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**HELICOPTER TRANSMISSION VIBRATION AND NOISE
REDUCTION PROGRAM
Volume II - User's Manual**

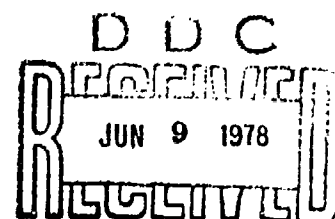
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March 1978

Final Report for Period June 1974 - October 1977

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Prepared for

APPLIED TECHNOLOGY LABORATORY

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APPLIED TECHNOLOGY LABORATORY POSITION STATEMENT

This report provides the details of the eight computer programs that comprise the analytical tool developed under this effort. These computer programs have been recorded on tape and are available, upon application, through the Applied Technology Laboratory on a reimbursable basis.

Mr. Allen C. Royal of the Propulsion Technical Area, Technology Applications Division, served as project engineer for this effort.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM	
1. REPORT NUMBER USARTL-TR-78-2B	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) HELICOPTER TRANSMISSION VIBRATION AND NOISE REDUCTION PROGRAM, Volume II. User's Manual.		5. TYPE OF REPORT & PERIOD COVERED Final Report. Jun 74 - Oct 77	
6. AUTHOR(s) John J. Sciarra, Joseph W. Lenski, Jr. Robert W. Howells, Raymond J. Drago		7. PERFORMING ORGANIZATION REPORT NUMBER D218-11236-2	
8. PERFORMING ORGANIZATION NAME AND ADDRESS Boeing Vertol Company P.O. Box 16858 Philadelphia, PA 19142		9. CONTRACT OR GRANT NUMBER(s) DAAJ02-74-C-0040	
10. CONTROLLING OFFICE NAME AND ADDRESS Applied Technology Laboratory US Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, VA		11. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBER 62207A 1G26227AH89 02 004 EK	
12. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) U.S. Army Materials and Mechanics Research Center Watertown, Massachusetts		13. REPORT DATE Mar 78	
14. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		15. SECURITY CLASS. (of this report) Unclassified	
16. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		17. NUMBER OF PAGES 429	
18. SUPPLEMENTARY NOTES Volume II of a 2-volume report			
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Helicopter transmission Design stage Longer life Vibration/noise reduction Computer-oriented Analytical tools for prediction Computer programs Trade studies Use and application Dynamically quiet Reduced vibration/noise			
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The objective of the Helicopter Transmission Vibration/Noise Reduction Program was to generate analytical tools for the prediction and reduction of helicopter transmission vibration/noise that provide the capability to perform trade studies during the design stage of a program. Application of this optimization capability yields drive train components that are dynamically quiet with reduced vibration/noise levels and inherently longer			

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life. The work conducted under this program is highly computer-oriented and makes extensive use of several computer programs as indicated in the technical report (Volume I). This User's Manual describes these computer programs, presents rationale for their use, and discusses their application.

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PREFACE

This report summarizes the results of the "Helicopter Transmission Vibration and Noise Reduction Program." The report covers the work accomplished during the 40-month period from June 1974 through October 1977 and is composed of two volumes. Volume I is the Technical Report, and Volume II is the User's Manual.

The work outlined herein has been performed under U.S. Army contract DAAJ02-74-C-0040 and under the technical cognizance of Mr. Allen Royal, U.S. Army Research and Technology Laboratories, Fort Eustis, Virginia.

This program was conducted at the Boeing Vertol Company under the technical direction of Mr. A. J. Lemanski (Program Manager), Chief of the Advanced Power Train Technology Department. Principal investigators for the program were Mr. John J. Sciarra (Project Engineer), Mr. Robert W. Howells, Mr. Joseph W. Lenski, Jr., and Mr. Raymond J. Drago.

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INTRODUCTION

Considerable attention has been focused in recent years on the reduction of noise levels for both military and civil helicopters. Helicopter noise emanates from three major sources - the rotor blades, engines, and transmissions. Exterior noise is dominated by the rotors and engines, although the transmission also contributes to this noise. Minimization of the exterior noise is important to reduce the annoyance to communities near civil helicopter operations and to reduce the detectable noise signature of military helicopters. The interior cabin noise is predominantly due to the transmissions, with the engines and rotors being secondary sources. Interior noise not only degrades crew performance by causing annoyance and fatigue, but interferes with reliable communication and may cause hearing damage. Comfortable interior noise levels are essential for passenger acceptance of civil helicopters.

By any of the numerous standards in existence for scaling annoyance and reactions to noise, transmission noise is particularly objectionable. Noise in excess of 120 dB has been measured for the transmission of a medium transport helicopter which, for comparison, approaches the noise level of an air-raid siren. Not only is this noise level high, but its frequency typically falls within the sensitive 1000-5000 Hz range which is particularly annoying to the human ear. Furthermore, the pure tonal content, which results in a high-pitched whine, is subjectively much more annoying than broadband noise.

Transmission noise and the inherent structural vibrations which generate this noise have been of concern to helicopter designers for many years. Until recently, analytical methods have not been available to predict and reduce transmission vibration/noise problems in advance. The conventional means of controlling transmission noise has generally been to add acoustical enclosures after the hardware is built and a noise problem has become evident. Since practical enclosures are limited in noise attenuation by unavoidable sound leaks in seams and access doors, adequate attenuation is not provided for advanced helicopter drive systems of increased power. Not only do these enclosures impose considerable weight and maintainability penalties, but they do not reduce the deleterious effect of the accompanying vibrations which contribute to material fatigue and fretting at joints. The objective of this report is to document computer programs that will provide the capability to perform trade studies during the design stage of a program. This capability will yield optimized drive train components that are dynamically quiet with inherently longer life and reduced vibration and attendant noise levels.

The following programs which were used in this contract are briefly described and sample input and output cases are provided to assist the user in applying these programs to other applications. The programs identified in this report are:

- Gear Tooth Mesh Excitation and Compliance Input Generator Program (Tregold's Approximation)
- Mesh Dynamics for High-Contact-Ratio Spur Gears (R-75)
- Program for Prediction of Gear Mesh Excitation Spectra - GGEAR (R-67)
- Dynamic Gear Tooth Force Analyses - TORRP (R-32)
- Complex Structural Dynamic Analysis Computer Program Using Stiffness Methods (D-82/C-51)
- NASA Structural Analysis Program - NASTRAN (S-70)
- Strain Energy Analysis Programs (S-68 and S-83)

BACKGROUND

The transfer of torque between mating gears is not uniform due to tooth profile errors and the elastic deformation of the gear teeth under load. This nonuniform transfer of torque produces a dynamic force at the gear mesh frequency (number of teeth x rpm) and its multiples which excites the coupled torsional/lateral vibratory modes of the gear shaft. This lateral vibration (or bending) produces displacements at the bearing locations which excite the housing and cause it to vibrate, thus radiating noise (Figure 1). Furthermore, the dynamic characteristics of the housing may magnify its displacements and the resulting noise. This transfer of mesh energy from its source to remote locations is shown in Figure 2 as measured noise levels.

Controlling the dynamic response of the transmission is a desirable approach to noise reduction, since avoidance of resonance reduces shaft deflections at the bearings and inherently increases the life of dynamic components and transmission reliability.

Computer program GGEAR/HCR (R-75) has been prepared by Mechanical Technology Incorporated (MTI) for the Boeing Vertol Company. High-contact-ratio (HCR) gearing reduces the non-uniform load transfer between gears and hence mesh noise/vibration generation.

Computer program GGEAR (R-67) (Reference 1), which was also prepared by MTI as an extension of GEARO (Reference 2), takes gear tooth geometry (driving/driven) as well as material properties to simulate mesh cycles. This computer program is used to calculate approximate gear mesh compliance (Reference 1, page 156) and harmonics of the meshing error.

Utilizing the mesh compliance and a meshing error of R-67, the gear teeth dynamic load may be obtained using TORRP (R-32). This is basically an uncoupled torsional Holtzer analysis with planetary capability (Reference 2). Other input would be shaft and gear geometry as well as exciting frequency.

1. Badgley, R. H., and Laskin, I., PROGRAM FOR HELICOPTER GEARBOX NOISE PREDICTION AND REDUCTION, Mechanical Technology Incorporated, USAAVLABS Technical Report 70-12, U.S. Army Aviation Materiel Laboratories, Fort Eustis, Virginia, March 1970, AD869822.
2. Laskin, I., Orcutt, F. K., and Shipley, E. E., ANALYSIS OF NOISE GENERATED BY UH-1 HELICOPTER TRANSMISSION, Mechanical Technology Incorporated, USAAVLABS Technical Report 68-41, U.S. Army Aviation Materiel Laboratories, Fort Eustis, Virginia, June 1968, AD675457.

Reduction of the dynamic excitation of the housing is accomplished by minimizing the dynamic forces at the shaft support bearings. This is a two-fold task. First, the excitation due to the dynamic tooth forces is calculated from the gear geometry and operating conditions. Second, the damped force response of the shafts responding to the tooth mesh excitation loads is calculated from a finite element model and the shaft is detuned using strain energy methods to minimize the displacement at the bearings. The development of this method,

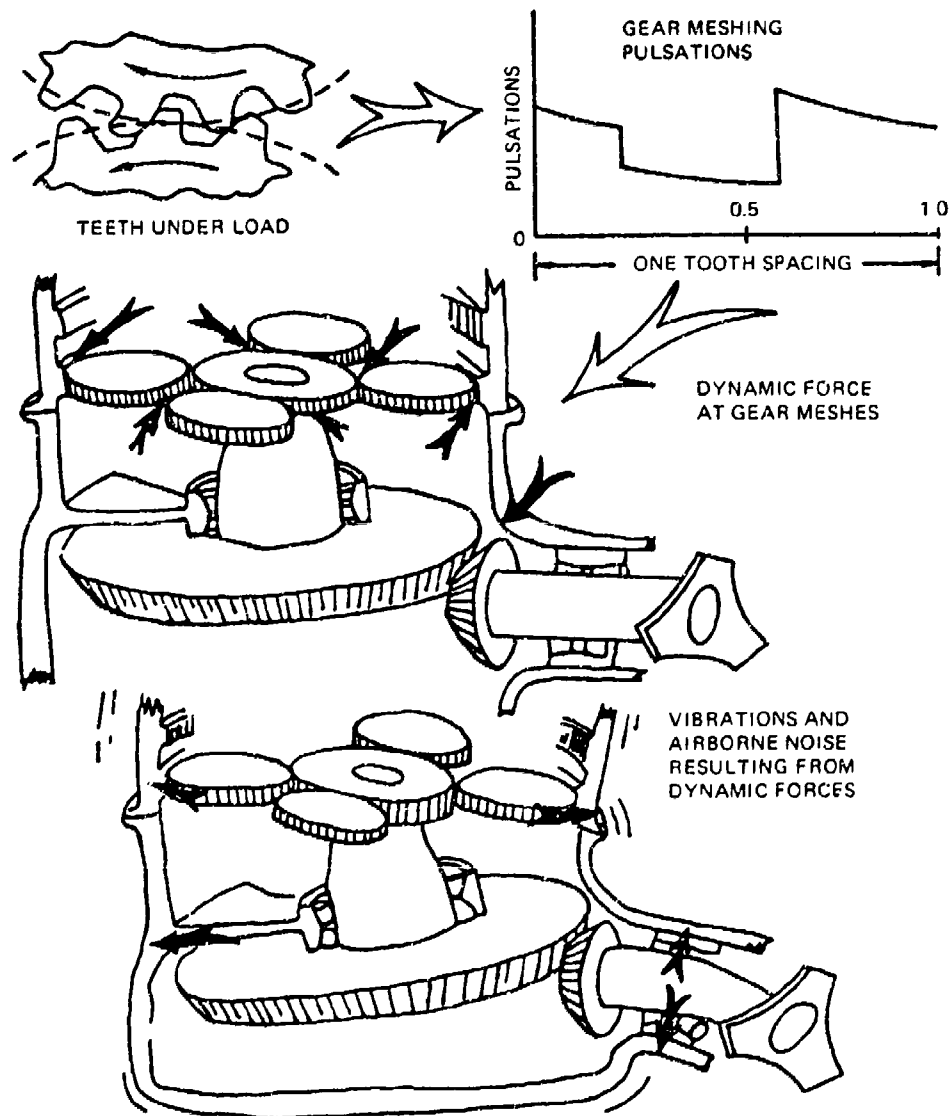


Figure 1. Sources of Transmission Noise.

accomplishment of extensive dynamic testing, and correlation of data are described fully in References 3 and 4. Finally, the dynamic forces associated with the optimum configuration of the internal components are applied to the model of the housing. To study the response of the transmission housing to these forces and to minimize the noise produced, a finite element model of the housing was developed and analyzed using NASTRAN.

MICROPHONE INSTALLATION

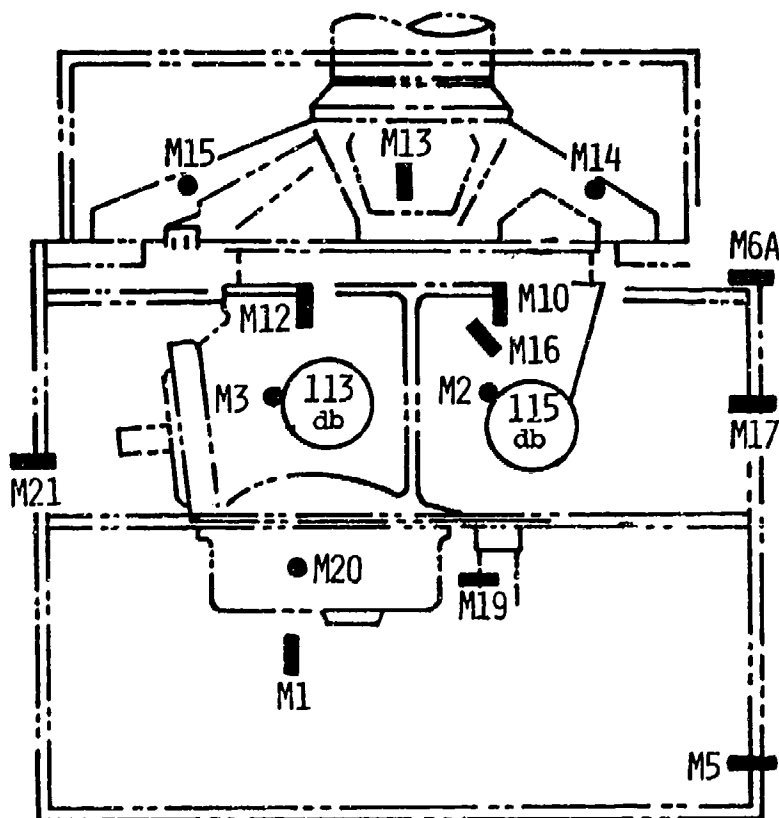


Figure 2. Maximum Measured Noise Levels (7460 RPM at 80% Torque).

3. Hartman, R. M., A DYNAMICS APPROACH TO HELICOPTER TRANSMISSION NOISE REDUCTION AND IMPROVED RELIABILITY, Presented at the 29th Annual National Forum of the American Helicopter Society, Washington, D.C., May 1973.
4. Hartman, R. M., and Badgley, R. H., MODEL 301 HLH/ATC TRANSMISSION NOISE REDUCTION PROGRAM, The Boeing Vertol Company, USAAMRDL Technical Report 74-58, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, May 1974, AD784132.

Two computer programs have been developed to calculate the strain energy/density distribution of finite element models vibrating in various modes (References 5 and 6).

The first, S-68, takes any mode shape of the internal components finite element model as determined by finite element computer program D-82 and calculates the strain energy/density distribution. D-82 calculates the coupled bending (vertical and lateral)/torsion natural frequencies and mode shapes of the internal components finite element model which includes shaft data, gear tooth mesh compliance, bearing spring rates, lower planetary representation, and sync shaft torsional spring constant.

The second strain density computer program, S-83, takes a NASTRAN modified checkpoint tape as input and calculates the strain density distribution for the transmission housing plate structural elements.

The basis for finding the strain density distribution is that it yields the optimum locations for structural modification for detuning a structure for least weight penalty.

Work conducted under this program was directed toward analyzing the Boeing Vertol CH-47 forward rotor transmission housing which is composed of three major sections: upper cover, ring gear, and case. The upper cover provides lugs for mounting the transmission to the airframe and transmits the rotor system loads. The case contains and supports the main bevel gears. The ring gear, which connects the upper cover and case, contains the planetary gear system. This natural division of the housing was adhered to for all the modeling completed during this program.

The geometric grid points for the model were defined from design drawings and by cross-checking on an actual housing. CQUAD2 (Quadrilateral) and CTRIA2 (Triangular) plate structural elements were used.

-
5. Sciarra, J. J., VIBRATION REDUCTION BY USING BOTH THE FINITE ELEMENT STRAIN ENERGY DISTRIBUTION AND MOBILITY TECHNIQUES, 45th Shock and Vibration Symposium, Dayton, Ohio, August 1974.
 6. Sciarra, J. J., USE OF THE FINITE ELEMENT DAMPED FORCED RESPONSE STRAIN ENERGY DISTRIBUTION FOR VIBRATION REDUCTION, U.S. Army Research Office - Durham, Final Report Contract DAH-CO4-71-C-0048, July 1974.

GEAR TOOTH MESH EXCITATION AND COMPLIANCE
INPUT GENERATOR PROGRAM

PROGRAM DESCRIPTION

The original computer program for predicting spur gear tooth mesh excitation and compliance, which was entitled GEARO, was presented in Reference 2. GEARO was subsequently improved and renamed GGEAR (R-67) to include a sideband analysis capability and was modularized as indicated in Figure 3 to allow convenient inclusion of future improvements for helical and spiral bevel gears (Reference 7).

Under this contract, the analysis of the mesh dynamics for high-contact-ratio (HCR) spur gears was developed under a Boeing Vertol subcontract to Mechanical Technology Incorporated and was included as a subroutine in GGEAR. This revised program (GGEAR/HCR) has been completed and tested; the details of the HCR analysis and test cases are presented herein. The work accomplished is summarized below:

- Gear tooth mesh geometry analysis for HCR spur gears was developed.
- Tooth profiles, tooth bending, tooth contact surface deformation, and tooth support flexibility for meshes with two, three, or four pairs of teeth in contact instantaneously have been included.
- Load sharing between pairs of teeth, stiffness of individual tooth pairs and of the total mesh, and mesh excitation expressed in terms of deviation from true conjugate action tangent to the mesh pitch circle result from the analysis.
- Representative estimated values of tooth support flexibility are provided internally in the program with a user-controlled option for employing them.
- Restructured analytical expressions and input parameters to provide more efficient execution and improved utility were included.
- Automatic plotting capability for loads and tangential errors was completed.

-
7. Gu, A. L., and Badgley, R. H., PREDICTION OF GEAR-MESH-INDUCED HIGH-FREQUENCY VIBRATION SPECTRA IN GEARED POWER TRAINS, Mechanical Technology Incorporated, USAAMRDL Technical Report 74-5, U. S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, January 1974, AD777496.

To apply the mesh excitation and compliance program to helical or bevel gears, it is currently necessary to employ the Tregold approximation (Reference 7). This method reduces a helical or bevel gear to an "equivalent" spur gear representation which is then input to GGEAR.

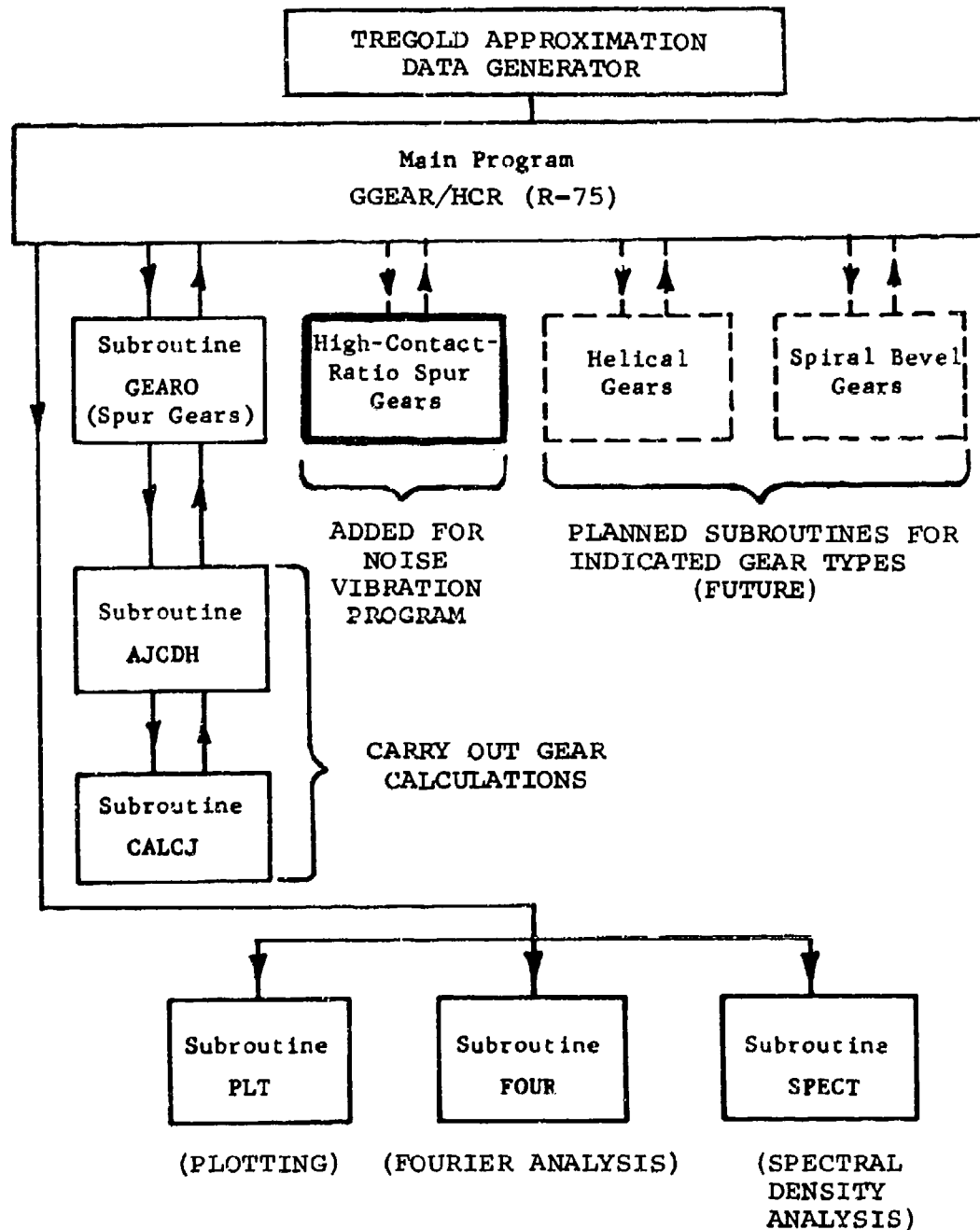


Figure 3. Gear Mesh Compliance/Excitation Computer Program Structure.

INPUT PREPARATION

A sample worksheet for developing input data required by Tregold's approximation for converting a spiral bevel gear into an equivalent spur gear is shown in Table 1. Table 2 shows data generated for the CH-47 forward rotor transmission spiral bevel input pinion and bevel ring gear. This data was used to fill in the data input sheet shown in Figure 4. A source listing of the Tregold's approximation program for calculating gear tooth mesh excitation and compliances is provided in Appendix A.

PROGRAM OUTPUT

The Tregold approximation program provides punched card output in a format for direct input into GGEAR (R-67). Also, it is convenient to use the Tregold program strictly as a data deck generator even when only spur gears are being considered. A sample output case is shown in Figure 5. In addition to the program calculated output data, the input data in Table 2 is also listed. This procedure provides a complete record of the computer run, including both input and output data. Also provided with the output listing is a set of punched cards for use as input into program GGEAR/HCR (R-75).

TABLE 1. TREGOLD'S APPROXIMATION-CONVERSION OF SPIRAL BEVEL INTO EQUIVALENT SPUR GEARS

SYM	DEFINITION	PINION			GEAR		
		SPIRAL	HELICAL	SPUR	SPIRAL	HELICAL	SPUR
N	NO. OF TEETH						
γ	PITCH CONE ANGLE						
	$\cos \gamma$						
	$\sin \gamma$						
ψ	SPIRAL ANGLE MEAN						
	$\cos \psi$						
	$\cos^2 \psi$						
	$\cos^3 \psi$						
NV	$N / \cos \gamma$						
Ns	$NV / \cos^2 \psi$						
F	FACE WIDTH						
Fv	F						
fv	$Fv / \cos \psi$						
R							
Rm	$R = (F/2) \sin \gamma$						
Rv	$Rm / \cos \gamma$						
Rs	$Rv / \cos^2 \psi$						
α	Rm/R						
a	ADDENDUM @ LARGE END						
aV	αa						
as	aV						
Ray	$Rv + aV$						
Ras	$Rs + as$						
b	DEDENDUM @ LARGE END						
bV	αb						
bs	bV						
Rrv	$Rv - bV$						
Rrs	$Rs - bs$						
d	WORKING DEPTH @ LARGE END						
dM	αd						
dV	dM						
ds	dV						
TIFRv	$R_{rv} - dV$						
TIFR:	$R_{rs} - ds$						
T	CIR. TOOTH THK. @ LARGE END						
TM	αT FOR ψ						
Tv	TM						
Ts	Tv						
Cv	TIF Rv - Rrv						
Cs	TIF R _s - Rrs						
Tv	.75 Cv						
Ts	.75 Cs						

TABLE

SYMBOL	DEFINITION	UNITS	PINION [14D104(12)]			GEAR [14D105(13)]		
			SPINAL LEVEL	METALIC	SPUR	SPINAL LEVEL	METALIC	SPUR
N	NUMBER OF TEETH OF SPINAL LEVEL	—	39			51		
Y	PITCH CONE ANGLE OF SPINAL LEVEL	DEGREES	31° 39'			43° 21'		
Y	SIN Y	—	.58122			.32287		
Y	COS Y	—	.53473			.25°		
Y	COS ² Y	—	.28593			.06331		
Y	COS ³ Y	—	.09631			.02140		
Nv	NUMBER OF TEETH OF EQUIVALENT HELICAL	—	.87160			.74444		
Ns	NUMBER OF TEETH OF EQUIVALENT SPUR	—	.74444			.34.0655		177.9058
Yv	PITCH CONE ANGLE OF EQUIVALENT HELICAL	—	2.188		45.7623	2.188		2.188
Yv	SIN Yv	—	3.775		2.4142	6.639		8.4152
Yv	COS Yv	—	3.2010		3.7601	5.6294		14.6180
Nh	NUMBER OF TEETH OF EQUIVALENT HELICAL	—	.8479		4.2776	.8479		17.2864
Nh	SIN Yh	—	.297		.146	.1237		.1237
Nh	COS Yh	—	.2518		.2518	14.7417		17.8201
Nh	COS ² Yh	—	4.0319		4.8294	.2933		.2933
Nh	COS ³ Yh	—	.1653		.1653	14.3747		17.5631
Nh	COS ⁴ Yh	—	3.5948		4.4123	.3756		.3756
Nh	COS ⁵ Yh	—	.3756		.3756	14.5661		17.5645
Nh	COS ⁶ Yh	—	3.6363		4.4538	.312		.312
Nh	COS ⁷ Yh	—	.2397		.2397	.2397		.2397
Nh	COS ⁸ Yh	—	.3688		.3688	.0414		.0414
Nh	COS ⁹ Yh	—	.0415		.0415	.0310		.0310
Nh	COS ¹⁰ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹¹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹² Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹³ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁴ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁵ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁶ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁷ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁸ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ²⁰ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ²¹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ²² Yh	—	.0311		.0311	.0310		.0310
Nh	COS ²³ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ²⁴ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ²⁵ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ²⁶ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ²⁷ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ²⁸ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ²⁹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ³⁰ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ³¹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ³² Yh	—	.0311		.0311	.0310		.0310
Nh	COS ³³ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ³⁴ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ³⁵ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ³⁶ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ³⁷ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ³⁸ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ³⁹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁴⁰ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁴¹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁴² Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁴³ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁴⁴ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁴⁵ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁴⁶ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁴⁷ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁴⁸ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁴⁹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁵⁰ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁵¹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁵² Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁵³ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁵⁴ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁵⁵ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁵⁶ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁵⁷ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁵⁸ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁵⁹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁶⁰ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁶¹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁶² Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁶³ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁶⁴ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁶⁵ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁶⁶ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁶⁷ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁶⁸ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁶⁹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁷⁰ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁷¹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁷² Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁷³ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁷⁴ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁷⁵ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁷⁶ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁷⁷ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁷⁸ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁷⁹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁸⁰ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁸¹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁸² Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁸³ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁸⁴ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁸⁵ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁸⁶ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁸⁷ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁸⁸ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁸⁹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁹⁰ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁹¹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁹² Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁹³ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁹⁴ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁹⁵ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁹⁶ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁹⁷ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁹⁸ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ⁹⁹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁰⁰ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁰¹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁰² Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁰³ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁰⁴ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁰⁵ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁰⁶ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁰⁷ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁰⁸ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁰⁹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹¹⁰ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹¹¹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹¹² Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹¹³ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹¹⁴ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹¹⁵ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹¹⁶ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹¹⁷ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹¹⁸ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹¹⁹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹²⁰ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹²¹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹²² Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹²³ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹²⁴ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹²⁵ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹²⁶ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹²⁷ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹²⁸ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹²⁹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹³⁰ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹³¹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹³² Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹³³ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹³⁴ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹³⁵ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹³⁶ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹³⁷ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹³⁸ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹³⁹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁴⁰ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁴¹ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁴² Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁴³ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁴⁴ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁴⁵ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁴⁶ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁴⁷ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁴⁸ Yh	—	.0311		.0311	.0310		.0310
Nh	COS ¹⁴⁹ Yh	—	.0311					

TREGOLD'S APPROXIMATION

DATA INPUT SHEET

Page 1 of __

GEAR TOOTH MESH EXCITATION AND COMPLIANCE PROGRAM

CARD 1		CARD 2				
TITLE		SYMBOL	CASE 1	CASE 2	CASE 3	CASE 4
OUTPUT SELECTION		J				
0 END EXECUTION						
1 TREGOLD ONLY 3 R-67 (GGEAR)						
2 R-33 (GEARO) 4 R-75 (GGEAR/HCR)						
NO OF TEETH - DRIVING		TN1				
DRIVEN		TN2				
PITCH CONE ANGLE (°) DRIVING		PCA1				
DRIVEN		PCA2				
SPIRAL OR HELIX ANGLE (°) *		SA				
FACE WIDTH (IN) - DRIVING		FW1				
DRIVEN		FW2				
DIAMETRAL PITCH		PD				
OUTSIDE BREAK		RO1				
RADIUS (IN) (+) DRIVING		RO2				
ADDENDUM (IN) (-)		RR1				
ROOT RADIUS DRIVING		RR2				
(IN) (+) DRIVEN						
DEDENDUM (IN) (-)						
CIRCULAR THICKNESS		T1				
DRIVING		T2				
DRIVEN						
PERCENT TO DRIVING (-)						
BACKLASH (+)						
PRESSURE ANGLE (°)		PA				
CALCULATION POINTS		FI				
TOOTH SPACE ERROR (IN) - DRIVING		TSE1				
DRIVEN		TSE2				
INTERNAL (0) OR EXTERNAL (1) **		MN				
NO. OF FOURIER TERMS		MMM				
TORQUE (IN-LB) - DRIVING		TORK				
RPM - DRIVING		WS				
PLOT (0 = NO, 1 = YES)		IPLT				
DEVIATION FROM STANDARD CENTER DISTANCE (IN)		DEV				
DEVIATION AND COMPLIANCE METHOD		NZJ				

NOTES: * For helical gears - input operating normal values.

** Program will not work if internal gear is driving.

Separate numbers by 2 spaces.

Figure 4. Data Input Sheet for Tregold's Approximation.

CARD	<u>If NZJ = 0, 4, or 5</u>		
	INSERT CARDS FOR TOOTH - DRIVING		UJ1
	PROFILE DEVIATIONS (IN) - DRIVEN		UJ2
	(Format 6E13.5)		
CARD	<u>If NZJ = 0 or 3</u>		
	INSERT CARDS FOR TOOTH - DRIVING		ZJ1
	COMPLIANCE (IN) - DRIVEN		ZJ2
	(Format 6E13.5)		
CARD	<u>If TORK < 0</u>		
	INSERT CARDS FOR VARIABLE - DRIVING		TOR
	TORQUE (IN-LB)		
	(Format 6E13.5)		
CARD	<u>If NZJ = 1 or 4</u>		
	INSERT CARDS FOR TOOTH PROFILE - DRIVING		
	DEVIATION OF 4 POINTS ALONG - DRIVEN		
	PROFILE (OD, HP, LE, TIF)		
	(Format 6E13.5)		
CARD	<u>If J < 0</u>		
	MATERIAL - MODULUS OF ELASTICITY - DRIVING	YE(1)	
	PROPERTIES - POISSONS RATIO - DRIVING	POS(1)	
	MODULUS OF ELASTICITY - DRIVEN	YE(2)	
	POISSONS RATIO - DRIVEN	POS(2)	

Figure 4. Continued.

TREGOLD APPROXIMATION FOR EQUIVALENT SPUR GEARS

SPIRAL BEVEL GEAR DESIGN DATA GEAR NO. 1		
NUMBER OF TEETH - SPIRAL BEVEL	29.000000	
PITCH CONE ANGLE - SPIRAL BEVEL	31.649970	DEGREES
SPIRAL ANGLE OF SPIRAL BEVEL	24.999980	DEGREES
FACE WIDTH OF SPIRAL BEVEL	2.188000	INCH
PITCH RADIUS OF SPIRAL BEVEL	3.775059	INCH
MEAN PITCH RADIUS OF SPIRAL BEVEL	3.201014	INCH
RATIO OF RADII OF SPIRAL BEVEL	0.847937	INCH
ADDENDUM OF SPIRAL BEVEL AT LARGE END	0.297000	INCH
DEDENDUM OF SPIRAL BEVEL AT LARGE END	0.195000	INCH
WORKING DEPTH OF SPIRAL BEVEL AT LARGE END	0.443000	INCH
CIR. TOOTH THICKNESS-SPIRAL BEVEL-LARGE END	0.506000	INCH
MEAN CIR. TOOTH THICKNESS-SPIRAL BEVEL	0.388858	INCH

EQUIVALENT HELICAL GEAR GEAR NO. 1		
EQUIVALENT NUMBER OF TEETH - HELICAL	34.066570	
EQUIVALENT FACE WIDTH - HELICAL	2.188000	INCH
EQUIVALENT PITCH RADIUS - HELICAL	3.760261	INCH
EQUIVALENT ADDENDUM - HELICAL	0.251837	INCH
EQUIVALENT OUTER RADIUS - HELICAL	4.012097	INCH
EQUIVALENT DEDENDUM - HELICAL	0.165348	INCH
EQUIVALENT ROOT RADIUS - HELICAL	3.594913	INCH
EQUIVALENT WORKING DEPTH - HELICAL	0.375636	INCH
EQUIVALENT T.I.F. RADIUS - HELICAL	3.636460	INCH
EQUIVALENT CIRCULAR TOOTH THICKNESS-HELICAL	0.388858	INCH
EQUIVALENT RADIAL CLEARANCE-HELICAL	0.041548	INCH
EQUIVALENT TOOTH FILLET RADIUS-HELICAL	0.031161	INCH

EQUIVALENT SPUR GEAR GEAR NO. 1		
EQUIVALENT NUMBER OF TEETH - SPUR	45.761130	
EQUIVALENT FACE WIDTH - SPUR	2.414182	INCH
EQUIVALENT PITCH RADIUS - SPUR	4.577871	INCH
EQUIVALENT ADDENDUM - SPUR	0.251837	INCH
EQUIVALENT OUTER RADIUS - SPUR	4.829708	INCH
EQUIVALENT DEDENDUM - SPUR	0.165348	INCH
EQUIVALENT ROOT RADIUS - SPUR	4.412523	INCH
EQUIVALENT WORKING DEPTH - SPUR	0.375636	INCH
EQUIVALENT T.I.F. RADIUS - SPUR	4.454071	INCH
EQUIVALENT CIRCULAR TOOTH THICKNESS-SPUR	0.388858	INCH
EQUIVALENT RADIAL CLEARANCE-SPUR	0.041548	INCH
EQUIVALENT TOOTH FILLET RADIUS-SPUR	0.031161	INCH

Figure 5. Sample Output from Tregold's Input Generator;
Punched Output Provided for GGEAR/HCR (R-75).

TREGOLD APPROXIMATION FOR EQUIVALENT SPUR GEARS

SPIRAL BEVEL GEAR DESIGN DATA GEAR NO. 2		
NUMBER OF TEETH - SPIRAL BEVEL	51.000000	
PITCH CONE ANGLE - SPIRAL BEVEL	67.349960	DEGREES
SPIRAL ANGLE OF SPIRAL BEVEL	24.999960	DEGREES
FACE WIDTH OF SPIRAL BEVEL	2.188000	INCH
PITCH RADIUS OF SPIRAL BEVEL	6.638896	INCH
MEAN PITCH RADIUS OF SPIRAL BEVEL	5.629280	INCH
RATIO OF RADII OF SPIRAL BEVEL	0.847924	INCH
ADDENDUM OF SPIRAL BEVEL AT LARGE END	0.146000	INCH
DEDENDUM OF SPIRAL BEVEL AT LARGE END	0.346000	INCH
WORKING DEPTH OF SPIRAL BEVEL AT LARGE END	0.443000	INCH
CIR. TOOTH THICKNESS-SPIRAL BEVEL-LARGE END	0.312000	INCH
MEAN CIR. TOOTH THICKNESS-SPIRAL BEVEL	0.239767	INCH

EQUIVALENT HELICAL GEAR GEAR NO. 2		
EQUIVALENT NUMBER OF TEETH - HELICAL	132.426400	
EQUIVALENT FACE WIDTH - HELICAL	2.188000	INCH
EQUIVALENT PITCH RADIUS - HELICAL	14.616960	INCH
EQUIVALENT ADDENDUM - HELICAL	0.123797	INCH
EQUIVALENT OUTER RADIUS - HELICAL	14.740760	INCH
EQUIVALENT DEDENDUM - HELICAL	0.293382	INCH
EQUIVALENT ROOT RADIUS - HELICAL	14.323580	INCH
EQUIVALENT WORKING DEPTH - HELICAL	0.375630	INCH
EQUIVALENT T.I.F. RADIUS - HELICAL	14.365130	INCH
EQUIVALENT CIRCULAR TOOTH THICKNESS-HELICAL	0.239767	INCH
EQUIVALENT RADIAL CLEARANCE-HELICAL	0.041549	INCH
EQUIVALENT TOOTH FILLET RADIUS-HELICAL	0.031162	INCH

EQUIVALENT SPUR GEAR GEAR NO. 2		
EQUIVALENT NUMBER OF TEETH - SPUR	177.886400	
EQUIVALENT FACE WIDTH - SPUR	2.414182	INCH
EQUIVALENT PITCH RADIUS - SPUR	17.795190	INCH
EQUIVALENT ADDENDUM - SPUR	0.123797	INCH
EQUIVALENT OUTER RADIUS - SPUR	17.918990	INCH
EQUIVALENT DEDENDUM - SPUR	0.293382	INCH
EQUIVALENT ROOT RADIUS - SPUR	17.501800	INCH
EQUIVALENT WORKING DEPTH - SPUR	0.375630	INCH
EQUIVALENT T.I.F. RADIUS - SPUR	17.543350	INCH
EQUIVALENT CIRCULAR TOOTH THICKNESS-SPUR	0.239767	INCH
EQUIVALENT RADIAL CLEARANCE-SPUR	0.041550	INCH
EQUIVALENT TOOTH FILLET RADIUS-SPUR	0.031162	INCH

Figure 5. Continued.

THE FOLLOWING IS THE PUNCHED INPUT FOR R-75 GGEAR/MCR

CARD NUMBER 1
CH-47C FORWARD XMSN SPIRAL BEVEL MESH

CARD NUMBER 2

NMC	INT	MN	MM	IPL1	IFOUR	ISPECT	IMCR
1	0	1	10	0	1	1	0

CARD NUMBER 2A

IRM	IPERC	IRF	IPROP	ICENT	N2J	IOIAG
0	0	1	0	0	2	0

CARD NUMBER 3

FN1	FN2	DPIT	PANG	RG1	R02 OR R12
45.761130	177.866400	4.998080	22.500000	4.829708	17.918290

CARD NUMBER 4

RM1	RF2	F1	T1
4.412523	17.501400	12.000000	0.388858

CARD NUMBER 5

T2	F1	F2	RF1	RF2
0.239767	2.414182	2.414182	0.031161	0.031162

CARD NUMBER 7

EL	VPT1	VPT2
27.373960	0.000500	0.000500

CARDS NUMBER AC

NTS
1

ICM	0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05
0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05
0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05
0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05
0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05	0.30400E 05

CARD NUMBER 9

W	W
1	7460.0

Figure 5. Continued.

TREGOLD APPROXIMATION FOR EQUIVALENT SPUR GEARS

EQUIVALENT SPUR GEAR GEAR NO. 1		
EQUIVALENT NUMBER OF TEETH - SPUR	28.000000	
EQUIVALENT FACE WIDTH - SPUR	1.770000	INCH
EQUIVALENT FITCH RADIUS - SPUR	2.799999	INCH
EQUIVALENT ADDENDUM - SPUR	0.200000	INCH
EQUIVALENT OUTER RADIUS - SPUR	2.999999	INCH
EQUIVALENT DEDENDUM - SPUR	0.232500	INCH
EQUIVALENT ROOT RADIUS - SPUR	2.567499	INCH
EQUIVALENT WORKING DEPTH - SPUR	0.399000	INCH
EQUIVALENT T.I.F. RADIUS - SPUR	2.600999	INCH
EQUIVALENT CIRCULAR TOOTH THICKNESS-SPUR	0.274500	INCH
EQUIVALENT RADIAL CLEARANCE-SPUR	0.033500	INCH
EQUIVALENT TOOTH FILLET RADIUS-SPUR	0.025125	INCH

Figure 5. Continued.

TREGOLD APPROXIMATION FOR EQUIVALENT SPUR GEARS

EQUIVALENT SPUR GEAR GEAR NO. 2

EQUIVALENT NUMBER OF TEETH - SPUR	39.000000	
EQUIVALENT FACE WIDTH - SPUR	1.550000	INCH
EQUIVALENT PITCH RADIUS - SPUR	3.900000	INCH
EQUIVALENT ADDENDUM - SPUR	0.199000	INCH
EQUIVALENT OUTER RADIUS - SPUR	4.098999	INCH
EQUIVALENT ADDENDUM - SPUR	0.217000	INCH
EQUIVALENT ROOT RADIUS - SPUR	3.683000	INCH
EQUIVALENT WORKING DEPTH - SPUR	0.399000	INCH
EQUIVALENT T.I.F. RADIUS - SPUR	3.699999	INCH
EQUIVALENT CIRCULAR TOOTH THICKNESS-SPUR	0.345800	INCH
EQUIVALENT RADIAL CLEARANCE-SPUR	0.016999	INCH
EQUIVALENT TOOTH FILLET RADIUS-SPUR	0.012749	INCH

Figure 5. Continued.

THE FOLLOWING IS THE PUNCHED INPUT FOR R-75 GGEAR/HCR

CARD NUMBER 1

CHART FORWARD MESH LOWER PLANETARY SUN/PLANET MESH

CARD NUMBER 2

NMC	INT	MN	MNM	IPLT	IFOUR	ISPECT	INICR
1	0	1	10	0	1	1	0

CARD NUMBER 2A

IRM	IPERC	IRF	IPROP	ICENT	NZJ	IDIAG
0	0	1	0	0	2	0

CARD NUMBER 3

FN1	FN2	DPIT	PANG	RO1	RO2 OR R12
28.000000	39.000000	5.000001	25.000030	2.999999	4.000000

CARD NUMBER 4

FM1	RP2	F1	F1
2.567490	3.683000	12.000000	0.274500

CARD NUMBER 5

T2	F1	F2	RF1	RF2
0.345000	1.770000	1.550000	0.025125	0.012749

CARD NUMBER 7

CL	VPT1	VPT2
6.654454	0.006300	0.000500

CARD NUMBER 8C

ATS

1

TOP

0.13365E 05	0.13365E 05	0.13365E 05	0.13365E 05	0.13365E 05	0.13365E 05
0.13365E 05	0.13365E 05	0.13365E 05	0.13365E 05	0.13365E 05	0.13365E 05
0.13365E 05	0.13365E 05	0.13365E 05	0.13365E 05	0.13365E 05	0.13365E 05
0.13365E 05	0.13365E 05	0.13365E 05	0.13365E 05	0.13365E 05	0.13365E 05

CARD NUMBER 9

W5	W5
1	4242.0

Figure 5. Continued.

PROGRAM DESCRIPTION

A method has been developed for predicting the level and character of gear-mesh-induced vibrations in high-contact-ratio spur gears. The vibration amplitude is calculated with consideration of load sharing among pairs of engaging gear teeth. In addition to tooth compliance, which varies along the length of the tooth, tooth profile error and tooth spacing error are also included in the load sharing computation. The spectrum of the vibration is obtained by performing a Fourier analysis of the calculated mesh-induced profile of deviation from uniform rotation. The frequency spectra of gear-mesh-induced vibrations and the load sharing characteristics of a set of high-contact-ratio spur gears were calculated, and the results are discussed. This method of analysis is useful for designing low-vibration gears by properly controlling relevant gear parameters.

The meshing of gears introduces vibration because of the non-uniform deflection resulting from varying tooth compliance along the length of the tooth, errors in manufacturing, flexibility and accuracy of mountings, and varying tooth load through sharing during the course of meshing. This nonuniform deflection or displacement deviation introduces irregular motion, superimposed on the uniform rotation of gears, which becomes one of the major sources of vibration in a drive system. This irregularity of motion was recognized in the mid 1960's, and was analyzed as the initial step (Reference 2) in the development of an approach to the reduction of gear noise. Later efforts confirmed the precise source of the noise and recognized it as a mechanical vibration problem (References 1, 8, 9, 10, and 11). The validity of the entire concept and approach was experimentally verified as reported in Reference 12.

8. Badgley, R. H., MECHANICAL ASPECTS OF GEAR-INDUCED NOISE IN COMPLETE POWER TRAIN SYSTEMS, ASME Paper No. 70-WA/DGP-1, Presented at the ASME Winter Annual Meeting, New York, December 1970.
9. Badgley, R. H., GEARBOX DYNAMICS -- THE KEY TO UNDERSTANDING AND REDUCING ACOUSTIC-FREQUENCY ENERGY IN GEARED POWER TRAINS, Presented at the Meeting of the Aerospace Gearing Committee of the American Gear Manufacturers Association, Cleveland, Ohio, January 17-18, 1972.
10. Badgley, R. H., and Chiang, T., INVESTIGATION OF GEARBOX DESIGN MODIFICATIONS FOR REDUCING HELICOPTER GEARBOX NOISE, Mechanical Technology Incorporated, USAAMRDL Technical Report 72-6, U. S. Army Mobility Research and Development Laboratory, Fort Eustis, Virginia, March 1972, AD742735.

More recent efforts have incorporated this new approach into the design and redesign of gearbox components (References 4 and 13). Simultaneously, additional techniques have been added (References 7 and 14) to the mesh vibration analysis to treat various mesh irregularities. In this work a method of computing the gear-induced vibration and the associated frequency spectrum for high-contact-ratio spur gears is developed. The range of contact ratio under consideration is between 1 and 3; thus, there are up to four pairs of teeth in contact simultaneously for the spur gears being investigated. The method of load sharing calculation and the computation of mesh displacement deviation due to tooth bending, shear deflection, contact surface deformation, support flexibility, and tooth profile errors for high-contact-ratio spur gears are presented. These methods are generalized from those of Reference 7 which is limited to spur gears with contact ratio between one and two.

The limitations and assumptions in the calculations are:

1. Two cases of spur gears are treated: an external gear driving an external gear, and an external gear driving an internal gear.
 2. The working portions of the tooth profiles are essentially involute. Design and manufacturing profile deviations are small enough not to affect load location, load direction, or tooth stiffness.
-
11. Badgley, R. H., REDUCTION OF NOISE AND ACOUSTIC-FREQUENCY VIBRATIONS IN AIRCRAFT TRANSMISSIONS, AHS Paper No. 661, Presented at the 28th Annual National Forum of the American Helicopter Society of Washington, D.C., May 1972.
 12. Badgley, R. H., and Hartman, R. M., GEARBOX NOISE REDUCTION: PREDICTION AND MEASUREMENT OF MESH-FREQUENCY VIBRATIONS WITHIN AN OPERATING HELICOPTER ROTOR-DRIVE GEARBOX, ASME Paper No. 73-DET-31, Presented at the ASME Design Engineering Technical Conference, Cincinnati, Ohio, September 9-12, 1973.
 13. Chiang, T., and Badgley, R. H., REDUCTION OF VIBRATION AND NOISE GENERATED BY PLANETARY RING GEARS IN HELICOPTER AIRCRAFT TRANSMISSIONS, ASME Paper No. 72-PTG-11, Presented at ASME Mechanisms Conference and International Symposium on Gearing and Transmissions, San Francisco, California, October 8-12, 1972.
 14. Gu, A. L., and Badgley, R. H., PREDICTION OF VIBRATION SIDEBANDS IN GEAR MESHES, ASME Paper 74-DET-95, Presented at the Design Engineering Technical Conference, New York, New York, October 5-9, 1974.

3. There is no tip interference, either due to excessive addendum length or to tooth deflection under load.
4. In any single interval between the pitch points of two successive pairs of teeth, contact and load sharing are limited to a maximum of four consecutive pairs of teeth. In the same interval, there must at all times be at least one pair of teeth in contact and carrying load. Thus, the contact ratio of the gears is limited to between one and four.
5. The load is assumed to be transmitted uniformly across the face of the gear, except for normal end effects in stress distribution. This excludes any consideration of face crowning, lead modification, lead manufacturing error, gear windup, or nonuniform deflection of gear supports.
6. All variations in tooth deflection as the load point moves along the tooth profile are either confined to elastic effects on the tooth alone or are supplied as point-by-point compliances in the input data. This means that variations such as might result from the deflection of the thin rims are not calculated by the analysis.
7. Any lubricant film separating the mating teeth is assumed to have a constant thickness independent of the magnitude or the location of the transmitted load. The contact deformation is assumed to be independent of the lubricating film.

In the calculation of load sharing among tooth pairs in contact and the tooth deflection during a mesh cycle, tooth compliance is first computed point-by-point along the tooth profile for both the driving and driven gears. The basic kinematics of an involute spur gear mesh for high-contact-ratio spur gears is described below. Although external involute spur gears are used in the example, the case of an external gear driving an internal gear may be treated similarly. In Figure 6, O is the gear center, ϕ_p the pressure angle, R_p the pitch radius, R_b the base radius, and R_o the outside radius. Subscript "1" stands for the driving gear and "2" for the driven gear. Segment b_1b_2 is the arc of action, which is the course of the contact point during mesh. Tooth contact begins at b_1 , where the tip of the driven tooth first touches the flank of the driving tooth, and the mesh cycle ends at b_2 , where the tip of the driving tooth last contacts the flank of the driven tooth. Figure 6 shows the contact occurring at the pitch point A. In Figure 7, X is an arbitrary contact point lying on the arc of action b_1b_2 . V_1 and V_2 are the instantaneous velocities of the contact points on the two meshing teeth. The contact tangent plane is always perpendicular to the arc of action. P and P_t are the normal load and tangential load, respectively, shared by the pair of contacting teeth.

The base pitch p_b is the tooth-to-tooth distance between meshing pairs along the line of action. The mesh geometry analysis is limited to cases where

$$1 < m_p = \frac{b_1 b_2}{p_b} < 3, \text{ and } m_p \text{ is the contact ratio.}$$

During one mesh cycle each of the two teeth in a meshing pair rotates an angle of $2\pi/N_i$, where N_i is the number of teeth for the driving gear ($i = 1$) or the driven gear ($i = 2$). For the purposes of computational convenience, the angle is divided into N_J equal intervals. These intervals form a scale which may be associated with the point of contact which moves along the involute profile as the gear rotates. Starting from a zero position when contact is at the pitch point, the successive values of J identify the intervals of rotation as

$$\alpha_{J1} = J_1 \frac{2\pi}{N_1 N_J} \quad (1)$$

$$\alpha_{J2} = J_2 \frac{2\pi}{N_2 N_J} \quad (2)$$

J is defined to be positive as contact moves outward on the involute and negative as it moves inward. Figure 8 shows a pitch-point contact of a pair of engaging teeth of two external involute spur gears, where R_M is the root circle radius and R_T defines the manufactured starting point of the involute profile. According to Equations (1) and (2), $\alpha_{J1} = \alpha_{J2} = 0$ for the tooth pair.

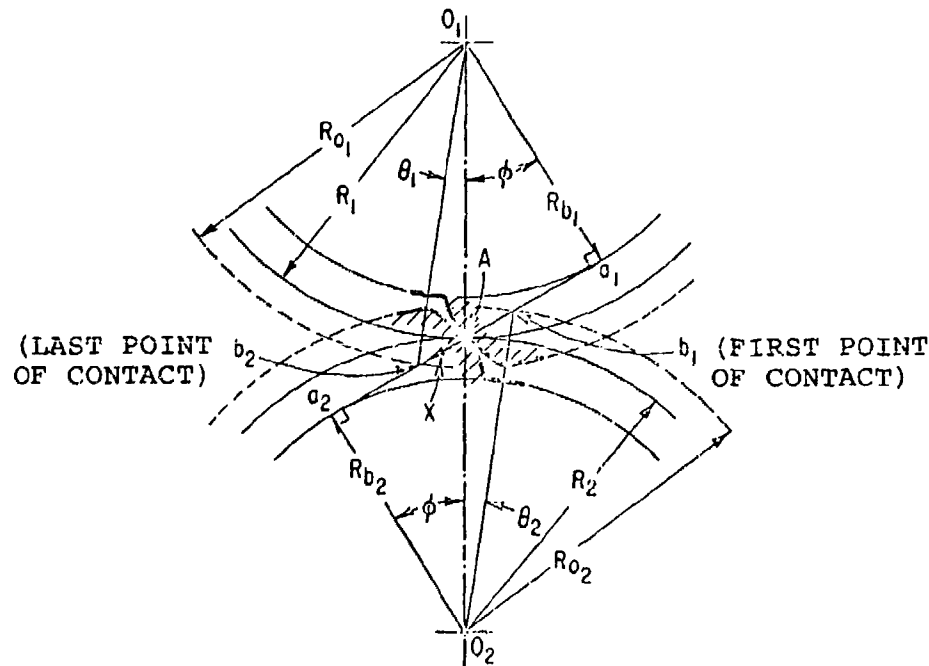


Figure 6. Involute Gears.

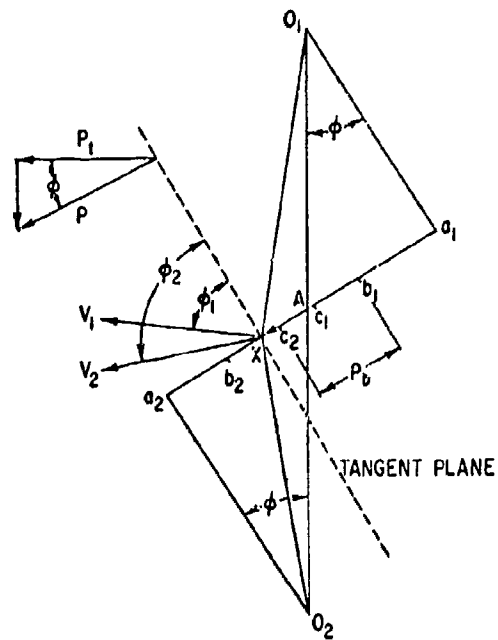


Figure 7. Tooth Mesh Kinematics.

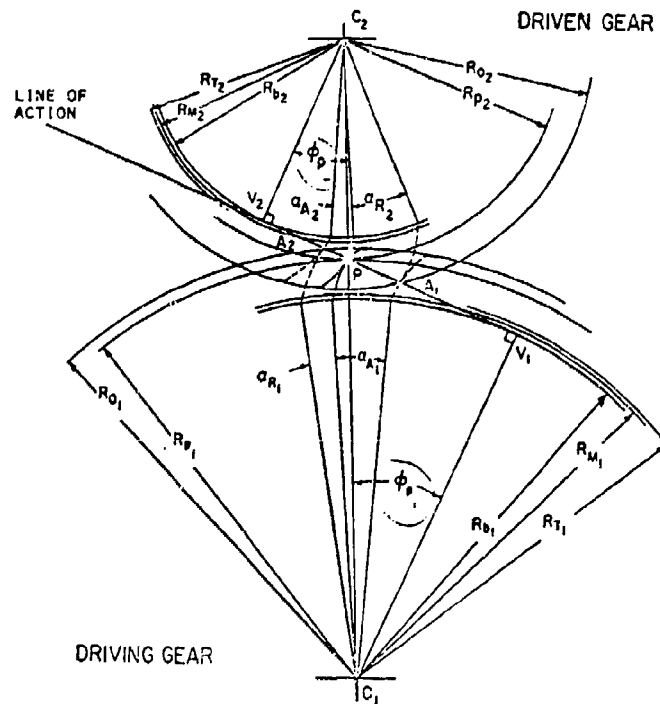


Figure 8. External Involute Spur Gears.

To check for engagement between the teeth of one meshing pair at any rotational position, the particular value of α_{J1} or α_{J2} is compared to the angles of approach and recess, α_{Ai} and α_{Ri} respectively, which limit the range of engagement (see Figure 8). Engagement is possible only when

$$\alpha_{R1} \geq \alpha_{J1} \geq \alpha_{A1} \quad (3)$$

and

$$\alpha_{R2} \geq \alpha_{J2} \geq \alpha_{A2} \quad (4)$$

It is noted that $\alpha_{A1} < 0$, since a rotation backward from the pitch-point contact is required. The angles of approach and recess may be expressed as follows (Reference 2):

$$\alpha_{A1} = -\frac{N_2}{N_1} \left[\sqrt{\rho_{o2}^2 - 1} - \tan \phi_p \right] \quad (5)$$

$$\alpha_{R1} = \sqrt{\rho_{o1}^2 - 1} - \tan \phi_p \quad (6)$$

$$\alpha_{A2} = -\frac{N_1}{N_2} \left[\sqrt{\rho_{o1}^2 - 1} - \tan \phi_p \right] \quad (7)$$

$$\alpha_{R2} = \sqrt{\rho_{o2}^2 - 1} - \tan \phi_p \quad (8)$$

where

$$\rho_{o1} = \frac{R_{o1}}{R_{b1}} \quad (9)$$

$$\rho_{o2} = \frac{R_{o2}}{R_{b2}} \quad (10)$$

When more than one pair of teeth are engaged in mesh instantaneously, the points of contact on the successive meshing teeth from the same gear have a fixed relationship as shown in Figure 9.

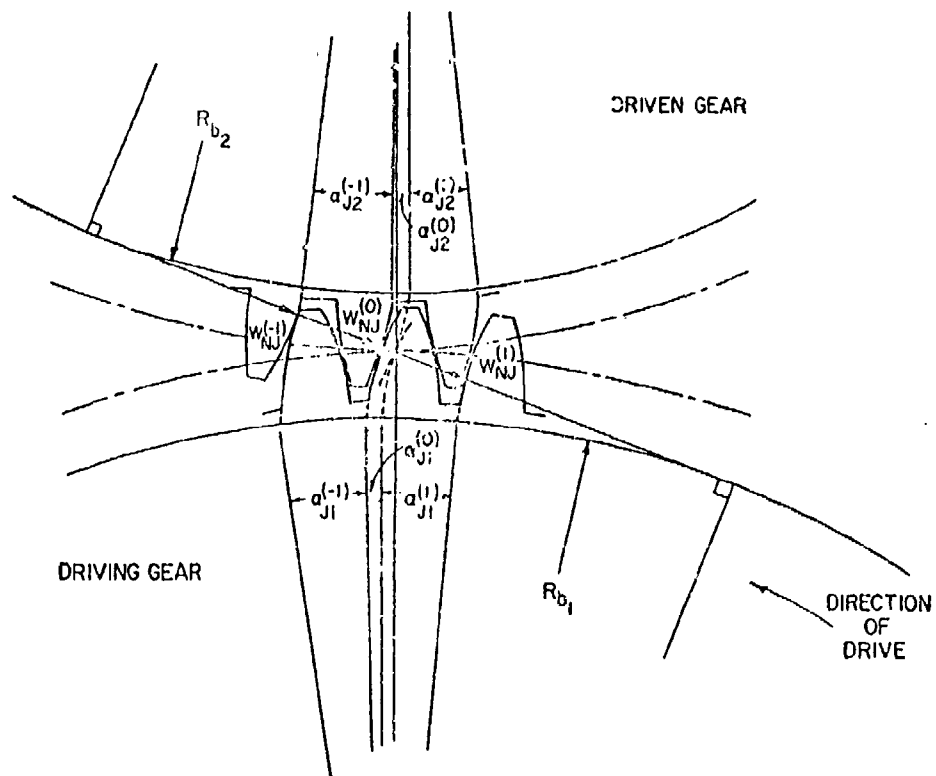


Figure 9. Three Successive Pairs of Teeth in Mesh.

$$\alpha_{J1}^{(-1)} + \alpha_{J1}^{(0)} = \alpha_{J1}^{(0)} + (-\alpha_{J1}^{(1)}) = \frac{2\pi}{N_1} \quad (11)$$

$$(-\alpha_{J2}^{(-1)}) + (-\alpha_{J2}^{(0)}) = (-\alpha_{J2}^{(0)}) + \alpha_{J2}^{(1)} = \frac{2\pi}{N_2} \quad (12)$$

where superscript (j) stands for jth pair. For high-contact-ratio spur gears in general, the above relationship may be generalized to

$$\left| \alpha_{J1}^{(j)} \right| + \left| \alpha_{J1}^{(j+1)} \right| = \frac{2\pi}{N_1} \quad (13)$$

$$\left| \alpha_{J2}^{(j)} \right| + \left| \alpha_{J2}^{(j+1)} \right| = \frac{2\pi}{N_2} \quad (14)$$

The division of transferred tooth load among the tooth pairs that are simultaneously in contact was determined from a consideration of gear tooth compliances and the relevant manufacturing errors for the contact points. Letting the meshing pairs be denoted by superscript (j) and (j) = (j-), (j+1), ..., (-1), (0), (1), ..., (j+ -1), and (j+) successively, the total number of pairs of teeth in mesh instantaneously is (j- + j+ + 1). It is noted that j- < 0, and j+ > 0. Using (0)th and (1)th pair of gears as representative, a schematic diagram of displacement deviation and load sharing relationships is shown in Figure 10. The gear teeth are represented as slender, spring-like members with deflections (B) caused by their respective loads. Profile errors (Z) at the points of contact are shown as buttons interacting with the deflections of the spring-teeth. Tooth spacing errors (V) are pictured as offsets in the projections of the bases of the spring-teeth. The deviation (V_{NJ}) in the position of the driven gear relative to the driving gear of the (0)th pair, which results from the combination of deflections and errors, is shown by the offset between the base of the (0)th pair's spring-tooth on the driving gear and the base of the meshing spring-tooth on the driven gear. The profile errors, the tooth spacing errors, and the position deviations are all measured along the line of action (normal to the tooth surface). To separate the effects of profile error and tooth spacing, the former is defined as zero at the pitch point and the latter is measured between pitch points of successive teeth. To be consistent with the requirement of direction along the line of action, the tooth spacing error as measured between pitch points must be multiplied by the factor cos ϕ_p . (Z) is positive if material is added to the true involute, and

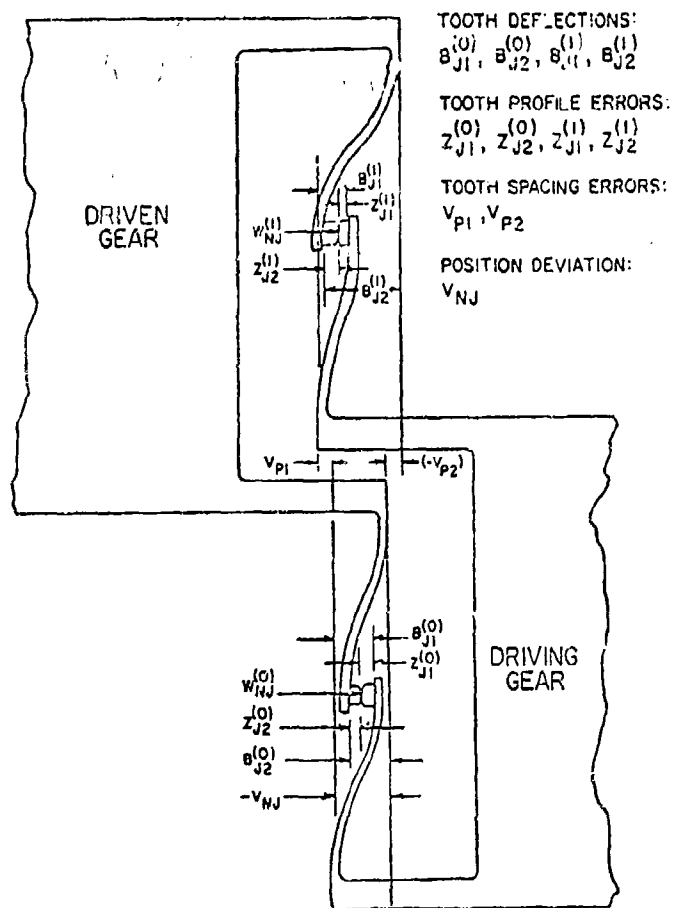


Figure 10. Schematic Diagram of Displacement Deviation and Load Sharing Relationships.

negative if material is subtracted; (V) is positive if the tooth spacing is smaller than the desired spacing.

The chain of displacements shown in Figure 10 yields the following equations:

$$-v_{NJ} = B_{J1}^{(0)} + B_{J2}^{(0)} - z_{J1}^{(0)} - z_{J2}^{(0)} \quad (15)$$

$$-v_{NJ} + v_{P1} - v_{P2} = B_{J1}^{(1)} + B_{J2}^{(1)} - z_{J1}^{(1)} - z_{J2}^{(1)} \quad (16)$$

For simplification, define

$$z_J^{(j)} = z_{J1}^{(j)} + z_{J2}^{(j)} \quad (17)$$

and express deflections in terms of loads and elastic compliances of tooth as follows:

$$Q_J^{(j)} = Q_{J1}^{(j)} + Q_{J2}^{(j)} + v_{12}^{(j)} \quad (18)$$

where

$$B_{J1}^{(j)} + B_{J2}^{(j)} = w_{NJ}^{(j)} Q_J^{(j)} \quad (19)$$

In the above, $Q_{J1}^{(j)}$ and $Q_{J2}^{(j)}$ are, respectively, the tooth compliance at the Jth calculation point of the tooth profile of the driving and driven gears. $U_{J2}^{(j)}$ represents any additional combined tooth support compliance of the tooth pair.

Substituting Equations (17) and (18) into (15) and (16),

$$Q_J^{(0)} w_{NJ}^{(0)} + v_{NJ} = z_J^{(0)} \quad (20)$$

$$Q_J^{(1)} w_{NJ}^{(1)} + v_{NJ} = z_J^{(1)} + (v_{P1} - v_{P2}) \quad (21)$$

From the above derivation and the deflection and load sharing diagram shown in Figure 10, Equations (20) and (21) may be generalized to apply to the mesh system where there are $(j_- + j_+ + 1)$ pairs of teeth that contact instantaneously:

$$Q_J^{(j)} w_{NJ}^{(j)} + v_{NJ} = z_J^{(j)} + (v_{p1} - v_{p2}) j \quad (22)$$

for $j_- \leq j \leq j_+$

The sum of the transferred loads is equal to the total normal tooth load,

$$\sum_{j=j_-}^{j_+} w_{NJ}^{(j)} = w_N \quad (23)$$

The system of Equations (22) and (23) consists of $(j_- + j_+ + 2)$ linear equations in $w_{NJ}^{(j)}$ and v_{NJ} . It may be solved by standard method of matrix inversion to obtain the transferred load distribution $w_{NJ}^{(j)}$ and the normal displacement deviation v_{NJ} . If $w_{NJ}^{(j_-)}$ is found to be less than zero, it means that the (j_-) th pair is no longer in contact. Consequently, $w_{NJ}^{(j_-)}$ should be set equal to zero and a new j_- that equals the old j_- plus 1 should be used. Similarly, if $w_{NJ}^{(j_+)}$ is found to be less than zero, $w_{NJ}^{(j_+)}$ should be set zero and a new j_+ that equals the old j_+ minus 1 should be used.

The pitch line deviation v_J is related to the normal deviation v_{NJ} by

$$v_J = \frac{v_{NJ}}{\cos \phi_p} \quad (24)$$

v_J is computed and recorded from one calculation point to the next point by varying J from 0 to N_J . The total interval corresponds to one mesh cycle, and all teeth rotate an angle of $\frac{2\pi}{N_i}$. At $J = 0$, the (0)th pair may be set at the pitch-point position and thus $\alpha_{01}^{(0)} = \alpha_{02}^{(0)} = 0$. At any intermediate

$J, \alpha_{J1}^{(0)}$ and $\alpha_{J2}^{(0)}$ are calculated from Equations (1) and (2). The rotational positions of other engaging teeth may be obtained from Equations (13) and (14), and the engagement condition given in Equations (3) and (4) may be examined. At $J = N_J$ the (1)st pair of teeth moves to the pitch-point position and a new mesh cycle begins. The frequency spectrum of the gear-mesh-induced vibration is then obtained by a Fourier analysis of the tooth displacement deviations.

In the computation of mesh excitation expressed in terms of deviation from true conjugate action, tooth deflection due to elastic compliance as well as tooth profile error and tooth spacing error are considered. The consideration of the combined tooth compliance $Q_{12}^{(j)}$ is similar to that given in Reference 2.

The combined compliance is the sum of the compliances of the two contacting teeth,

$$Q_{J12}^{(j)} = Q_{J1}^{(j)} + Q_{J2}^{(j)} \quad (25)$$

where the subscript J stands for the J th calculation point along the involute profile, and subscripts 1 and 2 represent the driving and driven gears respectively. Superscript (j) indicates the j th contacting pair of teeth.

The computation of $Q_{J1}^{(j)}$ and $Q_{J2}^{(j)}$ are similar; thus, only the compliance of the driving gear, $Q_{J1}^{(j)}$, will be considered.

The effective deflection at the contact point (load point) in the direction of the applied normal load is the quantity of interest. The total value of this deflection will be derived from the summation of four individual contributors, each formed by applying a simple deflection analysis. These four deflections are:

1. Displacement due to bending of the tooth as a cantilevered beam, $(B_{J1}^{(1)})_a$. The gear tooth is treated as a sequence of transverse segments, each of uniform rectangular cross-section. The depth of the uniform section is taken as the average of the depths at both ends of the segment. Figure 11 shows an external gear tooth with one such segment. Each segment will be identified by a K value

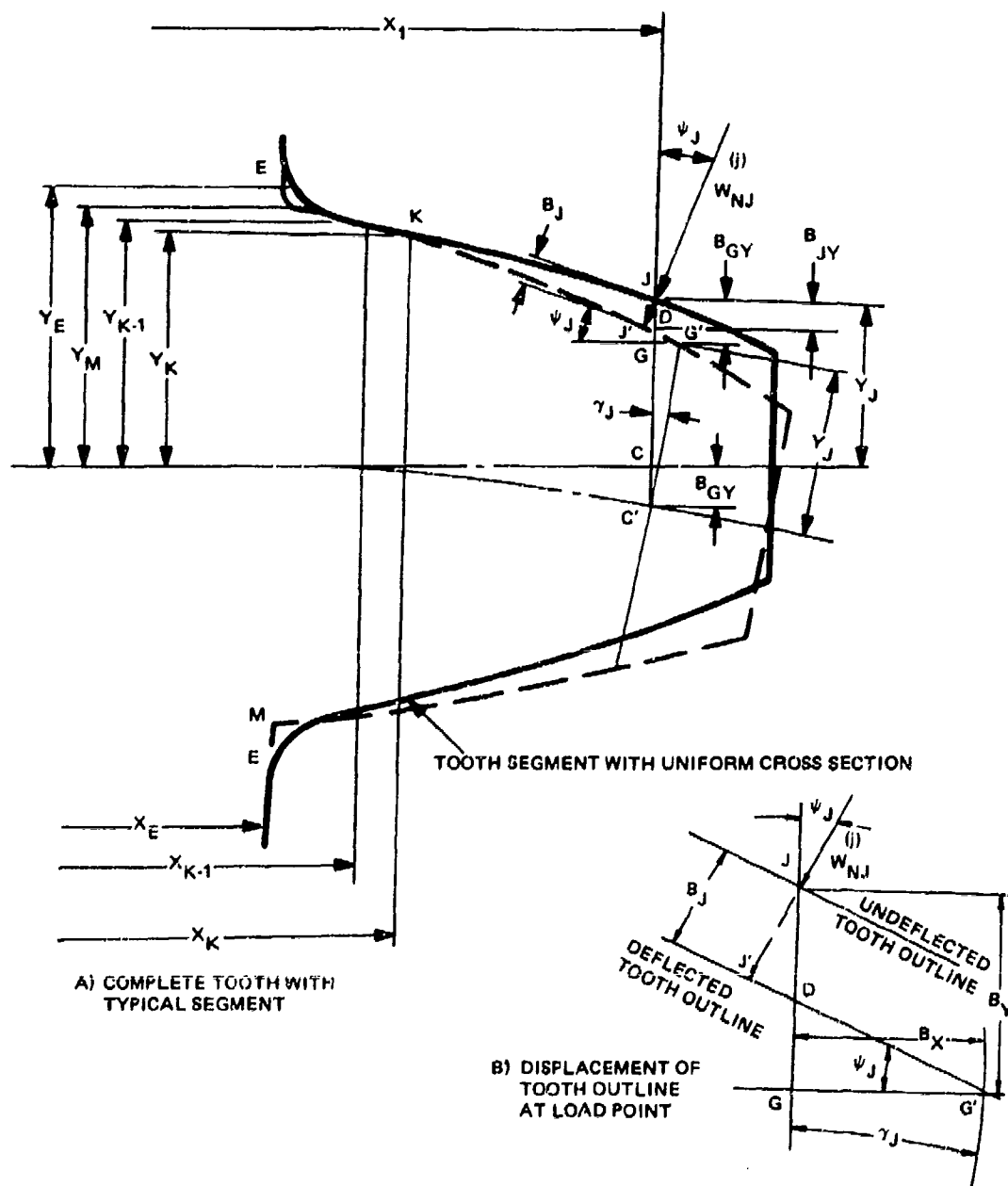


Figure 11. Beam Deflections in the Gear Tooth.

associated with its outer section, and the K value increases as the section moves out toward the tip of the tooth. The selection of the location of each K section may be made to correspond to the location of each of the N_J calculation points, as long as the N_J points are sufficiently close to each other. In Figure 11, J represents the point at which the load is applied. The angle ψ_J gives the direction of this load relative to the tooth centerline. The analysis which follows traces the contribution of each K segment to the displacement at the point J, which itself remains fixed. As the mating gear rotates, J moves into successive positions, and the deflection calculations must be repeated for each new position.

The moment of inertia of the rectangular cross-sectional area at K may be expressed in terms of the Y-coordinate and the tooth face width F.

$$I_K = \frac{1}{12} F (2Y_K)^3 = \frac{2FY_K^3}{3} \quad (26)$$

At the K-1 cross-section, which is the other end of the K segment,

$$I_{K-1} = \frac{2FY_{K-1}^3}{3} \quad (27)$$

For the assumed uniform cross-section of the segment between K and K-1, the mean of the two moments of inertia will be used.

$$\bar{I}_K = \frac{I_K + I_{K-1}}{2} \quad (28)$$

In the same manner, the mean area for the two cross-sections may be found:

$$A_K = F(2Y_K) = 2FY_K \quad (29)$$

$$A_{K-1} = 2FY_{K-1} \quad (30)$$

$$\bar{A}_K = \frac{A_K + A_{K-1}}{2} \quad (31)$$

The length of the K segment is

$$L_K = x_K - x_{K-1} \quad (32)$$

The distance of the K segment, at its outer end, from the point J of load application is similarly found:

$$S_{JK} = x_J - x_K \quad (33)$$

In Figure 11, the normal load at J acting on the cantilevered gear tooth is equivalent to a concentrated transverse load equal to $w_{NJ}^{(j)} \cos \psi_J$, and a counterclockwise moment being $w_{NJ}^{(j)} \sin \psi_J y_J$.

In the bending of the tooth, each of these load conditions causes a transverse displacement and a rotation of the tooth centerline under the point of load application. These two displacements will be evaluated for each of the two load conditions and then combined.

The first case considered is that of a tooth segment subjected to a transverse load applied some distance away, with the rest of the gear tooth serving as a rigid support of a rigid extension (Figure 12a).

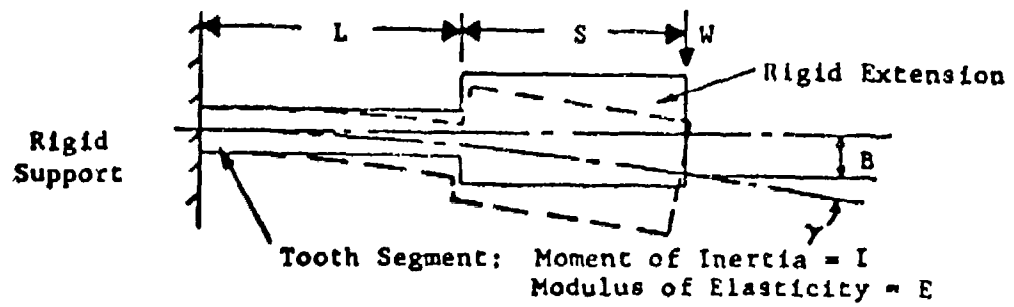
From standard beam deflection theory, the transverse deflection at the load is

$$(B_{Y1K})_{al} = \frac{w_{NJ}^{(j)} \cos \psi_J L_K}{2 E_v \bar{I}_K} (L_K^2 + 3S_{JK}L_K + 3S_{JK}^2) \quad (34)$$

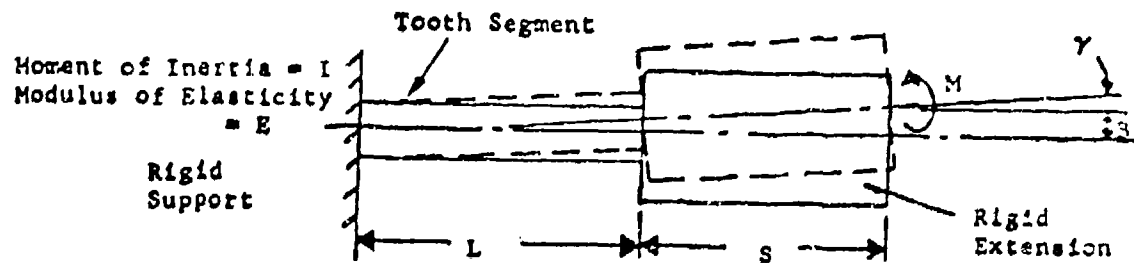
The centerline rotation at the load is

$$(\gamma_{J1K})_{al} = \frac{w_{NJ}^{(j)} \cos \psi_J L_K}{2 E_v \bar{I}_K} (L_K + 2S_{JK}) \quad (35)$$

In the above, E_v is the effective bending modulus of elasticity for gears whose face width is large compared to the tooth thickness:



a. Under a Concentrated Load.



b. Under a Moment.

Figure 12. Beam Deflection Diagrams.

$$E_v = \frac{E}{1 - \nu^2} \quad (36)$$

where E is the Young's modulus of elasticity and ν the Poisson's ratio. If the gear tooth is narrow relative to its thickness, the factor $\frac{1}{1 - \nu^2}$ should be eliminated.

The second case considered is that of the tooth segment subjected to a moment load applied some distance away, with the rest of the gear tooth serving as a rigid support or a rigid extension (Figure 12b).

From the beam deflection theory, the transverse deflection at the load is

$$(B_{YJK})_{a2} = \frac{-W_{NJ}^{(j)} \sin \psi_J Y_J L_K}{2 E_v \bar{I}_K} (L_K + 2S_{JK}) \quad (37)$$

The centerline rotation at the load is

$$(\gamma_{JK})_{a2} = \frac{-W_{NJ}^{(j)} \sin \psi_J Y_J L_K}{E_v \bar{I}_K} \quad (38)$$

The deflections for each tooth segment may be summed to yield the total transverse deflection at the load $(B_{Y1})_{a1}$ and $(B_{Y1})_{a2}$, and the centerline rotation at the load $(\gamma_{J1})_{a1}$ and $(\gamma_{J1})_{a2}$.

The displacement in the direction of the load (Figure 12) due to a transverse deflection B_Y and a centerline rotation γ_J is

$$B_J = B_Y \cos \psi_J - Y_J \gamma_J \sin \psi_J \quad (39)$$

By summing the deflections for all tooth segments and computing the displacement due to the concentrated load and moment load together, the total displacement of the tooth in the load direction is

$$\begin{aligned}
(B_{J1}^{(j)})_a = \frac{W_{NJ}^{(j)}}{E_v \bar{I}_K} & \left[\frac{\cos^2 \psi_J}{3} \sum L_K (L_K^2 + 3S_{JK}L_K + 3S_{JK}^2) \right. \\
& - \cos \psi_J \sin \psi_J \cdot Y_J \sum L_K (L_K + 2S_{JK}) \\
& \left. + \sin^2 \psi_J \cdot Y_J^2 \sum L_K \right]
\end{aligned}
\tag{40}$$

which gives the total deflection from the bending of the tooth loaded as a cantilevered beam.

2. Displacement due to the shear deformation of the tooth as a cantilevered beam, $(B_{J1}^{(j)})_b$. The shear deflection of the tooth as a cantilevered beam is also caused by the transverse component of the applied load, $W_{NJ}^{(j)} \cos \psi_J$. This deflection offsets the centerline without rotating any transverse section. The deflection at the load point then becomes the sum of the deflections for each of the tooth segments defined previously.

The individual segment subjected to the shear load is represented in Figure 13, with the rest of the gear tooth appearing as a rigid support or a rigid extension.

From standard methods for beam shear deflection analysis, the transverse deflection when the cross-section is rectangular is

$$(B_{Y1K}^{(j)})_b = \frac{1.2 W_{NJ}^{(j)} \cos \psi_J \cdot L_K}{G \bar{A}_K}
\tag{41}$$

$$(Y_{J1K}^{(j)})_b = 0
\tag{42}$$

where G is the shear modulus of elasticity.

Summing the deflection for all segments from the base of the tooth to the applied load point J ,

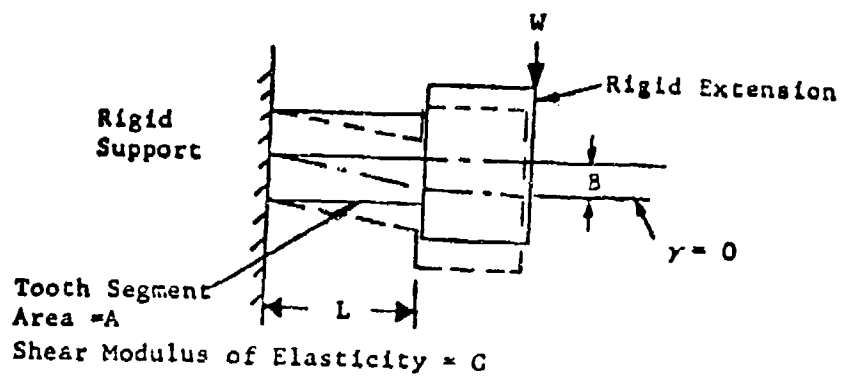


Figure 13. Shear Deflection Diagram.

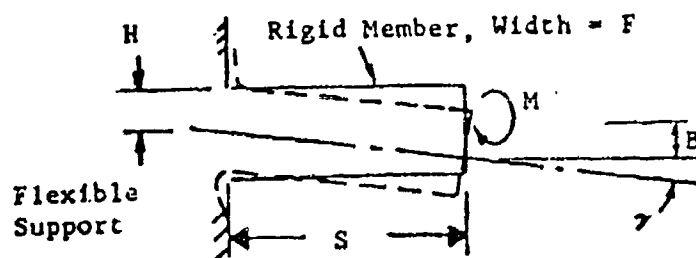


Figure 14. Base Rotation Deflection Diagram.

$$\left(B_{Y1}^{(j)}\right)_b = \frac{1.2W_{NJ}^{(j)} \cos \psi_J}{G} \sum \frac{L_K}{\bar{A}_K} \quad (43)$$

$$\left(V_{J1}^{(j)}\right)_b = 0 \quad (44)$$

To obtain the resulting displacement due to the shear deformation of the tooth as a cantilevered beam in the direction of the load, the factor $\cos \psi_J$ is multiplied by $\left(B_{Y1}^{(j)}\right)_b$.

$$\left(B_{J1}^{(j)}\right)_b = \frac{1.2W_{NJ}^{(j)} \cos^2 \psi_J}{G} \sum \frac{L_K}{\bar{A}_K} \quad (45)$$

3. Displacement due to the rotation of the tooth in the supporting structure at its base, $\left(B_{J1}^{(j)}\right)_c$. The moment that causes this rotation is due to the applied load. The transverse component of this load $W_{NJ}^{(j)} \cos \psi_J$ will create the moment $W_{NJ}^{(j)} \cos \psi_J \cdot S_J$, where S_J is the distance from the load point to the base of the tooth. The axial component, as noted previously, will create the moment $W_{NJ}^{(j)} \sin \psi_J$.

Figure 14 shows this loading and the resulting deflection in simplified form.

The equation for the displacements at the load point from Reference 15 is

$$\left(B_{Y1}^{(j)}\right)_c = \frac{1.327W_{NJ}^{(j)} (\cos \psi_J \cdot S_J - \sin \psi_J \cdot Y_J) S_J}{E_V Y_E^2 F} \quad (46)$$

$$\left(V_{J1}^{(j)}\right)_c = \frac{1.327W_{NJ}^{(j)} (\cos \psi_J \cdot S_J - \sin \psi_J \cdot Y_J)}{E_V Y_E^2 F} \quad (47)$$

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15. O'Donnel, W. J., STRESS AND DEFLECTION IN BUILT-IN BEAMS, ASME Paper No. 62-WA-16, 1962.

The resulting displacement in the direction of the load due to the rotation of the tooth in its supporting structure is

$$\begin{aligned} \left(B_{J1}^{(j)} \right)_c &= \frac{1.327 W_{NJ}^{(j)} (\cos \psi_J \cdot S_J - \sin \psi_J \cdot Y_J) (\cos \psi_J \cdot S_J - \sin \psi_J \cdot Y_J)}{E_V Y_E^2 F} \\ &= \frac{1.327 W_{NJ}^{(j)} (\cos \psi_J \cdot S_J - \sin \psi_J \cdot Y_J)^2}{E_V Y_E^2 F} \end{aligned} \quad (48)$$

4. Displacement due to the contact or Hertzian deformation, $B_{J12}^{(j)}$ d. This deformation is based on a semiempirical equation (Reference 16) developed for a contacting cylinder in roller bearings,

$$B_{12} = \frac{3 \times 10^{-4} \epsilon_E^{2.7} W^{0.9}}{F_{12}^{0.8}} \quad (49)$$

where

$$\epsilon_E = \sqrt[3]{\frac{11,500 (E_{v1} + E_{v2})}{(E_{v1} E_{v2})}} \quad (50)$$

This equation treats the general case where the materials of the two mating surfaces may have different properties. Subscripts 1 and 2 are used to refer to the two surfaces. The deflection given by the equation is for the two contracting surfaces combined; hence, the notation 12 is used in the subscript. Since the face widths of the two surfaces may be unequal, F_{12} refers to the effective face width of the combination. A suitable approximation of this effective face width is the smaller of the two widths.

After the substitution of the equation for a composite modulus of elasticity,

$$\frac{1}{E_{v12}} = \frac{1}{2} \left(\frac{1}{E_{v1}} + \frac{1}{E_{v2}} \right) = \frac{(E_{v1} + E_{v2})}{2(E_{v1} E_{v2})} \quad (51)$$

16. Palmgren, David, BALL AND ROLLER BEARING ENGINEERING, 3rd Edition, SKF Industries, Inc.

into Equation (50), the result is combined with Equation (49) and this becomes

$$B_{12} = \frac{2.55 W^{0.9}}{E_{v12}^{0.9} F_{12}^{0.8}} \quad (52)$$

There is a major difference between the conditions applying to a roller between bearing races and those applying to a loaded gear tooth. Although in both cases contact is between cylindrical surfaces, the nature of the support of the bodies with these cylindrical surfaces is quite different. The force at one contacting surface on the roller is opposed by an equal force located diametrically opposite. As a result the entire roller is loaded with the full compressive force, and the deflection given by Equation (52) is the deflection at the contact point and throughout the roller. A gear tooth does not provide the full cylindrical cross-section of the roller. Furthermore, the applied load is not supported by a diametrically opposed force but by the shear forces distributed across the base of the tooth. The first item calls attention to a reduced material cross-section available for deformation. The second item points out that, due to the side support, the internal loading in the cross-section of the tooth is not constant but reduces with increased distance from the contact point. These differences make the contact deflection in gear teeth significantly less than indicated by Equation (52), and the estimate used for this reduction in deflection is 50 percent. This correction gives calculated results which are still somewhat larger than the experimental results to which they were compared. However, the apparent excess in calculated contact deflection will be more than offset in many practical applications by the increase in deflection resulting from slight errors in the contacting surfaces.

By including the 50 percent correction, Equation (52) may be rewritten to adapt more closely to the displacement due to Hertzian deformation of contacting gear teeth.

$$\left(B_{J12}^{(j)} \right)_d = \frac{1.275 W_{NJ}^{(j) 0.9}}{E_{v12}^{0.9} F_{12}^{0.8}} \quad (53)$$

From the four displacement equations, (40), (45), (48), and (53), the compliance may be computed from

$$Q_{J1}^{(j)} = \frac{B_{J1}^{(j)}}{W_{NJ}} \quad (54)$$

From Equations (40), (45), and (48),

$$\begin{aligned} \{Q_{J1}^{(j)}\}_a = \frac{1}{E_V I_K} \left[\frac{\cos^2 \psi_J}{3} \sum L_K (L_K^2 + 3S_K L_K + 3S_{JK}^2) \right. \\ \left. - \cos \psi_J \sin \psi_J \cdot Y_J \sum L_K (L_K + 2S_{JK}) \right. \\ \left. + \sin^2 \psi_J \cdot Y_J^2 \sum L_K \right] \end{aligned} \quad (55)$$

$$\{Q_{J1}^{(j)}\}_b = \frac{1.2 \cos^2 \psi_J}{G} \sum \frac{L_K}{\bar{A}_K} \quad (56)$$

$$\{Q_{J1}^{(j)}\}_c = \frac{1.327 (\cos \psi_J \cdot S_J - \sin \psi_J \cdot Y_J)^2}{E_V Y_E^2 F} \quad (57)$$

These three compliances combined may be viewed as the total beam compliance of the driving gear tooth of the jth pair

$$\{Q_{J1}^{(j)}\}_{abc} = \{Q_{J1}^{(j)}\}_a + \{Q_{J1}^{(j)}\}_b + \{Q_{J1}^{(j)}\}_c \quad (58)$$

The total beam compliance of the driven gear, $Q_{J2}^{(j)}$, may be similarly computed.

The contact deformation compliance may be obtained by combining Equations (53) and (54):

$$\{Q_{J12}^{(j)}\}_d = \frac{1.275}{E_{V12}^{0.9} F_{12}^{0.8} [W_{NJ}^{(j)}]^{0.1}} \quad (59)$$

Equation (59) shows that the compliance is somewhat dependent on the value of the applied load. Since the load appears to the one-tenth power, there will be little variation in compliance over a reasonably wide range of load, and $w_{NJ}^{(j)}$ may be replaced by an average value covering all conditions of loading without appreciable error. A suitable average value would be one-half the total load carried by the gear teeth,

$$w_{NJ}^{(j)} = .5 w_N \quad (60)$$

and then Equation (59) becomes

$$\{Q_{J12}^{(j)}\}_d = \frac{1.37}{E_{v12}^{0.9} F_{12}^{0.8} w_N^{0.1}} \quad (61)$$

Because this relationship is independent of surface curvature, it will apply for all load positions and for both the case of two external gears and the case of one external and one internal gear. The contact compliance requires the additional input information of the total transmitted load w_N and, in this respect, differs from the other compliance components.

In summary, the total elastic compliance of the j th pair mating gear teeth may be found by applying Equations (55), (56), and (57) for each of the gears, combining the results, and then adding the contact compliance for the two gears in combination.

$$Q_{J12}^{(j)} = \{Q_{J1}^{(j)}\}_{abc} + \{Q_{J2}^{(j)}\}_{abc} + \{Q_{J12}^{(j)}\}_d \quad (62)$$

SAMPLE GEAR MESH DYNAMICS CALCULATIONS

A set of high-contact-ratio spur gears, described in Table 3, was studied using the analysis previously described. The meshing error, tangential tooth load sharing, and frequency spectrum of mesh induced vibration are shown in Figures 15, 16, and 17 respectively. In each figure, there are three curves representing gears with (a) perfect tooth profile without spacing error, (b) the tooth profile modifications listed in Table 4, but with no spacing error, and (c) tooth modification and spacing errors of 0.000187 in. for the driving gear and -0.000187 in. for the driven gear.

