STATISTICAL ENERGY ANALYSIS
COMPUTER PROGRAM

USER'S GUIDE

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PREFACE

The work reported herein was performed for the National Aeronautics and Space Administrations's Marshall Space Flight Center under contract NAS8-33191, Supplemental Agreements 2 and 3. This effort involved the development of a computer program to perform Statistical Energy Analysis. This volume constitutes the final deliverable item under the contract. A card deck of the computer program was forwarded previously by MDAC letter A3-130-GWJ-1283.

Programming was accomplished by S. J. Nygaard, McDonnell Douglas Automation Company - Huntington Beach.

CONTENTS

FIGURES

TABLES

Section 1
INTRODUCTION

Significant high frequency random vibration environments are generated during the operation of aerospace vehicles within the atmosphere. To achieve optimum vehicle design, vibration and acoustic criteria are developed early in the vehicle development program and are updated periodically as the design matures.

High frequency random vibration response prediction does not lend itself well to classical structural dynamics and such predictions are usually made by extrapolation from existing data banks. This method gives excellent results when similar structures are involved. However, as similarity decreases and associated extrapolations become large, uncertainty over accuracy also increases.

The efforts of numerous investigators (Maidanik, Lyons, et al.) have examined a more general high frequency random vibration analysis approach - the so-called Statistical Energy Analysis method. The SEA method is able to accomplish high frequency prediction of arbitrary structural configurations and is therefore a significant improvement over extrapolation methods when little or no previous data exist. The SEA method also represents a great improvement over normal mode methods for high frequency random vibration prediction because of the greatly reduced computational complexity associated with the more general SEA model elements and the attendant improvement in analysis turnaround time.

SEA has been developed for complex structures by MDAC under contract to MSFC (Ref. 1 and 2) over the past three years. The past year's effort has created a general SEA computer program which is described in this manual. The manual contains (1) a summary of SEA theory, (2) example problems of SEA program application, (3) a description of the computer program, and (4) a complete program listing (Appendices).

Section 2

A SUMMARY OF STATISTICAL ENERGY ANALYSIS PRINCIPLES

Statistical Energy Analysis (SEA) is a powerful tool for estimating the high frequency vibration spectra of complex systems. The analysis method is based on the estimation of the power flow between idealized gross elements of a vibrating system. The method is statistical in that averaging assumptions are made with regard to distribution of energy within an element, distribution of resonant modes, and the coupling between elements. These assumptions greatly simplify the computational complexity associated with normal mode methods. These same assumptions impose the limitation that point response predictions cannot be made.

The assumptions on which the method rests and their implications can be quite rigorously stated as follows:

1. The total vibrating system can be partitioned into SEA elements (with suitable boundary conditions) whose modes approximate the modes of the original vibrating system.

2. The modes of the elements of a system contain all of the vibratory energy of the system.

3. The energy in one frequency band of a system element is equally distributed among the modes of that element occurring in the frequency band.

4. Only modes occurring within the same frequency band are coupled.

5. For two coupled elements, all of the modes occurring in one of the elements in one frequency band are equally coupled to each mode occurring in the same frequency band in the other element.

Assumption 1 contains the fundamental existence basis for SEA: the concept of partitionability. This concept implies that a coupled vibrating system with system modes can be approximated by two or more separately idealized vibrating elements, each with its own independent mode set. These sets are coupled only in the sense of having power flow to and from each set across the partition boundary (later referred to as the "joint"). The approximation to this model exists in most structures having reflective boundaries in the higher frequencies. For example, a skin/stringer structure has higher order skin panel modes that are nearly the same frequency and shape as an ideally supported panel because the stringer is a comparatively massive boundary causing reflection of flexural waves from the skin panel. An SEA plate element could logically be equal to the panel area bounded by stringers or frames. Such elements will then have to be coupled with joint elements in order to develop an SEA model which emulates the vibratory power flow of the real structure.

Assumption 3 is the most important simplifying assumption of SEA because it eliminates the necessity to calculate generalized modal forces and responses. The conditions implicit in this assumption are usually approximated by the higher order modes of a structure in a reasonable bandwidth, say 1/3 octave. One-third octave bands represent a reasonable compromise between the necessity to get a fairly large number of modes (>20) in the band for good statistics and the necessity to have some frequency response resolution in the vibration prediction. The number of modes in a unit bandwidth can be estimated for simple structural forms (such as beams, plates, etc.) using algebraic expressions for modal density such as those given in Section 4 of this report. Estimation of modal density in this way is a considerable simplification over normal mode methods.

Given SEA elements with the properties described above it is now necessary to join them to permit power flow between the modes of one element and the modes of another. This is done with a parameter called the coupling loss factor ϕ and leads to assumptions 4 and 5. Assumption 4 is directly linked to assumption 2 and the further assumption of a linear process. Assumption 5 follows directly from assumption 3 as part of the simplification associated with a statistical rather than explicit description of modes.

With these properties and assumptions we can now write the SEA equation systems as follows:

$$\begin{vmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} & \cdots & \alpha_{1j} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} & \cdots & \alpha_{2j} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} & \cdots & \alpha_{3j} \\ & & & & \\ \alpha_{i1} & \alpha_{i2} & \alpha_{i3} & \cdots & \alpha_{M,M} \end{vmatrix} \begin{Bmatrix} E_1 \\ E_2 \\ E_3 \\ \\ E_i \end{Bmatrix} = \begin{Bmatrix} S_1 \\ S_2 \\ S_3 \\ \\ S_i \end{Bmatrix} \tag{1}$$

where

M is the number of SEA elements

$$\alpha_{ij} = \begin{cases} -N_i \phi_{ij} & i \neq j \\ \omega \eta_j + \sum_{k=1}^{M} N_k \phi_{ik} & i = j \end{cases}$$

N_i = number of modes resonant in element i

η_i = element i loss factor

ϕ_{ij} = power transfer coefficient for coupling between modes in elements i and j

ω = center frequency of bandwidth

$E_i = m_i \dfrac{\langle \overline{a_i}^2 \rangle}{\omega^2}$ = total energy of element i, $\langle a^2 \rangle$ being the mean square acceleration

S_i = external acoustic or mechanical excitation in the bandwidth of interest

Note that the matrix α is square but not symmetric. The lack of symmetry arises from the nature of the term $-N_i \phi_{ij}$. Using the first two rows as an example the power balance equations are

$$(\omega \eta_1 + \sum_{k=1}^{M} N_k \phi_{1k})\, E_1 - N_1 \phi_{12} E_2 - N_1 \sum_{k=3}^{M} \phi_{1k} E_k = S_1$$

$$-N_2 \phi_{12} + (\omega \eta_2 + \sum_{k=1}^{M} N_k \phi_{2k})\, E_2 - N_2 \sum_{k=3}^{M} \phi_{1k} E_k = S_2$$

Note that the "symmetric" positions α_{21} and α_{12} actually carry the number of modes belonging to the row number only. This unsymmetric form preserves the power flow both to and from each element.

Each equation in the matrix states the following relationship for each element. The net power flow into element i (S_i) equals the difference between (1) the power flow dissipated within the element ($\omega\eta_i E_i$) plus the power flow lost to other elements across the joints

$$E_i \sum_{k=1}^{M} N_k \phi_{ik}$$

and (2) the power flow added to element i from all other elements

$$N_i \sum_{k=1}^{M} E_k \phi_{ik}, \; i \neq k$$

It must be remembered that the coupling term ϕ_{ik} has nothing to do with coupling modes; it only relates the fractional amount of energy resident in the modes of element i that flows to the modes of element k.

For all but the simplest of systems even the SEA equations can be laborious to evaluate by hand. The computer program described in the following sections performs all of the computations necessary to evaluate terms and solves the above system of equations for element energies and prints the results as vibration PSD or RMS levels for all elements. This program relieves the analyst of the necessity to have an extensive knowledge of how to compute SEA parameters and permits the use of SEA model sizes that would otherwise be intractable. The program is described in detail in Section 2; some SEA modeling examples and corresponding program inputs are described in Section 3.

Section 3

EXAMPLES OF SEA PROGRAM APPLICATIONS

An SEA computer program has been developed that performs the organization of specific problem solutions for up to a 20-element system. A number of different element and joint types are available to describe a wide variety of structural forms in terms of an SEA model. Random acoustic or mechanical excitation can be applied in 1/3 octave bands to any arbitrary number of elements within a given model. The resulting equations are then solved giving the vibration response spectrum for each element. This section illustrates the use of SEA and the computer program with specific examples. The basic analysis procedure is divided into three steps:

1. Idealization
2. Parameter Generation
3. Problem Solution

The idealization step must be performed entirely by the user as it consists of modeling the physical structure in terms of available SEA program elements - a conceptual process. The second step is one of simply providing the proper data to the program which then carries out the third step. These steps will be illustrated below with specific examples, and the SEA program elements will be discussed in detail.

The idealization step is by far the most crucial step in the process. It is here that the art of engineering judgement must reach a well developed state, balancing the realities of the structural article to be analyzed with the capabilities and assumptions implicit in the SEA process to obtain a useful engineering solution. Consider the model shown in Figure 3-1. This is the basic form of all SEA models. It consists of elements, denoted as boxes, which may be plates, beams, etc., and joints denoted by connecting lines which correspond to the physical interfaces at the selected partitions.

The model shows the articles included in each SEA element and the connection relationships between or among the elements. To gain a better understanding of what these elements and connections are it is helpful to now explain in detail the various types available in the computer program. Each of the elements is made up of one or more sub-elements, the first of which is the main sub-element. The sub-element system provides a convenient way to compute and include the modal density and mass properties of individual structural pieces that make up the element on a piece-by-piece basis. However, the sub-element with the most important property being modelled in that SEA element should always be the first or main sub-element. The joint properties must also be consistent with this sub-element as it is the only one that can be coupled to other SEA main elements. An example is given by element 1 of the model. This element has structure elements exposed to an acoustic field and those that are not. The most important property is the reception of acoustic excitation and transmission of vibration through its boundaries to other main elements. That portion must therefore be sub-element 1.

It is often the case that structures are made of different materials; this condition is taken into account when the program sets up the solution. The program automatically recomputes properties (thickness, density, etc.) to match the elastic modulus of element 1, sub-element 1. Furthermore, only sub-element 1 of each element can receive acoustic excitation; the others contribute only to the modal density and to the element mass. Sub-element 1 will always be used for the structure element that is the main piece of the given SEA element because all other properties except mass and modal density will be those of this sub-element.

The types of sub-elements available are beams, plates, cylinders, membrane, and reverberant room. In general, beams, plates and cylinders can

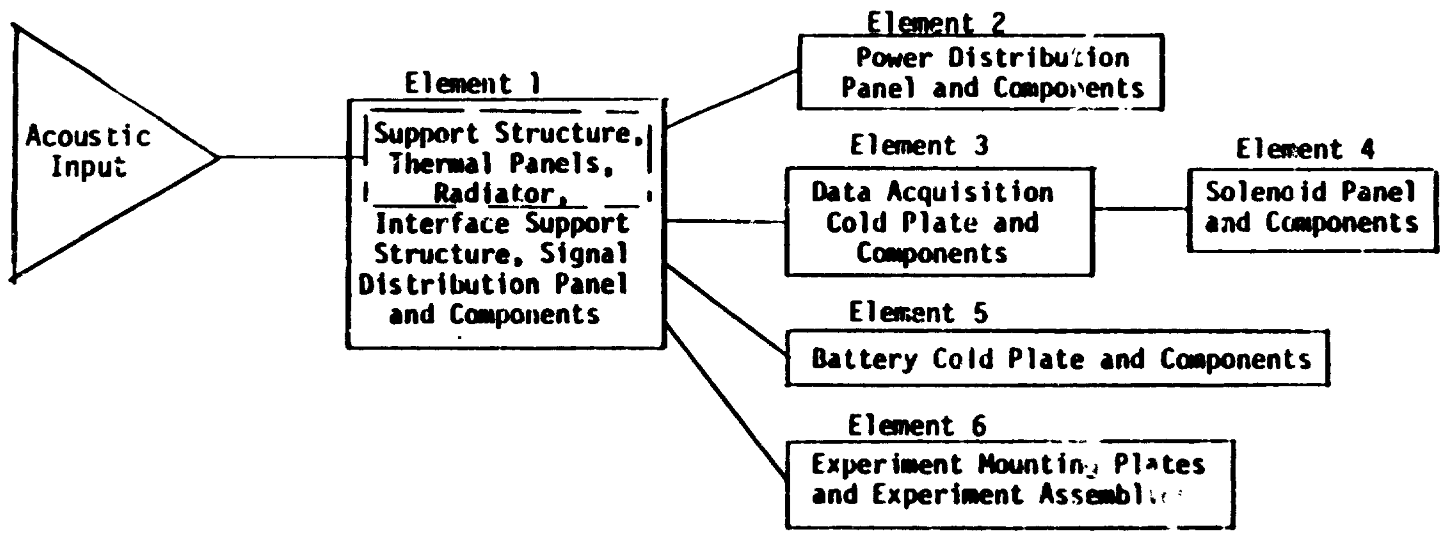


Figure 3-1. SEA Model Elements for Acoustic Test Configuration

be freely mixed in describing a structure. The membrane sub-element should only be used as an ancillary sub-element (i.e., sub-element number > 1). The room sub-element requires special treatment in that the loss factor must be developed from the reverberation time ($n = 2.2/fT_{60}$) and the answers must be converted from q^2 to pressure^2 using energy density relationships. The room sub-element must always be the only sub-element in that particular element.

Given these SEA elements, joint properties must now be developed to describe the power flow from the modes of one element to another. The program gives the user a choice of four types: (1) plate to plate, (2) beam to plate, (3) bolted joint, and (4) plate to acoustic. Each joint has two ends for accounting purposes and the word order used describes the A and B ends respectively. For example, in joint (2) the beam is always at the A end and plate is always at the B end. The joint loss factors are from the literature (cited in References 1 and 2) except for the bolted joint. This joint is a plate-to-plate joint with an additional insertion loss to account for internal losses in the joint due to fastener effects. The insertion loss is a load sheet input which provides to the user a more general purpose alternative to joints (1) and (2). Values of the inertion loss parameter for various fastener arrangements are not well defined, however, and must be the topic of continuing research. In the case of the Materials Experiment Assembly (MEA) analyzed during the last phase of this study, the empirically determined insertion loss factor was approximately 10 for each bolted joint.

With the basics of the program now given, two examples will be shown as a guide for program use. The first example will be a segment of skin stringer structure exposed to an acoustic field with an equipment panel on the opposite side. The second example will be a simplified MEA analysis.

The first case can be idealized with two SEA elements as shown in Figure 3-2. The relevant parameters are shown in the following table:

Skin Thickness	.040"
Segment Dimensions	18" x 72"
Stringer Spacing	10" O.C.
Stringer Dimensions	1-1/2" high x 1" wide with 3/4 flanges,.063 thick (full hat section)
Internal Frames	400 in^2 of .063 thick aluminum
Panel	1" honeycomb with .020 face sheets 17 x 30 with 16 lb of small equipment items mounted on its surface. Panel riveted to frames at four places (U-shaped channels) .063" thick x 1-1/2" high

The SEA element 1 shown in Figure 3-2 will consist of all structural elements in the table except the panel and its mounted equipment which is SEA element 2. From this information an elementary SEA analysis can be made. The load sheet entries are determined as follows and are shown in Figures 3-3 through 3-10 in the proper sequence.

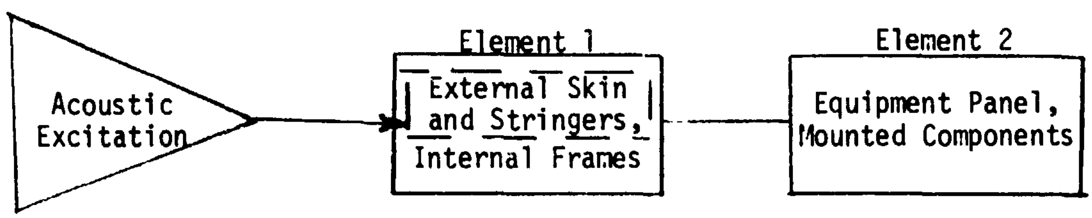


Figure 3-2. Two-Element SEA Model Example

Figure 3-3 shows the header card which basically describes the problem as consisting of two elements and eleven 1/3 octave bands from 250 to 2500 Hz and that the output will be a vibration PSD. Figure 3-4 describes element 1 as consisting of two sub-elements, the first of which is exposed to acoustic excitation, and describes the damping vs. frequency curve. Figure 3-5 shows the 1/3 octave sound pressure levels; Figures 3-6 and 3-7 describe the sub-element properties in detail.

LOADSHEET (1): HEADER CARD

- One required per case
- First card in sequence

1 2	3 4	5 6 7 8 9 10 11 12 13 14	15	16 17 18
2	11	250.0		PSD

DATA ENTRY DESCRIPTION

Card Columns	Value	Definition
1-2	Integer	Total number of elements in model ($2 \le E \le 20$)
3-4	Integer	Total number of analysis frequencies ($1 \le F \le 40$) (Analysis frequencies are spaced 1/3 octave apart)
5-14	Real	Lowest analysis frequency
15	Alpha	Units; M = metric (MKS), default = English (in, lb, sec)
16-18	Alpha	Output mode; RMS or PSD

Figure 3-3. Card 1, Example Case 1

LOADSHEET (2): SEA ELEMENT PROPERTIES CARD

- One required for each element ($2 \le E \le 20$)
- Must be in ascending numerical sequence

1-2	3-4	5	6-8	9-18	19-28	29-38
1	2	A		0.1	-1.	250.

DATA ENTRY DESCRIPTION

Card Column	Value	Definition
1-2	Integer	Element number
3-4	Integer	Number of sub-elements ($SE \ge 1$)
5	Alpha	Excitation type on this element (if any) A = acoustic M = direct mechanical
6-8	Alpha	If CC5 = A, leave blank; defaults to dB re 20 μbar If CC5 = M, RMS = 1/3 octave RMS g's PSD = g^2/Hz input at 1/3 octave centers
9-18	Real	Element loss factor constant(η_0)
19-28	Real	Loss factor high frequency slope (s) } such that $\eta(f) = \eta_0\left(\frac{f}{f_0}\right)^s$
29-38	Real	Loss factor crossover frequency (f_0) }

Figure 3-4. Card 2, Example Case 1

LOADSHEET (3): EXCITATION SPECTRUM CARD

- Must immediately follow element properties if LS#2, CC5 ≠ blank
- All entries are real numbers, and must be consistent with LS #2, CC6-8 (units) and LS #1, CC 3-4 (no. of frequencies - 40 max)
- Make entries across in order of increasing frequency

147.0	147.5	148.0	149.0	149.5	150.0	150.0	150.0
150.0	150.0	150.0					

Figure 3-5. Card 3, Example Case 1

LOADSHEET (4): SUB-ELEMENT PROPERTIES, CARDS 1 AND 2

- Must be consistent with Loadsheet 2, CC 3-4 (SE ≥ 1)
- Two cards (records) per sub-element
- Must follow associated element card and excitation card (if any)

1B	2.617E-4	10.0E+6	0.040	1296.	0.33		

F			13400.0	0.01306

DATA ENTRY DESCRIPTION

	Card Columns	Value	Definition
Card 1	1-2	Integer	Sub-element number (Sub-element 1 is always the main sub-element)
	3	Alpha	Sub-element type; B = beam, C = cylinder, M = membrane, P = plate R = room (acoustic element)
	4-13	Real	Mass density (B, C, M, P, R)
	14-23	Real	Elastic modulus (B, C, M, P)
	24-33	Real	Thickness (B, C, M, P)
	34-43	Real	Area (section if B; surface if M or P)
	44-53	Real	Poisson's ratio (C, P)
	54-63	Real	Length (B, C)
	64-73	Real	Pressure (M only)
Card 2	1	Logical	Replace F with T if stiffness increase is desired (B, C, P)
	2-11	Real	Radius (C only)
	12-21	Real	Volume (R only)
	22-31	Real	Speed of sound - Sub-element 1 only and if {(P) and CC5, LS2 = A, or (R) unconditionally
	32-41	Real	Added non-structural mass (B, C, M, P)

Figure 3-6. Card 4, Example Case 1

LOADSHEET (4): SUB-ELEMENT PROPERTIES, CARDS 1 AND 2

- Must be consistent with Loadsheet 2, CC 3-4 (SE ≥ 1)
- Two cards (records) per sub-element
- Must follow associated element card and excitation card (if any)

2P	2.617E-4	10.0E+6	0.063	508.	0.33		

F				1.3E-3

DATA ENTRY DESCRIPTION

	Card Columns	Value	Definition
	1-2	Integer	Sub-element number (Sub-element 1 is always the main sub-element)
	3	Alpha	Sub-element type; B = beam, C = cylinder, M = membrane, P = plate R = room (acoustic element)
	4-13	Real	Mass density (B, C, M, P, R)
Card 1	14-23	Real	Elastic modulus (B, C, M, P)
	24-33	Real	Thickness (B, C, M, P)
	34-43	Real	Area (section if B; surface if M or P)
	44-53	Real	Poisson's ratio (C, P)
	54-63	Real	Length (B, C)
	64-73	Real	Pressure (M only)
	1	Logical	Replace F with T if stiffness increase is desired (B, C, P)
	2-11	Real	Radius (C only)
Card 2	12-21	Real	Volume (R only)
	22-31	Real	Speed of sound - Sub-element 1 only and if (P) and CC5, LS2 = A, or (R) unconditionally
	32-41	Real	Added non-structural mass (B, C, M, P)

Figure 3-7. Card 5, Example Case 1

Sub-element 1 consists of the skin and stringer elements. The skin is used as the principal property because it is the major element being excited by the acoustic field. The stringers are added as a smeared mass because their internal resonant frequencies are very high and therefore would be expected only to load the skin in the frequency range of interest. Sub-element 2 (Figure 3-7) represents the properties of the internal frames and channels which mount the panel.

Figures 3-8 and 3-9 show the loadsheets for the inside equipment panel. Figure 3-8 defines the panel as Element 2, with one sub-element and constant damping vs. frequency. Figure 3-9 has the panel properties which have been equivalenced to an isotropic plate because the panel is a composite structure. Note that both the thickness and the density have been changed to be consistent. Any other equivalence could also be used, e.g. leave the thickness = 1.0 and the density and Young's modulus will be recalculated using

$$\frac{1}{T} \sum_i e_i T_i = \rho_{eff}$$

and $$E_{eff} = \frac{12E(1-\gamma^2) \sum_i I_i}{bt^3}$$

There is no requirement that sub-elements be of similar materials, but all plate, beam and cylinder sub-element properties must always be isotropic equivalents.

The weight of the components is treated as a non-structural mass. If half or more of the panel area were covered with these components, the F should be changed to a T as shown on the sheet to account for the reduction of modal density associated with stiffening of the panel by the components as reported in Reference 2.

Figure 3-10 describes the joint properties between the skin and the plate. Note that an added insertion loss factor of 2 is used to account for rivet effects.

LOADSHEET (2): SEA ELEMENT PROPERTIES CARD

- One required for each element ($2 \leq E \leq 20$)
- Must be in ascending numerical sequence

1–2	3–4	5	6–8	9–18	19–28	29–38
2	1			0.05		

DATA ENTRY DESCRIPTION

Card Column	Value	Definition
1-2	Integer	Element number
3-4	Integer	Number of sub-elements (SE ≥ 1)
5	Alpha	Excitation type on this element (if any) A = acoustic M = direct mechanical
6-8	Alpha	If CC5 = A, leave blank; defaults to dB re 20 μbar If CC5 = M, RMS = 1/3 octave RMS g's PSD = g^2/Hz input at 1/3 octave centers
9-18	Real	Element loss factor constant(η_0)
19-28	Real	Loss factor high frequency slope (s) } such that $\eta(f) = \eta_0\left(\frac{f}{f_0}\right)^s$
29-38	Real	Loss factor crossover frequency (f_0)

Figure 3-8. Card 6, Example Case 1

LOADSHEET (4): SUB-ELEMENT PROPERTIES, CARDS 1 AND 2

- Must be consistent with Loadsheet 2, CC 3-4 (SE $\geq$ 1)
- Two cards (records) per sub-element
- Must follow associated element card and excitation card (if any)

1-2	3	4-13	14-23	24-33	34-43	44-53	54-63	64-73
1	P	3.49E-5	10.0E+6	0.3	510.	0.33		

1	2-11	12-21	22-31	32-41
F				0.0416

DATA ENTRY DESCRIPTION

	Card Columns	Value	Definition
Card 1	1-2	Integer	Sub-element number (Sub-element 1 is always the main sub-element)
	3	Alpha	Sub-element type; B = beam, C = cylinder, M = membrane, P = plate R = room (acoustic element)
	4-13	Real	Mass density (B, C, M, P, R)
	14-23	Real	Elastic modulus (B, C, M, P)
	24-33	Real	Thickness (B, C, M, P)
	34-43	Real	Area (section if B; surface if M or P)
	44-53	Real	Poisson's ratio (C, P)
	54-63	Real	Length (B, C)
	64-73	Real	Pressure (M only)
Card 2	1	Logical	Replace F with T if stiffness increase is desired (B, C, P)
	2-11	Real	Radius (C only)
	12-21	Real	Volume (R only)
	22-31	Real	Speed of sound - Sub-element 1 only and if {(P) and CC5, LS2 = A, or (R) unconditionally
	32-41	Real	Added non-structural mass (B, C, M, P)

Figure 3-9. Card 7, Example Case 1

LOADSHEET (5): JOINT PROPERTIES

- Must follow all element and sub-element cards at end of deck.
- Must be consistent with elements being joined.

1	2	BJ		36.	0.04	0.3			2.0

DATA ENTRY DESCRIPTION

Card Columns	Value	Definition
1-2	Integer	Element number of A end of joint
3-4	Integer	Element number of B end of joint
5-6	Alpha	Joint type: PP = plate-to-plate, BP = beam-to-plate, BJ = bolted joint, PA = plate to acoustic
7-8	Integer	No. of sides exposed to acoustic input (1 or 2 for PA only)
9-18	Real	Joint length
19-28	Real	Thickness of A end of joint
29-38	Real	Thickness of B end of joint
39-48	Real	Acoustic space mass density (P/RT)
49-58	Real	Beam length (BP only)
59-68	Real	Energy reduction factor (BJ only)

Figure 3-10. Card 8, Example Case 1

These data are then assembled as a file which the program reads as an input.

The corresponding program output is shown in Figure 3-11 and consists of a labeled list of the input data, a display of the element modal densities, and a table of vibration responses. The adequacy of the SEA model with regard to assumptions 4 and 5 can be checked using the modal density tables of the figure. For example, element 1 contains more than 20 modes per 1/3 octave over the entire analysis range, whereas element 2 has far fewer. Since frequency response will be smoother with more modes per band, it is expected that the panel prediction will be poorer than the skin predictions. Specifically, the actual panel response may have some peaks which exceed the SEA prediction.

The SEA response prediction is shown in Table 3-1. The levels for element 1 are high compared to the criteria published in Reference 3, but one must remember that this estimate includes a space average over the skin. The stringer and frame vibration levels which are inputs to the panel are a factor of ~100 less.

Simple changes can be made to improve the prediction. For example, an internal acoustic field can be put on the panel by also placing an A in card column 5 of Figure 3-8 and entering the appropriate table immediately after, as shown in Figure 3-12. The results of this modification are shown in Table 3-2. As can be seen, the panel vibration increases considerably and critical frequency behavior is evident around 625 Hz. It should be noted that SEA often overpredicts in the critical frequency region. This simple example illustrates some of the possibilities of SEA with the help of this computer program.

A more extensive example is that of the MEA done in the previous phase. The input for this six-element model (Fig. 3-1) is extensive and much too elaborate to be explained in detail here, but the breakdown of the subelements used is given in Table 3-3. The input listing is given in Appendix III and the output is shown in Table 3-4.

A mechanical vibration input may also be applied if the known vibration level is included as an additional element. Load sheet 2 card column 5

```
RECORD
NUMBER               DATA READ FROM UNIT 3
------               --------------------

  1     NUMBER OF ELEMENTS =  2
        NUMBER OF ANALYSIS FREQUENCIES = 11
        FIRST ANALYSIS FREQUENCY =  2.50000E+02
        TYPE OF UNITS =
        TYPE OF OUTPUT = PSD
  2     ELEMENT NUMBER =  1
        NUMBER OF SUB-ELEMENTS =  2
        TYPE OF EXCITATION = A
        TYPE OF MECHANICAL INPUT =
        DAMPING =  1.00000E-01
        SLOPE = -1.00000E+00
        STARTING FREQUENCY =  2.50000E+02
                  SOUND PRESSURE LEVELS
  3          1.47000E+02   1.47500E+02   1.46000E+02   1.49000E+02
             1.49500E+02   1.50000E+02   1.50000E+02   1.50000E+02
  4          1.50000E+02   1.50000E+02   1.50000E+02   0.
             0.            0.            0.            0.
  5         SUB-ELEMENT NUMBER =  1
            TYPE OF SUB-ELEMENT = P
            DENSITY =  2.61700E-04
            MODULUS OF ELASTICITY =  1.00000E+07
            THICKNESS =  4.00000E-02
            AREA =  1.29600E+03
            POISSONS RATIO =  3.30000E-01
            LENGTH =  0.
            PRESSURE =  0.
  6         STIFFNESS REDUCTION REQUIRED = F
            RADIUS =  0.
            VOLUME =  0.
            SPEED OF SOUND IN ROOM MEDIUM =  1.34000E+04
            ADDED MASS =  1.30500E-02
  7         SUB-ELEMENT NUMBER =  2
            TYPE OF SUB-ELEMENT = P
            DENSITY =  2.61700E-04
            MODULUS OF ELASTICITY =  1.00000E+07
            THICKNESS =  6.30000E-02
            AREA =  5.04000E+02
            POISSONS RATIO =  3.30000E-01
            LENGTH =  0.
            PRESSURE =  0.
  8         STIFFNESS REDUCTION REQUIRED = F
            RADIUS =  0.
            VOLUME =  0.
            SPEED OF SOUND IN ROOM MEDIUM =  0.
            ADDED MASS =  0.
```

(Continued)

Figure 3-11. Two-Element SEA Program Output - External Acoustic Excitation

```
 9      ELEMENT NUMBER =  2
        NUMBER OF SUB-ELEMENTS =  1
        TYPE OF EXCITATION =
        TYPE OF MECHANICAL INPUT =
        DAMPING =  5.00000E-02
        SLOPE =  0.
        STARTING FREQUENCY =  0.
10           SUB-ELEMENT NUMBER =  1
             TYPE OF SUB-ELEMENT = P
             DENSITY =  3.49000E-05
             MODULUS OF ELASTICITY =  1.00000E+07
             THICKNESS =  3.00000E-01
             AREA =  5.10000E+02
             POISSONS RATIO =  3.30000E-01
             LENGTH =  0.
             PRESSURE =  0.
11           STIFFNESS REDUCTION REQUIRED = F
             RADIUS =  0.
             VOLUME =  0.
             SPEED OF SOUND IN ROOM MEDIUM =  0.
             ADDED MASS =  4.15000E-02
```

CENTER FREQ(HZ)	MODAL DENSITY - MODES/(RAD/SEC) ELEMENT 1	ELEMENT 2
250.00	5.38653E-02	8.26429E-04
312.50	5.38653E-02	8.26429E-04
400.00	5.38653E-02	8.26429E-04
500.00	5.38653E-02	8.26429E-04
625.00	5.38653E-02	8.26429E-04
787.50	5.38653E-02	8.26429E-04
1000.00	5.38653E-02	8.26429E-04
1250.00	5.38653E-02	8.26429E-04
1575.00	5.38653E-02	8.26429E-04
2000.00	5.38653E-02	8.26429E-04
2500.00	5.38653E-02	8.26429E-04

```
RECORD
NUMBER                    DATA READ FROM UNIT 3
------                    -------------------

 12     FIRST ELEMENT =  1
        SECOND ELEMENT =  2
        TYPE OF JOINT = RJ
        NUMBER OF SIDES =  0
        JOINT LENGTH =  3.60000E+01
        THICKNESS OF FIRST ELEMENT =  4.00000E-02
        THICKNESS OF SECOND ELEMENT =  3.00000E-01
        ACOUSTIC SPACE DENSITY =  0.
        BEAM LENGTH =  0.
        INSERTION LOSS FACTOR =  2.00000E+00
```

Figure 3-11 (Continued)

Table 3-1

TWO-ELEMENT SEA VIBRATION PREDICTION
EXTERNAL ACOUSTIC EXCITATION

Center Frequency (Hz)	PSD Levels (G^2/Hz) Element 1	Element 2
250.0	4.90675E+01	3.38593E-01
312.5	3.59925E+01	2.37220E-01
400.0	2.53599E+01	1.58301E-01
500.0	2.11177E+01	1.25095E-01
625.0	1.53027E+01	8.85583E-02
787.5	1.17827E+01	6.21389E-02
1000.0	7.83661E+01	3.86783E-02
1250.0	5.44536E+00	2.51832E-02
1575.0	3.81675E+00	1.64492E-02
2000.0	2.72180E+00	1.08695E-02
2500.0	2.05294E+00	7.61286E-03

for that element would contain an M and the vibration spectrum description would follow. The only restriction is that this element may not also have an acoustic input as it will be eliminated in the solution because the energy level is already known.

The possible permutations and combinations of elements, sub-elements, and other factors which this computer program can create go far beyond the ability to document in this report. These few examples give some insight into the processes involved in the performance of SEA using this program. Although determination of some of the parameters such as damping and insertion loss is still a difficult and often obscure process which requires substantial future improvement, this computer program provides a significant step toward streamlining and simplifying SEA for the analyst.

