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A COMPUTER PROGRAM FOR HYDROSTATIC BEARINGS INCLUDING THE EFFECTS OF NON-UNIFORM FILM THICKNESS AND RELATIVE VELOCITY FOR VARIOUS METHODS OF LUBRICANT SUPPLY

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by

J. G. Hinkle
V. Castelli
H. C. Rippel
C. D. Zimmerman, Jr.

April, 1964

Prepared for

CALIFORNIA INSTITUTE OF TECHNOLOGY
Jet Propulsion Laboratory

Purchase Order No. BP3 - 211570

THE FRANKLIN INSTITUTE
LABORATORIES FOR RESEARCH AND DEVELOPMENT
PHILADELPHIA PENNSYLVANIA

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ABSTRACT

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This is a final report describing the development and use of a computer program for the determination of the load carrying capacity, flow requirements, and righting moments of hydrostatic bearings using an incompressible fluid, including the effects of variable film thickness, relative velocity, and method of lubricant supply. The basic equations, numerical approximations, method of solution, numerical treatment and Fortran Program are presented along with instructions on the use of the program and a sample problem. This work is an extension of that reported in Final Report No. F-B2015 dated January 11, 1963, prepared for California Institute of Technology, Jet Propulsion Laboratory.

Author

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INTRODUCTION

The increasing demands for bearings to support heavy loads have caused the development of hydrostatic lubrication to proceed at an accelerated pace. This was accompanied by a need for more sophisticated analysis of bearing characteristics. For some years hydrostatic bearings have been analyzed by techniques that fell short of a rigorous analysis. This was because of the impossibility of producing by hand an exact analytical solution and, therefore, the necessity for resorting to techniques yielding approximate results, e.g., the electric analog.[1*]

One of the major shortcomings of the conducting-sheet electric-analog is its inability to treat problems involving non-uniform film thicknesses and relative velocity of bearing members. These problems can often be adequately treated by numerical integration techniques, the utilization of which is only hampered by the extremely lengthy and tedious calculations they require. However, the recent development of high speed digital computers has eliminated this drawback, and numerical integration techniques are at present quite feasible.

In the case at hand, hydrostatic bearings are to be designed for the support of a large radio telescope antenna. A number of rectangular pads will transfer the load of the moving superstructure through the pressurized film of oil to a stationary member on the concrete base. While at first glance the analysis of the bearing (flat slider) appears to offer no problem; in reality, the unit loads are high enough to give rise to non-negligible distortions of the bearing members thus requiring the treatment of variable film thicknesses. While, the particular application involves relatively slow velocity of bearing members, there will be a significant contribution of hydrodynamic effects particularly for favorable film clearance distributions. A previous work[2] describes in detail the development of a computer program which did not include the effect of relative velocity of bearing members.

*Superscript numerals refer to references at the end of this report.

This report is a complete development of the computer program for the evaluation of pressure distributions, loads, moments, and flows in a hydrostatically-lubricated, rectangular bearing-pad with four or six symmetrically placed rectangular recesses and includes the effect of velocity. The lubricant is to be incompressible, the clearance uniform or non-uniform, and the fluid supply one of the three specified types:

1. Separate pumps feeding each recess
2. Separate pumps feeding opposite pairs of recesses with capillary compensation.
3. Common manifold feeding all recesses with capillary compensation.

This report contains details of the hydrodynamic equations used to analyze the problem, of the numerical technique used for solution, and of the Fortran Program executing the solution complete with block diagrams and flow charts. A guide chart is furnished complete with all the information necessary for using the program and compiling the appropriate input data cards. A sample problem complete with output is also furnished.

BASIC EQUATIONS AND NUMERICAL APPROXIMATIONS

Utilizing the usual lubrication approximations for a continuous film bearing operating with an incompressible lubricant, Reynolds Equation governs the pressure distribution in the clearance space. For bearings with relative motion, Reynolds Equation assumes the following form[3]

$$\frac{\partial}{\partial x}\left(h^3 \frac{\partial p}{\partial x}\right) + \frac{\partial}{\partial y}\left(h^3 \frac{\partial p}{\partial y}\right) = -6\mu\, U\left(\frac{\partial h}{\partial x}\right) \qquad [1]$$

For a bearing of rectangular geometry the length of one of the sides can be used as a characteristic length (say L). Then the following dimensionless quantities can be defined in an x-y rectangular coordinate system:

$$X = \frac{x}{L},$$

$$Y = \frac{y}{L},$$

$$H = \frac{h}{c},$$

$$P = \frac{p - p_a}{p_{ref} - p_a}$$

where c is a characteristic film thickness (any value), p_{ref} is a reference pressure (any value), p_a is the ambient pressure (any value), and h and p refer to film thickness and pressure respectively at location (x,y).

Reynolds equation now assumes the dimensionless form

$$\left(\frac{\partial^2 P}{\partial X^2} + \frac{\partial^2 P}{\partial Y^2}\right) + \frac{3}{H}\left(\frac{\partial H}{\partial X}\frac{\partial P}{\partial X} + \frac{\partial H}{\partial Y}\frac{\partial P}{\partial Y}\right) = -\frac{\Lambda}{H^3}\frac{\partial H}{\partial X} \qquad [2]$$

where $\Lambda = \dfrac{6\mu UL}{c^2\,(p_{ref} - p_a)}$

Three types of bearing feed will be used:

(a) Specified flow to each recess as given by a positive displacement pump feeding the recess.

(b) Specified total flow to pairs of diametrically opposite recesses as fed by a single constant displacement pump through capillary compensation.

(c) Single manifold having a specified supply pressure feeding all recesses through capillary compensation.

METHOD OF SOLUTION

The solution of equation [2] can be split into two parts;

a) a particular solution of the non-homogenous equation.

b) the solution of the homogeneous equation.

Part (a) is accomplished by solving equation [2] numerically with the conditions that $P = 0$ on the boundaries and all recess areas. This solution shall be called $P_\Lambda(X,Y)$. Due to the linearity in P of equation [2], part (b) can be accomplished by the method of superposition. Namely, component solutions, $P_j(X,Y)$, are obtained corresponding to a value of the dimensionless pressure, P, equal to 1 in the j^{th} recess and 0 in all other recesses and at the free boundary. Then the pressure distribution, $P(X,Y)$, corresponding to any operating condition is expressible as the linear combination,

$$P(X,Y) = \sum_j \alpha_j P_j(X,Y) + P_\Lambda(X,Y) \qquad [3]$$

where α_j is a dimensionless number representing pressure in the j^{th} recess. Defining;

Q_{ij} = flow out of i^{th} recess corresponding to j^{th} component solution.

$Q_{i\Lambda}$ = flow out of i^{th} recess corresponding to $P_\Lambda(X,Y)$ solution.

The dimensionless flow q_i, out of the i^{th} recess when the pressure distribution $P(X,Y)$ exists is,

$$q_i = \sum_j \alpha_j Q_{ij} + Q_{i\Lambda} \qquad [4]$$

Integration of the pressure distribution and evaluation of the moments of the pressure distribution with respect to two non-parallel axes (say X and Y) produces the total load (W) and the location of the center of pressure (ξ, η) in the following manner (see Nomenclature):

$$W_j = \iint P_j(X,Y)\, dXdY \quad j=1,\ldots,N,\Lambda \tag{5}$$

$$\xi_j = \iint \frac{P_j(X,Y)X\, dXdY}{W_j} \quad j=1,\ldots,N,\Lambda \tag{6}$$

$$\eta_j = \iint \frac{P_j(X,Y)Y\, dXdY}{W_j} \quad j=1,\ldots,N,\Lambda \tag{7}$$

For the total solution:

$$W = \sum_j \alpha_j W_j + W_\Lambda , \tag{8}$$

$$\xi = \sum_j \frac{\alpha_j \xi_j W_j}{W} + \frac{\xi_\Lambda W_\Lambda}{W} , \tag{9}$$

$$\eta = \sum_j \frac{\alpha_j \eta_j W_j}{W} + \frac{\eta_\Lambda W_\Lambda}{W} , \tag{10}$$

The attractive feature of the method of superposition is that a given set of component solutions can be utilized with any number of feeding methods as long as the bearing geometry is not altered. The computer program is equipped to take advantage of this feature. Specification of the values of the pertinent parameters in the feeding equations leads to the determination of the appropriate values of the coefficients α_j.

In correspondence to the three feeding methods under consideration the determining equations are:

A. Specified Flow to Each Recess:

It is necessary to solve the system

$$q_i = \sum_{j=1}^{N} \alpha_j Q_{ij} + Q_{i\Lambda} \quad (i = 1, \; .....N) \qquad [11]$$

where

q_i = specified quantities (dimensionless)

$Q_{ij}, Q_{i\Lambda}$ = known quantities from component solutions (dimensionless)

Equations (11) form a non-homogeneous system of N algebraic equations in N unknowns (where N is the number of recesses) which can be solved by conventional methods.

B. Specified Flow to Pairs of Recesses With Capillary Compensation.

The following equations hold:

$$QQQ^{(1)} = q_1 + q_2 \qquad [12]$$

$$QQQ^{(2)} = q_3 + q_4 \qquad [13]$$

$$\left. QQQ^{(3)} = q_5 + q_6 \right\} \text{ only for } N = 6 \qquad [14]$$

$$q_1 = f_1(p^{(1)} - \alpha_1) \qquad [15]$$

$$q_2 = f_2(p^{(1)} - \alpha_2) \qquad [16]$$

$$q_3 = f_3(p^{(2)} - \alpha_3) \qquad [17]$$

$$q_4 = f_4(p^{(2)} - \alpha_4) \qquad [18]$$

$$\left.\begin{aligned} q_5 &= f_5(p^{(3)}-\alpha_5) \\ q_6 &= f_6(p^{(3)}-\alpha_6) \end{aligned}\right\} \text{ only for } N = 6 \qquad \begin{aligned} &[19] \\ &[20] \end{aligned}$$

$$q_i = \sum_{j=1}^{N} \alpha_j\, Q_{ij} + Q_{i\Lambda}\ (i = 1,\ldots..N) \qquad [21]$$

The system of 2.5N equations [12] through [21] has 2.5N unkowns q_i, $\alpha_{j=i}$ $(i = 1\ldots N)$, $p^{(K)}$ $(K = 1\ldots N/2)$ and can be solved by conventional methods. The quantities $QQQ^{(K)}$ $(K = 1\ldots N/2)$ are specified and the f_i's are known characteristics of the N capillaries.

C. Common Reservoir With Specified Pressure and Capillary Feed to Each Recess.

The following equations hold

$$q_i = f_i(p^{(f)}-\alpha_i) \qquad i = 1,\ldots..N \qquad [22]$$

$$q_i = \sum_{j=1}^{N} \alpha_j\, Q_{ij} + Q_{i\Lambda} \quad i = 1,\ldots..N \qquad [23]$$

This system of 2N equations in the 2N unknowns q_i and α_i $(i = 1,\ldots N)$, can be easily solved by conventional methods.

NUMERICAL TREATMENT

Equation [2] is approximated by numerical methods with the adoption of "three point, central difference" formulae. Thus the bearing area is divided in K by M rectangular elements, in the x and y directions respectively. The pressure distribution is represented by these values at the nodal points of the resulting grid.

The coordinates of the nodal points are

$$X_k = (i - 1)\Delta X, \quad [24]$$

$$Y_m = (j - 1)\Delta Y, \quad [25]$$

where i and j designate the location of a particular nodal point in the X and Y directions respectively. (Note that this use of i and j differs from the use of i and j as recess designations.)

For the pressures

$$P_{k,m} = P\left(X_k, Y_m\right), \quad [26]$$

$$\left.\frac{\partial P}{\partial X}\right|_{X_k Y_m} = \frac{P_{i+1,\,j} - P_{i-1,\,j}}{2\,\Delta X}, \quad [27]$$

$$\left.\frac{\partial P}{\partial Y}\right|_{X_k Y_m} = \frac{P_{i,\,j+1} - P_{i,\,j-1}}{2\,\Delta Y}, \quad [28]$$

$$\left.\frac{\partial^2 P}{\partial X^2}\right|_{X_k Y_m} = \frac{P_{i+1,\,j} - 2P_{i,\,j} + P_{i-1,\,j}}{\Delta X^2} \quad [29]$$

$$\left.\frac{\partial^2 P}{\partial Y^2}\right|_{X_k Y_m} = \frac{P_{i,\,j+1} - 2P_{i,\,j} + P_{i,\,j-1}}{\Delta Y^2}\,, \qquad [30]$$

Equation [2] becomes

$$\frac{P_{i+1,\,j} + P_{i-1,\,j}}{\Delta X^2} + \frac{P_{i,\,j+1} + P_{i,\,j-1}}{\Delta Y^2} - 2P_{i,j}\left(\frac{1}{\Delta X^2} + \frac{1}{\Delta Y^2}\right) \qquad [31]$$

$$+ \frac{3}{H_{k,m}}\left(\frac{P_{i+1,\,j} - P_{i-1,\,j}}{2\Delta X}\left.\frac{\partial H}{\partial X}\right|_{X_k Y_m} + \frac{P_{i,\,j+1} - P_{i,\,j-1}}{2\Delta Y}\left.\frac{\partial H}{\partial Y}\right|_{X_k Y_m}\right)$$

$$= -\frac{\Lambda}{H^3}\frac{\partial H}{\partial X}$$

which is solved for $P_{k,m}$.

$$P_{k,m}^{(\text{evaluated})} = \frac{1}{2(1+\alpha)}\left[P_{i+1,\,j} + P_{i-1,\,j} + \left\{P_{i+1,\,j} - P_{i-1,\,j} + \frac{2\Lambda\Delta X}{3H_{k,m}^2}\right\}\left(HX_{i,j}\right) + \alpha\left\{P_{i,\,j+1} + P_{i,\,j-1} + \left(P_{i,\,j+1} - P_{i,\,j-1}\right)\left(HY_{i,j}\right)\right\}\right]$$

$$\alpha = \left[\frac{\Delta X}{\Delta Y}\right]^2$$

where

$$HX_{i,j} = 1.5\left.\frac{\partial H}{\partial X}\right|_{i,j}\frac{\Delta X}{H_{i,j}}$$

$$HY_{i,j} = 1.5\left.\frac{\partial H}{\partial Y}\right|_{i,j}\frac{\Delta Y}{H_{i,j}}$$

Starting with an assumed pressure distribution (P = 1 in the j^{th} recess and P = 0 at the boundaries and in all other recesses for the j^{th} component solution or P = 0 at the boundaries and in all recesses for the N + 1 component solution), a value of the pressure, $P_{k,m}$, at a grid point is evaluated in terms of the pressure at its four immediately neighboring grid points.

Assuming

$$P'_{k,m} = \gamma P_{k,m}^{(evaluated)} + (1 - \gamma)\, P_{k,m}^{(old)} \qquad [32]$$

to be a new pressure distribution, the process is repeated until negligible changes are obtained from any one iteration. γ is called a "relaxation factor" and its magnitude sets the rate of growth of the pressure distribution. Limiting the value of γ is the well known phenomena of numerical instability.

For excessive values of γ, the rate of growth can be seen to increase steadily in time thereby indicating lack of convergence of the iteration. The occurrence of this phenomenon is internally detected and is automatically eliminated by successive reduction of the value of γ by the factor 0.8. An initial value of γ = 1.5 was used and was revealed to be overly-optimistic. Hence, an initial value of 1.1 was adopted for this program in order to avoid waste of computer time in unstable interations.

COMPUTER PROGRAM

The computer program is functionally separated into the following four sub-programs.

(1) Subroutine FORMH

Generation of the bearing geometry gridwork and the clearance distribution either by evaluation of appropriate analytic function or by direct input.

(2) Subroutine TILTH

Tilting by any specifiable amount of the clearance distribution already existing in core storage.

(3) Subroutine REYN

Generation of the component solutions P_j (X,Y) and the corresponding component solution values of the loads W_j, center of pressure coordinates ξ_j, and η_j, and flows $Q_{i,j}$.

(4) Subroutine FLOW

Matching of the component solutions with the proper feeding equations and evaluation of the corresponding pressure distribution P (X,Y), load W, center of pressure coordinates ξ and η, and flows out of each recess, q_j, for any specified feeding conditions.

The program is such that for any given clearance distribution and velocity, the loading and moment results for any of the other feeding methods can be evaluated by repeated, direct entry into Subroutine Flow. It is also possible to make available to the computer the essential results of component solutions W_j, ξ_j, η_j, $Q_{i,j}$ by direct input, so that new feeding conditions can be studied in combination with component solutions obtained during a previous group of runs.

The internal generation of the clearance distribution is executed by a function of the following type.

Define $X - X_o = s$ where $X_o = A_{22}$

$Y - Y_o = t$ $\qquad Y_o = A_{23}$

then

$$
\begin{aligned}
H_1(X,Y) = {} & A_1 + A_2 s + A_3 t + A_4 s^2 + A_5 t^2 + A_6 st + A_7 s^3 \\
& + A_8 t^3 + A_9 s^2 t + A_{10} st^2 + A_{11} \sqrt{A_{12} + A_{13} s^2 + A_{14} t^2} \\
& + A_{15} \cos\left(A_{16} s\right) + A_{17} \cos\left(A_{18} t\right) + A_{19} \cos\left(A_{16} s\right) \cos\left(A_{18} t\right) \\
& - A_{20} \left\{ e^{-A_{21} X} \cos\left(A_{21} X\right) + e^{-A_{21}(1-X)} \cos\left[A_{21}(1 - X)\right] \right. \\
& \left. -2e^{-\frac{1}{2}A_{21}} \left[\cos\left(\tfrac{1}{2}A_{21}\right)\right] \right\}
\end{aligned}
\qquad [33]
$$

The inclusion of the part of the preceeding expression containing the coefficients A_{20} and A_{21} was motivated by the results of analyses of the deformation of a beam on elastic foundations under a uniformly distributed load over a finite region[4].

The constants A_{20} and A_{21} are defined as,

$$A_{20} = \frac{\text{load per unit length}}{2kc}$$

$$A_{21} = \Lambda' = \lambda L$$

where

$$\lambda = \sqrt[4]{k/4\ E\ I}$$

It should be noticed that these terms detract from any clearance distribution given by the remainder of the formula an amount equal to the difference between the deflection at the center and the deflection at any point. It is also the task of FORMH to compile an internal tabulation of the derivatives of the clearance distribution necessary for the solution.

Subroutine TILTH acts by the use of the following formula:

$$H(X,Y) = H_1(X,Y) + T_x(X-X1) + T_y(Y-Y1) \qquad [34]$$

where: $H_1(X,Y)$ represents the distribution of clearance which is to be modified (tilted).

This corresponds to saying that the line,

$$T_x(X - X1) + T_y (Y - Y1) = 0$$

is the hinge and that the bearing is tilted in space by an amount,

$$\beta = T_x^{\ 2} + T_y^{\ 2} \qquad [35]$$

This feature is particularly useful in the evaluation of restoring moments corresponding to misalignments. The use of TILTH is optional.

In the use of subroutine REYN, it is important to adopt an appropriate value of the truncation constant (TRUNC). Indeed, a large value of TRUNC will accept component solutions that are only a rough approximation to the asymptotic solution, whereas, exceedingly small values of TRUNC will result in wastefully long computation time.

Originally, TRUNC was evaluated within the computer program as the change in the summation of pressure values at all of the active sill points from one iteration to the next divided by the number of active sill points. This was found to be unrealistic in that for a given value of TRUNC the degree of convergence varied considerably depending upon total grid size (X + 1 by M + 1) and relative recess sizes (with respect to bearing size). After further study it was found that a more realistic truncation criteria is the change in the summation of pressure values at all of the active sill points from one iteration to the next multiplied by the total number of grid points and divided by the product of γ and the summation of the pressure values at all of the active sill points.

Figure 1 shows the number of iterations required (as a function of TRUNC) to satisfy various assigned values of TRUNC for a typical large-size grid. Figure 2 shows the convergence of the dimensionless recess pressures and dimensionless recess loads. It can be seen that a truncation constant (TRUNC) of approximately 0.3 yields results that agree with the probable asymptotic value within less than one percent and require approximately 230 iterations. This is a reasonable compromise between accuracy and computer time. Several other gridwork sizes and configurations investigated have yielded satisfactory results using 0.3 for the truncation constant.

It was mentioned previously that the value of the relaxation factor γ is internally adjusted to cope with numerical instability. However, if persistent occurrence of this phenomenon forces the adoption of a value of γ lower than 0.16, subroutine REYN abandons the solution, and a note to this effect is introduced in the output tape.

Use of subroutine REYN requires the specification of the quantity LITER. Termination of the iteration is forced whenever a number of iterations equal to LITER have been performed regardless of the truncation criterion. As presently set up, the program will allow a

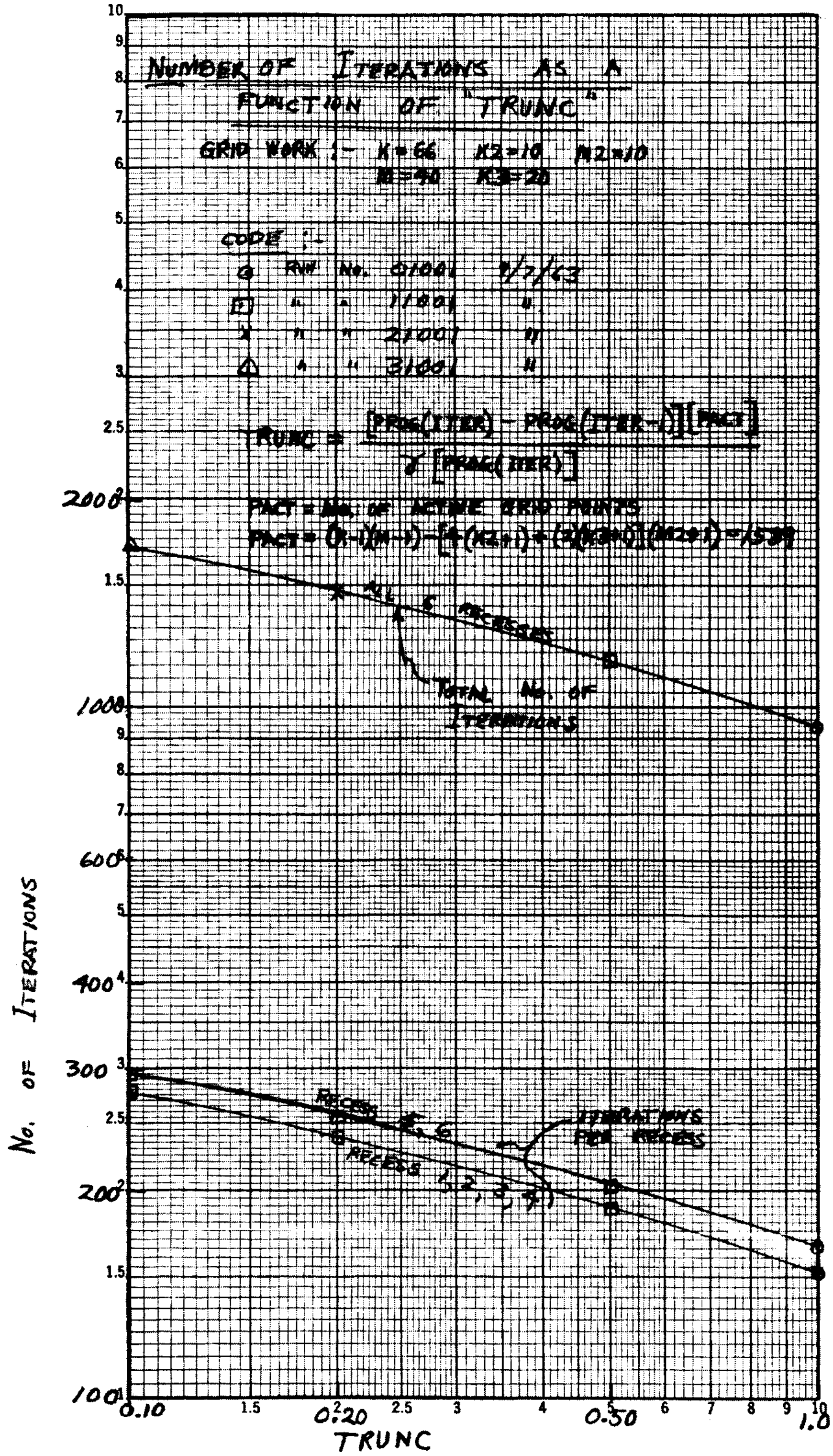

Fig. 1 - NUMBER OF ITERATIONS AS A FUNCTION OF "TRUNC"

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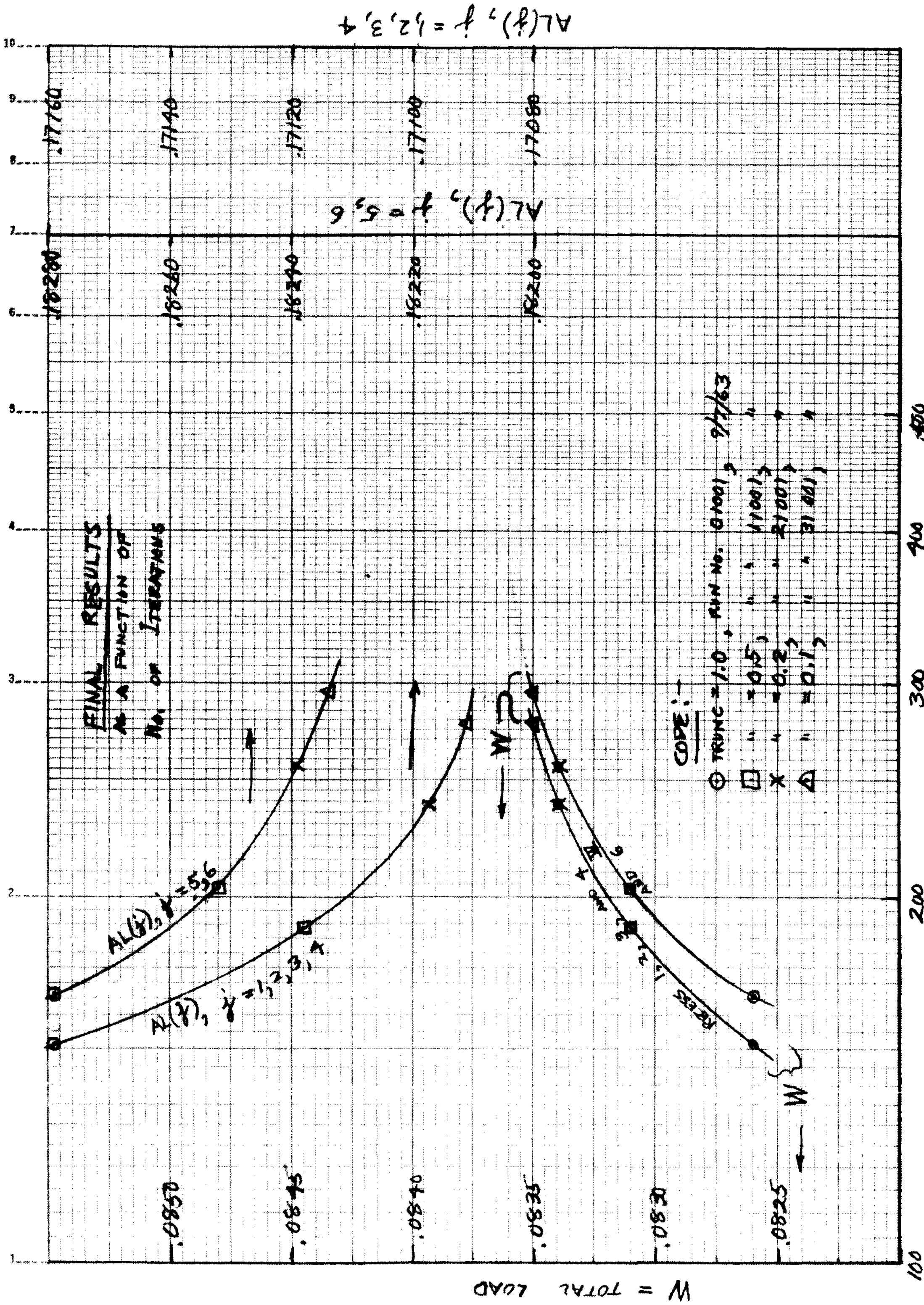

Fig. 2 - FINAL RESULTS AS A FUNCTION OF THE NUMBER OF ITERATIONS

value of LITER up to 1000. If larger values become desirable, the dimension of PROG in Subroutine REYN should be altered to the maximum value of LITER.