The tooth meshing error, or deviation from pure conjugate action, as a pitch-line linear measurement of the motion of the driving gear leading the driven gear is shown in Figure 15 as the solid curve. The mesh cycle is represented by 25 calculation points. In the initial period of the mesh cycle there are three pairs of teeth in contact simultaneously. The beginning of the mesh cycle corresponds to the pitch-point contact of the middle pair. In the middle of the cycle there are only two pairs in contact; therefore, the tooth meshing error experiences a step change. Near the end of the cycle a new pair of teeth engages in the mesh and the meshing error drops accordingly. The end of the mesh cycle is again a pitch-point contact.

The tangential load shared by a tooth during its meshing engagement is represented by the solid curve given in Figure 16. A step change of the tangential load corresponds to the point at which another pair of teeth comes in or goes out of engagement. The pitch-point contact is identified in Figure 16. The mesh cycle over which the tooth meshing error is presented in Figure 15 is indicated. The cycle begins when the contact is at the pitch-point of the tooth, and ends when the following tooth gets to the pitch-point contact position.

The frequency spectrum of the gear-mesh-induced vibration is shown in Figure 17 and is identified by the case of $Z_J = V_p = 0$. In the figure, f_M is the mesh frequency. It is seen that the spectrum is discrete and the amplitude decreases with increasing frequency.

TABLE 3. GEAR DATA

	<u>DRIVING GEAR</u>	<u>DRIVEN GEAR</u>
Number of Teeth	33	58
Diametral Pitch, 1/in.	4.55	4.55
Pressure Angle, deg	21	21
Outer Diameter, in.	7.900	7.900
Root Diameter, in.	6.594	6.038
Circular Tooth Thickness at Pitch Diameter, in.	0.369	0.314
Tooth Face Width, in.	0.5	0.5
Tooth Fillet Radius, in.	0.087	0.083
Center Distance, in.	10	10
Young's Modulus, lb/in. ²	3×10^7	3×10^7
Shear Modulus, lb/in. ²	1.15×10^7	1.15×10^7
Poisson's Ratio	0.3	0.3
Driving Torque, in.-lb	9831	

TABLE 4. TOOTH PROFILE MODIFICATION

	<u>Driving Gear</u>				
Z _J (in.)	-0.00095	-0.00008	0	-0.00009	-0.00075
Roll Angle (deg)	34.43	28	21.99	18	9.57
	<u>Driven Gear</u>				
Z _J (in.)	-0.00075	-0.0001	0	-0.0003	-0.00055
Roll Angle (deg)	29.06	24.56	21.99	16.65	14.91

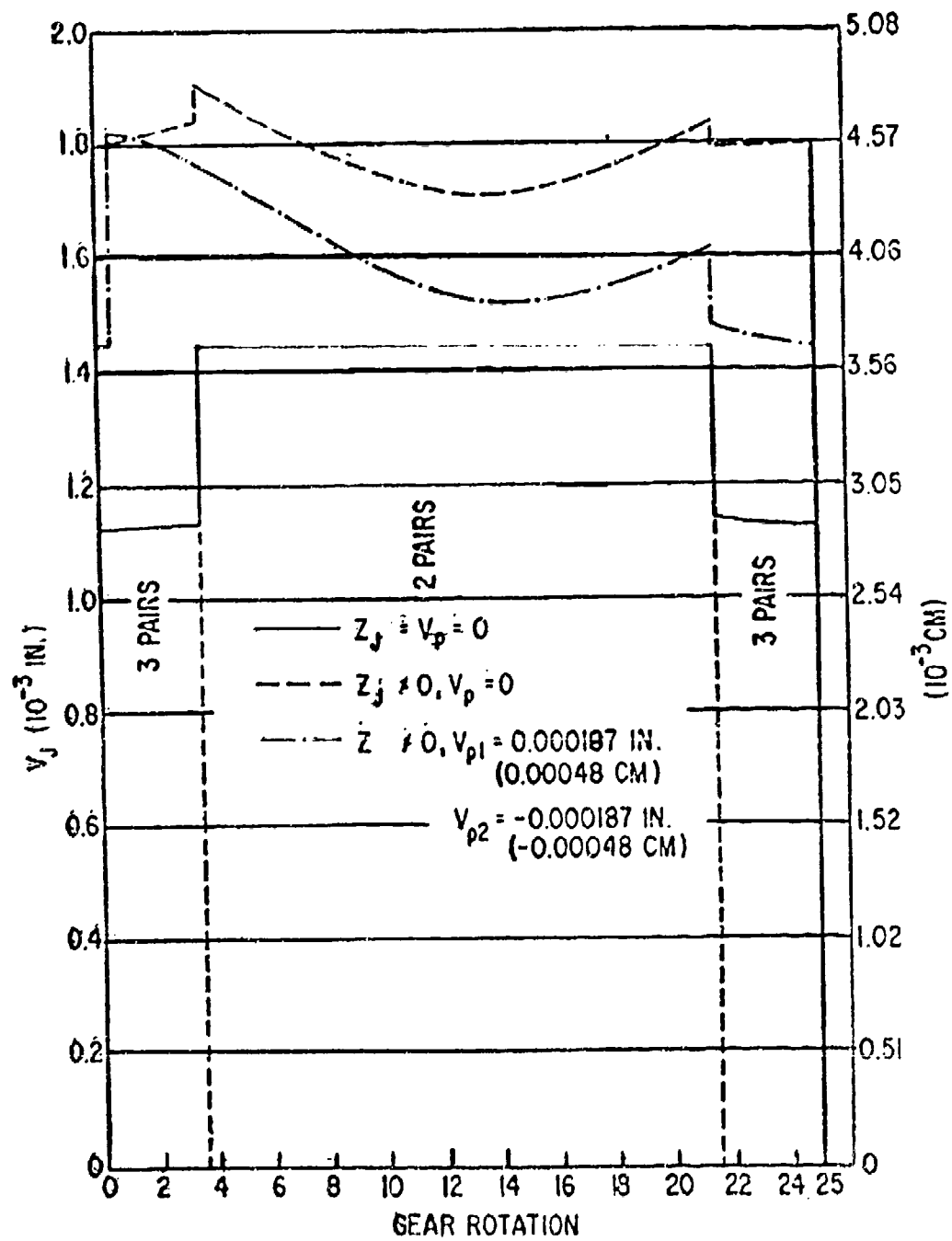


Figure 15. Tooth Meshing Error.

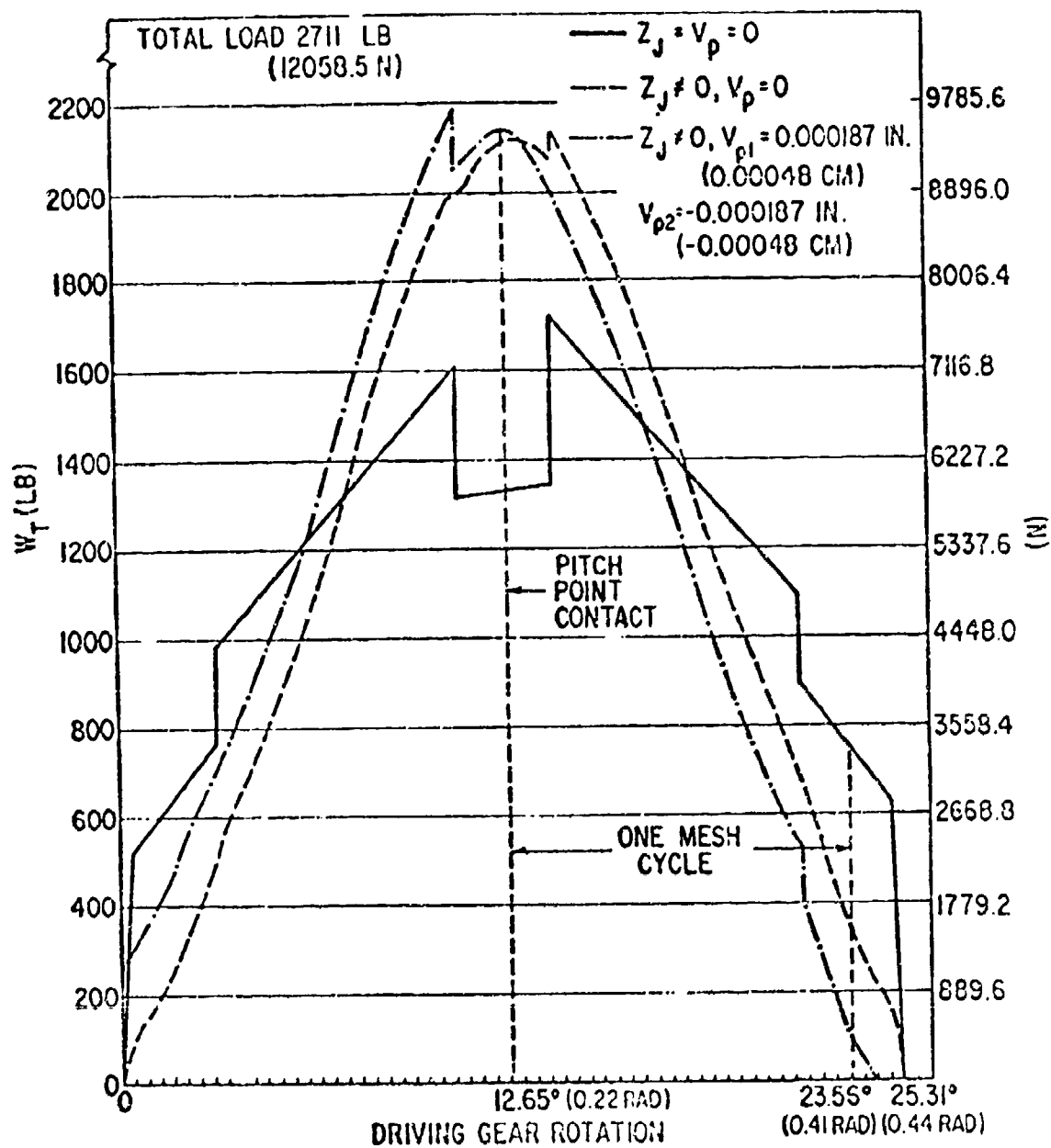


Figure 16. Tangential Tooth Load.

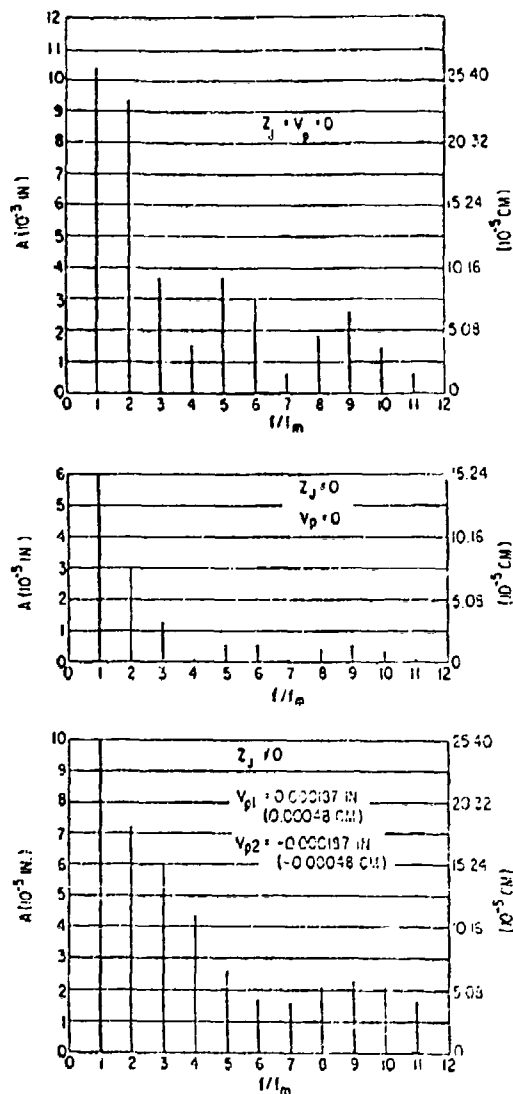


Figure 17. Gear Vibration Frequency Spectra.

The gears with the tooth profile modification still have three pairs of teeth in contact at the beginning and end of the mesh cycle and two pairs in the middle portion of the cycle as seen from Figure 15. However, the transition when a tooth pair comes in and out of engagement is smoother with the profile modifications. The pitch-line tooth spacing errors decrease the total time that a tooth shares the tangential load relative to cases with perfect involute profiles. This is observed in Figure 16. The effect of the spacing errors on peak tooth load is small, although the spacing errors modify the load sharing transition among engaging tooth pairs.

The frequency spectra of the vibration induced by gear mesh for all cases are discrete as shown in Figure 17. The amplitude is non-zero only at integer multiples of the mesh frequency. This is because all the teeth in each of the meshing gears are assumed identical, and all other gear parameters such as center distance and tangential tooth load are assumed constant. The only characteristic frequency is the mesh frequency. The spectrum of the vibration associated with the gear mesh thus contains signals at only the mesh frequency and its higher harmonics. If the gear parameters change or if the teeth in a gear are not identical the tooth meshing error pattern will, in general, vary between mesh cycles. The associated vibration will then contain signal components at the so-called sideband frequencies, not being the mesh frequency harmonics. This fact has been extensively discussed in Reference 14. Figure 17 shows that the vibration amplitude in general decreases with increasing frequency. The frequency spectra of the three cases shown in Figure 17 have the largest amplitudes at the first harmonic. The tooth profile modification appears to decrease the vibration signals at all harmonic frequencies, although the mean tooth deflection is calculated to be larger with the profile modification. The tooth spacing error is seen to have the effect of raising the signals at all frequencies. The amplitudes at some high harmonics are even larger than those of the case with perfect tooth profiles and no spacing error.

SUMMARY

A method has been developed for predicting the level and character of gear-mesh-induced vibrations in high-contact-ratio spur gears. In the computation of vibration amplitude, the load sharing among pairs of engaging gear teeth is calculated by considering all modes of tooth compliance, as well as any tooth profile modification and tooth spacing error.

Mesh dynamics calculations have been performed for a set of high-contact-ratio spur gears. It was found that the frequency spectrum of the gear-mesh-induced vibration depends strongly upon the tooth profile modification and the spacing error. The profile modification can effectively change the contact ratio of the gears by altering the maximum number of tooth pairs in contact simultaneously.

This analysis is useful for designing low-vibration gears by properly controlling relevant gear parameters such as tooth profile modifications. This approach may also be used to control peak tooth loads.

COMPUTER PROGRAM (R-75) INPUT FORMAT

The mesh dynamics analysis for high-contact-ratio spur gears has been programmed in computer program GGEAR/HCR (R-75), and a listing is provided in Appendix B. The limitations and assumptions involved in the analysis were stated previously. The user specifies a pair of geometrically compatible spur gears and their operating conditions; the program computes the load sharing among pairs of teeth, the stiffness of individual tooth pairs, the tooth displacement deviation, and the frequency spectrum of the associated vibration.

Figure 18 shows a sample input, and following is a brief discussion of the input variables, format, and important instructions for setting up the input data required for program R-75.

Input Variables, Format, and Instructions

Card 1 Title, columns 2 through 72.

Card 2 Control numbers. Format (16I5).

a. NMC Number of mesh cycles (last digit in column 5).

b. INT Specifies if this control card represents the last complete set of input data being submitted.

If more sets of input data follow use 0.

If this is the last set use 1 (column 10).

c. MN Specifies the types of spur gears considered.

If both the driving and driven gears are external gears use 1.

If the driving gear is an external gear and if the driven gear is an internal (ring) gear use 0 (The program will not run properly if the internal gear is submitted as the driving gear.) (column 15).

d. MMM Number of initial terms of the Fourier analysis for which coefficients will be printed, beyond the coefficient for the constant term. This number cannot exceed $(FI \times NMC + NMC/2)$ where FI is the input variable submitted on Card 4 (last digit in column 20).

Figure 18. Sample R-75 Input Deck.

- e. IPLT Specifies if the calculated tooth mesh error is to be plotted.

If tooth meshing error is to be plotted use 1.

If plotting is to be bypassed use 0 (column 25).

- f. IFOUR Specifies if a Fourier analysis of the tooth mesh error is to be performed.

If it is to be performed use 1.

If it is to be bypassed use 0 (column 30).

- g. ISPECT Specifies if a power spectral density function for the tooth mesh error is to be calculated.

If it is to be calculated use 1 and input NWS and WS on Card 9.

If it is to be bypassed use 0 (column 30).

- h. IHICR Specifies if the pair of gears is high-contact-ratio.

If the contact ratio of the gears is less than 2 use 0.

If the contact ratio is greater than 2 use 1.

Note that the contact ratio has to be less than 4 (column 35).

Card 2a Option Card. Format (16I5)

- a. IRM Specifies if tooth depth or root radius is input.

If IRM = 0 omit Card 4a and root radius is input.

If IRM = 1 submit Card 4a and tooth depth is input (column 5).

- b. IPERC Specifies if circular tooth thickness or a percentage quantity which allocates to drive and driven gears the difference between the actual circular pitch and the working backlash is input.
- If this is 0 omit Card 5a and input the circular tooth thickness.
- If this is 1 submit Card 5a on which the backlash and percent split to driving member are input (column 10).
- c. IRF Specifies if the fillet radius is input.
- If it is 0 fillet radii RF1 and RF2 are input.
- If it is 1 RF1 and RF2 are calculated based on a circular fillet (column 15).
- d. IPROP Specifies if the gear material properties are input.
- If it is 0 omit Card 6 and steel properties are provided internally.
- If it is 1 submit Card 6 for material properties (column 20).
- e. ICENT Specifies how center distance is input.
- If it is 0 input center distance on Card 7 and omit variable DEV on Card 7.
- If it is 1 omit variable CL on Card 7 and input DEV (deviation from standard center distance) on Card 7.
- If it is 2, standard center distance is used and omit variables CL and DEV on Card 7 (column 25).
- f. NZJ Specifies how the tooth profile deviation and tooth support compliance are to be input, according to the following table:

If	Submit					
	NZJ	U pt-by-pt	On Card	Z pt-by-pt	On Card	4 Zvalues
0		Yes	8a	Yes	8b	no
1		No		No		Yes 8d
2		No		No		No
3		No		Yes	8b	No
4		Yes	8a	No		Yes 8d
5		Yes	8a	No		No

In the Table U is the tooth support compliance explained in the description of Card 8a. If U is not input (NZJ = 1, 2, or 3) a value of 0 is used internally. Z is the deviation of points on the actual tooth profile from a true involute. Z is explained in the description of Cards 8b and 8d (column 30).

g. IDIAG Specifies if diagnostic information is to be printed.

If it is 0 no diagnostics are printed.

If it is 1 diagnostics are printed out (column 35).

Card 3 Gear Design Data Format (6E 13.5).

a. FNI Number of teeth, driving gear.
Use columns 1 through 13.

b. FN2 Number of teeth, driven gear.
Use columns 14 through 26.

c. DPIT Diametral pitch, 1/in. (columns 27 through 39).

d. PANG Cutting pressure angle, deg (columns 40 through 52).

- e. RØ1 Radius to the outside diameter of the driving gear, in. This should be reduced by any radial loss in working surface at the tip of the teeth from rounding or chamfering (columns 53 through 65)
- f. RØ2 Radius to the outside diameter of the driven gear, if external, and to the inside diameter, if internal, in. This should be corrected for any radial loss in working surface at the tip of the teeth from tip rounding or chamfering. In the case of an internal gear, this radius must be equal to or greater than the base circle radius. No check for this is provided (columns 66 through 78)
- or
 RI2

Card 4 Gear design data, continued Format (6E 13.5)

- a. RM1 Radius to the tooth circle of the driving gear, in. If this radius is smaller than the computed base circle radius the input value of root radius is used at some points in the program and this is noted in the output. If the root radius is smaller than the base circle radius so that the root fillet center lies inside the base circle, the tooth outline between the base circle and the fillet is assumed to be a radial line by the program. Omit if IRM $\neq$ 0 (columns 1 through 13)
- b. RM2 Radius to the root circle of the driven gear, in. For the case of an external gear, the same comments as above apply. Omit if IRM $\neq$ 0 (columns 14 through 26)
- c. FI Number which establishes the number of calculation points (N_J) where $N_J = 1 + 2 (FI)$. The calculation points may be viewed as selected contact points on the true involute profile, extended where necessary. These contact points with the mating involute area are associated with specific angular positions of the gear as it is rotated, where the angular positions correspond to uniform subdivisions of the tooth spacing angle. A greater number of these points will give more closely spaced point-by-point output data and more accurate calculations of tooth deflections and Fourier coefficients. A value of FI = 12, giving 25 calculation points, has been found to be convenient. (Maximum value of FI = 12.) (Columns 27 through 39)

- d. T1 Circular tooth thickness at the pitch circle,
driving gear, in. Omit if IPERC $\neq$ 0
(columns 40 through 52).

Card 4a Gear Design Data, Continued Format (6E 13.5)

This card is needed only if IRM $\neq$ 0.

- a. HT1 Tooth depth, driving gear, in.
(columns 1 through 13).
b. HT2 Tooth depth, driven gear, in.
(columns 14 through 26).

Card 5 Gear Design Data, Continued Format (5E 13.5)

- a. T2 Circular tooth thickness at the pitch circle,
driven gear, in. Omit if IPERC $\neq$ 0
(columns 1 through 13).
b. F1 Effective tooth face width, driving gear, in.
If the face widths of the mating gears are
similar, use the actual face width. If one
tooth is much wider than its mate use an effect-
ive face width which allows for the limited add-
itional support that the greater width provides
(columns 14 through 26).
c. F2 Effective tooth face width, driven gear, in.
The comments for F1 also apply here
(columns 27 through 39).
d. RF1 Fillet radius, driving gear, in. Omit if IRF
 $\neq$ 0
(columns 40 through 52).
e. RF2 Fillet radius, driven gear, in. Omit if IRF $\neq$
0 (columns 53 through 65).

Card 5a Tooth Thickness Parameter Format (6E 13.5)

This card is needed only if IPERC = 1.

BL Backlash (in.) (columns 1 through 13).

PT1 Percent tooth thickness split to driving
member (columns 14 through 26).

Card 6 Gear Design Data, Continued Format (6E 13.5)

This card is needed only if IPROP = 1.

If IPROP = 0, material is assumed to be steel.

- a. YE1 Young's modulus (in bending) driving gear, lb/in² (columns 1 through 13).
- b. YE2 Young's modulus (in bending) driven gear, lb/in² (columns 14 through 26).
- c. GE1 Shear modulus, driving gear, lb/in² (columns 27 through 39).
- d. GE2 Shear modulus, driven gear, lb/in² (columns 40 through 52).
- e. PØS1 Poisson's ratio, driving gear (columns 53 through 65).

Since this ratio is used only in the allowance for the "wide beam effect", it should be reduced for cases where tooth face width is not much greater than tooth thickness with a limiting value of zero when the tooth width is smaller than the thickness (columns 53 through 65).

- f. PØS2 Poisson's ratio, driven gear. Comments for PØS1 also apply here (columns 66 through 78).

There are NMC sets of the following Card 7 and Card 8. Each set supplies center distance, tooth spacing errors, tooth profile errors, tooth support compliances and transmitted torque for one mesh cycle.

Card 7 Center distance and tooth spacing error data.
Format (3E 13.5)

- a. CL Center distance, in.

This is the actual center distance including any spreading under load. Omit if ICENT ≠ 0 (columns 1 through 13).

- b. VPT1 Tooth spacing error, driving gear, in. This error is based on the distance between the pitch points of successive teeth, adjusted to the direction of the line of action. This adjustment is accomplished by multiplying the pitch line error by the cosine of the pressure angle. The error is positive if the measured spacing is smaller than the desired spacing (columns 14 through 26).

- c. VPT2 Tooth spacing error, driven gear, in. The comments under VPT1 also apply here (columns 27 through 39).
- d. DEV Deviation from standard center distance. Omit if ICENT $\neq$ 1 (columns 40 through 52).

The total number of Cards 8a, 8b, 8c and 8d depends on the number of calculation points (NJ) (see Card 4). The total number of points along the tooth profile (M) at which the tooth profile deviation ZJ and the tooth support compliance UJ must be specified is $M = 2N_J$. If IHICR = 0 unless it is a high contact ratio mesh (IHICR = 1) in which case $M = 4N_J$. When the point-by-point option is used to input the values of ZJ (Cards 8b-1 and 8b-2) and UJ (Cards 8a-1 and 8a-2), the specification of these values is described below. A value of ZJ or UJ must be introduced even if there is no contact at the particular calculation point or if the tooth profile does not actually extend to the calculation point. A blank space may be used for these points.

For the driving gear, the first value is for the calculation point located $(M/2-1)$ points preceding the pitch point (or inside the pitch circle); the $(M/2)$ th value is for the pitch point; the last, or (M) th, value is for the calculation point located $(M/2)$ points after the pitch point (or outside the pitch circle). This last point may also be described as the point of contact on one meshing tooth when the point of contact on the next meshing tooth is the pitch point.

For an external driven gear, the first value is for the calculation point located $(M/2)$ points before the pitch point (or inside the pitch circle); the $(M/2 + 1)$ th value is for the pitch point; the last, or (M) th, value is for the calculation point located $(M/2 - 1)$ points after the pitch point (or outside the pitch circle). The first point may also be described as the point of contact on one meshing tooth when the point of contact on the previous meshing tooth is the pitch point.

For an internal driven gear, the first value is for the calculation point located $(M/2)$ points following the pitch point (or outside the pitch circle); the $(M/2 + 1)$ th value is for the pitch point; the last, or (M) th, value is for the calculation point located $(M/2 - 1)$ points before the pitch point (or inside the pitch circle). The first point may also be described as the point of contact on the meshing tooth when the point of contact on the next meshing tooth is the pitch point.

Card 8a-1 Tooth support compliance, driving gear. Format (6E 13.5)

This group of cards is needed only if NZJ = 0, 4 or 5.

UJ1 Tooth support compliance or any compliance supplementary to the tooth compliance included in the analysis for the driving gear, in/lb. This compliance is the deflection normal to the profile under unit load at the calculation point on the profile. A uniform compliance for all calculation points, such as would result from a uniform gear shaft compliance, will not affect motion irregularities or load transfer. It will, however, increase the mean deviation in transmitted motion. There are M values required.

Card 8a-2 Tooth support compliance, driven gear. Format
(6E 13.5)

This group of cards is needed only if NZJ = 0, 4 or 5.

UJ2 Tooth support compliance for the driven gear, in/lb. The comments under UJ1 also apply here.

Card 8b-1 Tooth profile deviation data, driving gear. Format
(6E 13.5)

This group of cards is needed only if NZJ = 0 or 3.

ZJ1 Deviation from a true involute, measured normal to the profile, of the point on the actual tooth profile of the driving gear, in. This true involute is positioned relative to the actual profile so that its deviation at the pitch point is zero. Where the deviation represents material added to the true involute, it is positive; where it represents material subtracted, it is negative. If the profile does not extend to a particular calculation point or if the mating gear will not contact at this point, the deviation may be input as zero. There are M values required.

Card 8b-2 Tooth profile deviation data, driven gear. Format
(6E 13.5)

This group of cards is needed only if NZJ = 0 or 3.

ZJ2 Deviation from a true involute of the point on the actual tooth profile of the driven gear, in. The comments under ZJ1 also apply here.

Card 8c-1 Torque. Format (1615)

NTS Specifies if the torque input on the next group of cards applies to the driving or driven gears, 1 = driving gear, 2 = driven gear.

Card 8c-2 Transmitted torque. Format (6E13.5)

TØR Torque values of driving or driven gear, in/lb. A variable torque through one mesh cycle is allowed. There are N_J values required for the N_J calculation points. The first calculation point corresponds to the first data point outside the pitch circle of the driving gear. In the case of constant torque N_J equal values should be input.

In specifying the deviation data, the true involute is positioned relative to the actual profile so that its deviation at the pitch point is zero. Where the deviation represents material added to the true involute, it is positive; where it represents material subtracted, it is negative. The roll angles for the high and low points must be specified. The tooth profile deviations at all other calculation points are obtained internally by linear interpolation.

Card 8d-1 Tooth profile deviation, driving gear. Format (6E13.5).

This card is needed only if $NZJ = 1$ or 4.

- a. $Z(1,1)$ Deviation of the outer diameter point on the actual tooth profile from the true involute, in. (columns 1 through 13).
- b. $Z(5,1)$ Deviation of the high point (between outer diameter point and pitch point) on the actual tooth profile from the true involute, in. (columns 40 through 52).
- c. $Z(4,1)$ Deviation of the low point (between pitch point and the first contact point near the tooth root) on the actual tooth profile from the true involute, in. (columns 27 through 39).
- d. $Z(3,1)$ Deviation of the true involute point (the first contact point) on the actual tooth profile from the true involute, in. (columns 40 through 52).
- e. $RHIGH(1)$ Roll angle of the high point, deg. (columns 53 through 65).

- f. RLOW(1) Roll angle of the low point, deg. (columns 66 through 78).

Card 8d-2 Tooth profile deviation, driven gear. Format (6E13.5).

This card is needed only if NZJ = 1 or 4.

- a. Z(1,2) Deviation of the outer diameter point for an external gear. For an internal gear, it is the deviation of the inner diameter point, in. (columns 1 through 13).
- b. Z(5,2) Deviation of the high point (between inner diameter and pitch point for internal gear), in. (columns 14 through 26).
- c. Z(4,2) Deviation of the low point, in. (columns 27 through 39).
- d. Z(3,2) Deviation of the true involute point, in. (columns 45 through 52).
- e. RHIGH(2) Roll angle of the high point, deg. (columns 53 through 65).
- f. RLOW(2) Roll angle of the low point, deg. (columns 66 through 78).

Card 9 Gear speed. Format (I5, E 13.5)

- a. NWS Identifies if the input speed is the speed of driving or driven gear. 1 = driving gear, 2 = driven gear (column 5).
- b. WS Driving or driven gear speed, rpm (columns 6 through 18).

PROGRAM OUTPUT AND DESCRIPTION

Figure 19 shows a sample output for the case defined in Figure 18. Following is a brief discussion on the output data.

Output Variables and Explanations

1. Title
2. Control Number - NMC, INT, MN, MMM, IPLT, IFOUR, ISPECT, IHICR, IRM, IPERC, IRF, IPROP, ICENT, NZJ, as in input Cards 2 and 2a.
3. Design Data - FI(=I), FN1(=N1), DPIT(DIA. PITCH), RO1, RT1, RM1, BLANK, FN2(=N2), PANG(CUT. PRESS ANG), RO2 or RI2, RT2, RM2, T1, F1, RF1, YE1, GE1, PØS1, T2, F2, RF2, YE2, GE2, PØS2, as in input Cards 3 through 6.

Items 4 through 11 are printed for each of the NMC mesh cycles specified.

4. Mesh Cycle Identification, Center Distance and Tooth Spacing Errors.
5. Input Listing of Transmitted Torques at N_j Calculation Points and Listing of Calculated Tangential Tooth Loads at N_j Calculation Points.
6. Input Listing of Profile Error and Supplementary Compliance - ZJ1, ZJ2, UJ1, UJ2, as in input Cards 8a, 8b and 8d.
7. Operating Pressure Angle, deg.
8. Miscellaneous Data:

RP1 pitch circle radius, driving gear, in.

RP2 pitch circle radius, driven gear, in.

RB1 base circle radius, driving gear, in.

RB2 base circle radius, driven gear, in.

BA1 arc of approach, driving gear, rad.

BA2 arc of approach, driven gear, rad. (negative on internal gear)

BR1 arc of recess, driving gear, rad.

BR2 arc of recess, driven gear, rad. (negative on internal gear)

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MOEING VENTOL: H-C-R SPUR GEAR TEST CASE 2
PNO335=COMPUTATIONS OF GEAR TOOTH MESHING ERRORS 3-22-1966

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ANC	INT	MM	MM	PLT	IFOUN	ISPECT	INCH	IRH	IFENC	IMF	IMHOP	ICENT	NZJ
1	1	1	12	0	1	0	0	0	0	0	0	0	1

```

I N1 DIA. PITCH R01 RT1 WM1
1.2E+00E+01 3.30000E+01 4.55000E+00 3.95000E+00 3.38451E+00 3.29700E+00
N2 CUT. PRESS ANG R02 RT2 WM2
5.00000E+01 2.10000E+01 4.67200E+00 6.08415E+00 6.01900E+00
T1 F1 RFF1 YOUNGS MOD-1 SHEAR MOD-1 POS.RATIO-1
3.68500E-01 5.00000E-01 4.70000E-02 3.00000E-07 1.15000E-07 3.00000E-01
T2 F2 RFF2 YOUNGS MOD-2 SHEAR MOD-2 POS.RATIO-2
3.10000E-01 5.00000E-01 4.70000E-02 3.00000E-07 1.15000E-07 3.00000E-01

```

CALCULATED DATA

```

MESH CIRCLE NO. 1 CENTER DISTANCE = 1.000000E+01 IN.
VP1: TOOTH SPACING ERROR (DRIVING GEAR) = 1.873300E-04 IN.
VP12: TOOTH SPACING ERROR (DRIVEN GEAR) = -1.873300E-04 IN.

```

DRIVING GEAR TRANSMITTED TORQUE (IN-LB)									
9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03
9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03
9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03	9.8310E+03

```

TOTAL LOAD TANGENT TO PITCH CIRCLE, TRANSMITTED BY GEAR TEETH (LB)
2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03
2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03
2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03 2.7110E+03

```

DEVIATION OF POINT ON ACTUAL TOOTH PROFILE FROM TRUE INVOLUTE

DRIVING GEAR				
AT OUTER DIA.	HIGH POINT	PITCH POINT	LOW POINT	TRUE INVOLUTE
2	-9.50000E-04	-4.00000E-05	0.	-7.00000E-05
ROLL ANGLE	-3.44743E-01	2.70000E-01	2.19934E-01	1.80000E-01

DEVIATION OF POINT ON ACTUAL TOOTH PROFILE FROM TRUE INVOLUTE

DRIVEN GEAR				
AT OUTER DIA.	HIGH POINT	PITCH POINT	LOW POINT	TRUE INVOLUTE
2	-7.50000E-04	-1.00000E-04	0.	-3.00000E-04
ROLL ANGLE	-2.90626E-01	2.45640E-01	2.19934E-01	1.80000E-01

ANGLE OF APPROACH ON DRIVING GEAR IS GREATER THAN TOOTH SPACING ANGLE.
PROGRAM CONTINUED WITHOUT OVERLAP

ANGLE OF RECESS ON DRIVING GEAR IS NOT SMALLER THAN TOOTH SPACING ANGLE.
PROGRAM CONTINUED WITHOUT OVERLAP

R01	R02	R01	WM1	AT1
-3.02637E+00	-3.38551E+00	2.16638E-01	2.17197E-01	-3.83864E-01
R02	R02	R02	WM2	AT2
-6.37363E+00	5.95029E+00	1.23478E-01	1.23373E-01	1.70565E-01

DRIVING GEAR INPUT HOOT RADIUS SMALLER THAN BASE CIRCLE RADIUS

DRIVING GEAR INPUT RADIUS TO FILLET CENTER INSIDE BASE CIRCLE.

PROGRAM CONTINUES WITH CORRECT TREATMENT.

CJ1	CJ1	AJ1	GJ1ABC	XJ1	YJ1	ZJ1
-4.40000E+01	0.	-3.73183E-01				
-4.40000E+01	0.	-3.65567E-01				
-4.40000E+01	0.	-3.57951E-01				
-4.40000E+01	0.	-3.50335E-01				
-4.40000E+01	0.	-3.42719E-01				
-4.40000E+01	0.	-3.35103E-01				
-4.40000E+01	0.	-3.27487E-01				
-4.40000E+01	0.	-3.19871E-01				
-4.40000E+01	0.	-3.12255E-01				
-4.40000E+01	0.	-3.04639E-01				
-4.40000E+01	0.	-2.97023E-01				
-4.40000E+01	0.	-2.89407E-01				
-4.40000E+01	0.	-2.81791E-01				
-4.40000E+01	0.	-2.74175E-01				
-4.40000E+01	0.	-2.66559E-01				
-4.40000E+01	0.	-2.58943E-01				
-4.40000E+01	0.	-2.51327E-01				
-4.40000E+01	0.	-2.43711E-01				
-4.40000E+01	0.	-2.36095E-01				
-4.40000E+01	0.	-2.28479E-01				
-4.40000E+01	0.	-2.20863E-01				
-4.40000E+01	0.	-2.13247E-01				
-4.40000E+01	0.	-2.05631E-01				
-4.40000E+01	0.	-1.98015E-01				
-4.40000E+01	0.	-1.90399E-01				
-4.40000E+01	0.	-1.82783E-01				
-4.40000E+01	0.	-1.75167E-01				
-4.40000E+01	0.	-1.67551E-01				
-4.40000E+01	0.	-1.59935E-01				
-4.40000E+01	0.	-1.52319E-01				
-4.40000E+01	0.	-1.44703E-01				
-4.40000E+01	0.	-1.37087E-01				
-4.40000E+01	0.	-1.29471E-01				
-4.40000E+01	0.	-1.21855E-01				
-4.40000E+01	0.	-1.14239E-01				
-4.40000E+01	0.	-1.06623E-01				
-4.40000E+01	0.	-9.9007E-02				
-4.40000E+01	0.	-9.1391E-02				
-4.40000E+01	0.	-8.3775E-02				
-4.40000E+01	0.	-7.6159E-02				
-4.40000E+01	0.	-6.8543E-02				
-4.40000E+01	0.	-6.0927E-02				
-4.40000E+01	0.	-5.3311E-02				
-4.40000E+01	0.	-4.5695E-02				
-4.40000E+01	0.	-3.8079E-02				
-4.40000E+01	0.	-3.0463E-02				
-4.40000E+01	0.	-2.2847E-02				
-4.40000E+01	0.	-1.5231E-02				
-4.40000E+01	0.	-7.6159E-03				
-4.40000E+01	0.	0.				

Figure 19. R-75 Computer Output.

-2.43000E+01	1.00000E+00	-1.42784E-01	4.97130E-08	3.44587E+00	2.26057E-01	-5.97241E-04
-2.30000E+01	1.00000E+00	-1.75144E-01	9.33144E-08	3.45110E+00	2.25132E-01	-5.43677E-04
-2.20000E+01	1.00000E+00	-1.67552E-01	9.71075E-08	3.45653E+00	2.24544E-01	-5.28914E-04
-2.10000E+01	1.00000E+00	-1.59437E-01	1.01113E-07	3.46214E+00	2.23894E-01	-5.14751E-04
-2.00000E+01	1.00000E+00	-1.52323E-01	1.05337E-07	3.46793E+00	2.23251E-01	-5.00580E-04
-1.90000E+01	1.00000E+00	-1.44704E-01	1.09789E-07	3.47392E+00	2.22711E-01	-4.86423E-04
-1.80000E+01	1.00000E+00	-1.37888E-01	1.14400E-07	3.48009E+00	2.22051E-01	-4.72261E-04
-1.70000E+01	1.00000E+00	-1.29472E-01	1.18420E-07	3.48644E+00	2.21497E-01	-4.58096E-04
-1.60000E+01	1.00000E+00	-1.21155E-01	1.22664E-07	3.49298E+00	2.20947E-01	-4.43931E-04
-1.50000E+01	1.00000E+00	-1.12445E-01	1.26104E-07	3.50070E+00	2.20401E-01	-4.29766E-04
-1.40000E+01	1.00000E+00	-1.06624E-01	1.29874E-07	3.50860E+00	2.19859E-01	-4.15601E-04
-1.30000E+01	1.00000E+00	-9.90774E-02	1.33911E-07	3.51668E+00	2.19321E-01	-4.01436E-04
-1.20000E+01	1.00000E+00	-9.13614E-02	1.38231E-07	3.52495E+00	2.18787E-01	-3.87271E-04
-1.10000E+01	1.00000E+00	-8.37754E-02	1.42844E-07	3.53340E+00	2.18257E-01	-3.73106E-04
-1.00000E+01	1.00000E+00	-7.61594E-02	1.47744E-07	3.54203E+00	2.17731E-01	-3.58941E-04
-9.00000E+00	1.00000E+00	-6.85434E-02	1.52944E-07	3.55084E+00	2.17209E-01	-3.44776E-04
-8.00000E+00	1.00000E+00	-6.09274E-02	1.58444E-07	3.55992E+00	2.16691E-01	-3.30611E-04
-7.00000E+00	1.00000E+00	-5.33114E-02	1.64244E-07	3.56927E+00	2.16177E-01	-3.16446E-04
-6.00000E+00	1.00000E+00	-4.56954E-02	1.70344E-07	3.57889E+00	2.15667E-01	-3.02281E-04
-5.00000E+00	1.00000E+00	-3.80794E-02	2.03922E-07	3.57672E+00	2.15161E-01	-2.88116E-04
-4.00000E+00	1.00000E+00	-3.04634E-02	2.24011E-07	3.59421E+00	2.14659E-01	-2.73951E-04
-3.00000E+00	1.00000E+00	-2.28474E-02	2.34911E-07	3.60221E+00	2.14161E-01	-2.59786E-04
-2.00000E+00	1.00000E+00	-1.52314E-02	2.44430E-07	3.61237E+00	2.13667E-01	-2.45621E-04
-1.00000E+00	1.00000E+00	-7.6159E-03	2.54611E-07	3.62169E+00	2.13177E-01	-2.31456E-04
0.00000E+00	1.00000E+00	0.00000E+00	2.64496E-07	3.63118E+00	2.12691E-01	-2.17291E-04
1.00000E+00	1.00000E+00	7.6159E-03	2.74967E-07	3.64084E+00	2.12209E-01	-2.03126E-04
2.00000E+00	1.00000E+00	1.5231E-02	2.85135E-07	3.65065E+00	2.11731E-01	-1.88961E-04
3.00000E+00	1.00000E+00	2.2847E-02	2.94940E-07	3.66062E+00	2.11257E-01	-1.74796E-04
4.00000E+00	1.00000E+00	3.0463E-02	3.04430E-07	3.67075E+00	2.10787E-01	-1.60631E-04
5.00000E+00	1.00000E+00	3.8079E-02	3.13611E-07	3.68103E+00	2.10321E-01	-1.46466E-04
6.00000E+00	1.00000E+00	4.5695E-02	3.22444E-07	3.69147E+00	2.09859E-01	-1.32301E-04
7.00000E+00	1.00000E+00	5.3311E-02	3.30944E-07	3.70207E+00	2.09401E-01	-1.18136E-04
8.00000E+00	1.00000E+00	6.0927E-02	3.39111E-07	3.71284E+00	2.08947E-01	-1.03971E-04
9.00000E+00	1.00000E+00	6.8543E-02	3.46944E-07	3.72378E+00	2.08497E-01	-9.98056E-05
1.00000E+01	1.00000E+00	7.6159E-02	3.54430E-07	3.73489E+00	2.08051E-01	-9.56341E-05
1.10000E+01	1.00000E+00	8.3775E-02	3.61594E-07	3.74617E+00	2.07609E-01	-9.14626E-05
1.20000E+01	1.00000E+00	9.1361E-02	3.68444E-07	3.75762E+00	2.07171E-01	-8.72911E-05
1.30000E+01	1.00000E+00	9.9077E-02	3.74944E-07	3.76924E+00	2.06737E-01	-8.31196E-05
1.40000E+01	1.00000E+00	1.06624E-01	3.81113E-07	3.78103E+00	2.06307E-01	-7.89481E-05
1.50000E+01	1.00000E+00	1.14400E-01	3.86944E-07	3.79298E+00	2.05881E-01	-7.47766E-05
1.60000E+01	1.00000E+00	1.21155E-01	3.92444E-07	3.80509E+00	2.05459E-01	-7.06051E-05
1.70000E+01	1.00000E+00	1.29472E-01	3.97611E-07	3.81737E+00	2.05041E-01	-6.64336E-05
1.80000E+01	1.00000E+00	1.37888E-01	4.02444E-07	3.82982E+00	2.04627E-01	-6.22621E-05
1.90000E+01	1.00000E+00	1.46624E-01	4.06944E-07	3.84244E+00	2.04217E-01	-5.80906E-05
2.00000E+01	1.00000E+00	1.55860E-01	4.11113E-07	3.85524E+00	2.03811E-01	-5.39191E-05
2.10000E+01	1.00000E+00	1.65496E-01	4.14944E-07	3.86824E+00	2.03409E-01	-4.97476E-05
2.20000E+01	1.00000E+00	1.75532E-01	4.18444E-07	3.88144E+00	2.03011E-01	-4.55761E-05
2.30000E+01	1.00000E+00	1.85968E-01	4.21611E-07	3.89484E+00	2.02617E-01	-4.14046E-05
2.40000E+01	1.00000E+00	1.96804E-01	4.24444E-07	3.90844E+00	2.02227E-01	-3.72331E-05
2.50000E+01	1.00000E+00	2.08040E-01	4.26944E-07	3.92224E+00	2.01841E-01	-3.30616E-05
2.60000E+01	1.00000E+00	2.19676E-01	4.29111E-07	3.93644E+00	2.01459E-01	-2.88901E-05
2.70000E+01	1.00000E+00	2.31712E-01	4.30944E-07	3.95094E+00	2.01081E-01	-2.47186E-05
2.80000E+01	1.00000E+00	2.44148E-01	4.32444E-07	3.96564E+00	2.00707E-01	-2.05471E-05
2.90000E+01	1.00000E+00	2.56984E-01	4.33611E-07	3.98054E+00	2.00337E-01	-1.63756E-05
3.00000E+01	1.00000E+00	2.70220E-01	4.34444E-07	3.99564E+00	2.00000E-01	-1.22041E-05
3.10000E+01	1.00000E+00	2.83856E-01	4.34944E-07	4.01094E+00	1.99667E-01	-8.03296E-06
3.20000E+01	1.00000E+00	2.97892E-01	4.35113E-07	4.02644E+00	1.99337E-01	-3.84041E-06
3.30000E+01	1.00000E+00	3.12328E-01	4.34944E-07	4.04214E+00	1.99009E-01	3.35326E-06
3.40000E+01	1.00000E+00	3.27164E-01	4.34444E-07	4.05804E+00	1.98681E-01	7.76611E-06
3.50000E+01	1.00000E+00	3.42400E-01	4.33611E-07	4.07414E+00	1.98351E-01	1.20896E-05
3.60000E+01	1.00000E+00	3.58036E-01	4.32444E-07	4.09044E+00	1.98021E-01	1.64181E-05
3.70000E+01	1.00000E+00	3.74072E-01	4.30944E-07	4.10694E+00	1.97691E-01	2.06466E-05
3.80000E+01	1.00000E+00	3.90508E-01	4.29111E-07	4.12364E+00	1.97361E-01	2.47751E-05
3.90000E+01	1.00000E+00	4.07344E-01	4.26944E-07	4.14054E+00	1.97031E-01	2.88036E-05
4.00000E+01	1.00000E+00	4.24580E-01	4.24444E-07	4.15764E+00	1.96701E-01	3.27321E-05
4.10000E+01	1.00000E+00	4.42216E-01	4.21611E-07	4.17494E+00	1.96371E-01	3.65606E-05
4.20000E+01	1.00000E+00	4.60252E-01	4.18444E-07	4.19244E+00	1.96041E-01	4.02891E-05
4.30000E+01	1.00000E+00	4.78688E-01	4.14944E-07	4.21014E+00	1.95711E-01	4.39176E-05
4.40000E+01	1.00000E+00	4.97524E-01	4.11113E-07	4.22804E+00	1.95381E-01	4.74461E-05
4.50000E+01	1.00000E+00	5.16760E-01	4.06944E-07	4.24614E+00	1.95051E-01	5.08746E-05
4.60000E+01	1.00000E+00	5.36396E-01	4.02444E-07	4.26444E+00	1.94721E-01	5.42031E-05
4.70000E+01	1.00000E+00	5.56432E-01	4.07611E-07	4.28294E+00	1.94391E-01	5.74316E-05
4.80000E+01	1.00000E+00	5.76868E-01	4.02444E-07	4.30164E+00	1.94061E-01	6.05601E-05
4.90000E+01	1.00000E+00	5.97704E-01	4.06944E-07	4.32054E+00	1.93731E-01	6.35886E-05
5.00000E+01	1.00000E+00	6.18940E-01	4.11113E-07	4.33964E+00	1.93401E-01	6.65171E-05

COORD. OF EFFECTIVE TOOTH PROFILE AT HOOT CIRCLE

X Y
-3.286198E+00 -2.647722E-01

J1	QJ1A	QJ1B	QJ1C
-2.40000E+01	-3.15134E-04	9.00078E-08	-1.53011E-08
-2.30000E+01	-3.38334E-04	8.05439E-08	-1.60701E-08
-2.20000E+01	-3.64211E-04	6.25672E-08	-1.68523E-08
-2.10000E+01	-3.92232E-04	6.46773E-08	-1.77004E-08
-2.00000E+01	-4.22554E-04	6.64337E-08	-1.86241E-08
-1.90000E+01	-4.54634E-04	6.78401E-08	-1.96174E-08
-1.80000E+01	-4.88472E-04	6.89444E-08	-2.06809E-08
-1.70000E+01	-5.24072E-04	7.02844E-08	-2.18144E-08
-1.60000E+01	-5.61334E-04	7.07444E-08	-2.30179E-08
-1.50000E+01	-6.00272E-04	7.13517E-08	-2.42914E-08
-1.40000E+01	-6.40896E-04	7.20049E-08	-2.56349E-08
-1.30000E+01	-6.83216E-04	7.27404E-08	-2.70484E-08
-1.20000E+01	-7.27232E-04	7.35444E-08	-2.85319E-08
-1.10000E+01	-7.72944E-04	7.44084E-08	-3.00854E-08
-1.00000E+01	-8.20256E-04	7.53224E-08	-3.17089E-08
-9.00000E+00	-8.69172E-04	7.62864E-08	-3.33924E-08
-8.00000E+00	-9.19688E-04	7.73004E-08	-3.51359E-08
-7.00000E+00	-9.71804E-04	7.83644E-08	-3.69394E-08
-6.00000E+00	-1.025472E-03	7.94784E-08	-3.88029E-08
-5.00000E+00	-1.084632E-03	8.06424E-08	-4.07264E-08
-4.00000E+00	-1.149296E-03	8.18564E-08	-4.27099E-08
-3.00000E+00	-1.219456E-03	8.31204E-08	-4.47534E-08
-2.00000E+00	-1.295016E-03	8.44344E-08	-4.68569E-08
-1.00000E+00	-1.375976E-03	8.57984E-08	-4.90204E-08
0.00000E+00	-1.462336E-03	8.72124E-08	-5.12439E-08
1.00000E+00	-1.554096E-03	8.86764E-08	-5.35274E-08
2.00000E+00	-1.651256E-03	9.01904E-08	-5.58709E-08
3.00000E+00	-1.753816E-03	9.17544E-08	-5.82744E-08
4.00000E+00	-1.861776E-03	9.33684E-08	-6.07379E-08
5.00000E+00	-1.975136E-03	9.50324E-08	-6.32614E-08
6.00000E+00	-2.093896E-03	9.67464E-08	-6.58449E-08
7.00000E+00	-2.218056E-03	9.85004E-08	-6.84884E-08
8.00000E+00	-2.347616E-03	1.00294E-07	-7.11919E-08
9.00000E+00	-2.482576E-03	1.02134E-07	-7.39454E-08
1.00000E+01	-2.622936E-03	1.04024E-07	-7.67489E-08
1.10000E+01	-2.768696E-03	1.05964E-07	-7.95924E-08
1.20000E+01	-2.929856E-03	1.07954E-07	-8.24759E-08
1.30000E+01	-3.096416E-03	1.10004E-07	-8.53994E-08
1.40000E+01	-3.268376E-03	1.12114E-07	-8.83629E-08
1.50000E+01	-3.445736E-03	1.14284E-07	-9.13664E-08
1.60000E+01	-3.628496E-03	1.16514E-07	-9.44099E-08
1.70000E+01	-3.816656E-03	1.18804E-07	-9.74934E-08
1.80000E+01	-4.010216E-03	1.21154E-07	-1.006169E-07
1.90000E+01	-4.209176E-03	1.23564E-07	-1.037994E-07
2.00000E+01	-4.413536E-03	1.26034E-07	-1.070819E-07
2.10000E+01	-4.623296E-03	1.28564E-07	-1.104644E-07
2.20000E+01	-4.838456E-03	1.31154E-07	-1.139469E-07
2.30000E+01	-5.058916E-03	1.33804E-07	-1.175294E-07
2.40000E+01	-5.284676E-03	1.36514E-07	-1.212119E-07
2.50000E+01	-5.515736E-03	1.39284E-07	-1.249944E-07
2.60000E+01	-5.752096E-03	1.42114E-07	-1.288769E-07
2.70000E+01	-5.993756E-03	1.45004E-07	-1.328594E-07
2.80000E+01	-6.240716E-03	1.47954E-07	-1.369419E-07
2.90000E+01	-6.492976E-03	1.50964E-07	-1.411244E-07
3.00000E+01	-6.750536E-03	1.54034E-07	-1.454069E-07
3.10000E+01	-7.013496E-03	1.57164E-07	-1.497894E-07
3.20000E+01	-7.281856E-03	1.60354E-07	-1.542719E-07
3.30000E+01	-7.555616E-03	1.63604E-07	-1.588544E-07
3.40000E+01	-7.834776E-03	1.66914E-07	-1.635369E-07
3.50000E+01	-8.119336E-03	1.70284E-07	-1.683194E-07
3.60000E+01	-8.409296E-03	1.73714E-07	-1.732019E-07
3.70000E+01	-8.704656E-03	1.77204E-07	-1.781844E-07
3.80000E+01	-9.005416E-03	1.80754E-07	-1.832669E-07
3.90000E+01	-9.311576E-03	1.84364E-07	-1.884494E-07
4.00000E+01	-9.623136E-03	1.88034E-07	-1.937319E-07
4.10000E+01	-9.939996E-03	1.91764E-07	-1.991144E-07
4.20000E+01	-1.026215E-02	1.95554E-07	-2.045969E-07
4.30000E+01	-1.058955E-02	1.99404E-07	-2.101794E-07
4.40000E+01	-1.092215E-02	2.03314E-07	-2.158619E-07
4.50000E+01	-1.125995E-02	2.07284E-07	-2.216444E-07
4.60000E+01	-1.160295E-02	2.11314E-07	-2.275269E-07
4.70000E+01	-1.195115E-02	2.15404E-07	-2.335094E-07
4.80000E+01	-1.230455E-02	2.19554E-07	-2.395919E-07
4.90000E+01	-1.266315E-02	2.23764E-07	-2.457744E-07
5.00000E+01	-1.302695E-02	2.28034E-07	-2.520569E-07
5.10000E+01	-1.339595E-02	2.32364E-07	-2.584394E-07
5.20000E+01	-1.377015E-02	2.36754E-07	-2.649219E-07
5.30000E+01	-1.414955E-02	2.41204E-07	-2.715044E-07
5.40000E+01	-1.453415E-02	2.45714E-07	-2.781869E-07
5.50000E+01	-1.492395E-02	2.50284E-07	-2.849694E-07
5.60000E+01	-1.531895E-02	2.54914E-07	-2.918519E-07
5.70000E+01	-1.571915E-02	2.59604E-07	-2.988344E-07
5.80000E+01	-1.612455E-02	2.64354E-07	-3.059169E-07
5.90000E+01	-1.653515E-02	2.69164E-07	-3.130994E-07
6.00000E+01	-1.695095E-02	2.74034E-07	-3.203819E-07
6.10000E+01	-1.737195E-02	2.78964E-07	-3.277644E-07
6.20000E+01	-1.779815E-02	2.83954E-07	-3.352469E-07
6.30000E+01	-1.822955E-02	2.89004E-07	-3.428294E-07
6.40000E+01	-1.866615E-02	2.94114E-07	-3.505119E-07
6.50000E+01	-1.910795E-02	2.99284E-07	-3.582944E-07
6.60000E+01	-1.955495E-02	3.04514E-07	-3.661769E-07
6.70000E+01	-2.000715E-02	3.09804E-07	-3.741594E-07
6.80000E+01	-2.046455E-02	3.15154E-07	-3.822419E-07
6.90000E+01	-2.092715E-02	3.20564E-07	-3.904244E-07
7.00000E+01	-2.139495E-02	3.26034E-07	-3.987069E-07
7.10000E+01	-2.186795E-02	3.31564E-07	-4.070894E-07
7.20000E+01	-2.234615E-02	3.37154E-07	-4.155719E-07
7.30000E+01	-2.282955E-02	3.42804E-07	-4.241544E-07
7.40000E+01	-2.331815E-02	3.48514E-07	-4.328369E-07
7.50000E+01	-2.381195E-02	3.54284E-07	-4.416194E-07
7.60000E+01	-2.431095E-02	3.60114E-07	-4.505019E-07
7.70000E+01	-2.481515E-02	3.66004E-07	-4.594844E-07
7.80000E+01	-2.532455E-02	3.71954E-07	-4.685669E-07
7.90000E+01	-2.583915E-02	3.77964E-07	-4.777494E-07
8.00000E+01	-2.635895E-02	3.84034E-07	-4.870319E-07
8.10000E+01	-2.688395E-02	3.90164E-07	-4.964144E-07
8.20000E+01	-2.741415E-02	3.96354E-07	-5.058969E-07
8.30000E+01	-2.794955E-02	4.02604E-07	-5.154794E-07
8.40000E+01	-2.849015E-02	4.08914E-07	-5.251619E-07
8.50000E+01	-2.903595E-02	4.15284E-07	-5.349444E-07
8.60000E+01	-2.958695E-02	4.21714E-07	-5.448269E-07
8.70000E+01	-3.014315E-02	4.28204E-07	-5.548094E-07
8.80000E+01	-3.070455E-02	4.34754E-07	-5.648919E-07
8.90000E+01	-3.127115E-02	4.41364E-07	-5.750744E-07
9.00000E+01	-3.184295E-02	4.48034E-07	-5.853569E-07
9.10000E+01	-3.241995E-02	4.54764E-07	-5.957394E-07
9.20000E+01	-3.300215E-02	4.61554E-07	-6.062219E-07
9.30000E+01	-3.358955E-02	4.68404E-07	-6.168044E-07
9.40000E+01	-3.418215E-02	4.75314E-07	-6.274869E-07
9.50000E+01	-3.478095E-02	4.82284E-07	-6.382694E-07
9.60000E+01	-3.538495E-02	4.89314E-07	-6.491519E-07
9.70000E+01	-3.599415E-02	4.96404E-07	-6.601344E-07
9.80000E+01	-3.660855E-02	5.03554E-07	-6.712169E-07
9.90000E+01	-3.722815E-02	5.10764E-07	-6.823994E-07
1.00000E+02	-3.785295E-02	5.18034E-07	-6.936819E-07

2.00000E+00	4.00000E+00	1.49999E-07	8.71941E-08				
3.00000E+00	5.24744E-08	1.54315E-07	9.24404E-08				
4.00000E+00	5.31187E-04	1.58814E-07	9.74953E-08				
5.00000E+00	6.34730E-04	1.63438E-07	1.01751E-07				
6.00000E+00	7.03083E-08	1.68145E-07	1.06840E-07				
7.00000E+00	7.73042E-04	1.73093E-07	1.12637E-07				
8.00000E+00	8.44944E-08	1.78144E-07	1.19293E-07				
9.00000E+00	9.34215E-04	1.83358E-07	1.26966E-07				
1.00000E+01	1.02479E-07	1.88731E-07	1.35730E-07				
1.10000E+01	1.12241E-07	1.94170E-07	1.45609E-07				
1.20000E+01	1.22606E-07	2.00117E-07	1.57105E-07				
1.30000E+01	1.33627E-07	2.06711E-07	1.61539E-07				
1.40000E+01	1.45378E-07	2.14059E-07	1.70353E-07				
1.50000E+01	1.58814E-07	2.22509E-07	1.79554E-07				
1.60000E+01	1.73093E-07	2.32090E-07	1.89183E-07				
1.70000E+01	1.88731E-07	2.42841E-07	1.99183E-07				
1.80000E+01	2.06711E-07	2.54812E-07	2.09610E-07				
1.90000E+01	2.26966E-07	2.68052E-07	2.20515E-07				
2.00000E+01	2.49592E-07	2.82700E-07	2.31850E-07				
2.10000E+01	2.73847E-07	2.98794E-07	2.43644E-07				
2.20000E+01	3.00000E-07	3.16382E-07	2.55921E-07				
2.30000E+01	3.28054E-07	3.35606E-07	2.68691E-07				
2.40000E+01	3.58067E-07	3.56504E-07	2.81942E-07				
2.50000E+01	3.90000E-07	3.79111E-07	2.95716E-07				
2.60000E+01	4.24000E-07	4.03423E-07	3.10015E-07				
2.70000E+01	4.60000E-07	4.29435E-07	3.24854E-07				
2.80000E+01	5.00000E-07	4.57155E-07	3.40244E-07				
2.90000E+01	5.44000E-07	4.86592E-07					
3.00000E+01	5.94000E-07	5.17762E-07					
3.10000E+01	6.49000E-07	5.50695E-07					
3.20000E+01	7.10000E-07	5.85422E-07					
3.30000E+01	7.77000E-07	6.21999E-07					
3.40000E+01	8.50000E-07	6.60499E-07					
3.50000E+01	9.30000E-07	7.00966E-07					
3.60000E+01	1.02000E-06	7.43466E-07					
3.70000E+01	1.12000E-06	7.88054E-07					
3.80000E+01	1.23000E-06	8.34782E-07					
3.90000E+01	1.35000E-06	8.83700E-07					
4.00000E+01	1.48000E-06	9.34866E-07					
4.10000E+01	1.62000E-06	9.88333E-07					
4.20000E+01	1.77000E-06	1.04422E-06					
4.30000E+01	1.93000E-06	1.10177E-06					
4.40000E+01	2.10000E-06	1.16111E-06					
4.50000E+01	2.29000E-06	1.22222E-06					
4.60000E+01	2.49000E-06	1.28556E-06					
4.70000E+01	2.70000E-06	1.35111E-06					
4.80000E+01	2.93000E-06	1.41889E-06					
4.90000E+01	3.18000E-06	1.48889E-06					
5.00000E+01	3.45000E-06	1.56111E-06					
5.10000E+01	3.74000E-06	1.63556E-06					
5.20000E+01	4.05000E-06	1.71222E-06					
5.30000E+01	4.39000E-06	1.79111E-06					
5.40000E+01	4.75000E-06	1.87222E-06					
5.50000E+01	5.14000E-06	1.95556E-06					
5.60000E+01	5.56000E-06	2.04111E-06					
5.70000E+01	6.01000E-06	2.12889E-06					
5.80000E+01	6.49000E-06	2.21889E-06					
5.90000E+01	7.00000E-06	2.31111E-06					
6.00000E+01	7.54000E-06	2.40556E-06					
6.10000E+01	8.11000E-06	2.50222E-06					
6.20000E+01	8.71000E-06	2.60111E-06					
6.30000E+01	9.34000E-06	2.70222E-06					
6.40000E+01	1.00000E-05	2.80556E-06					
6.50000E+01	1.06900E-05	2.91111E-06					
6.60000E+01	1.14100E-05	3.01889E-06					
6.70000E+01	1.21600E-05	3.12889E-06					
6.80000E+01	1.29400E-05	3.24111E-06					
6.90000E+01	1.37500E-05	3.35556E-06					
7.00000E+01	1.46000E-05	3.47222E-06					
7.10000E+01	1.54900E-05	3.59111E-06					
7.20000E+01	1.64100E-05	3.71222E-06					
7.30000E+01	1.73600E-05	3.83556E-06					
7.40000E+01	1.83400E-05	3.96111E-06					
7.50000E+01	1.93500E-05	4.08889E-06					
7.60000E+01	2.04000E-05	4.21889E-06					
7.70000E+01	2.14900E-05	4.35111E-06					
7.80000E+01	2.26200E-05	4.48556E-06					
7.90000E+01	2.37900E-05	4.62222E-06					
8.00000E+01	2.50000E-05	4.76111E-06					
8.10000E+01	2.62500E-05	4.90222E-06					
8.20000E+01	2.75400E-05	5.04556E-06					
8.30000E+01	2.88700E-05	5.19111E-06					
8.40000E+01	3.02400E-05	5.33889E-06					
8.50000E+01	3.16500E-05	5.48889E-06					
8.60000E+01	3.31000E-05	5.64111E-06					
8.70000E+01	3.45900E-05	5.79556E-06					
8.80000E+01	3.61200E-05	5.95222E-06					
8.90000E+01	3.76900E-05	6.11111E-06					
9.00000E+01	3.93000E-05	6.27222E-06					
9.10000E+01	4.09400E-05	6.43778E-06					
9.20000E+01	4.26200E-05	6.60556E-06					
9.30000E+01	4.43400E-05	6.77556E-06					
9.40000E+01	4.61000E-05	6.94778E-06					
9.50000E+01	4.79000E-05	7.12222E-06					
9.60000E+01	4.97400E-05	7.30000E-06					
9.70000E+01	5.16200E-05	7.48000E-06					
9.80000E+01	5.35400E-05	7.66222E-06					
9.90000E+01	5.55000E-05	7.84667E-06					
1.00000E+02	5.75000E-05	8.03333E-06					
1.10000E+02	5.95400E-05	8.22222E-06					
1.20000E+02	6.16200E-05	8.41333E-06					
1.30000E+02	6.37400E-05	8.60667E-06					
1.40000E+02	6.59000E-05	8.80222E-06					
1.50000E+02	6.81000E-05	9.00000E-06					
1.60000E+02	7.03400E-05	9.20000E-06					
1.70000E+02	7.26200E-05	9.40222E-06					
1.80000E+02	7.49400E-05	9.60667E-06					
1.90000E+02	7.73000E-05	9.81333E-06					
2.00000E+02	7.97000E-05	1.00222E-05					
2.10000E+02	8.21400E-05	1.02333E-05					
2.20000E+02	8.46200E-05	1.04444E-05					
2.30000E+02	8.71400E-05	1.06556E-05					
2.40000E+02	8.97000E-05	1.08667E-05					
2.50000E+02	9.23000E-05	1.10778E-05					
2.60000E+02	9.49400E-05	1.12889E-05					
2.70000E+02	9.76200E-05	1.15000E-05					
2.80000E+02	1.00340E-04	1.17111E-05					
2.90000E+02	1.03100E-04	1.19222E-05					
3.00000E+02	1.05900E-04	1.21333E-05					
3.10000E+02	1.08740E-04	1.23444E-05					
3.20000E+02	1.11620E-04	1.25556E-05					
3.30000E+02	1.14540E-04	1.27667E-05					
3.40000E+02	1.17500E-04	1.29778E-05					
3.50000E+02	1.20500E-04	1.31889E-05					
3.60000E+02	1.23540E-04	1.34000E-05					
3.70000E+02	1.26620E-04	1.36111E-05					
3.80000E+02	1.29740E-04	1.38222E-05					
3.90000E+02	1.32900E-04	1.40333E-05					
4.00000E+02	1.36100E-04	1.42444E-05					
4.10000E+02	1.39340E-04	1.44556E-05					
4.20000E+02	1.42620E-04	1.46667E-05					
4.30000E+02	1.45940E-04	1.48778E-05					
4.40000E+02	1.49300E-04	1.50889E-05					
4.50000E+02	1.52700E-04	1.52999E-05					
4.60000E+02	1.56140E-04	1.55111E-05					
4.70000E+02	1.59620E-04	1.57222E-05					
4.80000E+02	1.63140E-04	1.59333E-05					
4.90000E+02	1.66700E-04	1.61444E-05					
5.00000E+02	1.70300E-04	1.63556E-05					
5.10000E+02	1.73940E-04	1.65667E-05					
5.20000E+02	1.77620E-04	1.67778E-05					
5.30000E+02	1.81340E-04	1.69889E-05					
5.40000E+02	1.85100E-04	1.72000E-05					
5.50000E+02	1.88900E-04	1.74111E-05					
5.60000E+02	1.92740E-04	1.76222E-05					
5.70000E+02	1.96620E-04	1.78333E-05					
5.80000E+02	2.00540E-04	1.80444E-05					
5.90000E+02	2.04500E-04	1.82556E-05					
6.00000E+02	2.08500E-04	1.84667E-05					
6.10000E+02	2.12540E-04	1.86778E-05					
6.20000E+02	2.16620E-04	1.88889E-05					
6.30000E+02	2.20740E-04	1.91000E-05					
6.40000E+02	2.24900E-04	1.93111E-05					
6.50000E+02	2.29100E-04	1.95222E-05					
6.60000E+02	2.33340E-04	1.97333E-05					
6.70000E+02	2.37620E-04	1.99444E-05					
6.80000E+02	2.41940E-04	2.01556E-05					
6.90000E+02	2.46300E-04	2.03667E-05					
7.00000E+02	2.50700E-04	2.05778E-05					
7.10000E+02	2.55140E-04	2.07889E-05					
7.20000E+02	2.59620E-04	2.09999E-05					
7.30000E+02	2.64140E-04	2.12111E-05					
7.40000E+02	2.68700E-04	2.1422					

3.00000E+01	1.70000E-01	1.70000E-01	1.70000E-01
3.10000E+01	1.34330E-01	1.34330E-01	1.34330E-01
3.20000E+01	1.34663E-01	1.34663E-01	1.34663E-01
3.30000E+01	1.42097E-01	1.42097E-01	1.42097E-01
3.40000E+01	1.47313E-01	1.47313E-01	1.47313E-01
3.50000E+01	1.51631E-01	1.51631E-01	1.51631E-01
3.60000E+01	1.55949E-01	1.55949E-01	1.55949E-01
3.70000E+01	1.60330E-01	1.60330E-01	1.60330E-01
3.80000E+01	1.64663E-01	1.64663E-01	1.64663E-01
3.90000E+01	1.68986E-01	1.68986E-01	1.68986E-01
4.00000E+01	1.73329E-01	1.73329E-01	1.73329E-01
4.10000E+01	1.77652E-01	1.77652E-01	1.77652E-01
4.20000E+01	1.81986E-01	1.81986E-01	1.81986E-01
4.30000E+01	1.86329E-01	1.86329E-01	1.86329E-01
4.40000E+01	1.90662E-01	1.90662E-01	1.90662E-01
4.50000E+01	1.94995E-01	1.94995E-01	1.94995E-01
4.60000E+01	1.99329E-01	1.99329E-01	1.99329E-01
4.70000E+01	2.03662E-01	2.03662E-01	2.03662E-01
4.80000E+01	2.07995E-01	2.07995E-01	2.07995E-01
4.90000E+01	2.12328E-01	2.12328E-01	2.12328E-01

COORD. OF EFFECTIVE TOOTH PROFILE AT ROOT CIRCLE

X
Y
6.012502E-00-2.798188E-01

J2	QJ2A	QJ2B	QJ2C
-2.50000E+01	1.31644E-09	5.35709E-08	7.16836E-09
-2.40000E+01	1.00914E-09	5.44507E-08	8.14125E-09
-2.30000E+01	1.93591E-09	5.97243E-08	9.10342E-09
-2.20000E+01	2.38163E-09	6.23516E-08	1.05103E-08
-2.10000E+01	2.71167E-09	6.5315E-08	1.14143E-08
-2.00000E+01	3.17164E-09	6.84709E-08	1.12203E-08
-1.90000E+01	3.65844E-09	7.16149E-08	1.47322E-08
-1.80000E+01	4.26901E-09	7.44167E-08	1.63543E-08
-1.70000E+01	4.92047E-09	7.80775E-08	1.80910E-08
-1.60000E+01	5.65124E-09	8.13946E-08	1.99406E-08
-1.50000E+01	6.47733E-09	8.47814E-08	2.19256E-08
-1.40000E+01	7.38151E-09	8.82277E-08	2.40324E-08
-1.30000E+01	8.41315E-09	9.17346E-08	2.62716E-08
-1.20000E+01	9.55674E-09	9.53181E-08	2.86440E-08
-1.10000E+01	1.08345E-08	9.89842E-08	3.11600E-08
-1.00000E+01	1.22598E-08	1.02642E-07	3.38306E-08
-0.90000E+01	1.38432E-08	1.06474E-07	3.64466E-08
-0.80000E+01	1.56022E-08	1.10341E-07	3.96144E-08
-0.70000E+01	1.75536E-08	1.14277E-07	4.27522E-08
-0.60000E+01	1.97154E-08	1.18314E-07	4.60514E-08
-0.50000E+01	2.21066E-08	1.22427E-07	4.95226E-08
-0.40000E+01	2.47533E-08	1.26627E-07	5.31701E-08
-0.30000E+01	2.76730E-08	1.30929E-07	5.69941E-08
-0.20000E+01	3.08724E-08	1.35309E-07	6.10150E-08
-0.10000E+01	3.44482E-08	1.39749E-07	6.52232E-08
0.00000E+01	3.83643E-08	1.44344E-07	6.96243E-08
0.10000E+01	4.26374E-08	1.49100E-07	7.42377E-08
0.20000E+01	4.73567E-08	1.53924E-07	7.90550E-08
0.30000E+01	5.25330E-08	1.58871E-07	8.40866E-08
0.40000E+01	5.82149E-08	1.63949E-07	8.93374E-08
0.50000E+01	6.44551E-08	1.69144E-07	9.48141E-08
0.60000E+01	7.12772E-08	1.74531E-07	1.00522E-07
0.70000E+01	7.87535E-08	1.80152E-07	1.06406E-07
0.80000E+01	8.69454E-08	1.8592E-07	1.12654E-07
0.90000E+01	9.58477E-08	1.91812E-07	1.19084E-07
1.00000E+01	1.05734E-07	1.97875E-07	1.25700E-07
1.10000E+01	1.16444E-07	2.03984E-07	1.32711E-07
1.20000E+01	1.28263E-07	2.10477E-07	1.39949E-07
1.30000E+01	1.41142E-07	2.17191E-07	1.47439E-07
1.40000E+01	1.55262E-07	2.24282E-07	1.55209E-07
1.50000E+01	1.70711E-07	2.31844E-07	1.63304E-07
1.60000E+01	2.08357E-07	2.47117E-07	1.80672E-07
1.70000E+01	2.26445E-07	2.54444E-07	1.84400E-07
1.80000E+01	2.49395E-07	2.64317E-07	1.98459E-07
1.90000E+01	2.76254E-07	2.73614E-07	2.08033E-07
2.00000E+01	3.07124E-07	2.83815E-07	2.17731E-07
2.10000E+01	3.42154E-07	2.94938E-07	2.28100E-07
2.20000E+01	3.85583E-07	3.05362E-07	2.38124E-07
2.30000E+01	4.38634E-07	3.17429E-07	2.49632E-07
2.40000E+01	4.95831E-07	3.30579E-07	2.60890E-07
2.50000E+01	5.57302E-07	3.44927E-07	2.72505E-07
2.60000E+01	6.24149E-07	3.60766E-07	2.84487E-07
2.70000E+01	6.96747E-07	3.78423E-07	2.96831E-07
2.80000E+01	7.74447E-07	3.98415E-07	3.09557E-07
2.90000E+01	8.57330E-07	4.21463E-07	3.22806E-07
3.00000E+01	9.45041E-07	4.48694E-07	3.36166E-07

CALCULATED: MESHING ERRORS AND LOADS

J2	AICI	TANG. EPWON	TANGENTIAL LOAD				WN	NT	QJD
			-2-PAIR	-1-PAIR	0-PAIR	1-PAIR			
1.00000E+00	7.61599E-03	1.41441E-03	0.00000E+00	5.45328E+02	2.12287E+03	4.27729E+01	2.90384E+03	2.71097E+03	1.84067E-07
2.00000E+00	1.52327E-02	1.80502E-03	0.00000E+00	5.19444E+02	2.09153E+03	0.00000E+00	2.90384E+03	2.71097E+03	1.84067E-07
3.00000E+00	2.24474E-02	1.70004E-03	0.00000E+00	6.02616E+02	2.02836E+03	0.00000E+00	2.90384E+03	2.71097E+03	1.84067E-07
4.00000E+00	3.06613E-02	1.75179E-03	0.00000E+00	7.49044E+02	1.96193E+03	0.00000E+00	2.90384E+03	2.71097E+03	1.84067E-07
5.00000E+00	3.85707E-02	1.72247E-03	0.00000E+00	8.18574E+02	1.89240E+03	0.00000E+00	2.90384E+03	2.71097E+03	1.84067E-07
6.00000E+00	4.56994E-02	1.69612E-03	0.00000E+00	8.91016E+02	1.81996E+03	0.00000E+00	2.90384E+03	2.71097E+03	1.84067E-07
7.00000E+00	5.31119E-02	1.66876E-03	0.00000E+00	9.66133E+02	1.74486E+03	0.00000E+00	2.90384E+03	2.71097E+03	1.84067E-07
8.00000E+00	6.07277E-02	1.64117E-03	0.00000E+00	1.04365E+03	1.66732E+03	0.00000E+00	2.90384E+03	2.71097E+03	1.84067E-07
9.00000E+00	6.85643E-02	1.61319E-03	0.00000E+00	1.12326E+03	1.58772E+03	0.00000E+00	2.90384E+03	2.71097E+03	1.84067E-07
1.00000E+01	7.61599E-02	1.58441E-03	0.00000E+00	1.20460E+03	1.50637E+03	0.00000E+00	2.90384E+03	2.71097E+03	1.84067E-07
1.10000E+01	8.37771E-02	1.55515E-03	0.00000E+00	1.28732E+03	1.42365E+03	0.00000E+00	2.90384E+03	2.71097E+03	1.84067E-07
1.20000E+01	9.13910E-02	1.52603E-03	0.00000E+00	1.38746E+03	1.33751E+03	0.00000E+00	2.90384E+03	2.71097E+03	1.84067E-07
1.30000E+01	9.90270E-02	1.49713E-03	0.00000E+00	1.49147E+03	1.25190E+03	0.00000E+00	2.90384E+03	2.71097E+03	1.84067E-07
1.40000E+01	1.06667E-01	1.46742E-03	0.00000E+00	1.60766E+03	1.16132E+03	0.00000E+00	2.90384E+03	2.71097E+03	1.84067E-07
1.50000E+01	1.14260E-01	1.43751E-03	0.00000E+00	1.70254E+03	1.08083E+03	0.00000E+00	2.90384E+03	2.71097E+03	1.84067E-07
1.60000E+01	1.21855E-01	1.40727E-03	0.00000E+00	1.79126E+03	9.91771E+02	0.00000E+00	2.90384E+03	2.71097E+03	1.84067E-07
1.70000E+01	1.29472E-01	1.37663E-03	0.00000E+00	1.87134E+03	8.39614E+02	0.00000E+00	2.90384E+03	2.71097E+03	1.84067E-07
1.80000E+01	1.37098E-01	1.34580E-03	0.00000E+00	1.94766E+03	7.63300E+02	0.00000E+00	2.90384E+03	2.71097E+03	1.84067E-07

1.90000E+01	1.44714E-01	-1.57316E-03	0.	2.02180E+03	6.49171E-02	0.	2.90384E-03	2.71097E+03	1.84067E-07
2.00000E+01	1.52710E-01	-1.58793E-03	0.	2.09342E+03	6.17557E-02	0.	2.90384E+03	2.71097E+03	1.84067E-07
2.10000E+01	1.59766E-01	-1.60250E-03	0.	2.16218E+03	5.44790E-02	0.	2.90384E+03	2.71097E+03	1.84067E-07
2.20000E+01	1.67552E-01	-1.61650E-03	2.94515E+02	2.05624E+03	3.60218E-02	0.	2.90384E+03	2.71097E+03	1.84067E-07
2.30000E+01	1.75144E-01	-1.62954E-03	3.50420E+02	2.09079E+03	2.69852E-02	0.	2.90384E+03	2.71097E+03	1.84067E-07
2.40000E+01	1.82764E-01	-1.64244E-03	4.09907E+02	2.11791E+03	1.84252E-02	0.	2.90384E+03	2.71097E+03	1.84067E-07
2.50000E+01	1.90430E-01	-1.65516E-03	4.69744E+02	2.13730E+03	1.03931E-02	0.	2.90384E+03	2.71097E+03	1.84067E-07

JCL	AUC1	TANG	ERROR
1.00000E+00	7.81594E-03	-1.21441E-03	
2.00000E+00	1.52320E-02	-1.80502E-03	
3.00000E+00	2.29474E-02	-1.79306E-03	
4.00000E+00	3.04431E-02	-1.75179E-03	
5.00000E+00	3.82744E-02	-1.72343E-03	
6.00000E+00	4.58954E-02	-1.69632E-03	
7.00000E+00	5.37114E-02	-1.66974E-03	
8.00000E+00	6.15274E-02	-1.64110E-03	
9.00000E+00	6.95434E-02	-1.61319E-03	
1.00000E+01	7.61594E-02	-1.59441E-03	
1.10000E+01	8.37754E-02	-1.56615E-03	
1.20000E+01	9.13914E-02	-1.54202E-03	
1.30000E+01	9.90074E-02	-1.53617E-03	
1.40000E+01	1.06624E-01	-1.52842E-03	
1.50000E+01	1.14240E-01	-1.52153E-03	
1.60000E+01	1.21856E-01	-1.52477E-03	
1.70000E+01	1.29472E-01	-1.52433E-03	
1.80000E+01	1.37088E-01	-1.55609E-03	
1.90000E+01	1.44704E-01	-1.57316E-03	
2.00000E+01	1.52320E-01	-1.58793E-03	
2.10000E+01	1.59936E-01	-1.60250E-03	
2.20000E+01	1.67552E-01	-1.61650E-03	
2.30000E+01	1.75168E-01	-1.62954E-03	
2.40000E+01	1.82784E-01	-1.64244E-03	
2.50000E+01	1.90400E-01	-1.65516E-03	

CALCULATED FOURIER COEFFICIENTS FOR ERRORS

I	A(I)	B(I)	C	RM
0	-3.147479E-03	0.	3.197470E-03	0.000000
1	3.7334977E-05	-0.3046172E-05	1.0024697E-04	1.000000
2	4.251036E-05	-5.621773E-05	7.204610E-05	2.000000
3	2.5267277E-05	-5.347554E-05	5.9144480E-05	3.000000
4	1.335456E-05	-4.175845E-05	4.3842617E-05	4.000000
5	9.0454477E-06	-2.4040744E-05	2.5704141E-05	5.000000
6	9.4102963E-06	-1.4013434E-05	1.6490202E-05	6.000000
7	1.5146607E-05	-4.5057404E-06	1.5802497E-05	7.000000
8	2.0324879E-05	-4.6627445E-06	2.0852863E-05	8.000000
9	2.1916954E-05	-4.7485406E-06	2.2932423E-05	9.000000
10	1.8747232E-05	-9.4900498E-06	2.0816781E-05	10.000000
11	1.4677511E-05	-8.6498529E-06	1.6225230E-05	11.000000
12	1.0631614E-05	-3.2780210E-06	1.0553615E-05	12.000000

AT1 angle of rotation, driving gear, between the position where the line of action intersects the involute at the start of the involute profile to the position where the line of action intersects the involute at the pitch point, rad.

AT2 angle of rotation, driven gear, rad.

Check for message to determine if part of the profile extends within the base circle. If so, program will continue and, where necessary, the root radius will be set equal to the base circle radius. In the tooth profile and the tooth deflection calculations, the original root circle radius will be used with the specified or calculated fillet radius. If the root circle lies inside the base circle by more than this fillet radius, a radial line is assumed to connect fillet and involute.

9. Driving Gear Data - J1, CJ1, AJ1, QJ1ABC, XJ1, YJ1, ZJ1, XME1(=X), YME1(=Y), J1, QJ1A, QJ1B, QJ1C

J1 Number of calculation points (see FI on Card 4 of the input data). Listed for values of $(-M/2 + 1)$ to $(M/2)$. (See description of Cards 8a, 8b, 8c and 8d.)

CJ1 Condition of engagement if equal to one and no engagement if equal to zero.

AJ1 Angle of rotation from the position of contact at the pitch point to the position of contact at the calculation point - negative for points inside the pitch circle, rad.

XJ1 Coordinates of the calculation point on the and involute profile with the origin at the gear center and the X-axis as the centerline of the tooth. Given only for points at which contact takes place with the mating gear, in.

ZJ1 Tooth profile deviation, in.

XME1 Coordinates of the point on the root circle and midway between the tangent point of the fillet radius and the involute profile extended (and radial inside the base circle), in. This point is considered to be the end of the effective base of the tooth for deflection purposes.

QJ1A Elastic compliance normal to the profile of the gear tooth acting as a cantilever beam in bending only, in/lb.

QJ1B Elastic compliance of the gear tooth as a cantilever beam in shear only, in/lb.

QJ1C Elastic compliance of the gear tooth as a rigid member rotating in its supporting structure, in/lb.

QJ1ABC Combined compliance of QJ1A, QJ1B, QJ1C, QJ1ABC, in/lb.

10. Driven Gear Data - J2, BLANK, AJ2, QJ2ABC, XJ2, YJ2, ZJ2, XME2, YME2, J2, QJ2A, QJ2B, QJ2C

J2 Number of calculation points. For external gears, J2 is listed for values of $(-M/2)$ to $(M/2 - 1)$ and contact takes place between points where $J1 = -J2$. For internal gears, J2 is listed for values of $(M/2)$ to $(-M/2 + 1)$ and contact takes place between points where $J1 = J2$.

All other variables are similar to their counterparts for the driving gears.

11. Tooth meshing errors, loads and contact compliance - JCl, AJCl, TANG ERROR, TANG LOAD, WN, WT, QJD

JCl Number of the calculation point on the driving gear tooth of the (0)th pair, starting with the first point after the pitch point and ending with the point corresponding to the pitch point of the next tooth ((1)st pair).

AJCl Angle of rotation of the driving gear from the position with contact at the pitch point of the first mesh cycle to the position with contact at the calculation point, rad. The last angle in the first mesh cycle is the tooth spacing angle.

TANG ERROR Tooth meshing error or deviation from pure conjugate action, as a pitch-line linear measurement of the motion of the driven gear leading the driving gear, in. A negative value indicates that the driven gear is lagging the driving gear, as might be caused by deflection of the teeth.

TANG LOAD Load sharing among contacting tooth pairs is printed. The (+1)th pair is the pair following the (0)th pair, the (-1)th pair is the pair in front of the (0)th pair and the (+2)th pair follows the (+1)th pair, lb.

WN Total normal load transmitted by the teeth, lb.

WT Total tangential tooth load, lb.

QJD Contact or Hertzian compliance combined for both teeth at the contact point, in/lb.

If IHICR = 0, TANG LOAD is replaced by WTC and WTD as follows:

WTC Tangential load carried by the (0)th pair of teeth, lb.

WTD Tangential load carried by the (1)th pair of teeth, lb.

12. List of Tooth Meshing Error over NMC Mesh Cycles - JCl, AJCl, EJT

JCl Number of the calculation point. The last value should be equal to (NMC x NJ).

AJCl Same as AJCl above.

EJT Same as TANG ERROR above.

13. Plot of Tooth Meshing Error.

Appears only if IPLT = 1 on input Card 2.

14. Fourier Coefficients - I, A, B, C, KM

I Order of the harmonic to which the coefficients apply. The zero order refers to the constant component.

A The Fourier coefficient of the cosine or real component for that harmonic of the meshing error, in. The value for I = 0 is twice the constant component or mean value of the meshing error.

B The Fourier coefficient of the sine or imaginary component for that harmonic of the meshing error, in.

C Square root of $(A^2 + B^2)$. Appears only if
IFOUR = 1 on input Card 2.

KM Ratio of frequency to tooth mesh frequency.

The following output is concerned with the power spectral
density function of the tooth meshing error. Appears only if
ISPECT = 1 on input Card 2.

15. Mesh Frequency, cps.

16. Incidental Data - FC, FO, BE, H, TR, TMAX, SM

FC Cutoff frequency, cps.

FO Fundamental frequency, cps.

BE Equivalent resolution bandwidth, cps.

H Sampling interval, cps.

TR Total record time, sec.

TMAX Maximum displacement, sec.

SM Maximum lag number.

17. Power Spectral Density Function - K, FR, GK, GKK, KM

K Harmonic number, from 0 to SM.

FR Frequency, cps.

GK "Raw" power spectral density function, in^2 .

GKK "Smooth" power spectral density function, in^2 .

KM Ratio of frequency to tooth mesh frequency.

COMPUTER PROGRAM FOR PREDICTION OF GEAR MESH
EXCITATION SPECTRA - GGEAR (R-67)

PROGRAM DESCRIPTION

Computer program GGEAR (R-67) is used for noise/vibration reduction analysis in order to calculate standard gear meshing errors and compliance. A listing of this program is provided in Appendix C. The output from this program is used in the finite element model of the internal components; in fact, R-67 is similar to program R-75 with the exception of the inclusion of high-contact-ratio capability; so the discussion of program R-75 is equally applicable here.

GGEAR is an outgrowth of GEARO (R-33). GEARO theory is thoroughly discussed in Reference 2, and that theory shall not be repeated here. The differences between GEARO and GGEAR are outlined below, and GGEAR is thoroughly discussed in Reference 7.

Characteristics of vibration spectra induced by gear meshes in both single gear reductions and planetary gear reductions were first investigated. Methods were then developed to analyze the planet-pass induced vibrations which exist in normal planetary gear reduction systems. It was found that the planet-pass vibration sideband frequencies occurred both below and above the base signal at integer multiples of planet-pass frequency and that the sideband amplitudes could exceed those of the base signal. These sideband calculations were programmed into GEARO.

The effect of planet pair phasing on the vibration sideband spectra was analyzed for the CH-47 helicopter forward rotor drive transmission first-stage planetary reduction. GGEAR has been established for predicting vibration sidebands produced by variations in centerline distance, tooth transmitted force, and tooth support discontinuities for single gear mesh systems. The sidebands are normally found at mesh frequency harmonics plus and minus integer multiples of the frequency of variation of the gear parameters. The sideband amplitudes depend on the magnitude of variations of the gear parameters. The vibrations sideband spectra produced by spiral bevel gear shaft runout, externally imposed tooth mesh force variation, and a decrease in support stiffness over a number of consecutive ring gear teeth were obtained for gear meshes in the CH-47 helicopter forward rotor drive transmission. The GGEAR sideband analysis is useful both for designing low-vibration gear systems by properly controlling various gear parameters, and for identifying the existence of several types of gear problems such as gear runout, high dynamic tooth force, and tooth cracks.

COMPUTER PROGRAM R-67 INPUT FORMAT

A complete set of input data for R-67 comprises data of nine input cards. The input data instructions are given below and are for the most part self-explanatory. The cards are laid out in the format of an 80-column data card. A description of the variables is given and a sample case is provided in Figure 20.

Input Variables, Format, and Instructions

Card 1 Title, columns 2 through 72.

Card 2 Control numbers. Format (7I5)

- a. NMC Number of mesh cycles.

Place the last digit of this number in column 5.
- b. INT Identification as to whether this control card represents the last complete set of input data being submitted.
If more sets of input data follow, use 0.
If this is the last set, use 1.

Place this digit in column 10.
- c. MN Classification of the types of spur gears to be considered.
If both the driving and the driven gears are external gears, use 1.
If the driving gear is an external gear and if the driven gear is an internal (ring) gear, use 0.
(The program will not run properly if the internal gear is submitted as the driving gear.)

Place this digit in column 15.
- d. MMM Number of initial terms of the Fourier analysis for which coefficients will be printed, beyond the coefficient for the constant term. This number cannot exceed $(FI \times NMC + NMC/2)$, where FI is the input variable submitted on card 4.

Place the last digit of this number in column 20.
- e. IPLT Instruction as to whether the calculated tooth meshing error is to be plotted.
If tooth meshing error is to be plotted, use 1.
If plotting is to be bypassed, use 0.

Place this digit in column 25.

NOTE		DATA PROCESSING WORKSHEET		FORM NO. 1	
In order to avoid misinterpretation in key punching, print these letters in the corner shown.		See Office Instruction 2021		1 of 2	
GGEAR (R-67) INPUT SHEET					
CARD 1. TITLE. CARO. COLUMNS. 2 THRU. 72					
SPIRAL BEVEL SUN GEAR MESH FOR R-67 INPUT. TREGOLD APPROX.					
CARD 2. CONTROL NUMBERS. FORMAT(7,15) RIGHT JUSTIFY					
NMC	INT	MN	MM	IP	TF
1	1	1	1	1	1
CARD 3. GEAR DESIGN DATA. FORMAT(5E13.5) INCLUDE DECIMAL POINT					
FN1	FN2	PB1	R01	R02 OR R12	
0.45762	E020.17790	E030.42293	E010.48297	E010.17920	E02
CARD 4. GEAR DESIGN DATA. FORMAT(5E13.5) INCLUDE DECIMAL POINT					
RT1	RT2	RM1	RM2	FI	T1
0.44540	E010.17545	E020.44125	E010.17503	E020.12000	E020.38886
CARD 5. GEAR DESIGN DATA. FORMAT(5E13.5) INCLUDE DECIMAL POINT					
T2	F1	F2	RF1	RF2	
0.23977	E000.24142	E010.24142	E010.31161	E-010.31162	E-01

Figure 20. GGEAR (R-67) Input Sheet.

