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FOR SAFEGUARD TSE SYSTEMS AND EQUIPMENT.

(9) Final rept.

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SHOCK ISOLATION

DESIGN MANUAL

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Total number of pages in this manual is 619, consisting of the following:

Page No.	Change No. & Date
Title	0 - 1 Aug. 73
A	0 - 1 Aug. 73
Foreword	0 - 1 Aug. 73
i thru viii	0 - 1 Aug. 73
1-1	0 - 1 Aug. 73
1-2 Blank	0 - 1 Aug. 73
1-3 thru 1-161	0 - 1 Aug. 73
1-162 Blank	0 - 1 Aug. 73
2-1	0 - 1 Aug. 73
2-2 Blank	0 - 1 Aug. 73
2-3 thru 2-86	0 - 1 Aug. 73
3-1 thru 3-131	0 - 1 Aug. 73
3-132 Blank	0 - 1 Aug. 73
3-133 thru 3-152	0 - 1 Aug. 73
4-1 thru 4-208	0 - 1 Aug. 73

Zero in the No. column indicates an original page.

FOREWORD

The design analysis procedures of shock isolation systems to protect equipment within hardened structures are presented in the manual by the use of two computer programs, ISIP and ISIP2. ISIP is formulated on the basis of considering the shock isolation platform and the equipment on it as a rigid body six-degree-of-freedom system having large response amplitudes. ISIP2 is capable of analyzing shock isolation systems having relatively flexible platforms. Both ISIP and ISIP 2 accept acceleration-time history excitation. For a given shock spectrum, one of the subprograms, WAVSYN, synthesizes the required excitation as the first step toward problem solution. The guidelines for the selection of using ISIP or ISIP2 are provided.

The manual is divided into four parts as follows: Part I, Design and Theoretical Considerations; Part II, User's Instructions For Computer Programs; Part III, ISIP and ISIP2 Program Listings; and Part IV, Examples.

The manual is a consolidation from several previous studies on shock isolation design analysis under the direction of the Huntsville Division, Corps of Engineers. Much of the information in Part I and Part II is extracted from "Development of Standard Design Specifications and Techniques for Shock Isolation Systems", Vols I, II and III (SAF-37) prepared by the Ralph M. Parsons Company. The material in Part III and Part IV is based on a report (SP-232-0594) prepared by the Space Support Division of Sperry Rand Corporation, Huntsville, Alabama.

TABLE OF CONTENTS

		Page
FOREWORD		
TABLE OF CONTENTS		i
LIST OF ILLUSTRATIONS		vi
LIST OF TABLES		viii
PART I:	DESIGN AND THEORETICAL CONSIDERATIONS	1-1
SECTION 1:	INTRODUCTION	1-3
1.1	Basis for Study	1-3
1.2	Background	1-3
1.3	Scope of Study	1-5
1.4	Prerequisite	1-5
1.5	Manual Contents	1-6
SECTION 2:	DESIGN CONSIDERATIONS	1-7
2.1	Design Process	1-7
2.1.1	Requirement for Shock Mounting	1-7
2.1.2	Performance Objectives	1-17
2.1.3	Selection of Configuration	1-19
2.1.4	Design Verification	1-21
2.2	Design and Analysis Requirements Summary	1-24
2.2.1	General	1-24
2.2.2	Performance	1-24
2.2.3	Design Details	1-25
2.2.4	Analysis Requirements	1-29
2.2.5	Analysis Procedures	1-30
SECTION 3:	SHOCK ISOLATION DESIGN FUNDAMENTAL	1-35
3.1	System Configuration Criteria	1-35
3.1.1	Optimum System	1-35
3.1.2	The Balanced System	1-35
3.1.3	Equipment Arrangement	1-45
3.2	Isolation System Hardware	1-49
3.2.1	Scope	1-49
3.2.2	Configuration Development	1-50
3.2.3	Suspension Arrangements	1-51

TABLE OF CONTENTS (Continued)

		Page
3.2.4	Platform Design	1-56
3.2.5	Elastic and Energy Dissipative Components	1-59
3.2.6	Connections	1-73
3.2.7	Attachments	1-75
3.2.8	Two Special Base Mounted Isolators	1-76
SECTION 4:	THEORY: SHOCK ISOLATION SYSTEM OF A RIGID PLATFORM	1-79
4.1	Introduction	1-79
4.1.1	Background	1-79
4.1.2	Analysis Methods	1-79
4.2	Equations of Motion for a Rigid-Body Six Degrees-of-Freedom Shock Isolation System	1-80
4.2.1	Introduction	1-80
4.2.2	Coordinate Systems	1-82
4.2.3	Equations of Motion	1-84
4.2.4	Transformation of Coordinates	1-86
4.2.5	Forces and Moments Due to Springs and Dampers	1-90
4.2.6	Initial Conditions	1-92
4.2.7	Small Angle Formulation	1-94
4.2.8	Numerical Integration	1-95
4.3	Forces and Moments from Special Base-Mounted Shock Isolators	1-97
4.3.1	Introduction	1-97
4.3.2	Short-Pendulum Type Isolator	1-97
4.3.3	Rolling-Ball Type Isolator	1-101
4.4	Dynamic Analysis of Linear Shock Isolation Systems	1-108
4.4.1	Introduction	1-108
4.4.2	Normal Mode Method	1-108
4.4.3	Use of Response Spectra as Inputs	1-113
4.4.4	Linear Six Degree-of-Freedom Shock Isolation System	1-114
SECTION 5:	THEORY: SHOCK ISOLATION SYSTEM OF A NON-RIGID PLATFORM	1-119
5.1	Introduction	1-119
5.2	Platform Stiffness Matrix by Finite-Element Technique	1-120
5.3	Eigenvalue and Eigenvector Solution	1-124

TABLE OF CONTENTS (Continued)

		Page
SECTION 6:	THEORY: WAVEFORM SYNTHESIS	1-129
6.1	Synthesis of a Waveform to Match a Given Shock Response Spectrum	1-129
6.1.1	Introduction	1-129
6.1.2	Basic Principle	1-130
6.1.3	Selection of Forcing Function	1-131
6.1.4	Analytical Solutions	1-133
6.1.5	Determination of Coefficient	1-137
6.1.6	Description of Iteration Procedure	1-138
6.1.7	Choice of System Frequency on the Spectrum	1-139
6.1.8	Computer Program	1-140
6.2	Further Improvement for the Waveform Synthesis Program	1-141
6.2.1	Objectives	1-141
6.2.2	Background	1-142
6.2.3	Normalized Response Characteristics of the Waveform Component	1-142
6.2.4	Selection of Frequency Match Points on the Spectrum	1-146
6.2.5	Phasing of Waveform Components	1-150
6.2.6	Conclusions	1-155
REFERENCES		1-159
PART II:	USER'S INSTRUCTIONS FOR COMPUTER PROGRAMS	2-1
SECTION 1:	INTRODUCTION	2-3
SECTION 2:	PROGRAM TERMINOLOGY	2-6
SECTION 3:	USER'S MANUAL FOR ISØLIN PROGRAM	2-7
SECTION 4:	USER'S MANUAL FOR WAVSYN PROGRAM	2-15
SECTION 5:	USER'S MANUAL FOR NWVSYN PROGRAM	2-16
SECTION 6:	USER'S MANUAL FOR SYNSØL PROGRAM	2-27
SECTION 7:	USER'S MANUAL FOR ISØL PROGRAM	2-31
SECTION 8:	USER'S MANUAL FOR PLTSUB PROGRAM	2-45
SECTION 9:	USER'S MANUAL FOR SPCTRM PROGRAM	2-51
SECTION 10:	USER'S MANUAL FOR FØURIE AND FILTER PROGRAMS	2-56
SECTION 11:	USER'S MANUAL FOR ISIP PROGRAM	2-64
SECTION 12:	USER'S MANUAL FOR PLTFRM PROGRAM	2-72
SECTION 13:	USER'S MANUAL FOR FVØUS PROGRAM	2-78
SECTION 14:	USER'S MANUAL FOR ISIP2 PROGRAM	2-85

TABLE OF CONTENTS (Continued)

		Page
PART III:	ISIP AND ISIP2 PROGRAM LISTINGS	3-1
SECTION 1	ISIP LISTING	3-1
CØNTRL		3-2
CHECK		3-5
ISØL		3-6
INPUT		3-31
LEINT		3-35
AMBS3/AMBC3		3-35
INV/MTRAN3/DET3		3-36
DED/DEI/DES		3-37
DEDIS		3-38
BALL		3-42
SHPED		3-45
PLTSUB		3-47
CALID/CALEND/IDENT/ENJØB		3-48
PLØTS etc./QUKLØG etc.		3-49
YUPLØT		3-50
CPLØT1/CPLØT3		3-53
CPLØT2/CPLØT4		3-55
CPLØT5		3-57
WAVSYN		3-58
NWVSYN		3-59
MATINV		3-71
SHØCK		3-72
INTERP		3-77
PØWØUT		3-78
SHKPM		3-80
ACCEL/INTRP3		3-82
LNPLT		3-85

TABLE OF CONTENTS (Continued)

	PAGE
SPCTRM	3-87
ACCL/INTRP2	3-92
GDPLT	3-94
SYNSØL	3-95
WVTRAN	3-102
ISØLIN	3-103
ISØL2	3-105
ISØL4	3-115
FØURIE	3-125
INTERQ/SPECT	3-128
FILTER	3-129
LEINTR	3-130
SECTION 2: ISIP2 LISTING	3-131
ISIP2	3-133
PLTFRM	3-135
FVØUS	3-141
RIGMAT	3-143
EIGA	3-146
SEQUN	3-151
INTERP	3-152
PART IV EXAMPLES	4-1
SECTION 1: EXAMPLE TO ISØLIN	4-2
SECTION 2: EXAMPLES TO NWVSYN	4-7
SECTION 3: EXAMPLE TO SYNSØL	4-23
SECTION 4: EXAMPLE TO ISØL	4-33
SECTION 5: EXAMPLE TO SPCTRM	4-36
SECTION 6: EXAMPLE TO FILTER	4-41
SECTION 7: EXAMPLE TO FØURIE	4-49
SECTION 8: EXAMPLES TO ISIP	4-58
SECTION 9: EXAMPLE TO FVØUS	4-163
SECTION 10: EXAMPLE TO ISIP2	4-164
SECTION 11: EXAMPLE TO ISØL, WITH CALCOMP PLOTTING	4-202

LIST OF ILLUSTRATIONS

Figure	Title	Page
1-1	Typical Equipment Shock Tolerance Spectrum	1-11
1-2	Comparison of Spectra of Shock Environment and Equipment Shock Tolerance	1-14
1-3	Maximum Spectra of Attenuated Shock Environment	1-26
1-4	Design Analysis Procedure	1-33
1-5	Planar Model of Statically Balanced System	1-38
1-6	Planar Model of Static Balanced Beam	1-38
1-7	Three Base-Mounted Isolation System Configurations	1-52
1-8	Two Arrangements of Overheat Pendulum Shock Isolation Using Platforms	1-54
1-9	Comparison of the Variation in Frequency with Static Load of a Helical, A Liquid, and a Gas Spring	1-65
1-10	Arrangement of a Short Pendulum Type of Isolator	1-77
1-11	Arrangement of a Rolling Ball Type of Isolator	1-78
1-12	Coordinate Axes of Shock Isolation System	1-83
1-13	Schematic Diagram of the i-th Pendulum Type Isolator	1-98
1-14	Detail Motions of One Pendulum	1-100
1-15	Schematic Diagram of the i-th Rolling-Ball Type Isolator	1-102
1-16	Forces Acting on the i-th Ball	1-105
1-17	General Rigid Body Showing Typical Elastic Suspension at Point A_i	1-115
1-18	Mass Matrix for the General Rigid Body with Six Degree-of-Freedom	1-116
1-19	Stiffness Matrix for the General Rigid Body with Six Degree-of-Freedom	1-117
1-20	Coordinate Syste, Deflection and Load Components of Straight Beam Segment	1-120
1-21	Form of Selected Forcing Function, N = 5	1-132
1-22	Maximum Response as a Fraction of Frequency Ratio	1-140
1-23	Normalized Maximum and Residual Response Spectra of the Selected Waveform Component for N = 3, 5, 7, and 9	1-145
1-24	Three Selected System Frequency Match Points on a Response Spectrum	1-147
1-25	Maximum Deviation Versus System Frequency Ratio for Three System Frequency Match Points at N = 3, 5, 7, 9, 11, and 13	1-149
1-26	Time Delay and Relative Time Delay of the Waveform Component	1-152
1-27	Maximum Deviation Versus Time Delay Ratio Calculated at Optimum System Frequency Ratio for N = 3, 5, 7, 9, 11, and 13	1-153
1-28	Comparison of the Input Simusoidal Motion to the Filtered Response Motion	1-158

LIST OF ILLUSTRATIONS (CONTD.)

Figure	Title	Page
2-1	Flow Chart of ISØLIN Program	2-9
2-2	Programmed Standard Amplification Ratio Spectra and Time-delay	2-17
2-3	Flow Chart of NWVSYN Program	2-18
2-4	A typical WAVSYN Spectrum, plotted by on-line printer	2-25
2-5	Flow Chart of SYNSØL Program	2-29
2-6	Flow Chart of ISØL Program	2-33
2-7	Flow Chart of PLTSUB Program	2-46
2-8	Shock Spectrum Plot from a WAVSYN Run	2-49
2-9	Acceleration-Time Plot from a WAVSYN Run	2-50
2-10	Flow Chart of SPECTRM Program	2-52
2-11	Flow Chart of FILTER Program	2-57
2-12	Flow Chart of FØURIE Program	2-58
2-13	Flow Chart of ISIP Program	2-66
2-14	Flow Chart of PLTFRM Program	2-74
2-15	Flow Chart of FVØUS Program	2-79
2-16	Flow Chart of ISIP2 Program	2-86

LIST OF TABLES

Table	Title	Page
I	Analyses and Tests to Verify Performance of Shock Isolation Systems	1-23
II	Shock Isolator Elastic and Dissipative Elements	1-27
III	Optimum System Frequency Ratios for Different N Values	1-148
IV	Ranges of Acceptable Time Delay Ratios for Different N Values	1-154
V	Acceptable Time Delay Ratio for Different Number of Half-Cycle Oscillations	1-156

PART I

DESIGN AND THEORETICAL CONSIDERATIONS

SECTION 1: INTRODUCTION

1.1 BASIS FOR STUDY.

The need for protection for both equipment and personnel from in-structure shock environments generated by the nearby explosion of a nuclear weapon was investigated in the early phases of the NIKE-X program. Although a consensus has yet to be reached regarding a requirement for protecting personnel, it was determined that the predicted level of shock environment to which both personnel and equipment might be subjected to under nuclear attack was so low that the isolation of equipment was unnecessary. Accordingly, no shock isolation systems were considered in the design of the early NIKE-X facilities.

As more descriptive prediction methods were developed and employed, however, estimates of the shock severity were revised upward to a level where, if commercial grade facility equipment were to be installed without modification, there would be serious concern regarding its capability to survive. Estimates regarding equipment survivability could not be made during the initial design phase of a facility since the equipment was to be procured by open bidding subsequent to completion of the facility design. Consequently, no data on specific items of equipment was available during the initial planning. Moreover, a survey conducted by the U.S. Army Engineer Division, Huntsville (USAEDH), revealed that if a fragility level requirement was imposed upon the equipment manufacturer, the added cost of the equipment would far exceed that of protection by shock isolation. If equipment already developed, produced, and proven to be capable of surviving given shock environments were to be specified, USAEDH also estimated that the overall cost of the facility would be significantly higher.

Thus, early in the SAFEGUARD program, a study effort was initiated by USAEDH to identify the commercial equipment items which should be isolated, to establish the performance objectives of the isolation systems, and to formulate shock isolation system design and design verification procedures.

1.2 BACKGROUND.

Transient motion environments generated within most protective structures by their exposure to effects of nuclear weapons are so severe that shock protection

must usually be provided for some critical items of equipment and, often, for personnel. As in the analysis conducted by USAEDH, the decision to hard mount or to shock isolate equipment usually is based on considerations of economy. Sometimes it is less expensive to shock isolate commercial grade equipment than to design the equipment to survive hard mounting. Even when special equipment must be designed to meet operational requirements, the cost of incorporating sufficient ruggedness to withstand the predicted motion environment is often much greater than that of constructing less rugged equipment and providing shock isolation. Further, the performance of a properly designed shock isolation system can be predicted with a greater measure of confidence than can the shock tolerance level of a complex item of equipment. Thus, the consideration of shock isolation throughout the design of a protective structure can have a significant bearing on the cost of the facility, the cost of the special equipment, and on the level of confidence which can be placed on survival of the equipment.

Principles of dynamics describing the responses of a shock isolation or other dynamic system to an arbitrary time dependent disturbance have been treated extensively in literature and have been applied to a wide variety of dynamical systems of much greater complexity than those of interest here. Despite this fact, experiences with shock isolation systems installed in earlier protective structures have not been encouraging. While none of these systems has ever been exposed to a nuclear burst, their capabilities during tests to fulfill their primary functions of protecting equipment and their general behavior under non-shock conditions have been disappointing.

The problems encountered were not due to a lack of availability of basic knowledge of the nature of the phenomena, of engineering information relating to the materials and processes involved, nor of proven engineering design and evaluation techniques. Rather the problems arose simply because this information and these data were not considered and utilized in design.

In approaching any engineering project, the first and most vital step is to define its objectives. The more completely and explicitly the objectives are stated, the greater the probability will be that they will be achieved. Formulation of a complete statement of objectives of a shock isolation system requires a comprehensive understanding of the many elements which comprise it, both physical and dynamical. While the broad objectives themselves may be stated only in terms of principal performance features of the entire system, an intimate

knowledge of the characteristics of each of its elements as well as those of the complete system is essential in order to express the objectives in terms of general parameters of fundamental importance.

If the objectives of the system are established completely and explicity, the problem of arriving at a design which will fulfill all requirements is greatly simplified. Obviously, careful design and design verification practices are essential but the objectives themselves constitute the criteria against which the adequacy of the practices can be evaluated. It is believed that it was the lack of definitive objectives which lead to the oversights in earlier shock isolation system designs.

1.3 SCOPE OF STUDY.

The purposes of the Parsons Company study effort were to provide complete performance objectives and standard design and design verification methods for the design of all shock isolation systems to be installed in SAFEGUARD facilities. In addition to minimizing the possibility of oversights of the type which handicapped earlier system designs, these objectives and methods would enhance the uniformity of systems to be installed in facilities being designed by different engineering contractors. However, the results of the study were not imposed as contractual requirements on the engineering contractors but were only suggested by USAEDH as recommended practices. Thus, in the actual designs, some deviations from these practices do exist.

As the procedures outlined in the Parsons Company study effort were developed specifically for use in the design of shock isolation systems incorporated in SAFEGUARD facilities, attention was focused on problems peculiar to SAFEGUARD designs, and examples used to demonstrate the various procedures were selected from systems to be installed in SAFEGUARD structures. The basic requirements of these systems, however, are no different from those of systems installed in any other protective structure. Indeed, the principles outlined in the procedure are applicable to shock isolation systems intended for any service, although, for some services, emphasis on each of the design considerations may vary.

1.4 PREREQUISITE.

The results of the study were reported in Document No. SAF-37, "Development of Standard Design Specifications and Techniques for Shock Isolation System", in three volumes, by The Ralph M. Parsons Company of Los Angeles[1,2,15]. This manual edits and condenses the said document and others[10,11,21,23] in a single volume. The major task of this manual was to integrate, improve, and standardize

various computer programs, primarily developed by Parsons, into two distinct programs, ISIP and ISIP2. The user of this manual must possess adequate engineering knowledge in the applied field of shock and vibration, and mathematics to follow the theoretical and practical treatments of the subject. Elementary knowledge in structural finite element techniques and matrix manipulation may be helpful. Knowledge in computer programming may be useful especially in computer program input preparation. A qualified engineer and programmer working together as a team may produce the same results.

1.5 MANUAL CONTENTS.

This manual is divided into four parts: Part I contains the design and design analysis of the shock isolation system, input shock motion, and platform structural analysis.

Part II discusses the computer programs developed for this study - program features, limitations, and input preparations. There are a total of ten individual computer programs which may be executed independently, or continuously from one program to another in a very flexible, sequential manner provided by ISIP or ISIP2.

Part III presents the complete listings of ISIP and ISIP2. Several examples are presented in Part IV for illustration purpose. Some of these examples contain complete input and output listings, while others contain only input lists to avoid redundancy.

SECTION 2: DESIGN CONSIDERATIONS

2.1 DESIGN PROCESS.

The process of designing a shock isolation system involves four major tasks. These are to:

- Identify equipment requiring isolation
- Formulate explicity performance objectives
- Select appropriate configurations
- Verify by analysis or experiment, or both, that the selected systems will fulfill the objectives

As almost every shock isolation system design will involve some unique mechanical or performance requirements or limitations, it is futile even to attempt to describe each of these tasks by a set of rigid rules which must be applied in every instance. On the other hand, considerations leading to the formulation of a set of specific rules can be established, particularly as applied to systems intended for use in protective structures.

To arrive at anything near an optimum system, the possible need for shock isolation must be considered early in the design of the facility. The isolation system is just one of many systems comprising the facility, and its interfaces with other systems can have a significant impact, not only on the general arrangement of the facility, but on the performance requirements of the interfacing systems as well.

2.1.1 REQUIREMENT FOR SHOCK MOUNTING.

The first task in the design process is that of determining whether or not there is a need for shock isolation. The hard mount/shock isolate decision is based on three considerations:

- Criticality of the equipment or personnel
- Strength of the shock environment
- Shock tolerance of the equipment or personnel

Only that equipment whose survival is essential to the mission of the facility need be considered in evaluating shock isolation requirements. By comparing the shock tolerances of the critical equipment with the predicted shock

environment, the probable survivability of these critical items can be evaluated. Obviously, items which can survive can be hard mounted. For equipment whose tolerances fall below the predicted environment, the choice can be made between ruggedizing the item and hard mounting (increasing its shock tolerance), or providing shock isolation (reducing the severity of the environment). In some cases it may be found that some combination involving both ruggedizing and shock isolating is the most economical approach.

Identification of Critical Equipment. Generally, not all equipment installed in the facility is vital to its mission and, even in that equipment which must survive, some degradation in performance may be acceptable. To provide a basis for easily identifying survivability requirements, critical equipment lists are prepared in which all critical equipment is divided into one of three classes: Class I consists of items which must survive and must continue to function throughout attack; Class II includes all items which must survive, but are not required to function during attack; and in Class III are grouped those items which are not required to survive,but which, as a result of exposure to attack, must not form debris which could be hazardous to Class I and II equipment and to personnel. All three classes of equipment, therefore, must be examined for their possible need for shock isolation.

In assessing the need for shock protection, as much supplementary information as is available should be provided for each item, defining failure modes and specifying quantitatively the maximum permissible transient and permanent degradation in performance due to shock. Of importance, for example, are such factors as whether or not Class II equipment must be reset automatically following shock or may be reset by hand. In compiling the critical equipment lists, comprehensive analyses of all critical systems must be conducted beginning with the performance tolerances of the weapon system as a whole.

Usually personnel will fall within either Class I or Class II, that is, they may or may not be required to perform vital functions during, as well as following, attack. However, the possibility of damage to adjacent equipment due to personnel who have lost their balance cannot be disregarded.

There is one other group of equipment which may require shock isolation even though the tolerance spectrum of the equipment is higher than that of the environment. Some equipment, such as rotating machinery for example, may generate vibrations so severe that they must be prevented from damaging adjacent equipment.

Were the vibrating equipment to be mounted on conventional vibration isolators, the loads which would be transmitted to the equipment during shock could be disastrous. Equipment which must be vibration isolated, therefore, should be included with that which must be shock isolated since the vibration isolator must be designed to fulfill both functions.

Shock Environment. The severity of the shock environment to which equipment may be exposed is usually expressed by a response spectrum of the motion predicted to occur at the structure/equipment interface. The use of a response spectrum for this purpose has a significant advantage. As the transient response of the protective structure to nuclear weapon generated loads cannot be considered to be unique, the spectrum, which defines a large family of possible motions, is a more appropriate definition than an explicity time-history.

In the SAFEGUARD program, bounding spectra of structural motions have been established for various zones throughout each of the major buildings. These spectra are envelopes of spectra of the response motions at many locations within the appropriate zone due to a variety of weapon and site conditions. For example, bounding spectra of motions with zones in the Missile Site Control Building (MSCB) and the Spartan Launch Station are given in References 3 and 4 respectively.

In employing these response spectra to define the severity of motions to which equipment will be exposed, the assumption is accepted, deliberately or otherwise, that the disturbance is completely uncoupled from the dynamic responses of the equipment itself. In calculating the structural motions from which the spectra were generated, equipment was modelled as rigid masses since the dynamic properties of the equipment were not known at the time the structural analysis was conducted. Even had they been available, however, their inclusion in the dynamic model of the structure would have increased prohibitively the complexity of the structural analysis.

Where the mass of the equipment is small compared to the mass of the local structure which supports it, the effect of the dynamic responses of the equipment on the motion of the structure will be negligible. Where the ratio of equipment-to-structure mass is high, however, the possibility of a significant effect on the base motion should be re-examined once the dynamic characteristics of the equipment are known.

Shock Tolerance. At the present time, the most commonly employed criterion of damage potential to equipment of a transient motion is the response spectrum of the motion. While it can be shown rigorously that other parameters, such as the

amplitudes and phase relationships of the frequency components of the motion, can influence peak responses of most classes of practical systems, the spectrum does have some significance, it is convenient to use and it is a decided improvement over the older criterion, peak acceleration. As the damage potential of the shock environment is expressed in terms of a response spectrum, then, it is appropriate that the shock tolerances of equipment be expressed in the same manner. The use of a spectrum to bound both the severity of the shock and the tolerance level of the equipment greatly facilitates the comparison of load to resistance.

However, a unique shock tolerance spectrum for an item of equipment would not only be difficult but perhaps impossible to determine. If the tolerance spectrum is considered as an upper bound of spectra of all tolerable motions, any motion whose spectrum exceeded the bounding spectrum in any part of the frequency range would, by definition, produce damage. Whether this condition exists is questionable, particularly in view of the fact that the spectrum alone does not define all parameters which influence the magnitude of responses. Further, even attempting to obtain experimentally such a bounding spectrum would necessitate extensive shock tests. Variations in presumable "identical" specimens would also tend to broaden the margin of uncertainty.

In practice, therefore, the "tolerance spectrum" of an item of equipment is simply the spectrum of a motion the item will be expected to survive, or of the most severe motion it has survived. It is possible that the spectrum of a motion which is lower than the tolerance spectrum in some part of the frequency range may have essentially the same damage potential for the equipment, or that the equipment may survive motions whose spectra exceed the tolerance spectrum.

However, in employing the tolerance spectrum in making the hard-mount/shock-isolate decision, it is assumed that, if in any frequency region, the spectrum of the shock environment exceeds that of the tolerance spectrum, either shock isolation or ruggedization will be required.

One possible form, although not necessarily a typical one, of a shock tolerance spectrum for an item of equipment is shown in Figure 1-1 where, in this case, the spectrum consists of a line at a constant response acceleration of 3g. A tolerance spectrum drawn in this manner implies that the equipment will survive a 3g dynamic response in all modes. If the lowest modal frequency is estimated at 10 Hz based on an observation of a static deflection in this mode of 0.1 inch due to gravity, the portion of spectrum below a frequency range of 10 Hz is meaningless insofar as the survivability of the equipment is concerned. Thus,

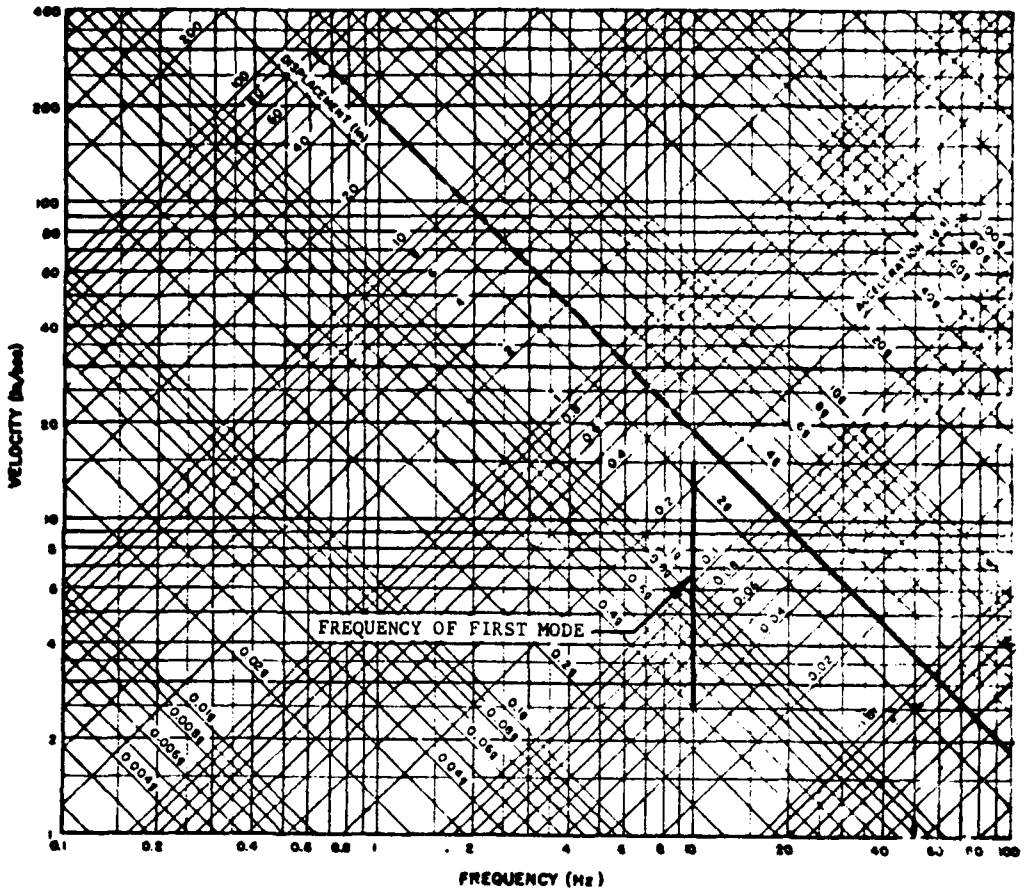


Figure 1-1. Typical Equipment Shock Tolerance Spectrum

in drawing a tolerance spectrum, the spectrum should be terminated at the approximate lowest modal frequency of the equipment.

If frequency response data for the equipment are available from tests, identifying the lowest frequency is a simple task. In most design cases, however, such data are not available. In fact, usually at the time the survivability of the equipment must be evaluated, the equipment has been identified only by general type, such as an electrical distribution panel of a specified capacity or a motor-generator set of a specified power output. Where the equipment will be designed especially for use in the facility, its tolerance spectrum will be more in the nature of a design goal rather than an estimate of the resistance capability of an existing item of equipment.

The highest frequency to which equipment tolerance spectra should be defined is also difficult to estimate unless test data are available. In Figure 1-1 the highest frequency noted is 100 Hz, but this frequency should not be interpreted necessarily as the upper limit of interest since many items of equipment may contain elements which are sensitive to higher frequency motions. For example, tests have been reported in which vacuum tube filaments have failed and relay contacts chattered during relatively low amplitude, 500 Hz input motions. Test specifications for equipment installed in the MINUTEMAN Weapon System called for test motions to 2.0 kHz although this frequency was later reduced to 1.2 kHz.

In the SAFEGUARD program an upper frequency limit of interest in equipment shock survival has been established tentatively at 500 Hz, although there is some concern that this frequency may be too low. Even so, a frequency of 500 Hz is not only well above that to which nuclear weapons effects can be defined with any confidence, but also to which responses of the structures can be calculated.

Obviously, then, the construction of tolerance spectra for equipment without the availability of test data is an operation demanding considerable engineering experience and will involve a large measure of uncertainity. The direction of conservatism, of course, is evident not only for the low- and high-frequency limits, but also for response amplitudes. Yet, overconservatism can lead to the provision of shock isolation where hard mounting is acceptable, or vice versa, or to stringent limitations on the low-frequency dynamic performance of the isolation system which could lead to an unsatisfactory static performance.

Few, if any, data are available which can be applied directly to establish tolerances of personnel to motions of the types encountered in protective structures as generated by a shock isolation system. Failure of personnel may be defined as the incapacity to perform a vital function either during or following an attach, or as malfunction or damage to adjacent equipment caused inadvertently by personnel. Mechanism leading to damage, however, are many. Direct injury due to a severe load, secondary injury caused by loss of balance, or simply loss of balance could result in failure.

Most tests conducted to date to determine tolerances of human beings to motion are concerned with vehicular environments, either ground or airborne. Input loads usually consist either of sustained high accelerations or prolonged vibrations, the input loads being applied along a single axis. Frequently the subject is

restrained. In most of the tests the criterion of failure is direct injury.

While these data, summarized in Reference 5, are not directly applicable to the environments encountered in most protective structures, they can be employed to obtain a gross indication of whether or not personnel will sustain direct injury. However, these data do not provide a basis for determining the type and strength of complex motions, typical of those of a shock isolated support, which the unprepared, unrestrained human being can tolerate without losing balance. Since loss of balance under these conditions could lead to injury or to improper performance, it must be classed as a failure.

In the MINUTEMAN Weapon System this problem was resolved by supporting personnel on a platform which was shock isolated to a low-level acceleration, attaching the chairs rigidly to the platform and providing seat belts. Personnel were not required to perform vital functions during attack.

The problem has yet to be completely resolved for the SAFEGUARD system. Early proposals for investigations of measures to ensure personnel protection[6,7] were discouraged since it was contended that[8]:

- Personnel would be given sufficient warning time to prepare for the shock.
- Personnel would not be required to perform vital functions during attack.
- The level of shock would be low.

Recently the validity of these contentions was reviewed[9] and, while the need for shock isolating personnel was not anticipated, provision of restraints for personnel performing critical functions was recommended.

In any case, shock tolerance spectra for personnel must clearly designate the mode of failure and thus several such spectra may be required. Where critical functions must be performed during or immediately following attack, whether or not shock isolation is provided, it is probable that some type of support for the personnel should be provided.

Hard-Mount Versus Shock-Isolate. The decision as to whether or not an item of critical equipment will survive the shock can be based on a comparison of the environment and tolerance spectra for that item. A typical comparison is shown in Figure 1-2 where the equipment tolerance spectrum of Figure 1-1 has been reproduced. Clearly, in this case, the equipment would not survive the shock environment and would require either ruggedizing or shock mounting.

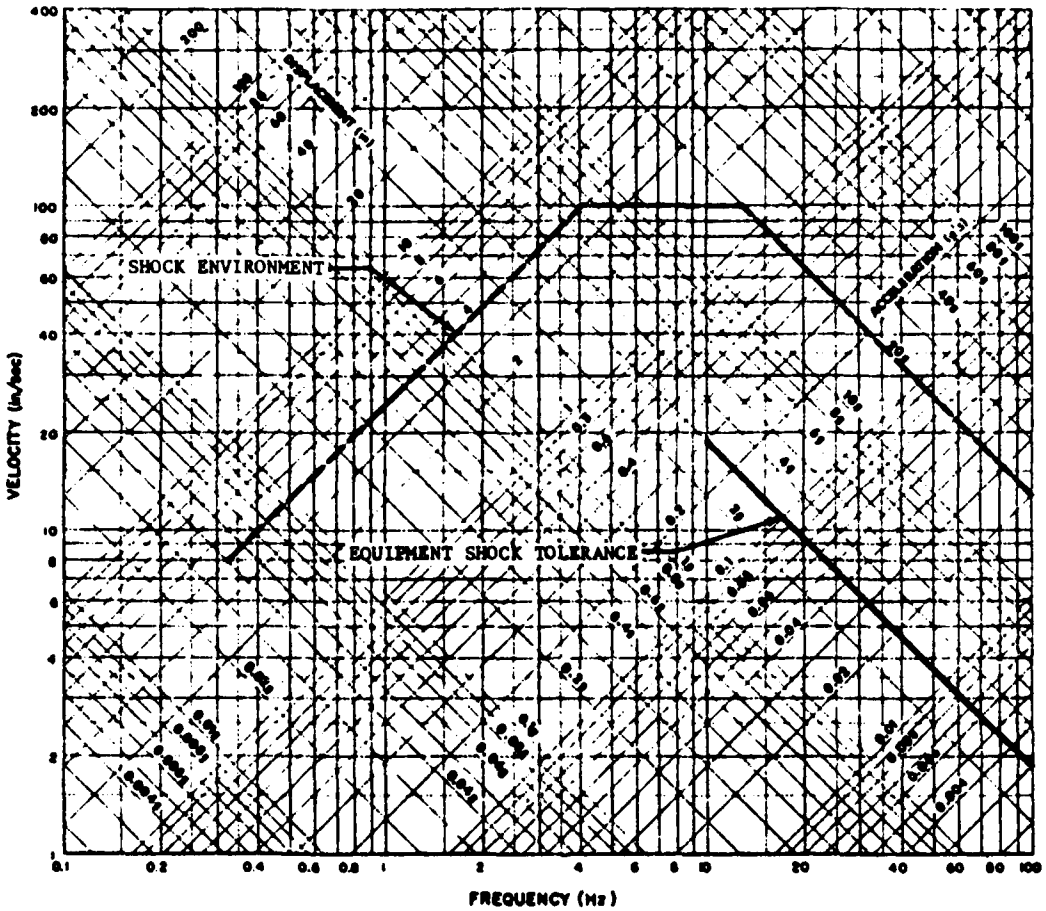


Figure 1-2. Comparison of Spectra of Shock Environment and Equipment Shock Tolerance

For equipment designed and constructed specifically for use in the facility, the choice of whether to shock isolate or to ruggedize is largely a matter of relative cost. Notable exceptions, of course, are the cases of personnel or of a missile or similar device where ruggedization might not be possible or might degrade performance to the point where the success of the entire system would be jeopardized. But, in general, a choice is offered not only between these two extremes, but also of intermediate approaches where both isolation and ruggedizing in varying degrees may be employed if it appears to offer an economic advantage.

A great deal of equipment installed in protective structures, and almost all Tactical Support Equipment (TSE), however, is selected from commercial grade stock. As noted earlier, shock tolerance data for such equipment is almost non-existent. Here again, however, the choice is offered between accepting the equipment at whatever the level of ruggedness may be estimated to be and reducing the shock environment to this usually very low level by isolation or by imposing on the manufacturer a requirement for a specified shock tolerance and hard mounting. And again, both isolation and ruggedizing can be employed if it appears to be advantageous.

There are some important differences between the use of equipment built especially for the facility and of equipment procured commercially, whether or not it is to be ruggedized. The first category consists almost exclusively of Weapon System Equipment (WSE) whose development and test is initiated several years before deployment. Indeed, the schedule for completion of the facilities is frequently based on the date such WSE will be available. Thus, there is sufficient time to conduct an orderly program to ensure that the required ruggedness goals are achieved.

On the other hand, TSE, most of which is obtained from commercial sources, is rarely, if ever, procured until after construction of the facilities has begun. Until this late data, therefore, the exact item of equipment which will be installed in the facility is not known, although the hard-mount/shock-isolate decision must be made as early as several years prior to this. From the viewpoint of conservatism, then, it would appear mandatory that procurement packages for TSE include a specification for a minimum ruggedness level. However, the very short period of time available to the manufacturer to proof-test his equipment, coupled with his uncertainty as to the ruggedness of his standard design and the possibility of extensive modification, all prompt him to add a significant premium to his prices.

In the TITAN and MINUTEMAN Weapon System designs, the decision was made to accept the cost penalty and schedule delay involved in specifying a shock tolerance level for TSE. Tolerance levels were established on the basis of estimates of those which commercial grade equipment could survive and, where these fell short of the predicted shock environment, shock isolation was also provided. All manufacturers' equipment was required to survive a shock test prior to acceptance.

The other approach was taken in the SAFEGUARD design. No shock tolerance requirements were imposed on manufacturers of TSE. On the basis of estimates of the shock tolerances of each general class of equipment and on the results of

shock tests conducted on a few "typical" items, the hard-mount/shock-isolate decision was made. Subsequent to the installation of all TSE in the first and possibly the second sites, tests will be conducted on all items and, if indicated, corrections made by adding or deleting shock isolation systems or by ruggedizing equipment.

On the basis of cost there is probably very little to choose between the two approaches. In the Air Force approach, a premium price must be paid the manufacturer owing to his uncertainty as to the amount of ruggedizing his equipment will require. In the SAFEGUARD approach some of the shock isolation systems installed in the first one or two sites may not be necessary and a need for ruggedizing some of the equipment may be indicated by the results of the shock tests. The addition of shock isolation systems in a facility already constructed will also be more expensive than had they been included in the original construction program. In both approaches, tests of all items of equipment are required.

The most significant difference between the two approaches is in the time at which a high level of confidence can be placed in survivability. In the Air Force approach once the system is activated, confidence in its survivability is high. This same level of confidence can be realized in the SAFEGUARD approach only after the equipment testing program has been completed and all required modifications performed at sites already activated.

A technical disadvantage of both approaches is that, in order to optimize the design of a shock isolation system, the dynamic characteristics of the equipment to be isolated as well as its ruggedness level must be known. However, such data can be obtained only by test and, as in both approaches the tests are conducted subsequent to the isolation system design, the designer is faced with the necessity for estimating them.

The three most vital elements in the resolution of the hard-mount/shock-isolate problem for commercial grade equipment are an early recognition of its importance, the formulation of a detailed, realistic plan of approach in which all significant parameters are considered, and a rigid enforcement of the plan. The approach itself will be strongly influenced by the level of hardness required, by the amount of TSE involved, by the availability of useful ruggedness level data from earlier programs, and by schedule and cost. In almost every case, however, the effort and cost required to achieve a high level of confidence in the survivability of TSE will be significant when compared with that associated with other elements of the survivability assurance program. If this fact is

not recognized at an early date, penalties either in cost or in confidence level, or in both, will be inevitable.

2.1.2 PERFORMANCE OBJECTIVES.

Once the decision to shock isolate has been reached, performance objectives for each system must be established. Clearly one of the most fundamental of the objectives is to reduce the strength of the shock environment as specified by its response spectrum to a level where under no conceivable circumstance can the spectrum of the motion at the equipment exceed the shock tolerance spectrum. However, there are then many other considerations which must be satisfied if the system is to perform in an acceptable manner. Although all these considerations are lumped here under the heading of performance objectives, in fact they may be separated into four groups of requirements: those defining the interfaces between the shock isolation system and the facility and load, those specifying the output performance, those specifying life requirements, and those specifying cost goals.

Requirements and goals which must be established for each system include:

A. <u>EXTERNAL INTERFACES</u>

1. Environment

- Input Shock Motion - Input shock in both frequency and time domains are desirable in shock isolation design, and design analysis.
- Rattlespace - A practical but often neglected design parameter.
- Vibration - The effect of externally generated vibration in a shock isolation system must be significantly reduced or eliminated for the protective structures or equipments.
- Other External Loads - The performance objective must include the shock and vibration from every possible externally-originated source such as earthquake, hard-mounted rotating machinary located in the proximity of the isolation system attachments, pressure loads and vibration due to circulation of air or liquid in ducts to hard-mounted equipments or structures.

- Temperature - The effect of temperature extreme upon isolation system performance may not be neglected.

- Contaminats - Dust, humidity, corrosive gas and similar impurities might degrade the performance of the isolation system.

2. Shock Isolated Load Data

- Shock Tolerance - Interaction among input motion and all elastic systems (shock isolation system and equipment) defines the "equipment tolerance system" which is a prime parameter in performance consideration.

- Dynamic Characteristics - As the shock isolated equipment system is not rigid, and no rigidity is assumed, the response of the equipment to base motion is characterized by resonances and antiresonances which tend to dictate the effectiveness of the base motion upon the isolation system.

- Static Properties - The static properties, such as the geometric shape and size, weights, and weight distribution, must be defined in the early phases of design, although none of these properties are known with certainty. The effect of these properties on the response of the shock isolation system depends also on the shock isolation system configuration.

B. PERFORMANCE

1. Dynamic - The fundamental dynamic performance requirement of the shock isolation system is to attenuate the shock environment to the level specified by an output response spectrum. The magnitude of the output response spectrum must be no greater than the tolerance spectrum of the most vulnerable item of equipment which the isolation system supports.

2. Statics - Two basic static performance characteristics are the static position of the isolated equipment relative to its surroundings and the stiffness of the system.

3. Reliability - The ultimate reliability of any system or element installed in a protective structure is the probability it will perform adequately under all expected environments during its design life period.

C. COST

Initial and maintenance.

D. LIFE

In a specific case, some of these considerations may not be expected to be pertinent but nonetheless they should be defined. Further, the list should be augmented by any special limitations or requirements which are imposed on the system.

Frequently significant data to define these requirements completely are not available at the time the shock isolation system concepts must be drafted. In these cases, the requirement should be estimated and a range specified throughout which the requirement might vary. This is almost always the case, for example, in describing the load where even the weight of the equipment and its other static properties will be known only within perhaps ± 30 percent. Even less is usually known about the dynamic characteristics of the equipment.

Nonetheless, as the shock isolation system design is directed specifically toward meeting the stated performance objectives, these requirements must be specified as completely and as accurately as possible. As the facility design progresses, improvements in the objectives may be made and their impact in the shock isolation systems evaluated. Indeed, the shock isolation system design program should include provisions for reviewing periodically the objectives and examining the impact of changes on the system designs.

2.1.3 SELECTION OF CONFIGURATION.

Development of a satisfactory shock isolation system configuration, like most design processes, entails an iterative procedure. Several concepts are conceived which appear to meet the performance objectives and, on the basis of engineering judgement augmented by simple analyses, the most promising configuration is selected. More comprehensive analyses are then conducted and, if indicated, the configuration is modified and re-analyzed until satisfactory performance is achieved. The design is then fabricated, tests conducted, and if further modifications are required they are incorporated, and the analyses and tests repeated.

In some cases, tests are also employed to obtain empirical data required in the analysis.

The isolation system configuration comprises all elements connecting the structure and the supported equipment. Functionally these elements will consist of energy storage and energy dissipative mechanisms arranged in such a fashion as to support the equipment. These may be augmented by structural members such as links and auxiliary supports for the equipment. But the entire assembly constitutes the shock isolation system configuration. Characteristics of these elements which dictate the response of the system are the transmission characteristics of the

- Energy storage elements
- Energy dissipative elements
- Auxiliary members

Choices are available in selecting desirable transmission characteristics for each of these three basic elements. Energy storage may be provided by mechanical springs, liquid springs, pneumatic springs, elastomers, or other devices each of which has some characteristic behavior. Similarly, for energy dissipative elements a choice is available among others of coulomb, viscous, hydraulic, pneumatic, or friction devices. The transmission characteristics of the auxiliary devices are dependent on their inherent energy storage and dissipative properties and in their kinematic configuration, that is, the geometry of the system connecting the equipment to the hard structure.

The problem of selecting a satisfactory configuration, then, is one of choosing an auxiliary structure, and energy storage and dissipative devices and arranging them geometrically such that, when supporting the equipment, all performance objectives are fulfilled.

In recent years, considerable attention has been devoted by several investigators to identify an "optimum" shock isolation system. The criterion for optimization usually established by the investigator applies only to a specific kinematic configuration (frequently a single degree-of-freedom system) and consists of either the minimum output acceleration which can be achieved within a prescribed maximum relative displacement or, conversely, the minimum relative displacement which can be achieved for a prescribed peak output acceleration. Clearly, both of these criteria fall far short of defining a system which would meet the performance objectives considered as "optimum" in this study.

First, peak output acceleration alone is not a meaningful criterion of the severity of an output motion. Indeed, it is for this reason, that the responce spectrum has all but replaced peak acceleration as a criterion of damage potential in shock tests. A high acceleration at a low frequency may be far less damaging to an item of equipment than a lower acceleration at a higher frequency. Yet the parameter frequency, which is of vital importance to equipment response, is not even included in the definition of a desirable output motion.

Second, the kinematic configuration, since it influences the frequencies of the output motion, cannot be excluded from the optimization process. An isolator characteristic "optimum" for one configuration may be far from "optimum" for another. Further, since the physical system will respond in three-dimensional space, the optimization procedure must consider all appropriate degrees-of-freedom. And last, other significant performance requirements such as sensitivity to off-design load and to other input conditions must be considered.

Several of the optimization studies have compared performance of active and passive systems and concluded that significant improvements in performance can be gained by the use of active systems. In these comparisons, the passive systems have incorporated only linear elements. For systems installed in protective structures, however, even by these limited performance criteria the reduction in rattlespace volume which can be obtained by active isolation is only a few percent of the total. Further, equal, if not greater, reductions can be obtained in passive systems by employing simple, reliable nonlinear isolation elements and by a careful choice of a suspension configuration. Thus, in the study of systems for SAFEGUARD facilities, only passive systems are considered.

While the procedure for selecting a promising configuration is to a large extent a trial and error process, several guidelines can be established to minimize the number of iterations. While these guidelines are presented in some detail in a later section, briefly they are based on the use of simplified models in which the effect of each of the major contributions can be examined independently.

2.1.4 DESIGN VERIFICATION.

<u>Approach</u>. The design verification program for almost all shock isolators must consist of two parts, analytical verification and experimental verification. The analyses and experiments are not simply two independent means for verifying isolation system performance since neither the analyses nor the experiments alone can provide this verification.

The limitation of the analytical method is that the high-frequency transmission characteristics of the system cannot be calculated accurately. In the low-frequency range, an order of magnitude above the fundamental, correlations of analyses with experiments have been excellent. As the frequency increases, however, not only do the analytical techniques become less accurate, but also the formulation of meaningful models and the acquisition of precise engineering information becomes increasingly difficult.

The limitation of the experimental method is the lack of testing facilities of sufficient capacity and capability to accommodate these systems and to the impracticality (although perhaps not impossibility) of constructing such facilities. Tests, therefore, must be confined to components of the system where the specified input can be properly introduced, or to complete systems subjected to inputs different from those specified for design.

The fact that neither analysis nor experiment alone can be employed to verify the shock isolation systems, however, is not considered to be a serious limitation since by employing both, a high level of confidence in the system performance can be achieved.

Table I presents a chart which indicates how analyses and experiments can be combined to verify the performance of a shock isolation system throughout the required frequency bandwidth. The analyses and experiments shown are not the only combinations which can be used to verify the design nor does the chart include the secondary analyses and tests used to facilitate design or to provide engineering data. However, the tests and analyses shown in Table I would constitute a complete verification program.

TABLE I

ANALYSES AND TESTS TO VERIFY PERFORMANCE
OF SHOCK ISOLATION SYSTEMS

	TASK	OBJECTIVE	APPROXIMATE FREQUENCY RANGE HZ (0.1, 1, 10, 10^2, 10^3)
ANALYSES	1. ANALYSIS TO DETERMINE ELASTIC MODES OF PLATFORM INCLUDING MAJOR ITEMS OF EQUIPMENT USING ESTIMATED ELASTIC PROPERTIES OF THE EQUIPMENT	TO OBTAIN MODAL DATA TO BE USED IN ANALYSIS (4) AND TO SUPPORT RIGID BODY ASSUMPTION IN ANALYSIS (2)	(30-40)
ANALYSES	2. SIX-DEGREE-OF-FREEDOM ANALYSIS OF SUSPENSION SYSTEM ASSUMING RIGID PLATFORM AND EQUIPMENT	TO DETERMINE LOW FREQUENCY RESPONSES AND ESTABLISH RATTLESPACE REQUIREMENTS	
ANALYSES	3. ANALYSIS OF SINGLE ISOLATOR ASSEMBLY	TO DETERMINE TRANSMISSION CHARACTERISTICS OF ISOLATOR ASSEMBLIES IN LOW- AND MID-FREQUENCY RANGES	
ANALYSES	4. ANALYSIS OF COMPLETE SYSTEM	TO IDENTIFY SIGNIFICANT INTER-ACTIONS BETWEEN ISOLATORS, PLATFORMS AND EQUIPMENT IN LOW- AND MID-FREQUENCY RANGES	(500)
TESTS	5. PLATFORM WITH SIMULATED EQUIPMENT TESTS	TO VERIFY AND EXTEND FREQUENCY RANGE OF ANALYSIS (1) AND TO EVALUATE EFFECTIVENESS OF VIBRATION DAMPING MATERIALS	
TESTS	6. SINGLE ISOLATOR TESTS	TO VERIFY ISOLATOR PERFORMANCE AND TO EXTEND RESULTS OF ANALYSIS (3) TO UPPER FREQUENCY LIMIT	
TESTS	7. SHOCK ISOLATED EQUIPMENT TESTS*	TO DETERMINE DRIVING POINT IMPEDANCES AT EQUIPMENT ATTACHMENT POINTS	
TESTS	8. COMPLETE SYSTEM TESTS (NECESSARY TO BE EVALUATED)		

NOTE:
*OBJECTIVES OF THE EQUIPMENT TESTS INDICATED HERE ARE DIFFERENT FROM THOSE OF THE EQUIPMENT FRAGILITY TESTS. HOWEVER THE TWO OBJECTIVES MAY BE ACHIEVED IN A SINGLE TEST.

2.2 DESIGN AND ANALYSIS REQUIREMENTS SUMMARY.

2.2.1 GENERAL.

Objective. This design requirement is intended to ensure completeness and to establish uniformity in the design and design analysis of all shock isolation systems protecting Technical Support Equipment (TSE) throughout the SAFEGUARD facilities, or similar applications.

Scope. This design requirement shall apply to all shock isolation systems for TSE including individual and platform mounts, pendulum and under-floor supports. The requirements define the performance of the shock isolation systems, the design details of the shock isolation system components, the dynamic analysis requirements and the analysis procedures.

Approach. The damage potential of an input motion to equipment whether shock isolated or hard mounted can better be described by a response spectrum than by a maximum acceleration. This assumption applied to shock isolated equipment is consistent with the specifications of input motions to all hard mounted equipment for the SAFEGUARD system and thus provides a unified approach.

2.2.2 PERFORMANCE.

DEFINITION OF INPUT

Shock Spectra. Envelopes of the shock spectra of time-motion histories of all node points considered in the dynamic analyses of the SAFEGUARD structures, and lying within a specified zone, shall constitute the basic definition of the shock environment for all shock isolation systems whose attachments to the structure lie within that zone. In constructing enveloping spectra of the horizontal motions, spectra of all such motions within the zone shall be included within the envelope, regardless of the azimuthal direction. For both vertical and horizontal spectra, the relative displacement shall be assumed as a consistent 4 inches relative displacement line below a frequency of 2 Hz.

Time-Motion Histories. Where time-motion histories are required in the dynamic response analyses of shock isolation systems, one vertical and one horizontal acceleration waveform shall be synthesized whose response spectra envelope the appropriate design spectra for that zone. The synthesized waveform shall consist of a series of sinusoidal components of appropriate frequencies whose amplitudes first increase and then decrease in time. The amplification ratio of each sinusoidal component shall be established such that it approximates the median ratio at the corresponding frequency of those motions calculated for the

node points in the appropriate zone. The maximum bandwidth of frequencies over which the spectrum shall be enveloped shall extend from not more than 1/2 of the lowest frequency of the isolation system being analyzed to not less than 5 times the highest frequency of the model. Where motion-time histories resulting from the dynamic analysis are available which completely populate the spectra for the zone under consideration for shock isolation, they may be used in lieu of a synthesized waveform. A recommended waveform synthesis procedure is described in Section 6.

Attenuation Requirements. A response spectrum of the maximum attenuated shock motion at any location on a shock isolated item of equipment or a shock isolated platform is shown in Figure 1-3. This requirement applies to both vertical and horizontal components of the response motion. If this requirement cannot be met at any frequency within a range of 0.1 to 500 Hz, permission for such a deviation must be obtained from the U.S. Army Engineer Division, Huntsville, Corps of Engineers (HND).

Rattlespace Allowance. For purposes of defining required clearances and overall space envelopes, a minimum rattlespace envelope shall be established for each shock isolation system on the basis of the maximum relative displacement calculated in a dynamic analysis of the system plus an additional allowance of 25% of the maximum calculated relative displacement, but not less than one inch in each direction.

Platform Position Recovery. All shock isolated systems shall return after a dynamic disturbance of design strength to within 5% of the initial vertical static deflection or horizontal position.

2.2.3 DESIGN DETAILS.

System Configurations. Shock isolation systems shall be configured in such a manner as to minimize rattlespace, minimize coupling between modes, avoid large non-linearities, and make maximum use of elements whose dynamic characteristics are readily predictable or can be verified in simple tests.

All shock isolation system components shall be designed to remain within the elastic limit of the materials when exposed to the maximum calculated dynamic forces.

System Component - Shock Isolated Platform. All shock isolated platforms shall be designed to allow the fabricator the option of constructing the platform in segments and assembling it in place with minimum field work. Splicing and

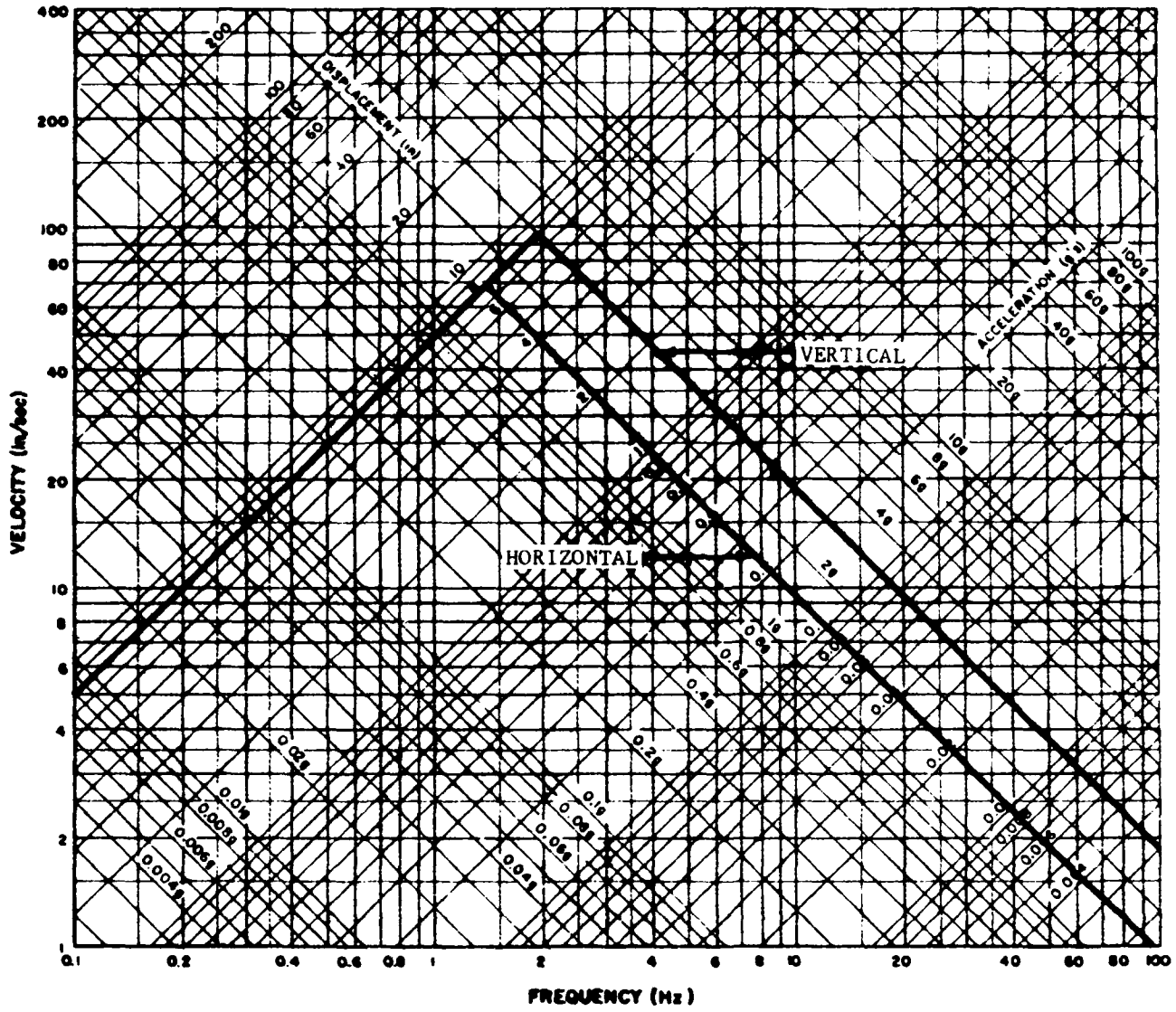


Figure 1-3. Maximum Spectra of Attenuated Shock Environment

other details shall be specified in the drawings to ensure that any field-assembled modules preserve the structural integrity and stiffness of the original platform.

Equipment shall be attached to platforms through major structural members or through special stiffeners which will transmit the load to major structural members.

All platforms shall be treated with a high frequency energy dissipative media such as undercoating or interface damping materials which can be demonstrated to reduce substantially the persistance of motions in the 80 to 500 Hz frequency range.

Platforms whose free-field frequency in the fundamental elastic mode is equal to or greater than four times the highest rigid body mode of the suspension system may be assumed to be rigid in calculating system responses. For the purpose of estimating the suspension system frequencies, coupling between modes of the suspension system may be neglected.

System Component - Isolators. Isolators shall be specified or designed to minimize the transmission of motions in all directions except axial and at all frequencies in the axial direction above the fundamental of the unit.

Isolator types shall be chosen on the basis of the most economical which can meet all of the requirements as set forth herein. As a general guide, consideration shall be given to the use of elastic elements of shock isolators of the types shown in Table II for the various load ranges.

TABLE II

SHOCK ISOLATOR ELASTIC AND DISSIPATIVE ELEMENTS

Static Load Range Lb.	Type of Element	
	Elastic	Dissipative
0-200	Wire Spring or Elastomer	Elastomer
200-3000	Wire Helical Spring	(see below)
3000-above	Air Spring	(see below)

Energy Dissipative Element. All shock isolators shall be provided with an energy dissipative element equal in magnitude to not less than 10 percent equivalent viscous critical damping at the nominal load. The type of element for the 0-200 lb. range isolator shall be elastomeric. For the 200 lb. range and above, the dissipative element shall be of a near-viscous type such as air or fluid damper or an air orifice. All damping elements shall meet the platform position recovery requirement.

Adjustment. Provisions shall be incorporated in the isolator or isolator/connector assembly to permit levelling under the extremes of all load, center of gravity and stiffness tolerance conditions. A graduated scale and pointer shall be installed on each adjustment device, or if ballast is used, on each isolator to indicate the distance of the platform at that location from the nominal horizontal plane of reference.

Specifications. Specifications for each isolator shall include the following data.

(a) Maximum dynamic axial displacement plus over-travel allowance (tension and compression).

(b) Maximum dynamic side load.

(c) Nominal installed load and tolerance.

(d) Maximum Stroke.

(e) Nominal stiffness and tolerance.

(f) Adjustment from nominal position (if included in isolator).

(g) Damping, permissible types and maximum damping force at stated conditions.

(h) End fitting details. (See below)

(i) Maximum overall isolator length and width dimensions.

Isolator/Platform/Structure Attachments. Attachments of pendulum isolators and connectors to platforms or to hard structure shall consist of spherical ball fittings or double pin universal joints of standard designs and sizes as specified by HND. For base mounted isolators, attachment connections will be dependent on the type of system employed.

Connectors between isolators and platforms or hard structure shall be designed to minimize the transmission of high frequency motions.

2.2.4 ANALYSIS REQUIREMENTS.

Analyses to verify the structural integrity and dynamic performance of the shock isolation system shall consider these tolerance and input conditions:

SYSTEM TOLERANCES

Maximum and Minimum Weights. All platform weights, W_p, shall be assumed to vary from the nominal by not less than ± 2 percent and all supported equipment weight, W_e, shall be assumed to vary by not less than ± 10 percent from the nominal, which includes ± 5 percent for estimating error and ± 5 percent for subsequent change of weight. If ballast is to be employed to obtain static balance, its weight, W_B, shall be added to the above maximum weight.

Then the maximum weight to be considered in the dynamic analyses shall not be less than

$$W_{Max} = 1.02\ W_p + 1.1\ W_e + W_B$$

nor the minimum weight greater than

$$W_{Min} = 0.98\ W_p + 0.9\ W_e$$

Variations in Load Location. Changes in the location of the center of gravity of the weights shall be based on these tolerances:

Platform. The center of gravity of supporting platforms shall be assumed to vary from the nominal location in each of the three principal orthogonal directions by ± 5 percent of the major platform dimension in the corresponding direction.

Equipment. The center of gravity of shock isolated equipment, supported on platforms or individually, shall be assumed to vary from its estimated location in each of the three principal orthogonal directions by ± 10 percent of the major dimension in the corresponding direction. This requirement may be relaxed if manufacturers' guarantees of closer tolerances are available. The mass effects on the motion of the shock isolation systems of electrical cables and piping connections to the equipment shall be considered in estimating nominal equipment weights.

Isolator Stiffness. Tolerances on the stiffnesses of isolators shall be determined from manufacturers' guarantees, or if detailed on facility drawings, from calculations based on the accumulative indicated tolerances. Recommended maximum permissible tolerances are:

Elastomers	±15 percent of nominal value
Wire Helical Spring	±10 percent of nominal value
Air Springs	Adjustable to within ±1/2 percent of nominal value

Static Balance Adjustment. Static adjustments shall be provided in all isolation systems to return the isolated equipment or platforms to the nominal level position under the most adverse tolerances of weight, center of gravity location and isolator stiffness tolerances specified in the preceding paragraphs, plus an additional allowance of ±1/4 inch. The sensitivity of the adjustment and indexing methods shall be sufficient to permit leveling of the equipment or platform within ±5 minutes of arc without recourse to external leveling tools. A placard detailing the adjustment instructions shall be permanently attached to each shock isolation system.

Input Shock. Design analyses of shock isolation systems shall consider these input shock conditions:

Phasing. The design vertical and the uni-directional design horizontal shock motions shall be considered to act simultaneously and in phase at each attachment of the shock isolation system to the hard structure.

Direction. The azimuthal direction of the horizontal shock motion shall be varied such that critical responses of the shock isolation system are identified.

2.2.5 ANALYSIS PROCEDURES.

Systems to be Analyzed. Dynamic Analysis shall be conducted on each isolation system except:

(a) Only one analysis need be conducted on identical units if the most severe input motion is considered in the analyses.

(b) Only one analysis need be conducted on similar types of units provided it can be shown by other means that the responses of the other unit of that type will be less severe.

ANALYTICAL MODELS

Complete System. Selection of the shock isolation system configuration to be analyzed shall be based on the following steps:

(a) The platform and/or equipment system shall first be assumed to be at the nominal weight, center of gravity location, and center of stiffness location.

(b) The center of gravity shall then be assumed to be shifted to an extreme corner of the center of gravity tolerance parallepiped.

(c) The center of stiffness variation shall then be calculated which will place the center of stiffness at the maximum distance from the center of gravity.

(d) Calculate the maximum and minimum weights of the system (exclusive of ballast).

(e) Using first the maximum weight and then the minimum weight, and using the adjustment procedure specified by the designer, statically balance the platform to 10 minutes of arc of a level position. (Note that if ballast is employed, the center of gravity will shift and the ballast weight must be added to the platform weights. If air-filled isolators are employed, the center of stiffness will shift.)

(f) The three possible configurations which shall then be analyzed for dynamic responses shall be:

1. Maximum platform and/or equipment weight (plus ballast if used) and maximum eccentricity of center of gravity and center of stiffness.

2. Minimum platform and/or equipment weight (plus ballast if used) and maximum eccentricity of center of gravity and center of stiffness.

3. Minimum platform and/or equipment weight with center of gravity and center of stiffness at nominal locations.

Isolators and Other Connecting Links to Hard Structure. To determine the frequency transmission characteristics in higher modes of the isolators and other connecting links between the shock isolated item and the hard structure, detail analytical models may be constructed.

Required Analysis. Figure 1-4 shows the sequence of required analysis which will establish

(a) Low frequency range of the attenuated response spectra.

(b) Rattlespace requirements.

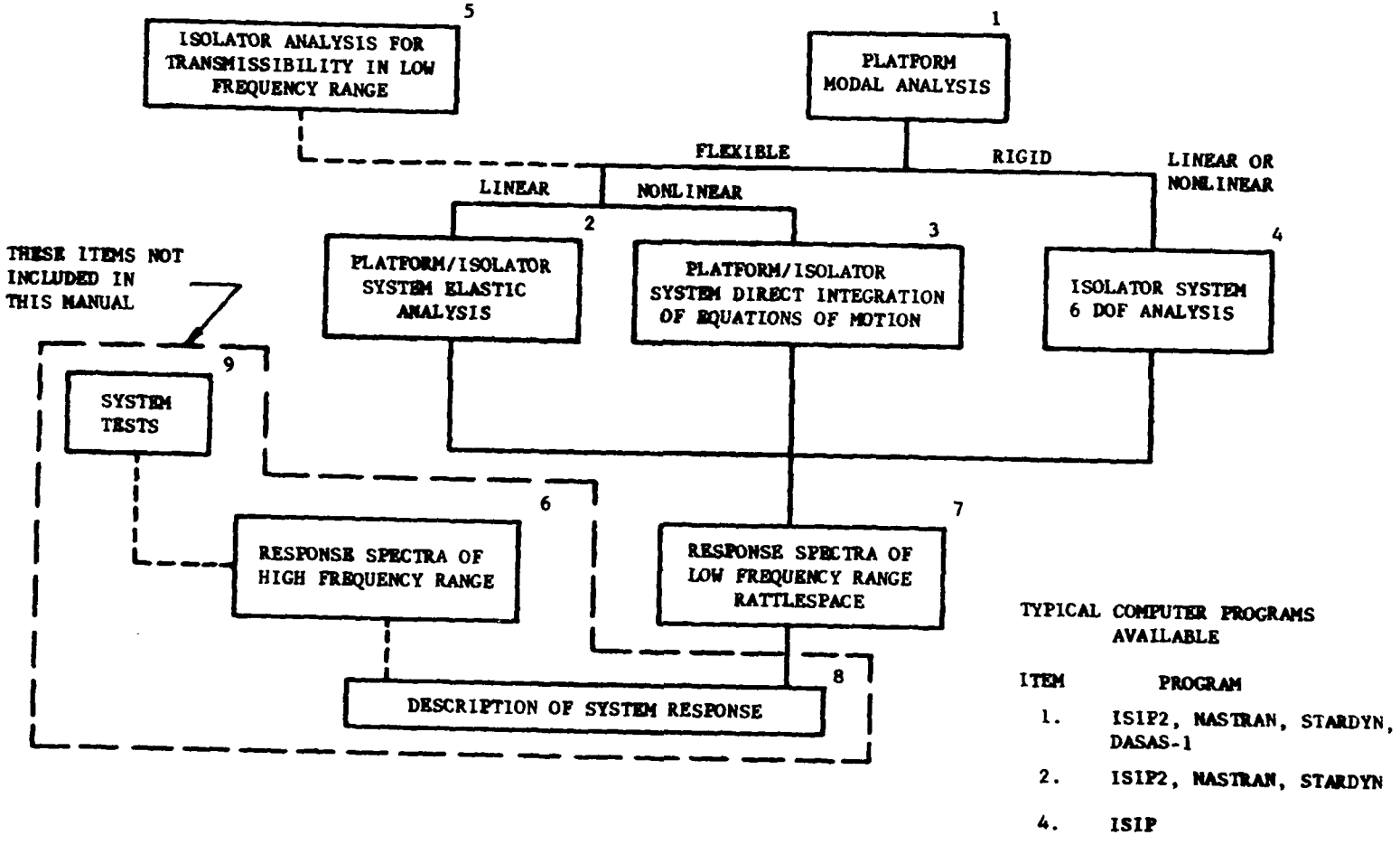
(c) Isolator specification data.

Platform Modal Analysis (if platform is employed). This analysis is performed to determine the first mode frequency and to assure proper separation of frequencies of first six or eight modes. On the basis of this analysis the decision shall be made as to whether or not the platform may be considered as being rigid. A computer program, ISIP2, is available for the analysis.

Platform/Isolator System Elastic Analysis. If, on the basis of the criteria of Section 2.2.3, the platform cannot be assumed to be rigid, and the isolators and the suspension configuration are linear, a modal analysis shall be conducted to establish the responses of the complete platform/isolator system. (Computer program ISIP2 can be used for the analysis).

Platform/Isolator System Non-linear Analysis. If, on the basis of the criteria of Section 2.2.3, the platform cannot be assumed to be rigid, but the isolators or suspension configuration is non-linear, the responses of the system shall be determined by a direct integration of the equations of motion for the complete system.

Rigid Platform Analysis. If, on the basis of the criteria of Section 2.2.3, the platform can be assumed to be rigid, and the isolators and suspension systems are linear, either a six degree-of-freedom modal analysis or a direct integration may be employed to calculate dynamic responses. If the isolators or suspension systems are non-linear, the direct integration of equation will be required. Computer programs (ISIP and/or ISØL) are available for pendulum suspension system, base mounted system, and for two types of non-linear under-floor mounts.



TYPICAL COMPUTER PROGRAMS AVAILABLE

ITEM	PROGRAM
1.	ISIP2, NASTRAN, STARDYN, DASAS-1
2.	ISIP2, NASTRAN, STARDYN
4.	ISIP

Figure 1-4. Design Analysis Procedure

Isolators and Connecting Links. Detail analysis of more complete models of the isolator and connecting link assemblies shall be conducted if necessary to define the axial and transverse frequencies in higher modes.

3.1 SYSTEM CONFIGURATION CRITERIA.

3.1.1 OPTIMUM SYSTEM.

On the basis of requirements discussed earlier, the optimum shock isolation system can be described as one which will transform any and all of a family of input shock motions, bounded principally by a limiting response spectrum, to motions whose response spectra do not exceed the tolerance spectra of the equipment to be isolated. This transformation must be accomplished despite the fact that the static and dynamic properties of the equipment are definable usually only within broad ranges of possible values, and that, in some cases, these properties may be variable in time. Further, the system must fulfill certain static performance requirements and must have a long life, low total cost, and high ultimate reliability.

In this section, the most significant relationships between performance objectives and configuration characteristics are discussed. Emphasis is placed on identifying what the system must do to meet the performance objectives and how, with available hardware, this may be accomplished.

3.1.2 THE BALANCED SYSTEM.

Criteria. One of the two most important objectives in selecting a shock isolation system configuration is that of achieving dynamic balance. Balance is simply that property of the system which requires it to respond to a transient input force or moment only in the same direction as that of the input. For example, if the input is a force applied vertically, the balanced system will respond by translating only vertically, or if the input is a moment about a given axis, the system will rotate only about that same axis.

Advantages of a balanced system are that it will traverse a minimum volume during its oscillations and also generate a minimum strength output motion. These advantages are the direct result of the fact that, in a balanced system, its modes of oscillation in facility-oriented coordinates are uncoupled. In large systems, small angles of rotation can result in large translations at extreme locations from the center of mass.

Since in protective structures the rotational component of the input is small, it is of particular importance to avoid system configurations in which the rotational modes are coupled to the translational modes.

Balance in a shock isolation system can be achieved by selecting a configuration such that the principal elastic axes and the principal inertia axes of the system coincide. Principal elastic axes of a system are those axes along which the system will deflect collinearly with an applied force with no rotation. Principal inertia axes are those about which the products of inertia vanish. Obviously then, if they coincide, the origin of both sets of axes must lie at the mass center.

A second objective in selecting the isolation system configuration is to ensure that the coordinates of the dynamically balanced system are coincident with those of principal importance in the environment; that is, with those of the building in which the system is installed. If this second requirement can also be met, the isolation system will not only produce a minimum output motion environment but will also occupy the minimum useful space within the structure.

All protective structures, if not all structures, are designed with respect to gravity axes, that is, walls are parallel to the direction of gravity and floors are perpendicular to this direction. Efficient usage of the space within these structures then dictates that occupied volumes be oriented in the same coordinate system. Thus, not only must the isolation system be balanced dynamically to occupy the minimum space, but this space must be oriented with respect to the facility to ensure that it is also the minimum useful space. To achieve this, the dynamical axes must be alined with the gravity axes of the system when the system is in its equilibrium position.

A simple planar model of a balanced system is shown in Figure 1-5. Here the equipment is supported about its center of mass by eight identical elastic elements symmetrically located. Assuming that all displacements will be small, so that the change in length of the horizontal and vertical elements is small for vertical and horizontal displacements, respectively of the center of mass, a force applied at the center of mass in the X-direction will be

accompanied only by a translation of the center of mass in that direction. Similarly, a force in the Y-direction will cause a pure translation in the Y-direction, and a moment applied at the center of mass will produce a pure rotation. Thus, the X and Y coordinates are the principal elastic axes.

If the mass of the equipment is distributed uniformly throughout its volume, the X and Y coordinates are also the principal inertia axes. Thus the system is completely balanced.

Another example is shown in Figure 1-6 in which balance in only the vertical direction is considered. The load consists of three items of equipment weighing (from left to right) W, W, and 2W pounds, the equipment being connected by rigid massless bars. The system is supported from hard structure by two elastic elements, R_1 and R_2. To satisfy static equilibrium, $R_1 = 2.4W$ and $R_2 = 1.6W$.

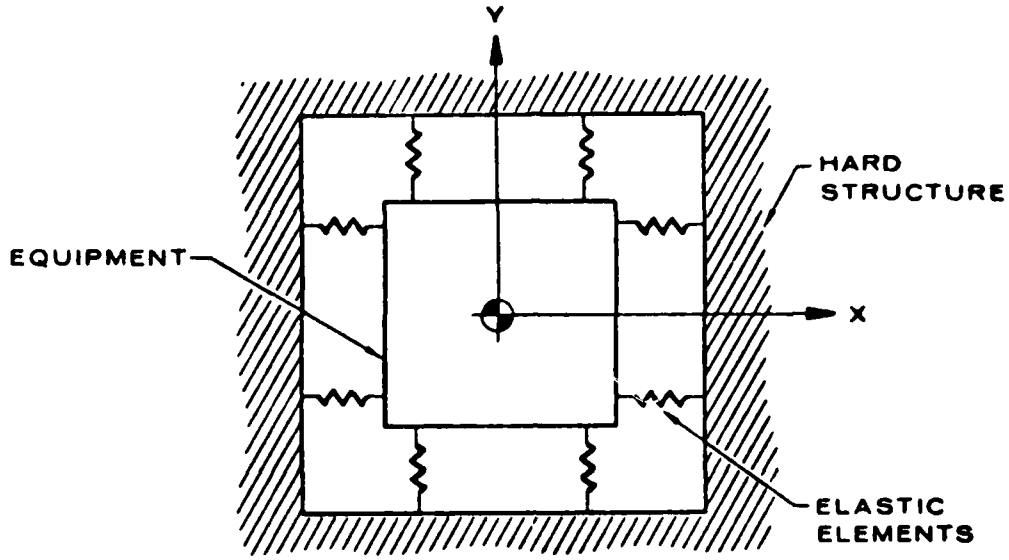


Figure 1-5. Planar Model of Statically Balanced System

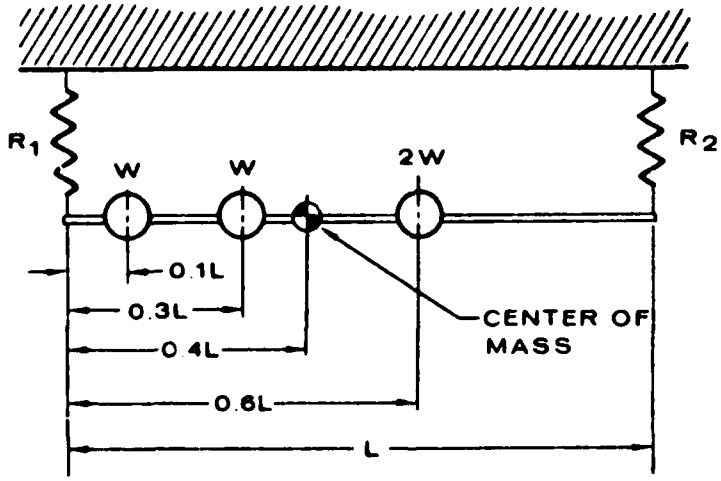


Figure 1-6. Planar Model of Static Balanced Beam

Suppose now, that a force is applied downward at the center of mass. To maintain static equilibrium, the forces in elements R_1 and R_2 must be increased in proportion to the load these elements carried initially, that is $\Delta R_1 = 0.6F$, where F is the applied force, and $\Delta R_2 = 0.4F$. If the principal elastic axis is to pass through the mass center, and no rotation is to result from the application of the force, these incremental forces in R_1 and R_2 must occur as a result of an increase in their length by the same displacement, ΔX. Thus, the ratio of stiffness K_1 of element R_1, to stiffness K_2 of element R_2, must be

$$\frac{K_1}{K_2} = \frac{\Delta R_1/\Delta X}{\Delta R_2/\Delta X} = \frac{\Delta R_1}{\Delta R_2} = \frac{R_1}{R_2} = 1.5$$

If the stiffnesses of the elastic elements are fixed in proportion to the loads they support, the principal elastic axis will pass through the mass center.

Suppose that, instead of a unit force, a unit moment, ΔM, is applied in the clockwise direction at the center of mass. The decrease in force in the element R_1 is $\Delta R_1 = -\Delta M/L$, and the increase in force in R_2 is $\Delta R_2 = +\Delta M/L$. A pure rotation of the system about the center of mass will require that the relationship between the incremental displacement ΔX_1 at R_1, and the incremental displacement ΔX_2 at R_2, is

$$\frac{\Delta X_1}{\Delta X_2} = -\frac{R_2}{R_1}$$

Then the required stiffness of the elastic element for static balance in rotation is

$$\frac{K_1}{K_2} = \frac{\dfrac{-\Delta M}{-R_2 L}}{\dfrac{-\Delta M}{R_1 L}} = \frac{R_1}{R_2} = 1.5$$

or precisely the same ratio as that required above.

Although the masses are not distributed symmetrically about the mass center, since they are alined collinearly, one principal inertia axis will lie along the beam and the other in the plane of the paper orthogonal to it. Thus, the system is balanced.

Minimizing Coupling Effects. However desirable a dynamically balanced system may be, the fact remains that if balance is highly dependent on properties of the load and if these properties, such as mass and mass distribution can be defined only within broad ranges, the probability that imbalances will occur must be accepted, and provisions made for offsetting them. Two general methods can be employed: First, the effects of moderate amounts of coupling can be minimized by the proper selection of system parameters, and second, adjustments can be incorporated in the system to restore it, at least in part, to its balanced condition.

Three general approaches can be employed to minimize the effects of coupling due to imbalance. First, the frequencies of all six uncoupled frequencies in the system coordinates should be separated such that they avoid direct resonances. Since the mass and mass distribution of the load may vary, in some cases the frequencies, the separation of frequencies should be maintained over the expected range of load variations. Actually, this approach is simply a restatement of the requirement for dynamic balance as separation of these frequencies will reduce the coupling. Second, extremely low stiffnesses in the rotational modes should be avoided. While increasing these stiffnesses will add higher-frequency components to the system responses, the amplitudes of these rotational modes should be relatively low, if the system is properly balanced, as there is little rotational energy introduced directly into them. An important effect of these higher stiffnesses is to lower the displacements in the rotational modes for a given amount of energy introduced into them.

There are other advantages of maintaining high rotational frequencies. For example, it was noted in the performance objectives that friction forces could cause residual inclinations of the load under static conditions. The higher the frequency in rotation, the less these inclinations will be for a given friction force. Another advantage of high rotational stiffness is that it reduces inclinations in cases where the load position may vary in time, such as where personnel are free to move about the floor.

The third approach by which the effects of coupling can be reduced is by installing energy dissipative devices in the coupled energizing modes. For example, if energy can be transmitted to a rotational mode only through its coupling to a translational mode, a rapid attenuation of motion in the translational mode by damping will reduce the amount of energy transferred. As damping is also required in the system to meet other performance requirements, its use for this purpose does not add to cost or complexity.

Adjustment. Even though all of the methods described above for minimizing the effects of coupling are utilized, variations in mass and mass distribution and in system properties may be so great that the system must be provided with an adjustment capability to return the system to a condition nearer to dynamic balance, and to maintain the static position of the system within a specified nominal translational and rotational tolerance.

There are two basic methods for providing this adjustability. The first method involves the use of ballast weights and in the past has only been employed to maintain nominal position. The position and weight of the ballast is regulated so that if the mass or mass distribution of the equipment varies, the total weight remains constant, and its center of gravity always remains at some fixed location. For small items of equipment, the use of ballast offers a simple means for maintaining static position. For very large items of equipment, however, the cost and space occupied by the ballast can be significant, and its proper adjustment to accommodate later modifications to equipment presents something of a problem. Further, of course, ballast cannot be used to offset imbalance where the loads are varying rapidly in time.

A more common method for maintaining both static position and some measure of dynamic balance is by the adjustment of properties of the isolation system itself. To fulfill this objective completely, four adjustment features would be necessary:

- Translational adjustment of the system vertically to maintain the nominal position throughout changes in total weight.
- Rotational adjustment of the system about both horizontal axes to maintain the inclination tolerance throughout changes in the center-of-gravity locations.

- Stiffness adjustment in all six system coordinates to control location of principal elastic axes.
- Mass adjustment to control location of principal inertia axes.

In no isolation system installed to date in a protective structure have all these adjustment capabilities been incorporated. In all facilities since the TITAN II Weapon System, provisions have been incorporated in most shock isolation systems for maintaining the nominal position of the system throughout predicted variations in the mass and mass distribution of the supported load. One isolation system installed in early MINUTEMAN facilities, and many systems to be installed in SAFEGUARD, also include a stiffness adjustment in some of the coordinates. The provision of stiffness adjustment in all six coordinates, however, would require a very complex configuration. Aside from ballasting to maintain nominal position, mass adjustment has not been incorporated in any of the systems.

System Tolerances. In addition to variations in properties of the load, there is a further factor which also influences the nominal position of the isolation system and its balance. Manufacturing tolerances of the components of the system, particularly those of the elastic and damping elements, can often be so large that their variations can have a significant effect on system balance. While the choice is offered between imposing stringent manufacturing tolerances and designing the system to accept elements with more generous tolerances, economic considerations have always favored the latter approach. While for some types of components these tolerances can have an important effect on system performance, a capability for offsetting their effect on nominal position can be incorporated in the adjustment provisions. Further, by selecting other types of system components, both the magnitude of the tolerance and its effect on both static and dynamic balance can be reduced to negligible quantities.

Transmissibility. One very significant concept in the design of shock isolation systems, yet one which has been adopted only in the past few years, is the use of a shock response spectrum rather than a peak acceleration as a criterion of the output of the system. The greater significance of the spectrum was discussed earlier. Nonetheless, however well justified, the concept does impose on the shock isolation designer a need for a reorientation of approach.

Insofar as is known, the use of the response spectrum as a means specifying the output of a shock isolation system was first suggested in Reference 11, this despite the fact that spectra had been employed as criteria of damage potential for hard-mounted equipment for many years. Although Reference 11 was published almost a decade ago, the significant differences between this and the earlier criterion have yet to be fully appreciated. While the earlier criterion established peak acceleration of the base motion as the sole parameter of damage, the spectrum concept is more concerned with what a base motion does to the supported system. Peak acceleration is still important but frequency and the duration of the acceleration are of equal significance.

If the shock isolated load were rigid and the elastic elements massless, the response of the system to any disturbance would be characterized by six components, each with its unique frequency, peak amplitude, phase angle, and decay rate. Further, for a well balanced system, the three most predominate frequency components would be those due only to translations. A spectrum of the response motion then would be a direct reflection of the characteristics of these three components.

The supported load, however, is not a rigid body but an elastic one. As noted earlier, it has its own modes of response to the input and these will interact with the system to alter its motion not only in amplitude but in frequency, phase angle, and decay rate, as well. Further, the elastic elements are not massless but are mechanical devices bridging the gap between the hard environment and the equipment. At their hard-mounted ends, they are exposed to the full intensity of the shock environment and their own dynamic responses at their characteristic frequencies can be transmitted to the equipment.

Describing the potential damage to equipment of this complex motion by only a peak acceleration clearly overlooks many important parameters. By failing to identify these parameters, no direction is provided the designer as to how he may reduce their severity. While the response spectrum is not a rigorous criterion of damage potential, it does have the very important advantage of reflecting the contribution of many parameters other than peak acceleration.

Elastic responses of the equipment and the mechanical components of the isolation system itself can have a significant effect on the response spectrum of the motion at the equipment/system interface. While the peak acceleration of the interface motion may not be altered appreciably, many components may be added to it at frequencies well above the rigid-body frequencies of the system. These will be reflected in the response spectrum, perhaps making it difficult to achieve the attenuation in the high-frequency region specified by the equipment tolerance spectrum. In selecting an isolation system configuration, therefore, care should be taken to reduce the severity of the output spectrum throughout the required frequency range by minimizing the transmission of the higher-frequency components to the supported load, and providing for energy dissipation throughout the entire frequency bandwidth.

There are several ways for minimizing the transmission of high-frequency energy through the isolation system component connecting the hard structure and the equipment. One is to employ lightweight components which cannot absorb much energy. Impact between any of the elements of the system, of course, must be avoided at all costs since impact will energize high-frequency modes. The basic elastic element should also be selected such that the forces it transmits in the higher modes are negligible.

Probably the most effective means for minimizing the response spectrum of the output motion, not only in the high-frequency region but in the range of the rigid body frequencies as well, is through the use of energy-dissipative elements throughout the system. Damping in the fundamental modes can often be incorporated directly in the primary elastic element or inserted in parallel with it. Energy dissipation in the higher modes can be accomplished by the careful selection of materials used for structural members, and through the use of special materials at critical interfaces.

There can be large differences, however, in the effectiveness of various types of energy-dissipative elements and, unless care is taken in selecting those with appropriate properties, their use may increase rather than decrease the severity of the output response at some frequencies. Characteristics of some of the more frequently used damping devices are discussed later in this section.

With regard to transmissibility, then, the basic objectives in selecting the isolation system configuration is to reduce the response spectrum of the output motion throughout the entire specified frequency range. The ideal goal would be to permit only those motions due to rigid body responses to reach the equipment and to attenuate these quickly by damping devices, thus reducing the severity of their response spectra. In actual practice, many other motions generated by the elastic responses of the components of the shock isolation system itself will be transmitted to the equipment. This "noise" must be minimized by selecting components which transmit only pure tones and by incorporating damping to attenuate the noise which is transmitted.

3.1.3 EQUIPMENT ARRANGEMENT.

Once all equipment which must be shock isolated has been identified and performance objectives defined for each item, the decision then must be made as to the general approach to be adopted in selecting the equipment shock mounting arrangements. The two basic approaches are to mount each item of equipment individually or to assemble two or more items on a common shock-isolated platform. The final decision should be based on functional as well as shock isolation considerations. All existing facilities contain both types of mounting arrangements. The basis for the selection of the arrangement is simply to arrive at the most efficient overall system.

The problem can best be viewed by overlaying on a preliminary layout of the facility the proposed location of all equipment to be shock isolated, and indicating on each item the strength of the shock environment to which it may be exposed, and the required attenuation. Where personnel must be shock isolated, they and all equipment that they may be required to operate during or immediately following attack should be provided with a common platform.

There are other cases in which the use of an individual mounting system is the only practical choice; for example, a pump which must be located far from any other shock isolated item, pipe and conduit hangers, and light fixtures. Very large, stiff items of equipment such as a turbine or diesel engine may also be more easily shock-isolated individually. But on reviewing

the layout drawings, it will usually be found that large numbers of items of equipment can be grouped together on a common platform and, possibly with some rearrangement, the majority of equipment could be isolated in this manner.

Where the decision between individual and group mounting is not clear cut, there are many considerations which must be evaluated. The most important of these are ultimate reliability and cost, but each of these basic standards consists of many factors. In general, however, except for special cases such as those noted above, where either one or the other of these approaches is impractical, or unless the static and dynamic properties of the equipment are known with good confidence at the time the isolation system is designed, the use of group mounting will result in a higher ultimate reliability and usually a lower overall cost.

There are many advantages to group mounting. First, the weight of the platform supporting the quipment is a large fraction of, if not equal to, the weight of the equipment. As the platform is designed by the facility engineer, its static and dynamic properties are known within close tolerances. Thus, the effect of significant variations in weight of the equipment on the weight of the total shock-isolated assembly is reduced considerably. Further, as the location of the equipment on the platform is specified, a variation in center-of-gravity location of say 50 percent of its principal dimension will shift the center-of-gravity of the entire assembly by an amount more than an order of magnitude less than this. Also, as many items of equipment are supported on the platform, the probability is small that all of their weights will be larger than estimated, or that all of the center-of-gravity locations will be shifted in the same direction. In short, the fact that the isolated assembly now includes a large, massive platform, the effect on performance of variations in equipment properties is reduced by a large factor.

A second advantage of group mounting is that it tends to reduce the amount of rattlespace required. It is easily shown that the rattlespace required by several independently mounted items is greater than that required by a single item having their total volume. As the number of such items increases, so does the saving in rattlespace. This comparison pre-supposes that rattlespace is independent of the size of the load and, if the system

is well balanced, the increase in rattlespace with load should be small, certainly not sufficient to contradict the results of this comparison. From the saving in rattlespace, of course, must be subtracted the volume of the platform, but even so, significant net savings in rattlespace usually can be achieved. Further, the space within the platform can frequently be utilized to install equipment, ducts, conduits, etc., and thus it is not entirely wasted.

A third advantage of group mounting is cost. It was noted in the previous section that there are many factors contributing to cost and, in making cost comparisons, it is essential that the cost factors to be considered are specified. For example, the cost of individually isolating an item of equipment where the equipment properties can be defined only within broad ranges must include the cost of the more complex adjustment system required to accommodate these possible variations. If the system is not provided with a broad balancing capability, the possibility exists that it will require some rework prior to activation, again adding to the cost.

Another factor which results in significant differences between the costs of the two types of mounting arrangements is the number and types of isolators needed. For example, the cost of many types of isolators per pound of supported load decreases exponentially with the magnitude of the load. For example, an isolator purchased in moderate quantities to support a 1000-pound static load might cost one dollar per pound of load, while one supporting 10,000 pounds would cost 15 cents per pound of supported load.

As individual mounting requires large numbers of small isolators of different sizes, the cost of the isolators is high. On the other hand, while isolators for group-mounted equipment must also support the weight of the platform as well as that of the equipment, only a few isolators are required to support the system and, since there is a choice of location, their sizes can be standardized. Although the cost of the platform must also be considered in the comparison, it is usually found that the initial cost of the group-mounted system is comparable if not lower than that of the individually mounted equipment.

If the cost of connections with hard structure, maintenance, and spares are considered in the comparison, the cost advantage of the group-mounted system becomes even more significant. However, this cost advantage will be reduced unless the experimental phases of the design verification program of the very large system are maintained within realistic bounds.

In examining possible arrangements for grouping the equipment on a common platform, it is often found that the shock tolerances are not the same for all items which otherwise might functionally be mounted together. The question is then raised as to whether or not a cost penalty is involved in shock isolating some of the equipment to a level well below its tolerance.

The first consideration, of course, should be that of selecting an arrangement which is functional. However, unless the shock tolerance of the preponderance of equipment is at the higher level, almost all cost factors favor mixing the equipment and shock isolating to the lowest tolerance level. While an isolation system for the higher-tolerance equipment may require less rattlespace than that of the low-tolerance equipment, the rattlespace required by two separate platforms will be greater than that required by a single platform of the same total area. Within some bound, the cost per pound of a platform increases with its area. However, it is also a function of the severity of the isolation system output. Thus, the cost (and weight) of the single platform may be less than that of the two smaller platforms. Finally, if all platforms are isolated to the same output level, the number of different sizes of isolators can be reduced, with a significant saving in isolator cost.

In arriving at a preliminary mounting arrangement for shock-isolated equipment and personnel, therefore, these factors must be considered:

- Optimum functional arrangement
- Severity of shock environment
- Attenuation requirement
- Reliability of data on equipment properties
- Proximity to other shock-isolated equipment
- Rattlespace
- Connections to hard structure

All of these relate directly to the ultimate reliability of the system and to the overall cost of the facility.

Once the arrangement configuration has been selected, it may now be necessary to revise the performance objective document to reflect the properties required of systems which will be employed to shock isolate more than one item of equipment.

3.2 ISOLATION SYSTEM HARDWARE.

3.2.1 SCOPE.

In this section some of the shock isolation system configurations and components most commonly employed in major systems installed in protective structures are presented and their characteristics examined. Particular attention is focused on configurations and components which were considered for use in the SAFEGUARD facilities.

At this point in the development of the design, it is assumed that the general arrangement of the equipment has been selected and that the performance objective document has been modified to reflect changes necessitated by any rearrangements. The next task is to select system components and fabrication techniques which will ensure that all performance objectives are met.

The basic elements of the shock isolation system are:

- Platform (if required)
- Energy-storage component
- Energy-dissipative component
- Connecting links
- Attachments

Each of these elements has one basic function to fulfill, but also has many other requirements placed on it by performance as well as by cost, reliability, and such factors. Characteristics which dictate the capability of an actual item of hardware to meet these requirements are not always independent, and thus an item which fulfills the basic function may have many objectionable side effects. In comparing various elements, then, it is important that all its essential characteristics be identified before a final selection is made.

3.2.2 CONFIGURATION DEVELOPMENT.

Proof that the system will fulfill all its objectives is the purpose of the design verification program, both its analytical and experimental phases, discussed in a later section. However, throughout the selection of a detailed configuration and system components, simple analyses are invaluable in assuring the designer that he is following the proper approach.

One of the first analyses which may be employed is that of ensuring that the suspension configuration and the nominal stiffness properties have been selected so as to constitute a reasonably well-balanced system. Although the actual system may be somewhat nonlinear, the model used in this preliminary analysis may be assumed to be linear. Further, the equipment may be assumed to be rigid and the springs massless.

The analysis consists of calculating the modal properties of the system: model frequencies, mode shapes, and modal participation factors. From the frequency data it can then be determined whether or not the system has adequate modal stiffnesses. For a system ideally balanced, the mode shapes will consist of three pure translations and three pure rotations about axes coincident with the system reference coordinates. If the mode shapes indicate otherwise, coupling in the reference system coordinates will exist. In few actual systems can an ideal balance be achieved, but an effort should be made to reduce the coupling to a small value.

While modal data cannot be employed to determine a response spectrum of the output motion of the system, they can be used as a basis for estimating whether or not the required attenuation has been achieved. Using the modal frequencies and participation factors together with the input response spectra, the peak amplitude of the motion in each of the six modes can be determined. Depending upon the amount of damping which will be incorporated in the system, an amplification ratio for each modal response can then be estimated and multiplied by the peak amplitude. If the resulting peak response exceeds the tolerance spectrum for the equipment, it is probable that insufficient attenuation has been provided. Further, the modal data can be employed to establish gross bounds on the rattlespace requirement, and to evaluate the relative importance of coupling.

This analysis is very simple to perform with a computer program, and it allows the designer to explore a large number of configurations in a very short period of time. One word of caution should be emphasized, however. As the model of the system is linearized, the implicit assumption is made that rotations of the elastic elements are small, that is $\sin\theta = 0$, $\cos\theta = 1$, where θ is the angle of rotation of the element from its nominal position. In actual practice some rotation is inevitable and must be tolerated. However, large amounts are usually objectionable since the rotation increases the coupling between modes. In selecting a configuration, of course, care should be taken to ensure that the rotation angles will not be large. In any case, these rotations as well as any nonlinearities in the isolators and damping devices must be considered in the later, more detailed analyses.

3.2.3 SUSPENSION ARRANGEMENTS.

Although there are innumerable ways to support an item to be shock isolated, the two types most commonly employed are the base support and the overhead pendulum support. The base-mounted type consists of arranging a set of elastic elements between the floor and the equipment such that the equipment is supported both statically and dynamically. In the overhead pendulum system, the load is supported by pendulum arms incorporating elastic elements and suspended from hard structure overhead. Both types of systems can be used, either with equipment mounted individually or grouped together on a platform.

There are no essential differences in these two suspension arrangements. Rather the significant differences are in the stiffness requirements imposed on the elastic element. For example, consider the three base-mounted systems shown in Figure 1-7. The system in Figure 1-7 (a) is supported only by four vertical elastic elements. Thus, each element must provide a vertical stiffness, a horizontal stiffness, and, unless it is free to rotate at its connection to the load, a rotational stiffness.

In Figure 1-7 (b), a configuration much preferred in vibration isolation, is shown in which the isolators are re-oriented so that their axes are directed more toward the center of mass. By the use of this technique it is possible, if the location of the center and inertia properties of the mass are known, to decouple certain modes. Again, however, both axial, shear,

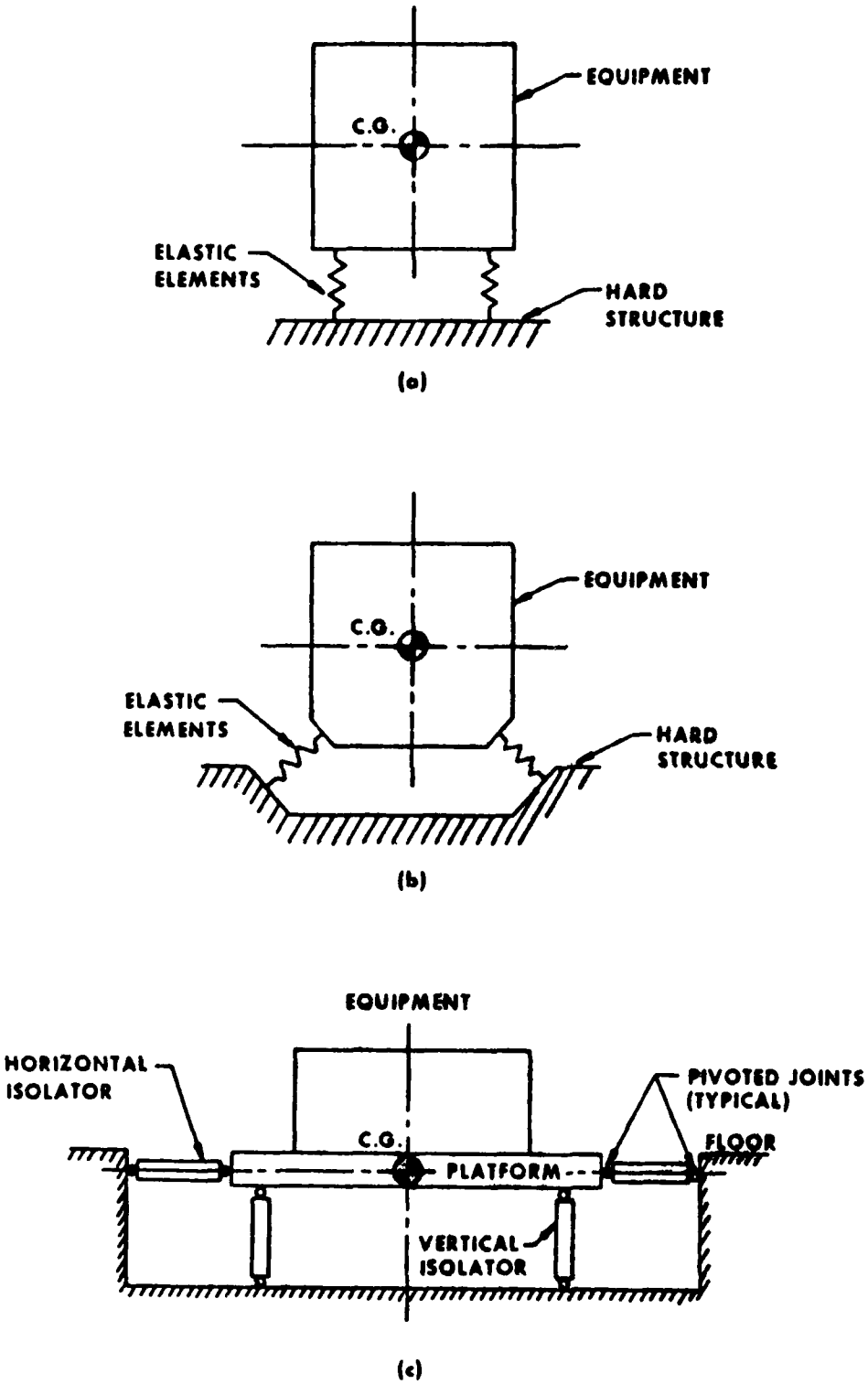


Figure 1-7. Three Base-Mounted Isolation System Configurations

and rotational stiffnesses must be provided by the elastic elements.

A third base-mounted system is shown in Figure 1-7 (c) where the supported load includes a platform. In this configuration independent elastic elements are installed parallel to the three orthogonal system coordinates. As each elastic element is free to rotate both at its hard-mounted end and at its attachment to the platform, it is only required to produce a force along its own axis.

A system employing an overhead pendulum configuration is shown in Figure 1-8 (a). Each of the pendulum arms is installed vertically, incorporates an axial elastic element, and is provided at each end with fittings which permit rotation about all three axes. Again it is seen that, for small displacements, the elastic element alone contributes to the vertical stiffness. Lateral stiffness is provided by gravity acting on the pendulum system and is a function only of the pendulum length.

In Figure 1-8 (a), the center of mass of the platform assembly is collinear with the axis of the horizontal elastic elements. In most cases, the center of mass will lie either above or below the point of attachment. Two alternate methods for shifting the horizontal elastic axis so that it passes through the center of mass are shown in Figure 1-8 (b), where the isolator itself, or auxiliary supports, are mounted rigidly to the platform to raise the pendulum attachment point.

It is seen then that, while in the configurations of Figures 1-7 (a) and (b) which are base-mounted systems, the elastic elements must provide axial shear, and rotational stiffnesses, those of Figure 1-7 (c) and Figure 1-8, the former base and the latter overhead-mounted, are required only to provide axail stiffness.

One of the requirements for good performance is that a reasonably close dynamic balance be maintained about the system-oriented coordinates. This requirement implies that the stiffness of the system in each of the system coordinates can be set independently to match the requirements of the configuration. Eminently satisfactory elastic elements can be designed in which, in a single unit, stiffnesses in more than one coordinate are both

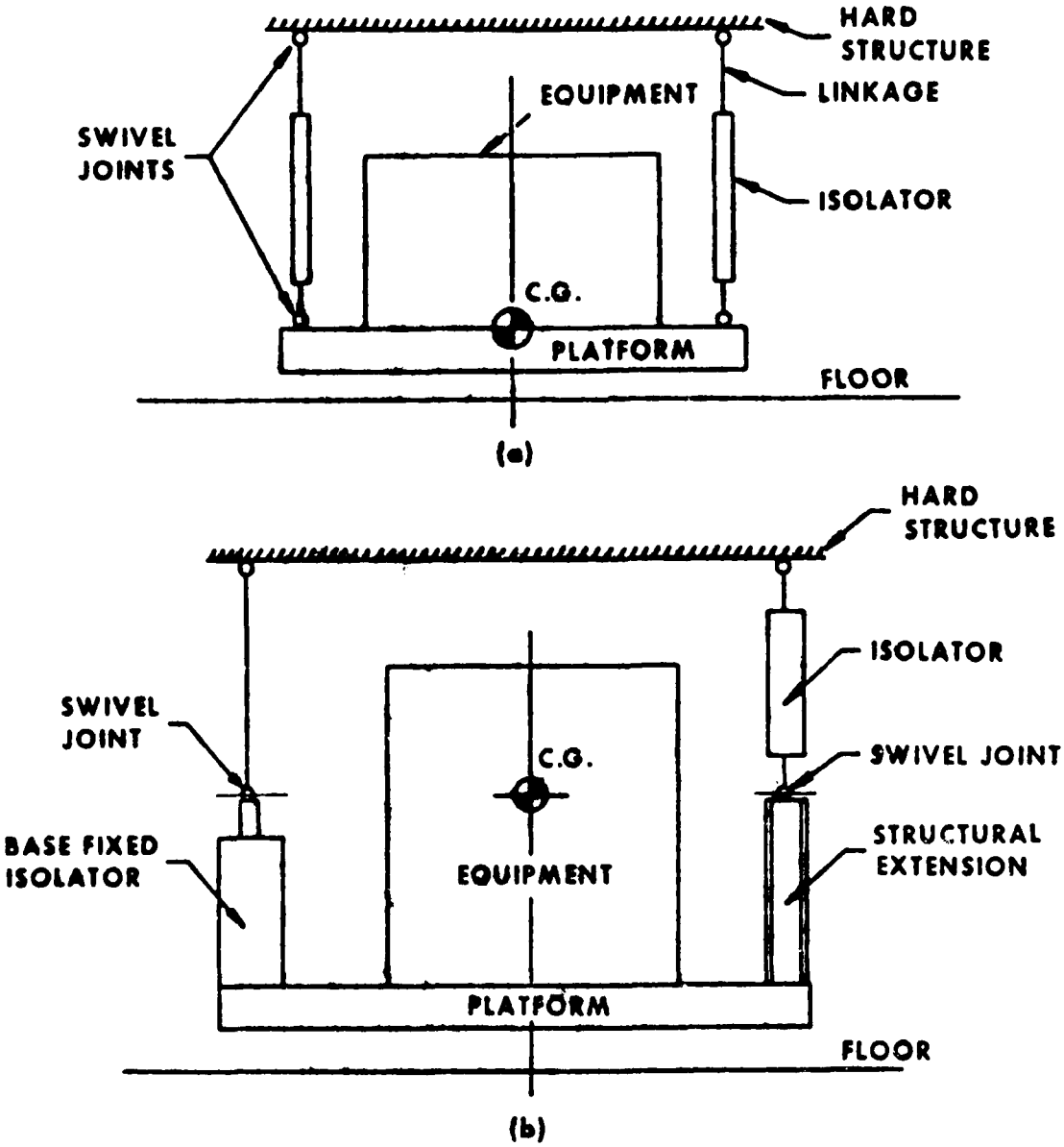


Figure 1-8. Two Arrangements of Overhead Pendulum Shock Isolations Using Platforms

uncoupled and independently controlled. However, in many elastic elements which are frequently used in this type of configuration, notably helical springs, the stiffnesses are highly coupled and can be predicted only within very broad ranges. Balancing a system employing these elements is virtually impossible.

These examples have been presented to emphasize that while, ideally, balance may be achieved by a variety of configurations, there may be a great variation in the ideal and the actual properties of real components, and these variations may be difficult to define. Large displacements of the system may introduce imbalance at off-nominal positions, but these effects can be predicted with good confidence. Nonlinearities in the elastic or damping element may also cause some imbalance,but if these are predictable they too may be acceptable. The situation to avoid is that of specifying components whose properties cannot be predicted with good confidence.

It should also be noted that, in all of the configurations shown in Figures 1-7 and 1-8, coupling of the horizontal translational modes with rotations about the horizontal axes is dependent on the elevation of the point of attachment (or elastic center) of the isolators which provide the lateral stiffness relative to the elevation of the center of mass of the system. This coupling cannot be eliminated by altering the stiffness of the springs but must be offset either by changing the center of mass location by the use of ballast, or by a physical adjustment in the elastic axes such as that shown in Figure 1-8 (b).

In selecting the system configuration, then, these considerations should be borne firmly in mind:

(a) Throughout all specified variations in loading conditions the system should be balanced dynamically as closely as possible. Coupling due to imbalance can be reduced by separating frequencies of the modes in the system coordinates.

(b) Moderate amounts of coupling due to the kinematic configuration may be offset by providing an adjustment capability. Where the coupling is excessive, a better balanced configuration should be selected.

(c) The suspension configuration should be selected such that, throughout the full range of stroke, rotations of the lines of action of the connecting links are small.

(d) No configuration should be selected which necessitates the use of either elastic or damping elements whose characteristics cannot be predicted with good confidence.

(e) The system must incorporate sufficient adjustability both in translation and rotation to enable it to be returned to its nominal position under all specified variations in load and system tolerances.

A further point which should be emphasized is that, in order to accommodate the broad ranges in load properties specified by the performance objectives, it may be more advantageous to accept small imbalances under all possible dynamic conditions than to demand a perfect balance under nominal conditions, but which might result in greater imbalances under off-nominal conditions. In other words, the objective should be to obtain the most favorable responses throughout the specified ranges of environmental and system parameters.

3.2.4 PLATFORM DESIGN.

Elastic Properties. If an individual mounting system is selected, the dynamic characteristics of the equipment may have a strong influence on the motion at the isolation system/equipment interface. Where the basic geometry and construction details of the equipment are known, an analytical model of the first few modes can be included in the model of the system, and the low-frequency responses of the system calculated. Indeed, if one or two of the modes lie within the frequency range of the rigid-body modes of the isolation system, it is essential that these elastic properties of the equipment be included in preliminary analyses to determine system balance.

On the other hand, if the equipment is to be group mounted on a platform, the relatively large size of the platform, coupled with the desire to reduce its cost to a minimum, can also result in a platform/equipment system whose fundamental frequencies lie well within the range of the rigid-body modes of the isolation system, even though those of the equipment which it supports are higher.

If it is practical to make the platform sufficiently stiff so that the frequencies of the platform/equipment system lie well above those of the rigid-body frequencies of the suspension system, it is advisable to do so. If the platform is very large, however, and/or the weight of the supported equipment great, the size and cost of a platform to provide the desired stiffness could be a significant cost factor. In these cases, the effect of platform flexibility on the system response must be investigated in the preliminary analyses of system balance.

Free-free modal properties of the platform can be greatly influenced by the elastic and weight properties of the equipment which it supports. While the platform alone may be relatively stiff, the stiffness of the load which it supports may be low, and its weight high. Thus, the fundamental frequency of the platform/equipment system can be low. The stiffness of each item of equipment which the platform supports need not be low in order to have a low system stiffness since the equipment may consist of several stiff items all mounted individually to the platform but with no stiff connections between them.

Conversely, the platform stiffness may be low, but that of the supported load so high that it effectively stiffens the entire system. As it is the stiffness of the supported system rather than that of the platform alone which is of importance, the design requirements for the platform cannot be established until the properties and locations of the equipment are determined.

Another important goal in selecting the platform design is that it should include provisions for attenuating any high frequencies transmitted through its connections to hard structure. While it was noted earlier that the connections to hard structure should be selected with a view toward minimizing the transmission of high frequencies, the possibility that some will reach the platform cannot be dismissed. All existing protective structures, including SAFEGUARD, have employed welded steel platforms, unfortunately a most efficient transmitter of high frequencies. While this construction method may be economical, it is probable that some reduction in stiffness, in return for improved damping characteristics, would have been an attractive compromise.

Number and Arrangement of Elastic Supports. A question which must always be resolved whenever a platform is used to support the equipment is that regarding the number of elastic elements to employ in supporting the platform

and their optimum arrangement. Statically, of course, the suspension system must maintain the platform in equilibrium, and to maintain static balance the six equations of equilibrium must be satisfied. If the platform is horizontal, however, these equations are sufficient to define the loads and stiffness properties in only three vertical isolators. If a greater number of vertical isolators are to be employed, the system is redundant.

A number of methods imposing additional and somewhat arbitrary constraints (e.g. Reference 12) have been suggested to reduce the redundancy of the problem, and while these constraints may lead to improved system balance, they fail to identify and to satisfy all of the fundamental requirements for optimum balance. These are that the principal elastic and inertia axes of the system coincide with the system coordinates, that the frequencies be properly separated, and that the frequencies of the rotational modes be maintained at a reasonable level. While these latter requirements do not define a unique arrangement, they do place emphasis on relationships of greater importance to system performance.

Materials and Fabrication Methods. Several trade-off studies have been conducted to determine the optimum material and fabrication process for constructing platforms, and all have recommended the use of welded steel. However, the basis for the trade-off decisions has only been the initial cost required to achieve a given stiffness, and has not included such important considerations as the performances advantages to be gained by damping or total cost of the shock isolated system. Unquestionably, damping can be effective in reducing or even eliminating the propagation of high-frequency motion throughout the platform. Yet the economic value of high-frequency attenuation is difficult to assess and thus, at the time the trade-off studies were performed, it was simply ignored. Later, if it is found in tests of the complete system that the high-frequency responses of the platform exceed those specified by the tolerance spectrum, the cost of reworking the system to reduce the severity of the responses is not charged to the platform cost.

Another cost factor these studies have failed to consider is that of reworking the platforms to accommodate the equipment mounting arrangement. From considerations of rigidity and strength, the thickness of the top plate

of steel platforms need not be large. Thus, at locations where the equipment will be supported, stiffners must be provided. Yet in the SAFEGUARD program the attachment bolt patterns of the equipment were not known until after the platforms for the first site were fabricated, and it was necessary to rework the platform by adding stiffners to match the bolt patterns. If the same type and model of equipment installed in the first site is to be used in SAFEGUARD sites subsequent to the first, of course, additional rework will not be required.

A further cost factor which weighed heavily in favor of steel platforms for SAFEGUARD was the assumption that the platforms would be constructed on-site. This assumption was based on the fact that many of the platforms were so large that it was impossible to get them into the buildings once the buildings were constructed. Fabrication of the platforms on-site by any other than standard construction techniques was assumed to involve a severe cost penalty. Use of a modular concept where shop fabrication could be employed was examined only briefly.

And, finally, these trade-offs have not taken into account the added cost of the larger shock isolators required to support the weight of the platform. For isolators supporting static loads ranging say from 1000 to 20,000 pounds, the cost of the isolator per pound of static load will vary from about one dollar to 15 cents, certainly a significant percentage of the cost of the platform itself.

Identification of optimum platform materials and fabrication techniques, therefore, appears to be a problem which has yet to be resolved. It is believed that the many potential advantages offered by the use of lightweight laminates and modular design have yet to be fully explored. It is quite possible, indeed probable, that no universal optimum exists, but that the most effective type of platform ultimately will depend on its size, on the dimensions, weight, and attachment pattern of the supported load, and on the output motion requirements.

3.2.5 ELASTIC AND ENERGY DISSIPATIVE COMPONENTS.

In earlier discussions of the dynamic behavior of the complete shock isolation system it was pointed out that the basic elastic and energy dissipative characteristics of the isolators contribute principally to responses

in the rigid-body modes of the system. It was also noted, however, that any real energy-storage element has mass and dissipation, and any real energy-dissipative element has compliance and mass. Thus, both of them will transmit energy not only in a fundamental mode, but in many higher-frequency modes as well. In selecting energy storage and dissipative devices for incorporation in the isolation system, therefore, their real, as well as their ideal, properties must be considered.

While there is a wide variety of elements from which to choose, almost all of these will have differences in their transmission characteristics, not only in the higher modes, but in the fundamental modes as well. Further, no single type of element incorporates all cost and performance features which renders it the optimum for all cases. In this section, the most important of these characteristics are reviewed and compared.

Elastic Element Requirements. On the basis of earlier discussions of system requirements, the features and characteristics of the ideal elastic element can be summarized:

(a) The dynamic force displacement relationship of the elastic element should be predictable with good accuracy. If the same element is to be used to provide stiffness in more than one direction, its stiffness properties in each of these directions should be closely predictable, and they should be uncoupled.

(b) The force-displacement characteristics of the elastic element should be linear to minimize dynamic imbalance of the system throughout its stroke. There are several types of nonlinear elements which have been found to be very effective, but their nonlinearity is only accepted in return for other desirable performance features.

(c) The elastic element should have low mass in order to minimize the transmission of high frequencies.

(d) The frequency of the elastic element should remain constant with changes in load, that is, its stiffness should vary in direct proportion to the load it supports. This feature enables the system to remain dynamically balanced throughout changes in the supported mass and its position.

(e) The static position of the elastic element should be easily adjustable to return the system to its nominal position when subjected to load changes.

(f) The elastic element should have high reliability, long life, and low cost.

As noted earlier, there is a wide variety of methods and materials which can be used to design an elastic element which will satisfy almost all of these objectives. However, in the usual case it has been found that, while these elements might meet the performance requirements, they usually fail to achieve the cost goal. Thus, in the past, attention has been concentrated on five relatively simple types of elastic elements :

- Beams
- Torsion bars
- Helical springs
- Liquid springs
- Gas springs
- Elastomers

In the TITAN I facilities, combined beam-torsion bar elements were employed extensively. They were highly coupled, and owing to their configuration, their stiffnesses were difficult to estimate accurately. None of them were provided with adjustments to offset either changes in load or variations in the location of the center of mass. The NORAD suspension system consists of helical springs mounted under large platforms. The same springs provide stiffnesses vertically, horizontally, and in rotation. Large load changes combined with insufficient adjustability necessitated extensive rework of the system to maintain static position and balance. Both the TITAN II and MINUTEMAN facilities include a large number of overhead pendulum systems where the elastic element is a helical spring incorporated in the pendulum arm and thus loaded only in the axial direction. Adjustments are provided to maintain the nominal position under changes in load and center of mass.

None of the systems described above incorporate provisions for adjusting stiffness, and none of them include damping.

To meet a special and very stringent performance requirement, one of the MINUTEMAN systems incorporated, first, a gas isolator (Wings I thru V), and later a liquid spring (Wing VI). The system was required to damp vertical translational motions to one-third amplitude within one-half a cycle, and thus, undamped helical springs, used throughout the remainder of the facility, could not be employed. Both gas and liquid springs have a capability for maintaining balance which is superior to that of the helical spring and, in addition, can easily be designed to incorporate a damping element. The gas spring has an inherent nonlinearity which ensures vertical balance under all load and center of mass variations.

Costs and maintenance requirements for both the gas and liquid springs were higher than desired under most design conditions. However, the higher costs were not a consequence of employing a gas or liquid as the elastic element, but rather were the result of the special attenuation features which the systems demanded. Further, while it is probable that the maintenance required for a gas or liquid isolator will always be greater than that say of a beam, the more important consideration is ultimate reliability. As, in this respect, the gas and liquid systems, particularly the former, have significant advantages; some sacrifice in maintenance may be accepted if a higher ultimate reliability can be gained.

Stiffness of Elastic Element. One characteristic of an elastic element which is of value in those cases where the load may vary significantly from its nominal conditions is that the stiffness of the element about its equilibrium position should vary linearly with the load it supports. Both beams and torsion bars can be designed to provide this feature as their stiffness is a function of their length. By providing a length adjustment capability, therefore, the stiffness can be controlled. However, owing to the complexity of incorporating this feature, no such device has been employed in a protective structure. Where beams, torsion bars, or helical springs have been employed, no length adjustment capability has been provided.

For all these types of mechanical elements, therefore, the stiffness of the element about its equilibrium position has been by design a constant, that is

$$\frac{dF}{dX} = k$$

where

F = static load on element

X = displacement

k = stiffness, a constant

The frequency of this type of element about its equilibrium position then is

$$\omega = \sqrt{\frac{kg}{W}}$$

where

ω = circular frequency

g = gravitational acceleration

W = weight of supported load

As the stiffness of the spring is constant, being a function of its dimensions and material properties, it is seen that the frequency will vary inversely as the square root of the static weight.

Consider now the stiffness and equilibrium frequency of a gas spring. The pressure-volume relationship for a gas is

$$PV^n = \text{constant}$$

where

P = pressure

V = volume

n = an exponent defining the relationship for a given compression process

As the volume of the enclosed gas is proportional to the stroke of the piston, the stiffness of the spring bout the equilibrium position X_o is

$$\frac{dF}{dX} = -\frac{nW}{X_o}$$

The circular frequency about this position is

$$\omega_o = \left(\frac{ng}{X_o}\right)^{1/2}$$

where the subscript o denotes the value at the nominal position.

Note that the frequency of the gas spring about its equilibrium position is independent of the load it supports. Thus, if a system incorporating gas springs is initially balanced, it will remain balanced under all changes in load or positions of its center of mass.

The pressure-density relationship for a compressible liquid is

$$\frac{dP}{d\rho} = \frac{\beta}{\rho}$$

where

ρ = density of the liquid

β = bulk modulus of elasticity of the liquid

For a liquid spring containing a constant amount of fluid

$$\frac{d\rho}{\rho} = -\frac{dV}{V} = -\frac{dX}{X}$$

where V and X are the same as above.

Bulk moduli of elasticity for most liquids employed in springs can be approximated by the relationship

$$\beta = a + bP$$

where a and b are coefficients characteristic of the liquid. The frequency of a liquid spring of a unit effective area then is

$$\omega_0 = \left[\frac{g}{X_0}\left(\frac{a}{W} + b\right)\right]^{1/2}$$

It may be seen from the above equation that the liquid spring acts partially as a constant stiffness spring and partially as a gas spring. The first term in the parentheses indicates that the frequency varies inversely as the square root of the static weight, while the second term is independent of weight.

Consider, for example, three isolators, a mechanical spring with constant stiffness, a gas spring, and a liquid spring (containing Union Carbide L-45 silicone fluid), each supporting a nominal load of 20,000 pounds and at this

load having a circular frequency of 3.76 radians per second (0.6 Hz). A comparison of the variations of their frequencies due to off-design loads is shown in Figure 1-9. When the static weight supported by the helical spring is reduced to 10,000 pounds, its frequency is increased to 5.33 radians per second while for the same load change that of the liquid spring is increased to 4.81 radians per second. At twice the nominal load, the frequencies of the two springs are reduced to 2.66 and 3.12 radians per second respectively. Throughout this entire range, of course, the frequency of the gas spring remains constant.

Equations given above for the stiffnesses of gas and liquid springs are typical of these elements about their equilibrium positions. While the equations for both can be easily transformed into a more general form defining the force as a function of displacement at any position, it is clear that both functions are nonlinear; that is, in neither case is the force

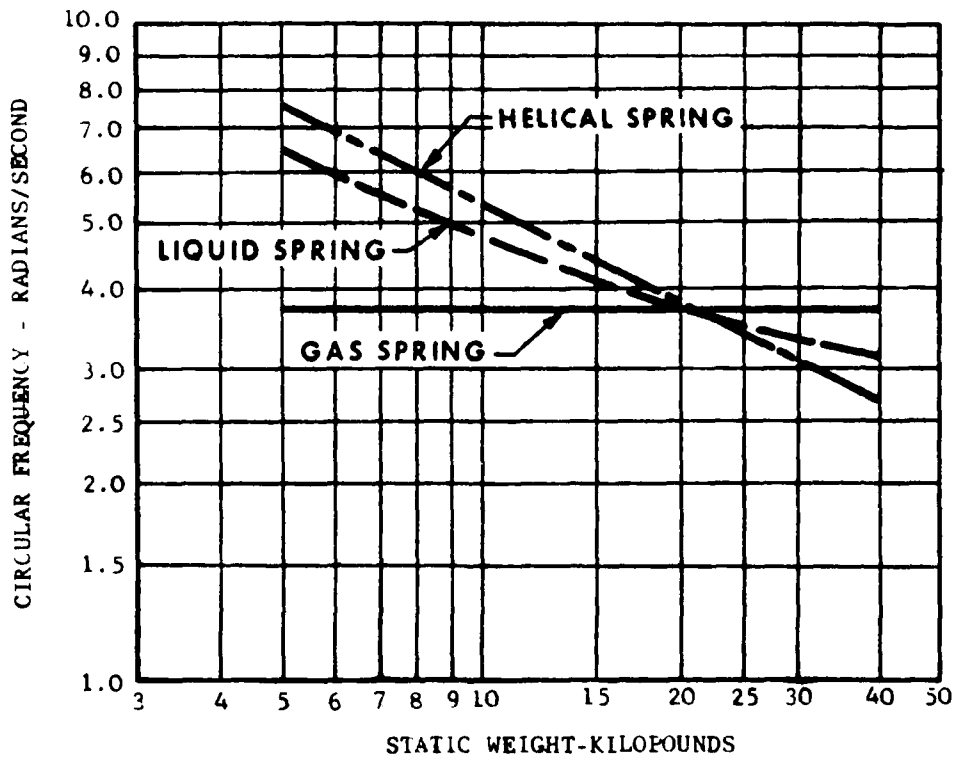


Figure 1-9. Comparison of the Variation in Frequency With Static Load of a Helical, a Liquid and a Gas Spring

directly proportional to displacement. In this respect, the liquid spring is the more nearly linear of the two. On the other hand, had the requirement for constant frequency been met by a mechanical change in the length of a beam or torsion bar at each discrete length, the force-displacement characteristic of the element would have remained linear.

The acceptability of nonlinearities in the energy storage element of a shock isolation system is dependent not only on their nature, that is, whether they are functions of displacement only, of displacement and time, or of these and other parameters, but most importantly on whether the nonlinear characteristics are predictable with good confidence, whether they may transmit high-frequency energy to the higher modes of the system, whether they contribute to improved system performance under all other specified conditions, and finally, whether they may react abruptly if the system were exposed to environments somewhat beyond those specified for design but still within the realm of remote possibility. If the nonlinear element can meet all of these challenges, not only may its use be acceptable but it may be desirable in achieving significant performance advantages. It must be cautioned, however, that some nonlinear elements which may appear to offer attractive performance advantages in fact may lead to inferior performance under the specified environments, and to a strong uncertainty as to whether or not the system would survive environments or loading conditions even slightly off those specified by design requirements.

Neither the gas nor the liquid spring, undamped, is of this type. Their stiffnesses are smoothly continuous functions of their displacements and they are predictable with even greater accuracies, considering manufacturing tolerances, than those of a helical spring. Their nonlinearities contribute to imbalance only in rotational modes but since they also minimize the coupling of energized translational with the relatively inert translational modes their net effect on the response of the properly designed system can be highly beneficial. Inclusion of damping devices as integral elements of the fluid spring, discussed later in this section, can amplify the nonlinear aspects of the spring/damper system, but this fact that the damping element can be incorporated easily in the basic elastic element has distinct cost advantages.

The relative transmissibility in higher modes of these three general types of elements is in the same order as their variability in equilibrium

frequency. Owing to their larger mass, forces due to surges in the mechanical springs are the highest, while those resulting from gas springs are the lowest.

One important limitation of all fluid springs employed to date, however, should be noted. No fluid spring employed in a protective structure has had the capability of resisting both tensile and compressive loads. Promising configurations have been conceived but none of these has been developed to the point where its performance has been proven. Until such concepts are developed, then, the fluid spring should be employed only in those applications where the peak output acceleration is less than 1 g.

The use of elastomers as the primary elastic element in major shock isolation systems installed in protective structures has been limited to only a very few applications where the displacements were small. Their more common use has been as snubbers and as interface devices to inhibit the transmission of high frequencies. Even in these latter two cases, care must be taken in employing elastomers unless their inherent damping is high, since to be effective, the energy absorbed both by snubbers and interface treatments should be largely dissipative.

Other Considerations of Elastic Elements. With regard to fluid-type elements, another factor which must be considered in their application is the range of the temperature environment in which they will be expected to operate. Mechanical systems, of course, are essentially unaffected by temperature changes of the magnitudes of those encountered in protective structures. Fluid systems, however, are and their excursions from their nominal static positions due to these changes must be considered in design.

Difference equations for calculating excursions of gas and liquid springs due to changes in ambient temperature are given in Reference 1. It may be noted that, of the two types of fluid elements, the liquid spring is by far the more sensitive to temperature.

Ease of adjustment and installation of systems incorporating fluid elements are also superior to those containing mechanical energy storage devices. Adjustements to return the isolation system to its nominal position both in translation and rotation after changes in the load conditions can be easily accomplished in a fluid system by the injection or release of the

appropriate amount of fluid. Indeed, an index incorporated in the fluid element to indicate the nominal position will also denote its position of dynamic equilibrium. On the other hand, while an index can be incorporated in the constant frequency element to indicate the return of the system to its nominal static position, a large degree of dynamic imbalance at this position may be incurred with no external indication that the imbalance exists.

Installation and replacement of the fluid element are also more readily accomplished than for those elements whose stored energy is a function only of position. For example, the installation of a fluid element need only consist of blocking the equipment or platform in its nominal position, installing the de-energized fluid elements, and energizing them by the insertion of fluid until they reach sufficient pressure to support the load. Removal of one or all of the fluid elements can be accomplished as easily by blocking the load at its static position and relieving the pressure on the fluid element.

The maintenance required and the frequency at which routine inspections should be made for each of the three basic types of elastic elements depends directly on their design and the materials employed in their fabrication. In general, the purely mechanical systems will require little maintenance. Maintenance requirements for gas isolators are principally dependent on the leakage rate of the gas and the life of the seals. The maximum leakage rate of gas isolators being procured for the SAFEGUARD system has been fixed at that which will permit the isolator under static load to displace 1/2-inch in a 1-year period. Preliminary tests indicate that a much lower leakage rate is being achieved. These isolators employ elastomeric seals, but although they have a guaranteed life of 10 years, their actual life in service has yet to be determined.

Other detail configurations for gas isolators are possible, however, depending principally on requirements imposed by the application. For example, for isolators whose displacement requirements are small, metal seals can be employed, thus reducing the maintenance requirement to that comparable to mechanical systems.

Maintenance and inspection requirements for liquid springs are no less, and are probably greater, than those for the gas spring. Again, however,

these requirements are highly dependent on the design of the particular element and its service environment.

Energy-Dissipative Elements. It has been noted on several occasions that the inclusion of energy-dissipative devices in the isolation system has several very significant advantages. Damping can:

- Reduce the severity of response spectrum of output motion
- Reduce the effect of coupling between modes, thus reducing rattlespace requirement
- Restore the system quickly to equilibrium
- Decrease the sensitivity of system to variations in input environment.

Thus, damping may improve the system performance, decrease the cost for rattlespace, and increase confidence in survival.

Not all types of damping, however, are effective in achieving all of these benefits. For example, while some types may attenuate the low-frequency components of the output, they may also increase the severity of the output at higher frequencies. Damping, in which the force is proportional to some power of the velocity greater than unity, is particularly objectionable in this regard, and becomes more undesirable as the value of the exponent increases. This characteristic, of course, is typical of viscous, hydraulic, and quadratic dampers.

Another factor which must be considered in selecting the type of damping is that the damping force should not prevent the system from returning after an excursion to a position near its nominal one. Coulomb damping, where the damping force near the nominal position is large, has this disadvantage. To overcome this disadvantage, coulomb dampers installed in the SAFEGUARD facilities have been designed to generate a friction force which is proportional to stroke, the constant of proportionality being selected to ensure that the system will return within a close tolerance to its nominal position. The high-frequency transmission characteristics of the SAFEGUARD coulomb dampers have yet to be investigated.

In addition to the usual requirements for high reliability and low maintenance and cost, performance objectives of the damping element are to:

(a) Provide maximum energy dissipation with a minimum peak damping force.

(b) Transmit damping forces whose frequencies lie only within the low-frequency region.

(c) Permit the system to return to a position near to its nominal one.

(d) Maintain the effective damping ratio within a close tolerance when the system is adjusted to offset changes in load.

Again, of course, the requirement for employing elements whose performance characteristics are predictable within close tolerance and with good confidence is of vital importance. Although at moderate damping ratios damping does not influence the frequency of the system by a large factor, small differences in energy dissipation rate, integrated over several cycles, can have an appreciable effect on the amplitude of the motion. Unless all dampers in the system behave in the same manner, the system may become unbalanced.

Owing to the low damping inherent in materials from which mechanical springs are usually fabricated, it is necessary to parallel this type of elastic element with a separate damping device. The damper may be of the friction, gas, liquid, or other type, but each damper must be sized to match the spring with which it will be installed. Whenever the load on the associated spring is changed, for example, to compensate for a change in center-of-gravity location, the effective damping ratio for the spring/damper assembly will also change, thus contributing even further to imbalance in the system. While adjustments could be provided in the damper to reset the damping ratio to its nominal value, the system is already imbalanced owing to the change in spring load, and this imbalance is greater than that due to damping. In addition, in general, it has not been considered to be advisable to incorporate any more adjustments in shock isolation systems than are absolutely essential since, without expert operation and maintenance supervision, the system could be imbalanced even further without any physical indication that this situation exists.

Both in gas and liquid springs, the damping element can be incorporated in the same unit which provides energy storage. Damping is accomplished by installing a diaphragm in the cylinder containing the fluid separating it into two smaller volumes, and by inserting an orifice in the diaphragm. Energy

dissipation is accomplished by forcing the fluid through the orifice, and the damping rate is a function of the orifice size and the two cylinder volumes.

Two characteristics of a fluid spring/damper system containing an integral dashpot can have a significant and beneficial impact on system performance. First, as the orifice is in series rather than in parallel with the elastic element, the transmission of high frequencies by orifice flow is reduced. This feature permits the use of higher damping ratios than would be acceptable were the damper placed in parallel with the spring. Second, throughout large variations in load on the isolator, the effective damping ratio remains essentially constant. As the frequency of the elastic element also remains constant during changes in load, the isolation system remains balanced under off-nominal conditions without the need for external adjustment.

If the orifice area were set equal to the cylinder area, obviously the system would be undamped and the equilibrium frequency of the elastic element would be a function of the total volume of the cylinder. On the other hand, if the orifice area were set equal to zero, again the system would be undamped but the system frequency would now be a function of the total volume of the cylinder, less the volume of the damping chamber. Between these two limiting orifice areas, therefore, there must be, and there is, an orifice area which will result in a maximum damping ratio attainable by the spring/damper assembly. For the gas isolators employed in the SAFEGUARD system whose equilibrium isothermal frequencies are 0.6 Hz and whose loads vary from 900 to 20,000 pounds, the maximum damping ratio was found to occur when the ratio of the areas of the orifice to the cylinder cross section was about 0.001.

The maximum effective damping ratio which can be attained has been found to be a function of the ratio of the volume of the damping chamber to that of the remainder of the cylinder volume. Again, for the SAFEGUARD isolators this ratio was found to be about 2.0, that is, the volume of the damping chamber was about two-thirds of the total volume of the cylinder at the equilibrium position of the system. With this volume ratio, effective damping ratios of 25 percent of critical were found to be achievable.

It should be noted that all practical damping mechanisms, other than the viscous damper, are nonlinear and thus the term "damping ratio" which

defines the amount of damping in a viscously damped system does not apply to them. To equate the energy dissipated in one steady-state cycle of a system incorporating a nonlinear damping element with that dissipated in a viscously damped system, the concept of "equivalent viscous damping ratio" was advanced in Reference 13. For transient motions, however, equivalent viscous damping ratio has no significance, and thus to quantify the energy dissipation rate of a nonlinearly damped system, other criteria must be employed.

One of the prime objectives of incorporating damping in a shock isolation system is to reduce the severity of the response spectrum of the output motion. This objective is accomplished by causing the response motions to subside quickly and, in accomplishing this attenuation, to introduce as few high-frequency responses as possible. It would appear then that the response spectrum of the decaying motion might be employed as a criterion of the effectiveness of various damping mechanisms. However, this concept has yet to be developed.

In this report, the term "effective damping ratio" is used. Effective damping ratio is based on a comparison of the decay rate of a given system with that of a viscously damped system. The comparison is made for the condition where both systems are energized by a step displacement of a specified magnitude. The systems are then permitted to oscillate freely and their peak amplitudes of the second, third, fourth, or other specified cycle are compared. In the examples cited above, peak amplitudes of the second cycle was used as a basis for comparison.

It should be remembered, however, that the prime objective still is to reduce the severity of the response spectrum of the output motion. Thus, in selecting the amount of damping to include in the isolation system, the criterion should simply be that amount which results in the least severe spectrum.

Neither analytical nor experimental data have been generated which define the fundamental performance characteristics of liquid springs incorporating integral damping elements. While the basic mechanisms are essentially the same as those of gas springs, the large numerical differences in the properties of a liquid and those of a gas unquestionably shift their transmitted motions to a higher-frequency range. Until further work is done on the fundamental

behavior of liquid spring/damper devices, however, the advantages of the liquid spring in this application cannot be properly evaluated.

In the overhead pendulum suspension system, vertical stiffness is provided by elastic elements incorporated in the pendulum arms. To these, dampers can be installed either in parallel with the elastic element or integral with it. Stiffness in the horizontal direction, however, is due only to gravity, and there are no horizontal elastic elements. Thus, if damping is to be provided in the horizontal direction, special devices must be installed.

Horizontal damping devices can easily be installed in overhead pendulum systems, of course, and in the early MINUTEMAN Wings they were employed. Later in the MINUTEMAN facilities these horizontal dampers were removed but the fault lay not with the dynamic principle but with the design of the dampers themselves. However, one of the attractions of the overhead pendulum system has been that they require no horizontal stiffness elements. If dampers must be installed, the attractiveness of this configuration is greatly diminished.

None of the pendulum support systems to be installed in the SAFEGUARD facilities incorporate horizontal dampers. This decision was justified on the basis of two considerations. First, it hoped that there will be sufficient friction in the pendulum connections to damp the lateral oscillation of pendulum systems within a reasonable period of time. Although the friction forces will be small, their effectiveness will be erhanced by the very low horizontal frequencies of most of the pendulum systems. Second, also owing to the very low lateral frequencies of the system, response spectra of the horizontal output motion can tolerate higher amplification ratios without exceeding the horizontal tolerance spectra for the supported equipment.

3.2.6 CONNECTIONS.

In some shock isolation system installations, the combined elastic/damping element itself forms the connecting link between the isolated load and hard structure. In other systems, notably overhead pendulum configurations, auxiliary connectors are required to satisfy a fixed dimension between the hard structure and the supported load. Where auxiliary connectors are to be employed, it is preferable that they be installed between the elastic/damper

assembly and the hard structure to avoid exposing the elastic/damper assembly which is usually the more sensitive, to the full strength of the shock environment. In either case, the entire connector assembly is subjected to both axial and shear loads which at the hard-mounted end are typical of those generated by the input shock environment, and at the shock-isolated end by those typical of the isolation system response.

Whether or not an auxiliary connector is employed, design objectives for the connecting members between the isolation system and the hard structure are that they have adequate strength to prevent permanent deformation and that they will not transmit, when excited dynamically, a significant amount of high-frequency energy to the supported load. Thus, both the mass and the in- and out-of-plane stiffnesses of the connector assembly are parameters which will have an impact on system performance.

Problems with connector assemblies most frequently encountered in the past have been due principally to insufficient consideration being given to the many details which govern their dynamic behavior. Excessive bending in the auxiliary connector due to combined axial and transverse loads, lateral impacting between piston rods and their clearance holes and between helical springs and the walls of their containers, and surges in the basic elastic and damping elements, also sometimes accompanied by impact, all have led to a performance of the system less satisfactory than expected, if not to structural failure.

Although connector assemblies are often treated in early analyses of system performance as massless elements, they are not. Not only can their masses and elastic properties have significant effects on the performance of the isolation system as a whole, but the dynamic loads on the connectors themselves cannot be determined unless these properties are considered. Too often have these aspects of the design configuration been overlooked in the design analyses.

In overhead pendulum systems where the output motion is attenuated to less than one g, the use of auxiliary connectors fabricated from chain or cable has often been suggested. In employing elements which will not carry compression, however, care must be taken to ensure that no compression will occur in all significant modes of the connectors, not just in their fundamental. Once the connector is unloaded axially, severe transients may be

generated when the load is re-established. In general, the use of connectors which have abrupt discontinuities in their elastic properties should be avoided.

The need for adjustment in length of the connection between the hard structure and the supported load to compensate for changes in static load and load location and to offset manufacturing tolerances in the stiffness of the elastic element was mentioned earlier. Another requirement for length adjustment is imposed by tolerances in the construction of the protective structure itself. For base-mounted systems the variation between a true horizontal and the level of the base usually may be neglected. For overhead pendulum systems, however, where the equipment must be oriented with respect to a floor but the system is attached to a ceiling, a significant difference in the nominal and the possible lengths must be expected. For example, in the SAFEGUARD system the possible variation in the distance between a floor and a ceiling was set tentatively at ± 3 inches. To date, post-construction measurements have not been made to verify this estimate.

In a fluid spring, compensation for changes in static load can be made by inserting or withdrawing fluid from the unit so that its nominal length always remains the same. Thus, only compensation for building tolerances need be incorporated in the connector assembly. On the other hand, unless they are provided with a means for stiffness adjustment, mechanical springs will not assume the same nominal position when adjusted for load changes or stiffness tolerances. For connector assemblies incorporating mechanical springs, therefore, provisions for accommodating changes in length due to load variations, stiffness tolerances, and variations in building dimensions, all must be provided.

3.2.7 ATTACHMENTS.

Fittings to attach the connector assemblies to the shock-isolated load and to the hard structure also must be given careful attention in their design if the performance objectives of the system are to be satisfied. Structural integrity, obviously, is a basic requirement of the fittings, but the possibility that they may generate high-frequency noise is a consideration of no less importance. To avoid the generation of noise, abrupt changes in the elastic properties of all contributing mechanisms must be avoided. The most important of these mechanisms, of course, is the impacting of any of the mechanical elements comprising the attachment configuration.

It is essential, therefore, that the transmissibility of all potentially impacting mechanisms be reduced first, by minimizing the severity of the impact by specifying close manufacturing tolerances, and second, by the use of interface damping materials to reduce the severity of those impacts which cannot otherwise be avoided.

To reduce the effects of impact, fittings for attaching the connector assemblies to the load and to the environment should specify tolerances closer than those usually attainable in field fabrication. The fittings should be structurally stiff and all mating surfaces should be machined to obtain the closest practical tolerances. The fittings should then be installed on the platform and to the hard structure by bolts unless a welding technique is employed by which it can be assured that the effects of distortion will not exceed the specified fitting tolerances.

Despite these precautions, however, the elimination of all potentially impacting elements in metal attachment fittings is a practical impossibility. Thus, in any case, provisions should be made through the use of preloaded, hysteretic elastomers to minimize the effect of impact. The use of soft materials at attachment fittings and other interfaces in the connector assembly, however, should not be adopted without careful regard to their elastic and dissipative properties and, thus, their effect on the dynamic performance of the system. For example, if the force-displacement characteristic of such materials is largely elastic rather than dissipative, they can augment rather than attenuate responses of the system.

3.2.8 TWO SPECIAL BASE MOUNTED ISOLATORS.

In view of some of the problems associated with conventional base mounted shock isolation systems, two new types of base mounted isolators were studied for their specific applications to the SAFEGUARD facilities. Both types have the feature of one isolator assembly providing uncoupled vertical and horizontal stiffness. The first type, as shown in Figure 1-10, is called a short-pendulum isolator. Schematically, it consists of a base plate that is connected to the floor through short-rigid pendulums and a casing. An isolator elastic element and damper is rigidly fixed to the base plate and connected through swivel joints to the platform. To minimize the assembly size, the pendulum length is limited to twelve inches, which corresponds approximately to an uncoupled horizontal pendulum frequency of

one cps. The assembly may be mounted directly underneath the platform or at the side of the platform to decrease the floor clearance requirement.

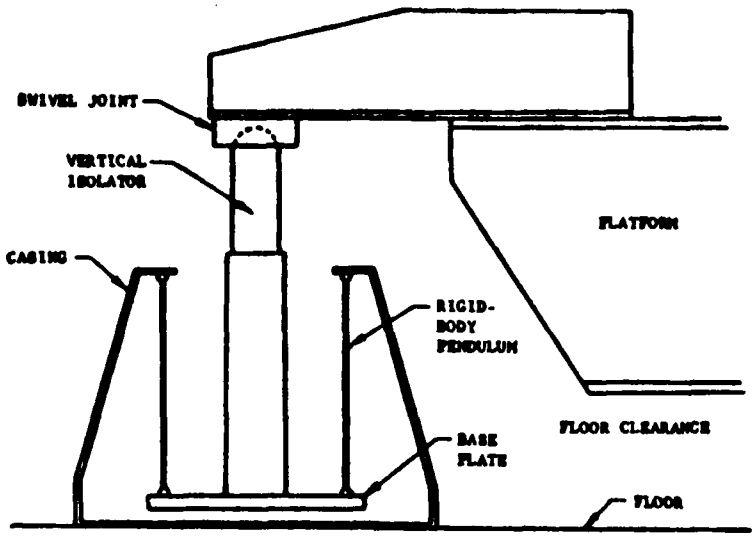


Figure 1-10. Arrangement of a Short Pendulum Type of Isolator.

The second type of system uses a rolling ball element on a spherical concave plate. The radius of curvature of the concave plate determines the uncoupled horizontal frequency of the unit. An elastic element and damper is installed between the platform and the rolling ball assembly to provide vertical isolation. Under a normal loading condition, the rolling action causes local yielding of the plate material. This feature is desirable not only because a relatively small ball is required to support a sizable load, but also the yielding action provides slight damping in the horizontal direction. Figure 1-11 shows the installation of the rolling ball isolator in a platform. This method of installation facilitates servicing of the isolator and minimizes the floor clearance requirement.

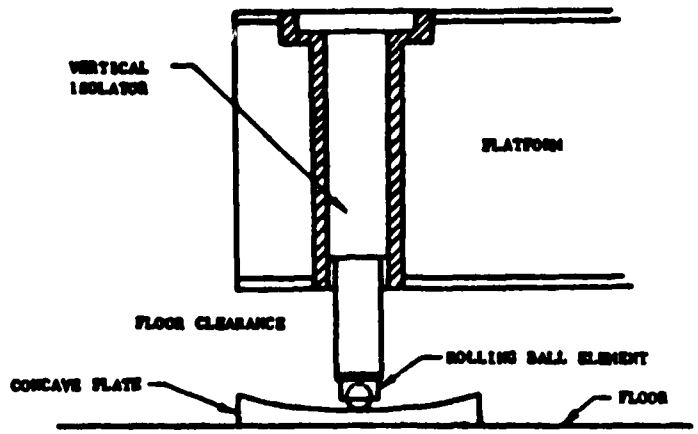


Figure 1-11. Arrangement of a Rolling Ball Type of Isolator

Even though a complete experimental evaluation of these types of isolators has not been conducted, there are sufficient analytical results to demonstrate their feasibilities. Considering the many advantages offered, especially the relatively small space requirements under the platform, these types should be evaluated more thoroughly and specified as typical types of base mounted shock isolators to be used in SAFEGUARD facilities.

SECTION 4: THEORY: SHOCK ISOLATION SYSTEM OF A RIGID PLATFORM

4.1 INTRODUCTION.

4.1.1 BACKGROUND.

Base motions to which equipment, hard-mounted in advanced nuclear protective structures, could be exposed during attack are frequently estimated to be well beyond the tolerance range of the equipment. Even if the equipment is designed specifically for the application, it is often more economical to provide shock isolation than to build sufficient ruggedness into the equipment itself to ensure survival. Thus one of the critical tasks in designing such a facility is to estimate the ruggedness level of the commercial equipment to be installed in the equipment and to perform trade-offs for specialized gear to determine whether hardening or shock isolating will be the more advantageous. Once the decision for shock isolation has been reached, the only problem remaining is to devise a system which will achieve the goals established for shock attenuation, cost, and reliability.

However, shock isolation systems installed in earlier protective structures have been plagued by a host of problems which have required extensive cost and time to rectify. Indeed, it is probable that many problem areas inherent in these systems have yet to be identified. In recognition of many of these deficiencies a comprehensive study directed toward their prevention in the SAFEGUARD program was initiated early in 1969 by the U.S. Army Engineer Division, Huntsville (USAEDH). The program encompassed the development of detailed design criteria, and the formulation of standard design techniques. Later work will include drafting a modest proof-test program to ensure that the program objectives have been met. This approach was based on the conviction that by placing major emphasis on the achievement of a sound design, costly proof testing could be reduced significantly, and rework minimized or even eliminated without sacrificing system reliability.

4.1.2 ANALYSIS METHODS.

In this section, equations are developed for certain configurations and isolator elements which, properly selected and designed, should find wide application in protective structures.

In Section 4.2 derivations are presented of the equations of motion of a six degree-of-freedom spring-pendulum type of shock isolation system. The equations are formulated for a general system supporting a rigid body and where both the locations and the physical characteristics of the isolator elements can be specified arbitrarily. Two special base-mounted shock isolators, the short-pendulum and the rolling-ball types, are discussed in Section 4.2.8. Owing to the unusual physical constraints inherent in these isolators, their forces and moments are not described by the more general equations developed in Section 4.2. Thus, in Section 4.3, equations are derived for calculating forces and moments for the special base-mounted shock isolators.

Where both the system configuration and elements can be considered as linear, the normal mode method can be applied effectively to calculate dynamic responses. Further, with this type of system response, spectra of the input disturbances may be used to establish a maximum bound of the responses. This method of analysis is described in Section 4.4.

A method of synthesizing a waveform to match a given response spectrum is presented in Section 4.5. The method employs a series of transient sinusoidal components whose frequencies can be assigned arbitrarily and whose amplification ratios can be matched approximately to those of the basic disturbance. The derivations of various equations for representing isolator elastic elements and damping values are included in the last section.

Many variables are employed in the derivations, and in each section, the variables are defined when they first appear. Capital letters are used to indicate vectors in Sections 4.2 and 4.3 only. In other sections vectors are represented by a bar under the letter.

4.2 EQUATIONS OF MOTION FOR A RIGID-BODY SIX DEGREE-OF-FREEDOM SHOCK ISOLATION SYSTEM.

4.2.1 INTRODUCTION.

One type of shock isolation suspension configuration which has found wide application in protective structures is the spring-pendulum system. Several items of equipment which are known or suspected of being sensitive to the design shock are gathered together and mounted on a single platform. The

platform is then suspended from the ceiling by pendulum arms in which elastic and possibly damping elements are installed. The advantage of the spring-pendulum system is that it employs gravity as the horizontal restoring force thus obviating the need for independent horizontal isolators.

Properly designed, the pendulum suspension system can be very effective from both the viewpoints of performance and cost. However, in their design and analysis, as in those of most other types of shock isolation systems, there are certain physical mechanisms which are too frequently overlooked with the result that these systems rarely achieve their full potential.

To ensure that these effects are not omitted from analyses of SAFEGUARD systems, equations of motion for a six degree-of-freedom spring-pendulum type shock isolation system are derived in this section. A mathematical model is constructed to represent the dynamic characteristics of a rigid platform suspended by multiple spring/damper elements to a building structure which provides excitations to the shock isolation system. The equations are derived for a system such that both the locations and the dynamic characteristic of the spring/damper elements can be specified arbitrarily. The center of gravity of the system may also be at any location. The weight distribution of the platform may also be non-symmetric.

There are many possible approaches to the development of equations of motion of the shock isolation system. When response rotations cannot be neglected, the approach usually adopted is to write the basic equations of motion with respect to a coordinate system fixed to the platform. The principal argument is that in this formulation the inertia tensor is invariant. However, the equations tend to be more cumbersome, and extensive transformations must be applied to resolve forces and moments into the platform-fixed coordinate system.

The approach taken here is to develop the basic equations of motion with respect to a coordinate system fixed in inertia space, and to accept the complexity associated with a variable inertia tensor. It is felt that this formulation is easier to visualize in a physical sense, and is readily adapted to digital computer solutions.

Approaches for calculating the initial displacements of the platform are discussed. Linearization of the equations of motion for small platform rotations is also shown in this section.

4.2.2 COORDINATE SYSTEMS.

It is convenient, in describing the motion of the platform, to consider several Cartesian coordinate systems as shown in Figure 1-12. Since the basic equations are written in terms of motion with respect to inertia space, an inertial coordinate system is defined. The axes of this coordinate system are denoted by the subscript I in Figure 1-12. A second (moving) coordinate system is assumed to be fixed (locally) to the building structure. Since translational motion only (no rotation) of the local region of the building is to be considered (maximum dynamic rotation angle of all major SAFEGUARD structures has been found to be less than 0.25 degree), the axes of this coordinate system are assumed to remain parallel to the corresponding axes of the inertia-fixed system. The axes of this coordinate system are denoted by the subscript B in Figure 1-12. It is the motion of this coordinate system in inertia space which constitutes the excitation to the shock isolation system. Displacement of the origin of the building-fixed coordinate system with respect to the origin of the inertia-fixed coordinate system is denoted (Figure 1-12),

$$x_{BI} = \begin{Bmatrix} x_{BI} \\ y_{BI} \\ z_{BI} \end{Bmatrix}$$

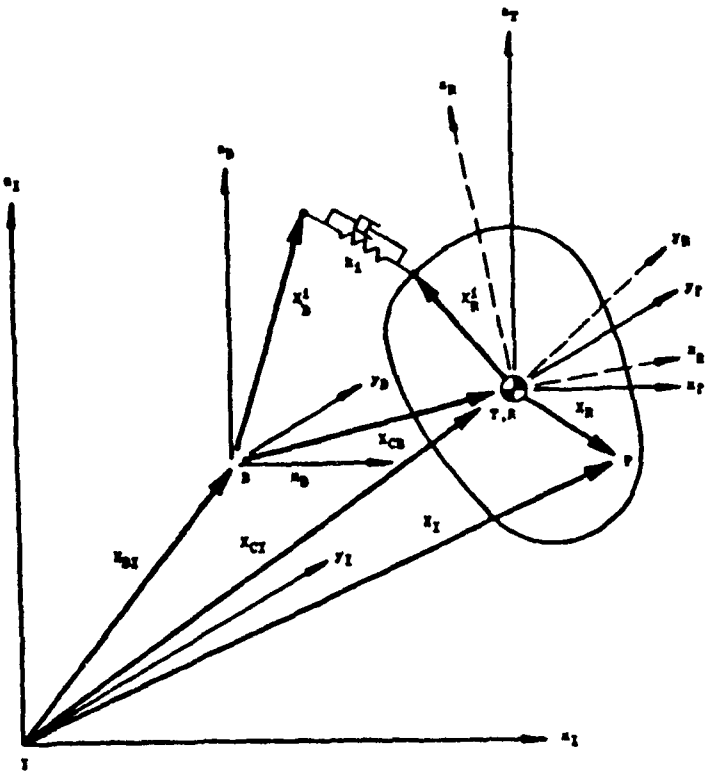


Figure 1-12. Coordinate Axes of Shock Isolation System

A third coordinate system, the axes of which are denoted by the subscript T, has its origin fixed at, and moves with, the center of gravity of the platform system. The axes of this coordinate system remain parallel to the corresponding axes of the building-fixed (and, therefore, the inertia-fixed) coordinate system. The displacement of the center of gravity of the platform system with respect to the origin of the building-fixed coordinate system is

$$X_{CB} = \begin{Bmatrix} x_{CB} \\ y_{CB} \\ z_{CB} \end{Bmatrix}$$

Finally, a fourth coordinate system is defined with its origin fixed at, and moving with, the center of gravity of the platform system, and with its axes fixed with respect to the platform (which is assumed to be rigid); that is, this coordinate system both translates and rotates with the rigid platform. The axes of this coordinate system are denoted by the subscript R in Figure 1-12, and its angular orientation in space is defined by the successive rotations through the angles γ, β, and α right-handedly about the positive z_R, y_R and x_R axes respectively.

4.2.3 EQUATIONS OF MOTION.

Newton's equations of motion for the platform system can be written

$$M\ddot{X}_{CI} = F\left(X_{CB}, \dot{X}_{CB}, \alpha, \beta, \gamma, \dot{\alpha}, \dot{\beta}, \dot{\gamma}\right) + G \tag{1}$$

and

$$\frac{d}{dt}\left\{I_T\Omega\right\} = L\left(X_{CB}, \dot{X}_{CB}, \alpha, \beta, \gamma, \dot{\alpha}, \dot{\beta}, \dot{\gamma}\right) \tag{2}$$

where

$$X_{CI} = \begin{Bmatrix} x_{CI} \\ y_{CI} \\ z_{CI} \end{Bmatrix}$$

$$M = \begin{bmatrix} m_x & 0 & 0 \\ 0 & m_y & 0 \\ 0 & 0 & m_z \end{bmatrix} = \text{mass matrix}$$

$$F = \begin{Bmatrix} F_x \\ F_y \\ F_z \end{Bmatrix} = \text{force vector, i.e. force due to the suspension system springs and dampers}$$

$$G = M \begin{Bmatrix} 0 \\ 0 \\ -g \end{Bmatrix}$$ = acceleration force due to gravity

$$I_T = \begin{bmatrix} I_{T_{xx}} & I_{T_{xy}} & I_{T_{xz}} \\ I_{T_{yx}} & I_{T_{yy}} & I_{T_{yz}} \\ I_{T_{yx}} & I_{T_{zy}} & I_{T_{zz}} \end{bmatrix}$$ = rotatory inertia tensor of the platform system with respect to the x_T, y_T, and z_T coordinate systems

$$\Omega = \begin{Bmatrix} \omega_x \\ \omega_y \\ \omega_z \end{Bmatrix}$$ = angular velocity vector, the components being taken right-handedly about the positive x_I, y_I, and z_I axes respectively

$$L = \begin{Bmatrix} \ell_x \\ \ell_y \\ \ell_z \end{Bmatrix}$$ = moment vector; i.e. moment due to the forces in the suspension system springs and dampers

Note that the inertia tensor I_T is, in general, a function of the angular position of the platform system. The inertia tensor I_R, referenced to the platform-fixed coordinate system, is constant and can be computed from the known mass distribution of the platform system and the assumed initial orientation. Transformations of vector and tensor components from one coordinate system to another are considered in the next subsection.

Since $X_{CI} = X_{BI} + X_{CB}$, Equation 1 can be rewritten in more convenient form as

$$M\ddot{X}_{CB} = F + G - M\ddot{X}_{BI}$$

and $M\ddot{X}_{BI}$, the local translational accelerations of the building structure, can be considered as forcing functions.

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4.2.4 TRANSFORMATION OF COORDINATES.

Vectors can be transformed between the R and T coordinate systems as follows:

$$X_T = AX_R$$
$$X_R = A^T X_T \tag{4}$$

where A is the orthogonal transformation matrix (of direction cosines)

$$A = \begin{bmatrix} \cos\beta\cos\gamma & -\cos\alpha\sin\gamma + \sin\alpha\sin\beta\cos\gamma & \sin\alpha\sin\gamma + \cos\alpha\sin\beta\cos\gamma \\ \cos\beta\sin\gamma & \cos\alpha\cos\gamma + \sin\alpha\sin\beta\sin\gamma & -\sin\alpha\cos\gamma + \cos\alpha\sin\beta\sin\gamma \\ -\sin\beta & \sin\alpha\cos\beta & \cos\alpha\cos\beta \end{bmatrix}$$

and

$$A^{-1} = A^T, \quad X_T = \begin{Bmatrix} x_T \\ y_T \\ z_T \end{Bmatrix}, \quad X_R = \begin{Bmatrix} x_R \\ y_R \\ z_R \end{Bmatrix}$$

The inertia tensor I_T can be defined by

$$I_T = \int_D \begin{bmatrix} y_T^2 + z_T^2 & -x_T y_T & -x_T z_T \\ -y_T x_T & x_T^2 + z_T^2 & -y_T z_T \\ -z_T x_T & -z_T y_T & x_T^2 + y_T^2 \end{bmatrix} \rho dV \tag{5}$$

where D is the domain of the platform system, dV is a volume element, and ρ is the mass density of the volume element.

Equation 5 may be written in matrix form as

$$I_T = \int_D \left[\{X_T\}^T \{X_T\} [\vartheta] - \{X_T\} \{X_T\}^T \right] \rho dV \tag{6}$$

and $[\vartheta]$ is the unit matrix

$$\vartheta = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Using Equation 4, Equation 6 can be written

$$I_T = \int_D \left[|AX_R|^T |AX_R| [\vartheta] - |AX_R| |AX_R|^T \right] \rho dV$$

which can be reduced to

$$I_T = A \left[\int_D \left[|X_R|^T |X_R| [\vartheta] - |X_R| |X_R|^T \right] \rho dV \right] A^T$$

or

$$I_T = A I_R A^T \tag{7}$$

where I_R is the inertia tensor with respect to the platform-fixed coordinate system, and is constant in time. Equation 7 provides a means for calculating the variable inertia tensor I_T from the body-fixed inertia tensor I_R and the rotational matrix A.

The velocity $\dot{X}_T$ with respect to the non-rotating platform-fixed coordinate system of a point P fixed at X_R in the platform system is

$$\dot{X}_T = \dot{A} X_R \tag{8}$$

Since X_R is constant, $\dot{X}_T$ can also be expressed in terms of the angular velocity Ω of the platform system; that is

$$\dot{X}_T = \Omega \times X_T = \Omega \times A X_R \tag{9}$$

where the vector cross product is indicated. In matrix notation Equation 9 can be written as

$$\dot{X}_T = \psi A X_R \tag{10}$$

where $\Omega \times$ is replaced by ψ and

$$\psi = \begin{bmatrix} 0 & -\omega_z & \omega_y \\ \omega_z & 0 & -\omega_x \\ -\omega_y & \omega_x & 0 \end{bmatrix}$$

The validity of this expression can be demonstrated by carrying out the vector cross-product operation indicated in Equation 9, and comparing with the vector product in Equation 10. Note that, since an angular orientation is not a vector quantity except in the limit for small angles, the angular orientation (α, β, γ) cannot be obtained by integrating Ω.

Comparing Equation 8 with Equation 10, it is clear that

$$\dot{A} = \psi A \tag{11}$$

Substituting Equation 7 into Equation 2

$$\frac{d}{dt}\left\{A I_R A^T \Omega\right\} = L$$

or

$$\left[\dot{A} I_R A^T + A I_R \dot{A}^T\right] \Omega + A I_R A^T \dot{\Omega} = L$$

and using Equation 11

$$\left[\psi A I_R A^T + A I_R A^T \psi^T\right] \Omega + A I_R A^T \dot{\Omega} = L \tag{12}$$

and finally

$$I_T\dot{\Omega} + \psi I_T\Omega = L \tag{13}$$

Note that $\left[\psi I_T\right]^T\Omega = 0$

Equation 13 represents three second-order differential equations which can, in principle, be integrated to yield the angular velocities ω_x, ω_y, and ω_z. Equation 11 can be integrated once to yield A, which is required to compute I_T from Equation 7. The angular orientations α, β, γ can also be computed from elements of A.

Equation 3 can be integrated twice to yield the velocity X_{CB} and the displacement X_{CB} of the platform center of gravity with respect to the building fixed coordinate system. This velocity and displacement are required to compute the support system spring and damper forces.

To obtain the rattlespace requirement, it is desirable to compute motions at selected points on the platform system. The displacement in inertia coordinates X_I of a point P on the platform (See Figure 1-12) is.

$$X_I = X_{BI} + X_{CB} + X_T$$

or, using Equation 4

$$X_I = X_{BI} + X_{CB} + AX_R$$

and

$$\dot{X}_I = \dot{X}_{BI} + \dot{X}_{CB} + \dot{A}X_R$$

$$= \dot{X}_{BI} + \dot{X}_{CB} + \psi AX_R$$

and

$$\ddot{X}_I = \ddot{X}_{BI} + \ddot{X}_{CB} + \left[\dot{\psi}A + \psi\dot{A}\right] X_R$$
$$= \ddot{X}_{BI} + \ddot{X}_{CB} + \left[\dot{\psi} + \psi^2\right] AX_R \tag{14}$$

In some cases it may be desirable to determine the components of this absolute acceleration in the platform-fixed coordinate system, such as would be sensed by an accelerometer attached to the platform.

The transformation of Equation 4 can be applied to give

$$\ddot{X}_{IR} = A^T\ddot{X}_I \tag{15}$$

where $\ddot{X}_{IR}$ is the absolute acceleration vector referred to platform-fixed coordinates.

4.2.5 FORCES AND MOMENTS DUE TO SPRINGS AND DAMPERS.

Let $f_i\ (\Delta L_i, \Delta\dot{L}_i)$ be the magnitude of the force acting on the platform through the i-th suspension element, where ΔL_i is the change in length of the i-th suspension element from its free length L_i and $\Delta\dot{L}_i$ is the time rate-of-change of ΔL_i. Let X_B^i be the coordinates of the point of attachment of the i-th suspension element to the building (in the building-fixed coordinate system) and let X_R^i be the coordinates in the platform-fixed coordinate system of the point of attachment of the i-th suspension element to the platform. Then

$$\Delta L_i = L_i - \left(\left\{X_B^i - X_{CB} - A\,X_R^i\right\}^T \left\{X_B^i - X_{CB} - A\,X_R^i\right\}\right)^{1/2}$$
$$= L_i - ||X_B^i - X_{CB} - A\,X_R^i|| \tag{16}$$

where $||\ ||$ indicates absolute value or scalar magnitude, and

$$\Delta\dot{L}_i = -\frac{\left\{X_B^i - X_{CB} - A\,X_R^i\right\}^T \left\{\dot{X}_{CB} + \dot{A}\,X_R^i\right\}}{||X_B^i - X_{CB} - A\,X_R^i||} \tag{17}$$

The vector force F_i due to the i-th element is then

$$F_i = \frac{f_i\left(\Delta L_i, \Delta \dot{L}_i\right)}{||X_B^i - X_{CB} - A\, X_R^i||} \left\{X_B^i - X_{CB} - A\, X_R^i\right\} \tag{18}$$

Here, compression of the elastic element ($\Delta L_i < 0$) gives a positive force.

From F_i, F in Equation 1 is obtained as

$$F = \sum_{i=1}^{n} F_i \tag{19}$$

where n = number of suspension elements.

The moment ℓ_i about the center of gravity of the platform system due to the force F_i in the i-th suspension element is

$$\ell_i = X_T \times F_i$$

This can be expressed conveniently in matrix notation. Define

$$\Phi_i = \begin{bmatrix} 0 & -z_{T_i} & y_{T_i} \\ z_{T_i} & 0 & -x_{T_i} \\ -y_{T_i} & x_{T_i} & 0 \end{bmatrix}$$

then

$$\ell_i = \frac{f_i}{||X_B^i - X_{CB} - A\, X_R^i||} \left[\Phi_i\right] \left\{X_B^i - X_{CB} - A\, X_R^i\right\} \tag{20}$$

and the net moment due to all the suspension elements is

$$L = \sum_{i=1}^{n} \ell_i \tag{21}$$

The spring and damper forces f_i appearing in Equations 18 and 20 can be arbitrary functions of the extensions ΔL_i and extensional velocities $\Delta \dot{L}_i$ of the suspension elements. In the computer-program implementation of this analysis, provision is made to treat linear, bilinear, or arbitrary (tabular input) spring characteristics. Damping characteristics considered include viscous, coulomb, and arbitrary (tabular input) dampers.

4.2.6 INITIAL CONDITIONS.

The problem has been formulated in terms of the assumed geometry and inertia distribution of the platform, the assumed locations of attachment points of the suspension elements on the platform, and on the building structure, and the assumed free lengths of the spring elements. Initially, due to the force of gravity, the platform will seek some equilibrium position. This equilibrium position must be determined and used as the initial position for the dynamic response calculations.

Due to possible nonlinearities resulting either from nonlinear spring characteristics and/or from large platform rotations, the determination of the initial position is not straightforward. Several possible approaches to determining this initial position may be considered.

A relatively simple iterative procedure is to assume a locally linear relationship between the displacement and rotation of the platform from an assumed position and orientation and the incremental force and moment acting on the platform; that is

$$\left\{ \frac{F_0}{L_0} \right\} = \left\{ \frac{F_1}{L_1} \right\} + [K] \{\delta\} \tag{22}$$

where δ is the column matrix of the incremental displacement which includes the translation and rotation of the center of gravity of the platform with respect to the building-fixed coordinate axes, and

$$\delta = \begin{Bmatrix} \Delta x_{CB} \\ \Delta y_{CB} \\ \Delta z_{CB} \\ \Delta\alpha \\ \Delta\beta \\ \Delta\gamma \end{Bmatrix}$$

F_1 and L_1 are computed from Equations 16 thru 21 with all time derivatives (hence all damper forces) zero. Initially, F_1 and L_1 may be computed with an assumed position of the platform center of gravity. The translation of that initial position is X_{CBi} and the rotations with respect to the inertia axes are α_i, β_i and γ_i. The stiffness matrix K in Equation 22 is computed from the local tangents to the spring element force versus displacement relationships. The incremental displacement δ is that required to satisfy Equation 22, where

$$\{F_o\} = [M] \begin{Bmatrix} 0 \\ 0 \\ -g \end{Bmatrix}$$

and

$$\{L_o\} = \begin{Bmatrix} 0 \\ 0 \\ 0 \end{Bmatrix}$$

Solving Equation 22 for δ yields

$$\{\delta\} = [K^{-1}] \left\{ \begin{Bmatrix} F_o \\ \hline L_o \end{Bmatrix} - \begin{Bmatrix} F_1 \\ \hline L_1 \end{Bmatrix} \right\} \tag{23}$$

Adding these incremental displacements and rotations to the originally assumed displacement and rotation yields a second estimate of the initial position and orientation. This second estimate can now be used to recompute the forces F_1, moments L_1, and stiffness matrix K in Equation 22. This procedure can then be repeated until the maximum computed incremental displacement or rotation in δ is smaller than an arbitrarily small assigned value. The resulting position of the center of gravity of the platform is then taken as the equilibrium position under the action of gravity only.

Another method of computing the initial position is simply by integrating the six equations of motion with an assumed initial displacement in translation and rotation of the platform center of gravity. The system motion is under no external excitations except the gravitational acceleration. By introducing high damping forces, the transient motion will decay and the equilibrium position reached in a short time. The time period required to reach the equilibrium position depends, in general, on the estimated initial position of the platform center of gravity and the amount of damping provided.

4.2.7 SMALL ANGLE FORMULATION.

If α, β, γ are sufficiently small, the transformation matrix A can be linearized by neglecting the square and product terms, thus

$$A = \begin{bmatrix} 1 & -\gamma & \beta \\ \gamma & 1 & -\alpha \\ -\beta & \alpha & 1 \end{bmatrix}$$

Equation 11 is rewritten and expanded as follows:

$$\begin{bmatrix} 0 & -\dot{\gamma} & \dot{\beta} \\ \dot{\gamma} & 0 & -\dot{\alpha} \\ -\dot{\beta} & \dot{\alpha} & 0 \end{bmatrix} = \begin{bmatrix} 0 & -\omega_z & \omega_y \\ \omega_z & 0 & -\omega_x \\ -\omega_y & \omega_x & 0 \end{bmatrix} \begin{bmatrix} 1 & -\gamma & \beta \\ \gamma & 1 & -\alpha \\ -\beta & \alpha & 1 \end{bmatrix} \qquad (24)$$

Equating the like elements of the right-hand side and the left-hand side of Equation 24, we have

$$\begin{aligned} \dot{\alpha} &= \omega_x + \gamma\omega_y = \omega_x - \beta\omega_z \\ \dot{\beta} &= \omega_y + \alpha\omega_z = \omega_y - \gamma\omega_x \\ \dot{\gamma} &= \omega_z + \beta\omega_x = \omega_z - \alpha\omega_y \end{aligned} \tag{25}$$

Neglecting the product terms in Equation 25 results in

$$\dot{\alpha} = \omega_x, \ \dot{\beta} = \omega_y, \ \dot{\gamma} = \omega_z$$

or

$$\Omega = \begin{Bmatrix} \dot{\alpha} \\ \dot{\beta} \\ \dot{\gamma} \end{Bmatrix}$$

Neglecting all the cross products of angles and angular velocities, Equation 2 reduces to

$$I_R \dot{\Omega} = L \tag{26}$$

where

$$I_R \cong I_T$$

4.2.8 NUMERICAL INTEGRATION.

The differential equations developed above are readily adapted to solution by digital computer. Simple difference equation approximation to the differential equation can be written, and a straight-forward step-by-step (in time) procedure can be established to provide approximate solutions for the responses due to arbitrary acceleration motions of the building structure.

Alternatively, standard existing integration routines (e.g. Runge-Kutta) can be applied. The use of the latter approach may provide some advantages in terms of reduced programming effort and improved (and controlled) accuracy resulting from such sophistications as variable integration time intervals, predictor-corrector features, and built-in convergence criteria.

In the large angle problem it is necessary to solve Equations 1, 2, and 11 (a total of 15 scalar coupled equations) simultaneously. In the small angle problem only Equations 1 and 26 need to be solved (a total of six coupled equations).

4.3 FORCES AND MOMENTS FROM SPECIAL BASE-MOUNTED SHOCK ISOLATORS.

4.3.1 INTRODUCTION.

The general equations of motion for the spring-pendulum system with overhead support, derived in Section 4.2, are applicable also to a rigid body, supported at its base by a shock isolation system. However, the equations for calculating forces and moments shown in Section 4.2 are limited to isolators whose attachments to both the platform and building connections are not constrained in rotation. Obviously, if the rigid body is supported from well below the center of gravity, the system will be statically unstable unless other separate isolators are added to resist lateral motion or the vertical isolator attachments are designed to resist moments. Thus for the short-pendulum and the rolling-ball types of base-mounted isolators, as suggested in Section 3.2, a more complicated formulation of force and moment relationships with respect to the motions of center of gravity is required, owing to the different physical constraints at the attachments.

In the coordinate systems developed in Section 4.2, the equations of motion (Equations 1 and 2) were written

$$M\ddot{X}_{CI} = F\left(X_{CB}, \dot{X}_{CB}, \alpha, \beta, \gamma, \dot{\alpha}, \dot{\beta}, \dot{\gamma}\right) + G$$

$$\frac{d}{dt}\left\{I_T\Omega\right\} = L\left(X_{CB}, \dot{X}_{CB}, \alpha, \beta, \gamma, \dot{\alpha}, \dot{\beta}, \dot{\gamma}\right)$$

In this section forcing functions F and L for the two types of special isolators are derived.

4.3.2 SHORT-PENDULUM TYPE ISOLATOR.

In Section 3.2, the operating principle of the short-pendulum type of isolator is described in detail. Consider schematically the i-th short-pendulum type isolator shown in Figure 1-13. The isolator is attached to the platform at point a^i and to the isolator base plate at point b^i which is connected through rigid short-pendulum length of ℓ to the base support. Here again it is assumed that the base support undergoes translation only with no rotation.

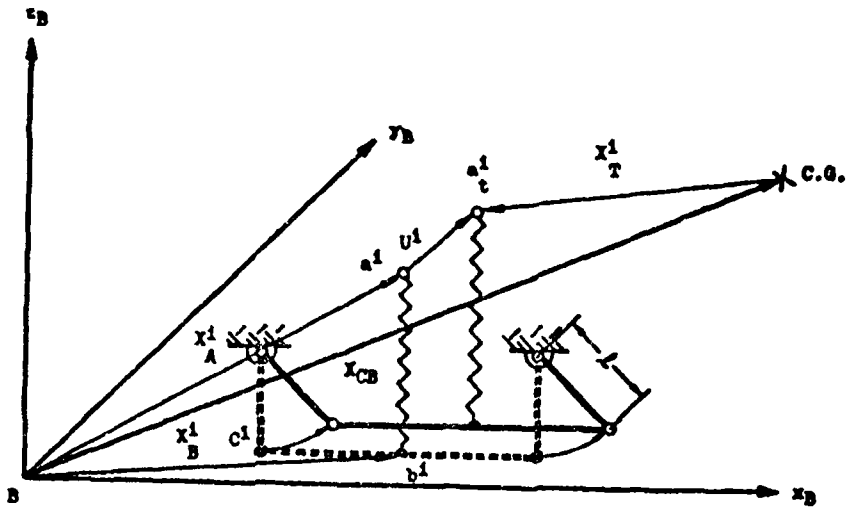

Figure 1-13. Schematic Diagram of the i-th Short Pendulum Type Isolator

After application of ground excitations, the point a^i is moved to a_t^i and the displacement vector U^i connecting these two points can be represented by

$$U^i = X_{CB} + X_T^i - X_{Ao}^i \tag{27}$$

where X_{Ao} is the initial position vector of point a^i. The vector X_T^i represents the position of a_t^i with respect to the center of gravity after rotation of the platform, or

$$X_T^i = AX_R^i$$

where A is the orthogonal transformation matrix established in Section 4.2 and X_R^i are the coordinates of i-th isolator attachment to the platform in the

platform-fixed coordinate system (R, x, y, z). In other words, from given translational motions of the center of gravity (X_{CB}) and rotational motions of the platform (α,β,γ), the motions of the isolator attachment point to the platform can be determined.

Since X^i_{Ao} is invariant with time, differentiation of Equation 27 with time gives

$$\dot{U}^i = \dot{X}_{CB} + \dot{X}^i_T$$

The physical constraint of the isolator is such that the elastic/damping element is connected by a rigid joint to the base plate. Thus the motions of the pendulum in the x_B directions are the same as those of the isolator attachment to the platform a^i, and the centerline of the elastic/damping element remains vertical in the z_B direction.

Figure 1-14 shows the detailed motions of one pendulum. The pendulum attachment C^i to the base plate is moved to a position where u^i_x and u^i_y are the components of U^i in the x_B and y_B directions if the pendulum is initially vertical. At this position, the pendulum prescribes two angles ϕ^i_1 and ϕ^i_2 as shown in Figure 1-14, where

$$\phi^i_1 = \sin^{-1}\left\{\left[\left(u^i_x\right)^2 + \left(u^i_y\right)^2\right]^{1/2} \Big/ \ell\right\}$$

and

$$\phi^i_2 = \tan^{-1}\left(\frac{u^i_y}{u^i_x}\right) \qquad 0 \leq \phi^i_2 < 2\pi$$

From these relationships and constraints, the deflection of the i-th elastic/damping element can be written as,

$$\delta^i = -u^i_z + \ell\left(1 - \cos\phi^i_1\right) + \ell^i_{sf} - \left(x^i_{Aoz} - x^i_{Boz}\right) \tag{28}$$

where u^i_z is the component of U^i in the z_B direction, ℓ^i_{sf} is the free length of the i-th elastic/damping element, and x^i_{Aoz} and x^i_{Boz} are the initial positions

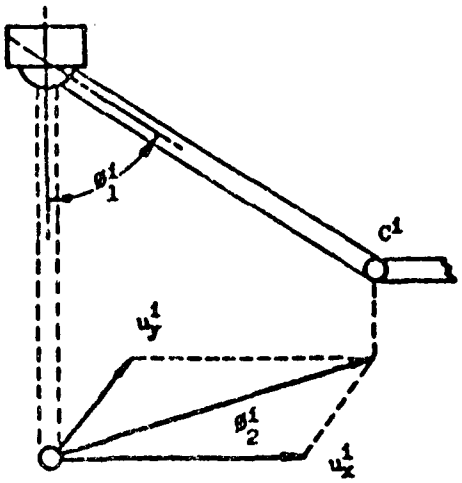

Figure 1-14. Detail Motions of One Pendulum

of attachment points a^i and b^i in the z_B direction. Compression of the element is assumed to be positive.

The rate of change of deflection can be obtained by differentiating Equation 28, or

$$\dot{\delta}^i = -\dot{u}_z^i + \dot{\phi}_1^i \ell \sin \phi_1^i \tag{29}$$

Depending on the characteristics of the elastic/damping element, the force in the z_B direction at the attachment point a^i due to the i-th isolator is then

$$F_z^i = f^i\left(\delta^i, \dot{\delta}^i\right)$$

or the force is related to deflection and rate of deflection through linear or nonlinear elastic constants and damping coefficients.

Again, considering the physical constraint of the system, the force F_z^i is reacted through the pendulum to the base support at angles ϕ_1^i and ϕ_2^i. This geometrical condition generates reaction forces at the attachment point in the x_B and y_B directions. These forces can be obtained by transformation as follows:

$$F_x^i = -F_z^i \cos \phi_2^i \tan \phi_1^i$$

and

$$F_y^i = -F_z^i \sin \phi_2^i \tan \phi_1^i$$

The total force applied to the platform is given by a summation of contribution from each isolator, or

$$F = \begin{Bmatrix} F_x \\ F_y \\ F_z \end{Bmatrix} = \sum_{i=1}^{n} \begin{Bmatrix} F_x^i \\ F_y^i \\ F_z^i \end{Bmatrix} \tag{30}$$

where n = number of isolators in the system.

Since the attachment point a^i is a universal joint, it cannot transmit moments. Thus, the total moment on the system is simply

$$L = \sum_{i=1}^{n} L^i = \sum_{i=1}^{n} X_T^i \times F^i \tag{31}$$

4.3.3 ROLLING-BALL TYPE ISOLATOR.

The rolling-ball type isolator consists of an elastic/damping element supported on a ball which is free to roll on a spherical plate attached to the base support. The isolator is fixed to the platform such that only translational motion in the direction of the elastic/damping element axis is allowed. A more detailed description of the rolling-ball type isolator is given in Section 3.2.8.

Figure 1-15 shows schematically the i-th rolling-ball type isolator. The isolator is attached to the platform at point a^i and the ball touches the curved plate initially at point b^i. The center of the ball is designated as p^i and the center of curvature of the spherical plate is O^i.

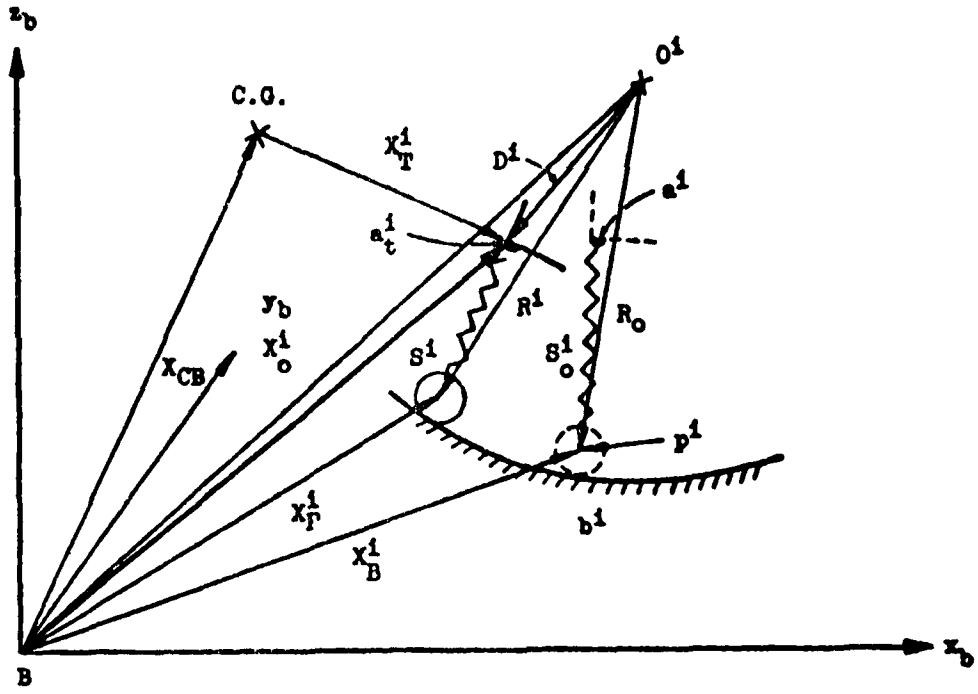

Figure 1-15. Schematic Diagram of the i-th Rolling-Ball Type Isolator

After base excitation, the isolator attachment points are moved to new positions and the displacement vector of the attachment point a_t^i from the center of curvature O^i is given by

$$D^i = X_T^i + X_{CB} - X_o^i \tag{32}$$

where X_o^i, the position vector of O^i, is constant in Bxyz frame and vector X_T^i is defined

$$X_T^i = AX_R^i$$

Differentiation of Equation 32 with respect to time gives

$$\dot{D}^i = \dot{X}_T^i + \dot{X}_{CB} \tag{33}$$

The physical constraint of the isolator as shown in Figure 1-15 requires

$$D^i + S^i = R^i \tag{34}$$

where R^i is the radius vector which has a constant magnitude of R_o and S^i is the elastic/damping element vector between the points a^i and p^i.

From given motions of center of gravity and point a^i and the physical constraint represented by Equation 34, the vector S^i can be determined. First, since the elastic/damping element is rigidly connected to the platform, the direction cosines of S^i are

$$\left\{C^i_s\right\} = [A] \left\{C^i_{so}\right\}$$

where [A] is the orthogonal transformation matrix defined in Section 2 and $\left\{C^i_{so}\right\}$ are the direction cosines of the initial elastic/damping element vector S^i_o. Equation 34 can be expanded to indicate the magnitude of vectors. Thus

$$|S^i|^2 + 2|S^i|\ |D^i| \cos\theta^i + |D^i|^2 = |R^i|^2 = \text{Constant} \tag{35}$$

where θ^i is the angle between the vectors S^i and D^i.

Usually, the magnitude of D^i is less than R^i. The solution of Equation 35 gives two real roots of S^i with opposite signs where the positive root is the magnitude of vector S^i.

Having obtained S^i, the deflection and the rate of deflection of the elastic/damping element can easily be found as

$$\delta^i = S^i_o - S^i$$

and (36)

$$\dot{\delta}^i = -\dot{S}^i$$

where compression is defined as positive.

Furthermore, the position of the ball can also be obtained by the following equation

$$X_p^i = X_{CB}^i + X_T^i + S^i \tag{37}$$

From this equation, the direction of the radius vector R^i can be determined as

$$R^i = X_p^i - X_o^i \tag{38}$$

Note that there is another physical constraint which is implied in the above formulation. The ball is always in contact with the curved plate or the ball is constrained to move in a plane perpendicular to the radius vector R^i. Mathematically, it means $\dot{X}_p^i \times R = 0$.

In formulating forces and moments developed by the isolator, the following assumptions are made. First, the radius of the ball is sufficiently small so that forces may be assumed to act at the center of the ball. Second, the mass of the ball may be neglected; thus, the force balance at the ball is essentially a static problem.

For example, consider the ball as a free body as shown in Figure 1-16. The forces acting at the center of the ball are

$$F_R^i + F_n^i + F_f^i = 0 \tag{39}$$

where

F_R^i is the reaction force at the plate in a direction opposite to the radius vector R^i.

F_n^i is the isolator force which is not necessarily in the same direction as the elastic/damping element or S^i.

F_f^i is the friction force between the ball and the curved plate.

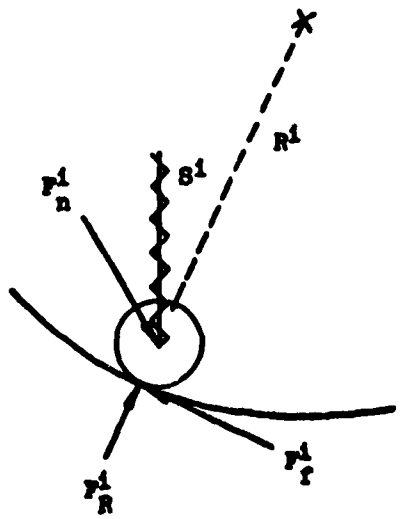

Figure 1-16. Forces Acting on the i-th Ball

Taking the components of the forces in the direction of the elastic/damping element, Equation 35 becomes

$$|F_s^i| - |F_R^i| \cos \phi_1^i + |F_f^i| \cos \phi_2^i = 0 \tag{40}$$

where F^i is the component of F_n^i in the S^i direction and is a function of S^i and $\dot{S}_i$ or

$$F_s^i = f^i \left(S^i, \dot{S}^i\right)$$

ϕ_1^i is the angle between S^i and R^i, and

ϕ_2^i is the angle between S^i and F_f^i.