LOADSHEET (3): EXCITATION SPECTRUM CARD

- Must immediately follow element properties if LS#2, CC5 ≠ blank
- All entries are real numbers, and must be consistent with LS #2, CC6-8 (units) and LS #1, CC 3-4 (no. of frequencies - 40 max)
- Make entries across in order of increasing frequency

146.5	147.0	147.0	147.5	146.0	148.0	148.0	147.0
146.0	144.0	142.0					

Figure 3-12. Internal Acoustic Input Table for Example 1

Table 3-2

TWO-ELEMENT SEA VIBRATION PREDICTION
EXTERNAL AND INTERNAL ACOUSTIC EXCITATION

Center Frequency (Hz)	PSD Levels (G^2/Hz) Element 1	Element 2
250.0	4.96984E+01	9.69548E-01
312.5	3.67160E+01	1.04475E+00
400.0	2.62012E+01	1.21999E+00
500.0	2.26604E+01	2.29959E+00
625.0	2.05716E+01	7.59740E+00
787.5	1.40047E+01	3.98634E+00
1000.0	8.75443E+00	1.86390E+00
1250.0	5.75084E+00	7.03965E-01
1575.0	3.94377E+00	3.33085E-01
2000.0	2.76144E+00	1.22184E-01
2500.0	2.06547E+00	4.69292E-02

Table 3-3

SUB-ELEMENT BREAKDOWN FOR MEA TEST CASE

ELEMENT 1

Sub-element	
1	Thermal Panels
2	Orbiter Interface Panels
3, 4, 5, 6, 7	Support Structure
8, 9	Radiator
10, 11, 12	Interface Support Structure
13	Signal Distributor Panel
14, 15, 16	Signal Distribution Box
17, 18, 19	Support Brace Assembly and Gusset
20	Pressure Sensor and Voltage Regulator Panels

ELEMENT 2

Sub-element	
1	Power Distribution Panel
2, 3, 4	Power Distribution Box

ELEMENT 3

Sub-element	
1, 2, 3	Data Acquisition Cold Plate

ELEMENT 4

Sub-element	
1	Solenoid Panel

ELEMENT 5

Sub-element	
1, 2, 3	Battery Cold Plate

ELEMENT 6

Sub-element	
1, 2	Experiment Mounting Plates

Table 3-4

SEA COMPUTER PROGRAM OUTPUT FOR MEA/ACOUSTIC EXCITATION CASE

CENTER FREQ(HZ)	PSD LEVELS (G**2/HZ) ELEMENT 1	ELEMENT 2	ELEMENT 3	ELEMENT 4
31.50	1.37117E+01	6.40344E-02	1.23606E-02	7.74395E-02
39.38	1.39434E+01	5.33723E-02	1.16254E-02	7.03306E-02
50.40	1.35352E+01	5.01950E-02	1.03534E-02	6.00698E-02
63.00	1.37834E+01	4.58005E-02	9.75593E-03	5.43442E-02
78.75	1.40495E+01	4.16226E-02	9.20447E-03	4.90858E-02
99.23	1.41144E+01	3.74861E-02	8.53649E-03	4.33913E-02
126.00	1.39873E+01	3.30110E-02	7.79522E-03	3.75635E-02
157.50	1.13790E+01	2.40471E-02	5.87560E-03	2.68592E-02
198.45	1.02517E+01	1.93208E-02	4.89243E-03	2.11104E-02
252.00	7.25080E+00	1.22183E-02	3.20463E-03	1.30301E-02
315.00	4.73043E+00	8.57629E-03	2.19825E-03	9.29518E-03
393.75	3.10091E+00	6.04840E-03	1.51521E-03	6.65439E-03
504.00	1.95717E+00	4.13889E-03	1.01107E-03	4.62347E-03
630.00	8.21163E-01	1.36311E-03	4.46156E-04	2.11322E-03
787.50	3.47857E-01	8.51231E-04	1.98790E-04	9.74010E-04
992.25	9.28257E-02	2.44964E-04	5.59056E-05	2.33312E-04
1260.00	4.96000E-02	1.41506E-04	3.15427E-05	1.65277E-04
1575.00	2.77460E-02	8.51314E-05	1.85675E-05	1.00240E-04
1984.50	1.24869E-02	4.13079E-05	8.81054E-06	4.59341E-05
2520.00	5.74855E-03	2.05537E-05	4.28491E-06	2.45336E-05
3150.00	2.92043E-03	1.08428E-05	2.21322E-06	1.30057E-05
3937.50	1.48151E-03	6.12308E-06	1.22397E-06	7.37309E-06
5040.00	8.43835E-04	3.77799E-06	7.38086E-07	4.56355E-06

CENTER FREQ(HZ)	PSD LEVELS (G**2/HZ) ELEMENT 5	ELEMENT 6
31.50	3.60958E-03	9.53944E-03
39.38	3.55841E-03	8.88172E-03
50.40	3.13632E-03	7.90207E-03
63.00	2.92061E-03	7.24503E-03
78.75	2.71710E-03	6.72258E-03
99.23	2.47660E-03	6.11710E-03
126.00	2.21901E-03	5.46337E-03
157.50	1.63920E-03	4.02753E-03
198.45	1.33442E-03	3.27234E-03
252.00	8.53722E-04	2.08991E-03
315.00	5.94798E-04	1.45769E-03
393.75	4.16159E-04	1.02111E-03
504.00	2.82109E-04	6.93161E-04
630.00	1.26179E-04	3.10445E-04
787.50	5.69414E-05	1.40294E-04
992.25	1.62123E-05	4.00061E-05
1260.00	9.25557E-06	2.28779E-05
1575.00	5.50341E-06	1.36259E-05
1984.50	2.63620E-06	6.53879E-06
2520.00	1.29324E-06	3.21405E-06
3150.00	6.72712E-07	1.67509E-06
3937.50	3.74282E-07	9.33860E-07
5040.00	2.26942E-07	5.67554E-07

Section 4
SEA COMPUTER PROGRAM DESCRIPTION AND USAGE

This section describes the computer code and the input requirements for problem solutions.

The program was written in ASCII Fortran V for the MSFC UNIVAC 1108 with the EXEC8 operating system resident in the computer. The program is designed to be run in the demand/interactive mode using the system editor to assemble and sequence the load sheet information.

The SEA computer code uses a main program whose function is essentially to call the various subroutines in the correct order. First called are two subroutines, EPROP and JINPUT, which read user-supplied data. Then for each analysis frequency, three other subroutines (JPROP, EXCITE, and ANSWER) are called to perform the various calculations. The subroutine ANSWER calls the UNIVAC library subroutine GASSEM from SYS $*MATHSTAT$. Finally, subroutine RITER is called to print the solution. The complete program listing is given in Appendix I and the program flow charts are given in Appendix II.

4.1 SUBROUTINE DESCRIPTION

Subroutine EPROP reads user-supplied data giving element and sub-element properties and calls one of five subroutines (BEAM, MEMBR, PLATE, ROOM, or CYLIN) to calculate element modal densities. See Appendix I for the list of variables read by EPROP. EPROP first reads a record giving the number of elements, number of analysis frequencies, the first frequency, and the type of units (metric or English). EPROP checks that the number of elements and analysis frequencies is within the bounds allowed by the program, since memory is reserved with maximum values in mind. Then EPROP creates a table of analysis frequencies by multiplying each element of a predefined 1/3 octave table by the first frequency. The predefined table consists of a series of frequencies, each of which is approximately one-third octave higher than the preceding one, and the first one of which is equal to 1. EPROP then reads element properties. If the type of excitation indicated on this read operation is acoustic, EPROP then reads a list of sound pressure levels for each analysis frequency for this element. Next, sub-element properties are read. Included in sub-element properties is the type of sub-element. Depending on whether this is a beam, membrane, plate, room or cylinder, EPROP calls the appropriate subroutine to calculate the modal density.

Subroutines BEAM, MEMBR, PLATE, ROOM and CYLIN calculate the modal density for a sub-element which is a beam, membrane, plate, room or cylinder, respectively. First, the part of the equation which is not frequency dependent is calculated. If stiffness reduction has been indicated, this partial value is multiplied by 1/ 2. Then for each analysis frequency, the rest of the modal density equation is computed and the result summed to element modal density. The sub-element mass is summed to the element mass. If this is the first sub-element for the given element, it is assumed to be the main sub-element and element properties other than mass are set equal to the properties of this sub-element. The following equations are used to calculate modal densities:

Beam: $$n(\omega) = \frac{L}{2\pi}\left(\omega\sqrt{\frac{Et^2}{12\rho}}\right)^{-1/2}$$

Membrane: $$n(\omega) = \frac{A\omega\rho t}{2\pi S}$$

Plate: $$n(\omega) = \frac{A}{4\pi}\left(\frac{Et^2}{12\rho(1-\gamma^2)}\right)^{-1/2}$$

Room: $$n(\omega) = \frac{V\omega^2}{2\pi^2 c^3}$$

Cylindrical shell:

$$n(\omega) = \begin{cases} \dfrac{A}{4\pi}\left(\dfrac{Et^2}{12\rho(1-\gamma^2)}\right)^{-1/2} & \text{if } \omega r\left(\dfrac{\rho}{E}\right)^{1/2} > 1 \\[2ex] \dfrac{A}{4\pi}\left(\dfrac{Et^2}{12\rho(1-\gamma^2)}\right)^{-1/2}\left(\omega r\left(\dfrac{\rho}{E}\right)^{1/2}\right)^{2/3} & \text{if } \omega r\left(\dfrac{\rho}{E}\right)^{1/2} < 1 \end{cases}$$

Symbol	FORTRAN Name	Description
n	N	Modal Density
L	L	Length
ω	OMEGA	2π Times the Frequency
E	E	Modulus of Elasticity
t	T	Thickness
ρ	RHO	Density
A	A	Area
S	S	Pressure
γ	GAMMA	Poisson's Ratio
V	V	Volume
c	C	Speed of Sound

Subroutine JINPUT reads joint properties supplied by the user. See Appendix I for a list of the variables read by JINPUT. JINPUT checks that element numbers are within range (i.e., less than or equal to the number of elements in the system) and that no pair of element numbers is input more than once. JINPUT keeps a running total of the number of pairs input and continues reading until the end of file is encountered. JINPUT checks to see that at least one pair of elements was read.

Subroutine JPROP calculates coupling coefficients based on the data read by JINPUT, using one of the following equations, depending on the type of joint as read by JINPUT:

Plate to plate at right angles:

$$\phi_{12} = \frac{1.07L}{\pi A N_2}\left(\omega t_1\left(\frac{E_1}{\rho_1(1-\gamma^2)}\right)^{1/2}\right)^{1/2} \tau$$

$$A = n_1 2 t_1\left(\frac{E_1}{12\rho_1(1-\gamma^2)}\right)$$

$$\tau = \begin{cases} \frac{8}{27} & \text{if } t_1 > \frac{t_2}{2} \\ \frac{t_1}{t_2} & \text{if } t_1 < \frac{t_2}{2} \end{cases}$$

Beam to plate (cantilevered):

$$\phi_{12} = \frac{2\pi f b}{N_2 4L}$$

Plate to acoustic space:

$$\phi_{12} = \left(\frac{4.33\pi c_2^4}{f\omega^2 V_2}\right)\left(\frac{\alpha\rho_1\sigma}{\rho_A}\right)$$

Bolted or riveted joints:

1) Calculate PHI as if for a plate-to-plate rigid joint.

2) Reduce PHI by insertion loss factor.

Symbol	FORTRAN Name	Description
ϕ	PHI	Coupling Coefficient
L	JL	Joint Length
N	MODES	Number of Modes in Bandwidth
ω	OMEGA	2π Times the Frequency
t	T	Thickness
E	EE	Modulus of Elasticity
ρ	DENSE	Density
γ	EGAMMA	Poisson's Ratio
τ	TAU	Thickness Ratio
n	N	Modal Density
f	FREQ	Frequency
b	BW	Beam Width
c	EC	Speed of Sound in Room Medium
V	VOL	Volume
α	NS	Number of Sides
σ	SIGMA	Radiation Efficiency
ρ_A	ASD	Acoustic Space Density

Function SIGF returns a value for the radiation efficiency of a panel. A single argument, X, is passed to SIGF. The value of X is the ratio of the analysis frequency to the critical frequency. An internal table of 16 values of the log of the radiation efficiency for $0 \leq X \leq 4$ is maintained. The first value, 0, is the value of X for which SIGF is a minimum. When X = 0, SIGF = -1.8. Each subsequent value of the internal table is the value of X for which SIGF increases by 0.2 over the previous value. The 13th value in the table is 1. Since this is the 12th value after the 1st, SIGF = 12 * 0.2 + (-1.8) = 0.6 when X = 1. This is the maximum value of SIGF. SIGF = 0 for X = 4, the final value of the table. The value of SIGF is calculated by finding the least value of the table that is greater than X. This value and the preceding one give two values of SIGF that differ by 0.2. Linear interpolation is then used to find the actual value of SIGF.

Subroutine EXCITE calculates acoustic and mechanical energy inputs for the elements of the system. These values are initially set to 0. Then for each element, the acoustic or mechanical energy input is calculated according to the following equations, depending on the type of excitation as read by EPROP:

$$\text{Acoustic:}\quad S = \frac{0.66\pi^2 c^2 A^2 \langle \bar{p}^2 \rangle}{\omega^3 m}\, \sigma N$$

$$\langle \bar{p}^2 \rangle = 10^{SPL/10}(8.41 \times 10^{-18})$$

$$\text{Mechanical in } g_{rms}\text{:}\quad E = \frac{m}{\omega^2}\, g^2_{rms} g^2$$

$$\text{Mechanical in PSD Levels:}\quad E = \frac{m}{\omega^2}\, PSD\; g^2 \frac{f}{4.33}$$

Symbol	FORTRAN Name	Description
S	S	Acoustic Energy Input
c	EC	Speed of Sound in Room Medium
A	A	Surface Area Exposed to Sound Field
σ	SIGMA	Radiation Efficiency
N	MODES	Number of Modes in Bandwidth
ω	OMEGA	2π Times the Frequency
m	MSUB	Mass
SPL	SPL	Sound Pressure Level
E	E	Element Energy Level
g_{rms}	MECH	Mechanical Input
g	G	Gravitational Constant
PSD	MECH	Mechanical Input
f	FREQ	Frequency

Subroutine ANSWER solves the SEA system of equations for element energy levels. First, element damping is determined. If the damping is constant, it is equal to the value read by EPROP. Otherwise the following equation is used:

$$\eta_2 = \eta_f \left(\frac{f}{f_s}\right)^s$$

Symbol	FORTRAN Name	Description
η_2	ETA2	Element Damping
η_f	ETA	Constant Level of Damping
f_s	SFREQ	Start Frequency
s	SLOPE	Slope

Next, the elements of the alpha matrix of equation 1, Section 1, are calculated.

If there are any elements for which the energy levels (the E matrix) are already known, these are eliminated from the equation as shown by the following example: Suppose the system has six elements and the second and fifth have known energy levels. Then the equation becomes:

$$\begin{vmatrix} \alpha_{11} & \alpha_{13} & \alpha_{14} & \alpha_{16} \\ \alpha_{31} & \alpha_{33} & \alpha_{34} & \alpha_{36} \\ \alpha_{41} & \alpha_{43} & \alpha_{44} & \alpha_{46} \\ \alpha_{61} & \alpha_{63} & \alpha_{64} & \alpha_{66} \end{vmatrix} \begin{Bmatrix} E_1 \\ E_3 \\ E_4 \\ E_6 \end{Bmatrix} = \begin{Bmatrix} S_1 - \alpha_{12}E_2 - \alpha_{15}E_5 \\ S_3 - \alpha_{32}E_2 - \alpha_{35}E_5 \\ S_4 - \alpha_{42}E_2 - \alpha_{45}E_5 \\ S_6 - \alpha_{62}E_2 - \alpha_{65}E_5 \end{Bmatrix}$$

Since (for example) $S_1 = \alpha_{11}E_1 + \alpha_{12}E_2 + \alpha_{13}E_3 + \alpha_{14}E_4 + \alpha_{15}E_5 + \alpha_{16}E_6$, it can be seen that this has the same solution as the original equation. ANSWER recalculates the values of the S matrix and calls SOLVE to eliminate the unnecessary rows and columns from the matrices and find the solution. The solution is then used to calculate the average acceleration with the formula

$$\langle \bar{a} \rangle = E \frac{\omega^2}{m}$$

Symbol	FORTRAN Name	Description
$\langle \bar{a} \rangle$	ABAR	Average Acceleration
E	E	Element Energy Levels
ω	OMEGA	2π Times the Frequency
m	MASS	Mass

Subroutine SOLVE solves the SEA system of equations. It copies the alpha and S matrices to new matrices, leaving out those rows and columns which were to be eliminated. It then calls MATHSTAT library subroutine GASSEM to solve the equation. SOLVE then puts the solution in the element energy array E, and subroutine RITER prints the solution.

4.2 PROGRAM USAGE

4.2.1 Deck Setup and Sequence

At present, the source program resides on element C of file S1, so that it is necessary to compile and collect it before execution. The program reads the SEA load sheet data on logical unit 3, which must be created by the user with the text editor or data processor, using the Q option so that file 3 is in ASCII code. The following sequence of control statements illustrates the creation of file 3 and the excecution of the program:

```
@RUN ...
@ASG,C 3.
@ED,IQ 3.
   Statements creating file 3
EXIT
@ASG,A S1
@FTN,N S1.C,REL
@MAP,IN SYM,ABS
LIB SYS$*MATHSTAT$.
LIB SYS$*MSFC$.
LIB SYS$*MSFC$.
END
@XQT ABS
@FIN
```

4.2.2 Input - Drum/Disk

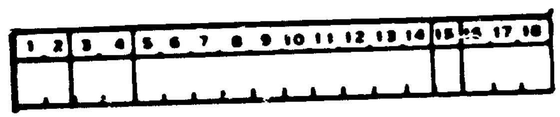
The only input for the program is on logical unit 3, which contains the user's data. This file consists of the following five types of records:

1. Initial information used to process the other records.
2. Element properties.
3. Sound pressure levels or mechanical inputs.
4. Sub-element properties.
5. Joint properties.

The arrangement of these records and their data elements is shown on the following five loadsheet pages (Figures 4-1 through 4-5).

LOADSHEET (1): HEADER CARD

- One required per case
- First card in sequence



DATA ENTRY DESCRIPTION

Card Columns	Value	Definition
1-2	Integer	Total number of elements in model ($2 \le E \le 20$)
3-4	Integer	Total number of analysis frequencies ($1 \le F \le 40$) (Analysis frequencies are spaced 1/3 octave apart)
5-14	Real	Lowest analysis frequency
15	Alpha	Units; M = metric (MKS), default = English (in, lb, sec)
16-18	Alpha	Output mode; RMS or PSD

Figure 4-1. Loadsheet 1

LOADSHEET (2): SEA ELEMENT PROPERTIES CARD

- One required for each element ($2 \le E \le 20$)
- Must be in ascending numerical sequence

1 2	3 4	5	6 7 8	9 10 11 12 13 14 15 16 17 18	19 20 21 22 23 24 25 26 27 28	29 30 31 32 33 34 35 36 37 38	39 40 41 42 43 44 45 46 47 48

DATA ENTRY DESCRIPTION

Card Column	Value	Definition
1-2	Integer	Element number
3-4	Integer	Number of sub-elements ($SE \ge 1$)
5	Alpha	Excitation type on this element (if any) A = acoustic M = direct mechanical
6-8	Alpha	If CC5 = A, leave blank; defaults to dB re 20 μbar If CC5 = M, RMS = 1/3 octave RMS g's PSD = g^2/Hz input at 1/3 octave centers
9-18	Real	If CC5 = A, input surface area exposed to acoustic excitation (consistent units)
19-28	Real	Element loss factor constant(η_o)
29-38	Real	Loss factor high frequency slope (s) } such that $\eta(f) = \eta_o\left(\frac{f}{f_o}\right)^s$
39-48	Real	Loss factor crossover frequency (f_o) }

Figure 4-2. Loadsheet 2

LOADSHEET (3): EXCITATION SPECTRUM CARD

- Must immediately follow element properties if LS#2, CC5 ≠ blank
- All entries are real numbers, and must be consistent with LS #2, CC 6-8 (units) and LS #1, CC 3-4 (no. of frequencies - 40 max)
- Make entries across in order of increasing frequency

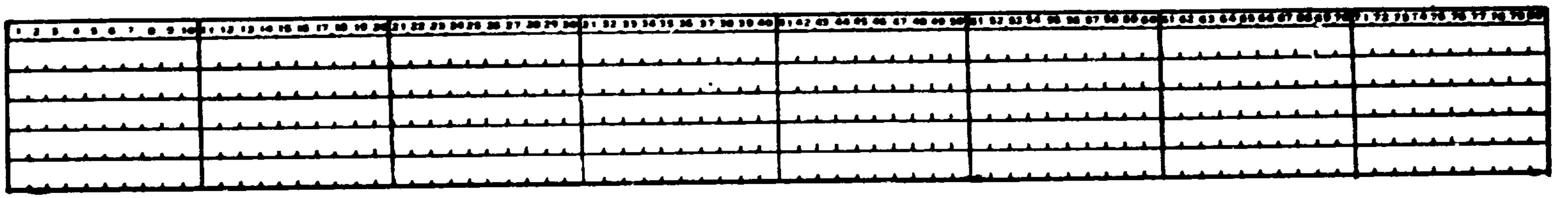
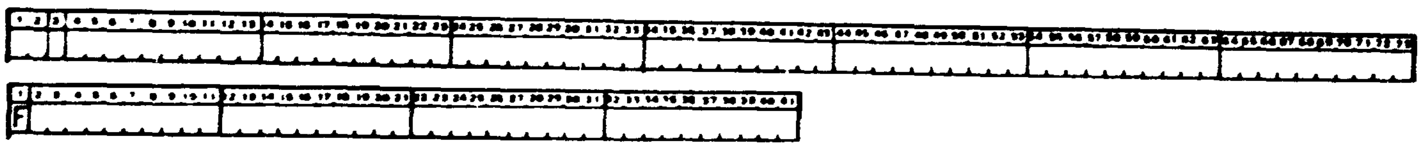


Figure 4-3. Loadsheet 3

LOADSHEET (4): SUB-ELEMENT PROPERTIES, CARDS 1 AND 2

- Must be consistent with Loadsheet 2, CC 3-4 (SE ≥ 1)
- Two cards (records) per sub-element
- Must follow associated element card and excitation card (if any)



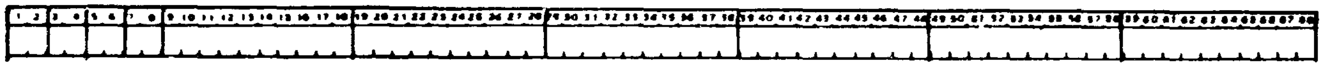
DATA ENTRY DESCRIPTION

	Card Columns	Value	Definition
Card 1	1-2	Integer	Sub-element number
	3	Alpha	Sub-element type; B = beam, C = cylinder, M = membrane, P = plate R = room (acoustic element)
	4-13	Real	Mass density (B, C, M, P, R)
	14-23	Real	Elastic modulus (B, C, M, P)
	24-33	Real	Thickness (B, C, M, P)
	34-43	Real	Area (section if B; surface if M or P)
	44-53	Real	Poisson's ratio (C, P)
	54-63	Real	Length (B, C)
	64-73	Real	Pressure (M only)
Card 2	1	Logical	Replace F with T if stiffness increase is desired (B, C, P)
	2-11	Real	Radius (C only)
	12-21	Real	Volume (R only)
	22-31	Real	Speed of sound (R, or if LS #2, CC5 = A)
	32-41	Real	Added non-structural mass (B, C, M, P)

Figure 4-4. Loadsheet 4

LOADSHEET (5): JOINT PROPERTIES

- Must follow all element and sub-element cards at end of deck.
- Must be consistent with elements being joined.



DATA ENTRY DESCRIPTION

Card Columns	Value	Definition
1-2	Integer	Element number of A end of joint
3-4	Integer	Element number of B end of joint
5-6	Alpha	Joint type: PP = plate-to-plate, BP = beam-to-plate, BJ = bolted joint, PA = plate to acoustic
7-8	Integer	No. of sides exposed to acoustic input (1 or 2)
9-18	Real	Joint length
19-28	Real	Thickness of A end of joint
29-38	Real	Thickness of B end of joint
39-48	Real	Acoustic space mass density (P/RT)
49-58	Real	Beam length (BP only)
59-68	Real	Bolt spacing (BJ only)

Figure 4-5. Loadsheet 5

4.2.3 Output - Printout

The output consists of a list of input parameters, calculated modal densities, and calculated PSD levels (or G_{rms}), if this was specified on input by the user) for each element for each analysis frequency, arranged in five columns below a heading. The first column is the frequencies, the other four columns list the PSD levels for elements 1 to 4. This is followed by five more columns below a new heading and containing the frequencies and PSD levels for elements 5 to 8. This is repeated until all the elements have been listed.

4.2.4 Program Diagnostic Messages

The program can produce the error messages listed below. Suggestions for their cause and correction are also given. Lower case x's indicate values (usually, but not always, integers) that depend on the particular error.

*** ERROR *** THE INPUT FILE IS EMPTY. THE END OF FILE WAS ENCOUNTERED WHILE TRYING TO READ THE FIRST INPUT RECORD. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** WHILE TRYING TO READ ELEMENT PROPERTIES, THE END OF FILE WAS ENCOUNTERED BEFORE INPUT RECORD xxxx. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** WHILE TRYING TO READ SUB-ELEMENT PROPERTIES, THE END OF FILE WAS ENCOUNTERED BEFORE INPUT RECORD xxxx. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** WHILE TRYING TO READ SOUND PRESSURE LEVELS, THE END OF FILE WAS ENCOUNTERED BEFORE INPUT RECORD xxxx. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** WHILE TRYING TO READ MECHANICAL INPUTS, THE END OF FILE WAS ENCOUNTERED BEFORE INPUT RECORD xxxx. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** THE END OF FILE WAS REACHED BEFORE ANY INFORMATION ABOUT JOINT PROPERTIES WAS READ. THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT.

These errors are the result of an incomplete data file. The data file cannot end before joint properties for at least one pair of elements are read. The message indicates what kind of data the program was looking for when the end of file was encountered.

*** ERROR *** A FORTRAN ERROR OCCURRED WHILE TRYING TO READ ELEMENT PROPERTIES ON INPUT RECORD xxxx. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** A FORTRAN ERROR OCCURRED WHILE TRYING TO READ SUB-ELEMENT PROPERTIES ON INPUT RECORES xxxx AND xxxx. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** A FORTRAN ERROR OCCURRED WHILE TRYING TO READ THE FIRST INPUT RECORD. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** A FORTRAN ERROR OCCURRED WHILE TRYING TO READ SOUND PRESSURE LEVELS ON OR BEFORE INPUT RECORD xxxx. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** A FORTRAN ERROR OCCURRED WHILE TRYING TO READ MECHANICAL INPUTS ON OR BEFORE INPUT RECORD xxxx. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** WHILE ATTEMPTING TO READ JOINT PROPERTIES, A FORTRAN ERROR OCCURRED ON INPUT RECORD xxxx. THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT.

A FORTRAN error is usually the result of invalid characters appearing in a data field; for example, alphabetic characters appearing where the program expects to read an integer. This is likely to occur if data RECORDS are missing or out of order; for example, if an element properties record says there are four sub-elements for that element, but records for only three sub-elements are present. A FORTRAN error on the first record may indicate that the data file was not given the name 3. If the external file name is not 3, the internal file name should be made 3 by a USE statement.

*** ERROR *** THE NUMBER OF ELEMENTS WAS GIVEN AS xx. IT MUST BE BETWEEN 2 AND 20 INCLUSIVE. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** THE NUMBER OF ANALYSIS FREQUENCIES WAS GIVEN AS xx. IT MUST BE BETWEEN 1 AND 40 INCLUSIVE. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** THE TYPE OF MECHANICAL INPUT GIVEN FOR ELEMENT xx ON INPUT RECORD xxxx IS xxx. THIS IS NOT A VALID TYPE. THE TYPE MUST BE RMS OR PSD. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** TYPE = x ON INPUT RECORD xxxx IS AN INVALID TYPE. TYPE MUST BE B, M, P, C, OR R. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** THE TYPE OF JOINT GIVEN FOR ELEMENT PAIR xx AND xx ON INPUT RECORD xxxx IS xx. THIS IS NOT A VALID TYPE. THE TYPE MUST BE PP, BP, BJ, OR PA. THIS ERROR WAS DISCOVERED BY SUBROUTINE JPROP.

*** ERROR *** THE DETERMINANT OF THE SEA EQUATION MATRIX IS 0. HENCE THERE IS NO SOLUTION. THIS ERROR WILL CAUSE THE PROGRAM TO ABORT. THIS ERROR WAS DISCOVERED BY SUBROUTINE SOLVE.

These messages are self explanatory. If any of the errors listed thus far occur, the subroutine in which they occur will continue processing. Before control is transferred to another subroutine, however, the following message is printed and the program is aborted through a CALL FERR statement:

BECAUSE OF THE ERRORS LISTED ABOVE, THE SEA PROGRAM WILL ABORT.

The following errors will not cause the program to abort, but may put the results in error:

> *** WARNING *** ON INPUT RECORD xxxx THE ELEMENT NUMBER WAS GIVEN AS xx, WHICH IS OUT OF ORDER. IT HAS BEEN CHANGED TO xx. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

Element properties are stored in arrays in the order in which they are read. If elements are referenced in the joint properties section in any other order, that is, when they are referenced as one element of a pair, the results are almost certainly erroneous.

> *** WARNING *** ON INPUT RECORD xxxx THE SUB-ELEMENT NUMBER WAS GIVEN AS xx, WHICH IS OUT OF ORDER. IT SHOULD BE xx. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

Sub-element properties are not stored in arrays so this is not likely to result in an error. If other errors occur, this message probably indicates that there are missing or extraneous records.

> *** WARNING *** ON INPUT RECORD xxxx, ONE OR BOTH MEMBERS OF THE ELEMENT PAIR xx AND xx WAS EITHER LESS THAN 1 OR GREATER THAN xx, THE TOTAL NUMBER OF ELEMENTS. THIS PAIR WILL BE IGNORED. THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT.

> *** WARNING *** THE ELEMENT PAIR xx AND xx ON INPUT RECORD xxxx WAS PREVIOUSLY READ ON INPUT RECORD xxxx. THE FIRST VALUES WILL BE USED. THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT.

> *** WARNING *** ON INPUT RECORD xxxx, BOTH ELEMENT NUMBERS WERE GIVEN AS xx. THEY MUST BE DIFFERENT. THIS RECORD WILL BE IGNORED. THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT.

These errors result in the indicated record being ignored. Whether or not the results are erroneous depends on whether the indicated record is necessary to the results.

In addition, data which causes overflow, negative arguments to the square root functions, etc., will produce ASCII FORTRAN diagnostics.

Section 5
REFERENCES

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2. R. F. Davis. Statistical Energy Analysis Reponse Prediction Methods for Structural Systems - Final Report. McDonnell Douglas Astronautics Company - Huntington Beach report MDC G8150, October 1979.

3. Acoustic, Shock and Vibration Criteria for Design Evaluation/ Qualification and Formal Qualification Test Programs - Model Saturn S-IVB-IB/V. Douglas Missile & Space Systems Division report DAC 56624, June 1968.

Appendix I

SEA PROGRAM FORTRAN LISTING

MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•

11/4/81 AG1YIMG

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LCAO 3541

FINAL

NYGAARD

SEA

SEAFILE

UNIVAC

MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•

AG1YIMG

MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•MCAUTO•

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C           *****************  SEA PROGRAM  *****************          MAIN   3
C                                                                      MAIN   4
C                                                                      MAIN   5
C           STATISTICAL ENERGY ANALYSIS OF COMPLEX STRUCTURES          MAIN   6
C                                                                      MAIN   7
C INPUT IS READ FROM UNIT 3 IN ASCII CODE                              MAIN   8
C OUTPUT IS WRITTEN TO UNIT 6, THE PRINTER (OR TERMINAL IN DEMAND MODE) MAIN  9
C                                                                      MAIN  10
C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:               MAIN  11
C    NAME    TYPE          DESCRIPTION                                 MAIN  12
C    ----    ----          -----------                                 MAIN  13
C AF         INT   ANALYSIS FREQUENCY ORDINAL (FROM 1 TO NUMAF)        MAIN  14
C FREQ       REAL  FREQUENCY                                           MAIN  15
C FTAB(40)   REAL  TABLE OF ANALYSIS FREQUENCIES                       MAIN  16
C NUMAF      INT   NUMBER OF ANALYSIS FREQUENCIES                      MAIN  17
C OMEGA      REAL  2*PI*FREQUENCY                                      MAIN  18
C                                                                      MAIN  19
C THE FOLLOWING COMMON BLOCKS ARE USED:                                MAIN  20
C BLOCK      OTHER PROGRAM UNITS USING THIS COMMON BLOCK               MAIN  21
C -----      -------------------------------------------               MAIN  22
C  CB1   EPROP,BEAM,MEMBR,PLATE,ROOM,CYLIN,RITER,BLOCK DATA            MAIN  23
C  CB2   EPROP,JINPUT,BLOCK DATA                                       MAIN  24
C  CB3   JPROP,EXCITE,ANSWER                                           MAIN  25
C                                                                      MAIN  26
C                                                                      MAIN  27
      INTEGER AF                                                       MAIN  28
      LOGICAL ERROR                                                    MAIN  29
      COMMON /CB1/ FTAB(40),NUMAF,FREQ1                                MAIN  30
      COMMON /CB2/ ERROR                                               MAIN  31
      COMMON /CB3 /FREQ,AF,OMEGA                                       MAIN  32
      DATA PI /3.141592/                                               MAIN  33
   30 FORMAT (10HBECAUSE OF THE ERRORS LISTED ABOVE, THE SEA PROGRAM,  MAIN  34
     *   T WILL ABORT.1)                                               MAY13  1
      REWIND 3                                                         MAIN  36
C CALL EPROP TO READ ELEMENT PROPERTIES INPUT                          MAIN  37
      CALL EPROP (A5)                                                  UNIVAC 1
C CALL JINPUT TO READ JOINT PROPERTIES INPUT                           MAIN  39
      CALL JINPUT                                                      MAIN  40
C IF AN ERROR HAS OCCURRED ON INPUT, WRITE A MESSAGE AND               MAIN  41
C TERMINATE THE PROGRAM.                                               MAIN  42
    5 IF (.NOT. ERROR) GO TO 10                                        MAIN  43
      WRITE (6,30)                                                     MAIN  44
      CALL FERR                                                        MAIN  45
C DO FOR EACH ANALYSIS FREQUENCY                                       MAIN  46
   10 DO 20 AF = 1,NUMAF                                               MAIN  47
C DEFINE THE CURRENT ANALYSIS FREQUENCY                                MAIN  48
         FREQ = FTAB(AF)                                               MAIN  49
         OMEGA = 2. * PI * FREQ                                        MAIN  50
C CALL JPROP TO CALCULATE JOINT PROPERTIES                             MAY13  3
         CALL JPROP                                                    MAIN  52
C CALL EXCITE TO DETERMINE ENERGY SOURCES FROM EXCITATION INPUTS       MAIN  53
         CALL EXCITE                                                   MAIN  54
C CALL ANSWER TO SOLVE THE SEA EQUATIONS FOR ELEMENT ENERGIES          JUNE25 1
         CALL ANSWER                                                   MAIN  56
   20 CONTINUE                                                         MAIN  57
C CALL RITER TO WRITE OUT THE ANSWER                                   MAIN  58
```

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      CALL RITER                                                        MAIN  59
      STOP                                                              MAIN  60
      END                                                               MAIN  61
```

```
      SUBROUTINE EPROP(*)                                               EPROP  2
C THIS SUBROUTINE READS ELEMENT AND SUB-ELEMENT PROPERTIES FROM UNIT    EPROP  3
C 3 AND CALLS THE APPROPRIATE SUBROUTINE, DEPENDING ON THE TYPE OF      EPROP  4
C SUB-ELEMENT, TO CALCULATE ELEMENT MODAL DENSITIES. EPROP IS CALLED    EPROP  5
C FROM THE MAIN PROGRAM.                                                EPROP  6
C                                                                       EPROP  7
C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:                EPROP  8
C    NAME     TYPE            DESCRIPTION                               EPROP  9
C    ----     ----            -----------                               EPROP 10
C A           REAL  AREA                                                EPROP 11
C C           REAL  SPEED OF SOUND IN ROOM MEDIUM                       EPROP 13
C E           REAL  MODULUS OF ELASTICITY                               EPROP 14
C ELNUM       INT   ELEMENT NUMBER                                      EPROP 15
C ETA(20)     REAL  DAMPING                                             EPROP 16
C ETYPE(20)   CHAR  TYPE OF EXCITATION                                  EPROP 17
C FREQ1       REAL  FIRST ANALYSIS FREQUENCY                            EPROP 18
C FTAB(40)    REAL  TABLE OF ANALYSIS FREQUENCIES                       EPROP 19
C G           REAL  GRAVITATIONAL CONSTANT                              EPROP 20
C GAMMA       REAL  POISSON'S RATIO                                     EPROP 21
C G1          REAL  GRAVITATIONAL CONSTANT IN METRIC UNITS              EPROP 22
C INP         INT   NUMBER OF INPUT RECORDS READ                        EPROP 23
C L           REAL  LENGTH                                              EPROP 24
C M           REAL  MASS                                                AUG26  1
C MAIN        LOG   TRUE IF SUB-ELEMENT IS MAIN SUB-ELEMENT             EPROP 25
C MECH(20,40)REAL MECHANICAL INPUT                                      EPROP 26
C MTYPE(20)   CHAR  TYPE OF MECHANICAL INPUT                            EPROP 27
C NUMAF       INT   NUMBER OF ANALYSIS FREQUENCIES                      EPROP 28
C NUMEL       INT   NUMBER OF ELEMENTS                                  EPROP 29
C NUMSUB      INT   NUMBER OF SUB-ELEMENTS                              EPROP 30
C OTYPE       CHAR  TYPE OF OUTPUT                                      MAY14  1
C R           REAL  RADIUS                                              EPROP 31
C RHO         REAL  DENSITY                                             EPROP 32
C S           REAL  PRESSURE                                            EPROP 33
C SFREQ(20)   REAL  STARTING FREQUENCY                                  EPROP 34
C SLOPE(20)   REAL  SLOPE                                               EPROP 35
C SPL(20,40)REAL  SOUND PRESSURE LEVEL                                  EPROP 36
C STIFF       LOG   TRUE IS STIFFNESS REDUCTION REQUIRED                EPROP 37
C SUBNUM      INT   SUB-ELEMENT NUMBER                                  AUG26  2
C T           REAL  THICKNESS                                           EPROP 38
C TYPE        CHAR  TYPE OF SUB-ELEMENT                                 EPROP 39
C UNITS       CHAR  'MT' IF METRIC, OTHERWISE ENGLISH UNITS             EPROP 40
C V           REAL  VOLUME                                              EPROP 41
C                                                                       EPROP 42
C                                                                       EPROP 43
C THE FOLLOWING COMMON BLOCKS ARE USED:                                 EPROP 44
C BLOCK       OTHER PROGRAM UNITS USING THE COMMON BLOCK                EPROP 45
C -----       ------------------------------------------                EPROP 46
C  CB1   MAIN,BEAM,MEMBR,PLATE,ROOM,CYLIN,RITER,BLOCK DATA              EPROP 47
C  CB2   MAIN,JINPUT,BLOCK DATA                                         EPROP 48
C  CB4   BEAM,MEMBR,PLATE,ROOM,CYLIN                                    EPROP 49
C  CB5    BEAM,MEMBR,PLATE,ROOM,CYLIN,MPROP,EXCITE,ANSWER               EPROP 50
C  CB6   PLATE,EXCITE                                                   OCT28  1
C  CB7   JINPUT,JPROP,EXCITE,ANSWER,SOLVE,RITER,BLOCK DATA              EPROP 52
C  CB8   ANSWER,RITER,BLOCK DATA                                        EPROP 53
C  CB9   BEAM,MEMBR,PLATE,ROOM,CYLIN,JPROP,EXCITE,BLOCK DATA            EPROP 54
C  CB10  JINPUT,BLOCK DATA                                              EPROP 55
```