DATA PROCESSING WORKSHEET		1-1	5-5	2-2
NOTE: In order to avoid misunderstanding and errors, please print these letters in the appropriate column. See Office Instruction 2101.		0-9	2-2	
CARD 6	GEAR MATERIAL PROPERTIES	FORMAT (GE13.5)		
YE1	YE2	GE1	GE2	POS1 POS2
3.0	E07B.0	E07B.1278	E07B.1278	E07B.33 E07B.33
CARD 7	CENTER DISTANCE AND TOOTH SPACING ERROR	FORMAT (3E13.5)		
CL	VP11	VP12	E-04	
0.22374	E025.0	E-045.0	E-04	
CARD 8	ADD 25 BLANK CARDS HERE			
P01	P02	P03	P04	P05
1.1	1.1	1.1	1.1	1.1
CARD 9	ADD 25 OF ABOVE CARD HERE			
GEAR SPEED	FORMAT (15.513.5)			
WWS(RPM)				
11.3	E03			

Figure 20. Continued.

- f. IFOUR Instruction as to whether Fourier analysis of the tooth meshing error is to be performed.
If it is to be performed, use 1.
If it is to be bypassed, use 0.

Place this digit in column 30.

- g. ISPECT Instruction as to whether power spectral density function for the tooth meshing error is to be calculated.
If it is to be calculated, use 1.
If it is to be bypassed, use 0.

Card 3 Gear design data. Format (6E 13.5)

- a. FN1 Number of teeth in the driving gear.
Use columns 1 through 13. (Do not omit decimal point.)
- b. FN2 Number of teeth in the driven gear.
Use columns 14 through 26. (Do not omit decimal point.)
- c. RB1 Base circle radius of driving gear, in.
Use columns 27 through 39.
- d. RØ1 Radius to the outside diameter of the driving gear, in. This should be reduced by any radial loss in working surface at the tip of the teeth, as from tip rounding or chamfering.
Use columns 40 through 52.
- e. RØ2 Radius to the outside diameter of the driven gear, if external, and to the inside diameter, if internal, in. This should be corrected for any radial loss in working surface at the tip of the teeth, as from tip rounding or chamfering. In the case of an internal gear, this radius must be equal to or greater than the base circle radius. No check for this is provided.

Use columns 53 through 65.

Card 4 Gear design data, continued. Format (6E 13.5)

- a. RT1 Radius to the beginning (near the base of the tooth) of the involute profile on the driving gear, in.

This is used in the program only in a design check as to whether adequate length of involute has been provided for contact on the teeth of the mating gear up to its tip. If this radius is not specified in the gear design data, this check may be bypassed by substituting the root circle radius.

Use columns 1 through 13.

- b. RT2 Radius to the beginning (near the base of the tooth) of the involute profile on the driven gear, in.
See above for substitute when not specified.

Use columns 14 through 26.

- c. RM1 Radius to the root circle of the driving gear, in.
If the radius submitted is smaller than the computed base circle radius, this is noted in the output, and the input value of root radius is used at some points in the program. If the root radius is sufficiently smaller than the base circle radius so that the root fillet center lies inside the base circle, the tooth outline between the base circle and the fillet is assumed to be a radial line by the program.

Use columns 27 through 39.

- d. RM2 Radius to the root circle of the driven gear, in.
For the case of an external gear, the same comments as above apply.

Use columns 40 through 52.

- e. FI Number which indirectly establishes the number of calculation points. The number of these points will equal one plus twice the value of FI. The calculation points may be viewed as selected contact points on the true involute profile, extended where necessary. These contact points with the mating involute are associated with specific angular positions taken by the gear as it is rotated, where the angular positions correspond to uniform subdivisions of the tooth spacing angle. A greater number of these points will give more closely spaced point-by-point output data. A greater number will also give more accurate calculations of tooth deflections and

Fourier coefficients. A value of FI equal to 12 giving 25 calculation points has been found to be convenient.

Use columns 52 through 65. (Do not omit decimal point.)

- f. T1 Circular tooth thickness at the pitch circle of the driving gear, in. The radius of the pitch circle is as defined in card 3. If not specified in the gear design data, it may be estimated as one-half of the difference between the actual circular pitch and the working backlash.

Use columns 66 through 78.

Card 5 Gear design data, continued. Format (5E 13.5)

- a. T2 Circular tooth thickness at the pitch circle of the driven gear, in. The comments for T1 also apply here.

Use columns 1 through 13.

- b. F1 Effective tooth face width of the driving gear, in. Where the face widths of the two gears are similar, use the actual face width without any reduction for normal end chamfering or rounding. Where one tooth is much wider, use as its effective face width an amount suitably larger than the narrower width to allow for the limited additional support that the greater width provides.

Use columns 14 through 26.

- c. F2 Effective tooth face width of the driven gear, in. The comments for F1 also apply here.

Use columns 27 through 39.

- d. RF1 Fillet radius on the driving gear, in.

Use columns 40 through 52.

- e. RF2 Fillet radius on the driven gear, in.

Use columns 53 through 65.

Card 6 Gear material properties. Format (6E 13.5)

- a. YE1 Young's modulus (in bending) for the material of the driving gear, lb/in.²
Use columns 1 through 13.
- b. YE2 Young's modulus (in bending) for the material of the driven gear, lb/in.²
Use columns 14 through 26.
- c. GE1 Shear modulus for the material of the driving gear, lb/in.²
Use columns 27 through 39.
- d. GE2 Shear modulus for the material of the driven gear, lb/in.²
Use columns 40 through 52.
- e. PØS1 Poisson's ratio for the material of the driving gear. Since this ratio is used only in the allowance for the "wide beam effect," it should be reduced for the cases where tooth face width is not much greater than tooth thickness, with a limiting value of zero when the teeth have a width smaller than the thickness.
Use columns 53 through 65.
- f. PØS2 Poisson's ratio for the material of the driven gear. Comments for PØS1 also apply here.
Use columns 66 through 78.

There are NMC sets of the following Card 7 and Card 8. Each set supplies center distance, tooth spacing errors, tooth profile errors, tooth support compliances and tangential load for one mesh cycle.

Card 7 Center distance and tooth spacing error data. Format (3E 13.5)

- a. CL Center distance, in.
This must be the actual center distance, including any substantial spreading under load.
Use columns 1 through 13.
- b. VPT1 Tooth spacing error on the driving gear, in. This error is based on the distance between the pitch points of successive teeth, but the error is ad-

justed to apply to the direction of the line of action. This adjustment is accomplished by multiplying the pitch line error by the cosine of the pressure angle. The error is positive if the measured spacing is smaller than the desired spacing.

Use columns 14 through 26.

- c. VPT2 Tooth spacing error on the driven gear, in. The comments under VPT1 also apply here.

Use columns 27 through 39.

Cards 8-1 to 8-2N Point-by-point data. Format (5E 13.5)

Total number of cards equal to twice the number of calculation points (N_J) between pitch points of adjacent teeth, or the same as two plus four times the value of F1 (see card 4). This specifies that cards must be introduced even if it is known that there is no contact at the particular calculation point or even if the tooth profile does not actually extend to the calculation point. As explained below, a blank card may be used for these points.

For the driving gear, the first card is for the calculation point located (N_J-1) points preceding the pitch point (or inside the pitch circle); the (N_J)th card is for the pitch point; the last or ($2N_J$)th card is for the calculation point located (N_J) points after the pitch point (or outside the pitch circle). The last point may also be described as the point of contact on one meshing tooth when the pitch point is the point of contact on the next meshing tooth.

For the driven gear which is an external gear, the first card is for the calculation point located (N_J) points before the pitch point (or inside the pitch circle); the (N_J+1)th card is for the pitch point; the last or ($2N_J$)th card is for the calculation point located (N_J-1) points after the pitch point (or outside the pitch circle). The point for the first card may also be described as the point of contact on one meshing tooth when the pitch point is the point of contact on the previous meshing tooth.

For the driven gear which is an internal gear, the first card is for the calculation point located (N_J) points following the pitch point (or outside the pitch circle); the (N_J+1)th card is for the pitch point; the last or ($2N_J$)th card is for the calculation point located (N_J-1) points before the pitch point (or inside the pitch circle). The point for the first card may also be described as the point of contact on the meshing tooth when the pitch point is the point of contact on the next meshing tooth.

- a. ZJ1 Deviation of the point on the actual tooth profile on the driving gear from the true involute (as defined by the gear design data), in. This true involute is positioned relative to the actual profile so that its deviation at the pitch point is zero. Where the deviation represents material added to the true involute, it is positive; where it represents material subtracted, it is negative. The deviation is measured normal to the involute profile. If the profile does not extend to the particular calculation point or if it is known that the mating gear will not contact at this point, the deviation may be noted as zero.

Use columns 1 through 12.

- b. UJ1 Tooth support compliance, or any compliance supplementary to the tooth compliance included in the analysis, on the driving gear, in./lb. This compliance is the deflection under unit load at the calculation point on the profile in the direction of the load (or normal to the profile). A uniform compliance for all calculation points, such as would result from a uniform gear shaft compliance, would not affect the final results as far as motion irregularities or load transfer is concerned; it would only increase the mean deviation in transmitted motion.

Use columns 14 through 26.

- c. ZJ2 Deviation of the point on the actual tooth profile on the driven gear from the true involute, in. The comments under ZJ1 also apply here.

Use columns 27 through 39.

- d. UJ2 Tooth support compliance, etc., on the driven gear, in./lb. The comments under UJ1 also apply here.

Use columns 40 through 52.

- e. WT Total load, tangent to the pitch circle, transmitted by the gear teeth, lb.

In the first N card 8s, WT should be left blank.
WT in the second N card 8s represents the loads at the N calculation points in one gear mesh.

Use columns 53 through 65.

Card 9 Gear Speed. Format (I5,E 13.5)

- a. NWS Identification as to whether the input speed is the speed of driving or driven gear.
If driving gear speed is inputted, use 1.
If driven gear speed is inputted, use 2.

Place this digit in column 5.

- b. WS Driving or driven gear speed, rpm.

Use columns 6 through 18.

PROGRAM OUTPUT

The output generated from the sample case defined in Figure 20 is shown in Figure 21. In addition to the calculated output data, the input data is also listed, thus producing a complete record of the computer run. Key output variables from R-67 are discussed briefly below.

Output Variables and Explanations

1. Title
2. Control numbers - NMC, INT, NMZ, MMM, as in input card 2.
3. Design - FI(=I), FN1(=N1), RB1, R01, TR1, EM1
BLANK, FN2(=N2), BLANK, R02 or RI2, RT2, RM2
T1, F1, RF1, YE1, GE1, POS1
T2, F2, RF2, YE2, GE2, POS2
all as in input cards 3 through 6.

Items 4-11 are printed for every mesh cycle, totally NMC cycles.

4. Mesh cycle identification and center distance.
5. Input listing of profile error and supplementary compliance - ZJ1, UJ1, ZJ2, UJ2 as in input card 8.
6. Pressure angle, degrees.

7. Incidental data -- RPl, RB1, BA1, BR1, AT1
RP2, RB2, BA2, BR2, AT2

where: RPL pitch circle radius of driving gear, in.
RP2 pitch circle radius of driven gear, in.
RB1 base circle radius of driving gear, in.
RB2 base circle radius of driven gear, in.
BA1 arc of approach of driving gear, rad.
BA2 arc of approach of driven gear, rad (negative on internal gears).
BR1 arc of recess of driven gear, rad.
BR2 arc of recess of driving gear, rad (negative on internal gears).
AT1 angle of rotation of driving gear from the position at which the line of action intersects the involute at the start of the involute profile to the position at which the line of action intersects the involute at the pitch point, rad.
AT2 similar angle of rotation of driven gear, rad.

Check statement when part of the profile extends within the base circle.

Program will continue in any case, and, where necessary, the root radius will be set equal to the base circle radius. However, in calculating the tooth profile and the tooth deflections, the original root circle radius will be used with the specified fillet radius. If the root circle lies inside the base circle by more than this fillet radius, a radial line is assumed to connect fillet and involute.

8. Driving gear data -- J1, CJ1, AJ1, QJ1ABC, XJ1, YJ1, XME1(=X), YME1(=Y), J1, QJ1A, QJ1B, QJ1C

where: J1 identification number for calculation points (see under F1 of card 4 in the input data). Listed for values of $(-2I)$ to $(2I+1)$.

CJ1 condition of engagement if equal to one and no engagement if equal to zero.

AJ1 angle of rotation from the position of contact at the pitch point to the position of contact at the calculation point - negative for points inside the pitch circle, rad.

XJ1 coordinates of the calculation point on the involute profile with the origin at the gear center and with the X-axis as the centerline of the tooth, given only for the points at which contact will take place with the mating gear, in.

YJ1

XME1 coordinates of the point on the root circle midway and between the tangent point of the fillet radius and the involute profile extended (and radial inside the base circle), in. This point is considered to be the end of the effective base of the tooth for deflection purposes.

YME1

QJ1A elastic compliance of the gear tooth acting as a cantilever beam in bending only, normal to the profile at the calculation point, in./lb.

QJ1B elastic compliance of the gear tooth as a cantilever beam in shear only; otherwise as above.

QJ1C elastic compliance of the gear tooth as a rigid member rotating in its supporting structure; otherwise as above.

QJ1ABC combined compliance of the three above, in./lb.

9. Driven gear data - J2, BLANK, AJ2, QJ2ABC, XJ2, YJ2, XME2, YME2, J2, QJ2A, QJ2B, QJ2C

where: J2 identification number for the calculation points. For external gears, J2 is listed for values of $(-2I-1)$ to $(2I)$. For this case, contact takes place between points of the two gears for which $J1 = -J2$. For internal gears, J2 is listed for values of $(2I+1)$ to $(-2I)$. For this case, contact takes place between points of the two gears for which $J1 = J2$.

All other variables are similar to their counterparts for the driving gear.

10. Input tooth spacing error data - VPT1, VPT2
as in input card 7.
11. Tooth meshing errors, loads and contact compliance - JCl, AJCl, EJT, WTC, WTD, WN, WT, QJD

where: JCl identification number for the calculation point on the first tooth of the driving gear, starting with the first point after the pitch point and ending with the point corresponding to the pitch point of the next tooth.

AJCl angle of rotation of the driving gear from the position with contact at the pitch point of the first mesh cycle to the position with contact at the calculation point, rad. The last angle in the first mesh cycle is the tooth spacing angle.

EJT tooth meshing error or deviation from pure conjugate action, as a pitch-line linear measurement of the motion of the driven gear leading the driving gear, in. A negative value indicates that the driven gear is lagging the driving gear, as might be caused by deflection of the teeth.

WTC tangential load carried by the first pair of teeth, lb.

WTD tangential load carried by the second pair of teeth, lb.

WN total normal load transmitted by the teeth, lb.

WT input tangential tooth load, lb.

QJD contact or Hertzian compliance combined for both teeth at the contact point, in./lb.

12. List of tooth meshing error over NMC mesh cycles - JCl, AJCl, EJT

where: JCl identification number for the calculation point. The last value should be equal to (NMCxN).

AJCl same as AJCl in item 11.

EJT same as EJT in item 11.

13. Plot of tooth meshing error.
Appears only if IPLT in input card 2 is set to be 1.
14. Fourier coefficients - I, A, B, C, KM

where: I order of the harmonic to which the coefficients apply. The zero order refers to the constant component.

A the Fourier coefficient of the cosine or real component for that harmonic of the meshing error, in. The value for I = 0 is twice the constant component or mean value of the meshing error.

B the Fourier coefficient of the sine or imaginary component for that harmonic of the meshing error, in.

C square root of $(A^2 + B^2)$. Appears only if IFOUR in input card 2 is set to be 1.

KM ratio of frequency to tooth mesh frequency.

The following output is concerned with the power spectral density function of the tooth meshing error. Appears only if ISPECT in input card 2 is set to be 1.

15. Mesh frequency, cps
16. Incidental data - FC, FO, BE, H, TR, TMAX, SM

where: FC cutoff frequency, cps.

FO fundamental frequency, cps.

BE equivalent resolution bandwidth, cps.

H sampling interval, cps.

TR total record time, sec.

TMAX maximum displacement, sec.

SM maximum lag number.

17. Power spectral density function - K, FR, GK, GKK, KM

where: K harmonic number, from 0 to SM.

FR frequency, cps.
GK "raw" power spectral density function, in.²
GKK "smooth" power spectral density function, in.²
KM ratio of frequency to tooth mesh frequency.

PH0335# COMPUTATIONS OF GEAR TOOTH MESHING ERRORS 3-22-1966

I		M1		RM1		R01		RT1		RM1	
0.12098E 02	0.45762E 02	0.42293E 01	0.48297E 01	0.44548E 01	0.44125E 01						
U2		U2		R02		RT2		RM2			
0.0	0.17790E 03			0.17920E 02	0.17545E 02	0.17503E 02					
T1		F1		RF1		YOUNGS MOD=1		SHEAR MOD=1		POS.RATIO=1	
0.34886E 00	0.24142E 01	0.31161E -01	0.30880E 08	0.11278E 08	0.33808E 00						
T2		F2		RF2		YOUNGS MOD=2		SHEAR MOD=2		POS.RATIO=2	
0.23977E 00	0.24142E 01	0.31162E -01	0.30090E 08	0.11278E 08	0.33080E 00						

MESH CYCLE NO.# 1, CENTER DISTANCE# 0.223740E 02

[illegible]

Figure 21. R-67 Sample Run and Plot.

	RP1		RB1		BA1		BR1		AT1				
	0.45778E 01		0.42293E 01		0.75007E-01		0.13720E 00		0.83960E-01				
	RP2		RB2		BA2		BR2		AT2				
	0.17746E 02		0.16441E 02		0.35291E-01		0.19294E-01		0.41744E-01				
	J1		QJ1		AJ1		QJ1ABC		XJ1		YJ1		
0	-0.24000E 02	0.0		-0.13181E 00									
0	-0.23000E 02	0.0		-0.12632E 00									
	-0.22000E 02	0.0		-0.12083E 00									
	-0.21000E 02	0.0		-0.11533E 00									
	-0.20000E 02	0.0		-0.10984E 00									
	-0.19000E 02	0.0		-0.10435E 00									
	-0.18000E 02	0.0		-0.98857E-01									
	-0.17000E 02	0.0		-0.93365E-01									
	-0.16000E 02	0.0		-0.87873E-01									
	-0.15000E 02	0.0		-0.82381E-01									
	-0.14000E 02	0.0		-0.76889E-01									
	-0.13000E 02	0.10000E 01		-0.71397E-01	0.51419E-08	0.44650E 01	8.22985E 00						
	-0.12000E 02	0.10000E 01		-0.65905E-01	0.58141E-08	0.44727E 01	0.22762E 00						
	-0.11000E 02	0.10000E 01		-0.60413E-01	0.65209E-06	0.44806E 01	0.22531E 00						
	-0.10000E 02	0.10000E 01		-0.54921E-01	0.72650E-08	0.44885E 01	0.22292E 00						
	-0.90000E 01	0.10000E 01		-0.49428E-01	0.80487E-08	0.44965E 01	0.22045E 00						
	-0.80000E 01	0.10000E 01		-0.43936E-01	0.88748E-08	0.45047E 01	0.21790E 00						
	-0.70000E 01	0.10000E 01		-0.38444E-01	0.97463E-08	0.45129E 01	0.21526E 00						
	-0.60000E 01	0.10000E 01		-0.32952E-01	0.10566E-07	0.45213E 01	0.21254E 00						
	-0.50000E 01	0.10000E 01		-0.27460E-01	0.11638E-07	0.45298E 01	0.20974E 00						
	-0.40000E 01	0.10000E 01		-0.21968E-01	0.12666E-07	0.45383E 01	0.20684E 00						
	-0.30000E 01	0.10000E 01		-0.16476E-01	0.13753E-07	0.45470E 01	0.20386E 00						
	-0.20000E 01	0.10000E 01		-0.10984E-01	0.14904E-07	0.45558E 01	0.20079E 00						
	-0.10000E 01	0.10000E 01		-0.54921E-02	0.16124E-07	0.45647E 01	0.19763E 00						
0.6	0.10000E 01	0.10000E 01	0.0	0.17417E-07	0.45737E 01	0.19437E 00							
	0.10000E 01	0.10000E 01	0.54921E-02	0.18788E-07	0.45828E 01	0.19102E 00							
	0.20000E 01	0.10000E 01	-0.10984E-01	0.20243E-07	0.45919E 01	0.18758E 00							
	0.30000E 01	0.10000E 01	-0.16476E-01	0.21749E-07	0.46012E 01	0.18404E 00							
	0.40000E 01	0.10000E 01	-0.21968E-01	0.23431E-07	0.46106E 01	0.18041E 00							
	0.50000E 01	0.10000E 01	-0.27460E-01	0.25179E-07	0.46201E 01	0.17667E 00							
	0.60000E 01	0.10000E 01	-0.32952E-01	0.27038E-07	0.46297E 01	0.17294E 00							
	0.70000E 01	0.10000E 01	-0.38444E-01	0.29018E-07	0.46394E 01	0.16890E 00							
	0.80000E 01	0.10000E 01	-0.43936E-01	0.31129E-07	0.46492E 01	0.16487E 00							
	0.90000E 01	0.10000E 01	-0.49428E-01	0.33340E-07	0.46590E 01	0.16075E 00							
	0.10000E 02	0.10000E 01	-0.54921E-01	0.35783E-07	0.46698E 01	0.15649E 00							
	0.11000E 02	0.10000E 01	-0.60413E-01	0.38350E-07	0.46791E 01	0.15214E 00							
	0.12000E 02	0.10000E 01	-0.65905E-01	0.41045E-07	0.46892E 01	0.14764E 00							
	0.13000E 02	0.10000E 01	-0.71397E-01	0.44034E-07	0.46995E 01	0.14312E 00							
	0.14000E 02	0.10000E 01	-0.76889E-01	0.47183E-07	0.47098E 01	0.13845E 00							
	0.15000E 02	0.10000E 01	-0.82381E-01	0.50562E-07	0.47202E 01	0.13367E 00							
	0.16000E 02	0.10000E 01	-0.87873E-01	0.54192E-07	0.47307E 01	0.12878E 00							
	0.17000E 02	0.10000E 01	-0.93365E-01	0.58098E-07	0.47413E 01	0.12377E 00							
	0.18000E 02	0.10000E 01	-0.98857E-01	0.62336E-07	0.47520E 01	0.11865E 00							
	0.19000E 02	0.10000E 01	-0.10435E 00	0.66849E-07	0.47628E 01	0.11345E 00							
	0.20000E 02	0.10000E 01	-0.10984E 00	0.71763E-07	0.47737E 01	0.10808E 00							
	0.21000E 02	0.10000E 01	-0.11533E 00	0.77091E-07	0.47846E 01	0.10261E 00							
	0.22000E 02	0.10000E 01	-0.12083E 00	0.82883E-07	0.47957E 01	0.97033E-01							
	0.23000E 02	0.10000E 01	-0.12632E 00	0.89200E-07	0.48068E 01	0.91333E-01							
	0.24000E 02	0.10000E 01	-0.13181E 00	0.96112E-07	0.48180E 01	0.85514E-01							
	0.25000E 02	0.0	-0.13730E 00										
COORD. OF EFFECTIVE TOOTH PROFILE AT ROOT CIRCLE													
							X	Y					
							0.440502E 01	0.256857E 00					
	J1		QJ1A		QJ1B		QJ1C						
	-0.13000E 02	0.11133E-09		0.50229E-08		0.76719E-11							
	-0.12000E 02	0.12235E-09		0.56915E-08		0.33034E-12							
	-0.11000E 02	0.13325E-09		0.63718E-08		0.15958E-10							
	-0.10000E 02	0.14409E-09		0.70645E-08		0.55556E-10							
	-0.90000E 01	0.15482E-09		0.77698E-08		0.12074E-09							
	-0.80000E 01	0.17441E-09		0.84876E-08		0.21273E-09							
	-0.70000E 01	0.19465E-09		0.92187E-08		0.33291E-09							
	-0.60000E 01	0.22037E-09		0.99653E-08		0.48824E-09							
	-0.50000E 01	0.25318E-09		0.10722E-07		0.66334E-09							
	-0.40000E 01	0.29483E-09		0.11495E-07		0.87643E-09							
	-0.30000E 01	0.34731E-09		0.12283E-07		0.11233E-08							
	-0.20000E 01	0.41283E-09		0.13086E-07		0.14055E-08							
	-0.10000E 01	0.49385E-09		0.13906E-07		0.17244E-08							
0.0		0.59307E-09		0.14742E-07		0.20818E-08							
0.10000E 01		0.71352E-09		0.15596E-07		0.24745E-08							
0.20000E 01		0.84855E-09		0.16468E-07		0.29168E-08							
0.30000E 01		0.10319E-08		0.17359E-07		0.33979E-08							
0.40000E 01		0.12376E-08		0.18270E-07		0.39235E-08							
0.50000E 01		0.14802E-08		0.19203E-07		0.44951E-08							
0.60000E 01		0.17648E-08		0.20159E-07		0.51143E-08							
0.70000E 01		0.20970E-08		0.21138E-07		0.57826E-08							
0.80000E 01		0.24830E-08		0.22144E-07		0.65021E-08							
0.90000E 01		0.29297E-08		0.23176E-07		0.72741E-08							
0.10000E 02		0.34448E-08		0.24234E-07		0.81004E-08							

0.11000E 02	0.40368E-08	0.25331E-07	0.89825E-08
0.12700E 02	0.47193E-08	0.26458E-07	0.99223E-08
0.13000E 02	0.54913E-08	0.27621E-07	0.10421E-07
0.14000E 02	0.63766E-08	0.28825E-07	0.11982E-07
0.15000E 02	0.73450E-08	0.30072E-07	0.13105E-07
0.16000E 02	0.84321E-08	0.31367E-07	0.14293E-07
0.17000E 02	0.96354E-08	0.32715E-07	0.15547E-07
0.18000E 02	0.11315E-07	0.34121E-07	0.16870E-07
0.19000E 02	0.12994E-07	0.35592E-07	0.18262E-07
0.20000E 02	0.14900E-07	0.37136E-07	0.19727E-07
0.21000E 02	0.17064E-07	0.38761E-07	0.21265E-07
0.22000E 02	0.19524E-07	0.40480E-07	0.22979E-07
0.23000E 02	0.22323E-07	0.42307E-07	0.24570E-07
0.24000E 02	0.25514E-07	0.44257E-07	0.26341E-07

J2	AJ2	GJ2ABC	XJ2	YJ2
-0.25000E 02	-0.35519E-01	0.79709E-08	0.17589E 02	0.19982E 00
-0.24000E 02	-0.33906E-01	0.88824E-08	0.17598E 02	0.19676E 00
-0.23000E 02	-0.32493E-01	0.98540E-08	0.17606E 02	0.19368E 00
-0.22000E 02	-0.31080E-01	0.10886E-07	0.17614E 02	0.19057E 00
-0.21000E 02	-0.29668E-01	0.11941E-07	0.17623E 02	0.18745E 00
-0.20000E 02	-0.28255E-01	0.13145E-07	0.17631E 02	0.18429E 00
-0.19000E 02	-0.26842E-01	0.14384E-07	0.17639E 02	0.18112E 00
-0.18000E 02	-0.25429E-01	0.15697E-07	0.17648E 02	0.17792E 00
-0.17000E 02	-0.24017E-01	0.17093E-07	0.17656E 02	0.17470E 00
-0.16000E 02	-0.22604E-01	0.18575E-07	0.17665E 02	0.17146E 00
-0.15000E 02	-0.21191E-01	0.20145E-07	0.17673E 02	0.16819E 00
-0.14000E 02	-0.19778E-01	0.21916E-07	0.17682E 02	0.16489E 00
-0.13000E 02	-0.18366E-01	0.23587E-07	0.17691E 02	0.16158E 00
-0.12000E 02	-0.16953E-01	0.25468E-07	0.17699E 02	0.15824E 00
-0.11000E 02	-0.15540E-01	0.27462E-07	0.17708E 02	0.15487E 00
-0.10000E 02	-0.14127E-01	0.29583E-07	0.17717E 02	0.15148E 00
-0.90000E 01	-0.12715E-01	0.31932E-07	0.17725E 02	0.14807E 00
-0.80000E 01	-0.11302E-01	0.34221E-07	0.17734E 02	0.14463E 00
-0.70000E 01	-0.98892E-02	0.36756E-07	0.17743E 02	0.14117E 00
-0.60000E 01	-0.84765E-02	0.39449E-07	0.17752E 02	0.13769E 00
-0.50000E 01	-0.70637E-02	0.42307E-07	0.17760E 02	0.13418E 00
-0.40000E 01	-0.56910E-02	0.45351E-07	0.17769E 02	0.13064E 00
-0.30000E 01	-0.42382E-02	0.48584E-07	0.17778E 02	0.12708E 00
-0.20000E 01	-0.28255E-02	0.52019E-07	0.17787E 02	0.12349E 00
-0.10000E 01	-0.14127E-02	0.55682E-07	0.17796E 02	0.11988E 00
0.0	0.0	0.59579E-07	0.17805E 02	0.11625E 00
0.10000E 01	0.14127E-02	0.63726E-07	0.17814E 02	0.11259E 00
0.20000E 01	0.28255E-02	0.68158E-07	0.17823E 02	0.10891E 00
0.30000E 01	0.42382E-02	0.72875E-07	0.17832E 02	0.10520E 00
0.40000E 01	0.56910E-02	0.77933E-07	0.17841E 02	0.10146E 00
0.50000E 01	0.70637E-02	0.83319E-07	0.17850E 02	0.97700E-01
0.60000E 01	0.84765E-02	0.89066E-07	0.17859E 02	0.93913E-01
0.70000E 01	0.98892E-02	0.95293E-07	0.17868E 02	0.89103E-01
0.80000E 01	0.11302E-01	0.10194E-06	0.17877E 02	0.86265E-01
0.90000E 01	0.12715E-01	0.10909E-06	0.17886E 02	0.82403E-01
0.10000E 02	0.14127E-01	0.11679E-06	0.17895E 02	0.78514E-01
0.11000E 02	0.15540E-01	0.12510E-06	0.17905E 02	0.74599E-01
0.12000E 02	0.16953E-01	0.13409E-06	0.17914E 02	0.70659E-01
0.13000E 02	0.18366E-01			
0.14000E 02	0.19778E-01			
0.15000E 02	0.21191E-01			
0.16000E 02	0.22604E-01			
0.17000E 02	0.24017E-01			
0.18000E 02	0.25429E-01			
0.19000E 02	0.26842E-01			
0.20000E 02	0.28255E-01			
0.21000E 02	0.29668E-01			
0.22000E 02	0.31080E-01			
0.23000E 02	0.32493E-01			
0.24000E 02	0.33906E-01			

COORDS OF EFFECTIVE TOOTH PROFILE AT ROOT CIRCLE X Y
0.175013E 02 0.242182E 00

J2	GJ2A	GJ2B	GJ2C
-0.24000E 02	0.19481E-04	0.7244E-08	0.51658E-10
-0.23000E 02	0.21733E-04	0.85283E-08	0.13671E-09
-0.22000E 02	0.24297E-04	0.93478E-08	0.26321E-09
-0.21000E 02	0.27399E-04	0.10180E-07	0.43128E-09
-0.20000E 02	0.31286E-04	0.11027E-07	0.64123E-09
-0.19000E 02	0.36234E-04	0.11889E-07	0.89388E-09
-0.18000E 02	0.42546E-04	0.12769E-07	0.11902E-08
-0.17000E 02	0.50492E-04	0.13663E-07	0.15291E-08
-0.16000E 02	0.60448E-04	0.14576E-07	0.19129E-08
-0.15000E 02	0.72735E-04	0.15506E-07	0.23408E-08
-0.14000E 02	0.87727E-04	0.16455E-07	0.28130E-08
-0.13000E 02	0.10589E-03	0.17425E-07	0.33318E-08
-0.12000E 02	0.12761E-03	0.18415E-07	0.38959E-08
-0.11000E 02	0.15340E-03	0.19427E-07	0.45067E-08
-0.10000E 02	0.18371E-03	0.20461E-07	0.51636E-08
-0.90000E 01	0.21922E-03	0.21521E-07	0.58695E-08

-0.40000E 01	0.26091E-08	0.22606E-07	0.66224E-08
-0.70000E 01	0.30800E-08	0.23717E-07	0.74241E-08
-0.60000E 01	0.36260E-08	0.24856E-07	0.82719E-08
-0.50000E 01	0.42507E-08	0.26025E-07	0.91734E-08
-0.40000E 01	0.49612E-08	0.27224E-07	0.10122E-07
-0.30000E 01	0.57692E-08	0.28460E-07	0.11122E-07
-0.20000E 01	0.66820E-08	0.29729E-07	0.12173E-07
-0.10000E 01	0.77103E-08	0.31035E-07	0.13274E-07
0.0	0.88693E-08	0.32385E-07	0.14428E-07
0.10000E 01	0.10169E-07	0.33776E-07	0.15635E-07
0.20000E 01	0.11623E-07	0.35211E-07	0.16892E-07
0.30000E 01	0.13252E-07	0.36700E-07	0.18206E-07
0.40000E 01	0.15068E-07	0.38238E-07	0.19570E-07
0.50000E 01	0.17100E-07	0.39840E-07	0.20993E-07
0.60000E 01	0.19356E-07	0.41497E-07	0.22466E-07
0.70000E 01	0.21874E-07	0.43226E-07	0.23997E-07
0.80000E 01	0.24679E-07	0.45030E-07	0.25584E-07
0.90000E 01	0.27780E-07	0.46913E-07	0.27227E-07
0.10000E 02	0.31278E-07	0.48886E-07	0.28927E-07
0.11000E 02	0.35149E-07	0.50956E-07	0.30684E-07
0.12000E 02	0.39469E-07	0.53134E-07	0.32499E-07
0.13000E 02	0.44289E-07	0.55436E-07	0.34371E-07

INPUT DATA ON TOOTH SPACING ERROR

VPT1	VPT2
0.50000E-03	0.50000E-03

CALCULATED TOOTH MESHING ERRORS AND LOADS

JCI	AJCI	TANG. ERROR	WTC	WTD	WN	WT	QJD
0.10000E 01	0.54921E-02	-0.13169E-02	0.97000E 04	0.0	0.10499E 05	0.97000E 04	0.45073E-07
0.20000E 01	0.10984E-01	-0.12944E-02	0.97000E 04	0.0	0.10499E 05	0.97000E 04	0.45073E-07
0.30000E 01	0.16476E-01	-0.12752E-02	0.97000E 04	0.0	0.10499E 05	0.97000E 04	0.45073E-07
0.40000E 01	0.21968E-01	-0.12593E-02	0.97000E 04	0.0	0.10499E 05	0.97000E 04	0.45073E-07
0.50000E 01	0.27460E-01	-0.12467E-02	0.97000E 04	0.0	0.10499E 05	0.97000E 04	0.45073E-07
0.60000E 01	0.32952E-01	-0.12372E-02	0.97000E 04	0.0	0.10499E 05	0.97000E 04	0.45073E-07
0.70000E 01	0.38444E-01	-0.12309E-02	0.97000E 04	0.0	0.10499E 05	0.97000E 04	0.45073E-07
0.80000E 01	0.43936E-01	-0.12277E-02	0.97000E 04	0.0	0.10499E 05	0.97000E 04	0.45073E-07
0.90000E 01	0.49428E-01	-0.12278E-02	0.97000E 04	0.0	0.10499E 05	0.97000E 04	0.45073E-07
0.10000E 02	0.54921E-01	-0.12310E-02	0.97000E 04	0.0	0.10499E 05	0.97000E 04	0.45073E-07
0.11000E 02	0.60413E-01	-0.12375E-02	0.97000E 04	0.0	0.10499E 05	0.97000E 04	0.45073E-07
0.12000E 02	0.65905E-01	-0.12476E-02	0.97000E 04	0.36204E 04	0.10499E 05	0.97000E 04	0.45073E-07
0.13000E 02	0.71397E-01	-0.12522E-02	0.97000E 04	0.37501E 04	0.10499E 05	0.97000E 04	0.45073E-07
0.14000E 02	0.76889E-01	-0.12602E-02	0.97000E 04	0.38830E 04	0.10499E 05	0.97000E 04	0.45073E-07
0.15000E 02	0.82381E-01	-0.12701E-02	0.97000E 04	0.40191E 04	0.10499E 05	0.97000E 04	0.45073E-07
0.16000E 02	0.87873E-01	-0.12825E-02	0.97000E 04	0.41584E 04	0.10499E 05	0.97000E 04	0.45073E-07
0.17000E 02	0.93365E-01	-0.12975E-02	0.97000E 04	0.43005E 04	0.10499E 05	0.97000E 04	0.45073E-07
0.18000E 02	0.98857E-01	-0.13157E-02	0.97000E 04	0.44456E 04	0.10499E 05	0.97000E 04	0.45073E-07
0.19000E 02	0.10435E 00	-0.13360E-02	0.97000E 04	0.45931E 04	0.10499E 05	0.97000E 04	0.45073E-07
0.20000E 02	0.10984E 00	-0.13585E-02	0.97000E 04	0.47427E 04	0.10499E 05	0.97000E 04	0.45073E-07
0.21000E 02	0.11533E 00	-0.13830E-02	0.97000E 04	0.48948E 04	0.10499E 05	0.97000E 04	0.45073E-07
0.22000E 02	0.12083E 00	-0.14095E-02	0.97000E 04	0.50483E 04	0.10499E 05	0.97000E 04	0.45073E-07
0.23000E 02	0.12632E 00	-0.14381E-02	0.97000E 04	0.52035E 04	0.10499E 05	0.97000E 04	0.45073E-07
0.24000E 02	0.13181E 00	-0.14682E-02	0.97000E 04	0.53599E 04	0.10499E 05	0.97000E 04	0.45073E-07
0.25000E 02	0.13730E 00	-0.14990E-02	0.97000E 04	0.55180E 04	0.10499E 05	0.97000E 04	0.45073E-07

JCI	AJCI	TANG. ERROR
0.10000E 01	0.54921E-02	-0.13169E-02
0.20000E 01	0.10984E-01	-0.12944E-02
0.30000E 01	0.16476E-01	-0.12752E-02
0.40000E 01	0.21968E-01	-0.12593E-02
0.50000E 01	0.27460E-01	-0.12467E-02
0.60000E 01	0.32952E-01	-0.12372E-02
0.70000E 01	0.38444E-01	-0.12309E-02
0.80000E 01	0.43936E-01	-0.12277E-02
0.90000E 01	0.49428E-01	-0.12278E-02
0.10000E 02	0.54921E-01	-0.12310E-02
0.11000E 02	0.60413E-01	-0.12375E-02
0.12000E 02	0.65905E-01	-0.12476E-02
0.13000E 02	0.71397E-01	-0.12522E-02
0.14000E 02	0.76889E-01	-0.12602E-02
0.15000E 02	0.82381E-01	-0.12701E-02
0.16000E 02	0.87873E-01	-0.12825E-02
0.17000E 02	0.93365E-01	-0.12975E-02
0.18000E 02	0.98857E-01	-0.13157E-02
0.19000E 02	0.10435E 00	-0.13360E-02
0.20000E 02	0.10984E 00	-0.13585E-02
0.21000E 02	0.11533E 00	-0.13830E-02
0.22000E 02	0.12083E 00	-0.14095E-02
0.23000E 02	0.12632E 00	-0.14381E-02
0.24000E 02	0.13181E 00	-0.14682E-02
0.25000E 02	0.13730E 00	-0.14990E-02

CALCULATED FOURIER COEFFICIENTS FOR ERRORS

	AXIC	BRIC	C	KH
1	-0.1997923E-02	0.0	0.1997923E-02	0.0
2	-0.7584484E-04	-0.3095591E-03	0.3187149E-03	1.0000000
3	-0.4375001E-05	-0.2272174E-04	0.2313910E-04	2.0000000
4	-0.5979773E-04	-0.9571236E-04	0.1128566E-03	3.0000000
5	0.4939244E-05	-0.2052319E-04	0.2110918E-04	4.0000000
6	-0.5422770E-04	-0.4221746E-04	0.6872376E-04	5.0000000
7	0.1870019E-05	-0.2232479E-04	0.2240296E-04	6.0000000
8	-0.4757154E-04	-0.1511329E-04	0.4991455E-04	7.0000000

MESHING FREQUENCY IN CPS # 0.22881E 03

FC	FO	FE																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					

POWER SPECTRAL DENSITY FUNCTION

K	FR	GR	GKK	KH
0	0.0	-0.75325E-10	-0.22342E-10	0.0
1	0.28601E 04	-0.38641E-10	0.23034E 06	12.50000

CH-47 BEVEL SUN MESH USING TREGOLDS APP
 ROX./TRUE INVOLUTE GEARS JS
 TANG. FORCE = 9700.00 LB.

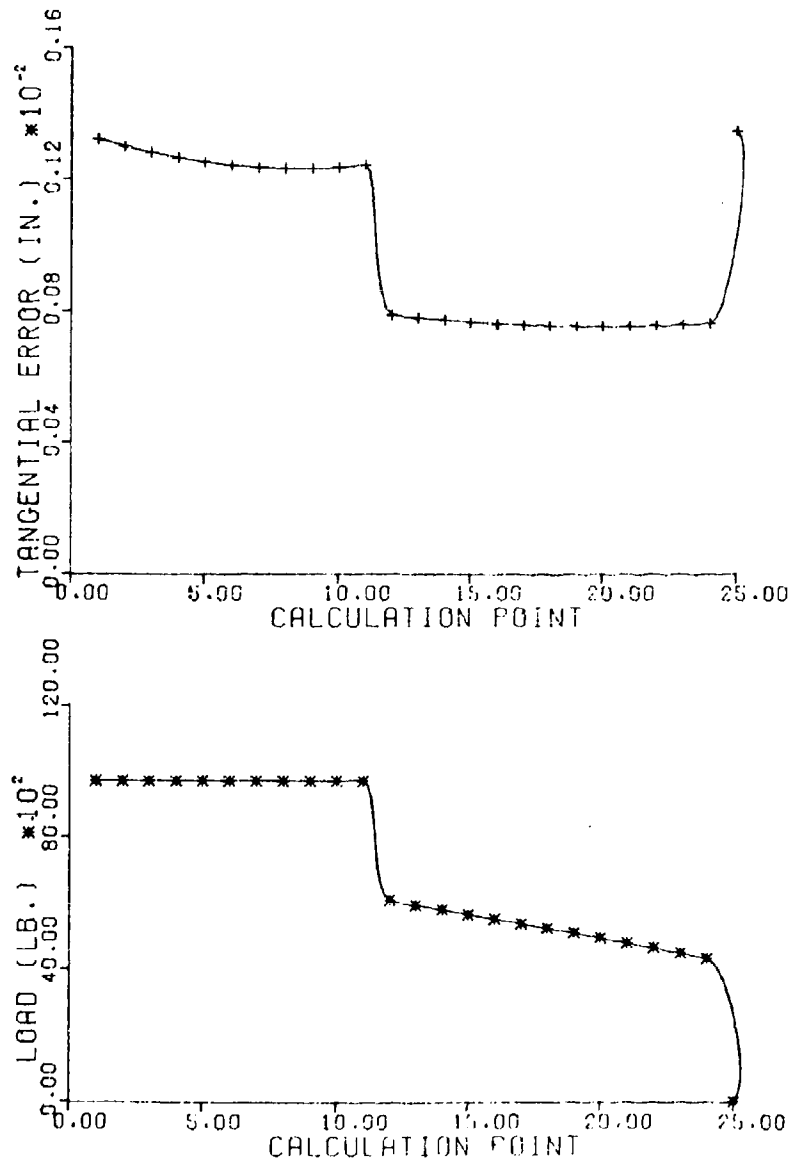


Figure 21. Continued.

CALCULATION OF GEAR MESH COMPLIANCE

In Reference 1, methodology is outlined in detail for approximately calculating the gear mesh compliance utilizing R-67 (GGEAR) output.

In Table 5, a worksheet is given for calculating the modified contact ratio using basic mesh data.

This modified contact ratio, along with GGEAR output data, is used to calculate the mesh compliance (Reference 1, page 156). An equivalent cross-sectional area must be calculated for input to the finite element model of the internal components. This calculation is shown in Table 6.

TABLE 5. CALCULATION OF MODIFIED CONTACT RATIO FOR
CH-47 FORWARD ROTOR TRANSMISSION SPIRAL
BEVEL GEARS

SYMBOL	DEFINITION	UNITS	PINTON [114D1044(12)]	GEAR [114D1053(13)]
A_o	OUTER CONE DISTANCE	INCHES	7.134	7.134
a_o	LARGE END ADDENDUM	INCHES	.297	.146
D	LARGE END PITCH DIAMETER	INCHES	7.550	13.276
F'	FACE WIDTH	INCHES	2.188	2.188
P_d	LARGE END DIAMETRAL PITCH	—	3.841	3.841
Γ	PITCH ANGLE	DEGREES	31° 39'	67° 21'
Γ_o	FACE ANGLE	DEGREES	34° 44'	69° 13'
θ	NORMAL PRESSURE ANGLE	DEGREES	22° 30'	22° 30'
ϕ	MEAN SPIRAL ANGLE	DEGREES	25° 00'	25° 00'
A	MEAN CONE DISTANCE = $A_o - (0.5)P'$	INCHES	6.100	6.100
σ	ADDENDUM ANGLE = $\Gamma_o - \Gamma$	DEGREES	3° 5'	1° 52'
a	MEAN ADDENDUM = $a_o - (0.5)P'(\tan \theta)$	INCHES	.238	.110
P	LARGE END TRANSVERSE CIRCULAR PITCH = π/P_d	—	.818	.818
P_n	MEAN NORMAL CIRCULAR PITCH = $(A/A_o)P(\cos \theta)$	—	.629	.629
P_z	FACTOR = $P_n/(\cos \theta)(\cos^2 \theta + \tan^2 \theta)$	—	.685	.685
R	MEAN TRANSVERSE PITCH RADIUS = $(D/2 \cos \Gamma)(A/A_o)$	INCHES	3.760	14.618
R_n	MEAN NORMAL PITCH RADIUS = $R/\cos \theta$	INCHES	4.578	17.796
R_{nN}	MEAN NORMAL BASE RADIUS = $R_n(\cos \theta)$	INCHES	4.229	16.442
R_{nN}	MEAN NORMAL OUTSIDE RADIUS = $R_n + a$	INCHES	4.816	17.907
ΔO	PROPORTIONAL LENGTH OF ACTION = $\sqrt{R_{nN}^2 - R_n^2} - R_n + a$	INCHES	.551	.283
Z_n	LENGTH OF ACTION IN MEAN NORMAL SECTION = $\Delta O_p + \Delta O_g$	INCHES	.835	.835
E_2	FACTOR = $P'/A_o [2 - (P'/A_o)/2(1 - P'/A_o)]$	—	.371	.371
N_p	TRANSVERSE CONTACT RATIO = $2/\sqrt{E_2}$	—	1.219	1.219
N_g	FACE CONTACT RATIO = $[(1.25 \tan \theta - 1)/\tan^2 \theta] A_o P_d / \pi$	—	1.505	1.505
N_o	MODIFIED CONTACT RATIO = $\sqrt{N_p^2 + N_g^2}$	—	1.936	1.936

TABLE 6. GEAR TOOTH COMPLIANCE CALCULATION

$$(q_{1-2})_{\text{MIN}} = (QJ1ABC + QJ2ABC) \text{ MIN} + QJD$$

$$(QJ1ABC + QJ2ABC) \text{ MIN} = 0.6248 \times 10^{-7} \text{ IN./LB}$$

$$QJD = 0.459319 \times 10^{-7} \text{ IN./LB}$$

$$(q_{1-2})_{\text{MIN}} = 0.1084 \times 10^{-6} \text{ IN./LB} = 0.1084 \mu \text{ IN./LB}$$

$$h = M-1 = 1.936-1 = 0.936$$

$$q_{R1} = \frac{(q_{1-2}) \text{ MIN}}{\cos^2 \psi \cos^2 \phi}$$

$$\psi = 25^\circ \quad \phi = 22.5^\circ$$

$$q_{R1} = \frac{0.1084}{\cos^2 \psi \cos^2 \phi} = 0.1546 \mu \text{ IN./LB}$$

$$q_{1-2} = q_{R1} (1-0.3h) = 0.1546(1-0.3(0.936))$$

$$q_{1-2} = 0.1112 \mu \text{ IN./LB}$$

$$k_{1-2} = \frac{1}{q_{1-2}} = 8.99 \times 10^6 \text{ LB/IN.}$$

$$\text{AREA} = A = \frac{Lk_{1-2}}{E} = \frac{10(8.99 \times 10^6)}{30 \times 10^6} = \underline{\underline{2.998 \text{ IN.}^2}}$$

PROGRAM DESCRIPTION

This program, which is based on a variation of the Holzer analysis, calculates the dynamic forces at a gear mesh. It can calculate system torsional resonances and dynamic tooth forces for a complex transmission system including planetary gears. The complete analysis is contained in Reference 2. The program source listing (Appendix D), input sheets, and a sample case have been included herein for completeness.

A gear system transmitting power is susceptible to torsional vibration since it possesses the necessary properties of rotational inertia, torsional elasticity, and a source of excitation. The inertia may be concentrated as in the body of a gear or distributed as in the shafting. Similarly, the elasticity (or compliance) may be concentrated as in a coupling or in the flexing gear teeth, or it may be distributed with the inertia in the shaft sections. As in any other torsionally vibrating system, the excitation may come from externally applied pulsating torques or from a fluctuating resistance to the steady rotation. However, in a geared system there is also an excitation due to displacement which comes from the imperfect transfer of motion between the meshing gears. Due to this excitation, the mating teeth at any point of excitation are subject to dynamic changes in relative motion, which can be achieved only if there is generated a dynamic force acting between the teeth to impose the necessary accelerations. This dynamic force, generated in response to the gear displacement excitation, can subject the gear teeth to greater loads than required for the steady transmission of power. In addition, it can become a factor in the generation of noise in the transmission system. The excitation, as well as the equivalent gear tooth compliance, is calculated from program GGEAR and used as input to TORRP.

Several features make the analysis sufficiently versatile to deal with a wide range of gear system designs. The analysis provides for branches in the vibrating system. It not only treats multiple cases of the simple gear set involving only one gear driving a second, but it can also treat multiple cases of one type of planetary gear set (the sun gear driving, the ring gear restrained, and the planet carrier transmitting the vibration to the balance of the system). Third, it includes the effects of externally applied damping such as might be developed at the bearings. The analysis presents the resulting dynamic gear tooth forces in a form giving their phase relationships as well as their magnitudes.

ORGANIZATION OF STATIONS WITHIN MAIN COMPUTER PROGRAM

The following provides a brief description of how to organize the data required to operate computer program - TORRP (R-32). Method of selecting and number stations will be presented.

Selection of Stations

Stations are established where one or more of the following descriptions apply:

- a. The free end of any portion of the system, including the end and beginning of the main system and the end of any branch.
- b. The point at which a concentrated inertia is acting. By concentrated inertia is meant an inertia which is not calculated by the program for given cylindrical dimensions.
- c. The point at which a concentrated compliance is connected to the inertia which precedes or follows it. This inertia may be either concentrated or of the distributed type calculated by the program.
- d. The point at which external constraints are applied to the system in the form of an elastic restraint or in the form of damping.
- e. Each member of a simple gear set, but without any stations between these two.
- f. The start and end of a planetary gear stage.
- g. Where inertias and compliances are to be computed by the program, at any point where there are changes in any of the diameters used to define the cylindrical portions of the system. Any noncylindrical portion, such as a tapered portion, may be approximated by converting it into a series of stepped diameters.

Numbering of Stations

The stations are numbered in accordance with the following procedure. Refer also to Figure 22.

- a. Select a "main system" which begins at a free end and trace a path through the system components until it reaches another free end. This path has the restriction that any branches which remain may not have further branching on themselves. Also, the path must enter each planetary stage through the sun gear. In Figure 22, which is a model of the closed-loop test stand and the

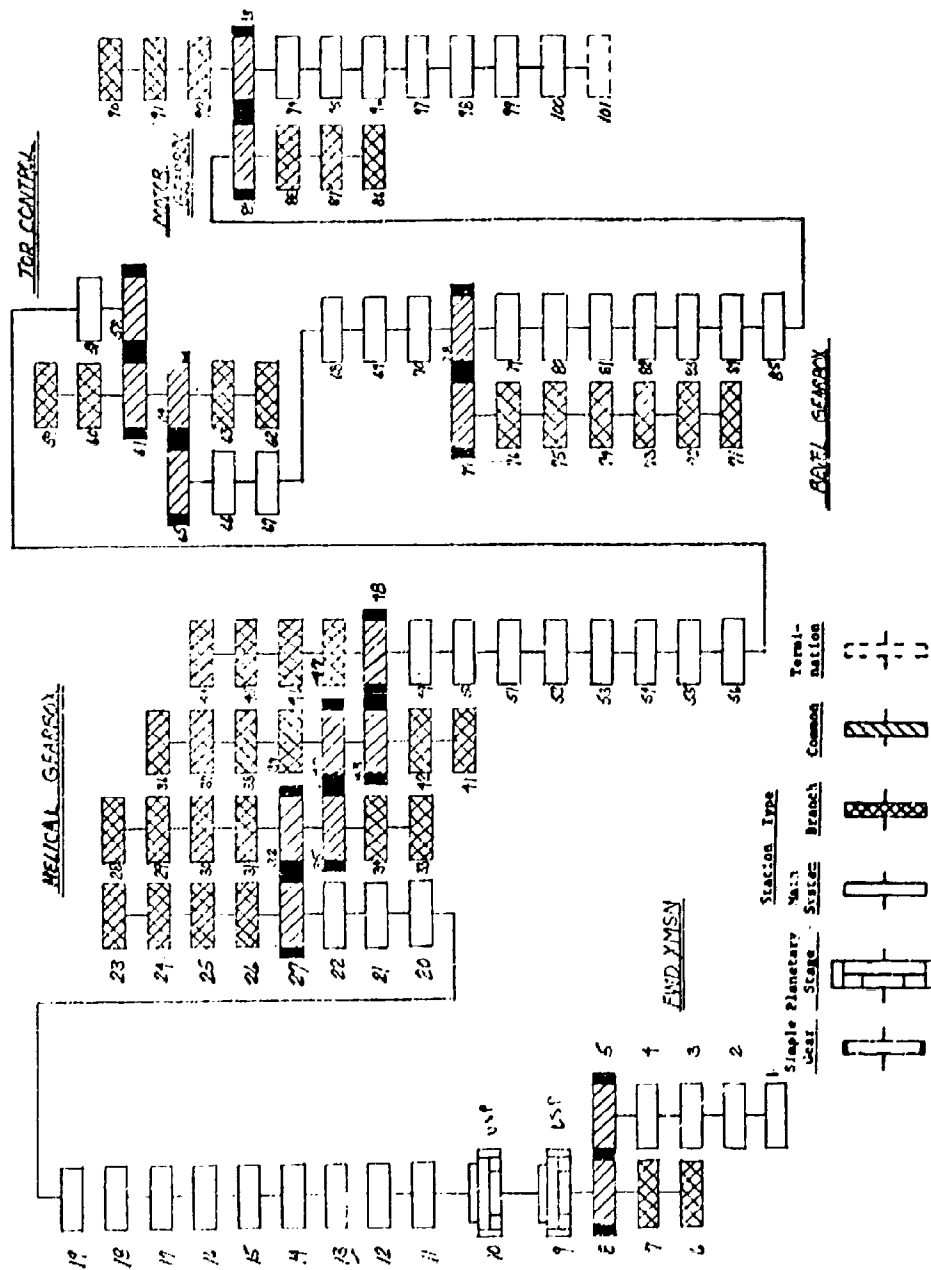


Figure 22. Schematic Diagram of Torsional System Model for CH-47 Forward Transmission and Closed-Loop Test Stand.

CH-47C forward transmission shown in Figure 23, the main system selected consists of the paths 1-5, 8-22, 27, 32, 35, 40, 43, 48-58, 61, 64-70, 78-85, 89, and 93-101.

- b. Start numbering the stations beginning with 1 at the starting free end, continuing in sequence until a common station with a branch is reached. Do not give the common station the next number. Instead, go to the free, far end of the branch, continuing the numbering sequence at this far end and numbering along the branch until the common is reached. The common then receives the next number, and numbering is continued along the main system. The same procedure is followed whenever another branch is encountered. The end of the main system receives the highest station number.

PROGRAM (R-32) INPUT FORMAT

A set of input sheets required to program R-32 is shown in Figure 24. A complete set of input data comprises data of nine distinct categories. Within these categories, cards which convey specific kinds of information are referred to as card types. Depending on the complexity of the problem, the input data set may contain none, one or several cards of a given type. The categories are listed below:

I	Title Card
II	Control Number Card
III	Rotor Material Properties Card
IV	Rotor Data Card
V	External Constraints Cards
VI	Simple Gear Set Data Cards
VII	Planetary Gear Stage Data Cards
VIII	Branch Data Cards
IX	Gear Excitation Data Cards

A description of the input variables, format and instructions for each card is given below.

Card 1 Title, Format (72H). This card precedes each set of input data.

- a. Printing instructions, column 1.
For printer to skip a line, use 0.
For printer to go to next sheet, use 1.
- b. Title, columns 2 through 72.

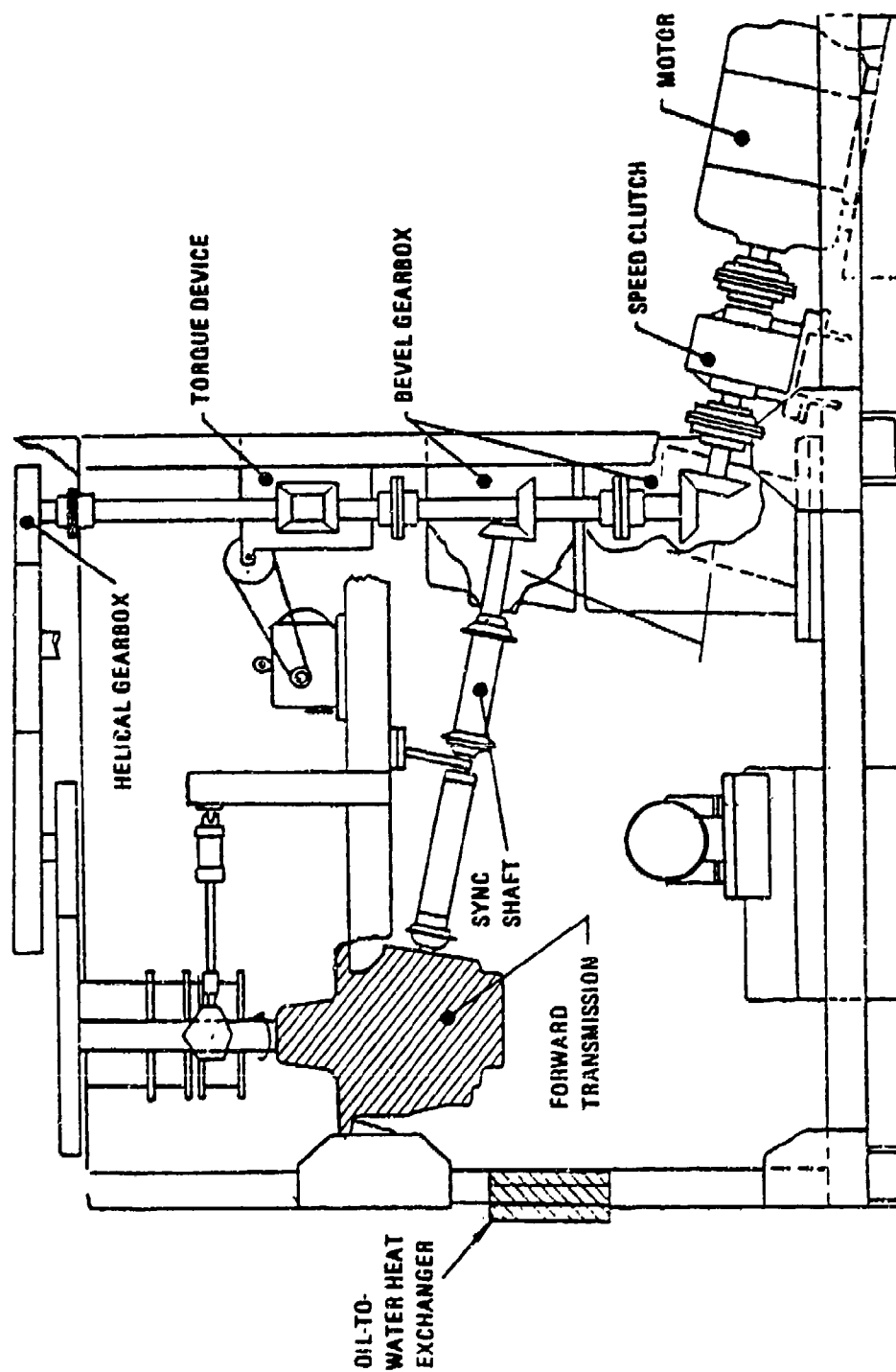


Figure 23. Schematic Diagram of Closed-Loop Test Stand.

First Item

R-32

PAGE ____ OF ____

TORSIONAL RESPONSE PROGRAM

TORRP

INPUT SHEETS

ENGINEER _____

DATE _____

PHONE _____

ALL NUMBERS RIGHT JUSTIFIED

TITLE - PLEASE PUNCH

CARD 0	2	72
1	Col. 1	

NO. OF STATIONS		NO. OF EXT. CONST.		NO. OF BRANCHES		NO. OF EXCITN.		END 0=MORE 1=LAST	#SIMPLE GEAR SETS	#PLANET GEAR SETS	MDIAG				
1	5	6	10	11	15	16	20	21	25	26	30	31	35	36	40
CARD 2															

MODULUS G LB/IN. ²		WEIGHT DENSITY LB/IN. ³	
6	17 18	29	
CARD 3			

Figure 24. TORRP (R-32) Input Sheet.

ALL NUMBERS RIGHT JUSTIFIED EXTERNAL CONSTRAINTS AND GEAR DATA

[illegible][illegible]

Figure 24. Continued.

GEAR EXCITATION DATA

[illegible]

Figure 24. Continued.

Card 2 Control numbers. Format (7I5).

- a. NS Total number of stations. ($NS \leq 200$)
Specification for selection of stations
given in earlier section. (Place last
digit in column 5.)
- b. NB Number of stations with external con-
straints, in the form of elastic
restraint or damping, both with respect
to ground. ($NB \leq NS$) (Place last
digit in column 10.)
- c. NBR Number of branches, without including
main system. ($NBR \leq 20$) (Place last
digit in column 15.)
- d. NMPG Total number of cases of gear excitation.
A change in station number, frequency,
or magnitude of either component consti-
tutes a separate case. In the planetary
stations, one pair of sun and ring
excitations of the same frequency
constitutes one case. Individual solu-
tions are found for each case, except
in the planetary stages. When there
are multiple excitations of the same
frequency at different points in the
system, the solutions for the individual
excitations must be combined outside
the program. (Place last digit in
column 20.)
- e. INP Specifies if this is the last complete
set of input data (column 25).
If more sets of input data follow, use 0.
If this is the last set, use 1.
- f. NSRG Number at simple gear sets. ($0 < NSRG$
 ≤ 20) Each set consists of two gears.
If an idler is used between two gears,
the combination must be represented by
two simple gear sets where the idler
is replaced by two connected gears with
no compliance between them and with a
total inertia equal to that of the
idler. Where one gear drives two or
more gears, each leading off to separate
branches, a similar conversion must be
made. If one gear drives through
multiple gears back into the main
system, in a so-called star arrangement,

the only treatment possible in this program is to combine the multiple intermediate gears into one composite gear, assuming that the excitations, if any, are torsionally synchronous. (Place the last digit in column 30.)

- g. NPLG Number of planetary gear stages
(NPLG $\leq$ 2) (column 35).

Card 3 Rotor material properties. Format (5X, 2E12.4).

- a. GM Shear modulus of elasticity, lb-in^2 . May be zero only if all values of RL in the rotor data are zero (columns 6 through 17).
- b. DENST Weight density, lb/in^3 . May be zero only if all values of RL in the rotor data are zero (columns 18 through 29).

Card 4-1 to 4-NS Rotor data. Format (I5, 6E12.4).

- a. NSTA Station number at or after which the rotor data apply. These must be given in numerical sequence with no omissions. (Place the last digit in column 5.)
- b. RIP Moment of inertia concentrated at station, lb-in^2 . This includes any inertia in the system which is not to be calculated by the program from dimensional data. At the stations for simple gear sets, list the inertias of both members in the rotor data. All planetary inertias are included only in the separate planetary data cards. The station which immediately follows the planetary may have its own inertia (columns 6 through 17).
- c. RL Length of uniform cylindrical shaft section between this station and the adjoining, higher-numbered station, in. At the station for the first member of a simple gear set and at the station for a planetary gear stage, use 0.0. At the terminating or last station, use 0.0 or 1.0 (columns 18 through 29).

- d. DST Outer diameter for stiffness calculation of the cylindrical shaft section, in. This diameter measures the section which transmits torque. If the actual shaft section is reduced as by a keyway, a diameter which approximates the reduced section should be used. At the station for the first member of a simple gear set and at the station for a planetary gear stage, use 0.0. At the terminating station, use 0.0 (columns 30 through 41).
- e. DMS Outer diameter for mass calculation of the cylindrical shaft section, in. This diameter measures the section which contributes inertia. It may include any assembled sleeves or hubs which extend the full distance and which rotate with the shaft. Use 0.0 for the special stations as described under DST (columns 42 through 53).
- f. DIN Inner diameter for both stiffness and mass calculation of the shaft section, in. If the shaft section is solid, use 0.0. Use 0.0 for the special stations as described under DST (columns 54 through 65).
- g. CCOM Concentrated compliance acting between this station and the adjoining, higher-numbered station, rad/in-lb. This compliance is separate from that calculated by the program from the dimensional data, and it can be used only when there are no such dimensional data between the same two stations. Any value listed as a concentrated compliance will enter into the computation only if RL = 0 for the same station. Use 0.0 for the special stations as described under DST. Concentrated compliances associated with any of the gears are included only in the special data cards for the particular type of gear stage (columns 66 through 77).

Cards 5-1 to 5-NB External constraints. Format (I5,
2E 12.4) (These cards are omitted in NB = 0)

- a. LB Station number at which the constraints are acting. These must be given in numerical sequence. (Place last digit in column 5.)
- b. BK External, torsional, elastic restraint acting at the station, expressed as a torsional stiffness, in-lb/rad. In an actual system which has steady rotation, the stiffness must be 0 if the restraint is to ground. If in such a rotating system the restraint is to an "infinite" but rotating mass, the stiffness may have any finite value (columns 6 through 17).
- c. BCB Coefficient of the external damping constraint acting at the station, in-lb-sec/rad (columns 18 through 29).
- d. DMP Coefficient of interstation damping, in-lb-sec/rad (columns 30 through 41).

Cards 6-1 to 6-NSRG Simple gear set data. Format (I5,
4E 12.4) (At least one card must be submitted.)

- a. LS Station number at which the first, or lower-numbered, member of the gear set is located. (The second member of the gear set is understood to be at the station LS+1, unless it serves as a common station to a branch. In this case, the second member has the number which completes the branch.) The simple gear set station numbers must be given in numerical sequence. (Place last digit in column 5.)
- b. RP Pitch radius of the first member of the gear set at station LS, in. (columns 6 through 17). Negative.
- c. RG Pitch radius of the second member of the gear set, in. (columns 18 through 29). Negative.
- d. SG Combined linear compliance of the two gears, tangential to their pitch circles, in/lb (columns 30 through 41). (From GGEAR Output, $A/2 W_t$.)

Cards 7-1-A, B, C to 7-NPLG-A, B, C Planetary gear stage data. (These cards are omitted if NPLG = 0. When they are included, they must appear in sets of three, and each set must be arranged in the order given.)

First card of set - A Planetary geometry. Format (I5, 3E 12.4)

- a. LEC Station number at the start of the planetary stage. This location of the station is at the connecting point to the sun gear, but the station does not include the sun gear. The sun gear and other planetary components, including the planet carrier, lie between this station and the one following it. (Place the last digit in column 5.)
- b. PN Number of planet gears in the planetary stage (columns 6 through 17). Do not omit decimal point.
- c. RS Pitch radius of the sun gear, in. (columns 18 through 29).
- d. RW Pitch radius of the planet gear, in. The pitch radius of the ring gear will be calculated within the program by adding double the planet radius to the sun radius (columns 30 through 41).

Second card of set -B Planetary inertias. Format (I5, 5E 12.4)

- a. IPL Station number of the planetary stage, the same as LEC. (Place the last digit in column 5.)
- b. PMS Weight on one planet gear, lb. This includes all components which rotate with the planet - everything between bearing surface and gear teeth. One-half the weight of any rolling elements in the bearing should be included (columns 6 through 17).
- c. PSP Moment of inertia of the sun gear, lb-in². This includes all components between the point of connection to the outside system and the gear teeth (columns 18 through 29).

- d. PIP Moment of inertia of each planet gear, lb-in². This includes all components used in computing the weight, PMS. (columns 30 through 41).
- e. PRP Moment of inertia of the ring gear, lb-in². This includes all components between the gear teeth and the point of elastic connection to ground. If the connection to ground is rigid, with zero compliance, any finite inertia may be used for the ring gear (columns 42 through 53).
- f. PCP Moment of inertia of the planet carrier, lb-in². This includes all components between the bearing surfaces in the planet gears and the point of connection to the outside system (columns 54 through 65).

Third card of set -C Planetary compliances. Format (I5, 5E 12.4)

- a. IPL Station number of the planetary stage, a repetition of the value in the previous card. (Place the last digit in column 5.)
- b. SS Combined linear compliance of each sun-planet gear mesh, tangential to its pitch circle, in-lb. If the sun gear construction is such that there is a significant compliance between the hub and the rim, the starting connection point to the sun gear should be defined as located at the rim. The hub would then be associated with the outside system as a separate station, with the structural compliance of the sun gear as a connecting concentrated compliance. In this case, the mesh compliance still appears under SS, but the sun gear inertia under PSP would be limited to that of the rim construction (columns 6 through 17) from GGEAR.
- c. SR Combined linear compliance of each planet-ring gear mesh, tangential to its pitch circle, in-lb (columns 18 through 29) from GGEAR.

- d. SW Linear compliance of the planet support in the planet carrier, tangential to the path of planet centers, in-lb. This compliance is the combination of the compliance of the planet bearing and the compliance of any portion of the carrier which will deflect with the individual planet. If the carrier construction is such that there is a compliance between a hub and a rim-type member which supports all the planets collectively, this structural compliance may be combined with the others to give a total planet carrier compliance. Alternatively, the system may be changed so that the end of the planetary stage, that is, its connection to the external system, is taken at the rim-type member. In this case, the hub becomes associated with the outside system as a separate station. The compliance between hub and rim then appears as a separate concentrated compliance between the station at the close of the planetary stage and the new station for the hub. With this change, the compliance used under SW is the combination of only the first two compliances mentioned above; namely, those associated with the individual planet (columns 30 through 41).
- e. Blank Columns 42 through 53 are not read in this main computer program.
- f. ST Angular compliance of the support between the ring and ground, rad/in-lb. If the ring is rigidly connected to ground, set this compliance equal to zero (columns 54 through 65).

Cards 8-1 to 8-BR Branch data. Format (2I5) These cards are omitted if BR = 0.)

- a. LBR Number of the first or free end station of the branch. (Place the last digit in column 5.)
- b. LBS Number of the common station of the branch at which it is connected to the main system. (Place the last digit in column 10.)

Cards 9-1 to 9-NMPG Gear excitation data. Format (I5,
6E 12.4) (These cards may be submitted in any order.)

- a. IT Station number which identifies the
 gears at which the excitation is intro-
 duced. For simple gear sets, the
 number of the first member is used, as
 for LS in card 6. For planetary gear
 stages, the station number at the
 start of the planetary is used, as for
 LEC in card 7-A. (Place the last digit
 in column 5.)
- b. FFQ Frequency of the excitation, cps.
 (TE1) (TE1 is used for temporary storage.)
 (columns 6 through 17.)
- c. AXY The real or cosine component of the
 or linear excitation in the simple gear
 AXY1 set (AXY) or in the sun-planet mesh
 (TE2) of the planetary gear stage (AXY1),
 in. This excitation is introduced at
 the gear mesh tangential to the pitch
 circles. (TE2 is used for temporary
 storage.) (columns 18 through 29.)
- d. BXY The imaginary or sine component of the
 or linear excitation described above,
 BXY in. (columns 30 through 41).
 (TE3)
- e. AXY2 The real or cosine component of the
 (TE4) linear excitation in the planet-ring
 mesh of the planetary gear stage, in.
 This excitation is introduced at the
 gear mesh tangential to the pitch
 circles. On a card with excitation for
 a simple gear set, this field is left
 blank. (TE4 is used for temporary
 storage.) (columns 42 through 53)
- f. BXY2 The imaginary or sine component of the
 (TE5) linear excitation described just above,
 in. (columns 54 through 65).

PROGRAM OUTPUT

The output data generated from program R-32 is shown in Figure 25, along with the input data previously described. This procedure provides a complete record of the computer run. Key output variables from R-32 are discussed briefly below.

Tabulation of Input Data

1. Title - as in input card 1.
2. Control numbers - NS, NB, NBR, NMPG, INP, NSRG, NPLG, as in input card 2.
3. Rotor material properties - GM, DENST, as in input card 3.
4. Rotor data - NSTA, RIP, RL, DST, DMS, DIN, CCOM, as in input card 4.
5. External constraint data - LB, BK, BCB, as in input card 5.
6. Simple gear set data - LS, RP, RG, SG, as in input card 6.
7. Planetary gear stage data - LEC, PN, RS, RW, IPL, PMS, PSP, PID, PRP, PCP, SS, SR, SW, Blank, ST, as in input card 7.
8. Branch data - LBR, LBS, as in input card 8.
9. Excitation data - IT, FFO, AXY or AXX1, BXY or BXY1, AXY2, BXY2, as in input card 9. Each set of excitation data is given separately followed by its own calculated response.

Calculated Data

Computed response at each simple gear set - LS, TTFR, TTFE

where LS - Station number identifying the simple gear set.

TTFR - Real or cosine component of the dynamic tangential tooth force developed at the gear mesh, lb.

TTFE - Imaginary or sine component of the same force, lb.

```

//BVE053P  .D YNEV746CR3200.000000.2054.3-01.95.9999.2.60.1356
OCH-47 SPINAL REVEL GEAR MESH R32 BADGLEF
53 0 05 1 1 2 2
11.32E6 .281
1 652.9 1.0 4.12 4.12 0.0 0.0
2 0.0 1.56 3.54 5.512 0.0 0.0
3 0.0 4.25 3.348 5.214 0.0 0.0
4 46.3 3.828 3.0 3.0 0.0 0.0
5 101.658 26.86 4.346 4.337 4.25 0.0
6 46.388 26.68 4.346 4.337 4.25 0.0
7 89.388 1.15 2.10 2.1 0. 0.0
8 0.0 2.04 2.10 2.1 0. 0.0
9 0.0 0.81 2.10 2.1 0. 0.0
10 0.0 2.20 4.32 4.75 3.6 0.0
11 0.0 0.97 4.32 4.65 3.6 0.0
12 0.0 1.50 4.32 4.95 3.6 0.0
13 0.0 3.28 4.50 5.3 3.6 0.0
14 0.0 0.75 7.00 7.0 0. 0.0
15 0.3653 2.2 3.16 3.16 2.9 0.0
16 72.3 0. 0.00 0. 0. 0.0
17 0.216 0.95 0.86 0.86 0.62 0.0
18 0.1293 1.00 2.50 2.50 2.14 0.0
19 0.1293 9.00 0.64 0.64 0.50 0.0
20 0.174 3.4 0.64 0.64 0.50 0.0
21 4.199 4.20 3.00 3.3 2.50 0.0
22 26.20 0.93 3.60 3.60 0. 0.0
23 0. 2.50 4.10 4.10 0. 0.0
24 0. 0.47 4.30 4.30 0. 0.0
25 568.0 1.0 6.00 6.0 0. 0.0
26 0. 2.3 6.00 6.0 0. 0.0
27 0.0 0.0 0.00 0.0 0.0 0.0
28 0.0 0.0 0.00 0.0 0.0 0.0
29 0.0 7.08 6.90 6.9 6.1 0.0
30 0.0 11.9 5.86 6.6 4.7 0.0
31 0.0 11.5 5.30 5.3 3.4 0.0
32 2148.743 7.955 8.625 11.22 3.25 0.0
33 2656.536 1.235 11.251 13.109 0.0 0.0
34 0.0 2.0 10.919 10.919 0.0 0.0
35 0.0 10.88 8.178 9.0 0.0 0.0
36 51673.308 21.406 18.25 18.25 16.624 0.0
37 51673.308 15.75 8.178 9.00 0.0 0.0
38 0.0 3.0 8.25 8.25 0.0 0.0
39 0.0 2.75 9.333 9.333 0.0 0.0
40 0.0 4.62 9.752 12.7967 0.0 0.0
41 0.0 1.53 6.986 6.986 0.0 0.0
42 0.0 2.03 7.483 10.433 0.0 0.0
43 0.0 0.69 8.25 8.25 0.0 0.0
44 0.0 1.0 11.50 11.5 0.0 0.0
45 4.8056E6 0.0 0.00 0.0 0.0 0.0
46 0.0 1.4 5.834 5.834 0.625 0.0
47 0.0 2.6 6.30 9.3425 0.0 0.0
48 0.0 0.69 7.04 7.04 0.0 0.0
49 0.0 0.87 9.00 9.0 0.0 0.0
50 62347.3 11.75 8.02 20.0 0.0 0.0
51 0.0 1.44 5.89 6.758 0.0 0.0
52 0.0 6.62 7.00 9.218 0.0 0.0
53 72786.6 0.0 0.00 0.0 0.0 0.0
16 3.201 -5.629 0.1126E-06
45 35.227 -10.0155 0.0153E-06
27 4.0 2.8 03.9
27 14.3 34.7 117.8 2660.0 1218.
27 0.1717E-06 0.1866E-06 00.10 E-05 0.0
28 6.0 4.0 03.3
28 13.75 254. 110. 4780. 4050.
28 .874E-7 .8915E-7 .5E-6 0.0

```

Figure 25. Sample Output for R-32 Torsional Response.

17 25
 41 45
 46 50
 51 53
 16 117.66 16.35070E-6 0.

CH-47 SPIRAL PLEVEL GEAR MESH R32 BADGLEY

TORSIONAL RESPONSE OF THE SYSTEM WITH GEARS, EPICYCLIC GEARS AND BRANCHES PN408.

STATIONS PRG+EXT.COV. BRANCHES NO.OF FRQ INP SETS SR GEARS PL GEARS

SHEAR MOD. WT. DENSITY
 LRS/IN**2 LRS/IN**3
 0.115200 00 0.281000 00

ROTOR DATA

STA NO.	MOD. INERT. LRS-IN**2	LENGTH IN	STIFFN. DIA IN	MASS DIA IN	INNER DIA IN	CONC. COMPL. RAD/IN-LB
1	0.652900 03	0.100000 01	0.412000 01	0.412000 01	0.0	0.0
2	0.0	0.156000 01	0.354000 01	0.551200 01	0.0	0.0
3	0.0	0.425000 01	0.334000 01	0.521600 01	0.0	0.0
4	0.463000 02	0.382800 01	0.300000 01	0.300000 01	0.0	0.0
5	0.101660 03	0.254600 02	0.434600 01	0.433700 01	0.425000 01	0.0
6	0.463800 02	0.266800 02	0.434600 01	0.433700 01	0.425000 01	0.0
7	0.493880 02	0.115000 01	0.210000 01	0.210000 01	0.0	0.0
8	0.0	0.204000 01	0.210000 01	0.210000 01	0.0	0.0
9	0.0	0.810000 00	0.210000 01	0.210000 01	0.0	0.0
10	0.0	0.220000 01	0.432000 01	0.475000 01	0.360000 01	0.0
11	0.0	0.970000 00	0.432000 01	0.465000 01	0.360000 01	0.0
12	0.0	0.158900 01	0.432000 01	0.495000 01	0.360000 01	0.0
13	0.0	0.328000 01	0.450000 01	0.530000 01	0.360000 01	0.0
14	0.0	0.750000 00	0.700000 01	0.700000 01	0.0	0.0
15	0.365300 00	0.220000 01	0.316000 01	0.316000 01	0.290000 01	0.0
16	0.723000 02	0.0	0.0	0.0	0.0	0.0
17	0.216000 00	0.950000 00	0.860000 00	0.860000 00	0.520000 00	0.0
18	0.129300 00	0.190000 01	0.250000 01	0.250000 01	0.214000 01	0.0
19	0.129300 00	0.900000 01	0.640000 00	0.640000 00	0.500000 00	0.0
20	0.174000 00	0.340000 01	0.640000 00	0.640000 00	0.500000 00	0.0
21	0.419900 01	0.420000 01	0.300000 01	0.330000 01	0.250000 01	0.0
22	0.262000 02	0.930000 00	0.360000 01	0.360000 01	0.0	0.0
23	0.0	0.250000 01	0.410000 01	0.410000 01	0.0	0.0
24	0.0	0.470000 00	0.430000 01	0.430000 01	0.0	0.0
25	0.568000 03	0.100000 01	0.600000 01	0.600000 01	0.0	0.0
26	0.0	0.230000 01	0.600000 01	0.600000 01	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.708000 01	0.690000 01	0.690000 01	0.610000 01	0.0
30	0.0	0.119000 02	0.586000 01	0.600000 01	0.470000 01	0.0
31	0.0	0.115000 02	0.530000 01	0.530000 01	0.340000 01	0.0
32	0.214870 04	0.795500 01	0.562500 01	0.112200 02	0.325000 01	0.0
33	0.265650 04	0.123500 01	0.112510 02	0.131090 02	0.0	0.0
34	0.0	0.200000 01	0.109190 02	0.109190 02	0.0	0.0
35	0.0	0.105800 02	0.817800 01	0.900000 01	0.0	0.0
36	0.516730 05	0.214060 02	0.182500 02	0.182500 02	0.166240 02	0.0
37	0.516730 05	0.157500 02	0.817800 01	0.900000 01	0.0	0.0
38	0.0	0.300000 01	0.825000 01	0.825000 01	0.0	0.0
39	0.0	0.275000 01	0.933300 01	0.933300 01	0.0	0.0
40	0.0	0.462000 01	0.975200 01	0.127970 02	0.0	0.0
41	0.0	0.153000 01	0.698500 01	0.698500 01	0.0	0.0
42	0.0	0.203000 01	0.744300 01	0.104330 02	0.0	0.0
43	0.0	0.690000 00	0.825000 01	0.825000 01	0.0	0.0
44	0.0	0.100000 01	0.115000 02	0.115000 02	0.0	0.0
45	0.48560 07	0.0	0.0	0.0	0.0	0.0
46	0.0	0.140000 01	0.583400 01	0.583400 01	0.625000 00	0.0
47	0.0	0.260000 01	0.630000 01	0.934250 01	0.0	0.0
48	0.0	0.690000 00	0.704000 01	0.704000 01	0.0	0.0

49	0.0	0.870000	00	0.900000	01	0.900000	01	0.0	0.0
50	0.523470	05	0.117500	02	0.802000	01	0.200000	02	0.0
51	0.0	0.144000	01	0.582000	01	0.675800	01	0.0	0.0
52	0.0	0.662000	01	0.700000	01	0.921800	01	0.0	0.0
53	0.727860	06	0.0	0.0	0.0	0.0	0.0	0.0	0.0

SINGLE REDUCTION GEAR DATA

STA GEAR SET RADII (IN.) COMBINED TANGENTIAL COMPLIANCES

FIRST GEAR SECOND GEAR (IN/LB)

16	0.320100	01-0.562900	01	0.112600-06
45	0.352270	02-0.100160	02	0.153900-07

PLANETARY SET DATA

STA	NO. OF	SUN	PLANET
NO.	PLANETS	RADIUS(IN)	RADIUS(IN)
27	0.400000	01	0.280000 01 0.390000 01

STA	WEIGHT(LB)	POLAR MASS	MOMENTS OF INERTIA (LBS-IN**2)
NO.	PLANET	SUN	PLANET RING CARRIER
27	0.143800	02-0.747000	02 0.117400 03 0.266600 04-0.121800 04

STA	COMPLIANCE- LINEAR(IN./LB)	COM-ANG(RAD/LB)
NO.	SUN-PLANET-PLANET-RING-PLAN-CAR.	RING-GROUND
27	0.17170-06 0.19660-05 0.10000-05	0.0

STA	NO. OF	SUN	PLANET
NO.	PLANETS	RADIUS(IN)	RADIUS(IN)
28	0.600000	01	0.400000 01 0.330000 01

STA	WEIGHT(LB)	POLAR MASS	MOMENTS OF INERTIA (LBS-IN**2)
NO.	PLANET	SUN	PLANET RING CARRIER
28	0.137500	02-0.254800	03 0.110000 03 0.478800 04-0.405900 04

STA	COMPLIANCE- LINEAR(IN./LB)	COM-ANG(RAD/LB)
NO.	SUN-PLANET-PLANET-RING-PLAN-CAR.	RING-GROUND
28	0.87400-07 0.89150-07 0.50000-06	0.0

BRANCHES	FOR FND	COMMON
15	16	
17	25	
41	45	
46	50	
51	53	

SINGLE REDUCTION GEAR- LINEAR EXCITATION (IN.)

STA	FREQUENCY	REAL	IMAGINARY
16	0.117660	03 0.163510-04	0.0

COMPUTED RESPONSE AT SIMPLE GEAR SET

STA TANGENTIAL TOOTH FORCE (LBS)

	REAL	IMAGINARY
16	0.107860	02 0.0
45	0.203850	02 0.0

COMPUTED RESPONSE AT PLANETARY GEAR SETS

TANGENTIAL TOOTH FORCE AT EACH PLANET (LBS)

STA	SUN-PLANET	RING-PLANET
NO.	REAL IMAGINARY	REAL IMAGINARY
27	0.127040 01 0.0	0.631200 00 0.0
28	0.365210-01 0.0	-0.216070 00 0.0

Computer response at each planetary gear stage - LEC, C1, C2, C3, C4

where LEC - Station number identifying the planetary gear stage.

- C1 - Real component of the dynamic tangential tooth force developed at the sun-planet gear mesh, lb.
- C2 - Imaginary component of the same force, lb.
- C3 - Real components of the dynamic tangential tooth force developed at the planet-ring gear mesh, lb.
- C4 - Imaginary component of the same force, lb.

This program R-32 is written in FORTRAN II - extended and may be compiled with FORTRAN IV. In the source deck listing shown in Appendix D, the READ and WRITE statements are written with the variable NR = 5 to specify the standard reading unit and the variable NW = 6 to specify the standard writing unit. To recompile the program for any nonstandard computer, introduce the required unit numbers, making the necessary changes on the cards as noted in the listing.

In addition to the controlling portion of this torsional response program, named TORRP, there are other subroutines. One, named PLNST, treats the planetary stage. Another, named MATIN, performs the matrix inversion that solves the simultaneous equations of the PLNST subroutine. Another, named BLOOP, applies to the branch treatment. The others, named CDIV, CDIV2, PANGF, AMPF, CAD, CSUB and CMPY, perform arithmetic operations.

COMPLEX STRUCTURAL DYNAMIC ANALYSIS COMPUTER PROGRAM
USING STIFFNESS METHODS (D-82/C-51)

PROGRAM DESCRIPTION

Program D-82 calculates the natural frequencies and mode shapes of a complex structure composed of axial members, skins (membrane triangular), and beams. The program builds a stiffness matrix on tape of maximum order 3000 utilizing up to 5000 structural elements and 999 node points and 3 different materials. Using matrix arithmetic and assuming lumped masses, the stiffness matrix is reduced to a matrix of order 215. The dynamic matrix is formed using the masses, and natural frequencies and mode shapes are found. The program is completely general and may be used for most types of elastic systems. Axial, torsional, and bending motions may also be coupled by skewing the beam orienting node.

The input is composed of node points and their coordinates, structural elements including axials (areas), skins (thicknesses) and beams (moment of inertia, torsional moment of inertia and shear area), and masses for all degrees of freedom. The output includes the printout of the input, the initial gross stiffness matrix, the reduced stiffness matrix, the flexibility and dynamic matrices, and the eigenvalues and eigenvectors (natural frequencies and mode shapes). The mode shapes, as an option, may be used to calculate the damped forced response using program C-51. Vibratory loads are also calculated.

The C-51 program is a normal mode solution method which calculates vibration levels from external harmonic loads. In the solution, the natural modes from the D-82 analysis are used as generalized coordinates for representing the dynamic system. By simulating structural damping, the resulting second order nonhomogenous differential equations are solved. From these equations the program computes the response for each mode for sine and cosine forcing functions and obtains the total responses by a summation of the modal contributions. The maximum number of degrees of freedom is 215 and the maximum number of mode shapes is 30. The input of C-51 is in a standard loader format so that various cases may be run simultaneously and consists of a D-82 mode shape tape, exciting frequency, the eigenvectors desired, modal damping, and phased oscillatory forces and moments. The output of C-51 consists of a listing of the input plus the exciting frequency, forcing frequency ratios, amplification factors, modal phase angles, modal amplitudes, sine/cosine components, the resultants, phase angles and the "G" loading. In addition, vibratory forces and moments are calculated.

PROCEDURE FOR PREDICTING DAMPED FORCED RESPONSE

Helicopter vibration traceable to rotor excitation is of primary concern in the analysis of the airframe. Much effort has been expended on the development of computer techniques which assist in the design of structures with acceptable vibration levels. These procedures, initiated for the structure, are also applicable to the transmission system. The Unified Structural Analysis (or Damped Force Response) Computer Program (D-82) developed by J. Sciarra for the dynamic analysis of a helicopter fuselage has been extended for this purpose (References 17 and 18).

This program is capable of calculating the dynamic characteristics for a large complex structure. A typical helicopter transmission analytical model contains many structural elements, and the important elements of any analysis are:

1. Generation of a finite element structural idealization and discrete mass model.
 2. Formulation of the internal components system stiffness matrix.
 3. Reduction in the stiffness matrix of the unloaded nodal degrees of freedom to the loaded nodal degrees of freedom (mass points).
 4. Dynamic matrix generalization combining mass and stiffness properties.
 5. Determination of eigen solution.
 6. Calculation of dynamic tooth loads from system torsional response analysis.
 7. Formulation of dynamic equations and determination of a nodal representation of the transmission.
 8. Solution for the damped response to be associated with the vibratory tooth loads.
-
17. Sciarra, J.J., A COMPUTER METHOD FOR DYNAMIC STRUCTURAL ANALYSIS USING STIFFNESS MATRIXES, Journal of Aircraft, Vol. 6, No. 1, January-February 1969.
 18. Sciarra, J.J., USE OF THE FINITE ELEMENT DAMPED FORCED RESPONSE STRAIN ENERGY DISTRIBUTION FOR VIBRATION REDUCTION, Presented at the ARO-D Military Theme Review, The Helicopter and V/STOL Aircraft Research Conference, Moffett Field, California, September 1972.

The damped forced response of a multi-degree-of-freedom system is the normal mode solution to the following matrix equation:

$$\begin{aligned} [M] \{\dot{X}\} + [C] \{\dot{X}\} + [K] \{X\} &= \{F_s\} \sin \Omega t \\ &+ \{F_c\} \cos \Omega t \quad (63) \end{aligned}$$

where $[M]$ = mass matrix
 $[C]$ = damping matrix
 $[K]$ = stiffness matrix
 $\{F_c\} \{F_s\}$ = sine or cosine component of the exciting loads - lb, in.-lb
 $\{X\}$ =, displacement-inches, rotation-radians
 Ω = exciting frequency - rad/sec
 t = time - sec

It is well known that the solution of the previous equation is

$$\{X\} = \{X_s\} \sin \Omega t + \{X_c\} \cos \Omega t.$$

where $\{X_s\}, \{X_c\}$ = sine or cosine components of the displacement (or rotation) of the nodes of the structural element, inches, radians

Stiffness Method

Consider a complex structure, i.e., a transmission system, which for analysis will be idealized. Thus, junction or node points are selected where structural members meet, and such points will possess six degrees of freedom. Assume these latter members to be axial (resisting tension or compression), skin (resisting shear), and beams (opposing bending), such that each element contributes stiffness to the node at which it is attached. If forces or moments are applied to this structure, deflections or rotations will occur. The resulting set of simultaneous equations represent continuity and equilibrium of the collection of junctions and may be written as

$$F_i = \sum_{j=1}^n K_{ij} X_j \quad (i=1,2,\dots,n)$$

where n = number of degrees of freedom.

or, in matrix form,

$$\{F\} = [K] \{X\} \quad (64)$$

From physical consideration it may be shown that

$$K_{ij} = K_{ji}.$$

Dynamic Considerations

From equation (63), we may obtain the differential equations expressing the undamped free vibration of a system; thus,

$$[M] \{\ddot{X}\} + [K] \{X\} = 0 \quad (65)$$

Assuming a harmonic solution, it may be shown that equation (65) may be reduced to the form

$$[M^{-1}K - \lambda] \{X\} = 0$$

where λ = natural frequency squared (eigenvalue)

Utilization of the $M^{-1}K$ - matrix to ascertain the eigenvalues is cumbersome and numerically unpredictable; hence, an artifice known as reduction is employed to circumvent this difficulty. Partitioning equation (64), we may write

$$\begin{Bmatrix} F_1 \\ F_2 \end{Bmatrix} = \begin{bmatrix} K_{11} & K_{12} \\ K_{21} & K_{22} \end{bmatrix} \begin{Bmatrix} X_1 \\ X_2 \end{Bmatrix} \quad (66)$$

Then by lumping masses and moments of inertia at only " F_1 " degrees of freedom, the inertia forces and torques at the " F_2 " degrees of freedom are zero; equation (66) may be shown to yield

$$\{F_1\} = [K_{11} - K_{12} K_{22}^{-1} K_{21}] \{X_1\}$$

This technique, known as the reduction process, still admits deflections and rotations at the X_2 's, and all stiffness contributions of the original K -matrix are included at the loaded nodes. However, the procedure yields a smaller dynamic matrix from which the system eigenvalues and eigenvectors are obtainable.