The operation of Subroutine FLOW is controlled by the specification of NCASE which, assuming one of the values 1, 2, or 3, indicates the adoption of the first, second, or third feeding method respectively.

The quantity IOUT enables the user to obtain the pressure and clearance profiles on the output tape (IOUT = 1). A value of IOUT = 0 specifies that output of those distributions is not desired. If IOUT = 2, the pressure profile only will appear in the output. If IOUT = 3, the clearance profile only will appear in the output.

The information in Table I will be useful in handling the quantities used in the program.

Subroutine FLOW makes use of a FUNCTION subprogram (FUNCTION DETER) in order to evaluate 4 x 4 or 6 x 6 determinants.

The utilization of the above mentioned sub-programs in the solution of specific problems is coordinated by the MAIN program. Specification of the quantity NSWICH instructs the program to solve one of six possible problems:

NSWICH = 1; CALL EXIT

NSWICH = 2; Solve non-velocity flow problem only with read-in values of W_j, ξ_j, η_j, $Q_{i,j}$.

NSWICH = 3; Solve new flow problem with component solutions already existing in core storage.

Table I - PROGRAM QUANTITIES

Equation	Fortran Symbol	Output Name
$W_j = \dfrac{w_j}{L^2(p_{ref} - p_a)}$	W(I)	W(I)
$\xi_j = \dfrac{x_j}{L}$	CSI(I)	CSI(I)
$\eta_j = \dfrac{y_j}{L}$	ETA(I)	ETA(I)
$Q_{i,j} = \dfrac{q_{rc}\ (12\mu)}{(p_{ref} - p_a)c^3}$	Q(I,J)	Q(I,J)
$q_i = \dfrac{q_{ri}\ (12\mu)}{(p_{ref} - p_a)c^3}$	QQ(I)	QQ(I)
$QQQ^{(K)} = \dfrac{q_{2ri}\ (12\mu)}{(p_{ref} - p_a)c^3}$	QQQ(K)	Pump Flows
$f_i = 0.2945\ \dfrac{d^4}{lc^3}$	FF(I)	Capillary Factors F(I)
$p^{(f)} = \dfrac{p_s - p_a}{p_{ref} - p_a}$	PF	Common Constant Pressure
$P_{i,j} = \dfrac{p_{i,j} - p_a}{p_{ref} - p_a}$	PPPP(I,J)	Pressure Distribution
$\alpha_j = \dfrac{(p_r)_j - p_a}{p_{ref} - p_a}$	AL(L)	Recess Pressures, AL(j), j=1→N
$W = \dfrac{w}{L^2(p_{ref} - p_a)}$	WW	Total Load
$\xi = \dfrac{M_{x=0}}{wL}$	CCSI	CSI
$\eta = \dfrac{M_{y=0}}{wL}$	EETA	ETA

NSWICH = 4; Entirely new problem with or without velocity.

NSWICH = 5; Tilt clearance distribution existing in core storage and solve resulting problem.

NSWICH = 6; Solve the previous problem considering velocity.

In the event NSWICH = 2, the quantity NIMJ should be specified to inform the computer of the number of recesses in the pad under consideration.

Appendix I contains a block diagram of the entire program, the detailed flow charts, Fortran instrucution listings, and IBM 7094 compilation records of the six subprograms (MAIN, FLOW, REYN, TILTH, FORMH, DETER).

Appendix II contains the loading record for use with an IBM 7094. This information is essential if the allowable grid size of 67 x 45 is to be extended.

USE OF THE PROGRAM AND SAMPLE PROBLEMS

A. Input

In order to use the program, the proper input data for the problem to be solved must be put on cards in a prescribed manner. The Input Guide Chart shown in Appendix III indicates the necessary data to be put on cards, its proper format, and the proper sequence of such cards. Figure 3 shows the standard form which is used to facilitate the preparation of punched cards. All of the input data required for solving a single problem is entered in the proper blocks of Figure 3. The number at the upper right-hand corner of each block is for the convenience of the typist to obtain proper word location when right-indexing is used. The following is a detailed explanation of how to specify the numbers to be entered in Figure 3 for proper execution of the particular problem to be solved.

1. Card No. 1 (always required)

   The following input data are required in MAIN program

   a. NSWICH: - Any number 1 through 6 may be entered as dictated by the following:

      1 = Last problem has been solved. Terminate program.

      2 = Solve flow problem only using basic solution results contained on input cards. It should be noted that the input form, Fig. 3, does not allow for these required cards. See the Input Guide Chart in Appendix III for the proper formats and card sequence.

      3 = Solve new flow problem with basic solution already in machine (as obtained from previous problem solved).

      4 = New problem to be solved.

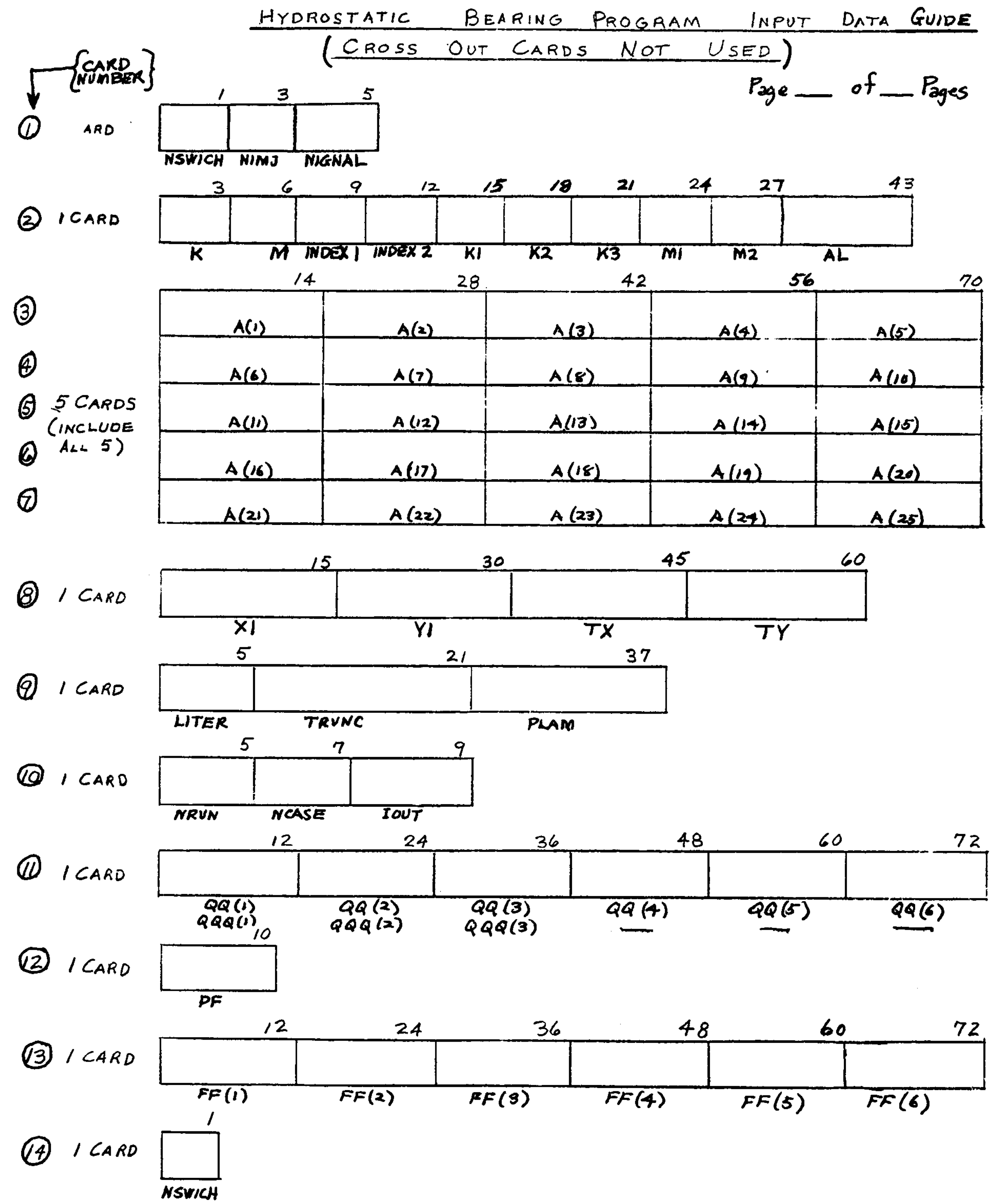

Fig. 3 - HYDROSTATIC BEARING PROGRAM INPUT DATA GUIDE

5 = The distribution of clearance already in the machine will be tilted and new basic solutions and final results for the new clearance distribution will be obtained.

6 = The previous zero-velocity problem will be solved considering velocity.

b. NIMJ: - If NSWICH = 2 is used, then the value of NIMJ is equal to the total number of recesses. Otherwise NIMJ is left blank.

c. NIGNAL: - A 1 is entered here if velocity (PLAM) is to be considered. Otherwise PLAM will not be used by the program.

2. Card No. 2 (Only required when NSWICH = 4)

The following input data are required in Subroutine FORMH

a. K: - This is the number of cells in the X-direction formed by the gridwork which simulates the pad. (See Fig. 5). K must be even. The maximum value of K allowed is 66*. (See Section B below.)

b. M: - This is the number of cells in the Y-direction formed by the gridwork. (See Fig. 5). M must also be even. The maximum value of M allowed is 44*. (See Section B below.)

c. INDEX 1: - If the clearance distribution is to be read in from cards then the value 1 is used for INDEX 1. It should be noted that the standard input form, Fig. 3, does not allow for these required cards. Consult the Input Guide Chart in Appendix III for the proper format and card sequence. If the clearance distribution is to be generated within the machine, INDEX 1 is not equal to 1 (normally left blank).

d. INDEX 2: - If the clearance distribution as read in from cards or generated internally (per INDEX 1) is to be tilted, then INDEX 2 = 1. Otherwise, INDEX 2 is not equal to 1.

---

*The allowable gridwork size (K + 1) x (M + 1) may be increased by changing all of the subscripted dimension statements from (67,45) to $\left[(K+1)_{max}, (M+1)_{max}\right]$.

e. K1: - This is the number of cells in the X-direction between edges of pad and recesses 1, 2, 3 and 4. (See Section B below.)

f. K2: - This is the number of cells representing the length of recesses 1, 2, 3 and 4 in the X-direction. (See Section B below.)

g. K3: - This is the number of cells representing the length of recesses 5 and 6 in the X-direction. If only a total of four recesses are to be used, K3 = 0. K3 must be an even number (See Section B below.)

h. M1: - This is the number of cells in the Y-direction between edges of pad and all of the recesses. (See Section B below.)

i. M2: - This is the number of cells representing the width of the recesses in the Y-direction (See Section B below.)

j. AL: - This is the ratio of the length of the pad in the Y-direction and the length of the pad in the X-direction (See Fig. 4). AL = LY/LX. (See Section B below.)

3. <u>Card Numbers 3 through 7</u> (Used only if NSWICH = 4 and INDEX $\neq$ 1)

The following input data are required in Subroutine FORMH.

a. A(1) thru A(23): - These are the values of the 23 constants used to generate the clearance distribution within the computer. It is important to note that <u>all</u> five cards must be used even if the values contained on any of them are all zeros.

4. <u>Card No. 8</u> (Used only when; NSWICH = 4 <u>and</u> INDEX 2 = 1, or NSWICH = 5)

The following input data are required in Subroutine TILTH.

a. X1: - The value to be used is the dimensionless distance in the X-direction to the line about which it is desired to rotate the pad. X1 can be any value between 0 and 1. If X1 is 0 then the pad will be rotated about the I = 1 gridwork line. If X1 = 1, the pad will be rotated about the I = (K+1) gridwork line. If 1X = 0.5, the pad will be rotated about the center line I = K/2 + 1, and so forth.

The value of X1 need <u>not</u> necessarily fall on a gridwork line.

b. Y1: - The value to be used is the dimensionless distance in the Y-direction to the line about which it is desired to rotate the pad. Y1 can be any value between 0 and AL. If Y1 = 0 then the pad will be rotated about the J = 1 gridwork line. If Y1 = AL, the pad will be rotated about the J =(M+1) gridwork line, and so forth. The value of Y1 need not necessarily fall on a gridwork line.

c. TX: - The value of TX required to obtain a specific amount of tilt about X1 may be obtained using the following equation:

$$TX = [H(1, AL/2) - H(0, AL/2)] - [H_1(1, AL/2) - H_1(0, AL/2)] \quad [36]$$

where $H(1, AL/2)$ = desired value of H at X = 1, Y = AL/2
$H(0, AL/2)$ = desired value of H at X = 0, Y = AL/2
$H_1(1, AL/2)$ = previous value of H at X = 1, Y = AL/2
$H_1(0, AL/2)$ = previous value of H at X = 0, Y = AL/2

d. TY: - The value of TY required to obtain a specific amount of tilt about Y1 may be obtained by using the following equation:

$$TY = [H(1/2, AL) - H(1/2, 0)] - [H_1(1/2, AL) - H_1(1/2, 0)] \quad [37]$$

where $H(1/2, AL)$ = desired value of H at X = 1/2, Y = AL
$H(1/2, 0)$ = desired value of H at X = 1/2, Y = 0
$H_1(1/2, AL)$ = previous value of H at X = 1/2, Y = AL
$H_1(1/2, 0)$ = previous value of H at X = 1/2, Y = 0

5. Card No. 9 (used only if NSWICH = 4, 5 or 6)

The following input data are required in Subroutine REYN.

a. LITER: - Maximum number of iterations allowable to obtain a component solution. When this number of iterations is reached, the iteration procedure will stop and rest of problem will be solved using component solutions obtained.

b. TRUNC: - This is the value assigned to the truncation constant. Usually, a value of TRUNC = 0.30 yields adequate convergence. However, it is usually good practice to experimentally evaluate a satisfactory value for a particular grid work pattern by varying the assigned value of TRUNC and observing the convergence of the final results.

c. PLAM: - The number assigned to PLAM is Λ, where

$$\Lambda = \frac{6\mu U L}{(p_{ref} - p_a)c^2}$$

Since $(p_{ref}-p_a)$ is an unknown value prior to solution, PLAM is usually assigned a magnitude of 1.0 although any number may be used.

6. Card No. 10 (always used)

The following input data are required in Subroutine FLOW

a. NRUN: - The identifying run number is inserted in this block.

b. NCASE: - The method of feeding code number is inserted in this block per the following:

1 = separate constant displacement pumps feeding each recess.

2 = one constant displacement pump feeding two opposite recesses, i.e., in Fig. 4, one pump feeds recesses 1 and 2, one pump feeds recesses 3 and 4, and the third pump (if used) feeds recesses 5 and 6 with capillary tubes used between pumps and recesses they feed.

3 = common pressure regulated supply manifold feeding each recess through capillary tubes.

c. IOUT: - The number used here dictates the output desired with regard to clearance and pressure distributions per the following code.

0 = do not print out clearance and pressure distribution.

1 = print out clearance and pressure distribution.

2 = print out pressure distribution only.

3 = print out clearance distribution only.

7. Card No. 11 (Used only if NCASE = 1 or 2)

   The following input data are required in Subroutine FLOW.

   a. QQ(1), ... QQ(N): - If NCASE = 1, the values of $q_i \ldots q_N$ are inserted in the first N blocks. N is either 4 recesses or 6 recesses. q_i is the constant flow to each recess.

      or,

   b. QQQ(1),.... QQ(N/2):-If NCASE = 2, the values of $q_1 \ldots q_{N/2}$ to be used are,

      $QQQ(1) = q_1 + q_2$

      $QQQ(2) = q_3 + q_4$

      $QQQ(3) = q_5 + q_6$ (if used)

   Note: - If NCASE = 3, this card (number 11) is not used.

8. Card No. 12 (Used only if NCASE = 3)

   The following input data is required in Subroutine FLOW.

   a. PF: - The number to be used here is the dimensionless manifold pressure, $p^{(f)}$, where

$$p^{(f)} = \frac{(p_s - p_a)}{(p_{ref} - p_a)} = \frac{q_i}{f_i} + \alpha_j \qquad [38]$$

   Since q_i and α_j are unknown, a value of $p^{(f)} = 1.0$ is usually used although any number may be used.

9. Card No. 13 (Used only if NCASE = 2 or 3)

   The following input data is required in Subroutine FLOW.

   a. FF(1), ... FF(N): - Any number may be assigned for FF(I) (the capillary constant, fi). N is either 4 or 6 recesses. Hence 4 or 6 values of FF(I) are required.

10. Card No. 14 (Used only if previous cards are last problem to be solved).

    The following input data is required in the MAIN program.

    a. NSWICH: - The number 1 is used to indicate that last problem has been solved.

B. Selection and Specification of Gridwork Pattern to be Used

As has been previously indicated it is necessary that a proper balance be achieved between maximum and minimum number of grid points to be used in order to achieve reasonably accurate results without an undue amount of computer time. It should also be evident that there may have to be some compromise between recess size and locating dimensions and computer program gridwork. That is, some of the recess dimensions desired to be used may have to be slightly modified in order to fit into a finite grid point pattern.

Figure 4 shows the required geometry of a 6-recess pad. Note that if a four recess pad is to be considered, the dimension L_{x3} is equal to zero. In order to illustrate how a suitable grid work may be selected and specified, consider the pad of Figure 4 to have the following dimensions:

X-Direction	Y-Direction
LX = 32.0"	LY = 30.0"
L_{x1} = 3.0"	L_{y1} = 4.5"
L_{x2} = 5.0"	L_{y2} = 6.0"
L_{x3} = 8.0"	L_{y4} = 9.0"
L_{x4} = 4.0"	

The first step is to select the smallest sill dimension in the x-direction (L_{x1} or L_{x4} for 6-recesses, L_{x1} or $2L_{x4}$ for 4-recesses) and the y-direction (L_{y1} or L_{y4}). For the above problem we would select,

$$L_{x1} = 3.0'' \text{ and } L_{y1} = 4.5''$$

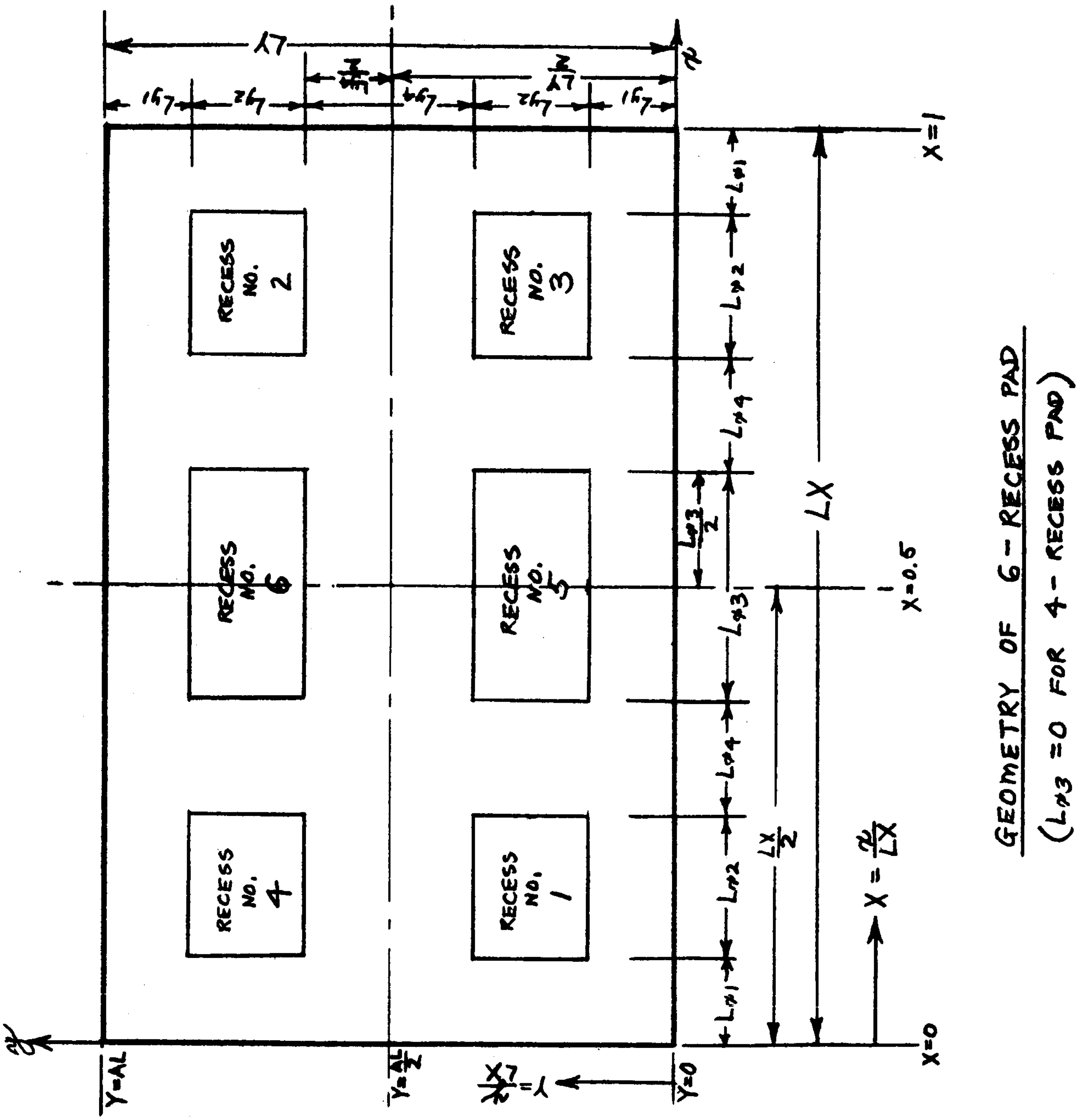

Fig. 4 - GEOMETRY OF 6-RECESS PAD

We can write the following equations;

$$\left.\begin{aligned} K2 &= K1\left(\frac{L_{x2}}{L_{x1}}\right) & M2 &= M1\left(\frac{L_{y2}}{L_{y1}}\right) \\ K3 &= K1\left(\frac{L_{x3}}{L_{x1}}\right) & M4 &= M1\left(\frac{L_{y4}}{L_{y1}}\right) \\ K4 &= K1\left(\frac{L_{x4}}{L_{x1}}\right) & M &= M1\left(\frac{LY}{L_{y1}}\right) \\ K &= K1\left(\frac{LX}{L_{x1}}\right) & & \end{aligned}\right\} \quad [39]$$

Substituting the pad dimensions into equations [39] yields,

$$\left.\begin{aligned} K2 &= \tfrac{5}{3}(K1) & M2 &= \tfrac{4}{3}(M1) \\ K3 &= \tfrac{8}{3}(K1) & M4 &= 2(M1) \\ K4 &= \tfrac{4}{3}(K1) & M &= \tfrac{20}{3}(M1) \\ K &= \tfrac{32}{3}(K1) & & \end{aligned}\right\} \quad [40]$$

If we now select a number of integer values for K1 we can evaluate all of the other values of interest. In order to have at least one grid point in the sill, K1, and M1 (or K4 and M4 if $L_{x4} < L_{x1}$, and $L_{y4} < L_{y1}$) must be at least 2. The following table summarizes the results obtained when various integer values of K1 are used in equations [40].

K1	K2	K3 (Even)	K4	K (Even)
2	3-1/3 = 3	5-1/3 = 6	2-2/3 = 3	21-1/3 = 22
3	5 = 5	8 = 8	4 = 4	32 = 32
4	6-2/3 = 7	10-2/3 = 10	5-1/3 = 5	42-2/3 = 42
5	8-1/3 = 8	13-1/3 = 14	6-2/3 = 7	53-1/3 = 54
6	10 = 10	16 = 16	8 = 8	64 = 64
7	11-2/3 = 12	18-2/3 = 18	9-1/3 = 9	74-2/3 = 74
8	13-1/3 = 13	21-1/3 = 22	10-2/3 = 11	85-1/3 = 86

M1	M2	M4 (Even)	—	M (Even)
2	2-2/3 = 3	4	—	13-1/3 = 14
3	4 = 4	6	—	20 = 20
4	5-1/3 = 5	8	—	26-2/3 = 26
5	6-2/3 = 7	10	—	33-1/3 = 34
6	8 = 8	12	—	40 = 40
7	9-1/3 = 9	14	—	46-2/3 = 46
8	10-2/3 = 11	16	—	53-1/3 = 54

The following items should be noted in the above table.

1. The fractional values when obtained for K2, K4 are rounded-off to the nearest odd or even integer.
2. The fractional values when obtained for K3, K, M4 and M are rounded-off to the nearest <u>even</u> integer.
3. The values obtained for K1 = 7 and K1 = 8 should not be considered since K > 66. (maximum value currently permissible).

While it is permissible to use any combination of the above listed values of K1 and M1 (except K1 = 7 or 8) we can further narrow down the combination to be selected by considering the following:

1. The maximum value of K1, M1, K4 and M4 should not be greater than 8 in order to yield 7 or less active sill grid points between adjacent recesses or between any recess and the outer periphery of the pad in order to keep computer time within reasonable limits. On this basis we would, therefore, eliminate from consideration K1 = 7 or 8, M1 = 5, 6, 7 or 8.
2. While it is permissible to use only one active sill point (K1 = 2 and M1 = 2) it is not recommended if other permissible values exist. On this basis we would, therefore, eliminate from consideration K1 = 2 and M1 = 2.
3. This leaves us with possible combinations of K1 = 3, 4, 5 or 6 and M1 = 3 or 4. Notice that for K1 =4 and 5 and for M1 =4, that non-integer values were obtained. This means for these values, the resulting grid work will only approximate the actual pad and recess dimensional relationship. On this basis, we therefore eliminate from consideration K1 = 4 and 5 and M1 = 4.
4. This leaves us with two possible combinations, K1 = 3, M1 = 3 or K1 = 6, M1 = 3. Of these two we would select the smaller grid combination (K1 = 3, M1 = 3) in order to conserve computer time.

