ.1) GO TO 4	00047700
ISN 00018	IF (I.EQ.M+1) GO TO 5	00047800
ISN 00019	V(I,J) = (PSI(I-1,J)-PSI(I+1,J)) / (2.0*DR)	00047900
ISN 00020	GO TO 10	00048000
	C	00048100
ISN 00021	4 V(I,J) = (PSI(I,J)-PSI(I+1,J)) / DR	00048200
ISN 00022	GO TO 10	00048300
ISN 00023	5 V(I,J) = (PSI(I-1,J)-PSI(I,J)) / DR	00048400
ISN 00024	10 CONTINUE	00048500
ISN 00025	RETURN	00048600
ISN 00026	END	00048700

FACOM OSIV/F4 FORTRAN IV (HE) V04L18 DATE 83.01.17 TIME 14.02.22

SPECIFIED OPTIONS: NONAME, FLAG(I), BYNAME, GOSTMT, NOSTATIS, ISN(D), NOMAP, ELM(*)

```

ISN 00001      SUBROUTINE VORTIC(RADA, TN, DR, RI, PHI, DPH, MCAL, NCAL, ZETA)      00048800
C                                                     00048900
C      RADA      RA * DA      00049000
C      TNS      TEMPERATURE      00049100
C      DR      RADIAL MESH SIZE      00049200
C      RI      RADIUS      00049300
C      PHI      ANGLE FROM BOTTOM CENTER      (RAD)      00049400
C      DPH      ANGULAR MESH SIZE      00049500
C      ZETA      VORTICITY      00049600
C                                                     00049700
ISN 00002      DIMENSION TN(MCAL, NCAL), RI(MCAL), PHI(NCAL), ZETA(MCAL, NCAL)      00049800
ISN 00003      DOUBLE PRECISION RADA, DR, RI, PHI, DPH, D, E      00049900
C                                                     00050000
ISN 00004      DO 60 J=1, NCAL      00050100
ISN 00005      DO 60 I=1, MCAL      00050200
ISN 00006      IF (J.EQ.1) GO TO 10      00050300
ISN 00007      IF (J.EQ.NCAL) GO TO 20      00050400
C                                                     00050500
ISN 00008      E = (TN(I, J+1) - TN(I, J-1)) / (2. * DPH * RI(I)) * DCOS(PHI(J))      00050600
ISN 00009      GO TO 30      00050700
ISN 00010      10 E = (TN(I, 2) - TN(I, 1)) / (DPH * RI(I)) * DCOS(PHI(J))      00050800
ISN 00011      GO TO 30      00050900
ISN 00012      20 E = (TN(I, NCAL) - TN(I, NCAL-1)) / (RI(I) * DPH) * DCOS(PHI(J))      00051000
C                                                     00051100
ISN 00013      30 IF (I.EQ.1) GO TO 40      00051200
ISN 00014      IF (I.EQ.MCAL) GO TO 50      00051300
ISN 00015      D = (TN(I+1, J) - TN(I-1, J)) / (2.0 * DR) * DSIN(PHI(J))      00051400
ISN 00016      GO TO 60      00051500
ISN 00017      40 D = (TN(2, J) - TN(1, J)) / DR * DSIN(PHI(J))      00051600
ISN 00018      GO TO 60      00051700
ISN 00019      50 D = (TN(MCAL, J) - TN(MCAL-1, J)) / DR * DSIN(PHI(J))      00051800
C                                                     00051900
C                                                     00052000
ISN 00020      60 ZETA(I, J) = -RADA * (D+E)      00052100
C                                                     00052200
C                                                     00052300
ISN 00021      RETURN      00052400
ISN 00022      END
    
```

