FINAL REPORT
DEVELOPMENT OF DIGITAL COMPUTER PROGRAM FOR THERMAL NETWORK CORRECTION

PHASE II - PROGRAM DEVELOPMENT

PHASE III - DEMONSTRATION/APPLICATION

SEPTEMBER 1970

Prepared by

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Prepared for
AERONAUTICS AND SPACE ADMINISTRATION
Manned Spacecraft Center
Houston, Texas

NASA Contract 9-2289

TRW SYSTEMS
REDONDO BEACH, CALIFORNIA

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T. Ishimoto
Project Manager

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SUMMARY

The overall objective of this program was the development of a computer program that corrects soft parameters of a thermal network such that the temperatures from the updated thermal network correlates with the measured temperature data. Evaluation of the thermal network correction program with the use of two 50-node models and one 500-node model revealed rather promising results in many respects on the one hand but also indicated some limitations on the other. When complete temperature measurements are available in a region or a subregion (a smallest subregion consists of a measured node surrounded by measured nodes), the Kalman filtering method of processing the set of equations sequentially and each equation timewise in a sequential sense yielded rather accurate correction of those parameters that were both observable and subject to significantly changing nodal temperatures. Parameters that were not observable and/or insensitive to nodal temperatures were corrected; parameters that were subject to temperatures that did not change significantly were corrected very little.

Limitations included the lack of adequately correcting for the parameters associated with arithmetic nodes and the correction difficulties encountered when a soft capacitance is mixed with soft sources and/or conductors. Difficulties with arithmetic nodes in part stem from the non-uniform temperature change of arithmetic nodes from one time slice to another.

Weighing the overall results, the present thermal network correction program has fulfilled to a large extent the overall objective of the present program.

1.0 INTRODUCTION

1.1 Review of Phase I

1.1.1 Objective

The overall objective of this program was to develop a computer program that corrects parameters of a thermal network given transient temperature measurement such that the temperatures from the updated thermal network correlates with the measured temperature data.

1.1.2 Results

Results of Phase I effort*[1,2] indicated quite clearly that updating and correction of a thermal network is dependent upon the observability of the parameters relative to the temperature measurements. If all nodes are monitored, sufficient information is available to correct all parameters (less one) of the system. For this situation, it appeared that the objective to correct a large thermal network can be fulfilled by using the Kalman filter correction technique (other correction techniques[1] can also be used). Kalman filtering was chosen over other methods because it offered a way to solve some of the problems presented by temperature measurement sparsity, yet retain solution simplicity when the number of measured temperatures in a region is complete.

It also became quite clear that if all nodes are not monitored, observability becomes a primary consideration that determines the extent to which a thermal network can be corrected; in general, smaller is the number of unmeasured nodes, larger is the network observability. Observability is also dependent upon unmeasured node location relative to measured nodes. Corrected parameters are also dependent upon temperature measurement accuracy of the measured nodes and availability of accurate initial temperature of the unmeasured nodes. This means that attainment of the overall objective is governed by availability of necessary temperature information. If this information does not exist, it appears that the objectives cannot be met by any correction method.

Recognizing that temperature measurements will indeed be available at some of the nodal locations but in no particular pattern, a study was

* Superscript numbers refer to the references listed in the Reference Section.

made to isolate those situations under which parameters are observable and those conditions under which these parameters are accurately correctable. Many types of temperature sparsity situations were examined in the Phase I effort;[2] these results led conceptually to a network correction procedure that separates the thermal network into regions that are correctable from those that are totally uncorrectable. Those regions that are identified as correctable are subdivided into smaller network subregions that have total measurements and subregions that have sparse measurements but yet are observable. This overall network correction procedure thus provides a systematic means of operating on only those network portions that are correctable and hence presents a network subdivision procedure that is not dependent upon a fixed pattern for the measured nodes.

Attainment of program objectives is dependent upon the quantity and quality of the measured temperature information. For a normal thermal test, measured temperatures are expected to be of sufficient number and accuracy to permit network parameter corrections.

It was indicated above that if all of the nodes are monitored, a very large network can be corrected. This is possible because the governing heat balance equations can be operated singly and timewise sequentially. The Kalman filter was formulated to take advantage of this special temperature measurement situation.

An important consideration of the sequential method in the equationwise sense is that the expected parameter correction accuracy of this Kalman filtering method cannot be expected to be as high as the Kalman filtering method when the entire network is considered simultaneously. The reason for this is that more information is available for correcting an individual parameter with simultaneous network processing than with the equationwise sequential method. The need for the latter arises from the need for correcting a large network but subject to computer core limitations and computational constraints.

The development of the Kalman filtering equations is presented in Appendix B. Users instructions are described briefly in Appendix B, but the user should refer to Reference 3 for more detail.

1.2 Phase II - A Programming Effort

Translation of the Phase I results into a systems package of subroutines required major program improvements to CINDA-3G.[4] Subroutine additions that comprise primarily the thermal network correction package also required further developmental investigation because of systems programming considerations. Included in this consideration was the handling of arithmetic nodes which do not lend themselves readily to the Kalman filtering method because of the incompatibility of the network solution method and the filtering method. Phase II represented this programming effort.

1.2.1 Modifications to CINDA-3G

Changes to CINDA-3G are reported in Section 2. Many of these changes were rather major in scope and were required to accommodate the requirements of the thermal network correction package; others were made to improve the capabilities of the program. Detailed information from a user's standpoint is found in the SINDA Users Manual.[3] It should be particularly noted here that the acronym CINDA-3G has been replaced by the acronym SINDA (Systems Improved Numerical Differencing Analyzer) in order to reflect major improvements and subroutine additions to CINDA-3G.

1.2.2 Thermal Network Correction Package

The thermal network correction package is more than just a number of separate subroutines but is rather an integrated system that must compare experimental and analytical temperatures, select observable and unobservable network regions, as well as make the proper parameter value corrections. Generation of a parameter correction package for a large network is far different than for a small network. Accommodation of a large network required the modification of Kalman filtering so that a single nodal equation in sequence could be processed and associated parameters corrected in lieu of total network processing and parameter correction; this method is applicable only if complete temperature measurements are available. As a result, two Kalman filtering versions have been developed for the conditions of complete and incomplete temperature measurements. The various subroutine additions are reported in Section 2 and systems operational procedures are detailed in Appendix A.

1.3 Phase III - An Application Phase

In this phase, the thermal network correction package was applied to two relatively small thermal models with the number of nodes numbering approximately 50 and one large model numbering about 500 nodes. The two "50-node" models served the purpose of determining the systems operational aspect of the thermal network correction package. The larger model provided information about the network size effects on the parameter correction method. A description of the two "50-node" models and the large 500-node model is found in Appendix D. Results of the thermal network correction as applied to these models are discussed in Section 3.

2.0 PROGRAM MODIFICATIONS TO CINDA-3G AND SUBROUTINE ADDITIONS

The integration of the thermal network correction subroutine package into the existing CINDA-3 program required a number of major improvements to CINDA-3G; in order to reflect these changes in the preprocessor and the variables library, the improved program has been given the acronym SINDA as reported in the previous section.

The thermal network correction package is composed of several subroutines that are concerned only with the correction procedure. In addition, a number of peripheral subroutines that interface with the thermal network correction package were required to form the systems (overall) operational package for thermal network correction.

The program changes to CINDA-3G and a brief description of subroutines specifically developed for the present study are discussed below. A more detailed discussion and users instructions for the thermal network correction procedure are found in Appendix B; for a more integrated SINDA thermal network correction se of user instructions the SINDA Users Manual should be consulted.[3] Systems operational procedure for thermal network correction is presented in Appendix A.

2.1 Preprocessor Modifications

CINDA-3G preprocessor modifications and the CINDA-3G/SINDA relationship are indicated below; detailed user instructions on data input requirements are described in the SINDA Users Manual.[3] Note that the codes CGS and CGD have been replaced by mnemonics SIV (single interpolation variable) and DIV (double interpolation variable) but SINDA will accept either code.

2.1.1 Data Blocks

These inputs blocks accept CINDA-3G header and end cards and the same general format. The use of a C in column one is allowed and has the same comment meaning as in FØRTRAN.

2.1.2 Title Block

The three standard options (THERMAL SPCS, THERMAL LPCS or GENERAL) are continued. An output page heading of up to 20 BCD words is stored as H.

2.1.3 Node Data

Input options are as follows:

```
(Col)  8   12
           N#,Ti,C                      $Diffusion node
           N#,Ti,-C                     $Arithmetic node
           -N#,Ti,C                     $Boundary node
       CAL N#,Ti,X,Y,Z,W                $C=X*Y*Z*W
       GEN N#S,#N,IN,Ti,C               $Generates sequence of nodes
```

The following represent linear interpolation from array:

```
SIV N#,Ti,A,F                  $Allows temperature varying capacitance
DIV N#,Ti,A1,F1,A2,F2          $Allows temperature varying
                                capacitance of two dissimilar
                                materials
SIM N#,#N,IN,A,F               $Combination of GEN & SIV options
DIM N#,#N,IN,Ti,A1,F1,A2,F2    $Combination of GEN & DIV options
```

The following referenced array contains polynomial coefficients, otherwise identical to SIV, DIV, SIM & DIM.

```
SPV N#,Ti,A,F                    } The maximum actual and relative
DPV N#,Ti,A1,F1,A2,F2            } number is 16383 for arrays
SPM N#,#N,IN,Ti,A,F              } and constants.
DPM N#S,#N,IN,Ti,A1,F1,A2,F2     }

BIV N#,Ti,A,F                  $Allows bivariate specification of
                                capacitance (refer to pg.4-10,Ref.3)
```

where, N# is the node number

N#S is the node number starting

#N is the number of nodes to be generated

Ti is the initial temperature

C is the capacitance

IN is the increment for node generation (nodal index)

A is the array

F is a constant

Diffusion, arithmetic and boundary nodes may be intermingled. When processing node data, the program stores $\pm$N# and Ti for arithmetic and boundary nodes in a temporary array; when node data end is reached, the program will recover them and make two passes (arithmetic then boundary), add them to the actual node number array (NAN) and temperature value array. Each time an actual node number is recorded the 1 bit is used to indicate a nonlinear capacitance. Each time a variable capacitance is encountered its type (NLC), actual array number (LA) and actual constant number (LK) will be stored in a single core locatiion. If an argument is a literal it will be stored in an extended constants array (EC) and the negative of its relative position in the EC array stored in the address position.

The input data are stored as follows:

NAN	Ti	C	NLC,LA,LF	EC	TA
±N#			± ±		

and the following constants are calculated:

N#D	number of diffusion nodes
N#A	number of arithmetic nodes
N#B	number of boundary nodes
NLCLAF	number of locations for NLC,LA,LF storage
NEC	number of extra constants

The nonlinear type NLC is stored in bits 0 through 5; 15 bits each are used for the array and constant locations. Then the number of nodes total (N#I+N#D+N#A+N#B) is used to write the initial temperatures off on a data tape followed by the number of calculated nodes (N#C+N#D+N#A) used for dummy Q values followed by N#D used for outputting capacitance values. Then the list of actual node numbers can be written off on a dictionary tape. The arrays of NLC,LA,LF and EC can be held or be buffered out as they will be added to.

2.1.4 Optional Source Data

A source data block which is not available in CINDA-3G has been included as part of the CINDA-3G preprocessor modifications. This source data block is required for the thermal network correction package and follows an input format that is consistent with the other input data blocks. Consistency of the options and the mnemonic codes was also maintained. The input data is stored in much the same manner as for the node data as described above.

Optional means that if there are no data for the source data block then the block header card and the END (mnemonic code) need not be included in the data deck. As in the node data block, the user input number is the actual number and the program assigned number is the relative source number. Within the optional source data block, the source may be a constant, a function of time, a function of temperature or a function of both time and temperature. It should be particularly noted that a source may not be impressed on a boundary node.

Input options are as follows:

```
(Col)   8    12
             N#,Q                    $ Q may be a user constant or a
                                       literal
        GEN  N#S,#N,IN,Q             $ Generates a sequence of sources
        SIV  N#, A, F                $ Allows a temperature varying
                                       source
        SIT  N#, A, F                $ Allows a time varying source
        DIT  N#,A1,F1,A2,F2          $ Allows two time varying sources
                                       to a node
        DTV  N#,A1,F1,A2,F2          $ Allows a time varying source and
                                       a temperature varying source to
                                       a node
```

where,
- N# is the node number
- N#S is the starting node number
- #N is the number of nodes to be generated
- Q is the source as a user constant or as a literal
- IN is the increment for node generation (nodal index)
- A is the array
- F is a factor that may be a user constant or a literal

2.1.5 Conductor Data

Input options have been expanded and the description is similar to node data described previously; the user may intermingle radiation conductors with regular ones. Options are as follows:

```
(Col)  8   12
           G#,NA,NB,G                   $Regular conductor
           G#,NA1,NB1,NA2,NB2,G         $Multiple connections
           -G#,NA,NB,G                  $Radiation conductors
           G#,-NA,NB,G                  $One way conductor (from NA to NB)
       CAL G#,NA,NB,X,Y,Z,W             $G=X*Y*Z/W
       GEN G#S,#G,IG,INA,NB,INB,G       $Generates sequence of conductors.
                                         Allows X,Y,Z,W instead of G

       SIV G#,NA,NB,A,F                             }
       DIV G#,NA,NB,A1,F1,A2,F2                     } Linear interpolation
       SIM G#S,#G,IG,NA,INA,NB,INB,A,F              } of array
       DIM G#S,#G,IG,NA,INA,NB,INB,A1,F1,A2,F2      }

       SPV G#,NA,NB,A,F                             }
       DPV G#,NA,NB,A1,F1,A2,F2                     } Referenced array
       SPM G#,#G,IG,NA,INA,NB,INB,A,F               } contains polynomial
       DPM G#,#G,IG,NA,INA,NB,INB,A1,F1,A2,F2       } coefficients

       BIV G#,NA,NB,A,F                 $Allows simulation of bivariate
                                         property (refer to pg.4-12,Ref.3)
```

where,
- G# is the conductor number
- NA is the first adjoining node
- NB is the second adjoining node
- G is the conductor value
- G#S is the starting conductor number
- #G is the number of conductors
- IG is the conductor numbering index
- INA is one nodal index
- INB is the second nodal index
- A is an array
- F is a constant

In reading the conductor data the conductor number is stored in one array with the conductor value in another; the NA-NB values are stored in a third array which will use the 0 bit to indicate a multiple use conductor and the 1 bit to indicate nonlinearity, NA and NB each receive 17 locations. Nonlinear and radiation conductors will cause the nonlinear bit to be set. The type is stored as NLG and the array and constant positions in LA and LF. If literals are encountered they are stored in the EC array and the negative of their EC position is stored as LA or LF. The input data is stored as follows:

NAG	M,N,NA,NB	V	NLG,LA,LF	EC
±	± ± ± ±		± ± ±	

and the following constants are calculated

NGT	number of total conductors
NGC	number of conductor connections
NCR	number of radiation conductors
NLCLAF	number of locations for NLG,LA,LF storage
NEC	number of extra constants

A radiation conductor sets the N nonlinear and NLG sign minus. The nonlinear type is stored in NLG. When all conductors have been processed the actual conductor number (NGT long) can be written on the dictionary tape, the conductor values (NGT long) can be written out on the data tape. The M,N,NA,NB array (NGC long) can be output to an intermediate tape as can the NLG,LA,LF array and EC array. It is mandatory that multiple use conductors be constant. Duplicate conductor numbers are not allowed.

2.1.6 Constants Data

The same program constants and permanent storage for are identical to CINDA-3G; user constant numbers and values are stored as two separate arrays and the number of user constants (NUC) is calculated. The values are added to the data tape and the extended constants (NEC long) added on the end. Between the constant number and value a comma or equal sign is allowed. Data s orage is as follows:

NAF VF

The NAF array is then added to the dictionary tape.

2.1.7 Array Data

Array data is processed as in CINDA-3G but the 200 array limit should be removed. Array data is stored as follows:

NAA AV

and the constants NAE (number of array entries) and NAV (number of array values) are calculated. The dictionary and data tape are then added to.

2.1.8 Pseudo-Pseudo Compute Sequence

The CINDA-3G pseudo-compute sequence construction has been modified such that each core location contains two relative addresses (conductor and adjoining node locations), two nonlinear type indicators, and an impressed source indicator. The indicators are keyed through a simple counter to a second pseudo compute sequence which contains integer addresses of relative constant and array starting locations necessary for evaluation of temperature varying coefficients and time varying coefficients for sources. When the input data contains literal values in SIV type calls, the preprocessor stores the values as extended user constants and supplies the relative constant address to the second pseudo compute sequence.

Due to the above modifications, all temperature varying network element values have the form A = B*f(T). The coefficient and functional form can be determined via the pseudo compute sequence thereby permitting the parameter correction subroutines to evaluate the constant B term of the nonlinear coefficient. In addition, the core storage requirements for standard thermal analysis of problems containing numerous temperature varying elements are significantly reduced. An additional SIV type option allowing for polynomial evaluation has been generated.

Prior to the operation of forming the pseudo-pseudo compute sequence, the constants and array dictionaries are brought into core and the NLC,LA,LF and NLG,LA,LF arrays are processed in order to convert LA and LF arguments from actual to relative. Negative arguments indicate values in EC and the absolute argument plus NUC is used to replace the argument. When this is done the actual node number array, the M,N,NA,NB array and NLG,LA,LF array is also brought in. The actual node number if negative indicates a variable capacitance. Bits 1 and 2 of the actual node numbers are used as indicators for variable capacitance and impressed source, respectively. All indicator bits are set such that 0 means no and a 1 means yes. The information contained in the two pseudo compute sequences are indicated as follows:

PCS 1

Largest Integer	1	1	1	1	1	65535	1	16383
Bits	0	1	2	3	4	5-20	21	22-35

In PCS 1 the 0 bit (called the sign bit) if equal to 1 designates the last connection into a node, the 1 bit a nonlinear C, the 2 bit a nonlinear G, the 3 bit a radiation G, and the 4 bit an impressed source. Bits 5 through 20 contain the relative G number. Bit 21 designates a one-way conductor, and bits 22 through 35 contain the relative adjoining node number. Note that 65535 is the largest relative conductor number and 16383 is the largest relative node number that can be stored.

PCS 2

Largest Integer	63 ,	16383 ,	16383
Bits	0-5 ,	6-20 ,	21-35

In PCS 2 the 0 through 5 bits designate up to 63 types on nonlinearities and 6 through 20 bits designate the relative array or constant location. Bits 21 through 35 designate the relative constant location. PCS 2 is a combination of the NLC,LA,LF and NLG,LA,LF and impressed source arrays. Note 16383 is the largest stored integer based upon overall program constraints.

The NA-NB values are searched for a match, but each time N indicates a nonlinearity a pointer is advanced and NLG checked for double advance. PCS 1 and PCS 2 can be buffered out as they are being formed. Each time a match is found the adjoining node number must be checked to see if it is valid. When a nonlinear conductor is found and processed it is flagged so that it is not reprocessed. If the short PCS is being formed the adjoining node number in the M,N,NA,NB array is set negative (same as one way conductor) so that it is not recognized later.

2.1.9 Pack and Unpack Subroutines

The Fortran V FLD function was used to generate five pack and unpack subroutines. These routines were then used with a dummy pseudo-pseudo compute sequence and a modified CNFRDL execution subroutine to simulate internal handling of the SIV-DIV options. The assembly language routines that were used to perform the packing operations (PACK 43 and ORMIN) have been deleted.

2.2 Execution Subroutines (Modifications and Additions)

Execution subroutines in the Variables library have been modified to utilize the new pseudo-pseudo compute sequence and three additional execution subroutines CNVARB, CNDUFR, and CNQUIK have been generated.

2.2.1 Subroutine CNDUFR

This subroutine performs an unconditionally stable explicit finite differencing solution often called the Du Fort-Frankel method.[5] This is basically the forward differencing equation, but the present temperature of the node being operated on is replaced by a time weighted average of future and past temperatures. This substitution is performed on the space derivative temperatures only. The user may specify time steps larger than stability criteria, but within reason. Calling sequence is CNDUFR.

2.2.2 Subroutine CNVARB

This subroutine applies an implicit finite differencing solution to the diffusion equation. It internally calculates a variable beta, β, weighting factor as the ratio of the explicit stability criteria, CSGMIN, divided by the computational time step used, DTIMEU. A constraint that beta must be equal to or larger than one half is imposed. Hence, the method of solution lies somewhere between backward and forward-backward differencing.

The beta-weighting factor β mentioned above is identified in the following parabolic equation with the prime indicating implicit "backward" differencing and the unprimed indicating "forward" differencing.[6]

$$\frac{\partial T}{\partial t} = \beta(\alpha\nabla^2 T + S) + (1 - \beta)\ (\alpha'\nabla^2 T' + S') \qquad (2\text{-}1)$$

$$0 \le \beta \le 1$$

Any value of β less than one yields an implicit set of equations which must be solved in a simultaneous manner (more than one unknown exists in each equation). Any value of β equal to or less than one half yields an unconditionally stable set of equations, or in other words, any time step desired may be used. Values of β greater than one half invoke stability criteria or limitations on the magnitude of the time step. A value of β equal to one half yields an unconditionally stable implicit set of equations commonly known as "forward backward" differencing, or the Crank-Nicholson method.[7] Various transformations or first order integration applied to the parabolic equation generally yield an implicit set of equations similar to equation (2-1) with β equal to one half. Calling sequence is CNVARB.

2.2.3 Subroutine CNQUIK

This is an unconditionally stable explicit method of solution which allows SINDA users to employ computation intervals larger than CNFRWD. The method of solution is a 50-50 combination of exponential predictions (CNEXPN) and DuFort-Frankel (CNDUFR). For a temperature rising situation the CNEXPN routine tends to undershoot while CNDUFR tends to overshoot; however, CNQUIK falls between the two and generally yields better results than either CNEXPN or CNDUFR. Calling sequence is CNQUIK.

2.3 Thermal Network Correction Package

The thermal network correction package consists of a number of subroutines, many of which are internally programmed as part of a larger program subpackage such as STEP. These subpackage programs are not totally integrated and must be employed as indicated in Appendix A. Major subpackages are denoted here as Sensitivity Analysis, Data Comparison and Plotting, and Parameter Correction. Sensitivity analysis is discussed in Appendix C, whereas the latter two are detailed in Appendix B.

3. EVALUATION OF CORRECTION METHOD APPLIED TO THERMAL MODELS

The thermal network correction technique was applied to the three thermal models identified here as: (1) TRW Systems "50-node" model; (2) NASA/MSC "50-node" model; and (3) NASA/MSC "500-node" model. Specifics of these models are described in Appendix D. The TRW 50-node and the NASA/MSC 50-node model provided systems evaluation of the correction technique as well as accuracy evaluation. The large 500-node provided for the demonstration of network size on the correction method.

Evaluation of the network correction method was conducted with the use of computer-generated temperature values in order to provide accuracy information on the correction technique without the added problems that would be imposed by the use of inaccurate test data.

In the presentation to follow, emphasis was placed on complete temperature measurements because the parameter correction procedure as discussed in Appendix B allows the correction of completely measured subregions even though the remainder of the network may be uncorrectable. Subroutine KALØBS (TABLE B-1, Appendix B) corrects the soft parameters within a measured region or subregion which may be as small as a single measured node surrounded by measured nodes. The corrected soft parameters are then set hard and the remainder of the sparse thermal network is evaluated with subroutine KALFIL (TABLE B-3). This subroutine performs an initial pass in order to reduce (set hard) those network elements which are uncorrectable due to observability criteria and then makes a second pass in order to remove from the calculation procedure measured nodes which do not contribute to the solution. The basic limitation to the use of KALFIL is the core capacity since several square matrices of order N are formed; N is the number of remaining measured temperatures and soft parameters. For the UNIVAC-1108 65K core computer, this maximum allowable N is approximately ninety (90).

3.1 Correction of the TRW "50-node" Model

The TRW "50-node" model as described in Appendix D provided a rather wide selection of nodal and conductor characteristics with which to evaluate the Kalman filtering correction method. The number of nodes was of sufficient size to allow considerable flexibility in the choice of "soft" conductors and the distribution of the measured nodes. Selection of the soft conductors is in reality arbitrary but in order to provide some semblance of order, the selection was based upon the numbers consideration of approximately one per node, approximately two per node, and more than three per node. The correction of the model was further categorized as either complete temperature measurement or sparse temperature measurement. No attempt will be made here to include all of the cases studied but to present only those that were representative.

With the TRW 50-node model, the emphasis was on the correction of the conductors. The length of the transient was taken to be sufficiently long to allow a significant change in nodal temperatures.

3.1.1 Complete Temperature Measurements

When all of the nodal temperatures are measured, subroutine KALØBS is used as discussed previously. Tables 3-1, 3-3, and 3-5 show the correction of forty soft conductors when perturbed +10%, +50%, and +100%, respectively and Tables 3-2, 3-4, and 3-6 show the corresponding nodal temperatures using the corrected conductors in comparison with the nodal temperatures with the original conductor values; the temperatures are taken at the end of the transient (refer to Table 3-21 for the time period).

These results indicate that as the magnitude of the perturbation increases the accuracy of the correction decreases. In general the accuracy of correction did not decrease appreciably except for a single conductor, conductor 260, which became negative as shown in Tables 3-3 and 3-5 for 50% and 100% perturbations, respectively. It appears that the negative value is due to numerical round-off errors. Note that when the conductors were perturbed -50% conductor 260 did not become negative as shown in Table 3-7.

Except for the negative conductor which is physically unrealistic the corrections were rather accurate in most instances. There were a number of conductors, however, that appeared to be uncorrectable. For example conductor 11 could not be corrected even a small amount. A close examination showed that conductor 11 is a connection between nodes 97 and 98 which have identical temperatures throughout the transient; conductor 250 which is a connection between essentially identical nodal temperatures 96 and 97 was also uncorrectable.

Other non-accurately corrected conductors such as conductors 25 and 26 did not connect identical temperatures. In order to obtain a better insight towards the behavior of these conductors, a sensitivity analysis of the TRW 50-node network was conducted by using subroutine STEP (refer to Appendix C). Examination of the static sensitivity coefficients revealed that conductors 25 and 26 had very little effect on the node to which they were attached. An examination of conductor 260 which is a connection between nodes 53 and 50 revealed that these temperatures are very insensitive to conductor 260. On the other hand those conductors that were corrected accurately were found to have relatively high sensitivity coefficient values.

The temperatures listed in Tables 3-2, 3-4, and 3-6 are the values at the end of the transient period considered in the correction process. Since negative conductors can cause numerical integration instability, for the purpose of calculating temperatures, the negative conductor was arbitrarily set positive. Comparison of the temperatures shows that the temperatures calculated with the corrected conductors are in very good agreement with the computer-generated temperatures with the original conductor values.

The network correction method was studied further by setting 90 conductors as soft for perturbations of -10%, +50% and +100% and 115 conductors as soft for perturbations of +10%, +50% and +100%. Corrected conductors are listed in Tables 3-9, 3-11 and 3-13 for the 90 soft conductors and in Tables 3-15, 3-17 and 3-19 for the 115 soft conductors. Corresponding temperature comparisons for these identified cases are listed in Tables 3-10, 3-12, 3-14, 3-16, 3-18 and 3-20. Examination of these results reveal that the correction of the conductors in general were good except for those conductors which are either uncorrectable because of identical adjoining temperatures or because of apparent low sensitivity coefficient values.

The temperature comparison listed in the even numbered tables from 3-2 through 3-20 represents temperatures at the end of the transient period. Comparison of transient temperatures using the original conductor values, the perturbed conductor values, and corrected conductor values is indicated in Table 3-21 for two nodes, one typifying nodal temperatures that were relatively close for all three categories of conductor values and the other typifying nodal temperatures that were close for the correct and original conductor values but far apart from temperatures with the perturbed conductors.

3.1.2 Sparse Temperature Measurements

For sparse temperature measurements, the distribution of the measured temperatures within the network can be enormously large. However, in practice temperature measurements are normally concentrated in regions that represent critical components and/or structures; as a result the pattern of measured temperatures can in general be expected to be subregions of total measurements with the remainder of the network with very little temperature measurements. With this assumed distribution of temperature data, subroutine KALØBS would be used followed by subroutine KALFIL. Since the correction procedure for the measured subregions of a sparse network is subroutine KALØBS, the pattern of the results would be similar to the cases already studied. Of the cases examined it was difficult to satisfy the size limitations of measured temperatures and soft parameters. The results for the TRW 50-node model are not shown here but are shown for the NASA/MSC 50-node mass spectrometer model which is discussed below.

3.2 Correction of the NASA/MSC "50-Node" Model

The NASA/MSC 50-node model as described in Appendix D provided wide selection of nodal and conductor characteristics including arithmetic nodes. With this model, conductors, capacitances, and heat sources were corrected.

3.2.1 Complete Temperature Measurements

With complete temperature measurements, again subroutine KALØBS was employed. Tables 3-22, 3-24, and 3-26 show the correction of fifty soft conductors when perturbed +10%, +50% and +100%, respectively and Tables 3-23, 3-25 and 3-27 show the corresponding nodal temperatures using the corrected conductors in comparison with the nodal temperatures with the original conductor values at the end of the transient period (refer to Table 3-34 for the time period). In much the same manner as the correction of the TRW 50-node model, the results show that as the magnitude of the perturbation increases the accuracy of the correction decreases. Although many of the conductors were corrected quite accurately, a number of conductors were uncorrectable. An examination of these conductors showed that in general the lack of correction was due to approximately equal temperatures of adjoining nodes or to very low sensitivity coefficient values. With this set of examples none of the conductors associated with an arithmetic node was designated as soft. The percentage column associated with these tables represent the percentage difference between the corrected and original values; for the temperature comparison, percentage is calculated in terms of the absolute scale.

Tables 3-28, 3-30, and 3-32 show the correction of 100 soft conductors including a number associated with arithmetic nodes for the cases of +10%, +50% and +100% perturbation, respectively. In general the greater the perturbation, less accurate was the correction. The major consideration indicated by these results was the correction of conductors associated with arithmetic nodes; these conductors are identified as conductors 215 through 223 and 322 through 329. The correction of these conductors was rather poor; in fact, several of the conductors became negative. The inaccuracy of correction is not due to low sensitivity coefficients or adjoining temperatures that are equal, but it appears that the inaccuracies are due to inherent non-smoothness of numerically evaluated arithmetic nodes.

In order to supplement the temperature comparisons at the end of the transient period, comparison of transient temperatures using the original conductor values, the perturbed conductor values, and corrected conductor values is tabulated in Table 3-34 for node 61 which is a diffusion node (has a capacitance) and node 2 which is an arithmetic node (zero-capacity). The diffusion nodal temperatures were found to correlate rather well in general as typified by nodal temperature 21 in Table 3-34 whereas the arithmetic nodes correlated rather poorly as typified by nodal temperature 2.

Heretofore, evaluation of the thermal network correction program was confined to conductors, both conduction and radiation; correction of nodal capacity and heat source were examined by the use of the NASA/MSC 50-node model. One of the cases examined was the correction of all nodal heat capacities and four heat sources. Note that only four heat sources are present in the thermal model as described in Appendix D. Since three of the sources, Q_{45}, Q_{46}, and Q_{47} were zero for a long period of time it was necessary to adjust the time schedule of these three sources for this example. The results of the correction are shown in Table 3-35 and the corresponding temperature correlation is tabulated in Table 3-36. Most of the capacities corrected reasonably well, a few corrected exceptionally well, and the remainder corrected poorly. Note that capacitances 6 and 48 were corrected rather poorly, part of the problem stems from the presence of both a soft source and a soft capacity on these nodes. When a soft parameter is present on a node with a soft capacitance, difficulties were anticipated because of the need to correct for a ratio(s) and in turn separate out the soft parameters from the capacity. It is then not surprising that the heat sources did not correct accurately. Even though the capacities and sources were not corrected accurately the temperature correlation appears to be remarkably good for most of the nodes. Table 3-37 compares the transient temperatures of two nodes, 61 and 6. Source and capacity of node 61 were corrected accurately whereas the source and capacity of node 6 were corrected poorly.

A mixture of soft conductors, capacities and sources were examined to determine the thermal correction capabilities with soft parameters in all parameter categories. The results are listed in Tables 3-38 and 3-39 for the case of 42 soft conductors, 5 capacities, and 3 sources. The conductors were not corrected as accurately as anticipated but part of the difficulties was due to the large number of soft parameters associated with a given node. For example node 61 had 10 soft conductors, 5 through 14, and one soft source. Low sensitivity coefficient values also contributed to the inaccuracies of the correction. The capacity correction was relatively accurate but the source correction was not as good as anticipated, but the inaccuracies of source 61 is probably due to too many soft parameters on node 61 and the inaccuracy of source 6 may be due to the presence of a soft capacity. In general the temperature correlation was surprisingly good as indicated in Table 3-39. A transient comparison for two nodes, 61 and 48, are listed in Table 3-40.

3.2.2 Sparse Temperature Measurements

A number of sparse temperature measurement conditions that met the size limitations (number of soft parameters and measured temperatures) of subroutine KALFIL were generated. Since the number and variety of measured temperature patterns are considerable, it will suffice here to indicate the correction results for a "typical" temperature sparsity condition. A mixture of soft conductors, capacitors and sources were examined for the model consisting of 24 measured temperatures out of 54 total nodes including two boundary nodes. The original, perturbed and corrected soft parameters which consist of 2 soft capacitors, 2 soft heat sources and 19 soft conductors are listed in Table 3-41 and the comparison of the temperatures with the original perturbed and corrected parameter values is listed in Table 3-42. The correction of the soft heat sources was excellent but the correction one of the capacitors (node 61) was rather inaccurate. The reason for this is not apparent since node 61 is surrounded by measured nodes. Howver subroutine KALFIL unlike subroutine KALØBS solves the sparse network simultaneously; as a result the pattern and magnitude of sparsity can be expected to influence the correction accuracy. The correction of the conductors was not as accurate as desired with the inaccuracy apparently due to the small temperature difference between adjoining nodes. For example conductor 15 which connects nodes 63 and 91 was corrected to a negative value; this is apparently due to almost identical temperature values of nodes 63 and 91. Even though the parameters were not corrected accurately, the temperatures with the corrected parameters and the temperatures with the original parameter values correlated well as shown in Table 3-42.

A particular note of interest is that the soft capacitors and heat sources could have been corrected with the use of subroutine KALØBS since the capacitors and sources are associated with subregions with complete temperature measurements. Examination of Table 3-35 which lists the parameters corrected with subroutine KALØBS for the same thermal math-model used with subroutine KALFIL except for different heat sources reveals the correction of capacitor 61 to be accurate.

3.3 Correction of the NASA/MSC "500-Node" STB Model

A number of cases were evaluated using the NASA/MSC STB thermal model whose nodal characteristics are described in Appendix D. Correction of the conductors was remarkably good in many instances and in others the correction could not be achieved because of: (1) very little change in nodal temperatures during period of the time transient; (2) approximately equal adjoining nodal temperatures; and (3) low sensitivity coefficient values. An apparent fourth cause are arithmetic nodes. Correction of conductors associated with arithmetic nodes had a tendency to diverge. A typical case is given in Table 3-41 with 481 soft conductors and +100% perturbation. Note particularly the conductors associated with the arithmetic nodes (identified by a star). The temperature correlation was remarkably good except for arithmetic nodes (the temperature comparison is not shown).

3.4 Evaluation of Results

Evaluation of the thermal network correction program with the use of two 50-node models and one large 500-node model revealed rather encouraging results in many respects on the one hand but also indicated some limitations on the other. When complete temperature measurements are available in a region or a subregion (a smallest subregion consists of a measured node surrounded by measured nodes), the Kalman filtering method of processing the set of equations sequentially and each equation timewise in a sequential sense yielded rather accurate correction of those parameters that were both observable and subject to significantly changing nodal temperatures. Parameters that were not observable and/or insensitive to nodal temperatures were not corrected; parameters that were subject to temperatures that did not change significantly were corrected very little.

Limitations in the present thermal network correction program included the lack of adequately correcting for the parameters associated with arithmetic nodes and the lack of bounding soft parameters. Difficulties experienced with arithmetic (zero-capacity) nodes in part stem from the non-uniform temperature change of arithmetic nodes from one time slice to another. Since difficulties are generally encountered even when numerically solving for just the nodal temperatures of zero-capacity nodes, parameter estimation for these nodes can be expected to be rather erratic. Mixing of soft sources and conductors with a soft capacitance presented correction difficulties because of the need to treat the soft parameters as soft ratios.

Many of the correction difficulties have been associated with the sparsity of temperature measurements. As a result, a relatively large effort has been expended to develop a technique, code the method and demonstrate the method on large mathematical models. Although considerable progress has been made in the correction of parameters of networks with sparse temperature measurements, the results show that the thermal network correction program is far from optimum. A particular difficulty is the large core requirements when temperature sparsity exists.

In spite of the limitations and correction difficulties that have been experienced, the results in a general sense were rather encouraging.

TABLE 3-1 - COMPARISON OF CONDUCTOR VALUES
+10% PERTURBATION, 40 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1%, KALØBS

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
11	7.50623-01	8.25685-01	8.25685-01
14	1.39718-01	1.53690-01	1.39956-01
17	1.39718-01	1.53690-01	1.39954-01
18	1.78571-02	1.96428-02	1.84852-02
20	8.00000-01	8.80000-01	8.05790-01
22	8.00000-01	8.80000-01	8.18524-01
23	4.00000-01	4.40000-01	4.06951-01
24	4.00000-01	4.40000-01	4.44571-01
25	4.76190-02	5.23809-02	5.18535-02
30	9.86857-01	1.08554+00	1.00273+00
31	9.86857-01	1.08554+00	1.02475+00
33	6.01833-01	6.62016-01	6.50372-01
42	2.43309-01	2.67640-01	2.51549-01
50	3.17460-02	3.49206-02	3.51516-02
54	2.54453-02	2.79898-02	2.79898-02
60	2.43902+00	2.68292+00	2.43429+00
73	1.04167-01	1.14584-01	1.06707-01
74	4.00000+00	4.40000+00	4.04556+00
79	1.19048+01	1.30953+01	1.09126+01
81	7.46269-03	8.20896-03	7.63414-03
103	1.25000-02	1.37500-02	1.36921-02
107	2.50000-02	2.75000-02	2.51769-02
108	2.50000-02	2.75000-02	2.52023-02
220	2.55083-08	2.80591-08	2.55091-08
231	1.78893-10	1.96782-10	1.79801-10
235	2.14672-10	2.36139-10	2.15331-10
250	5.29174-11	5.82091-11	5.81912-11
251	6.84986-11	7.53485-11	7.53185-11
260	1.45330-11	1.59863-11	3.39588-12
282	1.24748-09	1.37223-09	1.27556-09
308	7.04977-12	7.75475-12	7.62223-12
319	9.63684-12	1.06005-11	1.03443-11
324	3.06127-11	3.36740-11	3.25476-11
351	1.42948-11	1.57243-11	1.57470-11
244	6.71060-11	7.38166-11	7.49070-11
219	2.05200-08	2.25720-08	2.05055-08
212	2.83000-10	3.11300-10	2.83313-10
213	2.83000-10	3.11300-10	2.83461-10
214	2.83000-10	3.11300-10	2.83233-10
215	2.83000-10	3.11300-10	2.83313-10

TABLE 3-2 - COMPARISON OF TEMPERATURES AT END OF TRANSIENT
+10% PERTURBATION, 40 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	CORRECTED TEMPERATURE
49	7.74405+01	7.78155+01	7.74449+01
110	9.93312+01	9.88296+01	9.94361+01
53	1.00933+02	9.89655+01	1.00946+02
103	1.01741+02	9.98930+01	1.01756+02
71	1.01289+02	9.94014+01	1.01303+02
72	3.92558+01	3.94057+01	3.92655+01
85	3.82171+01	3.81504+01	3.82239+01
86	3.82171+01	3.84490+01	3.82288+01
87	3.82812+01	3.82112+01	3.82887+01
88	3.82812+01	3.82059+01	3.82899+01
89	5.36418+01	5.31100+01	5.36470+01
90	5.36418+01	5.29825+01	5.36426+01
91	5.58945+01	5.62218+01	5.59043+01
96	5.61584+01	5.62448+01	5.61627+01
97	5.61584+01	5.62462+01	5.61634+01
98	5.58945+01	5.62200+01	5.59022+01
99	1.11478+02	1.11280+02	1.11483+02
101	1.02041+02	1.01686+02	1.01991+02
102	1.75006+02	1.74627+02	1.74936+02
104	1.17466+02	1.17347+02	1.17437+02
105	7.41745+01	7.38813+01	7.41733+01
106	1.00358+02	9.99927+01	1.00442+02
108	8.87776+01	8.86736+01	8.87447+01
111	8.89981+01	8.89196+01	8.90048+01
112	7.20880+01	7.23157+01	7.21055+01
114	7.30700+01	7.33294+01	7.30823+01
115	7.50606+01	7.50472+01	7.50507+01
116	5.50989+01	5.17098+01	5.50943+01
134	4.92689+01	4.45096+01	4.92659+01
135	1.03509+02	1.03210+02	1.03580+02
50	1.00037+02	9.98217+01	9.99871+01
51	1.26638+02	1.26538+02	1.26640+02
52	3.24561+01	3.25487+01	3.24912+01
100	9.75068+01	9.70433+01	9.74688+01
107	9.84798+01	9.80447+01	9.85082+01
109	8.03788+01	8.05240+01	8.01654+01
113	7.37442+01	7.38088+01	7.37390+01
117	4.53193+01	3.58611+01	4.54014+01
120	6.89250+01	6.73479+01	6.89371+01
180	6.95429+01	6.88364+01	6.95951+01
189	1.99405+01	1.87713+01	1.99304+01
196	4.39288+01	4.25991+01	4.39056+01
197	4.39288+01	4.25827+01	4.39209+01
198	1.99405+01	1.87712+01	1.99304+01
199	6.05670+01	6.05561+01	6.05670+01
280	6.15069+01	6.14915+01	6.15067+01
282	-4.60000+02	-4.60000+02	-4.60000+02
1	8.50000+01	8.50000+01	8.50000+01
10	9.30000+01	9.30000+01	9.30000+01

TABLE 3-3 - COMPARISON OF CONDUCTOR VALUES
+50% PERTURBATION, 40 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1/2%, KALØBS

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
11	7.50623-01	1.12593+00	1.12593+00
14	1.39718-01	2.09577-01	1.41972-01
17	1.39718-01	2.09577-01	1.41965-01
18	1.78571-02	2.67856-02	2.19030-02
20	8.00000-01	1.20000+00	8.51769-01
22	8.00000-01	1.20000+00	9.29096-01
23	4.00000-01	6.00000-01	4.50906-01
24	4.00000-01	6.00000-01	6.09687-01
25	4.76190-02	7.14285-02	6.99587-02
30	9.86857-01	1.48029+00	1.07739+00
31	9.86857-01	1.48029+00	1.23277+00
33	6.01833-01	9.02750-01	8.67278-01
42	2.43309-01	3.64963-01	2.96701-01
50	3.17460-02	4.76190-02	4.86650-02
54	2.54453-02	3.81679-02	3.81679-02
60	2.43902+00	3.65853+00	2.42615+00
73	1.04167-01	1.56250-01	1.20648-01
74	4.00000+00	6.00000+00	4.29201+00
79	1.19048+01	1.78572+01	7.38007+00
81	7.46269-03	1.11940-02	1.00120-02
103	1.25000-02	1.87500-02	1.86034-02
107	2.50000-02	3.75000-02	2.62926-02
108	2.50000-02	3.75000-02	2.65611-02
220	2.55083-08	3.82624-08	2.55150-08
231	1.78893-10	2.68339-10	1.85889-10
235	2.14672-10	3.22008-10	2.20182-10
250	5.29174-11	7.93761-11	7.93016-11
251	6.84966-11	1.02748-10	1.02623-10
260	1.45330-11	2.17995-11	-5.54876-12
282	1.24748-09	1.87122-09	1.43692-09
308	7.04977-12	1.05747-11	1.01757-11
319	9.63684-12	1.44553-11	1.36071-11
324	3.06127-11	4.59190-11	4.20549-11
351	1.42948-11	2.14422-11	2.20199-11
244	6.71060-11	1.00659-10	1.04918-10
219	2.05200-08	3.07800-08	2.04533-08
212	2.83000-10	4.24500-10	2.86090-10
213	2.83000-10	4.24500-10	2.86630-10
214	2.83000-10	4.24500-10	2.85558-10
215	2.83000-10	4.24500-10	2.86090-10