The resulting grid work for K1 = 3 and M1 = 3 is shown in Figure 5. The values of K1 = 3, K2 = 5, K3 = 8, K = 32, M1 = 3, M2 = 4 and M = 20 are the values that would be entered on input card no. 2 of Fig. 3.

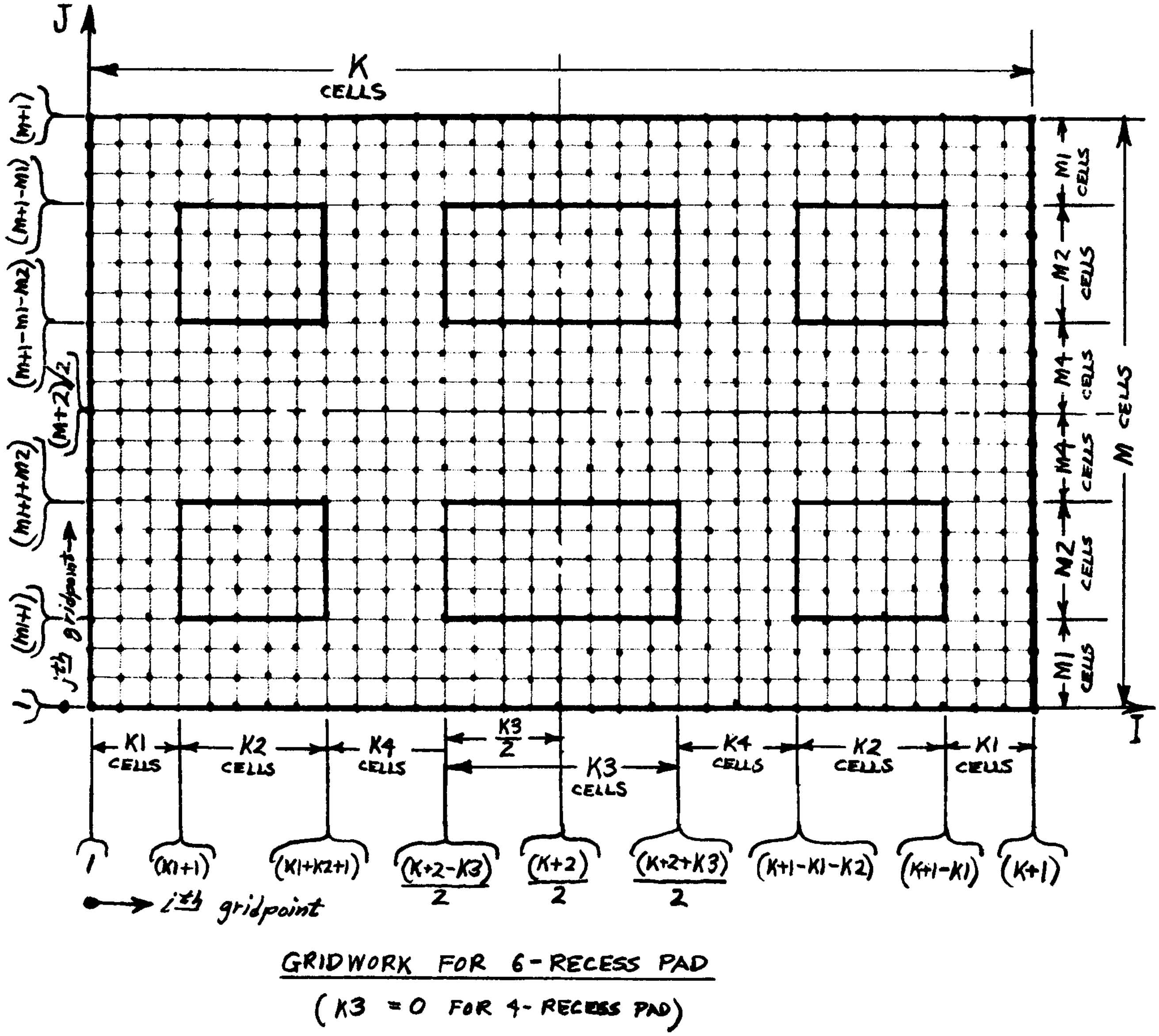

Fig. 5 - GRIDWORK FOR A 6-RECESS PAD

C. Output

The output of the program consists of two result pages and a listing of the pressure and clearance distributions over the grid. The first output page contains:

1. Run number
2. Title containing information on bearing type (hybrid includes velocity), number of recesses, and feeding method.
3. Value of Lambda, if used
4. Grid work data
5. Clearance distribution coefficients (for non-zero values)
6. Values of essential results of the component solutions.
7. Final results
8. Recess pressures

The second page contains:

1. Run number
2. Title containing information on bearing type (hybrid includes velocity), number of recesses, and feeding method.
3. A digit array representing configuration of pad with the following code.

   0 = external boundary point

   1 = recess point

   2 = sill point

D. Relationships Among the Dimensionless Variables

A number of dimensionless quantities are defined and evaluated by the computer program. These are:

Load Factor = $$W = \frac{w}{L^2(p_{ref} - p_a)} \quad [41]$$

Flow Factor = $$q_i = \frac{q_{ri}\ (12\mu)}{c^3(p_{ref} - p_a)} \quad [42]$$

Film Thickness Factor = $$H_{i,j} = \frac{h_{i,j}}{c} \quad [43]$$

Velocity Factor = $$\Lambda = \frac{6\mu UL}{c^2(p_{ref} - p_a)} \quad [44]$$

Recess Pressure Factor = $$\alpha_j = \frac{(p_r)_j - p_a}{(p_{ref} - p_a)} \quad [45]$$

Supply Pressure Factors

Separate pumps feeding each recess (Case 1)

$$\alpha_{js} = \alpha_j \quad [46]$$

One pump feeding two recess thru capillary tubes (Case 2)

$$p_i^{(K)} = \frac{q_i}{f_i} + \alpha_j \quad [47]$$

Each recess fed through capillary tubes from a common supply manifold (Case 3)

$$p^{(f)} = \frac{q_i}{f_i} + \alpha_j = PF \quad [48]$$

Capillary Factors

Case 1; $$f_i = \infty \qquad [49]$$

Case 2; $$f_i = \frac{q_i}{(p_i^{(K)} - \alpha_j)} \qquad [50]$$

Case 3; $$f_i = \frac{q_i}{(p^{(f)} - \alpha_j)} \qquad [51]$$

Moment Factors

Component about X = 0

$$\xi = \frac{M_{xo}}{wL} \qquad [52]$$

Component about Y = 0

$$\eta = \frac{M_{yo}}{wL} \qquad [53]$$

Depending upon the feeding method used, the values of the above mentioned dimensionless quantities are either assigned as input or evaluated within the computer program. The following table indicates whether the quantities are specified as input, (I), appear as output (O), or are able to be evaluated from the output (E).

Dimensionless Factor	FEEDING METHOD		
	Separate Pumps Feeding Each Recess	Separate Pumps Feeding Two Recesses Through Capillaries	Common Manifold at Fixed Pressure Through Capillaries
W	0	0	0
q_i	I	I	0
$H_{i,j}$	I	I	I
Λ	I	I	I
α_j	0	0	0
ξ	0	0	0
η	0	0	0
$p^{(K)}$	–	E	–
$p^{(f)}$	–	–	I
f_i	–	I	I

From the above listed dimensionless factors we can obtain relations useful for evaluating the dimensional quantities of the variables of interest. The following relationships may be derived using the above listed dimensionless factors.

Load-Film Thickness-Flow Coefficient

$$\frac{w(h_{i,j})^3}{L^2 q_{ri}\ \mu} = \frac{12(W)(H_{i,j})^3}{(q_i)} = (\overline{LHQ_i}) \qquad [54]$$

Load-Film Thickness-Velocity Coefficient

$$\frac{L^3\ \mu\ U}{w(h_{i,j})^2} = \frac{(\Lambda)}{6(W)(H_{i,j})^2} = (\overline{LHV}) \qquad [55]$$

Film Thickness-Flow-Velocity Coefficient

$$\frac{UL(h_{i,j})}{q_{ri}} = \frac{2(\Lambda)(H_{i,j})}{(q_i)} = (\overline{HQ_i V}) \qquad [56]$$

Load-Flow-Velocity Coefficient

$$U\left[\frac{L^5 \mu}{q_{ri}^{\ 2}\ w}\right]^{1/3} = \frac{2(\Lambda)}{\left[12(W)(q_i)^2\right]^{1/3}} = (\overline{LQ_i V}) \qquad [57]$$

Load-Film Thickness-Flow-Velocity Coefficient

$$\frac{w(h_{i,j})^4\ U}{q_{ri}^{\ 2}\ L\ \mu} = \frac{24(W)(H_{i,j})^4(\Lambda)}{(q_i)^2} = (\overline{LHQ_i V}) \qquad [58]$$

Recess Pressure Coefficient

$$\frac{(p_{rj} - p_a)L^2}{w} = \frac{(\alpha_j)}{(W)} = (\overline{PR_jW}) \qquad [59]$$

Supply Pressure Coefficients

Case 1 feed method;

$$\frac{(p_{sj} - p_a)L^2}{w} = \frac{(\alpha_j)}{(W)} = (\overline{PS_jW1}) \qquad [60]$$

Case 2 feed method;

$$\frac{(p_{sj} - p_a)L^2}{w} = \frac{(q_i/f_i) + (\alpha_j)}{(W)} = (\overline{PS_jW2}) \qquad [61]$$

Case 3 feed method;

$$\frac{(p_{sj} - p_a)L^2}{w} = \frac{(q_i/f_i) + (\alpha_j)}{(W)} = (\overline{PS_jW3}) \qquad [62]$$

Pressure Ratio Coefficients

Case I feed method;

$$\frac{(p_{rj} - p_a)}{(p_{sj} - p_a)} = 1.0 = (\overline{\beta_j1}) \qquad [63]$$

Case 2 feed method;

$$\frac{(p_{rj} - p_a)}{(p_{sj} - p_a)} = \frac{(\alpha_j)}{(q_i/f_i) + (\alpha_j)} = (\overline{\beta_j2}) \qquad [64]$$

Case 3 feed method;

$$\frac{(p_{rj} - p_a)}{(p_{sj} - p_a)} = \frac{(\alpha_j)}{(p^{(f)})} = (\overline{\beta_j3}) \qquad [65]$$

Pad Righting Moment-Load Coefficients (about pad center)

Component (about X = 0.5)

$$\frac{M_x}{wL} = (0.5 - \xi) = (\overline{MXW}) \qquad [66]$$

Component [about Y = 0.5 (AL)]

$$\frac{M_y}{wL} = [0.5(AL) - \eta] = (\overline{MYW}) \qquad [67]$$

Total moment coefficient (about pad center)

$$\frac{M}{wL} = \left[(1/2 - \xi)^2 + (AL/2 - \eta)^2 \right]^{\frac{1}{2}} = (\overline{MW}) \qquad [68]$$

Direction Angle

$$\phi = \tan^{-1} \left\{ \frac{(AL/2 - \eta)}{(1/2 - \xi)} \right\} = (\overline{MANG}) \qquad [69]$$

Pad Righting Moment-Film Thickness-Flow Coefficient

Component about X = 0.5

$$\frac{M_x (h_{i,j})^3}{L^3 \, q_{ri} \, \mu} = \frac{12(1/2 - \xi)(W)(H_{i,j})^3}{(q_i)} = (\overline{MXHQ_i}) \qquad [70]$$

Component about Y = 0.5(AL)

$$\frac{M_y (h_{i,j})^3}{L^3 \, q_{ri} \, \mu} = \frac{12(AL/2 - \eta)(W)(H_{i,j})^3}{(q_i)} = (\overline{MYHQ_i}) \qquad [71]$$

Total moment

$$\frac{M(h_{i,j})^3}{L^3 \, q_{ri} \, \mu} = \frac{12(W)(H_{i,j})^3}{(q_i)} \left[(1/2 - \xi)^2 + (AL/2 - \eta)^2\right]^{1/2} \qquad [72]$$

E. Sample Problems

A flat bearing pad having the dimensions shown in Figure 6 is to be analyzed using the computer program. Each recess is fed from a separate constant displacement pump for the following conditions of clearance distribution and velocity.

Run Number	Clearance Distribution	Velocity
7701	Uniform clearance all over	0
7702	Tilted about X = 1/2, ($H_{1,j} = 0.5$),($H_{KK,j} = 1.5$)	0
7703	Tilted about X = 1/2 ($H_{1,j}= 0.5$), ($H_{KK,j}=1.5$)	$\Lambda = 1.0$

Copies of the input data sheets for these three runs are shown in Appendix IV.

For convenience, let the dimensionless clearance at the center of the pad be

$$H_c = H\left(\frac{K+2}{2}, \ \frac{M+2}{2}\right) \qquad [73]$$

For all three runs, $H_c = 1.0$

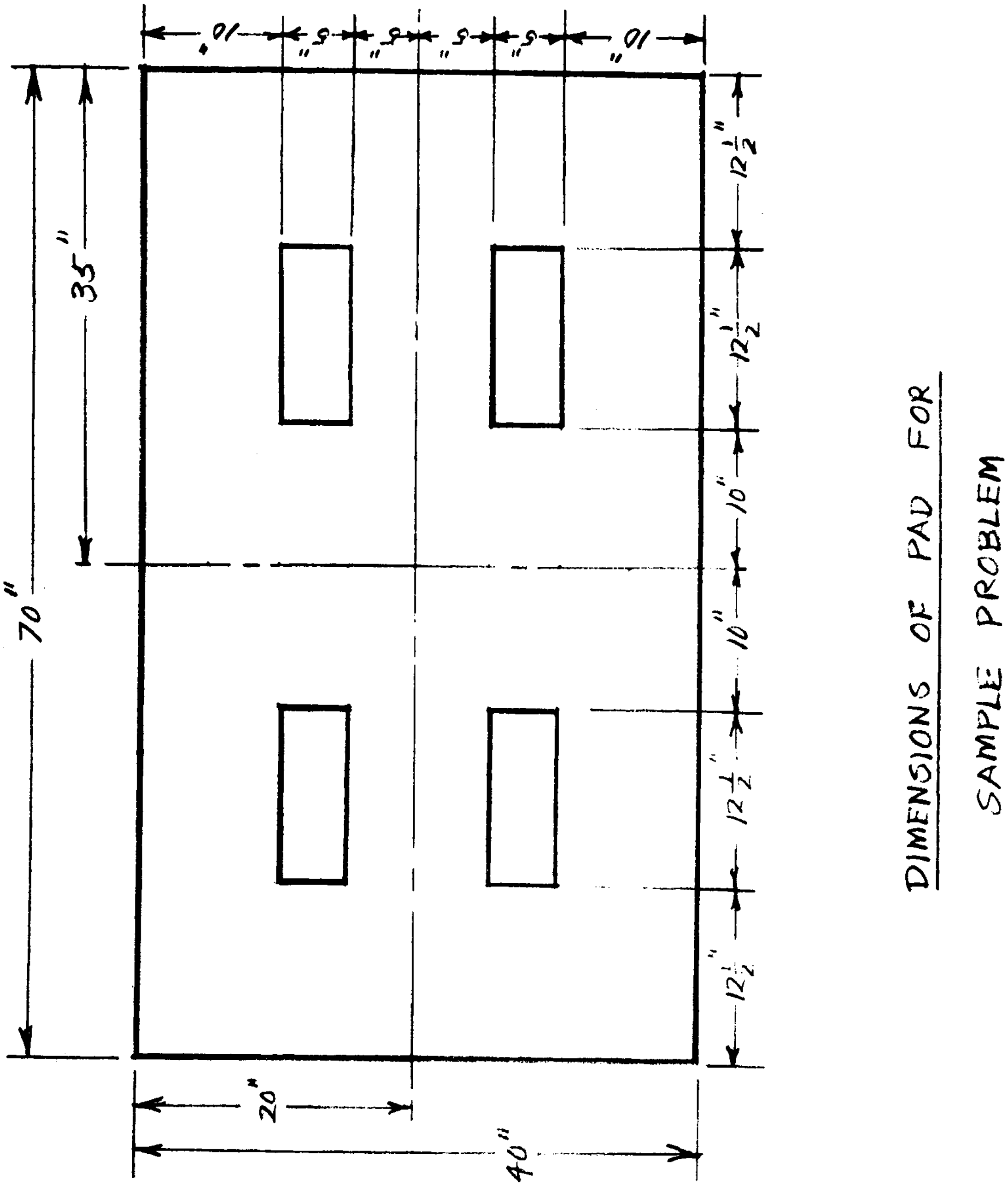

Fig. 6 - DIMENSIONS OF PAD FOR SAMPLE PROBLEM

The dimensionless computer input and output data are summarized below.

Dimensionless Factors	Run Number		
	7701	7702	7703
W	0.0933	0.1187	0.1308
q_i	1.0	1.0	1.0
H_c	1.0	1.0	1.0
ξ	0.5000	0.3708	0.3694
η	0.2857	0.2857	0.2857
α_1	0.30184	0.60023	0.64679
α_2	0.30184	0.17013	0.18384
α_3	0.30184	0.17013	0.18384
α_4	0.30184	0.60023	0.64679
Λ	0	0	1.0

Dimensionless performance coefficients in terms of H_c may be evaluated using equations [54] through [72], yielding the results listed below:

Performance Coefficients	Run Number		
	7701	7702	7703
$\overline{LHQ_i}$	1.1196	1.4244	1.5696
$\overline{LHV}$	0	0	1.275
$\overline{HQ_iV}$	0	0	2.0
$\overline{LQ_iV}$	0	0	1.72
$\overline{LHQ_iV}$	0	0	3.14
$\overline{PR_jW}$	3.23	5.07 for 1 & 4 1.44 for 2 & 3	4.95 for 1 & 4 1.40 for 2 & 3
$\overline{PS_jW1}$	3.23	5.07 for 1 & 4 1.44 for 2 & 3	4.95 for 1 & 4 1.40 for 2 & 3
$\overline{\beta_j1}$	1.0	1.0	1.0
$\overline{MXW}$	0	0.1292	0.1306
$\overline{MYW}$	0	0	0
$\overline{MW}$	0	0.1292	0.1306
$\overline{MANG}$	0	0	0
$\overline{MXHQ_i}$	0	15.48	15.32
$\overline{MYHQ_i}$	0	0	0
$\overline{MHQ_i}$	0	15.48	15.32

Problem 1: - Determine the recess and supply pressure required for a load $w = 1.5 \times 10^6$ pounds, and the given pad length of $L = 70"$.

The equations to be used are,

$$\frac{(p_{rj} - p_a)L^2}{w} = \overline{PR_jW}$$

$$\frac{(p_{sj} - p_a)L^2}{w} = PS_jW1$$

For the given pad length of $L = 70"$.

$$(p_{rj} - p_a) = (\overline{PR_jW}) \; \frac{1.5 \times 10^6}{4900} = 306(\overline{PR_jW})$$

Since $\overline{PR_jW} = \overline{PS_jW1}$,

$$(p_{sj} - p_a) = (p_{rj} - p_a) = 306(PR_jW)$$

Using the computed values of $\overline{PR_jW}$, The values of recess pressure and supply pressure (pump discharge) in psig are,

Recess No.	Run Number		
	7701	7702	7703
1	988	1550	1515
2	988	441	428
3	988	441	428
4	988	1550	1515

Problem 2: - Determine the required flow to each recess for a film thickness at the center of the pad of $h_c = 10 \times 10^{-3}$ in, at a load $w = 1.5 \times 10^6$ pounds.

To evaluate the flow, we use the performance coefficient relating load, film thickness and flow.

$$\overline{LHQ_i} = \frac{w(h_c)^3}{L^2 q_{ri} \mu}$$

$$q_{ri} = \frac{w(h_c)^3}{(\overline{LHQ_i}) L^2 \mu}$$

Assuming an SAE 30 oil at an operating temperature of 100°F, $\mu = 15 \times 10^{-6}$ lb-sec/in^2. Since the same flow is supplied to each recess,

$$q_{ri} = q_r = \frac{1.5 \times 10^6 \; (10 \times 10^{-3})^3}{(\overline{LHQ_i})(70)^2 \; (15 \times 10^{-6})}$$

$$q_r = \frac{20.4}{(\overline{LHQ_i})}$$

Using the computed values of $\overline{LHQ_i}$ for the three runs gives,

Run No.	$\overline{LHQ_i}$	q_r, (in^3/sec)	q_r, (GPM)
7701	1.1196	18.23	4.74
7702	1.4244	14.33	3.73
7703	1.5696	13.00	3.38

Problem 3: - What will be the film thickness at the center of the pad if the flow for all recesses in all three cases is 11.53 in^3/sec (3 GPM) for a load of $w = 1.5 \times 10^6$ lbs with $\mu = 15 \times 10^{-6}$ $lb\text{-}sec/in^2$.

Case 7701

$$\frac{w(h_c)^3}{L^2 q_{ri} \mu} = (\overline{LHQ_i}) = 1.1196$$

$$h_c = \left[\frac{1.1196\ (4900)(11.53)(15 \times 10^{-6})}{1.5 \times 10^{+6}}\right]^{1/3}$$

$h_c = 0.0086$ in.

Case 7702

$$h_c = (h_c \text{ for } 7701)\left[\frac{\overline{LHQ_i} \text{ for } 7702}{\overline{LHQ_i} \text{ for } 7701}\right]^{1/3} = 0.0086\left(\frac{1.4244}{1.1196}\right)^{1/3}$$

$h_c = 0.0093$ in.

Case 7703

$$h_c = (h_c \text{ for } 7701)\left[\frac{\overline{LHQ_i} \text{ for } 7703}{\overline{LHQ_i} \text{ for } 7701}\right]^{1/3} = 0.0086\left(\frac{1.5696}{1.1196}\right)^{1/3}$$

$h_c = 0.0096$ in.

Problem 4: - What velocity of relative motion will yield a film thickness at the center of 0.010 inch for a 13.0 in^3/sec flow and a load of 1.5×10^6 pounds for Run No. 7703.

Using the relationship

$$\overline{HQ_i V} = \frac{UL(h_c)}{q_{ri}} = 2.0$$

$$U = \frac{2.0(13.0)}{(70)(10 \times 10^{-3})}$$

$$U = 37.2 \text{ in./sec.}$$

Problem 5: - What is the pad righting moment for all three cases when the load is 1.5×10^6 lbs.

To find the pad righting moment,

$$\frac{M}{wL} = (\overline{MW})$$

$$\therefore M = (\overline{MW})wL = (\overline{MW})(1.5 \times 10^6)(70)$$

For the three runs

Run No.	$\overline{MW}$	M(in - lb)
7701	0	0
7702	.1292	13.6×10^6
7703	.1306	13.7×10^6

CLOSURE

In the interim between when the above described computer program was first successfully compiled and the writing of this report, a large number of problems have been run. The operating experience compiled has indicated that the program can readily handle a large variety of hydrostatic bearing design and analysis problems. To date, the computer program results have shown good correlation with the results obtained from the electric analog field plotter technique[1] (uniform clearance, zero velocity). It should be mentioned here that in two similar, previously developed hydrostatic bearing computer programs (which allowed the solution of bearing geometries capable of being solved analytically) the correlation between computer program results and known analytical solutions was extremely good.

An experimental program currently underway at The Franklin Institute (being conducted for the Jet Propulsion Laboratory, Contract No. 950-735) is directed toward establishing the correlation between computer program results and those obtainable experimentally (zero velocity, non-uniform film clearance).

In the course of working with the above described computer program, a number of possible additions, modifications and refinements aimed at making the program more efficient and useful have occurred to Jet Propulsion Laboratory and Franklin Institute personnel. They are enumerated below for the record.

1. Input:- The format of the required input information should be changed in order to make key punching and checking of the same much more convenient.

2. Internal Changes:

    a. The initial value of gamma should be reduced to 1.0 from 1.1.

b. Assign a new FORTRAN name to the ratio of pad y-direction length to x-direction length. Change from "AL" to "YOX". The name AL is confusing since AL (I) is also used as a superscripted variable.

c. Evaluate the following quantities for subsequent appearance as output.

$$HC = H \ @ \ \frac{KK+1}{2}, \frac{MM+1}{2}$$

$$ALHCQ(I) = 12(W)(HC)^3/[QQ(I)]$$

$$ALHCV = (\Lambda)/[6(W)(HC)^2]$$

$$HCQV(I) = 2(\Lambda)(HC)/[QQ(I)]$$

$$PRW(I) = [AL(I)]/(W)$$

$$PSW1(I) = [AL(I)]/(W)$$

$$PSW2(I) = \{[QQ(I)]/[FF(I)] + [AL(I)]\}/(W)$$

$$PSW3(I) = (PF)/(W)$$

$$BETA1(I) = [PRW(I)]/[PSW1(I)]$$

$$BETA2(I) = [PRW(I)]/[PSW2(I)]$$

$$BETA3(I) = [PRW(I)]/[PSW3(I)]$$

$$AMXW = (0.50 - CCSI)$$

$$AMYW = [0.50(YOX) - EETA]$$

$$AMW = \{(AMXW)^2 + (AMYW)^2\}^{\frac{1}{2}}$$

$$AMANG = \tan^{-1}\left\{\frac{(AMYW)}{(AMXW)}\right\}$$

d. Two recommendations are suggested for reducing the computer time required to obtain the component solutions within subroutine REYN. The first is to initially assign active sill point pressure values other than the currently used value of zero. This would, however, require considerable study before changing. A second possibility is to have the program recognize beforehand when identical component solutions for the individual recesses will be obtained. For example a symmetrical distribution of clearance in both the x and y-directions yields identical component solutions for recess combinations 1, 2, 3 and 4 and also for 5 and 6. Tilting of such a symmetrical film distribution about only X1 produces identical component solutions for recess combinations 1 and 4, 2 and 3, and 5 and 6. Tilting of a symmetrical film distribution about only Y1 produces identical solutions for recess combinations 1 and 3, and 2 and 4.

3. Output: -

   a. The numerical values of the following quantities should also be written for inclusion in the output:
   YOX, X1, Y1, TX, TY, LITER, TRUNC, PLAM, HC, ALHCQ(I), HCQV(I), ALHCV, PRW(I), PSW1(I), PSW2(I), PSW3(I), BETA1(I), BETA2(I) BETA3(I), AMXW, AMYW, AMW, and AMANG.

   Appropriate titles should also be used for these quantities (See equations [54] through [69].

   b. Eliminate writing out all "progress indicators". Write out only the last two or three values of PROG(ITER). The run number (NRUN) should also be written out in this portion of the output.