FACOM OSIV/F4 FORTRAN IV (HE) V04L18

DATE 83.01.17 TIME 14.02.22

SPECIFIED OPTIONS: NONAME, FLAG(I), BYNAME, GOSTMT, NOSTATIS, ISN(D), NOMAP, ELM(*)

```

ISN 00001      SUBROUTINE PSISOL                                00052500
C                                                       00052600
C   THIS ROUTINE SOLVES EQ. OF MOTION IN HORIZONTAL ANNULAR POROUS 00052700
C   MEDIA BY EXTRAPOLATED LIEBMANN METHOD                      00052800
C                                                       REVISID ON MARCH 1978 00052900
C   TN          DIMENSIONLESS TEMPERATURE AT MESH POINTS (I,J) 00053000
C   PSI         DIMENSIONLESS STREAM FUNCTION AT MESH POINTS (I,J) 00053100
C   OMPSI       RELAXATION FACTOR                             00053200
C                                                       00053300
ISN 00002      COMMON/TNPSI/ TN( 41, 41),PSI( 41, 41),RADA    00053400
ISN 00003      COMMON/SIGMA/ SNEW,SOLD,SPSI,SPSIO              00053500
ISN 00004      COMMON/INDEP/ RI( 41),PHI( 41),DR,DPH          00053600
ISN 00005      COMMON/INTEC/ M,N,MCAL,NCAL                    00053700
ISN 00006      COMMON/SORCD/ OMEGA,ITERA,ITEL,ITEP,ERROR,ERRPSI,EPS,APS,OMPSI 00053800
C                                                       00053900
C                                                       00054000
ISN 00007      DOUBLE PRECISION TN,PSI,OMEGA,DR,RI,DPH,RADA,PHI,A,B,C,D,E,F,OMPSI 00054100
C                                                       00054200
C                                                       00054300
C                                                       00054400
ISN 00008      ITEP = 0                                       00054500
ISN 00009      1 SPSI = 0.                                       00054600
ISN 00010      SPSIO = 0.                                       00054700
C                                                       00054800
ISN 00011      DO 10 J=2,N                                       00054900
ISN 00012      DO 10 I=2,M                                       00055000
ISN 00013      A = 2.0/DR**2 + 2.0/(RI(I)*DPH)**2                00055100
ISN 00014      B = (PSI(I+1,J)+PSI(I-1,J))/DR**2                00055200
ISN 00015      C = (PSI(I+1,J) - PSI(I-1,J))/(2.0*RI(I)*DR)    00055300
ISN 00016      D = (PSI(I,J+1)+PSI(I,J-1))/(RI(I)*DPH)**2     00055400
ISN 00017      E = (TN(I+1,J)-TN(I-1,J))/(2.0*DR)*DSIN(PHI(J)) 00055500
ISN 00018      F = (TN(I,J+1)-TN(I,J-1))/(2.0*RI(I)*DPH)*DCOS(PHI(J)) 00055600
C                                                       00055700
ISN 00019      SPSIO = SPSIO+PSI(I,J)                             00055800
ISN 00020      PSI(I,J) = (1.0-OMPSI)*PSI(I,J)+OMPSI/A*(B+C+D+RADA*(E+F)) 00055900
ISN 00021      10 SPSI = SPSI + PSI(I,J)                          00056000
C                                                       00056100
ISN 00022      ITEP = ITEP+1                                       00056200
ISN 00023      ERRPSI = ABS((SPSI-SPSIO)/SPSI)                   00056300
ISN 00024      IF (ITEP.GT.ITEL) GO TO 20                          00056400
ISN 00025      IF (ERRPSI.LT.ERROR) GO TO 30                      00056500
C                                                       00056600
ISN 00026      GO TO 1                                             00056700
C                                                       00056800
ISN 00027      20 PRINT 100, ITERA,ITEP,ERRPSI,EPS               00056900
C                                                       00057000
C                                                       00057100
ISN 00028      STOP                                             00057200
ISN 00029      30 RETURN                                          00057300
C                                                       00057400
ISN 00030      100 FORMAT ( '1' // T20, ' PSI DOES NOT CONVERGE IN PSISOL ' // 00057500
1          T20, ' ITERA= ', I4, T50, '(TEMP-LOOP)'              00057600
2          / T20, ' ITEP = ', I4, T50, '(PSI-LOOP)'             00057700
3          / T20, ' ERRPSI= ', 1PE13.4, T50, '(PSI-ERROR)'      00057800
4          / T20, ' EPS = ', 1PE13.4, T50, '(TEMP-ERROR)'/ )    00057900
C

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FACOM OSIV/F4 FORTRAN IV (HE) V04L18 DATE 83.01.17 TIME 14.02.22

SPECIFIED OPTIONS: NONAME, FLAG(1), BYNAME, GOSTMT, NOSTATIS, ISN(D), NOMAP, ELM(*)

```

ISN 00001      SUBROUTINE INERTA                                00058100
C                                                       00058200
C                                                       00058300
ISN 00002      COMMON/TNPSI/ TN(41,41),PSI(41,41),RADA        00058400
ISN 00003      COMMON/INDEP/ RI(41),PHI(41),DR,DPH            00058500
ISN 00004      COMMON/INTEC/ M,N,MCAL,NCAL                    00058600
ISN 00005      COMMON/VELCO/ U( 41, 41),V( 41, 41)            00058700
ISN 00006      COMMON/INERC/ SAHEN(41,41),UHEN(41,41),SBYU(41,41) 00058800
C                                                       00058900
ISN 00007      DOUBLE PRECISION TN,PSI,RADA,RI,PHI,DR,DPH     00059000
ISN 00008      DOUBLE PRECISION U,V                            00059100
C                                                       00059200
ISN 00009      SBUMAX = 0.0                                     00059300
C                                                       00059400
ISN 00010      DO 1000 J = 1,N+1                                00059500
ISN 00011      DO 1000 I = 1,M+1                                00059600
C                                                       00059700
ISN 00012      IF (I.EQ.1) GO TO 15                             00059800
ISN 00013      IF (I.EQ.M+1) GO TO 10                           00059900
C                                                       00060000
C                                                       00060100
C               *** I = 2 TO M ***
ISN 00014      D2PDR2 = (PSI(I-1,J)-2.*PSI(I,J)+PSI(I+1,J))/DR**2 00060200
ISN 00015      D3R2DP = (RI(I-1)*U(I-1,J)-2.*RI(I)*U(I,J)+RI(I+1)*U(I+1,J))/DR**2 00060300
ISN 00016      D2DRDP = (RI(I+1)*U(I+1,J)-RI(I-1)*U(I-1,J))/(2.*DR) 00060400
ISN 00017      DTDR=(TN(I+1,J)-TN(I-1,J))/(2.*DR)            00060500
ISN 00018      IF (I.EQ.M) GO TO 30                             00060600
C                                                       00060700
C                                                       00060800
C               *** I = 2 TO M-1 ***
ISN 00019      D3PDR3 = (-PSI(I-1,J)+3.*PSI(I,J)-3.*PSI(I+1,J)+PSI(I+2,J))/DR**3 00060900
ISN 00020      GO TO 50                                         00061000
C                                                       00061100
C               *** I = M+1 ***
ISN 00021      10 ASIGN = -1.0                                   00061200
ISN 00022      ISX = -1                                         00061300
ISN 00023      GO TO 20                                         00061400
C                                                       00061500
C               *** I = 1 ***
ISN 00024      15 ASIGN = 1.0                                    00061600
ISN 00025      ISX = 1                                          00061700
C                                                       00061800
C               *** I = 1 OR M+1 ***
ISN 00026      20 IX1 = ISX                                     00061900
ISN 00027      IX2 = 2*ISX                                      00062000
ISN 00028      IX3 = 3*ISX                                      00062100
ISN 00029      IX4 = 4*ISX                                      00062200
C                                                       00062300
ISN 00030      D2PDR2 = ASIGN*(2.*PSI(I,J)-5.*PSI(I+IX1,J)+4.*PSI(I+IX2,J) 00062400
1          -1.*PSI(I+IX3,J))/DR**2                               00062500
ISN 00031      D3R2DP = ASIGN*(2.*RI(I)*U(I,J)-5.*RI(I+IX1)*U(I+IX1,J) 00062600
1          +4.*RI(I+IX2)*U(I+IX2,J)-RI(I+IX3)*U(I+IX3,J))/DR**2 00062700
ISN 00032      D2DRDP = ASIGN*(-RI(I)*U(I,J)+RI(I+IX1)*U(I+IX1,J))/DR 00062800
ISN 00033      DTDR = ASIGN*(-TN(I,J)+TN(I+IX1,J))/DR         00062900
ISN 00034      GO TO 40                                         00063000
C                                                       00063100
C               *** I = M ***
ISN 00035      30 ASIGN = -1.0                                   00063200
ISN 00036      IX1 = -1                                         00063300