The collection of eigenvectors arranged in columns is called the modal matrix, $[\phi]$; hence, we let

$$\{x\} = [\phi] \{a\} \quad (67)$$

where ϕ = modal matrix (of order j by i)

a = modal displacements in row " i "

Then, by using equation (67) and premultiplying equation (65) by the transpose of the modal matrix, we have

$$[\phi^T M] \{\ddot{a}\} + [\phi^T K] \{a\} = 0$$

Assuming a harmonic solution, we find the matrix form of Rayleigh's quotient,

$$\lambda [\phi^T M \phi] = [\phi^T K \phi] \quad (68)$$

Now, if the eigenvalues are distinct, it may be shown that $\phi^T M \phi$ is a diagonal matrix. This diagonal matrix is called the effective mass matrix and by definition,

$$M_{\text{eff}} = \phi^T M \phi \quad (\text{a diagonal matrix}) \quad (69)$$

Substituting equation (69) into equation (68), we have

$$\phi^T K \phi = \lambda M_{\text{eff}} = K_{\text{eff}}$$

where K_{eff} = effective-stiffness matrix (a diagonal matrix)

Damped Forced Response due to Phased Excitation

Equation (63) represents the matrix equation for a complex structure. Premultiplying this equation by ϕ^T and introducing equation (67), we obtain

$$\begin{aligned} & [\phi^T M \phi] \{\ddot{a}\} + [\phi^T C \phi] \{\dot{a}\} + [\phi^T K \phi] \{a\} \\ &= \{\phi^T F_s\} \sin \Omega t + \{\phi^T F_c\} \cos \Omega t \end{aligned} \quad (71)$$

Assuming modal damping, we may write

$$[\phi^T C \phi] = [2 \xi_i M_{\text{eff}} \lambda^{1/2}] = [C_{\text{eff}i}] \quad (72)$$

where ξ_i = critical modal damping coefficient

$C_{\text{eff}i}$ = effective-damping matrix (a diagonal matrix)

Further, let us define

$$\begin{aligned} \{F_{\text{eff } s}\} &= \{\phi^T F_s\} \\ \{F_{\text{eff } c}\} &= \{\phi^T F_c\} \end{aligned} \quad (73)$$

Substituting equations (69), (70), (72), and (73) into equation (71), we have

$$\begin{aligned} [M_{\text{eff } i}] \{\ddot{a}_i\} + [C_{\text{eff } i}] \{\dot{a}_i\} + [K_{\text{eff } i}] \{a_i\} = \\ \{F_{\text{eff } s_i}\} \sin \Omega t + \{F_{\text{eff } c_i}\} \cos \Omega t \end{aligned} \quad (74)$$

If it is assumed that the undamped natural frequency equals the damped natural frequency, because of small structural damping, and since equations (67), (70), and (72) are diagonal, then equation (74) represents a set of uncoupled, second order, differential equations.

It may be shown that the solutions of equation (74) are given by

$$\{a_i\} = \{G_i\} \sin \Omega t - \{H_i\} \cos \Omega t \quad (75)$$

$$\text{where } \{G_i\} = \{R_{s_i} \cos \phi_i + R_{c_i} \sin \phi_i\}$$

$$\{H_i\} = \{R_{s_i} \sin \phi_i - R_{c_i} \cos \phi_i\}$$

$$R_{s_i} = \mu_i F_{s_i} / K_{\text{eff } i}$$

$$R_{c_i} = \mu_i F_{c_i} / K_{\text{eff } i}$$

$$\phi_i = \text{TAN}^{-1} \left[2 \{ \beta_i \} / (1 - \beta_i^2) \right]$$

$$\mu_i = 1 / \left[(1 - \beta_i^2)^2 + (2 \{ \beta_i \})^2 \right]^{1/2}$$

$$\beta_i = \Omega / \sqrt{\lambda}$$

Therefore, by equations (67) and (75) the rotations and displacements are expressible as

$$\{x_i\} = \{P_j\} \sin \Omega t - \{S_j\} \cos \Omega t \quad (76)$$

$$\text{where } P_j = \phi G_i$$

$$S_j = \phi H_i$$

Employing trigonometric relations, equation (76) may be written in the form,

$$\{X_i\} = \left\{ (P_j^2 + S_j^2)^{1/2} \sin(\Omega t - \psi_j) \right\}$$

$$\text{where } \psi_j = \tan^{-1} (S_j / P_j)$$

To complete the analysis of the internal components, the total displacements of the structure are found corresponding to the dynamic tooth forces. These loads are determined by the torsional response computer program TORRP (R-32), in which the exciting frequencies are taken to be multiples of the mesh frequencies.

COMPUTER MODELING OF DYNAMIC COMPONENTS

Modeling of the dynamic components of the system is an involved, lengthy procedure. It is important to remember that growth and improvements should be provided for in the development of the model. The procedure for modeling shafts in the Unified Structure Analysis Program (D-82), which is a finite element analysis, is outlined below:

1. Shafts are divided into small cylindrical sections, and the lengths of these sections are determined by the variation of the shaft diameter. Conical sections are also divided into small cylinders which vary in a discontinuous manner.
2. Physical properties (mass, inertia, cross-sectional area, etc.) are calculated for each individual cylinder.
3. Masses and polar moments of inertia are averaged between adjacent stations, if computer capacity allows; otherwise, an equivalent mass and inertia are fixed to selected positions along the shaft length.
4. Gear meshes are represented by four masses located at the appropriate pitch diameter. It is important, however, that the mass concentrated at the gear nodes be representative of the actual mass distribution. These masses are connected to the main shaft by beams exhibiting elastic properties similar to the actual gears. Additional beams are provided to insure that the four masses remain at equal distance from one another.
5. Radial stiffness of bearings is included in the analysis by pairs of linear and torsional springs. To allow for nonuniform stiffness characteristics, two mutually perpendicular springs of different stiffness are required at

each bearing location. Thrust stiffness is represented by a linear spring acting in the axial direction. These stiffnesses are a function of torque and were calculated on the basis of a scheme developed by A. B. Jones (Reference 19).

6. Contacting gears are represented by a spring exhibiting an elastic behavior similar to the tooth stiffness as calculated by Computer Program GGEAR (R-67).
7. A synchronizing shaft is modeled as a torsional spring determined by the geometry of the device.
8. Existence of planetary stages is represented by a torsional spring whose stiffness is extracted from the Computer Program TORRP (R-32).
9. The four planets of the lower stage planetary system are depicted by four equally spaced linear springs. Stiffness of these springs was determined to be approximately one-half of the calculated carrier post stiffness.

This model, developed for the CH-47 forward transmission, is illustrated in Figure 26. The necessity of coupling the shafts was dictated by comparative analysis of the experimental and initial analytical results.

19. Jones, A.B., A GENERAL THEORY FOR ELASTICALLY CONSTRAINED BALL AND RADIAL ROLLER BEARINGS UNDER ARBITRARY LOAD AND SPEED CONDITIONS, ASME Paper 59-LUB-10.

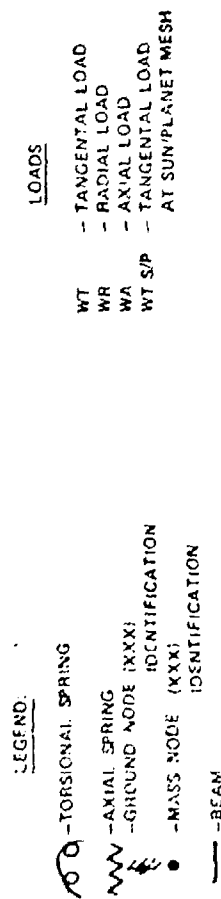
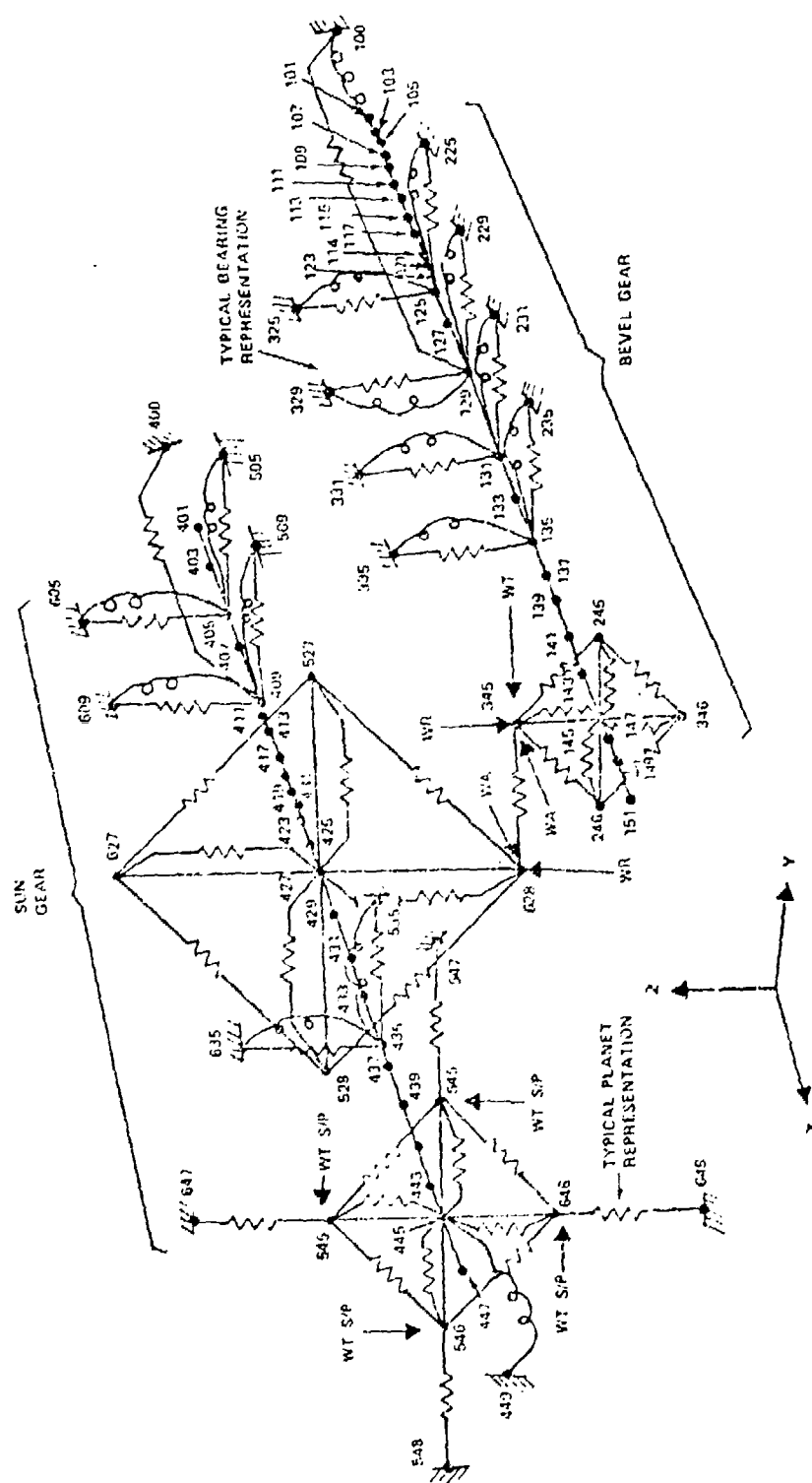


Figure 26. Mathematical Model of CH-47 Transmission.

PROGRAM USAGE - INPUT PREPARATION

There are four basic dynamic analysis input sheets:

- Control Numbers - Figure 27
- Coordinates and Nodal Boundary Conditions (Action Table) - Figure 28
- Structural Elements (Sat Table) - Figure 29
- Masses and Mass Moments of Inertia - Figure 30

Figures 31 and 32 are used for the damped forced response. Assuming that the idealization of the structure is complete, fill in the control cards (Figure 33) as follows:

- Input the title in the header block.
- Count the number of nodes and enter with decimal in the block "# nodes". The maximum number of nodes and the maximum number allowable for a node number is 999. This count must be correct.
- Count the number of different structural elements and enter with decimal in the block "# SATS". The maximum number of structural elements is 5000. This count must be correct.
- Count the number of retained degrees of freedom for the node points. This corresponds to the number of "2's" in the action table input sheets. The maximum number of retained degrees of freedom is 215. This count must be right. Each retained degree of freedom must have a mass or mass moment of inertia associated with it.
- Count the number of reduced degrees of freedom and enter in "# REDUCED" box. This corresponds to the number of "1's" in the action table input sheets. The sum of the reduced and retained degrees of freedom must be less than 3000. If a nodal degree of freedom is reduced, the node will be allowed motion, but there will be no mass or moment of inertia for that particular degree of freedom. The count of the number of reduced degrees of freedom must be correct or the program will fail.

Engineer _____

INPUT SHEET

Page _____

Date _____

CONTROL NUMBERS

SCIARRA/WOLFINGER USA METHOD

TITLE CARD PLEASE PUNCH

7

72

0001	# NODES (MAX. = 999.)	
	# SATS (MAX. = 3000.)	
	# RETAIN D.O.F.'s (MAX. = 215.)	
	# REDUCED D.O.F.	
	# MATERIAL CODES (MAX.=3.)	
0006	MAX. NODE # (MAX. = 999.)	
	YOUNG'S MODULUS 1ST MATERIAL	
	YOUNG'S MODULUS 2ND MATERIAL	
	YOUNG'S MODULUS 3RD MATERIAL	
	POISSON'S RATIO 1ST MATERIAL	
0011	POISSON'S RATIO 2ND MATERIAL	
	POISSON'S RATIO 3RD MATERIAL	
	# VARIATIONS (MASS)	1.
	# EIGENVECTORS	
	# MASS GROUPS	
0016	SCALE FACTOR	1.
	SAVE TAPE (1.=YES 0.=NO)	1.
0018	PRINT STRAIN ENERGY (1.=YES)	0.
	#SPECIAL ELEMENTS	0.
	1.=DON'T PRINT INPUT	0.
0021	1.=DON'T PRINT FULL K	0.
	1.=DON'T PRINT REDUCED K	0.
	CALCULATE EIGENVECTORS > THIS.	
0026	1. = FLEXIBILITY MATRIX = K^{-1}	
	0=D82. 1.=C51 Only	
0031	0=D82. 1.=D82 and C51	
	ROW NORMALIZED TO UNITY	

NOTE: MAKES 2 TAPES

Figure 27. Input Sheet - Control Numbers.

(SECOND ITEM)

[illegible]

PUT A "9" PUNCH IN COL 72 OF THE LAST CARD OF THE "ATS".

MASSSES OR MOMENTS OF INERTIA

[illegible]

MODE	LEFT ADJUST	NUMBERS
1	2	3
4	5	6
7	8	9
10	11	12
13	14	15
16	17	18
19	20	21
22	23	24
25	26	27
28	29	30
31	32	33
34	35	36
37	38	39
40	41	42
43	44	45
46	47	48
49	50	51
52	53	54
55	56	57
58	59	60
61	62	63
64	65	66
67	68	69
70	71	72
73	74	75
76	77	78
79	80	81
82	83	84
85	86	87
88	89	90
91	92	93
94	95	96
97	98	99
100	101	102
103	104	105
106	107	108
109	110	111
112	113	114
115	116	117
118	119	120
121	122	123
124	125	126
127	128	129
130	131	132
133	134	135
136	137	138
139	140	141
142	143	144
145	146	147
148	149	150
151	152	153
154	155	156
157	158	159
160	161	162
163	164	165
166	167	168
169	170	171
172	173	174
175	176	177
178	179	180
181	182	183
184	185	186
187	188	189
190	191	192
193	194	195
196	197	198
199	200	201
202	203	204
205	206	207
208	209	210
211	212	213
214	215	216
217	218	219
220	221	222
223	224	225
226	227	228
229	230	231
232	233	234
235	236	237
238	239	240
241	242	243
244	245	246
247	248	249
250	251	252
253	254	255
256	257	258
259	260	261
262	263	264
265	266	267
268	269	270
271	272	273
274	275	276
277	278	279
280	281	282
283	284	285
286	287	288
289	290	291
292	293	294
295	296	297
298	299	300
301	302	303
304	305	306
307	308	309
310	311	312
313	314	315
316	317	318
319	320	321
322	323	324
325	326	327
328	329	330
331	332	333
334	335	336
337	338	339
340	341	342
343	344	345
346	347	348
349	350	351
352	353	354
355	356	357
358	359	360
361	362	363
364	365	366
367</		

1. "9" PUNCH, COL 80, LAST MASS CARD
2. "99999", COLS 1-5, AFTER LAST MASS

Figure 30. Masses and Mass Moments of Inertia.

DAMPED FORCED RESPONSE

NAME _____

DATE _____

0001			0048
0002	1.		0049
0003			0050
0004			0051
0005			0052
0006		EIGENVECTORS	0053
0007		DESIRED	0054
0008			0055
0009			0056
0010			0057
0011			0058
0012			0059
0013			0060
0014			0061
0015			0062
0016			0063
0017			0064
0018			0065
0019			0066
0020			1.
0021			
0022			
0023			
0024			
0025			
0026			
0027			
0028			
0029			
0030			
0031			
0032			
0033			
0034			
0035			
0036		CRITICAL	
0037		DAMPING	
0038			
0039			
0040			
0041			
0042			
0043			
0044			
0045			
0046			
0047			

38888 (LAST CARD)

Figure 31. Damped Forced Response Parameters.

NAME _____

PAGE _____

PHASED EXTERNAL EXCITING LOADS = $F_s \sin \Omega t + F_c \cos \Omega t$

[illegible]

SINE
COMPONENT (F_s),
(lbs or inch/lbs)
maximum of 215.

88888

[illegible]

COSINE
COMPONENT (F_c),
maximum of 215.

88888

Figure 32. Exciting Loads.

Engineer _____

INPUT SHEET

Page _____

Date _____

CONTROL NUMBERS

SCIARRA/WOLFINGER USA METHOD

TITLE CARD PLEASE PUNCH

7	SCIARRA TEST CASE	72

0001	# NODES (MAX. = 999.)	18.
	# SATS (MAX. = 3000.)	35.
	# RETAIN D.O.F.'s (MAX. = 215.)	30.
	# REDUCED D.O.F.	20.
	# MATERIAL CODES (MAX.=3.)	1.
0006	MAX. NODE # (MAX. = 999.)	600.
	YOUNG'S MODULUS 1ST MATERIAL	30.E6
	YOUNG'S MODULUS 2ND MATERIAL	0.
	YOUNG'S MODULUS 3RD MATERIAL	0.
	POISSON'S RATIO 1ST MATERIAL	.33
0011	POISSON'S RATIO 2ND MATERIAL	0.
	POISSON'S RATIO 3RD MATERIAL	0.
	# VARIATIONS (MASS)	1.
	# EIGENVECTORS	5.
	# MASS GROUPS	10.
0016	SCALE FACTOR	1.
	SAVE TAPE (1.=YES 0.=NO)	1.
0018	PRINT STRAIN ENERGY (1.=YES)	0.
	#SPECIAL ELEMENTS	0.
	1.=DON'T PRINT INPUT	0.
0021	1.=DON'T PRINT FULL K	0.
	1.=DON'T PRINT REDUCED K	0.
	CALCULATE EIGENVECTORS > THIS.	0.
0026	1. = FLEXIBILITY MATRIX = K^{-1}	0.
	0=D82, 1=C51 Only	0.
0031	0=D82, 1=D82 and C51	1.
	ROW NORMALIZED TO UNITY	650.

NOTE: MAKES 2 TAPES

Figure 33. Input Sheet - Control Numbers.

In locations 5 and 6, numbers indicated on the input sheet are used. In location 7, enter Young's modulus. "E" notation may be used. In location 10, enter Poisson's ratio. In location 14, enter the number of eigenvectors desired (maximum of 30). In location 15, enter the number of mass points. Location 25 is the lower bound for the eigenvalues for which eigenvectors are desired. Location 26 is the indicator for forming the inverse of the stiffness matrix. Locations 13, 16, 17, 18, and 31 are to be input as indicated on the input sheet. All other input quantities are ignored for the present.

The second input sheet (Figure 34) is the "AT" or action table. In columns 1 to 3 enter the node number (maximum number is 999). If the node number is "5", enter as 005. In columns 4 to 33, enter the x, y, and z coordinates of the node point. Use a decimal point. In columns 34 to 39, enter the boundary conditions for the node point as follows:

- "0" means delete the degree of freedom. This means no motion is allowed for that particular degree of freedom. It also means no rotation in the case of a node point connecting only by axial or skin members. It is also used for degrees of freedom associated with beams oriented in some specialized direction. It is also input for nodes used only for orienting beams, but with no structural duty.
- "1" means reduce the degree of freedom. This means that no mass or moment of inertia is to be associated with that particular degree of freedom. However, motion will be allowed and the element stiffness will be merged into the final retained matrix.
- "2" means retain the degree of freedom. This implies that a mass or mass moment of inertia will be associated with that particular degree of freedom.

The order that these boundary conditions are input is x, y, z, θ_x , θ_y , and θ_z . The last three represent rotations about the respective axes.

The third table (Figure 35) is the "SAT" (Structural Assemblage Table) and is filled out as follows:

- In Column 3, put "2" if the element is an axial member, "3" if a skin (triangular) element, and "4" if a beam element.
- In columns 4 to 12, insert the node numbers associated with the member. If it is an axial (stringer) element,

SAT TABLE (STRUCTURAL CONNECTORS) (THIRD ITEM)

TYPE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	1221	1222	1223	1224	1225	1226	1227	1228	1229	1230	1231	1232	1233	1234	1235	1236	1237	1238	1239	1240	1241	1242	1243	1244	1245	1246	1247	1248	1249	1250	1251	1252	1253	1254	1255	1256	1257	1258	1259	1260	1261	1262	1263	1264	1265	1266	1267	1268	1269	1270	1271	1272	1273	1274	1275	1276	1277	1278	1279	1280	1281	1282	1283	1284	1285	1286	1287	1288	1289	1290	1291	1292	1293	1294	1295	1296	1297	1298	1299	1300	1301	1302	1303	1304	1305	1306	1307	1308	1309	1310	1311	1312	1313	1314	1315	1316	1317	1318	1319	1320	1321	1322	1323	1324	1325	1326	1327	1328	1329	1330	1331	1332	1333	1334	1335	1336	1337	1338	1339	1340	1341	1342	1343	1344	1345	1346	1347	1348	1349	1350	1351	1352	1353	1354	1355	1356	1357	1358	1359	1360	1361	1362	1363	1364	1365	1366	1367	1368	1369	1370	1371	1372	1373	1374	1375	1376	1377	1378	1379	1380	1381	1382	1383	1384	1385	1386	1387	1388	1389	1390	1391	1392	1393	1394	1395	1396	1397	1398	1399	1400	1401	1402	1403	1404	1405	1406	1407	1408	1409	1410	1411	1412	1413	1414	1415	1416	1417	1418	1419	1420	1421	1422	1423	1424	1425	1426	1427	1428	1429	1430	1431	1432	1433	1434	1435	1436	1437	1438	1439	1440	1441	1442	1443	1444	1445	1446	1447	1448	1449	1450	1451	1452	1453	1454	1455	1456	1457	1458	1459	1460	1461	1462	1463	1464	1465	1466	1467	1468	1469	1470	1471	1472	1473	1474	1475	1476	1477	1478	1479	1480	1481	1482	1483	1484	1485	1486	1487	1488	1489	1

these would be the two end nodes only. Leave the last node box empty. If the member is a triangular (shear panel) element, input the three node points. If the member is a beam, input the end node points of the beam. In the third box for the beam enter an orienting node. The two end node points define the $\bar{x}$ - axis (neutral axis) of the beam. The orienting node point defines the $\bar{z}$ - axis of the beam. The $\bar{y}$ - axis would be perpendicular to the $\bar{x}$ - $\bar{z}$ plane.

- For an axial member, insert the cross-sectional area in columns 14 to 23. Leave columns 24 to 43 empty. For the skin member, input the thickness resisting in-plane shear t_s , the thickness in the $\bar{x}$ -direction (from node 1 to node 2) $t_{\bar{x}}$, and the thickness in the $\bar{y}$ direction (perpendicular to the $\bar{x}$ direction) $t_{\bar{y}}$. For a beam, input the moment of inertia about the $\bar{y}$ -axis, $I_{\bar{y}}$, the torsional moment of inertia about the $\bar{x}$ - axis, $J_{\bar{x}}$, and the cross-sectional area effective in resisting shear, A_w .

The fourth input sheet (Figure 36) is for the masses or mass moments of inertia that are associated with a retained degree of freedom. In columns 1 to 4, input the node number. For example input 0125, 0001. Note that 4 digits are used. Column 5 is skipped. Columns 6 to 65 have room for 6 numbers or 6 degrees of freedom for any node. Use decimals. If less than 6 degrees of freedom are associated with a node point, only input masses or moments of inertia for the exact number of degrees of freedom. Move all numbers to the left. For example: 0023 1. 10. might be a mass in the x - direction and a moment of inertia about the z - axis for node 23. The numbers 1. and 10. would appear in blocks 1 and 2.

In order to calculate the damped forced response, sheets 5 (Figure 37) and 6 (Figure 38) are used.

On Figure 37, location 0001 inputs the exciting frequency. Repeat this number in location 0003. In locations 5 to 34, enter the number of the eigenvector desired (e.g., 1., 2., 3., 4. for the first to fourth modes). In locations 35 to 64, input the assumed modal damping for each mode (e.g., 0.03).

On Figure 38, input the external sine and cosine loads. In the first column, input the row number of the degree of freedom being excited (e.g., row 0017 for exciting node 10 in the x - direction). This corresponds to the location in the stiffness matrix of the degree of freedom involved.

[illegible]

NØDE
LEFT ADJUST
NUMBERS

1. "9" PUNCH, COL 80, LAST MASS CARD
2. "99999", COLS 1-5, AFTER LAST MASS

Figure 36. Masses and Mass Moments of Inertia.

DAMPED FORCED RESPONSE

NAME _____

DATE _____

0001	62.8318	Ω RAD/SEC	
0002	1.		
0003	62.8318		
0004			
0005	1.		
0006	2.	EIGENVECTORS DESIRED	
0007	3.		
0008	4.		
0009	5.		
0010			
0011			
0012			
0013			
0014			
0015			
0016			
0017			
0018			
0019			
0020			
0021			
0022			
0023			
0024			
0025			
0026			
0027			
0028			
0029			
0030			
0031			
0032			
0033			
0034			
0035	.02	CRITICAL DAMPING	
0036	.02		
0037	.02		
0038	.02		
0039	.02		
0040			
0041			
0042			
0043			
0044			
0045			
0046			
0047			

0048
0049
0050
0051
0052
0053
0054
0055
0056
0057
0058
0059
0060
0061
0062
0063
0064
0065
0066 1.
88888 (LAST CARD)

Figure 37. Damped Forced Response Parameters.

PAGE _____

[illegible]

SINE
COMPONENT (F_s),
(lbs or inch/lbs)
maximum of 215.

[illegible]

NOTES: 1. For static deflection use F_C only and set F_S 's and Ω to zero.

2. After this run, these loads are erased and must be input again for subsequent runs.

Figure 38. Exciting Loads.

PROGRAM OUTPUT

The output data generated for the test problem from program D-82/C-51 is shown in Figure 39, along with the input data previously described. In addition to the above data, program D-82/C-51 will produce a tape of mode shapes containing modal information for the transmission internal components which is used as input into program S68. A listing of the actual internal components shafting model is shown in Figure 40.

FUSELAGE ANALYSIS PROGRAM-MELAN FUD
DE200 SCIARRA / JACKSON / JOANNE

NO. OF LOSES = 14
NO. OF STRUCTURAL ELEMENTS = 35
NO. OF RETAINED DOFS = 30
NO. OF REDUCED DOFS = 20
NO. OF MATERIAL PROPERTIES = 1
NO. OF DELETED DOFS = 5
FULL SCALE STIFFNESS REDUCTION = 50
NO. OF VARIATIONS = 1
NO. OF EIGENVECTORS = 5
NO. OF MASS GROUPS = 10
NO. OF SPECIAL ELEMENTS = 0

* THE TAPE BUFFER HAS PRESERVED IS *****

MATERIAL PROPERTIES
MODULUS POISSON RATIO
3000000.0 0.3300

INPUT OPTIONS
INPUT YES
FULL YES
SPECIAL YES

EIGENVECTORS CALCULATED FOR EIGENVALUES GREATER THAN 0.0
ACTION TABLE

MODE	X	Y	Z	DOF	MASS
1	0.0	0.0	10.2500	0	0
2	0.0	0.0	0.0	0	0
3	20.0000	0.0	10.2500	222	101
4	20.0000	0.0	0.0	222	101
5	40.0000	0.0	10.2500	222	101
6	40.0000	0.0	0.0	222	101
7	60.0000	0.0	10.2500	222	101
8	60.0000	0.0	0.0	222	101
9	80.0000	0.0	10.2500	222	101
10	80.0000	0.0	0.0	222	101
11	100.0000	0.0	10.2500	222	101
12	100.0000	0.0	0.0	222	101
13	100.0000	1.0000	10.2500	0	0
14	100.0000	1.0000	0.0	0	0
15	20.0000	1.0000	10.2500	0	0
16	40.0000	1.0000	10.2500	0	0
17	60.0000	1.0000	10.2500	0	0
18	80.0000	1.0000	10.2500	0	0

MAP-RETAINED

5 5 5 4 4 4 5 5 5 6 6 6 7 7 7 6
6 6 9 9 9 10 10 10 11 11 11 12 12 12

MAP-REDUCED

3 3 4 4 5 5 6 6 7 7 8 8 9 9 10 10
11 11 12 12

Figure 39. Sample D-82/C-51 Output.

SOJAKKA - JACKSON - JOHNSON USA METHOD OF STRUCTURAL ANALYSIS

```

TOTAL NUMBER OF AXIAL ELEMENTS
N1= 13 N2= 11 N3= 12 MATERIAL CODE= 1 IY= 0.4150 JX= 0.4150
IY= 0.4150 0.0 0.0 0.0
-----
TOTAL NUMBER OF BEAM ELEMENTS
N1= 1 N2= 3 N3= 13 MATERIAL CODE= 1 IY= 0.582500 02 JX= 0.584700 02
AY= 0.685000 01 0.0 0.0
-----
TOTAL NUMBER OF BEAM ELEMENTS
N1= 5 N2= 5 N3= 13 MATERIAL CODE= 1 IY= 0.582500 02 JX= 0.584700 02
AY= 0.685000 01 0.0 0.0
-----
TOTAL NUMBER OF BEAM ELEMENTS
N1= 15 N2= 7 N3= 13 MATERIAL CODE= 1 IY= 0.582500 02 JX= 0.582700 02
AY= 0.685000 01 0.0 0.0
-----
TOTAL NUMBER OF BEAM ELEMENTS
N1= 7 N2= 9 N3= 13 MATERIAL CODE= 1 IY= 0.582500 02 JX= 0.582700 02
AY= 0.685000 01 0.0 0.0
-----
TOTAL NUMBER OF BEAM ELEMENTS
N1= 9 N2= 11 N3= 13 MATERIAL CODE= 1 IY= 0.582500 02 JX= 0.582700 02
AY= 0.685000 01 0.0 0.0
-----
TOTAL NUMBER OF BEAM ELEMENTS
N1= 2 N2= 4 N3= 14 MATERIAL CODE= 1 IY= 0.582500 02 JX= 0.582700 02
AY= 0.685000 01 0.0 0.0
-----
TOTAL NUMBER OF BEAM ELEMENTS
N1= 4 N2= 6 N3= 14 MATERIAL CODE= 1 IY= 0.582500 02 JX= 0.582700 02
AY= 0.685000 01 0.0 0.0
-----
TOTAL NUMBER OF BEAM ELEMENTS
N1= 6 N2= 8 N3= 14 MATERIAL CODE= 1 IY= 0.582500 02 JX= 0.582700 02
AY= 0.685000 01 0.0 0.0
-----
TOTAL NUMBER OF BEAM ELEMENTS
N1= 8 N2= 10 N3= 14 MATERIAL CODE= 1 IY= 0.582500 02 JX= 0.582700 02
AY= 0.685000 01 0.0 0.0
-----
TOTAL NUMBER OF BEAM ELEMENTS
N1= 10 N2= 12 N3= 14 MATERIAL CODE= 1 IY= 0.582500 02 JX= 0.582700 02
AY= 0.685000 01 0.0 0.0
-----
TOTAL NUMBER OF BEAM ELEMENTS
N1= 5 N2= 4 N3= 15 MATERIAL CODE= 1 IY= 0.120000 00 JX= 0.276000 03
AY= 0.830000 01 0.0 0.0
-----
TOTAL NUMBER OF BEAM ELEMENTS
N1= 6 N2= 5 N3= 16 MATERIAL CODE= 1 IY= 0.120000 00 JX= 0.276000 03
AY= 0.830000 01 0.0 0.0
-----
TOTAL NUMBER OF BEAM ELEMENTS
N1= 7 N2= 6 N3= 17 MATERIAL CODE= 1 IY= 0.120000 00 JX= 0.276000 03
AY= 0.830000 01 0.0 0.0
-----
TOTAL NUMBER OF BEAM ELEMENTS
N1= 8 N2= 7 N3= 18 MATERIAL CODE= 1 IY= 0.120000 00 JX= 0.276000 03
AY= 0.830000 01 0.0 0.0
-----
TOTAL NUMBER OF BEAM ELEMENTS
N1= 9 N2= 8 N3= 19 MATERIAL CODE= 1 IY= 0.120000 00 JX= 0.276000 03
AY= 0.830000 01 0.0 0.0
-----
TOTAL NUMBER OF STRUCTURAL ELEMENTS 35
NO. OF AXIAL ELEMENTS 10
NO. OF BEAM ELEMENTS 10
NO. OF BEAM ELEMENTS 15

```

SCIAFRA - JACKSON - JOANNE USA METHOD OF STRUCTURAL ANALYSIS

RETAINED STIFFNESS MATRIX

MATRIX	1	30 ROWS	30 COLUMNS	STORAGE MODE 1	PAGE 1
	COLUMN	1	2	3	4
ROW 1	1	0.366330D 08	0.0	-0.464552D 07	-0.913259D 07
ROW 2	2	0.0	0.278567D 07	0.137389D 06	0.0
ROW 3	3	-0.464552D 07	0.137389D 06	0.296671D 08	0.464552D 07
ROW 4	4	-0.913259D 07	0.0	0.464552D 07	0.369330D 08
ROW 5	5	0.0	-0.186563D 06	-0.743391D 04	0.0
ROW 6	6	0.464552D 07	-0.743391D 04	-0.272616D 08	-0.464552D 07
ROW 7	7	-0.139002D 08	0.0	0.230530D 07	0.0
ROW 8	8	0.0	-0.156131D 07	-0.779609D 05	0.0
ROW 9	9	0.234023D 07	-0.779609D 05	-0.120326D 07	-0.464552D 07
ROW 10	10	0.0	0.0	0.0	-0.139002D 08
ROW 11	11	0.0	0.245664D 04	-0.360112D 02	0.0
ROW 12	12	0.0	0.380112D 02	0.190056D 01	0.230530D 07
ROW 13	13	0.0	0.0	0.0	0.0
ROW 14	14	0.0	-0.365620D 06	-0.183532D 05	0.0
ROW 15	15	0.0	0.183532D 05	0.917662D 03	0.0
ROW 16	16	0.0	0.0	0.0	0.0
ROW 17	17	0.0	0.145005D 06	-0.717799D 04	0.0
ROW 18	18	0.0	0.717799D 04	0.358900D 03	0.0
ROW 19	19	0.0	0.0	0.0	0.0
ROW 20	20	0.0	-0.445025D 05	-0.216064D 04	0.0
ROW 21	21	0.0	-0.216064D 04	-0.108042D 03	0.0
ROW 22	22	0.0	0.0	0.0	0.0
ROW 23	23	0.0	-0.278144D 05	-0.145500D 04	0.0
ROW 24	24	0.0	-0.145500D 04	-0.727501D 02	0.0
ROW 25	25	0.0	0.0	0.0	0.0
ROW 26	26	0.0	0.319486D 04	0.220167D 03	0.0
ROW 27	27	0.0	0.220167D 03	0.110084D 02	0.0
ROW 28	28	0.0	0.0	0.0	0.0
ROW 29	29	0.0	-0.478432D 04	-0.178892D 03	0.0
ROW 30	30	0.0	0.178492D 03	0.894461D 01	0.0

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NO. 1 50 ROWS 30 COLUMNS STORAGE FILE 1 PAGE 2

NO.	1	2	3	4	5	6	7	8
NO. 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO. 2	-0.1865630 06	-0.7433910 04	-0.2720160 06	0.2305300 07	-0.1390020 08	0.0	-0.1561310 07	-0.7790090 05
NO. 3	-0.7433910 04	-0.2720160 06	0.2305300 07	-0.1390020 08	0.0	-0.1561310 07	-0.7790090 05	0.0
NO. 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO. 5	0.2785670 07	0.1313600 06	0.0	0.0	0.0	0.0	0.2456640 04	0.3801120 02
NO. 6	0.1313600 06	0.2785670 07	0.0	0.0	0.0	0.0	0.3801120 02	0.2456640 04
NO. 7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO. 8	0.2456640 04	0.3801120 02	0.0	0.0	0.0	0.0	0.2456640 04	0.3801120 02
NO. 9	0.3801120 02	0.2456640 04	0.0	0.0	0.0	0.0	0.1195930 06	0.2785670 07
NO. 10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO. 11	-0.1561310 07	-0.7790090 05	0.0	0.0	0.0	0.0	-0.3193240 06	-0.1414430 05
NO. 12	-0.7790090 05	-0.3193240 06	0.0	0.0	0.0	0.0	-0.1414430 05	-0.3193240 06
NO. 13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO. 14	0.1453050 06	0.7177990 04	0.0	0.0	0.0	0.0	0.1519420 07	0.7582200 05
NO. 15	0.7177990 04	0.1453050 06	0.0	0.0	0.0	0.0	0.7582200 05	0.1519420 07
NO. 16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO. 17	0.3801120 02	0.2456640 04	0.0	0.0	0.0	0.0	0.3288200 05	0.1495030 04
NO. 18	0.2456640 04	0.3801120 02	0.0	0.0	0.0	0.0	0.1495030 04	0.3288200 05
NO. 19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO. 20	-0.2785670 07	-0.1313600 06	0.0	0.0	0.0	0.0	0.3536020 06	0.1781270 05
NO. 21	-0.1313600 06	-0.2785670 07	0.0	0.0	0.0	0.0	0.1781270 05	0.3536020 06
NO. 22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO. 23	-0.4455200 07	-0.2305300 07	0.0	0.0	0.0	0.0	0.1365400 06	0.6694320 04
NO. 24	-0.2305300 07	-0.4455200 07	0.0	0.0	0.0	0.0	0.6694320 04	0.1365400 06
NO. 25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO. 26	0.4786320 04	0.1788920 03	0.0	0.0	0.0	0.0	-0.3604260 05	0.1677430 04
NO. 27	0.1788920 03	0.4786320 04	0.0	0.0	0.0	0.0	0.1677430 04	-0.3604260 05
NO. 28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO. 29	0.3194450 06	0.2201670 03	0.0	0.0	0.0	0.0	-0.1805130 05	-0.1027270 04
NO. 30	0.2201670 03	0.3194450 06	0.0	0.0	0.0	0.0	-0.1027270 04	-0.1805130 05

NO.	9	10	11	12
NO. 1	0.0	0.0	0.0	0.0
NO. 2	-0.1865630 06	-0.7433910 04	-0.2720160 06	0.2305300 07
NO. 3	-0.7433910 04	-0.2720160 06	0.2305300 07	-0.1390020 08
NO. 4	0.0	0.0	0.0	0.0
NO. 5	0.2785670 07	0.1313600 06	0.0	0.0
NO. 6	0.1313600 06	0.2785670 07	0.0	0.0
NO. 7	0.0	0.0	0.0	0.0
NO. 8	0.2456640 04	0.3801120 02	0.0	0.0
NO. 9	0.3801120 02	0.2456640 04	0.0	0.0
NO. 10	0.0	0.0	0.0	0.0
NO. 11	-0.1561310 07	-0.7790090 05	0.0	0.0
NO. 12	-0.7790090 05	-0.1561310 07	0.0	0.0
NO. 13	0.0	0.0	0.0	0.0
NO. 14	0.1453050 06	0.7177990 04	0.0	0.0
NO. 15	0.7177990 04	0.1453050 06	0.0	0.0
NO. 16	0.0	0.0	0.0	0.0
NO. 17	0.3801120 02	0.2456640 04	0.0	0.0
NO. 18	0.2456640 04	0.3801120 02	0.0	0.0
NO. 19	0.0	0.0	0.0	0.0
NO. 20	-0.2785670 07	-0.1313600 06	0.0	0.0
NO. 21	-0.1313600 06	-0.2785670 07	0.0	0.0
NO. 22	0.0	0.0	0.0	0.0
NO. 23	-0.4455200 07	-0.2305300 07	0.0	0.0
NO. 24	-0.2305300 07	-0.4455200 07	0.0	0.0
NO. 25	0.0	0.0	0.0	0.0
NO. 26	0.4786320 04	0.1788920 03	0.0	0.0
NO. 27	0.1788920 03	0.4786320 04	0.0	0.0
NO. 28	0.0	0.0	0.0	0.0
NO. 29	0.3194450 06	0.2201670 03	0.0	0.0
NO. 30	0.2201670 03	0.3194450 06	0.0	0.0

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MATRIX	1	30 ROWS	30 COLUMNS	STORAGE MODE 1	PAGE 4
COLUMN	13	14	15	16	
ROW 1	0.0	0.0	0.0	0.0	
ROW 2	0.0	0.3656200 06	0.1835320 05	0.0	
ROW 3	0.0	0.1835320 05	0.9176620 03	0.0	
ROW 4	0.0	0.0	0.0	0.0	
ROW 5	0.0	0.1450050 06	0.7177990 04	0.0	
ROW 6	0.0	0.7177990 04	0.3589000 03	0.0	
ROW 7	-0.1390020 08	0.0	0.2340230 07	0.0	
ROW 8	0.0	-0.1519420 07	-0.7582200 05	0.0	
ROW 9	0.2305300 07	-0.7582200 05	-0.1203160 07	0.0	
ROW 10	0.0	0.0	-0.4645520 07	-0.1390020 08	
ROW 11	0.0	0.3288260 05	0.1495030 04	0.0	
ROW 12	-0.4645520 07	0.1495030 04	0.7475170 02	0.2340230 07	
ROW 13	0.3693300 08	0.0	-0.4645520 07	-0.9132590 07	
ROW 14	0.0	0.2416270 07	0.1190520 06	0.0	
ROW 15	-0.4645520 07	0.1190520 06	0.2966610 08	0.4645520 07	
ROW 16	-0.9132590 07	0.0	0.4645520 07	0.3693300 08	
ROW 17	0.0	-0.3277870 06	-0.1462790 05	0.0	
ROW 18	0.4645520 07	-0.1462790 05	-0.2726220 08	-0.4645520 07	
ROW 19	-0.1390020 08	0.0	0.2305300 07	0.0	
ROW 20	0.0	-0.1482470 07	-0.7391380 05	0.0	
ROW 21	0.2340230 07	-0.7391380 05	-0.1203060 07	-0.4645520 07	
ROW 22	0.0	0.0	0.0	-0.1390020 08	
ROW 23	0.0	0.6824510 05	0.3202630 04	0.0	
ROW 24	0.0	0.3202630 04	0.1601310 03	0.2305300 07	
ROW 25	0.0	0.0	0.0	0.0	
ROW 26	0.0	0.2858650 06	0.1449030 05	0.0	
ROW 27	0.0	0.1449030 05	0.7245150 03	0.0	
ROW 28	0.0	0.0	0.0	0.0	
ROW 29	0.0	0.9810700 05	0.4208300 04	0.0	
ROW 30	0.0	0.4208300 04	0.2104150 03	0.0	
COLUMN	17	18	19	20	
ROW 1	0.0	0.0	0.0	0.0	
ROW 2	0.1450050 06	0.7177990 04	0.0	-0.4450250 05	
ROW 3	0.7177990 04	0.3589000 03	0.0	-0.2160840 04	
ROW 4	0.0	0.0	0.0	0.0	
ROW 5	0.3656200 06	0.1835320 05	0.0	-0.2781440 05	
ROW 6	0.1835320 05	0.9176620 03	0.0	-0.1455000 04	
ROW 7	0.0	0.0	0.0	0.0	
ROW 8	0.3288260 05	0.1495030 04	0.0	0.3536020 06	
ROW 9	0.1495030 04	0.7475170 02	0.0	0.1781270 05	
ROW 10	0.0	0.2305300 07	0.0	0.0	
ROW 11	-0.1519420 07	-0.7582200 05	0.0	0.1365400 06	
ROW 12	-0.7582200 05	-0.1203160 07	0.0	0.6694320 04	
ROW 13	0.0	-0.4645520 07	-0.1390020 08	0.0	
ROW 14	-0.3277870 06	-0.1462790 05	0.0	-0.1482470 07	
ROW 15	-0.1462790 05	-0.2726220 08	0.2305300 07	-0.7391380 05	
ROW 16	0.0	-0.4645520 07	0.0	0.0	
ROW 17	0.2416270 07	0.1190520 06	0.0	0.6824510 05	
ROW 18	0.1190520 06	0.2966610 08	-0.4645520 07	0.3202630 04	
ROW 19	0.0	-0.4645520 07	0.3693300 08	0.0	
ROW 20	0.6824510 05	0.3202630 04	0.0	0.2136620 07	
ROW 21	0.3202630 04	0.1601310 03	-0.4645520 07	0.1052340 06	
ROW 22	0.0	0.2340230 07	-0.9132590 07	0.0	
ROW 23	-0.1482470 07	-0.7391380 05	0.0	-0.5402770 06	
ROW 24	-0.7391380 05	-0.1203060 07	0.4645520 07	-0.2531680 05	
ROW 25	0.0	0.0	-0.1390020 08	0.0	
ROW 26	0.9810700 05	0.4208300 04	0.0	-0.9506460 06	
ROW 27	0.4208300 04	0.2104150 03	0.2340230 07	-0.4725030 05	
ROW 28	0.0	0.0	0.0	0.0	
ROW 29	0.2858650 06	0.1449030 05	0.0	0.3380610 06	
ROW 30	0.1449030 05	0.7245150 03	0.0	0.1664110 05	

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TABLE	1	30 ROWS	50 COLUMNS	STORAGE MODE 1	PAGE 61
COLUMN	21	22	23	24	
ROW 1	0.0	0.0	0.0	0.0	
ROW 2	-0.2160820 04	0.0	-0.2741440 03	-0.1455000 04	
ROW 3	-0.1080420 03	0.0	-0.1455000 04	-0.7275010 02	
ROW 4	0.0	0.0	0.0	0.0	
ROW 5	-0.1454950 04	0.0	-0.0490250 05	-0.2160820 04	
ROW 6	-0.7275010 02	0.0	-0.2160820 04	-0.1080420 03	
ROW 7	0.0	0.0	0.0	0.0	
ROW 8	0.1781270 05	0.0	0.1365400 06	0.6694320 03	
ROW 9	0.6694320 03	0.0	0.5594320 04	0.5347160 03	
ROW 10	0.0	0.0	0.0	0.0	
ROW 11	0.6694320 03	0.0	0.5594320 04	0.1781270 05	
ROW 12	0.5347160 03	0.0	0.1781270 05	0.6694320 03	
ROW 13	-0.2349250 07	0.0	0.0	0.0	
ROW 14	-0.7275010 02	0.0	0.6694320 03	0.3202630 04	
ROW 15	-0.1295080 07	0.0	0.3202630 04	0.1001310 03	
ROW 16	-0.4645520 07	-0.1350020 08	0.0	0.2349250 07	
ROW 17	0.3202630 04	0.0	-0.1350020 08	-0.7391580 05	
ROW 18	0.1001310 03	0.2349250 07	-0.7391580 05	-0.1295080 07	
ROW 19	-0.4645520 07	-0.1350020 08	0.0	0.4645520 07	
ROW 20	0.1052340 06	0.0	-0.5402170 06	-0.2531680 05	
ROW 21	0.2956520 06	0.4645520 07	-0.2531680 05	-0.2726270 08	
ROW 22	-0.1350020 08	0.1350020 08	0.0	-0.4645520 07	
ROW 23	-0.2531680 05	0.0	0.2726270 08	0.1052340 06	
ROW 24	-0.2726270 08	-0.2531680 05	0.1052340 06	0.2956520 06	
ROW 25	0.2349250 07	0.0	0.0	-0.4645520 07	
ROW 26	-0.4725030 05	0.0	0.3344610 06	0.1664110 05	
ROW 27	-0.1664110 05	-0.4645520 07	0.1664110 05	0.8320530 03	
ROW 28	0.0	0.1350020 08	0.0	0.2349250 07	
ROW 29	0.1664110 05	0.0	-0.3344610 06	-0.4725030 05	
ROW 30	-0.1350020 08	0.2349250 07	-0.4725030 05	-0.1664110 05	
ROW 1	0.0	0.0	0.0	0.0	
ROW 2	0.0	0.3194360 04	0.2201670 03	0.0	
ROW 3	0.0	0.2201670 03	0.1105840 02	0.0	
ROW 4	0.0	0.0	0.0	0.0	
ROW 5	0.0	0.4746320 04	0.1788920 03	0.0	
ROW 6	0.0	0.1788920 03	0.0744610 01	0.0	
ROW 7	0.0	0.0	0.0	0.0	
ROW 8	0.0	-0.3604200 05	-0.1677430 04	0.0	
ROW 9	0.0	-0.1677430 04	-0.8587150 02	0.0	
ROW 10	0.0	0.0	0.0	0.0	
ROW 11	0.0	-0.1305150 05	-0.1027270 04	0.0	
ROW 12	0.0	-0.1027270 04	-0.5130430 02	0.0	
ROW 13	0.0	0.0	0.0	0.0	
ROW 14	0.0	0.2656650 06	0.1429030 05	0.0	
ROW 15	0.0	0.1429030 05	0.7245150 03	0.0	
ROW 16	0.0	0.0	0.0	0.0	
ROW 17	0.0	0.6810720 05	0.4298300 04	0.0	
ROW 18	0.0	0.4298300 04	0.2104150 03	0.0	
ROW 19	-0.1390020 08	0.0	0.2349250 07	0.0	
ROW 20	0.0	-0.9506460 06	-0.4725030 05	0.0	
ROW 21	0.2349250 07	-0.4725030 05	-0.1201730 07	0.0	
ROW 22	0.0	0.0	-0.4645520 07	-0.1390020 08	
ROW 23	0.0	0.3344610 06	0.1664110 05	0.0	
ROW 24	-0.4645520 07	0.1664110 05	0.8320530 03	0.2349250 07	
ROW 25	0.1664110 05	0.0	0.0	-0.4645520 07	
ROW 26	0.0	0.7171780 06	0.3424680 05	0.0	
ROW 27	0.0	0.3424680 05	0.1433180 08	0.2305300 07	
ROW 28	-0.4645520 07	0.0	-0.2305300 07	0.1846650 08	
ROW 29	0.0	-0.4317200 06	-0.1497400 05	0.0	
ROW 30	0.2349250 07	-0.1497400 05	-0.1363170 06	-0.4645520 07	

SCIENCE - JACKSON - JOHNSON METHOD OF STRUCTURAL ANALYSIS

TABLE 1 30 ROAS 20 ELEMENT STORAGE CODE 1 PAGE 8

CODE	20	30
ROA 1	0.0	0.0
ROA 2	0.4786320 04	0.1788920 03
ROA 3	0.1788920 03	0.8944010 01
ROA 4	0.0	0.0
ROA 5	0.3190660 04	0.2201670 04
ROA 6	0.2201670 04	0.1100840 02
ROA 7	0.0	0.0
ROA 8	-0.1605130 05	-0.1027270 04
ROA 9	-0.1027270 04	-0.5136330 02
ROA 10	0.0	0.0
ROA 11	-0.1677430 04	-0.1677430 04
ROA 12	-0.1677430 04	-0.8387150 02
ROA 13	0.0	0.0
ROA 14	0.8610700 05	0.4208300 04
ROA 15	0.4208300 04	0.2104150 03
ROA 16	0.0	0.0
ROA 17	0.2459650 06	0.1669030 05
ROA 18	0.1669030 05	0.7245150 03
ROA 19	0.0	0.0
ROA 20	0.3354610 05	0.1664110 05
ROA 21	0.1664110 05	0.8320530 03
ROA 22	0.0	0.2305300 07
ROA 23	-0.2305300 07	-0.8725840 05
ROA 24	-0.8725840 05	-0.1201710 07
ROA 25	0.0	0.2340250 07
ROA 26	-0.4517210 05	-0.1997490 05
ROA 27	-0.1997490 05	-0.1365170 05
ROA 28	0.0	0.4605420 07
ROA 29	0.7171700 06	0.3424540 05
ROA 30	0.3424540 05	0.1463180 05

MASSIS

5	0.13000 00	0.13000 00	0.13000 00	0.0	0.0	0.0
6	0.13000 00	0.13000 00	0.13000 00	0.0	0.0	0.0
5	0.13000 00	0.13000 00	0.13000 00	0.0	0.0	0.0
6	0.13000 00	0.13000 00	0.13000 00	0.0	0.0	0.0
7	0.13000 00	0.13000 00	0.13000 00	0.0	0.0	0.0
8	0.13000 00	0.13000 00	0.13000 00	0.0	0.0	0.0
9	0.13000 00	0.13000 00	0.13000 00	0.0	0.0	0.0
10	0.13000 00	0.13000 00	0.13000 00	0.0	0.0	0.0
11	0.13000 00	0.13000 00	0.13000 00	0.0	0.0	0.0
12	0.13000 00	0.13000 00	0.13000 00	0.0	0.0	0.0

NO. 300 - JACKSON - QUADRENS METHOD OF STRUCTURAL ANALYSIS

EIGENVALUES					
0.15010607-03	RAD/SEC	EIGENVALUE =	0.227735190 05	CPS =	0.2401800 02
0.33285710-03	RAD/SEC	EIGENVALUE =	0.11041640 06	CPS =	0.5288580 02
0.847007100 03	RAD/SEC	EIGENVALUE =	0.876057350 06	CPS =	0.1291360 03
0.91197060 03	RAD/SEC	EIGENVALUE =	0.691509600 06	CPS =	0.1502740 03
0.153301270 04	RAD/SEC	EIGENVALUE =	0.241433400 07	CPS =	0.2472980 03
0.216015030 04	RAD/SEC	EIGENVALUE =	0.569355620 07	CPS =	0.3797670 03
0.2522333 04	RAD/SEC	EIGENVALUE =	0.635356110 07	CPS =	0.4614910 03
0.27099130 04	RAD/SEC	EIGENVALUE =	0.846222440 07	CPS =	0.4629820 03
0.32835750 04	RAD/SEC	EIGENVALUE =	0.107818630 08	CPS =	0.5225990 03
0.35675070 04	RAD/SEC	EIGENVALUE =	0.154923580 08	CPS =	0.6264360 03
0.44778640 04	RAD/SEC	EIGENVALUE =	0.200512710 08	CPS =	0.7126770 03
0.49011100 04	RAD/SEC	EIGENVALUE =	0.229451590 08	CPS =	0.7623730 03
0.505208170 04	RAD/SEC	EIGENVALUE =	0.295140310 08	CPS =	0.8646420 03
0.507102670 04	RAD/SEC	EIGENVALUE =	0.323477600 08	CPS =	0.9059590 03
0.52935160 04	RAD/SEC	EIGENVALUE =	0.396127470 08	CPS =	0.1001650 04
0.55222290 04	RAD/SEC	EIGENVALUE =	0.429345140 08	CPS =	0.1042920 04
0.44803770 04	RAD/SEC	EIGENVALUE =	0.719166080 08	CPS =	0.1349700 04
0.106660350 05	RAD/SEC	EIGENVALUE =	0.116131650 09	CPS =	0.1729640 04
0.13124710 05	RAD/SEC	EIGENVALUE =	0.172764400 09	CPS =	0.2022060 04
0.13466570 05	RAD/SEC	EIGENVALUE =	0.192062850 09	CPS =	0.2205340 04
0.14744790 05	RAD/SEC	EIGENVALUE =	0.216730570 09	CPS =	0.2353720 04
0.17237120 05	RAD/SEC	EIGENVALUE =	0.297119430 09	CPS =	0.2743370 04
0.17424630 05	RAD/SEC	EIGENVALUE =	0.703095230 09	CPS =	0.2770840 04
0.180008420 05	RAD/SEC	EIGENVALUE =	0.348525540 09	CPS =	0.2971250 04
0.18190680 05	RAD/SEC	EIGENVALUE =	0.502521070 09	CPS =	0.3430320 04
0.100725630 05	RAD/SEC	EIGENVALUE =	0.344919570 09	CPS =	0.3162830 04
0.20635350 05	RAD/SEC	EIGENVALUE =	0.425817790 09	CPS =	0.3284230 04
0.21306620 05	RAD/SEC	EIGENVALUE =	0.457132100 09	CPS =	0.3402850 04
0.232436770 05	RAD/SEC	EIGENVALUE =	0.540733500 09	CPS =	0.3700950 04
0.251004950 05	RAD/SEC	EIGENVALUE =	0.630054440 09	CPS =	0.3994950 04

TIME = 0.0131460-02

EIGENVALUES

			0.22773520 05	0.11041640 06	0.87605735 06
EIGENVECTORS					
1	3	0.17893560-03	0.13811590-01	0.57705320-03	
2	3	0.44196290-01	0.8417760-04	0.17131140 00	
3	3	0.54868040-03	0.42561730-01	0.62616500-02	
4	4	0.18360940-03	0.13424480-01	0.61283210-03	
5	4	0.31966640-01	0.11869760-03	0.17129740 00	
6	4	0.55752670-03	0.43250940-01	0.64601690-02	
7	5	0.50433900-03	0.73516520-01	0.52952550-04	
8	5	0.10990490 00	0.61327610-03	0.39890860 00	
9	5	0.16746220-02	0.13119330 00	0.11271490-01	
10	6	0.30667660-03	0.23657880-01	0.55226430-04	
11	6	0.11899660 00	0.78652840-03	0.39885830 00	
12	6	0.17829970-02	0.13154270 00	0.11373970 01	
13	7	0.50244650-03	0.24521330-01	0.12049450-02	
14	7	0.20025230 00	0.25123440-02	0.40617530 00	
15	7	0.32251010-02	0.24909980 00	0.99735440-02	
16	8	0.38450070-03	0.50763510-01	0.11068140-02	
17	8	0.21625280 00	0.24919410-02	0.40609870 00	
18	8	0.52322630-02	0.24989860 00	0.98746530-02	
19	9	0.16055520-03	0.32109040-01	0.21929620-02	
20	9	0.30177530 00	0.47933980-02	0.11291370 00	
21	9	0.40455470-02	0.38225280 00	0.14134710-02	
22	10	0.40247890-03	0.53107170-01	0.21126810-02	
23	10	0.38147540 00	0.47783040-02	0.11286710 00	
24	10	0.40545300-02	0.38203480 00	0.13046290-02	
25	11	0.40255330-03	0.53152350-01	0.25382720-02	
26	11	0.53847970 00	0.74573870-02	0.30520630 00	
27	11	0.61677930-02	0.51784190 00	0.10421360-01	
28	12	0.43901250-03	0.33902160-01	0.24966180-02	
29	12	0.53077960 00	0.74449870-02	0.36537500 00	
30	12	0.67112840-02	0.51817810 00	0.10554360-01	

SCIARRA - JACKSON - JOANNE USA METHOD OF STRUCTURAL ANALYSIS

EIGENVECTORS NORMALIZED WITH RESPECT TO THE MAXIMUM ELEMENT

ROW	NODE			
1	3	0.33655490-03	-0.26654140-01	0.14206860-02
2	3	0.62577780-01	-0.16870200-03	0.42176290 00
3	3	-0.10343100-02	0.82137260-01	-0.15415980-01
4	4	-0.33943340-03	0.26479720-01	-0.15087750-02
5	4	0.62578520-01	-0.22906720-03	0.42172950 00
6	4	-0.10509860-02	0.83467320-01	-0.15904720-01
7	5	0.57370070-03	-0.45363080-01	-0.81128040-04
8	5	0.22442240 00	0.15694910-02	0.98209460 00
9	5	-0.31945070-02	0.25318200 00	-0.27751270-01
10	6	-0.58188160-03	0.46041850-01	-0.13596660-03
11	6	0.22432300 00	0.15178730-02	0.98197610 00
12	6	-0.32102060-02	0.25443510 00	-0.28002350-01
13	7	-0.72083520-03	-0.56971390-01	-0.20763830-02
14	7	0.45289570 00	0.48486040-02	0.10000000 01
15	7	-0.60796690-02	0.48120490 00	-0.24382320-01
16	8	-0.73386540-03	0.58017710-01	-0.27249380-02
17	8	0.45239720 00	0.48090440-02	0.99980150 00
18	8	-0.60530930-02	0.48226390 00	-0.24311070-01
19	9	0.79145170-03	-0.62544220-01	-0.53990000-02
20	9	0.71911360 00	0.92446950-02	0.27813010 00
21	9	-0.93284460-02	0.73768590 00	-0.34799180-02
22	10	-0.80847460-03	0.63691490-01	-0.52013520-02
23	10	0.71911400 00	0.92213550-02	0.27787520 00
24	10	-0.93378300-02	0.73642340 00	-0.32119530-02
25	11	-0.80971600-03	-0.63976880-01	-0.62491320-02
26	11	0.99999990 00	0.14391550-01	-0.69925670 00
27	11	-0.12644390-01	0.99944770 00	0.25671070-01
28	12	-0.62925400-03	0.65541480-01	-0.61470830-02
29	12	0.10000000 01	0.14377270-01	-0.89954120 00
30	12	-0.12651350-01	0.10000000 01	0.25984530-01

EIGENVALUES

0.89150960 06 0.24143340 07

EIGENVECTORS

ROW	NODE		
1	3	0.28715350-05	0.21402940-01
2	3	0.95859410-01	0.16509620-03
3	3	-0.14050300-04	-0.23561440 00
4	4	0.77073890-06	-0.22977480-01
5	4	-0.95903580-01	0.67292730-03
6	4	0.15011410-06	-0.24298430 00
7	5	0.68537260-05	-0.99679570-03
8	5	0.21539660 00	-0.64359960-02
9	5	-0.29265430-04	-0.41586540 00
10	6	0.53254600-05	-0.27041130-02
11	6	-0.21550170 00	-0.60556990-02
12	6	0.30379560-07	-0.41940720 00
13	7	0.12494300-04	-0.42734400-01
14	7	0.31859750 00	-0.13554080-01
15	7	-0.40566090-04	-0.36489450 00
16	8	0.12895270-04	0.38405220-01
17	8	-0.31870240 00	-0.13447690-01
18	8	0.24342780-05	-0.36375940 00
19	9	0.19778050-04	-0.76949230-01
20	9	0.39352010 00	-0.61405880-02
21	9	-0.44133920-04	-0.69492930-01
22	10	-0.22409900-04	0.73293970-01
23	10	-0.39334870 00	-0.62933920-02
24	10	0.09555460-05	-0.65724550-01
25	11	0.20160520-04	-0.69102810-01
26	11	0.45379650 00	0.12531710-01
27	11	-0.54383810-04	0.33080600 00
28	12	0.44562140-04	0.86765730-01
29	12	-0.43370210 00	0.12336860-01
30	12	0.00543930-04	0.34138400 00

SCIARRA - JACKSON - JOANNE USA METHOD OF STRUCTURAL ANALYSIS

EIGENVECTORS-NORMALIZED-WITH-RESPECT-TO-THE-MAXIMUM-ELEMENT

ROW	NODE		
1	5	0.55195510-05	-0.51031400-01
2	3	0.22097910 00	-0.39304170-03
3	3	-0.52389190-04	0.56177950 00
4	4	-0.17787310-05	0.54785610-01
5	4	-0.22107990 00	-0.16044730-02
6	4	0.36679070-06	0.57955180 00
7	5	-0.15799020-04	0.23766780-02
8	5	0.49654350 00	0.20114100-01
9	5	-0.68386580-04	0.99155540 00
10	6	0.12276020-01	0.64474650-02
11	6	-0.44678120 00	0.19207350-01
12	6	0.70031900-07	0.10000000 01
13	7	-0.28802250-04	0.10190190 00
14	7	0.73440000 00	0.32317230-01
15	7	-0.93516280-04	0.87002460 00
16	8	0.29704500-04	-0.91570240-01
17	8	-0.73465280 00	0.32063500-01
18	8	0.56115730-05	0.86731810 00
19	9	0.45502980-04	0.18347140 00
20	9	0.90609360 00	0.14760330-01
21	9	-0.10173890-03	0.16569320 00
22	10	0.51884420-04	-0.17475610-00
23	10	-0.90675960 00	0.15005450-01
24	10	0.20648600-04	0.15070820 00
25	11	0.60300050-04	0.21244940 00
26	11	0.10000000 01	-0.29879570-01
27	11	-0.12536730-03	-0.60324340 00
28	12	0.10272600-03	-0.20687710-00
29	12	-0.99978350 00	-0.29415000-01
30	12	0.13956770-03	-0.61396790 00

SCIARRA - JACKSON

(DAE PROGRAM)

DAMPED FORCED RESPONSE OF COMPLEX STRUCTURE

INPUT

NUMBER OF ROWS = 30

NUMBER OF COLUMNS = 5

TAPE/CARD INPUT OPTION =****

EIGENVECTORS DESIRED

1

2

3

4

5

EIGENVALUES

MODAL DAMPING

0.2277330 05

0.2000000-01

0.1104160 06

0.2000000-01

0.8780570 06

0.2000000-01

0.8915100 06

0.2000000-01

0.2414330 07

0.2000000-01

NATURAL FREQ RAD/SEC

0.1509090 03

0.3322900 03

0.9370470 03

0.9441980 03

0.1553810 04

SEIARNA - JACKSON
(DRP PROGRAM)
DAMPED FORCED RESPONSE OF COMPLEX STRUCTURE.

MODAL MATRIX										
COLUMNS	1	2	3	4	5					
ROW										
1	0.178535550	-0.138115890	0.577053200	-0.3 0.287153470	-0.5 0.214029360	-0.1				
2	0.331962440	-0.1 0.874177010	-0.4 0.171311350	0.0 0.958594660	-0.1 0.165090150	-0.3				
3	0.547680010	-0.3 0.425617200	-0.1 0.626165050	-0.2 0.140503030	-0.4 0.235014360	0.0				
4	0.180009530	-0.3 0.139284820	-0.1 0.612833060	-0.3 0.770738880	-0.6 0.229774760	-0.1				
5	0.331966360	-0.1 0.118697590	-0.3 0.171297760	0.0 0.959035760	-0.1 0.672927270	-0.3				
6	0.557526700	-0.3 0.432509380	-0.1 0.646018880	-0.2 0.159114090	-0.6 0.242984270	0.0				
7	0.334339810	-0.3 0.235105180	-0.1 0.329525300	-0.4 0.625372570	-0.5 0.296795710	-0.3				
8	0.116996480	0.0 0.313276090	-0.3 0.398966460	0.0 0.215398670	0.0 0.643599630	-0.2				
9	0.109462150	-0.2 0.131193340	0.0 0.112719910	-0.1 0.290658280	-0.4 0.415865440	0.0				
10	0.308676420	-0.3 0.236578770	-0.1 0.552268350	-0.4 0.342546620	-0.5 0.270411310	-0.2				
11	0.118998810	0.0 0.786528450	-0.3 0.398858330	0.0 0.215501710	0.0 0.805569890	-0.2				
12	0.170299770	-0.2 0.131842700	0.0 0.113739740	-0.1 0.303795570	-0.7 0.419407160	0.0				
13	0.352388480	-0.3 0.295213260	-0.1 0.120694500	-0.2 0.124943030	-0.4 0.427383950	-0.1				
14	0.240252530	0.0 0.251254370	-0.2 0.406179270	0.0 0.318597520	0.0 0.135540790	-0.1				
15	0.322514130	-0.2 0.249149840	0.0 0.990359380	-0.2 0.405669890	-0.4 0.364894550	0.0				
16	0.309300750	-0.3 0.500835070	-0.1 0.110681350	-0.2 0.128952720	-0.4 0.384052160	-0.1				
17	0.240252780	0.0 0.249194140	-0.2 0.406098650	0.0 0.318702370	0.0 0.134476880	-0.1				
18	0.323226260	-0.2 0.249898610	0.0 0.987465310	-0.2 0.243427810	-0.5 0.365759400	0.0				
19	0.410455160	-0.3 0.324090420	-0.1 0.219296190	-0.2 0.197780540	-0.4 0.764492250	-0.1				
20	0.381475300	0.0 0.479639620	-0.2 0.112976690	0.0 0.393320060	0.0 0.619058780	-0.2				
21	0.494654750	-0.2 0.382252650	0.0 0.141347050	-0.2 0.441359180	-0.4 0.694929250	-0.1				
22	0.428676860	-0.3 0.331071720	-0.1 0.211266150	-0.2 0.224899040	-0.4 0.732939720	-0.1				
23	0.381475430	0.0 0.477830390	-0.2 0.112867150	0.0 0.393348700	0.0 0.629339150	-0.2				
24	0.445352950	-0.2 0.382634810	0.0 0.130482650	-0.2 0.595554560	-0.5 0.657245480	-0.1				
25	0.429536250	-0.3 0.331523510	-0.1 0.253627190	-0.2 0.281605250	-0.4 0.691028130	-0.1				
26	0.530479690	0.0 0.745738720	-0.2 0.365266260	0.0 0.433796000	0.0 0.125317060	-0.1				
27	0.676754350	-0.2 0.517841910	-0.1 0.104270580	-0.1 0.543838150	-0.4 0.336886030	-0.0				
28	0.439902470	-0.3 0.339621590	-0.1 0.249681760	-0.2 0.445621400	-0.4 0.867657300	-0.1				
29	0.530479760	0.0 0.744998670	-0.2 0.365375010	0.0 0.433702080	0.0 0.123368630	-0.1				
30	0.671128400	-0.2 0.518178090	-0.1 0.105543780	-0.1 0.605439270	-0.4 0.341383990	-0.0				

FINAL EFFECTIVE MASS MATRIX

COLUMNS	1	2	3	4	5		
ROW	1	0.130000000	0.0 0.102980180	-12 0.268707440	-15 0.254456150	-13 0.252087850	-14
2	0.102980340	-12 0.130000000	0.0 0.536394390	-13 0.219319960	-11 0.364965820	-14	
3	0.275040580	-15 0.536396710	-13 0.130000000	0.0 0.260038490	-11 0.178218980	-13	
4	0.254444480	-13 0.219319960	-11 0.260038490	-11 0.130000000	0.0 0.741131940	-12	
5	0.252109530	-14 0.364638870	-14 0.178218980	-13 0.741131940	-12 0.130000000	0.0	

OSCILLATORY FORCES FOR THIS CASE

FORCE COMPONENTS							
ROW	SINE	COSINE					
27	0.1000000 04	0.1000000 04					
PSEUDO-VALUES							
M	C	K	F	SINE	F	COS	
EFF			EFF		EFF		
0.1300000 00	0.7847270 00	0.2960540 04	0.6707590 01		0.6707590 01		
0.1300000 00	0.1727910 01	0.1435540 05	0.5178920 03		0.5178920 03		
0.1300000 00	0.4872450 01	0.1141470 06	0.1042710 02		0.1042710 02		
0.1300000 00	0.4909830 01	0.1158960 06	0.5438380 01		0.5438380 01		
0.1300000 00	0.8079830 01	0.3138630 06	0.3368860 03		0.3368860 03		

SCIAKRA - JACKSON
(DR2 PROGRAM)
DAMPED FORCED RESPONSE OF COMPLEX STRUCTURE

EXCITING FREQUENCY = 62,83180 RAD/SEC

SINE COMPONENT PSEUDO-VALUES			
FORCING FREQ.	AMPLIFICATION FACTOR	PHASE ANGLE (RAD)	AMPLITUDE
0.416356	1.209459	0.020144	0.002740
0.189087	1.037048	0.007844	0.037416
0.067053	1.004513	0.002694	0.000092
0.066545	1.004444	0.002674	-0.000000
0.040437	1.001637	0.001620	0.001075

COSINE COMPONENT PSEUDO-VALUES			
FORCING FREQ.	AMPLIFICATION FACTOR	PHASE ANGLE (RAD)	AMPLITUDE
0.416356	1.209459	0.020144	0.002740
0.189087	1.037048	0.007844	0.037416
0.067053	1.004513	0.002694	0.000092
0.066545	1.004444	0.002674	-0.000000
0.040437	1.001637	0.001620	0.001075

NODE	SINE COMPONENT	COSINE COMPONENT	RESULTANT	PHASE ANGLE	G LOADING
3	0.000490	-0.000498	0.000699	135.47	0.00715
3	0.000077	-0.000080	0.000111	136.33	0.00113
3	-0.001328	-0.001352	0.001895	315.52	0.01938
4	-0.000493	0.000501	0.000703	315.47	0.00719
4	0.000077	-0.000081	0.000112	136.32	0.00114
4	-0.001346	-0.001370	0.001920	315.52	0.01964
5	0.000875	-0.000889	0.001247	135.45	0.01275
5	0.000262	-0.000274	0.000379	136.33	0.00388
5	-0.004427	0.004503	0.006315	315.49	0.06459
6	-0.000884	0.000898	0.001260	315.45	0.01288
6	0.000262	-0.000275	0.000380	136.33	0.00389
6	-0.004448	0.004524	0.006344	315.49	0.06488
7	0.001143	-0.001160	0.001629	135.44	0.01666
7	0.000529	-0.000554	0.000766	136.32	0.00784
7	-0.008872	0.009018	0.012651	315.47	0.12939
8	-0.001158	0.001176	0.001651	315.44	0.01688
8	0.000530	-0.000554	0.000767	136.32	0.00784
8	-0.008890	0.009040	0.012681	315.47	0.12970
9	0.001267	-0.001306	0.001834	135.43	0.01876
9	0.000843	-0.000882	0.001220	136.30	0.01248
9	-0.014126	0.014353	0.020140	315.45	0.20598
10	-0.001309	0.001329	0.001865	315.43	0.01908
10	0.000843	-0.000882	0.001220	136.30	0.01248
10	-0.014147	0.014372	0.020166	315.45	0.20625
11	0.001328	-0.001348	0.001892	135.42	0.01935
11	0.001167	-0.001222	0.001690	136.30	0.01728
11	-0.019606	0.019911	0.027944	315.44	0.28579
12	-0.001355	0.001376	0.001931	315.43	0.01975
12	0.001167	-0.001222	0.001690	136.30	0.01728
12	-0.019621	0.019927	0.027966	315.44	0.28602

SCIARNA/MOFFA

VIBRATORY INTERNAL LOADS

CASE 1

SINE DEFLECTIONS (INCHES) (4)	SINE LOADS LBS & IN-LBS (45)	COSINE DEFLECTIONS (INCHES) (4)	COSINE LOADS LBS & IN-LBS (46)
0.00049016	0.1445	-0.00049821	-0.2374
0.00007655	-1.5295	-0.00000018	1.5277
-0.00132796	56.7582	0.00135218	-56.8574
-0.00049281	0.3241	0.00050093	-0.2318
0.00007768	-1.6942	-0.00008073	1.6928
-0.00134564	58.6758	0.00137024	-58.7776
0.00087456	12.6093	-0.00088870	-13.0687
0.00026191	-0.8008	-0.00027040	0.7820
-0.00422726	70.2990	0.00450300	-69.6484
-0.00088357	-11.8035	0.00089759	12.0017
0.00026230	-0.9376	-0.00027480	0.9191
-0.00440757	71.1071	0.00452368	-70.4950
0.00114269	30.1442	-0.00116041	-30.4399
0.00052921	-0.9113	-0.00055410	-0.9606
-0.00847237	-9.8587	0.00901781	11.5611
-0.00115634	-26.9723	0.00117620	29.2678
0.00052957	-0.6526	-0.00055447	-0.9018
-0.00849394	-10.5339	0.00903975	12.2422
0.00126750	43.2188	-0.00130634	-43.5763
-0.00084272	1.4041	-0.00084199	-1.4900
-0.01412842	-180.2962	0.01435309	183.4424
-0.00130911	-42.3588	0.00132875	42.7180
0.00084292	1.4044	-0.00084219	-1.4902
-0.01414667	-181.7705	0.01437158	184.9241
0.00132770	47.7130	-0.00134751	-48.0900
-0.00116740	-0.1404	-0.00122172	-0.0228
-0.01900557	-389.6143	0.01991148	394.3486
-0.00135527	-47.3508	0.00137556	47.7381
0.00114749	-0.1109	-0.00122181	-0.0007
-0.01902105	-391.2852	0.01992713	396.0251

7.7777

CH-47C XMSN SYSTEM COUPLED SCIARRA .5 POST 122 DOF

0001579.	173.	122.	203.	1.	9353
00065599.	29.0009000E 060.	0.	0.	.333	9353
001150.	0.	1.	20.	42.	
001651.	1.	0.	0.	0.	9460
002150.	0.	0.	0.	0.	8829
002651.	0.	0.	0.	0.	935
003121.	0.				
88888					
100-10.0	0.0	0.0	000000	SYNC SHAFT	
1010.0001	0.0	0.0	022211		
1030.40	0.0	0.0	011111		
1050.75	0.0	0.0	022211		
1071.0	0.0	0.0	011111		
1091.4	0.0	0.0	022211		
1113.4	0.0	0.0	022211		
1133.75	0.0	0.0	011111		
1154.7	0.0	0.0	022211		
1175.0	0.0	0.0	011111		
1195.3	0.0	0.0	011111		
1215.6	0.0	0.0	022211		
1236.0	0.0	0.0	011111		
1256.55	0.0	0.0	022211	BRG 1	
1277.25	0.0	0.0	011111		
1287.55	0.0	0.0	022211	PROBES	
1298.95	0.0	0.0	022211	BRG 2	
13110.25	0.0	0.0	022211	BRG 3	
13211.25	0.0	0.0	022211	PROBES	
13311.75	0.0	0.0	011111		
13512.75	0.0	0.0	022211	BRG 4	
13713.5	0.0	0.0	011111		
13913.85	0.0	0.0	022211		
14114.1	0.0	0.0	011111		
14314.6	0.0	0.0	011111		
14515.0	0.0	0.0	022211	S.B. PINION	
14715.5	0.0	0.0	011111		
14915.75	0.0	0.0	011111		
15116.00	0.0	0.0	022211		
2256.55	10.0	0.1	000000		
3256.55	0.1	10.0	000000		
23512.75	10.0	0.1	000000		
33512.75	0.1	10.0	000000		
24515.00	3.2	0.0	222101		
24615.00	-3.2	0.0	222101		
34515.00	0.0	3.2	222110		
34615.00	0.0	-3.2	222110		
4016.83	-10.0000	8.8500	022211		
4037.54	-10.0000	8.8500	011111		
4058.03	-10.0000	8.8500	022211	BRG 1	
4078.53	-10.0000	8.8500	011111		
4099.01	-10.0000	8.8500	022211	BRG 2	
4119.51	-10.0000	8.8500	011111		
4129.71	-10.0000	8.8500	022211	PROBES	
4139.99	-10.0000	8.8500	011111		
41510.7	-10.0000	8.8500	022211		
41711.45	-10.0000	8.8500	011111		
41911.65	-10.0000	8.8500	022211		
42112.7	-10.0000	8.8500	022211		
42313.75	-10.0000	8.8500	022211		
42514.8	-10.0000	8.8500	011111		
42715.00	-10.0000	8.8500	022211	S.B. GEAR	
42915.3	-10.0000	8.8500	011111		
43115.81	-10.0000	8.8500	022211		
43316.16	-10.0000	8.8500	011111		

Figure 40. D-82/C-51 Model of Internal Components.

43516.63	-10.0000	8.8500	022211000 0
43717.090	-10.0000	8.8500	011111
43917.67	-10.0000	8.8500	022211PROBES
44118.25	-10.0000	8.8500	011111
44318.51	-10.0000	8.8500	022211
44519.41	-10.0000	8.8500	022211SUNGEAR
44720.3	-10.0000	8.8500	022211
44929.41	-10.0000	8.8500	0000006ND
5058.03	0.0	8.9500	000000
58.03	-10.1000	18.8500	000000
53516.630	0.0	8.95	000000
3516.630	-10.1000	18.8500	000000
52715.000	-4.35	8.8500	222101
52815.000	-15.6500	8.8500	222101
2715.000	-10.0000	14.5000	222110
2815.000	-10.0000	3.2000	222110
54519.4100	-7.1600	8.8500	212101
54619.4100	-12.8400	8.8500	212101
54719.4100	2.8400	8.8500	000000
54819.4100	-22.8400	8.9500	000000
4512.4100	-10.0000	11.6900	221110
4619.4100	-10.0000	6.0100	221110
4719.4100	-10.0000	21.6900	000000
4819.4100	-10.0000	-3.9900	000000
002125225	1.41		
004125225325	.01	63.6	.01
002125325	.78		
004125325225	.01	89.6	.01
002135235	3.21		
004135235335	.01	63.6	.01
002135335	2.03		
004135335235	.01	89.6	.01
002405505	.77		
004405505005	.01	115.5	.01
002405005	.94		
004405005407	.01	106.5	.01
002435535	2.06		
004435535035	.01	115.5	.01
002435035	1.68		
004435035535	.01	106.5	.01
004101103225	231.0	462.0	40.9
004101103325	231.0		40.1
004103105225	12.4	24.9	7.9
004103105325	12.4		7.9
004105107225	2.5	5.0	3.0
004105107325	2.5		3.0
004107109225	1.7	3.4	3.3
004107109325	1.7		3.3
004109111225	1.7	3.4	3.3
004109111325	1.7		3.3
004111113225	0.63	1.3	2.3
004111113325	0.63		2.3
004113115225	1.34	2.7	3.5
004113115325	1.34		3.5
004115117225	1.8	3.5	2.5
004115117325	1.8		2.5
004117119225	11.0	22.0	6.2
004117119325	11.0		6.2
004119121225	7.3	14.6	3.6
004119121325	7.3		3.6
004121123225	7.3	14.6	3.6
004121123325	7.3		3.6
004123125225	6.4	12.8	3.1
004123125325	6.4		3.1
004125127225	5.7	11.5	2.7
004125127325	5.7		2.7
004127112825	5.7	11.5	2.7
004127128325	5.7		2.7
004128129225	5.7	11.5	2.7

004128129325	5.7		2.7
004129131225	5.7	11.5	2.7
004129131325	5.7		2.7
004131132235	5.7	11.5	2.7
004131132335	5.7		2.7
004132133235	5.7	11.5	2.7
004132133335	5.7		2.7
004133135335	13.0		5.6
004133135235	13.0	26.0	5.6
004135137235	7.57	15.2	2.6
004135137335	7.57		2.6
004137139235	25.6	51.2	9.3
004137139335	25.6		9.3
004139141235	110.7	221.4	24.7
004139141335	110.7		24.7
004141143235	109.3	218.5	22.1
004141143335	109.3		22.1
004143145235	65.4	130.8	14.4
004143145335	65.4		14.4
004145147235	105.9	211.7	22.6
004145147335	105.9		22.6
004147149235	32.1	64.1	9.7
004147149335	32.1		9.7
004149151235	14.2	28.5	4.2
004149151335	14.2		4.2
004100101225	.01	.085	.01
004145245345	15.6	130.	22.6
004145245135	113.5		22.6
002145245	4.16		
004145246345	15.6	130.	22.6
004145246135	113.5		22.6
002145246	4.16		
004145345245	15.6	130.	22.6
004145345135	113.5		22.6
002145345	4.16		
004145346245	15.6	130.	22.6
004145346135	113.5		22.6
002145346	4.16		
002245345	2.08		
002245346	2.08		
002246345	2.08		
002246346	2.08		
002345028	2.92		
004401403505	2.2	4.5	2.6
004401403005	2.2		2.6
004403405505	2.8	5.5	3.1
004403405005	2.8		3.1
004405407505	2.8	5.5	3.1
004405407005	2.8		3.1
004407409505	2.8	5.5	3.1
004407409005	2.8		3.1
004409411505	2.8	5.5	3.1
004409411005	2.8		3.1
004411412505	4.4	8.8	3.9
004411412005	4.4		3.9
004412413505	3.2	6.4	2.6
004412413005	3.2		2.6
004413415505	3.6	7.2	2.6
004413415005	3.6		2.6
004415417505	4.1	8.3	2.9
004415417005	4.1		2.9
004417419505	8.2	16.3	5.1
004417419005	8.2		5.1
0044194215	6.2	12.5	4.1
004419421005	6.2		4.1
004421423505	10.5	21.1	5.6
004421423005	10.5		5.6
004423425505	14.3	28.6	6.1
004423425005	14.3		6.1

004425427505	14.5	29.0	4.9
004425427005	14.5		4.9
004427429535	199.6	392.1	36.1
004427429035	199.6		36.1
004429431535	31.5	63.0	7.8
004429431035	31.5		7.8
004431433535	21.1	42.1	5.0
004431433035	21.1		5.0
004433435535	42.9	85.8	9.3
004433435035	42.9		9.3
004435437535	42.9	85.8	9.3
004435437035	42.9		9.3
004437439535	16.3	32.6	4.3
004437439035	16.3		4.3
004439441535	11.2	22.5	3.8
004439441035	11.2		3.8
004441443035	10.6	21.3	4.1
004441443535	10.6		4.1
004443445535	35.2	70.5	11.2
004443445035	35.2		11.2
004445447535	35.2	70.5	11.2
004445447035	35.2		11.2
002545547	1.7		
002546548	1.7		
002045047	1.7		
002046048	1.7		
002427527	5.70		
004427527027	900.	2300.	120.
004427527435	1400.		120.
002427528	5.70		
004427528027	900.	2300.	120.
004427528435	1400.		120.
002427027	5.70		
004427027527	900.	2300.	120.
004427027435	1400.		120.
002427028	5.70		
004427028527	900.	2300.	120.
004427028435	1400.		120.
002445545	3.14		
004445545045	6.3	54.3	14.4
004445545435	48.0		14.4
002445546	3.14		
004445546045	6.3	54.3	14.4
004445546435	48.0		14.4
002445045	3.14		
004445045545	6.3	54.3	14.4
004445045435	48.0		14.4
002445046	3.14		
004445046545	6.3	54.3	14.4
004445046435	48.0		14.4
004447449547	.01	347.0	.01
002527027	2.85		
002527028	2.85		
002528027	2.85		
002528028	2.85		
002546046	1.57		
002546045	1.57		
002545045	1.57		
002545046	1.57		
0101 .0063	.0063	.0736	
0109 .0037	.0037	.0041	
0111 .0027	.0027	.0030	
0115 .0009	.0009	.0018	
0121 .0027	.0027	.009	
0125 .006	.006	.0123	
0128 .0058	.0058	.0106	
0129 .0122	.0122	.0122	
0131 .0069	.0069	.0112	

0132 .0035	.0035	.0157
0135 .0095	.0095	.0091
0139 .0142	.0142	.1256
0145 .0196	.0196	.1954
0151 .0031	.0031	.0237
0245 .0003	.0003	.0003
0246 .0003	.0003	.0003
0345 .0003	.0003	.0003
0346 .0003	.0003	.0003
0401 .0014	.0014	.0021
0405 .0043	.0043	.0035
0409 .0044	.0044	.0036
0412 .0026	.0026	.0057
0415 .0023	.0023	.0041
0419 .0087	.0087	.0109
0421 .0045	.0045	.0155
0423 .0049	.0049	.0210
0427 .0403	.0403	.0557
0431 .0092	.0092	.0822
0435 .0046	.0046	.0404
0439 .0033	.0033	.0193
0443 .0077	.0077	.0542
0445 .0085	.0085	.0632
0447 .0042	.0042	.0315
0527 .008	.008	.008
0528 .008	.008	.008
0027 .008	.008	.008
0028 .008	.008	.008
0545 .0005	.0005	
0546 .0005	.0005	
0045 .0005	.0005	
0046 .0005	.0005	

9

99999

000138705.16	1.	8705.16		
000551.	2.	3.	4.	5.
001056.	7.	8.	9.	10.
0015511.	12.	13.	14.	15.
0020516.	17.	18.	19.	20.
00355.03	.03	.03	.03	.03
00405.03	.03	.03	.03	.03
00455.03	.03	.03	.03	.03
00505.03	.03	.03	.03	.03

88888

00523-29. -200. -127.

01121121.

0114148.

88888

005210.

88888

000149838. 1. 9838. 1.

006511.

88888

00523-58. -400. -254.

01121242.

0114196.

88888

005210.

88888

0001420045. 1. 20045. 1.

88888

00523-120. -832. -529.

01121504.

01141201.

88888

005210.

88888

0001422655. 1. 22655. 1.

88888

00523-120. -832. -529.

01121504.			
01141201.			
88888			
005210.			
88888			
0001419676.	1.	19676.	1.
88888			
00523-87.	-600.	-382.	
01123369.	0.	145.	
88888			
005210.			
88888			
0001429514.	1.	29514.	1.
88888			
00523-80.	-555.	-353.	
01123336.	0.	134.	
88888			
005210.			
88888			
000412.			
88888			
99999			

PROGRAM DESCRIPTION

NASTRAN employs a lumped element approach, wherein the distributed physical properties of a structure are represented by a model composed of a finite number of idealized elements that are interconnected at a finite number of grid points. Loads are applied at these grid points, and all input and output data pertain to the idealized structural model. The steps in the definition and loading of a structural model are summarized in Figure 41.

The grid point definition forms the basic framework for the structural model. All other parts of the structural model are referenced either directly or indirectly to the grid points. A geometric grid point is a point in three-dimensional space at which three components of translation and three components of rotation are defined. The coordinates of each grid point are specified by the user.

Various kinds of constraints can be applied to the grid points. Constraints are used to specify boundary conditions, including enforced displacements of grid points, or to specify a linear relationship among selected degrees of freedom. Omitted points are used as a tool in matrix partitioning and for reducing the number of degrees of freedom used in dynamic analysis.

The elemental structural element is a convenient means for specifying many of the properties of the structure, including material properties, mass distribution, and some types of applied loads. Structural elements are defined on connection cards by referencing grid points. Generally, connection cards refer to property cards on which the cross-sectional properties of the element are specified. The property cards in turn refer to material cards which define the material properties.

The extensive computer-generated plotting capability available in NASTRAN has been used to plot the undeformed structural model and has provided for visual inspection of the model to check-out and debug the input data. Plots of the deformed structure have also been obtained to provide mode shape definition.