In the judgement of the personnel of The Franklin Institute, all of the goals set forth in our work proposal have been achieved during the course of this program.

James G. Hinkle
J. G. Hinkle
Project Engineer

Approved by:

W W Shugarts Jr
W. W. Shugarts, Jr., Mgr.
Friction & Lubrication Laboratory

N R Droulard
N. R. Droulard
Technical Director

Joseph R. Feldmeier
Joseph R. Feldmeier
Director of Laboratories

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1. Loeb, A. M., "The Determination of the Characteristics of Hydrostatic Bearings through the use of the Electric Analog Field Plotter," ASLE Transactions, Vol. 1, No. 1, April, 1958.

2. Hinkle, J. G. and V. Castelli, "A Computer Solution for Hydrostatic Bearings with Variable Film Thickness," Franklin Institute Final Report No. F-B2015, January 11, 1963, Prepared for Jet Propulsion Laboratory, Contract No. 950 448.

3. Shaw, M. C. and E. F. Macks, "Analysis and Lubrication of Bearings," McGraw Hill, 1949, N. Y., N. Y.

4. Hetenji, M., "Beams on Elastic Foundation," The University of Michigan Press.

NOMENCLATURE

AL	= ratio of pad y-length/pad x-length
A_n	= dimensionless clearance coefficients
E	= Youngs Modulus (psi)
H	= dimensionless film thickness = h/c
K	= the number of grid cells in the x-direction
L	= length of pad in the x-direction, inches
M	= the number of grid cells in the y-direction
M_x	= moment about $x = \frac{1}{2}$ axis (in-lbs)
M_y	= moment about $y = \frac{AL}{2}$ axis (in-lbs)
N	= total number of recesses
P_{ij}	= dimensionless pressure at grid point i,j
Q_{ij}	= dimensionless flow out of i^{th} recess corresponding to j^{th} component solution
$QQQ^{(k)}$	= dimensionless flow out of k^{th} pair of opposite recesses
T_x	= dimensionless tilt components in x-direction
T_y	= dimensionless tilt components in y-direction
U	= relative velocity of bearing members, in./sec.
W	= dimensionless load
W_j	= dimensionless load of the j^{th} component solution
X	= dimensionless x-coordinate = (x/L)
Y	= dimensionless y-coordinate = (x/L)
c	= a characteristic film thickness, (in.)
d	= capillary diameter (in.)
f_i	= capillary flow factor for i^{th} recess
h	= film thickness, (in.)
i	= grid index
j	= grid index
k	= modulus of the foundation (lb/in^2) as defined in reference 4
l	= capillary length (in.)
p	= pressure, (psia)

NOMENCLATURE (Cont'd)

p_a = ambient pressure, (psia)

$p^{(f)}$ = dimensionless supply manifold pressure

p_r = recess pressure, (psia)

p_{ref} = reference pressure, (psia)

p_s = supply manifold pressure, (psia)

q_i = dimensionless flow out of the i^{th} recess

q_{ri} = volume flow out of i^{th} recess (in^3/sec)

q_{rc} = volume flow out of i^{th} recess corresponding to j^{th} component solution (in^3/sec)

q_{2r} = total volume flow out of one pair of opposite recesses (in^3/sec)

$s = X - X_o$

$t = Y - Y_o$

w = total load, (lbs)

w_j = load carried by j^{th} recess, (lbs)

x = cartesian coordinate, (in.)

x_j = distance in x-direction to center of pressure of component solution (in.)

y = cartesian coordinate, (in.)

y_j = distance in y-direction to center of pressure of component solution (in.)

Λ = velocity factor = $\dfrac{6\mu UL}{c^2(p_{ref} - p_a)}$

$\Lambda' = \lambda L$

$\alpha = \left[\dfrac{\Delta X}{\Delta Y}\right]^2$

α_j = dimensionless recess pressure

β = slope of tilted pad in h, x, y space

γ = relaxation factor governing pressure distribution growth

$\Delta X = 1/K$

$\Delta Y = \dfrac{AL}{M}$

NOMENCLATURE (Cont'd)

η = dimensionless y coordinate of center of pressure

η_j = dimensionless y coordinate of center of pressure for i^{th} component solution

$\lambda = \sqrt[4]{\frac{k}{4\,E\,1}}$

μ = absolute viscosity coefficient (reyns)

ξ = dimensionless x coordinate of center of pressure

ξ_j = dimensionless x coordinate center of pressure for i^{th} component solution

APPENDIX I

PROGRAM BLOCK DIAGRAM

MAIN SUBPROGRAM

Fortran Instruction Listings
IBM 7094 Compilation Records
Flow Chart

FLOW SUBPROGRAM

Fortran Instruction Listings
IBM 7094 Compilation Records
Flow Chart

REYN SUBPROGRAM

Fortran Instruction Listings
IBM 7094 Compilation Records
Flow Chart

FORMH SUBPROGRAM

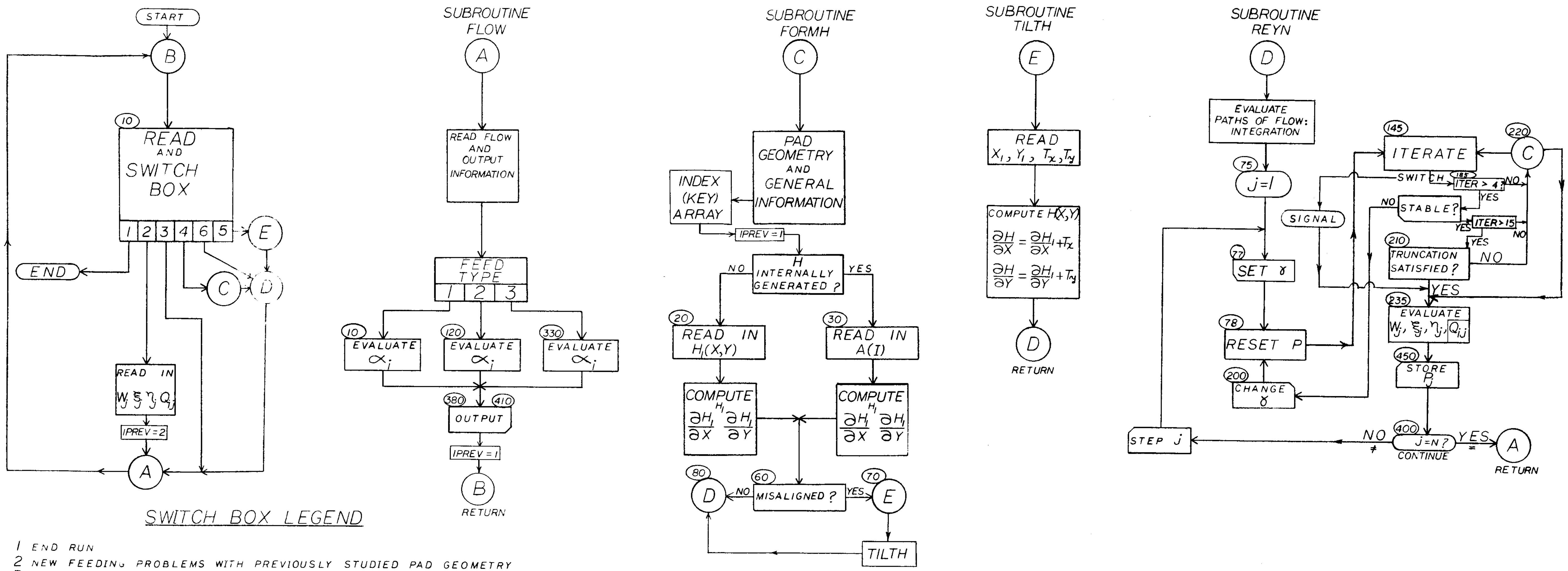
Fortran Instruction Listings
IBM 7094 Compilation Records
Flow Chart

TILTH SUBPROGRAM

Fortran Instruction Listings
IBM 7094 Compilation Records
Flow Chart

FUNCTION DETER SUBPROGRAM

Fortran Instruction Listings
IBM 7094 Compilation Records
Flow Chart



SWITCH BOX LEGEND

1 END RUN
2 NEW FEEDING PROBLEMS WITH PREVIOUSLY STUDIED PAD GEOMETRY
3 NEW FEEDING PROBLEMS WITH NEW PAD GEOMETRY
4 INTRODUCE NEW GEOMETRY
5 GENERATE NEW DATA FOR SAME GEOMETRY WITH MISALIGNMENT
6 GENERATE NEW DATA FOR SAME GEOMETRY WITH VELOCITY (LAMBDA)

J.P.L. VARIABLE FILM HYDROSTATIC BEARING PROGRAM-- BLOCK DIAGRAM

```
      MAIN PROGRAM FOR HYDROSTATIC BEARINGS WITH VARIABLE FILM THICKNES
C      DEVELOPED FOR J.P.L.  JH/VC  NOVEMBER, 1962
      DIMENSION H(67,45), HX(67,45), HY(67,45), Q(6,7), W(7), CSI(7),
     1 ETA(7), KEY(67,45), P(67,45), A(23)
      COMMON KK,MM,DX,DY,H,HX,HY,K1,K2,K3,M1,M2,TRUNC,Q,LIMJ,W,CSI,ETA,
     1 IPREV,KEY,LITER,P,NIGNAL,PLAM,X1,Y1,TX,TY,A,INDEX1,INDEX2
      REWIND 15
   10 READ INPUT TAPE 5, 1, NSWICH, NIMJ, NIGNAL
    1 FORMAT ( I1, 2I2)
      GO TO (20,30,40,50,60,70) , NSWICH
   20 CONTINUE
      CALL EXIT
   30 READ INPUT TAPE 5, 2,(W(J),J=1,6),(CSI(J),J=1,6),(ETA(J),J=1,6),((
     1Q(I,J), J=1,6), I=1,NIMJ)
    2 FORMAT (6E12.6)
      LIMJ = NIMJ
      IPREV = 2
      NIGNAL = 0
      CALL FLOW
      GO TO 10
   40 CALL FLOW
      GO TO 10
   50 CALL FORMH
      CALL REYN
      CALL FLOW
      GO TO 10
   60 CALL TILTH
      CALL REYN
      CALL FLOW
      GO TO 10
   70 CALL REYN
      CALL FLOW
      GO TO 10
      END(1,0,0,0,0,0,0,0,0,1,0,0,0,0,0)
```

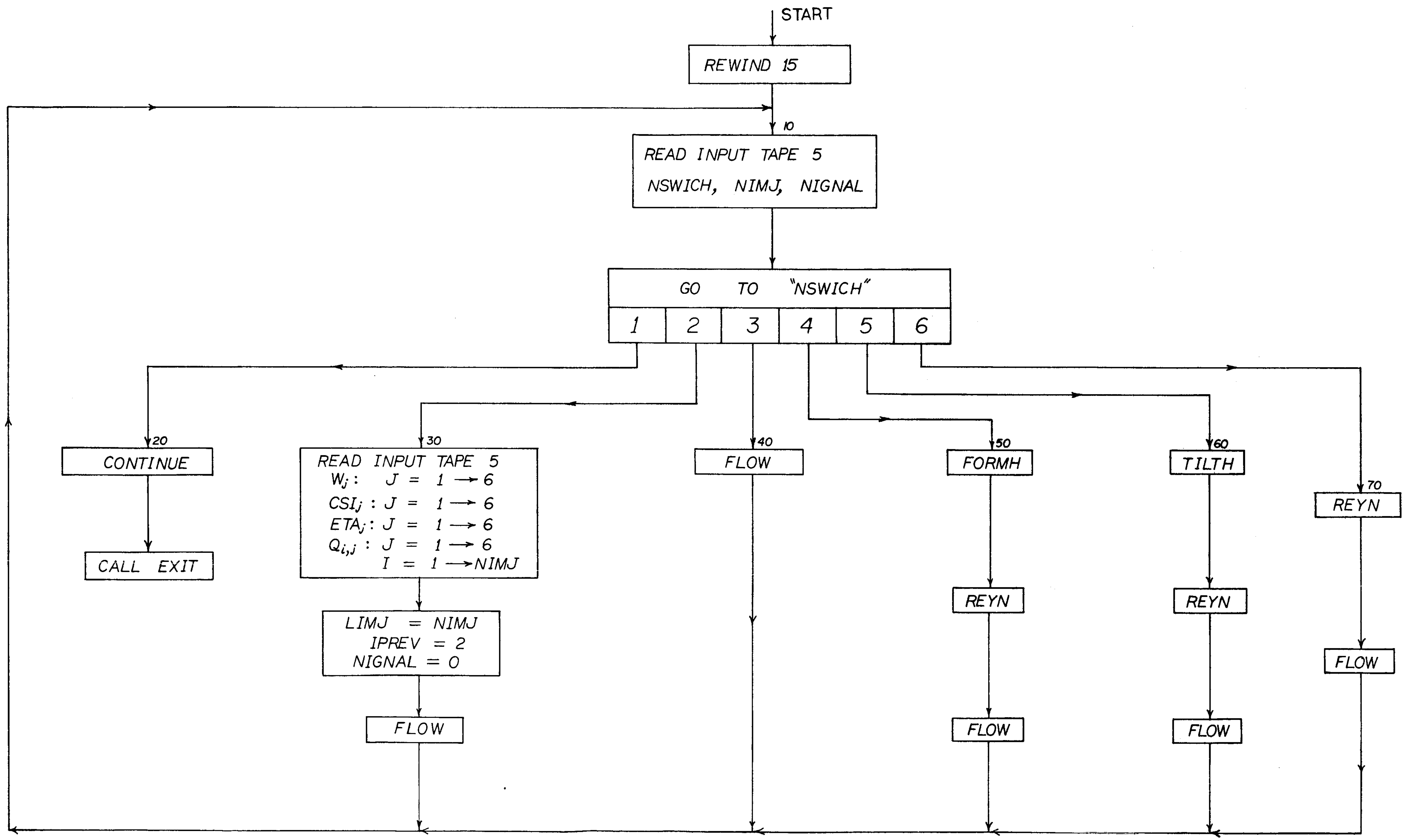
```
MAIN PROGRAM FOR HYDROSTATIC BEARINGS WITH VARIABLE FILM THICKNES

                          STORAGE NOT USED BY PROGRAM

   DEC   OCT            DEC   OCT
   112 00160          17379 41743

            STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

      DEC   OCT             DEC   OCT             DEC   OCT               DEC   OCT               DEC   OCT
   A 17404 41774       CSI 23456 55640       DX 32559 77457         DY 32558 77456          ETA 23449 55631
   H 32557 77455        HX 29542 71546       HY 26527 63637     INDEX1 17381 41745       INDEX2 17380 41744
IPREV 23442 55622       K1 23512 55730       K2 23511 55727         K3 23510 55726          KEY 23441 55621
  KK 32561 77461      LIMJ 23464 55650    LITER 20426 47712         M1 23509 55725           M2 23508 55724
  MM 32560 77460    NIGNAL 17410 42002     PLAM 17409 42001          P 20425 47711            Q 23506 55722
TRUNC 23507 55723       TX 17406 41776       TY 17405 41775          W 23463 55647           X1 17408 42000
  Y1 17407 41777

  STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

      DEC   OCT             DEC   OCT             DEC   OCT               DEC   OCT               DEC   OCT
NIMJ  111 00157    NSWICH  110 00156

            SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

      EFN   LOC             EFN   LOC             EFN   LOC               EFN   LOC               EFN   LOC
8)1     1 00154      8)2     2 00152

            LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

      DEC   OCT             DEC   OCT             DEC   OCT               DEC   OCT               DEC   OCT
  2)   94 00136       4) 32767 77777        6)    99 00143       C)GO   109 00155        D)401    16 00020
 E)2   38 00046      E)E     77 00115      E)F    80 00120        E)G    85 00125          E)H    90 00132

                     LOCATIONS OF NAMES IN TRANSFER VECTOR

      DEC   OCT             DEC   OCT             DEC   OCT               DEC   OCT               DEC   OCT
EXIT    4 00004      FLOW    5 00005     FORMH    6 00006       REYN      7 00007       TILTH      8 00010
(FPT)   0 00000     (RTN)    3 00003     (RWT)    1 00001      (TSH)      2 00002

                ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXIT      FLOW      FORMH      REYN      TILTH      (FPT)      (RTN)      (RWT)      (TSH)

    EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

 EFN  IFN   LOC      EFN  IFN   LOC      EFN  IFN   LOC      EFN  IFN   LOC      EFN  IFN   LOC
  10    7 00021       20   10 00047       30   12 00050       40   33 00116       50   35 00121
  60   39 00126       70   43 00133
```

MAIN PROGRAM

JET PROPULSION LABORATORY'S VARIABLE FILM HYDROSTATIC BEARING PROGRAM -- BLOCK DIAGRAM

DIMENSION: H, HX, HY, Q, W, CSI, ETA, KEY, P, A

COMMON : KK, MM, DX, DY, H, HX, HY, K1, K2, K3, M1, M2, TRUNC, Q, LIMJ, W, CSI, ETA, IPREV, KEY, LITER, P, NIGNAL, PLAM, X1, Y1, TX, TY, INDEX1, INDEX2



SUBROUTINE FLOW

```
      SUBROUTINE FLOW
      DIMENSION H(67,45), HX(67,45), HY(67,45), Q(6,7), W(7), CSI(7),
     1 ETA(7),AL(7), AA(6,7), F(6,6), D(6), QQQ(6), FF(6), PQ(6),
     1 P(67,45), PPPP(67,45), KEY(67,45), MK(10), T(6,6), TT(6), QQ(6),
     1 A(23),B(23),LOO(6),NC(23)
      COMMON KK,MM,DX,DY,H,HX,HY,K1,K2,K3,M1,M2,TRUNC,Q,LIMJ,W,CSI,ETA,
     1 IPREV,KEY,LITER,P,NIGNAL,PLAM,X1,Y1,TX,TY,A,INDEX1,INDEX2
      READ INPUT TAPE 5,1, NRUN, NCASE, IOUT
    1 FORMAT(I5,2I2)
      IF (NIGNAL - 1) 111, 1112, 111
  111 LLLL = LIMJ
      GO TO 1115
 1112 LLLL = LIMJ + 1
      AL(LLLL) = 1.0
 1115 GO TO (10, 120, 330) , NCASE
   10 READ INPUT TAPE 5, 2, (QQ(III),III=1,LIMJ)
    2 FORMAT (6E12.4)
      DO 80 LK = 1,LIMJ
      DO 40 I = 1, LIMJ
      DO 40 J = 1, LIMJ
      IF (J - LK) 30, 20, 30
   20 IF (NIGNAL - 1) 26, 27, 26
   26 AA(I,J) = QQ(I)
      GO TO 40
   27 AA(I,J) = QQ(I) - Q(I,LLLL)
      GO TO 40
   30 AA(I,J) = Q(I,J)
   40 CONTINUE
      D(LK) = DETER(AA,LIMJ)
   80 CONTINUE
      DQ = DETER(Q,LIMJ)
      DO 115 LK = 1, LIMJ
  115  AL(LK) = D(LK) / DQ
      GO TO 380
  120 LIMJ2 = LIMJ / 2
      READ INPUT TAPE 5, 2, (QQQ(III),III=1,LIMJ2)
      READ INPUT TAPE 5, 2, (FF(III), III=1,LIMJ)
      DO 130 I = 1, LIMJ, 2
      DO 130 J = 1, LIMJ
      T(I,J) = Q(I,J) + Q(I+1,J)
  130 CONTINUE
      IF (NIGNAL - 1) 132, 135, 132
  132 DO 133 I = 1,LIMJ, 2
      II = (I+1)/2
  133 TT(I) = QQQ(II)
      GO TO 139
  135 DO 138 I = 1, LIMJ, 2
      II = (I+1)/2
      TT(I)=QQQ(II) - Q(I,LIMJ+1) - Q(I+1,LIMJ+1)
  138 CONTINUE
  139 DO 200 I = 2,LIMJ,2
      IF ( NIGNAL - 1) 142, 145, 142
  142 TT(I) = 0.0
      GO TO 146
  145 TT(I) = Q(I,LIMJ+1)/FF(I) - Q(I-1,LIMJ+1)/FF(I-1)
  146 DO 200 J = 1, LIMJ
```

```
      SUBROUTINE FLOW

      IF (I-1-J) 140, 150, 140
  140 DEL = 0.0
      GO TO 160
  150 DEL = 1.0
  160 IF (I-J) 170, 180, 170
  170 DDEL = 0.0
      GO TO 190
  180 DDEL = 1.0
  190 T(I,J) = (Q(I-1,J)+DEL*FF(I-1))/FF(I-1)-(Q(I,J)+DDEL*FF(I))/FF(I)
  200 CONTINUE
  205 DO 270 LK = 1, LIMJ
      DO 230 I = 1, LIMJ
      DO 230 J = 1, LIMJ
      IF (J-LK) 220, 210, 220
  210 AA(I,J) = TT(I)
      GO TO 230
  220 AA(I,J) = T(I,J)
  230 CONTINUE
      D(LK) = DETER(AA,LIMJ)
  270 CONTINUE
      DT = DETER (T,LIMJ)
      DO 305 LK = 1, LIMJ
  305 AL(LK) = D(LK) / DT
      DO 310 I = 1, LIMJ
      QQ(I) = 0.0
      DO 310 J = 1, LLLL
  310 QQ(I) = QQ(I) + AL(J) * Q (I,J)
      IF (NCASE - 2 )  315, 315, 380
  315 DO 320 I = 1, LIMJ2
  320 PQ(I)=QQ(2*I-1)/FF(2*I-1) +AL(2*I-1)
      GO TO 380
  330 READ INPUT TAPE 5, 5, PF
    5 FORMAT  (F10.4)
      READ INPUT TAPE 5, 2, (FF(III), III=1,LIMJ)
      DO 370 I = 1, LIMJ
      IF ( NIGNAL - 1) 332, 333, 332
  332 TT(I) = PF * FF(I)
      GO TO 335
  333 TT(I) = PF * FF(I) - Q(I,LIMJ+1)
  335 DO 370 J = 1, LIMJ
      IF (I-J) 340, 350, 340
  340 DDEL = 0.0
      GO TO 360
  350 DDEL = 1.0
  360 T(I,J) = Q(I,J) + DDEL * FF(I)
  370 CONTINUE
      GO TO 205
  380 WW = 0.0
      DO 390 I = 1, LLLL
  390 WW = WW + AL(I) * W(I)
      CCSI = 0.0
      EETA = 0.0
      DO  400 I = 1,LLLL
      CCSI = CCSI + AL(I) * CSI(I)*W(I)/WW
  400 EETA = EETA + AL(I) * ETA(I) * W(I)/ WW
      IF ( NIGNAL - 1) 402, 403, 402
```

```
      SUBROUTINE FLOW
  402 WRITE OUTPUT TAPE 6,6,NRUN,LIMJ
      GO TO 410
  403 WRITE OUTPUT TAPE 6,32, NRUN, LIMJ
  410 GO TO (420, 430, 440),NCASE
  420 WRITE OUTPUT TAPE 6,7
    7 FORMAT (31X 58HFEEDING = POSITIVE DISPLACEMENT PUMPS FEEDING EACH
     1RECESS.   /)
      GO TO 450
  430 WRITE OUTPUT TAPE  6,8
    8 FORMAT(14X 92HFEEDING = POSITIVE DISPLACEMENT PUMPS FEEDING PAIRS
     1OF RECESSES WITH CAPILLARY COMPENSATION.    )
      GO TO 450
  440 WRITE OUTPUT TAPE 6,9,PF
    9 FORMAT (5X 36HFEEDING = COMMON CONSTANT PRESSURE (F7.3,67H ATM.) R
     1ESERVOIR FEEDING ALL RECESSES WITH CAPILLARY COMPENSATION.   /)
  450 IF (NCASE - 2) 452, 451, 452
  451 WRITE OUTPUT TAPE 6,15,(QQQ(I), I=1,LIMJ2)
   15 FORMAT ( 11H PUMP FLOWS  3E18.7   )
  452 GO TO (460, 480), IPREV
  460 K = KK - 1
      M = MM - 1
      IF ( NIGNAL - 1) 454, 453, 454
  453 WRITE OUTPUT TAPE 6,28, PLAM
   28 FORMAT ( 10H LAMBDA = F8.4)
   29 FORMAT ( 17H GRID POINTS, K = I3,2X 4H M = I3, 5X 5H K1 = I3, 2X
     1 5H K2 = I3, 2X 5H K3 = I3, 3X 5H M1 = I3, 2X 5H M2 = I3   )
  454 WRITE OUTPUT TAPE 6,29, K, M, K1, K2, K3, M1, M2
      IF ( INDEX1 - 1) 455, 459, 455
  455 KI = 0
      DO 458  L = 1, 23
      IF ( ABSF(A(L)) - 0.1E-06)  458, 456, 456
  456 KI = KI + 1
      B (KI) = A(L)
      NC(KI) = L
  458 CONTINUE
      WRITE OUTPUT TAPE 6,4441,(NC(I),B(I), I = 1,KI)
 4441 FORMAT (24H CLEARANCE COEFFICIENTS /5(4H ,AA I2,3H)= E14.8))
  459 IF (INDEX2 - 1) 4460, 461, 4460
 4460 IF (NSWICH - 5) 462, 461, 462
  461 WRITE OUTPUT TAPE 6,31, X1, Y1, TX, TY
   31 FORMAT ( 19H TILTED PAD, X1 =  E15.8, 2X 6H Y1 = E15.8, 2X 6H TX =
     1  E15.8, 2X 6H TY =  E15.8 )
  462 CONTINUE
      GO TO 480
C      START A  NEW PAGE OF OUTPUT
 4620 IF (NIGNAL - 1)  463, 464, 463
  463 WRITE OUTPUT TAPE 6, 6, NRUN, LIMJ
      GO TO 465
  464 WRITE OUTPUT TAPE 6,32, NRUN, LIMJ
   32 FORMAT (12H1RUN NUMBER I5, 26X  25H HYBRID BEARING PAD WITH  I1,
     1 10H RECESSES )
  465 GO TO ( 466,467,468),NCASE
  466 WRITE OUTPUT TAPE 6,7
      GO TO  469
  467 WRITE OUTPUT TAPE 6,8
      GO TO  469
```

```
      SUBROUTINE FLOW
  468 WRITE OUTPUT TAPE 6,9, PF
  469 WRITE OUTPUT TAPE 6,3, (KEY(I,1), I = 1,KK)
      DO 470 J = 2, MM
  470 WRITE OUTPUT TAPE 6,4,(KEY(I,J), I=1,KK )
      GO TO 549
    3 FORMAT(20H PAD CONFIGURATION.   67I1    )
    4 FORMAT ( 20X  67I1         )
  480 WRITE OUTPUT TAPE 6,4801
 4801 FORMAT ( // 54X 10H OUTPUT       )
      IF (LIMJ - 4) 490, 490, 500
  490 IF (NIGNAL - 1) 494, 496, 494
  494 WRITE OUTPUT TAPE 6,12,(QQ(I),I=1,4),(Q(1,J),J=1,4),(W(I),I=1,4) ,
     1(Q(2,J),J=1,4),(CSI(I),I=1,4),(Q(3,J),J=1,4),(ETA(I),I=1,4),(Q(4,J
     1) , J=1,4)
      GO TO 510
   12 FORMAT ( 8H QQ(I)= 4F9.2,10X10H** Q(I,J)= 4F9.4/8H W(I)=  4F9.4,10
     1X2H**8X 4F9.4/8H CSI(I)= 4F9.4,10X 2H** 8X 4F9.4/8H ETA(I)= 4F9.4,
     110X 2H** 8X 4F9.4 )
  496 WRITE OUTPUT TAPE 6,112,(QQ(I),I=1,4),(W(I),I=1,5),(CSI(I),I=1,5),
     1(ETA(I),I=1,5), ((Q(I,J),J=1,5),I=1,4)
      GO TO 510
  112 FORMAT ( 8H QQ(I)= 4F11.4/8H W(I)=  5F9.4/ 8H CSI(I)= 5F9.4/  8H E
     1TA(I)= 5F9.4// 10X 5H J=1, 4X 5H J=2, 4X 5H J=3, 4X 5H J=4, 4X
     1 5H J=5, / 8H Q(1,J)= 5F9.4/ 8H Q(2,J)= 5F9.4/ 8H Q(3,J)= 5F9.4/
     1 8H Q(4,J)= 5F9.4  )
  500 IF (NIGNAL - 1) 504, 506, 504
  504 WRITE OUTPUT TAPE 6,13,(QQ(I),I=1,6),(Q(1,J),J=1,6),(W(I),I=1,6)
     1,(Q(2,J),J=1,6),(CSI(I),I=1,6),(Q(3,J),J=1,6),(ETA(I),I=1,6),(Q(4,
     1J),J=1,6),(Q(5,J),J=1,6),(Q(6,J),J=1,6)
      GO TO 510
   13 FORMAT( 8H QQ(I)= 6F8.2, 2X 10H** Q(I,J)= 6F8.4/8H W(I)=  6F8.4,2X
     1 2H** 8X 6F8.4/8H CSI(I)= 6F8.4, 2X 2H** 8X 6F8.4/8H ETA(I)= 6F8.4
     1,2X 2H** 8X 6F8.4/58X 2H** 8X 6F8.4/58X 2H** 8X 6F8.4)
  506 WRITE OUTPUT TAPE 6,113,(QQ(I),I=1,6),(W(I),I=1,7),(CSI(I),I=1,7),
     1 (ETA(I),I=1,7),((Q(I,J),J=1,7),I=1,16)
  113 FORMAT ( 8H QQ(I)= 6F11.4/ 8H W(I)=  7F9.4/ 8H CSI(I)= 7F9.4/ 8H E
     1TA(I)= 7F9.4// 10X 5H J=1, 4X 5H J=2, 4X 5H J=3, 4X 5H J=4, 4X
     1 5H J=5, 4X 5H J=6,  4X 5H J=7,/  8H Q(1,J)= 7F9.4 / 8H Q(2,J)= 7F
     19.4/ 8H Q(3,J)= 7F9.4/ 8H Q(4,J)= 7F9.4/ 8H Q(5,J)= 7F9.4/
     1 8H Q(6,J)= 7F9.4 )
  510 IF (NCASE - 2) 530, 520, 520
  520 WRITE OUTPUT TAPE 6,14,(FF(I), I=1,LIMJ     )
   14 FORMAT(24H CAPILLARY FACTORS F(I)=   6E16.7 )
  530 QQQQ = 0.0
      DO 540 I=1,LIMJ
  540 QQQQ = QQQQ + QQ(I)
    6 FORMAT (12H1RUN NUMBER I5,23X 29HHYDROSTATIC BEARING PAD WITH  I1,
     1 10H RECESSES.  )
      WRITE OUTPUT TAPE 6,16,WW,CCSI,EETA,QQQQ
   16 FORMAT (28H FINAL RESULTS = TOTAL LOAD= F8.4, 6H  CSI=F7.4  , 6H E
     1TA= F7.4, 13H  TOTAL FLOW= E15.7  )
      DO 543 L = 1, LIMJ
  543 LOO(L) = L
      WRITE OUTPUT TAPE 6,5432,(LOO(L),AL(L), L = 1,LIMJ)
 5432 FORMAT (17H RECESS PRESSURES / 2X 6(6H,  AL( I1, 4H) = F8.5))
      GO TO (4620,549), IPREV
```

```
      SUBROUTINE FLOW
  549 IOUT = IOUT + 1
      GO TO ( 550, 555, 555, 695),IOUT
  550 IPREV=1
      WRITE OUTPUT TAPE 6,8888
 8888 FORMAT (1H1)
      RETURN
   17 FORMAT (8E15.8  )
  555 GO TO(560,556),IPREV
  556 WRITE OUTPUT TAPE 6,5555
 5555 FORMAT(52HOPRESSURE AND CLEARANCE DISTRIBUTIONS NOT AVAILABLE.    )
      GO TO 550
  560 DO 570 I=1,KK
      DO 570 J=1,MM
  570 PPPP(I,J) = 0.0
      REWIND  15
      DO 580 II = 1, LIMJ
      READ TAPE 15,P
      DO 580 I=1,KK
      DO 580 J = 1, MM
  580 PPPP(I,J) = PPPP(I,J) + AL(II) * P( I,J)
      REWIND  15
      KK1 = 0
  590 IF (KK - KK1 - 10) 600, 600, 610
  600 KK2 = KK
      GO TO 620
  610 KK2 = KK1 + 10
  620 DO 630  L = 1,10
  630 MK(L) = KK1 + L
      IF (KK-KK2) 640, 640, 650
  640 KK3 = KK2 - KK1
      WRITE OUTPUT TAPE 6, 18, NRUN,  (MK(L),L = 1,KK3)
      GO TO 660
  650 WRITE OUTPUT TAPE 6, 18,  NRUN, (MK(L), L = 1,10 )
  660 KK11 = KK1 + 1
      DO 670 J = 1, MM
  670 WRITE OUTPUT TAPE 6, 19,J,(PPPP(I,J),I=KK11,KK2)
   19 FORMAT (3H J= I3, 4H,     10F11.4)
      IF ( KK - KK2)  690, 690, 680
  680 KK1 = KK1 + 10
      GO TO 590
   18 FORMAT ( 1H1 49X 22H PRESSURE DISTRIBUTION//5H RUN I5, 5X 2HI= I3
     1,9(8H      I=  I3)/)
  690 CONTINUE
      IF (IOUT - 2) 550, 695, 550
  695 KK1 = 0
  700 IF (KK-KK1 - 10) 710, 710, 720
  710 KK2 = KK
      GO TO 730
  720 KK2 = KK1 + 10
  730 DO 740 L = 1, 10
  740 MK(L) = KK1 + L
      IF (KK - KK2) 750, 750, 760
  750 KK3 =  KK2 - KK1
      WRITE OUTPUT TAPE 6, 21, NRUN, (MK(L), L = 1,KK3)
   21 FORMAT ( 1H1 49X 22HCLEARANCE DISTRIBUTION //5H RUN  I5, 6H    I=
     1I3, 9( 8H      I= I3)/)
```

```
      SUBROUTINE FLOW

      GO TO 770
  760 WRITE OUTPUT TAPE 6, 21, NRUN,(MK(L),L=1,10)
  770 KK11 = KK1 + 1
      DO 780  J = 1, MM
  780 WRITE OUTPUT TAPE 6, 22, J,(H(I,J), I = KK11,KK2)
   22 FORMAT (3H J= I3, 4H,    10F11.7 )
      IF (KK - KK2)  550, 550, 790
  790 KK1 = KK1 + 10
      GO TO 700
      END(1,0,0,0,0,0,0,0,0,1,0,0,0,0,0)
```