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      C                                                                 EPROP 56
      C                                                                 EPROP 57
            CHARACTER TYPE,ETYPE,MTYPE*3,UNITS,OTYPE*3                  MAY13  5
            INTEGER ELNUM,SUBNUM                                        EPROP 59
            REAL MECH,M,L,N                                             EPROP 60
            LOGICAL ERROR,STIFF,MAIN                                    EPROP 61
            COMMON /CB1/ FTAB(40),NUMAF,FREQ1                           EPROP 62
            COMMON /CB2/ ERROR                                          EPROP 63
            COMMON /CB4/ ELNUM,T,E,GAMMA,RHO,N,STIFF,L,A,V,C,R,S,MAIN   MAY13  6
            COMMON /CB5/ THICK(20),AREA(20),DENSE(20),VOL(20),EE(20),   EPROP 65
           *   EGAMMA(20),EC(20)                                        EPROP 66
            COMMON /CB6/ SPL(20,40),MECH(20,40),ANM(20),ETYPE(20),MTYPE(20)  UNVAC2 1
            COMMON /CB7/ NUMEL,G                                        EPROP 68
            COMMON /CB8/ SLOPE(20),SFREQ(20),ETA(20),OTYPE              UNIVAC 2
            COMMON /CB9/ N(20,40)                                       EPROP 70
            COMMON /CB10/ INPUT                                         EPROP 71
            DATA G1 /9.81/                                              EPROP 72
        300 FORMAT (2I2,F10.2,A1,A3)                                    EPROP 73
        310 FORMAT (2I2,A1,A3,3F10.2)                                   OCT28  3
        320 FORMAT (I2,A1,7F10.2,/L1,4F10.2)                            EPROP 75
        330 FORMAT ('0*** ERROR ***    TYPE = ',A1,' ON INPUT RECORD ',  EPROP 76
           1   I4,' IS AN INVALID TYPE.'/' TYPE MUST BE B, M, P, C, OR R.'/  EPROP 77
           $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.')       EPROP 78
        340 FORMAT ('0*** ERROR ***    A FORTRAN ERROR OCCURRED WHILE ', EPROP 79
           1   'TRYING TO READ'/' SUB-ELEMENT PROPERTIES ON INPUT RECORDS ',  EPROP 80
           2   I4,' AND ',I4,'.'/                                       MAY13 11
           $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.')       EPROP 82
        350 FORMAT ('0*** ERROR ***    A FORTRAN ERROR OCCURRED WHILE ', EPROP 83
           1   'TRYING TO READ'/' ELEMENT PROPERTIES ON INPUT RECORD ',I4,'.'/EPROP 84
           $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.')       EPROP 85
        360 FORMAT ('0*** ERROR ***    A FORTRAN ERROR OCCURRED WHILE ', EPROP 86
           1    'TRYING TO READ'/' THE FIRST INPUT RECORD.'/            EPROP 87
           $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.')       EPROP 88
        370 FORMAT ('0*** ERROR ***    THE INPUT FILE IS EMPTY. THE ',  MAY13 12
           1   'END OF FILE WAS ENCOUNTERED'/' WHILE TRYING TO READ THE ',  MAY13 13
           2    'FIRST INPUT RECORD.'/                                  EPROP 91
           $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.')       EPROP 92
        380 FORMAT ('0*** ERROR ***    WHILE TRYING TO READ ELEMENT ',  MAY13 14
           *   'PROPERTIES,'/                                           MAY13 15
           1    ' THE END OF FILE WAS ENCOUNTERED BEFORE INPUT RECORD ',  EPROP 94
           2   I4,'.'/                                                  EPROP 95
           $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.')       EPROP 96
        390 FORMAT ('0*** ERROR ***    WHILE TRYING TO READ SUB-ELEMENT', EPROP 97
           1    'PROPERTIES,'/' THE END OF FILE WAS ENCOUNTERED BEFORE ',  EPROP 98
           2    'INPUT RECORD ',I4,'.'/                                 EPROP 99
           $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.')       EPROP100
        400 FORMAT (8F10.2)                                             EPROP101
        410 FORMAT ('0*** ERROR ***    A FORTRAN ERROR OCCURRED WHILE ', EPROP102
           1    'TRYING TO READ'/' SOUND PRESSURE LEVELS ON OR BEFORE INPUT ',EPROP104
           2    'RECORD ',I4,'.'/                                       EPROP105
           $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.')       EPROP106
        420 FORMAT ('0*** ERROR ***    WHILE TRYING TO READ SOUND ',    EPROP107
           1    'PRESSURE LEVELS,'/' THE END OF FILE WAS ENCOUNTERED ', EPROP108
           2    'BEFORE INPUT RECORD ',I4,'.'/                          EPROP109
           $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.')       EPROP110
        430 FORMAT ('0*** WARNING ***    ON INPUT RECORD ',I4,' THE ',  EPROP111
```

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      1   'ELEMENT NUMBER WAS GIVEN'/' AS ',I2,', WHICH IS OUT OF ',       EPROP112
      2   'ORDER. IT HAS BEEN CHANGED TO ',I2,'.'/                         EPROP113
      $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.')               EPROP114
  440 FORMAT ('0*** WARNING ***     ON INPUT RECORD ',I4,' THE ',          EPROP115
      1   'SUB-ELEMENT NUMBER WAS GIVEN'/' AS ',I2,', WHICH IS OUT OF ', EPROP116
      2   'ORDER. IT SHOULD BE ',I2,'.'/                                   EPROP117
      $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.')               EPROP118
  450 FORMAT ('0*** ERROR ***     THE NUMBER OF ELEMENTS ',                EPROP119
      1   'WAS GIVEN AS ',I2,'. IT MUST BE'/' BETWEEN 2 AND 20, ',         EPROP120
      2   'INCLUSIVE.'/                                                    EPROP121
      $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.')               MAY13 16
  460 FORMAT ('0*** ERROR ***     THE NUMBER OF ANALYSIS FREQUENCIES ',    MAY13 17
      1   'WAS GIVEN AS ',I2,'. IT MUST BE'/' BETWEEN 1 AND 40, ',         EPROP124
      2   'INCLUSIVE.'/                                                    EPROP125
      $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.')               EPROP126
  470 FORMAT ('0*** ERROR ***     A FORTRAN ERROR OCCURRED WHILE ',        EPROP127
      1    'TRYING TO READ'/' MECHANICAL INPUTS ON OR BEFORE INPUT',       EPROP128
      2     'RECORD ',I4,'.'/                                              EPROP129
      $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.')               EPROP130
  480 FORMAT ('0*** ERROR ***     WHILE TRYING TO READ ',                  EPROP131
      1    'MECHANICAL INPUTS,'/' THE END OF FILE WAS ENCOUNTERED ',       EPROP132
      2    'BEFORE INPUT RECORD ',I4,'.'/                                  EPROP133
      $    ' THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.')              EPROP134
  490 FORMAT ('0*** ERROR ***     THE TYPE OF MECHANICAL INPUT ',          EPROP135
      1   'GIVEN FOR ELEMENT ',I2/' ON INPUT RECORD ',I4,' IS ',           EPROP136
      2   A3,'. THIS IS NOT A VALID TYPE. THE TYPE MUST'/                  EPROP137
      3   ' BE RMS OR PSD.'/                                               EPROP138
      $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.')               EPROP139
  500 FORMAT (//5X,'CENTER',15X,'MODAL DENSITY - MODES/(RAD/SEC)'/         AUG24  1
      *         4X,'FREQ(HZ)',4(5X,'ELEMENT ',I2:))                        AUG24  2
  510 FORMAT (F12.2,4(1PE15.5E2))                                          AUG24  3
  520 FORMAT (1H1 /// 11X, 'STATISTICAL ENERGY ANALYSIS OF COMPLEX ',      AUG26  3
      1   'STRUCTURES' /// ' RECORD' / ' NUMBER', 13X, 'DATA READ ',       AUG26  4
      2   'FROM UNIT 3' / 1X, 6(1H-), 13X, 21(1H-) / )                     AUG26  5
  530 FORMAT (5X, '1', 4X, 'NUMBER OF ELEMENTS = ', I2 / 10X,              AUG26  6
      1   'NUMBER OF ANALYSIS FREQUENCIES = ', I2 / 10X, 'FIRST ',         AUG26  7
      2   'ANALYSIS FREQUENCY = ', 1PE12.5E2 / 10X, 'TYPE OF UNITS = ',    AUG26  8
      3   A1 / 10X, 'TYPE OF OUTPUT = ', A3)                               AUG26  9
  540 FORMAT (I8, 4X, 'ELEMENT NUMBER = ', I2 / 10X, 'NUMBER OF ',         AUG26 10
      1   'SUB-ELEMENTS = ', I2 / 10X, 'TYPE OF EXCITATION = ', A1 /       AUG26 11
      2   10X, 'TYPE OF MECHANICAL INPUT = ', A3 / 10X,                    NOV4   1
      4   'DAMPING = ', 1PE12.5E2 / 10X, 'SLOPE = ', 1PE12.5E2 /           AUG26 14
      5   10X, 'STARTING FREQUENCY = ', 1PE12.5E2)                         AUG26 15
  550 FORMAT (28X, 'SOUND PRESSURE LEVELS' / (I6, 7X,                      AUG26 16
      1   4(2X, 1PE12.5E2) / 13X, 4(2X, 1PE12.5E2)))                       AUG26 17
  560 FORMAT (28X, 'MECHANICAL INPUTS' / (I6, 7X,                          AUG26 18
      1   4(2X, 1PE12.5E2) / 13X, 4(2X, 1PE12.5E2)))                       AUG26 19
  570 FORMAT (I6, 9X, 'SUB-ELEMENT NUMBER = ', I2 / 15X, 'TYPE OF ',       AUG26 20
      1   'SUB-ELEMENT = ', A1 / 15X, 'DENSITY = ', 1PE12.5E2 / 15X,       AUG26 21
      2   'MODULUS OF ELASTICITY = ', 1PE12.5E2 / 15X, 'THICKNESS = ',     AUG26 22
      3   1PE12.5E2 / 15X, 'AREA = ', 1PE12.5E2 / 15X, 'POISSONS ',        AUG26 23
      4   'RATIO = ', 1PE12.5E2 / 15X, 'LENGTH = ', 1PE12.5E2 / 15X,       AUG26 24
      5   'PRESSURE = ', 1PE12.5E2 / I6, 9X, 'STIFFNESS REDUCTION ',       AUG26 25
      6   'REQUIRED = ', L1 / 15X, 'RADIUS = ', 1PE12.5E2 / 15X,           AUG26 26
      7   'VOLUME = ', 1PE12.5E2 / 15X, 'SPEED OF SOUND IN ROOM ',         AUG26 27
      8   'MEDIUM = ', 1PE12.5E2 / 15X, 'ADDED MASS = ', 1PE12.5E2)        NOV4   2
```

```
C WRITE THE HEADING FOR THE OUTPUT                                      AUG26 29
      WRITE (6,520)                                                     AUG26 30
C READ HOW MANY ELEMENTS AND ANALYSIS FREQUENCIES THERE ARE, THE         EPROP143
C FIRST FREQUENCY, THE SYSTEM OF UNITS, AND THE TYPE OF OUTPUT          EPROP144
      READ (3,380,ERR=210,END=220)NUMEL,NUMAF,FREQ1,UNITS,OTYPE         EPROP145
C WRITE THE FIRST RECORD TO OUTPUT                                      AUG26 31
      WRITE (6,530) NUMEL, NUMAF, FREQ1, UNITS, OTYPE                   AUG26 32
C CHECK TO SEE THAT THE NUMBER OF ELEMENTS AND ANALYSIS                 EPROP146
C FREQUENCIES IS WITHIN RANGE                                           EPROP147
      IF (NUMEL .LT. 2 .OR. NUMEL .GT. 20) GO TO 260                    EPROP148
      IF (NUMAF .LT. 1 .OR. NUMAF .GT. 40) GO TO 270                    EPROP149
C IF THE SYSTEM OF UNITS IS METRIC, CONVERT THE GRAVITATIONAL           EPROP150
C CONSTANT TO METRIC UNITS                                              EPROP151
      IF (UNITS .EQ. 'M') G = G1                                        EPROP152
C PUT THE VALUES OF THE ANALYSIS FREQUENCIES IN THE FREQUENCY TABLE     MAY13 18
      DO 10 I = 1,NUMAF                                                 EPROP154
         FTAB(I) = FTAB(I) + FREQ1                                      EPROP155
   10 CONTINUE                                                          EPROP156
C DO FOR EACH ELEMENT                                                   EPROP157
      DO 200 I = 1,NUMEL                                                EPROP158
C INCREMENT INPUT                                                       EPROP159
         INPUT = INPUT + 1                                              EPROP160
C READ THE ELEMENT PROPERTIES                                           EPROP161
         READ (3,310,ERR=120,END=230) ELNUM,NUMSUR,ETYPE(I),MTYPE(I),   MAY13 19
     *      ETA(I),SLOPE(I),SFREQ(I)                                    OCT28  4
C WRITE THE ELEMENT PROPERTIES TO OUTPUT                                AUG26 33
         WRITE (6,540) INPUT, ELNUM, NUMSUR, ETYPE(I), MTYPE(I),        AUG26 34
     *      ETA(I),SLOPE(I),SFREQ(I)                                    NOV4   3
C IF THE ELEMENT NUMBER IS OUT OF ORDER, WRITE A WARNING                EPROP164
C MESSAGE                                                               EPROP165
         IF (ELNUM .EQ. I) GO TO 12                                     EPROP166
         WRITE (6,430) INPUT,ELNUM,I                                    EPROP167
         ELNUM = I                                                      EPROP168
C IF THE TYPE OF ELEMENT IS MECHANICAL BUT THE TYPE OF MECHANICAL       EPROP169
C INPUT IS NEITHER RMS NOR PSD, WRITE A MESSAGE AND SET THE             EPROP170
C ERROR FLAG                                                            EPROP171
   12    IF (ETYPE(I) .NE. 'M' .OR. MTYPE(I) .EQ. 'RMS' .OR.            EPROP172
     *      MTYPE(I) .EQ. 'PSD') GO TO 15                               EPROP173
         WRITE (6,490) ELNUM,INPUT,MTYPE                                EPROP174
         ERROR = .TRUE.                                                 EPROP175
C IF THE TYPE OF EXCITATION IS ACOUSTIC                                 MAY13 20
   15    IF (ETYPE(I) .NE. 'A') GO TO 18                                EPROP177
C THEN INCREMENT INPUT                                                  EPROP178
         INPUT1 = INPUT                                                 AUG26 36
         LINES = (NUMAF + 7) / 8                                        AUG26 37
         INPUT = INPUT + LINES                                          AUG26 38
C AND READ THE SOUND PRESSURE LEVEL FOR EACH FREQUENCY                  EPROP180
         READ (3,400,ERR=130,END=250) (SPL(I,J),J=1,NUMAF)              MAY13 21
C WRITE THE SOUND PRESSURE LEVELS TO OUTPUT                             AUG26 39
         WRITE (6,550) (INPUT1 + K, (SPL(I, 8 * (K - 1) + J),           AUG26 40
     *      J = 1, 8), K = 1, LINES)                                    AUG26 41
C ELSE IF THE TYPE OF EXCITATION IS MECHANICAL,                         EPROP182
   18    IF (ETYPE(I) .NE. 'M') GO TO 20                                EPROP183
C THEN INCREMENT INPUT                                                  EPROP184
         INPUT1 = INPUT                                                 AUG26 42
         LINES = (NUMAF + 7) / 8                                        AUG26 43
```

```
            INPUT = INPUT + LINES                                      AUG26 44
C AND READ THE MECHANICAL INPUTS FOR EACH FREQUENCY                    MAY13 22
            READ (3,400,ERR=140,END=280) (MECH(I,J),J=1,NUMAF)         MAY13 23
C WRITE THE MECHANICAL INPUTS TO OUTPUT                                AUG26 45
            WRITE (6,550) (INPUT1 + K, (MECH(I, 8 * (K - 1) + J),      AUG26 46
     *         J = 1, 8), K = 1, LINES)                                AUG26 47
C END IF                                                               EPROP188
C INITIALIZE MAIN TO SIGNIFY THAT THE FIRST SUB-ELEMENT IS THE         EPROP189
C MAIN SUB-ELEMENT                                                     EPROP190
 20         MAIN = .TRUE.                                              EPROP191
C DO FOR EACH SUB-ELEMENT                                              EPROP192
            DO 100 J =1,NUMSUB                                         EPROP193
C INCREMENT INPUT                                                      EPROP194
               INPUT = INPUT + 2                                       EPROP195
C READ THE SUB-ELEMENT PROPERTIES                                      EPROP196
               READ (3,320,ERR=80,END=240)SUBNUM,TYPE,RHO,E,           EPROP197
     *            T,A,GAMMA,L,S,STIFF,R,V,C,M                          EPROP198
C WRITE THE SUB-ELEMENT PROPERTIES TO OUTPUT                           AUG26 48
               WRITE (6,570) INPUT - 1, SUBNUM, TYPE, RHO, E, T, A,    AUG26 49
     *            GAMMA, L, S, INPLT, STIFF, R, V, C, M                AUG26 50
C CHANGE ALL PLATE, BEAM, CYLINDER, AND MEMBRANE TYPE SUB-             AUG15M 1
C ELEMENTS TO THE SAME MODULUS OF ELASTICITY AS THE ELEMENT 1          AUG15M 2
C MAIN SUB-ELEMENT AND SET THEIR THICKNESS SO THAT :                   AUG15M 3
C     T = T * (E / EE(1) ) ** ( 1./3. )                                AUG14L 3
              IF ( ((ELNUM .EQ. 1) .AND. (J .EQ. 1)) .OR.              AUG14L 4
     *           ( TYPE .NE. 'P' .AND. TYPE .NE. 'B' .AND.             AUG14L 5
     *           TYPE .NE. 'C' .AND. TYPE .NE. 'M' ) .OR.              AUG15M 4
     *           E .EQ. EE(1)  ) GO TO 22                              AUG14L 7
              T1 = T * (E / EE(1)) ** (1. / 3.)                        OCT28  5
              RHO = RHO * T / T1                                       OCT28  6
              T = T1                                                   OCT28  7
              E = EE(1)                                                OCT28  8
 22           CONTINUE                                                 JULY10 8
C IF THE SUB-ELEMENT NUMBER IS OUT OF ORDER, WRITE A WARNING           EPROP199
C MESSAGE                                                              EPROP200
               IF (SUBNUM .EQ. J) GO TO 25                             EPROP201
               WRITE (6,440) INPUT-1,SUBNUM,J                          EPROP202
C IF THE SUB-ELEMENT IS A BEAM, CALL BEAM                              EPROP203
 25            IF (TYPE .NE. 'B') GO TO 30                             EPROP204
               CALL BEAM                                               EPROP205
               GO TO 100                                               EPROP206
C IF THE SUB-ELEMENT IS A MEMBRANE, CALL MEMBR                         EPROP207
 30            IF (TYPE .NE. 'M') GO TO 40                             EPROP208
               CALL MEMBR                                              EPROP209
               GO TO 100                                               EPROP210
C IF THE SUB-ELEMENT IS A PLATE, CALL PLATE                            EPROP211
 40            IF (TYPE .NE. 'P') GO TO 50                             EPROP212
               CALL PLATE                                              EPROP213
               GO TO 100                                               EPROP214
C IF THE SUB-ELEMENT IS A ROOM, CALL ROOM                              EPROP215
 50            IF (TYPE .NE. 'R') GO TO 60                             EPROP216
               CALL ROOM                                               EPROP217
               GO TO 100                                               EPROP218
C IF THE SUB-ELEMENT IS A CYLINDER, CALL CYLIN                         EPROP219
 60            IF (TYPE .NE. 'C') GO TO 70                             EPROP220
               CALL CYLIN                                              EPROP221
```

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              GO TO 100                                               EPROP222
C ELSE IF THE TYPE OF SUB-ELEMENT IS NONE OF THE ABOVE, WRITE AN     EPROP223
C ERROR MESSAGE AND SET THE ERROR FLAG TO TERMINATE THE PROGRAM      EPROP224
   70         WRITE (6,330) TYPE,INPUT-1                              EPROP225
              ERROR = .TRUE.                                          EPROP226
              GO TO 100                                               EPROP227
C END IF                                                              EPROP228
C IF AN ERROR WAS ENCOUNTERED WHILE READING SUB-ELEMENT PROPERTIES,   EPROP229
C WRITE A MESSAGE AND SET THE ERROR FLAG                              EPROP230
   80         WRITE (6,340) INPUT-1,INPUT                             EPROP231
              ERROR = .TRUE.                                          EPROP232
  100     CONTINUE                                                    EPROP233
          GO TO 200                                                   EPROP234
C IF AN ERROR WAS ENCOUNTERED WHILE READING ELEMENT PROPERTIES,       EPROP235
C WRITE A MESSAGE AND SET THE ERROR FLAG                              EPROP236
  120     WRITE (6,350) INPUT                                         EPROP237
          ERROR = .TRUE.                                              EPROP238
          GO TO 200                                                   EPROP239
C IF AN ERROR WAS ENCOUNTERED WHILE READING SOUND PRESSURE LEVELS,    EPROP240
C WRITE A MESSAGE AND SET THE ERROR FLAG                              EPROP241
  130     WRITE (6,410) INPUT                                         EPROP242
          ERROR = .TRUE.                                              EPROP243
          GO TO 20                                                    EPROP244
C IF AN ERROR WAS ENCOUNTERED WHILE READING MECHANICAL INPUTS,        EPROP245
C WRITE A MESSAGE AND SET THE ERROR FLAG                              EPROP246
  140     WRITE (6,470) INPUT                                         EPROP247
          ERROR = .TRUE.                                              EPROP248
          GO TO 20                                                    EPROP249
  200 CONTINUE                                                        EPROP250
        DO 207 K = 1, NUMEL, 4                                        EPROP251
              KPLUS3 = MIN(NUMEL, K + 3)                              JUNE25 6
              WRITE (6,500) (I,I=K,KPLUS3)                            JUNE25 7
        DO 207 J2 = 1, NUMAF                                          AUG12J 1
              WRITE(6,510) FTAB(J2),(N(J,J2),J=K,KPLUS3)              AUG24  4
  207 CONTINUE                                                        EPROP257
        IF (ERROR) RETURN 1                                           EPROP258
        RETURN                                                        EPROP259
C IF AN ERROR OCCURRED WHILE READING THE FIRST INPUT RECORD,          EPROP260
C WRITE A MESSAGE AND SET THE ERROR FLAG                              EPROP261
  210 WRITE (6,360)                                                   EPROP262
        GO TO 285                                                     JUNE25 9
C IF AN END OF FILE WAS ENCOUNTERED WHILE TRYING TO READ THE          EPROP265
C FIRST INPUT RECORD, WRITE A MESSAGE AND SET THE ERROR FLAG          EPROP266
  220 WRITE (6,370)                                                   EPROP267
        GO TO 285                                                     EPROP268
C IF AN END OF FILE WAS ENCOUNTERED WHILE READING ELEMENT PROPERTIES, EPROP269
C WRITE A MESSAGE AND SET THE ERROR FLAG                              EPROP270
  230 WRITE (6,380) INPUT                                             EPROP271
        GO TO 285                                                     EPROP272
C IF AN END OF FILE WAS ENCOUNTERED WHILE READING SUB-ELEMENT         EPROP273
C PROPERTIES, WRITE A MESSAGE AND SET THE ERROR FLAG                  EPROP274
  240 WRITE (6,350) INPUT                                             EPROP275
        GO TO 285                                                     EPROP276
C IF AN END OF FILE WAS ENCOUNTERED WHILE READING SOUND PRESSURE      EPROP277
C LEVELS, WRITE A MESSAGE AND SET THE ERROR FLAG                      EPROP278
  250 WRITE (6,420) INPUT                                             EPROP279
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      GO TO 285                                                       EPROP280
C IF THE NUMBER OF ELEMENTS IS OUT OF RANGE, WRITE A                  EPROP281
C MESSAGE AND SET THE ERROR FLAG                                      EPROP282
  260 WRITE (6,450) NUMEL                                             EPROP283
      GO TO 285                                                       EPROP284
C IF THE NUMBER OF ANALYSIS FREQUENCIES IS OUT OF RANGE, WRITE A      EPROP285
C MESSAGE AND SET THE ERROR FLAG                                      EPROP286
  270 WRITE (6,460) NUMAF                                             EPROP287
      GO TO 285                                                       EPROP288
C IF AN END OF FILE WAS ENCOUNTERED WHILE READING MECHANICAL          EPROP289
C INPUTS, WRITE A MESSAGE AND SET THE ERROR FLAG                      EPROP290
  280 WRITE (6,480) INPUT                                             EPROP291
  285 ERROR = .TRUE.                                                  EPROP292
      RETURN 1                                                        EPROP293
      END                                                             EPROP294
```

```
      SUBROUTINE BEAM                                                   BEAM   2
C THIS SUBROUTINE CALCULATES THE MODAL DENSITY FOR A SUB-ELEMENT        BEAM   3
C WHICH IS A BEAM AND SUMS THIS VALUE TO THE ELEMENT MODAL              BEAM   4
C DENSITY. BEAM IS CALLED FROM EPROP.                                   BEAM   5
C                                                                       BEAM   6
C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:                BEAM   7
C    NAME     TYPE            DESCRIPTION                               BEAM   8
C    ----     ----            -----------                               BEAM   9
C A           REAL  SUB-ELEMENT AREA                                    BEAM  10
C AREA(20)    REAL  ELEMENT AREA                                        BEAM  11
C C           REAL  SPEED OF SOUND IN SUB-ELEMENT ROOM MEDIUM           BEAM  12
C DENSE(20)   REAL  ELEMENT DENSITY                                     BEAM  13
C E           REAL  SUB-ELEMENT MODULUS OF ELASTICITY                   BEAM  14
C EC(20)      REAL  SPEED OF SOUND IN ELEMENT ROOM MEDIUM               MAY13 25
C EE(20)      REAL  ELEMENT MODULUS OF ELASTICITY                       BEAM  16
C EGAMMA(20)REAL    POISSONS RATIO FOR ELEMENT                          BEAM  17
C ELNUM       INT   ELEMENT NUMBER                                      BEAM  18
C FTAB(40)    REAL  TABLE OF ANALYSIS FREQUENCIES                       BEAM  19
C GAMMA       REAL  POISSONS RATIO FOR SUB-ELEMENT                      BEAM  20
C L           REAL  LENGTH                                              BEAM  21
C M           REAL  SUB-ELEMENT ADDED MASS (NON-STRUCTURAL)             OCT16  1
C MASS(20)    REAL  ELEMENT MASS                                        BEAM  23
C MSUB        REAL  SUB-ELEMENT TOTAL MASS                              OCT16  2
C N(20,40)    REAL  ELEMENT MODAL DENSITY                               BEAM  24
C NUMAF       INT   NUMBER OF ANALYSIS FREQUENCIES                      BEAM  25
C OMEGA       REAL  2*PI*FREQUENCY                                      BEAM  26
C PSUBMD      REAL  PARTIAL SUB-ELEMENT MODAL DENSITY                   BEAM  27
C R           REAL  RADIUS                                              BEAM  28
C RHO         REAL  SUB-ELEMENT DENSITY                                 BEAM  29
C S           REAL  PRESSURE                                            BEAM  30
C SUBMD       REAL  SUB-ELEMENT MODAL DENSITY                           BEAM  31
C T           REAL  SUB-ELEMENT THICKNESS                               BEAM  32
C THICK(20)   REAL  ELEMENT THICKNESS                                   BEAM  33
C V           REAL  SUB-ELEMENT VOLUME                                  BEAM  34
C VOL(20)     REAL  ELEMENT VOLUME                                      BEAM  35
C                                                                       BEAM  36
C                                                                       BEAM  37
C THE FOLLOWING COMMON BLOCKS ARE USED:                                 BEAM  38
C BLOCK       OTHER PROGRAM UNITS USING THIS COMMON BLOCK               BEAM  39
C -----       ---------------------------------------------             BEAM  40
C  CB1   MAIN,EPROP,MEMBR,PLATE,ROOM,CYLIN,RITER,BLOCK DATA             MAY13 26
C  CB4   EPROP,MEMBR,PLATE,ROOM,CYLIN                                   BEAM  42
C  CB5   EPROP,MEMBR,PLATE,ROOM,CYLIN,JPROP,EXCITE,ANSWER               BEAM  43
C  CB9   EPROP,MEMBR,PLATE,ROOM,CYLIN,JPROP,EXCITE,BLOCK DATA           MAY13 27
C  CB11  MEMBR,PLATE,ROOM,CYLIN,ANSWER,BLOCK DATA                       BEAM  45
C                                                                       BEAM  46
C                                                                       BEAM  47
      INTEGER ELNUM                                                     BEAM  48
      REAL M,L,N,MASS,MSUB                                              OCT16  3
      LOGICAL STIFF,MAIN                                                BEAM  50
      COMMON /CB1/ FTAB(40),NUMAF,FREQ1                                 MAY14  2
      COMMON /CB4/ ELNUM,T,E,GAMMA,RHO,M,STIFF,L,A,V,C,R,S,MAIN         BEAM  52
      COMMON /CB5/ THICK(20),AREA(20),DENSE(20),VOL(20),EE(20),         MAY13 28
     *   EGAMMA(20),EC(20)                                              BEAM  54
      COMMON /CB9/ N(20,40)                                             BEAM  55
      COMMON /CB11/ MASS(20)                                            BEAM  56
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```
      DATA PI /3.141592/                                               BEAM  57
C CALCULATE THE PART OF THE SUB-ELEMENT MODAL DENSITY THAT IS         BEAM  58
C NOT FREQUENCY DEPENDENT                                             BEAM  59
      FSUBMD = L / (2. * PI) * SQRT(SQRT(12. * RHO / E) / T)          MAY13 29
C IF STIFFNESS REDUCTION IS REQUIRED, MULTIPLY BY SQRT(.5)            BEAM  61
      IF (STIFF) PSUBMD = SQRT(.5) * PSUBMD                           BEAM  62
C DO FOR EACH ANALYSIS FREQUENCY                                      BEAM  63
      DO 20 I = 1,NUMAF                                               BEAM  64
         OMEGA = 2. * PI * FTAB(I)                                    BEAM  65
C CALCULATE THE SUB-ELEMENT MODAL DENSITY                             BEAM  66
         SUBMD = PSUBMD / SQRT(OMEGA)                                 BEAM  67
C SUM THE SUB-ELEMENT MODAL DENSITY TO THE ELEMENT MODAL DENSITY      BEAM  68
         N(ELNUM,I) = N(ELNUM,I) + SUBMD                              MAY13 30
   20 CONTINUE                                                        BEAM  70
C SUM THE SUB-ELEMENT MASS TO THE ELEMENT MASS                        BEAM  71
      MSUB = RHO * A * L * M                                          OCT16  4
      MASS(ELNUM) = MASS(ELNUM) + MSUB                                OCT16  5
C IF THIS IS NOT THE MAIN SUB-ELEMENT, RETURN TO EPROP                BEAM  73
      IF (.NOT. MAIN) RETURN                                          BEAM  74
C ELSE PUT THE VALUES OF THE FOLOWING SUB-ELEMENT VARIABLES INTO      BEAM  75
C THE CORRESPONDING ELEMENT ARRAYS                                    BEAM  76
      EE(ELNUM) = E                                                   BEAM  77
      THICK(ELNUM) = T                                                BEAM  78
      DENSE(ELNUM) = RHO                                              BEAM  79
      AREA(ELNUM) = A                                                 BEAM  80
      VOL(ELNUM) = V                                                  BEAM  81
      EGAMMA(ELNUM) = GAMMA                                           BEAM  82
      EC(ELNUM) = C                                                   BEAM  83
C SET MAIN TO INDICATE THAT ANY FOLLOWING SUB-ELEMENTS ARE NOT        BEAM  84
C THE MAIN SUB-ELEMENT                                                JUNE2510
      MAIN = .FALSE.                                                  BEAM  86
      RETURN                                                          BEAM  87
      END                                                             BEAM  88
```