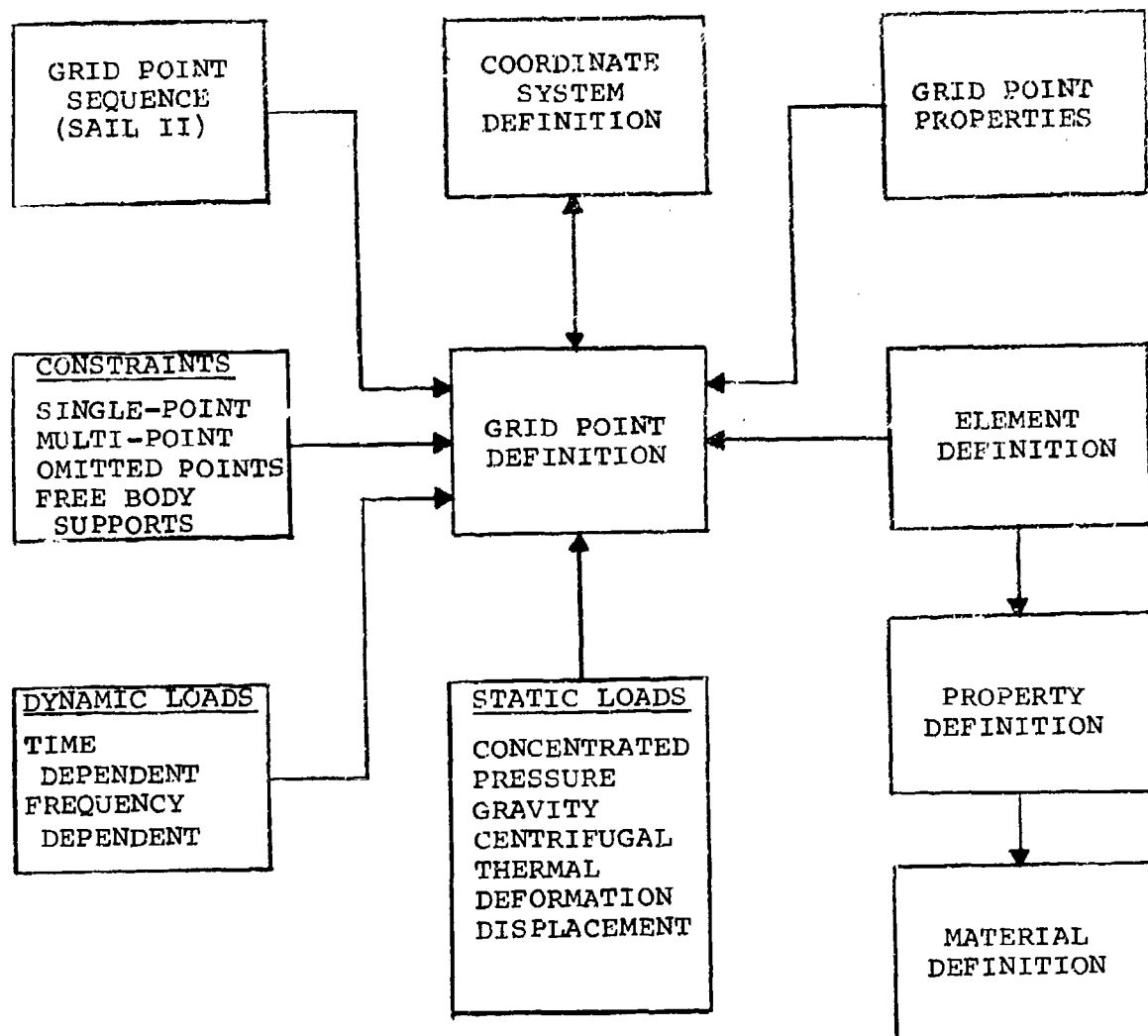


Figure 41. NASTRAN Structural Model Procedure.

PROGRAM UTILIZATION - CHECKOUT AND CORRELATION WITH SIREN
TEST DATA

A cylinder has been modeled by Boeing Vertol using NASTRAN with the intent of determining the feasibility of using NASTRAN to dynamically analyze cylindrical shells. Since a survey of the literature indicated the lack of any other analytical model to correlate with the NASTRAN results, siren tests were conducted on an actual cylinder. Correlation was obtained after study through the use of a particular detailed analytical model of the cylinder, and it was concluded that NASTRAN was feasible to use. The results of the uniform cylinder test are summarized below.

A steel cylinder 6 inches high, 5.75 inches in diameter, and with a wall thickness of 1/8 inch was excited with the Boeing Vertol siren and its natural frequencies were measured. For comparison and correlation, a NASTRAN model was made of the test cylinder using three different mesh sizes. The model was comprised of homogeneous quadrilateral plate elements and was assumed to be a free-free body. A plane of symmetry was used to reduce the number of grid points to reduce computer run time. Grid points off the plane of symmetry were allowed inertial properties only in radial, azimuthal, and vertical directions. Rotations were omitted. The spacing between grid points was varied as 45, 22.5, and 10 degrees, and the model was eight plates high for each of the three spacings (Figure 42). The computer execution time for the various configurations is indicated by Figure 43.

The natural frequencies predicted by NASTRAN (Rigid Format 3) were compared to the experimentally measured frequencies. Good correlation was not obtained in the frequency range up to 3000 Hz until the grid spacing was reduced to 10 degrees. Table 7 and Figure 44 summarize the predicted and measured frequencies, and the first six mode shapes predicted by NASTRAN are shown in Figure 45.

An analytical solution for a uniform disc, which served as a second test case, is also available in Timoshenko. This was also modeled by Boeing Vertol using NASTRAN. The second diametral mode is shown in Figure 46. The reason for this correlation study was to justify the use of NASTRAN as a design tool for the dynamic analysis of turbine discs such as those used in the T55-L-11A gas turbine engine. The results of the Timoshenko analysis of the uniform disc compared well with the NASTRAN prediction. Figure 47 shows correlation of NASTRAN versus test for the third stage bolted turbine disc.

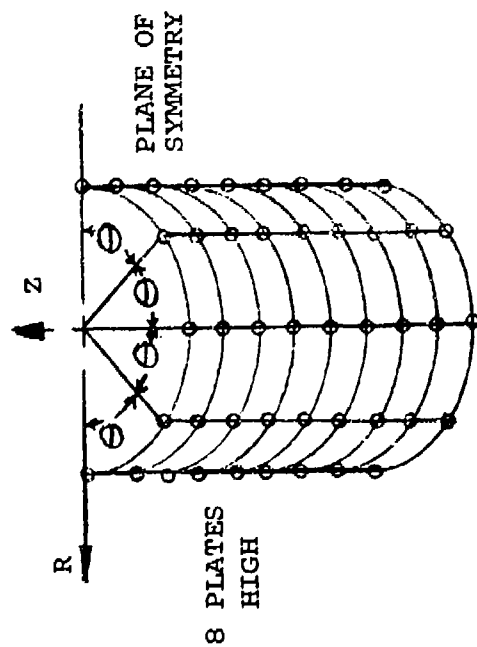


Figure 42. NASTRAN Model of Cylinder.

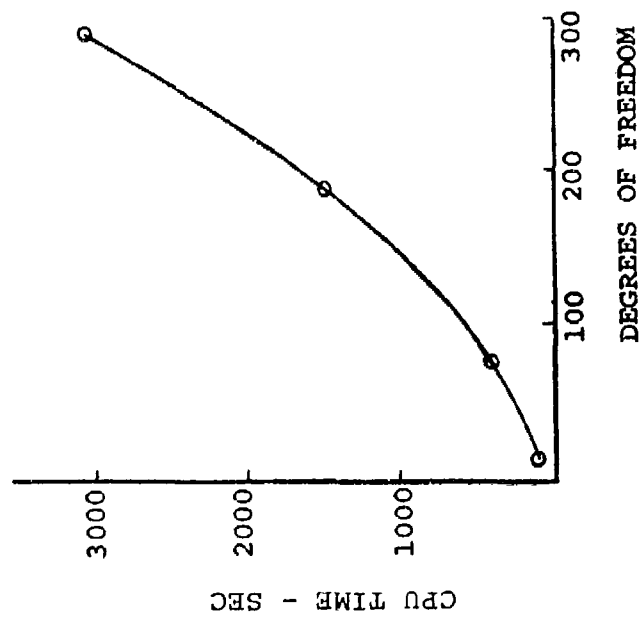


Figure 43. NASTRAN CPU Time.

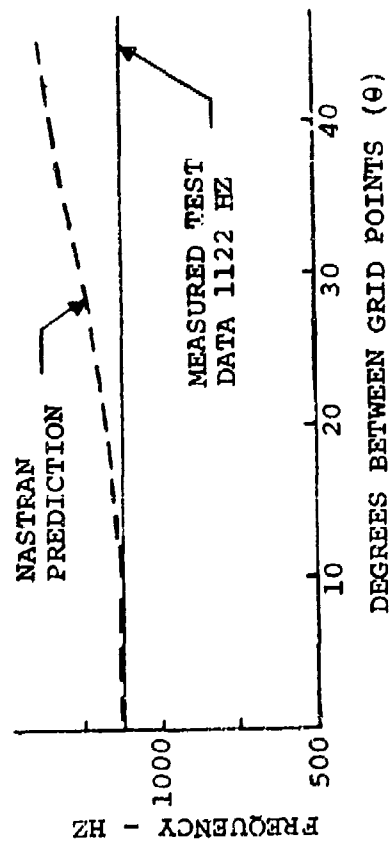


Figure 44. Convergence Plot.

TABLE 7. COMPARISON OF NASTRAN
PREDICTED AND MEASURED
FREQUENCIES.

FREQUENCY - HZ	DEGREES BETWEEN GRID POINTS θ			TEST DATA	ERROR BETWEEN TEST AND DATA $\theta = 10$
	45°	22.5°	10°		
249	252	187			
468	418	398			
577	579	545			
1393	1207	1128	1122		0.5%
1463	1386	1320	1315		0.4%
2147	2373	2160	2144		0.7%
2165	2554	2382	2364		0.7%
5920	3947	3495	3456		1.0%
	4100	3735	3698		1.2%
	4669	4291	4191		2.4%
		4781	4712		1.4%
		4979	4874		2.1%

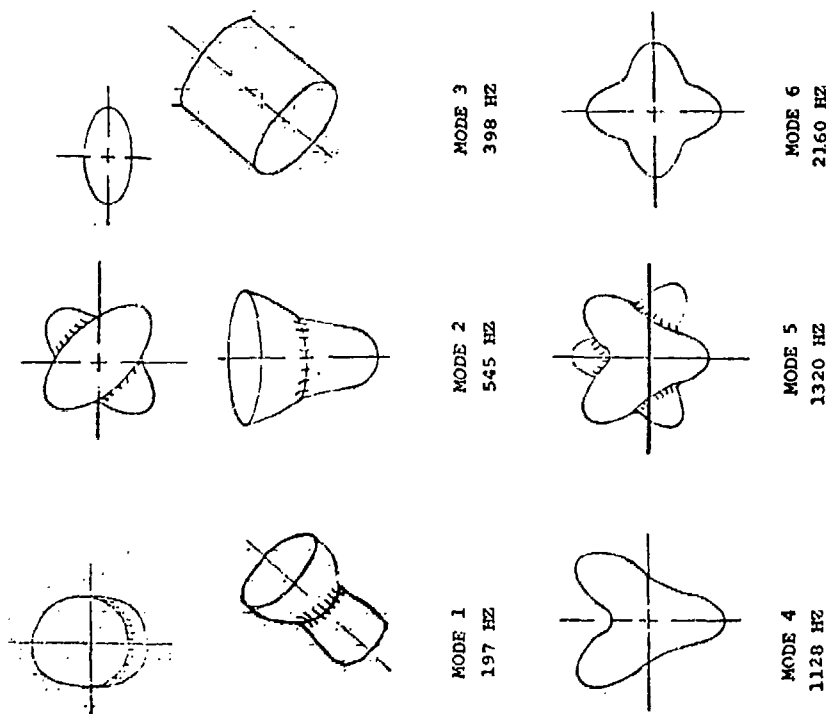


Figure 45. Predicted Mode Shapes for
Cylinder.

$\rho = .286$
 $\mu = .3$
 $E = 30 \times 10^6 \text{ PSI}$
 $t = .25''$

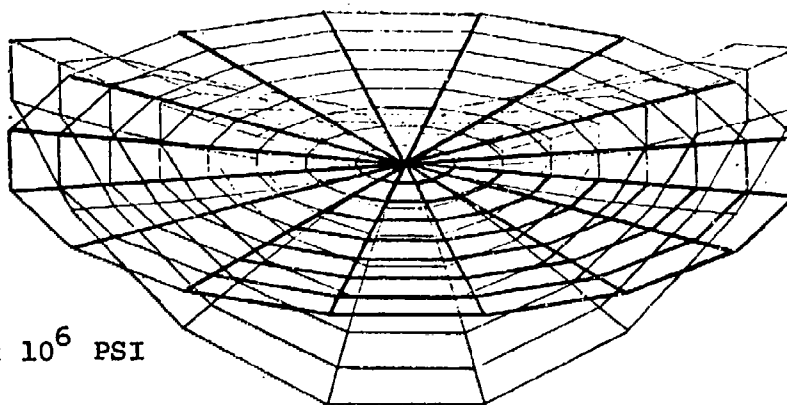


Figure 46. NASTRAN Plot of Disc (2-D Mode).

MODEL NO.			MODEL #1	MODEL #2	MEASURED DATA (ENGINE TEST)
BOUNDARY CONDITIONS			ATTACH TO TWO SHAFTS	FREE-FREE	
MODEL NO.	MODEL NAME	MODE SHAPE	CPS	CPS	CPS
1	FIRST DIAMETRAL		291	-	315
2	FIRST CIRCUM-FERENTIAL		361	776	
3	SECOND DIAMETRAL		415	362	400
4	THIRD DIAMETRAL		907	895	

Figure 47. T55-L-11A 3rd Stage Bolted Turbine Disk
NASTRAN Natural Frequencies and Mode Shapes.

STRUCTURAL ANALYSES INPUT LANGUAGE PREPROCESSOR PROGRAM
(SAIL II)

The contractor has developed pre- and post-processor computer programs compatible with NASTRAN to improve its utility. One of these is a sophisticated finite element input capability for use with NASTRAN entitled SAIL II (Structural Analyses Input Language). This preprocessor allows the user to take advantage of any pattern which occurs in the data by making available straightforward techniques for describing algorithms to generate blocks of data. Grid points and element connections may be generated. This program, although proprietary to the contractor, has been utilized and is available for purchase by industry. An alternative for nodal generation and/or connectivity would be user generated WATFOR computer programs which would punch out the NASTRAN input bulk data cards. Although the contractor has chosen to use SAIL II and feels that this program is more versatile, other users of NASTRAN can conduct the same work by the alternate method. The Boeing Vertol SAIL II computer program is compatible for use with NASTRAN Level 16.

For this contract, NASTRAN Level 15.5 was specifically used.

HELICOPTER TRANSMISSION HOUSING ANALYSIS (INCLUDING COMPOSITES)

In order to determine the dynamic or stress characteristics of the CH-47C forward transmission housing and to evaluate the use of various composite or isotropic materials, a finite element model of the housing, ring gear, and upper cover was constructed and analyzed. The modeling and analysis consisted of the following items:

1. Establishment of the grid point network to define the housing structural model.
 2. Definition of the structural element connections and section properties of transmission housing. The housing was assumed in parts to be axisymmetric, and automatic node generation and structural connectivity computer programs were employed to generate the full transmission housing (e.g., SAIL II).
 3. Definition of material properties of anisotropic or isotropic transmission housing by computing equivalent orthotropic material properties using an existing NASTRAN preprocessor (S-71, Point Stress Laminate Analysis) (Reference 20). This same computer program (S-71) may be used after the NASTRAN analysis as a post-processor to obtain interlaminar and laminar stresses in transmission
-
20. Reed, D.L., POINT STRESS LAMINATE ANALYSIS, Document FZM-5494, Prepared for Advanced Composite Division, Air Force Materials Laboratory, WPAFB, Ohio, April 1970.

housing areas of highest strain. Figure 48 illustrates the lamina or layer coordinate system (1-2) which is transformed by S-71 to the laminate (X-Y) axis system. In Figure 48, the resultant stresses and moments of the laminate are shown. These represent a system which is statistically equivalent to the stress system that is acting on the laminate. The notation used in computer program S-71 for a particular lamina within a laminate is also shown in Figure 48. The program will accommodate up to 400 layers. The equivalent material properties of the lamina may be calculated for the laminate. These would be used as input for the NASTRAN analysis. Also, a point stress analysis can be performed and thermal loads may be calculated. Lamina stresses and interlaminar shears can also be calculated.

4. Establish appropriate constraints for the 6 degrees of freedom at each grid point.
5. Optimize grid point sequencing and matrix bandwidth for efficient computer execution (BANDIT).
6. Plot and debug structural model.
7. Define and apply dynamic loads (bearing reaction) to model.
8. Run dynamic analysis (NASTRAN Rigid Formats 3 and 11) to predict dynamic deflections and loads.

Optimization techniques using a strain energy density approach have been developed to identify those areas of the housing which are most sensitive dynamically. The analysis as it is being applied to the CH-47C rotor transmission is outlined below.

The Boeing Vertol CH-47 forward rotor transmission housing is composed of three major sections: upper cover, ring gear, and case (Figure 49). The upper cover provides lugs for mounting the transmission to the airframe and transmits the rotor system loads. The case contains and supports the main bevel gears. The ring gear, which connects the upper cover and case, contains the planetary gear system. This natural division of the housing was adhered to for ease of modeling.

The geometric grid points for the model were defined from design drawings and by cross-checking on an actual housing. CQUAD2 (Quadrilateral) and CTRIA2 (Triangular) homogeneous plate (membrane and bending) elements were used to connect the grid points and build the NASTRAN structural model. A Boeing Vertol preprocessor program (SAIL II - Structural Analyses Input Language) for the automatic generation of grid point coordinates and structural element connections was used.

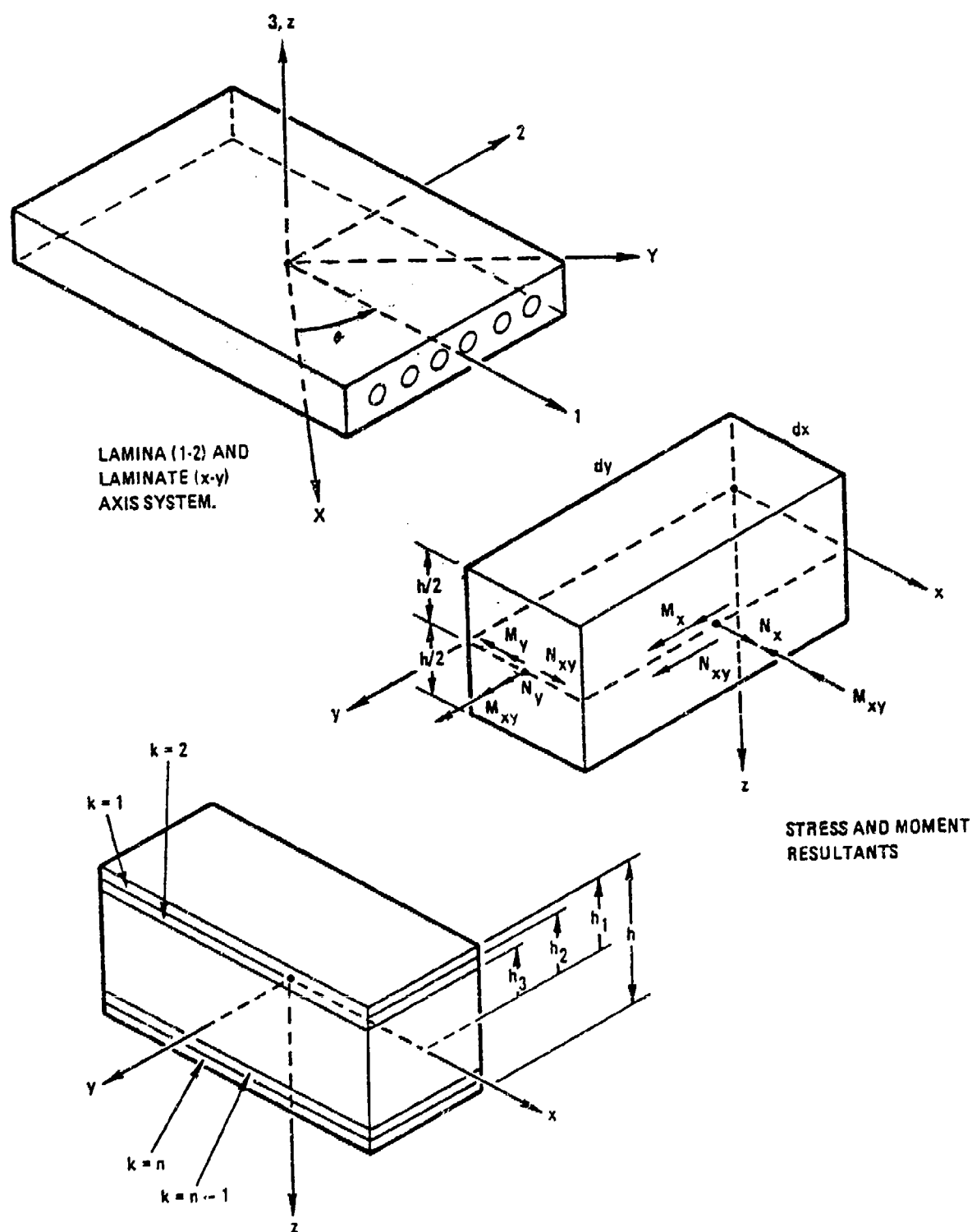


Figure 48. Lamina Notation.

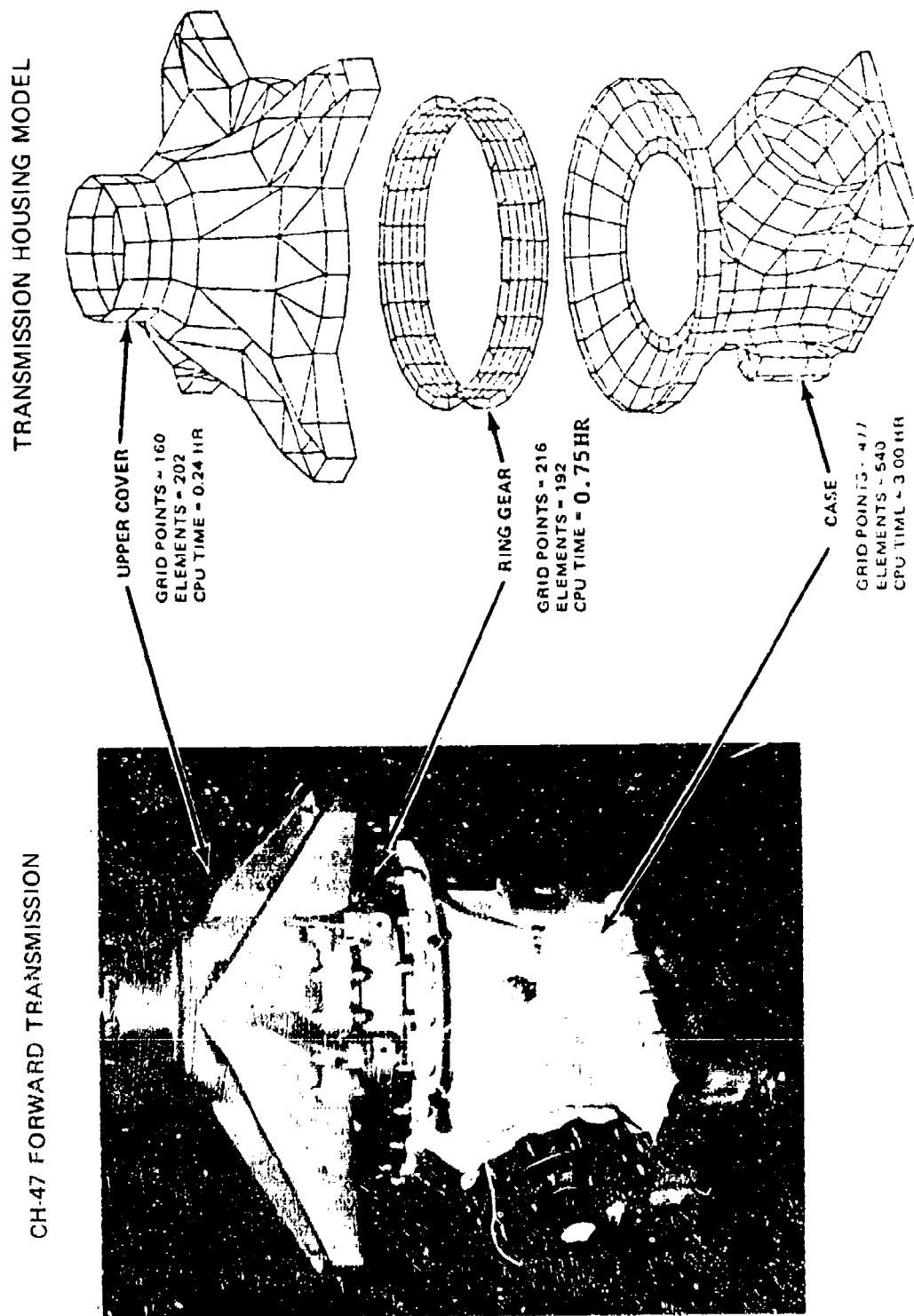


Figure 49. Boeing Vertol CH-47 Helicopter Forward Rotor Transmission Housing and NASTRAN Model.

This preprocessor allows the user to take advantage of any pattern which occurs in the data by providing straightforward techniques for describing algorithms to generate blocks of data. The extensive computer-generated plotting capability of NASTRAN was used to debug the structural model.

For ease of identification the housing was subdivided into several regions and the grid points in each region were labeled with a specific, but arbitrary, series of numbers. Although these grid point numbers act only as labels, they affect the bandwidth of the stiffness and mass matrices. In order to minimize the matrix bandwidth for most efficient running of NASTRAN, the BANDIT computer program (Reference 21) was used to automatically renumber and assign internal sequence numbers to the grid points. The output from BANDIT is a set of SEQGP cards which are then included in the NASTRAN bulk data deck and which relate the original external grid numbers of the internal numbers.

The model includes grid points representative of the structure where the shafts are supported by their bearings. These grid points are used to apply the dynamic excitations at the mesh frequencies to analytically excite the housing. Although each geometric grid point has six possible degrees of freedom (three translational and three rotational), the displacements normal to the outer surface of the housing are of most interest for noise evaluation since it is this out-of-plane motion which generates sound waves. To conveniently evaluate the motion normal to the housing surface, numerous local coordinate systems were defined and oriented such that the displacements and accelerations calculated at each grid point could be referred to a coordinate system having an axis normal to the housing surface (Figure 50). One degree of freedom, rotation about the normal to the surface, was constrained since the stiffness for this component is undefined for NASTRAN plate elements. The other two rotational degrees of freedom were omitted. All translational degrees of freedom were retained to accurately represent the motion of the actual housing. Because of the large model size, the Guyan reduction technique was used to reduce the size of the analysis set. The Givens method of eigenvalue extraction was used and the model parameters are summarized in Figure 51. The NASTRAN weight generator feature was also used to calculate the model weights, which are also summarized in Figure 51.

The contractor has developed confidence that the modeling procedure provides an accurate representation of the actual transmission housing for the following reasons:

21. Everstine, G., BANDIT - A COMPUTER PROGRAM TO RENUMBER NASTRAN GRID POINTS FOR REDUCED BANDWIDTH, Naval Ship Research and Development Center Technical Note AML-6-70, February 1970.

DISPLACEMENTS

T_1 = Out-Of-Plane

T_2 = In-Plane

T_3

ROTATIONS

R_1 = Fixed

R_2 = Unrestrained

R_3

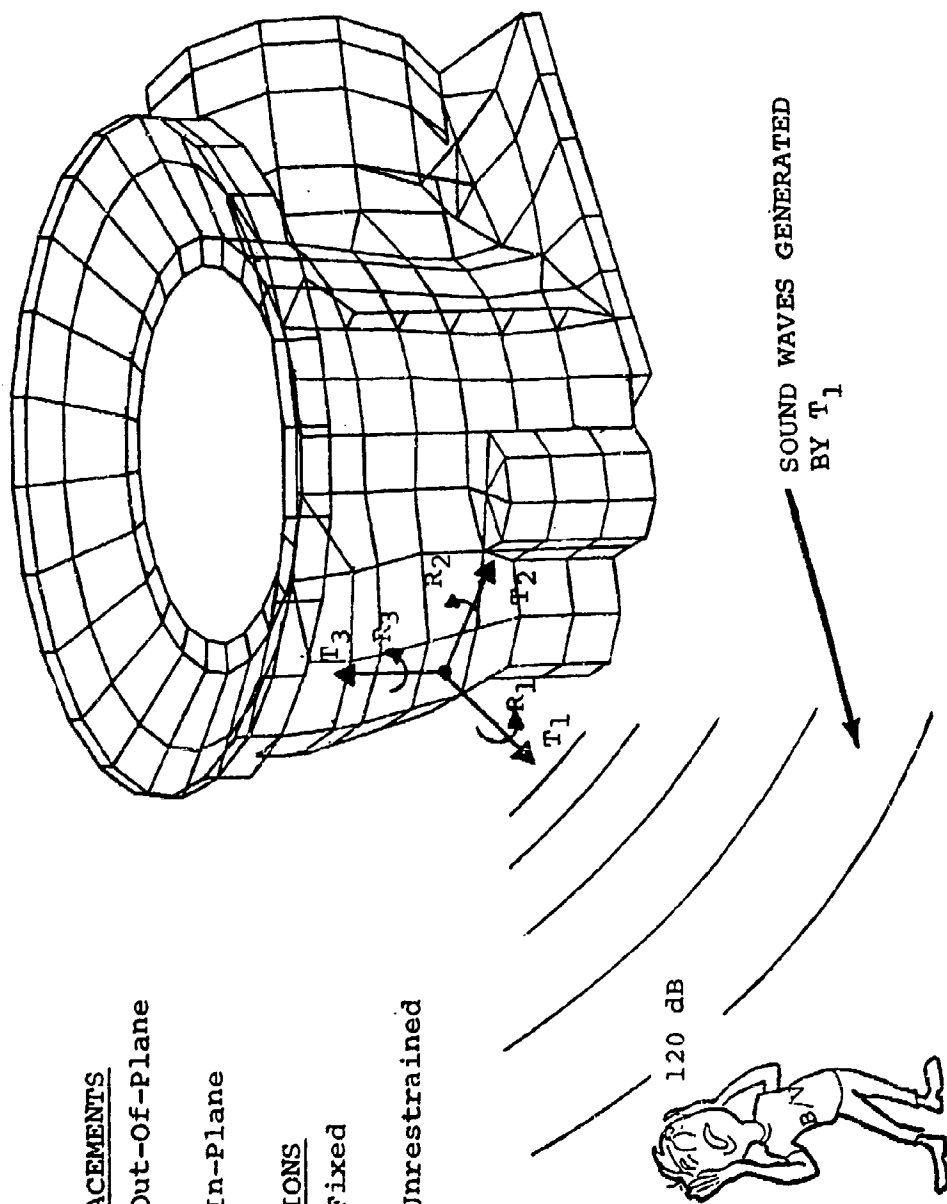


Figure 50. Transmission Noise Generated by Out-Of-Plane Displacements of Housing.

MODEL PARAMETERS

	NUMBER GRID POINTS	NUMBER ELEMENTS	NUMBER DEGREES OF FREEDOM	BANDWIDTH	CPU TIME (HOURS) *
			TOTAL SPC OMIT RETAINED	FULL REDUCED COLUMNS	ACTIVE
Upper Cover	160	202	960 184 614 162	34 162	0 0.24
Ring Gear	216	192	1296 216 828 252	- 252	0 0.75
Case	477	540	2862 529 2024 309	61 309	0 3.00
TOTAL	853	934			

*RIGID FORMAT 3 ON IBM 370

COMPARISON OF CALCULATED AND ACTUAL WEIGHTS*

	MODEL	HARDWARE	DIFFERENCE
Sump	3.7 kg (8.2 lb)	5.5 kg (12.2 lb)	**
Case	25.1 kg (55.4 lb)	24.6 kg (54.2 lb)	+ 2.2%
Ring Gear	34.9 kg (77.0 lb)	34.9 kg (77.0 lb)	0% (Lumped Masses for Teeth)
Upper Cover	62.8 kg (138.5 lb)	64.1 kg (141.4 lb)	- 2.0%

*(Case weight based on AZ91C cast magnesium alloy, density .065 lb/in³; upper cover weight based on 2014-T6 forged aluminum, density .101 lb/in³, both per MIL-HDBK-5B 1 September 71.)

**Model excludes internal passageways.

Figure 51. Summary of CH-47 Forward Transmission Housing NASTRAN Model.

- o Use of a widely accepted and thoroughly validated computer program (NASTRAN).
- o Extensive computer-generated plotting capability used to debug model.
- o Cross-checking of model, design drawings, and hardware.
- o Good correlation of model and hardware weights.
- o Further validation is ongoing in the form of correlation of dynamic response of model with test data.

Each natural mode of a structure contributes to vibration in proportion to its amplification factor. Consequently, since each mode whose frequency is in the vicinity of a forcing frequency will be a major contributor to the overall dynamic response, it is desirable to alter the housing natural frequencies so that none fall close to an exciting frequency.

Strain energy techniques for structural optimization have evolved in recent years. For applications such as helicopters where weight is critical, it is more appropriate to evaluate the strain density (strain energy/volume) distribution within a structure which provides guidance for vibration reduction by identifying the structural elements participating in the modes. To optimize a housing for minimum vibration/noise, the NASTRAN normal modes analysis is used to obtain a dynamic solution; by employing the ALTER feature of NASTRAN, a checkpoint tape containing the stresses for each element is generated. The natural frequencies calculated are compared with the gear mesh exciting frequencies to identify each mode shape whose natural frequency is close to an exciting frequency and which it is desirable to shift. A post-processor program (S-S3) has been developed which uses the data stored on the checkpoint tape to calculate the strain density of NASTRAN plate elements and tabulate the elements in order of descending strain density. The structural elements with the highest strain density are the best candidates for effective modification of the natural frequency, since a minimal weight change will yield a maximum shift in natural frequency. By locally altering the housing wall to change the mass and stiffness in these areas of high strain density, the natural frequency may be shifted away from an exciting frequency. Thus, the possibility of resonance is eliminated and the vibration and radiated noise are reduced. This strain density distribution concept will also be utilized statically to identify structural load paths and evaluate the efficiency of the housing structural design (stiffness/weight). By controlling this energy distribution, stress, vibration/noise, and weight may be reduced.

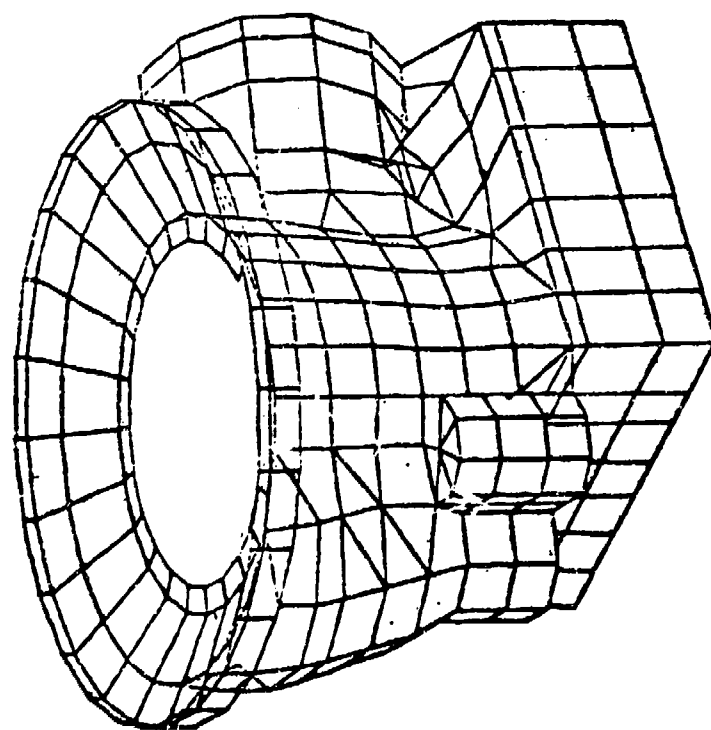
Figures 52, 53, and 54, respectively, show a NASTRAN plot of the housing (left and aft views), some typical natural frequencies in the vicinity of meshing frequencies, and a NASTRAN plot of a typical mode shape.

NASTRAN, LEVEL 16

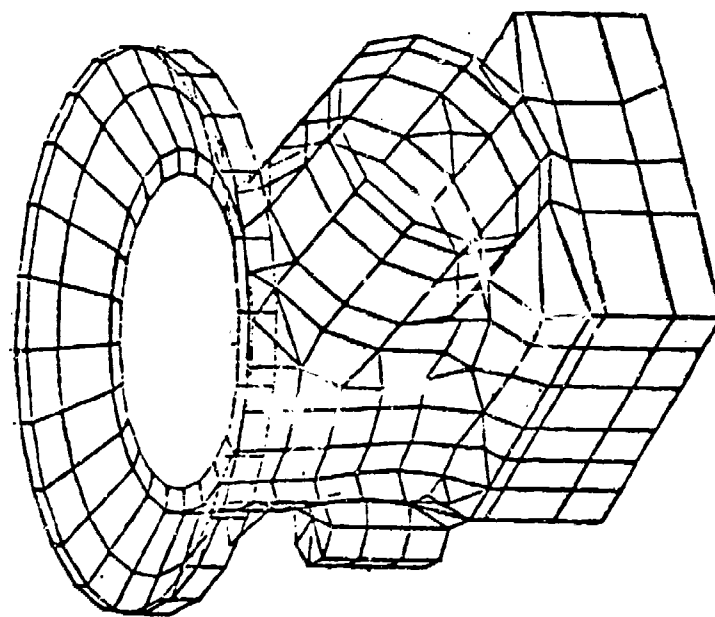
With the advent of NASTRAN, Level 16, with its capability to calculate strain energy, it may be used in place of D-82, S-68, and S-83 for all calculations (shafts and housing). This can be done as follows:

1. Conduct a dynamic analysis (Rigid Format 3) for shafts and housing. Punch out eigenvectors.
2. Reformat the punched output to SPC type input. Execute Rigid Format 1 to obtain strain energy for structural elements.

Two post-processor computer programs were developed to expedite and expand upon the above-mentioned procedures. A listing of a computer program for use with NASTRAN, Level 16 in order to take punched strain energy output from Rigid Format 1 and sort and analyze is shown in Appendix F. Appendix G contains the listing of a second computer program to be used with NASTRAN, Level 16, to reformat Rigid Format 3 to punched eigenvector output for execution with Rigid Format 1 as SPC cards for strain energy calculations. A sample strain energy output which was sorted and analyzed using the above programs is shown in Figure 55.



**LEFT SIDE
VIEW**



AFT VIEW

Figure 52. Computer-Generated Plots of NASTRAN Model; CH-47C
Forward Rotor Transmission Case with Sump.

FORCING FREQUENCIES (AT 243 ROTOR RPM)

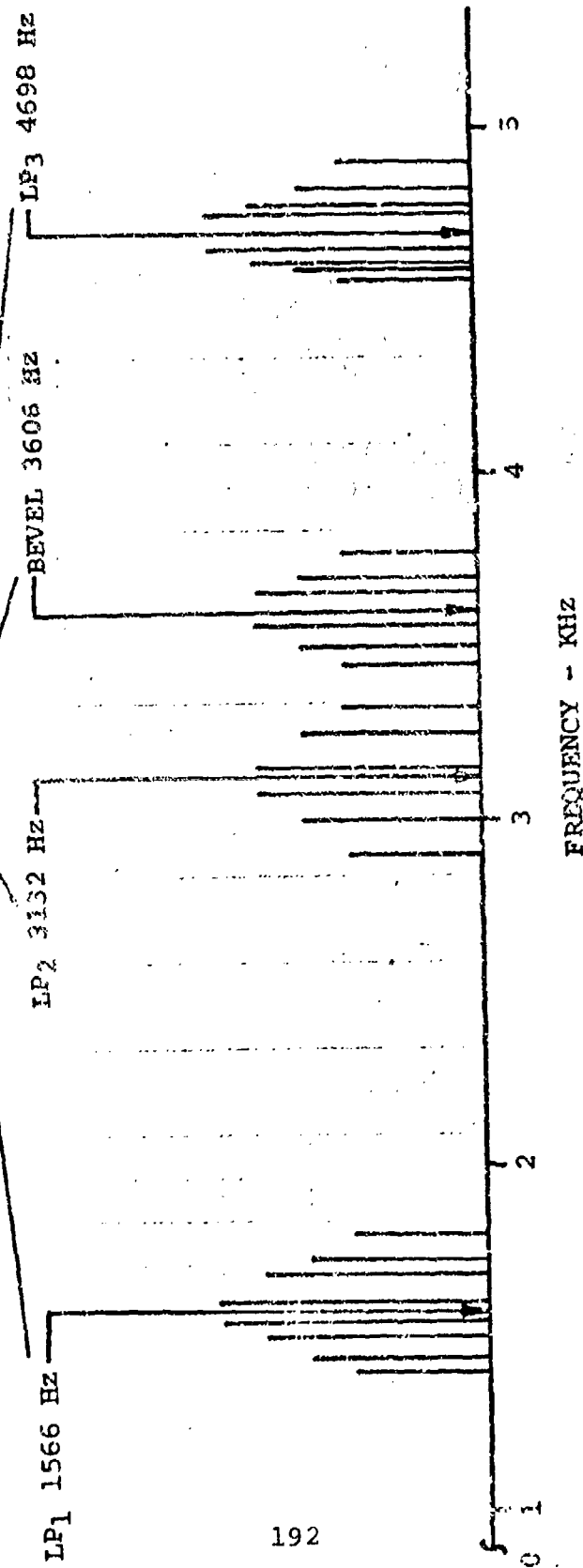


Figure 53. Spectrum of Forcing Frequencies Versus
NASTRAN Predicted Natural Frequencies for
CH-47C Forward Transmission Case.

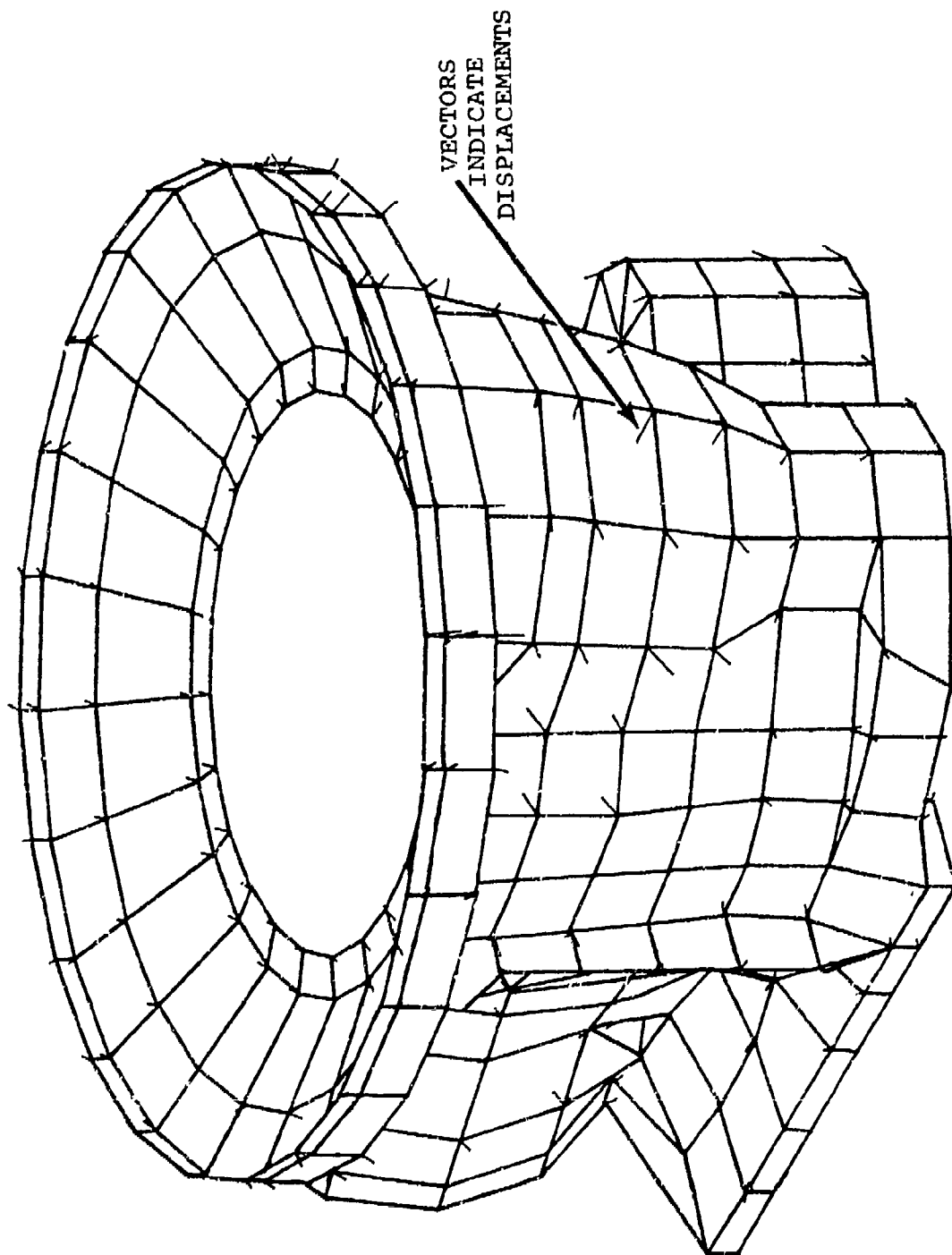


Figure 54. NASTRAN Plot of Deformed Housing,
Mode #46, Frequency 3141 Hz.

TITLE	FULLY STRESSSED DESIGN	106
SUBTITLE		108
LABEL	F	111
LIBRARY STRAIN ENERGY		112
REAL OUTPUT		113
SUBCASE 1		114

INDEX NO.	ELEMENT NO.	STRAIN	PERCENT	ACCUMULATED PERCENT
1	6010	426.75036	5.46636	5.46636
2	71	275.19745	3.51115	8.97751
3	6010	271.44727	3.47184	12.44935
4	6017	267.62219	3.42165	15.87100
5	60	189.78973	2.40442	18.27542
6	61	184.21742	2.35675	20.63217
7	115	171.79651	2.22293	22.85510
8	6001	173.34951	2.22296	25.07806
9	60	159.48729	2.01219	27.09025
10	67	150.71225	2.01317	29.10342
11	60	154.27717	2.02399	31.12741
12	71	154.21127	1.98324	33.11065
13	63	153.92069	1.98321	35.09386
14	71	146.79133	1.87377	36.96763
15	67	144.94716	1.85433	38.82196
16	4016	145.22226	1.77253	40.59449
17	511	133.69754	1.70596	42.29945
18	6010	118.62335	1.51678	43.81623
19	6016	118.29569	1.49487	45.31110
20	6016	112.71373	1.44128	46.75238
21	67	109.79535	1.40377	48.15615
22	60	105.19770	1.34555	49.50170
23	63	96.91559	1.23220	50.73390
24	65	95.87767	1.21524	51.94914
25	5006	94.33553	1.20521	53.15435
26	4016	92.72212	1.18558	54.33993
27	111	91.87479	1.17475	55.51468
28	60	81.17059	1.03746	56.55214
29	4017	75.87186	0.97313	57.52527
30	6011	72.61074	0.92954	58.45481
31	61	71.79743	0.91730	59.37211
32	77	71.35747	0.90598	60.27809
33	501	65.82515	0.84167	61.11976
34	64	64.72321	0.82758	61.94734
35	62	62.94674	0.77318	62.72052
36	61	61.63114	0.77525	63.49577
37	50	59.64013	0.76083	64.25660
38	70	59.86732	0.75271	65.00931
39	507	58.65145	0.74954	65.75885
40	76	56.73559	0.72550	66.48435
41	67	52.94134	0.67594	67.16029
42	61	52.27777	0.67676	67.83705
43	1002	51.15431	0.65418	68.49123
44	70	49.77717	0.64738	69.13861
45	4007	48.23337	0.62555	69.76416
46	61	47.75111	0.62691	70.39107
47	513	48.41112	0.61721	71.00828
48	607	46.76731	0.61444	71.62272
49	517	48.71557	0.61475	72.23747

Figure 55. Sample Strain Energy Output
(Sorted and Analyzed).

57	310	47.16133	0.60175	72.96918	176
TITLE: FULLY STRESSED DESIGN					176
SUBTITLE:					176
LABEL:					111
ELEMENT STRAIN EFFECTIVE					112
REAL OUTPUT					113
SUPCASE 11.4					114
INDEX NO.	ELEMENT NO.	STRAIN	PERCENT	ACCUMULATED PERCENT	
51	67	45.52327	0.55206	72.57127	
52	310	45.50766	0.57548	74.14671	
53	6012	44.88559	0.57492	74.72164	
54	41	44.94524	0.56830	75.29093	
55	56	42.43554	0.54360	75.83151	
56	76	41.63477	0.53315	76.36469	
57	170	41.22279	0.52818	76.89197	
58	76	40.54791	0.51130	77.40326	
59	96	39.85125	0.50750	77.91075	
60	76	38.64654	0.49414	78.40489	
61	5012	38.54166	0.49281	78.89770	
62	4110	37.41527	0.47041	79.36811	
63	18	36.11528	0.46105	79.82916	
64	26	35.44257	0.45370	80.28286	
65	92	35.13773	0.44990	80.73276	
66	64	35.05796	0.44821	81.17997	
67	5110	31.28191	0.3957	81.57567	
68	16	30.91196	0.39524	81.97091	
69	59	28.24854	0.36677	82.33768	
70	101	26.21233	0.38631	82.72400	
71	315	24.46791	0.37335	83.10735	
72	17	23.61179	0.37863	83.48598	
73	5217	24.15156	0.37273	83.85871	
74	7017	22.49257	0.36555	84.22426	
75	318	22.33919	0.36236	84.58662	
76	78	24.01282	0.35918	84.94580	
77	108	27.49731	0.35538	85.30118	
78	81	27.11313	0.34668	85.64786	
79	44	27.23011	0.34502	85.99288	
80	91	25.63233	0.33615	86.32903	
81	352	25.50087	0.32826	86.65729	
82	78	25.48792	0.32598	86.97927	
83	327	23.57674	0.32146	87.30073	
84	1	22.57575	0.28871	87.58944	
85	5013	21.53124	0.27594	87.86538	
86	63	20.42514	0.26832	88.13370	
87	615	21.44559	0.26075	88.39445	
88	620	20.38536	0.26006	88.65451	
89	815	20.71687	0.25650	88.91101	
90	73	19.92973	0.25073	89.16174	
91	6081	18.54424	0.25374	89.41548	
92	621	17.64747	0.24525	89.66073	
93	312	19.22311	0.24607	89.90680	
94	15	18.27013	0.23341	90.14021	
95	23	17.85712	0.22837	90.36858	
96	16	17.83412	0.22813	90.59671	
97	612	17.22345	0.22112	90.81783	
98	507	17.12435	0.21555	91.03338	
99	47	15.85757	0.21616	91.24954	

Figure 55. Continued.

100	100	16.75165	0.21413	91.44381
101	5005	16.74965	0.21317	91.61757
TITLE # FULLY STRESSED DESIGN				
SUBTITLE #				106
CAPLE #				108
ELEMENT STRAIN ENERGIES				111
REAL OUTPUT				112
SURFACE IN #				113
				114
INDEX NO.	ELEMENT NO.	STRAIN	PERCENT	ACCUMULATED PERCENT
102	701	16.46009	0.21246	91.90843
103	20	16.74416	0.20517	92.11361
104	4012	15.73586	0.20120	92.31479
105	92	15.69755	0.19951	92.51430
106	103	15.54655	0.19470	92.71307
107	20	15.50710	0.19026	92.91135
108	24	15.29923	0.18563	93.10896
109	15	14.53976	0.17669	93.29364
110	5007	13.82050	0.17471	93.47735
111	6011	13.65458	0.16692	93.65727
112	22	12.76402	0.16321	93.83047
113	12	12.19447	0.15892	93.99839
114	306	12.17999	0.15574	94.16212
115	6005	12.57572	0.15441	94.32653
116	65	12.05874	0.15419	94.48170
117	4037	11.63115	0.14972	94.63341
118	314	11.61799	0.14450	94.77791
119	5011	11.11485	0.14212	94.91602
120	21	11.10542	0.14200	95.05801
121	35	10.89921	0.13885	95.19485
122	6004	10.38404	0.13277	95.32762
123	58	10.35713	0.13179	95.45941
124	5022	9.74969	0.12466	95.58306
125	14	9.60355	0.12279	95.70285
126	13	9.52035	0.12173	95.81957
127	4011	9.34369	0.11447	95.93463
128	40	9.95543	0.11451	96.04853
129	5014	8.74483	0.11181	96.16033
130	43	8.73700	0.11171	96.27204
131	2	8.47608	0.10938	96.38041
132	6014	8.37784	0.10712	96.48453
133	707	8.18700	0.10366	96.58518
134	94	8.00674	0.10238	96.68255
135	4013	7.84901	0.10035	96.77591
136	107	7.64464	0.09781	96.86572
137	801	7.54136	0.09643	96.95819
138	4005	7.11464	0.09097	97.04509
139	55	6.87924	0.08755	97.12704
140	4	6.80863	0.08735	97.21410
141	5006	6.55646	0.08363	97.29793
142	10	6.52655	0.08345	97.38138
143	11	6.52399	0.08342	97.46479
144	5015	6.40151	0.08185	97.54663
145	3	6.36874	0.08143	97.62805
146	35	6.23876	0.07977	97.70781
147	54	6.21585	0.07947	97.78729
148	37	5.98641	0.07667	97.86354
149	95	5.70743	0.07258	97.93690

Figure 55 Continued.

150	9	5.65877	0.07236	98.00925
151	710	5.37497	0.06873	98.07797
152	93	4.98250	0.06371	98.14168
TITLE # FULLY STRESSED DESIGN				
SUBTITLE				
LABEL #				
ELEMENT STRAIN ENERGIES				
REAL OUTPUT				
SUBCASE ID #				
INDEX NO.	ELEMENT NO.	STRAIN	PERCENT	ACCUMULATED PERCENT
153	57	4.46240	0.06346	98.20512
154	5	4.95967	0.06342	98.26854
155	5009	4.95411	0.06335	98.33188
156	39	4.84310	0.06244	98.39430
157	311	4.82462	0.06169	98.45598
158	104	4.81942	0.06162	98.51759
159	48	4.77685	0.06108	98.57866
160	704	4.74314	0.06065	98.63930
161	62	4.65905	0.05957	98.69887
162	4739	4.61252	0.05898	98.75784
163	10	4.59195	0.05871	98.81654
164	16	4.56091	0.05832	98.87485
165	6022	4.51710	0.05776	98.93261
166	92	4.48036	0.05729	98.98988
167	305	4.33798	0.05547	99.04535
168	100	4.18970	0.05357	99.10189
169	6020	4.06903	0.05203	99.15692
170	27	3.62178	0.04631	99.19722
171	8	3.55622	0.04547	99.24269
172	11	3.39886	0.04346	99.28615
173	705	3.38133	0.04324	99.32938
174	7	3.31455	0.04238	99.37175
175	304	3.29408	0.04212	99.41386
176	4009	3.04433	0.03893	99.45279
177	706	2.92461	0.03740	99.49017
178	712	2.86452	0.03663	99.52679
179	4015	2.85441	0.03650	99.56328
180	45	2.76855	0.03540	99.59868
181	46	2.73507	0.03497	99.63364
182	28	2.79035	0.03453	99.66815
183	34	2.45320	0.03137	99.69951
184	33	2.32077	0.02967	99.72917
185	803	2.30650	0.02949	99.75865
186	6	2.26079	0.02891	99.78755
187	6021	2.22328	0.02843	99.81598
188	32	2.15386	0.02767	99.84364
189	31	1.81150	0.02316	99.86679
190	40	1.74436	0.02236	99.88914
191	702	1.61172	0.02061	99.90974
192	4022	1.55935	0.01949	99.92943
193	804	1.50761	0.01928	99.94870
194	402	1.45147	0.01856	99.96725
195	711	0.85332	0.01091	99.97815
196	703	0.52720	0.00674	99.98488
197	4014	0.47319	0.00505	99.99052
198	4120	0.46522	0.00500	99.99552
199	4021	0.26334	0.00337	100.00021

Figure 55. Continued.

STRAIN ENERGY ANALYSIS PROGRAMS (S-68 AND S-83)

PROGRAM DESCRIPTION

Engineering judgment has traditionally provided an approach to the optimization of a helicopter structure for vibration. This requires the engineer to have a prior comprehensive understanding of the analytical model, i.e., the eigenvalues and eigenvectors of the structure together with their influence on critical structural elements. Many cases of structural changes would be evaluated using the finite element dynamic solution, and the most favorable changes for the final design would be chosen from the study. This has proved to be a virtually impossible method, however, because the enormous number of structural elements and the need for side constraints make the number of possibilities for structural changes quite large. This approach is limited in that it only provides for studies of known structural change effects. For a new design, identification of the structural components that have a critical influence on vibration would be difficult. Also, no criteria exist to ensure that the final structural changes are optimum. The engineering judgment approach at best provides a minimal analytical tool for vibration design of new structures.

In recent years, a trend to dynamic optimization by strain energy techniques has evolved. This has mainly been for the optimal alteration of one undesirable natural frequency. To understand the technique, consider that in general each natural mode of the structure contributes to vibration in proportion to its amplification factor. Consequently, each mode whose frequency is in the vicinity of the forcing frequency would be a major contributor to the overall dynamic response. In the modal method, which operates principally on the amplification factor, the natural frequency immediately above the exciting frequency is usually increased. One could also reduce the natural frequency immediately below the exciting frequency if it is possible structurally.

Analysis has previously been developed verifying that a minimum weight structure with a specified natural frequency is one wherein the density differential is uniform throughout the structure when deformed in its natural mode (Reference 6). The density differential of a structural element is the difference between the strain energy per unit volume (strain density) and the kinetic energy per unit volume (kinetic density). In most cases, the strain density may be used as an approximation of the density differential, since the kinetic density is relatively small. Since the objective for aircraft is a maximum eigenvalue shift for a minimum

weight change, the strain energy density is used rather than the strain energy itself. It follows that a complex structure can most efficiently be redesigned dynamically by ensuring that the modal strain density is uniform throughout the structure. Hence, vibration optimization of a structure can be put on a more scientific basis if one considers its modal strain energy or density distribution.

A finite element analysis is first employed in the modal method to yield a dynamic solution. The eigenvectors (mode shapes) are obtained, then the modal strain energy distribution throughout the structure is found for any given mode shape whose natural frequency is to be modified. The strain energies for all structural elements are obtained and then tabulated from the highest to lowest. The structural elements in the highest strain would be the best candidates for modification of the natural frequency. This follows intuitively in the modal case from the almost invariency of the mode shapes and from Rayleigh's quotient. Theory also substantiates this in that it has been proven analytically that the rate of change of a natural frequency (eigenvalue) with respect to a structural parameter (thickness herein) of an element is equal to the strain energy of the structural element when the entire structure is deformed according to the mode shape. For example, in the case of increasing the lowest mode, the elements with the highest strain density, when deformed in this mode, would be the best candidates for modification to obtain a maximum eigenvalue shift for a minimum weight penalty (i.e., optimally).

Two computer programs have been utilized to evaluate the strain energy of the transmission components. Using the mode shapes calculated in D-82 for the shaft model, program S-68 has been used to identify the areas of high strain energy density for the shafting. A listing of this program is contained in Appendix H. S-68 computes the normalized strain energy for each structural element using the critical modes independently. Then the strain density of each element is determined as a function of its volume. These are then sorted from the highest to lowest strain density, and the elements with high strain density are then the optimal members to change for a minimum weight penalty in order to shift the natural frequency. This program was developed by Boeing Vertol under Army Research Office contract DAHCO4-71-C-0048. A second strain energy program (S-83) compatible with NASTRAN (plate elements) has been developed and used to identify the listing of this program is contained in Appendix I. These areas are directly associated with undesirable vibrations and noise. Though variations exist in wall thickness and geometry, these regions can be modified to provide an improved design configuration. To optimize a housing for minimum vibration/noise, the NASTRAN normal modes analysis is used to obtain a

dynamic solution. By employing the ALTER feature of NASTRAN, specifically for Rigid Format 3,

ALTER 107

CHKPNT OES1, OEF1.\$

ENDALTER

a checkpoint tape containing the stresses (data block OES1) and forces (data block OEF1) for each element is generated. These should come last in the case control. "ELFORCES" and "STRESSES" should also be calculated. The S-83 post-processor program reads the modal dynamic stresses from the checkpoint tape for each mode shape, calculates the strain density of each of the NASTRAN plate elements,

$$S.D. = \frac{S.E.}{V} = \frac{1}{2E} (\sigma_{\max}^2 + \sigma_{\min}^2 - 2\mu \sigma_{\max} \sigma_{\min}) \frac{1}{V}$$

where

S.D. is the strain density,

S.E. is the strain energy,

E is Young's modulus,

$\sigma_{\max}$, $\sigma_{\min}$ are principal stresses,

μ is Poisson's ratio, and

V is the volume of the element,

and then tabulates the elements in order of descending strain density.

In the calculation of the plate stresses, NASTRAN calculates the stresses for the upper and lower surfaces. S-83 has options whereby the strain density calculation may be based on upper stresses, lower stresses, or membrane stresses, where

$$\sigma_u = \sigma_b + \sigma_a$$

$$\sigma_L = \sigma_b - \sigma_a$$

yields

$$\sigma_b = \frac{\sigma_u + \sigma_L}{2}$$

$$\sigma_a = \frac{\sigma_u - \sigma_L}{2}$$

and where the subscripts

u is upper,
L is lower,
b is bending, and
a is membrane.

The above separation of bending and membrane stress would yield another and more exacting strain density analysis. For the housing, the outer combined bending-membrane stresses were used.

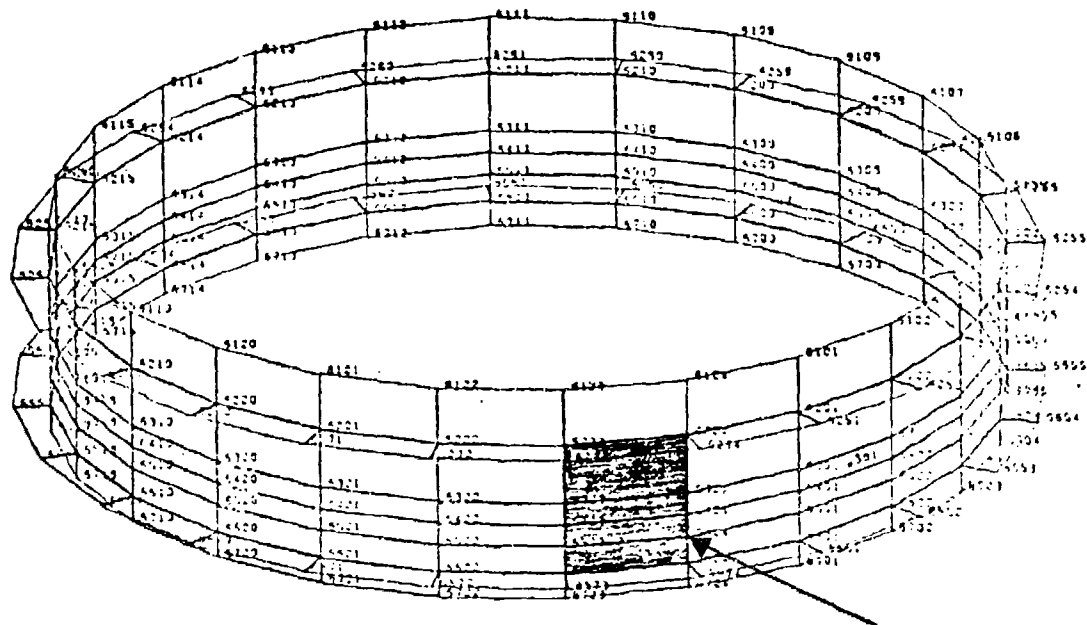
In order to determine whether strain energy methods could be used for the vibration reduction of a large, complex structure, some evidence as to feasibility was needed. These methods have been successfully applied to the vibration reduction of the Boeing Vertol Model 347 helicopter. Impedance methodology (applied to the design of absorbers) and detuning of the 347 fuselage (by structural modification) have resulted in an exceptionally low final vibration level throughout the entire flight envelope. The structure to be modified for detuning was indicated by the modal strain energy technique. Hence, the feasibility of strain energy methods was established as a practical means for dynamic design for large complex structures (Reference 5). Figures 56 and 57 show this (analytically) for the CH-47C forward transmission ring gear.

This strain density distribution concept can also be utilized statically to identify structural load paths and evaluate the efficiency of the housing structural design (stiffness/weight).

PROGRAM INPUT AND OUTPUT FORMAT

The input format to S-68 is compatible with D-82 input format except as noted.

1. Cards after loader locations 0026 must be removed up to the "88888" card (sheet 1).
2. C-51 cards must be removed after the "99999" card following the masses input.
3. At end of deck, add number of modes to be analyzed (15, card 1) and mode shapes desired (1615, card 2).



MODIFIED
ELEMENTS (TYP)
WALL THICKNESS
INCREASED BY
0.2"

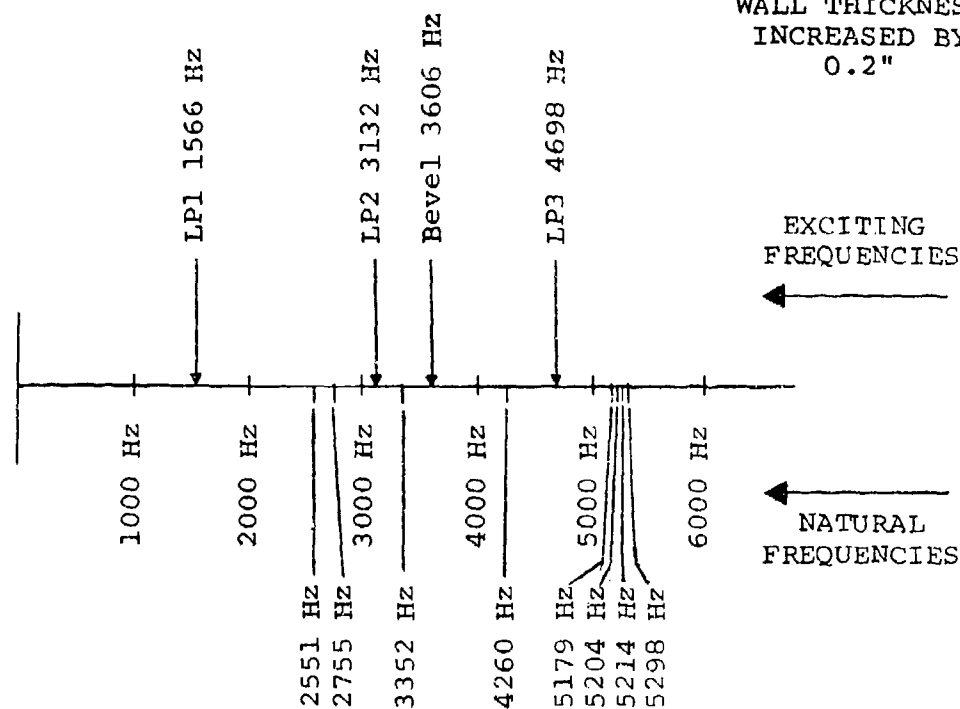


Figure 57. CH-47 Forward Rotor Transmission Ring Gear; Modified Configuration and Resulting Spectrum (at 80% Torque, 7460 RPM Sync Shaft Speed).

An example of output from the strain energy density computer program S-68 is shown in Figure 58. In addition, a flow diagram of the operation of computer program S-68 is shown in Figure 59. Figure 60 illustrates the application of computer program S-68 to the CH-47C forward pylon natural frequencies alteration. This example shows how modification to the structure can move the natural frequencies away from an exciting frequency and thereby reduce the amplification factor.

Since S-83 will calculate centerline stresses from data containing bending stresses, a flag must be input to indicate whether or not bending forces are to be processed and, if not, which of the two fiber distances will be used. Output includes a reference plate thickness, and when CTRIAL or CQUAD1 elements exist, the user must flag the thickness to be output; the default is membrane thickness. The thickness specified has no effect on the output.

Figure 61 shows a typical S-83 input sheet which is rather standard except for Poisson's ratio and the modulus of elasticity. The cards are divided into ten fields of eight columns each. Figure 62 shows a typical S-83 strain density output (sorted) for the CH-47C forward transmission housing. Using this output to identify high strain density areas, a compromise modification (two contour plates) to the housing for detuning natural frequencies near four mesh excitations is shown in Figure 63.

CARD 1

FIELD

Col	1-8	-	GPL	(LEFT JUSTIFIED)
Col	9-16	-	EST	(LEFT JUSTIFIED)
Col	17-24	-	ØES1	(LEFT JUSTIFIED)
Col	25-32	-	ØEF1	(LEFT JUSTIFIED)
Col	33-40	-	BENDING OR MEMBRANE	(LEFT JUSTIFIED)
Col	41-48	-	FORCE FLAG	(RIGHT JUSTIFIED INTEGER)
Col	57-64	-	MODE OPTION	(LEFT JUSTIFIED)
Col	65-72	-	e-Young's Modulus	(REAL)
Col	73-80	-	u-Poisson's Ratio	(REAL)

Natural Frequency = 1526 Hz

**** MODE SHAPE NO. 7 ****

Lower Planetary

First Harmonic = 1566 Hz

```

-----
              AXIAL ELEMENT
N1= 135 N2= 335 MATERIAL CODE= 1 AREA= C.203000 01
              STRAIN ENERGY = C.44052330-02
EL. VOL. / GROUP VOL.= C.33964710-C1 EL. VOL. / TOTAL VOL.= C.33964710-01
-----
              AXIAL ELEMENT
N1= 125 N2= 325 MATERIAL CODE= 1 AREA= C.780000 00
              STRAIN ENERGY = C.88740010-03
EL. VOL. / GROUP VOL.= C.13050430-C1 EL. VOL. / TOTAL VOL.= C.13050480-01
-----
              BEAM ELEMENT
N1= 125 N2= 225 N3= 325 MATERIAL CODE= 1 IY= C.100000-01 JX= C.336000 02
AW= C.100000-01 STRAIN ENERGY = C.17770840-03
EL. VOL. / GROUP VOL.= C.14963120-C4 EL. VOL. / TOTAL VOL.= C.14731380-03
-----
              AXIAL ELEMENT
N1= 435 N2= 535 MATERIAL CODE= 1 AREA= C.206000 01
              STRAIN ENERGY = C.15394100-03
EL. VOL. / GROUP VOL.= C.34466650-C1 EL. VOL. / TOTAL VOL.= C.34466650-01
-----
              BEAM ELEMENT
N1= 135 N2= 137 N3= 335 MATERIAL CODE= 1 IY= C.130000 02 JX= C.0
AW= C.560000 01 STRAIN ENERGY = C.13519690-03
EL. VOL. / GROUP VOL.= C.62841970-C3 EL. VOL. / TOTAL VOL.= C.72683000-02
-----
              BEAM ELEMENT
N1= 113 N2= 115 N3= 325 MATERIAL CODE= 1 IY= C.120000 01 JX= C.0
AW= C.260000 01 STRAIN ENERGY = C.11617010-03
EL. VOL. / GROUP VOL.= C.36957060-C3 EL. VOL. / TOTAL VOL.= C.43244500-02
-----
              BEAM ELEMENT
N1= 111 N2= 113 N3= 325 MATERIAL CODE= 1 IY= C.500000 00 JX= C.0
AW= C.130000 01 STRAIN ENERGY = C.75123870-04
EL. VOL. / GROUP VOL.= C.68078800-C4 EL. VOL. / TOTAL VOL.= C.70123990-03
-----
              BEAM ELEMENT
N1= 109 N2= 111 N3= 325 MATERIAL CODE= 1 IY= C.170000 01 JX= C.0
AW= C.330000 01 STRAIN ENERGY = C.67698160-04
EL. VOL. / GROUP VOL.= C.98751660-C3 EL. VOL. / TOTAL VOL.= C.11042160-01
-----
              BEAM ELEMENT
N1= 128 N2= 129 N3= 325 MATERIAL CODE= 1 IY= C.570000 01 JX= C.0
AW= C.270000 01 STRAIN ENERGY = C.55683090-04
EL. VOL. / GROUP VOL.= C.56557770-C3 EL. VOL. / TOTAL VOL.= C.62414700-02
-----
              AXIAL ELEMENT
N1= 545 N2= 547 MATERIAL CODE= 1 AREA= C.170000 01
              STRAIN ENERGY = C.52620690-04
EL. VOL. / GROUP VOL.= C.28441930-C1 EL. VOL. / TOTAL VOL.= C.28441930-01
-----
              AXIAL ELEMENT
N1= 546 N2= 548 MATERIAL CODE= 1 AREA= C.170000 01
              STRAIN ENERGY = C.52820530-04
EL. VOL. / GROUP VOL.= C.28441930-C1 EL. VOL. / TOTAL VOL.= C.28441930-01

```

Figure 58. Example of Strain Density Output (S-68).

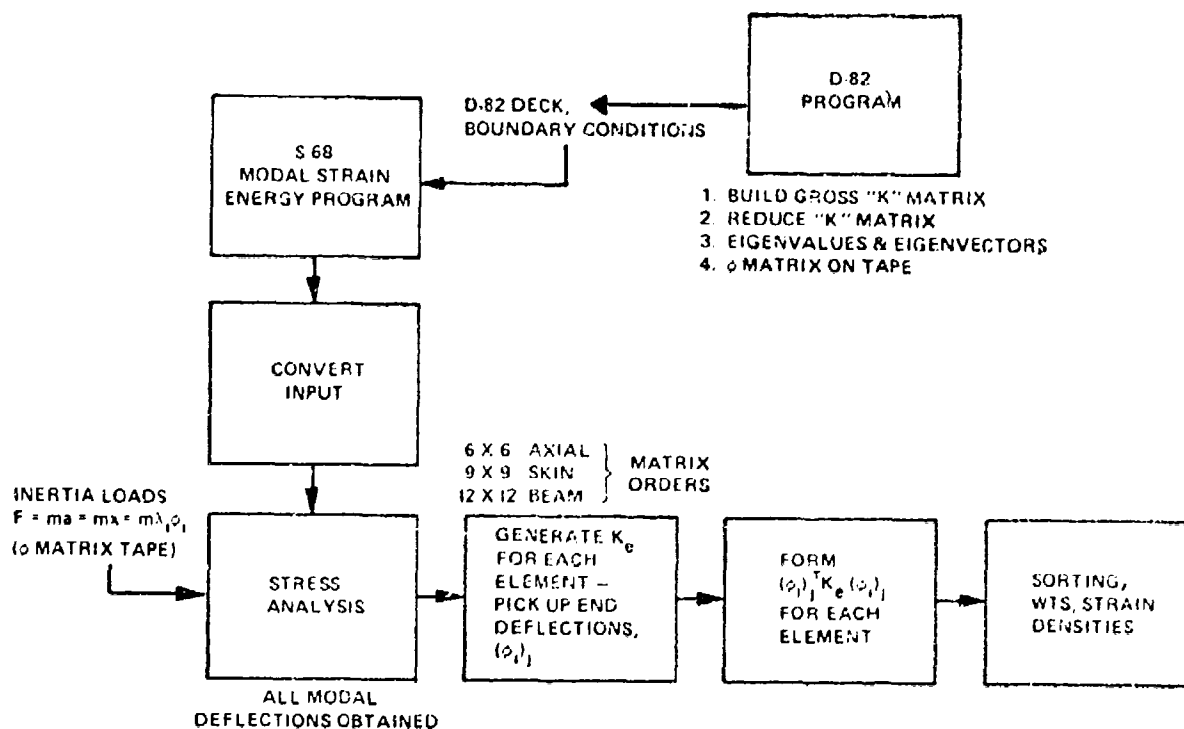


Figure 59. S-68 Modal Strain Energy Program Flow Diagram.

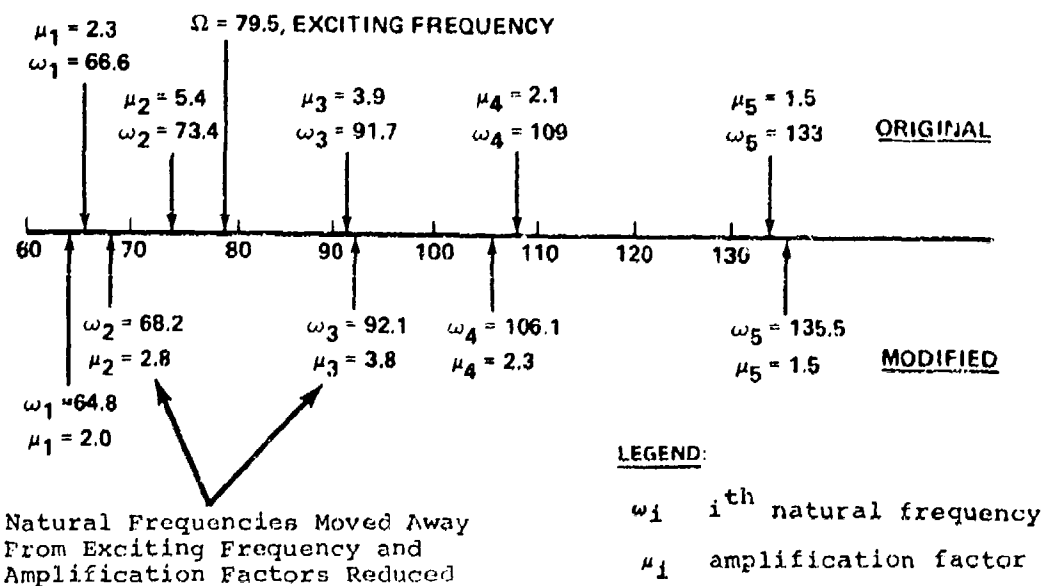


Figure 60. Example of Optimization of Natural Frequency Spectrum, CH-47 Helicopter Fuselage Forward Pylon Structure.

ELEMENT ID	PRINCIPAL STRESSES MAJOR	MINOR	STRAIN DENSITY
6317	-2839416F 07	-3863717E C7	0.269813E C6
6316	-2335387E 07	-3063722E 07	0.269841E C6
6315	-2495112E 07	-3163735E C7	0.269791E C6
6314	-2839255E 07	-3863558E 07	0.269752E C6
6314	-2839277F 07	-3863446E C7	0.269715E C6
6319	-2839100E 07	-3863273E 07	0.269751E C6
6313	-2839044F 07	-3863203E 07	0.269741E C6
6312	-2839254E 07	-3863272E 07	0.269719E C6
6311	-2818827E 07	-3862854E C7	0.269698E C6
6310	-2637757E 07	-3862797E 07	0.269685F C6
6320	-2636721E 07	-3862782E C7	0.269662E C6
6309	-2818662F 07	-3862555F C7	0.269670E C6
6308	-2818550E 07	-3862555E C7	0.269693E C6
6371	-2638487E 07	-3862414E C7	0.269632F C6
6307	-2836427E 07	-3862382F 07	0.269628E C6
6306	-2836352E 07	-3862272E 07	0.269606E C6
6305	-2836277F 07	-3862078E C7	0.269586E C6
6322	-2818056E 07	-3861935E C7	0.269503E C6
6304	-2835100E 07	-3861503E C7	0.269500E C6
6303	-2837918E 07	-3861465E 07	0.269527E C6
6323	-2837900F 07	-3861521F C7	0.269511E C6
6302	-2837755E 07	-3861444E C7	0.269498E C6
6324	-2837613E 07	-3861204E C7	0.269464E C6
6301	-2837624E 07	-3861177E C7	0.269462E C6
6267	-1233874F 07	-4158710F C7	0.265661E C6
6266	-1233805E 07	-4158657E 07	0.265588E C6
6255	-1233803E 07	-4158555E C7	0.265645E C6
6288	-1233805E 07	-4158453E 07	0.265628E C6
6284	-1233732E 07	-4158428E C7	0.265624E C6
6289	-1233705E 07	-4158370E 07	0.265596E C6
6283	-1233680E 07	-4158316F 07	0.265590E C6
6262	-1233584E 07	-4157564E 07	0.265585E C6
6261	-1233562E 07	-4157532E C7	0.265545E C6
6260	-1233481E 07	-4157313E 07	0.265536E C6
6259	-1233541E 07	-4157350E C7	0.265525E C6
6270	-1233394E 07	-4157260E 07	0.265523F C6
6256	-1233354E 07	-4157144E C7	0.265502E C6
6271	-1233484E 07	-4157350E 07	0.265470E C6
6257	-1233475E 07	-4157277E C7	0.265478E C6
6256	-1233284E 07	-4157070E 07	0.265452E C6
6255	-1233365E 07	-4156925E C7	0.265433E C6
6272	-1233240F 07	-4156806E C7	0.265419F C6
6254	-1233150E 07	-4156755E C7	0.265413E C6
6253	-1233222E 07	-4156730E C7	0.265384F C6
6273	-1233150E 07	-4156674E C7	0.265371F C6
6252	-1233100E 07	-4156600E C7	0.265355E C6
6274	-1233128E 07	-4156604F 07	0.265322E C6
6251	-1233031E 07	-4156601E C7	0.265318E C6
6267	0.2312432E 07	0.5977417E C6	0.608221E C5
6266	0.2312003E 07	0.5977836E C6	0.608220E C5
6265	0.2312748E 07	0.5977732E C6	0.608184E C5
6264	0.2312720E 07	0.5977719E C6	0.608152E C5
6264	0.2312641E 07	0.5977530E C6	0.608103E C5
6262	0.2312577E 07	0.5977646E C6	0.608043E C5
6263	0.2312559E 07	0.5977726F C6	0.607971E C5
6262	0.2312453E 07	0.5977570E C6	0.607958E C5
6261	0.2312372E 07	0.5977617E C6	0.607903F C5
6270	0.2312254E 07	0.5977635F C6	0.607850E C5
6260	0.2312280F 07	0.5977636F C6	0.607844E C5
6259	0.2312229F 07	0.5977656E C6	0.607801E C5
6258	0.2312137E 07	0.5977550E C6	0.607753E C5
6257	0.2312065E 07	0.5977617E C6	0.607687E C5
6271	0.2312044F 07	0.5977613F C6	0.607672E C5
6256	0.2311965E 07	0.5977554E C6	0.607620E C5
6255	0.2311877E 07	0.5977561E C6	0.607554E C5
6272	0.2311777E 07	0.5977522E C6	0.607481E C5
6254	0.2311755E 07	0.5977503E C6	0.607473E C5
6253	0.2311629F 07	0.5977486E C6	0.607382F C5
6273	0.2311548E 07	0.5977441E C6	0.607326F C5
6252	0.2311513E 07	0.5977454E C6	0.607301E C5
6274	0.2311427F 07	0.5977432E C6	0.607239F C5
6251	0.2311410E 07	0.5977413E C6	0.607229E C5
6116	0.9715977E 06	-1690540E C7	0.803900E C5
6117	0.9716066F 06	-1690544E C7	0.803898E C5
6118	0.9715129F 06	-1690535E C7	0.803336E C5
6115	0.9715240F 06	-1690520E C7	0.803331E C5
6114	0.9715038E 06	-1690420E C7	0.803295E C5
6119	0.9716184E 06	-1690438E C7	0.803208E C5
6113	0.9716267E 06	-1690327E 07	0.803155E C5
6112	0.9716476E 06	-1690270E C7	0.803119E C5
6111	0.9716807E 06	-1690191E 07	0.803041E C5
6110	0.9716009E 06	-1690145E 07	0.803021E C5
6129	0.9712480E 06	-1690253E C7	0.803017E C5
6109	0.9713168F 06	-1690115F 07	0.802559E C5
6108	0.9713876E 06	-1690066E 07	0.802938E C5
6121	0.9714537E 06	-1690544E C7	0.802836E C5
6137	0.9712254F 06	-1690560E C7	0.802781E C5
6106	0.9712375E 06	-1690578E C7	0.802783E C5
6105	0.9711603E 06	-1690539F C7	0.802698E C5
6104	0.9712244E 06	-1690573E C7	0.802653E C5
6122	0.9710257E 06	-1690562E C7	0.802648E C5
6103	0.9710259F 06	-1690567E C7	0.802524E C5

Figure 62. S-83 Strain Density Output (4770 Hz).

6123	0.4712077E 06	-0.1689500E 07	0.652490E 05
6102	0.47111347E 06	-0.1689533E 07	0.652490E 05
6124	0.4705142E 06	-0.1689463E 07	0.652490E 05
6101	0.4705111E 06	-0.1689394E 07	0.652490E 05
6516	0.1667465E 07	0.7373211E 05	0.452153E 05
6517	0.1667451E 07	0.7365511E 05	0.452153E 05
6515	0.1667441E 07	0.7365511E 05	0.452153E 05
6514	0.1667434E 07	0.7365511E 05	0.452153E 05
6518	0.1667434E 07	0.7365511E 05	0.452153E 05
6513	0.1667269E 07	0.7365275E 05	0.452153E 05
6519	0.1667264E 07	0.7367663E 05	0.452153E 05
6512	0.1667152E 07	0.7367731E 05	0.452153E 05
6511	0.1667141E 07	0.7367700E 05	0.452153E 05
6520	0.1667084E 07	0.7370413E 05	0.452153E 05
6520	0.1667084E 07	0.7366431E 05	0.452153E 05
6529	0.1667084E 07	0.7368375E 05	0.452153E 05
6504	0.1667084E 07	0.7366223E 05	0.452153E 05
6507	0.1667084E 07	0.7366104E 05	0.452153E 05
6521	0.1667084E 07	0.7363950E 05	0.452153E 05
6506	0.1667084E 07	0.7365404E 05	0.452153E 05
6525	0.1667084E 07	0.7367515E 05	0.452153E 05
6522	0.1667084E 07	0.7368244E 05	0.452153E 05
6504	0.1657582E 07	0.7366444E 05	0.452153E 05
6503	0.1657582E 07	0.7366025E 05	0.452153E 05
6523	0.1657582E 07	0.7367350E 05	0.452153E 05
6502	0.1657582E 07	0.7366431E 05	0.452153E 05
6524	0.1657582E 07	0.7367500E 05	0.452153E 05
6501	0.1657582E 07	0.7363555E 05	0.452153E 05
6510	0.7083128E 06	-0.1075474E 07	0.355095E 05
6517	0.7083128E 06	-0.1075468E 07	0.355095E 05
6515	0.7083128E 06	-0.1075468E 07	0.355095E 05
6514	0.7083128E 06	-0.1075413E 07	0.355095E 05
6518	0.7083128E 06	-0.1075426E 07	0.355095E 05
6513	0.7083128E 06	-0.1075343E 07	0.355095E 05
6519	0.7083128E 06	-0.1075305E 07	0.355095E 05
6512	0.7083128E 06	-0.1075313E 07	0.355095E 05
6511	0.7083128E 06	-0.1075272E 07	0.355095E 05
6520	0.7083128E 06	-0.1075272E 07	0.355095E 05
6520	0.7083128E 06	-0.1075250E 07	0.355095E 05
6509	0.7083128E 06	-0.1075219E 07	0.355095E 05
6508	0.7083128E 06	-0.1075177E 07	0.355095E 05
6507	0.7083128E 06	-0.1075130E 07	0.355095E 05
6521	0.7083128E 06	-0.1075100E 07	0.355095E 05
6506	0.7083128E 06	-0.1075064E 07	0.355095E 05
6505	0.7083128E 06	-0.1075030E 07	0.355095E 05
6522	0.7083128E 06	-0.1075021E 07	0.355095E 05
6504	0.7083128E 06	-0.1074954E 07	0.355095E 05
6503	0.7083128E 06	-0.1074940E 07	0.355095E 05
6523	0.7083128E 06	-0.1074932E 07	0.355095E 05
6502	0.7083128E 06	-0.1074885E 07	0.355095E 05
6524	0.7083128E 06	-0.1074845E 07	0.355095E 05
6501	0.7083128E 06	-0.1074816E 07	0.355095E 05
6510	0.6276733E 06	-0.8294016E 06	0.234019E 05
6517	0.6276733E 06	-0.8294016E 06	0.234019E 05
6515	0.6276733E 06	-0.8294016E 06	0.234019E 05
6514	0.6276733E 06	-0.8294016E 06	0.234019E 05
6518	0.6276733E 06	-0.8294016E 06	0.234019E 05
6513	0.6276733E 06	-0.8294016E 06	0.234019E 05
6519	0.6276733E 06	-0.8294016E 06	0.234019E 05
6512	0.6276733E 06	-0.8294016E 06	0.234019E 05
6511	0.6276733E 06	-0.8294016E 06	0.234019E 05
6520	0.6276733E 06	-0.8294016E 06	0.234019E 05
6520	0.6276733E 06	-0.8294016E 06	0.234019E 05
6509	0.6276733E 06	-0.8294016E 06	0.234019E 05
6508	0.6276733E 06	-0.8294016E 06	0.234019E 05
6507	0.6276733E 06	-0.8294016E 06	0.234019E 05
6521	0.6276733E 06	-0.8294016E 06	0.234019E 05
6506	0.6276733E 06	-0.8294016E 06	0.234019E 05
6505	0.6276733E 06	-0.8294016E 06	0.234019E 05
6522	0.6276733E 06	-0.8294016E 06	0.234019E 05
6504	0.6276733E 06	-0.8294016E 06	0.234019E 05
6503	0.6276733E 06	-0.8294016E 06	0.234019E 05
6523	0.6276733E 06	-0.8294016E 06	0.234019E 05
6502	0.6276733E 06	-0.8294016E 06	0.234019E 05
6524	0.6276733E 06	-0.8294016E 06	0.234019E 05
6501	0.6276733E 06	-0.8294016E 06	0.234019E 05
6510	0.3461401E 06	0.1221094E 06	0.180873E 04
6517	0.3461401E 06	0.1221094E 06	0.180873E 04
6515	0.3461401E 06	0.1221094E 06	0.180873E 04
6514	0.3461401E 06	0.1221094E 06	0.180873E 04
6518	0.3461401E 06	0.1221094E 06	0.180873E 04
6513	0.3461401E 06	0.1221094E 06	0.180873E 04
6519	0.3461401E 06	0.1221094E 06	0.180873E 04
6512	0.3461401E 06	0.1221094E 06	0.180873E 04
6511	0.3461401E 06	0.1221094E 06	0.180873E 04
6520	0.3461401E 06	0.1221094E 06	0.180873E 04
6520	0.3461401E 06	0.1221094E 06	0.180873E 04
6509	0.3461401E 06	0.1221094E 06	0.180873E 04
6508	0.3461401E 06	0.1221094E 06	0.180873E 04
6507	0.3461401E 06	0.1221094E 06	0.180873E 04
6521	0.3461401E 06	0.1221094E 06	0.180873E 04
6506	0.3461401E 06	0.1221094E 06	0.180873E 04
6505	0.3461401E 06	0.1221094E 06	0.180873E 04
6522	0.3461401E 06	0.1221094E 06	0.180873E 04
6504	0.3461401E 06	0.1221094E 06	0.180873E 04
6503	0.3461401E 06	0.1221094E 06	0.180873E 04
6523	0.3461401E 06	0.1221094E 06	0.180873E 04
6502	0.3461401E 06	0.1221094E 06	0.180873E 04
6524	0.3461401E 06	0.1221094E 06	0.180873E 04
6501	0.3461401E 06	0.1221094E 06	0.180873E 04

Figure 62. Continued.

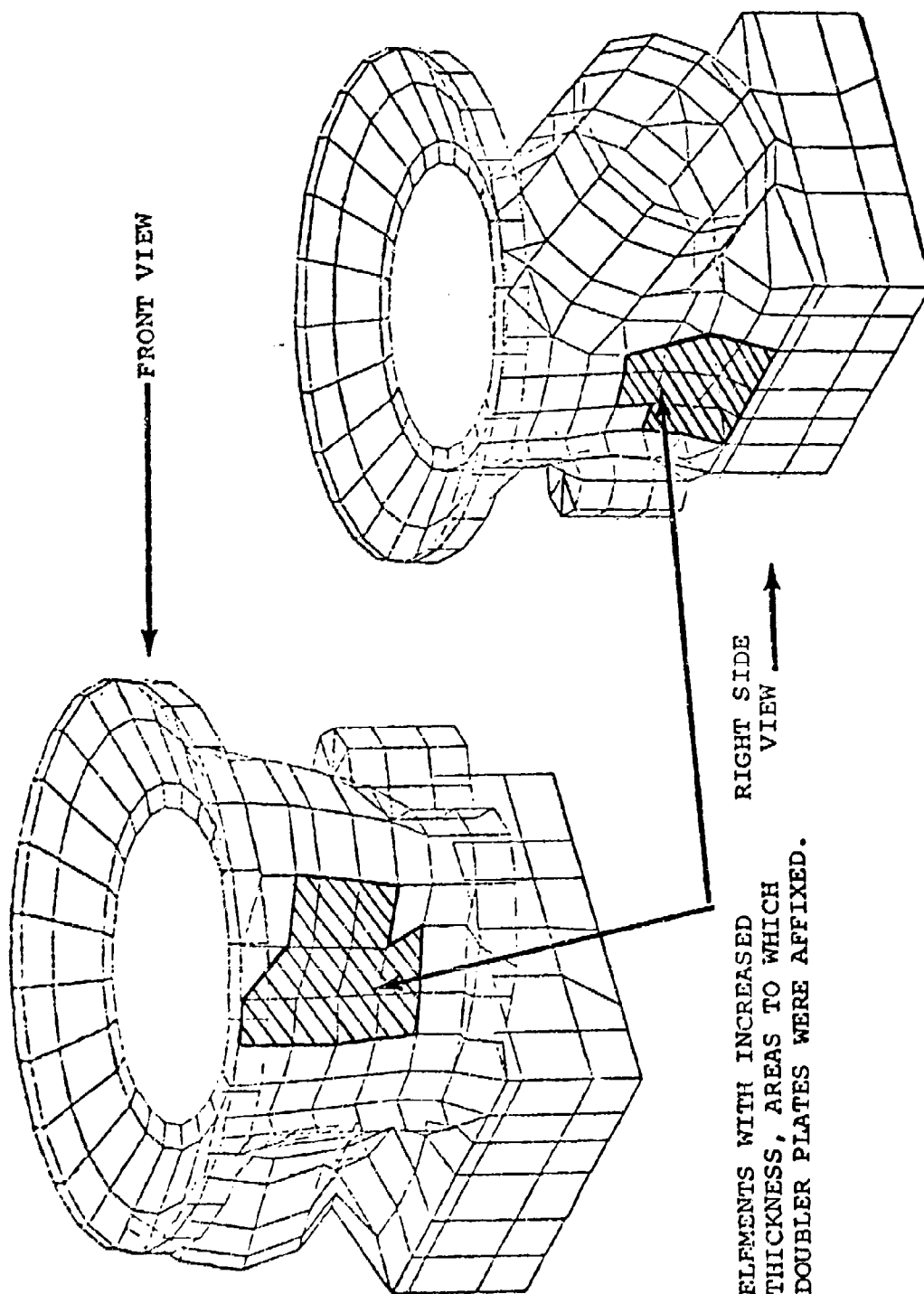


Figure 63. CH-47 Forward Transmission Case With Modifications
(Crosshatched Areas) to Wall Thickness.