SUBROUTINE FLOW

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
5109	11765	17379	41743

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A	17404	41774	CSI	23456	55640	DX	32559	77457	DY	32558	77456	ETA	23449	55631
H	32557	77455	HX	29542	71546	HY	26527	63637	INDEX1	17381	41745	INDEX2	17380	41744
IPREV	23442	55622	K1	23512	55730	K2	23511	55727	K3	23510	55726	KEY	23441	55621
KK	32561	77461	LIMJ	23464	55650	LITER	20426	47712	M1	23509	55725	M2	23508	55724
MM	32560	77460	NIGNAL	17410	42002	PLAM	17409	42001	P	20425	47711	Q	23506	55722
TRUNC	23507	55723	TX	17406	41776	TY	17405	41775	W	23463	55647	X1	17408	42000
Y1	17407	41777												

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
AA	5003	11613	AL	5108	11764	B	5055	11677	D	5101	11755	FF	5089	11741
F	4961	11541	LOO	5032	11650	MK	5077	11725	NC	5026	11642	PPPP	4925	11475
PQ	5083	11733	QQQ	5095	11747	QQ	5061	11705	T	1910	03566	TT	5067	11713

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
CCSI	1874	03522	DDEL	1873	03521	DEL	1872	03520	DQ	1871	03517	DT	1870	03516
EETA	1869	03515	II	1868	03514	IOUT	1867	03513	I	1866	03512	J	1865	03511
KI	1864	03510	KK11	1863	03507	KK1	1862	03506	KK2	1861	03505	KK3	1860	03504
K	1859	03503	LIMJ2	1858	03502	LK	1857	03501	LLLL	1856	03500	L	1855	03477
M	1854	03476	NCASE	1853	03475	NRUN	1852	03474	NSWICH	1851	03473	PF	1850	03472
QQQQ	1849	03471	WW	1848	03470									

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)1	1	03447	8)2	2	03445	8)3	3	03254	8)4	4	03246	8)5	5	03443
8)6	6	03014	8)7	7	03441	8)8	8	03425	8)9	9	03403	8)C	12	03235
8)D	13	03140	8)E	14	03023	8)F	15	03356	8)G	16	02777	8)H	17	02744
8)I	18	02723	8)J	19	02730	8)L	21	02705	8)M	22	02667	8)S	28	03351
8)T	29	03345	8)V	31	03310	8)10	32	03271	8)3G	112	03204	8)3H	113	03102
8)4AP	4441	03321	8)4M1	4801	03242	8)590	5432	02757	8)5DJ	5555	02742	8)8LO	8888	02745

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	1832	03450	2)	1440	02640	3)	1450	02652	6)	1453	02655	C)G0	1836	03454
C)G1	1837	03455	C)G3	1838	03456	C)G4	1839	03457	C)G5	1840	03460	C)G8	1841	03461
C)GA	1842	03462	C)GB	1843	03463	C)100	1844	03464	C)101	1845	03465	C)102	1846	03466
C)200	1847	03467	D)108	88	00130	D)114	276	00424	D)11J	353	00541	D)127	484	00744
D)130	628	01164	D)23B	716	01314	D)27D	1324	02454	D)27E	1329	02461	D)314	275	00423
D)327	483	00743	D)37D	1323	02453	D)37E	1328	02460	D)40E	114	00162	D)420	580	01104
D)43T	841	01511	D)714	274	00422	D)727	482	00742	E)C	105	00151	E)29	492	00754

SUBROUTINE FLOW

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
DETER	2	00002	(FIL)	4	00004	(RLR)	8	00010	(RTN)	1	00001	(RWT)	5	00005
(SLI)	7	00007	(STH)	3	00003	(TSB)	6	00006	(TSH)	0	00000			

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

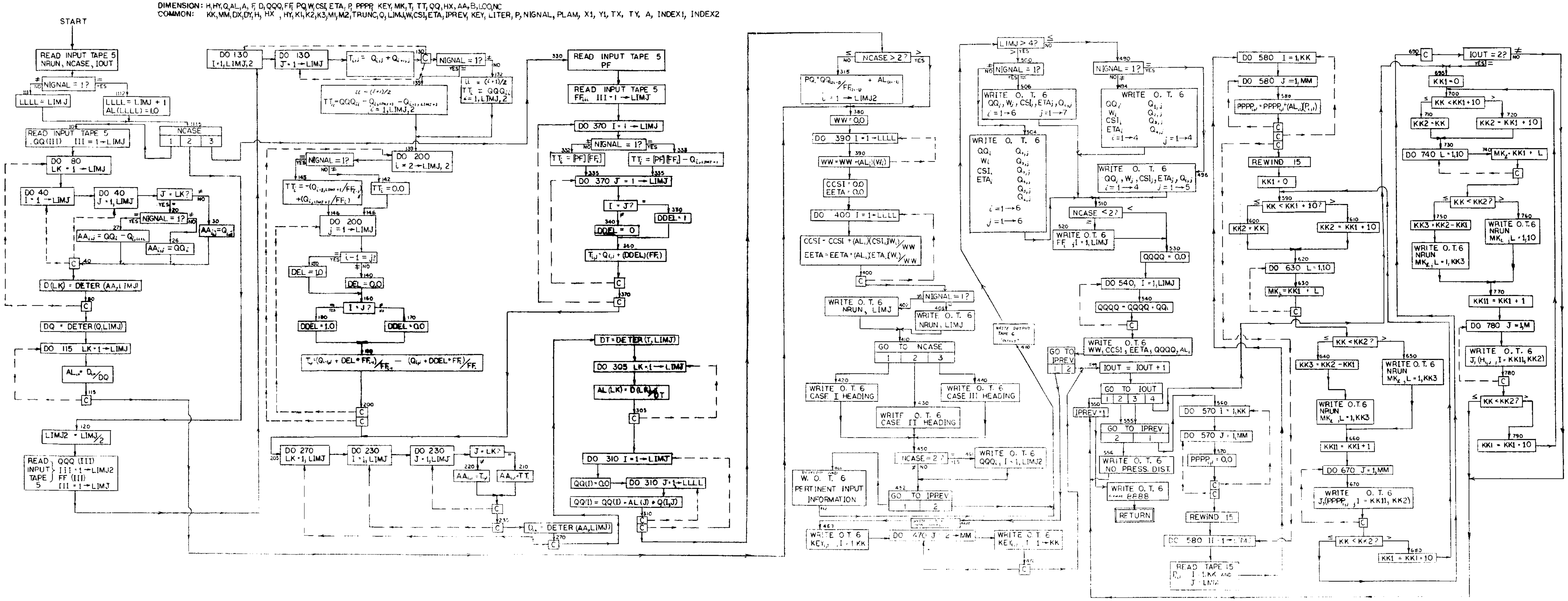
DETER (FIL) (RLR) (RTN) (RWT) (SLI) (STH) (TSB) (TSH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
111	38	00045	1112	40	00052	1115	42	00061	10	43	00064	20	52	00143
26	53	00146	27	55	00152	30	57	00157	40	58	00163	80	61	00204
115	65	00217	120	67	00225	130	81	00277	132	83	00307	133	85	00325
135	87	00333	138	90	00370	139	91	00374	142	93	00430	145	95	00433
146	96	00443	140	98	00454	150	100	00457	160	101	00461	170	102	00464
180	104	00467	190	105	00471	200	106	00505	205	107	00522	210	111	00554
220	113	00557	230	114	00561	270	117	00577	305	121	00612	310	125	00636
315	127	00656	320	128	00662	330	130	00673	332	139	00750	333	141	00755
335	142	00761	340	144	00771	350	146	00774	360	147	00776	370	148	01002
380	150	01020	390	152	01025	400	157	01050	402	159	01063	403	162	01074
410	164	01105	420	165	01110	430	167	01117	440	169	01126	450	171	01140
451	172	01145	452	177	01165	460	178	01167	453	181	01202	454	183	01214
455	186	01245	456	189	01262	458	192	01273	459	198	01315	4460	199	01320
461	200	01325	462	202	01341	4620	204	01342	463	205	01345	464	208	01362
465	210	01376	466	211	01401	467	213	01410	468	215	01417	469	217	01431
470	223	01467	480	229	01512	490	231	01524	494	232	01527	496	259	01610
500	279	01655	504	280	01660	506	313	01753	510	332	02017	520	333	02024
530	338	02043	540	340	02050	543	344	02102	549	351	02133	550	353	02144
555	357	02161	556	358	02164	560	360	02173	570	362	02206	580	369	02247
590	372	02270	600	373	02275	610	375	02300	620	376	02303	630	377	02306
640	379	02320	650	387	02345	660	393	02364	670	395	02410	680	402	02442
690	404	02446	695	406	02455	700	407	02462	710	408	02467	720	410	02472
730	411	02475	740	412	02500	750	414	02512	760	422	02537	770	428	02556
780	430	02602	790	437	02634									

FLOW

DIMENSION: H,HY,Q,AL,A, F, D,QQQ,FF, PQ,W,CSI, ETA, P, PPPP, KEY, MK,T, TT, QQ, HX, AA, B, LOQ,NC
COMMON: KK,MM,DX,DY,H, HX , HY, K1, K2, K3,M1,M2,TRUNC,Q, LIMJ,W,CSI,ETA, IPREV, KEY, LITER, P, NIGNAL, PLAM, X1, Y1, TX, TY, A, INDEX1, INDEX2



```
      SUBROUTINE REYN

      SUBROUTINE REYN
      DIMENSION H(67,45), HX(67,45), HY(67,45), Q(6,7), W(7), CSI(7),
     1 ETA(7), A(23), PPP(67), P(67,45), PROG(1000),KR(6),KRR(6),MR(6),
     1 MRR(6), KEY(67,45)
      COMMON KK,MM,DX,DY,H,HX,HY,K1,K2,K3,M1,M2,TRUNC,Q,LIMJ,W,CSI,ETA,
     1 IPREV,KEY,LITER,P,NIGNAL,PLAM,X1,Y1,TX,TY,A,INDEX1,INDEX2
      READ INPUT TAPE 5,1, LITER, TRUNC, PLAM
    1 FORMAT (I5, 2E16.8)
      ALPHA = (DX * DX) /(DY * DY )
      FACTOR = 1.0/(2.0*(1.0 + ALPHA))
      K = KK- 1
       M = MM-1
      NREL = K + M - K1 - K2 - M1 - M2 - 2
      FK = K
      FM = M
      NACT = (K-1)*(M-1)-(4*(K2+1)+ 2*(K3+1)) *(M2+1)
      PACT = NACT
      IF(K3) 10, 10, 20
   10 LIMJ = 4
      NACT = (K-1)*(M-1) - 4*(K2+1)*(M2+1)
      PACT = NACT
      GO TO 30
   20 LIMJ = 6
   30 KR(1) = 2
      MR(1) = 2
      MR(3) = 2
      KRR(3) = K
      MRR(4) = M
      KR(4) =  2
      KRR(2) = K
      MRR(2) =  M
      IF (LIMJ-4) 50,50,40
   40 MR(5) = 2
      MRR(6) = M
   50 MR(4) = M/2+1
      MRR(1) = M/2+1
      MR(6) = M/2+1
      MRR(5) = M/2+1
      MR(2) = M/2+1
      MRR(3) = M/2+1
      REWIND 15
      IF (LIMJ -4)  60,60,70
   60 KRR(1) = K/2+1
      KR(3) = K/2 + 1
      KRR(4) = K/2+1
      KR(2) = K/2+1
      GO TO 71
   70 KKRC = (K-K3+2*K1+2*K2+4)/4
      KRR(1) = KKRC
      KRR(4) = KKRC
      KR (6) = KKRC
      KR (5) = KKRC
      KRR(5) = K - KKRC + 2
      KRR(6) = K - KKRC + 2
      KR (2) = K - KKRC + 2
      KR (3) = K - KKRC + 2
```

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      SUBROUTINE REYN
   71 IF (NIGNAL - 1) 72, 74, 72
   72 LLLL = LIMJ
      GO TO 75
   74 LLLL = LIMJ + 1
   75 DO 460 JJJ = 1, LLLL
   77 GAMMA = 1.1
   78 DO 140 I = 1,KK
      DO 140 J = 1,MM
      IF ( JJJ-LIMJ-1) 79, 80, 80
   79 KEYIJ = KEY(I,J) + 1
      GO TO ( 80, 90, 80), KEYIJ
   80 P(I,J) = 0.0
      GO TO 140
   90 IF (I-KR(JJJ)) 80,100, 100
  100 IF(I-KRR(JJJ)) 110,110,80
  110 IF (J - MR(JJJ))  80, 120, 120
  120 IF (J-MRR(JJJ)) 130, 130, 80
  130 P(I,J) = 1.0
  140  CONTINUE
      PGAMMA = 1.0 - GAMMA
  145 DO 220 ITER = 1, LITER
      PROG(ITER) = 0.0
      DO 146 I = 2,K
  146 PPP(I) = P (I,1)
      IF ( JJJ - LIMJ - 1) 147, 1147,1147
  147 DO 170 J = 2,M
      DO 170 I = 2,K
      KEYIJ = KEY(I,J) + 1
      GO TO (150, 150, 160) , KEYIJ
  150 PP  = P(I,J)
      GO TO 165
  160 PPRIME=FACTOR*(P(I+1,J)+P(I-1,J)+(P(I+1,J)-P(I-1,J))*HX(I,J)+ALPHA
     1*(P(I,J+1)+P(I,J-1)+(P(I,J+1) - P(I,J-1))*HY(I,J)))
      PP = GAMMA * PPRIME + PGAMMA * P(I,J)
      PROG(ITER) = PROG(ITER) + PP
  165 P(I,J-1) = PPP(I)
      PPP(I) = PP
  170 CONTINUE
      GO TO 179
 1147 DO 1170 J = 2, M
      DO 1170 I = 2, K
      KEYIJ = KEY(I,J) + 1
      GO TO (1150,  1150, 1160), KEYIJ
 1150 PP = P(I,J)
      GO TO 1165
 1160 PPRIME=FACTOR*(P(I+1,J)+P(I-1,J)+(P(I+1,J)-P(I-1,J)+(PLAM/1.5)*DX/
     1(H(I,J)*H(I,J)))*HX(I,J) + ALPHA*(P(I,J+1)+P(I,J-1)+(P(I,J+1) -
     1P(I,J-1))*HY(I,J)))
      PP = GAMMA * PPRIME + PGAMMA * P(I,J)
      PROG(ITER) = PROG(ITER) + PP
 1165 P(I,J-1) = PPP(I)
      PPP(I) = PP
 1170 CONTINUE
  179 DO 180 I = 2, K
  180 P(I,M) = PPP(I)
      IF ( GAMMA - 0.16) 181,181, 185
```

```
      SUBROUTINE REYN
 181 WRITE OUTPUT TAPE 6,3333, ITER
3333 FORMAT (25H FORCED OUT AT ITERATION  I4, 21H, SOLUTION NOT VALID )
     GO TO 235
 185 IF (ITER - 6) 220, 220, 190
 190 IF(PROG(ITER) -2.0*PROG(ITER-1)+PROG(ITER-2)) 210, 210, 200
 200 GAMMA = GAMMA *0.8
     WRITE OUTPUT TAPE 6, 1111,JJJ,GAMMA,ITER
1111 FORMAT (7H RECESS I3, 19H, GAMMA CHANGED TO  F10.4, 11H, ITERATION
    1 I5)
     GO TO 78
 210 IF (ITER - NREL) 220, 220, 215
 215 IF((PROG(ITER)-PROG(ITER-1))*PACT/(GAMMA*PROG(ITER))-TRUNC) 230,
    1 230, 220
 220 CONTINUE
     ITER = LITER
 230 WRITE OUTPUT TAPE 6,2222,JJJ,ITER,(PROG(LKK), LKK = 1,ITER)
2222 FORMAT (7H RECESS I3, 25H, CONVERGED AT ITERATION I5 / 20H PROGRES
    1S INDICATORS / (10F11.6))
 235 AAW=0.0
     AACSI = 0.0
     AAETA = 00.0
     J1 = 2
     J2 = M
     J3 = 2
 240 DO 310 J =J1,J2,J3
     AW = 0.0
     ACSI = 0.0
     AETA = 0.0
     FJ = J-1
     I1 = 2
     I2 = K
     I3 = 2
 250 DO 260 I = I1, I2, I3
     FI = I-1
     AW = AW + P(I,J)
     ACSI = ACSI + FI*P(I,J)
 260 AETA = AETA + FJ*P(I,J)
     IF (I3 - K )  270, 300, 300
 270 AW = 2.0 * AW
     ACSI = 2.0 * ACSI
     AETA = 2.0 * AETA
     IF(I1-2) 280, 280, 290
 280 I1 = 3
     GO TO 250
 290 I1 = 1
     I2 = KK
     I3 =  K
      GO TO  250
 300 AAW = AAW + AW
     AACSI = AACSI + ACSI
 310   AAETA = AAETA + AETA
     IF (J3 - M) 320, 350, 350
 320 AAW = AAW * 2.0
     AACSI = AACSI * 2.0
     AAETA = AAETA * 2.0
     IF (J1-2)  330, 330, 340
```