If $\dot{X}_p^i$ is a non-zero vector and the friction coefficient is a constant μ, the friction force F_f^i is in the direction opposite to the velocity vector which is perpendicular to R^i with a magnitude equal to $\mu \left|F_R^i\right|$. If $\dot{X}_p^i$ is a zero vector, i.e.,there is no relative motion between the ball and the plate, a more complicated situation results where further assumptions are required to simplify the mathematical formulation.

Due to a possible unsymmetrical weight distribution on the platform, the initial loading on the various ball elements may be different. Thus, under ground excitations, some balls may be in motion while others remain stationary with respect to the spherical plate. The condition for the initial motion of the ball is governed by the friction force at the ball and the inertia force caused by the ground acceleration. The assumption is made that the distribution of the inertia force to the i-th isolator is governed by

$$F^i_{in} = \frac{m}{n} \ddot{X}^i_{gn}$$

where

- m is the mass of the system
- n is the number of isolators
- $\ddot{X}^i_{gn}$ is the component of the ground acceleration in the plane normal to R^i

Then, there are two possible ways to evaluate the friction force.

- Case A $\qquad F^i_f < F^i_{in}$ (42)

  In this case, $F^i_f = \mu |F^i_R| \dfrac{\ddot{X}^i_{gn}}{|\ddot{X}_{gn}|}$

- Case B $\qquad F^i_f \geq F^i_{in}$ (43)

  In this case, $F^i_f = F^i_{in}$

Finally, considering the complete platform and isolators, the total of the external forces on the system is

$$F = \sum_{i=1}^{n} F^i = \sum_{i=1}^{n} \left(F^i_R + F^i_f \right) \tag{44}$$

where F_f^i is related to F_R^i and $\dot{X}_p^i$ by Equations 42 and 43 for static case and $F_f^i = \mu|F_R^i| \frac{\dot{X}_p^i}{|\dot{X}_p^i|}$ once the ball is in motion. The magnitude of vector F_R^i is obtained from Equation 40 and its direction from Equation 38.

The total moment on the system is given by

$$L = \sum_{i=1}^{n} L^i = \sum_{i=1}^{n} X_p^i \times F^i \tag{45}$$

Note that the vector X_p^i includes the contribution of the moment arm due to the length of the isolators.

4.4 DYNAMIC ANALYSIS OF LINEAR SHOCK ISOLATION SYSTEMS.

4.4.1 INTRODUCTION.

In the previous sections, equations of motions and isolator forces and moments were described for a six degree-of-freedom shock isolation system where the requirement of linearity was not imposed on either the suspension configuration or the system components. While the mathematical model of a six degree-of-freedom system is adequate in calculating the response motions of most shock isolation systems, there are designs in which large platforms are employed whose natural frequencies lie close to the isolation system frequencies. Under this condition the assumption of a rigid body is invalid and the flexibility of the platform must be considered.

The platform and supported equipment are represented by discrete mass points connected by elastic bars and combined with the shock isolator elements. Thus a greater than six-degree-of-freedom system is formed. The solutions of the response motions of a general multi-degree-of-freedom shock isolation system with nonlinear elements are rather complicated and the development of such a method is beyond the scope of work. However, if the expected responses are relatively small, the system and the system elements may be linearized for analysis. This section describes the use of the normal mode method for determining the dynamic responses of linear shock isolation systems. The use of response spectra directly as inputs to establish maximum dynamic response envelopes is also discussed.

4.4.2 NORMAL MODE METHOD.

The normal mode method of analysis, described in many standard text books on structural dynamics, enables the determination of the natural frequencies and modal configurations of a structural system subjected to free vibrations.

Considering a structural system which contains n degrees-of-freedom, the set of differential equations representing the equations of motion is shown in matrix form as

$$[M]\{\ddot{u}\} + [K]\{u\} = \{P\} \tag{46}$$

where [M] is the inertia matrix, [K] is the stiffness matrix, {P} is the column vector of applied forces corresponding to the displacement {u} , and {u} is the column matrix of the displacement coordinates.

In the normal mode analysis only the homogenous part of the equations is considered; that is, the external load {P} is set to zero. Equation 46 then is reduced to,

$$[M]\{\ddot{u}\} + [K]\{u\} = \{0\} \tag{47}$$

Assume the solutions to be harmonic functions of time and in the form of

$$u_j(t) = e^{i\omega t}\,\phi_j(u) \qquad j = 1,2,3 \ldots n \tag{48}$$

where $u_j(t)$ is the displacement vector describing the vibration of the system in the j-th mode, ω is the frequency, $\phi_j(u)$ is the amplitude of the required solution and is independent of time t

Substituting Equation 48 into Equation 47, the following result is obtained:

$$\omega^2 [M]\{\phi\} - [K]\{\phi\} = 0$$

or (49)

$$\left([K] - \omega^2 [M]\right)\{\phi\} = 0$$

It is seen that for a non-trivial solution, the determinant of the coefficient $|[K] - \omega^2 [M]|$ must vanish and expansion of the determinant will yield the characteristic equation. The roots of characteristic equation ω^2 are the frequencies of the system. ω^2 is real, positive but not necessarily distinct.

As a consequence, Equation 49 possesses a non-trivial vector solution in terms of $\emptyset$. The modal vector $\emptyset_j$ is a column vector whose n components describe the relative amplitudes of the various points of the system when it vibrates in its j-th mode at frequency ω_j.

When the modal vectors are collected into a single square matrix of order n, the resulting matrix is called the "modal" matrix.

$$[\emptyset] = \begin{bmatrix} \emptyset_{11} & \emptyset_{12} & \cdots\cdots & \emptyset_{1n} \\ \emptyset_{21} & \emptyset_{22} & & \\ \vdots & & & \\ \emptyset_{n1} & & & \emptyset_{nn} \end{bmatrix} \tag{50}$$

When calculating the normal mode $\emptyset_i$ the amplitude of some chosen point is assumed as unity. Thus, since the characteristic vectors $\emptyset_r$ and $\emptyset_s$ are determined only within the ratio of an arbitrary constant, it becomes convenient to normalize these eigenvectors with respect to either $[M]$ or $[K]$.

The normalized modal matrix $[\bar{\emptyset}]$ consisting of the normalized characteristic vectors $[\bar{\emptyset}_i]$ has the property that

$$\begin{aligned} [\bar{\emptyset}]^T [M] [\bar{\emptyset}] &= [1] \\ [\bar{\emptyset}]^T [K] [\bar{\emptyset}] &= [\omega^2] \end{aligned} \tag{51}$$

and $\{\bar{\emptyset}_i\}$ is determined by

$$\{\bar{\emptyset}_i\} = C\{\emptyset_i\} \tag{52}$$

where C is an arbitrary constant to be determined.

Using a system of normal coordinates q which are a special type of generalized coordinates, Equation 46 is transformed into a set of decoupled equations of motion as follows:

$$[\bar{M}] \{\ddot{q}\} + [\bar{K}] \{q\} = \{\bar{P}\} \tag{53}$$

where

$$[\bar{M}] = [\phi]^T [M][\phi] = \text{generalized mass matrix}$$

$$[\bar{K}] = [\phi]^T [K][\phi] = \text{generalized stiffness matrix}$$

$$\{\bar{P}\} = [\phi]^T \{P\} = \text{generalized force}$$

$$\{u\} = [\phi]\{q\}$$

For the shock isolation system, the generalized forces consist of the transformations of ground shock accelerations at the shock isolator attachment points and Equation 53 may be changed into a different form from the energy considerations.

The total kinetic energy of the system is

$$T = \frac{1}{2} \sum_{i=1}^{n} M_i \left(\dot{u}_i + \dot{X}_i\right)^2$$

where $\dot{X}_i$ is the i-th ground velocity, and the total potential energy is

$$V = \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} K_{ij} u_i u_j$$

Transforming to normal coordinates q by the equations

$$u_i = \sum_{k=1}^{n} \phi_{ik} q_k \quad , \quad \dot{u}_i = \sum_{k=1}^{n} \phi_{ik} \dot{q}_k$$

the kinetic energy equation becomes

$$T = \frac{1}{2} \sum_{i=1}^{n} M_i \sum_{k=1}^{n} \phi_{ik}^2 \dot{q}_k^{\,2} + \sum_{i=1}^{n} M_i \dot{X}_i \sum_{k=1}^{n} \phi_{ik} \dot{q}_k + \frac{1}{2} \sum_{i=1}^{n} M_i \dot{X}_i^{\,2}$$

and the potential energy equation is

$$V' = \frac{1}{2} \sum_{i=1}^{n} M_i \sum_{k=1}^{n} \phi_{ik}^2 \omega_k^2 q_k^2$$

where ω_k is the frequency of the k-th mode.

From Lagrange's equation

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_k}\right) - \frac{\partial T}{\partial q_k} + \frac{\partial V}{\partial q_k} = 0,$$

the following equation is obtained

$$\ddot{q}_k + \omega_k^2 q_k = \sum_{i=1}^{n}\left(- \Gamma_{ik}\ddot{X}_i\right) \Big/ \sum_{i=1}^{n} M_i \phi_{ik}^2 \qquad k = 1,2,3 \ldots m \quad (54)$$

where m is the number of mode calculated.

$\ddot{X}_i$ is the i-th input acceleration and where Γ_{ik} is the participation factor which is defined as

$$\Gamma_{ik} = M_i \phi_{ik} \qquad (55)$$

Thus, from given ground excitations, Equation 54 can be solved for q_i and the response motion can be obtained by the transformation

$$\{u\} = [\phi]\{q\}$$

To reduce relative motions in a shock isolation system dampers can usually be added to the shock isolators. In this case, Equation 54 is changed to include the damping term as follows:

$$\ddot{q}_k + 2\zeta_k\omega_k\dot{q}_k + \omega_k^2 q_k = \sum_{i=1}^{n}\left(- \Gamma_{ik}\ddot{x}_i\right) \Big/ \sum_{i=1}^{n} M_i \phi_{ik}^2 \qquad (56)$$

$$k = 1,2,\ldots\ldots m$$

where ζ_k = fraction of critical damping

$$= \frac{C_k}{2M_k\omega_k}$$

and C_k is the damping coefficient in the generalized coordinate system. The inclusion of the damping term in Equation 56 implies that the modes are not coupled by the damping term or that the damping matrix contains only diagonal elements. This restriction is necessary in order to decouple the modal equations and is permissible provided the damping values are small.

4.4.3 USE OF RESPONSE SPECTRA AS INPUTS.

For a linear shock isolation system, response spectra can be used directly as definitions of the input excitation function to establish a maximum response motion envelope. Equation 54 is recognized as a set of m single degree-of-freedom equations at frequencies ω_k where k = 1, 2, ...m. The input excitations consist of ground accelerations modified by participation factors. From the definition of a response spectrum, the maximum displacements in normal coordinates q can, therefore, be obtained as

$$(q_k)_{max} = \sum_{i=1}^{n} \Gamma_{ik} D_{ik} \Big/ \sum_{i=1}^{n} M_i \phi_{ik}^2 \qquad (57)$$

$$k = 1,2,\ldots\ldots m$$

where D_{ik} is the displacement indicated on the response spectrum at frequency ω_k due to a ground shock in the i-th direction. It follows then that the maximum displacements in generalized coordinates are

$$(u_i)_{max} = \sum_{k=1}^{m} \phi_{ik} (q_k)_{max} \qquad (58)$$

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

Maximum acceleration and velocity responses of the i-th point can be calculated by differentiation of Equation 58. To include the effects of damping, the values of D_{ik} may be obtained from a damped spectrum.

4.4.4 LINEAR SIX DEGREE-OF-FREEDOM SHOCK ISOLATION SYSTEM.

If the platform of a linear shock isolation system can be designed such that its lowest fundamental frequency is at least five times higher than the highest mode frequency of the system, the elastic responses of the platform will be small compared to the total response motions and only the rigid body motions of the platform need to be considered.

The shock isolation system is reduced to an analytical model with six degrees of freedom. In this case, both the $[M]$ and $[K]$ matrices as in Equation 46 are sixth-order symmetric square matrices and can be easily established.

Figure 1-17 shows a completely general rigid body, elastically supported at n points by springs with stiffnesses K_i. The springs are attached to the body and to the ground at points A_i (x_{Ai}, y_{Ai}, z_{Ai}) and $B_i(x_{Bi}, y_{Bi}, z_{Bi})$. The positions are referred to a set of coordinate axes x, y, z fixed in space. The body contains m number of masses M_i located by the coordinates x_i, y_i, z_i. Each mass has three principle moments of inertia $I_{x'}$, $I_{y'}$, $I_{z'}$ with respect to three axes x', y', z' which are fixed through the center of gravity of the masses and parallel to the coordinate axes x, y, z. The total mass of the body is $\sum^{n} M_i$ and the center of gravity of the body O is given by the coordinates $\bar{x}$, $\bar{y}$, $\bar{z}$. Using the following sixth-order displacement vector:

$$u = \begin{bmatrix} x \\ y \\ z \\ \theta_x \\ \theta_y \\ \theta_z \end{bmatrix}$$

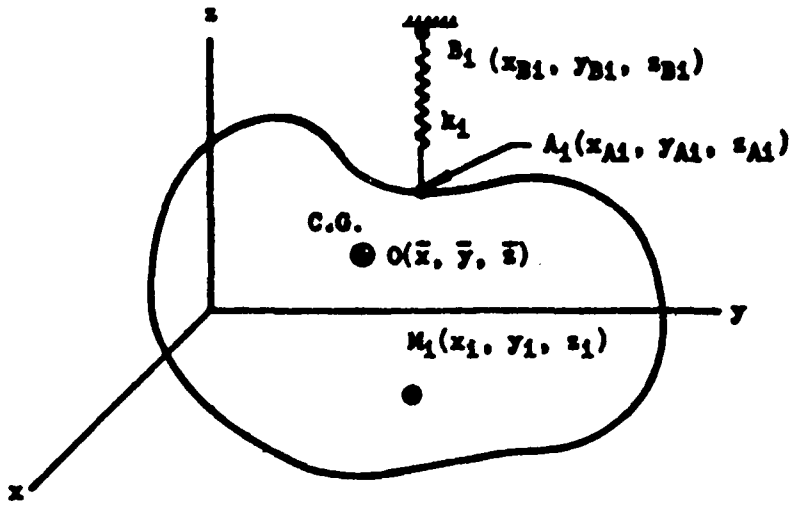

Figure 1-17. General Rigid Body Showing Typical Elastic Suspension at Point A_i

where the first three elements describe the translations of 0 and the second three elements describe the rotations of the body with respect to the axes passing through its center of gravity, the mass and stiffness matrices may be developed as shown in Figures 1-18 and 1-19. The derivation of these matrices are described partly in Sections 3 and 28 of Reference 20.

Assuming the center of gravity of the body has maximum translational responses of x_o, y_o, z_o and rotational responses of θ_x, θ_y, θ_z, then the maximum translational motions of a point in the body which is at x_d, and z_d distances away from the center of gravity can be obtained by the following transformation:

$$
\begin{bmatrix} x' \\ y' \\ z' \end{bmatrix}_{max} = \begin{bmatrix} x_o \\ y_o \\ z_o \end{bmatrix} + \begin{bmatrix} \cos\theta_y \cdot \cos\theta_z + \sin\theta_x \cdot \sin\theta_y \cdot \cos\theta_z & -\cos\theta_y \cdot \sin\theta_z - \sin\theta_x \cdot \sin\theta_y \cdot \sin\theta_z & \sin\theta_y \\ -\cos\theta_x \cdot \sin\theta_z - \cos\theta_x \cdot \cos\theta_z \cdot \sin\theta_y & \cos\theta_x \cdot \cos\theta_z + \cos\theta_x \cdot \sin\theta_y \cdot \sin\theta_z & -\sin\theta_x \cdot \cos\theta_z \\ \sin\theta_x \cdot \sin\theta_z & \sin\theta_x \cdot \cos\theta_z & \cos\theta_x \cdot \cos\theta_y \end{bmatrix} \cdot \begin{bmatrix} x_d \\ y_d \\ z_d \end{bmatrix} - \begin{bmatrix} x_d \\ y_d \\ z_d \end{bmatrix} \qquad (59)
$$

$$
M = \begin{bmatrix}
\sum_{i=1}^{n} M_i & 0 & 0 & 0 & \sum_{i=1}^{n} M_i D_{zi} & -\sum_{i=1}^{n} M_i D_{yi} \\
0 & \sum_{i=1}^{n} M_i & 0 & -\sum_{i=1}^{n} M_i D_{zi} & 0 & \sum_{i=1}^{n} M_i D_{xi} \\
0 & 0 & \sum_{i=1}^{n} M_i & \sum_{i=1}^{n} M_i D_{yi} & -\sum_{i=1}^{n} M_i D_{xi} & 0 \\
0 & -\sum_{i=1}^{n} M_i D_{zi} & \sum_{i=1}^{n} M_i D_{yi} & \sum_{i=1}^{n} \left[I_{xi} + M_i \left(D_{yi}^2 + D_{zi}^2 \right) \right] & -\sum_{i=1}^{n} M_i \left(D_{xi} \cdot D_{yi} \right) & -\sum_{i=1}^{n} M_i \left(D_{xi} \cdot D_{zi} \right) \\
\sum_{i=1}^{n} M_i D_{zi} & 0 & -\sum_{i=1}^{n} M_i D_{xi} & -\sum_{i=1}^{n} M_i \left(D_{xi} \cdot D_{yi} \right) & \sum_{i=1}^{n} \left[I_{yi} + M_i \left(D_{xi}^2 + D_{zi}^2 \right) \right] & -\sum_{i=1}^{n} M_i \left(D_{yi} \cdot D_{zi} \right) \\
-\sum_{i=1}^{n} M_i D_{yi} & \sum_{i=1}^{n} M_i D_{xi} & 0 & -\sum_{i=1}^{n} M_i \left(D_{xi} \cdot D_{zi} \right) & -\sum_{i=1}^{n} M_i \left(D_{yi} \cdot D_{zi} \right) & \sum_{i=1}^{n} \left[I_{zi} + M_i \left(D_{xi}^2 + D_{yi}^2 \right) \right]
\end{bmatrix}
$$

$$
D_{xi} = x_i - \bar{x}, \quad D_{yi} = y_i - \bar{y}, \quad D_{zi} = z_i - \bar{z}
$$

Figure 1-18. Mass Matrix for the General Rigid Body With Six Degrees-of-Freedom

$$
K = \begin{bmatrix}
\sum_{i=1}^{n} k_i (cx_i \cdot cx_i) & \sum_{i=1}^{n} k_i (cx_i \cdot cy_i) & \sum_{i=1}^{n} k_i (cx_i \cdot cz_i) & \sum_{i=1}^{n} k_i \left[(cx_i \cdot cz_i) \cdot ry_i - (cx_i \cdot cy_i) \cdot rz_i \right] & \sum_{i=1}^{n} k_i \left[(cx_i \cdot cz_i) \cdot rx_i - (cx_i \cdot cx_i) \cdot rz_i \right] & \sum_{i=1}^{n} k_i \left[(cx_i \cdot cy_i) \cdot rx_i - (cx_i \cdot cx_i) \cdot ry_i \right] \\
 & \sum_{i=1}^{n} k_i (cy_i \cdot cy_i) & \sum_{i=1}^{n} k_i (cy_i \cdot cz_i) & \sum_{i=1}^{n} k_i \left[(cy_i \cdot cz_i) \cdot ry_i - (cy_i \cdot cy_i) \cdot rz_i \right] & \sum_{i=1}^{n} k_i \left[(cz_i \cdot cy_i) \cdot rx_i - (cy_i \cdot cx_i) \cdot rz_i \right] & \sum_{i=1}^{n} k_i \left[(cy_i \cdot cy_i) \cdot rx_i - (cx_i \cdot cy_i) \cdot ry_i \right] \\
 & & \sum_{i=1}^{n} k_i (cz_i \cdot cz_i) & \sum_{i=1}^{n} k_i \left[(cz_i \cdot cz_i) \cdot ry_i - (cy_i \cdot cz_i) \cdot rz_i \right] & \sum_{i=1}^{n} k_i \left[(cz_i \cdot cz_i) \cdot rx_i - (cx \cdot cz_i) \cdot rz_i \right] & \sum_{i=1}^{n} k_i \left[(cy_i \cdot cz_i) \cdot rx_i - (cx_i \cdot cz_i) \cdot ry_i \right] \\
 & \text{SYMMETRIC} & & \sum_{i=1}^{n} k_i \left[(cy_i \cdot cy_i) \cdot rz_i^2 - 2(cy_i \cdot cz_i) \cdot ry_i \cdot rz_i + (cz_i \cdot cz_i) \cdot ry_i^2 \right] & \sum_{i=1}^{n} k_i \left[(cy_i \cdot cz_i) \cdot rx_i \cdot rz_i - (cz_i \cdot cy_i) \cdot rz_i^2 + (cz_i \cdot cz_i) \cdot ry_i \cdot rz_i - (cx_i \cdot cz_i) \cdot rx_i \cdot rz_i \right] & \sum_{i=1}^{n} k_i \left[(cz_i \cdot cy_i) \cdot rx_i \cdot rz_i - (cy_i \cdot cy_i) \cdot rz_i^2 + (cy_i \cdot cz_i) \cdot ry_i \cdot rz_i - (cx_i \cdot cz_i) \cdot rx_i \cdot ry_i \right] \\
 & & & & \sum_{i=1}^{n} k_i \left[(cz_i \cdot cz_i) \cdot rx_i^2 - 2(cx_i \cdot cz_i) \cdot rx_i \cdot rz_i + (cx_i \cdot cx_i) \cdot rz_i^2 \right] & \sum_{i=1}^{n} k_i \left[(cz_i \cdot cy_i) \cdot rx_i \cdot rz_i - (cx_i \cdot cx_i) \cdot ry_i \cdot rz_i + (cx_i \cdot cz_i) \cdot ry_i \cdot rx_i - (cy_i \cdot cz_i) \cdot rx_i^2 \right] \\
 & & & & & \sum_{i=1}^{n} k_i \left[(cz_i \cdot cz_i) \cdot ry_i^2 - 2(cz_i \cdot cy_i) \cdot ry_i \cdot rz_i + (cy_i \cdot cy_i) \cdot rz_i^2 \right]
\end{bmatrix}
$$

where:

$rx_i = x_{Bi} - \bar{x}, \quad ry_i = y_{Bi} - \bar{y}, \quad rz_i = z_{Bi} - \bar{z}$

$cx_i = \cos\alpha_i = (x_{Bi} - x_{Ai})/L_i, \quad cy_i = \cos\beta_i = (y_{Bi} - y_{Ai})/L_i, \quad cz_i = \cos\gamma_i = (z_{Bi} - z_{Ai})/L_i$

$L_i = \sqrt{(x_{Bi} - x_{Ai})^2 + (y_{Bi} - y_{Ai})^2 + (z_{Bi} - z_{Ai})^2}$

Figure 1-19. Stiffness Matrix for the General Rigid Body with Six Degrees-of-Freedom

If the rotational angles θ_x, θ_y, and θ_z are small, $\cos\theta_x \approx \cos\theta_y \approx \cos\approx\theta_z$ 1 and $\sin\theta_x \approx \theta_x$, $\sin\theta_y \approx \theta_y$ and $\sin\theta_z \approx \theta_z$ where the angles are in radians. Using this substitution, Equation 59 is reduced to the following form:

$$\begin{bmatrix} x' \\ y' \\ z' \end{bmatrix}_{max} = \begin{bmatrix} x_o \\ y_o \\ z_o \end{bmatrix} + \begin{bmatrix} 1 & -\theta_z & \theta_y \\ +\theta_z & 1 & -\theta_x \\ -\theta_y & +\theta_x & 1 \end{bmatrix} \cdot \begin{bmatrix} x_d \\ y_d \\ z_d \end{bmatrix} - \begin{bmatrix} x_d \\ y_d \\ z_d \end{bmatrix}$$

$$= \begin{bmatrix} x_o \\ y_o \\ z_o \end{bmatrix} + \begin{bmatrix} 0 & -\theta_z & \theta_y \\ +\theta_z & 0 & -\theta_x \\ -\theta_y & +\theta_x & 0 \end{bmatrix} \cdot \begin{bmatrix} x_d \\ y_d \\ z_d \end{bmatrix} \qquad (60)$$

Although the normal mode method is a very useful tool in dynamic analyses, caution should be exercised in its application to shock isolation problems. As described in this section the method is applicable only where the motions are small. For large motions most shock isolation systems become highly non-linear. Furthermore, the isolator elements themselves must fulfill the strict linearity requirements.

SECTION 5:

THEORY: SHOCK ISOLATION SYSTEM OF A NON-RIGID PLATFORM

5.1 INTRODUCTION

The structural dynamic response analysis, using the normal mode technique discussed in Section 4.4.2, is not limited to the rigid-body six-degree-of-freedom structure. In particular, the stiffness matrix [k], in Equation 46, could represent the stiffness matrix of a multi-degree-of-freedom system, in which a six-degree-of freedom rigid-body matrix is a special case. The analysis of a non-rigid platform can be treated mathematically as a multi-degree-of-freedom problem. The dynamic response can be computed either directly or by the normal mode technique.

The stiffness of a non-rigid platform, controlled by the bending and shear stiffness of the basic components that comprise the platform, could be estimated on the basis of elementary beam bending theory with limited accuracy. A preferred approach is to divide the platform structure into several elements (or components), to compute the stiffness of each element, and then to compute the overall stiffness by recombining the elements using equilibrium and compatibility at each joint where the elements are connected.

Digital computers are ideally suited to the latter type of analysis. There are many existing computer programs available, such as NASTRAN[25], STARDYN[19] and DASAS-I[18], that could be utilized for determining the dynamic response of a non-rigid platform. The purpose of this section is to describe the key operations and theory of a computer program, ISIP2, especially developed for this shock isolation design manual. ISIP2, which takes advantage of many special features of a flat, horizontal platform, should not be used as a general structural utility program. ISIP2 is designed to analyze a three-dimensional platform using three dimensional beam elements. The beam element stiffness is modified to include the effects of the platform surface panel. This feature and ISIP2's limitations are discussed in Sections 12, 13 and 14, Part II of this manual.

5.2 PLATFORM STIFFNESS MATRIX BY FINITE-ELEMENT TECHNIQUE.

The following discussion illustrates the calculation of the finite element stiffness matrix. A two dimensional beam was used for simplicity.

Consider a straight beam of length L shown in Figure 1-20. This beam is connected between joints m and n and has a local, right-hand (y_1, y_2, y_3) coordinate system with the y_1-axis directed towards joint n, and the y_3-axis directed normal to the platform surface. Loads and deflections at the two ends of the beam are oriented along the y_1-axis system and are defined as follows:

F_{ni} = force at joint n along the i-axis.

M_{ni} = moment at joint n about the i-axis (right-rand rule).

U_{ni} = deflection at joint n along the i-axis.

θ_{ni} = rotation at joint n about the i-axis (right-hand rule).

It is assumed that the beam can develop axial elongation and compression along the y_1-axis and bending in the y_1 and y_2 plane, and that these two types of deformation are uncoupled. The relationships between the end loads and end deflections are expressed by the following 6 x 6 stiffness matrix equation:

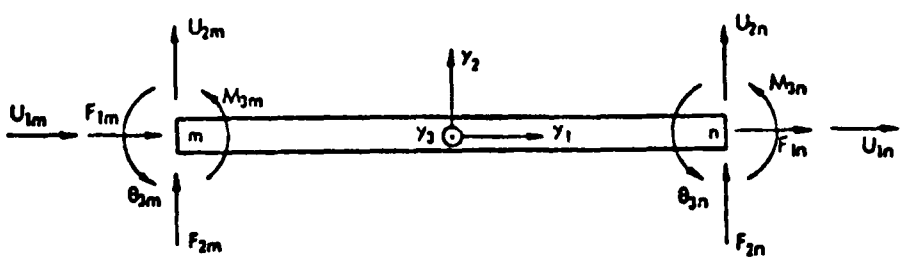

Figure 1-20. Coordinate System, Deflection and Load Components of Straight Beam Segment

$$
\begin{bmatrix} F_{m1} \\ F_{m2} \\ M_{m3} \\ F_{n1} \\ F_{n2} \\ M_{n3} \end{bmatrix}
=
\begin{bmatrix}
\frac{EA}{L} & 0 & 0 & -\frac{EA}{L} & 0 & 0 \\
0 & 12\frac{EI_3}{L^3} & 6\frac{EI_3}{L^2} & 0 & -12\frac{EI_3}{L^3} & 6\frac{EI_3}{L^2} \\
0 & 6\frac{EI_3}{L^3} & 4\frac{EI^3}{L} & 0 & -6\frac{EI_3}{L^2} & 2\frac{EI_3}{L} \\
-\frac{EA}{L} & 0 & 0 & \frac{EA}{L} & 0 & 0 \\
0 & -12\frac{EI_3}{L^3} & -6\frac{EI_3}{L^2} & 0 & 12\frac{EI_3}{L^3} & -6\frac{EI_3}{L^2} \\
0 & 6\frac{EI_3}{L^2} & 2\frac{EI_3}{L} & 0 & -6\frac{EI_3}{L^2} & 4\frac{EI_3}{L}
\end{bmatrix}
\cdot
\begin{bmatrix} U_{m1} \\ U_{m2} \\ \theta_{m3} \\ U_{n1} \\ U_{n2} \\ \theta_{n3} \end{bmatrix}
\qquad (61)
$$

where

E = Young's modulus of elasticity

L = beam length

A = cross-section area

I_3 = cross-section area moment of inertia about y_3-axis.

Equation 61 can be rewritten in the condensed form

$$\{F_{mn}\} = [k] \cdot \{U_{mn}\} \qquad (62)$$

where

$$\left.\begin{array}{ll} \{F_{mn}\} & = 6 \times 1 \text{ force matrix} \\ [K] & = 6 \times 6 \text{ stiffness matrix} \\ \{u_{mn}\} & = 6 \times 1 \text{ deflection matrix} \end{array}\right\} \text{ as defined by Equation 61}$$

A platform structure is generally composed of many interconnected beam-like elements. For the purpose of identifying the various elements, it is convenient to number these elements with an integer numbering index e = 1, 2, 3 ... Thus, if the above beam represents element e of such a frame, Equation 62 can be written in the form

$$\left\{F_{mne}\right\} = [K_e] \cdot \left\{U_{mne}\right\} \tag{63}$$

The elements of a platform may be arbitrarily oriented so that the local y_1 and y_2 coordinates of the various elements are not parallel. This implies that the component end loads and deflections of two beams attached to a common joint may not be parallel. In order to eliminate this difficulty it is desirable to establish a common (x_1, x_2, x_3) - coordinate system for all joints of the platform, and to transform the load and deflection components from the local y_i-axes to the x_i-axes for all elements of the platform structure. Let $[T_e]$ denote the 6 x 6 transformation matrix for the load and deflection components of element e, and define the transformed loads and deflections as follows:

$$\left.\begin{aligned} \left\{\mathcal{F}_{mne}\right\} &= [T_e]\left\{F_{mne}\right\} = \text{6 x 1 matrix of loads for element e defined with respect to the } x_i \text{ -axes.} \\ \left\{\mathcal{U}_{mne}\right\} &= [T_e]\left\{U_{mne}\right\} = \text{6 x 1 matrix of deflections for element e defined with respect to the } x_i \text{ -axes} \end{aligned}\right\} \tag{64}$$

Substitution of Equation 64 into Equation 63 leads to the transformed stiffness matrix equation:

$$\left.\begin{aligned} \left\{\mathcal{F}_{mne}\right\} &= [\mathcal{K}_e]\left\{\mathcal{U}_{mne}\right\} \\ [\mathcal{K}_e] &= [T_e]\,[K_e]\,[T_e]^{-1} = \text{6 x 6 transformed stiffness matrix} \end{aligned}\right\} \tag{65}$$

For rigid frame joints, all elements attached to a given joint have equal deflection components (at that joint) with respect to the x_i -axes, and since this compatibility condition is valid at all joints, the subscript e in the

deflection matrix $\left\{\mathcal{U}_{mne}\right\}$ can be deleted, giving simply $\left\{\mathcal{U}_{mn}\right\}$. Thus, Equation 65 can be written in the form:

$$\left\{\mathcal{F}_{mne}\right\} = \left[\mathcal{K}_e\right]\left\{\mathcal{U}_{mn}\right\} \tag{66}$$

Each joint must be in equilibrium under the action of all loads applied to the joint. Thus, for each axis at each joint of the frame, the summation of component loads for all elements attached to the joint must be equal to the corresponding externally applied load. To express this condition mathematically requires the following quantities to be defined:

$\bar{F}_{mie}$ = force along the x_i-axis at joint m due to element e.

$\bar{U}_{nj}$ = deflection along the x_i-axis at node n.

$(K^{nj}_{mi})_e$ = stiffness of element e (which attached between joints m and n) which leads to a force $\bar{F}_{mie}$ due to a deflection $\bar{U}_{nj}$.

$\bar{F}_{mi}$ = external force along the x_i -axis at joint m.

Then the external force $\bar{F}_{mi}$ is defined by the equation

$$\begin{aligned}\bar{F}_{mi} &= \sum_e \bar{F}_{mie} = \sum_e \sum_n \sum_j (K^{nj}_{mi})_e \bar{U}_{nj} \\ &= \sum_e \sum_n \sum_j (K^{nj}_{mi})_e \bar{U}_{nj} \\ &= \sum_n \sum_j K^{nj}_{mi} \bar{U}_{nj}\end{aligned} \tag{67}$$

where

$$K^{nj}_{mi} = \sum_e (K^{nj}_{mi}) = \text{element of overall stiffness matrix of platform} \tag{68}$$

The set of Equations 67 for all (mi) can be written in matrix notation which leads to the stiffness matrix for the entire platform structure. The common x_i -coordinate system used in this section is replaced by $(X, Y, Z, \theta_x, \theta_y, \theta_z)$ in ISIP2 output for convenience.

5.3 EIGENVALUE AND EIGENVECTOR SOLUTION.

The normal mode solution of the equations of motion (Equation 46) has been discussed in Section 3.4. The equation to be solved was reduced to the form presented in Equation 49.

$$([K] - \omega^2 [M]) \{\phi\} = 0 \tag{49}$$

This expression represents a set of n homogeneous equations for the vibrations of a n-degree-of-freedom system in their normal modes. The non-trivial solution to this set of equations (one for which $\{\phi\} \neq 0$) is obtained by setting the determinant of the first matrix equal to zero or

$$|([K] - \omega^2 [M])| = 0 \tag{69}$$

This is the characteristic equation for the system, and its roots are the eigenvalues, ω_n, which cause the determinant to go to zero. These are the natural frequencies of the normal modes. For n-degree-of-freedoms, there will be n real eigenvalues, or natural frequencies, which satisfy the equation. The normal mode shapes $\{\phi_n\}$, or eigenvectors, are determined separately by substituting the natural frequencies back to Equation 49. The deflection amplitude $\{\mathscr{U}_n\}$ are determined by solving n-1 of the resulting simultaneous equations with any one of the amplitudes arbitrarily set to unity. The resulting values of $\{\mathscr{U}_n\}$ (one for each degree-of-freedom and modal frequency (ω_n) are then normalized to a unit value for the maximum deflection in each mode shapes $\{\phi_n\}$.

Several methods[26] may be used to find the eigenvalues and eigenvectors from Equation 69. Each of these methods may have its inherent advantages and disadvantages depending on the nature of the problem. Some methods will compute all the natural frequencies of the system, while others may give the highest of lowest frequencies of one's choice. Some methods are much more

complicated in theory and programming, but very efficient in eigenvalue and eigenvector evaluation for structures up to certain size, while other methods are simple and straight foreward, but not necessarily efficient. However, the efficiency of any method is drastically affected when the size of the characteristic equation matrix of Equation 69 exceeds the computer core space limitation.

The following method, used in ISIP2 computer program, is an alternate form of the Stodola method. This method has the advantage of providing the simultaneous solution for both the natural frequency ω_n and the normal mode shapes $\{\phi_n\}$ in one basic iteration process. Basically it is a matrix iteration operation using the inverse stiffness matrix, and is most useful when only the lowest few modes are to be determined.

Equation 49 is premultiplied by the inverse stiffness matrix $[K]^{-1}$ and rearranged to give

$$\begin{aligned} \{\phi\} &= \omega^2 \, [K]^{-1} \, [M] \, \{\phi\} \\ &= \omega^2 \, [B] \, \{\phi\} \end{aligned} \tag{70}$$

where $[B] = [K]^{-1} \, [M]$

The iteration process, carried out with this expression converges on the lowest or first natural frequency of the system in the following steps:

- A trial value of the column matrix of amplitudes $\{\phi\}$ is assumed. If this trival value is arbitrarily chosen so that its largest element is unity, it may be considered to be a first order approximation for the mode shape $\{\phi_1\}_{r=1}$ for the first normal mode.

- The assumed value $\{\phi_1\}$ is inserted in the right side of Equation 70 and the product $[B] \{\phi_1\}$ is evaluated. The largest absolute value in this product is identified as the quantity a_{r+1}. If this quantity is now divided out of the product $[B] \{\phi_1\}_r$, then the first iteration step provides

a second order approximation $\{\phi_1\}_{r+1}$ for the mode shape given by

$$\{\phi_1\}_{r+1} = \omega^2 a_{r+1} [B] \{\phi_1\}_{r=1} \tag{71}$$

where the bar signifies a normalized value for the product matrix using the normalizing factor a_{r+1}.

- If $\{\phi_1\}_{r+1} = \{\phi_1\}_r$, within the desired accuracy, then the lowest natural frequency is found,

$$\omega_1 = \sqrt{1/a_{r+1}} \text{ - the lowest or first natural frequency.}$$

The lowest mode shape is the column matrix

$$\{\phi_1\}_r \text{ or } \{\phi_1\}_{r+1}$$

- If the desired accuracy is not achieved in the first iteration the new estimated mode shape column matrix $\{\phi_1\}_{r+1}$ is inserted back to the right side of Equation 70 and the iteration process continued (i.e., r = 1, 2...etc.) until Equation 71 is satisfied to the desired accuracy.
- An alternative way to check the accuracy is to compare the normalization factor a_{r+1} with the previous iteration. If the two values are equal, within the desired accuracy, the iteration process is accomplished.
- For most problems, only a few iterations are required to achieve good accuracy unless the natural frequencies are very closely spaced.

For the next higher natural frequency ω_2, additional steps are required. The next higher mode is modified, based on the concept of orthogonality of the normal modes, to remove all influence of the previously computed modes. This is carried out using a "sweeping matrix" technique[27].

A "sweeping matrix", $[S_1]$ for the first mode is defined,

$$[S_1] = \begin{bmatrix} 1 & 0 & 0 & . & . & . & . & 0 \\ 0 & 1 & 0 & . & . & . & . & 0 \\ 0 & 0 & 1 & . & . & . & . & 0 \\ . & & & . & & & & . \\ . & & & & . & & & . \\ . & & & & & . & & . \\ 0 & 0 & 0 & . & . & . & 1 & 0 \\ C_1 & C_2 & C_3 & . & . & . & C_{n-1} & 0 \end{bmatrix} \quad \text{where:} \quad C_i = -\frac{M_i}{M_n}\frac{Q_{1i}}{Q_{1n}} \tag{72}$$

This matrix has the form of an identity matrix with the nth row replaced by the coefficients for the nth displacement amplitude in terms of the remaining variables and the nth column has only zeros. This sweeping matrix is then used to define a new frequency equation for the second lowest mode,

$$\{\phi_2\} = \omega^2 \, [B] \, [S_1] \, \{\phi_2\} \tag{73}$$

The same iteration process carried out for the first mode is not repeated except that the iteration Equation 71 is modified by the sweeping matrix to become

$$\{\phi_2\}_{r+1} = \omega^2 \, a_{r+1} \, \overline{[B] \, [S_1] \, \{\phi_2\}_r} \tag{74}$$

In this case, the normaling factor a_{r+1} is the quantity necessary to normalize to unity the largest element in the product $[B] \, [S_1] \, \{\phi_2\}_r$. Again, the bar designates a normalized value for this product.

For the next higher mode (ω_3), a sweeping matrix $[S_2]$ contains two rows of coefficients and two columns of zeros thus eliminating the influences of the first and second modes previously computed. The same iteration process defined by Equation 73 is then repeated using $[S_2]$ in place of $[S_1]$ to find the value of ω_3 and $\{\phi_3\}$.

This iteration process, which is based on systems defined by the inverse stiffness matrix coefficients, has the advantage of relative simplicity for determination of the lowest modes of a system. The characteristic matrix [B] of Equation 70 reduces in size, by one row and one column, every time a sweep matrix $[S_n]$ is applied.

The dynamic response of a linear system by the normal mode method has been discussed in Section 4.4. The use of shock spectra as input forcing function was also presented there. The dyanmic response of a non-rigid platform using the normal mode method is, therefore, not repeated here.

6.1 SYNTHESIS OF A WAVEFORM TO MATCH A GIVEN SHOCK RESPONSE SPECTRUM.

6.1.1 INTRODUCTION.

In many practical cases, the shock motion to which the isolation system may be exposed and for which it is to be designed is specified by criteria as a shock response spectrum rather than as a waveform. If the system can be assumed to be linear, the spectrum can be employed to bound the peak responses of the system as shown in the previous section. However, if the response of the isolation system must be defined in time or by a response spectrum,or if the suspension configuration or its elements cannot be assumed to be linear, the input motion must also be defined in time.

There are an infinite number of waveforms which can be generated whose response spectra will match any given spectrum. This is due to the fact that the spectrum itself does not define uniquely component amplification ratios, frequencies, or their phase relationships. Indeed, the design shock is rarely unique and in many cases it is for this reason that the input is defined by the more general response spectrum.

In examining the types of motions to which shock isolation systems installed in protective structures might be exposed, however, there are some qualitative statements which can be made regarding broad aspects of their time-histories. For example, at frequencies well below the fundamental of the structure embedded in the soil, response motions of the structure will be almost identical to those of the nuclear weapon generated disturbance. At higher frequencies, motions at the frequencies of the modes of the constrained elastic structure will predominate. Thus,from the nature of the disturbance and the dynamic characteristics of the embedded structure,some indication of the ranges of component frequencies and amplitudes can be obtained.

Methods employed heretofore in synthesizing a waveform to match a given response spectrum have relied heavily on trial and error techniques. Their disadvantages have been first, that rarely was a good match with the specified spectrum achieved,and second, that they did not enable a systematic variation in component frequencies, component amplification ratios, and component phase relationships to be made. Recently Yang[6] developed an approach which overcomes all of these disadvantages. The method is described in detail in Reference 21 and is reviewed here in a simple form.

6.1.2 BASIC PRINCIPLE.

The equation of motion of a simple linear spring mass system subjected to base excitation is

$$\ddot{x} + \omega_n^2 x = \omega_n^2 W(t) \tag{75}$$

where $\ddot{x}$ is the absolute acceleration of the mass, ω_n is the system frequency, and W(t) is the base excitation acceleration expressed as a function of time. The response spectrum of the excitation function W(t) is a plot of the maximum response of a series of single degree of freedom systems, defined by equation 75, as a continuous function of the system frequencies ω_n.

W(t) can be written as a linear combination of some function $f_m(t)$, such that

$$W(t) = \sum_{m=1}^{M} A_m f_m(t) \tag{76}$$

Where A_m is a constant coefficient in in./sec^2, associated with the function $f_m(t)$. The problem here is that from a selected set of M function of $f_m(t)$, $(m = 1,2,\cdots M)$, M number of A_m coefficients are determined such that the response spectrum generated by this waveform, as expressed by equation 76, matches M points on a given response spectrum. To match a spectum exactly, infinite number of terms might be required. However, since the response spectrum to be matched represents usually an envelope of many spectra, it is only necessary to match the spectrum, as generated by the synthesized waveform, within a specified tolerance, especially at the region of the spectrum lying between the system frequencies ω_n. This tolerance is acceptable so long as it does not exceed the prescribed bounds set by the user of this waveform synthesis technique.

If an analytical solution of Equation 75 can be derived for the forcing function $f_m(t)$, the problem is reduced to the solution of a set of M simultaneous algebraic equations for m unknown values of A_m. However, depending on the nature of the forcing function, the process may not be this simple. The following sections discuss the selection of forcing functions, the analytical solution of Equation 75, the method of determination of coefficient A_m, and the convergence of an iterative procedure.

6.1.3 SELECTION OF FORCING FUNCTION.

The selected acceleration forcing function must fulfill two basic requirements. First, the velocity and usually the displacement of the function must vanish at the end of excitation if it is to represent a physical transient phenomenon. Second, the function must be adjustable to provide some control on the response amplification ratio. While adjustability in phase is also desirable, it is not treated in this section.

Equation 77 is one possible form of such a forcing function.

$$\begin{aligned} f_m(t) &= \sin 2\pi b_m t \sin 2\pi N b_m t \qquad && 0 \le t \le T_m \\ &= 0 && t > T_m \end{aligned} \tag{77}$$

where b_m is frequency in Hz, N is an integer, and $T_m = \frac{1}{2b_m}$. Figure 1-21 is a plot of this function where N = 5.

If N is an odd number, say $N = 2\lambda + 1$, where λ is an integer, $f_m(t)$ may be integrated with respect to t, and, taking the limit from 0 to T_m, there results

$$\begin{aligned} \int_0^{T_m} f_m(t)dt &= \int_0^{T_m} \sin 2\pi b_m t \sin 2\pi N b_m t dt \\ &= \frac{1}{2}\left\{\frac{1}{4\pi\lambda b_m}\sin 4\pi\lambda b_m t - \frac{1}{4\pi(\lambda+1)b_m}\sin 4\pi(\lambda+1)b_m t\right\}_0^{\frac{1}{2b_m}} = 0 \end{aligned} \tag{78}$$

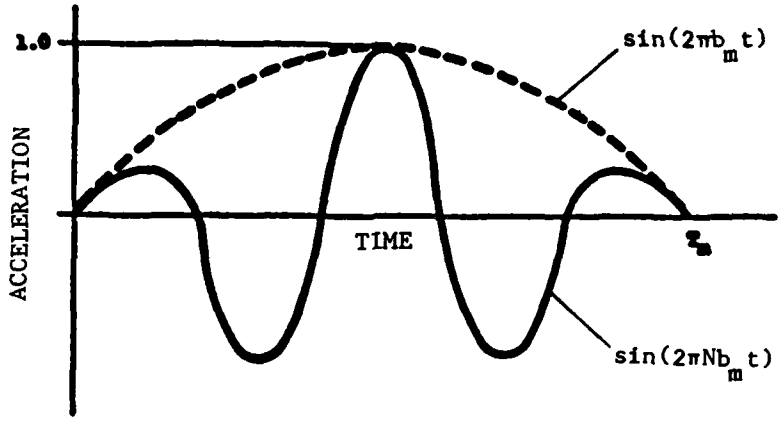

Figure 1-21. Form of Selected Forcing Function, N = 5

Double integrating $f_m(t)$ there is obtained

$$\int_0^{T_m} \int_0^t f_m(a)\,da\,dt = \frac{-1}{2} \left\{ \frac{1}{(4\pi\lambda b_m)^2} \cos 4\pi\lambda b_m t - \frac{1}{[4\pi(\lambda+1)b_m]^2} \cos 4\pi(\lambda+1)b_m t \right\}_0^{\frac{1}{2b_m}} = 0$$

Therefore, if N assumes any odd number except unit, both the terminal velocity and displacement at $t \geq T_m$ are zero.

The response amplification ratio for a given component frequency ω_n may be varied by changing the parameters b_m and N in the forcing function. The effects of the variation of these parameters will be discussed in the following sections.

6.1.4 ANALYTICAL SOLUTIONS.

Substituting Equation 77 into Equation 76

$$W(t) = \sum_{m=1}^{M} A_m \sin 2\pi b_m t \sin 2\pi N b_m t \qquad 0 \le t \le T_m \tag{79}$$

$$= 0 \qquad t > T_m$$

and Equation 75 becomes

$$\ddot{x} + \omega_n^2 x = \omega_n^2 \sum_{m=1}^{M} A_m \sin 2\pi b_m t \sin 2\pi N b_m t \qquad 0 \le t \le T_m \tag{80}$$

$$= 0 \qquad t > T_m$$

Since Equation 80 is linear, it can be solved independently for each x from $f_m(t)$ only and the final result can be obtained by superposition. Therefore, the problem becomes the solution of the equations

$$\ddot{x} + \omega_n^2 x = \omega_n^2 A_m \sin 2\pi b_m t \sin 2\pi N b_m t \qquad 0 \le t \le T_m \tag{81}$$

$$\ddot{x} + \omega_n^2 x = 0 \qquad t \ge T_m \tag{82}$$

where the initial conditions are

$$x(0) = \dot{x}(0) = 0$$

The solution of Equation 81 can be obtained by Laplace transforms. The transform of Equation 81 gives the following equation:

$$\bar{X}S^2 + \omega_n^2 \bar{X} = \omega_n^2 A_m \left\{ \frac{2BCS}{[S^2 + (B-C)^2] \cdot [S^2 + (B+C)^2]} \right\} \tag{83}$$

where $\bar{X} = L(x)$, $B = 2\pi b_m$ and $C = 2\pi N b_m$.

Rearranging Equation 83 to the form

$$\bar{X} = 2\omega_n^2 A_m BC \left\{ \frac{S}{[S^2 + \omega_n^2]\cdot[S^2 + (B-C)^2]\cdot[S^2 + (B+C)^2]} \right\} \tag{84}$$

and taking the inverse Laplace transform of Equation 84 there is obtained

$$x(t) = \frac{A_m \omega_n^2}{2}\left[\frac{\cos\omega_n t - \cos(B-C)t}{(B-C)^2 - \omega_n^2} - \frac{\cos\omega_n t - \cos(B+C)t}{(B+C)^2 - \omega_n^2} \right] \tag{85}$$

$$0 \leq t \leq T_m$$

Differentiating Equation 85 with respect to time

$$\dot{x}(t) = \frac{A_m \omega_n^2}{2}\left[\frac{-\omega_n \sin\omega_n t + (B-C)\sin(B-C)t}{(B-C)^2 - \omega_n^2} - \frac{-\omega_n \sin\omega_n t + (B+C)\sin(B+C)t}{(B+C)^2 + \omega_n^2} \right] \tag{86}$$

The Laplace transform of Equation 82 with the initial conditions at $t=T_m$: $x(0)=x(T_m)$ and $\dot{x}(0)=\dot{x}(T_m)$, gives the following equation:

$$\bar{X}S^2 + \omega_n^2\bar{X} = Sx(T_m) + \dot{x}(T_m) \tag{87}$$

Substituting Equations 85 and 86 in Equation 87 at $t = T_m$ and rearranging there is obtained

$$\begin{aligned} \bar{X} = {} & \frac{A_m \omega_n^2 S}{2(S^2 + \omega_n^2)}\left[\frac{\cos\omega_n T_m - \cos(B-C)T_m}{(B-C)^2 - \omega_n^2} - \frac{\cos\omega_n T_m - \cos(B+C)T_m}{(B+C)^2 - \omega_n^2} \right] \\ & + \frac{A_m \omega_n^2}{2(S^2 + \omega_n^2)}\left[-\left(\frac{\omega_n \sin\omega_n T_m - (B-C)\sin(B-C)T_m}{(B-C)^2 - \omega_n^2} \right) \right. \\ & \left. + \left(\frac{\omega_n \sin\omega_n T_m - (B+C)\sin(B+C)T_m}{(B+C)^2 - \omega_n^2} \right) \right] \end{aligned} \tag{88}$$

Taking the inverse Laplace transform of Equation 86

$$x(t) = \frac{A_m\omega_n^2}{2}\cos\omega_n t\left(\frac{1}{(B-C)^2-\omega_n^2}-\frac{1}{(B+C)^2-\omega_n^2}\right)$$

$$+\frac{A_m\omega_n}{4}\left\{-\frac{\cos\left[\omega_n(t-T_m)+(B-C)T_m\right]}{(B-C-\omega_n)}+\frac{\cos\left[\omega_n(t-T_m)-(B-C)T_m\right]}{(B-C+\omega_n)}\right.$$

$$\left.+\frac{\cos\left[\omega_n(t-T_m)+(B+C)T_m\right]}{(B+C-\omega_n)}-\frac{\cos\left[\omega_n(t-T_m)-(B+C)T_m\right]}{(B+C+\omega_n)}\right\} \tag{89}$$

$$t \geq T_m$$

Equations 85 and 89 can then be rearranged to obtain

$$x(t,\bar{\omega}_n,b_m) = \frac{1}{2}A_m\bar{\omega}_n^2\left\{\frac{\cos 2\pi\bar{\omega}_n t-\cos\left[2\pi(1-N)b_m t\right]}{(1-N)^2b_m^2-\bar{\omega}_n^2}\right.$$

$$\left.-\frac{\cos 2\pi\omega_n t-\cos\left[2\pi(1+N)b_m t\right]}{(1+N)b_m^2-\bar{\omega}_n^2}\right\}H(T_m-t) \tag{90}$$

$$+2A_mN\bar{\omega}_n^2\,\frac{b_m^2\left\{\cos 2\pi\bar{\omega}_n t-(-1)^{N+1}\cos\left[2\pi\bar{\omega}_n(t-T_m)\right]\right\}}{\left[(1-N)^2b_m^2-\bar{\omega}_n^2\right]\left[(1+N)^2b_m^2-\omega_n^2\right]}H(t-T_m)$$

where $\omega_n = 2\pi\bar{\omega}_n$ and H is Heaviside function.

Finally, solutions of Equation 84 can be written

$$x(t,\bar{\omega}_n,b_m) = \sum_{m=1}^{M}A_mQ_m(t,\bar{\omega}_n,b_m) \tag{91}$$

where $Q_m(t,\bar{\omega}_n,b_m)$ takes the form of the right-hand side of Equation 90 without A_m. The first part of Q_m defines the responses of a system with frequency ω_n during application of the excitation function W(t), and the second part defines the responses after termination of the excitation function.

Equation 91 is valid for all values of t, $\bar{\omega}_n$, and b_m with the exception that at $b_m = \bar{\omega}_n/(1 - N_m)$ and $b_m = \bar{\omega}_n/(1 + N_m)$, both numerator and denominator of the equation vanish and the value of the equation is undetermined. However, as b_m approaches either $\bar{\omega}_n/(1 - N_m)$ or $\bar{\omega}_n/(1 + N_m)$, the limiting value of Q_m can be obtained by applying L'Hospital's rule. Hence, Equation 91 can be rearranged as follows to resolve this difficulty.

$$Q_m\left(t, \bar{\omega}_n, b_m\right) = \left\{\frac{1}{2}\bar{\omega}_n \pi t\left[\pi\delta(N-1)\bar{\omega}_n t \cos 2\pi\bar{\omega}_n t + \sin 2\pi\bar{\omega}_n t\right]\right.$$

$$\left. - \frac{(N-1)^2\left[\cos 2\pi\bar{\omega}_n t - \cos 2\pi\frac{N+1}{N-1}\left[1+\delta(N-1)\right]\bar{\omega}_n t\right]}{4\left[2N + \delta(N+1)^2(N-1)\right]}\right\} H\left(T_m - t\right) \tag{92}$$

$$+ \left\{\frac{N(N-1)\pi\left[1+2\delta(N-1)\right]\left[\delta\pi(N-1)^2\cos 2\pi\bar{\omega}_n t + 2\sin 2\pi\bar{\omega}_n t\right]}{4\left[2N + \delta(N+1)^2(N-1)\right]}\right\} H\left(t - T_m\right)$$

where $\delta = \frac{1}{\bar{\omega}_n}\left(\frac{\bar{\omega}_n}{1-N} - b_m\right)$ and $|\delta| << |$

and

$$Q_m\left(t, \bar{\omega}_n, b_m\right) = \left\{\frac{(N+1)^2\left\{\cos 2\pi\bar{\omega}_n t - \cos 2\pi\frac{N-1}{N+1}\left[1+\delta(N+1)\right]\bar{\omega}_n t\right\}}{4\left[-2N+\delta(N-1)^2(N+1)\right]}\right.$$

$$\left. - \frac{\pi t\bar{\omega}_n}{2}\left[\pi\delta\bar{\omega}_n(N+1)t \cos 2\pi\bar{\omega}_n t + \sin 2\pi\bar{\omega}_n t\right]\right\} H\left(T_m - t\right) \tag{93}$$

$$+ \left\{\frac{N(N+1,\ \pi\left[1+2\delta\ (N+1)\right]\left[\delta\pi(N+1)^2\cos 2\pi\bar{\omega}_n t + 2\sin 2\pi\bar{\omega}_n t\right]}{4\left[-2N+\delta(N-1)^2(N+1)\right]}\right\} H\left(t - T_m\right)$$

where $\delta = \frac{1}{\bar{\omega}_n}\left(\frac{\bar{\omega}_n}{1+N} - b_m\right)$ and $|\delta| << |$

Depending on the value of b_m, Q_m in Equation 91 may take the form of Equation 90, 92, or 93.

From the given response spectrum, M numbers of y_k maximum response at $\bar{\omega}_k$ frequency can be selected and from the selected $\bar{\omega}_k$ (k = 1,2,....M) frequencies. **M numbers of waveform components are fixed where each component has a frequency b_m determined as a function of $\bar{\omega}_k$ and N_m. It is shown later that the proper selection of b_m and N_m approximates the amplification ratio at the frequency $\bar{\omega}_k$.**

6.1.5 DETERMINATION OF COEFFICIENT.

The next step is to determine the coefficients A_m. From the given response spectrum, M number of x_k maximum response at $\bar{\omega}_k$ frequency are selected.

Since Q_m is also a function of t, the time t_k at which the maximum response x_k occurs must be determined. Differentiating Equation 91 there is obtained

$$\frac{\partial}{\partial t} x\,(t, \bar{\omega}_n b_m) = \sum_{m=1}^{M} A_m \frac{\partial}{\partial t} Q_m\,(t, \bar{\omega}_n, b_m) \tag{94}$$

Setting Equation 94 to zero, the time t_k can be determined at which x is a maximum. Hence, there are 2M equations as follows.

$$x_k = \sum_{m=1}^{M} A_m Q_{km}(t_k, \bar{\omega}_k, b_m) \qquad k = 1, 2 \ldots\ldots M \tag{95}$$

and

$$\sum_{m=1}^{M} A_m \frac{\partial}{\partial t} Q_{km}\,(t_k, \bar{\omega}_k, b_m) = 0 \qquad k = 1, 2 \ldots\ldots M \tag{96}$$

From these equations, M unknowns of A_m and M unknowns of t_k can be found. **However, this procedure is acceptable only for relatively simple functions of Q_m. If Q_m is a continuous function which changes slope more than twice, then Equation 96 will have more than two values of t_k and another operation is required to select the t_k which corresponds to the maximum value of x.**

Furthermore, for the selected waveform, the response function contains transcendental terms. An analytical solution to obtain coefficients is almost impossible. The alternative is to use a numerical iteration process.

6.1.6 DESCRIPTION OF ITERATION PROCEDURE.

Assume first a set of trial coefficients $\bar{A}_1$, $\bar{A}_2$, --$\bar{A}_M$ where M is the number of points to be matched on the given response spectrum. Then, by utilizing a computer a search can be made for the maximum value of Equation 91 for a given set of M number of $\bar{\omega}_k$ frequencies during a specified time range of $0 \leq t \leq T$ where T is greater than T_m. In the process, a set of M number of t_k is also established where t_k is the time when the maximum response occurred. Therefore

$$\left\{\bar{x}_k\right\} = \left[Q_{km}\right]\left\{\bar{A}_m\right\} \qquad (97)$$

Where:

$k = 1, 2, 3, \ldots\ldots M$

$m = 1, 2, 3, \ldots\ldots M$

where $\bar{x}_k$ is the maximum value of $\sum_{m=1}^{M} A_m Q_{km}$ corresponding to $\bar{\omega}_k$, and Q_{km} is a numerical value evaluated at $t = t_k$.

Usually, the calculated maximum response $\bar{x}_k$ from the first values of A_m does not coincide with the maximum response values from the given spectrum at frequency $\bar{\omega}_k$. A new set of A_m values can be calculated as follows:

$$\left\{A_m\right\} = \left[Q_{km}\right]^{-1}\left\{x_k\right\} \qquad (98)$$

Where:

$k = 1, 2, 3, \ldots\ldots M$

$m = 1, 2, 3, \ldots\ldots M$

where x_k is the maximum response value from the given spectrum at frequency $\bar{\omega}_k$. In order to invert the matrix $\left[Q_{km}\right]$, the determinant $\left|Q_{km}\right|$ must not vanish.

From the calculated new values of coefficients, a new set of $\bar{x}_k$ and t_k values are determined. This process can be repeated until the calculated maximum responses are approximately equal to the required response values from the response spectrum or $|x_k - \bar{x}_k| < \zeta$, where ζ is an arbitrarily small number.

In summary, the iteration procedures can be listed as follows:

- Choose M as the number of points to be matched on a given response spectrum.
- Select a set of trial values of A_m's ($m = 1, 2, \ldots M$).
- Specify a time range $0 \leq t < T$ where $T > T_m$.
- Search for maximum values of $\sum_{m=1}^{M} A_m Q_{km}$ for each $\bar{\omega}_k$ and record t_k at which time the maximum calculated response $\bar{x}_k$ occurs.
- Evaluate the numerical values of Q_{km} at $t = t_k$.
- Invert matrix $\left[Q_{km}\right]$.
- Calculate new values of coefficient by Equation 98.
- Repeat the process until $|x_k - \bar{x}_k| < \zeta$.

6.1.7 CHOICE OF SYSTEM FREQUENCY ON THE SPECTRUM.

In the last section no mathematical proof was given to show that the iteration procedure is convergent for any value of forcing function frequency b_m. However, it has been found by trial computer runs that if b_m is chosen properly, then the diagonal elements in $\left[Q_{km}\right]$ are large when compared to the off-diagonal elements and in this case, the iteration procedure converges.

From Equation 90 it can be shown that if the ratio of b_m to $\bar{\omega}_n$ is large, the value of Q_m $(t, \bar{\omega}_n, b_m)$ is small and decreases in the order of the ratio of $\left(\frac{b_m}{\bar{\omega}_n}\right)^2$. It can also be shown that the function Q_m attains a maximum when the ratio b_m/ω_n is approximately in the range of $\frac{1}{N+1}$ to $\frac{1}{\sqrt{N^2-1}}$. The value of Q_m is shown as a function of the ratio b_m/ω_n for $N = 5$ in Figure 1-22.

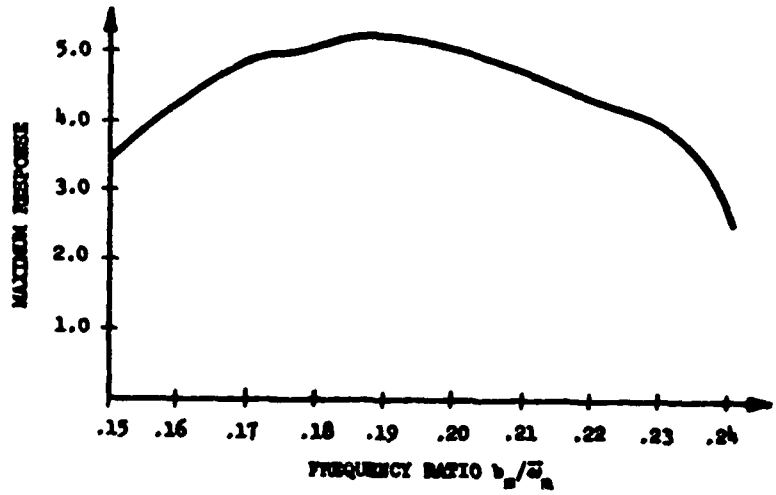

Figure 1-22. Maximum Response as a Fraction of Frequency Ratio

Thus, the proper choice of b_m for a given $\bar{\omega}_n$ guarantees the convergence of the iteration process and in combination with the value of N, controls the amplification of the response motions at the system frequency $\bar{\omega}_n$. However, if any two system frequencies are too close, the magnitude of the element next to the diagonal element is of the same order as the diagonal element and the iteration procedure does not converge. From a series of computer trial runs, the following table was compiled and can be used as guidelines for the system frequencies selection for different N values.

N	3	5	7	9
ω_n/ω_{n-1}	1.95	1.7	1.61	1.43

6.1.8 COMPUTER PROGRAM.

A computer program has been developed to systhesize the time-motion history from a given response spectrum by the method described in this section. It is called the WAVSYN program.

6.2 FURTHER IMPROVEMENT FOR THE WAVEFORM SYNTHESIS PROGRAM.

6.2.1 OBJECTIVES.

The WAVSYN technique described in Section 6.1, consists of superimposing a series of sinusoidal components, each component first increasing and then decreasing in amplitude. Each component consists of an odd number of half-cycle oscillations. The number of half-cycle oscillations is also approximately equal to the amplification ratio of the frequency component. Discrete points on the response spectrum to be matched are then selected, and from the required number of half-cycles, the frequencies of the waveform components are fixed to generate resonances at the system frequency match points. By an iteration process, the computation adjusts the component amplitudes until the required responses are obtained at the selected frequencies.

This waveform synthesis approach guarantees a good match at the selected frequencies on the spectrum. However, at intermediate points between the selected frequencies at which a match is fixed, the spectrum of the synthesized wave may differ considerably from the desired spectrum. Locations of the selected frequency points then must be adjusted or additional frequency points added to improve the correlation. However, there are no clear guidelines as to how the frequency points should be controlled to improve the matching results at intermediate frequency points, and there is no guarantee that the adjusted result could not be improved further.

Thus, the first objective of the improvement in this section is to examine, in detail, the contribution of each frequency component to the spectrum of the composite motion and, from this examination, attempt to establish mathematical rules for proper selection of the frequency points. These mathematical rules would serve the following purposes: (1) increase efficiency of the application of the WAVSYN program, and (2) improve accuracy of the results.

The waveform synthesis technique presented in Section 6.1 requires that all frequency components be initiated simultaneously at the beginning of the wave. In many applications, however, some information on the phasing of the frequency components is available, and rarely are the components observed to begin simultaneously. In the SAFEGUARD design, a notable example is the free-field ground motions where it is known that the relatively low-frequency outrunning components precede, by a significant time period, the high frequencies associated with the airblast-induced motion.

While the shock response spectrum does not contain phasing information, it is easily shown that the responses of coupled linear systems and of nonlinear systems are sensitive to phasing of the frequency component of the input wave. Just as in the present WAVSYN program an attempt is made to approximate the amplification ratio of each of the components, so would it be desirable to approximate the phasing of each component if such data are available. Thus the second objective of this study was to incorporate the arbitrary phasing of the frequency components in the WAVSYN program to achieve a realistic simulation of the SAFEGUARD environment.

6.2.2 BACKGROUND.

A waveform, synthesized by the method just described, yields a response spectrum which matches M points on the given response spectrum and approximates the amplification ratios at these points. There are two further items which must be considered. The first item is the method of selecting the M frequency points on a given spectrum, and the second item is that of controlling the responses between the selected system frequency points. If the frequency points are selected too close together, the response contribution of one frequency component to the other frequency component may be so high that the elements for the matrix $[Q_{km}]$ cannot be fulfilled. That is, responses between the frequency points are much higher than the spectrum between these same frequencies because the contributions from both the frequency points are too high. On the other hand, if the frequency points are selected too far apart, the responses at the frequencies between the selected points are so low that they cannot meet the given response spectrum requirement at these intermediate frequencies.

Based on a series of trial computer runs, a set of system frequency ratios has been established for different N values as shown in Reference 21. The following sections present a systematic approach to the selection of optimum system frequency points.

6.2.3 NORMALIZED RESPONSE CHARACTERISTICS OF THE WAVEFORM COMPONENT.

To establish the contribution of the waveform components to the total responses between the selected frequency points, the response characteristics of each waveform component must be understood. From Equations 90 and 91 the response of one waveform component to the system frequency $\bar{\omega}_n$ can be written as

$$x_m = \frac{1}{2} A_m \bar{\omega}_n^2 \left\{ \frac{\cos 2\pi\bar{\omega}_n t - \cos\left[2\pi\left(1-N_m\right) b_m t\right]}{\left(1-N_m\right)^2 b_m^2 - \bar{\omega}_n^2} - \frac{\cos 2\pi\bar{\omega}_n t - \cos\left[2\pi\left(1+N_m\right) b_m t\right]}{\left(1+N_m\right)^2 b_m^2 - \bar{\omega}_n^2} \right\} \qquad 0 \le t \le T_m$$

$$= 2A_m N_m \bar{\omega}_n^2 b_m^2 \left\{ \frac{\left\{\cos 2\pi\bar{\omega}_n t - \cos\left[2\pi\bar{\omega}_n \left(t - T_m\right)\right]\right\}}{\left[\left(1-N_m\right)^2 b_m^2 - \bar{\omega}_n^2\right]\left[\left(1+N_m\right)^2 b_m^2 - \bar{\omega}_n^2\right]} \right\} \qquad t \ge T_m \tag{99}$$

Setting $(1 - N_m) = C_1$, $(1 + N_m) = C_2$, $t/T_m = \tau$, and $b_m/\bar{\omega}_n = R$, Equation 99 is reduced to the form

$$\frac{y_m}{A_m} = \frac{4N_m R^2}{\left(C_1^2R^2 - 1\right)\left(C_2^2R^2 - 1\right)} \left\{ \frac{1}{2}\left(\cos\frac{\pi\tau}{R} - \cos\pi\tau \cos N_m \pi\tau\right) + \frac{1}{4}\left(\frac{1}{N_m R^2} - \frac{1}{N_m} - N_m\right) \sin\pi\tau \sin N_m \pi\tau \right\} \qquad 0 \le \tau \le 1$$

$$= \frac{4N_m R^2}{\left(C_1^2R^2 - 1\right)\left(C_2^2R^2 - 1\right)} \sin\frac{\pi}{2R} \sin\left(\frac{\pi}{2R} - \frac{\pi\tau}{R}\right) \qquad \tau \ge 1 \tag{100}$$

For different numbers of half-cycle oscillations, Equation 100 shows the normalized response motions as a function of the frequency ratio R. Note that during the application of excitation function, the normalized time τ varies from zero to one. Different values of frequency ratios can be interpreted as the response motions of different systems at frequency $\bar{\omega}_n$ due to a waveform component at frequency b_m. For example, if the waveform component frequency is 1 Hz, then when R is equal to 0.1, 0.5, or 1, the system frequency is 0.1 Hz, 0.5 Hz, or 1.0 Hz respectively.

The normalized response spectrum can be obtained from Equation 100 for different values of half-cycle oscillations. As shown in Figure 1-23, the solid lines represent the maximax spectra and the dotted lines are the residual spectra. These plots confirm the conclusion reached in Reference 21 that the resonance conditions or the maximum responses occur at R equal to 0.28 and 0.19 for N equal to 3 and 5 respectively and equal to 1/N for N equal to 7 or greater. As indicated on the residual spectra, the responses are zero at certain values of R. On examination of the second part of Equation 100, it can be seen that when R equals to 0.5, 0.25, 0.1667, 0.125, 0.1, etc., $\sin \frac{\pi}{2R}$ is equal to zero and x/A vanishes. However, depending on the values of N, there are exceptions. For example, at N = 3 the denominator also is equal to zero at R = 0.5 and 0.25. Then, a finite response can be obtained at these values of R for N = 3.

It is also interesting to note that the maximum residual responses have the same values as the maximax responses. Analytically, this can be evaluated as follows:

Differentiating the second part of Equation 100 with respect to τ, the following equation is obtained:

$$\frac{d\,x/A}{d\tau} = -\frac{4N_m R^2(\pi/R)}{\left(C_1{}^2R^2 - 1\right)\left(C_2{}^2R^2 - 1\right)} \sin\frac{\pi}{2R} \cos\left(\frac{\pi}{2R} - \frac{\pi\tau}{R}\right) \quad \tau \geq 1 \qquad (101)$$

Setting Equation 101 equal to zero and solving for τ, the results are

$$\tau = \left(\frac{1}{2} + \frac{R}{2}\right), \left(\frac{1}{2} + \frac{3R}{2}\right), \left(\frac{1}{2} + \frac{5R}{2}\right), \ldots\ldots\ldots\ldots$$

Substituting the values of τ into the second part of Equation 100, the maximum residual response is

$$\left(\frac{x}{A}\right)_{max.} = -\frac{4N_m R^2}{\left(C_1{}^2R^2 - 1\right)\left(C_2{}^2R^2 - 1\right)} \sin\frac{n\pi}{2} \qquad n = 1,3,5,\ldots. \qquad (102)$$

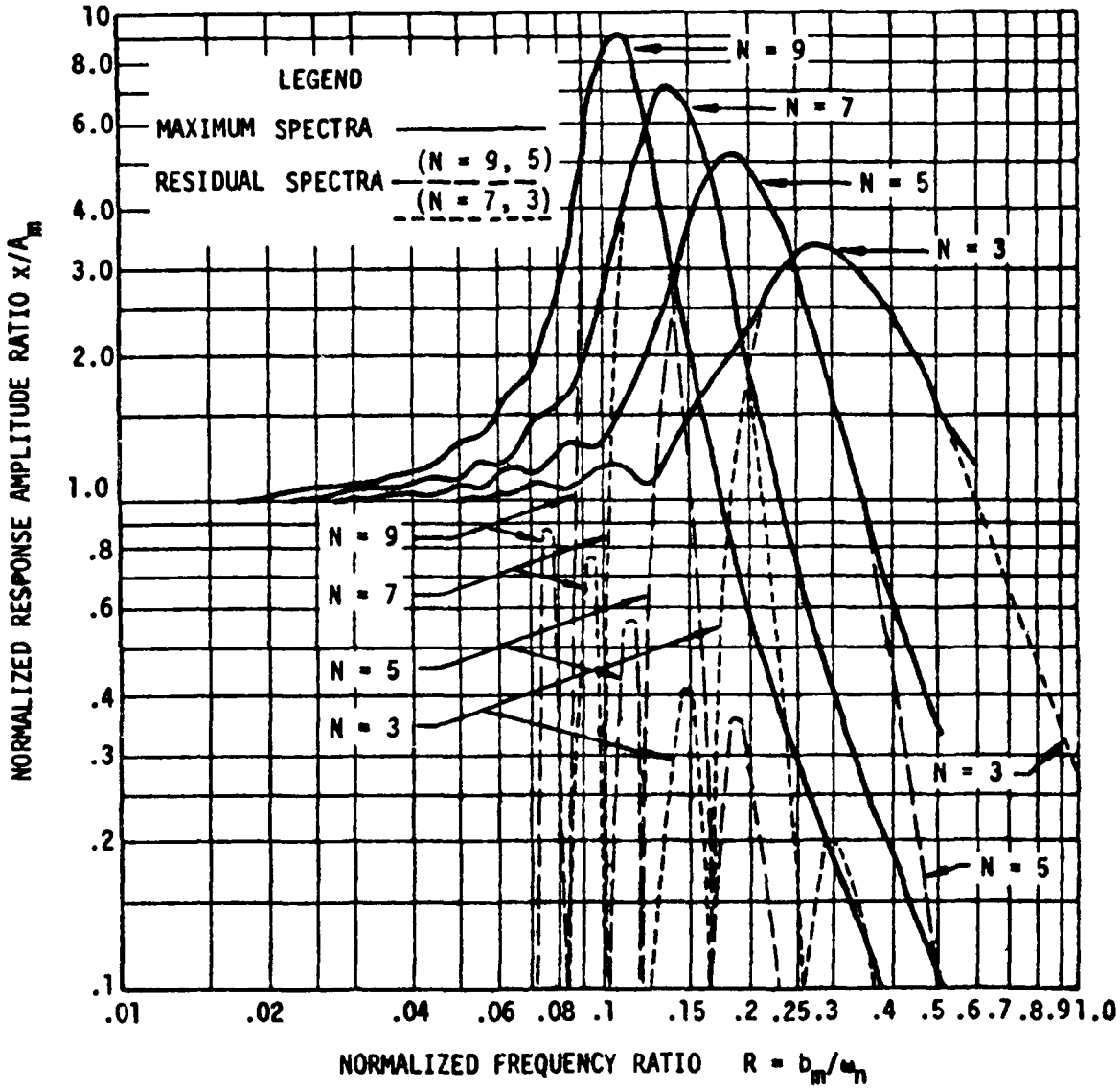

Figure 1-23. Normalized Maximax and Residual Response Spectra of the Selected Waveform Component for N = 3, 5, 7, and 9

For a given value of N, the normalized time-motion histories is a function of R alone. At a small value of R, say .02, the response motion is almost identical to the input motion and the maximum normalized response amplitude is one. As the value of R increases, the response amplitude also increases. At the resonance condition of R = 0.28, the maximum response amplitude of 3.3 is reached first during application of the input motion at τ less than one and then during the residual vibration phase. As the value of R increases further, the response amplitude begins to decrease.

As mentioned earlier, the waveform component frequency is selected to produce a resonance condition at a system frequency, so the convergence of the interaction solution is guaranteed. The response contribution of the waveform component is relatively low to the other system frequencies which are much higher than the resonance system frequency. On the other hand, for those system frequencies which are much lower, the normalized response amplitude approaches one. In general, the magnitude of a response spectrum in terms of absolute acceleration increases as a function of increasing frequency. Thus, a selected waveform component has only substantial response contributions to those system frequencies which are in the vicinity of a resonance system frequency.

6.2.4 SELECTION OF FREQUENCY MATCH POINTS ON THE SPECTRUM.

The complicated nature of the response motions precludes use of a pure analytical approach to select optimum locations of the frequency match points on the spectrum. However, a set of system frequency ratios can be established for the constant displacement, velocity, and acceleration regions on the spectrum.

The results in the previous section indicate that the response contribution from one waveform component is primarily due to those system frequencies which are nearest the waveform component frequency. To establish the optimum system frequency ratios, an approach was adopted which considered only three system frequency match points on the spectrum.

Figure 1-24 shows three selected system frequency points, labeled as $\bar{\omega}_1$, $\bar{\omega}_2$, and $\bar{\omega}_3$ on a spectrum. The system frequency ratios are $\alpha = \bar{\omega}_2/\bar{\omega}_1 = \bar{\omega}_3/\bar{\omega}_1$. The waveform component frequencies are selected to produce resonance conditions at the system frequency points. Thus, $b_1/\bar{\omega}_1 = b_2/\bar{\omega}_2 = b_3/\bar{\omega}_3 = R_n$ where R_n is a function of N, the required half-cycle oscillation. At the constant displacement region of the response spectrum, the required response amplitude is related to the system frequency by the following ratios:

$$\frac{x_1}{x_2} = \frac{\bar{\omega}_1^2}{\bar{\omega}_2^2} \quad , \quad \frac{x_2}{x_3} = \frac{\bar{\omega}_2^2}{\bar{\omega}_3^2}$$

Similarly, the relationships are $x_1/x_2 = \bar{\omega}_1/\bar{\omega}_2$, $x_2/x_3 = \bar{\omega}_2/\bar{\omega}_3$ for the constant velocity region, and $x_1 = x_2 = x_3$ for the constant acceleration region.

Based on this formulation of three system frequency points, a series of waveforms are synthesized to match the three regions on the spectrum. At each region, both the values of N and α are varied. The response spectrum generated by the synthesized waveform is then compared with the required spectrum, and the maximum deviation from the requirement in the region between frequency points $\bar{\omega}_1$ and $\bar{\omega}_2$ is established.

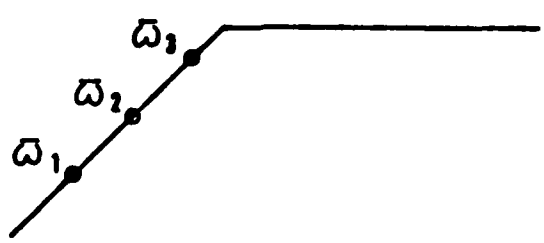

Figure 1-24. Three Selected System Frequency Match Points on a Response Spectrum

The results are summarized and plotted as in Figure 1-25 for N = 3, 5, 7, 9, 11, and 13. On each figure, the maximum deviation is shown as a function of the system frequency ratios for the constant displacement, velocity, and acceleration regions.

At N = 7 or greater, the deviation is less than 10 percent at low system frequency ratios. As the system frequency ratio increases, the deviation increases to a peak of between 40 and 50 percent and then decreases to a valley of less than 15 percent. It would seem that the optimum system frequency ratio should be selected in this valley region because it has an acceptable deviation level and also has a high system frequency ratio which means fewer frequency match points on a given spectrum. There are relatively small deviation differences between the constant displacement, velocity, and acceleration regions. Thus, one optimum system frequency ratio can be used for all three regions.

For N = 3, the iteration process does not converge at system frequency ratios of higher than 1.4 at the constant displacement region. The deviation is less than 10 percent up to $\alpha = 1.55$ for the constant velocity and acceleration region. For N = 5, the function of maximum deviation versus system frequency ratio follows the general shape as for N = 7 or greater. However, the peak occurs at a high value of α. Thus, for both N = 3 and N = 5, the optimum system frequency ratio must be selected at a relatively low value.

Table III summarizes the optimum system frequency ratios for different N values.

TABLE III

OPTIMUM SYSTEM FREQUENCY RATIOS FOR DIFFERENT N VALUES

N	3	5	7	9	11	13
$\alpha = \frac{\bar{\omega}_m}{\bar{\omega}_{m-1}}$	1.3	1.35	1.6	1.45	1.35	1.3

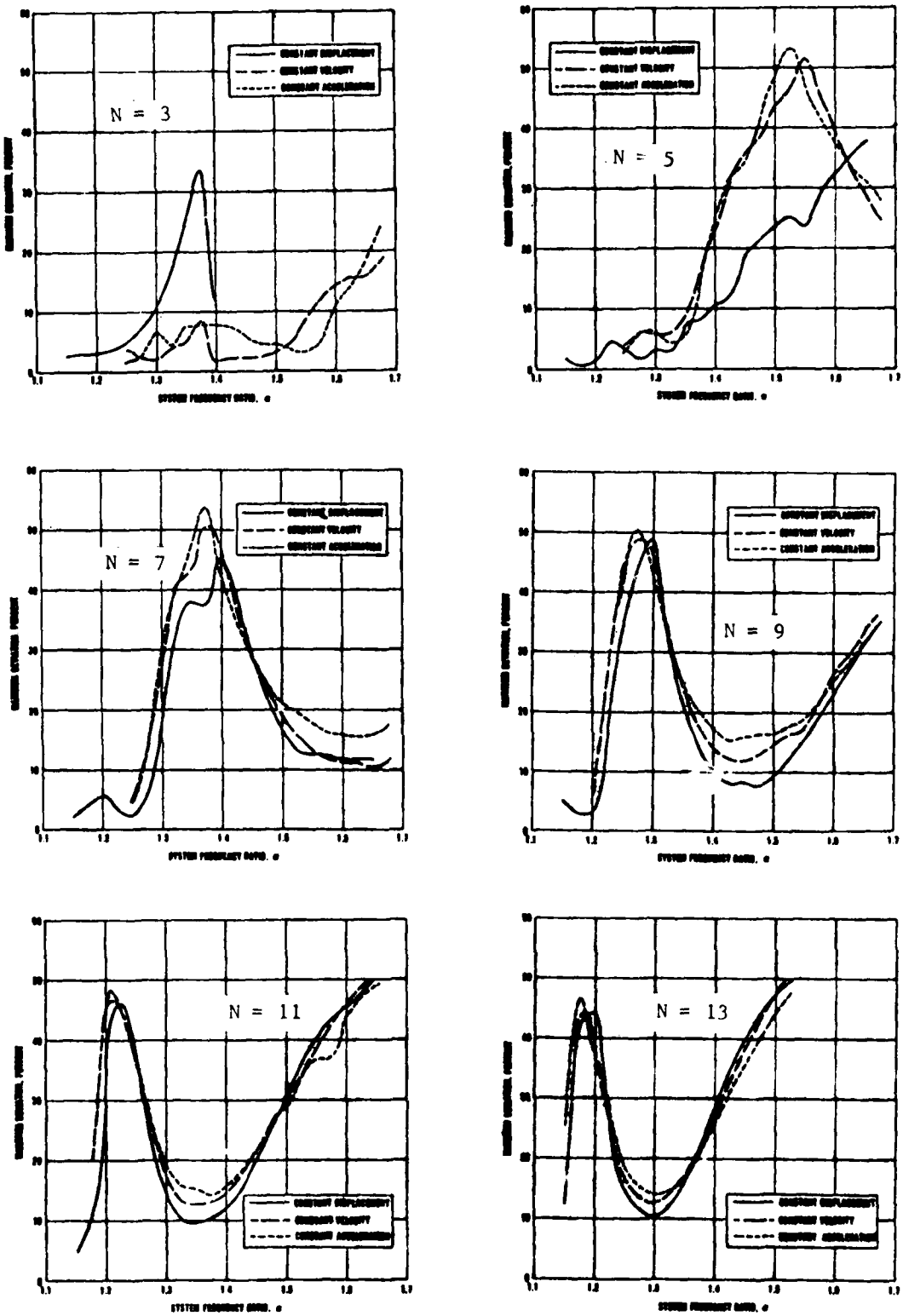

Figure 1-25. Maximum Deviation Versus System Frequency Ratio for Three System Frequency Match Points at N = 3, 5, 7, 9, 11, and 13

The above system frequency ratios are established on the basis of considering only three waveform components which have identical number of half-cycle oscillations. Even though the response contribution from more remote waveform components is small, the deviation may change to a higher value when more waveform components are involved. Furthermore, when the adjacent waveform component has a different value of half-cycle oscillations, the established system frequency ratios may also change. Thus, the optimum system frequency ratios shown in Table III can be used as a starting point to initiate a solution. Depending on the factors such as the shape of the required spectrum, the number of frequency match points, and the values of N, minor adjustments on these ratios are still required to obtain an optimum total solution.

6.2.5 PHASING OF WAVEFORM COMPONENTS.

As stated earlier, phasing of the waveform components can be represented by a given time delay of the waveform component with respect to the starting time of the total waveform. Mathematically, the waveform with the time delay can be written as

$$W(t) = \sum_{m=1}^{M} A_m f_m \tag{103}$$

$$\begin{aligned} f_m &= 0 && 0 \leq t \leq t_{dm} \\ &= \sin 2\pi\, b_m t \sin 2\pi\, N_m b_m t && t_{dm} \leq t \leq t_{dm} + T_m \\ &= 0 && t \geq t_{dm} + T_m \end{aligned} \tag{104}$$

where t_{dm} is the required time delay for the mth waveform component.

Equation 104 is identical to Equation 77 except that it is valid in a different time region. Thus, with the change of time region, the response motions shown in Equations 90 thru 93 are also valid for a waveform with time delay. In other words, the response motion of the mth waveform component is also delayed by the time t_{dm}. Since the waveform component frequency is selected to produce a resonance condition at a given system frequency, the time delay has little

effect on the response motions at the selected system frequency match points and hence, it has no effect on the convergence of the iteration solution.

The plots of the normalized response motions in reference 10 indicate that the time frame shift due to the time delay of the waveform component has a drastic effect on the systems which have frequencies between the selected frequency match points. The optimum system frequency ratios established in the last section are no longer applicable to a synthesized waveform which contains time delays in its components.

The inclusion of the time delay effect in the waveform synthesis technique is a refinement similar to the simulation of amplification ratio, where a less accurate approximation must be accepted. The main objective is still to match a given spectrum as closely as possible. However, instead of accepting any arbitrary time delay, for any waveform component at any number of half-cycle oscillations, some type of constraint must be established. The spectrum generated by the synthesized waveform with time delay will then match the given spectrum within a reasonable tolerance at all locations. The following paragraphs explain a systematic approach to establish the constraints.

Again select three system frequency points, $\bar{\omega}_1$, $\bar{\omega}_2$, and $\bar{\omega}_3$ on a spectrum and the corresponding waveform component frequencies are b_1, b_2, and b_3 for a given N. If the time delays of the second and third waveform components are t_d2 and t_d3, then the relative time delay between the first and second waveform components is $t_d2 - 0 = t_d21$ and $t_d3 - t_d2 = t_d32$ between the second and third waveform components. The definition of relative time delay is clarified in Figure 1-26.

If the relative time delay between two waveform components is longer than the duration of the first waveform component, the response of the system between the selected frequency match points is limited to the contribution from the after shock effect of the first waveform component, and it is doubtful if a good match of the spectrum at that system frequency location can be achieved. Thus, the first constraint is to use a relative time delay not longer than the duration of the waveform component, or the waveform components must be overlapped in time.

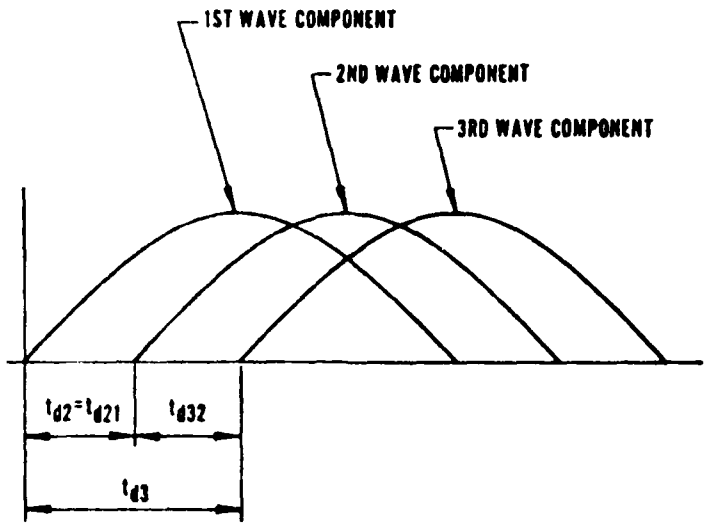

Figure 1-26. **Time Delay and Relative Time Delay of the Waveform Component**

From the b_m and N_m of a given waveform component, the duration of each half-cycle oscillation is $1/(2b_m N_m)$. The relative time delay $t_{d(m+1)m}$ can then be related to this duration by a ratio $D_r = t_{d(m+1)m} \cdot (2b_m N_m)$. For example, a waveform component has N = 5 and b = 1 Hz. The duration of each half-cycle oscillation is 1/(2)(1)(5) = 0.1 seconds. If the relative time delay between this waveform component and the next waveform component of higher frequency is 0.25 seconds, the time delay ratio is D_r = 0.25/0.1 = 2.5. To satisfy the first constraint, D_r must not be more than 5 for N = 5.

Using the optimum system frequency ratios established in the last section for a waveform with no time delay as a guide, the response deviation from the requirement is established as a function of different values of time delay ratio D_r for a synthesized waveform which contains three components.

The results are plotted in Figure 1-27 for N = 3, 5, 7, 9, 11, and 13. As indicated by the figure, the time delay has a drastic effect on the peak response motion. In general, the function of maximum deviation versus time delay ratio follows an oscillatory pattern. It varies from a maximum of over 50 percent to a minimum of less than 10 percent. From these results, a set of acceptable time delay ratio ranges can be established for a given value of N, such that the deviation from the required spectrum is minimized. Finally, the range of acceptable time delay for the waveform components can be calculated from the acceptable time delay ratios. Table IV shows a summary of the range of acceptable time delay ratios for N = 3, 5, 7, 9, 11, and 13. If the required phasing

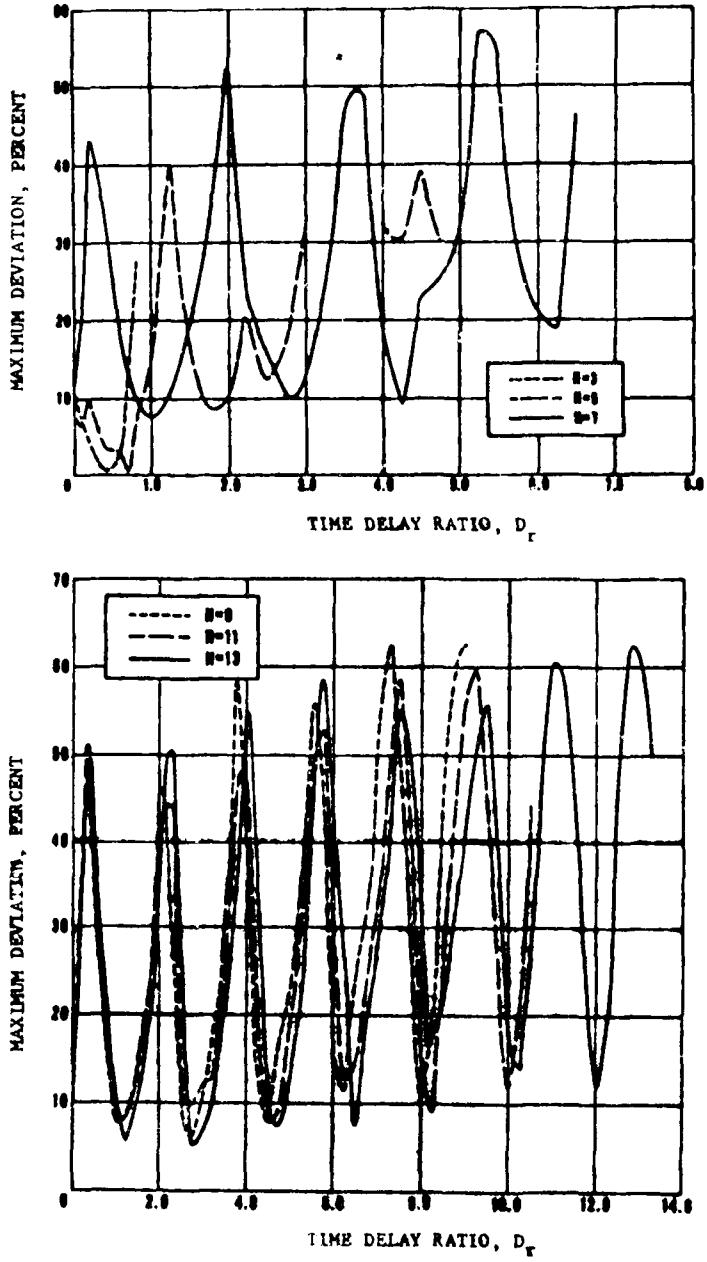

Figure 1-27. Maximum Deviation Versus Time Delay Ratio Calculated at Optimum System Frequency Ratio for N = 3, 5, 7, 9, 11, and 13

or time delay is not in the acceptable range, a compromise must be made to adjust the time delay, so this constraint can be met.

The acceptable time delay ratios shown in Table IV are developed for three system frequencies spaced according to the optimum system frequency ratios shown in Table III. There are many other possible combinations of time delay ratios and system frequency ratios which are also acceptable. Therefore, the constraint on the acceptable range of time delay ratios is directed towards one possible combination used in this study to facilitate the application of waveform synthesis technique. Under special circumstances both the established system frequency ratios and the time delay ratios may be altered to improve the accuracy of the overall response results.

TABLE IV

RANGE OF ACCEPTABLE TIME DELAY RATIOS FOR DIFFERENT N VALUES

N	3	5	7	9	11	13
Time Delay Ratio Range	0 0.15-0.45	0-0.15 0.5-0.6 1.7-2.0	0 0.8-1.2 2.7-3.0 4.15-4.3	0 0.9-1.3 2.5-3.0 4.4-4.6 6.2-6.3 7.95-8.1	0 0.9-1.3 2.5-3.0 4.5-4.8 6.25 8.1-8.3 10.0	0 1.0-1.45 2.7-3.2 4.5-4.9 6.4-6.6 8.25 10.25

6.2.6 CONCLUSIONS.

The two major objectives of the waveform systhesis modification were to include phasing of the waveform components in the program and to establish rules for the proper selection of the system frequency match points. These objectives have been successfully achieved.

The use of time delay function to represent phasing of the waveform components simplifies the modification of the WAVSYN program. However, because of the response characteristics of the selected waveform, constraints are required to limit the acceptable range of time delay for a given system frequency and amplification ratio in order to ensure that an accurate match of the spectrum at the intermediate frequency points can be made. Although this restriction is not desirable, it does not detract significantly from the usefulness of the phasing feature. In most practical situations, exact information on the phasing of the frequency components is not available. Further, the approximate simulation permits variations in phasing to be made, thus providing a means for the systematic evaluation of system responses to phasing.

Early in this study, a closed-form, analytical approach was attempted and failed to establish mathematical rules for the proper selection of the system frequency match points. A reasonable alternative was to employ the semi-empirical method described in this report. The rules shown in Sections 6.2.3, 6.2.4, and 6.2.5 were established on the basis of different combinations of system frequencies, amplification ratios, and time delays. As there are an infinite number of such combinations, the recommended rules do not ensure optimum results for all the possible situations. It is expected, however, that by applying these rules, an accuracy of at least 15 percent can be achieved in matching the required spectrum.

Addition of an automatic method in the new program minimizes the trial and error process required in synthesizing a waveform. In some cases, the manual method is useful to suppress the constraints built into the program and to allow fine adjustments on system frequency ratios and time delays. As shown in the sample problems, the results obtained from the automatic method can usually be improved, if necessary, by manually adjusting the parameters.

The waveform synthesis technique as described in Reference 21 and expanded in this study constitutes a new development in supplementing the response spectrum as a definition of shock environment. There are many other possible

applications of this technique, and the developed approach must be considered as a beginning rather than an end in solving this type of problem. Further research should be made on the program to improve its accuracy, to eliminate the limitations on amplification ratio and time delay, and to extend its application to other areas.

Based on the theories and results developed in this section, the original version of WAVSYN program has been modified to include phasing of the waveform components. The program has been reorganized extensively such that accurate results can be systematically obtained with minimum trial and error effort. The size of the program is also increased from a maximum of 15 to 25 system frequency points on the spectrum. Based on the half-cycle oscillations at the selected sytem frequency points, the time delays are forced to equal one of the values listed in Table V. Minimum accuracy tolerance is usually set at 15 percent. The modified version of the program is titled NWVSYN.

TABLE V

ACCEPTABLE TIME DELAY RATIOS FOR DIFFERENT NUMBER OF HALF-CYCLE OSCILLATIONS

N	3	5	7	9	11	13
Acceptable Time Delay Ratios D_R	0 0.2 0.4	0 0.1 0.55 1.75	0 1.0 2.75 4.25	0 1.0 2.75 4.50 6.25 8.00	0 1.0 2.75 4.50 6.25 8.25 10.00	0 1.25 2.75 4.75 6.50 8.25 10.25

Part II and Part IV include two additional computer programs, FOURIE and FILTER, for the computation of the amplification ratio spectrum from an actual time-acceleration history record. FOURIE transforms the time history into its frequency domain, and FILTER computes the steady-state response at the predominant component frequencies. The amplification ratio spectrum is the ratios of the response spectrum of the actual time-acceleration history (obtained from the SPCTRM) to the filtered response, at their corresponding component frequencies. Each computed amplification ratio in the amplification ratio spectrum must be multiplied by a modification factor if the input motion time history is not long enough to allow sufficient oscillation. Figure 1-28 compares the input sinusoidal motion to the filtered response motion. For example, if the duration of an actual time motion is 4.75 seconds, and assuming a low frequency component occurs at 0.4Hz, the maximum possible number of cycles is therefore 1.9. Using Figure 1-28, the filtered maximum response is 59% of the steady-state response for the input motion of 1.9 cycles. Therefore the modification factor to the calculated amplification ratio is about 0.6 at the frequency component of 0.4Hz.

The actual amplification ratio spectrum input to WAVSYN/NWVSYN can be derived from an envelope of several amplification ratio spectra obtained at points around the location where the synthesized waveform is going to be applied. The envelope, therefore, represents a severe environment for the hardware to be analyzed.

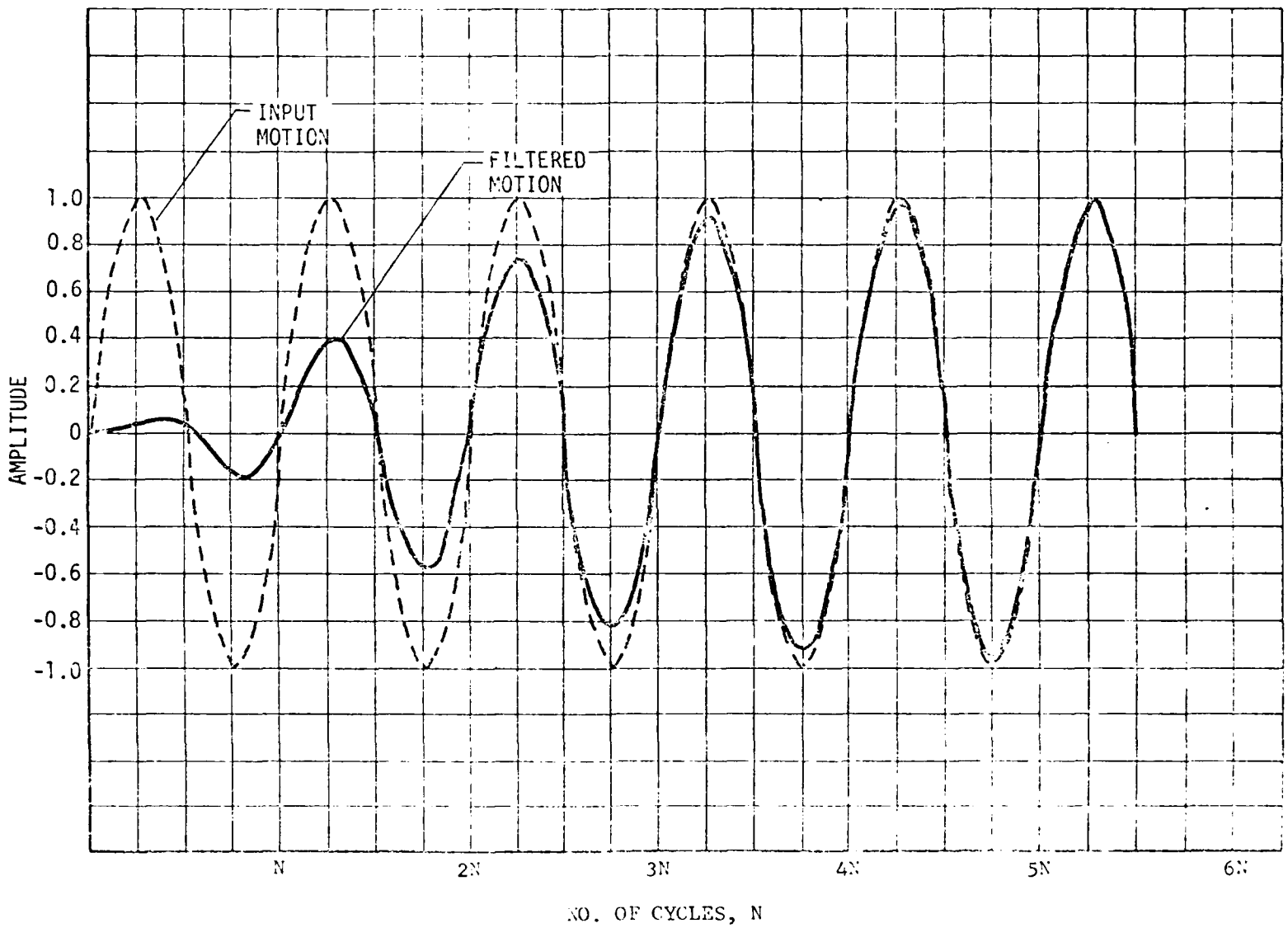

Figure 1-28 Comparison of the Input Sinusoidal Motion to the Filtered Response Motion

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PART II

USER'S INSTRUCTIONS FOR COMPUTER PROGRAMS

USER'S INSTRUCTIONS

1.0 INTRODUCTION

Thirteen computer programs were developed to analyze the shock response of a shock-isolated platform. A majority of these programs were developed by the Ralph M. Parsons Company, Los Angeles, California, 1969-70, based on the analytical approach discussed in Part I. Numerous modifications, additions, and plotting packages were incorporated into these programs by the Engineering Analysis department of the Sperry Rand Corporation, Space Support Division, Huntsville, Alabama. Many of these modifications and additions were motivated by the need of improved program efficiency, reduction of required computer core capacity, and the need to integrate all the shock analysis programs. Physically, these thirteen computer programs are integrated into two computer packages, ISIP (Integrated Shock Isolation Program) and ISIP2. A few of these thirteen programs may require new input parameters to increase programs' efficiancy or flexibility. However, the original input format to any of these programs has been carefully preserved such that an input deck to any of the previous Parsons' version can be executed without difficulty in these integrated versions.

ISØLIN is the first program of the ISIP series. Engineering data of the platform, dimensions, configurations, weights, platform design resonant frequency, and the design critical damping ratio, are used to compute the spring/damper constants for a level platform. WAVSYN and NWVSYN generate the acceleration-time forcing function from a given shock spectrum. NWVSYN is an extensively revised version of WAVSYN with two added features: (1) time-delay feature allows the phasing of the wave components that make up the synthesized waveform; and (2) an automatic feature, for data-adjusting, allows repeated iterations for the waveform synthesis process until the synthesized spectrum meets closely the given input spectrum specification. WAVSYN is currently deleted and only NWVSYN is included in ISIP.

SYNSØL was developed by Sperry Rand to synchronize the output of WAVSYN/NWVSYN to the ISØL input requirement. The process includes data-points limitation, data-table arrangement, conversion of units, and conversion of input-output formats.

ISØL computes the shock response of a rigid platform due to foundation motions. The main input to ISØL comes from the computed results of ISØLIN and SYNSØL. The time-dependent responses of the platform's C.G., and as many as four other points on the platform, are computed and tabulated in an ISØL run.

These time-dependent variables can be plotted by exercising the YUPLØT subroutine in the PLTSUB program. Any of the time-acceleration variables can be analyzed and the corresponding shock spectra plotted by the SPCTRM program. The PLTSUB program handles most of the time-dependent and spectrum plots from ISØL, as well as from WAVSYN/NWVSYN, SYNSØL, and SPCTRM. The PLTSUB program, developed by Sperry Rand, provides the necessary software for plotting on the user's SC4020 scope camera plotter, Calcomp pen plotter, or on-line printer.

ISIP was developed by Sperry Rand to make shock analysis of a rigid platform a continuous process, with minimum input repetition. Computer programs, ISØLIN, SYNSØL, etc., and two additional programs, FILTER and FØURIE, were incorporated into ISIP as subprograms. An overlay programming technique was used to eliminate huge computer core requirements. The intermediate results from these subprograms are automatically stored and retrieved when needed, without intermediate card-punches, as required in the use of individual subprograms. ISIP has been successfully run on an UNIVAC-1108 computer system with a word-core space of 32,000 (decimal), and on a CDC-6400 computer system with 76,000 (octal) words. Six logical units (3, 11, 12, 13, 14, and 15) are needed for an ISIP overlay run.

To assist the user of WAVSYN and NWVSYN in evaluation of amplification ratios for the single-degree-of-freedom approach to the waveform synthesis technique, two preliminary computer programs, FILTER and FØURIE, were developed. FØURIE computes the major frequency components of a time-motion function, to be used as the midband frequencies in the FILTER program. FILTER computes the filtered responses of the function at the selected midband frequencies. The amplification ratio input to WAVSYN/NWVSYN can be determined from the ratio of the response spectrum levels versus the filtered responses at the corresponding frequencies. FILTER and FØURIE, however, are not included in the process of a complete platform shock analysis since they serve only as precursors for the WAVSYN/NWVSYN programs.

ISIP2 program, not as sophisticated as the ISIP and its subprograms, was developed to solve the shock response of a non-rigid platform based on the finite element technique and modal analysis. ISIP2, also an overlay computer program, contains two subprograms: (1) PLTFRM, developed by Sperry Rand, generates the flexibility matrix of a non-rigid platform; and (2) FVØUS, developed by R.M. Parsons Company, computes the shock response by the modal analysis technique.

Part III presents the complete listings of the ISIP (and its nine subprograms) and ISIP2 (and its two subprograms). A user can execute, through ISIP, any or all of the subprograms with an option to skip or terminate the computation process at the end of any subprogram. Similarly, a user can execute any or all of the ISIP2 programs. The following sections describe, in greater detail, the input preparation, program features, and program limits of each computer program.

In Part I, an approximation based on engineering judgement was recommended to determine platform rigidity. The platform can be considered rigid if the lowest natural frequency of the platform, in a free-free boundary condition, is roughly five times the resonant frequency of the platform system. The ISOL program is valid only when this rigidity criteria is guaranteed. ISIP2, of course, computes the resonant frequencies of a general platform, and computes the shock response of a linear shock isolation system.

ISIP has been permanently cataloged (1 year period) in the SAFEGUARD's CDC-6400 computer system in Huntsville, Alabama, under program title P8500AD. An ISIP production run setup is as follows:

```
P8500,CM77000.                          CHAN          12
BØXC(CØE,ISIP)
ATTACH(ØLDPL,P8500,PW=AA,BB,ID=CE1CHAN)
UPDATE(Q)
FTN(I=CØMPILE)
LGØ.
@
*IDENT ISIP11
*CØMPILE ISIP10
@
(INPUT DATA DECK)
#
```

Where @ is a 7-8-9 multiple punch, and # is 6-7-8-9 multiple punch. All cards begin at column 1.

ISIP2 is also cataloged under the same program title P8500AD. The above IDENT CØMPILE cards should changed to *IDENT ISIP21 and *CØMPILE ISIP20 respectively for the execution of the ISIP2 computer program.

2.0 PROGRAM TERMINOLOGY

The program names presented in this manual conform to the FORTRAN name specification. Each name consists of six alphanumeric characters, or less, with the first being an alphabetic character. However, all the program names do have meanings and the understanding of these name derivatives may help future communication among the users of this manual.

PROGRAM	FUNCTION
ISØLIN	ISØL INput
WAVSYN	WAVeform SYNthesis (Deleted)
NWVSYN	New WaVSYN
SYNSØL	A program between wavSYN and ISØL
PLTSUB	PLoT SUBroutine
SPCTRM	SPeCTRuM analysis
FILTER	FILTER process
FØURIE	FOURIEr spectrum analysis
ISIP	Integrated Shock Isolation Program
ISIP2	2nd program of ISIP
PLTFRM	PLaTFoRM
FVØUS	Free Vibration Of Unrestrained Structures

3.0 USER'S MANUAL FOR ISØLIN PROGRAM

Program Features. The ISØLIN program, developed to relieve the design engineer from tedious work in input data preparation for the ISØL computer program, has the following main features:

a. Units in inch (in.), second (sec.) pound (lb.) and Hertz (hz).
b. Spring/damper constants are computed for the static equilibrium condition of a level platform.
c. Selection of four points of interest on the platform.
d. Computation of a single equivalent weight, its C.G., mass moment of inertia, and isolator centroid.
e. Computation of shifted C.G. location and mass moment at inertia where arbitrary shifting of equipment weight (further away from system isolator centroid) is desired.
f. Estimation of system frequencies.
g. Multiple problems can be solved with one run setup.

Program Limits.

Maximum number of masses	50
Maximum number of isolators (spring/damper)	50

The limits can be expanded by changing the program dimensions as long as they do not exceed the capacity of the computer core. A platform with three isolators is not eligible. Vertical isoltors only are evaluated in ISØLIN.

Platform Design Considerations. A few design considerations, from an engineer's view, must be recognized for practical reasons and for convenience.

a. A right-handed Cartesian coordinate system is used. For convenience, align the X-axis along the bottom surface of the platform, from left to right. Z-axis is in the vertical direction (up), and Y-axis perpendicular to the X-Z plane.
b. Some of the computed resonant frequencies may not exist in the real situation, such as the uncoupled modes in a complicated structural system. Some of these frequencies have been replaced by zeros in certain configurations, such as the pendulum frequencies in an under-floor mount shock isolation system. However, these frequencies are computed in ISØLIN for design consideration purposes.

c. Simple first approximation equations are used in the solution of resonant frequencies of a platform system. For example, a compound pendulum frequency equation is used in the ISØLIN program for the pendulum type isolation system using the first isolation length, L, as the pendulum height. The frequency equation is as follows:

$$f_n = \frac{1}{2\pi} (LW/I_o)^{1/2}$$

where W = total weight of pendulum

I_o = moment of inertia about axis of support

Conversely, the frequency based on a simple pendulum,

$$f_n = \frac{1}{2\pi} \sqrt{g/L}$$

could give a more realistic value in certain configurations.

d. Estimations of the mass moments of inertia of the equipment and platform weights are as follows:

mass moment of inertia = $W(A^2 + B^2)/12g$

For the moment about XX axis, A = Depth, B= Weight

For the moment about YY axis, A = Width, B = Height

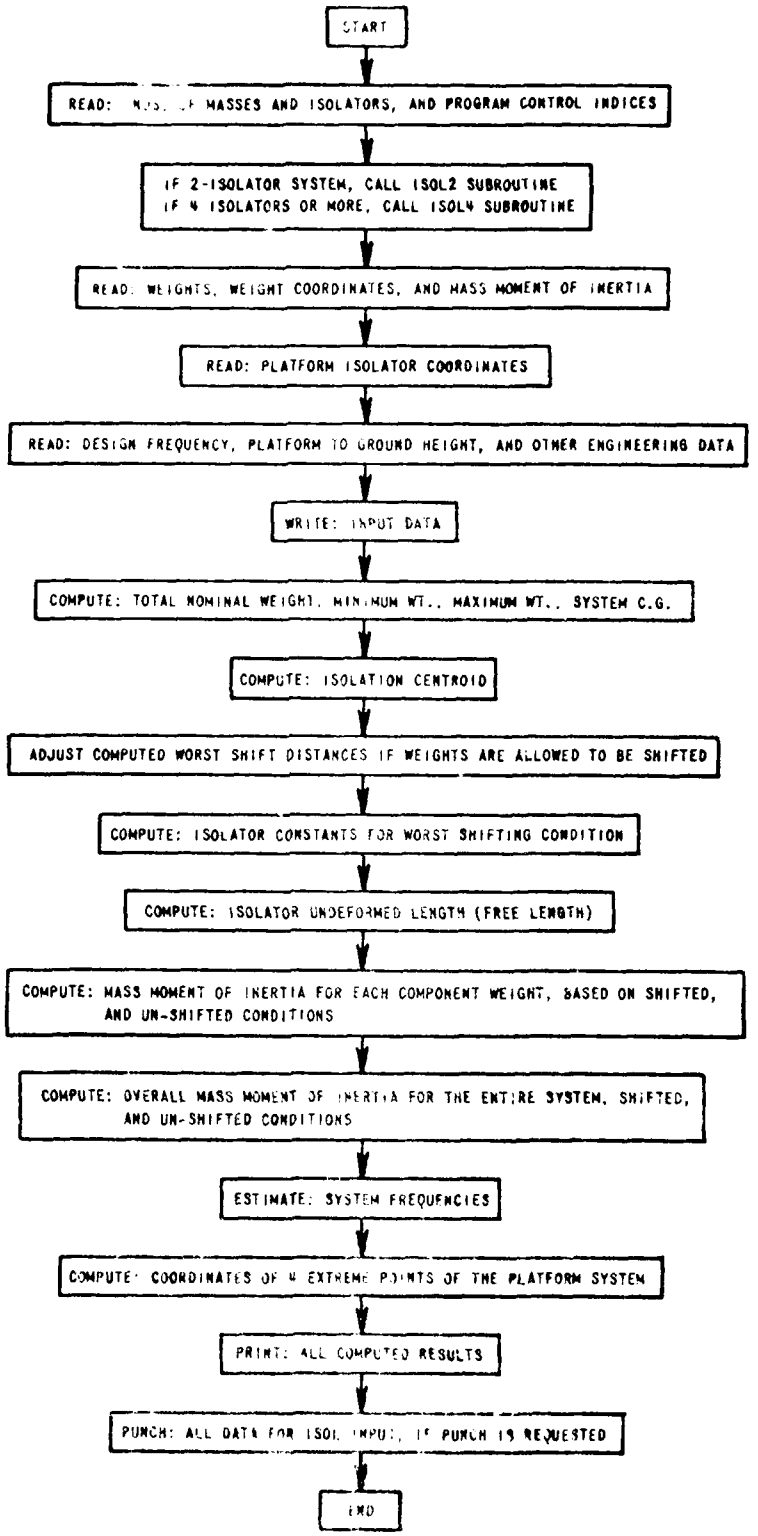
For the moment about ZZ axis, A = Width, B = Depth

g = 386.4

Since the mass moment of inertia equation is for a solid rectangular weight, the effective depth, width, and height should be used for most equipment mounted on the platform. Errors in these dimensions may result in huge moments of inertia, and therefore erratic frequency computations and an erratic end result.

e. To minimize possible error; in estimations of the mass moments of inertia, and to provide easy input preparation, a user may input the nominal dimensions of the equipment (not the platform) and use the NØ4 parameter in input group 3 for obtaining the effective depth, width, and height for the mass moment of inertia computation.

Figure 2-1 gives the flow chart of the ISØLIN computer program.


START
READ: NO. OF MASSES AND ISOLATORS, AND PROGRAM CONTROL INDICES
IF 2-ISOLATOR SYSTEM, CALL ISOL2 SUBROUTINE
IF 4 ISOLATORS OR MORE, CALL ISOL4 SUBROUTINE
READ: WEIGHTS, WEIGHT COORDINATES, AND MASS MOMENT OF INERTIA
READ: PLATFORM ISOLATOR COORDINATES
READ: DESIGN FREQUENCY, PLATFORM TO GROUND HEIGHT, AND OTHER ENGINEERING DATA
WRITE: INPUT DATA
COMPUTE: TOTAL NOMINAL WEIGHT, MINIMUM WT., MAXIMUM WT., SYSTEM C.G.
COMPUTE: ISOLATION CENTROID
ADJUST COMPUTED WORST SHIFT DISTANCES IF WEIGHTS ARE ALLOWED TO BE SHIFTED
COMPUTE: ISOLATOR CONSTANTS FOR WORST SHIFTING CONDITION
COMPUTE: ISOLATOR UNDEFORMED LENGTH (FREE LENGTH)
COMPUTE: MASS MOMENT OF INERTIA FOR EACH COMPONENT WEIGHT, BASED ON SHIFTED, AND UN-SHIFTED CONDITIONS
COMPUTE: OVERALL MASS MOMENT OF INERTIA FOR THE ENTIRE SYSTEM, SHIFTED, AND UN-SHIFTED CONDITIONS
ESTIMATE: SYSTEM FREQUENCIES
COMPUTE: COORDINATES OF 4 EXTREME POINTS OF THE PLATFORM SYSTEM
PRINT: ALL COMPUTED RESULTS
PUNCH: ALL DATA FOR ISOL INPUT, IF PUNCH IS REQUESTED
END

[illegible] Program

ISØLIN Input Instructions. There are seven groups of input data as follows:

a. Project title or identification.

b. Number of masses and isolators associated with the platform.

c. Inertia data and coordinates.

d. Mass moments of inertia.

e. Isolator coordinates.

f. Engineering design parameter of the platform.

g. Blank cards signaling end of run.

A detailed explanation of each group follows:

Group 1 - Program title

Number of cards = 1.

12345678901234567890123456789012345678901234567890123456789012345678901234567890	
TITLE(I), I = 1, 12 (12A6)	BLANK

Any alpha-numeric data can be inputed in columns 1 through 72 on this card.

Group 2 - Control indices

Number of cards = 1.

12345678901	12345678902	12345678903	12345678904	12345678905	12345678906	12345678907	12345678908
NM (I10)	NI (I10)	NØ1 (I10)	NØ2 (I10)	NØ3 (I10)	NØ4 (I10)	BLANK	

NM - Number of weights including the platform.

NI - Number of isolators supporting platform.

NØ1 - Punch card control. No punch if NØ 1 = -1; platform properties and an equivalent total weight are punched if NØ 1 = 0; all component weights and platform properties are punched if NØ 1 = 1.

NØ2 - Isolator design control index.

NØ2 = 0 for isolator attachment position platform at same level (height) as system C.G.

= 1 for isolator and moment points on platform surface. (Top surface for pendulum configuration and bottom surface for underflow mount configuration.)

= -1 for rolling ball configuration isolators.

NØ3 - Moment of inertia input control.

NØ3 ≠ 0, moments of inertia are read in from cards.

= 0, moments of inertia are computed internally.

NØ4 - An effective width, depth, and height adjustment parameter.

NØ4 = M (integer), the width, depth, and height dimensions of group 3 input, with exception of the first weight, are adjusted automatically by $\frac{M}{100}$%.

= 100 if no input value is given.

Group 3 - Inertia data, coordinates, and dimensions (Right handed coordinate system with Z positive up)

Number of cards = NM.

1234567891	1234567892	1234567893	1234567894	1234567895	1234567896	1234567897	1234567898
W(I) (F10.2)	X(I) (F10.2)	Y(I) (F10.2)	Z(I) (F10.2)	WID(I) (F10.2)	DEP(I) (F10.2)	HI(I) (F10.2)	BLANK

W (I) - weight of point mass (lb). The first weight is always that of the platform.

X (I) - X coordinate of the weight with respect to building - fixed coordinate system (in.). (Positive X axis is parallel to the longer edge of the platform.)

Y (I) - Y coordinate of the weight with respect to building - fixed coordinate system (in.).

Z (I) - Z coordinate of the weight with respect to building - fixed coordinate system (in.).

WID (I) - Width (along X axis) of point weight (in.).

DEP (I) - Depth (along Y axis) of point weight (in.).

HI (I) - Height (along Z axis) of point weight (in.).

Group 4 - Mass moments of inertia

Number of cards = NM. If NØ3 = 0, omit this group.

1234567891	1234567892	1234567893	1234567894 1234567895 1234567896 1234567897 1234567898
XX(J) (F10.2)	YY(J) (F10.2)	ZZ(J) (F10.2)	BLANK

Where J = 1, NM

XX (J) - Mass moment of inertia of J-th weight, about XX axis (lb-sec^2-in).

YY (J) - Mass moment of inertia of J-th weight, about YY axis (lb-sec^2-in).

ZZ (J) - Mass moment of inertia of J-th weight, about ZZ axis (lb-sec^2-in).

Group 5 - Coordinates of spring/damper element attachment points

Number of cards = NI.

12345678910	12345678920	12345678930	12345678940 12345678950 12345678960 12345678970 12345678980
XI(I) (F10.2)	YI(I) (F10.2)	ALB(I) (F10.2)	BLANK

Where I = 1, NI

XI (I) - X coordinate of attachment point on platform (in.).

YI (I) - Y coordinate of attachment point on platform (in.).

ALB (I) - Ground attachment point adjustment (in.). Point is raised if ALB(I) is positive, and lowered if negative.

Group 6 - Platform engineering data (Positive X axis is parallel to the longer edge of the platform)

Number of cards = 2.

12345678910	12345678920	12345678930	12345678940	12345678950	12345678960	12345678970	12345678980
FREQ (F10.2)	DELZ (F10.2)	RATØL (F10.2)	STIFF (F10.2)	XJ (F10.2)	ZETA (F10.2)	FRICP (F10.2)	RADP (F10.2)

12345678910	12345678920	12345678930	12345678940 12345678950 12345678960 12345678970 12345678980
DGX (F10.2)	DGY (F10.2)	DGZ (F10.2)	BLANK

FREQ - Vertical design frequency of the shock-isolated platform.

DELZ - Vertical dimension from platform bottom surface to isolator pivot point on ceiling or floor, at equilibrium condition.

RATØL - Isolator spring rate tolerance, a fractional number.

STIFF - Platform's area moment of inertia about Y axis (through platform C.G.) (in^4).

XJ - Platform's torsional stiffness around X axis (in). (Same as area moment of inertia about X axis in this program.)

ZETA - Isolator damping constant, as fraction of critical damping.

DGX,DGY, DGZ - Mass C.G. location shift in the directions away from the isolator centroid (fractional numbers, eg., 0.05 for 5% shift).

RADP - Spherical plate radius in rolling ball isolator configuration (in.).

FRICP - Rolling friction coefficient, between plate and ball in rolling ball isolator.

Group 7 - Blank cards

Number of cards = 2.

Repeat groups 1 through 6 as many times as there are problems, then group 7 follows, which will signal a normal job termination.

Message of ISØLIN. A warning message is printed out if the first weight input (weight of the platform) is not the heaviest. Possible analytical error may result from misplacing the platform weight.

ISØLIN Output. The output of ISØLIN begins, for each problem, begins with the project title and is followed by the plan view and the front view of a typical platform, control indices and two tables. The first table lists the individual input weight, C.G. location, width, depth and height, and the computed mass moments of inertia. The second table lists the X and Y coordinates, the computed load value, spring rate, and the initial unstretched length (both nominal and adjusted values using manufacturer's tolerances), and the damping constant for each isolator. The last entries in this table, SIGNX and SIGNY, indicate the isolator position with respect to the C.G. location. The remainder of the output is in the following order:

- Equivalent total system weight, the maximum value (102% of platform weight +110% of total equipment weight) and the minimum value (98% of platform +90% of equipment) of this equivalent weight.
- The nine parameters (design frequency, floor/ceiling height, etc.) of group 6 input.
- The system C.G. coordinates (nominal and adjusted), the isolator centroid coordinates, and the offset of this centroid from the system C.G.

- The computed mass moments of inertia and the system frequencies.
- A list of the punch output to be used for ISØL program. This list contains:

    1. Project title (group 1 of ISØL input)
    2. System weight, C.G. location and mass moment of inertia. (group 3 of the ISØL input)
    3. Isolator coordinates (group 4 of ISØL input)
    4. Coordinates of four computed points of interest (group 7 of ISØL input)
    5. Isolator constants. (group 8 of ISØL input)

Program Initialization. To execute ISØLIN by itself, an input card with an integer 1 in column 8 is needed before group 1 input. This program initialization is described in Program ISIP.

4.0 USER'S MANUAL FOR WAVSYN PROGRAM

Program Features. WAVSYN was developed to synthesize the acceleration time history to match a given shock spectrum. The time-dependent history can be used as the forcing function in any transient response base excitation program, such as ISØL. A waveform synthesis technique of super-imposing a series of sinusoidal components with an odd number of half-cycle oscillations is employed. A good match of up to 15 points between the spectrum of the synthesized waveform and the given spectrum, within a certain number of convergent iterations, terminates the waveform synthesizing process. The time-dependent history is then printed out, and punched out on cards, if requested. The complete spectrum of the synthesized waveform is then computed, printed, and plotted. A plot of the calculated spectrum and the original spectrum input data is made using the on-line printer, thus providing an immediate diagnosis of the performance of WAVSYN. Provisions included in WAVSYN allow the user to follow the convergency process for further input deck improvement. If the maximum number of iterations is altered (other than 10), the shock spectrum of the synthesized waveform is plotted, disregarding the fact that convergence of the match points on the spectra has not been obtained with the maximum iteration limit. A sample of a shock spectrum plot, with explanations, is shown in Figure 2-4.

Program Limits. This version of WAVSYN has the following limits:

Match points on given spectrm (= number of assumed functions)	15
Unknown coefficients	15
Number of half-cycle oscillations	3 to 11
Points on time table and amplitude table	2700
Maximum number of convergent iterations	10

Program Deletion. This version of WAVSYN has been deleted in this manual. The user is urged to use NWVSYN instead.

5.0 USER'S MANUAL FOR NWVSYN PROGRAM

Program Feature. NWVSYN was developed to aid the WAVSYN user when the spectrum of the synthesized waveform differs considerably from the desired spectrum in the intermediate regions between the selected frequency points. NWVSYN offers a manual and an automatic method of waveform synthesis. A time-delay feature is also offered, in both manual and automatic methods, to allow phasing of the component waves which make up the synthesized waveform. The manual method is similar to WAVSYN except for the added time-delay feature and the removal of the assumed and trial coefficients input. The automatic method eliminates much of the initial guess work required by the user to obtain an acceptable waveform whose spectrum matches the given spectrum within a certain tolerance unit. An amplification ratio spectrum must be defined in the input preparation for the automatic method, in addition to the "regular" input data required by the manual method or the WAVSYN program. This amplification ratio spectrum will allow the program (automatic method) to shift the selected frequencies to obtain a better synthesized waveform.

Two amplification ratio spectra, based on the outrunning ground motions defined by SAFEGUARD nuclear effect studies, are programmed into NWVSYN as an option (see index NAR in group 4 input). A time delay model of 1.75 seconds for frequencies above 15 Hz is also programmed into NWVSYN as a time-delay option (see index NTD in group 4 input). Both the amplification ratio spectra and the time-delay model are shown in figure 2-2. A third option, spectrctrum tolerance limit, is also available (see index ITLC in group 4 input).
An iteration limit of 10, for convergence at the selected frequency points, is present in both the manual and the automatic methods as in the case of WAVSYN. In the automatic method, a limit of 4 frequency shifts, based on a semi-empierical approach, is allowed in order to match the computed spectrum with the given shock spectrum within the input tolerance limits. The complete synthesized waveform is computed and its spectrum plotted only when the above limits are not exceeded.

Figure 2-3 shows the flow chart of NWVSYN computer program.

Program Limits.

Maximum number of selected frequency points on the spectrum	25
Maximum number of points on time table and motion table	2,000

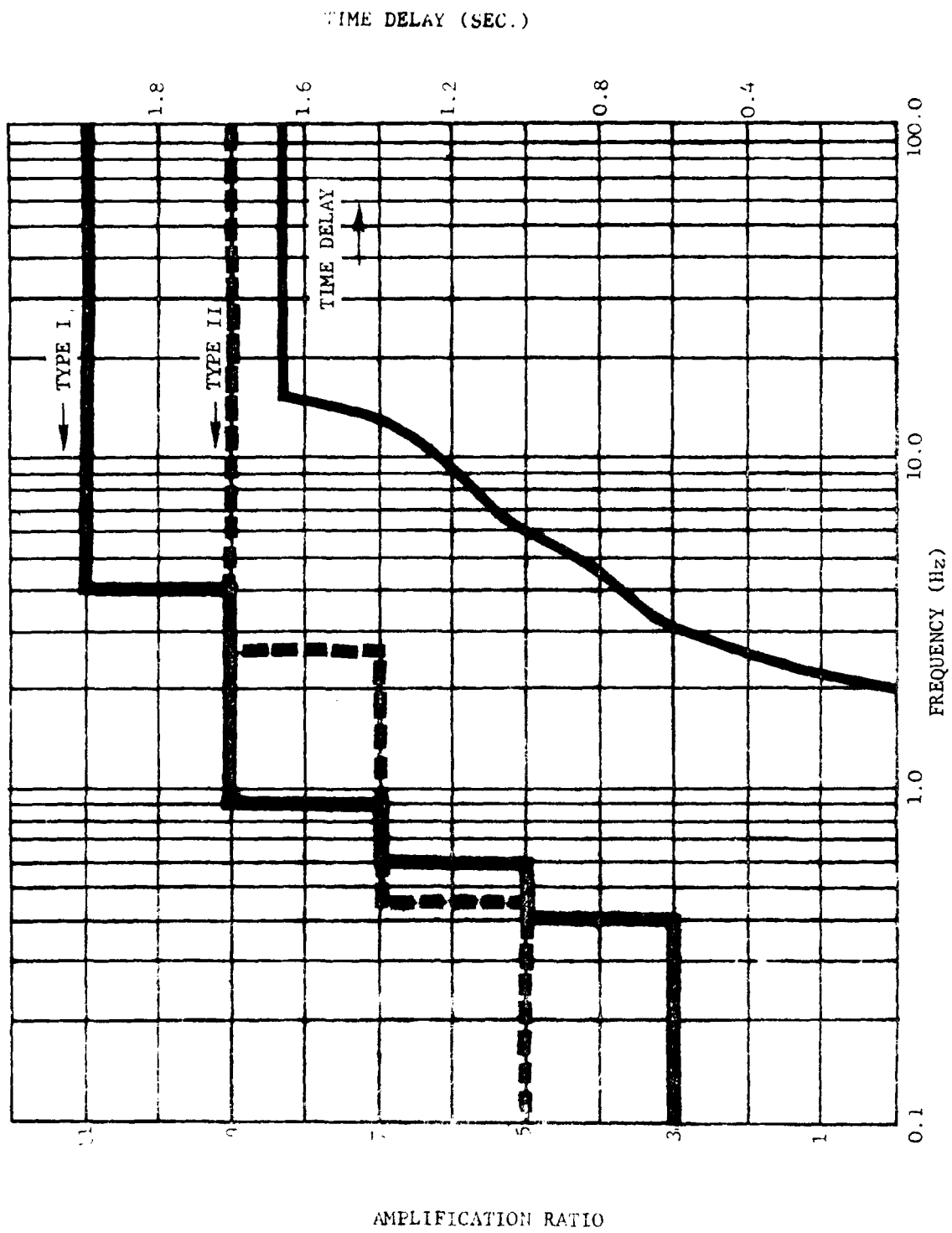


FIGURE 2-2 PROGRAMMED AMPLIFICATION RATIO SPECTRA AND TIME-DELAY

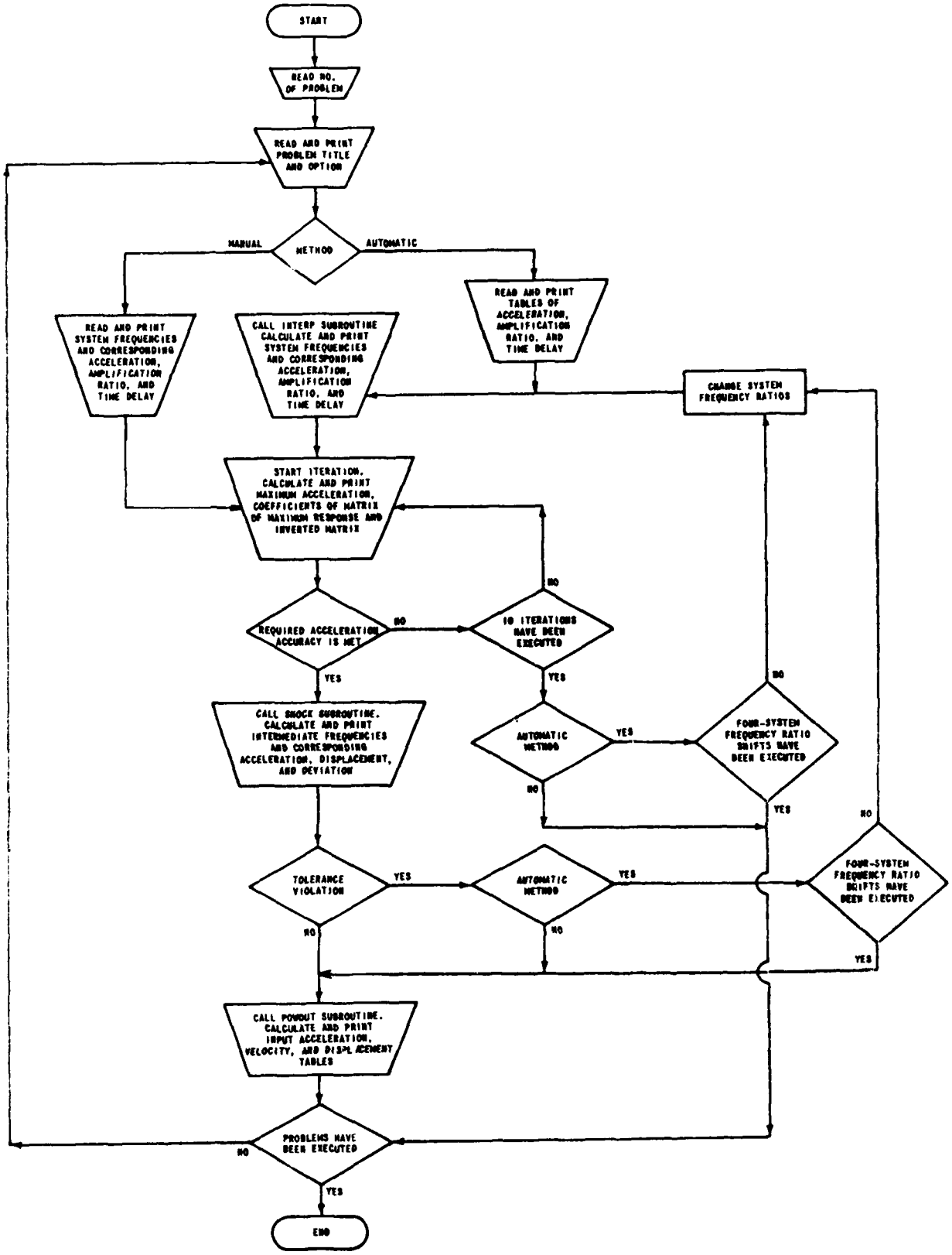


FIGURE 2-3 FLOW CHART FOR NWVSYN

Maximum data points to define a response spectrum (automatic method)	25
Maximum data points to define an amplification ratio spectrum (automatic method)	25
Maximum data points to define time delay versus system frequency function (automatic method)	25
Maximum number of half-cycle oscillations	13
Minimum number of half-cycle oscillations	3

NWVSYN Input Instructions. Input data to the NWVSYN program are divided into 16 groups. Group 1 thru group 3 are used to identify the problem and to select the program options. Group 4 thru group 11 define the input data for the automatic method. Group 12 thru group 16 are the input data for the manual method.

Group 1 - Program control

Number of cards = 1.

12345678901234567890123456789012345678901234567890123456789012345678901234567890	
ND (I5)	BLANK

ND - Number of problems for one run.

This group is used only for the first problem.

Group 2 - TITLE

Number of cards = 1.

12345678901234567890123456789012345678901234567890123456789012345678901234567890	
TITLE(K), K = 1, 12 (12A6)	BLANK

TITLE - Problem title

Group 3 - Program option

Number of cards = 1.

12345678901234567890123456789012345678901234567890123456789012345678901234567890			
KØP (I5)	NØSHFT (I5)	NØIT (I5)	BLANK

KØP - Method option control: = 2, for automatic method; = 1, for manual.

NØSHPT - No. of frequency shifting control (KØP=2 only): = 4 if not specified.

NØIT - No. of iteration control: = 10 if not specified.

Group 4 - Control indices for automatic method. (Omit this group through group 11 if KØP = 1.)

Number of cards = 1.

12345	67890	12345	67890	12345	67890	12345678901234567890123456789012345678901234567890
NS (I5)	NAR (I5)	NTD (I5)	IIP (I5)	NPLØT (I5)	ITLC (I5)	BLANK

NS - **Number of data points to define a given response spectrum.**

NAR - **Number of data points to define a given amplification ratio spectrum**, or

NAR = -1 for Type I ground motion.
NAR = -2 for Type II ground motion. } See Figure 2-2.

NTD - **Number of data points to define a given time delay versus system frequency function.**

NTD < 0 for a 1.75 sec time delay model, See Figure 2-2.

IIP - **Card punch out control:**

IIP = 0, No punch out.
= 1, Punch acceleration.
= 2, Punch velocity.
= 3, Punch displacement.
= -1, Punch acceleration, velocity and displacement.
= 4, an equivalent manual input data deck, which would produce the same final result in an automatic run, will be punched out for later use.

NPLØT - Plot control:

NPLØT = 0, No plot.
= 1, Plot acceleration.
= 2, Plot velocity.
= 3, Plot displacement.
} (For choice of plotters, SC4020, CALCOMP, or on-line printer, see input parameter IPLT of ISIP)

ITLC - **A standard tolerance limit to be used instead of group 2 input. If ITLC = 0, ITLC is automatically set to 25.**

Group 5 - Selected frequencies of the given spectrum

Number of cards = (NS + 7)/8.

1234567891	1234567892	1234567893	1234567894	1234567895	1234567896	1234567897	1234567898
		WS(I), I = 1, NS (8F10.3)					

WS - Selected system frequency points on the required response spectrum, Hz.

Group 6 - Amplitude of the given spectrum

Number of cards = (NS + 7)/8.

1234567891	1234567892	1234567893	1234567894	1234567895	1234567896	1234567897	1234567898
		XS(I), I = 1, NS (8F10.3)					

XS - Amplitude, for the required response spectrum. Positive XS denotes acceleration in g's, and negative XS denotes positive displacement in inches.

Group 7 - Frequencies of the amplification ratio spectrum. This group and next are omitted if NAR < 0

Number of cards = (NAR + 7)/8.

1234567891	1234567892	1234567893	1234567894	1234567895	1234567896	1234567897	1234567898
		WAR(I), I = 1, NAR (8F10.3)					

WAR - Frequency, for the required amplification ratio spectrum, Hz.

Group 8 - Amplitude of the amplification ratio spectrum

Number of cards = (NAR + 7)/8.

1234567891	1234567892	1234567893	1234567894	1234567895	1234567896	1234567897	[illegible]
		AR(I), I = 1, NAR (8F10.3)					

AR - Amplification ratio for the required amplification [illegible]

AD-A094 299 ARMY ENGINEER DIV HUNTSVILLE AL F/G 14/2
SHOCK TEST PROGRAM. SHOCK ISOLATION DESIGN MANUAL FOR SAFEGUARD--ETC(U)
AUG 73 G C CHAN, R YANG, H SAFFELL, C C HUANG
UNCLASSIFIED HNDSP-73-98-ED-R NL

3 OF 7
AD
A094299

Group 9 - Frequencies of the time-delay function. This group and next are omitted if NTD ≤ 0.

Number of cards = (NTD + 7)/8.

1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
		WTD(I), I = 1, NTD (8F10.3)					

WTD - Frequency data, for the time-delay versus system frequency function, Hz.

Group 10 - Time delay

Number of cards = (NTD + 7)/8.

1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
		TD(I), I = 1, NTD (8F10.3)					

TD - Time dela, for the time-delay versus system-frequency function, sec.

Group 11 - Allowable tolerance. This group is omitted if NAR < 0.

Number of cards = (NS + 6)/8.

1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
		TLC(I), I = 1, NS-1 (8F10.3)					

TLC - Response tolerance at regions between selected frequencies, percent. All TLC(I) are set equal to ITLC of group 4 if NAR < 0.

Group 12 - Control indices for manual method (Omit this group thru group 16 if KØP=2)

Number of cards = 1.

1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
M (I5)	IIP (I5)	NPLØT (I5)	BLANK				

M - Number of selected frequency points on the given response spectrum.

IIP - See group 4.

NPLØT - See group 4.

Group 13 - Selected frequencies of a given spectrum

Number of cards = (M + 7)/8.

12345678910	12345678920	12345678930	12345678940	12345678950	12345678960	12345678970	12345678980
		W(I), I = 1, M (8F10.3)					

W - Selected system frequency points on the given response spectrum, Hz.

Group 14 - Number of half-cycle oscillations

Number of cards = (M + 7)/8.

12345678910	12345678920	12345678930	12345678940	12345678950	12345678960	12345678970	12345678980
		YCLE(I), I = 1, M (8F10.3)					

YCLE - Number of half-cycle oscillations corresponding to the selected system frequency points.

Group 15 - Amplitude of the given spectrum

Number of cards = (M + 7)/8.

12345678910	12345678920	12345678930	12345678940	12345678950	12345678960	12345678970	12345678980
		X(I), I = 1, M (8F10.3)					

X - Amplitude corresponding to the selected system frequency points. Positive X denotes acceleration in g's, and negative X denotes positive displacement in inches.

Group 16 - Time delay

Number of cards = (M + 7)/8.

12345678910	12345678920	12345678930	12345678940	12345678950	12345678960	12345678970	12345678980
		DELAY(I), I = 1, M (8F10.3)					

DELAY - Time delays corresponding to the selected system frequency points, sec.

NWVSYN Program Output Data Format. Output data of the NWVSYN program can be divided into three basic groups. In the manual method, the first basic group consists of a printout of the input data including the number of system frequency points selected on the response spectrum, the selected frequency points and the corresponding amplitudes, time delays, and the number of half-cycle oscillations. For each selected system frequency point, the frequency and time duration of the synthesized waveform component and the time duration used in establishing the time table are also shown.

Since different input data are required in the automatic method, the information first shown consists of data defining the required response spectrum, amplification ratio spectrum, time-delay versus system-frequency point function, and response tolerance. Then, data similar to the first basic group in the manual method are generated by the program and printed.

The second basic group consists of data generated at the end of the iteration process and includes the response spectrum of the synthesized waveform in terms of either maximum displacement or maximum acceleration response at the selected system frequency points, and the intermediate frequency points. Results of comparison of the response spectrum generated by the synthesized waveform and the required response spectrum are shown as a percentage of maximum deviation at various frequency points. In the automatic method, the first basic group thru the third basic group are repeated for each shift of the system frequency point ratio.

The third group of output data is generated only at the end of a successful run. In this group, time-motion histories of the synthesized waveform are presented in terms of acceleration, velocity, and displacement. The spectrum of the synthesized waveform is plotted on a line-printer. Various combinations of time-motion histories can be plotted and/or punched on cards as controlled by the index IIP and NPLØT. Formats for the variables punched on cards are as follows:

Time (Sec)	9E8.2
Acceleration (g)	9E8.2
Time (Sec)	7F10.4
Velocity (in./sec)	7F10.4
Time (Sec)	7F10.4
Displacement (in.)	7F10.4

A sample of a shock spectrum plot, with explanation, is shown in Figure 2-4.

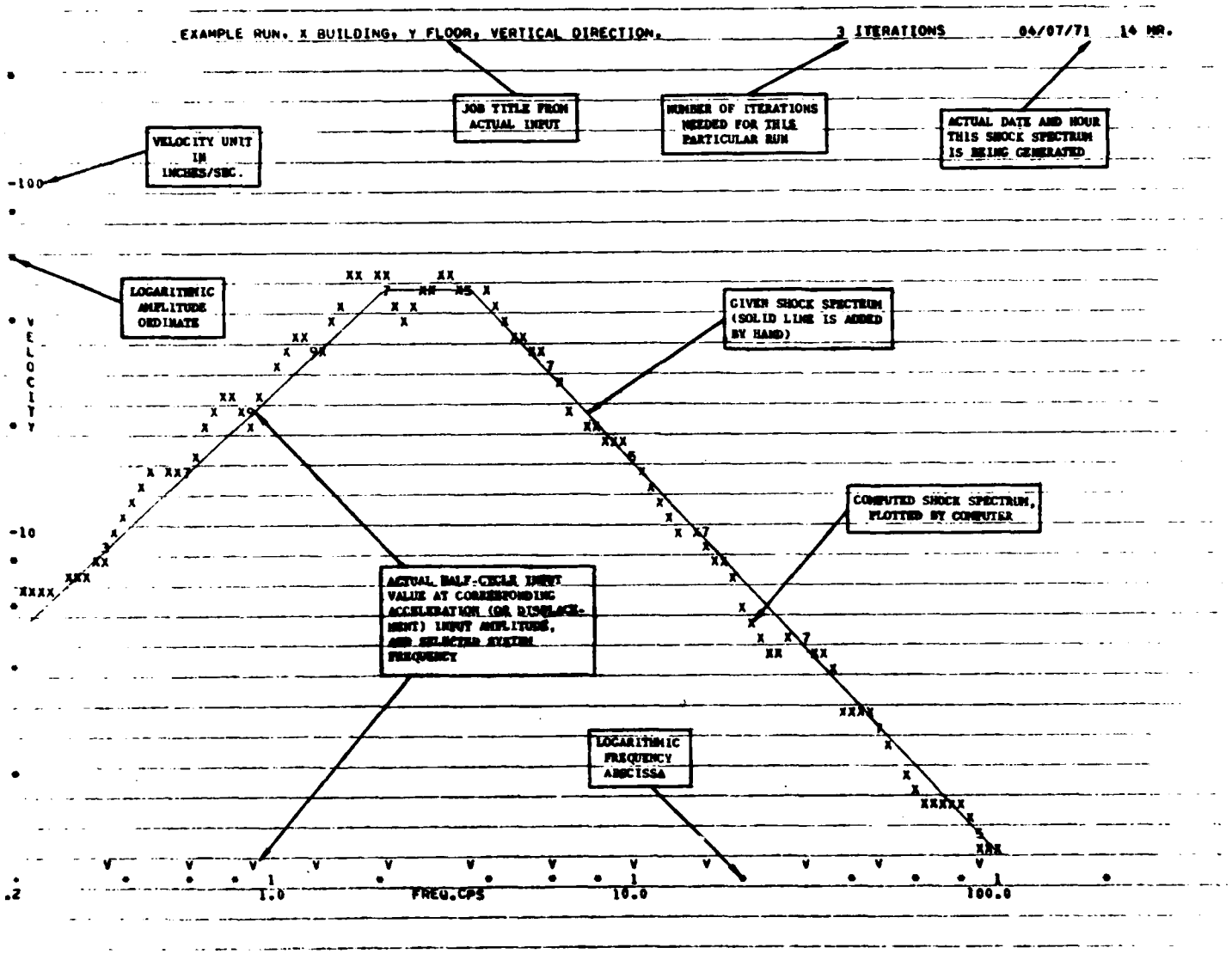


FIGURE 2-4. A TYPICAL WAVSYN SPECTRUM, PLOTTED BY AN ON-LINE PRINTER

Program Initialization: To execute NWVSYN by itself, an input card with an integer 2 in column 8 is needed before group 1 input. If an integer 9 is punched instead of 2, program SYNSØL will be executed automatically after the completion of a NWVSYN run. This program option initialization is described in Program ISIP. If option 10 is punched (columns 7 and 8), the output of a NWVSYN-SYNSØL run will be printed and/or punched according to NASTRAN input format specification. (NASTRAN is a general finite element structural analysis computer program developed by the National Aeronautics and Space Administration, NASA).

The input deck for a NWVSYN under options 9 or 10, is limited to one horizontal and one vertical spectra. The output will consists of three time-histories about X, Y and Z axis, where X and Y are horizontal, and Z is the vertical case. All three are synchronized to one common time base.

6.0 USER'S MANUAL FOR SYNSØL PROGRAM

Program Feature. This program was developed as an interfacing program to be used between WAVSYN/NWVSYN and ISØL. The acceleration-time histories of the synthesized waveforms from WAVSYN/NWVSYN are synchronized to a common time base, and the output tables are reduced, if necessary, to 500 data points each as required by ISØL program. The dimensions of the modified waveforms are also made compatible with ISØL. The flexibility of this program makes it suitable for general data manipulation. The program has the following main features:

a. Synchronization of tables (of two variables) to a common independent variable base.

b. Reduction of the tables to a specified number of data points.

c. Output unit conversion.

d. Duplication of any table upon request.

e. Flexible punch format to insure significant digits are punched in cards.

f. A high order polynomial curve fitting method is used in data interpolation.

g. Output table can be arbitrarily multiplied by a constant factor.

h. Output tables are labeled and numbered for easy identification.

Figure 2-5 shows the flow chart of SYNSØL computer program.

Program Limits

Output table length	1990 data points or less
First input table length	1990 if time duration of first set is longest
Other input table lengths	2000 data points
Number of input tables	4 sets

The limits can be easily changed to a larger or small number by changing the program dimensions, as long as they do not exceed the capacity of the computer core.

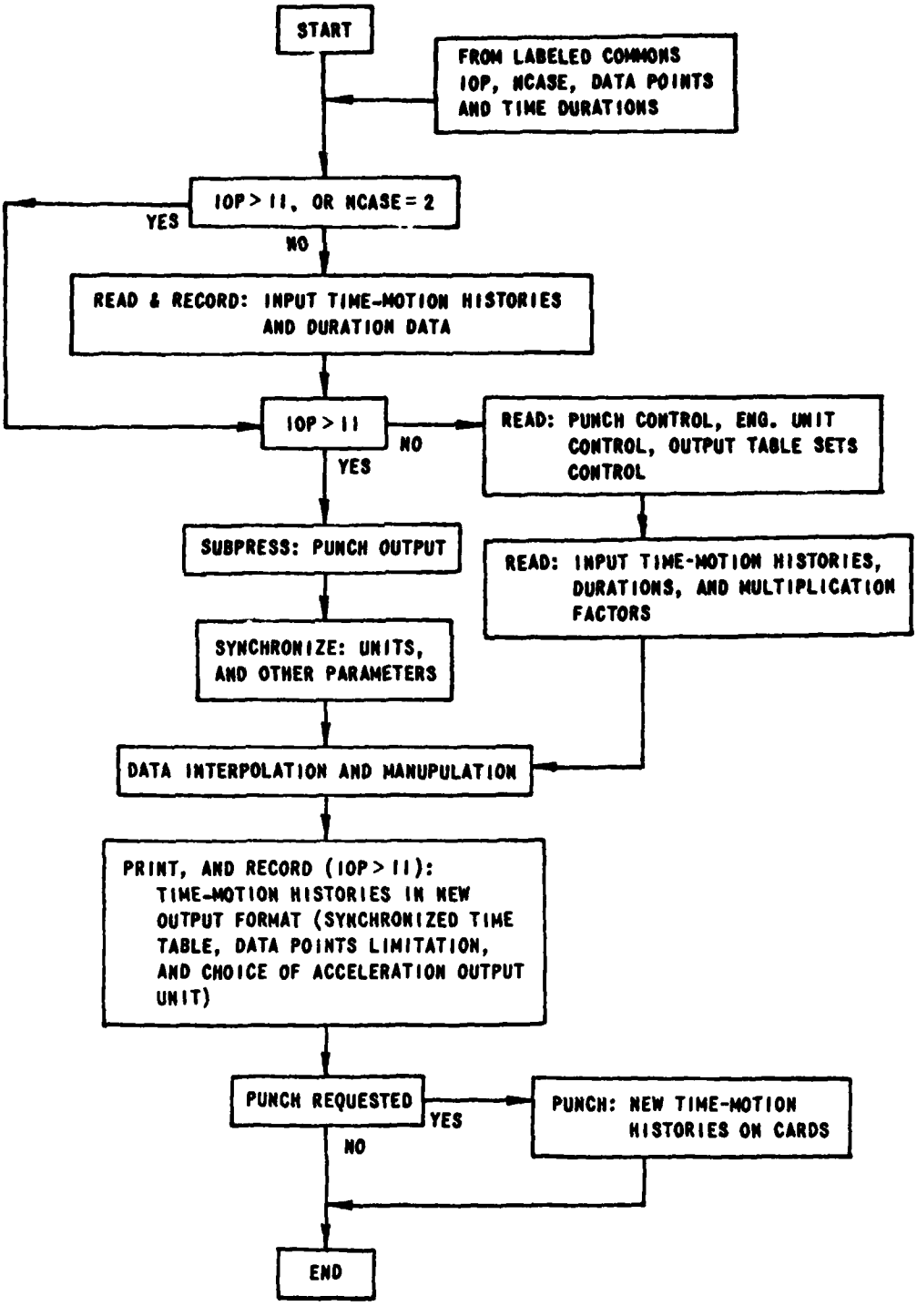


Figure 2-5. Flow Chart of SYNSØL Program

SYNSØL Input Instructions. There are three groups of input data as follows:

a. Control indices.

b. Table constants.

c. Table inputs.

Group 1 - Program controls

Number of cards = 1.

1234567890	1234567890	1234567890	1234567890	1234567890 1234567890 1234567890 1234567890
IIP (I10)	IGV (I10)	NST (I10)	MAXPTS (I5)	BLANK

IIP - Punch option; IIP = 0 for no punch and IIP = 1 for punch output tables.

IGV - Output unit control:

IGV = 0, output unit same as input

IGV = 1, output unit is devided by g, 386.4

IGV = 2, output unit is multiplied by g.

MAXPTS - No. of output data points control

MAXPTS = M, M data points are generated

= 0, or blank. 500 points are generated.

NST - Number of table sets to be processed. Maximum value of NST is 4.

Group 2 - Table controls

Number of cards = NST.

1234567890	1234567890	1234567890	1234567890 1234567890 1234567890 1234567890
NPT(J) (I10)	TM(J) (F10.4)	FACTØR(J) (F10.4)	BLANK

NPT(J) - Number of data points in J-th table. The previous table will be printed and punched out if NPT(J) = 0.

TM(J) - Time duration of the J-th table. (last value of the independent variable in J-th table)

FACTØR(J) - Multiplication constant to be applied to the modified table.

Group 3. **Time and time dependent tables are as follows:**

a. Two blank cards.

b. One identification card in 12A6 format.

c. One blank card.

d. Independent variable table (Time table), **Number of cards** = NPT(J)/9.

12345678901	23456789012	34567890123	45678901234	56789012345	67890123456	78901234567	89012345678	90123456789	0
		T(I), I = 1, NPT(J) (9F8.3)							BLANK

T(I) - Independent variable, such as time (sec)

e. Two blank cards.

f. One identification card in 12A6 format.

g. One blank card.

h. **Dependent variable table (acceleration table), number of cards** = NPT(J)/9.

12345678901	23456789012	34567890123	45678901234	56789012345	67890123456	78901234567	89012345678	90123456789	0
		YY(I), I = 1, NPT(J) (9F8.3)							BLANK

YY(I) - Dependent variable, such as acceleration (in/sec^2).

Groups 2 and 3 are repeated NST times. Complete Group 3 is obtainable from WAVSYN/NWVSYN.

SYNSØL Ø**utput. Groups 1 and 2 input data are printed in a simplified format. Group 3 input data are not printed. All of the output data have self-explanatory headings. Lables and sequential numbering are added to the printout tables and punched cards for easy identification.** The punch and print formats are automatically adjusted depending on the actual output values and the unit selected to insure significant numbers of digits are printed and punched in all cases. Subroutine WVTRAN is added to SYNSØL for the SYNSØL output suitable for NASTRAN program.

Program Initilization. To execute SYNSØL by itself, an input card with an integer 3 in column 8 is needed before group 1 input. This program initialization is described in Program ISIP. For NWVSYN-SYNSØL or NWVSYN-SYNSØL-WVTRAN combination runs, the user is referred to page 2-25.

7.0 USER'S MANUAL FOR ISØL PROGRAM

Program Features. The ISØL computer program was developed to calculate the dynamic response of a shock isolation system supporting rigid masses and subjected to base excitations. The equations of motion and selected coordinate systems were developed and described in Part I. ISØL was organized in accordance with these analytical approaches. The principal features of the ISØL program are:

a. The program can be used to analyze elastic-pendulum shock isolation systems, pivoted base-mounted shock isolation systems, and systems with special types of isolators such as the short pendulum and the rolling ball.

b. The force-displacement characteristics of spring and/or damper elements can be specified arbitrarily. Linear or nonlinear elements are acceptable.

c. The locations of attachment points of the spring/damper units to the base structure are completely arbitrary.

d. Two methods for integrating the equations of motion are available. They are based on either the exact large-angle formulation or the small-angle approximation.

e. The static equilibrium position of the shock isolation system can be determined through use of the ISØL program. It is necessary to obtain an equilibrium position of the isolation system prior to computing responses due to shock excitation of the base. In redundant systems, hand calculations are cumbersome and may be impractical. To determine the static equilibrium position of the system using ISØL, terminal responses of the system starting at any arbitrary initial condition can be computed. To expedite the solution, a temporary large value of velocity damping should be provided between the supported load and its base. The system will then reach equilibrium quickly as the relative motions are highly damped.

f. Multiple cases can be processed within one run setup. In successive cases, either the responses of several independent shock isolations can be calculated or the responses of one system subjected to different excitations can be determined.

g. An option is available to write on a plot tape (logical unit 3) the response-time histories of all computed parameters for any case within the run setup. The plot tape can be used as an input to an independent YUPLØT routine to generate off-line CALCOMP plots of the selected response data. Inputs for YUPLØT are detailed in PLTSUB program.

An abbreviated flow chart of ISØL is shown in Figure 2-6.

Program Limits. The present version of ISØL has the following limits:

Number of masses	50
Number of spring/damper elements	50
Number of points of interest	4
Number of points in excitation table (TIME, XE, YE, ZE)	500

These limitations can be expanded by changing the dimension statements of the program as long as they do not exceed the memory core capacity of the computer system.

ISØL Input Instructions. The 11 required input instructions are:

a. Project title or identification (ID).
b. Control indices.
c. Inertia data and coordinates.
d. Coordinates of spring/damper element attachment points.
e. Data for short pendulums.
f. Data for spherical plates.
g. Coordinates of "points of interest".
h. Spring/damper characteristics.
i. Excitation tables.
j. Program constants.
k. Initial conditions.

As noted earlier, the ISØL program allows uninterrupted sequential computations of multiple cases in a single run setup. Each case begins with the project ID and usually ends with the initial conditions for the succeeding case, except for the group (or groups) which may be omitted, depending on options requested

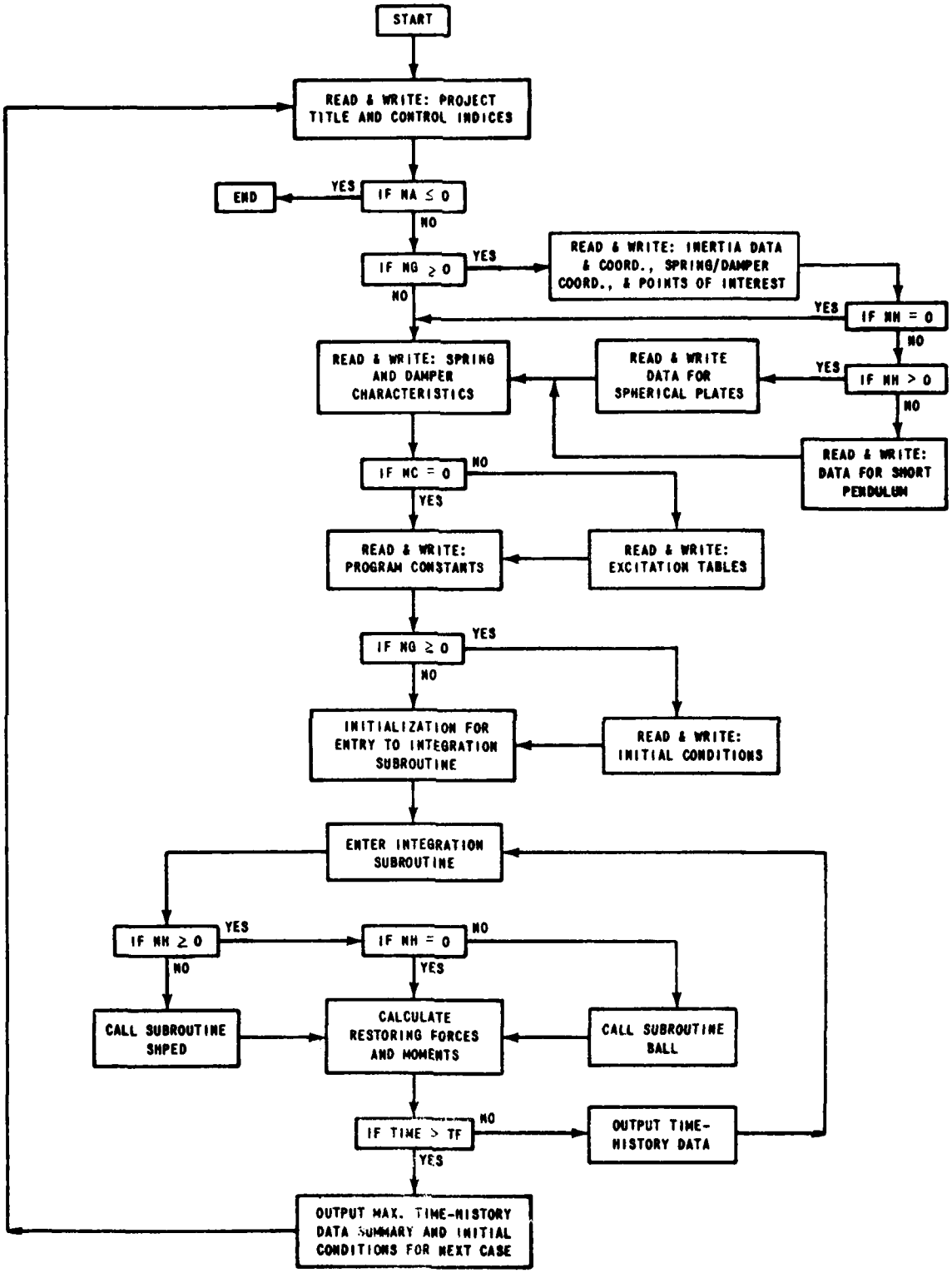


Figure 2-6. Flow Chart of ISØL Program

in the control indices. Two blank cards are required following the input data of the last case so that a proper exit or termination of the run will result. More detailed explanations of each input group are provided in the following subsections.

Group 1 - Program title

Number of cards = 1.

12345678901234567892012345678930123456789401234567895012345678960123456789701234567898 0	
TITLE (72H)	BLANK

Any alpha-numeric data for program identification.

Group 2 - Control indices

Number of cards = 1.

12345678901234567892012345678930123456789401234567895012345678960123456789701234567898 0								
NA (I4)	NB (I4)	NC (I4)	ND (I4)	NE (I4)	NF (I4)	NG (I4)	NH (I4)	BLANK

NA - Number of inertia stations or number of weights on the platform (positive integer).

NOTE: When NA $\leqslant$ 0, program run will be terminated. At the end of the last case for a run setup, two blank cards should be provided. The first card is normally the title card and the second card provides NA = 0.

NB - Number of spring/damper elements (always positive integer).

NC - Control of inputing excitation tables.

NC = +A. A is a positive integer which also serves as the length of the excitation tables. Excitation tables must be inputed.

NC = 0. No excitation tables are required for this case. Skip inputing group 9.

ND - Option for large-angle or small-angle integration of the equations of motion (either ND = 1 or ND = 2).

ND = 1. Large-angle exact solution.

ND = 2. Small-angle approximation.

NE - Option for computing response data at points of interest.

NE = 0. No points of interest are required for this case. Skip inputing group 7.

NE = B. B is the number of points of interest. The maximum number for B is 4.

NF - Input acceleration unit control.

NF = 0. Excitation acceleration function in unit of g's.

≠ 0. Excitation acceleration function in unit of in./sec^2.

NG - Initial conditions control.

NG ⩾ 0. Initial conditions for this case are to be inputed.

NG < 0. Initial conditions for this case are the end time of the preceeding case. Skip inputing group 11.

NH - Option for types of isolator mount.

NH < 0. Short-pendulum type isolator. Skip inputing group 6.

NH = 0. Spring/pendulum type isolator. Skip inputing group 5 and 6.

NH > 0. Rolling-ball type isolator. Skip inputing group 5.

Group 3 - **Inertia data and coordinates (right hand coordinate system with Z positive up)**

Number of cards = NA. If NG<0, omit this group.

12345678	9012345678	9201234567	8930123456	7894012345	6789501234	5678960123	4567897012	3456789801	2345678901
WT(I) (E8.0)	XM(I) (E8.0)	YM(I) (E8.0)	ZM(I) (E8.0)	XXI(I) (E8.0)	YYI(I) (E8.0)	ZZI(I) (E8.0)	XYI(I) (E8.0)	XZI(I) (E8.0)	YZI(I) (E8.0)

Where I = 1, NA:

WT(I) - Weight of a point mass (lb).

XM(I) - X coordinate of the weight with respect to the building-fixed coordinate system (in.).

YM(I) - Y coordinate of the weight with respect to the building-fixed coordinate system (in.).

ZM(I) - Z coordinate of the weight with respect to the building-fixed coordinate system (in.).

XXI(I) - I_{xx} mass moment of inertia of a point mass with respect to X axis (in-lb-sec^2) through the mass C.G.

YYI(I) - I_{yy} mass moment of inertia of a point mass with respect to Y axis (in-lb-sec^2) through the mass C.G.

ZZI(I) - I_{zz} mass moment of inertia of a point mass with respect to Z axis (in-lb-sec^2) through the mass C.G.

XYI(I) - I_{xy} mass product of inertia of a point mass with respect to X-Y axis (in-lb-sec^2) through the mass C.G.

XZI(I) - I_{xz} mass product of inertia of a point mass with respect to X-Z axis (in-lb-sec^2) through the mass C.G.

YZI(I) - I_{yz} mass product of inertia of a point mass with respect to Y-Z axis (in-lb-sec^2) through the mass C.G.

Group 4 - **Coordinates of spring/damper element attachment points**

Number of cards = NB. If NG<0, omit this group.

12345678	9012345	67892012	34567893012	34567894012	34567895012	34567896012345678970123456789 80
XA(I) (E8.0)	YA(I) (E8.0)	ZA(I) (E8.0)	XB(I) (E8.0)	YB(I) (E8.0)	ZB(I) (E8.0)	BLANK

Where I = 1 to NB:

XA(I) - X coordinate of attachment point on platform (in.).

YA(I) - Y coordinate of attachment point on platform (in.).

ZA(I) - Z coordinate of attachment point on platform (in.).

XB(I) - X coordinate of attachment point on building (in.).

YB(I) - Y coordinate of attachment point on building (in.).

ZB(I) - Z coordinate of attachment point on building (in.).

NOTE: The origin of the coordinate system is the same as that of the coordinates of group 3.

Group 5 - Data for short pendulums

Number of cards = NB. If NH ≥ 0 or NG < 0, omit this group.

12345678	9012345678	9201234567	8930123456789401234567895012345678960123456789701234567898 0
SLG(I) (E8.0)	DX(I) (E8.0)	DY(I) (E8.0)	BLANK

Where I = 1 to NB:

SLG(I) - Length of pendulums (in.).

DX(I) - Deviation in X-direction of the lower end of short pendulum from its vertical position (in.).

DY(I) - Deviation in Y-direction of the lower end of short pendulum from its vertical position (in.).

Group 6 - Data for spherical plates

Number of cards = NB. If NH ≤ 0 or NG < 0, omit this group.

12345678	9012345678	9201234567	8930123456	7894012345	6789501234567896012345678970123456789 8 0
XBØ(I) (E8.0)	YBØ(I) (E8.0)	ZBØ(I) (E8.0)	R(I) (E8.0)	UM(I) (E8.0)	BLANK

Where I = 1 to NB:

XBØ(I) - X coordinate of center of plate (in.).

YBØ(I) - Y coordinate of center of plate (in.).

ZBØ(I) - Z coordinate of center of plate (in.).

R(I) - Radius of spherical plate (in.).

UM(I) - Rolling friction coefficient between plate and ball.

Group 7 - Coordinates of points of interest

Number of cards = NE. If NG < 0, omit this group.

12345678	9012345678	9201234567	8930123456789401234567895012345678960123456789701234567898 0
XP(I) (E8.0)	YP(I) (E8.0)	ZP(I) (E8.0)	BLANK

Where I = 1 to NE:

XP(I) - X coordinate of the point of interest (in.).

XP(I) - Y coordinate of the point of interest (in.).

ZP(I) - Z coordinate of the point of interest (in.).

NOTE: The origin of these coordinates are the same as the previous coordinates.

Group 8 - Spring/damper characteristics

There are NB number of sub-groups of cards. Each Ith sub-group begins with one card as follows.

12345678	9012345678	9012345678	9012345678	9012345678	9012345678	9012345678	9012345678	9012345678	9012345678	9012345678	9012345678	9012345678	9012345678	9012345678	9012345678	9012345678	9012345678	9012345678	9012345678
NX(I) (I4)	NY(I) (I4)	SL(I) (E8.0)	SK(I) (E8.0)	DA(I) (E8.0)	BLANK														

(where I = 1 to NB):

NX(I) - NX(I) = 0. Linear spring.

NX(I) = A. nonlinear spring characteristics are given in an input table of length A.

NY(I) - NY(I) = 0. Linear viscous damping.

NY(I) = B. Variable damping coefficients are given in an input table of length B.

SL(I) - Free length of the spring (in.).

SK(I) - Constant linear spring rate (lb/in.).

DA(I) - Constant linear viscous damping coefficient (lb-sec/in.).

NOTE: Following this card will be the nonlinear spring table input. Whether or not the table will be inputed depends on the value of NX(I).

IF NX(I) = 0, skip inputing the deflection-force table.

IF NX(I) = A, the next cards are deflection-force tables of the spring element.

The deflections and forces are specified on two separate groups of cards.

Spring deflection (DF) table - NX(I) > 0 orly.

1234567891	1234567892	1234567893	1234567894	1234567895	1234567896	1234567897	1234567898 0
		DF(J,I), J = 1, A (10E8.0)					

Spring force (FS) table - NX(I) > 0 only.

1234567891	1234567892	1234567893	1234567894	1234567895	1234567896	1234567897	1234567898 0
		FS(J,I), J = 1, A (10E8.0)					

DF(J,I) - Deflection (in.).

FS(J,I) - Forces (lb).

NOTE: The number of cards for DF(J,I) and FS(J,I) depends on A; for example, if A = 15, two cards each will be required for the tables. Compression or shortening of the spring produces a positive force.

The damping table for the Ith element follows the spring table. The requirements for this table will depend on the value of NY(I).

If NY(I) = 0, skip the velocity-damping tables.

If NY(I) = B, the next cards are velocity-damping tables of the damper element. The velocity and damping forces are specified on two separate groups of cards similar to the spring tables.

Rate of spring deflections (VD) table - NY(I) > 0 only.

1234567891	1234567892	1234567893	1234567894	1234567895	1234567896	1234567897	1234567898 0
		VD(J,I), J = 1, B (10E8.0)					

Damping forces (FD) table - NY(I) > 0 only.

1234567891	1234567892	1234567893	1234567894	1234567895	1234567896	1234567897	1234567898 0
		FD(J,I), J = 1, B (10E8.0)					

VD(J,I) - Velocity (in./sec).

FD(J,I) - Damping force (lb-sec/in.).

The preceeding completes the sub-group for the Ith spring/damper element. The input for spring/damper characteristics continues until NB sub-groups are inputed.

Group 9 - Excitation tables

There are four input tables in this group. Each table is NC long. Omit this group if NC = 0.

a. Time table

Number of cards = (NC + 8)/9.

12345678901	23456789012	34567890123	45678901234	56789012345	67890123456	78901234567	89012345678	90123456789	0
			TTAB(I), I = 1, |NC| (9E8.0)						BLANK

b. X-direction excitation

Number of cards = (NC + 8)/9.

12345678901	23456789012	34567890123	45678901234	56789012345	67890123456	78901234567	89012345678	90123456789	0
			XE(I), I = 1, |NC| (9E8.0)						BLANK

c. Y-direction excitation

Number of cards = (NC + 8)/9.

12345678901	23456789012	34567890123	45678901234	56789012345	67890123456	78901234567	89012345678	90123456789	0
			YE(I), I = 1, |NC| (9E8.0)						BLANK

d. Z-direction excitation

Number of cards = (NC + 8)/9.

12345678901	23456789012	34567890123	45678901234	56789012345	67890123456	78901234567	89012345678	90123456789	0
			ZE(I), I = 1, |NC| (9E8.0)						BLANK

TTAB(I) - **Time table (sec).**

XE(I) - X-direction excitation

YE(I) - Y-direction excitation

ZE(I) - Z-direction excitation

Units in in./sec^2 or g's depending on NF value.

Group 10 - **Program constants**

Number of cards = 1.

12345678	9012345	67892012	34567893	012345678	94012345	67895012	34567896	012345678	9701234	5678980
TS (E8.0)	TF (E8.0)	DTI (E8.0)	DTP (E8.0)	TCP (E8.0)	DTPC (E8.0)	PLT (E8.0)	DCGX (E8.0)	DCGY (E8.0)	DCGZ (E8.0)	

TS - Start time (sec).

TF - End time (sec).

DTI - Integrating time interval (sec).

DTP - Printout time interval (sec).

TCP - Time for changing DTP (sec).

DTPC - New printout time interval (sec).

PLT - Plot request (Not use if ØPTN $\geq$ 11; see ISIP first input card).

PLT = 0. Do not write output data on plot tape.

PLT $\neq$ 0. Write output data on plot tape.

DCGX - Shift of C.G. in X direction (in.).

DCGY - Shift of C.G. in Y direction (in.).

DCGZ - Shift of C.G. in Z direction (in.).

Group 11 - **Initial conditions.** Omit this group if NG $\neq$ 0.

Number of cards = 1.

12345678	9012345	67892012	34567893	012345678	94012345	67895012	34567896	012345678	9701234	5678980
ALPHA (E8.0)	BETA (E8.0)	GAMMA (E8.0)	ALDØT (E8.0)	BETDØT (E8.0)	GAMDØT (E8.0)	XCBDX (E8.0)	XCBDY (E8.0)	XCBDZ (E8.0)	BLANK	

ALPHA - α(deg).

BETA - β(deg).

GAMMA - γ(deg).

ALDØT - $\dot{\alpha}$(rad/sec).

BETDØT- $\dot{\beta}$(rad/sec).

GAMDØT- $\dot{\gamma}$(rad/sec).

XCBDX - $\dot{X}_{CBx}$ (in./sec).

XCBDY - X_{CBy} (in./sec).

XCBDZ - $\dot{X}_{CBz}$ (in./sec).

NOTE: If NG < 0, Initial conditions of this current run are the conditions at TF of the last cases.

Group 12 - Blank cards.

Repeat group 1 through group 11 if needed. Otherwise, 2 blank cards signal a normal exit. (See NA of group 2.)

Messages of ISØL. Certain messages are printed out to indicate that the input tables are out of range or that some events of interest have occurred. The messages are:

a. DEFLECTION-FORCE TABLE OUT OF RANGE - The values in the deflection table are out of range.

b. VELOCITY-DAMPING TABLE OUT OF RANGE - The values in the velocity table are out of range.

c. TIME-EXCITATION TABLE OUT OF RANGE - The current time is beyond the last time of the time table.

d. SOMETHING WRONG IN TIME CONTROL - There is something wrong in the time control input, either DTP or DTPC.

e. PLOT RUN NUMBER X - Sequence X of plot case time-history data will be written on the plot tape.

f. END OF RUN - WILL EXIT - All the cases for this run setup have been completed successfully.

g. WRONG PLATE INPUT - It is assumed that C(J) is always less than zero; i.e., the support point is inside the spherical plate.

h. WRONG SHORT PENDULUM INPUT - Magnitude of cosine function is greater than one.

ISØL Output. The input data for each case are printed beginning with the project title. The printout of the input data has been arranged for each reading, and does not use the same format as the input cards. All of the data outputs have proper self-explanatory headings. The response data consists of 49 parameters maximum for each time period. Headings are provided at the top of each page of the response output data. The output parameters are explained as follows:

Parameter Number	Parameter
1	TIME - TIME (sec).
2	XC - X component of the relative* displacement (in.).
3	YC - Y component of the relative* displacement (in.).
4	ZC - Z component of the relative* displacement (in.).
5	AX - X component of the absolute acceleration (in./sec sq).
6	AY - Y component of the absolute acceleration (in./sec sq).
7	AZ - Z component of the absolute acceleration (in./sec sq).
8	ØX - α (deg).
9	ØY - β (deg).
10	ØZ - γ (deg).
11	ØDX - $\dot{\omega}_x$ (rad/sec^2).
12	ØDY - $\dot{\omega}_y$ (rad/sec^2).
13	ØDZ - $\dot{\omega}_z$ (rad/sec^2).
14	ABX - X-input excitation (in./sec^2).
15	ABY - Y-input excitation (in./sec^2).
16	ABZ - Z-input excitation (in./sec^2).
17-25	A11, A12, ...A33 - A Matrix.
26,32,38,44	XPN - X relative* displacement of the Nth point of interest (in.), where N = 1,...,4
27,33,39,45	YPN - Y relative* displacement of the Nth point of interest (in.), where N = 1,...,4
28,34,40,46	ZPN - Z relative* displacement of the Nth point of interest (in.), where N = 1,...,4
29,35,41,47	AXPN - X component of absolute acceleration of the Nth point of interest (in./sec^2), where N = 1,...,4
30,36,42,48	AYPN - Y component of absolute acceleration of the Nth point of interest (in./sec^2), where N = 1,...,4
31,37,43,49	AZPN - Z component of absolute acceleration of the Nth point of interest (in./sec^2), where N = 1,...,4

NOTE: Parameters 2 through 13 are those of the platform's C.G.

At time between print-out intervals

*relative to the initial equilibrium conditions

At the end of the time-history response data output, a table summarizes the maximum values of the response data. Data at TF are used as initial conditions for the next case and are printed following the maximum response data summary.

Program Initialization. To execute ISØL by itself, an input card with an integer 4 in column 8 is needed before group 1 input. This program initialization is described in Program ISIP. Option 14 (in columns 7 and 8) can also be used instead of 4 if on-line plotting (no magnetic tape is required) or spectrum analysis follows.

8.0 USER'S MANUAL FOR PLTSUB PROGRAM

Program Features. A fairly complicated plotting package was developed for the shock spectrum and time-dependent variable plots. However, this program must be through the ISIP program (to be described later) where data storage and retrieval become automatic. The user requests the preferred plotter from the plotter choice of ISIP.

Three distinct plotting programs are enclosed in PLTSUB to generate SC-4020 scope camera plots, the Calcomp pen plots and the line-printer plots. The use of the first two, depends on the availability of these plotters in a computer system. The line-printer, however, is always present.

When the plotter is requested (see the first input card of ISIP), the following will be executed:

a. Shock spectrum and the time-acceleration history of the synthesized waveform will be plotted at the end of the WAVSYN/NWVSYN run. No inputs to PLTSUB are required. Spectrum is plotted in log-log scale and the time-acceleration history in a linear plot.

b. YUPLØT subroutine will be called by PLTSUB at the end of an ISØL run. Any of the 49 time-dependent variables computed by ISØL can be plotted. Two or more input cards are needed.

c. Shock spectra and the time acceleration histories of the responses requested in SPCTRM will be automatically plotted in log-log and linear plots as in (a.). No inputs to PLTSUB are required.

Figure 2-7 shows the flow chart of PLTSUB program.

Program Limits. The PLTSUB plotting package assumes on-line plotters (SC-4020, Calcomp, and line-printer) are available in a computer installation. With minimal FORTRAN changes, a magnetic tape can be created for generating Calcomp or SC-4020 plots on off-line equipment.

Subroutines of PLTSUB. The PLTSUB has four subroutines:

a. YUPLØT - extraction of variables from ISØL output.
b. CPLØT 1, CPLØT 3 - Calcomp plotting package.
c. CPLØT 2, CPLØT 4 - SC-4020 plotting package.
d. CPLØT 5 - line-printer plotting package.

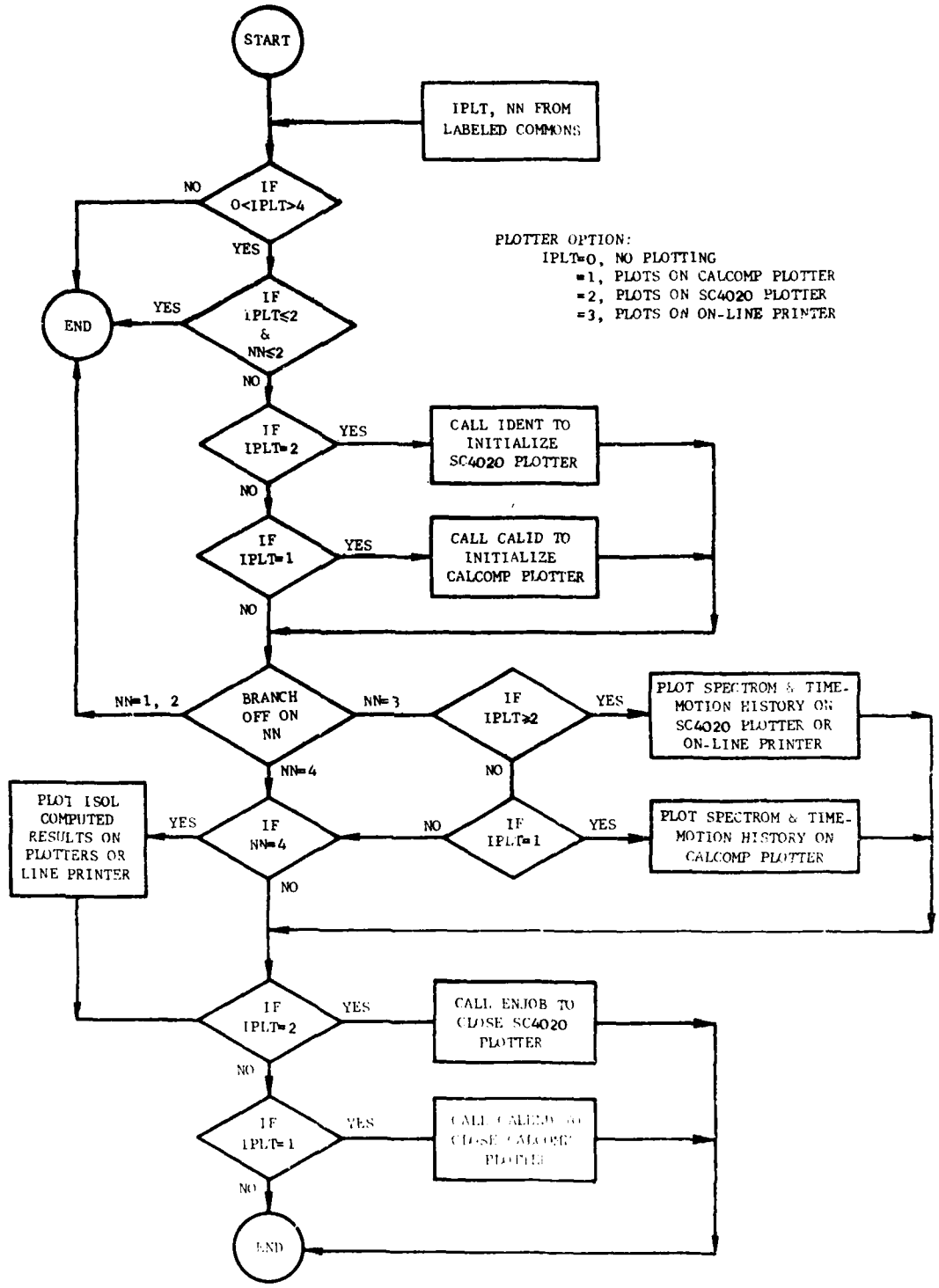


Figure 2-7. FLOW CHART ON PLTSUB PROGRAM

All subroutines are written in FORTRAN V language and therefore are easily adapted to many computer systems. However, since many computer installations may not have the SC-4020 plotting capability, an extra subroutine QUKLØC is added to temporarily nullify subroutines CPLØT2 and 4 in the SC4020 plotting package. A similar technique can be used to nullify subroutines CPLØT1 and 2, Calcomp plotting package.

YUPLØT Input Instructions. YUPLØT allows plotting of any dependent variable versus time from a previous ISØL run. Input instructions for YUPLØT are straightforward. Only one FORTRAN read statement is used in the entire routine.

123	4567890123456789012345678901234567890123456789012345678901234567	8901234567890
NUM1 (I3)	LØT(I), I = 1, 23 (23I3)	BLANK

NUM1 - Positive integer indicates the plot case number. A negative integer terminates the input.

LØT (I) - Any of the 49 time-history data from an ISØL run; each card allows a maximum request of 23 plots.

YUPLOT Example Input. To illustrate the use of YUPLØT, an example is provided. Suppose we are interested in creating plots of the following parameters computed by ISØL.

PLOT CASE 1 SC, ZC, AX, AZ, ØX, ØDZ vs TIME
PLOT CASE 3 YC, ØDX, XP1, AZP1 vs TIME

Three cards of (24I3) format are required for this example run.

COL ENDING	3	6	9	12	15	18	21
1st Card	1	2	4	5	7	8	13
2nd Card	3	3	11	26	31		
3rd Card	-1						

The first word of the first card is the plot case number which is 1. The last word of the first card ends at column 21 and is the dependent variable ØDZ which is the 13th parameter of the 49 time-history parameters starting with TIME, being the first parameter. The first word of the second card is 3 (plot case 3) with similar parameter requests. The third card has only

one word, NUM1 = neg. integer, which results in proper termination of the YUPLØT run.

Messages from PLTSUB. There is no message printout when plotting is called from sources other than YUPLØT. The dimensions in these subroutines are large enough that they will never go out of range. However, the maximum table length allowed in any parameter of YUPLØT routine is 450. Should this limit be exceeded, the execution will still proceed, except the plot points for this particular plot request will end at the 450th point. A message will be printed out at the YUPLØT output indicating the buffer has been exceeded.

There are other messages from YUPLØT which may result from wrong input data, etc. These messages are self-explanatory. At the end of the run a message reading "END OF PLOT RUN" will be printed. If this message does not occur, there is something wrong with the input data and/or plotting subroutines. The most likely source of error is the omission of the NUM1 = neg. integer card.

Sample Plots. Figures 2-8 and 2-9 show two sample plots from a WAVSYN run, using SC-4020 scope camera plotter (1PLT = 1).

Program Initialization. To execute PLTSUB by itself, an input card with an integer 5 in column 8 is needed before group 1 input. This program initialization is described in Program ISIP.