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FACOM DSIV/F4 FORTRAN IV (HE) V04L18 INERTA DATE 83.01.17 TIME 14.02.22

ISN 00037	IX2 = -2	00063700
ISN 00038	IX3 = -3	00063800
ISN 00039	IX4 = -4	00063900
		00064000
	C	00064100
	C	00064200
ISN 00040	40 D3PDR3 = 0.5*ASIGN*(1 -5.*PSI(I,J)+18.*PSI(I+IX1,J)-24.*PSI(I+IX2,J) +14.*PSI(I+IX3,J)-3.*PSI(I+IX4,J))/DR**3	00064300
	C	00064400
	C	00064500
ISN 00041	50 IF (J.EQ.1) GO TO 65	00064600
ISN 00042	IF (J.EQ.N+1) GO TO 60	00064700
	C	00064800
	C	00064900
ISN 00043	D2PDP2 = (PSI(I,J-1)-2.*PSI(I,J)+PSI(I,J+1))/DPH**2	00065000
ISN 00044	D3P2DR = -(V(I,J-1)-2.*V(I,J)+V(I,J+1))/DPH**2	00065100
ISN 00045	DTDP = (TN(I,J+1)-TN(I,J-1))/(2.*DPH)	00065200
ISN 00046	IF (J.EQ.N) GO TO 80	00065300
	C	00065400
	C	00065500
ISN 00047	D3PDP3=(-PSI(I,J-1)+3.*PSI(I,J)-3.*PSI(I,J+1)+PSI(I,J+2))/DPH**3	00065600
ISN 00048	GO TO 95	00065700
	C	00065800
	C	00065900
ISN 00049	60 BSIGN = -1.0	00066000
ISN 00050	JSX = -1	00066100
ISN 00051	GO TO 70	00066200
	C	00066300
	C	00066400
ISN 00052	65 BSIGN = 1.0	00066500
ISN 00053	JSX = 1	00066600
	C	00066700
	C	00066800
ISN 00054	70 JX1 = JSX	00066900
ISN 00055	JX2 = 2*JSX	00067000
ISN 00056	JX3 = 3*JSX	00067100
ISN 00057	JX4 = 4*JSX	00067200
	C	00067300
ISN 00058	D2PDP2 = BSIGN*(2.*PSI(I,J)-5.*PSI(I,J+JX1)+4.*PSI(I,J+JX2) 1 -PSI(I,J+JX3))/DPH**2	00067400
ISN 00059	D3P2DR = -BSIGN*(2.*V(I,J)-5.*V(I,J+JX1)+4.*V(I,J+JX2) 1 -V(I,J+JX3))/DPH**2	00067600
ISN 00060	DTDP = BSIGN*(-TN(I,J)+TN(I,J+JX1))/DPH	00067700
ISN 00061	GO TO 90	00067800
	C	00067900
	C	00068000
ISN 00062	80 BSIGN = -1.0	00068100
ISN 00063	JX1 = -1	00068200
ISN 00064	JX2 = -2	00068300
ISN 00065	JX3 = -3	00068400
ISN 00066	JX4 = -4	00068500
	C	00068600
	C	00068700
ISN 00067	90 D3PDP3 = 0.5*BSIGN*(1 -5.*PSI(I,J)+18.*PSI(I,J+JX1)-24.*PSI(I,J+JX2) +14.*PSI(I,J+JX3)-3.*PSI(I,J+JX4))/DPH**3	00068800
	C	00068900
	C	00069000
	C	00069100
ISN 00068	95 S1 = U(I,J)*D3PDR3	00069200
ISN 00069	S2 = V(I,J)*D3R2DP/RI(I)	00069300
ISN 00070	S3 = V(I,J)*D3PDP3/RI(I)**3	00069400