```
      SUBROUTINE REYN
  330 J1 = 3
      GO TO 240
  340 J1 = 1
      J2 = MM
      J3 = M
      GO TO 240
  350 W(JJJ) = AAW * DX * DY / 9.0
      CSI(JJJ) = AACSI * DX * DX * DY / (9.0*W(JJJ))
      ETA(JJJ) = AAETA * DX * DY * DY / (9.0*W(JJJ))
  360 DO 440 III = 1, LIMJ
      QQ = 0.0
      J = MR(III)
      I1=KR(III)
      I2=KRR(III)
  370 DO 380 I = I1, I2
  380 QQ=QQ-H(I,J)*H(I,J)*H(I,J)*(P(I,J+1) - P(I,J-1))
      QQ=QQ+0.5*(H(I1,J)*H(I1,J)*H(I1,J)*(P(I1,J+1)-P(I1,J-1))+(H(I2,J)*
     1H(I2,J)*H(I2,J)*(P(I2,J+1)-P(I2,J-1))))
      IF (J - MR(III)) 400, 390, 400
  390 QQ = -QQ
      J = MRR(III)
      GO TO 370
  400 TT = 0.0
      I = KR(III)
      J1=MR(III)
      J2=MRR(III)
  410 IF (JJJ- LIMJ- 1) 420, 1420,1420
  420 DO 421 J = J1, J2
  421 TT = TT - H(I,J)*H(I,J)*H(I,J)*(P(I+1,J) - P(I-1,J))
      TT = TT + 0.5*(H(I,J1)*H(I,J1)*H(I,J1)*(P(I+1,J1)-P(I-1,J1))+ H(I,
     1J2)*H(I,J2)*H(I,J2)*(P(I+1,J2) - P(I-1,J2)))
      GO TO 425
 1420 DO 1421 J = J1, J2
 1421 TT = TT - H(I,J)*H(I,J)*H(I,J)*(P(I+1,J)-P(I-1,J)) - 2.0*PLAM*DX
     1 * H(I,J)
      TT = TT + 0.5*(H(I,J1)*H(I,J1)*H(I,J1)*(P(I+1,J1) - P(I-1,J1)) +
     1 H(I,J2)*H(I,J2)*H(I,J2)*(P(I+1,J2)-P(I-1,J2)) + 2.0*DX*PLAM*
     1(H(I,J2) + H(I,J1)))
  425 IF (I - KR(III)) 440, 430, 440
  430 TT = - TT
      I = KRR(III)
      GO TO 410
  440 Q(III,JJJ) = QQ*DX*0.5/DY+TT*DY*0.5/DX
  450 WRITE TAPE 15,P
    2 FORMAT (8E15.8)
  460 CONTINUE
      END FILE 15
      REWIND 15
      RETURN
      END(1,0,0,0,0,0,0,0,0,1,0,0,0,0,0)
```

SUBROUTINE REYN

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
2418	04562	17379	41743

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A	17404	41774	CSI	23456	55640	DX	32559	77457	DY	32558	77456	ETA	23449	55631
H	32557	77455	HX	29542	71546	HY	26527	63637	INDEX1	17381	41745	INDEX2	17380	41744
IPREV	23442	55622	K1	23512	55730	K2	23511	55727	K3	23510	55726	KEY	23441	55621
KK	32561	77461	LIMJ	23464	55650	LITER	20426	47712	M1	23509	55725	M2	23508	55724
MM	32560	77460	NIGNAL	17410	42002	PLAM	17409	42001	P	20425	47711	Q	23506	55722
TRUNC	23507	55723	TX	17406	41776	TY	17405	41775	W	23463	55647	X1	17408	42000
Y1	17407	41777												

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
KRR	1344	02500	KR	1350	02506	MRR	1332	02464	MR	1338	02472	PPP	2417	04561
PROG	2350	04456												

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
AACSI	1326	02456	AAETA	1325	02455	AAW	1324	02454	ACSI	1323	02453	AETA	1322	02452
ALPHA	1321	02451	AW	1320	02450	FACTOR	1319	02447	FI	1318	02446	FJ	1317	02445
FK	1316	02444	FM	1315	02443	GAMMA	1314	02442	I1	1313	02441	I2	1312	02440
I3	1311	02437	I	1310	02436	ITER	1309	02435	J1	1308	02434	J2	1307	02433
J3	1306	02432	JJJ	1305	02431	J	1304	02430	KEYIJ	1303	02427	KKRC	1302	02426
K	1301	02425	LLLL	1300	02424	M	1299	02423	NACT	1298	02422	NREL	1297	02421
PACT	1296	02420	PGAMMA	1295	02417	PPRIME	1294	02416	PP	1293	02415	QQ	1292	02414
IT	1291	02413												

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)1	1	02365	8)2	2	02316	8)12N	1111	02350	8)25E	2222	02335	8)385	3333	02362

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	1270	02366	2)	1205	02265	3)	1214	02276	6)	1223	02307	A)103	1153	02201
A)104	1166	02216	A)105	1179	02233	A)106	1192	02250	C)G1	1278	02376	C)G2	1279	02377
C)G3	1280	02400	C)G6	1281	02401	C)100	1282	02402	C)103	1283	02403	C)104	1284	02404
C)105	1285	02405	C)106	1286	02406	C)107	1287	02407	C)204	1288	02410	C)205	1289	02411
C)206	1290	02412	D)11S	689	01261	D)20D	315	00473	D)212	469	00725	D)21A	548	01044
D)21M	641	01201	D)210	648	01210	D)40C	311	00467	D)40H	347	00533	D)40Q	395	00613
E)G	337	00521	E)M	373	00565	E)11	435	00663	E)13	477	00735	E)19	506	00772
E)1B	556	01054	E)23	775	01407	E)10H	349	00535	E)20H	349	00535			

LOCATIONS OF NAMES IN TRANSFER VECTOR

SUBROUTINE REYN

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
(EFT)	8	00010	(FIL)	4	00004	(RTN)	1	00001	(RWT)	2	00002	(SLO)	6	00006
(STB)	5	00005	(STH)	3	00003	(TSH)	0	00000	(WLR)	7	00007			

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

(EFT) (FIL) (RTN) (RWT) (SLO) (STB) (STH) (TSH) (WLR)

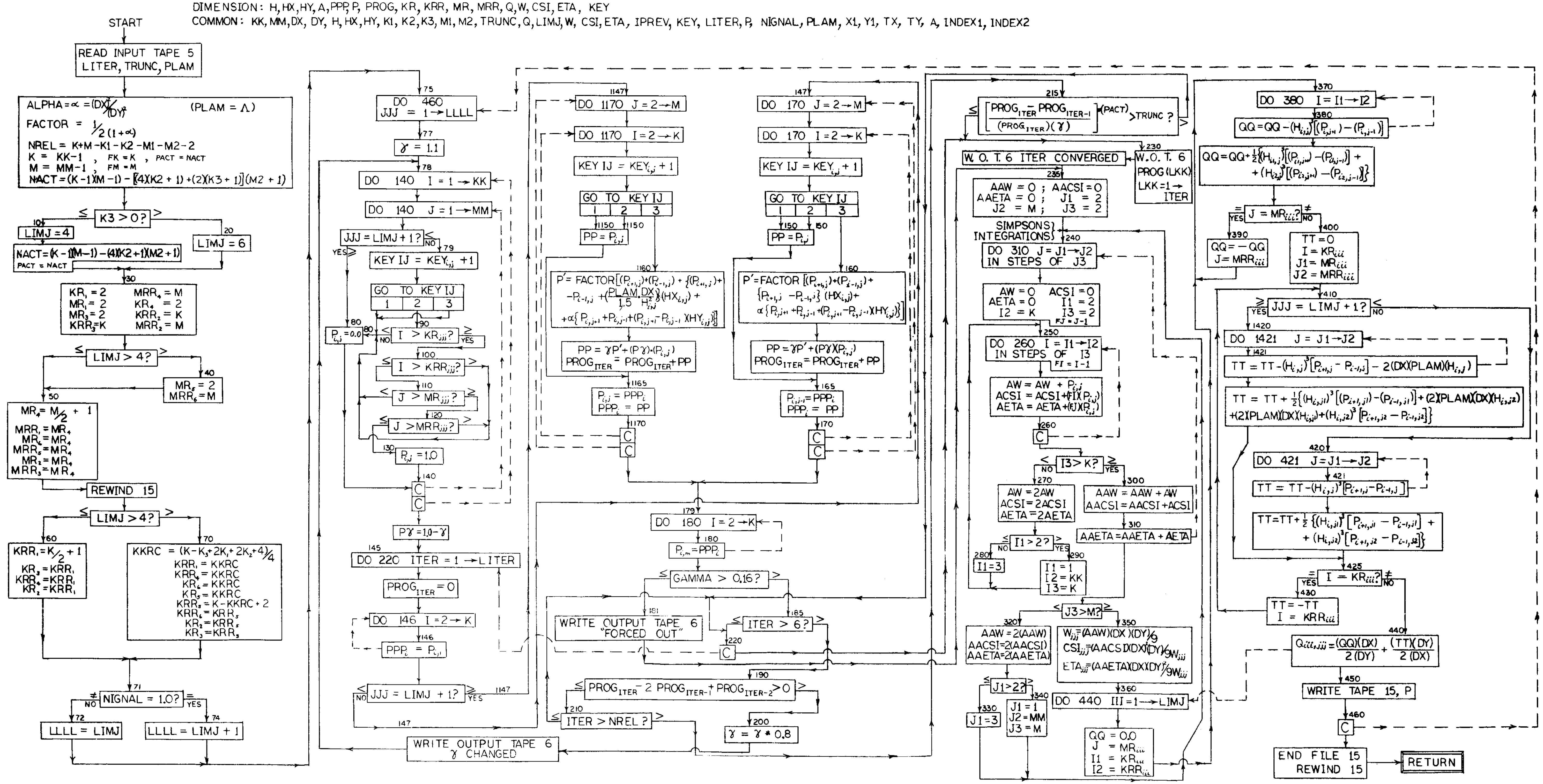
EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
10	22	00153	20	26	00212	30	27	00214	40	36	00241	50	38	00245
60	46	00333	70	51	00374	71	60	00444	72	61	00447	74	63	00452
75	64	00455	77	65	00470	78	66	00474	79	69	00523	80	71	00537
90	73	00542	100	74	00550	110	75	00554	120	76	00561	130	77	00566
140	78	00571	145	80	00605	146	83	00622	147	85	00634	150	89	00660
160	91	00665	165	94	00726	170	96	00732	1147	98	00743	1150	102	00767
1160	104	00774	1165	107	01045	1170	109	01051	179	110	01061	180	111	01075
181	113	01106	185	116	01121	190	117	01126	200	118	01137	210	122	01161
215	123	01166	220	124	01202	230	126	01211	235	132	01234	240	138	01262
250	146	01314	260	150	01353	270	152	01367	280	156	01404	290	158	01410
300	162	01417	310	164	01425	320	166	01437	330	170	01454	340	172	01461
350	176	01474	360	179	01526	370	184	01562	380	185	01576	390	188	01652
400	191	01665	410	195	01707	420	196	01714	421	197	01730	1420	200	01777
1421	201	02013	425	203	02103	430	204	02111	440	207	02124	450	208	02146
460	210	02156												

REYN

DIMENSION: H, HX, HY, A, PPP, P, PROG, KR, KRR, MR, MRR, Q, W, CSI, ETA, KEY

COMMON: KK, MM, DX, DY, H, HX, HY, K1, K2, K3, M1, M2, TRUNC, Q, LIMJ, W, CSI, ETA, IPREV, KEY, LITER, P, NIGNAL, PLAM, X1, Y1, TX, TY, A, INDEX1, INDEX2



```
      SUBROUTINE  FORMH

      SUBROUTINE  FORMH
     DIMENSION H(67,45), HX(67,45), HY(67,45), A(23), KEY(67,45),
    1 Q(6,7), W(7), CSI(7), ETA(7), P(67,45)
     COMMON KK,MM,DX,DY,H,HX,HY,K1,K2,K3,M1,M2,TRUNC,Q,LIMJ,W,CSI,ETA,
    1 IPREV,KEY,LITER,P,NIGNAL,PLAM,X1,Y1,TX,TY,A,INDEX1,INDEX2
   1 FORMAT(9I3,E16.8)
     READ INPUT TAPE 5, 1,K,M,INDEX1,INDEX2,K1,K2,K3,M1,M2,AL
     KK = K + 1
     MM = M + 1
     FK = K
     FM = M
     DX = 1.0/FK
     DY = AL/FM
     FX = 0.5/DX
     FY = 0.5/DY
     DO 11  J = 2,M
     KEY(1,J) = 0
     KEY(KK,J)  = 0
     DO 11  I = 2, K
  11 KEY(I,J) = 1
     DO 21  I = 1, KK
     KEY(I,1) = 0
  21 KEY(I,MM) = 0
     KK1 = K1 + K2 + 2
     KK2 = (K - K3)/2
     DO 51  J = 2, M
     DO 31  I = 2, K1
     II = K + 2 - I
     KEY(I,J) = 2
  31 KEY(II,J) = 2
     DO 41  I = KK1, KK2
     II = K + 2 - I
     KEY(I,J)  =  2
  41 KEY(II,J) = 2
     IF (K3) 42,42,51
  42 II = K/2 + 1
     KEY(II,J) = 2
  51 CONTINUE
     MM2 = M - M1 - M2
     MM1 = M1 + M2 + 2
     DO 81  I = 2, K
     DO  61  J = 2, M1
     JJ = M + 2 - J
     KEY(I,J) = 2
  61 KEY(I,JJ) = 2
     DO  71  J = MM1, MM2
  71 KEY(I,J)  =  2
  81  CONTINUE
     IPREV = 1
   2 FORMAT (6E11.8)
     IF(INDEX1 - 1)  30, 20, 30
  20 READ INPUT TAPE 5,2,((H(I,J), I=1,KK), J=1,MM)
     DO 25 I = 2, K
     DO 25 J =  2, M
      HX(I,J) = (H(I+1,J)-H(I-1,J))*.75/H(I,J)
  25 HY(I,J) = (H(I,J+1)-H(I,J-1))*.75/H(I,J)
```

```
      SUBROUTINE  FORMH
    3 FORMAT (5E14.8)
      GO TO 60
   30 READ INPUT TAPE 5,3,(A(L), L = 1,23)
      CON = EXPF(-0.5*A(21))*COSF(A(21)*0.5) * 2.0
      DO 50  I = 1,KK
      FI = I
      X = (FI - 1.0) * DX
      S = (FI - 1.0) * DX - A(22)
      SS = S * S
      SSS = SS * S
      DO 50  J = 1, MM
      FJ  =  J
      T = (FJ - 1.0) * DY - A(23)
      TT = T * T
      TTT = TT * T
      H(I,J)=A(1)+A(2)*S +A(3)*T+A(4)*SS+A(5)*TT+A(6)*S*T+A(7)*SSS+A(8)*
     1TTT+A(9)*SS*T+A(10)*S*TT+A(11)*SQRTF(A(12)+A(13)*SS+A(14)*TT)+
     1 A(15)*COSF(A(16)*S)+A(17)*COSF(A(18)*T)+A(19)*COSF(A(16)*S)*COSF(
     1A(18)*T)-A(20)*(EXPF(-A(21)*X)*COSF(A(21)*X)+EXPF(-A(21)*(1.0-X))*
     1COSF(A(21)*(1.0-X))-CON)
      HX(I,J) = (A(2)+2.*A(4)*S+A(6)*T+3.*A(7)*SS+2.*A(9)*S*T+A(10)*TT-
     1A(16)*SINF(A(16)*S)*(A(15)+A(19)*COSF(A(18)*T)))*1.5*DX/H(I,J)+A(
     120)*A(21)*(EXPF(-A(21)*X)*(COSF(A(21)*X)+SINF(A(21)*X))-EXPF(-A(21
     1)*(1.0-X))*(COSF(A(21)*(1.0-X))+SINF(A(21)*(1.0-X))))*1.5*DX/H(I,
     1 J)
      HY(I,J)=(A(3)+2.*A(5)*T+A(6)*S+3.*A(8)*TT+A(9)*SS-A(18)*SINF(A(18)
     1*T)*(A(17)+A(19)*COSF(A(16)*S)))*1.5*DY/H(I,J)
      SL = A(12)+A(13)*SS+A(14)*TT
      IF (SL) 50, 50, 40
   40 SLL = A(11)/SQRTF(SL)
      HX(I,J) = HX(I,J)+SLL*A(13)*S*1.5*DX/H(I,J)
      HY(I,J) = HY(I,J) + SLL*A(14)*T*1.5*DY/H(I,J)
   50 CONTINUE
   60 IF (INDEX2 - 1)  80, 70, 80
   70 CALL TILTH
   80 RETURN
      END(1,0,0,0,0,0,0,0,0,1,0,0,0,0,0)
```

SUBROUTINE FORMH

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
941	01655	17379	41743

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A	17404	41774	CSI	23456	55640	DX	32559	77457	DY	32558	77456	ETA	23449	55631
H	32557	77455	HX	29542	71546	HY	26527	63637	INDEX1	17381	41745	INDEX2	17380	41744
IPREV	23442	55622	K1	23512	55730	K2	23511	55727	K3	23510	55726	KEY	23441	55621
KK	32561	77461	LIMJ	23464	55650	LITER	20426	47712	M1	23509	55725	M2	23508	55724
MM	32560	77460	NIGNAL	17410	42002	PLAM	17409	42001	P	20425	47711	Q	23506	55722
TRUNC	23507	55723	TX	17406	41776	TY	17405	41775	W	23463	55647	X1	17408	42000
Y1	17407	41777												

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
AL	940	01654	CON	939	01653	FI	938	01652	FJ	937	01651	FK	936	01650
FM	935	01647	FX	934	01646	FY	933	01645	II	932	01644	I	931	01643
JJ	930	01642	J	929	01641	KK1	928	01640	KK2	927	01637	K	926	01636
MM1	925	01635	MM2	924	01634	M	923	01633	SLL	922	01632	SL	921	01631
S	920	01630	SS	919	01627	SSS	918	01626	T	917	01625	TT	916	01624
TTT	915	01623	X	914	01622									

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)1	1	01552	8)2	2	01550	8)3	3	01546						

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	875	01553	2)	850	01522	3)	857	01531	6)	863	01537	A)105	824	01470
A)106	837	01505	C)G2	903	01607	C)100	904	01610	C)101	905	01611	C)102	906	01612
C)105	907	01613	C)106	908	01614	C)200	909	01615	C)201	910	01616	C)203	911	01617
C)206	912	01620	C)208	913	01621	D)20A	194	00302	D)30A	193	00301	D)40I	318	00476
D)411	436	00664	E)C	215	00327									

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
COS	2	00002	EXP	3	00003	SIN	5	00005	SQRT	4	00004	TILTH	6	00006
(RTN)	1	00001	(TSH)	0	00000									

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

COS EXP SIN SQRT TILTH (RTN) (TSH)

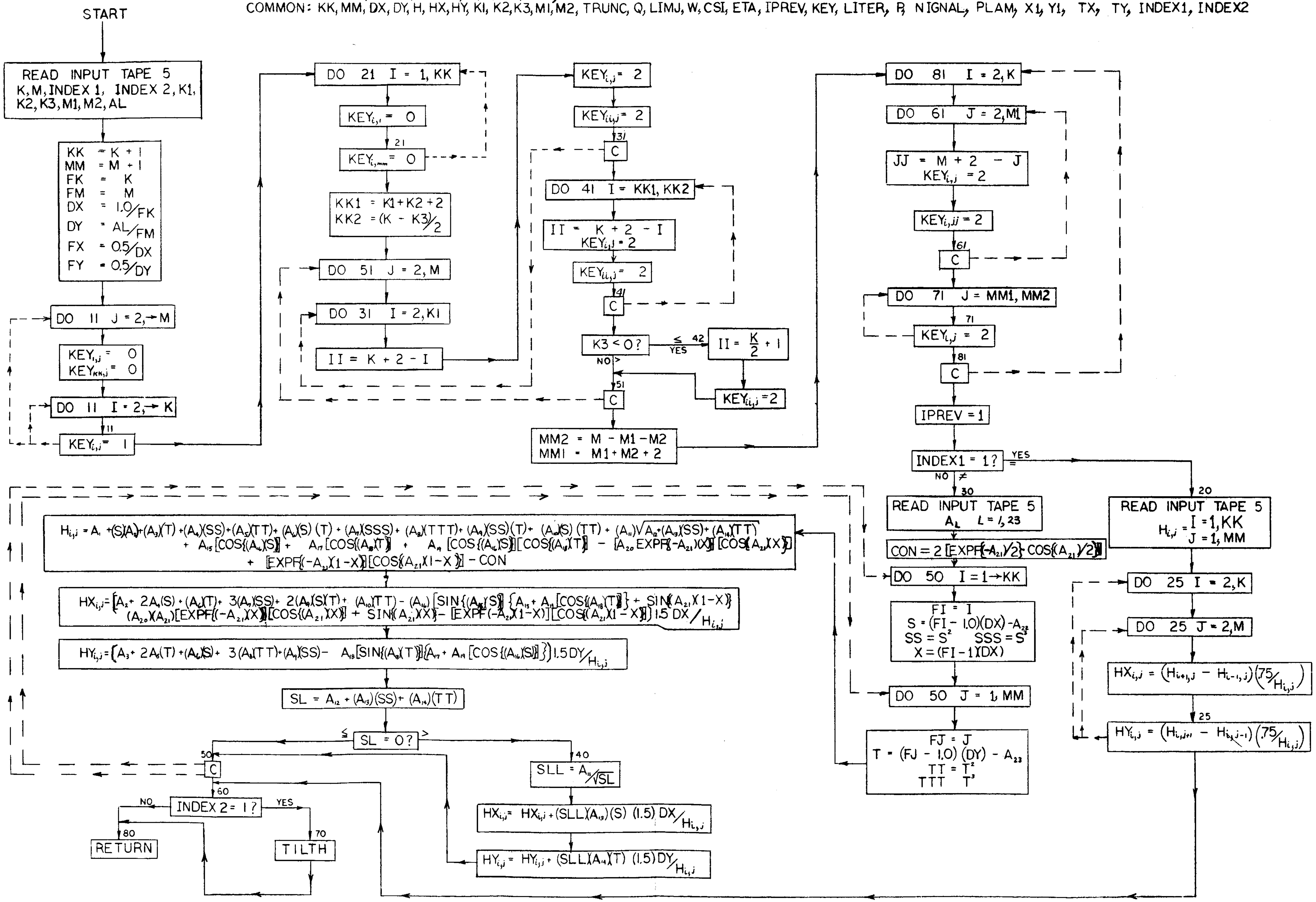
EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

SUBROUTINE FORMH

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
11	22	00141	21	25	00172	31	32	00263	41	36	00315	42	38	00330
51	40	00346	61	47	00467	71	49	00477	81	50	00504	20	53	00526
25	63	00606	30	65	00621	40	87	01407	50	90	01443	60	91	01456
70	92	01463	80	93	01464									

FORMH

DIMENSION: H, HX, HY, A, KEY, Q, W, CSI, ETA, P
COMMON: KK, MM, DX, DY, H, HX, HY, K1, K2, K3, M1, M2, TRUNC, Q, LIMJ, W, CSI, ETA, IPREV, KEY, LITER, P, NIGNAL, PLAM, X1, Y1, TX, TY, INDEX1, INDEX2



```
      SUBROUTINE  TILTH

      SUBROUTINE  TILTH
      DIMENSION H(67,45), HX(67,45), HY(67,45), KEY(67,45), Q(6,7), W(7)
     1, CSI(7), ETA(7), A(23), P(67,45)
      COMMON KK,MM,DX,DY,H,HX,HY,K1,K2,K3,M1,M2,TRUNC,Q,LIMJ,W,CSI,ETA,
     1 IPREV,KEY,LITER,P,NIGNAL,PLAM,X1,Y1,TX,TY,A,INDEX1,INDEX2
      READ INPUT TAPE  5, 1, X1, Y1, TX, TY
    1 FORMAT (4E15.8  )
      DO 90 I = 1, KK
      FI = I
      X = (FI - 1.0)* DX - X1
      DO 90  J = 1, MM
      FJ = J
      H(I,J) = H(I,J)+TX*X+TY*((FJ-1.)*DY-Y1)
      HX(I,J) = HX(I,J) + TX * 1.5 * DX / H(I,J)
      HY(I,J) = HY(I,J) + TY * 1.5 * DY / H(I,J)
   90 CONTINUE
      RETURN
      END(1,0,0,0,0,0,0,0,0,1,0,0,0,0,0)
```

SUBROUTINE TILTH

STORAGE NOT USED BY PROGRAM

DEC	OCT	DEC	OCT
115	00163	17379	41743

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
A	17404	41774	CSI	23456	55640	DX	32559	77457	DY	32558	77456	ETA	23449	55631
H	32557	77455	HX	29542	71546	HY	26527	63637	INDEX1	17381	41745	INDEX2	17380	41744
IPREV	23442	55622	K1	23512	55730	K2	23511	55727	K3	23510	55726	KEY	23441	55621
KK	32561	77461	LIMJ	23464	55650	LITER	20426	47712	M1	23509	55725	M2	23508	55724
MM	32560	77460	NIGNAL	17410	42002	PLAM	17409	42001	P	20425	47711	Q	23506	55722
TRUNC	23507	55723	TX	17406	41776	TY	17405	41775	W	23463	55647	X1	17408	42000
Y1	17407	41777												

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
FI	114	00162	FJ	113	00161	I	112	00160	J	111	00157	X	110	00156

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
8)1	1	00151												

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
1)	106	00152	2)	93	00135	3)	96	00140	6)	98	00142			

LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
(RTN)	1	00001	(TSH)	0	00000									

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

(RTN) (TSH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

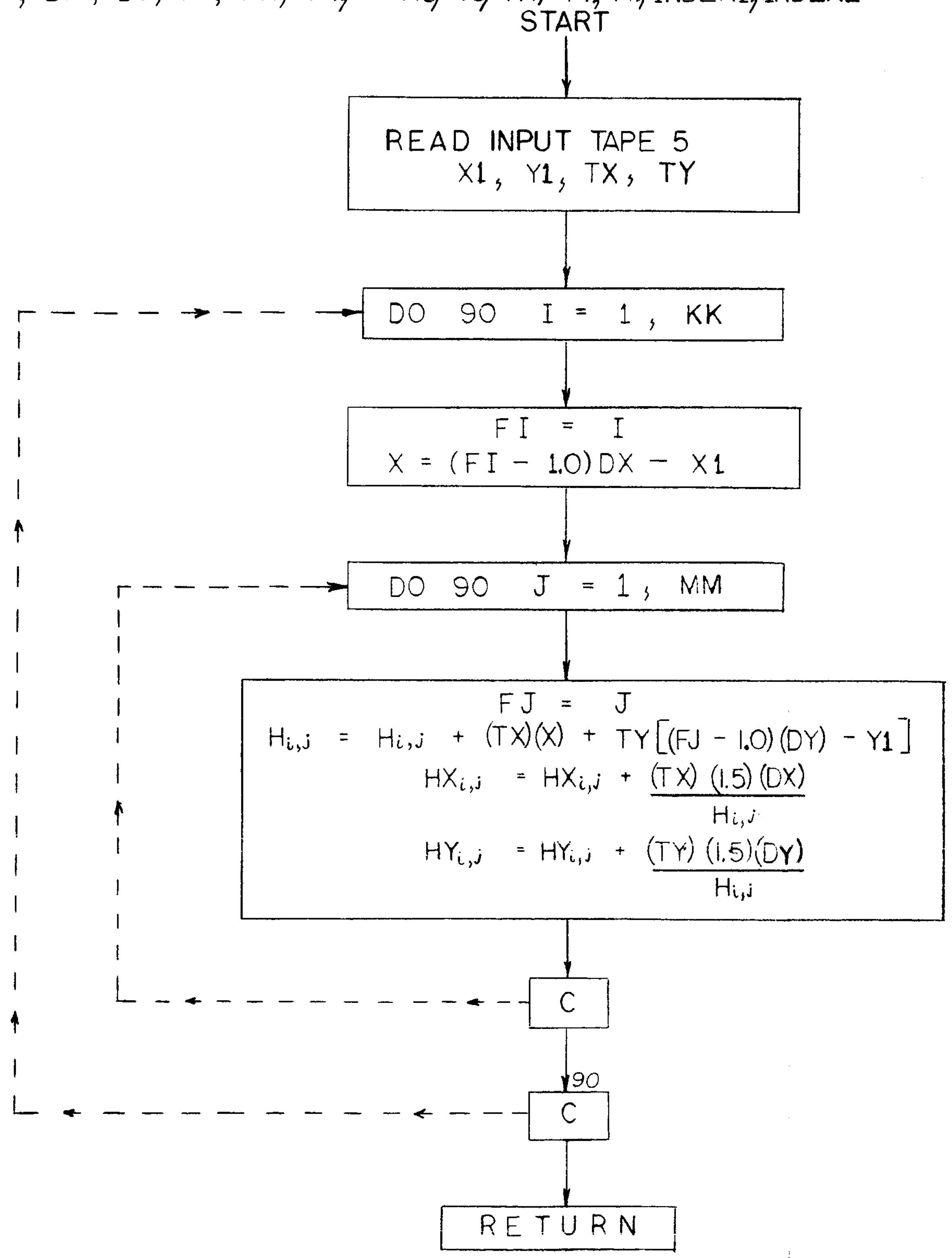
EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
90	16	00120												

TILTH

JPL VARIABLE FILM HYDROSTATIC BEARING PROGRAM -- BLOCK DIAGRAM

DIMENSION : H, HX, HY, A, KEY, Q, W, CSI, ETA, A, P

COMMON : KK, MM, DX, DY, H, HX, HY, ... X1, Y1, TX, TY, A, INDEX1, INDEX2



FUNCTION DETER(AA,LIMJ)

```
      FUNCTION DETER(AA,LIMJ)
      DIMENSION AA(6,7)
       DETER = 0.0
      IF (LIMJ/2 - 2) 100, 100, 110
  100 SIGN =  1.0
      GO TO 1
  110 SIGN = -1.0
    1 DO 13 I = 1,LIMJ
    2 DO 12 J = 1,LIMJ
      CONTINUE
      IF (I-J) 21, 12, 21
   21 SIGN = -SIGN
    3 DO 11 K = 1,LIMJ
      IF(I-K) 31, 11, 31
   31 IF(J-K) 4, 11, 4
    4 DO 10 L = 1,LIMJ
      IF(I-L) 41, 10, 41
   41 IF(J-L) 42, 10, 42
   42 IF(K-L) 43, 10, 43
   43 PROD = AA(1,I)*AA(2,J)*AA(3,K)*AA(4,L)
      SIGN = -SIGN
      IF (LIMJ-4)44,44,5
   44 DETER = DETER + PROD *SIGN
      GO TO 10
    5 DO 9 M= 1,LIMJ
      IF (I-M) 51, 9, 51
   51 IF (J-M) 52, 9, 52
   52 IF(K-M) 53, 9, 53
   53 IF(L-M) 6, 9, 6
    6 DO 8 N = 1,LIMJ
      IF(I-N) 61, 8, 61
   61 IF(J-N) 62, 8, 62
   62 IF(K-N) 63, 8, 63
   63 IF(L-N)  64, 8, 64
   64 IF(M-N)7,8,7
    7 PRODD = - PROD * AA(5,M)*AA(6,N) * SIGN
      SIGN = -SIGN
      DETER = DETER + PRODD
    8 CONTINUE
    9 CONTINUE
   10 CONTINUE
   11 CONTINUE
   12 CONTINUE
   13 CONTINUE
      RETURN
      END(1,0,0,0,0,0,0,0,0,1,0,0,0,0,0)
```

```
FUNCTION DETER(AA,LIMJ).