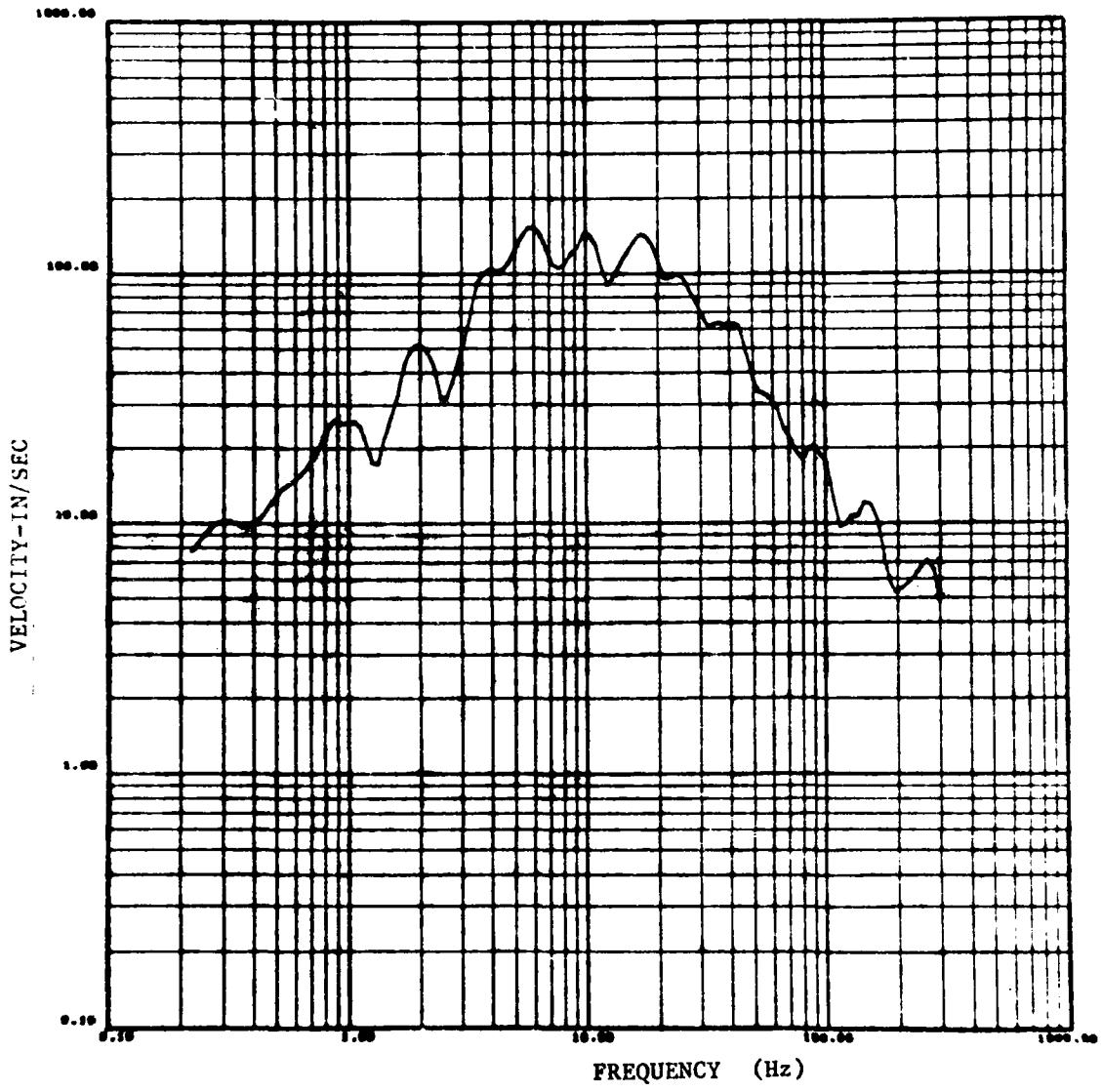


FIGURE 2-8. SHOCK SPECTRUM PLOT FROM A WAVSYN RUN

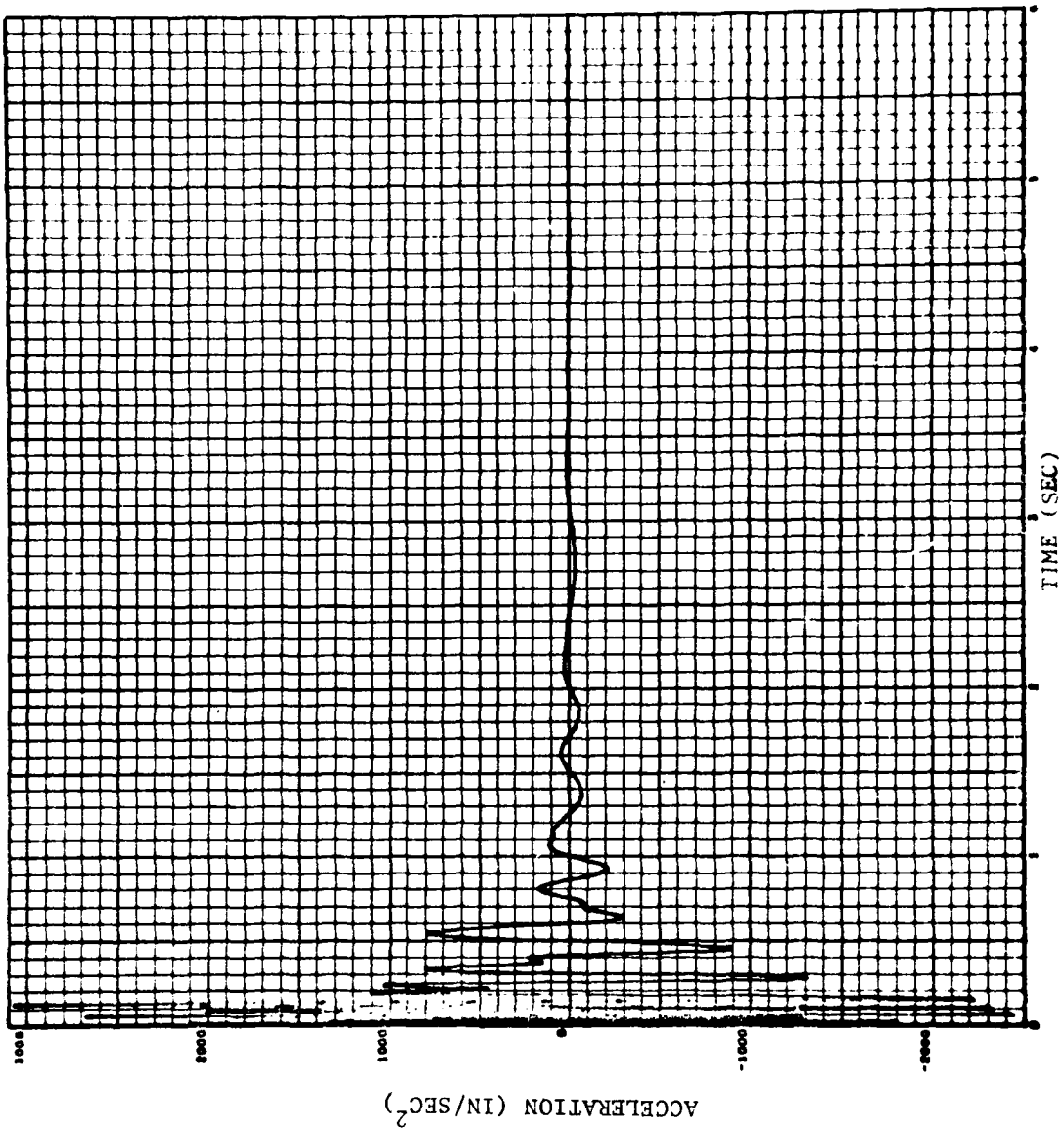


FIGURE 2-9. ACCELERATION-TIME PLOT FROM A WAVSYN RUN

9.0 USER'S MANUAL FOR SPECTRM PROGRAM

Program Features. The SHOCK RESPONSE program was developed to generate a shock response spectrum from a given acceleration-time motion history. The program has the following main features:

a. Acceleration amplitude can be in units of "g" or "in./sec^2".

b. Damped shock response spectrum can be produced by reading in the required critical damping ratio.

c. Multiple problems can be solved with one run setup.

d. Different acceleration-time motion history can be used for each problem run.

e. A linear acceleration method is used to solve the second-order differential equation.

Figure 2-10 shows the flow chart of the SPCTRM computer program.

Program Limits.

Frequency ranges	50
Frequency intervals within the range	50
Acceleration-time history data points	520
Integration time interval steps	12,000

The above limits can be expaned by changing the program dimensions as long as they do not exceed the capacity of the computer core.

Shock Response Input Instructions. The input can be divided into six groups. They are:

Group 1 - Time, damping and initial condition and input parameter controls

Number of cards = 1.

12345678	9012345678	9201234567	8930123456	7894012345	6789501234	5678960123	4567897012	3456789801	2345678990
TS (F8.0)	TE (F8.0)	TH (F8.0)	BET (F8.0)	XI (F8.0)	VI (F8.0)	LØT(I), I = 1,4 (4I5)			BLANK

TS - Starting time on time table. (A dummy input variable. Actual input value not used.)

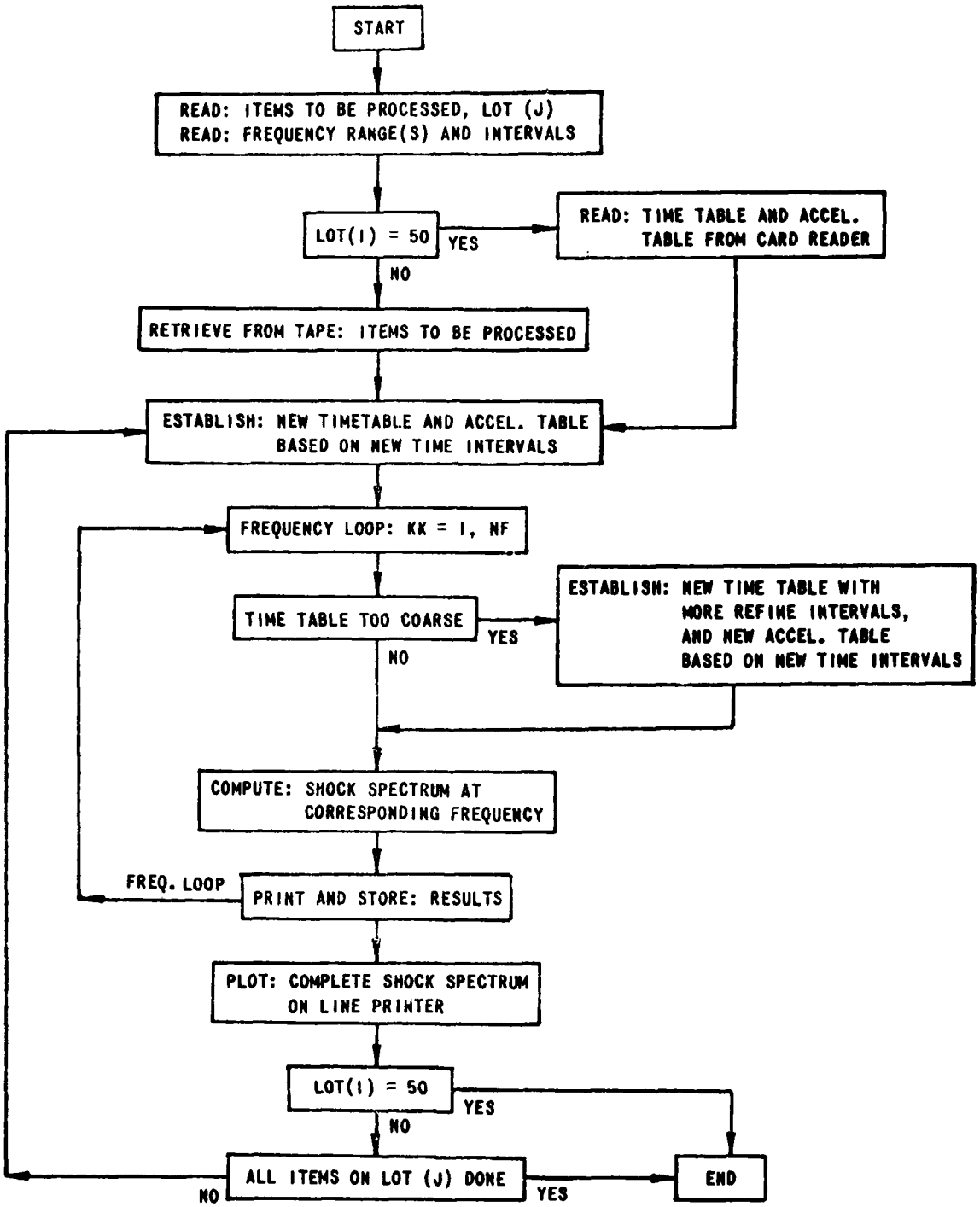


Figure 2-10. Flow Chart of SPCTRM Program

TE - Ending time on time table. (A dummy input variable. Actual input value not used)

TH - Integration time interval (suggest 1/10 period or less of the highest time/motion history frequency).

BET - Damping ratio.

XI - Initial displacement.

VI - Initial velocity.

LØT (I) - Up to 4 parameters from IØØL run to be processed by SPCTRM. Parameters 5, 6, and 7 are automatically included.

- LØT(1) = 50 for an independent SPCTRM run.

Group 2 - Shock analysis constants

Number of cards = 1.

12345678901234567890123456789012345678901234567890123456789012345678901234567890				
NF (I5)	ICP (I5)	IDEL (I5)	NT (I5)	BLANK

NF - Number of frequency range.

ICP - Number of residual vibration cycles (suggest three or less).

IDEL - Integration constant (suggest no less than five. A default value of 5 will be used if no input value is given.)

NT - Number of points on time table.

Group 3 - Frequencies on shock spectrum

Number of cards = NF, K = 1, NF.

12345678901234567890123456789012345678901234567890123456789012345678901234567890			
SSF(K) (F8.0)	EEF(K) (F8.0)	HHF(K) (F8.0)	BLANK

SSF(K) - Starting frequency, Hz

EEF(K) - Ending frequency, Hz

HHF(K) - If NF $\geq$ 2, HHF(K) is the linear frequency increment within the range EEF(K)-SSF(K). If NF = 1, HHF(1) is the number of logarithmic frequency intervals within the frequency range EEF(1)-SSF(1). A default value of 100 intervals will be used if input value of HHF(1) is less than five and NF is one.

Group 4 - Time table

Number of cards = (NT + 6)/7.

12345678901	12345678902	12345678903	12345678904	12345678905	12345678906	12345678907	12345678908
		TT(I), I = 1, NT (7F10.2)					BLANK

TT(I) - Time table (maximum of 520 data points).

Group 5 - Title and problem controls

Number of cards = 1.

12345678901	12345678902	12345678903	12345678904	12345678905	12345678906	12345678907	12345678908
TITLE(I), I = 1, 11 (11A5)					BLANK	IK (I5)	LAST (I5)

TITLE(I) - Designation of the problem title.

IK - Read acceleration table in g if IK $\leq$ 0. Read acceleration table in in./sec^2 if IK > 0.

LAST - Next problem has same time table if LAST = 1. Next problem has different time table if LAST = 2. Last problem if LAST = 0.

Group 6 - Acceleration table

Number of cards = (NT + 6)/7.

12345678901	12345678902	12345678903	12345678904	12345678905	12345678906	12345678907	12345678908
		FT(I), I = 1,NT (7F10.2)					BLANK

FT(I) - Acceleration table (maximum of 520 data points).

Output Data. The output data from the program can be divided into two parts. First part is the printout of input data which consists of the control indexes, the frequency information on the required response spectrum, and the time table and acceleration amplitude table of the input forcing function. Second part is the printout of the calculated results. For each selected frequency point on the required response spectrum, both the maximum displacement and acceleration responses are listed.

Program Initialization. To execute SPCTRM by itself, an input card with an integer 6 in column 8 is needed before group 1 input. This program initialization is described in Program ISIP.

Comment. SPCTRM is an improved version of the shock spectrum analysis computer programs, SHØC and SHØCA, originally developed by Parsons Company of Las Angles. In SPCTRM, the input deck retains the original input format of SHØC/SHØCA, such that the input deck can be executed in all three versions. Some obsolete input parameters, such as TS, TE in group 1 input, remain in SPCTRM, and some input parameters, such as HHF in group 3, may have additional definitions. Several other input parameters become optional. and the computer program will automatical supply optimal values if no input values are given.

10.0 USER'S MANUAL FOR FØURIE AND FILTER PROGRAMS

Program Features. To establish the amplification ratio requirement of a synthesized waveform, as in the case of WAVSYN, or NWVSYN program, the time-motion histories used to generate the required spectrum must be given. FILTER program is designed to determine, one at a time, the amplitudes of the major frequency components of these time-histories. By comparing the filtered results with the amplitudes of the response spectra generated by these motions at the filtered midband frequencies, amplification ratios can be established as a function of frequency. The major frequency components of a time-motion history can be selected from their Fourier amplitude spectrum. The FØURIE program was developed to fill this need. Fourier amplitude versus frequency is plotted on a line-printer for quick selection of the major frequency components. Figure 2-11 and 2-12 show the flow charts of FILTER and FØURIE programs.

Program Limits. The calculated amplification ratio must be corrected by a modification factor for the low-frequency components. This factor is necessary since the filtered results are accurate only for steady-state responses and the duration of the input motion may not be long enough to allow sufficient oscillations at low frequency. The FILTER program has no limit on the number of frequency components which can be extracted, nor on the number of problems that it can process within one run setup. The maximum number of data points on the input time-motion history is 1125, which corresponds to a dimension array of 4500 each for TTAB and VIN. The maximum number of the data points in FØURIE is 500. These dimension limits can be expanded to larger values by changing the program dimensions, as long as they do not exceed the capacity of the computer core.

FILTER Input Instructions. There are six groups of input data as follows:

Group 1 - Number of problems

Number of cards = 1.

12345678901234567890123456789012345678901234567890123456789012345678901234567890
ND (14) BLANK

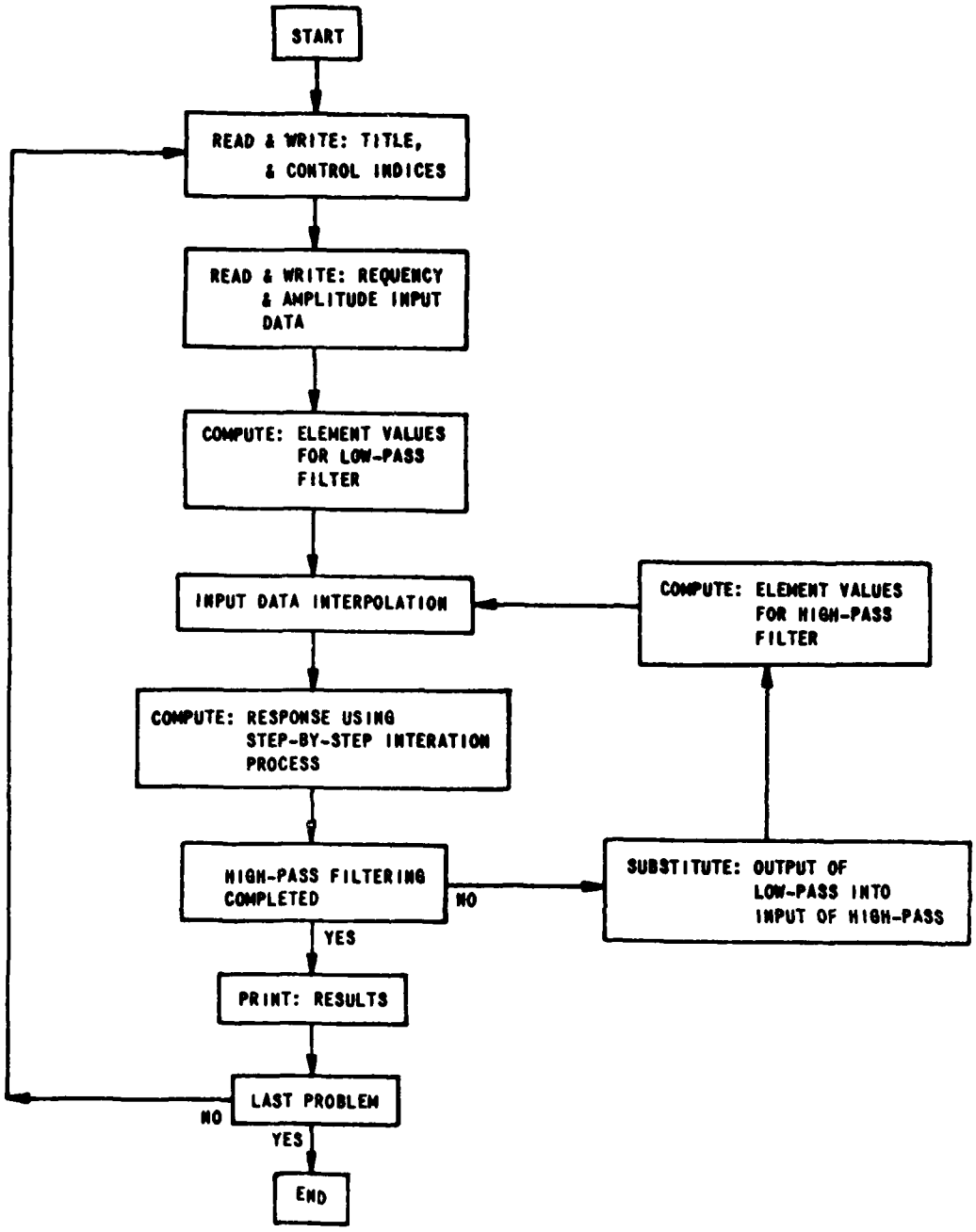


Figure 2-11. Flow Chart for FILTER Program

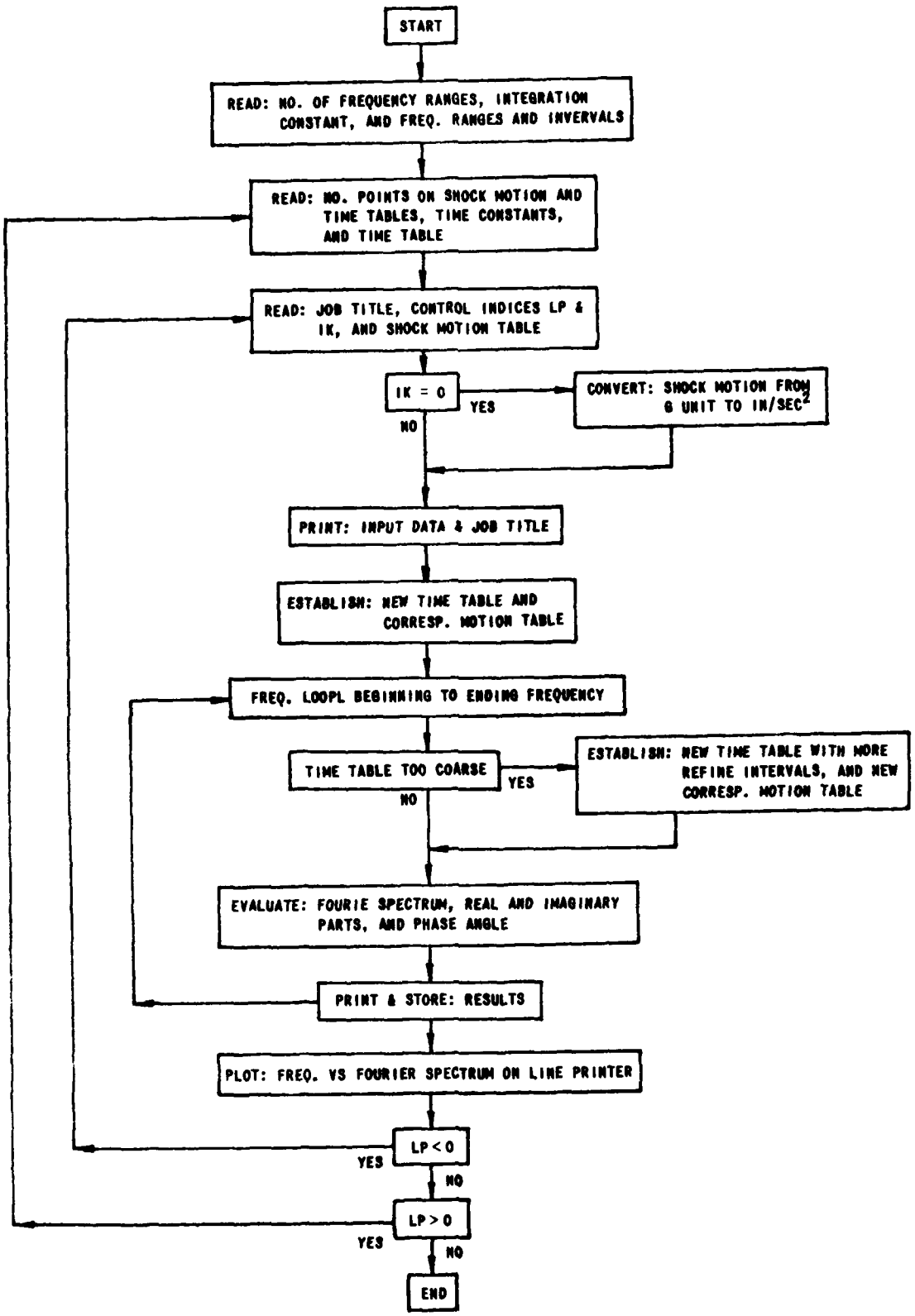


Figure 2-12. Flow Chart of FØURIE Program

ND - Number of problems.

Group 2 - Title

Number of cards - 1.

1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
TITLE(I), I = 1, 12 (12A6)							BLANK

TITLE(I) - Problem title. Any alpha-numeric data for problem identification.

Group 3 - Control indices

Number of cards = 1.

1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
NW (I5)	NI (I5)	NQ (I5)	TH (F10.5)	BLANK			

NW - Number of midband frequencies.

NI - Number of data points on time table.

IF NI = 0, time table is the same as the preceeding problem.

NQ - Printout option control.

IF NQ = 0, only the maximum response value is printed for each midband frequency.

IF NQ ≠ 0, time-motion history of filtered response at each midband frequency is printed.

TH - Integration time interval. If TH = 0, one-tenth of midband frequency is used.

Group 4 - Midband frequencies

Number of cards = (NW + 7)/8

1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
		OMEGA(I), I = 1, NW (8F10.3)					

ØMEGA(I) - Midband frequency, Hz.

Group 5 - Time table. Omit this group if NI = 0.

Number of cards = (NI + 8)/9.

12345678901234567890123456789012345678901234567890123456789012345678901234567890								
		TDUM(I), I = 1, NI (9F8.0)						BLANK

TDUM(I) - Input motion time table.

Group 6 - Amplitude table

Number of cards = (NV + 8)/9.

12345678901234567890123456789012345678901234567890123456789012345678901234567890								
		VDUM(I), I = 1, NV (9F8.0)						BLANK

VDUM(I) - Input motion amplitude table.

NV = NI, if NI is non-zero
= NI of the last problem, if current NI = 0.

FØURIE Input Instructions. There are seven groups of input data as follows:

Group 1 - Program constants

Number of cards = 1.

12345678901234567890123456789012345678901234567890123456789012345678901234567890		
NF (I5)	IDEL (I5)	BLANK

NF - Number of frequency ranges.

IDEL- An integration constant (suggest not less than five).
IDEL is automatically set to 5 if IDEL is zero on INPUT card.

Group 2 - Frequencies

Number of cards = NF.

12345678901234567890123456789012345678901234567890123456789012345678901234567890			
SSF(K) (F15.8)	EEF(K) (F15.8)	HHF(K) (F15.8)	BLANK

SSF(K) - starting frequency, Hz

EEF(K) - ending frequency, Hz

HHF(K) - If NF of group 1 is greater than 1, HHF(K) is the linear frequency interval within the range SSF(K) to EEF(K), Hz.

- If NF of group 1 is 1, HHF(I) is the number of logarithmic intervals within the frequency range SSF(I) to EEF(I), a real number.

Group 3 - Number of data points

Number of cards = 1.

12345678901234567890123456789012345678901234567890123456789012345678901234567890	
NS (I5)	BLANK

NS - Number of data points for the shock motion and time tables.

Group 4 - Time constants

Number of cards = 1.

12345678901234567890123456789012345678901234567890123456789012345678901234567890			
TS (F15.8)	TE (F15.8)	TH (F15.8)	BLANK

TS - Starting time for the time table.

TE - Ending time for the time table.

TH - Integration time interval.

Group 5 - Time table

Number of cards = (NS + 8)/9

12345678901234567890123456789012345678901234567890123456789012345678901234567890									
		TT(J), J = 1, NS (9F8.0)							BLANK

TT(J) - Time table for shock motion, sec.

Group 6 - Title and run control indices

Number of cards = 1.

12345678901234567890123456789012345678901234567890123456789012345678901234567890									
TITLE (J), J = 1,12 (12A6)								LP (I3)	IK (I3)

TITLE - Any alpha-numeric data used for problem identification.

LP - Repeat run control index.

If LP < 0, repeat run starting from group 6

If LP = 0, end of normal run

LF LP > 0, repeat run starting from group 3

IK - Motion input unit control.

IK = 0, Input motion unit in in/sec^2

IK = 1, Input motion unit in g's.

Group 7 - Motion table

Number of cards = (NS + 8)/9.

12345678901234567890123456789012345678901234567890123456789012345678901234567890									
		FT(J), J = 1, NS (9F8.0)							BLANK

FT(J) - Input shock motion.

Repeat the above input group according to the run control index LP in group 6.

FILTER and FØURIE Outputs. The output data for FILTER and FØURIE programs contain the printout of the input data. In FILTER, the lower and upper cutoff frequencies for each midband frequency are listed, and the output is printed in three columns. The first column is the time table. The second and third columns are the amplitude of the input motion and the filtered result respectively. At the conclusion of the program the maximum amplitude of the filtered motion is summarized with the time at which it occurred.

In FØURIE, a Fourier amplitude table is printed at the end of the analysis. This table consists of five columns. The first is the frequency, while the second, third and fourth columns are the real part, the imaginary part, and the phase angle of the real and imaginary components. The last column is the modulus of the Fourier amplitude spectrum. The Fourier amplitude in logarithmic scale is plotted against frequency.

Program Initialization. To execute FØURIE or FILTER computer program by itself, an input card with an integer 7, for FØURIE, or an integer 8, for FLTER, in column 8 is needed before group 1 input of either FØURIE or FILTER. This program initialization is described in Program ISIP.

11.0 USER'S MANUAL FOR ISIP PROGRAM

Program Features. The ISIP program integrates the previous nine programs (to be called subprograms in this section) into one package, and makes the shock isolation analysis a continuous process. Data storage and retrieval, and subprogram sequencing become automatic in ISIP. The principal features of ISIP are:

a. An overlay computer program structure which eliminates massive core requirements. 32,000 (decimal), equivalent to 76,000 (octal), core word size is needed.

b. Reduction in input preparation due to automatic data storage and retrieval among the sub-programs. For example, the number of data points, and the time and acceleration tables generated by WAVSYN are automatically fed into SYNSØL, and the user of ISIP does not need to account for the number of data points in each of these tables or where these tables are stored. The reduction of input preparation also reduces possible human errors.

c. Automatic linking of subprograms in a sequential executable order However, user can execute any particular subprogram, or he may skip or terminate ISIP at any stage of the sequential run.

d. The interval execution order of the subprograms is important in ISIP input preparation for a shock analysis of a rigid platform. This order is:

ISØLIN
WAVSYN/NWVSYN
SYNSØL
ISØL
PLTSUB
SPCTRM
FILTER
FØURIE

PLTSUB, however, is also called to execute at the ends of WAVSYN/ NWVSYN, SYNSØL, and SPCTRM, besides its present location after ISOL. Subprograms FILTER and FØURIE are physically outside this internal execution order, and they can be called to execute individually only through ISIP.

e. Both WAVSYN and NWVSYN were originally programmed in ISIP. However, in this manual, WAVSYN has be deleted and only NWVSYN survives. Provision for the reinstatement of WAVSYN into ISIP, if needed, is readily availble.

f. Automatic NWVSYN-SYNSØL, or NWVSYN-SYNSØL-WVTRAN runs are provided for convience. In these combination runs, the output of the synthesized waveform can be printed and punched in a variety of output formats.

g. Automatic recycling of ISØL-SPCTRM run when ISIP is executed. The analysis of a platform due to X-Z ground excitation is first computed by ISØL, and the response spectra of various points in the platform are analyzed by SPCTRM. This process is then repeated for Y-Z excitation, and last, for an X-Y-Z excitation where X-Y ground excitation is combined first to formulate excitation arriving from a horizonal angle in the X-Y plane. This horizontal angle, currently set internally at 45°, can be changed or varied to cover any horizontal angle.

An abbreviated flow chart of ISIP is shown in Figure 2-13.

Program Limits. The limits of all subprograms are essentially the limits of ISIP. In addition, the computer system must have the program overlay capacity with six logical units (3, 11, 12, 13, 14 and 15). Without the overlay structure, however, a core size of 300,000 (decimal) words would be required.

ISIP Input Instructions. ISIP program reads only one program control card and one problem identification card. The rest of the input deck is read by the various subprograms. A comment card, optionally preceeded by one or more blank cards, must preceed each subprogram input dect. These comment

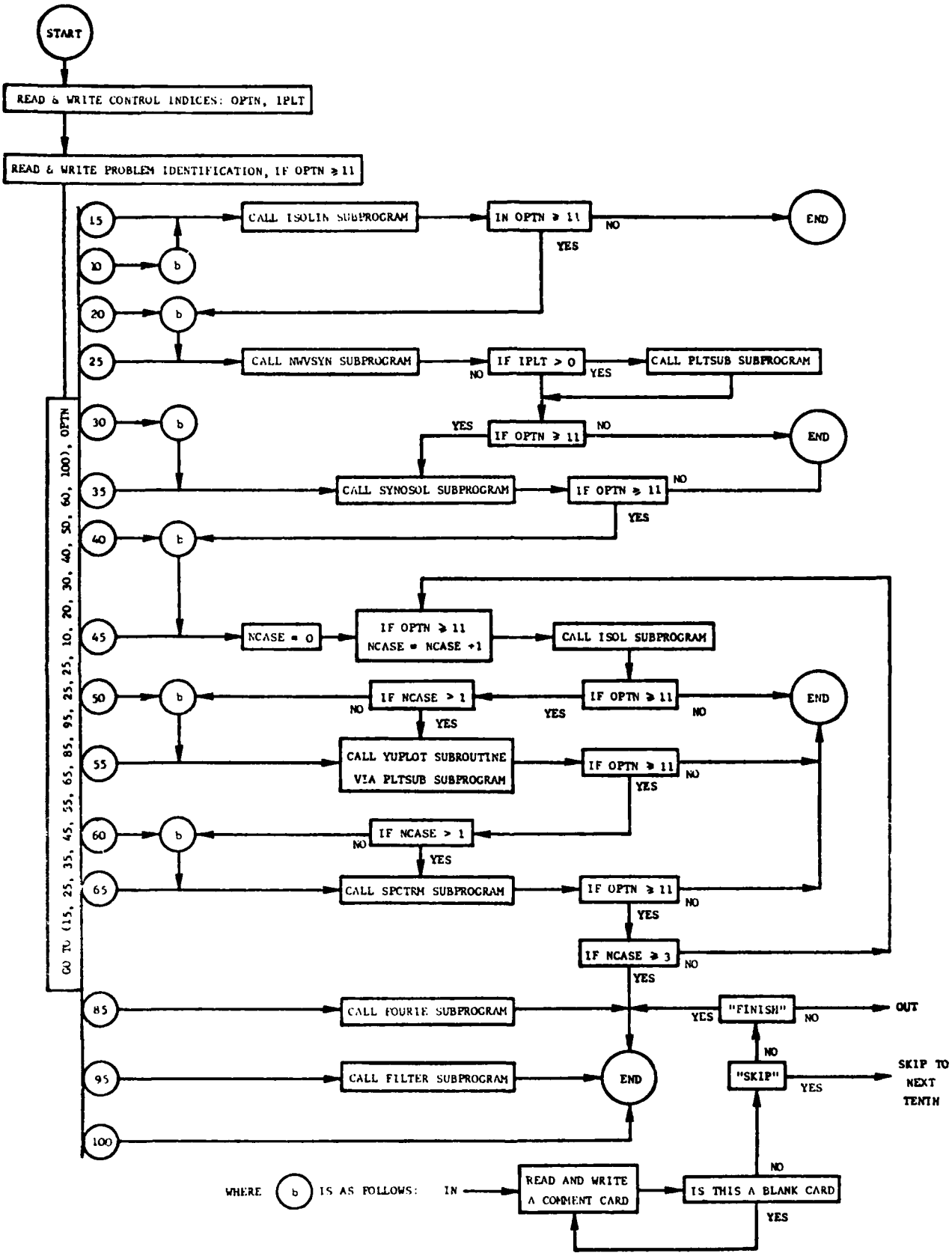


FIGURE 2-13. FLOW CHART OF ISIP PROGRAM

cards physically divide each subprogram input deck for easy identification, and can have any message, such as, 'Input deck to ISØLIN', 'INPUT to WAVSYN', etc. If the word "Skip" is punched in columns 1 through 4, in place of the comment card, that particular subprogram will be skipped. The word "Finish" punched in columns 1 through 6 will terminate a ISIP run. "Finish" is not needed for a complete ISIP run setup, from ISØLIN through SPCTRM.

A detailed explanation of input instructions follows:

a. Input to ISIP.

Number of cards = 2.

(1) The first card is as follows:

12345678	90123456	7892012345678930123456789401234567895012345678960123456789701234567898 0
ØPTN (I8)	IPLT (I8)	BLANK

ØPTN - An ISIP execution control index.

ØPTN = 1, only ISØLIN is executed
= 2, only NWVSYN is executed
= 3, only SYNSØL is executed
= 4, only ISØL is executed
= 5, only YUPLØT of PLTSUB is executed
= 6, only SPCTRM is executed
= 7, only FØURIE is executed
= 8, only FILTER is executed
= 9, NWVSYN and SYNSØL are executed
=10, NWVSYN-SYNSØL-WVTRAN are executed (see page 2-25)
=11, an ISIP run, starting from ISØLIN
=12, an ISIP run, starting from NWVSYN
=13, an ISIP run, starting from SYNSØL
=14, an ISIP run, starting from ISØL
=15, an ISIP run, starting from PLTSUB
=16, an ISIP run, starting from SPCTRM

IPLT - Plotting and plotter choice control index.

IPLT = 0, no plotting requested
= 1, plots, on CALCOMP pen plotter
= 2, plots, on SC4020 scope platter
= 3, plots, on line-printer

(2) The second card is an ID card. (Omitted if OPTN $\leq$ 10)

12345678901234567890123456789012345678901234567890123456789012345678901234567890	
TITLE(I), I = 1, 12 (12A6)	BLANK

TITLE(I) - Problem title. This title will be used throughout an ISIP run and its subprograms.

b. INPUT to ISØLIN

Input to ISØLIN begins with a comment card, then follows the entire deck of ISØLIN input, except group 1 - the program title card. (See User's Manual for ISØLIN Program)

c. INPUT to WAVSYN/NWVSYN

Input to WAVSYN/NWVSYN begins with a comment card, followed by the entire deck of WAVSYN/NWVSYN input. (See User's Manual for WAVSYN or NWVSYN). The user must synthesize the horizontal waveform first, and followed by the vertical case. Currently, only NWVSYN is in the ISIP run stream.

d. INPUT to SYNSØL

The only input card needed for SYNSØL in an ISIP run is the comment card.

e. INPUT to ISØL

The input stream begins with a comment card. The ISØL input portion is as follows:

ISØL individual run, (ØPTN = 4, See User's Manual for ISØL Program)	ISØL, as run through ISIP (ØPTN ≥ 11)
Group	Group
1. Program title	1. Omitted
2. Control indices: NA, NB, NC, ND, NE, NF, NG, NH (8I4)	2. Only NA, NB, NC, NE and NF require input values. Others = blank NA = 1, System initially at rest. = -1, Initial conditon of group 11 will be read. NB = 0,1 Linear spring/damper used. = -1, Nonlinear spring/damper used. = M, M extra spring/damper are to be read in from card reader (this will allow a user to input horizontal springs/dampers since ISØLIN sizes only the vertical spring isolators). NC = 0, no excitation force input. = 1, excitation forcing function read in from SYNSØL. =-N, excitation force tables, of length N, are read in from cards as before. NE = 0,1 4 points of interest are read in from ISØLIN. = -K, |K| points of interest will be read. |K| ≤ 4 NF, same input format as before.
3. Inertia data and coordinates	3. Omitted if NB = 0,1 Otherwise, same input format as before.
4. Coordinates of spring/damper	4. Omitted if NB = 0,1 Otherwise, same input format as before.
5. Data for short pendulums	5. Omitted

6. Data for spherical plates	6. Omitted
7. Coordinates of points of interest XP(I), YP(I), ZP(I) (4E8.0)	7. Omitted only when NE ≠ -K in Group 2. Otherwise, same input format as before.
8. Spring/damper characteristics. o Subgroup 1 o Subgroups 2 and 3 DF(J,I), J = 1, NX(I) FS(J,I), J = 1, NX(I) VD(J,I), J = 1, NY(I) FD(J,I), J = 1, NY(I) (10E8.0)	8. o Subgroup 1 omitted o Subgroups 2 and 3 Omitted when NB ≠ -1 in group 2. Otherwise, same input format as before.
9. Excitation tables	9. Omitted
10. Program constants TS, TF, DTI, DTP, TCP, DTPC, PLT, DCGX, DCGY, DCGZ (10E8.0)	10. Must be input as before. The plotting control index PLT is replaced by IPLT. See Input to ISIP.
11. Initial conditions. $\alpha, \beta, \gamma, \dot{\alpha}, \dot{\beta}, \dot{\gamma}, \dot{X}_{CBDX}, \dot{X}_{CBDY}, \dot{X}_{CBDZ}$ (9E8.0)	11. Omitted when NA ≠ -1 in group 2. Otherwise, same input format as before.

f. INPUT to YUPLØT of PLTSUB

Input to YUPLØT of PLTSUB begins with a comment card, then follows the entire deck of YUPLØT input. (See YUPLØT Input instructions in the User's Manual for PLTSUB program). A comment card is needed for YUPLØT even when no plotting is requested (IPLT in Input to ISIP is zero).

g. INPUT to SPCTRM

Input to SPCTRM begins with a comment card, followed by groups 1, 2, and 3 of SPCTRM input (See User's Manual for SPCTRM). NT of group 2 is not needed.

ISIP Output. The output of ISIP is almost identical to the conglomerate sum of the individual sub-programs. The values of ØPTN and IPLT are first printed on a page. The ID card of the ISIP input is printed at the beginning of each subprogram. An "end of input" statement is printed at the end of each sub-program input list to separate the input from the computation portion of the program. The rest of the outputs arriving from individual sub-programs are self-explanatory.

A Suggested Procedure in Running ISIP. A user of ISIP may find it essential to run WAVSYN or NWVSYN subprograms first, and repeat if necessary until the synthesized waveforms are satisfactory. The input to WAVSYN/NWVSYN of the satisfactory waveforms is then added to the ISIP input stream for a complete ISIP run starting from ISØLIN. The initial runs would normally use the line-printer or no plots at all. Plotting on a Calcomp plotter is time consuming, and should not be requested until the final analysis of the problem is completely satisfactory. A complete run from ISØLIN to SPCTRM without recycling the ISØL-SPCTRM loop, as discussed previously, will take 10 to 15 minutes of computer time in most computer systems (IBM-360, CDC-6400, and UNIV-1108). Twice as much time is needed when the ISØL-SPCTRM recycling loop is included .

12.0 USER'S MANUAL FOR PLTFRM PROGRAM

Program Features. In this program a three-dimensional stiffness matrix of a flat, horizontal and un-restrained platform is assembled using the structural finite element technique. Only the beam and linear spring elements are presently employed. One end of the spring element is grounded while the other end is attached to the platform. The stiffness of the beam element is modified to include the stiffening effect of any top and bottom platform panels. The system of units used is pound, inch, and second (lb., in., and sec.). A stiffness matrix of the platform is developed and inverted to give the flexibility matrix of the system.

The platform is described by its node points (or joints) where the beam elements are connected. (See Section 5.2). The position of the node points are defined by the coordinates of a X-Y-Z coordinate system. Six-degrees-of-freedom (DOF) are associated at each node point with the following sequential order:

DOF[(n-1)*6 + 1] = translational displacement (or force) along X axis of the n-th node

DOF[(n-1)*6 + 2] = translational displacement (or force) along Y axis of the n-th node

DOF[(n-1)*6 + 3] = translational displacement (or force) along Z axis of the n-th node

DOF[(n-1)*6 + 4] = torsional displacement (or torque) about X axis (θ_x axis) of the n-th node

DOF[(n-1)*6 + 5] = torsional displacement (or torque) about Y axis (θ_y axis) of the n-th node

DOF[(n-1)*6 + 6] = torsional displacement (or torque) about Z axis (θ_z axis) of the n-th node

Figure 2-14 shows the flow chart of PLTFRM computer program.

Program Limits

Maximum number of Node points	22 (for a 32K computer)
Number of beam and spring elements	Unlimited
Material limitation (presently)	Steel and Aluminum
Joints	Rigid

Platform and beam elements	On X-Y plane
Node point identification number	In sequential order, no missing node
Beam's length-to-thickness ratio	5 or more

The platform's boundary condition is un-restrained except through the grounded ends of the spring isolators. The maximum number of node points is increased to 37 (estimated) if a 64,000 (decimal) word computer is used, and to 50 (estimated) for a 96,000 word computer. As a general structural program, PLTFRM contains a minimum capability for finite element analysis. Further improvement, with a more sophisticated matrix handling and reduction scheme, could greatly increase the platform size limit (in terms of its node point numbers).

PLTFRM Input Instructions. There are six groups of input data as follows:

a. Program option indices
b. Project title or identification
c. Program control indices
d. Node point coordinates
e. Beam input data
f. Spring isolator input data

A detailed explanation of each group follows:

Group 1 - Program Option

Number of cards = 1

12345678	9D12345678920123456789301234567894012345678950123456789601234567897012345678980
ØPTN (I8)	BLANK

ØPTN - a '1' in column 8 signals a PLTFRM run.

Group 2 - Project Title

Number of Cards = 1

12345678	9D12345678920123456789301234567894012345678950123456789601234567897012345678980
ID(I), I=1, 12 (12A6)	BLANK

Any alpha-numeric data can be inputed in columns 1 through 72 on this card.

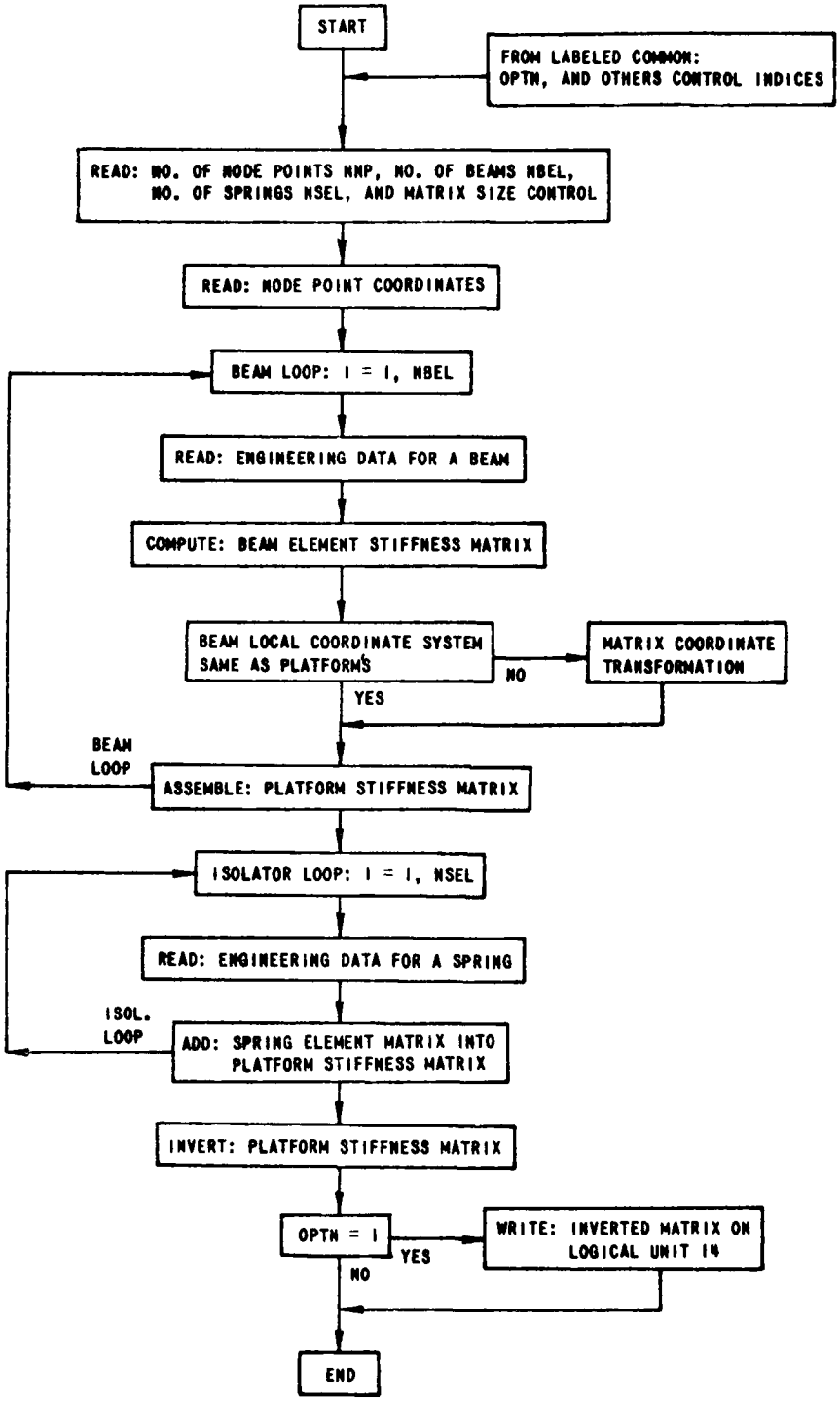


Figure 2-14. Flow Chart of PLTFRM Program

Group 3 - Control Indices

Number of cards = 1

12345678	9012345678	9201234567	8930123456	7894012345	6789501234	5678960123	4567897012	3456789801	2345678901
NNP (I8)	NBEL (I8)	NSEL (I8)	NSIZE (I8)	BLANK					

NNP - Total number of nodes used in the platform system (must equal the largest node number)

NBEL - Total number of beam elements

NSEL - Total number of spring elements

NSIZE - Matrix size printout control:
Matrices bigger than NSIZE are not printed,
Matrices are not printed if NSIZE = 1.
Default value = 36.

Group 4 - Node Point Coordinates

Number of cards = NNP

12345678	9012345678	9201234567	8930123456	7894012345	6789501234	5678960123	4567897012	3456789801	2345678901
NP (I8)	XC (F8.0)	YC (F8.0)	BLANK						

NP - Node point number, integer, 1 through NNP

XC, YC - X and Y coordinates of NP, in. (Z coordinate of NP = 0)

Group 5 - Beam Input Data

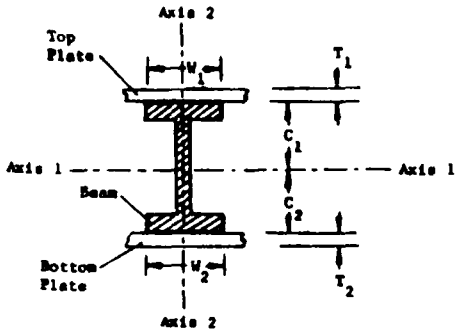
Number of cards = NBEL

12345678	9012345678	9201234567	8930123456	7894012345	6789501234	5678960123	4567897012	3456789801	2345678901
N1(I3) N2(I3) MAT(A2	I1 (F8.0)	I2 (F8.0)	A (F8.0)	C1 (F8.0)	C2 (F8.0)	W1 (F8.0)	W2 (F8.0)	T1 (F8.0)	T2 (F8.0)

N1, N2 - First and second node points of the beam elements.

MAT - Material selection:
ST for steel
AL for aluminium
** indicates that the current beam is identical to the previous one. Input data for the rest of this card are not needed.

I1, I2 - Area moment of inertia about 1-1, and 2-2 axis, in^4



A - Crossectional area, in^2

C1,C2 - Distance from neutral axis to extreme most fibers of beams, in. (See diagram above.)

W1,W2 - Beam top and bottom widths, in. (See diagram above.)

T1,T2 - Top and bottom plate thicknesses, in. (See diagram above.)

Group 6 - Spring [illegible]

(Omit this group [illegible]

Number of Cards - [illegible]

12345678	90123456	7890123	4567890	1234567	8901234	5678901	2345678	90
N3 (I8)	R1 (F8.0)	R2 (F8.)	R3 (F8.0)	R4 (F8.0)	R5 (F8.0)	R6 (F8.0)	BLANK	

N3 - Node point number on platform where spring attaches

NOTE: The other end of spring is attached to ground.

R1, R2, R3 - Translational spring rates along X, Y, Z axes of the platform system lb/in

R4, R5, R6 - Torsional spring rates about X, Y, Z axes of the platform system in-lb/rad

Messages of PLTFRM. Warning messages are printed if there are input errors. Messages include:

- Maximum node points are exceeded
- Node points are not in sequence (i.e., there is at least one missing node).
- Material selection error
- 'Stop 777' is printed out if the stiffness matrix has no inverse

PLTFRM Output. The program output is in the following order:

- Project title
- Group 3 input data
- Node point coordinates
- Stiffness matrices of input beam elements
- Spring rates of spring isolators
- Platform stiffness matrix

The flexibility matrix of the platform is not printed by the program. The matrix is recorded on logical unit 14, for later use.

PLATFORM Boundary Conditions. In order that the stiffness matrix of the platform structure can be inverted to give the flexibility matrix, as required by FVØUS program, the platform must be constrained, through the use of the spring isolator elements, to eliminate the presence of the rigid body modes. A message - "Flex. matrix in doubt" is printed if the inversion process is in error due to matrix singularity.

13.0 USER'S MANUAL FOR FVØUS PROGRAM

Program Features. The free vibration of an un-restrained structure is analyzed in FVØUS by the normal mode technique described in Section 4.4. FVØUS accepts either the mass and spring input data for a rigid platform analysis, or the flexibility matrix of a non-rigid platform from any structural program such as PLTFRM. A linear shock isolation system is assumed in both cases. Figure 2-15 shows the flow chart of FVØUS.

Program Limits

Maximum degrees-of-freedom	132 (for a 32K computer)
	222* (for a 64K computer)
(*Estimated)	300* (for a 96K computer)
Number of weight points	144
Number of springs	Unlimited
Maximum number of normal nodes	20
Maximum data points on spectrum tables	20

Nine response spectra are input in one analysis. Three response spectra are in each of the three principal directions with three damping values of 0%, 5%, and 10%.

FVØUS Input Instructions. The input can be divided into nine groups. They are:

a. Program option indices
b. Project title or identification
c. Weights, their coordinates and moments of inertia with respect to X, Y, Z axes.
d. Spring constants and their attachment coordinates
e. Flexibility matrix
f. Inertia matrix or lumped weight
g. Program control indices
h. Frequency table
i. Shock response tables in X, Y, Z directions corresponding to given frequency table

Group 1 - Program Option

Number of cards = 1

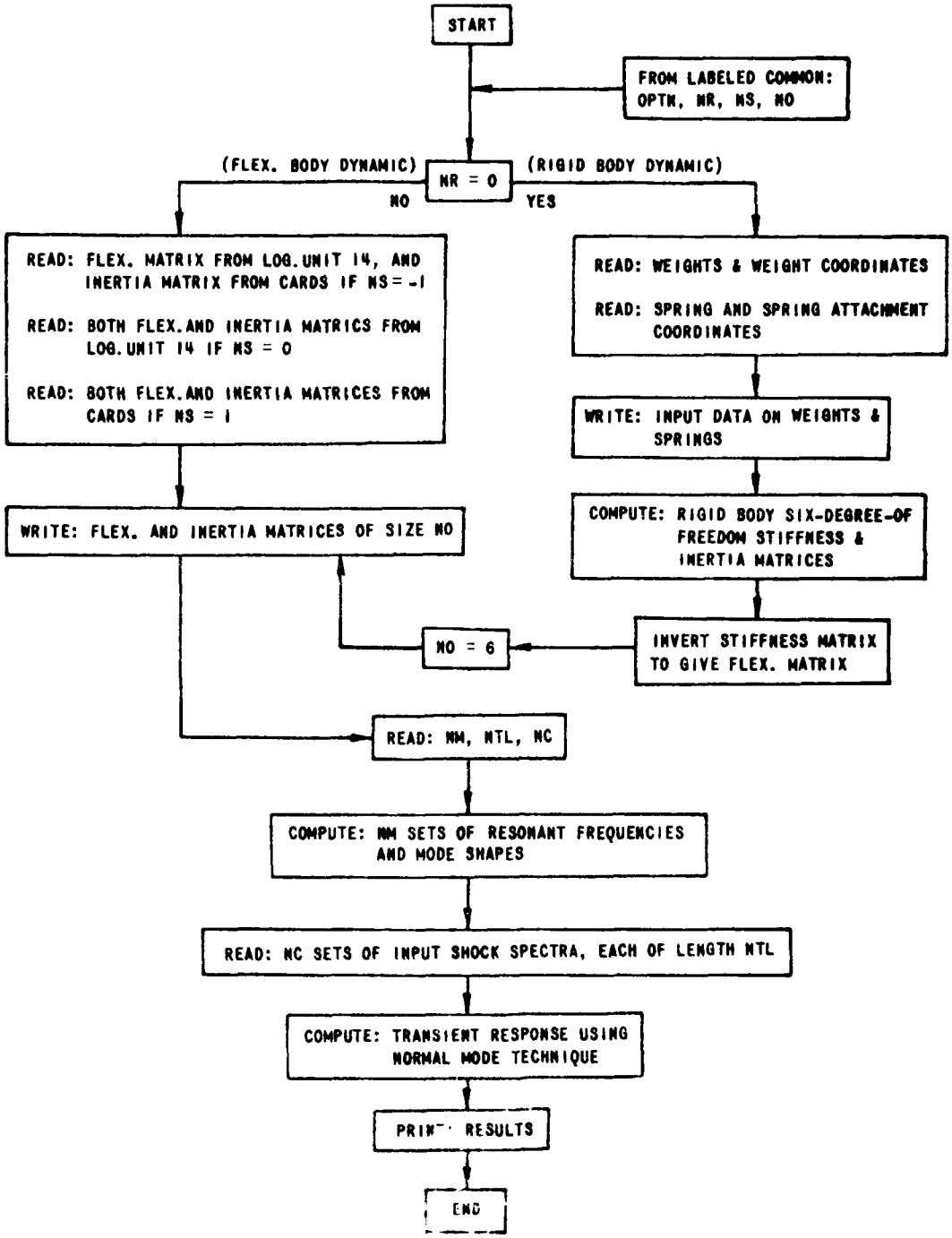


Figure 2-15. Flow Chart of FVØUS Program.

12345678	9012345678	9201234567	8930123456	7894012345	6789501234	5678960123	4567897012	3456789801
ØPTN (I8)	NR (I8)	NS (I8)	NØ (I8)	BLANK				

ØPTN - A '2' in column 8 signals a FVØUS run

NR - Choice of rigid (NR = 0) or non-rigid (NR = 1) structural analysis

NS - Flexibility matrix retrieval control

-1, matrix in core

0, matrix read in from logical unit 14

1, matrix read in from card reader

NØ - Dimension of flexibility matrix

NOTE: No input for NS and NØ if NR = 0

Group 2 - Program Title

Number of cards = 1.

12345678	9012345678	9201234567	8930123456	7894012345	6789501234	5678960123	4567897012	3456789801
ID(I), I=1, 12 (12A6)								BLANK

Any alpha-numeric data can be used as an input starting with column 1 thru column 72 on this card.

Group 3 - Weights, Weight Coordinates and Moments of Inertia

(Omit this group through group 6 if NR = 1)

Number of cards = up to 144

12345678	9012345678	9201234567	8930123456	7894012345	6789501234	5678960123	4567897012	3456789801
AM(K) (F10.0)	XM(K) (F10.0)	YM(K) (F10.0)	ZM(K) (F10.0)	AMX(K) (F10.0)	AMY(K) (F10.0)	AMZ(K) (F10.0)	BLANK	

AM - Weight of each mass point, lb.

XM, YM, ZM - X, Y, Z coordinates of AM, in.

AMX, AMY, AMZ - Moments of inertia of AM with respect to X, Y, and Z axes

Group 4

Number of cards = 1

A blank card signals the end of ground 3.

Group 5 - Spring Constants and Spring Attachment Coordinates

Number of cards = no limit

12345678910	12345678920	12345678930	12345678940	12345678950	12345678960	12345678970	12345678980
AK (F10.0)	XA (f10.0)	XB (F10.0)	YA (F10.0)	YB (F10.0)	ZA (F10.0)	ZB (F10.0)	BLANK

AK - Spring constant

XA, XB - Coordinate of spring at both ends in X direction

YA, YB - Coordinate of spring at both ends in Y direction

ZA, ZB - Coordinate of spring at both ends in Z direction

(Point A on Platform, B on ground)

Group 6

Number of cards = 1

A blank card signals the end of ground 5.

Group 7 - Flexibility Matrix

(Omit this group and next if NR = 0)

(Omit this group if NS = 0)

Number of cards = (NØ*NØ)/6

12345678910	12345678920	12345678930	12345678940	12345678950	12345678960	12345678970	12345678980
		AK(I, J), I=1, NØ, J=1, NØ (6E12.8)					BLANK

AK - Flexibility matrix

Group 8 - Lumped Weight

(Omit this group if NS = 0)

Number of cards = NØ/6

12345678910	12345678920	12345678930	12345678940	12345678950	12345678960	12345678970	12345678980
		AM(I), I=1, NØ (6F10.0)					BLANK

AM - Weight and moments of inertia with respect to X, Y, Z axes, lbs and lb-in-sec^2

Group 9 - Program Control Indices

Number of cards = 1

12345678	9D12345678	9201234567	8930123456789401234567895012345678960123456789701234567898 0
NM (I8)	NTL (I8)	NC (I8)	BLANK

NM - Number of normal mode to be computed

NTL - Number of points on shock spectrum

NC = 0, No spectrum is read in.

= M sets of spectra will be read in. (A set consists of 9 spectrum tables as discussed in "Program Limits".)

Group 10 - Frequency Table

Number of cards = (NTL + 8)/9

12345678	9D12345678	9201234567	8930123456789401234567895012345678960123456789701234567898 0				
			CPSTAB (I), I=1, NTL (9F8.0)				BLANK

CPSTAB - Frequency table, Hz

Group 11 - Spectrum Displ. Amplitude Tables

Number of cards = 9*((NTL +8)/9)

12345678	9D12345678	9201234567	8930123456789401234567895012345678960123456789701234567898 0				
			TABOX (I), I=1, NTL (9F8.0)				BLANK

12345678	9D12345678	9201234567	8930123456789401234567895012345678960123456789701234567898 0				
			TABOY (I), I=1, NTL (9F8.0)				BLANK

12345678	9D12345678	9201234567	8930123456789401234567895012345678960123456789701234567898 0				
			TABOZ (I), I=1, NTL (9F8.0)				BLANK

12345678	9D12345678	9201234567	8930123456789401234567895012345678960123456789701234567898 0				
			TAB5X (I), I=1, NTL (9F8.0)				BLANK

12345678901234567890123456789012345678901234567890123456789012345678901234567890							
			TAB5Y (I), I=1, NTL (9F8.0)				BLANK

12345678901234567890123456789012345678901234567890123456789012345678901234567890							
			TAB5Z (I), I=1, NTL (9F8.0)				BLANK

12345678901234567890123456789012345678901234567890123456789012345678901234567890							
			TAB10X (I), I=1, NTL (9F8.0)				BLANK

12345678901234567890123456789012345678901234567890123456789012345678901234567890							
			TAB10Y (I), I=1, NTL (9F8.0)				BLANK

12345678901234567890123456789012345678901234567890123456789012345678901234567890							
			TAB10Z (I), I=1, NTL (9F8.0)				BLANK

TABOX,TABOY,TABOZ - Shock spectrum amplitudes in X, Y, Z directions for zero damping, in.

TAB5X,TAB5Y,TAB5Z - Shock spectrum amplitudes in X, Y, and Z directions for 5% damping, in.

TAB10X,TAB10Y,TAB10Z - Shock Spectrum amplitudes in X, Y, and Z directions for 10% damping, in.

Output Data. Output data from the program can be divided into two parts. The first part is the printout of input data and the second part is the printout of calculated results. The results are divided into nine groups.

Group 1 [illegible] matrix (6 x 6) - for rigid body motions only.

Group 2 [illegible] matrix [illegible] - for rigid body motions only.

Group 3 [illegible] matrix ([illegible]) - for rigid body motions only.

Group 4 [illegible] flexibility matrix (NØ x NØ) - for flexible body motions only.

Group 5 [illegible] matrix (NØ x [illegible]) - for flexible body motions only.

Group 6 Eignevectors (NM sets).

Group 7 Participation factor (NM sets).

Group 8 Orthogonality check (NM x NM).

Group 9 Response data. For rigid body motion, the program prints out the relative displacements and absolute accelerations of the C.G. in X, Y, Z directions and the angular displacements and accelerations of the system with respect to X, Y, Z axes passing through C.G. For flexible body motions, the program prints out the relative displacements and absolute accelerations of each mass point in the X, Y, Z directions and the angular displacements and accelerations of the system with respect to the X, Y, Z axes of the mass point.

14.0 USER'S MANUAL FOR ISIP2 PROGRAM

Program Features. ISIP2 is an overlay computer program automatically linking the PLTFRM and FVØUS programs for non-rigid platform analysis. Figure 2-16 shows the overlay structure of ISIP2.

Program Limits. The program limits are the same as those in PLTFRM and FVØUS.

ISIP2 Input Instruction. The input to ISIP2 is the combination of the input to PLTFRM plus that to FVØUS, except the group 1's of both programs, and group 2 through 7 of FVØUS are not used. A new group 1 input, with a '3' in column 8 (one card), preceeds the combined input deck, signaling a ISIP2 run.
Number of cards = 1

12345678	9012345678901234567890123456789012345678901234567890123456789012345678901234567890
ØPTN (I8)	BLANK

ØPTN - A '3' in column 8 signals a ISIP2 run.

ISIP2 Output. The output of ISIP2, including any warning messages and computed results, are the combined outputs of PLTFRM and FVØUS.

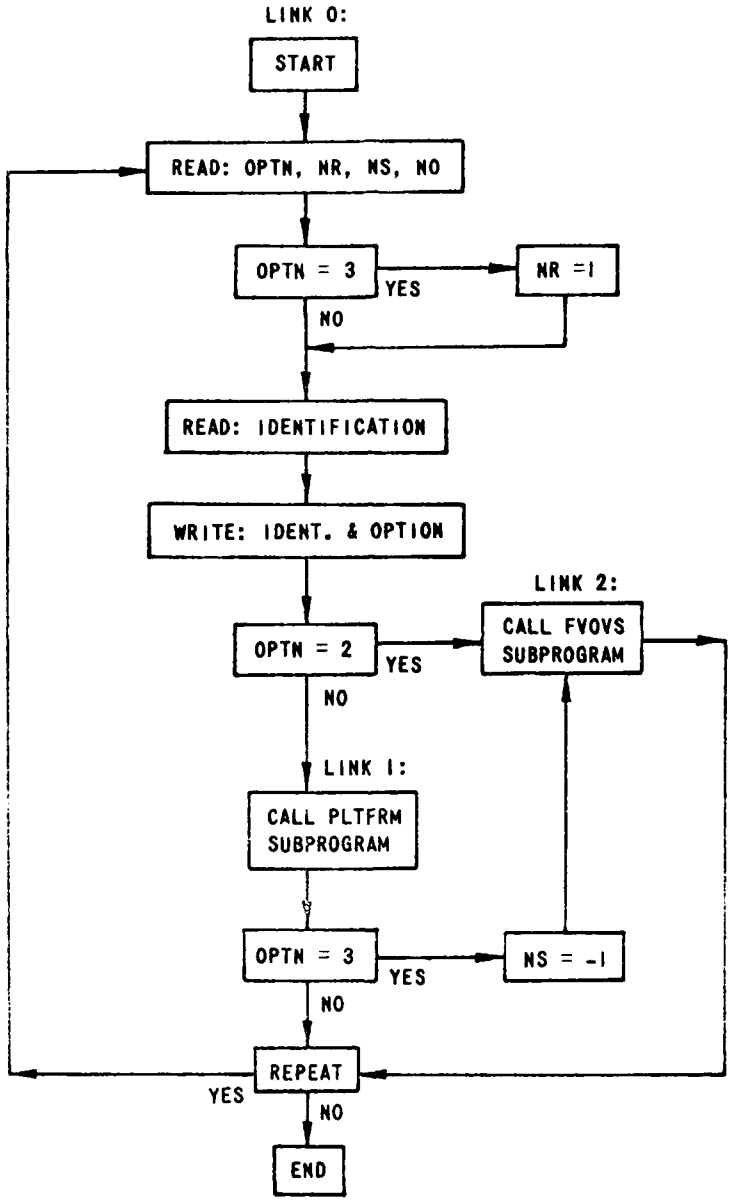


Figure 2-16. Flow Chart of ISIP2 Program

PART III

ISIP AND ISIP2 PROGRAM LISTINGS

SECTION 1: ISIP LISTING

```
      OVERLAY (ISICP,0,0)
      PROGRAM CONTRL (INPUT=193,OUTPUT=193,PUNCH=193,TAPE5=INPUT,TAPE6=
     X       OUTPUT,TAPE7=PUNCH,TAPE3=513,TAPE11=513,TAPE12=513,TAPE13
     Y       =513,TAPE14=513,TAPE15=513)
      COMMON /OPTION/OPTN,IPLT,LU11,LU12,LU13,LU14,LU15
      COMMON /ID12/ID(12),NVAL
      COMMON /WSL/X(9)
      COMMON /NSN/NS(3)
      COMMON /ARRY/NCASE,CMARY(22)
      COMMON /LLOT/LOT(25)
      INTEGER OPTN
      EQUIVALENCE (ISOLIN,WAVSYN,SYNSOL,ISOL,SPCTRM,NWVSYN,PLTSUB,FOURIE
     1            ,FILTER)
      DATA LU11,LU12,LU13,LU14,LU15/11,12,13,14,15/
      DATA ISOLIN/5HISICP/
C
C     ******* ISIP  -  VERSION 3.0, SEPT. 1973 *******
C
C        CORE REQUIREMENT     - 32K, DECIMAL, OR 77K, OCTAL WORDS.
C        TAPE (DISC OR DRUM)  -  UNITS 3,11,12,13,14, AND 15 FOR OVERLAY RUN
C                             -  NONE, FOR NON-OVERLAY RUN
C                             -  MAGNETIC TAPE UNIT 3, IF RESULT OF ISOL IS TO BE
C                                STORED FIRST, AND PLOTTED LATER.
C
C     ISIP (INTEGRATED SHOCK ISOLATION PROGRAM) IS A CONGLOMERATE OF EIGHT
C     SUBPROGRAMS, INTEGRATED BY G. CHAN/SPERRY RAND, SPACE SUPPORT  DIVISION,
C     HUNTSVILLE, ALA.    TEL. NO. (205) 533-3708
C
C     SEVEN OF THESE SUBPROGRAMS -ISOLIN,WAVSYN/NWVSYN,SYNSOL,ISOL,PLTSUB, AND
C     SPCTRM- CAN BE CALLED TO EXECUTE INDIVIDUALLY, OR SEQUENTIALLY WITH OPTION
C     TO SKIP, OR TERMINATE AT THE END OF EACH SUBPROGRAM RUN.  SUBPROGRAMS
C     FILTER AND FOURIE CAN BE EXECUTE ONLY INDIVIDUALLY.
C
C     ISOLIN, WAVSYN, SPCTRM, AND ISOL WERE DEVELOPED BY PARSONS COMPANY OF L.A.
C     UNDER CONTRACT NO. DACA01-67-C-0016 WITH THE U.S. ARMY ENGINEER DIV.,
C     HUNTSVILLE.   ISOLIN PREPARES ENGINEERING DATA TO BE USED IN ISOL.  WAVSYN
C     (RE-  DOCUMENT NOS. SAF-64 AND SAF-82) SYNTHESIZES ACCELERATION-TIME
C     HISTORY FROM A GIVEN SHOCK SPECTRUM SPEC, AND THE RESULT IS TO BE USED AS
C     EXCITATION FUNCTION FOR THE ISOL PROGRAM.  SPCTRM TRANSFORMS ACCELERATION
C     -TIME HISTORY CURVE BACK TO SHOCK SPECTRUM.  ISOL (RE-  DOCUMENT NO. SAF-
C     37) ANALYZES A RIGID PLATFORM WITH SHOCK ISOLATION MOUNTS (UNDER-FLOOR,
C     PENDULUM, OR ROLLING BALL MOUNT), UNDER TRANSIENT EXCITATION ENVIROMENT.
C     CHANGES,MODIFICATIONS, AND ADDITIONS TO THESE SUBPROGRAMS ARE WELL MARKED.
C
C     SYNSOL WAS DEVELOPED BY G. CHAN/SPERRY RAND, FOR DATA INTERFACING BETWEEN
C     WAVSYN AND ISOL, SUCH THAT THE OUTPUT OF WAVSYN IS COMPATIBLE TO ISOL
C     INPUT FORMAT.
C
C     WAVSYN COMPUTER PROGRAM HAS BEEN DELETED.  USE NWVSYN INSTEAD.    2/73
C
C     PLTSUB IS A PLOTTING SUBROUTINE USING CAL-COMP PLOTTER OR SC4020 SCOPE
C     PLOTTER. THE YUPLOT SUBROUTINE IN PLTSUB WAS ORIGINALLY DEVELOPED BY
C     PARSONS, AND WAS LATER EXTENSIVELY REVISED BY G. CHAN. THE SC4020 PLOTTING
C     PACKAGE AND THE LINE-PRINTER PLOTS OF THE COMPUTED SPECTRA IN WAVSYN AND
C     AND IN SPCTRM WERE DEVELOPED BY G. CHAN OF SPERRY.
C
C     THOSE FORTRAN STATEMENTS BEING MODIFIED BY G.CHAN ARE MARKED BY A STAR (*)
```

```
C     IN COLUMN 79.
C
C     RUN OPTION SWITCH .......  OPTN
C      * EACH PROGRAM (ISOL,WAVSYN, ETC.) WILL RUN INDEPENDENTLY IF OPTN .LE. 10
C      * PROGRAMS WILL RUN SEQUENTIALLY IF OPTN .GT. 11.  SEE ≠GO TO (...),OPTN≠
C      * RUNNING STREAM ....   OPTN=1,11   ISOLIN
C                                  =2,12   WAVSYN/NWVSYN
C                                  =3,13   SYNSOL
C                                  =4,14   ISOL
C                                  =5,15   PLTSUB
C                                  =6,16   SPCTRM
C                                  =7      FOURIE ONLY
C                                  =8      FILTER ONLY
C                                  =9      NWVSYN-SYNSOL
C                                  =10     NWVSYN-SYNSOL-WVTRAN
C
C     NOTE..  FOURIE AND FILTER ARE TO BE RUN INDEPENDENTLY.
C
C     CHOICE OF PLOTTING AND PLOTTER.....
C        IPLT = 0, FOR NO PLOTTING,
C             = 1, PLOTTING, ON CAL-COMP PLOTTER,
C             = 2, PLOTTING, ON SC 4020 SCOPE PLOTTER,  AND
C             = 3, PLOTTING, ON-LINE PRINTER.
C
C     INPUT SEQUENCE ******
C        1. PROGRAM OPTION AND PLOTTING CHOICE CARD                    (2I8)
C        2. PROBLEM ID CARD                                            (12A6)
C        3. INDIVIDUAL SUBPROGRAM INPUT ID CARD (OVERLAY RUN ONLY)     (12A6)
C        4. INDIVIDUAL SUBPROGRAM INPUT DATA DECK
C        *  EXTRA BLANK CARD(S) AT END OF 4 IS PERMISSIBLE IN AN OVERLAY RUN
C        5. SKIP OR FINISH OPTION CARD BETWEEN SUBPROGRAMS (OVERLAY RUN ONLY)
C                                                                      (1A6)
C
C     OVERLAY STRUCTURE OF ISIP  ****
C
C        -LEVEL 1-                  -LEVEL2-
C                      ** ISOLIN (ISICP,6,0)/OR (LINK2)
C                     *   WAVSYN (ISICP,3,0)/OR (LINK3)
C          CONTRL     *   SYNSOL (ISICP,5,0)/OR (LINK4)
C      (LINK1)/OR ***    ISOL   (ISICP,1,0)/OR (LINK5)
C      (ISICP,0,0)    *   SPCTRM (ISICP,4,0)/OR (LINK6)
C                     *   NWVSYN (ISICP,7,0)/OR (LINK8)
C                     *   PLTSUB (ISICP,2,0)/OR (LINK7)
C                     *   FOURIE (ISICP,11,0)/OR (LINK9)
C                      ** FILTER (ISICP,10,0)/OR (LINK10)
C
C     THE BLANK COMMONS ON LOWER LINKAGES ARE NOT RELATED IN THIS CCC VERSION.
C     IN SOME MACHINES, SUCH AS UNIVAC 1108, THEY SHOULD BE CHANGED TO LABELED
C     COMMONS TO BE DISTINGUISHABLE FORM ONE ANOTHER.  FOR IBM TYPE MACHINES,
C     WHICH PUT ALL LABELED COMMONS INTO THE MAIN LINKAGE, SOME EQUIVALENCE
C     TECHNIQUES CAN BE USED TO RECLAIM CORE SPACE.
C
C     ANY FORTRAN CHANGE BY G.CHAN IS MARKED BY A STAR (*) IN COLUMN 79.
C
      REWIND 3                                                          16
      REWIND LU11                                                       17
      REWIND LU12                                                       18
      REWIND LU13                                                       19
```

```
      REWIND LU14
      REWIND LU15
C     THE FOLLOWING 4 STATEMENTS ARE FOR CDC COMPUTER ONLY...
      READ (3) X(1)
      WRITE (3) X(1)
      ENDFILE 3
      REWIND 3
      WRITE (6,1)
 1    FORMAT (1HR)
C     THE 1HR ASKS FOR 60 LINES PER PAGE PRINTOUT FORMAT - A CDC SPECIALTY.
      READ (5,2) OPTN,IPLT
 2    FORMAT (2I5)
      IF (OPTN .EQ. 7 .OR. OPTN .EQ. 8) IPLT=0
      WRITE (6,3) OPTN,IPLT
 3    FORMAT (1H1,//5X,14HOPTION, PLOT =,2I7/)
C     OPEN CALCOMP/SC4020 PLOTTER HERE IF SYSTEM ALLOWS.
      IF (OPTN .LE. 10) GO TO 9
      READ (5,7) ID
      WRITE (6,5) ID
 5    FORMAT (1H1,//10X,12A6,//)
 7    FORMAT (12A6)
 9    NCASE=1
      ISK=0
      JSK=0
      GO TO (15,25,35,45,55,65,85,95,25,025,10,20,30,40,50,60,100), OPTN
C     OPTN =  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16  17
 10   CALL CHECK, RETURNS(15,20,100)
 15   CALL OVERLAY (ISOLIN,6,0)
      IF (OPTN .LE. 1) GO TO 100
 20   CALL CHECK, RETURNS(25,30,100)
 25   NCASE=2
C     WAVSYN COMPUTER PROGRAM HAS BE REPLACED BY NWVSYN HERE.
      IF (OPTN .EQ. 2930) CALL OVERLAY (WAVSYN,3,0)
      CALL OVERLAY (NWVSYN,7,6)
      NVAL=3
      IF (IPLT .NE. 0) CALL OVERLAY (PLTSUB,2,0)
      IF (OPTN .LE. 2) GO TO 100
 30   IF (OPTN .GE. 11) CALL CHECK, RETURNS(35,40,100)
 35   CALL OVERLAY (SYNSOL,5,0)
      IF (OPTN .LE. 10) GO TO 100
 40   CALL CHECK, RETURNS(45,50,100)
 45   NCASE=0
 47   IF (OPTN .GE. 11) NCASE=NCASE+1
      CALL OVERLAY (ISOL,1,0)
      IF (OPTN .EQ. 14) GO TO 50
      IF (NCASE .GT. 1) GO TO 53
      IF (IPLT .GT. 0) GO TO 50
      IF (OPTN .LE. 4) GO TO 100
 50   CALL CHECK, RETURNS(55,60,100)
 53   IF (ISK .EQ. 0) GO TO 67
 55   NVAL=4
      IF (IPLT .NE. 0) CALL OVERLAY (PLTSUB,2,0)
      IF (IPLT .NE. 0) ISK=ISK+1
      IF (ISK .GT. 1) GO TO 67
      IF (OPTN .LE. 5) GO TO 100
 60   CALL CHECK, RETURNS(65,70,100)
 65   IF (OPTN .LE. 10) NCASE=0
      JSK=1
```

```
67    IF (JSK .NE. 0) CALL OVERLAY (SPCTRM,4,0)
      IF (OPTN .LE. 6) GO TO 100
70    CONTINUE
      IF (OPTN .EQ. 14) GO TO 40
      IF (NCASE.GT.0 .AND. NCASE.LT.3) GO TO 47
      GO TO 100
85    CALL OVERLAY (FOURIE,9,0)
      GO TO 100
95    CALL OVERLAY (FILTER,9,0)
100   WRITE (6,105)
105   FORMAT (/////5X,15HEND OF ANALYSIS,/1H1)
C     CLOSE CALCOMP/SC4020 PLOTTER HERE IF SYSTEM ALLOWS.
      END
```

```
      SUBROUTINE CHECK, RETURNS(K,L,M)
      DIMENSION II(8)
      DATA IFNSH,ISKIP,IBLNK/10HFINISH    ,10HSKIP      ,10H          /
      WRITE (6,10)
10    FORMAT (1H1)
20    READ (5,30) II
30    FORMAT (8A10)
      IF (II(1) .EQ. IFNSH) RETURN M
      IF (II(1) .EQ. ISKIP) RETURN L
      DO 40 J=1,8
      IF (II(J) .NE. IBLNK) GO TO 50
40    CONTINUE
      GO TO 20
50    WRITE (6,60) II
60    FORMAT (//25X,8A10////)
      RETURN K
      END
```

```
      OVERLAY (ISICP,1,0)
      PROGRAM ISOL
      COMMON /OPTION/IOP,IPLT,IL
      COMMON /WSL/NO(8),NV
      COMMON /NSN/NA,NB,NC,ND,NE,NF,NG,NH
      COMMON XH(50),WT(50),XXI(50),YYI(50),ZZI(50),XYI(50),XZI(50),
     1YZI(50),YM(50),ZM(50),XE(501),NX(50),NY(50),SL(50),SK(50),
     2DA(50),FS(20,50),DF(20,50),FD(20,50),VD(20,50),YE(501),ZE(501),
     3TTAB(501),RI(3,3),TI(3,3),RINV(3,3),TINV(3,3),A(3,3),AT(3,3),
     4ADOT(3,3),PSI(3,3),ATEMP(3,3),BTEMP(3,3),XCB(3),
     5XCBD(3),XCIDD(3),XBIDD(3),XCBDD(3),
     6AMASS(3),OM(3),OMD(3),AL(3),AVEC(3),BVEC(3),FORCE(3),
     7ZETA(3),XT(3,50),XR(3,50),PHI(3,3,50),F(3,50),ALEL(3,50),
     8XEL(3,50),XELD(3,50),DEF(50),DDEF(50),SLMAG(50),FSEL(50),FDEL(50),
     9DCB(3),OCBD(3),OCBDD(3),XP(4),YP(4),ZP(4),XTD(3,50),FFL(50),
     XXA(50),YA(50),ZA(50),XB(50),YB(50),ZB(50),DVAL(3),EVAL(3),OMI(3),
     XONI(3),ON(3),OND(3),ANEW(3,3),ADNU(3,3),        XPR(3,4),XPDD(3,4),
     X XPT(3,4),COMAX(3),CBMIN(3),AGMAX(3),ACMIN(3),TCBMAX(3),TCBMIN(3),
     XTACMAX(3),TACMIN(3),DX(50),DY(50),SLG(50),UM(50),R(50),XBO(50),
     XYBO(50),ZBO(50),XPB(3,50),U(3,50)
      COMMON /CMI/T(300),TSXJC5,NPASS,ALPA,RR,SW1,SW2,DECRH,INCRH
      COMMON /ARRY/NCASE,TS,TF,DTI,DTP,TCP,DTPC,PLT,DCGX,DCGY,DCGZ,XS,
     X YS,ZS,ALPHA,BETA,GAMMA,ALDOT,BETDOT,GAMDOT,XCBDX,XCBDY,XCBDZ
      EQUIVALENCE (T,NUM1)
      DATA GRAV,RADC,MXSZ/386.4,0.0174533,9800/
C
C     IF IOP IS GREATER THAN 10 (BUT NOT 14), SKIP INPUT GROUPS 1,2,3,4,6,7, AND
C     PARTALLY 8 AND 9.  (SEE SUBROUTINE INPUT WHICH HANDLES INPUT READINGS)
C     HOWEVER, IOP 14 IS ESSENTIALLY SAME AS IOP 4, EXCEPTS PLTSUB AND SPCTRM
C     PROGRAMS WILL BE EXECUTED AUTOMATICALLY AFTER ISOL.
C
    1 FORMAT(72H
     1                )
    2 FORMAT(18I4)
    3 FORMAT(//11H INPUT DATA//5H  NA=I4,5H  NB=I4,5H  NC=I4,5H  ND=I4,
     1        5H  NE=I4,5H  NF=I4,5H  NG=I4,5H  NH=I4//)
    4 FORMAT(10E8.0)
C     THE FOLLOWING 4 CARDS CHANGED BY HND 70 DEC 14
    5 FORMAT(44H MASSES, COORDINATES, AND MOMENTS OF INERTIA// 3X,10H MA
     1SS(LBM),6X,3H XM,7X,3H YM,7X,3H ZM,5X,4H IXX,9X,4H IYY,9X,4H IZZ,
     29X,4H IXY,9X,4H IXZ,9X,4H IYZ//)
    6 FORMAT (I3,4F10.2,6E13.5)
C
    7 FORMAT (6E8.0)
    8 FORMAT (//28H SPRING ATTACHMENT LOCATIONS//12X,3H XA,7X,3H YA,7X,
     1        3H ZA,7X,3H XB,7X,3H YB,7X,3H ZB//)
    9 FORMAT (I5,6F10.2)
   10 FORMAT (//24H SPECIAL POINT LOCATIONS//12X,3H XP,7X,3H YP,7X,3H ZP
     1        //)
   11 FORMAT (I5,3F10.2)
   12 FORMAT (2I4,3E8.0)
   13 FORMAT (//34H SPRING AND DAMPER CHARACTERISTICS//)
   14 FORMAT (  1X,I3,16H)     FREE LGTH =F8.2,5X,12H SPR CONST =F8.2,5X,
     1        12H DAMP COEF =F8.2,7H   NX =I3,7H   NY =I3/)
   15 FORMAT (/9H DEFL(IN),6X,11H FORCE(LBF))
   16 FORMAT (F10.3,5X,F12.3)
   18 FORMAT (/10H V(IN/SEC),5X,11H FORCE(LBF))
```

```
19 FORMAT (//46H EXCITATION INPUT,  TIME IN SEC, ACCELERATION IN,A10,
  X        //,2(17X,33HTIME        AX          AY          AZ),//)
20 FORMAT (2(10X,4F10.4))
21 FORMAT (//23H INITIAL CG LOCATION IS 3F10.3//)
22 FORMAT (25H INERTIA TENSOR (LBM-IN2)//3E20.6//3E20.6//3E20.6)
23 FORMAT (//8H    TS =F8.4,8H    TF =F8.4,9H    DTI =F8.4,9H    DTP
  X=F8.4,9H    TOP =F8.4,9H    DTPC =F8.4//9H    PLT =F8.4,9H    DCGX =
  XF8.4,9H    DCGY =F8.4,9H    DCGZ =F8.4//)
24 FORMAT (//10H   ALPHA =F8.3,10H    BETA =F8.3,11H    GAMMA =F8.3,
  X11H    ALDOT =F8.3,12H    BETDOT =F8.3,12H    GAMDOT =F8.3//10H
  XXCBDX =F8.3,10H    XCBDY =F6.3,10H    XCBDZ =F8.3//)
100 FORMAT (45H DEFLECTION-FORCE TABLE OUT OF RANGE DEF(I) =F8.3)
101 FORMAT (46H VELOCITY-DAMPING TABLE OUT OF RANGE DDEF(I) =F8.3)
102 FORMAT (24H   DETERMINANT OF ANEW =F6.3)
103 FORMAT (43H TIME-EXCITATION TABLE OUT OF RANGE  TIME =F8.4)
104 FORMAT (1X,3F14.3)
105 FORMAT (1H1)
106 FORMAT (//1X,42HSPRING COORDINATES (XR) WITH RESPECT TO CG)
107 FORMAT (//1X,47H  SPR.NO.        XAR            YAR            ZAR//)
110 FORMAT (9F8.0)
114 FORMAT (1X,I7,3F14.3)
200 FORMAT (42H   SOMETHING WRONG IN TIME CONTROL    TIME=F10.4,8H    DE-
  XLT=F10.4//)
201 FORMAT (//8H   TIME=F10.4)
202 FORMAT (12F11.5)
203 FORMAT(128H     TIME        XC          YC          ZC          AX
  X AY          AZ          OX          OY          OZ          ODX         ODY
  X    ODZ)
204 FORMAT(129H                ABX         ABY         ABZ         A11
  X A12         A13         A21         A22         A23         A31         A32
  X     A33)
205 FORMAT(129H                XP1         YP1         ZP1         AXP1
  XAYP1         AZP1        XP2         YP2         ZP2         AXP2        AYP2
  X     AZP2)
206 FORMAT(129H                XP3         YP3         ZP3         AXP3
  XAYP3         AZP3        XP4         YP4         ZP4         AXP4        AYP4
  X     AZP4)
207 FORMAT (/18H  PLOT  ON NUMBER=I4//)
208 FORMAT (//24H  END OF RUN - WILL EXIT//)
210 FORMAT (/ 1X,13F10.3)
211 FORMAT (11X,12F10.3)
220 FORMAT (86H1          SUMMARY OF MAX. AND MIN. CG RELATIVE DISPLACEM
  XENTS AND ABSOLUTE ACCELERATIONS//)
221 FORMAT (23X,6HTIME =,F8.4,11H    X MAX =,F10.3,
  1        /23X,6HTIME =,F8.4,11H    Y MAX =,F10.3,
  2        /23X,6HTIME =,F8.4,11H    Z MAX =,F10.3,
  3        /23X,6HTIME =,F8.4,11H    X MIN =,F10.3,
  4        /23X,6HTIME =,F8.4,11H    Y MIN =,F10.3,
  5        /23X,6HTIME =,F8.4,11H    Z MIN =,F10.3,
  6        /23X,6HTIME =,F8.4,11H  ACX MAX =,F10.3,
  7        /23X,6HTIME =,F8.4,11H  ACY MAX =,F10.3,
  8        /23X,6HTIME =,F8.4,11H  ACZ MAX =,F10.3,
  9        /23X,6HTIME =,F8.4,11H  ACX MIN =,F10.3,
  A        /23X,6HTIME =,F8.4,11H  ACY MIN =,F10.3,
  B        /23X,6HTIME =,F8.4,11H  ACZ MIN =,F10.3)
233 FORMAT (/80H  SPR NO  FREE LGTH   EXTD LGTH   DELTA L    SPR FORCE
  X     DEL L DOT   DAMP FORCE//)
234 FORMAT (I7,6F12.3)
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235 FORMAT (//12H    A MATRIX//)
236 FORMAT (9F12.7)
237 FORMAT (//38H   INITIAL CONDITIONS FOR NEXT PROBLEM//)
238 FORMAT (10H   XCBDX =F10.4,10H   XCBDY =F10.4,10H   XCBDZ =F10.4//
   X10H      XO =F10.4,10H      YO =F10.4,10H      ZO =F10.4//10H   AL
   XDOT =F10.4,10H  BETDOT =F10.4,10H  GAMDOT =F10.4//10H   ALPHA =F10
   X.4,10H    BETA =F10.4,10H   GAMMA =F10.4)
240 FORMAT (//36H POSITIONS OF ROLLING BALL ISOLATORS//12X,3H XA,7X,
   13H YA,7X,3H ZA,7X,3H XB,7X,3H YB,7X,3H ZB,6X,4H XBO,6X,4H YBO,
   26X,4H ZBO,6X,2H R,7X,3H MU//)
244 FORMAT (//38H POSITIONS OF SHORT PENDULUM ISOPATORS//12X,3H XA,7X,
   13H YA,7X,3H ZA,7X,3H XB,7X,3H YB,7X,3H ZB,6X,4H SLG,7X,3H DX,7X,
   23H DY//)
245 FORMAT(/116H  SPR NO  FREE LGTH   EXTD LGTH   DELTA L     SPR FORCE
   X     DEL L DOT   DAMP FORCE      XPP-XBO      YPP-YBO      ZPP-ZBO//)
247 FORMAT(/102H  SPR NO  FREE LGTH   EXTD LGTH   DELTA L     SPR FORCE
   X     DEL L DOT   DAMP FORCE        UX           UY//)
248 FORMAT (I5,11F10.2)
249 FORMAT (I5, 9F10.2)
250 FORMAT (I7, 9F12.3)
251 FORMAT (I7, 8F12.3)
261 FORMAT (/////45X,10HX-Z ACCEL.)
262 FORMAT (/////45X,10HY-Z ACCEL.)
263 FORMAT (/////45X,10HXYZ ACCEL.,15X,7HANGLE =,F9.3/
264 FORMAT (40X,20H*******************////)
C
C     ******************************************************************
      ANGLE=45.0
C     ENTER A NEGATIVE ANGLE VALUE IF ANGLE OF INCIDENCE IS OTHER THAN
C     0.0, 45.0, AND 90.0 DEGREES (RE.. X-AXIS) IS NEEDED.              5/71-GC.
C     ANGLE=-30.0,  FOR EXAMPLE                                          5/71-GC.
C     ******************************************************************
C
      KFLAG = 0
      REWIND 3
400   CONTINUE
      WRITE (6,105)
C
      IF (IOP.LE.10 .OR. IOP.EQ.14) GO TO 404
C     ALL INPUT UP TO STATEMENT 537 IS HANDLED BY SUBROUTINE INPUT FOR THE CASES
C         WHERE IOP.GE.11 AND IOP.NE.14.
      IF (NCASE .LE. 1) GO TO 471
      READ (IL) (XM(J),J=1,MXSZ),(T(J),J=1,300)
      GO TO 571
471   CALL INPUT
      IF (NA .EQ. 0) GO TO 5800
      NEX=IABS(NC)
      IF (NC) 537,550,537
C
C     TWO BLANKS CARDS ARE NEEDED FOR NORMAL EXIT IF NOT AN OVERLAY RUN (I.E.
C         IOP.LE.10 OR IOP=14)
C
C                  *****  GROUP 1 INPUT, NOT READ ON OVERLAY RUN.
C
404   READ (5,1)
      WRITE (6, 1)
C
C                  *****  GROUP 2 INPUT, NOT READ ON OVERLAY RUN.
```

```
C       NA = NO. OF WTS.                                        8I4
C       NB = NO. OF SPRINGS/DAMPERS
C       NC = NO. OF POINTS ON FORCING FUNCTION TABLE
C       ND = SMALL/LARGE ANGLE SELECTION
C       NE = NO. OF POINTS OF INTEREST
C       NF = ACCEL. EXCITATION INPUT UNIT CONTROL ....                  9/72-GC.
C          = 0, UNIT IN G,      = NON-ZERO, UNIT IN IN/SEC/SEC          9/72-GC.
C       NG = INITIAL CONDITION INDEX,  SKIP INPUT GROUP 11 IF NG .LT. 0
C       NH = ISOLATOR MOUNTING TYPE CONTROL
C            IF .LT. 0, SHORT PENDULUM,  SKIP INPUT GROUP 6
C            IF .EQ. 0, SPRING/DAMPER,  SKIP INPUT GROUP 5
C            IF .GT. 0, ROLLING-BALL,  SKIP INPUT GROUP 5.
C
      READ  (5,2) NA,NB, NC, ND, NE, NF, NG, NH                         148
      IF (NA) 5000,5000,450                                             149
  450 CONTINUE                                                          150
      WRITE (6,3) NA,NB, NC, ND, NE, NF, NG, NH                         151
      IF (NG .GE. 0) GO TO 561                                          152 *
      READ (IL) (XM(J),J=1,MXSZ),(T(J),J=1,300)                         153 *
      REWIND IL                                                         154 *
      GO TO 507                                                         155 *
C
C     READ INERTIAS AND SPRING COORDINATES
C
C                    *****  GROUP 3 INPUT, NOT READ ON OVERLAY RUN.
C       WT = WT. IN LBS
C       XM,YM,ZM = COORDINATES WRT BUILDING-FIXED COORD.
C       XXI,YYI,ZZI = MASS MOMENTS OF INERTIA
C       XYI,XZI,YZI = PRODUCTS OF INERTIA.
C
  501 DO 502 I=1,NA                                                     156
  502 READ (5,4)WT(I),XM(I),YM(I),ZM(I),XXI(I),YYI(I),ZZI(I),XYI(I),    157
     XXZI(I),YZI(I)                                                     158
      WRITE (6,5)                                                       159
      WRITE (6,6)  (I,WT(I),XM(I),YM(I),ZM(I),XXI(I),YYI(I),ZZI(I),     160
     1             XYI(I), XZI(I), YZI(I) ,I= 1, NA)                    161
C
C                    *****  GROUP 4 INPUT, NOT READ ON OVERLAY RUN.
C       XA,YA,ZA = ISOLATOR ATTACHMENT POINT COORD. ON PLATEFORM
C       XB,YB,ZB = ISOLATOR ATTACHMENT POINT COORD. ON BUILDING.
C
      DO 503 I=1,NB                                                     162
  503 READ (5,7)XA(I),YA(I),ZA(I),XB(I),YB(I),ZB(I)                     163
      IF (NH.NE.0) GO TO 490                                            164
      WRITE (6,8)                                                       165
      WRITE (6,9)  (I, XA(I),YA(I),ZA(I),XB(I), YB(I), ZB(I) ,I=1,NB)   166
      GO TO 497                                                         167
  490 IF (NH.LT.0) GO TO 494                                            168
C
C                    *****  GROUP 6 INPUT, NOT READ ON OVERLAY RUN, OR NH=0.
C       XBO,YBO,ZBO = COORD. OF CENTER OF SPHERICAL PLATE
C       R,UM = RADIUS AND FRICTION COEFF.
C
      DO 492 I=1,NB                                                     169
  492 READ (5,7) XBO(I),YBO(I),ZBO(I),R(I),UM(I)                        170
      WRITE (6,240)                                                     171
      WRITE (6,248)  (I,XA(I),YA(I),ZA(I),XB(I),YB(I),ZB(I),XBO(I),     172
     1YBO(I),ZBO(I),R(I),UM(I) ,I=1,NB)                                 173
```

```
      GO TO 497
C
C                 *****  GROUP 5 INPUT, *** , NOT READ IF NH .GE. 0.
C        SLG = SHORT PENDULUM LENGTH
C        DX,DY = VERTICAL POSITION DEVIATION.
C
  494 DO 496 I=1,NB
  496 READ(5,7) SLG(I),DX(I),DY(I)
      WRITE (6,244)
      WRITE (6,249)  (I,XA(I),YA(I),ZA(I),XB(I),YB(I),ZB(I),SLG(I),
     1DX(I),DY(I) ,I=1,NB)
  497 CONTINUE
      IF (NE)507,507,504
C
C                 *****  GROUP 7 INPUT, NOT READ ON OVERLAY RUN, OR NE .LE. 0.
C        XP,YP,ZP = COORD. OF POINTS OF INTEREST.
C
  504 DO 505 I=1,NE
  505 READ (5,7)XP(I),YP(I),ZP(I)
      WRITE (6,10)
      WRITE (6,11) (I,XP(I),YP(I),ZP(I) , I = 1, NE)
  507 CONTINUE
      WRITE (6,13)
C
C                 *****  GROUP 6A INPUT, NOT READ ON OVERLAY RUN IF LINE. SPRG.
C        NX,NY, = LINEAR/NONLINEAR SPRING-DAMPER CONTROLS
C        SK,DA = SPRING RATE AND DAMPING COEFF. FOR LINEAR ELEMENTS
C        SL = SPRING FREE LENGTH.
C
      DO 521 I = 1, NB
      READ  (5,12) NX(I), NY(I), SL(I), SK(I), DA(I)
      WRITE (6,14)I,SL(I),SK(I),DA(I),NX(I),NY(I)
      IF (NX(I))511,515,510
  510 WRITE (6,15)
C
C                 *****  GROUP 8B NONLINEAR SPRING INPUT, IF NX IN 8A .GT. 0.
C        DF,FS = DEFLECTION AND FORCE TABLE INPUT.
C
      L = NX(I)
      READ  (5,4) ((DF(J,I)), J = 1, L)
      READ  (5,4) ((FS(J,I)), J = 1, L)
      WRITE (6,16) (DF(J,I), FS(J,I) , J = 1, L)
  511 CONTINUE
  515 IF (NY(I))516,521,520
  520 WRITE (6,18)
C
C                 *****  GROUP 8C NONLINEAR DAMPER INPUT, IF NY OF 8A .GT. 0.
C        VD,FD = VELOCITY AND FORCE TABLE INPUT.
C
      L = NY(I)
      READ (5,4)  (VD(J,I) , J = 1, L)
      READ (5,4)  (FD(J,I) , J = 1, L)
      WRITE (6,16) (VD(J,I),FD(J,I) ,J=1,L)
  516 CONTINUE
  521 CONTINUE
  525 IF (NC) 535,550,535
  535 NEX=IABS(NC)
C
```

```
C     READ EXCITATION TABLES
C
C                    *****  GROUP 9 INPUT, NOT READ ON OVERLAY RUN.
C        TTAB,XE,YE,ZE = TIME-ACCELERATIONS (G) FORCING FUNCTION TABLE.
C
      READ (5,110) (TTAB(I),I=1,NEX)                                    208
      READ (5,110)(XE(I),I=1,NEX)                                       209
      READ (5,110)(YE(I),I=1,NEX)                                       210
      READ (5,110)(ZE(I),I=1,NEX)                                       211
  537 J=10H IN/SEC**2                                                   212 *
      IF (NF .EQ. 0) J=10H  G,S                                         213 *
      WRITE (6,19) J                                                    214 *
      WRITE (6,20) (TTAB(I),XE(I),YE(I),ZE(I),I=1,NEX)                  215
      IF (NF .NE. 0) GO TO 541                                          216 *
      DO 540 I=1,NEX                                                    217
      XE(I)=XE(I)*GRAV                                                  218
      YE(I)=YE(I)*GRAV                                                  219
  540 ZE(I)=ZE(I)*GRAV                                                  220
  541 NF=0                                                              221 *
C     INTERMEDIATE CHECKS ARE PRINTED OUT IF NF IS .NE. 0 FROM HERE ON. 9/72-GG.
  550 IF (NC.LE.0 .AND. IOP.GE.11) IOP=14                               222 *
C
C     READ CASE PARAMETERS
C
C                    *****  GROUP 10 INPUT, ALWAYS READIN, OVERLAY OR NOT.
C        TS,TF,DTI = STARTING, ENDING, AND INTEGRATING TIMES.
C        DTP = PRINTOUT TIME INTERVALS
C        TCP = TIME CHANGE FOR DTP PRINTOUT, WITH NEW TIME INTERVAL DTPC
C        PLT = PLOT OPTION,  =0, FOR NO PLOT,  =.NE. ZERO FOR PLOT
C        DCGX,DCGY,DCGZ = C.G. POSITION SHIFT.
C
      READ (5,4) TS,TF,DTI,DTP,TCP,DTPC,PLT,DCGX,DCGY,DCGZ              223
      IF (IOP .LT. 10) GO TO 555                                        224 *
      PLT=FLOAT(IPLT)                                                   225 *
      IF (DTP.GT.DTI*2. .OR. DTPC.GT.DTI*5.) WRITE (6,553)              226 *
  553 FORMAT (///5X,45HPRINTOUT TIME INTERVALS DTP AND DTPC ADJUSTED)   227 *
      IF (DTP .GT. 2.*DTI) DTP=2.*DTI                                   228 *
      IF (DTPC .GT. 5.*DTI) DTPC=5.*DTI                                 229 *
C     PERFORM CHECK ON TCP AND DTPC
  555 IF (TCP .LE. TS) TCP=TF                                           230 *
      IF (DTPC .LE. 0.0) DTPC=DTP                                       231 *
  556 CONTINUE                                                          232
      WRITE(6,23)TS,TF,DTI,DTP,TCP,DTPC,PLT,DCGX,DCGY,DCGZ              233
C
C     READ IN INITIAL CONDITIONS AND CONVERT ANGULAR DEGREES TO RADIANS
C
C                    *****  GROUP 11 INPUT, READ IN ONLY WHEN NG .GE. ZERO, OR
C                                                  NA = -VE ON OVERLAY RUN.
C        ALPHA,BETA,... = PLATEFORM INITIAL CONDITIONS.
C
      IF (NG.LT.0)   GO TO 560                                          234
      READ(5,4) ALPHA,BETA,GAMMA,ALDOT,BETDOT,GAMDOT,XCBDX,XCBDY,XCBDZ  235
      GO TO 570                                                         236
  560 CONTINUE                                                          237
      XS=T(NV-3)                                                        238
      YS=T(NV-4)                                                        239
      ZS=T(NV-5)                                                        240
      ALPHA=T(NV-9)/RADC                                                241 *
```

```
      BETA=T(NV-10)/RADC                                                242 *
      GAMMA=T(NV-11)/RADC                                               243 *
      ALDOT=T(NV-6)                                                     244
      BETDOT=T(NV-7)                                                    245
      GAMDOT=T(NV-8)                                                    246
      XCBDX=T(NV)                                                       247
      XCBDY=T(NV-1)                                                     248
      XCBDZ=T(NV-2)                                                     249
  570 IF (IOP .LE. 10) GO TO 586                                        250 *
      WRITE (IL) (XM(J),J=1,MXSZ),(T(J),J=1,300)                        251 *
      ENDFILE IL                                                        252 *
  571 REWIND IL                                                         253 *
  586 NEX=IABS(NC)                                                      254 *
      IF (IOP.LT.11 .OR. NCASE.EQ.1) WRITE (6,24) ALPHA,BETA,GAMMA,     255 *
     X   ALDOT,BETDOT,GAMDOT,XCBDX,XCBDY,XCBDZ                          256 *
      IF (NCASE .LE. 1) WRITE (6,537)                                   257 *
  587 FORMAT (///5X,17HEND INPUT TO ISOL///)                            258
      IF (IOP.EQ.14 .OR. NCASE.LT.1 .OR. NCASE.GE.4 .OR. ANGLE.LT.0.)   259 *
     X   GO TO 580                                                      260 *
      GO TO (572,574,577), NCASE                                        261 *
  572 DO 573 I=1,NEX                                                    262 *
  573 YE(I)=0.0                                                         263 *
      WRITE (6,261)                                                     264 *
      GO TO 585                                                         265 *
  574 DO 575 I=1,NEX                                                    266 *
  575 XE(I)=0.0                                                         267 *
      WRITE (6,262)                                                     268 *
      GO TO 585                                                         269 *
  577 WRITE (6,263) ANGLE                                               270 *
      ANGLE=ANGLE*RADC                                                  271 *
      COSA=COS(ANGLE)                                                   272 *
      SINA=SIN(ANGLE)                                                   273 *
      DO 578 I=1,NEX                                                    274 *
      XE(I)=XE(I)*COSA                                                  275 *
  578 YE(I)=YE(I)*SINA                                                  276 *
      GO TO 585                                                         277 *
  580 IF (ANGLE .GT. 0.0) GO TO 585                                     278 *
C
C     SPECIAL ANGLE INPUT (DEG.) IS PROVIDED THROUGH A -VE VALUE,     5/71-GC.
C     OTHERWISE, A +45.0 DEG. ANGLE IS AUTOMATICALLY USED.            5/71-GC.
C     A LOOP CAN BE SET UP HERE FOR SEVERAL ANGLES OF INCIDENCE.      5/71-GC.
C
      ANGLE=ABS(ANGLE)                                                  279 *
      IF (NCASE .GE. 3) GO TO 577                                       280 *
      NCASE=3                                                           281 *
      GO TO 577                                                         282 *
  585 IF (NCASE .NE. 0) WRITE (6,264)                                   283 *
      ALPHA = ALPHA * RADC                                              284
      BETA = BETA * RADC                                                285
      GAMMA = GAMMA * RADC                                              286
C
C     FORMULATE ELEMENTS OF A MATRIX FOR NC .LE. 0
C
      SA = SIN(ALPHA)                                                   287
      SB = SIN(BETA)                                                    288
      SG = SIN(GAMMA)                                                   289
      CA = COS(ALPHA)                                                   290
      CB = COS(BETA)                                                    291
```

```
      CG = COS(GAMMA)
      AL1 = CB * CG
      AL2 = -CA * SG + SA * SB * CG
      AL3 = SA * SG + CA * SB * CG
      AM1 = CB * SG
      AM2 = CA * CG + SA * SB * SG
      AM3 = -SA * CG + CA * SB * SG
      AN1 = - SB
      AN2 = SA * CB
      AN3 = CA * CB
C
C     COMPUTE CG AND INERTIA TENSOR
C
      WTOT = 0.0
      SUM1 = 0.0
      SUM2 = 0.0
      SUM3 = 0.0
      DO 600 I= 1, NA
      WTOT = WTOT + WT(I)
      SUM1 = SUM1 + WT(I) * XM(I)
      SUM2 = SUM2 + WT(I) * YM(I)
  600 SUM3 = SUM3 + WT(I) * ZM(I)
      XO = SUM1/WTOT + DCGX
      YO = SUM2/WTOT + DCGY
      ZO = SUM3/WTOT + DCGZ
      XX = 0.0
      YY = 0.0
      ZZ = 0.0
      XY = 0.0
      XZ = 0.0
      YZ = 0.0
      DO 620 I=1,NA
      XMC=XM(I)-XO
      YMC=YM(I)-YO
      ZMC=ZM(I)-ZO
      XX=XX+WT(I)*(YMC*YMC+ZMC*ZMC)/GRAV+XXI(I)
      YY=YY+WT(I)*(XMC*XMC+ZMC*ZMC)/GRAV+YYI(I)
      ZZ=ZZ+WT(I)*(XMC*XMC+YMC*YMC)/GRAV+ZZI(I)
      XY=XY+WT(I)*XMC*YMC/GRAV+XYI(I)
      XZ=XZ+WT(I)*XMC*ZMC/GRAV+XZI(I)
  620 YZ=YZ+WT(I)*YMC*ZMC/GRAV+YZI(I)
      RI(1,1) = XX
      RI(2,2) = YY
      RI(3,3) = ZZ
      RI(1,2) = -XY
      RI(1,3) = -XZ
      RI(2,1) = -XY
      RI(2,3) = -YZ
      RI(3,1) = -XZ
      RI(3,2) = -YZ
C
C     WRITE OUT CG LOCATION AND INERTIA TENSOR
C
      WRITE (6,21)  XO,YO,ZO
      WRITE (6,22) ((RI(I,J),J=1,3),I =1,3)
C
C     FORMULATE MASS MATRIX
C
```

```
      AMASS(1)=WTOT/GRAV
      AMASS(2)=WTOT/GRAV
      AMASS(3)=WTOT/GRAV
C
C     COMPUTE SPRING ATTACHMENT PTS ON PLATFORM WITH RESPECT TO CG (XR)
C
      DO 650 I=1,NB
      XR(1,I)=XA(I)-XO
      XR(2,I)=YA(I)-YO
  650 XR(3,I)=ZA(I)-ZO
      WRITE (6,106)
      WRITE (6,107)
      IP=1
      DO 675 J=1,NB
      WRITE (6,114) IP,(XR(I,J),I=1,3)
  675 IP=IP+1
      WRITE (6,677)
  677 FORMAT (///5X,59HDISPLS. IN THE NEXT TABLE ARE RELATIVE TO INITIAL
     X LOCATIONS,//5X,30HACCELERATION UNIT IN IN/SEC**2)
C
C     OBTAIN XP-XO, YP-YO, AND ZP-ZO AND STORE IN XPT
C
      IF (NE.EQ.0) GO TO 800
      DO 700 IA= 1, NE
      XPR(1,IA) = XP(IA) - XO
      XPR(2,IA) = YP(IA) - YO
  700 XPR(3,IA) = ZP(IA) - ZO
  800 CONTINUE
      KFLAG=KFLAG+1
C
C     PRINT OUT PLOT RUN NO.
      IF (PLT.GT.0. .AND. IOP.LE.10) WRITE (6,207) KFLAG
C
C     INITIALIZE NO. OF OUTPUT BLOCKS PER PAGE
      IF (NF.EQ.0) GO TO 2900
      NPAGE=3
      GO TO 2920
 2900 IF (NE.GT.2) GO TO 2910
      IF (NE.GT.0) GO TO 2905
      NPAGE =19
      GO TO 2920
 2905 NPAGE = 14
      GO TO 2920
 2910 NPAGE = 11
 2920 NPAGE=NPAGE-1
C     LINE ADJUSTMENT***   -1 FOR UNIVAC 1108,  0 FOR CDC.          5/71-GC.
      NPAGE1=NPAGE
C     PRINT OUT FIRST HEADING
      WRITE (6,105)
      WRITE (6,203)
      WRITE (6,204)
      IF (NF.EQ.0) GO TO 2940
      WRITE (6,205)
      IF (NE.LE.2) GO TO 2940
      WRITE (6,206)
 2940 CONTINUE
C
C     OPTION FOR METHOD OF SOLUTION
```

```
C     ND=1  RUNGE-KUTTA  LARGE ANGLE
C     ND=2  RUNGE-KUTTA  SMALL ANGLE
C     ND=3  DELTA T STEP  LARGE ANGLE
C     ND=4  DELTA T STEP  SMALL ANGLE
      GO TO (3000,3010,5000,5000,3000), ND
C
C     SET UP PARAMETERS FOR INTEGRATION ROUTINE
 3000 CONTINUE
C     ND = 1  RUNGE-KUTTA  LARGE ANGLE
C
      NUM=21
      NUM1=21
      GO TO 3025
C     ND = 2  RUNGE-KUTTA  SMALL ANGLE
C
 3010 CONTINUE
      NUM = 12
      NUM1=12
 3025 DELP=DTP
      TIME = TS
      TRIG1=TIME+DELP
      NV=12*NUM
      NW=11*NUM
      T(NV+1) = DTI
      T(NV+2) = TS
C     FORCE INTEGRATION STEP TO BE LESS OR EQUAL THAN PRINT INTERVAL
      IF (T(NV+1) .GT. DTP) T(NV+1)=DTP
      DELTS=T(NV+1)
      IND=1
      T(NV +4) =0.5
      T(NV +5) =1.0E-7
      T(NV +6) =10.0
      T(NV +7) =1.0
      T(NV +8) =1000.0
      T(NV +9) =1.0E-6
C     INITIALIZE DEPENDENT VARIABLE BANK
      DO 3070 I=1,NUM
      T(NW+1-I) = 0.0
 3070 T(NV+1-I) = 0.0
      IF (NG.LT.0)  GO TO 3075
      T(NV-3)=XO
      T(NV-4)=YO
      T(NV-5)=ZO
      GO TO 3076
 3075 CONTINUE
      T(NV-3)=XS
      T(NV-4)=YS
      T(NV-5)=ZS
 3076 CONTINUE
      T(NV) = XCBDX
      T(NV-1) = XCBDY
      T(NV-2) = XCBDZ
      T(NV-6) = ALDOT
      T(NV-7) = BETDOT
      T(NV-8) = GAMDOT
      T(NV-9) = ALPHA
      T(NV-10) = BETA
      T(NV-11) = GAMMA
```

```
      IF(ND.EQ.2) GO TO 3080
      ATEMP(1,1) = AL1
      ATEMP(1,2) = AL2
      ATEMP(1,3) = AL3
      ATEMP(2,1) = AM1
      ATEMP(2,2) = AM2
      ATEMP(2,3) = AM3
      ATEMP(3,1) = AN1
      ATEMP(3,2) = AN2
      ATEMP(3,3) = AN3
      T(NV-12) = AL1
      T(NV-13) = AL2
      T(NV-14) = AL3
      T(NV-15) = AM1
      T(NV-16) = AM2
      T(NV-17) = AM3
      T(NV-18) = AN1
      T(NV-19) = AN2
      T(NV-20) = AN3
      PSI(1,1) = 0.0
      PSI(1,2) = -T(NV-8)
      PSI(1,3) = T(NV-7)
      PSI(2,1) = T(NV-8)
      PSI(2,2) = 0.0
      PSI(2,3) = -T(NV-6)
      PSI(3,1) = -T(NV-7)
      PSI(3,2) = T(NV-6)
      PSI(3,3) = 0.0
      CALL AMBS3(PSI,ATEMP,BTEMP)
      T(NW-12) = BTEMP(1,1)
      T(NW-13) = BTEMP(1,2)
      T(NW-14) = BTEMP(1,3)
      T(NW-15) = BTEMP(2,1)
      T(NW-16) = BTEMP(2,2)
      T(NW-17) = BTEMP(2,3)
      T(NW-18) = BTEMP(3,1)
      T(NW-19) = BTEMP(3,2)
      T(NW-20) = BTEMP(3,3)
 3080 CONTINUE
C
C     INITIALIZE CBMAX ACMAX ETC ETC
      DO 3095 I=1,3
      CBMAX(I)=T(NV-2-I)
      CBMIN(I)=T(NV-2-I)
      ACMAX(I)=T(NW+1-I)
      ACMIN(I)=T(NW+1-I)
      TCBMAX(I)=TS
      TCBMIN(I)=TS
      TACMAX(I)=TS
      TACMIN(I)=TS
 3095 CONTINUE
C
C     ENTER INTEGRATION SUBROUTINE
C
      CALL DES (NUM1,IND,NTEST)
 3100 IF (NTEST) 3300,3300,3200
 3200 CALL DEI (NUM,IND,NTEST)
C
```

```
C     COMPUTE DERIVATIVES AND STORE IN DERIVATIVE BANK
C
 3300 CONTINUE
C
      IF (ND .EQ. 2) GO TO 3305
C     STORE A AND A DOT VALUES IN MARIX FORM FOR CASE ND = 1
      A(1,1) = T(NV-12)
      A(1,2) = T(NV-13)
      A(1,3) = T(NV-14)
      A(2,1) = T(NV-15)
      A(2,2) = T(NV-16)
      A(2,3) = T(NV-17)
      A(3,1) = T(NV-18)
      A(3,2) = T(NV-19)
      A(3,3) = T(NV-20)
      ADOT(1,1) =T(NW-12)
      ADOT(1,2) =T(NW-13)
      ADOT(1,3) =T(NW-14)
      ADOT(2,1) =T(NW-15)
      ADOT(2,2) =T(NW-16)
      ADOT(2,3) =T(NW-17)
      ADOT(3,1) =T(NW-18)
      ADOT(3,2) =T(NW-19)
      ADOT(3,3) =T(NW-20)
      GO TO 3307
 3305 CONTINUE
      A(1,1)=1.0
      A(2,2)=1.0
      A(3,3)=1.0
      A(1,2)=-T(NV-11)
      A(1,3)=T(NV-10)
      A(2,1)=T(NV-11)
      A(2,3)=-T(NV-9)
      A(3,1)=-T(NV-10)
      A(3,2)=T(NV-9)
      ADOT(1,1)=0.0
      ADOT(2,2)=0.0
      ADOT(3,3)=0.0
      ADOT(1,2)=-T(NV-8)
      ADOT(1,3)=T(NV-7)
      ADOT(2,1)=T(NV-8)
      ADOT(2,3)=-T(NV-6)
      ADOT(3,1)=-T(NV-7)
      ADOT(3,2)=T(NV-6)
 3307 CONTINUE
C     OBTAIN PSI XT AND PHI MATRICES
C
      PSI(1,1)=0.0
      PSI(1,2)=-T(NV-8)
      PSI(1,3)=T(NV-7)
      PSI(2,1)=T(NV-8)
      PSI(2,2)=0.0
      PSI(2,3)=-T(NV-6)
      PSI(3,1)=-T(NV-7)
      PSI(3,2)= T(NV-6)
      PSI(3,3)=0.0
      DO 3399 I=1, NB
      AVEC(I)=XR(1,I)
```

```
      AVEC(2)=XR(2,I)
      AVEC(3)=XR(3,I)
      CALL AMBC3 (A,AVEC,BVEC)
      XT(1,I)=BVEC(1)
      XT(2,I)=BVEC(2)
      XT(3,I)=BVEC(3)
      PHI(1,1,I)=0.0
      PHI(1,2,I)=-XT(3,I)
      PHI(1,3,I)= XT(2,I)
      PHI(2,1,I)= XT(3,I)
      PHI(2,2,I)=0.0
      PHI(2,3,I)=-XT(1,I)
      PHI(3,1,I)=-XT(2,I)
      PHI(3,2,I)= XT(1,I)
      PHI(3,3,I)=0.0
C
C     COMPUTE ADOT X XR
C
      CALL AMBC3 (ADOT,AVEC,BVEC)
      XTD(1,I)=BVEC(1)
      XTD(2,I)=BVEC(2)
      XTD(3,I)=BVEC(3)
 3399 CONTINUE
C
C     INTERPOLATE ACCELERATION EXCITATIONS
C
      NER=0
      IF (NC.EQ.0)   GO TO 3610
      NER=2
      CALL LEINT (TIME,XEXC,NEX,TTAB,XE,NER)
      IF (NER.EQ.0)   GO TO 3600
      WRITE (6,103)TIME
 3555 KFLAG=-KFLAG
      GO TO 4700
 3600 NER=2
      CALL LEINT (TIME,YEXC,NEX,TTAB,YE,NER)
      IF (NER.EQ.0) GO TO 3605
      WRITE (6,103) TIME
      GO TO 3555
 3605 NER=2
      CALL LEINT (TIME,ZEXC,NEX,TTAB,ZE,NER)
      IF (NER.EQ.0) GO TO 3606
      WRITE (6,103) TIME
      GO TO 3555
 3606 CONTINUE
      XBIDD(1)=XEXC
      XBIDD(2)=YEXC
      XBIDD(3)=ZEXC
      GO TO 3309
 3610 CONTINUE
      XBIDD(1)=0.0
      XBIDD(2)=0.0
      XBIDD(3)=0.0
 3309 CONTINUE
      TNV = T(NV)
      TNV1 = T(NV-1)
      TNV2 = T(NV-2)
      TNV3 = T(NV-3)
```

```
      TNV4 = T(NV-4)
      TNV5 = T(NV-5)
      IF (NH) 3312, 3313, 3311
 3311 CALL BALL (M,ADOT,XT,XTD,SL,SK,DA,XBIDD,NX,DF,FS,NER,NY,VD,FD,
     1AMASS,F,ALEL,NB, TNV3,TNV4,TNV5,TNV,TNV1,TNV2,XA,
     2YA,ZA,XB,YB,ZB,UM,R,XBD,YBD,ZBD,SLMAG,DEF,FSEL,DDEF,FDEL,XPB)
      GO TO 3401
 3312 CALL SHPED (SL,XT,XTD,SK,DA,NX,DF,FS,NER,NY,VD,FD,      F,ALEL
     1,NB,TNV3,TNV4,TNV5,TNV,TNV1,TNV2,SLG,XA,YA,ZA,
     2DX,DY,U,SLMAG,DEF,FSEL,DDEF,FDEL,XB,YB,ZB)
      GO TO 3401
 3313 CONTINUE
      DO 3400 I=1,NB
C
C     GENERATE (XB - XCB -A X XR) VECTOR
C
      XEL(1,I)=XB(I) -T(NV-3)-XT(1,I)
      XEL(2,I)=YB(I) -T(NV-4)-XT(2,I)
      XEL(3,I)=ZB(I) -T(NV-5)-XT(3,I)
      XELD(1,I)=T(NV)     +XTD(1,I)
      XELD(2,I)=T(NV-1)   +XTD(2,I)
      XELD(3,I)=T(NV-2)   +XTD(3,I)
C
C     COMPUTE MAGNITUDE OF (XB - XCB - A X XR)  AND DEF DDEF
C
      SLMAG(I)=SQRT(XEL(1,I)**2+XEL(2,I)**2+XEL(3,I)**2)
      DEF(I)=SL(I)-SLMAG(I)
      DDEF(I)=(XEL(1,I)*XELD(1,I)+XEL(2,I)*XELD(2,I)+XEL(3,I)*XELD(3,I))
     X/SLMAG(I)
C
C     TABLE LOOK UP FOR SPRING AND DAMPER FORCES
C
      IF (NX(I))3310,3310,3330
 3310 FSEL(I)=DEF(I)*SK(I)
      GO TO 3345
 3330 DEFI=DEF(I)
      NXX=NX(I)
      NER=1
      CALL LEINT (DEFI,FSELI,NXX   ,DF,FS,NER)
      IF (NER.EQ.0)   GO TO 3340
      WRITE (6,100)DEF(I)
      STOP 3340
 3340 FSEL(I)=FSELI
 3345 IF(NY(I))3350,3350,3360
 3350 FDEL(I)=DDEF(I)*DA(I)
      GO TO 3375
 3360 DDEFI=DDEF(I)
      NYY=NY(I)
      NER=1
      CALL LEINT (DDEFI,FDELI,NYY,  VD,FD,NER)
      IF (NER.EQ.0)   GO TO 3370
      WRITE (6,101)DDEF(I)
      STOP 3370
 3370 FDEL(I)=FDELI
 3375 FEL(I)=FSEL(I)+FDEL(I)
C
C     COMPUTE PHI X XEL
C
```

```
      DO 3380 IA=1,3
      DO 3380 IB=1,3
 3380 ATEMP(IA,IB)=PHI(IA,IB,I)
      ZETA(1)=XEL(1,I)
      ZETA(2)=XEL(2,I)
      ZETA(3)=XEL(3,I)
      CALL AMBC3 (ATEMP,ZETA,AVEC)
C
C     COMPUTE FI AND LI
C
      DO 3390 IA=1,3
      F(IA,I)=-FEL(I)*ZETA(IA)/SLMAG(I)
 3390 ALEL(IA,I)=-FEL(I)*AVEC(IA)/SLMAG(I)
 3400 CONTINUE
 3401 CONTINUE
C
C     SUMMARIZE FORCES AND MOMENTS
C
      DO 3500 J=1,3
      SUM=0.0
      SUM1=0.0
      DO 3450 I=1,NB
      SUM=SUM+F(J,I)
 3450 SUM1=SUM1+ALEL(J,I)
      FORCE(J)=SUM
      AL(J)=SUM1
 3500 CONTINUE
 3620 CONTINUE
C     MODIFY FORCE COMPONENT TO INCLUDE G MATRIX
C
      FORCE(3)=FORCE(3)-GRAV*AMASS(3)
C
C     COMPUTE DERIVATIVES FOR XCB (I) DOUBLE DOT
      F(NW) = (FORCE(1)/AMASS(1))-XBIDD(1)
      F(NW-1) = (FORCE(2)/AMASS(2))-XBIDD(2)
      F(NW-2) = (FORCE(3)/AMASS(3))-XBIDD(3)
      IF (ND.NE.1 ) GO TO 3800
C
C     FIRST IT= A X IR X AT AND  IT INVERSE
C
      CALL MTRAN3 (A,AT)
      CALL AMBS3 (RI,AT,ATEMP)
      CALL AMBS3 (A,ATEMP,TI)
C     COMPUTE PSI X IT AND ITS TRANSPOSE
C
      CALL INV3  (TI,TINV)
      CALL AMBS3 (PSI,TI,ATEMP)
      CALL MTRAN3 (ATEMP,BTEMP)
C
C     ADD  ATEMP AND B TEMP
C
      DO 3650 I=1,3
      DO 3650 J=1,3
 3650 ATEMP(I,J)=ATEMP(I,J)+BTEMP(I,J)
C
      CALL AMBS3 (TINV,ATEMP,BTEMP)
      CALL AMBC3 (TINV,AL,AVEC)
C     COMPUTE OMEGA DOT (I) FOR LARGE ANGLE CASE
```

```
      T(NW-6)=AVEC(1)-(BTEMP(1,1)*T(NV-6)+BTEMP(1,2)*T(NV-7)+BTEMP(1,3)*
     *T(NV-8))
      T(NW-7)=AVEC(2)-(BTEMP(2,1)*T(NV-6)+BTEMP(2,2)*T(NV-7)+BTEMP(2,3)*
     *T(NV-8))
      T(NW-8)=AVEC(3)-(BTEMP(3,1)*T(NV-6)+BTEMP(3,2)*T(NV-7)+BTEMP(3,3)*
     *T(NV-8))
C     COMPUTE A DOT (I) FOR LARGE ANGLE CASE
      T(NW-12)=T(NV-12)*PSI(1,1)+T(NV-13)*PSI(2,1)+T(NV-14)*PSI(3,1)
      T(NW-13)=T(NV-12)*PSI(1,2)+T(NV-13)*PSI(2,2)+T(NV-14)*PSI(3,2)
      T(NW-14)=T(NV-12)*PSI(1,3)+T(NV-13)*PSI(2,3)+T(NV-14)*PSI(3,3)
      T(NW-15)=T(NV-15)*PSI(1,1)+T(NV-16)*PSI(2,1)+T(NV-17)*PSI(3,1)
      T(NW-16)=T(NV-15)*PSI(1,2)+T(NV-16)*PSI(2,2)+T(NV-17)*PSI(3,2)
      T(NW-17)=T(NV-15)*PSI(1,3)+T(NV-16)*PSI(2,3)+T(NV-17)*PSI(3,3)
      T(NW-18)=T(NV-18)*PSI(1,1)+T(NV-19)*PSI(2,1)+T(NV-20)*PSI(3,1)
      T(NW-19)=T(NV-18)*PSI(1,2)+T(NV-19)*PSI(2,2)+T(NV-20)*PSI(3,2)
      T(NW-20)=T(NV-18)*PSI(1,3)+T(NV-19)*PSI(2,3)+T(NV-20)*PSI(3,3)
      GO TO 4000
 3000 CONTINUE
      CALL INV3  (RI,RINV)
      CALL AMBC3 (RINV,AL,AVEC)
C     STORE OMEGA DOT VALUES IN DERIVATIVE BOX FOR SMALL ANGLE CASE
      T(NW-6)=AVEC(1)
      T(NW-7)=AVEC(2)
      T(NW-8)=AVEC(3)
 4000 CONTINUE
C     TRANSFER XCB (1,2,3) DOT TO DERIVATIVE TABLE
      T(NW-3) = T(NV)
      T(NW-4) = T(NV-1)
      T(NW-5) = T(NV-2)
C     TRANSFER OMEGA IN DERIVATIVE BOX TO OBTAIN INTEGRAL OF OMEGA
      T(NW-9) = T(NV-6)
      T(NW-10) = T(NV-7)
      T(NW-11) = T(NV-8)
C     END OF DERIVATIVE COMPUTATION
      CALL DED (NUM,IND,NTEST), RETURNS(3100)
      IF(NE.EQ.0) GO TO 4250
C
C     COMPUTE PSIDOT + PSI SQUARED
C
      ATEMP(1,1) = 0.0
      ATEMP(2,2) = 0.0
      ATEMP(1,2) = -T(NW-8)
      ATEMP(1,3) =  T(NW-7)
      ATEMP(3,1) = -T(NW-7)
      ATEMP(2,3) = -T(NW-6)
      ATEMP(2,1) =  T(NW-8)
      ATEMP(3,3) = 0.0
      ATEMP(3,2) =  T(NW-6)
      CALL AMBS3 (PSI, PSI, BTEMP)
      DO 4050 I = 1, 3
      DO 4050 J = 1, 3
 4050 ATEMP(I,J) = ATEMP(I,J) + BTEMP(I,J)
      IF (NE.EQ.0) GO TO 4250
C     COMPUTE XPT AND XPDD (POINTS OF INTEREST)
C
      DO 4200 K = 1, NE
      DO 4110 KA = 1, 3
 4110 AVEC(KA) = XPR(KA,K)
```

```
      CALL AMBC3(A,AVEC,BVEC)
      DO 4120 KA = 1, 3
 4120 XPT(KA,K) = BVEC(KA) + T(NV-KA-2)
      CALL AMBC3 (ATEMP, BVEC, AVEC)
      DO 4150 KA = 1, 3
 4150 XPDD(KA, K) = T(NW - KA + 1) +XBIDD(KA) + AVEC(KA)
 4200 CONTINUE
 4250 CONTINUE
C
C     STORE MAX AND MIN VALUES
C
      XCIDD(1)=T(NW)    +XBIDD(1)
      XCIDD(2)=T(NW-1) +XBIDD(2)
      XCIDD(3)=T(NW-2) +XBIDD(3)
      DO 4300 I=1,3
      IF (T(NV-2-I).LE.CBMAX(I))  GO TO 4260
      CBMAX(I)=T(NV-2-I)
      TCBMAX(I)=T(NV+2)
 4260 IF (XCIDD(I).LE.ACMAX(I))   GO TO 4265
      ACMAX(I)=XCIDD(I)
      TACMAX(I)=T(NV+2)
 4265 IF (T(NV-2-I).GE.CBMIN(I))  GO TO 4270
      CBMIN(I)=T(NV-2-I)
      TCBMIN(I)=T(NV+2)
 4270 IF (XCIDD(I).GE.ACMIN(I))   GO TO 4300
      ACMIN(I)=XCIDD(I)
      TACMIN(I)=T(NV+2)
 4300 CONTINUE
C     TIME CONTROL LOGIC
      TIME = T(NV+2)
 4500 IF (ABS(TIME-TRIG1) -1.0E-6) 4550,4550,4505
 4505 IF (TIME-TRIG1) 4520,4550,4510
 4510 WRITE (6,200) TIME,T(NV+1)
      GO TO 4550
 4520 TMDT=TIME+DELTS
      IF (TMDT .LE. TRIG1) T(NV+1)=DELTS
      IF (TMDT .GT. TRIG1) T(NV+1)=TRIG1-TIME
      GO TO 3200
 4550 IF (TRIG1 .LT. TCP) GO TO 4570
      IF (DELTS .LT. DTPC) GO TO 4560
      DELTS =DTPC
 4560 DELP =DTPC
 4570 T(NV+1) = DELTS
      TRIG1 =TRIG1+DELP
      FOLLOWING IS THE TIME DEPENDENT PRINT OUT
C
C     PRINTOUT OPTIONS  (NF GT 0) CODE CHECK PRINT  (NF = 0) STANDARD
C
      ALP = T(NV-9)/RADC
      BETP = T(NV-10)/RADC
      GAMP = T(NV-11)/RADC
C     PRINT AREA FOR STANDARD BLOCK OUTPUT
      TVN3=T(NV-3) - X0
      TVN4=T(NV-4) - Y0
      TVN5=T(NV-5) - Z0
      WRITE (6,210) TIME,TVN3,TVN4,TVN5,(XCIDD(I),I=1,3),
     XALP,BETP,GAMP,T(NW-6),T(NW-7),T(NW-8)
C     THE FOLLOWING 4 CARDS CHANGED BY WND 70 DEC 14
```

```
      IF(NG.EQ.0) GO TO 99222
      IF (NG.NE.0) GO TO 99222
      PUNCH 99111, TIME,XCIDD(1), XCIDD(2), XCIDD(3)
99111 FORMAT(4F10.4)
99222 CONTINUE
      WRITE (6,211) (XBIDD(I),I=1,3),((A(I,J),I=1,3),J=1,3)
      IF (NE.EQ.0) GO TO 4580
      X1X=XPT(1,1)-XP(1)
      X1Y=XPT(2,1)-YP(1)
      X1Z=XPT(3,1)-ZP(1)
      X2X=0.
      X2Y=0.
      X2Z=0.
      XPDD(1,2)=0.0
      XPDD(2,2)=0.0
      XPDD(3,2)=0.0
      IF (NE .EQ. 1) GO TO 4574
      X2X=XPT(1,2)-XP(2)
      X2Y=XPT(2,2)-YP(2)
      X2Z=XPT(3,2)-ZP(2)
 4574 CONTINUE
      WRITE (6,211) X1X,X1Y,X1Z,(XPDD(I,1),I=1,3),X2X,X2Y,X2Z,
     X(XPDD(I,2),I=1,3)
      IF (NE.LE.2) GO TO 4580
      X3X=XPT(1,3)-XP(3)
      X3Y=XPT(2,3)-YP(3)
      X3Z=XPT(3,3)-ZP(3)
      X4X=0.
      X4Y=0.
      X4Z=0.
      XPDD(1,4)=0.0
      XPDD(2,4)=0.0
      XPDD(3,4)=0.0
      IF (NE .EQ. 3) GO TO 4576
      X4X=XPT(1,4)-XP(4)
      X4Y=XPT(2,4)-YP(4)
      X4Z=XPT(3,4)-ZP(4)
 4576 CONTINUE
      WRITE (6,211) X3X,X3Y,X3Z,(XPDD(I,3),I=1,3),X4X,X4Y,X4Z,
     X(XPDD(I,4),I=1,3)
C     CHECK FOR CODE CHECK PRINT OPTION
 4580 IF (NF.EQ.0) GO TO 4630
 4600 WRITE (6,201 ) TIME
      WRITE (6,202) (T(NV+1-I),I=1,12)
      WRITE (6,202) (T(NW+1-I),I=1,12)
      IF (ND .EQ.2) GO TO 4610
C     LARGE ANGLE CASE
      J=NV-11
      K=NW-11
      WRITE (6,202) (T(J-I),I=1,9)
      WRITE (6,202) (T(K-I),I=1,9)
C     SMALL ANGLE CASE
 4610 WRITE (6, 202) ((A(I,J), I = 1,3), J = 1, 3)
      WRITE (6, 202) ((ADOT(I,J), I = 1, 3), J = 1, 3)
      WRITE (6,104)((TI(I,J),I=1,3),J=1,3)
      WRITE (6,104) (FORGE(I),AL(I),XBIDD(I) ,I=1,3)
      WRITE (6,104) (DEF(I),DDEF(I),SLMAG(I),FSEL(I),FDEL(I) ,I=1,NB)
C     PRINT DETERMINANT OF MATRIX A
```

```
 4620 CALL DET3 (A,DETER)
      WRITE (6,102) DETER
C     CHECK PAGE NO. COUNT
 4630 CONTINUE
      NPAGE1=NPAGE1-1
      IF (NPAGE1) 4640,4640,4670
 4640 WRITE (6,105)
      WRITE (6,203)
      WRITE (6,204)
      IF (NE.EQ.0) GO TO 4660
      WRITE (6,205)
      IF (NE.LE.2) GO TO 4660
      WRITE (6,206)
 4660 NPAGE1=NPAGE
 4670 CONTINUE
C     CHECK FOR END TIME
      IF (TRIG1 .GT. TF) KFLAG=-KFLAG
C     CHECK TO SEE IF BINARY PLOT TAPE IS TO BE WRITTEN
C     IF (PLT) 4700,4900,4730                                    7/71-GC.
C     WRITE PLOT TAPE
 4700 CONTINUE
C     WRITE PLOT RECORD ON LOGICAL TAPE 3
      WRITE (3) KFLAG,TIME,TVN3,TVN4,TVN5,(XCIDD(I),I=1,3),
     XALP,BETP,GAMP,T(NW-6),T(NW-7),T(NW-8),(XBIDD(I),I=1,3),
     X((A(I,J),I=1,3),J=1,3),X1X,X1Y,X1Z,(XPDD(I,1),I=1,3),
     XX2X,X2Y,X2Z,(XPDD(I,2),I=1,3),X3X,X3Y,X3Z,
     X(XPDD(I,3),I=1,3),X4X,X4Y,X4Z,(XPDD(I,4),I=1,3)
 4900 IF (KFLAG) 4920,3200,3200
C     END OF RUN  WRAP IT UP
 4920 KFLAG=IABS(KFLAG)
      WRITE (6,220)
      CBMAX(1)=CBMAX(1)-XO
      CBMAX(2)=CBMAX(2)-YO
      CBMAX(3)=CBMAX(3)-ZO
      CBMIN(1)=CBMIN(1)-XO
      CBMIN(2)=CBMIN(2)-YO
      CBMIN(3)=CBMIN(3)-ZO
      WRITE (6,221)
     1 TCBMAX(1),CBMAX(1),TCBMAX(2),CBMAX(2),TCBMAX(3),CBMAX(3),
     2 TCBMIN(1),CBMIN(1),TCBMIN(2),CBMIN(2),TCBMIN(3),CBMIN(3),
     3 TACMAX(1),ACMAX(1),TACMAX(2),ACMAX(2),TACMAX(3),ACMAX(3),
     4 TACMIN(1),ACMIN(1),TACMIN(2),ACMIN(2),TACMIN(3),ACMIN(3)
      IF (NH.NE.0) GO TO 4930
      WRITE (6,233)
      WRITE (6,234) (I,SL(I),SLMAG(I),DEF(I),FSEL(I),DDEF(I),FDEL(I) ,I=
     X1,NB)
      GO TO 4990
 4930 IF (NH.LT.0) GO TO 4960
      WRITE (6,245)
      WRITE (6,250) (I,SL(I),SLMAG(I),DEF(I),FSEL(I),DDEF(I),FDEL(I),
     1(XPB(J,I),J=1,3) ,I=1,NB)
      GO TO 4990
 4960 WRITE (6,247)
      WRITE (6,251) (I,SL(I),SLMAG(I),DEF(I),FSEL(I),DDEF(I),FDEL(I),
     1(U(J,I),J=1,2) ,I=1,NB)
 4990 CONTINUE
      IF (IOP.GE.11 .AND. IOP.NE.14) GO TO 5800
      WRITE (6,235)
```

```
      WRITE (6,236)((A(I,J),I=1,3),J=1,3)
      WRITE (6,237)
      WRITE (6,238)(T(NV+1-I),I=1,9),ALP,BETP,GAMP
      IF (IOP .NE. 14) GO TO 400
      WRITE (IL) (XM(I),I=1,MXSZ),(T(I),I=1,300)
      ENDFILE IL
      REWIND IL
      GO TO 5800
C
C     END OF RUNGE-KUTTA PROGRAM OPTIONS
C
 5000 CONTINUE
C
C
C     INITIALIZE ALL QUANTITIES AT TIME = TS FOR NC LESS THAN OR = 0
C
      TIME=TS
      TPRT=TS+DTP-DTI
C     STEP TIME FOR INTEGRATION
C
      IF (NC)5001,5301,5005
 5001 DO 5004 I=1,3
      DCBD(I)=0.0
      DCBDD(I)=0.0
      OMI(I)=0.0
      OM(I)=0.0
      OMD(I)=0.0
      DO 5002 J=1,3
      A(I,J)=0.0
 5002 ADOT(I,J)=0.0
 5004 CONTINUE
      DCB(1)=XO
      DCB(2)=YO
      DCB(3)=ZO
      A(1,1)=1.0
      A(2,2)=1.0
      A(3,3)=1.0
 5005 CONTINUE
      TIME=TIME+DTI
C
C     START COMPUTE ALL QUANTITIES AT OLD TIME
C
C
C     OBTAIN PSI XT AND PHI MATRICES
C
      PSI(1,1)=0.0
      PSI(1,2)=-OM(3)
      PSI(1,3)=OM(2)
      PSI(2,1)=OM(3)
      PSI(2,2)=0.0
      PSI(2,3)=-OM(1)
      PSI(3,1)=-OM(2)
      PSI(3,2)=OM(1)
      PSI(3,3)=0.0
      DO 5100 I=1,NB
      AVEC(1)=XR(1,I)
      AVEC(2)=XR(2,I)
      AVEC(3)=XR(3,I)
```

```
      CALL AMBC3 (A,AVEC,BVEC)
      XT(1,I)=BVEC(1)
      XT(2,I)=BVEC(2)
      XT(3,I)=BVEC(3)
      PHI(1,1,I)=0.0
      PHI(1,2,I)=-XT(3,I)
      PHI(1,3,I)= XT(2,I)
      PHI(2,1,I)= XT(3,I)
      PHI(2,2,I)=0.0
      PHI(2,3,I)=-XT(1,I)
      PHI(3,1,I)=-XT(2,I)
      PHI(3,2,I)= XT(1,I)
      PHI(3,3,I)=0.0
C
C     COMPUTE ADOT X XR
C
      CALL AMBC3 (ADOT,AVEC,BVEC)
      XTD(1,I)=BVEC(1)
      XTD(2,I)=BVEC(2)
      XTD(3,I)=BVEC(3)
C
C     GENERATE (XB - XCB -A X XR) VECTOR
C
      XEL(1,I)=XB(I)  -OCB(1)-XT(1,I)
      XEL(2,I)=YB(I)  -OCB(2)-XT(2,I)
      XEL(3,I)=ZB(I)  -OCB(3)-XT(3,I)
      XELD(1,I)=OCBD(1)  +XTD(1,I)
      XELD(2,I)=OCBD(2)  +XTD(2,I)
      XELD(3,I)=OCBD(3)  +XTD(3,I)
C
C     COMPUTE MAGNITUDE OF (XB - XCB - A X XR)  AND DEF DDEF
C
      SLMAG(I)=SQRT(XEL(1,I)**2+XEL(2,I)**2+XEL(3,I)**2)
      DEF(I)=SL(I)-SLMAG(I)
      DDEF(I)=(XEL(1,I)*XELD(1,I)+XEL(2,I)*XELD(2,I)+XEL(3,I)*XELD(3,I))
     X/SLMAG(I)
C
C     TABLE LOOK UP FOR SPRING AND DAMPER FORCES
C
      IF (NX(I))5010,5010,5030
 5010 FSEL(I)=DEF(I)*SK(I)
      GO TO 5045
 5030 DEFI=DEF(I)
      NXX=NX(I)
      NER=1
      CALL LEINT (DEFI,FSELI,NXX  ,DF,FS,NER)
      IF (NER.EQ.0)   GO TO 5040
      WRITE (6,100)DEF(I)
      STOP 5040
 5040 FSEL(I)=FSELI
 5045 IF (NY(I))5050,5050,5060
 5050 FDEL(I)=DDEF(I)*DA(I)
      GO TO 5075
 5060 DDEFI=DDEF(I)
      NYY=NY(I)
      NER=1
      CALL LEINT (DDEFI,FDELI,NYY,  VD,FD,NER)
      IF (NER.EQ.0)   GO TO 5070
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      WRITE (6,101)DDEF(I)
      STOP 5070
 5070 FDEL(I)=FDELI
 5075 FEL(I)=FSEL(I)+FDEL(I)
C
C     COMPUTE PHI X XEL
C
      DO 5060 IA=1,3
      DO 5080 IB=1,3
 5060 ATEMP(IA,IB)=PHI(IA,IB,I)
      ZETA(1)=XEL(1,I)
      ZETA(2)=XEL(2,I)
      ZETA(3)=XEL(3,I)
      CALL AMBO3 (ATEMP,ZETA,AVEC)
C
C     COMPUTE FI AND LI
C
      DO 5090 IA=1,3
      F(IA,I)=-FEL(I)*ZETA(IA)/SLMAG(I)
 5090 ALEL(IA,I)=-FEL(I)*AVEC(IA)/SLMAG(I)
 5100 CONTINUE
C
C     SUMMARIZE FORCES AND MOMENTS
C
      DO 5200 J=1,3
      SUM=0.0
      SUM1=0.0
      DO 5150 I=1,NB
      SUM=SUM+F(J,I)
 5150 SUM1=SUM1+ALEL(J,I)
      FORCE(J)=SUM
      AL(J)=SUM1
 5200 CONTINUE
C
C     INTERPOLATE ACCELERATION EXCITATIONS
C
      IF (NC.EQ.0)   GO TO 5310
      NER=0
      CALL LEINT (TIME,XEXC,NEX,TTAB,XE,NER)
      IF (NER.EQ.0)   GO TO 5300
      WRITE (6,103)TIME
      STOP 5300
 5300 CALL LEINT (TIME,YEXC,NEX,TTAB,YE,NER)
      CALL LEINT (TIME,ZEXC,NEX,TTAB,ZE,NER)
      X3IDD(1)=XEXC
      X3IDD(2)=YEXC
      X3IDD(3)=ZEXC
      GO TO 5315
 5310 CONTINUE
      X3IDD(1)=0.0
      X3IDD(2)=0.0
      X3IDD(3)=0.0
 5315 CONTINUE
C     MODIFY FORCE COMPONENT TO INCLUDE G MATRIX
C
      FORCE(3)=FORCE(3)-GRAV*AMASS(3)
C
C     ESTABLISH DVAL AND EVAL AND SOLVING XCB,XCBD, AND XCBDD
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C
      DO 5320 I=1,3                                                     1003
      DVAL(I)=6.0*(OCB(I)/DTI+OCBD(I))/DTI+2.0*OCBDD(I)                 1004
      EVAL(I)=3.0*OCB(I)/DTI+2.0*OCBD(I)+0.5*OCBDD(I)*DTI               1005
      XCB(I)=DTI*DTI*(FORCE(I)/AMASS(I)-XBIDD(I)+DVAL(I))/6.0           1006
      XCBD(I)=3.0*XCB(I)/DTI-EVAL(I)                                    1007
 5320 XCBDD(I)=6.0*XCB(I)/(DTI*DTI)-DVAL(I)                             1008
C
C     ESTABLISH DVAL AND EVAL FOR THE MOMENT EQUATIONS
      DO 5340 I=1,3                                                     1009
      DVAL(I)=6.0*(OMI(I)/DTI+OM(I))/DTI+2.0*OMD(I)                     1010
 5340 EVAL(I)=3.0*OMI(I)/DTI+2.0*OM(I)+0.5*DTI*OMD(I)                   1011
      IF (ND.NE.3 ) GO TO 5500                                          1012
C
C     FIRST IT= A X IN X AT AND  IT INVERSE
C
C     OPTIONS FOR DELTA T STEP  ND=3 (LARGE ANGLE)  ND=4 (SMALL ANGLE)
      CALL MTRAN3 (A,AT)                                                1013
      CALL AMBS3 (RI,AT,ATEMP)                                          1014
      CALL AMBS3 (A,ATEMP,TI)                                           1015
C     COMPUTE PSI X IT AND ITS TRANSPOSE
C
      CALL INV3  (TI,TINV)                                              1016
      CALL AMBS3 (PSI,TI,ATEMP)                                         1017
      CALL MTRAN3 (ATEMP,BTEMP)                                         1018
C
C     ADD  ATEMP AND B TEMP
C
      DO 5350 I=1,3                                                     1019
      DO 5350 J=1,3                                                     1020
 5350 ATEMP(I,J)=ATEMP(I,J)+BTEMP(I,J)                                  1021
C
      CALL AMBS3 (TINV,ATEMP,BTEMP)                                     1022
      CALL AMBC3 (TINV,AL,AVEC)                                         1023
      CALL AMBC3 (BTEMP,EVAL,BVEC)                                      1024
      DO 5360 I=1,3                                                     1025
 5360 AVEC(I)=AVEC(I)+DVAL(I)+BVEC(I)                                   1026
      DO 5390 I=1,3                                                     1027
      DO 5390 J=1,3                                                     1028
 5390 BTEMP(I,J)=3.0*BTEMP(I,J)/DTI                                     1029
      BTEMP(1,1)=BTEMP(1,1)+6.0/(DTI*DTI)                               1030
      BTEMP(2,2)=BTEMP(2,2)+6.0/(DTI*DTI)                               1031
      BTEMP(3,3)=BTEMP(3,3)+6.0/(DTI*DTI)                               1032
      CALL INV3 (BTEMP,ATEMP)                                           1033
      CALL AMBC3 (ATEMP,AVEC,ONI)                                       1034
      DO 5400 I=1,3                                                     1035
      ON(I)=3.0*ONI(I)/DTI-EVAL(I)                                      1036
 5400 OND(I)=6.0*ONI(I)/(DTI*DTI)-DVAL(I)                               1037
C
C     START INTEGRATTING ADOT EQUATIONS USING EULERS PREDICTOR-CORRECTOR
C      METHOD.   A REFER TO OLD TIME   ANEW REFER TO NEW TIME
C      ADOT REFER TO OLD TIME   ADNU REFER TO NEW TIME
C
      DO 5450 I=1,3                                                     1038
      DO 5450 J=1,3                                                     1039
 5450 ANEW(I,J)=DTI*ADOT(I,J)+A(I,J)                                    1040
      PSI(1,1)=0.0                                                      1041
      PSI(1,2)=-ON(3)                                                   1042
```

```
      PSI(1,3)=ON(2)
      PSI(2,1)=ON(3)
      PSI(2,2)=0.0
      PSI(2,3)=-ON(1)
      PSI(3,1)=-ON(2)
      PSI(3,2)=ON(1)
      PSI(3,3)=0.0
      CALL AMBS3 (PSI,ANEW,ADNU)
      DO 5460 I=1,3
      DO 5460 J=1,3
 5460 ATEMP(I,J)=   0.5 *(ADOT(I,J)+ADNU(I,J))
      DO 5465 I=1,3
      DO 5465 J=1,3
 5465 ANEW(I,J)=DTI*ATEMP(I,J)+A(I,J)
C
C     END OF INTEGRATINON FOR NO=3 OPTION
C
      GO TO 5700
 5500 CONTINUE
      CALL INV3  (RI,RINV)
      CALL AMBC3 (RINV,AL,AVEC)
      DO 5550 I=1,3
 5550 ONI(I)=(AVEC(I)+DVAL(I))*DTI*DTI/6.0
      DO 5600 I=1,3
      ON(I)=3.0*ONI(I)/DTI-EVAL(I)
 5600 ONO(I)=6.0*ONI(I)/(DTI*DTI)-DVAL(I)
C
C     ESTABLISHING ANEW AND ADNU FOR NO=4 OPTION
      ANEW(1,1)=1.0
      ANEW(1,2)=-ONI(3)
      ANEW(1,3)=ONI(2)
      ANEW(2,1)=ONI(3)
      ANEW(2,2)=1.0
      ANEW(2,3)=-ONI(1)
      ANEW(3,1)=-ONI(2)
      ANEW(3,2)=ONI(1)
      ANEW(3,3)=1.0
      ADNU(1,1)=0.0
      ADNU(1,2)=-ON(3)
      ADNU(1,3)=ON(2)
      ADNU(2,1)=ON(3)
      ADNU(2,2)=0.0
      ADNU(2,3)=-ON(1)
      ADNU(3,1)=-ON(2)
      ADNU(3,2)=ON(1)
      ADNU(3,3)=0.0
 5700 CONTINUE
C
C     END OF TIME STEP    TRANSFER NEW TO OLD
C
      DO 5750 I=1,3
      XOB(I)=XOB(I)
      XOBO(I)=XOBO(I)
      XOBOO(I)=XOBOO(I)
      ON(I)=ON(I)
      ONI(I)=ONI(I)
      DO 5720 J=1,3
      A(I,J)=ANEW(I,J)
```

```
5720 AOOT(I,J)=AONU(I,J)                                                1093
5750 CONTINUE                                                           1094
C
C     EVALUATE DETERMINANT OF ANEW
C
      CALL DET3 (ANEW,DETER)                                            1095
C
C     STEP UP PRINT
C
      IF (TIME-TPRT)5770,5760,5760                                      1096
5760  CONTINUE                                                          1097
      WRITE (6,201)TIME                                                 1098
      WRITE (6,104) ((XOB(I),XOBD(I),XOBDD(I)),I=1,3),                  1099 *
     1              ((ONI(I),ON(I),OND(I)),I=1,3),                      1100 *
     2              ((ANEW(I,J),I=1,3),J=1,3),((AONU(I,J),I=1,3),J=1,3) 1101 *
     3              ,((TI(I,J),I=1,3),J=1,3),                           1102 *
     4              ((FORCE(I),AL(I),XBIDD(I)),I=1,3)                   1103 *
      WRITE (6,102) DETER                                               1104
      WRITE (6,104)((DEF(I),DDEF(I),SLMAG(I),FSEL(I),FDEL(I)),I=1,NB)   1105
      TPRT=TPRT+DTP                                                     1106
5770  CONTINUE                                                          1107
      IF (TIME.LT.TF) GO TO 5005                                        1108
      IF (NCASE .EQ. 0) GO TO 400                                       1109
C     END OF RUN , EOF AND REWIND TAPE 3
5800  IF (IOP .LE. 10 .AND. PLT .LE. 0.0) GO TO 5801                    1110 *
      ENDFILE 3                                                         1111
      REWIND 3                                                          1112
5801  IF (IOP .LE. 10) WRITE (6,208)                                    1113
      END                                                               1114
```

```
      SUBROUTINE INPUT
C
C     THIS SUBROUTINE WAS ADDED TO ISOL FOR OVERLAY RUN BY G.C.CHAN     2/71-GC.
C
      COMMON /OPTION/IOP,IPLT,IL,IL2,IL3,IL4,IK
      COMMON /NBN/NA,NB,NC,ND,NE,NF,NG,NH
      COMMON /ID12/ID(12)
      COMMON XM(50),WT(50),XXI(50),YYI(50),ZZI(50),XYI(50),XZI(50),
     1YZI(50),YM(50),ZM(50),XE(501),NX(50),NY(50),SL(50),SK(50),
     2DA(50),FS(20,50),OF(20,50),FO(20,50),VD(20,50),YE(501),ZE(501),
     3TTAB(501),RI(3,3),TI(3,3),RINV(3,3),TINV(3,3),A(3,3),AT(3,3),
     4ADDT(3,3),FEI(3,3),ATEMP(3,3),BTEMP(3,3),XCB(3),
     5XCBL(3),XIBD(3),XBIDD(3),XCBDD(3),
     6AMAS(3),OM(3),OMD(3),AL(3),AVEC(3),BVEC(3),FORCE(3),
     7ZETA(3),XT(3,50),XR(3,50),PHI(3,3,50),F(3,50),ALEL(3,50),
     8XFE(3,50),XFLD(3,50),DFL(50),DDEF(50),SLMAG(50),FSFL(50),FDEL(50),
     9DCB(3),OCBD(3),OCBDD(3),XP(4),YP(4),ZP(4),XTU(3,50),FEL(50),
     XXA(50),YA(50),ZA(50),XB(50),YB(50),ZB(50),DVAL(3),EVAL(3),OMI(3),
     XDNI(3),DN(3),DND(3),ANEW(3,3),ADNU(3,3),        XPR(3,4),XPDD(3,4),
     XXPB(3,4),CBMAX(3),CBMIN(3),ACMAX(3),ACMIN(3),TCBMAX(3),TCBMIN(3),
     XTACMAX(3),TACMIN(3),DX(50),DY(50),SLG(50),SM(50),R(50),XBO(50),
     XYBO(50),ZBO(50),XPB(3,50),U(3,50)
C
C     NO TITLE CARD READ AND WRITE IN THIS SUBROUTINE.
C     NO NA,NB,NC,...,NH CARD READ,  ND AND NF ARE SET TO 1 AND 0 RESPECTIVELY.
C
C     INPUT SEQUENCE FOR OVERLAY ISOL RUN *****
C        1. NAN,NBN,NCN,...,NHN CARD      (18I4)
C        2. GROUP 5 INPUT IF SHORT PENDULUM.
C        3. GROUP 8A INPUT IF NBN IS -VE.
C        4. GROUP 8A AND 8C IF NONLINEAR SPRING/DAMPER INPUT
C        5. GROUP 10
C        6. GROUP 11 IF NAN IS -VE
C        7. A BLANK CARD FOR NORMAL EXIT.
C
C     NOTE ***
C        IF NAN = 0, NORMAL EXIT
C               = +VE, NORMAL EXECUTION WITH NO INITIAL CONDITIONS (GP 11) READ
C               = -VE, NORMAL EXECUTION PLUS INITIAL CONDITION READ.
C        IF NBN = 0, SPRING/DAMPER READ FROM ISOLIN, GROUPS 8A,8C ARE SKIPPED,
C               =+M, M EXTRA SPRING/DAMPER ARE READ IN FROM CARDS,
C               =-1, COMPLETE NB SETS OF SPRING/DAMPER ARE READ IN FROM CARDS.
C        IF NCN = 0, NO EXCITATION FORCE INPUT
C               = +VE, EXCITATION FORCE READIN FROM SYNGOL
C               = -N, EXCITATION TABLES (OF LENGTH N) ARE READ IN FROM CARDS
C        IF NFN = +VE OR ZERO, GROUP 7 (PTS. OF INTEREST) IS SKIPPED
C                 -VE, GROUP 7 IS READ,  NO. OF POINTS = ABS(NEN).
C        IF NEN = 0, ACCELERATION EXCITATION INPUT IN G UNIT
C        IF NEN = 1, ACCELERATION EXCITATION INPUT IN IN/SEC**2 UNIT.
C
    1 FORMAT (20X,12A6,//)
    2 FORMAT(18I4)
    3 FORMAT(//11H INPUT DATA//5H  NA=I4,5H  NB=I4,5H  NC=I4,5H  ND=I4,
     1        5H  NE=I4,5H  NF=I4,5H  NG=I4,5H  NH=I4//)
    4 FORMAT(10F8.0)
C     THE FOLLOWING 4 CARDS CHANGED BY HND 10 DEC 14
    5 FORMAT(44H MASSES, COORDINATES, AND MOMENTS OF INERTIA// 3X,10H MA
```

AD-A094 299 ARMY ENGINEER DIV HUNTSVILLE AL F/G 14/2
SHOCK TEST PROGRAM. SHOCK ISOLATION DESIGN MANUAL FOR SAFEGUARD--ETC(U)
AUG 73 G C CHAN, R YANG, H SAFFELL, C C HUANG
UNCLASSIFIED HNDSP-73-98-ED-R NL