```
      SUBROUTINE MEMBR                                                  MEMBR  2
C THIS SUBROUTINE CALCULATES THE MODAL DENSITY FOR A SUB-ELEMENT        MEMBR  3
C WHICH IS A MEMBRANE AND SUMS THIS VALUE TO THE ELEMENT MODAL          MEMBR  4
C DENSITY. MEMBR IS CALLED FROM EPROP.                                  MEMBR  5
C                                                                       MEMBR  6
C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:                MEMBR  7
C    NAME     TYPE            DESCRIPTION                               MEMBR  8
C    ----     ----            -----------                               MEMBR  9
C A           REAL   SUB-ELEMENT AREA                                   MEMBR 10
C AREA(20)    REAL   ELEMENT AREA                                       MEMBR 11
C C           REAL   SPEED OF SOUND IN SUB-ELEMENT ROOM MEDIUM          MEMBR 12
C DENSE(20)   REAL   ELEMENT DENSITY                                    MEMBR 13
C E           REAL   SUB-ELEMENT MODULUS OF ELASTICITY                  MEMBR 14
C EC(20)      REAL   SPEED OF SOUND IN ELEMENT ROOM MEDIUM              MEMBR 15
C EE(20)      REAL   ELEMENT MODULUS OF ELASTICITY                      MEMBR 16
C EGAMMA(20)  REAL   POISSON'S RATIO FOR ELEMENT                        MEMBR 17
C ELNUM       INT    ELEMENT NUMBER                                     MEMBR 18
C FTAB(40)    REAL   TABLE OF ANALYSIS FREQUENCIES                      MEMBR 19
C GAMMA       REAL   POISSON'S RATIO FOR SUB-ELEMENT                    MEMBR 20
C L           REAL   LENGTH                                             MEMBR 21
C M           REAL   SUB-ELEMENT ADDED MASS (NON-STRUCTURAL)            OCT16  6
C MASS(20)    REAL   ELEMENT MASS                                       MEMBR 23
C MSUB        REAL   SUB-ELEMENT TOTAL MASS                             OCT16  7
C N(20,40)    REAL   ELEMENT MODAL DENSITY                              MEMBR 24
C NUMAF       INT    NUMBER OF ANALYSIS FREQUENCIES                     MEMBR 25
C OMEGA       REAL   2*PI*FREQUENCY                                     MEMBR 26
C PSUBMD      REAL   PARTIAL SUB-ELEMENT MODAL DENSITY                  MEMBR 27
C R           REAL   RADIUS                                             MEMBR 28
C RHO         REAL   SUB-ELEMENT DENSITY                                MEMBR 29
C S           REAL   PRESSURE                                           MEMBR 30
C SUBMD       REAL   SUB-ELEMENT MODAL DENSITY                          MEMBR 31
C T           REAL   SUB-ELEMENT THICKNESS                              MEMBR 32
C THICK(20)   REAL   ELEMENT THICKNESS                                  MEMBR 33
C V           REAL   SUB-ELEMENT VOLUME                                 MEMBR 34
C VOL(20)     REAL   ELEMENT VOLUME                                     MEMBR 35
C                                                                       MEMBR 36
C                                                                       MEMBR 37
C THE FOLLOWING COMMON BLOCKS ARE USED:                                 MEMBR 38
C BLOCK      OTHER PROGRAM UNITS USING THIS COMMON BLOCK                MEMBR 39
C -----      ---------------------------------------------              MEMBR 40
C  CB1   MAIN,EPROP,BEAM,PLATE,ROOM,CYLIN,RITER,BLOCK DATA              MEMBR 41
C  CB4   EPROP,BEAM,PLATE,ROOM,CYLIN                                    MEMBR 42
C  CB5   EPROP,BEAM,PLATE,ROOM,CYLIN,JPROP,EXCITE,ANSWER                MEMBR 43
C  CB9   EPROP,BEAM,PLATE,ROOM,CYLIN,JPROP,EXCITE,BLOCK DATA            MEMBR 44
C  CB11  BEAM,PLATE,ROOM,CYLIN,ANSWER,BLOCK DATA                        MEMBR 45
C                                                                       MEMBR 46
C                                                                       MEMBR 47
      INTEGER ELNUM                                                     MAY13 31
      REAL N,L,M,MASS,MSUB                                              OCT16  8
      LOGICAL STIFF,MAIN                                                MEMBR 50
      COMMON /CB1/ FTAB(40),NUMAF,FREQ1                                 MEMBR 51
      COMMON /CB4/ ELNUM,T,E,GAMMA,RHO,M,STIFF,L,A,V,C,R,S,MAIN         MEMBR 52
      COMMON /CB5/ THICK(20),AREA(20),DENSE(20),VOL(20),EE(20),         MEMBR 53
     *   EGAMMA(20),EC(20)                                              MEMBR 54
      COMMON /CB9/ N(20,40)                                             MEMBR 55
      COMMON /CB11/ MASS(20)                                            MEMBR 56
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```
      DATA PI /3.1415927/                                              MEMBR 57
C CALCULATE THE PART OF THE SUB-ELEMENT MODAL DENSITY THAT IS          MEMBR 58
C NOT FREQUENCY DEPENDENT                                              MEMBR 59
      PSUBMD = A * RHO * T / (2. * PI * S)                             MEMBR 60
C IF STIFFNESS REDUCTION IS REQUIRED, MULTIPLY BY SQRT(.5)             MEMBR 61
      IF (STIFF) PSUBMD = SQRT(.5) * PSUBMD                            MEMBR 62
C DO FOR EACH ANALYSIS FREQUENCY                                       MEMBR 63
      DO 20 I = 1,NUMAF                                                MEMBR 64
         OMEGA = 2. * PI * FTAB(I)                                     MEMBR 65
C CALCULATE THE SUB-ELEMENT MODAL DENSITY                              MEMBR 66
         SUBMD = PSUBMD * OMEGA                                        MEMBR 67
C SUM THE SUB-ELEMENT MODAL DENSITY TO THE ELEMENT MODAL DENSITY       MEMBR 68
         N(ELNUM,I) = N(ELNUM,I) + SUBMD                               MEMBR 69
   20 CONTINUE                                                         MEMBR 70
C SUM THE SUB-ELEMENT MASS TO THE ELEMENT MASS                         MEMBR 71
      MSUB = RHO * A * T * M                                           OCT16  9
      MASS(ELNUM) = MASS(ELNUM) + MSUB                                 OCT16 10
C IF THIS IS NOT THE MAIN SUB-ELEMENT, RETURN TO EPROP                 MEMBR 73
      IF (.NOT. MAIN) RETURN                                           MEMBR 74
C ELSE PUT THE VALUES OF THE FOLLOWING SUB-ELEMENT VARIABLES INTO      MEMBR 75
C THE CORRESPONDING ELEMENT ARRAYS                                     MEMBR 76
      EE(ELNUM) = E                                                    MEMBR 77
      THICK(ELNUM) = T                                                 MEMBR 78
      DENS(ELNUM) = RHO                                                MEMBR 79
      AREA(ELNUM) = A                                                  MEMBR 80
      VOL(ELNUM) = V                                                   MEMBR 81
      EGAMMA(ELNUM) = GAMMA                                            MEMBR 82
      EC(ELNUM) = C                                                    MEMBR 83
C SET MAIN TO INDICATE THAT ANY FOLLOWING SUB-ELEMENTS ARE NOT         MEMBR 84
C THE MAIN SUB-ELEMENT                                                 MEMBR 85
      MAIN = .FALSE.                                                   MEMBR 86
      RETURN                                                           MEMBR 87
      END                                                              MEMBR 88
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      SUBROUTINE PLATE                                          PLATE  2
C THIS SUBROUTINE CALCULATES THE MODAL DENSITY FOR A SUB-ELEMENT PLATE  3
C WHICH IS A PLATE AND SUMS THIS VALUE TO THE ELEMENT MODAL     PLATE  4
C DENSITY. PLATE IS CALLED FROM EPROP.                          PLATE  5
C                                                               PLATE  6
C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:        PLATE  7
C    NAME    TYPE          DESCRIPTION                          PLATE  8
C    ----    ----          -----------                          PLATE  9
C A          REAL  SUB-ELEMENT AREA                             PLATE 10
C ANM(20)    REAL  (AREA * MODES / MASS) OF SURFACE EXCITED BY  OCT28  9
C                  ACOUSTIC FIELD                               OCT28 10
C AREA(20)   REAL  ELEMENT AREA                                 PLATE 11
C C          REAL  SPEED OF SOUND IN SUB-ELEMENT ROOM MEDIUM    PLATE 12
C DENSE(20)  REAL  ELEMENT DENSITY                              PLATE 13
C E          REAL  SUB-ELEMENT MODULUS OF ELASTICITY            PLATE 14
C EC(20)     REAL  SPEED OF SOUND IN ELEMENT ROOM MEDIUM        PLATE 15
C EE(20)     REAL  ELEMENT MODULUS OF ELASTICITY                PLATE 16
C EGAMMA(20)REAL   POISSON'S RATIO FOR ELEMENT                  PLATE 17
C ELNUM      INT   ELEMENT NUMBER                               PLATE 18
C FTAB(40)   REAL  TABLE OF ANALYSIS FREQUENCIES                PLATE 19
C GAMMA      REAL  POISSON'S RATIO FOR SUB-ELEMENT              PLATE 20
C L          REAL  LENGTH                                       PLATE 21
C M          REAL  SUB-ELEMENT ADDED MASS (NON-STRUCTURAL)       OCT16 11
C MASS(20)   REAL  ELEMENT MASS                                 PLATE 23
C MSUB       REAL  SUB-ELEMENT TOTAL MASS                       OCT16 12
C N(20,40)   REAL  ELEMENT MODAL DENSITY                        PLATE 24
C NUMAF      INT   NUMBER OF ANALYSIS FREQUENCIES               PLATE 25
C OMEGA      REAL  2*PI*FREQUENCY                               PLATE 26
C PSUBMD     REAL  PARTIAL SUB-ELEMENT MODAL DENSITY            PLATE 27
C R          REAL  RADIUS                                       PLATE 28
C RMC        REAL  SUB-ELEMENT DENSITY                          PLATE 29
C S          REAL  PRESSURE                                     PLATE 30
C SUBMD      REAL  SUB-ELEMENT MODAL DENSITY                    PLATE 31
C T          REAL  SUB-ELEMENT THICKNESS                        PLATE 32
C THICK(20)  REAL  ELEMENT THICKNESS                            PLATE 33
C V          REAL  SUB-ELEMENT VOLUME                           PLATE 34
C VOL(20)    REAL  ELEMENT VOLUME                               PLATE 35
C                                                               PLATE 36
C                                                               PLATE 37
C THE FOLLOWING COMMON BLOCKS ARE USED:                         MAY13 32
C BLOCK      OTHER PROGRAM UNITS USING THIS COMMON BLOCK        PLATE 39
C -----      -----------------------------------------          PLATE 40
C  CP1   MAIN,EPROP,BEAM,MEMBR,ROOM,CYLIN,RITER,BLOCK DATA      PLATE 41
C  CP4   EPROP,BEAM,MEMBR,ROOM,CYLIN                            PLATE 42
C  CB5   EPROP,BEAM,MEMBR,ROOM,CYLIN,JPROP,EXCITE,ANSWER        PLATE 43
C  CB6   EPROP,EXCITE                                           OCT28 11
C  CP9   EPROP,BEAM,MEMBR,ROOM,CYLIN,JPROP,EXCITE,BLOCK DATA    PLATE 44
C  CP11  BEAM,MEMBR,ROOM,CYLIN,ANSWER,BLOCK DATA                PLATE 45
C                                                               PLATE 46
C                                                               PLATE 47
      INTEGER ELNUM                                             PLATE 48
      CHARACTER ETYPE,MTYPE*3                                   OCT28 12
      REAL N,L,M,MASS,MSUB                                      OCT16 13
      LOGICAL STIFF,MAIN                                        PLATE 50
      COMMON /CP1/ FTAB(40),NUMAF,FREQ1                         PLATE 51
      COMMON /CP4/ ELNUM,T,E,GAMMA,RMC,M,STIFF,L,A,V,C,R,S,MAIN PLATE 52
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      COMMON /CB5/ THICK(20),AREA(20),DENSE(20),VOL(20),EE(20),           PLATE 53
     *   EGAMMA(20),EC(20)                                                PLATE 54
      COMMON /CB6/ SPL(20,40),MECH(20,40),ANM(20),ETYPE(20),MTYPE(20)     UNVAC2 2
      COMMON /CB9/ N(20,40)                                               MAY13 33
      COMMON /CB11/ MASS(20)                                              PLATE 56
      DATA PI /3.141592/                                                  PLATE 57
C CALCULATE THE SUB-ELEMENT MODAL DENSITY                                 PLATE 58
      SUBMD = A / (4. * PI) * SQRT(12. * RHO * (1. - GAMMA ** 2)          PLATE 59
     *   / (E * T ** 2))                                                  PLATE 60
C IF STIFFNESS REDUCTION IS REQUIRED, MULTIPLY BY SQRT(.5)                PLATE 61
      IF (STIFF) SUBMD = SQRT(.5) * SUBMD                                 JULY16G1
C DO FOR EACH ANALYSIS FREQUENCY                                          PLATE 63
      DO 20 I = 1,NUMAF                                                   PLATE 64
C SUM THE SUB-ELEMENT MODAL DENSITY TO THE ELEMENT MODAL DENSITY          PLATE 65
         N(ELNUM,I) = N(ELNUM,I) + SUBMD                                  MAY13 34
   20 CONTINUE                                                            PLATE 67
C SUM THE SUB-ELEMENT MASS TO THE ELEMENT MASS                            PLATE 68
      MSUB = RHO * A * T + M                                              OCT16 14
      MASS(ELNUM) = MASS(ELNUM) + MSUB                                    OCT16 15
      IF (ETYPE(ELNUM) .EQ. TAT .AND. MAIN) ANM(ELNUM) =                  NOV2   1
     *   ((A * SUBMD) / MSUB) * 2. * PI                                   NOV2   2
C IF THIS IS NOT THE MAIN SUB-ELEMENT, RETURN TO EPROP                    PLATE 70
      IF (.NOT. MAIN) RETURN                                              PLATE 71
C ELSE PUT THE VALUES OF THE FOLLOWING SUB-ELEMENT VARIABLES INTO         PLATE 72
C THE CORRESPONDING ELEMENT ARRAYS                                        PLATE 73
      EE(ELNUM) = E                                                       PLATE 74
      THICK(ELNUM) = T                                                    PLATE 75
      DENSE(ELNUM) = RHO                                                  PLATE 76
      AREA(ELNUM) = A                                                     PLATE 77
      VOL(ELNUM) = V                                                      PLATE 78
      EGAMMA(ELNUM) = GAMMA                                               PLATE 79
      EC(ELNUM) = C                                                       PLATE 80
C SET MAIN TO INDICATE THAT ANY FOLLOWING SUB-ELEEMENTS ARE NOT           PLATE 81
C THE MAIN SUB-ELEMENT                                                    PLATE 82
      MAIN = .FALSE.                                                      PLATE 83
      RETURN                                                              PLATE 84
      END                                                                 PLATE 85
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```
      SUBROUTINE ROOM                                                   ROOM   2
C THIS SUBROUTINE CALCULATES THE MODAL DENSITY FOR A SUB-ELEMENT        ROOM   3
C WHICH IS A ROOM AND SUMS THIS VALUE TO THE ELEMENT MODAL              ROOM   4
C DENSITY. ROOM IS CALLED FROM EPROP.                                   ROOM   5
C                                                                       ROOM   6
C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:                ROOM   7
C    NAME      TYPE            DESCRIPTION                              MAY13 35
C    ----      ----            -----------                              MAY13 36
C A            REAL  SUB-ELEMENT AREA                                   ROOM  10
C AREA(20)     REAL  ELEMENT AREA                                       ROOM  11
C C            REAL  SPEED OF SOUND IN SUB-ELEMENT ROOM MEDIUM          ROOM  12
C DENSE(20)    REAL  ELEMENT DENSITY                                    ROOM  13
C E            REAL  SUB-ELEMENT MODULUS OF ELASTICITY                  ROOM  14
C EC(20)       REAL  SPEED OF SOUND IN ELEMENT ROOM MEDIUM              ROOM  15
C EE(20)       REAL  ELEMENT MODULUS OF ELASTICITY                      ROOM  16
C EGAMMA(20)REAL     POISSON'S RATIO FOR ELEMENT                        ROOM  17
C ELNUM        INT   ELEMENT NUMBER                                     ROOM  18
C FTAB(40)     REAL  TABLE OF ANALYSIS FREQUENCIES                      ROOM  19
C GAMMA        REAL  POISSON'S RATIO FOR SUB-ELEMENT                    ROOM  20
C L            REAL  LENGTH                                             ROOM  21
C M            REAL  SUB-ELEMENT ADDED MASS (NON-STRUCTURAL)            OCT16 16
C MASS(20)     REAL  ELEMENT MASS                                       ROOM  23
C MSUB         REAL  SUB-ELEMENT TOTAL MASS                             OCT16 17
C N(20,40)     REAL  ELEMENT MODAL DENSITY                              ROOM  24
C NUMAF        INT   NUMBER OF ANALYSIS FREQUENCIES                     ROOM  25
C OMEGA        REAL  2*PI*FREQUENCY                                     ROOM  26
C PSUBMD       REAL  PARTIAL SUB-ELEMENT MODAL DENSITY                  ROOM  27
C R            REAL  RADIUS                                             ROOM  28
C RHO          REAL  SUB-ELEMENT DENSITY                                MAY13 37
C S            REAL  PRESSURE                                           ROOM  30
C SUBMD        REAL  SUB-ELEMENT MODAL DENSITY                          ROOM  31
C T            REAL  SUB-ELEMENT THICKNESS                              ROOM  32
C THICK(20)    REAL  ELEMENT THICKNESS                                  ROOM  33
C V            REAL  SUB-ELEMENT VOLUME                                 ROOM  34
C VOL(20)      REAL  ELEMENT VOLUME                                     ROOM  35
C                                                                       ROOM  36
C                                                                       ROOM  37
C THE FOLLOWING COMMON BLOCKS ARE USED:                                 ROOM  38
C BLOCK      OTHER PROGRAM UNITS USING THIS COMMON BLOCK                ROOM  39
C -----      -----------------------------------------                  ROOM  40
C  CB1   MAIN,EPROP,BEAM,MEMBR,PLATE,CYLIN,RITER,BLOCK DATA             ROOM  41
C  CB4   EPROP,BEAM,MEMBR,PLATE,CYLIN                                   ROOM  42
C  CB5   EPROP,BEAM,MEMBR,PLATE,CYLIN,JPROP,EXCITE,ANSWER               ROOM  43
C  CB9   EPROP,BEAM,MEMBR,PLATE,CYLIN,JPROP,EXCITE,BLOCK DATA           ROOM  44
C  CB11  BEAM,MEMBR,PLATE,CYLIN,ANSWER,BLOCK DATA                       ROOM  45
C                                                                       ROOM  46
C                                                                       ROOM  47
      INTEGER ELNUM                                                     MAY13 38
      REAL N,L,M,MASS,MSUB                                              OCT16 18
      LOGICAL STIFF,MAIN                                                ROOM  50
      COMMON /CB1/ FTAB(40),NUMAF,FREQ1                                 ROOM  51
      COMMON /CB4/ ELNUM,T,E,GAMMA,RHO,M,STIFF,L,A,V,C,R,S,MAIN         ROOM  52
      COMMON /CB5/ THICK(20),AREA(20),DENSE(20),VOL(20),EE(20),         ROOM  53
     *   EGAMMA(20),EC(20)                                              ROOM  54
      COMMON /CB9/ N(20,40)                                             ROOM  55
      COMMON /CB11/ MASS(20)                                            ROOM  56
```

```
      DATA PI /3.141592/                                              ROOM   57
C CALCULATE THE PART OF THE SUB-ELEMENT MODAL DENSITY THAT IS         ROOM   58
C NOT FREQUENCY DEPENDENT                                             ROOM   59
      FSUBMD = V / (2. * PI ** 2 * C ** 3)                            ROOM   60
C DO FOR EACH ANALYSIS FREQUENCY                                      ROOM   63
      DO 20 I = 1,NUMAF                                               ROOM   64
         OMEGA = 2. * PI * FTAB(I)                                    ROOM   65
C CALCULATE THE SUB-ELEMENT MODAL DENSITY                             ROOM   66
         SUBMD = OMEGA ** 2 * PSUBMD                                  MAY13  40
C SUM THE SUB-ELEMENT MODAL DENSITY TO THE ELEMENT MODAL DENSITY      ROOM   68
         N(ELNUM,I) = N(ELNUM,I) + SUBMD                              ROOM   69
   20 CONTINUE                                                        ROOM   70
C SUM THE SUB-ELEMENT MASS TO THE ELEMENT MASS                        ROOM   71
      MSUB = RHO * V                                                  OCT16  19
      MASS(ELNUM) = MASS(ELNUM) + MSUB                                OCT16  20
C IF THIS IS NOT THE MAIN SUB-ELEMENT, RETURN TO FPROP                ROOM   73
      IF (.NOT. MAIN) RETURN                                          ROOM   74
C ELSE PUT THE VALUES OF THE FOLLOWING SUB-ELEMENT VARIABLES INTO     ROOM   75
C THE CORRESPONDING ELEMENT ARRAYS                                    ROOM   76
      EE(ELNUM) = E                                                   ROOM   77
      THICK(ELNUM) = T                                                ROOM   78
      DENSE(ELNUM) = RHO                                              ROOM   79
      AREA(ELNUM) = A                                                 ROOM   80
      VOL(ELNUM) = V                                                  ROOM   81
      FGAMMA(ELNUM) = GAMMA                                           ROOM   82
      EC(ELNUM) = C                                                   ROOM   83
C SET MAIN TO INDICATE THAT ANY FOLLOWING SUB-ELEMENTS ARE NOT        MAY13  41
C THE MAIN SUB-ELEMENT                                                ROOM   85
      MAIN = .FALSE.                                                  ROOM   86
      RETURN                                                          ROOM   87
      END                                                             ROOM   88
```

```
      SUBROUTINE CYLIN                                                  CYLIN  2
C THIS SUBROUTINE CALCULATES THE MODAL DENSITY FOR A SUB-ELEMENT         NOV4   4
C WHICH IS A CYLINDER AND SUMS THIS VALUE TO THE ELEMENT MODAL          CYLIN  4
C DENSITY. CYLIN IS CALLED FROM EPROP.                                  CYLIN  5
C                                                                       CYLIN  6
C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:                CYLIN  7
C    NAME     TYPE           DESCRIPTION                                CYLIN  8
C    ----     ----           -----------                                MAY13 42
C A           REAL  SUB-ELEMENT AREA                                    MAY13 43
C AREA(20)    REAL  ELEMENT AREA                                        CYLIN 11
C C           REAL  SPEED OF SOUND IN SUB-ELEMENT ROOM MEDIUM           CYLIN 12
C DENSE(20)   REAL  ELEMENT DENSITY                                     CYLIN 13
C E           REAL  SUB-ELEMENT MODULUS OF ELASTICITY                   CYLIN 14
C EC(20)      REAL  SPEED OF SOUND IN ELEMENT ROOM MEDIUM               CYLIN 15
C EE(20)      REAL  ELEMENT MODULUS OF ELASTICITY                       CYLIN 16
C EGAMMA(20)REAL    POISSONS RATIO FOR ELEMENT                          MAY13 44
C ELNUM       INT   ELEMENT NUMBER                                      CYLIN 18
C FTAB(40)    REAL  TABLE OF ANALYSIS FREQUENCIES                       CYLIN 19
C GAMMA       REAL  POISSONS RATIO FOR SUB-ELEMENT                      CYLIN 20
C L           REAL  LENGTH                                              CYLIN 21
C M           REAL  SUB-ELEMENT ADDED MASS (NON-STRUCTURAL)             OCT16 21
C MASS(20)    REAL  ELEMENT MASS                                        CYLIN 23
C MSUB        REAL  SUB-ELEMENT TOTAL MASS                              OCT16 22
C N(20,40)    REAL  ELEMENT MODAL DENSITY                               CYLIN 24
C NUMAF       INT   NUMBER OF ANALYSIS FREQUENCIES                      CYLIN 25
C OMEGA       REAL  2*PI*FREQUENCY                                      CYLIN 26
C PSUBMD      REAL  PARTIAL SUB-ELEMENT MODAL DENSITY                   CYLIN 27
C R           REAL  RADIUS                                              CYLIN 28
C RHO         REAL  SUB-ELEMENT DENSITY                                 CYLIN 29
C S           REAL  PRESSURE                                            CYLIN 30
C SUBMD       REAL  SUB-ELEMENT MODAL DENSITY                           CYLIN 31
C T           REAL  SUB-ELEMENT THICKNESS                               CYLIN 32
C THICK(20)   REAL  ELEMENT THICKNESS                                   CYLIN 33
C V           REAL  SUB-ELEMENT VOLUME                                  CYLIN 34
C VOL(20)     REAL  ELEMENT VOLUME                                      CYLIN 35
C                                                                       CYLIN 36
C                                                                       CYLIN 37
C THE FOLLOWING COMMON BLOCKS ARE USED:                                 CYLIN 38
C BLOCK      OTHER PROGRAM UNITS USING THIS COMMON BLOCK                CYLIN 39
C -----      -------------------------------------------                CYLIN 40
C  CB1   MAIN,EPROP,BEAM,MEMBR,PLATE,ROOM,RITER,BLOCK DATA              MAY13 45
C  CB4   EPROP,BEAM,MEMBR,PLATE,ROOM                                    CYLIN 42
C  CB5   EPROP,BEAM,MEMBR,PLATE,ROOM,JPROP,EXCITE,ANSWER                CYLIN 43
C  CB9   EPROP,BEAM,MEMBR,PLATE,ROOM,JPROP,EXCITE,BLOCK DATA            CYLIN 44
C  CB11  BEAM,MEMBR,PLATE,ROOM,ANSWER,BLOCK DATA                        MAY13 46
C                                                                       CYLIN 46
C                                                                       CYLIN 47
      INTEGER ELNUM                                                     CYLIN 48
      REAL N,L,M,MASS,MSUB                                              OCT16 23
      LOGICAL STIFF,MAIN                                                CYLIN 50
      COMMON /CB1/ FTAB(40),NUMAF,FREQ1                                 CYLIN 51
      COMMON /CB4/ ELNUM,T,E,GAMMA,RHO,M,STIFF,L,A,V,C,R,S,MAIN         CYLIN 52
      COMMON /CB5/ THICK(20),AREA(20),DENSE(20),VOL(20),EE(20),         CYLIN 53
     *   EGAMMA(20),EC(20)                                              CYLIN 54
      COMMON /CB9/ N(20,40)                                             MAY13 47
      COMMON /CB11/ MASS(20)                                            CYLIN 56
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```
      DATA PI /3.141592/                                              CYLIN 57
C CALCULATE THE PART OF THE SUB-ELEMENT MODAL DENSITY THAT IS         CYLIN 58
C NOT FREQUENCY DEPENDENT                                             CYLIN 59
      FSUBMD = R * L / 2. * SQRT(12. * RHO *                          OCT16 24
     *    (1. - GAMMA ** 2) / (E * T ** 2))                           CYLIN 61
C IF STIFFNESS REDUCTION IS REQUIRED, MULTIPLY BY SQRT(.5)            CYLIN 62
      IF (STIFF) FSUBMD = SQRT(.5) * FSUBMD                           MAY13 48
C DO FOR EACH ANALYSIS FREQUENCY                                      CYLIN 64
      DO 20 I = 1,NUMAF                                               CYLIN 65
         SUBMD = FSUBMD                                               CYLIN 66
         OMEGA = 2. * PI * FTAB(I)                                    CYLIN 67
C CALCULATE THE CRITERION FOR THE FREQUENCY DEPENDENT PART            CYLIN 68
C OF THE SUB-ELEMENT MODAL DENSITY                                    CYLIN 69
         CRIT = OMEGA * R * SQRT(RHO / E)                             CYLIN 70
C IF THE CRITERION IS GREATER THAN 1, ALTER THE MODAL DENSITY         CYLIN 71
C APPROPRIATELY                                                       CYLIN 72
         IF (CRIT .LE. 1.) SUBMD = SUBMD * CRIT ** (2./3.)            AUG13K 2
C SUM THE SUB-ELEMENT MODAL DENSITY TO THE ELEMENT MODAL DENSITY      CYLIN 74
         N(ELNUM,I) = N(ELNUM,I) + SUBMD                              CYLIN 75
   20 CONTINUE                                                        CYLIN 76
C SUM THE SUB-ELEMENT MASS TO THE ELEMENT MASS                        CYLIN 77
      A = 2. * PI * R * L                                             OCT16 25
      MSUB = A * T * RHO * M                                          OCT16 26
      MASS(ELNUM) = MASS(ELNUM) + MSUB                                OCT16 27
C IF THIS IS NOT THE MAIN SUB-ELEMENT, RETURN TO EPROP                CYLIN 79
      IF (.NOT. MAIN) RETURN                                          CYLIN 80
C ELSE PUT THE VALUES OF THE FOLLOWING SUB-ELEMENT VARIABLES INTO     CYLIN 81
C THE CORRESPONDING ELEMENT ARRAYS                                    CYLIN 82
      EE(ELNUM) = E                                                   CYLIN 83
      THICK(ELNUM) = T                                                CYLIN 84
      DENSE(ELNUM) = RHO                                              CYLIN 85
      AREA(ELNUM) = A                                                 CYLIN 86
      VOL(ELNUM) = V                                                  CYLIN 87
      EGAMMA(ELNUM) = GAMMA                                           CYLIN 88
      EC(ELNUM) = C                                                   CYLIN 89
C SET MAIN TO INDICATE THAT ANY FOLLOWING SUB-ELEMENTS ARE NOT        CYLIN 90
C THE MAIN SUB-ELEMENT                                                CYLIN 91
      MAIN = .FALSE.                                                  CYLIN 92
      RETURN                                                          CYLIN 93
      END                                                             CYLIN 94
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      SUBROUTINE JINPUT                                              MAY13 49
C THIS SUBROUTINE READS JOINT PROPERTIES FROM UNIT 3 AND CHECKS      JINPUT 3
C THAT ELEMENT PAIRS ARE NOT INPUT MORE THAN ONCE. JINPUT IS         JINPUT 4
C CALLED FROM THE MAIN PROGRAM.                                      JINPUT 5
C                                                                    JINPUT 6
C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:             JINPUT 7
C    NAME    TYPE            DESCRIPTION                             JINPUT 8
C    ----    ----            -----------                             JINPUT 9
C ASD(150)   REAL  ACOUSTIC SPACE DENSITY                            JINPUT10
C BL(150)    REAL  BEAM LENGTH                                       AUG12J 4
C INPUT      INT   NUMBER OF INPUT RECORDS READ                      JINPUT12
C JL(190)    REAL  JOINT LENGTH                                      JINPUT13
C JTYPE(190)CHAR  TYPE OF JOINT                                      JINPUT14
C NE1(150)   INT   FIRST ELEMENT                                     JINPUT15
C NE2(190)   INT   SECOND ELEMENT                                    JINPUT16
C NS(190)    INT   NUMBER OF SIDES                                   JINPUT17
C NUMEL      INT   NUMBER OF ELEMENTS                                JINPUT18
C SP(190)    REAL  BOLT SPACING                                      JINPUT19
C T1(190)    REAL  THICKNESS OF FIRST ELEMENT OF PAIR                JINPUT20
C T2(190)    REAL  THICKNESS OF SECOND ELEMENT OF PAIR               JINPUT21
C TOTAL      INT   NUMBER OF ELEMENT PAIRS INPUT                     JINPUT22
C                                                                    JINPUT23
C                                                                    JINPUT24
C THE FOLLOWING COMMON BLOCKS ARE USED:                              JINPUT25
C BLOCK      OTHER PROGRAM UNITS USING THIS COMMON BLOCK             JINPUT26
C -----      ---------------------------------------                 JINPUT27
C  CB2   MAIN,EPROP,BLOCK DATA                                       JINPUT28
C  CB7   EPROP,JPROP,EXCITE,ANSWER,SOLVE,RITER,BLOCK DATA            JINPUT29
C  CB10  EPROP,BLOCK DATA                                            JINPUT30
C  CB12  JPROP                                                       JINPUT31
C                                                                    JINPUT32
C                                                                    JINPUT33
      CHARACTER*2 JTYPE                                              JINPUT34
      INTEGER TOTAL                                                  JINPUT35
      REAL JL                                                        JINPUT36
      LOGICAL ERROR                                                  JINPUT37
      COMMON /CB2/ ERROR                                             JINPUT38
      COMMON /CB7/ NUMEL,G                                           JINPUT39
      COMMON /CB10/ INPUT                                            JINPUT40
      COMMON /CB12C/ JTYPE(190)                                      MAY13 50
      COMMON /CB12/ NE1(190),NE2(190),JL(190),BL(190),               AUG12J 5
     *   T1(190),T2(190),ASD(190),NS(190),SP(190),JPUT(190),TOTAL    JINPUT42
  100 FORMAT (2I2,A2,I2,6F10.2)                                      JINPUT43
  110 FORMAT ('0*** WARNING ***     ON INPUT RECORD ',I4,', ONE OR',  JINPUT44
     1   ' BOTH MEMBERS OF THE'/' ELEMENT PAIR ',I2,' AND ',I2,      MAY13 52
     2   ' WAS EITHER LESS THAN 1 OR GREATER THAN ',I2,', THE '/     MAY13 53
     *   ' TOTAL NUMBER OF ELEMENTS. THIS PAIR WILL BE IGNORED. '/   JINPUT47
     $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT.')         JINPUT48
  120 FORMAT ('0*** WARNING ***     THE ELEMENT PAIR ',I2,' AND ',   JINPUT49
     1   I2,' ON INPUT RECORD ',I4,' WAS'/' PREVIOUSLY READ ON ',    MAY13 54
     2   'INPUT RECORD ',I4,'. THE FIRST VALUES WILL BE USED.'/      JINPUT51
     $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT.')         JINPUT52
  130 FORMAT ('0*** ERROR ***     WHILE ATTEMPTING TO READ JOINT ',  JINPUT53
     1   'PROPERTIES,'/' A FORTRAN ERROR OCCURRED ON INPUT RECORD ', MAY13 55
     2   I4,'.'/                                                     JINPUT55
     $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT.')         JINPUT56
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  140 FORMAT (?0*** ERROR ***    THE END OF FILE WAS REACHED BEFORE ?,  JINPUT57
     1   ?ANY INFORMATION?/? ABOUT JOINT PROPERTIES WAS READ.?/         JINPUT58
     $   ? THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT.?)             JINPUT59
  150 FORMAT (?0BECAUSE OF THE ERRORS LISTED ABOVE, THE SEA PROGRAM?,   JINPUT60
     *   ? WILL ABORT.?)                                                 JINPUT61
  160 FORMAT (?0*** WARNING ***    ON INPUT RECORD ?,I4,                 JINPUT62
     1   ?BOTH ELEMENT NUMBERS WERE?/? GIVEN AS ?,I2,                    JINPUT63
     2   ?. THEY MUST BE DIFFERENT. THIS RECORD WILL BE IGNORED.?/       JINPUT64
     $   ? THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT.?)             JINPUT65
  170 FORMAT (I8, 4X, ?FIRST ELEMENT = ?, I2 / 10X, ?SECOND ?,          AUG26 51
     1   ?ELEMENT = ?, I2 / 10X, ?TYPE OF JOINT = ?, A2 / 10X,          AUG26 52
     2   ?NUMBER OF SIDES = ?, I2 / 10X, ?JOINT LENGTH = ?,             AUG26 53
     3   1PE12.5E2 / 10X, ?THICKNESS OF FIRST ELEMENT = ?,              AUG26 54
     4   1PE12.5E2 / 10X, ?THICKNESS OF SECOND ELEMENT = ?,             AUG26 55
     5   1PE12.5E2 / 10X, ?ACOUSTIC SPACE DENSITY = ?, 1PE12.5E2 /      AUG26 56
     6   10X, ?BEAM LENGTH = ?, 1PE12.5E2 / 10X, ?INSERTION LOSS ?,     NOV4    5
     7   ?FACTOR = ?, 1PE12.5E2)                                        NOV4    6
  180 FORMAT (//// ? RECORD? / ? NUMBER?, 18X, ?DATA READ ?,            AUG26 59
     2   ?FROM UNIT 3? / 1X, 6(1H-), 18X, 21(1H-) / )                   AUG26 60
C WRITE A HEADING TO CONTINUE PRINTING INPUT DATA                       AUG26 61
      WRITE (6,180)                                                     AUG26 62
C INITIALIZE TOTAL                                                      JINPUT66
      TOTAL = 0                                                         JINPUT67
C INITIALIZE I                                                          JINPUT68
      I = 0                                                             JINPUT69
C INCREMENT I                                                           JINPUT70
    5 I = I + 1                                                         JINPUT71
C INCREMENT INPUT                                                       JINPUT72
   10 INPUT = INPUT + 1                                                 JINPUT73
C READ THE JOINT PROPERTIES                                             JINPUT74
      READ (3,108,ERR=60,END=70)NE1(I),NE2(I),JTYPE(I),NS(I),JL(I),     JINPUT75
     *   T1(I),T2(I),ASD(I),BL(I),SP(I)                                 AUG12J 6
C WRITE THE JOINT PROPER      TO OUTPUT                                 AUG26 63
      WRITE (6,170) INP      1(I), NE2(I), JTYPE(I), NS(I), JL(I),      AUG26 64
     *   T1(I), T2(I), ASD(I), BL(I), SP(I)                             AUG26 65
C PUT THE INPUT RECORD NUMBER IN JPUT                                   JINPUT77
      JPUT(I) = INPUT                                                   JINPUT78
C IF EITHER ELEMENT NUMBER IS OUT OF RANGE,                             JINPUT79
      IF (NE1(I) .GE. 1 .AND. NE1(I) .LE. NUMEL .AND. NE2(I) .GE. 1     JINPUT80
     *   .AND. NE2(I) .LE. NUMEL) GO TO 15                              JINPUT81
C THEN WRITE A WARNING MESSAGE                                          JINPUT82
      WRITE (6,110) INPUT,NE1(I),NE2(I),NUMEL                           JINPUT83
      GO TO 10                                                          JINPUT84
C END IF                                                                JINPUT85
C IF BOTH ELEMENTS IN THE PAIR ARE THE SAME,                            JINPUT86
   15 IF (NE1(I) .NE. NE2(I)) GO TO 20                                  MAY13 56
C THEN WRITE A WARNING MESSAGE                                          JINPUT88
      WRITE (6,160) INPUT,NE1(I)                                        JINPUT89
      GO TO 10                                                          JINPUT90
C END IF                                                                JINPUT91
C IF THIS IS THE FIRST ELEMENT PAIR, SKIP THE FOLLOWING TEST            JINPUT92
   20 IF (I .LE. 1) GO TO 50                                            JINPUT93
C DO FOR EACH PAIR OF ELEMENTS PREVIOUSLY INPUT                         JINPUT94
      DO 30 J = 1, TOTAL                                                JINPUT95
C IF THE CURRENT PAIR OF ELEMENTS MATCHES A PREVIOUS PAIR,              JINPUT96
         IF ((NE1(I) .NE. NE1(J) .OR. NE2(I) .NE. NE2(J)) .AND.         JINPUT97
```