TABLE 3-4 - COMPARISON OF TEMPERATURES AT END OF TRANSIENT
+50% PERTURBATION, 40 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1/2%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	CORRECTED TEMPERATURE
110	7.74405+01	7.95101+01	7.74538+01
53	9.93312+01	9.68938+01	9.99448+01
103	1.00933+02	9.94701+01	1.00992+02
71	1.01741+02	9.58633+01	1.01820+02
72	1.01289+02	9.52090+01	1.01356+02
85	3.92548+01	3.94906+01	3.93365+01
86	3.82171+01	3.75924+01	3.82541+01
87	3.82171+01	3.87753+01	3.83086+01
88	3.82812+01	3.76094+01	3.83216+01
89	3.82812+01	3.75683+01	3.83290+01
90	5.36418+01	5.13530+01	5.36684+01
91	5.36418+01	5.08128+01	5.36314+01
96	5.58945+01	5.76036+01	5.59779+01
97	5.61584+01	5.67175+01	5.61959+01
98	5.61584+01	5.67338+01	5.62011+01
99	5.58945+01	5.76060+01	5.59676+01
101	1.11478+02	1.10508+02	1.11481+02
102	1.02041+02	1.00199+02	1.01680+02
104	1.75006+02	1.73315+02	1.74632+02
105	1.17466+02	1.16892+02	1.17280+02
106	7.41745+01	7.27391+01	7.41699+01
108	1.00358+02	9.84326+01	1.00832+02
111	8.87776+01	8.82648+01	8.85972+01
112	8.89961+01	8.85609+01	8.90626+01
114	7.20680+01	7.29928+01	7.21858+01
115	7.30700+01	7.40793+01	7.31362+01
116	7.50606+01	7.49989+01	7.50022+01
134	5.50989+01	3.92113+01	5.50624+01
135	4.92669+01	2.71988+01	4.92454+01
50	1.03509+02	1.01865+02	1.03889+02
51	1.00037+02	9.66786+01	9.96926+01
52	1.26638+02	1.26121+02	1.26616+02
100	3.24561+01	3.26493+01	3.26652+01
107	9.75068+01	9.53707+01	9.72042+01
109	9.84798+01	9.63934+01	9.85951+01
113	8.03768+01	8.11049+01	7.95954+01
117	7.37442+01	7.39717+01	7.37040+01
120	4.53193+01	5.85048+00	4.57224+01
180	6.89250+01	6.20866+01	6.89962+01
189	6.95429+01	6.71150+01	6.98725+01
196	1.99405+01	1.42615+01	1.98338+01
197	4.39268+01	3.76255+01	4.37614+01
198	4.39268+01	3.76054+01	4.38322+01
199	1.99405+01	1.42616+01	1.98336+01
280	6.05670+01	6.05152+01	6.05672+01
282	6.15069+01	6.14536+01	6.15060+01
1	-4.60000+02	-4.60000+02	-4.60000+02
10	8.50000+01	8.50000+01	8.50000+01
20	9.30000+01	9.30000+01	9.30000+01

TABLE 3-5 - COMPARISON OF CONDUCTOR VALUES
+100% PERTURBATION, 40 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1/2%, KALØBS

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
11	7.50623-01	1.50125+00	1.50125+00
14	1.39718-01	2.79436-01	1.42507-01
17	1.39718-01	2.79436-01	1.42490-01
18	1.78571-02	3.57142-02	2.45793-02
20	8.00000-01	1.60000+00	8.67340-01
22	8.00000-01	1.60000+00	1.00168+00
23	4.00000-01	8.00000-01	4.76970-01
24	4.00000-01	8.00000-01	6.37747-01
25	4.76190-02	9.52380-02	9.06385-02
30	9.86857-01	1.97371+00	1.14982+00
31	9.86857-01	1.97371+00	1.39297+00
33	6.01833-01	1.20367+00	1.09973+00
42	2.43309-01	4.86618-01	3.31589-01
50	3.17460-02	6.34920-02	6.57641-02
54	2.54453-02	5.08906-02	5.08906-02
60	2.43902+00	4.87804+00	2.39675+00
73	1.04167-01	2.08334-01	1.31196-01
74	4.00000+00	8.00000+00	4.48326+00
79	1.19048+01	2.38096+01	2.15389+00
81	7.46269-03	1.49254-02	1.03122-02
103	1.25000-02	2.50000-02	2.45078-02
107	2.50000-02	5.00000-02	2.69301-02
108	2.50000-02	5.00000-02	2.72438-02
220	2.55083-08	5.10166-08	2.55175-08
231	1.78893-10	3.57786-10	1.88964-10
235	2.14672-10	4.29344-10	2.22134-10
250	5.29174-11	1.05835-10	1.05664-10
251	6.84986-11	1.36997-10	1.36712-10
260	1.45330-11	2.90660-11	-7.38668-11
282	1.24748-09	2.49496-09	1.55048-09
308	7.04977-12	1.40995-11	1.29191-11
319	9.63684-12	1.92737-11	1.69370-11
324	3.06127-11	6.12254-11	5.08835-11
351	1.42948-11	2.85896-11	2.91060-11
244	6.71060-11	1.34212-10	1.44690-10
219	2.05200-08	4.10400-08	2.03775-08
212	2.83000-10	5.66000-10	2.86711-10
213	2.83000-10	5.66000-10	2.88110-10
214	2.83000-10	5.66000-10	2.85858-10
215	2.83000-10	5.66000-10	2.86711-10

TABLE 3-6 - COMPARISON OF TEMPERATURES AT END OF TRANSIENT
+100% PERTURBATION, 40 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1/2%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	CORRECTED TEMPERATURE
49	7.74405+01	8.11515+01	7.71817+01
110	9.93312+01	9.51248+01	1.02063+02
53	1.00933+02	9.10543+01	1.01025+02
103	1.01741+02	9.30014+01	1.01857+02
71	1.01289+02	9.21514+01	1.01367+02
72	3.92558+01	3.96590+01	3.93620+01
85	3.82171+01	3.72878+01	3.82905+01
86	3.82171+01	3.91454+01	3.83446+01
87	3.82812+01	3.72142+01	3.83574+01
88	3.82812+01	3.71994+01	3.83709+01
89	5.36418+01	5.01117+01	5.36940+01
90	5.36418+01	4.91899+01	5.36442+01
91	5.58945+01	5.91935+01	5.60058+01
96	5.61584+01	5.72995+01	5.62086+01
97	5.61584+01	5.73430+01	5.62191+01
98	5.58945+01	5.92219+01	5.59875+01
99	1.11478+02	1.09661+02	1.11736+02
101	[illegible].02041+02	9.87351+01	1.00389+02
102	1.75006+02	1.72162+02	1.74275+02
104	1.17466+02	1.16324+02	1.17034+02
105	7.41745+01	7.16074+01	7.41561+01
106	1.00358+02	9.69070+01	1.02434+02
108	8.87776+01	8.78058+01	8.84473+01
111	8.89981+01	8.80833+01	8.91209+01
112	7.20880+01	7.37482+01	7.22152+01
114	7.30700+01	7.48151+01	7.30963+01
115	7.50606+01	7.4954[illegible]+01	7.49535+01
116	5.50989+01	2.54430+01	5.50520+01
134	4.92689+01	8.71154+00	4.92369+01
135	1.03509+02	1.00505+02	1.05176+02
50	1.00037+02	9.74168+01	9.85752+01
51	1.26638+02	1.25723+02	1.26693+02
52	3.24561+01	3.27344+01	3.28205+01
100	9.75068+01	9.39055+01	9.54714+01
107	9.84798+01	9.47349+01	9.92101+01
109	8.03788+01	8.18820+01	7.87437+01
113	7.37442+01	7.42757+01	7.36968+01
117	4.53193+01	-2.09451+01	4.61280+01
120	6.89250+01	5.68030+01	6.90429+01
180	6.95429+01	6.55447+01	7.00442+01
189	1.99405+01	9.02617+00	1.98186+01
196	4.39288+01	3.19625+01	4.36831+01
197	4.39288+01	3.18386+01	4.38284+01
198	1.99405+01	9.02674+00	1.98184+01
199	6.05670+01	6.04744+01	6.05673+01
280	6.15069+01	6.14157+01	6.15049+01
282	-4.60000+02	-4.60000+02	-4.60000+02
1	8.50000+01	8.50000+01	8.50000+01
10	9.30000+01	9.30000+01	9.30000+01

TABLE 3-7 - COMPARISON OF CONDUCTOR VALUES
-50% PERTURBATION, 40 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1%, KALØBS

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
11	7.50623-01	3.75312-01	3.75312-01
14	1.39718-01	6.98590-02	1.35397-01
1	1.39718-01	6.98590-02	1.35397-01
13	1.78571-02	8.92855-03	1.28304-02
20	8.00000-01	4.00000-01	7.12279-01
22	8.00000-01	4.00000-01	6.24533-01
23	4.00000-01	2.00000-01	3.28899-01
24	4.00000-01	2.00000-01	1.97820-01
25	4.76190-02	2.38095-02	2.45412-02
30	9.86857-01	4.93428-01	8.73608-01
31	9.86857-01	4.93428-01	6.79305-01
33	6.01833-01	3.00917-01	3.19840-01
42	2.43309-01	1.21655-01	1.76364-01
50	3.17460-02	1.58730-02	1.50215-02
54	2.54453-02	1.27226-02	1.27226-02
60	2.43902+00	1.21951+00	2.43531+00
73	1.04167-01	5.20835-02	8.19033-02
74	4.00000+00	2.00000+00	3.60628+00
79	1.19048+01	5.95240+00	1.56301+01
81	7.46269-03	3.73135-03	4.20354-03
103	1.25000-02	6.25000-03	6.31816-03
107	2.50000-02	1.25000-02	2.29801-02
108	2.50000-02	1.25000-02	2.25117-02
220	2.55083-08	1.27541-08	2.54958-08
231	1.78893-10	8.94465-11	1.67760-10
235	2.14672-10	1.07336-10	2.05180-10
250	5.29174-11	2.64587-11	2.65202-11
251	6.84986-11	3.42493-11	3.43523-11
260	1.45330-11	7.26650-12	1.75757-11
282	1.24748-09	6.23740-10	9.95816-10
308	7.04977-12	3.52489-12	3.73416-12
319	9.63684-12	4.81842-12	5.30403-12
324	3.06127-11	1.53063-11	1.76537-11
351	1.42948-11	7.14740-12	6.38557-12
244	6.71060-11	3.35530-11	3.08116-11
219	2.05200-08	1.02600-08	2.05794-08
212	2.83000-10	1.41500-10	2.76815-10
213	2.83000-10	1.41500-10	2.76636-10
214	2.83000-10	1.41500-10	2.77602-10
215	2.83000-10	1.41500-10	2.76815-10

TABLE 3-8 - COMPARISON OF TEMPERATURES AT END OF TRANSIENT
-50% PERTURBATION, 40 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	CORRECTED TEMPERATURE
49	7.74405+01	7.44197+01	7.72019+01
110	9.93312+01	1.02913+02	9.91208+01
53	1.00933+02	1.15276+02	1.00469+02
103	1.01741+02	1.15509+02	1.01236+02
71	1.01289+02	1.15288+02	1.00800+02
72	3.92558+01	3.96322+01	3.92565+01
85	3.82171+01	4.04636+01	3.83380+01
86	3.82171+01	3.60024+01	3.82086+01
87	3.82812+01	4.04665+01	3.83892+01
88	3.82812+01	4.05110+01	3.83819+01
89	5.36418+01	5.98585+01	5.37175+01
90	5.36418+01	6.08095+01	5.37819+01
91	5.58945+01	5.40517+01	5.57134+01
96	5.61584+01	5.55981+01	5.60589+01
97	5.61584+01	5.56303+01	5.60617+01
98	5.58945+01	5.40848+01	5.57284+01
99	1.11478+02	1.12707+02	1.11584+02
101	1.02041+02	1.05011+02	1.02333+02
102	1.75006+02	1.78594+02	1.75435+02
104	1.17466+02	1.18065+02	1.17658+02
105	7.41745+01	7.03808+01	7.42152+01
106	1.00358+02	1.03012+02	1.00243+02
108	8.87776+01	8.93384+01	8.89758+01
111	8.89981+01	8.93496+01	8.89106+01
112	7.20880+01	7.11766+01	7.19858+01
114	7.30700+01	7.17335+01	7.29908+01
115	7.50606+01	7.51278+01	7.51188+01
116	5.50989+01	7.37816+01	5.61423+01
134	4.92689+01	7.64082+01	4.93083+01
135	1.03509+02	1.05713+02	1.03445+02
50	1.00037+02	1.01261+02	1.00325+02
51	1.26638+02	1.27566+02	1.26720+02
52	3.24561+01	3.22812+01	3.22698+01
100	9.75068+01	1.01147+02	9.76496+01
107	9.84798+01	1.01181+02	9.86425+01
109	8.03788+01	7.99663+01	8.12638+01
113	7.37442+01	7.39425+01	7.39306+01
117	4.53193+01	1.15946+02	4.48870+01
120	6.89250+01	7.87426+01	6.87786+01
180	6.95429+01	7.33143+01	6.89066+01
189	1.99405+01	2.66340+01	2.01838+01
196	4.39288+01	5.13862+01	4.41867+01
197	4.39288+01	5.13047+01	4.41124+01
198	1.99405+01	2.66345+01	2.01841+01
199	6.05670+01	6.06437+01	6.05676+01
280	6.15069+01	6.15761+01	6.15032+01
282	-4.60000+02	-4.60000+02	-4.60000+02
1	8.50000+01	8.50000+01	8.50000+01
10	9.30000+01	9.30000+01	9.30000+01

TABLE 3-9 - COMPARISON OF CONDUCTOR VALUES
-10% PERTURBATION, 90 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1/2%, KALØBS

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
11	7.50623-01	6.75561-01	6.75561-01
14	1.39718-01	1.25746-01	1.36264-01
17	1.39718-01	1.25746-01	1.36318-01
18	1.78571-02	1.60714-02	1.67953-02
21	1.89708+00	1.70737+00	1.69990+00
20	8.00000-01	7.20000-01	7.53772-01
22	8.00000-01	7.20000-01	7.56059-01
23	4.00000-01	3.60000-01	3.77537-01
24	4.00000-01	3.60000-01	3.59813-01
25	4.76190-02	4.28571-02	4.30242-02
26	1.66667-02	1.50000-02	1.50357-02
30	9.86857-01	8.88171-01	9.72103-01
31	9.86857-01	8.88171-01	9.27734-01
33	6.01833-01	5.41650-01	5.44818-01
42	2.43309-01	2.18978-01	2.29213-01
50	3.17460-02	2.85714-02	2.84850-02
54	2.54453-02	2.29008-02	2.29008-02
55	2.54453-02	2.29008-02	2.29043-02
56	2.54453-02	2.29008-02	2.29008-02
60	2.43902+00	2.19512+00	2.43707+00
61	3.93701+00	3.54331+00	3.86285+00
70	1.56250+00	1.40625+00	1.54840+00
73	1.04167-01	9.37503-02	1.05877-01
74	4.00000+00	3.60000+00	4.12554+00
79	1.19048+01	1.07143+01	1.27005+01
80	7.46269-03	6.71642-03	5.75934-03
81	7.46269-03	6.71642-03	6.73676-03
90	1.68390+01	1.51551+01	1.64413+01
103	1.25000-02	1.12500-02	1.12727-02
107	2.50000-02	2.25000-02	2.35425-02
108	2.50000-02	2.25000-02	2.35404-02
115	3.70370-02	3.33333-02	3.30246-02
116	3.70370-02	3.33333-02	3.46488-02
117	3.70370-02	3.33333-02	3.50485-02
118	3.70370-02	3.33333-02	3.30964-02
130	2.08333-02	1.67500-02	1.84339-02
131	1.63132-02	1.46819-02	1.48007-02
200	1.02446-10	9.22014-11	1.01455-10
201	1.02446-10	9.22014-11	1.01563-10
202	1.02446-10	9.22014-11	1.01529-10
203	1.02446-10	9.22014-11	1.01695-10
204	1.02446-10	9.22014-11	1.01728-10
210	1.37158-09	1.23442-09	1.37297-09
211	1.37158-09	1.23442-09	1.37358-09
220	2.55083-08	2.29575-08	2.54833-08
231	1.78893-10	1.61004-10	1.66796-10
232	2.14672-10	1.93205-10	2.04363-10
235	2.14672-10	1.93205-10	2.03805-10
236	1.61004-10	1.44904-10	1.52215-10
239	1.61004-10	1.44904-10	1.52583-10
250	5.29174-11	4.76257-11	4.76234-11

TABLE 3-9 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
251	6.84986-11	6.16487-11	6.16449-11
253	5.29174-11	4.76257-11	4.76257-11
254	6.84986-11	6.16487-11	6.16712-11
255	5.29174-11	4.76257-11	4.76359-11
256	4.64580-12	4.18122-12	4.18104-12
257	2.54923-11	2.29431-11	2.27873-11
258	4.64580-12	4.18122-12	4.20937-12
260	1.45330-11	1.30797-11	1.44763-11
261	6.43264-11	5.78938-11	8.29685-11
262	5.84894-11	5.26405-11	5.15285-11
266	8.49347-11	7.64412-11	7.80406-11
270	4.52299-11	4.07069-11	4.11528-11
271	2.41700-11	2.17530-11	2.16234-11
272	1.80364-10	1.62328-10	1.68949-10
273	2.92157-10	2.62941-10	2.67917-10
274	2.12853-09	1.91568-09	2.13392-09
279	4.23467-09	3.81120-09	4.10964-09
280	1.36602-09	1.22942-09	1.35854-09
281	7.19710-10	6.47739-10	4.42768-10
282	1.24748-09	1.12273-09	1.13019-09
291	1.82854-11	1.64569-11	1.64380-11
308	7.04977-12	6.34479-12	6.41882-12
319	9.63684-12	8.67316-12	8.81889-12
324	3.06127-11	2.75514-11	2.69473-11
351	1.42948-11	1.28653-11	1.27211-11
356	9.14865-12	8.23378-12	8.11918-12
357	1.80114-11	1.62103-11	1.71833-11
358	1.35536-10	1.21982-10	1.38008-10
205	4.99446-10	4.49501-10	4.99708-10
333	4.99446-10	4.49501-10	4.98912-10
335	4.99446-10	4.49501-10	4.99058-10
206	2.86759-10	2.58083-10	2.87270-10
360	6.68757-12	6.01881-12	5.99537-12
244	6.71060-11	6.03954-11	5.99109-11
219	2.05200-08	1.84680-08	2.03746-08
212	2.83000-10	2.54700-10	2.79254-10
213	2.83000-10	2.54700-10	2.80618-10
214	2.83000-10	2.54700-10	2.80956-10
215	2.83000-10	2.54700-10	2.79295-10

TABLE 3-10 - COMPARISON OF TEMPERATURES AT END OF TRANSIENT
-10% PERTURBATION, 90 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1/2%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	CORRECTED TEMPERATURE
49	7.74405+01	7.6876[illegible]+01	7.72950+01
110	9.93312+01	9.98320+01	9.93461+01
53	1.00933+02	1.09941+02	1.00493+02
103	1.01741+02	1.10491+02	1.01365+02
71	1.01289+02	1.10109+02	1.00913+02
72	3.92558+01	4.41687+01	3.93859+01
85	3.82171+01	4.31611+01	3.83448+01
86	3.82171+01	4.31691+01	3.83465+01
87	3.82812+01	4.33223+01	3.84122+01
88	3.82812+01	4.33159+01	3.84103+01
89	5.36418+01	6.21059+01	5.37695+01
90	5.36418+01	6.21815+01	5.37874+01
91	5.58945+01	5.59461+01	5.58677+01
96	5.61584+01	5.64101+01	5.61483+01
97	5.61584+01	5.64151+01	5.61460+01
98	5.58945+01	5.59490+01	5.58693+01
99	1.11478+02	1.12254+02	1.11567+02
101	1.02041+02	1.03108+02	1.02143+02
102	1.75006+02	1.79217+02	1.75067+02
104	1.17466+02	1.17693+02	1.17504+02
105	7.41745+01	7.48283+01	7.42631+01
106	1.00358+02	1.00698+02	1.00403+02
108	8.87776+01	8.88781+01	8.88207+01
111	8.89981+01	8.91285+01	8.90100+01
112	7.20880+01	7.19335+01	7.20910+01
114	7.30700+01	7.28228+01	7.30815+01
115	7.50606+01	7.50743+01	7.50726+01
116	5.50989+01	5.84121+01	5.51006+01
134	4.92689+01	5.40197+01	4.92615+01
135	1.03509+02	1.03748+02	1.03570+02
50	1.00037+02	1.01163+02	1.00132+02
51	1.26638+02	1.27328+02	1.26515+02
52	3.24561+01	3.24239+01	3.24680+01
100	9.75068+01	9.80024+01	9.75682+01
107	9.84798+01	9.89437+01	9.86892+01
109	8.03788+01	8.02530+01	8.04859+01
113	7.37442+01	7.37396+01	7.38053+01
117	4.53193+01	5.62622+01	4.53060+01
120	6.89250+01	7.01757+01	6.88859+01
180	6.95429+01	6.98257+01	6.94170+01
189	1.99405+01	2.10832+01	1.99979+01
196	4.39288+01	4.52453+01	4.39678+01
197	4.39288+01	4.52384+01	4.39534+01
198	1.99405+01	2.10833+01	1.99983+01
199	6.05670+01	6.05175+01	6.05147+01
280	6.15069+01	6.14033+01	6.14197+01
282	-4.60000+02	-4.60000+02	-4.60000+02
1	8.50000+01	8.50000+01	8.50000+01
10	9.30000+01	9.30000+01	9.30000+01

TABLE 3-11 - COMPARISON OF CONDUCTOR VALUES
+50% PERTURBATION, 90 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1/2%, KALØBS

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
11	7.50623-01	1.12593+00	1.12593+00
14	1.39718-01	2.09577-01	1.52287-01
17	1.39718-01	2.09577-01	1.51789-01
18	1.78571-02	2.67856-02	2.07724-02
21	1.89708+00	2.84562+00	2.80473+00
20	8.00000-01	1.20000+00	9.83952-01
22	8.00000-01	1.20000+00	9.67140-01
23	4.00000-01	6.00000-01	4.91240-01
24	4.00000-01	6.00000-01	6.09687-01
25	4.76190-02	7.14285-02	7.00826-02
26	1.66667-02	2.50000-02	2.47937-02
30	9.86857-01	1.48029+00	1.02694+00
31	9.86857-01	1.48029+00	1.19367+00
33	6.01833-01	9.02750-01	8.67278-01
42	2.43309-01	3.64963-01	2.96701-01
50	3.17460-02	4.76190-02	4.82367-02
54	2.54453-02	3.81679-02	3.81679-02
55	2.54453-02	3.81679-02	3.81421-02
56	2.54453-02	3.81679-02	3.81679-02
60	2.43902+00	3.65853+00	2.42615+00
61	3.93701+00	5.90551+00	4.47252+00
70	1.56250+00	2.34375+00	1.67407+00
73	1.04167-01	1.56250-01	4.11687-02
74	4.00000+00	6.00000+00	2.76496+00
79	1.19048+01	1.78572+01	5.47545+00
80	7.46269-03	1.11940-02	5.88887-02
81	7.46269-03	1.11940-02	1.07434-02
90	1.68390+01	2.52585+01	1.84995+01
103	1.25000-02	1.87500-02	1.84235-02
107	2.50000-02	3.75000-02	3.20493-02
108	2.50000-02	3.75000-02	3.20518-02
115	3.70370-02	5.55555-02	5.37169-02
116	3.70370-02	5.55555-02	4.76498-02
117	3.70370-02	5.55555-02	4.42505-02
118	3.70370-02	5.55555-02	5.30396-02
130	2.08333-02	3.12499-02	3.84117-02
131	1.63132-02	2.44698-02	2.35883-02
200	1.02446-10	1.53669-10	1.05861-10
201	1.02446-10	1.53669-10	1.05051-10
202	1.02446-10	1.53669-10	1.05281-10
203	1.02446-10	1.53669-10	1.04558-10
204	1.02446-10	1.53669-10	1.04358-10
210	1.37158-09	2.05737-09	1.36740-09
211	1.37158-09	2.05737-09	1.36577-09
220	2.55083-08	3.82624-08	2.56070-08
231	1.78893-10	2.68339-10	2.21684-10
232	2.14672-10	3.22008-10	2.45404-10
235	2.14672-10	3.22008-10	2.48983-10
236	1.61004-10	2.41506-10	1.86495-10
239	1.61004-10	2.41506-10	1.84235-10
250	5.29174-11	7.93761-11	7.94372-11

TABLE 3-11 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
251	6,84986-11	1.02748-10	1.02850-10
253	5,29174-11	7.93761-11	7.93761-11
254	6,84986-11	1.02748-10	1.02480-10
255	5,29174-11	7.93761-11	7.92750-11
256	4,64580-12	6.96870-12	6.97058-12
257	2,54923-11	3.82384-11	3.92746-11
258	4,64580-12	6.96870-12	6.54351-12
260	1,45330-11	2.17995-11	7.07239-13
261	6,43264-11	9.64896-11	-2.61791-10
262	5,84894-11	8.77341-11	9.67370-11
266	8,49347-11	1.27402-10	1.13150-10
270	4,52299-11	6.78449-11	6.42263-11
271	2,41700-11	3.62550-11	3.76569-11
272	1,80364-10	2.7[illegible]46-10	2.17138-10
273	2,92157-10	4.38235-10	3.80837-10
27[illegible]	2,12853-09	3.19279-09	2.10143-09
279	4,23467-09	6.35200-09	4.76995-09
280	1,36602-09	2.04903-09	1.39885-09
281	7,19710-10	1.07956-09	2.24509-09
282	1,24746-09	1.87122-09	1.71756-09
291	1,82854-11	2.74281-11	2.75547-11
308	7,04977-12	1.05747-11	1.00714-11
319	9,63684-12	1.44553-11	1.34695-11
324	3,06127-11	4.59190-11	5.08334-11
351	1,42948-11	2.14422-11	2.23487-11
356	9,14865-12	1.37230-11	1.65471-11
357	1,80114-11	2.70171-11	1.90130-11
358	1,35536-10	2.03304-10	1.32773-10
205	4,99446-10	7.49169-10	4.98085-10
333	4,99446-10	7.49169-10	5.01945-10
335	4,99446-10	7.49169-10	5.01242-10
206	2,86759-10	4.30138-10	2.83965-10
360	6,68757-12	1.00314-11	1.02041-11
244	6,71060-11	1.00659-10	1.02733-10
219	2,05200-08	3.07800-08	2.13179-08
212	2,83000-10	4.24500-10	2.95814-10
213	2,83000-10	4.24500-10	2.90713-10
214	2,83000-10	4.24500-10	2.88375-10
215	2,83000-10	4.24500-10	2.95419-10

TABLE 3-12 - COMPARISON OF TEMPERATURES AT END OF TRANSIENT
+50% PERTURBATION, 90 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1/2%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	CORRECTED TEMPERATURE
110	7.74405+01	7.96662+01	7.75586+01
53	9.93312+01	9.71327+01	1.01088+02
103	1.00933+02	6.48512+01	1.00947+02
71	1.01741+02	6.71602+01	1.01456+02
72	1.01289+02	6.64125+01	1.01006+02
85	3.92558+01	1.77837+01	3.93104+01
86	3.82171+01	1.63330+01	3.82885+01
87	3.82171+01	1.63000+01	3.82815+01
88	3.82812+01	1.65406+01	3.83507+01
89	3.82812+01	1.65716+01	3.83558+01
90	5.36418+01	2.00479+01	5.35644+01
91	5.36418+01	1.99526+01	5.34852+01
96	5.58945+01	5.57651+01	5.58268+01
97	5.61584+01	5.49646+01	5.60542+01
98	5.61584+01	5.50476+01	5.60729+01
99	5.58945+01	5.57617+01	5.58226+01
101	1.11478+02	1.08178+02	1.11358+02
102	1.02041+02	9.76972+01	1.01901+02
104	1.75006+02	1.56270+02	1.74957+02
105	1.17466+02	1.16377+02	1.17266+02
106	7.41745+01	7.12254+01	7.39186+01
108	1.00358+02	9.68431+01	1.01630+02
111	8.87776+01	8.82932+01	8.86151+01
112	8.89981+01	8.83268+01	8.89648+01
114	7.20830+01	7.29319+01	7.22668+01
115	7.30700+01	7.41402+01	7.31844+01
116	7.50606+01	7.50006+01	7.50068+01
134	5.50989+01	3.90559+01	5.50004+01
135	4.92689+01	2.88279+01	4.93028+01
50	1.03509+02	1.02338+02	1.04438+02
51	1.00037+02	9.52872+01	9.98475+01
52	1.26638+02	1.23691+02	1.21998+02
100	3.24561+01	3.26454+01	3.26138+01
107	9.75068+01	9.53918+01	9.76409+01
109	9.84798+01	9.65240+01	9.82335+01
113	8.03788+01	8.11650+01	7.98722+01
117	7.37442+01	7.39954+01	7.37430+01
120	4.53193+01	5.42545+00	4.51874+01
180	6.89250+01	6.39585+01	6.85553+01
189	6.95429+01	6.79803+01	6.80309+01
196	1.99405+01	1.47625+01	.98928+01
197	4.39288+01	3.79066+01	.37410+01
198	4.39288+01	3.78911+01	4.38133+01
199	1.99405+01	1.47624+01	1.98900+01
280	6.05670+01	6.07940+01	6.07977+01
282	6.15069+01	6.19079+01	6.17633+01
1	-4.60000+02	-4.60000+02	-4.60000+02
10	8.50000+01	8.50000+01	8.50000+01
20	9.30000+01	9.30000+01	9.30000+01

TABLE 3-13 - COMPARISON OF CONDUCTOR VALUES
+100% PERTURBATION, 90 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1/2%, KALØBS

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
11	7.50623-01	1.50125+00	1.50125+00
14	1.39718-01	2.79436-01	1.60047-01
17	1.39718-01	2.79436-01	1.58761-01
18	1.78571-02	3.57142-02	2.03611-02
21	1.89708+00	3.79416+00	3.567[illegible]6+00
20	8.00000-01	1.60000+00	1.11672+00
22	8.00000-01	1.60000+00	1.08318+00
23	4.00000-01	8.00000-01	5.58334-01
24	4.00000-01	8.00000-01	8.37747-01
25	4.76190-02	9.52380-02	9.17400-02
26	1.66667-02	3.33334-02	3.28639-02
30	9.86857-01	1.97371+00	1.04735+00
31	9.86857-01	1.97371+00	1.30041+00
33	6.01833-01	1.20367+00	1.09973+00
42	2.43309-01	4.86618-01	3.31589-01
50	3.17460-02	6.34920-02	6.48579-02
54	2.54453-02	5.08906-02	5.08906-02
55	2.54453-02	5.08906-02	5.08273-02
56	2.54453-02	5.08906-02	5.08906-02
60	2.43902+00	4.87804+00	2.39675+00
61	3.93701+00	7.87402+00	5.12719+00
70	1.56250+00	3.12500+00	1.85895+00
73	1.04167-01	2.08334-01	-7.79350-02
74	4.00000+00	8.00000+00	1.10467+00
79	1.19048+01	2.38096+01	-3.84821+00
80	7.46269-03	1.49254-02	2.20322-01
81	7.46269-03	1.49254-02	1.33173-02
90	1.68390+01	3.36780+01	1.98923+01
103	1.25000-02	2.50000-02	2.38303-02
107	2.50000-02	5.00000-02	3.90080-02
108	2.50000-02	5.00000-02	3.90031-02
115	3.70370-02	7.40740-02	6.54307-02
116	3.70370-02	7.40740-02	5.72248-02
117	3.70370-02	7.40740-02	4.85871-02
118	3.70370-02	7.40740-02	6.36516-02
130	2.08333-02	4.16666-02	7.04571-02
131	1.63132-02	3.26264-02	3.05327-02
200	1.02446-10	2.04892-10	1.07926-10
201	1.02446-10	2.04892-10	1.06194-10
202	1.02446-10	2.04892-10	1.06709-10
203	1.02446-10	2.04892-10	1.05247-10
204	1.02446-10	2.04892-10	1.04816-10
210	1.37158-09	2.74316-09	1.36560-09
211	1.37158-09	2.74316-09	1.36372-09
220	2.55083-08	5.10166-08	2.56867-08
231	1.78893-10	3.57786-10	2.48203-10
232	2.14672-10	4.29344-10	2.58588-10
235	2.14672-10	4.29344-10	2.66447-10
236	1.61004-10	3.22008-10	1.95154-10
239	1.61004-10	3.22008-10	1.90203-10
250	5.29174-11	1.05835-10	1.06032-10

TABLE 3-13 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
251	6.84986-11	1.36997-10	1.37328-10
253	5.29174-11	1.05835-10	1.05835-10
254	6.84986-11	1.36997-10	1.36101-10
255	5.29174-11	1.05835-10	1.05545-10
256	4.64580-12	9.29160-12	9.29576-12
257	2.54923-11	5.09846-11	5.31677-11
258	4.64580-12	9.29160-12	7.87196-12
260	1.45330-11	2.90660-11	-4.23836-11
261	6.43264-11	1.28653-10	-9.61640-10
262	5.84894-11	1.16979-10	1.39464-10
266	8.49347-11	1.69869-10	1.31437-10
270	4.52299-11	9.04598-11	8.10837-11
271	2.41700-11	4.83400-11	5.22422-11
272	1.80364-10	3.60728-10	2.22622-10
273	2.92157-10	5.84314-10	4.12563-10
274	2.12853-09	4.25706-09	2.09984-09
279	4.23467-09	8.46934-09	5.19019-09
280	1.36602-09	2.73204-09	1.41421-09
281	7.19710-10	1.43942-09	3.90921-09
282	1.24748-09	2.49496-09	1.95824-09
291	1.82854-11	3.65708-11	3.68625-11
308	7.04977-12	1.40995-11	1.30020-11
319	9.63684-12	1.92737-11	1.71217-11
324	3.06127-11	6.12254-11	7.33804-11
351	1.42948-11	2.85896-11	3.07053-11
356	9.14865-12	1.82973-11	2.88187-11
357	1.80114-11	3.60228-11	1.57419-11
358	1.35536-10	2.71072-10	1.46180-10
205	4.99446-10	9.98892-10	4.96695-10
333	4.99446-10	9.98892-10	5.04381-10
335	4.99446-10	9.98892-10	5.02980-10
206	2.86759-10	5.73518-10	2.80975-10
360	6.68757-12	1.33751-11	1.37963-11
244	6.71060-11	1.34212-10	1.31521-10
219	2.05200-08	4.10400-08	2.21739-08
212	2.83000-10	5.66000-10	3.03388-10
213	2.83000-10	5.66000-10	2.95684-10
214	2.83000-10	5.66000-10	2.90410-10
215	2.83000-10	5.66000-10	3.02343-10

TABLE 3-14 - COMPARISON OF TEMPERATURES AT END OF TRANSIENT
+100% PERTURBATION, 90 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1/2%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	CORRECTED TEMPERATURE
110	7.74405+01	8.14009+01	7.78086+01
53	9.93312+01	9.52034+01	1.02796+02
103	1.00933+02	3.94255+01	1.00805+02
71	1.01741+02	4.24591+01	1.01028+02
72	1.01289+02	4.14686+01	1.00423+02
85	3.92558+01	-3.71919-01	3.93291+01
86	3.82171+01	-2.33369+00	3.83113+01
87	3.82171+01	-2.37143+00	3.82989+01
88	3.82812+01	-1.59009+00	3.83767+01
89	3.82812+01	-1.48086+00	3.83840+01
90	5.36418+01	-4.81690+00	5.35209+01
91	5.36418+01	-4.66694+00	5.33692+01
96	5.58945+01	5.57749+01	5.57472+01
97	5.61584+01	5.39088+01	5.59613+01
98	5.61584+01	5.41298+01	5.60016+01
99	5.58945+01	5.57665+01	5.57425+01
101	1.11478+02	1.05476+02	1.11210+02
102	1.02041+02	9.43371+01	1.01855+02
104	1.75006+02	1.40034+02	1.74932+02
105	1.17466+02	1.15364+02	1.17214+02
106	7.41145+01	6.87256+01	7.38564+01
108	1.00358+02	9.74027+01	1.02875+02
111	8.877[illegible]6+01	8.78302+01	8.84841+01
112	8.89981+01	8.76500+01	8.89206+01
114	7.20880+01	7.36817+01	7.24416+01
115	7.30700+01	7.49230+01	7.33298+01
116	7.50606+01	7.49592+01	7.49679+01
134	5.50989+01	2.47906+01	5.49874+01
135	4.92689+01	1.23338+01	4.93607+01
50	1.03509+02	1.01051+02	1.05272+02
51	1.00037+02	9.15487+01	9.63332+01
52	1.26638+02	1.21200+02	1.13190+02
100	3.24561+01	3.27220+01	3.26231+01
107	9.75068+01	9.36158+01	9.82693+01
109	9.84798+01	9.49160+01	9.82987+01
113	8.03788+01	8.20159+01	7.94157+01
117	7.37442+01	7.43276+01	7.38148+01
120	4.53193+01	-2.06001+01	4.50525+01
180	6.89250+01	6.07616+01	6.86656+01
189	6.95429+01	6.67736+01	6.84819+01
196	1.99405+01	1.01143+01	1.99105+01
197	4.39288+01	3.25887+01	4.36635+01
198	4.39288+01	3.24842+01	4.37917+01
199	1.99405+01	1.01140+01	1.99035+01
280	6.05670+01	6.09922+01	6.09769+01
282	6.15069+01	6.21765+01	6.18054+01
1	-4.60000+02	-4.60000+02	-4.60000+02
10	8.50000+01	8.50000+01	8.50000+01
20	9.30000+01	9.30000+01	9.30000+01

TABLE 3-15 - COMPARISON OF CONDUCTOR VALUES
+10% PERTURBATION, 115 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1/2%, KALØ[illegible]S

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
11	7.50623-01	8.25685-01	8.25685-01
14	1.39718-01	1.53690-01	1.42484-01
17	1.39718-01	1.53690-01	1.40552-01
18	1.78571-02	1.96428-02	1.87530-02
21	1.89708+00	2.0 679+00	2.09295+00
20	8.00000-01	8.80000-01	8.34324-01
22	8.00000-01	8.80000-01	8.36624-01
23	4.00000-01	4.40000-01	4.17646-01
24	4.00000-01	4.40000-01	4.40709-01
25	4.76190-02	5.23809-02	5.21799-02
26	1.66667-02	1.83334-02	1.82959-02
30	9.86857-01	1.08554+00	9.89253-01
31	9.86857-01	1.08554+00	1.03836+00
33	6.01833-01	6.62016-01	6.57593-01
42	2.43309-01	2.67640-01	2.56058-01
50	3.17460-02	3.49206-02	3.51018-02
54	2.54453-02	2.79898-02	2.79898-02
55	2.54453-02	2.79898-02	2.79847-02
56	2.54453-02	2.79898-02	2.79898-02
60	2.43902+00	2.68292+00	2.43801+00
61	3.93701+00	4.33071+00	4.02565+00
70	1.56250+00	1.71875+00	1.57879+00
73	1.04167-01	1.14584-01	9.82497-[illegible]
74	4.00000+00	4.40000+00	3.81984+[illegible]
79	1.19048+01	1.30953+01	1.0922[illegible]
80	7.46269-03	6.20896-03	1.12207-02
81	7.46269-03	6.20896-03	8.17083-03
90	1.68390+01	1.85229+01	1.76033+01
103	1.25000-02	1.37500-02	1.37154-02
107	2.50000-02	2.75000-02	2.64332-02
108	2.50000-02	2.75000-02	2.64347-02
115	3.70370-02	4.07407-02	4.04191-02
116	3.70370-02	4.07407-02	3.91013-02
117	3.70370-02	4.07407-02	3.86739-02
118	3.70370-02	4.07407-02	3.95365-02
130	2.08333-02	2.29166-02	2.32875-02
131	1.63132-02	1.79445-02	1.77992-02
200.	1.02446-10	1.12691-10	1.02813-10
201	1.02446-10	1.12691-10	1.04642-10
202	1.02446-10	1.12691-10	1.02679-10
203	1.02446-10	1.12691-10	1.02677-10
204	1.02446-10	1.12691-10	1.02674-10
210	1.37158-09	1.50874-09	1.37089-09
211	1.37158-09	1.50874-09	1.37076-09
220	2.55083-08	2.80591-08	2.55528-08
231	1.78893-10	1.96782-10	1.83827-10
232	2.14672-10	2.36139-10	2.17122-10
235	2.14672-10	2.[illegible]6139-10	2.17723-10
236	1.61004-10	1.77104-10	1.63979-10
239	1.61004-10	1.77104-10	1.63555-10
250	5.2917[illegible]-11	5.82091-11	5.82203-11

TABLE 3-15 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
251	6.04966-11	7.53485-11	7.53671-11
253	5.29174-11	5.[illegible]-11	5.82091-11
254	6.04966-11	7.53485-11	7.53046-11
255	5.29174-11	5.82091-11	5.81852-11
256	4.64580-12	5.11038-12	5.11060-12
257	2.54923-11	2.80415-11	2.82472-11
258	4.64580-12	5.11038-12	5.06530-12
260	1.45330-11	1.59863-11	1.37600-11
261	6.43264-11	7.07590-11	3.08149-11
262	5.84894-11	6.43383-11	6.56934-11
266	8.49347-11	9.34282-11	9.14131-11
270	4.52299-11	4.97529-11	4.92140-11
271	2.41700-11	2.65870-11	2.03562-11
272	1.80364-10	1.98400-10	1.90420-10
273	2.92157-10	3.21373-10	3.17576-10
274	2.12853-09	2.34138-09	2.12227-09
279	4.23467-09	4.65814-09	4.28262-09
280	1.36602-09	1.50262-09	1.64548-09
281	7.19710-10	7.91681-10	1.00672-09
282	1.24748-09	1.37223-09	1.36563-09
283	4.66262-09	5.12888-09	5.14929-09
289	3.93818-10	4.33200-10	4.76734-10
290	1.82854-11	2.01139-11	2.00618-11
291	1.82854-11	2.01139-11	2.01400-11
293	2.24547-11	2.47002-11	2.46894-11
294	2.24547-11	2.47002-11	2.46092-11
300	6.40888-12	7.04977-12	6.94980-12
301	5.76799-12	6.34479-12	6.27466-12
302	5.76799-12	6.34479-12	6.27691-12
303	7.04977-12	7.75475-12	7.62941-12
304	7.04977-12	7.75475-12	7.62929-12
305	6.40888-12	7.04977-12	6.94980-12
306	5.76799-12	6.34479-12	6.27466-12
307	5.76799-12	6.34479-12	6.27691-12
308	7.04977-12	7.75475-12	7.62941-12
309	7.04977-12	7.75475-12	7.62929-12
310	8.76076-12	9.63684-12	9.44824-12
311	7.88469-12	8.67316-12	8.54086-12
312	7.88469-12	8.67316-12	8.54512-12
313	9.63684-12	1.06005-11	1.03641-11
314	9.63684-12	1.06005-11	1.03639-11
315	8.76076-12	9.63684-12	9.44824-12
316	7.88469-12	8.67316-12	8.54086-12
317	7.88469-12	8.67316-12	8.54512-12
318	9.63684-12	1.06005-11	1.03641-11
319	9.63684-12	1.06005-11	1.03639-11
322	4.46108-11	4.90719-11	4.90536-11
323	3.64997-11	4.01497-11	4.08368-11
324	3.06127-11	3.36740-11	3.36643-11
351	1.42948-11	1.57243-11	1.58620-11
356	9.14865-12	1.00635-11	1.02892-11

TABLE 3-15 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
357	1.80114-11	1.98125-11	1.86206-11
358	1.35536-10	1.49090-10	1.33571-10
205	4.99446-10	5.49391-10	4.99179-10
333	4.99446-10	5.49391-10	4.99962-10
335	4.99446-10	5.49391-10	4.99819-10
206	2.86759-10	3.15435-10	2.86225-10
360	6.68757-12	7.35633-12	7.30955-12
244	6.71060-11	7.38166-11	7.43616-11
219	2.05200-08	2.25720-08	2.06913-08
212	2.83000-10	3.11300-10	2.86001-10
213	2.83000-10	3.11300-10	2.84993-10
214	2.83000-10	3.11300-10	2.84542-10
215	2.83000-10	3.11300-10	2.85493-10