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ISN 00071      S4 = U(I,J)*D3P2DR/RI(I)**2      00069500
ISN 00072      S5 = U(I,J)*D2PDR2/RI(I)        00069600
ISN 00073      S6 = V(I,J)*D2DRDP/RI(I)**2     00069700
ISN 00074      S7 = U(I,J)*V(I,J)/RI(I)**2     00069800
ISN 00075      SAHEN(I,J) = S1 + S2 + S3 + S4 + S5 + S6 + S7 00069900
ISN 00075      SAHEN(I,J) = S1 + S2 + S3 + S4 + S5 + S6 + S7 00070000
C
ISN 00076      U1 = D2PDR2 - V(I,J)/RI(I) + D2PDP2/RI(I)**2 00070100
ISN 00077      U2 = RADA*(DTDR*DSIN(PHI(J)) + DTDP/RI(I)*DCOS(PHI(J))) 00070200
ISN 00078      UHEN(I,J) = U1 + U2              00070300
ISN 00079      IF (ABS(UHEN(I,J)).GT.0.0) GO TO 96 00070400
ISN 00080      UHEN(I,J)=0.                    00070510
ISN 00081      SBYU(I,J)=0.                    00070520
ISN 00082      GO TO 1000                       00070600
ISN 00083      96 SBYU(I,J) = SAHEN(I,J)/UHEN(I,J) 00070700
C
ISN 00084      IF (SBYU(I,J).GT.SBUMAX) GO TO 100 00070800
ISN 00085      GO TO 1000                       00070900
C
ISN 00086      100 SBUMAX = SBYU(I,J)           00071000
ISN 00087      ISUMAX = I                       00071100
ISN 00088      JSUMAX = J                       00071200
ISN 00089      1000 CONTINUE                    00071300
C
ISN 00090      PRINT 1500                       00071400
ISN 00091      1500 FORMAT ('1'/// T10,10('*'),'RESULTS BY SUBROUTINE INERTA',10('*')) 00071500
C
ISN 00092      PRINT 2000, ISUMAX,JSUMAX,SAHEN(ISUMAX,JSUMAX),UHEN(ISUMAX,JSUMAX) 00071600
ISN 00092      1, SBYU(ISUMAX,JSUMAX)          00071700
C
ISN 00093      2000 FORMAT ( // T10,'MAX INERTIA TERM POINT I =', I3, 3X,'J =', 00071800
ISN 00093      1 13// T10,'SAHEN(I,J) (INERTIA TERM) =',6X,E12.4// 00071900
ISN 00093      2 T10,'UHEN(I,J) (BUDYANCY+DARCY) =',6X,E12.4// 00072000
ISN 00093      3 T10,'SBYU(I,J) PR/DA*(SAHEN)/(UHEN) =', E12.4// 00072100
C
ISN 00094      RETURN                           00072200
ISN 00095      END                             00072300
ISN 00095      END                             00072400
ISN 00095      END                             00072500
ISN 00095      END                             00072600
ISN 00095      END                             00072700
ISN 00095      END                             00072800
ISN 00095      END                             00072900