4 OF 7
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A094299

```
     1SS(LBM),6X,3H XM,7X,3H YM,7X,3H ZM,5X,4H IXX,9X,4H IYY,9X,4H IZZ,
     29X,4H IXY,9X,4H IXZ,9X,4H IYZ//)
    6 FORMAT (I3,4F10.2,6E13.5)
    8 FORMAT (//28H SPRING ATTACHMENT LOCATIONS//12X,3H XA,7X,3H YA,7X,
     1        3H ZA,7X,3H XB,7X,3H YB,7X,3H ZB//)
    9 FORMAT (I5,6F10.2)
   10 FORMAT (//24H SPECIAL POINT LOCATIONS//12X,3H XP,7X,3H YP,7X,3H ZP
     1        //)
   11 FORMAT (I5,3F10.2)
   12 FORMAT (2I4,3E8.0)
   13 FORMAT (//34H SPRING AND DAMPER CHARACTERISTICS//)
   14 FORMAT (//I5,   12H FREE LGTH =F8.2,5X,12H SPR CONST =F8.2,5X,
     1        12H DAMP COEF =F8.2,7H   NX =I3,7H   NY =I3/)
   15 FORMAT (/9H DEFL(IN),6X,11H FORCE(LBF))
   16 FORMAT (F10.3,5X,F12.3)
   18 FORMAT (/10H V(IN/SEC),5X,21H FORCE(LBF))
  240 FORMAT (//36H POSITIONS OF ROLLING BALL ISOLATORS//12X,3H XA,7X,
     13H YA,7X,3H ZA,7X,3H XB,7X,3H YB,7X,3H ZB,6X,4H XBO,6X,4H YBO,
     26X,4H ZBO,8X,2H R,7X,3H MU//)
  244 FORMAT (//38H POSITIONS OF SHORT PENDULUM ISOPATORS//12X,3H XA,7X,
     13H YA,7X,3H ZA,7X,3H XB,7X,3H YB,7X,3H ZB,6X,4H SLG,7X,3H DX,7X,
     23H DY//)
  248 FORMAT (I5,11F10.2)
  249 FORMAT (I5, 9F10.2)
      REWIND IK
      REWIND IL
      READ (5,2) NAN,NBN,NCN,NDN,NEN,NFN,NGN,NHN
      IF (NBN .LE. 0) N=NB
      IF (NCN .LE. 0) NC=IABS(NCN)
      ND=1
      NF=NFN
      NG=1
      IF (NAN .LT. 0) NG=0
      IF (NEN .LT. 0) NE=-NEN
      WRITE (6,3) NA,N,NC,ND,NE,NF,NG,NH
      IF (NG) 507,501,501
C
C     READ INERTIAS AND SPRING COORDINATES
C
  501 DO 502 I=1,NA
  502 READ (IK          ) WT(I),XM(I),YM(I),ZM(I),XXI(I),YYI(I),ZZI(I),
C                 ,END=540
     XXYI(I),XZI(I),YZI(I)
      WRITE (6,5)
      WRITE (6,6)  (I,WT(I),XM(I),YM(I),ZM(I),XXI(I),YYI(I),ZZI(I),
     1             XYI(I), XZI(I), YZI(I) ,I= 1, NA)
      DO 503 I=1,NB
  503 READ (IK          ) XA(I),YA(I),ZA(I),XB(I),YB(I),ZB(I)
C                 ,END=540
      IF (NH.NE.0) GO TO 490
      IF (NBN .LE. 0) GO TO 485
      DO 480 N=1,NBN
      I=N+NS
  480 READ (5,7) XA(I),YA(I),ZA(I),XB(I),YB(I),ZB(I)
    7 FORMAT (6F8.0)
  485 IF (NH .NE. 0) GO TO 490
      WRITE (6,8)
      WRITE (6,9)  (I, XA(I),YA(I),ZA(I),XB(I), YB(I), ZB(I) ,I=1,NB)
```

```
      GO TO 497
  490 IF (NH.LT.0) GO TO 494
      DO 492 I=1,NB
  492 READ (IK          ) XBO(I),YBO(I),ZBO(I),R(I),UM(I)
C                 ,END=540
      WRITE (6,240)
      WRITE (6,248)  (I,XA(I),YA(I),ZA(I),XB(I),YB(I),ZB(I),XBO(I),
     1YBO(I),ZBO(I),R(I),UM(I) ,I=1,NB)
      GO TO 497
  494 DO 496 I=1,NB
  496 READ (IK          ) SLG(I),DX(I),DY(I)
C                 ,END=540
      WRITE (6,244)
      WRITE (6,249)  (I,XA(I),YA(I),ZA(I),XB(I),YB(I),ZB(I),SLG(I),
     1DX(I),DY(I) ,I=1,NB)
  497 CONTINUE
      DO 505 I=1,4
      READ (IK          ) XP(I),YP(I),ZP(I)
C                 ,END=540
      IF (EOF(IK)) 540,504
  504 IF (NEN.LT.0 .AND. I.LE.NE) READ (5,4) XP(I),YP(I),ZP(I)
  505 CONTINUE
      WRITE (6,10)
      WRITE (6,11) (I,XP(I),YP(I),ZP(I) , I = 1, NE)
  507 WRITE (6,13)
      N=NB
      IF (NBN .GT. 0) N=NB+NBN
C     READ IN NBN EXTRA SETS OF SPRING/DAMPER VALUES IF NBN IS NON-ZERO,  OR
C     REPLACE EXACT NO. OF SPRING/DAMPER VALUES FROM CARD INPUT IF NBN IS -VE.
      DO 521 I=1,N
      IF (I .LE. NB) READ (IK          ) NX(I),NY(I),SL(I),SK(I),DA(I)
      IF (NBN.LT.0.OR.I.GT.NB) READ (5,12) NX(I),NY(I),SL(I),SK(I),DA(I)
C                                 ,END=540
      WRITE (6,14) I,SL(I),SK(I),DA(I),NX(I),NY(I)
      IF (NX(I))511,515,510
  510 WRITE (6,15)
C     NOTE... READ, FORM CARD READER, THE NON-LINEAR SPRING AND DAMPING TABLES.
      L = NX(I)
      READ  (5,4) ((DF(J,I)), J = 1, L)
      WRITE (6,16) (DF(J,I), FS(J,I) , J = 1, L)
  511 CONTINUE
  515 IF (NY(I))516,521,520
  520 WRITE (6,18)
      L = NY(I)
      READ (5,4)  (VD(J,I) , J = 1, L)
      READ (5,4)  (FD(J,I) , J = 1, L)
      WRITE (6,16) (VD(J,I),FD(J,I) ,J=1,L)
  516 CONTINUE
  521 CONTINUE
      NB=N
  525 IF (NC .EQ. 0) RETURN
      NE=IABS(NC)
C
C     READ EXCITATION TABLES
C
      IF (NCN .GT. 0) GO TO 555
      READ (5,550) (TTAB(I),I=1,NC)
      READ (5,550) (XE(I),I=1,NC)
```

```
      READ (5,550) (YE(I),I=1,NC)
      READ (5,550) (ZE(I),I=1,NC)
  550 FORMAT (9F8.0)
      RETURN
  555 CONTINUE
      READ (IL          ) (ITAB(I),I=1,NEX)
      READ (IL          ) (XE(I),I=1,NEX)
      READ (IL          ) (YE(I),I=1,NEX)
      READ (IL          ) (ZE(I),I=1,NEX)
                ,END=540
      IF (EOF(IL)) 540,530
  530 REWIND IL
      RETURN
  540 WRITE (6,545)
  545 FORMAT (//,5X,9HEOF ERROR)
      STOP
      END
```

```
      SUBROUTINE LEINT  (X,Y,NI,TABLEX,TABLEY,NER)
C     LINEAR INTERPOLATION SUBROUTINE
      DIMENSION TABLEX(1),TABLEY(1)
C     Y IS SET TO ZERO WHEN X EXCEEDS TABLEX(NI) ONLY IF NER EQUALS TO 2
      IF (X.GT.TABLEX(NI) .AND. NER.EQ.2) GO TO 115
      IF (X.GT.TABLEX(NI) .OR. X.LT.TABLEX(1)) GO TO 103
      NER=0
      DO 100 I=1,NI
      IF(TABLEX(I)-X)97,101,98
   97 IF(TABLEX(I+1)-X)100,99,102
   98 IF(TABLEX(I+1)-X)102,99,100
  100 CONTINUE
  103 NER=1
      GO TO 109
   99 Y=TABLEY(I+1)
      GO TO 109
  101 Y=TABLEY(I)
      GO TO 109
  102 IF (NI-I) 103,109,104
  104 PART1=TABLEY(I)*(TABLEX(I+1)-X)
      PART2=TABLEY(I+1)*(TABLEX(I)-X)
      Y=(PART1-PART2)/(TABLEX(I+1)-TABLEX(I))
  109 RETURN
  115 Y=0.0
      NER=0
      RETURN
      END
```



```
      SUBROUTINE AMBS3 (A,B,C)
C     3X3 MATRIX MULTIPLY BY 3X3 MATRIX
      DIMENSION A(3,1),B(3,1),C(3,1)
      DO 10 I=1,3
      DO  9 J=1,3
      SUM=0.0
      DO  8 IA=1,3
    8 SUM=SUM+A(I,IA)*B(IA,J)
    9 C(I,J)=SUM
   10 CONTINUE
      RETURN
C
      ENTRY AMBC3
C     3X3 MATRIX MULTIPLY BY 1X3 MATRIX
      DO 20 I=1,3
      SUM=0.0
      DO 15 J=1,3
   15 SUM=A(I,J)*B(J,1)+SUM
   20 C(I,1)=SUM
      RETURN
      END
```

```
      SUBROUTINE INV3 (A,B)
C     INVERSION OF 3X3 MATRIX
      DIMENSION A(3,1),B(3,1),C(3,4)
      DO 50 I=1,3
      DO 51 J=1,3
   50 C(I,J) = A(I,J)
      DO 105 I=1,3
      DO 65 IJ=1,3
   65 C(IJ,4) = 0.0
      C(I,4) = 1.0
      DO 75 J=1,4
      IF (I-J) 70,75,70
   70 C(I,J) = C(I,J)/C(I,I)
   75 CONTINUE
      DO 95 IK=1,3
      IF (IK-I) 80,95,80
   80 DO 90 J=1,4
      IF (I-J) 95,90,85
   85 C(IK,J) = C(IK,J)-C(IK,I)*C(I,J)
   90 CONTINUE
   95 CONTINUE
      DO 100 II=1,3
  100 C(II,I) = C(II,4)
  105 CONTINUE
      DO 110 I=1,3
      DO 110 J=1,3
  110 B(I,J) = C(I,J)
      RETURN
C
      ENTRY MTRAN3
C     TRANSPOSE 3X3 MATRIX
      DO 120 I=1,3
      DO 120 J=1,3
  120 B(I,J)=A(J,I)
      RETURN
C
      ENTRY DET3
C     EVALUATES A 3 X 3 DETERMINANT
      B(1,1)=A(1,1)*A(2,2)*A(3,3) + A(1,2)*A(2,3)*A(3,1) +
     X      A(2,1)*A(3,2)*A(1,3) - A(1,3)*A(2,2)*A(3,1) -
     Y      A(1,2)*A(2,1)*A(3,3) - A(1,1)*A(2,3)*A(3,2)
      RETURN
      END
```

```
      SUBROUTINE DED (NUM,IND,NTEST), RETURNS(A)
      I=3
      CALL DEDIS (NUM,IND,NTEST,I)
      IF (I .GT. 3) RETURN
      RETURN A
C
      ENTRY DEI
      CALL DEDIS(NUM,IND,NTEST,2)
      RETURN
C
      ENTRY DES
      CALL DEDIS (NUM,IND,NTEST,1)
      RETURN
      END
```

```
      SUBROUTINE DDIS (NUM,IND,NTEST,IFROM)
      DOUBLE PRECISION DP
      INTEGER ALPHA,R,TSXJC5
      LOGICAL SW1,SW2,DECRH,INCRH
      DIMENSION D(2),RKA(7,4)
      EQUIVALENCE (DP,D(1))
      COMMON /CMI/T(300),TSXJC5,NPASS,ALPHA,R,SW1,SW2,DECRH,INCRH
      DATA RKA/0.,2.,-1.,3.,-.5,1.,0.,0.,2.,-.5,-1.
     1,.5,-.333333333,0.,-.5,1.,0.,-1.,0.,1.,0.,2.,6.,1.,3.,-.5,-3.,0./
      DATA ERRN1/6HN=0   /,ERRN2/6HN FLT /,ERRHB/6HH=0   /,ERRE/6HE=0
     1/,ERR1/6HIND   /
      IADD=1
      JND=1
      N=NUM
      N1=IADD+N
      N2=N1+N
      N3=N2+N
      N4=N3+N
      N5=N4+N
      N6=N5+N
      N7=N6+N
      N8=N7+N
      N9=N8+N
      N10=N9+N
      N11=N10+N
      N12=N11+N
      GO TO (5,105,180), IFROM
    5 SW1=.TRUE.
      SW2=.TRUE.
C     TEST IF N = 0
      IF (N.EQ.0) GO TO 330
C     TEST IF N IS REAL
      IF (N.GT.4096) GO TO 335
C     TEST IF H=0
      IF (ABS(T(N12)).LT.1.E-35) GO TO 340
C     ASSURE IND=0, 1, OR 2
      IF (((IABS(IND).NE.0).AND.(IND.NE.1)).AND.(IND.NE.2)) GO TO 350
C     IND IS 0, 1, OR 2
      IF(IND.NE.0)GO TO 10
C     TEST IF E=0
      IF (ABS(T(N12+8)).LT.1.E-35) GO TO 345
   10 IF (IND-1) 25,20,15
   15 SW2=.FALSE.
      GO TO 100
   20 SW1=.FALSE.
      GO TO 100
   25 IF (T(N12+3)) 35,30,35
   30 BETA=.5
      GO TO 40
   35 BETA=T(N12+3)
   40 EBAR=14.*T(N12+8)
      IF (T(N12+7)) 50,45,50
   45 EBARDM=EBAR/100.
      GO TO 55
   50 EBARDM=EBAR/T(N12+7)
   55 IF (T(N12+6)) 65,60,65
   60 A=1.
```

```
      GO TO 70
65    A=T(N12+6)
70    IF (T(N12+5)) 80,75,80
75    INGRH=.FALSE.
      GO TO 85
80    INGRH=.TRUE.
      HMAXTB=T(N12+5)*BETA
85    IF (T(N12+4)) 95,90,95
90    DECRH=.FALSE.
      GO TO 100
95    DECRH=.TRUE.
      HMINDB=T(N12+4)/BETA
100   TSXJC5=1
      GO TO 295
105   HINT = ABS(T(N12))
      IF (.NOT.SM1) GO TO 175
      IF (ALPHA-3) 135,110,120
110   DO 115 I=1,N
      DP=DBLE(T(N12-I))+DBLE(T(N10-I))/3.00+00
      T(N12-I)=D(1)
115   T(N10-I)=D(2)
120   DO 125 I=1,N
      T(N8-I)=T(N12-I)
      T(N1-I)=T(N11-I)
125   T(N7-I)=T(N10-I)
      DO 130 I=1,N
      D(1)=T(N12-I)
      D(2)=T(N10-I)
      TEMP=T(N12)*(T(N1-I)*(55./24.)-(59./24.)*T(N2-I)+(37./24.)*T(N3-I)
     X     -(3./8.)*T(N4-I))
      T(N9-I)=SNGL(DP)+TEMP
130   T(N12-I)=T(N9-I)
      T(N12+1)=T(N12+1)+T(N12)
      TSXJC5=2
      GO TO 295
135   IF (ALPHA-1) 160,150,140
140   DO 145 I=1,N
145   T(N2-I)=T(N11-I)
      GO TO 170
150   DO 155 I=1,N
155   T(N3-I)=T(N11-I)
      GO TO 170
160   DO 165 I=1,N
      T(N4-I)=T(N11-I)
      T(N6-I)=T(N12-I)
165   T(N5-I)=T(N10-I)
170   ALPHA=ALPHA+1
175   NPASS=1
      GO TO 305
180   GO TO (185,195,300,225,240),TSXJC5
185   DO 190 I=1,N
      T(N9-I)=0.
190   T(N10-I)=0.
      ALPHA=0.
      R=0
      NTEST = 1
      RETURN
195   EMP1=0.
```

```
      DO 200 I=1,N
      Q(1)=T(N8-I)
      Q(2)=T(N10-I)
      TEMP=T(N12)*((1./24.)*T(N3-I)-(5./24.)*T(N2-I)+(19./24.)*T(N1-I)+(
     X     3./8.)*T(N11-I))
      DP=DP+DBLE(TEMP)
      T(N13-I)=Q(2)
      T(N12-I)=Q(1)
  200 ENP1=AMAX1(ENP1,(ABS(T(N9-I)-T(N12-I))/AMAX1(A,ABS(T(N12-I)))))
  205 IF (.NOT.SW2) GO TO 285
      IF (EBAR-ENP1) 210,210,255
  210 IF (.NOT.DECRH) GO TO 215
      IF (ABS(T(N12)).LT.HMINDB) GO TO 280
  215 TEMP=T(N12)
      T(N12)=T(N12)*BETA
      IF (ALPHA.EQ.7) GO TO 320
      T(N12+1)=T(N12+1)-TEMP
      DO 220 I=1,N
      T(N11-I)=T(N1-I)
      T(N12-I)=T(N3-I)
  220 T(N10-I)=T(N7-I)
  225 DO 230 I=1,N
  230 T(N10-I)=-3.*T(N10-I)
  235 ALPHA=0
      R=0
C     IF P-C MODE CHECK IF INTEGRATION IS GOOD POINT
  240 IF (IABS(JNO).NE.0) GO TO 250
C     IND=0 P-C MODE
      IF (ALPHA.NE.0) GO TO 245
C     ALPHA = 0
      IF (ABS(T(N12)).GT.HINT) GO TO 250
C     H DECREASED
      GO TO 160
C     ALPHA NOT 0
  245 IF (ALPHA.LE.3) GO TO 105
C     SUCCESS FROM D.E. ALPHA GREATER THAN 3 FOR P-C MODE
  250 IFROM = 4
      RETURN
  255 IF (EBARDM-ENP1) 280,280,260
  260 IF (.NOT.INDRH) GO TO 270
  265 IF (ABS(T(N12)).GT.HMAXTB) GO TO 285
  270 R=R+1
      IF (R.LT.3) GO TO 285
  275 T(N12)=T(N12)/BETA
      TSXJC5=4
      GO TO 295
  280 R=0
  285 DO 290 I=1,N
      T(N4-I)=T(N3-I)
      T(N3-I)=T(N2-I)
  290 T(N2-I)=T(N1-I)
      ALPHA=ALPHA+1
      TSXJC5=5
  295 NTEST = 0
      RETURN
  300 IF (NPASS.EQ.4) GO TO 240
      NPASS=NPASS+1
  305 RKA(7,1)=T(N12)/2.
```

```
      RKA(7,3)=RKA(7,1)
      DO 310 I=1,N
      T(N9-I)=RKA(1,NPASS)*T(N9-I)+T(N12)*T(N11-I)
      TEMP=T(N9-I)/RKA(2,NPASS)+RKA(3,NPASS)*T(N10-I)
310   T(N12-I)=T(N12-I)+TEMP
315   T(N10-I)=T(N10-I)*RKA(6,NPASS)+TEMP*RKA(4,NPASS)+T(N9-I)*
     X          RKA(5,NPASS)
      T(N12+1)=T(N12+1)+RKA(7,NPASS)
      TSXJC5=3
      GO TO 295
320   T(N12+1)=T(N12+1)-4.*TEMP
      DO 325 I=1,N
      T(N11-I)=T(N4-I)
      T(N12-I)=T(N6-I)
325   T(N10-I)=T(N5-I)
      GO TO 235
330   ERROR = ERRN1
      GO TO 355
335   ERROR = ERRN2
      GO TO 355
340   ERROR = ERRHB
      GO TO 355
345   ERROR = ERRE
      GO TO 355
350   ERROR = ERR1
355   WRITE(6,360) ERROR
360   FORMAT(51H0DIFFERENTIAL EQUATION SUBROUTINE DES INPUT ERROR  A6)
      STOP
      END
```

```
      SUBROUTINE BALL (A,DA,XT,XTD,SL,SK,SC,AXG,NX,DF,FS,NER,NY,VD,FD,
     1AMASS,F,FXL,N,XO1,XO2,XO3,DXO1,DXO2,DXO3,XA,YA,ZA,XB,YB,ZB,UM,R,
     2XBO,YBO,ZBO,S,TELT,FSS,DTELT,FSD,XPB)
C
C     FORCING FUNCTION OF ROLLING BALL ISOLATION SYSTEM
C
      DIMENSION A(3,3),DA(3,3),XO(3),DXO(3),XB(50),YB(50),ZB(50),XA(50)
     1,YA(50),ZA(50),XT(3,50),XTD(3,50),SL(50),SK(50),SC(50),AXG(3),
     2DF(20,50),FS(20,50),VD(20,50),FD(20,50),AMASS(50),F(3,50),SLO(50),
     3FXL(3,50),B(50),DB(50),CC(50),DC(50),XC(3,50),S(50),TELT(50),
     4DTELT(50),COSPH(50),DCS(3),VP2(50),VP(50),CF(3,50),GRACR(50),
     5DR(3,50),GRACF2(50),AXGF(3,50),GRACF(50),COSPS(50),NX(50),FSS(50),
     6NY(50),FSD(50),FSP(50),FR(50),FF(50),FINER(50),FJ(3),FXLJ(3),
     7ARM(3,3),CS(3),C(50),DS(50),DVA(3,50),DDVA(3,50),XPP(3,50),
     8DXPP(3,50),CSO(3,50),CSOJ(3),XPB(3,50),R(50),UM(50),XBO(50),
     9YBO(50),ZBO(50),DFJ(20),FSJ(20),VDJ(20),FDJ(20)
 1010 FORMAT (46H DEFLECTION-FORCE TABLE OUT OF RANGE DEF(I) =F8.3)
 1020 FORMAT (46H VELOCITY-DAMPING TABLE OUT OF RANGE DDEF(I) =F8.3)
 1500 FORMAT (46H SOMETHING WRONG WITH THE PLATE INPUTS - C(J)=F10.2)
      DATA  EPSL/0.1/
      XO(1) = XO1
      XO(2) = XO2
      XO(3) = XO3
      DXO(1) = DXO1
      DXO(2) = DXO2
      DXO(3) = DXO3
      DO 210  J=1, N
      SLO(J) = SQRT((XB(J)-XA(J))**2+(YB(J)-YA(J))**2+(ZB(J)-ZA(J))**2)
      CSO(1,J) = (XB(J)-XA(J)) / SLO(J)
      CSO(2,J) = (YB(J)-YA(J)) / SLO(J)
      CSO(3,J) = (ZB(J)-ZA(J)) / SLO(J)
      DO 103  I=1, 3
  103 CSOJ(I) = CSO(I,J)
      CALL AMBC3 (A,CSOJ,CS)
      CALL AMBC3 (DA,CSOJ,DCS)
      B(J) = 0.0
      DB(J) = 0.0
      CC(J) = 0.0
      DC(J) = 0.0
      XC(1,J) = XBO(J)
      XC(2,J) = YBO(J)
      XC(3,J) = ZBO(J) + R(J)
      DO 110  I=1, 3
      DVA(I,J) = XT(I,J) + XO(I) - XC(I,J)
      DDVA(I,J) = XTD(I,J) + DXO(I)
      B(J) = B(J) + CS(I)*DVA(I,J)
      CC(J) = CC(J) + DVA(I,J)**2
      DB(J) = DB(J) + CS(I)*DDVA(I,J) + DCS(I)*DVA(I,J)
      DC(J) = DC(J) + 2.*DVA(I,J)*DDVA(I,J)
  110 CONTINUE
      C(J) = CC(J) - R(J)**2
      IF (C(J). LT. 0.) GO TO 112
      WRITE (6,1500) C(J)
      STOP 112
  112 CONTINUE
      S(J) = -B(J) + SQRT(B(J)**2-C(J))
      DS(J) = -DB(J) +(2.*B(J)*DB(J)-DC(J)) / (2.*SQRT(B(J)**2-C(J)))
```

```
      TELT(J) = SL(J) - S(J)
      DTELT(J) = -DS(J)
      COSPH(J) = 0.0
      VP2(J) = 0.0
      DO 115  I=1, 3
      XPP(I,J)= XT(I,J) + S(J)*CS(I) + X0(I)
      DXPP(I,J)= XTD(I,J) + DX0(I) + S(J)*DCS(I) + DS(J)*CS(I)
      SK(I,J) = (XPP(I,J) - XG(I,J)) / R(J)
      COSPH(J) = COSPH(J) + CR(I,J)*CS(I)
  115 VP2(J) = VP2(J) +DXPP(I,J)**2
      XPB(1,J) = XPP(1,J) -XB0(J)
      XPB(2,J) = XPP(2,J) -YB0(J)
      XPB(3,J) = XPP(3,J) -ZB0(J)
      VP(J) = SQRT(VP2(J))
      IF (VP(J). LE. EPSL) GO TO 122
      DO 120  I=1, 3
  120 CF(I,J) =-DXPP(I,J) / VP(J)
      GO TO 147
  122 GRACR(J) = 0.0
      DO 125  I=1, 3
  125 GRACR(J) = GRACR(J) + CR(I,J)*AXG(I)
      GRACE2(J) = 0.0
      DO 130  I=1, 3
      AXGE(I,J) = AXG(I) - GRACR(J)*CR(I,J)
  130 GRACE2(J) = GRACE2(J) + AXGE(I,J)**2
      GRACE(J) = SQRT(GRACE2(J))
      IF (GRACE(J). LE. EPSL) GO TO 140
      DO 145  I=1, 3
  145 CF(I,J) = AXGE(I,J) / GRACE(J)
      GO TO 147
  140 CONTINUE
      DO 142  I=1, 3
  142 CF(I,J) = 0.0
  147 CONTINUE
      COSPS(J) = 0.0
  155 DO 160  I=1, 3
  160 COSPS(J) = COSPS(J) + CS(I)*CF(I,J)
      IF (NX(J)) 165, 165, 167
  165 FSS(J) = SK(J)*TELT(J)
      GO TO 175
  167 TELTJ = TELT(J)
      NXJ = NX(J)
      DO 170  I=1, NXJ
      DFJ(I) = DF(I,J)
  170 FSJ(I) = FS(I,J)
      CALL LEINT (TELTJ,FSSJ,NXJ,DFJ,FSJ,NER)
      IF (NER. EQ. 0) GO TO 173
      WRITE (6, 1010) TELT(J)
      STOP 173
  173 FSS(J) = FSSJ
  175 IF (NY(J)) 180, 180, 183
  180 FSD(J) = DTELT(J)*SC(J)
      GO TO 190
  183 DTELTJ = DTELT(J)
      NYJ = NY(J)
      DO 185  I=1, NYJ
      VDJ(I) = VD(I,J)
  185 FDJ(I) = FD(I,J)
```

```
      CALL LEINT (DTELTJ,FSDJ,NYJ,VDJ,FDJ,NER)
      IF(NER. EQ. 0) GO TO 188
      WRITE (6,1020) DTELT(J)
      STOP
  188 FSD(J) = FSDJ
  190 FSP(J)= FSS(J) + FSD(J)
      FR(J) = FSP(J)/ (COSPH(J)-UM(J)*COSPS(J))
      FF(J) = FR(J)*UM(J)
      FINER(J) = AMASS(3)*GRACE(J) / FLOAT(N)
      IF (FF(J). GE.FINER(J). AND. VP(J).LE.EPSL) GO TO 200
      DO 195  I=1, 3
  195 F(I,J) = -FR(J)*(CR(I,J)-UM(J)*CF(I,J))
      GO TO 206
  200 FR(J) = (FINER(J)*COSPS(J) +FSP(J))/ COSPH(J)
      FF(J) = FINER(J)
      DO 205  I=1, 3
  205 F(I,J) = -FR(J)*CR(I,J) + FINER(J)*CF(I,J)
  206 CONTINUE
      DO 208  I=1, 3
      FJ(I) = F(I,J)
  208 CONTINUE
      ARM(1,1) = 0.0
      ARM(1,2) =-XPP(3,J) -XO(3)
      ARM(1,3) =XPP(2,J) -XO(2)
      ARM(2,1) =XPP(3,J) -XO(3)
      ARM(2,2) = 0.0
      ARM(2,3) =-XPP(1,J) - XO(1)
      ARM(3,1) =-XPP(2,J) - XO(2)
      ARM(3,2) =XPP(1,J) - XO(1)
      ARM(3,3) = 0.0
      CALL AMBC3 (ARM, FJ, FXLJ)
      DO 209  I=1, 3
  209 FXL(I,J) = FXLJ(I)
  210 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SHPED (SL,XT,XTD,SK,SC,NX,DF,FS,NER,NY,VD,FD,
     1F,FXL,N,XO1,XO2,XO3,DXO1,DXO2,DXO3,SLG,AX,AY,AZ,DX,DY,U,S,TELT,
     2FSS,DTELT,FSD,BX,BY,BZ)
C
C     FORCING FUNCTION FOR SHORT PENDULUM ISOLATION SYSTEM
C
      DIMENSION XA(3,50),XO(3),XT(3,50),XTD(3,50),SK(50),SC(50),SL(50),
     1 DF(20,50),FS(20,50),VD(20,50),FD(20,50),F(3,50),FXL(3,50),
     2  DU(3,50),DXO(3),UV(50),SIPHA(50),COPHA(50),GAMA(50),DGAMA(50),
     3TELT(50),DTELT(50),NX(50),NY(50),FSS(50),FSD(50),FSP(50),FJ(3),
     4FXLJ(3),ARM(3,3),AX(50),AY(50),AZ(50),DX(50),DY(50),S(50),SLG(50),
     5U(3,50),XB(3,50),BX(50),BY(50),BZ(50),DFJ(20),FSJ(20),VDJ(20),
     6FDJ(20)
 1000 FORMAT (/54H MAGNITUDE OF COSINE FUNCTION GREATER THAN ONE - ARG=
     1F10.2)
 1010 FORMAT (45H DEFLECTION-FORCE TABLE OUT OF RANGE DEF(I) =F8.3)
 1020 FORMAT (46H VELOCITY-DAMPING TABLE OUT OF RANGE DDEF(I) =F8.3)
      DATA  EPSL/0.001/
      XO(1) = XO1
      XO(2) = XO2
      XO(3) = XO3
      DXO(1) = DXO1
      DXO(2) = DXO2
      DXO(3) = DXO3
      DO 250  J=1, N
      XA(1,J) = AX(J)
      XA(2,J) = AY(J)
      XA(3,J) = AZ(J)
      XB(1,J)= BX(J)
      XB(2,J)= BY(J)
      XB(3,J)= BZ(J)
      U(1,J) = DX(J)
      U(2,J) = DY(J)
      U(3,J) = 0.
      DO 105  I=1, 3
      U(I,J) = XT(I,J) + XO(I) - XA(I,J) + U(I,J)
  105 DU(I,J) = XTD(I,J) + DXO(I)
      UV(J) = U(1,J)**2 + U(2,J)**2
      IF (UV(J). LE. EPSL)  GO TO 115
      SIPHA(J) = U(2,J) / SQRT(UV(J))
      COPHA(J) = U(1,J) / SQRT(UV(J))
      ARG = SQRT(UV(J)) / SLG(J)
      IF (ARG.LT.1.) GO TO 110
      WRITE (6,1000) ARG
      STOP 110
  110 GAMA(J) = ACOS(ARG)
      DGAMA(J) = -(U(1,J)*DU(1,J)+U(2,J)*DU(2,J)) / (UV(J)*SQRT(1./ARG**
     12-1.))
      TELT(J)=-U(3,J)+SLG(J)*(1.-SIN(GAMA(J)))+ SL(J)-XA(3,J)+XB(3,J)
      DTELT(J) = -DU(3,J) - SLG(J)*COS(GAMA(J))*DGAMA(J)
      GO TO 120
  115 TELT(J) = -U(3,J) +SL(J) -XA(3,J) + XB(3,J)
      DTELT(J) = -DU(3,J)
      S(J) = SL(J) -TELT(J)
  120 IF (NX(J)) 165, 165, 167
  165 FSS(J) = SK(J)*TELT(J)
      GO TO 175
```

```
167 TELTJ = TELT(J)
    NXJ = NX(J)
    DO 170  I=1, NXJ
    DFJ(I) = DF(I,J)
170 FSJ(I) = FS(I,J)
    CALL LEINT (TELTJ,FSSJ,NXJ,DFJ,FSJ,NER)
    IF (NER. EQ. 0) GO TO 173
    WRITE (6, 1010) TELT(J)
    STOP 173
173 FSS(J) = FSSJ
175 IF (NY(J)) 180, 180, 183
190 FSD(J) = DTELT(J)*SG(J)
    GO TO 190
183 DTELTJ = DTELT(J)
    NYJ = NY(J)
    DO 185 I=1, NYJ
    VDJ(I) = VD(I,J)
185 FDJ(I) = FD(I,J)
    CALL LEINT (DTELTJ,FSDJ,NYJ,VDJ,FDJ,NER)
    IF(NER. EQ. 0) GO TO 188
    WRITE (6,1020) DTELT(J)
    STOP
188 FSD(J) = FSDJ
190 FSP(J)= FSS(J) + FSD(J)
    F(3,J) = FSP(J)
    IF (UV(J).LE.EPSL) GO TO 195
    F(1,J) = -F(3,J)*COPHA(J)*COS(GAMA(J))/SIN(GAMA(J))
    F(2,J) = -F(3,J)*SIPHA(J)*COS(GAMA(J))/SIN(GAMA(J))
    GO TO 198
195 F(1,J) = 0.
    F(2,J) = 0.
198 DO 200 I=1,3
    FJ(I) = F(I,J)
200 CONTINUE
    ARM(1,1) = 0.0
    ARM(1,2) = -XT(3,J)
    ARM(1,3) = XT(2,J)
    ARM(2,1) = XT(3,J)
    ARM(2,2) = 0.0
    ARM(2,3) = -XT(1,J)
    ARM(3,1) = -XT(2,J)
    ARM(3,2) = XT(1,J)
    ARM(3,3) = 0.0
    CALL AMBC3 (ARM,FJ,FXLJ)
    DO 210  I=1, 3
210 FXL(I,J) = FXLJ(I)
250 CONTINUE
    RETURN
    END
```

```
      OVERLAY (ISICP,2,0)
      PROGRAM PLTSUB
      COMMON /ID12/ID(12),NN
      COMMON /IO8/IDI(8)
      COMMON /OPTION/IOP,IPLT,IL
      COMMON /X1/IBUF(1000)
      COMMON T3(5175),T4(5175),LOT(25),X(49)
C
C     MOST PLOTTINGS ARE HANDLED IN THIS OVERLAY LINKAGE, WHICH ARE PUT TOGETHER
C     BY G.CHAN/SPERRY RAND.                                          9/72-GC.
C
C     OPENING AND CLOSING OF THE PLOTTER PACKAGE COULD MOVED TO MAIN CONTROL
C     LINKAGE IF SYSTEM ALLOWS.
C
C     PLOTTER CHOICE **  IPLT=1, FOR CALCOMP PLOTTER,
C                        IPLT=2, FOR SC-4020 SCOPE PLOTTER, AND
C                        IPLT=3, FOR LINE-PRINTER PLOTS.
C
C     NN = PLOTTING OPTION **     =1, FOR PROPER OPENNING,
C                                 =2, FOR PROPER CLOSING,
C                                 =3, FOR REQUESTING CPLOT3/4,  AND
C                                 =4, FOR REQUESTING YUPLOT SUBROUTINE.
C
      ENCODE (72,5,IDI) ID
    5 FORMAT (12A6)
      IF (IPLT.LE.0 .OR. IPLT.GE.4) GO TO 50
C     GO TO (10,40,20,30), NN
C     NN = 1 AND 2 OPTIONS ARE SUBPRESSED.......
      IF (IPLT.LE.2 .AND. NN.LE.2) GO TO 50
   10 IF (IPLT .EQ. 2) CALL IDENT
      IF (IPLT .EQ. 1) CALL CALID
      GO TO (50,50,20,30), NN
   20 IF (IPLT .GE. 2) CALL CPLOT4 (7,T3,0,A,C,T4,0,B)
      IF (IPLT .EQ. 1) CALL CPLOT3 (0,T3,12.0,A,C,T4,8.0,B)
   30 IF (NN .EQ. 4) CALL YUPLOT
   40 IF (IPLT .EQ. 2) CALL ENDJOB
      IF (IPLT .EQ. 1) CALL CALEND
   50 CONTINUE
      END
```

```
      SUBROUTINE CALID
C
C     THIS SUBROUTINE HANDLES THE OPENING AND CLOSING OF CALCOMP AND SC 4020
C        PLOTTERS.
C
      COMMON /ID8/ID(8)
      COMMON /XY/IBUF(1000)
      DIMENSION USARMY(6)
      DATA USARMY/10HU.S. ARMY ,10HENGINEER D,10HIVISION, H,10HUNTSVILLE
     X,10H CORPS OF ,10HENGINEERS /
C
      DAT=DATE(DUMMY)
      CALL PLOTS (IBUF,-1000,DUMMY)
C     CALL FACTOR (0.5)
      CALL PLTISTR (10HDAVIS/CHAN,5HP8500,4HUNCL,5HWHITE,3HINK,5HBLACK,
     X              5H20 MIN,15HSET PEN LOWER RIGHT)
      CALL PLOT (1.0,-15.,-3)
      CALL PLOT (0.0,1.0,-3)
      CALL SYMBOL (0.0,0.0,0.14,USARMY,90.0,59)
      CALL SYMBOL (0.5,00.0,0.14,DAT,90.0,10)
      CALL SYMBOL (0.5,03.0,0.14,4HISIP,90.0,4)
      CALL PLOT (2.0,-1.5,-3)
      RETURN
C
      ENTRY CALEND
      CALL SYMBOL (1.0,0.0,0.14,ID,90.0,80)
      CALL SYMBOL (3.0,0.0,0.14,USARMY,90.0,59)
      CALL SYMBOL (3.5,00.0,0.14,DAT,90.0,10)
      CALL SYMBOL (3.5,2.6,0.14,10HISIP/P8500,90.0,10)
      CALL SYMBOL (3.5,6.0,0.14,10HDAVIS/CHAN,90.0,10)
      CALL PLOT (5.0,0.0,-3)
      CALL PLOT (0.,0.,999)
      CALL ENDPLOT (9H** COE **)
      RETURN
C
      ENTRY IDENT
      ENTRY ENDJOB
C
C     THESE TWO ENTRIES ARE RESERVED FOR OPENING AND CLOSE OF SC 4020 PLOTTER.
C
      RETURN
      END
```

```
      SUBROUTINE PLOTS (A,B,C,D,E,F,G,H)
C
C     REMOVE THIS SUBROUTINE AND ENTRIES IF CALCOMP PLOTTER AND/OR SC 4020
C     PLOTTER ARE AVAILABLE.
C
      ENTRY PLOT
      ENTRY SCALE
      ENTRY AXIS
      ENTRY NUMBER
      ENTRY SYMBOL
      ENTRY PLTISTR
      ENTRY ENDPLOT
C
      ENTRY QUKLOG
      ENTRY QUIK3V
      ENTRY PRINTV
      ENTRY LABLV
      ENTRY SMODE
C     ENTRY IDENT
C     ENTRY ENDJOB
      RETURN
      END
```

```
      SUBROUTINE YUPLOT
C
C     THIS PROGRAM HAS BEEN EXTENSIVELY REVISED TO REDUCE CORE SPACE REQUIREMENT
C     BY G. CHAN/SPERRY RAND.  ..... JAN. 1971
C     THE ORIGINAL PROGRAMMING WORK IS, HOWEVER, PRESERVED, AND RECOGNIZABLE.
C
C     CHOICE OF PLOTTER ...   IPLT =1 FOR CAL-COMP.,  =2 FOR SC4020 SCOPE.
C                             IPLT =3 FOR LINE-PRINTER PLOT.
C
      COMMON /OPTION/IOP,IPLT
      COMMON /ID12/ID(12)
      COMMON /ARRY/NCASE
      COMMON /LLOT/LOT(25)
      COMMON TT(450,23),X(49)
      DIMENSION XLABEL(5),YLABEL(100),T1(452),T2(452)
      INTEGER CURV,PTS
      DATA  XLABEL(1)/6H TIME /
      DATA (YLABEL(I),I=1,26,2)   /6H TIME ,6H  XC  ,6H  YC  ,6H  ZC  ,
     X6H  AX  ,6H  AY  ,6H  AZ  ,6H  OX  ,6H  OY  ,6H  OZ  ,6H OOX  ,
     X6H OOY  ,6H OOZ  /
      DATA (YLABEL(I),I=27,50,2)   /6H  ABX ,6H ABY  ,6H ABZ  ,6H A11  ,
     X6H A12  ,6H A13  ,6H A21  ,6H A22  ,6H A23  ,6H A31  ,6H A32  ,
     X6H A33  /
      DATA (YLABEL(I),I=51,74,2)   /6H XP1  ,6H YP1  ,6H ZP1  ,6H AXP1 ,
     X6H AYP1 ,6H AZP1 ,6H XP2  ,6H YP2  ,6H ZP2  ,6H AXP2 ,6H AYP2 ,
     X6H AZP2 /
      DATA (YLABEL(I),I=75,98,2)  /6H XP3  ,6H YP3  ,6H ZP3  ,6H AXP3 ,
     X6H AYP3 ,6H AZP3 ,6H XP4  ,6H YP4  ,6H ZP4  ,6H AXP4 ,6H AYP4 ,
     X6H AZP4 /
   97 FORMAT (E20.6,10X,F9.4)
   98 FORMAT (2I5,2F10.2)
   99 FORMAT (5X,8I6)
      ISERV=0
      REWIND 3
      NUM1=1
      IF (NCASE .GT. 1) GO TO 100
  100 READ (5,101) NUM1,(LOT(I),I=1,23)
  101 FORMAT (24I3)
      IF (NUM1 .LE. 0) GO TO 220
      IF (IOP .GE. 11) NUM1=1
      J=0
      DO 80 I=1,23
      IF (LOT(I) .EQ. 0) GO TO 80
      J=J+1
      LOT(J)=LOT(I)
   80 CONTINUE
      LOT(J+1)=0
      WRITE (6,99) NUM1,(LOT(I),I=1,J)
      WRITE (6,102)
  102 FORMAT (///5X,19HEND INPUT TO PLTSUB,///)
C     CHECK FOR END OF RUN FLAG = -NUM1
  108 WRITE (6,109) ID
  109 FORMAT (/////25X,12A6///)
      IF (NUM1-NUM2)-103,150,110
  103 WRITE (6,105) NUM1,NUM2
  105 FORMAT (18H  CARD RUN NUMBER=I5,35H IS LESS THAN LAST CARD RUN NUM
     XBER=I5,39H CHECK CARD DECK -WILL SKIP AND PROCEED//)
```

```
      GO TO 100
  110 READ (3) NUM3,T1(1),(X(JJ),JJ=2,49)
      IF(EOF(3))9999,8888
 8888 IF (ISERV .EQ. 1) WRITE (6,99) NUM1,NUM3
  112 IF (NUM1-NUM3) 114,130,120
  114 WRITE (6,115) NUM1,NUM3
  115 FORMAT (18H  CARD RUN NUMBER=I5,30H IS LESS THAN TAPE RUN NUMBER=I
     X5,29H WILL SKIP CARD AND READ NEXT//)
      READ (5,101) NUM1,(LOT(I),I=1,23)
      GO TO 112
  120 NUM =NUM1-NUM3
      WRITE (6,99) NUM,NUM1,NUM3
      K=0
  122 READ (3) NUM4
      IF(EOF(3))9999,999
  999 IF (NUM4) 124,122,122
  124 K=K+1
      IF (K.LT.NUM) GO TO 122
      WRITE (6,128) NUM
  128 FORMAT (14H  HAVE SKIPPEDI4,18H TRAJECTORY FILES //)
      GO TO 110
  130 K=1
      DO 132 L=1,23
      LL=LOT(L)
      IF (LL .LE. 0) GO TO 133
      IF (LL .LE. 49) GO TO 131
      WRITE (6,162) NUM1
      GO TO 132
  131 TT(K,L)=X(LL)
  132 CONTINUE
  133 DO 140 I=2,450
      K=K+1
  135 READ (3) NUM3,T1(K),(X(JJ),JJ=2,49)
      DO 137 L=1,23
      LL=LOT(L)
      IF (LL .LE. 0) GO TO 138
  137 IF (LL .LE. 49) TT(K,L)=X(LL)
C 138 WRITE (6,99) NUM1,NUM3,K
  138 CONTINUE
      IF (NUM3) 150,140,140
  140 CONTINUE
      WRITE (6,142)
  142 FORMAT (5X,52HONLY THE FIRST 450 DATA POINTS ARE USED FOR PLOTTING
     X        //,5X,42HAND THE REMAINING DATA (BELOW) ARE IGNORED/)
  145 READ (3) NUM4,DUMMY1,DUMMY2
      WRITE (6,97) DUMMY1,DUMMY2
      IF (NUM4 .EQ. NUM1) GO TO 145
  150 PIS=K
      CURV=NUM1
  152 DO 200 I=1,23
C     WRITE (6,99) NUM1,NUM3,K,LOT(I)
      IF (LOT(I) .LE. 0) GO TO 210
      IF (LOT(I) .GT. 49) GO TO 200
      J=2*LOT(I)-1
      WRITE (6,87) YLABEL(J)
   87 FORMAT (/13X, A6//)
  162 FORMAT (66H  INPUT ERROR PARAMETER REQUEST GREATER THAN 49 FOR TRA
     XJ. RUN NO.=I5//)
```

```
      DO 170 N=1,PTS
  170 T2(N)=TT(N,I)
      IF (IOP .LE. 10) WRITE (6,150) I,CURV,PTS
  150 FORMAT (///5X,6HPLOT NO.,I4,5X,11HCURV, PTS =,2I7)
      IF (IPLT.EQ.1) CALL CPLOT1(CURV,T1,15.,XLABEL,PTS,T2,8.,YLABEL(J))
      IF (IPLT.EQ.2) CALL CPLOT2(CURV,T1, 20,XLABEL,PTS,T2, 7,YLABEL(J))
      IF (IPLT.EQ.3) CALL CPLOT5(CURV,T1,15.,XLABEL,PTS,T2,8.,YLABEL(J))
  200 CONTINUE
  210 NUM2=NUM1
      IF (IOP .LE. 10) GO TO 100
C     THE -NUM1 CARD FOR NORMAL EXIT IS NOT NEEDED IN AN OVERLAY RUN (IOP.GE.11)
  220 WRITE (6,221)
  221 FORMAT (/////5X,15HEND OF PLOT RUN)
      REWIND 3
      RETURN
 9999 WRITE (6,888)
  888 FORMAT (///,9HEOF ERROR/)
      END
```

```
      SUBROUTINE CPLOT1 (NCURV,XARRAY,XAXIS,XLABEL,NPTS,YARRAY,YAXIS,
     XYLABEL)
      COMMON /OPTION/IOP,IPLT,IL,IK
      COMMON /WSL/NPS(4)
      COMMON /IO8/IO(8)
      DIMENSION XARRAY(1),YARRAY(1),XLABEL(1),YLABEL(1)
C
C     CRL-COMP PLOT INTERFACE SUBROUTINE  YNY/WJS
C
      JJ=1
      VALUE=FLOAT(NCURV)
    5 J=NPTS+1
      CALL PLOT (0.0,-.5,3)
      CALL SCALE (XARRAY,XAXIS,NPTS, 1)
      CALL SCALE (YARRAY,YAXIS,NPTS, 1)
      CALL AXIS ( 0.,1.0,XLABEL,  6,XAXIS, 0.0,XARRAY(J),XARRAY(J+1))
      CALL AXIS ( 0.,1.0,YLABEL,  6,YAXIS, 90.,YARRAY(J),YARRAY(J+1))
      IF (JJ .NE. 1) GO TO 10
      CALL SYMBOL(1.,9.,.14,8HCASE NO ,0.,8)
      CALL NUMBER (999.,999.,.14,VALUE,0.,-1)
   10 CALL SYMBOL (0.0,9.7,0.14,ID,0.0,72)
      IF (JJ .EQ. 2) CALL SYMBOL (1.,.1,.14,42HSHOCK SPECTRUM FROM NWVSY
     XN, LOG-LOG VALUES,0.,42)
      IF (JJ .EQ. 3) CALL SYMBOL (1.,.1,.14,37HTIME-ACCEL. HISTRY FROM N
     XWVSYN/SYNSOL ,0.,37)
      CALL PLOT (0.,1.,-3)
      CALL LINE (XARRAY,YARRAY,NPTS,1,0,0)
      CALL PLOT (10.0,-1.,-3)
      GO TO (60,15,45), JJ
C
      ENTRY CPLOT3
      JJ=2
      XSAVE=XLABEL(1)
      YSAVE=YLABEL(1)
   15 READ (IK        ) NPTS
      IF (EOF(IK)) 30,17
   17 IF (NPTS .LE. 0) GO TO 15
      IF (NPTS .GT. 5175) NPTS=5175
      READ (IK) (XARRAY(J),YARRAY(J),J=1,NPTS)
      DO 20 J=1,NPTS
      XARRAY(J)=ALOG10(XARRAY(J))
   20 YARRAY(J)=ALOG10(YARRAY(J))
      XLABEL(1)=6HFREQ.
      YLABEL(1)=6HVELOC.
      GO TO 5
   30 REWIND IK
      JJ=3
      KK=0
   45 KK=KK+1
      NPTS=NPS(KK)
      IF (NPTS .EQ. 1) GO TO 50
      READ (IL        ) (XARRAY(J),J=1,NPTS)
      IF (EOF(IL)) 50,47
   47 READ (IL        ) (YARRAY(J),J=1,NPTS)
      XLABEL(1)=6HTIME
      YLABEL(1)=6HACCEL.
      GO TO 5
```

```
50    REWIND IL
      XLABEL(1)=XSAVE
      YLABEL(1)=YSAVE
60    RETURN
      END
```

```
      SUBROUTINE CPLOT2 (NCURV,XARRAY,XAXIS,XLABEL,NPTS,YARRAY,YAXIS,
     1                   YLABEL)
      COMMON /OPTION/IOP,IPLT,IL,IK
      COMMON /WSL/NPS(4)
      COMMON /ID8/ID(8)
C
C     SUBROUTINES CPLOT2,CPLOT3,CPLOT4, AND CPLOT5 WERE ADDED BY G. CHAN/SPERRY.
C
C     SC4020 PLOT INTERFACE SUBROUTINE.          G.CHAN/SPERRY RAND
C
      DIMENSION XARRAY(1),YARRAY(1),XLABEL(1),FLDX(12),FLDY(12)
      INTEGER XAXIS,YAXIS
      DATA N1/1/
      JJ=1
      VALUE=FLOAT(NCURV)
    5 DO 10 I=1,12
      FLDX(I)=6H
   10 FLDY(I)=6H
      NNPTS=-NPTS
      FLDX(5)=XLABEL(1)
      FLDX(6)=6H(SEC)
      FLDY(2)=YLABEL
      GO TO (15,12,13),JJ
   12 FLDX(5)=6HFREQ.
      FLDX(6)=6H (HZ)
      FLDY(2)=6HVELOC.
      FLDY(3)=6HIN/SEC
      GO TO 30
   13 FLDY(2)=6H  ACCE
      FLDY(3)=6HL. IN/
      FLDY(4)=6HSEC**2
   15 CALL QUIK3V (N1,5,FLDX,FLDY,NNPTS,XARRAY,YARRAY)
      CALL PRINTV (72,ID,80,1018)
      IF (N1 .EQ. 1) N1=-1
      GO TO (20,30,25), JJ
   20 CALL PRINTV (8,8HCASE NO.,XAXIS,YAXIS)
      KAX=XAXIS+60
      CALL LABLV (VALUE,KAX,YAXIS,4,1,3)
      RETURN
   25 CALL PRINTV (38,38HACCEL. TIME HISTORY FROM NWVSYN/SYNSOL,XAXIS,
     X             YAXIS)
      GO TO 65
   30 CALL QUKLOG (N1,XL,XR,YB,YT,5,FLDX,FLDY,NNPTS,XARRAY,YARRAY)
      CALL PRINTV (26,26HSHOCK SPECTRUM FROM NWVSYN,XAXIS,YAXIS)
      IF (N1 .EQ. 1) N1=-1
      GO TO 35
C
      ENTRY CPLOT4
      IF (IPLT .EQ. 3) GO TO 62
      JJ=2
C     TO PLOT SHOCK SPECTRUM FORM WAVSYN ******
      REWIND IK
      CALL SMODE (1,1)
   35 READ (IK          ) NPTS
C            ,END=60
      IF (EOF(IK)) 60,36
   36 IF (NPTS .LE. 0) GO TO 35
```

```
      IF (NPTS .GT. 5175) NPTS=5175
      READ (IK) (XARRAY(J),YARRAY(J),J=1,NPTS)
      XL=XARRAY(1)
      XR=XARRAY(1)
      YB=YARRAY(1)
      YT=YARRAY(1)
      DO 38 I=2,NPTS
      IF (XARRAY(I) .LT. XL) XL=XARRAY(I)
      IF (XARRAY(I) .GT. XR) XR=XARRAY(I)
      IF (YARRAY(I) .LT. YB) YB=YARRAY(I)
      IF (YARRAY(I) .GT. YT) YT=YARRAY(I)
38    CONTINUE
      XL=10.**(IFIX(ALOG10(XL)-.99))
      XR=10.**(IFIX(ALOG10(XR)+.99))
      YB=10.**(IFIX(ALOG10(YB)-.99))
      YT=10.**(IFIX(ALOG10(YT)+.99))
      GO TO 5
60    REWIND IK
      CALL SMODE (0,0)
      JJ=3
C     TO PLOT ACCEL. TIME HISTORY FROM WAVSYN ******
      REWIND IL
62    KK=0
65    KK=KK+1
      NPTS=NPS(KK)
      IF (NPTS .EQ. 1) GO TO 70
      READ (IL        ) (XARRAY(J),J=1,NPTS)
0             ,END=70
      IF (EOF(IL)) 70,66
66    READ (IL        ) (YARRAY(J),J=1,NPTS)
      IF (EOF(IL)) 70,67
67    XLABEL(1)=6H TIME
      IF (IPLT .NE. 3) GO TO 5
      YLABEL=6HACCEL.
      CALL CPLOT5 (NCURV,XARRAY,XAXIS,XLABEL,NPTS,YARRAY,YAXIS,YLABEL)
      GO TO 65
70    REWIND IL
      RETURN
      END
```

```
      SUBROUTINE CPLOTS (NO,XX,A,XLAB,NPTS,YY,B,YLAB)
C
C     THIS SUBROUTINE PLOTS A TIME-ACCEL. HISTORY CURVE ON A LINE PRINTER.
C
      DIMENSION XX(1),YY(1),V(9)
      COMMON /XY/X(800),Y(120)
      DATA V/0.0025,0.005,0.01,0.025,0.05,0.1,0.25,0.5,1.0/
      NPT=300
      XMIN=XX(1)
      XMAX=XX(1)
      YMIN=YY(1)
      YMAX=YY(1)
      DO 5 I=2,NPTS
      IF (XX(I) .LT. XMIN) XMIN=XX(I)
      IF (XX(I) .GT. XMAX) XMAX=XX(I)
      IF (YY(I) .LT. YMIN) YMIN=YY(I)
      IF (YY(I) .GT. YMAX) YMAX=YY(I)
    5 CONTINUE
      RANGE=YMAX-YMIN
      XS=(XMAX-XMIN)/(FLOAT((NPT+4)/5)*(1.+2.+4.+8.+16.))
      DO 10 I=2,9
      IF (XS .GT. V(I) .OR. XS .LT. V(I-1)) GO TO 10
      XS=V(I)
      GO TO 15
   10 CONTINUE
      IF (XS .LE. V(1)) XS=0.4*V(1)
      IF (XS .GT. V(9)) XS=2.0*V(9)
   15 N=1+IFIX((XMAX-XMIN)*5./(XS*(1.+2.+4.+8.+16.)))
      N5=N/5
      N1=1
      X(1)=XX(1)
      DO 17 J=2,N
      IF (J .NE. N1*N5) GO TO 17
      N1=N1+1
      XS=XS+XS
   17 X(J)=X(J-1)+XS
      X(N+1)=X(N)+XS
      J0=IFIX(119.*(-YMIN)/RANGE)+1
      WRITE (6,20) XLAB,YLAB,YMIN,YMAX
   20 FORMAT (1H1,2X,A6,30X,A6,3H  (,2F10.4,1H))
      I=1
      K=0
   22 DO 25 J=1,120
   25 Y(J)=1H
      IF (J0.GE.1 .AND. J0.LE.120) Y(J0)=1H1
   30 K=K+1
      IF (X(K) .LT. XX(I)) GO TO 30
   35 J=IFIX(119.*(YY(I)-YMIN)/RANGE)+1
      Y(J)=1H*
      I=I+1
      IF (I .GT. NPTS) GO TO 50
      IF (XX(I) .LT. X(K)) GO TO 35
      WRITE (6,45) X(K),(Y(J),J=1,120)
   45 FORMAT (1X,F8.4,1X,120A1)
      GO TO 22
   50 RETURN
      END
```

```
      OVERLAY (ISICP,3,0)
      PROGRAM WAVSYN
C
C     THIS OLDER VERSION OF WAVE SYNTHESIS PROGRAM HAS BEEN REMOVED FROM ISIP,
C     USE NWVSYN INSTEAD.
C
      WRITE (6,10)
 10   FORMAT (/////5X,42HWAVSYN IS NOT AVAILABE, USE NWVSYN INSTEAD//)
      STOP 1234
      END
```

```
      OVERLAY (ISICP,7,0)                                                1
      PROGRAM NWVSYN                                                     2
C
C     THIS PROGRAM IS USED TO SYNTHESIZE THE COEFFICEINTS OF A SEQUENCE
C     WAVE FORM TO MATCH THE GIVEN DYNAMIC SHOCK RESPONSE SPECTRUM
C
C     THIS PROGRAM REQUIRES  64 OCTAL K STORAGE.
C
C     NOMENCLATURE ******
C        ND   = NO. OF PROBLEMS FOR ONE RUN
C        KOP  = AUTOMATIC (=2) VS. MANUAL (=1) METHOD CONTROL
C        NOSHFT,NOIT = EXACT NOS. OF SHIFT AND ITERATION FOR FORCED TERMINATION.
C        NS   = NO. OF DATA PTS TO DEFINE A GIVEN SHOCK SPECTRUM
C        NAR  = NO. OF DATA PTS TO DEFINE A GIVEN AMPLIF. RATIO SPECTRUM
C             * PROGRAMMED TYPE I OR TYPE II AMPL. RATIO SPECTRUM IS USED IF NAR
C               IS -1 OR -2 RESPECTIVELY.
C        NTD  = NO. OF DATA PTS TO DEFINE A GIVEN TIME DELAY VS SYSTEM FREQ.
C               FUNCTION
C             * PROGRAMMED A 9 POINT TIME-DELAY MODEL IS USED IF NTD=-VE.
C        IIP,NPLOT = CARD PUNCH AND PLOTTING CONTROLS
C             = 0, NO PUNCH AND NO PLOT
C             = 1, ACCELERATION, G
C             = 2, VELOCITY, IN/SEC.
C             = 3, DISPLACEMENT, IN.
C             = 4, AN EQUIVALENT MANUAL INPUT DATA DECK IS PUNCHED IF KOP=2
C             = 5, ACCELERATION, IN/SEC/SEC.
C             =-1, 1+2+3 ABOVE, FOR PUNCH ONLY.
C        WS   = FREQ. DATA ON THE REQUIRED RESPONSE SPECTRUM, HZ
C        XS   = AMPLITUDE DATA ON THE REQUIRED RESPONSE SPECTRUM, G
C               (+VE VALUE FOR ACCEL. AMPL. IN G, AND -VE FOR DISPL. IN INS.)
C        WAR  = FREQ. DATA ON THE REQUIRED AMPLIF. RATIO SPECTRUM, HZ
C        AR   = AMPLIF. RATIO DATA ON THE REQUIRED AMPLIF. RATIO SPECTRUM
C        WTD  = FREQ. DATA ON THE TIME-DELAY VS SYSTEM FREQ. FUNCTION, HZ
C        TD   = TIME DEALY DATA ON THE TIME-DELAY VS SYSTEM FREQ. FUNCTION, SEC
C        TLC  = RESPONSE TOLERANCE, PERCENT
C             * STANDARD OF 15 PERCENT (OR ITLC 0/0) IS USED IF NAR IS -VE.
C        M    = NO. OF SELECTED FREQ. PTS ON THE GIVEN SHOCK SPECTRUM
C        W    = SELECTED SYSTEM FREQ.
C        YCLE = NO. OF HALF-CYCLE OSCILLATIONS CORRESP. TO SELECTED SYSTEM FREQ.
C        X    = AMPLITUDE CORRESPONDING TO THE SELECTED SYSTEM FREQUENCIES
C               (+VE VALUE FOR ACCEL. AMPL. IN G, AND -VE FOR DISPL. IN INS.)
C        DELAY= TIME DELAYS CORRESPONDING TO THE SELECTED SYSTEM FREQ., SEC
C
C     NOTE***  PRESENTLY NO MIXED AMPLIF. RATIO SPECTRA AND/OR MIXED TIME-DELAY
C              ARE ALLOWED IN A MULTIPLE PROBLEMS RUN (ND .GT. 1), REQUIRING
C              PRE-SET SPECTRA AND/OR DELAY VALUES,  SINCE THSE VALUES ARE PRE-
C              STORED BY FORTRAN DATA STATEMENTS.
C
C     INPUT SEQUENCE *******
C        1.  ND ARED                                          (I5)
C        2.  TITLE CARD                                       (12A6)
C        3.  KOP CARD                                         (I5)
C     * THRU 11 FOR AUTOMATIC RUN (KOP=2) ***
C        4.  NS,NAR,NTD,IIP,NPLOT,ITLC CONTROL CARD           (6I5)
C        5.  WS(I),I=1,NS                                     (8F10.3)
C        6.  XS(I),I=1,NS                                     (8F10.3)
C        7.  WAR(I),I=1,NAR  *  SKIP IF NAR IS -VE.           (8F10.3)
```

```
C        8.  AR(I), I=1,NAR  *  SKIP IF NAR IS -VE.              (8F10.3)
C        9.  WTD(I),I=1,NTD  *  SKIP IF NTD IS .LE. ZERO         (8F10.3)
C       10.  TD(I), I=1,NTD  *  SKIP IF NTD IS .LE. ZERO         (8F10.3)
C       11.  TLG(I),I=1,NS-1 *  SKIP IF NAR IS -VE.              (8F10.3)
C     12 THRU 16 FOR MANUAL RUN (KOP=1) ***
C       12.  M,IIP,NPLOT CARD                                    (3I5)
C       13.  W(I),I=1,M                                          (8F10.3)
C       14.  YCLE(I),I=1,M                                       (8F10.3)
C       15.  X(I),I=1,M                                          (8F10.3)
C       16.  DELAY(I),I=1,M                                      (8F10.3)
C     ****   REPEAT 2 THRU 16 FOR NO CASES ****
C
C     PROGRAMMED BY DICK JEI CHANG/PARSONS,  MODIFIED BY G.CHAN/SPERRY RAND.
C     MODIFICATION OR ADDITION OF FORTRAN STATEMENT IS MARKED BY A * IN COL. 79
C
C     IAR=1, ACCEL. IS STORED, READY FOR PLOTTING OR PUNCHOUT IN TABLE FORM
C         2, VEL.   IS STORED, READY FOR PLOTTING OR PUNCHOUT IN TABLE FORM
C         3, DISPL. IS STORED, READY FOR PLOTTING OR PUNCHOUT IN TABLE FORM.
C     IPRT=0, NO ACCEL.-TIME HISTORY PRINTOUT IN CASE RESTRICTIONS DO NOT MEET,
C         =1, WAVEFORM TIME-HISTORY WILL BE COMPUTED EVEN RESTRICTIONS NOT MET.
C
      DIMENSION C(25),E(25),F(25),REV(25),QOT(25),TITLE(12)                 3 *
     X          ,RAR(10),WAW(10),DTD(10),WTW(10)                            4
      COMMON /ABC/WS(25),TLG(25),CSHT(25),STDEV(25,5)                       5
      COMMON       KOP,XC(25,5),WC(25,5),T(5000),STR(2),BNK(4998)           6 *
      COMMON /EEE/W(25),A(25,26),X(25),H(25),TP(25),RTS(25),U(25),          7 *
     X            XS(25),WAR(25),AR(25),WTD(25),TD(25),SLP(25),BLK(75)      8 *
      COMMON /FFF/ SSDEV(25,5),ABSHT(25,5)                                  9
      COMMON /GGG/M,NF,NS,KIK,MNK,NTD,B(25),YCLE(25),ALP(25),BLP(25),      10 *
     X            TINT(25),DELAY(25),NCTL(25)                              11 *
      COMMON /HHH/MNK2,PI,PI2,IAR,JJJ,NJN,FREQCY(260),VEL(260),CMX(75)     12 *
      COMMON /OPTION/IOP,IPLT,IL,IK                                        13 *
      COMMON /WSL/NPME(8)                                                  14 *
      REAL MAX                                                             15
C     *** PRE-SETTING A STANDARD AMPLIFICATION RATIO SPECTRUM.  (TYPE I MOTION)
      DATA RAR/3.0,3.0,5.0,5.0,7.0,7.0,9.0,9.0,11.0,11.0/                  16 *
      DATA WAW/.10,.40,.41,.60,.61,.90,.91,4.0,4.01,999./                  17 *
C     *** PRE-SETTING A STANDARD TIME-DELAY MODEL INPUT.
      DATA DTD/0.00,0.64,0.81,1.08,1.29, 1.43, 1.75, 1.75, 1.75,0./        18 *
      DATA WTW/2.00,3.20,4.64,6.73,9.76,14.15,15.00,80.00,999.9,0./        19 *
      DATA PI,GV,NPME/3.141592654,386.4,8*1/                               20 *
      IAR=1                                                                21 *
      IPRT=1                                                               22 *
      ISHOCK=1                                                             23 *
      ISERV=1                                                              24 *
      MIT=10                                                               25 *
      ISHRNK=100                                                           26 *
C     NO SHRINK IN M IF ISHRNK IS GREATER THAN NOSHFT (KOP=2 ONLY).
    2 FORMAT (8F10.3)                                                      27
    3 FORMAT (/2X,16F8.4)                                                  28
   13 FORMAT(1X,97H      W(I)            B(I)            TINT(I)          RTS(   29
     1I)          DELAY(I)          X(I)          CYCLE(I),/89H     (C.P.S.)   30
     2  (C.P.S.)          (SEC.)          (SEC.)          (SEC.)        (IN/SE   31
     3C**2) //)                                                            32
   14 FORMAT (F13.5,4F15.7,F15.5,F8.1)                                     33 *
   15 FORMAT(10X,34HNO. OF POINTS SELECTED ON SPECTRUM,7X,I6,//)           34
  153 FORMAT (5(3X,2HC(,I3,2H)=,F12.2,3X))                                 35
  154 FORMAT(//40X,13MITERATION NO.,I3)                                    36
```

```
200 FORMAT (16I5)
460 FORMAT(1H1,106X,A10,5X,A3,6H60 HR,/)
406 FORMAT(12A6)
407 FORMAT(12A6//)
425 FORMAT(1H0)
426 FORMAT(20X,28HTRIAL VALUES OF COEFFICIENTS /)
427 FORMAT(// 10X,39HCOEFFICIENTS OF MATRIX OF MAX. RESPONSE/)
428 FORMAT(// 10X,31HCOEFFICIENTS OF INVERTED MATRIX/)
430 FORMAT(// 10X,27HMAX. VALUES OF ACCELERATION,/)
436 FORMAT(   4X,56HVALUES OF COEFFICIENT CALCULATED FROM PREVIOUS ITE
   1RATION /)
437 FORMAT( 4X,13HAT FREQUENCY=,F7.2,26H G.P.S. MAX. ACCELERATION=,
   1E14.7,3X,18HIN/SEC**2 AT TIME=,E12.5,1X,4HSEC.,5X,1H/,E13.7,A1/)
731 FORMAT (///36H   NO. OF PTS ON SHOCK SPECTRA  NS =,I2//
   13X,14HFREQUENCY (HZ),5X,16HMAX. ACC./DISPL./)
732 FORMAT (10X,F8.3,11X,F8.3)
703 FORMAT (///49H   NO. OF PTS ON AMPLIFICATION RATIO CURVE  NAR =,I2
   1//-8X,14HFREQUENCY (HZ),7X,16HAMP. RATIO/)
704 FORMAT (///40H   NO. OF PTS ON TIME DELAY CURVE  NTD =,I2//
   17X,14HFREQUENCY (HZ),3X,18H TIME DELAY (SEC)/)
735 FORMAT (///     16H TOLERANCE LIMIT,//
   1,10X,9HLINE SEG.,10X,16H TOLERANCE (0/0),/)
706 FORMAT (12X,I3,14X,F8.3)
707 FORMAT (F18.3,F19.3,A4)
708 FORMAT (///10X,34HNO. OF PTS. ON SHOCK SPECTRA,  M =,I3,//5X,
   X        14HFREQUENCY (HZ),3X,16HMAX. ACC./DISPL.,3X,6HCYCLES,8X,
   Y        11HDELAY (SEC),30X,12HIIP, NPLOT =,2I4,/)
709 FORMAT (5X,F12.3,9X,F10.4,5X,F6.1,8X,F10.5)
714 FORMAT (1H1,///,5X,23H EXCEEDS 10 ITERATIONS,,
   114H RUN WILL EXIT,5X,16H (MANUAL OPTION))
716 FORMAT (1H1,///,5X,72H REQUIRED TOLERANCE CANNOT BE MET AFTER 4 SY
   1STEM FREQUENCY RATIO SHIFTS,,14H RUN WILL EXIT,5X,
   219H (AUTOMATIC OPTION))
718 FORMAT (/10X,35H SYSTEM FREQUENCY ARRANGEMENT  NO. ,I3,5X,
   129H (AUTOMATIC OPTION),///)
      PI2=2.*PI
      PI2G=PI2*PI2/GV
      JJJ=0
      REWIND IL
      READ (5,200) ND
   22 STR(1)=1H
      STR(2)=1H*
      DO 24 I=1,10
      AR(I)=RAR(I)
      WAR(I)=WAW(I)
      TD(I)=DTD(I)
   24 WTD(I)=WTW(I)
      READ(5,406) (TITLE(K),K=1,12)
      IF (IOP.EQ.9 .OR. IOP.EQ.10) PUNCH 406, (TITLE(K),K=1,12)
      DAT=DATE(DUMMY)
      TIM=TIME(DUMMY)
C     DATE AND TIME ARE SYSTEM FUNCTIONS.
      WRITE (6,400) DAT,TIM
      WRITE (6,406) (TITLE(I),I=1,12)
      NSFA=0
      III=0
      PO3=0.03
      READ (5,200) KOP,NOSHFT,NOIT
```

```
      IF (KOP.EQ.1) GO TO 983
C
C     AUTOMATIC METHOD, KOP=2,  ***
C
      WRITE (6,722)
  722 FORMAT (/5X,30HWAVEFORM SYNTHESIS BY AUTOMATIC OPTION///)
      READ (5,200) NS,NAR,NTD,IIP,NPLOT,ITLC
      IF (IIP .EQ. 2) IAR=2
      IF (IIP .EQ. 3) IAR=3
      IF (IOP .GE. 9) IIP=0
      IF (IIP.EQ.4 .AND. KOP.EQ.2) WRITE (6,200) ND
      IF (IOP.GE.11 .AND. IOP.NE.12) IIP=6
C     NPLOT IS ELIMINATED IN THIS NWVSYN VERSION, AND IIP IS AUTOMATICALLY SET
C     TO ZERO IN OVERLAY RUN.
      IF (ITLC .EQ. 0) ITLC=25
      TTLC=FLOAT(ITLC)
      READ (5,2) (WS(I),I=1,NS)
      READ (5,2) (XS(I),I=1,NS)
      NNAR=10
      IF (NAR .LT. 0) GO TO 755
      READ (5,2) (WAR(I),I=1,NAR)
      READ (5,2) (AR(I),I=1,NAR)
  755 IF (NAR .GT. -2) GO TO 757
C
C     PRESCRIBING A TYPE II MOTION ***
C
      NNAR=6
      WAR(1)=0.1
      WAR(2)=0.45
      WAR(3)=0.46
      WAR(4)=2.50
      WAR(5)=2.51
      WAR(6)=999.
      AR(1)=5.0
      AR(2)=5.0
      AR(3)=7.0
      AR(4)=7.0
      AR(5)=9.0
      AR(6)=9.0
  757 NNTD=9
      IF (NTD.LE.0) GO TO 761
      READ (5,2) (WTD(I),I=1,NTD)
      READ (5,2) (TD(I),I=1,NTD)
  761 IF (NTD .LT. 0) NTD=NNTD
      NS1=NS-1
      IF (NAR .LT. 0) GO TO 767
      READ (5,2) (TLC(I),I=1,NS1)
      DO 764 I=1,NS1
      IF (TLC(I) .LE. 0.1) TLC(I)=35.
  764 CONTINUE
      GO TO 787
  767 IF (NAR .LT. 0) NAR=NNAR
      DO 731 I=1,NS1
      WP=WS(I  )
      IF (WP .GE. 1.00) TLC(I)=TTLC
      IF (WP .LT. 1.00 .AND. WP .GE. 0.55) TLC(I)=TTLC*1.20
      IF (WP .LT. 0.55) TLC(I)=TTLC*1.50
  731 CONTINUE
```

```
787 WRITE (6,701) NS
    DO 747 I=1,NS
    AXS=ABS(XS(I))
    LLT=4H G.S
    IF (XS(I) .LT. 0.0) LLT=4H IN.
    WRITE (6,707) WS(I),AXS,LLT
    IF (XS(I) .LT. 0.0) XS(I)=-XS(I)*WS(I)*WS(I)*PI2G
747 CONTINUE
    WRITE (6,703) NAR
    WRITE (6,702) (WAR(I),AR(I),I=1,NAR)
    IF (NTD.EQ.0) GO TO 804
    WRITE (6,704) NTD
    WRITE (6,702) (WTD(I),TD(I),I=1,NTD)
804 WRITE (6,705)
    DO 805 I=1,NS1
    WRITE (6,706) I,FLG(I)
    TEMP1=XS(I+1)/XS(I)
    TEMP2=WS(I+1)/WS(I)
805 SLP(I)=ALOG(TEMP1)/ALOG(TEMP2)
    R3=1.30
    R5=1.35
    R7=1.6
    R9=1.45
    R11=1.35
    R13=1.30
    MNK=0
    MNKS=0
    MNK2=0
    DO 741 I=1,25
    NCTL(I)=0
    DO 741 J=1,4
    STDEV(I,J)=0.0
    SSDEV(I,J)=0.0
741 ABSHT(I,J)=0.0
    W(1)=WS(1)
    XC(1,1)=XS(1)
    WC(1,1)=W(1)
    YCLE(1)=3.0
    CALL INTERP (W(1),Y,NAR,WAR,AR)
    IF (Y.GT.4.0.AND.Y.LE.6.0) YCLE(1)=5.0
    IF (Y.GT.6.0.AND.Y.LE.8.0) YCLE(1)=7.0
    IF (Y.GT.8.0.AND.Y.LE.10.0) YCLE(1)=9.0
    IF (Y.GT.10.0.AND.Y.LE.12.0) YCLE(1)=11.0
    IF (Y.GT.12.0) YCLE(1)=13.0
907 CONTINUE
    DO 62 I=1,50
 62 CSHT(I)=0.0
901 X(1)=XS(1)
    W(1)=WS(1)
    DO 951 I=2,50
    IM1=I-1
    ACSHT=ABS(CSHT(IM1))
    W(I)=R3*W(IM1)
    IF (ACSHT.GT.0.1) W(I)=(R3-0.025*CSHT(IM1))*W(IM1)
    CALL INTERP (W(I),Y,NAR,WAR,AR)
    IF (Y.LT.1.9) STOP 0111
    IF (Y.GE.4.0) GO TO 911
    YCLE(I)=3.0
```

```
      GO TO 950
  911 W(I)=R5*W(IM1)
      IF (ACSHT.GT.0.1) W(I)=(R5-0.025*CSHT(IM1))*W(IM1)
      CALL INTERP (W(I),Y,NAR,WAR,AR)
      IF (Y.GE.6.0) GO TO 921
      YCLE(I)=5.0
      GO TO 950
  921 W(I)=R7*W(IM1)
      IF (ACSHT.GT.0.1) W(I)=(R7+0.025*CSHT(IM1))*W(IM1)
      CALL INTERP (W(I),Y,NAR,WAR,AR)
      IF (Y.GE.8.0) GO TO 931
      YCLE(I)=7.0
      GO TO 950
  931 W(I)=R9*W(IM1)
      IF (ACSHT.GT.0.1) W(I)=(R9+0.025*CSHT(IM1))*W(IM1)
      CALL INTERP (W(I),Y,NAR,WAR,AR)
      IF (Y.GE.10.0) GO TO 936
      YCLE(I)=9.0
      GO TO 950
  936 W(I)=R11*W(IM1)
      IF (ACSHT.GT.0.1) W(I)=(R11+0.025*CSHT(IM1))*W(IM1)
      CALL INTERP (W(I),Y,NAR,WAR,AR)
      IF (Y.GE.12.0) GO TO 941
      YCLE(I)=11.0
      GO TO 950
  941 W(I)=R13*W(IM1)
      IF (ACSHT.GT.0.1) W(I)=(R13+0.025*CSHT(IM1))*W(IM1)
      YCLE(I)=13.0
  950 WSLT=WS(NS)/1.05
      IF (W(I).GE.WSLT) GO TO 955
  951 CONTINUE
  955 M=I
      IF (III .GE. ISHRNK) M=M-1
      MM1=M-1
      DO 981 I=1,M
      DELAY(I)=0.0
      IF (NTD.NE.0) CALL INTERP (W(I),DELAY(I),NTD,WTD,TD)
  981 CONTINUE
      DO 987 I=1,MM1
      IP1=I+1
      IF (YCLE(I).GT. 4.0) GO TO 922
      RTMDY=(DELAY(IP1)-DELAY(I))*(1.68*W(I))
      IF (RTMDY.LT.0.100) RTMDY=0.0
      IF (RTMDY.GE.0.100.AND.RTMDY.LT.0.300) RTMDY=0.2
      IF (RTMDY.GE.0.300) RTMDY=0.4
      DELAY(IP1)=DELAY(I)+RTMDY/(1.68*W(I))
      GO TO 987
  922 IF (YCLE(I).GT. 6.0) GO TO 923
      RTMDY=(DELAY(IP1)-DELAY(I))*(1.9*W(I))
      IF (RTMDY.LT.0.050) RTMDY=0.0
      IF (RTMDY.GE.0.050.AND.RTMDY.LT.0.325) RTMDY=0.10
      IF (RTMDY.GE.0.325.AND.RTMDY.LT.1.150) RTMDY=0.55
      IF (RTMDY.GE.1.150) RTMDY=1.75
      DELAY(IP1)=DELAY(I)+RTMDY/(1.9*W(I))
      GO TO 987
  923 RTMDY=(DELAY(IP1)-DELAY(I))*W(I)/0.5
      IF (YCLE(I).GT. 8.0) GO TO 97
      IF (RTMDY.LT.0.5) RTMDY=0.0
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```
      IF (RTMDY.GE.0.500.AND.RTMDY.LT.1.875) RTMDY=1.0
      IF (RTMDY.GE.1.875.AND.RTMDY.LT.3.500) RTMDY=2.75
      IF (RTMDY.GE.3.500) RTMDY=4.25
      GO TO 928
  924 IF (YCLE(I).GT.10.0) GO TO 925
      IF (RTMDY.LT.0.5) RTMDY=0.0
      IF (RTMDY.GE.0.500.AND.RTMDY.LT.1.875) RTMDY=1.0
      IF (RTMDY.GE.1.875.AND.RTMDY.LT.3.625) RTMDY=2.75
      IF (RTMDY.GE.3.625.AND.RTMDY.LT.5.375) RTMDY=4.50
      IF (RTMDY.GE.5.375.AND.RTMDY.LT.7.125) RTMDY=6.25
      IF (RTMDY.GE.7.125) RTMDY=8.0
      GO TO 928
  925 IF (YCLE(I).GT.12.0) GO TO 926
      IF (RTMDY.LT.0.5) RTMDY=0.0
      IF (RTMDY.GE.0.500.AND.RTMDY.LT.1.875) RTMDY=1.0
      IF (RTMDY.GE.1.875.AND.RTMDY.LT.3.625) RTMDY=2.75
      IF (RTMDY.GE.3.625.AND.RTMDY.LT.5.375) RTMDY=4.50
      IF (RTMDY.GE.5.375.AND.RTMDY.LT.7.250) RTMDY=5.25
      IF (RTMDY.GE.7.250.AND.RTMDY.LT.9.125) RTMDY=8.25
      IF (RTMDY.GE.9.125) RTMDY=10.0
      GO TO 928
  926 IF (RTMDY.LE.0.625) RTMDY=0.0
      IF (RTMDY.GE.0.625.AND.RTMDY.LT.1.950) RTMDY=1.25
      IF (RTMDY.GE.1.950.AND.RTMDY.LT.3.750) RTMDY=2.75
      IF (RTMDY.GE.3.750.AND.RTMDY.LT.5.625) RTMDY=4.75
      IF (RTMDY.GE.5.625.AND.RTMDY.LT.7.375) RTMDY=6.50
      IF (RTMDY.GE.7.375.AND.RTMDY.LT.9.250) RTMDY=8.25
      IF (RTMDY.GE.9.250) RTMDY=10.25
  928 DELAY(IP1)=DELAY(I)+0.5*RTMDY/W(I)
  987 CONTINUE
      GO TO 988
C
C     CASE OF KOP .EQ. 1  ***
C
  983 WRITE (6,984)
  984 FORMAT (/5X,35HWAVEFORM SYNTHESIS BY MANUAL OPTION///)
      READ (5,200) M,IIP,NPLOT
      WRITE (6,708) M,IIP,NPLOT
      IF (IIP .EQ. 2) IAR=2
      IF (IIP .EQ. 3) IAR=3
      READ (5,2) (W(I),I=1,M)
      READ (5,2) (YCLE(I),I=1,M)
      READ (5,2) (X(I),I=1,M)
      READ (5,2) (DELAY(I),I=1,M)
      WRITE (6,709) (W(I),X(I),YCLE(I),DELAY(I),I=1,M)
      IF (IOP .GE. 9) IIP=0
      NTD=0
      DO 935 I=1,M
      IF (ABS(DELAY(I)) .GT. 1.0E-07) NTD=1
      IF (X(I) .LT. 0.0) X(I)=-X(I)*W(I)*W(I)*PI2G
  935 CONTINUE
      XC(1,1)=X(1)
      WC(1,1)=W(1)
  988 MM1=M-1
      FKK1=1./3.
      FKK2=2./3.
      IF (W(1) .LE. 0.60) NMIT=12
      IF (W(1) .LE. 0.30) NMIT=14
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```
      IF (W(1) .LE. 0.15) NMIT=16                                       315 *
      NMIT=NMIT+2                                                       316 *
      IF (NOSHFT .LE. 0) NOSHFT=5                                       317 *
      NOSHFT=NOSHFT-1                                                   318 *
      NOIT=NOIT+1                                                       319 *
      DO 942 I=1,MM1                                                    320
      IP1=I+1                                                           321
      WC(I,2)=W(I)*((W(IP1)/W(I))**FKK1)                                322
      WC(I,3)=W(I)*((W(IP1)/W(I))**FKK2)                                323
      WC(I,4)=W(IP1)                                                    324
  942 WC(IP1,1)=W(IP1)                                                  325
      IF (KOP.EQ.1) GO TO 967                                           326
      DO 968 I=1,MM1                                                    327
      IP1=I+1                                                           328
      DO 966 K=2,4                                                      329
      DO 964 J=2,NS                                                     330
      IF (WS(J).GE.WC(I,K)) GO TO 965                                   331
  964 CONTINUE                                                          332
      XC(I,K)=XS(NS)*((WC(I,K)/WS(NS))**(SLP(NS1)))                     333
      GO TO 966                                                         334
  965 XC(I,K)=XS(J-1)*((WC(I,K)/WS(J-1))**(SLP(J-1)))                   335
  966 CONTINUE                                                          336
      XC(IP1,1)=XC(I,4)                                                 337
  968 X(IP1)=XC(I,4)                                                    338
      GO TO 969                                                         339
  967 DO 994 I=1,MM1                                                    340
      IP1=I+1                                                           341
      TSLP=ALOG(X(IP1)/X(I)) / ALOG(W(IP1)/W(I))                        342
      DO 992 K=2,4                                                      343
  992 XC(I,K)=X(I)*((WC(I,K)/W(I))**TSLP)                               344
  994 XC(IP1,1)=XC(I,4)                                                 345
  969 DO 9 I=1,M                                                        346
      C(I)=1.0                                                          347
      B(I)=W(I)/YCLE(I)                                                 348
      CP1=ABS(YCLE(I)-3.0)                                              349
      CP2=ABS(YCLE(I)-5.0)                                              350
      IF (CP1.LT.0.01) B(I)=0.28*W(I)                                   351
      IF (CP2.LT.0.01) B(I)=0.19*W(I)                                   352
      TINT(I)=0.5/B(I)+DELAY(I)                                         353
      RTS(I)=2.*TINT(I)-DELAY(I)                                        354
      X(I)=X(I)*GV                                                      355 *
    9 CONTINUE                                                          356
      WRITE(6,400)                                                      357
      WRITE(6,407)(TITLE(K),K=1,12)                                     358
      WRITE(6,15) M                                                     359
      IF (KOP.EQ.1) GO TO 587                                           360
      NSFA=NSFA+1                                                       361
      WRITE (6,718) NSFA                                                362
  587 WRITE (6,13)                                                      363
      WRITE(6,14) (W(I),B(I),TINT(I),RTS(I),DELAY(I),X(I),YCLE(I),I=1,M) 364
      II=2                                                              365
      DO 433 I=1,M                                                      366
      B(I)=PI2   *B(I)                                                  367
      W(I)=PI2   *W(I)                                                  368
      ALP(I)=(1.-YCLE(I))*B(I)                                          369
  433 BLP(I)=(1.+YCLE(I))*B(I)                                          370
  432 KKK=II-1                                                          371
      WRITE(6,408)                                                      372
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```
      WRITE(6,154) KKK
      WRITE(6,425)
      IF(KKK-1) 376,376,377
  376 WRITE(6,426)
      GO TO 378
  377 WRITE(6,436)
  378 WRITE(6,153) (K,C(K),K=1,M)
      WRITE(6,430)
      DO 303 K=1,M
      WK=W(K)
      WK2=WK*WK
      CYCLE=YCLE(K)
      T(1)=DELAY(K)
      CALL DELTIM (DT,CYCLE,B(K),16.)
      TF=DELAY(K)+   PI2/B(K)
      DO 5015 JJ=2,5001
      T(JJ)=T(JJ-1)+DT
      IF (T(JJ).GE.TF) GO TO 5025
 5015 CONTINUE
      STOP 5015
 5025 NP=JJ
      EPS=3.00001*WK
      DO 434 I=1,M
      E(I)=ALP(I)+WK
      F(I)=BLP(I)-WK
      REV(I)=ALP(I)*ALP(I)-WK2
  434 QOT(I)=BLP(I)*BLP(I)-WK2
      MAX=0.0
      DO 300 J=1,NP
      H(K)=0.0
      IF (NTD .NE. 0) GO TO 298
      AA1=WK*T(J)
      COSAA1=COS(AA1)
      SINAA1=SIN(AA1)
  298 DO 301 I=1,M
      TY=T(J)-DELAY(I)
      IF (TY.LE.0.0) GO TO 301
      IF (NTD .EQ. 0) GO TO 299
      AA1=WK  *TY
      COSAA1=COS(AA1)
      SINAA1=SIN(AA1)
  299 CYCLE=YCLE(I)
      CP1=CYCLE+1.
      CM1=CYCLE-1.
      CP2=CP1*CP1
      CM2=CM1*CM1
      CYCLE2=2.*CYCLE
      IF(ABS(E(I)/CM1).GT.EPS) GO TO 7003
      DELTA=(E(I)-WK/CM1)/WK
      DELCM1=DELTA*CM1
      AA3=4.*(CYCLE2+DELCM1*CP2)
      IF(T(J).GT.TINT(I)) GO TO 7001
      AA5=AA1*CP1*(1.+DELCM1)/CM1
      Q=-CM2*(COSAA1-COS(AA5))/AA8+.25*AA1*(DELCM1*.5*AA1*COSAA1+SINAA1)
      GO TO 323
 7001 Q=CYCLE*CM1*PI*(1.+2.*DELCM1)*(2.*SINAA1+PI*DELCM1*CM1*COSAA1)/AA8
       GO TO 323
 7003 IF(ABS(F(I)/CP1).GT.EPS) GO TO 294
```

```
      DELTA=(B(I)-WK/CP1)/WK
      DELCP1=DELTA*CP1
      AA7=4.*(-CYCLE2+DELCP1)*CM2
      IF(T(J).GT.TINT(I)) GO TO 7002
      AA6=AA1*CM1*(1.+DELCP1)/CP1
      Q=CP2*(COSAA1-COS(AA6))/AA7-.25*AA1*(DELCP1*.5*AA1*COSAA1+SINAA1)
       GO TO 323
 7002 Q=CYCLE*CP1*PI*(1.+2.*DELCP1)*(2.*SINAA1+PI*DELCP1*CP1*COSAA1)/AA7
       GO TO 323
  294 IF(T(J).GT.TINT(I)) GO TO 100
      AA2=ALP(I)*TY
      AA3=BLP(I)*TY
      Q=WK2/2.*((COSAA1-COS(AA2))/REV(I)-(COSAA1-COS(AA3))/QOT(I))
      GO TO 323
  100 AA4=WK  *(T(J)-TINT(I))
      Q=CYCLE2*WK2*B(I)*B(I)*(COSAA1-COS(AA4))/(REV(I)*QOT(I))
  323 S=C(I)*Q
      H(K)=H(K)+S
  301 CONTINUE
      IF (ABS(H(K)) .LE. MAX) GO TO 300
      MAX=ABS(H(  K))
      SR=H(K)
      TP(K)=T(J)
  300 CONTINUE
      U(K)=MAX
      FREQ=W(K)/PI2
      JNJ=(K-1)*3+1
      GMX(JNJ)=MAX/GV
      JNJ=1
      XXC=XC(K,1)*GV
      IF (KOP .EQ. 1) XXC=X(K)
      IF (ABS((MAX-XXC)/XXC) .GT. P03) JNJ=2
      WRITE (6,437) FREQ,MAX,TP(K),XXC,STR(JNJ)
      IF (SR .LE. 0) X(K)=-X(K)
  341 CONTINUE
      DO 303 I=1,M
      Q=0.0
      TY=TP(K)-DELAY(I)
      IF(TY.LE.0.0) GO TO 506
      AA1=WK  *TY
      COSAA1=COS(AA1)
      SINAA1=SIN(AA1)
      CYCLE=YCLE(I)
      CP1=CYCLE+1.
      CM1=CYCLE-1.
      CP2=CP1*CP1
      CM2=CM1*CM1
      CYCLE2=2.*CYCLE
      IF(ABS(E(I)/CM1).GT.EPS) GO TO 7005
      DELTA=(B(I)-WK/CM1)/WK
      DELCM1=DELTA*CM1
      AA8=4.*(CYCLE2+DELCM1*CP2)
      IF(TP(K).GT.TINT(I)) GO TO 7006
      AA5=AA1*CP1*(1.+DELCM1)/CM1
      Q=-CM2*(COSAA1-COS(AA5))/AA8+.25*AA1*(DELCM1*.5*AA1*COSAA1+SINAA1)
      GO TO 506
 7006 Q=CYCLE*CM1*PI*(1.+2.*DELCM1)*(2.*SINAA1+PI*DELCM1*CM1*COSAA1)/AA8
      GO TO 506
```

```
7005 IF(ABS(F(I)/CP1).GT.EPS) GO TO 7007
     DELTA=(B(I)-WK/CP1)/WK
     DELCP1=DELTA*CP1
     AA7=4.*(-CYCLE2+DELCP1)*CM2
     IF(TP(K).GT.TINT(I)) GO TO 7008
     AA6=AA1*CM1*(1.+DELCP1)/CP1
     Q=CP2*(COSAA1-COS(AA6))/AA7-.25*AA1*(DELCP1*.5*AA1*COSAA1+SINAA1)
     GO TO 506
7008 Q=CYCLE*CP1*PI*(1.+2.*DELCP1)*(2.*SINAA1+PI*DELCP1*CP1*COSAA1)/AA7
     GO TO 506
7007 IF(TP(K).GT.TINT(I)) GO TO 505
     AA2=ALP(I)*TY
     AA3=BLP(I)*TY
     Q=WK2/2.*((COSAA1-COS(AA2))/REV(I)-(COSAA1-COS(AA3))/QOT(I))
     GO TO 506
 505 AA4=WK *(TP(K)-TINT(I))
     Q=CYCLE2*WK2*B(I)*B(I)*(COSAA1-COS(AA4))/(REV(I)*QOT(I))
 506 A(K,I)=Q
 303 CONTINUE
     DO 403 K=1,M
     XK=ABS(X(K))
     DIF=(ABS(U(K)-XK))/XK
     IF (DIF .GT. P03) GO TO 443
 403 CONTINUE
     GL=TINT(1)
     DO 29 I=2,M
     IF(GL.LE. TINT(I)) GL=TINT(I)
  29 CONTINUE
     DO 353 K=1,M
 353 X(K)=ABS(X(K))
     CALL SHOCK (C,TITLE,GL)
     IF (KIK.NE.0) GO TO 603
 367 IF (ISHOCK .EQ. 1) GO TO 368
     GGL=-GL
     CALL SHOCK (C,TITLE,GGL)
     CALL LNPLT (TITLE,YCLE)
 368 CONTINUE
     IF (III .LE. 4 .OR. IPRT .EQ. 1) CALL POWOUT (IIP,M,GL,
    1   TITLE,B,C,TINT,DELAY,YCLE)
     GO TO 201
 603 IF (KOP.EQ.1) GO TO 367
     III=III+1
     IF (III-NOSHFT) 901,901,367
 443 IF (ISERV .LT. 2) GO TO 307
     WRITE(6,427)
     DO 306 K=1,M
 306 WRITE (6,3) (A(K,I),I=1,M)
 307 CALL MATINV (A,M,25)
     IF (ISERV .LT. 2) GO TO 309
     WRITE(6,428)
     DO 308 K=1,M
 308 WRITE (6,3) (A(K,I),I=1,M)
 309 DO 305 K=1,M
     C(K)=0.0
     DO 305 I=1,M
 305 C(K)=C(K)+A(K,I)*X(I)
     DO 351 K=1,M
 351 X(K)=ABS(X(K))
```

```
      II=II+1
      IF (III.NE.NOSHFT .OR. II.NE.NOIT) GO TO 135
      P03=1.0E+07
      DO 133 K=1,NS1
  133 TLC(K)=P03
  135 IF (II .LT. NMIT) GO TO 432
      IF (KOP.EQ.1) GO TO 201
      III=III+1
      IF (III.GE.4) GO TO 201
      IF (MNK.EQ.0) GO TO 312
      IF (MNK2.GT.0.AND.MNK.EQ.MNKS) GO TO 201
      MNKS=MNK
      MNK2=MNK2+1
      DO 311 I=1,M
      IF (STDEV(I,MNK).GE.0.001) CSHT(I)=-CSHT(I)
  311 CONTINUE
      DO 314 I=1,M
      NOTL(I)=0
      DO 314 J=1,5
      STDEV(I,J)=0.0
  314 SSDEV(I,J)=0.0
      MNK=0
      GO TO 901
  312 R3=R3-0.025
      R5=R5-0.025
      R7=R7+0.025
      R9=R9+0.025
      R11=R11+0.025
      R13=R13+0.025
      GO TO 987
  201 IF (II.GE.NMIT .AND. KOP.EQ.1) WRITE (6,714)
      IF (III.GT.3.AND.KIK.NE.0) WRITE (6,716)
      IF (IIP.NE.4 .OR. KOP.NE.2) GO TO 399
      IPI=0
      KPO=1
      LU=6
      WRITE (6,545)
  545 FORMAT (///5X,52HPRINT AND PUNCH AN EQUIVALENT MANUAL INPUT DATA DE
     XCK//)
  546 WRITE (LU,406) (TITLE(K),K=1,12)
      WRITE (LU,200) KPO
      WRITE (LU,200) M,IPI,NPLOT
      WRITE (LU,2) (WC(I,1),I=1,M)
      WRITE (LU,2) (YGLE(I),I=1,M)
      WRITE (LU,2) (XC(I,1),I=1,M)
      WRITE (LU,2) (DELAY(I),I=1,M)
      IF (LU .EQ. 7) GO TO 399
      LU=7
      GO TO 546
  399 IF (IIP .NE. 0) WRITE (6,402)
  402 FORMAT (////5X,27HA DECK OF CARDS WAS PUNCHED//)
      ND=ND-1
      IF (ND) 401,401,22
  401 CONTINUE
      IF (IOP.LE.8 .AND. IPLT.EQ.0) GO TO 500
      ENDFILE IL
      REWIND IL
      ENDFILE IK
```

```
      REWIND IK                                                         605 *
  500 WRITE (6,501)                                                     606 *
  501 FORMAT (//5X,13HEND OF NWVSYN)                                    607 *
      END                                                               608


      SUBROUTINE MATINV (A,N,NA)                                          1
C
C     THIS NEW MATRIX INVERSION SUBROUTINE, DEVELOPED BY G. CHAN, REPLACES THE
C     ORIGINAL VERSION SUPPLIED BY PARSONS.                          6/71-SC.
C
      DIMENSION A(NA,1)                                                   2
      M=N+1                                                               3
      DO 20 I=1,N                                                         4
      DO 7 K=1,N                                                          5
    7 A(K,M)=0.0                                                          6
      A(I,M)=1.0                                                          7
      W=A(I,I)                                                            8
      IF (W) 8,26,8                                                       9
    8 DO 9 J=1,M                                                         10
    9 A(I,J)=A(I,J)/W                                                    11
      DO 15 K=1,N                                                        12
      IF (K .EQ. I) GO TO 15                                             13
      W=A(K,I)                                                           14
      IF (ABS(W) .LT. 1.0E-36) GO TO 15                                  15
      DO 14 J=1,M                                                        16
   14 A(K,J)=A(K,J)-W*A(I,J)                                             17
   15 CONTINUE                                                           18
      DO 18 K=1,N                                                        19
   18 A(K,I)=A(K,M)                                                      20
   20 CONTINUE                                                           21
      RETURN                                                             22
   26 STOP 26                                                            23
      END                                                                24


      SUBROUTINE DELTIM (T,C,B,V)                                         1 *
C
C     THIS ROUTINE IS ADDED BY G.CHAN TO COMPUTE THE OPTIMAL DELTA TIME STEP.
C
      T=V+8.                                                              2
      X=6.25                                                              3
      IF (V .LT. 20.) X=12.5                                              4
   10 T=T-8.                                                              5
      IF (T .LT. 10.) GO TO 20                                            6
      X=2.*X                                                              7
      IF (B .GT. X) GO TO 10                                              8
   20 IF (C .LT. 6.) T=80.                                                9
      IF (C .LT. 4.) T=33.3                                              10
      T=6.283185/(T*C*B)                                                 11
      RETURN                                                             12
      END                                                                13
```

```
      SUBROUTINE SHOCK (C,TITLE,TFS)
C
      COMMON /OPTION/IOP,IPLT,IL,IK
      DIMENSION C( 1),E(25),F(25),REV(25),QOT(25),TITLE(1)
      COMMON /ABC/WS(25),TLC(25),CSHT(25),STDEV(25,5)
      COMMON      KOP,XC(25,5),WC(25,5),T(5000)
      COMMON /FFF/ SSDEV(25,5),ABSHT(25,5)
      COMMON /GGG/M,NF,NS,KIK,MNK,NTD,B(25),  CY(25),ALP(25),BLP(25),
     X            TINT(25),DELAY(25),NCTL(25)
      COMMON /HHH/MNK2,PI,PI2,IAR,JJJ,NJN,FREQCY(260),VEL(260),CMX(75)
      REAL MAX,MIN
  345 FORMAT ( 93X,19HTOLERANCE VIOLATION)
  368 FORMAT (24X,4F15.5)
  369 FORMAT (//5X,8HSPECTRUM//29X,10HFREQ. (HZ),7X,8HACCEL.,G,4X,
     X        13HVELOC. IN/SEC,5X,3HDISPL. IN//)
  315 FORMAT (2X,F12.5,80X,2F12.5)
  399 FORMAT (2X,7F12.5,8X,2F12.5)
  531 FORMAT (1H1)
  700 FORMAT(30X,28HGENERALIZED  SHOCK  SPECTRUM//42X,3HFOR//,28X,
     1        33HDAMPED  AND  UNDAMPED  VIBRATIONS///11X,10HINPUT DATA//
     2  11X, 13HSTARTING TIME,23X,F10.4//11X,8HEND TIME,28X,F10.4//
     311X,36HINITIAL DISPLACEMENT                    ,F10.4//
     411X,36HINITIAL VELOCITY                        ,F10.4//  )
  802 FORMAT (///4X,12H   FREQUENCY,12H    TIME    ,12H MAX.P.DIS. ,12
     1H MAX.P.ACC. ,12H    TIME    ,12H MAX.N.DIS. ,12H MAX.N.ACC. ,6X,
     214H ACC.ON SPEC. ,12H DEVIATION  /,4X          ,12H   C.P.S.   ,12
     3H    SEC.    12H    INS.    ,12H    G,S     ,12H    SEC.    ,12
     4H    INS.    ,12H    G,S     ,8X,12H    G,S     ,12H    0/0     /)
 1001 FORMAT (//10X,12A6//)
      TS=0.0
      X1=0.0
      V1=0.0
      JK3=3
      IF (TFS .LT. 0.0) JK3=150/M
      TFS=ABS(TFS)
      IF (JK3 .GT. 3) GO TO 9000
      KIK=0
      MNK=MNK+1
      WRITE(6,531)
 9000 NJN=0
      XJK3=FLOAT(JK3)
      WRITE(6,1001) (TITLE(I),I=1,12)
      IF (JK3 .EQ. 3) WRITE (6,700) TS,TFS,X1,V1
      T(1)=DELAY(1)
      CALL DELTIM (DT,CY(1),B(1),64.)
      TF=DELAY(1)+   PI2/B(1)
      DO 5015 JJ=2,5001
      T(JJ)=T(JJ-1)+DT
      IF (T(JJ).GE.TF) GO TO 5025
 5015 CONTINUE
      STOP 5025
 5025 NP=JJ
      IF (JK3 .EQ. 3) WRITE (6,802)
      IF (JK3 .GT. 3) WRITE (6,369)
      DO 95 KK=1,M
      KKP1=KK+1
      CP=0.0
```

```
      CPSC=0.0
      NNO=0
      DO 75 JK=1,JK3
      IF (JK3.EQ.3 .OR. KK.EQ.M) W=WC(KK,JK)
      IF (JK3.GT.3 .AND. KK.LT.M) W=WC(KK,1)*(WC(KKP1,1)/WC(KK,1))**
     1                            (FLOAT(JK-1)/XJK3)
      FREQ=W
      W=W*PI2
      W2=W*W
      NJN=NJN+1
      IF (JK .NE. 1) GO TO 2
      DEV=(GMX(NJN)-XC(KK,1))*100.0/XC(KK,1)
      WRITE (6,395) FREQ,XC(KK,1),DEV
      IF (JK3 .EQ. 3) GO TO 70
      MAX=GMX(NJN)
      MIN=0.
      GO TO 310
    2 IF (JK.NE.JK3 .OR. KK.EQ.M) GO TO 4
      T(1)=DELAY(KKP1)
      CALL DELTIM (DT,CY(KKP1),B(KKP1),64.)
      TF=DELAY(KKP1)+   PI2/B(KKP1)
      DO 6 JJ=2,5000
      T(JJ)=T(JJ-1)+DT
      IF (T(JJ).GE.TF) GO TO 16
    6 CONTINUE
   16 NP=JJ
    4 EPS=0.00001*W
      DO 434 I=1,M
      E(I)=ALP(I)+W
      F(I)=BLP(I)-W
      REV(I)=ALP(I)*ALP(I)-W2
  434 QOT(I)=BLP(I)*BLP(I)-W2
      MAX=0.0
      MIN=3.0
      DO 300 J=1,NP
      H=0.0
      IF (NTD .NE. 0) GO TO 298
      AA1=W*T(J)
      COSAA1=COS(AA1)
      SINAA1=SIN(AA1)
  298 DO 301 I=1,M
      TY=T(J)-DELAY(I)
      IF(TY.LE. 0.0) GO TO 301
      IF (NTD .EQ. 0) GO TO 299
      AA1=W*TY
      COSAA1=COS(AA1)
      SINAA1=SIN(AA1)
  299 CYCLE=CY(I)
      CP1=CYCLE+1.
      CM1=CYCLE-1.
      CP2=CP1*CP1
      CM2=CM1*CM1
      CYCLE2=2.*CYCLE
      IF(ABS(E(I)/CM1).GT.EPS) GO TO 7003
      DELTA=(B(I)-W/CM1)/W
      DELCM1=DELTA*CM1
      AA8=4.*(CYCLE2+DELCM1*CP2)
      IF(T(J).GT.TINT(I)) GO TO 7001
```

```
      AA5=AA1*CP1*(1.+DELCM1)/CM1                                       115 *
      Q=-CM2*(COSAA1-COS(AA5))/AA8+.25*AA1*(DELCM1*.5*AA1*COSAA1+SINAA1)  116 *
      GO TO 323                                                         117
 7001 Q=CYCLE*CM1*PI*(1.+2.*DELCM1)*(2.*SINAA1+PI*DELCM1*CM1*COSAA1)/AA8  118 *
      GO TO 323                                                         119
 7003 IF(ABS(F(I)/CP1).GT.EPS) GO TO 294                                120
      DELTA=(B(I)-W/CP1)/W                                              121
      DELCP1=DELTA*CP1                                                  122 *
      AA7=4.*(-CYCLE2*DELCP1)*CM2                                       123 *
      IF(T(J).GT.TINT(I)) GO TO 7002                                    124
      AA6=AA1*CM1*(1.+DELCP1)/CP1                                       125 *
      Q=CP2*(COSAA1-COS(AA6))/AA7-.25*AA1*(DELCP1*.5*AA1*COSAA1+SINAA1)  126 *
      GO TO 323                                                         127
 7002 Q=CYCLE*CP1*PI*(1.+2.*DELCP1)*(2.*SINAA1+PI*DELCP1*CP1*COSAA1)/AA7  128 *
      GO TO 323                                                         129
  294 IF(T(J).GT.TINT(I)) GO TO 100                                     130
      AA2=ALP(I)*TY                                                     131
      AA3=BLP(I)*TY                                                     132
      Q= W2/2.*((COSAA1-COS(AA2))/REV(I)-(COSAA1-COS(AA3))/QOT(I))      133 *
      GO TO 323                                                         134
  100 AA4=W    *(T(J)-TINT(I))                                          135
      Q=CYCLE2*W2*B(I)*B(I)*(COSAA1-COS(AA4))/(REV(I)*QOT(I))           136 *
  323 S=C(I)*Q                                                          137
      H=H+S                                                             138
  301 CONTINUE                                                          139
      IF(H-MAX) 306,300,302                                             140
  302 MAX=H                                                             141
      TP=T(J)                                                           142
      GO TO 300                                                         143
  306 IF(H-MIN) 307,300,300                                             144
  307 MIN=H                                                             145
      TP1=T(J)                                                          146
  300 CONTINUE                                                          147
      IF (JK3 .EQ. 3) GO TO 9010                                        148 *
  310 FREQCY(NJN)=FREQ                                                  149 *
      AMX=ABS(MAX)                                                      150 *
      AMN=ABS(MIN)                                                      151 *
      ACCEL=AMAX1(AMX,AMN)                                              152 *
      VEL(NJN)=ACCEL/W                                                  153 *
      DISPL=ACCEL/W2                                                    154 *
      ACCEL=ACCEL/386.4                                                 155 *
      WRITE (6,388) FREQ,ACCEL,VEL(NJN),DISPL                           156 *
      IF (KK-M) 75,95,95                                                157 *
 9010 XPB=MAX/W2                                                        158
      XNB=MIN/W2                                                        159
      MAX=MAX/386.4                                                     160
      MIN=MIN/386.4                                                     161
      ABSMX=ABS(MAX)                                                    162 *
      ABSMN=ABS(MIN)                                                    163 *
      GMX(NJN)=AMAX1(ABSMX,ABSMN)                                       164 *
      XTEMP=XC(KK,JK)                                                   165
      DEV=(GMX(NJN)-XTEMP)*100.0/XTEMP                                  166 *
      WRITE (6,399) FREQ,TP,XPB,MAX,TP1,XNB,MIN,XTEMP,DEV               167
   73 IF (KK .EQ. M) GO TO 69                                           168
      IF (KOP.EQ.1) GO TO 75                                            169
      ADEV=ABS(DEV)                                                     170
      DO 71 IJ=2,NS                                                     171
      IF (WS(IJ).GE.WG(KK,JK)) GO TO 73                                 172
```

```
71 CONTINUE
   IJ=NS
73 TLCLT=TLC(IJ-1)
   IF (ADEV.LE.TLCLT) GO TO 75
   WRITE (6,345)
   IF (NCTL(KK).EQ.1) GO TO 75
   KIK=KIK+1
   IF (CP.GE.ADEV) GO TO 74
   CP=ADEV
   CPSC=DEV
74 TLC15=1.5*TLCLT
   IF (ADEV.GT.TLC15) MNO=1
75 CONTINUE
   STDEV(KK,MNK)=CP
   SSDEV(KK,MNK)=CPSC
   IF (KOP.EQ.1.OR.NCTL(KK).EQ.1) GO TO 95
   IF (CP.LT.0.01.OR.MNK.GT.4) GO TO 95
   IF (MNK2.EQ.0) GO TO 58
   IF (MNK.GT.1) GO TO 41
51 IF (CSHT(KK).GT.0.001) GO TO 52
   CSHT(KK)=CSHT(KK)-1.0
   IF (MNO.EQ.1) CSHT(KK)=CSHT(KK)-2.0
   GO TO 54
52 CSHT(KK)=CSHT(KK)+1.0
   IF (MNO.EQ.1) CSHT(KK)=CSHT(KK)+2.0
54 GO TO 89
41 JJ1=MNK-1
   JJ2=MNK-2
   IF (STDEV(KK,JJ1).LT.0.01) GO TO 51
   CKKS=STDEV(KK,MNK)+STDEV(KK,JJ1)-ABS(SSDEV(KK,MNK)+SSDEV(KK,JJ1))
   IF (CKKS.GE.0.0001.AND.MNK.NE.3) GO TO 55
   IF (CKKS.GE.0.0001.AND.MNK.EQ.3) GO TO 46
   IF (MNK.GT.2) GO TO 47
42 IF (CSHT(KK).GT.0.001) GO TO 44
   IF (STDEV(KK,MNK).LT.STDEV(KK,JJ1)) GO TO 43
   CSHT(KK)=-CSHT(KK)
   IF (MNO.EQ.1) CSHT(KK)=CSHT(KK)+2.0
   GO TO 89
43 CSHT(KK)=CSHT(KK)-1.0
   IF (MNO.EQ.1) CSHT(KK)=CSHT(KK)-2.0
   GO TO 89
44 IF (STDEV(KK,MNK).LT.STDEV(KK,JJ1)) GO TO 45
   CSHT(KK)=-CSHT(KK)
   IF (MNO.EQ.1) CSHT(KK)=CSHT(KK)-2.0
   GO TO 89
45 CSHT(KK)=CSHT(KK)+1.0
   IF (MNO.EQ.1) CSHT(KK)=CSHT(KK)+2.0
   GO TO 89
46 CSHTST=ABSHT(KK,JJ2)
   CSHT(KK)=CSHTST+(ABSHT(KK,JJ1)-CSHTST)
  1   *STDEV(KK,JJ1)/(STDEV(KK,JJ1)+STDEV(KK,MNK))
   GO TO 89
47 IF (STDEV(KK,JJ2).LT.0.01) GO TO 42
   KIK=0
   GO TO 89
58 IF (MNK.GT.1) GO TO 77
76 CSHT(KK)=1.0
   IF (MNO.EQ.1) CSHT(KK)=CSHT(KK)+2.0
```

```
      GO TO 89
   77 JJ1=MNK-1
      JJ2=MNK-2
      IF (STDEV(KK,JJ1).LT.0.01) GO TO 76
      CKKS=STDEV(KK,MNK)+STDEV(KK,JJ1)-ABS(SSDEV(KK,MNK)+SSDEV(KK,JJ1))
      ACKKS=ABS(CKKS)
      IF (ACKKS.LT.0.1) GO TO 78
   55 CSHTST=0.0
      IF (MNK .GT. 2) CSHTST=ABSHT(KK,JJ2)
      CSHT(KK)=CSHTST+(ABSHT(KK,JJ1)-CSHTST)
     1   *STDEV(KK,JJ1)/(STDEV(KK,JJ1)+STDEV(KK,MNK))
      IF (MNK.EQ.3.AND.STDEV(KK,2).GE.STDEV(KK,1))  CSHT(KK)=
     1   ABSHT(KK,JJ1)*STDEV(KK,1)/(STDEV(KK,1)+STDEV(KK,MNK))
      NCTL(KK)=1
      GO TO 89
   78 IF (MNK.GT.2) GO TO 80
   79 CSHT(KK)=CSHT(KK)+1.0
      IF (MNO.EQ.1) CSHT(KK)=CSHT(KK)+2.0
      IF (STDEV(KK,MNK).LT.STDEV(KK,JJ1)) GO TO 89
      CSHT(KK)=-1.0
      IF (MNO.EQ.1) CSHT(KK)=CSHT(KK)-2.0
      GO TO 89
   80 IF (STDEV(KK,JJ2).LT.0.01) GO TO 79
      IF (MNK.GT.3) GO TO 85
   81 IF (STDEV(KK,MNK).LT.STDEV(KK,JJ1)) GO TO 82
      CSHT(KK)=0.5*ABSHT(KK,JJ2)
      IF (STDEV(KK,JJ1).LT.STDEV(KK,JJ2).AND.STDEV(KK,MNK).LT.
     1   STDEV(KK,JJ2)) CSHT(KK)=ABSHT(KK,JJ2)+0.5*(ABSHT(KK,JJ1)-
     2   ABSHT(KK,JJ2))
      NCTL(KK)=1
      GO TO 89
   82 IF (STDEV(KK,JJ1).LT.STDEV(KK,JJ2)) GO TO 84
      IF (STDEV(KK,MNK).LT.STDEV(KK,JJ2)) GO TO 83
      CSHT(KK)=0.5*ABSHT(KK,JJ1)
      NCTL(KK)=1
      GO TO 89
   83 CSHT(KK)=CSHT(KK)-1.0
      IF (MNO.EQ.1) CSHT(KK)=CSHT(KK)-2.0
      GO TO 89
   84 CSHT(KK)=CSHT(KK)+1.0
      IF (MNO.EQ.1) CSHT(KK)=CSHT(KK)+2.0
      GO TO 89
   85 JJ3=MNK-3
      IF (STDEV(KK,JJ3).LT.0.01) GO TO 81
      IF (ABSHT(KK,JJ1).GE.0.01) GO TO 87
      IF (STDEV(KK,MNK).LT.STDEV(KK,JJ1)) GO TO 86
      CSHT(KK)=0.5*ABSHT(KK,JJ2)
      IF (STDEV(KK,MNK).LT.STDEV(KK,JJ3)) CSHT(KK)=ABSHT(KK,JJ2)+
     1   0.5*(ABSHT(KK,JJ1)-ABSHT(KK,JJ2))
      NCTL(KK)=1
      GO TO 89
   86 CSHT(KK)=CSHT(KK)-1.0
      IF (MNO.EQ.1) CSHT(KK)=CSHT(KK)-2.0
      GO TO 89
   87 IF (STDEV(KK,MNK).LT.STDEV(KK,JJ1)) GO TO 88
      CSHT(KK)=ABSHT(KK,JJ3)+0.5*(ABSHT(KK,JJ2)-ABSHT(KK,JJ3))
      IF (STDEV(KK,MNK).LT.STDEV(KK,JJ2)) CSHT(KK)=ABSHT(KK,JJ2)+
     1   0.5*(ABSHT(KK,JJ1)-ABSHT(KK,JJ2))
```

```
      NCTL(KK)=1
      GO TO 89
   83 CSHT(KK)=CSHT(KK)+1.0
      IF (MNO.EQ.1) CSHT(KK)=CSHT(KK)+2.0
   89 ABSHT(KK,MNK)=CSHT(KK)
   95 CONTINUE
      IF (JK3 .LE. 3 .OR. IPLT .EQ. 0) RETURN
      WRITE (IK) NJN,M,(CMX(J),WC(J,1),J=1,75)
      WRITE (IK) (FREQCY(J),VEL(J),J=1,NJN)
      RETURN
      END
```

```
      SUBROUTINE INTERP (X,Y,NI,TABLEX,TABLEY)
C
C     THIS NEW SUBROUTINE, DEVELOPED BY G. CHAN, REPLACES THE OLDER VERSION
C          ORIGINALLY SUPPLIED BY PARSONS.                          7/71-GC.
C
      DIMENSION TABLEX(1),TABLEY(1)
      IF (X .GT. TABLEX(1) .AND. X .LT. TABLEX(NI)) GO TO 5
      IF (X .LE. TABLEX(1)) Y=TABLEY(1)
      IF (X .GE. TABLEX(NI)) Y=TABLEY(NI)
      RETURN
    5 I=1
   10 I=I+1
      IF (TABLEX(I)-X) 10,15,20
   15 Y=TABLEY(I)
      RETURN
   20 J=I-1
      Y=(TABLEY(I)-TABLEY(J))/(TABLEX(I)-TABLEX(J))
      Y=TABLEY(J)+(X-TABLEX(J))*Y
      RETURN
      END
```

```
      SUBROUTINE POWOUT (IIP,M,GL,TITLE,B,C,TINT,DELAY,YCLE)
C
      DIMENSION TITLE(1),DELAY(1),TINT(1),B(1),YCLE(1),C(1)
      COMMON      XXX(251),T(5000),AR(5000)
      COMMON /HHH/ MNK2,PI,PI2,IAR,JJJ
      COMMON /OPTION/IOP,IPLT,IL
      COMMON /WSL/NPS(4),TYME(4)
    1 FORMAT (9F8.5)
    8 FORMAT(//20X,14HVELOCITY TABLE,6X,9H(INS/SEC),/)
   10 FORMAT (///5X,20HSYNTHESIZED WAVEFORM,//5X,34HNO. OF DATA POINTS O
     1N TIME TABLE =,I6)
   19 FORMAT (//20X,18HACCELERATION TABLE,4X,1H(,A9,1H),/)
   38 FORMAT(//20X,18HDISPLACEMENT TABLE,6X,5H(INS),/)
  402 FORMAT (4F15.6)
  405 FORMAT (26X,F10.6,3(4X,F14.5))
  407 FORMAT (1H0,//31X,4HTIME,12X,6HACCEL.,10X,8HVELOCITY,12X,6HDISPL.
     X ,/31X,4HSEC.,9X,A10,9X,8HINS/SEC.,14X,4HINS./)
  408 FORMAT (//20X,10HTIME TABLE,6X,5H(SEC),/)
  409 FORMAT (8X,4HTIME,6X,6HACCEL.,8X,8HVELOCITY,6X,6HDISPL.)
C
      FMT=10H(9F8.4)
      IF (IAR.EQ.2 .OR. IIP.EQ.5) FMT=10H(9F8.2)
      IF (IIP .EQ. 5) UNIT=10HIN/SEC**2
      IF (IIP .NE. 5) UNIT=10H      G,S
      IP4=IIP
      IF (IIP .EQ. 4) IIP=0
      T(1)=0.0
      IT=2
      IIT=1
   26 I=M
      IF(T(IIT).GE.GL) GO TO 31
   25 IF(T(IIT).GE.DELAY(I) .AND. T(IIT).LT. TINT(I)) GO TO 27
      I=I-1
      GO TO 25
   27 CALL DELTIM (DDT,YCLE(I),B(I),32.)
      T(IT)=T(IIT)+DDT
      IK=I+1
      IF(IK.GT. M) GO TO 28
      IF(T(IT).GT. DELAY(IK) .AND. T(IIT).LT.DELAY(IK)) GO TO 33
   28 CONTINUE
      GO TO 34
   33 DIFF=(DELAY(IK)-T(IIT))/DDT
      IF(DIFF.GE. 0.2) GO TO 32
      IT=IT-1
      IIT=IIT-1
      T(IT)=DELAY(IK)
      GO TO 34
   32 T(IT)=DELAY(IK)
   34 IIT=IT
      IT=IT+1
      GO TO 26
   31 CONTINUE
      IT=IIT
      WRITE (6,10) IT
      WRITE (6,407) UNIT
      IF (IIP .LT. 0) PUNCH 409
      DO 501 J=1,IT
```

```
      AA=0.0                                                            56 *
      RR=0.0                                                            57 *
      HH=0.0                                                            58 *
      DO 502 I=1,M                                                      59
      TY=T(J)-DELAY(I)                                                  60
      IF (TY.LE.0.0.OR.T(J).GE.TINT(I)) GO TO 502                       61
      CYCLE=YCLE(I)                                                     62
      AA8=CYCLE-1.0                                                     63
      AA9=CYCLE+1.0                                                     64
      BI=B(I)                                                           65 *
      BI2=BI*BI*2.                                                      66 *
      COSB8Y=COS(BI*AA8*TY)                                             67 *
      COSB9Y=COS(BI*AA9*TY)                                             68 *
      AA10=AA8*AA8*BI2                                                  69 *
      AA11=AA9*AA9*BI2                                                  70 *
      QA=(COSB8Y-COSB9Y)*0.5                                            71 *
      QQ=(SIN(BI*AA8*TY)/AA8 - SIN(BI*AA9*TY)/AA9)*0.5/BI               72 *
      QR=(1.-COSB8Y)/AA10 - (1.-COSB9Y)/AA11                            73 *
      BB=C(I)*QA                                                        74
      SS=C(I)*QQ                                                        75
      ZZ=C(I)*QR                                                        76
      AA=AA+BB                                                          77 *
      HH=HH+SS                                                          78 *
      RR=RR+ZZ                                                          79 *
  502 CONTINUE                                                          80
      AAA=AA/386.4                                                      81 *
      IF (IIP .EQ. 5) AAA=AA                                            82 *
      WRITE (6,405) T(J),AAA,HH,RR                                      83 *
      IF (IIP .LT. 0) PUNCH 402, T(J),AAA,HH,RR                         84 *
      AR(J)=AAA                                                         85 *
      IF (IAR .EQ. 2) AR(J)=HH                                          86 *
      IF (IAR .EQ. 3) AR(J)=RR                                          87 *
  501 CONTINUE                                                          88
      IF (IIP .LE. 0) GO TO 558                                         89 *
      PUNCH 408                                                         90
      PUNCH 1, (T(J),J=1,IT)                                            91
      IF (IAR .EQ. 1) PUNCH 19, UNIT                                    92 *
      IF (IAR .EQ. 2) PUNCH 8                                           93 *
      IF (IAR .EQ. 3) PUNCH 38                                          94 *
      PUNCH FMT, (AR(J),J=1,IT)                                         95 *
  550 IF (IOP.LE.8 .AND. IPLT.EQ.0) GO TO 555                           96
      JJJ=JJJ+1                                                         97 *
      NPS(JJJ)=IT                                                       98 *
      TYME(JJJ)=T(IT)                                                   99 *
      WRITE (IL) (T(J),J=1,IT)                                         100 *
      WRITE (IL) (AR(J),J=1,IT)                                        101 *
  555 IIP=IP4                                                          102 *
      IF (IAR .NE. 1) RETURN                                           103 *
      CALL SHKSPM (IT,M,IIP)                                           104 *
      CALL LNPLT (TITLE,YCLE)                                          105 *
      RETURN                                                           106
      END                                                              107
```

```
      SUBROUTINE SHKSPM (IT,M,IIP)
      COMMON /OPTION/IOP,IPLT,IL,IK
      COMMON       XXX(126),WC(25,5),TM(5000),ACC(5000)
      COMMON /EEE/TT(1000)
      COMMON /HHH/COMM(5),NJN,FREQ(260),VEL(260),CMX(75)
      DIMENSION FT(1000),F(9000)
      EQUIVALENCE (FT(1),TM(1)),(F(1),TM(1001))
C
      ISERV=1
      GV=1.0
      IF (IIP .EQ. 5) GV=386.4
      SSF=WC(1,1)
      EF=WC(M,1)
      WRITE (6,410)
  410 FORMAT (/////)
      NT=IT
      IF (IT .GT. 1000) NT=1000
      DO 415 I=1,NT
      TT(I)=TM(I)
  415 FT(I)=ACC(I)/GV
      TH=0.0001
      IDEL=5
      TS=TT(1)
      TE=TT(NT)
      DEL=1./FLOAT(IDEL)
  424 N=IFIX((TE-TS)*EF/DEL+1.5)
      IF (N .LE. 9000) GO TO 428
      IF (TE .LE. 15.0) GO TO 426
      TE=15.0
      WRITE (6,425)
  425 FORMAT (///5X,18HTIME LIMIT 15 SEC.//)
      GO TO 424
  426 SF=AINT(8999.*DEL/(TE-TS))
      WRITE (6,427)
  427 FORMAT (///5X,24HENDING FREQ. EF ADJUSTED//)
  428 H1=150
      WRITE (6,430) SSF,EF,H1
  430 FORMAT (11X,16HSTARTING FREQ. =,12X,F15.4,//11X,16HENDING FREQ.
     1=,12X,F15.4,//11X,16HINTERVAL STEPS =,12X,F12.1)
      IF (ISERV .EQ. 1) WRITE (6,432)
  432 FORMAT (1H1,13X,13H      TIME     ,9X,13H  FREQUENCY  ,9X,16HMAX.DIS
     1PLACEMENT,9X,15HMAX.ACCELERATION//,19X,4HSEC.,16X,6HC.P.S.,19X,4HIN
     2S.,22X,3HG'S//)
  436 XN=AINT((TE-TS)/TH+1.5)
      IF (XN .LT. 9000.) GO TO 438
      TH=TH*TH
      GO TO 436
  438 N=IFIX(XN)+1
      TH2=(TE-TS)/XN
      CALL INTRP3 (N,NT,TS,DUM1,TH2,DUM3,DUM4)
      NJN=3
      RATIO=EF/SSF
      CNT=-1.0
  440 CNT=CNT+1.0
      IF (CNT .GT. H1) GO TO 450
      SF=SSF*RATIO**(CNT/H1)
      OMEG=6.283185*SF
```

```
      NJN=NJN+1
      TH1=DEL/SF
      IF (TH2 .LE. TH1) GO TO 448
      XN=AINT((TE-TS)/TH1+1.5)
      N=IFIX(XN)+1
      DO 442 I=1,6
      I1=I*1500
      IF (N.GT.I1-1500 .AND. N.LE.I1) N=I1
  442 CONTINUE
      IF (N .LE. 9000) GO TO 446
      WRITE (6,445) N
  445 FORMAT (//5X,21HF DIMENSION TOO SMALL,I7)
      RETURN
  446 TH2=(TE-TS)/FLOAT(N-1)
      CALL INTRP3 (N,NT,TS,DUM1,TH2,DUM3,DUM4)
  448 CALL ACCEL (N,NT,TS,SF,TH2,OMEG,ISERV)
      GO TO 440
  450 IF (IPLT .EQ. 0) RETURN
      K=0
      DO 455 I=1,25
      DO 455 J=1,3
      K=K+1
  455 ACC(K)=WC(I,J)
      WRITE (IK) NJN,M,(ACC(J),GMX(J),J=1,75)
      WRITE (IK) (FREQ(J),VEL(J),J=1,NJN)
      RETURN
      END
```

```
      SUBROUTIN· ·CCEL (N,NT,TS,SF,TH2,OMEG,ISERV)
      COMMON       XXX(251),FT(1000),F(9000)
      COMMON /EEE/TT(1000)
      COMMON /HHH/CM(5),NJN,FREQCY(260),VEL(260)
      DATA P1/3.00001/
      OMEG2=OMEG*OMEG
      TH=TH2
      TI=TS
      XI=0.
      VI=0.
      AI=-F(1)-OMEG2*XI
      Q=1./(1.+OMEG2*TH*TH/6.)
      TH3=TH*TH/3.
      XABS=XI
      TIME=TI
      DO 4 I=2,N
      TI=TI+TH
      FI=F(I)
      XJ=XI
      VJ=VI
      AJ=AI
      S=XJ+TH*VJ+TH3*AJ
      AI=-Q*(FI+OMEG2*S)
      VI=VJ+0.5*TH*(AJ+AI)
    2 XI=XJ+TH*VJ+TH3*AJ+0.5*TH3*AI
      IF (ABS(XI) .LE. XABS) GO TO 4
      XABS=ABS(XI)
      TIME=TI
    4 CONTINUE
      AABS=OMEG*OMEG*XABS
      XABS=XABS*386.4
      FREQ=OMEG/6.283185
      IF (NJN .GT. 260) GO TO 6
      VEL(NJN)=OMEG*XABS
      FREQCY(NJN)=FREQ
    6 IF (ISERV .EQ. 1) WRITE (6,7) TIME,FREQ,XABS,AABS
    7 FORMAT (13X,F13.4,9X,F13.4,11X,F13.4,10X,F13.4)
      RETURN
C
      ENTRY INTRP3
      TI=TS
      F(1)=FT(1)
      K=1
      DO 15 J=2,N
      TI=TI+TH2
    8 I=K+1
      IF (I .GT. NT) GO TO 10
      IF (TT(I) .GE. TI) GO TO 12
      K=I
      GO TO 8
   10 F(J)=0.0
      GO TO 15
   12 XL=ABS(TT(I)-TI)
      IF (XL .LE. P1) F(J)=FT(I)
      IF (XL .GT. P1) F(J)=FT(K)+((FT(I)-FT(K))/(TT(I)-TT(K)))*
     1                (TI-TT(K))
   15 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE LNPLT (TITLE,CY)
      DIMENSION TITLE(1),CY(1),VELO(8),DNO(6)
      COMMON       KOP,XC(25,5),WC(25,5),GRID(55,130)
      COMMON /GGG/M
      COMMON /HHH/ ANK2,PI,PI2,IAR,JJJ,NJN,FREQCY(260),VEL(260),CMX(75)
      DATA VELO/1HV,1HE,1HL,1HO,1HG,1HI,1HT,1HY/
      DATA DNO/1H3,1H5,1H7,1H9,1H1,1H3/

C     THIS SUBROUTINE IS ADDED BY S. CHAN, TO PLOT OUT SPECTRUM ON LINE PRINTER.

      WRITE (6,2999)
 2999 FORMAT (////5X,38HSPECTRUM FROM THE SYNTHESIZED WAVEFORM)
      D=DATE(DUMMY)
      T=TIME(DUMMY)
      DO 3000 J=1,7150
 3000 GRID(J,1)=1H
      IF (NJN .GT. 260) NJN=260
      DO 3001 K=1,NJN
      I=56-IFIX(23.0*(ALOG10(VEL(K)))+0.499)
      J=IFIX(40.0*(ALOG10(FREQCY(K))+1.0)+0.499)-11
      IF (I.GE.1.AND.I.LE.55 .AND. J.GE.1.AND.J.LE.130) GRID(I,J)=1HX
 3001 CONTINUE
      FQQ=366.4/6.28318531
      K3=3
      KK=0
      DO 3004 L=1,M
      LL=IFIX(CY(L))/2
      N=56-IFIX(23.0*(ALOG10(XC(L,1)/WC(L,1)*FQQ))+0.499)
      IF (L .GE. M) K3=1
      DO 3004 K=1,K3
      KK=KK+1
      J=IFIX(40.0*(ALOG10(WC(L,K))+1.0)+0.499)-11
      IF (J.LT.1 .OR. J.GT.130) GO TO 3004
      FQ=FQQ/WC(L,K)
      I=56-IFIX(23.0*(ALOG10(CMX(KK)*FQ))+0.499)
      IF (I.GE.1 .AND. I.LE.55) GRID(I,J)=1HY
      IF (K .GT. 1) GO TO 3004
      GRID(55,J)=1HV
      IF (N.GE.1 .AND. N.LE.55) GRID(N,J)=DNO(LL)
 3004 CONTINUE
      DO 3005 I=1,8
 3005 GRID(I+18,3)=VELO(I)
      GRID(1,130)=1H+
      GRID(33,1)=1H+
      GRID(33,2)=1H1
      GRID(33,3)=1H0
      GRID(10,1)=1H+
      GRID(10,2)=1H1
      GRID(10,3)=1H0
      GRID(10,4)=1H0
      GRID( 3,1)=1H*
      GRID(12,1)=1H*
      GRID(15,1)=1H*
      GRID(19,1)=1H*
      GRID(26,1)=1H*
      GRID(35,1)=1H*
      GRID(38,1)=1H*
```

```
      GRID(42,1)=1H*
      GRID(49,1)=1H*
      GRID(55,2)=1H/
      GRID(54,3)=1H1
      GRID(54,4)=1H.
      WRITE (6,3002) (TITLE(I),I=1,12),D,T
 3002 FORMAT (1H1,24X,12A6,15X,A10,5X,A3,6H00 HR.)
      WRITE (6,3006) ((GRID(I,J),J=1,130),I=1,55)
 3006 FORMAT (2X,130A1)
      WRITE (6,3009)
 3009 FORMAT (2X,1H+,11X,1H*,6X,1H*,4X,1H*,3X,1H+,11X,1H*,11X,1H*,6X,
     2 1H*,4X,1H*,3X,1H+,11X,1H*,11X,1H*,6X,1H*,4X,1H*,3X,1H+,11X,1H*,
     3 /1X,2H.2,26X,3H1.0,14X,6HFREQ.CPS,14X,4H10.0,35X,5H100.0,/1H1)
      RETURN
      END
```

```
      OVERLAY (ISICP,4,0)
      PROGRAM SPCTRM
C
C     THIS PROGRAM GENERATES SHOCK SPETRUM FORM GIVEN ACCEL.-TIME HISTORY INPUT.
C
C     LINEAR   ACCELERATION   METHOD  FOR  SOLVING   ORDINARY  DIFFERENTIAL
C     EQUATIONS
C     FOLLOWING   VARIABLES  ARE  USED  IN  THIS  PROGRAM
C     NONLINEAR  EQUATIONS  CAN  BE  SOLVED   BY  THIS  METHOD
C
C     NT =NO OF POINTS IN TIME-ACCEL. TABLE,  NOT AN INPUT VARIABLE.
C     TS,TE =STARTING AND ENDING TIMES ON TIME TABLE, DUMMY INPUT VALUES NEEDED.
C     TH =INTEGRATION TIME STEP
C     BET =CRITIAL DAMPING RATIO, TYPICAL VALUE 0.01, 0.03, 0.05
C     XI,VI =INITIAL DISPL. AND VELOCITY VALUES.
C     ICP =RESIDUAL VIBRATION CYCLES (2 OR LARGER).
C     IDEL =AN INTEGRATION CONSTANT (5 OR LARGER)
C     NF =NO. OF FREQUENCY RANGES ON OUTPUT SPECTRUM.
C         IF NF=1, HHF(1) IS THE NO. OF LOG. INCREMENTS WITHIN FREQ. RANGE.
C     SSF,EEF,HHF =STARTING AND ENDING FREQUENCIES, AND FREQ. INCREMENT, ON
C                  OUTPUT SPECTRUM.
C     IK =0, INPUT ACCEL. IN G UNITS,   OR =1, INPUT ACCEL. IN IN/SEC**2 UNITS.
C     LOT(I) = ACCEL. COMPUTATION SELECTION.
C     LAST =0, END OF RUN,   =2, TOTAL REPEAT,   =1, PARTIAL REPEAT, STARTING
C              FROM TIME-ACCEL. TABLE (TT,FT) INPUT.
C              LAST IS SET TO ZERO ON OVERLAY RUN.
C     FOR AN INDEPENDENT SPCTRM RUN, SET LOT(1)=50.
C
C     PROGRAM ACCEPTS PUNCH DATA FROM ISOL,  TIME IN SECOND AND ACCEL. IN G.
C
C     INPUT SEQUENCE *******
C       1.  TS,TE,TH BET,XI,VI CARD            (6F8.0)
C       2.  NF,ICP,IDEL,NT CARD                (4I5)
C       3.  FREQ. RANGE(S)                     (3F8.0)
C       4.  TIME TABLE                         (7F10.2)
C       5.  TITLE,IK,LAST CARD                 (11A6,4X,2I5)
C       6.  ACCEL. TABLE                       (7F10.2)
C
      DIMENSION SSF(15),EEF(15),HHF(15),LOT(12),FMT(3),LLT(46)
      COMMON /ID12/TITLE(12)
      COMMON /OPTION/IOP,IPLT,LU1,LU2,LU
      COMMON /ARRY/NCASE
      COMMON       VI,XI,TS,F(12000)
      COMMON /CMS/OMEG,BET,TH2,IO,NT,TT(750),FT(750)
      COMMON /VFQ/NLT,JJJ,VEL(500),FREQCY(500)
      DATA LLT/4H  AX,4H  AY,4H  AZ,6*0,4H ABX,4H ABY,4H ABZ,12*0,
     1 4HAXP1,4HAYP1,4HAZP1,3*0,4HAXP2,4HAYP2,4HAZP2,3*0,4HAXP3,
     2 4HAYP3,4HAZP3,3*0,4HAXP4,4HAYP4,4HAZP4,4HSPCL/
      DATA FMT/10H(//10X,    ,10H11A6//)    ,10H          /
      DATA IFSZ/12000/
      IF (IOP .GE. 11) FMT(2)=10H12A6//)
  200 FORMAT(4I5)
  300 FORMAT(3F8.0)
  400 FORMAT (6F8.0,8I4)
 4124 FORMAT(7F10.2)
 1000 FORMAT (11A6,4X,2I5)
 1100 FORMAT (4///5X,13HLOADING CASE ,A6//)
```

```
    1 IF (NCASE .LE. 1) READ (5,400) TS,TE,TH,BET,XI,VI,(LOT(J),J=1,8)
      I=6H    X-Z
      IF (NCASE .EQ. 2) I=6H    Y-Z
      IF (NCASE .EQ. 3) I=6H X-Y-Z
      IF (LOT(1) .EQ. LLT(46)) I=LLT(46)
      IF (NCASE.GT.0 .OR. I.EQ.LLT(46)) WRITE (6,1100) I
      IF (I .EQ. LLT(46)) GO TO 4030
      IF (NCASE .GE. 2) GO TO 4002
      LOT(12)=0
      J=12
      DO 4001 I=1,8
      J=J-1
 4001 LOT(J)=LOT(J-3)
 4002 N=NCASE+1
      IF (NCASE .LT. 2) GO TO 4003
      READ (LU) TS,TE,TH,BET,XI,VI,(LOT(J),J=1,12),NF,ICP,DEL,IDEL,H1
      READ (LU) (SSF(J),EEF(J),HHF(J),J=1,NF)
      REWIND LU
 4003 GO TO (4004,4006,4008,4010,4020), N
 4004 LOT(1)=-1
      LOT(2)=-1
      LOT(3)=-1
      GO TO 4020
 4006 LOT(1)=5
      LOT(2)=7
      LOT(3)=-1
      IF (LOT(4).EQ.5 .OR. LOT(4).EQ.7) LOT(4)=-1
      IF (LOT(5).EQ.5 .OR. LOT(5).EQ.7) LOT(5)=-1
      IF (LOT(6).EQ.5 .OR. LOT(6).EQ.7) LOT(6)=-1
      GO TO 4020
 4008 LOT(1)=6
      LOT(2)=7
      LOT(3)=-1
      IF (LOT(4).EQ.6 .OR. LOT(4).EQ.7) LOT(4)=-1
      IF (LOT(5).EQ.6 .OR. LOT(5).EQ.7) LOT(5)=-1
      IF (LOT(6).EQ.6 .OR. LOT(6).EQ.7) LOT(6)=-1
      GO TO 4020
 4010 LOT(1)=5
      LOT(2)=6
      LOT(3)=7
      IF (LOT(4).EQ.5 .OR. LOT(4).EQ.6 .OR. LOT(4).EQ.7) LOT(4)=-1
      IF (LOT(5).EQ.5 .OR. LOT(5).EQ.6 .OR. LOT(5).EQ.7) LOT(5)=-1
      IF (LOT(6).EQ.5 .OR. LOT(6).EQ.6 .OR. LOT(6).EQ.7) LOT(6)=-1
 4020 NCS=0
      IF (NCASE .GE. 2) GO TO 4030
      READ (5,200) NF,ICP,IDEL,NT
      IF (NF .GT. 15) WRITE (6,777) NF
  777 FORMAT (///5X,30HINCREASE SSF, EEF, HHF EACH TO,I5)
      IF (IDEL .EQ. 0) IDEL=5
      DEL=1./FLOAT(IDEL)
      DO 323 KK =1,NF
  323 READ (5,300) SSF(KK),EEF(KK),HHF(KK)
      IF (NF .GT. 1) GO TO 5000
      H1=ABS(HHF(1))
      IF (H1 .LT. 5.) H1=100.0
      IF (H1 .GT. 500.) WRITE (6,2004) H1
 2004 FORMAT (///5X,31HVEL,FREQCY DIMENSIONS TOO SMALL,I12)
 5000 IF (ICP .LE. 10) GO TO 4030
```

```
      REWIND LU
      WRITE (LU) TS,TE,TH,BET,XI,VI,(LOT(J),J=1,12),NF,ICP,DEL,IDEL,H1
      WRITE (LU) (SSF(J),EEF(J),HHF(J),J=1,NF)
      ENDFILE LU
      REWIND LU
 4030 J=12
      IF (IOP .GE. 11) GO TO 5001
      READ(5,4124)  (TT(I),I=1,NT)
  330 READ(5,1000)  (TITLE(I),I=1,11),IK,LAST
      WRITE(6,531)
      J=11
 5001 WRITE (6,FMT) (TITLE(I),I=1,J)
      IF (IOP .GE. 11) GO TO 5002
      READ(5,4124)  (FT(I),I=1,NT)
      GO TO 5012
 5002 NCS=NCS+1
      NLT=LOT(NCS)
      IF (NLT .EQ. -1) GO TO 5002
      IF (NLT .LE. 4 .OR. NLT .GT. 50) GO TO 5020
      NT=0
 5005 NT=NT+1
      IF (NT .GT. 750) STOP 5005
      READ (3          ) JJ,TT(NT),(F(NT),J=3,NLT),FT(NT)
C           ,END=5010
      IF (JJ) 5010,5005,5005
 5010 REWIND 3
      IF (NT .EQ. 1) GO TO 5002
      IK=1
 5012 TS=TT(1)
      TE=TT(NT)
      WRITE (6,700) NT,TS,TE,TH,BET,XI,VI,ICP,IDEL
      IF (NF .GT. 1) GO TO 5015
      WRITE (6,326) SSF(1),EEF(1),H1
  326 FORMAT (11X,16HSTARTING FREQ. =,12X,F15.4,//11X,16HENDING FREQ.
     1=,12X,F15.4,//11X,16HINTERVAL STEPS =,12X,F12.1)
      GO TO 5018
 5015 WRITE (6,324)
      DO 333 KK=1,NF
  333 WRITE (6,325) SSF(KK),EEF(KK),HHF(KK)
  324 FORMAT (12X,8HSTARTING,11X,10H   END    ,10X,9HFREQUENCY/
     1        12X,9HFREQUENCY,10X,9HFREQUENCY,11X,8HINTERVAL/)
  325 FORMAT  (4X,F15.4,5X,F15.4,6X,F15.4)
  700 FORMAT(30X,28HGENERALIZED  SHOCK  SPECTRUM//42X,3HFOR//,28X,
     1       33HDAMPED  AND  UNDAMPED  VIBRATIONS///11X,10HINPUT DATA//
     2   11X,21HNO OF POINTS IN TABLE,13X,I9,//11X, 13HSTARTING TIME,23X
     3   ,F10.4//11X,8HEND TIME,28X,F10.4//,11X,13HTIME INTERVAL,23X,
     4    F10.4//11X,27HPERCENTAGE CRITICAL DAMPING, 9X,F10.4//
     511X,36HINITIAL DISPLACEMENT                ,F10.4//
     611X,36HINITIAL VELOCITY                    ,F10.4//
     711X,36HNO OF CYCLES OF RESIDUAL VIBRATION  ,I4//
     811X,36HFACTOR FOR INTEGRATION TIME INTERVAL,I4////)
 5018 WRITE (6,666)
  666 FORMAT (/// 11X,10HTIME TABLE //)
      WRITE (6,801) (TT(I),I=1,NT)
      IF (IK .GT. 0) WRITE (6,820)
      IF (IK .LE. 0) WRITE (6,800)
  800 FORMAT (// 11X,18HACCL. TABLE IN G S  //)
  820 FORMAT (// 11X,26HACCL. TABLE IN IN/SEC. SQ. //)
```

```
      WRITE (6,801) (FT(I),I=1,NT)
  801 FORMAT (9(2X,F12.4))
      IF (NLT.LE.0 .AND. IOP.LE.10) NLT=50
      LT=LLT(NLT-4)
      IF (LT .EQ. 0) LT=6H
      WRITE (6,5022) LT
 5022 FORMAT (///5X,21HEND INPUT TO SPCTRM -,A4///)
      IF (IK.LE.0)  GO TO 935
      DO 840 I=1,NT
  840 FT(I)=FT(I)/386.4
  835 WRITE (6,802)
  802 FORMAT (1H1,13X,13H      TIME     ,9X,13H  FREQUENCY  ,9X,16HMAX.DIS
     1PLACEMENT,9X,15HMAX.ACCLERATION//,18X,4HSEC.,17X,6HC.P.S.,19X,4HIN
     2S.,22X,3H6*S//)
      JJJ=0
      DO 89 KK=1,NF
      SF=SSF(KK)
      EF=EEF(KK)
      HF=HHF(KK)
      N=IFIX((TE-TS)*EF/DEL+1.5)
      IF (N .LE. IFSZ) GO TO 422
      WRITE (6,419) N,IFSZ,SF,EF
  419 FORMAT (//5X,34HDIMENSION OF F IN SPCTRM TOO SMALL,2I10,/5X,
     X        5HFREQ.,F7.2,3H TO,F7.2,8H SKIPPED//)
      GO TO 89
  422 TH2=(TE-TS)/FLOAT(N-1)
      CALL INTRP2 (N,DUM1,DUM2)
      IF (NF .GT. 1) GO TO 87
      RATIO=EF/SF
      CNT=-1.0
   86 CNT=CNT+1.0
      IF (CNT .GT. H1) GO TO 89
      SF=SSF(1)*RATIO**(CNT/H1)
   87 OMEG=6.283185*SF
      JJJ=JJJ+1
      CALL ACCL (N,SF,ICP)
      IF (NF .EQ. 1) GO TO 86
      SF=HF+SF
      IF (SF.LE.EF) GO TO 87
   89 CONTINUE
      CALL GDPLT (LT)
      IF (IOP .GE. 11) GO TO 5002
      WRITE (6,531)
  531 FORMAT (1H1)
      IF (LAST-1) 5020,330,1
 5020 CONTINUE
      END
```

```
      SUBROUTINE ACCL (N,SF,ICP)
      COMMON       VII,XII,TS,F(1)
      COMMON /CMS/OMEG,BET,TH2,IO,NT,TT(750),FT(750)
      COMMON /VFQ/NLT,JJJ,VEL(500),FREQCY(500)
      DATA P1/0.00001/
      OMEG2=OMEG*OMEG
      BO2=2.*OMEG*BET
      TH=TH2
      TI=TS
      XI=XII
      VI=VII
      AI=-F(1)-BO2*VI-OMEG2*XI
      Q=1./(1.+BET*OMEG*TH+OMEG2*TH*TH/6.)
      IO=N
      IN=2
      XABS=XI
      TIME=TS
    2 TH3=TH*TH/3.
      DO 3 I=IN,IO
      XJ=XI
      VJ=VI
      AJ=AI
      IF (IO .EQ. N) FI=F(I)
      TI=TI+TH
      R=VJ+0.5*TH*AJ
      S=XJ+TH*VJ+TH3*AJ
      AI=-Q*(FI+BO2*R+OMEG2*S)
      VI=VJ+0.5*TH*(AJ+AI)
      XI=XJ+TH*VJ+TH3*AJ+0.5*TH3*AI
      IF (ABS(XI) .LE. XABS) GO TO 3
      XABS=ABS(XI)
      TIME=TI
    3 CONTINUE
      IF (ICP.LE.0 .OR. IO.GT.N) GO TO 4
      IO=N+ICP*30
      IN=N+1
      TH=1./(30.*SF)
      FI=0.0
      GO TO 2
    4 AABS=OMEG2*XABS
      XABS=XABS*386.4
      FREQ=OMEG/6.2831853
      IF (JJJ .GT. 500) GO TO 5
      VEL(JJJ)=OMEG*XABS
      FREQCY(JJJ)=FREQ
    5 WRITE (6,6) TIME,FREQ,XABS,AABS
    6 FORMAT (13X,F13.4,9X,F13.4,11X,F13.4,10X,F13.4)
      RETURN
C
      ENTRY INTRP2
C     LINEAR  INTERPOLATION  SUBROUTINE   FOR  DYNAMIC  PROGRAM
C     FOLLOWING  STATEMENTS  READ  THE  CARDS  DEFINING  THE  CURVE
      TT=TS
      F(1)=FT(1)
      K=1
      DO 15 J=2,N
      TI=TI+TH2
```

```
8     I=K+1
      IF (I .GE. NT) GO TO 10
      IF (TT(I) .GE. TI) GO TO 12
      K=I
      GO TO 8
10    F(J)=0.0
      GO TO 15
12    XL=ABS(TT(I)-TI)
      IF (XL .LE. P1) F(J)=FT(I)
      IF (XL .GT. P1) F(J)=FT(K)+((FT(I)-FT(K))/(TT(I)-TT(K)))*
     1                (TI-TT(K))
15    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE GOPLT (LT)
C     THIS SUBROUTINE IS ADDED BY S. CHAN, TO PLOT OUT SPECTRUM ON LINE PRINTER.
      DIMENSION VELO(8)
      COMMON       VXITS(3),GRID(54,130)
      COMMON /VFQ/NLT,JJJ,VEL(500),FREQCY(500)
      COMMON /IO12/TITLE(11)
      DATA VELO/1HV,1HE,1HL,1HO,1HC,1HI,1HT,1HY/
      IF (JJJ .GT. 500) JJJ=500
      VMAX=-1.0E+10
      DO 2000 J=1,JJJ
      IF (VEL(J) .GT. VMAX) VMAX=VEL(J)
 2000 CONTINUE
      IF (VMAX .GT. .015) GO TO 2222
      WRITE (6,2020)
 2020 FORMAT (///5X,46HSPECTRUM NOT PLOTTED DUE TO LOW RESPONSE LEVEL//)
      RETURN
 2222 DO 3000 J=1,7020
 3000 GRID(J,1)=1H
      ONE=1.0-FLOAT(IFIX(ALOG10(0.48*VMAX)))
      IF (ONE .LT. -1.5) ONE=-1.0
      TWO=0.0
      IF (FREQCY(1) .LT. 1.0) TWO=1.0
      DO 3003 K=1,JJJ
      I=55-IFIX(23.0*(ALOG10(VEL(K))+ONE)+0.499)
      J=IFIX(40.0*(ALOG10(FREQCY(K))+TWO)+0.499)-11
      IF (I.GE.1.AND.I.LE.54 .AND. J.GE.1.AND.J.LE.130) GRID(I,J)=1HX
 3003 CONTINUE
      DO 3005 I=1,8
 3005 GRID(I+17,3)=VELO(I)
      GRID(32,1)=1H+
      GRID(32,2)=1H1
      GRID( 9,1)=1H+
      GRID( 9,2)=1H1
      GRID( 9,3)=1H0
      GRID( 2,1)=1H*
      GRID(11,1)=1H*
      GRID(14,1)=1H*
      GRID(18,1)=1H*
      GRID(25,1)=1H*
      GRID(34,1)=1H*
      GRID(37,1)=1H*
      GRID(41,1)=1H*
      GRID(48,1)=1H*
      GRID(54,2)=1H/
      GRID(53,3)=1H.
      GRID(53,4)=1H1
      IF (ONE .LT. 1.5) GO TO 3008
      GRID(2,130)=1H+
      GRID(32,2)=1H.
      GRID(32,3)=1H1
      GRID( 9,3)=1H.
      GRID(53,4)=1H0
      GRID(53,5)=1H1
 3008 IF (ONE .GT. 0.5) GO TO 3010
      GRID(32,3)=1H0
      GRID( 9,4)=1H0
      GRID(53,3)=1H1
```

```
      GRID(53,4)=1H.
      IF (ONE .GT. -0.5) GO TO 3010
      GRID(32,4)=1H0
      GRID( 9,5)=1H0
      GRID(53,4)=1H0
 3010 WRITE (6,3012) TITLE,LT
 3012 FORMAT (1H1,24X,11A6,17X,A4,9H RESPONSE)
      WRITE (6,3016) ((GRID(I,J),J=1,130),I=2,54)
 3016 FORMAT (2X,130A1)
      WRITE (6,3019)
 3019 FORMAT (2X,1H+,11X,1H*,6X,1H*,4X,1H*,3X,1H+,11X,1H*,11X,1H*,6X,
     2 1H*,4X,1H*,3X,1H+,11X,1H*,11X,1H*,6X,1H*,4X,1H*,3X,1H+,11X,1H*)
      IF (TWO .GT. 0.5) WRITE (6,3021)
      IF (TWO .LE. 0.5) WRITE (6,3024)
 3021 FORMAT (1X,2H.2,26X,3H1.0,14X,8HFREQ.CPS,14X,4H10.0,35X,5H100.0)
 3024 FORMAT (1X,2H2.,26X,3H10.,14X,8HFREQ.CPS,14X,4H100.,35X,5H1000.)
      WRITE (6,330)
  330 FORMAT (1H1)
      RETURN
      END
```

```
      OVERLAY (ISICP,5,0)
      PROGRAM SYNSOL
      COMMON /OPTION/IOP,IPLT,IL
      COMMON /WSL/NPS(4),TYME(4)
      COMMON /NSN/NAN,NBN,MAX
      COMMON /ARRY/NCASE
      COMMON X(2000),Y(2000),T(2000),YY(2000),NPT(4),TM(4),FACTOR(4)
      DIMENSION FMT1(3),FMT2(3),ID(12)
      DATA FMT1/10H(2X,9F12.3,10H,5X,4HNO. ,10HI1,1H-,I3)/
      DATA FMT2/10H(9F8.2, 1X,10H,2HA ,I1,1,10HH-,I3)    /
      DATA GRAV,DELTA/386.4,1.0E-05/
      DATA ID/12*6H      /
C
C     SYNSOL VERSION 4.0  NOV. 1972
C
C     THIS PROGRAM WILL MODIFY THE TIME-ACCEL. HISTORY OF THE WAVSYN PROGRAM,
C     SUCH THAT THE SECOND, AND/OR THIRD TIME-ACCELERATION HISTORIES OF THE
C     WAVSYN OUTPUT WILL HAVE THE SAME TIME INCREMENT STEPS AS THE FIRST CASE.
C
C     THIS PROGRAM ALSO LIMITS THE OUTPUT TO MAX. OF 500 POINTS (OR LESS) AS
C     REQUIRED BY ISOL INPUT FORMAT.
C     HOWEVER, THE FIRST TIME-ACCEL. HISTORY INPUT IS LIMITED TO 1000 POINTS OR
C     LESS.  THE REMAINING TIME-ACCEL. HISTORY INPUTS ARE NOT LIMITED.
C
C     THE TIME DURATIONS OF THE ORIGINAL TIME-ACCEL. HISTORIES MAY BE LENGTHENED
C     OR SHORTENED, AUTOMATICALLY BY THIS PROGRAM, SO THAT ALL CASES WILL HAVE
C     IDENTICAL TIME DURATION AND TIME STEPS.
C     NOTE.. TIME TABLE OF THE VERY FIRST SET IS USED AS REFERENCE IN SYNCRON-
C            IZATION PROCESS AMONG OTHER SETS.
C
C     COMPLETE NEW SETS OF TIME-ACCEL. HISTORIES ARE PUNCHED OUT IN FORMAT
C     COMPATIBLE TO ISOL PROGRAM.
C
C     IIP=PUNCH OPTION....  IIP=0 FOR NO PUNCH, AND  =1, FOR PUNCH.
C     IGV=OUTPUT UNIT OPTION ....
C        =0, OUTPUT UNIT SAME AS INPUT UNIT,
C        =1, OUTPUT UNIT WILL BE DEVIDED BY G, 386.4
C        =2, OUTPUT UNIT WILL BE MULTIPLIED BY G, 386.4
C     NST= NO. OF TIME-HISTRORY SETS TO BE COMPUTED.   (CURRENTLY, MAX. OF 4)
C
C     INPUT SEQUENCE.........
C        **** - NO INPUT CARD NEEDED ON AN OVERLAY RUN.
C        1-ST - OPTIONS CARD (IIP,IGV,NST,MAXPTS)                    (4I10)
C        2-ND - NPT(J),TM(J),FACTOR(J) CARD   (J=1,NST)            (I10,2F10.4)
C        3-RD - ALL THE OUTPUT CARDS FROM A WAVSYN RUN (BLANKS INCLUDED).
C
C     NPT(J)= NO. OF POINTS IN J-TH CASE.
C             INPUT A -VE NUMBER FOR REPEATED CASE ON OVERLAY RUN (IOP .GE. 11).
C     TM(J) = TIME DURATION (=TIME SHOWN ON LAST PT. OF TIME TABLE) OF J-TH CASE
C     FACTOR(J)..  TO MODIFY END PRODUCT (I.E. ACCEL.) OF J-TH CASE BY A
C                  CONSTANT FACTOR,  SUCH AS  ONE, SQRT(2), AND ZERO.
C     IF IOP IS .GE. 11 (ON OVERLAY RUN), NO INPUT NEEDED FOR NPT AND TM, AND
C        FACTOR IS SET TO 1.0 IF INPUT VALUE IS .LE. 0.00001.
C        I.E. NST BLANKS CARDS ARE STILL NEEDED IN INPUT DATA.
C
C     THIS PROGRAM USES A6 (OR LARGER) HOLLERITH WORD LENGTH.
C
```

```
C     AN EXAMPLE OF INPUT DECK TO THIS PROGRAM ............
C             1         20         30         40         50         60        COL.
C     .........1.........1.........1.........1.........1.........1......
C             1         0          3        575
C           556     9.2462       1.0
C           557     9.7723      .7077
C             0         0       .7077
C     (THE ENTIRE OUTPUT DECK OF A WAVSYN RUN (BLANK CARDS INCLUDED))
C
C     EXPLANATION .......
C        * THE  0 0 .7077  CARD WILL CAUSE AN EXTRA ACCEL. SET OUTPUT, IDENTICAL
C          TO THE PRECEEDING SET EXCEPT THE NEW SET HAS ITS OWN MULT. FACTOR.
C        * ALSO NOTICE THAT HERE WILL BE 3 SETS OF ACCEL. OUTPUT WHILE THERE
C          ARE ONLY 2 SETS OF ACCEL. TIME HISTRORY INPUT IN THIS EXAMPLE.
C
C     THIS SUBR. USES DISC 13 AS SCRATCH TAPE, AND TIME-ACCEL. HISTORIES ARE
C        HANDLED THROUGH DISC IL WHEN IOP IS SET FOR OVERLAY RUN.
C     READ-IN TABLES IF IOP .GE. 11 AND WAVSYN/NWVSYN  HAS BEEN SKIPPED.
C
C     TWO POSIBLE INPUT TABLE FORMATS  .......  CONTROLLED VIA  NST
C     NST = NO. OF SETS OF INPUT TABLES
C        =+VE, TABLES ARRANGED IN PAIRS (I.E. TIME-ACCEL. PAIRS)
C        =-VE, TABLES ARRANGED IN ONE COMMON TIME BASE AND MULTIP. ACCEL. SETS
C              ALL TABLES IN 9F8.X  FORMAT.
C
C     IFORM = TIME AND ACCEL. OUTPUT FORMAT CONTROL
C           =1, FORMAT IN 9FX.X,   =2 FORMAT IN 7FX.X
C
C     MAXPT = MAX. NO. OF OUTPUT DATA POINTS REQUESTED.
C
      MAXPT=500                                                          13
      IFORM=1                                                            14
C
      K9=9                                                               15
      IF (IFORM .EQ. 2) K9=7                                             16
      K8=K9-1                                                            17
      IF (IOP.LE.10 .OR. NCASE.EQ.2) GO TO 148                           18
      REWIND IL                                                          19
      READ (5,130) NST,(NPS(I),TYME(I),I=1,4)                            20
  130 FORMAT (I5,4(I5,F10.0))                                            21
      IF (NST .LT. 0) GO TO 140                                          22
      DO 138 I=1,NST                                                     23
      READ (5,132)                                                       24
  132 FORMAT (////)                                                      25
      K=NPS(I)                                                           26
      READ (5,134) (T(J),J=1,K)                                          27
  134 FORMAT (9F8.3)                                                     28
      READ (5,132)                                                       29
      READ (5,136) (X(J),J=1,K)                                          30
  136 FORMAT (9F8.3)                                                     31
      WRITE (IL) (T(J),J=1,K)                                            32
  138 WRITE (IL) (X(J),J=1,K)                                            33
      GO TO 146                                                          34
  140 NST=-NST                                                           35
      K=NPS(1)                                                           36
      READ (5,142) (T(J),J=1,K)                                          37
  142 FORMAT (9F8.0)                                                     38
      DO 144 I=1,NST                                                     39
```

```
      READ (5,142) (X(J),J=1,K)
      DO 143 J=1,K
143   X(J)=X(J)*386.4
      WRITE (IL) (T(J),J=1,K)
144   WRITE (IL) (X(J),J=1,K)
146   ENDFILE IL
      REWIND IL
148   IF (IOP-8) 150,155,155
150   WRITE (6,115)
      WRITE (6,100)
      READ (5,9) IIP,IGV,NST,MAXPTS
      IF (MAXPTS .LE. 0) MAXPTS=MAXPT
      MAXPT=MAXPTS
      WRITE (6,109) IIP,IGV,NST,MAXPTS
      GO TO 1
155   REWIND 13
      NST=3
      IF (IOP.GE.16 .AND. IOP.NE.12) IIP=0
      IF (IOP .EQ. 9) IIP=1
      IGV=0
1     IF (IOP.LE.8 .OR. NCASE.EQ.1) WRITE (6,153)
153   FORMAT (///5X,13HEND INPUT TO SYNSOL,///)
      IF (NST .LE. 1) GO TO 127
      GV=1.0
      IF (IGV .EQ. 1) GV=1./GRAV
      IF (IGV .EQ. 2) GV=GRAV
      WRITE (6,105)
      IF (IGV .EQ. 0) WRITE (6,101)
      IF (IGV .EQ. 1) WRITE (6,102)
      IF (IGV .EQ. 2) WRITE (6,103)
      WRITE (6,105)
      IF (IIP .EQ. 0) GO TO 2
      PUNCH 100
      IF (IGV .EQ. 0) PUNCH 101
      IF (IGV .EQ. 1) PUNCH 102
      IF (IGV .EQ. 2) PUNCH 103
2     IF (IOP .GE. 9) GO TO 3
      READ (5,5) (NPT(J),TM(J),FACTOR(J),J=1,NST)
      DO 13 J=1,NST
      IF (ABS(FACTOR(J)) .LT. 1.0E-12) FACTOR(J)=1.0E-12
13    CONTINUE
      GO TO 4
3     NPT(1)=NPS(1)
      TM(1)=TYME(1)
      FACTOR(1)=1.0
      NPT(2)=0
      TM(2)=0.0
      FACTOR(2)=1.0
      NPT(3)=NPS(2)
      TM(3)=TYME(2)
      FACTOR(3)=1.0
4     CONTINUE
5     FORMAT (I10,2F10.4)
      WRITE (6,6) NST
6     FORMAT (//2X,I2,6H CASES)
      WRITE (6,7) (NPT(J),TM(J),FACTOR(J),J=1,NST)
7     FORMAT (3(/5X,12HTIME STEPS =,I5,3X,15HTIME DURATION =,F10.4,5X,
     X        14HMULT. FACTOR =,F9.5))
```

```
      WRITE(6,100)
C     CHECKING MAX. TIME
      XAM=TM(1)
      DO 8 J=2,NST
      IF (TM(J) .GT. XAM) XAM=TM(J)
    8 CONTINUE
    9 FORMAT (4I10)
C     STARTING THE MAIN COMPUTATION LOOP.
      II=0
   10 II=II+1
      IF (II .GT. NST) GO TO 120
      NPTI=NPT(II)
      IF (NPTI .EQ. 0) GO TO 16
      IF (IOP .LE. 8) READ (5,80) (ID(J),J=1,12)
      IF (II .GT. 1) GO TO 30
      WRITE (6,95) II,(ID(J),J=2,12)
      IF (IOP .GE. 9) GO TO 160
      READ (5,92) (T(J),J=1,NPTI)
      READ (5,80) (ID(J),J=1,12)
      READ (5,92) (YY(J),J=1,NPTI)
      GO TO 165
  160 READ (IL) (T(J),J=1,NPTI)
      READ (IL) (YY(J),J=1,NPTI)
  165 MAX=NPTI
C     DOUBLE THE TIME STEPS OF THE FIRST TIME TABLE IN CASE IT IS TOO COURSE,
C     AND LESS THAN 500 POINTS.
      IF (NPTI .GT. 500) GO TO 240
      DO 230 J=2,NST
      IF (NPTI*1.33 .LT. NPT(J)) MAX=NPT(J)
  230 CONTINUE
      IF (MAX .LE. NPTI) GO TO 240
      IM1=NPTI*2
      JM1=NPTI
      DO 235 L=2,NPTI
      I=IM1
      IM1=IM1-1
      J=JM1
      JM1=JM1-1
      T(I)=T(J)
      YY(I)=YY(J)
      T(IM1)=0.5*(T(J)+T(JM1))
      YY(IM1)=0.5*(YY(J)+YY(JM1))
  235 IM1=IM1-1
      T(2)=T(1)
      YY(2)=YY(1)
      T(1)=0.5*T(1)
      YY(1)=0.5*YY(1)
      NPTI=NPTI+NPTI
      GO TO 165
C     TO DTERMIND INITIAL MAX TIME
  240 MAX=NPTI
      A=(T(MAX)-T(MAX-10))*0.1
      B=XAM-T(MAX)
      K=IFIX((B+0.9*A)/A)
      IF (K .LE. 0) GO TO 19
      MM=MAX+1
      MAX=MAX+K
      DO 15 J=MM,MAX
```

```
      YY(J)=0.0
 15   T(J)=T(J-1)+A
C     FOR THE CASE WHERE MAX EXCEEDS MAXPT LIMIT SET BY ISOL.
 19   IF (MAX .LE. MAXPT) GO TO 14
      J=2*MAXPT-MAX
      IF (J .GT. 0) GO TO 11
      WRITE (6,119) MAX
      STOP
 11   L=J+1
      DO 12 I=L,MAX,2
      J=J+1
      T(J)=T(I)
 12   YY(J)=YY(I)
      MAX=MAXPT
 14   WRITE (6,110) MAX
      WRITE (6,105)
      IF (IIP .EQ. 1) PUNCH 110, MAX
C     TO GENERATE A FEW EXTRA TERMS BEYOND MAX. TIME (FOR PUNCH FORMAT PURPOSE).
      MM=MAX+1
      LL=MM+K8
      DO 16 I=MM,LL
      T(I)=T(I-1)+A
      IF (I .GT. MAX) T(I)=T(MAX)
 16   YY(I)=0.0
      IJ=0
      K=0
      DO 17 I=1,MAX,K9
      K=K+1
      L=I+K8
      IF (IFORM .EQ. 1) WRITE (6,65) (T(J),J=I,L),IJ,K
      IF (IFORM .EQ. 2) WRITE (6,86) (T(J),J=I,L),IJ,K
      IF (IIP .NE. 1) GO TO 17
      IF (IFORM .EQ. 1) PUNCH 82, (T(J),J=I,L),IJ,K
      IF (IFORM .EQ. 2) PUNCH 83, (T(J),J=I,L),IJ,K
 17   CONTINUE
      IF (IOP .GE. 10) WRITE (13) (T(J),J=1,MAX)
 18   FCTR=FACTOR(II)*GV
      YMAX=0.
      DO 20 J=1,MAX
      Y(J)=YY(J)*FCTR
      ABSY=ABS(Y(J))
      IF (ABSY .GT. YMAX) YMAX=ABSY
 20   CONTINUE
      FMT1(1)=10H(2X,9F12.5
      IF (YMAX .GT. 10.000) FMT1(1)=10H(2X,9F12.4
      IF (YMAX .GT. 100.00) FMT1(1)=10H(2X,9F12.3
      IF (YMAX .GT. 1000.0) FMT1(1)=10H(2X,9F12.2
      IF (YMAX .GT. 10000.) FMT1(1)=10H(2X,9F12.1
      IF (IFORM .EQ. 2) GO TO 24
      FMT2(1)=10H(9F8.5, 1X
      IF (YMAX .GT. 10.000) FMT2(1)=10H(9F8.4, 1X
      IF (YMAX .GT. 100.00) FMT2(1)=10H(9F8.3, 1X
      IF (YMAX .GT. 1000.0) FMT2(1)=10H(9F8.2, 1X
      IF (YMAX .GT. 10000.) FMT2(1)=10H(9F8.1, 1X
      GO TO 26
 24   FMT2(1)=10H(7F10.6,1X
      IF (YMAX .GT. 10.000) FMT2(1)=10H(7F10.5,1X
      IF (YMAX .GT. 100.00) FMT2(1)=10H(7F10.4,1X
```

```
      IF (YMAX .LE. 1000.0) FMT2(1)=10H(7F10.3,1X                       207
      IF (YMAX .GT. 10000.) FMT2(1)=10H(7F10.2,1X                       208
 20   WRITE (6,95) II,(ID(J),J=2,12)                                    209
      IF (FACTOR(II) .GT. 0.0 .AND. FACTOR(II) .LT. 1.0) WRITE (6,107)  210
     X   FACTOR(II)                                                     211
      DO 21 I=MM,LL                                                     212
 21   Y(I)=0.0                                                          213
      K=0                                                               214
      DO 22 I=1,MAX,KS                                                  215
      K=K+1                                                             216
      L=I+KS                                                            217
      WRITE (6,FMT1) (Y(J),J=I,L),II,K                                  218
      IF (IIP .EQ. 1) PUNCH FMT2, (Y(J),J=I,L),II,K                     219
 22   CONTINUE                                                          220
      IF (IOP .GE. 10) WRITE (13) (Y(J),J=1,MAX)                        221
C     BRANCH OFF HERE FOR PLOTTING IF NEEDED... (TIME(I) VS. ACCEL(YY)),CASE(II)
      GO TO 18                                                          222
 30   IF (IOP .GE. 9) GO TO 31                                          223
      READ (5,92) (X(J),J=1,NPTI)                                       224
      READ (5,80) (ID(J),J=1,12)                                        225
      READ (5,92) (Y(J),J=1,NPTI)                                       226
      GO TO 32                                                          227
 31   READ (IL) (X(J),J=1,NPTI)                                         228
      READ (IL) (Y(J),J=1,NPTI)                                         229
 32   CONTINUE                                                          230
C     CURVE INTERPOLATION STARTS HERE
      IF (NPTI .NE. NPT(1) .OR. ABS(TM(II)-TM(1)) .GT. DELTA .OR.       231
     X   NPTI .GT. MAXPT) GO TO 37                                      232
C     SPECIAL CASE WHERE TIME SCALE IS INDENTICAL AND LESS THAN MAXPT DATA PTS.
      IF (NPTI .GE. MAX) GO TO 34                                       233
      DO 33 J=NPTI,MAX                                                  234
 33   YY(J)=0.0                                                         235
 34   DO 35 J=1,NPTI                                                    236
      IF (ABS((T(J)-X(J))/T(J)) .GT. 0.05) GO TO 37                     237
 35   YY(J)=Y(J)                                                        238
      GO TO 18                                                          239
 37   YY(1)=Y(1)                                                        240
C     CASE WHERE TIME SCALE NOT THE SAME OR ACCEL. INPUT TABLE EXCEEDS MAXPT PTS
      J=1                                                               241
      M=1                                                               242
 40   M=M+1                                                             243
      DO 45 I=J,NPTI                                                    244
      IF (X(I) .GE. T(M)) GO TO 50                                      245
 45   CONTINUE                                                          246
      YY(M)=0.0                                                         247
      GO TO 70                                                          248
 50   J=I                                                               249
      IF (X(J)-T(M) .GT. DELTA) GO TO 55                                250
      YY(M)=Y(J)                                                        251
      GO TO 70                                                          252
 55   IF (J .GT. 2) GO TO 60                                            253
      YY(M)=Y(M)                                                        254
      IF (X(2) .GT. 0.0) YY(M)=Y(1)+Y(2)*(T(M)-X(1))/(X(2)-X(1))        255
      GO TO 70                                                          256
 60   IF (T(M)-X(J-1) .GT. DELTA) GO TO 65                              257
      YY(M)=Y(J-1)                                                      258
      GO TO 70                                                          259
 65   Z=T(M)                                                            260
```

```
      A=Z-X(J-1)
      B=Z-X(J)
      C=X(J-2)-X(J-1)
      D=X(J-2)-X(J)
      E=Z-X(J-2)
      F=X(J-1)-X(J)
      R=Y(J-2)*A*B/(C*D)
      S=Y(J-1)*E*B/(-C*F)
      Q=Y(J)*E*A/(D*F)
      YY(M)=R+S+Q
   70 IF (M-MAX) 40,18,18
   80 FORMAT (//12A6/)
   82 FORMAT (9F8.5,1X,2HT ,I1,1H-,I3)
   83 FORMAT (7F10.6,3X,2HT ,I1,1H-,I3)
   85 FORMAT (2X,9F12.5,5X,4HNO. ,I1,1H-,I3)
   86 FORMAT (2X,7F12.6,5X,4HNO. ,I1,1H-,I3)
   92 FORMAT (9F8.3)
   95 FORMAT (//3X,7HSET NO.,I3,1146,/)
  100 FORMAT (65H ....WAVSYN OUTPUT DECK HAS BEEN MODIFIED BY SYNSOL, RE
     1MOVE FIRST,/7X,44H4 COMMENT CARDS BEFORE USING IN ISOL PROGRAM)
  101 FORMAT (5X,30HOUTPUT UNIT SAME AS INPUT UNIT)
  102 FORMAT (5X,40HOUTPUT UNIT HAS BEEN DEVIDED BY G, 386.4)
  103 FORMAT (5X,43HOUTPUT UNIT HAS BEEN MULTIPLIED BY G, 386.4)
  105 FORMAT (//)
  107 FORMAT (/5X,48HACCEL. OUTPUT HAS BEEN MULTIPLIED BY A FACTOR OF,
     X        F10.4/)
  109 FORMAT (//5X,4I10/)
  110 FORMAT (5X,38HTOTAL NUMBER OF POINTS (=NG IN ISOL) =,I8)
  115 FORMAT (1H1,/)
  119 FORMAT (//5X,43HORIGINAL MAX. POINTS EXCEED 1000 ..... BANG,I10)
  120 CONTINUE
      IF (IIP .EQ. 1) WRITE (6,122)
  122 FORMAT (//5X,27HA DECK OF CARDS WAS PUNCHED)
      IF (IOP .LT. 10) GO TO 127
      ENDFILE 13
      REWIND 13
      REWIND IL
      IF (IOP .NE. 10) GO TO 123
      CALL WVTRAN (X,Y,MAX)
      GO TO 127
  123 K=NST+1
C     TRANSFERRING RESULTS FROM FILE 13 TO FILE IL.
      DO 124 I=1,K
      READ (13) (YY(J),J=1,MAX)
  124 WRITE (IL) (YY(J),J=1,MAX)
      ENDFILE IL
      REWIND IL
      REWIND 13
  127 WRITE (6,410)
  410 FORMAT (/////)
      END
```

```
      SUBROUTINE WVTRAN (T,A,N)
      DIMENSION T(1),A(1)
C
C     THE OUTPUT OF SYNSOL IS REARRANGED TO BE COMPATIBLE TO NASTRAN INPUT
C     FORMAT. (NASTRAN- A GENERAL STRUCTURAL ANALYSIS PROGRAM DEVELOPED BY NASA)
C
C     N = NUMBER OF DATA POINTS
C     M = NUMBER OF EXCITAION FUNCTIONS, TIME TABLE EXCLUDED
C
      M=3
      N2=N+2
      N4=N+4
      IL=13
      REWIND IL
      DO 10 L=N2,N4
      T(L)=1.0E+10
10    A(L)=1.0E+10
      READ (IL) (T(I),I=1,N)
      MM=0
      WVN=WM+WVN
20    MM=MM+1
      READ (IL) (A(I),I=1,N)
      IE=0
      INDY=MM*1000
25    INDX=INDY
      INDY=INDY+1
      IB=IE+1
      IE=IE+4
      WRITE (6,30) WVN,INDX,(T(I),A(I),I=IB,IE),WVN,INDY
30    FORMAT (5X,A4,I4,4(F8.5,F8.4),A4,I4)
      PUNCH 40, WVN,INDX,(T(I),A(I),I=IB,IE),WVN,INDY
40    FORMAT (A4,I4,4(F8.5,F8.4),A4,I4)
      IF (IE .LT. N) GO TO 25
      IF (MM .LT. M) GO TO 20
      REWIND IL
      RETURN
      END
```

```
      OVERLAY (ISICP,6,0)
      PROGRAM ISOLIN
      COMMON /OPTION/IOP,IPLT,IL1,IL2,IL3,IL4,IK
      COMMON /I012/ A(12)
      COMMON /NSN/NM,NI,NO,NO,NE,NF,NG,NH
      COMMON X1450(1450)
C
C     INPUT NOMENCLATURE..........
C     NM       NUMBER OF MASSES INCLUDING THE PLATFORM
C     NI       NUMBER OF ISOLATORS
C     NO1      PUNCH CONTROL. IF 0, SYSTEM PROPERTIES PUNCHED. IF 1, ALL
C              MASSES PUNCHED,  -1, NO PUNCH.
C     NO2      ISOLATOR CONTROL. IF 0, ISOLATOR AT CG. IF 1, ISOLATOR ON
C              PLATFORM SURFACE,IF NEGATIVE ROLLING BALL CONFIGURATION
C     NO3      MOMENT OF INERTIA CONTROL,IF ZERO MOI ARE COMPUTED,
C              IF NOT ZERO MOI READ IN
C     NO4      EFFECTIVE WIDTH, DEPTH, AND HEIGHT CONTROL FOR EQUIPMENTS MOUNTED
C              ON PLATFORM. (FOR MASS MOMENT OF INERTIA COMPUTATION)
C              NO4 = M, THE EFFECTIVE WIDTH, DEPTH, AND HEIGHT, EXCEPT THOSE OF
C                      THE PLATFORM, ARE MULTIPLIED BY A FACTOR OF M/100.
C              NO4 = 100, IF NO INPUT VALUE IS GIVEN.
C
C     ISOLON INPUT SEQUENCE ***
C     1.  ID CARD (NOT NEEDED IN OVERLAY RUN)                    (12A6)
C     2.  NOS. OF MASSES, ISOLATORS, AND CONTROL INDICES         (8I10)
C     3.  MASS INPUT DATA                                        (8F10.2)
C     4.  MASS MOMENT OF INERTIA, IF INDEX NO3 IS .NE. ZERO      (3F10.2)
C     5.  PLATFORM ISOLATOR COORD.                               (8F10.2)
C     6.  FREQ,...,FRICTION DATA (2 CARDS)                       (8F10.2)
C     -   *REPEAT 1 THRU 6 IF APPLICABLE
C     7.  2 BLANK CARDS FOR NORMAL EXIT (NOT NEEDED IN OVERLAY RUN).
C
C       OVERLAY RUN WHEN OPTN IS .GE. 11
C
      IF (IOP .GE. 11) REWIND IK
    1 CONTINUE
C     * READ PLATFORM IDENTIFICATION
      IF (IOP .LE. 10) READ (5,3) (A(I),I=1,12)
    3 FORMAT(12A6)
C     * READ NUMBER OF MASSES AND ISOLATORS,PUNCH CONTROL
      READ (5,6) NM,NI,NO1,NO2,NO3,NO4
    6 FORMAT(8I10)
      IF (NO4 .EQ. 0) NO4=100
      IF=NO4
      IF (NO4 .NE. 100) WRITE (6,5) NO4
    5 FORMAT (///10X,30HEQUIPMENT DIMENSIONS ADJUSTED,,I5,8H PERCENT//)
      WRITE (6,7) (A(I),I=1,12)
    7 FORMAT (////35X,20HPLATFORM NUMBER*****,12A6///)
      NM50=50
      IF (NI .LT. 3) NM50=20
      NI50=50
      IF (NI .LT. 3) NI50=20
      IF (NM.GT.NM50 .OR. NI.GT.NI50) WRITE (6,9) NM50
    9 FORMAT (//5X,37HVIOLATION OF MASS OR SPRING LIMITS OF,I7//)
      IF (IOP .GE. 11) NO1=-1
      IF (NI .LE. 1) GO TO 12
      IF (NI-3) 8,12,10
```

```
    8 CALL ISOL3 (NO1,NO2,NO3)
      GO TO 11
   10 CALL ISOL4 (NO1,NO2,NO3)
   11 IF (IOP .LE. 10) GO TO 1
      ENDFILE IK
      REWIND IK
      GO TO 20
   12 WRITE (6,15)
   15 FORMAT (///21H ERRONEOUS INPUT DATA)
      STOP
   20 CONTINUE
      END
```

```
      SUBROUTINE ISOL2 (NO1,NO2,NO3)                                    1
C
C     ****** TWO SUPPORTS ONLY ******
C
C     PROGRAM TO COMPUTE CG,SUSPENSION LOADS,SPRING RATES,
C     ISOLATOR FREE LENGTHS,ROCKING,BENDING AND TORSION FREQUENCIES,
C     DAMPING CONSTANTS, MOMENTS OF INERTIA
C     X AXIS ALWAYS LONGEST AXIS(WIDTH)
C                                                                     1100
C     INPUT NOMENCLATURE..........
C     NM      NUMBER OF MASSES INCLUDING THE PLATFORM
C     NI      NUMBER OF ISOLATORS
C     NO1     PUNCH CONTROL. IF 0, SYSTEM PROPERTIES PUNCHED. IF 1, ALL
C             MASSES PUNCHED
C     NO2     ISOLATOR CONTROL. IF 0, ISOLATOR AT CG. IF 1, ISOLATOR ON
C             PLATFORM SURFACE,IF NEGATIVE ROLLING BALL CONFIGURATION
C     NO3     MOMENT OF INERTIA CONTROL,IF ZERO MOI ARE COMPUTED,
C             IF NOT ZERO MOI READ IN
C     W(J)    WEIGHT OF EACH MASS (THE FIRST IS ALWAYS THE PLATFORM), LBS
C     X(J)    X COORD OF MASS CG, IN
C     Y(J)    Y COORD OF MASS CG, IN
C     Z(J)    Z COORD OF MASS CG, IN
C     WID(J)  WIDTH OF EACH MASS(ALONG X AXIS), IN
C     DEP(J)  DEPTH OF EACH MASS(ALONG Y AXIS), IN
C     HI(J)   HEIGHT OF EACH MASS(ALONG Z AXIS), IN
C     XI(I)    X COORD OF EACH ISOLATOR ON PLATFORM, IN                 2/71-GC.
C     YI(I)    Y COORD OF EACH ISOLATOR ON PLATFORM, IN                 2/71-GC.
C     FREQ    VERTICAL ISOLATION FREQUENCY, CPS
C     DELZ    VERTICAL DIMENSION FROM PLATFORM BOTTOM TO ISOLATOR PIVOT ON
C             CEILING OR FLOOR FOR EQUILIBRIM CONDITIONS
C     RATOL   ISOLATOR SPRING RATE TOLERANCE (A FRACTIONAL NUMBER).
C     STIFF   PLATFORM AREA MOMENT OF INERTIA ABOUT Y AXIS (THRU PL. CG), IN**4
C     XJ      TORSIONAL STIFFNESS OF PLATFORM AROUND X AXIS,  IN**4
C     ZETA    ISOLATOR DAMPING CONSTANT AS FRACTION OF CRITICAL DAMPING
C     DG      MASS CG SHIFT
C     RADP    SPHERICAL PLATE RADIUS                                   2/71-GC.
C     FRICP   FRICTION COEFFICIENT                                     2/71-GC.
C
      COMMON /OPTION/IOP,IPLT,IL1,IL2,IL3,IL4,IK                        2 *
      COMMON /NSN/NM,NI,NC,ND,NE,NF,NG,NH                               3 *
      COMMON /ID12/A(12)                                                4
      COMMON W(20),X(20),Y(20),Z(20),HI(20),WID(20),DEP(20),            5
     1          XI(20),YI(20),XL(20),YL(20),SIGNX(20),SIGNY(20),R(20),  6
     2          RS(20),RATE(20),XO(20),RATES(20),XOS(20),XX(20),YY(20), 7
     3          ZZ(20),DX(20),DY(20),DZ(20),DAMPS(20),DXS(20),DYS(20),  8
     4          DZS(20)                                                 9
      F4=FLOAT(NF)/100.                                                10 *
    1 CONTINUE                                                         11
    5 FORMAT(8F10.2)                                                   12 *
C     * READ FOR EACH MASS,WEIGHT,XCG,YCG,ZCG,WIDTH,DEPTH,HEIGHT
      DO 6 J=1,NM                                                      13
    6 READ(5,5)W(J),X(J),Y(J),Z(J),WID(J),DEP(J),HI(J)                 14
      DO 166 J=1,NM                                                    15 *
      IF (J .EQ. 1) GO TO 166                                          16 *
      WID(J)=WID(J)*F4                                                 17 *
      DEP(J)=DEP(J)*F4                                                 18 *
      HI(J)=HI(J)*F4                                                   19 *
```

```
  166 CONTINUE                                                          20 *
      IF(NO3)15,17,15                                                   21
C     * READ FOR EACH MASS MOMENTS OF INERTIA
   15 READ(5,2)(XX(J),YY(J),ZZ(J),J=1,NM)                               22
    2 FORMAT(3F10.2)                                                    23 *
   17 CONTINUE                                                          24
C     * READ PLATFORM ISOLATOR COORDINATES
      DO 7 I=1,NI                                                       25
    7 READ(5,5)XI(I),YI(I)                                              26
C     * READ ISOLATION FREQUENCY,PLATFORM BOTTOM TO CEILING HEIGHT,ISOLATOR
C       STIFFNESS, TOLERANCE,PLATFORM AREA MOMENT,TORSIONAL STIFFNESS,ISOLATOR
C       VISCOUS DAMPING RATIO,PLATE RADIUS,ROLLING BALL FRICTION
      READ (5,5) FREQ,DELZ,RATOL,STIFF,XJ,ZETA,FRICP,RADP,DGX,DGY,DGZ   27 *
      IF (DGX.GT..99 .OR. DGY.GT..99 .OR. DGZ.GT..99) WRITE (6,4)       28 *
    4 FORMAT (//5X,25HERROR IN DGX,DGY, AND/OR DGZ//)                   29 *
      NH=0                                                              30 *
      IF (NO2 .LT. 0) NH=1                                              31 *
      IF (RADP .GT. 0.001) NH=-1                                        32 *
      ZERO=0.0                                                          33 *
      WRITE(6,9)                                                        34
    9 FORMAT(////45H      Y AXIS (DEPTH)                                35
     1          /45H      1                                             36
     1          /45H      1                                             37
     1          /45H      1                                             38
     4          /45H      ************************                      39
     7          /45H      *                      *                      40
     5          /45H      *0    PLATFORM         0*                     41
     6          /45H      *      PLAN            *                      42
     8          /45H      ************************--X AXIS (WIDTH) //   ) 43
      WRITE(6,10)                                                       44
   10 FORMAT(///3X44H   Z AXIS (HEIGHT)                                 45
     1        /1X46H     1                                             46
     2        /1X46H     1                                             47
     3        /1X46H    ///                  ///                        48
     4        /1X46H--/--0                    0----/--                  49
     5        /1X46H  1 1                     1    1                    50
     7        /1X46H  1 /                     /  LENGTH+LOAD/RATE       51
     6        /1X46H  1 /                     /    1                    52
     8        /1X46H  1 *0********************0*---/--                  53
     9        /1X46H  1 *                     *                         54
     X        /1X46HDELZ*                CG   *---/---                  55
     1        /1X46H  1 *                     *   1                     56
     2        /1X46H  1 *                     *  ZBAR                   57
     3        /1X46H  1 *    PLATFORM (ELEV)  *   1                     58
     4        /1X50H--/-************************---/----X AXIS (WIDTH)   59
     5        /1X46H    1              1                                60
     5        /1X46H    1              1                                61
     8        /1X46H    /-XBAR---------/                                62
     9        /1X46H    1              1                             )  63
C     * WRITE CONTROL INDICES
      WRITE(6,12)                                                       64
   12 FORMAT(////3X,6X4H  NM,6X4H  NI,6X4H NO1,6X4H NO2,6X4H NO3,/)     65
      WRITE(6,13)NM,NI,NO1,NO2,NO3                                      66
   13 FORMAT(3X,8I10)                                                   67
      DO 771 J=2,NM                                                     68 *
      IF (Z(J).GT.0.0 .AND. Z(J)-HI(1).LT.0.35*HI(J)) WRITE (6,770) J   69 *
      IF (Z(J).LE.0.0 .AND. -Z(J).LT.0.35*HI(J)) WRITE (6,770) J        70 *
  770 FORMAT (/5X,18HIS G.G. OF WT. NO.,I6,33H MEASURED FROM BOTTOM OF P 71 *
```

```
      XLATFORM/)
      IF (W(J) .GT. W(1)) GO TO 772
  771 CONTINUE
      GO TO 774
  772 WRITE (6,773)
  773 FORMAT (///5X,46H*** DOES THE FIRST WEIGHT BELONG TO PLATFORM ***)
  774 CONTINUE
C     * TOTAL WEIGHT
      WTOT=0.
      DO 110 J=1,NM
  110 WTOT=WTOT+W(J)
      WTOTG=WTOT/386.
C     * WEIGHT LIMITS
      WMIN=0.98*W(1)+.90*(WTOT-W(1))
      WMAX=1.02*W(1)+1.1*(WTOT-W(1))
C     * CALCULATE FIRST MOMENTS OF WEIGHTS
      XMOM=0.
      YMOM=0.
      ZMOM=0.
      DO 120 J=1,NM
      XMOM=XMOM+X(J)*W(J)
      YMOM=YMOM+Y(J)*W(J)
  120 ZMOM=ZMOM+Z(J)*W(J)
C     * OVERALL C.G.
      XBAR=XMOM/WTOT
      YBAR=YMOM/WTOT
      ZBAR=ZMOM/WTOT
C     * CENTROID OF ISOLATORS
      SUMXI=0.
      SUMYI=0.
      DO 140 I=1,NI
C     *****
      YI(I)=YBAR
C     *****
      SUMXI=SUMXI+XI(I)
  140 SUMYI=SUMYI+YI(I)
      XBARI=SUMXI/FLOAT(NI)
      YBARI=SUMYI/FLOAT(NI)
C     * ECCENTRICITIES
      EX=XBAR-XBARI
      EY=YBAR-YBARI
C     * FIRST MOMENT OF SHIFTED CG
C     *****
C     * CG SHIFT ( DG   OF PLATFORM LENGTH PLUS DG OF EQUIP LENGTH )
C     *****
      XMOMS=0.
      YMOMS=0.
      ZMOMS=0.
      DO 130 J=1,NM
      XMOMS=XMOMS+W(J)*(X(J)+DGX*WID(J)*SIGN(1.,EX))
      YMOMS=YMOMS+W(J)*(Y(J)+DGY*DEP(J)*SIGN(1.,EY))
  130 ZMOMS=ZMOMS+W(J)*(Z(J)+DGZ*HI(J))
C     * SHIFTED CG LOCATION
      XBARS=XMOMS/WTOT
C     *****
      YBARS=YBAR
C     *****
      ZBARS=ZMOMS/WTOT
```

```
C     * ECCENTRICITIES OF SHIFTED CG
      EXS=XBARS-XBARI
      EYS=YBARS-YBARI
C     * ISOLATOR LOADS
      DO 142 I=1,NI
      XL(I)=ABS(XI(I)-XBARI)
  142 YL(I)=ABS(YI(I)-YBARI)
      SUMXL2=0.
      SUMYL2=0.
      DO 150 I=1,NI
      SUMXL2=SUMXL2+XL(I)**2
      SUMYL2=SUMYL2+YL(I)**2
      SIGNX(I)=SIGN(1.,XI(I)-XBAR)
  150 SIGNY(I)=SIGN(1.,YI(I)-YBAR)
      ON=1./FLOAT(NI)
      DO 160 I=1,NI
  160 R(I)=WTOT*((ON+SIGNX(I)*EX*XL(I)/SUMXL2))
      DO 162 I=1,NI
      SIGNX(I)=SIGN(1.,XI(I)-XBARS)
      SIGNY(I)=SIGN(1.,YI(I)-YBARS)
  162 RS(I)=WTOT*((ON+SIGNX(I)*EXS*XL(I)/SUMXL2))
C     * FREQUENCY CONSTANT          (RATE=R*FCON)
      FCON=(6.28*FREQ)**2/386.4
      FCONI=1./FCON
      FCON1=1./6.28
C     * ISOLATOR RATES
      DO 168 I=1,NI
      RATE(I)=R(I)*FCON
C     * ISOLATOR RATES FOR MAXIMUM COUPLING
  168 RATES(I)=RATE(I)*(1.-SIGNX(I)*RATOL*SIGN(1.,EXS))
      IF (NO2) 170,172,174
  170 HIGH=0.
      HIGHS=0.
      GO TO 202
  172 HIGH=ZBAR
      HIGHS=ZBAR
      GO TO 176
  174 HIGH =HI(1)
      HIGHS=HI(1)
      IF (DELZ .GE. 0.) GO TO 176
      HIGH =0.
      HIGHS=0.
C     * CALC FREE LENGTHS FOR NOMINAL CASE
  176 DO 180 I=1,NI
      XO(I)=DELZ-HIGH-R(I)/RATE(I)
C     * FREE LENGTH FOR SHIFTED CG
  180 XOS(I)=DELZ-HIGHS-RS(I)/RATES(I)
      GO TO 206
  202 DO 204 I=1,NI
      XO(I)=DELZ+R(I)/RATE(I)
  204 XOS(I)=DELZ+RS(I)/RATES(I)
  206 CONTINUE
      DO 207 I=1,NI
      XO(I)=ABS(XO(I))
  207 XOS(I)=ABS(XOS(I))
      IF(NO3)208,209,212
C     * CALC INDIVIDUAL MASS MOMENTS OF INERTIA
C     XX=W/G(A**2+B**2)/12.
```

```
  208 CONTINUE
      DO 210 J=1,NM
      XX(J)=W(J)*(DEP(J)**2+ HI(J)**2)/4630.
      YY(J)=W(J)*(WID(J)**2+ HI(J)**2)/4630.
  210 ZZ(J)=W(J)*(WID(J)**2+DEP(J)**2)/4630.
C     * CALC SYSTEM MASS MOMENT OF INERTIA
C     * CALC TRANSFER DIMENSIONS FOR ORIGINAL SYSTEM C G
  212 CONTINUE
      DO 220 J=1,NM
      DX(J)=(Y(J)-YBAR)**2+(Z(J)-Z3AR)**2
      DY(J)=(X(J)-X3AR)**2+(Z(J)-Z3AR)**2
  220 DZ(J)=(X(J)-X9AR)**2+(Y(J)-YBAR)**2
      XXXS=0.
      YYYS=0.
      ZZZS=0.
      XXXSS=0.
      YYYSS=0.
      ZZZSS=0.
C     * CALC TRANSFER DIMENSIONS FOR SHIFTED C G
      DO 222 J=1,NM
      XJX=(X(J)+DGX*WID(J)*SIGN(1.,EX)-XBARS)**2                    *
      YJY=(Y(J)+DGY*DEP(J)*SIGN(1.,EY)-YBARS)**2                    *
      ZJZ=(Z(J)+DGZ* HI(J)-ZBARS)**2                                *
      DXS(J)=YJY+ZJZ                                                *
      DYS(J)=XJX+ZJZ                                                *
  222 DZS(J)=XJX+YJY                                                *
C     * MOMENTS OF INERTIA AROUND ORIGINAL C G
      DO 230 J=1,NM
      XXXS=XXXS+XX(J)+W(J)/386.*DX(J)
      YYYS=YYYS+YY(J)+W(J)/386.*DY(J)
      ZZZS=ZZZS+ZZ(J)+W(J)/386.*DZ(J)
C     * CALC SYSTEM MASS MOMENTS AROUND SHIFTED SYSTEM CG
      XXXSS=XXXSS+XX(J)+W(J)/386.*DXS(J)
      YYYSS=YYYSS+YY(J)+W(J)/386.*DYS(J)
      ZZZSS=ZZZSS+ZZ(J)+W(J)/386.*DZS(J)
  230 CONTINUE
C     * CALC IXX AROUND  CEILING SUPPORTS
      XCEIL=XXXSS+WTOTG*(DELZ-ZBARS)**2
C     * CALC IYY AROUND CEILING SUPPORTS
      YCEIL=YYYSS+WTOTG*(DELZ-ZBARS)**2
C     * CALC IXX AROUND PLATFORM SUPPORTS
      XPLAT=XXXSS+WTOTG*(HI(1)-ZBARS)**2
C     * CALC MASS MOMENT OF INERTIA AROUND X AXIS THRU PLATFORM CENTER FOR
C       TORSIONAL FREQUENCY
      DL=(ZBAR-HI(1)/2.)**2+(YBAR-DEP(1)/2.)**2
      XXXX=XXXS+WTOT/386.*DL
C     * CALC EQUIVALENT MASS MOMENT HEIGHT
      HE=SQRT(XXXX*386./WTOT)
C     * CALC ROCKING FREQUENCY AROUND Y AXIS
      TORQY=0
      DO 242 I=1,NI
  242 TORQY=TORQY+(XI(I)-XBAR )**2*RATES(I)
      FREQY=FCON1*SQRT(TORQY/YYYSS)
      SUMKS=0.
      SUMXIR=0.
      SXR2=0.
      DO 244 I=1,NI
      SUMKS=SUMKS+RATES(I)
```

```
      SUMXIR=SUMXIR+(XI(I)-XBARS)*RATES(I)
  244 SXR2=SXR2+(XI(I)-XBARS)**2*RATES(I)
      ACON=SUMKS/WTOTG
      BCONX=SUMXIR/WTOTG
      CCONX=1./YYYSS*SXR2
      RY2=YYYSS/WTOTG
C     * CALC COUPLED (ROCKING PLUS VERTICAL) FREQUENCIES
      FREQY1=FCON1*SQRT((ACON+CCONX)/2.-SQRT((ACON-CCONX)**2/4.+
     1       BCONX**2/RY2))
      FREQY2=FCON1*SQRT((ACON+CCONX)/2.+SQRT((ACON-CCONX)**2/4.+
     1       BCONX**2/RY2))
      FREQY1=0.
      FREQY2=0.
      FREQY3=0.
      FREQZ =0.
      FCEIL =0.
      FPLAT =0.
      FCOMP =0.
      IF (DELZ .LE. 0.) GO TO 2468
C     * CALC PENDULUM FREQ AROUND CEILING SUPPORTS
      FCEIL=FCON1*SQRT(WTOT*(DELZ-ZBARS)/XCEIL)
C     * CALC PENDULUM FREQ AROUND PLATFORM SUPPORTS
      FPLAT=FCON1*SQRT(WTOT*(HI(1)-ZBARS)/XPLAT)
C     * CALC COMPOUND PLATFORM FREQ AROUND SYSTEM CG
      SL1=HI(1)-ZBARS
      SL2=DELZ-HI(1)
      FCOMP=FCON1*SQRT(WTOT*SL1/XXXSS*(1.+SL1/SL2))
C     * CALC PENDULUM FREQ AROUND CEIL Y AXIS IN CPS
      FREQY3=FCON1*SQRT(WTOT*(XOS(1)+RS(1)/RATES(1))/YCEIL)
C     * CALC PENDULUM TORSIONAL FREQ IN CPS
      SUMWR2=0.
      DO 262 I=1,NI
  262 SUMWR2=RS(I)*((XBARI  -XI(I))**2+(YBARI  -YI(I))**2)
      DTOR=XOS(1)+RS(1)/RATES(1)
      TORQZ=SUMWR2/DTOR
      FREQZ=FCON1*SQRT(TORQZ/ZZZSS)
 2468 CONTINUE
C     * CALC TORSIONAL FREQ FOR UNIFORM MASS DISTRIBUTION AROUND X-X AXIS
      FTOR=1600.*SQRT(XJ/WID(1)/XXXX)
C     * CALC BENDING FREQ, FIRST MODE AROUND Y-Y AXIS
      FBEND=3.85E05*SQRT(STIFF/WTOT/WID(1)**3)
C     * CALC ISOLATOR DAMPING CONSTANTS
      ZETAF=ZETA*FREQ*.0326
      DO 270 I=1,NI
      DAMPS(I)=ZETAF*RS(I)
  270 CONTINUE
C     * CALC POINTS OF INTEREST
      PEX1= 0.
      PEX2=X(1)-WID(1)/2.
      PEX3=X(1)+WID(1)/2.
      PEX4=PEX2
      PEY1= 0.
      PEY2=Y(1)-DEP(1)/2.
      PEY3=Y(1)+DEP(1)/2.
      PEY4=PEY3
      PEZ1=ZBAR
      PEZ2=0.
      PEZ3=0.
```

```
      PEZ4=2.*ZBAR                                                      258
      DELZC=DELZ                                                        259 *
      IF (NO2 .LT. 0) DELZC=-DELZ                                       260 *
      IF (IOP .GE. 11) GO TO 333                                        261 *
C     NO CARDS ARE PUNCHED IF IOP IS .GE. 11                          2/71-GC.
C     * PUNCH TITLE
      IF (NO1 .GE. 0) PUNCH 272,(A(I),I=1,12)                           262 *
  272 FORMAT(1X,12A6)                                                   263
C     * PUNCH WEIGHTS,COORDS AND MOMENTS OF INERTIA        *** GROUP 3 ISOL INPUT
      IF(NO1)335,274,276                                                264 *
C     * PUNCH SYSTEM PROPERTIES FOR SINGLE MASS INPUT TO ISOL
  274 PUNCH 290,WTOT,XBARS,YBARS,ZBARS,XXXSS,YYYSS,ZZZSS                265
      GO TO 292                                                         266
  276 DO 280 J=1,NM                                                     267
  280 PUNCH 290,W(J),X(J),Y(J),Z(J),XX(J),YY(J),ZZ(J)                   268
  290 FORMAT(1F8.0,3F8.2,3F8.0)                                         269
  292 CONTINUE                                                          270
C     * PUNCH ISOLATOR COORDS                              *** GROUP 4 ISOL INPUT
  298 DO 300 I=1,NI                                                     271
  300 PUNCH 310,XI(I),YI(I),HIGHS,XI(I),YI(I),DELZC                     272
      IF(NO2)302,304,304                                                273
C     * PUNCH SPERICAL PLATE DATA                          *** GROUP 6 ISOL INPUT
  302 DO 303 I=1,NI                                                     274
  303 PUNCH 307, XI(I), YI(I), DELZC, RADP, FRICP                       275
C     * PUNCH POINTS OF INTEREST (LOWER CORNERS OF PLATFORM) ** GRP 7 ISOL INPUT
  304 PUNCH 305,PEX1,PEY1,PEZ1,PEX2,PEY2,PEZ2,PEX3,PEY3,PEZ3,           276
     1          PEX4,PEY4,PEZ4                                          277
  305 FORMAT(3F8.2)                                                     278
  307 FORMAT(5F8.2)                                                     279
  310 FORMAT(6F8.2)                                                     280
C     * PUNCH ISOLATOR CONTROL CHARACTERS,FREE LENGTH,RATE AND DAMPING COEF
      P=0.                                                              281
C     ***                                                 *** GROUP 8 ISOL INPUT
      DO 320 I=1,NI                                                     282
  320 PUNCH 330,P,P,XOS(I),RATES(I),DAMPS(I)                            283
  330 FORMAT(2I4,3F8.2)                                                 284
      GO TO 335                                                         285 *
C     THE FOLLOWING CARDS, UP TO STATEMENT 335, ARE ADDED FOR OVERLAY RUN.
  333 IF (NO1) 1274,1274,1276                                           286 *
 1274 WRITE (IK)WTOT,XBARS,YBARS,ZBARS,XXXSS,YYYSS,ZZZSS,ZERO,ZERO,ZERO 287 *
      GO TO 1292                                                        288 *
 1276 DO 1280 J=1,NM                                                    289 *
 1280 WRITE (IK) W(J),X(J),Y(J),Z(J),XX(J),YY(J),ZZ(J),ZERO,ZERO,ZERO   290 *
 1292 DO 1300 I=1,NI                                                    291 *
 1300 WRITE (IK) XI(I),YI(I),HIGHS,XI(I),YI(I),DELZC                    292 *
      IF (NO2) 1302,1304,1304                                           293 *
 1302 DO 1303 I=1,NI                                                    294 *
 1303 WRITE (IK) XI(I),YI(I),DELZC,RADP,FRICP                           295 *
 1304 NE=4                                                              296 *
      WRITE (IK) PEX1,PEY1,PEZ1                                         297 *
      WRITE (IK) PEX2,PEY2,PEZ2                                         298 *
      WRITE (IK) PEX3,PEY3,PEZ3                                         299 *
      WRITE (IK) PEX4,PEY4,PEZ4                                         300 *
      P=0.                                                              301 *
      DO 1320 I=1,NI                                                    302 *
 1320 WRITE (IK) P,P,XOS(I),RATES(I),DAMPS(I)                           303 *
  335 CONTINUE                                                          304 *
C     * WRITE OUTPUT
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      WRITE(6,340)
  340 FORMAT(///9X4HMASS 4X6HWEIGHT 7X3HXCG 7X3HYCG 7X3HZCG 5X5HWIDTH
     1        5X5HDEPTH 4X6HHEIGHT 7X3HIXX 7X3HIYY 7X3HIZZ)
C     * WRITE MASS NUMBER,WEIGHT,XCG,YCG,ZCG,WIDTH,DEPTH,HEIGHT,IXX,IYY,IZZ
      DO 350 J=1,NM
  350 WRITE(6,360)J,W(J),X(J),Y(J),Z(J),WID(J),DEP(J),HI(J),XX(J),YY(J)
     1            ,ZZ(J)
  360 FORMAT(  3X,I10,   10F10.1)
      WRITE(6,370)
  370 FORMAT(////3X 2X5HISOLATOR 3X7HX COORD 3X7HY COORD 6X4HLOAD
     1        6X4HRATE   4X6HLENGTH 3X7HLOAD(S) 3X7HRATE(S) 3X7HLENG(S)
     2        3X7HDAMP(S) 5X5HSIGNX 5X5HSIGNY)
C     * WRITE ISOLATOR NUMBER,COORDINATES,LOAD,RATE,FREE LENGTH,SHIFTED LOAD
C       RATE,LENGTH,DAMPING COEF,LOAD INCREMENT SIGNS
      DO 330 I=1,NI
      SIGNX(I)=SIGNX(I)*SIGN(1.,EX )
      SIGNY(I)=SIGNY(I)*SIGN(1.,EY )
  390 WRITE(6,390)I,XI(I),YI(I),R(I),RATE(I),XO(I),RS(I),RATES(I),XOS(I)
     1            ,DAMPS(I),SIGNX(I),SIGNY(I)
  390 FORMAT(3X,I10,  11F10.1)
      WRITE (6,392)
  392 FORMAT (///5X,19HEND INPUT TO ISOLIN,///)
C     * WRITE SYSTEM WEIGHT,MINIMUM WT,MAX WEIGHT,VERTICAL SUSPENSION FREQ,
C       PLATFORM BOTTOM TO CEILING HEIGHT,PLATFORM AREA MOMENT,TORSIONAL
C       CONSTANT,DAMPING RATIO,PLATE RADIUS, ROLLING BALL FRICTION
      WRITE(6,400) WTOT, WMIN, WMAX
  400 FORMAT(////2X,6X4HWTOT 6X4HWMIN 6X4HWMAX/2X,3F10.0)
      WRITE (6,402) FREQ,DELZ,RATOL,STIFF,XJ,ZETA,DGX,DGY,DGZ,HIGHS,RADP
     X              ,FRICP
  402 FORMAT(////2X,6X4HFREQ 6X4HDELZ 5X5HRATOL 7X3HIXX 2X8HJ(IN**4)
     1 6X,4HZETA 7X3HDGX  7X3HDGY  7X3HDGZ  5X5HHIGHS 6X4HRADP  5X,
     2 5HFRICP,/2X,3F10.2,2F10.0,7F10.2)
C     * WRITE SYSTEM XCG,YCG,ZCG,SHIFTED XCG,YCG,ZCG,ISOLATOR CENTROID COORDS,
C       * AND Y ECCENTRICITIES,SHIFTED ECCENTRICITIES
      WRITE(6,410)XBAR,YBAR,ZBAR,XBARS,YBARS,ZBARS,XBARI,YBARI,EX,EY,
     1            EXS,EYS
  410 FORMAT(////3X,6X4HXBAR 6X4HYBAR 6X4HZBAR 5X5HXBARS 5X5HYBARS
     1        5X5HZBARS 5X5HXBARI 5X5HYBARI 8X2HEX 8X2HEY 7X3HEXS
     1        7X3HEYS/3X,12F10.1)
C     * WRITE SYSTEM IXX,IXXS,IYY,IYYS,IZZ,IZZS,IXX THRU PLATFORM CG,EQUIV HT,
C       IXX AROUND CEILING,IXX AROUND PLATFORM SUPPORTS,IYY AROUND CEILING
C       SUPPORTS
      WRITE(6,240)XXXS,XXXSS,YYYS,YYYSS,ZZZS,ZZZSS,XXXX,HE,XCEIL,XPLAT,
     1XCEIL
  240 FORMAT(//54H    IXX OF COMBINED EQUIP AND PLATFORM THRU SYSTEM CG
     2,F8.0///,54H    IXX OF COMBINED EQUIP AND PLATFORM THRU SHIFTED CG
     2,F8.0///,54H    IYY OF COMBINED EQUIP AND PLATFORM THRU SYSTEM CG
     2,F8.0///,54H    IYY OF COMBINED EQUIP AND PLATFORM THRU SHIFTED CG
     4,F8.0///,54H    IZZ OF COMBINED EQUIP AND PLATFORM THRU SYSTEM CG
     2,F8.0///,54H    IZZ OF COMBINED EQUIP AND PLATFORM THRU SHIFTED CG
     6,F8.0///,54H    IXX OF EQUIP AND PLATFORM THRU PLATFORM CG
     8,F8.0///,54H    MASS MOMENT EQUIVALENT HEIGHT
     A,F8.0///,54H    IXX OF EQUP AND PLATFORM AROUND CEILING SUPPORTS
     C,F8.0///,54H    IXX OF EQUP AND PLATFORM AROUND PLATFORM SUPPORTS
     A,F8.0///,54H    IYY OF EQUP AND PLATFORM AROUND CEILING SUPPORTS
     D     , F8.0///
C     * WRITE UNCOUPLED ROCKING FREQUENCY,2 COUPLED ROCKING FREQUENCIES,
C       THREE PENDULUM FREQUENCIES AROUND X AXIS,TORSIONAL PENDULUM FREQ
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      WRITE(6,250)FREQY,                        FREQY1,FREQY2,FCEIL,FPLAT,
     1            FCOMP,FREQZ
  250 FORMAT(/3X,44H UNCOUPLED ROCKING FREQ AROUND Y AXIS IN CPS,F8.2///
     4         3X,44H FIRST  COUPLED FREQ AROUND Y AXIS IN CPS    ,F8.2///
     5         3X,44H SECOND COUPLED FREQ AROUND Y AXIS IN CPS    ,F8.2///
     6         3X,44H PENDULUM FREQ AROUND CEIL  X AXIS IN CPS    ,F8.2///
     7         3X,44H PENDULUM FREQ AROUND PLATFORM SUPPORTS      ,F8.2///
     8         3X,44H COMPOUND PENDULUM FREQ  IN CPS              ,F8.2///
     9         3X,44H TORSIONAL PENDULUM FREQUENCY IN CPS         ,F8.2//)
C     * WRITE TORSIONAL AND BENDING FREQUENCIES
      WRITE(6,260)FTOR,FBEND
  260 FORMAT (/3X,36H FIRST MODE TORSIONAL FREQUENCY, CPS ,F15.2///
     1          3X,36H FIRST MODE BENDING FREQUENCY, CPS   ,F15.2///)
C     * WRITEOUT ALL PUNCH OUTPUT CARDS FOR ISOL INPUT
      WRITE(6,494)
  494 FORMAT (1H1,///23X,39HPRINT PUNCH OUTPUT CARDS FOR ISOL INPUT///)
C     * WRITE PLATFORM IDENTIFICATION
      WRITE(6,495)(A(I),I=1,12)
  495 FORMAT(1X,12A6)
C     * WRITE COORDINATES AND INERTIA DATA OF MASSES
      IF(NO1)500,500,520
  500 WRITE(6,510)WTOT,XBARS,YBARS,ZBARS,XXXSS,YYYSS,ZZZSS
  510 FORMAT (////7X,4HWTOT,3X,5HXBARS,3X,5HYBARS,3X,5HZBARS,3X,4HIXXS,
     1        4X,4HIYYS,4X,4HIZZS,24X,1HJ,//3X,F8.0,3F8.2,3F8.0,23X,1H1)
      NM=1
      GO TO 555
  520 WRITE(6,530)
  530 FORMAT(///3X,2X6HWEIGHT,5X3HXCG,5X3HYCG,5X3HZCG,5X3HIXX,5X3HIYY,
     1            5X3HIZZ,4X4HMASS/)
      DO 540 J=1,NM
  540 WRITE(6,550)W(J),X(J),Y(J),Z(J),XX(J),YY(J),ZZ(J),J
  550 FORMAT(3X,1F8.0,3F8.2,3F8.0,16X,I8)
  555 CONTINUE
C     * COORDINATES OF ISOLATORS
      WRITE(6,560)
  560 FORMAT(///3X,3X5HXA(I),3X5HYA(I),3X5HZA(I),3X5HXB(I),3X5HYB(I),
     1            3X5HZB(I),24X8HISOLATOR/)
      DO 570 I=1,NI
  570 WRITE(6,580)XI(I),YI(I),HIGHS,XI(I),YI(I),DELZC,I
  580 FORMAT(3X,6F8.2,24X,I8)
C     * DATA FOR SPHERICAL PLATES
      IF(NO2)582,588,588
  582 WRITE(6,583)
  583 FORMAT(///3X,2X6HXBO(I),2X6HYBO(I),2X6HZBO(I),4X4HR(I),3X5HMU(I),
     1          32X8HISOLATOR/)
      DO 584 I=1,NI
  584 WRITE(6,586)XI(I),YI(I),DELZC,RADP,FRICP,I
  586 FORMAT(3X,5F8.2,32X,I8)
C     * WRITE POINTS OF INTEREST
  588 WRITE(6,590)
  590 FORMAT(///3X,3X5HXP(I),3X5HYP(I),3X5HZP(I),48X,2X6HPOINTS/)
      WRITE(6,600)PEX1,PEY1,PEZ1,PEX2,PEY2,PEZ2,PEX3,PEY3,PEZ3,
     1            PEX4,PEY4,PEZ4
  600 FORMAT(3X,3F8.2)
C     * WRITE ISOLATOR CONTROL CHARACTERS,FREE LENGTH,RATE AND DAMPING COEFF.
      NX=0
      NY=0
      WRITE(6,610)
```

```
610 FORMAT(////,3X5HNX(I),3X5HNY(I),3X5HSL(I),3X5HSK(I),3X5HDA(I),
   1            32X8HISOLATOR/)
    DO 620 I=1,NI
620 WRITE(6,630)NX,NY,XOS(I),RATES(I),DAMPS(I),I
630 FORMAT(3X,5F8.2,32X,I8)
    RETURN
    END
```

```
      SUBROUTINE ISOL4 (NO1,NO2,NO3)
      COMMON /OPTION/IOP,IPLT,IL1,IL2,IL3,IL4,IK
      COMMON /NSN/NM,NI,NC,ND,NE,NF,NG,NH
      COMMON /ID12/A(12)
C
C     ****** FOUR OR MORE SUPPORTS ******
C
C     PROGRAM TO COMPUTE CG,SUSPENZION LOADS,SPRINS RATES,
C     ISOLATOR FREE LENGTHS,ROCKING,BENDING AND TORSION FREQUENCIES,
C     DAMPING CONSTANTS, MOMENTS OF INERTIA
C     X AXIS ALWAYS LONGEST AXIS(WIDTH)
C
C     INPUT NOMENCLATURE IDENTICAL TO ISOL2
C
      COMMON W(50),X(50),Y(50),Z(50),HI(50),WID(50),DEP(50),
     1          XI(50),YI(50),XL(50),YL(50),SIGNX(50),SIGNY(50),R(50),
     2          RS(50),RATE(50),XO(50),RATES(50),XOS(50),XX(50),YY(50),
     3          ZZ(50),DX(50),DY(50),DZ(50),DAMPS(50),DXS(50),DYS(50),
     4          DZS(50),ALB(50)
C     ALL ARRAYS, EXCEPT A, HAVE BEEN INCREASED TO 50 EACH FROM ORIG. 20 BY G.C.
      F4=FLOAT(NF)/100.
    1 CONTINUE
    5 FORMAT(8F10.2)
C     * READ FOR EACH MASS,WEIGHT,XCG,YCG,ZCG,WIDTH,DEPTH,HEIGHT
      DO 6 J=1,NM
    6 READ(5,5)W(J),X(J),Y(J),Z(J),WID(J),DEP(J),HI(J)
      DO 166 J=1,NM
      IF (J .EQ. 1) GO TO 166
      IF (WID(J).GT.WID(1) .OR. DEP(J).GT.DEP(1)) WRITE (6,167) J
  167 FORMAT (//5X,10HWEIGHT NO.,I5,17H APPEARS IN ERROR//)
      WID(J)=WID(J)*F4
      DEP(J)=DEP(J)*F4
      HI(J)=HI(J)*F4
  166 CONTINUE
      IF(NO3)15,17,15
C     * READ FOR EACH MASS MOMENTS OF INERTIA
   15 READ(5,2)(XX(J),YY(J),ZZ(J),J=1,NM)
    2 FORMAT(3F10.2)
   17 CONTINUE
C     * READ PLATFORM ISOLATOR COORDINATES
      DO 7 I=1,NI
    7 READ (5,5) XI(I),YI(I),ALB(I)
      IF (XI(I).GT.WID(1) .OR. YI(I).GT.DEP(1)) WRITE (6,8) I
    8 FORMAT (//5X,10HSPRING NO.,I5,17H APPEARS IN ERROR//)
C     * READ ISOLATION FREQUENCY,PLATFORM BOTTOM TO CEILING HEIGHT,ISOLATOR
C       STIFFNESS, TOLERANCE,PLATFORM AREA MOMENT,TORSIONAL STIFFNESS,ISOLATOR
C       VISCOUS DAMPING RATIO,PLATE RADIUS,ROLLING BALL FRICTION
      READ (5,5) FREQ,DELZ,RATOL,STIFF,XJ,ZETA,FRICP,RADP,DGX,DGY,DGZ
      IF (DGX.GT..99 .OR. DGY.GT..99 .OR. DGZ.GT..99) WRITE (6,4)
    4 FORMAT (//5X,28HERROR IN DGX,DGY, AND/OR DGZ//)
      NH=0
      IF (NO2 .LT. 0) NH=1
      IF (RADP .GT. 0.001) NH=-1
      ZERO=0.0
      WRITE(6,3)
    3 FORMAT(////45H      Y AXIS (DEPTH)
     1          /45H      1
```

```
     1          /45H      1
     1          /45H      1
     4          /45H     ************************
     7          /45H     *0                    0*
     5          /45H     *      PLATFORM        *
     6          /45H     *        PLAN          *
     7          /45H     *0                    0*--X AXIS (WIDTH)
     8          /45H     ************************                  //   )
      IF (DELZ .GT. 0.) WRITE (6,10)
   10 FORMAT(///3X44H  Z AXIS (HEIGHT)
     1        /1X46H     1
     2        /1X46H     1
     3        /1X46H    ///                  ///
     4        /1X46H--/--0                    0----/--       ---/--
     5        /1X46H  1  1                    1    1           1
     6        /1X46H  1  /                    /    1           1
     7        /1X46H  1  /                    /  LENGTH+LOAD/RATE
     8        /1X46H  1  /        ***********  /    1 (NO2=0)   1
     9        /1X52H  1  1        *         *  1    1           1 (NO2=1)
     *        /1X46HDELZ 0        *     CG  *  0----/--         1
     1        /1X46H  1  *        *         *  *    1           1
     2        /1X46H  1 ************************  ZBAR     -----/--
     3        /1X46H  1 *      PLATFORM (ELEV)  *   1
     4        /1X50H--/-************************---/----X AXIS (WIDTH)
     5        /1X46H     1              1
     5        /1X46H     1              1
     8        /1X46H     /-XBAR---------/
     5        /1X46H     1              1                                )
      IF (DELZ .LE. 0) WRITE (6,11)
   11 FORMAT(///3X44H  Z AXIS (HEIGHT)
     A        /1X46H     1
     B        /1X46H     1        ***********
     C        /1X46H     1        *         *
     D        /1X46H     1        *     CG  *  -----/--
     E        /1X46H     1        *         *      1
     F        /1X46H    ************************  ZBAR
     G        /1X46H    *      PLATFORM (ELEV)  *   1
     H        /1X52H    *0*********************0* --/------X AXIS (WIDTH)
     I        /1X46H     /              1      /    1
     J        /1X53H     /              1      /  DELZ (=LENGTH-LOAD/RATE)
     K        /1X46H     /-----XBAR-----/      /    1
     L        /1X46H     0              1      0 ---/--
     M        /1X46H   /////                 /////                    )
C     * WRITE CONTROL INDICES
      WRITE(6,12)
   12 FORMAT(////3X,6X4H  NM,6X4H  NI,6X4H NO1,6X4H NO2,6X4H NO3,/)
      WRITE(6,13)NM,NI,NO1,NO2,NO3
   13 FORMAT(3X,8I10)
      DO 771 J=2,NM
      IF (Z(J).GT.0.0 .AND. Z(J)-HI(1).LT.0.35*HI(J)) WRITE (6,770) J
      IF (Z(J).LE.0.0 .AND. -Z(J).LT.0.35*HI(J)) WRITE (6,770) J
  770 FORMAT (/5X,18HIS C.G. OF WT. NO.,I3,33H MEASURED FROM BOTTOM OF P
     XLATFORM/)
      IF (W(J) .GT. W(1)) GO TO 772
  771 CONTINUE
      GO TO 774
  772 WRITE (6,773)
  773 FORMAT (///5X,48H*** DOES THE FIRST WEIGHT BELONG TO PLATFORM ***)
```

```
  774 CONTINUE                                                          98 *
C     * TOTAL WEIGHT
      WTOT=0.                                                           99
      DO 110 J=1,NM                                                    100
  110 WTOT=WTOT+W(J)                                                   101
      IF (WTOT .LT. 0.) STOP 1                                         102 *
      WTOTG=WTOT/386.                                                  103
C     * WEIGHT LIMITS
      WMIN=0.98*W(1)+.90*(WTOT-W(1))                                   104
      WMAX=1.02*W(1)+1.1*(WTOT-W(1))                                   105
C     * CALCULATE FIRST MOMENTS OF WEIGHTS
      XMOM=0.                                                          106
      YMOM=0.                                                          107
      ZMOM=0.                                                          108
      DO 120 J=1,NM                                                    109
      XMOM=XMOM+X(J)*W(J)                                              110
      YMOM=YMOM+Y(J)*W(J)                                              111
  120 ZMOM=ZMOM+Z(J)*W(J)                                              112
C     * OVERALL C.G.
      XBAR=XMOM/WTOT                                                   113
      YBAR=YMOM/WTOT                                                   114
      ZBAR=ZMOM/WTOT                                                   115
C     * CENTROID OF ISOLATORS
      SUMXI=0.                                                         116
      SUMYI=0.                                                         117
      DO 140 I=1,NI                                                    118
      SUMXI=SUMXI+XI(I)                                                119
  140 SUMYI=SUMYI+YI(I)                                                120
      XBARI=SUMXI/FLOAT(NI)                                            121
      YBARI=SUMYI/FLOAT(NI)                                            122
C     * ECCENTRICITIES
      EX=XBAR-XBARI                                                    123
      EY=YBAR-YBARI                                                    124
C     * FIRST MOMENT OF SHIFTED CG
C       CG SHIFT ( DG/2 OF PLATFORM LENGTH PLUS DG OF EQUIP LENGTH )
      XMOMS=W(1)*(X(1)+.5*DGX*WID(1)*SIGN(1.,EX))                      125 *
      YMOMS=W(1)*(Y(1)+.5*DGY*DEP(1)*SIGN(1.,EY))                      126 *
      ZMOMS=W(1)*(Z(1)+.5*DGZ*HI(1))                                   127 *
      IF (NM .EQ. 1) GO TO 135                                         128 *
      DO 130 J=2,NM                                                    129
      XMOMS=XMOMS+W(J)*(X(J)+DGX*WID(J)*SIGN(1.,EX))                   130 *
      YMOMS=YMOMS+W(J)*(Y(J)+DGY*DEP(J)*SIGN(1.,EY))                   131 *
  130 ZMOMS=ZMOMS+W(J)*(Z(J)+DGZ*HI(J))                                132 *
  135 CONTINUE                                                         133 *
C     * SHIFTED CG LOCATION
      XBARS=XMOMS/WTOT                                                 134
      YBARS=YMOMS/WTOT                                                 135
      ZBARS=ZMOMS/WTOT                                                 136
C     * ECCENTRICITIES OF SHIFTED CG
      EXS=XBARS-XBARI                                                  137
      EYS=YBARS-YBARI                                                  138
C     * ISOLATOR LOADS
      DO 142 I=1,NI                                                    139
      XL(I)=ABS(XI(I)-XBARI)                                           140
  142 YL(I)=ABS(YI(I)-YBARI)                                           141
      SUMXL2=0.                                                        142
      SUMYL2=0.                                                        143
      DO 150 I=1,NI                                                    144
```

```
      SUMXL2=SUMXL2+XL(I)**2
      SUMYL2=SUMYL2+YL(I)**2
      SIGNX(I)=SIGN(1.,XI(I)-XBAR)
  150 SIGNY(I)=SIGN(1.,YI(I)-YBAR)
      ON=1./FLOAT(NI)
      DO 160 I=1,NI
  160 R(I)=WTOT*((ON+SIGNX(I)*EX*XL(I)/SUMXL2+SIGNY(I)*EY*YL(I)/SUMYL2))
      DO 162 I=1,NI
      SIGNX(I)=SIGN(1.,XI(I)-XBARS)
      SIGNY(I)=SIGN(1.,YI(I)-YBARS)
  162 RS(I)=WTOT*((ON+SIGNX(I)*EXS*XL(I)/SUMXL2+SIGNY(I)*EYS*YL(I)/SUMYL
     12))
C     * FREQUENCY CONSTANT            (RATE=R*FCON)
      FCON=(6.28*FREQ)**2/386.4
      FCONI=1./FCON
      FCON1=1./6.28
C     * ISOLATOR RATES
      DO 168 I=1,NI
      RATE(I)=R(I)*FCON
C     * ISOLATOR RATES FOR MAXIMUM COUPLING
  168 RATES(I)=RATE(I)*(1.-SIGNX(I)*RATOL*SIGN(1.,EXS))
      IF (NO2) 170,172,174
  170 HIGH=0.
      HIGHS=0.
      GO TO 202
  172 HIGH=ZBAR
      HIGHS=ZBAR
      GO TO 176
  174 HIGH =HI(1)
      HIGHS=HI(1)
      IF (DELZ .GE. 0.) GO TO 176
      HIGH =0.
      HIGHS=0.
C     * CALC FREE LENGTHS FOR NOMINAL CASE
  176 DO 180 I=1,NI
      XO(I)=DELZ-HIGH-R(I)/RATE(I)
C     * FREE LENGTH FOR SHIFTED CG
  180 XOS(I)=DELZ-HIGHS-RS(I)/RATES(I)
      GO TO 206
  202 DO 204 I=1,NI
      XO(I)=DELZ+R(I)/RATE(I)
  204 XOS(I)=DELZ+RS(I)/RATES(I)
  206 CONTINUE
      DO 207 I=1,NI
      XO(I)=ABS(XO(I))+ALB(I)
  207 XOS(I)=ABS(XOS(I))+ALB(I)*SIGN(1.,DELZ)
      IF(NO3)208,208,212
C     * CALC INDIVIDUAL MASS MOMENTS OF INERTIA
C     XX=W/G(A**2+B**2)/12.
  208 CONTINUE
      DO 210 J=1,NM
      XX(J)=W(J)*(DEP(J)**2+ HI(J)**2)/4630.
      YY(J)=W(J)*(WID(J)**2+ HI(J)**2)/4630.
  210 ZZ(J)=W(J)*(WID(J)**2+DEP(J)**2)/4630.
C     * CALC SYSTEM MASS MOMENT OF INERTIA
C     * CALC TRANSFER DIMENSIONS FOR ORIGINAL SYSTEM C G
  212 CONTINUE
      DO 220 J=1,NM
```

```
      DX(J)=(Y(J)-YBAR)**2+(Z(J)-ZBAR)**2
      DY(J)=(X(J)-XBAR)**2+(Z(J)-ZBAR)**2
  220 DZ(J)=(X(J)-XBAR)**2+(Y(J)-YBAR)**2
      XXXS=0.
      YYYS=0.
      ZZZS=0.
      XXXSS=0.
      YYYSS=0.
      ZZZSS=0.
C     * CALC TRANSFER DIMENSIONS FOR SHIFTED C G
      DXS(1)=(Y(1)+.5*DGY*DEP(1)*SIGN(1.,EY)-YBARS)**2
     X        +(Z(1)+.5*DGZ* HI(1)-ZBARS)**2
      DYS(1)=(X(1)+.5*DGX*WID(1)*SIGN(1.,EX)-XBARS)**2
     X        +(Z(1)+.5*DGZ* HI(1)-ZBARS)**2
      DZS(1)=(X(1)+.5*DGX*WID(1)*SIGN(1.,EX)-XBARS)**2
     X        +(Y(1)+.5*DGY*DEP(1)*SIGN(1.,EY)-YBARS)**2
      DO 222 J=2,NM
      XJX=(X(J)+DGX*WID(J)*SIGN(1.,EX)-XBARS)**2
      YJY=(Y(J)+DGY*DEP(J)*SIGN(1.,EY)-YBARS)**2
      ZJZ=(Z(J)+DGZ* HI(J)-ZBARS)**2
      DXS(J)=YJY+ZJZ
      DYS(J)=XJX+ZJZ
  222 DZS(J)=XJX+YJY
C     * MOMENTS OF INERTIA AROUND ORIGINAL C G
      DO 230 J=1,NM
      XXXS=XXXS+XX(J)+W(J)/386.*DX(J)
      YYYS=YYYS+YY(J)+W(J)/386.*DY(J)
      ZZZS=ZZZS+ZZ(J)+W(J)/386.*DZ(J)
C     * CALC SYSTEM MASS MOMENTS AROUND SHIFTED SYSTEM CG
      XXXSS=XXXSS+XX(J)+W(J)/386.*DXS(J)
      YYYSS=YYYSS+YY(J)+W(J)/386.*DYS(J)
      ZZZSS=ZZZSS+ZZ(J)+W(J)/386.*DZS(J)
  230 CONTINUE
C     * CALC IXX AROUND  CEILING SUPPORTS
      XCEIL=XXXSS+WTOTG*(DELZ-ZBARS)**2
C     * CALC IYY AROUND CEILING SUPPORTS
      YCEIL=YYYSS+WTOTG*(DELZ-ZBARS)**2
C     * CALC MASS MOMENT OF INERTIA AROUND X AXIS THRU PLATFORM CENTER FOR
C       TORSIONAL FREQUENCY
      DL=(ZBAR-HI(1)/2.)**2+(YBAR-DEP(1)/2.)**2
      XXXX=XXXS+WTOT/386.*DL
      IF (XXXX .LT. 0.) STOP 2
C     * CALC EQUIVALENT MASS MOMENT HEIGHT
      HE=SQRT(XXXX*386./WTOT)
C     * CALC ROCKING FREQUENCY
      TORQX=0
      TORQY=0
      DO 242 I=1,NI
      TORQX=TORQX+(YI(I)-YBAR )**2*RATES(I)
  242 TORQY=TORQY+(XI(I)-XBAR )**2*RATES(I)
      TQX=TORQX/XXXSS
      TQY=TORQY/YYYSS
      IF (TQX .LT. 0.) TQX=0.
      IF (TQY .LT. 0.) TQY=0.
      FREQX=FCON1*SQRT(TQX)
      FREQY=FCON1*SQRT(TQY)
      SUMKS=0.
      SUMYIR=0.
```

```
      SUMXIR=0.
      SXR2=0.
      SYR2=0.
      DO 244 I=1,NI
      SUMKS=SUMKS+RATES(I)
      SUMYIR=SUMYIR+(YI(I)-YBARS)*RATES(I)
      SUMXIR=SUMXIR+(XI(I)-XBARS)*RATES(I)
      SYR2=SYR2+(YI(I)-YBARS)**2*RATES(I)
  244 SXR2=SXR2+(XI(I)-XBARS)**2*RATES(I)
      ACON=SUMKS/WTOTG
      BCONY=SUMYIR/WTOTG
      BCONX=SUMXIR/WTOTG
      CCONY=1./XXXSS*SYR2
      CCONX=1./YYYSS*SXR2
      RX2=XXXSS/WTOTG
      RY2=YYYSS/WTOTG
C     * CALC COUPLED (ROCKING PLUS VERTICAL) FREQUENCIES
      CKSQRT=(ACON-CCONY)**2/4. + BCONY**2/RX2
      IF (CKSQRT .LT. 0.) CKSQRT=0.
      CKSQ=(ACON+CCONY)/2.-CKSQRT
      IF (CKSQ.LT.0. .OR. CKSQRT.LE.0.) CKSQ=0.
      FREQX1=FCON1*CKSQ
      CKSQ=(ACON+CCONY)/2.+CKSQRT
      IF (CKSQ.LT.0. .OR. CKSQRT.LE.0.) CKSQ=0.
      FREQX2=FCON1*CKSQ
      CKSQRT=(ACON-CCONX)**2/4. + BCONX**2/RY2
      IF (CKSQRT .LT. 0.) CKSQRT=0.
      CKSQ=(ACON+CCONX)/2.-CKSQRT
      IF (CKSQ.LT.0. .OR. CKSQRT.LE.0.) CKSQ=0.
      FREQY1=FCON1*CKSQ
      CKSQ=(ACON+CCONX)/2.+CKSQRT
      IF (CKSQ.LT.0. .OR. CKSQRT.LE.0.) CKSQ=0.
      FREQY2=FCON1*CKSQ
      FREQY3=0.
      FREQY3=0.
      FREQZ =0.
      IF (DELZ .LE. 0.) GO TO 2468
C     * CALC PENDULUM FREQ AROUND CEIL X AXIS IN CPS
      XOSX=(XOS(1)+RS(1)/RATES(1))/XCEIL
      IF (XOSX .LT. 0.) XOSX=0.
      FREQX3=FCON1*SQRT(WTOT*XOSX)
C     * CALC PENDULUM FREQ AROUND CEIL Y AXIS IN CPS
      XOSY=(XOS(1)+RS(1)/RATES(1))/YCEIL
      IF (XOSY .LT. 0.) XOSY=0.
      FREQY3=FCON1*SQRT(WTOT*XOSY)
C     * CALC PENDULUM TORSIONAL FREQ IN CPS
      SUMWR2=0.
      DO 262 I=1,NI
  262 SUMWR2=RS(I)*((XBARI  -XI(I))**2+(YBARI  -YI(I))**2)
      DTOR=XOS(1)+RS(1)/RATES(1)
      TORQZ=SUMWR2/DTOR
      TQZ=TORQZ/ZZZSS
      IF (TQZ .LT. 0.) TQZ=0.
      FREQZ=FCON1*SQRT(TQZ)
 2468 CONTINUE
C     * CALC TORSIONAL FREQ FOR UNIFORM MASS DISTRIBUTION AROUND X-X AXIS
      XJX=XJ/WID(1)/XXXX
      IF (XJX .LT. 0.) XJX=0.
```

```
      FTOP=1600.*SQRT(XJX)                                              296 *
C     * CALC BENDING FREQ, FIRST MODE AROUND Y-Y AXIS
      IF (STIFF/WID(1) .LT. 0.) STOP 3                                  297 *
      FBEND=3.85E05*SQRT(STIFF/WTOT/WID(1)**3)                          298
C     * CALC ISOLATOR DAMPING CONSTANTS
      ZETAF=ZETA*FREQ*.0326                                             299
      DO 270 I=1,NI                                                     300
      DAMPS(I)=ZETAF*WS(I)                                              301
  270 CONTINUE                                                          302
C     * CALC POINTS OF INTEREST
      PEX1= 0.                                                          303
      PEX2=X(1)-WID(1)/2.                                               304
      PEX3=X(1)+WID(1)/2.                                               305
      PEX4=PEX2                                                         306
      PEY1= 0.                                                          307
      PEY2=Y(1)-DEP(1)/2.                                               308
      PEY3=Y(1)+DEP(1)/2.                                               309
      PEY4=PEY3                                                         310
      PEZ1=ZBAR                                                         311
      PEZ2=0.                                                           312
      PEZ3=0.                                                           313
      PEZ4=2.*ZBAR                                                      314
      DELZC=DELZ                                                        315 *
      IF (NO2 .LT. 0) DELZC=-DELZ                                       316 *
      DO 297 I=1,NI                                                     317 *
  297 ALB(I)=DELZC*ALB(I)                                               318 *
      IF (IOP .GE. 11) GO TO 333                                        319 *
C     NO CARDS ARE PUNCHED IF IOP IS .GE. 11                            2771-GC.
C     * PUNCH TITLE
      IF (NO1 .GE. 0) PUNCH 272,(A(I),I=1,12)                           320 *
  272 FORMAT(1X,12A6)                                                   321
C     * PUNCH WEIGHTS,COORDS AND MOMENTS OF INERTIA      *** GROUP 3 ISOL INPUT
      IF(NO1)335,274,276                                                322 *
C     * PUNCH SYSTEM PROPERTIES FOR SINGLE MASS INPUT TO ISOL
  274 PUNCH 290,WTOT,XBARS,YBARS,ZBARS,XXXSS,YYYSS,ZZZSS                323
      GO TO 292                                                         324
  276 DO 280 J=1,NM                                                     325
  280 PUNCH 290,W(J),X(J),Y(J),Z(J),XX(J),YY(J),ZZ(J)                   326
  290 FORMAT(1F8.0,3F8.2,3F8.0)                                         327
  292 CONTINUE                                                          328
      IF(NO2)294,296,296                                                329
  294 DELZC=-DELZ                                                       330
      GO TO 298                                                         331
  296 DELZC=DELZ                                                        332
C     * PUNCH ISOLATOR COORDS                            *** GROUP 4 ISOL INPUT
  298 DO 300 I=1,NI                                                     333
  300 PUNCH 310, XI(I),YI(I),HIGHS,XI(I),YI(I),ALB(I)                   334 *
      IF(NO2)302,304,304                                                335
C     * PUNCH SPERICAL PLATE DATA                         *** GROUP 6 ISOL INPUT
  302 DO 303 I=1,NI                                                     336
  303 PUNCH 307, XI(I), YI(I), DELZC, RADP, FRICP                       337
C     * PUNCH POINTS OF INTEREST (LOWER CORNERS OF PLATFORM) ** GRP 7 ISOL INPUT
  304 PUNCH 305,PEX1,PEY1,PEZ1,PEX2,PEY2,PEZ2,PEX3,PEY3,PEZ3,           338
     1          PEX4,PEY4,PEZ4                                          339
  305 FORMAT(3F8.2)                                                     340
  307 FORMAT(5F8.2)                                                     341
  310 FORMAT(6F8.2)                                                     342
C     * PUNCH ISOLATOR CONTROL CHARACTERS,FREE LENGTH,RATE AND DAMPING COEF
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C     ***                                                    *** GROUP 8 ISOL INPUT
      P=0.
      DO 320 I=1,NI
  320 PUNCH 330,P,P,XOS(I),RATES(I),DAMPS(I)
  330 FORMAT(2I4,3F8.2)
      GO TO 335
C     THE FOLLOWING CARDS, UP TO STATEMENT 335, ARE ADDED FOR OVERLAY RUN.
  333 IF (NO1) 1274,1274,1276
 1274 WRITE (IK)WTOT,XBARS,YBARS,ZBARS,XXXSS,YYYSS,ZZZSS,ZERO,ZERO,ZERO
      GO TO 1292
 1276 DO 1280 J=1,NM
 1280 WRITE (IK) W(J),X(J),Y(J),Z(J),XX(J),YY(J),ZZ(J),ZERO,ZERO,ZERO
 1292 DO 1300 I=1,NI
 1300 WRITE (IK) XI(I),YI(I),HIGHS,XI(I),YI(I),ALB(I)
      IF (NO2) 1302,1304,1304
 1302 DO 1303 I=1,NI
 1303 WRITE (IK) XI(I),YI(I),DELZC,RADP,FRICP
 1304 NE=4
      WRITE (IK) PEX1,PEY1,PEZ1
      WRITE (IK) PEX2,PEY2,PEZ2
      WRITE (IK) PEX3,PEY3,PEZ3
      WRITE (IK) PEX4,PEY4,PEZ4
      P=0.
      DO 1320 I=1,NI
 1320 WRITE (IK) P,P,XOS(I),RATES(I),DAMPS(I)
  335 CONTINUE
C     * WRITE OUTPUT
      WRITE(6,340)
  340 FORMAT(//9X4HMASS 4X6HWEIGHT 7X3HXCG 7X3HYCG 7X3HZCG 5X5HWIDTH
     1       5X5HDEPTH 4X6HHEIGHT 7X3HIXX 7X3HIYY 7X3HIZZ)
C     * WRITE MASS NUMBER,WEIGHT,XCG,YCG,ZCG,WIDTH,DEPTH,HEIGHT,IXX,IYY,IZZ
      DO 350 J=1,NM
  350 WRITE(6,360)J,W(J),X(J),Y(J),Z(J),WID(J),DEP(J),HI(J),XX(J),YY(J)
     1       ,ZZ(J)
  360 FORMAT(  3X,I10,   10F10.1)
      WRITE(6,370)
  370 FORMAT(////3X 2X8HISOLATOR 3X7HX COORD 3X7HY COORD 6X4HLOAD
     1       6X4HRATE   4X6HLENGTH 3X7HLOAD(S) 3X7HRATE(S) 3X7HLENG(S)
     2       3X7HDAMP(S) 5X5HSIGNX 5X5HSIGNY)
C     * WRITE ISOLATOR NUMBER,COORDINATES,LOAD,RATE,FREE LENGTH,SHIFTED LOAD
C       RATE,LENGTH,DAMPING COEF,LOAD INCREMENT SIGNS
      DO 380 I=1,NI
      SIGNX(I)=SIGNX(I)*SIGN(1.,EX )
      SIGNY(I)=SIGNY(I)*SIGN(1.,EY )
  380 WRITE(6,390)I,XI(I),YI(I),R(I),RATE(I),XO(I),RS(I),RATES(I),XOS(I)
     1       ,DAMPS(I),SIGNX(I),SIGNY(I)
  390 FORMAT(3X,I10,  11F10.1)
      WRITE (6,392)
  392 FORMAT (///5X,19HEND INPUT TO ISOLIN,///)
C     * WRITE SYSTEM WEIGHT,MINIMUM WT,MAX WEIGHT,VERTICAL SUSPENSION FREQ,
C       PLATFORM BOTTOM TO CEILING HEIGHT,PLATFORM AREA MOMENT,TORSIONAL
C       CONSTANT,DAMPING RATIO,PLATE RADIUS,ROLLING BALL FRICTION
      WRITE(6,400) WTOT, WMIN, WMAX
  400 FORMAT(////2X,6X4HWTOT 6X4HWMIN 6X4HWMAX/2X,3F10.6)
      WRITE (6,402) FREQ,DELZ,RATOL,STIFF,XJ,ZETA,DGX,DGY,DGZ,HIGHS,RADP
     X       ,FRICP
  402 FORMAT(////2X,6X4HFREQ 6X4HDELZ 5X5HRATOL 7X3HIXX 2X8HJ(IN**4)
     1 6X,4HZETA 7X3HDGX  7X3HDGY  7X3HDGZ  5X5HHIGHS 6X4HRADP  5X,
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    2 5HFRICP,/2X,3F10.2,2F10.0,7F10.2)
C     * WRITE SYSTEM XCG,YCG,ZCG,SHIFTED XCG,YCG,ZCG,ISOLATOR CENTROID COORDS,
C       X AND Y ECCENTRICITIES,SHIFTED ECCENTRICITIES
      WRITE(6,410)XBAR,YBAR,ZBAR,XBARS,YBARS,ZBARS,XBARI,YBARI,EX,EY,
     1            EXS,EYS
  410 FORMAT(////3X,6X4HXBAR 6X4HYBAR 6X4HZBAR 5X5HXBARS 5X5HYBARS
     1        5X5HZBARS 5X5HXBARI 5X5HYBARI 8X2HEX 8X2HEY 7X3HEXS
     1        7X3HEYS/3X,12F10.1)
C     * WRITE SYSTEM IXX,IXXS,IYY,IYYS,IZZ,IZZS,IXX THRU PLATFORM CG,EQUIV HT,
C       IXX AROUND CEILING SUPPORTS,IYY AROUND CEILING SUPPORTS
      WRITE(6,240)XXXS,XXXSS,YYYS,YYYSS,ZZZS,ZZZSS,XXXX,HE,XCEIL,YCEIL
  240 FORMAT(//54H     IXX OF COMBINED EQUIP AND PLATFORM THRU SYSTEM CG
     2,F8.0///,54H     IXX OF COMBINED EQUIP AND PLATFORM THRU SHIFTED CG
     2,F8.0///,54H     IYY OF COMBINED EQUIP AND PLATFORM THRU SYSTEM CG
     2,F8.0///,54H     IYY OF COMBINED EQUIP AND PLATFORM THRU SHIFTED CG
     4,F8.0///,54H     IZZ OF COMBINED EQUIP AND PLATFORM THRU SYSTEM CG
     2,F8.0///,54H     IZZ OF COMBINED EQUIP AND PLATFORM THRU SHIFTED CG
     6,F8.0///,54H     IXX OF EQUIP AND PLATFORM THRU PLATFORM CG
     6,F8.0///,54H     MASS MOMENT EQUIVALENT HEIGHT
     4,F8.0///,54H     IXX OF EQUP AND PLATFORM AROUND CEILING SUPPORTS
     4,F8.0///,54H     IYY OF EQUP AND PLATFORM AROUND CEILING SUPPORTS
     9          ,F8.0///
C     * WRITE UNCOUPLED ROCKING FREQUENCIES,COUPLED ROCKING FREQUENCIES,
C       TWO PENDULUM FREQUENCIES AROUND X AND Y AXIS,TORSIONAL PENDULUM FREQ
      WRITE(6,250)FREQX,FREQY,FREQX1,FREQX2,FREQY1,FREQY2,FREQX3,
     1FREQY3,FREQZ
  250 FORMAT(/3X,44H UNCOUPLED ROCKING FREQ AROUND X AXIS IN CPS,F8.2///
     1        3X,44H UNCOUPLED ROCKING FREQ AROUND Y AXIS IN CPS,F8.2///
     2        3X,44H FIRST  COUPLED FREQ AROUND X AXIS IN CPS   ,F8.2///
     3        3X,44H SECOND COUPLED FREQ AROUND X AXIS IN CPS   ,F8.2///
     4        3X,44H FIRST  COUPLED FREQ AROUND Y AXIS IN CPS   ,F8.2///
     5        3X,44H SECOND COUPLED FREQ AROUND Y AXIS IN CPS   ,F8.2///
     6        3X,44H PENDULUM FREQ AROUND X AXIS IN CPS         ,F8.2///
     8        3X,44H PENDULUM FREQ AROUND Y AXIS IN CPS         ,F8.2///
     6        3X,44H TORSIONAL PENDULUM FREQUENCY IN CPS        ,F8.2//)
C     * WRITE TORSIONAL AND BENDING FREQUENCIES
      WRITE(6,260)FTOR,FBEND
  260 FORMAT (/3X,36H FIRST MODE TORSIONAL FREQUENCY, CPS ,F15.2///
     1         3X,36H FIRST MODE BENDING FREQUENCY, CPS   ,F15.2///)
C     * WRITEOUT ALL PUNCH OUTPUT CARDS FOR ISOL INPUT
      WRITE(6,494)
  494 FORMAT (1H1,///20X,39HPRINT PUNCH OUTPUT CARDS FOR ISOL INPUT///)
C     * WRITE PLATFORM IDENTIFICATION
      WRITE(6,495)(A(I),I=1,12)
  495 FORMAT(1X,12A6)
C     * WRITE COORDINATES AND INERTIA DATA OF MASSES
      IF(NO1)500,500,520
  500 WRITE(6,510)WTOT,XBARS,YBARS,ZBARS,XXXSS,YYYSS,ZZZSS
  510 FORMAT (///7X,4HWTOT,3X,5HXBARS,3X,5HYBARS,3X,5HZBARS,3X,4HIXXS,
     1        4X,4HIYYS,4X,4HIZZS,24X,1HJ,//3X,F8.0,3F8.2,3F8.0,23X,1H1)
      NM=1
      GO TO 555
  520 WRITE(6,530)
  530 FORMAT(///3X,2X6HWEIGHT,5X3HXCG,5X3HYCG,5X3HZCG,5X3HIXX,5X3HIYY,
     1            5X3HIZZ,4X4HMASS/)
      DO 540 J=1,NM
  540 WRITE(6,550)W(J),X(J),Y(J),Z(J),XX(J),YY(J),ZZ(J),J
  550 FORMAT(3X,1F8.0,3F8.2,3F8.0,16X,I8)
```

```
555 CONTINUE
C     * COORDINATES OF ISOLATORS
      WRITE(6,560)
560 FORMAT(///3X,3X5HXA(I),3X5HYA(I),3X5HZA(I),3X5HXB(I),3X5HYB(I),
   1            3X5HZB(I),24X6HISOLATOR/)
      DO 570 I=1,NI
570 WRITE (6,580) XI(I),YI(I),HIGHS,XI(I),YI(I),ALB(I),I
580 FORMAT(3X,6F8.2,24X,I8)
C     * DATA FOR SPHERICAL PLATES
      IF(NO2)582,586,588
582 WRITE(6,583)
583 FORMAT(///3X,2X6HXBO(I),2X6HYBO(I),2X6HZBO(I),4X4HR(I),3X5HMU(I),
   1            32X6HISOLATOR/)
      DO 584 I=1,NI
584 WRITE(6,586)XI(I),YI(I),DELZC,RADP,FRICP,I
586 FORMAT(3X,5F8.2,32X,I8)
C     * WRITE POINTS OF INTEREST
588 WRITE(6,590)
590 FORMAT(///3X,3X5HXP(I),3X5HYP(I),3X5HZP(I),48X,2X6HPOINTS/)
      WRITE(6,600)PEX1,PEY1,PEZ1,PEX2,PEY2,PEZ2,PEX3,PEY3,PEZ3,
   1            PEX4,PEY4,PEZ4
600 FORMAT(3X,3F8.2)
C     * WRITE ISOLATOR CONTROL CHARACTERS,FREE LENGTH,RATE AND DAMPING COEFF.
      NX=0
      NY=0
      WRITE(6,610)
610 FORMAT(///3X,3X5HNX(I),3X5HNY(I),3X5HSL(I),3X5HSK(I),3X5HDA(I),
   1            32X6HISOLATOR/)
      DO 620 I=1,NI
620 WRITE(6,630)NX,NY,XOS(I),RATES(I),DAMPS(I),I
630 FORMAT(3X,5F8.2,32X,I8)
      RETURN
      END
```

```
      OVERLAY (ISICP,11,3)
      PROGRAM FOURIE
      DIMENSION TITLE(12),SSF(25),EEF(25),HHF(25)
      COMMON /BLK2/TS,TE,TH,SF,NS
      COMMON /BLK1/FT(500)    /BLK3/TT(500)
      COMMON F(15000)
C
C     A DIGITAIL COMPUTER PROGRAM FOR EVALUATING A FOURIER SPECTRUM
C
C     THIS PROGRAM REQUIRES 76 OCTAL K STORAGE.
C
C     PROGRAMMED  BY S. K. DIVEGHA/PARSONS.   MODIFIED BY G. CHAN/SPERRY RAND.
C
C     NOMENCLATURE ***
C     NF        NO OF FREQUENCY RANGES
C     IDEL      AN INTEGRATION CONSTANT,  IF ZERO INPUT, IDEL IS SET TO 5
C     SSF       STARTING FREQ IN C.P.S.
C     EEF       END FREQUENCY IN C.P.S.
C     HHF       FREQUENCY INTERVAL IN C.P.S.
C     NS        NO OF POINTS ON SHOCK MOTION AND TIME TABLES
C     TS        STARTING TIME
C     TE        END TIME
C     TH        INTEGRATING TIME INTERVAL
C     TT        TIME TABLE FOR SHOCK MOTION
C     FT        INPUTED SHOCK MOTION TABLE
C     IK        FORCE INPUT UNIT CONTROL,  IK=0 FOR FT IN IN/SEC**2,  =1, IN G
C     LP        REPEAT RUN CONTROL
C     FOUR      FOURIER SPECTRUM
C     NOTE***   IF NF=1, HHF IS THE NO. OF LOGARITH. STEPS BETWEEN SSF AND EEF.
C
C     INPUT SEQUENCE *******
C        1.  NF,IDEL                                  (2I5)
C        2.  SSF,EEF,HHF, (K=1,NF)                    (3F15.8)
C        3.  NS                                       (I5)
C        4.  TS,TE,TH                                 (3F15.8)
C        5.  TT, (J=1,NS)                             (9F8.0)
C        6.  TITLE,LP,IK                              (12A6,2I3)
C        7.  FT, (J=1,NS)                             (9F8.0)
C        *   REPEAT 3 THRU 7 IF LP=+1
C        *   REPEAT 6 THRU 7 IF LP=-1
C        *   NORMAL EXIT IF LP=0
C
      READ (5,100) NF,IDEL
      DO 510 K=1,NF
  510 READ (5,200) SSF(K),EEF(K),HHF(K)
  200 FORMAT (5F15.8)
    1 READ (5,100) NS
      READ (5,200) TS,TE,TH
  100 FORMAT (16I5)
      READ (5,120) (TT(J),J=1,NS)
  120 FORMAT (9F8.0)
  110 FORMAT (12A6,2I3)
    2 READ (5,110) (TITLE(J),J=1,12),LP,IK
      READ (5,120) (FT(J),J=1,NS)
C
      REWIND 11
      XMIN=1.0E+21
```

```
      XMAX=0.0                                                          *
      NPTS=0                                                            *
      IF (IK .EQ. 0) GO TO 190
      DO 191 I=1,NS
  191 FT(I)=FT(I)*386.4
  190 CONTINUE
      WRITE (6,130) (TITLE(I),I=1,12)
  130 FORMAT (1H1,20X,12A6//)
      WRITE (6,140) TS,TE,TH,NS,NF
  140 FORMAT  (20X,10HINPUT DATA,//
     1          20X,30HSTARTING TIME                  =,5X,F12.6//
     2          20X,30HEND TIME                       =,5X,F12.6//
     3          20X,30HINTEGRATING TIME INTERVAL      =,5X,F12.6//
     4          20X,30HNO OF POINTS ON FORCE TABLE    =,10X,I3//
     5          20X,30HNO OF FREQUENCY RANGES         =,10X,I3///
     6          20X,10HTIME TABLE,/)                                     *
      WRITE (6,150) (TT(J),J=1,NS)                                      *
  150 FORMAT (5X,12F10.4)                                               *
      WRITE (6,520)                                                     *
  520 FORMAT (///20X,11HFORCE TABLE,/)                                  *
      WRITE (6,150) (FT(J),J=1,NS)                                      *
      IF (NF .GT. 1) WRITE (6,160)
  160 FORMAT (20X,51HSTARTING                  END                FREQUENCY
     1/        20X,50HFREQUENCY              FREQUENCY             INTERVAL)
      IF (NF .EQ. 1) GO TO 600                                          *
      DO 530 J=1,NF
  530 WRITE (6,170) SSF(J),EEF(J),HHF(J)
  170 FORMAT (19X,E12.5,9X,E12.5,8X,E12.5)
      GO TO 610                                                         *
  600 H1=ABS(HHF(1))                                                    *
      IF (H1 .LT. 5.0) H1=120.0                                         *
      WRITE (6,605) SSF(1),EEF(1),H1                                    *
  605 FORMAT (//11X,16HSTARTING FREQ. =,F15.4,//11X,16HENDING FREQ.   =  *
     1        ,F15.4,//11X,16HINTERVAL STEPS =,F12.1)                   *
  610 WRITE (6,180)
  180 FORMAT (1H1,40X,16HFOURIER SPECTRUM//
     1       20X,9HFREQUENCY,11X, 9HREAL PART,11X,10HIMAG. PART,15X,
     2        5HPHASE       17X, 7HFOURIER/ 22X,6HC.P.S.,13X, 8HF(OMEGA),
     3       13X,8HF(OMEGA),15X,5HANGLE,16X,8HSPECTRUM,/
     4       85X,6H(DEG.),15X,8H(IN/SEC)//)                             *
      XNN=(TE-TS)/TH + 2.                                               *
      TH=(TE-TS)/XNN                                                    *
      N=IFIX(XNN)+1                                                     *
      IF (N .LE. 16000) GO TO 412                                       *
  408 WRITE (6,410) N                                                   *
  410 FORMAT (//5X,21HF DIMENSION TOO SMALL,I10,//5X,                   *
     X         29HREMAINING COMPUTATION SKIPPED/)                       *
      GO TO 540                                                         *
  412 CALL  INTERQ (N,XMIN,XMAX,NPTS)                                   *
      IF (IDEL .EQ. 0) IDEL =5
      DEL=1./FLOAT(IDEL)                                                *
      DO 540 KK = 1,NF
      SF=SSF(KK)
      EF=EEF(KK)
      HF=HHF(KK)
      IF (NF .GT. 1) GO TO 310                                          *
      RATIO=EF/SF                                                       *
      ONT=-1.0                                                          *
```

```
620 CNT=CNT+1.0                                                          79 *
    IF (CNT .GT. M1) GO TO 540                                           80 *
    SF=SSF(1)*RATIO**(CNT/M1)                                            81 *
310 TM1 = DFL/SF                                                         82 *
    IF (TM1 .GT.TM)  GO TO  300                                          83
    XNN =(TE-TS)/TM1 + 2.                                                84 *
    TM=(TE-TS)/XNN                                                       85 *
    N=IFIX(XNN)+1                                                        86 *
    IF (N .GT. 16000) GO TO 408                                          87 *
    IF (N.GT.1500 .AND. N.LE.3000) N=3000                                88 *
    IF (N.GT.3000 .AND. N.LE.4800) N=4800                                89 *
    IF (N.GT.4800 .AND. N.LE.7000) N=7000                                90 *
    IF (N.GT.7000 .AND. N.LE.9600) N=9600                                91 *
    IF (N.GT.9600 .AND. N.LE.12500) N=12500                              92 *
    IF (N .GT. 12500) N=16000                                            93 *
    TM=(TE-TS)/FLOAT(N-1)                                                94 *
    CALL  INTERQ (N,XMIN,XMAX,NPTS)                                      95 *
300 CALL  SPEGT (N,XMIN,XMAX,NPTS)                                       96 *
    IF (NF .EQ. 1) GO TO 620                                             97 *
    SF = SF + HF                                                         98
    IF (SF .LE. EF) GO TO 310                                            99
540 CONTINUE                                                            100 *
    ENDFILE 11                                                          101 *
    REWIND 11                                                           102 *
    WRITE (6,400) XMIN,XMAX                                             103 *
400 FORMAT (1H1,1X,9HFREQ.(HZ),30X,26HFOURIER AMPLITUDE (IN/SEC),       104 *
   X        2F15.7/)                                                    105 *
    RANGE=XMAX-XMIN                                                     106 *
    DO 402 J=1,120                                                      107 *
402 FT(J)=1H                                                            108 *
    DO 404 I=1,NPTS                                                     109 *
    READ (11) FREQ,FOUR                                                 110 *
    J=IFIX(119.*(FOUR-XMIN)/RANGE)+1                                    111 *
    IF (J .GT. 0) FT(J)=1H*                                             112 *
    WRITE (6,406) FREQ,(FT(K),K=1,120)                                  113 *
404 FT(J)=1H                                                            114 *
406 FORMAT (1X,F8.3,1X,120A1)                                           115 *
    IF (LP) 2,541,1                                                     116 *
541 CONTINUE                                                            117
    END                                                                 118
```

```
      SUBROUTINE INTERQ (N,XMIN,XMAX,NPTS)
      COMMON /BLK2/TS,TE,TH,SF,NS
      COMMON /BLK1/FT(1)      /BLK3/TT(1)
      COMMON F(1)
      P1=0.00001
      T=TT(1)
      F(1) = FT(1)
      K=0
      DO 15 J=2,N
      T=T+TH
    8 I=K+1
      IF (TT(I) .GE. T) GO TO 12
      IF (I .GE. NS) GO TO 10
      K=I
      GO TO 8
   10 F(J)=0.0
      GO TO 15
   12 XL=ABS(TT(I)-T)
      IF (XL .LE. P1) F(J)=FT(I)
      IF (XL .GT. P1) F(J)=FT(K)+((FT(I)-FT(K))/(TT(I)-TT(K)))*
     X                (T-TT(K))
   15 CONTINUE
      RETURN
C
      ENTRY SPECT
      OMEG=6.2831853*SF
      THH=0.5*TH
      T=TT(1)
      FC=0.0
      FS=0.0
      FC2= F(1)*COS(OMEG*T)
      FS2=-F(1)*SIN(OMEG*T)
      DO 50 K=2,N
      T=T+TH
      OMEGT=OMEG*T
      FC1=FC2
      FS1=FS2
      FC2= F(K)*COS(OMEGT)
      FS2=-F(K)*SIN(OMEGT)
      FC=FC+(FC1+FC2)*THH
   50 FS=FS+(FS1+FS2)*THH
      FOUR  = SQRT(FC*FC+FS*FS)
      IF (ABS(FC) .LT. 1.0E-12) AX1=0.0
      IF (ABS(FC) .GE. 1.0E-12) AX1=FS/FC
      PHSANG =57.29578*ATAN (AX1)
      WRITE (6,100)  SF,FC,FS,PHSANG,FOUR
  100 FORMAT (18X,F12.5,8X,E12.5,9X,E12.5,9X,F12.5,10X,E12.5)
      WRITE (11) SF,FOUR
      IF (FOUR .LT. XMIN) XMIN=FOUR
      IF (FOUR .GT. XMAX) XMAX=FOUR
      NPTS=NPTS+1
      RETURN
      END
```

```
      OVERLAY (ISICP,10,0)
      PROGRAM FILTER
      PROGRAM FILTER (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE15)
C
C     THIS PROGRAM REQUIRES 70,300 OCTAL STORAGE ON A CDC 6400 MACHINE.
C
C     NOMENCLATURE ***
C     NW = NO. OF MIDBAND FREQUENCIES
C     NI = NO. OF DATA POINTS ON TIME AND MOTION TABLES
C     NQ = OUTPUT PRINTOUT CONTROL, ZERO FOR PARTIAL PRINTOUT, NONZERO FOR ALL
C     TH = INTEGRATION TIME INTERVAL, IF ZERO,, 1/10 OF MIDBAND FREQ. IS USED
C     OMEGA = MIDBAND FREQUENCY, HZ.
C
C     INPUT SEQUENCE ***
C        1. NO. OF PROBLEMS                                    (I5)
C        2. TITLE                                              (12A6)
C        3. NW,NI,NQ,TH CARD                                   (3I5,F10.5)
C        4. OMEGA, I=1,NW                                      (8F10.3)
C        5. TIME TABLE, I=1,NI                                 (9F8.0)
C        6. MOTION AMPL. TABLE, I=1,NI                         (9F8.0)
C        *, REPEAT 2 THRU 6 IF MORE THAN 1 PROBLEM.
C
      DIMENSION OMEGA(50),A(2),B(2),Q(2),QDOT(2),QDDOT(2),TEMQDD(2),
     X          PREQ(2),PREQD(2),PREQDD(2),TDUM(1),VDUM(1),TITLE(12)
      COMMON    TTAB(4500),VIN(4500),VTEMP(4500),TTEMP(4500)
      EQUIVALENCE (TTAB,TDUM),(VIN,VDUM)
      REAL MAXOUT
      DATA MAIT,EPSL1,EPSL2,RST/25,1.0E-07,1.0E-03,1.0E-04/
    2 FORMAT (12A6)
    3 FORMAT (1H1,5X,12A6)
   10 FORMAT (3I5,F10.5)
   11 FORMAT (//15X,5H TIME,14X,6H INPUT/)
   12 FORMAT (9F8.0)
   13 FORMAT (2F20.4)
   15 FORMAT (//38H  NUMBER OF MID-BAND FREQUENCIES,  NW =,I5,
     X         //38H  NUMBER OF INPUT DATA POINTS,     NI =,I5,
     Y         //38H  OPTION FOR PRINT OUTPUT,         NQ =,I5,
     Z         //38H  INTEGRATION TIME INTERVAL,       TH =,F10.5)
   19 FORMAT (/5X,34H INTEGRATION INTERVAL IS TOO LARGE,9X,2F15.6)
   20 FORMAT (8F10.3)
   25 FORMAT (//22H  FREQUENCY TABLE (HZ),//)
   30 FORMAT (2F16.4)
   35 FORMAT (////27H  LOWER CUT-OFF FREQUENCY =,F10.3)
   40 FORMAT (//27H  UPPER CUT-OFF FREQUENCY =,F10.3)
   45 FORMAT (//12X,4HTIME,11X,6HOUTPUT/)
   50 FORMAT (//22H  MID-BAND FREQUENCY =,F10.3,10H AT TIME =,F10.3,
     X         17H MAXIMUM OUTPUT =,F10.5)
      IL=15
      REWIND IL
      PI2=2.*3.1415926536
      READ (5,10) ND
      NDD = ND
   51 READ (5,2) (TITLE(I),I=1,12)
      WRITE (6,3) (TITLE(I),I=1,12)
      READ (5,10) NW,NI,NQ,TH
      IF (NI .GT. 4500) STOP 51
      READ (5,20) (OMEGA(I),I=1,NW)
```