TABLE 3-16 - COMPARISON OF TEMPERATURES AT END OF TRANSIENT
+10% PERTURBATION, 115 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1/2%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	CORRECTED TEMPERATURE
110	7.74405+01	7.78514+01	7.74604+01
53	9.93312+01	9.89194+01	9.93968+01
103	1.00933+02	9.23360+01	1.00978+02
71	1.01741+02	9.34190+01	1.01724+02
72	1.01269+02	9.29038+01	1.01273+02
85	3.92556+01	3.47777+01	3.92903+01
86	3.82171+01	3.36847+01	3.82524+01
87	3.82171+01	3.36763+01	3.82510+01
88	3.82812+01	3.37089+01	3.83168+01
89	3.82812+01	3.37098+01	3.83171+01
90	5.36418+01	4.60184+01	5.36440+01
91	5.36418+01	4.59692+01	5.36316+01
96	5.58945+01	5.58123+01	5.58772+01
97	5.61584+01	5.58689+01	5.61306+01
98	5.61584+01	5.58718+01	5.61302+01
99	5.58945+01	5.58048+01	5.58654+01
101	1.11478+02	1.10760+02	1.11417+02
102	1.02341+02	1.01127+02	1.02014+02
104	1.75306+02	1.71637+02	1.74995+02
105	1.17466+02	1.17231+02	1.17425+02
106	7.41745+01	7.33284+01	7.40793+01
108	1.00358+02	1.00105+02	1.00406+02
111	8.87776+01	8.86719+01	8.87362+01
112	8.89981+01	8.88714+01	8.89961+01
114	7.20880+01	7.23139+01	7.21423+01
115	7.30730+01	7.33441+01	7.30991+01
116	7.50636+01	7.50474+01	7.50488+01
134	5.50989+01	5.18820+01	5.50600+01
135	4.92689+01	4.48131+01	4.92846+01
50	1.03509+02	1.03344+02	1.03543+02
51	1.00037+02	9.90431+01	1.00012+02
52	1.26638+02	1.26014+02	1.26996+02
100	3.24561+01	3.25484+01	3.25007+01
107	9.75068+01	9.70872+01	9.74838+01
109	9.84798+01	9.80745+01	9.83690+01
113	8.03788+01	8.05320+01	6.02606+01
117	7.37442+01	7.38134+01	7.37369+01
120	4.53193+01	3.56537+01	4.53020+01
180	6.89250+01	6.69696+01	6.85837+01
189	6.95429+01	6.86680+01	6.92980+01
196	1.99405+01	1.88637+01	1.99159+01
197	4.39288+01	4.26293+01	4.38754+01
198	4.39268+01	4.26330+01	4.38895+01
199	1.99405+01	1.88639+01	1.99121+01
280	6.05670+01	6.06052+01	6.06016+01
282	6.15069+01	6.15851+01	6.15770+01
1	-4.60000+02	-4.60000+02	-4.60000+02
10	8.50000+01	8.50000+01	8.50000+01
20	9.30000+01	9.30000+01	9.30000+01

TABLE 3-17 - COMPARISON OF CONDUCTOR VALUES
+50% PERTURBATION, 115 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1/2%, KALØBS

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
11	7.50623-01	1.12593+00	1.12593+00
14	1.39718-01	2.09577-01	1.50121-01
17	1.39718-01	2.09577-01	1.39285-01
16	1.78571-02	2.67856-02	2.07724-02
21	1.89708+00	2.84562+00	2.82351+00
20	8.00000-01	1.20000+00	9.34555-01
22	8.00000-01	1.20000+00	9.50401-01
23	4.00000-01	6.00000-01	4.73475-01
24	4.00000-01	6.00000-01	6.09756-01
25	4.76190-02	7.14285-02	7.00826-02
26	1.66667-02	2.50000-02	2.47937-02
30	9.86857-01	1.48029+00	9.80457-01
31	9.86857-01	1.48029+00	1.18847+00
33	6.01833-01	9.02750-01	8.67278-01
42	2.43309-01	3.64963-01	2.96731-01
50	3.17460-02	4.76190-02	4.87150-02
54	2.54453-02	3.81679-02	3.81679-02
55	2.54453-02	3.81679-02	3.81376-02
56	2.54453-02	3.81679-02	3.81679-02
60	2.43902+00	3.65853+00	2.42234+00
61	3.93701+00	5.90551+00	4.47252+00
70	1.56250+00	2.34375+00	1.67407+00
73	1.04167-01	1.56250-01	4.11687-02
74	4.00000+00	6.00000+00	2.76496+00
79	1.19048+01	1.78572+01	5.47545+00
80	7.46269-03	1.11940-02	5.88556-02
81	7.46269-03	1.11940-02	1.07434-02
90	1.68390+01	2.52585+01	2.05007+01
103	1.25000-02	1.87500-02	1.84235-02
107	2.50000-02	3.75000-02	3.20493-02
108	2.50000-02	3.75000-02	3.20518-02
115	3.70370-02	5.55555-02	5.07910-02
116	3.70370-02	5.55555-02	4.62366-02
117	3.70370-02	5.55555-02	4.37366-02
118	3.70370-02	5.55555-02	4.43655-02
130	2.08333-02	3.12499-02	3.50623-02
131	1.63132-02	2.44698-02	2.35512-02
200	1.02446-10	1.53669-10	1.03048-10
201	1.02446-10	1.53669-10	1.02117-10
202	1.02446-10	1.53669-10	1.02332-10
203	1.02446-10	1.53669-10	1.02423-10
204	1.02446-10	1.53669-10	1.02410-10
210	1.37158-09	2.05737-09	1.37052-09
211	1.37158-09	2.05737-09	1.37075-09
220	2.55063-08	3.82624-08	2.57179-08
231	1.78893-10	2.68339-10	1.88738-10
232	2.14672-10	3.22008-10	2.11338-10
235	2.14672-10	3.22008-10	2.14758-10
236	1.61004-10	2.41506-10	1.62110-10
239	1.61004-10	2.41506-10	1.61972-10
250	5.29174-11	7.93761-11	7.94776-11

TABLE 3-17 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
251	6.84986-11	1.02748-10	1.02918-10
253	5.29174-11	7.93761-11	7.93761-11
254	6.84986-11	1.02748-10	1.02379-10
255	5.29174-11	7.93761-11	7.91819-11
256	4.64580-12	6.96870-12	6.97200-12
257	2.54923-11	3.82384-11	3.94776-11
258	4.64580-12	6.96870-12	6.54351-12
260	1.45330-11	2.17995-11	7.07239-13
261	6.43264-11	9.64896-11	-2.61791-10
262	5.84894-11	8.77341-11	9.67370-11
266	8.49347-11	1.27402-10	1.13150-10
270	4.52299-11	6.78448-11	6.42263-11
271	2.41700-11	3.62550-11	-2.52138-11
272	1.80364-10	2.70546-10	2.17138-10
273	2.92157-10	4.38235-10	4.33338-10
274	2.12853-09	3.19279-09	2.10143-09
279	4.23467-09	6.35200-09	4.42167-09
280	1.36602-09	2.04903-09	2.90769-09
281	7.19710-10	1.07956-09	2.21872-09
282	1.24748-09	1.87122-09	1.77772-09
283	4.66262-09	6.99393-09	7.11351-09
289	3.93818-10	5.90727-10	9.81704-10
290	1.82854-11	2.74281-11	2.71367-11
291	1.82854-11	2.74281-11	2.75841-11
293	2.24547-11	3.36820-11	3.36182-11
294	2.24547-11	3.36820-11	3.31431-11
300	6.40888-12	9.61332-12	9.01152-12
301	5.76799-12	8.65199-12	8.25024-12
302	5.76799-12	8.65199-12	8.26430-12
303	7.04977-12	1.05747-11	9.83994-12
304	7.04977-12	1.05747-11	9.83948-12
305	6.40888-12	9.61332-12	9.01152-12
306	5.76799-12	8.65199-12	8.25024-12
307	5.76799-12	8.65199-12	8.26430-12
308	7.04977-12	1.05747-11	9.83994-12
309	7.04977-12	1.05747-11	9.83948-12
310	8.76076-12	1.31411-11	1.20057-11
311	7.88469-12	1.18270-11	1.10691-11
312	7.88469-12	1.18270-11	1.10956-11
313	9.63684-12	1.44553-11	1.30691-11
314	9.63684-12	1.44553-11	1.30682-11
315	8.76076-12	1.31411-11	1.20057-11
316	7.88469-12	1.18270-11	1.10691-11
317	7.88469-12	1.18270-11	1.10956-11
318	9.63684-12	1.44553-11	1.30691-11
319	9.63684-12	1.44553-11	1.30682-11
322	4.46108-11	6.69162-11	6.48961-11
323	3.64997-11	5.47495-11	5.75654-11
324	3.06127-11	4.59190-11	4.49460-11
351	1.42948-11	2.14422-11	2.23487-11
356	9.14865-12	1.37230-11	1.65471-11

TABLE 3-17 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
357	1.80114-11	2.70171-11	1.90130-11
358	1.35536-10	2.03304-10	1.32773-10
205	4.99446-10	7.49169-10	4.98085-10
333	4.99446-10	7.49169-10	5.01945-10
335	4.99446-10	7.49169-10	5.01242-10
206	2.86759-10	4.30138-10	2.83965-10
360	6.68757-12	1.00314-11	1.02422-11
244	6.71060-11	1.00659-10	1.02733-10
219	2.05200-08	3.07800-08	2.14504-08
212	2.83000-10	4.24500-10	2.94108-10
213	2.83000-10	4.24500-10	2.90161-10
214	2.83000-10	4.24500-10	2.88176-10
215	2.83000-10	4.24500-10	2.90362-10

TABLE 3-18 - COMPARISON OF TEMPERATURES AT END OF TRANSIENT
+50% PERTURBATION, 115 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1/2%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	CORRECTED TEMPERATURE
110	7.74405+01	7.96704+01	7.75612+01
53	9.93312+01	9.71221+01	1.01107+02
103	1.00933+02	6.49017+01	1.00947+02
71	1.01741+02	6.72084+01	1.01455+02
72	1.01269+02	6.64593+01	1.01005+02
85	3.92558+01	1.82300+01	3.93916+01
86	3.62171+01	1.67631+01	3.83494+01
87	3.82171+01	1.67283+01	3.83441+01
68	3.62812+01	1.69527+01	3.84193+01
89	3.82812+01	1.69546+01	3.84206+01
90	5.36418+01	2.02882+01	5.36681+01
91	5.36418+01	2.01688+01	5.36215+01
96	5.58945+01	5.55634+01	5.57900+01
97	5.61584+01	5.47829+01	5.60221+01
98	5.61584+01	5.48152+01	5.60239+01
99	5.58945+01	5.53692+01	5.57406+01
101	1.11478+02	1.08175+02	1.11361+02
102	1.02041+02	9.76701+01	1.01913+02
104	1.75006+02	1.56279+02	1.74957+02
105	1.17466+02	1.16333+02	1.17266+02
106	7.41745+01	6.94246+01	7.37169+01
108	1.00358+02	9.88319+01	1.01651+02
111	8.67776+01	8.82526+01	8.66155+01
112	8.89981+01	8.83169+01	8.90075+01
114	7.20860+01	7.29967+01	7.23320+01
115	7.30700+01	7.41439+01	7.31947+01
116	7.50606+01	7.50008+01	7.50076+01
134	5.50989+01	3.95820+01	5.48907+01
135	4.92689+01	2.90267+01	4.93369+01
50	1.03509+02	1.02330+02	1.04453+02
51	1.00037+02	9.52207+01	9.98540+01
52	1.26638+02	1.23692+02	1.21999+02
100	3.24561+01	3.26455+01	3.26137+01
107	9.75068+01	9.53802+01	9.76597+01
109	9.84798+01	9.65208+01	9.84600+01
113	8.03788+01	8.11560+01	7.97600+01
117	7.37442+01	7.39978+01	7.37503+01
120	4.53193+01	5.81885+00	4.51787+01
180	6.89250+01	5.94262+01	6.73251+01
189	6.95429+01	6.56014+01	6.76248+01
196	1.99405+01	1.47649+01	1.98812+01
197	4.39288+01	3.79095+01	4.37431+01
198	4.39288+01	3.78934+01	4.38141+01
199	1.99405+01	1.47616+01	1.98555+01
280	6.05670+01	6.07042+01	6.07770+01
282	6.15069+01	6.17917+01	6.17462+01
1	-4.60000+02	-4.60000+02	-4.60000+02
10	8.50000+01	8.50000-01	8.50000+01
20	9.30000+01	9.30000+01	9.30000+01

TABLE 3-19 - COMPARISON OF CONDUCTOR VALUES
+100% PERTURBATION, 115 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1/2%, KALØBS

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
11	7.50623-01	1.50125+00	1.50125+00
14	1.39718-01	2.79436-01	1.54536-01
17	1.39718-01	2.79436-01	1.31696-01
18	1.78571-02	3.57142-02	2.03611-02
21	1.89708+00	3.79416+00	3.61331+00
20	8.00000-01	1.60000+00	1.00544+00
22	8.00000-01	1.60000+00	1.04753+00
23	4.00000-01	8.00000-01	5.23055-01
24	4.00000-01	8.00000-01	8.37997-01
25	4.76190-02	9.52380-02	9.17400-02
26	1.66667-02	3.33334-02	3.28639-02
30	9.86857-01	1.97371+00	9.53376-01
31	9.86857-01	1.97371+00	1.28704+00
33	6.01833-01	1.20367+00	1.09973+00
42	2.43309-01	4.86618-01	3.31589-01
50	3.17460-02	6.34920-02	6.60078-02
54	2.54453-02	5.08906-02	5.08906-02
55	2.54453-02	5.08906-02	5.08230-02
56	2.54453-02	5.08906-02	5.08906-02
60	2.43902+00	4.87804+00	2.38847+00
61	3.93701+00	7.87402+00	5.12719+00
70	1.56250+00	3.12500+00	1.85895+00
73	1.04167-01	2.08334-01	-7.79350-02
74	4.00000+00	8.00000+00	1.10467+00
79	1.19048+01	2.38096+01	-3.84821+00
80	7.46269-03	1.49254-02	2.20197-01
81	7.46269-03	1.49254-02	1.33173-02
90	1.68390+01	3.36780+01	2.39436+01
103	1.25000-02	2.50000-02	2.38303-02
107	2.50000-02	5.00000-02	3.90080-02
108	2.50000-02	5.00000-02	3.90031-02
115	3.70370-02	7.40740-02	5.78440-02
116	3.70370-02	7.40740-02	5.33539-02
117	3.70370-02	7.40740-02	4.78976-02
118	3.70370-02	7.40740-02	4.18072-02
130	2.08333-02	4.16666-02	5.39884-02
131	1.63132-02	3.26264-02	3.04156-02
200	1.02446-10	2.04892-10	1.01809-10
201	1.02446-10	2.04892-10	9.99401-11
202	1.02446-10	2.04892-10	1.00413-10
203	1.02446-10	2.04892-10	1.00650-10
204	1.02446-10	2.04892-10	1.00620-10
210	1.37158-09	2.74316-09	1.37321-09
211	1.37158-09	2.74316-09	1.37503-09
220	2.55083-08	5.10166-08	2.59113-08
231	1.78893-10	3.57786-10	1.75735-10
232	2.14672-10	4.29344-10	1.85283-10
235	2.14672-10	4.29344-10	1.92704-10
236	1.61004-10	3.22008-10	1.41957-10
239	1.61004-10	3.22008-10	1.41640-10
250	5.29174-11	1.05835-10	1.06139-10

TABLE 3-19 (Cont)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
251	6.84966-11	1.36997-10	1.37507-10
253	5.29174-11	1.05835-10	1.05835-10
254	6.84966-11	1.36997-10	1.35798-10
255	5.29174-11	1.05835-10	1.05223-10
256	4.64580-12	9.29160-12	9.30040-12
257	2.54923-11	5.09846-11	5.37579-11
258	4.64580-12	9.29160-12	7.87196-12
260	1.45330-11	2.90660-11	-4.23636-11
261	6.43264-11	1.28653-10	-9.61640-10
262	5.84894-11	1.16979-10	1.39464-10
266	8.49347-11	1.69869-10	1.31437-10
270	4.52299-11	9.04598-11	8.10837-11
271	2.41700-11	4.83400-11	-1.83499-10
272	1.80364-10	3.60728-10	2.22622-10
273	2.92157-10	5.84314-10	7.12627-10
274	2.12853-09	4.25706-09	2.09984-09
279	4.23467-09	8.46934-09	4.50667-09
280	1.36602-09	2.73204-09	4.78475-09
281	7.19710-10	1.43942-09	3.80779-09
282	1.24748-09	2.49496-09	2.13677-09
283	4.66262-09	9.32524-09	9.59920-09
289	3.93818-10	7.87636-10	1.99365-09
290	1.82854-11	3.65708-11	3.59341-11
291	1.82854-11	3.65708-11	3.69325-11
293	2.24547-11	4.49094-11	4.47496-11
294	2.24547-11	4.49094-11	4.37036-11
300	6.40888-12	1.28178-11	1.14390-11
301	5.76799-12	1.15360-11	1.06369-11
302	5.76799-12	1.15360-11	1.06721-11
303	7.04977-12	1.40995-11	1.24614-11
304	7.04977-12	1.40995-11	1.24612-11
305	6.40888-12	1.28178-11	1.14390-11
306	5.76799-12	1.15360-11	1.06369-11
307	5.76799-12	1.15360-11	1.06721-11
308	7.04977-12	1.40995-11	1.24614-11
309	7.04977-12	1.40995-11	1.24612-11
310	8.76076-12	1.75215-11	1.49201-11
311	7.88469-12	1.57694-11	1.40733-11
312	7.88469-12	1.57694-11	1.41395-11
313	9.63684-12	1.92737-11	1.61824-11
314	9.63684-12	1.92737-11	1.61819-11
315	8.76076-12	1.75215-11	1.49201-11
316	7.88469-12	1.57694-11	1.40733-11
317	7.88469-12	1.57694-11	1.41395-11
318	9.63684-12	1.92737-11	1.61824-11
319	9.63684-12	1.92737-11	1.61819-11
322	4.46108-11	8.92216-11	8.06394-11
323	3.64997-11	7.29994-11	7.57655-11
324	3.06127-11	6.12254-11	5.70917-11
351	1.42948-11	2.85896-11	3.07053-11
356	9.14865-1	1.82973-11	2.88186-11

TABLE 3-19 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES
357	1.80114-11	3.60228-11	1.57419-11
358	1.35536-10	2.71072-10	1.46180-10
205	4.99446-10	9.98892-10	4.96695-10
333	4.99446-10	9.98892-10	5.04381-10
335	4.99446-10	9.98892-10	5.02980-10
206	2.86759-10	5.73518-10	2.80975-10
360	6.68757-12	1.33751-11	1.38909-11
244	6.71060-11	1.34212-10	1.31521-10
219	2.05200-08	4.10400-08	2.25178-08
212	2.83000-10	5.66000-10	2.98932-10
213	2.83000-10	5.66000-10	2.94158-10
214	2.83000-10	5.66000-10	2.90136-10
215	2.83000-10	5.66000-10	2.89513-10

TABLE 3-20 - COMPARISON OF TEMPERATURES AT END OF TRANSIENT
+100% PERTURBATION, 115 SOFT CONDUCTORS
TRW 50-NODE MODEL, NOISE 1/2%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	CORRECTED TEMPERATURE
110	7.74405+01	8.14014+01	7.78102+01
53	9.93312+01	9.51758+01	1.02839+02
103	1.00933+02	3.85178+01	1.00001+02
71	1.01741+02	4.25454+01	1.01024+02
72	1.01289+02	4.15501+01	1.00419+02
85	3.92558+01	9.42357-01	3.94616+01
86	3.82171+01	-1.06043+00	3.84063+01
87	3.82171+01	-1.10938+00	3.83990+01
88	3.82812+01	-3.80783-01	3.84848+01
89	3.82812+01	-3.51890-01	3.84879+01
90	5.36418+01	-4.06479+00	5.37109+01
91	5.36418+01	-4.18715+00	5.36411+01
96	5.58945+01	5.51047+01	5.56833+01
97	5.61584+01	5.32998+01	5.59008+01
98	5.61564+01	5.33784+01	5.59084+01
99	5.58945+01	5.44760+01	5.56068+01
101	1.11478+02	1.05470+02	1.11219+02
102	1.02041+02	9.42616+01	1.01883+02
104	1.75006+02	1.40051+02	1.74932+02
105	1.17466+02	1.15261+02	1.17215+02
106	7.41745+01	6.40535+01	7.34664+01
108	1.00358+02	9.73785+01	1.02926+02
111	8.87776+01	8.77558+01	8.85047+01
112	8.89981+01	8.75904+01	8.90102+01
114	7.20880+01	7.37708+01	7.25716+01
115	7.30700+01	7.49142+01	7.33481+01
116	7.50606+01	7.49596+01	7.49702+01
134	5.50989+01	2.59138+01	5.47470+01
135	4.92689+01	1.28168+01	4.93998+01
50	1.03509+02	1.01035+02	1.05307+02
51	1.00037+02	9.13824+01	9.63404+01
52	1.26638+02	1.21200+02	1.13203+02
100	3.24561+01	3.27220+01	3.26229+01
107	9.75068+01	9.35828+01	9.83090+01
109	9.84798+01	9.48960+01	9.87676+01
113	8.03788+01	8.19963+01	7.91912+01
117	7.37442+01	7.43278+01	7.38292+01
120	4.53193+01	-1.97204+01	4.50082+01
180	6.89250+01	5.06988+01	6.64914+01
1[illegible]	6.95429+01	6.16052+01	6.78033+01
19[illegible]	1.99405+01	1.01103+01	1.98814+01
197	4.39288+01	3.25869+01	4.36595+01
198	4.39288+01	3.24791+01	4.37924+01
199	1.99405+01	1.00917+01	1.98203+01
280	6.05670+01	6.07110+01	6.12649+01
282	6.15069+01	6.17785+01	6.17690+01
1	-4.60000+02	-4.60000+02	-4.60000+02
10	[illegible].50000+01	8.50000+01	6.50000+01
20	9.30000+01	9.30000+01	9.30000+01

TABLE 3-21 - COMPARISON OF TRANSIENT TEMPERATURES WITH ORIGINAL, PERTURBED AND CORRECTED CONDUCTOR VALUES, NODES 110 AND 85, TRW 50-NODE MODEL, +100% PERTURBATION, 90 SOFT CONDUCTORS, KALØBS, NOISE 1/2%

	NODE 110			NODE 85		
TIME (hr)	ORIGINAL (°F)	PERTURBED (°F)	CORRECTED (°F)	ORIGINAL (°F)	PERTURBED (°F)	CORRECTED (°F)
0.0	60.0	60.0	60.0	60.0	60.0	60.0
.004	61.6	62.3	61.7	58.7	57.0	58.7
.008	63.0	64.4	63.1	57.4	53.6	57.4
.012	64.4	66.2	64.4	56.1	50.0	56.1
.016	65.6	67.8	65.7	54.9	46.3	54.9
.020	66.7	69.3	66.8	53.7	42.6	53.6
.024	67.8	70.7	67.9	52.5	39.0	52.4
.028	68.8	71.9	68.9	51.3	35.4	51.3
.032	69.7	73.0	69.9	50.2	31.9	50.1
.036	70.6	74.1	70.8	49.1	28.5	49.0
.040	71.4	75.0	71.6	48.0	25.3	48.0
.044	72.2	75.9	72.4	47.0	22.2	47.0
.048	72.9	76.7	73.1	46.0	19.2	46.0
.052	73.6	77.5	73.8	45.1	16.3	45.0
.056	74.2	78.2	74.5	44.1	13.6	44.1
.060	74.8	78.8	75.1	43.2	11.0	43.2
[illegible]	75.4	79.4	75.7	42.4	8.5	42.4
.068	75.9	80.0	76.3	41.6	6.1	41.6
.072	76.5	80.5	76.8	40.8	3.8	40.8
.076	77.0	81.0	77.3	40.0	1.7	40.0
.080	77.4	81.4	77.8	39.3	- .4	39.3

TABLE 3-22 - COMPARISON OF SOFT CONDUCTOR VALUES
+10% PERTURBATION, 50 SOFT CONDUCTORS
NASA/MSC 50-NODE MODEL, NOISE 1/2%, KALØBS

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF
3	7.40000-07	8.14000-07	8.11866-07	9.71156+00
5	1.46000-05	1.60600-05	1.51309-05	3.63598+00
6	1.09000-05	1.19900-05	1.13165-05	3.82144+00
7	1.49000-05	1.63900-05	1.54370-05	3.60392+00
8	1.09000-05	1.19900-05	1.13165-05	3.82147+00
9	3.35000-04	3.68500-04	3.36190-04	3.55351-01
18	7.00000-08	7.70000-08	7.69957-08	9.99383+00
19	7.00000-08	7.70000-08	7.70073-08	1.00104+01
20	7.00000-08	7.70000-08	7.69956-08	9.99378+00
44	5.52000-07	6.07200-07	6.07201-07	1.00002+01
45	5.52000-07	6.07200-07	6.07200-07	1.00000+01
46	5.52000-07	6.07200-07	6.07201-07	1.00001+01
47	5.52000-07	6.07200-07	6.07201-07	1.00002+01
73	5.86000-07	6.44600-07	6.44598-07	9.99961+00
74	5.09000-07	5.59900-07	5.59900-07	1.00000+01
75	6.45000-07	7.09500-07	7.09487-07	9.99797+00
83	1.38900-06	1.52790-06	1.52788-06	9.99865+00
144	4.29000-06	4.71900-06	4.34533-06	1.28967+00
145	4.29000-06	4.71900-06	4.34533-06	1.28967+00
146	4.29000-06	4.71900-06	4.34533-06	1.28967+00
147	4.29000-06	4.71900-06	4.34533-06	1.28967+00
203	7.50000-07	8.25000-07	8.03613-07	7.14838+00
232	2.00000-08	2.20000-08	2.04365-08	2.18248+00
233	2.00000-08	2.20000-08	2.05013-08	2.50630+00
234	2.00000-08	2.20000-08	2.07133-08	3.55136+00
235	2.00000-08	2.20000-08	2.06567-08	3.28329+00
236	2.00000-08	2.20000-08	2.04490-08	2.24478+00
237	2.00000-08	2.20000-08	2.06294-08	3.14679+00
238	2.00000-08	2.20000-08	2.07054-08	3.52711+00
239	2.00000-08	2.20000-08	2.05841-08	2.92052+00
304	2.21180-13	2.43298-13	2.43298-13	1.00001+01
305	2.17000-13	2.38700-13	2.16577-13	1.95047-01
314	5.60000-14	6.16000-14	5.47288-14	2.27007+00
316	5.09000-14	5.59900-14	5.09440-14	8.63974-02
318	7.50000-14	8.25000-14	7.50627-14	8.35796-02
320	5.09000-14	5.59900-14	5.08255-14	1.46456-01
330	9.65000-14	1.06150-13	9.65323-14	3.34565-02
332	6.57000-14	7.22700-14	6.57239-14	3.64430-02
334	9.65000-14	1.06150-13	9.65322-14	3.33433-02
336	6.57000-14	7.22700-14	6.57460-14	7.00768-02
352	5.35500-14	5.89050-14	5.52163-14	3.11160+00
353	7.82200-14	8.60420-14	8.05110-14	2.92898+00
570	6.82400-14	7.50640-14	7.19694-14	5.46512+00
600	2.67000-15	2.93700-15	2.93235-15	9.82571+00
605	2.67000-15	2.93700-15	2.93224-15	9.82188+00
620	2.63400-14	2.89740-14	2.79453-14	6.09464+00
625	2.47000-15	2.71700-15	2.92599-15	1.84613+01
629	1.06900-14	1.17590-14	1.13730-14	6.38910+00
632	1.22400-14	1.34640-14	1.35471-14	1.06785+01
634	2.47700-14	2.72470-14	2.49265-14	6.31814-01

TABLE 3-23, COMPARISON OF TEMPERATURES AT END OF TRANSIENT
+10% PERTURBATION, 50 SOFT CONDUCTORS
NASA/MSC 50-NODE MODEL, NOISE 1/2%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	CORRECTED TEMPERATURE	PERCENTAGE OFF
5	-6.18823+00	-9.72703+00	-6.20019+00	1.93281-01
6	-7.35318+00	-1.09256+01	-7.36648+00	1.80919-01
7	-6.18554+00	-9.72595+00	-6.19760+00	1.94995-01
8	-7.35146+00	-1.08644+01	-7.33718+00	1.94223-01
21	4.13475+01	4.04781+01	4.13316+01	3.85379-02
22	3.95153+01	3.85838+01	3.95156+01	9.41239-04
23	4.13227+01	4.04406+01	4.13070+01	3.80014-02
24	3.95155+01	3.85845+01	3.95160+01	1.22722-03
25	5.06748+01	5.03379+01	5.07077+01	6.48369-02
26	5.00503+01	4.94333+01	5.00430+01	1.46099-02
39	5.17811+01	5.17487+01	5.17464+01	6.70533-02
27	5.05312+01	5.00858+01	5.05579+01	5.28793-02
28	5.02757+01	4.97142+01	5.02716+01	8.18129-03
29	5.36622+01	5.32845+01	5.36321+01	5.60816-02
45	1.77242+01	1.84765+01	1.79271+01	1.14510+00
46	1.62508+01	1.66658+01	1.62670+01	9.99166-02
47	1.91625+01	1.94612+01	1.91751+01	6.56996-02
48	1.85026+01	1.90869+01	1.85287+01	1.41502-01
49	3.86548+01	3.86420+01	3.86469+01	2.03183-02
51	4.62023+01	4.57314+01	4.61383+01	1.38475-01
52	4.62023+01	4.57314+01	4.61383+01	1.38475-01
53	4.62023+01	4.57314+01	4.61383+01	1.38475-01
54	4.62023+01	4.57314+01	4.61383+01	1.38475-01
61	3.80576+01	3.62167+01	3.81598+01	2.68690-01
63	4.07313+01	3.88615+01	4.08097+01	1.92432-01
67	4.24843+01	4.10276+01	4.25606+01	1.79775-01
81	4.99875+01	4.92480+01	5.00171+01	5.92848-02
82	5.14612+01	5.06537+01	5.14398+01	4.16245-02
83	5.12605+01	5.04634+01	5.12398+01	4.04461-02
84	5.17162+01	5.10359+01	5.16891+01	5.24393-02
85	5.25913+01	5.20834+01	5.25810+01	1.95073-02
86	4.99326+01	4.91790+01	4.99619+01	5.86098-02
87	5.03818+01	4.93966+01	5.03541+01	5.49261-02
88	5.10565+01	5.02114+01	5.10232+01	6.92685-02
89	5.15943+01	5.08764+01	5.15640+01	5.86981-02
90	5.21091+01	5.15000+01	5.20924+01	3.21246-02
91	5.22386+01	5.17564+01	5.22456+01	1.33616-02
92	5.12117+01	5.06426+01	5.12312+01	3.80731-02
1	-1.00202+01	-1.05586+01	-1.00273+01	7.08397-02
2	-6.74001+00	-7.33004+00	-6.74047+00	6.83684-03
3	-1.00302+01	-1.05738+01	-1.00372+01	6.98840-02
4	-6.73982+00	-7.32683+00	-6.73893+00	1.32637-02
71	3.91191+01	3.74313+01	3.92285+01	2.79766-01
72	4.13531+01	3.99887+01	4.14778+01	3.01774-01
73	4.33681+01	4.22826+01	4.35069+01	3.20262-01
74	4.46625+01	4.37569+01	4.48128+01	3.36597-01
75	4.53117+01	4.45006+01	4.54680+01	3.44826-01
76	3.90797+01	3.73812+01	3.91886+01	2.78630-01
77	4.12301+01	3.98324+01	4.13532+01	2.98481-01
78	4.32200+01	4.20940+01	4.33574+01	3.17878-01
79	4.44937+01	4.35417+01	4.46396+01	3.28107-01
80	4.51174+01	4.42527+01	4.52663+01	3.30112-01

TABLE 3-24 - COMPARISON OF SOFT CONDUCTOR VALUES
+50% PERTURBATION, 50 SOFT CONDUCTORS
NASA/MSC 50-NODE MODEL, NOISE 1/2%, KALØBS

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF
3	7.40000-07	1.11000-06	1.09702-06	4.62465+01
5	1.46000-05	2.19000-05	1.68730-05	1.55687+01
6	1.09000-05	1.63500-05	1.27087-05	1.65937+01
7	1.49000-05	2.23500-05	1.72024-05	1.54521+01
8	1.09000-05	1.63500-05	1.27087-05	1.65939+01
9	3.35000-04	5.02500-04	3.44376-04	2.79873+00
18	7.00000-08	1.05000-07	1.04965-07	4.99493+01
19	7.00000-08	1.05000-07	1.05061-07	5.00869+01
20	7.00000-08	1.05000-07	1.04964-07	4.99489+01
44	5.52000-07	8.28000-07	8.28009-07	5.00017+01
45	5.52000-07	8.28000-07	8.28001-07	5.00001+01
46	5.52000-07	8.28000-07	8.28005-07	5.00008+01
47	5.52000-07	8.28000-07	8.28007-07	5.00013+01
73	5.86000-07	8.79000-07	8.78985-07	4.99975+01
74	5.09000-07	7.63500-07	7.63502-07	5.00004+01
75	6.45000-07	9.67500-07	9.67395-07	4.99838+01
83	1.38900-06	2.08350-06	2.08339-06	4.99919+01
144	4.29000-06	6.43500-06	4.49403-06	4.75594+00
145	4.29000-06	6.43500-06	4.49403-06	4.75594+00
146	4.29000-06	6.43500-06	4.49403-06	4.75594+00
147	4.29000-06	6.43500-06	4.49403-06	4.75594+00
203	7.50000-07	1.12500-06	9.89979-07	3.19972+01
232	2.00000-08	3.00000-08	2.21381-08	1.06903+01
233	2.00000-08	3.00000-08	2.26055-08	1.30273+01
234	2.00000-08	3.00000-08	2.30482-08	1.52411+01
235	2.00000-08	3.00000-08	2.30315-08	1.51576+01
236	2.00000-08	3.00000-08	2.35777-08	1.78885+01
237	2.00000-08	3.00000-08	2.26857-08	1.34285+01
238	2.00000-08	3.00000-08	2.46643-08	2.33215+01
239	2.00000-08	3.00000-08	2.28392-08	1.41959+01
304	2.21180-13	3.31770-13	3.31772-13	5.00007+01
305	2.17000-13	3.25500-13	2.15249-13	8.07088-01
314	5.60000-14	8.40000-14	5.02506-14	1.02667+01
316	5.09000-14	7.63500-14	5.09556-14	1.09216-01
318	7.50000-14	1.12500-13	7.49550-14	5.99485-02
320	5.09000-14	7.63500-14	5.01108-14	1.55051+00
330	9.65000-14	1.44750-13	9.66422-14	1.47385-01
332	6.57000-14	9.85500-14	6.58076-14	1.63713-01
334	9.65000-14	1.44750-13	9.66417-14	1.46846-01
336	6.57000-14	9.85500-14	6.58992-14	3.03144-01
352	5.35500-14	8.03250-14	6.02324-14	1.24788+01
353	7.82200-14	1.17330-13	8.70722-14	1.13171+01
570	6.82400-14	1.02360-13	6.45453-14	2.38940+01
600	2.67000-15	4.00500-15	3.96354-15	4.84471+01
605	2.67000-15	4.00500-15	3.96310-15	4.84306+01
620	2.63400-14	3.95100-14	3.33937-14	2.67796+01
625	2.47000-15	3.70500-15	5.37428-15	1.17582+02
629	1.06900-14	1.60350-14	1.36007-14	2.72281+01
632	1.22400-14	1.83600-14	1.89965-14	5.52005+01
634	2.47700-14	3.71550-14	2.56448-14	3.53187+00

TABLE 3-25 - COMPARISON OF TEMPERATURES AT END OF TRANSIENT
+50% PERTURBATION, 50 SOFT CONDUCTORS
NASA/MSC 50-NODE MODEL, NOISE 1/2%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	CORRECTED TEMPERATURE	PERCENTAGE OFF
5	-6.18823+00	-2.14641+01	-6.24125+00	8.56903-01
6	-7.35318+00	-2.27453+01	-7.41284+00	8.11418-01
7	-6.18554+00	-2.14724+01	-6.23896+00	8.63634-01
8	-7.35146+00	-2.24043+01	-7.28388+00	9.19285-01
21	4.13475+01	3.58144+01	4.13050+01	1.02967-01
22	3.95153+01	3.36679+01	3.95440+01	7.26226-02
23	4.13227+01	3.57249+01	4.12812+01	1.00501-01
24	3.95155+01	3.36706+01	3.95447+01	7.40051-02
25	5.06748+01	4.86670+01	5.08003+01	2.47636-01
26	5.00503+01	4.63224+01	4.99944+01	1.11680-01
39	5.17811+01	5.15973+01	5.16269+01	2.97808-01
27	5.05312+01	4.78689+01	5.06401+01	2.15463-01
28	5.02757+01	4.68820+01	5.02611+01	2.90262-02
29	5.36622+01	5.10419+01	5.35378+01	2.31815-01
45	1.77242+01	2.10935+01	1.85864+01	4.86493+00
46	1.62508+01	1.62768+01	1.63224+01	4.40240-01
47	1.91625+01	2.06766+01	1.92145+01	2.71408-01
48	1.85026+01	2.11294+01	1.86167+01	6.16640-01
49	3.86548+01	3.87321+01	3.86123+01	1.09874-01
51	4.62023+01	4.40610+01	4.59633+01	5.17316-01
52	4.62023+01	4.40610+01	4.59633+01	5.17316-01
53	4.62023+01	4.40610+01	4.59633+01	5.17316-01
54	4.62023+01	4.40610+01	4.59633+01	5.17316-01
61	3.80576+01	2.90311+01	3.85272+01	1.23394+00
63	4.07313+01	3.15284+01	4.10662+01	8.22107-01
67	4.24843+01	3.51966+01	4.28358+01	8.27451-01
81	4.99875+01	4.58750+01	5.01230+01	2.71191-01
82	5.14612+01	4.65162+01	5.13559+01	2.04526-01
83	5.12605+01	4.64809+01	5.11628+01	2.10142-01
84	5.17162+01	4.76000+01	5.16270+01	1.72429-01
85	5.25913+01	4.93873+01	5.25573+01	6.45995-02
86	4.99326+01	4.57321+01	5.00584+01	2.51867-01
87	5.03818+01	4.45773+01	5.00973+01	5.64775-01
88	5.10585+01	4.59745+01	5.09163+01	2.78551-01
89	5.15943+01	4.72114+01	5.13896+01	3.96749-01
90	5.21091+01	4.83111+01	5.20468+01	1.19594-01
91	5.22386+01	4.95721+01	5.22678+01	5.57450-02
92	5.12117+01	4.80339+01	5.13026+01	1.77652-01
1	-1.00202+01	-1.32802+01	-1.00403+01	2.00236-01
2	-6.74001+00	-1.03065+01	-6.72987+00	1.50416-01
3	-1.00302+01	-1.33174+01	-1.00499+01	1.96010-01
4	-6.73982+00	-1.02888+01	-6.72342+00	2.43316-01
71	3.91191+01	3.08038+01	3.96193+01	1.27868+00
72	4.13531+01	3.45460+01	4.19187+01	1.36780+00
73	4.33681+01	3.78458+01	4.39907+01	1.43583+00
74	4.46625+01	3.99817+01	4.53259+01	1.48539+00
75	4.53117+01	4.10906+01	4.59992+01	1.51715+00
76	3.90797+01	3.06993+01	3.95904+01	1.30681+00
77	4.12301+01	3.42203+01	4.18285+01	1.45134+00
78	4.32200+01	3.74448+01	4.38818+01	1.53122+00
79	4.44937+01	3.95190+01	4.52082+01	1.60602+00
80	4.51174+01	4.05559+01	4.58402+01	1.60221+00

TABLE 3-26 - COMPARISON OF SOFT CONDUCTOR VALUES
+100% PERTURBATION, 50 SOFT CONDUCTORS
NASA/MSC 50-NODE MODEL, NOISE 1/2%, KALØBS

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF
3	7.40000-07	1.48000-06	1.44930-06	9.58516+01
5	1.46000-05	2.92000-05	1.86241-05	2.75624+01
6	1.09000-05	2.18000-05	1.41658-05	2.99619+01
7	1.49000-05	2.98000-05	1.89848-05	2.74151+01
8	1.09000-05	2.18000-05	1.41659-05	2.99622+01
9	3.35000-04	6.70000-04	3.58584-04	7.04010+00
18	7.00000-08	1.40000-07	1.39882-07	9.98321+01
19	7.00000-08	1.40000-07	1.40204-07	1.00291+02
20	7.00000-08	1.40000-07	1.39881-07	9.98305+01
44	5.52000-07	1.10400-06	1.10403-06	1.00005+02
45	5.52000-07	1.10400-06	1.10400-06	1.00000+02
46	5.52000-07	1.10400-06	1.10401-06	1.00002+02
47	5.52000-07	1.10400-06	1.10402-06	1.00004+02
73	5.86000-07	1.17200-06	1.17196-06	9.99936+01
74	5.09000-07	1.01800-06	1.01801-06	1.00001+02
75	6.45000-07	1.29000-06	1.28968-06	9.99510+01
83	1.38900-06	2.77800-06	2.77771-06	9.99793+01
144	4.29000-06	8.58000-06	4.60279-06	7.29107+00
145	4.29000-06	8.58000-06	4.60279-06	7.29107+00
146	4.29000-06	8.58000-06	4.60279-06	7.29107+00
147	4.29000-06	8.58000-06	4.60279-06	7.29107+00
203	7.50000-07	1.50000-06	1.18667-06	5.82221+01
232	2.00000-08	4.00000-08	2.45872-08	2.29358+01
233	2.00000-08	4.00000-08	2.83945-08	4.19724+01
234	2.00000-08	4.00000-08	1.90562-08	4.71895+00
235	2.00000-08	4.00000-08	2.48896-08	2.44481+01
236	2.00000-08	4.00000-08	2.03346-08	1.67282+00
237	2.00000-08	4.00000-08	2.71384-08	3.56921+01
238	2.00000-08	4.00000-08	2.91704-08	4.58518+01
239	2.00000-08	4.00000-08	2.69725-08	3.48624+01
304	2.21180-13	4.42360-13	4.42364-13	1.00002+02
305	2.17000-13	4.34000-13	2.13964-13	1.39910+00
314	5.60000-14	1.12000-13	4.58143-14	1.81888+01
316	5.09000-14	1.01800-13	5.08810-14	3.73185-02
318	7.50000-14	1.50000-13	7.45044-14	6.60752-01
320	5.09000-14	1.01800-13	4.88413-14	4.04461+00
330	9.65000-14	1.93000-13	9.67649-14	2.74503-01
332	6.57000-14	1.31400-13	6.59027-14	3.08583-01
334	9.65000-14	1.93000-13	9.67639-14	2.73420-01
336	6.57000-14	1.31400-13	6.60586-14	5.45868-01
352	5.35500-14	1.07100-13	6.41489-14	1.97925+01
353	7.82200-14	1.56440-13	9.16545-14	1.71753+01
570	6.82400-14	1.36480-13	9.62899-14	4.11047+01
600	2.67000-15	5.34000-15	5.20235-15	9.48445+01
605	2.67000-15	5.34000-15	5.20280-15	9.48615+01
620	2.63400-14	5.26800-14	3.86384-14	4.66908+01
625	2.47000-15	4.94000-15	9.97595-15	3.03885+02
629	1.06900-14	2.13800-14	1.52833-14	4.29685+01
632	1.22400-14	2.44800-14	2.65414-14	1.16841+02
634	2.47700-14	4.95400-14	2.66088-14	7.42332+00