                                          STORAGE NOT USED BY PROGRAM

         DEC   OCT                 DEC   OCT
         264 00410               32561 77461

               STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

         DEC   OCT                 DEC   OCT                 DEC   OCT                 DEC   OCT                 DEC   OCT
DETER    263 00407          I      262 00406          J      261 00405          K      260 00404          L      259 00403
    M    258 00402          N      257 00401      PRODD      256 00400       PROD      255 00377       SIGN      254 00376

                            LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

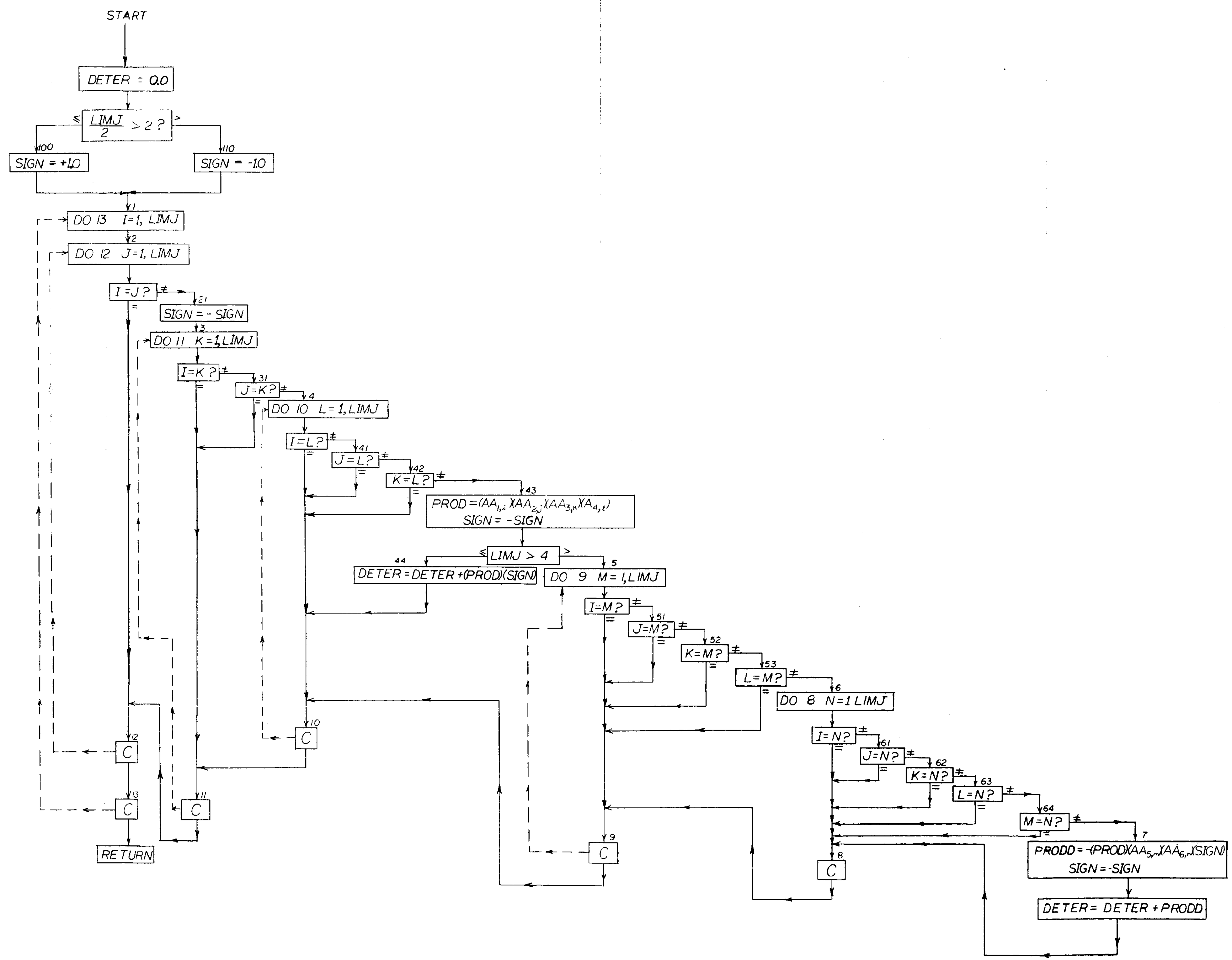
         DEC   OCT                 DEC   OCT                 DEC   OCT                 DEC   OCT                 DEC   OCT
   2)    227 00343         3)      230 00346         6)      232 00350         9)      238 00356      C)100      242 00362
C)101    243 00363      C)102      244 00364      C)103      245 00365      C)104      246 00366      C)105      247 00367
C)200    248 00370      C)201      249 00371      C)202      250 00372      C)203      251 00373      C)204      252 00374
C)205    253 00375      D)105       63 00077      D)107       77 00115      D)20T      185 00271      D)30T      184 00270
D)40V    193 00301      D)60V      192 00300        E)C       96 00140        E)H      131 00203        E)R      176 00260
  E)S    183 00267        E)T      187 00273       E)11      199 00307      E)10R      176 00260      E)10T      187 00273
E)111    199 00307      E)20R      176 00260      E)30T      187 00273

               EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

  EFN    IFN   LOC         EFN     IFN   LOC         EFN     IFN   LOC         EFN     IFN   LOC         EFN     IFN   LOC
  100      6 00052         110       8 00055           1       9 00057           2      10 00067          21      13 00103
    3     14 00105          31      16 00121           4      17 00124          41      19 00135          42      20 00143
   43     21 00146          44      24 00165           5      26 00172          51      28 00204          52      29 00207
   53     30 00212           6      31 00215          61      33 00226          62      34 00231          63      35 00234
   64     36 00237           7      37 00242           8      40 00263           9      41 00274          10      42 00302
   11     43 00310          12      44 00316          13      45 00326
```

FUNCTION DETER

DIMENSION: AA



APPENDIX II

IBM 7094 LOADING RECORD

(Six Subprograms)

```
ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,
    (FPT)      (RWT)      (TSHM)     (RTN)      EXIT       (STHM)     (FIL)      (TSB)      (SLI)      (RLR)
    (STB)      (SLO)      (WLR)      (EFT)      COS        EXP        SQRT       SIN
```

ENTRY NAME	ENTRY ADD.	NO. OF TRANSFERS	LOAD ADD.
MAIN	00155	00011	00144
FLOW	00341	00011	00324
REYN	12326	00011	12311
TILTH	17101	00002	17073
FORMH	17271	00007	17256
DETER	21137	00000	21133
ERRDMP	21544	00001	21543
EXIT	21547		
(TES)	21571	00000	21571
(FPT)	21572	00000	21572
EXP	21630	00000	21630
SIN	21710	00000	21707
COS	21707		
SQRT	22060	00000	22060
(RLR)	22221	00011	22134
(TSB)	22145		
(WLR)	22267	00007	22236
(STB)	22245		
(TSHM)	22334	00006	22323
(TSH)	22331		
(STHD)	22401	00006	22360
(STHM)	22371		
(STH)	22366		
(EFT)	22512	00002	22510
(RWT)	22521	00002	22517
(SLI)	22542	00000	22542
(SLO)	22557	00000	22557
(RDC)	22625	00007	22574
(RER)	22603		
(WTC)	22704	00012	22641
(WER)	22653		
(SET)	23011	00001	22734
(BUF)	23013		
(EXB)	23016		
(IOB)	22735		
(RTN)	25571	00002	24026
(FIL)	25560		
(IOH)	24030		
(ICO)	26037	00003	25745
(TEF)	26036		
(RCH)	26035		
(ETT)	26034		
(REW)	26033		
(WEF)	26032		
(BSR)	26031		
(WRS)	26030		
(RDS)	26027		
(IOS)	25750		
(TRC)	26040		
)PRNT(	26333	00002	26074
(EXEM)	26076		
(IOU)	26707	00000	26704

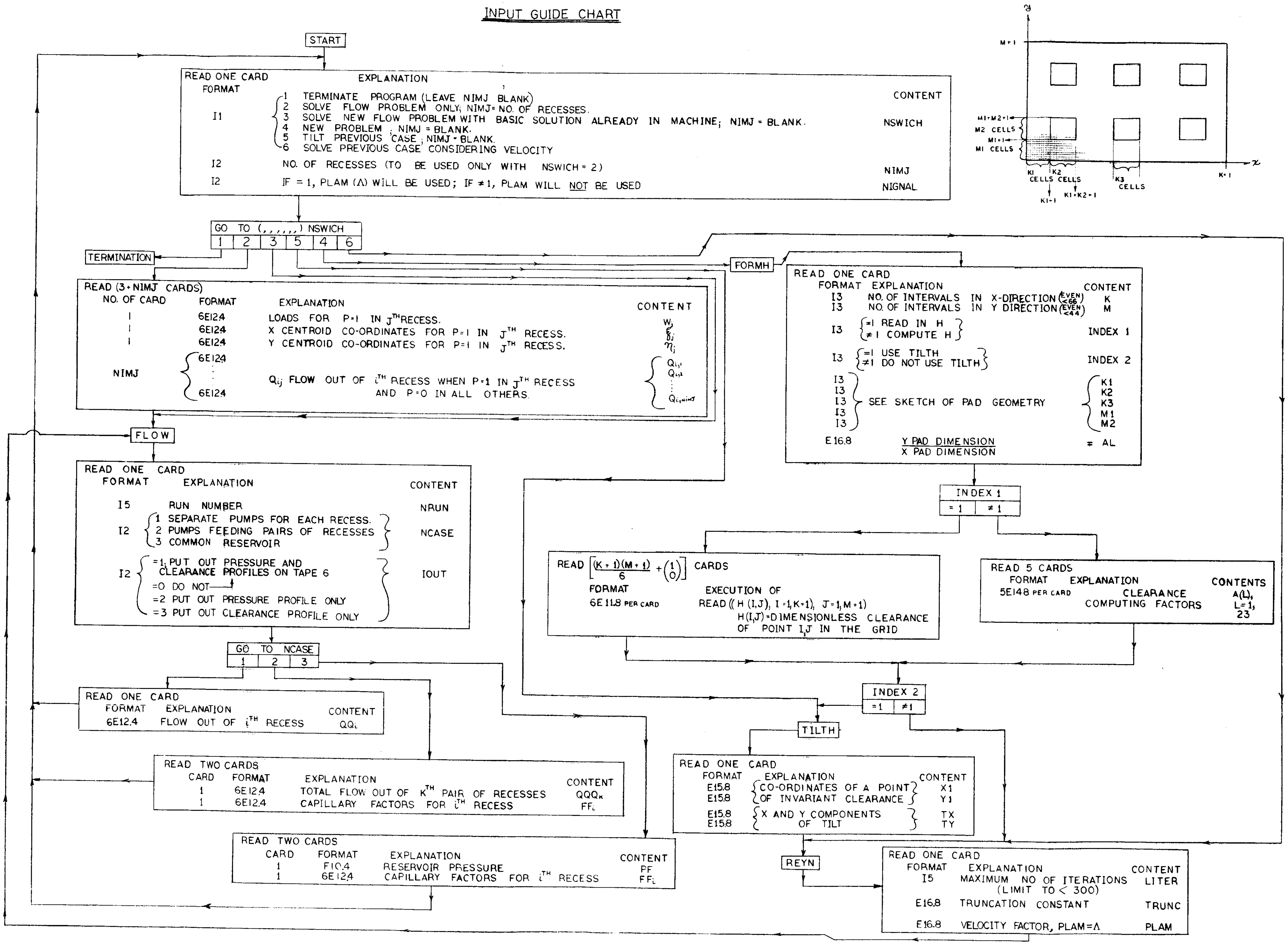
LOGICAL TAPE	MACHINE TAPE	TOTAL WRITES	TOTAL READS	NOISE RECORDS WRITING	NOISE RECORDS READING	TOTAL REDUNDANCIES WRITING	TOTAL REDUNDANCIES READING	POSITIONING ERRORS
1	A 1	0	493	0	0	0	0	0
2	B 2	1008	1142	0	0	0	0	0

(II-1)

APPENDIX III

INPUT GUIDE CHART

INPUT GUIDE CHART



APPENDIX IV

SAMPLE PROBLEM INPUT DATA

AND

OUTPUT RESULTS

HYDROSTATIC BEARING PROGRAM INPUT DATA

CROSS OUT CARDS NOT USED

1. CARD

1	3	5
4		0
NSWICH		NIGNAL

2. 1 CARD

3	6	9	12	15	18	21	24	27	43
28	16	0	0	5	5	0	4	2	0.57142857
K	M	INDEX1	INDEX2	K1	K2	K3	M1	M2	AL

3.–7. 5 CARDS (INCLUDE ALL 5)

	14	28	42	56	70
3.	1.0 A(1)	0.0 A(2)	0.0	0.0	0.0
4.	0.0	0.0	0.0	0.0	0.0
5.	0.0	0.0	0.0	0.0	0.0
6.	0.0	0.0	0.0	0.0	0.0
7.	0.0	0.0	0.0 A(23)	0.0	0.0

8. ~~1 CARD~~

15	30	45	60

9. 1 CARD

5	21	37
1000	0.30	0.0
LITER	TRUNC	PLAM

10. 1 CARD

5	7	9
7701	1	1
NRUN	NCASE	IOUT

11. 1 CARD

12	24	36	48	60	72
1.0	1.0	1.0	1.0	—	—
QQ(1)	QQ(2)	QQ(3)	QQ(4)		

12. ~~1 CARD~~

10

13. ~~1 CARD~~

12	24	36	48	6	72

14. ~~1 CARD~~

1

F-B2099

HYDROSTATIC BEARING PROGRAM INPUT DATA

CROSS OUT CARDS NOT USED

1. CARD

1	3	5
5		0
NSWICH		NIGNAL

~~2. 1 CARD~~

3	6	9	12	15	18	21	24	27	43

~~3.~~
~~4.~~
5. 5 CARDS (INCLUDE ALL 5)
~~6.~~
~~7.~~

14	28	42	56	70

8. 1 CARD

15	30	45	60
0.50	0.28571429	1.0	0.0
XI	YI	TX	TY

9. 1 CARD

5	21	37
1000	0.30	1.0
LITER	TRUNC	PLAM

10. 1 CARD

5	7	9
7702	1	1
NRUN	NCASE	IOUT

11. 1 CARD

12	24	36	48	60	72
1.0	1.0	1.0	1.0	—	—
QQ(1)	QQ(2)	QQ(3)	QQ(4)		

~~12. 1 CARD~~

10

~~13. 1 CARD~~

12	24	36	48	60	72

~~14. 1 CARD~~

1

F-B2099

HYDROSTATIC BEARING PROGRAM INPUT DATA

CROSS OUT CARDS NOT USED

1. CARD

1	3	5
6		1
NSWICH		NIGNAL

~~2. 1 CARD~~

3	6	9	12	15	18	21	24	27	43

~~3.~~
~~4.~~
~~5. 5 CARDS~~ (INCLUDE ALL 5)
~~6.~~
~~7.~~

14	28	42	56	70

~~8. 1 CARD~~

15	30	45	60

9. 1 CARD

5	21	37
1000	0.30	1.0
LITER	TRUNC	PLAM

10. 1 CARD

5	7	9
7703	1	2
NRUN	NCASE	IOUT

11. 1 CARD

12	24	36	48	60	72
1.0	1.0	1.0	1.0	—	—
QQ(1)	QQ(2)	QQ(3)	QQ(4)		

~~12. 1 CARD~~

10

~~13. 1 CARD~~

12	24	36	48	60	72

14. 1 CARD

1
1
NSWICH

```
RUN NUMBER  7701                          HYDROSTATIC BEARING PAD WITH 4 RECESSES.
                                FEEDING = POSITIVE DISPLACEMENT PUMPS FEEDING EACH RECESS.
GRID POINTS, K = 28   M = 16        K1 =  5   K2 =  5   K3 =  0    M1 =  4   M2 =  2
CLEARANCE COEFFICIENTS
,AA 1)= 0.09999999E 01 ,AA


                                                  OUTPUT
QQ(I)=       1.00      1.00      1.00      1.00          ** Q(I,J)=    5.4774  -0.1477  -0.2798  -1.7369
W(I)=      0.0773    0.0773    0.0773    0.0773          **           -0.1477   5.4774  -1.7369  -0.2798
CSI(I)=    0.2922    0.7078    0.7078    0.2922          **           -0.2798  -1.7369   5.4774  -0.1477
ETA(I)=    0.1900    0.3815    0.1900    0.3815          **           -1.7369  -0.2798  -0.1477   5.4774
FINAL RESULTS = TOTAL LOAD=  0.0933  CSI= 0.5000 ETA=  0.2857  TOTAL FLOW=  0.4000000E 01
RECESS PRESSURES
 ,  AL(1) =  0.30184,  AL(2) =  0.30184,  AL(3) =  0.30184,  AL(4) =  0.30184,  AL(


RUN NUMBER  7701                          HYDROSTATIC BEARING PAD WITH 4 RECESSES.
                                FEEDING = POSITIVE DISPLACEMENT PUMPS FEEDING EACH RECESS.
PAD CONFIGURATION. 0000000000000000000000000000
                   0222222222222222222222222220
                   0222222222222222222222222220
                   0222222222222222222222222220
                   0222211111122222221111112220
                   0222211111122222221111112220
                   0222211111122222221111112220
                   0222222222222222222222222220
                   0222222222222222222222222220
                   0222222222222222222222222220
                   0222211111122222221111112220
                   0222211111122222221111112220
                   0222211111122222221111112220
                   0222222222222222222222222220
                   0222222222222222222222222220
                   0222222222222222222222222220
                   0000000000000000000000000000
```

PRESSURE DISTRIBUTION

RUN 7701	I= 1	I= 2	I= 3	I= 4	I= 5	I= 6	I= 7	I= 8	I= 9	I= 10
J= 1,	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
J= 2,	0.	0.0117	0.0237	0.0362	0.0487	0.0596	0.0665	0.0699	0.0708	0.0694
J= 3,	0.	0.0230	0.0470	0.0725	0.0991	0.1232	0.1365	0.1425	0.1438	0.1412
J= 4,	0.	0.0334	0.0687	0.1077	0.1519	0.1977	0.2140	0.2198	0.2208	0.2180
J= 5,	0.	0.0419	0.0866	0.1379	0.2031	0.3018	0.3018	0.3018	0.3018	0.3018
J= 6,	0.	0.0477	0.0980	0.1543	0.2209	0.3018	0.3018	0.3018	0.3018	0.3018
J= 7,	0.	0.0508	0.1036	0.1604	0.2243	0.3018	0.3018	0.3018	0.3018	0.3018
J= 8,	0.	0.0520	0.1051	0.1596	0.2143	0.2632	0.2835	0.2918	0.2942	0.2922
J= 9,	0.	0.0523	0.1052	0.1586	0.2101	0.2534	0.2770	0.2879	0.2912	0.2887
J= 10,	0.	0.0520	0.1051	0.1596	0.2143	0.2632	0.2835	0.2918	0.2942	0.2922
J= 11,	0.	0.0508	0.1036	0.1604	0.2243	0.3018	0.3018	0.3018	0.3018	0.3018
J= 12,	0.	0.0477	0.0980	0.1543	0.2209	0.3018	0.3018	0.3018	0.3018	0.3018
J= 13,	0.	0.0419	0.0866	0.1379	0.2031	0.3018	0.3018	0.3018	0.3018	0.3018
J= 14,	0.	0.0334	0.0687	0.1077	0.1519	0.1977	0.2140	0.2198	0.2208	0.2180
J= 15,	0.	0.0230	0.0470	0.0725	0.0991	0.1232	0.1365	0.1425	0.1438	0.1412
J= 16,	0.	0.0117	0.0237	0.0362	0.0487	0.0596	0.0665	0.0699	0.0708	0.0694
J= 17,	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PRESSURE DISTRIBUTION

RUN 7701	I= 11	I= 12	I= 13	I= 14	I= 15	I= 16	I= 17	I= 18	I= 19	I= 20
J= 1,	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
J= 2,	0.0657	0.0600	0.0545	0.0507	0.0494	0.0507	0.0545	0.0600	0.0657	0.0694
J= 3,	0.1337	0.1201	0.1076	0.0995	0.0967	0.0995	0.1076	0.1201	0.1337	0.1412
J= 4,	0.2082	0.1797	0.1573	0.1439	0.1396	0.1439	0.1573	0.1797	0.2082	0.2180
J= 5,	0.3018	0.2340	0.1989	0.1808	0.1752	0.1808	0.1989	0.2340	0.3018	0.3018
J= 6,	0.3018	0.2562	0.2249	0.2071	0.2013	0.2071	0.2249	0.2562	0.3018	0.3018
J= 7,	0.3018	0.2649	0.2390	0.2234	0.2182	0.2234	0.2390	0.2649	0.3018	0.3018
J= 8,	0.2843	0.2639	0.2447	0.2318	0.2273	0.2318	0.2447	0.2639	0.2843	0.2922
J= 9,	0.2798	0.2630	0.2461	0.2343	0.2301	0.2343	0.2461	0.2630	0.2798	0.2887
J= 10,	0.2843	0.2639	0.2447	0.2318	0.2273	0.2318	0.2447	0.2639	0.2843	0.2922
J= 11,	0.3018	0.2649	0.2390	0.2234	0.2182	0.2234	0.2390	0.2649	0.3018	0.3018
J= 12,	0.3018	0.2562	0.2249	0.2071	0.2013	0.2071	0.2249	0.2562	0.3018	0.3018
J= 13,	0.3018	0.2340	0.1989	0.1808	0.1752	0.1808	0.1989	0.2340	0.3018	0.3018
J= 14,	0.2082	0.1797	0.1573	0.1439	0.1396	0.1439	0.1573	0.1797	0.2082	0.2180
J= 15,	0.1337	0.1201	0.1076	0.0995	0.0967	0.0995	0.1076	0.1201	0.1337	0.1412
J= 16,	0.0657	0.0600	0.0545	0.0507	0.0494	0.0507	0.0545	0.0600	0.0657	0.0694
J= 17,	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PRESSURE DISTRIBUTION

RUN 7701	I= 21	I= 22	I= 23	I= 24	I= 25	I= 26	I= 27	I= 28	I= 29	I=
J= 1,	0.	0.	0.	0.	0.	0.	0.	0.	0.	
J= 2,	0.0708	0.0699	0.0665	0.0596	0.0487	0.0362	0.0237	0.0117	0.	
J= 3,	0.1438	0.1425	0.1365	0.1232	0.0991	0.0725	0.0470	0.0230	0.	
J= 4,	0.2208	0.2198	0.2140	0.1977	0.1519	0.1077	0.0687	0.0334	0.	
J= 5,	0.3018	0.3018	0.3018	0.3018	0.2031	0.1379	0.0866	0.0419	0.	
J= 6,	0.3018	0.3018	0.3018	0.3018	0.2209	0.1543	0.0980	0.0477	0.	
J= 7,	0.3018	0.3018	0.3018	0.3018	0.2243	0.1604	0.1036	0.0508	0.	
J= 8,	0.2942	0.2918	0.2835	0.2632	0.2143	0.1596	0.1051	0.0520	0.	
J= 9,	0.2912	0.2879	0.2770	0.2534	0.2101	0.1586	0.1052	0.0523	0.	
J= 10,	0.2942	0.2918	0.2835	0.2632	0.2143	0.1596	0.1051	0.0520	0.	
J= 11,	0.3018	0.3018	0.3018	0.3018	0.2243	0.1604	0.1036	0.0508	0.	
J= 12,	0.3018	0.3018	0.3018	0.3018	0.2209	0.1543	0.0980	0.0477	0.	
J= 13,	0.3018	0.3018	0.3018	0.3018	0.2031	0.1379	0.0866	0.0419	0.	
J= 14,	0.2208	0.2198	0.2140	0.1977	0.1519	0.1077	0.0687	0.0334	0.	
J= 15,	0.1438	0.1425	0.1365	0.1232	0.0991	0.0725	0.0470	0.0230	0.	
J= 16,	0.0708	0.0699	0.0665	0.0596	0.0487	0.0362	0.0237	0.0117	0.	
J= 17,	0.	0.	0.	0.	0.	0.	0.	0.	0.	

CLEARANCE DISTRIBUTION

RUN 7701	I= 1	I= 2	I= 3	I= 4	I= 5	I= 6	I= 7	I= 8	I= 9	I= 10
J= 1,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 2,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 3,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 4,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 5,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 6,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 7,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 8,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 9,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 10,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 11,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 12,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 13,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 14,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 15,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 16,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 17,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000

CLEARANCE DISTRIBUTION

RUN 7701	I= 11	I= 12	I= 13	I= 14	I= 15	I= 16	I= 17	I= 18	I= 19	I= 20
J= 1,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 2,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 3,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 4,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 5,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 6,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 7,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 8,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 9,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 10,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 11,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 12,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 13,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 14,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 15,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 16,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
J= 17,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000

CLEARANCE DISTRIBUTION

RUN 7701	I= 21	I= 22	I= 23	I= 24	I= 25	I= 26	I= 27	I= 28	I= 29	I=
J= 1,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	
J= 2,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	
J= 3,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	
J= 4,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	
J= 5,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	
J= 6,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	
J= 7,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	
J= 8,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	
J= 9,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	
J= 10,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	
J= 11,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	
J= 12,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	
J= 13,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	
J= 14,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	
J= 15,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	
J= 16,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	
J= 17,	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	