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SPECIFIED OPTIONS: NONAME, FLAG(I), BYNAME, GOSTMT, NOSTATIS, ISN(D), NOMAP, ELM(*)

```

ISN 00001      SUBROUTINE SIMSOL                                00073000
C                                                       00073100
C                                                       00073200
C                                                       00073300
C                                                       00073400
C                                                       00073500
C                                                       00073600
C                                                       00073700
C                                                       00073800
C                                                       00073900
C                                                       00074000
C                                                       00074100
C                                                       00074200
C                                                       00074300
ISN 00002      COMMON/SORCO/ OMEGA,ITERA,ITEL,ITEP,ERROR,ERRPSI,EPS,APS,OMPSI 00074400
ISN 00003      COMMON/INTEC/ M,N,MCAL,NCAL                                00074500
ISN 00004      COMMON/INDEP/ RI( 41),PHI( 41),DR,DPH                    00074600
ISN 00005      COMMON/SIGMA/ SNEW,SOLD,SPSI,SPSIO                        00074700
ISN 00006      COMMON/TNPSI/ TN( 41, 41),PSI( 41, 41),RADA            00074800
ISN 00007      COMMON/VELCO/ U( 41, 41),V( 41, 41)                    00074900
C                                                       00075000
C                                                       00075100
ISN 00008      DOUBLE PRECISION TN,PSI,OMEGA,DR,RI,DPH,RADA,PHI,A,B,C,D,E,F,OMPSI 00075200
ISN 00009      DOUBLE PRECISION U,V                                     00075300
C                                                       00075400
C                                                       00075500
C                                                       00075600
ISN 00010      CALL VELOCI                                           00075700
ISN 00011      SOLD = 0.0                                           00075800
ISN 00012      SNEW = 0.0                                           00075900
C                                                       00076000
C                                                       00076100
C                                                       00076200
C                                                       00076300
ISN 00013      DD 80 J=1,N+1                                         00076400
ISN 00014      DD 80 I=2,M                                           00076500
C                                                       00076600
C                                                       00076700
C                                                       00076800
ISN 00015      IF (U(I,J).GT.0.0) GO TO 10                            00076900
ISN 00016      A = -U(I,J)/DR*RI(I)                                  00077000
ISN 00017      E = -U(I,J)*TN(I+1,J)/DR*RI(I)                       00077100
ISN 00018      GO TO 20                                              00077200
C                                                       00077300
C                                                       00077400
C                                                       00077500
ISN 00019      10 A = U(I,J)/DR*RI(I)                                 00077600
ISN 00020      E = U(I,J)*TN(I-1,J)/DR*RI(I)                        00077700
C                                                       00077800
C                                                       00077900
C                                                       00078000
ISN 00021      20 IF (V(I,J).GT.0.0) GO TO 30                        00078100
ISN 00022      A = A - V(I,J)/DPH                                    00078200
ISN 00023      F = -V(I,J)*TN(I,J+1)/DPH                            00078300
ISN 00024      GO TO 40                                              00078400
C                                                       00078500
C                                                       00078600
ISN 00025      30 A = A + V(I,J)/DPH                                  00078700
ISN 00026      F = V(I,J)*TN(I,J-1)/DPH                             00078800
C                                                       00078900
C                                                       00079000
ISN 00027      40 A = A + 2.0*RI(I)/DR**2 + 1.0/DR + 2.0/(RI(I)*DPH**2) 00079100
C                                                       00079200
C                                                       00079300
ISN 00028      B = RI(I)*(TN(I+1,J)+TN(I-1,J))/DR**2                00079400
C                                                       00079500
C                                                       00079600
ISN 00029      C = TN(I+1,J)/DR                                      00079700
C                                                       00079800
C                                                       00079900
ISN 00030      IF (J.EQ.1) GO TO 50                                  00080000
    
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ISN 00031      IF (J.EQ.N+1) GO TO 60                                00078600
ISN 00032      D = (TN(I,J+1)+TN(I,J-1))/(RI(I)*DPH**2)          00078700
ISN 00033      GO TO 70                                           00078800
ISN 00034      C 50 D = 2.0*TN(I,2)/(RI(I)*DPH**2)                00078900
ISN 00035      GO TO 70                                           00079000
ISN 00036      C 60 D = 2.0*TN(I,N)/(RI(I)*DPH**2)                00079100
ISN 00037      C 70 IF (J.EQ.1.OR.J.EQ.N+1) F = 0.0              00079200
ISN 00038      SOLD = SOLD + TN(I,J)                               00079300
ISN 00039      TO=TN(I,J)                                          00079400
ISN 00040      TN(I,J) = (1.0-OMEGA)*TN(I,J) + OMEGA/A*(B+C+D+E+F) 00079500
ISN 00041      IF (TN(I,J).LT.0.0) GO TO 75                       00079600
ISN 00042      GO TO 80                                           00079700
ISN 00043      75 PRINT 100, I,J,TN(I,J),A,B,C,D,E,F              00079800
ISN 00044      100 FORMAT ( T2,'TSOL',I2,'I=',I2,' J=',I2,' TN=', 1PD11.3, ' A=', 00079900
                1 1PD11.3, ' B=', 1PD11.3, ' C=', 1PD11.3, ' D=',1PD11.3, 00080000
                2  ' E=', 1PD11.3, ' F=', 1PD11.3 )              00080100
ISN 00045      X=TO*(1.0-OMEGA)                                    00080200
ISN 00046      Y=OMEGA/A*(B+C+D+E+F)                               00080300
ISN 00047      PRINT 200, X,Y,TO,TN(I,J),ITERA                    00080400
ISN 00048      STOP ' TEMPERATURE IN SIMSOL IS ABNORMAL '        00080500
ISN 00049      200 FORMAT ( T10, '(1.0-OMEGA)*TO = ',1PE13.3,T50,'OMEGA/A*(B+C+D+E+F) 00080600
                1 = ', 1PE13.3, T90, 'TO = ',1PE13.3, T110, 'TN = ', 1PD13.3, T128, 00080700
                2 'ITE=', I3 )                                     00080800
ISN 00050      80 SNEW = SNEW + TN(I,J)                            00080900
ISN 00051      C CALL PSISOL                                       00081000
ISN 00052      C RETURN                                           00081100
                00081200
                00081300
                00081400
                00081500
                00081600
                00081700

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DATE 83.01.17 TIME 14.02.23

SPECIFIED OPTIONS: NONAME,FLAG(I),BYNAME,GOSTMT,NOSTATIS,ISN(D),NOMAP,ELM(*)

```

ISN 00001      SUBROUTINE VISUAL ( X,Y,Z,M,N,XA,YA,ZA,ZYJ,ZIIJ,ZII,KZ,NZ,OPT )      00081900
C                                                       00082000
C   THIS ROUTINE VISUALIZE 3-DIMENSIONAL ARRAYS BY EASY METHOD.      00082100
C                                                       00082200
C   X(I)   X-COORDINATE OF Z(I,J)   I=1,2, ... ,M      00082300
C   Y(J)   Y-COORDINATE OF Z(I,J)   J=1,2, ... ,N      00082400
C   Z(I,J) FUNCTION OF X(I),Y(J)   (VISUALIZING VALUES)      00082500
C                                                       00082600
C   **REMARKS**      00082700
C   (1) X AND Y MUST BE MONOTONIC CHANGE AND EQ.-SPACES      00082800
C   (2) VISUALIZING PLANE IS 50 X 50 CHARACTERS      00082900
C   (3) X AND Y DIRECTION ARE HORIZONTAL AND VERTICAL RESPECTI-      00083000
C       VLY      00083100
C   (4) THIS ROUTINE NEEDS SUBROUTINE 'D2ITPL' AND 'INTPL2'      00083200
C   (5) IF OPT = 'SIMA', Z(I,J) WITHOUT EVEN NUMBERS ARE PRINTED.      00083300
C                                                       00083400
ISN 00002      ODIMENSION X(M),Y(N),Z(M,N),XA(50),YA(50),ZA(50,50),ZYJ(M),ZII(N),      00083500
1              ZIIJ(50,N),KZ(50,50),NZ(50,50)      00083600
C                                                       00083700
ISN 00003      DATA KBLANK,OPT1 / ' ', 'SIMA' /      00083800
C                                                       00083900
ISN 00004      CALL D2ITPL (X,Y,Z,M,N,XA,YA,ZA,50,50,IERR,ZYJ,ZIIJ,ZII)      00084000
ISN 00005      IF (IERR.EQ.0) GO TO 10      00084100
ISN 00006      PRINT 1000      00084200
ISN 00007      STOP      00084300
C                                                       00084400
C                                                       00084500
ISN 00008      10 XAMAX = XA(1)      00084600
ISN 00009      XAMIN = XA(1)      00084700
ISN 00010      YAMAX = YA(1)      00084800
ISN 00011      YAMIN = YA(1)      00084900
ISN 00012      ZAMAX = ZA(1,1)      00085000
ISN 00013      ZAMIN = ZA(1,1)      00085100
C                                                       00085200
C                                                       00085300
ISN 00014      DO 20 I=2,50      00085400
ISN 00015      IF (XA(I).GT.XAMAX) XAMAX = XA(I)      00085500
ISN 00016      IF (XA(I).LT.XAMIN) XAMIN = XA(I)      00085600
ISN 00017      20 CONTINUE      00085700
C                                                       00085800
C                                                       00085900
ISN 00018      DO 30 J=2,50      00086000
ISN 00019      IF (YA(J).GT.YAMAX) YAMAX = YA(J)      00086100
ISN 00020      IF (YA(J).LT.YAMIN) YAMIN = YA(J)      00086200
ISN 00021      30 CONTINUE      00086300
C                                                       00086400
C                                                       00086500
ISN 00022      DO 40 J=1,50      00086600
ISN 00023      DO 40 I=1,50      00086700
ISN 00024      IF (ZA(I,J).GT.ZAMAX) ZAMAX = ZA(I,J)      00086800
ISN 00025      IF (ZA(I,J).LT.ZAMIN) ZAMIN = ZA(I,J)      00086900
ISN 00026      40 CONTINUE      00087000
C                                                       00087100
C                                                       00087200
C                                                       00087300
C                                                       00087400
C   NORMALIZATION OF Z(I,J)
ISN 00027      DO 50 J=1,50
ISN 00028      DO 50 I=1,50
ISN 00029      ZA(I,J) = (ZA(I,J)-ZAMIN)/(ZAMAX-ZAMIN)*1.1
ISN 00030      IF (ZA(I,J).GE.1.1) ZA(I,J) = 1.0