TABLE 3-27 - COMPARISON OF TEMPERATURES AT END OF TRANSIENT
+100% PERTURBATION, 50 SOFT CONDUCTORS
NASA/MSC 50-NODE MODEL, NOISE 1/2%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	CORRECTED TEMPERATURE	PERCENTAGE OFF
5	-6.18823+00	-3.34002+01	-6.28766+00	1.60677+00
6	-7.35318+00	-3.47080+01	-7.46449+00	1.51385+00
7	-6.18554+00	-3.34127+01	-6.28557+00	1.61714+00
8	-7.35146+00	-3.39645+01	-7.22702+00	1.69278+00
21	4.13475+01	3.05311+01	4.12758+01	1.73565-01
22	3.95153+01	2.81953+01	3.95648+01	1.25499-01
23	4.13227+01	3.03953+01	4.12521+01	1.70914-01
24	3.95155+01	2.82004+01	3.95660+01	1.27699-01
25	5.06748+01	4.71579+01	5.08618+01	3.68945-01
26	5.00503+01	4.35554+01	5.00384+01	2.37865-02
39	5.17811+01	5.14155+01	5.15088+01	5.25830-01
27	5.05312+01	4.60068+01	5.07016+01	3.37144-01
28	5.02757+01	4.43653+01	5.02507+01	4.97611-02
29	5.36622+01	4.91052+01	5.34223+01	4.46907-01
45	1.77242+01	2.30985+01	1.91711+01	8.16383+00
46	1.62508+01	1.94334+01	1.63972+01	9.00698-01
47	1.91625+01	2.15105+01	1.92588+01	5.02354-01
48	1.85026+01	2.25754+01	1.87080+01	1.11045+00
49	3.86548+01	3.65865+01	3.85677+01	2.25335-01
51	4.62023+01	4.21425+01	4.58304+01	8.04795-01
52	4.62023+01	4.21425+01	4.58304+01	8.04795-01
53	4.62023+01	4.21425+01	4.58304+01	8.04795-01
54	4.62023+01	4.21425+01	4.58304+01	8.04795-01
61	3.80576+01	2.20427+01	3.88043+01	1.96203+00
63	4.07313+01	2.43687+01	4.12137+01	1.18435+00
67	4.24843+01	2.96831+01	4.30466+01	1.32358+00
81	4.99875+01	4.30274+01	5.02013+01	4.27743-01
82	5.14612+01	4.22892+01	5.11495+01	6.05752-01
83	5.12605+01	4.26836+01	5.07870+01	9.23648-01
84	5.17162+01	4.45176+01	5.19932+01	5.35619-01
85	5.25913+01	4.70940+01	5.25710+01	3.85804-02
86	4.99326+01	4.28235+01	5.01733+01	4.82019-01
87	5.03818+01	3.97316+01	5.05881+01	4.09476-01
88	5.10585+01	4.19282+01	5.07181+01	6.66735-01
89	5.15943+01	4.38665+01	5.11863+01	7.90836-01
90	5.21091+01	4.54385+01	5.18851+01	4.29863-01
91	5.22386+01	4.77159+01	5.22755+01	7.05343-02
92	5.12117+01	4.59327+01	5.13615+01	2.92559-01
1	-1.00202+01	-1.60961+01	-1.00546+01	3.42759-01
2	-6.74001+00	-1.33748+01	-6.72288+00	2.54164-01
3	-1.00302+01	-1.61532+01	-1.00641+01	3.38126-01
4	-6.73982+00	-1.33565+01	-6.71115+00	4.25324-01
71	3.91191+01	2.44694+01	3.99160+01	2.03722+00
72	4.13531+01	2.95941+01	4.22573+01	2.18673+00
73	4.33681+01	3.40418+01	4.43418+01	2.24526+00
74	4.46625+01	3.69383+01	4.55959+01	2.08978+00
75	4.53117+01	3.84750+01	4.62923+01	2.16407+00
76	3.90797+01	2.42954+01	3.98753+01	2.03589+00
77	4.12301+01	2.90518+01	4.21305+01	2.18378+00
78	4.32200+01	3.33750+01	4.43097+01	2.52121+00
79	4.44937+01	3.61620+01	4.56998+01	2.71086+00
80	4.51174+01	3.75662+01	4.63636+01	2.76212+00

TABLE 3-28 - COMPARISON OF SOFT CONDUCTOR VALUES
+10% PERTURBATION, 100 SOFT CONDUCTORS
NASA/MSC 50-NODE MODEL, NOISE 1/2%, KALØBS

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF
3	7.40000-07	8.14000-07	8.11832-07	9.70705+00
5	1.46000-05	1.60600-05	1.51299-05	3.62960+00
6	1.09000-05	1.19900-05	1.13176-05	3.83087+00
7	1.49000-05	1.63900-05	1.54361-05	3.59783+00
8	1.09000-05	1.19900-05	1.13256-05	3.90431+00
9	3.35000-04	3.68500-04	3.64461-04	8.79437+00
18	7.00000-08	7.70000-08	7.70014-08	1.00020+01
19	7.00000-08	7.70000-08	7.69978-08	9.99687+00
20	7.00000-08	7.70000-08	7.70014-08	1.00020+01
44	5.52000-07	6.07200-07	6.07201-07	1.00002+01
45	5.52000-07	6.07200-07	6.07200-07	1.00000+01
46	5.52000-07	6.07200-07	6.07201-07	1.00001+01
47	5.52000-07	6.07200-07	6.07201-07	1.00002+01
73	5.86000-07	6.44600-07	6.44595-07	9.99922+00
74	5.09000-07	5.59900-07	5.59900-07	1.00001+01
75	6.45000-07	7.09500-07	7.09487-07	9.99802+00
83	1.38900-06	1.52790-06	1.52786-06	9.99866+00
144	4.29000-06	4.71900-06	4.34533-06	1.28967+00
145	4.29000-06	4.71900-06	4.34533-06	1.28967+00
146	4.29000-06	4.71900-06	4.34533-06	1.28967+00
147	4.29000-06	4.71900-06	4.34533-06	1.28967+00
203	7.50000-07	8.25000-07	7.88449-07	5.12650+00
232	2.00000-08	2.20000-08	2.03850-08	1.92515+00
233	2.00000-08	2.20000-08	2.05758-08	2.87689+00
234	2.00000-08	2.20000-08	2.07345-08	3.67274+00
235	2.00000-08	2.20000-08	2.05903-08	2.95144+00
236	2.00000-08	2.20000-08	2.05194-08	2.59719+00
237	2.00000-08	2.20000-08	2.06212-08	3.10601+00
238	2.00000-08	2.20000-08	2.06888-08	3.44387+00
239	2.00000-08	2.20000-08	2.05566-08	2.78297+00
304	2.21180-13	2.43298-13	2.43298-13	1.00001+01
305	2.17000-13	2.38700-13	2.16788-13	9.77382-02
314	5.60000-14	6.16000-14	5.47440-14	2.24287+00
316	5.09000-14	5.59900-14	5.08616-14	7.54849-02
318	7.50000-14	8.25000-14	7.49779-14	2.94632-02
320	5.09000-14	5.59900-14	5.08091-14	1.78605-01
330	9.65000-14	1.06150-13	9.67365-14	2.45106-01
332	6.57000-14	7.22700-14	6.58679-14	2.55586-01
334	9.65000-14	1.06150-13	9.67368-14	2.45350-01
336	6.57000-14	7.22700-14	6.58388-14	2.11204-01
352	5.35500-14	5.89050-14	5.51961-14	3.07394+00
353	7.82200-14	8.60420-14	8.04876-14	2.89899+00
570	6.82400-14	7.50640-14	7.19376-14	5.41850+00
600	2.67000-15	2.93700-15	2.94166-15	1.01747+01
605	2.67000-15	2.93700-15	2.93088-15	9.77092+00
620	2.63400-14	2.89740-14	2.79294-14	6.03424+00
625	2.47000-15	2.71700-15	2.92114-15	1.82648+01
629	1.06900-14	1.17590-14	1.09994-14	2.89383+00
632	1.22400-14	1.34640-14	1.36000-14	1.11110+01
634	2.47700-14	2.72470-14	2.49237-14	6.20616-01
2	4.80000-07	5.28000-07	5.27007-07	9.79318+00

TABLE 3-28 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF
10	2.56000-04	2.81600-04	2.38389-04	6.87939+00
15	2.14000-05	2.35400-05	2.27185-05	6.16106+00
16	5.42000-05	5.96200-05	5.32646-05	1.72574+00
40	4.60000-07	5.06000-07	5.05999-07	9.99972+00
41	4.60000-07	5.06000-07	5.06002-07	1.00005+01
42	4.60000-07	5.06000-07	5.05999-07	9.99971+00
43	4.60000-07	5.06000-07	5.05999-07	9.99972+00
51	1.25900-06	1.38490-06	1.38500-06	1.00081+01
52	1.07200-06	1.17920-06	1.17919-06	9.99936+00
53	5.11000-07	5.62100-07	5.62099-07	9.99985+00
54	1.07200-06	1.17920-06	1.17919-06	9.99900+00
55	5.11000-07	5.62100-07	5.62103-07	1.00005+01
80	2.87900-06	3.16690-06	3.15936-06	9.73804+00
81	1.50500-06	1.65550-06	1.65527-06	9.98444+00
82	4.40700-06	4.84770-06	4.84657-06	9.97439+00
119	7.18600-07	7.90460-07	7.78720-07	8.36624+00
120	4.69000-07	5.15900-07	5.07594-07	8.22908+00
121	7.18600-07	7.90460-07	7.78733-07	8.36813+00
122	4.69000-07	5.15900-07	5.06748-07	8.04866+00
215	6.05400-04	6.65940-04	7.85858-04	2.98080+01
216	4.61500-04	5.07650-04	6.55444-04	4.20247+01
217	4.61500-04	5.07650-04	5.24379-04	1.36248+01
218	4.61500-04	5.07650-04	-1.85670-04	1.40232+02
220	6.05400-04	6.65940-04	7.65688-04	2.64764+01
221	4.61500-04	5.07650-04	6.22377-04	3.48596+01
222	4.61500-04	5.07650-04	4.60278-04	2.64850-01
223	4.61500-04	5.07650-04	-3.46666-04	1.75117+02
322	1.38600-14	1.52460-14	1.35126-14	2.50635+00
323	6.62000-15	7.28200-15	-7.00572-14	1.15827+03
324	9.07000-15	9.97700-15	3.07153-14	2.38647+02
325	4.28000-15	4.70800-15	-3.64412-14	9.51430+02
326	1.38600-14	1.52460-14	1.35034-14	2.57304+00
327	6.62000-15	7.28200-15	-7.00733-14	1.15851+03
328	9.07000-15	9.97700-15	3.07147-14	2.38641+02
329	4.28000-15	4.70800-15	-3.64417-14	9.51442+02
331	6.78000-14	7.45800-14	6.88273-14	1.51525+00
333	4.56000-14	5.01600-14	4.62704-14	1.47028+00
335	6.78000-14	7.45800-14	6.88286-14	1.51714+00
337	4.56000-14	5.01600-14	4.60988-14	1.09390+00
562	2.36300-14	2.59930-14	2.57316-14	8.89397+00
563	2.36300-14	2.59930-14	2.58948-14	9.58447+00
564	6.11300-14	6.72430-14	6.74409-14	1.03237+01
565	6.11300-14	6.72430-14	6.86748-14	1.23422+01
566	6.11300-14	6.72430-14	6.66919-14	9.09845+00
567	6.11300-14	6.72430-14	6.97652-14	1.41260+01
568	6.11300-14	6.72430-14	6.97954-14	1.41753+01
569	6.11300-14	6.72430-14	6.77761-14	1.08720+01
627	1.13000-14	1.24300-14	1.05625-14	6.52685+00
630	3.00000-15	3.30000-15	3.25321-15	8.44031+00

TABLE 3-29.- COMPARISON OF TEMPERATURES AT END OF TRANSIENT
+10% PERTURBATION, 100 SOFT CONDUCTORS
NASA/MSC 50-NODE MODEL, NOISE 1/2%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	CORRECTED TEMPERATURE	PERCENTAGE OFF
5	-6.18822+00	-8.75829+00	-5.90658+00	6.20630-02
6	-7.35318+00	-9.91088+00	-7.33736+00	3.49479-03
7	-6.18554+00	-8.75884+00	-5.90260+00	6.23482-02
8	-7.35146+00	-9.85187+00	-7.32788+00	5.20965-03
21	4.13475+01	4.02664+01	4.60803+01	9.44005-01
22	3.95153+01	3.83176+01	3.90167+01	9.98035-02
23	4.13227+01	4.02314+01	4.60283+01	9.38642-01
24	3.95155+01	3.83219+01	3.90199+01	9.92126-02
25	5.06748+01	5.03259+01	5.07314+01	1.10839-02
26	5.00503+01	4.94661+01	4.99798+01	1.38081-02
39	5.17811+01	5.17512+01	5.17461+01	6.82691-03
27	5.05312+01	4.99425+01	5.07169+01	3.63769-02
28	5.02757+01	4.97425+01	5.01945+01	1.59126-02
29	5.36622+01	5.32322+01	5.35775+01	1.64901-02
45	1.77242+01	1.84862+01	1.79287+01	4.28134-02
46	1.62508+01	1.66955+01	1.62845+01	7.07265-03
47	1.91625+01	1.94682+01	1.91821+01	4.08115-03
48	1.85026+01	1.90809+01	1.85276+01	5.22884-03
49	3.86548+01	3.86374+01	3.86412+01	2.72234-03
51	4.62023+01	4.57301+01	4.61367+01	1.29544-02
52	4.62023+01	4.57301+01	4.61367+01	1.29544-02
53	4.62023+01	4.57301+01	4.61367+01	1.29544-02
54	4.62023+01	4.57301+01	4.61367+01	1.29544-02
61	3.80576+01	3.64492+01	3.85382+01	9.64947-02
63	4.07313+01	3.91172+01	4.09656+01	4.67858-02
67	4.24843+01	4.09443+01	4.30730+01	1.17176-01
81	4.99875+01	4.93325+01	5.01218+01	2.63377-02
82	5.14612+01	5.06596+01	5.13683+01	1.81588-02
83	5.12605+01	5.04337+01	5.09913+01	5.26658-02
84	5.17162+01	5.09640+01	5.14089+01	6.00633-02
85	5.25913+01	5.19912+01	5.25395+01	1.00921-02
86	4.99326+01	4.92581+01	5.00629+01	2.55548-02
87	5.03818+01	4.94269+01	5.03042+01	1.52136-02
88	5.10585+01	5.01696+01	5.08267+01	4.53627-02
89	5.15943+01	5.07938+01	5.13648+01	4.48578-02
90	5.21091+01	5.14000+01	5.19653+01	2.80774-02
91	5.22386+01	5.16416+01	5.21695+01	1.35038-02
92	5.12117+01	5.03568+01	5.14317+01	4.30371-02
1	-1.00202+01	-1.25562+01	1.42075+01	5.38419+00
2	-6.74001+00	-9.37072+00	-1.37113+01	1.53803+00
3	-1.00302+01	-1.25698+01	1.42108+01	5.38724+00
4	-6.73982+00	-9.36592+00	-1.37100+01	1.53778+00
71	3.91191+01	3.76813+01	3.96293+01	1.02222-01
72	4.13531+01	4.00380+01	4.13957+01	8.50721-03
73	4.33681+01	4.21664+01	4.28625+01	1.00429-01
74	4.46625+01	4.35388+01	4.40264+01	1.26052-01
75	4.53117+01	4.42311+01	4.56058+01	5.82017-02
76	3.90797+01	3.76303+01	3.95893+01	1.02117-01
77	4.12301+01	3.98884+01	4.13355+01	2.10319-02
78	4.32200+01	4.19833+01	4.28613+01	7.12766-02
79	4.44937+01	4.33289+01	4.41747+01	6.32199-02
80	4.51174+01	4.39901+01	4.50215+01	1.89863-02

TABLE 3-30 - COMPARISON OF SOFT CONDUCTOR VALUES
+50% PERTURBATION, 100 SOFT CONDUCTORS
NASA/MSC 50-NODE MODEL, NOISE 1/2%, KALØBS

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF
3	7.40000-07	1.11000-06	1.09697-06	4.82386+01
5	1.46000-05	2.19000-05	1.68683-05	1.55366+01
6	1.09000-05	1.63500-05	1.27139-05	1.66415+01
7	1.49000-05	2.23500-05	1.71978-05	1.54212+01
8	1.09000-05	1.63500-05	1.27542-05	1.70112+01
9	3.35000-04	5.02500-04	4.78925-04	4.29626+01
18	7.00000-08	1.05000-07	1.05008-07	5.00116+01
~~19~~	~~7.00000-08~~	~~1.05000-07~~	~~1.04987-07~~	~~4.99809+01~~
20	7.00000-08	1.05000-07	1.05008-07	5.00119+01
44	5.52000-07	8.28000-07	8.28010-07	5.00017+01
45	5.52000-07	8.28000-07	8.28001-07	5.00001+01
46	5.52000-07	8.28000-07	8.28005-07	5.00008+01
47	5.52000-07	8.28000-07	8.28007-07	5.00013+01
~~73~~	~~5.86000-07~~	~~8.79000-07~~	~~8.78969-07~~	~~4.99947+01~~
74	5.09000-07	7.63500-07	7.63504-07	5.00008+01
75	6.45000-07	9.67500-07	9.67401-07	4.99846+01
83	1.38900-06	2.08350-06	2.08339-06	4.99918+01
144	4.29000-06	6.43500-06	4.49403-06	4.75594+00
145	4.29000-06	6.43500-06	4.49403-06	4.75594+00
~~146~~	~~4.29000-06~~	~~6.43500-06~~	~~4.49403-06~~	~~4.75594+00~~
147	4.29000-06	6.43500-06	4.49403-06	4.75594+00
203	7.50000-07	1.12500-06	8.71587-07	1.62116+01
232	2.00000-08	3.00000-08	2.18566-08	9.28291+00
233	2.00000-08	3.00000-08	2.30131-08	1.50653+01
234	2.00000-08	3.00000-08	2.31681-08	1.58406+01
~~235~~	~~2.00000-08~~	~~3.00000-08~~	~~2.26234-08~~	~~1.31172+01~~
236	2.00000-08	3.00000-08	2.42702-08	2.13512+01
~~237~~	~~2.00000-08~~	~~3.00000-08~~	~~2.23549-08~~	~~1.17746+01~~
238	2.00000-08	3.00000-08	2.44691-08	2.23457+01
~~239~~	~~2.00000-08~~	~~3.00000-08~~	~~2.28077-08~~	~~1.40387+01~~
304	2.21180-13	3.31770-13	3.31772-13	5.00007+01
~~305~~	~~2.17000-13~~	~~3.25500-13~~	~~2.16656-13~~	~~2.05014-01~~
314	5.60000-14	8.40000-14	5.05040-14	9.81429+00
~~316~~	~~5.09000-14~~	~~7.63500-14~~	~~5.06050-14~~	~~5.78084-01~~
318	7.50000-14	1.12500-13	7.44981-14	6.69166-01
~~320~~	~~5.09000-14~~	~~7.63500-14~~	~~4.99822-14~~	~~1.80311+00~~
330	9.65000-14	1.44750-13	9.75949-14	1.13465+00
~~332~~	~~6.57000-14~~	~~9.85500-14~~	~~6.64951-14~~	~~1.21010+00~~
334	9.65000-14	1.44750-13	9.75959-14	1.13568+00
~~336~~	~~6.57000-14~~	~~9.85500-14~~	~~6.64375-14~~	~~1.12250+00~~
352	5.35500-14	8.03250-14	6.01235-14	1.22754+01
~~353~~	~~7.82200-14~~	~~1.17330-13~~	~~8.69477-14~~	~~1.11579+01~~
570	6.82400-14	1.02360-13	8.43945-14	2.36730+01
~~600~~	~~2.67000-15~~	~~4.00500-15~~	~~4.03984-15~~	~~5.13049+01~~
605	2.67000-15	4.00500-15	3.95185-15	4.80093+01
~~620~~	~~2.63400-14~~	~~3.95100-14~~	~~3.33674-14~~	~~2.66794+01~~
625	2.47000-15	3.70500-15	5.29366-15	1.14318+02
629	1.04900-14	1.60350-14	1.09918-14	2.82162+00
632	1.22400-14	1.83600-14	1.95468-14	5.96960+01
~~634~~	~~2.47700-14~~	~~3.71550-14~~	~~2.54596-14~~	~~2.70373+00~~
2	4.80000-07	7.20000-07	7.14003-07	4.87506+01

TABLE 3-3C (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF
10	2.56000-04	3.84000-04	1.75407-04	3.14815+01
15	2.14000-05	3.21000-05	2.21222-05	3.37496+00
16	5.42000-05	8.13000-05	5.08121-05	6.25083+00
40	4.60000-07	6.90000-07	6.89989-07	4.99976+01
41	4.60000-07	6.90000-07	6.90020-07	5.00043+01
42	4.60000-07	6.90000-07	6.89989-07	4.99976+01
43	4.60000-07	6.90000-07	6.89989-07	4.99976+01
51	1.25900-06	1.88850-06	1.88931-06	5.00640+01
52	1.07200-06	1.60800-06	1.60795-06	4.99957+01
53	5.11000-07	7.66500-07	7.66493-07	4.99986+01
54	1.07200-06	1.60800-06	1.60793-06	4.99930+01
55	5.11000-07	7.66500-07	7.66525-07	5.00048+01
80	2.87900-06	4.31850-06	4.26007-06	4.79705+01
81	1.50500-06	2.25750-06	2.25597-06	4.98984+01
82	4.40700-06	6.61050-06	6.60071-06	4.97778+01
119	7.18600-07	1.07790-06	9.87329-07	3.73962+01
120	4.69000-07	7.03500-07	6.39098-07	3.62683+01
121	7.18600-07	1.07790-06	9.87430-07	3.74103+01
122	4.69000-07	7.03500-07	6.35177-07	3.54321+01
215	6.05400-04	9.08100-04	8.49283-04	4.02345+01
216	4.61500-04	6.92250-04	7.90804-04	7.13551+01
217	4.61500-04	6.92250-04	8.17072-04	7.72203+01
218	4.61500-04	6.92250-04	4.64268-04	5.99739-01
220	6.05400-04	9.08100-04	8.30814-04	3.72336+01
221	4.61500-04	6.92250-04	7.36481-04	5.95843+01
222	4.61500-04	6.92250-04	7.33761-04	5.89948+01
223	4.61500-04	6.92250-04	2.[illegible]813-04	4.50027+01
322	1.38600-14	2.07900-14	6.08245-15	5.61151+01
323	6.62000-15	9.93000-15	-8.29507-14	1.35303+03
324	9.07000-15	1.36050-14	2.56286-14	1.82565+02
325	4.28000-15	6.42000-15	-4.80935-14	1.22368+03
326	1.38600-14	2.07900-14	6.07363-15	5.61787+01
327	6.62000-15	9.93000-15	-8.29675-14	1.35329+03
328	9.07000-15	1.36050-14	2.56282-14	1.82560+02
329	4.28000-15	6.42000-15	-4.80911-14	1.22362+03
331	6.78000-14	1.01700-13	7.23200-14	6.66674+00
333	4.56000-14	6.84000-14	4.86072-14	6.59466+00
335	6.78000-14	1.01700-13	7.23260-14	6.67548+00
337	4.56000-14	6.84000-14	4.81806-14	5.65928+00
562	2.36300-14	3.54450-14	3.35635-14	4.20376+01
563	2.36300-14	3.54450-14	3.46560-14	4.66611+01
564	6.11300-14	9.16950-14	9.44816-14	5.45584+01
565	6.11300-14	9.16950-14	1.05582-13	7.27169+01
566	6.11300-14	9.16950-14	9.53759-14	5.60214+01
567	6.11300-14	9.16950-14	1.51580-13	1.47964+02
568	6.11300-14	9.16950-14	1.14166-13	8.67601+01
569	6.11300-14	9.16950-14	6.70747-14	9.72465+00
627	1.13000-14	1.69500-14	2.50192-15	7.78591+01
630	3.00000-15	4.50000-15	4.18835-15	3.96115+01

TABLE 3-31 - COMPARISON OF TEMPERATURES AT END OF TRANSIENT
+50% PERTURBATION, 100 SOFT CONDUCTORS
NASA/MSC 50-NODE MODEL, NOISE 1/2%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	CORRECTED TEMPERATURE	PERCENTAGE OFF
5	-6.18822+00	-1.60440+01	-5.6320[illegible]00	1.22565-01
6	-7.35318+00	-1.71192+01	-7.09910+00	5.61304-02
7	-6.18554+00	-1.60648+01	-5.62461+00	1.23603-01
8	-7.35146+00	-1.68328+01	-7.06708+00	6.28262-02
21	4.13475+01	3.53488+01	4.72072+01	1.16878+00
22	3.95153+01	3.30565+01	4.10893+01	3.15117-01
23	4.13227+01	3.52706+01	4.71490+01	1.16218+00
24	3.95155+01	3.30808+01	4.10979+01	3.16787-01
25	5.06748+01	4.82516+01	5.08113+01	2.67278-02
26	5.00503+01	4.64074+01	4.99397+01	2.16723-02
39	5.17811+01	5.16142+01	5.16269+01	3.01218-02
27	5.05312+01	4.65442+01	5.11293+01	1.17162-01
28	5.02757+01	4.69366+01	5.01961+01	1.56010-02
29	5.36622+01	5.04970+01	5.33646+01	5.79322-02
45	1.77242+01	2.11218+01	1.86142+01	1.86301-01
46	1.62608+01	1.44026+01	1.64007+01	3.14654-02
47	1.91625+01	2.07067+01	1.92543+01	1.91615-02
48	1.85026+01	2.11128+01	1.85920+01	1.86860-02
49	3.86548+01	3.87119+01	3.85909+01	1.28089-02
51	4.62023+01	4.40557+01	4.59572+01	4.84078-02
52	4.62023+01	4.40557+01	4.59572+01	4.84078-02
53	4.62023+01	4.40557+01	4.59572+01	4.84078-02
54	4.62023+01	4.40557+01	4.59572+01	4.84078-02
61	3.80576+01	3.02969+01	3.91041+01	2.10115-01
63	4.07313+01	3.29359+01	4.09064+01	3.49569-02
67	4.24843+01	3.48866+01	4.46056+01	4.22170-01
81	4.99875+01	4.63234+01	5.03334+01	6.78356-02
82	5.14612+01	4.65455+01	5.13553+01	2.07119-02
83	5.12605+01	4.62169+01	5.09434+01	6.20253-02
84	5.17162+01	4.70116+01	5.12432+01	9.24325-02
85	5.25913+01	4.86009+01	5.21895+01	7.83748-02
86	4.99326+01	4.61331+01	5.02424+01	6.07494-02
87	5.03818+01	4.47874+01	5.01377+01	4.78338-02
88	5.10585+01	4.56395+01	5.06128+01	8.72207-02
89	5.15943+01	4.65443+01	5.09534+01	1.25273-01
90	5.21091+01	4.74760+01	5.18031+01	5.97619-02
91	5.22386+01	4.86234+01	5.21437+01	1.85320-02
92	5.12117+01	4.60923+01	5.20146+01	1.57458-01
1	-1.00202+01	-2.10164+01	2.17628+01	7.06321+00
2	-6.74001+00	-1.82302+01	-3.49980+00	7.14868-01
3	-1.00308+01	-2.10433+01	2.17642+01	7.06589+00
4	-6.73982+00	-1.82046+01	-3.49808+00	7.15205-01
71	3.91191+01	3.21635+01	4.02784+01	2.32269-01
72	4.13631+01	3.47862+01	4.20340+01	1.36815-01
73	4.33681+01	3.71662+01	4.33710+01	5.77470-04
74	4.46625+01	3.87262+01	4.42054+01	9.05689-02
75	4.53117+01	3.95349+01	4.49332+01	7.49113-02
76	3.90799+01	3.20490+01	4.02209+01	2.28664-01
77	4.12301+01	3.45100+01	4.19288+01	1.39395-01
78	4.32208+01	3.68095+01	4.32828+01	1.24785-02
79	4.44937+01	3.83079+01	4.41659+01	6.[illegible]766-02
80	4.51174+01	3.90590+01	4.53565+01	4.[illegible]470-02

TABLE 3-32 - COMPARISON OF SOFT CONDUCTOR VALUES
+100 % PERTURBATION, 100 SOFT CONDUCTORS
NASA/MSC 50-NODE MODEL, NOISE 1/2%, KALØBS

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF
3	7.40000-07	1.48000-06	1.44972-06	9.59076+01
5	1.46000-05	2.92000-05	1.86147-05	2.74979+01
6	1.09000-05	2.18000-05	1.41763-05	3.00578+01
7	1.49000-05	2.98000-05	1.89756-05	2.73530+01
8	1.09000-05	2.18000-05	1.42573-05	3.08011+01
9	3.35000-04	6.70000-04	5.93115-04	7.70492+01
18	7.00000-08	1.40000-07	1.40020-07	1.00028+02
19	7.00000-08	1.40000-07	1.39966-07	9.99516+01
20	7.00000-08	1.40000-07	1.40020-07	1.00029+02
44	5.52000-07	1.10400-06	1.10403-06	1.00005+02
45	5.52000-07	1.10400-06	1.10400-06	1.00000+02
46	5.52000-07	1.10400-06	1.10401-06	1.00002+02
47	5.52000-07	1.10400-06	1.10402-06	1.00004+02
73	5.86000-07	1.17200-06	1.17192-06	9.99865+01
74	5.09000-07	1.01800-06	1.01801-06	1.00003+02
75	6.45000-07	1.29000-06	1.28971-06	9.99551+01
83	1.38900-06	2.77800-06	2.77771-06	9.99789+01
144	4.29000-06	8.58000-06	4.60279-06	7.29107+00
145	4.29000-06	8.58000-06	4.60279-06	7.29107+00
146	4.29000-06	8.58000-06	4.60279-06	7.29107+00
147	4.29000-06	8.58000-06	4.60279-06	7.29107+00
203	7.50000-07	1.50000-06	8.13692-07	8.49224+00
232	2.00000-08	4.00000-08	1.99225-08	3.87558-01
233	2.00000-08	4.00000-08	2.92297-08	4.61486+01
234	2.00000-08	4.00000-08	2.84681-08	4.23404+01
235	2.00000-08	4.00000-08	2.27407-08	1.37036+01
236	2.00000-08	4.00000-08	2.03351-08	1.67554+00
237	2.00000-08	4.00000-08	2.75743-08	3.78714+01
238	2.00000-08	4.00000-08	2.85581-08	4.27905+01
239	2.00000-08	4.00000-08	2.70856-08	3.54278+01
304	2.21180-13	4.42360-13	4.42364-13	1.00002+02
305	2.17000-13	4.34000-13	2.17221-13	1.02016-01
314	5.60000-14	1.12000-13	4.66802-14	1.66425+01
316	5.09000-14	1.01800-13	5.02955-14	1.18764+00
318	7.50000-14	1.50000-13	7.35411-14	1.94523+00
320	5.09000-14	1.01800-13	4.84599-14	4.79393+00
330	9.65000-14	1.93000-13	9.86658-14	2.24435+00
332	6.57000-14	1.31400-13	6.72918-14	2.42288+00
334	9.65000-14	1.93000-13	9.86676-14	2.24621+00
336	6.57000-14	1.31400-13	6.73945-14	2.57912+00
352	5.35500-14	1.07100-13	6.39178-14	1.93610+01
353	7.82200-14	1.56440-13	9.13933-14	1.68413+01
570	6.82400-14	1.36480-13	9.60093-14	4.06936+01
600	2.67000-15	5.34000-15	5.43030-15	1.03382+02
605	2.67000-15	5.34000-15	5.16900-15	9.35957+01
620	2.63400-14	5.26800-14	3.88295-14	4.74165+01
625	2.47000-15	4.94000-15	9.58886-15	2.88213+02
629	1.06900-14	2.13800-14	8.61867-15	1.93764+01
632	1.22400-14	2.44800-14	2.86577-14	1.34131+02
634	2.47700-14	4.95400-14	2.57874-14	4.10749+00
2	4.80000-07	9.60000-07	9.45979-07	9.70790+01

TABLE 3-32 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF
10	2.56000-04	5.12000-04	1.29202-04	4.95306+01
15	2.14000-05	4.28000-05	1.40533-05	3.43302+01
16	5.42000-05	1.08400-04	4.98466-05	8.03202+00
40	4.60000-07	9.20000-07	9.19946-07	9.99926+01
41	4.60000-07	9.20000-07	9.20064-07	1.00014+02
42	4.60000-07	9.20000-07	9.19965-07	9.99925+01
43	4.60000-07	9.20000-07	9.19966-07	9.99926+01
51	1.25900-06	2.51800-06	2.52056-06	1.00203+02
52	1.07200-06	2.14400-06	2.14388-06	9.99891+01
53	5.11000-07	1.02200-06	1.02198-06	9.99952+01
54	1.07200-06	2.14400-06	2.14380-06	9.99816+01
55	5.11000-07	1.02200-06	1.02208-06	1.00016+02
80	2.87900-06	5.75800-06	5.58789-06	9.40913+01
81	1.50500-06	3.01000-06	3.00622-06	9.97486+01
82	4.40700-06	8.81400-06	8.77966-06	9.92207+01
119	7.18600-07	1.43720-06	1.16265-06	6.17931+01
120	4.69000-07	9.38000-07	7.41164-07	5.80308+01
121	7.18600-07	1.43720-06	1.16294-06	6.18348+01
122	4.69000-07	9.38000-07	7.42079-07	5.62259+01
215	6.06400-04	1.21080-03	8.95294-04	4.78847+01
216	4.61500-04	9.23000-04	9.19305-04	9.91994+01
217	4.61500-04	9.23000-04	1.02372-03	1.21825+02
218	4.61500-04	9.23000-04	8.95610-04	9.40649+01
220	6.05400-04	1.21080-03	8.78214-04	4.50635+01
221	4.61500-04	9.23000-04	8.83997-04	9.15987+01
222	4.61500-04	9.23000-04	9.78364-04	1.11997+02
223	4.61500-04	9.23000-04	7.75171-04	6.79677+01
322	1.38600-14	2.77200-14	7.40082-17	9.94660+01
323	6.62000-15	1.32400-14	-9.27783-14	1.50148+03
324	9.07000-15	1.81400-14	2.06097-14	1.27229+02
325	4.28000-15	8.56000-15	-5.83479-14	1.46327+03
326	1.38600-14	2.77200-14	6.92530-17	9.95003+01
327	6.62000-15	1.32400-14	-9.27914-14	1.50168+03
328	9.07000-15	1.81400-14	2.06084-14	1.27215+02
329	4.28000-15	8.56000-15	-5.83508-14	1.46334+03
331	6.78000-14	1.35600-13	7.62300-14	1.24336+01
333	4.56000-14	9.12000-14	5.12993-14	1.24984+01
335	6.78000-14	1.35600-13	7.62414-14	1.24509+01
337	4.56000-14	9.12000-14	5.15476-14	1.30429+01
562	2.36300-14	4.72600-14	4.22762-14	7.89090+01
563	2.36300-14	4.72600-14	4.49322-14	9.01491+01
564	6.11300-14	1.22260-13	5.81768-14	4.83096+00
565	6.11300-14	1.22260-13	2.46711-13	3.03585+02
566	6.11300-14	1.22260-13	2.28715-13	2.74146+02
567	6.11300-14	1.22260-13	1.04023-13	7.01673+01
568	6.11300-14	1.22260-13	1.81192-13	1.96322+02
569	6.11300-14	1.22260-13	4.15621-14	3.20102+01
627	1.13000-14	2.26000-14	-1.94043-14	2.71720+02
630	3.00000-15	6.00000-15	5.20795-15	7.35982+01

TABLE 3-33 - COMPARISON OF TEMPERATURES AT END OF TRANSIENT
+100% PERTURBATION, 100 SOFT CONDUCTORS
NASA/MSC 50-NODE MODEL, NOISE 1/2%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	CORRECTED TEMPERATURE	PERCENTAGE OFF
5	-6.18872+00	-2.21103+01	-4.99026+00	2.63979-01
6	-7.35318+00	-2.30746+01	-6.47638+00	1.93706-01
7	-6.16554+00	-2.21484+01	-4.98497+00	2.64551-01
8	-7.35146+00	-2.25382+01	-6.43298+00	2.02913-01
21	4.13475+01	3.06036+01	4.70123+01	1.12991+00
22	3.95153+01	2.61510+01	4.16037+01	4.18093-01
23	4.13227+01	3.04890+01	4.69401+01	1.12052+00
24	3.95155+01	2.62019+01	4.16142+01	4.20141-01
25	5.06748+01	4.57511+01	5.07995+01	2.44129-02
26	5.00503+01	4. 6642+01	4.91762+01	1.71359-01
39	5.17811+01	5.14549+01	5.14951+01	5.58723-02
27	5.05312+01	4.26093+01	5.09969+01	9.12203-02
28	5.02757+01	4.43975+01	4.94644+01	1.58990-01
29	5.36622+01	4.76496+01	5.22745+01	2.70145-01
45	1.77242+01	2.31265+01	1.95109+01	3.74011-01
46	1.62508+01	1.96457+01	1.68045+01	1.16257-01
47	1.91625+01	2.15623+01	1.95845+01	8.80654-02
48	1.85026+01	2.25641+01	1.88652+01	7.57915-02
49	3.86548+01	3.85512+01	3.87098+01	1.10429-02
51	4.62023+01	4.21340+01	4.58832+01	6.30409-02
52	4.62023+01	4.21340+01	4.58832+01	6.30409-02
53	4.62023+01	4.21340+01	4.58832+01	6.30409-02
54	4.62023+01	4.21340+01	4.58832+01	6.30409-02
61	3.80576+01	2.47288+01	3.85854+01	1.05982-01
63	4.07313+01	2.73353+01	3.99095+01	1.64115-01
67	4.24848+01	2.92940+01	4.53005+01	5.60465-01
81	4.99875+01	4.39042+01	4.96859+01	5.91333-02
82	5.14612+01	4.24921+01	5.08119+01	1.26940-01
83	5.12605+01	4.20678+01	4.96869+01	3.07801-01
84	5.17162+01	4.30768+01	5.00576+01	3.24135-01
85	5.25913+01	4.51245+01	5.09865+01	3.13068-01
86	4.99326+01	4.35821+01	4.95637+01	7.23567-02
87	5.03818+01	4.03546+01	4.96556+01	1.42284-01
88	5.10586+01	4.11812+01	4.94625+01	3.12291-01
89	5.15943+01	4.22532+01	4.95936+01	3.91075-01
90	5.21091+01	4.33734+01	5.03802+01	3.37611-01
91	5.22386+01	4.53312+01	5.22589+01	3.96298-03
92	5.12117+01	4.15239+01	5.19393+01	1.42339-01
1	-1.00202+01	-2.78446+01	2.66805+01	8.15609+00
2	-6.74001+00	-2.54618+01	3.89324+00	2.34595+00
3	-1.00302+01	-2.78790+01	2.66762+01	8.15752+00
4	-6.73982+00	-2.54103+01	3.89703+00	2.34674+00
71	3.91191+01	2.73717+01	3.97990+01	1.36231-01
72	4.13531+01	3.01539+01	4.15258+01	3.44632-02
73	4.33681+01	3.26859+01	4.27830+01	1.16236-01
74	4.46625+01	3.43628+01	4.34945+01	2.31439-01
75	4.53117+01	3.52453+01	4.38669+01	2.85928-01
76	3.90797+01	2.71669+01	3.97459+01	1.33492-01
77	4.12301+01	2.97322+01	4.14292+01	3.97267-02
78	4.32200+01	3.21319+01	4.27018+01	1.02986-01
79	4.44937+01	3.37055+01	4.34482+01	2.07225-01
80	4.51174+01	3.44987+01	4.39133+01	2.38364-01

TABLE 3-34 - COMPARISON OF TRANSIENT TEMPERATURES WITH ORIGINAL, PERTURBED, AND CORRECTED CONDUCTOR VALUES, NODES 61 AND 2
NASA/MSC 50-NODE MODEL, +100% PERTURBATION, 100 SOFT CONDUCTORS
NOISE 1/2%, KALØBS

		NODE 61			NODE 2	
TIME (SEC)	ORIGINAL (°F)	PERTURBED (°F)	CORRECTED (°F)	ORIGINAL (°F)	PERTURBED (°F)	CORRECTED (°F)
0.0	55.0	55.0	55.0	70.0	70.0	70.0
60	64.1	56.1	58.4	28.7	21.4	45.8
120	60.3	52.8	56.4	27.4	19.6	44.3
180	57.8	50.7	55.0	26.2	17.8	42.8
240	56.0	48.9	53.8	24.9	16.0	41.3
300	54.7	47.4	52.8	23.6	14.2	39.8
360	53.5	46.0	52.0	22.3	12.5	38.4
420	52.5	44.8	51.2	21.0	10.7	36.9
480	51.6	43.6	50.4	19.7	9.0	35.4
540	50.8	42.5	49.7	18.4	7.3	33.9
600	50.0	41.4	49.0	17.1	5.6	32.4
660	49.2	40.4	48.4	15.8	3.9	31.0
720	48.5	39.5	47.8	14.6	2.2	29.5
780	47.8	38.5	47.2	13.3	5.2	28.0
840	47.1	37.6	46.6	12.0	- 1.1	26.6
900	46.5	36.7	46.0	10.8	- 2.8	25.1
960	45.8	35.9	45.5	9.6	- 4.4	23.7
1020	45.2	35.0	44.9	8.3	- 6.0	22.2
1080	44.6	34.2	44.4	7.1	- 7.6	20.8
1140	44.0	33.4	43.9	5.9	- 9.1	19.4
1200	43.4	32.6	43.4	4.7	-10.7	17.9
1260	42.9	31.7	42.9	3.5	-12.2	16.5
1320	42.3	30.9	42.4	2.3	-13.8	15.1
1380	41.7	30.1	41.9	1.2	-15.3	13.7
1440	41.2	29.4	41.4	- .3	-16.8	12.3
1500	40.7	28.6	40.9	- 1.2	-18.3	10.8
1560	40.1	27.8	40.5	- 2.3	-19.7	9.4
1620	39.6	27.0	40.0	- 3.4	-21.1	8.0
1680	39.1	26.3	39.5	- 4.5	-22.6	6.7
1740	38.6	25.5	39.0	- 5.6	-24.1	5.3
1800	38.1	24.7	38.6	- 6.7	-25.1	3.9

TABLE 3-35 - COMPARISON OF SOFT CAPACITY AND SOURCE VALUES
+100% PERTURBATION, 32 SOFT CAPACITIES AND 4 SOFT SOURCES
NASA/MSC 50-NODE MODEL, NOISE 1/2%, KALØBS

CAPACITOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	KALOBS CORRECTIONS	PERCENTAGE OFF
5	6.80000-02	1.36000-01	6.82710-02	3.98587-01
6	4.45000-02	8.90000-02	2.17733-02	5.10713+01
7	6.80000-02	1.36000-01	6.82710-02	3.98602-01
8	4.45000-02	8.90000-02	4.46917-02	4.30691-01
21	3.25000-02	6.50000-02	3.42123-02	5.26850+00
22	2.00000-02	4.00000-02	2.11040-02	5.51979+00
23	3.25000-02	6.50000-02	3.42069-02	5.25199+00
24	2.00000-02	4.00000-02	2.09563-02	4.78133+00
25	1.95000-02	3.90000-02	2.27885-02	1.68640+01
26	1.18000-02	2.36000-02	1.45321-02	2.31533+01
39	7.20000-01	1.44000+00	9.01081-01	2.51502+01
27	1.95000-02	3.90000-02	2.29495-02	1.76898+01
28	1.18000-02	2.36000-02	1.34952-02	1.43663+01
29	3.54000-02	7.08000-02	4.65126-02	3.13916+01
45	2.90000-02	5.80000-02	2.95744-02	1.98057+00
46	2.79000-02	5.58000-02	2.82098-02	1.11046+00
47	4.27000-02	8.54000-02	4.34317-02	1.71358+00
48	2.79000-02	5.58000-02	1.34494-02	5.17941+01
49	9.17000-02	1.83400-01	9.81411-02	7.02414+00
51	1.01000-02	2.02000-02	1.09886-02	8.79805+00
52	1.01000-02	2.02000-02	1.09886-02	8.79805+00
53	1.01000-02	2.02000-02	1.09886-02	8.79805+00
54	1.01000-02	2.02000-02	1.09886-02	8.79805+00
61	2.20400-01	4.40800-01	2.45774-01	1.15126+01
63	6.84000-02	1.36800-01	8.94129-02	3.07206+01
67	6.84000-02	1.36800-01	8.69974-02	2.71892+01
81	9.52000-02	1.90400-01	1.12061-01	1.77114+01
82	9.80000-02	1.96000-01	1.18083-01	2.04932+01
83	6.64000-02	1.32800-01	8.10080-02	2.20000+01
84	6.64000-02	1.32800-01	8.25116-02	2.42644+01
85	8.58000-02	1.71600-01	1.09858-01	2.80400+01
86	9.52000-02	1.90400-01	1.11973-01	1.76186+01
87	6.68000-02	1.33600-01	7.95340-02	1.90628+01
88	6.64000-02	1.32800-01	8.05682-02	2.13377+01
89	6.64000-02	1.32800-01	8.22463-02	2.38650+01
90	6.58000-02	1.31600-01	8.43506-02	2.81925+01
91	1.01600-01	2.03200-01	1.24634-01	2.26712+01
92	1.26600-01	2.53200-01	1.50613-01	1.89677+01