AD-A094 299 ARMY ENGINEER DIV HUNTSVILLE AL F/G 14/2
SHOCK TEST PROGRAM. SHOCK ISOLATION DESIGN MANUAL FOR SAFEGUARD--ETC(U)
AUG 73 G C CHAN, R YANG, H SAFFELL, C C HUANG
UNCLASSIFIED HNDSP-73-98-ED-R NL

5 OF 7
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```
      IF (NI .EQ. 0) GO TO 54
      READ (5,12) (TDUM(I),I=1,NI)
      WRITE (IL) (TDUM(I),I=1,NI)
      TEND = TDUM(NI)
   54 IF (NI .EQ. 0) NI=NV
      NV=NI
      READ (5,12) (VDUM(I),I=1,NI)
      WRITE (6,15) NW,NI,NQ,TH
      WRITE (6,25)
      WRITE (6,20) (OMEGA(I),I=1,NW)
      READ (IL) (TTAB(I),I=1,NI)
      WRITE (IL) (VDUM(I),I=1,NI)
      ENDFILE IL
      REWIND IL
      WRITE (6,11)
      DO 55 I=1,NI
   55 WRITE (6,13) TDUM(I),VDUM(I)
      DO 600 K=1,NW
      IF (K .EQ. 1) GO TO 57
      READ (IL) (TTAB(I),I=1,NI)
      READ (IL) (VIN(I),I=1,NI)
      REWIND IL
   57 NN=NV
      TTAB(NN) = TEND
      OMEGAM=2./OMEGA(K)
      IF (TEND .LT. OMEGAM) TTAB(NN) = OMEGAM
      TF = TTAB(NN)
      OMEGAM=4.*OMEGAM
      IF (TF .GT. OMEGAM) TF=OMEGAM
      II = 0
      NP=1
      WLOW=OMEGA(K)/8.9
      WHIGH=OMEGA(K)/1.1
      WRITE (6,35) WLOW
      WRITE (6,40) WHIGH
      IF (NQ .NE. 0) WRITE (6,45)
   65 MAXOUT = 0.
      GO TO (80,90), NP
C     ELEMENT VALUES OF CONSTANT-K LOW-PASS FILTER
   80 WLOW=WLOW*PI2
      ZL1 = RST/WLOW
      ZC2C = 2./(WLOW*RST)
      GO TO 95
C     ELEMENT VALUES OF CONSTANT-K HIGH-PASS FILTER
   90 WHIGH=WHIGH*PI2
      ZLH = RST/(2.*WHIGH)
      ZCH = 1./(WHIGH*RST)
   95 H=0.05/OMEGA(K)
      IF (H.GT.TH .AND. TH.GT.0.0) H=TH
      TIME=TDUM(1)
      DELT = 0.
      ITER = 0
      DO 100 I=1,2
      Q(I)=0.
  100 DDOT(I)=0.
  104 CALL LEINTR (TIME,VINT,NN,TTAB,VIN,NER)
      IF (NER .EQ. 0) GO TO 105
      WRITE (6,20) TIME
```

```
      STOP 105
  105 GO TO (107,109), NP
C     ENTERING ITERATION PROCESS
C     EQUATIONS OF LOW-PASS FILTER
  107 QDDOT(1) = (VINT - (Q(1)-Q(2))/ZC2C) / ZL1
      QDDOT(2) = -(RST * QDOT(2) + (Q(2)-Q(1))/ZC2C) /ZL1
      GO TO 110
C     EQUATIONS OF HIGH-PASS FILTER
  109 QDDOT(2) = (VINT-(QDOT(1)+QDOT(2))/ZCH) /RST
      QDDOT(1) = QDDOT(2) + (RST *QDOT(2)+Q(2)/ZCH)/ZLH
  110 IF (ITER .EQ. 0) GO TO 120
      DO 118 I=1,2
      IF (QDDOT(I)) 111,112,111
  111 ERRE=ABS((QDDOT(I)-TEMQDD(I))/QDDOT (I))
      IF (ERRE-EPSL2) 118,118,115
  112 IF (ABS(QDDOT(I)-TEMQDD(I)) .LE. EPSL1) GO TO 118
  115 IF (ITER .LE. MAIT) GO TO 230
      DELT =DELT/2.
      IF (DELT .GE. H/4.) GO TO 116
      WRITE (6,19) DELT,H
      STOP 116
  116 CONTINUE
      ITER=1
      TIME = TIME - DELT
      GO TO 170
  118 CONTINUE
      DO 119 I=1,2
      Q(I)=Q(I)+DELT*DELT*QDDOT(I)/6.
  119 QDOT(I)=A(I)+DELT*QDDOT(I)/2.
  120 NCASE=1
      IF (NP .EQ. 2) GO TO 222
      II = II +1
      VTEMP(II) = QDDOT(2)*RST
      TTEMP(II) = TIME
  222 VOUT = QDOT(2) *RST /1.95
      IF (NQ.NE.0 .AND. NP.EQ.2) WRITE (6,30) TIME,VOUT
      IF (ABS(VOUT) .LE. MAXOUT) GO TO 122
      MAXOUT=ABS(VOUT)
      TIMAX = TIME
  122 CONTINUE
      DO 125 I=1,2
      PREQDD(I) = QDDOT(I)
      PREQD(I) = QDOT(I)
  125 PREQ(I) = Q(I)
      DELT = H
      ITER = 1
      TIME = TIME + DELT
      IF (TIME-TF) 180,180,500
  170 NCASE = 3
  180 DO 200 I=1,2
      A(I) = PREQD(I) + 0.5*DELT*PREQDD(I)
      B(I) = PREQ(I) +DELT*PREQD(I)+DELT*DELT*PREQDD(I)/3.
      QDDOT(I) = PREQDD(I)
      QDOT(I)=PREQD(I)
  200 Q(I) = PREQ(I)
      GO TO 240
  230 NCASE = 2
      ITER = ITER + 1
```

```
  240 CONTINUE
C     LINEAR ACCELERATION APPROXIMATION
      DO 250 I=1,2
      FEMQDD(I)=QDDOT(I)
      Q(I)=B(I)+DELT*DELT*QDDOT(I)/6.
  250 QDOT(I)=A(I)+DELT*QDDOT(I)/2.
      GO TO (104,105,104), NCASE
  500 IF (NP .EQ. 2) GO TO 555
      DO 540 M=1,II
      VIN(M)=VTEMP(M)
  540 TTAB(M)=TTEMP(M)
      NP = 2
      TF = TTAB(II)
      NN = II
      GO TO 65
  555 WRITE (6,50) OMEGA(K),TIMAX,MAXOUT
  600 CONTINUE
      NDD = NDD-1
      IF (NDD) 650,650,51
  650 CONTINUE
      END
```

```
      SUBROUTINE LEINTR (X,Y,NI,TABLEX,TABLEY,NER)
      DIMENSION TABLEX(1),TABLEY(1)
C     LINEAR INTERPOLATION SUBROUTINE
      DO 100 I=1,NI
      IF(TABLEX(I)-X)97,101,98
   97 IF(TABLEX(I+1)-X)100,99,102
   98 IF(TABLEX(I+1)-X)102,99,100
  100 CONTINUE
      NER=1
      GO TO 109
   99 Y=TABLEY(I+1)
      NER=3
      GO TO 109
  101 Y=TABLEY(I)
      NER=0
      GO TO 109
  102 IF(NI-I)103,103,104
  103 NER=1
      GO TO 109
  104 PART1=TABLEY(I)*(TABLEX(I+1)-X)
      PART2=TABLEY(I+1)*(TABLEX(I)-X)
      Y=(PART1-PART2)/(TABLEX(I+1)-TABLEX(I))
      NER=3
  109 RETURN
      END
```

SECTION 2: ISIP2 LISTING

```
      OVERLAY(LINK0,0,0)
      PROGRAM ISIP2 (INPUT=193,OUTPUT=193,TAPE5=INPUT,TAPE6=OUTPUT,
     X               TAPE14=257)
      COMMON /ONE/ID(12),AMA(144)
      COMMON /TWO/NT,NO,NM,NR,NV,NTL,NC,NS,MSZ,NSZ,OPTN,IK
      COMMON /THREE/S(144,145)
      INTEGER OPTN
      DATA IK,MSZ/14,144/
      DATA PLTFRM,FVOUS/5HLINK1,5HLINK2/
C
C     ISIP2  -  VERSION 1.2                JAN. 1973.
C
C     THIS PROGRAM ANALYZES THE SHOCK RESPONSE OF A FLEXIBLE PLATFORM.
C     LINEAR STRUCTURE IS ASSUMED.
C
C     ENGINEER-PROGRAMMER... G. CHAN/SPERRY RAND, HUNTSVILLE, AL. (205) 533-3700
C     SUBPROGRAM PLTFRM IS DEVELOPED BY G. CHAN,   FVOUS BY PARSONS/LOS ANGELES,
C        AND MODIFIED BY G. CHAN.
C
C     THIS PROGRAM REQUIRES 33 K (DECIMAL) OR 102 K (OCTAL) CORE WORDS.
C
C     INPUT SEQUENCE*******
C        1. RUN OPTN AND PLATFRM RIGIDITY CHOICE- OPTN,NR,NS,NO  (4I8)
C           NR,NS,NO ARE NEEDED ONLY WHEN OPTN=2
C        2. ID CARD                                              (12A6)
C
C       **  FOR NONRIGID PLATFORM ONLY (NR=1)
C        3. NNP,NBEL,NSEL,NSIZE                                  (4I8)
C        4. NODE POINT COORD.  (NNP CARDS)                       (I8,2F8.0)
C        5. BEAM ELEMENT DATA  (NBEL CARDS)                      (2I3,A2,9F8.0)
C        6. SPRING ELEMENT DATA (NSEL CARDS)                     (I8,6E8.2)
C        7. WEIGHTS (LB) (6 WTS./LAMPED MASS)  (NNP CARDS)       (6F10.0)
C
C       **  FOR RIGID PLATFORM ONLY (NR=0)
C        3. WT., WT. COORD., AND WT. MOMENT OF INERTIA           (7F10.0)
C        4. REPEAT 3 AS MANY TIMES AS THERE ARE WTS.  THEN, FOLLOWED BY A BLANK
C           CARD
C        5. SPRING AND SPRING COORD.   LB/IN.                    (7F10.0)
C        6. REPEAT 5 AS MANY TIMES AS THERE ARE SPRINGS.  THEN, FOLLOWED BY A
C           BLANK CARD
C
C       **  FOR BOTH RIGID AND NON-RIGID PLATFORMS
C        8. NM,NTL,NC,NV                                         (4I8)
C        9. TIME TABLE,  SEC.                                    (9F8.0)
C       10. THREE FORCE TABLES ( 0 PERCENT DAMPING),  IN.        (9F8.0)
C       11.      DITTO         ( 5 PERCENT DAMPING)              (9F8.0)
C       12.      DITTO         (10 PERCENT DAMPING)              (9F8.0)
C       13. REPEAT 1 THRU 12 IF THE WORD *REPEAT* IS PUNCHED ON COLUMNS 1-6,
C           OTHERWISE, A BLANK CARD SIGNALLING NORMAL EXIT.
C
C     OPTION OPTN*  =1, FLEXIBILITY MATRIX IS COMPUTED BY PLTFRM
C                   =2, LINEAR RESPONSE ANALYSIS BY FVOUS
C                   =3, BOTH 1 AND 2.
C
C     MSZ MUST BE IN MULTIPLE OF 6.
C
C     SEE PLTFRM AND FVOUS FOR NOMENCLATURE.
```

```
C
      WRITE (6,1)
 1    FORMAT (1HH)
C     FORMAT 1HH IS CDC LINES/PAGE CONTROL.
 3    READ (5,5) OPTN,NR,NS,NO
 5    FORMAT (4I6)
C     READ IN RIGID (NR=0) OR NON-RIGID (NR=1) OPTION.
      IF (OPTN .EQ. 3) NR=1
      NRN=4HNON-
      IF (NR .EQ. 0) NRN=4H
C     READ IN JOB IDENTIFICATION
      READ (5,10) ID
 10   FORMAT (12A6)
      WRITE (6,15) ID,NRN
 15   FORMAT (1H1,/////20X,12A6,///32X,A4,23HRIGID PLATFORM ANALYSIS/)
      NT=0
      GO TO (20,25,20), OPTN
 20   IF (NR .EQ. 1) CALL OVERLAY (PLTFRM,1,0)
C20   IF (NR .EQ. 1) CALL PLTFRM
      IF (OPTN .LE. 1) GO TO 30
      IF (OPTN .EQ. 3) NS=-1
 25   CALL OVERLAY (FVOUS,2,0)
C25   CALL FVOUS
 30   READ (5,35) I
 35   FORMAT (A10)
      IF (I .EQ. 10HREPEAT    ) GO TO 3
      END
```

```
      OVERLAY(LINK1,1,0)
      PROGRAM PLTFRM
C     SUBROUTINE PLTFRM
      REAL I1,I2,JP
      DOUBLE PRECISION FF,WW
      COMMON /ONE/ID(12),IG(24),X(24),Y(24),Z(12)
      COMMON /TWO/NNP,NO,CM(6),M144,NSIZE,IOP,IK
      COMMON /THREE/F(144,145)
      COMMON /FOUR/ RI(1),R2,R3,R4,R5,R6
      DIMENSION B(12,12),T(12,12),EX(2),YM(2),MT(3),FF(145),BT(290)
      EQUIVALENCE (FF,BT),(BT(1),B(1)),(BT(145),T(1)),(BT(289),EX(1)),
     A            (R1,RI(1))
      DATA IL,PI/14,3.1415926536/
      DATA EPSI,T17,T24/1.0E-06,1.0E-17,1.0E-24/
      DATA MT,YM,V/2HST,2HAL,2H**,3.0E+07,1.0E+07,0.333/
C
C     THIS PROGRAM FORMULATES THE STIFFNESS MATRIX OF A FLEXIBLE PLATFORM.
C     6 DEG. OF FREEDOM PER NODE POINT.  MAX. NODE POINT IS 24.  NODE POINTS
C     BEGIN AT 1, CONTINUOUS.  NO MISSING PT. ALLOWED.
C     PLATFORM ON X-Y PLANE, SINGLE LAYER.  COMPOSED OF BEAMS AND COVER PLATES.
C
C     NNP   = NO. OF NODE POINTS, INTEGER.        MAX. NNP=24.
C     NBEL  = NO. OF BEAM ELEMENTS,    INTEGER,   NO MAX. LIMIT
C     NSEL  = NO. OF SPRING ELEMENTS,  INTEGER,   NO MAX. LIMIT
C     NSIZE = MAX. MATRIX SIZE FOR PRINTOUT CONTROL,  INTEGER
C             A DEFAULT VALUE OF 36 IF NSIZE .LE. 0 OR .GT. 144,
C             MATRICES ARE NOT PRINTED IF NSIZE = 1
C
C     N1,N2 = FIRST AND SECOND NODES OF BEAM,  INTEGERS.
C     MAT   = MATERIAL SELECTION.  ST FOR STEEL, AL FOR ALUMINUM.
C             ** INDICATES THAT THE CURRENT BEAM IS IDENTICAL (LENGTH AND BEAM
C                SECTIONAL PROPERTIES) AND PARALLEL TO THE PRECEEDING BEAM INPUT
C     I1,I2 = AREA MOMENTS OF INERTIA OF BEAM SECTION. 2-2 AXIS IS SAME AS Z
C             AXIS.  PLATFORM LIES ON X-Y PLANE.  IN**4
C     JP    = POLAR MOMENT OF INERTIA OF BEAM = I1 + I2.    NOT AN INPUT VALUE.
C     A     = CROSS-SECTIONAL AREA,  IN**2
C     W1,W2 = BEAM TOP AND BOTTOM WIDTHS,  IN.
C     T1,T2 = COVERED PLAT THICKNESSES, AT TOP AND BOTTOM OF BEAM,  IN.
C
C                      AXIS 2
C                     1
C                     1                  BEAM          PLATE
C                  XXXXXXX  -----   TOP WIDTH W1, THICKNESS T1
C                     X       1 C1
C                     X       1
C     AXIS 1 ----------X----------- AXIS 1
C                     X       1
C                     X       1 C2      BEAM            PLATE
C                  XXXXXXX  -----  BOTTOM WIDTH W2, THICKNESS T2
C                     1
C                     1
C                      AXIS 2
C
C     ST = STEEL,   AL = ALUMINUM,   V = POISONS RATIO.
C
C     BT MUST DIMENSIONED TO TWICE THE SIZE OF FF, AND EQUIVALENCE FT,BT,T
C     ACCORDINGLY.
```

```
C     KEY INTERMEDIATE COMPUTATIONS ARE PRINTED OUT IF ISERV=1
      ISERV=1
      ISERV=0
      M24=M144/6
      JZZ=M144*M144
      IF (ISERV.EQ.1 .OR. IOP.EQ.1) REWIND IK
C     INITIALIZING IG AND F
      DO 10 I=1,M24
 10   IG(I)=IMX
      DO 15 I=1,JZZ
 15   F(I,1)=0.0
C     READ IN NO. OF NODE PTS. NO. OF ELEMENTS, AND MATRIX PRINTOUT SIZE CONTROL
      READ (5,30) NNP,NBEL,NSEL,NSIZE
 30   FORMAT (4I8)
      IF (NSIZE .GT. 144) NSIZE=36
      WRITE (6,32) NNP,NBEL,NSEL,NSIZE,NSIZE
 32   FORMAT (/////5X,14HNO. OF NODES =,I7,//5X,28HTOTAL NO. OF BEAM ELE
     XMENTS =,I7,//5X,30HTOTAL NO. OF SPRING ELEMENTS =,I7,//5X,
     Y 32HMAX. MATRIX SIZE TO BE PRINTED =,I7,3H BY,,I4,/////,
     Z 9X,8HNODE PT.,7X,7HX COORD,5X,7HY COORD,/26X,3HIN.,9X,3HIN./)
      MR=NNP*6
C     READ IN NODE POINT COORD.
      DO 40 I=1,NNP
      READ (5,35) NP,XC,YC
 35   FORMAT (I8,2F8.0)
      WRITE (6,36) NP,XC,YC
 36   FORMAT (10X,I5,5X,2F12.3)
      IF (NP .LE. M24) GO TO 37
      WRITE (6,155)
      GO TO 40
 37   X(NP)=XC
      Y(NP)=YC
      IG(NP)=NP
 40   CONTINUE
      DO 45 I=1,NNP
      IF (IG(I) .EQ. IMX) GO TO 160
 45   CONTINUE
      WRITE (6,48)
 48   FORMAT (1H1,///5X, 76HFIRST AND SECOND NODES, MATERIAL, INERTIA, AR
     XEA, C-DISTANCES, AND BEAM WIDTHS/)
      DO 120 M=1,NBEL
C     READ IN A BEAM AT A TIME.
      READ (5,50) N1,N2,MAT,I1,I2,A,C1,C2,W1,W2,T1,T2
 50   FORMAT (2I3,A2,9F8.2)
      IF (MAT .NE. MT(3)) GO TO 53
      WRITE (6,51) N1,N2
 51   FORMAT (25X,2I10,10X,5HDITTO)
      GO TO 107
 53   WRITE (6,54) N1,N2,MAT,I1,I2,A,C1,C2,W1,W2,T1,T2
 54   FORMAT (5X,2I10,7X,A2,9F10.3)
      IF (MAT .NE. MT(1) .AND. MAT .NE. MT(2)) GO TO 170
      IF (MAT .EQ. MT(1)) E=YM(1)
      IF (MAT .EQ. MT(2)) E=YM(2)
      G=0.5*E/(1+V)
C     TO ADD EFFECTIVE PLATE STIFFNESS TO BEAM SECTIONAL MODULI I1 AND I2.
      IF (T1 .LT. EPSI .AND. T2 .LT. EPSI) GO TO 56
      X2=16.04
      IF (MAT .EQ. MT(2)) X2=14.05
```

```
      Y1=W1+X2*T1
      Y2=W2+X2*T2
C     WHERE CONSTANT X2=3000./SQRT(YIELD STRENGTH)  35KSI FOR ST., 20KSI FOR AL.
      X1=(C1*T1*T1*T1+C2*T2*T2*T2)/12.0
      X1=X1+(C1+.5*T1)*(C1+.5*T1)*Y1*T1+(C2+.5*T2)*(C2+.5*T2)*Y2*T2
      I1=I1+X1
      X2=(T1*Y1*Y1*Y1+T2*Y2*Y2*Y2)/12.0
      I2=I2+X2
      WRITE (6,55) I1,I2
 55   FORMAT (35X,1H(,F8.3,1H),1X,1H(,F7.3,1H))
 56   JP=I1+I2
C     TO COMPUTE BEAM LENGTH AND COORD. TRANSFORMATION ANGLE.
      X1=X(N1)
      X2=X(N2)
      Y1=Y(N1)
      Y2=Y(N2)
      X2=X2-X1
      Y2=Y2-Y1
      BL=SQRT(X2*X2+Y2*Y2)
      IF (ABS(X2) .GE. EPSI) ANG=ATAN(Y2/X2)
      IF (ABS(X2) .LT. EPSI .AND. Y2 .GE. 0.0) ANG=PI/2.
      IF (ABS(X2) .LT. EPSI .AND. Y2 .LT. 0.0) ANG=1.5*PI
      IF (ABS(Y2) .LT. EPSI .AND. X2 .GE. 0.0) ANG=0.0
      IF (ABS(Y2) .LT. EPSI .AND. X2 .LT. 0.0) ANG=PI
      ANG=-ANG
C     TO COMPUTE BEAM STIFFNESS MATRIX.
      DO 57 I=1,144
 57   B(I,1)=0.
      ELI1=E*I1/BL
      ELI2=E*I2/BL
      BL2=BL*BL
      B(1,1)=E*A/BL
      B(2,2)=12.*ELI1/BL2
      B(3,3)=12.*ELI2/BL2
      B(4,4)=G*JP/BL
      B(5,5)=4.*ELI2
      B(6,6)=4.*ELI1
      DO 58 I=1,6
 58   B(I+6,I+6)=B(I,I)
      B(1,7)=-B(1,1)
      B(2,6)=6.*ELI1/BL
      B(2,12)=B(2,6)
      B(2,8)=-12.*ELI1/BL2
      B(3,5)=-6.*ELI2/BL
      B(3,11)=B(3,5)
      B(3,9)=-B(3,3)
      B(4,10)=-B(4,4)
      B(5,9)=-B(3,5)
      B(5,11)=0.5*B(5,5)
      B(6,8)=-B(2,6)
      B(6,12)=0.5*B(6,6)
      B(8,12)=B(6,8)
      B(9,11)=B(5,9)
      DO 60 I=1,12
      DO 60 J=1,I
 60   B(I,J)=B(J,I)
C     COORD. TRANSFORMATION IF ANG .GT. 0.0
      IF (ABS(ANG) .LT. EPSI) GO TO 100
```

```
      GNA=ANG*57.2957795
      WRITE (6,62) GNA
 62   FORMAT (/5X,28HCOORD. TRANSF. ANG. (DEG.) =,F11.4/)
      SA=SIN(ANG)
      CA=COS(ANG)
      DO 70 I=1,12
      DO 65 J=1,12
 65   T(I,J)=0.0
 70   T(I,I)=CA
      T(3,3)=1.0
      T(6,6)=1.0
      T(9,9)=1.0
      T(12,12)=1.0
      T(1,2)=SA
      T(2,1)=-SA
      T(4,5)=SA
      T(5,4)=-SA
      T(7,8)=SA
      T(8,7)=-SA
      T(10,11)=SA
      T(11,10)=-SA
C     TO PERFORM (T-INVERS)*(H)*(T) MATRIX MULTIPLICATIONS.
C     FIRST.....  (H)*(T)
      DO 80 I=1,12
      DO 75 J=1,12
      Z(J)=0.0
      DO 75 K=1,12
 75   Z(J)=Z(J)+H(I,K)*T(K,J)
      DO 80 J=1,12
 80   H(I,J)=Z(J)
C     SECOND.....  (T-INVERSE)*PRODUCT OF (H*T)
C     NOTE**   (T-INVERSE)=(T-TRANSPOSE) FOR ORTHOG. MATRIX.
      DO 90 J=1,12
      DO 85 I=1,12
      Z(I)=0.0
      DO 85 K=1,12
 85   Z(I)=Z(I)+T(K,I)*H(K,J)
      DO 90 I=1,12
      IF (ABS(Z(I)) .LT. EPSI) Z(I)=0.
 90   H(I,J)=Z(I)
 100  WRITE (6,104)
 104  FORMAT (//)
      IF (NSIZE .NE. 0) WRITE (6,105) ((H(I,J),J=1,12),I=1,12)
 105  FORMAT (3X,12E10.3)
 107  WRITE (6,104)
C     TO GENERATE THE STIFFNESS MATRIX FOR THE COMPLETE PLATFORM.
      K=(N1-1)*6
      L=(N2-1)*6
      DO 110 I=1,6
      KI=K+I
      LI=L+I
      I6=I+6
      DO 110 J=1,6
      KJ=K+J
      LJ=L+J
      J6=J+6
      F(KI,KJ)=F(KI,KJ)+H(I,J)
      F(KI,LJ)=F(KI,LJ)+H(I,J6)
```

```
      F(LI,KJ)=F(LI,KJ)+B(I6,J)
 110  F(LI,LJ)=F(LI,LJ)+M(I6,J6)
 120  CONTINUE
      IF (NSEL .LE. 0) GO TO 132
C     TO ADD SPRING ISOLATOR ELEMENTS
      DO 130 I=1,NSEL
      READ (5,124) N3,R1,R2,R3,R4,R5,R6
 124  FORMAT (I8,6E8.2)
      WRITE (6,126) N3,R1,R2,R3,R4,R5,R6
 126  FORMAT (//5X,33HSPRING ISOLATOR, ATTACHED TO NODE,I7,//10X,
     1 14HR1,R2,....,R6 =,5X,6E14.4//)
      IF (N3 .GT. M24) WRITE (6,128)
 128  FORMAT (/5X,17HNODE OUT OF RANGE//)
      DO 130 J=1,6
      IF (ABS(RI(J)) .LT. EPSI) GO TO 130
      K=(N3-1)*6+J
      F(K,K)=F(K,K)+RI(J)
 130  CONTINUE
C     TO WRITE OUT STIFFNESS MATRIX IF NSIZE IS NON-ZERO.
 132  IF (NSIZE .EQ. 0) GO TO 147
      WRITE (6,133)
 133  FORMAT (1H1,//25X,25HPLATFORM STIFFNESS MATRIX,//)
      IF (NSIZE .GT. MR) NSIZE=MR
      DO 140 I=1,NSIZE
      WRITE (6,135) I
 135  FORMAT (1X,I3,1H))
 140  WRITE (6,145) (F(I,J),J=1,NSIZE)
 145  FORMAT (4X,10E12.3)
C     STIFFNESS MATRIX HAS BEEN ASSEMBLED.
 147  DO 150 I=1,MR
      IF (ISERV .EQ. 1) WRITE (IK) (F(I,J),J=1,MR)
      DO 150 J=1,MR
 150  F(I,J)=F(I,J)*EPSI
      GO TO 180
 155  FORMAT (///5X,25HLARGEST NODE ALLOWABLE IS,I3,I10)
 160  WRITE (6,165) I
 165  FORMAT (//5X,8HNODE PT.,I3,11H IS MISSING)
      STOP
 170  WRITE (6,175) MAT
 175  FORMAT (//5X,14HMATERIAL ERROR,5X,A2)
 178  STOP 777
 180  M=MR+1
C     TO OBTAIN FLEXIBILITY MATRIX FROM INVERTING THE STIFFNESS MATRIX.
      DO 220 I=1,MR
      DO 207 K=1,MR
 207  F(K,M)=0.0
      F(I,M)=1.0
      IF (ABS(F(I,I)) .LT. T24) GO TO 178
      WW=1.0D+00/DBLE(F(I,I))
      DO 209 J=1,M
      FF(J)=DBLE(F(I,J))*WW
 209  F(I,J)=SNGL(FF(J))
      DO 215 K=1,MR
      IF (K .EQ. I) GO TO 215
      IF (ABS(F(K,I)) .LT. T24) GO TO 215
      AW=DBLE(F(K,I))
      DO 214 J=1,M
 214  F(K,J)=F(K,J)-SNGL(AW*FF(J))
```

```
215  CONTINUE
     DO 218 K=1,MR
218  F(K,I)=F(K,M)
220  CONTINUE
     DO 225 I=1,MR
     DO 225 J=1,MR
     IF (ABS(F(I,J)) .LT. T17) F(I,J)=0.
225  F(I,J)=F(I,J)*EPSI
     IF (ISERV .NE. 1) GO TO 245
     REWIND IK
     NSZ=NSIZE
     IF (NSIZE .EQ. 0) NSZ=36
     IF (NSIZE .GT. MR) NSZ=MR
     IF (NSIZE .GT. 0) WRITE (6,230)
230  FORMAT (///5X,24HINVERSION ACCURACY CHECK//)
     L=0
     DO 240 I=1,NSZ
     IF (NSIZE .GT. 0) WRITE (6,135) I
     READ (IK) (T(J,1),J=1,MR)
     DO 235 J=1,NSZ
     BT(J)=0.
     DO 235 K=1,MR
235  BT(J)=BT(J)+T(K,1)*F(K,J)
     IF (NSIZE .GT. 0) WRITE (6,145) (BT(J),J=1,NSZ)
     IF (ABS(BT(I)-1.00) .GT. 0.1) L=1
240  CONTINUE
     IF (L .EQ. 1) WRITE (6,243)
243  FORMAT (////5X,21HFLEX. MATRIX IN DOUBT////)
     REWIND IK
245  IF (IOP .NE. 1) GO TO 250
     DO 247 I=1,MR
247  WRITE (IK) (F(I,J),J=1,MR)
     ENDFILE IK
     REWIND IK
250  IF (IOP .EQ. 3) NO=MR
     END
```

```
      OVERLAY(LINK2,2,0)
      PROGRAM FVOUS
C     SUBROUTINE FVOUS
      COMMON /ONE/ID(12),AH(144)
      COMMON /TWO/NT,NO,NM,NR,NV,NTL,NC,NS,KA,NSIZE,IUP,IK
      COMMON /THREE/AK(144,145)
      DATA EIGA,HIGMAT/6HLINK2A,6HLINK2B/
C
C     FREE VIBRATION OF 3-D UNRESTRAINED STRUCTURES
C
C     THIS FVOUS PROGRAM, ORIGINALLY DEVELOPED BY PARSONS CO./L.A., HAS BEEN
C     EXTENSIVELY MODIFIED BY G.CHAN.
C
C     NT = NUMBER OF JOINTS.
C     NO = DIMENSION OF DYNAMIC MATRIX.
C     NM = NUMBER OF NORMAL MODES TO BE COMPUTED.
C     NS =-1, FLEXIBILITY MATRIX IN CORE, READ IN ONLY INERTIA MATRIX (N X 1)
C            FROM CARDS.
C        = 0, BOTH FLEX. MATRIX AND INERTIA MATRIX ARE READ FROM TAPE (UNIT 14).
C        = 1, BOTH FLEX. MATRIX (N X N), AND INERTIA MATRIX ARE READ FROM CARDS.
C     NR = 0, RIGID BODY MOTION.
C        = 1, FLEXIBLE BODY MOTION.
C     N  = DIMENSION OF INERTIA MATRX.
C     NV = NUMBER OF NORMAL MODES TO BE USED IN MODAL ANALYSIS,   NV .LE. NM.
C     FOR RIGID BODY MOTION ONLY.....
C        AM - WEIGHT (LB.) OF EACH MASS POINT,
C        XM,YM,ZM - X,Y,Z COORD. OF AM.  IN.
C        AMX,AMY,AMZ - WT. MOMNET OF INERTIA OF AM WITH RESPECT TO X,Y,Z AXES.
C        AK - SPRING CONSTANT,  LB/IN.
C        XA,XB - COORD OF SPRING AT BOTH ENDS, X DIRECTION,  IN.
C        YA,YB - COORD OF SPRING AT BOTH ENDS, Y DIRECTION,  IN.
C        ZA,ZB - COORD OF SPRING AT BOTH ENDS, Z DIRECTION.  IN.
C     FOR FLEXIBLE BODY MOTIONS .....
C        AK - FLEXIBILITY MATRIX, N X N,
C        AM(I) - WEIGHT AND WT. MOMENTS OF INERITA WITH RESPECT TO X,Y,Z AXES,
C                THRU NODAL MASS C.G.,   I=1,...,N   (6 VALUES PER NODE PT.)
C                UNITS IN LB. AND LB-IN**2
C     NTL= TABLE LENGTH ON SHOCK SPECTRUM.
C     NC = 0, NO SPECTRUM IS READ IN,
C        = M, M SETS OF SPECTRA WILL BE READ.
C     CPSTAB = FREQUENCY TABLE, HZ,
C     TAB0X,TAB0Y,TAB0Z = SHOCK SPECTRUM AMPLITUDE IN X,Y,Z DIRECTIONS FOR ZERO
C                         DAMPING, IN.
C     TAB5X,TAB5Y,TAB5Z = DITTO, EXCEPT  5 PERCCENT DAMPING, IN.
C     TAB10X,TAB10Y,TAB10Z = DITTO, EXCEPT 10 PERCCENT DAMPING, IN.
C
 1001 FORMAT (4I8)
 1002 FORMAT (///15H0 TOTAL JOINTS=I4,23H   DYNAMIC MATRIX SIZE=I4,23H
     X   NO OF FLEX. MODES=I2,6H   NS=I2,6H   NR=I2,6H   NV=I2//)
 1004 FORMAT (6F10.0)
 1006 FORMAT (4X,6F12.3)
 1007 FORMAT (////32H     FLEXIBILITY MATRIX     ORDER,I5///)
 1008 FORMAT (1X,I3,1H1)
 1009 FORMAT (6E12.5)
 1010 FORMAT (4X,10E12.3)
 1011 FORMAT (///41H0     INERTIA VECTOR,  LB. OR LB-IN-SEC**2//)
 1013 FORMAT (5X,14HONLY THE FIRST,I5,3H BY,I4,11H IS PRINTED///)
```

```
      IF (NR .EQ. 0) NO=6
      N=NO
      IF (NR .EQ. 0) CALL OVERLAY (RIGMAT,2,2)
C     IF (NR .EQ. 0) CALL RIGMAT
C     READ IN WTS. FOR NON-RIGID PLATFORM.
      IF (NR .EQ. 1) READ (5,1004) (AM(I),I=1,N)
C     READ IN NO. OF NORAL MODES. NO. OF FORCE TABLE SETS. AND TABLE LENGTH.
      READ (5,1001) NM,NTL,NC,NV
      IF (NM .GT. 20) NM=20
      IF (NR.EQ.0 .AND. NM.GT.6) NM=6
      IF (NV .EQ. 0) NV=NM
      IF (NR .EQ. 0) GO TO 50
      WRITE (6,1002) NT,NO,NM,NS,NR,NV
      WRITE (6,1007) N
      IF (NS .EQ. 0) REWIND IK
      NSZ=N
      IF (N .LE. NSIZE) GO TO 20
      WRITE (6,1013) NSIZE,NSIZE
      NSZ=NSIZE
   20 DO 30 I=1,N
      IF (NS .EQ. 0) READ (IK) (AK(I,J),J=1,N)
      IF (NS .GT. 0) READ (5,1009) (AK(I,J),J=1,N)
      IF (I .GT. NSIZE) GO TO 30
      WRITE (6,1008) I
      WRITE (6,1010) (AK(I,J),J=1,NSZ)
   30 CONTINUE
      WRITE (6,1011)
      IF (NS .EQ. 0) READ (IK) (AM(I),I=1,N)
      IF (NS .EQ. 0) REWIND IK
      WRITE (6,1006) (AM(I),I=1,N)
      DO 40 I=1,N
      DO 40 J=1,N
   40 AK(I,J)=AK(I,J)*AM(J)
   50 CALL OVERLAY (EIGA,2,1)
C  50 CALL EIGA
      END
```

```
      OVERLAY(LINK2H,2,2)
      PROGRAM RIGMAT
C     SUBROUTINE RIGMAT
C
      DIMENSION S(144,145)
      COMMON /ONE/ID(12),AM(144)
      COMMON /THREE/A(1000),XM(144),YM(144),ZM(144),AMX(144),AMY(144),
     X                AMZ(144),G(6,6),GI(6,7)
      EQUIVALENCE (S,A)
      DATA AMT,XT,YT,ZT,EPSI/4*0.0,1.0E-10/
C
 1000 FORMAT (/F10.0)
 1002 FORMAT (23H MASSES AND COORDINATES//48H WEIGHT (LB.)     X   (IN)
     1  Y   (IN)      Z   (IN),29H     IXX          IYY          IZZ//)
 1003 FORMAT (/F12.2)
 1004 FORMAT (39H1SPRING STIFFNESSES AND END COORDINATES//84H KI (LBF/IN
     1)      XA (IN)      XB (IN)      YA (IN)      YB (IN)      ZA (IN)
     2ZH (IN)//)
 1005 FORMAT (13H1MASS MATRIX //5X,4H MI1,9X,4H MI2,9X,4H MI3,9X,4H MI4,
     1          9X,4H MI5,9X,4H MI6//)
 1006 FORMAT (6E13.4)
 1007 FORMAT (18H0STIFFNESS MATRIX //5X,4H KI1,9X,4H KI2,9X,4H KI3,9X,
     1          4H KI4,9X,4H KI5,9X,4H KI6//)
 1008 FORMAT (//27H CENTER OF GRAVITY LOCATION//6H XCG =F12.2,6H YCG =,
     1          F12.2,6H ZCG =F12.2,14H     TOTAL WT =F12.2,4H LBS//)
 1009 FORMAT (///5X,25HSTIFFNESS MATRIX SINGULAR//)
 1010 FORMAT (4X,10E12.3)
 1012 FORMAT (/////23H          DYNAMIC MATRIX//)
      DO 2 J=1,36
      G(J,1)=0.0
    2 GI(J,1)=0.0
C     *READ AND WRITE MASSES AND COORDINATES
      WRITE (6,1002)
      K = 1
    4 READ (5,1000) AM(K), XM(K), YM(K), ZM(K), AMX(K), AMY(K), AMZ(K)
      W = AM(K)
      IF (ABS(W) .LT. EPSI) GO TO 5
      WRITE (6,1003) AM(K), XM(K), YM(K), ZM(K),AMX(K),AMY(K),AMZ(K)
C     *COMPUTE TOTAL MASS AND MOMENTS CONTRIBUTING TO CG CALCULATION
      AMT = AMT + W
      XT = XT + W * XM(K)
      YT = YT + W * YM(K)
      ZT = ZT + W * ZM(K)
      K  = K + 1
      GO TO 4
C     *COMPUTE CENTER OF GRAVITY
    5 M  = K - 1
      XC = XT / AMT
      YC = YT / AMT
      ZC = ZT / AMT
      WRITE (6, 1008) XC, YC, ZC, AMT
C     * COMPUTE MASS MATRIX
      DO 7 J = 1, M
      AMJ=AM(J)
      CX=XM(J)-XC
      CY=YM(J)-YC
      CZ=ZM(J)-ZC
```

```
      C1=CX*CX
      C2=CY*CY
      C3=CZ*CZ
      C4=CX*CY
      C5=CX*CZ
      C6=CY*CZ
      DO 6 I=1,3
    6 G(I,I)=G(I,I)+AMJ
      G(1,5)=G(1,5)+AMJ*CZ
      G(1,6)=G(1,6)-AMJ*CY
      G(2,4)=G(2,4)-AMJ*CZ
      G(2,6)=G(2,6)+AMJ*CX
      G(3,4)=G(3,4)+AMJ*CY
      G(3,5)=G(3,5)-AMJ*CX
      G(4,4)=G(4,4)+AMJ*(C2+C3)+AMX(J)
      G(4,5)=G(4,5)-AMJ*C4
      G(4,6)=G(4,6)-AMJ*C5
      G(5,5)=G(5,5)+AMJ*(C1+C3)+AMY(J)
      G(5,6)=G(5,6)-AMJ*C6
      G(6,6)=G(6,6)+AMJ*(C1+C2)+AMZ(J)
    7 CONTINUE
      WRITE (6,1004)
C     *DIAGONALIZE THE MASS MATRIX
      DO 8 I = 1, 6
      DO 8 J = I, 6
    8 G(J, I) = G(I, J)
C     *READ AND WRITE SPRING STIFFNESSES AND END COORDINATES
    9 READ (5,1000) AK, XA, XB, YA, YB, ZA, ZB
      IF (ABS(AK) .LT. EPSI) GO TO 10
      WRITE (6,1003) AK, XA, XB, YA, YB, ZA, ZB
C     *COMPUTE STIFFNESS MATRIX
      CX=XB-XA
      CY=YB-YA
      CZ=ZB-ZA
      SL=SQRT (CX*CX+CY*CY+CZ*CZ)
      CX=CX/SL
      CY=CY/SL
      CZ=CZ/SL
      BX =XA-XC
      BY =YA-YC
      BZ =ZA-ZC
      C1 =CX*CX
      C2 =CY*CY
      C3 =CZ*CZ
      C4 = CX * CY
      C5 = CX * CZ
      C6 = CY * CZ
      XX = BX * BX
      YY = BY * BY
      ZZ = BZ * BZ
      XY = BX * BY
      XZ = BX * BZ
      YZ = BY * BZ
      GI(1,1) = GI(1,1) + AK * C1
      GI(1,2) = GI(1,2) + AK * C4
      GI(1,3) = GI(1,3) + AK * C5
      GI(1,4) = GI(1,4) + AK * (C5 * BY - C4 * BZ)
      GI(1,5) = GI(1,5) + AK * (C1 * BZ - C5 * BX)
```

```
      GI(1,6) = GI(1,6) + AK * (C4 * HX - C1 * HY)
      GI(2,2) = GI(2,2) + AK * C2
      GI(2,3) = GI(2,3) + AK * C6
      GI(2,4) = GI(2,4) + AK * (C6 * HY - C2 * HZ)
      GI(2,5) = GI(2,5) + AK * (C4 * HZ - C6 * HX)
      GI(2,6) = GI(2,6) + AK * (C2 * HX - C4 * HY)
      GI(3,3) = GI(3,3) + AK * C3
      GI(3,4) = GI(3,4) + AK * (C3 * HY - C6 * HZ)
      GI(3,5) = GI(3,5) + AK * (C5 * HZ - C3 * HX)
      GI(3,6) = GI(3,6) + AK * (C6 * HX - C5 * HY)
      GI(4,4) = GI(4,4) + AK * (C2 * ZZ - 2.0 * C6 * YZ + C3 * YY)
      GI(4,5) = GI(4,5) + AK * (C6 * XZ - C4 * ZZ + C5 * YZ - C3 * XY)
      GI(4,6) = GI(4,6) + AK * (C4 * YZ - C2 * XZ - C5 * YY + C6 * XY)
      GI(5,5) = GI(5,5) + AK * (C1 * ZZ - 2.0 * C5 * XZ + C3 * XX)
      GI(5,6) = GI(5,6) + AK * (C4 * XZ - C1 *YZ + C5 * XY - C6 * XX)
      GI(6,6) = GI(6,6) + AK * (C1 * YY - 2.0 * C4 * XY + C2 * XX)
      GO TO 9
C     *DIAGONALIZE THE STIFFNESS MATRIX
   10 DO 11 I=1,6
      DO 11 J=1,6
   11 GI(J,I) = GI(I,J)
C     *WRITE OUT THE MASS AND STIFFNESS MATRICES
      WRITE (6,1005)
      WRITE (6,1006) ((G(I,J),J=1,6),I=1,6)
      WRITE (6,1007)
      WRITE (6,1006) ((GI(I,J),J=1,6),I=1,6)
C     *TO COMPUTE DYNAMIC MATRIX.
      DO 30 I=1,6
      IF (ABS(GI(I,I)) .LT. 1.0E-24) WRITE (6,1009)
      DO 14 IJ=1,6
   14 GI(IJ,7)=0.0
      GI(I,7)=1.0
      DO 18 J=1,7
      IF (J .NE. I) GI(I,J)=GI(I,J)/GI(I,I)
   18 CONTINUE
      DO 23 L=1,6
      IF (L .EQ. I) GO TO 23
      DO 20 J=1,7
      IF (J .NE. I) GI(L,J)=GI(L,J)-GI(L,I)*GI(I,J)
   20 CONTINUE
   23 CONTINUE
      DO 26 II=1,6
   26 GI(II,I)=GI(II,7)
   30 CONTINUE
      DO 32 I=1,6
      DO 32 J=1,6
   32 GI(J,I)=GI(I,J)
      WRITE (6,1012)
      DO 40 IX=1,6
      DO 37 I=1,6
      SUM=0.0
      DO 35 J=1,6
   35 SUM=SUM+GI(IX,J)*G(J,I)
   37 S(IX,I)=SUM
   40 WRITE (6,1010) (S(IY,IY),IY=1,6)
      END
```

```
      OVERLAY(LINK2A,2,1)
      PROGRAM EIGA
C     SUBROUTINE EIGA
      DOUBLE PRECISION BKK,EVTK,EVL,SSUM,BBIG,ZZERO,OONE,EEPSI,EIGOLD,
     X        EIGNEW,RRATIO,BK,WWT,YA,YB,ACOEFF,GGVPI,GGV,PPI,SSUM3,EVT,
     Y        PPIGV
      DIMENSION BKK(144),EVTK(144),EVTJ(144),AK(144,1)
      COMMON /ONE/ID(12),AMA(144)
      COMMON /TWO/NT,NO,NM,NR,NV,NIL,NC,CM(4),IK
      COMMON /THREE/BK(20,144),CK(20,144),YA(144),YB(144),CPSTAB(23),
     1       TAB0X(23),TAB0Y(23),TAB0Z(23),TAB5X(23),TAB5Y(23),TAB5Z(23),
     2        TAB10X(23),TAB10Y(23),TAB10Z(23),ETATAB(3,144),FTAB1(3,144)
     3        ,FTAB2(3,144),FTAB3(3,144),PHITAB(3,144),PHIBAR(3,144)
     4        ,EVT(144,20),EVL(20),JCOL(20),COUNT(20),WWT(144),FRQ(20)
      EQUIVALENCE (AK,BK),(EVTK,EVTJ)
      DATA EEPSI,GGV,PPI,ZZERO,OONE/1.0D-12,386.4D+00,3.1415926536D+00,
     X      0.0D+00,1.0D+00/
C
C     THIS SUBROUTINE HAS BEEN EXTENSIVELY MODIFIED BY G. CHAN, TO INCREASE
C     COMPUTER CORE UTILIZATION.
C
      GGVPI=DSQRT(GGV)/(2.0D+00*PPI)
      PPIGV=4.0D+00*PPI*PPI/(GGV*GGV)
      CLIMIT=3.0*FLOAT(NO)
      IF (CLIMIT .LT. 100.) CLIMIT=100.
C
 1068 FORMAT (/25X,I4,6H MODE,,F10.1,11H ITERATIONS)
 1098 FORMAT (3X,4HNODE,I4,1H))
 1100 FORMAT (///7X,20HEIGENSYSTEM SOLUTION,//7X,14HDYNAMIC MATRIX,I7,
     X         3H BY,I7,//7X,38HNO. OF RESONANT MODES TO BE COMPUTED =,
     Y         I10,//7X,59HEIGENVALUE ACCURACY CONTROLS, EPSILON AND ITER
     ZATION LIMIT =,D12.4,F9.1///)
 1101 FORMAT (10H MODE NO. ,I9,11I10)
 1102 FORMAT (11H FREQ (HZ) ,12F10.4)
 1103 FORMAT (7H DOF NO,I4,12F10.5)
 1104 FORMAT (/////20H ORTHOGONALITY CHECK///)
 1105 FORMAT (6D20.8)
 1106 FORMAT (1X)
 1107 FORMAT (1X,I3,1H))
 1108 FORMAT (6E20.8)
 1109 FORMAT (26H1        FLEXIBLE BODY MODES///)
 1250 FORMAT (///35H0        MODAL PARTICIPATION FACTORS//)
 1255 FORMAT (///6H  * MODE,I7,//,26H  GENERALIZED MASS (LB.) =,D16.8/)
C1351 FORMAT (10F7.0)
 1360 FORMAT (/////5X,61HINPUT OF SHOCK SPECTRA TABLES.      NO. OF POINT
     1S ON SPECTRA =,I4,15X,I4,7H SET(S))
 1361 FORMAT (29H0        FREQUENCY TABLE (CPS),/)
 1362 FORMAT (//7X,36HX Y Z TABLES ON SHOCK SPECTRA (INS.),I6,
     X         12H 0/0 DAMPING//)
 1363 FORMAT (20H1        RESPONSE DATA,5X,65H(DISPL. IN INCH AND RAD., AC
     1CEL. IN INCH/SEC**2, AND RAD./SEC**2))
 1364 FORMAT (3F16.4,3E16.5)
 1365 FORMAT (10F12.4)
 1366 FORMAT (93H0              X                  Y                  Z          T
     XHETA X          THETA Y          THETA Z/)
 1367 FORMAT (93H0          XDDOT            YDDOT            ZDDOT
     XTXDDOT          TYDDOT          TZDDOT/)
```

```
 1376 FORMAT (//5X,I2,12H 0/0 DAMPING)
 1400 FORMAT (9F8.0)
      N=NO
      WRITE (6,1100) N,N,NM,EEPSI,CLIMIT
      REWIND 1R
C     START COMPUTING EIGENVALUS.
      DO 70 K=1,NM
C     INITIALIZE CONT,BKK(J),EIGOLD.
      EIGOLD=0.0D+00
      CONT=1.0
      DO 25 J=1,N
   25 BKK(J)=DONE
   26 DO 30 I=1,N
      SSUM=ZZERO
      DO 29 J=1,N
   29 SSUM=SSUM+DBLE(AK(I,J))*BKK(J)
   30 EVTK(I)=SSUM
C     NORMALIZING BKK(J) AND COMPARISON OF EIGOLD AND EIGNEW
      BBIG=ZZERO
      JCK=1
      DO 35 J=1,N
      IF (DABS(EVTK(J)) .LE. BBIG) GO TO 35
      BBIG=DABS(EVTK(J))
      JCK=J
   35 CONTINUE
      EIGNEW=BBIG
      DO 36 J=1,N
   36 BKK(J)=EVTK(J)/BBIG
      BRATIO=DABS(DONE-BBIG/EIGOLD)
      IF (BRATIO.LE.EEPSI .OR. CONT.GT.CLIMIT) GO TO 40
      CONT=CONT+1.0
      EIGOLD=EIGNEW
      GO TO 26
C     MAKE PREPARATION FOR NEXT HIGHER MODE.
   40 IF (CONT .GT. 2.5) GO TO 45
      DO 42 J=1,N
   42 BKK(J)=ZZERO
      BKK(JCK)=DONE
   45 IF (BKK(JCK) .GT. ZZERO) GO TO 50
      DO 48 J=1,N
   48 BKK(J)=-BKK(J)
   50 WRITE (1R) (BKK(J),J=1,NO),(AK(JCK,J),J=1,NO),JCK,EIGNEW,CONT
      IF (K .GE. NM) GO TO 67
      DO 60 I=1,N
      IF (I .EQ. JCK) GO TO 60
      DO 55 J=1,N
   55 AK(I,J)=AK(I,J)-SNGL(BKK(I)*DBLE(AK(JCK,J)))
   60 CONTINUE
      NM1=N-1
      DO 65 I=1, NM1
      II=I
      IF (I .GE. JCK) II=I+1
      DO 65 J=1, NM1
      JJ=J
      IF (J .GE. JCK) JJ=J+1
   65 AK(I,J)=AK(II,JJ)
   67 WRITE (6,1068) K,CONT
      N=N-1
```

```
   70 CONTINUE
      ENDFILE IK
      REWIND IK
      DO 71 K=1,NM
   71 READ (IK) (BK(K,J),J=1,NO),(CK(K,J),J=1,NO),
     X            JCOL(K),EVL(K),COUNT(K)
      REWIND IK
C     TO COMPUTE EIGENVECTORS FOR ALL COMPUTED MODES.
      DO 90 K=1,NM
      KA=NM-K+1
      KB=NO-NM+K
      IF (COUNT(KA) .LT. 2.5) GO TO 73
      IF (KA .GT. 1) GO TO 76
      DO 72 J=1,NO
   72 EVT(J,1)=BK(1,J)
      GO TO 90
C     FOR THE CASE OF UNCOUPLED EIGENVECTOR.
   73 DO 74 J=1,NO
   74 EVT(J,KA)=0.0
      J=JCOL(KA)-1
      DO 75 I=1,KA
      IF (JCOL(I) .LE. JCOL(KA)) J=J+1
   75 CONTINUE
      EVT(J,KA)=1.0
      GO TO 90
   76 DO 77 J=1,KB
   77 YA(J)=BK(KA,J)
      KD=KB+1
      KE=KA-1
   78 JCK=JCOL(KE)
      DO 80 J=1,KD
      YB(J)=ZZERO
      IF (J .LT. JCK) YB(J)=YA(J)
      IF (J .GT. JCK) YB(J)=YA(J-1)
   80 CONTINUE
C     COMPUTING A COEFFICIENT
      SSUM=ZZERO
      DO 81 J=1,KD
   81 SSUM=SSUM+DBLE(CK(KE,J))*YB(J)
      ACOEFF=EVL(KA)-EVL(KE)
      ACOEFF=ACOEFF/SSUM
C     NORMALIZE YA(J)
      DO 82 J=1,KD
   82 YA(J)=BK(KE,J)+ACOEFF*YB(J)
      BBIG=ZZERO
      DO 85 J=1,KD
      IF (DABS(YA(J)) .GT. DABS(BBIG)) BBIG=YA(J)
   85 CONTINUE
      DO 86 J=1,KD
   86 YA(J)=YA(J)/BBIG
      IF (KD .GE. NO) GO TO 88
      KD=KD+1
      KE=KE-1
      GO TO 78
   88 DO 89 J=1,NO
   89 EVT(J,KA)=YA(J)
   90 CONTINUE
      DO 95 K=1,NM
```

```
      EIGNEW=DONE/EVL(K)
   95 EVL(K)=GGVPI*DSQRT(EIGNEW)
      CALL SEQUN (EVL,EVT,NM,NO)
C     OUTPUT MODES AND FREQUENCIES
      WRITE (6,1109)
      DO 96 K=1,NM
      FRQ(K)=SNGL(EVL(K))
   96 JCOL(K)=K
      WRITE (6,1101) (JCOL(K),K=1,NM)
      WRITE (6,1106)
      WRITE (6,1102) (FRQ(K),K=1,NM)
      WRITE (6,1106)
      I=0
      L=5
      DO 100 J=1,NO
      L=L+1
      DO 98 K=1,NM
   98 EVTJ(K)=SNGL(EVT(J,K))
      IF (L .LT. 6) GO TO 100
      I=I+1
      L=0
      WRITE (6,1098) I
  100 WRITE (6,1103) J,(EVTJ(K),K=1,NM)
C     ORTHOGONALITY EXAMINATION
      DO 102 J=1,NO
  102 WWT(J)=DBLE(AMA(J))
C     COMPUTE GENERALIZED WEIGHTS. (COMMON FACTORS)
      DO 117 K=1,NV
      SSUM=ZZERO
      DO 115 J=1,NO
  115 SSUM=SSUM+EVT(J,K)*EVT(J,K)*WWT(J)
  117 YA(K)=SSUM
      DO 120 K=1,NV
      DO 120 J=1,NO
  120 BK(K,J)=EVT(J,K)
      WRITE (6,1250)
      DO 126 K=1,NV
      DO 122 J=1,NO
  122 BK(K,J)=BK(K,J)*WWT(J)
      WRITE (6,1255) K,YA(K)
      WRITE (6,1105) (BK(K,I),I=1,NO)
      DO 126 I=1,NV
      SSUM=ZZERO
      DO 124 J=1,NO
  124 SSUM=SSUM+EVT(J,K)*EVT(J,I)*WWT(J)/YA(K)
  126 CK(K,I)=SNGL(SSUM)
      WRITE (6,1104)
      DO 128 K=1,NV
      WRITE (6,1107) K
  128 WRITE (6,1108) (CK(K,I),I=1,NV)
      DO 130 K=1,NV
      DO 130 J=1,NO
  130 BK(K,J)=BK(K,J)/YA(K)
C     READ INPUT TABLES IN
      IF (NC .EQ. 0) GO TO 200
      READ (5,1400) (CPSTAH(I),I=1,NTL)
  132 WRITE (6,1360) NTL,NC
      WRITE (6,1361)
```

```
      WRITE (6,1365) (CPSTAB(I),I=1,NTL)
      JCOL(1)=0
      JCOL(2)=5
      JCOL(3)=10
      L=0
      DO 134 I=1,3
      WRITE (6,1362) JCOL(I)
      DO 134 K=1,3
      LL=L*23
      L=L+1
      READ (5,1400) (TAB0X(J+LL),J=1,NTL)
      WRITE (6,1106)
  134 WRITE (6,1365) (TAB0X(J+LL),J=1,NTL)
      CALL INTERP (EVL,FTAB1,NTL,CPSTAB,TAB0X,ERR,1)
      IF (ERR .GT. 0.5) STOP 1
      CALL INTERP (EVL,FTAB1,NTL,CPSTAB,TAB0Y,ERR,2)
      CALL INTERP (EVL,FTAB1,NTL,CPSTAB,TAB0Z,ERR,3)
      CALL INTERP (EVL,FTAB2,NTL,CPSTAB,TAB5X,ERR,1)
      IF (ERR .GT. 0.5) STOP 2
      CALL INTERP (EVL,FTAB2,NTL,CPSTAB,TAB5Y,ERR,2)
      CALL INTERP (EVL,FTAB2,NTL,CPSTAB,TAB5Z,ERR,3)
      CALL INTERP (EVL,FTAB3,NTL,CPSTAB,TAB10X,ERR,1)
      IF (ERR .GT. 0.5) STOP 3
      CALL INTERP (EVL,FTAB3,NTL,CPSTAB,TAB10Y,ERR,2)
      CALL INTERP (EVL,FTAB3,NTL,CPSTAB,TAB10Z,ERR,3)
C     COMPUTE ETA FOR 0.5 AND 10 DAMPING FACTORS
      NX=(NO+5)/6
      N=NO
      DO 138 K=1,NV
      SUM1=0.0
      SUM2=0.0
      SUM3=0.
      DO 136 I=1,NX
      NA=6*(I-1)+1
      DO 136 J=1,3
      BKNA=SNGL(BK(K,NA))
      SUM1=SUM1+FTAB1(J,K)*BKNA
      SUM2=SUM2+FTAB2(J,K)*BKNA
      SUM3=SUM3+FTAB3(J,K)*BKNA
  136 NA=NA+1
      ETATAB(1,K)=SUM1
      ETATAB(2,K)=SUM2
  138 ETATAB(3,K)=SUM3
      IF(NP .LE. 0) N=6
      DO 145 J=1,3
      DO 145 K=1,N
      SUM2=0.0
      SSUM=ZZERO
      DO 140 I=1,NV
      SSUM3=EVT(K,I)*DBLE(ETATAB(J,I))
      SUM2=SUM2+SNGL(SSUM3)
  140 SSUM=SSUM+SSUM3*EVL(I)*EVL(I)*PPTGV
      PHITAB(J,K)=SUM2/SNGL(DGV)
  145 PHIBAR(J,K)=SNGL(SSUM)
      WRITE (6,1363)
      DO 150 I=1,3
      WRITE (6,1370) JCOL(I)
      WRITE (6,1366)
```

```
      WRITE (6,1364) (PHITAB(I,K),K=1,N)
      WRITE (6,1367)
  150 WRITE (6,1364) (RHIBAR(I,K),K=1,N)
      NC=NC-1
      IF (NC .GE. 1) GO TO 132
  200 CONTINUE
      END


      SUBROUTINE SEQUN (FR,EV,NM,MR)
      DOUBLE PRECISION FR,Z,EV,VE
      DIMENSION FR(1),EV(144,1)
      COMMON /THREE/Z(144),VE(144,20),IC(20),JC(20)
C
C     THIS SUBROUTINE IS ADDED BY G. CHAN SUCH THAT THE FREQ. AND MODE-SHAPES
C     ARE IN AN ASCENDING SEQUENCE.
C
      IF (NM .LE. 1) RETURN
      DO 10 I=1,NM
      JC(I)=I
      DO 10 J=1,MR
   10 VE(J,I)=EV(J,I)
      Z(1)=FR(1)
      IC(1)=JC(1)
      DO 50 I=2,NM
      IM1=I-1
      DO 20 J=1,IM1
      IF (FR(I) .LT. Z(J)) GO TO 30
   20 CONTINUE
      Z(I)=FR(I)
      IC(I)=JC(I)
      GO TO 50
   30 L=I
      DO 40 K=J,IM1
      L=L-1
      IC(L+1)=IC(L)
   40 Z(L+1)=Z(L)
      IC(J)=JC(I)
      Z(J)=FR(I)
   50 CONTINUE
      DO 60 I=1,NM
      FR(I)=Z(I)
      L=IC(I)
      DO 60 J=1,MR
   60 EV(J,I)=VE(J,L)
      RETURN
      END
```

```
      SUBROUTINE INTERP (XX,YY,NI,TABLEX,TABLEY,FR,L)
      DOUBLE PRECISION XX
      DIMENSION TABLEX(1),TABLEY(1),XX(1),YY(3,1)
      COMMON /TWO/NT,NO,NM,NR,NV
C
C     THIS SUBROUTINE HAS BEEN SIMPLIFIED BY G. CHAN
C
      DO 5 K=1,3
      I=NI+K
      TABLEX(I)=0.0
 5    TABLEY(I)=TABLEY(NI)
      EW=0.0
      DO 60 K=1,NV
      Y=0.0
      X=SNGL(XX(K))
      DO 20 I=1,NI
      IF (TABLEX(I)-X) 10,30,15
 10   IF (TABLEX(I+1)-X) 20,20,35
 15   IF (TABLEX(I+1)-X) 35,20,20
 20   CONTINUE
      WRITE (6,25) X
 25   FORMAT (//5X,68HINPUT SPECTRUM TOO SHORT, CONSTANT ACCEL. VALUE IS
     * EXTENDED TO FREQ.,F10.5,4H HZ./)
      Y=TABLEY(NI)*TABLEX(NI)*TABLEX(NI)/(X*X)
      GO TO 60
 30   Y=TABLEY(I)
      GO TO 60
 35   M=I
      IF (I-1) 45,55,40
 40   M=I-1
      IF (I-(NI-1)) 55,50,45
 45   EW=1.0
      GO TO 60
 50   M=I-2
 55   MP1=M+1
      MP2=M+2
      MP3=M+3
      FX0X1=(TABLEY(M)-TABLEY(MP1))/(TABLEX(M)-TABLEX(MP1))
      FX1X2=(TABLEY(MP1)-TABLEY(MP2))/(TABLEX(MP1)-TABLEX(MP2))
      FX2X3=(TABLEY(MP2)-TABLEY(MP3))/(TABLEX(MP2)-TABLEX(MP3))
      FX0X2=(FX0X1-FX1X2)/(TABLEX(M)-TABLEX(MP2))
      FX1X3=(FX1X2-FX2X3)/(TABLEX(MP1)-TABLEX(MP3))
      FX0X3=(FX0X2-FX1X3)/(TABLEX(M)-TABLEX(MP3))
      Y=TABLEY(M)+(X-TABLEX(M))*(FX0X1+((X-TABLEX(MP1))*FX0X2)+((X-
     X        TABLEX(MP1))*(X-TABLEX(MP2))*FX0X3))
 60   YY(L,K)=Y
      RETURN
      END
```

PART IV

EXAMPLES

SECTION 1: EXAMPLE TO ISOLIN

AN ISOLIN EXAMPLE RUN

A FLOOR-MOUNTED PLATFORM WITH UNEQUAL ISOLATOR LENGTHS.

```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

       1                                                                              1
  SI PLATFORM PAR POWER RM                                                            2
         5         4        -1         1         0        60                         3
 5000.     75.0      50.0      5.0      150.0     100.0     10.0                      4
 1000.0    0.0       0.0      15.0      10.0      10.0      10.0                      5
 1000.0    0.0       100.0    15.0      10.0      10.0      10.0                      6
 1000.0    150.0     100.0    15.0      10.0      10.0      10.0                      7
 1000.0    150.0     0.0      15.0      10.0      10.0      10.0                      8
 0.0       0.0                                                                        9
 0.0       100.                                                                      10
 150.      100.      5.                                                              11
 150.                -2.                                                             12
 .7547     -36.         .05       19872. 999999.      .08                            13
0.05      0.10      0.07                                                              14
                              (A BLANK CARD)                                         15
                              (A BLANK CARD)                                         16
```

THE RESULT OF THIS EXAMPLE RUN IS PRESENTED ON THE FOLLOWING PAGES.

```
OPTION, PLOT =      1     -0

     EQUIPMENT DIMENSIONS ADJUSTED,   60 PERCENT

                              PLATFORM NUMBER*****  SI PLATFORM PAR POWER RM

SPRING NO.    5 APPEARS IN ERROR

 Y AXIS (DEPTH)
 1
 1
 1
***********************
*0                    0*
*     PLATFORM         *
*       PLAN           *
*0                    0*--X AXIS (WIDTH)
***********************

Z AXIS (HEIGHT)
 1
 1       ***********
 1       *         *
 1       *     CG  *  -----/--
 1       *         *       1
***********************  ZBAR
*     PLATFORM (ELEV)  *   1
*0********************0* --/------X AXIS (WIDTH)
 /              1     /    1
 /              1     /  DELZ (=LENGTH-LOAD/RATE)
 /-----XBAR-----/     /    1
 0              1     0 ---/--
/////                /////

      NM        NI        NO1       NO2       NO3
      [illegible]        4        -1         1         0
```

MASS	WEIGHT	XCG	YCG	ZCG	WIDTH	DEPTH	HEIGHT	IXX	IYY	IZZ
1	5000.0	75.0	50.0	5.0	150.0	100.0	10.0	10907.1	24406.0	35097.2
2	1000.0	0.0	0.0	15.0	6.0	6.0	6.0	15.6	15.6	15.6
3	1000.0	0.0	100.0	15.0	6.0	6.0	6.0	15.6	15.6	15.6
4	1000.0	150.0	100.0	15.0	6.0	6.0	6.0	15.6	15.6	15.6
5	1000.0	150.0	0.0	15.0	6.0	6.0	6.0	15.6	15.6	15.6

ISOLATOR	X COORD	Y COORD	LOAD	RATE	LENGTH	LOAD(S)	RATE(S)	LENG(S)	DAMP(S)	SIGNX	SIGNY
1	0.0	0.0	2250.0	130.8	53.2	2046.5	137.3	50.9	4.0	-1.0	-1.0
2	0.0	100.0	2250.0	130.8	53.2	2320.5	137.3	52.9	4.6	-1.0	1.0
3	150.0	100.0	2250.0	130.8	58.2	2453.5	124.3	50.7	4.8	1.0	1.0
4	150.0	-0.0	2250.0	130.8	51.2	2179.5	124.3	55.5	4.3	1.0	-1.0

END INPUT TO ISOLIN

WTOT	WMIN	WMAX
9000.	8500.	9500.

FREQ	DELZ	RATOL	IXX	J(IN**4)	ZETA	DGX	DGY	DGZ	HIGHS	RAMP	FRICP
.75	-36.00	.05	19872.	999999.	.08	.05	.10	.07	0.00	-0.00	-0.00

XBAR	YBAR	ZBAR	XBARS	YBARS	ZBARS	XBARI	YBARI	EX	EY	EXS	EYS
75.0	50.0	9.4	77.2	53.0	9.8	75.0	50.0	0.0	0.0	2.2	3.0

IXX OF COMBINED EQUIP AND PLATFORM THRU SYSTEM CG 37452.

IXX OF COMBINED EQUIP AND PLATFORM THRU SHIFTED CG 37571.

IYY OF COMBINED EQUIP AND PLATFORM THRU SYSTEM CG 83334.

IYY OF COMBINED EQUIP AND PLATFORM THRU SHIFTED CG 83411.

IZZ OF COMBINED EQUIP AND PLATFORM THRU SYSTEM CG 119356.

IZZ OF COMBINED EQUIP AND PLATFORM THRU SHIFTED CG 119536.

IXX OF EQUIP AND PLATFORM THRU PLATFORM CG 37912.

MASS MOMENT EQUIVALENT HEIGHT 40.

IXX OF EQUP AND PLATFORM AROUND CEILING SUPPORTS	86535.
IYY OF EQUP AND PLATFORM AROUND CEILING SUPPORTS	132374.
UNCOUPLED ROCKING FREQ AROUND X AXIS IN CPS	.94
UNCOUPLED ROCKING FREQ AROUND Y AXIS IN CPS	.95
FIRST COUPLED FREQ AROUND X AXIS IN CPS	0.00
SECOND COUPLED FREQ AROUND X AXIS IN CPS	11.25
FIRST COUPLED FREQ AROUND Y AXIS IN CPS	0.00
SECOND COUPLED FREQ AROUND Y AXIS IN CPS	12.11
PENDULUM FREQ AROUND X AXIS IN CPS	0.00
PENDULUM FREQ AROUND Y AXIS IN CPS	0.00
TORSIONAL PENDULUM FREQUENCY IN CPS	0.00
FIRST MODE TORSIONAL FREQUENCY, CPS	670.94
FIRST MODE BENDING FREQUENCY, CPS	311.40

PRINT PUNCH OUTPUT CARDS FOR ISOL INPUT

SI PLATFORM PAW POWER PM

WTOT	XBARS	YBARS	ZBARS	IXXS	IYYS	IZZS	J
9000.	77.22	53.04	9.83	37571.	83411.	119536.	1

XA(I)	YA(I)	ZA(I)	XB(I)	YB(I)	ZB(I)	ISOLATOR
0.00	0.00	0.00	0.00	0.00	-36.00	1
0.00	100.00	0.00	0.00	100.00	-36.00	2
150.00	100.00	0.00	150.00	100.00	-31.00	3
150.00	-0.00	0.00	150.00	-0.00	-38.00	4

XP(I)	YP(I)	ZP(I)	POINTS
0.00	0.00	9.44	
0.00	0.00	0.00	
150.00	100.00	0.00	
0.00	100.00	18.89	

NX(I)	NY(I)	SL(I)	SK(I)	DA(I)	ISOLATOR
0.00	0.00	50.90	137.34	4.03	1
0.00	0.00	52.90	137.34	4.57	2
0.00	0.00	50.74	124.26	4.83	3
0.00	0.00	55.54	124.26	4.29	4

PLATFORM NUMBER*****

END OF ANALYSIS

SECTION 2: EXAMPLES TO NWVSYN

A NWVSYN EXAMPLE RUN, MANUAL METHOD (KOP=1), AND CALCOMP PLOTINGS.
(EXECUTED THROUGH ISIP OPTION 12).

```
          10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

       12       3                                                                      1
     1                                                                                2
     I NEED A TITLE CARD HERE TO INDENTIFY MY PROBLEM ***                             3
     1                                                                                4
    14    0    0                                                                      5
0.4       0.6       1.0       2.0       4.0       6.0       10.       17.             6
25.       40.       56.       90.       150.      260.                               7
3.0       7.0       9.0       9.0       9.0       9.0       9.0       9.0             8
9.0       9.0       9.0       9.0       9.0       9.0                                 9
0.065     0.145     0.41      1.7       6.8       15.       24.       40.            10
40.       40.       30.       30.       30.       30.                                11
                          (A BLANK CARD)                                            12
                          (A BLANK CARD)                                            13
FINISH                                                                              14
```

THE RESULT OF THIS EXAMPLE RUN HAS BEEN DELETED.

A NWVSYN EXAMPLE RUN. AUTOMATIC METHOD (KØP=2)

```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

       9                                                                              1
    4                                                                                 2
      WAVEFORM SYNTHESIS FOR ANNEX M,  VERTICAL                                       3
    2                                                                                 4
    5   -1    0    4    0   30                                                       5
0.5       7.0       30.0      120.0     500.0                                        6
-4.0      -4.0      44.0      20.0      20.0                                         7
      WAVEFORM SYNTHESIS FOR ANNEX M,  HORIZONTAL                                     8
    2                                                                                 9
    7    5   -1    0    0   30                                                      10
0.5       1.65      3.4       20.0      64.0      285.0     500.0                    11
-4.0      -4.0      -15.0     19.0      40.0      15.0      15.0                     12
0.5       1.0       2.2       6.1       120.0                                        13
5.0       7.0       11.0      9.0       9.0                                          14
      BUILDING AA,  VERTICAL                                                          15
    2                                                                                 16
    3    4    8    4                                                                17
   2.0      12.3      80.0                                                           18
   0.813     5.0       5.0                                                           19
   1.0       3.6       3.61    100.0                                                 20
   7.0       7.0       9.0       9.0                                                 21
   2.0       3.2       4.64      6.728     9.7556    14.14562  15.0      80.0        22
   0.0       0.63628   0.8125    1.08115   1.28873   1.43188   1.75      1.75        23
  55.0      55.0      55.0                                                            24
          VERTICAL RESPONSE                                                           25
    1                                                                                 26
    14     0     0                                                                   27
0.4     0.6     1.0     2.0     4.0     6.0     10.0    17.0    25.0                28
40.0    56.0    90.0    150.0   260.0                                               29
3.0     7.0     9.0     9.0     9.0     9.0     9.0     9.0     9.0                 30
9.0     9.0     9.0     9.0     9.0                                                 31
0.065   0.145   0.41    1.7     6.8     15.0    24.0    40.0    40.0                32
40.0    30.0    30.0    30.0    30.0                                                33
                                                                                    34
                                                                                    35
```

THE RESULT OF FIRST EXAMPLE IS PRESENTED ON THE FOLLOWING PAGES.

OPTION, PLOT = 9 -0

WAVEFORM SYNTHESIS BY AUTOMATIC OPTION

1

12/17/71 0100 HR.

WAVEFORM SYNTHESIS FOR ANNEX M. VERTICAL

NO. OF PTS ON SHOCK SPECTRA NS = 5

FREQUENCY (HZ)	MAX. ACC./DISPL.
.500	4.000 IN.
7.000	4.000 IN.
30.000	44.000 G.S
120.000	20.000 G.S
500.000	20.000 G.S

NO. OF PTS ON AMPLIFICATION RATIO CURVE NAR =10

FREQUENCY (HZ)	AMP. RATIO
.100	3.000
.400	3.000
.410	5.000
.600	5.000
.610	7.000
.900	7.000
.910	9.000
4.000	9.000
4.010	11.000
99.900	11.000

TOLERANCE LIMIT

LINE SEG.	TOLERANCE (0/0)
1	45.000
2	30.000
3	30.000
4	30.000

WAVEFORM SYNTHESIS FOR ANNEX M. VERTICAL

NO. OF POINTS SELECTED ON SPECTRUM 23

SYSTEM FREQUENCY ARRANGEMENT NO. 1 (AUTOMATIC OPTION).

W(I) (C.P.S.)	B(I) (C.P.S.)	TINT(I) (SEC.)	RTS(I) (SEC.)	DELAY(I) (SEC.)	X(I) (IN/SEC**2)	CYCLE(I)
.50000	.0950000	5.2631579	10.5263158	0.0000000	39.47842	5.0
.80000	.1142857	4.3750000	8.7500000	0.0000000	101.06475	7.0
1.16000	.1288889	3.8793103	7.7586207	0.0000000	212.48863	9.0
1.68200	.1868889	2.6753864	5.3507729	0.0000000	446.75736	9.0
2.43890	.2709889	1.8450941	3.6901882	0.0000000	939.30734	9.0
3.53640	.3929339	1.2724787	2.5449574	0.0000000	1974.89368	9.0
4.77415	.4340133	1.1520383	2.3040766	0.0000000	3599.24373	11.0
6.44510	.5859180	.8533617	1.7067234	0.0000000	6559.62170	11.0
8.70088	.7909893	.6321198	1.2642396	0.0000000	8703.90126	11.0
11.74619	1.0678356	.4682369	.9364738	0.0000000	10237.97572	11.0
15.85736	1.4415780	.3468421	.6936843	0.0000000	12042.43290	11.0
21.40743	1.9461303	.2569201	.5138402	0.0000000	14164.92812	11.0
28.90004	2.6272759	.1903112	.3806224	0.0000000	16661.51600	11.0
39.01505	3.5468225	.1409712	.2819425	0.0000000	14641.61642	11.0
52.67031	4.7882104	.1044231	.2088463	0.0000000	12344.15779	11.0
71.10492	6.4640841	.0773505	.1547010	0.0000000	10407.20008	11.0
95.99165	8.7265135	.0572967	.1145933	0.0000000	8774.17604	11.0
129.58873	11.7807932	.0424420	.0848839	0.0000000	7728.00000	11.0
174.94478	15.9040708	.0314385	.0628770	0.0000000	7728.00000	11.0
236.17545	21.4704956	.0232878	.0465755	0.0000000	7728.00000	11.0
318.83686	28.9851691	.0172502	.0345004	0.0000000	7728.00000	11.0
430.42976	39.1299783	.0127779	.0255559	0.0000000	7728.00000	11.0
581.08018	52.8254707	.0094651	.0189303	0.0000000	7728.00000	11.0

ITERATION NO. 1

TRIAL VALUES OF COEFFICIENTS

C(1)=	1.00	C(2)=	1.00	C(3)=	1.00	C(4)=	1.00	C(5)=	1.00
C(6)=	1.00	C(7)=	1.00	C(8)=	1.00	C(9)=	1.00	C(10)=	1.00
C(11)=	1.00	C(12)=	1.00	C(13)=	1.00	C(14)=	1.00	C(15)=	1.00
C(16)=	1.00	C(17)=	1.00	C(18)=	1.00	C(19)=	1.00	C(20)=	1.00
C(21)=	1.00	C(22)=	1.00	C(23)=	1.00	C(			

MAX. VALUES OF ACCELERATION

AT FREQUENCY=	.50	C.P.S.	MAX. ACCELERATION=	.5113946E+01	IN/SEC**2	AT TIME=	.51579E+01	SEC.	/	.3947842E+02*
AT FREQUENCY=	.80	C.P.S.	MAX. ACCELERATION=	.7354604E+01	IN/SEC**2	AT TIME=	.37500E+01	SEC.	/	.1010647E+03*
AT FREQUENCY=	1.16	C.P.S.	MAX. ACCELERATION=	.1000702E+02	IN/SEC**2	AT TIME=	.34483E+01	SEC.	/	.2124886E+03*
AT FREQUENCY=	1.68	C.P.S.	MAX. ACCELERATION=	.1155208E+02	IN/SEC**2	AT TIME=	.26754E+01	SEC.	/	.4467574E+03*
AT FREQUENCY=	2.44	C.P.S.	MAX. ACCELERATION=	.1051047E+02	IN/SEC**2	AT TIME=	.16401E+01	SEC.	/	.9393073E+03*
AT FREQUENCY=	3.54	C.P.S.	MAX. ACCELERATION=	.1042619E+02	IN/SEC**2	AT TIME=	.11311E+01	SEC.	/	.1974894E+04*
AT FREQUENCY=	4.77	C.P.S.	MAX. ACCELERATION=	.1256059E+02	IN/SEC**2	AT TIME=	.10473E+01	SEC.	/	.3599244E+04*
AT FREQUENCY=	6.45	C.P.S.	MAX. ACCELERATION=	.1359770E+02	IN/SEC**2	AT TIME=	.77578E+00	SEC.	/	.6559622E+04*
AT FREQUENCY=	8.70	C.P.S.	MAX. ACCELERATION=	.1270515E+02	IN/SEC**2	AT TIME=	.57465E+00	SEC.	/	.8703901E+04*
AT FREQUENCY=	11.75	C.P.S.	MAX. ACCELERATION=	.1299789E+02	IN/SEC**2	AT TIME=	.42567E+00	SEC.	/	.1023798E+05*
AT FREQUENCY=	15.86	C.P.S.	MAX. ACCELERATION=	.1272346E+02	IN/SEC**2	AT TIME=	.31531E+00	SEC.	/	.1204243E+05*
AT FREQUENCY=	21.41	C.P.S.	MAX. ACCELERATION=	.1284054E+02	IN/SEC**2	AT TIME=	.23356E+00	SEC.	/	.1416493E+05*
AT FREQUENCY=	28.90	C.P.S.	MAX. ACCELERATION=	.1285097E+02	IN/SEC**2	AT TIME=	.17301E+00	SEC.	/	.1666152E+05*
AT FREQUENCY=	39.02	C.P.S.	MAX. ACCELERATION=	.1281129E+02	IN/SEC**2	AT TIME=	.12816E+00	SEC.	/	.1464162E+05*
AT FREQUENCY=	52.67	C.P.S.	MAX. ACCELERATION=	.1279306E+02	IN/SEC**2	AT TIME=	.94930E-01	SEC.	/	.1234416E+05*
AT FREQUENCY=	71.10	C.P.S.	MAX. ACCELERATION=	.1279395E+02	IN/SEC**2	AT TIME=	.70319E-01	SEC.	/	.1040720E+05*
AT FREQUENCY=	95.99	C.P.S.	MAX. ACCELERATION=	.1280155E+02	IN/SEC**2	AT TIME=	.52088E-01	SEC.	/	.8774176E+04*
AT FREQUENCY=	129.59	C.P.S.	MAX. ACCELERATION=	.1280609E+02	IN/SEC**2	AT TIME=	.38584E-01	SEC.	/	.7728000E+04*
AT FREQUENCY=	174.94	C.P.S.	MAX. ACCELERATION=	.1281746E+02	IN/SEC**2	AT TIME=	.28580E-01	SEC.	/	.7728000E+04*
AT FREQUENCY=	236.18	C.P.S.	MAX. ACCELERATION=	.1265084E+02	IN/SEC**2	AT TIME=	.21171E-01	SEC.	/	.7728000E+04*
AT FREQUENCY=	318.84	C.P.S.	MAX. ACCELERATION=	.1289208E+02	IN/SEC**2	AT TIME=	.15682E-01	SEC.	/	.7728000E+04*
AT FREQUENCY=	430.43	C.P.S.	MAX. ACCELERATION=	.1289337E+02	IN/SEC**2	AT TIME=	.11416E-01	SEC.	/	.7728000E+04*
AT FREQUENCY=	581.08	C.P.S.	MAX. ACCELERATION=	.1295325E+02	IN/SEC**2	AT TIME=	.86047E-02	SEC.	/	.7728000E+04*

ITERATION NO. 2

VALUES OF COEFFICIENT CALCULATED FROM PREVIOUS ITERATION

C(1)=	8.92	C(2)=	16.57	C(3)=	26.25	C(4)=	49.40	C(5)=	107.11
C(6)=	216.28	C(7)=	322.11	C(8)=	547.14	C(9)=	715.29	C(10)=	804.71
C(11)=	948.66	C(12)=	1115.37	C(13)=	1309.80	C(14)=	1075.90	C(15)=	870.43
C(16)=	755.53	C(17)=	646.20	C(18)=	579.75	C(19)=	586.94	C(20)=	594.68
C(21)=	605.57	C(22)=	613.98	C(23)=	612.90	C(			

MAX. VALUES OF ACCELERATION

AT FREQUENCY=	.50	C.P.S. MAX. ACCELERATION=	.3994508E+02	IN/SEC**2	AT TIME=	.52105E+01	SEC.	/	.3947842E+02
AT FREQUENCY=	.80	C.P.S. MAX. ACCELERATION=	.1019525E+03	IN/SEC**2	AT TIME=	.43750E+01	SEC.	/	.1010647E+03
AT FREQUENCY=	1.16	C.P.S. MAX. ACCELERATION=	.2124886E+03	IN/SEC**2	AT TIME=	.34483E+01	SEC.	/	.2124886E+03
AT FREQUENCY=	1.68	C.P.S. MAX. ACCELERATION=	.4467574E+03	IN/SEC**2	AT TIME=	.26754E+01	SEC.	/	.4467574E+03
AT FREQUENCY=	2.44	C.P.S. MAX. ACCELERATION=	.9467367E+03	IN/SEC**2	AT TIME=	.18451E+01	SEC.	/	.9393073E+03
AT FREQUENCY=	3.54	C.P.S. MAX. ACCELERATION=	.1988221E+04	IN/SEC**2	AT TIME=	.12725E+01	SEC.	/	.1974894E+04
AT FREQUENCY=	4.77	C.P.S. MAX. ACCELERATION=	.3599244E+04	IN/SEC**2	AT TIME=	.10473E+01	SEC.	/	.3599244E+04
AT FREQUENCY=	5.45	C.P.S. MAX. ACCELERATION=	.6559622E+04	IN/SEC**2	AT TIME=	.77578E+00	SEC.	/	.6559622E+04
AT FREQUENCY=	8.70	C.P.S. MAX. ACCELERATION=	.8703901E+04	IN/SEC**2	AT TIME=	.57465E+00	SEC.	/	.8703901E+04
AT FREQUENCY=	11.75	C.P.S. MAX. ACCELERATION=	.1023798E+05	IN/SEC**2	AT TIME=	.42567E+00	SEC.	/	.1023798E+05
AT FREQUENCY=	15.56	C.P.S. MAX. ACCELERATION=	.1204243E+05	IN/SEC**2	AT TIME=	.31531E+00	SEC.	/	.1204243E+05
AT FREQUENCY=	21.41	C.P.S. MAX. ACCELERATION=	.1416493E+05	IN/SEC**2	AT TIME=	.23356E+00	SEC.	/	.1416493E+05
AT FREQUENCY=	28.90	C.P.S. MAX. ACCELERATION=	.1666152E+05	IN/SEC**2	AT TIME=	.17301E+00	SEC.	/	.1666152E+05
AT FREQUENCY=	39.02	C.P.S. MAX. ACCELERATION=	.1464162E+05	IN/SEC**2	AT TIME=	.12816E+00	SEC.	/	.1464162E+05
AT FREQUENCY=	52.67	C.P.S. MAX. ACCELERATION=	.1234416E+05	IN/SEC**2	AT TIME=	.94930E-01	SEC.	/	.1234416E+05
AT FREQUENCY=	71.10	C.P.S. MAX. ACCELERATION=	.1040720E+05	IN/SEC**2	AT TIME=	.70319E-01	SEC.	/	.1040720E+05
AT FREQUENCY=	95.99	C.P.S. MAX. ACCELERATION=	.8774176E+04	IN/SEC**2	AT TIME=	.52088E-01	SEC.	/	.8774176E+04
AT FREQUENCY=	129.59	C.P.S. MAX. ACCELERATION=	.7728000E+04	IN/SEC**2	AT TIME=	.38584E-01	SEC.	/	.7728000E+04
AT FREQUENCY=	174.94	C.P.S. MAX. ACCELERATION=	.7728000E+04	IN/SEC**2	AT TIME=	.28580E-01	SEC.	/	.7728000E+04
AT FREQUENCY=	236.14	C.P.S. MAX. ACCELERATION=	.7728000E+04	IN/SEC**2	AT TIME=	.21171E-01	SEC.	/	.7728000E+04
AT FREQUENCY=	318.84	C.P.S. MAX. ACCELERATION=	.7728000E+04	IN/SEC**2	AT TIME=	.15682E-01	SEC.	/	.7728000E+04
AT FREQUENCY=	430.43	C.P.S. MAX. ACCELERATION=	.7819837E+04	IN/SEC**2	AT TIME=	.12778E-01	SEC.	/	.7728000E+04
AT FREQUENCY=	581.08	C.P.S. MAX. ACCELERATION=	.7912763E+04	IN/SEC**2	AT TIME=	.94651E-02	SEC.	/	.7728000E+04

WAVEFORM SYNTHESIS FOR ANNEX M, VERTICAL

GENERALIZED SHOCK SPECTRUM

FOR

DAMPED AND UNDAMPED VIBRATIONS

INPUT DATA

STARTING TIME	0.0000
END TIME	5.2632
INITIAL DISPLACEMENT	0.0000
INITIAL VELOCITY	0.0000

FREQUENCY C.P.S.	TIME SEC.	MAX.P.DIS. INS.	MAX.P.ACC. G.S	TIME SEC.	MAX.N.DIS. INS.	MAX.N.ACC. G.S	ACC.ON SPEC. G.S	DEVIATION 0/0
.50000	5.21053	4.04728	.10338	6.21053	-4.04727	-.10338	.10217	1.18207
.58480	4.97368	4.75822	.16626	5.84211	-4.74625	-.16584	.13977	18.95558
.68399	4.64844	5.24459	.25069	6.85547	-5.14033	-.24570	.19120	31.11466
.80000	4.39453	4.06620	.26588	3.76953	-4.01640	-.26263	.26155	1.65508
.90548	4.25781	4.18177	.35030	3.71094	-4.20057	-.35188	.33507	4.54418
1.02487	5.03772	4.61075	.49480	3.56950	-4.74030	-.50871	.42926	15.26873
1.16000	4.75485	3.84409	.52848	3.46175	-4.01836	-.55244	.54992	-3.89785
1.31295	4.49892	4.39018	.77321	3.35399	-4.63503	-.81634	.70449	9.75450
1.48606	2.81473	5.02134	1.13296	3.16773	-4.66720	-1.05306	.90252	25.53343
1.68200	2.69397	4.04906	1.17039	2.38741	-3.86571	-1.11739	1.15620	1.22653
1.90377	2.57320	4.19373	1.55294	2.30380	-4.34350	-1.60840	1.48120	4.84321
2.15479	1.94119	4.75993	2.25804	2.18464	-4.67811	-2.21923	1.89754	18.99816
2.43890	1.85150	4.04799	2.46008	1.64008	-4.00000	-2.43092	2.43092	1.19972
2.76047	2.85733	4.03472	3.14125	1.58883	-4.07467	-3.17235	3.11422	.86789
3.12444	1.33875	4.58422	4.57229	1.50665	-4.43227	-4.42073	3.98959	14.60553
3.53640	1.27690	4.04995	5.17483	1.13109	-4.00000	-5.11101	5.11101	1.24879
3.90847	1.24155	3.63273	5.66942	1.10900	-3.74016	-5.83748	6.24304	-9.18175
4.31968	1.89170	4.09222	7.80161	1.08331	-4.20245	-8.01176	7.62579	2.30557
4.77415	1.36477	3.94232	9.18049	1.05058	-4.00345	-9.32285	9.31481	-1.44200
5.27643	.91967	3.78181	10.75729	1.01785	-3.74610	-10.65572	11.37793	-5.45483
5.83156	.89215	4.22162	14.66804	.80245	-4.05314	-14.08266	13.89801	5.54060
6.44510	.85579	3.78009	16.04295	.77578	-4.00000	-16.97625	16.97625	-5.49764
7.12318	.67881	3.20928	16.63713	.75154	-3.32381	-17.23085	20.21514	-17.69964
7.87261	.65906	3.19904	20.25723	.59441	-2.97839	-18.86000	21.33913	-5.07005
8.70088	.63392	2.79314	21.66435	.57465	-2.91224	-22.52562	22.52562	-4.08984
9.61630	.50282	2.29154	21.65035	.55670	-2.33127	-22.02577	23.77809	-8.94816
10.62802	.48819	2.09231	24.14645	.43897	-1.98227	-22.87656	25.10019	-3.79966
11.74619	.47090	1.73803	24.50034	.42567	-1.87958	-26.49580	26.49580	-7.53106
12.98200	.37246	1.48000	25.48435	.41370	-1.50853	-25.97525	27.96901	-8.88465
14.34783	.36162	1.37736	28.96954	.32516	-1.26019	-26.50524	29.52413	-1.87843
15.85736	.34881	1.14920	29.52433	.31531	-1.21309	-31.16572	31.16572	-5.26664
17.52570	.27590	.94071	29.521[illegible]2	.30546	-.97428	-30.57434	32.89858	-10.26660
19.36457	.24787	.87724	33.82540	.24086	-.80855	-30.99350	34.72780	-3.17133

21.40743	.25838	[illegible]	34.58664	.23356	-.18293	-36.65872	36.65872	-5.65229
23.65970	.37370	.08691	34.71095	.22626	-.62050	-35.48821	38.69700	-10.30066
26.14892	.19842	.55560	38.81403	.17842	-.51186	-35.75873	40.84862	-4.98080
28.90004	.19085	.47582	40.60322	.17301	-.50531	-43.11987	43.11987	-5.83639
31.94059	.15084	.36907	38.46998	.16760	-.37499	-39.08650	42.45905	-9.39510
35.30104	.14658	.28729	36.57834	.13176	-.26386	-33.59535	40.11078	-8.80670
39.01505	.14177	.22424	34.87357	.12816	-.24365	-37.89238	37.89238	-7.96679
43.11980	.11174	.17732	33.68389	.12415	-.18120	-34.42163	35.79668	-5.90218
47.65641	.10858	.13607	31.57352	.09730	-.12424	-28.82797	33.81688	-6.63386
52.67031	.10502	.10194	28.89370	.09493	-.11271	-31.94658	31.94658	-9.55621
56.21173	.15159	.08327	28.82995	.09196	-.08550	-29.60009	30.17972	-4.47243
64.33615	.08043	.06444	27.25186	.07208	-.05622	-23.77555	28.51057	-4.41491
71.10492	.07779	.04940	25.51900	.07032	-.05214	-26.93375	26.93375	-5.25269
78.58583	.15053	.04098	25.85733	.09339	-.04184	-26.39732	25.44413	1.62394
86.85381	.05958	.02952	22.75314	.05339	-.02638	-20.33051	24.03690	-5.34078
95.99165	.10955	.02373	22.34183	.05209	-.02412	-22.70749	22.70749	-1.61032
106.09088	.11150	.02017	23.19061	.06918	-.01947	-22.39119	21.45162	8.10658
117.25264	.04413	.01466	20.58798	.06583	-.01289	-18.10633	20.26520	1.59280
129.58873	.08103	.01164	19.97799	.03858	-.01166	-20.00000	20.00000	-.11004
143.22268	.08259	.00993	20.81294	.05124	-.00947	-19.84565	20.00000	4.06469
158.29106	.03278	.00763	19.52164	.02938	-.00678	-17.35304	20.00000	-2.39179
174.94478	.06002	.00608	19.01844	.02858	-.00640	-20.00000	20.00000	-4.98781
193.35062	.06118	.00514	19.64306	.03796	-.00505	-19.28150	20.00000	-1.78472
213.69294	.02428	.00411	19.17887	.02177	-.00371	-17.29103	20.00000	-4.10566
236.17545	.04446	.00337	19.19360	.02117	-.00351	-20.00000	20.00000	-4.03280
261.02334	.04532	.00286	19.90618	.02812	-.00278	-19.37438	20.00000	-.46912
288.48546	.01799	.00234	19.86836	.02676	-.00203	-17.22412	20.00000	-.65821
318.83686	.01735	.00190	19.76773	.01568	-.00193	-20.00000	20.00000	-1.16134
352.38151	.03357	.00154	19.52255	.02083	-.00151	-19.19160	20.00000	-2.38725
389.45538	.01332	.00132	20.45183	.01194	-.00109	-16.86468	20.00000	2.25914
430.42976	.01285	.00108	20.49363	.01162	-.00106	-20.00000	20.00000	2.46814
475.71504	.01013	.00084	19.48857	.01543	-.00080	-18.52016	20.00000	-2.55715
525.76476	.00987	.00071	20.05936	.00887	-.00057	-16.09635	20.00000	.29680
581.08018	.00952	.00060	20.66463	.00860	-.00058	-20.00000	20.00000	3.32317

WAVEFORM SYNTHESIS FOR ANNEX M, VERTICAL

SPECTRUM

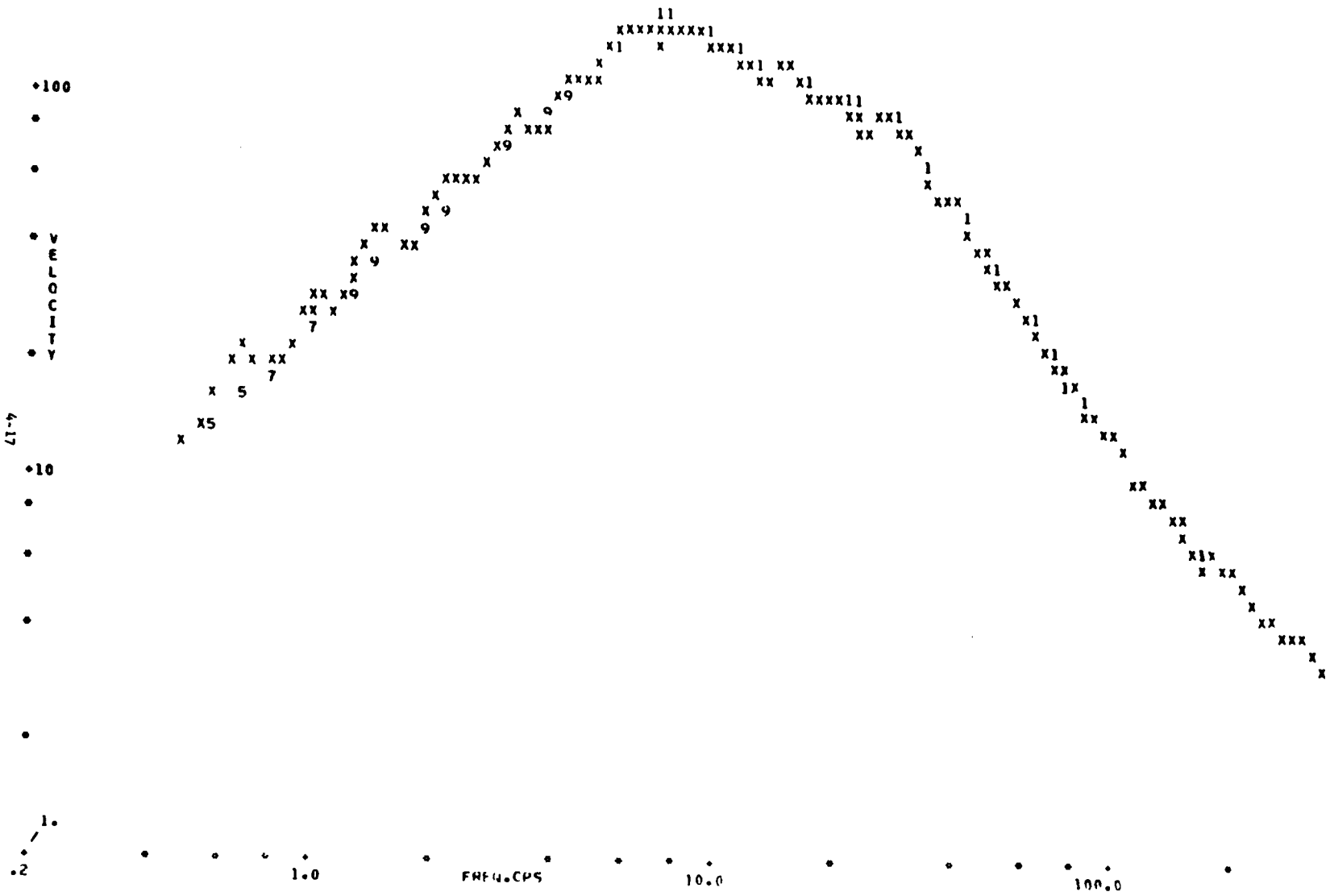
FREQ. (HZ)	ACC. IN/SEC**2	VELOC. IN/SEC	DISPL. IN
.50000	39.94508	12.71491	4.04728
.54074	48.57482	14.29688	4.20796
.58480	64.24281	17.48375	4.75872
.63246	82.55668	20.77506	5.22796
.68399	96.94125	22.55687	5.24867
.73972	102.52155	22.05796	4.74587
.80000	102.73745	20.43897	4.06620
.85111	111.27426	20.80799	3.89104
.90548	135.96487	23.89833	4.20057
.96333	169.76848	28.04808	4.63393
1.02487	196.67893	30.54283	4.74308
1.09034	207.00835	30.21624	4.41060
1.16000	213.46388	29.28779	4.01836
1.23411	248.07827	31.99309	4.12595
1.31295	315.43300	38.23666	4.63503
1.39682	379.14751	43.20026	4.92226
1.48606	437.83005	46.89095	5.02195
1.58100	454.50671	45.75400	4.60594
1.68200	452.23697	42.79177	4.04906
1.78945	494.25918	43.96320	3.91011

1.90377	621.48403	.45589	4.34350
2.02540	766.28753	60.21461	4.73154
2.15479	872.63080	64.45343	4.76060
2.29245	939.86479	65.25085	4.53009
2.43890	950.57639	62.03163	4.04799
2.59471	1019.21971	62.51717	3.83469
2.76047	1225.79702	70.67330	4.07467
2.93682	1496.28968	81.08823	4.39440
3.12444	1766.90078	90.00355	4.58466
3.32405	1954.58001	93.58500	4.48084
3.53640	1999.55593	89.98947	4.04995
3.71779	2047.53491	87.65307	3.75235
3.90847	2255.60358	91.84940	3.74016
4.10893	2645.20001	102.45892	3.96863
4.31968	3097.23680	114.11517	4.20448
4.54123	3430.57364	120.23016	4.21367
4.77415	3602.34744	120.09086	4.00345
5.01901	3761.10715	119.26631	3.78199
5.27643	4156.61474	125.37748	3.78181
5.54706	4915.24530	141.02713	4.04632
5.83156	5664.97401	154.60841	4.21957
6.13066	6206.06509	161.11249	4.18256
6.44510	6559.62170	161.98298	4.00000
6.77566	6611.63358	155.30201	3.64792
7.12318	6658.00207	148.76129	3.32381
7.48853	7063.93573	150.13103	3.19076
7.87261	7828.81875	158.26966	3.19962
8.27639	8326.86410	160.12554	3.07921
8.70088	8703.90126	159.21016	2.91224
9.14715	8708.78579	151.52774	2.63649
9.61630	8510.75755	140.85766	2.33127
10.10951	8795.02307	138.46083	2.17980
10.62802	9329.01206	139.70222	2.09204
11.17313	9758.38880	139.00278	1.98002
11.74619	10237.97572	138.71939	1.87958
12.34865	10237.87452	131.95036	1.70064
12.98200	10036.83569	123.04821	1.50853
13.64784	10474.20630	122.14545	1.42440
14.34783	11193.55448	124.16577	1.37732
15.08372	11592.87675	122.32150	1.29067
15.85736	12042.43290	120.86583	1.21309
16.67067	12063.81141	115.17323	1.09956
17.52570	11813.92326	107.28496	.97428
18.42459	12117.85354	104.67624	.90421
19.36957	12992.77466	106.75839	.87721
20.36303	13534.69903	105.78557	.82681
21.40743	14164.92812	105.31007	.78293
22.50541	14138.89593	99.98819	.70710
23.65970	13712.64451	92.24273	.62050
24.87319	13940.46233	89.20020	.57076
26.14892	14999.92970	91.29680	.55568
27.49008	15800.11453	91.47539	.52960
28.90004	16661.51600	91.75638	.50531
30.38230	16425.24756	86.04218	.45072
31.94059	15103.02210	75.25598	.37499
33.57881	14383.53865	68.17429	.32313
35.30104	14127.43129	63.69360	.28716
37.11161	14024.34788	60.14409	.25793
39.01505	14641.61642	59.72787	.24365
41.01611	14450.32453	56.07164	.21757
43.11980	13300.51848	49.09214	.18120
45.33139	12615.54373	44.29218	.15551
47.65641	12194.73119	40.72593	.13601
50.10068	11838.48270	37.60733	.11947
52.67031	12344.15773	37.30059	.11271
55.37174	12252.62024	35.21769	.10123

58.21173	11437.47292	31.27085	.08550
61.19738	11018.44690	28.65548	.07452
64.33615	10525.92843	26.03907	.06442
67.63592	10346.94725	24.34753	.05729
71.10492	10407.20008	23.29455	.05214
74.75186	10404.08298	22.15144	.04716
78.58583	10199.92625	20.65727	.04184
82.61646	9858.30386	18.99135	.03659
86.85381	8789.31660	16.10595	.02951
91.30849	8621.57626	15.02781	.02619
95.99165	8774.17604	14.54766	.02412
100.91500	8763.40692	13.82093	.02180
106.09088	8960.85145	13.44285	.02017
111.53222	8709.11266	12.42778	.01773
117.25264	7951.98849	10.79377	.01465
123.26646	7824.14811	10.10211	.01304
129.58873	7728.00000	9.49118	.01166
136.23526	7761.67343	9.06747	.01059
143.22268	8042.11912	8.93673	.00993
150.56849	8151.86378	8.61674	.00911
158.29106	7538.70871	7.57985	.00762
166.40972	7583.15977	7.25257	.00694
174.94478	7728.00000	7.03050	.00640
183.91760	7745.80922	6.70291	.00580
193.35062	7590.07695	6.24771	.00514
203.26746	7745.28066	6.06442	.00475
213.69294	7406.44753	5.51620	.00411
224.65312	7524.38294	5.33063	.00378
236.17545	7728.00000	5.20778	.00351
248.28875	7714.61487	4.94513	.00317
261.02334	7691.74670	4.68992	.00286
274.41108	7699.70488	4.46573	.00259
288.48546	7673.35358	4.23332	.00234
303.28172	7821.82953	4.10471	.00215
318.83686	7728.00000	3.85761	.00193
335.18982	7675.47203	3.64447	.00173
352.38151	7543.51314	3.40707	.00154
370.45495	7651.59273	3.28728	.00141
389.45538	7899.56627	3.22824	.00132
409.43032	8094.22294	3.14641	.00122
430.42976	7918.73809	2.92802	.00108
452.50625	7628.58711	2.68312	.00094
475.71504	7530.38354	2.51936	.00084
500.11419	7499.96398	2.38677	.00076
525.76476	7750.71909	2.34623	.00071
552.73093	8087.77096	2.32882	.00067
581.08018	7984.81484	2.18700	.00060

SPECTRUM FROM THE SYNTHESIZED WAVEFORM

WAVEFORM SYNTHESIS FOR ANNEX M. VERTICAL 12/17/71 0100 HR.



SYNTHESIZED WAVEFORM

NO. OF DATA POINTS ON TIME TABLE = 1019

TIME SEC.	ACCEL. G.S	VELOCITY INS/SEC.	DISPL. INS.
0.0000	0.0000	0.0000	0.0000
.0001	.0140	.0001	.0000
.0001	.0551	.0008	.0000
.0002	.1210	.0027	.0000
.0002	.2079	.0063	.0000
.0003	.3110	.0121	.0000
.0003	.4243	.0202	.0000
.0004	.5415	.0309	.0000
.0005	.6557	.0442	.0000
.0005	.7605	.0599	.0000
.0006	.8499	.0778	.0000
.0006	.9186	.0974	.0000
.0007	.9627	.1183	.0000
.0007	.9795	.1399	.0000
.0008	.9680	.1615	.0000
.0009	.9287	.1826	.0000
.0009	.8638	.2025	.0001
.0010	.7768	.2207	.0001
.0010	.6727	.2368	.0001
.0011	.5574	.2505	.0001
.0011	.4376	.2615	.0001
.0012	.3203	.2699	.0001
.0013	.2123	.2758	.0001
.0013	.1202	.2794	.0002
.0014	.0497	.2813	.0002
.0014	.0053	.2818	.0002
.0015	-.0099	.2817	.0002
.0015	.0057	.2816	.0002
.0016	.0519	.2822	.0002
.0017	.1268	.2841	.0003
.0017	.2269	.2880	.0003
.0018	.3471	.2943	.0003
.0018	.4815	.3035	.0003
.0019	.6227	.3157	.0003
.0020	.7634	.3311	.0003
.0020	.8959	.3495	.0004
.0021	1.0129	.3707	.0004
.0021	1.1078	.3942	.0004
.0022	1.1752	.4196	.0004
.0022	1.2114	.4461	.0005
.0023	1.2136	.4731	.0005
.0024	1.1817	.4997	.0005
.0024	1.1172	.5252	.0005
.0025	1.0234	.5490	.0006
.0025	.9053	.5704	.0006
.0026	.7694	.5890	.0006
.0026	.6235	.6044	.0007
.0027	.4758	.6166	.0007
.0028	.3341	.6256	.0007
.0028	.2100	.6316	.0008

.0029	.1043	.6351	.0008
.0029	.0368	.6366	.0008
.0030	.0009	.6369	.0009
.0030	.0042	.6369	.0009
.0031	.0480	.6374	.0010
.0032	.1317	.6394	.0010
.0032	.2526	.6435	.0010
.0033	.4056	.6508	.0011
.0033	.5839	.6617	.0011
.0034	.7791	.6768	.0011
.0034	.9816	.6963	.0012
.0035	1.1813	.7203	.0012
.0036	1.3678	.7486	.0013
.0036	1.5309	.7808	.0013
.0037	1.6617	.8162	.0014
.0037	1.7523	.8541	.0014
.0038	1.7970	.8935	.0015
.0038	1.7921	.9334	.0015
.0039	1.7365	.9726	.0016
.0040	1.6315	1.0100	.0016
.0040	1.4811	1.0446	.0017
.0041	1.2917	1.0754	.0017
.0041	1.0720	1.1016	.0018
.0042	.8325	1.1228	.0019
.0042	.5848	1.1385	.0019
.0043	.3417	1.1487	.0020
.0044	.1159	1.1538	.0021
.0044	-.0803	1.1541	.0021
.0045	-.2357	1.1505	.0022
.0045	-.3405	1.1440	.0023
.0046	-.3875	1.1358	.0023
.0046	-.3717	1.1273	.0024
.0047	-.2913	1.1198	.0025
.0048	-.1472	1.1149	.0025
.0048	.0563	1.1138	.0026
.0049	.3120	1.1177	.0026
.0049	.6101	1.1279	.0027
.0050	.9384	1.1450	.0028
.0050	1.2829	1.1696	.0028
.0051	1.6286	1.2019	.0029
.0052	1.9598	1.2417	.0030
.0052	2.2610	1.2886	.0031
.0053	2.5179	1.3416	.0031
.0053	2.7176	1.3998	.0032
.0054	2.8494	1.4616	.0033
.0054	2.9055	1.5255	.0034
.0055	2.8812	1.5898	.0035
.0056	2.7753	1.6526	.0036
.0056	2.5901	1.7122	.0037
.0057	2.3312	1.7669	.0038
.0057	2.0080	1.8151	.0039
.0058	1.6323	1.8555	.0040
.0059	1.2188	1.8872	.0041
.0059	.7837	1.9094	.0042
.0060	.3448	1.9219	.0043
.0060	-.0801	1.9248	.0044
.0061	-.4732	1.9186	.0045
.0061	-.8179	1.9042	.0046
.0062	-1.0996	1.8828	.0047

12 computer output pages have been deleted hereafter.

.0065	-.9941	1.7075	.0053
.0066	-.6714	1.6889	.0054

1.8409	.1041	-4.6887	.7886
1.8546	.1170	-4.1043	.7284
1.8744	.1319	-3.1482	.6564
1.8942	.1413	-2.0988	.6043
1.9140	.1450	-.9987	.5735
1.9339	.1430	.1079	.5647
1.9537	.1354	1.1774	.5776
1.9735	.1226	2.1684	.6109
1.9933	.1053	3.0435	.6627
2.0131	.0841	3.7707	.7305
2.0330	.0601	4.3244	.8110
2.0528	.0342	4.6866	.9007
2.0726	.0076	4.8469	.9955
2.0924	-.0189	4.8030	1.0914
2.1122	-.0442	4.5605	1.1845
2.1320	-.0674	4.1317	1.2709
2.1519	-.0878	3.5355	1.3472
2.1717	-.1048	2.7959	1.4101
2.1915	-.1179	1.9406	1.4572
2.2113	-.1271	.9999	1.4865
2.2311	-.1320	.0053	1.4965
2.2509	-.1331	-1.0122	1.4865
2.2708	-.1303	-2.0229	1.4564
2.2906	-.1243	-2.9998	1.4066
2.3104	-.1154	-3.9191	1.3379
2.3302	-.1043	-4.7614	1.2518
2.3500	-.0914	-5.5114	1.1498
2.3699	-.0775	-6.1585	1.0340
2.3897	-.0630	-6.6963	.9064
2.4095	-.0484	-7.1224	.7693
2.4293	-.0341	-7.4379	.6249
2.4491	-.0205	-7.6465	.4752
2.4689	-.0077	-7.7538	.3225
2.4888	.0042	-7.7667	.1685
2.5086	.0151	-7.6924	.0152
2.5284	.0251	-7.5379	-.1358
2.5482	.0345	-7.3094	-.2831
2.5680	.0432	-7.0116	-.4251
2.5878	.0516	-6.6483	-.5606
2.6077	.0598	-6.2214	-.6882
2.6275	.0680	-5.7319	-.8067
2.6473	.0762	-5.1796	-.9150
2.6671	.0845	-4.5641	-1.0116
2.6869	.0926	-3.8854	-1.0954
2.7157	.1020	-2.8021	-1.1918
2.7444	.1083	-1.6313	-1.2556
2.7731	.1112	-.4092	-1.2850
2.8019	.1108	.8267	-1.2790
2.8306	.1071	2.0395	-1.2377
2.8594	.1003	3.1938	-1.1624
2.8881	.0908	4.2574	-1.0551
2.9168	.0790	5.2024	-.9188
2.9456	.0655	6.0062	-.7574
2.9743	.0507	6.6517	-.5752
3.0030	.0352	7.1286	-.3768
3.0318	.0196	7.4326	-.1671
3.0605	.0045	7.5658	.0488
3.0892	-.0097	7.5359	.2661
3.1180	-.0225	7.3557	.4804
3.1467	-.0336	7.0424	.6876
3.1754	-.0428	6.6162	.8841
3.2042	-.0499	6.0993	1.0670
3.2329	-.0549	5.5150	1.2340
3.2617	-.0579	4.8867	1.3835
3.2904	-.0589	4.2363	1.5146
3.3191	-.0583	3.5840	1.6269

3.3479	-.0562	2.9474	1.7207
3.3766	-.0529	2.3406	1.7966
3.4053	-.0489	1.7747	1.8556
3.4341	-.0443	1.2569	1.8991
3.4628	-.0396	.7911	1.9284
3.4915	-.0348	.3782	1.9450
3.5203	-.0304	.0163	1.9506
3.5490	-.0264	-.2986	1.9464
3.5777	-.0229	-.5717	1.9338
3.6065	-.0200	-.8094	1.9139
3.6352	-.0176	-1.0180	1.8876
3.6639	-.0158	-1.2032	1.8556
3.6927	-.0143	-1.3701	1.8186
3.7214	-.0131	-1.5222	1.7770
3.7502	-.0120	-1.6617	1.7313
3.7789	-.0109	-1.7891	1.6816
3.8076	-.0096	-1.9031	1.6286
3.8364	-.0081	-2.0016	1.5724
3.8651	-.0062	-2.0811	1.5137
3.8938	-.0040	-2.1379	1.4530
3.9355	-.0013	-2.1802	1.3629
3.9772	.0007	-2.1843	1.2719
4.0188	.0021	-2.1605	1.1813
4.0605	.0030	-2.1183	1.0921
4.1022	.0035	-2.0652	1.0049
4.1438	.0037	-2.0072	.9201
4.1855	.0037	-1.9476	.8377
4.2272	.0037	-1.8878	.7578
4.2688	.0039	-1.8266	.6804
4.3105	.0043	-1.7611	.6056
4.3522	.0050	-1.6869	.5337
4.3938	.0060	-1.5991	.4652
4.4640	.0073	-1.4185	.3591
4.5342	.0080	-1.2101	.2668
4.6044	.0082	-.9898	.1896
4.6745	.0078	-.7723	.1278
4.7447	.0070	-.5704	.0808
4.8149	.0059	-.3941	.0471
4.8851	.0047	-.2501	.0247
4.9552	.0034	-.1414	.0112
5.0254	.0021	-.0675	.0041
5.0956	.0011	-.0243	.0010
5.1658	.0004	-.0048	.0001
5.2359	.0000	-.0001	.0000
5.3061	0.0000	0.0000	0.0000

TO WRITE AND PUNCH AN EQUIVALENT MANUAL INPUT DATA DECK

WAVEFORM SYNTHESIS FOR ANNEX M, VERTICAL

```
 1
23    0     0
   .500      .800     1.160     1.682     2.439     3.536     4.774     6.445
  8.701    11.746    15.857    21.407    28.900    39.015    52.670    71.105
 95.992   129.589   174.945   236.175   318.837   430.430   581.080
  5.000     7.000     9.000     9.000     9.000     9.000    11.000    11.000
 11.000    11.000    11.000    11.000    11.000    11.000    11.000    11.000
 11.000    11.000    11.000    11.000    11.000    11.000    11.000
   .102      .262      .550     1.156     2.431     5.111     9.315    16.976
 22.526    26.496    31.166    36.659    43.120    37.892    31.947    26.934
 22.707    20.000    20.000    20.000    20.000    20.000    20.000
  0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
  0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
  0.000     0.000     0.000     0.000     0.000     0.000     0.000
```

A DECK OF CARDS IS PUNCHED

END OF ANALYSIS

SECTION 3: EXAMPLE TO SYNSOL

AN INDEPENDENT SYNSOL EXAMPLE RUN

```
        10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+   NO.