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ISN 00031	ZA(I,J) = ZA(I,J)*10.0	00087500
ISN 00032	KZ(I,J) = ZA(I,J) + 1	00087600
ISN 00033	KZ(I,J) = KZ(I,J)*1000	00087700
ISN 00034	50 CALL IBTOD(NZ(I,J),KZ(I,J))	00087800
	C	00087900
ISN 00035	IF (OPT.NE.OPT1) GO TO 55	00088000
ISN 00036	DO 54 J=1,50	00088100
ISN 00037	DO 54 I=1,50	00088200
ISN 00038	KZA = (KZ(I,J)/2000)*2000	00088300
ISN 00039	54 IF (KZA.EQ.KZ(I,J)) NZ(I,J)=KBLANK	00088400
ISN 00040	55 CONTINUE	00088500
	C	00088600
ISN 00041	PRINT 1010, XAMAX,XAMIN	00088700
ISN 00042	PRINT 1020, YAMAX,YAMIN	00088800
ISN 00043	PRINT 1030, ZAMAX,ZAMIN	00088900
	C	00089000
ISN 00044	DO 60 J=1,50	00089100
ISN 00045	60 PRINT 1040, (NZ(I,J), I=1,50)	00089200
	C	00089300
	C	00089400
ISN 00046	RETURN	00089500
	C	00089600
	C	00089700
ISN 00047	1000 FORMAT ('1 ERROR HAPPENED IN SUBROUTINE VISUAL ')	00089800
	C	00089900
ISN 00048	1010 FORMAT('1' // T10, 'XMAX =',1PE13.4 / T10, 'XMIN =',1PE13.4)	00090000
	C	00090100
ISN 00049	1020 FORMAT (T10,'YMAX =',1PE13.4 / T10, 'YMIN =',1PE13.4)	00090200
ISN 00050	1030 FORMAT (T10,'ZMAX =',1PE13.4 / T10, 'ZMIN =',1PE13.4 /)	00090300
	C	00090400
ISN 00051	1040 FORMAT (T40, 50A1)	00090500
	C	00090600
ISN 00052	END	00090700

FACOM OSIV/F4 FORTRAN IV (HE) V04L18

DATE 83.01.17 TIME 14.02.24

SPECIFIED OPTIONS: NONAME, FLAG(I), BYNAME, GOSTMT, NOSTATIS, ISN(D), NOMAP, ELM(*)

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ISN 00001      SUBROUTINE SIMPSN (M,H,F,S,IER)
C
C           THIS ROUTINE INTEGRATES GIVEN FUNCTION F(1),F(2),...F(M) BY
C           SIMPSON METHOD.
C
C           M           NUMBER OF MESH POINTS (M MUST BE ODD NUMBER)
C           H           MESH WIDTH OF INDEPENDENT VARIABLES (EQ-SPACES)
C           F(I)        DIMENSION OF GIVEN FUNCTION I=1,2,...,M
C           S           INTEGRATED VALUE OF FUNCTION
C           IER         ERROR CODE      =0  NORMAL
C                               =1  ABNORMAL, S IS SET FOR S = 0.0
C
C
C
ISN 00002      DIMENSION F(M)
C
ISN 00003      MM = (M-1)/2*2
ISN 00004      IF (MM.EQ.M-1) GO TO 10
ISN 00005      IER = 1
ISN 00006      S = 0.0
ISN 00007      PRINT 100, IER,M
ISN 00008      RETURN
C
ISN 00009      10 N = (M-1)/2
ISN 00010      S2 = 0.0
ISN 00011      S4 = 0.0
C
ISN 00012      DO 20 I=1,N
ISN 00013      IF (I.EQ.N) GO TO 15
ISN 00014      K2 = 2*I+1
ISN 00015      S2 = S2+F(K2)
ISN 00016      15 K4 = 2*I
ISN 00017      20 S4 = S4+F(K4)
C
ISN 00018      S = H*(F(1)+F(M)+4.0*S4+2.0*S2)/3.0
ISN 00019      IER = 0
ISN 00020      RETURN
ISN 00021      100 FORMAT (/// T10, 10('*'), ' ERROR IN SUBROUTINE-SIMPSN ',10('*'),
1          / T10, 'M MUST BE ODD NUMBER IER =',I2, ' M =', I4 )
C
ISN 00022      END