SOURCE NUMBER	ORIGINAL VALUES	PERTURBED VALUES	KALOBS CORRECTIONS	PERCENTAGE OFF
6	1.00000+00	2.00000+00	4.79714-01	5.20086+01
48	1.00000+00	2.00000+00	4.52464-01	5.47536+01
61	1.00000+00	2.00000+00	1.10109+00	1.01090+01
2	1.00000+00	2.00000+00	1.99998+00	9.99978+01

TABLE 3-36 - COMPARISON OF TEMPERATURES AT END OF TRANSIENT
+100% PERTURBATION, 32 SOFT CAPACITIES AND 4 SOFT SOURCES
NASA/MSC 50-NODE MODEL, NOISE 1/2%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	KALOBS TEMP CORR	PERCENTAGE OFF
5	-6.14031+00	1.25009+01	-6.05442+00	1.89250-02
6	4.56245+01	8.58769+01	1.09731+01	6.85318+00
7	-6.13592+00	1.25032+01	-6.04867+00	1.92238-02
8	-7.33687+00	1.13740+01	-7.22019+00	2.57758-02
21	4.19168+01	4.93126+01	4.29595+01	2.07752-01
22	5.06824+01	6.06675+01	5.97156+01	1.76886+00
23	4.19011+01	4.93221+01	4.29505+01	2.09081-01
24	4.01535+01	4.83854+01	4.12612+01	2.21456-01
25	5.08388+01	5.35002+01	5.14536+01	1.20349-01
26	5.35448+01	5.71074+01	5.21566+01	2.70320-01
39	5.30064+01	5.48324+01	5.28135+01	3.76123-02
27	5.08126+01	5.37391+01	5.16052+01	1.55152-01
28	5.05277+01	5.35381+01	5.11802+01	1.27808-01
29	5.39780+01	5.52152+01	5.44738+01	9.64643-02
45	2.11441+01	3.06278+01	1.93225+01	3.78587-01
46	1.77905+01	2.73307+01	1.70686+01	1.51104-01
47	2.19971+01	3.12134+01	2.05298+01	3.04424-01
48	5.88108+01	9.42028+01	3.49215+01	4.60462+00
49	4.12775+01	4.61546+01	4.01911+01	2.16742-01
51	4.69145+01	5.12693+01	4.71261+01	4.17392-02
52	4.69145+01	5.12693+01	4.71261+01	4.17392-02
53	4.69145+01	5.12693+01	4.71261+01	4.17392-02
54	4.69145+01	5.12693+01	4.71261+01	4.17392-02
61	3.96289+01	4.97626+01	4.15465+01	3.83791-01
63	4.21122+01	5.17637+01	4.42248+01	4.20742-01
67	4.37184+01	5.23899+01	4.56658+01	3.86597-01
81	5.05949+01	5.46295+01	5.17112+01	2.18635-01
82	5.19256+01	5.49019+01	5.28308+01	1.76828-01
83	5.17438+01	5.48904+01	5.27007+01	1.86992-01
84	5.21531+01	5.49499+01	5.30434+01	1.73834-01
85	5.29453+01	5.50174+01	5.36584+01	1.39032-01
86	5.05883+01	5.46538+01	5.16916+01	2.16087-01
87	5.11144+01	5.48723+01	5.20924+01	1.91358-01
88	5.17029+01	5.49742+01	5.26198+01	1.79170-01
89	5.21779+01	5.50305+01	5.30175+01	1.63934-01
90	5.26239+01	5.50301+01	5.33666+01	1.44869-01
91	5.25417+01	5.48523+01	5.33363+01	1.55031-01
92	5.16545+01	5.48360+01	5.26762+01	1.99685-01
1	-9.78656+00	-5.84126+00	-9.35910+00	9.49470-02
2	4.61839+01	9.01143+01	8.72527+01	8.11341+00
3	-9.79270+00	-5.83736+00	-9.36247+00	9.55637-02
4	-6.45116+00	-1.88886+00	-5.94842+00	1.11287-01
71	4.06026+01	5.01676+01	4.24381+01	3.66655-01
72	4.26516+01	5.10182+01	4.43149+01	3.30911-01
73	4.44994+01	5.17801+01	4.60066+01	2.98757-01
74	4.56856+01	5.22556+01	4.70882+01	2.77367-01
75	4.62800+01	5.24818+01	4.76259+01	2.65855-01
76	4.05778+01	5.01701+01	4.24139+01	3.66794-01
77	4.25740+01	5.10260+01	4.42392+01	3.31336-01
78	4.44175+01	5.17982+01	4.59219+01	2.98253-01
79	4.55954+01	5.22780+01	4.69939+01	2.76594-01
80	4.61710+01	5.25035+01	4.75155+01	2.65633-01

TABLE 3-37 - COMPARISON OF TRANSIENT TEMPERATURES WITH ORIGINAL, PERTURBED, AND CORRECTED CAPACITY AND SOURCE VALUES, NODES 61 AND 6, NASA/MSC 50-NODE MODEL, +100% PERTURBATION, 100 SOFT CONDUCTORS, NOISE 1/2%, KALØBS

	NODE 61			NODE 6		
TIME (SEC)	ORIGINAL (°F)	PERTURBED (°F)	CORRECTED (°F)	ORIGINAL (°F)	PERTURBED (°F)	CORRECTED (°F)
0.0	55.0	55.0	55.0	55.0	55.0	55.0
60	64.2	60.1	63.4	56.5	57.9	53.4
120	60.6	59.4	60.4	57.7	60.6	51.8
180	58.2	58.6	58.3	58.6	63.2	50.2
240	56.5	58.0	56.7	59.4	65.5	48.7
300	55.2	57.5	55.5	59.9	67.7	47.1
360	54.2	57.0	54.5	60.3	69.7	45.5
420	53.2	56.6	53.7	60.5	71.6	44.0
480	52.4	56.2	52.9	60.6	73.3	42.4
540	51.6	55.8	52.2	60.6	74.9	40.9
600	50.9	55.5	51.6	60.4	76.3	39.4
660	50.1	55.2	51.0	60.1	77.6	37.9
720	49.5	54.9	50.4	59.8	78.8	36.4
780	48.8	54.6	49.8	59.3	79.9	34.9
840	48.2	54.3	49.2	58.8	80.9	33.4
900	47.5	54.0	48.7	58.3	81.7	31.9
960	46.9	53.7	48.2	57.6	82.5	30.4
1020	46.4	53.4	47.6	56.9	83.2	29.0
1080	45.8	53.1	47.1	56.2	83.8	27.5
1140	45.2	52.8	46.6	55.5	84.3	26.1
1200	44.7	52.5	46.1	54.7	84.7	24.6
1260	44.1	52.2	45.6	53.8	85.1	23.2
1320	43.6	52.0	45.2	53.0	85.4	21.8
1380	43.1	51.7	44.7	52.1	85.6	20.4
1440	42.6	51.4	44.2	51.2	85.8	19.0
1500	42.1	51.1	43.7	50.3	85.9	17.7
1560	41.6	50.9	43.3	49.4	86.0	16.3
1620	41.1	50.6	42.9	48.5	86.0	15.0
1680	40.6	50.3	42.4	47.5	86.0	13.6
1740	40.1	50.0	42.0	46.6	86.0	12.3
1800	39.6	49.8	41.5	45.6	85.9	11.0

TABLE 3-38 - COMPARISON OF SOFT CONDUCTOR, CAPACITY AND SOURCE VALUES, 42 CONDUCTORS, 5 CAPACITIES AND 3 SOURCES +100% PERTURBATION, NASA/MSC 50-NODE MODEL, NOISE 1/2%,KALØBS

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	KALOBS CORRECTIONS	PERCENTAGE OFF
1	5.30000-07	1.06000-06	1.04069-06	9.63570+01
2	4.80000-07	9.60000-07	9.42620-07	9.63792+01
3	7.40000-07	1.48000-06	1.44366-06	9.50897+01
4	4.80000-07	9.60000-07	9.73052-07	1.02719+02
5	1.46000-05	2.92000-05	1.61580-05	1.06713+01
6	1.09000-05	2.18000-05	1.43506-05	3.16565+01
7	1.49000-05	2.98000-05	1.94412-05	3.04781+01
8	1.09000-05	2.18000-05	1.44539-05	3.26046+01
9	3.35000-04	6.70000-04	-4.73776-03	1.51426+03
10	2.56000-04	5.12000-04	4.79716-03	1.77389+03
11	1.28000-03	2.56000-03	5.67697-03	3.43513+02
12	1.28000-03	2.56000-03	-3.44316-03	3.68997+02
13	2.71000-05	5.42000-05	-2.55336-04	1.04220+03
14	2.71000-05	5.42000-05	-2.62201-04	1.06753+03
15	2.14000-05	4.28000-05	3.92989-04	1.73640+03
16	5.42000-05	1.08400-04	2.58898-04	3.77671+02
18	7.00000-08	1.40000-07	6.95341-08	6.65517-01
19	7.00000-08	1.40000-07	-1.01776-08	1.14539+02
20	7.00000-08	1.40000-07	7.03343-08	4.77608-01
40	4.60000-07	9.20000-07	4.86138-07	5.68212+00
41	4.60000-07	9.20000-07	9.20046-07	1.00010+02
42	4.60000-07	9.20000-07	9.19967-07	9.99929+01
43	4.60000-07	9.20000-07	4.86138-07	5.68223+00
44	5.52000-07	1.10400-06	1.10399-06	9.99975+01
45	5.52000-07	1.10400-06	1.10378-06	9.99594+01
46	5.52000-07	1.10400-06	1.10400-06	9.99992+01
47	5.52000-07	1.10400-06	1.10400-06	9.99998+01
48	4.69000-06	9.38000-06	4.95540-06	5.65891+00
49	1.25900-06	2.51800-06	2.52137-06	1.00268+02
50	4.69000-06	9.38000-06	9.39601-06	1.00341+02
51	1.25900-06	2.51800-06	2.52038-06	1.00189+02
52	1.07200-06	2.14400-06	2.14395-06	9.99957+01
53	5.11000-07	1.02200-06	1.02198-06	9.99962+01
54	1.07200-06	2.14400-06	2.14451-06	1.00047+02
55	5.11000-07	1.02200-06	1.02210-06	1.00019+02
73	5.86000-07	1.17200-06	1.17127-06	9.98761+01
74	5.09000-07	1.01800-06	1.01256-06	9.89314+01
75	6.45000-07	1.29000-06	1.27529-06	9.77189+01
80	2.87900-06	5.75800-06	5.62522-06	9.53879+01
81	1.50500-06	3.01000-06	2.97355-06	9.75778+01
82	4.40700-06	8.81400-06	8.63338-06	9.59015+01
83	1.38900-06	2.77800-06	3.65944-06	1.63459+02

TABLE 3-38 (Cont.)

CAPACITOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	KALOBS CORRECTIONS	PERCENTAGE OFF
5	6.80000-02	1.36000-01	6.82708-02	3.98257-01
6	4.45000-02	8.90000-02	2.17844-02	5.10462+01
7	6.80000-02	1.36000-01	6.83123-02	4.59237-01
6	4.45000-02	8.90000-02	4.46917-02	4.30679-01
21	3.25000-02	6.50000-02	3.43466-02	5.68184+00

SOURCE NUMBER	ORIGINAL VALUES	PERTURBED VALUES	KALOBS CORRECTIONS	PERCENTAGE OFF
6	1.00000+00	2.00000+00	4.80361-01	5.19639+01
48	1.00000+00	2.00000+00	9.46890-01	5.31103+00
61	1.00000+00	2.00000+00	1.78365+00	7.83652+01

TABLE 3-3[illegible] - COMPARISON OF TEMPERATURES AT END OF TRANSIENT
+100% PERTURBATION, 42 SOFT CONDUCTORS, 5 CAPACITIES, 3 SOURCES
NASA/MSC 50-NODE MODEL, NOISE 1/2%, KALØBS

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	KALOBS TEMP CORR	PERCENTAGE OFF
5	-6.14069+00	1.27566+01	-5.40021+00	1.63153-01
6	4.52956+01	8.52653+01	1.07783+01	6.83112+00
7	-6.13638+00	1.27572+01	-5.38301+00	1.65991-01
8	-7.33712+00	1.16069+01	-6.52887+00	1.78554-01
21	4.18651+01	4.90275+01	4.45720+01	5.39362-01
22	4.05274+01	4.51448+01	4.33858+01	5.71092-01
23	4.18487+01	4.56901+01	4.44845+01	5.25205-01
24	4.01045+01	4.47082+01	4.32766+01	6.34300-01
25	5.08303+01	5.25239+01	4.91280+01	3.33227-01
26	5.34625+01	5.72732+01	5.17742+01	3.28812-01
39	5.30061+01	5.43062+01	5.28334+01	3.36628-02
27	5.07971+01	5.25492+01	4.97870+01	1.97757-01
28	5.05129+01	5.25582+01	5.09736+01	9.02531-02
29	5.39637+01	5.49812+01	5.44192+01	8.86363-02
45	2.11440+01	2.50844+01	2.15964+01	9.40253-02
46	1.77905+01	1.99053+01	1.83993+01	1.27437-01
47	2.19970+01	2.53444+01	2.24565+01	9.53276-02
48	5.88107+01	9.18617+01	5.70534+01	3.38727-01
49	4.12775+01	4.40777+01	4.13517+01	1.48166-02
51	4.69146+01	4.76961+01	4.69493+01	6.86686-03
52	4.69145+01	4.76961+01	4.69493+01	6.86686-03
53	4.69145+01	4.76961+01	4.69493+01	6.86686-03
54	4.69145+01	4.76961+01	4.69493+01	6.86686-03
61	3.94608+01	4.76752+01	4.75313+01	1.61584+00
63	4.19759+01	4.86061+01	4.77313+01	1.14655+00
67	4.36000+01	4.92783+01	4.77468+01	8.23431-01
81	5.05493+01	5.28387+01	4.95488+01	1.95966-01
82	5.18919+01	5.40644+01	5.33509+01	2.85015-01
83	5.17079+01	5.39776+01	5.34100+01	3.32622-01
84	5.21212+01	5.41407+01	5.36091+01	2.90531-01
85	5.29210+01	5.44679+01	5.39695+01	2.04419-01
86	5.05415+01	5.28779+01	4.94962+01	2.04730-01
87	5.10683+01	5.38558+01	5.28903+01	3.56508-01
88	5.16628+01	5.41186+01	5.33765+01	3.34915-01
89	5.21425+01	5.42997+01	5.36111+01	2.86746-01
90	5.25934+01	5.44416+01	5.38040+01	2.36162-01
91	5.25215+01	5.36446+01	4.91335+01	6.61053-01
92	5.16246+01	5.30409+01	5.01227+01	2.93552-01
1	-9.80755+00	-6.13[illegible]57+00	-9.00810+00	1.77581-01
2	-3.80858+00	-7.19380-02	-4.44906+00	1.40398-01
3	-9.81398+00	-7.47600+00	-9.04263+00	1.71339-01
4	-6.47331+00	-3.69198+00	-5.31114+00	2.56252-01
71	4.04451+01	4.79377+01	4.76444+01	1.43857+00
72	4.25165+01	4.90419+01	4.86970+01	1.22991+00
73	4.43844+01	5.00345+01	4.76538+01	1.04472+00
74	4.55835+01	5.06656+01	5.02653+01	9.26021-01
75	4.61842+01	5.09768+01	5.05686+01	8.66163-01
76	4.04197+01	4.79377+01	4.77100+01	1.45685+00
77	4.24372+01	4.90419+01	4.87186+01	1.25[illegible]18+00
78	4.43003+01	5.00531+01	4.96600+01	1.06280+00
79	4.54907+01	5.06917+01	5.02594+01	9.43371-01
80	4.60724+01	5.09[illegible]87+01	5.05497+01	8.84723-01

TABLE 3-40 - COMPARISON OF TRANSIENT TEMPERATURES WITH ORIGINAL, PERTURBED AND CORRECTED CONDUCTOR, CAPACITY AND SOURCE VALUES
42 SOFT CONDUCTORS, 5 SOFT CAPACITORS & 3 SOFT HEAT SOURCES
+100% PERTURBATION, NASA/MSC 50-NODE MODEL, NOISE 1/2%, KALØBS

	NODE 61			NODE 48		
TIME	ORIGINAL (°F)	PERTURBED (°F)	CORRECTED (°F)	ORIGINAL (°F)	PERTURBED (°F)	CORRECTED (°F)
0.0	55.0	55.0	55.0	55.0	55.0	55.0
60	64.2	62.8	58.0	59.8	65.9	59.1
120	60.5	60.3	57.1	63.6	74.7	62.4
180	58.1	59.0	56.4	66.5	81.6	64.9
240	56.5	58.2	55.9	68.7	87.1	66.9
300	55.2	57.5	55.5	70.3	91.3	68.3
360	54.1	56.9	55.1	71.4	94.5	69.3
420	53.2	56.4	54.8	72.1	96.8	70.0
480	52.3	55.9	54.5	72.5	98.5	70.4
540	51.5	55.4	54.1	72.6	99.7	70.5
600	50.8	54.9	53.8	72.6	100	70.5
660	50.1	54.5	53.6	72.4	100	70.3
720	49.4	54.1	53.3	72	101	70
780	48.7	53.7	53	71.6	101	69.6
840	48.1	53.3	52.7	71.1	101	69.1
900	47.4	52.9	52.4	70.5	100	68.5
960	46.8	52.5	52	69.8	100	67.9
1020	46.2	52.1	51.7	69.1	99.9	67.3
1080	45.7	51.8	51.4	68.4	99.4	66.6
1140	45.1	51.4	51.1	67.7	98.9	65.8
1200	44.5	51.1	50.8	66.9	98.3	65.1
1260	44.0	50.7	50.5	66.1	97.7	64.3
1320	43.4	50.4	50.1	65.3	97.1	63.5
1380	42.9	50.0	49.8	64.5	96.4	62.7
1440	42.4	49.7	49.5	63.7	97.8	61.9
1500	41.9	49.3	49.2	62.9	95.1	61.1
1560	41.4	49	48.8	62.1	94.5	60.3
1620	40.9	48.6	48.5	61.2	93.8	59.5
1680	40.4	48.3	48.2	60.4	93.1	58.7
1740	39.9	48.0	47.8	59.6	92.5	57.8
1800	39.4	47.6	47.5	58.8	91.8	57.0

TABLE 3-41 COMPARISON OF SOFT CONDUCTOR, CAPACITY AND SOURCE VALUES
19 CONDUCTORS, 2 CAPACITIES AND 2 HEAT SOURCES
+50% PERTURBATION, NASA/MSC 50-NODE MODEL, NOISE 1%, KALFIL

CAPACITOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	KALFIL CORRECTIONS	PERCENTAGE OFF
39	7.20000-01	1.08000+00	9.01101-01	2.51529+01
61	2.20400-01	3.30600-01	9.97998-01	3.52812+02
SOURCE NUMBER	**ORIGINAL VALUES**	**PERTURBED VALUES**	**KALFIL CORRECTIONS**	**PERCENTAGE OFF**
6	1.00000+00	1.50000+00	1.00020+00	2.00316-02
48	1.00000+00	1.50000+00	1.00083+00	8.33705-02
CONDUCTOR NUMBER	**ORIGINAL VALUES**	**PERTURBED VALUES**	**KALFIL CORRECTIONS**	**PERCENTAGE OFF**
15	2.14000-05	3.21000-05	-1.49615-05	-1.69914+02
16	5.42000-05	8.13000-05	1.05579-05	-8.05204+01
20	7.00000-08	1.05000-07	1.04873-07	4.98184+01
40	4.60000-07	6.90000-07	6.59250-07	4.33152+01
41	4.60000-07	6.90000-07	6.57916-07	4.30252+01
42	4.60000-07	6.90000-07	6.86716-07	4.92860+01
43	4.60000-07	6.90000-07	6.86697-07	4.92820+01
49	1.25900-06	1.88850-06	1.83059-06	4.54007+01
53	5.11000-07	7.66500-07	7.68810-07	5.04521+01
73	5.86000-07	8.79000-07	8.99258-07	5.34570+01
80	2.87900-06	4.31850-06	3.72790-06	2.94684+01
113	7.00000-08	1.05000-07	1.04873-07	4.98185+01
115	4.48000-06	6.72000-06	3.06785-06	-3.15212+01
215	6.05400-04	9.08100-04	2.51485-04	-5.84597+01
220	6.05400-04	9.08100-04	2.25369-04	-6.27735+01
330	9.65000-14	1.44750-13	9.65960-14	1.01554-01
334	9.65000-14	1.44750-13	9.65991-14	1.02671-01
562	2.36300-14	3.54450-14	6.93875-16	-9.70636+01
605	2.67000-15	4.00500-15	4.80073-15	7.98025+01

TABLE 3-42 COMPARISON OF TEMPERATURES AT END OF TRANSIENT
19 SOFT CONDUCTORS, 2 SOFT CAPACITIES & 2 SOFT HEAT SOURCES
+50% PERTURBATION, NASA/MSC 50-NODE MODEL, NOISE 1%, KALFIL

NODE NUMBER	ORIGINAL TEMPERATURE	PERTURBED TEMPERATURE	KALFIL TEMP CORR	PERCENTAGE OFF
5	1.10499+01	-2.53627+00	1.10185+01	-6.65267-03
6	5.46673+01	7.48480+01	5.46798+01	2.42779-03
7	1.10540+01	-2.53120+00	1.10213+01	-6.94948-03
8	1.00169+01	9.98914+00	1.00189+01	4.36696-04
21	4.76140+01	4.79018+01	4.86703+01	2.08093-01
22	5.44087+01	5.52724+01	5.53847+01	1.89731-01
23	4.76087+01	4.79039+01	4.86848+01	2.11993-01
24	4.64500+01	4.68740+01	4.77111+01	2.49001-01
25	5.29504+01	5.23436+01	5.29894+01	7.61470-03
26	5.53161+01	5.65930+01	5.55503+01	4.54508-02
39	5.43412+01	5.47892+01	5.44897+01	2.49938-02
27	5.31863+01	5.26902+01	5.32914+01	2.04821-02
28	5.29896+01	5.30411+01	5.32085+01	4.26847-02
29	5.51220+01	5.51921+01	5.53509+01	4.43408-02
45	3.15402+01	3.29910+01	3.15676+01	5.56889-03
46	2.90573+01	2.96484+01	2.90675+01	2.07366-03
47	3.22155+01	3.33751+01	3.22283+01	2.60210-03
48	6.69400+01	8.33929+01	6.69790+01	7.40494-03
49	4.91228+01	5.01962+01	4.91360+01	2.58807-03
51	5.29642+01	5.31653+01	5.29649+01	1.23819-04
52	5.29642+01	5.31653+01	5.29649+01	1.23819-04
53	5.29642+01	5.31653+01	5.29649+01	1.23819-04
54	5.29642+01	5.31653+01	5.29649+01	1.23819-04
61	4.46793+01	4.64695+01	5.07835+01	1.20951+00
63	4.71408+01	4.67542+01	5.20217+01	9.62929-01
67	4.83907+01	4.98979+01	5.23495+01	7.78695-01
81	5.33566+01	5.37552+01	5.44595+01	2.14842-01
82	5.41241+01	5.43149+01	5.50457+01	1.79253-01
83	5.40418+01	5.42653+01	5.50479+01	1.95710-01
84	5.42369+01	5.44335+01	5.51124+01	1.70250-01
85	5.45555+01	5.46966+01	5.51799+01	1.21358-01
86	5.33732+01	5.37732+01	5.45306+01	2.25457-01
87	5.37628+01	5.40834+01	5.50091+01	2.42580-01
88	5.40891+01	5.43595+01	5.51503+01	2.06429-01
89	5.42988+01	5.45303+01	5.52156+01	1.78261-01
90	5.44238+01	5.46242+01	5.52120+01	1.53215-01
91	5.42681+01	5.42032+01	5.46824+01	8.05650-02
92	5.40074+01	5.39582+01	5.47091+01	1.36520-01
1	1.87147+00	1.30444+00	2.28067+00	8.85961-02
2	5.44127+01	5.54666+01	5.46907+01	5.40440-02
3	1.86962+00	1.30553+00	2.28644+00	9.02464-02
4	4.86543+00	5.04828+00	5.41281+00	1.17750-01
71	4.54257+01	4.71291+01	5.10598+01	1.11473+00
72	4.69937+01	4.80500+01	5.24582+01	1.07781+00
73	4.84013+01	4.92907+01	5.29798+01	9.00565-01
74	4.92896+01	5.00729+01	5.33057+01	7.88559-01
75	4.97209+01	5.04517+01	5.34596+01	7.33468-01
76	4.54171+01	4.71256+01	5.10526+01	1.11502+00
77	4.69668+01	4.80417+01	5.25728+01	1.10579+00
78	4.83797+01	4.92925+01	5.30881+01	9.26164-01
79	4.92669+01	5.00769+01	5.34083+01	8.13193-01
80	4.96894+01	5.04494+01	5.35564+01	7.58701-01

TABLE 3-43 - COMPARISON OF SOFT CONDUCTOR VALUES
+100% PERTURBATION, 481 SOFT CONDUCTORS
NASA/MSC 500-NODE MODEL, NOISE 1/2%, KALØBS

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF
2	1.72000-04	3.44000-04	3.41250-04	9.84013+01
3	1.72000-04	3.44000-04	3.46011-04	1.01169+02
4	1.72000-04	3.44000-04	3.43181-04	9.95239+01
5	1.72000-04	3.44000-04	3.44723-04	1.00420+02
6	1.72000-04	3.44000-04	3.44725-04	1.00422+02
7	1.72000-04	3.44000-04	3.43177-04	9.95214+01
8	1.72000-04	3.44000-04	3.46260-04	1.01314+02
9	1.72000-04	3.44000-04	3.40860-04	9.81743+01
14	2.98000-04	5.96000-04	5.95930-04	9.99764+01
15	1.72000-04	3.44000-04	3.43970-04	9.99826+01
10	1.72000-04	3.44000-04	3.41041-04	9.82797+01
11	1.72000-04	3.44000-04	3.46243-04	1.01304+02
12	1.72000-04	3.44000-04	3.43777-04	9.98703+01
13	2.98000-04	5.96000-04	5.95939-04	9.99794+01
16	1.72000-04	3.44000-04	3.46155-04	1.01253+02
17	1.72000-04	3.44000-04	3.41052-04	9.82863+01
18	1.72000-04	3.44000-04	3.41079-04	9.83017+01
19	1.72000-04	3.44000-04	3.46211-04	1.01285+02
20	1.72000-04	3.44000-04	3.43170-04	9.95173+01
21	1.72000-04	3.44000-04	3.44730-04	1.00425+02
22	1.72000-04	3.44000-04	3.44725-04	1.00422+02
23	1.72000-04	3.44000-04	3.43182-04	9.95241+01
24	1.72000-04	3.44000-04	3.46244-04	1.01305+02
25	1.72000-04	3.44000-04	3.40933-04	9.82169+01
26	1.72000-04	3.44000-04	3.40855-04	9.81715+01
27	1.72000-04	3.44000-04	3.46265-04	1.01317+02
28	1.72000-04	3.44000-04	3.43786-04	9.98756+01
29	2.98000-04	5.96000-04	5.95958-04	9.99859+01
30	2.98000-04	5.96000-04	5.95947-04	9.99824+01
31	1.72000-04	3.44000-04	3.43934-04	9.99618+01
32	1.72000-04	3.44000-04	3.46024-04	1.01177+02
33	1.87000-04	3.74000-04	3.74000-04	1.00000+02
34	1.87000-04	3.74000-04	3.74000-04	1.00000+02
35	1.87000-04	3.74000-04	3.74000-04	1.00000+02
36	1.87000-04	3.74000-04	3.74000-04	1.00000+02
50	1.72000-04	3.44000-04	3.42364-04	9.90489+01
51	1.72000-04	3.44000-04	3.42884-04	9.93509+01
52	1.72000-04	3.44000-04	3.44909-04	1.00529+02
53	1.72000-04	3.44000-04	3.43566-04	9.97479+01
54	1.72000-04	3.44000-04	3.44374-04	1.00218+02
55	1.72000-04	3.44000-04	3.44008-04	1.00005+02
56	1.72000-04	3.44000-04	3.43992-04	9.99954+01
57	1.72000-04	3.44000-04	3.45085-04	1.00631+02
58	1.72000-04	3.44000-04	3.42503-04	9.91296+01
59	1.72000-04	3.44000-04	3.42899-04	9.93599+01
60	1.72000-04	3.44000-04	3.44875-04	1.00508+02
61	1.72000-04	3.44000-04	3.43589-04	9.97611+01
62	1.72000-04	3.44000-04	3.44343-04	1.00199+02
63	1.72000-04	3.44000-04	3.43962-04	9.99780+01
64	1.72000-04	3.44000-04	3.44037-04	1.00021+02
65	1.72000-04	3.44000-04	3.45018-04	1.00592+02

TABLE 3-43 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF
66	1.72000-04	3.44000-04	3.42485-04	9.91192+01
67	1.72000-04	3.44000-04	3.43131-04	9.94949+01
68	1.72000-04	3.44000-04	3.44757-04	1.00440+02
69	1.72000-04	3.44000-04	3.43575-04	9.97529+01
70	1.72000-04	3.44000-04	3.44370-04	1.00215+02
71	1.72000-04	3.44000-04	3.44009-04	1.00005+02
72	1.72000-04	3.44000-04	3.43991-04	9.99948+01
73	1.72000-04	3.44000-04	3.45143-04	1.00664+02
74	1.72000-04	3.44000-04	3.42382-04	9.90594+01
75	1.72000-04	3.44000-04	3.42883-04	9.93505+01
76	1.72000-04	3.44000-04	3.44897-04	1.00521+02
77	1.72000-04	3.44000-04	3.43571-04	9.97505+01
78	1.72000-04	3.44000-04	3.44366-04	1.00213+02
79	1.72000-04	3.44000-04	3.44024-04	1.00014+02
80	1.72000-04	3.44000-04	3.43975-04	9.99854+01
81	1.72000-04	3.44000-04	3.45148-04	1.00668+02
82	1.87000-04	3.74000-04	3.74000-04	1.00000+02
83	1.87000-04	3.74000-04	3.74000-04	1.00000+02
84	1.87000-04	3.74000-04	3.74000-04	1.00000+02
85	1.87000-04	3.74000-04	3.74000-04	1.00000+02
1210	4.82000-04	9.64000-04	9.14852-04	8.98033+01
1212	8.30000-04	1.66000-03	1.51312-03	8.23032+01
1215	6.58000-04	1.31600-03	1.29786-03	9.72424+01
1217	6.58000-04	1.31600-03	1.31396-03	9.96899+01
1219	6.58000-04	1.31600-03	1.31585-03	9.99768+01
1221	6.58000-04	1.31600-03	1.31599-03	9.99989+01
1223	6.58000-04	1.31600-03	1.31600-03	1.00001+02
1225	8.30000-04	1.66000-03	1.66008-03	1.00009+02
1227	4.20000-04	8.40000-04	8.39673-04	9.99222+01
1228	1.17800-03	2.35600-03	2.36171-03	1.00484+02
1231	4.58000-04	9.16000-04	9.46608-04	1.06683+02
1233	5.16000-04	1.03200-03	1.17192-03	1.27116+02
1235	4.83000-04	9.66000-04	9.29946-04	9.25354+01
1252	4.82000-04	9.64000-04	9.16298-04	9.01032+01
1254	8.30000-04	1.66000-03	1.51540-03	8.25788+01
1257	6.58000-04	1.31600-03	1.29811-03	9.72808+01
1259	6.58000-04	1.31600-03	1.31399-03	9.96942+01
1261	6.58000-04	1.31600-03	1.31585-03	9.99771+01
1263	6.58000-04	1.31600-03	1.31599-03	9.99989+01
1265	6.58000-04	1.31600-03	1.31600-03	1.00001+02
1267	8.30000-04	1.66000-03	1.66008-03	1.00009+02
1269	4.20000-04	8.40000-04	8.39673-04	9.99222+01
1270	1.17800-03	2.35600-03	2.36154-03	1.00470+02
1272	4.58000-04	9.16000-04	9.45160-04	1.06367+02
1274	5.16000-04	1.03200-03	1.16652-03	1.26069+02
1276	4.83000-04	9.66000-04	9.33282-04	9.32260+01
1410	4.82000-04	9.64000-04	9.12753-04	8.93678+01
1412	8.30000-04	1.66000-03	1.50910-03	8.18191+01
1415	6.58000-04	1.31600-03	1.29739-03	9.71724+01
1417	6.58000-04	1.31600-03	1.31390-03	9.96816+01
1419	6.58000-04	1.31600-03	1.31584-03	9.99763+01

TABLE 3-43 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF
1421	6.58000-04	1.31600-03	1.31599-03	9.99989+01
1423	6.58000-04	1.31600-03	1.31600-03	1.00001+02
1425	8.30000-04	1.66000-03	1.66008-03	1.00009+02
1427	4.20000-04	8.40000-04	8.39678-04	9.99232+01
1428	1.17800-03	2.35600-03	2.36160-03	1.00476+02
1431	4.58000-04	9.16000-04	9.45980-04	1.06546+02
1433	5.16000-04	1.03200-03	1.16992-03	1.26729+02
1435	4.83000-04	9.66000-04	9.31190-04	9.27929+01
1452	4.82000-04	9.64000-04	9.14066-04	8.96402+01
1454	8.30000-04	1.66000-03	1.51081-03	8.20250+01
1457	6.58000-04	1.31600-03	1.29757-03	9.71996+01
1459	6.58000-04	1.31600-03	1.31392-03	9.96845+01
1461	6.58000-04	1.31600-03	1.31585-03	9.99765+01
1463	6.58000-04	1.31600-03	1.31599-03	9.99989+01
1465	6.58000-04	1.31600-03	1.31600-03	1.00001+02
1467	8.30000-04	1.66000-03	1.66008-03	1.00009+02
1469	4.20000-04	8.40000-04	8.39678-04	9.99232+01
1470	1.17800-03	2.35600-03	2.36147-03	1.00464+02
1472	4.58000-04	9.16000-04	9.44831-04	1.06295+02
1474	5.16000-04	1.03200-03	1.16556-03	1.25884+02
1476	4.83000-04	9.66000-04	9.33836-04	9.33408+01
1610	4.82000-04	9.64000-04	9.26954-04	9.23140+01
1612	8.30000-04	1.66000-03	1.53597-03	8.50561+01
1615	6.58000-04	1.31600-03	1.30040-03	9.76289+01
1617	6.58000-04	1.31600-03	1.31425-03	9.97333+01
1619	6.58000-04	1.31600-03	1.31587-03	9.99796+01
1621	6.58000-04	1.31600-03	1.31599-03	9.99990+01
1623	6.58000-04	1.31600-03	1.31600-03	1.00001+02
1625	8.30000-04	1.66000-03	1.66008-03	1.00009+02
1627	4.20000-04	8.40000-04	8.39681-04	9.99242+01
1628	1.17800-03	2.35600-03	2.36157-03	1.00473+02
1631	4.58000-04	9.16000-04	9.45930-04	1.06535+02
1633	5.16000-04	1.03200-03	1.16996-03	1.26736+02
1635	4.83000-04	9.66000-04	9.31163-04	9.27873+01
1652	4.82000-04	9.64000-04	9.14674-04	8.97664+01
1654	8.30000-04	1.66000-03	1.51135-03	8.20909+01
1657	6.58000-04	1.31600-03	1.29763-03	9.72079+01
1659	6.58000-04	1.31600-03	1.31393-03	9.96853+01
1661	6.58000-04	1.31600-03	1.31585-03	9.99765+01
1663	6.58000-04	1.31600-03	1.31599-03	9.99989+01
1665	6.58000-04	1.31600-03	1.31600-03	1.00001+02
1667	8.30000-04	1.66000-03	1.66008-03	1.00009+02
1669	4.20000-04	8.40000-04	8.39681-04	9.99242+01
1670	1.17800-03	2.35600-03	2.36135-03	1.00454+02
1672	4.58000-04	9.16000-04	9.44039-04	1.06122+02
1674	5.16000-04	1.03200-03	1.16271-03	1.25331+02
1676	4.83000-04	9.66000-04	9.35499-04	9.36852+01
1810	4.82000-04	9.64000-04	9.13954-04	8.96170+01
1812	8.30000-04	1.66000-03	1.51114-03	8.20654+01
1815	6.58000-04	1.31600-03	1.29763-03	9.72077+01
1817	6.58000-04	1.31600-03	1.31393-03	9.96857+01

TABLE 3-43 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF
1819	6.58000-04	1.31600-03	1.31585-03	9.99765+01
1821	6.58000-04	1.31600-03	1.31599-03	9.99989+01
1823	6.58000-04	1.31600-03	1.31600-03	1.00001+02
1825	8.30000-04	1.66000-03	1.66008-03	1.00009+02
1827	4.20000-04	8.40000-04	8.39673-04	9.99222+01
1828	1.17800-03	2.35600-03	2.36170-03	1.00484+02
1831	4.58000-04	9.16000-04	9.46530-04	1.06666+02
1833	5.16000-04	1.03200-03	1.17156-03	1.27047+02
1835	4.83000-04	9.66000-04	9.30230-04	9.25943+01
1852	4.82000-04	9.64000-04	9.14191-04	8.96661+01
1854	8.30000-04	1.66000-03	1.51091-03	8.20378+01
1857	6.58000-04	1.31600-03	1.29759-03	9.72014+01
1859	6.58000-04	1.31600-03	1.31392-03	9.96846+01
1861	6.58000-04	1.31600-03	1.31585-03	9.99765+01
1863	6.58000-04	1.31600-03	1.31599-03	9.99989+01
1865	6.58000-04	1.31600-03	1.31600-03	1.00001+02
1867	8.30000-04	1.66000-03	1.66008-03	1.00009+02
1869	4.20000-04	8.40000-04	8.39673-04	9.99222+01
1870	1.17800-03	2.35600-03	2.36153-03	1.00470+02
1872	4.58000-04	9.16000-04	9.45119-04	1.06358+02
1874	5.16000-04	1.03200-03	1.16638-03	1.26042+02
1876	4.83000-04	9.66000-04	9.33398-04	9.32501+01
8011	2.74000-03	5.48000-03	5.30596-03	9.36482+01
8012	2.74000-03	5.48000-03	5.31039-03	9.38100+01
8013	1.59500-03	3.19000-03	2.34786-03	4.72015+01
8014	1.59500-03	3.19000-03	2.37637-03	4.89888+01
8015	1.59500-03	3.19000-03	2.41701-03	5.15369+01
8016	1.59500-03	3.19000-03	2.48385-03	5.57272+01
8021	3.30000-04	6.60000-04	6.60149-04	1.00045+02
8022	3.30000-04	6.60000-04	6.55585-04	9.86622+01
8023	3.30000-04	6.60000-04	8.91591-04	1.70179+02
8024	3.30000-04	6.60000-04	9.06221-04	1.74612+02
8025	3.30000-04	6.60000-04	8.68048-04	1.63045+02
8026	3.30000-04	6.60000-04	8.46808-04	1.56609+02
8031	4.32000-05	8.64000-05	9.67564-05	1.23973+02
8032	4.32000-05	8.64000-05	9.67568-05	1.23974+02
8033	4.32000-05	8.64000-05	9.67286-05	1.23909+02
8034	4.32000-05	8.64000-05	9.67271-05	1.23905+02
8035	4.32000-05	8.64000-05	9.67312-05	1.23915+02
8036	4.32000-05	8.64000-05	9.67330-05	1.23919+02
8041	4.32000-05	8.64000-05	1.22801-06	9.71574+01
8042	4.32000-05	8.64000-05	1.21746-06	9.71818+01
8043	4.32000-05	8.64000-05	1.67380-06	9.61255+01
8044	4.32000-05	8.64000-05	1.70716-06	9.60482+01
8045	4.32000-05	8.64000-05	1.62810-06	9.62312+01
8046	4.32000-05	8.64000-05	1.58727-06	9.63258+01
8051	3.28000-05	6.56000-05	2.28708-05	3.02720+01
8052	3.28000-05	6.56000-05	2.28709-05	3.02716+01
8053	3.28000-05	6.56000-05	2.17095-05	3.38124+01
8054	3.28000-05	6.56000-05	2.17092-05	3.38135+01
8055	3.28000-05	6.56000-05	2.17106-05	3.38092+01

TABLE 3-43 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF	
8056	3.28000-05	6.56000-05	2.17115-05	3.38064+01	
8061	8.00000-06	1.60000-05	4.21080-05	4.26350+02	
8062	8.00000-06	1.60000-05	4.21077-05	4.26346+02	
8063	8.00000-06	1.60000-05	4.45388-05	4.56736+02	
8064	8.00000-06	1.60000-05	4.45397-05	4.56746+02	
8065	8.00000-06	1.60000-05	4.45362-05	4.56702+02	
8066	8.00000-06	1.60000-05	4.45339-05	4.56674+02	
8071	1.69000-05	3.38000-05	-9.12792-04	5.50114+03	*
8072	1.69000-05	3.38000-05	-9.12792-04	5.50113+03	*
8073	1.69000-05	3.38000-05	3.15670+33	3.15670+35	*
8074	1.69000-05	3.38000-05	-9.44588-04	5.68928+03	*
8075	1.69000-05	3.38000-05	-9.44579-04	5.68923+03	*
8076	1.69000-05	3.38000-05	-9.44573-04	5.68919+03	
301	2.42250-12	4.84500-12	2.39079-12	1.30912+00	
302	2.42250-12	4.84500-12	2.39212-12	1.25428+00	
303	2.42250-12	4.84500-12	2.39301-12	1.21714+00	
304	2.42250-12	4.84500-12	2.39212-12	1.25417+00	
305	2.42250-12	4.84500-12	2.39079-12	1.30907+00	
306	2.42250-12	4.84500-12	2.39131-12	1.28747+00	
307	1.48875-12	2.97750-12	1.46270-12	1.74971+00	
308	2.42250-12	4.84500-12	2.39126-12	1.28976+00	
309	2.42250-12	4.84500-12	2.39079-12	1.30913+00	
310	2.42250-12	4.84500-12	2.39211-12	1.25429+00	
311	2.42250-12	4.84500-12	2.39301-12	1.21715+00	
312	2.42250-12	4.84500-12	2.39212-12	1.25418+00	
313	2.42250-12	4.84500-12	2.39079-12	1.30909+00	
314	2.42250-12	4.84500-12	2.39131-12	1.28750+00	
315	1.48875-12	2.97750-12	1.46270-12	1.74974+00	
316	2.42250-12	4.84500-12	2.39126-12	1.28978+00	
317	2.97375-12	5.94750-12	2.93779-12	1.20914+00	
318	2.97375-12	5.94750-12	2.93792-12	1.20490+00	
319	2.97375-12	5.94750-12	2.93777-12	1.20996+00	
320	2.97375-12	5.94750-12	2.93602-12	1.26870+00	
321	2.97375-12	5.94750-12	2.93779-12	1.20914+00	
322	2.97375-12	5.94750-12	2.93792-12	1.20491+00	
323	2.97375-12	5.94750-12	2.93777-12	1.20996+00	
324	2.97375-12	5.94750-12	2.93602-12	1.26874+00	
325	3.12750-12	6.25500-12	3.08001-12	1.51858+00	
326	3.12750-12	6.25500-12	3.08009-12	1.51598+00	
327	3.12750-12	6.25500-12	3.08001-12	1.51858+00	
328	3.12750-12	6.25500-12	3.08008-12	1.51614+00	
330	4.43625-12	8.87250-12	4.36651-12	1.57215+00	
331	5.37000-12	1.07400-11	5.29182-12	1.45587+00	
332	5.37000-12	1.07400-11	5.29232-12	1.44659+00	
333	5.37000-12	1.07400-11	5.29182-12	1.45587+00	
334	4.43625-12	8.87250-12	4.36651-12	1.57216+00	
335	5.37000-12	1.07400-11	5.29157-12	1.46052+00	
336	2.17125-12	4.34250-12	2.13783-12	1.53926+00	
337	5.37000-12	1.07400-11	5.29146-12	1.46257+00	
338	4.43625-12	8.87250-12	4.36648-12	1.57261+00	
339	5.37000-12	1.07400-11	5.29179-12	1.45637+00	

* Associated with arithmetic nodes.