```
     *       (NE1(I) .NE. NE2(J) .OR. NE2(I) .NE. NE1(J))) GO TO 30      JINPUT98
C THEN WRITE A WARNING MESSAGE                                           JUNE2511
            WRITE (6,120) NE1(I),NE2(I),INPUT,JPUT(J)                    JINPU100
            GO TO 10                                                     JINPU101
C END IF                                                                 JINPU102
   30 CONTINUE                                                           JINPU103
C INCREMENT TOTAL                                                        JINPU104
   50 TOTAL = I                                                          JINPU105
      GO TO 5                                                            JINPU106
C IF AN ERROR OCCURRED ON READING, WRITE AN ERROR MESSAGE                JINPU107
   60 WRITE (6,130) INPUT                                                JINPU108
      ERROR = .TRUE.                                                     JINPU109
      GO TO 10                                                           JINPU110
C IF THE END OF FILE WAS ENCOUNTERED, BUT NO RECORDS                     AU626 66
C WERE READ, WRITE A MESSAGE AND SET THE ERROR FLAG                      JINPU112
   70 IF (TOTAL .GE. 1) GO TO 80                                         JINPU113
      ERROR = .TRUE.                                                     JINPU114
      WRITE (6,140)                                                      JINPU115
C IF THERE WERE NO ERRORS, RETURN                                        JINPU116
   80 IF (.NOT. ERROR) RETURN                                            JINPU117
C ELSE WRITE A MESSAGE AND TERMINATE THE PROGRAM                         JINPU118
      WRITE (6,150)                                                      JINPU119
      CALL FERR                                                          JINPU120
      END                                                                JINPU121
```

```
      SUBROUTINE JPROP                                                JPROP   2
C THIS SUBROUTINE CALCULATES THE ELEMENT-TO-ELEMENT STRUCTURAL        JPROP   3
C COUPLING COEFFICIENT (PHI). JPROP IS CALLED FROM THE MAIN           JPROP   4
C PROGRAM.                                                            JPROP   5
C                                                                     JPROP   6
C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:              JPROP   7
C     NAME    TYPE            DESCRIPTION                             MAY13  57
C     ----    ----            -----------                             JPROP   9
C A           REAL  PSEUDO AREA                                       JPROP  10
C AF          INT   ANALYSIS FREQUENCY ORDINAL                        JPROP  11
C AREA(20)    REAL  SURFACE AREA                                      JPROP  12
C ASD(190)    REAL  ACOUSTIC SPACE DENSITY                            JPROP  13
C BL(190)     REAL  BEAM LENGTH                                       AUG12J  7
C CRFREQ      REAL  CRITICAL FREQUENCY                                JPROP  15
C DENSE(20)   REAL  DENSITY                                           JPROP  16
C EC(20)      REAL  SPEED OF SOUND IN ROOM MEDIUM                     JPROP  17
C EE(20)      REAL  MODULUS OF ELASTICITY                             JPROP  18
C EGAMMA(20)REAL  POISSON'S RATIO                                     JPROP  19
C E1          INT   FIRST ELEMENT                                     JPROP  20
C E2          INT   SECOND ELEMENT                                    JPROP  21
C FREQ        REAL  FREQUENCY                                         JPROP  22
C JL(190)     REAL  JOINT LENGTH                                      JPROP  23
C JTYPE(190)CHAR  TYPE OF JOINT                                       JPROP  24
C MODES       REAL  NUMBER OF MODES IN BANDWIDTH                      JPROP  25
C N(20,40)    REAL  MODAL DENSITY                                     JPROP  26
C NE1(190)    INT   FIRST ELEMENT                                     JPROP  27
C NE2(190)    INT   SECOND ELEMENT                                    JPROP  28
C NS(190)     INT   NUMBER OF SIDES                                   JPROP  29
C OMEGA       REAL  2*PI*FREQUENCY                                    JPROP  30
C PHI(20,20)REAL  COUPLING COEFFICIENT                                JPROP  31
C SIGMA(20)   REAL  RADIATION EFFICIENCY                              JPROP  32
C SP(190)     REAL  BOLT SPACING REDUCTION                            JPROP  33
C TAU         REAL  THICKNESS RATIO                                   JPROP  34
C THICK(20)   REAL  THICKNESS                                         JPROP  35
C TOTAL       INT   NUMBER OF ELEMENT PAIRS (I.E., JOINTS)            JPROP  36
C V(20)       REAL  VOLUME                                            JPROP  37
C                                                                     JPROP  38
C                                                                     JPROP  39
C THE FOLLOWING COMMON BLOCKS ARE USED:                               JPROP  40
C BLOCK       OTHER PROGRAM UNITS USING THIS COMMON BLOCK             JPROP  41
C -----       ---------------------------------------                 JPROP  42
C CB3    MAIN,EXCITE,ANSWER                                           JPROP  43
C  CB5   EPROP,BEAM,MEMBR,PLATE,ROOM,CYLIN,EXCITE,ANSWER              JPROP  44
C  CB7   EPROP,JINPUT,EXCITE,ANSWER,SOLVE,RITER,BLOCK DATA            JPROP  45
C  CB9   EPROP,BEAM,MEMBR,PLATE,ROOM,CYLIN,EXCITE,BLOCK DATA          JPROP  46
C  CB12  JINPUT                                                       JPROP  47
C  CB14  EXCITE,ANSWER                                                JPROP  48
C                                                                     JPROP  49
C                                                                     JPROP  50
      CHARACTER*2 JTYPE                                               JPROP  51
      INTEGER AF,E1,E2,TOTAL                                          JPROP  52
      REAL JL,A,MODES                                                 JPROP  53
      LOGICAL ERROR                                                   JPROP  54
      COMMON /CB3/ FREQ,AF,OMEGA                                      JPROP  55
      COMMON /CB5/ THICK(20),AREA(20),DENSE(20),VOL(20),EE(20),       JPROP  56
     * EGAMMA(20),EC(20)                                              JPROP  57
```

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      COMMON /CB7/ NUMEL,G                                              JPROP 58
      COMMON /CB9/ N(20,40)                                             JPROP 59
      COMMON /CB12C/ JTYPE(190)                                         MAY13 58
      COMMON /CB12/ NE1(190),NE2(190),JL(190),BL(190),                  AUG12J 8
     * T1(190),T2(190),ASD(190),NS(190),SP(190),JPUT(190),TOTAL         JPROP 61
      COMMON /CB14/ PHI(20,20),MODES(20)                                JPROP 62
      DATA PI, ERROR /3.141592, .FALSE./                                MAY13 60
  200 FORMAT (10*** ERROR ***    THE TYPE OF JOINT GIVEN FOR ',         JPROP 64
     1   'ELEMENT PAIR ',I2,' AND ',I2/' ON INPUT RECORD ',I4,' IS',    JPROP 65
     2   A2,'. THIS IS NOT A VALID TYPE. THE TYPE MUST'/                JPROP 66
     3   ' BE PP, BP, BJ, OR PA.'/                                      JPROP 67
     4   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE JPROP.')             JPROP 68
  220 FORMAT ('0BECAUSE OF THE ERRORS LISTED ABOVE, THE SEA PROGRAM',   JPROP 69
     *   ' WILL ABORT.')                                                JPROP 70
C INITIALIZE THE COUPLING COEFFICIENTS TO 0 AND CALCULATE MODES         JPROP 74
      DO 20 J = 1, 20                                                   JPROP 75
         MODES(J) = N(J,AF) * OMEGA / 4.33                              JPROP 76
         DO 10 I = 1, 20                                                JPROP 77
            PHI(I,J) = 0.                                               JPROP 78
   10    CONTINUE                                                       JPROP 79
   20 CONTINUE                                                          JPROP 80
C DO FOR EACH PAIR OF ELEMENTS FOR WHICH JOINT PROPERTIES               JPROP 81
C WERE INPUT                                                            JPROP 82
      DO 100 I = 1, TOTAL                                               JPROP 83
C PUT THE ELEMENT NUMBERS IN SIMPLE VARIABLES TO AVOID                  JPROP 84
C DOUBLE SUBSCRIPTS                                                     JPROP 85
         E1 = NE1(I)                                                    JPROP 86
         E2 = NE2(I)                                                    MAY13 61
C IF THE TYPE OF JOINT IS PLATE TO PLATE,                               JPROP 88
         IF (JTYPE(I) .NE. 'PP') GO TO 30                               JPROP 89
C THEN SET TAU TO 8/27                                                  JPROP 90
            TAU = 8. / 27.                                              JPROP 91
C UNLESS THE RATIO OF THICKNESS IS LESS THAN .5, IN WHICH CASE          JPROP 92
C SET TAU TO THE RATIO                                                  JPROP 93
            IF (T1(I) / T2(I) .LT. .5)                                  JPROP 94
     *         TAU = T1(I) / T2(I)                                      JPROP 95
C CALCULATE THE PSEUDO AREA                                             JPROP 96
            A = 2. * PI * N(E1,AF) * 2. * T1(I) * SQRT(EE(E1) /         JUNE2512
     *         (12. * DENSE(E1) * (1. - EGAMMA(E1) ** 2)))              JPROP 98
C CALCULATE THE COUPLING COEFFICIENT FOR PLATE TO PLATE COUPLING        JPROP 99
            PHI(E1,E2) = 1.07 * JL(I) / (PI * A * MODES(E2)) *          JPROP100
     E         SQRT(OMEGA * THICK(E1) * SQRT(EE(E1) / (DENSE(E1) *      JPROP101
     *         (1. - EGAMMA(E1) ** 2)))) * TAU                          JPROP102
            GO TO 90                                                    JPROP103
C ELSE IF TYPE OF JOINT IS BEAM TO PLATE,                               JPROP104
   30    IF (JTYPE(I) .NE. 'BP') GO TO 40                               JPROP105
C CALCULATE THE COUPLING COEFFICIENT FOR THAT TYPE                      JPROP106
            PHI(E1,E2) = 2. * PI * FREQ * JL(I) / (MODES(E2) *          AUG12J 9
     *         4. * BL(I))                                              AUG12J10
            GO TO 90                                                    JPROP109
C ELSE IF THE TYPE OF JOINT IS BOLTED OR RIVETED JOINT,                 JPROP110
   40    IF (JTYPE(I) .NE. 'BJ') GO TO 50                               JPROP111
C THEN SET TAU TO 8/27                                                  JPROP112
            TAU = 8. / 27.                                              JPROP113
C UNLESS THE RATIO OF THICKNESS IS LESS THAN .5, IN WHICH CASE          JPROP114
C SET TAU TO THE RATIO                                                  JPROP115
```

```
      IF (T1(I) / T2(I) .LT. .5)                                       JPROP116
     *    TAU = T1(I) / T2(I)                                          JPROP117
C CALCULATE THE PSEUDO AREA                                            JPROP118
      A = 2. * PI * N(E1,AF) * 2. * T1(I) * SQRT(EE(E1) /              JUNE2513
     *    (12. * DENSE(E1) * (1. - EGAMMA(E1) ** 2)))                  JPROP120
C CALCULATE THE COUPLING COEFFICIENT FOR THAT TYPE                     JPROP121
      PHI(E1,E2) = 1.07 * JL(I) / (PI * A * MODES(E2)) *               JPROP122
     *    SQRT(OMEGA * THICK(E1) * SQRT(EE(E1) / (DENSE(E1) *          JPROP123
     *    (1. - EGAMMA(E1) ** 2)))) * TAU / SP(I)                      MAY14  3
      GO TO 90                                                         JPROP125
C IF THE TYPE OF JOINT IS PLATE TO ACOUSTIC SPACE,                     JPROP126
   50   IF (JTYPE(I) .NE. TPAT) GO TO 60                               JPROP127
C CALCULATE THE CRITICAL FREQUENCY                                     JPROP128
      CRFREQ = EC(E2) ** 2 / (1.9 * THICK(E1)) *                       JPROP129
     *    SQRT(DENSE(E1) / EE(E1))                                     JPROP130
C CALCULATE THE RADIATION EFFICIENCY USING THE SIGF FUNCTION           JPROP131
      SIGMA = 10. ** SIGF(FREQ / CRFREQ)                               JPROP132
C CALCULATE THE COUPLING COEFFICIENT FOR THAT TYPE                     JPROP133
      PHI(E1,E2) = 4.33 * PI * EC(E2) ** 4 / (FREQ * OMEGA ** 2        MAY13 62
     *    * VOL(E2)) * NS(I) * DENSE(E1) * THICK(E1)                   AUG12J11
     *    * SIGMA / ASD(I)                                             AUG12J12
      GO TO 90                                                         JPROP136
C ELSE IF THE TYPE OF JOINT IS NONE OF THE ABOVE, SET THE ERROR        JPROP137
C FLAG AND WRITE AN ERROR MESSAGE                                      JPROP138
   60   ERROR = .TRUE.                                                 JPROP139
        WRITE (6,200) E1,E2,JPUT(I),JTYPE(I)                           JPROP140
C END IF                                                               JPROP141
   90   PHI(E2,E1) = PHI(E1,E2)                                        JPROP142
  100 CONTINUE                                                         JPROP143
C IF NO ERRORS IN JOINT TYPE WERE ENCOUNTERED, RETURN                  JPROP145
      IF (.NOT. ERROR) RETURN                                          JPROP146
C ELSE WRITE A MESSAGE AND TERMINATE THE PROGRAM                       JPROP147
      WRITE (6,220)                                                    JPROP148
      CALL FERR                                                        JPROP149
      END                                                              JPROP150
```

```
      FUNCTION SIGF(X)                                                  MAY13 63
C THIS FUNCTION SUBPROGRAM RETURNS A VALUE FOR THE RADIATION            SIGF   3
C EFFICIENTY OF A PANEL BASED ON THE FOLLOWING TABLE:                   SIGF   4
C                                                                       SIGF   5
C        X    SIGF  //  X    SIGF  //  X    SIGF  //  X    SIGF         SIGF   6
C       ---   ----  // ---   ----  // ---   ----  // ---   ----         SIGF   7
C       .00   -1.8  // .41   -1.0  // .77   -0.2  // 1.0    0.0         SIGF   8
C       .11   -1.6  // .50   -0.8  // .82    0.0  // 1.5    0.4         SIGF   9
C       .22   -1.4  // .60   -0.6  // .88    0.2  // 1.9    0.2         SIGF  10
C       .32   -1.2  // .68   -0.4  // .92    0.4  //  -     0.0         SIGF  11
C                                                                       SIGF  12
C THE ENTRY IN THE X COLUMN IS THE MAXIMUM VALUE OF X FOR WHICH         MAY13 64
C SIGF HAS THE INDICATED VALUE. SIGF IS CALLED FROM JPROP AND           SIGF  14
C EXCITE.                                                               SIGF  15
C                                                                       SIGF  16
C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:                SIGF  17
C    NAME    TYPE            DESCRIPTION                                SIGF  18
C    ----    ----            -----------                                SIGF  19
C D(16)      REAL    A TABLE OF VALUES TO COMPARE WITH X                SIGF  20
C I          INT     THE ORDINAL OF THE LEAST VALUE OF D GREATER THAN X SIGF  21
C X          REAL    THE RATIO OF THE ANALYSIS FREQUENCY TO THE         SIGF  22
C                    CRITICAL FREQUENCY                                 SIGF  23
C                                                                       SIGF  24
C                                                                       SIGF  25
      DIMENSION D(16)                                                   SIGF  26
      DATA D /0.0,.11,.22,.32,.41,.50,.60,.68,.77,                      SIGF  27
     1   .82,.88,.92,1.0,1.5,1.9,4.0/                                   JUNE2514
C DETERMINE WHERE X LIES IN THE TABLE                                   SIGF  29
      DO 20 I = 2, 15                                                   SIGF  30
         IF (X .LE. D(I)) GO TO 30                                      SIGF  31
   20 CONTINUE                                                          SIGF  32
      I = 16                                                            SIGF  33
C SIGF REACHES A MAXIMUM AT I = 13. A DIFFERENT ALGORITHM               SIGF  34
C FOR COMPUTING SIGF IS REQUIRED DEPENDING ON WHETHER I IS              SIGF  35
C GREATER OR LESS THAN 13.                                              SIGF  36
   30 IF (I .GT. 14) GO TO 50                                           SIGF  37
      SIGF = -2. + .2 * FLOAT(I)                                        SIGF  38
C INTERPOLATE                                                           SIGF  39
      SIGF = -.2 / (D(I) - D(I - 1)) * (D(I) -X) + SIGF                 SIGF  40
      RETURN                                                            SIGF  41
   50 SIGF = .6 - .2 * FLOAT(I - 13)                                    SIGF  42
C INTERPOLATE IF X IS LESS THAN 4                                       SIGF  43
      IF (X .GE. 4.) RETURN                                             SIGF  44
      SIGF = .2 / (D(I) - D(I - 1)) * (D(I) -X) + SIGF                  SIGF  45
      RETURN                                                            SIGF  46
      END                                                               SIGF  47
```

```
      SUBROUTINE EXCITE                                                EXCITE 2
C THIS SUBROUTINE DETERMINES ELEMENT ENERGY LEVELS OR ACOUSTIC         MAY13 65
C ENERGY INPUTS, DEPENDING ON THE TYPE OF EXCITATION. EXCITE IS        EXCITE 4
C CALLED FROM THE MAIN PROGRAM.                                        EXCITE 5
C                                                                      EXCITE 6
C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:               EXCITE 7
C    NAME    TYPE           DESCRIPTION                                EXCITE 8
C    ----    ----           -----------                                EXCITE 9
C AF         INT   ANALYSIS FREQUENCY ORDINAL                          EXCITE11
C ANM(20)    REAL  (AREA * MODES / MASS) OF SURFACE EXCITED BY         OCT28 17
C                  ACOUSTIC FIELD                                      OCT28 18
C AREA(20)   REAL  AREA                                                EXCITE12
C E(20)      REAL  ELEMENT ENERGY LEVELS                               EXCITE13
C EC(20)     REAL  SPEED OF SOUND IN ROOM MEDIUM                       EXCITE14
C ETYPE(20) CHAR   TYPE OF EXCITATION                                  EXCITE15
C MODES      REAL  NUMBER OF MODES IN BANDWIDTH                        EXCITE16
C FREQ       REAL  FREQUENCY                                           EXCITE17
C G          REAL  GRAVITATIONAL CONSTANT                              EXCITE18
C MASS(20)   REAL  MASS                                                EXCITE19
C MECH(20,40)REAL  MECHANICAL INPUT                                    EXCITE20
C MTYPE(20) REAL   TYPE OF MECHANICAL INPUT                            JULY12F1
C N(20,40)   REAL  MODAL DENSITY                                       EXCITE22
C NUMEL      INT   NUMBER OF ELEMENTS                                  EXCITE23
C OMEGA      REAL  2*PI*FREQUENCY                                      JUNE2515
C S(20)      REAL  ACOUSTIC ENERGY INPUT                               EXCITE25
C SIGMA(20) REAL   RADIATION EFFICIENCY                                EXCITE26
C SPL(20,40)REAL   SOUND PRESSURE LEVELS                               EXCITE27
C                                                                      EXCITE28
C THE FOLLOWING COMMON BLOCKS ARE USED:                                EXCITE29
C BLOCK       OTHER PROGRAM UNITS USING THIS COMMON BLOCK              EXCITE30
C -----       ------------------------------------------               EXCITE31
C  CB3    MAIN,JPROP,ANSWER                                            EXCITE32
C  CB5    EPROP,BEAM,MEMBR,PLATE,ROOM,CYLIN,JPROP,ANSWER               EXCITE33
C  CB6    EPROP,PLATE                                                  OCT28 19
C  CB7    EPROP,JINPUT,JPROP,ANSWER,SOLVE,RITER,BLOCK DATA             EXCITE35
C  CB9    EPROP,BEAM,MEMBR,PLATE,ROOM,CYLIN,JPROP,BLOCK DATA           EXCITE36
C  CB11   BEAM,MEMBR,PLATE,ROOM,CYLIN,ANSWER,BLOCK DATA                EXCITE37
C  CB4    JPROP,ANSWER                                                 EXCITE38
C  CB15   ANSWER,SOLVE                                                 EXCITE39
C                                                                      EXCITE40
C                                                                      EXCITE41
      CHARACTER ETYPE,MTYPE*3                                          EXCITE42
      INTEGER AF                                                       EXCITE43
      REAL N, MASS, MODES, MECH                                        JULY12F2
      COMMON /CB3/ FREQ,AF,OMEGA                                       EXCITE45
      COMMON /CB5/ THICK(20),AREA(20),DENSE(20),VOL(20),EE(20),        EXCITE46
     *   EGAMMA(20),EC(20)                                             EXCITE47
      COMMON /CB6/ SPL(20,40),MECH(20,40),ANM(20),ETYPE(20),MTYPE(20)  UNVAC2 3
      COMMON /CB7/ NUMEL,G                                             EXCITE49
      COMMON /CB9/ N(20,40)                                            EXCITE50
      COMMON /CB11/ MASS(20)                                           EXCITE51
      COMMON /CB14/ PHI(20,20),MODES(20)                               EXCITE52
      COMMON /CB15/ S(20),F(20)                                        EXCITE53
      DATA PI /3.141592/                                               EXCITE54
C DO FOR EACH ELEMENT                                                  EXCITE56
      DO 100 I = 1, NUMEL                                              EXCITE57
```

```
C INITIALIZE THE ACOUSTIC ENERGY INPUT AND ELEMENT ENERGY LEVELS        EXCITE58
          S(I) = 0.                                                     EXCITE59
          E(I) = 0.                                                     EXCITE60
C IF(1) THE TYPE OF EXCITATION IS ACOUSTIC,                             EXCITE61
          IF (ETYPE(I) .NE. 'AT') GO TO 20                              EXCITE62
C CALCULATE THE CRITICAL FREQUENCY                                      EXCITE63
             CRFREQ = EC(I) ** 2 / (1.8 * THICK(I)) *                   EXCITE64
     *          SQRT(DENSE(I) / EE(I))                                  EXCITE65
C CALCULATE THE RADIATION EFFICIENCY USING THE SIGF FUNCTION            EXCITE66
             SIGMA = 10. ** SIGF(FREQ / CRFREQ)                         EXCITE67
C THEN CALCULATE THE ACOUSTIC ENERGY INPUT                              EXCITE68
            S(I) = 4.33 * PI * EC(I) ** 2 * 8.41 * 10. **               OCT28 21
     *         (SPL(I, AF) / 10. - 18.) * SIGMA * ANM(I) /              OCT28 22
     *         (OMEGA ** 2)                                             OCT28 23
             GO TO 100                                                  EXCITE72
C ELSE IF(1) THE TYPE OF EXCITATION IS MECHANICAL,                      EXCITE73
   20     IF (ETYPE(I) .NE. 'MI') GO TO 100                             EXCITE74
C THEN IF(2) THE TYPE OF MECHANICAL INPUT IS RMS,                       EXCITE75
             IF (MTYPE(I) .NE. 'RMS') GO TO 30                          JULY1011
C THEN CALCULATE THE ELEMENT ENERGY LEVEL                               EXCITE77
                E(I) = MASS(I) / OMEGA ** 2 * (MECH(I,AF) * G) ** 2     EXCITE78
                GC TO 100                                               EXCITE79
C ELSE IF(2) THE TYPE OF MECHANICAL INPUT IS PSD,                       EXCITE80
C THEN CALCULATE THE ELEMENT ENERGY LEVEL                               EXCITE81
   30           ETEMP = MASS(I) / (OMEGA**2)                            JULY12E1
                E(I) = ETEMP * MECH(I,AF) * (G**2) * (FREQ/4.33)        JULY12E2
C END IF(2)                                                             EXCITE84
C END IF(1)                                                             EXCITE85
  100 CONTINUE                                                          EXCITE86
      RETURN                                                            EXCITE88
      END                                                               EXCITE89
```

```
      SUBROUTINE ANSWER                                              ANSWER 2
C THIS SUBROUTINE SOLVES THE SEA SYSTEM OF EQUATIONS FOR             ANSWER 3
C ELEMENT ENERGY LEVELS AND STORES THE SOLUTION IN ARRAY             ANSWER 4
C ABAR TO BE PRINTED OUT BY RITER. ANSWER IS CALLED FROM             ANSWER 5
C THE MAIN PROGRAM.                                                  ANSWER 6
C                                                                    ANSWER 7
C                                                                    ANSWER 8
C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:             ANSWER 9
C    NAME     TYPE           DESCRIPTION                             ANSWER10
C    ----     ----           -----------                             MAY13 69
C ABAR(20,40)REAL  AVERAGE ACCELLERATION                             ANSWER12
C ALPHA(20,20)REAL MATRIX OF COEFFICIENTS                            ANSWER13
C E(20)      REAL  ELEMENT ENERGY LEVELS                             ANSWER14
C ETA(20)    REAL  DAMPING                                           ANSWER15
C FREQ       REAL  FREQUENCY                                         ANSWER16
C MASS(20)   REAL  MASS                                              ANSWER17
C MODES(20)  REAL  NUMBER OF MODES IN BANDWIDTH                      ANSWER18
C NUMEL      INT   NUMBER OF ELEMENTS                                ANSWER19
C OMEGA      REAL  2*PI*FREQUENCY                                    ANSWER20
C OTYPE      CHAR  TYPE OF OUTPUT                                    MAY14  4
C PHI(20,20)REAL   COUPLING COEFFICIENT                              ANSWER21
C S(20)      REAL  ACOUSTIC ENERGY INPUT                             ANSWER22
C SFREQ(20)  REAL  STARTING FREQUENCY                                ANSWER23
C SIZE       INT   SIZE OF REDUCED ALPHA ARRAY                       ANSWER24
C SLOPE(20)  REAL  SLOPE                                             ANSWER25
C                                                                    ANSWER26
C                                                                    ANSWER27
C THE FOLLOWING COMMON BLOCKS ARE USED:                              ANSWER28
C BLOCK      OTHER PROGRAM UNITS USING THIS COMMON BLOCK             ANSWER29
C -----      -----------------------------------------               ANSWER30
C  CB3   MAIN,JPROP,EXCITE                                           ANSWER31
C  CB5   EPROP,BEAM,MEMBR,PLATE,ROOM,CYLIN,JPROP,EXCITE              ANSWER32
C  CB7   EPROP,JINPUT,JPROP,EXCITE,SOLVE,RITER,BLOCK DATA            ANSWER33
C  CB8   EPROP,RITER,BLOCK DATA                                      ANSWER34
C  CB11  BEAM,MEMBR,PLATE,ROOM,CYLIN,EXCITE,BLOCK DATA               ANSWER35
C  CB14  JPROP,EXCITE                                                ANSWER36
C  CB15  EXCITE,SOLVE                                                ANSWER37
C  CB16  SOLVE                                                       ANSWER38
C  CB17  RITER                                                       ANSWER39
C                                                                    ANSWER40
C                                                                    ANSWER41
      CHARACTER*1 OTYPE                                              ANSWER42
      INTEGER AF,SIZE                                                ANSWER43
      REAL MASS, MODES                                               ANSWER44
      DIMENSION AMAT(20,20),SMAT(20)                                 ANSWER45
      COMMON /CB3/ FREQ,AF,OMEGA                                     ANSWER46
      COMMON /CB5/ THICK(20),AREA(20),DENSE(20),VOL(20),EE(20),      ANSWER47
     *   GAMMA(20),EC(20)                                            ANSWER48
      COMMON /CB7/ NUMEL,G                                           ANSWER49
      COMMON /CB8/ SLOPE(20),SFREQ(20),ETA(20),OTYPE                 UNIVAC 3
      COMMON /CB11/ MASS(20)                                         ANSWER51
      COMMON /CB14/ PHI(20,20),MODES(20)                             ANSWER52
      COMMON /CB15/ S(20),E(20)                                      ANSWER53
      COMMON /CB16/ ALPHA(20,20)                                     ANSWER54
      COMMON /CB17/ ABAR(20,40)                                      ANSWER55
C DO FOR EACH ELEMENT                                                ANSWER56
```

```
      DO 100 I = 1, NUMEL                                              MAY13 72
C SET THE DAMPING FACTOR EQUAL TO THE INPUT VALUE                      ANSWER58
         ETA2 = ETA(I)                                                 ANSWER59
         SLOPE(I) = SLOPE(I) / 20.                                     AUG26 73
C IF DAMPING IS FREQUENCY DEPENDENT AND THE ANALYSIS FREQUENCY          ANSWER60
C IS GREATER THAN THE STARTING FREQUENCY OF THE DEPENDENCY,            ANSWER61
C CALCULATE THE DAMPING FACTOR                                         ANSWER62
         IF (SLOPE(I) .NE. 0. .AND. FREQ .GT. SFREQ(I))                MAY13 73
     *      ETA2 = ETA2 * (FREQ / SFREQ(I)) ** SLOPE(I)                ANSWER64
C IF THIS IS NOT THE LAST ELEMENT,                                     ANSWER65
         IF (I .EQ. NUMEL) GO TO 50                                    ANSWER66
C THEN FOR EACH SUCCEEDING ELEMENT,                                    ANSWER67
         IPLUS1 = I + 1                                                ANSWER68
         DO 40 J = IPLUS1,NUMEL                                        ANSWER69
C CALCULATE THE I-TH ROW OF ALPHA TO THE RIGHT OF THE MAIN             ANSWER70
C DIAGONAL                                                             ANSWER71
            ALPHA(I,J) = -MODES(I) * PHI(I,J)                          ANSWER72
C CALCULATE THE I-TH COLUMN OF ALPHA BELOW THE MAIN DIAGONAL           ANSWER73
            ALPHA(J,I) = -MODES(J) * PHI(J,I)                          ANSWER74
   40    CONTINUE                                                      ANSWER75
C END IF                                                               ANSWER76
C CALCULATE ALPHA ON THE MAIN DIAGONAL                                 ANSWER77
   50    ALPHA(I,I) = OMEGA * ETA2                                     ANSWER78
         DO 80 J = 1, NUMEL                                            ANSWER79
            ALPHA (I,I) = ALPHA(I,I) + MODES(J) * PHI(I,J)             ANSWER80
   80    CONTINUE                                                      ANSWER81
  100 CONTINUE                                                         ANSWER82
C INITIALIZE SIZE                                                      ANSWER83
      SIZE = NUMEL                                                     ANSWER84
C DO FOR EACH ELEMENT                                                  ANSWER85
      DO 150 I = 1, NUMEL                                              ANSWER86
C IF THE ENERGY LEVEL IS ALREADY KNOWN,                                ANSWER87
         IF (E(I) .EQ. 0.) GO TO 150                                   ANSWER88
C THEN DO FOR EACH ELEMENT                                             ANSWER89
         DO 130 J = 1, NUMEL                                           ANSWER90
C SUBTRACT FROM THE ACOUSTIC ENERGY ARRAY S THAT PORTION OF            MAY13 74
C THE VALUE WHICH CAME FROM THE PRODUCT OF THE ALPHA ARRAY             ANSWER92
C AND THE KNOWN ENERGY LEVEL                                           ANSWER93
            S(J) = S(J) - ALPHA(J,I) * E(I)                            ANSWER94
  130    CONTINUE                                                      ANSWER95
C DECREMENT SIZE TO SHOW THAT THE I-TH ROW AND COLUMN WILL BE          ANSWER96
C ELIMINATED FROM THE ALPHA ARRAY WHEN IT BECOMES AMAT AND THE         ANSWER97
C I-TH ELEMENT FROM THE S ARRAY WHEN IT BECOMES SMAT                   ANSWER98
         SIZE = SIZE - 1                                               ANSWER99
C END IF                                                               ANSWE100
  150 CONTINUE                                                         ANSWE101
C CALL SOLVE TO CREATE THE REDUCED ARRAYS AND SOLVE THE MATRIX         ANSWE102
C EQUATION                                                             ANSWE103
      CALL SOLVE (AMAT,SMAT,SIZE)                                      ANSWE104
C DO FOR EACH ELEMENT                                                  ANSWE105
      DO 200 I = 1, NUMEL                                              ANSWE106
C PUT THE SOLUTION IN ABAR                                             ANSWE107
         ABAR(I,AF) = E(I) * OMEGA ** 2 / MASS(I)                      ANSWE108
C IF THE DEFAULT OUTPUT TYPE PSD IS SELECTED, PUT ABAR IN THAT FORM    ANSWE109
         IF (OTYPE .EQ. TYPST) GO TO 190                               ANSWE110
         ABAR(I,AF) = ABAR(I,AF) / (G ** 2 * FREQ * 4.33               ANSWE111
```

```
            GO TO 200                                             ANSWE112
C ELSE IF THE OUTPUT TYPE IS RMS, PUT ARAR IN THAT FORM           ANSWE113
  IRC      ARAR(I,AF) = SQRT(ARAR(I,AF)) / G                      ANSWE114
C END IF                                                          ANSWE115
  200 CONTINUE                                                    ANSWE116
      RETURN                                                      ANSWE117
      END                                                         ANSWE118
```

```
      SUBROUTINE SOLVE (AMAT,SMAT ...)                                 SOLVE  2
C THIS SUBROUTINE CREATES MATRIX A  T F OM ALPHA BY ELIMINATING         SOLVE  3
C THOSE ROWS AND COLUMNS REPRESENTING ELEMENTS FOR WHICH THE           SOLVE  4
C ENERGY LEVELS ARE ALREADY KNOWN. IN THE SAME WAY, SMAT IS            SOLVE  5
C CREATED FROM S. SUBROUTINE GASSEM FR    BRARY SYS$MATHS:ATS          SOLVE  6
C IS THEN CALLED TO SOLVE THE MATRIX E    ON AMAT*X=SMAT FOR X.        SOLVE  7
C GASSEM PUTS THE SOLUTION IN SMAT, SO THIS SUBROUTINE PUTS            MAY13 75
C THE RESULTS IN E, LEAVING INTACT THOSE ELEMENTS OF E                 SOLVE  9
C WHICH WERE ALREADY KNOWN. SOLVE IS CALLED BY ANSWER.                 SOLVE 10
C                                                                      SOLVE 11
C                                                                      SOLVE 12
C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:               SOLVE 13
C    NAME          TYPE           DESCRIPTION                          SOLVE 14
C    ----          ----           -----------                          SOLVE 15
C ALPHA(20,20)     REAL   MATRIX OF COEFFICIENTS                       SOLVE 16
C AMAT(SIZE,SIZE)REAL     REDUCED ALPHA ARRAY                          SOLVE 17
C DET              REAL   DETERMINANT OF AMAT                          SOLVE 18
C E(20)            REAL   ELEMENT ENERGY LEVELS                        SOLVE 19
  NUMEL            INT    NUMBER OF ELEMENTS                           SOLVE 20
C S(20)            REAL   ACOUSTIC ENERGY INPUT                        SOLVE 21
C SIZE             INT    SIZE OF AMAT AND SMAT                        SOLVE 22
C SMAT(SIZE)       REAL   REDUCED S ARRAY                              MAY13 76
C                                                                      SOLVE 24
C                                                                      SOLVE 25
C THE FOLLOWING COMMON BLOCKS ARE USED:                                SOLVE 26
C BLOCK      OTHER PROGRAM UNITS USING THIS COMMON BLOCK               SOLVE 27
C -----      ---------------------------------------                   SOLVE 28
C  CB7   EPROP,JINPUT,JPROP,EXCITE,ANSWER,RITER,BLOCK DATA             SOLVE 29
C  CB15  EXCITE,ANSWER                                                 SOLVE 30
C  CB16  ANSWER                                                        SOLVE 31
C                                                                      SOLVE 32
C                                                                      SOLVE 33
      INTEGER SIZE                                                     MAY13 77
      DIMENSION AMAT(SIZE,SIZE),SMAT(SIZE)                             SOLVE 35
      COMMON /CB7/ NUMEL,G                                             SOLVE 36
      COMMON /CB15/ S(20),E(20)                                        SOLVE 37
      COMMON /CB16/ ALPHA(20,20)                                       SOLVE 38
  300 FORMAT ('0*** ERROR ***     THE DETERMINANT OF THE SEA ',        SOLVE 39
     1   'EQUATION MATRIX IS 0. '/' HENCE THERE IS NO SOLUTION.',      SOLVE 40
     2   ' THIS ERROR WILL CAUSE THE PROGRAM TO ABORT.'/               MAY13 79
     $   ' THIS ERROR WAS DISCOVERED BY SUBROUTINE SOLVE.')            SOLVE 42
C INITIALIZE I1                                                        SOLVE 43
      I1 = 0                                                           SOLVE 44
C DO FOR EACH ELEMENT FOR WHICH ENERGY LEVELS ARE UNKNOWN              SOLVE 45
      DO 100 I = 1, SIZE                                               SOLVE 46
C INCREMENT I1                                                         SOLVE 47
   10    I1 = I1 + 1                                                   SOLVE 48
C IF THE ENERGY LEVEL FOR ELEMENT I1 IS KNOWN, GO TO NEXT ELEMENT      SOLVE 49
         IF (E(I1) .NE. 0.) GO TO 10                                   SOLVE 50
C ELSE INITIALIZE J1                                                   SOLVE 51
         J1 = 0                                                        SOLVE 52
C DO FOR EACH ELEMENT FOR WHICH ENERGY LEVELS ARE UNKNOWN              SOLVE 53
         DO 80 J = 1, SIZE                                             SOLVE 54
C INCREMENT J1                                                         SOLVE 55
   30       J1 = J1 + 1                                                SOLVE 56
C IF ENERGY LEVEL FOR ELEMENT J1 IS KNOWN, GO TO NEXT ELEMENT          SOLVE 57
```

```
              IF (E(J1) .NE. 0.) GO TO 30                              SOLVE 58
C ELSE PUT THE VALUE OF ALPHA FOR ELEMENT PAIR I1,J1 IN AMAT           SOLVE 59
              AMAT(I,J) = ALPHA(I1,J1)                                 SOLVE 60
C END IF                                                               SOLVE 61
   80    CONTINUE                                                      SOLVE 62
C PUT THE VALUE OF S FOR ELEMENT I1 IN SMAT                            SOLVE 63
         SMAT(I) = S(I1)                                               SOLVE 64
  100 CONTINUE                                                         SOLVE 65
C SOLVE THE MATRIX EQUATION                                            SOLVE 66
      CALL GASSEM (AMAT,SIZE,1,DET,SMAT)                               UNIVAC 4
C IF THE DETERMINANT OF AMAT IS 0,                                     SOLVE 68
      IF (DET .NE. 0.) GO TO 150                                       UNIVAC 5
C THEN WRITE AN ERROR MESSAGE AND TERMINATE THE PROGRAM               SOLVE 70
      WRITE (6,380)                                                    SOLVE 71
      CALL FERR                                                        MAY13 82
C ELSE INITIALIZE I1 TO 1, REPRESENTING THE FIRST VALUE               SOLVE 73
C RETURNED BY GASSEM TO ARRAY SMAT                                     SOLVE 74
  150 I1 = 1                                                           SOLVE 75
C DO FOR EACH ELEMENT                                                  SOLVE 76
      DO 200 I = 1, NUMEL                                              SOLVE 77
C IF THE ELEMENT ENERGY LEVEL WAS UNKNOWN,                             SOLVE 78
         IF (E(I) .NE. 0.) GO TO 200                                   SOLVE 79
C THEN PLACE ITS VALUE IN THE ARRAY E                                  SOLVE 80
         E(I) = SMAT(I1)                                               SOLVE 81
C INCREMENT I1                                                         SOLVE 82
         I1 = I1 + 1                                                   SOLVE 83
C END IF                                                               SOLVE 84
  200 CONTINUE                                                         SOLVE 85
      RETURN                                                           SOLVE 86
      END                                                              SOLVE 87
```

```
      SUBROUTINE RITER                                                  RITER  2
C THIS SUBROUTINE WRITES OUT THE RESULTS THAT ARE STORED IN             RITER  3
C ARRAY ABAR. RITER IS CALLED FROM THE MAIN PROGRAM.                    RITER  4
C                                                                       RITER  5
C                                                                       RITER  6
C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:                RITER  7
C    NAME    TYPE           DESCRIPTION                                 RITER  8
C    ----    ----           -----------                                 RITER  9
C ABAR(20,20)REAL  AVERAGE ACCELERATION                                 RITER 10
C FTAB(40)   REAL  TABLE OF ANALYSIS FREQUENCIES                        RITER 11
C NUMAF      INT   NUMBER OF ANALYSIS FREQUENCIES                       RITER 12
C NUMEL      INT   NUMBER OF ELEMENTS                                   RITER 13
C OTYPE      CHAR  TYPE OF OUTPUT                                       MAY14  5
C                                                                       RITER 14
C                                                                       RITER 15
C THE FOLLOWING COMMON BLOCKS ARE USED:                                 RITER 16
C BLOCK      OTHER PROGRAM UNITS USING THIS COMMON BLOCK                RITER 17
C -----      ---------------------------------------                    RITER 18
C  CB1   MAIN,EPROP,BEAM,MEMBR,PLATE,ROOF,CYLIN,BLOCK DATA              RITER 19
C  CB7   EPROP,JINPUT,JPROP,EXCITE,ANSWER,SOLVE,BLOCK DATA              RITER 20
C  CB8  EPROP,ANSWER,BLOCK DATA                                         RITER 21
C  CB17  ANSWER                                                         RITER 22
C                                                                       RITER 23
C                                                                       RITER 24
      CHARACTER*20 TITLE / 'PSD LEVELS (G**2/HZ)' /,                    UNIVAC 6
     *  RMS / '       GRMS          ' /, OTYPE*3                        UNIVAC 7
      COMMON /CB1/ FTAB(40),NUMAF,FREQ1                                 RITER 27
      COMMON /CB7/ NUMEL,G                                              RITER 28
      COMMON /CB8/ SLOPE(20),SFREQ(20),ETA(20),OTYPE                    UNIVAC 8
      COMMON /CB17/ ABAR(20,40)                                         RITER 30
  100 FORMAT (/////5X,'CENTER',24X,A20/                                 RITER 31
     1    4X,'FREQ(HZ)',4(5X,'ELEMENT ',I2:))                           RITER 32
  110 FORMAT (F12.2,4(1PE15.5E2))                                       RITER 33
C IF THE TYPE OF OUTPUT IS RMS, CHANGE THE HEADING ACCORDINGLY          RITER 34
      IF (OTYPE .EQ. 'RMS' ) TITLE = RMS                                RITER 35
C DO FOR EACH ELEMENT IN GROUPS OF 4                                    RITER 36
      DO 20 I = 1, NUMEL, 4                                             RITER 37
C IPLUS3 WILL BE THE TERMINAL VARIABLE FOR IMPLIED DO LOOPS TO          RITER 38
C PRODUCE 4 COLUMNS UNLESS THERE ARE FEWER THAN 4 ELEMENTS              RITER 39
C REMAINING TO BE LISTED                                                RITER 40
        IPLUS3 = MIN(NUMEL, I + 3)                                      RITER 41
C WRITE THE HEADING FOR THESE 4 ELEMENTS                                RITER 42
        WRITE (6,100) TITLE,(J,J=I,IPLUS3)                              MAY13 88
C DO FOR EACH ANALYSIS FREQUENCY                                        RITER 44
        DO 10 J = 1, NUMAF                                              RITER 45
C WRITE THE RESULTS                                                     RITER 46
          WRITE (6,110) FTAB(J),(ABAR(K,J),K=I,IPLUS3)                  RITER 47
   10   CONTINUE                                                        RITER 48
   20 CONTINUE                                                          RITER 49
      RETURN                                                            RITER 50
      END                                                               RITER 51
```

```
      BLOCK DATA                                                        RITER 52
C                                                                       RITER 53
C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:                 RITER 54
C    NAME     TYPE            DESCRIPTION                               RITER 55
C    ----     ----            -----------                               RITER 56
C ERROR       LOG    TRUE IF A FATAL ERROR HAS OCCURRED                 RITER 57
C FTAB(40)    REAL   TABLE OF ANALYSIS FREQUENCIES                      RITER 58
C G           REAL   GRAVITATIONAL CONSTANT                             RITER 59
C INPUT       INT    NUMBER OF INPUT RECORDS READ                       RITER 60
C MASS(20)    REAL   MASS                                               RITER 61
C N(20,40)    REAL   MODAL DENSITY                                      RITER 62
C SLOPE       REAL   SLOPE                                              RITER 63
C                                                                       RITER 64
C THE FOLLOWING COMMON BLOCKS ARE USED:                                 RITER 65
C BLOCK       OTHER PROGRAM UNITS USING THIS COMMON BLOCK               RITER 66
C -----       -------------------------------------------               RITER 67
C  CB1    MAIN,EPROP,BEAM,MEMBR,PLATE,ROOM,CYLIN,RITER                  RITER 68
C  CB2    MAIN,EPROP,JINPUT                                             RITER 69
C  CB7    EPROP,JINPUT,JPROP,EXCITE,ANSWER,SOLVE,RITER                  RITER 70
C  CB8    EPROP,ANSWER,RITER                                            RITER 71
C  CB9    EPROP,BEAM,MEMBR,PLATE,ROOM,CYLIN,JPROP,EXCITE                RITER 72
C  CB10   EPROP,JINPUT                                                  RITER 73
C  CB11   BEAM,MEMBR,PLATE,ROOM,CYLIN,ANSWER                            RITER 74
C                                                                       RITER 75
C                                                                       RITER 76
      REAL N,MASS                                                       RITER 77
      LOGICAL ERROR                                                     RITER 78
      COMMON /CB1/ FTAB(40),NUMAF,FREG1                                 RITER 79
      COMMON /CB2/ ERROR                                                RITER 80
      COMMON /CB7/ NUMEL,G                                              RITER 81
      COMMON /CB8/ SLOPE(20),SFREQ(20),ETA(20),OTYPE                    UNIVAC 9
      COMMON /CB9/ N(20,40)                                             RITER 83
      COMMON /CB10/ INPUT                                               RITER 84
      COMMON /CB11/ MASS(20)                                            RITER 85
      DATA N,SLOPE,MASS,G,INPUT,ERROR /840 * 0., 386.4, 1, .FALSE./     RITER 86
      DATA FTAB /1.0,1.25,1.6,2.0,2.5,3.15,4.0,5.0,6.3,8.0,             RITER 87
     1   10.0,12.5,16.0,20.0,25.0,31.5,40.0,50.0,63.0,80.0,             RITER 88
     2   100.0,125.0,160.0,200.0,250.0,315.0,400.0,500.0,               RITER 89
     3   630.0,800.0,1000.0,1250.0,1600.0,2000.0,2500.0,                RITER 90
     4   3150.0,4000.0,5000.0,6300.0,8000.0/                            RITER 91
      END                                                               RITER 92
```