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ISN 00001      SUBROUTINE PLDATA (R,PHI,Z,M,N,RMAX)
C
C      THIS ROUTINE CHANGES POLAR COORDINATE TO RECTANGULAR
C      COORDINATE AND WRITES X,Y,ZNORM DATA IN DISK FILE FOR GPCP-1
C
C      R(I)      (I=1,2, ...,M)      RADIUS OF POLAR COORDINATE
C      PHI(J)    (J=1,2, ...,N)      ANGLES OF POLAR COORDINATE
C      Z(I,J)    NORMALIZED Z(I,J)   HEIGHT OF POINT R(I),PHI(J)
C      ZNORM     X COORDINATE OF R(I),PHI(J)
C      X         Y COORDINATE OF R(I),PHI(J)
C      Y
C
C      DIMENSION R(M),PHI(N),Z(M,N)
ISN 00002
C
ISN 00003      ZMIN=Z(1,1)
ISN 00004      ZMAX=Z(1,1)
C
ISN 00005      DO 10 J=1,N
ISN 00006      DO 10 I=1,M
ISN 00007      IF (Z(I,J).GT.ZMAX) ZMAX=Z(I,J)
ISN 00008      10 IF (Z(I,J).LT.ZMIN) ZMIN=Z(I,J)
C
ISN 00009      DO 20 J=1,N
ISN 00010      DO 20 I=1,M
ISN 00011      ZNORM = (Z(I,J)-ZMIN)/(ZMAX-ZMIN)
ISN 00012      X = R(I)*SIN(PHI(J))/RMAX
ISN 00013      Y = -R(I)*COS(PHI(J))/RMAX
C
C      WRITE( 3,1040) X,Y,ZNORM
ISN 00014
ISN 00015      20 CONTINUE
ISN 00016      WRITE( 3,1045)
ISN 00017      PRINT 1050
ISN 00018      1040 FORMAT ( 'CNTL' T6, 3F10.5, T72, '2' )
ISN 00019      1045 FORMAT ( 'BEND' )
ISN 00020      1050 FORMAT ( '1' // T10, 'X, Y, AND ZNORM ARE WRITTEN IN DISK FILE'//)
ISN 00021      RETURN
ISN 00022      END

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FACOM OSIV/F4 FORTRAN IV (HE) VO4L18

DATE 83.01.17 TIME 14.02.24

SPECIFIED OPTIONS: NONAME, FLAG(I), BYNAME, GOSTMT, NOSTATIS, ISN(D), NOMAP, ELM(*)

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ISN 00001      SUBROUTINE INTPL2( A, B, X, Y, N, IERR )      00098800
C                                                     00098900
C THIS ROUTINE INTERPOLATES THE Y-VALUE TO THE X-VALUE BY SECOND 00099000
C ORDER INTERPOLATION.                                       00099100
C                                                     00099200
C           A(N)      TABLE OF X(I), (I=1,2, / / , N)      00099300
C           B(N)      TABLE OF Y(I), (I=1,2, / / , N)      B(I)=FUNC(A(I)) 00099400
C           X         GIVEN X                                00099500
C           Y         Y-VALUE FOR X (CALCULATED VALUE)      00099600
C           N         NUMBER(SIZE) OF POINTS IN TABLE     00099700
C           IERR      ERROR CODE                             00099800
C                                                     00099900
C           IERR=0    NORMAL CONDITION                       00100000
C           =2       VALUE OF X IS OUT-SIDE OF A(N) (MUST BE INSIDE) 00100100
C           =3       A IS NOT UNIQUE                         00100200
C                                                     00100300
ISN 00002      DIMENSION A(N),B(N)                          00100400
C                                                     00100500
ISN 00003      DO 10 K=1,N                                  00100600
ISN 00004      IF ( A(K).NE.X ) GO TO 10                    00100700
ISN 00005      Y=B(K)                                       00100800
ISN 00006      IERR=0                                        00100900
ISN 00007      RETURN                                       00101000
ISN 00008      10 CONTINUE                                   00101100
C                                                     00101200
C           IF ( N .GE. 3 ) GO TO 11                          00101300
ISN 00009      IERR = 1                                      00101400
ISN 00010      RETURN                                       00101500
ISN 00011      11 IERR = 0                                    00101600
C                                                     00101700
ISN 00012      OX = A(1)                                     00101800
ISN 00013      IF ( A(N)-OX ) 31,12,21                      00101900
ISN 00014      12 IERR = 3                                   00102000
ISN 00015      RETURN                                       00102100
ISN 00016      21 IF ( X. LT. OX ) GO TO 19                  00102200
C                                                     00102300
C           DO 23 K=2,N                                       00102400
ISN 00018      IF ( A(K) .LE. OX ) GO TO 12                 00102500
ISN 00019      OX = A(K)                                     00102600
ISN 00020      IF ( X .LE. OX ) GO TO 100                   00102700
ISN 00021      23 CONTINUE                                   00102800
ISN 00022      19 IERR = 2                                    00102900
ISN 00023      RETURN                                       00103000
ISN 00024      31 IF ( X .GT. OX ) GO TO 19                  00103100
C                                                     00103200
C           DO 33 K=2,N                                       00103300
ISN 00025      IF ( A(K) .GE. OX ) GO TO 12                 00103400
ISN 00026      OX = A(K)                                     00103500
ISN 00027      IF ( X .GE. OX ) GO TO 100                   00103600
ISN 00028      33 CONTINUE                                   00103700
ISN 00029      GO TO 19                                      00103800
ISN 00030      100 DX = OX - A(K-1)                          00103900
ISN 00031      IF ( K .GT. 2 ) K=K-1                        00104000
C                                                     00104100
C           100 DX = OX - A(K-1)                              00104200
ISN 00032      IF ( K .GT. 2 ) K=K-1                        00104300
ISN 00033