```
RUN NUMBER  7702                    HYDROSTATIC BEARING PAD WITH 4 RECESSES.
                           FEEDING = POSITIVE DISPLACEMENT PUMPS FEEDING EACH RECESS.
GRID POINTS, K = 28   M = 16      K1 =  5   K2 =  5   K3 =  0    M1 =  4   M2 =  2
CLEARANCE COEFFICIENTS
,AA 1)= 0.09999999E 01 ,AA


                                                           OUTPUT
QQ(I)=      1.00      1.00      1.00      1.00          ** Q(I,J)=   2.5957  -0.1453  -0.2683  -0.8124
W(I)=     0.0762    0.0800    0.0800    0.0762          **          -0.1379  10.5371  -3.2231  -0.2692
CSI(I)=   0.2746    0.6943    0.6943    0.2746          **          -0.2692  -3.2231  10.5371  -0.1379
ETA(I)=   0.1889    0.3802    0.1913    0.3826          **          -0.8124  -0.2683  -0.1453   2.5957
FINAL RESULTS = TOTAL LOAD=  0.1187  CSI= 0.3708 ETA=  0.2857  TOTAL FLOW=  0.4000000E 01
RECESS PRESSURES
 ,  AL(1) =  0.60023,  AL(2) =  0.17013,  AL(3) =  0.17013,  AL(4) =  0.60023,  AL(


  RUN NUMBER  7702                    HYDROSTATIC BEARING PAD WITH 4 RECESSES.
                           FEEDING = POSITIVE DISPLACEMENT PUMPS FEEDING EACH RECESS.
  PAD CONFIGURATION. 00000000000000000000000000000
                     02222222222222222222222222220
                     02222222222222222222222222220
                     02222222222222222222222222220
                     02222111111222222211111122220
                     02222111111222222211111122220
                     02222111111222222211111122220
                     02222222222222222222222222220
                     02222222222222222222222222220
                     02222222222222222222222222220
                     02222111111222222211111122220
                     02222111111222222211111122220
                     02222111111222222211111122220
                     02222222222222222222222222220
                     02222222222222222222222222220
                     02222222222222222222222222220
                     00000000000000000000000000000
```

PRESSURE DISTRIBUTION

RUN 7702	I= 1	I= 2	I= 3	I= 4	I= 5	I= 6	I= 7	I= 8	I= 9	I= 10
J= 1,	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
J= 2,	0.	0.0337	0.0623	0.0878	0.1100	0.1273	0.1367	0.1398	0.1379	0.1310
J= 3,	0.	0.0661	0.1230	0.1746	0.2218	0.2603	0.2788	0.2846	0.2816	0.2694
J= 4,	0.	0.0956	0.1788	0.2572	0.3353	0.4088	0.4321	0.4382	0.4356	0.4236
J= 5,	0.	0.1196	0.2245	0.3265	0.4408	0.6002	0.6002	0.6002	0.6002	0.6002
J= 6,	0.	0.1360	0.2539	0.3649	0.4784	0.6002	0.6002	0.6002	0.6002	0.6002
J= 7,	0.	0.1453	0.2691	0.3810	0.4883	0.6002	0.6002	0.6002	0.6002	0.6002
J= 8,	0.	0.1494	0.2746	0.3827	0.4757	0.5482	0.5745	0.5819	0.5782	0.5627
J= 9,	0.	0.1505	0.2757	0.3820	0.4701	0.5347	0.5653	0.5746	0.5696	0.5495
J= 10,	0.	0.1494	0.2746	0.3827	0.4757	0.5482	0.5745	0.5819	0.5782	0.5627
J= 11,	0.	0.1453	0.2691	0.3810	0.4883	0.6002	0.6002	0.6002	0.6002	0.6002
J= 12,	0.	0.1360	0.2539	0.3649	0.4784	0.6002	0.6002	0.6002	0.6002	0.6002
J= 13,	0.	0.1196	0.2245	0.3265	0.4408	0.6002	0.6002	0.6002	0.6002	0.6002
J= 14,	0.	0.0956	0.1788	0.2572	0.3353	0.4088	0.4321	0.4382	0.4356	0.4236
J= 15,	0.	0.0661	0.1230	0.1746	0.2218	0.2603	0.2788	0.2846	0.2816	0.2694
J= 16,	0.	0.0337	0.0623	0.0878	0.1100	0.1273	0.1367	0.1398	0.1379	0.1310
J= 17,	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PRESSURE DISTRIBUTION

RUN 7702	I= 11	I= 12	I= 13	I= 14	I= 15	I= 16	I= 17	I= 18	I= 19	I= 20
J= 1,	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
J= 2,	0.1182	0.0997	0.0811	0.0658	0.0546	0.0473	0.0433	0.0416	0.0413	0.0412
J= 3,	0.2443	0.2020	0.1615	0.1297	0.1071	0.0926	0.0849	0.0823	0.0828	0.0830
J= 4,	0.3922	0.3084	0.2387	0.1885	0.1546	0.1335	0.1228	0.1206	0.1248	0.1258
J= 5,	0.6002	0.4111	0.3048	0.2377	0.1942	0.1674	0.1540	0.1532	0.1701	0.1701
J= 6,	0.6002	0.4496	0.3439	0.2716	0.2231	0.1921	0.1747	0.1683	0.1701	0.1701
J= 7,	0.6002	0.4601	0.3620	0.2914	0.2416	0.2081	0.1875	0.1763	0.1701	0.1701
J= 8,	0.5267	0.4444	0.3650	0.3001	0.2512	0.2170	0.1947	0.1813	0.1739	0.1705
J= 9,	0.5081	0.4377	0.3648	0.3024	0.2542	0.2197	0.1969	0.1830	0.1750	0.1705
J= 10,	0.5267	0.4444	0.3650	0.3001	0.2512	0.2170	0.1947	0.1813	0.1739	0.1705
J= 11,	0.6002	0.4601	0.3620	0.2914	0.2416	0.2081	0.1875	0.1763	0.1701	0.1701
J= 12,	0.6002	0.4496	0.3439	0.2716	0.2231	0.1921	0.1747	0.1683	0.1701	0.1701
J= 13,	0.6002	0.4111	0.3048	0.2377	0.1942	0.1674	0.1540	0.1532	0.1701	0.1701
J= 14,	0.3922	0.3084	0.2387	0.1885	0.1546	0.1335	0.1228	0.1206	0.1248	0.1258
J= 15,	0.2443	0.2020	0.1615	0.1297	0.1071	0.0926	0.0849	0.0823	0.0828	0.0830
J= 16,	0.1182	0.0997	0.0811	0.0658	0.0546	0.0473	0.0433	0.0416	0.0413	0.0412
J= 17,	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PRESSURE DISTRIBUTION

RUN 7702	I= 21	I= 22	I= 23	I= 24	I= 25	I= 26	I= 27	I= 28	I= 29	I=
J= 1,	0.	0.	0.	0.	0.	0.	0.	0.	0.	
J= 2,	0.0407	0.0394	0.0368	0.0323	0.0256	0.0185	0.0117	0.0055	0.	
J= 3,	0.0823	0.0802	0.0758	0.0671	0.0524	0.0371	0.0232	0.0109	0.	
J= 4,	0.1255	0.1238	0.1195	0.1091	0.0810	0.0554	0.0340	0.0159	0.	
J= 5,	0.1701	0.1701	0.1701	0.1701	0.1094	0.0712	0.0430	0.0200	0.	
J= 6,	0.1701	0.1701	0.1701	0.1701	0.1190	0.0797	0.0487	0.0228	0.	
J= 7,	0.1701	0.1701	0.1701	0.1701	0.1206	0.0827	0.0513	0.0242	0.	
J= 8,	0.1679	0.1644	0.1580	0.1446	0.1139	0.0818	0.0519	0.0248	0.	
J= 9,	0.1670	0.1623	0.1538	0.1381	0.1112	0.0811	0.0519	0.0249	0.	
J= 10,	0.1679	0.1644	0.1580	0.1446	0.1139	0.0818	0.0519	0.0248	0.	
J= 11,	0.1701	0.1701	0.1701	0.1701	0.1206	0.0827	0.0513	0.0242	0.	
J= 12,	0.1701	0.1701	0.1701	0.1701	0.1190	0.0797	0.0487	0.0228	0.	
J= 13,	0.1701	0.1701	0.1701	0.1701	0.1094	0.0712	0.0430	0.0200	0.	
J= 14,	0.1255	0.1238	0.1195	0.1091	0.0810	0.0554	0.0340	0.0159	0.	
J= 15,	0.0823	0.0802	0.0758	0.0671	0.0524	0.0371	0.0232	0.0109	0.	
J= 16,	0.0407	0.0394	0.0368	0.0323	0.0256	0.0185	0.0117	0.0055	0.	
J= 17,	0.	0.	0.	0.	0.	0.	0.	0.	0.	

CLEARANCE DISTRIBUTION

RUN 7702	I= 1	I= 2	I= 3	I= 4	I= 5	I= 6	I= 7	I= 8	I= 9	I= 10
J= 1,	0.5000000	0.5357143	0.5714286	0.6071429	0.6428571	0.6785714	0.7142857	0.7500000	0.7857143	0.8214286
J= 2,	0.5000000	0.5357143	0.5714286	0.6071429	0.6428571	0.6785714	0.7142857	0.7500000	0.7857143	0.8214286
J= 3,	0.5000000	0.5357143	0.5714286	0.6071429	0.6428571	0.6785714	0.7142857	0.7500000	0.7857143	0.8214286
J= 4,	0.5000000	0.5357143	0.5714286	0.6071429	0.6428571	0.6785714	0.7142857	0.7500000	0.7857143	0.8214286
J= 5,	0.5000000	0.5357143	0.5714286	0.6071429	0.6428571	0.6785714	0.7142857	0.7500000	0.7857143	0.8214286
J= 6,	0.5000000	0.5357143	0.5714286	0.6071429	0.6428571	0.6785714	0.7142857	0.7500000	0.7857143	0.8214286
J= 7,	0.5000000	0.5357143	0.5714286	0.6071429	0.6428571	0.6785714	0.7142857	0.7500000	0.7857143	0.8214286
J= 8,	0.5000000	0.5357143	0.5714286	0.6071429	0.6428571	0.6785714	0.7142857	0.7500000	0.7857143	0.8214286
J= 9,	0.5000000	0.5357143	0.5714286	0.6071429	0.6428571	0.6785714	0.7142857	0.7500000	0.7857143	0.8214286
J= 10,	0.5000000	0.5357143	0.5714286	0.6071429	0.6428571	0.6785714	0.7142857	0.7500000	0.7857143	0.8214286
J= 11,	0.5000000	0.5357143	0.5714286	0.6071429	0.6428571	0.6785714	0.7142857	0.7500000	0.7857143	0.8214286
J= 12,	0.5000000	0.5357143	0.5714286	0.6071429	0.6428571	0.6785714	0.7142857	0.7500000	0.7857143	0.8214286
J= 13,	0.5000000	0.5357143	0.5714286	0.6071429	0.6428571	0.6785714	0.7142857	0.7500000	0.7857143	0.8214286
J= 14,	0.5000000	0.5357143	0.5714286	0.6071429	0.6428571	0.6785714	0.7142857	0.7500000	0.7857143	0.8214286
J= 15,	0.5000000	0.5357143	0.5714286	0.6071429	0.6428571	0.6785714	0.7142857	0.7500000	0.7857143	0.8214286
J= 16,	0.5000000	0.5357143	0.5714286	0.6071429	0.6428571	0.6785714	0.7142857	0.7500000	0.7857143	0.8214286
J= 17,	0.5000000	0.5357143	0.5714286	0.6071429	0.6428571	0.6785714	0.7142857	0.7500000	0.7857143	0.8214286

CLEARANCE DISTRIBUTION

RUN 7702	I= 11	I= 12	I= 13	I= 14	I= 15	I= 16	I= 17	I= 18	I= 19	I= 20
J= 1,	0.8571429	0.8928571	0.9285714	0.9642857	1.0000000	1.0357143	1.0714286	1.1071429	1.1428571	1.1785714
J= 2,	0.8571429	0.8928571	0.9285714	0.9642857	1.0000000	1.0357143	1.0714286	1.1071429	1.1428571	1.1785714
J= 3,	0.8571429	0.8928571	0.9285714	0.9642857	1.0000000	1.0357143	1.0714286	1.1071429	1.1428571	1.1785714
J= 4,	0.8571429	0.8928571	0.9285714	0.9642857	1.0000000	1.0357143	1.0714286	1.1071429	1.1428571	1.1785714
J= 5,	0.8571429	0.8928571	0.9285714	0.9642857	1.0000000	1.0357143	1.0714286	1.1071429	1.1428571	1.1785714
J= 6,	0.8571429	0.8928571	0.9285714	0.9642857	1.0000000	1.0357143	1.0714286	1.1071429	1.1428571	1.1785714
J= 7,	0.8571429	0.8928571	0.9285714	0.9642857	1.0000000	1.0357143	1.0714286	1.1071429	1.1428571	1.1785714
J= 8,	0.8571429	0.8928571	0.9285714	0.9642857	1.0000000	1.0357143	1.0714286	1.1071429	1.1428571	1.1785714
J= 9,	0.8571429	0.8928571	0.9285714	0.9642857	1.0000000	1.0357143	1.0714286	1.1071429	1.1428571	1.1785714
J= 10,	0.8571429	0.8928571	0.9285714	0.9642857	1.0000000	1.0357143	1.0714286	1.1071429	1.1428571	1.1785714
J= 11,	0.8571429	0.8928571	0.9285714	0.9642857	1.0000000	1.0357143	1.0714286	1.1071429	1.1428571	1.1785714
J= 12,	0.8571429	0.8928571	0.9285714	0.9642857	1.0000000	1.0357143	1.0714286	1.1071429	1.1428571	1.1785714
J= 13,	0.8571429	0.8928571	0.9285714	0.9642857	1.0000000	1.0357143	1.0714286	1.1071429	1.1428571	1.1785714
J= 14,	0.8571429	0.8928571	0.9285714	0.9642857	1.0000000	1.0357143	1.0714286	1.1071429	1.1428571	1.1785714
J= 15,	0.8571429	0.8928571	0.9285714	0.9642857	1.0000000	1.0357143	1.0714286	1.1071429	1.1428571	1.1785714
J= 16,	0.8571429	0.8928571	0.9285714	0.9642857	1.0000000	1.0357143	1.0714286	1.1071429	1.1428571	1.1785714
J= 17,	0.8571429	0.8928571	0.9285714	0.9642857	1.0000000	1.0357143	1.0714286	1.1071429	1.1428571	1.1785714

CLEARANCE DISTRIBUTION

RUN 7702	I= 21	I= 22	I= 23	I= 24	I= 25	I= 26	I= 27	I= 28	I= 29	I=
J= 1,	1.2142857	1.2500000	1.2857143	1.3214286	1.3571429	1.3928571	1.4285714	1.4642857	1.5000000	
J= 2,	1.2142857	1.2500000	1.2857143	1.3214286	1.3571429	1.3928571	1.4285714	1.4642857	1.5000000	
J= 3,	1.2142857	1.2500000	1.2857143	1.3214286	1.3571429	1.3928571	1.4285714	1.4642857	1.5000000	
J= 4,	1.2142857	1.2500000	1.2857143	1.3214286	1.3571429	1.3928571	1.4285714	1.4642857	1.5000000	
J= 5,	1.2142857	1.2500000	1.2857143	1.3214286	1.3571429	1.3928571	1.4285714	1.4642857	1.5000000	
J= 6,	1.2142857	1.2500000	1.2857143	1.3214286	1.3571429	1.3928571	1.4285714	1.4642857	1.5000000	
J= 7,	1.2142857	1.2500000	1.2857143	1.3214286	1.3571429	1.3928571	1.4285714	1.4642857	1.5000000	
J= 8,	1.2142857	1.2500000	1.2857143	1.3214286	1.3571429	1.3928571	1.4285714	1.4642857	1.5000000	
J= 9,	1.2142857	1.2500000	1.2857143	1.3214286	1.3571429	1.3928571	1.4285714	1.4642857	1.5000000	
J= 10,	1.2142857	1.2500000	1.2857143	1.3214286	1.3571429	1.3928571	1.4285714	1.4642857	1.5000000	
J= 11,	1.2142857	1.2500000	1.2857143	1.3214286	1.3571429	1.3928571	1.4285714	1.4642857	1.5000000	
J= 12,	1.2142857	1.2500000	1.2857143	1.3214286	1.3571429	1.3928571	1.4285714	1.4642857	1.5000000	
J= 13,	1.2142857	1.2500000	1.2857143	1.3214286	1.3571429	1.3928571	1.4285714	1.4642857	1.5000000	
J= 14,	1.2142857	1.2500000	1.2857143	1.3214286	1.3571429	1.3928571	1.4285714	1.4642857	1.5000000	
J= 15,	1.2142857	1.2500000	1.2857143	1.3214286	1.3571429	1.3928571	1.4285714	1.4642857	1.5000000	
J= 16,	1.2142857	1.2500000	1.2857143	1.3214286	1.3571429	1.3928571	1.4285714	1.4642857	1.5000000	
J= 17,	1.2142857	1.2500000	1.2857143	1.3214286	1.3571429	1.3928571	1.4285714	1.4642857	1.5000000	

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RUN NUMBER  7703                               HYBRID BEARING PAD WITH 4 RECESSES
                                  FEEDING = POSITIVE DISPLACEMENT PUMPS FEEDING EACH RECESS.
LAMBDA =   1.0000
GRID POINTS, K = 28   M = 16      K1 =  5   K2 =  5   K3 =  0    M1 =  4   M2 =  2
CLEARANCE COEFFICIENTS
,AA 1)= 0.09999999E 01 ,AA


                                                         OUTPUT
QQ(I)=      1.0000     1.0000     1.0000     1.0000
W(I)=     0.0762   0.0800   0.0800   0.0762   0.0028
CSI(I)=   0.2746   0.6943   0.6943   0.2746   0.2974
ETA(I)=   0.1889   0.3802   0.1913   0.3826   0.2857

          J=1,     J=2,     J=3,     J=4,     J=5,
Q(1,J)=   2.5957  -0.1453  -0.2683  -0.8124  -0.0774
Q(2,J)=  -0.1379  10.5371  -3.2231  -0.2692  -0.0813
Q(3,J)=  -0.2692  -3.2231  10.5371  -0.1379  -0.0813
Q(4,J)=  -0.8124  -0.2683  -0.1453   2.5957  -0.0774
FINAL RESULTS = TOTAL LOAD=  0.1308  CSI= 0.3694 ETA=  0.2857  TOTAL FLOW=  0.4000000E 01
RECESS PRESSURES
 ,  AL(1) =  0.64679,  AL(2) =  0.18384,  AL(3) =  0.18384,  AL(4) =  0.64679,  AL(


RUN NUMBER  7703                               HYBRID BEARING PAD WITH 4 RECESSES
                                  FEEDING = POSITIVE DISPLACEMENT PUMPS FEEDING EACH RECESS.
PAD CONFIGURATION. 00000000000000000000000000000
                   02222222222222222222222222220
                   02222222222222222222222222220
                   02222222222222222222222222220
                   02222111111222222211111122220
                   02222111111222222211111122220
                   02222111111222222211111122220
                   02222222222222222222222222220
                   02222222222222222222222222220
                   02222222222222222222222222220
                   02222111111222222211111122220
                   02222111111222222211111122220
                   02222111111222222211111122220
                   02222222222222222222222222220
                   02222222222222222222222222220
                   02222222222222222222222222220
                   00000000000000000000000000000
```

PRESSURE DISTRIBUTION

RUN 7703	I= 1	I= 2	I= 3	I= 4	I= 5	I= 6	I= 7	I= 8	I= 9	I= 10
J= 1,	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
J= 2,	0.	0.0363	0.0672	0.0946	0.1185	0.1371	0.1473	0.1507	0.1486	0.1412
J= 3,	0.	0.0712	0.1325	0.1881	0.2390	0.2805	0.3005	0.3067	0.3034	0.2903
J= 4,	0.	0.1030	0.1927	0.2771	0.3613	0.4406	0.4656	0.4722	0.4694	0.4565
J= 5,	0.	0.1289	0.2419	0.3519	0.4750	0.6468	0.6468	0.6468	0.6468	0.6468
J= 6,	0.	0.1466	0.2736	0.3932	0.5155	0.6468	0.6468	0.6468	0.6468	0.6468
J= 7,	0.	0.1566	0.2900	0.4106	0.5262	0.6468	0.6468	0.6468	0.6468	0.6468
J= 8,	0.	0.1610	0.2959	0.4123	0.5126	0.5907	0.6190	0.6270	0.6230	0.6063
J= 9,	0.	0.1621	0.2971	0.4116	0.5066	0.5762	0.6091	0.6192	0.6138	0.5922
J= 10,	0.	0.1610	0.2959	0.4123	0.5126	0.5907	0.6190	0.6270	0.6230	0.6063
J= 11,	0.	0.1566	0.2900	0.4106	0.5262	0.6468	0.6468	0.6468	0.6468	0.6468
J= 12,	0.	0.1466	0.2736	0.3932	0.5155	0.6468	0.6468	0.6468	0.6468	0.6468
J= 13,	0.	0.1289	0.2419	0.3519	0.4750	0.6468	0.6468	0.6468	0.6468	0.6468
J= 14,	0.	0.1030	0.1927	0.2771	0.3613	0.4406	0.4656	0.4722	0.4694	0.4565
J= 15,	0.	0.0712	0.1325	0.1881	0.2390	0.2805	0.3005	0.3067	0.3034	0.2903
J= 16,	0.	0.0363	0.0672	0.0946	0.1185	0.1371	0.1473	0.1507	0.1486	0.1412
J= 17,	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PRESSURE DISTRIBUTION

RUN 7703	I= 11	I= 12	I= 13	I= 14	I= 15	I= 16	I= 17	I= 18	I= 19	I= 20
J= 1,	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
J= 2,	0.1273	0.1074	0.0874	0.0710	0.0589	0.0511	0.0467	0.0449	0.0447	0.0445
J= 3,	0.2632	0.2177	0.1741	0.1398	0.1155	0.0999	0.0916	0.0889	0.0894	0.0896
J= 4,	0.4226	0.3324	0.2573	0.2033	0.1668	0.1441	0.1325	0.1303	0.1348	0.1359
J= 5,	0.6468	0.4430	0.3286	0.2562	0.2094	0.1806	0.1662	0.1655	0.1838	0.1838
J= 6,	0.6468	0.4846	0.3707	0.2929	0.2406	0.2073	0.1886	0.1818	0.1838	0.1838
J= 7,	0.6468	0.4959	0.3902	0.3141	0.2605	0.2246	0.2024	0.1904	0.1838	0.1838
J= 8,	0.5676	0.4790	0.3935	0.3235	0.2710	0.2341	0.2101	0.1958	0.1879	0.1842
J= 9,	0.5475	0.4718	0.3933	0.3260	0.2741	0.2371	0.2126	0.1976	0.1890	0.1842
J= 10,	0.5676	0.4790	0.3935	0.3235	0.2710	0.2341	0.2101	0.1958	0.1879	0.1842
J= 11,	0.6468	0.4959	0.3902	0.3141	0.2605	0.2246	0.2024	0.1904	0.1838	0.1838
J= 12,	0.6468	0.4846	0.3707	0.2929	0.2406	0.2073	0.1886	0.1818	0.1838	0.1838
J= 13,	0.6468	0.4430	0.3286	0.2562	0.2094	0.1806	0.1662	0.1655	0.1838	0.1838
J= 14,	0.4226	0.3324	0.2573	0.2033	0.1668	0.1441	0.1325	0.1303	0.1348	0.1359
J= 15,	0.2632	0.2177	0.1741	0.1398	0.1155	0.0999	0.0916	0.0889	0.0894	0.0896
J= 16,	0.1273	0.1074	0.0874	0.0710	0.0589	0.0511	0.0467	0.0449	0.0447	0.0445
J= 17,	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PRESSURE DISTRIBUTION

RUN 7703	I= 21	I= 22	I= 23	I= 24	I= 25	I= 26	I= 27	I= 28	I= 29	I=
J= 1,	0.	0.	0.	0.	0.	0.	0.	0.	0.	
J= 2,	0.0440	0.0425	0.0397	0.0349	0.0277	0.0199	0.0126	0.0060	0.	
J= 3,	0.0889	0.0867	0.0819	0.0725	0.0566	0.0401	0.0250	0.0118	0.	
J= 4,	0.1356	0.1337	0.1291	0.1178	0.0875	0.0598	0.0367	0.0172	0.	
J= 5,	0.1838	0.1838	0.1838	0.1838	0.1182	0.0770	0.0464	0.0216	0.	
J= 6,	0.1838	0.1838	0.1838	0.1838	0.1286	0.0861	0.0526	0.0246	0.	
J= 7,	0.1838	0.1838	0.1838	0.1838	0.1303	0.0893	0.0554	0.0262	0.	
J= 8,	0.1814	0.1777	0.1708	0.1562	0.1231	0.0884	0.0561	0.0268	0.	
J= 9,	0.1804	0.1753	0.1662	0.1492	0.1201	0.0876	0.0561	0.0269	0.	
J= 10,	0.1814	0.1777	0.1708	0.1562	0.1231	0.0884	0.0561	0.0268	0.	
J= 11,	0.1838	0.1838	0.1838	0.1838	0.1303	0.0893	0.0554	0.0262	0.	
J= 12,	0.1838	0.1838	0.1838	0.1838	0.1286	0.0861	0.0526	0.0246	0.	
J= 13,	0.1838	0.1838	0.1838	0.1838	0.1182	0.0770	0.0464	0.0216	0.	
J= 14,	0.1356	0.1337	0.1291	0.1178	0.0875	0.0598	0.0367	0.0172	0.	
J= 15,	0.0889	0.0867	0.0819	0.0725	0.0566	0.0401	0.0250	0.0118	0.	
J= 16,	0.0440	0.0425	0.0397	0.0349	0.0277	0.0199	0.0126	0.0060	0.	
J= 17,	0.	0.	0.	0.	0.	0.	0.	0.	0.	