AG1YIMG . LPS 157F LINES PRINTED.*
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END OF JOB

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Appendix II

SEA PROGRAM LOGIC AND FLOW

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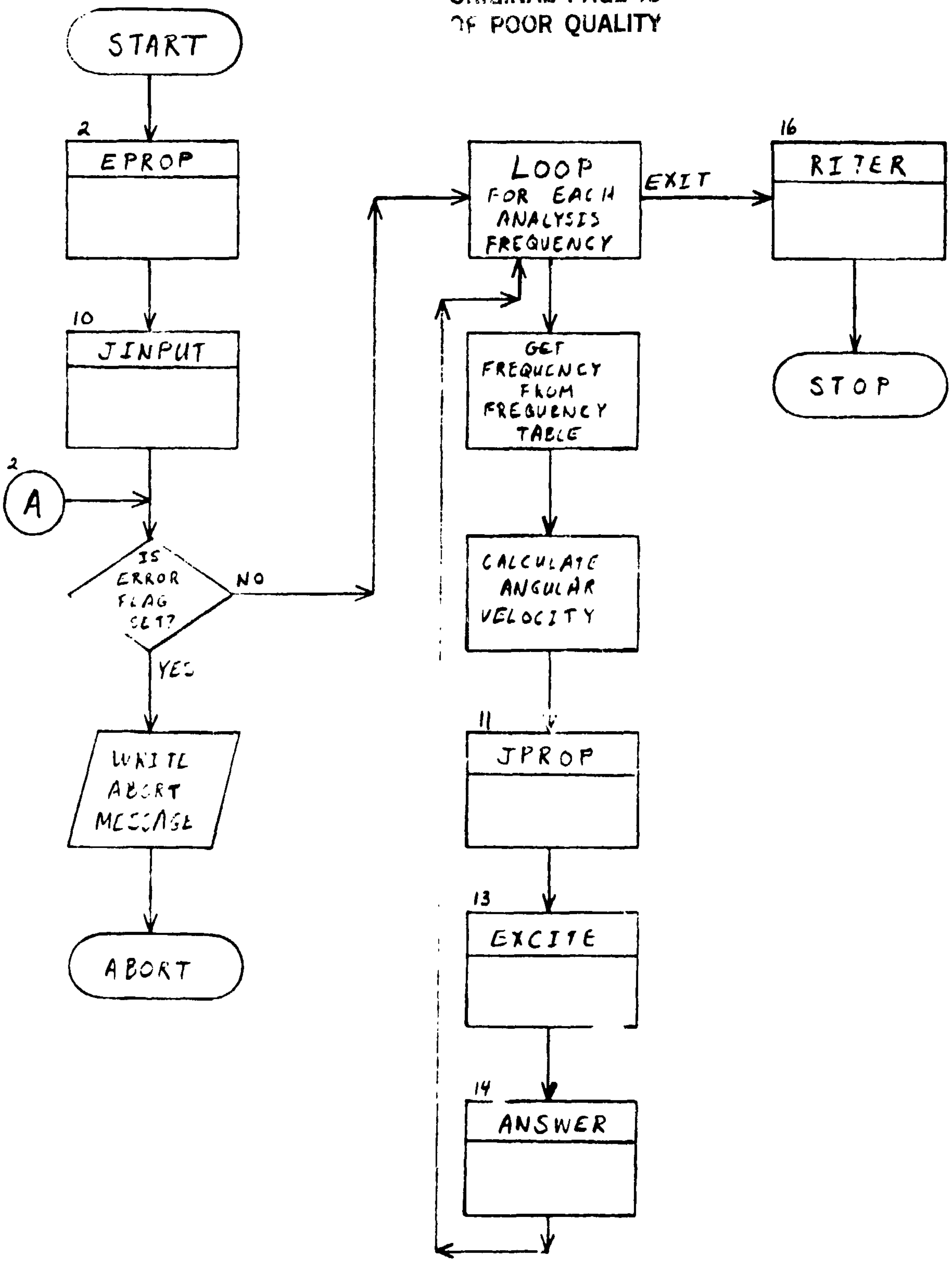

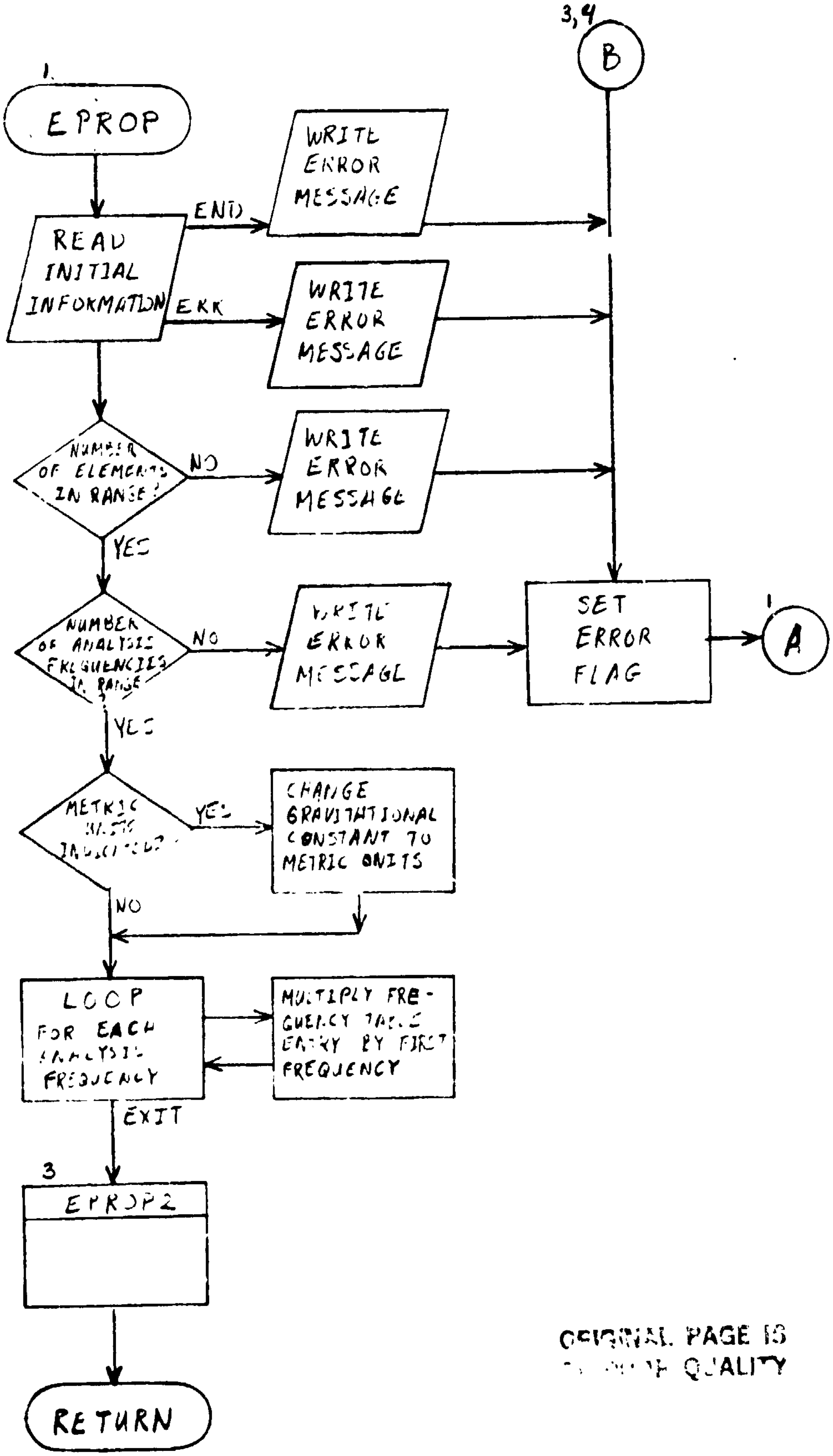

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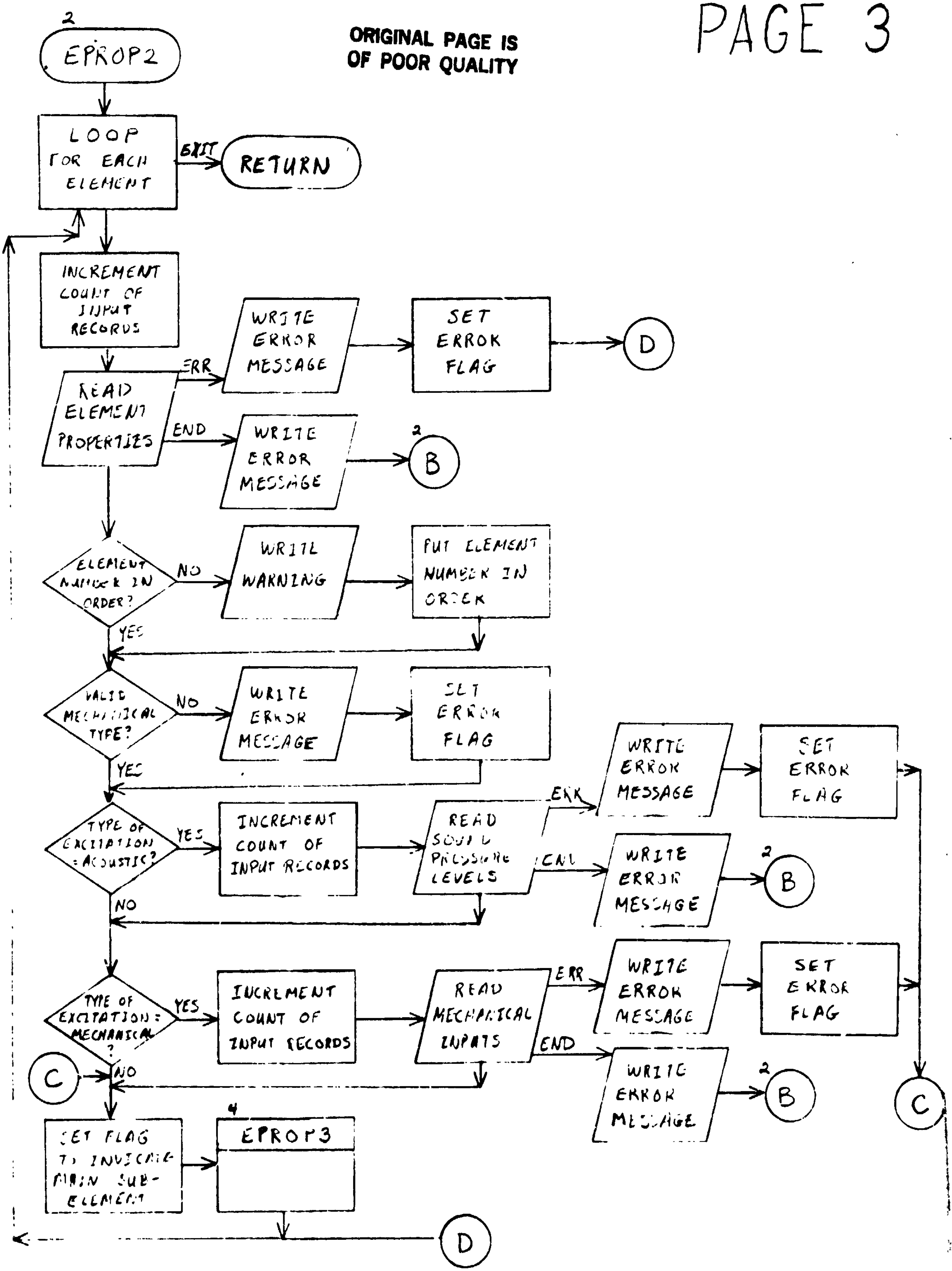
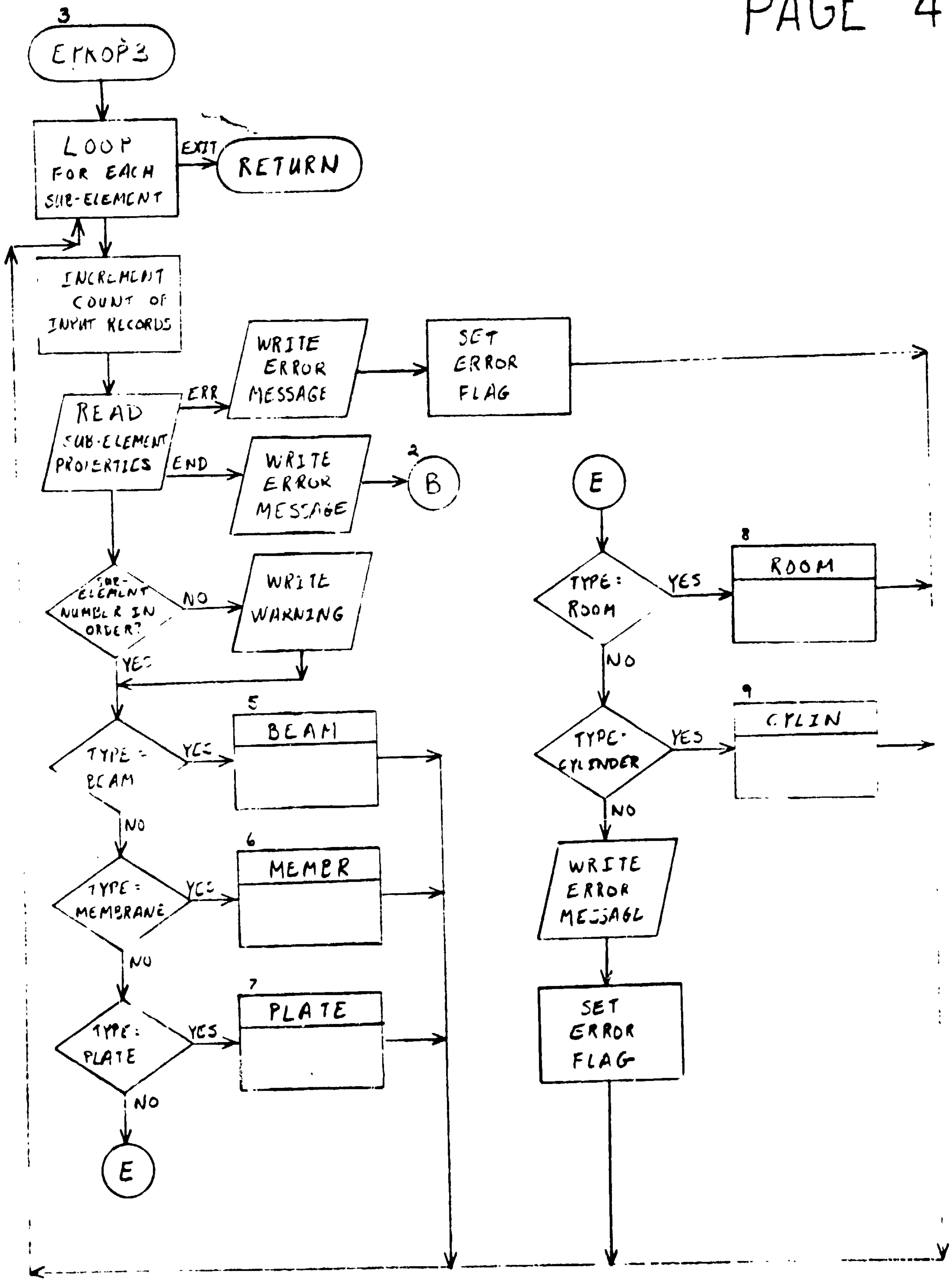
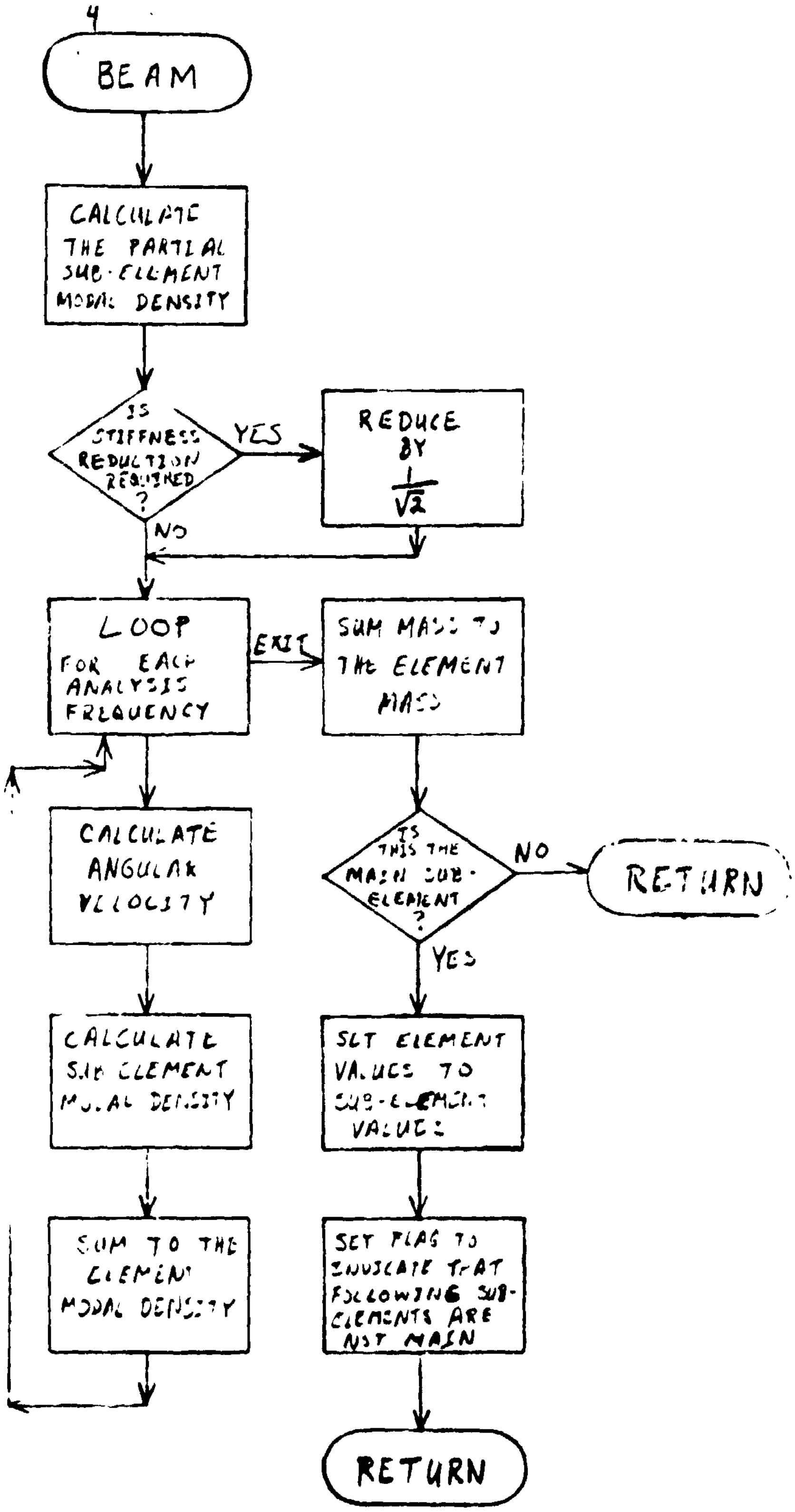
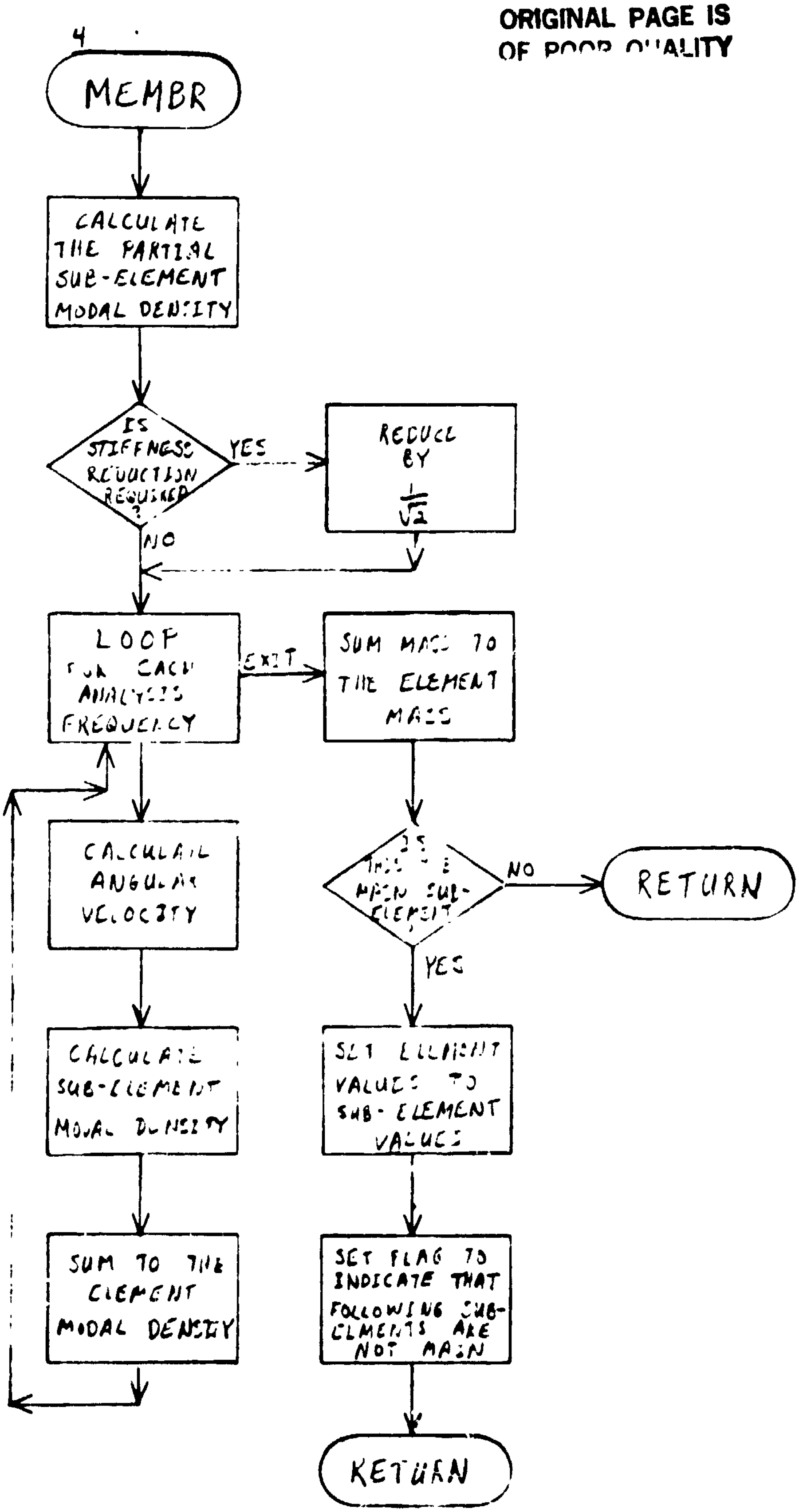
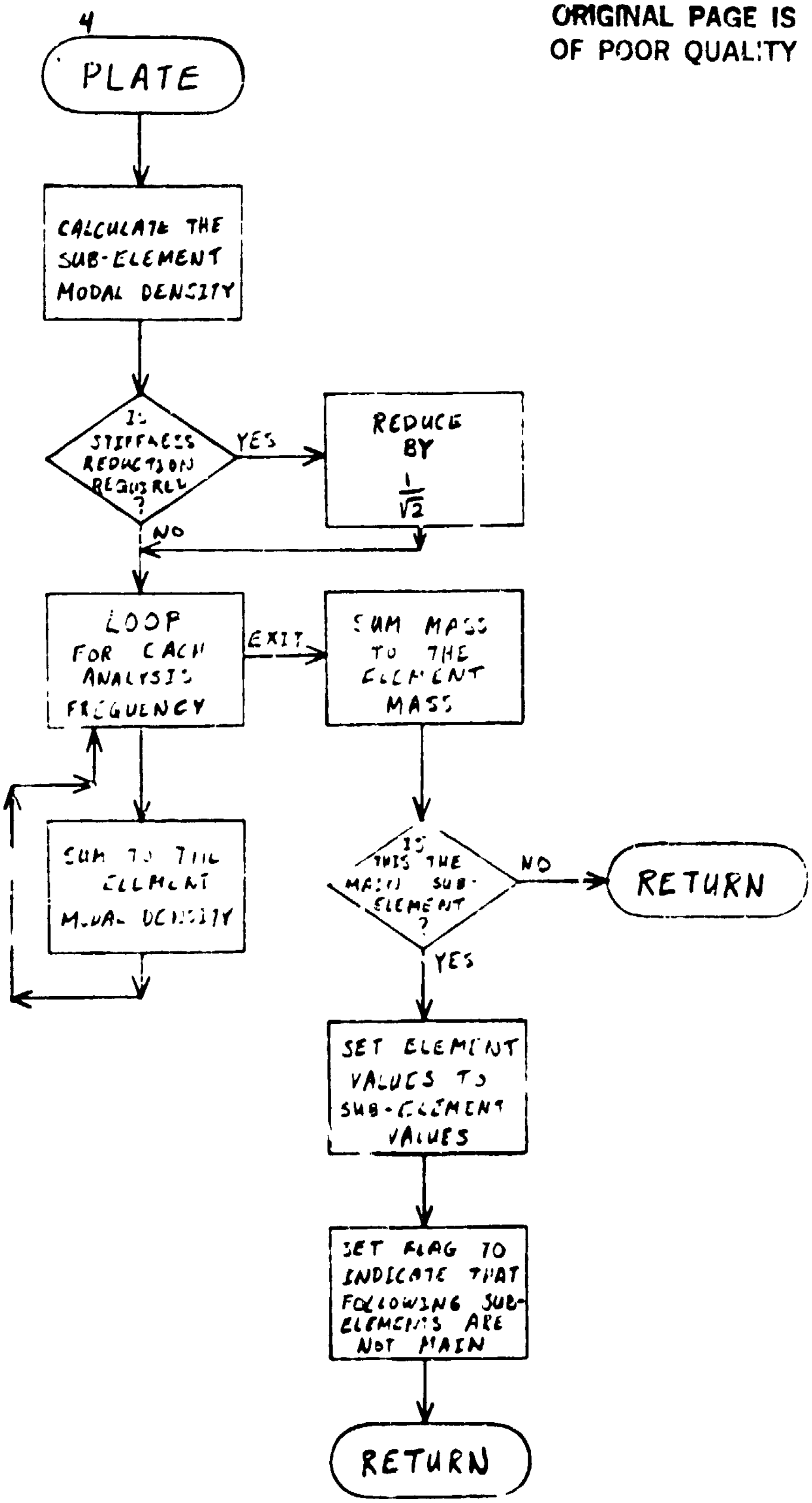
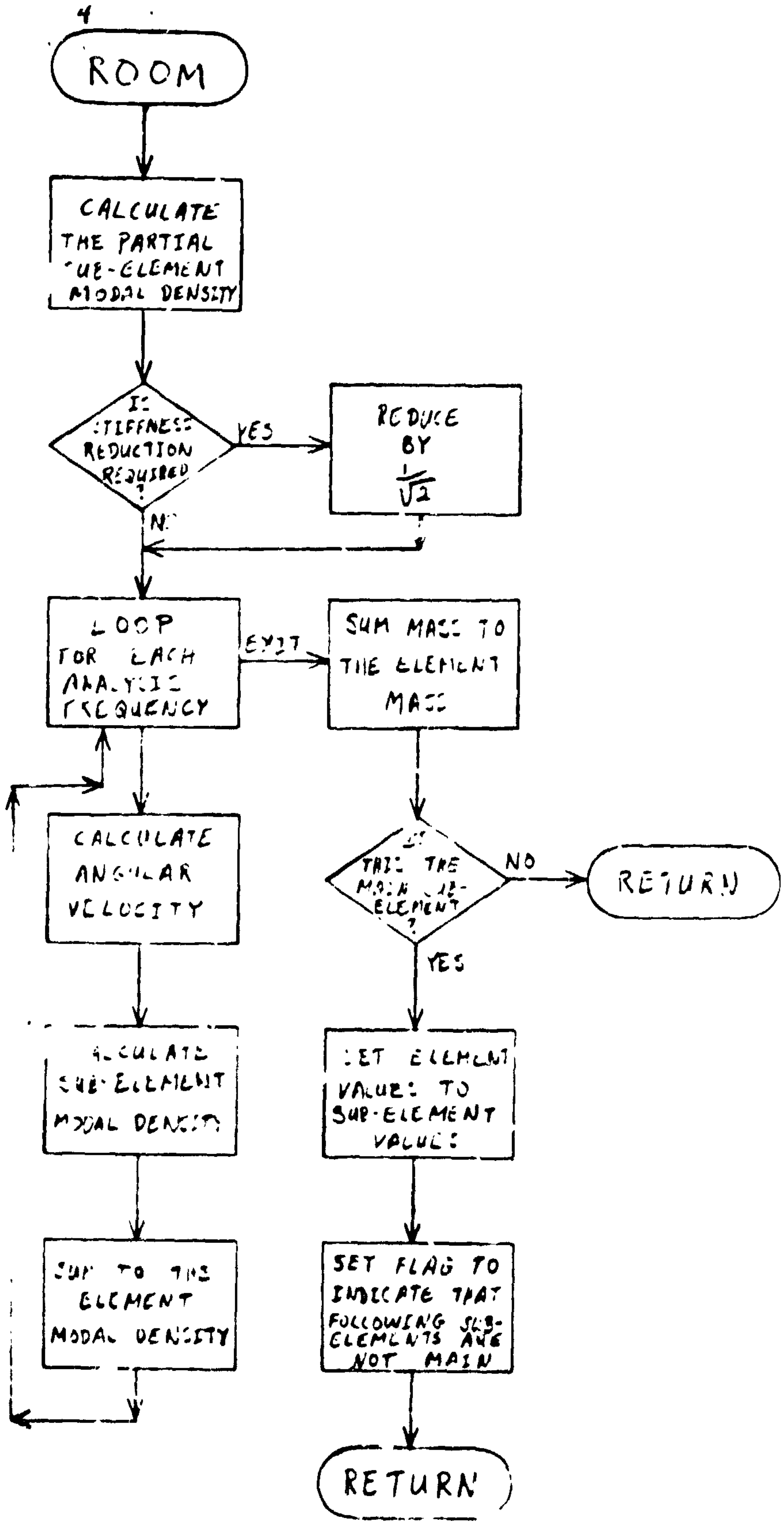