NOTES:

1. Mnemonics are "bending" or "membrane".
2. Force Flag: Process plate forces, calculate
 centerline stresses

 =-1, Do not process plate forces, use
 first fibre stress

 =-2, Do not process plate forces, use
 second fibre stress

CARD 2

COLUMN 2



\$OMIT IXCLUD = \$END

Program S-83 includes strain density calculations for CQUAD1,
CTRIA2, CQUAD2 and CTRIA2 elements.

CONCLUSIONS

A complex gearbox such as a helicopter rotor transmission typically has more than one gear mesh, hence more than one exciting frequency. For instance, the Boeing Vertol CH-47C helicopter forward rotor transmission employs a spiral bevel gear mesh plus a two-stage planetary gear system. Additional sources of exciting frequencies in the form of sidebands are introduced by planetary gear configurations and manufacturing variations. This occurrence of multiple exciting frequencies, coupled with the fact that the housing possesses many natural frequencies, makes it a complex task to detune the housing so that none of the exciting frequencies coincides with a natural frequency. The primary frequencies for the CH-47 forward rotor transmission have been identified experimentally as the bevel gear mesh frequency and the lower planetary gear mesh frequency (LP1) and its second (LP2) and third (LP3) harmonics.

Experimentation which included the dynamic testing of a CH-47C forward transmission with internal instrumentation to measure strains, displacements, and accelerations of the rotating components and external instrumentation to measure housing acceleration and noise indicated that by modifying the gear/shaft/bearing system geometry the internal components may be detuned to minimize excitation of the housing. Application of strain density techniques to these dynamic components has identified modifications which have analytically reduced the loads exciting the housing at the bevel mesh, LP2 and LP3 frequencies, but increased the loads at the LP1 frequency. Since the effects of multiple noise sources are added logarithmically, the reduction of three out of four noise sources may not appreciably reduce the overall noise level.

Noise measurements have tended to confirm that housing responses exist and generate noise. This is evidenced, for example, by the LP2 and LP3 frequencies. Although the exciting source for these frequencies is within the ring gear, the maximum noise at these frequencies emanates from the mid-case region.

It is important to note that since the exciting frequencies will vary with changes in operating speed, the housing must be detuned at a specific operation speed ($\pm 3\%$). The use of strain density has led to preliminary identification of the areas of the housing structure which must be modified to detune the housing for reduced vibration/noise. The strain density distribution was determined using the NASTRAN post-processor for the modes with frequencies nearest to the four main exciting frequencies, and the elements with high strain density were identified. For each mode considered, the elements with high strain density are generally different; however, some elements are common to two or more of the modes. Strictly speaking, the elements with highest strain density for each

mode should be modified to achieve the maximum frequency shift for each corresponding mode. This approach would be used during the design of a new housing. To modify an existing housing, however, it would be cumbersome to incorporate the numerous and varied modifications indicated by such a rigorous application of the analysis. Therefore, for practical application to the experimental housing herein, those elements with a relatively high strain density which are common to two or more modes have been identified and were used to shift the housing frequencies. In this manner a specified structural change altered two or more frequencies, although perhaps no single frequency would be shifted maximally. It is more feasible to modify these elements, since the actual changes to the existing housing design for testing were limited to a few easily accessible areas on the exterior walls of the housing. This approach provided sufficient detuning to demonstrate the validity of the analyses. Prior to finalizing the detuned design, the dynamic response of the model, with the structural modification incorporated, was recalculated using NASTRAN.

The basic analytical approach used as a design tool for transmission vibration/noise reduction has been partially validated. The method unites the internal components and the housing, and hence optimizes the transmission as a complete operating system. Since the housing provides structural support to the internal components, its physical characteristics grossly affect performance and life in terms of internal bearing capacity, gear capacity, fretting, misalignments, etc. Therefore, housing optimization is essential if the full benefit of the advancements in gear and bearing technology are to be realized.