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ISN 00034	P = (X-A(K)) / DX	00104400
ISN 00035	Y = P*(1.+P)/2.*B(K+1) + (1.+P)*(1.-P)*B(K) - P*(1.-P)/2.*B(K-1)	00104500
ISN 00036	RETURN	00104600
ISN 00037	END	00104700

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ISN 00001      SUBROUTINE D2ITPL( X,Y,Z,M,N,XX,YY,ZZ,MM,NN,IERR,ZYJ,ZIIJ,ZII ) 00104800
C
C      THIS ROUTINE TRANSFORMES 2-DIMENSIONAL ARRAY Z( X(I),Y(J) ) 00104900
C      TO ZZ( XX(II),YY(JJ) ) IN THE SAME PLANE BY 2ND-ORDER INTERPOLA- 00105000
C      TION. 00105100
C      WHERE, I=1,2,,, M (M.GE.3) 00105200
C      J=1,2,,, N (N.GE.3) 00105300
C      II=1,2,,, MM 00105400
C      JJ=1,2,,, NN 00105500
C      X(I),Y(J),XX(II) AND YY(JJ) MUST BE PLACED IN SAME SPACES. 00105600
C      ** THIS ROUTINE NEEDS SUBROUTINE INTPL2 00105700
C      Z( X(I),Y(J) ) OLD 2-D ARRAY (INPUT ARRAY) 00105800
C      ZZ(XX(II),YY(JJ)) NEW 2-D ARRAY (OUTPUT ARRAY) 00105900
C      IERR ERROR CODE IERR=0 GOOD CONDITION 00106000
C      IERR=1 BAD CONDITION 00106100
C      ZYJ(I) AUX ARRAY 00106200
C      ZIIJ(II,J) 00106300
C      ZII(J) 00106400
ISN 00002      DIMENSION X(M),Y(N),Z(M,N),XX(MM),YY(NN),ZZ(MM,NN),ZYJ(M), 00106500
C      1 ZIIJ(MM,N),ZII(N) 00106600
C      MESH POINTS TRANSFORMATION 00106700
ISN 00003      XL=X(M)-X(1) 00106800
ISN 00004      YL=Y(N)-Y(1) 00106900
ISN 00005      DO 10 II=1,MM 00107000
ISN 00006      10 XX(II)=X(1)+XL*(II-1)/(MM-1) 00107100
ISN 00007      DO 20 JJ=1,NN 00107200
ISN 00008      20 YY(JJ)=Y(1)+YL*(JJ-1)/(NN-1) 00107300
C      X-COORDINATE PITCH TRANSFORMATION (INTERPOLATION) 00107400
C      DO 30 J=1,N 00107500
ISN 00009      DO 25 I=1,M 00107600
ISN 00010      25 ZYJ(I)=Z(I,J) 00107700
ISN 00011      DO 30 II=1,MM 00107800
ISN 00012      CALL INTPL2( X, ZYJ, XX(II), ZIIJ(II,J), M, IER1 ) 00107900
ISN 00013      IF ( IER1.EQ.0 ) GO TO 30 00108000
ISN 00014      PRINT 100, IER1,J,II 00108100
ISN 00015      IERR=1 00108200
ISN 00016      RETURN 00108300
ISN 00017      30 CONTINUE 00108400
ISN 00018      C      Y-COORDINATE PITCH TRANSFORMATION 00108500
C      DO 40 II=1,MM 00108600
ISN 00019      DO 35 J=1,N 00108700
ISN 00020      35 ZII(J)=ZIIJ(II,J) 00108800
ISN 00021      DO 40 JJ=1,NN 00108900
ISN 00022      CALL INTPL2( Y, ZII, YY(JJ), ZZ(II,JJ), N, IER2 ) 00109000
ISN 00023      IF ( IER2.EQ.0 ) GO TO 40 00109100
ISN 00024      PRINT 200, IER2, II,JJ 00109200
ISN 00025      IERR=1 00109300
ISN 00026      RETURN 00109400
ISN 00027      40 CONTINUE 00109500
ISN 00028      IERR=0 00109600
ISN 00029      100 FORMAT ( /// T20,'ERROR HAPPEND IN SUBROUTINE D2ITPL (X-PITCH INT 00109700
ISN 00030      1ERPOLATION)',/T20,'ERROR CODE =',I5, T40,'REFER ITPL2' / 00109800
C      2 T20,' J =',I5, / 00109900
C      3 T20,' II =',I5 // ) 00110000

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	C		00110400
ISN 00031		200 FORMAT (/// T20,'ERROR HAPPEND IN SUBROUTINE D2ITPL (Y-PITCH INTO	00110500
		1ERPOLATION)'/,T20,'ERROR CODE =',I5, T40,'REFER ITPL2' /	00110600
		2 T20, 'II =',I5, /	00110700
		3 T20, 'JJ =',I5 //)	00110800
	C		00110900
ISN 00032		RETURN	00111000
ISN 00033		END	00111100