2
EPROP2
LOOP FOR EACH ELEMENT
EXIT
RETURN
INCREMENT COUNT OF INPUT RECORDS
READ ELEMENT PROPERTIES
ERR
WRITE ERROR MESSAGE
SET ERROR FLAG
D
END
WRITE ERROR MESSAGE
2
B
ELEMENT NUMBER IN ORDER?
NO
WRITE WARNING
PUT ELEMENT NUMBER IN ORDER
YES
VALID MECHANICAL TYPE?
NO
WRITE ERROR MESSAGE
SET ERROR FLAG
YES
TYPE OF EXCITATION = ACOUSTIC?
YES
INCREMENT COUNT OF INPUT RECORDS
READ SOUND PRESSURE LEVELS
ERR
WRITE ERROR MESSAGE
SET ERROR FLAG
END
WRITE ERROR MESSAGE
2
B
NO
TYPE OF EXCITATION = MECHANICAL?
YES
INCREMENT COUNT OF INPUT RECORDS
READ MECHANICAL INPUTS
ERR
WRITE ERROR MESSAGE
SET ERROR FLAG
END
WRITE ERROR MESSAGE
2
B
C
NO
C
SET FLAG TO INDICATE MAIN SUB-ELEMENT
4
EPROP3
D


3
EPROP3
LOOP FOR EACH SUB-ELEMENT
EXIT
RETURN
INCREMENT COUNT OF INPUT RECORDS
READ SUB-ELEMENT PROPERTIES
ERR
WRITE ERROR MESSAGE
SET ERROR FLAG
END
WRITE ERROR MESSAGE
2
B
SUB-ELEMENT NUMBER IN ORDER?
NO
WRITE WARNING
YES
5
TYPE = BEAM
YES
BEAM
NO
6
TYPE = MEMBRANE
YES
MEMBR
NO
7
TYPE = PLATE
YES
PLATE
NO
E
E
TYPE = ROOM
YES
8
ROOM
NO
TYPE = CYLINDER
YES
9
CYLIN
NO
WRITE ERROR MESSAGE
SET ERROR FLAG


4
BEAM
CALCULATE THE PARTIAL SUB-ELEMENT MODAL DENSITY
IS STIFFNESS REDUCTION REQUIRED ?
YES
REDUCE BY $\frac{1}{\sqrt{2}}$
NO
LOOP FOR EACH ANALYSIS FREQUENCY
EXIT
SUM MASS TO THE ELEMENT MASS
CALCULATE ANGULAR VELOCITY
IS THIS THE MAIN SUB-ELEMENT ?
NO
RETURN
YES
CALCULATE SUB ELEMENT MODAL DENSITY
SET ELEMENT VALUES TO SUB-ELEMENT VALUES
SUM TO THE ELEMENT MODAL DENSITY
SET FLAG TO INDICATE THAT FOLLOWING SUB-ELEMENTS ARE NOT MAIN
RETURN


4
MEMBR
CALCULATE THE PARTIAL SUB-ELEMENT MODAL DENSITY
IS STIFFNESS REDUCTION REQUIRED ?
YES
REDUCE BY $\frac{1}{\sqrt{2}}$
NO
LOOP FOR EACH ANALYSIS FREQUENCY
EXIT
SUM MASS TO THE ELEMENT MASS
CALCULATE ANGULAR VELOCITY
IS THIS THE MAIN SUB-ELEMENT ?
NO
RETURN
YES
CALCULATE SUB-ELEMENT MODAL DENSITY
SET ELEMENT VALUES TO SUB-ELEMENT VALUES
SUM TO THE ELEMENT MODAL DENSITY
SET FLAG TO INDICATE THAT FOLLOWING SUB-ELEMENTS ARE NOT MAIN
RETURN


4
PLATE
CALCULATE THE SUB-ELEMENT MODAL DENSITY
IS STIFFNESS REDUCTION REQUIRED ?
YES
REDUCE BY $\frac{1}{\sqrt{2}}$
NO
LOOP FOR EACH ANALYSIS FREQUENCY
EXIT
SUM TO THE ELEMENT MODAL DENSITY
SUM MASS TO THE ELEMENT MASS
IS THIS THE MAIN SUB-ELEMENT ?
NO
RETURN
YES
SET ELEMENT VALUES TO SUB-ELEMENT VALUES
SET FLAG TO INDICATE THAT FOLLOWING SUB-ELEMENTS ARE NOT MAIN
RETURN


4
ROOM
CALCULATE THE PARTIAL SUB-ELEMENT MODAL DENSITY
IS STIFFNESS REDUCTION REQUIRED ?
YES
REDUCE BY $\frac{1}{\sqrt{2}}$
NO
LOOP FOR EACH ANALYSIS FREQUENCY
EXIT
SUM MASS TO THE ELEMENT MASS
CALCULATE ANGULAR VELOCITY
IS THIS THE MAIN SUB-ELEMENT ?
NO
RETURN
YES
CALCULATE SUB-ELEMENT MODAL DENSITY
SET ELEMENT VALUES TO SUB-ELEMENT VALUES
SUM TO THE ELEMENT MODAL DENSITY
SET FLAG TO INDICATE THAT FOLLOWING SUB-ELEMENTS ARE NOT MAIN
RETURN

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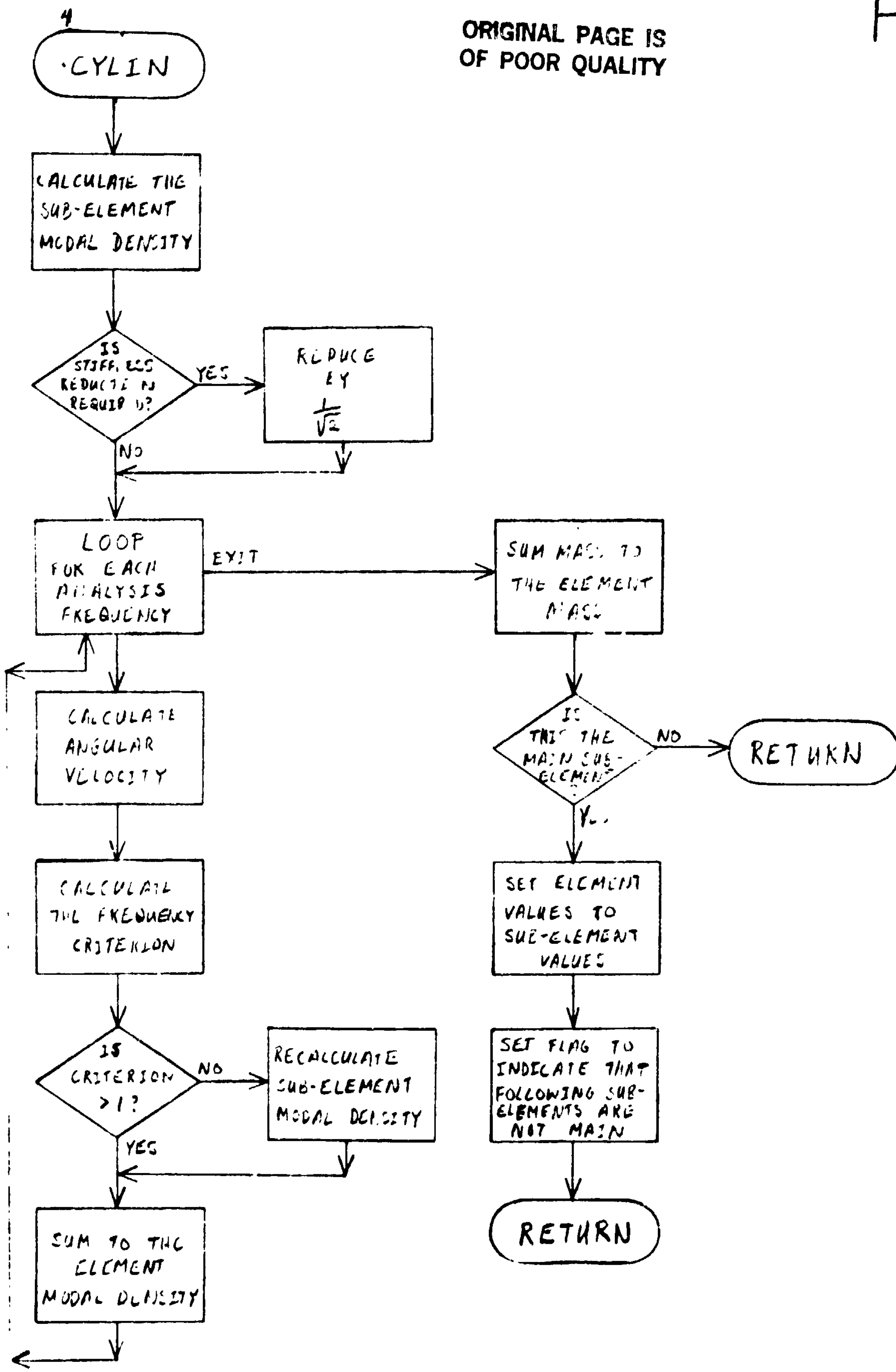
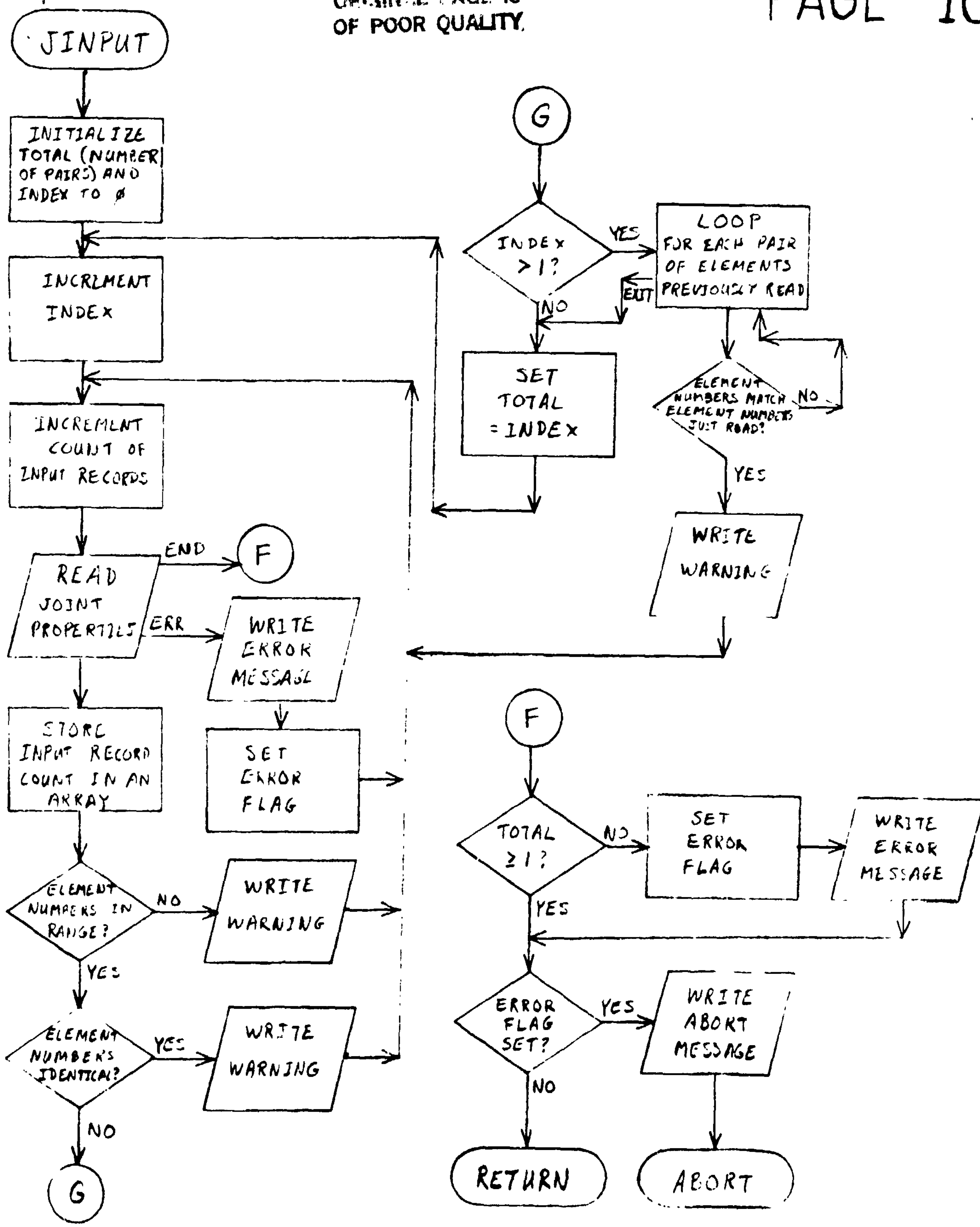
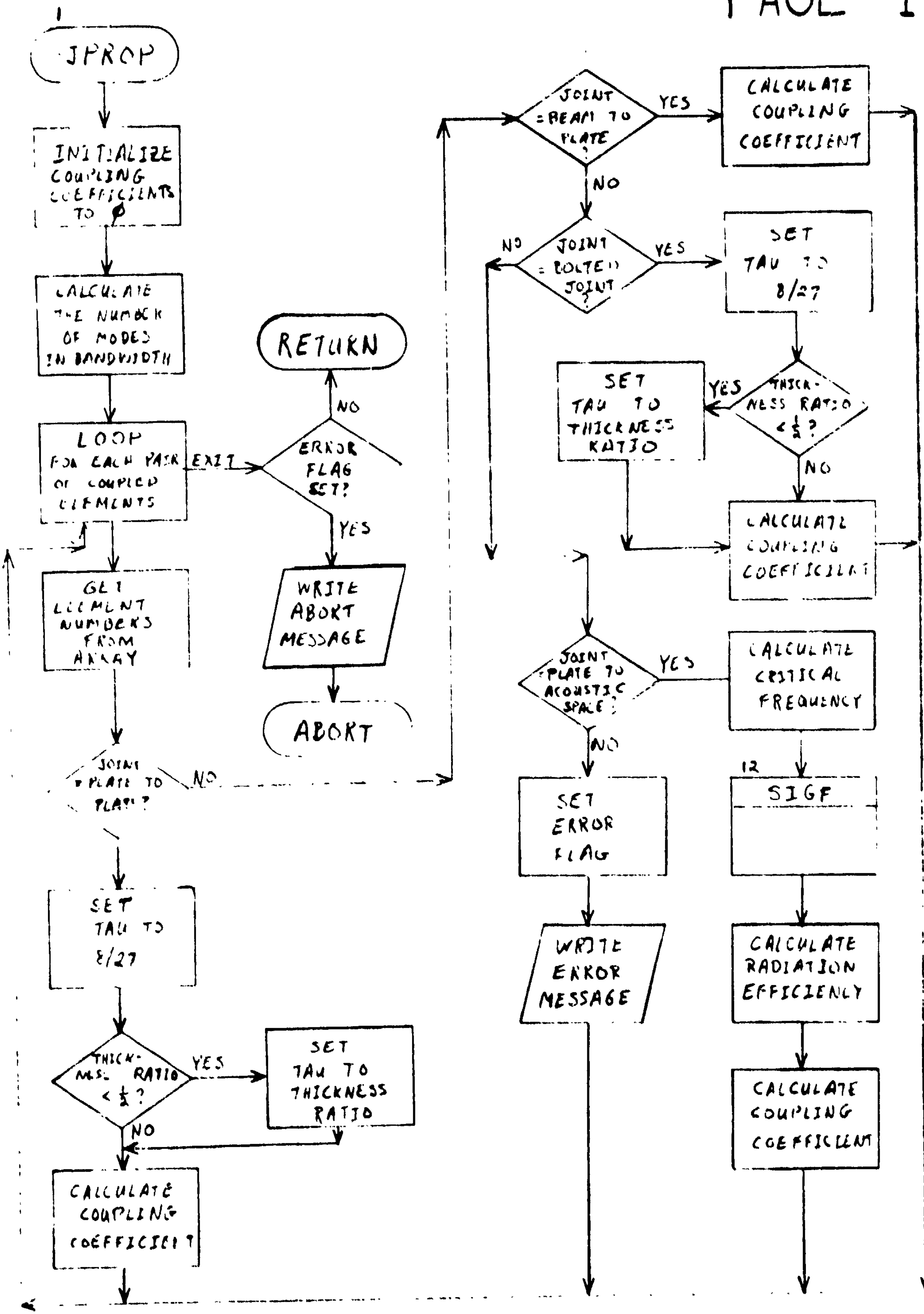
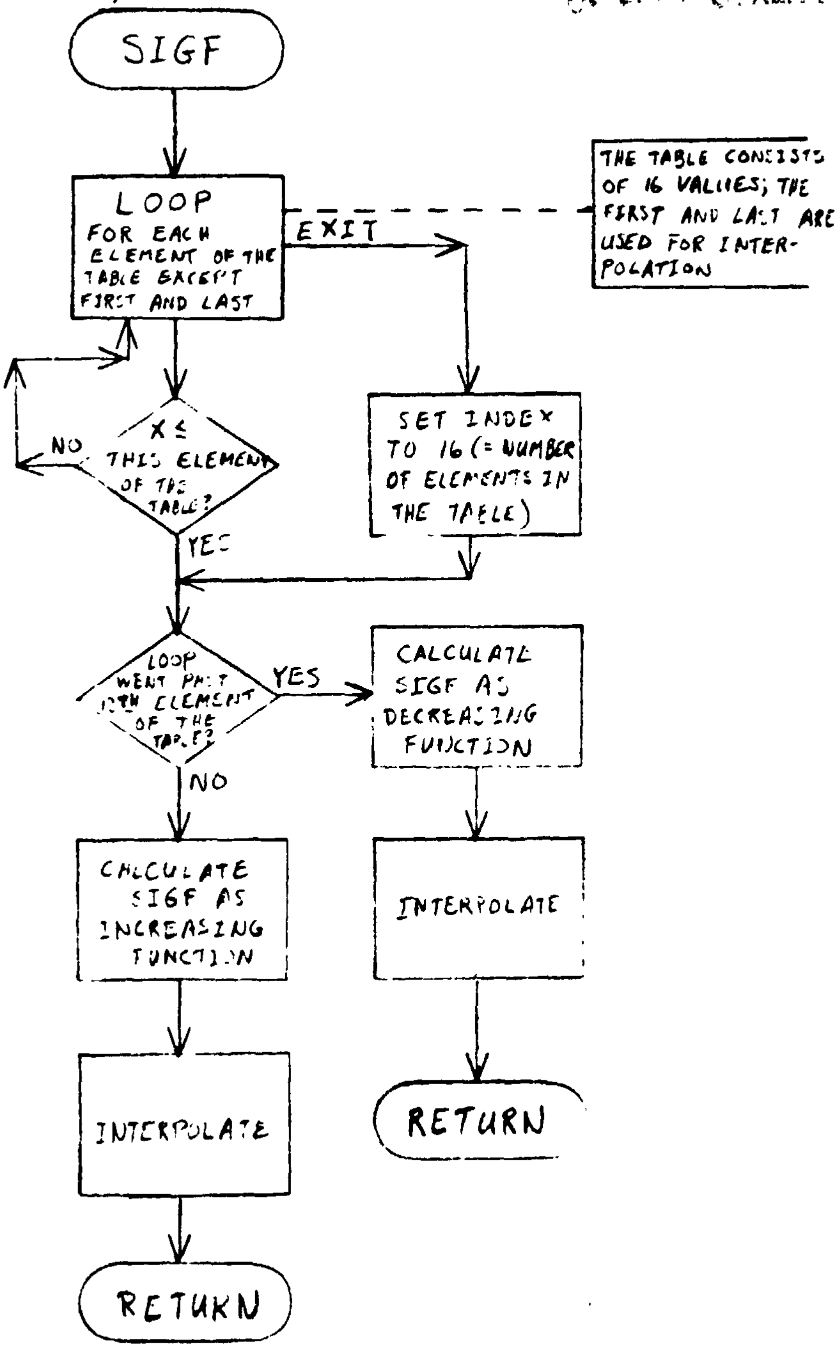


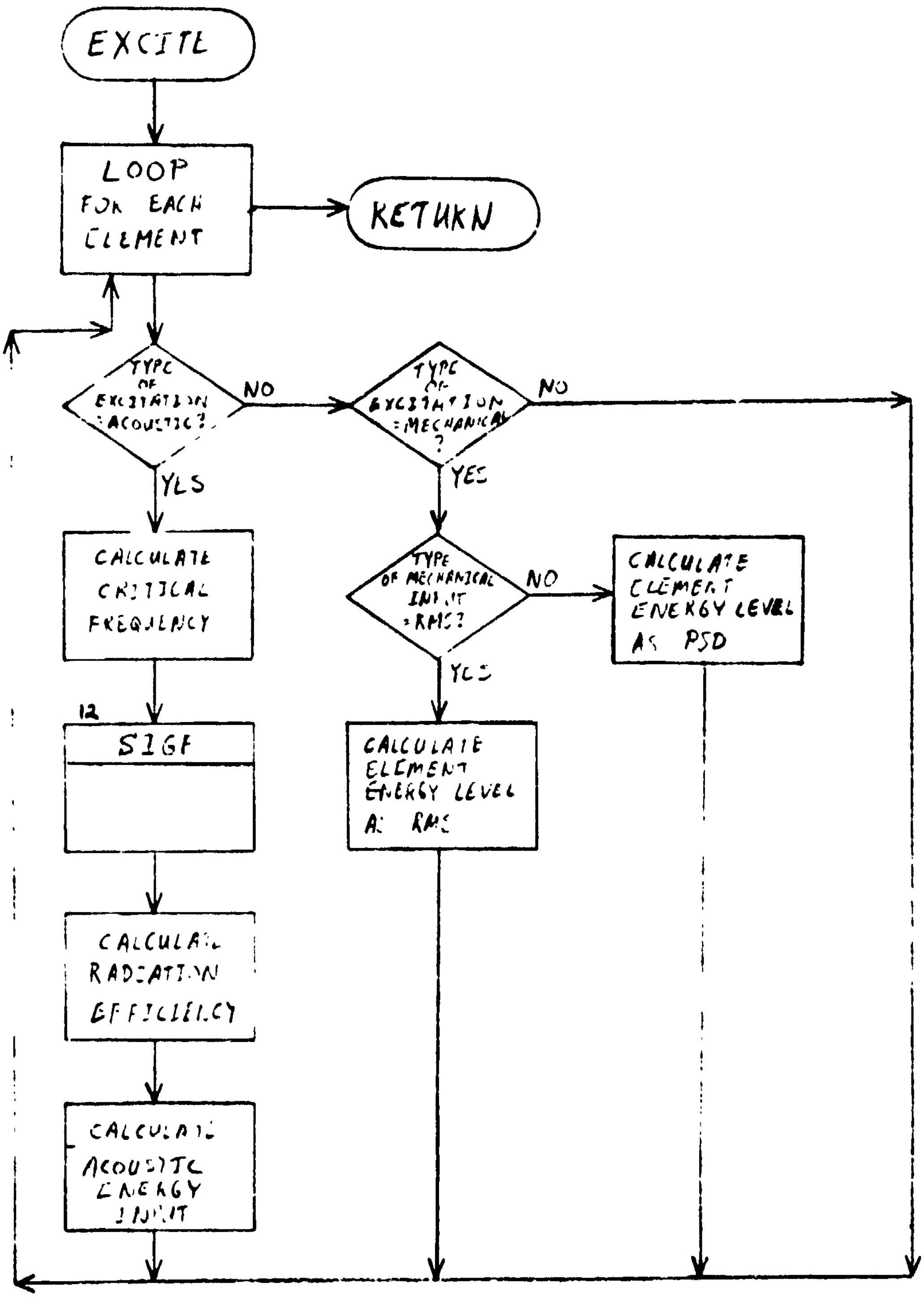

JINPUT
INITIALIZE TOTAL (NUMBER OF PAIRS) AND INDEX TO Ø
INCREMENT INDEX
INCREMENT COUNT OF INPUT RECORDS
READ JOINT PROPERTIES
END
F
ERR
WRITE ERROR MESSAGE
SET ERROR FLAG
STORE INPUT RECORD COUNT IN AN ARRAY
ELEMENT NUMBERS IN RANGE?
NO
WRITE WARNING
YES
ELEMENT NUMBERS IDENTICAL?
YES
WRITE WARNING
NO
G
G
INDEX > 1?
YES
LOOP FOR EACH PAIR OF ELEMENTS PREVIOUSLY READ
EXIT
NO
SET TOTAL = INDEX
ELEMENT NUMBERS MATCH ELEMENT NUMBERS JUST READ?
NO
YES
WRITE WARNING
F
TOTAL ≥ 1?
NO
SET ERROR FLAG
WRITE ERROR MESSAGE
YES
ERROR FLAG SET?
YES
WRITE ABORT MESSAGE
NO
RETURN
ABORT