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APPENDIX A

LISTING OF GEAR TOOTH MESH EXCITATION AND COMPLIANCE INPUT GENERATOR PROGRAM FOR R-75 (GGEAR/HCR) OR R-67 (GGEAR)

```

*JOB          R,DRAGO,KP=29,PAGES=250,LINES=60,RUN=CHECK
1  DIMENSION RB(10),YE(10),GE(10),POS(10),VPT(10),IDENT(20),FN(10)
2  DIMENSION RP(10),RO(10),RT(10),ARM(10),AT(10),F(10),RF(10)
3  DIMENSION UJ1(80),UJ2(80),ZJ1(80),ZJ2(80),TOR(80)
4  F=10.E6
5  ANU=0.3
6  NWS = 1
7  DEG TOR = 0.017453
8  1999 I = 1
9  IRM = 0
10 IPERC = 0
11 IRF = 1
12 IPROP = 0
13 ICENT = 0
14 IDIAG = 0
15 INICR=0
16 XINT=1.0
17 NTS=1
18 READ(5,4004) IDENT
19 4004 FORMAT(20A4)
C
C
C  TREGOLD APPROXIMATION OF A SPUR GEAR FROM A BEVEL OR HELICAL GEAR
C
C  INPUT DATA GENERATOR
C  PROVIDES PUNCHED DECK FOR DIRECT INPUT TO GEARD,GGEAR,OR GGEAR/HCR
C
C  * * * * * INPUT DATA * * * * *
C
C  CARD # 1 - TITLE
C
C  CARD #2
C      J = OUTPUT SELECTION
C          0 = END OF JOB,TERMINATE EXECUTION
C          1 = TREGOLD ONLY
C          2 = GEARD (R-33)
C          3 = GGEAR (R-67)
C          4 = GGEAR/HCR (R-75)
C      OR INPUT J AS NEGATIVE VALUE TO READ OPTIONAL
C      MATERIAL PROPERTIES CARD
C      TN1 = NO OF TEETH - DRIVING
C      TN2 = NO OF TEETH - DRIVEN
C      PCA1 = PITCH CONE ANGLE(DEGREES) - DRIVING
C      PCA2 = PITCH CONE ANGLE(DEGREES) - DRIVEN
C      SA = SPIRAL OR HELIX ANGLE(DEGREES)
C      FW1 = FACE WIDTH(INCHES) - DRIVING
C      FW2 = FACE WIDTH(INCHES) - DRIVEN
C      PD = DIAMETRAL PITCH
C
C      RO1 = OUTSIDE RADIUS(INCHES) - DRIVING
C          OR IF INPUT AS A NEGATIVE VALUE
C          = ADDENDUM(INCHES) - DRIVING
C
C      RO2 = OUTSIDE RADIUS(INCHES) - DRIVEN
C          OR IF INPUT AS A NEGATIVE VALUE
C          = ADDENDUM(INCHES) - DRIVEN
C
C      PR1 = ROOT RADIUS(INCHES) - DRIVING
C          OR IF INPUT AS A NEGATIVE VALUE
C          = DEEDENDUM (INCHES) - DRIVING
C
C      PR2 = ROOT RADIUS(INCHES) - DRIVEN
C          OR IF INPUT AS A NEGATIVE VALUE
C          = DEEDENDUM (INCHES) - DRIVEN

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C      T1 = CIRCULAR TOOTH THICK.(INCHES) - DRIVING
C      T2 = CIRCULAR TOOTH THICK.(INCHES) - DRIVEN
C      OR IF T1 IS INPUT AS A NEGATIVE VALUE
C      T1 = PERCENT OF TOOTH THICK. SPLIT TO DRIVING MEMBER
C      T2 = BACKLASH(INCHES)
C
C      PA = PRESSURE ANGLE(DEGREES)
C      F1 = NO. OF CALCULATION POINTS
C      TSE1 = TOOTH SPACING ERROR(INCHES) - DRIVING
C      TSE2 = TOOTH SPACING ERROR(INCHES) - DRIVEN
C      MN = 0 FOR INTERNAL, = 1 FOR EXTERNAL
C      MM = NO. OF FOURIER TERMS
C      YORK = TORQUE(IN-LB) - DRIVING (0=READ VARIABLE TORQUE
C      ON TORCH) CARDS)
C
C      WS = SPEED OF DRIVING MEMBER(RPM)
C      IPLT = PLOTTING CONTROL(0=NO, 1=YES)
C      DEV = DEVIATION FROM STANDARD CENTER DISTANCE(INCHES)
C      NZJ = SELECTOR FOR DEVIATION AND COMPLIANCE METHOD
C
C      CARD - IF NZJ = 0, 4, OR 5  INSERT CARDS FOR PROFILE DEVIATIONS
C      DRIVING(UJ1) AND DRIVEN(UJ2)
C
C      CARD - IF NZJ = 0 OR 3  INSERT CARDS FOR TOOTH COMPLIANCE
C      DRIVING(2J1) AND DRIVEN(2J2)
C
C      CARD - IF YORK .LT. 0  INSERT CARDS FOR VARIANCE TORQUE
C      DRIVING(TOR)
C
C      CARD - IF NZJ = 1 OR 4  INSERT CARDS FOR TOOTH PROFILE
C      DEVIATION AT 4 POINTS ALONG PROFILE
C      DRIVING AND DRIVEN
C
C      CARD - IF J .LT. 0  INSERT MATERIAL PROPERTIES
C      YE(1) = MODULUS OF ELASTICITY - DRIVING
C      POS(1) = POISSONS RATIO - DRIVING
C      YE(2) = MODULUS OF ELASTICITY - DRIVEN
C      POS(2) = POISSONS RATIO - DRIVEN
C
C      * * * * *
C
20 2000 READ,J,TN1,TN2,PCA1,PCA2,SA,FW1,FW2,RO1,RO2,RR1,RR2,T1,
    T2,PA,F1,TSE1,TSE2,MN,MM,YORK,WS,IPLT,DEV,NZJ
21 IF(J.EQ.0) GO TO 5556
22 IF(J.LT.0) IPROP=1
23 IF(IPROP.EQ.1) READ,YE(1),POS(1),YE(2),POS(2)
24 J=IABS(J)
25 N = 3
26 IF(PCA1.EQ.0.AND.SA.GT.0) N = 2
27 IF(SA.EQ.0) N = 1
28 IF(MN.EQ.0) XINT=-1.0
29 PAR=PA*DEGTOR
30 IF(T1.GT.0.0) GO TO 1326
31 CP=3.14159/PO-T2
32 T1=ABS(T1-CP)
33 T2=CP-T1
34 1326 R1=TN1/(2*PD)
35 R2=TN2/(2*PD)
36 C=XINT+R1+R2+DEV
37 IF(RO1.GT.0.) GO TO 1315
38 R1=ABS(RR1)
39 PO1=R1+A1
40 1315 IF(RO2.GT.0.) GO TO 1316
41 A2=A1*(RO2)
42 PO2=R2+(A2*XINT)
43 1316 IF(RR1.GT.0.) GO TO 1320
44 R1=ABS(RR1)
45 RR1=R1-R1
46 1320 IF(RO2.GT.0.) GO TO 1325
47 R2=ABS(RR2)
48 PR2=R2-(P2*XINT)
49 GO TO 1317

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50 1325 A1=R01-R1
51 A2=(R02-R2)*XINT
52 R1=R1-RR1
53 R2=(R2-RR2)*XINT
54 1317 C=A1+A2
55 RH1=R1+COS(PAR)
56 RH2=R2+COS(PAR)
57 BASEP=2.43.14159*RB1/TN1
58 CR=(SQRT(R01**2-RB1**2)+(SQRT(R02**2-RB2**2)-C*SIN(PAR))*XINT)/
IFASIP
59 IF(CR.GE.2.0) INICR=1
C
C TREGOLD APPROXIMATION OF A SPUR FROM A SPIRAL BEVEL GEAR
60 TN = TN1
61 PCA = PCA1
62 FW = FW1
63 R = R1
64 A = A1
65 P = B1
66 T = T1
67 TSC = TSE1
68 XIN=1.0
69 GO TO 6051
70 6050 I = I+1
71 TN = TN2
72 PCA = PCA2
73 FW = FW2
74 R = R2
75 A = A2
76 P = B2
77 T = T2
78 TSC = TSE2
79 XIN=XINT
80 6051 PCA=PCA/DEGTOR
81 SA=SA/DEGTOR
82 ETNH=TN/COS(PCA)
83 ETSC=ETNH/(COS(SA))*3.
84 CFVH=FW
85 FFWC=FW/COS(SA)
86 RHR=(FW/2.0)*SIN(PCA)
87 RV=FW/COS(PCA)
88 RS=RV/(COS(SA))*2.
89 ALP=RM/R
90 AV=ALP*A
91 AS=AV
92 POV=RV+(AV*XIN)
93 ROS=RS+(AS*XIN)
94 RV=ALP*P
95 PS=PV
96 PRV=RV-(RV*XIN)
97 PRS=RS-(RS*XIN)
98 DM=ALP*D
99 DV=DM
100 DS=DV
101 TIFRV=ROV-(OV*XIN)
102 TIFRS=ROS-(OS*XIN)
103 TM=ALP*T+COS(SA)
104 TV=TP
105 IF(D.EQ.2) TV = T
106 TS=TV
107 CVE=(TIFRV-PRV)*XIN
108 CS=(TIFRS-PRS)*XIN
109 FRV=0.75+CV
110 FRS=0.75+CS
111 SA=SA/DEGTOR
112 PCA=PCA/DEGTOR
113 WRITE(6,10)
114 10 FORMAT('1',*TREGOLD APPROXIMATION FOR EQUIVALENT SPUR GLARS',//)
115 GO TO (32,20,9),N
116 9 WRITE(6,1) I,TN,PCA,SA,FW,R,RH,ALP,A,P,D,T,TH
117 1 FORMAT('0', *SPIRAL BEVEL GEAR DESIGN DATA GEAR NO.',4X,12,/,
1 * NUMBER OF TEETH - SPIRAL BEVEL * ,14X,F10.1/)

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2* PITCH CONE ANGLE - SPIRAL REVEL          *.14X,F10.6,4X,*DEGREES*/
3* SPIRAL ANGLE OF SPIRAL REVEL              *.14X,F10.6,4X,*DEGREES*/
4* FACE WIDTH OF SPIRAL REVEL               *.14X,F10.6,4X,*INCH */
5* PITCH RADIUS OF SPIRAL REVEL             *.14X,F10.6,4X,*INCH */
6* MEAN PITCH RADIUS OF SPIRAL REVEL        *.14X,F10.6,4X,*INCH */
7* RATIO OF RADIUS OF SPIRAL REVEL          *.14X,F10.6,4X,*INCH */
8* ADDENDUM OF SPIRAL REVEL AT LARGE END*.13X,F10.6,4X,*INCH */
9* DEDENDUM OF SPIRAL REVEL AT LARGE END*.13X,F10.6,4X,*INCH */
1* WORKING DEPTH OF SPIRAL REVEL AT LARGE END*.8X,F10.6,4X,*INCH*/
2* CIR.Tooth THICKNESS-SPIRAL REVEL-LARGE END*.8X,F10.6,4X,*INCH*/
3* MEAN CIR.Tooth THICKNESS-SPIRAL REVEL*.13X,F10.6,4X,*INCH*)
118 20 WRITE(6,21) 1,ETNH,EFWH,RV,AV,ROV,HV,RRV,DV,TIFRV,TV,LV,FRV
119 21 FORMAT(////* EQUIVALENT HELICAL GEAR GEAR NO. *,4X,12,///
1* EQUIVALENT NUMBER OF TEETH - HELICAL*,14X,F10.6/
2* EQUIVALENT FACE WIDTH - HELICAL *,13X,F10.6,4X,*INCH */
3* EQUIVALENT PITCH RADIUS - HELICAL *,15X,F10.6,4X,*INCH */
4* EQUIVALENT ADDENDUM - HELICAL *,20X,F10.6,4X,*INCH */
5* EQUIVALENT OUTER RADIUS - HELICAL *,16X,F10.6,4X,*INCH */
6* EQUIVALENT DEDENDUM - HELICAL *,20X,F10.6,4X,*INCH */
7* EQUIVALENT ROOT RADIUS - HELICAL*,18X,F10.6,4X,*INCH */
8* EQUIVALENT WORKING DEPTH - HELICAL*,16X,F10.6,4X,*INCH */
9* EQUIVALENT T.I.F. RADIUS - HELICAL*,16X,F10.6,4X,*INCH */
1* EQUIVALENT CIRCULAR TOOTH THICKNESS-HELICAL*,7X,F10.6,4X,*INCH*/
2* EQUIVALENT RADIAL CLEARANCE-HELICAL*,15X,F10.6,4X,*INCH*/
3* EQUIVALENT TOOTH FILLET RADIUS-HELICAL*,12X,F10.6,4X,*INCH*)
120 32 WRITE(6,31) 1,ETNS,LFWS,RS,AS,ROS,RS,RRS,DS,TIFRS,TS,CS,FRS
121 31 FORMAT(////* EQUIVALENT SPUR GEAR GEAR NO. *,5X,12,///
1* EQUIVALENT NUMBER OF TEETH - SPUR*,17X,F10.6/
2* EQUIVALENT FACE WIDTH - SPUR *,21X,F10.6,4X,*INCH */
3* EQUIVALENT PITCH RADIUS - SPUR *,19X,F10.6,4X,*INCH */
4* EQUIVALENT ADDENDUM - SPUR *,23X,F10.6,4X,*INCH */
5* EQUIVALENT OUTER RADIUS - SPUR*,20X,F10.6,4X,*INCH */
6* EQUIVALENT DEDENDUM - SPUR*,24X,F10.6,4X,*INCH */
7* EQUIVALENT ROOT RADIUS - SPUR*,21X,F10.6,4X,*INCH */
8* EQUIVALENT WORKING DEPTH - SPUR *,16X,F10.6,4X,*INCH */
9* EQUIVALENT T.I.F. RADIUS - SPUR*,19X,F10.6,4X,*INCH */
1* EQUIVALENT CIRCULAR TOOTH THICKNESS-SPUR*,10X,F10.6,4X,*INCH*/
2* EQUIVALENT RADIAL CLEARANCE-SPUR*,18X,F10.6,4X,*INCH*/
3* EQUIVALENT TOOTH FILLET RADIUS-SPUR*,15X,F10.6,4X,*INCH*)
122 IN(1)=TNS
123 RP(1)=RS
124 RO(1)=ROS
125 RT(1)=TIFRS
126 ARP(1)=RRS
127 AT(1)=TS
128 F(1)=LFWS
129 RF(1)=FRS
130 RR(1)=RP(1)*COS(PAR)
131 ARGR=RP(1)/RT(1)
132 THETP=ARCCOS(ANGR)/DEGTOR
133 VPT(1)=TSE
134 IF(1PROP.EQ.1) GO TO 40
135 YC(1)=1
136 POS(1)=ANU
137 40 GE(1)=Y*(1)/(2.0*(1.0+POS(1)))
138 IF(1.EQ.1) GO TO 6050
C END OF TREGOLD APPROXIMATION ROUTINE
C
C
139 CL=RP(1)+RP(2)+DEV
140 CPIT=FD(1)/(2*RP(1))
141 IF(THICP.(Q.1.AND.J.NE.4) GO TO 5550
142 3001 GO TO (5555,3002,3003,3004),J
C
C R-33 OUTPUT ROUTINE
143 3002 WRITE(4,4005)
144 4005 FORMAT(*1*,5X,*THE FOLLOWING IS THE PUNCHED INPUT FOR R-33 GEAR*,
1////*)
145 4006 WRITE(4,4006) IDENT
146 4005 FORMAT(*0*,10X,*CARD NUMBER 1*//,20A4)
147 WRITE(7,4008) IDENT

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149 4008 FORMAT(20A4)
149 WRITE(6,4009)MN,MM
150 4009 FORMAT('0',10X,'CARD NUMBER 2'//
1      10X,'NUZ',10X,'INT',10X,'NMZ',10X,'MN',10X,'MM'//
2      11X,'1',12X,'1',12X,'1',11X,'1',12X,'12')
151 WRITE(7,4012) MN,MM
152 4012 FORMAT(4X,'1',4X,'1',4X,'1',4X,'1',3X,'12')
153 WRITE(6,4013)FN(1),FN(2),PP(1),THETP,RO(1),RO(2)
154 4013 FORMAT('0',10X,'CARD NUMBER 3'//
2      17X,'FN1',9X,'FN2',11X,'RP1',8X,'THETP',10X,'RO1',7X,'RO2 OR RI2'//
3      3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6)
155 WRITE(7,4016) FN(1),FN(2),PP(1),THETP,RO(1),RO(2)
156 4016 FORMAT(6E13.5)
157 WRITE(6,4017)RT(1),RT(2),ARM(1),ARM(2),FI,AT(1)
158 4017 FORMAT('0',10X,'CARD NUMBER 4'//
1      10X,'RT1',8X,'RT2',10X,'RM1',10X,'RM2',10X,'F1',11X,'I1'//
2      3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6)
159 WRITE(7,4016) RT(1),RT(2),ARM(1),ARM(2),FI,AT(1)
160 WRITE(6,4019) AT(2),F(1),F(2),RF(1),RF(2)
161 4019 FORMAT('0',10X,'CARD NUMBER 5'//
1      10X,'I2',10X,'F1',10X,'F2',10X,'RF1',10X,'RF2'//
2      3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6)
162 WRITE(7,4022) AT(2),F(1),F(2),RF(1),RF(2)
163 4022 FORMAT(5E13.5)
164 WRITE(6,4023) YE(1),YE(2),GE(1),GE(2),POS(1),POS(2)
165 4023 FORMAT('0',10X,'CARD NUMBER 6'//
1      10X,'YE1',11X,'YE2',13X,'GE1',13X,'GE2',15X,'POS1',9X,
2      1'POS2'//
3      3X,F13.5,3X,E13.5,3X,F13.5,3X,F13.5,3X,F13.6,3X,F10.6)
166 WRITE(7,4016) YE(1),YE(2),GE(1),GE(2),POS(1),POS(2)
167 NIT= P.+(2.-FI+1.)
168 DO 4025 I=1,NIT
169 WRITE(7,4026)
170 4026 FORMAT(FOX)
171 4025 CONTINUE
172 WRITE(6,4027) NIT,WT,VPT(1),VPT(2)
173 4027 FORMAT('0',10X,'CARDS NUMBER 7 HAS ',13,' BLANK CARDS'//
1,10X,'CARD NUMBER 8'//, 8X,'WT',9X,'VPT1',9X,'VPT2'//
2      3X,F10.2,3X,F10.6,3X,F10.6)
174 WRITE(7,4444) WT,VPT(1),VPT(2)
175 4444 FORMAT(3E13.5)
176 GO TO 5555
C END R-33 OUTPUT ROUTINE
C
C
C BEGIN OUTPUT ROUTINE FOR R-67 GGEAR PROGRAM
177 3003 WRITE(6,4040)
178 4040 FORMAT('1',5X,'THE FOLLOWING IS THE PUNCHED INPUT FOR R-67 GGEAR',
1'////////')
179 WRITE(6,4005) IDENT
180 WRITE(7,4008) IDENT
181 WRITE(6,4043) MN,MM,IPLT
182 4043 FORMAT('0',10X,'CARD NUMBER 2'//
1      10X,'MMC',10X,'INT',10X,'MN',10X,'MM',10X,'IPLT',10X,
2      2'FOUR',10X,'ISPECT'//
3      11X,'1',12X,'1',12X,'1',11X,'1',12X,'1',12X,'1',12X,'1',12X,'1')
183 WRITE(7,4046)MN,MM,IPLT
184 4046 FORMAT(4X,'1',4X,'1',4X,'1',4X,'1',3X,'12',4X,'1',4X,'1')
185 WRITE(6,4047)FN(1),FN(2),RH(1),RO(1),RO(2)
186 4047 FORMAT('0',10X,'CARD NUMBER 3'//
1      9X,'FN1',9X,'FN2',10X,'RH1',10X,'RO1',6X,'RO2 OR RI2'//
2      3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6)
187 WRITE(7,4050) FN(1),FN(2),RH(1),RO(1),RO(2)
188 4050 FORMAT(5E13.5)
189 WRITE(6,4051) RT(1),RT(2),ARM(1),ARM(2),FI,AT(1)
190 4051 FORMAT('0',10X,'CARD NUMBER 4'//
1      9X,'RT1',10X,'RT2',10X,'RM1',10X,'RM2',10X,'F1',11X,'I1'//
2      3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6)
191 WRITE(7,4054) RT(1),RT(2),ARM(1),ARM(2),FI,AT(1)
192 4054 FORMAT(6E13.5)
193 WRITE(6,4055) AT(2),F(1),F(2),RF(1),RF(2)
194 4055 FORMAT('0',10X,'CARD NUMBER 5'//

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1          10X,'12',10X,'F1',10X,'F2',10X,'RF1',10X,'RF2'/
2          3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6,3X,F10.6)
195      WRITE(7,4055) AT(2),F(1),F(2),RF(1),RF(2)
196      WRITE(7,4057) YE(1),YE(2),GE(1),GE(2),POS(1),POS(2)
197      4057 FORMAT('0',10X,'CARD NUMBER 6'//
1          1,10X,'YE1',12X,'YE2',12X,'GE1',13X,'GE2',11X,'POS1',10X,'POS2'//
2          3X,E13.5,3X,E13.5,3X,E13.5,3X,E13.5,3X,F10.6,3X,F10.6)
198      WRITE(7,4054) YE(1),YE(2),GE(1),GE(2),POS(1),POS(2)
199      WRITE(6,4060) CL,VPT(1),VPT(2)
200      4060 FORMAT('0',10X,'CARD NUMBER 7'//
1          1,8X,'CL',10X,'VPT1',10X,'VPT2',3X,F10.6,3X,F10.6,3X,F10.6)
201      WRITE(7,4063) CL,VPT(1),VPT(2)
202      4063 FORMAT(3E13.5)
203      NIT=2,'F1+1
204      DO 4064 I=1,NIT
205      WRITE(7,4065)
206      4065 FORMAT(POX)
207      4064 CONTINUE
208      DO 4066 I=1,NIT
209      WT=10X/R1
210      WRITE(7,4067) WT
211      4067 FORMAT(52X,F13.5)
212      4066 CONTINUE
213      WRITE(1,4068) NIT,NIT,NWS,WS
214      4068 FORMAT('0',10X,'THE 8TH CARDS HAVE THE FIRST',2X,12,2X,'CARDS BLAN
1          1K'//
2          10X,'AND',2X,12,2X,'CARDS WITH THE FIXED WT LOADING'//
3          2,10X,'CARD NUMBER 9'//
4          10X,'NWS',10X,'WS'//
5          11X,12,5X,F10.3)
215      WRITE(7,4073) NWS,WS
216      4073 FORMAT(15,F13.5)
217      5555 GO TO 1999
C
C
C BEGIN GET PUT ROUTINE FOR R75 GGEAR/HCR PROGRAM
218      3004 WRITE(6,4201)
219      4201 FORMAT('1',5X,' THE FOLLOWING IS THE PUNCHED INPUT FOR R-75 GGEAR/
1HCR'//)
220      WRITE(6,4005) IDENT
221      WRITE(7,4009) IDENT
222      WRITE(7,4205) MN,MNM,IPLT,THCR
223      4209 FORMAT('0',10X,'CARD NUMBER 2'//
1          1,10X,'NM',10X,'INT',10X,'MN',10X,'MM',10X,'IPLT',10X,
2          2,'FOUR',8X,'ISPECT',8X,'IHCR'//
3          3,11X,'1',12X,'0',11X,12,11X,12,12X,12,12X,'1',12X,'1',12X,11)
224      WRITE(7,4212) MN,MNM,IPLT,THCR
225      4212 FORMAT(4X,'1',4X,'0',315,4X,'1',4X,'1',15)
226      WRITE(6,4215) IRM,IPERC,IRF,IPROP,ICENT,NZJ,IDIAG
227      4215 FORMAT('0',10X,'CARD NUMBER 2A'//10X,'IRM',9X,'IPERC',8X,'IRF',8X,
1          1,'IPROP',8X,'ICENT',8X,'NZJ',8X,'IDIAG',7X,7(11X,11))
228      WRITE(7,4216) IRM,IPERC,IRF,IPROP,ICENT,NZJ,IDIAG
229      4216 FORMAT(715)
230      WRITE(6,4217) FN(1),FN(2),DPIT,THEIP, RO(1),RO(2)
231      4217 FORMAT('0',10X,'CARD NUMBER 3'//10X,'FN1',10X,'FN2',10X,'DPIT',8X,
1          1,'PANC',8X,'RO1',4X,'RO2 OR RI2',6(3X,F10.6))
232      WRITE(7,1360) FN(1),FN(2),DPIT,THEIP,RO(1),RO(2)
233      WRITE(6,4219) ARM(1),ARM(2),F1,AT(1)
234      4219 FORMAT('0',10X,'CARD NUMBER 4'//10X,'RM1',8X,'RM2',8X,'F1',10X,'T1
1          1',4(3X,F10.6))
235      WRITE(7,1360) ARM(1),ARM(2),F1,AT(1)
236      WRITE(6,4222) AT(2),F(1),F(2),RF(1),RF(2)
237      4222 FORMAT('0',10X,'CARD NUMBER 5'//10X,'T2',10X,'F1',10X,'F2',10X,'RF
1          1',10X,'RF2',5(3X,F10.6))
238      WRITE(7,1360) AT(2),F(1),F(2),RF(1),RF(2)
239      IF(1PRC.NE.1) GO TO 4230
240      WRITE(6,4224) YE(1),YE(2),GE(1),GE(2),POS(1),POS(2)

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241 4224 FORMAT('0',10X,'CARD NUMBER 6 '//
      1,10X,'YE1',12X,'YE2',12X,'GE1',13X,'GE2',11X,'POS1',10X,'POS2',
      3X,F13.5,3X,F13.5,3X,F13.5,3X,F13.5,3X,F13.5,3X,F10.6,3X,F10.6)
242 WRITE(7,1360) YE(1),YE(2),GE(1),GE(2),POS(1),POS(2)
243 4250 WRITE(6,4226) CL,VPT(1),VPT(2)
244 4226 FORMAT('0',10X,'CARD NUMBER 7'//10X,'CL',10X,'VPT1',10X,'VPT2'
      1
      /4(3X,F10.6))
245 WRITE(7,1360) CL,VPT(1),VPT(2)
246 NJ = 2.*F1+1
247 MNJ=2.*NJ
248 IF (INTCK.EQ.1) MNJ=4.*NJ
249 NZJTAB=NZJ+1
250 GO TO(1350,1353,1353,1351,1350,1350),NZJTAB
251 1350 READ(5,1360) (UJ1(I),I=1,MNJ)
252 1360 FORMAT(6E13.5)
253 READ(5,1360) (UJ2(I),I=1,MNJ)
254 WRITE(6,1361) (UJ1(I),I=1,MNJ)
255 1361 FORMAT('0',10X,'CARDS NUMBER RA'/20X,'UJ1'/6E13.5)
256 WRITE(6,1362) (UJ2(I),I=1,MNJ)
257 1362 FORMAT('0',20X,'UJ2'/6E13.5)
258 WRITE(7,1360) (UJ1(I),I=1,MNJ)
259 WRITE(7,1360) (UJ2(I),I=1,MNJ)
260 1351 GO TO(1352,1353,1353,1352,1353,1353),NZJTAB
261 1352 READ(5,1360) (ZJ1(I),I=1,MNJ)
262 READ(5,1360) (ZJ2(I),I=1,MNJ)
263 WRITE(6,1363) (ZJ1(I),I=1,MNJ)
264 1363 FORMAT('0',10X,'CARDS NUMBER RB'/20X,'ZJ1'/3X,6E13.5)
265 WRITE(6,1364) (ZJ2(I),I=1,MNJ)
266 1364 FORMAT('0',20X,'ZJ2'/6E13.5)
267 WRITE(7,1360) (ZJ1(I),I=1,MNJ)
268 WRITE(7,1360) (ZJ2(I),I=1,MNJ)
269 1353 IF (TORK.GT.0.01) GO TO 1355
270 READ(5,1360) (TOR(I),I=1,NJ)
271 GO TO 1356
272 1355 GO 1357 I=1,NJ
273 TOR(I)=TORK
274 1357 CONTINUE
275 1356 WRITE(6,1366) NTS
276 1366 FORMAT('0',10X,'CARDS NUMBER RC'//10X,'NTS'//10X,11//10X,'TOR' )
277 WRITE(6,1360) (TOR(I),I=1,NJ)
278 WRITE(7,1370) NTS
279 1370 FORMAT(I5)
280 WRITE(7,1360) (TOR(I),I=1,NJ)
281 IF (NZJTAB.NE.2.OR.NZJTAB.NE.5) GO TO 1354
282 READ(5,1360) Z11,Z51,Z41,Z31,RHIGH1,RLOW1
283 WRITE(6,1367) Z11,Z51,Z41,Z31,RHIGH1,RLOW1
284 1367 FORMAT('0',10X,'CARDS NUMBER RD'//20X,'Z1'/3X,6E13.5)
285 READ(5,1360) Z12,Z52,Z42,Z32,RHIGH2,RLOW2
286 WRITE(6,1368) Z12,Z52,Z42,Z32,RHIGH2,RLOW2
287 1368 FORMAT(20X,'Z2'/3X,6E13.5)
288 WRITE(7,1360) Z11,Z51,Z41,Z31,RHIGH1,RLOW1
289 WRITE(7,1360) Z12,Z52,Z42,Z32,RHIGH2,RLOW2
290 1354 CONTINUE
291 WRITE(6,1385) NWS,WS
292 1385 FORMAT('0',10X,'CARD NUMBER 9'//10X,'NWS',9X,'WS'//10X,13.5X,F10.1)
293 WRITE(7,1369) NWS,WS
294 1369 FORMAT(I5,E13.5)
295 1598 GO TO 1599
296 5550 WRITE(6,5551) CR
297 5551 FORMAT('////' * * THIS IS A HIGH CONTACT RATIO GEARSET'/15X,F10.4
      1/' PROGRAM HAS BEEN RESET TO USE GGEAR/MCR * *)
298 J=4
299 GO TO 3001
300 5556 STOP
301 END

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APPENDIX B

LISTING OF PROGRAM FOR PREDICTION OF GEAR MESH DYNAMICS FOR HIGH-CONTACT-RATIO SPUR GEARS (R-75)

FCRT	IV C LEVEL	21	MAIN	DATA	75C99	12/59/12	PAGE	0001
			C*** REMBER NAME R752MAN					
			MECHANICAL TECHNOLOGY INCORPORATED					CC01CC0C
			506 ALBANY-SHAKER ROAD					CC02CC0C
			LATHAP, NEW YORK 12110					CC03CC0C
			518-785-2211					CC04CC0C
								CC05CC0C
								CC06CC0C
								CC07CC0C
								CC08CC0C
								CC09CC0C
								CC10CC0C
								CC11CC0C
								CC12CC0C
								CC13CC0C
								CC14CC0C
								CC15CC0C
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								CC93CC0C
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								CC96CC0C
								CC97CC0C
								CC98CC0C
								CC99CC0C
								CC00CC0C

FCP1	IV C LEVEL 21	MAIN	DA	75C59	12/49/12
C031	51C	WRITE(NK,1C3)			00530000
C032		CC TO 512			00540000
C033	511	WRITE(NK,14C)			00550000
C034	512	WRITE(NK,158) TFE1F,FA2,FC2,RT2,RP2			00560000
C035		WRITE(NK,1C5)			00570000
C036		WRITE(NK,1C2) T1,F1,RF1,YE1,GE1,POS1			00580000
C037		WRITE(NK,1C7)			00590000
C038		WRITE(NK,1C2) T2,F2,RF2,YE2,GE2,POS2			00600000
C039		WRITE(NK,164)			00610000
C040		ANG=0,			00620000
C041		IMC=1.			00630000
C042		N=2.*F1+1.			00640000
C043		NN=N+N			00650000
C044		IF(IMCR.NE.C) NN= 4*N			00660000
C045		IF(MN.EC.C) T2=-T2			00670000
C046	15C	WRITE(NK,15CC)			00680000
C047		FEAC(NR,112) CL,VP11,VPT2			00690000
C048		WRITE(NK,1C00) IPC,CL			00700000
C049		WRITE(NK,110)			00710000
C050		IF(IMCR.NE.C) CC TC 40C			00720000
C051		L=AN			00730000
C052		CC 209 I=1,AN			00740000
C053		FEAC(NR,112) ZJ1(I),UJ1(I),ZJ2(I),UJ2(I),WT(I)			00750000
C054		WRITE(NK,1C2) ZJ1(I),UJ1(I),ZJ2(I),UJ2(I)			00760000
C055		ZM2(L)=ZJ2(I)			00770000
C056		LM2(L)=UJ2(I)			00780000
C057		IF(L-1) Z(C5,2C5,225			00790000
C058	225	L=L-1			00800000
C059	209	CONTINUE			00810000
C060		CC TO 41C			00820000
C061	40C	CONTINUE			00830000
C062		LL=5			00840000
C063		CC 210 I=1,4			00850000
C064		LL=LL-1			00860000
C065		L=N+1			00870000
C066		CC 210 J=1,N			00880000
C067		L=L-1			00890000
C068		FEAC(NR,112) ZJ(I,I),UJ(I,I),ZJ(L,LL,2),UJ(L,LL,2),WT(I,I)			00900000
C069		WRITE(NK,1C2) ZJ(I,I),UJ(I,I),ZJ(L,LL,2),UJ(L,LL,2),WT(I,I)			00910000
C070	21C	CONTINUE			00920000
C071	41C	CONTINUE			00930000
C072		CALL GEARC(CL,VP11,VPT2)			00940000
C073		NN=IMC*N			00950000
C074		CC 209 I=1,N			00960000
C075		J=NN+1-N			00970000
C076		ANG(JJ)=AJC(I)			00980000
C077		GGC(JJ)=EJ1(I)			00990000
C078		C(JJ)=GGC(JJ)			01000000
C079		HTC(JJ)=HJC(I)			01010000
C080	20C	FJCC(IJJ)=JJ			01020000
C081		IPC=IMC+1			01030000
C082		IF(IMC.LE.MNC) CC TC 15C			01040000

FCRT	IV C LEVEL	21	MAIN	DA	= 15099	12/49/12
C083			WRITE(N,1500)			C1050000
C084			WRITE(N,2000)			C1060000
C085			DO 2500 I=1,NN			C1070000
C086	2500		WRITE(N,102)FJCC(I),AANC(I),GGG(I)			C1080000
C087	500		CONTINUE			C1090000
C088			IF(IPLT.EC.1) CALL PLT(FJCC1,GGG,WTCC,ANN)			C1100000
C089			M=I			C1110000
C090			IF(IEOF.NE.1) GO TO 3000			C1120000
C091			WRITE(N,128)			C1130000
C092			CALL FOUR			C1140000
C093			LL=NN+1			C1150000
C094			GO 250 I=1,LL			C1160000
C095			IF=1-1			C1170000
C096			SMK=1*LP/NYC			C1180000
C097			RESULT=SCAT(A(I)*2+E(I)*2)			C1190000
C098	250		WRITE(N,129)LF,Z(I),E(I),RESULT,SMK			C1200000
C099	3000		IF(1/SPECT.NE.1) GO TO 3500			C1210000
C100			CALL SPECT			C1220000
C101	3500		CONTINUE			C1230000
C102			IF(NT13CC,158,300			C1240000
C103	300		CALL EXIT			C1250000
C104	100		FORMAT(20A4)			C1260000
C105	101		FORMAT(72FC PNC354COMPLUTATIONS OF GEAR TOOTH MESHING ERRORS			C1270000
	1	3-22-1564	)			C1280000
C106	102		FORMAT(7E13.5)			C1290000
C107	103		FORMAT(12FC PRE-ANGLE7X2F224X3HRT10X3HRT21CX3HRM2)			C1300000
C108	104		FORMAT(7X1F111X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1310000
C109	105		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1320000
	106		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1330000
C110	107		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1340000
	108		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1350000
C111	109		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1360000
C112	110		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1370000
C113	111		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1380000
	112		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1390000
C114	113		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1400000
C115	114		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1410000
C116	115		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1420000
	116		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1430000
C117	117		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1440000
C118	118		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1450000
C119	119		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1460000
C120	120		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1470000
C121	121		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1480000
C122	122		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1490000
C123	123		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1500000
C124	124		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1510000
C125	125		FORMAT(16X2F111X2F111X3HRT10X3HRT11CX3HRM1)			C1520000

PERT	TRAN	AV	C	LEVEL	Z1	AJCC	DATE	15C99	12/49/12
C050				FLK(I)=XJ(I)-XJ(I)-1)					00530000
C051				504 K=K+1					00540000
C052				503 IF(I-MN) 502,501,501					00550000
C053				502 IF(MV) 506,505,506					00560000
C054				505 FJ=FJ-1.					00570000
C055				GO TO 501					00580000
C056				506 FJ=FJ+1.C					00590000
C057				501 CONTINUE					00600000
C058				IF(I1-1) 301,301,302					00610000
C059				301 IF(MV) 601,302,601					00620000
C060				601 LL=NN					00630000
C061				CC 203 I=1,NN					00640000
C062				CC(I)=CJ(LL)					00650000
C063				IF(LL-1) 303,303,305					00660000
C064				305 LI=LL-1					00670000
C065				303 CONTINUE					00680000
C066				302 IP=K+IN-2					00690000
C067				410 CC 246 L=IP,IP					00700000
C068				E1=C.O					00710000
C069				E2=C.O					00720000
C070				E3=C.O					00730000
C071				E4=C.O					00740000
C072				EE=XJ(LL)-XP					00750000
C073				IP=L					00760000
C074				IF(MV) 202,203,202					00770000
C075				203 EE=EE					00780000
C076				202 CC 245 I=IP,IP					00790000
C077				C1=XJ(LL)-XJ(I)					00800000
C078				C5=FLK(I)					00810000
C079				IF(MV) 207,208,207					00820000
C080				206 C1=C1					00830000
C081				C5=C5					00840000
C082				207 C2=C5/6(K(I))					00850000
C083				C3=(C5+3-C4)*C5+3.C41=C1					00860000
C084				E4=E4+C2					00870000
C085				C4=2.O*C1+C5					00880000
C086				E1=E1+C3+C2					00890000
C087				E2=E2+C4+C2					00900000
C088				245 E3=E3+C5/AIK(I)					00910000
C089				IF(MV) 206,205,206					00920000
C090				205 IP=IP-1					00930000
C091				206 C1=CC(I)*CC(LL)					00940000
C092				C2=SO(LL)*YJ(LL)					00950000
C093				CA(LL)=C1/3-C*E1/EP+(C2+E4-CC(LL)*E2)/EP*C2					00960000
C094				CE(LL)=C1/IN+E3+1.2					00970000
C095				C1=(EE+CC(LL)-YJ(LL)+SC(LL))/YM					00980000
C096				CC(LL)=C1/EP+1.227/F*C1					00990000
C097				246 CJ(LL)=QA(LL)+CB(LL)+CC(LL)					01000000
C098				RETURN					01010000
C099				END					01020000

PCRTN	IV	G	LEVEL	21	EVIN	DATE	=	75099	12/49/12
C001				SUBROUTINE BVINANA, WICC, FJCC1, GGG1					0001C000
C002				PERFER NAME F75EVIN					0002C000
C003				CIPENSION GGG13000, KTC1(EG00), FJCC1(3000), RANG1(3000)					0003C000
C004				CIPENSION HJ1(25,4), HLJ1(25,4), FOLL1(3,2)					0004C000
C005				CIPENON PJ1(50), CJ1(50), CJ1(50), AJ1(50), XJ1(50), YJ1(50),					0005C000
C006				1A115000, R115000, G13000					0006C000
C007				CCP2CN, CC1EF, BA, FJ, CC, YA, NNA, FNJ, EF, TTAN, RB, CP, F, X4, MN, 11, P					0007C000
C008				CCAPON CA1(50), CC1(50), CC1(50), CC11(50), QB1(50), QA2(50), QB2(50), CC08000					0009C000
C009				1), CC2(50), 1H, IF					0010C000
C010				CCAPON A1(50), F1(115), H1(125)					0011C000
C011				CCAPON/CL/NAC, INT, WPM, 1E1T, FAL, X01, X02, RT1, RT2, F1, CC11C000					0012C000
C012				111, F2, F1, F2, RFL, RF2, YEL, YEL, CE1, GE2, POS1, PC52, ANG					0013C000
C013				CCAPON/INT, 1H1(1), J1(25,4,2), 2J1(25,4,2), 1H1(25,4), VP1, VP2, CS,					0014C000
C014				1 SUPJ1(25,4), QJ1(25,4,2)					0015C000
C015				CCAPON/INVR, 1FC1F, 1SFC1T, IRM, 1PERC, 1RF, 1PROP, 1CENT, NZJ					0016C000
C016				1, 1CAR1(25), 1CAR1(25, E)					0017C000
C017				CCAPON/1AB/ ALPH1(5,2), Z1(5,2), FLON(21), RHIGH(2)					0018C000
C018				CCAPON/CIAG/ 1C1G					0019C000
C019				CCAPON/VY/ 1UJ1(25), 1UJ2(25), 1UJ3(25), 1UJ4(25), 1UJ5(25), 1UJ6(25), 1UJ7(25), 1UJ8(25), 1UJ9(25), 1UJ10(25), 1UJ11(25), 1UJ12(25), 1UJ13(25), 1UJ14(25), 1UJ15(25), 1UJ16(25), 1UJ17(25), 1UJ18(25), 1UJ19(25), 1UJ20(25), 1UJ21(25), 1UJ22(25), 1UJ23(25), 1UJ24(25), 1UJ25(25), 1UJ26(25), 1UJ27(25), 1UJ28(25), 1UJ29(25), 1UJ30(25), 1UJ31(25), 1UJ32(25), 1UJ33(25), 1UJ34(25), 1UJ35(25), 1UJ36(25), 1UJ37(25), 1UJ38(25), 1UJ39(25), 1UJ40(25), 1UJ41(25), 1UJ42(25), 1UJ43(25), 1UJ44(25), 1UJ45(25), 1UJ46(25), 1UJ47(25), 1UJ48(25), 1UJ49(25), 1UJ50(25), 1UJ51(25), 1UJ52(25), 1UJ53(25), 1UJ54(25), 1UJ55(25), 1UJ56(25), 1UJ57(25), 1UJ58(25), 1UJ59(25), 1UJ60(25), 1UJ61(25), 1UJ62(25), 1UJ63(25), 1UJ64(25), 1UJ65(25), 1UJ66(25), 1UJ67(25), 1UJ68(25), 1UJ69(25), 1UJ70(25), 1UJ71(25), 1UJ72(25), 1UJ73(25), 1UJ74(25), 1UJ75(25), 1UJ76(25), 1UJ77(25), 1UJ78(25), 1UJ79(25), 1UJ80(25), 1UJ81(25), 1UJ82(25), 1UJ83(25), 1UJ84(25), 1UJ85(25), 1UJ86(25), 1UJ87(25), 1UJ88(25), 1UJ89(25), 1UJ90(25), 1UJ91(25), 1UJ92(25), 1UJ93(25), 1UJ94(25), 1UJ95(25), 1UJ96(25), 1UJ97(25), 1UJ98(25), 1UJ99(25), 1UJ100(25), 1UJ101(25), 1UJ102(25), 1UJ103(25), 1UJ104(25), 1UJ105(25), 1UJ106(25), 1UJ107(25), 1UJ108(25), 1UJ109(25), 1UJ110(25), 1UJ111(25), 1UJ112(25), 1UJ113(25), 1UJ114(25), 1UJ115(25), 1UJ116(25), 1UJ117(25), 1UJ118(25), 1UJ119(25), 1UJ120(25), 1UJ121(25), 1UJ122(25), 1UJ123(25), 1UJ124(25), 1UJ125(25), 1UJ126(25), 1UJ127(25), 1UJ128(25), 1UJ129(25), 1UJ130(25), 1UJ131(25), 1UJ132(25), 1UJ133(25), 1UJ134(25), 1UJ135(25), 1UJ136(25), 1UJ137(25), 1UJ138(25), 1UJ139(25), 1UJ140(25), 1UJ141(25), 1UJ142(25), 1UJ143(25), 1UJ144(25), 1UJ145(25), 1UJ146(25), 1UJ147(25), 1UJ148(25), 1UJ149(25), 1UJ150(25), 1UJ151(25), 1UJ152(25), 1UJ153(25), 1UJ154(25), 1UJ155(25), 1UJ156(25), 1UJ157(25), 1UJ158(25), 1UJ159(25), 1UJ160(25), 1UJ161(25), 1UJ162(25), 1UJ163(25), 1UJ164(25), 1UJ165(25), 1UJ166(25), 1UJ167(25), 1UJ168(25), 1UJ169(25), 1UJ170(25), 1UJ171(25), 1UJ172(25), 1UJ173(25), 1UJ174(25), 1UJ175(25), 1UJ176(25), 1UJ177(25), 1UJ178(25), 1UJ179(25), 1UJ180(25), 1UJ181(25), 1UJ182(25), 1UJ183(25), 1UJ184(25), 1UJ185(25), 1UJ186(25), 1UJ187(25), 1UJ188(25), 1UJ189(25), 1UJ190(25), 1UJ191(25), 1UJ192(25), 1UJ193(25), 1UJ194(25), 1UJ195(25), 1UJ196(25), 1UJ197(25), 1UJ198(25), 1UJ199(25), 1UJ200(25), 1UJ201(25), 1UJ202(25), 1UJ203(25), 1UJ204(25), 1UJ205(25), 1UJ206(25), 1UJ207(25), 1UJ208(25), 1UJ209(25), 1UJ210(25), 1UJ211(25), 1UJ212(25), 1UJ213(25), 1UJ214(25), 1UJ215(25), 1UJ216(25), 1UJ217(25), 1UJ218(25), 1UJ219(25), 1UJ220(25), 1UJ221(25), 1UJ222(25), 1UJ223(2					

FCR	N	IV	C	LEVEL	Z1	PVIN	D1	= 75099	12/49/12
C092					REAC(NR,112) CL=VPT1,VPT2,DEV				C1000000
C093					IF (ICENT-NE-C) CL=(FN1,FN2)/2,DP17				C1010000
C094					IF (ICENT-EC,1) WRITE(NW,1010) TEV				C1020000
C095					IF (ICENT-EC,1) CL=CL*DEV				C1030000
C096					FPI=CL*FAL/(FN1+FN2)				C1040000
C097					IF (MW,EC,0) FPI=CL*FAL/(FN2-FAL)				C1050000
C098					FPI=FP1*FN2/FAL				C1060000
C099					WRITE(NW,1000) I=C,CL,VPT1,VPT2				C1070000
C100					IF (MICH-NE-C) GC TC 400				C1080000
			C		SET ALL ZAS AND LES TO 0				C1090000
C101					CC 205 I=1,NN				C1100000
C102					ZJ1(I) = 0.0				C1110000
C103					LJ1(I) = C.C				C1120000
C104					ZJ2(I) = C.C				C1130000
C105					LJ2(I) = C.C				C1140000
C106					TCRK(I) = C.C				C1150000
C107					205 CONTINUE				C1160000
C108					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1170000
					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1180000
C109					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1190000
					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1200000
C110					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1210000
C111					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1220000
C112					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1230000
C113					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1240000
C114					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1250000
C115					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1260000
C116					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1270000
C117					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1280000
C118					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1290000
C119					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1300000
C120					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1310000
					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1320000
C121					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1330000
C122					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1340000
C123					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1350000
C124					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1360000
C125					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1370000
C126					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1380000
C127					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1390000
C128					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1400000
C129					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1410000
C130					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1420000
C131					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1430000
C132					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1440000
C133					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1450000
C134					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1460000
C135					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1470000
C136					IF (NZJ-EC,C,CR-NZJ-EC,3)				C1480000

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FCRTRAN IV C LEVEL 21 DATE = 75099 12/49/12
C137 JEINZ1,AE,1,CP,NZ,NE,4) GC IC 410 C1520000
C138 35 CONTINUE C1530000
C139 CC 40 J=1,2 C1540000
C140 Z(2,J) = Q,C C1550000
C141 REF(1NR,112) Z(1,J),Z(15,J),Z(4,J),Z(3,J),RHIGH(J),RLOW(J) C1560000
C142 40 CONTINUE C1570000
C143 SRECT= SCFI((CCL/ RB3)*2 - 1.) C1580000
C144 FBI=ANG*PI/180. C1590000
C145 TANG=TAN(PFI) C1600000
C146 ALPH(1,1) = SRECT - TANG C1610000
C147 SRECT = SCFI((R22/RB2)*2 - 1.) C1620000
C148 ALPH(1,2) = SRECT - TANG C1630000
C149 ALPH(2,1) = Q,C C1640000
C150 ALPH(2,2) = C,C C1650000
C151 ALPH(3,1) = -R22/RB1 * ( ALPH(1,2) ) C1660000
C152 ALPH(3,2) = -R1/RB2 * ( ALPH(1,1) ) C1670000
C153 IF (PR,NE,0) GO TO 45 C1680000
C154 ALPH(3,2) = ALPH(3,2) C1690000
C155 ALPH(3,1) = -R22/RB1 * (TANG - SRECT) C1700000
C156 ALPH(1,2) = R1/RB2 * ALPH(2,1) C1710000
C157 45 CONTINUE C1720000
C158 CC 50 J=1,2 C1730000
C159 ALPH(4,J) = FLOH(J)*PI/180. -TANG C1740000
C160 ALPH(5,J) = FHIGH(J)*PI/180. -TANG C1750000
C161 CC 46 L=1,3 C1760000
C162 FCL(1,J) = (ALPH(1,J)+TANG)*180./PI C1770000
C163 46 CONTINUE C1780000
C164 WRITE(NW,1021) C1790000
C165 IF (J.EQ.1) WRITE(NW,1024) C1800000
C166 IF (J.EQ.2) WRITE(NW,1025) C1810000
C167 IF (J.EQ.1,CP,NA,EC,1) *VELLE(NW,1021) C1820000
C168 IF (J.EQ.2,AND,MN,EC,0) *WRITE(NW,1022) C1830000
C169 WRITE(NW,1023) Z(1,J),Z(15,J),Z(4,J),Z(3,J),Z(2,J),Z(1,J),Z(13,J), C1840000
C170 1 RCL(1,J),RHIGH(J),RCL(2,J),RLOW(J),ROLL(3,J) C1850000
C171 50 CONTINUE C1860000
C172 IF (IDTAG.EC,1) WRITE(6,5010) ALPH,Z C1870000
C173 5010 FORMAT(5X,10E12.4) C1880000
C174 C ARRANGE ALPH IN ASCENDING ORDER C1890000
C175 CC 80 J = 1,2 C1900000
C176 CC 80 L = 2,5 C1910000
C177 I = 1 C1920000
C178 60 CONTINUE C1930000
C179 IF (ALPH(1-1,J).LT.ALPH(1,J)) GO TO 70 C1940000
C180 SWITCH= 2 (I-1,J) C1950000
C181 Z(1-1,J) = Z(1,J) C1960000
C182 Z(1,J) = SWITCH C1970000
C183 SWITCH= ALPH(1-1,J) C1980000
C184 ALPH(1-1,J) = ALPH(1,J) C1990000
C185 ALPH(1,J) = SWITCH C2000000
C186 70 CONTINUE C2010000
C187 I=I-1 C2020000
C188 IF (I,SE,2) GO TO 60 C2030000

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FORTRAN IV C LEVEL	21	BVIA	DATE = 75099	12/49/12
C187	8C CONTINUE			C2040000
C188	IF (C1AG.EC.1) WRITE(6,2000) ALPHA,Z			C2050000
C189	CC TO 410			C2060000
C190	350C CONTINUE			C2070000
	C	WRITE ALL L VALUES		C2080000
C191	WRITE(NH,1120)			C2090000
C192	WRITE(NH,1040)			C2100000
C193	WRITE(NH,102) (L,111),I=1,NN)			C2110000
C194	WRITE(NH,1120)			C2120000
C195	WRITE(NH,1050)			C2130000
C196	WRITE(NH,102) (L,211),I=1,NN)			C2140000
C197	CC TO 2050			C2150000
C198	3510 CONTINUE			C2160000
C199	WRITE(NH,1120)			C2170000
C200	WRITE(NH,1040)			C2180000
C201	WRITE(NH,102) (L,111),I=1,NN),I=1,4)			C2190000
C202	WRITE(NH,1120)			C2200000
C203	WRITE(NH,1050)			C2210000
C204	WRITE(NH,102) (L,111),I=1,NN),I=1,4)			C2220000
C205	CC TO 4450			C2230000
C206	40C CONTINUE			C2240000
	C	SET ALL U, Z AND 10PK TO 0		C2250000
C207	CC 445 I=1,25			C2260000
C208	CC 445 J=1,4			C2270000
C209	10FC(I,J)=C			C2270100
C210	CC 445 K=1,2			C2280000
C211	10F(I,J,K)=C			C2290000
C212	20(I,J,K)=C			C2300000
C213	445 CONTINUE			C2320000
C214	IF (NZJ.EC.0) NZJ.EC.2			C2330000
	1 READ(NR,112) ((ZJ(I,1),I=1,N),I=1,4)			C2340000
C215	IF (NZJ.EC.0) NZJ.EC.3			C2350000
	1 READ(NR,112) ((ZJ(I,1),I=1,N),I=1,4)			C2360000
C216	IF (NZJ.EC.0) NZJ.EC.4			C2370000
	1 READ(NR,112) ((ZJ(I,1),I=1,N),I=1,4)			C2380000
C217	IF (NZJ.EC.0) NZJ.EC.5			C2390000
	1 READ(NR,112) ((ZJ(I,1),I=1,N),I=1,4)			C2400000
C218	IF (NZJ.EC.0) NZJ.EC.6			C2410000
	1 READ(NR,112) ((ZJ(I,1),I=1,N),I=1,4)			C2420000
C219	IF (NZJ.EC.0) NZJ.EC.7			C2430000
	1 READ(NR,112) ((ZJ(I,1),I=1,N),I=1,4)			C2440000
C220	IF (NZJ.EC.0) NZJ.EC.8			C2450000
	1 READ(NR,112) ((ZJ(I,1),I=1,N),I=1,4)			C2460000
C221	IF (NZJ.EC.0) NZJ.EC.9			C2470000
	1 READ(NR,112) ((ZJ(I,1),I=1,N),I=1,4)			C2480000
C222	IF (NZJ.EC.0) NZJ.EC.10			C2490000
	1 READ(NR,112) ((ZJ(I,1),I=1,N),I=1,4)			C2500000
C223	IF (NZJ.EC.0) NZJ.EC.11			C2510000
	1 READ(NR,112) ((ZJ(I,1),I=1,N),I=1,4)			C2520000
C224	IF (NZJ.EC.0) NZJ.EC.12			C2530000
	1 READ(NR,112) ((ZJ(I,1),I=1,N),I=1,4)			C2540000
C225	IF (NZJ.EC.0) NZJ.EC.13			C2550000
	1 READ(NR,112) ((ZJ(I,1),I=1,N),I=1,4)			

FCRTR	IV C LEVEL	21	EVIA	DAI	75C99	12/49/12
C231		2JUL(1,1,2)=FZJ(1,1)				C2560000
C232		LJUL(1,1,2)=FZJ(1,1)				C2570000
C233	21C	CONTINUE				C2580000
C234	210C	CONTINUE				C2590000
C235		CIV=SPI				C2600000
C236		IF(NTS.EC.2) CIV=SPF2				C2610000
C237		CC 460 J=1,N				C2620000
C238		3T(J,1)=TCK(C,1,3)/DIV				C2630000
C239	46C	CONTINUE				C2640000
C240		WRITE(NN,105C)				C2650000
C241		IF(NTS.EC.1) WRITE(NN,104C)				C2660000
C242		IF(NTS.EC.2) WRITE(NN,105C)				C2670000
C243		WRITE(NN,110C) (105C(1,1,1),J=1,N)				C2680000
C244		WRITE(NN,110C)				C2690000
C245		WRITE(NN,110C) (NT(J,3),J=1,N)				C2700000
C246		IF(NTS.EC.3) OM.NJ=55.4) CC TC 35				C2710000
C247	41C	CONTINUE				C2720000
C248		IF(10DIAG-ET.C) WRITE(6,500C) 2J				C2730000
C249	500C	FORMAT(3H,1J,10C(1,2,3))				C2740000
C250		CALL GEAR(CCL,VPT1,VPT2)				C2750000
C251		NN=IMC*N				C2760000
C252		CC 200 I=1,N				C2770000
C253		J=NN+1-N				C2780000
C254		ANCL(J)=AUC(1)				C2790000
C255		CC(J)=EJ(1)				C2800000
C256		EJ(J)=CC(J)				C2810000
C257		NTCC(J)=NTC(1)				C2820000
C258	28C	FJCC(J)=N				C2830000
C259		IF(C=1)				C2840000
C260		IF(10C.LE.PPC) CC TC 15C				C2850000
C261		WRITE(NN,150C)				C2860000
C262		WRITE(NN,200C)				C2870000
C263		CC 2500 I=1,NN				C2880000
C264	2500	WRITE(NN,102L FJCC(1),ANCL(1),GG(1))				C2890000
C265		RETURN				C2900000
C266	10C	FORMAT(12CA4)				C2910000
C267	10L	FORMAT(72HC_PNC35C) (CALCULATIONS OF GEAR TOOTH MESHING ERRORS)				C2920000
C268	1	3-22-1966				C2930000
C269	102	FORMAT(10L,5)				C2940000
C270	104	FORMAT(1/ 7) ,1P1,11X,2P1,6X,10HDI A. P1TC,6X,3P1,10X,3HPT2,10X,				C2950000
C271	105	FORMAT(1/ 6X,2P1,11X,2P1,5X,12HYOUNG MOD-1,2X,				C2960000
C272	107	FORMAT(1/ 6X,2P1,11X,2P1,5X,12HYOUNG MOD-2,2X,				C2970000
C273	108	FORMAT(1/ 6X,2P1,11X,2P1,5X,12HYOUNG MOD-3,2X,				C2980000
C274	109	FORMAT(1/ 6X,2P1,11X,2P1,5X,12HYOUNG MOD-4,2X,				C2990000
C275	110	FORMAT(1/ 6X,2P1,11X,2P1,5X,12HYOUNG MOD-5,2X,				C3000000
		1ANCE/6X,2P1,11X,2P1,11X,2H12,11X,2H12)				C3010000

FORMAT	IV	C	LEVEL	21	RVIN	DATE	75099	12/49/12
C276	112	FORMAT(16E12.5)						03080000
C277	117	FORMAT(16E15)						03090000
C278	158	FORMAT(2E12.5,13X,2E12.5)						03100000
C279	160	FORMAT(15X,2E12.5X,14FCLT. PRESS ANG.3X,3HRC2,10X,3HRT2,10X, 1 3P82)						03110000
C280	161	FORMAT(113X,5E12.5)						03120000
C281	164	FORMAT(1716H,CALCULATED DATA)						03130000
C282	1000	FORMAT(16H MESH CYCLE NC.8,12,20H, CENTER DISTANCE#,E13.6 1,4H IN./						03140000
		12H VPT1, TOOTH SPACING ERROR 2DRIVING GEARC # ,E13.6,4H IN. /C3170000						
		24H VPT2, TOOTH SPACING ERROR 2DRIVEN GEARC # ,E13.6,4H IN. /C3180000						
C283	1010	FORMAT(17 43P EVIATION FROM STANDARD CENTER DISTANCE # , C3190000						
C284	1020	FORMAT(1712CX,75PERCENT DEVIATION OF POINT ON ACTUAL TOOTH PROFILE FROM TRUE INVOLUTE)						03200000
C285	1021	FORMAT(2CX,75HAT OUTER DIAM. HIGH POINT PITCH POINT LOW)						03210000
C286	1022	FORMAT(2CX,75HAT INNER DIAM. HIGH POINT PITCH POINT LOW)						03220000
C287	1023	FORMAT(16X,1H2,1,1X,51X,E13.5)/6X,10HROLL ANGLE,5X,51X,E13.5))						03230000
C288	1024	FORMAT(14CX,12HCRIVING GEAR)						03240000
C289	1025	FORMAT(14CX,12HCRIVING GEAR)						03250000
C290	1030	FORMAT(118X,5E12.5,6X,2E13.5)						03260000
C291	1040	FORMAT(11H,5X,12HCRIVING GEAR)						03270000
C292	1050	FORMAT(11H,5X,12HCRIVING GEAR)						03280000
C293	1060	FORMAT(15X,3CH100TH DEPTH 2DRIVING GEARC #,E13.5/)						03290000
C294	1070	FORMAT(15X,75PERCENT DIFFERENCE BETWEEN ACTUAL CIRCULAR PITCH AND3350000)						03300000
		10 WORKING BACKLASH # ,E13.5 /						03310000
		1 5X,10HBACKLASH # ,E13.5)						03320000
C295	1080	FORMAT(15E13.5,15)						03330000
C296	1090	FORMAT(12CX,50HTRANSMITTED TORQUE 2IN-LBC)						03340000
C297	1100	FORMAT(12CX,8CHTOTAL LCAO TANGENT TO PITCH CIRCLE, TRANSMITTED BY 103410000						
		10EAR TEETH 2LBC						03420000
C298	1110	FORMAT(12X,10E12.4)						03430000
C299	1120	FORMAT(12CX,40H100TH SUFFORT COMPLIANCE 2IN/LBC)						03440000
C300	1500	FORMAT(16X,2011H,2X1/)						03450000
C301	2000	FORMAT(15X,3FJCI,5X,4HAJCI,6X,11HTANG. ERROR)						03460000
C302		ENC						

FCRTRAN	IV	G	LEVEL	Z1	CALCJ	DATE - 75C99	12/49/12
COJ1					SUBROUTINE CALCJ(C1,C2,C3,C4)		00010000
					C**** MEMBER NAME R75CALCJ		00020000
COJ2					IF(C3) 240,211,241		00030000
COJ3					241 IF(C1) 230,218,218		00050000
COJ4					230 IF(PBS (C1)-C3) 220,220,219		00060000
COJ5					231 IF(C1) 219,218,218		00070000
COJ6					240 IF(C1) 219,219,242		00080000
COJ7					242 C3=C3		00090000
COJ8					IF(C1-C3) 219,218,218		00100000
COJ9					219 IF(C2-C1) 215,220,220		00110000
COLC					220 C4=1.0		00120000
COL1					GO TO 221		00130000
COL2					219 C4=C4.0		00140000
COL3					221 RETURN		00150000
COL4					ENC		00160000

PORTA	V	C	LEVEL	21	FCUR	DATE	15099	12/49/12
COJ1				SUBROUTINE FCUR				00010000
	C***			MEMBER NAME R75FCUR				00020000
	C			REQUIRES 2*81 FCINTS F3J<				00030000
	C			FCINTS CORRESPOND TO IPETA#2*F1/2*81K,.,.,2*P1				00040000
	C			CLUTPUT A21K,81K REFER TO CCSINE AND SINE OF 81-1<*THETA				00050000
COJ2				COMMON PJ(50),QJ(50),XJ(50),YJ(50),				00060000
				1A(1500),R(1500),G(3000)				00070000
COJ3				COMMON CO,ER,PA,FJ,CC,YA,NA,N,FNJ,EF,TAN,RB,GP,F,XM,MN,II,P				00080000
COJ4				COMMON/GU/NMC,INT,PM,IFLT,FA1,FN2,R81,RQ1,RQ2,RT1,RT2,RM1,PM2,F1,CC090000				00090000
				IT1,IT2,FI,F2,RF1,RF2,YE1,YE2,GE1,GE2,POS1,POS2,ANG				00100000
COJ5				C=1.0				00110000
COJ6				S=C.0				00120000
COJ7				N=IFIX(FI)*NMC+NFC/2				00130000
COJ8				N1=N+1				00140000
COJ9				NA=N*NMC				00150000
COJ10				N2=NA-1				00160000
COJ11				IT1=2./NA				00170000
COJ12				IT2=IT1*3.1415927				00180000
COJ13				CI=COS (IT2)				00190000
COJ14				SI=SIN (IT2)				00200000
COJ15				CC 7 IP=1,N1				00210000
COJ16				LI=C.0				00220000
COJ17				L2=C.0				00230000
COJ18				CC 3 I=1,N2				00240000
COJ19				J=N2-I+2				00250000
COJ20				U3=G(J)+2.C*C*U1-U2				00260000
COJ21				L2=U1				00270000
COJ22				3 LI=L3				00280000
COJ23				A(IP)=T1*(C(I)+C*U1-U2)				00290000
COJ24				E(IP)=T1*S*U1				00300000
COJ25				2A=*(IP)*C-E(IP)*S				00310000
COJ26				EB=A(IP)*S+E(IP)*C				00320000
COJ27				A(IP)=AA				00330000
COJ28				E(IP)=BB				00340000
COJ29				C=CI*C-SI*S				00350000
COJ30				S=CI*S-SI*C				00360000
COJ31				7 C=C				00370000
COJ32				PETURN				00380000
COJ33				ENC				00390000

PERTAIN IV C LEVEL 21	GEARC	DATE	12/49/12
C042	EP1=VE1,EP1		C052C000
C043	EP2=1,0-FC52*PC52		C053C000
C044	EP2=VE2/EP2		C054C000
C045	EP1=1,0/EP1+1,0/EP2)*C,5		C055C000
C046	EP1=EP12*4C,5		C056C000
C047	RE2=RB1/F12		C057C000
C048	CI=EC1/RB1		C058C000
C049	C2=PC2/RB2		C059C000
C050	ER2=(SQRT (C2*C2-1,C1-TAN)		C060C000
C051	ER1=(SQRT (C1*C1-1,C1-TAN)		C061C000
C052	C3=TAN/F12		C062C000
C053	IF(ER1-C3) 403,403,404		C063C000
C054	404 ER1=C3		C064C000
C055	WRITE(NH,126)BR1		C065C000
C056	403 ER1=BR2/F12		C066C000
C057	ER2=RR1/F12		C067C000
C058	IF(NH) 440,450,440		C068C000
C059	450 ER1=BA1		C069C000
C060	440 ER2=BA2		C070C000
C061	440 IF(ER1-TAN) 401,401,402		C071C000
C062	402 ER1=TAN		C072C000
C063	WRITE(NH,125)BA1		C073C000
C064	401 CI=C,263,145/FN1		C074C000
C065	IF(ER1-C1) 213,213,611		C075C000
C066	611 WRITE(NH,174)		C076C000
C067	213 IF(ER1-C1) 215,215,612		C077C000
C068	612 WRITE(NH,175)		C078C000
C069	215 CI=FI1/FB1		C079C000
C070	C2=RT2/RB2		C080C000
C071	C1 =SQRT (C1*C1-1,C1-TAN		C081C000
C072	AT1=ABS (C1)		C082C000
C073	C2 =SQRT (C2*C2-1,C1-TAN		C083C000
C074	AT2=ABS (C2)		C084C000
C075	WRITE(NH,122)		C085C000
C076	WRITE(NH,1C2)RF1,RE1,ER1,AT1		C086C000
C077	WRITE(NH,162)		C087C000
C078	WRITE(NH,1C2)RF2,RP2,EA2,ER2,AT2		C088C000
C079	RP2=1		C089C000
C080	AU2=1		C090C000
C081	IF(AT1-BAL) 211,211,216		C091C000
C082	211 WRITE(NH,176)		C092C000
C083	216 IF(AT2-BR2) 305,217,217		C093C000
C084	305 IF(NH) 620,621,620		C094C000
C085	621 WRITE(NH,178)		C095C000
C086	CC TO 217		C096C000
C087	620 WRITE(NH,175)		C097C000
C088	217 IF(RH1-FB1) 191,192,192		C098C000
C089	191 RH1=1,0		C099C000
C090	WRITE(NH,118)		C100C000
C091	CC TO 1920		C101C000
C092	192 RH1=RH1/RB1		C102C000
C093	1920 CI=AM1		C103C000

FORTRAN IV C LEVEL 21			GEARC	DATE = 75C99	12/49/12
C094	FP1=SQRT (AM)*AM1-1.0)-1AN				01040000
C095	C2=RF1/RE1				01050000
C096	FF1=C2				01060000
C097	CI=RM1/RE1				01070000
C098	C3=(C1+C2)**2-1.0				01080000
C099	IF(C3) 406,406,407				01090000
C100	406 C3=C.0				01100000
C101	WRITE(NK,156)				01110000
C102	TPD1=0.0				01120000
C103	CC TO 408				01130000
C104	407 FDI=SQRT (C3)				01140000
C105	TPC1=ATAN (PC1)				01150000
C106	408 IF(CM2-FF2) 192,154,154				01160000
C107	192 AM2=1.0				01170000
C108	WRITE(NK,115)				01180000
C109	CC TO 1540				01190000
C110	154 AM2=RM2/RB2				01200000
C111	1540 CI=AM2				01210000
C112	AM2=SQRT (AM2*AM2-1.0)-1AN				01220000
C113	C2=RF2/RE2				01230000
C114	FF2=C2				01240000
C115	CI=AM2/RB2				01250000
C116	IF(MN) 456,455,456				01260000
C117	455 C2=C2				01270000
C118	456 C2=(C1+C2)**2-1.0				01280000
C119	IF(C3) 409,409,410				01290000
C120	409 C3=C.0				01300000
C121	WRITE(NK,155)				01310000
C122	TPC2=0.0				01320000
C123	CC TO 411				01330000
C124	410 FC2=SQRT (C3)				01340000
C125	TPC2=ATAN (PC2)				01350000
C126	411 M1=1				01360000
C127	E1=EFL				01370000
C128	E2=PD1				01380000
C129	E3=TP01				01390000
C130	E4=EML				01400000
C131	CC=C01				01410000
C132	CI=2M1				01420000
C133	201 C2=FO+C1				01430000
C134	CI=ATAN (TAN+C1)				01440000
C135	C4=C1-C2				01450000
C136	C2=E3-E2-FC+TAN				01460000
C137	IF(M1-1) 422,422,425				01470000
C138	425 IF(MN) 422,421,422				01480000
C139	421 C3=C3				01490000
C140	C4=C4				01500000
C141	422 CI=C3+E1				01510000
C142	C4=(C1+C4)/C.5				01520000
C143	Y=E4*SIN (C4)				01530000
C144	Z=E4*COS (C4)				01540000
C145	IF(M1-1) 202,202,203				01550000

FORTRAN IV C LEVEL 21		GEAR	DATE = 75099	12/49/12
C146	202 YP1=X			C1580000
C147	YP1=Y			C1570000
C148	K1=R1+1			C1580000
C149	IC=CD2			C1590000
C150	C1=PM2			C1600000
C151	E1=PF2			C1610000
C152	E2=PD2			C1620000
C153	E3=PD2			C1630000
C154	E4=PM2			C1640000
C155	CC TO 201			C1650000
C156	203 YP2=X			C1660000
C157	YP2=Y			C1670000
C158	EE=4.2831654/FNJ			C1680000
C159	CC=EE/FNJ			C1690000
C160	IF (HICR-NE.G) CC TO 395			C1700000
C161	FJ =-FNJ*1.C			C1710000
C162	ER=RB1			C1720000
C163	ER=RM1			C1730000
C164	EA=RA1			C1740000
C165	EC=ED1			C1750000
C166	YP=YM1			C1760000
C167	YP=YM1			C1770000
C168	CP=CE1			C1780000
C169	F=F1			C1790000
C170	II=1			C1800000
C171	EP=FB1			C1810000
C172	WRITE(NM,151)			C1820000
C173	CALL AJCCH			C1830000
C174	CC 221 I=1,N			C1840000
C175	C1 =XJ(I)			C1850000
C176	C2 =YJ(I)			C1860000
C177	FJ(I)=PJ(I)			C1870000
C178	C3=CJ(I)			C1880000
C179	FJ(I)=AJ(I)			C1890000
C180	IF(AJ.EC.1)			C1900000
C181	1CALL TLU(AJ(I),ZJ(I),ALPH(I),Z(I),1,5)			C1910000
C182	CJ(I)=CJ(I)			C1920000
C183	IM=IM			C1930000
C184	IP1=IP			C1940000
C185	CA(I)=CA(I)			C1950000
C186	CC(I)=CC(I)			C1960000
C187	CC(I)=CC(I)			C1970000
C188	IF(C3) 215,215,216			C1980000
C189	515 WRITE(NM,102)FJ(I),C3,AJ(I),CJ(I),C1,C2			C1990000
C190	CC TO 221			C2000000
C191	221 CONTINUE			C2010000
C192	WRITE(NM,120)NM1,YP1			C2020000
C193	WRITE(NM,101)			C2030000
C194	CC 517 I=IP1,IP1			C2040000
C195	517 WRITE(NM,102)FJ(I),QAI(I),QBI(I),QCI(I)			C2050000
C196	CC=CD2			C2060000
				C2070000

FCRTRAN	IV	G	LEVEL	ZI	GEARC	DATE = 15099	12/49/12
C197			PR=RA2				C2080000
C198			XP=XM2				C2090000
C199			YP=YP2				C2100000
C200			IF(MN) 302,301,302				C2110000
C201			301 FJ=FNJ				C2120000
C202			CC TO 31C				C2130000
C203			302 FJ=FNJ				C2140000
C204			31C F=F2				C2150000
C205			EP=EP2				C2160000
C206			CM=CE2				C2170000
C207			CC=EE/FN2				C2180000
C208			IT=2				C2190000
C209			WRITE(MN,12)				C2200000
C210			CALL AJCOP				C2210000
C211			L=NN				C2220000
C212			CC 222,1=1,NN				C2230000
C213			C4=XJ(1)				C2240000
C214			C5=YJ(1)				C2250000
C215			IF 2=IN				C2260000
C216			IP2=IP				C2270000
C217			CA2(1)=QA(1)				C2280000
C218			CA2(1)=CA(1)				C2290000
C219			CA2(1)=QC(1)				C2300000
C220			FJ2(1)=FJ(1)				C2310000
C221			CI=AJ(1)				C2320000
C222			AJ2(1)=CI				C2330000
C223			IF(IN2,EC,1)				C2340000
			1CALL TLUA(2(1),2(2),1),ALFE(1,2),Z(1,2),5)				C2350000
C224			C2=CJ(1)				C2360000
C225			CJ2(1)=C2				C2370000
C226			IF(C2,515,518,519				C2380000
C227			518 WRITE(MN,12)FJ2(1),C1				C2390000
C228			GO TO 520				C2400000
C229			515 WRITE(MN,12)FJ2(1),C1,C2,C4,C5				C2410000
C230			520 IF(L-1) 222,222,226				C2420000
C231			226 L=L-1				C2430000
C232			222 CC=INQUE				C2440000
C233			WRITE(MN,12)XP2,YP2				C2450000
C234			WRITE(MN,123)				C2460000
C235			CC 521,1=JP2,JP2				C2470000
C236			521 WRITE(MN,12)FJ2(1),QA2(1),QB2(1),QC2(1)				C2480000
C237			CC 251 1=1,N				C2490000
C238			JA=JAN				C2500000
C239			FJ(1)=FJ(1,N)				C2510000
C240			AJ(1)=AJ(1,N)				C2520000
C241			AJ(1)=AJ(1,N)				C2530000
C242			FJ(1)=FJ(1)				C2540000
C243			FJ(1)=FJ(1,N)				C2550000
C244			FJ(1)=FJ(1,N)				C2560000
C245			FJ(1)=FJ(1)				C2570000
C246			FJ(1)=FJ(1)				C2580000
C247			251 FJ(1)=FJ(1,N)				C2590000

FORTRAN IV C LEVEL 21			GEAPC	DATE = 75099	12/49/12
C248		NUZ=1			C2600000
C249		NPZ=1			C2610000
C250	157	CONTINUE			C2620000
C251		L=NA			C2630000
C252		CC 415 I=1,N			C2640000
C253		IN=I+1			C2650000
C254		LJC(1)=LJC(1)			C2660000
C255		LJC(1)=LJC(1)			C2670000
C256		LJC(1)=LJC(1)			C2680000
C257		LJC(1)=LJC(1)			C2690000
C258		LJC(1)=LJC(1)			C2700000
C259		LJC(1)=LJC(1)			C2710000
C260		LJC(1)=LJC(1)			C2720000
C261		LJC(1)=LJC(1)			C2730000
C262		LJC(1)=LJC(1)			C2740000
C263		LJC(1)=LJC(1)			C2750000
C264	415	LJC(1)=LJC(1)			C2760000
C265	155	CONTINUE			C2770000
C266		WRITE(N*,106)			C2780000
C267		WRITE(N*,102)VP1,VP2			C2790000
C268		VP1=VP1+CS			C2800000
C269		VP2=VP2+CS			C2810000
C270	418	CONTINUE			C2820000
C271		WRITE(N*,115)			C2830000
C272		CC 201 I=1,N			C2840000
C273		NT(1)=NT(1)			C2850000
C274		NT(1)=NT(1)			C2860000
C275		IF(NT(1).EQ.0)			C2870000
C276	800	CONTINUE			C2880000
C277		CC=1.37/FF2*PI/2/CI			C2890000
C278		LJC(1)=LJC(1)			C2900000
C279		LJC(1)=LJC(1)			C2910000
C280		CCC =LJC(1)+CC			C2920000
C281		CCC =LJC(1)+CC			C2930000
C282		CC=LJC(1)			C2940000
C283		CC=LJC(1)			C2950000
C284		IF(C1) 256,256,257			C2960000
C285	256	IF(C2) 257,257,258			C2970000
C286	257	IF(C2) 259,259,260			C2980000
C287	259	VJ(1)=LJC(1)-CCC *NA			C2990000
C288		LJC(1)=NA*CS			C3000000
C289		CC=0.0			C3010000
C290		CC=0.0			C3020000
C291	258	VJ(1)=LJC(1)-CCC *NA			C3030000
C292		LJC(1)=0.0			C3040000
C293		WRITE(N*,CS			C3050000
C294		CC=CC			C3060000
C295	260	C3=CCC *NA+LJC(1)-LJC(1)			C3070000
C296		C4=CCC *NA+LJC(1)-LJC(1)			C3080000
C297		IF(C3) 255,255,262			C3090000
C298	262	IF(C4) 256,256,263			C3100000
C299	263	C1=CCC+CCC			C3110000

FORTRAN IV C LEVEL	21	GEAF	DATE = 75C99	12/49/12
C340	162	FORMAT(10X2HDP210X3HDP210X3HAT2)		C364C000
C341	163	FORMAT(10X2H1210X4HCU2ASX4HCU2R9X4HCU2C)		C365C000
C342	170	FORMAT(43HCCALCULATED TOTAL CONTACT COMPLIANCE QJDM,E13.6)		C366C000
C343	171	FORMAT(23HCCALCULATED NORMAL WAVE E13.6)		C367C000
C344	174	FORMAT(8CH ANGLE OF APPROACH ON DRIVING GEAR IS GREATER THAN TOOTH CONTACT ANGLE IF SPACING ANGLE.		C368C000
	2	40P PROGRAM CONTINUED WITHOUT OVERLAP		C369C000
C345	175	FORMAT(175HC ANGLE OF RECESS ON DRIVING GEAR IS NOT SMALLER THAN TOOTH CONTACT ANGLE IF SPACING ANGLE. /34M PROGRAM CONTINUED WITHOUT OVERLAP)		C370C000
C346	176	FORMAT(8CH DRIVING GEAR TEETH MESHING ON PROFILE INSIDE OF TIF DIAMETER.		C371C000
	2	40P PROGRAM CONTINUED WITHOUT CORRECTION		C372C000
C347	178	FORMAT(8CH DRIVEN GEAR TEETH MESHING ON PROFILE OUTSIDE OF TIF DIAMETER.		C373C000
	2	40P PROGRAM CONTINUED WITHOUT CORRECTION		C374C000
C348	179	FORMAT(8CH DRIVEN GEAR TEETH MESHING ON PROFILE INSIDE OF TIF DIAMETER. PROGRAM CONTINUED WITHOUT CORRECTION)		C375C000
C349		END		C376C000

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FORTPAN IV C LEVEL 21                                HICCN                                DATE = 75C99                                12/49/12
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C001  SUBROUTINE HICCN                                C0010000
C***  PARAM NAME RTSHICCN                            C0020000
C002  DIMENSION ANCI(25,4)                            C0020100
C003  COMMON PJ(50),CJ(50),QJ(50),AJ(50),XJ(50),YJ(50),  C0030000
1  A(1500),E(1500),C(3000)                            C0040000
C004  COMMON BE,ER,BA,FJ,CC,YF,NA,N,FNJ,EP,TAN,RR,CF,F,XM,MN,II,M  C0050000
C005  COMMON CA(50),CE(50),CC(50),CCL(50),QCL(50),QCL(50),SAZ(50),QBZ(50)  C0060000
11,CC2(50),J,IP                                        C0070000
C006  COMMON NT(50),FEAC(15),FEAC2(15)                C0080000
C007  COMMON FIC/CAC(100),CAC(100),CNC(100),GNJ(100),XNJ(100),  C0090000
1  YNJ(100), ANGLE(100),FNJ(100),CONJ(100),CONCC(100),SND(100),  C0100000
2  CAD(100),EJAK(100),AINK(100),FLAK(100)            C0110000
C008  COMMON/NEWBAS/EP1,EP1,CL1,X1,Y1,EPI,DD2,FR2,PM2,YM2,EP2  C0120000
C009  COMMON/CL/ANC,INT,PMN,IFL1,FN1,FA2,FBI,RC1,RD2,RT1,RT2,RM1,RM2,FI,  C0130000
111,12,FL1,F1,FR1,FR2,YEL,YE2,CEL,GE2,POS1,POS2,ANG  C0140000
C010  COMMON/INP/1,1,ICR,JJ(25,4,2),ZJ(25,4,2),WTJ(25,4),VPT1,VPT2,CS,  C0150000
1  SUMJ(25,4),QJ(25,4,2)                              C0160000
C011  COMMON/CLT/1,EP1,EP2,FF2,M(25,4),VN(25)         C0170000
C012  COMMON/XY/ DUMJ(100),E,1(50),FJ2(50),AJC(125),CUM2(204)  C0180000
C013  COMMON/TAB/ ALPH(5,2),Z(15,2),FLUM(2),RHIGH(2)   C0190000
C014  COMMON/IAVE/ 1FOUR,ISPECT,IRN,IPERC,IRF,IPROP,ICENT,NZJ  C0200000
C015  COMMON/DIAC/ IELIAG                             C0210000
1  IELIAG,GT,C)                                        C0230000
C016  1  WRITE(6,GT,C)                                  C0240000
C017  1  ELIDING,GT,C)                                  C0250000
1  WRITE(6,1000) GJJ                                  C0260000
C018  N=6                                                C0270000
C019  EJ=2,FEJAJ1                                       C0280000
C020  FS=PBI                                            C0290000
C021  FR=PBI                                            C030000
C022  FA=PAI                                            C0310000
C023  IC=CDI                                            C0320000
C024  ME=XMI                                            C0330000
C025  ME=XMI                                            C0340000
C026  CP=GEI                                            C0350000
C027  F=PI                                             C0360000
C028  II=1                                              C0370000
C029  EP=EP1                                            C0380000
C030  WRITE(NK,151)                                     C0390000
C031  CALL NAME                                         C0400000
C032  P=C                                               C0410000
C033  CC 221 I=1,4                                     C0420000
C034  CC 221 J=1,N                                     C0430000
C035  N=K+1                                             C0440000
C036  FAC(1,1)=ANGLE(K)                                C0450000
C037  IF(NZJ,CC,1)                                     C0460000
1  CALL TUC(ANGLE(K),ZJ(J,1,2),ALPH(1,1),Z(1,1),5)  C0470000
IF(CONJ(K) .EQ.0) WRITE(NK,102) PMJ(K) ,CONJ(K) ,ANGLE(K)  C0480000
IF(CONJ(K) .EQ.1) WRITE(NK,102) PMJ(K) ,CONJ(K) ,ANGLE(K)  C0490000
1  CONJ(K) ,XNJ(K) ,YNJ(K) ,VNJ(K) ,20(J,1,1)         C0500000
C040  C0JUG,1,1)=CAJ(K)                                C0510000
C041  221 CONTINUE                                     C0520000

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FORTRAN IV G LEVEL	21	MICCA	DATE = 75099	12/49/72
C052	WRITE(NH,120) XPI,YPI			00530000
C053	WRITE(NH,121)			00540000
C054	DO 517 K=1,NH			00550000
C055	IF(CNJ(K).EQ.C.) GO TO 517			00560000
C056	WRITE(NH,122) FNJ(K),CNP(K),CNC(K)			00570000
C057	517 CONTINUE			00580000
C058	IC=IC2			00590000
C059	IC=IC2			00600000
C060	IC=IC2			00610000
C061	IC=IC2			00620000
C062	IC=IC2			00630000
C063	IC=IC2			00640000
C064	IC=IC2			00650000
C065	IC=IC2			00660000
C066	IC=IC2			00670000
C067	IC=IC2			00680000
C068	IC=IC2			00690000
C069	IC=IC2			00700000
C070	IC=IC2			00710000
C071	IC=IC2			00720000
C072	IC=IC2			00730000
C073	IC=IC2			00740000
C074	IC=IC2			00750000
C075	IC=IC2			00760000
C076	IC=IC2			00770000
C077	IC=IC2			00780000
C078	IC=IC2			00790000
C079	IC=IC2			00800000
C080	IC=IC2			00810000
C081	IC=IC2			00820000
C082	IC=IC2			00830000
C083	IC=IC2			00840000
C084	IC=IC2			00850000
C085	IC=IC2			00860000
C086	IC=IC2			00870000
C087	IC=IC2			00880000
C088	IC=IC2			00890000
C089	IC=IC2			00900000

FCSTRAN IV C LEVEL	21	HICCA	DATE = 15099	12/49/12
C020		QC=1.37/FF2*EF12/AN**1		C105CCCC
C091		AJCL(1)=ANG(11,21)+ANG		C106CCCC
C092	501	WRITE(AN,102) XI,A,CL(1),EJ(1),I(1),J(1),J=1,4),WN,WTT(1,3),QDC107CCCC		Q108CCCC
C093		ANG=AJCL(N)		C109CCCC
C094		FETU=N		C110CCCC
C095	102	FORMAT(10E12.5)		Q1110J00
C096	115	FORMAT(4HCCALCULATEE TOOTH MESHING ERRORS AND LOADS //		C112CCCC
	1	57X,15FTANGENTIAL LCAC/		C113CCCC
	2	6X,3HJC1,5X,4PAJCL,6X,11PTANG. ERROR,4X,7HE2 PAIR,6X,7HE1 PAIR, C114CCCC		C115CCCC
	3	6X,7HJC PAIR,6X,7H-1 PAIR,8X,2HWN,11X,2HNT,10X,3HQJD)		C116CCCC
C097	120	FORMAT(4E+CCCC. CF EFFECTIVE TOOTH PROFILE AT ROOT CIRCLE		C117CCCC
	111X,14X,13X,14Y,7.52X,2E13.6)			C118CCCC
C098	132	FORMAT(1E13.5,112X,5E13.2)		C119CCCC
C099	151	FORMAT(1/6X,2FJ1,11X,3HCJ1,10X,3HAJ1,8X,6HCJ1ABC,9X,3HXJ1,10X,3HYJ1C118CCCC		C120CCCC
	1,1CX,3HZJ1)			C121CCCC
C100	152	FORMAT(1/6X,2FJ2,24X,2HAJ2,6X,6FQJ2ABC,9X,3HXJ2,10X,3HZJ2)C120CCCC		C122CCCC
C101	161	FORMAT(1/ 6X,2FJ1,1CX,4FQJ1A,9X,4HCJ1S,9X,4HQJ1C)		C123CCCC
C102	163	FORMAT(1/6X, 2HJ2,10X,4HCJ2A,5X,4HCJ2B,9X,4HQJ2C)		
C103		END		

FCRTRAN IV C LEVEL 21		PATIAV	DATE = 750S9	12/49/12
CO+2	55C CONTINUE			00530000
CO+3	6CC RETURN			0054CCCC
CO+4	ENC			0055CCCC

FCRTAN IV C LEVEL	21	NANC	DATE = 75C99	12/49/12
CG01	****	SLEFOUTLINE A=NG		CG01CG00
CG02		COMMON P(150),C(150),A(150),X(150),Y(150),		CG02CG00
	1	A(150),E(150),C(150),C(150),		CG03CG00
CG03		COMMON C(150),E(150),C(150),C(150),		CG04CG00
CG04		COMMON C(150),E(150),C(150),C(150),		CG05CG00
	1	C(150),E(150),C(150),C(150),		CG06CG00
CG05		COMMON P(150),C(150),A(150),X(150),Y(150),		CG07CG00
	2	E(150),C(150),C(150),C(150),		CG08CG00
CG06		C(150),E(150),C(150),C(150),		CG09CG00
CG07		C(150),E(150),C(150),C(150),		CG10CG00
CG08		C(150),E(150),C(150),C(150),		CG11CG00
CG09		C(150),E(150),C(150),C(150),		CG12CG00
CG10		C(150),E(150),C(150),C(150),		CG13CG00
CG11		C(150),E(150),C(150),C(150),		CG14CG00
CG12		C(150),E(150),C(150),C(150),		CG15CG00
CG13		C(150),E(150),C(150),C(150),		CG16CG00
CG14		C(150),E(150),C(150),C(150),		CG17CG00
CG15		C(150),E(150),C(150),C(150),		CG18CG00
CG16		C(150),E(150),C(150),C(150),		CG19CG00
CG17		C(150),E(150),C(150),C(150),		CG20CG00
CG18		C(150),E(150),C(150),C(150),		CG21CG00
CG19		C(150),E(150),C(150),C(150),		CG22CG00
CG20		C(150),E(150),C(150),C(150),		CG23CG00
CG21		C(150),E(150),C(150),C(150),		CG24CG00
CG22		C(150),E(150),C(150),C(150),		CG25CG00
CG23		C(150),E(150),C(150),C(150),		CG26CG00
CG24		C(150),E(150),C(150),C(150),		CG27CG00
CG25		C(150),E(150),C(150),C(150),		CG28CG00
CG26		C(150),E(150),C(150),C(150),		CG29CG00
CG27		C(150),E(150),C(150),C(150),		CG30CG00
CG28		C(150),E(150),C(150),C(150),		CG31CG00
CG29		C(150),E(150),C(150),C(150),		CG32CG00
CG30		C(150),E(150),C(150),C(150),		CG33CG00
CG31		C(150),E(150),C(150),C(150),		CG34CG00
CG32		C(150),E(150),C(150),C(150),		CG35CG00
CG33		C(150),E(150),C(150),C(150),		CG36CG00
CG34		C(150),E(150),C(150),C(150),		CG37CG00
CG35		C(150),E(150),C(150),C(150),		CG38CG00
CG36		C(150),E(150),C(150),C(150),		CG39CG00
CG37		C(150),E(150),C(150),C(150),		CG40CG00
CG38		C(150),E(150),C(150),C(150),		CG41CG00
CG39		C(150),E(150),C(150),C(150),		CG42CG00
CG40		C(150),E(150),C(150),C(150),		CG43CG00
CG41		C(150),E(150),C(150),C(150),		CG44CG00
CG42		C(150),E(150),C(150),C(150),		CG45CG00
CG43		C(150),E(150),C(150),C(150),		CG46CG00
CG44		C(150),E(150),C(150),C(150),		CG47CG00
CG45		C(150),E(150),C(150),C(150),		CG48CG00
CG46		C(150),E(150),C(150),C(150),		CG49CG00
CG47		C(150),E(150),C(150),C(150),		CG50CG00
CG48		C(150),E(150),C(150),C(150),		CG51CG00
CG49		C(150),E(150),C(150),C(150),		CG52CG00

FCRTRAN	IV	C	LEVEL	21	NANC	DATE = 75099	12/49/12
C048	243	ELNK(I)=(YXJ(I)+3*YXJ(I-1))*21/3.0*F					00930000
C049		ATNK(I)=(YXJ(I)+YXJ(I-1))*F					00940000
C050		FLNK(I)=XNJ(I)-XNJ(I-1)					00950000
C051	504	M=M+1					00960000
C052	503	IF(I-NK) 5C2,5C1,5C1					00970000
C053	502	IF(M) 5C6,5C5,5C6					00980000
C054	505	FJ=FJ-1					00990000
C055		CC TC 501					00000000
C056	506	FJ=FJ+1.C					00010000
C057	501	CONTINUE					00020000
C058		IF(I-1) 3C1,301,302					00030000
C059	3C1	IF(M) 6C1,3C2,4C1					00040000
C060	601	LL=NN					00050000
C061		CC 303 1=1,NN					00060000
C062		CNC(I)=CNJ(LL)					00070000
C063		IF(LL-1) 3C3,303,3C5					00080000
C064	305	LL=LL-1					00090000
C065	303	CONTINUE					00100000
C066	3C2	IP=IP+2					00110000
C067	41C	CC 246 1=1F,1P					00120000
C068		E1=C.O					00130000
C069		E2=C.O					00140000
C070		E3=C.O					00150000
C071		E4=C.O					00160000
C072		EE=XNJ(LL)-YM					00170000
C073		1P=1					00180000
C074		IF(M) 2C2,2C3,2C2					00190000
C075	2C3	EE=EE					00200000
C076	2C2	CC 245 1=1P,1P					00210000
C077		C1=XNJ(LL)-XNJ(1)					00220000
C078		C5=FLNK(1)					00230000
C079		IF(M) 2C7,2C8,2C7					00240000
C080	2C8	C1=C1					00250000
C081		C5=C5					00260000
C082	2C7	C2=C5/ATNK(1)					00270000
C083		C3=1C5*(C1)*C5*(C1)*C1					00280000
C084		E4=E4+C2					00290000
C085		C4=C2*(C1)+C5					00300000
C086		E1=E1+C3*C2					00310000
C087		E2=E2+C4*C2					00320000
C088	245	E3=E3+C5/ATNK(1)					00330000
C089		IF(M) 2C6,2C5,2C6					00340000
C090	2C5	1P=1P-1					00350000
C091	2C6	C1=CNO(I)*CNC(I)					00360000
C092		C2=SNJ(LL)*YXJ(LL)					00370000
C093		CNAIL = C1/3*(E1/EP+(C2+E4-CNAIL)*E21/EP+C2					00380000
C094		CAPIL = C1/GM*(E3+1.2					00390000
C095		C1=(E5-CNAIL)-YXJ(LL)*SNC(I)/YP					00400000
C096		CNC(I)=C1/EP+1.327/F*C1					00410000
C097	246	CNJ(I)=CNA(LL)+CNC(LL)+CNC(LL)					00420000
C098		RETURN					00430000
C099		END					00440000

FCITRAN IV C LEVEL	21	PLT	DATE = 75C99	12/49/12
C001	SUBROUTINE PLT(X,Y,Z,NPTS)			
C002	C**** NUMBER NAME R75PLT			
C003	DIMENSION IPU(4000)			
C004	REAL*4 ILAEX(16), ILARY(16), ILARZ(13)			
C005	DIMENSION Y(3000), X(3000), Z(3000), AX(14), AYY(14), AZZ(14), HEAD3(4)			
C006	COMMON PU(50), CU(50), QU(50), JU(50), XU(50), YJ(50),			
C007	LA(1500), RI(1500), SI(3000)			
C008	COMMON CG, ER, PA, FU, CG, YP, AN, A, FNJ, EP, TAN, RB, GM, F, XM, MN, II, P			
C009	COMMON CA(50), CE(50), CC(50), CAI(50), QBI(50), QAI(50), QA2(50), QB2(50), QCB2(50)			
C010	1), CC2(50), IH, IP			
C011	COMMON RT(50), FEAC(115), FEED(115)			
C012	DATA ILARX//, 'CALC', 'LLAT', 'ION', 'PGIN', 'T' //			
C013	DATA ILARZ//TANC, 'ENTI', 'AL E', 'PRCR', ' (IN', 'I,)' //			
C014	DATA ILARZ//LGAD, ' ILB', 'I, ' //			
C015	DATA HEAC3//TANC, ' FC', 'RCE', 'I, ' //			
C016	DATA EHEAD3//LB, ' //			
C017	IN=5			
C018	IC=6			
C019	ICAL=22			
C020	CALL PLCTIS(1BU, 4C, IC, IZL)			
C021	CALL PLCT(4, 4, 5, -3)			
C022	CALL PLCT(-2, -4, -3)			
C023	CALL DAS*P(-2, -4, -25)			
C024	CALL SCALE(1, 5, NPTS, 1)			
C025	Y(NPTS+1)=C.			
C026	CC 10 K=1, NPTS			
C027	10 Y(K)=Y(K)			
C028	CALL SCALE(Y, 4, NPTS+1, 1)			
C029	Y(NPTS+2)=Y(NPTS+3)			
C030	CALL SCALE(2, 3, NPTS, 1)			
C031	AX(1)=Y(NPTS+1)			
C032	AX(2)=Y(NPTS+2)			
C033	AY(1)=Y(NPTS+1)			
C034	AY(2)=Y(NPTS+2)			
C035	AZZ(1)=Z(NPTS+1)			
C036	AZZ(2)=Z(NPTS+2)			
C037	CALL AXIS(C, 0, ILARX, -24, 5, C, AX(1), AX(2))			
C038	CALL AXIS(C, 0, ILARZ, 24, 4, SC, 0, AYY(2))			
C039	CALL FLINEX(Y, NPTS, 1, 1, 3)			
C040	CALL PLCT(C, -4, -2)			
C041	CALL AXIS(C, 0, ILARX, -24, 5, C, AX(1), AX(2))			
C042	CALL AXIS(C, 0, ILARZ, 24, 4, SC, AZZ(1), AZZ(2))			
C043	CALL FLINEX(Z, NPTS, 1, 1, 1)			
C044	CALL PLCT(5, 5, -3)			
C045	CALL SYMBCL(C, 6, 14, FEAC(1), C, 40)			
C046	CALL SYMBCL(C, -25, 14, FEED(2), 0, 40)			
C047	CALL SYMBCL(C, -5, 14, FEAC(3), C, 16)			
C048	CALL NUMBERS(55, 559, 14, NT, C, 2)			
C049	CALL SYMBCL(55, 559, 14, EHEAD3, 0, 4)			
C050	CALL PLCT(C, -5, -3)			
C051	CALL DAS*P(C, 5, -25)			
C052	CALL FLCT(C, 0, 559)			
C053	C050C000			
C054	C002C000			
C055	C002C100			
C056	C002C200			
C057	C003C000			
C058	C003C100			
C059	C003C200			
C060	C004C000			
C061	C004C100			
C062	C004C200			
C063	C005C000			
C064	C005C100			
C065	C005C200			
C066	C006C000			
C067	C006C100			
C068	C006C200			
C069	C007C000			
C070	C007C100			
C071	C007C200			
C072	C008C000			
C073	C008C100			
C074	C008C200			
C075	C009C000			
C076	C009C100			
C077	C009C200			
C078	C010C000			
C079	C010C100			
C080	C010C200			
C081	C011C000			
C082	C011C100			
C083	C011C200			
C084	C012C000			
C085	C012C100			
C086	C012C200			
C087	C013C000			
C088	C013C100			
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C093	C015C000			
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C107	C019C200			
C108	C020C000			
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C110	C020C200			
C111	C021C000			
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C120	C024C000			
C121	C024C100			
C122	C024C200			
C123	C025C000			
C124	C025C100			
C125	C025C200			
C126	C026C000			
C127	C026C100			
C128	C026C200			
C129	C027C000			
C130	C027C100			
C131	C027C200			
C132	C028C000			
C133	C028C100			
C134	C028C200			
C135	C029C000			
C136	C029C100			
C137	C029C200			
C138	C030C000			
C139	C030C100			
C140	C030C200			
C141	C031C000			
C142	C031C100			
C143	C031C200			
C144	C032C000			
C145	C032C100			
C146	C032C200			
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C153	C035C000			
C154	C035C100			
C155	C035C200			
C156	C036C000			
C157	C036C100			
C158	C036C200			
C159	C037C000			
C160	C037C100			
C161	C037C200			
C162	C038C000			
C163	C038C100			
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C173	C041C200			
C174	C042C000			
C175	C042C100			
C176	C042C200			
C177	C043C000			
C178	C043C100			
C179	C043C200			
C180	C044C000			
C181	C044C100			
C182	C044C200			
C183	C045C000			
C184	C045C100			
C185	C045C200			
C186	C046C000			
C187	C046C100			
C188	C046C200			
C189	C047C000			
C190	C047C100			
C191	C047C200			
C192	C048C000			
C193	C048C100			
C194	C048C200			
C195	C049C000			
C196	C049C100			
C197	C049C200			
C198	C050C000			
C199	C050C100			
C200	C050C200			

FCRTRAN IV C LEVEL	21	PLT	DATE = 75099	12/49/12
C050	FC 20 K=1, NPIS			C051CCCC
C051	20 Y(K)=-Y(K)			C0520000
C052	RETURN			C053CCCC
C053	END			C0540000

FORTRAN IV C LEVEL 21	SCLPA	DATE = 75C99	12/49/12
C044	CJJ(J,ISUB,2)=C*G		00530000
C045	IZERO=IZERC+1		00540000
C046	50 CONTINUE		00550000
C047	IF(IZERC.NE.G) GO TO 5		00560000
C048	GO TO K=1,IC		00570000
C049	ISLB=INDEX(K)		00580000
C050	K(J,ISUB)=RHS(K)*CS		00590000
C051	70 CONTINUE		00600000
C052	VN(J)=RHS(IC+1)		00610000
C053	100 CONTINUE		00620000
C054	RETURN		00630000
C055	END		00640000

FCFTRAN IV C LEVEL 21	SPECT	DATE = 75089	12/49/12
C047	SSS=0.		00530000
C048	DO 25 JK=1,N5		00540000
C049	J=JK+1		00550000
C050	AA=2.1416*JK*KK(N)/SN		00560000
C051	35 SSS=SSS+2.*R(J)*CCS(AA)		00570000
C052	40 GKN)=(GKN)+SSS)*2.*P		00580000
C053	GKN(1)=.5*GKN(1)+.5*GKN(2)		00590000
C054	GKN(4M)=.5*GKN(M)+.5*GKN(M+1)		00600000
C055	DO 50 LL=2,N		00610000
C056	GKN(LL)=.25*GKN(LL-1)+.5*GKN(LL)+.25*GKN(LL+1)		00620000
C057	50 CONTINUE		00630000
C058	WRITE(NK,120)		00640000
C059	WRITE(NK,140)		00650000
C060	DO 60 I=1,NM		00660000
C061	SK=KK(I)*N/(2.*SM)		00670000
C062	WRITE(NK,150)KK(I),FR(I),GK(I),GKN(I),SKM		00680000
C063	60 CONTINUE		00690000
C064	100 FORMAT(15,F13.5)		00700000
C065	110 FORMAT(11X,20FRESING FREQUENCY IN CPS #,E3.5)		00710000
C066	115 FORMAT(7X,2F11D2,F11X2,BE)		00720000
C067	120 FORMAT(6E13.5)		00730000
C068	125 FORMAT(7X,11F12.2,11X,4F12.2,11X,2HSM)		00740000
C069	130 FORMAT(11X,11F10.2,11X,10F10.2,11X,2HSM)		00750000
C070	140 FORMAT(16X,11F10.2,11X,10F10.2,11X,2HSM)		00760000
C071	150 FORMAT(17,2E13.5,F13.5)		00770000
C072	RETURN		00780000
C073	END		00790000

FORTRAN IV C LEVEL 21	TLU	DATE = 15099	12/49/12
C001	SUBROUTINE TLL(A,P,C,C,N)		C0010000
C	C*** MEMBER NAME R75TLU		C0020000
C	LINEAR INTERPOLATION ROUTINE		C0030000
C	P* INDEPENDENT VARIABLE		C0040000
C	B* INDEPENDENT VARIABLE ANSWER		C0050000
C	C* INDEPENDENT TABLE		C0060000
C	D* INDEPENDENT TABLE		C0070000
C	N* NUMBER OF POINTS IN TABLE		C0080000
C	INDEPENDENT TABLE MUST BE SORTED, EITHER ASCENDING OR DESCENDING		C0090000
C	DIMENSION C(1),D(1)		C0100000
C002	IF(A.LT.C(1))-CR.P.GT.C(N)) GC TO 1		C0110000
C003	IF(A.LT.C(1))-CR.P.GT.C(N)) GC TO 1		C0120000
C004	IF(A.LT.C(1))-CR.P.GT.C(N)) GC TO 1		C0130000
C005	1 B=C.		C0140000
C006	GC TO 100		C0150000
C007	2 B=C(1)		C0160000
C008	GC TO 100		C0170000
C009	3 PL=1		C0180000
C010	PL=N		C0190000
C011	8 IF(ND-ML-1) 15,15,5		C0200000
C012	5 M=(C(1)+ML)/2		C0210000
C013	IF(C(1)-C(2))11,2,10		C0220000
C014	10 IF(C(1)-A(12,12,14		C0230000
C015	11 IF(A-C(M))12,12,14		C0240000
C016	12 B=C(M)		C0250000
C017	GC TO 100		C0260000
C018	13 PD=5		C0270000
C019	GC TO 8		C0280000
C020	14 PL=N		C0290000
C021	GC TO 8		C0300000
C022	15 CONTINUE		C0310000
C023	B=D(ML)+(C(ML)-D(ML))*((B-C(PL))/(C(ML)-C(ML)))		C0320000
C024	100 CONTINUE		C0330000
C025	RETURN		C0340000
C026	END		

APPENDIX C

LISTING OF COMPUTER PROGRAM FOR PREDICTION OF GEAR MESH EXCITATION SPECTRA - GGEAR (R-67)

RUN VERSION 2.3 --PSR LEVEL 332--

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PROGRAM GGEAR(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE22)
COMMON/YYZ(UJC1(25),UJ01(25),UJ2(25),UJC2(25),UJ02(25),ZJ1(50)
1,ZJC1(25),ZJ01(25),ZJ2(50),ZJC2(25),ZJ02(25),QJ1(50),QJC1(25),QJ01
2(25),QJ2(50),QJC2(25),FJ1(50),UJ1(50),CJC1(2
35),CJ01(25),AJ1(50),AJ2(50),QJC(50),QJ0(50),ZJC(50),ZJ0(50
4),VJ(50),EJ1(56),FJ2(50),AJC1(25),AJC2(25),FJC1(27),QJ02(25),ZM2(
550),UM2(50),WTC(27)
COMMON/PJ(S01,CJ(S01),QJ(S01),AJ(S01),XJ(S01),YJ(S01))
COMMON/DO(BR,BA,FJ,CC,YM,NN,N,FNJ,EP,TAN,RB,GM,F,XM,MN,II,M
COMMON/QA(S01),QB(S01),QC(S01),QA1(S01),QB1(S01),QC1(S01),QA2(S01),QB2(S0
1),QC2(S01),IM,IP
COMMON/WT(S01),HEAD1(6),HEAD2(6)
COMMON/GU(NMC),INT,MNM,IPLT,FN1,FN2,RB1,RO1,RO2,RF1,RT2,BN1,RM2,F1,
1T1,T2,F1,F2,RF1,RF2,YE1,YE2,GE1,GE2,POS1,POS2,ANG
DIMENSION GGG(3000),WTC(3000),FJCC(3000),AANG(3000)
NR=5
'6
198 RL (NR,100) (HEAD1(I),I=1,4), (HEAD2(I),I=1,4)
REA (NR,117) L,MC,INT,MN,MNM,IPLT,IFOUR,ISPECT
READ(NR,112) FN1,FN2,RB1,RO1,RO2
READ(NR,112) RF1,RT2,RM1,RM2,F1,T1
READ(NR,112) T2,F1,F2,RF1,RF2
READ(NR,112) YE1,YE2,GE1,GE2,POS1,POS2
WRITE(NW,100) (HEAD1(I),I=1,4), (HEAD2(I),I=1,4)
WRITE(NW,101)
WRITE(NW,108)
WRITE(NW,109) NMC,INT,MN,MNM
WRITE(NW,104)
WRITE(NW,102) F1,FN1,RB1,RO1,RF1,RM1
IF(MN) 511,510,511
510 WRITE(NW,103)
GO TO 512
511 WRITE(NW,160)
512 WRITE(NW,150) IMETP,FN2,RO2,RT2,RM2
WRITE(NW,105)
WRITE(NW,102) T1,F1,RF1,YE1,GE1,POS1
WRITE(NW,107)
WRITE(NW,102) T2,F2,RF2,YE2,GE2,POS2
WRITE(NW,164)
ANG=0.
IMC=1.
N=2.*FI+1.
NM=NM+N
IF(MN.EQ.0) T2=T2
150 WRITE(NW,1500)
READ(NR,112) CL,VPT1,VPT2
WRITE(NW,1000) IMC,CL
WRITE(NW,110)
L=NM
DO 209 I=1,NN
READ(NR,112) ZJ1(I),UJ1(I),ZJ2(I),UJ2(I),WT(I)
WRITE(NW,102) ZJ1(I),UJ1(I),ZJ2(I),UJ2(I)
ZM2(IL)=ZJ2(I)

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RUN VERSION 2.3 --PSR LEVEL 332--

GGEAR

000442	UM2(L)=UJ2(I)	GGEAR	52
000444	IF(L-1) 209,209,225	GGEAR	53
000446	225 L=L-1	GGEAR	54
000450	209 CONTINUE	GGEAR	55
000453	CALL GEARO(CL,VPT1,VPT2)	GGEAR	56
000455	NNN=IMC*N	GGEAR	57
000460	DO 200 I=1,N	GGEAR	58
000461	JJ=NNN*I-N	GU	1
000463	AANG(JJ)=AJC(I)	MAY3	3
000466	GGG(JJ)=EJ(I)	GGEAR	60
000470	G(JJ)=GGG(JJ)	GGEAR	61
000472	WTCC(JJ)=WTC(I)	GGEAR	62
000474	200 FJCC(JJ)=JJ	MAY2	1
000500	IMC=IMC+1	GGEAR	64
000501	IF(IMC.LE.NMC) GO TO 150	GGEAR	65
000503	WRITE(NH,1500)	MAY3	4
000507	WRITE(NH,2000)	MAY3	5
000513	DO 2500 I=1,NNN	MAY3	6
000515	2500 WRITE(NH,102)FJCC(I),AANG(I),GGG(I)	MAY3	7
000531	IF(IPLT.EQ.1) CALL PLT(FJCC,GGG,WTCC,NNN)	GGEAR	66
000536	M=FI	GU	3
000540	IF(1FOUR.NE.1) GO TO 3000	MAY9	2
000542	WRITE(NH,120)	ALG	4
000546	CALL FOUR	GGEAR	67
000547	LL=MMN+1	GGEAR	68
000551	DO 250 I=1,LL	GGEAR	69
000553	LP=I-1	GGEAR	70
000554	SMK=1.*LP/NMC	JUNE7	1
000560	RESLT=SQRT(A(I)**2+B(I)**2)	GGEAR	71
000566	250 WRITE(NH,129)LP,A(I),B(I),RESLT,SMK	JUNE7	2
000606	3000 IF(1SPECT.NE.1) GO TO 3500	MAY9	3
000610	CALL SPECT	MAY9	4
000611	3500 CONTINUE	MAY9	5
000611	IF(INT)300,190,300	GGEAR	73
000612	300 CALL EXIT	GGEAR	74
000613	190 FORMAT(8A10)	GGEAR	75
000613	101 FORMAT(72H0 PN0335=COMPUTATIONS OF GEAR TOOTH MESHING ERRORS	GGEAR	76
000613	1 3-22-1966)	GGEAR	77
000613	102 FORMAT(7E13,5)	MAY9	6
000613	103 FORMAT(12H0 PRE.ANGLE7X2HN22X3HR1210X3HRT210X3HRM2)	GGEAR	79
000613	104 FORMAT(/7X1H111X2HN111X3HR8110X3HRO110X3HRT110X3HRM1)	GGEAR	80
000613	105 FORMAT(/6X2HT111X2HF111X3HRF15X12HYOUNGS MOD-12X11HSHEAR MOD-12X11	GGEAR	81
000613	1MPOS,RATIO-1)	GGEAR	82
000613	107 FORMAT(/6X2HT211X2HF211X3HRF25X12HYOUNGS MOD-22X11HSHEAR MOD-22X11	GGEAR	83
000613	1MPOS,RATIO-2)	GGEAR	84
000613	108 FORMAT(50H0 MESH CYCLES INPUT, DIFF.GEAR N.OF HARMONIC)	GGEAR	85
000613	109 FORMAT(4X14,4(8X14))	GGEAR	86
000613	110 FORMAT(60H0INPUT LISTING OF PROFILE ERROR AND SUPPLEMENTARY COMPLI	FINAL	2
000613	1ANCE/6X2HZ111X2HU111X2H211X2HU2)	FINAL	3
000613	112 FORMAT(6E13,5)	GGEAR	87
000613	117 FORMAT(815)	MAY9	7
000613	128 FORMAT(43H0CALCULATED FOURIER COEFFICIENTS FOR ERRORS//7H 19X	ALG	5
000613	15HA11 13X4HB1114X1HC14X2HMC)	JUNE7	3
000613	129 FORMAT(17,314X E14,7),F14,7)	JUNE7	4
000613	158 FORMAT(2E13,5,13X,3E13,5)	GGEAR	90
000613	160 FORMAT(12H0 7X2HN22X3HR0210X3HRT210X3HRM2)	GGEAR	91
000613	164 FORMAT(//16H CALCULATED DATA)	GGEAR	92
000613	1000 FORMAT(16H MESH CYCLE NO.=,13,20H, CENTER DISTANCE=E13,6)	MAY14	1
000613	1560 FORMAT(/6X 20(H*3X)/)	MAY3	8
000613	2000 FORMAT(5X 3HJC19X4HAJC16X11HTANG. ERROR)	MAY3	9
000613	STOP	GGEAR	94
000615	END	GGEAR	95

RUN VERSION 2.3 --PSR LEVEL 332--

SUBROUTINE GEARO(CL,VPT1,VPT2)		JUN13	1
000006	COMMON/XY/UJC1(25),UJD1(25),UJ2(25),UJC2(25),UJD2(25),ZJ1(50)	CZIG	3
	1,ZJC1(25),ZJD1(25),ZJ2(50),ZJC2(25),ZJD2(25),QJ1(50),QJC1(25),QJD1	GEARO	4
	2(25),QJ2(50),QJC2(25),FJ1(50),UJ1(50),CJC1(2	GEARO	5
	35),CJD1(25),AJ1(50),AJ2(50),QJC(50),QJD(50),ZJC(50),ZJD(50	GEARO	6
	4),VJ(50),EJ1(56),FJ2(50),AJC1(25),AJC2(25),FJC1(27),QJD2(25),ZM2(	GEARO	7
	550),UM2(50),WTC(27)	GEARO	8
000006	COMMON PJ(50),CJ(50),QJ(50),AJ(50),XJ(50),YJ(50),	GEARO	9
	1A(1500),B(1500),G(3000)	MAY11	3
000006	COMMON OD,BR,BA,FJ,CC,YM,NN,N,FNJ,EP,TAN,RB,GM,F,XM,MN,I,M	ALG	7
000006	COMMON QA(50),QB(50),QC(50),QA1(50),QB1(50),QC1(50),QA2(50),QB2(50)	GEARO	12
	1),QC2(50),IM,IP	GEARO	13
000006	COMMON WT(50),HEAD1(6),HEAD2(6)	GEARO	14
000006	COMMON/GU/NWC,INT,MM,IPLT,FN1,FN2,RP1,RO1,RO2,RT1,RT2,RH1,RH2,FI,	ALG	8
	IT1,T2,F1,F2,RF1,RF2,YE1,YE2,GE1,GE2,POS1,POS2,ANG	ALG	9
C SPECIFY AND INITIALIZE READING AND WRITING UNITS FOR IBM 1800		GEARO	17
000006	NR=5	GEARO	18
000006	NW=6	GEARO	19
000010	198 CONTINUE	GEARO	20
000010	RP1=CL*FN1/(FN1+FN2)	APR30	1
000013	IF(MN.EQ.0)RP1=CL*FN1/(FN2-FN1)	JUNE7	5
000017	CTT=RB1/RP1	GEARO	22
000021	TTT=SQRT(1.-CTT**2)/CTT	GEARO	23
000026	THETP=ATAN(TTT)	JUNES	1
000030	THETPP=THETP*180./3.1415927	JUNES	2
000033	WRITE(NW,112)	YUNG	1
000036	WRITE(NW,102) THETPP	JUNES	3
000044	IF(F1-F2) 320,320,321	GEARO	25
000051	321 FF2=FF2	GEARO	26
000053	GO TO 322	GEARO	27
000053	320 FF2=F1	GEARO	28
000055	322 FF2=FF2**0.8	GEARO	29
000061	304 OD1=-T1/2.0/RP1+THETP	GEARO	33
000065	F12=FN1/FN2	GEARO	34
000067	RP2=RP1/F12	GEARO	35
000070	OD2=-T2/2.0/RP2+THETP	GEARO	36
000074	FNJ=2.0*F1+1.0	GEARO	37
000077	N=FNJ	GEARO	38
000101	NN=N*N	GEARO	39
000102	CS=CTT	JUNE6	1
000104	TAN=TTT	JUNES	4
000105	EP1=1.0-POS1*POS1	GEARO	43
000107	EP1=YE1/EP1	GEARO	44
000111	EP2=1.0-POS2*POS2	GEARO	45
000114	EP2=YE2/EP2	GEARO	46
000115	EP12=(1.0/EP1+1.0/EP2)*0.5	GEARO	47
000121	EP12=EP12**0.9	GEARO	48
000125	RB2=RB1/F12	JUNES	5
000127	C1=RO1/RB1	GEARO	51
000130	C2=RO2/RB2	GEARO	52
000132	BR2=(SORT (C2*C2-1.0)-TAN)	GEARO	53
000140	BR1=(SORT (C1*C1-1.0)-TAN)	GEARO	54
000146	C3=TAN/F12	GEARO	55
000147	IF(BR1-C3) 403,403,404	GEARO	56

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GEAKU

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000154      404 BR1=C3
000156      WRITE(NW,126)BR1
000163      403 BA1=BR2/F12
000165      BA2=BR1*F12
000166      IF(MN) 440,450,440
000172      450 SA1=-BA1
000173      BA2=-BA2
000175      440 IF(BA1-TAN) 401,401,402
000200      402 BA1=TAN
000202      WRITE(NW,125)BA1
000207      401 C1=6.2831845/FN1
000211      IF(BA1-C1) 213,213,611
000216      611 WRITE(NW,174)
000222      213 IF(BR1-C1) 215,612,612
000227      612 WRITE(NW,175)
000233      215 C1=RT1/RB1
000235      C2=RT2/PB2
000237      C1 =SQRT (C1*C1-1.0)-TAN
000245      AT1=ABS (C1)
000246      C2 =SQRT (C2*C2-1.0)-TAN
000255      AT2=ABS (C2)
000257      WRITE(NW,122)
000262      WRITE(NW,102)RP1,RB1,BA1,RR1,AT1
000300      WRITE(NW,162)
000304      WRITE(NW,102)RP2,RB2,BA2,RR2,AT2
000322      NMZ=1
000323      NUZ=1
000324      IF(AT1-BA1) 311,216,216
000331      311 WRITE(NW,176)
000335      216 IF(AT2-BA2) 309,217,217
000342      309 IF(MN) 620,621,620
000343      621 WRITE(NW,173)
000347      GO TO 217
000352      620 WRITE(NW,179)
000356      217 IF(RM1-RB1) 191,192,192
000363      191 AM1=1.0
000365      WRITE(NW,118)
000370      GO TO 1920
000373      192 AM1=RM1/RB1
000375      1920 C1=AM1
000376      AM1=SQRT (AM1*AM1-1.0)-TAN
000404      C2=RF1/RB1
000406      PF1=C2
000407      C1=RM1/RB1
000411      C3=(C1+C2)**2-1.0
000414      IF(C3) 406,406,407
000420      406 C3=0.0
000421      WRITE(NW,156)
000425      TPD1=0.0
000426      WRITE(NW,156)PD1
000434      GO TO 408
000437      407 PD1=SQRT (C3)
000441      TPD1=ATAN (PD1)
000444      408 IF(RM2-RB2) 193,194,194
000451      193 AM2=1.0

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GEAKO      76
GEAKO      77
GEAKO      78
FINAL      6
GEAKO      80
GEAKO      81
JUN13      2
JUN13      3
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GEAKO     110
GEAKO     111

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RUN VERSION 2.3 --PSR LEVEL 332--

GEARU

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000453      WRITE(NW,119)
000456      GO TO 1940
000461      194 AM2=RH2/RB2
000463      1940 C1=AM2
000464      AM2=SQRT (AM2*AM2-1.0)-TAN
000472      C2=RF2/RB2
000474      PF2=C2
000475      C1=RM2/RB2
000477      IF (MN) 456,455,456
000502      455 C2=-C2
000503      456 C3=(C1+C2)*2-1.0
000506      IF (C3) 409,409,410
000510      409 C3=0.0
000511      WRITE(NW,155)
000515      TPD2=0.0
000516      WRITE(NW,155)PD2
000524      GO TO 411
000527      410 PD2=SQRT (C3)
000531      TPD2=ATAN (PD2)
000534      411 K1=1
000535      E1=PF1
000536      E2=PD1
000540      E3=TPD1
000541      E4=RM1
000543      DD=DD1
000544      C1=AM1
000546      201 C2=DD*C1
000550      C1=ATAN (TAN+C1)
000554      C4=C1-C2
000556      C3=E3-E2-DD*TAN
000562      IF (K1-1) 422,422,425
000567      425 IF (MN) 422,421,422
000570      421 C3=-C3
000571      C4=-C4
000573      422 C1=C3+E1
000575      C4=(C1+C4)*0.5
000600      Y=E4*SIN (C4)
000602      X=E4*COS (C4)
000605      IF (K1-1) 202,202,203
000612      202 XM1=X
000613      YM1=Y
000615      K1=K1+1
000617      DD=DD2
000620      C1=AM2
000621      E1=PF2
000623      E2=PD2
000624      E3=TPD2
000626      E4=RM2
000630      GO TO 201
000630      203 XM2=X
000631      YM2=Y
000633      EE=6.2831854/FNJ
000635      CC=EE/FN1
000636      FJ =-FNJ*1.0
000640      RB=RB1

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GEARO 112
GEARO 113
GEARQ 114
GEARO 115
GEARO 116
GEARO 117
GEARO 118
GEARO 119
GEARQ 120
GEARO 121
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GEARQ 126
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GEARO 165
GEARO 166

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RUN VERSION 2.3 --PSR LEVEL 332--

GEARQ

000641	BR=BR1	GEARQ	167
000643	BA=BA1	GEARQ	168
000644	OD=OD1	GEARQ	169
000646	XH=XM1	GEARQ	170
000647	YM=YM1	GEARQ	171
000651	GM=GE1	GEARQ	172
000652	F=F1	GEARQ	173
000654	II=I1	GEARQ	174
000655	EP=EP1	GEARQ	175
000657	WRITE(NW,151)	GEARQ	176
000662	CALL AJCDH	GEARQ	177
000663	DO 221 I=1,NN	GEARQ	178
000667	C1 =XJ(I)	GEARQ	179
000670	C2 =YJ(I)	GEARQ	180
000672	FJ1(I)=PJ(I)	GEARQ	181
000674	C3=CJ(I)	GEARQ	182
000675	AJ1(I)=AJ(I)	GEARQ	183
000677	CJ1(I)=QJ(I)	GEARQ	184
000701	IM1=IM	GEARQ	185
000702	IP1=IP	GEARQ	186
000704	QA1(I)=QA(I)	GEARQ	187
000706	QB1(I)=QB(I)	GEARQ	188
000710	QC1(I)=QC(I)	GEARQ	189
000712	IF(C3) 515,515,516	GEARQ	190
000714	515 WRITE(NW,102)FJ1(I),C3,AJ1(I)	GEARQ	191
000726	GO TO 221	GEARQ	192
000731	516 WRITE(NW,102)FJ1(I),C3,AJ1(I),QJ1(I),C1,C2	GEARQ	193
000751	221 CONTINUE	GEARQ	194
000756	WRITE(NW,120)XM1,YM1	GEARQ	195
000765	WRITE(NW,161)	GEARQ	196
000771	DO 517 I=IM1,IP1	GEARQ	197
000775	517 WRITE(NW,102)FJ1(I),QA1(I),QB1(I),QC1(I)	GEARQ	198
001015	DD=DD2	GEARQ	199
001016	RB=RB2	GEARQ	200
001017	XM=XM2	GEARQ	201
001021	YM=YM2	GEARQ	202
001022	IF(MN) 302,301,302	GEARQ	203
001024	301 FJ=FNJ	GEARQ	204
001026	GO TO 310	GEARQ	205
001026	302 FJ=-FNJ	GEARQ	206
001030	310 F=F2	GEARQ	207
001031	EP=EP2	GEARQ	208
001033	GM=GE2	GEARQ	209
001034	CC=EE/FN2	GEARQ	210
001036	II=2	GEARQ	211
001040	WRITE(NW,152)	GEARQ	212
001043	CALL AJCDH	GEARQ	213
001044	L=NN	GEARQ	214
001046	DO 222 I=1,NN	GEARQ	215
001051	C4 =XJ(I)	GEARQ	216
001052	C5 =YJ(I)	GEARQ	217
001054	IM2=IM	GEARQ	218
001055	IP2=IP	GEARQ	219
001057	QA2(I)=QA(I)	GEARQ	220
001061	QB2(I)=QB(I)	GEARQ	221

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GEARQ

001063	QC2(I)=QC(I)	GEARO	222
001065	FJ2(I)=PJ(I)	GEARO	223
001067	C1=AJ(I)	GEARO	224
001070	AJ2(I)=C1	GEARO	225
001073	C2=QJ(I)	GEARO	226
001075	QJ2(I)=C2	GEARO	227
001076	IF(C2) 519,518,519	GEARO	228
001076	518 WRITE(NW,132)FJ2(I),C1	GEARO	229
001106	GO TO 520	GEARO	230
001111	519 WRITE(NW,132)FJ2(I),C1,C2,C4,C5	GEARO	231
001127	520 IF(L-1) 222,222,226	GEARO	232
001133	226 L=L-1	GEARO	233
001135	222 CONTINUE	GEARO	234
001140	WRITE(NW,120)XM2,YM2	GEARO	235
001147	WRITE(NW,163)	GEARO	236
001153	DO 521 I=IM2,IP2	GEARO	237
001157	521 WRITE(NW,102)FJ2(I),QA2(I),QB2(I),QC2(I)	GEARO	238
001177	DO 251 I=1,N	GEARO	239
001200	IN=I+N	GEARO	240
001201	FJC1(I)=FJ1(IN)	GEARO	241
001204	AJC1(I)=AJ1(IN)	GEARO	242
001206	AJC2(I)=AJ2(IN)	GEARO	243
001210	QJC1(I)=QJ1(IN)	GEARO	244
001212	QJC1(I)=QJ1(IN)	GEARO	245
001214	QJC2(I)=QJ2(IN)	GEARO	246
001216	QJD2(I)=QJ2(I)	GEARO	247
001220	CJD1(I)=CJ1(I)	GEARO	248
001222	251 CJC1(I)=CJ1(IN)	GEARO	249
001226	MUZ=1	GEARO	250
001227	MMZ=1	GEARO	251
001230	197 CONTINUE	MAY1	1
001230	L=NM	GEARO	252
001232	DO 415 I=1,N	GEARO	254
001233	IN=I+N	GEARO	255
001234	UJD1(I)=UJ1(I)	GEARO	256
001236	UJC1(I)=UJ1(IN)	GEARO	257
001241	UJC2(I)=UM2(IN)	GEARO	258
001243	UJD2(I)=UM2(I)	GEARO	259
001245	ZJD1(I)=ZJ1(I)	GEARO	260
001247	ZJC1(I)=ZJ1(IN)	GEARO	261
001251	ZJC2(I)=ZM2(IN)	GEARO	262
001253	ZJD2(I)=ZM2(I)	GEARO	263
001255	QJC(I)=QJC1(I)+UJC1(I)+QJC2(I)+UJC2(I)	GEARO	264
001263	QJD(I)=QJD1(I)+UJD1(I)+QJD2(I)+UJD2(I)	GEARO	265
001273	415 ZJC(I)=ZJC1(I)+ZJC2(I)	GEARO	266
001301	199 CONTINUE	GEARO	267
001301	WRITE(NW,106)	GEARO	268
001305	WRITE(NW,102)VPT1,VPT2	GEARO	269
001317	VP1=VPT1/CS	GEARO	270
001322	VP2=VPT2/CS	GEARO	271
001324	418 CONTINUE	MAY1	2
001324	WRITE(NW,115)	GEARO	275
001330	DO 501 I=1,N	GEARO	276
001334	WT(I)=WT(N-I)	GEARO	277
001337	WN=WT(I)/CS	GEARO	278

RUN VERSION 2.3 --PSR LEVEL 332--

GEAR0

001341	IF(WN)214,214,800	GEAR0	279
001343	800 CONTINUE	GEAR0	280
001343	C1=WN*.1	MAY1	3
001347	QD=1.37/FF2*EP12/C1	MAY1	4
001352	ZJD(I)=ZJD1(I)+ZJD2(I)+VP1-VP2	GEAR0	281
001360	CCC =QJC(I)+QD	GEAR0	282
001362	DDD =QJD(I)+QD	GEAR0	283
001364	C1=CJC1(I)	GEAR0	284
001366	C2=CJD1(I)	GEAR0	285
001367	IF(C1) 256,256,257	GEAR0	286
001371	256 IF(C2) 501,501,258	GEAR0	287
001373	257 IF(C2) 259,259,260	GEAR0	288
001375	259 VJ(I)=ZJC(I)-CCC *WN	GEAR0	289
001401	WTC(I)=WN*CS	GEAR0	290
001403	WTD=0.0	GEAR0	291
001404	GO TO 261	GEAR0	292
001405	258 VJ(I)=ZJD(I)-DDD *WN	GEAR0	293
001411	WTC(I)=0.0	GEAR0	294
001412	WTD=WN*CS	GEAR0	295
001414	GO TO 261	GEAR0	296
001415	260 C3=CCC *WN+ZJD(I)-ZJC(I)	GEAR0	297
001422	C4=DDD *WN+ZJC(I)-ZJD(I)	GEAR0	298
001426	IF(C3) 259,259,262	GEAR0	299
001430	262 IF(C4) 258,258,263	GEAR0	300
001432	263 C1=CCC+DDD	GEAR0	301
001434	C2=CCC *ZJD(I)+DDD *ZJC(I)-CCC*DDD*WN	GEAR0	302
001442	VJ(I)=C2/C1	GEAR0	303
001444	C1=CS/C1	GEAR0	304
001445	WTC(I)=(DDD*WN+ZJC(I)-ZJD(I))*C1	GEAR0	305
001452	WTD=(CCC*WN+ZJD(I)-ZJC(I))*C1	GEAR0	306
001460	261 EJ1(I)=VJ(I)/CS	GEAR0	307
001463	AJC1(I)=ANG-AJC1(I)	GEAR0	308
001465	WRITE(NW,102)FJC1(I),AJC1(I),EJ1(I),WTC(I),WTD,WN,WI(I),QD	MAY1	5
001511	501 CONTINUE	GEAR0	310
001516	ANG=AJC1(N)	GEAR0	311
001517	24 IF(MUZ-MU2) 504,504,502	GEAR0	312
001522	502 MU2=MU2+1	GEAR0	313
001524	GO TO 199	GEAR0	314
001524	504 MU2=1	GEAR0	315
001525	IF(NMZ-MM2) 214,214,506	GEAR0	316
001530	506 NMZ=MMZ+1	GEAR0	317
001532	GO TO 197	GEAR0	318
001532	214 CONTINUE	GEAR0	319
001532	503 RETURN	GEAR0	320
001533	102 FORMAT(RE13,5)	MAY1	6
001533	106 FORMAT(/34H INPUT DATA ON TOOTH SPACING ERROR/6X4HVPT19X4HVPT2)	GEAR0	322
001533	110 FORMAT(60H0INPUT LISTING OF PROFILE ERROR AND SUPPLEMENTARY COMPLI	GEAR0	323
	1ANCE/6X2HZ111X2HU111X2HZ211X2HU2)	GEAR0	324
001533	112 FORMAT(16H0PRES,ANGLE(DEG))	FINAL	7
001533	115 FORMAT(42H0CALCULATED TOOTH MESHING ERRORS AND LOADS//6X3HJC19X4HA	GEAR0	325
	1JC16X11HTANG. ERROR6X3HWT10X3HWT111X2HWN11X2HWT10X3HQJD)	MAY1	7
001533	118 FORMAT(74H0DRIVING GEAR INPUT ROOT RADIUS SMALLER THAN BASE CIRCLE	GEAR0	327
	1 RADIUS)	GEAR0	328
001533	119 FORMAT(74H0DRIVEN GEAR INPUT ROOT RADIUS SMALLER THAN BASE CIRCLE	GEAR0	329
	1 RADIUS)	GEAR0	330

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GEAMQ

001533	120	FORMAT(48H0C000. OF EFFECTIVE TOOTH PROFILE AT HOOT CIRCLE11X1HX13	GEARO	331
		1X1HY/52X.2E13.6)	GEARO	332
001533	122	FORMAT(/6X3HRP110X3HR6110X3HBA110X3HBR110X3MAT1)	ALG	10
001533	125	FORMAT(66H0 DRIVEN GEAR TEETH ENGAGE UNDER CUT PORTION OF DRIVING	GEARO	334
		1GEAR TEETH//6H BA1=. E13.6)	GEARO	335
001533	126	FORMAT(66H0 DRIVING GEAR TEETH ENGAGE UNDER CUT PORTION OF DRIVEN	GEARO	336
		1GEAR TEETH//6H BR1=. E13.6)	GEARO	337
001533	132	FORMAT(E13.5.13X.4E13.5)	GEARO	338
001533	151	FORMAT(/6X2HJ111X3HCJ110X3HAJ18X6HQJ1ABC9X3HXJ110X3HYJ1)	GEARO	339
001533	152	FORMAT(/6X2HJ224X3HAJ28X6HQJ2ABC9X3HXJ210X3HYJ2)	GEARO	340
001533	155	FORMAT(63H0DRIVEN GEAR INPUT RADIUS TO FILLET CENTER INSIDE BASE	GEARO	341
		1CIRCLE./42H0PROGRAM CONTINUES WITH CORRECT TREATMENT.)	GEARO	342
001533	156	FORMAT(63H0DRIVING GEAR INPUT RADIUS TO FILLET CENTER INSIDE BASE	GEARO	343
		1CIRCLE./42H0PROGRAM CONTINUES WITH CORRECT TREATMENT.)	GEARO	344
001533	159	FORMAT(13X.4E13.5)	GEARO	345
001533	161	FORMAT(/6X2HJ110X4HQJ1A9X4HQJ1B9X4HQJ1C)	GEARO	346
001533	162	FORMAT(/6X3HRP210X3HR6210X3HBA210X3HBR210X3MAT2)	GEARO	347
001533	163	FORMAT(/6X2HJ210X4HQJ2A9X4HQJ2B9X4HQJ2C)	GEARO	348
001533	170	FORMAT(43H0CALCULATED TOTAL CONTACT COMPLIANCE QJD=.E13.6)	GEARO	349
001533	171	FORMAT(23H0CALCULATED NORMAL WN=. E13.6)	GEARO	350
001533	174	FORMAT(80H0 ANGLE OF APPROACH ON DRIVING GEAR IS GREATER THAN TOOT	GEARO	351
		1H SPACING ANGLE. PROGRAM/25HCONTINUED WITHOUT OVERLAP)	GEARO	352
001533	175	FORMAT(75H0 ANGLE OF RECESS ON DRIVING GEAR IS NOT SMALLER THAN TO	GEARO	353
		10TH SPACING ANGLE. /34H PROGRAM CONTINUED WITHOUT OVERLAP)	GEARO	354
001533	176	FORMAT(80H0 DRIVING GEAR TEETH MESHING ON PROFILE INSIDE OF TIF DI	GEARO	355
		1AMETER. PROGRAM CONTINU-/21HED WITHOUT CORRECTION)	GEARO	356
001533	178	FORMAT(80H0 DRIVEN GEAR TEETH MESHING ON PROFILE OUTSIDE OF TIF D	GEARO	357
		1IAMETER. PROGRAM CONTIN-/22HUED WITHOUT CORRECTION)	GEARO	358
001533	179	FORMAT(80H0 DRIVEN GEAR TEETH MESHING ON PROFILE INSIDE OF TIF DI	GEARO	359
		1AMETER. PROGRAM CONTINU-/21HED WITHOUT CORRECTION)	GEARO	360
001533		END	GEARO	361

RUN VERSION 2.3 --PSR LEVEL 332--

000002	SUBROUTINE AJCDH	AJCDH	2
000002	DIMENSION SD(50),CD(50),BK(50),AK(50),FLK(50),CDC(50)	AJCDH	3
000002	COMMON PJ(50),CJ(50),QJ(50),AJ(50),XJ(50),YJ(50)	MAY11	4
000002	1A(1500),B(1500),G(3000)	MAY11	5
000002	COMMON DD,BR,BA,FJ,CC,YH,MN,N,FNJ,EP,TAN,RB,GH,F,XH,MN,II,M	AJCDH	5
000002	COMMON QA(50),QB(50),QC(50),QA1(50),QB1(50),QC1(50),QA2(50),QB2(50)	AJCDH	6
000002	1),QC2(50),IH,IP	AJCDH	7
000002	DO 106 I=1,NM	AJCDH	8
000004	QA(I)=0.0	AJCDH	9
000005	QB(I)=0.0	AJCDH	10
000006	QC(I)=0.0	AJCDH	11
000007	QJ(I)=0.0	AJCDH	12
000010	XJ(I)=0.0	AJCDH	13
000011	106 YJ(I)=0.0	AJCDH	14
000014	IF(II-1) 405,405,403	AJCDH	15
000017	405 MM=1.0	AJCDH	16
000021	GO TO 404	AJCDH	17
000022	403 MM=MN	AJCDH	18
000024	404 K=1	AJCDH	19
000025	DO 501 I=1,NM	AJCDH	20
000027	AJ(I)=FJ*CC	AJCDH	21
000031	PJ(I)=FJ	AJCDH	22
000032	IF(II-1) 412,412,413	AJCDH	23
000035	412 CALL CALCDJ(AJ(I),BR,BA,XY)	AJCDH	24
000042	CJ(I)=XY	AJCDH	25
000044	GO TO 414	AJCDH	26
000045	413 XY=CDC(I)	AJCDH	27
000047	414 IF(XY) 503,503,101	AJCDH	28
000051	101 IF(K-1) 102,102,103	AJCDH	29
000054	102 IH=I	AJCDH	30
000056	103 AX=AJ(I)	AJCDH	31
000060	DJ=DD*AX	AJCDH	32
000062	SD(I)=SIN(DJ)	AJCDH	33
000066	CD(I)=COS(DJ)	AJCDH	34
000072	C1=ATAN(TAN*AX)	AJCDH	35
000076	CJ=COS(C1)	AJCDH	36
000100	C4=C1-DJ	AJCDH	37
000102	IF(MM) 402,401,402	AJCDH	38
000104	401 C4=-C4	AJCDH	39
000105	402 C5=SIN(C4)	AJCDH	40
000107	C6=COS(C4)	AJCDH	41
000111	C1=RB/C3	AJCDH	42
000113	XJ(I)=C1*C6	AJCDH	43
000116	YJ(I)=C1*C5	AJCDH	44
000120	IF(K-1) 242,242,243	AJCDH	45
000122	242 BK(I)=(YJ(I)*3-YH*3)/3.0*F	AJCDH	46
000130	AK(I)=(YJ(I)+YH)*F	AJCDH	47
000133	FLK(I)=XJ(I)-XH	AJCDH	48
000136	GO TO 504	AJCDH	49
000136	243 BK(I)=(YJ(I)*3-YJ(I-1)*3)/3.0*F	AJCDH	50
000144	AK(I)=(YJ(I)+YJ(I-1))*F	AJCDH	51
000147	FLK(I)=XJ(I)-XJ(I-1)	AJCDH	52
000152	504 K=K+1	AJCDH	53
000154	503 IF(I-NN) 502,501,501	AJCDH	54

RUN VERSION 2.3 --PSR LEVEL 332--

AJCDH

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000157 502 IF (MM) 506,505,506
000160 505 FJ=FJ-1.
000162 --- GO TO 501
000163 506 FJ=FJ+1.0
000165 501 CONTINUE
000170 IF (II-1) 301,301,302
000172 301 IF (MM) 601,302,601
000173 601 LL=NN
000175 DO 303 I=1,NN
000176 CDC(I)=CJ(LL)
000200 IF (LL-1) 303,303,305
000203 305 LL=LL-1
000205 303 CONTINUE
000210 302 IP=K+IM-2
000213 410 DO 246 L=IM,IP
000215 E1=0.0
000216 E2=0.0
000216 E3=0.0
000217 E4=0.0
000220 EE=XJ(L)-XM
000223 IM=L
000223 IF (MM) 202,203,202
000225 203 EE=-EE
000226 202 DO 245 I=IM,IM
000230 C1=XJ(L)-XJ(I)
000233 C5=FLK(I)
000234 IF (MM) 207,208,207
000236 208 C1=-C1
000237 C5=-C5
000241 207 C2=C5/BIK(I)
000243 C3=(C5+3.0*C1)*C5+3.0*C1*C1
000251 E4=E4+C2
000253 C4=2.0*C1*C5
000255 E1=E1+C3*C2
000260 E2=E2+C4*C2
000263 245 E3=E3+C5/AIK(I)
000271 IF (MM) 206,205,206
000272 205 IM=IM-1
000274 206 C1=CD(L)*CD(L)
000276 C2=SD(L)*YJ(L)
000300 QA(L)=C1/3.0*E1/EP+(C2*E4-CD(L)*E2)/EP*C2
000312 QB(L)=C1/GM*E3*1.2
000317 C1=(EE*CD(L)-YJ(L)*SD(L))/YM
000323 QC(L)=C1/EP*1.327/F*C1
000336 246 QJ(L)=QA(L)+QB(L)+QC(L)
000336 RETURN
000337 END

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AJCDH 55
AJCDH 56
AJCDH 57
AJCDH 58
AJCDH 59
AJCDH 60
AJCDH 61
AJCDH 62
AJCDH 63
AJCDH 64
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AJCDH 66
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AJCDH 88
AJCDH 89
AJCDH 90
AJCDH 91
AJCDH 92
AJCDH 93
AJCDH 94
AJCDH 95
AJCDH 96
AJCDH 97
AJCDH 98
AJCDH 99
AJCDH 100
AJCDH 101

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RUN VERSION 2.3 --PSR LEVEL 332--

	SUBROUTINE FOUR	FOUR	2
	REQUIRES 2*N+1 POINTS F(I)	FOUR	3
	POINTS CORRESPOND TO THETA=2*PI/(2*N+1)....2*PI	FOUR	4
	OUTPUT A(I),B(I) REFER TO COSINE AND SINE OF (I-1)*THETA	FOUR	5
000002	COMMON PJ(50),CJ(50),GJ(50),AJ(50),XJ(50),YJ(50)	FOUR	6
	IA(1500),B(1500),G(3000)	MAY11	6
000002	COMMON DO,BR,BA,FJ,CC,YM,NN,N,FNJ,EP,TAN,RR,GM,F,XM,MN,II,M	FOUR	8
000002	COMMON/GU/NMC,INT,MMH,IPLT,FN1,FN2,RR1,RO1,RO2,RT1,RT2,RM1,RM2,F1,	MAY9	8
	IT1,T2,F1,F2,RF1,RF2,YE1,YE2,GE1,GE2,POS1,POS2,ANG	MAY9	9
000002	C=1.0	FOUR	9
000003	S=0.0	FOUR	10
000004	M=FIX(F1)*NMC+NMC/2	MAY9	10
000010	N1=M-1	FOUR	11
000012	NA=N*NMC	MAY9	11
000014	N2=NA-1	MAY9	12
000015	T1=2./NA	MAY9	13
000020	T2=T1*3.1415927	FOUR	15
000021	C1=COS(T2)	FOUR	16
000023	S1=SIN(T2)	FOUR	17
000026	DO 7 IP=1,N1	FOUR	18
000027	U1=0.0	FOUR	19
000030	U2=0.0	FOUR	20
000031	DO 3 I=1,N2	FOUR	21
000032	J=N2-I+2	FOUR	22
000034	U3=G(J)+2.0*C*U1-U2	FOUR	23
000042	U2=U1	FOUR	24
000043	3 U1=U3	FOUR	25
000047	A(IP)=T1*(G(I)+C*U1-U2)	FOUR	26
000054	B(IP)=T1*S*U1	FOUR	27
000056	AA=A(IP)+C-B(IP)*S	FOUR	28
000062	BB=A(IP)*S+B(IP)+C	FOUR	29
000065	A(IP)=AA	FOUR	30
000067	B(IP)=BB	FOUR	31
000071	Q=C1+C-S1*S	FOUR	32
000074	S=C1*S+S1*C	FOUR	33
000077	7 C=Q	FOUR	34
000103	RETURN	FOUR	35
000103	END	FOUR	36
	SUBROUTINE CALCJ(C1,C2,C3,C4)	CALCJ	2
000007	IF(C3) 240,231,241	CALCJ	3
000011	DATA EMEAD3/4H LB./	CALCJ	4
000011	241 IF(C1) 230,218,218	CALCJ	5
000013	230 IF(ABS(C1)-C3) 220,220,219	CALCJ	6
000017	231 IF(C1) 219,218,218	CALCJ	7
000021	240 IF(C1) 219,219,242	CALCJ	8
000023	242 C3=-C3	CALCJ	9
000024	IF(C1-C3) 219,218,218	CALCJ	10
000026	218 IF(C2-C1) 219,220,220	CALCJ	11
000030	220 C4=1.0	CALCJ	12
000031	GO TO 221	CALCJ	13
000032	219 C4=0.0	CALCJ	14
000033	221 RETURN	CALCJ	15
000034	END	CALCJ	16

RUN VERSION 2.3 --PSR LEVEL 332--

000007	SUBROUTINE PLT(X,Y,Z,NPTS)	PLT	2
000007	DIMENSION Y(3000),X(3000),Z(3000),AXX(4),AYY(4),AZZ(4),ILABX(5),	MAY11	7
000007	1 ILABY(5),HEAD3(3)	PLT	4
000007	COMMON PJ(50),CJ(50),QJ(50),AJ(50),XJ(50),YJ(50),	MAY11	8
000007	IA(1500),9(1500),G(3000)	MAY11	9
000007	COMMON DD,RR,BA,FJ,CC,YH,NN,N,FNJ,EP,TAN,RB,GM,F,XM,MN,II,M	PLT	6
000007	COMMON QA(50),QB(50),QC(50),QAL(50),QBI(50),QCI(50),QA2(50),QB2(50)	PLT	7
000007	1),QC2(50),IH,IP	PLT	8
000007	COMMON WT(50),HEAD1(6),HEAD2(6)	MAY11	11
000007	DATA (ILABX(J),J=1,3)/10H CALCUL,10HATION POIN,2HT /	PLT	10
000007	DATA (ILABY(J),J=1,3)/10HTANGENTIAL,10H ERROR (IN,2H,1)/	PLT	11
000007	DATA ILABZ/10HLOAD (LB,1)/	PLT	12
000007	DATA (HEAD3(I),I=1,2)/10HTANG, FORC,4HE = /	PLT	13
000007	IN=5	PLT	14
000007	IO=6	PLT	15
000010	ICAL=22	PLT	16
000012	CALL PLOTS(1BUF,4000,ICAL)	PLT	17
000014	CALL PLOT(4,4,5,-3)	PLT	18
000017	CALL PLOT(-2,-4,-3)	PLT	19
000022	CALL DASHPT(-2,-6,...,25)	PLT	20
000025	CALL SCALE(X,5,NPTS,1)	PLT	21
000032	Y(NPTS+1)=0.	PLT	22
000036	DO 10 K=1,NPTS	PLT	23
000040	10 Y(K)=-Y(K)	PLT	24
000043	CALL SCALE(Y,4,NPTS+1,1)	PLT	25
000050	Y(NPTS+2)=Y(NPTS+3)	PLT	26
000056	CALL SCALE(Z,3,NPTS,1)	PLT	27
000061	AXX(1)=X(NPTS+1)	PLT	28
000065	AXX(2)=X(NPTS+2)	PLT	29
000067	AYY(1)=Y(NPTS+1)	PLT	30
000071	AYY(2)=Y(NPTS+2)	PLT	31
000073	AZZ(1)=Z(NPTS+1)	PLT	32
000074	AZZ(2)=Z(NPTS+2)	PLT	33
000077	CALL AXIS(0,0,ILABX,-22,5,0,AXX(1),AXX(2))	PLT	34
000106	CALL AXIS(0,0,ILABY,22,4,0,AYY(1),AYY(2))	PLT	35
000116	CALL FLINE(X,Y,-NPTS,1,1,3)	PLT	36
000125	CALL PLOT(0,-4,-3)	PLT	37
000130	CALL AXIS(0,0,ILABX,-22,5,0,AXX(1),AXX(2))	PLT	38
000140	CALL AXIS(0,0,ILABZ,10,3,0,AZZ(1),AZZ(2))	PLT	39
000150	CALL FLINE(X,Z,-NPTS,1,1,11)	PLT	40
000157	CALL PLOT(5,9,5,-3)	PLT	41
000162	CALL SYMBOL(0,0,...,14,HEAD1,0,40)	PLT	42
000166	CALL SYMBOL(0,-.25,.14,HEAD2,0,40)	PLT	43
000172	CALL SYMBOL(0,-.5,.14,HEAD3,0,14)	PLT	44
000176	CALL NUMBER(999,999,...,14,WT,0,2)	PLT	45
000202	CALL SYMBOL(999,999,...,14,EHEAD3,0,4)	PLT	46
000206	CALL PLOT(6,-9,-3)	PLT	47
000211	CALL DASHPT(0,9,...,25)	PLT	48
000214	CALL PLOT(0,0,999)	PLT	49
000217	DO 20 K=1,NPTS	PLT	50
000223	20 Y(K)=-Y(K)	PLT	51
000226	RETURN	PLT	52
000227	END	PLT	53

NOTE TO USERS OF COMPUTER PROGRAM

The computer program for the prediction of gear mesh excitation spectra has the ability to plot tooth meshing error. This meshing error can be plotted if, and only if, a CALCOMP Plotter is a part of the system's hardware. If this plotting hardware is unavailable, the plotting subroutine (subroutine PLT (X,Y,Z,NPTS)) must be bypassed. This is done by placing a zero in column 25 on card 2 of the input deck.

RUN VERSION 2.3 · PSR LEVEL 332--

000002	SUBROUTINE SPECT	MAY9	14
000002	DIMENSION GN(3000),RR(3000),FR(200),GK(200),KK(200),GKK(200)	MAY11	10
000002	COMMON PJ(50),CJ(50),OJ(50),AJ(50),XJ(50),YJ(50),	MAY11	11
000002	1A(1500),B(1500),G(3000)	MAY11	12
000002	COMMON DD,BR,BA,FJ,CC,YH,NN,N,FNJ,EP,TAN,RB,GH,F,XM,MN,II,M	GEARC	1
000002	COMMON/GU/NMC,INT,MMH,IPLT,FN1,FN2,RR1,R01,R02,HT1,RT2,RM1,RM2,F1,	MAY11	14
000002	1T1,T2,F1,F2,RF1,RF2,YE1,YE2,GE1,GE2,POS1,POS2,ANG	MAY11	15
000002	NR=5	MAY11	16
000003	NW=6	MAY11	17
	C NWS=1,WS=SPEED OF DRIVING GEAR IN RPM	MAY11	18
	C NWS=2,WS=SPEED OF DRIVEN GEAR IN RPM	MAY11	19
000004	READ(NR,100) NWS,WS	MAY11	20
000014	WS=WS*6.28/60.	MAY11	21
000016	FN=FN1*WS/6.28	MAY11	22
000020	IF(NWS.EQ.2) FN=FN2*WS/6.28	MAY11	23
000024	WRITE(NW,110) FN	MAY11	24
000032	FC=FN*M/2.	MAY11	25
000035	NT=N*NMC	MAY11	26
000037	TR=NMC/FN	MAY11	27
000041	M=1./FN/M	MAY11	28
000044	FO=1./TR	MAY11	29
000046	M=NT/20	MAY11	30
000051	SH=H	MAY11	31
000052	TMAX=M*H	MAY11	32
000055	BE=1./TMAX	MAY11	33
000057	WRITE(NW,115)	MAY11	34
000062	WRITE(NW,120) FC,FO,BE	MAY11	35
000074	WRITE(NW,125)	MAY11	36
000100	WRITE(NW,120) M,TR,TMAX,SH	MAY11	37
000114	SUM=0.	MAY11	38
000115	DO 10 I=1,NT	MAY11	39
000117	10 SUM=SUM+G(I)	MAY11	40
000123	SA=SUM/NT	MAY11	41
000125	DO 20 I=1,NT	MAY11	42
000127	GN(I)=G(I)-SA	MAY11	43
000132	20 CONTINUE	MAY11	44
000134	MM=M+1	MAY11	45
000136	DO 30 I=1,MM	MAY11	46
000137	IR=I-1	MAY11	47
000140	FR(I)=IR*FC/SH	MAY11	48
000144	CC=1./(NT-IR)	MAY11	49
000147	RR(I)=0.	MAY11	50
000151	DO 25 J=1,NT	MAY11	51
	C RR(I)=RR(I-1)	MAY11	52
000153	IF((J-IR).GT.NT) GO TO 30	MAY11	53
000157	25 RR(I)=GN(J)*GN(J-IR)+RR(I)	MAY11	54
000165	30 RR(I)=RR(I)*CC	MAY11	55
000172	MS=M-1	MAY11	56
000174	DO 40 K=1,MM	MAY11	57
000175	KK(K)=K-1	MAY11	58
000177	GK(K)=RR(1)+RR(MM)*(-1.)**KK(K)	MAY11	59
000206	SSS=0.	MAY11	60
000207	DO 35 JK=1,MS	MAY14	2
000211	JJ=JK+1	MAY14	3

RUN VERSION 2.3 --PSR LEVEL 332--

SPECT

000212	AA=3.1416*JK*KK(K)/SM	MAY11	62
000217	35 SSS=SSS+2.*RR(JJ)*COS(AA)	MAY11	63
000230	40 GK(K)=(GK(K)+SSS)*2.*H	MAY11	64
000235	GKK(1)=.5*GK(1)+.5*GK(2)	MAY11	65
000241	GKK(MM)=.5*GK(M)+.5*GK(MM)	MAY11	66
000246	DO 50 LL=2,M	MAY11	67
000247	GKK(LL)=.25*GK(LL-1)+.5*GK(LL)+.25*GK(LL+1)	MAY11	68
000255	50 CONTINUE	MAY11	69
000260	WRITE(NW,130)	MAY11	70
000264	WRITE(NW,140)	MAY11	71
000270	DO 60 I=1,MM	MAY11	72
000272	SKM=KK(I)*N/(2.*SM)	JUNE7	6
000277	WRITE(NW,150)KK(I),FR(I),GK(I),GKK(I),SKM	JUNE7	7
000314	60 CONTINUE	MAY11	74
000317	100 FORMAT(15,E13.5)	MAY11	75
000317	110 FORMAT(/1X26HMESHING FREQUENCY IN CPS =,E13.5)	MAY11	76
000317	115 FORMAT(/7X2HFC!1X2HFO11X2H8E)	MAY11	77
000317	120 FORMAT(8E13.5)	MAY11	78
000317	125 FORMAT(/7X1HM12X2HTR11X4HTMAX9X2HSM)	MAY11	79
000317	130 FORMAT(/1X31HPOWER SPECTRAL DENSITY FUNCTION)	MAY11	80
000317	140 FORMAT(/6X,1HK6X2HFR11X2HMK11X3HMKK10X2HMK)	JUNE7	8
000317	150 FORMAT(17,3E13.5,5F13.5)	JUNE7	9
000317	RETURN	MAY11	83
000317	END	MAY11	84

APPENDIX D

LISTING OF DYNAMIC GEAR TOOTH FORCE ANALYSES - TORRP (R-32)

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C MEMERNAME R32MAIN 00010000
C 00020000
C PROGRAM TORRP 00030000
C MECHANICAL TECHNOLOGY INCORPORATED, LATHAM, NEW YORK 00040000
C AVLARS COPY NO.1-1-29-70, RHH 00050000
C THIS PROGRAM REQUIRES SUBROUTINES PLANST,MATIN,BLOOP,CDIV,CDIV2, 00060000
C PANGF,AMPF,CADD,CSUB,CMPLY 00070000
C DIMENSION AXY(20),RXY(20),LEX(20) 00080000
C DIMENSION BRAT(2),TEMPS(2),LMC(20),LTW(20),LRST(20) 00090000
C COMMON TRR(2,2),THE(2,2),TPR(2,2),TPF(2,2),TFSPR(2,2),TFSPE(2,2), 00100000
C 1 TFPFR(2,2),TFPRE(2,2),TTPCR(2,2),TTPCE(2,2),TTGRR(2,2),TTGRE(2,2) 00110000
C COMMON RIP(200),DST(200),DMS(200),DIN(200),PCB(50),LR(50),ODT(200) 00120000
C 1,RK(50),LEC(2),RS(2),RW(2),PIP(2),PM(2),PN(2),SS(2),SW(2),SR(2), 00130000
C 2 ST(2),LBR(20),LRS(20),CCOM(200),AXY1,AXY2,BXY1,BXY2,TLR(200), 00140000
C 3 TLE(200),THR(200),THE(200),TRR(200),TRE(200),TRR1(200) 00150000
C COMMON A(7,7),B(7,2),LS(20),RP(20),RG(20),SG(20),TRR2(200), 00160000
C 1 TRE1(200),THE1(200),TLE1(200),TRE2(200),TTFR(20),TTFE(20), 00170000
C 2 PSP(2),THR(200),TLR1(200),THR2(200),TLR2(200),THE2(200), 00180000
C 3 TLE2(200),RL(200),PCP(2),PRP(2),DMP(50) 00190000
C COMMON IT, K4,L4,MDIAG,FRQ2,ANGR,ANGE,TQR,TQE ,J,NS ,M1,NW,NR,NPLG 00200000
C COMMON K1,K2,K3,K9,L1,L2,L3,L9,LG(10),IBRAN 00210000
C NR REFERS TO INPUT UNIT 00220000
C NW REFERS TO OUTPUT UNIT 00230000
C NR=5 00240000
C NW=6 00250000
C MDTW=0 00270000
C MTH=0 00280000
C MDSG=0 00290000
C IEXP=0 00300000
C 200 READ(NR,100) 00310000
C PEAD(NR,101),NS,NB,NBR,NMPG,INP,NSRG,NPLG,MDIAG 00320000
C IOP=0 00330000
C FFD=0.0 00340000
C CKY=0. 00350000
C DXY=0. 00360000
C MPOL = -1 00370000
C IF (MDIAG -2) 3021,3020,3021 00380000
C 3020 MPOL = 0 00390000
C GO TO 3025 00400000
C 3021 IF(MDIAG +2) 3025,3022,3025 00410000
C 3022 MPOL = 1 00420000
C 3025 READ (NR,102)GM,DENST 00430000
C WRITE(NW,100) 00440000
C WRITE(NW,103) 00450000
C WRITE(NW,106)NS,NR,NBR,NMPG,INP,NSRG,NPLG 00460000
C 2022 WRITE(NW,135) GM,DENST 00470000
C DENST=DFNST/386.059 00480000
C IF(IEXP) 2023,2024,2025 00490000
C 2023 IEXP=-IEXP 00500000
C AINT=1./10.**IEXP 00510000
C GO TO 2026 00520000
C 2024 AINT=1. 00530000
C GO TO 2026 00540000
C 2025 AINT=10.**IEXP 00550000
C 2026 WRITE(NW,107) 00560000
C DO 201 J=1,NS 00570000
C READ(NR,190)NSTA,RIP(J),RL(J),DSY(J),DMS(J),DIN(J),CCOM(J) 00580000
C IF(NSTA-J) 2000,2001,2000 00590000
C 2000 WRITE(NW,191) 00600000
C 2001 WRITE(NW,108)NSTA,RIP(J),RL(J),DSY(J),DMS(J),DIN(J),CCOM(J) 00610000

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201	RIP(J)=RIP(J)/386.069	00620000
	LF(1) = NS+2	00630000
	LH(1)=NS+2	00640000
	LFC(1)=NS+2	00650000
	LQUT = 0	00660000
	LF=0	00670000
	KL=0	00680000
	LI=0	00690000
	LHR(1)=NS+2	00700000
	LRS(1)=NS+2	00710000
	LS(1) =NS+2	00720000
	LG(1)=NS+2	00730000
	LFT=0	00740000
	KL=0	00750000
	LIT=0	00760000
	LTW(1)=NS+2	00770000
	IF(NR) 2031,2031,203	00780000
203	WRITE(NW,109)	00790000
	DO 204 J=1,NR	00800000
	READ(NR,190)LR(J),BK(J),BCB(J),DMP(J)	00810000
204	WRITE(NW,108)LR(J),BK(J),BCB(J),DMP(J)	00820000
2031	IF(NSRG)206,206,2032	00830000
2032	WRITE(NW,112)	00840000
	WRITE(NW,113)	00850000
	DO 205 I=1,NSRG	00860000
	READ(NR,190)LS(I),RP(I),RG(I),SG(I)	00870000
205	WRITE(NW,108)LS(I),RP(I),RG(I),SG(I)	00880000
206	IF(NPLG)210,210,209	00890000
209	WRITE(NW,114)	00900000
	DO 212 J=1,NPLG	00910000
	READ(NR,190)LEC(J),PN(J),RS(J),RW(J)	00920000
	WRITE(NW,127)	00930000
	WRITE(NW,108)LEC(J),PN(J),RS(J),RW(J)	00940000
	READ(NR,190)IPL,PMS(J),PSP(J),PIP(J),PRP(J),PCP(J)	00950000
	WRITE(NW,128)	00960000
	WRITE(NW,108)IPL,PMS(J),PSP(J),PIP(J),PRP(J),PCP(J)	00970000
	READ(NR,130)IPL,SS(J),SR(J),SW(J),ST(J)	00980000
	WRITE(NW,129)	00990000
	WRITE(NW,131)IPL,SS(J),SR(J),SW(J),ST(J)	01000000
	PSP(J) =PSP(J)/386.069	01010000
	PCP(J)=PCP(J)/386.069	01020000
	PRP(J)=PRP(J)/386.069	01030000
	PIP(J)=PIP(J)/386.069	01040000
212	PMS(J)=PMS(J)/386.069	01050000
210	IF(NRR) 2130,2130,214	01060000
214	WRITE(NW,118)	01070000
	DO 215 J=1,NRR	01080000
	READ(NR,101)LBR(J),LRS(J),LMC(J)	01090000
215	WRITE(NW,119)LBR(J),LRS(J)	01100000
2130	K5=NS-1	01110000
	DO 216 J=1,K5	01120000
	C1=RL(J)	01130000
	C2=DST(J)	01140000
	IF(C1) 217,216,217	01150000
217	IF(C2) 218,216,218	01160000
218	C5=DIN(J)*DIN(J)	01170000
	C4=C5*C5	01180000
	C6=DMS(J)*DMS(J)	01190000
	C8=0.09817477*(C2**4-C4)	01200000
	C3=C8*GM	01210000
	C4=0.09817477*DENS*(C6*C6-C4)	01220000
	DST(J)=C1/C3	01230000
	DMS(J) = C1*SQRT(C4/C3)	01240000
	DIN(J) = SQRT(C3*C4)	01250000
216	CONTINUE	01260000
	DO 501 IERR=1,NMPG	01270000
	FF0=0.0	01280000
	AXY1=0.0	01290000
	BXY1=0.0	01300000

AXY2=0.0	01310000
RXY2=0.0	01320000
MAX =1	01330000
TEX = 1	01340000
4009 READ (NR,190) IT,TE1,TE2,TE3,TE4,TE5,TE6,NEX	01350000
FFQ=TF1	01360000
CXY=TF2	01370000
DXY=TF3	01380000
IF (NFX) 2013,4010,4010	01390000
4010 IF (IEX-1) 4012,4011,4012	01400000
4011 MAX = NEX	01410000
4012 DO 2011 I=1,NSRG	01420000
IF (IT-LS(I)) 2011,2010,2011	01430000
2010 AXY(IEX) = TE2	01440000
RXY(IEX) = TE3	01450000
LEX(IEX) = IT	01460000
WRITE (NW,194)	01470000
WRITE (NW,108) IT,TE1,TE2,TE3	01480000
IEX = IEX +1	01490000
IF (IEX- MAX) 4009,4009,2020	01500000
2011 CONTINUE	01510000
IF (NPLG) 3019,3019,2013	01520000
2013 DO 2017 I=1,NPLG	01530000
IF (IT-LEC(I)) 2017,2014,2017	01540000
2014 WRITE (NW,195)	01550000
AXY1=TE2	01560000
RXY1=TE3	01570000
AXY2=TE4	01580000
RXY2=TE5	01590000
WRITE (NW,108) IT,TE1,TE2,TE3,TE4,TE5	01600000
GO TO 2020	01610000
2017 CONTINUE	01620000
3019 WRITE (NW,192)	01630000
IF (INP) 506,200,506	01640000
2020 FRQ=6.2831853*FFQ	01650000
IF (FRQ) 501,501,599	01660000
599 FRQ2=FRQ*FRQ	01670000
NEX=1	01680000
ISFP=0	01690000
5020 BRAT(1)=1.0	01700000
BRAT(2)=0.0	01710000
IRAT=0	01720000
IRAN=0	01730000
M1=1	01740000
502 ANGR=0.0	01750000
IF (IOP) 5021,5022,5021	01760000
5021 ANGR=AINI	01770000
5022 ANGE=0.0	01780000
ANGE=0.0	01790000
TOR=0.0	01800000
TQE=0.0	01810000
A13R=0.0	01820000
A13E=0.0	01830000
K1=1	01840000
K2=1	01850000
K4=1	01860000
K5=NS+2	01870000
K9=1	01880000
L1=LBR(1)	01890000
L2=LR(1)	01900000
K3=1	01910000
L3=LS(1)	01920000
L4=IFC(1)	01930000
L7=LS(1)	01940000
GO TO (227,228),M1	01950000
227 ANGR=AINI	01960000
228 J=1	01970000
IF (ITW) 2275,2275,227	01980000
2275 L7=L7W(1)	01990000

LIT=1	02000000
KLT=1	02010000
2275 IF(NRR) 2280,2280,2279	02020000
2279 LF=LRR(1)	02030000
LOUT=LMC(1)	02040000
IF(LOUT) 2277,2278,2278	02050000
2277 LOUT=-LOUT	02060000
2278 LI=1	02070000
KL=1	02080000
2280 IF(IOP) 2282,2281,2282	02090000
2281 IF(J-LF) 249,2300,249	02100000
2300 CALL BLOOP(LBR,LBS,LMC,LI,KL,LF,NBR,LIT,KLT,LFT)	02110000
GO TO 249	02120000
2282 IF(J-LI) 231,230,231	02130000
230 IF(MI-1) 232,232,234	02140000
234 IRRAN=1	02150000
232 TL1R=TQR	02160000
AL1R=ANGR	02170000
TL1E=TQE	02180000
AL1F=ANGE	02190000
562 ANGR=AINT	02200000
ANGE=0.	02210000
TQR=0.	02220000
TQE=0.	02230000
AL1R=0.	02240000
AL1E=0.	02250000
235 K5=LRS(K1)	02260000
K6=L1	02270000
K1=K1+1	02280000
IF(NRR-K1) 237,236,236	02290000
236 L1=LRR(K1)	02300000
GO TO 249	02310000
237 L1=NS+2	02320000
GO TO 249	02330000
231 IF(J-K5) 249,248,249	02340000
248 AA1=(ANGR*ANGR+ANGE*ANGE)	02350000
IRRAN=0	02360000
AA2=SQRT(AA1)	02370000
AA5=AL1R*ANGR+AL1E*ANGE	02380000
AA3=(AL1R*AL1R+AL1E*AL1E)	02390000
AA4=SQRT(AA3)	02400000
IF(AA2-1.0E-7*AA4) 242,241,241	02410000
241 AAR=AA5/AA1	02420000
AAF=(ANGR*AL1E-ANGE*AL1R)/AA1	02430000
TE1=TQR	02440000
TE2=TL1R	02450000
TE3=TQE	02460000
TE4=TL1E	02470000
ANGR=AL1R	02480000
ANGE=AL1E	02490000
K7=K6	02500000
K8=K5-1	02510000
IF(MI-2) 2420,2410,2420	02520000
2410 IF(IRRAT) 2411,2420,2411	02530000
2411 IF(IRRAT-2) 2420,2412,2420	02540000
2412 BRAT(1)=AAR	02550000
BRAT(2)=AAE	02560000
2413 IRRAT=1	02570000
GO TO 2420	02580000
242 AAR=AA5/AA3	02590000
AAF=(AL1R*ANGE-AL1E*ANGR)/AA3	02600000
TE1=TL1R	02610000
TE2=TQR	02620000
TE3=TL1E	02630000
TE4=TQE	02640000
K7=1	02650000
K8=K6-1	02660000
IF(MI-2) 2420,2440,2420	02670000
2440 IF(IRRAT) 2441,2420,2441	02680000
2441 IF(IRRAT-1) 2413,2412,2413	02690000

2420	TQR = AAR*TE1 - AAE*TE3 + TE2	02700000
	TQE = AAE*TE1 + AAR*TE3 + TE4	02710000
243	DO 244 L=K7,K8	02720000
	C1 = TLR(L)	02730000
	C2 = TLE(L)	02740000
	C3 = THR(L)	02750000
	C4 = THE(L)	02760000
	C5 = TRR(L)	02770000
	C6 = TRE(L)	02780000
	TLR(L) = AAR*C1 - AAE*C2	02790000
	THR(L) = AAR*C3 - AAE*C4	02800000
	TRR(L) = AAR*C5 - AAE*C6	02810000
	TLE(L) = AAE*C1 + AAR*C2	02820000
	THE(L) = AAE*C3 + AAR*C4	02830000
244	TQE(L) = AAE*C5 + AAR*C6	02840000
249	THE(J) = ANGE	02850000
	TLE(J) = TQE	02860000
	THR(J) = ANGR	02870000
	TLR(J) = TQR	02880000
	CN=0.0	02890000
	IF(J=L2) 284,283,284	02900000
283	C1=PK(K2)	02910000
	C0=DMP(K2)	02920000
	C2=RCB(K2)	02930000
	K2=K2+1	02940000
	IF(NR-K2) 261,260,260	02950000
260	L2=LR(K2)	02960000
	GO TO 285	02970000
261	L2=NS+2	02980000
	GO TO 285	02990000
284	C1=0.0	03000000
	C2=0.0	03010000
285	C1=C1-FRQ2*RIP(J)	03020000
	C2=FRQ2*C2	03030000
	TQE=TQE+C1*ANGE +C2*ANGR	03040000
	TQR=TQR+C1*ANGR-C2*ANGE	03050000
	IF(J=LOUT) 2853,2850,2853	03060000
2850	J1=LBR(KL-1)	03070000
	TQR=TQR-TLR(J1)	03080000
	TQE=TQE-TLE(J1)	03090000
	IF(KL-NBR) 2851,2851,2852	03100000
2851	LOUT=LMC(KL)	03110000
	IF(LOUY) 2848,2853,2853	03120000
2848	LOUT=-LOUT	03130000
	GO TO 2853	03140000
2852	LOUT=NS+2	03150000
2853	TRF(J)=TQE	03160000
	TRR(J)=TQR	03170000
	IF(J=NS) 286,287,287	03180000
287	IF(M1-1) 401,401,402	03190000
286	IF(J=L3) 288,289,288	03200000
289	C1=RP(K3)	03210000
	C2=RC(K3)	03220000
	A11=-C1/C2	03230000
	A22=1.0/A11	03240000
	A21=0.0	03250000
	A12=-SG(K3)/(C1+C2)	03260000
	K3=K3+1	03270000
	IF(K3-NSRG1) 1019,1019,1020	03280000
1019	L3=LS(K3)	03290000
	GO TO 1021	03300000
1020	L3=NS+2	03310000
1021	IF (M)-1) 351,351,251	03320000
251	IF (LFX(NEX) - J) 351,2899,351	03330000
2899	IF(M1-2) 290,2900,2900	03340000
2900	IF(IRRAN) 2901,2910,2901	03350000
2901	IF(IRRAT) 2902,2903,2902	03360000
2902	WRITE(NW,136)	03370000
	ISFP=1	03380000
	GO TO 351	03390000

2903	IRAT=2	05400000
	GO TO 290	03410000
2910	IF (IRAT) 2912,2911,2912	03420000
2911	IRAT=1	03430000
	GO TO 290	03440000
2912	IF (BRAT(2)-1.0) 2902,2913,2902	03450000
2913	IF (BRAT(2)) 2902,290,2902	03460000
290	A13R=-AXY(NEX)/C2	03470000
	A13E=-RXY(NEX)/C2	03480000
	IF (NEX-MAX) 5000,351,351	03490000
5000	NEX = NEX+1	03500000
	GO TO 351	03510000
288	IF (J-L4) 255,254,255	03520000
254	IF (MDIAG+1) 1092,1092,1095	03530000
1092	IF (K4-1) 1095,1096,1095	03540000
1096	IF (M1-1) 1093,1093,1094	03550000
1093	WRITE (NW,181)	03560000
	GO TO 1095	03570000
1094	WRITE (NW,182)	03580000
1095	CALL PLNST	03590000
	GO TO 503	03600000
255	C1=RL(J)	03610000
	IF (C1) 257,256,257	03620000
256	A11=1.0	03630000
	A12=CCOM(J)	03640000
	IF (CD) 3001,3000,3001	03650000
3000	A21=0.0	03660000
	A22=1.0	03670000
	GO TO 351	03680000
3001	TEMP=1.0+(FRQ*CD*A12)**2	03690000
	TEMP1=FRQ*CD*A12**2	03700000
	ANGR=ANGR+(A12*TQR+TEMP1*TQE)/TEMP	03710000
	ANGE=ANGE+(A12*TQE-TEMP1*TQR)/TEMP	03720000
	GO TO 503	03730000
257	C3=FRQ*DMS(J)	03740000
	IF (C3-0.0003) 258,258,259	03750000
258	C4=C3*C3	03760000
	A11=1.0-0.5*C4	03770000
	A22=A11	03780000
	A12=DNT(J)	03790000
	A21=-C3*DIN(J)*FRQ	03800000
	GO TO 351	03810000
259	A11= COS(C3)	03820000
	A22=A11	03830000
	C5=DIN(J)*FRQ	03840000
	C4= SIN(C3)	03850000
	A12=C4/C5	03860000
	A21=-C4*C5	03870000
351	C1=ANGE	03880000
	ANGE=A11*ANGE+A12*TQE+A13 E	03890000
	TQE=A21*C1 +A22*TQE	03900000
	C1=ANGR	03910000
	ANGR=A11*ANGR+A12*TQR+A13R	03920000
	TQR=A21*C1 +A22*TQR	03930000
	A13R=0.0	03940000
	A13E=0.0	03950000
503	J=J+1	03960000
	IF (J-NS) 2280,2280,401	03970000
401	IF (MDIAG+1) 410,410,411	03980000
410	IF (NPLG) 1090,1090,1091	03990000
1090	WRITE (NW,18)	04000000
1091	WRITE (NW,126)	04010000
	WRITE (NW,701)	04020000
411	DO 403 J=1,NS	04030000
	TRH1(J)=TRR(J)	04040000
	THR1(J)=THP(J)	04050000
	TLR1(J)=TLR(J)	04060000
	TRE1(J)=TRE(J)	04070000
	TWF1(J)=TWF(J)	04080000
	TLE1(J)=TLE(J)	04090000

IF (MDIAG+1) 1030,1030,403	04100000
1030 WRITE (NW,108) J,THR1(J),THE1(J),TLR1(J),TLE1(J),TRR1(J),TRE1(J)	04110000
403 CONTINUE	04120000
M1=M1+1	04130000
GO TO 50	04140000
402 IRAT=1	04150000
IF (IRAT(1)-1.0) 4132,4130,4132	04160000
4130 IF (IRAT(2)) 4132,4133,4132	04170000
4132 IRAT=2	04180000
4133 IF (MDIAG+1) 412,412,413	04190000
412 IF (NPLG) 414,414,415	04200000
414 WRITE (NW,182)	04210000
415 WRITE (NW,126)	04220000
WRITE (NW,701)	04230000
413 DO 404 J=1,NS	04240000
IF (IRAT-2) 4040,4041,4040	04250000
4040 TLR2(J)=TLR(J)	04260000
THE2(J)=THE(J)	04270000
TLE2(J)=TLE(J)	04280000
TRR2(J)=TRR(J)	04290000
TRF2(J)=TRF(J)	04300000
THR2(J)=THR(J)	04310000
GO TO 4045	04320000
4041 TEMPS(1)=TLR(J)	04330000
TEMPS(2)=TLE(J)	04340000
CALL CDIV(TEMPS,BRAT,TEMPS)	04350000
TLR2(J)=TEMPS(1)	04360000
TLE2(J)=TEMPS(2)	04370000
TEMPS(1)=THR(J)	04380000
TEMPS(2)=THE(J)	04390000
CALL CDIV(TEMPS,BRAT,TEMPS)	04400000
THR2(J)=TEMPS(1)	04410000
THE2(J)=TEMPS(2)	04420000
TEMPS(1)=TRR(J)	04430000
TEMPS(2)=TRE(J)	04440000
CALL CDIV(TEMPS,BRAT,TEMPS)	04450000
TRR2(J)=TEMPS(1)	04460000
TRF2(J)=TEMPS(2)	04470000
4045 IF (MDIAG+1) 1040,1040,404	04480000
1040 WRITE (NW,108) J,THR2(J),THE2(J),TLR2(J),TLE2(J),TRR2(J),TRE2(J)	04490000
404 CONTINUE	04500000
IF (IRAT-2) 4050,4046,4050	04510000
4046 IF (NPLG) 4050,4050,4047	04520000
4047 DO 4048 KK=1,NPLG	04530000
CALL CDIV2(TRR,TRE,BRAT,KK,MDIAG)	04540000
CALL CDIV2(TPR,TPE,BRAT,KK,MDIAG)	04550000
CALL CDIV2(TFSPR,TFSPR,BRAT,KK,MDIAG)	04560000
CALL CDIV2(TFPRR,TFPRE,BRAT,KK,MDIAG)	04570000
CALL CDIV2(TTPCR,TTPCE,BRAT,KK,MDIAG)	04580000
4048 CALL CDIV2(TTGRR,TTGRE,BRAT,KK,MDIAG)	04590000
4050 C1=TRR2(NS)	04600000
C2=THE2(NS)	04610000
C3=TRR1(NS)	04620000
C4=TRE1(NS)	04630000
C5=C4/C3	04640000
C6=C3+C4*C5	04650000
Q1R=-(C1+C5*C2)/C6	04660000
Q1E=(C1*C5-C2)/C6	04670000
IF (MDIAG-2) 1049,1051,1049	04680000
1049 IF (MDIAG) 1050,1051,1050	04690000
1050 WRITE (NW,183)	04700000
WRITE (NW,126)	04710000
WRITE (NW,701)	04720000
1051 L=1	04730000
DO 407 J=1,NS	04740000
C1=TLR1(J)*Q1R+TLR2(J)-Q1E*THE1(J)	04750000
C2=THR1(J)*Q1E+THE2(J)+Q1R*THE1(J)	04760000
C3=TLR1(J)*Q1R+TLR2(J)-Q1E*TLE1(J)	04770000
C4=TLR1(J)*Q1E+TLE2(J)+TLE1(J)*Q1R	04780000
C5=TRR1(J)*Q1R-Q1E*TRE1(J)+TRR2(J)	04790000

-----C6	-----TRR1(J)*Q1E+Q1R*TRE1(J)+TRE2(J)	-----04800000
	NGS =LS(L)	04810000
	IF(J-NGS) 1054,1100,1054	04820000
-1100	TTFR(L) =C5/RP(L)	04830000
	TTFE(L) =C6/RP(L)	04840000
	L =L+1	04850000
-1054	IF(MDIAG) 1055,407,1055	04860000
	1055 IF(MPOL) 1056,1057,1056	04870000
	1056 WRITE(NW,108)J,C1,C2,C3,C4,C5,C6	04880000
	IF(MPOL) 407,1057,1057	04890000
-1057	THR1(J)=AMPF(C1,C2)	04900000
	THE1(J)=PANGF(C1,C2)	04910000
	TLR1(J)=AMPF(C3,C4)	04920000
	TLE1(J)=PANGF(C3,C4)	04930000
	TLR2(J)=AMPF(C5,C6)	04940000
	TLE2(J)=PANGF(C5,C6)	04950000
-407	CONTINUE	04960000
	C TEST FOR POLAR FORM OPTION	04970000
	IF(MPOL) 1195,1058,1058	04980000
-1058	WRITE(NW,126)	04990000
	WRITE(NW,123)	05000000
	DO 1059 J=1,NS	05010000
-1059	WRITE(NW,108)J,THR1(J),THE1(J),TLR1(J),TLE1(J),TLR2(J),TLE2(J)	05020000
	1195 IF(NPLG) 1201,1201,1195	05030000
	1196 IF(MDIAG) 1199,1201,1199	05040000
-1199	DO 1200 J=1,NPLG	05050000
	C7 =PN(J) *RS(J)	05060000
	C8 =(RS(J) +2. *RW(J))*PN(J)	05070000
	C1 =TRR(1,J)*Q1R+TRR(2,J)-Q1E*TRE(1,J)	05080000
	C2 =TRR(1,J)*Q1E+TRE(2,J)+Q1R*TRE(1,J)	05090000
	C3 =C7*(TFSPR(1,J)*Q1R+TFSPR(2,J)-Q1E*TFSPF(1,J))	05100000
	C4 =C7*(TFSPR(1,J)*Q1E+TFSPF(2,J)+Q1R*TFSPF(1,J))	05110000
	C5 =TTPCR(1,J)*Q1R+TTPCR(2,J)-Q1E*TTTCE(1,J)	05120000
	C6 =TTPCR(1,J)*Q1E+TTTCE(2,J)+Q1R*TTTCE(1,J)	05130000
	IF(MPOL) 1060,1061,1060	05140000
1060	WRITE(NW,700)	05150000
	WRITE(NW,701)LEC(J),C1,C2,C3,C4,C5,C6	05160000
	IF(MPOL) 1063,1061,1061	05170000
1061	WRITE(NW,700)	05180000
	JP=1	05190000
-1062	TE1=AMPF(C1,C2)	05200000
	TE2=PANGF(C1,C2)	05210000
	TE3=AMPF(C3,C4)	05220000
	TE4=PANGF(C3,C4)	05230000
	TE5=AMPF(C5,C6)	05240000
	TE6=PANGF(C5,C6)	05250000
	WRITE(NW,123)	05260000
	WRITE(NW,108)LEC(J),TE1,TE2,TE3,TE4,TE5,TE6	05270000
	GO TO (1063,1200),JP	05280000
-1063	C1=TFR(1,J)*Q1R+TFR(2,J)-Q1E*TPE(1,J)	05290000
	C2 =TFR(1,J)*Q1E+TPE(2,J)+Q1R*TPE(1,J)	05300000
	C3 =C8*(TFPRR(1,J)*Q1R+TFPRR(2,J)-Q1E*TFPRE(1,J))	05310000
	C4 =C8*(TFPRR(1,J)*Q1E+TFPRE(2,J)+Q1R*TFPRE(1,J))	05320000
	C5 =TTGRR(1,J)*Q1R+TTGRR(2,J)-Q1E*TTGRE(1,J)	05330000
	C6 =TTGRR(1,J)*Q1E+TTGRE(2,J)+Q1R*TTGRE(1,J)	05340000
	IF(MPOL) 1064,1065,1064	05350000
1064	WRITE(NW,702)	05360000
	WRITE(NW,701)LEC(J),C1,C2,C3,C4,C5,C6	05370000
	IF(MPOL) 1200,1065,1065	05380000
1065	JP=2	05390000
	WRITE(NW,702)	05400000
	GO TO 1062	05410000
1200	CONTINUE	05420000
1201	IF(NSRG) 1207,1207,1202	05430000
-1202	IF(MPOL) 1203,1205,1203	05440000
1203	WRITE(NW,180)	05450000
	DO 1070 J=1,NSRG	05460000
-1070	WRITE(NW,108)LS(J),TTFR(J),TTFE(J)	05470000
	IF(MPOL) 1207,1205,1205	05480000
1205	WRITE(NW,124)	05490000

DO 1206 J=1,NSRG	05500000
C1=AMPF(TTFR(J),TTFE(J))	05510000
C2=PANGF(TTFR(J),TTFE(J))	05520000
1206 WPTF(NW,108)LS(J),C1,C2	05530000
1207 IF(NPLG) 1219,1219,1079	05540000
1079 IF(MPOL) 1210,1215,1210	05550000
1210 WRITE(NW,122)	05560000
1215 DO 1080 J=1,NPLG	05570000
TE1=TFSPR(1,J)	05580000
TE2=TFSPR(2,J)	05590000
TE3=TFSPR(1,J)	05600000
TE4=TFSPR(2,J)	05610000
C1=TE1*Q1R+TE2-TE3*Q1E	05620000
C2=TE1*Q1E+TE4-TE3*Q1R	05630000
1076 TE1=TFPRR(1,J)	05640000
TE2=TFPRR(2,J)	05650000
TE3=TFPRE(1,J)	05660000
TE4=TFPRE(2,J)	05670000
C3=TE1*Q1R+TE2-TE3*Q1E	05680000
C4=TE1*Q1E+TE4-TE3*Q1R	05690000
IF(MPOL) 1216,1077,1216	05700000
1077 THR1(J)=AMPF(C1,C2)	05710000
THE1(J)=PANGF(C1,C2)	05720000
TLR1(J)=AMPF(C3,C4)	05730000
TLE1(J)=PANGF(C3,C4)	05740000
GO TO 1080	05750000
1216 WRITE(NW,108)LEC(J),C1,C2,C3,C4	05760000
1080 CONTINUE	05770000
IF(MPOL) 1219,1217,1217	05780000
1217 WRITE(NW,125)	05790000
DO 1218 J=1,NPLG	05800000
1218 WRITE(NW,108) LEC(J),THR1(J),THE1(J),TLR1(J),TLE1(J)	05810000
1219 IF(NEX=MAX) 5007,501,501	05820000
5007 IF(ISEP=1) 5009,5008,5009	05830000
5008 ISEP=2	05840000
GO TO 5020	05850000
5009 NEX=NEX+1	05860000
IF(NEX=MAX) 5020,501,501	05870000
501 CONTINUE	05880000
5010 IF(INP) 506,200,506	05890000
506 CALL EXIT	05900000
100 FORMAT(72H)	05910000
1	05920000
101 FORMAT(9I5,5X,3I5,10X,I5)	05930000
102 FORMAT(5X,6E12,4)	05940000
103 FORMAT(82H0 TORSIONAL RESPONSE OF THE SYSTEM WITH GEARS,EPICYCLIC	05950000
1GEARS AND BRANCHES PN408)	05960000
105 FORMAT(8X,6E12,5)	05970000
106 FORMAT(1H0,1X,8HSTATIONS,1X,12HRRG+EXT.CON.,2X,8HRRANCHES,1X,	05980000
19HNO.OF FRQ,2X,8HINP SFTS,2X,8HSGEARS,2X,8HPL GEARS/	05990000
2 17,6X,I5,2X,5I10)	06000000
107 FORMAT(5X,10HREDTOR DATA//4X,3HSTA,1X,12H MOM.INERT.,3X,	06010000
16HLENGTH,4X,10HSTIFFN.DIA,3X,8HMASS DIA,3X,9HINNER DIA,2X,	06020000
212HCONC. COMPL./4X3HNO,2X,9HLSR-IN**2,7X,2HIN,10X,2HIN,10X,2HIN,	06030000
310X,2HIN,6X, 9HRAO/(IN-LB)	06040000
108 FORMAT(17,1X,6E12,5)	06050000
109 FORMAT(1H1,7X,46HEXTERNAL TORSIONAL CONSTRAINT AND DAMPING DATA//	06060000
1 4X,3HSTA,2X, 9HSTIFFNESS,2X,24HDAMPING- (LB-IN-SEC/RAD)/	06070000
2 4X,3HNO.,1X,11H(LR-IN/RAD),2X,9HTO GROUND,2X,12HTO NEXT STA.)	06080000
112 FORMAT(1H1,9X,26HSINGLE REDUCTION GFAR DATA)	06090000
113 FORMAT(1H1,9X,26HGEAR SET RADII (IN.),2X,	06100000
1 31HCOMBINED TANGENTIAL COMPLIANCES//4X,10HFIRST GEAR,2X	06110000
2 .11HSECOND GEAR,3X,7H(IN/LB))	06120000
114 FORMAT (1/15X,18HPLANETARY SET DATA)	06130000
118 FORMAT(1/5X,17HRRANCHES /6X,7HFAR END,5X,6HCOMMON)	06140000
119 FORMAT(6X,3(I5,5X))	06150000
120 FORMAT (1H0,5X,11HFREQUENCY =,E14,6,2X,3HCPS)	06160000
121 FORMAT(1H1)	06170000
122 FORMAT(1/ 4X,40HCOMPUTED RESPONSE AT PLANETARY GEAR SETS//	06180000
1 10X,43HTANGENTIAL TOOTH FORCE AT EACH PLANET (LRS)/	06190000
2 4X,3HSTA,4X,10HSUN-PLANET,13X,11HRRING-PLANET/	06200000


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-----3 4X,3HNO.,5X,4HREAL,6X,9HIMAGINARY,5X,4HREAL,6X,9HIMAGINARY) 06210000
123 FORMAT(9X,9HAMPLITUDE,1X,13HPHASE-ANG,DEG,1X,9HAMPLITUDE,1X, 06220000
1 13HPHASE-ANG,DEG,1X,9HAMPLITUDE,1X,13HPHASE-ANG,DEG) 06230000
-124 FORMAT(/4X,36HCOMPUTED RESPONSE AT SIMPLE GEAR SET/ 06240000
1/ 4X,3HSTA,2X,24HTANGENTIAL TOOTH FORCE (LBS)/ 9X,9HAMPLITUDE, 06250000
2 1X,13HPHASE-ANG,DEG) 06260000
-125 FORMAT(/ 4X,40HCOMPUTED RESPONSE AT PLANETARY GEAR SETS// 06270000
1 10X,43HTANGENTIAL TOOTH FORCE AT EACH PLANET (LBS)/ 06280000
2 4X, 3HSTA,8X,10HSUN-PLANET,13X,11HRING-PLANET/ 4X,3HNO.,2X, 06290000
3 9HAMPLITUDE,1X,13HPHASE-ANG,DEG,1X,9HAMPLITUDE,1X, 06300000
4 13HPHASE-ANG,DEG) 06310000
126 FORMAT(/ 4X,3HSTA,4X,19HANGULAR DISP.(RAD.) .5X, 8HTORQUE-1,2X, 06320000
1 8H(IN-LRS),4X, 8HTORQUE-2,2X,8H(IN-LRS)) 06330000
127 FORMAT(/4X,3HSTA,4X,6HNO. OF,8X,3HSUN,7X,6HPLANET/ 06340000
14X,3HNO.,3X,7HPLANETS,4X,10HRADIUS(IN),2X,10HRADIUS(IN)) 06350000
-128 FORMAT(/4X,3HSTA,2X,10HWEIGHT(LB),4X,41HPOLAR MASS MOMENTS OF INER 06360000
1TIA (LRS-IN**2)/ 4X,3HNO.,4X,6HPLANET,8X,3HSUN,7X,6HPLANET,7X, 06370000
24HRING,7X,7HCAHRIER) 06380000
-129 FORMAT(/4X,3HSTA,6X,26HCOMPLIANCE- LINEAR(IN./LB),16X, 06390000
1 15HCOM-ANG(RAD/LB)/ 4X,3HNO.,2X,10HSUN-PLANET,2X,11HPLANET-RING, 06400000
2 1X,10HPLAN.-CAR.,14X,11HRING-GROUND) 06410000
-130 FORMAT (15,3F12.4,12X,F12.4) 06420000
131 FORMAT(17,1X,3E12.4,12X,F12.4) 06430000
132 FORMAT(/5X,13HBRANCH OPTION,15) 06440000
-135 FORMAT(/9X,10HSHEAR MOD.,2X,11HWT. DENSITY/9X, 9HLBS/IN**2 ,3X, 06450000
1 9HLRS/IN**3/8X,2E12.5) 06460000
136 FORMAT(/5X,35HADDED EXCITATION TREATED SEPARATELY) 06470000
-140 FORMAT (/4X,36HCOMPUTED RESPONSE AT SIMPLE GEAR SET/ 06480000
1/4X,3HSTA,2X,24HTANGENTIAL TOOTH FORCE (LBS)/12X,4HREAL,6X, 06490000
2 9HIMAGINARY) 06500000
-141 FORMAT(12H0DIAGNOSTICS/5X,53HFIRST PASS- UNIT AMPLITUDE AT STATION 06510000
1 1-NO EXCITATION) 06520000
142 FORMAT(12H0DIAGNOSTICS/5X,57HSECOND PASS- ZERO AMPLITUDE AT STATIO 06530000
1N 1- WITH EXCITATION) 06540000
-143 FORMAT(42H0OUTPUT- COMPUTED RESPONSE AT ALL STATIONS/ 06550000
110X,63H(TORQUE-1- GOING INTO STATION, TORQUE-2- COMING OUT OF STAT 06560000
2ION)) 06570000
144 FORMAT(8X,6HTFSPR1,6X,6HTFSPR2,6X,6HTFSPE1,6X,6HTFSPE2,9X,3HQ1R, 06580000
19X,3HQ1E) 06590000
-145 FORMAT(8X,6HTFPRR1,6X,6HTFPRR2,6X,6HTFPRE1,6X,6HTFPRE2) 06600000
190 FORMAT (15,6E12.4,13) 06610000
191 FORMAT(38H0STATION NO. INCORRECT OR OUT OF ORDER) 06620000
-192 FORMAT( 37H0STATION NO. FOR GEAR ERROR INCORRECT) 06630000
194 FORMAT(1H1,14X,46HSINGLE REDUCTION GEAR- LINEAR EXCITATION (IN.)/ 06640000
14X,3HSTA,2X,9HFREQUENCY,6X,4HREAL,6X,9HIMAGINARY) 06650000
-195 FORMAT(1H1,14X,39HPLANETARY GEAR- LINEAR EXCITATION (IN.)/ 06660000
14X,3HSTA,2X,9HFREQUENCY,9X, 8HSUN GEAR,17X, 9HRING GEAR/ 06670000
224X,4HREAL,6X,9HIMAGINARY,5X,4HREAL,6X,9HIMAGINARY) 06680000
-700-FORMAT(/4X,3HSTA,1X,24HANG. DISP.-PLANET CENTER,1X, 06690000
1 22HTOT. TORQUE SUN-PLANET,2X,23HTOT TORQUE PLAN-CARRIFR) 06700000
701 FORMAT( 4X,3HNO.,5X,4HREAL,6X,9HIMAGINARY,5X,4HREAL,6X,9HIMAGINARY 06710000
15X,4HREAL,6X,9HIMAGINARY /1/1X,6E12.5) 06720000
-702-FORMAT(/ 4X,3HSTA,2X,22HANG. DISP.-PLANET BODY,2X, 06730000
1 23HTOT. TORQUE PLANET-RING,2X,22HTOT. TORQUE GRND.-RING) 06740000
END 06750000
-----FUNCTION AMPF(A,B) 00010000
C MEMBERNAME R32AMPF 00020000
AMPF=SQRT(A**2+B**2) 00040000
RETURN 00041000
END 00050000
SUBROUTINE RLOOP(LFE,LOC,LMC,LI,KL,LF,NRR,LIT,KLT,LFT) 00010000
-----C 00020000
C MEMBERNAME R32RLOOP 00030000
C 00040000
-----DIMENSION LT1(2),LT2(2),LT3(2),LT4(2),LT9(2),KT1(2),KT2(2),KT3(2) 00050000
1. KT4(2),KT9(2),MLIT(2),MKLT(2),MLFT(2) 00060000
DIMENSION LFE(20),LOC(20),LMC(20),TC(2),OC(2),TCT(2),OCT(2),TCZ(2) 00070000
1.OCZ(2),TMZ(2),OMZ(2),TM1(2),TBCZ(2),OM(2),TRM(2),TF(2),OM1(2), 00080000
2TCTH(2),OCTH(2),TEMP1(2),TEMP2(2),OF(2) 00090000
COMMON TRR(2,2),TRE(2,2),TPR(2,2),TPF(2,2),TFSPR(2,2),TFSPE(2,2), 00100000
1-TFPRR(2,2),TFPRE(2,2),TTPCR(2,2),TTPCE(2,2),TTGRR(2,2),TTGRE(2,2) 00110000

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COMMON R1P(200),DST(200),DMS(200),DIN(200),BCR(50),LB(50),DDT(200)	00120000
1 RK(50),LFC(2),RS(2),PV(2),PIP(2),PMS(2),PN(2),SS(2),SW(2),SR(2),	00130000
2 ST(2),LHR(20),LRS(20),CCOM(200),AXY1,AXY2,BXY1,BXY2,TLR(200),	00140000
3 TLE(200),THR(200),THE(200),TRR(200),TRE(200),TRR1(200)	00150000
COMMON A(7,7),B(7,7),LS(20),RP(20),RG(20),SG(20),TRR2(200),	00160000
1 TRE1(200),THE1(200),TLE1(200),TRE2(200),TTFR(20),TTFE(20),	00170000
2 PSP(2),THR1(200),TLR1(200),THR2(200),TLR2(200),THE2(200),	00180000
3 TLE2(200),RL(200),PCP(2),PRP(2),DHP(50)	00190000
COMMON IT, K4,L4,NDIAG,FRQ2,ANGR,ANGF,TQR,TQE,J,NS,M1,NW,NR,NPLG	00200000
COMMON K1,K2,K3,K9,L1,L2,L3,L9,LG(10),IBRAN	00210000
IF(LI-1)2,1,2	00220000
1 II=1	00230000
ID=0	00240000
IF(LMC(KL)) 5,4,4	00250000
5 ID=1	00260000
LMC(KL)=-LMC(KL)	00270000
GO TO 4	00280000
2 IF(LI-4) 9,3,9	00290000
3 II=2	00300000
4 LY1(II)=L1	00310000
LT2(II)=L2	00320000
LT3(II)=L3	00330000
LT4(II)=L4	00340000
LT9(II)=L9	00350000
KT1(II)=K1	00360000
KT2(II)=K2	00370000
KT3(II)=K3	00380000
KT4(II)=K4	00390000
KT9(II)=K9	00400000
MLIT(II)=LIT	00410000
MKLT(II)=KLT	00420000
MLFT(II)=LFT	00430000
9 GO TO (10,20,30,40,50,60,70,71),LI	00440000
10 DO 11 II=1,2	00450000
TC(II)=0.0	00460000
OC(II)=0.0	00470000
TCT(II)=0.0	00480000
OCT(II)=0.0	00490000
TCZ(II)=0.0	00500000
OCZ(II)=0.0	00510000
TMZ(II)=0.0	00520000
OM7(II)=0.0	00530000
TM1(II)=0.0	00540000
OM1(II)=0.0	00550000
TBCZ(II)=0.0	00560000
11 OM(II)=0.0	00570000
TBM(II)=0.0	00580000
TF(II)=0.0	00590000
TCTH(II)=0.0	00600000
OCTH(II)=0.0	00610000
OF(II)=0.0	00620000
TC(1)=TQR	00630000
TC(2)=TQE	00640000
OC(1)=ANGR	00650000
OC(2)=ANGE	00660000
ANGR=0.0	00670000
ANGE=0.0	00680000
TQR=0.0	00690000
TQE=0.0	00700000
LF=LOC(KL)	00710000
GO TO 90	00720000
20 TC7(1)=TQR	00730000
TC7(2)=TQE	00740000
OC7(1)=ANGR	00750000
OC7(2)=ANGE	00760000
ANGR=1.	00770000
ANGE=0.	00780000
TQR=0.	00790000
TQE=0.	00800000
GO TO 97	00810000

30 TCTH(1)=TQR	00820000
TCTH(2)=TQE	00830000
OCTH(1)=ANGR	00840000
OCTH(2)=ANGE	00850000
IF(LMC(KL)) 31,35,31	00860000
31 ANGR=0.0	00870000
ANGE=0.0	00880000
TQR=1.0	00890000
TQE=0.0	00900000
GO TO 97	00910000
35 TF(1)=0.0	00920000
TF(2)=0.0	00930000
GO TO 45	00940000
40 IF(LMC(KL)) 400,55,400	00950000
00 TCT(1)=TQR	00960000
TCT(2)=TQE	00970000
OCT(1)=ANGR	00980000
OCT(2)=ANGE	00990000
OF(1)=0.0	01000000
OF(2)=0.0	01010000
41 CALL CSUR(OCTH,OCZ,TEMP1)	01020000
CALL CMPY(TEMP1,OF,TEMP1)	01030000
CALL CSUR(OC,OCZ,TEMP2)	01040000
CALL CSUR(TEMP2,TEMP1,TEMP1)	01050000
CALL CSUR(OCT,OCZ,TEMP2)	01060000
CALL CDIV(TEMP1,TEMP2,TF)	01070000
IF(LI-6) 42,44,42	01080000
42 CALL CSUR(TCTH,TCZ,TEMP1)	01090000
CALL CMPY(TEMP1,OF,TEMP1)	01100000
CALL CSUR(TCT,TCZ,TEMP2)	01110000
CALL CMPY(TF,TEMP2,TEMP2)	01120000
CALL CADD(TEMP1,TEMP2,TEMP1)	01130000
CALL CADD(TEMP1,TCZ,TRCZ)	01140000
CALL CADD(TRCZ,TC,TEMP1)	01150000
ANGR=OC(1)	01160000
ANGE=OC(2)	01170000
LF=LMC(KL)	01180000
TQR=TEMP1(1)	01190000
TQE=TEMP1(2)	01200000
GO TO (90,90,90,80,98,97,90),LI	01210000
44 ANGR=OF(1)	01220000
ANGE=OF(2)	01230000
TQR=TF(1)	01240000
TQE=TF(2)	01250000
J=LFF(KL)	01260000
LF=LOC(KL)	01270000
J1=LF	01280000
J2=LMC(KL)	01290000
II=1	01300000
GO TO 99	01310000
45 CALL CSUR(OCTH,OCZ,TEMP1)	01320000
CALL CSUR(OC,OCZ,TEMP2)	01330000
CALL CDIV(TEMP2,TEMP1,OF)	01340000
ANGR=OF(1)	01350000
ANGE=OF(2)	01360000
TQR=TF(1)	01370000
TQE=TF(2)	01380000
GO TO 97	01390000
50 TMZ(1)=TQR	01400000
TMZ(2)=TQE	01410000
OMZ(1)=ANGR	01420000
OMZ(2)=ANGE	01430000
OF(1)=1.0	01440000
OF(2)=0.0	01450000
GO TO 41	01460000
55 CALL CSUR(TCTH,TCZ,TEMP1)	01470000
CALL CMPY(TEMP1,OF,TEMP1)	01480000
CALL CADD(TEMP1,TCZ,TRM)	01490000
CALL CADD(TC,TBM,TEMP2)	01500000
TQR=TEMP2(1)	01510000

TOE=TEMP2(2)	01520000
GO TO 71	01530000
60- TM1(1)=TOR	01540000
TM1(2)=TOF	01550000
OM1(1)=ANGR	01560000
OM1(2)=ANGE	01570000
TEMP1(1)=1.0-OM1(1)	01580000
TEMP1(2)=OM1(2)	01590000
CALL CADD(TEMP1,OM2,TEMP1)	01600000
CALL COTV(OM2,TEMP1,OF)	01610000
GO TO 41	01620000
70- TEMP1(1)=TOR	01630000
TEMP1(2)=TOE	01640000
CALL CADD(TEMP1,TC,TEMP1)	01650000
TOR=TEMP1(1)	01660000
TOE=TEMP1(2)	01670000
GO TO 85	01680000
71- KL=KL+1	01690000
IF (KL-NBR) 72,72,73	01700000
72 LF=LFE(KL)	01710000
LI=1	01720000
GO TO 74	01730000
73 LF=NS+2	01740000
LI=0	01750000
74- IF (IO) 75,92,75	01760000
75 J3=KL-1	01770000
IF (LMC(J3)) 77,76,77	01780000
76- J2=LOC(J3)	01790000
GO TO 78	01800000
77 J2=LMC(J3)	01810000
78- J1=LFF(J3)	01820000
LMC(J3)=-LMC(J3)	01830000
DO 79 IO=J1,J2	01840000
79- WRITE(NW,108) IO,THR(IO),THE(IO),TLR(IO),TLE(IO),TRR(IO),TRE(IO)	01850000
GO TO 91	01860000
80 J1=LFE(KL)	01870000
J2=LOC(KL)	01880000
GO TO 990	01890000
85 LF=LMC(KL)	01900000
GO TO 80	01910000
90 LI=LI+1	01920000
IF (IO) 91,92,91	01930000
91- WRITE(NW,100)	01940000
WRITE(NW,101) (TC(II),OC(II),YCT(II),OCT(II),TCZ(II),OCZ(II),	01950000
II=1,2)	01960000
WRITE(NW,102)	01970000
WRITE(NW,101) (TMZ(II),OMZ(II),TM1(II),OM1(II),TRCZ(II),OM(II),	01980000
II=1,2)	01990000
WRITE(NW,103)	02000000
WRITE(NW,101) (TBM(II),TF(II),TCTH(II),OCTH(II),OF(II),II=1,2)	02010000
92 RETURN	02020000
97- J=LFE(KL)	02030000
J2=LOC(KL)	02040000
J1=J	02050000
LF=J2	02060000
II=1	02070000
GO TO 99	02080000
98- J2=LMC(KL)	02090000
J=LOC(KL)	02100000
J1=J	02110000
LF=J2	02120000
II=2	02130000
99 L1=LT1(II)	02140000
L2=LT2(II)	02150000
L3=LT3(II)	02160000
L4=LT4(II)	02170000
L9=LT9(II)	02180000
K1=KT1(II)	02190000
K2=KT2(II)	02200000
K3=KT3(II)	02210000

K4=KT4(II)	02220000
K9=KT9(II)	02230000
IT=MLIT(II)	02240000
KLT=MKLT(II)	02250000
LFT=MLFT(II)	02260000
990 IF(I0) 90,90,992	02270000
992 WRITE(NW,125)	02280000
WRITE(NW,701)	02290000
DO 991 I0=J1,J2	02300000
991 WRITE(NW,108) I0,THR(I0),THE(I0),TLR(I0),TLE(I0),TRA(I0),TRE(I0)	02310000
GO TO 90	02320000
108 FORMAT(I7,1X,6E12.5)	02330000
126 FORMAT(/ 4X,3HSTA,4X,19HANGULAR DISP.(RAD.) ,5X, 8HTORQUE-1,2X,	02340000
1 8H(IN-LRS),6X, 8HTORQUE-2,2X,8H(IN-LRS))	02350000
701 FORMAT(4X,3HNO.,5X,4HREAL,6X,9HIMAGINARY,5X,4HREAL,6X,9HIMAGINARY	02360000
15X,4HREAL,6X,9HIMAGINARY /I7,1X,6E12.5)	02370000
100 FORMAT(/14X,3HT-C,9X,3HO-C,7X,5HT-C,T,3X,9HTHETA-C,T,4X,	02380000
1 5HT-C,0,3X,9HTHETA-C,0)	02390000
101 FORMAT(5X,6E12.5)	02400000
102 FORMAT(/12X,5HT-M,0,3X,9HTHETA-M,0,9X,5HT-M,1,3X,9HTHETA-M,1,	02410000
19X,3HTRC,5X,7HTHETA-M)	02420000
103 FORMAT(/14X,3HTRM,9X,3HT-F,3X,9HT-C,THETA,1X,11HTHETA-C,TH.,	02430000
15X,7HTHETA-F)	02440000
END	02450000
SUBROUTINE CADD(A,B,C)	00010000
C MEMBERNAME R32CADD	00020000
DIMENSION A(2),B(2),C(2)	00030000
C(1)=A(1)+B(1)	00040000
C(2)=A(2)+B(2)	00050000
RETURN	00060000
END	00070000
SUBROUTINE CDIV(A,B,C)	00010000
C MEMBERNAME R32CDIV	00020000
C	00030000
DIMENSION A(2),B(2),C(2)	00040000
IF(4(2)) 10,5,10	00050000
5 IF(B(1)) 7,6,7	00060000
6 WRITE(6,101)	00070000
GO TO 14	00080000
7 C7=A(1)/B(1)	00100000
CR=A(2)/B(1)	00110000
GO TO 15	00120000
10 IF(B(1)) 12,11,12	00130000
11 C7=A(2)/B(2)	00140000
CR=-A(1)/B(2)	00150000
GO TO 15	00160000
12 C5=B(2)/B(1)	00170000
C6=B(1)+B(2)*C5	00180000
C7=(A(1)+C5*A(2))/C6	00190000
CR=(A(2)-A(1)*C5)/C6	00200000
GO TO 15	00210000
14 WRITE(6,100) (A(I),B(I),I=1,2),C7,C8	00220000
15 C(1)=C7	00230000
C(2)=CR	00240000
RETURN	00250000
100 FORMAT(5X,15HDIAGNOSTIC-CDIV/6E13.5)	00260000
101 FORMAT(5X,24HCOMPLEX DIVISION BY ZERO)	00270000
END	00280000
SUBROUTINE CDIV2(A,B,C,K,M)	00010000
C	00020000
C MEMBERNAME R32CDIV2	00030000
C	00040000
DIMENSION A(2,2),B(2,2),C(2),TK(2)	00050000
TK(1)=A(2,K)	00060000
TK(2)=B(2,K)	00070000
IF(M=5) 10,5,10	00080000
5 WRITE(6,100) TK(1),TK(2),C(1),C(2)	00090000
10 CALL CDIV(TK,C,TK)	00100000
A(2,K)=TK(1)	00110000

B(2,K)=TK(2)	00120000
IF(M-5) 20,15,20	00130000
15 WRITE(6,101) TK(1),TK(2)	00140000
20 RETURN	00150000
100 FORMAT(/14X,3HPFR,9X,3HPFE,7X,5HBRATR,7X,5HBRATE/5X,4E12.5)	00160000
101 FORMAT(/10X,7HRATIO-R,5X,7HRATIO-E/5X,2E12.5)	00170000
END	00180000
SUBROUTINE CMPY(A,B,C)	00010000
C	00020000
C MEMBERNAME R3PCMPY	00030000
C	00040000
DIMENSION A(2),B(2),C(2)	00050000
C1=A(1)*B(1)-A(2)*B(2)	00060000
C2=A(1)*B(2)+A(2)*B(1)	00070000
C(1)=C1	00080000
C(2)=C2	00090000
RETURN	00100000
END	00110000
SUBROUTINE CSUB(A,B,C)	00010000
C	00020000
C MEMBERNAME R3PCSUB	00030000
C	00040000
DIMENSION A(2),B(2),C(2)	00050000
C(1)=A(1)-B(1)	00060000
C(2)=A(2)-B(2)	00070000
RETURN	00080000
END	00090000
SUBROUTINE MATIN(A,N1,B,M1,DETER,IO)	00010000
C	00020000
C MEMBERNAME R3PMATIN	00030000
C	00040000
DIMENSION A(7,7),B(7,2),INDEX(7,3)	00050000
C	00060000
C GENERAL FORM OF DIMENSION STATEMENT	00070000
C	00080000
C EQUIVALENCE--(IROW,JROW)--(ICOLU,JCOLU)--(AMAX, T, SWAP)	00090000
C	00100000
C INITIALIZATION	00110000
C	00120000
M=M1	00130000
N=N1	00140000
10 DETER =1.0	00150000
15 DO 20 J=1,N	00160000
20 INDEX(J,3) = 0	00170000
30 DO 550 I=1,N	00180000
C	00190000
C SEARCH FOR PIVOT ELEMENT	00200000
C	00210000
40 AMAX=0.0	00220000
45 DO 105 J=1,N	00230000
IF(INDEX(J,3)-1) 60, 105, 60	00240000
60 DO 100 K=1,N	00250000
IF(INDEX(K,3)-1) 80, 100, 715	00260000
80 IF (-- AMAX -ABS (A(J,K)))- 85, 100, 100	00270000
85 IROW=J	00280000
90 ICOLU =K	00290000
AMAX=ABS (A(J,K))	00300000
100 CONTINUE	00310000
105 CONTINUE	00320000
INDEX(ICOLU,3) = INDEX(ICOLU,3) +1	00330000
260 INDEX(I,1)=IROW	00340000
270 INDEX(I,2)=ICOLU	00350000
C	00360000
C INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL	00370000
C	00380000
130 IF (IROW-ICOLU) 140, 310, 140	00390000
140 DETER =-DETER	00400000
150 DO 200 L=1,N	00410000
160 SWAP=A(IROW,L)	00420000
170 A(IROW,L)=A(ICOLU, L)	00430000
200 A(ICOLU, L)=SWAP	00440000
IF(M) 310, 310, 210	00450000
210 DO 250 L=1, M	00460000

220	SWAP=R(IROW,L)	00470000
230	R(IROW,L)=R(ICOLU ,L)	00480000
240	R(ICOLU ,L)=SWAP	00490000
C		00500000
C	DIVIDE PIVOT ROW BY PIVOT ELEMENT	00510000
C		00520000
310	PIVOT =A(ICOLU ,ICOLU)	00530000
	DETER =DETER *PIVOT	00540000
330	A(ICOLU ,ICOLU)=1.0	00550000
340	DO 350 L=1,N	00560000
350	A(ICOLU ,L)=A(ICOLU ,L)/PIVOT	00570000
355	IF (M) 380, 380, 360	00580000
360	DO 370 L=1,M	00590000
370	R(ICOLU ,L)=R(ICOLU ,L)/PIVOT	00600000
C		00610000
C	REDUCE NON-PIVOT ROWS	00620000
C		00630000
380	DO 550 L1=1,N	00640000
390	IF (L1-ICOLU) 400, 550, 400	00650000
400	T=A(L1,ICOLU)	00660000
420	A(L1,ICOLU)=0.0	00670000
	IF (T) 430,550,430	00680000
430	DO 450 L=1,N	00690000
450	A(L1,L)=A(L1,L)-A(ICOLU ,L)*T	00700000
455	IF (M) 550, 550, 460	00710000
460	DO 500 L=1,M	00720000
500	R(L1,L)=R(L1,L)-R(ICOLU ,L)*T	00730000
550	CONTINUE	00740000
C		00750000
C	INTERCHANGE COLUMNS	00760000
C		00770000
600	DO 710 I=1,N	00780000
610	L=N+1-I	00790000
620	IF (INDEX(I,1)-INDEX(L,2)) 630, 710, 630	00800000
630	JROW=INDEX(L,1)	00810000
640	JCOLU =INDEX(L,2)	00820000
650	DO 705 K=1,N	00830000
660	SWAP=A(K,JROW)	00840000
670	A(K,JROW)=A(K,JCOLU)	00850000
700	A(K,JCOLU)=SWAP	00860000
705	CONTINUE	00870000
710	CONTINUE	00880000
	DO 730 K = 1,N	00890000
	IF (INDEX(K,3) -1) 715,720,715	00900000
720	CONTINUE	00910000
730	CONTINUE	00920000
	ID=1	00930000
740	RETURN	00940000
715	ID =2	00950000
	WRITE (6,760)	00960000
760	FORMAT (5X,18HMATRIX IS SINGULAR)	00970000
	GO TO 740	00980000
	END	00990000
	FUNCTION PANGF (A,B)	00010000
C		00020000
C	MEMBERNAME R32PANGF	00030000
C		00040000
	IF (A)-30,50,30	00050000
30	IF (B) 31,60,31	00060000
31	THET = ATAN(B/A)*57.29577951	00070000
	PANGF = THET	00080000
	IF (A) 32,32,35	00090000
32	PANGF = THET + 180.0	00100000
33	RETURN	00110000
35	IF (B) 36,33,33	00120000
36	PANGF = THET + 360.0	00130000
	GO TO 33	00140000
50	IF (B) 51,52,53	00150000
51	PANGF = 270.0	00160000
	GO TO 33	00170000

52 PANGF = 0.0	001A0000
GO TO 33	00190000
53 PANGF = 90.0	00200000
GO TO 33	00210000
60 IF (A) 61,52,52	00220000
61 PANGF = -190.0	00230000
GO TO 33	00240000
END	00250000
SURROUTINE PLNST	00010000
C	00020000
C MEMBERNAME R32PLNST	00030000
C	00040000
COMMON TRR(2,2),TRE(2,2),TPR(2,2),TPF(2,2),TFSPR(2,2),TFSPE(2,2),	00050000
1 TFPRR(2,2),TFPRE(2,2),TTPCR(2,2),TTPCE(2,2),TTGRR(2,2),TTGRE(2,2)	00060000
COMMON RIP(200),DST(200),OMS(200),DIN(200),RCB(50),LR(50),ODT(200)	00070000
1 RK(50),LEC(2),RS(2),RW(2),PIP(2),PMS(2),PN(2),SS(2),SW(2),SR(2),	00080000
2 ST(2),LBR(20),LBS(20),CCOM(200),AXY1,AXY2,BXY1,BXY2,TLR(200),	00090000
3 TLF(200),THR(200),THE(200),TRR(200),TRE(200),TRR1(200)	00100000
COMMON A(7,7),R(7,2),LS(20),RP(20),RG(20),SG(20),TRR2(200),	00110000
1 TRE1(200),THE1(200),TLE1(200),TRE2(200),TTFR(20),TTFE(20),	00120000
2 PSP(2),THR1(200),TLR1(200),THR2(200),TLR2(200),THE2(200),	00130000
3 TLE2(200),RL(200),PCP(2),PRP(2),DMP(50)	00140000
COMMON IT, K4,L4,MDIAG,FRQ2,ANGR,ANGF,TQR,TQE,J,NS,M1,NW,NR,NPLG	00150000
COMMON K1,K2,K3,K9,L1,L2,L3,L9,LG(10),IBRAN	00160000
C1=RS(K4)+RW(K4)	00170000
C2=C1+RW(K4)	00180000
FLNL=PN(K4)	00190000
A(1,1)=RW(K4)	00200000
A(1,2)=0.	00210000
A(1,3)=FRQ2*PIP(K4)	00220000
A(1,4)=0.	00230000
A(1,5)=0.	00240000
A(1,6)=0.	00250000
A(1,7)=0.	00260000
A(2,1)=1.0	00270000
A(2,2)=-1.0	00280000
A(2,3)=0.	00290000
A(2,4)=-FRQ2*PMS(K4)*C1	00300000
A(2,5)=0.	00310000
A(2,6)=0.	00320000
A(2,7)=0.	00330000
A(3,1)=0.	00340000
A(3,2)=C1	00350000
A(3,3)=0.	00360000
A(3,4)=0.	00370000
A(3,5)=-1.0	00380000
A(3,6)=0.	
A(3,7)=-FRQ2*PCP(K4)	00400000
A(4,1)=C2	00410000
A(4,2)=0.	00420000
A(4,3)=0.	00430000
A(4,4)=0.	00440000
A(4,5)=0.	00450000
A(4,6)=FRQ2*PRP(K4)*ST(K4)-1.0	00460000
A(4,7)=0.	00470000
A(5,1)=0.	00480000
A(5,2)=SW(K4)	00490000
A(5,3)=0.	00500000
A(5,4)=C1	00510000
A(5,5)=0.	00520000
A(5,6)=0.	00530000
A(5,7)=- (FLNL)*C1	00540000
A(6,1)=0.	00550000
A(6,2)=0.	00560000
A(6,3)=-RW(K4)	00570000
A(6,4)=-C1	00580000
A(6,5)=0.	00590000

A(6,6)=0.	00600000
A(6,7)=0.	00610000
A(7,1)=SR(K4)	00620000
A(7,2)=0.	00630000
A(7,3)=RW(K4)	00640000
A(7,4)=-C1	00650000
A(7,5)=0.	00660000
A(7,6)=FLNL*C2*ST(K4)	00670000
A(7,7)=0.	00680000
C3=PSP(K4)*FRQ2	00690000
FSR=(TLR(J)-C3*THR(J))/RS(K4)	00700000
FSI=(TLE(J)-C3*THE(J))/RS(K4)	00710000
R(1,1)=RW(K4)*FSR	00720000
R(1,2)=RW(K4)*FSI	00730000
R(2,1)=-FSR	00740000
R(2,2)=-FSI	00750000
R(3,1)=0.	00760000
R(3,2)=0.	00770000
R(4,1)=0.	00780000
R(4,2)=0.	00790000
R(5,1)=0.	00800000
R(5,2)=0.	00810000
IF(M1-1) 440,440,441	00820000
441 IF(L4-IT) 440,443,440	00830000
440 EE1=0.	00840000
EE2=0.	00850000
EE3=0.	00860000
EE4=0.	00870000
GO TO 442	00880000
443 EE1=AXY1*FLNL	00890000
EE2=AXY1*FLNL	00900000
EE3=AXY2*FLNL	00910000
EE4=AXY2*FLNL	00920000
442 R(6,1)=-RS(K4)*FLNL*THR(J)+EE1-SS(K4)*FSR	00930000
R(6,2)=-RS(K4)*FLNL*THE(J)+EE2-SS(K4)*FSI	00940000
R(7,1)=-EE3	00950000
R(7,2)=-EE4	00960000
CALL MATIN (A,7,8,2,CF9,IDD)	00970000
TOR=B(5,1)	00980000
EER=B(6,1)	00990000
ANGR=B(7,1)	01000000
TQE=R(5,2)	01010000
EEI=R(6,2)	01020000
ANGE=R(7,2)	01030000
TFPRR(M1,K4)=R(1,1)/FLNL	01040000
TFPRF(M1,K4)=R(1,2)/FLNL	01050000
TTPCR(M1,K4)=C)*R(2,1)	01060000
TTPCF(M1,K4)=C1*R(2,2)	01070000
C-TTPCR= TOTAL TORQUE, PLANET-CARRIER, REAL	01080000
C TTPCF= TOTAL TORQUE, PLANET-CARRIER, IMAGINARY	01090000
TQR(M1,K4)=R(3,1)/FLNL	01100000
TQF(M1,K4)=R(3,2)/FLNL	01110000
THR(M1,K4)=R(4,1)/FLNL	01120000
TRF(M1,K4)=R(4,2)/FLNL	01130000
TTGRR(M1,K4)=EER	01140000
TTGRE(M1,K4)=EEI	01150000
TFSPR(M1,K4)=FSR/FLNL	01160000
TFSPE(M1,K4)=FSI/FLNL	01170000
C3=RS(K4)*FSR	01180000
C4=RS(K4)*FSI	01190000
C5=C2*R(1,1)	01200000
C6=C2*R(1,2)	01210000
C TEST DIAGNOSTIC	01220000
IF(MDIAG) 600,608,608	01230000
600 IF(K4-1) 621,620,621	01240000
620 WRITE(NW,703)	01250000
621 WRITE(NW,700)	01260000

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WRITE(NW,701)L4,TBR(M1,K4),TBE(M1,K4),C3,C4,TTPCR(M1,K4),      01270000
1 TTPCE(M1,K4)                                                    01280000
WRITE(NW,702)                                                      01290000
WRITE(NW,701)L4,TPR(M1,K4),TPE(M1,K4),C5,C6,TTGRR(M1,K4),      01300000
1 TTGRF(M1,K4)                                                    01310000
600 K4=K4+1                                                        01320000
IF(K4-NFLG) 332,332,333                                           01330000
332 L4=LFC(K4)                                                    01340000
RETURN                                                            01350000
333 L4=NS+2                                                        01360000
RETURN                                                            01370000
700 FORMAT(/4X,3HSTA,1X,24HANG, DISP.-PLANET CENTER,1X,        01380000
1 22HTOT, TORQUE SUN-PLANET,2X,23HTOT TORQUE PLAN-CARRIER)      01390000
701 FORMAT( 4X,3HNO.,5X,4HREAL,6X,9HIMAGINARY,5X,4HREAL,6X,9HIMAGINARY,01400000
15X,4HREAL,6X,9HIMAGINARY /I7,1X,6E12.5)                        01410000
702 FORMAT(/ 4X,3HSTA,2X,22HANG, DISP.-PLANET BODY,2X,          01420000
1 23HTOT, TORQUE PLANET-RING,2X,22HTOT, TORQUE GRND.-RING)       01430000
703 FORMAT(/15X,-----66HALL-TORQUES GIVEN IN INCH-LB. AND ANGUL01440000
1AR DISPLACEMENTS IN RADIAN)                                     01450000
705 FORMAT(12X,4HREAL,6X,9HIMAGINARY,5X,4HREAL,6X,9HIMAGINARY,5X, 01460000
14HREAL,6X,9HIMAGINARY)                                          01470000
END                                                                01480000
***ERROR***      UN-1

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PROGRAMME WAS EXECUTING LINE 3 IN ROUTINE M/PROG WHEN TERMINATION OCCURRED

COMPILE TIME= 0.22-SEC, EXECUTION TIME= 11.55 SEC, OBJECT CODE=

512-BYTES, ARRAY AREA= 80-BYTES, UNUSED= 19408-BYTES

LISTING OF COMPLEX STRUCTURAL DYNAMIC ANALYSIS
COMPUTER PROGRAM USING STIFFNESS METHODS
(D-82/C-51)

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1SN 0062 2 FORMAT( ASSEMBLY PAT,/, 'BEGIN BLOCK INPUT',/, 'MATERIAL TABLE') 00761200
1SN 0063 WRITE(1,3)(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100) 00761300
1SN 0064 3 FORMAT(1M, (1,/, '002,33,70,/, '12.5,/, 'F10.4)) 00761400
1SN 0065 WRITE(7,4) 00761500
1SN 0066 4 FORMAT(1M, 'NODAL COORDINATES') 00761600
1SN 0067 NEWIND 10 00762100
1SN 0068 DO 1 I=1,NOROD 00770000
1SN 0069 READ (5,RUG) NODE,X(NODE),Y(NODE),Z(NODE),NONE(NODE),NTWO(NODE), 00780000
1 (CUM(IJ),IJ=1,4) 00790000
1SN 0070 T(1)=X(NODE) 00790010
1SN 0071 T(2)=Y(NODE) 00790020
1SN 0072 T(3)=Z(NODE) 00790030
1SN 0073 WRITE(7,SYMBOL,T(1),T(2),T(3)) 00790100
1SN 0074 5 FORMAT(1M, 13,3(' ',E11.4)) 00790300
1SN 0075 IF(AS-EV,1) GO TO 687 00791000
1SN 0076 IF(ICOUNT,NE,51) GO TO 9 00800000
1SN 0077 CALL LOADEN (SNP,2) 00810000
1SN 0078 WRITE (6,987) 00820000
1SN 0079 ICOUNT=0 00830000
1SN 0080 9 ICOUNT=ICOUNT+1 00840000
1SN 0081 600 FORMAT (13,5E10,0,213,4A 0) 00850000
1SN 0082 WRITE (6,59M)NODE,X(NODE),Y(NODE),Z(NODE),NONE(NODE),NTWO(NODE), 00860000
1 (CUM(IJ),IJ=1,4) 00870000
1SN 0083 998 FORMAT( 4X 13, 2X 3F11.4, 3X 13, 3X 15, 2X 4A6 ) 00880000
C 00890000
C UNPACK DOP OF NODE 00900000
C 687 CALL UNPACK(NONE(NODE),NTWO(NODE),KK) 00910000
1SN 0086 WRITE(10)NODE,KK 00920000
1SN 0087 DO 700 L=1,6 00930000
1SN 0088 IF (KK(L).NE.2) GO TO 32 00940000
C 00950000
C MAP(JJ)=NODE 00960000
1SN 0091 MAP1(JJ)=L 00970000
1SN 0092 JJ=JJ+1 00980000
1SN 0093 GO TO 700 00990000
1SN 0094 32 IF (KK(L).NE.1) GO TO 700 01000000
1SN 0095 KKK=K+1 01010000
1SN 0096 MAP(KKK)=NODE 01020000
1SN 0097 KKK+1 01030000
1SN 0098 700 CONTINUE 01040000
1SN 0099 1 CONTINUE 01050000
1SN 0100 NEWIND 10 01060000
1SN 0101 WRITE(7,90) 01070000
1SN 0102 90 FORMAT(1M, 'CONSTRAINT DATA-IMPOSED DISPLACEMENTS') 01080000
C 01090000
1SN 0103 DO 60 I=1,NOROD 01091000
1SN 0104 READ(10)NODE,KK 01092000
1SN 0105 K2=1 01093000
1SN 0106 DO 61 I1=1,6 01094000
1SN 0107 IF (KK(I1).EQ.0) GO TO 62 01095000
01096000

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ISN 0111	GO TO 61	01061500
ISN 0112	62 MAP2(1,2)=11	01061600
ISN 0113	K2=2+1	01061700
ISN 0114	61 CONTINUE	01061800
ISN 0115	K3=2-1	01061900
ISN 0116	IF (K3.EQ.0) GO TO 60	01062100
ISN 0117	IF (K3.EQ.1) WRITE(7,501) (NODE, MAP2(I), I=1, K3)	01062200
ISN 0118	IF (K3.EQ.2) WRITE(7,502) (NODE, MAP2(I), I=1, K3)	01062300
ISN 0119	IF (K3.EQ.3) WRITE(7,503) (NODE, MAP2(I), I=1, K3)	01062400
ISN 0120	IF (K3.EQ.4) WRITE(7,504) (NODE, MAP2(I), I=1, K3)	01062500
ISN 0121	IF (K3.EQ.5) WRITE(7,505) (NODE, MAP2(I), I=1, K3)	01062600
ISN 0122	IF (K3.EQ.6) WRITE(7,506) (NODE, MAP2(I), I=1, K3)	01062700
ISN 0123	501 FORMAT(/17,0,22,0*,1(,*,13,*,F,11))	01062800
ISN 0124	502 FORMAT(/17,0,22,0*,2(,*,13,*,F,11))	01062900
ISN 0125	503 FORMAT(/17,0,22,0*,3(,*,13,*,F,11))	01063000
ISN 0126	504 FORMAT(/17,0,22,0*,4(,*,13,*,F,11))	01063100
ISN 0127	505 FORMAT(/17,0,22,0*,5(,*,13,*,F,11))	01063200
ISN 0128	506 FORMAT(/17,0,22,0*,6(,*,13,*,F,11))	01063300
ISN 0129	60 CONTINUE	01063400
ISN 0130	WRITE(10)	01063500
ISN 0131	JSUB=JSU-1	01063600
ISN 0132	IF (JSUB.EQ.MORET) GO TO 747	01063700
ISN 0133	988 FORMAT(/ 98,30M RETAINED DUP COUNT SHOULD BE 16, 8M IT WAS 16 /)	01063800
ISN 0134	WRITE (6,988) JSUB,MORET	01063900
ISN 0135	CALL EXIT	01064000
ISN 0136	747 CONTINUE	01064100
ISN 0137	KSUB=1	01064200
ISN 0138	IF (KSUB.EQ.MORET) GO TO 748	01064300
ISN 0139	991 FORMAT(18X,29M REDUCED DUP COUNT SHOULD BE 16, 8M IT WAS 16 /)	01064400
ISN 0140	WRITE (6,991) KSUB,MORET	01064500
ISN 0141	CALL EXIT	01064600
ISN 0142	748 CONTINUE	01064700
ISN 0143	CALL LOADER(1,SKP,2)	01064800
ISN 0144	WRITE (6,200)	01064900
ISN 0145	989 FORMAT(1X,80(1H-)/18X,12M MAP=RETAINED 77 (3X,1614))	01065000
ISN 0146	WRITE (6,989) (MAP(I), I=1, MORET)	01065100
ISN 0147	911 FORMAT(1X,80(1H-))	01065200
ISN 0148	WRITE (6,911)	01065300
ISN 0149	IF (MORET.EQ.NW) GO TO 150	01065400
ISN 0150	K=MORET+1	01065500
ISN 0151	990 FORMAT(18X,12M MAP=REDUCED 77(3X,1614))	01065600
ISN 0152	WRITE (6,990) (MAP(I), I=1, NTOTAL)	01065700
ISN 0153	WRITE (6,911)	01065800
ISN 0154	150 IF (K.EQ.1) GO TO 688	01065900
ISN 0155	CALL LOADER(1,FLIP,2)	01066000
ISN 0156	WRITE (6,200)	01066100
ISN 0157	NAXIAL=0	01066200
ISN 0158	NSMIN=0	01066300
ISN 0159	NSMAX=0	01066400
ISN 0160		01066500
ISN 0161		01066600
ISN 0162		01066700
ISN 0163		01066800
ISN 0164		01066900
ISN 0165		01067000
ISN 0166		01067100
ISN 0167		01067200
ISN 0168		01067300
ISN 0169		01067400
ISN 0170		01067500
ISN 0171		01067600
ISN 0172		01067700
ISN 0173		01067800
ISN 0174		01067900
ISN 0175		01068000
ISN 0176		01068100
ISN 0177		01068200
ISN 0178		01068300
ISN 0179		01068400
ISN 0180		01068500
ISN 0181		01068600
ISN 0182		01068700
ISN 0183		01068800
ISN 0184		01068900
ISN 0185		01069000
ISN 0186		01069100
ISN 0187		01069200
ISN 0188		01069300
ISN 0189		01069400
ISN 0190		01069500
ISN 0191		01069600
ISN 0192		01069700
ISN 0193		01069800
ISN 0194		01069900
ISN 0195		01070000
ISN 0196		01070100
ISN 0197		01070200
ISN 0198		01070300
ISN 0199		01070400
ISN 0200		01070500
ISN 0201		01070600
ISN 0202		01070700
ISN 0203		01070800
ISN 0204		01070900
ISN 0205		01071000
ISN 0206		01071100
ISN 0207		01071200
ISN 0208		01071300
ISN 0209		01071400
ISN 0210		01071500
ISN 0211		01071600
ISN 0212		01071700
ISN 0213		01071800
ISN 0214		01071900
ISN 0215		01072000
ISN 0216		01072100
ISN 0217		01072200
ISN 0218		01072300
ISN 0219		01072400
ISN 0220		01072500
ISN 0221		01072600
ISN 0222		01072700
ISN 0223		01072800
ISN 0224		01072900
ISN 0225		01073000
ISN 0226		01073100
ISN 0227		01073200
ISN 0228		01073300
ISN 0229		01073400
ISN 0230		01073500
ISN 0231		01073600
ISN 0232		01073700
ISN 0233		01073800
ISN 0234		01073900
ISN 0235		01074000
ISN 0236		01074100
ISN 0237		01074200
ISN 0238		01074300
ISN 0239		01074400
ISN 0240		01074500
ISN 0241		01074600
ISN 0242		01074700
ISN 0243		01074800
ISN 0244		01074900
ISN 0245		01075000
ISN 0246		01075100
ISN 0247		01075200
ISN 0248		01075300
ISN 0249		01075400
ISN 0250		01075500
ISN 0251		01075600
ISN 0252		01075700
ISN 0253		01075800
ISN 0254		01075900
ISN 0255		01076000
ISN 0256		01076100
ISN 0257		01076200
ISN 0258		01076300
ISN 0259		01076400
ISN 0260		01076500
ISN 0261		01076600
ISN 0262		01076700
ISN 0263		01076800
ISN 0264		01076900
ISN 0265		01077000
ISN 0266		01077100
ISN 0267		01077200
ISN 0268		01077300
ISN 0269		01077400
ISN 0270		01077500
ISN 0271		01077600
ISN 0272		01077700
ISN 0273		01077800
ISN 0274		01077900
ISN 0275		01078000
ISN 0276		01078100
ISN 0277		01078200
ISN 0278		01078300
ISN 0279		01078400
ISN 0280		01078500
ISN 0281		01078600
ISN 0282		01078700
ISN 0283		01078800
ISN 0284		01078900
ISN 0285		01079000
ISN 0286		01079100
ISN 0287		01079200
ISN 0288		01079300
ISN 0289		01079400
ISN 0290		01079500
ISN 0291		01079600
ISN 0292		01079700
ISN 0293		01079800
ISN 0294		01079900
ISN 0295		01080000
ISN 0296		01080100
ISN 0297		01080200
ISN 0298		01080300
ISN 0299		01080400
ISN 0300		01080500
ISN 0301		01080600
ISN 0302		01080700
ISN 0303		01080800
ISN 0304		01080900
ISN 0305		01081000
ISN 0306		01081100
ISN 0307		01081200
ISN 0308		01081300
ISN 0309		01081400
ISN 0310		01081500
ISN 0311		01081600
ISN 0312		01081700
ISN 0313		01081800
ISN 0314		01081900
ISN 0315		01082000
ISN 0316		01082100
ISN 0317		01082200
ISN 0318		01082300
ISN 0319		01082400
ISN 0320		01082500
ISN 0321		01082600
ISN 0322		01082700
ISN 0323		01082800
ISN 0324		01082900
ISN 0325		01083000
ISN 0326		01083100
ISN 0327		01083200
ISN 0328		01083300
ISN 0329		01083400
ISN 0330		01083500
ISN 0331		01083600
ISN 0332		01083700
ISN 0333		01083800
ISN 0334		01083900
ISN 0335		01084000
ISN 0336		01084100
ISN 0337		01084200
ISN 0338		01084300
ISN 0339		01084400
ISN 0340		01084500
ISN 0341		01084600
ISN 0342		01084700
ISN 0343		01084800
ISN 0344		01084900
ISN 0345		01085000
ISN 0346		01085100
ISN 0347		01085200
ISN 0348		01085300
ISN 0349		01085400
ISN 0350		01085500
ISN 0351		01085600
ISN 0352		01085700
ISN 0353		01085800
ISN 0354		01085900
ISN 0355		01086000
ISN 0356		01086100
ISN 0357		01086200
ISN 0358		01086300
ISN 0359		01086400
ISN 0360		01086500
ISN 0361		01086600
ISN 0362		01086700
ISN 0363		01086800
ISN 0364		01086900
ISN 0365		01087000
ISN 0366		01087100
ISN 0367		01087200
ISN 0368		01087300
ISN 0369		01087400
ISN 0370		01087500
ISN 0371		01087600
ISN 0372		01087700
ISN 0373		01087800
ISN 0374		01087900
ISN 0375		01088000
ISN 0376		01088100
ISN 0377		01088200
ISN 0378		01088300
ISN 0379		01088400
ISN 0380		01088500
ISN 0381		01088600
ISN 0382		01088700
ISN 0383		01088800
ISN 0384		01088900
ISN 0385		01089000
ISN 0386		01089100
ISN 0387		01089200
ISN 0388		01089300
ISN 0389		01089400
ISN 0390		01089500
ISN 0391		01089600
ISN 0392		01089700
ISN 0393		01089800
ISN 0394		01089900
ISN 0395		01090000
ISN 0396		01090100
ISN 0397		01090200
ISN 0398		01090300
ISN 0399		01090400
ISN 0400		01090500
ISN 0401		01090600
ISN 0402		01090700
ISN 0403		01090800
ISN 0404		01090900
ISN 0405		01091000
ISN 0406		0109

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ISN 0171 6066 MAP=JOSSET+NSPEC 01384000
ISN 0172 I=0 01384100
ISN 0173 LA=0 01384200
ISN 0174 ITYPE=9 01384300
ISN 0175 DU 11 INDEX=1,MAP 01384400
ISN 0176 IF(INDEX.GT+NSPEC) GO TO 9065 01384500
ISN 0178 DO 28 LS=1,4 01384600
ISN 0179 28 MUMDS(LS)=TUMD(LS) 01384700
ISN 0180 M=0 01384800
ISN 0181 READ(5,5055) NTYP,LN1,LN2,LN3,LN4,MC,(SEMP(L),L=1,4) 01384900
ISN 0182 5055 FORMAT(5I5,11,4E10,0) 01385000
ISN 0183 WRITE(6,2371) NTYP,LN1,LN2,LN3,LN4,MC,(SEMP(L),L=1,4) 01385100
ISN 0185 2371 FORMAT(1X,60(1M=) / 21X 'SPECIAL ELEMENT' / , TYPE #,14, 01385200
1, LN1 #,14, LN2 #,14, LN3 #,14, LN4 #,14 / 01385300
2, PROPERTIES #,12, MC #,14,5) 01385400
ISN 0186 IF(NTYP.NE.5) GO TO 3035 01385500
ISN 0188 781 N1=LN1 01385600
ISN 0189 N2=LN2 01385700
ISN 0190 N3=LN3 01385800
ISN 0191 IF(MN.EQ.1) GO TO 5631 01385900
ISN 0193 NTYPE=2 01386000
ISN 0194 TEMP(1)=SEMP(4) 01386100
ISN 0195 TEMP(2)=0 01386200
ISN 0196 TEMP(3)=0 01386300
ISN 0197 N=1 01386400
ISN 0198 GO TO 7777 01386500
ISN 0199 5631 NTYPE=4 01386600
ISN 0200 DU 6181 J=1,3 01386700
ISN 0201 6181 TEMP(J)=SEMP(J) 01386800
ISN 0202 M=0 01386900
ISN 0203 GO TO 7777 01387000
ISN 0204 5035 IF(NTYP.NE.6) GO TO 4045 01387100
ISN 0206 881 IF(MN.GT.2) GO TO 3611 01387200
ISN 0208 NTYPE=3 01387300
ISN 0209 N1=LN4 01387400
ISN 0210 DO 6212 J=1,3 01387500
ISN 0211 6212 TEMP(J)=SEMP(1) 01387600
ISN 0212 IF(MN.EQ.2) GO TO 3711 01387700
ISN 0214 N1=LN1 01387800
ISN 0215 N2=LN2 01387900
ISN 0216 M=2 01388000
ISN 0217 GO TO 7777 01388100
ISN 0218 3711 N1=LN2 01388200
ISN 0219 N2=LN3 01388300
ISN 0220 M=3 01388400
ISN 0221 GO TO 7777 01388500
ISN 0222 3611 NTYPE=2 01388600
ISN 0223 N=0 01388700
ISN 0224 TEMP(2)=0 01388800
ISN 0225 TEMP(3)=0 01388900
ISN 0226 IF(MN.EQ.4) GO TO 3811 01389000

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TSN 0228	NI=ENI	01399920
ISN 0229	N2=LN2	01399930
ISN 0230	TEMP(1)=SEMP(2)	01399940
ISN 0231	MO=0	01399950
ISN 0232	GO TO 7777	01399960
ISN 0233	3811 NI=LN3	01399970
ISN 0234	N2=LN4	01399980
ISN 0235	TEMP(1)=SEMP(3)	01399990
ISN 0236	MO=0	01400000
ISN 0237	GO TO 7777	01400010
ISN 0238	4045 WRITE(6,7227)	01400020
ISN 0239	7227 FORMAT(// 5A *INCORRECT IDENTIFICATION FOR SPECIAL ELEMENT')	01400030
ISN 0240	CALL EXIT	01400040
ISN 0241	9065 READ(5,801) NTYPE,M1,M2,M3,MC,(TEMP(J),J=1,5),CF1,CF2,IXY,B	01400050
ISN 0242	IF(LK.EQ.0)WRITE(7,95)	01400060
ISN 0243	IF(LK.EQ.0.AND.NDM.GT.0)WRITE(8,95)	01400070
ISN 0244	95 FORMAT(' STRUCTURAL DATA')	01400080
ISN 0245	MB=IC	01400090
ISN 0246	IF(MB.EQ.0)MB=1	01400100
ISN 0247	801 FORMAT (2X,11,313,11,0E10.0,E7.0)	01400110
ISN 0248	LA=LN+1	01400120
ISN 0249	IF(NTYPE.EQ.2) GO TO 70	01400130
ISN 0250	IF(NTYPE.EQ.0)NTYPE=5	01400140
ISN 0251	IF(NTYPE.EQ.0) GO TO 71	01400150
ISN 0252	IF(NTYPE.EQ.0)WRITE(7,96)	01400160
ISN 0253	IF(NTYPE.EQ.0)WRITE(8,96)	01400170
ISN 0254	96 FORMAT(' ELEMENT TYPE=201')	01400180
ISN 0255	11TYPE=NTYPE	01400190
ISN 0256	T(2)=TEMP(2)	01400200
ISN 0257	T(3)=TEMP(3)	01400210
ISN 0258	T(1)=TEMP(1)	01400220
ISN 0259	IF(T(2).NE.0.) GO TO 5000	01400230
ISN 0260	IF(T(3).NE.0.) GO TO 5000	01400240
ISN 0261	T(2)=T(1)	01400250
ISN 0262	T(3)=T(1)	01400260
ISN 0263	5000 T(4)=CF1	01400270
ISN 0264	T(5)=CF2	01400280
ISN 0265	T(6)=IXY	01400290
ISN 0266	WRITE(7,97)LK,M1,M2,M3,T(2),T(3),T(1),B,T(4),T(5),T(6),MB	01400300
ISN 0267	IF(NDM.GT.0)WRITE(8,97)LK,M1,M2,M3,T(2),T(3),T(1),	01400310
ISN 0268	1B,T(4),T(5),T(6),MB	01400320
ISN 0269	97 FORMAT(1X,15,3(' ',10),3(' ',10),5,6(' ',0'),',', '+',',',5,4,1,	01400330
ISN 0270	13(' ',10,5),',',M(' ',11,' '))	01400340
ISN 0271	GO TO 8777	01400350
ISN 0272	70 CONTINUE	01400360
ISN 0273	IF(11TYPE.NE.NTYPE) WRITE(7,98)	01400370
ISN 0274	IF(11TYPE.NE.NTYPE.AND.NDM.GT.0)WRITE(8,98)	01400380
ISN 0275	98 FORMAT(' ELEMENT TYPE=101')	01400390
ISN 0276	11TYPE=NTYPE	01400400
ISN 0277	T(1)=TEMP(1)	01400410
ISN 0278	T(2)=CF1	01400420
ISN 0279	WRITE(7,99)LK,M1,M2,T(1),T(2),MB	01400430
ISN 0280		01400440
ISN 0281		01400450
ISN 0282		01400460
ISN 0283		01400470
ISN 0284		01400480
ISN 0285		01400490
ISN 0286		01400500
ISN 0287		01400510
ISN 0288		01400520
ISN 0289		01400530
ISN 0290		01400540


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ISN 0291 IF (NOM,GT,0)WRITE(8,99)IK,M1,M2,T(1),T(2),MB
ISN 0293 99 FORMAT(14,'15,2(',14,2(',E10.5),',M(',11,')')
ISN 0294 GO TO 8777
ISN 0295 71 CONTINUE
ISN 0296 IF (11TYPE,NE,NTYPE) WRITE(7,63)
ISN 0298 IF (11TYPE,NE,NTYPE,AND,NOM,GT,0)WRITE(8,63)
ISN 0300 63 FORMAT(14,'ELEMENT TYPE=122')
ISN 0301 11TYPE=NTYPE
ISN 0302 T(2)=TEMP(2)
ISN 0303 T(1)=TEMP(1)
ISN 0304 T(3)=TEMP(3)
ISN 0305 T(4)=E1
ISN 0306 WRITE(7,60)IK,M1,M2,N3,T(1),T(2),T(3),T(4),MB
ISN 0307 IF (NOM,GT,0)WRITE(8,64)IK,M1,M2,N3,T(2),T(1),T(3),T(4),MB
ISN 0309 64 FORMAT(14,'15,5(',14,5(',E10.5),',2(',0,')',E10.5,
ISN 0310 1,M(',11,')')
ISN 0310 GO TO 8777
C
C DATA EXPANSION
C
ISN 0311 7777 NOSAT=NOSAT+1
ISN 0312 8777 I=I+1
ISN 0313 IF (NTYPE,LE,0) NTYPE=5
ISN 0315 IF (NTYPE,GT,0) MCHI
C
ISN 0317 IF (NTYPE,NE,3), (TEMP(2),NE,0)) GO TO 100
ISN 0319 TEMP(2)=TEMP(1)
ISN 0320 TEMP(3)=TEMP(1)
ISN 0321 100 CONTINUE
C
C TEST FOR 3 TYPES OF OUTPUT AND PACKING
C
ISN 0322 IF (NTYPE,NE,2) GO TO 101
C
C PACKING FOR AXIAL ELEMENT
C
ISN 0324 IF (AS,EG,1) GO TO 681
ISN 0326 WRITE(6,992) N1,M2,MC,TEMP(1),CF1,CF2
ISN 0327 992 FORMAT (1X60(1M-)/21X14M AXIAL ELEMENT/2X3MN1=14,2X3MN2=14,2X,
ISN 0328 2 14MATERIAL CODE=12,2X,5MAREAS=12,5,2X,2E12,5 )
ISN 0329 681 MAXIAL=MAXIAL+1
ISN 0330 MODE1(1)=1+100+10*NTYPE+MC
ISN 0331 MODE2(1)=2+1000+M3
ISN 0332 TEMP(1)=TEMP(1)
ISN 0333 TEMP(2)=TEMP(2)
ISN 0334 TEMP(3)=TEMP(3)
ISN 0335 TEMP(4)=E1
ISN 0336 TEMP(5)=CF2
ISN 0336 GO TO 10
C
ISN 0337 101 IF (NTYPE,NE,3) GO TO 102

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ISN 0339	C	IF(CAS.EQ.1.7) GO TO 682	PACKING FOR TRIANGULAR SKIN ELEMENT	01780000
ISN 0340	C	WRITE (6,993)		01790000
ISN 0341	C	993 FORMAT (1X 80(1H-))24X 25M TRIANGULAR SKIN ELEMENT)		01800000
ISN 0342	C	994 FORMAT (2X, 3M1=14, 2X,		01810000
ISN 0343	C	3M2=14, 2X, 3M3=14, 2X, 3M4=14, 2X, 3M5=14, 2X, 3M6=14, 2X,		01820000
ISN 0344	C	3M7=14, 2X, 3M8=14, 2X, 3M9=14, 2X, 3M10=14, 2X, 3M11=14, 2X,		01830000
ISN 0345	C	3M12=14, 2X, 3M13=14, 2X, 3M14=14, 2X, 3M15=14, 2X, 3M16=14, 2X,		01840000
ISN 0346	C	3M17=14, 2X, 3M18=14, 2X, 3M19=14, 2X, 3M20=14, 2X, 3M21=14, 2X,		01850000
ISN 0347	C	3M22=14, 2X, 3M23=14, 2X, 3M24=14, 2X, 3M25=14, 2X, 3M26=14, 2X,		01860000
ISN 0348	C	3M27=14, 2X, 3M28=14, 2X, 3M29=14, 2X, 3M30=14, 2X, 3M31=14, 2X,		01870000
ISN 0349	C	3M32=14, 2X, 3M33=14, 2X, 3M34=14, 2X, 3M35=14, 2X, 3M36=14, 2X,		01880000
ISN 0350	C	3M37=14, 2X, 3M38=14, 2X, 3M39=14, 2X, 3M40=14, 2X, 3M41=14, 2X,		01890000
ISN 0351	C	3M42=14, 2X, 3M43=14, 2X, 3M44=14, 2X, 3M45=14, 2X, 3M46=14, 2X,		01900000
ISN 0352	C	3M47=14, 2X, 3M48=14, 2X, 3M49=14, 2X, 3M50=14, 2X, 3M51=14, 2X,		01910000
ISN 0353	C	3M52=14, 2X, 3M53=14, 2X, 3M54=14, 2X, 3M55=14, 2X, 3M56=14, 2X,		01920000
ISN 0354	C	3M57=14, 2X, 3M58=14, 2X, 3M59=14, 2X, 3M60=14, 2X, 3M61=14, 2X,		01930000
ISN 0355	C	3M62=14, 2X, 3M63=14, 2X, 3M64=14, 2X, 3M65=14, 2X, 3M66=14, 2X,		01940000
ISN 0356	C	3M67=14, 2X, 3M68=14, 2X, 3M69=14, 2X, 3M70=14, 2X, 3M71=14, 2X,		01950000
ISN 0357	C	3M72=14, 2X, 3M73=14, 2X, 3M74=14, 2X, 3M75=14, 2X, 3M76=14, 2X,		01960000
ISN 0358	C	3M77=14, 2X, 3M78=14, 2X, 3M79=14, 2X, 3M80=14, 2X, 3M81=14, 2X,		01970000
ISN 0359	C	3M82=14, 2X, 3M83=14, 2X, 3M84=14, 2X, 3M85=14, 2X, 3M86=14, 2X,		01980000
ISN 0360	C	3M87=14, 2X, 3M88=14, 2X, 3M89=14, 2X, 3M90=14, 2X, 3M91=14, 2X,		01990000
ISN 0361	C	3M92=14, 2X, 3M93=14, 2X, 3M94=14, 2X, 3M95=14, 2X, 3M96=14, 2X,		02000000
ISN 0362	C	3M97=14, 2X, 3M98=14, 2X, 3M99=14, 2X, 3M100=14, 2X, 3M101=14, 2X,		02010000
ISN 0363	C	3M102=14, 2X, 3M103=14, 2X, 3M104=14, 2X, 3M105=14, 2X, 3M106=14, 2X,		02020000
ISN 0364	C	3M107=14, 2X, 3M108=14, 2X, 3M109=14, 2X, 3M110=14, 2X, 3M111=14, 2X,		02030000
ISN 0365	C	3M112=14, 2X, 3M113=14, 2X, 3M114=14, 2X, 3M115=14, 2X, 3M116=14, 2X,		02040000
ISN 0366	C	3M117=14, 2X, 3M118=14, 2X, 3M119=14, 2X, 3M120=14, 2X, 3M121=14, 2X,		02050000
ISN 0367	C	3M122=14, 2X, 3M123=14, 2X, 3M124=14, 2X, 3M125=14, 2X, 3M126=14, 2X,		02060000
ISN 0368	C	3M127=14, 2X, 3M128=14, 2X, 3M129=14, 2X, 3M130=14, 2X, 3M131=14, 2X,		02070000
ISN 0369	C	3M132=14, 2X, 3M133=14, 2X, 3M134=14, 2X, 3M135=14, 2X, 3M136=14, 2X,		02080000
ISN 0370	C	3M137=14, 2X, 3M138=14, 2X, 3M139=14, 2X, 3M140=14, 2X, 3M141=14, 2X,		02090000
ISN 0371	C	3M142=14, 2X, 3M143=14, 2X, 3M144=14, 2X, 3M145=14, 2X, 3M146=14, 2X,		02100000
ISN 0372	C	3M147=14, 2X, 3M148=14, 2X, 3M149=14, 2X, 3M150=14, 2X, 3M151=14, 2X,		02110000
ISN 0373	C	3M152=14, 2X, 3M153=14, 2X, 3M154=14, 2X, 3M155=14, 2X, 3M156=14, 2X,		02120000
ISN 0374	C	3M157=14, 2X, 3M158=14, 2X, 3M159=14, 2X, 3M160=14, 2X, 3M161=14, 2X,		02130000
ISN 0375	C	3M162=14, 2X, 3M163=14, 2X, 3M164=14, 2X, 3M165=14, 2X, 3M166=14, 2X,		02140000
ISN 0376	C	3M167=14, 2X, 3M168=14, 2X, 3M169=14, 2X, 3M170=14, 2X, 3M171=14, 2X,		02150000
ISN 0377	C	3M172=14, 2X, 3M173=14, 2X, 3M174=14, 2X, 3M175=14, 2X, 3M176=14, 2X,		02160000
ISN 0378	C	3M177=14, 2X, 3M178=14, 2X, 3M179=14, 2X, 3M180=14, 2X, 3M181=14, 2X,		02170000
ISN 0379	C	3M182=14, 2X, 3M183=14, 2X, 3M184=14, 2X, 3M185=14, 2X, 3M186=14, 2X,		02180000
ISN 0380	C	3M187=14, 2X, 3M188=14, 2X, 3M189=14, 2X, 3M190=14, 2X, 3M191=14, 2X,		02190000
ISN 0381	C	3M192=14, 2X, 3M193=14, 2X, 3M194=14, 2X, 3M195=14, 2X, 3M196=14, 2X,		02200000
ISN 0382	C	3M197=14, 2X, 3M198=14, 2X, 3M199=14, 2X, 3M200=14, 2X, 3M201=14, 2X,		02210000
ISN 0383	C	3M202=14, 2X, 3M203=14, 2X, 3M204=14, 2X, 3M205=14, 2X, 3M206=14, 2X,		02220000