TABLE 3-43 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF
340	5.37000-12	1.07400-11	5.29229-12	1.44712+00
341	5.37000-12	1.07400-11	5.29179-12	1.45636+00
342	4.43625-12	8.87250-12	4.36650-12	1.57238+00
343	5.37000-12	1.07400-11	5.29155-12	1.46094+00
344	2.17125-12	4.34250-12	2.13783-12	1.53930+00
345	5.37000-12	1.07400-11	5.29147-12	1.46230+00
346	5.53125-12	1.10625-11	5.45506-12	1.37740+00
347	5.53125-12	1.10625-11	5.45535-12	1.37212+00
348	5.53125-12	1.10625-11	5.45540-12	1.37124+00
349	5.53125-12	1.10625-11	5.45538-12	1.37171+00
350	5.53125-12	1.10625-11	5.45505-12	1.37755+00
351	5.53125-12	1.10625-11	5.45518-12	1.37533+00
352	5.53125-12	1.10625-11	5.44930-12	1.48160+00
353	5.53125-12	1.10625-11	5.45518-12	1.37534+00
354	5.53125-12	1.10625-11	5.45503-12	1.37801+00
355	5.53125-12	1.10625-11	5.45532-12	1.37266+00
356	5.53125-12	1.10625-11	5.45537-12	1.37178+00
357	5.53125-12	1.10625-11	5.45535-12	1.37223+00
358	5.53125-12	1.10625-11	5.45503-12	1.37793+00
359	5.53125-12	1.10625-11	5.45516-12	1.37572+00
360	5.53125-12	1.10625-11	5.44930-12	1.48160+00
361	5.53125-12	1.10625-11	5.45520-12	1.37484+00
362	2.42250-12	4.84500-12	2.39070-12	1.31259+00
363	2.42250-12	4.84500-12	2.39155-12	1.27773+00
364	2.42250-12	4.84500-12	2.39245-12	1.24063+00
365	2.42250-12	4.84500-12	2.39210-12	1.25506+00
366	2.42250-12	4.84500-12	2.39070-12	1.31262+00
367	2.42250-12	4.84500-12	2.39154-12	1.27791+00
368	2.42250-12	4.84500-12	2.39234-12	1.24498+00
369	2.42250-12	4.84500-12	2.39209-12	1.25526+00
370	2.42250-12	4.84500-12	2.39070-12	1.31264+00
371	2.42250-12	4.84500-12	2.39155-12	1.27774+00
372	2.42250-12	4.84500-12	2.39245-12	1.24065+00
373	2.42250-12	4.84500-12	2.39210-12	1.25507+00
374	2.42250-12	4.84500-12	2.39070-12	1.31261+00
375	2.42250-12	4.84500-12	2.39154-12	1.27791+00
376	2.42250-12	4.84500-12	2.39234-12	1.24497+00
377	2.42250-12	4.84500-12	2.39209-12	1.25522+00
378	2.97375-12	5.94750-12	2.93779-12	1.20920+00
379	2.97375-12	5.94750-12	2.93789-12	1.20575+00
380	2.97375-12	5.94750-12	2.93779-12	1.20922+00
381	2.97375-12	5.94750-12	2.93789-12	1.20584+00
382	2.97375-12	5.94750-12	2.93779-12	1.20922+00
383	2.97375-12	5.94750-12	2.93789-12	1.20575+00
384	2.97375-12	5.94750-12	2.93779-12	1.20922+00
385	2.97375-12	5.94750-12	2.93789-12	1.20583+00
386	3.12750-12	6.25500-12	3.08009-12	1.51595+00
387	3.12750-12	6.25500-12	3.08008-12	1.51610+00
388	3.12750-12	6.25500-12	3.08008-12	1.51610+00
389	3.12750-12	6.25500-12	3.08008-12	1.51610+00
6361	8.45900-12	1.69180-11	9.37620-12	1.03429+01

TABLE 3- 43 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF	
8362	8.45900-12	1.69180-11	9.37620-12	1.08429+01	
8363	8.45900-12	1.69180-11	9.37346-12	1.08105+01	
8364	8.45900-12	1.69180-11	9.37346-12	1.08105+01	
8365	8.45900-12	1.69180-11	9.37347-12	1.08106+01	
8366	8.45900-12	1.69180-11	9.37347-12	1.08106+01	*
8371	1.46000-16	2.92000-16	5.17527-16	2.54471+02	*
8372	1.46000-16	2.92000-16	5.17527-16	2.54471+02	*
8373	1.46000-16	2.92000-16	8.12503+20	5.56509+36	*
8374	1.46000-16	2.92000-16	5.19536-16	2.55846+02	*
8375	1.46000-16	2.92000-16	5.19533-16	2.55845+02	*
8376	1.46000-16	2.92000-16	5.19532-16	2.55844+02	*
938	2.96000-14	5.92000-14	-1.81013+22	6.11529+37	*
939	2.15000-14	4.30000-14	1.80695+23	8.40440+36	*
940	2.15000-14	4.30000-14	1.34847+23	6.27197+36	*
941	1.23000-14	2.46000-14	-4.22888+21	3.43811+37	*
942	1.23000-14	2.46000-14	2.01121-14	6.35134+01	*
943	2.15000-14	4.30000-14	1.12905-13	4.25141+02	*
944	2.15000-14	4.30000-14	9.27543-14	3.31415+02	*
945	2.96000-14	5.92000-14	3.04013-14	2.70717+00	*
946	2.96000-14	5.92000-14	7.19471-15	7.56936+01	*
947	2.15000-14	4.30000-14	9.90620-14	3.60753+02	*
948	2.15000-14	4.30000-14	7.89395-14	2.67161+02	*
949	1.23000-14	2.46000-14	1.51358-14	2.30553+01	*
950	1.23000-14	2.46000-14	-2.03289+22	1.65276+38	*
951	2.15000-14	4.30000-14	1.28109+23	5.95858+36	*
952	2.15000-14	4.30000-14	8.22677+22	3.82640+36	*
953	2.96000-14	5.92000-14	-1.24119+23	4.19320+36	*
954	2.96000-14	5.92000-14	7.19471-15	7.56936+01	*
955	2.15000-14	4.30000-14	9.90620-14	3.60753+02	*
956	2.15000-14	4.30000-14	7.89395-14	2.67161+02	*
957	1.23000-14	2.46000-14	1.51358-14	2.30553+01	*
958	1.23000-14	2.46000-14	1.57040-14	2.76744+01	*
959	2.15000-14	4.30000-14	9.93201-14	3.61954+02	*
960	2.15000-14	4.30000-14	7.91973-14	2.68359+02	*
961	2.96000-14	5.92000-14	4.87624-15	8.35262+01	*
962	2.96000-14	5.92000-14	7.19471-15	7.56936+01	*
963	2.15000-14	4.30000-14	9.90620-14	3.60753+02	*
964	2.15000-14	4.30000-14	7.89395-14	2.67161+02	*
965	1.23000-14	2.46000-14	1.51358-14	2.30553+01	*
966	1.23000-14	2.46000-14	1.57040-14	2.76744+01	*
967	2.15000-14	4.30000-14	9.93201-14	3.61954+02	*
968	2.15000-14	4.30000-14	7.91973-14	2.68359+02	*
969	2.96000-14	5.92000-14	4.87624-15	8.35262+01	*
7020	1.42000-13	2.84000-13	2.84899-13	1.00633+02	
7021	1.74000-13	3.48000-13	3.47299-13	9.95974+01	
7022	1.52000-13	3.04000-13	3.04351-13	1.00231+02	
7023	1.83000-13	3.66000-13	3.71730-13	1.03131+02	
7024	1.52000-13	3.04000-13	3.18830-13	1.09756+02	
7025	1.74000-13	3.48000-13	3.42424-13	9.67954+01	
7120	1.42000-13	2.84000-13	2.86038-13	1.01435+02	
7121	1.74000-13	3.48000-13	3.48483-13	1.00277+02	

* Associated with arithmetic nodes.

TABLE 3-43 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF	
7122	1.52000-13	3.04000-13	3.04832-13	1.00548+02	
7123	1.83000-13	3.66000-13	3.75464-13	1.05171+02	
7124	1.52000-13	3.04000-13	3.33460-13	1.19382+02	
7125	1.74000-13	3.48000-13	3.57884-13	1.05680+02	
7220	1.42000-13	2.84000-13	2.86004-13	1.01411+02	
7221	1.74000-13	3.48000-13	3.45523-13	9.85764+01	
7222	1.52000-13	3.04000-13	3.04813-13	1.00535+02	
7223	1.83000-13	3.66000-13	3.75297-13	1.05080+02	
7224	1.52000-13	3.04000-13	3.32950-13	1.19046+02	
7225	1.74000-13	3.48000-13	3.57177-13	1.05274+02	
7320	1.42000-13	2.84000-13	2.84852-13	1.00600+02	
7321	1.74000-13	3.48000-13	3.47381-13	9.96444+01	
7322	1.52000-13	3.04000-13	3.04335-13	1.00220+02	
7323	1.83000-13	3.66000-13	3.71463-13	1.0298[illegible]+02	
7324	1.52000-13	3.04000-13	3.17608-13	1.08953+02	
7325	1.74000-13	3.48000-13	3.41308-13	9.61539+01	
7026	7.15000-13	1.43000-12	2.19741-11	2.97330+03	*
7028	1.29000-13	2.58000-13	-2.85145-11	2.22042+04	*
7029	9.10000-15	1.82000-14	2.04259+24	2.04259+26	*
7030	1.46000-13	2.92000-13	-1.42929-12	1.07897+03	*
7031	9.00000-13	1.80000-12	1.84983-10	2.04537+04	*
7126	7.15000-13	1.43000-12	1.02439-10	1.42271+04	*
7128	1.29000-13	2.58000-13	-2.86487-11	2.23083+04	*
7129	9.10000-15	1.82000-14	2.04190+24	2.04190+26	*
7130	1.46000-13	2.92000-13	-9.83636-12	6.83723+03	*
7131	9.00000-13	1.80000-12	1.77818-10	1.96575+04	*
7226	7.15000-13	1.43000-12	2.35517+25	3.29395+37	*
7228	1.29000-13	2.58000-13	-2.86434-11	2.23042+04	*
7229	9.10000-15	1.82000-14	5.19390-13	5.60758+03	*
7230	1.46000-13	2.92000-13	-9.82539-12	6.82972+03	*
7231	9.00000-13	1.80000-12	1.77771-10	1.96523+04	*
7326	7.15000-13	1.43000-12	2.19747-11	2.97339+03	*
7328	1.29000-13	2.58000-13	-2.85140-11	2.22039+04	*
7329	9.10000-15	1.82000-14	5.10813-13	5.51333+03	*
7330	1.46000-13	2.92000-13	-1.42836-12	1.07833+03	*
7331	9.00000-13	1.80000-12	1.84979-10	2.04532+04	*
1211	1.07000-14	2.14000-14	2.13787-14	9.98005+01	
1214	2.24000-14	4.48000-14	4.47839-14	9.99282+01	
1216	2.24000-14	4.48000-14	4.47984-14	9.99929+01	
1218	2.24000-14	4.48000-14	4.47999-14	9.99997+01	
1220	2.24000-14	4.48000-14	4.48000-14	1.00000+02	
1222	2.24000-14	4.48000-14	4.48000-14	1.00000+02	
1224	2.24000-14	4.48000-14	4.48000-14	1.00000+02	
1226	1.07000-14	2.14000-14	2.14000-14	9.99997+01	
1230	2.24000-14	4.48000-14	4.47921-14	9.99647+01	
1232	2.24000-14	4.48000-14	4.46809-14	9.94685+01	
1234	1.07000-14	2.14000-14	2.12923-14	9.89938+01	
1253	1.07000-14	2.14000-14	2.13790-14	9.98035+01	
1256	2.24000-14	4.48000-14	4.47841-14	9.99292+01	
1258	2.24000-14	4.48000-14	4.47984-14	9.99930+01	
1260	2.24000-14	4.48000-14	4.47999-14	9.99997+01	

* Associated with arithmetic nodes.

TABLE 3-43 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF
1262	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1264	2.24000-14	4.46000-14	4.48000-14	1.00000+02
1266	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1268	1.07000-14	2.14000-14	2.14000-14	9.99997+01
1271	2.24000-14	4.48000-14	4.47924-14	9.99660+01
1273	2.24000-14	4.48000-14	4.46853-14	9.94881+01
1275	1.07000-14	2.14000-14	2.12983-14	9.90492+01
1411	1.07000-14	2.14000-14	2.13781-14	9.97952+01
1414	2.24000-14	4.48000-14	4.47835-14	9.99265+01
1416	2.24000-14	4.48000-14	4.47984-14	9.99928+01
1418	2.24000-14	4.48000-14	4.47999-14	9.99997+01
1420	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1422	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1424	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1426	1.07000-14	2.14000-14	2.14000-14	9.99997+01
1430	2.24000-14	4.48000-14	4.47922-14	9.99653+01
1432	2.24000-14	4.48000-14	4.46826-14	9.94758+01
1434	1.07000-14	2.14000-14	2.12945-14	9.90142+01
1453	1.07000-14	2.14000-14	2.13783-14	9.97974+01
1456	2.24000-14	4.48000-14	4.47837-14	9.99272+01
1458	2.24000-14	4.48000-14	4.47984-14	9.99928+01
1460	2.24000-14	4.48000-14	4.47999-14	9.99997+01
1462	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1464	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1466	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1468	1.07000-14	2.14000-14	2.14000-14	9.99997+01
1471	2.24000-14	4.48000-14	4.47925-14	9.99664+01
1473	2.24000-14	4.48000-14	4.46861-14	9.94917+01
1475	1.07000-14	2.14000-14	2.12993-14	9.90587+01
1611	1.07000-14	2.14000-14	2.13819-14	9.98309+01
1614	2.24000-14	4.48000-14	4.47861-14	9.99381+01
1616	2.24000-14	4.48000-14	4.47986-14	9.99939+01
1618	2.24000-14	4.48000-14	4.47999-14	9.99998+01
1620	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1622	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1624	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1626	1.07000-14	2.14000-14	2.14000-14	9.99997+01
1630	2.24000-14	4.48000-14	4.47922-14	9.99654+01
1632	2.24000-14	4.48000-14	4.46826-14	9.94757+01
1634	1.07000-14	2.14000-14	2.12944-14	9.90132+01
1653	1.07000-14	2.14000-14	2.13784-14	9.97981+01
1656	2.24000-14	4.48000-14	4.47837-14	9.99274+01
1658	2.24000-14	4.48000-14	4.47984-14	9.99929+01
1660	2.24000-14	4.48000-14	4.47999-14	9.99997+01
1662	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1664	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1666	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1668	1.07000-14	2.14000-14	2.14000-14	9.99997+01
1671	2.24000-14	4.48000-14	4.47927-14	9.99672+01
1673	2.24000-14	4.48000-14	4.46885-14	9.95021+01
1675	1.07000-14	2.14000-14	2.13023-14	9.90868+01

TABLE 3-43 (Cont.)

CONDUCTOR NUMBER	ORIGINAL VALUES	PERTURBED VALUES	CORRECTED VALUES	PERCENTAGE OFF
1811	1.07000-14	2.14000-14	2.13784-14	9.97979+01
1814	2.24000-14	4.48000-14	4.47837-14	9.99274+01
1816	2.24000-14	4.48000-14	4.47984-14	9.99929+01
1818	2.24000-14	4.48000-14	4.47999-14	9.99997+01
1820	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1822	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1824	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1826	1.07000-14	2.14000-14	2.14000-14	9.99997+01
1830	2.24000-14	4.48000-14	4.47921-14	9.99647+01
1832	2.24000-14	4.48000-14	4.46812-14	9.94696+01
1834	1.07000-14	2.14000-14	2.12926-14	9.89966+01
1853	1.07000-14	2.14000-14	2.13783-14	9.97976+01
1856	2.24000-14	4.48000-14	4.47837-14	9.99272+01
1858	2.24000-14	4.48000-14	4.47984-14	9.99928+01
1860	2.24000-14	4.48000-14	4.47999-14	9.99997+01
1862	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1864	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1866	2.24000-14	4.48000-14	4.48000-14	1.00000+02
1868	1.07000-14	2.14000-14	2.14000-14	9.99997+01
1871	2.24000-14	4.48000-14	4.47924-14	9.99661+01
1873	2.24000-14	4.48000-14	4.46854-14	9.94886+01
1875	1.07000-14	2.14000-14	2.12984-14	9.90504+01

4.0 AREAS OF IMPROVEMENT AND STUDY

4.1 Areas of Improving Thermal Network Correction Program

Evaluation of the thermal network correction program with the use of two 50-node models and one 500-node model revealed rather encouraging results in many facets and also indicated correction difficulties that may be eased with improvements to the program. Improvements to the program include:

(1) Bounding of soft parameters
Some of the inaccuracies experienced in correcting a soft parameter were due to propagation of errors. This inaccuracy in the correction of soft parameters could be minimized by bounding the magnitude of correction that would be permitted.

(2) Use of double-precision
Numerical round-off errors appear to be another source of correction inaccuracies. Use of double-precision should improve the accuracy of correction considerably for those parameters that are sensitive to very small changes in values.

(3) Re-examination of arithmetic nodes
Most of the soft parameters associated with an arithmetic node were not corrected accurately. Part of this correction difficulty stems from the "non-smooth" temperature behavior of arithmetic nodes. A more detailed examination of zero-capacity nodes is required.

4.2 Areas of Additional Study

The present study using computer simulated temperatures provided baseline information on the correction capabilities of the thermal network correction program. The baseline study must be extended to the use of experimental temperature data. This study should also include the effects of different sets of temperature transients corresponding to different sets of environmental test conditions on the soft parameter corrections.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The overallobjective of this program was the development of a computer program that corrects soft parameters of a thermal network such that the temperatures from the updated thermal network correlates with the measured temperature data. Using computer-simulated temperature transients, evaluation of the thermal network correction program indicated reasonable correction of conductors and capacitances when corrected separately and relatively poor correction of sources. Mixture of a soft capacitance with the soft sources and conductors presented correction difficulties. Practical usage of the present program is to a large extent dependent upon the measured temperature distribution coupled with thermal model size. Accurate soft parameter correction was confined to measured subregions and the accommodation of subregions with sparse temperature measurements were rather restrictive because of the need for large computer core.

Weighing the overall results, the present thermal network correction program fulfills to a large extent the overall objective of the present development.

Because of the positive nature of the results generated in the present study, it is recommended that improvements to the present computer program as indicated in Section 4.0 be made and that additional studies as indicated in Section 4.0 be undertaken.

6.0 REFERENCES

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A. SYSTEMS OPERATIONAL PROCEDURE FOR THERMAL NETWORK CORRECTION

Operational procedure from test data to a corrected network is a multi-step process with the interface between steps, in general, requiring special user attention. Some attention was given to integrate or eliminate some of the interfaces but network size and the need for flexibility required direct user participation. Higher is the degree of automation, less flexible and less general is the resultant network correction program. The overall operational procedure for thermal network correction, as described below, recognized the need for user simplicity but was based primarily upon flexibility and generality considerations. A flow diagram with separate program packages and interfaces is shown in Figure A-1.

A.1 Data Editing and Smoothing

The test data, temperature and heat flux (when applicable), with a dictionary that correlates the test information with the node numbers of the thermal network must be available. The smoothing and filtering of the test data is done external to the thermal network correction program.

A.1.1 Input Requirements

A dictionary that correlates test data with thermal network nodal locations must be provided.

A.1.2 Output Requirements

A tape or deck with the necessary smoothed and filtered data in a format compatible with the thermal network correction package is required.

A.2 Data Translation to Analytical Nodal Location

If the measurements are not located at the analytical nodal locations, the user must provide manually (or otherwise) the necessary means of test data translation. This translation can be quite difficult because high accuracy is desired.

A.2.1 Input Requirements

Since the user must provide the necessary translation, the input requirements are the responsibility of the user.

A.2.2 Output Requirements

The user provides the necessary output as indicated in paragraph A.1.2 above.

A.3 Comparison of Test and Analytical Temperatures

Comparison of test and analytical temperatures for the purpose of isolating those that are out-of-tolerance requires several sub-steps before temperature comparison can begin. Subroutine COMPAR is used; users instructions are found in Appendix B.

A.3.1 Accuracy Assessment of Test Data

The user provides the accuracy bounds of the test data. Normally the information considers only the sensor accuracy and the recording accuracy, but realistically must also include the disruptive effects of the sensor.

A.3.2 Accuracy Assessment of Analytical Temperatures

The user must also provide the accuracy bounds of the analytical temperatures. A sensitivity analysis program called STEP (discussed in Appendix C) is available to the user for this evaluation but is nodal-size limited; for the UNIVAC-1108 (65 K core), approximately 180 nodes can be accommodated. Network partitioning offers a possible use of STEP; how and where STEP is employed is left to the discretion of the user. As an important note of interest, the user must provide the necessary parameter uncertainties that are required if temperature uncertainties are to be generated.

A.3.3 Input Requirements

In addition to the normal inputs to SINDA for a given thermal network, subroutine COMPAR is called. Test data and analytical temperature bounds as determined in paragraphs A.3.1 and A.3.2 represent additional input considerations.

A.3.4 Output

If the comparison program is utilized as an independent program, the output is graphical or tabular.

If the comparison program is part of the parameter correction procedure, the output of the comparison program couples directly with the Kalman filter.

A.3.5 Out-of-Tolerance Region

Identification of out-of-tolerance regions does not represent a distinct step insofar as the parameter correction procedure is concerned, but if the output of the comparison program were to be used manually, a user could generate the out-of-tolerance regions.

A.3.6 Parameter Correction

Once the preliminaries, as indicated by steps A.1 through A.4, have been completed, the parameter correction technique is employed. At this stage, the user must choose between subroutine KALFIL or KALØBS. The former is employed when complete temperature measurements are not available and the latter is used when complete temperature measurements are available. Discussion of these subroutines and users instructions are reported in Appendix B.

A.3.6.1 Input Requirements

Either subroutine KALFIL or KALØBS is called. Users instructions are found in Appendix B or reference 3.

A.3.7.2 Output

The output consists of original value of the "soft" parameters and the corrected values.

A.3.7 Verification of Parameter Values

The corrected parameters are used to re-compute the network temperatures; the adequacy of these parameter values can be determined only by re-computing the temperatures for the set of corrected parameter values.

A.3.8 Comparison

The re-computed temperatures are compared with test data.

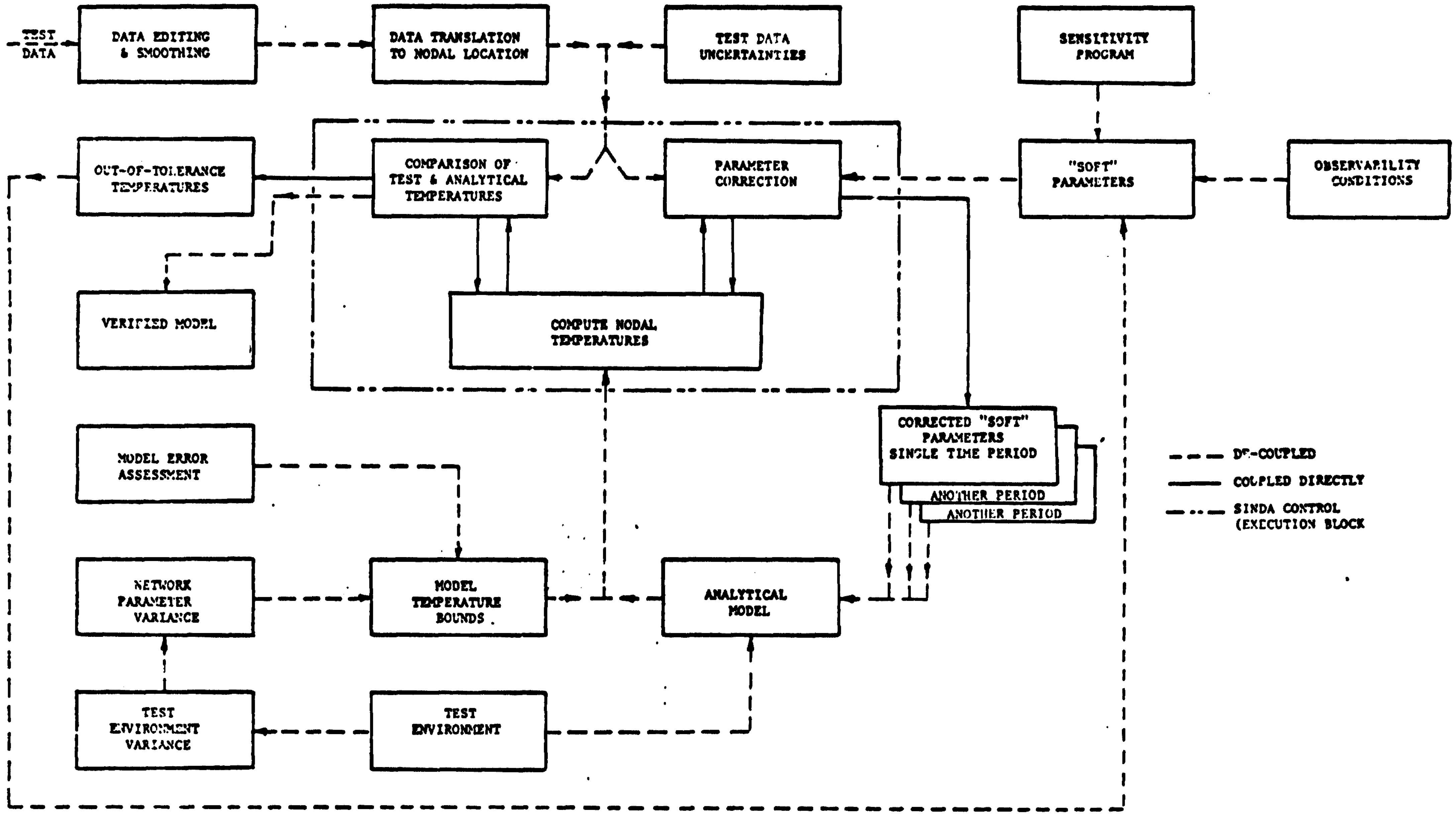


FIGURE A-1 FLOW DIAGRAM - PARAMETER CORRECTION TECHNIQUE

B. THERMAL NETWORK CORRECTION PACKAGE

B.1 Introduction

The thermal network correction package consists of a number of subroutines, many of which are internally programmed as part of a larger program subpackage such as STEP which is discussed in Appendix C. These subpackage programs are not totally integrated and must be employed in a setpwise procedure as indicated in Appendix A. Major subpackages are denoted as Data Comparison and Plotting, Sensitivity Analysis, and Parameter Correction. Operation procedure from test data to a corrected network was reported previously in Appendix A and detailed theoretical development is contained in Reference 1. Major considerations and users instructions are reported here.

B.2 Theoretical Development of Kalman Filtering

Kalman filtering was chosen over other methods because it offered a way to solve some of the problems presented by temperature measurement sparsity, yet retained solution simplicity when the number of measured temperatures in a region is complete. Governing equations are presented for the case of temperature sparsity and for the special condition of complete temperature measurement.

B.2.1 Sparse Temperature Measurements

Consider the heat balance equation,

$$\frac{dT_i}{dt} = \frac{Q_i(t)}{C_i} + \sum_{j=1}^{n} \frac{a_{ij}}{C_i} (T_j - T_i) + \sigma \sum_{j=1}^{n} \frac{b_{ij}}{C_i} (T_j^4 - T_i^4) \qquad \text{(B-1)}$$

$$i = 1,2,\ldots,n$$

where:

- T_i is the temperature of the ith node
- t is the time
- $Q_i(t)$ is the heat input to the ith node
- a_{ij} is the conductance
- C_i is the capacitance of the ith [illegible]
- b_{ij} is the radiation coefficient
- σ is the Stefan-Boltzmann constant

For a thermal model that contains n nodes with m nodal temperatures measured, where $m \leq n$, the random noise corrupted measurement vector, $\{y^*\}$, is an m by 1 vector whose elements are given by the m noise corrupted measured temperature. This is given by

$$\{y^*\}^T = (T_1^* , T_2^* , T_3^* , \dots , T_i^* , \dots , T_m^*) \tag{B-2}$$

where T_i^* = random noise corrupted measured temperature for the ith node, $i = 1,2,\dots,m$

Sum of model parameters and isothermal nodes is p. The state vector is a p by 1 vector whose elements are the n nodal temperatures and the (p-n) model parameters. The (p-n) parameters are represented by,

$$\frac{Q_i}{C_i} , \frac{a_{ij}}{C_i} , \text{ and } \frac{b_{ij}}{C_i} .$$

The state vector is indicated by,

$$\{x\}^T = (T_1,T_2,\dots,T_n,\frac{Q_i}{C_i},\dots,\frac{a_{ij}}{C_i},\dots,\frac{b_{ij}}{C_i}) \tag{B-3}$$

Relationship between the measurement vector and the state vector is given by the following matrix observation equation

$$\{y^*\} = [M]\{x\} + \{W\} \tag{B-4}$$

In equation (B-4), [M] is the m by p measurement matrix given by

$$[M] = \left[\begin{array}{c|c} I & \\ & 0 \\ (m \times m) & \end{array} \right] \tag{B-5}$$

and {W} is the m by 1 random measurement noise vector whose elements are the random noises associated with the m measured temperatures. This is given by

$$\{W\}^T = (W_1, W_2, \dots, W_m) \tag{B-6}$$

Details of the derivation of the Kalman filter may be found in Reference 1. The following summarizes the Kalman filter equations whereby the correction of the thermal model parameters can be obtained sequentially.

$$\{y^*\}_t = [M]_t\{x\}_t + \{W\}_t \tag{B-7}$$

$$\{x\}_{t+\Delta t} = [U]_t\{x\}_t \tag{B-8}$$

$$\{\hat{x}\}_t = \{x_a\}_t + [B]_t(\{y^*\}_t - \{y_a\}_t) \quad \text{(B-9)}$$

$$\{y_a\}_t = [M]_t\{x_a\}_t \quad \text{(B-10)}$$

$$[B]_t = [A]_t[M]_t^T([M]_t[A]_t[M]_t^T + [W]_t)^{-1} \quad \text{(B-11)}$$

$$[J]_t = ([I] - [B]_t[M]_t)\ [A]_t \quad \text{(B-12)}$$

$$\{x_a\}_{t+\Delta t} = [U]_t\{\hat{x}\}_t \quad \text{(B-13)}$$

$$[A]_{t+\Delta t} = [U]_t[J]_t[U]_t^T \quad \text{(B-14)}$$

where:

$\{y^*\}_t$	=	random noise corrupted measurement vector (temperature) obtained at time, t.
$\{x\}_t$	=	value of the state vector (unknown parameters) at time, t.
$\{W\}_t$	=	random noises associated with the measured data obtained at time, t.
$\{x\}_{t+\Delta t}$	=	value of the state vector (unknown parameters) at time, t+Δt
$\{M\}_t$	=	measurement matrix evaluated at time, t.
$\{\hat{x}\}_t$	=	new estimate of the state vector (unknown parameters) after processing the measured data obtained at time, t.
$\{\hat{x}_a\}_t$	=	a priori estimate of the state vector (unknown parameters) before processing the measured data obtained at time, t.
$[B]_t$	=	measurement weighting matrix evaluated at time, t (the time varying gain).
$[A]_t$	=	$E[(\{x\} - \{x_a\})(\{x\} - \{x_a\})^T]$, error covariance matrix for the a priori estimate state vector.
$[J]_t$	=	$E[(\{x\} - \{\hat{x}\})(\{x\} - \{\hat{x}\})^T]$, error covariance matrix for the newly estimated state vector.

Given the correction scheme whereby the Kalman filter equations are used, the following steps are performed:

(1) First obtain an a priori estimate for the state vector $\{x_a\}_t$ and the associated error covariance matrix $[A]_t$;

(2) Calculate the time varying gain $[B]_t$ using the equation (B-11) and the first set of measured data;

(3) Obtain new estimate for state vector, $\{\hat{x}\}_t$, using equation (B-9) and the first set of measured data;

(4) Calculate the error covariance matrix, $[J]_t$ for the newly estimated $\{\hat{x}\}_t$ using equation (B-12);

(5) Update the newly estimated state vector, $\{\hat{x}\}_t$, with equation (B-13) to obtain the new a priori estimate at time t+Δt and calculate its associated error covariance matrix using equation (B-14).

(6) Repeat Steps (2) to (5) using the new a priori estimate for the state vector and its associated error covariance matrix with the 2nd set of measured data.

(7) Repeat above until all the measured data have been processed or until desirable results* are obtained.

Temperature Dependent Parameters

For temperature dependent parameters, the coefficients are considered to be of the form

$$a_{ij} = a^{\circ}_{ij} \; f(T_i,T_j) \qquad \text{(B-15)}$$

$$b_{ij} = b^{\circ}_{ij} \; g(T_i,T_j) \qquad \text{(B-16)}$$

Only the constant portion of a_{ij} and b_{ij}, a°_{ij} and b°_{ij}, is to be corrected and the functions $f(T_i,T_j)$ and $g(T_i,T_j)$ are considered to be known.

Using equations (B-15) and (B-16) for the a_{ij}'s and the b_{ij}'s, the heat balance equation for node i can be written as,

$$\frac{dT_i}{dt} = \frac{Q_i}{C_i} + \sum_{j=1}^{n} \left(\frac{a^{\circ}_{ij}}{C_i}\right) f(T_i,T_j)(T_j-T_i) + \Sigma\sigma \sum_{j=1}^{n} \left(\frac{b^{\circ}_{ij}}{C_i}\right) g(T_i,T_j)(T_j^{\,4}-T_i^{\,4}) \qquad \text{(B-17)}$$

Capacitance as "Soft" Parameters

A capacitance as a "soft" parameter presents considerable network correction difficulties with the condition of temperature sparsity. Equation (B-17) indicates that if the capacitance is "hard", conductors and sources may be isolated from the capacitance but if the capacitance is "soft" all of the ratios, Q_i/C_i, a_{ij}/C_i, and b_{ij}/C_i appear to be "soft" even though an a_{ij} and/or b_{ij} may be hard. By a suitable programming procedure, the capacitance C_i may be corrected when the conductors are "hard" but the individual correction of the conductors and the capacitance becomes difficult when both categories of parameters are "soft". Thus when temperature sparsity is present, the present network correction method has been coded for the correction of a "soft" capacitance or "soft" conductors (including sources) associated with a given node. With complete temperature measurements, soft conductors and a "soft" capacitance associated with a given node may be corrected.

B.2.2 Complete Temperature Measurements

It was indicated above that if all of the nodes are monitored, a very large network can be corrected. This is possible because the governing heat balance equations can be operated singly and timewise sequentially. The Kalman filter is formulated to take advantage of this special temperature measurement situation.

The Kalman filtering equations may be formulated by first arranging the heat balance equation at the ith node such that the known quantities (hard parameters, temperature, and temperature derivatives, if C is hard) are on one side of the equation and the k unknown quantities (soft parameters) are on the other side.

The set of k equations of the ith node plus some random noise associated with the measurement data will yield the following matrix equation:

$$\{y_i^*\} = [M_i]\{x_i\} + [W_i] \tag{B-18}$$

where:

- y_i^* represents an artificial measurement vector at the ith node composed of hard parameters and temperature data.
- $[M_i]$ is the artificial measurement matrix that involves the coefficients of these unknown parameters.
- $\{x_i\}$ is the state vector formed with the unknown model parameters.
- $[W_i]$ is the random noise matrix associated with the measurement data.

If the unknown parameters are considered to be constant, the updating matrix, [U], is essentially an identity matrix. With $\{x_i\}$, $\{y_i^*\}$, $[M_i]$, and $[U_i]$ now formulated, the Kalman filtering method is completely identified by assuming a priori information for the unknown parameters.

After the unknown (soft) parameters for node i are determined the procedure is repeated for the jth node with the exception that any parameter of the jth node that was corrected with the ith node solution is set to corrected values and designated as hard for the jth node.

An important consideration of the sequential method in the equationwise sense is that the expected parameter correction accuracy of this Kalman filtering method cannot be expected to be as high as the Kalman filtering method when the entire network is considered simultaneously. The reason for this is that more information is available for correcting an individual parameter with simultaneous network processing than with the equationwise sequential method. The need for the latter arises from the need for correcting a large network but subject to computer core limitations and computational constraints.

B.3 Parameter Correction and Users Instructions

Parameter correction of a large thermal network with temperature sparsity requires a means of assessing unobservability, observability, and the correction of the parameters. Unobservability of a network is determined as part of the KALFIL subroutine, but observability of a network is pursued with a separate subroutine called KALØBS. The need for two separate subroutines is a direct result of the two Kalman filtering formulations. Subroutine KALFIL processes the network equations simultaneously whereas subroutine KALØBS processes the network equations singly and sequentially. In general, KALFIL should yield more accurate corrections than KALØBS. Integration of both subroutines into a single package would have unduly complicated the overall thermal network correction package; the user thus must make a decision based upon rather simple ground rules. If a network contains totally measured nodes, KALØBS is used unless the number of nodes plus the number of "soft" parameters total less than about 100; for the latter KALFIL is used. If a network contains a region or regions with complete temperature measurements, subroutine KALØBS is called first in order to correct and set hard those "soft" parameters which are totally observable; then subroutine KALFIL is called for the remainder of the network. If a network contains only a limited number of measured temperatures and the measurements are sparsely distributed, subroutine KALFIL is called.

An important consideration that should be discussed here is the accuracy of the "soft" parameter correction. The correction is subject to the observability of the conductors and the accuracy of the measured temperatures. In some instances, the corrected parameter values may be in gross error and physically not realizable, such as a negative conductor, but this should not be particularly surprising since the parameter values merely reflect the accuracy and observability conditions. On the other hand, the calculated temperatures with the corrected parameters should correlate quite closely with the measured temperatures.

B.3.1 Correction with Complete Temperature Measurements (KALØBS)

This subroutine is used to correct "soft" parameters that are contained in a totally observable network or subregions. These regions are identified as measured nodes surrounded by measured nodes with the basic smallest totally observable region being a single measured node surrounded by measured nodes. The heat balance equations are processed singly and sequentially with the "soft" parameters set "hard" after correction. For this subroutine theoretically all (less one) of the parameters associated with a given node may be selected as "soft" and correctable, the user should keep the number of "soft" parameters to a minimum and in general it is better not to mix a "soft" capacitance with "soft" conductances and/or source associated with a given node. User instructions for KALØBS are presented in Table B-1.

B.3.2 Correction with Temperature Sparsity (KALFIL)

This subroutine determines the unobservability of network elements and sets all unobservable elements as "hard" in the indicator vector, thereby eliminating them for corrective consideration. Subregions are identified and dummy pseudo compute sequences formed. These dummy pseudo compute sequences are then utilized by subroutine UMATRX to form the integration matrix utilized in calculating the B and J matrices. (Refer to paragraph B.2.1) Integration of the total network is performed by a standard SINDA network integration subroutine. In this manner the KALFIL parameter correction method for the condition of temperature sparsity is applied to the subregions simultaneously as though the rest of the network was totally hard. A subregion surrounded by unmeasured nodes is less desirable t. one surrounded by measured nodes. The latter isolates the

TABLE B-1 KALMAN NETWORK CORRECTION WITH COMPLETE TEMPERATURE MEASUREMENTS

SUBROUTINE NAME: KALØBS

PURPOSE:

This subroutine uses the Kalman filter method to correct soft parameters that are contained in totally observable subregions. This subroutine employs the heat balance equation singly and timewise sequentially. Such a subregion includes all the conductors into a measured node when all the surrounding nodes are also measured. If an adjoining node has identical temperatures as the node under consideration, correction is not possible. If total measurements are not available the user should continue the correction procedure by using the subroutine KALFIL. This subroutine removes node and conductor numbers from the IC and IG arrays for corrected parameters. KALØBS is called in the execution block.

RESTRICTIONS:

This subroutine requires the long pseudo-compute sequence (LPCS). The capacitor and conductor indicator arrays must have their contents in the same input order as the node source and conductor data, respectively. All temperatures must be in the Fahrenheit system.

CALLING SEQUENCE: KALØBS (IPNT,IT(IC),IQ(IC),IC(IC),IG(IC),HT,TNP,QNP,CNP,GNP)

Where: IPNT is an intermediate print indicator: I = 0,no; I ≠ 0,yes

IT is an array of actual node numbers of measured temperatures and must be in the same order as the test temperatures

IQ is an array of actual node numbers of soft sources

IC is an array of actual node numbers of soft capacitors

IG is an array of actual conductor numbers of soft conductors

HT is a time history matrix of test temperatures, each row being a time slice with time as the first value

TNP is the temperature noise estimate

QNP is the percent of estimated source error times 0.01

CNP is the percent of estimated capacitor error time 0.01

GNP is the percent of estimated conductor error time 0.01

subregion from outside influences, while the former is susceptible to error propagation from other subregions not yet corrected. In order to hold external influences to a minimum, all nodes outside the subregions under construction are forced to the measured temperatures, if available.

The conditions of observability and unobservability as determined in Reference 2 are listed in Table B-2. In subroutine KALFIL parameters between unmeasured nodes are automatically set hard (item 6, Table B-2, since these parameters are completely unobservable. Users instructions for KALFIL are presented in Table B-3.

B.3.3 Time-Temperature History Matrix (TESTMP)

Subroutine TESTMP which is part of the parameter correction package aids the user in forming a time-history matrix. Users instructions are given in Table B-4.

B.4 Sensitivity Analysis

Accuracy bounds of the analytical temperature may be generated by the use of the sensitivity-temperature error-program (STEP). Theoretical development of STEP and brief users instructions are presented in Appendix C. For details on the overall program instructions, the reader should refer to Reference 3. STEP provides a means of generating temperature uncertainty due to parameter uncertainties and a means of assessing the relative "hardness" or "softness" of a parameter with respect to a given temperature.

B.5 Data Comparison and Plotting

Comparison of test and analytical temperatures for the purpose of isolating those that are out-of-tolerance requires several sub-steps before temperature comparison can begin. Out-of-tolerance criterion is determined from accuracy assessment of test data and accuracy assessment of analytical temperatures; for the latter, a sensitivity analysis program called STEP offers a way for this assessment. Discussion of STEP and users instructions are presented in Appendix C.

Due to the indeterminate amount of data that have to be processed, the comparison and plotting capability was coded as two separate subroutines, CØMPAR and PLØTMP. These subroutines are coded in such a manner that they may be called in the same run or in a batched mode. The actual plotting is done by internal calls to SC-4060 quick plot subroutines which have identical names and arguments to the CINDA-3G SC-4060 quick plot subroutines in use at NASA/MSC. Description and users instructions for CØMPAR and PLØTMP are presented in Table B-5 and Table B-6 respectively.

B.6 Example of Input for Subroutine KALØBS

The NASA/MSC 50-node mass spectrometer model was selected to illustrate the input required for subroutine KALØBS; explanation of the various inputs is indicated directly on the computer print-out as shown in Table B-7. Model characteristics are the same as those indicated in Appendix D, but the input format for the heat source is different. In Appendix D the heat sources are placed in the BCD 3VARIABLES 1 block, whereas in the example shown in Table B-7 the heat sources are placed in the source data block since several sources of heat were selected to be "soft". For node data and conductor characteristics, the reader should refer to Appendix D.

The model considered here has complete temperature measurements, thirty-eight soft capacitors, twelve soft heat sources, and forty-two soft conductors with a perturbation of +100%. It should be particularly noted in this example that some of the input is for the generation of simulated temperature data and perturbed parameters. The input when experimental data are used would be different from the example shown here.

B.7 Example of Input for Subroutine KALFIL

An example of input for subroutine KALFIL is shown in Table B-8, again using the NASA/MSC 50-node mass spectrometer model. This example contains 24 measured temperatures, 2 soft capacitors, 2 soft heat sources, and 19 soft conductors. The perturbation factor is +50%. Explanation of the various inputs is indicated directly on the computer print-out.