       3                                                                          1
         1         1         3                                                    2
       502  5.943100     0.707                                                    3
         0       0.0     0.707                                                    4
       570  7.641600       1.0                                                    5
                                                                                  6
                                                                                  7
                                   TIME TABLE                                     8
                                                                                  9
  0.000    .000    .001    .001    .002    .002    .002    .003    .003            10
   .004    .004    .004    .005    .005    .005    .006    .006    .007            11
   .007    .007    .008    .008    .009    .009    .009    .010    .010            12
   .011    .011    .011    .012    .012    .012    .013    .013    .014            13
   .014    .014    .015    .015    .016    .016    .016    .017    .017            14
   .018    .018    .018    .019    .019    .019    .020    .020    .021            15
   .021    .021    .022    .022    .023    .023    .023    .024    .024            16
   .025    .025    .025    .026    .026    .027    .027    .027    .028            17
   .028    .028    .029    .029    .030    .030    .031    .032    .032            18
   .033    .034    .034    .035    .036    .036    .037    .038    .038            19
   .039    .040    .040    .041    .042    .042    .043    .044    .044            20
   .045    .046    .046    .047    .048    .048    .049    .050    .050            21
   .051    .052    .052    .053    .054    .054    .055    .056    .056            22
   .057    .058    .058    .059    .060    .060    .061    .062    .062            23
   .063    .064    .064    .065    .066    .066    .067    .068    .068            24
   .069    .070    .070    .071    .073    .074    .075    .076    .077            25
   .078    .080    .081    .082    .083    .084    .086    .087    .088            26
   .090    .092    .094    .096    .098    .100    .102    .105    .107            27
   .109    .111    .113    .115    .117    .119    .121    .123    .125            28
   .127    .130    .132    .134    .136    .138    .140    .142    .144            29
   .146    .148    .150    .152    .155    .157    .159    .161    .163            30
   .165    .167    .169    .171    .173    .175    .177    .180    .182            31
   .184    .186    .188    .190    .192    .194    .196    .198    .200            32
   .202    .205    .207    .209    .211    .213    .215    .217    .219            33
   .223    .226    .230    .233    .237    .240    .244    .247    .251            34
   .254    .258    .261    .265    .270    .276    .281    .287    .292            35
   .298    .304    .309    .315    .320    .326    .331    .337    .342            36
   .348    .354    .359    .365    .370    .376    .381    .387    .392            37
   .398    .404    .409    .415    .420    .426    .431    .437    .442            38
   .448    .454    .459    .465    .470    .476    .481    .487    .492            39
   .498    .504    .509    .515    .520    .526    .531    .537    .542            40
   .548    .554    .559    .565    .570    .576    .581    .587    .596            41
   .605    .614    .623    .632    .641    .650    .659    .668    .677            42
   .686    .695    .704    .713    .722    .731    .740    .749    .758            43
   .767    .776    .785    .794    .803    .812    .821    .830    .839            44
   .848    .857    .866    .875    .884    .893    .902    .911    .920            45
   .929    .938    .947    .963    .978    .994   1.009   1.025   1.040            46
  1.056   1.071   1.087   1.102   1.118   1.133   1.149   1.164   1.180            47
  1.195   1.211   1.226   1.242   1.257   1.273   1.288   1.304   1.319            48
  1.335   1.350   1.366   1.381   1.397   1.412   1.428   1.443   1.459            49
  1.474   1.490   1.505   1.521   1.536   1.552   1.567   1.583   1.598            50
  1.614   1.629   1.653   1.677   1.701   1.725   1.749   1.772   1.796            51
```

```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

   1.820     1.844     1.868     1.891     1.915     1.939     1.963     1.987     2.010      52
   2.034     2.058     2.082     2.106     2.129     2.153     2.177     2.201     2.225      53
   2.249     2.272     2.296     2.320     2.344     2.368     2.391     2.415     2.439      54
   2.463     2.487     2.510     2.534     2.558     2.582     2.606     2.629     2.653      55
   2.677     2.701     2.725     2.749     2.772     2.796     2.820     2.844     2.868      56
   2.891     2.915     2.939     2.963     2.987     3.010     3.034     3.058     3.082      57
   3.106     3.129     3.153     3.177     3.201     3.225     3.262     3.299     3.336      58
   3.373     3.410     3.447     3.484     3.521     3.558     3.595     3.632     3.669      59
   3.706     3.743     3.780     3.817     3.854     3.891     3.928     3.965     4.002      60
   4.040     4.077     4.114     4.151     4.188     4.225     4.262     4.299     4.336      61
   4.373     4.410     4.447     4.484     4.521     4.558     4.595     4.632     4.669      62
   4.706     4.743     4.780     4.817     4.854     4.891     4.928     4.965     5.002      63
   5.058     5.114     5.169     5.225     5.280     5.336     5.391     5.447     5.502      64
   5.558     5.614     5.669     5.725     5.780     5.836     5.943                          65
                                                                                              66
                                                                                              67
                                   ACCELERATION TABLE                                         68
                                                                                              69
     0.000     1.547     6.081    13.287    22.664    33.555    45.197    56.769    67.447     70
    76.460    83.145    86.992    87.679    85.099    79.370    70.828    60.012    47.630     71
    34.515    21.573     9.726     -.148    -7.276   -11.038   -11.015    -7.013     .909     72
    12.447    27.058    43.995    62.340    81.067    99.092   115.345   128.832   138.694     73
   144.265   145.110   141.057   132.210   118.946   101.899    81.922    60.044    37.411     74
    15.220    -5.347   -23.188   -37.349   -47.071   -51.838   -51.399   -45.786   -35.307     75
   -20.529    -2.239    18.599    40.901    63.525    85.338   105.277   122.406   135.966     76
   145.412   150.436   150.976   147.211   139.535   128.532   114.924    99.527    83.188     77
    66.739    50.937    36.423    23.686    11.963    -7.578   -25.509   -40.731   -52.224     78
   -59.116   -60.719   -56.582   -46.513   -30.600    -9.214    17.005    47.168    80.177     79
   114.774   149.595   183.235   214.310   241.523   263.720   279.948   289.494   291.915     80
   287.060   275.072   256.376   231.659   201.831   167.982   131.326    93.148    54.739     81
    17.345   -17.892   -49.980   -78.109  -101.684  -120.333  -133.915  -142.507  -146.381     82
  -145.980  -141.875  -134.729  -125.244  -114.126  -102.038   -89.568   -77.198   -65.286     83
   -54.055   -43.594   -33.867   -24.731   -15.961    -7.281     1.604    10.972    21.049     84
    31.988    43.837    56.372    76.455    92.809   104.790   112.028   114.433   112.189     85
   105.728    95.688    82.861    68.134    52.422    36.608    21.478     7.675    -4.360     86
   -25.182   -46.728   -67.911   -87.600  -104.675  -118.094  -126.946  -130.509  -128.290     87
  -120.061  -105.879   -86.093   -61.332   -32.483     -.654    32.873    66.702    99.390     88
   129.509   155.719   176.827   191.849   200.051   200.989   194.525   180.837   160.407     89
   133.998   102.615    67.462    29.879    -8.718   -46.900   -83.292  -116.633  -145.825     90
  -169.980  -188.449  -200.843  -207.036  -207.160  -201.578  -190.864  -175.751  -157.092     91
  -135.810  -112.843   -89.102   -65.421   -42.529   -21.016    -1.317    16.290    31.683     92
    44.884    56.031    65.355    73.141    79.696    85.313    90.238    94.643    98.585     93
   101.331    97.891    88.528    73.828    54.662    32.129     7.481   -17.948   -42.830     94
   -65.917   -86.116  -102.550  -114.887  -129.906  -139.358  -142.415  -138.555  -127.593     95
  -109.704   -85.421   -55.619   -21.473    15.586    53.946    91.882   127.645   159.543     96
   186.023   205.749   217.666   221.053   215.554   201.202   178.412   147.965   110.966     97
    68.796    23.041   -24.575   -72.279  -118.321  -161.055  -199.010  -230.949  -255.916     98
  -273.266  -282.683  -284.174  -278.055  -264.917  -245.580  -221.041  -192.414  -160.863     99
  -127.548   -93.560   -59.878   -27.328     3.448    31.997    58.066    81.581   102.629    100
   121.419   138.248   153.455   167.371   180.285   192.400   203.808   214.021   224.338    101
   226.386   220.181   206.103   184.869   157.495   125.233    89.513    51.865    13.845    102
   -23.041   -57.410   -88.059  -114.021  -134.595  -149.371  -158.236  -161.355  -159.154    103
  -152.274  -141.524  -127.824  -112.148   -95.458   -78.651   -62.511   -47.665   -34.559    104
```

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        10        20        30        40        50        60        70        80   CARD
........+.........+.........+.........+.........+.........+.........+.........+    NO.

-23.439 -14.351  -7.155  -1.545   2.913   6.737  10.485  14.704  19.878            105
 26.390  34.483  44.207  60.788  74.786  85.522  92.477  95.312  93.891            106
 88.278  78.739  65.725  49.844  31.835  12.523  -7.216 -26.505 -44.506            107
-60.458 -73.719 -83.786 -90.323 -93.167 -92.331 -88.000 -80.509 -70.325            108
-58.013 -44.206 -29.567 -14.752   -.378  13.011  24.962  35.139  43.330            109
 49.450  53.534  55.730  56.274  55.471  53.665  51.213  48.457  45.695            110
 43.164  41.013  36.989  31.306  24.188  15.923   6.852  -2.646 -12.170            111
-21.318 -29.707 -36.983 -42.845 -47.054 -49.444 -49.931 -48.511 -45.266            112
-40.353 -33.999 -26.491 -18.157  -9.354   -.451   8.188  16.221  23.344            113
 29.300  33.893  36.992  38.538  38.539  37.070  34.268  30.318  25.446            114
 19.905  13.959   7.874   1.901  -3.735  -8.843 -13.275 -16.929 -19.755            115
-21.749 -22.955 -23.451 -23.352 -22.790 -21.912 -20.864 -19.784 -18.793            116
-17.987 -17.428 -17.149 -17.144 -17.375 -17.773 -18.244 -18.679 -18.959            117
-18.966 -18.589 -17.739 -16.348 -14.382 -11.880  -7.603  -3.115   1.419            118
  5.832   9.971  13.692  16.874  19.423  21.272  22.383  22.752  22.404            119
 21.394  19.797  17.713  15.253  12.538   9.690   6.832   4.073   1.512            120
  -.771  -2.713  -4.276  -5.442  -6.215  -6.617  -6.687  -6.476  -6.046            121
 -5.461  -4.786  -4.081  -3.401  -2.788  -2.273  -1.873  -1.590  -1.416            122
 -1.328  -1.298  -1.289  -1.262  -1.185  -1.039   -.797   -.441    .035            123
   .767   1.368   1.817   2.103   2.228   2.202   2.046   1.790   1.465            124
  1.109    .759    .447    .203    .050   0.000   0.000                            125
                                                                                    126
                                                                                    127
                                  TIME TABLE                                        128
                                                                                    129
  0.000    .000    .001    .001    .001    .002    .002    .002    .003            130
   .003    .004    .004    .004    .005    .005    .005    .006    .006            131
   .006    .007    .007    .007    .008    .008    .008    .009    .009            132
   .009    .010    .010    .011    .011    .011    .012    .012    .012            133
   .013    .013    .013    .014    .014    .014    .015    .015    .015            134
   .016    .016    .016    .017    .017    .018    .018    .018    .019            135
   .019    .019    .020    .020    .020    .021    .021    .021    .022            136
   .022    .022    .023    .023    .024    .024    .024    .025    .025            137
   .025    .026    .026    .026    .027    .027    .028    .028    .029            138
   .029    .030    .031    .031    .032    .032    .033    .033    .034            139
   .034    .035    .036    .036    .037    .037    .038    .038    .039            140
   .039    .040    .041    .041    .042    .042    .043    .043    .044            141
   .044    .045    .046    .046    .047    .047    .048    .048    .049            142
   .049    .050    .051    .051    .052    .052    .053    .053    .054            143
   .054    .055    .056    .056    .057    .057    .058    .058    .059            144
   .060    .061    .062    .063    .064    .065    .066    .067    .068            145
   .069    .070    .071    .072    .073    .074    .075    .076    .078            146
   .079    .081    .083    .084    .086    .088    .089    .091    .093            147
   .094    .096    .098    .099    .101    .103    .104    .106    .108            148
   .109    .111    .113    .114    .116    .118    .119    .121    .123            149
   .124    .126    .128    .129    .131    .133    .134    .136    .138            150
   .139    .141    .143    .144    .146    .148    .149    .151    .153            151
   .154    .156    .158    .159    .161    .163    .164    .166    .168            152
   .169    .171    .173    .174    .176    .178    .179    .181    .183            153
   .184    .186    .188    .189    .191    .193    .194    .196    .198            154
   .199    .201    .203    .204    .206    .208    .209    .211    .213            155
   .214    .216    .218    .219    .221    .223    .224    .226    .228            156
   .231    .233    .235    .237    .240    .242    .244    .247    .249            157
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         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

    .251      .254      .256      .258      .260      .263      .265      .267      .270          158
    .272      .274      .277      .279      .281      .283      .286      .288      .290          159
    .293      .295      .297      .299      .302      .304      .306      .309      .311          160
    .314      .318      .321      .324      .328      .331      .334      .338      .341          161
    .344      .348      .351      .357      .362      .368      .373      .379      .384          162
    .390      .395      .401      .407      .412      .418      .423      .429      .434          163
    .440      .445      .451      .457      .462      .468      .473      .479      .484          164
    .490      .495      .501      .507      .512      .518      .523      .529      .534          165
    .540      .545      .551      .557      .562      .568      .573      .579      .584          166
    .593      .601      .609      .618      .626      .634      .643      .651      .659          167
    .668      .676      .684      .693      .701      .709      .718      .726      .734          168
    .743      .751      .759      .768      .776      .784      .793      .801      .809          169
    .818      .826      .834      .843      .851      .859      .868      .876      .889          170
    .903      .916      .929      .943      .956      .969      .983      .996     1.009          171
   1.023     1.036     1.049     1.063     1.076     1.089     1.103     1.116     1.129          172
   1.143     1.156     1.169     1.183     1.196     1.209     1.223     1.236     1.249          173
   1.263     1.276     1.289     1.303     1.316     1.329     1.343     1.356     1.369          174
   1.383     1.396     1.409     1.432     1.454     1.476     1.498     1.520     1.543          175
   1.565     1.587     1.609     1.632     1.654     1.676     1.698     1.720     1.743          176
   1.765     1.787     1.809     1.832     1.854     1.876     1.898     1.920     1.943          177
   1.965     1.987     2.009     2.032     2.054     2.076     2.098     2.120     2.143          178
   2.165     2.187     2.209     2.232     2.254     2.276     2.298     2.320     2.343          179
   2.376     2.409     2.443     2.476     2.509     2.543     2.576     2.609     2.643          180
   2.676     2.709     2.743     2.776     2.809     2.843     2.876     2.909     2.943          181
   2.976     3.009     3.043     3.076     3.109     3.143     3.176     3.209     3.243          182
   3.276     3.309     3.343     3.376     3.409     3.443     3.476     3.509     3.543          183
   3.576     3.609     3.643     3.676     3.709     3.743     3.776     3.809     3.843          184
   3.876     3.909     3.943     3.976     4.009     4.043     4.076     4.109     4.143          185
   4.176     4.209     4.243     4.276     4.309     4.343     4.376     4.409     4.443          186
   4.476     4.509     4.565     4.620     4.676     4.732     4.787     4.843     4.898          187
   4.954     5.009     5.065     5.120     5.176     5.232     5.287     5.343     5.398          188
   5.454     5.509     5.565     5.620     5.676     5.732     5.787     5.843     5.898          189
   5.954     6.009     6.065     6.120     6.176     6.232     6.287     6.343     6.398          190
   6.454     6.509     6.565     6.620     6.676     6.732     6.787     6.843     6.898          191
   6.954     7.009     7.065     7.120     7.176     7.232     7.287     7.343     7.398          192
   7.454     7.509     7.642                                                                    193
                                                                                                194
                                                                                                195
                                ACCELERATION TABLE                                              196
                                                                                                197
     0.000     4.165    16.410    36.009    61.797    92.250   125.577   159.834   193.046     198
   223.330   249.012   268.732   281.528   286.894   284.810   275.738   260.593   240.678     199
   217.600   193.162   169.245   147.685   130.150   118.030   112.346   113.675   122.113     200
   137.264   158.259   183.807   212.279   241.803   270.385   296.035   316.893   331.352     201
   338.159   336.504   326.074   307.078   280.244   246.780   208.301   166.740   124.229     202
    82.973    45.112    12.594   -12.948   -30.298   -38.734   -38.077   -28.707   -11.542     203
    12.008    40.124    70.685   101.386   129.880   153.910   171.443   180.795   180.721     204
   170.496   149.954   119.502    80.091    33.171   -19.401   -75.456  -132.638  -188.535     205
  -240.802  -287.290  -326.150  -355.921  -377.830  -399.265  -402.383  -385.493  -347.732     206
  -289.142  -210.696  -114.281    -2.639   120.741   251.764   385.902   518.388   644.426     207
   759.400   859.074   939.777   998.560  1033.315  1042.860  1026.973   986.385   922.727     208
   838.439   736.640   620.975   495.433   364.167   231.305   100.774   -23.864  -139.538     209
  -243.778  -334.779  -411.427  -473.292  -520.584  -554.076  -575.000  -584.928  -585.639     210
```

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         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

-578.986-566.766-550.608-531.873-511.590-490.414-468.614-446.093-422.440             211
-396.997-368.954-337.448-301.675-260.990-215.003-163.657-107.281 -49.150             212
  50.831 140.311 215.158 272.300 309.861 327.230 325.042 305.082 270.121             213
 223.688 169.805 112.694  56.477   4.896 -38.940 -72.754 -98.463-139.828             214
-178.158-211.059-236.331-252.093-256.898-249.827-230.549-199.357-157.171             215
-105.507 -46.409  17.641  83.844 149.221 210.760 265.572 311.044 344.972             216
 365.684 372.135 363.965 341.534 305.909 258.823 202.592 140.008  74.201             217
   8.482 -53.821-109.536-155.809-190.258-211.098-217.245-208.381-184.983             218
-148.312-100.369 -43.800  18.219  82.126 144.148 200.475 247.447 281.732             219
 300.490 301.519 283.364 245.405 187.891 111.951  19.548 -86.588-203.077             220
-326.025-451.184-574.129-690.439-795.880-886.570-959.134-1010.83-1039.65             221
-1044.37-1024.60-980.763-914.057-826.380-720.237-598.615-464.854-322.501             222
-175.174 -26.422 120.392 262.201 396.311 520.462 632.861 732.186 817.571             223
 888.571 945.102 987.381 1015.848 1031.096 1033.799 1024.647 1003.696 951.844        224
 875.010 776.397 659.850 529.684 390.491 246.944 103.608 -35.236-165.747             225
-284.650-389.335-477.909-549.225-602.866-639.099-658.797-663.341-654.504             226
-634.324-604.974-568.638-527.399-483.141-437.475-391.689-346.722-303.164             227
-261.283-221.066-182.285-144.566-107.469 -70.567 -33.517   3.878  41.454             228
  90.049 129.495 160.159 182.990 199.397 211.104 219.982 227.879 236.455             229
 247.034 260.484 276.797 296.838 302.938 294.404 271.253 234.216 184.707             230
 124.755  56.912 -15.880 -90.424-163.426-231.656-292.100-342.105-379.498             231
-[illegible].686-410.721-403.334-380.935-344.573-295.877-236.957-170.291 -98.597     232
 -2[illegible].691  48.644 118.792 183.420 240.571 288.739 326.911 354.579 371.730   233
 378.805 376.632 366.343 349.283 326.904 300.661 271.925 241.888 211.442             234
 160.806 103.572  42.163 -20.855 -82.900-141.492-194.372-239.602-275.643             235
-301.419-316.349-320.353-313.831-297.626-272.952-241.317-204.429-164.094             236
-122.116 -80.205 -39.886  -2.439  31.163  60.275  84.594 104.140 119.228             237
 130.411 138.420 144.086 148.266 151.766 155.269 159.279 164.049 168.366             238
 165.908 156.883 141.795 121.415  96.742  68.942  39.291   9.111 -20.299             239
 -47.726 -72.097 -92.529-108.367-119.204-124.892-125.537-121.479-113.266             240
-101.607 -87.331 -71.330 -54.506 -37.720 -21.747  -7.231   5.338  15.652             241
  23.582  29.180  32.662  34.377  34.780  34.383  33.719  33.295  33.549             242
  34.821  37.318  40.639  44.857  47.063  47.134  45.048  40.889  34.843             243
  27.184  18.262   8.487  -1.696 -11.827 -21.452 -30.149 -37.547 -43.340             244
 -47.306 -49.309 -49.309 -47.359 -43.599 -38.246 -31.579 -23.928 -15.647             245
  -7.102   1.351   9.383  16.709  23.098  28.382  32.463  35.309  36.955             246
  37.491  37.057  35.823  33.982  31.730  29.254  26.718  24.252  21.889             247
  17.722  12.763   7.206   1.272  -4.802 -10.776 -16.414 -21.499 -25.838             248
 -29.274 -31.691 -33.020 -33.239 -32.374 -30.498 -27.725 -24.204 -20.111             249
 -15.641 -10.999  -6.386  -1.994   2.003   5.461   8.266  10.344  11.657             250
  12.209  12.040  11.225   9.866   8.089   6.031   3.838   1.654   -.387             251
  -2.168  -3.594  -4.594  -5.130  -5.191  -4.798  -3.997  -2.859  -1.473             252
    .061   1.635   3.143   4.485   5.577   6.349   6.754   6.770   6.399             253
   5.666   4.621   3.329   1.873    .341  -1.172  -2.577  -3.790  -4.743             254
  -5.384  -5.692  -5.839  -5.650  -5.137  -4.328  -3.263  -1.997   -.592             255
    .883   2.358   3.762   5.030   6.103   6.935   7.490   7.747   7.701             256
   7.358   6.742   5.888   4.840   3.653   2.385   1.096   -.152  -1.306             257
  -2.314  -3.148  -3.789  -4.218  -4.427  -4.420  -4.213  -3.829  -3.302             258
  -2.669  -1.971  -1.250   -.546    .104    .670   1.128   1.464   1.671             259
   1.751   1.716   1.581   1.371   1.112    .832    .560    .322    .140             260
    .029   0.000   0.000                                                             261
```

THE RESULT OF THIS EXAMPLE RUN IS PRESENTED ON THE FOLLOWING PAGES.

OPTION, PLOT = 1

....WAVSYN OUTPUT DECK HAS BEEN MODIFIED BY SYNSOL, REMOVE FIRST
4 COMMENT CARDS BEFORE USING IN ISOL PROGRAM

1 1 3

END INPUT TO SYNSOL

ACCELERATION UNIT IN G.S

3 CASES

TIME STEPS =	502	TIME DURATION =	5.9431	MULT. FACTOR =	.70700
TIME STEPS =	0	TIME DURATION =	0.0000	MULT. FACTOR =	.70700
TIME STEPS =	570	TIME DURATION =	7.6416	MULT. FACTOR =	1.00000

SET NO. 1 TIME TABLE

TOTAL NUMBER OF POINTS (=NC IN ISOL) = 500

0.00000	0.00000	.00100	.00100	.00200	.00200	.00200	.00300	.00300	NO. 0- 1
.00400	.00400	.00400	.00500	.00500	.00500	.00600	.00600	.00700	NO. 0- 2
.00700	.00700	.00800	.00800	.00900	.00900	.00900	.01000	.01000	NO. 0- 3
.01100	.01100	.01100	.01200	.01200	.01200	.01300	.01300	.01400	NO. 0- 4
.01400	.01400	.01500	.01500	.01600	.01600	.01600	.01700	.01700	NO. 0- 5
.01800	.01800	.01800	.01900	.01900	.01900	.02000	.02000	.02100	NO. 0- 6
.02100	.02100	.02200	.02200	.02300	.02300	.02300	.02400	.02400	NO. 0- 7
.02500	.02500	.02500	.02600	.02600	.02700	.02700	.02700	.02800	NO. 0- 8
.02800	.02800	.02900	.02900	.03000	.03000	.03100	.03200	.03200	NO. 0- 9
.03300	.03400	.03400	.03500	.03600	.03600	.03700	.03800	.03800	NO. 0- 10
.03900	.04000	.04000	.04100	.04200	.04200	.04300	.04400	.04400	NO. 0- 11
.04500	.04600	.04600	.04700	.04800	.04800	.04900	.05000	.05000	NO. 0- 12
.05100	.05200	.05200	.05300	.05400	.05400	.05500	.05600	.05600	NO. 0- 13
.05700	.05800	.05800	.05900	.06000	.06000	.06100	.06200	.06200	NO. 0- 14
.06300	.06400	.06400	.06500	.06600	.06600	.06700	.06800	.06800	NO. 0- 15
.06900	.07000	.07000	.07100	.07300	.07400	.07500	.07600	.07700	NO. 0- 16
.07800	.08000	.08100	.08200	.08300	.08400	.08600	.08700	.08800	NO. 0- 17
.09000	.09200	.09400	.09600	.09800	.10000	.10200	.10500	.10700	NO. 0- 18
.10900	.11100	.11300	.11500	.11700	.11900	.12100	.12300	.12500	NO. 0- 19
.12700	.13000	.13200	.13400	.13600	.13800	.14000	.14200	.14400	NO. 0- 20
.14600	.14800	.15000	.15200	.15500	.15700	.15900	.16100	.16300	NO. 0- 21
.16500	.16700	.16900	.17100	.17300	.17500	.17700	.18000	.18200	NO. 0- 22
.18400	.18600	.18[illegible]	.19000	.19200	.19400	.19600	.19800	.20000	NO. 0- 23

.20[illegible]	.2[illegible]6	.20700	.20900	.2116	.21300	.21500	.21700	.21900	NO. 0-
.22300	.22600	.23000	.23300	.23700	.24000	.24400	.24700	.25100	NO. 0- 25
.25400	.25800	.26100	.26500	.27000	.27600	.28100	.28700	.29200	NO. 0- 26
.29800	.30400	.30900	.31500	.32000	.32600	.33100	.33700	.34200	NO. 0- 27
.34800	.35400	.35900	.36500	.37000	.37600	.38100	.38700	.39200	NO. 0- 28
.39800	.40400	.40900	.41500	.42000	.42600	.43100	.43700	.44200	NO. 0- 29
.44800	.45400	.45900	.46500	.47000	.47600	.48100	.48700	.49200	NO. 0- 30
.49800	.50400	.50900	.51500	.52000	.52600	.53100	.53700	.54200	NO. 0- 31
.54800	.55400	.55900	.56500	.57000	.57600	.58100	.58700	.59600	NO. 0- 32
.60500	.61400	.62300	.63200	.64100	.65000	.65900	.66800	.67700	NO. 0- 33
.68600	.69500	.70400	.71300	.72200	.73100	.74000	.74900	.75800	NO. 0- 34
.76700	.77600	.78500	.79400	.80300	.81200	.82100	.83000	.83900	NO. 0- 35
.84800	.85700	.86600	.87500	.88400	.89300	.90200	.91100	.92000	NO. 0- 36
.92900	.93800	.94700	.96300	.97800	.99400	1.00900	1.02500	1.04000	NO. 0- 37
1.05600	1.07100	1.08700	1.10200	1.11800	1.13300	1.14900	1.16400	1.18000	NO. 0- 38
1.19500	1.21100	1.22600	1.24200	1.25700	1.27300	1.28800	1.30400	1.31900	NO. 0- 39
1.33500	1.35000	1.36600	1.38100	1.39700	1.41200	1.42800	1.44300	1.45900	NO. 0- 40
1.47400	1.49000	1.50500	1.52100	1.53600	1.55200	1.56700	1.58300	1.59800	NO. 0- 41
1.61300	1.62900	1.65300	1.67700	1.70100	1.72500	1.74900	1.77200	1.79600	NO. 0- 42
1.82000	1.84400	1.86800	1.89100	1.91500	1.93900	1.96300	1.98700	2.01000	NO. 0- 43
2.03400	2.05800	2.08200	2.10600	2.12900	2.15300	2.17700	2.20100	2.22500	NO. 0- 44
2.24900	2.27200	2.29600	2.32000	2.34400	2.36800	2.39100	2.41500	2.43900	NO. 0- 45
2.46300	2.48700	2.51000	2.53400	2.55800	2.58200	2.60600	2.62900	2.65300	NO. 0- 46
2.67700	2.70100	2.72500	2.74900	2.77200	2.79600	2.82000	2.84400	2.86800	NO. 0- 47
2.89100	2.91500	2.93900	2.96300	2.98700	3.01000	3.03400	3.05800	3.08200	NO. 0- 48
3.10600	3.12900	3.15300	3.17700	3.20100	3.22500	3.26200	3.29900	3.33600	NO. 0- 49
3.37300	3.41000	3.44700	3.48400	3.52100	3.55800	3.59500	3.63200	3.66900	NO. 0- 50
3.70600	3.74300	3.78000	3.81700	3.85400	3.89100	3.92800	3.96500	4.00200	NO. 0- 51
4.04000	4.07700	4.11400	4.15100	4.18800	4.22500	4.26200	4.29900	4.33600	NO. 0- 52
4.37300	4.41000	4.44700	4.48400	4.55800	4.63200	4.70600	4.78000	4.85400	NO. 0- 53
4.92800	5.00200	5.11400	5.22500	5.33600	5.44700	5.55800	5.66900	5.78000	NO. 0- 54
5.94300	6.07133	6.19967	6.32800	6.45633	6.58467	6.71300	6.84133	6.96967	NO. 0- 55
7.09600	7.22633	7.35467	7.48300	7.61133	7.61133	7.61133	7.61133	7.61133	NO. 0- 56

SET NO. 1 ACCELERATION TABLE

ACCEL. OUTPUT HAS BEEN MULTIPLIED BY A FACTOR OF .7070

0.00000	.00283	.01113	.02431	.04147	.06140	.08270	.10387	.12341	NO. 1- 1
.13990	.15213	.15917	.16043	.15571	.14522	.12959	.10980	.08715	NO. 1- 2
.06315	.03947	.01780	-.00027	-.01331	-.02020	-.02015	-.01283	.00166	NO. 1- 3
.02277	.04951	.08050	.11406	.14833	.18131	.21105	.23573	.25377	NO. 1- 4
.26396	.26551	.25809	.24191	.21764	.18645	.14989	.10986	.06845	NO. 1- 5
.02785	-.00978	-.04243	-.06834	-.08613	-.09485	-.09405	-.08378	-.06460	NO. 1- 6
-.03756	-.00410	.03403	.07484	.11623	.15614	.19263	.22397	.24878	NO. 1- 7
.26606	.27525	.27624	.26935	.25531	.23518	.21028	.18211	.15221	NO. 1- 8
.12211	.09320	.06664	.04334	.02189	-.01387	-.04667	-.07453	-.09555	NO. 1- 9
-.10817	-.11110	-.10353	-.08511	-.05599	-.01686	.03111	.08630	.14670	NO. 1- 10
.21000	.27372	.33527	.39213	.44192	.48253	.51222	.52969	.53412	NO. 1- 11
.52524	.50330	.46909	.42387	.36929	.30736	.24029	.17043	.10016	NO. 1- 12
.03174	-.03274	-.09145	-.14292	-.18605	-.22017	-.24503	-.26075	-.26783	NO. 1- 13
-.26710	-.25959	-.24652	-.22916	-.20882	-.18670	-.16388	-.14125	-.11945	NO. 1- 14
-.09890	-.07976	-.06197	-.04525	-.02920	-.01332	.00293	.02008	.03851	NO. 1- 15
.05853	.08021	.10314	.13989	.16981	.19174	.20498	.20938	.20527	NO. 1- 16
.19345	.17508	.15151	.12467	.09592	.06698	.03930	.01404	-.00798	NO. 1- 17
-.04608	-.06550	-.12426	-.16028	-.19152	-.21608	-.23227	-.23879	-.23473	NO. 1- 18
-.21968	-.19373	-.15753	-.11222	-.05943	-.00120	.06015	.12205	.18185	NO. 1- 19
.23696	.28492	.32354	.35103	.36604	.36775	.35592	.33088	.29350	NO. 1- 20
.24518	.18776	.12344	.05467	-.01595	-.08581	-.15240	-.21340	-.26682	NO. 1- 21
-.31101	-.34481	-.36748	-.37882	-.37904	-.36883	-.34923	-.32157	-.28743	NO. 1- 22
-.24849	-.20647	-.16363	-.11970	-.07782	-.03845	-.00241	.02981	.05797	NO. 1- 23
.08212	.10252	.11958	.13383	.14582	.15610	.16511	.17317	.18038	NO. 1- 24
.18541	.17911	.16198	.13508	.10002	.05879	.01369	-.03294	-.07837	NO. 1- 25
-.12081	-.15757	-.18764	-.21021	-.23769	-.25499	-.26058	-.25352	-.23346	NO. 1- 26

-.20073	-.15630	-.10177	-.03929	.02852	.09871	.16812	.23355	.29192	NO. 1- 27
.34037	.37646	.39827	.40446	.39440	.36814	.32644	.27073	.20304	NO. 1- 28
.12588	.04216	-.04437	-.13225	-.21649	-.29468	-.36413	-.42257	-.46825	NO. 1- 29
-.50000	-.51723	-.51996	-.50876	-.48472	-.44934	-.40444	-.35206	-.29433	NO. 1- 30
-.23338	-.17119	-.10956	-.05000	.00631	.05855	.10624	.14927	.18778	NO. 1- 31
.22216	.25295	.28078	.30624	.32987	.35204	.37291	.39160	.41047	NO. 1- 32
.41422	.40287	.37711	.33826	.28817	.22914	.16378	.09490	.02533	NO. 1- 33
-.04216	-.10504	-.16112	-.20863	-.24627	-.27331	-.28953	-.29523	-.29121	NO. 1- 34
-.27862	-.25895	-.23388	-.20520	-.17466	-.14391	-.11438	-.08721	-.06323	NO. 1- 35
-.04289	-.02626	-.01309	-.00283	.00533	.01233	.01918	.02690	.03637	NO. 1- 36
.04829	.06309	.08089	.11122	.13684	.15648	.16921	.17439	.17179	NO. 1- 37
.16152	.14407	.12026	.09120	.05825	.02291	-.01320	-.04850	-.08143	NO. 1- 38
-.11062	-.13488	-.15330	-.16526	-.17047	-.16894	-.16101	-.14731	-.12867	NO. 1- 39
-.10615	-.08088	-.05410	-.02699	-.00069	.02381	.04567	.06429	.07928	NO. 1- 40
.09048	.09795	.10197	.10297	.10150	.09819	.09370	.08866	.08361	NO. 1- 41
.07898	.07504	.06768	.05728	.04426	.02913	.01254	-.00484	-.02227	NO. 1- 42
-.03901	-.05436	-.06767	-.07839	-.08610	-.09047	-.09136	-.08876	-.08282	NO. 1- 43
-.07383	-.06221	-.04847	-.03322	-.01712	-.00083	.01498	.02968	.04271	NO. 1- 44
.05361	.06201	.06768	.07051	.07052	.06783	.06270	.05547	.04656	NO. 1- 45
.03642	.02554	.01441	.00348	-.00683	-.01618	-.02429	-.03098	-.03615	NO. 1- 46
-.03979	-.04200	-.04291	-.04273	-.04170	-.04009	-.03818	-.03620	-.03439	NO. 1- 47
-.03291	-.03189	-.03138	-.03137	-.03179	-.03252	-.03338	-.03418	-.03469	NO. 1- 48
-.03470	-.03401	-.03246	-.02991	-.02631	-.02174	-.01391	-.00570	.00260	NO. 1- 49
.01067	.01824	.02505	.03087	.03554	.03892	.04095	.04163	.04099	NO. 1- 50
.03914	.03622	.03241	.02791	.02294	.01773	.01250	.00745	.00277	NO. 1- 51
-.00141	-.00496	-.00782	-.00996	-.01137	-.01211	-.01224	-.01185	-.01106	NO. 1- 52
-.00909	-.00876	-.00747	-.00622	-.00416	-.00291	-.00243	-.00236	-.00217	NO. 1- 53
-.00146	.00006	.00250	.00385	.00403	.00328	.00203	.00082	.00009	NO. 1- 54
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	NO. 1- 55
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	NO. 1- 56

SET NO. 2 ACCELERATION TABLE

ACCEL. OUTPUT HAS BEEN MULTIPLIED BY A FACTOR OF .7070

0.00000	.00283	.01113	.02431	.04147	.06140	.08270	.10387	.12341	NO. 2- 1
.13990	.15213	.15917	.16043	.15571	.14522	.12959	.10980	.08715	NO. 2- 2
.06315	.03947	.01780	-.00027	-.01331	-.02020	-.02015	-.01283	.00166	NO. 2- 3
.02277	.04951	.08050	.11406	.14833	.18131	.21105	.23573	.25377	NO. 2- 4
.26396	.26551	.25809	.24191	.21764	.18645	.14989	.10986	.06845	NO. 2- 5
.0278	-.00978	-.04243	-.06834	-.08613	-.09485	-.09405	-.08378	-.06460	NO. 2- 6
-.03756	-.00410	.03403	.07484	.11623	.15614	.19263	.22397	.24878	NO. 2- 7
.26606	.27525	.27624	.26935	.25531	.23518	.21028	.18211	.15221	NO. 2- 8
.12211	.09320	.06664	.04334	.02189	-.01387	-.04667	-.07453	-.09555	NO. 2- 9
-.10817	-.11110	-.10353	-.08511	-.05599	-.01686	.03111	.08630	.14670	NO. 2- 10
.21000	.27372	.33527	.39213	.44192	.48253	.51222	.52969	.53412	NO. 2- 11
.52524	.50330	.46909	.42387	.36929	.30736	.24029	.17043	.10016	NO. 2- 12
.03174	-.03274	-.09145	-.14292	-.18605	-.22017	-.24503	-.26075	-.26783	NO. 2- 13
-.26710	-.25959	-.24652	-.22916	-.20882	-.18670	-.16388	-.14125	-.11945	NO. 2- 14
-.09890	-.07976	-.06197	-.04525	-.02920	-.01332	.00293	.02008	.03851	NO. 2- 15
.05853	.08021	.10314	.13989	.16981	.19174	.20498	.20938	.20527	NO. 2- 16
.19345	.17508	.15161	.12467	.09592	.06698	.03930	.01404	-.00798	NO. 2- 17
-.04608	-.08550	-.12426	-.16028	-.19152	-.21608	-.23227	-.23873	-.23473	NO. 2- 18
-.21968	-.19373	-.15753	-.11222	-.05943	-.00120	.06015	.12265	.18185	NO. 2- 19
.23696	.28492	.32354	.35103	.36604	.36775	.35592	.33044	.29350	NO. 2- 20
.24518	.18776	.12344	.05467	-.01595	-.08581	-.15240	-.21340	-.26682	NO. 2- 21
-.31101	-.34481	-.36748	-.37882	-.37904	-.36883	-.34923	-.32157	-.28743	NO. 2- 22
-.24849	-.20647	-.16303	-.11970	-.07782	-.03845	-.00241	.02981	.05797	NO. 2- 23
.08212	.10252	.11958	.13383	.14582	.15610	.16511	.17317	.18038	NO. 2- 24
.18541	.17911	.16198	.13508	.10002	.05879	.01369	-.03284	-.07837	NO. 2- 25
-.12061	-.15757	-.18764	-.21021	-.23769	-.25498	-.26058	-.25352	-.23346	NO. 2- 26
-.20073	-.15630	-.10177	-.03929	.02852	.09871	.16812	.23355	.29192	NO. 2- 27
.34037	.37646	.39827	.40446	.39440	.36814	.32644	.27073	.20304	NO. 2- 28
.12588	.04216	-.04437	-.13225	-.21649	-.29468	-.36413	-.42257	-.46825	NO. 2- 29

-.50003	-.51723	-.51996	-.50876	-.48472	-.44934	-.40444	-.35236	-.29431	NO. 2- 30
-.03338	-.17119	-.10956	-.05000	.00631	.05855	.10624	.14927	.18778	NO. 2- 31
.22216	.25295	.28078	.30624	.32987	.35204	.37291	.39160	.41047	NO. 2- 32
.41422	.40287	.37711	.33826	.28817	.22914	.16378	.09490	.02533	NO. 2- 33
-.04216	-.10504	-.16112	-.20863	-.24627	-.27331	-.28953	-.29523	-.29121	NO. 2- 34
-.27862	-.25895	-.23388	-.20520	-.17466	-.14391	-.11438	-.08721	-.06323	NO. 2- 35
-.04289	-.02626	-.01309	-.00283	.00533	.01233	.01918	.02690	.03637	NO. 2- 36
.04929	.06309	.08089	.11122	.13684	.15648	.16921	.17439	.17179	NO. 2- 37
.16152	.14407	.12026	.09120	.05825	.02291	-.01320	-.04850	-.08143	NO. 2- 38
-.11062	-.13488	-.15330	-.16526	-.17047	-.16894	-.16101	-.14731	-.12867	NO. 2- 39
-.10615	-.08088	-.05410	-.02699	-.00069	.02381	.04567	.06429	.07928	NO. 2- 40
.09043	.09795	.10197	.10297	.10150	.09819	.09370	.08866	.08361	NO. 2- 41
.07898	.07504	.06768	.05728	.04426	.02913	.01254	-.00484	-.02227	NO. 2- 42
-.03903	-.05436	-.06767	-.07839	-.08610	-.09047	-.09136	-.08876	-.08282	NO. 2- 43
-.07383	-.06221	-.04847	-.03322	-.01712	-.00083	.01498	.02968	.04271	NO. 2- 44
.05361	.06201	.06768	.07051	.07052	.06783	.06270	.05547	.04656	NO. 2- 45
.03642	.02554	.01441	.00348	-.00683	-.01618	-.02429	-.03098	-.03615	NO. 2- 46
-.03279	-.04200	-.04291	-.04273	-.04170	-.04009	-.03818	-.03620	-.03439	NO. 2- 47
-.03241	-.03189	-.03138	-.03137	-.03179	-.03252	-.03338	-.03418	-.03469	NO. 2- 48
-.03470	-.03401	-.03246	-.02991	-.02631	-.02174	-.01391	-.00570	.00260	NO. 2- 49
.01067	.01824	.02505	.03087	.03554	.03892	.04095	.04163	.04099	NO. 2- 50
.03914	.03622	.03241	.02791	.02294	.01773	.01250	.00745	.00277	NO. 2- 51
-.00141	-.00496	-.00782	-.00996	-.01137	-.01211	-.01224	-.01185	-.01106	NO. 2- 52
-.00999	-.00876	-.00747	-.00622	-.00416	-.00291	-.00243	-.00236	-.00217	NO. 2- 53
-.00146	.00006	.00250	.00385	.00403	.00328	.00203	.00082	.00009	NO. 2- 54
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	NO. 2- 55
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	NO. 2- 56

SET NO. 3 ACCELERATION TABLE

0.00000	0.00000	.04247	.04247	.23874	.23874	.23874	.49960	.49960	NO. 3- 1
.64444	.64444	.64444	.74248	.74248	.74248	.67441	.67441	.49990	NO. 3- 2
.49990	.49990	.33683	.33683	.29419	.29419	.29419	.40957	.40957	NO. 3- 3
.54938	.54938	.54938	.76614	.76614	.76614	.87515	.87515	.79472	NO. 3- 4
.79472	.79472	.53908	.53908	.21473	.21473	.21473	-.03351	-.03351	NO. 3- 5
-.10024	-.10024	-.10024	-.02987	-.02987	-.02987	.18293	.18293	.39832	NO. 3- 6
.39832	.39832	.46770	.46770	.30927	.30927	.30927	.08585	.08585	NO. 3- 7
-.34327	-.34327	-.34327	-.74350	-.74350	-.97782	-.97782	-.97782	-1.04136	NO. 3- 8
-1.04136	-1.04136	-.89993	-.89993	-.54528	-.54528	-.29576	.31248	.31248	NO. 3- 9
.99871	1.66777	1.66777	2.27328	2.43214	2.43214	2.67421	2.65780	2.65780	NO. 3- 10
2.38801	1.90642	1.90642	1.60708	.94246	.94246	.26080	-.36112	-.36112	NO. 3- 11
-.86641	-1.06477	-1.06477	-1.34727	-1.48810	-1.48810	-1.51563	-1.46679	-1.46679	NO. 3- 12
-1.42497	-1.32399	-1.32399	-1.21277	-1.09327	-1.09327	-.95485	-.87331	-.87331	NO. 3- 13
-.67544	-.42354	-.42354	-.12720	.13155	.13155	.36312	.55683	.55683	NO. 3- 14
.70471	.80192	.80192	.64687	.84121	.84121	.78955	.69907	.69907	NO. 3- 15
.57890	.43945	.43945	.29165	.01267	-.10078	-.18829	-.25482	-.31268	NO. 3- 16
-.36187	-.52252	-.54622	-.58139	-.61162	-.65241	-.66485	-.65954	-.64655	NO. 3- 17
-.55312	-.46490	-.27305	-.12011	.04565	.33050	.46706	.77381	.85262	NO. 3- 18
.96639	.96308	.94194	.83380	.73447	.52431	.36234	.19203	-.08849	NO. 3- 19
-.21351	-.47287	-.52376	-.56223	-.53929	-.47873	-.31084	-.18934	.04715	NO. 3- 20
.21254	.37305	.60794	.68886	.79474	.76304	.63511	.48626	.28973	NO. 3- 21
-.12068	-.37148	-.84375	-1.16766	-1.48584	-1.97815	-2.18186	-2.58943	-2.66071	NO. 3- 22
-2.70282	-2.65166	-2.53821	-2.23239	-2.00729	-1.54921	-1.20304	-.83463	-.19793	NO. 3- 23
.12222	.91660	1.18952	1.63784	1.89489	2.11587	2.40963	2.50524	2.62901	NO. 3- 24
2.67546	2.59756	2.33047	2.00931	1.37082	1.01059	.26814	-.09114	-.73667	NO. 3- 25
-1.60760	-1.42139	-1.60673	-1.70496	-1.69385	-1.50032	-1.25036	-.95924	-.70423	NO. 3- 26
-.42260	-.18263	.01004	.26560	.38777	.50000	.54634	.58573	.62049	NO. 3- 27
.67413	.74771	.77752	.77855	.74248	.65734	.56016	.40063	.25768	NO. 3- 28
.05005	-.13699	-.30652	-.51807	-.66108	-.82861	-.92528	-1.01980	-1.05365	NO. 3- 29
-1.05939	-1.01970	-.95321	-.83053	-.70991	-.52555	-.37105	-.15525	.00870	NO. 3- 30
.22296	.39285	.53292	.69213	.78733	.88825	.93707	.97596	.98037	NO. 3- 31
.96412	.92821	.88308	.81185	.75030	.66330	.59802	.50199	.36411	NO. 3- 32
.18993	.01646	-.15261	-.32911	-.47571	-.60569	-.71336	-.78007	-.82155	NO. 3- 33
-.82793	-.80408	-.74888	-.67132	-.57946	-.46486	-.35121	-.23574	-.11604	NO. 3- 34
[illegible]	[illegible]	.16413	.22554	.28036	.31997	.34583	[illegible]	.37965	NO. 3- 35

.38943	.39457	.40989	.42285	.43273	.43586	.43046	.41698	.39567	NO. 3- 36
.36696	.33433	.29610	.21263	.12900	.03602	-.05253	-.13340	-.20394	NO. 3- 37
-.26203	-.29885	-.32182	-.32526	-.31182	-.28528	-.24697	-.20106	-.15030	NO. 3- 38
-.10106	-.05047	-.01101	.02686	.05328	.07256	.08403	.08915	.08996	NO. 3- 39
.08832	.08661	.08652	.08948	.09716	.10691	.11458	.11952	.12233	NO. 3- 40
.12219	.11919	.11374	.10523	.09541	.08264	.06839	.05170	.03489	NO. 3- 41
.01623	-.00096	-.02939	-.05659	-.08083	-.10087	-.11536	-.12463	-.12824	NO. 3- 42
-.12584	-.11785	-.10449	-.08759	-.06665	-.04428	-.02046	.00350	.02517	NO. 3- 43
.04481	.06248	.07664	.08706	.09347	.09660	.09672	.09411	.08955	NO. 3- 44
.08355	.07692	.06975	.06276	.05636	.04870	.04028	.03058	.02040	NO. 3- 45
.00951	-.00191	-.01289	-.02387	-.03457	-.04498	-.05450	-.06253	-.06977	NO. 3- 46
-.07599	-.08074	-.08401	-.08576	-.08610	-.08500	-.08250	-.07875	-.07371	NO. 3- 47
-.06785	-.06086	-.05336	-.04519	-.03652	-.02811	-.01964	-.01133	-.00320	NO. 3- 48
.00429	.01066	.01648	.02158	.02564	.02864	.03122	.03149	.02962	NO. 3- 49
.02591	.02079	.01495	.00856	.00235	-.00316	-.00785	-.01119	-.01307	NO. 3- 50
-.01347	-.01242	-.01003	-.00661	-.00254	.00200	.00645	.01048	.01389	NO. 3- 51
.01629	.01750	.01744	.01619	.01377	.01046	.00651	.00210	-.00224	NO. 3- 52
-.00635	-.00989	-.01251	-.01421	-.01513	-.01441	-.01227	-.00883	-.00447	NO. 3- 53
.00050	.00561	.01267	.01771	.02001	.01920	.01555	.00986	.00327	NO. 3- 54
-.00551	-.00996	-.01152	-.01022	-.00683	-.00258	.00126	.00377	.00454	NO. 3- 55
.00379	.00223	.00072	.00001	-.00002	0.00000	0.00000	0.00000	0.00000	NO. 3- 56

SECTION 4: EXAMPLE TO ISOL

AN INDEPENDENT ISOL EXAMPLE RUN

```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+   NO.
        4        0
 SAMPLE PROBLEM 1  SIP 250A  STATIC EQUILI. SOLN.(FS DA TABLES) 12/22/69
   3   4        1   2
  6320.0      0.0      0.0      7.06.84E+071.60E+067.00F+07
 20000.0      0.0    138.0     52.02.52E+071.84E+071.66F+07
 20000.0      0.0   -138.0     52.02.52E+071.84E+071.66F+07
   -27.0    180.0     52.0    -27.0    180.0    263.0
    27.0    180.0     52.0     27.0    180.0    263.0
   -27.0   -180.0     52.0    -27.0   -180.0    263.0
    27.0   -180.0     52.0     27.0   -180.0    263.0
   -27.0    180.0     52.0
    27.0   -180.0     52.0
   3   3    200.0   2900.0    300.0
  -100.0       0.    100.0
-290000.       0.  290000.
 -1000.0       0.   1000.0
-300000.       0.  300000.
   3   3    200.0   2900.0    300.0
  -100.0       0.    100.0
-290000.       0.  290000.
 -1000.0       0.   1000.0
-300000.       0.  300000.
   3   3    200.0   2900.0    300.0
  -100.0       0.    100.0
-290000.       0.  290000.
 -1000.0       0.   1000.0
-300000.       0.  300000.
   3   3    200.0   2900.0    300.0
  -100.0       0.    100.0
-290000.       0.  290000.
 -1000.0       0.   1000.0
-300000.       0.  300000.
    0.00     2.50   .0020     .020       5.0     .020
     0.0
 SAMPLE PROBLEM 2  SIP 250A CONTINUE PROBL1 X-Z EXCI. 40LB DAMP 12/22/69
   3   4 191   1   2      -1
            200.0   2900.0     40.0
            200.0   2900.0     40.0
            200.0   2900.0     40.0
            200.0   2900.0     40.0
  0.0000  0.0250  0.0500  0.0750  0.1000  0.1250  0.1500  0.1750  0.2000
  0.2250  0.2500  0.2750  0.3000  0.3250  0.3500  0.3750  0.4000  0.4250
  0.4500  0.4750  0.5000  0.5250  0.5500  0.5750  0.6000  0.6250  0.6500
  0.6750  0.7000  0.7250  0.7500  0.7750  0.8000  0.8250  0.8500  0.8750
  0.9000  0.9250  0.9500  0.9750  1.0000  1.0250  1.0500  1.0750  1.1000
  1.1250  1.1500  1.1750  1.2000  1.2250  1.2500  1.2750  1.3000  1.3250
  1.3500  1.3750  1.4000  1.4250  1.4500  1.4750  1.5000  1.5250  1.5500
  1.5750  1.6000  1.6250  1.6500  1.6750  1.7000  1.7250  1.7500  1.7750
  1.8000  1.8250  1.8500  1.8750  1.9000  1.9250  1.9500  1.9750  2.0000
  2.0250  2.0500  2.0750  2.1000  2.1250  2.1500  2.1750  2.2000  2.2250
  2.2500  2.2750  2.3000  2.3250  2.3500  2.3750  2.4000  2.4250  2.4500
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```
        10        20        30        40        50        60        70        80   CARD
.........*.........*.........*.........*.........*.........*.........*.........*    NO.

  2.4750    2.5000    2.5250    2.5500    2.5750    2.6000    2.6250    2.6500    2.6750      52
  2.7000    2.7250    2.7500    2.7750    2.8000    2.8250    2.8500    2.8750    2.9000      53
  2.9250    2.9500    2.9750    3.0000    3.0250    3.0500    3.0750    3.1000    3.1250      54
  3.1500    3.1750    3.2000    3.2250    3.2500    3.2750    3.3000    3.3250    3.3500      55
  3.3750    3.4000    3.4250    3.4500    3.4750    3.5000    3.5250    3.5500    3.5750      56
  3.6000    3.6250    3.6500    3.6750    3.7000    3.7250    3.7500    3.7750    3.8000      57
  3.8250    3.8500    3.8750    3.9000    3.9250    3.9500    3.9750    4.0000    4.0250      58
  4.0500    4.0750    4.1000    4.1250    4.1500    4.1750    4.2000    4.2250    4.2500      59
  4.2750    4.3000    4.3250    4.3500    4.3750    4.4000    4.4250    4.4500    4.4750      60
  4.5000    4.5250    4.5500    4.5750    4.6000    4.6250    4.6500    4.6750    4.7000      61
  4.7250       8.0                                                                            62
 -0.0082    0.0082    0.0181    0.0195    0.0152    0.0101    0.0068    0.0052    0.0046      63
  0.0060    0.0121    0.0239    0.0381    0.0476    0.0472    0.0372    0.0232    0.0112      64
  0.0018   -0.0091   -0.0241   -0.0382   -0.0386   -0.0149    0.0294    0.0738    0.0912      65
  0.0663    0.0091   -0.0483   -0.0711   -0.0441    0.0188    0.0842    0.1197    0.1113      66
  0.0664    0.0027   -0.0631   -0.1202   -0.1579   -0.1618   -0.1185   -0.0284    0.0830      67
  0.1700    0.1887    0.1235   -0.0003   -0.1275   -0.2027   -0.1994   -0.1305   -0.0363      68
  0.0401    0.0722    0.0568    0.0068   -0.0575   -0.1149   -0.1456   -0.1355   -0.0837      69
 -0.0073    0.0625    0.0966    0.0854    0.0462    0.0117    0.0069    0.0309    0.0579      70
  0.0574    0.0192   -0.0368   -0.0740   -0.0658   -0.0152    0.0464    0.0813    0.0713      71
  0.0278   -0.0189   -0.0420   -0.0356   -0.0140    0.0024    0.0039   -0.0041   -0.0086      72
 -0.0020    0.0118    0.0215    0.0182    0.0031   -0.0140   -0.0214   -0.0124    0.0116      73
  0.0437    0.0750    0.0955    0.0959    0.0697    0.0181   -0.0465   -0.1025   -0.1286      74
 -0.1148   -0.0693   -0.0147    0.0243    0.0339    0.0170   -0.0114   -0.0339   -0.0394      75
 -0.0257    0.0026    0.0378    0.0707    0.0908    0.0885    0.0593    0.0079   -0.0521      76
 -0.1039   -0.1361   -0.1473   -0.1433   -0.1295   -0.1043   -0.0616    0.0010    0.0736      77
  0.1340    0.1586    0.1374    0.0820    0.0200   -0.0202   -0.0259   -0.0050    0.0227      78
  0.0398    0.0413    0.0338    0.0254    0.0168    0.0010   -0.0287   -0.0686   -0.1031      79
 -0.1124   -0.0863   -0.0328    0.0246    0.0602    0.0610    0.0332   -0.0025   -0.0245      80
 -0.0224   -0.0018    0.0216    0.0327    0.0261    0.0077   -0.0103   -0.0176   -0.0117      81
  0.0009    0.0096    0.0062   -0.0104   -0.0338   -0.0533   -0.0604   -0.0521   -0.0318      82
 -0.0064    0.0183    0.0401    0.0593    0.0758    0.0860    0.0836    0.0626    0.0223      83
  0.0000    0.0000                                                                             84
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         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

                                                                                     105
                                                                                     106
  0.0000 -0.0003 -0.0024 -0.0073 -0.0150 -0.0254 -0.0381 -0.0517 -0.0624             107
 -0.0650 -0.0566 -0.0400 -0.0234 -0.0151 -0.0159 -0.0159  0.0013  0.0467             108
  0.1162  0.1890  0.2371  0.2395  0.1934  0.1142  0.0275 -0.0429 -0.0822             109
 -0.0879 -0.0683 -0.0400 -0.0231 -0.0329 -0.0694 -0.1120 -0.1268 -0.0858             110
  0.0112  0.1286  0.2102  0.2107  0.1253 -0.0054 -0.1183 -0.1659 -0.1414             111
 -0.0763 -0.0133  0.0240  0.0407  0.0561  0.0790  0.0958  0.0821  0.0267             112
 -0.0525 -0.1169 -0.1351 -0.1069 -0.0640 -0.0445 -0.0621 -0.0940 -0.0987             113
 -0.0507  0.0358  0.1135  0.1347  0.0859 -0.0017 -0.0741 -0.0918 -0.0548             114
  0.0020  0.0376  0.0353  0.0119  0.0001  0.0205  0.0639  0.0978  0.0916             115
  0.0394 -0.0342 -0.0907 -0.1028 -0.0706 -0.0189  0.0213  0.0328  0.0208             116
  0.0059  0.0077  0.0316  0.0666  0.0937  0.0994  0.0835  0.0575  0.0361             117
  0.0273  0.0280  0.0274  0.0152 -0.0108 -0.0432 -0.0692 -0.0780 -0.0663             118
 -0.0401 -0.0110  0.0089  0.0110 -0.0069 -0.0404 -0.0792 -0.1094 -0.1181             119
 -0.0993 -0.0577 -0.0083  0.0298  0.0433  0.0311  0.0044 -0.0207 -0.0333             120
 -0.0332 -0.0288 -0.0298 -0.0391 -0.0518 -0.0595 -0.0570 -0.0467 -0.0359             121
 -0.0307 -0.0318 -0.0337 -0.0288 -0.0128  0.0131  0.0430  0.0693  0.0855             122
  0.0882  0.0775  0.0573  0.0346  0.0173  0.0111  0.0167  0.0297  0.0437             123
  0.0547  0.0626  0.0689  0.0728  0.0691  0.0507  0.0158 -0.0282 -0.0665             124
 -0.0848 -0.0796 -0.0609 -0.0457 -0.0471 -0.0644 -0.0844 -0.0900 -0.0726             125
 -0.0375 -0.0001  0.0245  0.0306  0.0238  0.0153  0.0143  0.0228  0.0364             126
  0.0484  0.0544  0.0535  0.0475  0.0384  0.0283  0.0185  0.0105  0.0045             127
  0.0000  0.0000                                                                     128
    0.00    6.00   0.005    0.02    2.00    0.05                                    129
                          (A BLANK CARD)                                             130
                          (A BLANK CARD)                                             131
```

THE RESULT OF THIS EXAMPLE RUN HAS BEEN DELETED.

SECTION 5: EXAMPLE TO SPCTRM

AN INDEPENDENT SPCTRM EXAMPLE RUN

```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

       6       3                                                                      1
0.0     4.0     0.01                                50                                2
    1    2    5   93                                                                   3
1.0     200.0   120.0                                                                  4
0.        .11       .12       .14       .15       .2        .22                       5
.24       .25       .26       .27       .29       .30       .34                       6
.36       .4        .41       .43       .46       .51       .55                       7
.58       .6        .64       .675      .7        .72       .75                       8
.78       .8        .82       .85       .86       .9        .91                       9
.93       .95       .97       1.        1.04      1.06      1.1                      10
1.12      1.14      1.17      1.2       1.25      1.28      1.34                     11
1.35      1.36      1.4       1.45      1.46      1.47      1.48                     12
1.499     1.51      1.52      1.53      1.55      1.56      1.57                     13
1.6       1.61      1.62      1.645     1.65      1.67      1.675                    14
1.7       1.72      1.73      1.75      1.76      1.78      1.8                      15
1.81      1.84      1.85      1.86      1.87      1.9       1.92                     16
1.94      1.95      1.96      1.97      2.        2.02      2.03                     17
2.045     2.055                                                                      18
     RON SPECIAL                                                          0    0      19
-4.11     -4.11     -3.8      -3.85     -3.15     -2.3      -1.75                    20
-1.68     -1.9      -2.05     -1.95     -2.32     -2.0      -1.08                    21
-.65      -1.       -1.35     -1.7      -1.        .11      -.7                      22
-1.       -.4        .58       0.       -.5       -.85      -.2                      23
 .58       .36       .0       -.7       -.75       0.        .3                      24
 .46       .2       -.3       -.59       0.        .34       .0                      25
-.4       -.45       0.        .2        .0       -.3        .0                      26
 .12       .125      .0       -.25       .42      -.4        .75                     27
-1.        .3       -1.5       .96      -.89       1.5      -1.05                    28
 .95      -1.05      .4       -.9        .3        .1       -.58                     29
 .58      -.62       .45      -.85       .72      -.9        .53                     30
-.68       .42      -.42       .3       -.25       .0       -.32                     31
 .1       -.32       .28      -.3        .55      -.35       .4                      32
-.6        .05                                                                        33
```

THE RESULT OF THIS EXAMPLE RUN IS PRESENTED ON THE FOLLOWING PAGES.

OPTION, PLOT = 6 3

RON SPECIAL

GENERALIZED SHOCK SPECTRUM

FOR

DAMPED AND UNDAMPED VIBRATIONS

INPUT DATA

NO OF POINTS IN TABLE	93
STARTING TIME	0.0000
END TIME	2.0550
TIME INTERVAL	.0100
PERCENTAGE CRITICAL DAMPING	-0.0000
INITIAL DISPLACEMENT	-0.0000
INITIAL VELOCITY	-0.0000
NO OF CYCLES OF RESIDUAL VIBRATION	2
FACTOR FOR INTEGRATION TIME INTERVAL	5

STARTING FREQ. =	1.0000
ENDING FREQ. =	200.0000
INTERVAL STEPS =	120.0

TIME TABLE

0.0000	.1100	.1200	.1400	.1500	.2000	.2200	.2400	.2500
.2600	.2700	.2900	.3000	.3400	.3600	.4000	.4100	.4300
.4600	.5100	.5500	.5800	.6000	.6400	.6750	.7000	.7200
.7500	.7800	.8000	.8200	.8500	.8600	.9000	.9100	.9300
.9500	.9700	1.0000	1.0400	1.0600	1.1000	1.1200	1.1400	1.1700
1.2000	1.2500	1.2800	1.3400	1.3500	1.3600	1.4000	1.4500	1.4600
1.4700	1.4800	1.4990	1.5100	1.5200	1.5300	1.5500	1.5600	1.5700
1.6000	1.6100	1.6200	1.6450	1.6500	1.6700	1.6750	1.7000	1.7200
1.7300	1.7500	1.7600	1.7800	1.8000	1.8100	1.8400	1.8500	1.8600
1.8700	1.9000	1.9200	1.9400	1.9500	1.9600	1.9700	2.0000	2.0200
2.0300	2.0450	2.0550						

ACCL. TABLE IN G S

-4.1100	-4.1100	-3.8000	-3.8500	-3.1500	-2.3000	-1.7500	-1.6800	-1.9000
-2.0500	-1.9500	-2.3200	-2.0000	-1.0800	-.6500	-1.0000	-1.3500	-1.7000
-1.0000	.1100	-.7000	-1.0000	-.4000	.5800	0.0000	-.5000	-.8500
-.2000	.5800	.3600	0.0000	-.7000	-.7500	0.0000	.3000	.4600
.2000	-.3000	-.5900	0.0000	.3400	0.0000	-.4000	-.4500	0.0000
.2000	0.0000	-.3000	0.0000	.1200	.1250	0.0000	-.2500	.4200
-.4000	.7500	-1.0000	.3000	-1.5000	.9600	-.8900	1.5000	-1.0500
.9500	-1.0500	.4000	-.9000	.3000	.1000	-.5800	.5800	-.6200
.4500	-.8500	.7200	-.9000	.5300	-.6800	.4200	-.4200	.3000
-.2500	0.0000	-.3200	.1000	-.3200	.2800	-.3000	.5500	-.3500
.4000	-.6000	.0500						

END INPUT TO SPCTRM -

TIME SEC.	FREQUENCY C.P.S.	MAX.DISPLACEMENT INS.	MAX.ACCLERATION G#S
.3862	1.0000	52.2913	5.3426
.3763	1.0451	49.0853	5.4780
.3664	1.0923	46.0179	5.6098
.3565	1.1416	43.0841	5.7371
.3367	1.1932	40.2906	5.8604
.3268	1.2470	37.6567	5.9830
.3169	1.3033	35.1621	6.1024
.3070	1.3622	32.8104	6.2200
.2971	1.4236	30.6045	6.3374
.2773	1.4879	28.5558	6.4591
.2674	1.5551	26.6636	6.5879
.2575	1.6253	24.8911	6.7177
.2476	1.6986	23.2280	6.8476
.2377	1.7753	21.6592	6.9746
.2377	1.8555	20.1959	7.1038
.2278	1.9392	18.8188	7.2306
.2179	2.0268	17.5077	7.3479
.2080	2.1183	16.2546	7.4517
.2080	2.2139	15.0847	7.5538
.1981	2.3138	13.9967	7.6561
.1882	2.4183	12.9571	7.7418
.1882	2.5274	11.9737	7.8147
.1783	2.6415	11.0823	7.9006
.1684	2.7608	10.2229	7.9609
.1684	2.8854	9.4236	8.0159
.1585	3.0157	8.6886	8.0730
.1486	3.1518	7.9697	8.0887
.1486	3.2941	7.3446	8.1425
.1387	3.4428	6.7309	8.1509
.1387	3.5982	6.1808	8.1759
.1287	3.7606	5.6683	8.1901
.1287	3.9304	5.1911	8.1932
.1188	4.1078	4.7629	8.2112
.1188	4.2932	4.3552	8.2016
.1089	4.4870	3.9935	8.2147
.1089	4.6896	3.6512	8.2041
.0990	4.9013	3.3445	8.2087
.0990	5.1225	3.0630	8.2118
.0891	5.3538	2.7954	8.1863
.0891	5.5954	2.5697	8.2199
.0891	5.8480	2.3398	8.1756
.0792	6.1120	2.1495	8.2041
.0792	6.3879	1.9705	8.2152
.0792	6.6763	1.7887	8.1459
1.4756	6.9777	2.5350	12.6103
2.1186	7.2927	2.7882	15.1503
.8616	7.6219	1.6657	9.8862
.0594	7.9659	1.2588	8.1615
.0594	8.3255	1.1603	8.2171
.0594	8.7014	1.0600	8.1998
.0594	9.0942	.9586	8.1004
.0495	9.5047	.8819	8.1395
.0495	9.9337	.8143	8.2101
.0495	10.3822	.7456	8.2114
.0495	10.8508	.6762	8.1343
.0396	11.3407	.6068	7.9731
.0396	11.8526	.5653	8.1141
.0396	12.3877	.5229	8.1987

.0396	12.9469	.4799	8.2183
.0396	13.5313	.4364	8.1645
.1089	14.1421	.4020	8.2140
.0990	14.7805	.3506	7.8249
.0990	15.4478	.3368	8.2118
.0297	16.1451	.3051	8.1252
.0297	16.8739	.2820	8.2022
.0297	17.6356	.2586	8.2177
.0297	18.4317	.2352	8.1648
.0792	19.2638	.2135	8.0933
.0790	20.1334	.1985	8.2191
.0754	21.0423	.1817	8.2200
.0724	21.9921	.1663	8.2184
.0691	22.9849	.1523	8.2200
.0663	24.0225	.1394	8.2185
.0635	25.1069	.1276	8.2178
.0607	26.2403	.1168	8.2189
.0581	27.4248	.1069	8.2181
.0555	28.6628	.0979	8.2188
1.8621	29.9567	.1137	10.4250
2.1114	31.3090	.1139	11.4075
2.0652	32.7224	.0857	9.3772
1.6999	34.1995	.0763	9.1178
1.9102	35.7433	.0847	11.0553
.0427	37.3569	.0576	8.2165
1.7745	39.0432	.0779	12.1353
.0390	40.8057	.0483	8.2179
2.1011	42.6478	.0826	15.3482
2.0625	44.5730	.0567	11.5036
.0343	46.5851	.0371	8.2162
1.8790	48.6880	.0367	8.8878
.0314	50.8859	.0311	8.2152
.0300	53.1830	.0284	8.2162
.0287	55.5837	.0260	8.2169
2.0602	58.0929	.0309	10.6662
1.7163	60.7153	.0299	11.2458
1.5994	63.4561	.0204	8.3877
1.5706	66.3206	.0185	8.3083
.0230	69.3145	.0167	8.2158
.0220	72.4435	.0153	8.2152
.0211	75.7137	.0140	8.2137
.0202	79.1316	.0128	8.2155
.0193	82.7037	.0118	8.2139
.0185	86.4371	.0108	8.2150
.0177	90.3390	.0099	8.2147
.0169	94.4171	.0090	8.2148
.0051	98.6793	.0083	8.2199
.0247	103.1339	.0076	8.2200
.0236	107.7895	.0069	8.2200
.0771	112.6553	.0063	8.2180
.0391	117.7408	.0058	8.2183
.0792	123.0558	.0053	8.2199
.0360	128.6108	.0049	8.2187
.0421	134.4166	.0045	8.2198
.0257	140.4844	.0041	8.2193
.0247	146.8261	.0037	8.2200
.1049	153.4541	.0034	8.2196
.0617	160.3813	.0031	8.2196
.0966	167.6212	.0029	8.2199
.0689	175.1880	.0026	8.2188
.0144	183.0963	.0024	8.2195
.0802	191.3616	.0022	8.2098
.1055	200.0000	.0020	8.2192

END OF ANALYSIS

SECTION 6: **EXAMPLE TO FILTER**

A FILTER EXAMPLE RUN

```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

       8                                                                              1
  2                                                                                   2
  FILTERING OF IVY-MIKE WAVE IN HORIZONTAL DIRECTION                                  3
  10 191    0      0.025                                                              4
      0.19       0.4       0.68      1.04      1.76      2.24      3.52      4.16     5
      5.12      6.08                                                                 6
  0.0000   0.0250   0.0500   0.0750   0.1000   0.1250   0.1500   0.1750   0.2000    7
  0.2250   0.2500   0.2750   0.3000   0.3250   0.3500   0.3750   0.4000   0.4250    8
  0.4500   0.4750   0.5000   0.5250   0.5500   0.5750   0.6000   0.6250   0.6500    9
  0.6750   0.7000   0.7250   0.7500   0.7750   0.8000   0.8250   0.8500   0.8750   10
  0.9000   0.9250   0.9500   0.9750   1.0000   1.0250   1.0500   1.0750   1.1000   11
  1.1250   1.1500   1.1750   1.2000   1.2250   1.2500   1.2750   1.3000   1.3250   12
  1.3500   1.3750   1.4000   1.4250   1.4500   1.4750   1.5000   1.5250   1.5500   13
  1.5750   1.6000   1.6250   1.6500   1.6750   1.7000   1.7250   1.7500   1.7750   14
  1.8000   1.8250   1.8500   1.8750   1.9000   1.9250   1.9500   1.9750   2.0000   15
  2.0250   2.0500   2.0750   2.1000   2.1250   2.1500   2.1750   2.2000   2.2250   16
  2.2500   2.2750   2.3000   2.3250   2.3500   2.3750   2.4000   2.4250   2.4500   17
  2.4750   2.5000   2.5250   2.5500   2.5750   2.6000   2.6250   2.6500   2.6750   18
  2.7000   2.7250   2.7500   2.7750   2.8000   2.8250   2.8500   2.8750   2.9000   19
  2.9250   2.9500   2.9750   3.0000   3.0250   3.0500   3.0750   3.1000   3.1250   20
  3.1500   3.1750   3.2000   3.2250   3.2500   3.2750   3.3000   3.3250   3.3500   21
  3.3750   3.4000   3.4250   3.4500   3.4750   3.5000   3.5250   3.5500   3.5750   22
  3.6000   3.6250   3.6500   3.6750   3.7000   3.7250   3.7500   3.7750   3.8000   23
  3.8250   3.8500   3.8750   3.9000   3.9250   3.9500   3.9750   4.0000   4.0250   24
  4.0500   4.0750   4.1000   4.1250   4.1500   4.1750   4.2000   4.2250   4.2500   25
  4.2750   4.3000   4.3250   4.3500   4.3750   4.4000   4.4250   4.4500   4.4750   26
  4.5000   4.5250   4.5500   4.5750   4.6000   4.6250   4.6500   4.6750   4.7000   27
  4.7250    4.750                                                                   28
 -0.0082   0.0082   0.0181   0.0195   0.0152   0.0101   0.0068   0.0052   0.0046   29
  0.0060   0.0121   0.0239   0.0381   0.0476   0.0472   0.0372   0.0232   0.0112   30
  0.0018  -0.0091  -0.0241  -0.0382  -0.0386  -0.0149   0.0294   0.0738   0.0912   31
  0.0663   0.0091  -0.0483  -0.0711  -0.0441   0.0188   0.0842   0.1197   0.1113   32
  0.0664   0.0027  -0.0631  -0.1202  -0.1579  -0.1618  -0.1185  -0.0284   0.0830   33
  0.1700   0.1887   0.1235  -0.0003  -0.1275  -0.2027  -0.1994  -0.1305  -0.0363   34
  0.0401   0.0722   0.0568   0.0068  -0.0575  -0.1149  -0.1456  -0.1355  -0.0837   35
 -0.0073   0.0625   0.0966   0.0854   0.0462   0.0117   0.0069   0.0309   0.0579   36
  0.0574   0.0192  -0.0368  -0.0740  -0.0658  -0.0152   0.0464   0.0813   0.0713   37
  0.0278  -0.0189  -0.0420  -0.0356  -0.0140   0.0024   0.0039  -0.0041  -0.0086   38
 -0.0020   0.0118   0.0215   0.0182   0.0031  -0.0140  -0.0214  -0.0124   0.0116   39
  0.0437   0.0750   0.0955   0.0959   0.0697   0.0181  -0.0465  -0.1025  -0.1286   40
 -0.1148  -0.0693  -0.0147   0.0243   0.0339   0.0170  -0.0114  -0.0339  -0.0394   41
 -0.0257   0.0026   0.0378   0.0707   0.0908   0.0885   0.0593   0.0079  -0.0521   42
 -0.1039  -0.1361  -0.1473  -0.1433  -0.1295  -0.1043  -0.0616   0.0010   0.0736   43
  0.1340   0.1586   0.1374   0.0820   0.0200  -0.0202  -0.0259  -0.0050   0.0227   44
  0.0398   0.0413   0.0338   0.0254   0.0168   0.0010  -0.0287  -0.0686  -0.1031   45
 -0.1124  -0.0863  -0.0328   0.0246   0.0602   0.0610   0.0332  -0.0025  -0.0245   46
 -0.0224  -0.0018   0.0216   0.0327   0.0261   0.0077  -0.0103  -0.0176  -0.0117   47
  0.0009   0.0096   0.0062  -0.0104  -0.0338  -0.0533  -0.0604  -0.0521  -0.0318   48
 -0.0064   0.0183   0.0401   0.0593   0.0758   0.0860   0.0836   0.0626   0.0223   49
  0.0000   0.0000                                                                   50
  FILTERING OF IVY-MIKE WAVE IN VERTICAL DIRECTION                                    51
```

```
        10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

   9   0   0     0.025                                                                52
      0.24      0.68      0.96      1.20      1.52      2.24      2.72      4.48      53
      5.76                                                                            54
  0.0000 -0.0003 -0.0024 -0.0073 -0.0150 -0.0254 -0.0381 -0.0517 -0.0624              55
 -0.0650 -0.0566 -0.0400 -0.0234 -0.0151 -0.0159 -0.0159  0.0013  0.0467              56
  0.1162  0.1890  0.2371  0.2395  0.1934  0.1142  0.0275 -0.0429 -0.0822              57
 -0.0879 -0.0683 -0.0400 -0.0231 -0.0329 -0.0694 -0.1120 -0.1268 -0.0858              58
  0.0112  0.1286  0.2102  0.2107  0.1253 -0.0054 -0.1183 -0.1659 -0.1414              59
 -0.0763 -0.0133  0.0240  0.0407  0.0561  0.0790  0.0958  0.0821  0.0267              60
 -0.0525 -0.1169 -0.1351 -0.1069 -0.0640 -0.0445 -0.0621 -0.0940 -0.0987              61
 -0.0507  0.0358  0.1135  0.1347  0.0859 -0.0017 -0.0741 -0.0918 -0.0548              62
  0.0020  0.0376  0.0353  0.0119  0.0001  0.0205  0.0639  0.0978  0.0916              63
  0.0394 -0.0342 -0.0907 -0.1028 -0.0706 -0.0189  0.0213  0.0328  0.0208              64
  0.0059  0.0077  0.0316  0.0666  0.0937  0.0994  0.0835  0.0575  0.0361              65
  0.0273  0.0280  0.0274  0.0152 -0.0108 -0.0432 -0.0692 -0.0780 -0.0663              66
 -0.0401 -0.0110  0.0089  0.0110 -0.0069 -0.0404 -0.0792 -0.1094 -0.1181              67
 -0.0993 -0.0577 -0.0083  0.0298  0.0433  0.0311  0.0044 -0.0207 -0.0333              68
 -0.0332 -0.0288 -0.0298 -0.0391 -0.0518 -0.0595 -0.0570 -0.0467 -0.0359              69
 -0.0307 -0.0318 -0.0337 -0.0288 -0.0128  0.0131  0.0430  0.0693  0.0855              70
  0.0882  0.0775  0.0573  0.0346  0.0173  0.0111  0.0167  0.0297  0.0437              71
  0.0547  0.0626  0.0689  0.0728  0.0691  0.0507  0.0158 -0.0282 -0.0665              72
 -0.0848 -0.0796 -0.0609 -0.0457 -0.0471 -0.0644 -0.0844 -0.0900 -0.0726              73
 -0.0375 -0.0001  0.0245  0.0306  0.0238  0.0153  0.0143  0.0228  0.0364              74
  0.0484  0.0544  0.0535  0.0475  0.0384  0.0283  0.0185  0.0105  0.0045              75
  0.0000  0.0000                                                                      76
```

THE RESULT OF THIS EXAMPLE RUN IS PRESENTED ON THE FOLLOWING PAGES.

OPTION. PLOT = H 0

FILTERING OF IVY-MIKE WAVE IN HORIZONTAL DIRECTION

INPUT INDICES

NW= 10 NI= 191 NQ= 0 ND= 2 TH= .0250

FREQUENCY TABLE

.190	.400	.680	1.040	1.760	2.240	3.520	4.160	5.120	6.080

TIME INPUT TABLE

0.0000	.0250	.0500	.0750	.1000	.1250	.1500	.1750	.2000	.2250
.2500	.2750	.3000	.3250	.3500	.3750	.4000	.4250	.4500	.4750
.5000	.5250	.5500	.5750	.6000	.6250	.6500	.6750	.7000	.7250
.7500	.7750	.8000	.8250	.8500	.8750	.9000	.9250	.9500	.9750
1.0000	1.0250	1.0500	1.0750	1.1000	1.1250	1.1500	1.1750	1.2000	1.2250
1.2500	1.2750	1.3000	1.3250	1.3500	1.3750	1.4000	1.4250	1.4500	1.4750
1.5000	1.5250	1.5500	1.5750	1.6000	1.6250	1.6500	1.6750	1.7000	1.7250
1.7500	1.7750	1.8000	1.8250	1.8500	1.8750	1.9000	1.9250	1.9500	1.9750
2.0000	2.0250	2.0500	2.0750	2.1000	2.1250	2.1500	2.1750	2.2000	2.2250
2.2500	2.2750	2.3000	2.3250	2.3500	2.3750	2.4000	2.4250	2.4500	2.4750
2.5000	2.5250	2.5500	2.5750	2.6000	2.6250	2.6500	2.6750	2.7000	2.7250
2.7500	2.7750	2.8000	2.8250	2.8500	2.8750	2.9000	2.9250	2.9500	2.9750
3.0000	3.0250	3.0500	3.0750	3.1000	3.1250	3.1500	3.1750	3.2000	3.2250
3.2500	3.2750	3.3000	3.3250	3.3500	3.3750	3.4000	3.4250	3.4500	3.4750
3.5000	3.5250	3.5500	3.5750	3.6000	3.6250	3.6500	3.6750	3.7000	3.7250
3.7500	3.7750	3.8000	3.8250	3.8500	3.8750	3.9000	3.9250	3.9500	3.9750
4.0000	4.0250	4.0500	4.0750	4.1000	4.1250	4.1500	4.1750	4.2000	4.2250
4.2500	4.2750	4.3000	4.3250	4.3500	4.3750	4.4000	4.4250	4.4500	4.4750
4.5000	4.5250	4.5500	4.5750	4.6000	4.6250	4.6500	4.6750	4.7000	4.7250
4.7500									

AMPL. INPUT TABLE

-.0082	.0082	.0181	.0195	.0152	.0101	.0068	.0052	.0046	.0060
.0121	.0239	.0381	.0476	.0472	.0372	.0232	.0112	.0018	-.0091
-.0241	-.0382	-.0386	-.0149	.0294	.0738	.0912	.0663	.0091	-.0483
-.0711	-.0441	.0188	.0842	.2197	.1113	.0664	.0027	-.0631	-.1202
-.1579	-.1618	-.1185	-.0284	.0830	.1700	.1887	.1235	-.0003	-.1275
-.2027	-.1994	-.1305	-.0363	.0401	.0722	.0568	.0068	-.0575	-.1149
-.1456	-.1355	-.0837	-.0073	.0625	.0966	.0854	.0462	.0117	.0069
.0309	.0579	.0574	.0192	-.0368	-.0740	-.0658	-.0152	.0464	.0813
.0713	.0278	-.0189	-.0420	-.0356	-.0140	.0024	.0039	-.0041	-.0086
-.0020	.0118	.0215	.0182	.0031	-.0140	-.0214	-.0124	.0116	.0437
.0750	.0955	.0959	.0697	.0181	-.0465	-.1025	-.1286	-.1148	-.0693
-.0147	.0243	.0339	.0170	-.0114	-.0339	-.0394	-.0257	.0026	.0378
.0707	.0908	.0885	.0593	.0079	-.0521	-.1039	-.1361	-.1473	-.1433
-.1295	-.1043	-.0616	.0010	.0736	.1340	.1586	.1374	.0820	.0200
-.0202	-.0259	-.0050	.0227	.0398	.0413	.0338	.0254	.0168	.0010
-.0287	-.0686	-.1031	-.1124	-.0863	-.0328	.0246	.0602	.0610	.0332
-.0025	-.0245	-.0224	-.0018	.0216	.0327	.0261	.0077	-.0103	-.0176
-.0117	.0009	.0096	.0062	-.0104	-.0338	-.0533	-.0604	-.0521	-.0318
-.0064	.0183	.0401	.0593	.0758	.0860	.0836	.0626	.0223	0.0000
0.0000									

```
LOW PASS FILTER WITH CUT-OFF FREQ =      .211

 OUTPUT
FREQUENCY=      .190 AT TIME=     4.400 MAXIMUM OUTPUT=    .00333

HIGH PASS FILTER WITH CUT-OFF FREQ =      .173

 OUTPUT
FREQUENCY=      .190 AT TIME=     7.475 MAXIMUM OUTPUT=    .00255


LOW PASS FILTER WITH CUT-OFF FREQ =      .444

 OUTPUT
FREQUENCY=      .400 AT TIME=     2.325 MAXIMUM OUTPUT=    .01113

HIGH PASS FILTER WITH CUT-OFF FREQ =      .364

 OUTPUT
FREQUENCY=      .400 AT TIME=     3.675 MAXIMUM OUTPUT=    .00829


LOW PASS FILTER WITH CUT-OFF FREQ =      .756

 OUTPUT
FREQUENCY=      .680 AT TIME=     1.825 MAXIMUM OUTPUT=    .02411

HIGH PASS FILTER WITH CUT-OFF FREQ =      .618

 OUTPUT
FREQUENCY=      .680 AT TIME=     4.250 MAXIMUM OUTPUT=    .01396
```

```
LOW PASS FILTER WITH CUT-OFF FREQ =      1.156

 OUTPUT
FREQUENCY=      1.040 AT TIME=      1.700 MAXIMUM OUTPUT=     .02903

HIGH PASS FILTER WITH CUT-OFF FREQ =      .945

 OUTPUT
FREQUENCY=      1.040 AT TIME=      4.050 MAXIMUM OUTPUT=     .01709


LOW PASS FILTER WITH CUT-OFF FREQ =      1.956

 OUTPUT
FREQUENCY=      1.760 AT TIME=      3.450 MAXIMUM OUTPUT=     .05946

HIGH PASS FILTER WITH CUT-OFF FREQ =      1.600

 OUTPUT
FREQUENCY=      1.760 AT TIME=      4.075 MAXIMUM OUTPUT=     .05478


LOW PASS FILTER WITH CUT-OFF FREQ =      2.489

 OUTPUT
FREQUENCY=      2.240 AT TIME=      3.400 MAXIMUM OUTPUT=     .09500

HIGH PASS FILTER WITH CUT-OFF FREQ =      2.036

 OUTPUT
FREQUENCY=      2.240 AT TIME=      3.650 MAXIMUM OUTPUT=     .07636


LOW PASS FILTER WITH CUT-OFF FREQ =      3.911
```

```
 OUTPUT
FREQUENCY=     3.520 AT TIME=     1.400 MAXIMUM OUTPUT=    .13813

HIGH PASS FILTER WITH CUT-OFF FREQ =     3.200

 OUTPUT
FREQUENCY=     3.520 AT TIME=     1.425 MAXIMUM OUTPUT=    .12551


LOW PASS FILTER WITH CUT-OFF FREQ =     4.622

 OUTPUT
FREQUENCY=     4.160 AT TIME=     1.375 MAXIMUM OUTPUT=    .17400

HIGH PASS FILTER WITH CUT-OFF FREQ =     3.782

 OUTPUT
FREQUENCY=     4.160 AT TIME=     1.500 MAXIMUM OUTPUT=    .14650


LOW PASS FILTER WITH CUT-OFF FREQ =     5.689

 OUTPUT
FREQUENCY=     5.120 AT TIME=     1.325 MAXIMUM OUTPUT=    .17727

HIGH PASS FILTER WITH CUT-OFF FREQ =     4.655

 OUTPUT
FREQUENCY=     5.120 AT TIME=     1.562 MAXIMUM OUTPUT=    .07648


LOW PASS FILTER WITH CUT-OFF FREQ =     6.756

 OUTPUT
```

```
FREQUENCY=      6.080 AT TIME=      1.312 MAXIMUM OUTPUT=     .16848

HIGH PASS FILTER WITH CUT-OFF FREQ =      5.527

 OUTPUT
FREQUENCY=      6.080 AT TIME=      1.412 MAXIMUM OUTPUT=     .05173
```

```
FILTERING OF IVY-MIKE WQVE IN VERTICAL DIRECTION

INPUT INDICES

NW=   9  NI=   0  NQ=   0  ND=   2   TH=     .0250

FREQUENCY TABLE
      .240        .680        .960       1.200       1.520       2.240       2.720       4.480       5.760

   TIME INPUT TABLE
            :
            :

   AMPL. INPUT TABLE
            :
            :
```

The remaining output has been deleted.

SECTION 7: EXAMPLE TO FOURIE

A FOURIE EXAMPLE RUN

```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.
      7                                                                              1
    1    0                                                                            2
0.01            100.0          120.0                                                 3
  502                                                                                4
0.01            15.0           0.01                                                  5
   0.000     .000     .001     .001     .002     .002     .002     .003     .003     6
    .004     .004     .004     .005     .005     .005     .006     .006     .007     7
    .007     .007     .008     .008     .009     .009     .009     .010     .010     8
    .011     .011     .011     .012     .012     .012     .013     .013     .014     9
    .014     .014     .015     .015     .016     .016     .016     .017     .017    10
    .018     .018     .018     .019     .019     .019     .020     .020     .021    11
    .021     .021     .022     .022     .023     .023     .023     .024     .024    12
    .025     .025     .025     .026     .026     .027     .027     .027     .028    13
    .028     .028     .029     .029     .030     .030     .031     .032     .032    14
    .033     .034     .034     .035     .036     .036     .037     .038     .038    15
    .039     .040     .040     .041     .042     .042     .043     .044     .044    16
    .045     .046     .046     .047     .048     .048     .049     .050     .050    17
    .051     .052     .052     .053     .054     .054     .055     .056     .056    18
    .057     .058     .058     .059     .060     .060     .061     .062     .062    19
    .063     .064     .064     .065     .066     .066     .067     .068     .068    20
    .069     .070     .070     .071     .073     .074     .075     .076     .077    21
    .078     .080     .081     .082     .083     .084     .086     .087     .088    22
    .090     .092     .094     .096     .098     .100     .102     .105     .107    23
    .109     .111     .113     .115     .117     .119     .121     .123     .125    24
    .127     .130     .132     .134     .136     .138     .140     .142     .144    25
    .146     .148     .150     .152     .155     .157     .159     .161     .163    26
    .165     .167     .169     .171     .173     .175     .177     .180     .182    27
    .184     .186     .188     .190     .192     .194     .196     .198     .200    28
    .202     .205     .207     .209     .211     .213     .215     .217     .219    29
    .223     .226     .230     .233     .237     .240     .244     .247     .251    30
    .254     .258     .261     .265     .270     .276     .281     .287     .292    31
    .298     .304     .309     .315     .320     .326     .331     .337     .342    32
    .348     .354     .359     .365     .370     .376     .381     .387     .392    33
    .398     .404     .409     .415     .420     .426     .431     .437     .442    34
    .448     .454     .459     .465     .470     .476     .481     .487     .492    35
    .498     .504     .509     .515     .520     .526     .531     .537     .542    36
    .548     .554     .559     .565     .570     .576     .581     .587     .596    37
    .605     .614     .623     .632     .641     .650     .659     .668     .677    38
    .686     .695     .704     .713     .722     .731     .740     .749     .758    39
    .767     .776     .785     .794     .803     .812     .821     .830     .839    40
    .848     .857     .866     .875     .884     .893     .902     .911     .920    41
    .929     .938     .947     .963     .978     .994    1.009    1.025    1.040    42
   1.056    1.071    1.087    1.102    1.118    1.133    1.149    1.164    1.180    43
   1.195    1.211    1.226    1.242    1.257    1.273    1.288    1.304    1.319    44
   1.335    1.350    1.366    1.381    1.397    1.412    1.428    1.443    1.459    45
   1.474    1.490    1.505    1.521    1.536    1.552    1.567    1.583    1.598    46
   1.614    1.629    1.653    1.677    1.701    1.725    1.749    1.772    1.796    47
   1.820    1.844    1.868    1.891    1.915    1.939    1.963    1.987    2.010    48
   2.034    2.058    2.082    2.106    2.129    2.153    2.177    2.201    2.225    49
   2.249    2.272    2.296    2.320    2.344    2.368    2.391    2.415    2.439    50
   2.463    2.487    2.510    2.534    2.558    2.582    2.606    2.629    2.653    51
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        10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

   2.677   2.701   2.725   2.749   2.772   2.796   2.820   2.844   2.868              52
   2.891   2.915   2.939   2.963   2.987   3.010   3.034   3.058   3.082              53
   3.106   3.129   3.153   3.177   3.201   3.225   3.262   3.299   3.336              54
   3.373   3.410   3.447   3.484   3.521   3.558   3.595   3.632   3.669              55
   3.706   3.743   3.780   3.817   3.854   3.891   3.928   3.965   4.002              56
   4.040   4.077   4.114   4.151   4.188   4.225   4.262   4.299   4.336              57
   4.373   4.410   4.447   4.484   4.521   4.558   4.595   4.632   4.669              58
   4.706   4.743   4.780   4.817   4.854   4.891   4.928   4.965   5.002              59
   5.058   5.114   5.169   5.225   5.280   5.336   5.391   5.447   5.502              60
   5.558   5.614   5.669   5.725   5.780   5.836   5.943                              61
      ACCELERATION TABLE          (TYPE II)                                0  0      62
   0.000   1.547   6.081  13.287  22.664  33.555  45.197  56.769  67.447              63
  76.460  83.145  86.992  87.679  85.099  79.370  70.828  60.012  47.630              64
  34.515  21.573   9.726   -.148  -7.276 -11.038 -11.015  -7.013    .909              65
  12.447  27.058  43.995  62.340  81.067  99.092 115.345 128.832 138.694              66
 144.265 145.110 141.057 132.210 118.946 101.899  81.922  60.044  37.411              67
  15.220  -5.347 -23.188 -37.349 -47.071 -51.838 -51.399 -45.786 -35.307              68
 -20.529  -2.239  18.599  40.901  63.525  85.338 105.277 122.406 135.966              69
 145.412 150.436 150.976 147.211 139.535 128.532 114.924  99.527  83.188              70
  66.739  50.937  36.423  23.686  11.963  -7.578 -25.509 -40.731 -52.224              71
 -59.116 -60.719 -56.582 -46.513 -30.600  -9.214  17.005  47.168  80.177              72
 114.774 149.595 183.235 214.310 241.523 263.720 279.948 289.494 291.915              73
 287.060 275.072 256.376 231.659 201.831 167.982 131.326  93.148  54.739              74
  17.345 -17.892 -49.980 -78.109-101.684-120.333-133.915-142.507-146.381              75
-145.980-141.875-134.729-125.244-114.126-102.038 -89.568 -77.198 -65.286              76
 -54.055 -43.594 -33.867 -24.731 -15.961  -7.281   1.604  10.972  21.049              77
  31.988  43.837  56.372  76.455  92.809 104.790 112.028 114.433 112.189              78
 105.728  95.688  82.861  68.134  52.422  36.608  21.478   7.675  -4.360              79
 -25.182 -46.728 -67.911 -87.600-104.675-118.094-126.946-130.509-128.290              80
-120.061-105.879 -86.093 -61.332 -32.483   -.654  32.873  66.702  99.390              81
 129.509 155.719 176.827 191.849 200.051 200.989 194.525 180.837 160.407              82
 133.998 102.615  67.462  29.879  -8.718 -46.900 -83.292-116.633-145.825              83
-169.980-188.449-200.843-207.036-207.160-201.578-190.864-175.751-157.092              84
-135.810-112.843 -89.102 -65.421 -42.529 -21.016  -1.317  16.290  31.683              85
  4[illegible].884  56.031  65.355  73.141  79.696  85.313  90.238  94.643  98.585              86
 101.331  97.891  88.528  73.828  54.662  32.129   7.481 -17.948 -42.830              87
 -65.917 -86.116-102.550-114.887-129.906-139.358-142.415-138.555-127.593              88
-109.704 -85.421 -55.619 -21.473  15.586  53.946  91.882 127.645 159.543              89
 186.023 205.749 217.666 221.053 215.554 201.202 178.412 147.965 110.966              90
  68.796  23.041 -24.575 -72.279-118.321-161.055-199.010-230.949-255.916              91
-273.266-282.683-284.174-278.055-264.917-245.580-221.041-192.414-160.863              92
-127.548 -93.560 -59.878 -27.328   3.448  31.997  58.066  81.581 102.629              93
 121.419 138.248 153.455 167.371 180.285 192.400 203.808 214.021 224.338              94
 226.386 220.181 206.103 184.869 157.495 125.233  89.513  51.865  13.845              95
 -23.041 -57.410 -88.059-114.021-134.595-149.371-158.236-161.355-159.154              96
-152.274-141.524-127.824-112.148 -95.458 -78.651 -62.511 -47.665 -34.559              97
 -23.439 -14.351  -7.155  -1.545   2.913   6.737  10.485  14.704  19.878              98
  26.390  34.483  44.207  60.788  74.786  85.522  92.477  95.312  93.891              99
  88.278  78.739  65.725  49.844  31.835  12.523  -7.216 -26.505 -44.506             100
 -60.458 -73.719 -83.786 -90.323 -93.167 -92.331 -88.000 -80.509 -70.325             101
 -58.013 -44.206 -29.567 -14.752   -.378  13.011  24.962  35.139  43.330             102
  49.450  53.534  55.730  56.274  55.471  53.665  51.213  48.457  45.695             103
  43.164  41.013  36.989  31.306  24.188  15.923   6.852  -2.646 -12.170             104
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         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

-21.318 -29.707 -36.983 -42.845 -47.054 -49.444 -49.931 -48.511 -45.266             105
-40.353 -33.999 -26.491 -18.157  -9.354   -.451   8.188  16.221  23.344             106
 29.300  33.893  36.992  38.538  38.539  37.070  34.268  30.318  25.446             107
 19.905  13.959   7.874   1.901  -3.735  -8.843 -13.275 -16.929 -19.755             108
-21.749 -22.955 -23.451 -23.352 -22.790 -21.912 -20.864 -19.784 -18.79[illegible]     109
-17.987 -17.428 -17.149 -17.144 -17.375 -17.773 -18.244 -18.679 -18.959             110
-18.966 -18.589 -17.739 -16.348 -14.382 -11.880  -7.603  -3.115   1.419             111
  5.832   9.971  13.692  16.874  19.423  21.272  22.383  22.752  22.404             112
 21.394  19.797  17.713  15.253  12.538   9.690   6.832   4.073   1.512             113
  -.771  -2.713  -4.276  -5.442  -6.215  -6.617  -6.687  -6.476  -6.046             114
 -5.461  -4.786  -4.081  -3.401  -2.788  -2.273  -1.873  -1.590  -1.416             115
 -1.328  -1.298  -1.289  -1.262  -1.185  -1.039   -.797   -.441    .035             116
   .767   1.368   1.817   2.103   2.228   2.202   2.046   1.790   1.465             117
   1.109    .759    .447    .203    .050   0.000   0.000                            118
```

THE RESULT OF THIS EXAMPLE RUN IS PRESENTED ON THE FOLLOWING PAGES.

OPTION. PLOT = 7

ACCELERATION TABLE (TYPE II)

INPUT DATA

STARTING TIME	=	5.836000
END TIME	=	5.943000
INTEGRATING TIME INTERVAL	=	.010000
NO OF POINTS ON FORCE TABLE	=	507
NO OF FREQUENCY RANGES	=	1

TIME TABLE

0.0000	0.0000	.0010	.0010	.0020	.0020	.0020	.0030	.0030	.0040	.0040	.0040
.0050	.0050	.0050	.0060	.0060	.0070	.0070	.0070	.0080	.0080	.0090	.0090
.0090	.0100	.0100	.0110	.0110	.0110	.0120	.0120	.0120	.0130	.0130	.0140
.0140	.0140	.0150	.0150	.0160	.0160	.0160	.0170	.0170	.0180	.0180	.0180
.0190	.0190	.0190	.0200	.0200	.0210	.0210	.0210	.0220	.0220	.0230	.0230
.0230	.0240	.0240	.0250	.0250	.0250	.0260	.0260	.0270	.0270	.0270	.0280
.0280	.0280	.0290	.0290	.0300	.0300	.0310	.0320	.0320	.0330	.0340	.0340
.0350	.0360	.0360	.0370	.0380	.0380	.0390	.0400	.0400	.0410	.0420	.0420
.0430	.0440	.0440	.0450	.0460	.0460	.0470	.0480	.0480	.0490	.0500	.0500
.0510	.0520	.0520	.0530	.0540	.0540	.0550	.0560	.0560	.0570	.0580	.0580
.0590	.0600	.0600	.0610	.0620	.0620	.0630	.0640	.0640	.0650	.0660	.0660
.0670	.0680	.0680	.0690	.0700	.0700	.0710	.0730	.0740	.0750	.0760	.0770
.0780	.0800	.0810	.0820	.0830	.0840	.0860	.0870	.0880	.0900	.0920	.0940
.0960	.0980	.1000	.1020	.1050	.1070	.1090	.1110	.1130	.1150	.1170	.1190
.1210	.1230	.1250	.1270	.1300	.1320	.1340	.1360	.1380	.1400	.1420	.1440
.1460	.1480	.1500	.1520	.1550	.1570	.1590	.1610	.1630	.1650	.1670	.1690
.1710	.1730	.1750	.1770	.1800	.1820	.1840	.1860	.1880	.1900	.1920	.1940
.1960	.1980	.2000	.2020	.2050	.2070	.2090	.2110	.2130	.2150	.2170	.2190
.2230	.2260	.2300	.2330	.2370	.2400	.2440	.2470	.2510	.2540	.2580	.2610
.2650	.2700	.2760	.2810	.2870	.2920	.2980	.3040	.3090	.3150	.3200	.3260
.3310	.3370	.3420	.3480	.3540	.3590	.3650	.3700	.3760	.3810	.3870	.3920
.3980	.4040	.4090	.4150	.4200	.4260	.4310	.4370	.4420	.4480	.4540	.4590
.4650	.4700	.4760	.4810	.4870	.4920	.4980	.5040	.5090	.5150	.5200	.5260
.5310	.5370	.5420	.5480	.5540	.5590	.5650	.5700	.5760	.5810	.5870	.5920
.6050	.6140	.6230	.6320	.6410	.6500	.6590	.6680	.6770	.6860	.6950	.7040
.7130	.7220	.7310	.7400	.7490	.7580	.7670	.7760	.7850	.7940	.8030	.8120
.8210	.8300	.8390	.8480	.8570	.8660	.8750	.8840	.8930	.9020	.9110	.9200
.9290	.9380	.9470	.9630	.9780	.9940	1.0090	1.0250	1.0400	1.0560	1.0710	1.0870
1.1020	1.1180	1.1330	1.1490	1.1640	1.1800	1.1950	1.2110	1.2260	1.2420	1.2570	1.2730
1.2880	1.3040	1.3190	1.3350	1.3500	1.3660	1.3810	1.3970	1.4120	1.4280	1.4430	1.4590
1.4740	1.4900	1.5050	1.5210	1.5360	1.5520	1.5670	1.5830	1.5980	1.6140	1.6290	1.6530
1.6770	1.7010	1.7250	1.7490	1.7720	1.7960	1.8200	1.8440	1.8680	1.8910	1.9150	1.9390
1.9630	1.9870	2.0100	2.0340	2.0580	2.0820	2.1060	2.1290	2.1530	2.1770	2.2010	2.2250
2.2490	2.2720	2.2960	2.3200	2.3440	2.3680	2.3910	2.4150	2.4390	2.4630	2.4870	2.5100
2.5340	2.5580	2.5820	2.6060	2.6290	2.6530	2.6770	2.7010	2.7250	2.7490	2.7720	2.7960
2.8200	2.8440	2.8680	2.8910	2.9150	2.9390	2.9630	2.9870	3.0100	3.0340	3.0580	3.0820
3.1060	3.1290	3.1530	3.1770	3.2010	3.2250	3.2620	3.2990	3.3360	3.3730	3.4100	3.4470
3.4840	3.5210	3.5580	3.5950	3.6320	3.6690	3.7060	3.7430	3.7800	3.8170	3.8540	3.8910
3.9280	3.9650	4.0020	4.0400	4.0770	4.1140	4.1510	4.1880	4.2250	4.2620	4.2990	4.3360
4.3730	4.4100	4.4470	4.4840	4.5210	4.5580	4.5950	4.6320	4.6690	4.7060	4.7430	4.7800
4.8170	4.8540	4.8910	4.9280	4.9650	5.0020	5.0580	5.1140	5.1690	5.2250	5.2800	5.3360
5.3910	5.4470	5.5020	5.5580	5.6140	5.6690	5.7250	5.7800	5.8360	5.9430		

FORCE TABLE

0.0000	1.5470	6.0810	13.2870	22.6640	33.5550	45.1970	56.7690	67.4470	76.4600	83.1450	86.9920
87.6790	85.0990	79.3700	70.8280	60.0120	47.6300	34.5150	21.5730	9.7260	-.1480	-7.2760	-11.0380
-11.0150	-7.0130	.9090	12.4470	27.0580	43.9950	62.3400	81.0670	99.0920	115.3450	128.8320	138.6940
[illegible].2650	145.1100	141.0570	132.2100	118.9460	101.8990	81.9220	60.0440	37.4110	15.2200	-5.3470	-23.1880
-37.3[illegible]	-47.0710	-51.8380	-51.3990	-45.7860	-35.3070	-20.5290	-2.2390	18.5990	40.9010	63.5250	85.3380
1[illegible].2770	122.4060	135.9660	145.4120	150.4360	150.9760	147.2110	139.5350	128.5320	114.9240	99.5270	83.1880
6[illegible]	50.9370	36.4230	23.6860	11.9630	-7.5780	-25.5090	-40.7310	-52.2240	-59.1160	-60.7190	-56.5820
-4[illegible].5130	-30.6000	-9.2140	17.0050	47.1680	80.1770	114.7740	149.5950	183.2350	214.3100	241.5230	263.7200
279.[illegible]480	289.4940	291.9150	287.0600	275.0720	256.3760	231.6590	201.8310	167.9820	131.3260	93.1480	54.7390
17.[illegible]950	-17.8920	-49.9800	-78.1090	-101.6840	-120.3330	-133.9150	-142.5070	-146.3810	-145.9800	-141.8750	-134.7290
-125.[illegible]	-114.1260	-102.0380	-89.5680	-77.1980	-65.2860	-54.0550	-43.5940	-33.8670	-24.7310	-15.9610	-7.2810
1.[illegible]	10.9720	21.0490	31.9880	43.8370	56.3720	76.4550	92.8090	104.7900	112.0280	114.4330	112.1890
105.[illegible]	95.6880	82.8610	68.1340	52.4220	36.6080	21.4780	7.6750	-4.3600	-25.1820	-46.7280	-67.9110
-87.[illegible]000	-104.6750	-118.0940	-126.9460	-130.5090	-128.2900	-120.0610	-105.8790	-86.0930	-61.3320	-32.4830	-.6540
32.8730	66.7020	99.3900	129.5090	155.7190	176.8270	191.8490	200.0510	200.9890	194.5250	180.8370	160.4070
133.9[illegible]	102.6150	67.4620	29.8790	-8.7180	-46.9000	-83.2920	-116.6330	-145.8250	-169.9800	-188.4490	-200.8430
-207.0[illegible]	-207.1600	-20[illegible].5780	-190.8640	-175.7510	-157.0920	-135.8100	-112.8430	-89.1020	-65.4210	-42.5290	-21.0160
[illegible].2170	16.2900	31.6830	44.8840	56.0310	65.3550	73.1410	79.6960	85.3130	90.2380	94.6430	98.5850
101.3[illegible]	97.8910	88.5280	73.8280	54.6620	32.1290	7.4810	-17.9480	-42.8300	-65.9170	-86.1160	-102.5500
-114.[illegible]	-129.9060	-139.3580	-142.4150	-138.5550	-127.5930	-109.7040	-85.4210	-55.6190	-21.4730	15.5860	53.9460
[illegible]	127.6450	159.5430	186.0230	205.7490	217.6660	221.0530	215.5540	201.2020	178.4120	147.9650	110.9660
[illegible]	23.0410	-24.5750	-72.2790	-118.3210	-161.0550	-199.0100	-230.9490	-255.9160	-273.2660	-282.6830	-284.1740
-2[illegible]	-2[illegible].9170	-245.5800	-221.0410	-192.4140	-160.8630	-127.5480	-93.5600	-59.8780	-27.3280	3.4480	31.9970
[illegible]	81.5810	102.6290	121.4190	138.2480	153.4550	167.3710	180.2850	192.4000	203.8080	214.0210	224.3380
22[illegible].3860	720.1810	206.1030	184.8690	157.4950	125.2330	89.5130	51.8650	13.8450	-23.0410	-57.4100	-88.0590
-114.0210	-134.5950	-149.3710	-158.2360	-161.3550	-159.1540	-152.2740	-141.5240	-127.8240	-112.1480	-95.4580	-78.6510
-62.5110	-47.6650	-34.5590	-23.4390	-14.3510	-7.1550	-1.5450	2.9130	6.7370	10.4850	14.7040	19.8780
26.3900	34.4830	44.2070	60.7880	74.7860	85.5220	92.4770	95.3120	93.8910	88.2780	78.7390	65.7250
49.8440	31.8350	12.5230	-7.2160	-26.5050	-44.5060	-60.4580	-73.7190	-83.7860	-90.3230	-93.1670	-92.3310
-88.0000	-80.5090	-70.3250	-58.0130	-44.2060	-29.5670	-14.7520	-.3780	13.0110	24.9620	35.1390	43.3300
49.4500	53.5340	55.7300	56.2740	55.4710	53.6650	51.2130	48.4570	45.6950	43.1640	41.0130	36.9890
31.3060	24.1880	15.9230	6.8520	-2.6460	-12.1700	-21.3180	-29.7070	-36.9830	-42.8450	-47.0540	-49.4440
-49.9310	-48.5110	-45.2660	-40.3530	-33.9990	-26.4910	-18.1570	-9.3540	-.4510	8.1880	16.2210	23.3440
29.3000	33.8930	36.9920	38.5380	38.5390	37.0700	34.2680	30.3180	25.4460	19.9050	13.9590	7.8740
1.9010	-3.7350	-8.8430	-13.2750	-16.9290	-19.7550	-21.7490	-22.9550	-23.4510	-23.3520	-22.7900	-21.9120
-20.8640	-19.7840	-18.7930	-17.9870	-17.4280	-17.1490	-17.1440	-17.3750	-17.7730	-18.2440	-18.6790	-18.9590
-18.9660	-18.5890	-17.7390	-16.3480	-14.3820	-11.8800	-7.6030	-3.1150	1.4190	5.8320	9.9710	13.6920
16.8740	19.4230	21.2720	22.3830	22.7520	22.4040	21.3940	19.7970	17.7130	15.2530	12.5380	9.6900
6.8320	4.0730	1.5120	-.7710	-2.7130	-4.2760	-5.4420	-6.2150	-6.6170	-6.6870	-6.4760	-6.0460
-5.4610	-4.7860	-4.0810	-3.4010	-2.7880	-2.2730	-1.8730	-1.5900	-1.4160	-1.3280	-1.2980	-1.2890
-1.2620	-1.1850	-1.0390	-.7970	-.4410	.0350	.7670	1.3680	1.8170	2.1030	2.2280	2.2020
2.0460	1.7900	1.4650	1.1090	.7590	.4470	.2030	.0500	0.0000	0.0000		

STARTING FREQ. = .0100

ENDING FREQ. = 100.0000

INTERVAL STEPS = 120.0

FOURIER SPECTRUM

FREQUENCY C.P.S.	REAL PART F(OMEGA)	IMAG. PART F(OMEGA)	PHASE ANGLE	FOURIER SPECTRUM
.01000	.30580E+01	-.47856E-02	-.08966	.30580E+01
.01080	.30580E+01	-.51673E-02	-.09682	.30580E+01
.01166	.30580E+01	-.55796E-02	-.10454	.30580E+01
.01259	.30580E+01	-.60247E-02	-.11288	.30580E+01
.01359	.30580E+01	-.65053E-02	-.12189	.30580E+01
.01468	.30580E+01	-.70243E-02	-.13161	.30580E+01
.01585	.30580E+01	-.75846E-02	-.14211	.30580E+01
.01711	.30580E+01	-.81897E-02	-.15344	.30580E+01
.01848	.30580E+01	-.88431E-02	-.16569	.30580E+01
.01995	.30580E+01	-.95485E-02	-.17890	.30580E+01
.02154	.30580E+01	-.10310E-01	-.19318	.30580E+01
.02325	.30580E+01	-.11133E-01	-.20859	.30580E+01
.02512	.30580E+01	-.12021E-01	-.22523	.30580E+01
.02712	.30580E+01	-.12980E-01	-.24320	.30580E+01
.02929	.30580E+01	-.14015E-01	-.26260	.30580E+01
.03162	.30580E+01	-.15134E-01	-.28355	.30580E+01
.03415	.30580E+01	-.16341E-01	-.30617	.30580E+01
.03687	.30580E+01	-.17645E-01	-.33059	.30581E+01
.03981	.30580E+01	-.19052E-01	-.35697	.30581E+01
.04299	.30580E+01	-.20572E-01	-.38545	.30581E+01
.04642	.30580E+01	-.22214E-01	-.41620	.30581E+01
.05012	.30580E+01	-.23986E-01	-.44940	.30581E+01
.05412	.30580E+01	-.25900E-01	-.48526	.30581E+01
.05843	.30580E+01	-.27966E-01	-.52397	.30581E+01
.06310	.30580E+01	-.30198E-01	-.56578	.30582E+01
.06813	.30580E+01	-.32607E-01	-.61092	.30582E+01
.07356	.30580E+01	-.35209E-01	-.65967	.30582E+01
.07943	.30580E+01	-.38019E-01	-.71230	.30582E+01
.08577	.30580E+01	-.41053E-01	-.76914	.30583E+01
.09261	.30580E+01	-.44330E-01	-.83052	.30583E+01
.10000	.30580E+01	-.47868E-01	-.89680	.30584E+01
.10798	.30580E+01	-.51689E-01	-.96837	.30584E+01
.11659	.30580E+01	-.55815E-01	-1.04565	.30585E+01
.12589	.30580E+01	-.60271E-01	-1.12912	.30586E+01
.13594	.30580E+01	-.65084E-01	-1.21925	.30587E+01
.14678	.30580E+01	-.70281E-01	-1.31659	.30588E+01
.15849	.30580E+01	-.75895E-01	-1.42171	.30589E+01
.17113	.30580E+01	-.81958E-01	-1.53524	.30591E+01
.18478	.30580E+01	-.88507E-01	-1.65785	.30593E+01
.19953	.30580E+01	-.95582E-01	-1.79029	.30595E+01
.21544	.30580E+01	-.10322E+00	-1.93333	.30597E+01
.23263	.30580E+01	-.11148E+00	-2.08785	.30600E+01
.25119	.30580E+01	-.12040E+00	-2.25476	.30603E+01
.27123	.30580E+01	-.13004E+00	-2.43509	.30607E+01
.29286	.30579E+01	-.14046E+00	-2.62991	.30612E+01
.31623	.30579E+01	-.15172E+00	-2.84043	.30617E+01
.34145	.30579E+01	-.16389E+00	-3.06792	.30623E+01
.36869	.30579E+01	-.17706E+00	-3.31379	.30630E+01
.39811	.30579E+01	-.19129E+00	-3.57956	.30638E+01
.42987	.30578E+01	-.20669E+00	-3.86690	.30648E+01
.46416	.30578E+01	-.22335E+00	-4.17762	.30659E+01
.50119	.30577E+01	-.24138E+00	-4.51370	.30672E+01
.54117	.30576E+01	-.26091E+00	-4.87732	.30688E+01
.58434	.30575E+01	-.28207E+00	-5.27084	.30705E+01
.63096	.30574E+01	-.30500E+00	-5.69690	.30726E+01
.68129	.30572E+01	-.32987E+00	-6.15836	.30750E+01
.73564	.30570E+01	-.35686E+00	-6.65841	.30777E+01

.79433	.30568E+01	-.38617E+00	-7.20058	.30809E+01
.85770	.30562E+01	-.41804E+00	-7.78878	.30846E+01
.92612	.30556E+01	-.45270E+00	-8.42737	.30889E+01
1.00000	.30548E+01	-.49046E+00	-9.12121	.30939E+01
1.07978	.30537E+01	-.53163E+00	-9.87578	.30997E+01
1.16591	.30523E+01	-.57658E+00	-10.69721	.31063E+01
1.25893	.30504E+01	-.62573E+00	-11.59242	.31139E+01
1.35936	.30478E+01	-.67954E+00	-12.56925	.31226E+01
1.46780	.30443E+01	-.73856E+00	-13.63657	.31326E+01
1.58489	.30397E+01	-.80337E+00	-14.80446	.31441E+01
1.71133	.30335E+01	-.87467E+00	-16.08438	.31570E+01
1.84785	.30251E+01	-.95320E+00	-17.48936	.31718E+01
1.99526	.30140E+01	-.10398E+01	-19.03426	.31883E+01
2.15443	.29991E+01	-.11354E+01	-20.73591	.32069E+01
2.32631	.29794E+01	-.12410E+01	-22.61344	.32275E+01
2.51189	.29531E+01	-.13576E+01	-24.68843	.32502E+01
2.71227	.29184E+01	-.14861E+01	-26.98518	.32750E+01
2.92864	.28728E+01	-.16274E+01	-29.53084	.33017E+01
3.16228	.28129E+01	-.17821E+01	-32.35557	.33299E+01
3.41455	.27349E+01	-.19503E+01	-35.49258	.33591E+01
3.68695	.26342E+01	-.21314E+01	-38.97803	.33885E+01
3.98107	.25050E+01	-.23238E+01	-42.85089	.34169E+01
4.29866	.23411E+01	-.25240E+01	-47.15255	.34426E+01
4.64159	.21359E+01	-.27266E+01	-51.92622	.34636E+01
5.01187	.18827E+01	-.29231E+01	-57.21607	.34769E+01
5.41170	.15759E+01	-.31017E+01	-63.06592	.34791E+01
5.84341	.12128E+01	-.32467E+01	-69.51734	.34658E+01
6.30957	.79493E+00	-.33385E+01	-76.60672	.34318E+01
6.81292	.33126E+00	-.33548E+01	-84.36065	.33711E+01
7.35642	-.15940E+00	-.32729E+01	87.21181	.32768E+01
7.94328	-.64614E+00	-.30748E+01	78.13251	.31419E+01
8.57696	-.10858E+01	-.27534E+01	68.47896	.29597E+01
9.26119	-.14265E+01	-.23217E+01	58.43231	.27250E+01
10.00000	-.16184E+01	-.18213E+01	48.37519	.24365E+01
10.79775	-.16310E+01	-.13254E+01	39.09747	.21017E+01
11.65914	-.14780E+01	-.93069E+00	32.19859	.17466E+01
12.58925	-.12394E+01	-.72833E+00	30.44040	.14376E+01
13.59356	-.10653E+01	-.75180E+00	35.21031	.13039E+01
14.67799	-.11348E+01	-.91341E+00	38.83185	.14567E+01
15.84893	-.15514E+01	-.96927E+00	31.99538	.18293E+01
17.11328	-.21945E+01	-.57998E+00	14.80406	.22699E+01
18.47850	-.26185E+01	.47392E+00	-10.25880	.26611E+01
19.95262	-.21753E+01	.19633E+01	-42.06779	.29303E+01
21.54435	-.49296E+00	.30176E+01	-80.72216	.30576E+01
23.26305	.18595E+01	.24841E+01	53.18328	.31030E+01
25.11886	.41383E+01	-.16661E+01	-21.92929	.44611E+01
27.12273	.18465E+01	-.48523E+01	-69.16559	.51917E+01
29.28645	-.15544E+01	-.44964E+01	70.92944	.47575E+01
31.62278	-.36444E+01	-.16546E+01	24.41829	.40024E+01
34.14549	-.26734E+01	.12634E+01	-25.29413	.29568E+01
36.86945	-.98513E+00	.21585E+01	-65.46806	.23727E+01
39.81072	.79443E+00	.23946E+01	71.64640	.25229E+01
42.98662	.28088E+01	.69310E+00	13.86117	.28931E+01
46.41589	.17696E+01	-.21380E+01	-50.38666	.27753E+01
50.11872	-.64272E+00	-.19870E+01	72.07550	.20884E+01
54.11695	-.13513E+01	-.10390E+01	37.55720	.17045E+01
58.43414	-.19713E+01	.98517E+00	-26.55416	.22037E+01
63.09573	.68432E+00	.15646E+01	66.37622	.17077E+01
68.12921	.88485E+00	.27612E+00	17.33045	.92693E+00
73.56423	.93969E+00	-.50634E+00	-28.31753	.10674E+01
79.43282	.67964E+00	-.57262E+00	-40.11546	.88871E+00
85.76959	-.16961E+00	-.12043E+01	81.98380	.12162E+01
92.61187	-.51748E+00	-.10472E+01	63.70300	.11681E+01
100.00000	-.74984E+00	-.12459E+00	9.43351	.76012E+00

FREQ.(HZ) FOURIER AMPLITUDE (IN/SEC) .7601166 5.1917378

FREQ.(HZ)
.010
.011
.012
.013
.014
.015
.016
.017
.018
.020
.022
.023
.025
.027
.029
.032
.034
.037
.040
.043
.046
.050
.054
.058
.063
.068
.074
.079
.086
.093
.100
.108
.117
.126
.136
.147
.158
.171
.185
.200
.215
.233
.251
.271
.293
.316
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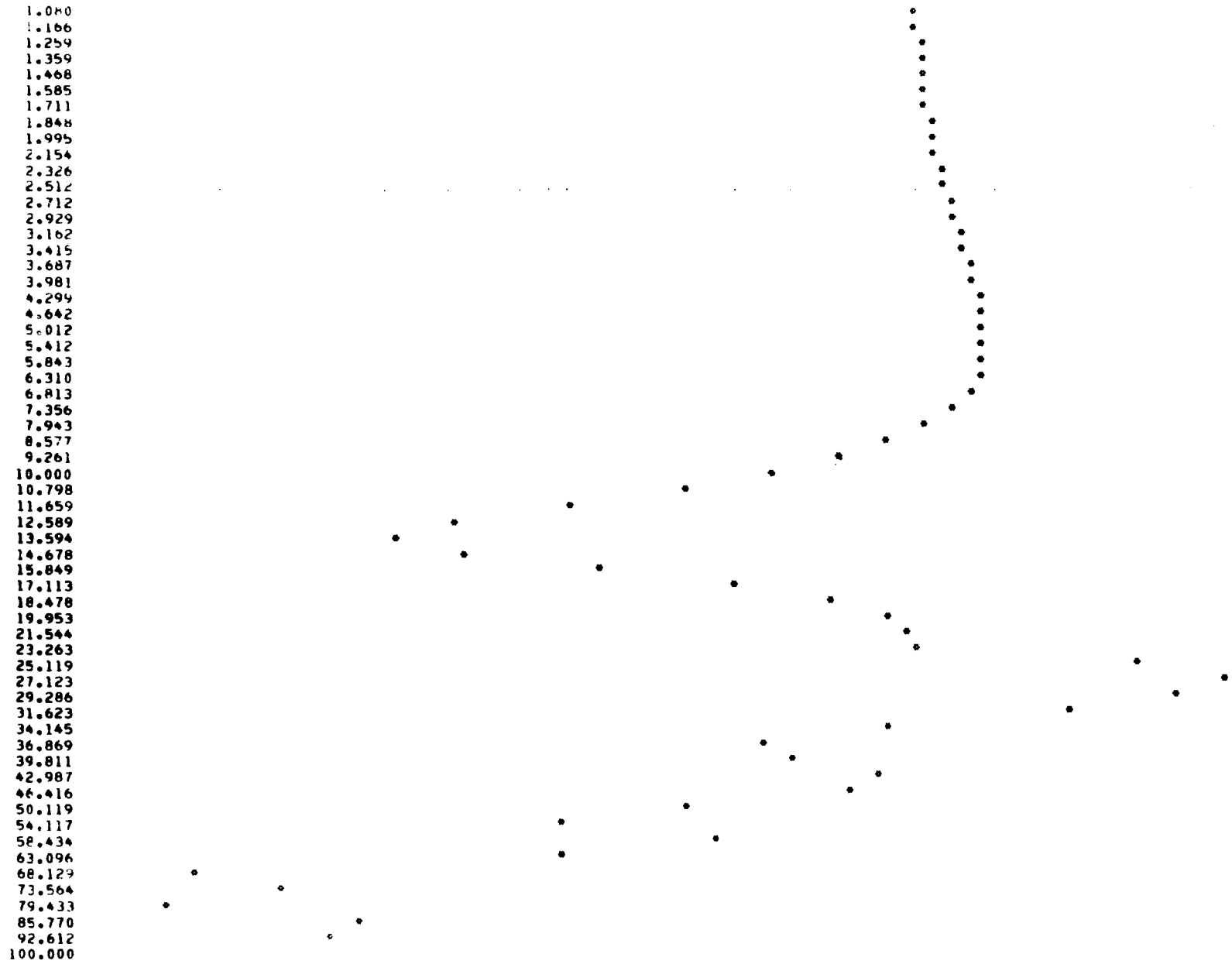
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85.770
92.612
100.000

SECTION 8: EXAMPLES TO ISIP

AN ISIP EXAMPLE RUN

THIS EXAMPLE USES A FLOOR-MOUNTED PLATFORM WITH UNEQUAL ISOLATOR LENGTHS.

```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

      11       3                                                                      1
  SI PLATFORM PAR POWER RM                                                           2
       ISOLIN INPUT DATA                                                             3
         5         4        -1         1         0        60                         4
 5000.     75.0      50.0      5.0       150.0     100.0     10.0                    5
 1000.0    0.0       0.0      15.0       10.0      10.0      10.0                    6
 1000.0    0.0       100.0    15.0       10.0      10.0      10.0                    7
 1000.0    150.0     100.0    15.0       10.0      10.0      10.0                    8
 1000.0    150.0     0.0      15.0       10.0      10.0      10.0                    9
 0.0       0.0                                                                      10
 0.0       100.                                                                     11
 150.      100.      5.                                                             12
 150.                -2.                                                            13
 .7547     -36.        .05       19872. 999999.      .08                            14
0.05      0.10      -0.07                                                           15
SKIP                                                                                16
SKIP                                                                                17
   ISOL   INPUT                                                                     18
   1   0  27   0  -3                                                                19
   106.    113.     81.                                                             20
   60.5    98.                                                                      21
   60.5    98.      80.                                                             22
  0.0000  0.0100  0.0200  0.0300  0.0399  0.0499  0.0599  0.0699  0.0799            23
  0.0899  0.0999  0.1099  0.1199  0.1299  0.1399  0.1499  0.1599  0.1699            24
  0.1799  0.1899  0.1999  0.2099  0.2199  0.2299  0.2399  0.2499  0.2599            25
  0.0000  1.1955  2.3153 -4.2828 -5.8567  0.8376  2.5178  3.1164  1.2262            26
 -2.6117 -3.3405 -1.6381  1.7029  2.5462  1.1887 -1.1830 -3.6089 -1.8298            27
  1.4888  2.9735  3.4603  3.2366  1.8746 -0.6405 -1.6589 -0.4104 -0.4104            28
                                                                                    29
                                                                                    30
                                                                                    31
 -0.4000 -1.6733  1.8361 -0.9891  1.0937  6.2473  0.3012  3.5266  4.0096            32
 -6.1345 -9.2733 -1.8550  6.5662  3.5776 -1.8397 -3.2752 -5.5273 -3.4537            33
  1.7026  5.8255  7.7845  5.9914  1.7344 -3.6018 -6.6832 -6.8183 -5.2723            34
           2.5     0.01      0.051 2.0     0.10                                    35
                                                                                    36
      INPUT TO YUPLOT OF PLTSUB                                                     37
  1  2 11 21 31                                                                     38
   INPUT  TO  SPECTRM                                                               39
           3.5     0.01     0.08                    29    36    31                   40
    1    2    5                                                                     41
  0.2    15.       20.                                                              42
```

THE RESULT OF THIS EXAMPLE RUN HAS BEEN DELETED.

AN ISIP EXAMPLE RUN

THIS EXAMPLE IS ALMOST THE SAME AS THE PREVIOUS ONE EXCEPT THE EXCITATION FORCES ARE READ IN THROUGH SYNSOL INSTEAD OF ISOL.

```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

      11        3                                                                      1
  S1 PLATFORM PAR POWER RM                                                           2
       ISOL IN INPUT DATA                                                            3
         5         4        -1         1         0        60                         4
 5000.     75.0      50.0      5.0       150.0     100.0     10.0                    5
 1000.0    0.0       0.0      15.0       10.0      10.0      10.0                    6
 1000.0    0.0       100.0    15.0       10.0      10.0      10.0                    7
 1000.0    150.0     100.0    15.0       10.0      10.0      10.0                    8
 1000.0    150.0     0.0      15.0       10.0      10.0      10.0                    9
 0.0       0.0                                                                      10
 0.0       100.                                                                     11
 150.      100.      5.                                                             12
 150.                -2.                                                            13
 .7547     -36.         .05       19872. 999999.      .08                           14
0.05      0.10      -0.07                                                           15
SKIP                                                                                16
     SYNSOL INPUT DATA                                                              17
   -2   27   0.2599    27   0.2599                                                   18
  0.0000  0.0100  0.0200  0.0300  0.0399  0.0499  0.0599  0.0699  0.0799            19
  0.0899  0.0999  0.1099  0.1199  0.1299  0.1399  0.1499  0.1599  0.1699            20
  0.1799  0.1899  0.1999  0.2099  0.2199  0.2299  0.2399  0.2499  0.2599            21
  0.0000  1.1955  2.3153 -4.2828 -5.8567  0.8376  2.5178  3.1164  1.2262            22
 -2.6117 -3.3405 -1.6381  1.7029  2.5462  1.1887 -1.1830 -3.6089 -1.8298            23
  1.4888  2.9735  3.4603  3.2366  1.8746 -0.6405 -1.6589 -0.4104 -0.4104            24
 -0.4000 -1.6733  1.8361 -0.9891  1.0937  6.2473  0.3012  3.5266  4.0096            25
 -6.1345 -9.2723 -1.8550  6.5662  3.5776 -1.8397 -3.2752 -5.5273 -3.4537            26
  1.7026  5.8255  7.7845  5.9914  1.7344 -3.6018 -6.6832 -6.8183 -5.2723            27
   ISOL   INPUT                                                                     28
   1   0   1   0  -3                                                                29
   106.    113.     81.                                                             30
   60.5    98.                                                                      31
   60.5    98.      80.                                                             32
           2.5    0.01      0.051 2.0    0.10                                       33
                                                                                    34
       INPUT TO YUPLOT                                                              35
  1  2 11 21 31                                                                      36
   INPUT  TO  SPECTRM                                                               37
           3.5     0.01    0.08                    29   36   31                      38
    1    2    5                                                                     39
  0.2    15.      20.                                                               40
```

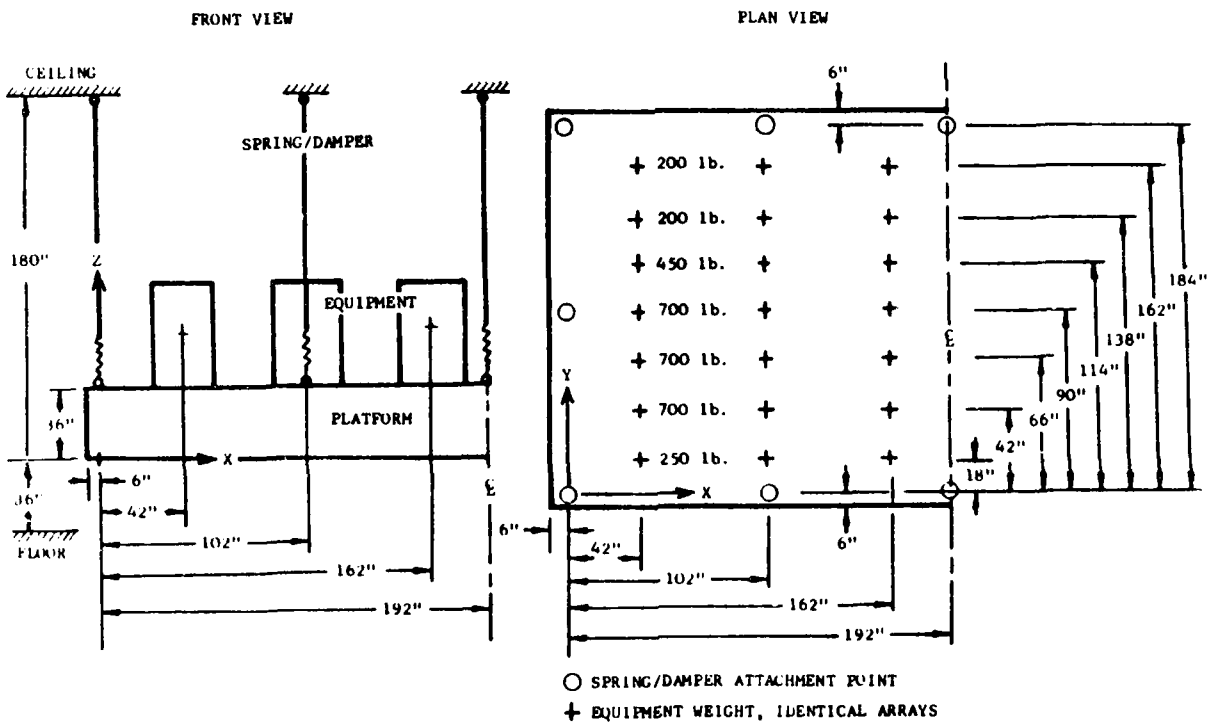
THE RESULT OF THIS EXAMPLE RUN HAS BEEN DELETED.

An ISIP Example.

An example is presented to illustrate a complete platform analysis using ISIP. A platform, supplied by BD&M Company of New Mexico, 16' x 33', is to be located in the second floor of the MSC Building. The floor to ceiling height is 21 feet. The platform is to be pendulum mounted from the ceiling. Three feet of clearance from floor to platform, and a platform thickness of three feet are assumed.

A twelve spring/damper arrangement was judged adequate for this platform. The vertical design frequency of the shock-isolated platform and the critical damping constant of the isolator system are assumed to be 1.4 Hz and 0.05 respectively. The spring/damper locations and the equipment weights, mounted on the platform, are shown in the following diagrams.

B D & M PLATFORM (16' X 33')



A COMPLETE FULLY AUTOMATIC ISIP RUN EXAMPLE

```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

       11        0                                                                    1
        BD AND M PLATEFORM,      APRIL, 1971                                         2
        ISOLIN INPUT DATA                                                            3
         43        12        -1         1         0        60                        4
12000.0   192.0     90.0      18.0      396.0     192.0     36.0                      5
200.0     42.0      162.0     102.0     24.0      24.0      132.0                     6
200.0     102.0     162.0     102.0     24.0      24.0      132.0                     7
200.0     162.0     162.0     102.0     24.0      24.0      132.0                     8
200.0     222.0     162.0     102.0     24.0      24.0      132.0                     9
200.0     282.0     162.0     102.0     24.0      24.0      132.0                    10
200.0     342.0     162.0     102.0     24.0      24.0      132.0                    11
200.0     42.0      138.0     102.0     24.0      24.0      132.0                    12
200.0     102.0     138.0     102.0     24.0      24.0      132.0                    13
200.0     162.0     138.0     102.0     24.0      24.0      132.0                    14
200.0     222.0     138.0     102.0     24.0      24.0      132.0                    15
200.0     282.0     138.0     102.0     24.0      24.0      132.0                    16
200.0     342.0     138.0     102.0     24.0      24.0      132.0                    17
450.0     42.0      114.0     114.0     24.0      24.0      132.0                    18
450.0     102.0     114.0     114.0     24.0      24.0      132.0                    19
450.0     162.0     114.0     114.0     24.0      24.0      132.0                    20
450.0     222.0     114.0     114.0     24.0      24.0      132.0                    21
450.0     282.0     114.0     114.0     24.0      24.0      132.0                    22
450.0     342.0     114.0     114.0     24.0      24.0      132.0                    23
700.0     42.0      90.0      114.0     24.0      24.0      132.0                    24
700.0     102.0     90.0      114.0     24.0      24.0      132.0                    25
700.0     162.0     90.0      114.0     24.0      24.0      132.0                    26
700.0     222.0     90.0      114.0     24.0      24.0      132.0                    27
700.0     282.0     90.0      114.0     24.0      24.0      132.0                    28
700.0     342.0     90.0      114.0     24.0      24.0      132.0                    29
700.0     42.0      66.0      114.0     24.0      24.0      132.0                    30
700.0     102.0     66.0      114.0     24.0      24.0      132.0                    31
700.0     162.0     66.0      114.0     24.0      24.0      132.0                    32
700.0     222.0     66.0      114.0     24.0      24.0      132.0                    33
700.0     282.0     66.0      114.0     24.0      24.0      132.0                    34
700.0     342.0     66.0      114.0     24.0      24.0      132.0                    35
700.0     42.0      42.0      102.0     24.0      24.0      132.0                    36
700.0     102.0     42.0      102.0     24.0      24.0      132.0                    37
700.0     162.0     42.0      102.0     24.0      24.0      132.0                    38
700.0     222.0     42.0      102.0     24.0      24.0      132.0                    39
700.0     282.0     42.0      102.0     24.0      24.0      132.0                    40
700.0     342.0     42.0      102.0     24.0      24.0      132.0                    41
250.0     42.0      18.0      114.0     24.0      24.0      132.0                    42
250.0     102.0     18.0      114.0     24.0      24.0      132.0                    43
250.0     162.0     18.0      114.0     24.0      24.0      132.0                    44
250.0     222.0     18.0      114.0     24.0      24.0      132.0                    45
250.0     282.0     18.0      114.0     24.0      24.0      132.0                    46
250.0     342.0     18.0      114.0     24.0      24.0      132.0                    47
0.0       0.0                                                                        48
102.0     0.0                                                                        49
192.0     0.0                                                                        50
```

```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

282.0     0.0                                                                         51
384.0     0.0                                                                         52
0.0       180.0                                                                       53
102.0     180.0                                                                       54
192.0     180.0                                                                       55
282.0     180.0                                                                       56
384.0     180.0                                                                       57
0.0       90.0                                                                        58
384.0     90.0                                                                        59
1.0       228.0     0.1       100000000.10000000. 0.05      0.0       0.0             60
0.05      0.04      0.03                                                              61
      NWVSYN INPUT DATA                                                               62
    2                                                                                 63
    TEST SPECTRUM, HORIZONTAL    (NOT A TRUE SPECTRUM FOR MSCB, 3-RD FLOOR)           64
    2                                                                                 65
    3   -1    0    1    0   20                                                       66
1.0       5.0       8.0                                                               67
-4.0      -4.0      12.0                                                              68
    TEST SPECTRUM, VERTICAL   (NOT A TRUE SPECTRUM FOR MSCB, 3-RD FLOOR)              69
    2                                                                                 70
    3   -1    0    1    0   50                                                       71
1.0       4.0       7.0                                                               72
-4.0      -4.0      8.0                                                               73
        SYNSOL INPUT DATA                                                             74
       ISOL INPUT DATA                                                                75
   1   0   1                                                                          76
0.00E+00 5.0E+00 .01E+00 .05E+004.95E+00 .10E+00                                     77
                                                                                      78
SKIP                                                                                  79
      SHOCK SPECTRUM INPUT                                                            80
0.0       8.0    0.05    0.05    0.0     0.0       29   42                            81
    1    3    0                                                                       82
0.2      100.0   110.0                                                                83
```

THE RESULT OF THIS EXAMPLE RUN IS PRESENTED ON THE FOLLOWING PAGES.

```
OPTION, PLOT =      11       3

                BD AND M PLATEFORM,      APRIL, 1971

                              ISOLIN INPUT DATA

        EQUIPMENT DIMENSIONS ADJUSTED,   60 PERCENT

                                  PLATFORM NUMBER*****       BD AND M PLATEFORM,      APRIL, 1971

      Y AXIS (DEPTH)
      1
      1
      1
     ***********************
     *0                    0*
     *     PLATFORM        *
     *       PLAN          *
     *0                    0*--X AXIS (WIDTH)
     ***********************