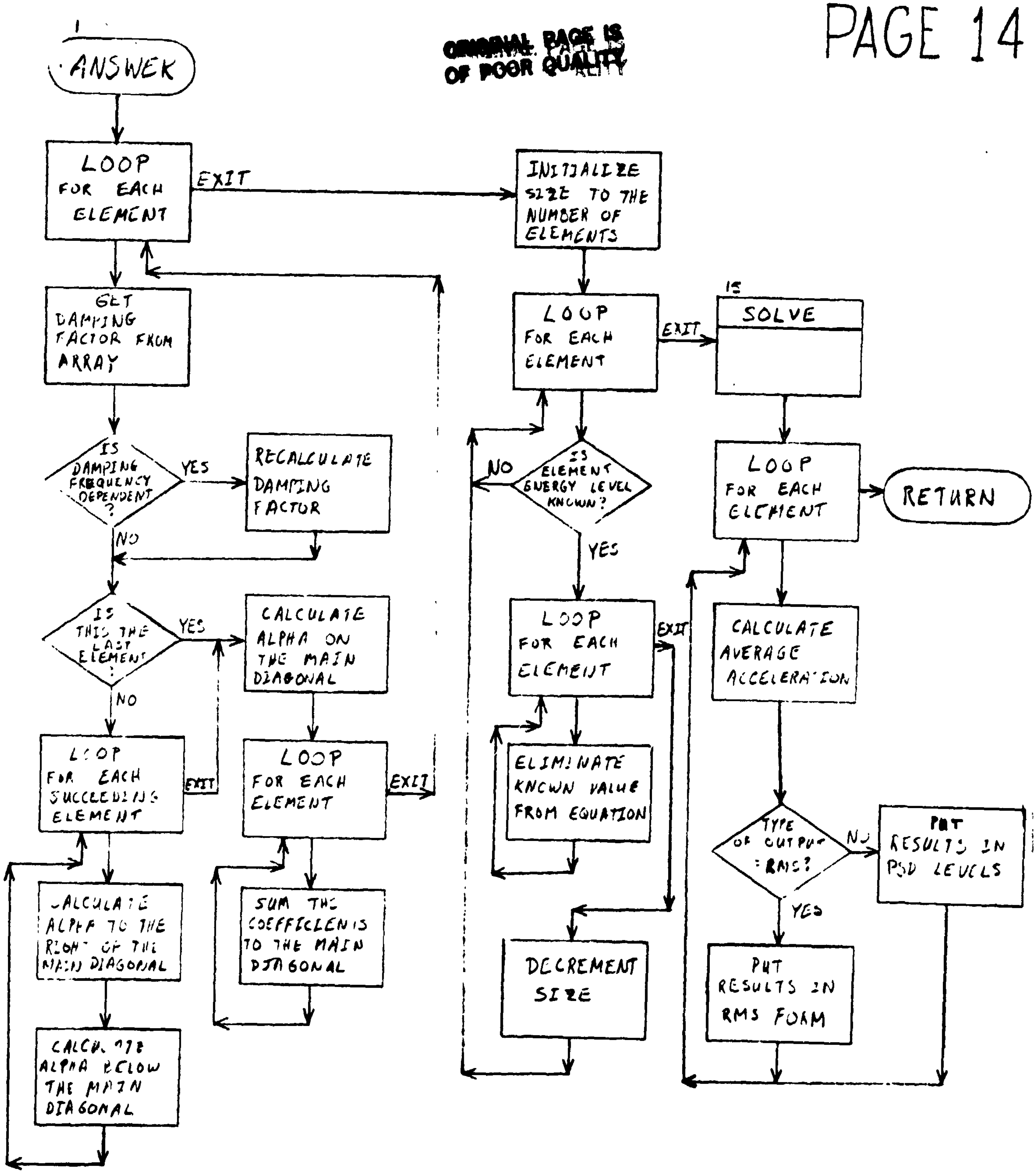


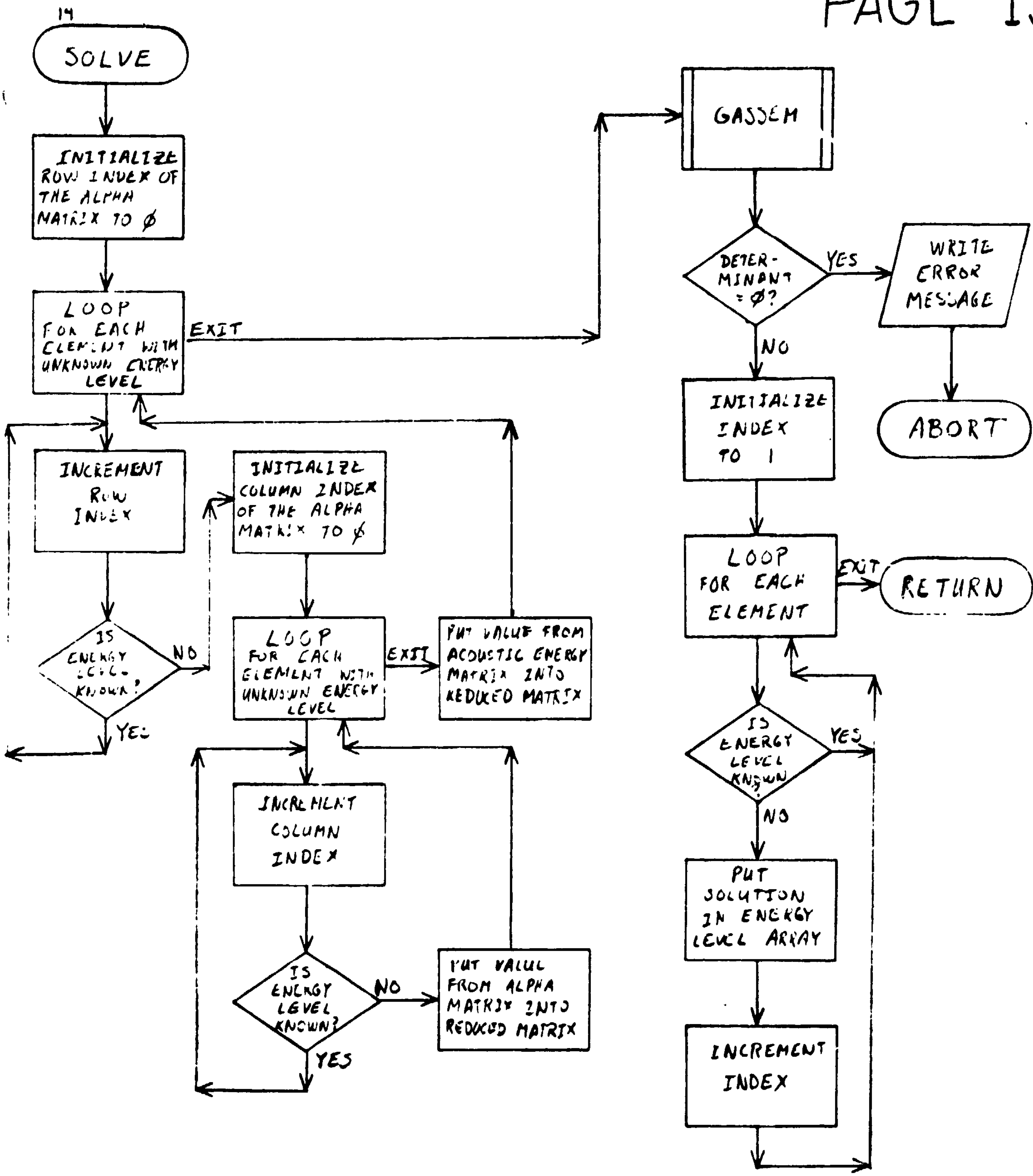
1
JPROP
INITIALIZE COUPLING COEFFICIENTS TO Ø
CALCULATE THE NUMBER OF MODES IN BANDWIDTH
LOOP FOR EACH PAIR OF COUPLED ELEMENTS
EXIT
ERROR FLAG SET?
NO
RETURN
YES
WRITE ABORT MESSAGE
ABORT
GET ELEMENT NUMBERS FROM ARRAY
JOINT = PLATE TO PLATE?
NO
SET TAU TO 8/27
THICKNESS RATIO < ½?
YES
SET TAU TO THICKNESS RATIO
NO
CALCULATE COUPLING COEFFICIENT
JOINT = BEAM TO PLATE?
YES
CALCULATE COUPLING COEFFICIENT
NO
JOINT = BOLTED JOINT?
NO
YES
SET TAU TO 8/27
THICKNESS RATIO < ½?
YES
SET TAU TO THICKNESS RATIO
NO
CALCULATE COUPLING COEFFICIENT
JOINT = PLATE TO ACOUSTIC SPACE?
YES
CALCULATE CRITICAL FREQUENCY
NO
SET ERROR FLAG
WRITE ERROR MESSAGE
12
SIGF
CALCULATE RADIATION EFFICIENCY
CALCULATE COUPLING COEFFICIENT

11,13.

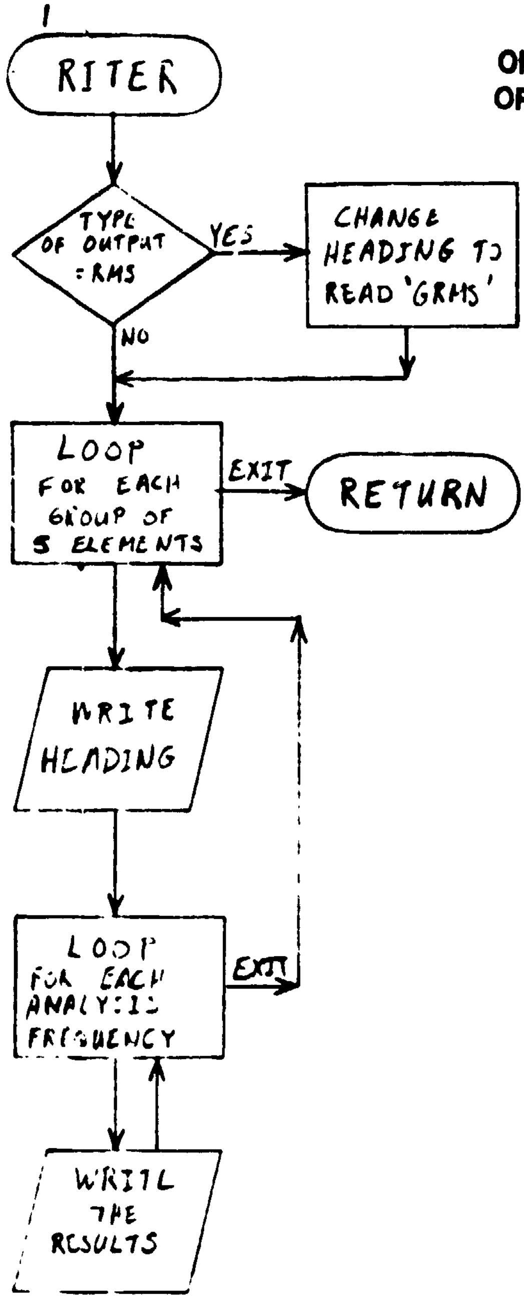

SIGF
LOOP
FOR EACH ELEMENT OF THE TABLE EXCEPT FIRST AND LAST
EXIT
THE TABLE CONSISTS OF 16 VALUES; THE FIRST AND LAST ARE USED FOR INTERPOLATION
NO
X ≤ THIS ELEMENT OF THE TABLE?
YES
SET INDEX TO 16 (= NUMBER OF ELEMENTS IN THE TABLE)
LOOP WENT PAST 12TH ELEMENT OF THE TABLE?
YES
CALCULATE SIGF AS DECREASING FUNCTION
NO
CALCULATE SIGF AS INCREASING FUNCTION
INTERPOLATE
INTERPOLATE
RETURN
RETURN


EXCITE
LOOP FOR EACH ELEMENT
RETURN
TYPE OF EXCITATION =ACOUSTIC?
NO
YES
TYPE OF EXCITATION =MECHANICAL ?
NO
YES
CALCULATE CRITICAL FREQUENCY
TYPE OF MECHANICAL INPUT =RMS?
NO
CALCULATE ELEMENT ENERGY LEVEL AS PSD
YES
12
SIGF
CALCULATE ELEMENT ENERGY LEVEL AS RMS
CALCULATE RADIATION EFFICIENCY
CALCULATE ACOUSTIC ENERGY INPUT


ANSWER
LOOP FOR EACH ELEMENT
EXIT
GET DAMPING FACTOR FROM ARRAY
IS DAMPING FREQUENCY DEPENDENT?
YES
RECALCULATE DAMPING FACTOR
NO
IS THIS THE LAST ELEMENT?
YES
CALCULATE ALPHA ON THE MAIN DIAGONAL
NO
LOOP FOR EACH SUCCEEDING ELEMENT
EXIT
LOOP FOR EACH ELEMENT
EXIT
CALCULATE ALPHA TO THE RIGHT OF THE MAIN DIAGONAL
SUM THE COEFFICIENTS TO THE MAIN DIAGONAL
CALCULATE ALPHA BELOW THE MAIN DIAGONAL
INITIALIZE SIZE TO THE NUMBER OF ELEMENTS
LOOP FOR EACH ELEMENT
EXIT
IS
SOLVE
NO
IS ELEMENT ENERGY LEVEL KNOWN?
YES
LOOP FOR EACH ELEMENT
EXIT
ELIMINATE KNOWN VALUE FROM EQUATION
DECREMENT SIZE
LOOP FOR EACH ELEMENT
RETURN
CALCULATE AVERAGE ACCELERATION
TYPE OF OUTPUT = RMS?
NO
PUT RESULTS IN PSD LEVELS
YES
PUT RESULTS IN RMS FORM


14
SOLVE
INITIALIZE ROW INDEX OF THE ALPHA MATRIX TO Ø
LOOP FOR EACH ELEMENT WITH UNKNOWN ENERGY LEVEL
EXIT
INCREMENT ROW INDEX
IS ENERGY LEVEL KNOWN?
NO
YES
INITIALIZE COLUMN INDEX OF THE ALPHA MATRIX TO Ø
LOOP FOR EACH ELEMENT WITH UNKNOWN ENERGY LEVEL
EXIT
PUT VALUE FROM ACOUSTIC ENERGY MATRIX INTO REDUCED MATRIX
INCREMENT COLUMN INDEX
IS ENERGY LEVEL KNOWN?
NO
YES
PUT VALUE FROM ALPHA MATRIX INTO REDUCED MATRIX
GASSEM
DETERMINANT = Ø?
YES
WRITE ERROR MESSAGE
ABORT
NO
INITIALIZE INDEX TO 1
LOOP FOR EACH ELEMENT
EXIT
RETURN
IS ENERGY LEVEL KNOWN?
YES
NO
PUT SOLUTION IN ENERGY LEVEL ARRAY
INCREMENT INDEX

ORIGINAL PAGE IS
OF POOR QUALITY



Appendix III

SEA PROGRAM INPUT LIST

MATERIALS EXPERIMENT ASSEMBLY - EXAMPLE 2

ORIGINAL PAGE IS
OF POOR QUALITY

```
                 STATISTICAL ENERGY ANALYSIS OF COMPLEX STRUCTURES

RECORD
NUMBER               DATA READ FROM UNIT 3
------               --------------------

   1      NUMBER OF ELEMENTS =  6
          NUMBER OF ANALYSIS FREQUENCIES = 23
          FIRST ANALYSIS FREQUENCY =  3.15000E+01
          TYPE OF UNITS =
          TYPE OF OUTPUT = PSD
   2      ELEMENT NUMBER =  1
          NUMBER OF SUB-ELEMENTS = 20
          TYPE OF EXCITATION = A
          TYPE OF MECHANICAL INPUT =
          DAMPING =  1.00000E-02
          SLOPE =  0.
          STARTING FREQUENCY =  0.
                     SOUND PRESSURE LEVELS
   3           1.20000E+02   1.22000E+02   1.24000E+02   1.26000E+02
               1.28000E+02   1.30000E+02   1.32000E+02   1.33000E+02
   4           1.34500E+02   1.35000E+02   1.35000E+02   1.35000E+02
               1.35000E+02   1.33000E+02   1.31000E+02   1.27000E+02
   5           1.26000E+02   1.25000E+02   1.23000E+02   1.21000E+02
               1.19000E+02   1.17000E+02   1.15000E+02   0.
   6           SUB-ELEMENT NUMBER =  1
               TYPE OF SUB-ELEMENT = P
               DENSITY =  2.61700E-04
               MODULUS OF ELASTICITY =  1.00000E+07
               THICKNESS =  3.70000E-02
               AREA =  2.35670E+04
               POISSONS RATIO =  3.30000E-01
               LENGTH =  0.
               PRESSURE =  0.
   7           STIFFNESS REDUCTION REQUIRED = F
               RADIUS =  0.
               VOLUME =  0.
               SPEED OF SOUND IN ROOM MEDIUM =  1.34000E+04
               ADDED MASS =  6.49000E-01
   8           SUB-ELEMENT NUMBER =  2
               TYPE OF SUB-ELEMENT = P
               DENSITY =  2.61700E-04
               MODULUS OF ELASTICITY =  1.00000E+07
               THICKNESS =  1.90000E-01
               AREA =  2.16500E+02
               POISSONS RATIC =  3.30000E-01
               LENGTH =  0.
               PRESSURE =  0.
   9           STIFFNESS REDUCTION REQUIRED = F
               RADIUS =  0.
               VOLUME =  0.
               SPEED OF SOUND IN ROOM MEDIUM =  0.
               ADDED MASS =  0.
  10           SUB-ELEMENT NUMBER =  3
               TYPE OF SUB-ELEMENT = P
               DENSITY =  2.61700E-04
               MODULUS OF ELASTICITY =  1.00000E+07
               THICKNESS =  9.50000E-02
               AREA =  3.31200E+03
               POISSONS RATIC =  3.30000E-01
```

LENGTH = 0.
PRESSURE = 0.
11 STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = 0.
ADDED MASS = 0.
12 SUB-ELEMENT NUMBER = 4
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 2.50000E-01
AREA = 6.90000E+02
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
13 STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = 0.
ADDED MASS = 0.
14 SUB-ELEMENT NUMBER = 5
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 9.50000E-02
AREA = 3.93000E+03
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
15 STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = 0.
ADDED MASS = 0.
16 SUB-ELEMENT NUMBER = 6
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 2.50000E-01
AREA = 1.22813E+03
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
17 STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = 0.
ADDED MASS = 0.
18 SUB-ELEMENT NUMBER = 7
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 2.00000E-01
AREA = 1.74720E+03
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
19 STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = 0.
ADDED MASS = 0.
20 SUB-ELEMENT NUMBER = 8
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04

```
         MODULUS OF ELASTICITY =  1.00000E+07
         THICKNESS =  4.64000E-02
         AREA =  2.84637E+03
         POISSONS RATIC =  3.30000E-01
         LENGTH =  0.
         PRESSURE =  0.
21       STIFFNESS REDUCTION REQUIRED = F
         RADIUS =  0.
         VOLUME =  0.
         SPEED OF SOUND IN ROOM MEDIUM =  C.
         ADDED MASS =  0.
22       SUB-ELEMENT NUMBER =  9
         TYPE OF SUB-ELEMENT = P
         DENSITY =  2.61700E-04
         MODULUS OF ELASTICITY =  1.00000E+07
         THICKNESS =  1.25000E-01
         AREA =  7.47320E+02
         POISSONS RATIC =  3.30000E-01
         LENGTH =  0.
         PRESSURE =  0.
23       STIFFNESS REDUCTION REQUIRED = F
         RADIUS =  0.
         VOLUME =  0.
         SPEED OF SOUND IN ROOM MEDIUM =  C.
         ADDED MASS =  0.
24       SUB-ELEMENT NUMBER = 10
         TYPE OF SUB-ELEMENT = P
         DENSITY =  2.61700E-04
         MODULUS OF ELASTICITY =  1.00000E+07
         THICKNESS =  5.62000E-01
         AREA =  6.00000E+01
         POISSONS RATIC =  3.30000E-01
         LENGTH =  0.
         PRESSURE =  0.
25       STIFFNESS REDUCTION REQUIRED = F
         RADIUS =  0.
         VOLUME =  0.
         SPEED OF SOUND IN ROOM MEDIUM =  C.
         ADDED MASS =  0.
26       SUB-ELEMENT NUMBER = 11
         TYPE OF SUB-ELEMENT = P
         DENSITY =  2.61700E-04
         MODULUS OF ELASTICITY =  1.00000E+07
         THICKNESS =  2.50000E-01
         AREA =  1.65920E+03
         POISSONS RATIC =  3.30000E-01
         LENGTH =  0.
         PRESSURE =  0.
27       STIFFNESS REDUCTION REQUIRED = F
         RADIUS =  0.
         VOLUME =  0.
         SPEED OF SOUND IN ROOM MEDIUM =  C.
         ADDED MASS =  0.
28       SUB-ELEMENT NUMBER = 12
         TYPE OF SUB-ELEMENT = P
         DENSITY =  2.61700E-04
         MODULUS OF ELASTICITY =  1.00000E+07
         THICKNESS =  3.75000E-01
         AREA =  5.00000E+01
         POISSONS RATIC =  3.30000E-01
         LENGTH =  0.
         PRESSURE =  0.
29       STIFFNESS REDUCTION REQUIRED = F
         RADIUS =  0.
         VOLUME =  0.
         SPEED OF SOUND IN ROOM MEDIUM =  C.
```

ADDED MASS = 0.
30 SUB-ELEMENT NUMBER = 13
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 1.90000E-01
AREA = 3.54160E+02
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
31 STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 0.
32 SUB-ELEMENT NUMBER = 14
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 1.50000E-01
AREA = 7.36200E+02
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
33 STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 0.
34 SUB-ELEMENT NUMBER = 15
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 2.00000E-01
AREA = 1.98000E+02
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
35 STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 0.
36 SUB-ELEMENT NUMBER = 16
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 2.50000E-01
AREA = 1.07100E+02
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
37 STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 0.
38 SUB-ELEMENT NUMBER = 17
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 1.90000E-01
AREA = 7.91500E+01
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.

```
39          STIFFNESS REDUCTION REQUIRED = F
            RADIUS =  0.
            VOLUME =  0.
            SPEED OF SOUND IN ROOM MEDIUM =  C.
            ADDED MASS =  0.
40          SUB-ELEMENT NUMBER = 18
            TYPE OF SUB-ELEMENT = P
            DENSITY =  2.61700E-04
            MODULUS OF ELASTICITY =  1.00000E+07
            THICKNESS =  2.50000E-01
            AREA =  1.?1800E+01
            POISSONS RATIO =  3.30000E-01
            LENGTH =  0.
            PRESSURE =  0.
41          STIFFNESS REDUCTION REQUIRED = F
            RADIUS =  0.
            VOLUME =  0.
            SPEED OF SOUND IN ROOM MEDIUM =  C.
            ADDED MASS =  0.
42          SUB-ELEMENT NUMBER = 19
            TYPE OF SUB-ELEMENT = P
            DENSITY =  2.61700E-04
            MODULUS OF ELASTICITY =  1.00000E+07
            THICKNESS =  2.00000E-01
            AREA =  1.55250E+01
            POISSONS RATIO =  3.30000E-01
            LENGTH =  0.
            PRESSURE =  0.
43          STIFFNESS REDUCTION REQUIRED = F
            RADIUS =  0.
            VOLUME =  0.
            SPEED OF SOUND IN ROOM MEDIUM =  C.
            ADDED MASS =  0.
44          SUB-ELEMENT NUMBER = 20
            TYPE OF SUB-ELEMENT = P
            DENSITY =  2.61700E-04
            MODULUS OF ELASTICITY =  1.00000E+07
            THICKNESS =  1.90000E-01
            AREA =  1.16476E+03
            POISSONS RATIO =  3.30000E-01
            LENGTH =  0.
            PRESSURE =  0.
45          STIFFNESS REDUCTION REQUIRED = T
            RADIUS =  0.
            VOLUME =  0.
            SPEED OF SOUND IN ROOM MEDIUM =  C.
            ADDED MASS =  0.
46      ELEMENT NUMBER =  2
        NUMBER OF SUB-ELEMENTS =  4
        TYPE OF EXCITATION =
        TYPE OF MECHANICAL INPUT =
        DAMPING =  1.00000E-02
        SLOPE = -8.30480E-01
        STARTING FREQUENCY =  2.50000E+02
47          SUB-ELEMENT NUMBER =  1
            TYPE OF SUB-ELEMENT = P
            DENSITY =  2.61700E-04
            MODULUS OF ELASTICITY =  1.00000E+07
            THICKNESS =  1.90000E-01
            AREA =  3.54160E+02
            POISSONS RATIO =  3.30000E-01
            LENGTH =  0.
            PRESSURE =  0.
48          STIFFNESS REDUCTION REQUIRED = F
            RADIUS =  0.
            VOLUME =  0.
```

```
                SPEED OF SOUND IN ROOM MEDIUM =  C.
                ADDED MASS =  8.60000E-03
49              SUB-ELEMENT NUMBER =  2
                TYPE OF SUB-ELEMENT = P
                DENSITY =  2.61700E-04
                MODULUS OF ELASTICITY =  1.00000E+07
                THICKNESS =  1.50000E-01
                AREA =  7.36000E+02
                POISSONS RATIC =  3.30000E-01
                LENGTH =  0.
                PRESSURE =  0.
50              STIFFNESS REDUCTION REQJIRED = F
                RADIUS =  0.
                VOLUME =  0.
                SPEED OF SOUND IN ROOM MEDIUM =  C.
                ADDED MASS =  0.
51              SUB-ELEMENT NUMBER =  3
                TYPE OF SUB-ELEMENT = P
                DENSITY =  2.61700E-04
                MODULUS OF ELASTICITY =  1.00000E+07
                THICKNESS =  2.00000E-01
                AREA =  1.98000E+02
                POISSONS RATIO =  3.30000E-01
                LENGTH =  0.
                PRESSURE =  0.
52              STIFFNESS REDUCTION REQUIRED = F
                RADIUS =  0.
                VOLUME =  0.
                SPEED OF SOUND IN ROOM MEDIUM =  C.
                ADDED MASS =  0.
53              SUB-ELEMENT NUMBER =  4
                TYPE OF SUB-ELEMENT = P
                DENSITY =  2.61700E-04
                MODULUS OF ELASTICITY =  1.00000E+07
                THICKNESS =  2.50000E-01
                AREA =  1.07100E+02
                POISSONS RATIC =  3.30000E-01
                LENGTH =  0.
                PRESSURE =  0.
54              STIFFNESS REDUCTION REQUIRED = F
                RADIUS =  0.
                VOLUME =  0.
                SPEED OF SOUND IN ROOM MEDIUM =  C.
                ADDED MASS =  0.
55          ELEMENT NUMBER =  3
            NUMBER OF SUB-ELEMENTS =  3
            TYPE OF EXCITATION =
            TYPE OF MECHANICAL INPUT =
            DAMPING =  1.00000E-02
            SLOPE = -8.30480E-01
            STARTING FREQUENCY =  2.50000E+02
56              SUB-ELEMENT NUMBER =  1
                TYPE OF SUB-ELEMENT = P
                DENSITY =  2.61700E-04
                MODULUS OF ELASTICITY =  1.00000E+07
                THICKNESS =  6.50000E-01
                AREA =  8.76300E+01
                POISSONS RATIC =  3.30000E-01
                LENGTH =  0.
                PRESSURE =  0.
57              STIFFNESS REDUCTION REQUIRED = T
                RADIUS =  0.
                VOLUME =  0.
                SPEED OF SOUND IN ROOM MEDIUM =  C.
                ADDED MASS =  1.44800E-01
58              SUB-ELEMENT NUMBER =  2
```

```
          TYPE OF SUB-ELEMENT = P
          DENSITY =  2.61700E-04
          MODULUS OF ELASTICITY =  1.00000E+07
          THICKNESS =  3.50000E-01
          AREA =  9.16700E+01
          POISSONS RATIC =  3.30000E-01
          LENGTH =  0.
          PRESSURE =  0.
59        STIFFNESS REDUCTION REQUIRED = T
          RADIUS =  0.
          VOLUME =  0.
          SPEED OF SOUND IN ROOM MEDIUM =  C.
          ADDED MASS =  0.
60        SUB-ELEMENT NUMBER =  3
          TYPE OF SUB-ELEMENT = P
          DENSITY =  2.61700E-04
          MODULUS OF ELASTICITY =  1.00000E+07
          THICKNESS =  7.00000E-01
          AREA =  6.21920E+02
          POISSONS RATIO =  3.30000E-01
          LENGTH =  0.
          PRESSURE =  0.
61        STIFFNESS REDUCTION REQUIRED = T
          RADIUS =  0.
          VOLUME =  0.
          SPEED OF SOUND IN ROOM MEDIUM =  C.
          ADDED MASS =  0.
62    ELEMENT NUMBER =  4
      NUMBER OF SUB-ELEMENTS =  1
      TYPE OF EXCITATION =
      TYPE OF MECHANICAL INPUT =
      DAMPING =  1.00000E-02
      SLOPE = -8.30480E-01
      STARTING FREQUENCY =  2.50000E+02
63        SUB-ELEMENT NUMBER =  1
          TYPE OF SUB-ELEMENT = P
          DENSITY =  2.61700E-04
          MODULUS OF ELASTICITY =  1.00000E+07
          THICKNESS =  2.50000E-01
          AREA =  7.05440E+02
          POISSONS RATIC =  3.30000E-01
          LENGTH =  0.
          PRESSURE =  0.
64        STIFFNESS REDUCTION REQUIRED = T
          RADIUS =  0.
          VOLUME =  0.
          SPEED OF SOUND IN ROOM MEDIUM =  C.
          ADDED MASS =  2.27000E-02
65    ELEMENT NUMBER =  5
      NUMBER OF SUB-ELEMENTS =  3
      TYPE OF EXCITATION =
      TYPE OF MECHANICAL INPUT =
      DAMPING =  1.00000E-02
      SLOPE = -8.30480E-01
      STARTING FREQUENCY =  2.50000E+02
66        SUB-ELEMENT NUMBER =  1
          TYPE OF SUB-ELEMENT = P
          DENSITY =  2.61700E-04
          MODULUS OF ELASTICITY =  1.00000E+07
          THICKNESS =  6.50000E-01
          AREA =  8.76300E+01
          POISSONS RATIC =  3.30000E-01
          LENGTH =  0.
          PRESSURE =  0.
67        STIFFNESS REDUCTION REQUIRED = T
          RADIUS =  0.
```

```
          VOLUME =  0.
          SPEED OF SOUND IN ROOM MEDIUM =  C.
          ADDED MASS =  1.58790E+00
68        SUB-ELEMENT NUMBER =  2
          TYPE OF SUB-ELEMENT = P
          DENSITY =  2.61700E-04
          MODULUS OF ELASTICITY =  1.00000E+07
          THICKNESS =  3.50000E-01
          AREA =  1.09960E+02
          POISSONS RATIO =  3.30000E-01
          LENGTH =  0.
          PRESSURE =  0.
69        STIFFNESS REDUCTION REQUIRED = T
          RADIUS =  0.
          VOLUME =  0.
          SPEED OF SOUND IN ROOM MEDIUM =  C.
          ADDED MASS =  0.
70        SUB-ELEMENT NUMBER =  3
          TYPE OF SUB-ELEMENT = P
          DENSITY =  2.61700E-04
          MODULUS OF ELASTICITY =  1.00000E+07
          THICKNESS =  7.00000E-01
          AREA =  6.71110E+02
          POISSONS RATIO =  3.30000E-01
          LENGTH =  0.
          PRESSURE =  0.
71        STIFFNESS REDUCTION REQUIRED = T
          RADIUS =  0.
          VOLUME =  0.
          SPEED OF SOUND IN ROOM MEDIUM =  C.
          ADDED MASS =  0.
72     ELEMENT NUMBER =  6
       NUMBER OF SUB-ELEMENTS =  2
       TYPE OF EXCITATION =
       TYPE OF MECHANICAL INPUT =
       DAMPING =  1.00000E-02
       SLOPE = -8.30480E-01
       STARTING FREQUENCY =  2.50000E+02
73        SUB-ELEMENT NUMBER =  1
          TYPE OF SUB-ELEMENT = P
          DENSITY =  2.61700E-04
          MODULUS OF ELASTICITY =  1.00000E+07
          THICKNESS =  5.00000E-01
          AREA =  7.26800E+02
          POISSONS RATIO =  3.30000E-01
          LENGTH =  0.
          PRESSURE =  0.
74        STIFFNESS REDUCTION REQUIRED = T
          RADIUS =  0.
          VOLUME =  0.
          SPEED OF SOUND IN ROOM MEDIUM =  C.
          ADDED MASS =  1.30320E+00
75        SUB-ELEMENT NUMBER =  2
          TYPE OF SUB-ELEMENT = P
          DENSITY =  2.61700E-04
          MODULUS OF ELASTICITY =  1.00000E+07
          THICKNESS =  3.75000E-01
          AREA =  7.26800E+02
          POISSONS RATIO =  3.30000E-01
          LENGTH =  0.
          PRESSURE =  0.
76        STIFFNESS REDUCTION REQUIRED = T
          RADIUS =  0.
          VOLUME =  0.
          SPEED OF SOUND IN ROOM MEDIUM =  C.
          ADDED MASS =  0.
```

CENTER FREQ(HZ)	MODAL DENSITY - MODES/(RAD/SEC) ELEMENT 1	ELEMENT 2	ELEMENT 3	ELEMENT 4
31.50	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
39.38	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
50.40	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
63.00	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
78.75	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
99.23	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
126.00	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
157.50	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
196.45	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
252.00	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
315.00	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
393.75	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
504.00	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
630.00	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
787.50	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
992.25	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
1260.00	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
1575.00	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
1984.50	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
2520.00	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
3150.00	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
3937.50	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03
5040.00	1.08892E+00	1.09014E-02	1.20975E-03	2.65614E-03

CENTER FREQ(HZ)	MODAL DENSITY - MODES/(RAD/SEC) ELEMENT 5	ELEMENT 6
31.50	1.32509E-03	3.19266E-03
39.38	1.32509E-03	3.19266E-03
50.40	1.32509E-03	3.19266E-03
63.00	1.32509E-03	3.19266E-03
78.75	1.32509E-03	3.19266E-03
99.23	1.32509E-03	3.19266E-03
126.00	1.32509E-03	3.19266E-03
157.50	1.32509E-03	3.19266E-03
198.45	1.32509E-03	3.19266E-03
252.00	1.32509E-03	3.19266E-03
315.00	1.32509E-03	3.19266E-03
393.75	1.32509E-03	3.19266E-03
504.00	1.32509E-03	3.19266E-03
630.00	1.32509E-03	3.19266E-03
787.50	1.32509E-03	3.19266E-03
992.25	1.32509E-03	3.19266E-03
1260.00	1.32509E-03	3.19266E-03
1575.00	1.32509E-03	3.19266E-03
1984.50	1.32509E-03	3.19266E-03
2520.00	1.32509E-03	3.19266E-03
3150.00	1.32509E-03	3.19266E-03
3937.50	1.32509E-03	3.19266E-03
5040.00	1.32509E-03	3.19266E-03

RECORD NUMBER — DATA READ FROM UNIT 3

77 FIRST ELEMENT = 1
SECOND ELEMENT = 2
TYPE OF JOINT = BJ
NUMBER OF SIDES = 0

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     JOINT LENGTH =  7.06700E+01
     THICKNESS OF FIRST ELEMENT =  2.50000E-01
     THICKNESS OF SECOND ELEMENT =  1.90000E-01
     ACOUSTIC SPACE DENSITY =  0.
     BEAM LENGTH =  0.
     INSERTION LOSS FACTOR =  1.00000E+02
76   FIRST ELEMENT =  1
     SECOND ELEMENT =  3
     TYPE OF JOINT = BJ
     NUMBER OF SIDES =  0
     JOINT LENGTH =  1.23840E+02
     THICKNESS OF FIRST ELEMENT =  2.50000E-01
     THICKNESS OF SECOND ELEMENT =  7.00000E-01
     ACOUSTIC SPACE DENSITY =  0.
     BEAM LENGTH =  0.
     INSERTION LOSS FACTOR =  1.00000E+02
79   FIRST ELEMENT =  1
     SECOND ELEMENT =  4
     TYPE OF JOINT = BJ
     NUMBER OF SIDES =  0
     JOINT LENGTH =  4.00000E+00
     THICKNESS OF FIRST ELEMENT =  2.50000E-01
     THICKNESS OF SECOND ELEMENT =  2.50000E-01
     ACOUSTIC SPACE DENSITY =  0.
     BEAM LENGTH =  0.
     INSERTION LOSS FACTOR =  1.00000E+02
80   FIRST ELEMENT =  4
     SECOND ELEMENT =  3
     TYPE OF JOINT = PP
     NUMBER OF SIDES =  0
     JOINT LENGTH =  1.87600E+01
     THICKNESS OF FIRST ELEMENT =  7.00000E-01
     THICKNESS OF SECOND ELEMENT =  2.50000E-01
     ACOUSTIC SPACE DENSITY =  0.
     BEAM LENGTH =  0.
     INSERTION LOSS FACTOR =  0.
81   FIRST ELEMENT =  1
     SECOND ELEMENT =  5
     TYPE OF JOINT = BJ
     NUMBER OF SIDES =  0
     JOINT LENGTH =  1.08840E+02
     THICKNESS OF FIRST ELEMENT =  2.50000E-01
     THICKNESS OF SECOND ELEMENT =  7.00000E-01
     ACOUSTIC SPACE DENSITY =  0.
     BEAM LENGTH =  0.
     INSERTION LOSS FACTOR =  1.00000E+02
82   FIRST ELEMENT =  1
     SECOND ELEMENT =  6
     TYPE OF JOINT = BJ
     NUMBER OF SIDES =  0
     JOINT LENGTH =  2.67500E+02
     THICKNESS OF FIRST ELEMENT =  2.50000E-01
     THICKNESS OF SECOND ELEMENT =  3.45000E-01
     ACOUSTIC SPACE DENSITY =  0.
     BEAM LENGTH =  0.
     INSERTION LOSS FACTOR =  1.00000E+02
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