TABLE B-2

SUMMARY OF OBSERVABILITY SITUATIONS AND CORRECTIBILITY CONDITIONS

(From Table 2-7, Reference 2)

SITUATIONS	OBSERVABILITY	ACCURACY
1. Complete temperature measurements	All parameters are observable	General: Comments discussed below apply
2. An unmeasured node surrounded by measured nodes	Parameters to unmeasured node are observable	General: Comments discussed below apply
3. An unmeasured node surrounded by measured nodes and one boundary node	Parameters from measured nodes to the unmeasured node are observable Parameter from boundary node to unmeasured node is unobservable Parameters from the measured node are observable	General: Comments discussed below apply Specific: The correction accuracy is very sensitive to the value of the parameter which is unobservable and thus not correctible
4. A measured node surrounded by unmeasured nodes	Parameters from the measured node are observable	General: Comments discussed below apply Specific: Even with exact initial temperatures of the unmeasured nodes, the convergence may not be to the exact parameter values
5. A measured node surrounded by unmeasured nodes and one boundary node	Parameters from the measured nodes are observable	The comment for situation 4 applies The value of the parameter from the measured node to the boundary node converges to the true value
6. Two adjacent unmeasured nodes	Parameters between unmeasured nodes are not observable	Parameters are not correctible
7. Parallel coupling	Parallel linear coupling is not individually observable Parallel linear and radiation coupling are individually observable	Parallel linear conductors cannot be individually corrected Parallel linear & radition coupling are individually correctible

General Comment: The accuracy of the parameter correction is dependent upon the accuracy of the experimental temperature data; a quantitative measure is not known at this time. For an unmeasured node the initial temperature must be known accurately; the accuracy of the parameter values are quite sensitive to the initial temperature value.

TABLE B-3 KALMAN NETWORK CORRECTION WITH SPARSE TEMPERATURE MEASUREMENTS

SUBROUTINE NAME: KALFIL

PURPOSE:

This subroutine performs network parameter correction by the Kalman filter method. In general it should be applied to the model being corrected after KALØBS has been applied. This routine must be called upon in the Variables 2 block with CNFRDL in the execution block. It performs an initial pass in order to reduce (set hard) those network elements which are uncorrectable due to observability criteria (unobservable). It then makes a second pass in order to remove from the calculation procedure measured nodes which do not contribute to the solution. It then sets up several square matrices of order N, where N is the number of remaining measured temperatures and soft parameters, and simultaneously solves the Kalman filter set of equations. All corrected parameters are set hard and the corrected values placed into the appropriate network locations. Immediately after the correction process, analytical check runs can be performed.

RESTRICTIONS:

Must be called in Variables 2 by CNFRDL in the execution block; may not be utilized more than once per run. Degrees Fahrenheit required.

CALLING SEQUENCE: KALFIL(I,IT(IC),IC(IC),IQ(IC),IG(IC),AT(IC),AJ(IC))

Where:
- I is an indicator for intermediate printout: I = 0,no; I ≠ 0,yes
- IT is an array of actual integer node numbers of the measured temperatures and must be in the same order as the TA array
- IC is an array of actual integer node numbers of soft capacitors; must be in the same order as the node data input
- IQ is an array of actual integer numbers of soft sources and must be in the same order as the source data input
- IG is an array of actual integer conductor numbers of soft conductors; must be in the same order as the conductor data input
- AT is a matrix of test temperature history with the number of rows being the number of time points, the first column representing time and the second column representing test temperatures in the same order as the IT array
- AJ is an array of noise and error estimate squared for each soft parameter and must be in order with IT, IC, IQ, and IG.

TABLE B-4

SUBROUTINE NAME: TESTMP

PURPOSE:

This subroutine aids the user in forming a time-temperature history matrix.

RESTRICTIONS:

See below.

CALLING SEQUENCE: TESTMP(I,J,AT(DV),X,AM(IC))

Where:
- I is always a zero integer
- J is the number of values to be stored from AT
- AT is the start of an array of values to be stored in AM
- X is generally TIMEN and is always stored ahead of AT
- AM is a matrix array which must have J+1 columns.

NOTE:

This subroutine is generally called upon in the Output Calls block. Each time it is called I is updated by one and another row added to the AM matrix. When AM is full its operation ceases.

TABLE B-5

TEMPERATURE-TIME HISTORY COMPARISON SUBROUTINE

SUBROUTINE NAME: CØMPAR

PURPOSE:

This subroutine compares two time-temperature history matrices to see if the data sets agree within some specified tolerance. The user must supply an array of integer node numbers in the corresponding order of the temperature data. Those temperature sets which are out-of-tolerance will have the node number set negative in preparation for plotting of out-of-tolerance temperatures by subroutine PLØTMP. (Table B-6)

RESTRICTIONS:

The two time-temperature history matrices must be of equal size and the node numbers input under the indicator array must be in the same order as the matrix temperature data.

CALLING SEQUENCE: CØMPAR (IA(IC),TØL,TM1(IC),TM2(IC))

Where:

	IA	is the address of the indicator array
	TØL	is the out-of-tolerance criterion (°F)
	TM1	is the first time-temperature matrix array*
	TM2	is the second time-temperature matrix array*

* Refer to page A.6-1, Reference 3 for matrix format (first column is time)

TABLE B-6

TEMPERATURE PLOT SUBROUTINE

SUBROUTINE NAME: PLØTMP

PURPOSE:

This subroutine should be used in conjunction with subroutine CØMPAR. The indicator array is searched until a negative node number is found which indicates an out-of-tolerance condition. The corresponding temperatures from array TM1 and TM2 are then plotted using x and o plotting symbols, respectively. The actual node number from the indicator array is printed as a top line heading. The plot produced requires further processing on the SC-4060.

RESTRICTIONS:

The user should consult Appendix E, Control Cards and Deck Setup, to check tape designation requirements. Subroutine PLØTMP selects the appropriate grid limits and then internally calls upon subroutine PLØTX2. The user must call upon subroutine PLTND after all plotting has been completed. Subroutine PLTND is an internal SC-4060 plot call.

CALLING SEQUENCE: PLØTMP (IA(IC),TM1(IC),TM2(IC))

Where:

	IA	is an indicator array of actual node numbers preprocessed by subroutine CØMPAR
	TM1	is a time-temperature matrix array*
	TM2	is a time-temperature matrix array*

* Refer to page A.6-1, Reference 3 for matrix format (first column is time)

TABLE B-7 EXAMPLE OF INPUT FOR SUBROUTINE KALØBS
NASA/MSC MASS SPECTROMETER MODEL, COMPLETE TEMPERATURE MEASUREMENTS
38 SOFT CAPACITORS, 12 SOFT HEAT SOURCES, & 42 SOFT CONDUCTORS

BCD 3NODE DATA

(For data refer to Table D-4)

```
BCD 3SOURCE DATA
SIT 5,A45,K705
SIT 6,A46,K706
SIT 7,A45,K707
SIT 8,A45,K708
SIT 21,A45,K721
SIT 22,A45,K722
SIT 23,A45,K723
SIT 24,A45,K724
SIT 25,A45,K725
SIT 26,A45,K726
SIT 48,A45,K748
SIT 61,A16,K761
END
```

BCD 3CONDUCTOR DATA

(For data refer to Table D-5)

BCD 3CONSTANTS DATA

(For constants data refer to Table D-6 except for those shown below)

```
99=2.0          $ PERTURBATION FACTOR, 100% PERTURBATION OF PARAMETERS
705,1.0,706,2.0,707,3.0,708,1.0,721,2.0,722,3.0,723,1.0,724,2.0
725,3.0,726,1.0,748,2.0,761,3.0  $ FOR SOURCE DATA
END
```

BCD 3ARRAY DATA

(For array data refer to Table D-6 except for those shown below)

```
16,0.0,0.0035,1800.0,0.0035,END
45,0.0,0.00307,1800.0,0.00307,END
46,0.0,0.00322,1800.0,0.00322,END

71        $ MEASURED TEMPERATURE NODES FOR KALØBS
5,6,7,8,21,22,23,24,25,26,39,27,28,29,45,46,47,48,49
51,52,53,54,61,63,67,81,82,83,84,85,86,87,88,89,90,91,92
1,2,3,4,71,72,73,74,75,76,77,78,79,80,END
```

TABLE B-7 (Cont.)

```
    72        $ MEASURED TEMPERATURE NODES FOR PRNTMI
    5,6,7,8,21,22,23,24,25,26,39,27,28,29,45,46,47,48,49
    51,52,53,54,61,63,67,81,82,83,84,85,86,87,88,89,90,91,92
    1,2,3,4,71,72,73,74,75,76,77,78,79,80,END
    73        $ CAPACITOR NUMBERS FOR KALØBS
    5,6,7,8,21,22,23,24,25,26,39,27,28,29,45,46,47,48,49,51,52,53,54
    61,63,67,81,82,83,84,85,86,87,88,89,90,91,92,END
    74        $ PARAMETER NUMBERS FOR PRNTMI
    5,6,7,8,21,22,23,24,25,26,39,27,28,29,45,46,47,48,49,51,52,53,54
    61,63,67,81,82,83,84,85,86,87,88,89,90,91,92 $ CAPS
    5,6,7,8,21,22,23,24,25,24,48,61   $ SOURCES
    1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,18,19,20,40,41,42,43,44,45
    46,47,48,49,50,51,52,53,54,55,73,74,75,80,81,82,83,END   $ CONDS
    75,SPACE,150,END   $ SPACE FOR ORIGINAL PARAMETERS
    76,SPACE,150,END   $ SPACE FOR PERTURBED PARAMETERS
    77,SPACE,150,END   $ SPACE FOR CORRECTED PARAMETERS
    78,SPACE,150,END
    79,SPACE,150,END
    81,SPACE,16,END
    82,SPACE,52,END    $ SPACE FOR INITIAL TEMPERATURES
    83,SPACE,52,END    $ SPACE FOR TEMPERATURES WITH ORIGINAL PARAMETER VALUES
    84,SPACE,52,END    $ SPACE FOR TEMPERATURES WITH PERTURBED PARAMETER VALUES
    85,SPACE,52,END    $ SPACE FOR TEMPERATURES WITH CORRECTED PARAMETER VALUES
    86,31,53,SPACE,1643,END   $ SPACE FOR TIME-TEMPERATURE MATRIX
    87,SPACE,52,END
    88,SPACE,52,END
    89,SPACE,150,END
    90,SPACE,52,END
    91,5,6,7,8,21,22,23,24,25,26,48,61,END $ SOFT SOURCES FOR KALØBS
    92        $ SOFT CONDUCTORS FOR KALØBS
    1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,18,19,20,40,41,42,43,44,45
    46,47,48,49,50,51,52,53,54,55,73,74,75,80,81,82,83,END
    96,87,1,SPACE,42
    .7-5,.5-5,.7-5,.5-5,2.-7,2.-7,2.-7,2.-7,3.-7,3.-7
    3.-7,3.-7,.6-6,.5-6,3.-7,.5-6,3.-7,4.-7,3.-7,.1-7
    .1-7,.1-7,.1-7,.1-12,7.-15,3.-15,7.-15,3.-15,5.-14,3.-14
    5.-14,3.-14,3.-14,4.-14,1.-14,1.-14,3.-14,3.-14,3.-14,3.-14
    3.-14,3.-14,3.-14,1.-15,1.-15,END
    97,SPACE,54,END
    98                     $ LABELS FOR PRNTMI
BCD 4    NODE         NUMBER
BCD 4  ORIGINAL     TEMPERATURE
BCD 4 PERTURBED     TEMPERATURE
BCD 4   KALOBS       TEMP CORR
    END
    99                     $ LABELS FOR PRNTMI
BCD 4 CAPACITOR      NUMBER
BCD 4   SOURCE       NUMBER
BCD 4  ORIGINAL        VALUES
BCD 4 PERTURBED        VALUES
BCD 4   KALOBS     CORRECTIONS
BCD 4 PERCENTAGE         OFF
BCD 4 CONDUCTOR      NUMBER
    END
```

TABLE B-7 (Cont.)

```
 BCD 3EXECUTION
DIMENSION X(25000)
NDIM = 25000
NTH = 0
OUTPUT = 60.0
TIMEND = 1800.0
      TPRINT
      GPRINT
      SHFTV(52,TS,A82)         $ SAVE INITIAL TEMPERATURES
      SHFTV(38,C5,A75)         $ SAVE ORIGINAL PARAMETERS
      SHFTV(12,K705,A75+38)    $          "
      SHFTV(19,G1,A75+50)      $          "
      SHFTV(23,K40,A75+69)     $          "
      CNFRDL        $ OBTAIN SIMULATED TEST DATA
      SHFTV(52,TS,A83)         $ SAVE ORIGINAL RESULTS
      ARYMPY(38,C5,K99,C5)     $ PERTURBED PARAMETERS
      ARYMPY(12,K705,K99,K705)
      ARYMPY(19,G1,K99,G1)
      ARYMPY(23,K40,K99,K40)
      SHFTV(38,C5,A76)         $ SAVE PERTURBED PARAMETERS
      SHFTV(12,K705,A76+38)
      SHFTV(19,G1,A76+50)
      SHFTV(23,K40,A76+69)
      SHFTV(52,A82,TS)         $ RESET INITIAL TEMPERATURES
TIMEO = 0.0
      CNFRDL        $ CALCULATE PERTURBED TEMPERATURES
      SHFTV(52,TS,A84)         $ SAVE PERTURBED RESULTS
NOW CALL UPON KALOBS TO CORRECT THE PERTURBED PARAMETERS
      KALOBS(0,A71,A91,A73,A92,A86,0.01,0.5,0.5,0.9)
      SHFTV(38,C5,A77)         $ SAVE CORRECTED PARAMETERS
      SHFTV(12,K705,A77+38)
      SHFTV(19,G1,A77+50)
      SHFTV(23,K40,A77+69)
      SUBARY(A74,A75,A77,A78)  $ EVALUATE CORRECTION PERCENTAGES
      DIVARY(A74,A78,A75,A78)
      ARYMPY(A74,A78,100.0,A78)
      ARYPLS(A74,A78)
      PRNTMI(38,A99+1,A74+1,A99+9,A75,A99+13,A76,A99+17,A77
              A99+21,A78)      $ PRINT CAPACITORS
      PRNTMI(12,A99+5,A74+39,A99+9,A75+38,A99+13,A76+38,A99+17
              A77+38,A99+21,A78+38)  $ PRINT SOURCES
      PRNTMI(42,A99+25,A74+51,A99+9,A75+50,A99+13,A76+50,A99+17
              A77+50,A99+21,A78+50)  $ PRINT CONDUCTORS
      SHFTV(52,A82,TS)         $ RESET INITIAL TEMPERATURES
TIMEO = 0.0
      ARYPLS(38,C5)      $ INSURE POSITIVE CORRECTION RESULTS
      ARYPLS(12,K705)
```

TABLE B-7 (Cont.)

```
     ARYPLS(19,G1)
     ARYPLS(23,K40)
     CNFRDL                $ CALCULATED CORRECTED TEMPERATURES
     SHFTV(52,TS,A85)          $ SAVE CORRECTED RESULTS
     SUBARY(A72,A83,A85,A87)  $ OBTAIN PERCENTAGE DIFFERENCES
     ARYADD(A72,A83,460.0,A83)    $ CONVERT TO RANKINE
     DIVARY(A72,A87,A83,A87)
     ARYSUB(A72,A83,460.0,A83)    $ CONVERT TO F
     ARYMPY(A72,A87,100.0,A87)
     ARYPLS(A72,A87)
     PRNTMI(A72,A98+1,A72+1,A98+5,A83,A98+9,A84,A98+13,A85
            A99+21,A87)
 END
 BCD 3VARIABLES 1
     DIDEGI(TIMEM,A20,T200)
     DIDEGI(TIMEM,A21,T300)
 END
 BCD 3VARIABLES 2
 END
 BCD 3OUTPUT CALLS
IF(TIMEO.EQ.0.0) CALL VARBL2
     TPRINT
     TESTMP(ITEST,52,TS,TIMEN,A86)  $ CONSTRUCT TEST TEMP. MATRIX
 END
```

TABLE B-8 EXAMPLE OF INPUT FOR SUBROUTINE KALFIL
NASA/MSC MASS SPECTROMETER MODEL, 24 MEASURED TEMPERATURES
2 SOFT CAPACITORS, 2 SOFT HEAT SOURCES & 19 SOFT CONDUCTORS

```
BCD 3NODE DATA
    (For node data, refer to Table D-4)
BCD 3SOURCE DATA
SIT 6,A46,K706
SIT 48,A45,K748
SIT 61,A16,K761
SIT 2,A47,K702
END
BCD 3CONDUCTOR DATA
    (For conductor data, refer to Table D-5)
BCD 3CONSTANT DATA
    (For constants data, refer to Table D-5)
    97=0.5          $ ERROR ESTIMATE FACTOR
    98=23           $ NUMBER OF SOFT PARAMETERS
    99=1.5          $ PERTURBATION FACTOR
END
BCD 3ARRAY DATA
    (For array data, refer to Table D-6 except for those shown below)
    16,0.0,0.0035,1800.0,0.0035,END
    45,0.0,0.00307,1800.0,0.00307,END
    46,0.0,0.00322,1800.0,0.00322,END
    47,0.0,0.0005,1800.0,0.0005,END
    71          $ MEASURED TEMPERATURE NODES FOR KALFIL
    5,6,7,8,21,22,23,24,26,39,29,45,46,47,48,49,61,63,67,
    81,86,2,71,76,END
    72          $ NODE NUMBERS FOR PRINTING RESULTS
    5,6,7,8,21,22,23,24,25,26,39,27,28,29,45,46,47,48,49
    51,52,53,54,61,63,67,81,82,83,84,85,86,87,88,89,90,91,92
    1,2,3,4,71,72,73,74,75,76,77,78,79,80,END
    73          $ CAPACITOR NUMBERS FOR KALFIL
    39,61,END
    74          $ CAPACITOR NUMBERS FOR PRNTMI
    39,61,END
    75,SPACE,150,END  $ SPACE FOR ORIGINAL PARAMETER VALUES
    76,SPACE,150,END  $ SPACE FOR PERTURBED PARAMETER VALUES
    77,SPACE,150,END  $ SPACE FOR CORRECTED PARAMETER VALUES
    78,SPACE,150,END  $ SPACE FOR PERCENTAGE OFF
    82,SPACE,52,END   $ SPACE FOR INITIAL TEMPERATURES
    83,SPACE,52,END   $ SPACE FOR ORIGINAL TEMPERATURE RESULTS
    84,SPACE,52,END   $ SPACE FOR PERTURBED TEMPERATURE RESULTS
    85,SPACE,52,END   $ SPACE FOR CORRECTED TEMPERATURE RESULTS
    86,21,25,SPACE,525,END $ SPACE FOR TIME-TEMPERATURE MATRIX
    87,SPACE,52,END   $ SPACE FOR TEMP PERCENTAGE OFF
```

TABLE B-8 (Cont.)

```
     91        $ SOFT SOURCE NUMBERS FOR KALFIL
     6,48,END
     92        $ SOFT SOURCE NUMBERS FOR PRNTMI
     6,48,END
     93        $ SOFT CONDUCTOR NUMBERS FOR KALFIL
     15,16,20,40,41,42,43,49,53,73,80,113,115,215,220,330,334,562,605,END
     94        $ SOFT CONDUCTOR NUMBERS FOR PRNTMI
     15,16,20,40,41,42,43,49,53,73,80,113,115,215,220,330,334,562,605,END
     95,SPACE,75,END    $ SPACE FOR TIME SLICE TEMPERATURES
     96,47,1,SPACE,24       $ SPACE FOR NOISE ESTIMATE
        SPACE,23,END         $ SPACE FOR SIGMA SQUARE ESTIMATES
     98
 BCD 4    NODE        NUMBER
 BCD 4  ORIGINAL   TEMPERATURE
 BCD 4 PERTURBED   TEMPERATURE
 BCD 4   KALFIL     TEMP CORR
     END
     99
 BCD 4 CAPACITOR    NUMBER
 BCD 4    SOURCE    NUMBER
 BCD 4 CONDUCTOR    NUMBER
 BCD 4  ORIGINAL       VALUES
 BCD 4 PERTURBED       VALUES
 BCD 4   KALFIL    CORRECTIONS
 BCD 4 PERCENTAGE       OFF
     END
 END

 BCD 3EXECUTION
INITALIZE CONTROL CONSTANTS AND DYNAMIC STORAGE ARRAY
DIMENSION X(35000)
NDIM = 35000
NTH = 0
OUTPUT = 60.0
TIMEND = 1200.0
     TPRINT
     CPRINT
     QIPRNT
     GPRINT
     STFSQS(0.01,24,A96+3)  $ SET INITIAL NOISE ESTIMATES
CONSTRUCT ERROR ESTIMATES SQUARED
     BLDARY(A75,C39,C61)      $ INITIAL C VALUES
     BLDARY(A75+2,Q6,Q48)     $ INITIAL Q VALUES
     BLDARY(A75+4,G15,G16,G20,G40,G41,G42,G43,G49,G53,G73,G80
            G113,G115,G215,G220,G330,G334,G562,G605)$ INITIAL G'S
     ARYMPY(K98,A75,K97,A75) $ FACTOR IN THE ERROR ESTIMATE FACTOR
     MPYARY(K98,A75,A75,A75)  $ SQUARE THE ERROR ESTIMATE
     SHFTV(K98,A75,A96+27)  $ STORE IT IN THE PROPER ARRAY
     SHFTV(52,T5,A82)         $ SAVE INITIAL TEMPERATURES
     BLDARY(A75,C39,C61)      $ SAVE INITIAL C VALUES
     BLDARY(A75+2,K706,K748)  $ SAVE INITIAL Q FACTORS
     BLDARY(A75+4,G15,G16,G20,K40,K41,K42,K43,K49,K53,K73,K80
            G113,G115,K215,K220,G330,G334,K562,K605)$ INITIAL G'S
```

TABLE B-8 (Cont.)

```
ITEST = 0
      CNFRDL          $ OBTAIN SIMULATED TEST DATA
      SHFTV(52,T5,A83)          $ SAVE ORIGINAL RESULTS
THE FOLLOWING SCALE CARDS PERTURB THE SOFT PARAMETERS
      SCALE(K99,C39,C39,C61,C61)  $ PERTURB SOFT C'S
      SCALE(K99,K706,K706,K748,K748)  $ PERTURB SOFT Q FACTORS
      SCALE(K99,G20,G20,K40,K40,K41,K41,K42,K42,K43,K43,K49,K49
            K53,K53,K73,K73,G113,G113,G330,G330,G334,G334
            K605,K605)  $ PERTURB SOFT G FACTORS OR VALUES
      SCALE(K99,G15,G15,G16,G16,K80,K80,G115,G115,K215,K215
            K220,K220,K562,K562)  $ PERTURB MORE SOFT G'S
      BLDARY(A76,C39,C61)        $ SAVE PERTURBED C VALUES
      BLDARY(A76+2,K706,K748)   $ SAVE PERTURBED Q FACTORS
      BLDARY(A76+4,G15,G16,G20,K40,K41,K42,K43,K49,K53,K73,K80
            G113,G115,K215,K220,G330,G334,K562,K605)$ PERTURB G'S
      SHFTV(52,A82,T5)          $ RESET INITIAL TEMPERATURES
TIMEO = 0.0
      CNFRDL          $ CALCULATE PERTURBED TEMPERATURES
      SHFTV(52,T5,A84)          $ SAVE PERTURBED RESULTS
      SHFTV(52,A82,T5)          $ RESET INITIAL TEMPERATURES
TIMEO = 0.0
JTEST = 1
      CNFRDL  $ NOW PERFORM THE KALF'' CORRECTION PASS
      BLDARY(A77,C39,C61)       $ SAVE CORRECTED C VALUES
      BLDARY(A77+2,K706,K748)   $ SAVE CORRECTED Q FACTORS
      BLDARY(A77+4,G15,G16,G20,K40,K41,K42,K43,K49,K53,K73,K80
            G113,G115,K215,K220,G330,G334,K562,K605)$ CORECTED G'S
      SUBARY(K98,A77,A75,A78) $ OBTAIN CORRECTION DIFFERENCE
      DIVARY(K98,A78,A75,A78) $ CONVERT TO PERCENTAGE
      ARYMPY(K98,A78,100.0,A78)
      PRNTMI(A74,A99+1,A74+1,A99+13,A75,A99+17,A76,A99+21,A77
            A99+25,A78)       $ PRINT CAPACITOR DATA
      PRNTMI(A92,A99+5,A92+1,A99+13,A75+2,A99+17,A76+2
            A99+21,A77+2,A99+25,A78+2)    $ PRINT SOURCE DATA
      PRNTMI(A94,A99+9,A94+1,A99+13,A75+4,A99+17,A76+4
            A99+21,A77+4,A99+25,A78+4) $ PRINT CONDUCTOR DATA
      SHFTV(52,A82,T5)          $ RESET INITIAL TEMPERATURES
TIMEO = 0.0
JTEST = 0
      SETPLS(C39,C61,K706,K748,G20,K40,K41,K42,K43,K49,K53,K73
            G113,G330,G334,K605)    $ INSURE POSITIVE CORRECTIONS
      SETPLS(G15,G16,K80,G115,K215,K220,K562)
      CNFRDL              $ CALCULATE CORRECTED TEMPERATURES
      SHFTV(52,T5,A85)          $ SAVE CORRECTED RESULTS
      SUBARY(A72,A85,A83,A87)  $ OBTAIN CORRECTION DIFFERENCE
      ARYADD(A72,A83,460.0,A83)    $ CONVERT TO RANKINE
      DIVARY(A72,A87,A83,A87) $ CONVERT TO PERCENTAGE, RANKINE BASE
      ARYSUB(A72,A83,460.0,A83)    $ CONVERT TO F
      ARYMPY(A72,A87,100.0,A87)
      PRNTMI(A72,A98+1,A72+1,A98+5,A83,A98+9,A84,A98+13,A85
            A99+25,A87)  $ PRINT TEMPERATURE DATA
 END
```

TABLE B-8 (Cont.)

```
 BCD 3VARIABLES 1
      DIDEG1(TIMEM,A20,T200)
      DIDEG1(TIMEM,A21,T300)
 END
 BCD 3VARIABLES 2
CALL KALFIL ON THE CORRECTION PASS ONLY
IF(JTEST.EQ.0) RETURN
      KALFIL(0,A71,A73,A91,A93,A86,A96)
 END
 BCD 3OUTPUT CALLS
FOLLOWING CARD INSURES KALFIL CALL FOR TIME 0.0
IF(TIMEO,EQ.0.0) CALL VARBL2
      TPRINT
BUILD TIME-TEMP MATRIX ON FIRST PASS ONLY
IF(ITEST.GE.21) RETURN
      BLDARY(A95,T5,T6,T7,T-,T21,T22,T23,T24,T26,T39,T29,T45,T46
              T47,T48,T49,T61,T63,T67,T81,T86,T2,T71,T76)
      TESTMP(ITEST,24,A95,TIMEN,A86) $ BUILD TIME-TEMP MATRIX
 END
```

C. STEP (SENSITIVITY TEMPERATURE ERROR PROGRAM)

C.1 Introduction

Subroutine STEP (Sensitivity-Temperature Error Program) generates static sensitivity coefficients that may be used to assess the relative parameter effects on a specified temperature or to assess the uncertainty of a given temperature. Theoretical development is reported elsewhere,* but briefly STEP is based upon a derivative operation on the steady state heat balance equations.

$$Q_i = \sum_{j=1}^{p} a_{ij} (T_i - T_j) + \sum_{j=1}^{p} \sigma b_{ij} (T_i^4 - T_j^4) \qquad \text{(C-1)}$$

$$i = 1,2,\ldots,n$$

where: Q_i is the net heat input to the ith node

a_{ij} is the coefficient for conduction and/or convection

b_{ij} is the coefficient for radiation exchange

p is the sum of n variable and p-n fixed temperatures

The derivative operation is conducted in terms of Q_i, a_{ij}, b_{ij}, and T_j ($j>n$) and is expressed in matrix form; the solution of matrix equations yields the sensitivity coefficients

$$\frac{\partial T_i}{\partial a_{k\ell}}, \text{ for } k = 1,\ldots,n \quad \ell = k+1,\ldots,p \qquad \text{(C-2)}$$

$$\frac{\partial T_i}{\partial b_{k\ell}}, \text{ for } i = 1,\ldots,n \quad k = 1,\ldots,n \qquad \text{(C-3)}$$

$$\frac{\partial T_i}{\partial a_{k\ell}}, \text{ for } i = 1,\ldots,n \quad k = 1,\ldots,n \quad \ell = k+1,\ldots,p \qquad \text{(C-4)}$$

$$\frac{\partial T_i}{\partial Q_k}, \text{ for } i = 1,\ldots,n \quad k = 1,\ldots,n \qquad \text{(C-5)}$$

$$\frac{\partial T_i}{\partial T_k}, \text{ for } i = 1,\ldots,n \quad k = n+1,\ldots,p \qquad \text{(C-6)}$$

---

* Ishimoto, T. and Bevans, J. T., "Temperature Variance in Spacecraft Thermal Analysis," J. of Spacecraft, Vol. 3, No. 11, pp 1372-1376, November 1968.

The sensitivity coefficients indicated by equations (C-2) through (C-6) are employed to generate temperature deviation expressions.

Random Temperature Deviation

The temperature deviation in the random sense, $(\Delta T_i)_r$ may be expressed as:

$$(\Delta T_i)_r = \left\{ \sum_{k=1}^{n} \left(\frac{\partial T_i}{\partial Q_k} \Delta Q_k\right)^2 + \sum_{k=n+1}^{p} \left(\frac{\partial T_i}{\partial T_k} \Delta T_k\right)^2 + \sum_{k=1}^{n} \sum_{\ell=k+1}^{p} \left[\left(\frac{\partial T_i}{\partial a_k} \Delta a_{k\ell}\right)^2 + \left(\frac{\partial T_i}{\partial b_{k\ell}} \Delta b_{k\ell}\right)^2 \right] \right\}^{1/2} \quad \text{(C-7)}$$

Linear Algebraic Temperature Deviation

If the parameter perturbations are deterministic, then the temperature variations should be based upon the algebraic sum of the individual parameter perturbation effects. If $(\Delta T_i)_a$ represents the linear algebraic temperature deviation, the expression is written as:

$$(\Delta T_i)_a = \sum_{k=1}^{n} \frac{\partial T_i}{\partial Q_k} \Delta Q_k + \sum_{k=n+1}^{p} \frac{\partial T_i}{\partial T_k} \Delta T_k + \sum_{k=1}^{n} \sum_{\ell=k+1}^{p} \left(\frac{\partial T_i}{\partial a_{k\ell}} \Delta a_{k\ell} + \frac{\partial T_i}{\partial b_{k\ell}} \Delta b_{k\ell}\right) \quad \text{(C-8)}$$

$$i = 1,2,\ldots,n$$

Linear Absolute Temperature Deviation

If a worst-case temperature deviation is desired, the partial derivatives and the individual parameter perturbations are evaluated in an "absolute" sense. If $(\Delta T_i)_{ab}$ represents the linear absolute temperature deviation, the expression is written as:

$$(\Delta T_i)_{ab} = \sum_{k\ 1}^{n} \left| \frac{\partial T_i}{\partial Q_k} \Delta Q_k \right| + \sum_{k=n+1}^{p} \left| \frac{\partial T_i}{\partial T_k} \Delta T_k \right| + \sum_{k=1}^{n} \sum_{\ell=k+1}^{p} \left[\left| \frac{\partial T_i}{\partial a_{k\ell}} \Delta a_{k\ell} \right| + \left| \frac{\partial T_i}{\partial b_{k\ell}} \Delta b_{k\ell} \right| \right]$$

$$i = 1,2,\ldots,n$$

C.2 STEP User's Directions*

C.2.1 SUBROUTINE NAME: STEP

C.2.2 PURPOSE

C.2.2.1 For generating static sensitivity coefficients with respect to $a_{k\ell}$, $b_{k\ell}$, Q_k, and T_k (for boundary nodes).

C.2.2.2 For generating temperature deviation in the root mean square sense, in the algebraic sum sense, and in the absolute value sense.

C.2.3 RESTRICTIONS

C.2.3.1 CINDSL must be called before STEP is called since the long pseudo compute sequence and the arrays containing temperatures, conductance, and heating rates are utilized.

C.2.3.2 Parallel linear or parallel radiation conductors are not permitted.

C.2.3.3 A1 and A2 must be positive arrays.

C.2.3.4 The maximum number of nodes (diffusion plus arithmetic) that can be accommodated is approximately 200.

C.2.4 CALLING SEQUENCE

C.2.4.1 STEP(A1(IC),A2(IC))

where: A1 is an array of print specifications

A2 is an array of variance specifications.

C.2.4.2 Format, A1 and A2

IC,PC,Op,Op,...,Op,PC,Op,...,END

where: IC is the table number

PC is a parameter code (Refer to Table (C-1))

Op is an option (for A1, refer to Table (C-2); for A2 refer to Table (C-3)

C.2.5 NOTES

C.2.5.1 This subroutine requires N^2 + P locations of dynamic storage. N is the sum of diffusion and arithmetic nodes (non boundary

*Directions are used in conjunction with the instructions contained in the SINDA Users Manual (Reference 3).

nodes) and P is the total number of nodes (diffusion plus boundary nodes).

C.2.5.2 In Table C-2, for the option designated by NODE, approximately 100 node numbers may be specified.

C.2.5.3 In Table C-3, approximately 35 individual variances may be specified, not including those generated under option ALL.

C.2.5.4 Based upon a number of models ranging from 30 to 164 nodes, the solution time can be estimated in a very approximate sense by,

$$\text{Solution time (minutes)} = 1/2 \left(\frac{n}{30}\right)^2$$

where n is the number of nodes (diffusion plus arithmetic)

C.2.6 ILLUSTRATIVE STEP INPUT

The STEP input itself is illustrated directly below and in Table C-4, but it should be noted that STEP requires SINDA input considerations as reported in Reference 3.

C.2.6.1 Array A1

```
1,A,LIST,ALL
  B,PURE,ALGORD,NODE,1,4
  Q,ABSORD,NODE,2,3
  CONT,ALL,PURE,DELTA
  DELTAT,END
```

C.2.6.2 Array A2

```
2,A,ALL,.1,B,ALL,1,.1,3,4,.05
  Q,ALL,.08,2,.1,4,.1,CONT,ALL,.05,END
```

C.2.6.3 Note that the node numbers specified are actual, not relative numbers.

C.2.7 FLOW DIAGRAM

A flow diagram of the major logic for the STEP subroutine is presented in Figure C-1.

TABLE C-1

PARAMETER CODE	PARAMETER
A	Linear conductors
B	Radiation conductors
Q	Source terms (heating rates)
CONT	Constant temperatures
DELTAT	This is not a parameter, but rather a signal to the program to calculate and print the three types of deviation. Use in array A1 only. Options in Table C-2 do not apply.

TABLE C-2

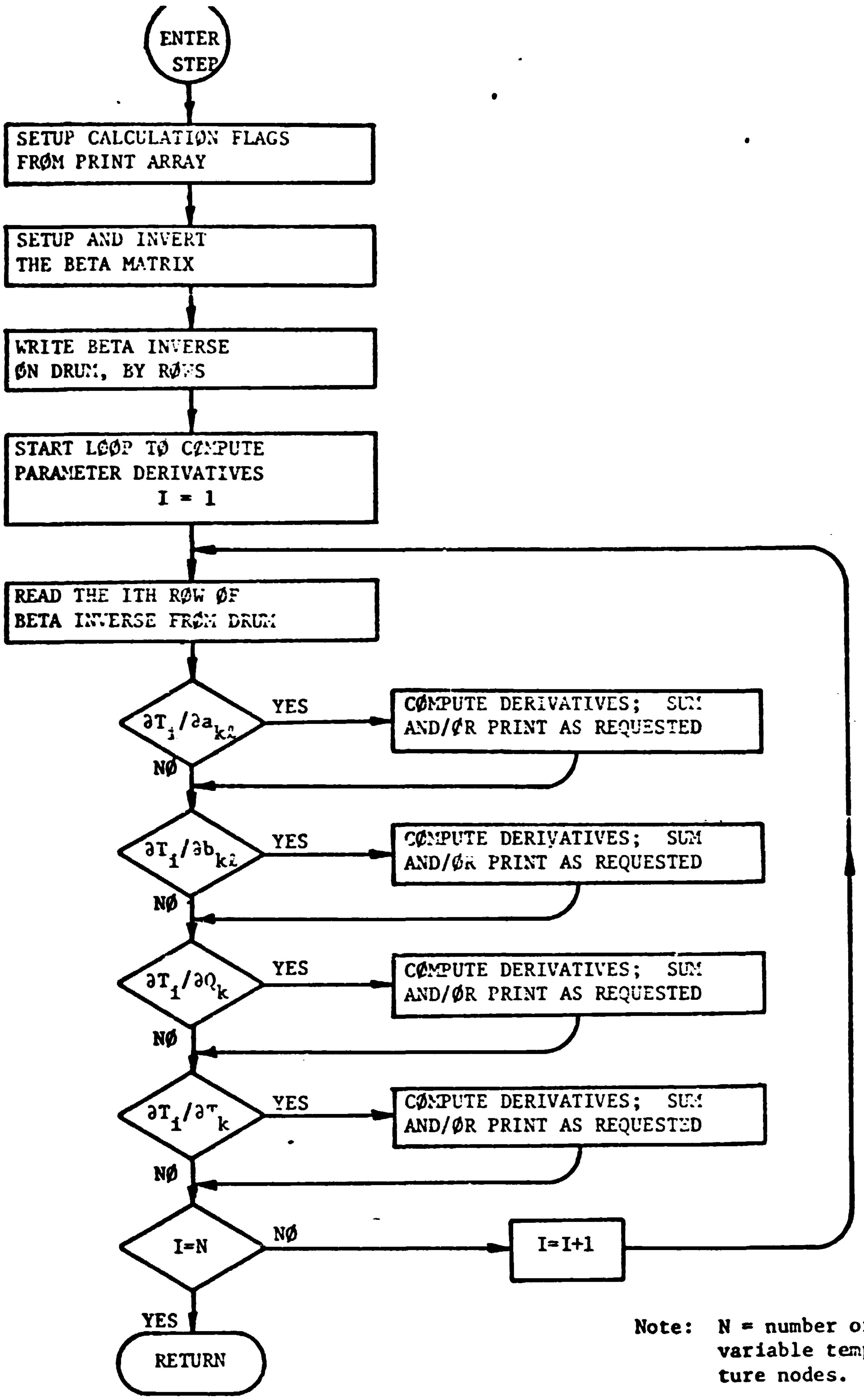
OPTIONS	EXPLANATION OF OPTIONS
LIST	The parameters and variance printed
ALL	All sensitivity coefficients multiplied by the parameter variance are printed.
PURE	Sensitivity coefficients (not multiplied by parameter variance) are printed.
DELTA	Sensitivity coefficients multipled by parameter variance are printed; this option need be used only in conjunction with the option PURE.
PURE, DELTA	Both outputs under PURE and DELTA are printed.
ALGORD	Each set of output called by ALL or PURE is arranged by the magnitude of algebraic values from the largest to the smallest.
ABSORD	Each set of output called by ALL or PURE is arranged by the magnitude of absolute values from the largest to the smallest.
MULT,n	Output as called by ALL or PURE is limited by the print limiting multiplier, n. The sensitivity coefficient, $\frac{dT}{dP}$, is not printed if $\left\lvert \frac{dT}{dP} \right\rvert < n \left\lvert \frac{dT}{dP} \right\rvert_{max}$
NODE, $i_1, i_2, \ldots$	The sensitivity coefficients for the specified nodes ($i_1, i_2, \ldots$) are printed.

TABLE C-3

OPTIONS	EXPLANATION OF OPTIONS
ALL,n,i_1,m_1,i_2,m_2,...i_k,m_k	This option applies to parameter codes Q and CONT only. The variance will be computed from the relationship variance of parameters = n (value of parameter) unless exceptions denoted by i_1,m_1,i_2,m_2,...,i_k,m_k are specified, i_k is the node number and m_k is the factor defined in the same manner as n.
ALL,n,i_1,j_1,m_1,...	This option applies to parameter codes A and B only. It is similar to the option above except that the user must supply the adjoining node numbers (i_k,j_k) for the conductors.

TABLE C-4

INPUT	COMMENTS
BCD 3ARRAY DATA	The array data contain the input data for the sensitivity coefficients of each parameter category denoted as A, B, Q, or CONT. The input designations and explanation are presented in Tables C-1, C-2, and C-3. To illustrate the options that are offered, the STEP input example of Section C.2-6 will be presented and discussed.
1,A,LIST,ALL	1 means array 1. A means linear conductors. LIST means that the A parameters and variance will be printed. ALL means that all sensitivity coefficients, in terms of A, multiplied by the parameter variance will be printed.
B,PURE,ALGORD,1,4	B means radiation conductors. PURE, ALGORD, NODE, 1, 4 means that the sensitivity coefficients in terms of B, but not multiplied by the variance, will be printed for nodes 1 and 4 only and will be arranged from the largest to the smallest in accordance with the algebraic values. Note: If all of the sensitivity coefficients were desired, the input would read: B,PURE,ALL,ALGORD.
Q,ABSORD,NODE,2,3	Q means heating rates. ABSORD,NODE,2,3 means that the sensitivity coefficients (multiplied by the variance) of nodes 2 and 3 will be printed and arranged from the largest to the smallest in accordance with the absolute values.
CONT,ALL,PURE,DELTA	CONT,ALL,PURE,DELTA means that both of the outputs as called by options PURE and DELTA, will be printed in terms of boundary temperatures, CONT.
DELTAT,END	DELTAT means that the three types of temperature deviation will be calculated and printed. END means the end of data.
2,A,ALL,.1,B,ALL,.1,3,4,.05, Q,ALL,.08,2,.1,4,.1,CONT ALL,.05,END	This input means that all variance of A is equal to .1A; all variance of B is .1B except for B between nodes 3 and 4, which is equal to .05B; all variance of Q is equal to .08Q, except for node 2, which is equal to .1Q; and node 4 which is equal to .1Q, and all variance of CONT (boundary temperatures) which is equal to .05 CONT.
END	END is the end of the data.



Note: N = number of variable temperature nodes.

FIGURE C-1. FLOW DIAGRAM OF MAJOR LOGIC

D. DESCRIPTION OF THERMAL MODELS USED IN THE EVALUATION OF PARAMETER CORRECTION TECHNIQUE

Three thermal models were used in the evaluation of the thermal network correction method. Both the TRW Systems "50-node" model and the NASA/MSC furnished "50-node" model provided systems evaluation of the correction technique as well as accuracy evaluation. The large "500-node" model furnished by NASA/MSC provided for the demonstration of network size on the correction method. Description of these models are in the main limited to nodal and conductor characteristics as listed on the computer printouts in the SINDA format; or discussion on SINDA format refer to Reference 3.

D.1 TRW Systems "50-Node" I3 Antenna Model

A schematic of this model with the nodal locations and descriptions is found in Figure D-1. This model represents an antenna region of the I3 satellite. On page D-4 is tabulated the node data charactistics with the first column being the node number, the second column being the initial temperature and the third column being the capacitance. It should be particularly noted that those nodes with a capacitance of .02 (the last 17 nodes with a capacitance value) were in reality arithmetic nodes but a small capacitance was included to facilitate the correction procedure. The Kalman filtering method does not accommodate zero-capacity nodes.

On pages D-5 and D-6 are listed the conductor values with the first column being the conductor number, the second and third columns being the conductor value. The minus sign in front of the node number (first column) means that the connection is radiation. A few of the conductors (radiation coefficients) are listed to be a function of temperature (denoted by the code CGS which is identical to the SINDA SIV mnemonic code); the letter A1 means array one and K11 means constant address 11.

Now array one, A1, contains the general functional relationship between the conductor value and the temperature; specific variable conductor values are generated by multiplying the data in A1 by the values in the constants address K11, K12,..., etc. The BCD 3 ARRAY DATA block, as shown on page D-7, shows a sequence of numbers: 1 is the array number, -460 is the temperature in °F and .35 is the thermal conductivity at -460°F and so forth. The BCD 3CONSTANTS DATA block shows a sequence of numbers: 11 is the constants address and -2.85 E-10 is the value contained in address 11. The minus sign means that the interpolation is based upon the first indicated nodal temperature.

The heat input to the various nodes is listed in the BCD 3VARIABLES 1 block instead of the source block and is shown on page D-7. For example, STFSEP (59.904, Q71, Q103, Q72) means that a constant heat input of 59.904 Btu/hr is impressed on nodes 71, 103, and 72. All impressed heat sources are constant.