     Z AXIS (HEIGHT)
      1
      1
     ///                  ///
  --/--0                   0----/--       ---/--
    1  1                   1    1            1
    1  /                   /    1            1
    1  /                   /  LENGTH+LOAD/RATE
    1  /        **********  /    1 (NO2=0)    1
    1  1        *        *  1    1            1 (NO2=1)
  DELZ 0        *     CG  *  0----/--          1
    1  *        *        *  *    1            1
    1 ***********************  ZBAR     -----/--
    1 *     PLATFORM (ELEV)  *    1
  --/-***********************---/----X AXIS (WIDTH)
      1              1
      1              1
      /-XBAR---------/
      1              1
```

NP	NI	NO1	NO2	NO3
43	12	-1	1	0

MASS	WEIGHT	XCG	YCG	ZCG	WIDTH	DEPTH	HEIGHT	IXX	IYY	IZZ
1	12000.0	192.0	90.0	18.0	396.0	192.0	36.0	98902.8	409793.5	501978.4
2	200.0	42.0	162.0	102.0	14.4	14.4	79.2	279.9	279.9	17.9
3	200.0	102.0	162.0	102.0	14.4	14.4	79.2	279.9	279.9	17.9
4	200.0	162.0	162.0	102.0	14.4	14.4	79.2	279.9	279.9	17.9
5	200.0	222.0	162.0	102.0	14.4	14.4	79.2	279.9	279.9	17.9
6	200.0	282.0	162.0	102.0	14.4	14.4	79.2	279.9	279.9	17.9
7	200.0	342.0	162.0	102.0	14.4	14.4	79.2	279.9	279.9	17.9
8	200.0	42.0	138.0	102.0	14.4	14.4	79.2	279.9	279.9	17.9
9	200.0	102.0	138.0	102.0	14.4	14.4	79.2	279.9	279.9	17.9
10	200.0	162.0	138.0	102.0	14.4	14.4	79.2	279.9	279.9	17.9
11	200.0	222.0	138.0	102.0	14.4	14.4	79.2	279.9	279.9	17.9
12	200.0	282.0	138.0	102.0	14.4	14.4	79.2	279.9	279.9	17.9
13	200.0	342.0	138.0	102.0	14.4	14.4	79.2	279.9	279.9	17.9
14	450.0	42.0	114.0	114.0	14.4	14.4	79.2	629.8	629.8	40.3
15	450.0	102.0	114.0	114.0	14.4	14.4	79.2	629.8	629.8	40.3
16	450.0	162.0	114.0	114.0	14.4	14.4	79.2	629.8	629.8	40.3
17	450.0	222.0	114.0	114.0	14.4	14.4	79.2	629.8	629.8	40.3
18	450.0	282.0	114.0	114.0	14.4	14.4	79.2	629.8	629.8	40.3
19	450.0	342.0	114.0	114.0	14.4	14.4	79.2	629.8	629.8	40.3
20	700.0	42.0	90.0	114.0	14.4	14.4	79.2	979.7	979.7	62.7
21	700.0	102.0	90.0	114.0	14.4	14.4	79.2	979.7	979.7	62.7
22	700.0	162.0	90.0	114.0	14.4	14.4	79.2	979.7	979.7	62.7
23	700.0	222.0	90.0	114.0	14.4	14.4	79.2	979.7	979.7	62.7
24	700.0	282.0	90.0	114.0	14.4	14.4	79.2	979.7	979.7	62.7
25	700.0	342.0	90.0	114.0	14.4	14.4	79.2	979.7	979.7	62.7
26	700.0	42.0	66.0	114.0	14.4	14.4	79.2	979.7	979.7	62.7
27	700.0	102.0	66.0	114.0	14.4	14.4	79.2	979.7	979.7	62.7
28	700.0	162.0	66.0	114.0	14.4	14.4	79.2	979.7	979.7	62.7
29	700.0	222.0	66.0	114.0	14.4	14.4	79.2	979.7	979.7	62.7
30	700.0	282.0	66.0	114.0	14.4	14.4	79.2	979.7	979.7	62.7
31	700.0	342.0	66.0	114.0	14.4	14.4	79.2	979.7	979.7	62.7
32	700.0	42.0	42.0	102.0	14.4	14.4	79.2	979.7	979.7	62.7
33	700.0	102.0	42.0	102.0	14.4	14.4	79.2	979.7	979.7	62.7
34	700.0	162.0	42.0	102.0	14.4	14.4	79.2	979.7	979.7	62.7
35	700.0	222.0	42.0	102.0	14.4	14.4	79.2	979.7	979.7	62.7
36	700.0	282.0	42.0	102.0	14.4	14.4	79.2	979.7	979.7	62.7
37	700.0	342.0	42.0	102.0	14.4	14.4	79.2	979.7	979.7	62.7
38	250.0	42.0	18.0	114.0	14.4	14.4	79.2	349.9	349.9	22.4
39	250.0	102.0	18.0	114.0	14.4	14.4	79.2	349.9	349.9	22.4
40	250.0	162.0	18.0	114.0	14.4	14.4	79.2	349.9	349.9	22.4
41	250.0	222.0	18.0	114.0	14.4	14.4	79.2	349.9	349.9	22.4
42	250.0	282.0	18.0	114.0	14.4	14.4	79.2	349.9	349.9	22.4
43	250.0	342.0	18.0	114.0	14.4	14.4	79.2	349.9	349.9	22.4

ISOLATOR	X COORD	Y COORD	LOAD	RATE	LENGTH	LOAD(S)	RATE(S)	LENG(S)	DAMP(S)	SIGNX	SIGNY
1	0.0	0.0	2824.0	564.9	187.0	2787.1	621.4	187.5	6.4	-1.0	1.0
2	102.0	0.0	2824.0	564.9	187.0	2840.4	621.4	187.4	6.5	-1.0	1.0
3	192.0	0.0	2824.0	564.9	187.0	2887.5	621.4	187.4	6.6	-1.0	1.0
4	282.0	0.0	2824.0	564.9	187.0	2934.6	508.4	186.2	6.7	1.0	1.0
5	384.0	0.0	2824.0	564.9	187.0	2987.9	508.4	186.1	6.8	1.0	1.0
6	0.0	180.0	2376.0	475.3	187.0	2212.1	522.9	187.8	5.0	-1.0	-1.0

7	102.0	180.0	2376.0	475.3	187.0	2265.4	522.9	187.7	5.2	-1.0	-1.0
8	192.0	180.0	2376.0	475.3	187.0	2312.5	522.9	187.6	5.3	-1.0	-1.0
9	282.0	180.0	2376.0	475.3	187.0	2359.6	427.8	186.5	5.4	1.0	-1.0
10	364.0	180.0	2376.0	475.3	187.0	2412.9	427.8	186.4	5.5	1.0	-1.0
11	0.0	90.0	2600.0	520.1	187.0	2499.6	572.1	187.6	5.7	-1.0	-1.0
12	364.0	90.0	2600.0	520.1	187.0	2700.4	468.1	186.2	6.2	1.0	-1.0

END INPUT TO ISOLIN

WTOT	WMIN	WMAX
31200.	29040.	33360.

FREQ	DELZ	RATOL	IXX J(IN**4)	ZETA	DGX	DGY	DGZ	HIGHS	RADP	FRICP
1.40	228.00	.10100000000.	10000000.	.05	.05	.04	.03	36.00	0.00	0.00

XBAR	YBAR	ZBAR	XBARS	YBARS	ZBARS	XBARI	YBARI	EX	EY	EXS	EYS
192.0	83.5	74.5	196.3	81.7	76.2	192.0	90.0	0.0	-6.5	4.3	-8.3

IXX OF COMBINED EQUIP AND PLATFORM THRU SYSTEM CG 304291.

IXX OF COMBINED EQUIP AND PLATFORM THRU SHIFTED CG 309703.

IYY OF COMBINED EQUIP AND PLATFORM THRU SYSTEM CG 1122047.

IYY OF COMBINED EQUIP AND PLATFORM THRU SHIFTED CG1130178.

IZZ OF COMBINED EQUIP AND PLATFORM THRU SYSTEM CG 1101393.

IZZ OF COMBINED EQUIP AND PLATFORM THRU SHIFTED CG1101898.

IXX OF EQUIP AND PLATFORM THRU PLATFORM CG 035221.

MASS MOMENT EQUIVALENT HEIGHT 89.

IXX OF EQUP AND PLATFORM AROUND CEILING SUPPORTS 2232061.

IYY OF EQUP AND PLATFORM AROUND CEILING SUPPORTS 2992536.

UNCOUPLED ROCKING FREQ AROUND X AXIS IN CPS	1.71
UNCOUPLED ROCKING FREQ AROUND Y AXIS IN CPS	1.72
FIRST COUPLED FREQ AROUND X AXIS IN CPS	0.00
SECOND COUPLED FREQ AROUND X AXIS IN CPS	70.85
FIRST COUPLED FREQ AROUND Y AXIS IN CPS	0.00
SECOND COUPLED FREQ AROUND Y AXIS IN CPS	95.25
PENDULUM FREQ AROUND X AXIS IN CPS	.26
PENDULUM FREQ AROUND Y AXIS IN CPS	.23
TORSIONAL PENDULUM FREQUENCY IN CPS	.11
FIRST MODE TORSIONAL FREQUENCY, CPS	319.01
FIRST MODE BENDING FREQUENCY, CPS	2765.93

PRINT PUNCH OUTPUT CARDS FOR ISOL INPUT

SL [illegible] M PLATEFORM, APRIL, 1971

WTOT	XBARS	YBARS	ZBARS	IXXS	IYYS	IZZS	J
31206.	195.25	81.71	76.21	369703.11	30178.1	101098.	1

XA(I)	YA(I)	ZA(I)	XB(I)	YB(I)	ZB(I)	ISOLATOR
0.00	0.00	36.00	0.00	0.00	228.00	1
102.00	0.00	36.00	102.00	0.00	228.00	2
192.00	0.00	36.00	192.00	0.00	228.00	3
282.00	0.00	36.00	282.00	0.00	228.00	4
384.00	0.00	36.00	384.00	0.00	228.00	5
0.00	180.00	36.00	0.00	180.00	228.00	6
102.00	180.00	36.00	102.00	180.00	228.00	7
192.00	180.00	36.00	192.00	180.00	228.00	8
282.00	180.00	36.00	282.00	180.00	228.00	9
384.00	180.00	36.00	384.00	180.00	228.00	10
0.00	90.00	36.00	0.00	90.00	228.00	11
384.00	90.00	36.00	384.00	90.00	228.00	12

XP(I)	YP(I)	ZP(I)	POINTS
0.00	0.00	74.54	
-6.00	-6.00	0.00	
390.00	186.00	0.00	
-6.00	186.00	149.08	

NX(I)	NY(I)	SL(I)	SK(I)	DA(I)	ISOLATOR
0.00	0.00	187.52	621.43	6.36	1
0.00	0.00	187.43	621.43	6.48	2
0.00	0.00	187.35	621.43	6.59	3
0.00	0.00	186.23	508.45	6.70	4
0.00	0.00	186.12	508.45	6.82	5
0.00	0.00	187.77	522.85	5.05	6
0.00	0.00	187.67	522.85	5.17	7
0.00	0.00	187.56	522.85	5.28	8
0.00	0.00	186.48	427.79	5.38	9
0.00	0.00	186.36	427.79	5.51	10
0.00	0.00	187.63	572.14	5.70	11
0.00	0.00	186.23	468.12	6.16	12

NAVSYN INPUT DATA

03/29/73 2300 HR.

TEST SPECIMEN. HORIZONTAL

WAVEFORM SYNTHESIS BY AUTOMATIC OPTION

NO. OF PTS ON SHOCK SPECTRA NS = 3

FREQUENCY (HZ)	MAX. ACC./DISPL.
1.000	4.000 IN.
5.000	4.000 IN.
8.000	12.000 G.S

NO. OF PTS ON AMPLIFICATION RATIO CURVE NAM =10

FREQUENCY (HZ)	AMP. RATIO
.100	3.000
.400	3.000
.410	5.000
.600	5.000
.610	7.000
.900	7.000
.910	9.000
4.000	9.000
4.010	11.000
999.000	11.000

TOLERANCE LIMIT

LINE SEG.	TOLERANCE (0/0)
1	20.000
2	20.000

TEST SPECTRUM. HORIZONTAL

NO. OF POINTS SELECTED ON SPECTRUM 8

SYSTEM FREQUENCY ARRANGEMENT NO. 1 (AUTOMATIC OPTION).

W(I) (C.P.S.)	σ(I) (C.P.S.)	TINT(I) (SEC.)	RTS(I) (SEC.)	DELAY(I) (SEC.)	X(I) (IN/SEC**2)	CYCLE(I)
1.60000	.1111111	4.5000000	9.0000000	0.0000000	157.91367	9.0
1.45000	.1611111	3.1034483	6.2068966	0.0000000	332.01349	9.0
2.10250	.2336111	2.1403092	4.2806183	0.0000000	698.05637	9.0
3.04563	.3387361	1.4760753	2.9521506	0.0000000	1467.06772	9.0
4.11564	.3741494	1.3363645	2.6727289	0.0000000	2674.02441	11.0
5.55612	.5051017	.9898996	1.9797992	0.0000000	4092.93635	11.0
7.50676	.6818873	.7332590	1.4665179	0.0000000	4535.00328	11.0
10.12663	.9205479	.5431548	1.0863096	0.0000000	5026.27933	11.0

ITERATION NO. 1

INIAL VALUES OF COEFFICIENTS

C(1)=	1.00	C(2)=	1.00	C(3)=	1.00	C(4)=	1.00	C(5)=	1.00
C(6)=	1.00	C(7)=	1.00	C(8)=	1.00	C(			

MAX. VALUES OF ACCELERATION

AT FREQUENCY=	1.00	C.P.S.	MAX. ACCELERATION=	.8817420E+01	IN/SEC**2	AT TIME=	.90000E+01	SEC.	/	.1579137E+03*
AT FREQUENCY=	1.45	C.P.S.	MAX. ACCELERATION=	.1010538E+02	IN/SEC**2	AT TIME=	.27586E+01	SEC.	/	.3320135E+03*
AT FREQUENCY=	2.10	C.P.S.	MAX. ACCELERATION=	.1009132E+02	IN/SEC**2	AT TIME=	.19029E+01	SEC.	/	.6980584E+03*
AT FREQUENCY=	3.05	C.P.S.	MAX. ACCELERATION=	.1071923E+02	IN/SEC**2	AT TIME=	.14761E+01	SEC.	/	.1467668E+04*
AT FREQUENCY=	4.12	C.P.S.	MAX. ACCELERATION=	.1238421E+02	IN/SEC**2	AT TIME=	.23083E+01	SEC.	/	.2674824E+04*
AT FREQUENCY=	5.56	C.P.S.	MAX. ACCELERATION=	.1300073E+02	IN/SEC**2	AT TIME=	.89991E+00	SEC.	/	.4092936E+04*
AT FREQUENCY=	7.50	C.P.S.	MAX. ACCELERATION=	.1323807E+02	IN/SEC**2	AT TIME=	.66660E+00	SEC.	/	.4535063E+04*
AT FREQUENCY=	10.13	C.P.S.	MAX. ACCELERATION=	.1304697E+02	IN/SEC**2	AT TIME=	.49378E+00	SEC.	/	.5026279E+04*

ITERATION NO. 2

VALUES OF COEFFICIENT CALCULATED FROM PREVIOUS ITERATION

C(1)=	20.02	C(2)=	37.20	C(3)=	70.88	C(4)=	156.42	C(5)=	243.47
C(6)=	327.12	C(7)=	354.06	C(8)=	381.78	C(			

MAX. VALUES OF ACCELERATION

AT FREQUENCY=	1.00	C.P.S.	MAX. ACCELERATION=	.1579137E+03	IN/SEC**2	AT TIME=	.90000E+01	SEC.	/	.1579137E+03	
AT FREQUENCY=	1.45	C.P.S.	MAX. ACCELERATION=	.3320135E+03	IN/SEC**2	AT TIME=	.27586E+01	SEC.	/	.3320135E+03	
AT FREQUENCY=	2.10	C.P.S.	MAX. ACCELERATION=	.6985958E+03	IN/SEC**2	AT TIME=	.21403E+01	SEC.	/	.6980584E+03	
AT FREQUENCY=	3.05	C.P.S.	MAX. ACCELERATION=	.1467668E+04	IN/SEC**2	AT TIME=	.14761E+01	SEC.	/	.1467668E+04	
AT FREQUENCY=	4.12	C.P.S.	MAX. ACCELERATION=	.2758323E+04	IN/SEC**2	AT TIME=	.12149E+01	SEC.	/	.2674824E+04*	
AT FREQUENCY=	5.56	C.P.S.	MAX. ACCELERATION=	.4092936E+04	IN/SEC**2	AT TIME=	.89991E+00	SEC.	/	.4092936E+04	
AT FREQUENCY=	7.50	C.P.S.	MAX. ACCELERATION=	.4535663E+04	IN/SEC**2	AT TIME=	.66660E+00	SEC.	/	.4535663E+04	
AT FREQUENCY=	10.13	C.P.S.	MAX. ACCELERATION=	.5026279E+04	IN/SEC**2	AT TIME=	.49378E+00	SEC.	/	.5026279E+04	

ITERATION NO. 3

VALUES OF COEFFICIENT CALCULATED FROM PREVIOUS ITERATION

C(1)=	20.00	C(2)=	37.20	C(3)=	76.77	C(4)=	156.38	C(5)=	235.75
C(6)=	328.20	C(7)=	354.86	C(8)=	381.36	C(			

MAX. VALUES OF ACCELERATION

AT FREQUENCY=	1.00	C.P.S.	MAX. ACCELERATION=	.1579137E+03	IN/SEC**2	AT TIME=	.90000E+01	SEC.	/	.1579137E+03
AT FREQUENCY=	1.65	C.P.S.	MAX. ACCELERATION=	.3320135E+03	IN/SEC**2	AT TIME=	.27586E+01	SEC.	/	.3320135E+03
AT FREQUENCY=	2.10	C.P.S.	MAX. ACCELERATION=	.6980584E+03	IN/SEC**2	AT TIME=	.21403E+01	SEC.	/	.6980584E+03
AT FREQUENCY=	3.05	C.P.S.	MAX. ACCELERATION=	.1467668E+04	IN/SEC**2	AT TIME=	.14761E+01	SEC.	/	.1467668E+04
AT FREQUENCY=	4.12	C.P.S.	MAX. ACCELERATION=	.2674824E+04	IN/SEC**2	AT TIME=	.12149E+01	SEC.	/	.2674824E+04
AT FREQUENCY=	5.56	C.P.S.	MAX. ACCELERATION=	.4092936E+04	IN/SEC**2	AT TIME=	.89991E+00	SEC.	/	.4092936E+04
AT FREQUENCY=	7.50	C.P.S.	MAX. ACCELERATION=	.4535663E+04	IN/SEC**2	AT TIME=	.66660E+00	SEC.	/	.4535663E+04
AT FREQUENCY=	10.13	C.P.S.	MAX. ACCELERATION=	.5026279E+04	IN/SEC**2	AT TIME=	.49378E+00	SEC.	/	.5026279E+04

AD-A094 299 ARMY ENGINEER DIV HUNTSVILLE AL F/G 14/2
SHOCK TEST PROGRAM. SHOCK ISOLATION DESIGN MANUAL FOR SAFEGUARD--ETC(U)
AUG 73 G C CHAN, R YANG, H SAFFELL, C C HUANG
UNCLASSIFIED HNDSP-73-98-ED-R NL

6 OF 7
AD
A094299

TEST SPECTRUM. HORIZONTAL

GENERALIZED SHOCK SPECTRUM

FOR

DAMPED AND UNDAMPED VIBRATIONS

INPUT DATA

STARTING TIME	0.0000
END TIME	4.5000
INITIAL DISPLACEMENT	0.0000
INITIAL VELOCITY	0.0000

FREQUENCY C.P.S.	TIME SEC.	MAX.P.DIS. INS.	MAX.P.ACC. G.S	TIME SEC.	MAX.N.DIS. INS.	MAX.N.ACC. G.S	ACC.ON SPEC. G.S	DEVIATION 0/0
1.00000							.40868	-.00000
1.13185	4.32813	4.28971	.50147	4.76563	-4.28539	-.56091	.52355	7.24265
1.28109	3.27586	4.69414	.70711	3.67457	-4.62177	-.77498	.67072	17.35347
1.45000							.85925	-.00000
1.64118	4.20259	4.02538	1.10776	2.67241	-4.15359	-1.14304	1.18077	3.83978
1.85756	2.25922	4.65209	1.84008	2.53419	-4.42057	-1.55846	1.41018	16.30218
2.10250							1.80657	-.00000
2.37972	3.31451	3.77437	2.16382	1.84304	-3.92538	-2.27160	2.31437	-1.86560
2.69349	1.55295	4.41106	3.20960	1.74771	-4.29734	-3.18531	2.96491	10.27647
3.04863							3.79831	-.00000
3.30937	2.32887	3.45616	4.00879	1.28044	-3.53976	-4.10576	4.63959	-11.50609
3.72386	2.19817	3.92516	5.50117	1.79574	-4.01265	-5.68512	5.66721	.31617
4.11564							6.92242	-.00000
4.54865	1.06681	3.47458	7.34497	1.18071	-3.39518	-7.17713	8.45566	-13.13543
5.02721	1.03490	3.53001	9.11491	.93084	-3.37071	-8.70358	10.23598	-10.95225
5.55612							10.59249	-.00000
6.14068	.78742	2.52923	9.74411	.87179	-2.59393	-9.99339	10.96141	-8.83116
6.78673	.76451	2.20858	10.67576	.68743	-2.08511	-9.81234	11.34319	-5.88392
7.50076							11.73826	-.00000
8.28991	.58119	1.50742	10.58417	.64577	-1.53525	-10.77960	12.14709	-11.29780
9.16209	.56636	1.31559	11.26318	.50921	-1.22007	-10.46398	12.57016	-10.23837
10.12603							13.00797	-.00000

SYNTHESIZED WAVEFORM

NO. OF DATA POINTS ON TIME TABLE = 435

TIME	ACCEL.	VELOCITY	DISPL.

SEC.	G.S	INS/SEC.	INS.
0.000000	0.00000	0.00000	0.00000
.003292	.00756	.00321	.00000
.006584	.02976	.06545	.00004
.009876	.06521	.08455	.00021
.013167	.11165	.19601	.00066
.016459	.16614	.31201	.00157
.019751	.22516	.06059	.00319
.023043	.28485	.99509	.00574
.026335	.34126	1.39384	.00949
.029627	.39051	1.81019	.01460
.032918	.42907	2.33274	.02147
.036210	.45395	2.87591	.03007
.039502	.46288	3.40078	.04056
.042794	.45446	4.00608	.05298
.046086	.42826	4.06932	.06730
.049378	.38472	5.19811	.08341
.052670	.32546	5.06133	.10113
.055961	.25288	5.97040	.12020
.059253	.17017	6.69034	.14032
.062545	.08117	6.99064	.16116
.065837	-.00989	6.99596	.18234
.069129	-.09858	6.37049	.20347
.072421	-.18056	6.19802	.22420
.075712	-.25175	5.96174	.24417
.079004	-.30862	5.50367	.26310
.082296	-.34838	5.19389	.28073
.085588	-.36912	4.80549	.29692
.088880	-.36995	4.61333	.31157
.092172	-.35104	3.69275	.32467
.095464	-.31366	3.36815	.33631
.098755	-.26008	2.90171	.34665
.102047	-.19349	2.67206	.35590
.105339	-.11783	2.97334	.36434
.108631	-.03758	2.37426	.37229
.111923	.04250	2.37766	.38008
.115215	.11758	2.40025	.38805
.118506	.18307	2.67270	.39651
.121798	.23488	2.99016	.40573
.125090	.26961	3.69298	.41593
.128382	.28479	3.91774	.42725
.131674	.27901	3.97657	.43975
.134966	.25204	4.31853	.45342
.138258	.20483	4.61115	.46813
.141549	.13952	4.83192	.48370
.144841	.05930	4.95974	.49984
.148133	-.03169	4.97820	.51623
.151425	-.12862	4.81660	.53249
.154717	-.22619	4.65072	.54820
.158009	-.31891	4.39324	.56297
.161301	-.40140	3.99377	.57641
.164592	-.46870	3.60855	.58817
.167884	-.51653	3.05970	.59798
.171176	-.54153	1.90423	.60563
.174468	-.54150	1.69272	.61102
.177760	-.51552	.94771	.61416
.181052	-.46403	-.00789	.61515
.184343	-.38885	-.95268	.61420
.187635	-.29314	-.98839	.61163
.190927	-.18123	-1.67153	.60784
.194219	-.05843	-1.99479	.60329

.197511	.06919	-1.43812	.59850
.200803	.19514	-1.26948	.59400
.204095	.31281	-.99520	.59031
.207386	.41582	-.47992	.58793
.210678	.49830	.10394	.58726
.213970	.55551	.77710	.58871
.217262	.58349	1.56473	.59246
.220554	.57992	2.24805	.59864
.223846	.54396	2.90624	.60723
.227137	.47639	3.61842	.61809
.230429	.37964	4.10576	.63094
.233721	.25760	4.37350	.64537
.237013	.11585	4.61283	.66086
.240305	-.03931	4.80255	.67684
.243597	-.20041	4.71031	.69266
.246889	-.35957	4.35353	.70763
.250180	-.50871	3.77984	.72110
.253472	-.64000	3.09696	.73245
.256764	-.74646	2.18216	.74113
.260056	-.82177	1.18120	.74669
.263348	-.86119	.10686	.74882
.266640	-.86150	-.99300	.74736
.269931	-.82129	-2.00754	.74231
.273223	-.74107	-3.00533	.73384
.276515	-.62324	-3.93680	.72227
.279807	-.47210	-4.93667	.70811
.283099	-.29361	-5.12619	.69198
.286391	-.09521	-5.37515	.67462
.289683	.11454	-5.50358	.65687
.292974	.32634	-5.48289	.63961
.296266	.53050	-4.53663	.62370
.299558	.71749	-3.79061	.61001
.302850	.87829	-2.72250	.59932
.306142	1.00486	-1.56083	.59229
.309434	1.09052	-.10356	.58945
.312725	1.13027	1.23389	.59117
.316017	1.12106	2.67099	.59760
.319309	1.06193	4.09461	.60871
.322601	.95414	5.39182	.62424
.325893	.80108	6.47266	.64376
.329185	.60819	7.37280	.66661
.332477	.38276	8.09603	.69201
.335768	.13359	8.33643	.71899
.339060	-.12934	8.39004	.74653
.342352	-.39531	8.09611	.77353
.345644	-.65333	7.33777	.79887
.348936	-.89255	6.33206	.82149
.352228	-1.10282	5.07946	.84038
.355519	-1.27502	3.58272	.85466
.358811	-1.40154	1.85528	.86362
.362103	-1.47654	.01917	.86674
.365395	-1.49624	-1.97746	.86368
.368687	-1.45904	-3.76302	.85439
.371979	-1.36563	-5.50531	.83900
.375271	-1.21889	-7.21445	.81792
.378562	-1.02384	-8.89559	.79174
.381854	-.78735	-9.49145	.76130
.385146			
.388438			
.391730			
.395022			
.398314			

5 computer output pages have been deleted hereafter.

4.450642	.00054	-.00348	.00004
4.483975	.00006	-.00012	.00000
4.517309	0.00000	0.00000	0.00000

STARTING FREQ. = 1.0000

ENDING FREQ. = 10.1240

INTERVAL STEPS = 150.0

SHOCK SPECTRUM

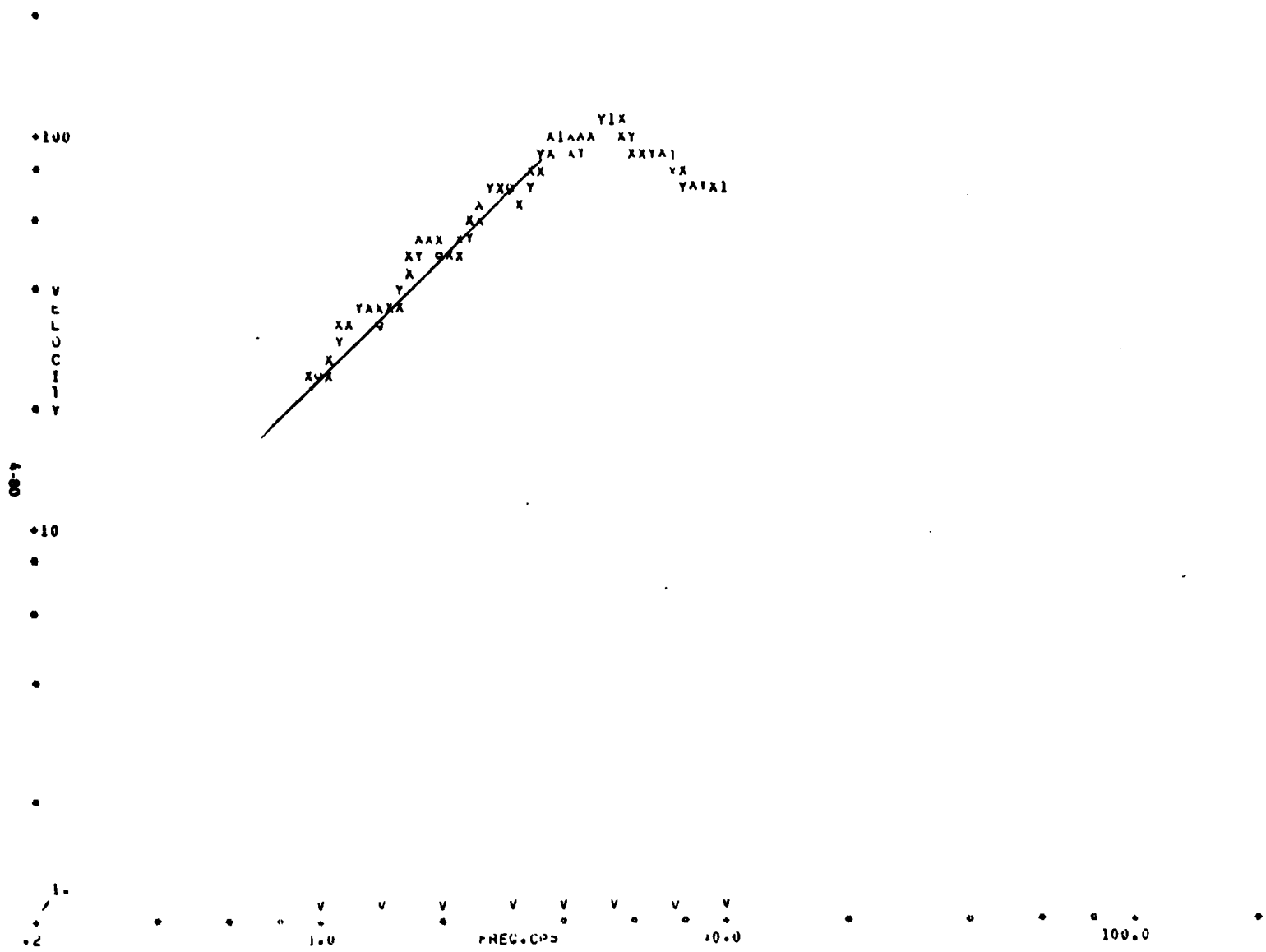
TIME SEC.	FREQUENCY C.P.S.	MAX.DISPLACEMENT INS.	MAX.ACCELERATION G'S
4.5173	1.0000	4.0152	.4102
4.4925	1.0156	3.9525	.4165
4.4701	1.0313	3.9139	.4253
4.4477	1.0474	3.9060	.4378
4.4245	1.0637	3.9315	.4545
4.4013	1.0802	3.9887	.4755
4.3773	1.0970	4.0715	.5006
4.3517	1.1141	4.1709	.5289
4.3246	1.1314	4.2765	.5593
4.2966	1.1490	4.3777	.5905
4.2662	1.1669	4.4652	.6212
4.2350	1.1850	4.5315	.6502
3.7823	1.2035	4.5020	.6810
3.7559	1.2222	4.4500	.7097
3.7287	1.2412	4.4685	.7348
3.2968	1.2605	4.4736	.7587
3.2752	1.2801	4.4843	.7843
3.2544	1.3000	4.4648	.8055
3.2336	1.3202	4.4170	.8222
3.2128	1.3408	4.5439	.8346
3.1928	1.3616	4.4499	.8424
3.1736	1.3828	4.3407	.8480
3.1552	1.4043	4.2233	.8509
3.1376	1.4262	4.1054	.8531
2.7697	1.4483	4.0131	.8601
2.7585	1.4709	3.9425	.8714
2.7481	1.4937	3.8933	.8876
2.7377	1.5170	3.8710	.9101
2.7265	1.5406	3.8779	.9403
2.7153	1.5645	3.9132	.9787
2.7033	1.5889	3.9729	1.0247
2.6898	1.6136	4.0505	1.0775
2.6762	1.6387	4.1382	1.1353
2.6610	1.6642	4.2278	1.1963
2.6450	1.6900	4.3116	1.2582
2.6282	1.7163	4.3830	1.3192
2.6106	1.7430	4.4367	1.3772
2.3010	1.7701	4.4894	1.4372
2.2866	1.7977	4.5679	1.5082
2.2731	1.8256	4.6205	1.5734
2.2587	1.8540	4.6454	1.6315
2.2443	1.8829	4.6423	1.6815
2.2299	1.9122	4.6117	1.7228
2.2155	1.9419	4.5553	1.7551
2.2011	1.9721	4.4762	1.7786
2.1875	2.0028	4.3784	1.7943
2.1747	2.0339	4.2669	1.8035
2.1619	2.0656	4.1480	1.8082
2.1499	2.0977	4.0284	1.8111
1.8979	2.1303	3.9252	1.8200
1.8899	2.1634	3.8540	1.8454
1.8819	2.1971	3.8101	1.8792
1.8747	2.2313	3.7837	1.9246
1.8667	2.2660	3.7821	1.9841
1.8596	2.3012	3.8050	2.0587
1.8508	2.3370	3.8448	2.1482
1.8420	2.3734	3.9112	2.2509

1.8316	2.4143	3.9831	2.3642
1.8212	2.4478	4.0589	2.4847
1.8108	2.4858	4.1321	2.6088
1.7988	2.5245	4.1970	2.7328
1.7868	2.5638	4.2490	2.8534
1.7748	2.6036	4.2844	2.9674
1.5668	2.6441	4.3339	3.0958
1.5572	2.6853	4.3994	3.2411
1.5476	2.7270	4.4403	3.3734
1.5380	2.7694	4.4551	3.4912
1.5284	2.8125	4.4434	3.5911
1.5188	2.8563	4.4056	3.6722
1.5092	2.9007	4.3433	3.7338
1.5004	2.9458	4.2589	3.7760
1.4916	2.9916	4.1564	3.8006
1.4828	3.0382	4.0406	3.8105
1.4756	3.0854	3.9177	3.8105
1.4676	3.1334	3.7953	3.8071
1.3605	3.1821	3.6845	3.8171
1.2965	3.2316	3.6142	3.8564
1.2925	3.2819	3.5602	3.9179
1.2885	3.3329	3.5334	4.0102
1.2853	3.3848	3.5371	4.1403
1.2813	3.4374	3.5709	4.3110
1.2773	3.4909	3.6312	4.5212
1.2733	3.5452	3.7112	4.7656
1.8236	3.6003	3.8100	5.0458
1.8100	3.6563	3.9082	5.3382
1.7964	3.7132	3.9933	5.6254
1.7828	3.7710	4.0574	5.8949
1.2461	3.8296	4.1049	6.1509
1.2397	3.8892	4.1307	6.3836
1.2333	3.9497	4.1290	6.5804
1.2269	4.0111	4.0996	6.7390
1.2205	4.0735	4.0447	6.8571
1.2149	4.1368	3.9684	6.9387
1.2085	4.2012	3.8758	6.9892
1.2029	4.2665	3.7737	7.0184
1.1973	4.3329	3.6690	7.0376
1.1909	4.4003	3.5688	7.0601
1.0701	4.4687	3.5050	7.1513
1.0661	4.5382	3.5743	7.3107
1.0613	4.6088	3.6595	7.5078
1.0573	4.6805	3.7596	7.7435
1.0525	4.7533	3.8713	8.0132
1.0477	4.8272	3.9898	8.3084
1.0429	4.9023	3.9088	8.6156
1.0373	4.9786	3.9227	8.9209
1.0318	5.0560	3.9255	9.2079
1.0254	5.1346	3.9129	9.4625
1.0198	5.2145	3.8811	9.6709
.9158	5.2956	3.8438	9.8818
.9110	5.3780	3.8086	10.2499
.9062	5.4616	3.8278	10.4468
.9014	5.5466	3.8625	10.5690
.8966	5.6328	3.8750	10.6169
.8918	5.7205	3.8691	10.5956
.8878	5.8094	3.8495	10.5153
.8830	5.8998	2.8217	10.3905
.8782	5.9916	2.7906	10.2353
.8742	6.0847	2.8622	10.0702
.8702	6.1794	2.9400	9.9093

.7814	6.2755	2.4397	9.8167
.7782	6.3731	2.3892	9.9148
.7750	6.4762	2.3488	10.0526
.7718	6.5729	2.3169	10.2271
.7686	6.6731	2.2905	10.4273
.7646	6.7790	2.2656	10.6375
.7606	6.8844	2.2387	10.8406
.7566	6.9915	2.2063	11.0187
.7526	7.1002	2.1653	11.1530
.6758	7.2107	2.1151	11.2360
.6726	7.3228	2.0964	11.4853
.6694	7.4367	2.0628	11.6558
.6654	7.5524	2.0149	11.7420
.6622	7.6698	1.9535	11.7411
.6590	7.7891	1.8804	11.6558
.6558	7.9103	1.7983	11.4966
.6526	8.0333	1.7108	11.2800
.6486	8.1503	1.6216	11.0274
.6462	8.2652	1.5343	10.7608
.5799	8.4140	1.4579	10.5455
.5775	8.5449	1.4150	10.5561
.5759	8.6778	1.3798	10.6156
.5735	8.8128	1.3529	10.7354
.5711	8.9498	1.3332	10.9106
.5687	9.0891	1.3186	11.1294
.5655	9.2304	1.3088	11.3754
.5631	9.3740	1.2940	11.6169
.5599	9.5198	1.2780	11.8330
.5015	9.6679	1.2669	12.0986
.4991	9.8182	1.2682	12.4905
.4967	9.9709	1.2589	12.7876
.4943	10.1260	1.2371	12.9595

SPECTRUM FROM THE SYNTHESIZED WAVEFORM

TEST SPECTRUM, HORIZONTAL 03/30/73 0000 HR.



03/30/73 0000 HR.

TEST SPECTRUM. VERTICAL

WAVEFORM SYNTHESIS BY AUTOMATIC OPTION

NO. OF PTS ON SHOCK SPECTRA NS = 3

FREQUENCY (HZ)	MAX. ACC./DISPL.
1.000	4.000 IN.
4.000	4.000 IN.
7.000	8.000 G.S

NO. OF PTS ON AMPLIFICATION RATIO CURVE NAR =10

FREQUENCY (HZ)	AMP. RATIO
.100	3.000
.400	3.000
.410	5.000
.600	5.000
.610	7.000
.900	7.000
.910	9.000
4.000	9.000
4.010	11.000
999.000	11.000

TOLERANCE LIMIT

LINE SEG.	TOLERANCE (0/0)
1	25.000
2	25.000

TEST SPECTRUM, VERTICAL

NO. OF POINTS SELECTED ON SPECTRUM 7

SYSTEM FREQUENCY ARRANGEMENT NO. 1 (AUTOMATIC OPTION).

W(I) (C.P.S.)	G(I) (C.P.S.)	TINT(I) (SEC.)	RTS(I) (SEC.)	DELAY(I) (SEC.)	X(I) (IN/SEC**2)	CYCLE(I)
1.00000	.1111111	4.5000000	9.0000000	0.0000000	157.91367	9.0
1.45600	.1611111	3.1034483	6.2068966	0.0000000	332.01349	9.0
2.10650	.2330111	2.1403042	4.2806183	0.0000000	698.05837	9.0
3.04653	.3387361	1.4760753	2.9521506	0.0000000	1467.00772	9.0
4.11504	.3741494	1.3363645	2.6727289	0.0000000	2552.70415	11.0
5.55012	.5051017	.9898996	1.9797992	0.0000000	2844.27044	11.0
7.50076	.6818873	.7332590	1.4665179	0.0000000	3169.13902	11.0

ITERATION NO. 1

FINAL VALUES OF COEFFICIENTS

C(1)=	1.00	C(2)=	1.00	C(3)=	1.00	C(4)=	1.00	C(5)=	1.00
C(6)=	1.00	C(7)=	1.00	C(					

MAX. VALUES OF ACCELERATION

AT FREQUENCY=	1.00	C.P.S.	MAX. ACCELERATION=	.8821032E+01	IN/SEC**2	AT TIME=	.90000E+01	SEC. / .1579137E+03*
AT FREQUENCY=	1.45	C.P.S.	MAX. ACCELERATION=	.10.6841E+02	IN/SEC**2	AT TIME=	.27586E+01	SEC. / .3320135E+03*
AT FREQUENCY=	2.10	C.P.S.	MAX. ACCELERATION=	.1059457E+02	IN/SEC**2	AT TIME=	.19025E+01	SEC. / .6980584E+03*
AT FREQUENCY=	3.05	C.P.S.	MAX. ACCELERATION=	.1075096E+02	IN/SEC**2	AT TIME=	.14761E+01	SEC. / .1467668E+04*
AT FREQUENCY=	4.12	C.P.S.	MAX. ACCELERATION=	.1242448E+02	IN/SEC**2	AT TIME=	.23083E+01	SEC. / .2552704E+04*
AT FREQUENCY=	5.56	C.P.S.	MAX. ACCELERATION=	.1356146E+02	IN/SEC**2	AT TIME=	.89991E+00	SEC. / .2844270E+04*
AT FREQUENCY=	7.50	C.P.S.	MAX. ACCELERATION=	.1329763E+02	IN/SEC**2	AT TIME=	.66660E+00	SEC. / .3169139E+04*

ITERATION NO. 2

VALUES OF COEFFICIENT CALCULATED FROM PREVIOUS ITERATION

C(1)=	19.77	C(2)=	36.72	C(3)=	70.24	C(4)=	154.60	C(5)=	230.41
C(6)=	212.87	C(7)=	242.60	C(					

MAX. VALUES OF ACCELERATION

AT FREQUENCY=	1.00 C.P.S.	MAX. ACCELERATION=	.1579137E+03	IN/SEC**2	AT TIME=	.90000E+01	SEC.	/	.1579137E+03
AT FREQUENCY=	1.45 C.P.S.	MAX. ACCELERATION=	.3320135E+03	IN/SEC**2	AT TIME=	.27586E+01	SEC.	/	.3320135E+03
AT FREQUENCY=	2.10 C.P.S.	MAX. ACCELERATION=	.6980880E+03	IN/SEC**2	AT TIME=	.21403E+01	SEC.	/	.6980584E+03
AT FREQUENCY=	3.05 C.P.S.	MAX. ACCELERATION=	.1407668E+04	IN/SEC**2	AT TIME=	.14761E+01	SEC.	/	.1407668E+04
AT FREQUENCY=	4.42 C.P.S.	MAX. ACCELERATION=	.2637625E+04	IN/SEC**2	AT TIME=	.12149E+01	SEC.	/	.2552704E+04*
AT FREQUENCY=	5.56 C.P.S.	MAX. ACCELERATION=	.2844270E+04	IN/SEC**2	AT TIME=	.89991E+00	SEC.	/	.2844270E+04
AT FREQUENCY=	7.50 C.P.S.	MAX. ACCELERATION=	.3169139E+04	IN/SEC**2	AT TIME=	.66660E+00	SEC.	/	.3169139E+04

ITERATION NO. 3

VALUES OF COEFFICIENT CALCULATED FROM PREVIOUS ITERATION

C(1)=	19.75	C(2)=	30.72	C(3)=	70.13	C(4)=	154.56	C(5)=	222.56
C(6)=	213.97	C(7)=	243.4-	C(					

MAX. VALUES OF ACCELERATION

AT FREQUENCY=	1.00	C.P.S.	MAX. ACCELERATION=	.1579137E+03	IN/SEC**2	AT TIME=	.90000E+01	SEC.	/	.1579137E+03
AT FREQUENCY=	1.45	C.P.S.	MAX. ACCELERATION=	.3320135E+03	IN/SEC**2	AT TIME=	.27586E+01	SEC.	/	.3320135E+03
AT FREQUENCY=	2.10	C.P.S.	MAX. ACCELERATION=	.6980584E+03	IN/SEC**2	AT TIME=	.21403E+01	SEC.	/	.6980584E+03
AT FREQUENCY=	3.05	C.P.S.	MAX. ACCELERATION=	.1467668E+04	IN/SEC**2	AT TIME=	.14761E+01	SEC.	/	.1467668E+04
AT FREQUENCY=	4.12	C.P.S.	MAX. ACCELERATION=	.2552704E+04	IN/SEC**2	AT TIME=	.12149E+01	SEC.	/	.2552704E+04
AT FREQUENCY=	5.56	C.P.S.	MAX. ACCELERATION=	.2844270E+04	IN/SEC**2	AT TIME=	.89991E+00	SEC.	/	.2844270E+04
AT FREQUENCY=	7.50	C.P.S.	MAX. ACCELERATION=	.3169139E+04	IN/SEC**2	AT TIME=	.66660E+00	SEC.	/	.3169139E+04

TEST SPECIMEN. VERTICAL

GENERALIZED SHOCK SPECTRUM

FOR

DAMPED AND UNDAMPED VIBRATIONS

INPUT DATA

STARTING TIME	0.0000
END TIME	4.5000
INITIAL DISPLACEMENT	0.0000
INITIAL VELOCITY	0.0000

FREQUENCY C.P.S.	TIME SEC.	MAX.P.DIS. INS.	MAX.P.ACC. G.S	TIME SEC.	MAX.N.DIS. INS.	MAX.N.ACC. G.S	ACC.ON SPEC. G.S	DEVIATION 0/0
1.00000							.40868	-.00000
1.13185	4.32813	4.20396	.55025	4.76563	-4.20075	-.54983	.52355	5.09909
1.28109	3.27586	4.61470	.77379	3.67457	-4.54624	-.76231	.67072	15.36740
1.45000							.85925	-.00000
1.64118	4.20259	3.94906	1.06675	2.67241	-4.07819	-1.12269	1.10077	1.95484
1.85758	2.25922	4.58734	1.61725	2.53419	-4.36106	-1.53748	1.41018	14.68361
2.10250							1.80857	-.00000
2.37972	3.31451	3.65347	2.11387	1.83561	-3.80304	-2.20041	2.31437	-4.92394
2.69349	1.55808	4.30112	3.16811	1.74771	-4.19545	-3.10978	2.96491	7.52796
3.04863							3.79831	-.00000
3.38937	2.32174	3.31921	3.84995	1.28044	-3.39320	-3.93576	4.63959	-15.17010
3.72386	2.19817	3.84071	5.15816	1.79574	-3.72769	-5.28139	5.66721	-6.80782
4.11564							6.60638	-.00000
4.54665	1.05922	3.06392	6.47686	1.17312	-2.93626	-6.20099	6.84889	-5.43198
5.02721	1.03208	2.56982	6.63560	.92522	-2.45411	-6.33680	7.10030	-6.54491
5.55612							7.36895	-.00000
6.14068	.78461	1.72408	6.84213	.87179	-1.78432	-6.79722	7.63116	-10.92804
6.78673	.76451	1.54798	7.24467	.68743	-1.37910	-6.48993	7.91129	-7.92062
7.50076							8.20171	0.00000

SYNTHESIZED WAVEFORM

NO. OF DATA POINTS ON TIME TABLE = 392

TIME SEC.	ACCEL. G.S	VELOCITY INS/SEC.	DISPL. INS.
0.000000	0.00000	0.00000	0.00000

.004444	.00481	.00276	.00000
.008888	.01894	.02186	.00005
.013332	.04149	.07203	.00024
.017776	.07105	.10838	.00076
.022220	.10574	.31959	.00182
.026664	.14333	.53320	.00369
.031108	.18138	.81210	.00666
.035552	.21736	1.15493	.01101
.039996	.24883	1.53602	.01701
.044440	.27355	2.00503	.02491
.048884	.28961	2.49050	.03489
.053328	.29557	2.97445	.04707
.057772	.29055	3.47930	.06151
.062216	.27425	3.96583	.07815
.066660	.24701	4.43490	.09686
.071104	.20979	4.82844	.11748
.075548	.16412	5.15055	.13968
.079992	.11202	5.30840	.16314
.084436	.05591	5.33297	.18744
.088880	-.00155	5.27963	.21217
.093324	-.05757	5.22847	.23689
.097768	-.10940	5.30432	.26117
.102212	-.15451	5.15660	.28462
.106656	-.19067	4.85882	.30689
.111100	-.21615	4.50791	.32772
.115544	-.22978	4.16329	.34691
.119988	-.23101	3.72588	.36435
.124432	-.22001	3.33694	.38004
.128876	-.19759	2.97685	.39405
.133320	-.16524	2.60404	.40657
.137764	-.12499	2.41390	.41782
.142208	-.07937	2.23786	.42813
.146652	-.03121	2.14278	.43783
.151096	.01647	2.13041	.44730
.155540	.06062	2.19732	.45689
.159984	.09837	2.33494	.46693
.164428	.12716	2.53002	.47773
.168872	.14488	2.70530	.48946
.173316	.15006	3.02040	.50233
.177760	.14187	3.27298	.51632
.182204	.12026	3.49493	.53139
.186648	.08594	3.67870	.54736
.191092	.04039	3.70864	.56398
.195536	-.01427	3.61218	.58090
.199980	-.07529	3.73598	.59771
.204424	-.13948	3.55180	.61395
.208868	-.20339	3.23712	.62912
.213312	-.26342	2.85552	.64274
.217756	-.31608	2.35669	.65435
.222200	-.35815	1.77609	.66356
.226644	-.38686	1.13436	.67005
.231088	-.40000	.45639	.67359
.235532	-.39633	-.22986	.67409
.239976	-.37512	-.89472	.67156
.244420	-.33673	-1.50829	.66626
.248864	-.28241	-2.04202	.65829
.253308	-.21422	-2.47022	.64822
.257752			
.262196			
.266640			
.271084			
.275528			

5 computer output pages have been deleted hereafter.

3.917473	-.01002	-.93261	.30671
3.950807	-.00582	-1.03454	.27378
3.984140	-.00179	-1.06324	.23834
4.017473	.00185	-1.06237	.20211
4.050807	.00495	-1.03790	.16666
4.084140	.00738	-.99773	.13332
4.117473	.00906	-.95093	.10311
4.150807	.01002	-.87714	.07678
4.184140	.01024	-.77594	.05472
4.217473	.00981	-.66620	.03703
4.250807	.00885	-.54554	.02354
4.284140	.00750	-.42993	.01383
4.317473	.00592	-.33335	.00733
4.350807	.00428	-.06705	.00337
4.384140	.00273	-.04256	.00126
4.417473	.00146	-.01580	.00033
4.450807	.00053	-.00341	.00004
4.484140	.00006	-.00012	.00000
4.517473	0.00000	0.00000	0.00000

STARTING FREQ. = 1.0000

ENDING FREQ. = 7.5008

INTERVAL STEPS = 150.0

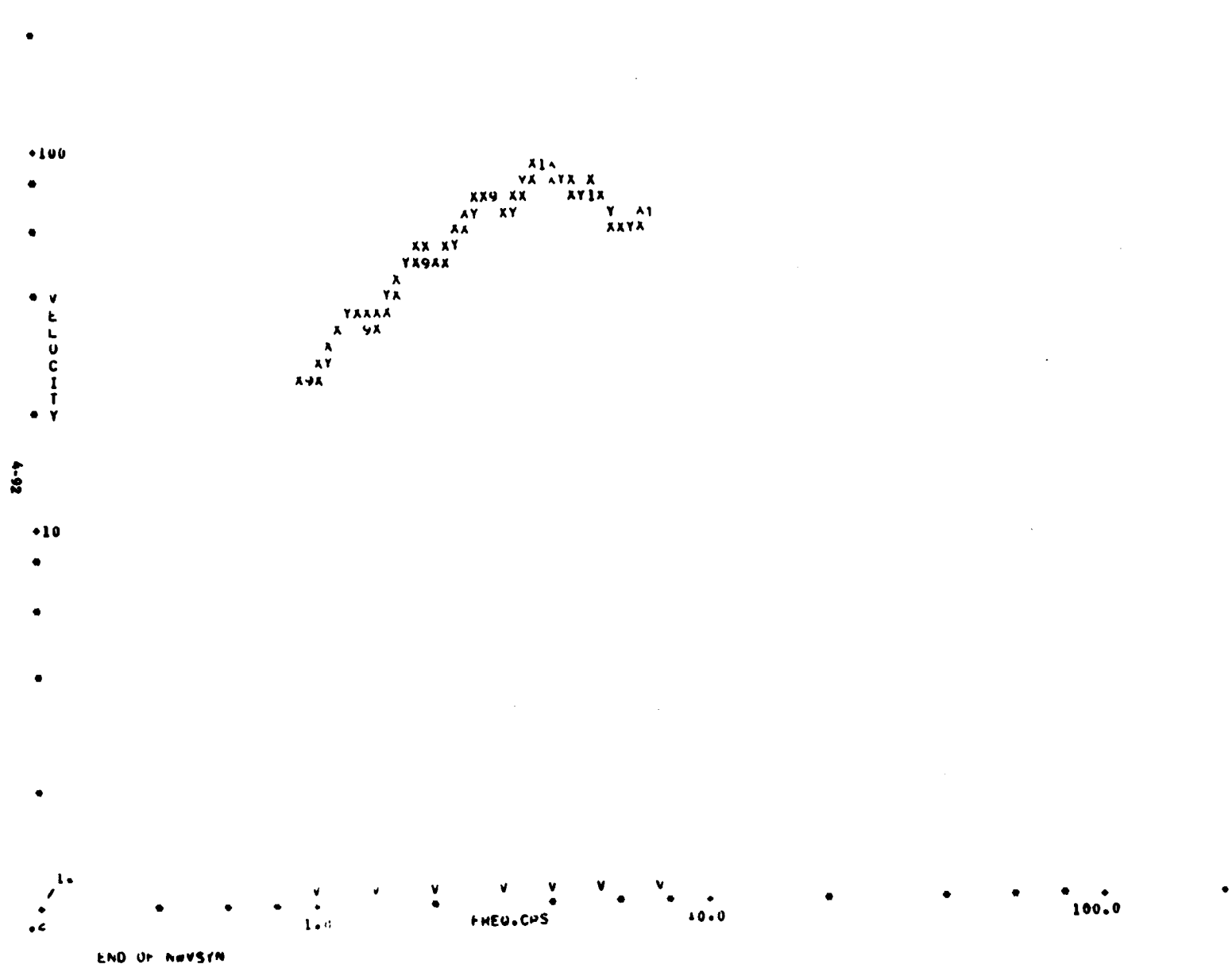
TIME SEC.	FREQUENCY C.P.S.	MAX.DISPLACEMENT INS.	MAX.ACCLERATION GMS
4.5175	1.0000	4.0154	.4102
4.4954	1.0135	3.9603	.4156
4.4751	1.0272	3.9193	.4225
4.4551	1.0411	3.8971	.4316
4.4351	1.0552	3.8968	.4433
4.4151	1.0695	3.9192	.4580
4.3943	1.0839	3.9629	.4757
4.3735	1.0986	4.0244	.4963
4.3511	1.1135	4.0984	.5191
4.3274	1.1285	4.1789	.5437
4.3034	1.1438	4.2594	.5693
4.2783	1.1592	4.3339	.5950
4.2514	1.1749	4.3971	.6202
3.8000	1.1908	4.4511	.6449
3.7776	1.2069	4.5110	.6714
3.7552	1.2232	4.5523	.6960
3.7312	1.2398	4.5734	.7182
3.3017	1.2565	4.5773	.7384
3.2833	1.2735	4.5010	.7624
3.2649	1.2908	4.6031	.7836
3.2473	1.3082	4.5841	.8016
3.2284	1.3259	4.5451	.8164
3.2113	1.3438	4.7881	.8281
3.1937	1.3620	4.4156	.8369
3.1764	1.3804	4.4310	.8432
3.1602	1.3991	4.2382	.8476
3.1442	1.4180	4.1418	.8509
2.7754	1.4372	4.0515	.8550
2.7650	1.4566	3.9842	.8637
2.7554	1.4763	3.9268	.8744
2.7458	1.4963	3.8836	.8884
2.7362	1.5165	3.8582	.9066
2.7274	1.5371	3.8527	.9300
2.7170	1.5578	3.8673	.9589
2.7066	1.5789	3.9006	.9935
2.6962	1.6003	3.9499	1.0335
2.6842	1.6219	4.0111	1.0780
2.6723	1.6438	4.0795	1.1263
2.6595	1.6661	4.1502	1.1770
2.6451	1.6886	4.2185	1.2284
2.6307	1.7114	4.2801	1.2808
2.6163	1.7346	4.3314	1.3315
2.6003	1.7580	4.3695	1.3798
2.2955	1.7818	4.4402	1.4403
2.2835	1.8059	4.5057	1.5014
2.2707	1.8303	4.5529	1.5584
2.2587	1.8551	4.5804	1.6105
2.2459	1.8802	4.5875	1.6570
2.2331	1.9056	4.5740	1.6972
2.2211	1.9314	4.5419	1.7310
2.2083	1.9575	4.4907	1.7581
2.1963	1.9840	4.4224	1.7787
2.1844	2.0108	4.3409	1.7933
2.1732	2.0380	4.2479	1.8026
2.1620	2.0656	4.1472	1.8078
2.1508	2.0935	4.0429	1.8104
2.0948	2.1219	3.9421	1.8133

1.5924	2.1505	3.0743	1.8306
1.5852	2.1796	3.0145	1.8514
1.2774	2.2091	3.1606	1.8780
1.5715	2.2394	3.1341	1.9125
1.5652	2.2692	3.1179	1.9566
1.2589	2.2999	3.1218	2.0114
1.2566	2.3310	3.1420	2.0774
1.2436	2.3625	3.1773	2.1541
1.8356	2.3945	3.2247	2.2405
1.8268	2.4269	3.2802	2.3349
1.8199	2.4597	3.3399	2.4354
1.8094	2.4930	3.3996	2.5396
1.7988	2.5267	4.0558	2.6454
1.7884	2.5608	4.1050	2.7504
1.7780	2.5955	4.1448	2.8527
1.5709	2.6306	4.1751	2.9518
1.5629	2.6662	4.2503	3.0868
1.5549	2.7022	4.3094	3.2150
1.5461	2.7388	4.3511	3.3345
1.5373	2.7758	4.3738	3.4432
1.5293	2.8133	4.3772	3.5396
1.5205	2.8514	4.3605	3.6222
1.5125	2.8899	4.3245	3.6901
1.5045	2.9290	4.2696	3.7424
1.4965	2.9686	4.1974	3.7794
1.4885	3.0088	4.1101	3.8015
1.4813	3.0495	4.0101	3.8100
1.4741	3.0907	3.9011	3.8074
1.4669	3.1325	3.7871	3.7968
1.2497	3.1749	3.6841	3.7941
1.2457	3.2178	3.5965	3.8048
1.2925	3.2613	3.5172	3.8221
1.2885	3.3054	3.4517	3.8531
1.2853	3.3501	3.4045	3.9040
1.2821	3.3954	3.3793	3.9805
1.2789	3.4414	3.3777	4.0870
1.2757	3.4879	3.3995	4.2254
1.2725	3.5351	3.4423	4.3951
1.8268	3.5829	3.5052	4.5973
1.8156	3.6313	3.5821	4.8260
1.8044	3.6805	3.6596	5.0647
1.7924	3.7302	3.7314	5.3048
1.2509	3.7807	3.7919	5.5375
1.2461	3.8318	3.8478	5.7722
1.2405	3.8836	3.8875	5.9905
1.2349	3.9361	3.9073	6.1851
1.2293	3.9894	3.9052	6.3501
1.2237	4.0433	3.8801	6.4810
1.2182	4.0980	3.8318	6.5747
1.2126	4.1534	3.7615	6.6299
1.2062	4.2096	3.6713	6.6470
1.2000	4.2665	3.5639	6.6283
1.1950	4.3242	3.4428	6.5774
1.0714	4.3827	3.3197	6.5150
1.0678	4.4420	3.2270	6.5055
1.0638	4.5021	3.1322	6.4863
1.0598	4.5630	3.0388	6.4643
1.0558	4.6247	2.9499	6.4460
1.0526	4.6872	2.8678	6.4372
1.0486	4.7506	2.7942	6.4429
1.0446	4.8148	2.7292	6.4644
1.0406	4.8800	2.6721	6.5015

1.0366	4.9960	2.0213	6.5516
1.0326	5.0128	2.0746	6.6099
1.0278	5.0806	2.0289	6.6694
1.0238	5.1493	2.0820	6.7241
.9182	5.2170	2.0521	6.8240
.9142	5.2876	2.0435	6.9853
.9110	5.3641	2.0200	7.1252
.9070	5.4336	2.0992	7.2370
.9030	5.5071	2.0609	7.3154
.8998	5.5816	2.0118	7.3594
.8958	5.6571	2.0521	7.3635
.8910	5.7336	2.1829	7.3318
.8878	5.8141	2.1061	7.2664
.8838	5.8847	2.0237	7.1723
.8800	5.9673	1.9386	7.0576
.8766	6.0501	1.8530	6.9247
.8734	6.1319	1.7693	6.7970
.8694	6.2148	1.6904	6.6706
.7814	6.2989	1.0477	6.6791
.7782	6.3841	1.0167	6.7321
.7758	6.4704	1.0922	6.8105
.7734	6.5579	1.0736	6.9143
.7702	6.6406	1.0601	7.0417
.7670	6.7365	1.0498	7.1857
.7638	6.8276	1.0408	7.3384
.7606	6.9199	1.0307	7.4884
.7566	7.0135	1.0173	7.6253
.7534	7.1084	1.0987	7.7370
.7486	7.2045	1.4734	7.8136
.6735	7.3019	1.4519	7.9092
.6703	7.4007	1.4423	8.0709
.6663	7.5008	1.4218	8.1730

SPECTRUM FROM THE SYNTHESIZED WAVEFORM

TEST SPECTRUM, VERTICAL 03/30/73 0300 HR.



TIME

0.0000
.0040
.0070
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.0170
.0200
.0240
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.0300
.0330
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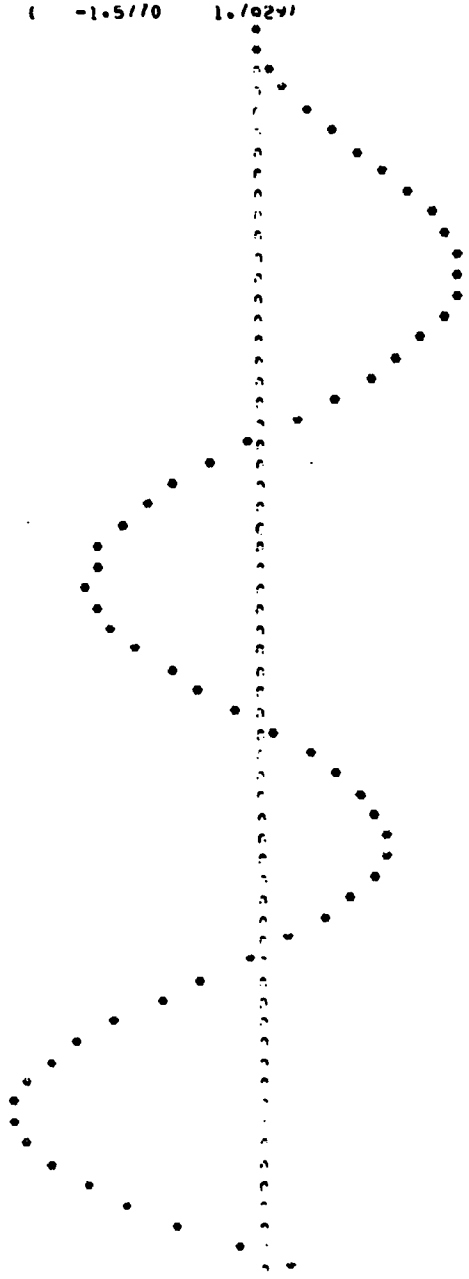
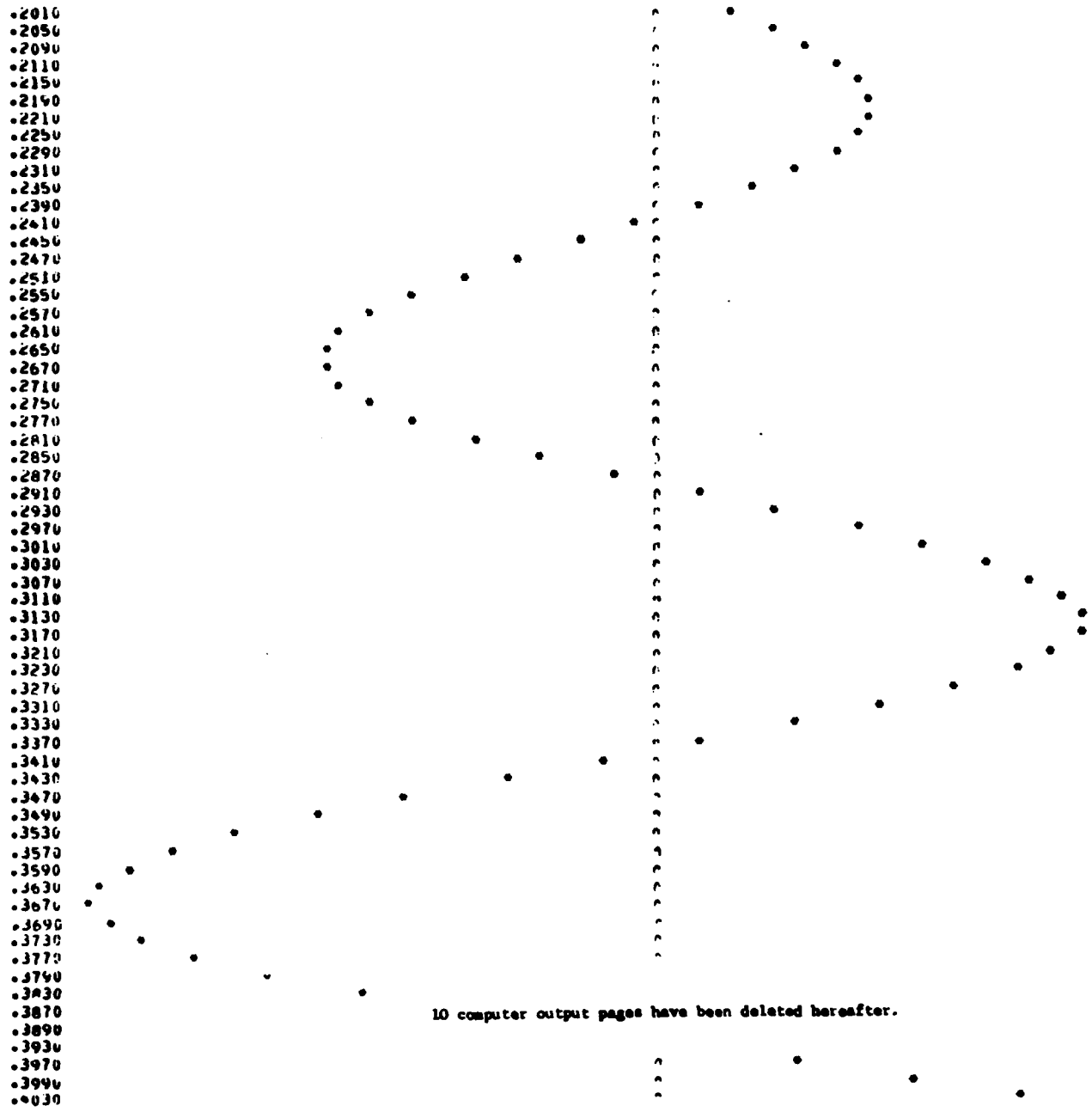
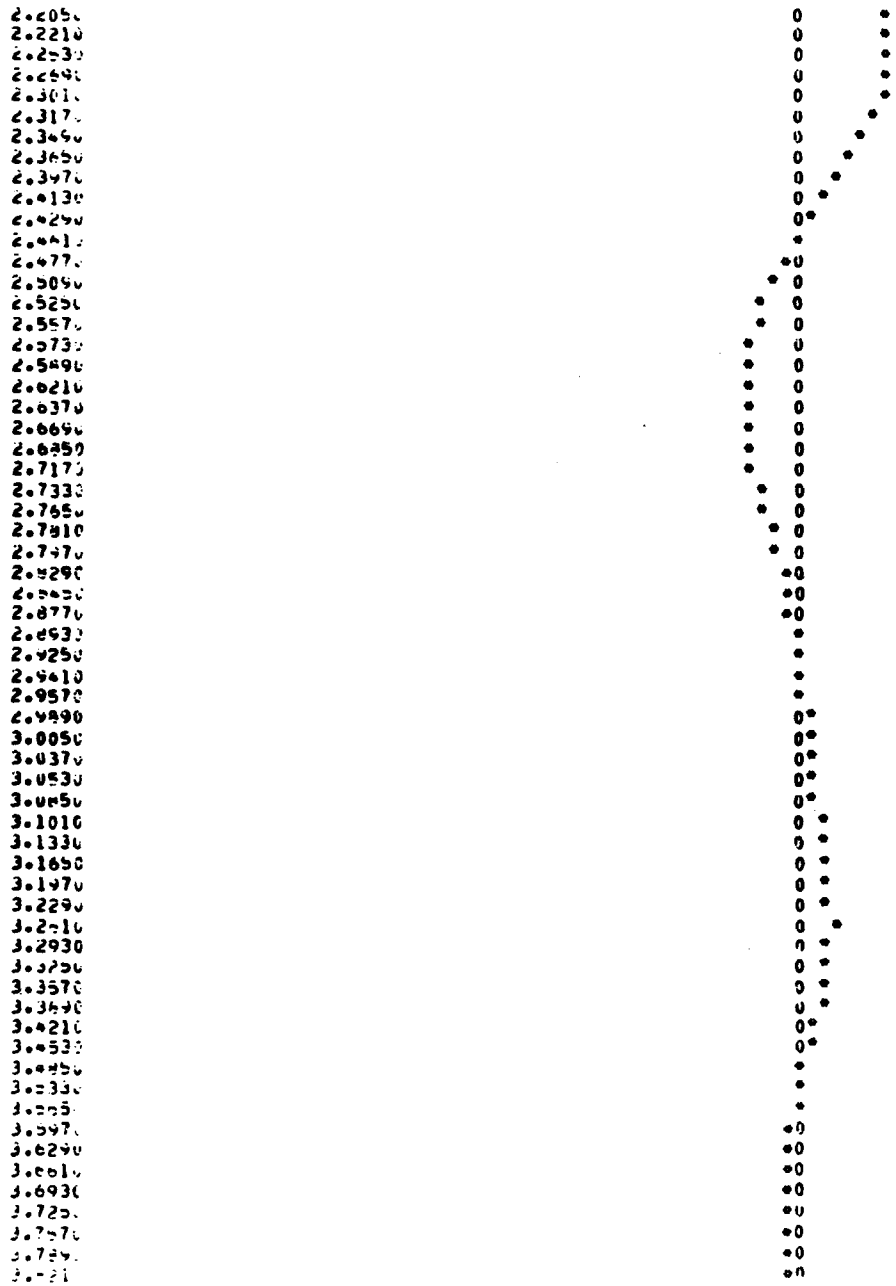
.1950
.1990

ACCEL. (-1.5770 1.7029)





10 computer output pages have been deleted hereafter.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2.2530
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3.6290
3.6610
3.6930
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3.7570
3.7890

3.6530	*0
3.6850	*0
3.9330	*
3.9650	*
3.9970	*
4.0290	0*
4.0610	0*
4.0930	0*
4.1250	0*
4.1570	0*
4.1890	0*
4.2210	0*
4.2530	0*
4.2850	0*
4.3330	*
4.3650	*
4.3970	*
4.4290	*
4.4610	*
4.4930	

SYNSOL INPUT DATA

OUTPUT UNIT SAME AS INPUT UNIT

3 CASES

TIME STEPS =	435	TIME DURATION =	4.5173	MULT. FACTOR =	1.00000
TIME STEPS =	0	TIME DURATION =	0.0000	MULT. FACTOR =	1.00000
TIME STEPS =	392	TIME DURATION =	4.5175	MULT. FACTOR =	1.00000

SET NO. 1

TOTAL NUMBER OF POINTS (=NC IN ISOL) = 435

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.02963	.03292	.03621	.03950	.04279	.04609	.04938	.05267	.05596	NO. 0- 2
.05925	.06255	.06584	.06913	.07242	.07571	.07900	.08230	.08559	NO. 0- 3
.08888	.09217	.09546	.09876	.10205	.10534	.10863	.11192	.11521	NO. 0- 4
.11851	.12180	.12509	.12838	.13167	.13497	.13826	.14155	.14484	NO. 0- 5
.14813	.15142	.15472	.15801	.16130	.16459	.16788	.17118	.17447	NO. 0- 6
.17776	.18105	.18434	.18764	.19093	.19422	.19751	.20080	.20409	NO. 0- 7
.20739	.21068	.21397	.21726	.22055	.22385	.22714	.23043	.23372	NO. 0- 8
.23701	.24030	.24360	.24689	.25018	.25347	.25676	.26006	.26335	NO. 0- 9
.26664	.26993	.27322	.27652	.27981	.28310	.28639	.28968	.29297	NO. 0- 10
.29627	.29956	.30285	.30614	.30943	.31273	.31602	.31931	.32260	NO. 0- 11
.32589	.32918	.33248	.33577	.33906	.34235	.34564	.34894	.35223	NO. 0- 12
.35552	.35881	.36210	.36540	.36869	.37198	.37527	.37856	.38185	NO. 0- 13
.38515	.38844	.39173	.39502	.39831	.40161	.40490	.40819	.41148	NO. 0- 14
.41477	.41806	.42136	.42465	.42794	.43123	.43452	.43782	.44111	NO. 0- 15
.44440	.44769	.45098	.45427	.45757	.46086	.46415	.46744	.47073	NO. 0- 16
.47403	.47732	.48061	.48390	.48719	.49049	.49378	.49707	.50036	NO. 0- 17
.50365	.50694	.51024	.51353	.51682	.52011	.52340	.52670	.52999	NO. 0- 18
.53328	.53657	.53986	.54315	.54645	.55089	.55533	.55978	.56422	NO. 0- 19
.56867	.57311	.57755	.58200	.58644	.59089	.59533	.59977	.60422	NO. 0- 20
.60866	.61311	.61755	.62199	.62644	.63088	.63533	.63977	.64421	NO. 0- 21
.64866	.65310	.65755	.66199	.66643	.67088	.67532	.67977	.68421	NO. 0- 22
.68865	.69310	.69754	.70199	.70643	.71087	.71532	.71976	.72421	NO. 0- 23
.72865	.73309	.73754	.74354	.74954	.75554	.76154	.76754	.77353	NO. 0- 24
.77953	.78553	.79153	.79753	.80353	.80953	.81553	.82153	.82753	NO. 0- 25
.83353	.83953	.84553	.85153	.85753	.86353	.86952	.87552	.88152	NO. 0- 26
.88752	.89352	.89952	.90552	.91152	.91752	.92352	.92952	.93552	NO. 0- 27
.94152	.94752	.95352	.95952	.96552	.97151	.97751	.98351	.98951	NO. 0- 28
.99551	1.00151	1.01171	1.01791	1.02791	1.03601	1.04411	1.05221	1.06031	NO. 0- 29

1.00040	1.07650	1.08460	1.09270	1.10080	1.10890	1.11700	1.12510	1.13320	NO. 0- 30
1.14130	1.14940	1.15750	1.16559	1.17369	1.18179	1.18989	1.19799	1.20609	NO. 0- 31
1.21419	1.22229	1.23039	1.23849	1.24659	1.25469	1.26279	1.27088	1.27898	NO. 0- 32
1.28708	1.29518	1.30328	1.31138	1.31948	1.32758	1.33568	1.34378	1.35471	NO. 0- 33
1.36564	1.37658	1.38751	1.39845	1.40938	1.42031	1.43125	1.44218	1.45312	NO. 0- 34
1.46405	1.47498	1.48592	1.50177	1.51763	1.53348	1.54933	1.56519	1.58104	NO. 0- 35
1.59690	1.61275	1.62860	1.64446	1.66031	1.67617	1.69202	1.70788	1.72373	NO. 0- 36
1.73958	1.75544	1.77129	1.78715	1.80300	1.81885	1.83471	1.85056	1.86642	NO. 0- 37
1.88227	1.89813	1.91398	1.92983	1.94569	1.96154	1.97740	1.99325	2.00910	NO. 0- 38
2.02496	2.04081	2.05667	2.07252	2.08837	2.10423	2.12008	2.13594	2.15179	NO. 0- 39
2.17476	2.19777	2.22076	2.24375	2.26673	2.28972	2.31271	2.33570	2.35869	NO. 0- 40
2.38168	2.40466	2.42765	2.45064	2.47363	2.49662	2.51961	2.54260	2.56558	NO. 0- 41
2.58857	2.61156	2.63455	2.65754	2.68053	2.70352	2.72650	2.74949	2.77248	NO. 0- 42
2.79547	2.81846	2.84145	2.86444	2.88742	2.91041	2.93340	2.95639	2.97938	NO. 0- 43
3.00237	3.02535	3.04834	3.07133	3.09432	3.11731	3.15004	3.18398	3.21731	NO. 0- 44
3.25064	3.28398	3.31731	3.35064	3.38398	3.41731	3.45004	3.48398	3.51731	NO. 0- 45
3.55064	3.58398	3.61731	3.65064	3.68398	3.71731	3.75004	3.78398	3.81731	NO. 0- 46
3.85064	3.88398	3.91731	3.95064	3.98398	4.01731	4.05064	4.08398	4.11731	NO. 0- 47
4.15064	4.18398	4.21731	4.25064	4.28398	4.31731	4.35004	4.38398	4.41731	NO. 0- 48
4.45064	4.48398	4.51731	4.51731	4.51731	4.51731	4.51731	4.51731	4.51731	NO. 0- 49

SET No. 1

0.00000	.00756	.02976	.06521	.11165	.16014	.22516	.28485	.34126	NO. 1- 1
.39051	.42907	.45395	.46288	.45446	.42822	.38472	.32546	.25288	NO. 1- 2
.17017	.08117	-.00939	-.09858	-.18056	-.25175	-.30862	-.34838	-.36912	NO. 1- 3
-.36995	-.35104	-.31366	-.26008	-.19349	-.11783	-.03758	.04250	.11758	NO. 1- 4
.17367	.23488	.26961	.28479	.27901	.25204	.20403	.13952	.05930	NO. 1- 5
-.03169	-.12862	-.22619	-.31891	-.40140	-.46870	-.51053	-.54153	-.54150	NO. 1- 6
-.51352	-.46403	-.38885	-.29314	-.18123	-.05843	.06919	.19514	.31281	NO. 1- 7
.41352	.49836	.55551	.56349	.57992	.54396	.47639	.37964	.25768	NO. 1- 8
.11385	-.03931	-.20041	-.35957	-.50871	-.64006	-.74646	-.82177	-.86119	NO. 1- 9
-.86150	-.82129	-.74107	-.62324	-.47210	-.29361	-.09521	.11454	.32634	NO. 1- 10
.53050	.71749	.87829	1.00486	1.09052	1.13027	1.12106	1.06193	.95414	NO. 1- 11
.80108	.60819	.38276	.13359	-.12934	-.39531	-.65333	-.89255	-1.10282	NO. 1- 12
-1.27502	-1.40154	-1.47654	-1.49624	-1.45904	-1.36563	-1.21889	-1.02384	-.78735	NO. 1- 13
-.51788	-.22514	.08034	.33764	.68587	.96461	1.21433	1.42066	1.59485	NO. 1- 14
1.71376	1.78020	1.79289	1.75249	1.66143	1.52380	1.34513	1.13203	.89197	NO. 1- 15
.61292	.36299	.09019	-.17794	-.43448	-.67343	-.88977	-1.07958	-1.24008	NO. 1- 16
-1.36958	-1.46741	-1.53382	-1.56982	-1.57704	-1.55752	-1.51357	-1.44762	-1.36207	NO. 1- 17
-1.25918	-1.14103	-1.00946	-.86608	-.71232	-.54946	-.37873	-.20143	-.01896	NO. 1- 18
.16700	.35449	.54116	.72430	.89687	1.10145	1.26705	1.39061	1.46721	NO. 1- 19
1.49008	1.47759	1.41379	1.30822	1.16574	.99223	.79433	.57915	.35396	NO. 1- 20
.12588	-.09833	-.31255	-.51145	-.69062	-.84066	-.97721	-1.08089	-1.15727	NO. 1- 21
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-.72452	-.60425	-.47635	-.34181	-.20152	-.05640	.09251	.24400	.39653	NO. 1- 23
.54826	.69698	.83672	1.00042	1.13065	1.22348	1.27049	1.28881	1.26110	NO. 1- 24
1.19543	1.09519	.96485	.80973	.63575	.44918	.25031	.06326	-.12428	NO. 1- 25
-.31127	-.46341	-.60732	-.73051	-.83147	-.90958	-.96503	-.99871	-1.01210	NO. 1- 26
-1.00707	-.98573	-.95031	-.90298	-.84575	-.78037	-.70829	-.63061	-.54812	NO. 1- 27
-.46132	-.37048	-.27575	-.17724	-.07516	.03015	.13805	.24758	.35741	NO. 1- 28
.46287	.56913	.69350	.77322	.82659	.85301	.85292	.82776	.77984	NO. 1- 29
.71223	.62854	.53276	.42905	.32159	.21432	.11004	.01428	-.07285	NO. 1- 30
-.14870	-.21210	-.26255	-.30021	-.32579	-.34045	-.34376	-.34344	-.33536	NO. 1- 31
-.32333	-.30905	-.29396	-.27920	-.26556	-.25347	-.24293	-.23375	-.22529	NO. 1- 32
-.21683	-.20748	-.19636	-.18263	-.16561	-.14487	-.12022	-.09386	-.06047	NO. 1- 33
-.03002	-.00265	.02183	.04380	.06384	.08264	.10066	.11915	.13797	NO. 1- 34
.15763	.17810	.19776	.21969	.23322	.23790	.23309	.22089	.20019	NO. 1- 35
.17256	.13924	.10164	.06133	.01989	-.02110	-.06016	-.09602	-.12751	NO. 1- 36
-.15380	-.17428	-.18866	-.19649	-.19920	-.19605	-.18607	-.17604	-.16082	NO. 1- 37
-.14331	-.12439	-.10460	-.08543	-.06667	-.04900	-.03207	-.01776	-.00424	NO. 1- 38

.00808	.01947	.03023	.04070	.05120	.06196	.07314	.08477	.09627	NO. 1- 39
.10990	.11942	.12458	.12530	.12169	.11403	.10276	.08844	.07175	NO. 1- 40
.05342	.03421	.01489	-.00383	-.02128	-.03693	-.05032	-.06114	-.06922	NO. 1- 41
-.07451	-.07709	-.07714	-.07496	-.07090	-.06535	-.05873	-.05145	-.04388	NO. 1- 42
-.03037	-.02918	-.02251	-.01647	-.01110	-.00637	-.00220	.00156	.00507	NO. 1- 43
.00850	.01200	.01572	.01974	.02410	.02860	.03396	.03765	.03955	NO. 1- 44
.03963	.03747	.03469	.03002	.02423	.01763	.01056	.00339	-.00356	NO. 1- 45
-.00996	-.01555	-.02011	-.02347	-.02555	-.02633	-.02586	-.02425	-.02165	NO. 1- 46
-.01829	-.01437	-.01017	-.00591	-.00183	.00186	.00500	.00746	.00918	NO. 1- 47
.01014	.01037	.00994	.00896	.00760	.00600	.00435	.00279	.00148	NO. 1- 48
.00054	.00006	0.00000	0.00000	.00000	0.00000	0.00000	0.00000	0.00000	NO. 1- 49

SET NO. 2

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.17017	.08117	-.00989	-.09658	-.18056	-.25175	-.30862	-.34838	-.36912	NO. 2- 3
-.36995	-.35104	-.31366	-.26008	-.19349	-.11783	-.03758	.04250	.11758	NO. 2- 4
.18307	.23488	.26961	.28479	.27901	.25204	.20403	.13952	.05930	NO. 2- 5
-.03169	-.12862	-.22619	-.31891	-.40140	-.46870	-.51653	-.54153	-.54150	NO. 2- 6
-.51552	-.46403	-.38885	-.29314	-.18123	-.05843	.06919	.19514	.31281	NO. 2- 7
.41582	.49836	.55551	.58349	.57992	.54396	.47639	.37964	.25768	NO. 2- 8
.11585	-.03931	-.20041	-.35957	-.50871	-.64006	-.74646	-.82177	-.86119	NO. 2- 9
-.86150	-.82129	-.74107	-.62324	-.47210	-.29361	-.09521	.11454	.32634	NO. 2- 10
.53050	.71749	.87829	1.00486	1.09052	1.1[illegible]927	1.12106	1.06193	.95414	NO. 2- 11
.86108	.60819	.32276	.13354	-.12934	-.39531	-.65333	-.89255	-1.10282	NO. 2- 12
-1.27502	-1.40154	-1.47654	-1.49624	-1.45904	-1.36563	-1.21889	-1.02384	-.78735	NO. 2- 13
-.51788	-.22514	.08034	.36764	.68587	.96461	1.21433	1.42068	1.59485	NO. 2- 14
1.71376	1.78020	1.79289	1.75249	1.66143	1.52380	1.34513	1.13203	.89197	NO. 2- 15
.63292	.36299	.09019	-.17794	-.43448	-.67343	-.88977	-1.07958	-1.24008	NO. 2- 16
-1.36958	-1.46741	-1.53382	-1.55982	-1.57704	-1.55752	-1.51357	-1.44762	-1.36207	NO. 2- 17
-1.25918	-1.14103	-1.00946	-.86608	-.71232	-.54946	-.37873	-.20143	-.01896	NO. 2- 18
.16700	.35449	.54116	.72430	.89687	1.10145	1.26705	1.39061	1.46721	NO. 2- 19
1.49608	1.47759	1.41379	1.30822	1.16574	.99223	.79433	.57915	.35396	NO. 2- 20
.12588	-.09833	-.31255	-.51145	-.69062	-.84666	-.97721	-1.08089	-1.15727	NO. 2- 21
-1.20074	-1.23038	-1.22980	-1.20697	-1.16409	-1.10344	-1.02721	-.93746	-.83603	NO. 2- 22
-.72452	-.60425	-.47635	-.34181	-.20152	-.05640	.09251	.24400	.39653	NO. 2- 23
.54826	.69698	.83672	1.00042	1.13065	1.22348	1.27049	1.28881	1.26110	NO. 2- 24
1.19543	1.09519	.96485	.80973	.63575	.44918	.25631	.06326	-.12428	NO. 2- 25
-.36127	-.46341	-.60732	-.73051	-.83147	-.90958	-.96503	-.99871	-1.01210	NO. 2- 26
-1.00707	-.98573	-.95031	-.90298	-.84575	-.78037	-.70829	-.63061	-.54812	NO. 2- 27
-.46132	-.37048	-.27575	-.17724	-.07516	.03015	.13805	.24756	.35741	NO. 2- 28
.46287	.58913	.69350	.77322	.82659	.85301	.85292	.82776	.77984	NO. 2- 29
.71223	.62854	.53276	.42905	.32159	.21432	.11084	.01428	-.07285	NO. 2- 30
-.14870	-.21210	-.26255	-.30021	-.32579	-.34046	-.34576	-.34344	-.33536	NO. 2- 31
-.32333	-.30905	-.29396	-.27920	-.26556	-.25347	-.24295	-.23375	-.22529	NO. 2- 32
-.21083	-.20748	-.19636	-.18263	-.16561	-.14487	-.12022	-.09346	-.06047	NO. 2- 33
-.03002	-.00265	.02183	.04380	.06384	.08264	.10086	.11915	.13797	NO. 2- 34
.15763	.17816	.19776	.21964	.23322	.23790	.23369	.22089	.20019	NO. 2- 35
.17256	.13924	.10164	.06133	.01989	-.02110	-.06018	-.09902	-.12751	NO. 2- 36
-.15380	-.17428	-.18866	-.19689	-.19920	-.19605	-.18807	-.17604	-.16082	NO. 2- 37
-.14331	-.12439	-.10486	-.08543	-.06667	-.04900	-.03267	-.01776	-.00424	NO. 2- 38
.00808	.01947	.03023	.04070	.05120	.06196	.07314	.08477	.09627	NO. 2- 39
.10990	.11942	.12458	.12530	.12169	.11403	.10276	.08844	.07175	NO. 2- 40
.05342	.03421	.01489	-.00383	-.02128	-.03693	-.05032	-.06114	-.06922	NO. 2- 41
-.07451	-.07709	-.07714	-.07496	-.07090	-.06535	-.05873	-.05145	-.04388	NO. 2- 42
-.03037	-.02918	-.02251	-.01647	-.01110	-.00637	-.00220	.00156	.00507	NO. 2- 43
.00850	.01200	.01572	.01974	.02410	.02860	.03396	.03765	.03955	NO. 2- 44
.03963	.03747	.03469	.03002	.02423	.01763	.01056	.00339	-.00356	NO. 2- 45
-.00996	-.01555	-.02011	-.02347	-.02555	-.02633	-.02586	-.02425	-.02165	NO. 2- 46
-.01829	-.01437	-.01017	-.00591	-.00183	.00186	.00500	.00746	.00918	NO. 2- 47

.01014	.01037	.00994	.00896	.00760	.00600	.00435	.00279	.00148	NO. 2- 48
.00054	.00005	0.00000	0.00000	.00000	0.00000	0.00000	0.00000	0.00000	NO. 2- 49

SET NO. 3

0.00000	.00350	.01045	.02322	.04051	.06157	.08584	.11248	.14045	NO. 3- 1
.10865	.19629	.22231	.24556	.26518	.28050	.29077	.29533	.29392	NO. 3- 2
.28637	.27261	.25288	.22757	.19714	.16231	.12416	.08343	.04114	NO. 3- 3
-.00155	-.04318	-.08305	-.12001	-.15296	-.18089	-.20331	-.21957	-.22917	NO. 3- 4
-.23198	-.22801	-.21741	-.20065	-.17838	-.15125	-.12019	-.08647	-.05113	NO. 3- 5
-.01526	.01986	.05271	.08239	.10784	.12801	.14190	.14913	.14922	NO. 3- 6
.14167	.12715	.10532	.07679	.04227	.00287	-.04060	-.08694	-.13462	NO. 3- 7
-.18212	-.22831	-.27168	-.31059	-.34380	-.37034	-.38909	-.39908	-.39989	NO. 3- 8
-.39120	-.37268	-.34514	-.30852	-.26365	-.21149	-.15359	-.09103	-.02532	NO. 3- 9
.04182	.10811	.17243	.23293	.28778	.33518	.37420	.40354	.42210	NO. 3- 10
.42929	.42487	.40867	.38100	.34256	.29408	.23673	.17222	.10213	NO. 3- 11
.02808	-.04791	-.12325	-.19629	-.26507	-.32747	-.38119	-.42513	-.45780	NO. 3- 12
-.47795	-.48456	-.47748	-.45645	-.42166	-.37394	-.31407	-.24330	-.16342	NO. 3- 13
-.07655	.01566	.11087	.20626	.29942	.38830	.47038	.54292	.60418	NO. 3- 14
.65251	.68621	.70381	.70481	.68872	.65539	.60537	.53941	.45858	NO. 3- 15
.36443	.25948	.14525	.02420	-.10083	-.22660	-.35109	-.47137	-.58434	NO. 3- 16
-.88728	-.77835	-.85525	-.91579	-.95866	-.98296	-.98782	-.97291	-.93854	NO. 3- 17
-.86520	-.81378	-.72602	-.62344	-.50791	-.38176	-.24821	-.10923	.03247	NO. 3- 18
.17395	.31167	.44395	.56811	.68157	.81402	.91903	.99343	1.03521	NO. 3- 19
1.04362	1.01908	.96317	.87852	.76862	.63769	.49045	.33194	.16729	NO. 3- 20
.00154	-.16057	-.31472	-.45716	-.58476	-.69520	-.78672	-.85839	-.90989	NO. 3- 21
-.94148	-.95392	-.94832	-.92610	-.88882	-.83808	-.77550	-.70256	-.62063	NO. 3- 22
-.53691	-.43443	-.33212	-.22476	-.11313	.00199	.11974	.23909	.35885	NO. 3- 23
.47756	.59354	.70247	.83088	.93403	1.00888	1.05342	1.06671	1.04897	NO. 3- 24
1.00141	.92624	.82648	.70584	.56850	.41901	.26200	.10211	-.05628	NO. 3- 25
-.20911	-.35250	-.48433	-.60129	-.70190	-.78499	-.85001	-.89691	-.92611	NO. 3- 26
-.93838	-.93478	-.91652	-.88491	-.84129	-.78692	-.72301	-.65062	-.57072	NO. 3- 27
-.48417	-.39179	-.29433	-.19258	-.08743	.02014	.12897	.23772	.34483	NO. 3- 28
.44661	.56868	.66981	.74736	.79968	.82616	.82718	.80410	.75908	NO. 3- 29
.69502	.61534	.52383	.42446	.32120	.21782	.11779	.02409	-.06085	NO. 3- 30
-.15520	-.19781	-.24816	-.28634	-.31296	-.32910	-.33016	-.33578	-.32967	NO. 3- 31
-.31955	-.30700	-.29338	-.27978	-.26696	-.25532	-.24495	-.23560	-.22678	NO. 3- 32
-.21781	-.20788	-.19620	-.18200	-.16469	-.14385	-.11935	-.09330	-.06024	NO. 3- 33
-.03010	-.00299	.02126	.04304	.06293	.08157	.09906	.11779	.13647	NO. 3- 34
.15595	.17630	.19570	.21745	.23086	.23551	.23134	.21868	.19818	NO. 3- 35
.17082	.13782	.10060	.06068	.01965	-.02093	-.05902	-.09509	-.12625	NO. 3- 36
-.15225	-.17250	-.18670	-.19482	-.19707	-.19391	-.18597	-.17403	-.15893	NO. 3- 37
-.14157	-.12282	-.10348	-.08425	-.06569	-.04822	-.03208	-.01736	-.00402	NO. 3- 38
.00813	.01935	.02995	.04026	.05060	.06120	.07222	.08370	.09504	NO. 3- 39
.10850	.11791	.12301	.12372	.12015	.11259	.10146	.08733	.07085	NO. 3- 40
.05275	.03379	.01471	-.00377	-.02100	-.03645	-.04907	-.06036	-.06834	NO. 3- 41
-.07356	-.07611	-.07617	-.07402	-.07001	-.06454	-.05800	-.05081	-.04335	NO. 3- 42
-.03593	-.02803	-.02224	-.01628	-.01097	-.00630	-.00218	.00154	.00500	NO. 3- 43
.00839	.01185	.01553	.01950	.02381	.02825	.03355	.03719	.03906	NO. 3- 44
.03915	.03750	.03426	.02965	.02393	.01741	.01043	.00335	-.00351	NO. 3- 45
-.00984	-.01536	-.01986	-.02318	-.02523	-.02601	-.02554	-.02395	-.02134	NO. 3- 46
-.01[illegible]	-.01420	-.01004	-.00584	-.00181	.00183	.00494	.00737	.00907	NO. 3- 47
.01002	.01024	.00981	.00885	.00751	.00593	.00429	.00276	.00146	NO. 3- 48
.00054	.00006	-.00000	0.00000	.00000	0.00000	0.00000	0.00000	0.00000	NO. 3- 49

ISCL INPUT DATA

INPUT DATA

NA= 1 NB= 12 NC= 435 ND= 1 NE= 4 NF= -0 NG= 1 NH= 0

MASSES, COORDINATES, AND MOMENTS OF INERTIA

	MASS(LBM)	XM	YM	ZM	IXX	IYY	IZZ	IXY	IXZ	IYZ
1	31200.00	196.25	51.71	76.21	.36970E+06	.11302E+07	.11019E+07	0.	0.	0.

SPRING ATTACHMENT LOCATIONS

	XA	YA	ZA	XB	YB	ZB
1	0.00	0.00	36.00	0.00	0.00	228.00
2	102.00	0.00	36.00	102.00	0.00	228.00
3	192.00	0.00	36.00	192.00	0.00	228.00
4	282.00	0.00	36.00	282.00	0.00	228.00
5	384.00	0.00	36.00	384.00	0.00	228.00
6	0.00	180.00	36.00	0.00	180.00	228.00
7	102.00	180.00	36.00	102.00	180.00	228.00
8	192.00	180.00	36.00	192.00	180.00	228.00
9	282.00	180.00	36.00	282.00	180.00	228.00
10	384.00	180.00	36.00	384.00	180.00	228.00
11	0.00	90.00	36.00	0.00	90.00	228.00
12	384.00	90.00	36.00	384.00	90.00	228.00

SPECIAL POINT LOCATIONS

	XP	YP	ZP
1	0.00	0.00	70.54
2	-6.00	-6.00	0.00
3	390.00	186.00	0.00
4	-6.00	186.00	149.08

SPRING AND DAMPER CHARACTERISTICS

1 FREE LGTH = 187.52 SPR CONST = 621.43 DAMP COEF = 6.70 NX = 0 NY = 0

2 FREE LGTH = 187.43 SPR CONST = 621.43 DAMP COEF = 6.68 NX = 0 NY = 0

FREE LGTH = 187.35 SPR CONST = 621.43 DAMP COEF = 6.59 NX = 0 NY = 0

4 FREE LGTH = 186.23 SPR CONST = 508.45 DAMP COEF = 6.70 NX = 0 NY = 0

5 FREE LGTH = 186.12 SPR CONST = 508.45 DAMP COEF = 6.42 NX = 0 NY = 0

6 FREE LGTH = 187.77 SPR CONST = 522.85 DAMP COEF = 5.05 NX = 0 NY = 0

7 FREE LGTH = 187.67 SPR CONST = 522.85 DAMP COEF = 5.17 NX = 0 NY = 0

8 FREE LGTH = 187.58 SPR CONST = 522.85 DAMP COEF = 5.28 NX = 0 NY = 0

9 FREE LGTH = 186.48 SPR CONST = 427.79 DAMP COEF = 5.38 NX = 0 NY = 0

10 FREE LGTH = 186.36 SPR CONST = 427.79 DAMP COEF = 5.51 NX = 0 NY = 0

11 FREE LGTH = 187.63 SPR CONST = 572.14 DAMP COEF = 5.70 NX = 0 NY = 0

12 FREE LGTH = 186.23 SPR CONST = 466.12 DAMP COEF = 6.16 NX = 0 NY = 0

EXCITATION	TIME	AX	AY	AZ	TIME	AX	AY	AZ
	0.0000	0.0000	0.0000	0.0000	.0033	2.9210	2.9210	1.3766
	.0066	11.5003	11.5003	4.6373	.0099	25.1968	25.1968	8.9726
	.0132	43.1433	43.1433	15.6521	.0165	64.1961	64.1961	23.7888
	.0198	87.0002	87.0002	33.1680	.0230	110.0677	110.0677	43.4640
	.0263	131.8631	131.8631	54.2691	.0296	150.8929	150.8929	65.1649
	.0329	165.7923	165.7923	75.8461	.0362	175.4058	175.4058	85.9012
	.0395	178.8570	178.8570	94.8846	.0428	175.6019	175.6019	102.4664
	.0461	165.4651	165.4651	108.3870	.0494	148.6553	148.6553	112.3531
	.0527	125.7586	125.7586	114.1143	.0560	97.7118	97.7118	113.5724
	.0593	65.7545	65.7545	110.0543	.0625	31.3645	31.3645	105.3368
	.0658	-3.8207	-3.8207	97.7145	.0691	-38.0931	-38.0931	87.9327
	.0724	-69.7675	-69.7675	76.1760	.0757	-97.2751	-97.2751	62.7154
	.0790	-119.2514	-119.2514	47.9736	.0823	-134.6145	-134.6145	32.2362
	.0856	-142.6283	-142.6283	15.8966	.0889	-142.9475	-142.9475	-.5989
	.0922	-135.6416	-135.6416	-16.0858	.0955	-121.1964	-121.1964	-32.0894
	.0988	-100.4931	-100.4931	-46.3708	.1020	-74.7639	-74.7639	-59.1023
	.1053	-45.5300	-45.5300	-69.8950	.1086	-14.5202	-14.5202	-78.5609
	.1119	16.4204	16.4204	-84.8418	.1152	45.4315	45.4315	-88.5529
	.1185	70.7399	70.7399	-89.0359	.1218	90.7589	90.7589	-88.1017
	.1251	104.1787	104.1787	-84.3059	.1284	110.0438	110.0438	-77.5295
	.1317	107.8113	107.8113	-68.9259	.1350	97.3889	97.3889	-58.4442
	.1383	79.1473	79.1473	-46.4414	.1415	53.9095	53.9095	-33.4109

.1448	22.9137	22.9137	-19.7580
.1514	-49.7004	-49.7004	7.9746
.1580	-123.2262	-123.2262	31.6338
.1646	-181.1058	-181.1058	49.4634
.1712	-209.2463	-209.2463	57.6253
.1778	-199.1958	-199.1958	54.6177
.1843	-150.2528	-150.2528	40.0968
.1909	-70.0260	-70.0260	18.3343
.1975	26.7366	26.7366	-15.0890
.2041	120.8706	120.8706	-52.0166
.2107	192.5676	192.5676	-88.2188
.2173	225.4589	225.4589	-120.0117
.2238	210.1844	210.1844	-143.0988
.2304	146.6940	146.6940	-154.2045
.2370	44.7050	44.7050	-151.4610
.2436	-77.4403	-77.4403	-133.3609
.2502	-196.5663	-196.5663	-101.0744
.2568	-288.4330	-288.4330	-59.3459
.2633	-332.7629	-332.7629	-9.7836
.2699	-317.3478	-317.3478	41.7749
.2765	-240.8217	-240.8217	90.0055
.2831	-113.4528	-113.4528	129.5120
.2897	44.2599	44.2599	155.9263
.2963	204.9863	204.9863	165.8785
.3028	339.3711	339.3711	157.9102
.3094	421.3769	421.3769	132.3648
.3160	433.1770	433.1770	91.9707
.3226	368.6792	368.6792	39.9649
.3292	235.0047	235.0047	-18.5107
.3358	51.6201	51.6201	-75.8467
.3424	-152.7489	-152.7489	-126.5352
.3489	-344.8826	-344.8826	-164.2697
.3555	-492.6677	-492.6677	-184.0782
.3621	-570.5348	-570.5348	-184.4995
.3687	-563.7740	-563.7740	-162.9308
.3753	-470.9807	-470.9807	-121.3575
.3819	-304.2302	-304.2302	-63.1455
.3884	-86.9944	-86.9944	6.0512
.3950	149.7837	149.7837	79.6979
.4016	372.7268	372.7268	150.0390
.4082	551.2673	551.2673	209.7837
.4148	662.1953	662.1953	252.1311
.4214	692.7737	692.7737	271.9507
.4279	641.9746	641.9746	266.1199
.4345	519.7573	519.7573	233.9134
.4411	344.6584	344.6584	177.1956
.4477	140.2596	140.2596	100.6626
.4543	-68.7548	-68.7548	9.3523
.4609	-260.2138	-260.2138	-87.3574
.4674	-417.1505	-417.1505	-182.1380
.4740	-529.2054	-529.2054	-265.5632
.4806	-592.6677	-592.6677	-330.4677
.4872	-609.3686	-609.3686	-370.4280
.4938	-584.8448	-584.8448	-381.0937
.5004	-526.3036	-526.3036	-362.0537
.5069	-440.8933	-440.8933	-314.4428
.5135	-334.6544	-334.6544	-240.8979
.5201	-212.3112	-212.3112	-147.5119
.5267	-77.8315	-77.8315	-42.6060
.5333	64.5291	64.5291	67.6135
.5399	209.1058	209.1058	171.5433
.5464	346.5487	346.5487	263.3584

.1481	-12.2461	-12.2461	-5.8963
.1547	-87.4004	-87.4004	20.3081
.1613	-155.1012	-155.1012	41.6678
.1679	-199.5853	-199.5853	54.8304
.1745	-209.2353	-209.2353	57.6575
.1811	-179.2998	-179.2998	49.1307
.1876	-113.2703	-113.2703	29.6723
.1942	-22.5767	-22.5767	1.1100
.2008	75.4035	75.4035	-33.5918
.2074	160.6737	160.6737	-70.3701
.2140	214.6480	214.6480	-104.9780
.2206	224.0794	224.0794	-132.8445
.2271	184.0780	184.0780	-150.3447
.2337	99.5658	99.5658	-154.5183
.2403	-15.1883	-15.1883	-144.0739
.2469	-138.9360	-138.9360	-119.2120
.2535	-247.3196	-247.3196	-81.7186
.2601	-317.5332	-317.5332	-35.1747
.2666	-332.8829	-332.8829	16.1576
.2732	-286.3488	-286.3488	66.6265
.2798	-182.4200	-182.4200	111.1974
.2864	-36.7900	-36.7900	144.5896
.2930	126.0960	126.0960	163.1007
.2996	277.2385	277.2385	164.1686
.3061	388.2779	388.2779	147.2195
.3127	436.7369	436.7369	113.6343
.3193	410.3314	410.3314	66.5474
.3259	309.5355	309.5355	10.8493
.3325	147.8984	147.8984	-47.6244
.3391	-49.9762	-49.9762	-102.4220
.3456	-252.4451	-252.4451	-147.2919
.3522	-426.1284	-426.1284	-176.8954
.3588	-541.5541	-541.5541	-187.2332
.3654	-578.1461	-578.1461	-176.3731
.3720	-527.6786	-527.6786	-144.4908
.3786	-395.6117	-395.6117	-94.0104
.3851	-200.1084	-200.1084	-29.5778
.3917	31.0436	31.0436	42.8397
.3983	265.0197	265.0197	115.6944
.4049	469.2154	469.2154	181.7541
.4115	616.2486	616.2486	233.4558
.4181	687.8677	687.8677	265.1512
.4246	677.1604	677.1604	272.3380
.4312	588.7982	588.7982	253.2410
.4378	437.4163	437.4163	208.4278
.4444	244.5589	244.5589	140.8167
.4510	34.8475	34.8475	56.1263
.4576	-167.8843	-167.8843	-38.9621
.4642	-343.8067	-343.8067	-135.6598
.4707	-479.1677	-479.1677	-225.7897
.4773	-567.0069	-567.0069	-300.7557
.4839	-606.5800	-606.5800	-353.8599
.4905	-601.8256	-601.8256	-379.8171
.4971	-559.3620	-559.3620	-375.9318
.5037	-486.5470	-486.5470	-342.0395
.5102	-390.0546	-390.0546	-280.5329
.5168	-275.2409	-275.2409	-196.2550
.5234	-146.3430	-146.3430	-95.9085
.5300	-7.3270	-7.3270	12.5453
.5366	136.9746	136.9746	120.4281
.5432	279.8678	279.8678	219.5195
.5509	425.6006	425.6006	314.5384

.5553	489.8194	489.8194	395.1151
.5642	566.9317	566.9317	400.0064
.5731	570.9406	570.9406	393.7710
.5820	505.4981	505.4981	339.4601
.5909	383.3976	383.3976	246.4030
.5998	223.7846	223.7846	128.2621
.6087	48.6405	48.6405	.5938
.6176	-120.7700	-120.7700	-121.0093
.6264	-266.8546	-266.8546	-225.9607
.6353	-377.5923	-377.5923	-303.9901
.6442	-447.1693	-447.1693	-351.5826
.6531	-475.4193	-475.4193	-368.5931
.6620	-466.3721	-466.3721	-357.0460
.6709	-426.3680	-426.3680	-323.8357
.6798	-362.2351	-362.2351	-271.4690
.6887	-279.9530	-279.9530	-205.1422
.6975	-184.0634	-184.0634	-128.3295
.7064	-77.8691	-77.8691	-43.7123
.7153	35.7475	35.7475	46.2672
.7242	153.2194	153.2194	138.0589
.7331	269.3113	269.3113	229.3422
.7435	386.5628	386.5628	321.0519
.7555	472.7537	472.7537	389.0330
.7675	497.9980	497.9980	412.1785
.7795	461.9142	461.9142	386.9459
.7915	372.8169	372.8169	319.5534
.8035	245.6546	245.6546	219.0689
.8155	99.0385	99.0385	101.2384
.8275	-48.0227	-48.0227	-21.7456
.8395	-179.0631	-179.0631	-136.3220
.8515	-282.2692	-282.2692	-232.3395
.8635	-351.4616	-351.4616	-303.3217
.8755	-385.9029	-385.9029	-346.5671
.8875	-389.1316	-389.1316	-362.5920
.8995	-367.2012	-367.2012	-354.1432
.9115	-326.7974	-326.7974	-325.0746
.9235	-273.6820	-273.6820	-279.3700
.9355	-211.7943	-211.7943	-220.5250
.9475	-143.1526	-143.1526	-151.3865
.9595	-68.4867	-68.4867	-74.9145
.9715	11.6506	11.6506	7.7817
.9835	95.6652	95.6652	91.0558
.9955	178.8525	178.8525	172.5690
1.0117	267.9675	267.9675	258.0139
1.0279	319.3954	319.3954	308.9965
1.0441	329.5678	329.5678	319.0230
1.0603	301.3315	301.3315	293.3081
1.0765	242.8674	242.8674	237.7665
1.0927	165.7860	165.7860	164.0127
1.1089	82.8114	82.8114	84.1673
1.1251	5.5184	5.5184	9.3071
1.1413	-57.4592	-57.4592	-52.2421
1.1575	-101.4506	-101.4506	-95.0901
1.1737	-125.8841	-125.8841	-120.9272
1.1899	-133.6010	-133.6010	-129.0930
1.2061	-129.5817	-129.5817	-127.3853
1.2223	-119.4165	-119.4165	-118.0233
1.2385	-107.8831	-107.8831	-108.1061
1.2547	-97.9391	-97.9391	-98.0571
1.2709	-90.3201	-90.3201	-91.0368
1.2871	-83.7820	-83.7820	-84.1604
1.3033	-75.8723	-75.8723	-75.8119

.5558	537.3336	537.3336	383.8610
.5647	578.0849	578.0849	403.2534
.5736	546.2880	546.2880	372.1699
.5824	450.4431	450.4431	296.9952
.5913	306.9297	306.9297	189.5103
.6002	136.7692	136.7692	64.6417
.6131	-37.9952	-37.9952	-62.0456
.6260	-197.6236	-197.6236	-176.6471
.6389	-327.1494	-327.1494	-268.6240
.6518	-417.6550	-417.6550	-331.6836
.6647	-466.2855	-466.2855	-363.7890
.6775	-475.1929	-475.1929	-366.4317
.6894	-449.8054	-449.8054	-343.4387
.6953	-396.9131	-396.9131	-299.6526
.6942	-323.0438	-323.0438	-239.8109
.6931	-233.4809	-233.4809	-167.8653
.7040	-132.0768	-132.0768	-86.8467
.7149	-21.7948	-21.7948	.7707
.7158	94.2807	94.2807	92.3857
.7267	211.8483	211.8483	184.5293
.7375	323.3092	323.3092	271.4363
.7485	436.8836	436.8836	360.9097
.7615	493.2374	493.2374	407.0400
.7745	487.2879	487.2879	405.3212
.7875	423.1817	423.1817	357.9005
.7975	312.8781	312.8781	272.7348
.8075	173.5621	173.5621	161.9037
.8215	24.4451	24.4451	39.4551
.8335	-116.4103	-116.4103	-80.7990
.8455	-234.6670	-234.6670	-187.1464
.8575	-321.2811	-321.2811	-271.2135
.8695	-372.8863	-372.8863	-328.4445
.8815	-391.0768	-391.0768	-357.8495
.8935	-380.8875	-380.8875	-361.1990
.9055	-348.9124	-348.9124	-341.9310
.9175	-301.5346	-301.5346	-304.0677
.9295	-243.6678	-243.6678	-251.3982
.9415	-178.2534	-178.2534	-187.0851
.9535	-106.5487	-106.5487	-113.7273
.9655	-29.0400	-29.0400	-33.7837
.9775	53.3425	53.3425	49.8351
.9895	138.1030	138.1030	133.2439
1.0056	227.6397	227.6397	219.7386
1.0218	298.7712	298.7712	288.7794
1.0380	329.6032	329.6032	319.2269
1.0542	319.8453	319.8453	310.7025
1.0704	275.2064	275.2064	268.5547
1.0866	205.8568	205.8568	202.4080
1.1028	124.2608	124.2608	124.1116
1.1190	42.8299	42.8299	45.5137
1.1352	-28.1506	-28.1506	-23.5116
1.1494	-81.9555	-81.9555	-76.4351
1.1636	-116.0018	-116.0018	-110.6405
1.1818	-131.5534	-131.5534	-127.1634
1.1980	-132.7052	-132.7052	-129.7447
1.2142	-124.9352	-124.9352	-123.4744
1.2304	-113.5854	-113.5854	-113.3608
1.2466	-102.6142	-102.6142	-103.1519
1.2628	-93.8772	-93.8772	-94.6493
1.2790	-87.0526	-87.0526	-87.6286
1.2952	-80.1708	-80.1708	-80.3265
1.3114	-70.5664	-70.5664	-70.3264

1.3195	-63.9922	-63.9922	-63.6346
1.3357	-46.4544	-46.4544	-46.1185
1.3547	-23.3641	-23.3641	-23.2753
1.3766	-1.0222	-1.0222	-1.1539
1.3984	16.9234	16.9234	16.6323
1.4203	31.9309	31.9309	31.5193
1.4422	46.0377	46.0377	45.5157
1.4640	60.9073	60.9073	60.2607
1.4859	76.4145	76.4145	75.6202
1.5176	90.1159	90.1159	89.2045
1.5493	90.2967	90.2967	89.3902
1.5810	77.3549	77.3549	76.5773
1.6128	53.8016	53.8016	53.2545
1.6445	23.6981	23.6981	23.4465
1.6762	-8.1543	-8.1543	-8.0891
1.7079	-37.1014	-37.1014	-36.7413
1.7396	-59.4270	-59.4270	-58.6292
1.7713	-72.8971	-72.8971	-72.1419
1.8030	-76.9723	-76.9723	-76.1480
1.8347	-72.6708	-72.6708	-71.8603
1.8664	-62.1417	-62.1417	-61.9116
1.8981	-48.0629	-48.0629	-47.4582
1.9298	-33.0095	-33.0095	-32.5531
1.9615	-18.9335	-18.9335	-18.6305
1.9932	-6.8641	-6.8641	-6.7081
2.0250	3.1230	3.1230	3.1422
2.0567	11.6799	11.6799	11.5711
2.0884	19.7821	19.7821	19.5500
2.1201	28.2596	28.2596	27.9061
2.1518	37.1969	37.1969	36.7243
2.1978	46.1449	46.1449	45.5609
2.2437	48.4177	48.4177	47.8054
2.2897	44.0615	44.0615	43.5053
2.3357	34.1733	34.1733	33.7434
2.3817	20.6400	20.6400	20.3825
2.4277	5.7528	5.7528	5.6843
2.4736	-8.2243	-8.2243	-8.1160
2.5196	-19.4430	-19.4430	-19.1936
2.5656	-26.7465	-26.7465	-26.4063
2.6116	-29.7857	-29.7857	-29.4093
2.6575	-28.9661	-28.9661	-28.6024
2.7035	-25.2516	-25.2516	-24.9370
2.7495	-19.8792	-19.8792	-19.9342
2.7955	-14.0547	-14.0547	-13.8841
2.8414	-8.6973	-8.6973	-8.5942
2.8874	-4.2883	-4.2883	-4.2397
2.9334	-.8485	-.8485	-.8416
2.9794	1.9590	1.9590	1.9327
3.0254	4.6373	4.6373	4.5793
3.0713	7.6291	7.6291	7.5350
3.1173	11.0523	11.0523	10.9153
3.1840	14.5480	14.5480	14.3689
3.2506	15.3144	15.3144	15.1259
3.3173	13.4045	13.4045	13.2396
3.3840	9.3609	9.3609	9.2459
3.4506	4.0819	4.0819	4.0319
3.5173	-1.3751	-1.3751	-1.3580
3.5840	-6.0094	-6.0094	-5.9353
3.6506	-9.0680	-9.0680	-8.9563
3.7173	-10.1738	-10.1738	-10.0486
3.7840	-9.3685	-9.3685	-9.2532
3.8506	-7.0654	-7.0654	-6.9785

1.3276	-55.9764	-55.9764	-55.5828
1.3438	-36.2664	-36.2664	-36.0513
1.3656	-11.6001	-11.6001	-11.6301
1.3875	8.4337	8.4337	8.2157
1.4094	24.6693	24.6693	24.3149
1.4312	38.9734	38.9734	38.5071
1.4531	53.3118	53.3118	52.7303
1.4750	68.8417	68.8417	68.1237
1.5018	84.8895	84.8895	84.0242
1.5335	91.9253	91.9253	91.0001
1.5652	85.3537	85.3537	84.4971
1.5969	66.6785	66.6785	66.0055
1.6286	39.2754	39.2754	38.8706
1.6603	7.6860	7.6860	7.5930
1.6920	-23.2531	-23.2531	-23.0353
1.7237	-49.2705	-49.2705	-48.7826
1.7554	-67.3424	-67.3424	-66.6551
1.7871	-76.0781	-76.0781	-75.2774
1.8189	-75.7542	-75.7542	-74.9273
1.8506	-68.0221	-68.0221	-67.2447
1.8823	-55.3757	-55.3757	-54.7041
1.9140	-40.5166	-40.5166	-39.9845
1.9457	-25.7617	-25.7617	-25.3822
1.9774	-12.6224	-12.6224	-12.3941
2.0091	-1.6381	-1.6381	-1.5518
2.0408	7.5213	7.5213	7.4756
2.0725	15.7272	15.7272	15.5564
2.1042	23.9398	23.9398	23.6468
2.1359	32.7559	32.7559	32.3426
2.1748	42.4636	42.4636	41.9262
2.2208	48.1393	48.1393	47.5302
2.2667	47.0220	47.0220	46.4278
2.3127	39.7054	39.7054	39.2049
2.3587	27.7235	27.7235	27.3758
2.4047	13.2185	13.2185	13.0553
2.4506	-1.4787	-1.4787	-1.4556
2.4966	-14.2692	-14.2692	-14.0847
2.5426	-23.6251	-23.6251	-23.3235
2.5886	-28.7898	-28.7898	-28.4248
2.6346	-29.8081	-29.8081	-29.4325
2.6805	-27.3961	-27.3961	-27.0534
2.7265	-22.6931	-22.6931	-22.4118
2.7725	-16.9569	-16.9569	-16.7493
2.8185	-11.2764	-11.2764	-11.1409
2.8644	-6.3628	-6.3628	-6.2887
2.9104	-2.4618	-2.4618	-2.4355
2.9564	.6041	.6041	.5938
3.0024	3.2826	3.2826	3.2406
3.0483	6.0746	6.0746	5.9993
3.0943	9.3140	9.3140	9.1993
3.1506	13.1237	13.1237	12.9619
3.2173	15.2816	15.2816	15.0934
3.2840	14.6704	14.6704	14.4899
3.3506	11.5995	11.5995	11.4569
3.4173	6.8109	6.8109	6.7273
3.4840	1.3093	1.3093	1.2934
3.5506	-3.8499	-3.8499	-3.8023
3.6173	-7.7690	-7.7690	-7.6733
3.6840	-9.8721	-9.8721	-9.7505
3.7506	-9.9918	-9.9918	-9.8688
3.8173	-8.3667	-8.3667	-8.2638
3.8840	-5.5544	-5.5544	-5.4862

3.9173	-3.9289	-3.9289	-3.6806	3.9506	-2.2838	-2.2838	-2.2558
3.9840	-.7086	-.7086	-.7000	4.0173	.7177	.7177	.7088
4.0506	1.9308	1.9308	1.9069	4.0840	2.8836	2.8836	2.8481
4.1173	3.5487	3.5487	3.5050	4.1506	3.9186	3.9186	3.8704
4.1840	4.0054	4.0054	3.9562	4.2173	3.8390	3.8390	3.7918
4.2506	3.4640	3.4640	3.4214	4.2840	2.9365	2.9365	2.9005
4.3173	2.3197	2.3197	2.2913	4.3506	1.6791	1.6791	1.6585
4.3840	1.0779	1.0779	1.0647	4.4173	.5729	.5729	.5659
4.4506	.2103	.2103	.2077	4.4840	.0225	.0225	.0222
4.5173	0.0000	0.0000	-.0003				

PRINTOUT TIME INTERVALS DTP AND DTPC ADJUSTED

TS = 0.0000 TF = 5.0000 DTI = .0100 DTP = .0200 TCP = 4.9500 DTPC = .0500

PLT = 3.0000 DCGX = -0.0000 DCGY = -0.0000 DCGZ = -0.0000

ALPHA = -0.000 BETA = -0.000 GAMMA = -0.000 ALDOT = -0.000 BETDOT = -0.000 GAMDOT = -0.000

XCBDX = -0.000 XCBDY = -0.000 XCBDZ = -0.000

END INPUT TO ISCL

X-Z ACCEL.

****

INITIAL CG LOCATION IS 196.251 81.707 76.208

INERTIA TENSOR (LBM-IN2)

.369703E+06	-.333955E-22	-.333955E-22
-.333955E-22	.113018E+07	-.166977E-22
-.333955E-22	-.166977E-22	.110190E+07

SPHERE COORDINATES (XB) WITH RESPECT TO CG)

SPH.NO.	XAR	YAR	ZAR
1	-196.251	-81.707	-40.208
2	-94.251	-81.707	-40.208
3	-4.251	-81.707	-40.208
4	85.749	-81.707	-40.208
5	187.749	-81.707	-40.208
6	-196.251	98.293	-40.208
7	-94.251	98.293	-40.208
8	-4.251	98.293	-40.208
9	85.749	98.293	-40.208
10	187.749	98.293	-40.208
11	-196.251	8.293	-40.208
12	187.749	8.293	-40.208

DISPLS. IN THE NEXT TABLE ARE RELATIVE TO INITIAL LOCATIONS

ACCELERATION UNIT IS IN/SEC**2

TIME	XC ABA XP1 XP3	YC AHY YP1 YP3	ZC ABZ ZP1 ZP3	AX A11 AAP1 AAP3	AY A12 AYP1 AYP3	AZ A13 AZP1 AZP3	OX A21 XP2 XP4	OY A22 YP2 YP4	OZ A23 ZP2 ZP4	ODX A31 AXP2 AXP4	ODY A32 AYP2 AYP4	OOZ A33 AZP2 AZP4
.020	-.002	-.000	-.001	.005	.000	.168	-.000	-.000	-.000	.000	.000	-.000
	25.875	0.000	9.225	1.000	-.000	.000	.000	1.000	-.000	-.000	.000	1.000
	-.002	.000	-.001	.005	.000	.178	-.002	.000	-.001	0.000	0.000	0.000
	-.002	-.000	-.001	.001	.002	.159	-.002	-.000	-.001	0.000	0.000	0.000
.040	-.092	-.000	-.025	.188	-.000	3.429	.000	.000	-.000	.001	.002	-.000
	152.583	0.000	66.376	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-.092	.000	-.025	.185	.001	3.716	-.092	.000	-.025	0.000	0.000	0.000
	-.092	.000	-.025	.052	.059	3.163	-.092	-.000	-.025	0.000	0.000	0.000
.060	-.470	-.000	-.139	.983	-.000	15.359	.000	.000	-.000	.004	.010	-.000
	144.327	0.000	112.666	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-.470	.000	-.139	.967	.007	16.922	-.470	.000	-.139	0.000	0.000	0.000
	-.470	.000	-.140	.246	.312	13.912	-.470	-.000	-.138	0.000	0.000	0.000
.080	-1.082	-.000	-.375	2.380	-.001	36.363	.000	.001	-.000	.010	.025	-.000
	-46.476	0.000	84.821	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-1.082	.000	-.372	2.336	.021	40.687	-1.083	.001	-.372	0.000	0.000	0.000
	-1.083	.001	-.378	.449	.792	32.739	-1.080	-.001	-.370	0.000	0.000	0.000
.100	-1.593	-.000	-.661	3.686	-.003	58.078	.002	.004	-.000	.017	.041	-.000
	-140.461	0.000	-6.073	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-1.593	.000	-.650	3.614	.034	65.459	-1.598	.002	-.650	0.000	0.000	0.000
	-1.598	.002	-.671	.533	1.248	52.375	-1.588	-.002	-.644	0.000	0.000	0.000
.120	-1.868	-.000	-.854	4.436	-.007	69.750	.004	.010	-.000	.017	.044	-.000
	-1.652	0.000	-81.173	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-1.868	.000	-.826	4.361	.032	77.095	-1.881	.005	-.825	0.000	0.000	0.000
	-1.881	.005	-.879	1.124	1.281	63.900	-1.855	-.005	-.812	0.000	0.000	0.000
.140	-2.145	-.000	-.853	5.053	-.013	65.065	.008	.019	-.000	.009	.022	-.000
	108.947	0.000	-73.301	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-2.146	.000	-.799	5.019	.009	68.560	-2.171	.010	-.798	0.000	0.000	0.000
	-2.170	.010	-.903	3.407	.675	61.833	-2.121	-.010	-.772	0.000	0.000	0.000
.160	-2.577	-.000	-.681	5.871	-.019	48.964	.012	.030	-.000	-.005	-.019	.000
	-33.487	0.000	1.800	1.000	-.000	-.001	.000	1.000	.000	.001	-.000	1.000
	-2.578	.000	-.597	5.906	-.032	45.720	-2.617	.016	-.595	0.000	0.000	0.000
	-2.617	.016	-.760	7.285	-.396	52.049	-2.540	-.015	-.555	0.000	0.000	0.000
.180	-2.899	-.000	-.451	6.346	-.024	30.850	.016	.039	-.000	-.020	-.059	.000
	-205.795	0.000	56.627	1.000	-.000	-.001	.000	1.000	.000	.001	-.000	1.000
	-2.900	.000	-.339	6.448	-.076	20.704	-2.951	.021	-.337	0.000	0.000	0.000
	-2.951	.021	-.554	10.825	-1.504	40.402	-2.849	-.020	-.283	0.000	0.000	0.000
.200	-2.852	-.000	-.241	6.016	-.027	14.072	.019	.045	-.000	-.030	-.085	.000
	-82.206	0.000	20.091	1.000	-.000	-.001	.000	1.000	.000	.001	-.000	1.000
	-2.854	.000	-.116	6.160	-.106	.500	-2.912	.025	-.113	0.000	0.000	0.000
	-2.911	.025	-.356	12.474	-2.310	27.940	-2.795	-.024	-.050	0.000	0.000	0.000

TIME	XC ABX XP1 XP3	YC ABY YP1 YP3	ZC ABZ ZP1 ZP3	AX A11 AAP1 AAP3	AY A12 AYP1 AYP3	AZ A13 AZP1 AZP3	OX A21 XP2 XP4	OY A22 YP2 YP4	OZ A23 ZP2 ZP4	ODX A31 AXP2 AXP4	ODY A32 AYP2 AYP4	ODZ A33 AZP2 AZP4
.220	-2.690	-.000	-.020	5.411	-.026	-40.424	.019	.043	-.000	-.036	-.097	.000
	185.996	0.000	-84.541	1.000	-.000	-.001	.000	1.000	.000	.001	-.000	1.000
	-2.691	.000	.102	5.578	-.119	-20.556	-2.747	.025	.104	0.000	0.000	0.000
	-2.747	.025	-.132	12.823	-2.772	10.034	-2.634	-.024	.168	0.000	0.000	0.000
.240	-2.847	-.000	.317	5.277	-.021	-34.967	.017	.035	-.000	-.040	-.106	.000
	151.569	0.000	-153.701	1.000	-.000	-.001	.000	1.000	.000	.001	-.000	1.000
	-2.848	.000	.412	5.467	-.126	-51.563	-2.893	.022	.414	0.000	0.000	0.000
	-2.893	.022	.229	13.330	-3.048	-17.747	-2.802	-.022	.470	0.000	0.000	0.000
.260	-3.204	-.001	.799	5.259	-.012	-73.755	.011	.018	.000	-.042	-.111	.000
	-193.408	0.000	-102.824	1.000	.000	-.000	-.000	1.000	.000	.000	-.000	1.000
	-3.204	-.000	.845	5.474	-.128	-92.438	-3.228	.014	.846	0.000	0.000	0.000
	-3.228	.014	.758	13.699	-3.174	-56.594	-3.181	-.015	.884	0.000	0.000	0.000
.280	-3.170	-.001	1.299	4.583	-.001	-110.652	.002	-.007	.000	-.038	-.099	.000
	-316.702	0.000	42.292	1.000	.000	.000	-.000	1.000	.000	-.000	-.000	1.000
	-3.169	-.001	1.271	4.797	-.108	-126.638	-3.160	.002	1.270	0.000	0.000	0.000
	-3.160	.003	1.327	12.105	-2.864	-94.758	-3.179	-.004	1.278	0.000	0.000	0.000
.300	-2.610	-.001	1.585	3.545	.010	-124.971	-.009	-.040	.000	-.022	-.053	.000
	52.152	0.000	156.618	1.000	.000	.001	-.000	1.000	-.000	-.001	.000	1.000
	-2.609	-.002	1.461	3.690	-.050	-133.352	-2.557	-.014	1.458	0.000	0.000	0.000
	-2.558	-.013	1.703	7.530	-1.662	-116.996	-2.661	.010	1.427	0.000	0.000	0.000
.320	-2.207	-.001	1.510	3.128	.025	-109.700	-.023	-.077	.000	.007	.031	-.000
	424.020	0.000	129.142	1.000	.000	.001	-.000	1.000	-.000	-.001	.000	1.000
	-2.205	-.003	1.279	3.112	.042	-104.208	-2.105	-.032	1.274	0.000	0.000	0.000
	-2.106	-.031	1.729	.729	.588	-114.923	-2.305	.027	1.198	0.000	0.000	0.000
.340	-2.543	-.001	1.144	4.017	.043	-75.304	-.036	-.112	.000	.044	.131	-.000
	213.431	0.000	-25.721	1.000	.000	.002	-.000	1.000	-.001	-.002	.001	1.000
	-2.539	-.003	.812	3.774	.159	-53.264	-2.394	-.050	.804	0.000	0.000	0.000
	-2.395	-.048	1.457	-5.903	3.342	-96.030	-2.685	.043	.685	0.000	0.000	0.000
.360	-3.162	-.002	.725	5.500	.060	-43.162	-.045	-.137	.000	.074	.210	-.000
	-371.148	0.000	-168.351	1.000	.000	.002	-.000	1.000	-.001	-.002	.001	1.000
	-3.157	-.004	.320	5.049	.275	-8.080	-2.978	-.063	.311	0.000	0.000	0.000
	-2.980	-.061	1.107	-10.362	5.598	-76.088	-3.336	.055	.159	0.000	0.000	0.000
.380	-3.049	-.002	.457	5.528	.068	-26.909	-.049	-.147	.000	.087	.243	-.000
	-549.376	0.000	-155.575	1.000	.000	.003	-.000	1.000	-.001	-.003	.001	1.000
	-3.044	-.004	.025	4.989	.319	13.938	-2.853	-.069	.015	0.000	0.000	0.000
	-2.855	-.066	.864	-12.833	6.572	-64.745	-3.235	.060	-.151	0.000	0.000	0.000
.400	-1.991	-.001	.325	5.633	.066	-18.727	-.047	-.138	.000	.082	.230	-.000
	-30.964	0.000	23.506	1.000	.000	.002	-.000	1.000	-.001	-.002	.001	1.000
	-1.986	-.004	-.080	5.153	.272	19.064	-1.807	-.065	-.089	0.000	0.000	0.000
	-1.809	-.063	.706	-13.767	6.215	-54.743	-2.166	.057	-.248	0.000	0.000	0.000

TIME	XC ABA XP1 XP3	YC ABY YP1 YP3	ZC ABZ ZP1 ZP3	AX A11 AAP1 AAP3	AY A12 AYP1 AYP3	AZ A13 AZP1 AZP3	OX A21 XP2 XP4	OY A22 YP2 YP4	OZ A23 ZP2 ZP4	ODX A31 AXP2 AXP4	ODY A32 AYP2 AYP4	OUZ A33 AZP2 AZP4
.420	-.965	-.001	.110	1.805	.057	2.462	-.038	-.111	.000	.067	.190	-.000
	587.016	0.000	222.806	1.000	.000	.002	-.000	1.000	-.001	-.002	.001	1.000
	-.965	-.003	-.217	1.463	.200	34.233	-.820	-.054	-.224	0.000	0.000	0.000
	-.822	-.051	.417	-12.630	5.132	-27.331	-1.111	.046	-.353	0.000	0.000	0.000
.440	-1.046	-.001	-.393	2.254	.041	48.038	-.025	-.070	.000	.052	.143	-.000
	608.700	0.000	258.061	1.000	.000	.001	-.000	1.000	-.000	-.001	.000	1.000
	-1.043	-.003	-.598	2.057	.148	72.088	-.952	-.035	-.602	0.000	0.000	0.000
	-.953	-.033	-.200	-6.684	3.967	26.945	-1.135	.029	-.685	0.000	0.000	0.000
.460	-2.184	-.001	-1.138	5.577	.014	109.055	-.007	-.018	.000	.037	.091	-.000
	66.327	0.000	69.307	1.000	.000	.000	-.000	1.000	-.000	-.000	.000	1.000
	-2.183	-.002	-1.189	5.517	.099	124.566	-2.160	-.010	-1.190	0.000	0.000	0.000
	-2.161	-.009	-1.090	-1.469	2.820	95.873	-2.207	.007	-1.212	0.000	0.000	0.000
.480	-3.369	-.000	-1.792	9.462	-.027	153.135	.014	.042	.000	.015	.019	-.000
	-465.337	0.000	-216.055	1.000	.000	-.001	-.000	1.000	.000	.001	-.000	1.000
	-3.370	-.000	-1.868	9.550	.009	155.612	-3.425	.018	-1.665	0.000	0.000	0.000
	-3.425	.019	-1.908	7.915	1.117	151.125	-3.315	-.019	-1.617	0.000	0.000	0.000
.500	-3.636	-.000	-1.945	10.219	-.070	147.947	.036	.103	.000	-.024	-.092	-.000
	-602.937	0.000	-378.433	1.000	.000	-.002	.000	1.000	.001	.002	-.001	1.000
	-3.639	.001	-1.642	10.473	-.141	131.920	-3.774	.048	-1.635	0.000	0.000	0.000
	-3.774	.048	-2.229	17.104	-1.852	163.665	-3.504	-.047	-1.514	0.000	0.000	0.000
.520	-2.751	-.000	-1.426	7.042	-.098	89.543	.057	.158	-.000	-.079	-.236	.000
	-393.704	0.000	-282.967	1.000	-.000	-.003	.000	1.000	.001	.003	-.001	1.000
	-2.755	.002	-.965	7.440	-.294	49.026	-2.961	.075	-.954	0.000	0.000	0.000
	-2.902	.075	-1.857	25.039	-6.060	127.071	-2.549	-.072	-.765	0.000	0.000	0.000
.540	-1.140	.000	-.455	2.604	-.102	6.150	.071	.195	-.000	-.135	-.378	.000
	-7.052	0.000	12.755	1.000	-.000	-.003	.000	1.000	.001	.003	-.001	1.000
	-1.145	.002	.112	3.081	-.354	-56.947	-1.399	.095	.126	0.000	0.000	0.000
	-1.400	.094	-.965	31.506	-10.329	65.161	-.890	-.090	.363	0.000	0.000	0.000
.560	.427	-.000	.479	-.483	-.090	-60.101	.076	.204	-.000	-.166	-.455	.000
	409.758	0.000	304.281	1.000	-.000	-.004	.000	1.000	.001	.004	-.001	1.000
	.422	.003	1.070	.028	-.311	-135.726	.156	.101	1.084	0.000	0.000	0.000
	.155	.100	-.072	34.381	-12.805	10.492	.688	-.096	1.336	0.000	0.000	0.000
.580	1.162	-.000	.935	-1.691	-.075	-80.439	.067	.178	-.000	-.156	-.419	-.000
	575.941	0.000	400.408	1.000	-.000	-.003	.000	1.000	.001	.003	-.001	1.000
	1.177	.002	1.449	-1.146	-.252	-149.974	.945	.090	1.461	0.000	0.000	0.000
	.944	.089	.455	30.416	-12.064	-15.561	1.410	-.086	1.687	0.000	0.000	0.000
.600	.851	-.001									-.271	-.000
	396.773	0.000									-.001	1.000
	.847	.002									0.000	0.000
	.691	.062									0.000	0.000

20 computer output pages have been deleted hereafter.

TIME	XC ADX XP1 XP3	YC ADY YP1 YP3	ZC ADZ ZP1 ZP3	AX A11 AAP1 AAP3	AY A12 AYP1 AYP3	AZ A13 AZP1 AZP3	OX A21 XP2 XP4	OY A22 YP2 YP4	OZ A23 ZP2 ZP4	ODX A31 AXP2 AXP4	ODY A32 AYP2 AYP4	ODZ A33 AZP2 AZP4
4.620	.889	-.295	.533	-1.792	.619	-33.136	-.043	-.119	.093	.067	.179	-.006
	0.000	0.000	0.000	1.000	.001	.002	-.002	1.000	-.001	-.002	.001	1.000
	1.005	-.586	.187	-2.587	1.867	-3.497	1.169	-.651	.174	0.000	0.000	0.000
	.901	-.067	.853	-14.804	4.566	-60.030	.569	-.538	.038	0.000	0.000	0.000
4.640	1.416	-.299	.266	-2.862	.630	-13.751	-.028	-.081	.093	.040	.120	-.006
	0.000	0.000	0.000	1.000	.001	.001	-.002	1.000	-.000	-.001	.000	1.000
	1.531	-.588	.051	-3.514	1.865	6.910	1.645	-.633	.040	0.000	0.000	0.000
	1.378	-.050	.507	-11.393	2.562	-32.070	1.145	-.560	-.044	0.000	0.000	0.000
4.660	1.938	-.301	.024	-4.013	.633	6.411	-.009	-.033	.092	.010	.047	-.006
	0.000	0.000	0.000	1.000	.001	.001	-.001	1.000	-.000	-.001	.000	1.000
	2.050	-.588	-.078	-4.518	1.851	14.760	2.102	-.609	-.085	0.000	0.000	0.000
	1.837	-.030	.115	-7.001	.212	-1.344	1.728	-.584	-.106	0.000	0.000	0.000
4.680	2.452	-.303	-.234	-5.226	.629	25.365	.010	.018	.091	-.021	-.031	-.006
	0.000	0.000	0.000	1.000	.001	-.000	-.001	1.000	.000	.000	-.000	1.000
	2.561	-.585	-.187	-5.609	1.831	21.054	2.546	-.580	-.191	0.000	0.000	0.000
	2.285	-.010	-.281	-2.298	-2.182	29.178	2.310	-.606	-.146	0.000	0.000	0.000
4.700	2.956	-.304	-.459	-5.466	.619	41.314	.028	.008	.090	-.048	-.103	-.007
	0.000	0.000	0.000	1.000	.001	-.001	-.001	1.000	.000	.001	-.000	1.000
	3.061	-.580	-.268	-6.770	1.806	25.059	2.982	-.552	-.269	0.000	0.000	0.000
	2.726	.008	-.641	2.021	-4.317	56.246	2.880	-.624	-.164	0.000	0.000	0.000
4.720	3.447	-.304	-.630	-7.688	.606	52.015	.043	.110	.088	-.069	-.162	-.007
	0.000	0.000	0.000	1.000	.001	-.002	-.001	1.000	.001	.002	-.001	1.000
	3.549	-.572	-.316	-7.953	1.775	26.773	3.414	-.525	-.314	0.000	0.000	0.000
	3.165	.023	-.927	5.319	-5.932	76.881	3.429	-.635	-.160	0.000	0.000	0.000
4.740	3.924	-.303	-.731	-8.843	.595	58.099	.052	.139	.085	-.081	-.200	-.006
	0.000	0.000	0.000	1.000	.001	-.002	-.001	1.000	.001	.002	-.001	1.000
	4.021	-.562	-.326	-9.093	1.738	26.365	3.847	-.503	-.324	0.000	0.000	0.000
	3.607	.024	-1.111	7.103	-6.837	89.063	3.948	-.637	-.140	0.000	0.000	0.000
4.760	4.383	-.302	-.753	-9.884	.586	59.147	.055	.154	.082	-.083	-.213	-.006
	0.000	0.000	0.000	1.000	.001	-.003	-.001	1.000	.001	.003	-.001	1.000
	4.475	-.550	-.306	-10.124	1.689	24.112	4.282	-.486	-.300	0.000	0.000	0.000
	4.052	.019	-1.177	7.090	-6.936	91.726	4.431	-.629	-.105	0.000	0.000	0.000
4.780	4.822	-.299	-.697	-10.772	.580	53.708	.052	.152	.078	-.074	-.201	-.006
	0.000	0.000	0.000	1.000	.001	-.003	-.001	1.000	.001	.003	-.001	1.000
	4.909	-.536	-.250	-10.999	1.629	20.346	4.719	-.475	-.244	0.000	0.000	0.000
	4.501	.005	-1.121	5.243	-6.238	94.840	4.875	-.609	-.061	0.000	0.000	0.000
4.800	5.241	-.296	-.566	-11.484	.577	43.268	.043	.135	.074	-.057	-.166	-.005
	0.000	0.000	0.000	1.000	.001	-.002	-.001	1.000	.001	.002	-.001	1.000
	5.322	-.519	-.168	-11.693	1.554	15.415	5.154	-.470	-.163	0.000	0.000	0.000
	4.949	-.018	-.950	1.766	-4.852	89.386	5.279	-.561	-.009	0.000	0.000	0.000

TIME	XC ABA XP1 XP3	YC ABY YP1 YP3	ZC ABZ ZP1 ZP3	AX A11 AAP1 AAP3	AY A12 AYP1 AYP3	AZ A13 AZP1 AZP3	OX A21 XP2 XP4	OY A22 YP2 YP4	OZ A23 ZP2 ZP4	ODX A31 AXP2 AXP4	ODY A32 AYP2 AYP4	ODZ A33 AZP2 AZP4
4.820	5.637	-.292	-.380	-12.012	.575	28.963	.030	.105	.070	-.034	-.113	-.005
	0.000	0.000	0.000	1.000	.001	-.002	-.001	1.000	.001	.002	-.001	1.000
	5.712	-.500	-.064	-12.212	1.467	4.064	5.582	-.466	-.061	0.000	0.000	0.000
	5.393	-.047	-.685	-2.931	-2.966	47.217	5.644	-.544	.048	0.000	0.000	0.000
4.840	6.006	-.287	-.153	-12.370	.571	12.266	.014	.066	.065	-.008	-.048	-.004
	0.000	0.000	0.000	1.000	.001	-.001	-.001	1.000	.000	.001	-.000	1.000
	6.078	-.479	.053	-12.583	1.370	3.927	5.998	-.467	.054	0.000	0.000	0.000
	5.826	-.080	-.355	-8.300	-.829	20.040	5.975	-.501	.108	0.000	0.000	0.000
4.860	6.356	-.282	.093	-12.594	.564	-5.166	-.003	.023	.060	.018	.019	-.004
	0.000	0.000	0.000	1.000	.001	-.000	-.001	1.000	-.000	.000	.000	1.000
	6.419	-.456	.175	-12.845	1.266	-2.958	6.395	-.466	.173	0.000	0.000	0.000
	6.240	-.114	.005	-13.735	1.293	-6.073	6.277	-.456	.171	0.000	0.000	0.000
4.880	6.678	-.276	.332	-12.733	.553	-21.050	-.019	-.019	.054	.041	.081	-.003
	0.000	0.000	0.000	1.000	.001	.000	-.001	1.000	-.000	-.000	.000	1.000
	6.735	-.432	.293	-13.043	1.159	-9.143	6.764	-.461	.288	0.000	0.000	0.000
	6.628	-.147	.358	-18.658	3.145	-32.998	6.555	-.411	.235	0.000	0.000	0.000
4.900	6.975	-.269	.544	-12.847	.538	-35.038	-.031	-.055	.049	.058	.131	-.002
	0.000	0.000	0.000	1.000	.001	.001	-.001	1.000	-.001	-.001	.001	1.000
	7.025	-.406	.400	-13.221	1.051	-14.759	7.100	-.451	.393	0.000	0.000	0.000
	6.983	-.176	.668	-22.590	4.518	-54.877	6.817	-.368	.297	0.000	0.000	0.000
4.920	7.246	-.261	.709	-12.999	.520	-45.056	-.039	-.081	.043	.067	.162	-.002
	0.000	0.000	0.000	1.000	.001	.001	-.001	1.000	-.001	-.001	.001	1.000
	7.288	-.379	.487	-13.416	.947	-19.420	7.397	-.434	.478	0.000	0.000	0.000
	7.299	-.199	.907	-25.205	5.277	-70.394	7.066	-.330	.355	0.000	0.000	0.000
4.940	7.491	-.253	.814	-13.240	.500	-51.422	-.043	-.095	.037	.067	.174	-.001
	0.000	0.000	0.000	1.000	.000	.002	-.001	1.000	-.001	-.002	.001	1.000
	7.526	-.350	.549	-13.663	.845	-22.743	7.652	-.408	.539	0.000	0.000	0.000
	7.574	-.215	1.052	-26.352	5.370	-78.177	7.304	-.296	.405	0.000	0.000	0.000
4.960	7.710	-.244	.850	-13.607	.480	-61.917	-.041	-.095	.031	.059	.165	-.001
	0.000	0.000	0.000	1.000	.000	.002	-.000	1.000	-.001	-.002	.001	1.000
	7.736	-.320	.561	-13.988	.748	-24.383	7.862	-.375	.570	0.000	0.000	0.000
	7.804	-.223	1.094	-26.063	4.834	-77.721	7.534	-.269	.443	0.000	0.000	0.000

SUMMARY OF MAX. AND MIN. CG RELATIVE DISPLACEMENTS AND ABSOLUTE ACCELERATIONS

TIME =	3.2200	X MAX =	10.498
TIME =	3.5300	Y MAX =	.500
TIME =	1.3800	Z MAX =	8.081
TIME =	1.9100	X MIN =	-10.276
TIME =	2.3200	Y MIN =	-.506
TIME =	1.5900	Z MIN =	-5.124
TIME =	1.9800	ACX MAX =	39.113
TIME =	2.3800	ACY MAX =	1.097
TIME =	1.5600	ACZ MAX =	605.588
TIME =	1.1400	ACX MIN =	-31.586
TIME =	1.6000	ACY MIN =	-1.700
TIME =	1.3700	ACZ MIN =	-610.229

SPR NO	FREE LGTH	EXTD LGTH	DELTA L	SPR FORCE	DEL L DOT	DAMP FORCE
1	187.515	191.581	-4.066	-2524.491	.395	.607
2	187.429	191.411	-3.982	-2474.651	-.163	-1.054
3	187.354	191.262	-3.908	-2428.739	-.390	-2.571
4	186.228	191.112	-4.884	-2423.144	-.618	-4.136
5	186.123	190.943	-4.819	-2450.277	-.875	-5.967
6	187.769	191.705	-3.936	-2058.072	.434	2.191
7	187.607	191.536	-3.869	-2022.748	.176	.910
8	187.577	191.386	-3.809	-1991.584	-.052	-.272
9	186.484	191.237	-4.752	-2032.997	-.279	-1.502
10	186.360	191.067	-4.707	-2013.805	-.337	-2.955
11	187.631	191.643	-4.012	-2295.446	.265	1.510
12	186.231	191.005	-4.773	-2234.548	-.766	-4.351

SHOCK SPECTRUM INPUT

LOADING CASE X-Z

BU AND M PLATEFORM, APRIL, 1971

GENERALIZED SHOCK SPECTRUM

FOR

DAMPED AND UNDAMPED VIBRATIONS

INPUT DATA

NO OF POINTS IN TABLE	248
STARTING TIME	.0200
END TIME	4.9600
TIME INTERVAL	.0500
PERCENTAGE CRITICAL DAMPING	.0500
INITIAL DISPLACEMENT	0.0000
INITIAL VELOCITY	0.0000
NO OF CYCLES OF RESIDUAL VIBRATION	3
FACTOR FOR INTEGRATION TIME INTERVAL	5

STARTING FREQ. =	.2000
ENDING FREQ. =	100.0000
INTERVAL STEPS =	110.0

TIME TABLE

.0200	.0400	.0600	.0800	.1000	.1200	.1400	.1600	.1800
.2000	.2200	.2400	.2600	.2800	.3000	.3200	.3400	.3600

.3800	.4000	.4200	.440	.4000	.4800	.5000	.5200	.5400
.5600	.5800	.6000	.620	.6400	.6600	.6800	.7000	.7200
.7400	.7600	.7800	.800	.8200	.8400	.8600	.8800	.9000
.9200	.9400	.9600	.980	1.0000	1.0200	1.0400	1.0600	1.0800
1.1000	1.1200	1.1400	1.160	1.1800	1.2000	1.2200	1.2400	1.2600
1.2800	1.3000	1.3200	1.340	1.3600	1.3800	1.4000	1.4200	1.4400
1.4600	1.4800	1.5000	1.520	1.5400	1.5600	1.5800	1.6000	1.6200
1.6400	1.6600	1.6800	1.700	1.7200	1.7400	1.7600	1.7800	1.8000
1.8200	1.8400	1.8600	1.880	1.9000	1.9200	1.9400	1.9600	1.9800
2.0000	2.0200	2.0400	2.060	2.0800	2.1000	2.1200	2.1400	2.1600
2.1800	2.2000	2.2200	2.240	2.2600	2.2800	2.3000	2.3200	2.3400
2.3600	2.3800	2.4000	2.420	2.4400	2.4600	2.4800	2.5000	2.5200
2.5400	2.5600	2.5800	2.600	2.6200	2.6400	2.6600	2.6800	2.7000
2.7200	2.7400	2.7600	2.780	2.8000	2.8200	2.8400	2.8600	2.8800
2.9000	2.9200	2.9400	2.960	2.9800	3.0000	3.0200	3.0400	3.0600
3.0800	3.1000	3.1200	3.140	3.1600	3.1800	3.2000	3.2200	3.2400
3.2600	3.2800	3.3000	3.320	3.3400	3.3600	3.3800	3.4000	3.4200
3.4400	3.4600	3.4800	3.500	3.5200	3.5400	3.5600	3.5800	3.6000
3.6200	3.6400	3.6600	3.680	3.7000	3.7200	3.7400	3.7600	3.7800
3.8000	3.8200	3.8400	3.860	3.8800	3.9000	3.9200	3.9400	3.9600
3.9800	4.0000	4.0200	4.040	4.0600	4.0800	4.1000	4.1200	4.1400
4.1600	4.1800	4.2000	4.220	4.2400	4.2600	4.2800	4.3000	4.3200
4.3400	4.3600	4.3800	4.400	4.4200	4.4400	4.4600	4.4800	4.5000
4.5200	4.5400	4.5600	4.580	4.6000	4.6200	4.6400	4.6600	4.6800
4.7000	4.7200	4.7400	4.760	4.7800	4.8000	4.8200	4.8400	4.8600
4.8800	4.9000	4.9200	4.940	4.9600				

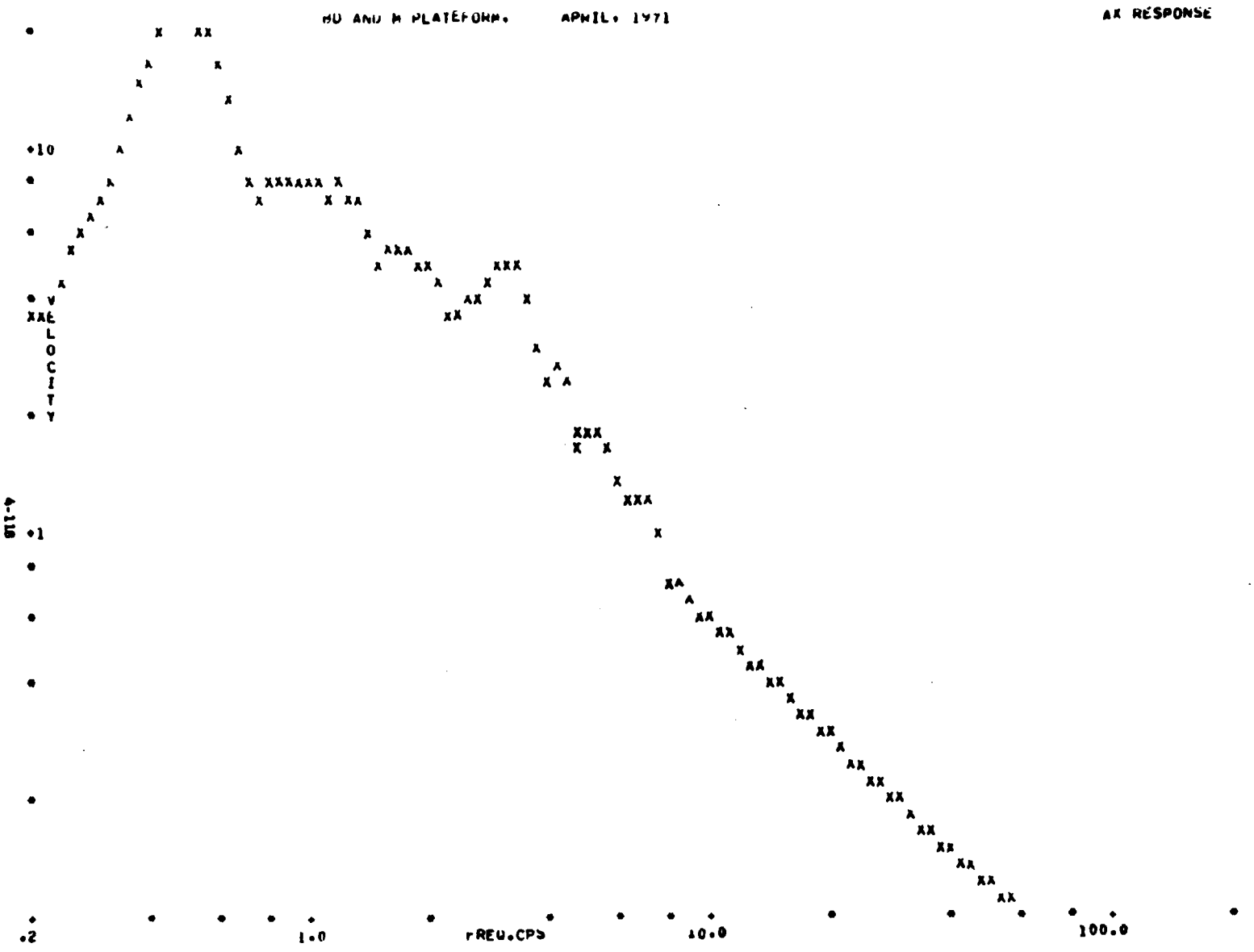
ACCL. TABLE IN IN/SEC. SQ.

.6049	.1877	.9830	2.3745	3.6001	4.4355	5.0534	5.8709	6.3455
6.0156	5.4111	5.2774	5.2592	4.5065	3.5454	3.1280	4.0171	5.5000
5.5283	3.6333	1.8053	2.2941	5.5775	9.4616	10.2187	7.0425	2.6043
-.4828	-1.6915	-1.3292	.4482	2.6197	3.3881	2.0166	-.4654	-2.5643
-3.8910	-5.3560	-7.7015	-10.0163	-10.3002	-7.5931	-3.2116	.2258	.8892
-.9794	-3.4060	-4.0918	-1.9363	2.0754	5.1579	4.3354	-1.5905	-11.2323
-21.4093	-28.8573	-31.6862	-29.8725	-24.8155	-18.4451	-12.4361	-7.7715	-4.6729
-2.7063	-1.3385	.2457	2.2502	4.3256	5.6013	5.1207	2.3006	-2.7544
-9.2351	-15.8641	-21.2615	-24.3145	-24.4099	-21.8182	-17.0568	-11.2054	-5.3474
-.3920	3.0552	4.7152	4.6021	2.9812	.3416	-2.6357	-5.1460	-6.3821
-5.6638	-2.6810	2.6056	9.7266	17.8417	25.8793	32.6800	37.2869	39.1130
38.0547	34.4837	29.1318	22.9066	16.6968	11.1905	6.8247	3.7371	1.8441
.9271	.7238	.9958	1.5623	2.3076	3.1727	4.1384	5.2015	6.3452
7.5128	8.5924	9.4234	9.8273	9.6596	8.8588	7.4946	5.7615	3.9495
2.3756	1.3073	.8997	1.1674	1.9938	3.1705	4.4470	5.5767	6.3505
6.6174	6.2990	5.3922	3.9770	2.2075	.2940	-1.5309	-3.0577	-4.1487
-4.7776	-5.0457	-5.1664	-5.4198	-6.0805	-7.3800	-9.3962	-12.0924	-15.2990
-18.7561	-22.1028	-25.2240	-27.6664	-29.3904	-30.1292	-29.9531	-28.8697	-26.9943
-24.5154	-21.6816	-18.7754	-15.0763	-13.8107	-12.1435	-11.0932	-10.5893	-10.4634
-10.4932	-10.4492	-10.1381	-9.434	-8.2968	-6.7507	-4.9084	-2.9089	-.9104
.9351	2.5194	3.7640	4.6502	5.2568	5.6563	5.4999	6.4451	7.1390
8.1908	9.6505	11.4959	13.6327	15.9074	18.1280	20.0937	21.6234	22.5816
22.8968	22.5694	21.6726	20.3345	18.7408	17.0701	15.5089	14.2090	13.2745
12.7325	12.6330	12.8546	13.3174	13.9408	14.4620	14.8486	15.0738	14.9443
14.4657	13.6428	12.5183	11.1547	9.6732	8.1390	6.5478	5.2628	4.0174
2.9139	1.9268	1.0114	.1175	-.8031	-1.7921	-2.8619	-4.0131	-5.2261
-6.4659	-7.6876	-8.8425	-9.8635	-10.7763	-11.4839	-12.0119	-12.3704	-12.5930
-12.7327	-12.8472	-12.9987	-13.2399	-13.6007				

END INPUT TO SPECTRM - AX

TIME SEC.	FREQUENCY C.P.S.	MAX.DISPLACEMENT IN.	MAX.ACCLERATION G'S
5.4000	.2000	2.9521	.0121
2.0454	.2116	2.9814	.0127
2.0454	.2234	2.0512	.0146
2.0454	.2369	2.9125	.0167
3.1816	.2507	2.9989	.0193
3.1816	.2653	3.3067	.0238
3.1816	.2807	3.9003	.0290
3.1322	.2970	3.0587	.0348
3.1322	.3143	4.0954	.0413
3.0828	.3325	4.4554	.0481
4.0708	.3519	4.8160	.0609
4.0214	.3743	5.9162	.0767
5.0446	.3940	6.9610	.0961
4.9600	.4169	6.0386	.1214
4.8612	.4411	7.9275	.1477
4.7624	.4667	7.9833	.1710
4.6636	.4939	7.9762	.1888
4.5648	.5226	7.1300	.1989
4.5154	.5529	6.9108	.2003
4.4166	.5851	5.9894	.1920
4.3178	.6191	4.9559	.1745
4.2684	.6551	3.9205	.1500
4.2190	.6931	2.9040	.1229
2.2924	.7334	1.9163	.1053
2.2430	.7761	1.9271	.1001
4.2684	.8212	1.9866	.1093
4.2190	.8689	1.5938	.1229
4.1696	.9194	1.9297	.1321
4.1202	.9728	1.9232	.1376
4.0708	1.0294	1.3137	.1422
4.0214	1.0892	1.2012	.1456
3.4286	1.1525	1.1030	.1497
3.3792	1.2195	1.0921	.1659
3.3298	1.2904	1.0047	.1709
3.3298	1.3654	.9702	.1658
3.2804	1.4448	.7182	.1532
2.1442	1.5287	.9706	.1363
2.1442	1.6176	.9628	.1505
2.1442	1.7116	.9371	.1606
2.0948	1.8111	.9019	.1682
2.0948	1.9163	.9480	.1681
3.3298	2.0277	.9117	.1730
3.2804	2.1456	.9402	.1629
1.6996	2.2703	.6586	.1362
1.6502	2.4022	.6615	.1542
1.6502	2.5419	.6740	.1842
1.6502	2.6896	.6541	.1878
2.0948	2.8454	.6551	.2111
2.0948	3.0114	.6845	.2636
2.0454	3.1804	.6499	.2592
2.0454	3.3716	.6392	.2778
2.0454	3.5676	.1824	.2372
1.9960	3.7749	.1335	.1944
1.9960	3.9943	.1074	.1752
1.9960	4.2265	.1085	.1981
1.9808	4.4721	.0880	.1797
1.9611	4.7321	.0604	.1519

1.1965	5.0071	.0581	.1437
1.1899	5.2961	.0579	.1660
1.1767	5.6061	.0548	.1761
1.1668	5.9319	.0467	.1677
1.1603	6.2707	.0373	.1503
1.1570	6.6415	.0317	.1424
1.1537	7.0275	.0298	.1505
1.1438	7.4360	.0265	.1504
1.1306	7.8862	.0205	.1297
1.9874	8.3235	.0153	.1087
1.9841	8.8094	.0137	.1082
1.9841	9.3215	.0121	.1070
1.9841	9.8633	.0106	.1058
1.9841	10.4365	.0095	.1053
1.9841	11.0431	.0084	.1050
1.9841	11.6850	.0075	.1044
1.9841	12.3642	.0067	.1040
1.9841	13.0828	.0059	.1036
1.9841	13.8432	.0053	.1032
1.9841	14.6478	.0047	.1029
1.9841	15.4992	.0042	.1027
1.9841	16.4000	.0037	.1025
1.9841	17.3533	.0033	.1022
1.9841	18.3619	.0030	.1021
1.9841	19.4291	.0026	.1019
1.9841	20.5584	.0024	.1018
1.9841	21.7533	.0021	.1016
1.9841	23.0177	.0019	.1015
1.9841	24.3535	.0017	.1014
1.9841	25.7712	.0015	.1013
1.9841	27.2690	.0013	.1012
1.9841	28.8540	.0012	.1012
1.9874	30.5311	.0011	.1011
1.9874	32.3056	.0009	.1011
1.9874	34.1833	.0008	.1011
1.9874	36.1702	.0008	.1011
1.9874	38.2725	.0007	.1011
1.9874	40.4970	.0006	.1012
1.9874	42.8508	.0005	.1015
1.9874	45.3414	.0005	.1021
1.9874	47.9767	.0004	.1031
1.9841	50.7653	.0004	.1027
1.9841	53.7159	.0003	.1026
1.9841	56.8380	.0003	.1029
1.9808	60.1416	.0003	.1023
1.9818	63.6372	.0002	.1017
1.9818	67.3360	.0002	.1016
1.9818	71.2498	.0002	.1014
1.9818	75.3910	.0002	.1013
1.9818	79.7729	.0002	.1013
1.9818	84.4096	.0001	.1012
1.9835	89.3157	.0001	.1013
1.9835	94.5070	.0001	.1014
1.9835	100.0000	.0001	.1017


BU AND M PLATEFORM. APRIL, 1971
AX RESPONSE
VELOCITY
+10
+1
.2
1.0
FREQ.CPS
10.0
100.0

GENERALIZED SHOCK SPECTRUM

FOR

DAMPED AND UNDAMPED VIBRATIONS

INPUT DATA

NO OF POINTS IN TABLE	248
STARTING TIME	.0200
END TIME	4.9600
TIME INTERVAL	.0500
PERCENTAGE CRITICAL DAMPING	.0500
INITIAL DISPLACEMENT	0.0000
INITIAL VELOCITY	0.0000
NO OF CYCLES OF RESIDUAL VIBRATION	3
FACTOR FOR INTEGRATION TIME INTERVAL	5

STARTING FREQ. =	.2000
ENDING FREQ. =	100.0000
INTERVAL STEPS =	110.0

TIME TABLE

.0200	.0400	.0600	.0800	.1000	.1200	.1400	.1600	.1800
.2000	.2200	.2400	.2600	.2800	.3000	.3200	.3400	.3600
.3800	.4000	.4200	.4400	.4600	.4800	.5000	.5200	.5400
.5600	.5800	.6000	.6200	.6400	.6600	.6800	.7000	.7200
.7400	.7600	.7800	.8000	.8200	.8400	.8600	.8800	.9000
.9200	.9400	.9600	.9800	1.0000	1.0200	1.0400	1.0600	1.0800
1.1000	1.1200	1.1400	1.1600	1.1800	1.2000	1.2200	1.2400	1.2600
1.2800	1.3000	1.3200	1.3400	1.3600	1.3800	1.4000	1.4200	1.4400
1.4600	1.4800	1.5000	1.5200	1.5400	1.5600	1.5800	1.6000	1.6200
1.6400	1.6600	1.6800	1.7000	1.7200	1.7400	1.7600	1.7800	1.8000
1.8200	1.8400	1.8600	1.8800	1.9000	1.9200	1.9400	1.9600	1.9800
2.0000	2.0200	2.0400	2.0600	2.0800	2.1000	2.1200	2.1400	2.1600
2.1800	2.2000	2.2200	2.2400	2.2600	2.2800	2.3000	2.3200	2.3400
2.3600	2.3800	2.4000	2.4200	2.4400	2.4600	2.4800	2.5000	2.5200
2.5400	2.5600	2.5800	2.6000	2.6200	2.6400	2.6600	2.6800	2.7000
2.7200	2.7400	2.7600	2.7800	2.8000	2.8200	2.8400	2.8600	2.8800
2.9000	2.9200	2.9400	2.9600	2.9800	3.0000	3.0200	3.0400	3.0600
3.0800	3.1000	3.1200	3.1400	3.1600	3.1800	3.2000	3.2200	3.2400
3.2600	3.2800	3.3000	3.3200	3.3400	3.3600	3.3800	3.4000	3.4200
3.4400	3.4600	3.4800	3.5000	3.5200	3.5400	3.5600	3.5800	3.6000

3.6200	3.6400	3.6600	3.6800	3.7000	3.7200	3.7400	3.7600	3.7800
3.8000	3.8200	3.8400	3.8600	3.8800	3.9000	3.9200	3.9400	3.9600
3.9800	4.0000	4.0200	4.0400	4.0600	4.0800	4.1000	4.1200	4.1400
4.1600	4.1800	4.2000	4.2200	4.2400	4.2600	4.2800	4.3000	4.3200
4.3400	4.3600	4.3800	4.4000	4.4200	4.4400	4.4600	4.4800	4.5000
4.5200	4.5400	4.5600	4.5800	4.6000	4.6200	4.6400	4.6600	4.6800
4.7000	4.7200	4.7400	4.7600	4.7800	4.8000	4.8200	4.8400	4.8600
4.8800	4.9000	4.9200	4.9400	4.9600				

ACCL. TABLE IN IN/SEC. SQ.

.1682	3.4287	15.3585	36.5629	58.6778	69.9496	65.0652	48.9640	30.8496
14.6715	-4.4240	-34.0666	-73.7540	-110.2523	-124.9711	-109.7003	-75.3043	-43.1617
-26.9093	-18.7268	2.4617	48.8379	109.6548	153.1352	147.9469	89.5427	6.1496
-60.1011	-80.4394	-54.6623	-7.5108	27.3098	25.6373	-16.6687	-85.3155	-155.2899
-198.9677	-193.6351	-130.1404	-17.0797	121.4439	252.2062	341.8991	366.2813	316.0754
198.2418	33.2896	-149.4661	-317.2241	-439.1081	-491.6737	-463.9117	-359.1505	-193.4707
7.5020	213.2046	393.1968	521.9310	582.4553	568.3035	483.4166	340.4903	158.2601
-41.4322	-236.3087	-405.7825	-532.5621	-603.9454	-613.3314	-561.0479	-453.9250	-304.1220
-127.4425	58.6180	235.7672	391.3944	509.7203	582.7290	605.6682	578.1138	503.7016
389.6208	245.9387	84.8127	-80.3912	-236.0930	-369.5726	-470.0582	-529.6859	-544.2408
-513.5189	-441.3024	-334.9454	-204.6624	-62.5038	78.3092	205.3131	307.1184	374.8419
402.8027	389.5070	337.0707	251.8255	143.3133	23.4010	-94.9415	-198.9859	-277.5740
-322.3374	-328.6253	-295.9927	-228.2307	-132.9401	-20.6714	96.2531	205.1058	294.1528
353.9324	378.2506	364.7936	315.3021	235.2940	133.3804	20.2026	-92.4667	-193.5833
-273.4059	-324.7543	-343.6108	-329.4184	-284.9992	-216.1215	-130.7826	-38.2904	51.7557
130.4704	190.5612	227.0011	237.4273	222.2359	184.3835	128.9354	62.4295	-7.8646
-74.7051	-131.5821	-173.3039	-196.4191	-199.4454	-182.8998	-149.1375	-102.0264	-46.4999
11.9516	67.8650	116.2020	152.8637	174.9453	180.9470	170.8455	146.0505	109.2484
64.1377	15.0940	-33.2316	-76.3321	-110.2532	-131.9605	-139.6147	-132.7447	-112.2851
-80.4538	-40.6828	3.0095	46.1210	84.2923	113.5587	131.0482	134.9781	124.9857
102.1342	68.7965	28.4085	-14.8974	-56.7238	-92.8690	-119.7650	-134.8366	-136.7616
-125.5660	-102.6998	-70.6699	-32.9477	6.5000	43.6477	74.7745	96.9035	108.0663
107.4890	95.6403	74.1474	45.5922	13.2101	-19.4680	-48.9974	-72.3771	-87.3483
-92.6080	-87.9094	-74.0530	-52.7641	-26.4709	1.9327	29.4635	53.3803	71.3061
81.6389	83.5904	77.2522	63.5502	44.1102	21.0931	-3.1004	-26.0233	-45.4550
-59.5053	-67.2753	-67.9516	-61.8282	-49.7508	-33.1357	-13.7513	6.4107	25.3646
41.3139	52.8147	58.8988	59.1469	53.7083	43.2676	28.9630	12.2660	-5.1660
-21.6504	-35.6380	-45.8560	-51.4215	-51.9172				

END INPUT TC SPCTRM - AZ

TIME SEC.	FREQUENCY C.P.S.	MAX.DISPLACEMENT IN.	MAX.ACCLERATION G'S
1.6008	.2000	3.0894	.0126
1.6008	.2116	3.4397	.0144
1.6008	.2239	3.1880	.0163
1.6008	.2369	3.2349	.0186
1.6008	.2507	3.2769	.0210
1.6008	.2653	3.3128	.0238
1.6008	.2807	3.3403	.0269
1.6008	.2970	3.3569	.0303
1.6008	.3143	3.3601	.0339
1.6008	.3325	3.3471	.0379
1.6008	.3519	3.3153	.0419
1.5514	.3723	3.2691	.0463
1.5514	.3940	3.2111	.0509
1.7984	.4169	3.1665	.0566
1.7984	.4411	3.3082	.0670
1.7984	.4667	3.3553	.0791
1.7984	.4939	3.7356	.0931
1.7984	.5226	3.8945	.1087
1.7984	.5529	4.0155	.1254
1.7984	.5851	4.0821	.1428
1.7984	.6191	4.0804	.1598
1.7984	.6551	4.0032	.1755
1.7984	.6931	3.8531	.1891
1.7984	.7334	3.6469	.2004
2.5888	.7761	3.8195	.2227
2.5888	.8212	4.0143	.2766
2.5888	.8669	4.1837	.3227
2.5888	.9194	4.1487	.3583
2.5888	.9728	4.0369	.3903
2.5888	1.0294	4.0204	.4353
2.5888	1.0892	4.1912	.5080
2.5888	1.1525	4.4491	.6038
1.7984	1.2195	4.6995	.7141
1.7984	1.2904	4.9013	.8338
2.7864	1.3654	5.3189	1.0131
2.7864	1.4448	5.5466	1.1829
1.7984	1.5287	5.9224	1.2947
1.7984	1.6176	5.9362	1.5869
1.9960	1.7116	6.7507	2.0804
1.9960	1.8111	8.2537	2.7660
1.9960	1.9163	9.1628	3.4379
2.1936	2.0277	9.9981	3.9901
1.9465	2.1456	10.0973	4.7442
2.1442	2.2703	10.9124	5.7165
2.5394	2.4022	11.2650	6.6419
2.6876	2.5419	12.0707	7.9683
2.6382	2.6896	11.9205	8.1452
1.8478	2.8459	[illegible]	8.3511
1.6512	3.0114	[illegible]	7.4720
1.600[illegible]	3.1804	5.8976	7.1553
1.60[illegible]	3.3716	5.9013	6.5055
1.4032	3.5676	4.9017	5.8018
1.4032	3.7749	3.7827	5.5073
1.4032	3.9943	2.9124	4.7474
[illegible]	4.2265	2.5608	4.6737
1.1866	4.4721	2.0373	4.1630
[illegible]	4.7[illegible]	[illegible].5299	3.5302

1.0350	5.0071	1.6089	3.2504
1.0219	5.2901	1.0153	2.9124
1.0087	5.6001	.7572	2.4313
.8867	5.9319	.5097	2.1919
1.1849	6.2707	.3509	2.2175
1.3778	6.6415	.5447	2.0042
1.3640	7.0275	.3574	1.8033
1.1965	7.4300	.3249	1.8353
1.3712	7.8032	.2848	1.8264
1.3778	8.3235	.2405	1.7029
1.3745	8.8094	.2207	1.7503
1.3745	9.3215	.1926	1.7100
1.3745	9.8633	.1705	1.6977
1.3745	10.4385	.1513	1.6837
1.3745	11.0931	.1392	1.6725
1.3745	11.6830	.1193	1.6636
1.3745	12.3092	.1039	1.6542
1.3745	13.0628	.0941	1.6460
1.3745	13.8432	.0837	1.6394
1.3745	14.6978	.0745	1.6334
1.3745	15.4942	.0653	1.6276
1.3745	16.4090	.0591	1.6228
1.3745	17.3533	.0526	1.6185
1.3745	18.3619	.0469	1.6148
1.3745	19.4291	.0419	1.6114
1.3745	20.5584	.0372	1.6084
1.3712	21.7533	.0332	1.6058
1.3712	23.0177	.0296	1.6037
1.3712	24.3595	.0264	1.6019
1.3712	25.7712	.0236	1.6004
1.3712	27.2690	.0210	1.5991
1.3712	28.8540	.0188	1.5981
1.3712	30.5341	.0168	1.5975
1.3712	32.3056	.0150	1.5970
1.3712	34.1853	.0134	1.5969
1.3712	36.1702	.0120	1.5973
1.3712	38.2725	.0107	1.5981
1.3712	40.4970	.0095	1.5999
1.3712	42.8508	.0085	1.6025
1.3679	45.3414	.0077	1.6086
1.3679	47.9707	.0069	1.6313
1.3843	50.7653	.0061	1.6121
1.3843	53.7159	.0055	1.6092
1.3811	56.8330	.0049	1.6212
1.3811	60.1946	.0043	1.6055
1.3790	63.6372	.0039	1.5974
1.3790	67.3360	.0034	1.5944
1.3790	71.2498	.0031	1.5920
1.3773	75.3940	.0027	1.5907
1.3773	79.7729	.0024	1.5899
1.3773	84.4096	.0022	1.5892
1.3757	89.3157	.0020	1.5894
1.75	94.5070	.0017	1.5907
[illegible]	100.0890	.0015	1.5940

SU AND M PLATEFORM.
APRIL, 1971
AZ RESPONSE
+10
+1
VELOCITY
40.0
100.0

Y-Z ACCEL.
****

INITIAL CG LOCATION IS 196.251 81.707 76.208

INERTIA TENSOR (LBM-IN2)

.309703E+06	-.333955E-22	-.333955E-22
-.333955E-22	.113018E+07	-.166977E-22
-.333955E-22	-.166977E-22	.113018E+07

AH COORDINATES

SPH.NO.	XAH	YAH	ZAH
1	-196.251	-81.707	-40.208
2	-94.251	-81.707	-40.208
3	-4.251	-81.707	-40.208
4	85.749	-81.707	-40.208
5	187.749	-81.707	-40.208
6	-196.251	98.293	-40.208
7	-94.251	98.293	-40.208
8	-4.251	98.293	-40.208
9	85.749	98.293	-40.208
10	187.749	98.293	-40.208
11	-196.251	8.293	-40.208
12	187.749	8.293	-40.208

ISPLS. IN THE NEXT TABLE : RELATIVE TO INITIAL LOCATIONS

ACCELERATION UNIT IN IN/SEC**2

TIME	XC ABA XP1 XP3	YC ABY YP1 YP3	ZC ABZ ZP1 ZP3	AX A11 AAP1 AAP3	AY A12 AYP1 AYP3	AZ A13 AZP1 AZP3	OX A21 XP2 XP4	OY A22 YP2 YP4	OZ A23 ZP2 ZP4	OOX A31 AXP2 AXP4	OOY A32 AYP2 AYP4	OOZ A33 AZP2 AZP4
.020	-.000	-.002	-.001	.000	.004	.168	-.000	-.000	-.000	.000	.000	-.000
	0.000	25.875	9.225	1.000	-.000	.000	.000	1.000	-.000	-.000	.000	1.000
	.000	-.002	-.001	-.000	.004	.177	.000	-.002	-.001	0.000	0.000	0.000
	-.000	-.002	-.001	-.005	.009	.161	.000	-.002	-.001	0.000	0.000	0.000
.040	.000	-.067	-.025	.000	.135	3.426	.000	.000	-.000	.002	.002	-.000
	0.000	152.583	66.376	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-.000	-.067	-.025	-.004	.139	3.122	-.000	-.067	-.025	0.000	0.000	0.000
	-.000	-.067	-.025	-.176	.282	3.180	.000	-.067	-.025	0.000	0.000	0.000
.060	.000	-.325	-.139	.000	.678	15.917	.000	.000	-.000	.010	.012	-.000
	0.000	144.327	112.686	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-.000	-.325	-.139	-.022	.699	16.938	-.000	-.324	-.139	0.000	0.000	0.000
	-.000	-.324	-.140	-.935	1.414	13.746	.000	-.325	-.138	0.000	0.000	0.000
.080	.000	-.735	-.375	.002	1.615	36.394	.001	.001	-.000	.023	.031	-.000
	0.000	-46.476	84.821	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-.000	-.735	-.372	-.060	1.677	40.950	-.002	-.734	-.372	0.000	0.000	0.000
	-.002	-.734	-.378	-2.362	3.331	32.732	.002	-.737	-.368	0.000	0.000	0.000
.100	.000	-1.077	-.661	.009	2.480	58.376	.004	.005	-.000	.033	.049	-.000
	0.000	-140.461	-6.073	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-.000	-1.077	-.650	-.096	2.591	45.324	-.006	-1.072	-.650	0.000	0.000	0.000
	-.006	-1.072	-.671	-3.708	4.939	52.298	.006	-1.082	-.637	0.000	0.000	0.000
.120	.000	-1.265	-.855	.020	2.976	69.379	.009	.012	-.000	.032	.050	-.000
	0.000	-1.662	-81.173	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-.000	-1.264	-.826	-.089	3.095	76.853	-.016	-1.253	-.826	0.000	0.000	0.000
	-.016	-1.253	-.879	-3.783	3.339	63.153	.015	-1.276	-.797	0.000	0.000	0.000
.140	.000	-1.459	-.855	.037	3.386	64.394	.016	.023	-.000	.019	.026	-.000
	0.000	108.947	-73.301	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-.001	-1.458	-.800	-.019	3.459	68.142	-.030	-1.437	-.799	0.000	0.000	0.000
	-.030	-1.438	-.903	-1.941	4.832	61.957	.029	-1.480	-.745	0.000	0.000	0.000
.160	.000	-1.756	-.685	.056	3.922	48.341	.025	.036	-.000	.001	-.016	.000
	0.000	-33.487	1.800	1.000	-.000	-.001	.000	1.000	.000	.001	-.000	1.000
	-.001	-1.755	-.599	.098	3.894	45.074	-.048	-1.722	-.598	0.000	0.000	0.000
	-.047	-1.723	-.761	1.289	3.997	51.384	.046	-1.786	-.513	0.000	0.000	0.000
.180	.000	-1.976	-.457	.072	4.226	30.241	.034	.048	-.000	-.021	-.060	.001
	0.000	-205.795	56.027	1.000	-.000	-.001	.000	1.000	.001	.001	-.001	1.000
	-.001	-1.975	-.343	.218	4.070	20.197	-.063	-1.930	-.341	0.000	0.000	0.000
	-.063	-1.931	-.356	4.592	2.710	39.049	.062	-2.019	-.226	0.000	0.000	0.000
.200	.001	-1.955	-.251	.079	4.013	14.373	.042	.055	-.000	-.043	-.091	.001
	0.000	-82.236	20.091	1.000	-.000	-.001	.000	1.000	.001	.001	-.001	1.000
	-.001	-1.953	-.122	.298	3.759	.034	-.073	-1.896	-.121	0.000	0.000	0.000
	-.072	-1.900	-.362	0.933	.890	27.996	.072	-2.007	.020	0.000	0.000	0.000

TIME	XC ABA XP1 XP3	YC ABY YP1 YP3	ZC ABZ ZP1 ZP3	AX A11 AAP1 AAP3	AY A12 AYP1 AYP3	AZ A13 AZP1 AZP3	OX A21 XP2 XP4	OY A22 YP2 YP4	OZ A23 ZP2 ZP4	ODX A31 AXP2 AXP4	ODY A32 AYP2 AYP4	ODZ A33 AZP2 AZP4
.220	.001	-1.555	-.033	.075	3.645	-4.394	.046	.056	-.000	-.060	-.108	.001
	0.000	185.996	-84.341	1.000	-.000	-.001	.000	1.000	.001	.001	-.001	1.000
	-.001	-1.863	.092	.332	3.339	-20.734	-.073	-1.802	.093	0.000	0.000	0.000
	-.073	-1.804	-.138	8.211	-.699	10.316	.073	-1.923	.248	0.000	0.000	0.000
.240	.002	-1.942	.299	.059	3.603	-33.910	.046	.048	-.000	-.067	-.118	.001
	0.000	151.569	-153.701	1.000	-.000	-.001	.000	1.000	.001	.001	-.001	1.000
	.001	-1.940	.398	.353	3.249	-51.003	-.062	-1.930	.399	0.000	0.000	0.000
	-.062	-1.931	.220	3.934	-1.279	-18.039	.064	-2.050	.553	0.000	0.000	0.000
.260	.003	-2.245	.778	.032	3.629	-73.494	.041	.032	.000	-.068	-.123	.001
	0.000	-193.403	-102.824	1.000	.000	-.001	-.000	1.000	.001	.001	-.001	1.000
	.002	-2.246	.828	.366	3.229	-92.025	-.039	-2.192	.827	0.000	0.000	0.000
	-.039	-2.141	.746	9.231	-1.290	-56.812	.043	-2.299	.964	0.000	0.000	0.000
.280	.004	-2.237	1.274	.000	3.216	-109.526	.030	.006	.000	-.063	-.110	.001
	0.000	-316.702	42.292	1.000	.000	-.000	-.000	1.000	.001	.000	-.001	1.000
	.004	-2.237	1.250	.322	2.853	-125.980	-.003	-2.196	1.247	0.000	0.000	0.000
	-.005	-2.195	1.310	6.234	-1.353	-94.760	.010	-2.277	1.349	0.000	0.000	0.000
.300	.005	-1.885	1.558	-.034	2.586	-123.941	.015	-.029	.001	-.044	-.062	.000
	0.000	52.152	156.618	1.000	.000	.001	-.000	1.000	.000	-.001	-.000	1.000
	.007	-1.888	1.437	.167	2.390	-132.192	.044	-1.868	1.433	0.000	0.000	0.000
	.041	-1.862	1.683	4.588	-.671	-116.213	-.034	-1.907	1.483	0.000	0.000	0.000
.320	.005	-1.650	1.483	-.078	2.414	-108.157	-.004	-.068	.001	-.004	.027	-.000
	0.000	424.020	129.142	1.000	.000	.001	-.000	1.000	-.000	-.001	.000	1.000
	.009	-1.655	1.254	-.104	2.458	-102.569	.098	-1.660	1.247	0.000	0.000	0.000
	.094	-1.650	1.707	-2.108	2.021	-113.746	-.084	-1.650	1.234	0.000	0.000	0.000
.340	.006	-1.907	1.118	-.132	3.148	-74.024	-.023	-.106	.002	.051	.134	-.001
	0.000	213.431	-25.721	1.000	.000	.002	-.000	1.000	-.000	-.002	.000	1.000
	.012	-1.914	.788	-.481	3.517	-51.844	.150	-1.944	.779	0.000	0.000	0.000
	.143	-1.932	1.434	-10.204	6.756	-94.711	-.132	-1.884	.702	0.000	0.000	0.000
.360	.006	-2.341	.702	-.180	4.259	-42.324	-.039	-.134	.002	.101	.222	-.003
	0.000	-371.148	-168.351	1.000	.000	.002	-.000	1.000	-.001	-.002	.001	1.000
	.014	-2.349	.299	-.850	4.997	-7.088	.188	-2.400	.289	0.000	0.000	0.000
	.180	-2.385	1.084	-16.723	11.423	-74.752	-.167	-2.299	.159	0.000	0.000	0.000
.380	.007	-2.279	.438	-.204	4.349	-26.109	-.047	-.145	.002	.121	.257	-.003
	0.000	-549.376	-155.575	1.000	.000	.003	-.000	1.000	-.001	-.003	.001	1.000
	.015	-2.288	.009	-.991	5.195	14.517	.203	-2.350	-.002	0.000	0.000	0.000
	.195	-2.334	.844	-14.401	12.936	-43.417	-.181	-2.228	-.159	0.000	0.000	0.000
.400	.006	-1.597	.312	-.196	3.131	-17.906	-.046	-.137	.002	.106	.239	-.002
	0.000	-30.984	23.508	1.000	.000	.002	-.000	1.000	-.001	-.002	.001	1.000
	.014	-1.605	-.091	-.842	3.740	20.355	.192	-1.665	-.101	0.000	0.000	0.000
	.184	-1.650	.691	-16.143	10.812	-53.211	-.171	-1.546	-.254	0.000	0.000	0.000

TIME	XC ABX XP1 XP3	YC ABY YP1 YP3	ZC ABZ ZP1 ZP3	AX A11 AXP1 AXP3	AY A12 AYP1 AYP3	AZ A13 AZP1 AZP3	OX A21 XP2 XP4	OY A22 YP2 YP4	OZ A23 ZP2 ZP4	ODX A31 AXP2 AXP4	ODY A32 AYP2 AYP4	OUZ A33 AZP2 AZP4
.420	.006	-.955	.103	-.168	1.989	2.948	-.036	-.110	.002	.080	.193	-.001
	0.000	587.016	222.800	1.000	.000	.002	-.000	1.000	-.001	-.002	.001	1.000
	.012	-.963	-.221	-.593	2.341	34.202	.155	-1.010	-.229	0.000	0.000	0.000
	.148	-.997	.409	-14.741	7.836	-26.234	-.137	-.915	-.351	0.000	0.000	0.000
.440	.004	-1.053	-.392	-.118	2.414	48.904	-.021	-.068	.002	.064	.145	-.001
	0.000	608.700	258.061	1.000	.000	.001	-.000	1.000	-.000	-.001	.000	1.000
	.009	-1.059	-.396	-.385	2.699	71.906	.098	-1.066	-.601	0.000	0.000	0.000
	.092	-1.075	-.200	-11.152	7.129	27.148	-.085	-1.032	-.671	0.000	0.000	0.000
.460	.003	-1.851	-1.131	-.035	4.743	108.478	-.000	-.015	.001	.064	.100	-.001
	0.000	66.327	69.307	1.000	.000	.000	-.000	1.000	-.000	-.000	.000	1.000
	.005	-1.855	-1.182	-.187	5.054	122.957	.025	-1.855	-1.183	0.000	0.000	0.000
	.021	-1.847	-1.081	-7.662	9.411	95.760	-.018	-1.854	-1.184	0.000	0.000	0.000
.480	.002	-2.668	-1.780	.085	7.348	150.942	.025	.046	.001	.054	.034	-.001
	0.000	-465.337	-216.055	1.000	.000	-.001	-.000	1.000	.000	.001	-.000	1.000
	.001	-2.669	-1.057	.107	7.543	153.179	-.059	-2.636	-1.655	0.000	0.000	0.000
	-.061	-2.632	-1.890	-2.547	11.370	150.102	.060	-2.702	-1.570	0.000	0.000	0.000
.500	.001	-2.867	-1.931	.211	7.758	145.578	.055	.110	.000	.003	-.081	.001
	0.000	-602.937	-378.433	1.000	.000	-.002	.000	1.000	.001	.002	-.001	1.000
	-.002	-2.865	-1.832	.524	7.539	159.449	-.146	-2.794	-1.626	0.000	0.000	0.000
	-.146	-2.793	-2.203	6.206	8.174	161.937	.141	-2.937	-1.442	0.000	0.000	0.000
.520	-.000	-2.299	-1.412	.240	5.490	87.646	.085	.168	-.000	-.092	-.242	.003
	0.000	-393.704	-282.967	1.000	-.000	-.003	.000	1.000	.001	.003	-.001	1.000
	-.005	-2.295	-.957	.897	4.788	47.930	-.224	-2.184	-.948	0.000	0.000	0.000
	-.224	-2.187	-1.826	16.427	-.944	125.084	.216	-2.405	-.665	0.000	0.000	0.000
.540	-.001	-1.253	-.445	.299	2.395	5.400	.108	.208	-.001	-.190	-.400	.003
	0.000	-7.052	12.755	1.000	-.000	-.004	.000	1.000	.002	.004	-.002	1.000
	-.007	-1.248	.114	1.006	1.591	-57.874	-.278	-1.107	.125	0.000	0.000	0.000
	-.277	-1.112	-.951	30.656	-11.597	62.057	.267	-1.389	.486	0.000	0.000	0.000
.560	-.000	-.249	.485	.261	.284	-40.924	.117	.218	-.001	-.247	-.487	.001
	0.000	409.758	304.281	1.000	-.000	-.004	.000	1.000	.002	.004	-.002	1.000
	-.007	-.243	1.065	.892	-.219	-136.293	-.291	-.090	1.077	0.000	0.000	0.000
	-.290	-.096	-.039	37.480	-18.412	7.474	.281	-.396	1.468	0.000	0.000	0.000
.580	.000	.205	.935	.214	-.448	-80.913	.108	.192	-.001	-.237	-.451	-.000
	0.000	575.941	400.408	1.000	-.000	-.003	.000	1.000	.002	.003	-.002	1.000
	-.006	.211	1.437	.806	-.728	-150.037	-.255	.352	1.446	0.000	0.000	0.000
	-.253	.345	.484	34.721	-18.611	-18.376	.247	.071	1.807	0.000	0.000	0.000
.600	.002	-.065									-.292	-.000
	0.000	396.773									-.001	1.000
	-.004	-.060									0.000	0.000
	-.170	.034									0.000	0.000

20 computer output pages have been deleted hereafter.

TIME	XC ABA XP1 XP3	YC ABY YP1 YP3	ZC ABZ ZP1 ZP3	AX A11 AAP1 AAP3	AY A12 AYP1 AYP3	AZ A13 AZP1 AZP3	OX A21 XP2 XP4	OY A22 YP2 YP4	OZ A23 ZP2 ZP4	ODX A31 AXP2 AXP4	ODY A32 AYP2 AYP4	ODZ A33 AZP2 AZP4
4.620	-.020	-3.494	.012	-.088	8.502	-37.007	-.060	-.105	.288	.147	.146	-.020
	0.000	0.000	0.000	1.000	.005	.002	-.005	1.000	-.001	-.002	.001	1.000
	.301	-4.419	.336	-1.981	10.723	-20.946	.527	-4.524	.327	0.000	0.000	0.000
	-.365	-2.860	.855	-9.146	13.739	-49.874	-.658	-4.372	.136	0.000	0.000	0.000
4.640	-.100	-3.670	.362	.118	7.142	-17.313	-.037	-.059	.295	.108	.071	-.021
	0.000	0.000	0.000	1.000	.005	.001	-.005	1.000	-.001	-.001	.001	1.000
	.290	-4.620	.209	-1.627	11.318	-12.258	.397	-4.696	.202	0.000	0.000	0.000
	-.519	-2.782	.493	-3.234	11.417	-19.096	-.693	-4.603	.089	0.000	0.000	0.000
4.660	-.180	-3.837	.087	.353	7.799	3.490	-.005	-.008	.301	.056	-.009	-.021
	0.000	0.000	0.000	1.000	.005	.000	-.005	1.000	-.000	-.000	.000	1.000
	.217	-4.906	.065	-1.242	11.860	-2.996	.257	-4.841	.060	0.000	0.000	0.000
	-.678	-2.888	.103	3.154	8.139	11.286	-.718	-4.831	.054	0.000	0.000	0.000
4.680	-.259	-3.994	-.184	.608	8.438	23.367	.032	.043	.305	-.002	-.086	-.020
	0.000	0.000	0.000	1.000	.005	-.001	-.005	1.000	.001	.001	-.001	1.000
	.142	-4.975	-.084	-.859	12.343	6.700	.116	-4.964	-.087	0.000	0.000	0.000
	-.833	-2.982	-.275	7.241	4.395	39.018	-.739	-5.048	.029	0.000	0.000	0.000
4.700	-.337	-4.139	-.426	.869	9.023	40.427	.068	.088	.307	-.059	-.149	-.020
	0.000	0.000	0.000	1.000	.005	-.002	-.005	1.000	.001	.002	-.001	1.000
	.067	-5.128	-.224	-.501	12.761	16.096	-.017	-5.070	-.226	0.000	0.000	0.000
	-.976	-3.071	-.602	14.310	.716	43.956	-.764	-5.248	.011	0.000	0.000	0.000
4.720	-.414	-4.273	-.615	1.115	9.521	53.102	.100	.122	.308	-.108	-.192	-.019
	0.000	0.000	0.000	1.000	.005	-.002	-.005	1.000	.002	.002	-.002	1.000
	-.009	-5.264	-.343	-.188	13.112	24.906	-.137	-5.165	-.346	0.000	0.000	0.000
	-1.099	-3.158	-.846	17.798	-2.394	78.848	-.799	-5.426	-.001	0.000	0.000	0.000
4.740	-.488	-4.393	-.734	1.332	9.906	60.280	.124	.141	.308	-.141	-.210	-.019
	0.000	0.000	0.000	1.000	.005	-.002	-.005	1.000	.002	.002	-.002	1.000
	-.085	-5.383	-.431	.064	13.395	30.945	-.237	-5.252	-.434	0.000	0.000	0.000
	-1.198	-3.249	-.985	19.369	-4.529	85.921	-.848	-5.575	-.009	0.000	0.000	0.000
4.760	-.560	-4.500	-.772	1.504	10.160	61.906	.137	.144	.306	-.157	-.202	-.019
	0.000	0.000	0.000	1.000	.005	-.002	-.005	1.000	.002	.003	-.002	1.000
	-.159	-5.483	-.479	.240	13.606	34.712	-.316	-5.335	-.482	0.000	0.000	0.000
	-1.270	-3.345	-1.010	18.948	-5.425	93.967	-.912	-5.693	-.012	0.000	0.000	0.000
4.780	-.629	-4.594	-.729	1.626	10.275	56.913	.139	.131	.303	-.152	-.172	-.019
	0.000	0.000	0.000	1.000	.005	-.002	-.005	1.000	.002	.002	-.002	1.000
	-.232	-5.565	-.480	.330	13.743	35.973	-.373	-5.414	-.485	0.000	0.000	0.000
	-1.316	-3.448	-.921	18.711	-4.987	73.917	-.991	-5.778	-.011	0.000	0.000	0.000
4.800	-.694	-4.674	-.609	1.698	10.255	46.214	.128	.105	.298	-.129	-.123	-.019
	0.000	0.000	0.000	1.000	.005	-.002	-.005	1.000	.002	.002	-.002	1.000
	-.304	-5.628	-.434	.333	13.800	32.948	-.412	-5.491	-.441	0.000	0.000	0.000
	-1.338	-3.558	-.733	18.052	-3.295	56.326	-1.081	-5.826	-.001	0.000	0.000	0.000

TIME	XC ABX XP1 XP3	YC ABY YP1 YP3	ZC ABZ ZP1 ZP3	AX A11 AAP1 AAP3	AY A12 AYP1 AYP3	AZ A13 AZP1 AZP3	OX A21 AP2 AP4	OY A22 YP2 YP4	OZ A23 ZP2 ZP4	ODX A31 AXP2 AXP4	ODY A32 AYP2 AYP4	ODZ A33 AZP2 AZP4
4.820	-.755	-4.740	-.427	1.728	10.113	31.025	.108	.070	.291	-.091	-.063	-.020
	0.000	0.000	0.000	1.000	.005	-.001	-.005	1.000	.002	.001	-.002	1.000
	-.375	-5.673	-.345	.261	13.773	26.075	-.437	-5.561	-.353	0.000	0.000	0.000
	-1.341	-3.672	-.467	6.513	-.584	34.178	-1.178	-5.844	.019	0.000	0.000	0.000
4.840	-.815	-4.792	-.201	1.726	9.874	14.258	.081	.029	.284	-.043	.001	-.020
	0.000	0.000	0.000	1.000	.005	-.000	-.005	1.000	.001	.001	-.001	1.000
	-.443	-5.700	-.219	.140	13.656	17.954	-.453	-5.622	-.229	0.000	0.000	0.000
	-1.331	-3.787	-.154	3.700	2.790	9.038	-1.274	-5.834	.051	0.000	0.000	0.000
4.860	-.870	-4.831	.045	1.708	9.572	-4.140	.050	-.012	.274	.009	.060	-.020
	0.000	0.000	0.000	1.000	.004	.000	-.005	1.000	.001	-.000	-.001	1.000
	-.511	-5.708	-.068	.007	13.452	6.039	-.468	-5.670	-.079	0.000	0.000	0.000
	-1.315	-3.849	.173	-.793	6.399	-14.723	-1.365	-5.800	.097	0.000	0.000	0.000
4.880	-.922	-4.858	.267	1.686	9.248	-21.151	.019	-.040	.264	.057	.107	-.020
	0.000	0.000	0.000	1.000	.004	.001	-.004	1.000	.000	-.001	-.000	1.000
	-.577	-5.698	.092	-.095	13.167	-5.914	-.488	-5.698	.080	0.000	0.000	0.000
	-1.298	-4.002	.463	-4.461	9.800	-36.493	-1.444	-5.749	.154	0.000	0.000	0.000
4.900	-.970	-4.872	.502	1.674	6.942	-36.967	-.007	-.077	.251	.096	.139	-.019
	0.000	0.000	0.000	1.000	.004	.001	-.004	1.000	-.000	-.001	.000	1.000
	-.643	-5.670	.247	-.131	12.818	-17.239	-.518	-5.703	.235	0.000	0.000	0.000
	-1.286	-4.092	.746	-6.941	12.591	-53.659	-1.506	-5.686	.220	0.000	0.000	0.000
4.920	-1.015	-4.873	.667	1.642	8.692	-48.054	-.027	-.095	.237	.122	.153	-.018
	0.000	0.000	0.000	1.000	.004	.002	-.004	1.000	-.000	-.002	.000	1.000
	-.707	-5.625	.378	-.076	12.427	-28.204	-.560	-5.682	.367	0.000	0.000	0.000
	-1.281	-4.166	.937	-6.042	14.466	-64.782	-1.549	-5.615	.287	0.000	0.000	0.000
4.940	-1.057	-4.863	.770	1.717	8.528	-54.287	-.037	-.101	.222	.131	.147	-.016
	0.000	0.000	0.000	1.000	.004	.002	-.004	1.000	-.001	-.002	.001	1.000
	-.776	-5.563	.473	.079	12.023	-36.163	-.617	-5.631	.462	0.000	0.000	0.000
	-1.287	-4.221	1.043	-7.760	15.249	-69.107	-1.571	-5.538	.350	0.000	0.000	0.000
4.960	-1.096	-4.842	.800	1.785	8.465	-55.045	-.037	-.096	.206	.123	.126	-.015
	0.000	0.000	0.000	1.000	.003	.002	-.003	1.000	-.001	-.002	.001	1.000
	-.833	-5.486	.521	.329	11.630	-40.420	-.687	-5.552	.510	0.000	0.000	0.000
	-1.302	-4.255	1.056	-6.254	14.916	-66.589	-1.573	-5.459	.398	0.000	0.000	0.000

SUMMARY OF MAX. AND MIN. CG RELATIVE DISPLACEMENTS AND ABSOLUTE ACCELERATIONS

TIME =	2.1300	X MAX =	1.255
TIME =	1.0700	Y MAX =	6.549
TIME =	1.3600	Z MAX =	8.369
TIME =	3.1700	X MIN =	-1.174
TIME =	2.6700	Y MIN =	-7.127
TIME =	1.5900	Z MIN =	-8.367
TIME =	1.6000	ACX MAX =	4.600
TIME =	2.7600	ACY MAX =	20.163
TIME =	1.5600	ACZ MAX =	631.010
TIME =	2.0600	ACX MIN =	-3.142
TIME =	1.5600	ACY MIN =	-28.360
TIME =	1.3700	ACZ MIN =	-642.232

SPR NO	FREE LGTH	EXTD LGTH	DELTA L	SPR FORCE	DEL L DOT	DAMP FORCE
1	187.515	191.562	-4.047	-2515.006	.549	3.492
2	187.429	191.381	-3.952	-2455.785	.044	.349
3	187.354	191.222	-3.868	-2403.824	-.381	-2.509
4	186.228	191.063	-4.834	-2458.032	-.813	-5.446
5	186.123	190.983	-4.760	-2420.076	-1.301	-8.869
6	187.769	191.679	-3.910	-2044.423	.925	4.670
7	187.667	191.498	-3.831	-2003.056	.930	2.223
8	187.577	191.339	-3.762	-1966.802	-.005	-.025
9	186.484	191.180	-4.696	-2008.743	-.437	-2.354
10	186.360	191.000	-4.641	-1985.268	-.925	-5.091
11	187.631	191.621	-3.989	-2282.469	.736	4.198
12	186.231	190.942	-4.710	-2204.925	-1.114	-6.864

LOADING CASE Y-Z

BD AND M PLATEFORM, APRIL, 1971

GENERALIZED SHOCK SPECTRUM

FOR

DAMPED AND UNDAMPED VIBRATIONS

INPUT DATA

NO OF POINTS IN TABLE	248
STARTING TIME	.0200
END TIME	4.9600
TIME INTERVAL	.0500
PERCENTAGE CRITICAL DAMPING	.0500
INITIAL DISPLACEMENT	0.0000

INITIAL VELOCITY 0.0000

NO OF CYCLES OF RESIDUAL VIBRATION 3

FACTOR FOR INTEGRATION TIME INTERVAL 5

STARTING FREQ. = .2000

ENDING FREQ. = 100.0000

INTERVAL STEPS = 110.0

TIME TABLE

.0200	.0400	.0600	.0800	.1000	.1200	.1400	.1600	.1800
.2000	.2200	.2400	.2600	.2800	.3000	.3200	.3400	.3600
.3800	.4000	.4200	.4400	.4600	.4800	.5000	.5200	.5400
.5600	.5800	.6000	.6200	.6400	.6600	.6800	.7000	.7200
.7400	.7600	.7800	.8000	.8200	.8400	.8600	.8800	.9000
.9200	.9400	.9600	.9800	1.0000	1.0200	1.0400	1.0600	1.0800
1.1000	1.1200	1.1400	1.1600	1.1800	1.2000	1.2200	1.2400	1.2600
1.2800	1.3000	1.3200	1.3400	1.3600	1.3800	1.4000	1.4200	1.4400
1.4600	1.4800	1.5000	1.5200	1.5400	1.5600	1.5800	1.6000	1.6200
1.6400	1.6600	1.6800	1.7000	1.7200	1.7400	1.7600	1.7800	1.8000
1.8200	1.8400	1.8600	1.8800	1.9000	1.9200	1.9400	1.9600	1.9800
2.0000	2.0200	2.0400	2.0600	2.0800	2.1000	2.1200	2.1400	2.1600
2.1800	2.2000	2.2200	2.2400	2.2600	2.2800	2.3000	2.3200	2.3400
2.3600	2.3800	2.4000	2.4200	2.4400	2.4600	2.4800	2.5000	2.5200
2.5400	2.5600	2.5800	2.6000	2.6200	2.6400	2.6600	2.6800	2.7000
2.7200	2.7400	2.7600	2.7800	2.8000	2.8200	2.8400	2.8600	2.8800
2.9000	2.9200	2.9400	2.9600	2.9800	3.0000	3.0200	3.0400	3.0600
3.0800	3.1000	3.1200	3.1400	3.1600	3.1800	3.2000	3.2200	3.2400
3.2600	3.2800	3.3000	3.3200	3.3400	3.3600	3.3800	3.4000	3.4200
3.4400	3.4600	3.4800	3.5000	3.5200	3.5400	3.5600	3.5800	3.6000
3.6200	3.6400	3.6600	3.6800	3.7000	3.7200	3.7400	3.7600	3.7800
3.8000	3.8200	3.8400	3.8600	3.8800	3.9000	3.9200	3.9400	3.9600
3.9800	4.0000	4.0200	4.0400	4.0600	4.0800	4.1000	4.1200	4.1400
4.1600	4.1800	4.2000	4.2200	4.2400	4.2600	4.2800	4.3000	4.3200
4.3400	4.3600	4.3800	4.4000	4.4200	4.4400	4.4600	4.4800	4.5000
4.5200	4.5400	4.5600	4.5800	4.6000	4.6200	4.6400	4.6600	4.6800
4.7000	4.7200	4.7400	4.7600	4.7800	4.8000	4.8200	4.8400	4.8600
4.8800	4.9000	4.9200	4.9400	4.9600				

ACCL. TABLE IN IN/SEC. SQ.

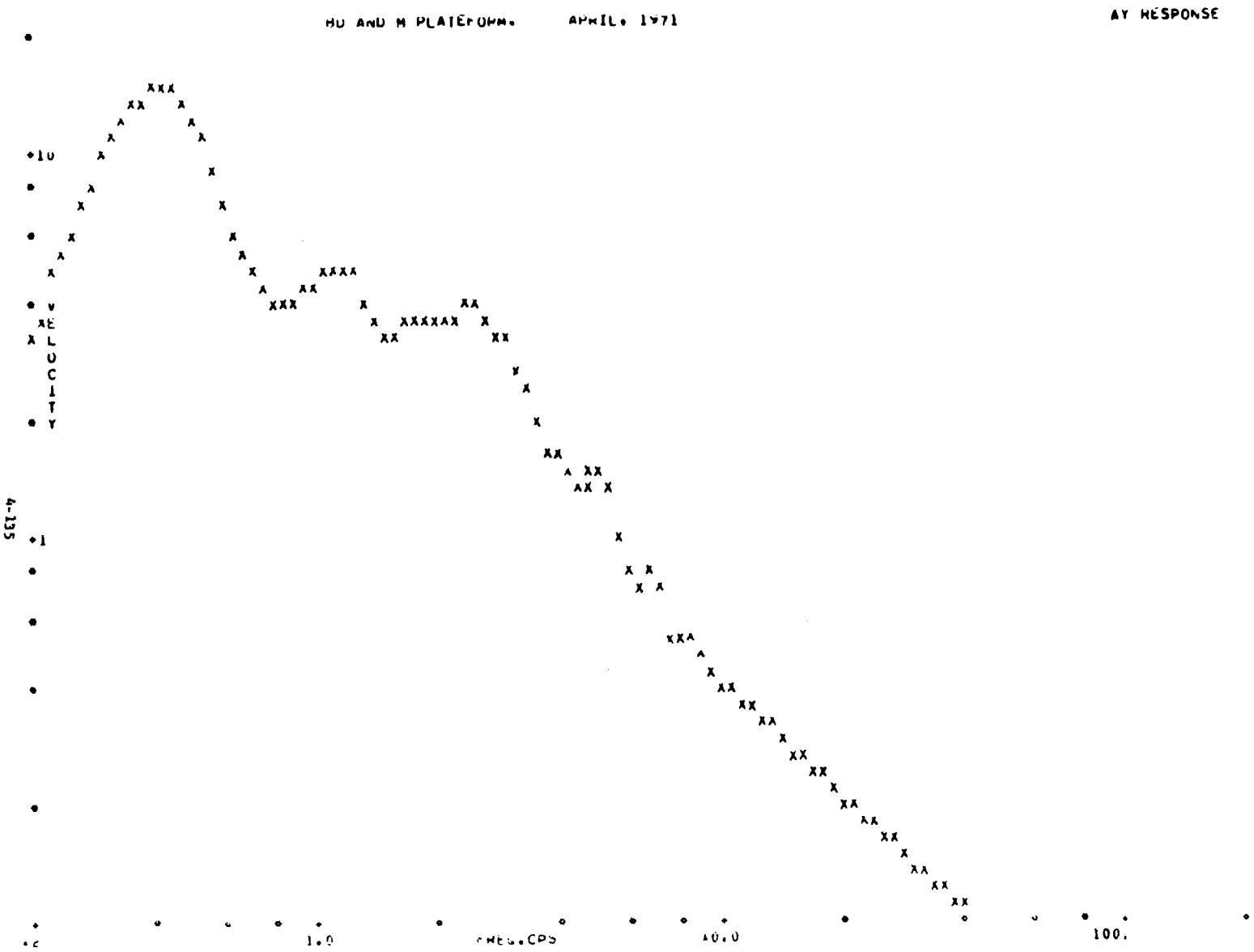
.0043	.1352	.6784	1.6146	2.4805	2.9757	3.3860	3.9222	4.2264
4.0132	3.6450	3.6026	3.6286	3.2158	2.5863	2.4135	3.1480	4.2593
4.3489	3.1314	1.9893	2.4137	4.7431	7.3484	7.7578	5.4896	2.3954
.2841	-.4485	.0156	1.5446	3.3351	4.0314	3.0583	1.1425	-.5706
-1.6386	-2.5510	-3.7928	-4.8144	-4.3936	-2.0739	1.0666	3.1814	3.1078
1.1777	-1.1065	-2.0916	-1.0123	1.4543	3.4370	3.0004	-.5635	-6.2813
-12.1482	-16.3055	-17.8961	-17.1796	-15.0603	-12.4722	-9.9966	-7.7994	-5.7866
-3.7461	-1.7262	.4051	2.4332	4.0366	4.7885	4.2778	2.2277	-1.4160

-6.4300	-12.3013	-18.2715	-23.4524	-27.0109	-28.3599	-27.2933	-24.0320	-19.1739
-13.5679	-8.1390	-3.7012	-.7930	.4287	.2082	-.8883	-2.1345	-2.8433
-2.5420	-1.0698	1.4210	4.5453	7.8006	10.7187	12.8982	14.1176	14.3164
13.5823	12.1110	10.1578	7.9906	5.8519	3.9341	2.3680	1.2218	.5094
.2039	.2568	.6182	1.2530	2.1504	3.3113	4.7385	6.4075	8.2432
10.1068	11.8002	13.0897	13.7482	13.6091	12.5952	10.7935	8.4267	5.8521
3.5054	1.8240	1.1598	1.7047	3.4958	6.1655	9.4839	12.9343	16.0495
18.4406	19.8518	20.1825	19.4811	17.9148	15.7270	13.1964	10.5921	8.1499
6.0478	4.3929	3.2135	2.4579	2.0031	1.6761	1.2860	.6640	-.3000
-1.6329	-3.2721	-5.0806	-6.8760	-8.4717	-9.7061	-10.4755	-10.7438	-10.5427
-9.9613	-9.1283	-8.1935	-7.3089	-6.6139	-6.2208	-6.2042	-6.5906	-7.3541
-8.4162	-9.6552	-10.9230	-12.0665	-12.9507	-13.4772	-13.5955	-13.3050	-12.6489
-11.7036	-10.5657	-9.3397	-8.1290	-7.0278	-6.1154	-5.4503	-5.0653	-4.9634
-5.1180	-5.4754	-5.9635	-6.5012	-7.0098	-7.4216	-7.6862	-7.7725	-7.6690
-7.3823	-6.9348	-6.3620	-5.7092	-5.0207	-4.3634	-3.7600	-3.2431	-2.8206
-2.4823	-2.2027	-1.9479	-1.6835	-1.3015	-1.0246	-.6081	-.1381	.3708
.8996	1.4272	1.9337	2.4024	2.8212	3.1851	3.4975	3.7708	4.0260
4.2898	4.5904	4.9523	5.3914	5.9143	6.5021	7.1416	7.7989	8.4381
9.0230	9.5210	9.9058	10.1590	10.2751	10.2547	10.1127	9.8740	9.5724
9.2479	8.9420	8.6924	8.5281	8.4049				

END INPUT TO SPCTRM - AY

TIME SEC.	FREQUENCY C.P.S.	MAX.DISPLACEMENT INS.	MAX.ACCLERATION G'S
2.3912	.2000	2.7761	.0113
3.6756	.2116	2.0502	.0130
3.6262	.2239	3.1548	.0162
3.6262	.2369	3.4577	.0198
3.5768	.2507	3.7492	.0241
3.5768	.2653	4.0136	.0289
3.5274	.2807	4.2483	.0342
4.8118	.2970	4.0081	.0433
4.7624	.3143	5.2857	.0533
4.6636	.3325	5.0482	.0638
4.5648	.3519	5.0649	.0742
4.4660	.3723	5.3400	.0841
5.6369	.3940	6.0033	.0952
5.4398	.4169	5.9899	.1064
5.3378	.4411	5.7557	.1144
5.1743	.4667	5.3073	.1181
5.0950	.4939	4.0552	.1160
3.9226	.5226	3.8677	.1079
3.8238	.5529	3.2857	.1026
3.7250	.5851	2.0698	.0934
3.6756	.6191	2.0733	.0812
2.5394	.6551	1.0135	.0707
2.4900	.6931	1.3640	.0670
2.4406	.7334	1.1394	.0626
2.3912	.7761	.9543	.0587
2.3418	.8212	.8101	.0558
3.7250	.8689	.7818	.0603
3.6756	.9194	.7705	.0665
3.6756	.9728	.7567	.0732
3.6262	1.0294	.7507	.0813
3.5274	1.0892	.7530	.0913
3.4780	1.1525	.7491	.1017
3.4286	1.2195	.7104	.1079
3.3792	1.2904	.6282	.1069
3.3298	1.3654	.5149	.0981
2.8358	1.4448	.4068	.0868
2.1442	1.5287	.3700	.0884
2.0948	1.6176	.3588	.0959
2.0948	1.7116	.3495	.1046
2.5888	1.8111	.3489	.1169
2.5888	1.9163	.3292	.1235
2.5394	2.0277	.3010	.1265
2.9346	2.1456	.2800	.1317
1.6996	2.2703	.2838	.1495
1.6996	2.4022	.2706	.1595
1.6502	2.5419	.2586	.1707
1.6502	2.6896	.2380	.1759
1.6502	2.8459	.1979	.1638
2.8358	3.0114	.1828	.1693
1.6008	3.1864	.1429	.1482
1.6008	3.3716	.1194	.1387
1.6008	3.5676	.0917	.1193
2.0454	3.7749	.0709	.1032
2.7894	3.9943	.0678	.1105
1.9940	4.2265	.0573	.1045
1.6119	4.4721	.0494	.1009
[illegible]	4.7321	.0483	.1104

1.5920	5.0071	.0500	.1280
1.5722	5.2901	.0479	.1373
1.5491	5.6031	.0391	.1257
1.1068	5.9319	.0286	.1027
1.1570	6.2707	.0222	.0894
1.5920	6.6415	.0188	.0849
1.5755	7.0275	.0191	.0963
1.5557	7.4300	.0168	.0948
1.1273	7.8602	.0122	.0773
1.5722	8.3205	.0113	.0799
1.5656	8.8074	.0100	.0794
1.5623	9.3215	.0088	.0781
1.5623	9.8633	.0079	.0785
1.5623	10.4365	.0068	.0760
1.5623	11.0431	.0062	.0769
1.5623	11.6850	.0054	.0759
1.5623	12.3642	.0048	.0756
1.5623	13.0828	.0043	.0754
1.5623	13.8432	.0038	.0751
1.5623	14.6478	.0034	.0748
1.5623	15.4992	.0030	.0746
1.5623	16.4000	.0027	.0744
1.5623	17.3533	.0024	.0742
1.5623	18.3619	.0021	.0741
1.5623	19.4291	.0019	.0739
1.5623	20.5584	.0017	.0738
1.5623	21.7533	.0015	.0737
1.5623	23.0177	.0014	.0736
1.5623	24.3555	.0012	.0735
1.5623	25.7712	.0011	.0734
1.5656	27.2690	.0010	.0733
1.5656	28.8540	.0009	.0733
1.5656	30.5311	.0008	.0732
1.5656	32.3056	.0007	.0732
1.5656	34.1833	.0006	.0732
1.5656	36.1702	.0005	.0731
1.5656	38.2725	.0005	.0731
1.5689	40.4970	.0004	.0732
1.5689	42.8508	.0004	.0734
1.5689	45.3414	.0004	.0739
1.5656	47.9707	.0003	.0747
1.5656	50.7653	.0003	.0744
1.5656	53.7159	.0003	.0742
1.5623	56.8360	.0002	.0747
1.5623	60.1416	.0002	.0743
1.5618	63.6372	.0002	.0738
1.5618	67.3360	.0002	.0736
1.5618	71.2498	.0001	.0735
1.5618	75.3910	.0001	.0735
1.5618	79.7769	.0001	.0734
1.5618	84.4076	.0001	.0734
1.5536	89.3157	.0001	.0734
1.5620	94.5070	.0001	.0735
1.5620	100.0000	.0001	.0737


BD AND M PLATEFORM. APRIL, 1971
AY RESPONSE
+10
+1
VELOCITY
1.0
FREQ.CPS
10.0
100.

GENERALIZED SHOCK SPECTRUM

FOR

DAMPED AND UNDAMPED VIBRATIONS

INPUT DATA

NO OF POINTS IN TABLE	248
STARTING TIME	.0200
END TIME	4.9600
TIME INTERVAL	.0500
PERCENTAGE CRITICAL DAMPING	.0500
INITIAL DISPLACEMENT	0.0000
INITIAL VELOCITY	0.0000
NO OF CYCLES OF RESIDUAL VIBRATION	3
FACTOR FOR INTEGRATION TIME INTERVAL	5

STARTING FREQ. =	.2000
ENDING FREQ. =	100.0000
INTERVAL STEPS =	110.0

TIME TABLE

.0200	.0400	.0600	.0800	.1000	.1200	.1400	.1600	.1800
.2000	.2200	.2400	.2600	.2800	.3000	.3200	.3400	.3600
.3800	.4000	.4200	.4400	.4600	.4800	.5000	.5200	.5400
.5600	.5800	.6000	.6200	.6400	.6600	.6800	.7000	.7200
.7400	.7600	.7800	.8000	.8200	.8400	.8600	.8800	.9000
.9200	.9400	.9600	.9800	1.0000	1.0200	1.0400	1.0600	1.0800
1.1000	1.1200	1.1400	1.1600	1.1800	1.2000	1.2200	1.2400	1.2600
1.2800	1.3000	1.3200	1.3400	1.3600	1.3800	1.4000	1.4200	1.4400
1.4600	1.4800	1.5000	1.5200	1.5400	1.5600	1.5800	1.6000	1.6200
1.6400	1.6600	1.6800	1.7000	1.7200	1.7400	1.7600	1.7800	1.8000
1.8200	1.8400	1.8600	1.8800	1.9000	1.9200	1.9400	1.9600	1.9800
2.0000	2.0200	2.0400	2.0600	2.0800	2.1000	2.1200	2.1400	2.1600
2.1800	2.2000	2.2200	2.2400	2.2600	2.2800	2.3000	2.3200	2.3400
2.3600	2.3800	2.4000	2.4200	2.4400	2.4600	2.4800	2.5000	2.5200
2.5400	2.5600	2.5800	2.6000	2.6200	2.6400	2.6600	2.6800	2.7000
2.7200	2.7400	2.7600	2.7800	2.8000	2.8200	2.8400	2.8600	2.8800
2.9000	2.9200	2.9400	2.9600	2.9800	3.0000	3.0200	3.0400	3.0600
3.0800	3.1000	3.1200	3.1400	3.1600	3.1800	3.2000	3.2200	3.2400
3.2600	3.2800	3.3000	3.3200	3.3400	3.3600	3.3800	3.4000	3.4200
3.4400	3.4600	3.4800	3.5000	3.5200	3.5400	3.5600	3.5800	3.6000

3.6200	3.6400	3.6600	3.680	3.7000	3.7200	3.7400	3.7600	3.7800
3.8000	3.8200	3.8400	3.860	3.8800	3.9000	3.9200	3.9400	3.9600
3.9800	4.0000	4.0200	4.040	4.0600	4.0800	4.1000	4.1200	4.1400
4.1600	4.1800	4.2000	4.220	4.2400	4.2600	4.2800	4.3000	4.3200
4.3400	4.3600	4.3800	4.400	4.4200	4.4400	4.4600	4.4800	4.5000
4.5200	4.5400	4.5600	4.580	4.6000	4.6200	4.6400	4.6600	4.6800
4.7000	4.7200	4.7400	4.760	4.7800	4.8000	4.8200	4.8400	4.8600
4.8800	4.9000	4.9200	4.940	4.9600				

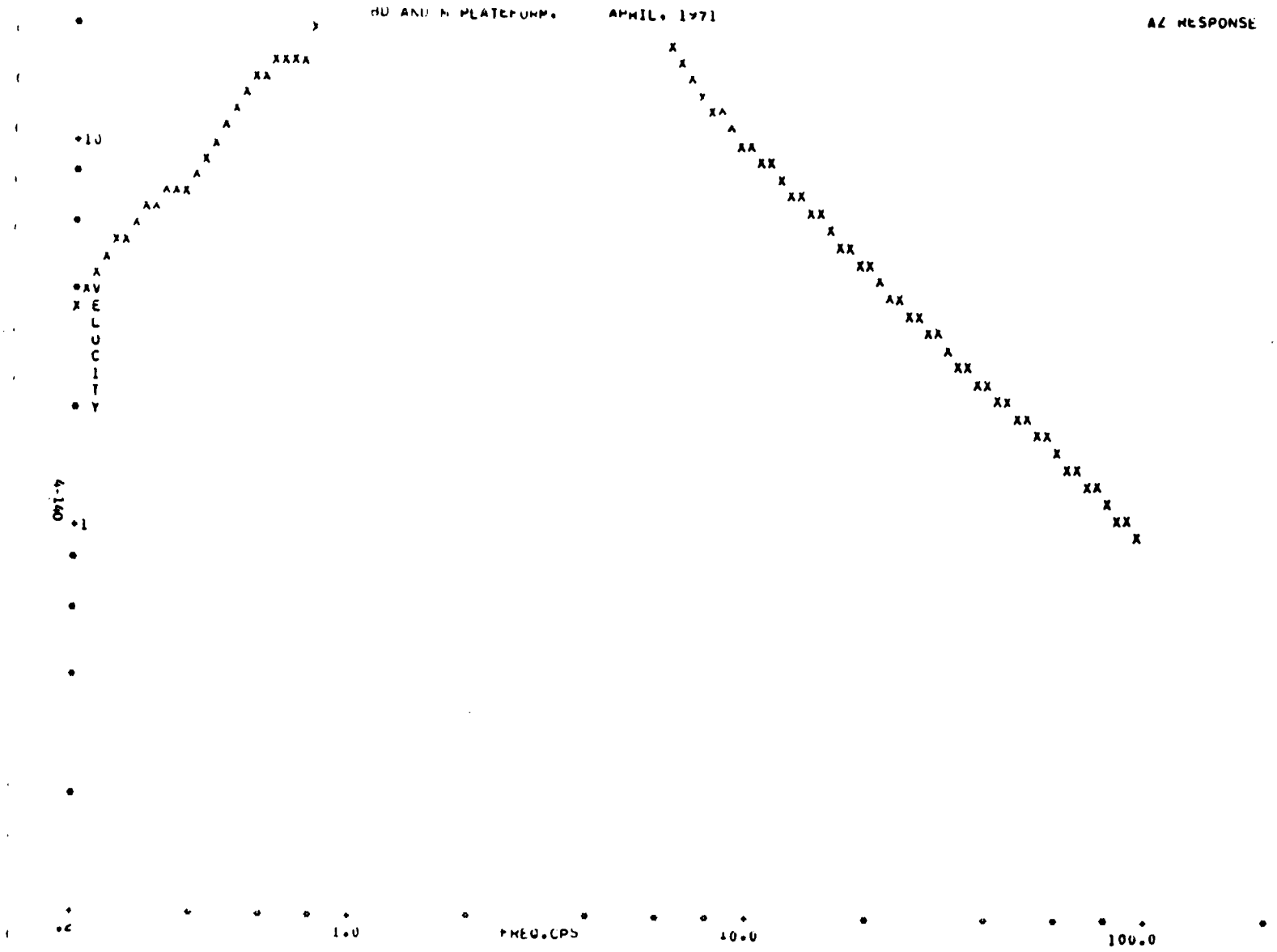
ACCL. TABLE IN IN/SEC. SQ.

.1082	3.4263	15.3169	34.3937	58.3704	69.5780	64.5943	48.3406	30.2414
14.3727	-4.3941	-33.9097	-73.4941	-109.5697	-123.6411	-108.1366	-74.0245	-42.3239
-26.1691	-17.9060	2.8474	48.6041	108.4776	150.9417	145.5783	87.8462	5.0996
-60.9241	-80.9131	-54.3443	-6.3907	28.9300	27.5776	-14.6571	-83.9202	-155.5159
-201.4612	-197.6313	-133.9024	-18.8126	122.4174	255.3379	348.0964	370.5689	319.7749
200.7873	33.9939	-151.4753	-322.7937	-445.5557	-504.1688	-477.2222	-370.0902	-198.8683
9.7602	223.6511	410.6309	543.9015	605.8316	589.8504	500.2597	350.4514	160.0705
-48.6363	-250.6229	-426.2660	-557.0634	-629.9334	-638.1089	-581.9608	-468.5900	-310.6781
-124.8020	70.5591	257.0149	417.8872	539.4235	612.0934	631.0101	596.1458	512.0085
367.6191	232.6523	62.4282	-109.1837	-267.9636	-400.8829	-497.5732	-550.7716	-557.1169
-517.3274	-436.0690	-321.4704	-184.385	-37.4693	106.0957	233.3499	333.0847	396.6747
418.9523	398.7486	339.0592	246.7872	132.0773	7.2964	-114.2314	-219.5998	-297.6616
-340.2385	-343.0177	-305.9894	-233.4170	-133.3509	-16.7234	103.8558	215.4725	306.2987
366.6551	390.9905	376.4789	325.1837	242.7728	138.0279	21.8379	-94.0064	-198.0799
-280.5065	-333.9290	-354.1828	-340.6043	-295.9583	-226.0112	-138.8178	-43.8042	49.2520
131.2315	194.5623	233.9083	245.5921	232.7298	195.0433	138.4944	69.6362	-4.0869
-75.1048	-136.4500	-182.3922	-208.9267	-214.0791	-198.0087	-162.9063	-112.7025	-52.6227
11.3605	73.1219	126.9607	168.1654	193.1601	200.1100	188.9815	161.2744	120.0566
69.5912	14.9232	-38.6151	-85.9143	-122.5734	-145.3182	-152.2965	-143.2395	-119.4614
-83.7080	-39.8697	7.4176	53.2391	92.8934	122.3627	138.7131	140.3817	127.3249
101.0087	64.2399	20.8663	-24.6368	-67.6337	-103.8112	-129.6224	-142.6382	-141.7849
-127.4275	-101.3060	-66.3267	-26.2316	14.8081	52.6390	83.5554	104.6731	114.2046
111.8122	97.6236	74.1145	43.8761	10.2912	-23.0363	-52.6041	-75.6607	-89.8865
-94.1856	-88.4626	-73.6515	-51.5773	-24.7339	3.9905	31.6378	55.4629	73.2108
83.3190	85.0429	78.4949	64.5954	44.9311	21.6642	-2.8855	-26.2837	-46.3126
-61.1553	-69.5558	-70.9197	-65.3477	-53.6041	-37.0070	-17.3131	3.4905	23.3673
40.4275	53.1017	60.2802	61.4057	58.5131	46.2138	31.6254	14.2579	-4.1399
-21.7508	-36.8670	-48.0538	-54.2867	-55.0446				

END INPUT TO SPCTRM - A7

TIME SEC.	FREQUENCY C.P.S.	MAX.DISPLACEMENT INS.	MAX.ACCELERATION G'S
1.6008	.2000	3.1204	.0128
1.6008	.2116	3.1759	.0145
1.6008	.2239	3.2240	.0165
1.6008	.2369	3.2694	.0188
1.6008	.2507	3.3106	.0213
1.6008	.2653	3.3455	.0241
1.6008	.2807	3.3721	.0271
1.6008	.2970	3.3875	.0305
1.5514	.3143	3.3950	.0343
1.5514	.3325	3.3948	.0384
1.5514	.3519	3.3776	.0427
1.5514	.3723	3.3407	.0473
1.5514	.3940	3.2820	.0520
1.7984	.4169	3.2304	.0574
1.7984	.4411	3.4110	.0678
1.7984	.4667	3.5965	.0800
1.7984	.4939	3.7749	.0941
1.7984	.5226	3.9316	.1097
1.7984	.5529	4.0495	.1265
1.7984	.5851	4.1132	.1439
1.7984	.6191	4.1079	.1609
1.7984	.6551	4.0266	.1765
1.7984	.6931	3.8718	.1901
1.7984	.7334	3.9604	.2012
2.5888	.7761	3.7116	.2284
2.5888	.8212	4.0952	.2821
2.5888	.8689	4.2470	.3276
2.5888	.9194	4.1872	.3616
2.5888	.9728	4.0448	.3911
2.5888	1.0294	3.9956	.4326
2.5888	1.0892	4.1387	.5017
2.5888	1.1525	4.3833	.5949
1.7984	1.2195	4.6944	.7133
1.7984	1.2904	4.9119	.8356
2.7864	1.3654	5.2726	1.0043
2.7864	1.4448	5.5101	1.1751
1.7984	1.5287	5.4917	1.3113
1.7984	1.6176	6.0156	1.6090
1.9960	1.7116	7.0334	2.1052
1.9960	1.8111	8.3506	2.7985
1.9960	1.9163	9.2625	3.4754
2.1936	2.0277	9.6907	4.0710
1.9466	2.1456	10.3756	4.8802
2.1442	2.2703	11.2643	5.9318
2.5394	2.4022	11.7007	6.8987
2.6876	2.5419	12.[illegible]	8.3066
2.6382	2.6896	11.4795	8.4845
1.8478	2.8459	10.4585	8.6545
1.7984	3.0114	10.3342	7.7217
1.6008	3.1034	7.1554	7.4329
1.6008	3.3716	5.8390	6.7816
1.4032	3.5676	4.0288	6.0191
1.4032	3.7749	3.9306	5.7226
1.4032	3.9943	3.0284	4.9365
1.2031	4.2265	2.0386	4.8160
1.1899	4.4721	2.0955	4.2887
1.1767	4.7321	1.5753	3.6052

1.0350	5.0071	1.0410	3.3068
1.0210	5.2901	1.0321	2.9600
1.0120	5.6091	.0695	2.4709
1.2031	5.9319	.0245	2.2450
1.1899	6.2707	.0751	2.3147
1.3775	6.6415	.0025	2.0843
1.3843	7.0215	.0744	1.8891
1.1932	7.4300	.0359	1.8975
1.3712	7.8602	.0000	1.8976
1.3775	8.3255	.0504	1.7730
1.3745	8.8094	.0298	1.8219
1.3745	9.3215	.0006	1.7807
1.3745	9.8653	.0776	1.7671
1.3745	10.4355	.1576	1.7543
1.3745	11.0431	.1397	1.7412
1.3745	11.6850	.1242	1.7324
1.3745	12.3642	.1103	1.7225
1.3745	13.0828	.0980	1.7141
1.3745	13.8432	.0872	1.7071
1.3745	14.6478	.0776	1.7006
1.3745	15.4992	.0691	1.6949
1.3745	16.4000	.0615	1.6898
1.3745	17.3533	.0548	1.6853
1.3712	18.3619	.0488	1.6815
1.3712	19.4291	.0435	1.6782
1.3712	20.5584	.0388	1.6753
1.3712	21.7533	.0346	1.6727
1.3712	23.0177	.0309	1.6705
1.3712	24.3555	.0275	1.6687
1.3712	25.7712	.0246	1.6671
1.3712	27.2690	.0219	1.6657
1.3712	28.8540	.0196	1.6647
1.3712	30.5311	.0175	1.6640
1.3712	32.3056	.0156	1.6635
1.3712	34.1853	.0139	1.6634
1.3712	36.1702	.0124	1.6638
1.3712	38.2765	.0111	1.6646
1.3712	40.4970	.0099	1.6664
1.3712	42.8508	.0089	1.6692
1.3679	45.3414	.0080	1.6762
1.3679	47.9707	.0072	1.7000
1.3646	50.7653	.0064	1.6803
1.3646	53.7159	.0057	1.6745
1.3811	56.8360	.0051	1.6868
1.3811	60.1416	.0045	1.6702
1.3790	63.6372	.0040	1.6622
1.3790	67.3350	.0036	1.6591
1.3790	71.2458	.0032	1.6566
1.3773	75.3910	.0029	1.6555
1.3773	79.7729	.0025	1.6548
1.3773	84.4096	.0023	1.6540
1.3757	89.3157	.0020	1.6546
1.3757	94.5070	.0018	1.6559
1.374[illegible]	100.0000	.0015	1.6598


HU AND N PLATFORM. APRIL, 1971
AZ RESPONSE
+10
+1
-140
VELOCITY
.2
1.0
FREQ.CPS
10.0
100.0

AYZ ACCEL.

ANGLE = 45.000

INITIAL CG LOCATION IS 196.251 81.707 76.208

INERTIA TENSOR (LBF-IN2)

.5097638E+06	-.333955E-22	-.333955E-22
-.333955E-22	.113018E+07	-.166977E-22
-.333955E-22	-.166977E-22	.110196E+07

AR COORDINATES

SPR.NO.	ARR	YAR	ZAR
1	-196.251	-81.707	-40.208
2	-99.251	-81.707	-40.208
3	-4.251	-81.707	-40.208
4	85.749	-81.707	-40.208
5	187.749	-81.707	-40.208
6	-196.251	98.293	-40.208
7	-99.251	98.293	-40.208
8	-4.251	98.293	-40.208
9	85.749	98.293	-40.208
10	187.749	98.293	-40.208
11	-196.251	8.293	-40.208
12	187.749	8.293	-40.208

DISPLS. IN THE NEXT TABLE ARE RELATIVE TO INITIAL LOCATIONS

ACCELERATION UNIT IN IN/SEC**2

TIME	XC ADX XP1 XP3	YC ADY YP1 YP3	ZC ADZ ZP1 ZP3	AX A11 AXP1 AXP3	AY A12 AYP1 AYP3	AZ A13 AZP1 AZP3	OX A21 XP2 XP4	OY A22 YP2 YP4	OZ A23 ZP2 ZP4	ODX A31 AXP2 AXP4	ODY A32 AYP2 AYP4	ODZ A33 AZP2 AZP4
.020	-.002	-.002	-.001	.003	.003	.168	-.000	-.000	-.000	.000	.000	-.000
	18.297	18.297	9.225	1.000	-.000	.000	.000	1.000	-.000	-.000	.000	1.000
	-.002	-.002	-.001	.003	.003	.176	-.002	-.002	-.001	0.000	0.000	0.000
	-.002	-.002	-.001	-.001	.007	.162	-.002	-.002	-.001	0.000	0.000	0.000
.040	-.065	-.047	-.025	.133	.096	3.427	.000	.000	-.000	.002	.002	-.000
	107.892	107.892	66.376	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-.065	-.047	-.025	.129	.098	3.978	-.065	-.047	-.025	0.000	0.000	0.000
	-.065	-.047	-.025	-.015	.217	3.218	-.065	-.047	-.025	0.000	0.000	0.000
.060	-.332	-.230	-.139	.695	.480	15.336	.000	.000	-.000	.008	.010	-.000
	102.054	102.055	112.080	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-.332	-.230	-.139	.676	.497	16.727	-.333	-.229	-.139	0.000	0.000	0.000
	-.333	-.229	-.140	-.099	1.091	14.157	-.332	-.230	-.138	0.000	0.000	0.000
.080	-.765	-.520	-.375	1.683	1.142	36.980	.001	.001	-.000	.019	.027	-.000
	-32.863	-32.863	84.821	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-.765	-.520	-.372	1.630	1.194	40.416	-.766	-.519	-.372	0.000	0.000	0.000
	-.766	-.519	-.377	-.367	2.587	33.244	-.763	-.521	-.369	0.000	0.000	0.000
.100	-1.126	-.762	-.661	2.608	1.754	58.531	.003	.004	-.000	.028	.044	-.000
	-99.321	-99.321	-6.073	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-1.126	-.761	-.651	2.517	1.846	44.791	-1.132	-.757	-.651	0.000	0.000	0.000
	-1.132	-.758	-.669	-.694	3.857	53.018	-1.121	-.765	-.641	0.000	0.000	0.000
.120	-1.321	-.894	-.854	3.141	2.103	89.173	.007	.010	-.000	.028	.045	-.000
	-1.168	-1.168	-81.173	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-1.321	-.894	-.829	3.045	2.204	76.940	-1.334	-.884	-.829	0.000	0.000	0.000
	-1.334	-.885	-.876	-.295	4.149	63.044	-1.307	-.904	-.804	0.000	0.000	0.000
.140	-1.517	-1.032	-.854	3.582	2.392	64.045	.014	.020	-.000	.016	.023	-.000
	77.037	77.037	-73.301	1.000	-.000	-.000	.000	1.000	.000	.000	-.000	1.000
	-1.518	-1.031	-.805	3.534	2.453	47.992	-1.544	-1.013	-.804	0.000	0.000	0.000
	-1.543	-1.014	-.897	1.852	3.615	62.131	-1.491	-1.049	-.758	0.000	0.000	0.000
.160	-1.823	-1.242	-.683	4.165	2.770	48.974	.021	.031	-.000	-.001	-.018	.000
	-23.679	-23.679	1.800	1.000	-.000	-.001	.000	1.000	.000	.001	-.000	1.000
	-1.824	-1.241	-.800	4.206	2.745	45.221	-1.865	-1.213	-.605	0.000	0.000	0.000
	-1.804	-1.214	-.751	3.524	2.717	52.981	-1.782	-1.269	-.533	0.000	0.000	0.000
.180	-2.050	-1.396	-.454	4.505	2.984	30.372	.029	.042	-.000	-.021	-.054	.001
	-145.519	-145.519	56.627	1.000	-.000	-.001	.000	1.000	.001	.001	-.001	1.000
	-2.051	-1.396	-.353	4.641	2.850	20.952	-2.106	-1.356	-.351	0.000	0.000	0.000
	-2.105	-1.360	-.542	0.971	1.488	39.869	-1.996	-1.434	-.254	0.000	0.000	0.000
.200	-2.018	-1.382	-.246	-.274	2.831	14.348	.035	.048	-.000	-.040	-.087	.001
	-58.128	-58.128	20.091	1.000	-.000	-.001	.000	1.000	.001	.001	-.001	1.000
	-2.018	-1.380	-.133	4.474	2.616	.174	-2.080	-1.335	-.132	0.000	0.000	0.000
	-2.080	-1.336	-.343	10.802	-.036	27.195	-1.956	-1.426	-.014	0.000	0.000	0.000

TIME	XC ABA XP1 XP3	YC ABY YP1 YP3	ZC ABZ ZP1 ZP3	AX A11 AAP1 AAP3	AY A12 AYP1 AYP3	AZ A13 AZP1 AZP3	OX A21 XP2 XP4	OY A22 YP2 YP4	OZ A23 ZP2 ZP4	ODX A31 AXP2 AXP4	ODY A32 AYP2 AYP4	ODZ A33 AZP2 AZP4
.220	-1.902	-1.319	-.026	3.849	2.570	-4.388	.038	.047	-.000	-.053	-.100	.001
	131.519	131.519	-84.541	1.000	-.000	-.001	.000	1.000	.001	.001	-.001	1.000
	-1.903	-1.317	.080	4.079	2.312	-19.754	-1.964	-1.267	.081	0.000	0.000	0.000
	-1.964	-1.268	-.115	11.411	-1.299	9.922	-1.841	-1.367	.210	0.000	0.000	0.000
.240	-2.012	-1.408	.308	3.750	2.541	-33.978	.038	.039	-.000	-.059	-.109	.001
	107.176	107.176	-153.701	1.000	-.000	-.001	.000	1.000	.001	.001	-.001	1.000
	-2.014	-1.407	.387	4.014	2.243	-50.971	-2.064	-1.358	.387	0.000	0.000	0.000
	-2.064	-1.359	.246	11.971	-1.789	-19.007	-1.963	-1.456	.513	0.000	0.000	0.000
.260	-2.265	-1.589	.789	3.729	2.561	-73.031	.032	.022	.000	-.061	-.114	.001
	-136.760	-136.760	-102.824	1.000	.000	-.000	-.000	1.000	.001	.000	-.001	1.000
	-2.265	-1.588	.819	4.030	2.225	-91.132	-2.294	-1.546	.818	0.000	0.000	0.000
	-2.294	-1.545	.774	12.315	-1.832	-57.785	-2.237	-1.630	.926	0.000	0.000	0.000
.280	-2.240	-1.582	1.287	3.244	2.270	-169.917	.022	-.003	.000	-.056	-.102	.001
	-223.942	-223.943	42.292	1.000	.000	.000	-.000	1.000	.000	-.000	-.000	1.000
	-2.240	-1.582	1.244	3.534	1.964	-125.730	-2.235	-1.553	1.241	0.000	0.000	0.000
	-2.236	-1.551	1.339	10.907	-1.791	-95.908	-2.245	-1.611	1.315	0.000	0.000	0.000
.300	-1.845	-1.333	1.572	2.503	1.827	-124.354	.008	-.037	.001	-.038	-.055	.000
	36.877	36.877	156.018	1.000	.000	.001	-.000	1.000	.000	-.001	-.000	1.000
	-1.842	-1.335	1.435	2.682	1.662	-132.127	-1.795	-1.325	1.431	0.000	0.000	0.000
	-1.797	-1.320	1.711	6.636	-.969	-117.347	-1.893	-1.346	1.457	0.000	0.000	0.000
.320	-1.559	-1.167	1.498	2.195	1.709	-108.993	-.009	-.074	.001	-.001	.030	-.000
	299.827	299.827	129.142	1.000	.000	.001	-.000	1.000	-.000	-.001	.000	1.000
	-1.556	-1.171	1.256	2.161	1.748	-103.029	-1.459	-1.183	1.250	0.000	0.000	0.000
	-1.463	-1.176	1.732	-.091	1.584	-114.079	-1.656	-1.159	1.218	0.000	0.000	0.000
.340	-1.797	-1.349	1.132	2.807	2.234	-74.743	-.027	-.110	.001	.049	.132	-.001
	150.919	150.919	-25.721	1.000	.000	.002	-.000	1.000	-.000	-.002	.000	1.000
	-1.791	-1.355	.794	2.482	2.545	-52.907	-1.648	-1.390	.785	0.000	0.000	0.000
	-1.653	-1.380	1.455	-7.090	5.734	-95.143	-1.939	-1.320	.695	0.000	0.000	0.000
.360	-2.234	-1.656	.715	3.840	3.025	-42.925	-.041	-.136	.002	.093	.213	-.002
	-262.441	-262.441	-168.351	1.000	.000	.002	-.000	1.000	-.001	-.002	.001	1.000
	-2.227	-1.663	.307	3.230	3.644	-8.089	-2.050	-1.716	.297	0.000	0.000	0.000
	-2.057	-1.704	1.100	-12.079	9.688	-74.356	-2.409	-1.610	.160	0.000	0.000	0.000
.380	-2.154	-1.612	.449	3.853	3.091	-26.576	-.048	-.146	.002	.111	.247	-.002
	-388.467	-388.467	-155.575	1.000	.000	.003	-.000	1.000	-.001	-.003	.001	1.000
	-2.147	-1.620	.017	3.136	3.802	12.745	-1.957	-1.682	.006	0.000	0.000	0.000
	-1.964	-1.669	.856	-14.590	11.045	-42.525	-2.342	-1.558	-.154	0.000	0.000	0.000
.400	-1.406	-1.129	.319	2.515	2.231	-19.349	-.046	-.137	.002	.099	.232	-.002
	-21.409	-21.409	23.508	1.000	.000	.002	-.000	1.000	-.001	-.002	.001	1.000
	-1.399	-1.137	-.085	1.914	2.747	19.081	-1.220	-1.197	-.095	0.000	0.000	0.000
	-1.227	-1.185	.099	-14.930	9.456	-52.998	-1.583	-1.077	-.250	0.000	0.000	0.000

TIME	XC AHA XP1 XP3	YC ABY YP1 YP3	ZC ABZ ZP1 ZP3	AX A11 AAP1 AAP3	AY A12 AYP1 AYP3	AZ A13 AZP1 AZP3	OX A21 XP2 XP4	OY A22 YP2 YP4	OZ A23 ZP2 ZP4	ODX A31 AXP2 AXP4	ODY A32 AYP2 AYP4	OOZ A33 AZP2 AZP4
.420	-.684	-.676	.107	1.229	1.423	2.959	-.037	-.111	.002	.076	.190	-.001
	415.083	415.083	222.806	1.000	.000	.002	-.000	1.000	-.001	-.002	.001	1.000
	-.678	-.682	-.220	.825	1.726	33.745	-.534	-.731	-.227	0.000	0.000	0.000
	-.539	-.720	.414	-13.175	7.053	-26.291	-.827	-.634	-.352	0.000	0.000	0.000
.440	-.738	-.745	-.393	1.559	1.720	48.755	-.022	-.069	.001	.061	.143	-.001
	430.416	430.416	258.061	1.000	.000	.001	-.000	1.000	-.000	-.001	.000	1.000
	-.734	-.750	-.599	1.309	1.963	71.932	-.644	-.779	-.604	0.000	0.000	0.000
	-.648	-.770	-.199	-7.339	6.217	27.342	-.828	-.721	-.678	0.000	0.000	0.000
.461	-1.543	-1.309	-1.135	3.930	3.363	109.130	-.002	-.017	.001	.056	.094	-.001
	46.900	46.901	69.307	1.000	.000	.000	-.000	1.000	-.000	-.000	.000	1.000
	-1.541	-1.312	-1.169	3.803	3.622	122.910	-1.520	-1.315	-1.191	0.000	0.000	0.000
	-1.523	-1.309	-1.083	-3.208	7.496	46.923	-1.566	-1.310	-1.198	0.000	0.000	0.000
.480	-2.381	-1.887	-1.787	6.703	5.200	152.134	.022	.043	.001	.043	.023	-.001
	-329.043	-329.043	-216.055	1.000	.000	-.001	-.000	1.000	.000	.001	-.000	1.000
	-2.382	-1.888	-1.669	6.745	5.359	153.116	-2.438	-1.859	-1.667	0.000	0.000	0.000
	-2.440	-1.856	-1.893	4.903	8.395	152.665	-2.327	-1.917	-1.593	0.000	0.000	0.000
.500	-2.571	-2.027	-1.939	7.273	5.479	146.843	.050	.105	.000	-.005	-.089	.001
	-426.341	-426.341	-378.433	1.000	.000	-.002	-.000	1.000	.001	.002	-.001	1.000
	-2.574	-2.026	-1.648	7.574	5.294	129.969	-2.711	-1.962	-1.642	0.000	0.000	0.000
	-2.712	-1.961	-2.205	13.879	5.277	163.930	-2.437	-2.091	-1.477	0.000	0.000	0.000
.520	-1.945	-1.625	-1.420	5.057	3.861	88.019	.077	.161	-.000	-.088	-.238	.002
	-278.391	-278.391	-282.967	1.000	-.000	-.003	.000	1.000	.001	.003	-.001	1.000
	-1.950	-1.622	-.978	5.609	3.279	49.359	-2.159	-1.522	-.969	0.000	0.000	0.000
	-2.154	-1.524	-1.824	22.964	-2.413	125.087	-1.739	-1.722	-.713	0.000	0.000	0.000
.540	-.806	-.886	-.450	1.927	1.664	5.727	.098	.199	-.001	-.174	-.384	.002
	-4.986	-4.986	12.755	1.000	-.000	-.003	.000	1.000	.002	.003	-.002	1.000
	-.812	-.882	.691	2.567	1.005	-55.323	-1.071	-.755	.102	0.000	0.000	0.000
	-1.070	-.758	-.944	31.089	-11.235	61.770	-.551	-1.009	.428	0.000	0.000	0.000
.560	.302	-.176	.482	-.265	.174	-60.949	.105	.208	-.001	-.224	-.463	.001
	289.742	289.743	304.281	1.000	-.000	-.004	.000	1.000	.002	.004	-.002	1.000
	.296	-.171	1.043	.315	-.228	-133.090	.025	-.034	1.054	0.000	0.000	0.000
	.026	-.034	-.028	35.188	-16.830	5.920	.569	-.309	1.406	0.000	0.000	0.000
.580	.836	.145	.925	-1.133	-.340	-80.055	.096	.182	-.001	-.214	-.428	-.000
	407.252	407.252	400.708	1.000	-.000	-.003	.000	1.000	.002	.003	-.002	1.000
	.836	.150	1.420	-.582	-.553	-147.139	.594	.276	1.429	0.000	0.000	0.000
	.595	.271	.496	31.629	-16.780	-20.165	1.070	.025	1.751	0.000	0.000	0.000
.600	.602	-.046									-.276	-.000
	280.581	280.581									-.001	1.000
	.598	-.041									0.000	0.000
	.440	.046									0.000	0.000

20 computer output pages have been deleted hereafter.

TIME	XC	YC	ZC	AX	AY	AZ	OX	OY	OZ	OOX	OOY	OOZ
	ABX	ABY	ABZ	A11	A12	A13	A21	A22	A23	A31	A32	A33
	XP1	YP1	ZP1	AAP1	AYP1	AZP1	XP2	YP2	ZP2	AXP2	AYP2	AZP2
	XP3	YP3	ZP3	AAP3	AYP3	AZP3	XP4	YP4	ZP4	AXP4	AYP4	AZP4
4.620	.688	-2.543	.569	-1.402	4.800	-34.374	-.056	-.113	.242	.124	.168	-.017
	0.000	0.000	0.000	1.000	.004	.002	-.004	1.000	-.001	-.002	.001	1.000
	1.008	-3.329	.261	-3.088	8.350	-11.980	1.179	-3.424	.251	0.000	0.000	0.000
	.431	-1.853	.845	-12.420	10.933	-54.043	.117	-3.280	.072	0.000	0.000	0.000
4.640	1.038	-2.674	.320	-2.106	5.255	-14.755	-.034	-.072	.247	.087	.103	-.018
	0.000	0.000	0.000	1.000	.004	.001	-.004	1.000	-.001	-.001	.001	1.000
	1.366	-3.472	.122	-3.670	8.809	-1.099	1.484	-3.541	.114	0.000	0.000	0.000
	.717	-1.932	.497	-6.194	8.522	-25.742	.509	-3.455	.008	0.000	0.000	0.000
4.660	1.385	-2.792	.050	-2.862	5.715	5.516	-.006	-.023	.252	.040	.028	-.018
	0.000	0.000	0.000	1.000	.004	.000	-.004	1.000	-.000	-.000	.000	1.000
	1.717	-3.605	-.020	-4.289	9.217	7.036	1.771	-3.637	-.026	0.000	0.000	0.000
	.990	-1.999	.112	-3.173	5.343	4.427	.911	-3.622	-.037	0.000	0.000	0.000
4.680	1.726	-2.904	-.214	-3.656	6.156	24.033	.026	.029	.255	-.012	-.050	-.018
	0.000	0.000	0.000	1.000	.004	-.001	-.004	1.000	.000	.001	-.000	1.000
	2.060	-3.725	-.152	-4.961	9.571	16.055	2.048	-3.717	-.157	0.000	0.000	0.000
	1.257	-2.058	-.269	1.936	1.856	33.276	1.312	-3.784	-.061	0.000	0.000	0.000
4.700	2.060	-3.006	-.446	-4.469	6.552	41.170	.057	.077	.256	-.061	-.119	-.018
	0.000	0.000	0.000	1.000	.004	-.001	-.004	1.000	.001	.001	-.001	1.000
	2.395	-3.832	-.264	-5.679	9.863	22.029	2.320	-3.785	-.266	0.000	0.000	0.000
	1.524	-2.115	-.608	6.431	-1.454	57.061	1.705	-3.932	-.068	0.000	0.000	0.000
4.720	2.385	-3.100	-.625	-5.272	6.885	53.047	.083	.110	.256	-.101	-.173	-.017
	0.000	0.000	0.000	1.000	.004	-.002	-.004	1.000	.001	.002	-.001	1.000
	2.720	-3.927	-.345	-6.418	10.094	27.368	2.594	-3.845	-.346	0.000	0.000	0.000
	1.796	-2.173	-.871	9.708	-4.144	75.787	2.080	-4.060	-.059	0.000	0.000	0.000
4.740	2.700	-3.185	-.733	-6.034	7.138	59.457	.102	.143	.255	-.128	-.204	-.017
	0.000	0.000	0.000	1.000	.004	-.002	-.004	1.000	.002	.002	-.002	1.000
	3.033	-4.007	-.391	-7.142	10.259	30.023	2.872	-3.901	-.391	0.000	0.000	0.000
	2.078	-2.236	-1.033	11.335	-5.865	85.433	2.431	-4.165	-.041	0.000	0.000	0.000
4.760	3.003	-3.261	-.762	-6.725	7.302	59.943	.111	.153	.253	-.137	-.210	-.017
	0.000	0.000	0.000	1.000	.004	-.003	-.004	1.000	.002	.003	-.002	1.000
	3.332	-4.074	-.396	-7.813	10.359	30.078	3.157	-3.955	-.396	0.000	0.000	0.000
	2.371	-2.308	-1.082	11.109	-6.406	86.095	2.752	-4.244	-.015	0.000	0.000	0.000
4.780	3.293	-3.326	-.711	-7.318	7.374	54.927	.110	.148	.249	-.130	-.192	-.016
	0.000	0.000	0.000	1.000	.004	-.003	-.004	1.000	.002	.003	-.002	1.000
	3.617	-4.127	-.362	-6.402	10.393	27.752	3.448	-4.009	-.362	0.000	0.000	0.000
	2.675	-2.387	-1.015	9.072	-5.716	78.917	3.042	-4.294	.014	0.000	0.000	0.000
4.800	3.569	-3.382	-.586	-7.794	7.357	44.175	.098	.128	.244	-.107	-.152	-.016
	0.000	0.000	0.000	1.000	.004	-.002	-.004	1.000	.002	.002	-.002	1.000
	3.880	-4.160	-.290	-5.892	10.361	23.200	3.743	-4.062	-.291	0.000	0.000	0.000
	2.980	-2.475	-.043	5.495	-3.904	62.328	3.300	-4.318	.047	0.000	0.000	0.000

TIME	XC	YC	ZC	AX	AY	AZ	OX	OY	OZ	OOX	OOY	OOZ
	BHA	[illegible]	BHZ	A11	A12	A13	A21	A22	A23	A31	A32	A33
	XP1	YP1	ZP1	AXP1	AYP1	AZP1	XP2	YP2	ZP2	AXP2	AYP2	AZP2
	XP3	YP3	ZP3	AXP3	AYP3	AZP3	XP4	YP4	ZP4	AXP4	AYP4	AZP4
4.820	3.824	-3.427	-.402	-0.148	7.200	29.720	.079	.096	.238	-.071	-.096	-.016
	0.000	0.000	0.000	1.000	.004	-.002	-.004	1.000	.001	.002	-.001	1.000
	4.137	-4.141	-.187	-9.281	10.265	16.725	4.036	-4.112	-.190	0.000	0.000	0.000
	3.301	-2.567	-.586	.831	-1.220	40.094	3.530	-4.317	.083	0.000	0.000	0.000
4.840	4.072	-3.453	-.176	-0.385	7.101	12.767	.054	.056	.231	-.027	-.032	-.016
	0.000	0.000	0.000	1.000	.004	-.001	-.004	1.000	.001	.001	-.001	1.000
	4.372	-4.232	-.062	-9.575	10.109	8.774	4.321	-4.155	-.066	0.000	0.000	0.000
	3.011	-2.062	-.272	-4.355	1.983	16.997	3.737	-4.294	.123	0.000	0.000	0.000
4.860	4.300	-3.490	.068	-3.529	0.900	-5.012	.026	.014	.222	.018	.033	-.015
	0.000	0.000	0.000	1.000	.004	-.000	-.004	1.000	.000	.000	-.000	1.000
	4.588	-4.200	.076	-9.787	9.900	-.065	4.592	-4.187	.070	0.000	0.000	0.000
	3.911	-2.754	.065	-9.470	5.297	-9.931	3.925	-4.255	.167	0.000	0.000	0.000
4.880	4.510	-3.507	.300	-0.611	0.685	-21.083	-.000	-.027	.212	.059	.090	-.015
	0.000	0.000	0.000	1.000	.003	.000	-.003	1.000	-.000	-.000	.000	1.000
	4.785	-4.184	.215	-9.934	9.648	-9.089	4.840	-4.205	.207	0.000	0.000	0.000
	4.193	-2.834	.392	-13.966	8.314	-33.987	4.102	-4.204	.216	0.000	0.000	0.000
4.900	4.703	-3.515	.517	-0.674	0.481	-36.243	-.022	-.060	.201	.091	.134	-.014
	0.000	0.000	0.000	1.000	.003	.001	-.003	1.000	-.000	-.001	.000	1.000
	4.963	-4.155	.342	-10.038	9.369	-17.524	5.061	-4.203	.333	0.000	0.000	0.000
	4.450	-2.913	.676	-17.409	10.681	-52.963	4.272	-4.146	.268	0.000	0.000	0.000
4.920	4.879	-3.514	.680	-0.760	0.314	-46.760	-.037	-.084	.189	.110	.159	-.013
	0.000	0.000	0.000	1.000	.003	.001	-.003	1.000	-.001	-.001	.001	1.000
	5.123	-4.114	.446	-10.120	9.076	-24.583	5.250	-4.180	.436	0.000	0.000	0.000
	4.679	-2.473	.890	-19.524	12.142	-66.073	4.440	-4.084	.320	0.000	0.000	0.000
4.940	5.037	-3.505	.781	-0.906	0.202	-52.522	-.044	-.095	.176	.115	.165	-.012
	0.000	0.000	0.000	1.000	.003	.002	-.003	1.000	-.001	-.002	.001	1.000
	5.262	-4.060	.518	-10.207	8.785	-59.547	5.403	-4.134	.508	0.000	0.000	0.000
	4.877	-3.017	1.017	-20.214	12.574	-72.512	4.608	-4.020	.369	0.000	0.000	0.000
4.960	5.178	-3.484	.812	-9.138	0.155	-53.059	-.042	-.093	.162	.105	.152	-.011
	0.000	0.000	0.000	1.000	.003	.002	-.003	1.000	-.001	-.002	.001	1.000
	5.383	-3.945	.951	-10.322	8.509	-31.048	5.520	-4.065	.541	0.000	0.000	0.000
	5.041	-3.044	1.048	-19.556	11.994	-71.538	4.775	-3.955	.409	0.000	0.000	0.000

SUMMARY OF MAX. AND MIN. CG RELATIVE DISPLACEMENTS AND ABSOLUTE ACCELERATIONS

TIME =	1.0700	X MAX =	7.587
TIME =	1.0700	Y MAX =	4.[illegible]26
TIME =	1.3800	Z MAX =	8.213
TIME =	1.9100	X MIN =	-7.[illegible]39
TIME =	2.0700	Y MIN =	-5.[illegible]97
TIME =	1.5900	Z MIN =	-8.235
TIME =	1.9800	ACX MAX =	27.607
TIME =	2.7500	ACY MAX =	14.276
TIME =	1.5600	ACZ MAX =	616.924
TIME =	1.1400	ACX MIN =	-23.214
TIME =	1.5600	ACY MIN =	-20.[illegible]11
TIME =	1.3700	ACZ MIN =	-628.[illegible]93

SPR NO	FREE LGTH	EXTD LGTH	DELTA L	SPR FORCE	DEL L DOT	DAMP FORCE
1	187.515	191.571	-4.056	-2520.559	.187	1.189
2	187.429	191.399	-3.970	-2466.951	-.155	-1.004
3	187.354	191.247	-3.894	-2419.831	-.455	-2.998
4	186.228	191.096	-4.868	-2475.005	-.754	-5.047
5	186.123	190.925	-4.802	-2441.340	-1.090	-7.434
6	187.769	191.691	-3.922	-2050.577	.048	3.271
7	187.667	191.519	-3.852	-2013.925	.366	1.582
8	187.577	191.367	-3.790	-1981.738	.006	.031
9	186.484	191.216	-4.732	-2024.220	-.293	-1.577
10	186.380	191.045	-4.665	-2004.349	-.630	-3.467
11	187.631	191.631	-4.000	-2288.441	.417	2.377
12	186.231	190.985	-4.754	-2225.193	-.861	-5.304

LOADING CASE X-Y-Z

BD AND M PLATEFORM, APRIL, 1971

GENERALIZED SHOCK SPECTRUM

FOR

DAMPED AND UNDAMPED VIBRATIONS

INPUT DATA

NO OF POINTS IN TABLE	248
STARTING TIME	.02[illegible]0
END TIME	4.96[illegible]0
TIME INTERVAL	.05[illegible]0
PERCENTAGE CRITICAL DAMPING	.05[illegible]0
INITIAL DISPLACEMENT	0.0[illegible]0

INITIAL VELOCITY 0.0000

NO OF CYCLES OF RESIDUAL VIBRATION 3

FACTOR FOR INTEGRATION TIME INTERVAL 5

STARTING FREQ. = .2000

ENDING FREQ. = 100.0000

INTERVAL STEPS = 110.0

TIME TABLE

.0200	.0400	.0600	.0800	.1000	.1200	.1400	.1600	.1800
.2000	.2200	.2400	.2600	.2800	.3000	.3200	.3400	.3600
.3800	.4000	.4200	.4400	.4600	.4800	.5000	.5200	.5400
.5600	.5800	.6000	.6200	.6400	.6600	.6800	.7000	.7200
.7400	.7600	.7800	.8000	.8200	.8400	.8600	.8800	.9000
.9200	.9400	.9600	.9800	1.0000	1.0200	1.0400	1.0600	1.0800
1.1000	1.1200	1.1400	1.1600	1.1800	1.2000	1.2200	1.2400	1.2600
1.2800	1.3000	1.3200	1.3400	1.3600	1.3800	1.4000	1.4200	1.4400
1.4600	1.4800	1.5000	1.5200	1.5400	1.5600	1.5800	1.6000	1.6200
1.6400	1.6600	1.6800	1.7000	1.7200	1.7400	1.7600	1.7800	1.8000
1.8200	1.8400	1.8600	1.8800	1.9000	1.9200	1.9400	1.9600	1.9800
2.0000	2.0200	2.0400	2.0600	2.0800	2.1000	2.1200	2.1400	2.1600
2.1800	2.2000	2.2200	2.2400	2.2600	2.2800	2.3000	2.3200	2.3400
2.3600	2.3800	2.4000	2.4200	2.4400	2.4600	2.4800	2.5000	2.5200
2.5400	2.5600	2.5800	2.6000	2.6200	2.6400	2.6600	2.6800	2.7000
2.7200	2.7400	2.7600	2.7800	2.8000	2.8200	2.8400	2.8600	2.8800
2.9000	2.9200	2.9400	2.9600	2.9800	3.0000	3.0200	3.0400	3.0600
3.0800	3.1000	3.1200	3.1400	3.1600	3.1800	3.2000	3.2200	3.2400
3.2600	3.2800	3.3000	3.3200	3.3400	3.3600	3.3800	3.4000	3.4200
3.4400	3.4600	3.4800	3.5000	3.5200	3.5400	3.5600	3.5800	3.6000
3.6200	3.6400	3.6600	3.6800	3.7000	3.7200	3.7400	3.7600	3.7800
3.8000	3.8200	3.8400	3.8600	3.8800	3.9000	3.9200	3.9400	3.9600
3.9800	4.0000	4.0200	4.0400	4.0600	4.0800	4.1000	4.1200	4.1400
4.1600	4.1800	4.2000	4.2200	4.2400	4.2600	4.2800	4.3000	4.3200
4.3400	4.3600	4.3800	4.4000	4.4200	4.4400	4.4600	4.4800	4.5000
4.5200	4.5400	4.5600	4.5800	4.6000	4.6200	4.6400	4.6600	4.6800
4.7000	4.7200	4.7400	4.7600	4.7800	4.8000	4.8200	4.8400	4.8600
4.8800	4.9000	4.9200	4.9400	4.9600				

ACCL. TABLE IN IN/SEC. SQ.

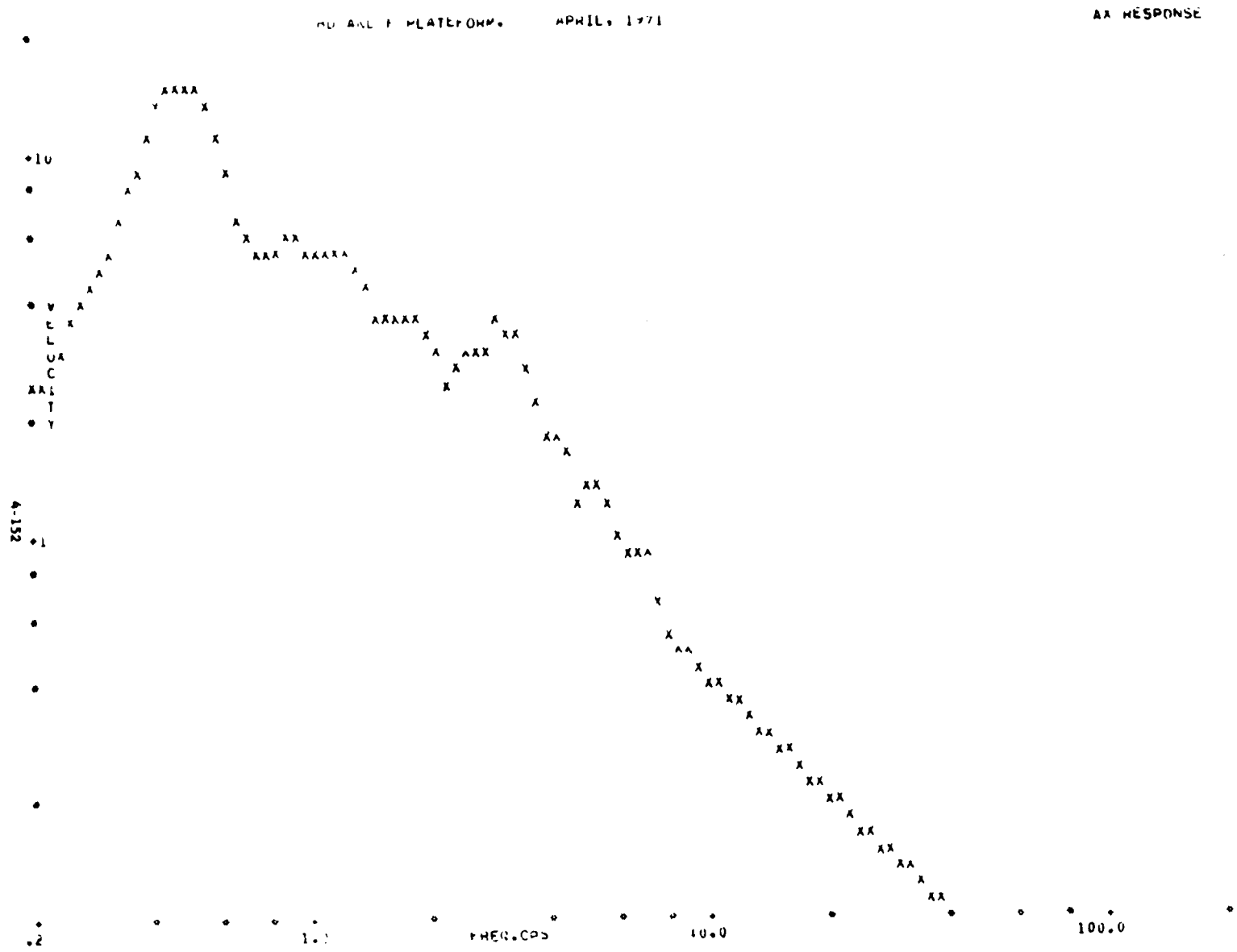
.0035	.1328	.6952	1.6830	2.6079	3.1409	3.5824	4.1650	4.5049
4.2756	3.8486	3.7497	3.7294	3.2443	2.5029	2.1949	2.8074	3.8404
3.8535	2.5147	1.2284	1.5592	3.9296	6.7029	7.2728	5.0568	1.9265
-.2656	-1.1328	-.8951	.3333	1.8328	2.3420	1.3553	-.3984	-1.8643
-2.7717	-3.7818	-5.4421	-7.1037	-7.3109	-5.3820	-2.2253	.2781	.8044
-.5017	-2.2510	-2.7912	-1.2919	1.5906	3.8677	3.3463	-.9236	-7.9942
-15.5414	-21.1078	-23.2136	-21.7787	-17.8373	-12.8866	-9.2710	-4.9048	-2.6740
-1.5386	-.7713	.2237	1.6911	3.3307	4.4176	4.1089	1.9256	-2.0178

-7.6113	-11.9794	-15.8155	-17.6955	-17.2745	-14.8418	-10.9991	-6.6339	-2.5685
.6619	2.5773	3.3190	2.9642	1.7534	.0009	-1.9031	-3.4946	-4.2746
-3.7669	-1.7325	1.4483	6.9899	12.8113	18.6007	23.4789	26.6969	27.8074
20.7561	23.8703	14.7551	15.1312	10.6702	6.8662	3.4762	2.0328	.9081
.3991	.3019	.4562	.7586	1.1038	1.6246	2.1743	2.8137	3.5423
4.3303	5.1037	5.7482	5.1289	6.1205	5.6895	4.8452	3.7259	2.5326
1.4861	.7792	.5126	.6961	1.2556	2.0491	2.9279	3.7397	4.3544
4.6869	4.6125	4.1547	3.3157	2.1731	.8584	-.4614	-1.6185	-2.4862
-3.6173	-3.2643	-3.3731	-3.5479	-3.9903	-4.8846	-6.2767	-8.1402	-10.3477
-12.7110	-15.0207	-17.0797	-18.7263	-19.8937	-20.3615	-20.2538	-19.5403	-18.2885
-16.6164	-14.6874	-12.6953	-10.8374	-9.2924	-8.1380	-7.4315	-7.1062	-7.0377
-7.6034	-7.0194	-6.7727	-6.2435	-5.4131	-4.3193	-3.0415	-1.6829	-.3511
.5564	1.8742	2.6585	3.2116	3.5722	3.8127	4.0301	4.3307	4.8126
5.5478	6.5667	7.8506	9.3315	10.9007	12.4238	13.7615	14.7891	15.4145
15.5707	15.3215	14.6609	13.7036	12.5726	11.4004	10.3126	9.4114	8.7651
8.4026	8.3142	8.4570	8.7634	9.1511	9.5331	9.8266	9.9615	9.8867
9.5767	9.0286	8.2720	7.3542	6.3301	5.2906	4.2722	3.3282	2.4823
1.7362	1.0721	.4594	-.1373	-.7995	-1.4019	-2.1061	-2.8615	-3.6562
-4.4067	-5.2715	-6.0337	-6.7245	-7.3175	-7.7942	-8.1478	-8.3855	-8.5288
-8.6113	-8.6743	-8.7603	-8.9065	-9.1300				

END INPUT TO SPCTRM - AX

TIME SEC.	FREQUENCY C.P.S.	MAX.DISPLACEMENT INS.	MAX.ACCLERATION G'S
5.2933	.2000	1.9957	.0082
2.0454	.2116	1.9137	.0088
2.0454	.2239	1.9041	.0101
1.9960	.2369	2.0080	.0115
1.9960	.2507	2.0547	.0132
3.1816	.2653	2.2142	.0154
3.1816	.2807	2.4228	.0195
3.1816	.2970	2.6053	.0235
3.1322	.3143	2.7723	.0280
3.0825	.3325	2.8843	.0326
4.0708	.3519	3.2101	.0407
4.0214	.3723	3.6343	.0515
5.0446	.3940	4.0380	.0640
4.9600	.4169	4.5767	.0813
4.8612	.4411	4.9867	.0991
4.7624	.4667	5.1096	.1151
4.6636	.4939	5.1045	.1272
4.5648	.5226	4.8067	.1341
4.5154	.5529	4.3099	.1346
4.4166	.5851	3.8838	.1288
4.3178	.6191	2.9808	.1167
4.2684	.6551	2.2682	.0994
4.2190	.6931	1.8427	.0806
2.2924	.7334	1.5353	.0734
2.2430	.7761	1.1372	.0700
4.2684	.8212	1.0910	.0752
4.2190	.8689	1.1092	.0856
4.1696	.9194	1.0713	.0925
4.1202	.9728	.9989	.0966
4.0708	1.0294	.9214	.0997
4.0214	1.0892	.8403	.1019
3.4286	1.1525	.7766	.1054
3.3792	1.2195	.7662	.1164
3.3298	1.2904	.7034	.1197
3.3298	1.3654	.6067	.1156
3.2804	1.4448	.5007	.1068
2.1442	1.5287	.3964	.0947
2.1442	1.6176	.3918	.1047
2.1442	1.7116	.3742	.1120
2.0948	1.8111	.3529	.1183
2.0948	1.9163	.3146	.1180
3.3298	2.0277	.2829	.1189
3.2310	2.1456	.2596	.1127
1.6996	2.2703	.1822	.0959
1.6502	2.4022	.1878	.1107
1.6502	2.5419	.1997	.1319
1.6502	2.6896	.1806	.1335
2.0948	2.8459	.1839	.1522
2.0948	3.0114	.2031	.1882
2.0454	3.1864	.1818	.1886
2.0454	3.3716	.1710	.1993
2.0454	3.5676	.1280	.1672
1.9960	3.7749	.0908	.1404
1.9960	3.9943	.0763	.1243
1.9960	4.2265	.0755	.1379
1.9775	4.4721	.0639	.1245
1.9578	4.7321	.0453	.1037

1.1965	5.0071	.0409	.1048
1.5623	5.2981	.0423	.1213
1.1747	5.6001	.0349	.1282
1.1694	5.5319	.0340	.1224
1.1603	6.2707	.0274	.1102
1.1570	6.6445	.0233	.1051
1.1537	7.0275	.0219	.1105
1.1436	7.4300	.0195	.1101
1.1306	7.8652	.0150	.0946
1.9841	8.3255	.0109	.0775
1.9808	8.8094	.0097	.0773
1.9808	9.3245	.0086	.0763
1.9808	9.8633	.0076	.0754
1.9808	10.4365	.0067	.0751
1.9808	11.0431	.0060	.0748
1.9808	11.6850	.0053	.0743
1.9808	12.3642	.0047	.0740
1.9808	13.0828	.0042	.0737
1.9808	13.8432	.0038	.0734
1.9808	14.6478	.0033	.0732
1.9808	15.4992	.0030	.0730
1.9808	16.4000	.0027	.0728
1.9808	17.3533	.0024	.0727
1.9808	18.3619	.0021	.0725
1.9808	19.4291	.0019	.0724
1.9808	20.5584	.0017	.0723
1.9808	21.7533	.0015	.0722
1.9808	23.0177	.0013	.0721
1.9808	24.3555	.0012	.0720
1.9808	25.7712	.0011	.0719
1.9808	27.2690	.0009	.0719
1.9841	28.8540	.0008	.0718
1.9841	30.5311	.0008	.0718
1.9841	32.3056	.0007	.0717
1.9841	34.1833	.0006	.0717
1.9874	36.1702	.0005	.0716
1.9874	38.2765	.0005	.0717
1.9874	40.4970	.0004	.0717
1.9874	42.8508	.0004	.0719
1.9874	45.3414	.0003	.0724
1.9874	47.9767	.0003	.0731
1.9841	50.7653	.0003	.0730
1.9841	53.7159	.0002	.0729
1.9841	56.8310	.0002	.0731
1.9808	60.1446	.0002	.0728
1.9802	63.6372	.0002	.0723
1.9802	67.3360	.0002	.0722
1.9802	71.2498	.0001	.0721
1.9818	75.3910	.0001	.0720
1.9818	79.7769	.0001	.0719
1.9818	84.4096	.0001	.0719
1.9818	89.3157	.0001	.0719
1.9835	94.5970	.0001	.0720
1.9835	100.0000	.0001	.0722


AX RESPONSE
APRIL, 1971
+10
+1
.2
1.0
FREQ.CPS
10.0
100.0
VELOCITY

GENERALIZED SHOCK SPECTRUM

FOR

DAMPED AND UNDAMPED VIBRATIONS

INPUT DATA

NO OF POINTS IN TABLE	248
STARTING TIME	.0200
END TIME	4.9600
TIME INTERVAL	.0500
PERCENTAGE CRITICAL DAMPING	.0500
INITIAL DISPLACEMENT	0.0000
INITIAL VELOCITY	0.0000
NO OF CYCLES OF RESIDUAL VIBRATION	3
FACTOR FOR INTEGRATION TIME INTERVAL	5

STARTING FREQ. =	.2000
ENDING FREQ. =	100.0000
INTERVAL STEPS =	110.0

TIME TABLE

.0200	.0400	.0600	.0800	.1000	.1200	.1400	.1600	.1800
.2000	.2200	.2400	.2600	.2800	.3000	.3200	.3400	.3600
.3800	.4000	.4200	.4400	.4600	.4800	.5000	.5200	.5400
.5600	.5800	.6000	.6200	.6400	.6600	.6800	.7000	.7200
.7400	.7600	.7800	.8000	.8200	.8400	.8600	.8800	.9000
.9200	.9400	.9600	.9800	1.0000	1.0200	1.0400	1.0600	1.0800
1.1000	1.1200	1.1400	1.1600	1.1800	1.2000	1.2200	1.2400	1.2600
1.2800	1.3000	1.3200	1.3400	1.3600	1.3800	1.4000	1.4200	1.4400
1.4600	1.4800	1.5000	1.5200	1.5400	1.5600	1.5800	1.6000	1.6200
1.6400	1.6600	1.6800	1.7000	1.7200	1.7400	1.7600	1.7800	1.8000
1.8200	1.8400	1.8600	1.8800	1.9000	1.9200	1.9400	1.9600	1.9800
2.0000	2.0200	2.0400	2.0600	2.0800	2.1000	2.1200	2.1400	2.1600
2.1800	2.2000	2.2200	2.2400	2.2600	2.2800	2.3000	2.3200	2.3400
2.3600	2.3800	2.4000	2.4200	2.4400	2.4600	2.4800	2.5000	2.5200
2.5400	2.5600	2.5800	2.6000	2.6200	2.6400	2.6600	2.6800	2.7000
2.7200	2.7400	2.7600	2.7800	2.8000	2.8200	2.8400	2.8600	2.8800
2.9000	2.9200	2.9400	2.9600	2.9800	3.0000	3.0200	3.0400	3.0600
3.0800	3.1000	3.1200	3.1400	3.1600	3.1800	3.2000	3.2200	3.2400
3.2600	3.2800	3.3000	3.3200	3.3400	3.3600	3.3800	3.4000	3.4200
3.4400	3.4600	3.4800	3.5000	3.5200	3.5400	3.5600	3.5800	3.6000

3.6200	3.6400	3.6600	3.6800	3.7000	3.7200	3.7400	3.7600	3.7800
3.8000	3.8200	3.8400	3.8600	3.8800	3.9000	3.9200	3.9400	3.9600
3.9800	4.0000	4.0200	4.0400	4.0600	4.0800	4.1000	4.1200	4.1400
4.1600	4.1800	4.2000	4.2200	4.2400	4.2600	4.2800	4.3000	4.3200
4.3400	4.3600	4.3800	4.4000	4.4200	4.4400	4.4600	4.4800	4.5000
4.5200	4.5400	4.5600	4.5800	4.6000	4.6200	4.6400	4.6600	4.6800
4.7000	4.7200	4.7400	4.7600	4.7800	4.8000	4.8200	4.8400	4.8600
4.8800	4.9000	4.9200	4.9400	4.9600				

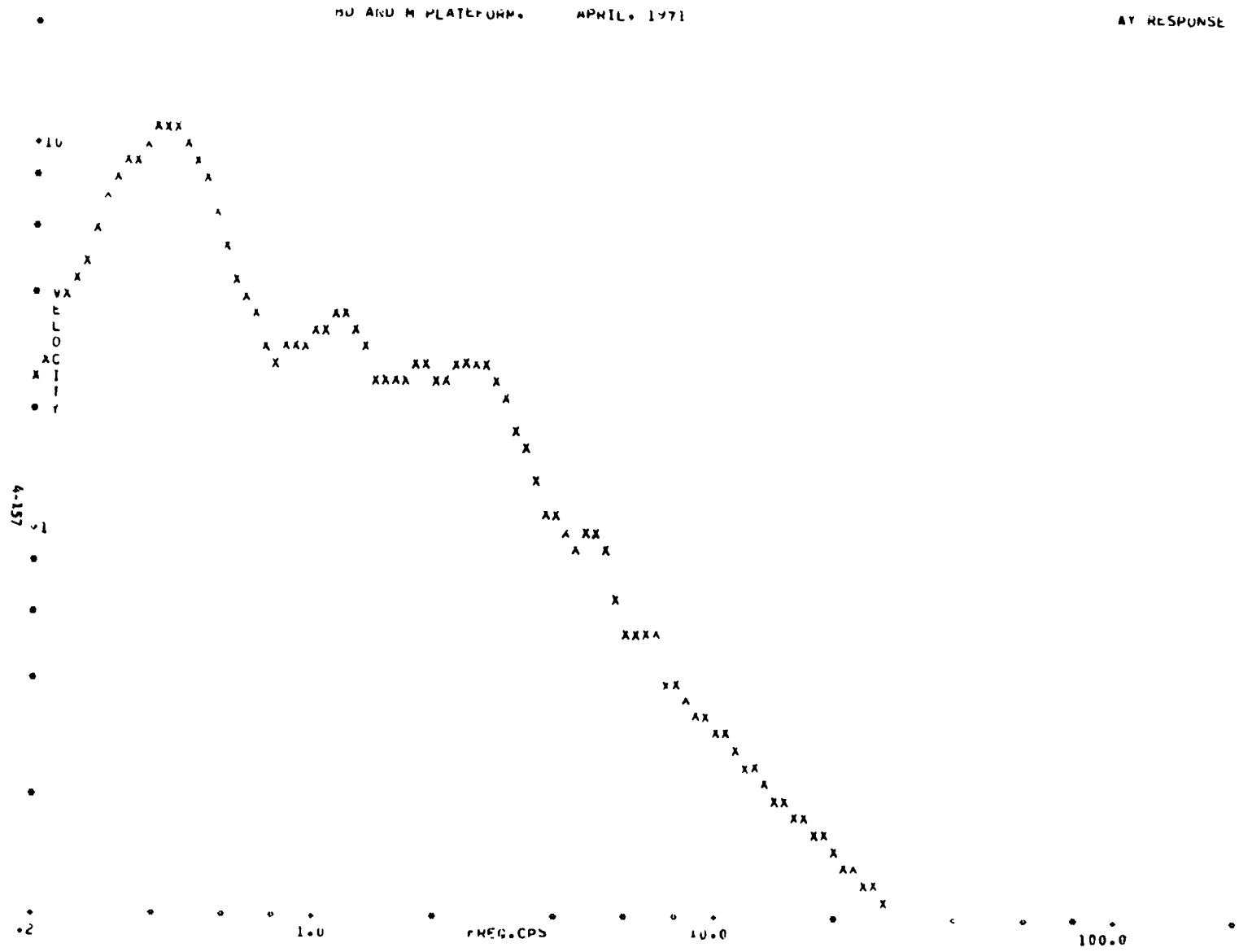
ACCL. TABLE IN IN/SEC. SQ.

.0031	.0956	.4797	1.1417	1.7538	2.1031	2.3919	2.7700	2.9838
2.5310	2.5698	2.5409	2.5613	2.2704	1.8269	1.7089	2.2336	3.0252
3.0914	2.2314	1.4231	1.7198	3.3027	5.2001	5.4786	3.8609	1.6664
.1745	-.3348	-.0060	1.0828	2.3387	2.8611	2.1803	.8292	-.3850
-1.1522	-1.8109	-2.6895	-3.3998	-3.0949	-1.4648	.7316	2.2002	2.1303
.7043	-.8361	-1.5150	-.7535	.9533	2.2971	1.9513	-.5369	-4.4674
-8.4594	-11.2625	-12.3266	-11.8569	-10.4756	-8.7982	-7.1837	-5.7104	-4.3004
-2.8577	-1.3486	.1758	1.5814	2.6572	3.1416	2.7911	1.4358	-.9736
-4.3247	-8.3168	-12.4678	-16.1762	-18.8728	-20.0109	-19.4756	-17.3356	-13.9745
-9.9829	-6.0355	-2.7509	-.5587	.3922	.2590	-.5479	-1.4884	-2.0478
-1.8734	-.8493	.9072	3.1111	5.4096	7.4471	8.9787	9.8512	10.0295
9.5736	8.6104	7.3032	5.8249	4.3370	2.9752	1.8406	.9958	.4646
.2367	.2793	.5527	1.0248	1.6801	2.5173	3.5368	4.7221	6.0207
7.3346	8.5233	9.4218	9.8708	9.7516	9.0206	7.7334	6.0523	4.2315
2.5809	1.4112	.9717	1.3960	2.6995	4.6290	6.9950	9.4272	11.5896
13.2092	14.1139	14.2480	13.6029	12.4918	10.9168	9.1353	7.3332	5.6657
4.2459	3.1374	2.3529	1.8496	1.5405	1.3033	1.0054	.5304	-.1955
-1.1860	-2.3408	-3.7073	-5.0024	-6.1412	-7.0124	-7.5469	-7.7253	-7.5764
-7.1675	-6.5405	-5.9490	-5.3454	-4.8719	-4.6027	-4.5877	-4.8463	-5.3636
-6.0375	-6.9439	-7.8266	-8.6318	-9.2044	-9.6531	-9.7594	-9.5792	-9.1398
-8.4922	-7.7023	-6.8421	-5.9836	-5.1928	-4.5264	-4.0274	-3.7215	-3.6143
-3.5706	-3.9158	-4.2411	-4.6109	-4.9071	-5.2672	-5.4671	-5.5439	-5.4863
-5.2753	-4.9861	-4.5808	-4.1117	-3.6136	-3.1288	-2.6825	-2.2974	-1.9808
-1.7237	-1.5142	-1.3221	-1.1246	-.9027	-.6437	-.3448	-.0104	.3498
.7228	1.0948	1.4526	1.7848	2.0833	2.3446	2.5712	2.7722	2.9628
3.1021	3.3900	3.6630	3.9905	4.3727	4.8001	5.2554	5.7154	6.1555
6.5520	6.8845	7.1378	7.3022	7.3793	7.3571	7.2605	7.1008	6.9003
6.6546	6.4810	6.3138	6.2018	6.1550				

END INPUT TO SPCTRM - AY

TIME SEC.	FREQUENCY C.P.S.	MAX.DISPLACEMENT INS.	MAX.ACCELERATION G'S
2.3912	.2000	1.9783	.0081
3.6262	.2118	2.0540	.0094
3.6262	.2239	2.2704	.0116
3.6262	.2369	2.4830	.0142
3.5768	.2507	2.6903	.0173
3.5768	.2653	2.8749	.0207
4.8612	.2807	3.0503	.0246
4.3119	.2970	3.4542	.0311
4.7624	.3143	3.7921	.0383
4.6635	.3325	4.0530	.0458
4.5645	.3519	4.2091	.0532
4.4660	.3723	4.2636	.0604
5.6369	.3940	4.3169	.0685
5.4396	.4169	4.3129	.0766
5.3378	.4411	4.1438	.0824
5.1743	.4667	3.8252	.0851
5.0950	.4939	3.3573	.0837
3.9226	.5226	2.7824	.0776
3.8238	.5529	2.3659	.0739
3.7250	.5851	1.9245	.0673
3.6756	.6191	1.4983	.0587
2.5394	.6551	1.1530	.0506
2.4900	.6931	.9744	.0478
2.4405	.7334	.8133	.0447
2.3912	.7761	.6802	.0419
2.3419	.8212	.5763	.0397
3.7250	.8689	.5552	.0428
3.6756	.9194	.5461	.0472
3.6756	.9728	.5356	.0518
3.6262	1.0294	.5316	.0576
3.5274	1.0892	.5333	.0646
3.4780	1.1525	.5307	.0720
3.4286	1.2195	.5034	.0765
3.3792	1.2904	.4452	.0757
3.3298	1.3654	.3849	.0695
2.8358	1.4448	.2879	.0614
2.1442	1.5287	.2617	.0625
2.0948	1.6176	.2527	.0676
2.0948	1.7116	.2463	.0737
2.5888	1.8111	.2458	.0824
2.5888	1.9163	.2323	.0872
2.5394	2.0277	.2128	.0894
1.6996	2.1456	.1957	.0921
1.6995	2.2703	.1993	.1050
1.6995	2.4022	.1904	.1123
1.6502	2.5419	.1801	.1189
1.6502	2.6896	.1662	.1228
1.6502	2.8459	.1387	.1148
2.8358	3.0114	.1249	.1194
2.7864	3.1864	.0991	.1028
1.6008	3.3716	.0830	.0964
1.6008	3.5676	.0640	.0832
2.0454	3.7744	.0503	.0733
2.7864	3.9943	.0473	.0771
1.9940	4.2265	.0407	.0742
1.6019	4.4721	.0346	.0707
1.6019	4.7321	.0337	.0771

1.5620	5.0071	.0348	.0891
1.5722	5.2901	.0330	.0946
1.5591	5.60[illegible]1	.0267	.0856
1.1635	5.9319	.0197	.0710
1.1570	6.2707	.0153	.0516
1.5920	6.6415	.0137	.0617
1.5785	7.0275	.0136	.0687
1.5557	7.4300	.0118	.0665
1.1273	7.8602	.0085	.0536
1.5722	8.3255	.0080	.0569
1.5656	8.8094	.0071	.0562
1.5656	9.3215	.0062	.0551
1.5656	9.8653	.0056	.0555
1.5656	10.4355	.0048	.0538
1.5656	11.0431	.0044	.0543
1.5656	11.6850	.0038	.0536
1.5656	12.3642	.0034	.0534
1.5656	13.0828	.0030	.0533
1.5656	13.8432	.0027	.0531
1.5656	14.6478	.0024	.0529
1.5656	15.4992	.0021	.0527
1.5656	16.4000	.0019	.0526
1.5656	17.3533	.0017	.0525
1.5656	18.3619	.0015	.0524
1.5656	19.4291	.0014	.0523
1.5656	20.5564	.0012	.0522
1.5656	21.7533	.0011	.0521
1.5656	23.0177	.0010	.0520
1.5656	24.3555	.0009	.0520
1.5656	25.7712	.0008	.0519
1.5656	27.2690	.0007	.0519
1.5656	28.8590	.0006	.0519
1.5656	30.5311	.0005	.0518
1.5656	32.3026	.0005	.0518
1.5689	34.1833	.0004	.0518
1.5689	36.1702	.0004	.0518
1.5689	38.2725	.0003	.0518
1.5689	40.4970	.0003	.0519
1.5689	42.8508	.0003	.0521
1.5689	45.3414	.0002	.0524
1.5656	47.9707	.0002	.0528
1.5656	50.7653	.0002	.0526
1.5656	53.7159	.0002	.0525
1.5623	56.8350	.0002	.0527
1.5623	60.1416	.0001	.0525
1.5618	63.6372	.0001	.0521
1.5618	67.3350	.0001	.0520
1.5618	71.2448	.0001	.0519
1.5618	75.3910	.0001	.0519
1.5618	79.7729	.0001	.0518
1.5634	84.4096	.0001	.0518
1.5634	89.3157	.0001	.0519
1.5634	94.5070	.0001	.0519
1.5634	100.0000	.0001	.0521


BD AND M PLATEFORM. APRIL, 1971
AY RESPONSE
VELOCITY
10
1
.2
1.0
FREQ.CPS
10.0
100.0

GENERALIZED SHOCK SPECTRUM

FOR

DAMPED AND UNDAMPED VIBRATIONS

INPUT DATA

NO OF POINTS IN TABLE	248
STARTING TIME	.0200
END TIME	4.9600
TIME INTERVAL	.0500
PERCENTAGE CRITICAL DAMPING	.0500
INITIAL DISPLACEMENT	0.0000
INITIAL VELOCITY	0.0000
NO OF CYCLES OF RESIDUAL VIBRATION	3
FACTOR FOR INTEGRATION TIME INTERVAL	5

STARTING FREQ. =	.2000
ENDING FREQ. =	100.0000
INTERVAL STEPS =	110.0

TIME TABLE

.0200	.0400	.0600	.0800	.1000	.1200	.1400	.1600	.1800
.2000	.2200	.2400	.2600	.2800	.3000	.3200	.3400	.3600
.3800	.4000	.4200	.4400	.4600	.4800	.5000	.5200	.5400
.5600	.5800	.6000	.6200	.6400	.6600	.6800	.7000	.7200
.7400	.7600	.7800	.8000	.8200	.8400	.8600	.8800	.9000
.9200	.9400	.9600	.9800	1.0000	1.0200	1.0400	1.0600	1.0800
1.1000	1.1200	1.1400	1.1600	1.1800	1.2000	1.2200	1.2400	1.2600
1.2800	1.3000	1.3200	1.3400	1.3600	1.3800	1.4000	1.4200	1.4400
1.4600	1.4800	1.5000	1.5200	1.5400	1.5600	1.5800	1.6000	1.6200
1.6400	1.6600	1.6800	1.7000	1.7200	1.7400	1.7600	1.7800	1.8000
1.8200	1.8400	1.8600	1.8800	1.9000	1.9200	1.9400	1.9600	1.9800
2.0000	2.0200	2.0400	2.0600	2.0800	2.1000	2.1200	2.1400	2.1600
2.1800	2.2000	2.2200	2.2400	2.2600	2.2800	2.3000	2.3200	2.3400
2.3600	2.3800	2.4000	2.4200	2.4400	2.4600	2.4800	2.5000	2.5200
2.5400	2.5600	2.5800	2.6000	2.6200	2.6400	2.6600	2.6800	2.7000
2.7200	2.7400	2.7600	2.7800	2.8000	2.8200	2.8400	2.8600	2.8800
2.9000	2.9200	2.9400	2.9600	2.9800	3.0000	3.0200	3.0400	3.0600
3.0800	3.1000	3.1200	3.1400	3.1600	3.1800	3.2000	3.2200	3.2400
3.2600	3.2800	3.3000	3.3200	3.3400	3.3600	3.3800	3.4000	3.4200
3.4400	3.4600	3.4800	3.5000	3.5200	3.5400	3.5600	3.5800	3.6000

3.6200	3.6400	3.6600	3.6800	3.7000	3.7200	3.7400	3.7600	3.7800
3.8000	3.8200	3.8400	3.8600	3.8800	3.9000	3.9200	3.9400	3.9600
3.9800	4.0000	4.0200	4.0400	4.0600	4.0800	4.1000	4.1200	4.1400
4.1600	4.1800	4.2000	4.220	4.2400	4.2600	4.2800	4.3000	4.3200
4.3400	4.3600	4.3800	4.4000	4.4200	4.4400	4.4600	4.4800	4.5000
4.5200	4.5400	4.5600	4.5800	4.6000	4.6200	4.6400	4.6600	4.6800
4.7000	4.7200	4.7400	4.7600	4.7800	4.8000	4.8200	4.8400	4.8600
4.8800	4.9000	4.9200	4.9400	4.9600				

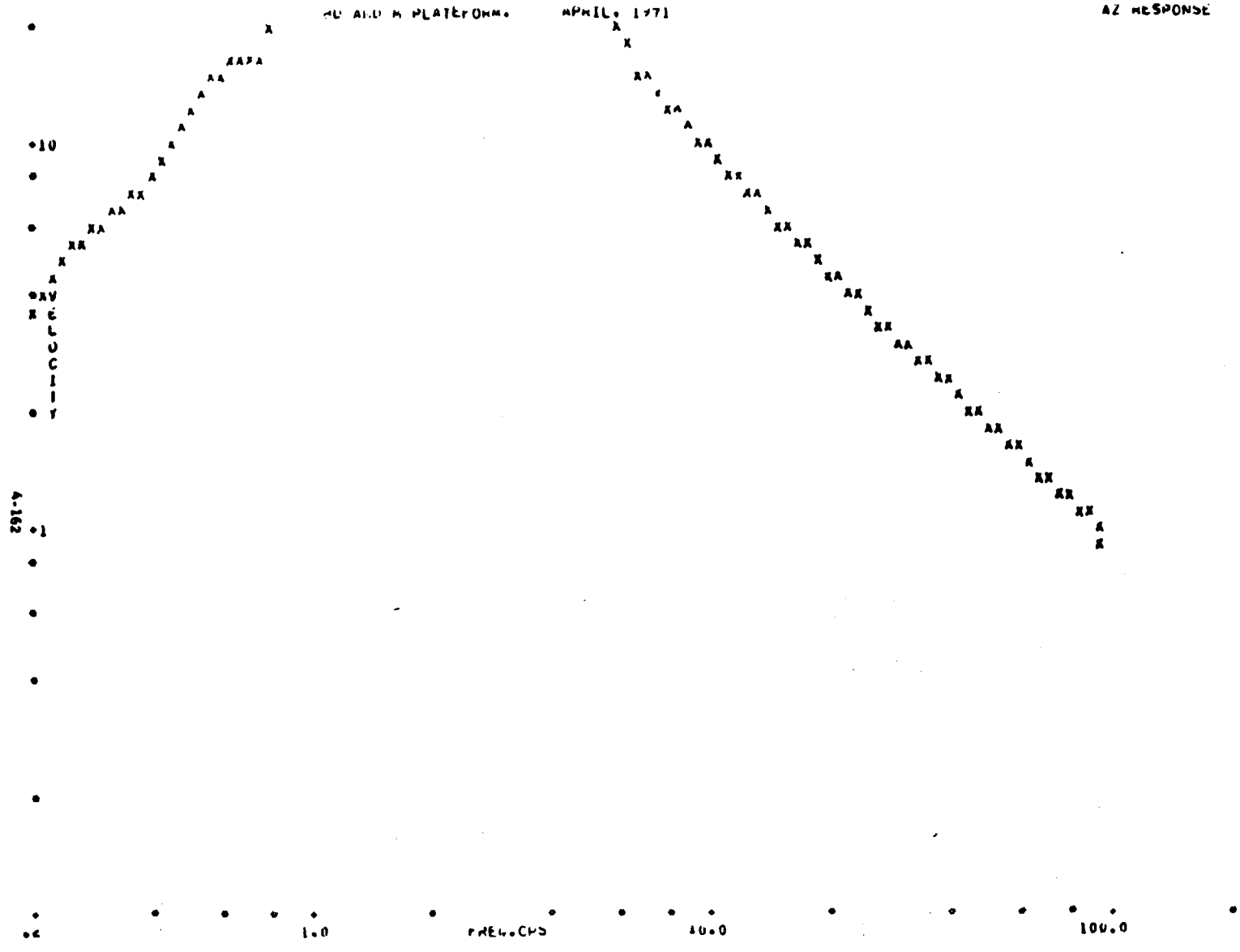
ACCL. TABLE IN IN/SEC. SQ.

.1082	3.4275	15.3379	36.4795	59.5309	69.7727	64.8446	48.6737	30.5715
14.5481	-4.3884	-33.9782	-73.6311	-109.9105	-124.3537	-108.9926	-74.7428	-42.8255
-26.5755	-18.3485	2.8585	48.7551	109.1301	152.1341	145.8829	88.8186	5.7265
-60.4494	-80.6545	-54.5242	-7.0212	27.9705	26.4511	-15.8210	-64.7438	-155.4760
-200.2408	-195.6013	-131.9556	-17.8019	122.0181	253.8523	344.0064	368.4810	317.9655
199.5915	33.6279	-150.5122	-320.0517	-443.8203	-497.8129	-470.3329	-364.2971	-195.8530
8.5281	218.3813	401.5651	532.3262	593.3747	578.2533	491.0991	344.9474	158.9594
-44.5626	-242.9135	-415.1320	-543.6055	-615.6394	-624.4479	-570.4077	-400.5042	-307.1385
-126.4321	63.6385	245.3896	402.7434	522.5996	595.5467	616.9241	586.3946	507.9228
389.1799	240.7982	75.5103	-92.8267	-250.2877	-384.0035	-483.2313	-540.3053	-551.3211
-516.4459	-439.8718	-329.3295	-195.3943	-50.5021	92.1322	219.6034	320.7493	386.5901
411.7783	394.8636	334.5448	249.4407	137.4477	14.7384	-105.4868	-210.3667	-288.7186
-332.2565	-336.5055	-301.2659	-230.6125	-132.4332	-17.5398	101.5340	211.9124	301.7825
361.6701	385.4302	370.8479	319.8011	237.9005	134.1308	19.1535	-95.2248	-197.6631
-278.3969	-330.2102	-349.0766	-334.4736	-289.2830	-219.3603	-132.7912	-38.9842	52.3632
132.2726	193.3657	231.5389	241.3041	229.1003	187.9403	131.6880	64.0088	-7.7451
-76.2059	-134.7017	-177.8567	-202.035	-203.5949	-188.9628	-154.3919	-105.8496	-48.3681
12.3825	70.6702	121.2265	159.6924	182.9573	189.3735	178.8765	152.9202	114.3311
67.6221	15.6293	-34.9244	-79.8867	-113.1109	-137.4499	-145.0394	-137.4690	-115.8079
-82.4910	-41.0746	4.1189	48.4294	87.3249	116.8531	134.0410	137.1913	126.0534
101.6419	67.1011	25.4367	-18.8696	-61.3002	-97.6113	-124.1978	-138.5308	-139.3714
-126.8840	-102.5972	-69.2207	-30.3373	9.4805	47.6376	78.8852	100.7611	111.3504
109.9624	97.1687	74.7053	45.2575	16.1472	-21.0344	-50.8116	-74.1837	-88.9198
-93.7670	-88.5424	-74.1150	-52.2750	-23.5135	3.2554	31.0269	55.0001	72.8672
83.6267	84.7175	78.0605	64.0089	44.2173	20.8456	-3.6749	-26.8957	-46.5886
-60.9565	-68.7912	-69.5686	-63.4713	-51.3417	-34.5735	-14.9553	5.5159	24.8332
41.1704	53.0473	59.4569	59.9433	54.6209	44.1754	29.7261	12.7669	-5.0123
-21.8632	-36.2434	-46.7663	-52.5223	-53.0308				

END INPUT TO SPCTRM - 02

TIME SEC.	FREQUENCY C.P.S.	MAX.DISPLACEMENT INS.	MAX.ACCELERATION G'S
1.6008	.2000	3.1065	.0127
1.6008	.2116	3.1564	.0144
1.6008	.2239	3.2049	.0164
1.6008	.2369	3.2508	.0186
1.6008	.2507	3.2924	.0211
1.6008	.2653	3.3278	.0239
1.6008	.2807	3.3548	.0270
1.6008	.2970	3.3710	.0304
1.6008	.3143	3.3738	.0340
1.6008	.3325	3.3604	.0380
1.5514	.3519	3.3360	.0422
1.5514	.3723	3.2995	.0467
1.5514	.3940	3.2411	.0514
1.7984	.4169	3.2060	.0569
1.7984	.4411	3.3872	.0673
1.7984	.4667	3.5735	.0795
1.7984	.4939	3.7529	.0935
1.7984	.5226	3.9107	.1091
1.7984	.5529	4.0303	.1259
1.7984	.5851	4.0953	.1432
1.7984	.6191	4.0918	.1602
1.7984	.6551	4.0125	.1759
1.7984	.6931	3.8601	.1895
1.7984	.7334	3.9512	.2007
2.5888	.7761	3.9648	.2255
2.5888	.8212	4.0533	.2793
2.5888	.8689	4.2131	.3250
2.5888	.9194	4.1650	.3597
2.5888	.9728	4.0374	.3904
2.5888	1.0294	4.0044	.4335
2.5888	1.0892	4.1614	.5044
2.5888	1.1525	4.4131	.5989
1.7984	1.2195	4.6954	.7134
1.7984	1.2904	4.9050	.8345
2.7864	1.3654	5.2910	1.0078
2.7864	1.4448	5.5243	1.1781
1.7984	1.5237	5.4557	1.3027
1.7984	1.6176	5.9763	1.5977
1.9960	1.7116	6.9871	2.0913
1.9960	1.8111	8.2974	2.7806
1.9960	1.9163	9.2088	3.4552
2.1936	2.0277	9.5855	4.0268
1.9466	2.1456	10.2291	4.8112
2.1442	2.2703	11.0515	5.8356
2.5394	2.4022	11.4728	6.7644
2.6876	2.5419	12.3252	8.1369
2.6382	2.6896	11.2607	8.3228
1.8474	2.8459	10.2619	8.4916
1.6512	3.0114	9.1835	7.5823
1.6008	3.1864	7.0191	7.2812
1.6008	3.3716	5.7081	6.6296
1.4032	3.5676	4.5396	5.9031
1.4032	3.7749	3.8510	5.6067
1.4032	3.9943	2.9552	4.8334
1.2031	4.2265	2.5983	4.7420
1.1899	4.4721	2.0669	4.2235
1.1767	4.7321	1.5519	3.5505

1.0350	5.0071	1.2799	3.2764
1.0216	5.2931	1.0238	2.9361
1.0187	5.6031	.7633	2.4508
.8867	5.9319	.6137	2.2064
1.1699	6.2707	.5021	2.2627
1.3778	6.6415	.4528	2.0406
1.3646	7.0275	.3652	1.8425
1.1965	7.4300	.3298	1.8631
1.3712	7.8802	.2938	1.8581
1.3778	8.3205	.2449	1.7342
1.3745	8.8094	.2248	1.7825
1.3745	9.3215	.1962	1.7418
1.3745	9.8653	.1739	1.7288
1.3745	10.4305	.1541	1.7154
1.3745	11.0431	.1367	1.7033
1.3745	11.6850	.1215	1.6945
1.3745	12.3042	.1079	1.6849
1.3745	13.0828	.0959	1.6766
1.3745	13.8432	.0853	1.6698
1.3745	14.6478	.0759	1.6637
1.3745	15.4992	.0675	1.6578
1.3745	16.4000	.0601	1.6529
1.3745	17.3533	.0536	1.6465
1.3745	18.3619	.0477	1.6447
1.3745	19.4291	.0426	1.6413
1.3712	20.5504	.0379	1.6384
1.3712	21.7533	.0338	1.6358
1.3712	23.0177	.0302	1.6337
1.3712	24.3555	.0269	1.6319
1.3712	25.7712	.0240	1.6304
1.3712	27.2690	.0214	1.6290
1.3712	28.8540	.0191	1.6280
1.3712	30.5311	.0171	1.6274
1.3712	32.3036	.0153	1.6269
1.3712	34.1853	.0136	1.6268
1.3712	36.1702	.0122	1.6272
1.3712	38.2725	.0109	1.6260
1.3712	40.4970	.0097	1.6258
1.3712	42.8508	.0087	1.6325
1.3679	45.3414	.0078	1.6390
1.3679	47.9707	.0071	1.6622
1.3646	50.7653	.0062	1.6425
1.3843	53.7159	.0056	1.6381
1.3811	56.8340	.0050	1.6506
1.3611	60.1416	.0044	1.6345
1.3790	63.6372	.0039	1.6265
1.3790	67.3350	.0035	1.6234
1.3790	71.2498	.0031	1.6210
1.3773	75.3910	.0028	1.6198
1.3773	79.7729	.0025	1.6190
1.3773	84.4096	.0022	1.6183
1.3757	89.3157	.0020	1.6187
1.3757	94.5070	.0018	1.6200
1.3740	100.0000	.0016	1.6238



END OF ANALYSIS

SECTION 9: EXAMPLE TO FVOUS

AN INDEPENDENT FVOUS RUN.

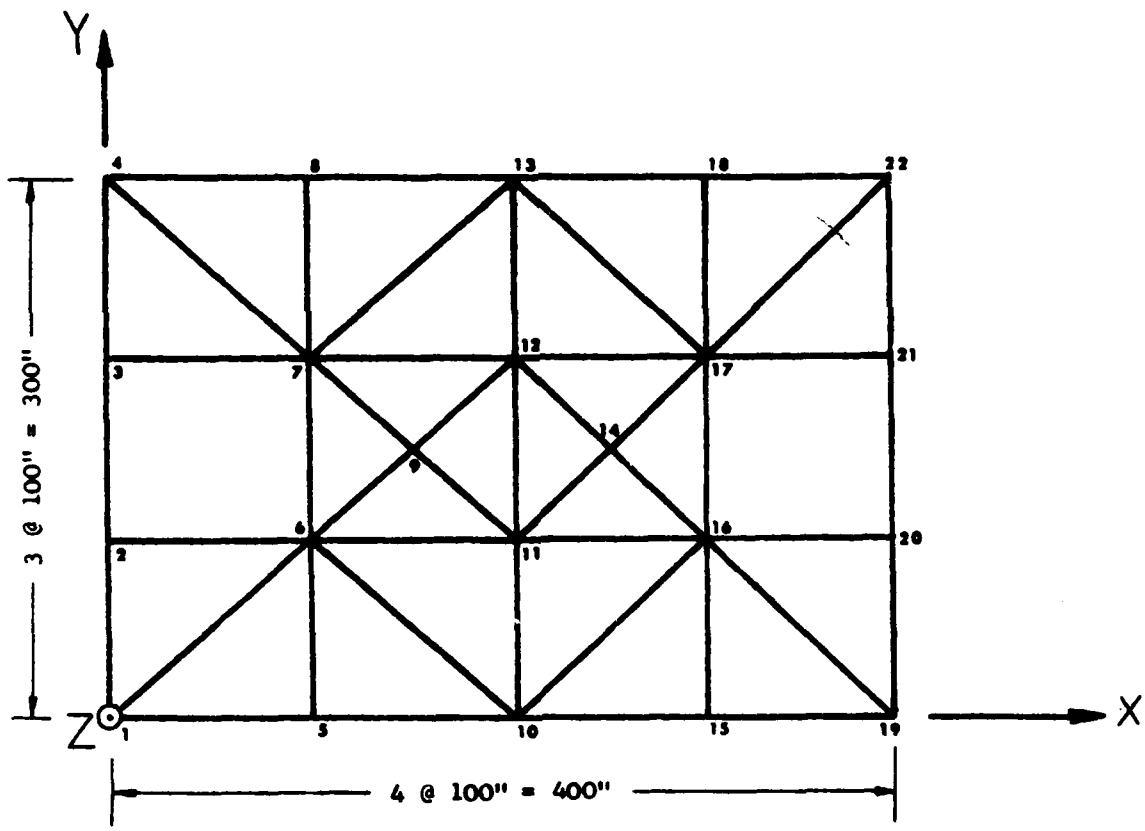
```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