D.2 NASA/MSC "50-Node" Mass Spectrometer Model

The NASA/MSC model of approximately 50 nodes is identified and described here by a SINDA computer listing. The node data block indicating node number, initial nodal temperature, and a capacitance are tabulated on pages D-8. On pages D-9 and D-10 are listed the conductor data; note that most of the conductors are temperature dependent as indicated by the SINDA mnemonic code SIV.

On page D-11 is the constants block containing constants address K1 through K14; constants in these addresses are used in conjunction with the heat input specified in BCD 3VARIABLES 1 on page D-12. On pages D-11 and D-12 are listed the array data A1 through A14 which are associated with the conductor data, arrays A16, A45, A46, and A47 associated with the heat source (time versus heat input), array 20 which is associated with the lunar plane (time versus temperature) and A21 which is associated with the cold wall (time versus temperature).

D.3 NASA/MSC "500-Node" STB Thermal Model*

NASA/MSC "500-node" subsystem test bed (STB) thermal model contains 380 diffusion nodes, 144 arithmetic nodes and 5 boundary nodes. Connections total 1346 which represents 1052 linear and 294 radiation coupling. Because of the large number of input entries only the node data are listed.

* Mobley, T.B., Smith, J.P., and Seward, R.E. "Subsystems Test Bed Thermal Mathematical Model Correlation," Report No. 12245-H003-R000, June 29, 1970, TRW Systems.

Mobley, T.B., Smith, J.P., and Seward, R.E. "Subsystems Test Bed (STB) Thermal Model (TMM) Documentation," Report No. 12245-H004-R000, June 29, 1970, TRW Systems.

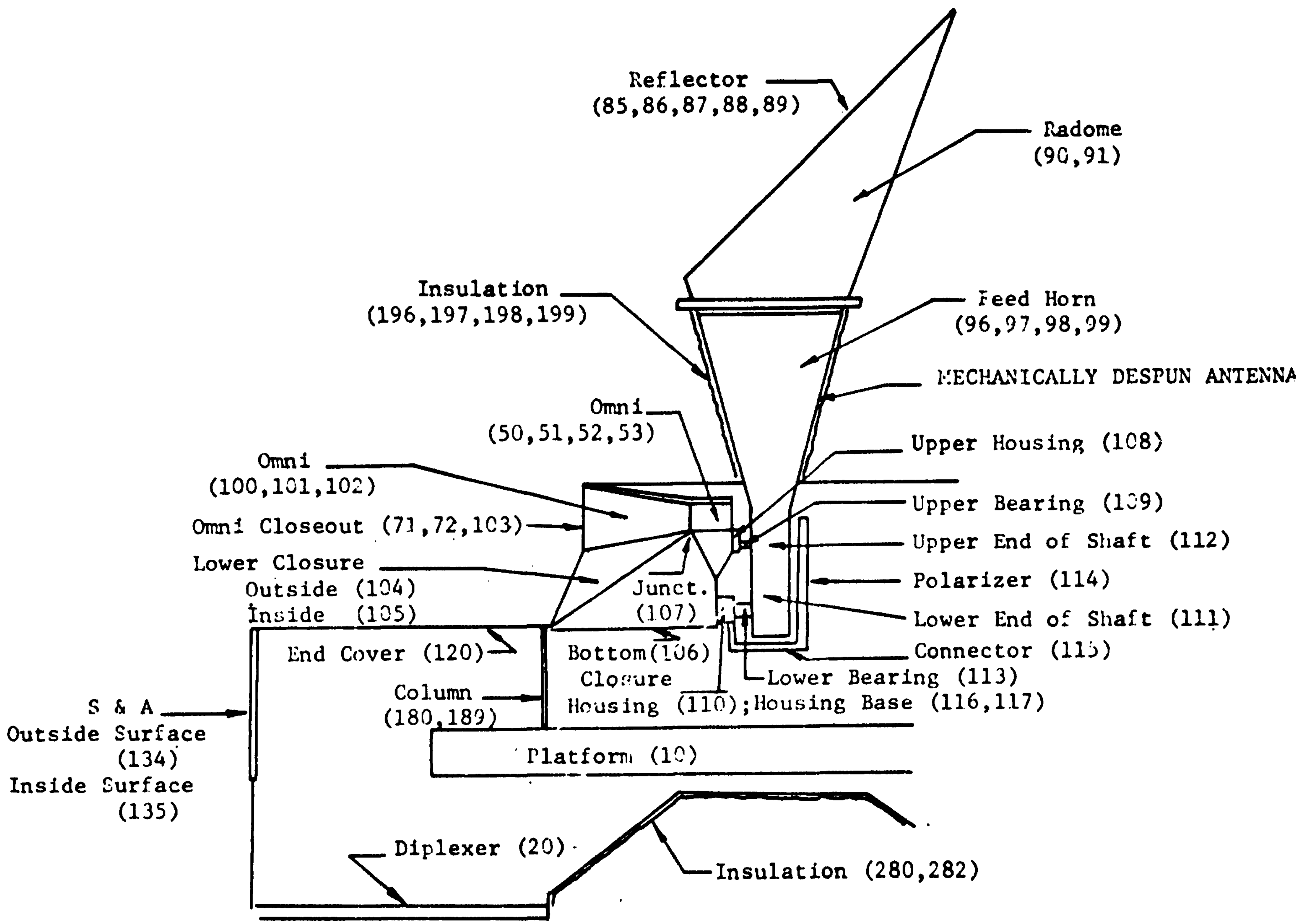


Figure D-1 TRW "50-Node" Model

TABLE D-1

NODE DATA, TRW 50-NODE MODEL

BCD 3NODE DATA

NODE NUMBER	INITIAL TEMP.	CAPACITANCE	
110,	6.00000E+01,	6.50000E-01	Motor housing
53,	1.15000E+02,	1.16000E-01	Omni
103,	5.00000E+01,	2.30000E-02	Omni closeout
71,	5.00000E+01,	2.30000E-02	" "
72,	5.00000E+01,	2.30000E-02	" "
85,	6.00000E+01,	1.67000E-02	Reflector
86,	6.00000E+01,	1.67000E-02	"
87,	6.00000E+01,	1.67000E-02	"
88,	6.00000E+01,	1.67000E-02	"
89,	6.00000E+01,	1.67000E-02	"
90,	7.00000E+01,	4.70000E-02	Radome
91,	7.00000E+01,	4.70000E-02	"
96,	5.00000E+01,	6.00000E-02	Feed horn
97,	5.00000E+01,	6.00000E-02	" "
98,	5.00000E+01,	6.00000E-02	" "
99,	5.00000E+01,	6.00000E-02	" "
101,	1.20000E+02,	1.89000E-01	Omni
102,	1.14000E+02,	1.89000E-01	"
104,	1.83000E+02,	7.30000E-02	Outside surface of lower closure
105,	1.19000E+02,	4.57200E-01	Inside " " " "
106,	7.90000E+01,	1.58000E-01	Bottom closure
108,	1.14000E+02,	2.65000E-01	Upper housing
111,	9.00000E+01,	2.20000E-01	Lower end of lower shaft
112,	9.10000E+01,	2.30000E-01	Upper end " " "
114,	7.00000E+01,	4.00000E-02	Polarizer
115,	7.50000E+01,	2.90000E-01	(As shown in Figure D-1)
116,	7.50000E+01,	3.28000E-01	Housing base
134,	5.00000E+01,	4.15800E-01	Outside surface of S & A
135,	4.90000E+01,	1.93000E+00	Inside surface of S & A
50,	1.00000E+02,	0.02	Omni
51,	1.10000E+02,	0.02	"
52,	1.36000E+02,	0.02	"
100,	4.00000E+01,	0.02	"
107,	1.14000E+02,	0.02	Junction
109,	1.04000E+02,	0.02	Upper bearing
113,	8.00000E+01,	0.02	Lower bearing
117,	7.50000E+01,	0.02	Housing base
120,	3.00000E+01,	0.02	End cover
180,	5.60000E+01,	0.02	Column
189,	5.00000E+01,	0.02	Top of column
196,	3.00000E+01,	0.02	Insulation
197,	3.00000E+01,	0.02	"
198,	3.00000E+01,	0.02	"
199,	3.00000E+01,	0.02	"
280,	6.00000E+01,	0.02	"
282,	6.00000E+01,	0.02	"
-1,	-4.60000E+02,	0.	Sink temperature
-10,	8.50000E+01,	0.	Boundary temperature (platform)
-20,	9.30000E+01,	0.	" " (diplexer)

TABLE D-2

CONDUCTOR DATA, TRW 50-NODE MODEL

COND. #	NODE #	NODE #	VALUE	COND. #	NODE #	NODE #	VALUE
BCD 3CONDUCTOR DATA							
10,	96,	97,	7.50623E-01	108,	72,	51,	2.50000E-02
11,	97,	98,	7.50623E-01	115,	96,	196,	3.70370E-02
12,	98,	99,	7.50623E-01	116,	97,	197,	3.70370E-02
13,	99,	96,	7.50623E-01	117,	98,	198,	3.70370E-02
14,	96,	112,	1.39718E-01	118,	99,	199,	3.70370E-02
15,	97,	112,	1.39718E-01	130,	120,	189,	2.08333E-02
16,	98,	112,	1.39718E-01	131,	20,	115,	1.63132E-02
17,	99,	112,	1.39718E-01	-200,	85,	1,	1.02446E-10
18,	101,	100,	1.78571E-02	-201,	86,	1,	1.02446E-10
19,	50,	100,	3.77358E-03	-202,	87,	1,	1.02446E-10
21,	112,	111,	1.09708E+00	-203,	88,	1,	1.02446E-10
20,	112,	109,	8.00000E-01	-204,	89,	1,	1.02446E-10
22,	109,	108,	8.00000E-01	-210,	90,	1,	1.37158E-09
23,	111,	113,	4.00000E-01	-211,	91,	1,	1.37158E-09
24,	113,	110,	4.00000E-01	-220,	135,	1,	2.55083E-08
25,	115,	106,	4.76190E-02	-230,	85,	90,	1.78893E-10
26,	106,	189,	1.66667E-02	-231,	85,	91,	1.78893E-10
30,	114,	115,	9.06857E-01	-232,	86,	90,	2.14672E-10
31,	115,	117,	9.46857E-01	-233,	86,	91,	1.43115E-10
32,	115,	110,	3.23235E+00	-234,	87,	90,	1.43115E-10
33,	116,	117,	6.01833E-01	-235,	87,	91,	2.14672E-10
40,	180,	189,	1.47200E+00	-236,	88,	90,	1.61004E-10
41,	189,	105,	1.57729E-01	-237,	88,	91,	1.96783E-10
42,	105,	107,	2.43309E-01	-238,	89,	90,	1.96783E-10
50,	85,	86,	3.17460E-02	-239,	89,	91,	1.61004E-10
51,	85,	87,	3.17460E-02	-250,	96,	97,	5.29174E-11
52,	85,	88,	3.17460E-02	-251,	96,	98,	6.84986E-11
53,	85,	89,	3.17460E-02	-252,	96,	99,	5.29174E-11
54,	86,	87,	2.54453E-02	-253,	97,	98,	5.29174E-11
55,	87,	88,	2.54453E-02	-254,	97,	99,	6.84986E-11
56,	88,	69,	2.54453E-02	-255,	98,	99,	5.29174E-11
57,	89,	86,	2.54453E-02	-256,	108,	50,	4.64580E-12
60,	110,	107,	2.43902E+00	-257,	108,	52,	2.54923E-11
61,	107,	102,	3.93701E+00	-258,	108,	53,	4.64580E-12
62,	110,	108,	1.17647E+00	-259,	50,	52,	6.43264E-11
70,	101,	50,	1.56250E+00	-260,	50,	53,	1.45330E-11
71,	50,	108,	6.25000E+00	-261,	52,	53,	6.43264E-11
73,	189,	51,	1.04167E-01	-262,	52,	101,	5.84894E-11
74,	51,	102,	4.00000E+00	-264,	52,	102,	5.84894E-11
78,	108,	53,	1.19048E+01	-266,	101,	102,	8.49347E-11
79,	53,	107,	1.19048E+01	-270,	280,	106,	4.52299E-11
80,	107,	52,	7.46269E-03	-271,	280,	180,	2.41700E-11
81,	50,	52,	7.46269E-03	-272,	282,	106,	1.80364E-10
90,	134,	135,	1.68390E+01	-273,	282,	280,	2.92157E-10
103,	71,	103,	1.25000E-02	-274,	180,	106,	2.12853E-09
104,	72,	103,	1.25000E-02	-279,	10,	134,	4.23467E-09
107,	71,	101,	2.50000E-02	-280,	10,	180,	1.36602E-09

TABLE D-2 (Cont.)

CONDUCTOR DATA, TRW 50-NODE MODEL

COND. #	NODE #	NODE #	VALUE
-281,	10,	120,	7.19710E-10
-282,	134,	120,	1.24748E-09
-283,	134,	180,	4.66262E-09
-289,	100,	120,	3.93818E-10
-290,	114,	111,	1.82854E-11
-291,	114,	112,	1.82854E-11
-293,	111,	110,	2.24547E-11
-294,	112,	108,	2.24547E-11
-300,	96,	85,	6.40888E-12
-301,	96,	86,	5.76799E-12
-302,	96,	87,	5.76799E-12
-303,	96,	88,	7.04977E-12
-304,	96,	89,	7.04977E-12
-305,	99,	85,	6.40888E-12
-306,	99,	86,	5.76799E-12
-307,	99,	87,	5.76799E-12
-308,	99,	88,	7.04977E-12
-309,	99,	89,	7.04977E-12
-310,	98,	85,	8.76076E-12
-311,	98,	86,	7.88469E-12
-312,	98,	87,	7.88469E-12
-313,	98,	88,	9.63684E-12
-314,	98,	89,	9.63684E-12
-315,	97,	85,	6.76076E-12
-316,	97,	86,	7.88469E-12
-317,	97,	87,	7.88469E-12
-318,	97,	88,	9.63684E-12
-319,	97,	89,	9.63684E-12
-320,	96,	90,	3.64997E-11
-321,	96,	91,	4.46108E-11
-322,	99,	90,	4.46108E-11
-323,	99,	91,	3.64997E-11
-324,	97,	90,	3.06127E-11
-325,	97,	91,	3.74155E-11
-326,	98,	90,	3.74155E-11
-327,	98,	91,	3.06127E-11
-328,	90,	91,	3.54311E-10
-349,	105,	102,	4.55050E-10
-350,	105,	104,	2.85895E-10
-351,	102,	104,	1.42948E-11
-352,	114,	85,	3.25778E-11

COND. #	NODE #	NODE #	VALUE
-353,	110,	106,	6.19440E-11
-354,	110,	105,	3.09720E-11
-355,	105,	106,	2.25821E-10
-356,	50,	1,	9.14865E-12
-357,	101,	1,	1.80114E-11
-358,	51,	1,	1.35536E-10
-205,	103,	1,	4.99446E-10
-333,	71,	1,	4.99446E-10
-335,	72,	1,	4.99446E-10
-263,	103,	52,	3.96680E-11
-265,	103,	101,	5.09251E-11
-267,	103,	102,	5.09251E-11
-337,	71,	52,	3.96680E-11
-338,	71,	101,	5.09251E-11
-339,	71,	102,	5.09251E-11
-340,	72,	52,	3.96680E-11
-341,	72,	101,	5.09251E-11
-342,	72,	102,	4.52667E-11
-206,	104,	1,	2.86759E-10
-360,	112,	1,	6.68757E-12
-223,	196,	120,	3.5208E-11
-224,	197,	120,	3.7849E-11
-225,	198,	120,	3.7849E-11
-226,	199,	120,	3.5208E-11
-243,	196,	100,	6.2424E-11
-244,	197,	100,	6.7106E-11
-245,	198,	100,	6.7106E-11
-246,	199,	100,	6.2424E-11
CGS -221,	120,	90,	A1, K11
CGS -222,	120,	91,	A1, K12
CGS -219,	120,	1,	A1, K13
CGS -212,	196,	1,	A1, K14
CGS -213,	197,	1,	A1, K15
CGS -214,	198,	1,	A1, K16
CGS -215,	199,	1,	A1, K17
CGS -216,	100,	1,	A1, K18
CGS -207,	103,	120,	A1, K19
CGS -334,	71,	120,	A1, K20
CGS -336,	72,	120,	A1, K21
CGS -208,	104,	120,	A1, K22

TABLE D-3

CONSTANTS, ARRAY, AND HEAT INPUT DATA

```
BCD 3CONSTANTS DATA
     NLOOP,50.,  DAMPD,.5,  DRLXCA,.01
     11,-2.85E-10,12,-2.85E-10,13,-2.052E-8,14,-2.83E-10
     15,-2.83E-10,16,-2.83E-10,17,-2.83E-10,18,-3.28E-9
     19,-3.017E-10,20,-3.019E-10,21,-3.019E-10,22,-1.32E-10
     88,1.5          $ PERTURBATION FACTOR
END
BCD 3ARRAY DATA
     1, -460.,.35,  -238.,.575,  -130.,.66,  -22.,.73
       140.,.79,  248.,.82,  500.,.84,END
END
BCD 3VARIABLES 1
     STFSEP(57.904,Q71,Q103,Q72)
     STFSEP(67.72,Q104)
     STFSEP(7.12,Q112)
     STFSEP(99.92,Q90,Q91)
     STFSEP(139.86,Q100)
     STFSEP(26.22,Q197,Q196)
     STFSEP(946.92,Q120)
     STFSEP(1640.83,Q135)
     STFSEP(.231,Q101)
     STFSEP(23.87,Q180)
     STFSEP(8.866,Q110)
     STFSEP(.5456,Q109)
     STFSEP(.3069,Q113)
     STFSEP(.682,Q116)
END
```

TABLE D-4
NODE DATA, NASA/MSC 50-NODE MODEL

```
BCD 3NODE DATA
      5,55.,0.0680
      6,55.,0.0445
      7,55.,0.068
      8,55.,0.0445
      21   ,55. ,    .0325
      22   ,55. ,    .0200
      23   ,55. ,    .0325
      24   ,55. ,    .0200
      25   ,55. ,    .0195
      26   ,55. ,    .0118
      39   ,55. ,    .72
      27   ,55. ,    .0195
      28   ,55. ,    .0118
      29   ,55. ,    .0354
      45,55.,.0290
      46,55.,.0279
      47,55.,.0427
      48,55.,.0279
      49,55.,.0917
      51,55.,0.0101,52,55.,0.0101,53,55.,0.0101,54,55.,.0101
      61,55.,0.2204
      63,55.,0.0684
      67,55.,0.0684
      81   ,55. ,    .0952
      82   ,55. ,    .0980
      83   ,55. ,    .0664
      84   ,55. ,    .0664
      85   ,55. ,    .0858
      86   ,55. ,    .0952
      87   ,55. ,    .0668
      88   ,55. ,    .0664
      89   ,55. ,    .0664
      90   ,55. ,    .0658
      91   ,55. ,    .1016
      92   ,55. ,    .1266
      1,70.,-1.,2,70.,-1.,3,70.,-1.,4,70.,-1.
      71,70.,-1.
      72,70.,-1.
      73,70.,-1.
      74,70.,-1.
      75,70.,-1.
      76,70.,-1.
      77,70.,-1.
      78,70.,-1.
      79,70.,-1.
      80,70.,-1.
      -200,-10.0,,-300,-400.,
END
```

TABLE D-5 .
CONDUCTOR DATA, NASA/MSC 50-NODE MODEL

```
BCD 3CONDUCTOR DATA
        1,45,39,.053E-05
        2,46,39,.048E-05
        3,47,39,.074E-05
        4,48,39,.048E-05
        5,61,21,1.46E-05
        6,61,22,1.09E-05
        7,61,23,1.49E-05
        8,61,24,1.09E-05
        9,61,63,33.5E-05
        10,61,67,25.6E-05
        11,61,71,128.E-05
        12,61,76,128.E-05
        13,61,81,2.71E-05
        14,61,86,2.71E-05
        15,63,91,2.14E-05
        16,67,92,5.42E-05
        18, 5, 6,0.70E-07
        19, 6, 7,0.70E-07
        20, 7, 8,0.70E-07
SIV     40,21,22,A1,K40,41,22,23,A1,K41
SIV     42,23,24,A1,K42,43,24,21,A1,K43,44,25,26,A1,K44,45,26,27,A1,K45
SIV     46,27,28,A1,K46,47,28,25,A1,K47,48,21,25,A1,K48
SIV     49,22,26,A1,K49,50,23,27,A1,K50,51,24,28,A1,K51
SIV     52,25,29,A1,K52,53,26,29,A1,K53,54,27,29,A1,K54
SIV     55,28,29,A1,K55,73,46,47,A1,K73,74,47,48,A1,K74
SIV     75,48,45,A1,K75,80,45,49,A1,K80,81,46,49,A1,K81,82,47,49,A1,K82
SIV     83,48,49,A1,K83
        113,8, 5,0.70E-07
        114,21,1,5.6E-6,115,22,2,4.48E-6,116,23,3,5.6E-6
        117,24,4,4.48E-6,119,1,5,7.186F-7,120,2,6,4.69E-7
        121,3,7,7.186E-7,122,4,8,4.690F-7
        118,5,39,0.1154E-05
        144,51,200,0.429E-05
        145,52,200,0.429E-05
        146,53,200,0.429E-05
        147,54,200,0.429E-05
        140,49,51, 0.429E-05
        141,49,52, 0.429E-05
        142,49,53, 0.429E-05
        143,49,54, 0.429E-05
        201,6,39,0.0750E-05
        202,7,39,0.1154E-05
        203,8,39,0.0750E-05
SIV                                   215,71,72,A9,K215
SIV     216,72,73,A9,K216,217,73,74,A9,K217,218,74,75,A9,K218
SIV                         220,76,77,A9,K220,221,77,78,A9,K221
SIV     222,78,79,A9,K222,223,79,80,A9,K223
```

TABLE D-5 (Cont.)

```
SIV 237,78,88,A3,K237,238,79,89,A3,K238,239,80,90,A3,K239
SIV -300,5,25,A5,K300,-301,6,26,A5,K301,-302,7,27,A5,K302
SIV -303,8,28,A5,K303,-304,29,39,A5,K304
    -305,61,300,0.217E-12
    -314,45,200,0.560E-13
    -315,45,300,0.338E-13
    -316,46,200,0.509E-13
    -317,46,300,0.304E-13
    -318,47,200,0.750E-13
    -319,47,300,0.452E-13
    -320,46,200,0.509E-13
    -321,48,300,0.384E-13
    -322,1,300,13.86E-15,-323,1,200,6.62E-15
    -324,2,300,9.070E-15,-325,2,200,4.28E-15
    -326,3,300,13.86E-15,-327,3,200,6.62E-15
    -328,4,300,9.070E-15,-329,4,200,4.28E-15
    -330,5,300,9.650E-14,-331,5,200,6.78E-14
    -332,6,300,6.570E-14,-333,6,200,4.56E-14
    -334,7,300,9.650E-14,-335,7,200,6.78E-14
    -336,8,300,6.570E-14,-337,8,200,4.56E-14
SIV                                                   -347,49,200,A6,K347
    -351,61, 81,3.60E-14
SIV                                                 -352,91,25,A8,K352
SIV -353,92,27,A8,K353
    -554,61, 86,3.60E-14
    -555,63,91,1.40E-14
    -556,67,92,2.70E-14
SIV -562,81,82,A8,K562,-563,86,87,A8,K563,-564,82,83,A8,K564
SIV -565,83,84,A8,K565,-566,84,85,A8,K566,-567,87,88,A8,K567
SIV -568,88,89,A8,K568,-569,89,90,A8,K569,-570,85,29,A8,K570
SIV -571,90,29,A8,K571,-600,81,28,A8,K600,-601,82,28,A8,K601
SIV -602,83,28,A8,K602,-603,84,28,A8,K603,-604,85,28,A8,K604
SIV -605,86,26,A8,K605,-606,87,26,A8,K606,-607,88,26,A8,K607
SIV -608,89,26,A8,K608,-609,90,26,A8,K609,-620,39,45,A11,K620
SIV -621,39,46,A11,K621,-622,39,47,A11,K622,-623,39,48,A11,K623
SIV -624,39,49,A11,K624,-625,45,46,A11,K625,-626,45,47,A11,K626
SIV -627,45,48,A11,K627,-628,45,49,A11,K628,-629,46,47,A11,K629
SIV -630,46,48,A11,K630,-631,46,49,A11,K631,-632,47,48,A11,K632
SIV -633,47,49,A11,K633,-634,48,49,A11,K634
END
```

TABLE D-6

CONSTANTS, ARRAY AND HEAT INPUT DATA

```
BCD 3CONSTANTS DATA
    NLOOP=10, DAMPA=0.9, ARLXCA=0.01
    1,1.7E-03,2,6.0E-06, 3,6.4E-04,4,2.7E-04,5,4.5E-04
    6,1.5E-03,7,6.3E-04,8,6.3E-04,9,6.3E-04
    10,3.6E-04,11,1.59E-03,12,1.91E-03
    60,1,61,0,62,-1,64,0.,65,85.000,66,-250.,67,200.,68,40
    69,-300.,70,250.
    40,4.6E-7,41,4.6E-7,42,4.6E-7,43,4.6E-7,44,5.52E-7,45,5.52E-7
    46,5.52E-7,47,5.52E-7,48,.469E-5,49,.1259E-5,50,.469E-5
    51,.1259E-5,52,.1072E-5,53,5.11E-7,54,.1072E-5,55,5.11E-7
                                            73,5.86E-7,74,5.09E-7
    75,6.45E-7
    80,.2879E-5,81,.1505E-5,82,.4407E-5,83,.1389E-5
                                                              215,60.54E-5
    216,46.15E-5,217,46.15E-5,218,46.15E-5                    ,220,60.54E-5
    221,46.15E-5,222,46.15E-5,223,46.15E-5
                                     232,.2E-7,233,.2E-7,234,.2E-7,235,.2E-7
    236,.2E-7,237,.2E-7,238,.2E-7,239,.2E-7,240,.65E-8
    300,134.82E-15,301,88.01E-15,302,134.82E-15,303,88.01E-15
    304,221.18E-15
                                                       347,191.19E-15
                                         352,53.55E-15,353,78.22E-15
                                      562,23.63E-15,563,23.63E-15,564,61.13E-15
    565,61.13E-15,566,61.13E-15,567,61.13E-15,568,61.13E-15,569,61.13E-15
    570,68.24E-15,571,66.24E-15,600,7.67E-15,601,10.66E-15,602,7.11E-15
    603,7.11E-15,604,7.11E-15,605,7.67E-15,606,10.66E-15,607,7.11E-15
    608,7.11E-15,609,7.11E-15,620,26.34E-15,621,17.71E-15,622,39.36E-15
    623,24.77E-15,624,129.14E-15,625,2.47E-15,626,11.2E-15,627,11.3E-15
    628,26.34E-15,629,10.69E-15,630,3.E-15,631,17.71E-15,632,12.24E-15
    633,39.35E-15,634,24.77E-15
    99=2.0          $ PERTURBATION FACTOR
END
BCD 3ARRAY DATA
    1,-300.,.06,300.,.112,END
    2,-300.,.06,300.,.112,END
    3,-100.,2134.,200.,1970.,END
    4,-100.,4.02,200.,4.02,END
    5,-300.,.035,300.,.035,END
    6,-300.,.96,300.,.96,END
    7,-300.,.90,300.,.90,END
    8,-300.,.95,300.,.95,END
    9,-400.,1.,400.,1.,END
    10,-300.,.82,300.,.82,END
    11,-300.,.90,300.,.90,END
    12,-100.,723.,200.,723.,END
    13,-100.,723.,200.,723.,END
    14,-100.,723.,200.,723.,END
    16,0.,0.00285,17100.,0.00285,17120.,0.00570,48600.,.0057
    48620.,0.0,65700.,0.0,65720.,.00570,68400.,.0057,68420.
    0.0,72900.,0.0,72920.,.0057,159400.,.0057,159420.,0.00
    197200.,0.0,197220.,.00495,242100.,.00495,242120.,.00350
    245520.,.0035,245525.,0.0,253380.,0.0,253382.,.0035
    281700.,.0035,END
```

TABLE D-6 (Cont.)

```
20,0.,66.,1800.,24.6,3600.,-24.2,5400.,-61.9,7200.,-89.8
9180.,-111.5,10200.,-120.3,12640.,-139.,14580.,-150.2
16320.,-158.8,18000.,-166.1
                   21600.,-178.9,25200.,-188.2,28800.,-195.0
32400.,-200.5,36000.,-204.9,39600.,-208.4,43200.,-208.6
46800.,-203.
48600.,-195.,50400.,-136.,54000.,-2.0,57600.,78.,61200.
150.,64800.,186.,68400.,-14.,72000.,-89.,75600.,-127.
76500.,-135.,80100.,-157.,87300.,-184.,94500.,-199.
101700.,-210.,108900.,-216.,116100.,-220.,123300.,-223.
126900.,-224.,144900.,-228.,173700.,-230.,195300.,-231.
197100.,-229.,198900.,-44.0,202500.,135.,206100.,154.
209700.,199.,213300.,257.,216900.,224.,220500.,188.
224100.,182.,242100.,182.,245700.,152.,247500.,183.
249300.,202.,251100.,186.,252900.,189.,254700.,222.
256500.,202.,260100.,190.,263700.,182.,267300.,187.
270900.,183.,274500.,192.,278100.,197.,281700.,203.,END
21,0.,-30.,1800.,-123.,3600.,-148.2,5400.,-162.8
7200.,-161.7,9180.,-167.9,10200.,-209.8,12660.,-279.5
14580.,-279.9,16320.,-280.2,18000.,-280.2
                   21600.,-280.9,25200.,-281.2,28800.,-277.9
32400.,-277.0,36000.,-277.1,39600.,-255.3,43200.,-218.9
46800.,-265.
48600.,-264.,50400.,-264.,54000.,-255.,57600.,-244.
61200.,-232.,64800.,-226.,68400.,-257.,72000.,-226.
75600.,-269.,76500.,-270.,80100.,-272.,87300.,-276.
94500.,-275.,101700.,-275.,108900.,-275.,116100.,-275.
123300.,-275.,126900.,-281.,144900.,-281.,173700.,-280.
195300.,-280.,197100.,-280.,198900.,-260.,202500.,-246.
206100.,-242.,209700.,-235.,213300.,-228.,216900.,-232.
220500.,-234.,224100.,-230.,242100.,-227.,245700.,-231.
247500.,-226.,249300.,-223.,251100.,-224.,252900.,-224.
254700.,-220.,256500.,-223.,260100.,-225.,263700.,-227.
267300.,-239.,270900.,-238.,274500.,-235.,278100.,-233.
281700.,-233.,END
45,0.,0.0,242100.,0.0,242120.,.00307,281700.,.00307,END
46,0.,0.0,242100.,0.0,242120.,.00322,281700.,.00322,END
47,0.,0.0,242100.,0.0,242120.,.00050,281700.,.00050,END
END
BCD 3VARIABLES 1
      DIDEGI(TIMEM,A20,T200)
      DIDEGI(TIMEM,A21,T300)
      DIDEGI(TIMEM,A16,Q61)
      DIDEGI(TIMEM,A47,Q02)
      DIDEGI(TIMEM,A46,Q06)
      DIDEGI(TIMEM,A45,Q48)
   IF(TIMEM.LE.48600.) GO TO 40
   IF(TIMEM.GT.48600..AND.TIMEM.LE.65700.) GO TO  0
   IF(TIMEM.GT.65700..AND.TIMEM.LE.117900.) GO TO 40
   IF(TIMEM.GT.117900.) GO TO 10
10 CONTINUE
      SHFTV(12,K1,Q81)
40 CONTINUE
   END
```

TABLE D-7

NODE DATA, NASA/MSC 500-NODE MODEL

```
BCD 3NODE DATA
    101, 70., 5.678,  102, 70., 7.404,  103, 70., 8.043,  104, 70., [illegible]
    105, 70., 5.428,  106, 70., 7.404,  107, 70., 5.720,  108, 70., 7.40
    109, 70., 5.428,  110, 70., 7.404,  111, 70., 8.043,  112, 70., 7.40
    113, 70., 5.428,  114, 70., 7.654,  115, 70., 5.970,  116, 70., 7.65
    117, 70., 9.020,  118, 70., 9.659,  119, 70., 9.470,  120, 70.,10.07
    121, 70., 9.020,  122, 70., 9.659,  123, 70., 9.020,  124, 70.,10.92
    125, 70.,32.762,  126, 70.,33.000,  127, 70.,32.250,  128, 70.,32.66
    130, 70., 4.286,  131, 70., 5.788,  132, 70., 5.056,  133, 70., 5.78
    134, 70., 4.566,  135, 70., 5.656,  136, 70., 8.937,  137, 70., 7.36
    138, 70., 5.209,  139, 70., 6.761,  140, 70., 5.829,  141, 70., 6.76
    142, 70., 4.909,  143, 70., 6.279,  144, 70., 9.237,  145, 70., 6.68
    146, 70., 7.034,  147, 70., 7.034,  148, 70., 7.034,  149, 70., 7.93
    150, 70., 7.409,  151, 70., 7.334,  152, 70.,13.359,  153, 70., 8.57
    154, 70., 8.677,  155, 70., 8.577,  156, 70., 8.577,  157, 70., 8.57
    158, 70., 8.577,  159, 70., 8.577,  160, 70.,13.359,  161, 70., 7.93
    162, 70., 7.705,  163, 70., 9.623,  164, 70.,10.263,  165, 70.,10.11
    166, 70., 7.855,  167, 70., 9.923,  168, 70.,10.563,  169, 70.,10.71
    170, 70., 8.005,  171, 70., 9.623,  172, 70.,10.263,  173, 70.,10.11
    174, 70., 7.705,  175, 70., 9.623,  176, 70.,10.263,  177, 70.,10.11
    178, 70., 9.482,  179, 70.,10.122,  180, 70., 9.482,  181, 70.,10.12
    182, 70., 9.482,  183, 70.,10.122,  184, 70., 9.482,  185, 70.,10.12
    186, 70.,35.854,  187, 70.,35.854,  188, 70.,36.495,  189, 70.,35.85
    501, 70., 6.790,  502, 70.,21.850,  503, 70., 7.810,  522, 70.,21.85
CGS 521, 70., A300, K60
    523, 70., 7.810,  541, 70., 6.790,  542, 70.,21.850,  543, 70., 7.81
    561, 70., 6.790,  562, 70.,21.850,  563, 70., 7.810
REM HEAT CAPACITY - METEOROID SHIELD
     1,70.,0.607,  2,70.,0.607,  3,70.,0.607,  4,70.,0.607
     5,70.,0.607,  6,70.,0.607,  7,70.,0.377,  8,70.,0.607
     9,70.,0.607, 10,70.,0.607, 11,70.,0.607, 12,70.,0.607
    13,70.,0.607, 14,70.,0.607, 15,70.,0.377, 16,70.,0.607, 17,70.,0.745
    18,70.,0.745, 19,70.,0.745, 20,70.,0.745, 21,70.,0.745
    22,70.,0.745, 23,70.,0.745, 24,70.,0.745, 25,70.,0.789
    26,70.,0.789, 27,70.,0.789, 28,70.,0.789, 30,70.,1.116
    31,70.,1.355, 32,70.,1.355, 33,70.,1.355, 34,70.,1.116
    35,70.,1.355, 36,70.,0.545, 37,70.,1.355, 38,70.,1.116
    39,70.,1.355, 40,70.,1.355, 41,70.,1.355, 42,70.,1.116
    43,70.,1.355, 44,70.,0.545, 45,70.,1.355, 46,70.,1.388
    47,70.,1.388, 48,70.,1.388, 49,70.,1.388, 50,70.,1.388
    51,70.,1.388, 52,70.,1.388, 53,70.,1.388, 54,70.,1.388
    55,70.,1.388, 56,70.,1.388, 57,70.,1.388, 58,70.,1.388
    59,70.,1.388, 60,70.,1.388, 61,70.,1.389, 62,70.,0.607
    63,70.,0.607, 64,70.,0.607, 65,70.,0.607, 66,70.,0.607
    67,70.,0.607, 68,70.,0.607, 69,70.,0.607, 70,70.,0.607
    71,70.,0.607, 72,70.,0.607, 73,70.,0.607, 74,70.,0.607
    75,70.,0.607, 76,70.,0.607, 77,70.,0.607, 78,70.,0.745
    79,70.,0.745, 80,70.,0.745, 81,70.,0.745, 82,70.,0.745
    83,70.0, .745, 84,70.0, .745, 85,70.0, .745,86,70.0, .789
    87,70.0, .789, 88,70.0, .789, 89,70.0, .789
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TABLE D-7 (Cont.)

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REM HEAT CAPACITY-TRUSSES-CGS A326
    1001,70.,,1002,70.,,1003,70.,,1004,70.,,1012,70.,,1016,70.,
    1017,70.,,1018,70.,,1021,70.,,1022,70.,,1023,70.,,1024,70.,
    1035,70.,,1036,70.,,1037,70.,,1051,70.,,1052,70.,,1053,70.,
    1054,70.,,1062,70.,,1066,70.,,1067,70.,,1068,70.,,1071,70.,
    1072,70.,,1073,70.,,1074,70.,,1085,70.,,1086,70.,,1087,70.,
    1101,70.,,1102,70.,,1103,70.,,1104,70.,,1112,70.,,1116,70.,
    1117,70.,,1118,70.,,1121,70.,,1122,70.,,1123,70.,,1124,70.,
    1135,70.,,1136,70.,,1137,70.,,1151,70.,,1152,70.,,1153,70.,
    1154,70.,,1162,70.,,1166,70.,,1167,70.,,1168,70.,,1171,70.,
    1172,70.,,1173,70.,,1174,70.,,1185,70.,,1186,70.,,1187,70.,
REM HEAT CAPACITY-TRUSSES-CGS A324
    1005,70.,,1006,70.,,1007,70.,,1008,70.,,1009,70.,,1010,70.,
    1011,70.,,1013,70.,,1014,70.,,1015,70.,,1025,70.,,1026,70.,
    1027,70.,,1028,70.,,1029,70.,,1030,70.,,1031,70.,,1032,70.,
    1033,70.,,1034,70.,,1055,70.,,1056,70.,,1057,70.,,1058,70.,
    1059,70.,,1060,70.,,1061,70.,,1063,70.,,1064,70.,,1065,70.,
    1075,70.,,1076,70.,,1077,70.,,1078,70.,,1079,70.,,1080,70.,
    1081,70.,,1082,70.,,1083,70.,,1084,70.,,1105,70.,,1106,70.,
    1107,70.,,1108,70.,,1109,70.,,1110,70.,,1111,70.,,1113,70.,
    1114,70.,,1115,70.,,1125,70.,,1126,70.,,1127,70.,,1128,70.,
    1129,70.,,1130,70.,,1131,70.,,1132,70.,,1133,70.,,1134,70.,
    1155,70.,,1156,70.,,1157,70.,,1158,70.,,1159,70.,,1160,70.,
    1161,70.,,1163,70.,,1164,70.,,1165,70.,,1175,70.,,1176,70.,
    1177,70.,,1178,70.,,1179,70.,,1180,70.,,1181,70.,,1182,70.,
    1183,70.,,1184,70.,
REM HEAT CAPACITY-TRUSSES-CGS A321
    1019,70.,.423,1020,70.,.090,1038,70.,.423,1039,70.,.090
    1069,70.,.423,1070,70.,.090,1088,70.,.423,1089,70.,.090
    1119,70.,.423,1120,70.,.090,1138,70.,.423,1139,70.,.090
    1169,70.,.423,1170,70.,.090,1188,70.,.423,1189,70.,.090
REM HEAT CAPACITY - WINDOWS
    685,70.,0.687, 675,70.,0.687, 644,70.,0.687, 654,70.,0.687
    664,70.,0.687, 604,70.,0.687
    686,70.,1.167, 676,70.,1.167, 645,70.,1.167, 655,70.,1.167
    665,70.,1.167, 605,70.,1.167
    688,70.,3.257, 678,70.,3.257, 648,70.,3.257, 658,70.,3.257
    668,70.,3.257, 608,70.,3.257
    683,70.,3.257, 673,70.,3.257, 643,70.,3.257, 653,70.,3.257
    663,70.,3.257, 603,70.,3.257
    682,70.,3.831, 672,70.,3.831, 642,70.,3.831, 652,70.,3.831
    662,70.,3.831, 602,70.,3.831
    681,70.,2.488, 671,70.,2.488, 641,70.,2.488,  51,70.,2.488
    661,70.,2.488, 601, 0.,2.488
    689,70.,-1., 679,70.,-1., 649,70.,-1., 659,70.,-1.
    669,70.,-1., 609,70.,-1.
    690,70.,-1., 680,70.,-1., 650,70.,-1., 660,70.,-1.
    670,70.,-1., 610,70.,-1.
    687,70.,-1.. 677,70.,-1., 647,70.,-1., 657,70.,-1.
    667,70.,-1., 607,70.,-1.
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TABLE D-7 (Cont.)

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REM HEAT CAPACITY-HARD POINTS AND FEED THRUS
               301,70.,-1.,  302,70.,-1.,  303,70.,-1.,  304,70.,-1.
  305,70.,-1., 306,70.,-1.,  307,70.,-1.,  308,70.,-1.,  309,70.,-1.
  310,70.,-1., 311,70.,-1.,  312,70.,-1.,  313,70.,-1.,  314,70.,-1.
  315,70.,-1., 316,70.,-1.,  317,70.,-1.,  318,70.,-1.,  319,70.,-1.
  320,70.,-1., 321,70.,-1.,  322,70.,-1.,  323,70.,-1.,  324,70.,-1.
  325,70.,-1., 326,70.,-1.,  327,70.,-1.,  328,70.,-1.,  340,70.,-1.
  341,70.,-1., 342,70.,-1.,  343,70.,-1.,  344,70.,-1.,  345,70.,-1.
  346,70.,-1., 347,70.,-1.,  348,70.,-1.,  349,70.,-1.,  350,70.,-1.
  351,70.,-1., 352,70.,-1.,  353,70.,-1.,  362,70.,-1.,  363,70.,-1.
  364,70.,-1., 365,70.,-1.,  366,70.,-1.,  367,70.,-1.,  368,70.,-1.
  369,70.,-1., 370,70.,-1.,  371,70.,-1.,  372,70.,-1.,  373,70.,-1.
  374,70.,-1., 375,70.,-1.,  376,70.,-1.,  377,70.,-1.,  378,70.,-1.
  379,70.,-1., 380,70.,-1.,  381,70.,-1.,  382,70.,-1.,  383,70.,-1.
  384,70.,-1., 385,70.,-1.,  386,70.,-1.,  387,70.,-1.,  388,70.,-1.
  389,70.,-1., 451,70.,-1.,  452,70.,-1.,  453,70.,-1.,  454,70.,-1.
REM HEAT CAPACITY - CENTER POSTS
  455,70.,-1., 456,70.,-1.,  457,70.,-1.,  458,70.,-1.,  459,70.,-1.
  460,70.,-1., 461,70.,-1.,  462,70.,-1.,  463,70.,-1.,  464,70.,-1.
  465,70.,-1., 466,70.,-1.
REM HEAT CAPACITY-DOCKING PORTS
                             504,70.,-1.,  505,70.,-1.,  506,70.,-1.
  507,70.,-1., 508,70.,-1.,  509,70.,-1.,  510,70.,-1.,  511,70.,-1.
  512,70.,-1., 513,70.,-1.,  524,70.,-1.,  525,70.,-1.,  526,70.,-1.
  527,70.,-1., 528,70.,-1.,  529,70.,-1.,  530,70.,-1.,  531,70.,-1.
  532,70.,-1., 533,70.,-1.,  544,70.,-1.,  545,70.,-1.,  546,70.,-1.
  547,70.,-1., 548,70.,-1.,  549,70.,-1.,  550,70.,-1.,  551,70.,-1.
  552,70.,-1., 553,70.,-1.,  564,70.,-1.,  565,70.,-1.,  566,70.,-1.
  567,70.,-1., 568,70.,-1.,  569,70.,-1.,  570,70.,-1.,  571,70.,-1.
  572,70.,-1., 573,70.,-1.
REM HEAT CAPACITY - ENVIRONMENT NODES
 -401,  70.,
 -402,  70.,
 -403,  70.,
 -404,  70.,
 -900,-320.,
END
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