       2       1       1       6                                                      1
   SAMPLE PROBLEM OF FLEXIBLE BODY MOTION                                             2
164200.   164200.   164200.   218900000.223400000.237100000.                         3
       6      10       1                                                              4
 .906601E-04-.473090E-04                                     .281601E-06             5
-.473090E-04 .141979E-03                                     -.47309E-06             6
                          .929184E-04-.322598E-06 .212252E-06                        7
                         -.322598E-06 .322598E-08                                    8
                          .212252E-06             .126340E-08                        9
 .281601E-06 -.47309E-06                                     .281601E-08            10
   0.4     0.5     0.6     0.7     0.8     0.9     1.0     2.0     3.0              11
   4.0                                                                              12
   4.486   4.797   4.738   4.279   4.459   3.541   3.690   4.945   3.711            13
   3.812                                                                            14
                                                                                    15
                                                                                    16
   6.039   5.698   5.029   4.096   3.217   2.848   2.826   2.679   1.438            17
   1.447                                                                            18
   3.784   4.079   3.758   3.301   3.141   3.312   3.426   3.790   2.508            19
   2.056                                                                            20
                                                                                    21
                                                                                    22
   5.234   4.861   4.222   3.386   2.596   2.586   2.561   1.971   1.022            23
   0.750                                                                            24
   3.274   3.500   3.209   2.788   2.979   3.116   3.197   2.985   1.970            25
   1.401                                                                            26
                                                                                    27
                                                                                    28
   4.592   4.207   3.602   2.858   2.385   2.367   2.338   1.490   0.787            29
   0.533                                                                            30
FINISH                                                                              31
```

THE RESULT OF THIS EXAMPLE RUN HAS BEEN DELETED.

SECTION 10: EXAMPLE TO 1S1P2

A platform, 300" x 400", is constructed by 12 WF 106 structural steel beams as shown. The platform is supported vertically by six spring-isolators at nodes 1, 4, 10, 13, 19, and 22. All nodes along the platform edges are loaded with a concentrated weight of 1500 lbs. each. The inner nodes (6,7,11, 12, 16, and 17) are loaded with 2000 lbs. each. Spring-isolators are provided at nodes 9 and 14 to eliminate possible platform rigid-body modes. All joints are rigidly welded. A top and a bottom covered plates, 0.25 inch thick each, are welded to the beams.



A 22-NODE PLATFORM IS ANALIZED HERE FIRST AS A NON-RIGID PLATFORM, THEN AS A RIGID ONE. PLATFORM IS SUPPORTED BY 6 SPRING-ISOLATORS. EXTRA SPRINGS ARE USED FOR THE PURPOSE OF ELIMINATING THE RIGID BODY MODES.
ALL BEAM ELEMENTS ARE OF 12WF-106 LB. TYPE.
PLATFORM IS SANDWICHED BY TOP AND BOTTEM PLATES WHICH ARE 1/4 IN. THICK.

```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

         3       1       0                                                            1
 A 22-NODE PLATFORM DYNAMIC ANALYSIS (NON-RIGID PLATFORM)                             2
        22      47       8      40                                                    3
         1     0.0     0.0                                                            4
         2     0.0   100.0                                                            5
         3     0.0   200.0                                                            6
         4     0.0   300.0                                                            7
         5   100.0     0.0                                                            8
         6   100.0   100.0                                                            9
         7   100.0   200.0                                                           10
         8   100.0   300.0                                                           11
         9   150.0   150.0                                                           12
        10   200.0     0.0                                                           13
        11   200.0   100.0                                                           14
        12   200.0   200.0                                                           15
        13   200.0   300.0                                                           16
        14   250.0   150.0                                                           17
        15   300.0     0.0                                                           18
        16   300.0   100.0                                                           19
        17   300.0   200.0                                                           20
        18   300.0   300.0                                                           21
        19   400.0     0.0                                                           22
        20   400.0   100.0                                                           23
        21   400.0   200.0                                                           24
        22   400.0   300.0                                                           25
  1  2ST930.7   300.9   31.19   6.45    6.45    12.25   12.25   0.25    0.25         26
  2  3**                                                                              27
  3  4**                                                                              28
  5  6**                                                                              29
  6  7**                                                                              30
  7  8**                                                                              31
 10 11**                                                                              32
 11 12**                                                                              33
 12 13**                                                                              34
 15 16**                                                                              35
 16 17**                                                                              36
 17 18**                                                                              37
 19 20**                                                                              38
 20 21**                                                                              39
 21 22**                                                                              40
  1  5ST930.7   300.9   31.19   6.45    6.45    12.25   12.25   0.25    0.25         41
  5 10**                                                                              42
 10 15**                                                                              43
 15 19**                                                                              44
  2  6**                                                                              45
  6 11**                                                                              46
```

```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+   NO.
 11 16**                                                                              47
 16 20**                                                                              48
  3  7**                                                                              49
  7 12**                                                                              50
 12 17**                                                                              51
 17 21**                                                                              52
  4  8**                                                                              53
  8 13**                                                                              54
 13 18**                                                                              55
 18 22**                                                                              56
  1  6ST930.7   300.9   31.19   6.45    6.45    12.25   12.25   0.25    0.25         57
 10 16**                                                                              58
  7 13**                                                                              59
 17 22**                                                                              60
 10  6ST930.7   300.9   31.19   6.45    6.45    12.25   12.25   0.25    0.25         61
 19 16**                                                                              62
  7  4**                                                                              63
 17 13**                                                                              64
  7  9ST930.7   300.9   31.19   6.45    6.45    12.25   12.25   0.25    0.25         65
  9 11**                                                                              66
 12 14**                                                                              67
 14 16**                                                                              68
  9  6ST930.7   300.9   31.19   6.45    6.45    12.25   12.25   0.25    0.25         69
 12  9**                                                                              70
 14 11**                                                                              71
 17 14**                                                                              72
       1                 5.0E+06                                                      73
       4                 5.0E+06                                                      74
      10                 5.0E+06                                                      75
      13                 5.0E+06                                                      76
      19                 5.0E+06                                                      77
      22                 5.0E+06                                                      78
       9 5.0E+06 5.0E+06                        5.0E+06                               79
      14 5.0E+06 5.0E+06                        5.0E+06                               80
1500.0    1500.0    1500.0                                                            81
1500.0    1500.0    1500.0                                                            82
1500.0    1500.0    1500.0                                                            83
1500.0    1500.0    1500.0                                                            84
1500.0    1500.0    1500.0                                                            85
2000.0    2000.0    2000.0                                                            86
2000.0    2000.0    2000.0                                                            87
1500.0    1500.0    1500.0                                                            88
0.0       0.0       0.0                                                               89
1500.0    1500.0    1500.0                                                            90
2000.0    2000.0    2000.0                                                            91
2000.0    2000.0    2000.0                                                            92
1500.0    1500.0    1500.0                                                            93
0.0       0.0       0.0                                                               94
1500.0    1500.0    1500.0                                                            95
2000.0    2000.0    2000.0                                                            96
2000.0    2000.0    2000.0                                                            97
1500.0    1500.0    1500.0                                                            98
1500.0    1500.0    1500.0                                                            99
```

```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

1500.0    1500.0    1500.0                                                          100
1500.0    1500.0    1500.0                                                          101
1500.0    1500.0    1500.0                                                          102
      10        3        1                                                          103
     0.2      5.9   200.0                                                           104
7.5       7.5       0.007                                                           105
                                                                                     106
7.5       7.5       0.007                                                           107
6.0       6.0       0.0041                                                          108
                                                                                     109
6.0       6.0       0.0041                                                          110
4.0       4.0       0.0037                                                          111
                                                                                     112
4.0       4.0       0.0037                                                          113
REPEAT                                                                               114
       2        0                                                                    115
     A 22-NODE PLATFORM DYNAMIC ANALYSIS   (PLATFORM ASSUMED RIGID)                  116
1500.0    0.0       0.0                                                             117
1500.0    0.0       100.0                                                           118
1500.0    0.0       200.0                                                           119
1500.0    0.0       300.0                                                           120
1500.0    100.0     0.0                                                             121
2000.0    100.0     100.0                                                           122
2000.0    100.0     200.0                                                           123
1500.0    100.0     300.0                                                           124
1500.0    200.0     0.0                                                             125
2000.0    200.0     100.0                                                           126
2000.0    200.0     200.0                                                           127
1500.0    200.0     300.0                                                           128
1500.0    300.0     0.0                                                             129
2000.0    300.0     100.0                                                           130
2000.0    300.0     200.0                                                           131
1500.0    300.0     300.0                                                           132
1500.0    400.0     0.0                                                             133
1500.0    400.0     100.0                                                           134
1500.0    400.0     200.0                                                           135
1500.0    400.0     300.0                                                           136
                                                                                     137
5000000.  0.0       0.0       0.0       0.0       0.0       -50.0                   138
5000000.  0.0       0.0       300.0     300.0     0.0       -50.0                   139
5000000.  200.0     200.0     0.0       0.0       0.0       -50.0                   140
5000000.  200.0     200.0     300.0     300.0     0.0       -50.0                   141
5000000.  400.0     400.0     0.0       0.0       0.0       -50.0                   142
5000000.  400.0     400.0     300.0     300.0     0.0       -50.0                   143
5000000.  150.0     100.0     150.0     150.0     0.0       0.0                     144
5000000.  250.0     200.0     150.0     150.0     0.0       0.0                     145
5000000.  150.0     150.0     150.0     100.0     0.0       0.0                     146
5000000.  250.0     250.0     150.0     100.0     0.0       0.0                     147
                                                                                     148
       6        3        1                                                           149
     0.2      5.9   200.0                                                           150
7.5       7.5       0.007                                                           151
                                                                                     152
```

```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

7.5      7.5       0.007                                                             153
6.0      6.0       0.0041                                                            154
                                                                                     155
6.0      6.0       0.0041                                                            156
4.0      4.0       0.0037                                                            157
                                                                                     158
4.0      4.0       0.0037                                                            159
FINISH                                                                               160
```

THE RESULT OF THIS EXAMPLE RUN IS PRESENTED ON THE FOLLOWING PAGES.

AD-A094 299 ARMY ENGINEER DIV HUNTSVILLE AL F/G 14/2
SHOCK TEST PROGRAM. SHOCK ISOLATION DESIGN MANUAL FOR SAFEGUARD--ETC(U)
AUG 73 G C CHAN, R YANG, H SAFFELL, C C HUANG
UNCLASSIFIED HNDSP-73-98-ED-R NL

7 OF 7
AD
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DATE
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3-81
DTIC

A 22-NODE PLATFORM DYNAMIC ANALYSIS (NON-RIGID PLATFORM)

NON-RIGID PLATFORM ANALYSIS

NO. OF NODES = 22

TOTAL NO. OF BEAM ELEMENTS = 47

TOTAL NO. OF SPRING ELEMENTS = 8

MAX. MATRIX SIZE TO BE PRINTED = 40 BY 40

NODE PT.	X COORD IN.	Y COORD IN.
1	0.000	0.000
2	0.000	100.000
3	0.000	200.000
4	0.000	300.000
5	100.000	0.000
6	100.000	100.000
7	100.000	200.000
8	100.000	300.000
9	150.000	150.000
10	200.000	0.000
11	200.000	100.000
12	200.000	200.000
13	200.000	300.000
14	250.000	150.000
15	300.000	0.000
16	300.000	100.000
17	300.000	200.000
18	300.000	300.000
19	400.000	0.000
20	400.000	100.000
21	400.000	200.000
22	400.000	300.000

FIRST AND SEOND NODES, MATERIAL, INERTIA, AREA, C-DISTANCES, AND BEAM WIDTHS

1	2	ST	930.700	300.900	31.190	6.450	6.450	12.250	12.250	.250	.250
			(1282.182)	(480.023)							

COORD. TRANSF. ANG. (DEG.) = -90.0000

.462E+06	.454E-04	0.	0.	0.	.231E+08	-.462E+06	-.454E-04	0.	0.	0.	.231E+08
.454E-04	.936E+07	0.	0.	0.	-.118E-03	-.454E-04	-.936E+07	0.	0.	0.	-.118E-03
0.	0.	.173E+06	-.864E+07	.441E-04	0.	0.	0.	-.173E+06	-.864E+07	.441E-04	0.
0.	0.	-.864E+07	.576E+09	-.193E-02	0.	0.	0.	.864E+07	.288E+09	-.248E-02	0.
0.	0.	.441E-04	-.193E-02	.198E+09	0.	0.	0.	-.441E-04	-.248E-02	-.198E+09	0.
.231E+08	-.118E-03	0.	0.	0.	.154E+10	-.231E+08	.118E-03	0.	0.	0.	.769E+09
-.462E+06	-.454E-04	0.	0.	0.	-.231E+08	.462E+06	.454E-04	0.	0.	0.	-.231E+08
-.454E-04	-.936E+07	0.	0.	0.	.118E-03	.454E-04	.936E+07	0.	0.	0.	.118E-03
0.	0.	-.173E+06	.864E+07	-.441E-04	0.	0.	0.	.173E+06	.864E+07	-.441E-04	0.
0.	0.	-.864E+07	.288E+09	-.248E-02	0.	0.	0.	.864E+07	.576E+09	-.193E-02	0.
0.	0.	.441E-04	-.248E-02	-.198E+09	0.	0.	0.	-.441E-04	-.193E-02	.198E+09	0.
.231E+08	-.118E-03	0.	0.	0.	.769E+09	-.231E+08	.118E-03	0.	0.	0.	.154E+10

2	3	DITTO
3	4	DITTO
5	6	DITTO
6	7	DITTO
7	8	DITTO
10	11	DITTO
11	12	DITTO
12	13	DITTO
15	16	DITTO

16	17	DITTO
17	18	DITTO
19	20	DITTO
20	21	DITTO
21	22	DITTO

1	5	ST	930.700 (1282.182)	300.900 (480.023)	31.190	6.450	6.450	12.250	12.250	.250	.250

.936E+07	0.	0.	0.	0.	0.	-.936E+07	0.	0.	0.	0.	0.
0.	.462E+06	0.	0.	0.	.231E+08	0.	-.462E+06	0.	0.	0.	.231E+08
0.	0.	.173E+06	0.	-.864E+07	0.	0.	0.	-.173E+06	0.	-.864E+07	0.
0.	0.	0.	.198E+09	0.	0.	0.	0.	0.	-.198E+09	0.	0.
0.	0.	-.864E+07	0.	.576E+09	0.	0.	0.	.864E+07	0.	.288E+09	0.
0.	.231E+08	0.	0.	0.	.154E+10	0.	-.231E+08	0.	0.	0.	.769E+09
-.936E+07	0.	[illegible]	0.	0.	0.	.936E+07	0.	0.	0.	0.	0.
0.	-.462E+06	0.	0.	0.	-.231E+08	0.	.462E+06	0.	0.	0.	-.231E+08
0.	0.	-.173E+06	0.	.864E+07	0.	0.	0.	.173E+06	0.	.864E+07	0.
0.	0.	0.	-.198E+09	0.	0.	0.	0.	0.	.198E+09	0.	0.
0.	0.	-.864E+07	0.	.288E+09	0.	0.	0.	.864E+07	0.	.576E+09	0.
0.	.231E+08	0.	0.	0.	.769E+09	0.	-.231E+08	0.	0.	0.	.154E+10

5	10	DITTO
10	15	DITTO
15	19	DITTO
2	6	DITTO
6	11	DITTO
11	16	DITTO
16	20	DITTO

3	7	DITTO
7	12	DITTO
12	17	DITTO
17	21	DITTO
4	8	DITTO
8	13	DITTO
13	18	DITTO
18	22	DITTO

1	6	ST	930.700 (1282.182)	300.900 (480.023)	31.190	6.450	6.450	12.250	12.250	.250	.250

COORD. TRANSF. ANG. (DEG.) = -45.0000

.339E+07	-.323E+07	0.	0.	0.	.816E+07	-.339E+07	.323E+07	0.	0.	0.	.816E+07
-.323E+07	.339E+07	0.	0.	0.	.816E+07	.323E+07	-.339E+07	0.	0.	0.	.816E+07
0.	0.	.611E+05	-.305E+07	-.305E+07	0.	0.	0.	-.611E+05	-.305E+07	-.305E+07	0.
0.	0.	-.305E+07	.274E+09	.134E+09	0.	0.	0.	.305E+07	.317E+08	.172E+09	0.
0.	0.	-.305E+07	.134E+09	.274E+09	0.	0.	0.	.305E+07	.172E+09	.317E+08	0.
.816E+07	.816E+07	0.	0.	0.	.109E+10	-.816E+07	-.816E+07	0.	0.	0.	.544E+09
-.339E+07	.323E+07	0.	0.	0.	-.816E+07	.339E+07	-.323E+07	0.	0.	0.	-.816E+07
.323E+07	-.339E+07	0.	0.	0.	-.816E+07	-.323E+07	.339E+07	0.	0.	0.	-.816E+07
0.	0.	-.611E+05	.305E+07	.305E+07	0.	0.	0.	.611E+05	.305E+07	.305E+07	0.
0.	0.	-.305E+07	.317E+08	.172E+09	0.	0.	0.	.305E+07	.274E+09	.134E+09	0.
0.	0.	-.305E+07	.172E+09	.317E+08	0.	0.	0.	.305E+07	.134E+09	.274E+09	0.
.816E+07	.816E+07	0.	0.	0.	.544E+09	-.816E+07	-.816E+07	0.	0.	0.	.109E+10

10	16	DITTO
7	13	DITTO

17 22 DITTO

10 6 ST 930.700 300.900 31.190 6.450 6.450 12.250 12.250 .250 .250
(1282.182) (480.023)

COORD. TRANSF. ANG. (DEG.) = 45.0000

.339E+07	.323E+07	0.	0.	0.	-.816E+07	-.339E+07	-.323E+07	0.	0.	0.	-.816E+07
.323E+07	.339E+07	0.	0.	0.	.816E+07	-.323E+07	-.339E+07	0.	0.	0.	.816E+07
0.	0.	.611E+05	.305E+07	-.305E+07	0.	0.	0.	-.611E+05	.305E+07	-.305E+07	0.
0.	0.	.305E+07	.274E+09	-.134E+09	0.	0.	0.	-.305E+07	.317E+08	-.172E+09	0.
0.	0.	-.305E+07	-.134E+09	.274E+09	0.	0.	0.	.305E+07	-.172E+09	.317E+08	0.
-.816E+07	.816E+07	0.	0.	0.	.109E+10	.816E+07	-.816E+07	0.	0.	0.	.544E+09
-.339E+07	-.323E+07	0.	0.	0.	.816E+07	.339E+07	.323E+07	0.	0.	0.	.816E+07
-.323E+07	-.339E+07	0.	0.	0.	-.816E+07	.323E+07	.339E+07	0.	0.	0.	-.816E+07
0.	0.	-.611E+05	-.305E+07	.305E+07	0.	0.	0.	.611E+05	-.305E+07	.305E+07	0.
0.	0.	.305E+07	.317E+08	-.172E+09	0.	0.	0.	-.305E+07	.274E+09	-.134E+09	0.
0.	0.	-.305E+07	-.172E+09	.317E+08	0.	0.	0.	.305E+07	-.134E+09	.274E+09	0.
-.816E+07	.816E+07	0.	0.	0.	.544E+09	.816E+07	-.816E+07	0.	0.	0.	.109E+10

19 16 DITTO

7 4 DITTO

17 13 DITTO

7 9 ST 930.700 300.900 31.190 6.450 6.450 12.250 12.250 .250 .250
(1282.182) (480.023)

COORD. TRANSF. ANG. (DEG.) = 45.0000

.727E+07	.596E+07	0.	0.	0.	-.326E+08	-.727E+07	-.596E+07	0.	0.	0.	-.326E+08
.596E+07	.727E+07	0.	0.	0.	.326E+08	-.596E+07	-.727E+07	0.	0.	0.	.326E+08
0.	0.	.489E+06	.122E+08	-.122E+08	0.	0.	0.	-.489E+06	.122E+08	-.122E+08	0.
0.	0.	.122E+08	.548E+09	-.267E+09	0.	0.	0.	-.122E+08	.634E+08	-.344E+09	0.
0.	0.	-.122E+08	-.267E+09	.548E+09	0.	0.	0.	.122E+08	-.344E+09	.634E+08	0.
-.326E+08	.326E+08	0.	0.	0.	.218E+10	.326E+08	-.326E+08	0.	0.	0.	.109E+10
-.727E+07	-.596E+07	0.	0.	0.	.326E+08	.727E+07	.596E+07	0.	0.	0.	.326E+08
-.596E+07	-.727E+07	0.	0.	0.	-.326E+08	.596E+07	.727E+07	0.	0.	0.	-.326E+08
0.	0.	-.489E+06	-.122E+08	.122E+08	0.	0.	0.	.489E+06	-.122E+08	.122E+08	0.
0.	0.	.122E+08	.634E+08	-.344E+09	0.	0.	0.	-.122E+08	.548E+09	-.267E+09	0.
0.	0.	-.122E+08	-.344E+09	.634E+08	0.	0.	0.	.122E+08	-.267E+09	.548E+09	0.
-.326E+08	.326E+08	0.	0.	0.	.109E+10	.326E+08	-.326E+08	0.	0.	0.	.218E+10

9 11 DITTO

```
                    12        14        DITTO

                    14        16        DITTO

        9        6       ST   930.700   300.900    31.190     6.450     6.450    12.250    12.250      .250      .250
                             (1282.182) (480.023)

COORD. TRANSF. ANG. (DEG.) =   -45.0000

 .727E+07 -.596E+07 0.        0.        0.        .326E+08 -.727E+07  .596E+07 0.        0.        0.        .326E+08
-.596E+07  .727E+07 0.        0.        0.        .326E+08  .596E+07 -.727E+07 0.        0.        0.        .326E+08
0.        0.        .489E+06 -.122E+06 -.122E+08 0.        0.        0.        -.489E+06 -.122E+08 -.122E+08 0.
0.        0.       -.122E+08  .548E+09  .267E+09 0.        0.        0.         .122E+08  .634E+08  .344E+09 0.
0.        0.       -.122E+08  .267E+09  .548E+09 0.        0.        0.         .122E+08  .344E+09  .634E+08 0.
 .326E+08  .326E+08 0.        0.        0.        .218E+10 -.326E+08 -.326E+08 0.        0.        0.        .109E+10
-.727E+07  .596E+07 0.        0.        0.       -.326E+08  .727E+07 -.596E+07 0.        0.        0.       -.326E+08
 .596E+07 -.727E+07 0.        0.        0.       -.326E+08 -.596E+07  .727E+07 0.        0.        0.       -.326E+08
0.        0.       -.489E+06  .122E+08  .122E+08 0.        0.        0.         .489E+06  .122E+08  .122E+08 0.
0.        0.       -.122E+08  .634E+08  .344E+09 0.        0.        0.         .122E+08  .548E+09  .267E+09 0.
0.        0.       -.122E+08  .344E+09  .634E+08 0.        0.        0.         .122E+08  .267E+09  .548E+09 0.
 .326E+08  .326E+08 0.        0.        0.        .109E+10 -.326E+08 -.326E+08 0.        0.        0.        .218E+10

                    12         9        DITTO

                    14        11        DITTO

                    17        14        DITTO


SPRING ISOLATOR, ATTACHED TO NODE      1

     R1,R2,...,R6 =        -0.          -0.          .5000E+07   -0.          -0.          -0.


SPRING ISOLATOR, ATTACHED TO NODE      4

     R1,R2,...,R6 =        -0.          -0.          .5000E+07   -0.          -0.          -0.


SPRING ISOLATOR, ATTACHED TO NODE     10

     R1,R2,...,R6 =        -0.          -0.          .5000E+07   -0.          -0.          -0.
```

```
SPRING ISOLATOR, ATTACHED TO NODE      13
     R1,R2,...,R6 =        -0.          -0.          .5000E+07   -0.          -0.          -0.

SPRING ISOLATOR, ATTACHED TO NODE      19
     R1,R2,...,R6 =        -0.          -0.          .5000E+07   -0.          -0.          -0.

SPRING ISOLATOR, ATTACHED TO NODE      22
     R1,R2,...,R6 =        -0.          -0.          .5000E+07   -0.          -0.          -0.

SPRING ISOLATOR, ATTACHED TO NODE       9
     R1,R2,...,R6 =        .5000E+07    .5000E+07   -0.          -0.          -0.          .5000E+07

SPRING ISOLATOR, ATTACHED TO NODE      14
     R1,R2,...,R6 =        .5000E+07    .5000E+07   -0.          -0.          -0.          .5000E+07
```

PLATFORM STIFFNESS MATRIX

1)									
.132E+08	-.323E+07	0.	0.	0.	.312E+08	-.462E+06	-.454E-04	0.	0.
0.	.231E+08	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	-.936E+07	0.	0.	0.	0.	0.
-.339E+07	.323E+07	0.	0.	0.	.816E+07	0.	0.	0.	0.
2)									
-.323E+07	.132E+08	0.	0.	0.	.312E+08	-.454E-04	-.936E+07	0.	0.
0.	-.118E-03	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	-.462E+06	0.	0.	0.	.231E+08
.323E+07	-.339E+07	0.	0.	0.	.816E+07	0.	0.	0.	0.
3)									
0.	0.	.541E+07	-.117E+08	-.117E+08	0.	0.	0.	-.173E+06	-.864E+07
.441E-04	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	-.173E+06	0.	-.864E+07	0.
0.	0.	-.611E+05	-.305E+07	-.305E+07	0.	0.	0.	0.	0.
4)									
0.	0.	-.117E+08	.105E+10	.134E+09	0.	0.	0.	.864E+07	.288E+09
-.248E-02	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	-.198E+09	0.	0.
0.	0.	.305E+07	.317E+08	.172E+09	0.	0.	0.	0.	0.
5)									
0.	0.	-.117E+08	.134E+09	.105E+10	0.	0.	0.	-.441E-04	-.248E-02
-.198E+09	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	.864E+07	0.	.288E+09	0.
0.	0.	.305E+07	.172E+09	.317E+08	0.	0.	0.	0.	0.
6)									
.312E+08	.312E+08	0.	0.	0.	.417E+10	-.231E+08	.118E-03	0.	0.
0.	.769E+09	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	-.231E+08	0.	0.	0.	.769E+09
-.816E+07	-.816E+07	0.	0.	0.	.544E+09	0.	0.	0.	0.
7)									
-.462E+06	-.454E-04	0.	0.	0.	-.231E+08	.103E+08	.908E-04	0.	0.
0.	0.	-.462E+06	-.454E-04	0.	0.	0.	.231E+08	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
-.936E+07	0.	0.	0.	0.	0.	0.	0.	0.	0.
8)									
-.454E-04	-.936E+07	0.	0.	0.	.118E-03	.908E-04	.192E+08	0.	0.
0.	.231E+08	-.454E-04	-.936E+07	0.	0.	0.	-.118E-03	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	-.462E+06	0.	0.	0.	.231E+08	0.	0.	0.	0.
9)									
0.	0.	-.173E+06	.864E+07	-.441E-04	0.	0.	0.	.518E+06	0.
-.864E+07	0.	0.	0.	-.173E+06	-.864E+07	.441E-04	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	-.173E+06	0.	-.864E+07	0.	0.	0.	0.	0.
10)									
0.	0.	-.864E+07	.288E+09	-.248E-02	0.	0.	0.	0.	.135E+10
-.386E-02	0.	0.	0.	.864E+07	.288E+09	-.248E-02	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	-.198E+09	0.	0.	0.	0.	0.	0.
11)									
0.	0.	.441E-04	-.248E-02	-.198E+09	0.	0.	0.	-.864E+07	-.386E-02
.973E+09	0.	0.	0.	-.441E-04	-.248E-02	-.198E+09	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	.864E+07	0.	.288E+09	0.	0.	0.	0.	0.
12)									
.231E+08	-.118E-03	0.	0.	0.	.769E+09	0.	.231E+08	0.	0.
0.	.462E+10	-.231E+08	.118E-03	0.	0.	0.	.769E+09	0.	0.

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	-.231E+08	0.	0.	0.	.769E+09	0.	0.	0.	0.
13)									
0.	0.	0.	0.	0.	0.	-.462E+06	-.454E-04	0.	0.
0.	-.231E+08	.103E+08	.908E-04	0.	0.	0.	0.	-.462E+06	-.454E-04
0.	0.	0.	.231E+08	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	-.936E+07	0.	0.	0.
14)									
0.	0.	0.	0.	0.	0.	-.454E-04	-.936E+07	0.	0.
0.	.118E-03	.908E-04	.192E+08	0.	0.	0.	.231E+08	-.454E-04	-.936E+07
0.	0.	0.	-.118E-03	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	-.462E+06	0.	0.
15)									
0.	0.	0.	0.	0.	0.	0.	0.	-.173E+06	.864E+07
-.441E-04	0.	0.	0.	.518E+06	0.	-.864E+07	0.	0.	0.
-.173E+06	-.864E+07	.441E-04	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	-.173E+06	0.
16)									
0.	0.	0.	0.	0.	0.	0.	0.	-.864E+07	.288E+09
-.248E-02	0.	0.	0.	0.	.135E+10	-.386E-02	0.	0.	0.
.864E+07	.288E+09	-.248E-02	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	-.198E+09
17)									
0.	0.	0.	0.	0.	0.	0.	0.	.441E-04	-.248E-02
-.198E+09	0.	0.	0.	-.864E+07	-.386E-02	.973E+09	0.	0.	0.
-.441E-04	-.248E-02	-.198E+09	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	.864E+07	0.
18)									
0.	0.	0.	0.	0.	0.	.231E+08	-.118E-03	0.	0.
0.	.769E+09	0.	.231E+08	0.	0.	0.	.462E+10	-.231E+08	.118E-03
0.	0.	0.	.769E+09	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	-.231E+08	0.	0.
19)									
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	-.462E+06	-.454E-04	0.	0.	0.	-.231E+08	.132E+08	.323E+07
0.	0.	0.	-.149E+08	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	-.339E+07	-.323E+07	0.	0.
20)									
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	-.454E-04	-.936E+07	0.	0.	0.	.118E-03	.323E+07	.132E+08
0.	0.	0.	.149E+08	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	-.323E+07	-.339E+07	0.	0.
21)									
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	-.173E+06	.864E+07	-.441E-04	0.	0.	0.
.541E+07	.559E+07	-.559E+07	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	-.611E+05	-.305E+07
22)									
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	-.864E+07	.288E+09	-.248E-02	0.	0.	0.
.559E+07	.105E+10	-.134E+09	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	.305E+07	.317E+08
23)									
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	.441E-04	-.248E-02	-.198E+09	0.	0.	0.
-.559E+07	-.134E+09	.105E+10	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	-.305E+07	-.172E+09
24)									
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	.231E+08	-.118E-03	0.	0.	0.	.769E+09	-.149E+08	.149E+08
0.	0.	0.	.417E+10	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	-.816E+07	.816E+07	0.	0.
25)									
-.936E+07	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	.192E+08	.454E-04	0.	0.	0.	.231E+08

	-.462E+06	-.454E-04	0.	0.	0.	.231E+08	0.	0.	0.	0.
26)										
	0.	-.462E+06	0.	0.	0.	-.231E+08	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	.454E-04	.103E+08	0.	0.	0.	-.118E-03
	-.454E-04	-.936E+07	0.	0.	0.	-.118E-03	0.	0.	0.	0.
27)										
	0.	0.	-.173E+06	0.	.864E+07	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	.518E+06	-.864E+07	.440E-04	0.
	0.	0.	-.173E+06	-.864E+07	.441E-04	0.	0.	0.	0.	0.
28)										
	0.	0.	0.	-.198E+09	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	-.864E+07	.973E+09	-.193E-02	0.
	0.	0.	.864E+07	.288E+09	-.248E-02	0.	0.	0.	0.	0.
29)										
	0.	0.	-.864E+07	0.	.288E+09	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	.440E-04	-.193E-02	.135E+10	0.
	0.	0.	-.441E-04	-.248E-02	-.198E+09	0.	0.	0.	0.	0.
30)										
	0.	.231E+08	0.	0.	0.	.769E+09	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	.231E+08	-.118E-03	0.	0.	0.	.462E+10
	-.231E+08	.118E-03	0.	0.	0.	.769E+09	0.	0.	0.	0.
31)										
	-.339E+07	.323E+07	0.	0.	0.	-.816E+07	-.936E+07	0.	0.	0.
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	-.462E+06	-.454E-04	0.	0.	0.	-.231E+08
	.337E+08	-.596E+07	0.	0.	0.	-.326E+08	-.462E+06	-.454E-04	0.	0.
32)										
	.323E+07	-.339E+07	0.	0.	0.	-.816E+07	0.	-.462E+06	0.	0.
	0.	-.231E+08	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	-.454E-04	-.936E+07	0.	0.	0.	.118E-03
	-.596E+07	.337E+08	0.	0.	0.	-.490E+08	-.454E-04	-.936E+07	0.	0.
33)										
	0.	0.	-.611E+05	.305E+07	.305E+07	0.	0.	0.	-.173E+06	0.
	.864E+07	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	-.173E+06	.864E+07	-.441E-04	0.
	0.	0.	.130E+07	.122E+08	.183E+08	0.	0.	0.	-.173E+06	-.864E+07
34)										
	0.	0.	-.305E+07	.317E+08	.172E+09	0.	0.	0.	0.	-.198E+09
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	-.864E+07	.288E+09	-.248E-02	0.
	0.	0.	.122E+08	.264E+10	.267E+09	0.	0.	0.	.864E+07	.288E+09
35)										
	0.	0.	-.305E+07	.172E+09	.317E+08	0.	0.	0.	-.864E+07	0.
	.288E+09	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	0.	0.	.441E-04	-.248E-02	-.198E+09	0.
	0.	0.	.183E+08	.267E+09	.264E+10	0.	0.	0.	-.441E-04	-.248E-02
36)										
	.816E+07	.816E+07	0.	0.	0.	.544E+09	0.	.231E+08	0.	0.
	0.	.769E+09	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	0.	.231E+08	-.118E-03	0.	0.	0.	.769E+09
	-.326E+08	-.490E+08	0.	0.	0.	.105E+11	-.231E+08	.118E-03	0.	0.
37)										
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	-.936E+07	0.	0.	0.	0.	0.	-.339E+07	-.323E+07
	0.	0.	0.	-.816E+07	0.	0.	0.	0.	0.	0.
	-.462E+06	-.454E-04	0.	0.	0.	-.231E+08	.337E+08	.596E+07	0.	0.
38)										
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	0.	0.	0.	-.462E+06	0.	0.	0.	-.231E+08	-.323E+07	-.339E+07
	0.	0.	0.	.816E+07	0.	0.	0.	0.	0.	0.
	-.454E-04	-.936E+07	0.	0.	0.	.118E-03	.596E+07	.337E+08	0.	0.

39)

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	-.173E+06	0.	.864E+07	0.	0.	0.
-.611E+05	.305E+07	-.305E+07	0.	0.	0.	0.	0.	0.	0.
0.	0.	-.173E+06	.864E+07	-.441E-04	0.	0.	0.	.130E+07	.122E+08

40)

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	-.198E+09	0.	0.	0.	0.
-.305E+07	.317E+08	-.172E+09	0.	0.	0.	0.	0.	0.	0.
0.	0.	-.864E+07	.288E+09	-.248E-02	0.	0.	0.	.122E+08	.264E+10

TOTAL JOINTS= 22 DYNAMIC MATRIX SIZE= 132 NO OF FLEX. MODES=10 NS=-1 NR= 1 NV=10

FLEXIBILITY MATRIX ORDER 132

ONLY THE FIRST 40 BY 40 IS PRINTED

1)

.532E-06	.372E-06	0.	0.	0.	-.334E-08	.208E-06	.345E-06	0.	0.
0.	-.259E-08	.475E-07	.321E-06	0.	0.	0.	-.179E-08	-.886E-07	.299E-06
0.	0.	0.	-.269E-09	.455E-06	.120E-06	0.	0.	0.	-.230E-08
.203E-06	.120E-06	0.	0.	0.	-.630E-09	.520E-07	.120E-06	0.	0.

2)

.372E-06	.734E-06	0.	0.	0.	-.422E-08	.716E-07	.678E-06	0.	0.
0.	-.289E-08	-.857E-07	.632E-06	0.	0.	0.	-.263E-08	-.293E-06	.591E-06
0.	0.	0.	-.504E-09	.324E-06	.303E-06	0.	0.	0.	-.339E-08
.685E-07	.299E-06	0.	0.	0.	-.894E-09	-.773E-07	.295E-06	0.	0.

3)

0.	0.	.199E-06	.108E-08	.130E-08	0.	0.	0.	.918E-07	.801E-09
.898E-09	0.	0.	0.	.309E-07	.389E-09	.389E-09	0.	0.	0.
.343E-09	.174E-09	.171E-09	0.	0.	0.	.695E-07	.633E-09	.996E-09	0.
0.	0.	.176E-07	.277E-09	.353E-09	0.	0.	0.	.975E-08	.794E-10

4)

0.	0.	.108E-08	.179E-08	-.398E-09	0.	0.	0.	-.672E-07	-.330E-10
-.499E-09	0.	0.	0.	-.385E-07	-.383E-09	-.296E-09	0.	0.	0.
-.632E-09	-.237E-09	-.173E-09	0.	0.	0.	.152E-07	.663E-09	.337E-10	0.
0.	0.	-.202E-07	.103E-09	-.203E-09	0.	0.	0.	-.165E-07	-.103E-09

5)

0.	0.	.130E-08	-.398E-09	.168E-08	0.	0.	0.	.242E-07	-.828E-10
.722E-09	0.	0.	0.	.177E-07	.139E-09	.329E-09	0.	0.	0.
.877E-10	.148E-09	.974E-10	0.	0.	0.	-.445E-07	-.287E-09	-.285E-09	0.
0.	0.	-.143E-07	-.224E-09	.971E-10	0.	0.	0.	-.340E-08	-.579E-11

6)

-.334E-08	-.422E-08	0.	0.	0.	.305E-09	.436E-09	-.365E-08	0.	0.
0.	-.208E-10	.340E-09	-.327E-08	0.	0.	0.	.201E-10	.175E-08	-.294E-08
0.	0.	0.	.409E-11	-.249E-08	-.414E-10	0.	0.	0.	-.183E-10
-.750E-10	-.580E-09	0.	0.	0.	.239E-11	.327E-09	-.834E-09	0.	0.

7)

.208E-06	.716E-07	0.	0.	0.	.436E-09	.288E-06	.735E-07	0.	0.
0.	-.538E-09	.976E-07	.752E-07	0.	0.	0.	-.118E-08	.551E-07	.744E-07
0.	0.	0.	.854E-10	.204E-06	.552E-07	0.	0.	0.	-.341E-09
.190E-06	.540E-07	0.	0.	0.	.841E-10	.918E-07	.404E-07	0.	0.

8)

.345E-06	.67[illegible]E-06	0.	0.	0.	-.365E-08	.745E-07	.730E-06	0.	0.

	0.	-.305E-08	-.860E-07	.667E-06	0.	0.	0.	-.283E-08	-.307E-06	.620E-06
	0.	0.	0.	-.567E-09	.305E-06	.297E-06	0.	0.	0.	-.309E-08
	.699E-07	.294E-06	0.	0.	0.	-.949E-09	-.768E-07	.297E-06	0.	0.
9)										
	0.	0.	.918E-07	-.672E-07	.242E-07	0.	0.	0.	.735E-05	-.293E-07
	.600E-07	0.	0.	0.	.503E-05	.471E-07	.421E-07	0.	0.	0.
	.738E-07	.331E-07	.214E-07	0.	0.	0.	-.720E-06	-.294E-07	-.164E-09	0.
	0.	0.	.149E-05	-.132E-07	.186E-07	0.	0.	0.	.159E-05	.945E-08
10)										
	0.	0.	.801E-09	-.330E-10	-.828E-10	0.	0.	0.	-.293E-07	.117E-08
	-.277E-09	0.	0.	0.	-.487E-07	-.364E-09	-.359E-09	0.	0.	0.
	-.757E-09	-.352E-09	-.180E-09	0.	0.	0.	.391E-08	.174E-10	.925E-12	0.
	0.	0.	-.557E-08	.181E-09	-.804E-10	0.	0.	0.	-.124E-07	-.509E-10
11)										
	0.	0.	.898E-09	-.499E-09	.722E-09	0.	0.	0.	.600E-07	-.277E-09
	.199E-08	0.	0.	0.	.460E-07	.368E-09	.875E-09	0.	0.	0.
	.351E-09	.366E-09	.287E-09	0.	0.	0.	-.226E-07	-.141E-09	-.108E-09	0.
	0.	0.	-.144E-07	-.109E-09	.100E-09	0.	0.	0.	-.463E-08	.311E-10
12)										
	-.259E-08	-.289E-08	0.	0.	0.	-.208E-10	-.538E-09	-.305E-08	0.	0.
	0.	.257E-09	.127E-08	-.270E-08	0.	0.	0.	-.271E-10	.167E-08	-.247E-08
	0.	0.	0.	.614E-11	-.216E-08	-.930E-09	0.	0.	0.	.270E-10
	-.542E-09	-.816E-09	0.	0.	0.	-.103E-10	.723E-09	-.105E-08	0.	0.
13)										
	.475E-07	-.857E-07	0.	0.	0.	.340E-09	.976E-07	-.860E-07	0.	0.
	0.	.127E-08	.290E-06	-.849E-07	0.	0.	0.	.492E-09	.215E-06	-.822E-07
	0.	0.	0.	-.636E-09	.485E-07	-.422E-07	0.	0.	0.	.531E-09
	.909E-07	-.425E-07	0.	0.	0.	.119E-09	.192E-06	-.579E-07	0.	0.
14)										
	.321E-06	.632E-06	0.	0.	0.	-.327E-08	.752E-07	.667E-06	0.	0.
	0.	-.270E-08	-.849E-07	.713E-06	0.	0.	0.	-.317E-08	-.325E-06	.659E-06
	0.	0.	0.	-.636E-09	.288E-06	.292E-06	0.	0.	0.	-.284E-08
	.712E-07	.290E-06	0.	0.	0.	-.822E-09	-.759E-07	.301E-06	0.	0.
15)										
	0.	0.	.309E-07	-.385E-07	.177E-07	0.	0.	0.	.503E-05	-.487E-07
	.460E-07	0.	0.	0.	.760E-05	.289E-07	.570E-07	0.	0.	0.
	.155E-06	.630E-07	.292E-07	0.	0.	0.	-.584E-06	-.179E-07	-.155E-09	0.
	0.	0.	.110E-05	-.154E-07	.139E-07	0.	0.	0.	.195E-05	.522E-08
16)										
	0.	0.	.389E-09	-.383E-09	.139E-09	0.	0.	0.	.471E-07	-.364E-09
	.368E-09	0.	0.	0.	.289E-07	.116E-08	.248E-09	0.	0.	0.
	-.705E-09	-.714E-10	.109E-09	0.	0.	0.	-.421E-08	-.183E-09	-.233E-12	0.
	0.	0.	.110E-07	-.105E-09	.109E-09	0.	0.	0.	.928E-08	.153E-09
17)										
	0.	0.	.389E-09	-.296E-09	.329E-09	0.	0.	0.	.421E-07	-.359E-09
	.875E-09	0.	0.	0.	.570E-07	.248E-09	.198E-08	0.	0.	0.
	.572E-09	.540E-09	.641E-09	0.	0.	0.	-.106E-07	-.851E-10	-.427E-10	0.
	0.	0.	-.616E-08	-.455E-10	.822E-10	0.	0.	0.	-.147E-07	.142E-09
18)										
	-.179E-08	-.263E-08	0.	0.	0.	.201E-10	-.118E-08	-.283E-08	0.	0.
	0.	-.271E-10	.492E-09	-.317E-08	0.	0.	0.	.260E-09	.264E-08	-.301E-08
	0.	0.	0.	-.379E-10	-.165E-08	-.930E-09	0.	0.	0.	.123E-10
	-.636E-09	-.925E-09	0.	0.	0.	.795E-11	.441E-09	-.699E-09	0.	0.
19)										
	-.886E-07	-.293E-06	0.	0.	0.	.175E-08	.551E-07	-.307E-06	0.	0.
	0.	.167E-08	.215E-06	-.325E-06	0.	0.	0.	.264E-08	.505E-06	-.343E-06
	0.	0.	0.	.678E-09	-.757E-07	-.113E-06	0.	0.	0.	.165E-08
	.565E-07	-.112E-06	0.	0.	0.	.505E-09	.206E-06	-.121E-06	0.	0.
20)										
	.299E-06	.591E-06	0.	0.	0.	-.294E-08	.744E-07	.620E-06	0.	0.
	0.	-.247E-08	-.822E-07	.659E-06	0.	0.	0.	-.301E-08	-.343E-06	.703E-06
	0.	0.	0.	-.852E-09	.272E-06	.287E-06	0.	0.	0.	-.263E-08
	.709E-07	.286E-06	0.	0.	0.	-.723E-09	-.731E-07	.303E-06	0.	0.
21)										
	0.	0.	.343E-09	-.632E-09	.877E-10	0.	0.	0.	.738E-07	-.757E-09
	.351E-09	0.	0.	0.	.155E-06	-.705E-09	.572E-09	0.	0.	0.

.197E-06	.291E-09	.266E-09	0.	0.	0.	-.188E-08	-.419E-09	.308E-10	0.
0.	0.	.432E-07	-.374E-09	.186E-09	0.	0.	0.	.884E-07	-.125E-09
22)									
0.	0.	.174E-09	-.237E-09	.148E-09	0.	0.	0.	.331E-07	-.352E-09
.366E-09	0.	0.	0.	.630E-07	-.714E-10	.540E-09	0.	0.	0.
.291E-09	.168E-08	.484E-09	0.	0.	0.	-.521E-08	-.950E-10	-.465E-11	0.
0.	0.	.416E-08	-.109E-09	.107E-09	0.	0.	0.	.113E-07	.178E-10
23)									
0.	0.	.171E-09	-.173E-09	.974E-10	0.	0.	0.	.214E-07	-.180E-09
.287E-09	0.	0.	0.	.292E-07	.109E-09	.641E-09	0.	0.	0.
.266E-09	.484E-09	.160E-08	0.	0.	0.	-.279E-08	-.909E-10	-.965E-11	0.
0.	0.	.511E-08	-.563E-10	.281E-10	0.	0.	0.	-.268E-09	.259E-09
24)									
-.269E-09	-.504E-09	0.	0.	0.	.409E-11	.854E-10	-.567E-09	0.	0.
0.	.614E-11	-.636E-09	-.636E-09	0.	0.	0.	-.379E-10	.678E-09	-.852E-09
0.	0.	0.	.267E-09	-.207E-09	-.501E-10	0.	0.	0.	.295E-11
.351E-10	-.418E-10	0.	0.	0.	.163E-11	-.931E-10	.333E-10	0.	0.
25)									
.455E-06	.324E-06	0.	0.	0.	-.249E-08	.204E-06	.305E-06	0.	0.
0.	-.216E-08	.485E-07	.288E-06	0.	0.	0.	-.165E-08	-.757E-07	.272E-06
0.	0.	0.	-.207E-09	.476E-06	.124E-06	0.	0.	0.	-.234E-08
.201E-06	.124E-06	0.	0.	0.	-.535E-09	.518E-07	.118E-06	0.	0.
26)									
.120E-06	.303E-06	0.	0.	0.	-.414E-10	.552E-07	.297E-06	0.	0.
0.	-.930E-09	-.422E-07	.292E-06	0.	0.	0.	-.930E-09	-.113E-06	.287E-06
0.	0.	0.	-.501E-10	.124E-06	.340E-06	0.	0.	0.	-.104E-08
.546E-07	.243E-06	0.	0.	0.	.450E-10	-.414E-07	.210E-06	0.	0.
27)									
0.	0.	.695E-07	.152E-07	-.445E-07	0.	0.	0.	-.720E-06	.391E-08
-.228E-07	0.	0.	0.	-.584E-06	-.421E-08	-.106E-07	0.	0.	0.
-.108E-08	-.521E-08	-.279E-08	0.	0.	0.	.411E-05	.295E-07	.323E-08	0.
0.	0.	.757E-06	.142E-07	-.602E-08	0.	0.	0.	.158E-06	.709E-09
28)									
0.	0.	.633E-09	.663E-09	-.287E-09	0.	0.	0.	-.294E-07	.174E-10
-.141E-09	0.	0.	0.	-.179E-07	-.183E-09	-.851E-10	0.	0.	0.
-.419E-09	-.950E-10	-.909E-10	0.	0.	0.	.295E-07	.169E-08	.190E-10	0.
0.	0.	-.230E-07	.781E-11	.277E-10	0.	0.	0.	-.129E-07	-.929E-10
29)									
0.	0.	.996E-09	.337E-10	-.285E-09	0.	0.	0.	-.164E-09	.925E-12
-.108E-09	0.	0.	0.	-.155E-09	-.233E-12	-.427E-10	0.	0.	0.
.308E-10	-.465E-11	-.965E-11	0.	0.	0.	.323E-08	.190E-10	.858E-09	0.
0.	0.	.188E-08	.478E-11	.776E-10	0.	0.	0.	.171E-08	.150E-11
30)									
-.230E-08	-.339E-08	0.	0.	0.	-.183E-10	-.341E-09	-.309E-08	0.	0.
0.	.270E-10	.531E-09	-.284E-08	0.	0.	0.	.123E-10	.165E-08	-.263E-08
0.	0.	0.	.295E-11	-.234E-08	-.104E-08	0.	0.	0.	.255E-09
-.212E-09	-.101E-08	0.	0.	0.	-.866E-11	.460E-09	-.102E-08	0.	0.
31)									
.203E-06	.685E-07	0.	0.	0.	-.750E-10	.190E-06	.699E-07	0.	0.
0.	-.542E-09	.909E-07	.712E-07	0.	0.	0.	-.636E-09	.565E-07	.709E-07
0.	0.	0.	.351E-10	.201E-06	.546E-07	0.	0.	0.	-.212E-09
.193E-06	.547E-07	0.	0.	0.	.131E-09	.891E-07	.417E-07	0.	0.
32)									
.120E-06	.299E-06	0.	0.	0.	-.580E-09	.540E-07	.294E-06	0.	0.
0.	-.816E-09	-.425E-07	.290E-06	0.	0.	0.	-.925E-09	-.112E-06	.286E-06
0.	0.	0.	-.418E-10	.124E-06	.243E-06	0.	0.	0.	-.101E-08
.547E-07	.245E-06	0.	0.	0.	.692E-10	-.419E-07	.211E-06	0.	0.
33)									
0.	0.	.176E-07	-.202E-07	-.143E-07	0.	0.	0.	.149E-05	-.557E-08
-.144E-07	0.	0.	0.	.110E-05	.110E-07	-.616E-08	0.	0.	0.
.432E-07	.416E-08	.511E-08	0.	0.	0.	.757E-06	-.230E-07	.188E-08	0.
0.	0.	.290E-05	-.405E-08	-.756E-08	0.	0.	0.	.157E-05	.978E-08
34)									
0.	0.	.277E-09	.103E-09	-.224E-09	0.	0.	0.	-.132E-07	.181E-09
-.109E-09	0.	0.	0.	-.154E-07	-.105E-09	-.455E-10	0.	0.	0.
-.174E-09	-.109E-09	-.563E-10	0.	0.	0.	.142E-07	.781E-11	.478E-11	0.

0.	0.	-.405E-09	.548E-09	-.923E-10	0.	0.	0.	-.105E-07	-.512E-10
35)									
0.	0.	.353E-09	-.203E-09	.971E-10	0.	0.	0.	.186E-07	-.804E-10
.100E-09	0.	0.	0.	.139E-07	.109E-09	.822E-10	0.	0.	0.
.186E-09	.107E-09	.281E-10	0.	0.	0.	-.602E-08	.277E-10	.776E-10	0.
0.	0.	-.756E-08	-.923E-10	.570E-09	0.	0.	0.	.382E-08	-.213E-10
36)									
-.630E-09	-.894E-09	0.	0.	0.	.239E-11	.841E-10	-.949E-09	0.	0.
0.	-.103E-10	.119E-09	-.822E-09	0.	0.	0.	.795E-11	.505E-09	-.723E-09
0.	0.	0.	.163E-11	-.535E-09	.450E-10	0.	0.	0.	-.866E-11
.131E-09	.692E-10	0.	0.	0.	.104E-09	.131E-09	-.114E-09	0.	0.
37)									
.520E-07	-.773E-07	0.	0.	0.	.327E-09	.918E-07	-.768E-07	0.	0.
0.	.723E-09	.192E-06	-.759E-07	0.	0.	0.	.441E-09	.206E-06	-.731E-07
0.	0.	0.	-.931E-10	.518E-07	-.414E-07	0.	0.	0.	.460E-09
.891E-07	-.419E-07	0.	0.	0.	.131E-09	.194E-06	-.570E-07	0.	0.
38)									
.120E-06	.295E-06	0.	0.	0.	-.834E-09	.404E-07	.297E-06	0.	0.
0.	-.105E-08	-.579E-07	.301E-06	0.	0.	0.	-.699E-09	-.121E-06	.303E-06
0.	0.	0.	.333E-10	.118E-06	.210E-06	0.	0.	0.	-.102E-08
.417E-07	.211E-06	0.	0.	0.	-.114E-09	-.570E-07	.250E-06	0.	0.
39)									
0.	0.	.975E-08	-.165E-07	-.340E-08	0.	0.	0.	.159E-05	-.124E-07
-.463E-08	0.	0.	0.	.195E-05	.928E-08	-.147E-07	0.	0.	0.
.884E-07	.113E-07	-.268E-09	0.	0.	0.	.158E-06	-.129E-07	.171E-08	0.
0.	0.	.157E-05	-.105E-07	.382E-08	0.	0.	0.	.305E-05	-.381E-08
40)									
0.	0.	.794E-10	-.103E-09	-.579E-11	0.	0.	0.	.945E-08	-.509E-10
.311E-10	0.	0.	0.	.522E-08	.153E-09	.142E-09	0.	0.	0.
-.125E-09	.178E-10	.259E-09	0.	0.	0.	.709E-09	-.929E-10	.150E-11	0.
0.	0.	.978E-08	-.512E-10	-.213E-10	0.	0.	0.	-.381E-08	.573E-09

INERTIA VECTOR, LB, OR LB-IN-SEC**2

1500.000	1500.000	1500.000	-0.000	-0.000	-0.000
1500.000	1500.000	1500.000	-0.000	-0.000	-0.000
1500.000	1500.000	1500.000	-0.000	-0.000	-0.000
1500.000	1500.000	1500.000	-0.000	-0.000	-0.000
1500.000	1500.000	1500.000	-0.000	-0.000	-0.000
2000.000	2000.000	2000.000	-0.000	-0.000	-0.000
2000.000	2000.000	2000.000	-0.000	-0.000	-0.000
1500.000	1500.000	1500.000	-0.000	-0.000	-0.000
0.000	0.000	0.000	-0.000	-0.000	-0.000
1500.000	1500.000	1500.000	-0.000	-0.000	-0.000
2000.000	2000.000	2000.000	-0.000	-0.000	-0.000
2000.000	2000.000	2000.000	-0.000	-0.000	-0.000
1500.000	1500.000	1500.000	-0.000	-0.000	-0.000
0.000	0.000	0.000	-0.000	-0.000	-0.000
1500.000	1500.000	1500.000	-0.000	-0.000	-0.000
2000.000	2000.000	2000.000	-0.000	-0.000	-0.000
2000.000	2000.000	2000.000	-0.000	-0.000	-0.000
1500.000	1500.000	1500.000	-0.000	-0.000	-0.000
1500.000	1500.000	1500.000	-0.000	-0.000	-0.000
1500.000	1500.000	1500.000	-0.000	-0.000	-0.000
1500.000	1500.000	1500.000	-0.000	-0.000	-0.000
1500.000	1500.000	1500.000	-0.000	-0.000	-0.000

EIGENSYSTEM SOLUTION

DYNAMIC MATRIX 132 BY 132

```
NO. OF RESONANT MODES TO BE COMPUTED =        10
EIGENVALUE ACCURACY CONTROLS, EPSILON AND ITERATION LIMIT =   .1000D-11    396.0

                1 MODE,      42.0 ITERATIONS
                2 MODE,      53.0 ITERATIONS
                3 MODE,      54.0 ITERATIONS
                4 MODE,     145.0 ITERATIONS
                5 MODE,      94.0 ITERATIONS
                6 MODE,      69.0 ITERATIONS
                7 MODE,     200.0 ITERATIONS
                8 MODE,     153.0 ITERATIONS
                9 MODE,     340.0 ITERATIONS
               10 MODE,     146.0 ITERATIONS
```

FLEXIBLE BODY MODES

MODE NO.	1	2	3	4	5	6	7	8	9	10
FREQ (HZ)	20.1369	21.7494	27.6311	32.1059	33.4236	36.5040	42.4761	45.3290	45.7394	47.0777
NODE 1)										
DOF NO 1	.00000	.00000	.00000	.75514	.00000	.00000	.00000	.03086	.09034	.99434
DOF NO 2	.00000	.00000	.00000	1.00000	.00000	.00000	.00000	.29543	.97540	.10811
DOF NO 3	.00936	-.00910	-.00296	-.00000	-.01106	-.01567	.02157	.02140	-.00000	.00000
DOF NO 4	-.00986	.00820	.00493	-.00000	-.00290	-.00105	.00153	.00428	.00000	-.00000
DOF NO 5	.00056	-.00328	-.01236	.00000	.01061	.00669	-.01083	-.00955	.00000	-.00000
DOF NO 6	-.00000	-.00000	-.00000	-.00601	-.00000	-.00000	-.00000	-.00060	-.00191	-.00107
NODE 2)										
DOF NO 7	.00000	.00000	.00000	.22165	.00000	.00000	.00000	-.00099	-.00736	.87333
DOF NO 8	.00000	.00000	.00000	.99929	.00000	.00000	.00000	.30274	1.00000	.06374
DOF NO 9	1.00000	-.95906	-.83423	.00006	.19887	-.09912	.03734	-.02740	-.00001	.00001
DOF NO 10	-.00576	.00627	.00668	-.00000	-.00047	.00055	.00004	-.00223	.00000	.00000
DOF NO 11	.00423	-.00773	-.01798	.00000	.00963	-.00013	-.00371	-.00197	-.00000	.00000
DOF NO 12	-.00000	-.00000	-.00000	-.00570	-.00000	-.00000	-.00000	-.00046	-.00146	-.00052
NODE 3)										
DOF NO 13	-.00000	-.00000	-.00000	-.24045	-.00000	-.00000	-.00000	-.01744	-.05453	.87735
DOF NO 14	.00000	.00000	.00000	.99299	.00000	.00000	.00000	.30251	.99932	.01657
DOF NO 15	.97477	-1.00000	-.99658	.00004	.08725	-.11223	.01943	.29830	-.00001	-.00000
DOF NO 16	.00641	-.00586	-.00437	.00000	.00153	-.00092	.00047	-.00062	-.00000	.00000
DOF NO 17	.00402	-.00699	-.01545	.00000	.01119	-.00626	.00323	-.00058	-.00000	.00000
DOF NO 18	-.00000	-.00000	-.00000	-.00570	-.00000	-.00000	-.00000	-.00049	-.00155	.00035
NODE 4)										
DOF NO 19	-.00000	-.00000	-.00000	-.72233	-.00000	-.00000	-.00000	-.04617	-.14267	.98004
DOF NO 20	.00000	.00000	.00000	.97258	.00000	.00000	.00000	.29404	.97124	-.02710
DOF NO 21	.02565	-.01880	-.00199	-.00001	-.03116	.02476	-.02342	.02701	.00000	.00000
DOF NO 22	.00636	-.00773	-.00989	.00000	.00356	-.00354	.00237	.00106	-.00000	-.00000
DOF NO 23	.00338	-.00418	-.00444	.00000	.00953	-.00987	.00806	-.00695	-.00000	-.00000
DOF NO 24	-.00000	-.00000	-.00000	-.00079	-.00000	-.00000	-.00000	-.00010	-.00031	.00004
NODE 5)										
DOF NO 25	.00000	.00000	.00000	.72927	.00000	.00000	.00000	.01309	.03105	1.00000
DOF NO 26	.00000	.00000	.00000	.42645	.00000	.00000	.00000	.22646	.75367	.06348
DOF NO 27	.00592	.11406	.65394	-.00015	-.87504	-.73650	1.00000	1.00000	-.00001	.00001
DOF NO 28	-.00770	.00337	-.00241	-.00000	-.00551	-.00483	.00538	.01087	-.00000	.00000
DOF NO 29	.00033	-.00002	.00109	-.00000	-.00015	.00063	.00174	.00181	.00000	-.00000
DOF NO 30	-.00000	-.00000	-.00000	-.00593	-.00000	-.00000	-.00000	-.00039	-.00120	-.00099
NODE 6)										
DOF NO 31	.00000	.00000	.00000	.21515	.00000	.00000	.00000	-.00143	-.00871	.83896
DOF NO 32	.00000	.00000	.00000	.42059	.00000	.00000	.00000	.21772	.72439	.06201
DOF NO 33	.62320	-.22262	.80225	-.00009	-.39434	-.12070	.34297	-.09766	.00001	-.00001
DOF NO 34	-.00217	.00290	.00301	.00000	-.00088	-.00332	.00311	.00220	-.00000	.00000
DOF NO 35	.00016	-.00307	-.00753	.00000	.00030	.00137	-.00186	.00178	.00000	.00000
DOF NO 36	-.00000	-.00000	-.00000	-.00129	-.00000	-.00000	-.00000	-.00013	-.00041	.00029
NODE 7)										
DOF NO 37	-.00000	-.00000	-.00000	-.22330	-.00000	-.00000	-.00000	-.01535	-.04781	.84202
DOF NO 38	.00000	.00000	.00000	.43325	.00000	.00000	.00000	.21993	.73161	-.01181
DOF NO 39	.60969	-.35161	.44022	-.00019	-.69184	.31361	-.20464	.04508	.00005	-.00001
DOF NO 40	.00204	-.00105	.00183	.00000	.00489	-.00524	.00409	-.00353	-.00000	-.00000
DOF NO 41	.00263	-.00403	-.00635	-.00000	-.00122	.00149	-.00120	.00342	.00000	-.00000
DOF NO 42	-.00000	-.00000	-.00000	-.00442	-.00000	-.00000	-.00000	-.00033	-.00103	.00075
NODE 8)										
DOF NO 43	-.00000	-.00000	-.00000	-.71726	-.00000	-.00000	-.00000	-.03061	-.09045	.99399
DOF NO 44	.00000	.00000	.00000	.44882	.00000	.00000	.00000	.22960	.76384	-.01256
DOF NO 45	.07024	.08565	.25402	-.00032	-1.00000	1.00000	-.81385	.72418	.00011	.00003
DOF NO 46	.00633	-.00559	.00031	.00000	.00111	-.00514	.00484	-.00567	-.00000	-.00000
DOF NO 47	-.00080	-.00004	-.00027	-.00000	-.00023	.00048	-.00164	.00217	.00000	.00000

DOF NO	48	-.00000	-.00000	-.00000	-.00604	-.00000	-.00000	-.00000	-.00044	-.00137	.00078
NODE	9)										
DOF NO	49	.00000	.00000	-.00000	-.00089	-.00000	-.00000	-.00000	-.00596	-.02012	.67775
DOF NO	50	.00000	.00000	.00000	.16794	.00000	.00000	.00000	.17162	.57388	.02278
DOF NO	51	.57879	-.14677	.84645	-.00007	-.27961	-.04764	.06879	-.21024	.00001	-.00001
DOF NO	52	-.00008	.00290	.00460	.00000	.00551	-.00183	-.00091	-.00338	-.00000	.00000
DOF NO	53	-.00009	-.00191	-.00290	-.00000	-.00263	.00235	-.00455	.00023	.00000	-.00000
DOF NO	54	.00000	.00000	.00000	.00145	.00000	.00000	.00000	.00005	.00013	.00060
NODE	10)										
DOF NO	55	.00000	.00000	.00000	.69863	.00000	.00000	.00000	-.00563	-.03131	.97557
DOF NO	56	.00000	.00000	-.00000	-.00021	-.00000	-.00000	-.00000	.20712	.69614	.02471
DOF NO	57	.02103	-.00102	.05449	.00000	.00332	.00315	.06529	.04817	-.00000	.00000
DOF NO	58	-.00416	-.00214	-.00593	-.00000	-.00445	-.00062	.00076	.00440	.00000	-.00000
DOF NO	59	-.00233	.00100	.00036	-.00000	-.01013	-.00928	.00007	.00149	-.00000	.00000
DOF NO	60	-.00000	-.00000	-.00000	-.00253	-.00000	-.00000	-.00000	-.00002	-.00003	-.00062
NODE	11)										
DOF NO	61	.00000	.00000	.00000	.18723	.00000	.00000	.00000	-.00646	-.02510	.78070
DOF NO	62	.00000	.00000	-.00000	-.00154	-.00000	-.00000	-.00000	.18934	.63639	.02354
DOF NO	63	.56881	.07865	1.00000	.00004	.20369	-.01656	.15803	-.36598	-.00001	.00000
DOF NO	64	-.00188	.00166	-.00349	.00000	.00341	.00100	.00054	.00153	-.00000	.00000
DOF NO	65	.00020	-.00180	.00104	-.00000	-.00645	-.00267	-.00049	.00036	.00000	-.00000
DOF NO	66	-.00000	-.00000	-.00000	-.00329	-.00000	-.00000	-.00000	.00010	.00040	-.00055
NODE	12)										
DOF NO	67	-.00000	-.00000	-.00000	-.18723	-.00000	-.00000	-.00000	-.00841	-.02510	.78070
DOF NO	68	.00000	.00000	.00000	.00154	.00000	.00000	.00000	.18935	.63639	.02354
DOF NO	69	.56881	-.07865	1.00000	-.00006	-.20369	-.01656	-.15803	-.36597	.00000	-.00001
DOF NO	70	.00188	.00166	.00349	.00000	.00341	-.00100	.00054	-.00153	-.00000	.00000
DOF NO	71	-.00020	-.00180	-.00104	-.00000	-.00645	.00267	-.00049	-.00036	.00000	-.00000
DOF NO	72	.00000	-.00000	-.00000	-.00329	-.00000	-.00000	-.00000	-.00014	-.00040	.00055
NODE	13)										
DOF NO	73	-.00000	-.00000	-.00000	-.69863	-.00000	-.00000	-.00000	-.01292	-.03131	.97557
DOF NO	74	.00000	.00000	.00000	.00021	.00000	.00000	.00000	.20712	.69614	.02471
DOF NO	75	.02103	.00102	.05449	-.00000	-.00332	.00315	-.06529	.04817	.00000	.00000
DOF NO	76	.00416	-.00214	.00593	-.00000	-.00445	.00062	.00076	-.00440	.00000	-.00000
DOF NO	77	.00233	.00100	-.00036	-.00000	-.01013	.00928	.00007	-.00149	.00000	.00000
DOF NO	78	-.00000	-.00000	-.00000	-.00253	-.00000	-.00000	-.00000	-.00000	.00003	.00062
NODE	14)										
DOF NO	79	.00000	.00000	.00000	.00089	.00000	.00000	.00000	-.00595	-.02012	.67775
DOF NO	80	.00000	.00000	-.00000	-.16794	-.00000	-.00000	-.00000	.16987	.57388	.02278
DOF NO	81	.57879	.14677	.84645	.00006	.27961	-.04764	-.06879	-.21025	-.00002	.00000
DOF NO	82	.00008	.00290	-.00460	.00000	.00551	.00183	-.00091	.00338	-.00000	.00000
DOF NO	83	.00009	-.00191	.00290	-.00000	-.00263	-.00235	-.00455	-.00023	-.00000	-.00000
DOF NO	84	.00000	.00000	.00000	.00145	.00000	.00000	.00000	-.00003	-.00013	-.00060
NODE	15)										
DOF NO	85	.00000	.00000	.00000	.71726	.00000	.00000	.00000	-.02312	-.09045	.99399
DOF NO	86	.00000	.00000	-.00000	-.44882	-.00000	-.00000	-.00000	.22492	.76384	-.01256
DOF NO	87	.07024	-.08565	.25402	.00015	1.00000	1.00000	.81385	.72415	.00002	-.00001
DOF NO	88	-.00633	-.00559	-.00031	-.00000	.00111	.00514	.00484	.00567	.00000	-.00000
DOF NO	89	.00080	-.00004	.00027	-.00000	-.00023	-.00048	-.00164	-.00217	-.00000	.00000
DOF NO	90	-.00000	-.00000	-.00000	-.00604	-.00000	-.00000	-.00000	.00038	.00137	-.00078
NODE	16)										
DOF NO	91	.00000	.00000	.00000	.22330	.00000	.00000	.00000	-.01302	-.04781	.84202
DOF NO	92	.00000	.00000	-.00000	-.43325	-.00000	-.00000	-.00000	.21541	.73161	-.01181
DOF NO	93	.60969	.35161	.44022	.00013	.69184	.31361	.20464	.04506	-.00001	.00001
DOF NO	94	-.00204	-.00105	-.00183	.00000	.00489	.00524	.00409	.00353	.00000	-.00000
DOF NO	95	-.00263	-.00403	.00635	-.00000	-.00122	-.00149	-.00120	-.00342	-.00000	-.00000
DOF NO	96	-.00000	-.00000	-.00000	-.00442	-.00000	-.00000	-.00000	.00028	.00103	-.00075
NODE	17)										
DOF NO	97	-.00000	-.00000	-.00000	-.21515	-.00000	-.00000	-.00000	-.00368	-.00871	.83896
DOF NO	98	.00000	.00000	-.00000	-.42059	-.00000	-.00000	-.00000	.21333	.72439	.06201
DOF NO	99	.62320	.22262	.80225	.00010	.39434	-.12070	-.34297	-.09767	-.00003	.00000
DOF NO	100	.00217	.00290	-.00301	-.00000	-.00088	.00332	.00311	-.00220	.00000	.00000
DOF NO	101	-.00016	-.00307	.00753	.00000	.00030	-.00137	-.00186	-.00178	-.00000	-.00000
DOF NO	102	-.00000	-.00000	-.00000	-.00129	-.00000	-.00000	-.00000	.00011	.00041	-.00029
NODE	18)										
DOF NO	103	-.00000	-.00000	-.00000	-.72927	-.00000	-.00000	-.00000	.00548	.03105	1.00000

DOF NO 104	.00000	.00000	-.00000	-.42645	-.00000	-.00000	-.00000	.22201	.75367	.06348
DOF NO 105	.00592	-.11406	.85394	.00026	.87504	-.73650	-1.00000	.99998	-.00009	-.00002
DOF NO 106	.00770	.00337	.00241	-.00000	-.00551	.00483	.00538	-.01087	.00000	.00000
DOF NO 107	-.00033	-.00002	-.00109	.00000	-.00015	-.00063	.00174	-.00181	-.00000	-.00000
DOF NO 108	-.00000	-.00000	-.00000	-.00593	-.00000	-.00000	-.00000	.00033	.00120	.00099
NODE 19)										
DOF NO 109	.00000	.00000	.00000	.72233	.00000	.00000	.00000	-.03863	-.14267	.98004
DOF NO 110	.00000	.00000	-.00000	-.97258	-.00000	-.00000	-.00000	.28389	.97124	-.02710
DOF NO 111	.02565	.01880	-.00199	.00001	.03116	.02476	.02342	.02701	.00000	-.00000
DOF NO 112	-.00636	-.00773	.00989	.00000	.00356	.00354	.00237	-.00106	.00000	-.00000
DOF NO 113	-.00338	-.00418	.00444	.00000	.00953	.00987	.00806	.00695	.00000	-.00000
DOF NO 114	-.00000	.00000	-.00000	-.00079	-.00000	-.00000	-.00000	.00009	.00031	-.00004
NODE 20)										
DOF NO 115	.00000	.00000	.00000	.24045	.00000	.00000	.00000	-.01493	-.05453	.87735
DOF NO 116	.00000	.00000	-.00000	-.99299	-.00000	-.00000	-.00000	.29214	.99932	.01657
DOF NO 117	.97477	1.00000	-.99658	-.00001	-.08725	-.11223	-.01943	.29830	-.00000	.00000
DOF NO 118	-.00641	-.00586	.00437	.00000	.00153	.00092	.00047	.00062	-.00000	.00000
DOF NO 119	-.00402	-.00699	.01545	.00000	.01119	.00626	.00323	.00058	-.00000	.00000
DOF NO 120	-.00000	-.00000	-.00000	-.00570	-.00000	-.00000	-.00000	.00043	.00155	-.00035
NODE 21)										
DOF NO 121	-.00000	-.00000	-.00000	-.22165	-.00000	-.00000	-.00000	-.00331	-.00736	.87333
DOF NO 122	.00000	.00000	-.00000	-.99929	-.00000	-.00000	-.00000	.29231	1.00000	.06374
DOF NO 123	1.00000	.95906	-.83423	-.00004	-.19887	-.09912	-.03734	-.02740	.00000	-.00001
DOF NO 124	.00576	.00627	-.00668	-.00000	-.00047	-.00055	.00004	.00223	-.00000	.00000
DOF NO 125	-.00423	-.00773	.01798	.00000	.00963	.00013	-.00371	.00197	-.00000	.00000
DOF NO 126	-.00000	-.00000	-.00000	-.00570	-.00000	-.00000	-.00000	.00040	.00146	.00052
NODE 22)										
DOF NO 127	-.00000	-.00000	-.00000	-.75514	-.00000	-.00000	-.00000	.02298	.09034	.99434
DOF NO 128	.00000	.00000	-.00000	-1.00000	-.00000	-.00000	-.00000	.28499	.97540	.10811
DOF NO 129	.00936	.00910	-.00296	.00000	.01106	-.01567	-.02157	.02140	-.00000	-.00000
DOF NO 130	.00986	.00820	-.00493	-.00000	-.00290	.00105	.00153	-.00428	.00000	-.00000
DOF NO 131	-.00056	-.00328	.01236	.00000	.01061	-.00669	-.01083	.00955	-.00000	-.00000
DOF NO 132	-.00000	-.00000	-.00000	-.00601	-.00000	-.00000	-.00000	.00054	.00191	.00107

MODAL PARTICIPATION FACTORS

* MODE 1

GENERALIZED MASS (LB.) = .10203523D+05

.11922255D-26	.27254651D-26	.14040106D+02	0.	0.	0.
.37564984D-27	.27562678D-26	.15000000D+04	0.	0.	0.
-.25991778D-27	.27412645D-26	.14621519D+04	0.	0.	0.
-.96909202D-27	.26676197D-26	.38474744D+02	0.	0.	0.
.10708145D-26	.16806379D-26	.88821521D+01	0.	0.	0.
.48143942D-27	.21713772D-26	.12463939D+04	0.	0.	0.
-.31121642D-27	.21935868D-26	.12193720D+04	0.	0.	0.
-.88124676D-27	.17133490D-26	.10535583D+03	0.	0.	0.
0.	0.	0.	0.	0.	0.
.93486439D-27	.10667960D-26	.31551467D+02	0.	0.	0.
.39225218D-27	.12982856D-26	.11376162D+04	0.	0.	0.
-.21715514D-27	.13032895D-26	.11376162D+04	0.	0.	0.
-.77059307D-27	.10673043D-26	.31551467D+02	0.	0.	0.
0.	0.	0.	0.	0.	0.
.86968193D-27	.61770693D-27	.10535583D+03	0.	0.	0.
.41558242D-27	.78341220D-27	.12193720D+04	0.	0.	0.
-.21883053D-27	.80241981D-27	.12463939D+04	0.	0.	0.
-.70943750D-27	.63960098D-27	.88821521D+01	0.	0.	0.
.79432850D-27	.24340733D-27	.38474744D+02	0.	0.	0.

.32705369D-27	.31722356D-27	.14621519D+04	0.	0.	0.
-.16541843D-27	.31686036D-27	.15000000D+04	0.	0.	0.
-.65116958D-27	.28431976D-27	.14040106D+02	0.	0.	0.

* MODE 2

GENERALIZED MASS (LB.) = .65392348D+04

.78891106D-27	.23812683D-26	-.13654227D+02	0.	0.	0.
.26127022D-27	.24177429D-26	-.14385877D+04	0.	0.	0.
-.11222907D-27	.24052815D-26	-.15000000D+04	0.	0.	0.
-.55581529D-27	.23357048D-26	-.28195915D+02	0.	0.	0.
.66799029D-27	.16194605D-26	.17109444D+03	0.	0.	0.
.33262727D-27	.20845457D-26	-.44523295D+03	0.	0.	0.
-.12660713D-27	.20970539D-26	-.70322573D+03	0.	0.	0.
-.45749880D-27	.16398390D-26	.12847687D+03	0.	0.	0.
0.	0.	0.	0.	0.	0.
.53393298D-27	.12431496D-26	-.15239578D+01	0.	0.	0.
.25830734D-27	.15143335D-26	.15730617D+03	0.	0.	0.
-.55172589D-28	.15169075D-26	-.15730617D+03	0.	0.	0.
-.34335659D-27	.12434111D-26	.15239578D+01	0.	0.	0.
0.	0.	0.	0.	0.	0.
.44318124D-27	.10762393D-26	-.12847687D+03	0.	0.	0.
.24725916D-27	.13716582D-26	.70322573D+03	0.	0.	0.
-.27592519D-28	.13803522D-26	.44523295D+03	0.	0.	0.
-.24777370D-27	.10839497D-26	-.17109444D+03	0.	0.	0.
.35123880D-27	.11144069D-26	.28195915D+02	0.	0.	0.
.18970983D-27	.11583516D-26	.15000000D+04	0.	0.	0.
-.17056009D-28	.11629084D-26	.14385877D+04	0.	0.	0.
-.15933383D-27	.11255399D-26	.13654227D+02	0.	0.	0.

* MODE 3

GENERALIZED MASS (LB.) = .13902356D+05

.17739940D-16	.23497233D-16	-.44463812D+01	0.	0.	0.
.52069274D-17	.23480645D-16	-.12513500D+04	0.	0.	0.
-.56485702D-17	.23332755D-16	-.14948646D+04	0.	0.	0.
-.16969168D-16	.22853070D-16	-.29880186D+01	0.	0.	0.
.17131954D-16	.10022533D-16	.98091430D+03	0.	0.	0.
.67389765D-17	.13179420D-16	.16044920D+04	0.	0.	0.
-.69941309D-17	.13576088D-16	.88044199D+03	0.	0.	0.
-.16849607D-16	.10548044D-16	.38103569D+03	0.	0.	0.
0.	0.	0.	0.	0.	0.
.16411818D-16	-.69529015D-21	.81732953D+02	0.	0.	0.
.58644463D-17	-.43036811D-19	.20000000D+04	0.	0.	0.
-.58643024D-17	.53268290D-19	.20000000D+04	0.	0.	0.
-.16411683D-16	.90888292D-20	.81732953D+02	0.	0.	0.
0.	0.	0.	0.	0.	0.
.16849040D-16	-.10538855D-16	.38103569D+03	0.	0.	0.
.69939534D-17	-.13564353D-16	.88044199D+03	0.	0.	0.
-.67385285D-17	-.13167749D-16	.16044920D+04	0.	0.	0.
-.17131055D-16	-.10013427D-16	.98091430D+03	0.	0.	0.
.16967966D-16	-.22841392D-16	-.29880186D+01	0.	0.	0.
.56483746D-17	-.23320716D-16	-.14948646D+04	0.	0.	0.
-.52065571D-17	-.23468573D-16	-.12513500D+04	0.	0.	0.
-.17738330D-16	-.23485433D-16	-.44463812D+01	0.	0.	0.

* MODE 4

GENERALIZED MASS (LB.) = .23124667D+05

.11327030D+04	.15000000D+04	-.19219004D-02	0.	0.	0.
.33246787D+03	.14989321D+04	.94437915D-01	0.	0.	0.
-.36067381D+03	.14894899D+04	.58444117D-01	0.	0.	0.
-.10834996D+04	.14588719D+04	-.14139866D-01	0.	0.	0.
.10939037D+04	.63968144D+03	-.22694658D+00	0.	0.	0.
.43029184D+03	.84117732D+03	-.17960991D+00	0.	0.	0.
-.44659293D+03	.86650388D+03	-.38700005D+00	0.	0.	0.
-.10758856D+04	.67323442D+03	-.48424058D+00	0.	0.	0.
0.	0.	0.	0.	0.	0.
.10479450D+04	-.31237434D+00	.12415305D-03	0.	0.	0.
.37445987D+03	-.30747010D+01	.82310789D-01	0.	0.	0.
-.37445987D+03	.30747010D+01	-.11018392D+00	0.	0.	0.
-.10479450D+04	.31237434D+00	-.22463353D-02	0.	0.	0.
0.	0.	0.	0.	0.	0.
.10758856D+04	-.67323442D+03	.22759678D+00	0.	0.	0.
.44659293D+03	-.86650388D+03	.26606779D+00	0.	0.	0.
-.43029184D+03	-.84117732D+03	.19244095D+00	0.	0.	0.
-.10939037D+04	-.63968144D+03	.39619307D+00	0.	0.	0.
.10834996D+04	-.14588719D+04	.79041163D-02	0.	0.	0.
.36067381D+03	-.14894899D+04	-.10118316D-01	0.	0.	0.
-.33246787D+03	-.14989321D+04	-.53257836D-01	0.	0.	0.
-.11327030D+04	-.15000000D+04	.58883249D-02	0.	0.	0.

* MODE 5

GENERALIZED MASS (LB.) = .81444065D+04

.20990755D-03	.27797342D-03	-.16595690D+02	0.	0.	0.
.61611487D-04	.27777553D-03	.29831153D+03	0.	0.	0.
-.66838489D-04	.27602574D-03	.13086753D+03	0.	0.	0.
-.20078940D-03	.27035175D-03	-.46745918D+02	0.	0.	0.
.20271744D-03	.11854296D-03	-.13125578D+04	0.	0.	0.
.79739796D-04	.15588329D-03	-.78868138D+03	0.	0.	0.
-.82760644D-04	.16057670D-03	-.13836709D+04	0.	0.	0.
-.19937839D-03	.12476085D-03	-.15000000D+04	0.	0.	0.
0.	0.	0.	0.	0.	0.
.19420058D-03	-.57887842D-07	.49851200D+01	0.	0.	0.
.69393261D-04	-.56979011D-06	.40738614D+03	0.	0.	0.
-.69393261D-04	.56979011D-06	-.40738614D+03	0.	0.	0.
-.19420058D-03	.57887842D-07	-.49851200D+01	0.	0.	0.
0.	0.	0.	0.	0.	0.
.19937839D-03	-.12476085D-03	.15000000D+04	0.	0.	0.
.82760644D-04	-.16057670D-03	.13836709D+04	0.	0.	0.
-.79739796D-04	-.15588329D-03	.78868138D+03	0.	0.	0.
-.20271744D-03	-.11854296D-03	.13125578D+04	0.	0.	0.
.20078940D-03	-.27035175D-03	.46745918D+02	0.	0.	0.
.66838489D-04	-.27602574D-03	-.13086753D+03	0.	0.	0.
-.61611487D-04	-.27777553D-03	-.29831153D+03	0.	0.	0.
-.20990755D-03	-.27797342D-03	.16595690D+02	0.	0.	0.

* MODE 6

GENERALIZED MASS (LB.) = .51499378D+04

.69438750D-04	.91954531D-04	-.23509594D+02	0.	0.	0.
.20381494D-04	.91889043D-04	-.14867806D+03	0.	0.	0.
-.22110594D-04	.91310203D-04	-.16835247D+03	0.	0.	0.
-.66422388D-04	.89433236D-04	.37142490D+02	0.	0.	0.
.67060272D-04	.39214063D-04	-.11047489D+04	0.	0.	0.
.26378462D-04	.51566287D-04	-.24139683D+03	0.	0.	0.

-.27377747D-04	.53118891D-04	.62722085D+03	0.	0.	0.
-.65955671D-04	.41270975D-04	.15000000D+04	0.	0.	0.
0.	0.	0.	0.	0.	0.
.64242899D-04	-.19853404D-07	.47175355D+01	0.	0.	0.
.22955781D-04	-.18934825D-06	-.33110232D+02	0.	0.	0.
-.22955754D-04	.18763272D-06	-.33110237D+02	0.	0.	0.
-.64242874D-04	.18445988D-07	.47175350D+01	0.	0.	0.
0.	0.	0.	0.	0.	0.
.65955815D-04	-.41272518D-04	.15000000D+04	0.	0.	0.
.27377832D-04	-.53120861D-04	.62722086D+03	0.	0.	0.
-.26378483D-04	-.51568242D-04	-.24139683D+03	0.	0.	0.
-.67060373D-04	-.39215588D-04	-.11047489D+04	0.	0.	0.
.66422638D-04	-.89435198D-04	.37142490D+02	0.	0.	0.
.22110669D-04	-.91312223D-04	-.16835247D+03	0.	0.	0.
-.20381513D-04	-.91891066D-04	-.14867806D+03	0.	0.	0.
-.69438972D-04	-.91956506D-04	-.23509594D+02	0.	0.	0.

* MODE 7

GENERALIZED MASS (LB.) = .57460835D+04

.31041814D-04	.41110847D-04	.32356583D+02	0.	0.	0.
.91111801D-05	.41081675D-04	.56010128D+02	0.	0.	0.
-.98843910D-05	.40822911D-04	.29152317D+02	0.	0.	0.
-.29693604D-04	.39983725D-04	-.35123141D+02	0.	0.	0.
.29978305D-04	.17533172D-04	.15000000D+04	0.	0.	0.
.11792008D-04	.23055922D-04	.68593013D+03	0.	0.	0.
-.12239020D-04	.23750027D-04	-.40928226D+03	0.	0.	0.
-.29484745D-04	.18452722D-04	-.12207676D+04	0.	0.	0.
0.	0.	0.	0.	0.	0.
.28718582D-04	-.59332536D-08	.97929518D+02	0.	0.	0.
.10261863D-04	-.81059109D-07	.31606362D+03	0.	0.	0.
-.10262115D-04	.87463883D-07	-.31606362D+03	0.	0.	0.
-.28718818D-04	.11187844D-07	-.97929518D+02	0.	0.	0.
0.	0.	0.	0.	0.	0.
.29484062D-04	-.18446956D-04	.12207676D+04	0.	0.	0.
.12238539D-04	-.23742664D-04	.40928226D+03	0.	0.	0.
-.11792095D-04	-.23048632D-04	-.68593013D+03	0.	0.	0.
-.29978070D-04	-.17527483D-04	-.15000000D+04	0.	0.	0.
.29692527D-04	-.39976394D-04	.35123141D+02	0.	0.	0.
.98839796D-05	-.40815368D-04	-.29152317D+02	0.	0.	0.
-.91112354D-05	-.41074127D-04	-.56010128D+02	0.	0.	0.
-.31041132D-04	-.41103484D-04	-.32356583D+02	0.	0.	0.

* MODE 8

GENERALIZED MASS (LB.) = .74348381D+04

.46296280D+02	.44314860D+03	.32098796D+02	0.	0.	0.
-.14901837D+01	.45411651D+03	-.41101335D+02	0.	0.	0.
-.26160305D+02	.45376170D+03	.44745458D+03	0.	0.	0.
-.69261573D+02	.44106620D+03	.40513413D+02	0.	0.	0.
.19635477D+02	.33969741D+03	.15000000D+04	0.	0.	0.
-.28591476D+01	.43544247D+03	-.19531895D+03	0.	0.	0.
-.30702905D+02	.43986585D+03	.90165546D+02	0.	0.	0.
-.45917046D+02	.34440612D+03	.10862633D+04	0.	0.	0.
0.	0.	0.	0.	0.	0.
-.84388057D+01	.31068108D+03	.72261309D+02	0.	0.	0.
-.12912288D+02	.37867242D+03	-.73195302D+03	0.	0.	0.
-.16821336D+02	.37870452D+03	-.73194240D+03	0.	0.	0.
-.19378475D+02	.31068434D+03	.72261437D+02	0.	0.	0.
0.	0.	0.	0.	0.	0.

-.34685701D+02	.33737812D+[illegible]	.10862248D+04	0.	0.	0.
-.26840849D+02	.43082027D+03	.90129325D+02	0.	0.	0.
-.73510344D+01	.42666129D+03	-.19533963D+03	0.	0.	0.
.82160376D+01	.33301967D+03	.14999664D+04	0.	0.	0.
-.57950743D+02	.42583679D+03	.40512185D+02	0.	0.	0.
-.22395172D+02	.43821268D+03	.44745659D+03	0.	0.	0.
-.49608701D+01	.43846891D+03	-.41094959D+02	0.	0.	0.
.34471808D+02	.42748985D+03	.32098357D+02	0.	0.	0.

* MODE 9

GENERALIZED MASS (LB.) = .22585266D+05

.13550569D+03	.14631074D+04	-.83070779D-03	0.	0.	0.
-.11040831D+02	.15000000D+04	-.17298999D-01	0.	0.	0.
-.81799400D+02	.14989839D+04	-.10757684D-01	0.	0.	0.
-.21400788D+03	.14568607D+04	.44044477D-02	0.	0.	0.
.46576630D+02	.11305052D+04	-.21282449D-01	0.	0.	0.
-.17414225D+02	.14487704D+04	.11687677D-01	0.	0.	0.
-.95616117D+02	.14632158D+04	.96108550D-01	0.	0.	0.
-.13568239D+03	.11457602D+04	.15941821D+00	0.	0.	0.
0.	0.	0.	0.	0.	0.
-.46970742D+02	.10442162D+04	-.17178785D-03	0.	0.	0.
-.50206153D+02	.12727858D+04	-.26387395D-01	0.	0.	0.
-.50206153D+02	.12727858D+04	.79487009D-02	0.	0.	0.
-.46970742D+02	.10442162D+04	.23817466D-03	0.	0.	0.
0.	0.	0.	0.	0.	0.
-.13568239D+03	.11457602D+04	.35085923D-01	0.	0.	0.
-.95616117D+02	.14632158D+04	-.21012432D-01	0.	0.	0.
-.17414225D+02	.14487704D+04	-.55201697D-01	0.	0.	0.
.46576630D+02	.11305052D+04	-.12990441D+00	0.	0.	0.
-.21400788D+03	.14568607D+04	.43450446D-03	0.	0.	0.
-.81799400D+02	.14989839D+04	-.43147010D-02	0.	0.	0.
-.11040831D+02	.15000000D+04	.32472225D-02	0.	0.	0.
.13550569D+03	.14631074D+04	-.22508938D-02	0.	0.	0.

* MODE 10

GENERALIZED MASS (LB.) = .27436436D+05

.14915137D+04	.16216327D+03	.77572200D-03	0.	0.	0.
.13100001D+04	.95613659D+02	.18248443D-01	0.	0.	0.
.13160231D+04	.24858533D+02	-.23421284D-02	0.	0.	0.
.14700609D+04	-.40651835D+02	.63212800D-03	0.	0.	0.
.15000000D+04	.95218061D+02	.13033417D-01	0.	0.	0.
16779228D+04	.12401418D+03	-.11573026D-01	0.	0.	0.
.16840462D+04	-.23629557D+02	-.18415969D-01	0.	0.	0.
.14909813D+04	-.18846249D+02	.41029907D-01	0.	0.	0.
0.	0.	0.	0.	0.	0.
.14633576D+04	.37066188D+02	.16903091D-03	0.	0.	0.
.15614003D+04	.47089841D+02	.85617717D-02	0.	0.	0.
.15614003D+04	.47089841D+02	-.13692224D-01	0.	0.	0.
.14633576D+04	.37066188D+02	.46247629D-04	0.	0.	0.
0.	0.	0.	0.	0.	0.
.14909814D+04	-.18846274D+02	-.17925173D-01	0.	0.	0.
.16840462D+04	-.23629588D+02	.25683570D-01	0.	0.	0.
.16779228D+04	.12401415D+03	.57372688D-02	0.	0.	0.
.15000000D+04	.95218038D+02	-.23589351D-01	0.	0.	0.
.14700609D+04	-.40651888D+02	-.21803971D-04	0.	0.	0.
.13160231D+04	.24858479D+02	.21618704D-02	0.	0.	0.
.13100001D+04	.95613604D+02	-.20010263D-01	0.	0.	0.
.14915137D+04	.16216322D+03	-.98474152D-03	0.	0.	0.

ORTHOGONALITY CHECK

1)						
	.10000000E+01	.48406031E-10	.12553842E-11	-.10284300E-05	-.96518629E-12	.11096679E-10
	.24778698E-13	-.22962596E-06	-.75482039E-06	-.24335824E-06		
2)						
	.75530556E-10	.10000000E+01	-.50504844E-10	-.21689306E-05	.10575060E-11	.34625148E-10
	.18668931E-12	-.45039296E-06	-.14791834E-05	-.28750075E-06		
3)						
	.92137923E-12	-.23755905E-10	.10000000E+01	-.77657070E-05	.17963026E-10	-.10669380E-11
	-.40240066E-12	-.94674665E-06	-.30930940E-05	-.43058149E-06		
4)						
	-.45378421E-06	-.61333410E-06	-.46686778E-05	.10000000E+01	.83688555E-04	-.18535089E-04
	.27404778E-07	.52195801E-02	-.46719302E-08	.17562218E-07		
5)						
	-.12092103E-11	.84908335E-12	.30662563E-10	.23761952E-03	.10000000E+01	.29530134E-08
	.11457952E-10	-.12855488E-04	-.41570788E-04	-.51515572E-05		
6)						
	.21985745E-10	.43965963E-10	-.28802195E-11	-.83227752E-04	.46700644E-08	.10000000E+01
	.28797046E-08	.20548392E-04	.65673444E-04	.66333995E-05		
7)						
	.44000406E-13	.21245867E-12	-.97358785E-12	.11028840E-06	.16240317E-10	.25809405E-08
	.10000000E+01	-.54831900E-08	.89062457E-11	-.58843790E-06		
8)						
	-.31513715E-06	-.39613846E-06	-.17703154E-05	.16234523E-01	-.14082394E-04	.14233389E-04
	-.42377341E-08	.10000000E+01	.90381179E+00	.16822187E-03		
9)						
	-.34101113E-06	-.42827600E-06	-.19039534E-05	-.47835093E-08	-.14990720E-04	.14974991E-04
	.22659034E-11	.29752558E+00	.10000000E+01	-.35570552E-06		
10)						
	-.90504149E-07	-.68523292E-07	-.21818056E-06	.14802230E-07	-.15292211E-05	.12451178E-05
	-.12323806E-06	.45585454E-04	-.29281149E-06	.10000000E+01		

INPUT OF SHOCK SPECTRA TABLES. NO. OF POINTS ON SPECTRA = 3 1 SET(S)

FREQUENCY TABLE (CPS)

.2000 5.9000 200.0000

X Y Z TABLES ON SHOCK SPECTRA (INS.) 0 0/0 DAMPING

7.5000 7.5000 .0070

-0.0000 -0.0000 -0.0000

7.5000 7.5000 .0070

X Y Z TABLES ON SHOCK SPECTRA (INS.) 5 0/0 DAMPING

6.0000	6.0000	.0041
-0.0000	-0.0000	-0.0000
6.0000	6.0000	.0041

X Y Z TABLES ON SHOCK SPECTRA (INS.) 10 0/0 DAMPING

4.0000	4.0000	.0037
-0.0000	-0.0000	-0.0000
4.0000	4.0000	.0037

RESPONSE DATA (DISPL. IN INCH AND RAD., ACCEL. IN INCH/SEC**2, AND RAD./SEC**2)

0 0/0 DAMPING

X	Y	Z	THETA X	THETA Y	THETA Z
-26.6335	-5.8101	-.2810	-.17847E-01	.15264E+00	.34405E-01
-23.1059	-4.7085	-1.7104	.34049E-01	.71982E-01	.18480E-01
-23.0412	-3.4578	-5.1929	-.81201E-02	.61207E-01	-.42141E-02
-25.4656	-2.2176	-.5540	-.19160E-02	.11542E+00	-.16615E-03
-26.6063	-3.9348	-13.7812	-.78368E-01	-.31413E-01	.30130E-01
-22.1919	-3.8090	-4.9443	-.19881E-01	.11678E-02	-.63148E-02
-22.1274	-1.8775	-6.4825	.41760E-01	-.38983E-01	-.16412E-01
-25.9892	-1.9540	-13.4923	.51630E-01	-.24267E-01	-.16303E-01
-17.8769	-2.3090	-3.5786	.31953E-01	.25553E-02	-.16244E-01
-25.7736	-2.7097	-.9679	-.10364E-01	.16055E-01	.16573E-01
-20.5997	-2.5023	-2.1483	.11521E-02	-.28382E-02	.13502E-01
-20.5740	-2.5025	-2.1481	-.11543E-02	.28412E-02	-.13050E-01
-25.6778	-2.7098	-.9679	.10368E-01	-.16065E-01	-.16226E-01
-17.8770	-2.2860	-3.5787	-.31956E-01	-.25496E-02	.16046E-01
-26.0876	-1.8924	-13.4910	-.51614E-01	.24266E-01	.17131E-01
-22.1580	-1.8181	-6.4829	-.41756E-01	.38985E-01	.17019E-01
-22.1624	-3.7513	-4.9444	.19875E-01	-.11680E-02	.64921E-02
-26.5064	-3.8764	-13.7803	.78363E-01	.31414E-01	-.29317E-01
-25.5646	-2.0843	-.5540	.19217E-02	-.11541E+00	.27476E-03
-23.0742	-3.3216	-5.1930	.81160E-02	-.61208E-01	.49954E-02
-23.0755	-4.5715	-1.7097	-.34050E-01	-.71988E-01	-.17697E-01
-26.5299	-5.6730	-.2810	.17850E-01	-.15263E+00	-.33581E-01

XDDOT	YDDOT	ZDDOT	TXDDOT	TYDDOT	TZDDOT
-6025.2915	-1263.3865	-54.7680	-.10649E+02	.27571E+02	.76837E+01
-5232.2353	-1012.6616	131.7267	.52702E+01	.99036E+01	.41017E+01
-5220.5721	-729.4798	-707.9224	.18773E+01	.75441E+01	-.10418E+01
-5774.7110	-450.1589	-88.6128	-.16974E+00	.23234E+02	-.54670E-01
-6022.2853	-851.0232	-2696.8100	-.25793E+02	-.56151E+01	.67530E+01
-5025.3324	-824.0719	-71.7006	-.53123E+01	-.31647E+01	-.14528E+01
-5013.2697	-386.3170	-507.7218	.10591E+02	-.86671E+01	-.37755E+01
-5890.5441	-401.9147	-2445.7365	.15920E+02	-.58884E+01	-.37702E+01
-4049.0995	-492.5782	210.0360	.86182E+01	-.56451E+00	-.36699E+01
-5837.0195	-577.1047	-155.2731	-.91918E+01	-.40834E+00	.37484E+01
-4665.6866	-533.2750	584.9566	-.30952E+01	-.39873E+00	.30748E+01
-4660.2948	-533.3193	585.0121	.30947E+01	.39944E+00	-.29800E+01
-5816.9005	-577.1107	-155.2728	.91927E+01	.40610E+00	-.36756E+01
-4049.1252	-487.7418	210.0035	-.86188E+01	.56580E+00	.36283E+01
-5911.1995	-388.9896	-2445.4471	-.15916E+02	.58883E+01	.39441E+01
-5019.7001	-373.8403	-507.8160	-.10590E+02	.86675E+01	.39029E+01
-5019.1367	-811.9599	-71.7308	.53109E+01	.31647E+01	.14900E+01
-6001.2840	-838.7422	-2696.6168	.25791E+02	.56153E+01	-.65821E+01
-5795.5125	-422.1507	-88.6085	.17100E+00	-.23231E+02	.77482E-01
-5227.4965	-700.8838	-707.9432	-.18783E+01	-.75445E+01	.12059E+01
-5225.8524	-983.8843	131.8707	-.52705E+01	-.99050E+01	-.39374E+01
-6003.5453	-1234.5888	-54.7603	.10650E+02	-.27570E+02	-.75106E+01

5 0/0 DAMPING

X	Y	Z	THETA X	THETA Y	THETA Z
-21.3068	-4.6481	-.2248	-.14278E-01	.12211E+00	.27524E-01
-18.4847	-3.7668	-1.3683	.27239E-01	.57586E-01	.14784E-01
-18.4210	-2.7662	-4.1543	-.64961E-02	.48965E-01	-.33713E-02

-20.3725	-1.7741	-.4432	-.15328E-02	.92335E-01	-.13292E-03
-21.2851	-3.1479	-11.0250	-.62695E-01	-.25131E-01	.24104E-01
-17.7535	-3.0472	-3.9555	-.15905E-01	.93426E-03	-.50519E-02
-17.7019	-1.5020	-5.1860	.33408E-01	-.31187E-01	-.13130E-01
-20.7914	-1.5632	-10.7939	.41304E-01	-.19414E-01	-.13042E-01
-14.3015	-1.8472	-2.8629	.25563E-01	.20442E-02	-.12995E-01
-20.6189	-2.1678	-.7743	-.82913E-02	.12844E-01	.13259E-01
-16.4797	-2.0019	-1.7186	.92165E-03	-.22705E-02	.10801E-01
-16.4592	-2.0020	-1.7185	-.92347E-03	.22729E-02	-.10440E-01
-20.5422	-2.1678	-.7743	.82946E-02	-.12852E-01	-.12981E-01
-14.3016	-1.8288	-2.8630	-.25565E-01	-.20397E-02	.12837E-01
-20.8701	-1.5139	-10.7928	-.41291E-01	.19413E-01	.13705E-01
-17.7264	-1.4545	-5.1863	-.33405E-01	.31188E-01	.13615E-01
-17.7299	-3.0011	-3.9556	.15900E-01	-.93439E-03	.51937E-02
-21.2051	-3.1011	-11.0243	.62690E-01	.25131E-01	-.23454E-01
-20.4517	-1.6674	-.4432	.15373E-02	-.92324E-01	.21981E-03
-18.4593	-2.6573	-4.1544	.64928E-02	-.48967E-01	.39964E-02
-18.4604	-3.6572	-1.3678	-.27240E-01	-.57590E-01	-.14158E-01
-21.2239	-4.5384	-.2248	.14280E-01	-.12211E+00	-.26865E-01

XDDOT	YDDOT	ZDDOT	TXDDOT	TYDDOT	TZDDOT
-4820.2332	-1010.7092	-43.8144	-.85196E+01	.22057E+02	.61469E+01
-4185.7883	-810.1293	105.3814	.42161E+01	.79229E+01	.32814E+01
-4176.4577	-583.5838	-566.3379	.15019E+01	.60353E+01	-.83345E+00
-4619.7688	-360.1271	-70.8902	-.13579E+00	.18587E+02	-.43736E-01
-4817.8283	-680.8185	-2157.4480	-.20634E+02	-.44921E+01	.54024E+01
-4020.2660	-659.2575	-57.3605	-.42498E+01	-.25318E+01	-.11622E+01
-4010.6157	-309.0536	-406.1775	.84731E+01	-.69337E+01	-.30204E+01
-4712.4353	-321.5317	-1956.5892	.12736E+02	-.47107E+01	-.30161E+01
-3239.2796	-394.0626	168.0288	.68946E+01	-.45161E+00	-.29360E+01
-4669.6156	-461.6838	-124.2185	-.73534E+01	-.32667E+00	.29988E+01
-3732.5493	-426.6200	467.9653	-.24762E+01	-.31898E+00	.24598E+01
-3728.2359	-426.6554	468.0097	.24757E+01	.31955E+00	-.23840E+01
-4653.5204	-461.6886	-124.2182	.73542E+01	.32488E+00	-.29405E+01
-3239.3002	-390.1934	168.0028	-.68951E+01	.45264E+00	.29026E+01
-4728.9596	-311.1917	-1956.3577	-.12733E+02	.47106E+01	.31553E+01
-4015.7601	-299.0722	-406.2528	-.84724E+01	.69340E+01	.31223E+01
-4015.30[illegible]	-649.5679	-57.3846	.42488E+01	.25317E+01	.11920E+01
-4801.0272	-670.9938	-2157.2934	.20633E+02	.44922E+01	-.52657E+01
-4636.4101	-337.7205	-70.8868	.13680E+00	-.18585E+02	.61986E-01
-4181.9972	-560.7070	-566.3546	-.15026E+01	-.60356E+01	.96474E+00
-418[illegible].6820	-787.1075	105.4965	-.42164E+01	-.79240E+01	-.31499E+01
-4802.836	-987.6710	-43.8083	.85202E+01	-.22056E+02	-.60085E+01

10 0/0 DAMPING

X	Y	Z	THETA X	THETA Y	THETA Z
-14.2045	-3.0987	-.1499	-.95185E-02	.81407E-01	.18349E-01
-12.3232	-2.5112	-.9122	.18159E-01	.38390E-01	.98558E-02
-12.2886	-1.8441	-2.7696	-.43307E-02	.32643E-01	-.22475E-02
-13.5816	-1.1827	-.2955	-.10219E-02	.61556E-01	-.88612E-04
-14.1900	-2.0986	-7.3500	-.41796E-01	-.16754E-01	.16070E-01
-11.8357	-2.0315	-2.6370	-.10603E-01	.62284E-03	-.33679E-02
-11.8013	-1.0014	-3.4573	.22272E-01	-.20791E-01	-.87532E-02
-13.8609	-1.0421	-7.1959	.27536E-01	-.12942E-01	-.86947E-02
-9.5344	-1.2315	-1.9086	.17042E-01	.13628E-02	-.86636E-02
-13.7459	-1.4452	-.5162	-.55275E-02	.85626E-02	.88390E-02
-10.9865	-1.3346	-1.1458	.61443E-03	-.15137E-02	.72009E-02
-10.9728	-1.3347	-1.1456	-.61565E-03	.15153E-02	-.69602E-02
-13.6948	-1.4452	-.5162	.55297E-02	-.85680E-02	-.86540E-02
-9.5344	-1.2192	-1.9087	-.17043E-01	-.13598E-02	.85578E-02
-13.9134	-1.0093	-7.1952	-.27528E-01	.12942E-01	.91365E-02
-11.8176	-.9697	-3.4575	-.22270E-01	.20792E-01	.90766E-02

-11.8199	-2.0007	-2.6370	.10600E-01	-.62293E-03	.34624E-02
-14.1367	-2.0674	-7.3495	.41793E-01	.16754E-01	-.15636E-01
-13.6345	-1.1116	-.2955	.10249E-02	-.61550E-01	.14654E-03
-12.3062	-1.7715	-2.7696	.43285E-02	-.32644E-01	.26642E-02
-12.3069	-2.4381	-.9119	-.18160E-01	-.38394E-01	-.94386E-02
-14.1493	-3.0256	-.1498	.95202E-02	-.81404E-01	-.17910E-01

XDDOT	YDDOT	ZDDOT	TXDDOT	TYDDOT	TZDDOT
-3213.4888	-673.8062	-29.2096	-.56797E+01	.14705E+02	.40980E+01
-2790.5255	-540.0862	70.2543	.28108E+01	.52819E+01	.21876E+01
-2784.3051	-389.0559	-377.5586	.10013E+01	.40235E+01	-.55563E+00
-3079.8458	-240.0847	-47.2602	-.90530E-01	.12392E+02	-.29157E-01
-3211.8855	-453.8790	-1438.2987	-.13756E+02	-.29947E+01	.36016E+01
-2680.1773	-439.5050	-38.2403	-.28332E+01	-.16878E+01	-.77482E+00
-2673.7438	-206.0357	-270.7850	.56488E+01	-.46225E+01	-.20136E+01
-3141.6235	-214.3545	-1304.3928	.84906E+01	-.31405E+01	-.20108E+01
-2159.5197	-262.7084	112.0192	.45964E+01	-.30107E+00	-.19573E+01
-3113.0771	-307.7892	-82.8123	-.49023E+01	-.21778E+00	.19992E+01
-2488.3662	-284.4133	311.9768	-.16508E+01	-.21265E+00	.16399E+01
-2485.4906	-284.4369	312.0065	.16505E+01	.21303E+00	-.15893E+01
-3102.3469	-307.7924	-82.8122	.49028E+01	.21658E+00	-.19603E+01
-2159.5334	-260.1290	112.0018	-.45967E+01	.30176E+00	.19351E+01
-3152.6397	-207.4611	-1304.2385	-.84887E+01	.31404E+01	.21035E+01
-2677.1734	-199.3815	-270.8352	-.56483E+01	.46227E+01	.20815E+01
-2676.8723	-433.0453	-38.2564	.28325E+01	.16878E+01	.79468E+00
-3200.6848	-447.3292	-1438.1956	.13755E+02	.29948E+01	-.35105E+01
-3090.9400	-225.1470	-47.2579	.91200E-01	-.12390E+02	.41324E-01
-2787.9982	-373.8047	-377.5697	-.10018E+01	-.40238E+01	.64316E+00
-2787.1213	-524.7383	70.3310	-.28109E+01	-.52826E+01	-.21000E+01
-3201.8908	-658.4473	-29.2055	.56801E+01	-.14704E+02	-.40057E+01

A 22-NODE PLATFORM DYNAMIC ANALYSIS (PLATFORM ASSUMED RIGID)

RIGID PLATFORM ANALYSIS

MASSES AND COORDINATES

WEIGHT (LB.)	X (IN)	Y (IN)	Z (IN)	IXX	IYY	IZZ
1500.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00
1500.00	0.00	100.00	-0.00	-0.00	-0.00	-0.00
1500.00	0.00	200.00	-0.00	-0.00	-0.00	-0.00
1500.00	0.00	300.00	-0.00	-0.00	-0.00	-0.00
1500.00	100.00	0.00	-0.00	-0.00	-0.00	-0.00
2000.00	100.00	100.00	-0.00	-0.00	-0.00	-0.00
2000.00	100.00	200.00	-0.00	-0.00	-0.00	-0.00
1500.00	100.00	300.00	-0.00	-0.00	-0.00	-0.00
1500.00	200.00	0.00	-0.00	-0.00	-0.00	-0.00
2000.00	200.00	100.00	-0.00	-0.00	-0.00	-0.00
2000.00	200.00	200.00	-0.00	-0.00	-0.00	-0.00
1500.00	200.00	300.00	-0.00	-0.00	-0.00	-0.00
1500.00	300.00	0.00	-0.00	-0.00	-0.00	-0.00
2000.00	300.00	100.00	-0.00	-0.00	-0.00	-0.00
2000.00	300.00	200.00	-0.00	-0.00	-0.00	-0.00
1500.00	300.00	300.00	-0.00	-0.00	-0.00	-0.00
1500.00	400.00	0.00	-0.00	-0.00	-0.00	-0.00
1500.00	400.00	100.00	-0.00	-0.00	-0.00	-0.00
1500.00	400.00	200.00	-0.00	-0.00	-0.00	-0.00
1500.00	400.00	300.00	-0.00	-0.00	-0.00	-0.00

CENTER OF GRAVITY LOCATION

XCG = 200.00 YCG = 150.00 ZCG = 0.00 TOTAL WT = 33000.00 LBS

SPRING STIFFNESSES AND END COORDINATES

KI (LBF/IN)	XA (IN)	XB (IN)	YA (IN)	YB (IN)	ZA (IN)	ZB (IN)
5000000.00	0.00	0.00	0.00	0.00	0.00	-50.00
5000000.00	0.00	0.00	300.00	300.00	0.00	-50.00
5000000.00	200.00	200.00	0.00	0.00	0.00	-50.00
5000000.00	200.00	200.00	300.00	300.00	0.00	-50.00
5000000.00	400.00	400.00	0.00	0.00	0.00	-50.00
5000000.00	400.00	400.00	300.00	300.00	0.00	-50.00
5000000.00	150.00	100.00	150.00	150.00	0.00	0.00
5000000.00	250.00	200.00	150.00	150.00	0.00	0.00
5000000.00	150.00	150.00	150.00	100.00	0.00	0.00
5000000.00	250.00	250.00	150.00	100.00	0.00	0.00

MASS MATRIX

MI1	MI2	MI3	MI4	MI5	MI6
.3300E+05	0.	0.	0.	0.	0.
0.	.3300E+05	0.	0.	0.	0.
0.	0.	.3300E+05	0.	0.	0.
0.	0.	0.	.3825E+09	0.	0.
0.	0.	0.	0.	.6200E+09	0.
0.	0.	0.	0.	0.	.1002E+10

STIFFNESS MATRIX

KI1	KI2	KI3	KI4	KI5	KI6
.1000E+08	0.	0.	0.	0.	0.
0.	.1000E+08	0.	0.	0.	0.
0.	0.	.3000E+08	0.	0.	0.
0.	0.	0.	.6750E+12	0.	0.
0.	0.	0.	0.	.8000E+12	0.
0.	0.	0.	0.	0.	.2500E+11

DYNAMIC MATRIX

.330E-02	0.	0.	0.	0.	0.
0.	.330E-02	0.	0.	0.	0.
0.	0.	.110E-02	0.	0.	0.
0.	0.	0.	.567E-03	0.	0.
0.	0.	0.	0.	.775E-03	0.
0.	0.	0.	0.	0.	.401E-01

EIGENSYSTEM SOLUTION

DYNAMIC MATRIX 6 BY 6

NO. OF RESONANT MODES TO BE COMPUTED = 6

EIGENVALUE ACCURACY CONTROLS, EPSILON AND ITERATION LIMIT = .1000D-11 100.0

1 MODE, 2.0 ITERATIONS

2 MODE, 2.0 ITERATIONS

3 MODE, 2.0 ITERATIONS

4 MODE, 2.0 ITERATIONS

5 MODE, 2.0 ITERATIONS

6 MODE, 2.0 ITERATIONS

FLEXIBLE BODY MODES

MODE NO.	1	2	3	4	5	6
FREQ (HZ)	15.6231	54.4605	54.4605	94.3284	112.3797	131.4241
NODE 1)						
DOF NO 1	0.00000	1.00000	0.00000	0.00000	0.00000	0.00000
DOF NO 2	0.00000	0.00000	1.00000	0.00000	0.00000	0.00000
DOF NO 3	0.00000	0.00000	0.00000	1.00000	0.00000	0.00000
DOF NO 4	0.00000	0.00000	0.00000	0.00000	0.00000	1.00000
DOF NO 5	0.00000	0.00000	0.00000	0.00000	1.00000	0.00000
DOF NO 6	1.00000	0.00000	0.00000	0.00000	0.00000	0.00000

MODAL PARTICIPATION FACTORS

* MODE 1

GENERALIZED MASS (LB.) = .20000000D+04

0. 0. 0. 0. 0. .20000000D+04

* MODE 2

GENERALIZED MASS (LB.) = .15000000D+04

.15000000D+04 0. 0. 0. 0. 0.

* MODE 3

GENERALIZED MASS (LB.) = .15000000D+04

0. .15000000D+04 0. 0. 0. 0.

* MODE 4

GENERALIZED MASS (LB.) = .15000000D+04

0. 0. .15000000D+04 0. 0. 0.

* MODE 5

GENERALIZED MASS (LB.) = .15000000D+04

0. 0. 0. 0. .15000000D+04 0.

```
* MODE      6
GENERALIZED MASS (LB.) =   .15000000D+04
    0.                  0.                  0.                  .15000000D+04       0.                  0.


ORTHOGONALITY CHECK


 1)
    .10000000E+01       0.                  0.                  0.                  0.                  0.
 2)
    0.                   .10000000E+01      0.                  0.                  0.                  0.
 3)
    0.                  0.                   .10000000E+01      0.                  0.                  0.
 4)
    0.                  0.                  0.                   .10000000E+01      0.                  0.
 5)
    0.                  0.                  0.                  0.                   .10000000E+01      0.
 6)
    0.                  0.                  0.                  0.                  0.                   .10000000E+01


  INPUT OF SHOCK SPECTRA TABLES.     NO. OF POINTS ON SPECTRA =   3                  1 SET(S)
     FREQUENCY TABLE (CPS)
    .2000       5.9000    200.0000

     X Y Z TABLES ON SHOCK SPECTRA (INS.)     0 0/0 DAMPING


    7.5000      7.5000       .0070
   -0.0000     -0.0000     -0.0000
    7.5000      7.5000       .0070

     X Y Z TABLES ON SHOCK SPECTRA (INS.)     5 0/0 DAMPING


    6.0000      6.0000       .0041
   -0.0000     -0.0000     -0.0000
    6.0000      6.0000       .0041

     X Y Z TABLES ON SHOCK SPECTRA (INS.)    10 0/0 DAMPING
```

4.0000	4.0000	.0037
-0.0000	-0.0000	-0.0000
4.0000	4.0000	.0037

RESPONSE DATA (DISPL. IN INCH AND RAD., ACCEL. IN INCH/SEC**2, AND RAD./SEC**2)

0 0/0 DAMPING

X	Y	Z	THETA X	THETA Y	THETA Z
-31.5208	0.0000	-72.3233	0.	0.	0.
XDDOT	YDDOT	ZDDOT	TXDDOT	TYDDOT	TZDDOT
-9551.7684	0.0000	-65748.4151	0.	0.	0.

5 0/0 DAMPING

X	Y	Z	THETA X	THETA Y	THETA Z
-25.2167	0.0000	-57.8586	0.	0.	0.
XDDOT	YDDOT	ZDDOT	TXDDOT	TYDDOT	TZDDOT
-7641.4147	0.0000	-52598.7325	0.	0.	0.

10 0/0 DAMPING

X	Y	Z	THETA X	THETA Y	THETA Z
-16.8111	0.0000	-38.5724	0.	0.	0.
XDDOT	YDDOT	ZDDOT	TXDDOT	TYDDOT	TZDDOT
-5094.2765	0.0000	-35065.8214	0.	0.	0.

SECTION 11: EXAMPLE TO ISOL, WITH CALCOMP PLOTTING

AN ISOL-PLTSUB EXAMPLE RUN, USING CALCOMP PLOTTER. 2 PROBLEMS. (END CONDITIONS OF FIRST PROBLEM = INITIAL CONDITIONS OF SECOND PROBLEM)

```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

     14       1                                                                      1
  SHORT PENDUL ISOL-PLTSUB SAMPLE RUN, USING OPTION 14.   PROBLEMS 1 AND 2.          2
 ISOL INPUT CARDS      -  PROBLEM 1.                                                 3
  SHORT PENDUL ISOL SAMPLE PROBLEM(A) - TO DETERM EQUIL POSITIONS - PROB 1.          4
  7   4   0   1   4   0   0  -1                                                      5
2390E+0   -1E+1  645E-1 5225E-2  719E+3  796E+2  248E+3       0       0             6
 229E+1   -1E+1        0 5225E-2  907E+3  762E+2  248E+3       0       0             7
   2E+3   -1E+1 -645E-1 5225E-2    6E+5  666E+2  208E+3       0       0             8
 251E+1    1E+1  645E-1 5225E-2  753E+3  835E+2  261E+3       0       0             9
   2E+3    1E+1        0 5225E-2  792E+3  666E+2  216E+3       0       0            10
 366E+0    1E+1 -645E-1 5225E-2   11E+4  122E+2   38E+3       0       0            11
3182E+0       0        0       0  104E+5  183E+4   56E+5       0       0            12
 -42E+0   99E+0   41E+0  -42E+0   99E+0   16E+0                                    13
  42E+0   99E+0   41E+0   42E+0   99E+0   16E+0                                    14
 -42E+0  -99E+0   41E+0  -42E+0  -99E+0   16E+0                                    15
  42E+0  -99E+0   41E+0   42E+0  -99E+0   16E+0                                    16
  13E+0       0        0                                                            17
  13E+0       0        0                                                            18
  13E+0       0        0                                                            19
  13E+0       0        0                                                            20
  -1E+1  645E-1 5225E-2                                                            21
  -1E+1 -645E-1 5225E-2                                                            22
   1E+1  645E-1 5225E-2                                                            23
   1E+1 -645E-1  725E-2                                                            24
  0   0   25E+0  766E+0   30E+1                                                     25
  0   0   25E+0  807E+0   30E+1                                                     26
  0   0   25E+0  751E+0   30E+1                                                     27
  0   0   25E+0  794E+0   30E+1                                                     28
      0    6E+0    5E-2    2E-1    3E+0    5E-1    1E+0       0   -1E+1             29
     0.      0.      0.      0.      0.      0.      0.      0.      0.             30
                                                                                    31
                                                                                    32
                                                                                    33
INPUT TO YUPLOT                                                                     34
  1  4 28                                                                           35
SKIP          (SKIPPING SPCTRM)                                                     36
  ISOL INPUT CARDS      -  PROBLEM 2.                                               37
   SHORT PENDUL ISOL SAMPLE PROBLEM(B) - X-Z GRPUND EXCITATIONS - PROB 2.           38
  7   4 191   1   4   0  -1  -1                                                      39
  3   3   25E+0  766E+0    8E+0                                                     40
  -1E+2       0    1E+2                                                            41
 -766E+2      0  766E+2                                                            42
  -1E+4       0    1E+4                                                            43
  -8E+4       0    8E+4                                                            44
  3   3   25E+0  807E+0    8E+0                                                     45
  -1E+2       0    1E+2                                                            46
 -807E+2      0  807E+2                                                            47
  -1E+4       0    1E+4                                                            48
  -8E+4       0    8E+4                                                            49
  3   3   25E+0  751E+0    8E+0                                                     50
  -1E+2       0    1E+2                                                            51
```

```
        10        20        30        40        50        60        70        80   CARD
........*.........*.........*.........*.........*.........*.........*.........*    NO.

-751E+2       0  751E+2                                                              52
  -1E+4       0    1E+4                                                              53
  -8E+4       0    8E+4                                                              54
  3   3  25E+0  794E+0    8E+0                                                       55
  -1E+2       0    1E+2                                                              56
-794E+2       0  794E+2                                                              57
  -1E+4       0    1E+4                                                              58
  -8E+4       0    8E+4                                                              59
 0.0000  0.0250  0.0500  0.0750  0.1000  0.1250  0.1500  0.1750  0.2000              60
 0.2250  0.2500  0.2750  0.3000  0.3250  0.3500  0.3750  0.4000  0.4250              61
 0.4500  0.4750  0.5000  0.5250  0.5500  0.5750  0.6000  0.6250  0.6500              62
 0.6750  0.7000  0.7250  0.7500  0.7750  0.8000  0.8250  0.8500  0.8750              63
 0.9000  0.9250  0.9500  0.9750  1.0000  1.0250  1.0500  1.0750  1.1000              64
 1.1250  1.1500  1.1750  1.2000  1.2250  1.2500  1.2750  1.3000  1.3250              65
 1.3500  1.3750  1.4000  1.4250  1.4500  1.4750  1.5000  1.5250  1.5500              66
 1.5750  1.6000  1.6250  1.6500  1.6750  1.7000  1.7250  1.7500  1.7750              67
 1.8000  1.8250  1.8500  1.8750  1.9000  1.9250  1.9500  1.9750  2.0000              68
 2.0250  2.0500  2.0750  2.1000  2.1250  2.1500  2.1750  2.2000  2.2250              69
 2.2500  2.2750  2.3000  2.3250  2.3500  2.3750  2.4000  2.4250  2.4500              70
 2.4750  2.5000  2.5250  2.5500  2.5750  2.6000  2.6250  2.6500  2.6750              71
 2.7000  2.7250  2.7500  2.7750  2.8000  2.8250  2.8500  2.8750  2.9000              72
 2.9250  2.9500  2.9750  3.0000  3.0250  3.0500  3.0750  3.1000  3.1250              73
 3.1500  3.1750  3.2000  3.2250  3.2500  3.2750  3.3000  3.3250  3.3500              74
 3.3750  3.4000  3.4250  3.4500  3.4750  3.5000  3.5250  3.5500  3.5750              75
 3.6000  3.6250  3.6500  3.6750  3.7000  3.7250  3.7500  3.7750  3.8000              76
 3.8250  3.8500  3.8750  3.9000  3.9250  3.9500  3.9750  4.0000  4.0250              77
 4.0500  4.0750  4.1000  4.1250  4.1500  4.1750  4.2000  4.2250  4.2500              78
 4.2750  4.3000  4.3250  4.3500  4.3750  4.4000  4.4250  4.4500  4.4750              79
 4.5000  4.5250  4.5500  4.5750  4.6000  4.6250  4.6500  4.6750  4.7000              80
 4.7250     8.0                                                                      81
-0.0082  0.0082  0.0181  0.0195  0.0152  0.0101  0.0068  0.0052  0.0046              82
 0.0060  0.0121  0.0239  0.0381  0.0476  0.0472  0.0372  0.0232  0.0112              83
 0.0018 -0.0091 -0.0241 -0.0382 -0.0386 -0.0149  0.0294  0.0738  0.0912              84
 0.0663  0.0091 -0.0483 -0.0711 -0.0441  0.0188  0.0842  0.1197  0.1113              85
 0.0664  0.0027 -0.0631 -0.1202 -0.1579 -0.1618 -0.1185 -0.0284  0.0830              86
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 0.0401  0.0722  0.0568  0.0068 -0.0575 -0.1149 -0.1456 -0.1355 -0.0837              88
-0.0073  0.0625  0.0966  0.0854  0.0462  0.0117  0.0069  0.0309  0.0579              89
 0.0574  0.0192 -0.0368 -0.0740 -0.0658 -0.0152  0.0464  0.0813  0.0713              90
 0.0278 -0.0189 -0.0420 -0.0356 -0.0140  0.0024  0.0039 -0.0041 -0.0086              91
-0.0020  0.0118  0.0215  0.0182  0.0031 -0.0140 -0.0214 -0.0124  0.0116              92
 0.0437  0.0750  0.0955  0.0959  0.0697  0.0181 -0.0465 -0.1025 -0.1286              93
-0.1148 -0.0693 -0.0147  0.0243  0.0339  0.0170 -0.0114 -0.0339 -0.0394              94
-0.0257  0.0026  0.0378  0.0707  0.0908  0.0885  0.0593  0.0079 -0.0521              95
-0.1039 -0.1361 -0.1473 -0.1433 -0.1295 -0.1043 -0.0616  0.0010  0.0736              96
 0.1340  0.1586  0.1374  0.0820  0.0200 -0.0202 -0.0259 -0.0050  0.0227              97
 0.0398  0.0413  0.0338  0.0254  0.0168  0.0010 -0.0287 -0.0686 -0.1031              98
-0.1124 -0.0863 -0.0328  0.0246  0.0602  0.0610  0.0332 -0.0025 -0.0245              99
-0.0224 -0.0018  0.0216  0.0327  0.0261  0.0077 -0.0103 -0.0176 -0.0117             100
 0.0009  0.0096  0.0062 -0.0104 -0.0338 -0.0533 -0.0604 -0.0521 -0.0318             101
-0.0064  0.0183  0.0401  0.0593  0.0758  0.0860  0.0836  0.0626  0.0223             102
 0.0000  0.0000                                                                     103
    0.0                                                                             104
```

```
         10        20        30        40        50        60        70        80   CARD
.........+.........+.........+.........+.........+.........+.........+.........+    NO.

     0.0                                                                            105
     0.0                                                                            106
     0.0                                                                            107
     0.0                                                                            108
     0.0                                                                            109
     0.0                                                                            110
     0.0                                                                            111
     0.0                                                                            112
     0.0                                                                            113
     0.0                                                                            114
     0.0                                                                            115
     0.0                                                                            116
     0.0                                                                            117
     0.0                                                                            118
     0.0                                                                            119
     0.0                                                                            120
     0.0                                                                            121
     0.0                                                                            122
     0.0                                                                            123
     0.0                                                                            124
     0.0                                                                            125
  0.0000 -0.0003 -0.0024 -0.0073 -0.0150 -0.0254 -0.0381 -0.0517 -0.0624            126
 -0.0650 -0.0566 -0.0400 -0.0234 -0.0151 -0.0159 -0.0159  0.0013  0.0467            127
  0.1162  0.1890  0.2371  0.2395  0.1934  0.1142  0.0275 -0.0429 -0.0822            128
 -0.0879 -0.0683 -0.0400 -0.0231 -0.0329 -0.0694 -0.1120 -0.1268 -0.0858            129
  0.0112  0.1286  0.2102  0.2107  0.1253 -0.0054 -0.1183 -0.1659 -0.1414            130
 -0.0763 -0.0133  0.0240  0.0407  0.0561  0.0790  0.0958  0.0821  0.0267            131
 -0.0525 -0.1169 -0.1351 -0.1069 -0.0640 -0.0445 -0.0621 -0.0940 -0.0987            132
 -0.0507  0.0358  0.1135  0.1347  0.0859 -0.0017 -0.0741 -0.0918 -0.0548            133
  0.0020  0.0376  0.0353  0.0119  0.0001  0.0205  0.0639  0.0978  0.0916            134
  0.0394 -0.0342 -0.0907 -0.1028 -0.0706 -0.0189  0.0213  0.0328  0.0208            135
  0.0059  0.0077  0.0316  0.0666  0.0937  0.0994  0.0835  0.0575  0.0361            136
  0.0273  0.0280  0.0274  0.0152 -0.0108 -0.0432 -0.0692 -0.0780 -0.0663            137
 -0.0401 -0.0110  0.0089  0.0110 -0.0069 -0.0404 -0.0792 -0.1094 -0.1181            138
 -0.0993 -0.0577 -0.0083  0.0298  0.0433  0.0311  0.0044 -0.0207 -0.0333            139
 -0.0332 -0.0288 -0.0298 -0.0391 -0.0518 -0.0595 -0.0570 -0.0467 -0.0359            140
 -0.0307 -0.0318 -0.0337 -0.0288 -0.0128  0.0131  0.0430  0.0693  0.0855            141
  0.0882  0.0775  0.0573  0.0346  0.0173  0.0111  0.0167  0.0297  0.0437            142
  0.0547  0.0626  0.0689  0.0728  0.0691  0.0507  0.0158 -0.0282 -0.0665            143
 -0.0848 -0.0796 -0.0609 -0.0457 -0.0471 -0.0644 -0.0844 -0.0900 -0.0726            144
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  0.0484  0.0544  0.0535  0.0475  0.0384  0.0283  0.0185  0.0105  0.0045            146
  0.0000  0.0000                                                                    147
       0    8E+0    1E-2    5E-2    5E+0    1E-1    1E+0       0   -1E+1            148
                                                                                    149
INPUT TO YUPLOT                                                                     150
  1  4 11                                                                           151
FINISH                                                                              152
```
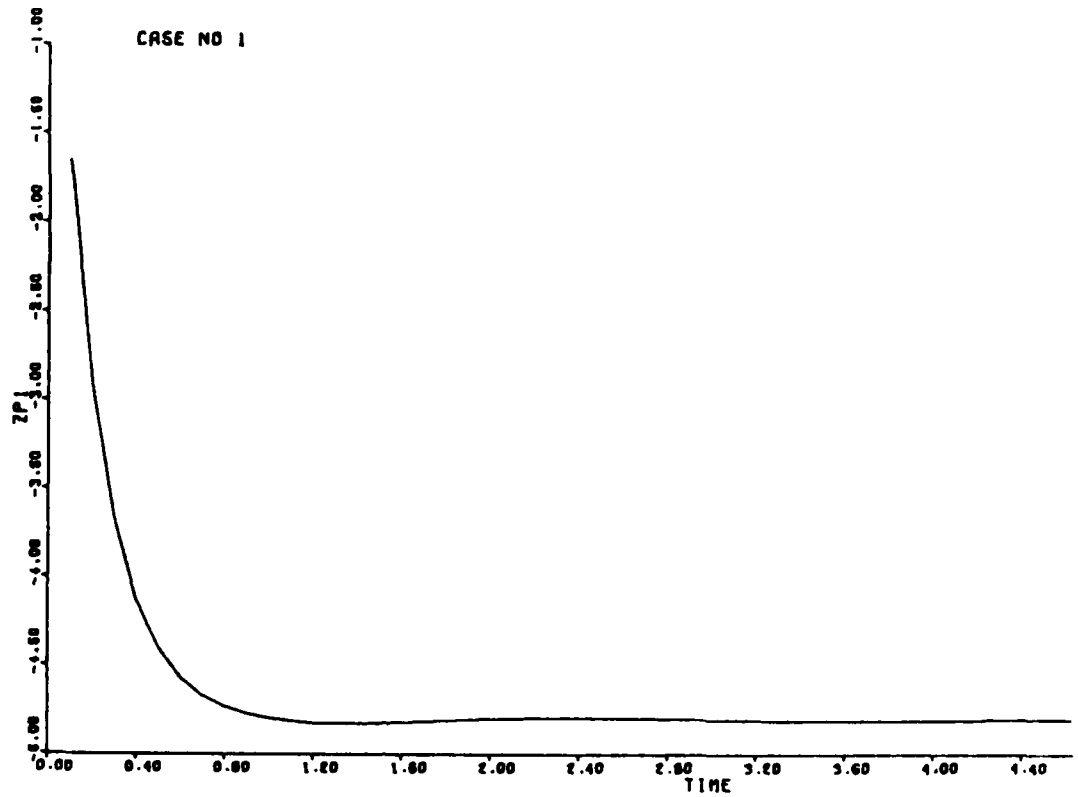
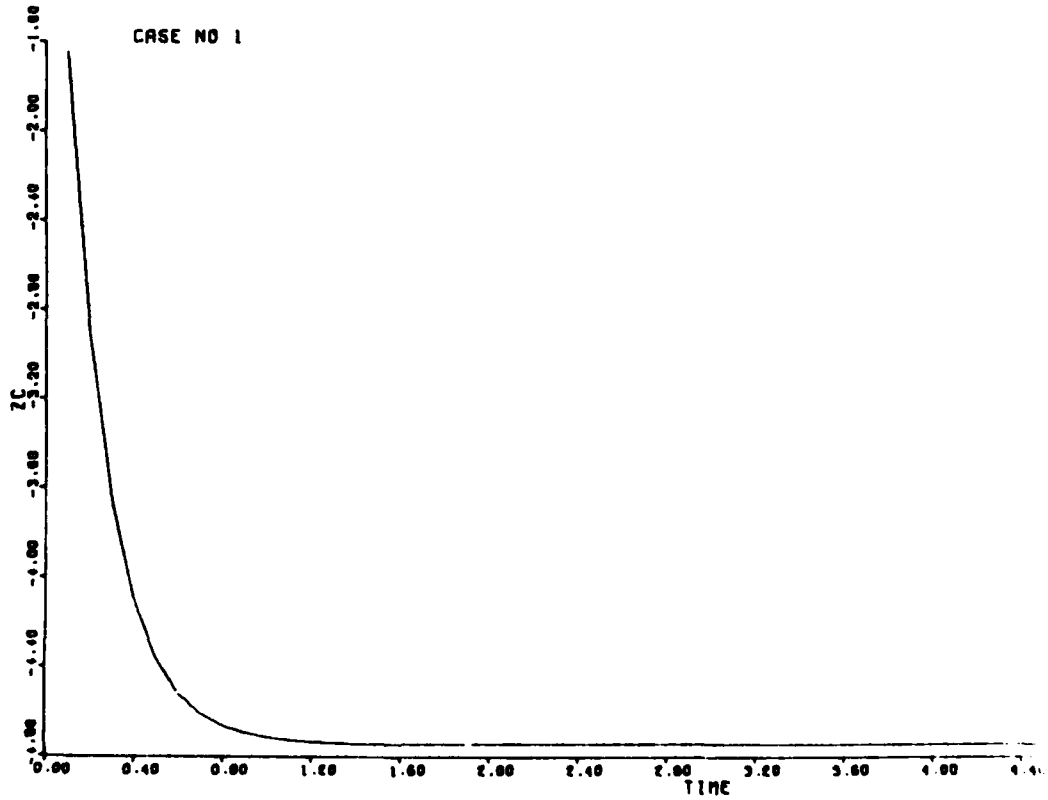

THE NUMERICAL RESULT OF THIS EXAMPLE RUN HAS BEEN DELETED.

THE CALCOMP PLOTS OF THIS EXAMPLE RUN ARE PRESENTED IN THE FOLLOWING TWO PAGES.

ISOL-PLTSUB OPTION 14 RUN - PROBLEMS 1 AND 2



ISOL-PLTSUB OPTION 14 RUN - PROBLEMS 1 AND 2



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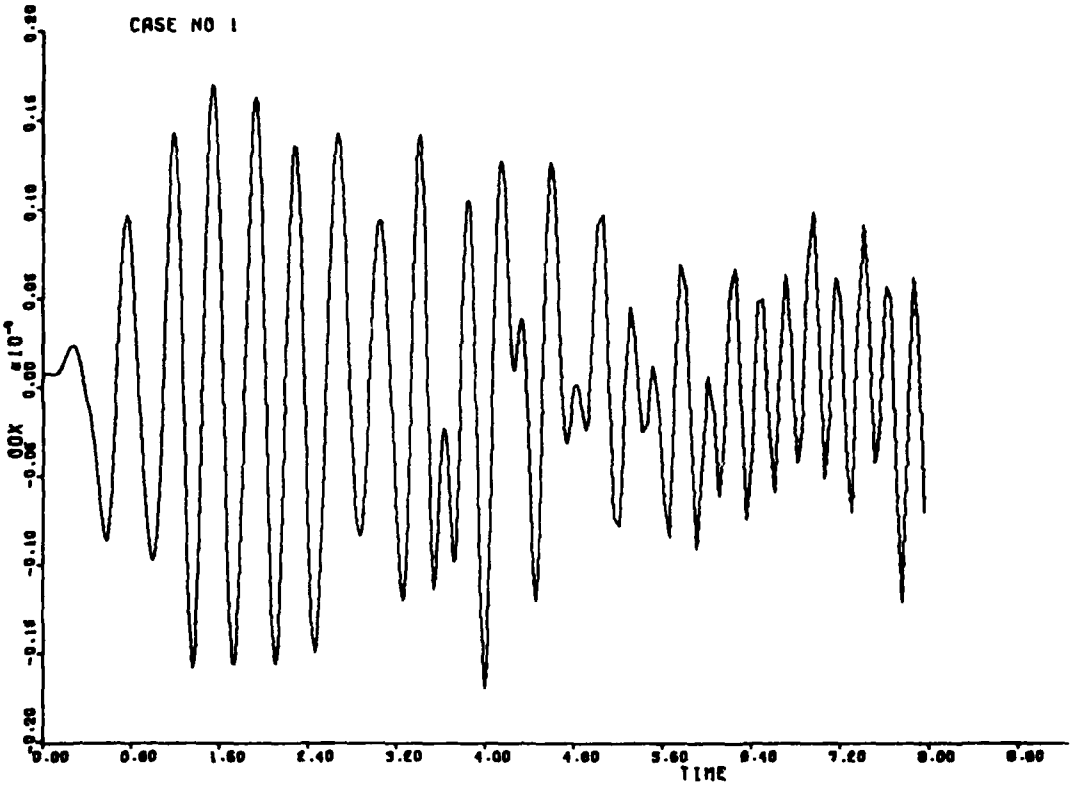
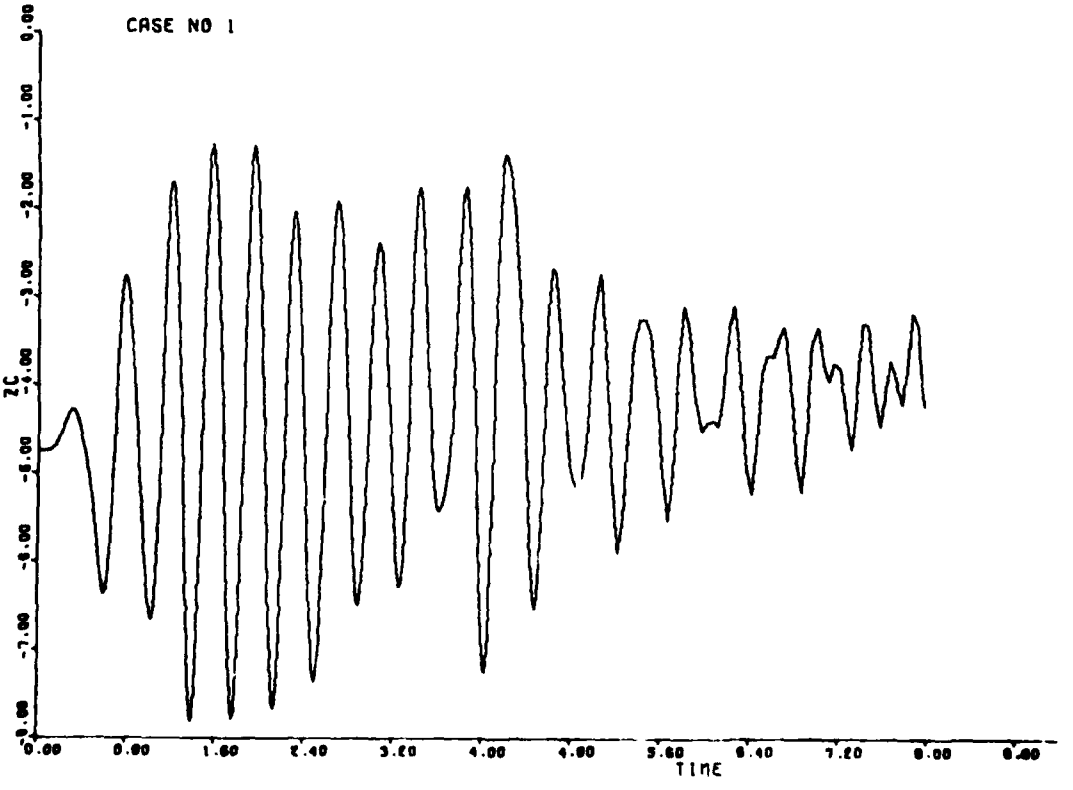
ISOL-PLTSUB OPTION 14 RUN - PROBLEMS 1 AND 2



ISOL-PLTSUB OPTION 14 RUN - PROBLEMS 1 AND 2



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REPORT DOCUMENTATION PAGE

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7. AUTHOR(s): Gordon C. Chan, Herbert Saffell, Robert Yang, Charles C. Huang

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number):

Shock Isolation System
Shock Isolation Platform
Hard Mounting
Integrated Shock Isolation Program (ISIP)
ISIP
ISIP2
Waveform Synthesis
WAVSYN, NWAVSYN
Shock (response) Spectrum
Isolator

20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

The report contains 4 parts. Part I, Design and Theoretical Considerations, Part II, User's Instructions for Computer Program, Part III Program Listings for both ISIP (Integrated Shock Isolation Program) and ISIP2, and Part IV, examples. ISIP is formulated on the basis of considering the shock isolation platform and the equipment on it as a rigid body six-degree of freedom system having large response amplitudes. ISIP2 includes a treatment of shock isolation systems having relatively flexible platforms. Both ISIP and ISIP2 accept acceleration-time history excitation. For the shock isolation systems the

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19. Rattlespace
Pendulum Shock Isolation System
Base-mounted Isolation System
Torsion Bars
Helical Spring
Liquid Spring
Gas (Pneumatic) Spring
Elastomer
ISOL
SYNSOL

20. excitation of which is given in terms of a shock spectrum, a synthesized acceleration time function must be obtained as the first step toward problem solution. Waveform Synthesis is performed by WAVSYN which is a subprogram of ISIP and ISIP2. The design parameters and their interrelationships which affect the performance of a shock isolation system are discussed, and several design configurations and various elastic and dissipative elements in shock isolation systems are investigated. Analytical treatments of the problem, which forms the basis of computational procedures, are included. The report is organized for the convenience of practicing engineers who have had previous exposures to rigid body mechanics, structural dynamics and the Fortran language.

LME