```

1SV 0380 997 FORMAT (X, 10H ***** WARNING ***** / 02250000
2 10X,1M3M NO, OF STRUCTURAL ELEMENTS SHOULD BE 16, 1M / 02250000
3 10X,1M4 9H IT WAS 16,31X,1M4 /9X,02260000
40H ***** /02270000
1SV 0385 CALL EXIT 02280000
1SV 0386 30 CONTINUE 02290000
1SV 0387 WRITE (6,977) NIUT,AXIAL,NSKIN,NREAM 02300000
1SV 0388 977 FORMAT (9X,37H TOTAL NUMBER OF STRUCTURAL ELEMENTS 16/9X, 02310000
1 23H NO, OF AXIAL ELEMENTS 16/9X, 02320000
2 23H NO, OF SKIN ELEMENTS 16/9X, 02330000
3 23H NO, OF BEAM ELEMENTS 16/ 02340000
C 02350000
1SV 0389 REMIND 1 02350100
1SV 0390 IF (ISM,EO,1.) GO TO 684 02351000
1SV 0391 CALL LOADER (SKP,2) 02360000
1SV 0392 WRITE (6,400) 02370000
1SV 0393 964 FORMAT (20X,21H FULL STIFFNESS MATRIX//) 02380000
1SV 0395 WRITE (6,964) 02390000
C 02400000
1SV 0396 684 GO 40 ILL=1,NTOTAL 02410000
C 02420000
1SV 0397 DO 41 LIL=1,NN 02430000
1SV 0398 41 M04(LIL)=0.0 02440000
1SV 0399 DO 42 LIZ=1,12 02450000
1SV 0400 442 M042(LIZ)=0.0 02460000
C 02470000
1SV 0401 JJ=MAX(NN) 02480000
C 02490000
C 02500000
C 02510000
1SV 0402 DO 42 J=1,N04AT 02520000
C 02530000
1SV 0403 M1=MODE1(J)/100 02540000
1SV 0404 M2=MODE2(J)/1000 02550000
1SV 0405 M3=MODE2(J)-1000*M2 02560000
1SV 0406 M4=M1 02570000
C 02580000
1SV 0407 MTYPE=(MODE1(J)-100*M01)/10 02590000
C 02600000
1SV 0408 IF (M1,EO,JJ) GO TO 45 02610000
C 02620000
1SV 0410 IF (M2,NE,JJ) GO TO 46 02630000
1SV 0412 IF (MTYPE,EO,JJ) GO TO 45 02640000
C 02650000
1SV 0414 MAC=1 02660000
1SV 0415 M1=M2 02670000
1SV 0416 M2=MAC 02680000
1SV 0417 GO TO 45 02690000
C 02700000
1SV 0418 44 IF (MTYPE,NE,3) GO TO 42 02710000
1SV 0420 IF (M3,NE,JJ) GO TO 42 02720000

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ISN 0422	C	05 MCRNODE(IJ)=100-N01-ID*NTYPE	02730000
ISN 0423	C	TEMP(MC)	02740000
ISN 0424	C	TEMP(IJXNU(MC)	02750000
ISN 0425	C	IF (NTYPE,EG,2) TEMP(I)=TEMP(IJ)	02760000
ISN 0426	C	TEMP(2)=TEMP(IJ)	02770000
ISN 0427	C	TEMP(3)=TEMP(IJ)	02780000
ISN 0428	C	TEMP(4)=TEMP(IJ)	02790000
ISN 0429	C	CF1=TEMP4(IJ)	02800000
ISN 0430	C	CF2=TEMP5(IJ)	02810000
ISN 0431	C		02820000
	C	DETERMINE STRUCTURAL ELEMENTS FOR STRING, SKIN AND BEAM, MATRIX (XRB)	02830000
	C		02840000
	C		02850000
ISN 0432	C	CALL SETUP(NTYPE,N1,N2,N3,E,TEMP,X,Y,Z,NONE,NTNU,XBK,IZ,CF1,CF2)	02860000
ISN 0433	C	IF (NTYPE,EW,4) CALL RESORT (XRB)	02870000
ISN 0435	C	IF (NTYPE,EW,3) CALL SHIFT (N1,N2,N3,IJ,XBK)	02880000
ISN 0437	C	NBDR=2	02890000
ISN 0438	C	IF (N1,GT,NORET) NBUR=1	02900000
	C	SEARCHING DOF NO. FOR RETAINED,	02910000
	C	REDUCED UN DELETE	02920000
ISN 0440	C	CALL UNPACK (NONE(IJ),NTNU(IJ),NKS)	02930000
ISN 0441	C	DO 48 I=1,6	02940000
ISN 0442	C	JK=7-1	02950000
ISN 0443	C	IF (NKS(IJ),EW,NBUR) GO TO 49	02960000
ISN 0445	C	48 CONTINUE	02970000
ISN 0446	C	GO TO 500	02980000
	C		02990000
ISN 0447	C	49 DO 50 I=1,12	03000000
ISN 0448	C	50 ROW2(I)=XNK(IJ,I)	03010000
ISN 0449	C	IF ((JK,GT,3).AND.(NTYPE,NE,4)) GO TO 52	03020000
	C	PURPOSE OF TRAFER IS 1,UNPACK DOF NO.	03030000
	C	2,FIND NODE IN MAP(RET,OR,RED)	03040000
	C	3,TRANSFER FROM ROW2 TO ROW(NN)	03050000
	C		03060000
	C		03070000
	C		03080000
ISN 0451	C	JO=0	03090000
ISN 0452	C	CALL TRAFER (N1,MAP,NDR1,NTOTAL,JO,NONE,NTNU,ROW,ROW2,NTYPE)	03100000
ISN 0453	C	JO=3	03110000
ISN 0454	C	IF (NTYPE,EW,4) JO=6	03120000
ISN 0456	C	CALL TRAFER (N2,MAP,NDR2,NTOTAL,JO,NONE,NTNU,ROW,ROW2,NTYPE)	03130000
ISN 0457	C	IF (NTYPE,NE,3) GO TO 42	03140000
ISN 0459	C	JO=6	03150000
	C		03160000
	C		03170000
	C		03180000
	C		03190000
	C		03200000
	C		03210000
	C		03220000

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ISN 0480 --- CALL INAPEN (N3,MAP,NOMET,NTOTAL,JU,NONE,NINO,NOM,NOMZ,NTYPE) 03230000
ISN 0481 --- C 42 CONTINUE 03240000
ISN 0482 --- IF (N3=1) GO TO 685 03250000
ISN 0483 --- 960 FORMAT (X 60(14=) / 20X 6H NUDESI4, 14, 2X 4HNUM=14) 03260000
ISN 0484 --- WRITE (6,960) J,NN 03270000
ISN 0485 --- I1=1 03280000
ISN 0486 --- I2=I1+3 03290000
ISN 0487 --- N9=NN-4 03300000
ISN 0488 --- IF (N9.LT.0) GO TO 553 03310000
ISN 0489 --- DO 343 I=1,N9,4 03320000
ISN 0490 --- 342 IF (N9=13) (N9=0) GO TO 331 03330000
ISN 0491 --- GO TO 344 03340000
ISN 0492 --- 331 WRITE (6,962) (I4,NOM(I9),I9=I1,I2) 03350000
ISN 0493 --- 962 FORMAT (1X 4(14,2H)E13.6) 03360000
ISN 0494 --- 344 I1=I1+4 03370000
ISN 0495 --- 343 I2=I1+3 03380000
ISN 0496 --- 553 WRITE (6,962) (I9,NOM(I9),I9=I1,NN) 03390000
ISN 0497 --- C 03400000
ISN 0498 --- 685 IF (NOMET.NE.NTOTAL) GO TO 300 03410000
ISN 0499 --- WRITE (1) (NOM(I5),I5=1,NN) 03420000
ISN 0500 --- GO TO 333 03430000
ISN 0501 --- C 03440000
ISN 0502 --- 300 CONTINUE 03450000
ISN 0503 --- I4=1 03460000
ISN 0504 --- CALL ZUOT(NOM,I4,NN,NMAP) 03470000
ISN 0505 --- C 03480000
ISN 0506 --- LNN=NMAP(NN) 03490000
ISN 0507 --- C 03500000
ISN 0508 --- WRITE (1) (NOM(I5),I5=1,LN) 03510000
ISN 0509 --- C 03520000
ISN 0510 --- 333 CONTINUE 03530000
ISN 0511 --- C 03540000
ISN 0512 --- KILL=1000*NONE(JJ)+NTAU(JJ) 03550000
ISN 0513 --- KILLERILL=(10*(6-JK))*RDB 03560000
ISN 0514 --- C 03570000
ISN 0515 --- NONE(JJ)=KILL/1000 03580000
ISN 0516 --- NTAU(JJ)=KILL-1000*NONE(JJ) 03590000
ISN 0517 --- C 03600000
ISN 0518 --- 40 N9=NN-1 03610000
ISN 0519 --- C 03620000
ISN 0520 --- NENINO 3 03630000
ISN 0521 --- WRITE (3) (NMAP(JTN),JTN=1,NTOTAL) 03640000
ISN 0522 --- NENINO 3 03650000
ISN 0523 --- NENINO 1 03660000
ISN 0524 --- DO 20 ILAP =1,NOMET 03670000
ISN 0525 --- 20 LAP(ILAP)=NMAP(ILAP) 03680000
ISN 0526 --- 500 METUM, 03690000
ISN 0527 --- END 03700000
ISN 0528 --- 03710000
ISN 0529 --- 03720000

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COMPILER OPTIONS	NAME	VALUE	DESCRIPTION
C	DB2-PROGRAM	ALTERNATIVE VERSION OF DB2-6 USING ROUTINES EIGEN & GELS FROM THE SCIENTIFIC SUBMODULE TIME PACKAGE (SSP). LARGER RETAINED MATRICES CAN BE HANDLED BY USING THE STORAGE COMPRESSION MODE FOR SYMMETRIC MATRICES.	
C	IF DESIRED	AN ENTRY TO A C51 TYPE OF PARAMETRIC STUDY MAY BE MADE. ONE HAS THE OPTION OF PROVIDING ONE'S OWN MODAL MATRIX OR OF PERFORMING THE DB2 CALCULATIONS.	
C	MEMBER-NAME	DB2MAIN	
C	ADDED TO S11 ON 10TH, MARCH, 1969		
C	DOUBLE PRECISION GUL		
C	COMMON /LINKA/	LAP, XNODD, XNOSAT, XNOMET, XNORED, XNORUP, XNOD, EC, XNU, XNRIASV, XNEIG, XNMASS, SCALE, EVSAVE, XNSAVE, XNSPEC, AS, FSM, XSM, DM, UM, WNE, UIN, UUM(3), BIL, MMK, FUNKM	
C	COMMON /LINKA1/	NTUTAL, NUNET, NIAP	
C	COMMON /VJT/	GUL	
C	COMMON /TKO/	IKO, KEY	
C	DIMENSION DATA(32), LAP(250), RE(3), GUL(66), FNU(3)		
C	DOUBLE PRECISION TIME		
C	EQUIVALENCE (DATA(1), XNODD)		
C	REWARD 5		
C	IKO=0		
C	KEY=0		
C	CALL ERSET(208, 0, -1, 0, 0)		
C	DO 10 I=1, 32		
C	10 DATA(I) = 0.0		
C	DO 20 I=1, 66		
C	20 GUL(I) = 0.0		
C	30 CALL LUADER(DATA, 1)		
C	IF (BIL, NE, 0.0) GO TO 50		
C	IF (DMA, NE, 0.0) EVSAVE=1.0		
C	CALL ASLNA1		
C	CALL MEDLK2		
C	CALL ABLNK3		
C	M = XNOMET		
C	N = XNEIG		
C	IF (EVSAVE, NE, 1) GO TO 40		
C	CALL TPCU(M, 3, 2)		
C	40 CONTINUE		

TSN 0032	IF (GMA.EQ.0.) GO TO 30	00560000
TSN 0033	IF (GMA.NE.0.) READ(5,100) NINE	00563000
TSN 0034	100 FORMAT (15)	00568000
TSN 0035	50 CALL CS1LK4	00570000
TSN 0036	CALL ABLNRS	00571000
TSN 0037	GO TO 30	00580000
TSN 0038	END	00590000

LEVEL 21, (JAN 73)

US/360 PUMIKAN M

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      .JMP (LEN-1) OPT=1, OPT=2, LINE=1, SIZE=10000,
      SOURCE, EBCDIC, NOLIST, NOCHECK, LOAD, MAP, NOEDIT, ID, NOXREF
      SUBROUTINE CSILK4 - ADAPTED FROM CSI PROGRAM
      MEMBER=NAME 082C51
      ADDED TO SM1 ON 7TH, APRIL, 1969
      SUBROUTINE CSILK4
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION AS(250), C(250), EFH(50,50), EIG(30),
      1 FORCE(250), G(250), GUL(66),
      2 MAP(250), NI(30), PM(250,50), QI(250,30),
      3 SK(30), TWP(250,30), XI(50), XNI(30), SIG(30)
      COMMON /GEM/ AS, EIG, FORCE, FORCE2, SK, MAP, NTR, NTC
      COMMON /MIX/ EFH, PM, QI, G, NDUS, NSPLIT
      COMMON /VJT/ DMC, OLD, FDM, XJP, ANI, XI, DD3IP, SPLIT
      COMMON /TRU/ IKU, KEY, VI
      EQUIVALENCE (GUL(1),DMC), (TWP(1,1),QI(1,1))
      ABS(X)=DABS(X)
      DO 10 I=1,250
      6(I)=0.0
      FORCE(1)=0.0
      10 FORCE2(1)=0.0
      DO 15 I=1,250
      DO 15 J=1,30
      6(I,J)=0.0
      CALL DLUALM(GUL,1)
      ND03=DD03TH+.1
      NTP=2
      135 MEAND NTP
      HEAD (NTP) NTR, NTC
      NSPLIT=SPILL+.00001
      NTRIG=0
      DO 20 I=1,NTC
      SIG(1)=0.
      6(I)=0
      IF (NSPLIT,EO,0) NI(I)=XNI(1)+.0001
      20 CONTINUE
      200 CONTINUE
      NC=1
      11=1
      12=1
      30 HEAD (NTP) (C(1),I=1,NTR)
      IF (C(12),EQ,11) GO TO 40
      11=11+1
      IF (11,GT,NTC) GO TO 60
  
```


ISN 0041	GO TO 30	00400000
ISN 0042	30 CONTINUE	00410000
ISN 0043	DO 50 J=1,NTR	00420000
ISN 0044	50 J(I,J,NC) = C(J)	00430000
ISN 0045	IF(I1,EU,NTC) GO TO 60	00440000
ISN 0046	NC = NC + 1	00450000
ISN 0047	I1 = I1 + 1	00460000
ISN 0048	I2 = I2 + 1	00470000
ISN 0049		00480000
ISN 0050	GO TO 30	00490000
ISN 0051	60 READ (NTP) MAP	00500000
ISN 0052	READ (NTP) AS	00510000
ISN 0053	READ (NTP) EIG	00520000
ISN 0054	DO 65 I=1,NTC	00530000
ISN 0055	J=K(I,J)	00540000
ISN 0056	IF(NTRIG,EU,1,0,NTRIG,EU,2)J=N1(I)	00550000
ISN 0057	IF(J,NE,0) GO TO 67	00560000
ISN 0058	EIG(I)=C	00570000
ISN 0059	GO TO 65	00580000
ISN 0060	67 EIG(I)=ABS(EIG(J))	00590000
ISN 0061	IF(NTRIG,EU,0)EIG(I)=EIG(I)	00600000
ISN 0062	65 CONTINUE	00610000
ISN 0063	IF(SPLIT,EU,0) GO TO 70	00620000
ISN 0064	IF(NTRIG,EU,2) GO TO 63	00630000
ISN 0065	IF(NTRIG,EU,1) GO TO 69	00640000
ISN 0066	DMG2=DMG**2	00650000
ISN 0067	IF(DMG2,LT,EIG(I)) GO TO 64	00660000
ISN 0068	REIND NTP	00670000
ISN 0069	READ(NTP)NTR,NTC	00680000
ISN 0070	DO 61 I=1,250	00690000
ISN 0071	DO 61 J=1,30	00700000
ISN 0072	61 U(I,J)=0.	00710000
ISN 0073	NTRIG=1	00720000
ISN 0074	DO 62 I=1,30	00730000
ISN 0075	IF(EIG(I),GT,DMG2) GO TO 200	00740000
ISN 0076	62 N1(I)=N1(I)+.0001	00750000
ISN 0077	69 NTRIG=2	00760000
ISN 0078	GO TO 70	00770000
ISN 0079	63 NTRIG=0	00780000
ISN 0080	GO TO 70	00790000
ISN 0081	64 NTRIG=2	00800000
ISN 0082	WRITE(5,301)	00810000
ISN 0083	CALL DLOADR(FORCE2,1)	00820000
ISN 0084	CALL DLOADR(FORCE2,1)	00830000
ISN 0085	301 FORMAT(1M1,10X,'TIME FORCING FREQUENCY IS LESS THAN ALL THE EIGENVA	00840000
ISN 0086	VALUES')	00850000
ISN 0087	GO TO 130	00860000
ISN 0088	70 DO 80 I=1,250	00870000
ISN 0089	DO 80 J=1,30	00880000
ISN 0090	P(I,J) = U(I,J)	00890000
ISN 0091	80 CONTINUE	00900000
ISN 0092	WRITE(10) OI	00910000
ISN 0093		00920000
ISN 0094		00930000
ISN 0095		00940000
ISN 0096		00950000
ISN 0097		00960000
ISN 0098		00970000
ISN 0099		00980000
ISN 0099		00990000

ISN 0100	C	06 90 I=1,NTM	00570000
ISN 0101		00 90 J=1,NTC	00580000
ISN 0102		90 FMP(I,J) = AS(I) * PH(I,J)	00590000
ISN 0103		00 110 I=1,NTC	00600000
ISN 0104		00 110 J=1,NTC	00610000
ISN 0105		EF*(I,J) = 0.0	00620000
ISN 0106		00 100 K=1,NTM	00630000
ISN 0107		100 EF*(I,J) = EFM(I,J) + FMP(K,I)*PH(K,J)	00640000
ISN 0108		110 CONTINUE	00650000
ISN 0109		00 120 I=1,NTC	00660000
ISN 0110		120 SM(I)=EF*(I,I)*SIG(I)	00670000
	C		00680000
ISN 0111		121 READ 10	00700000
ISN 0112		READ (10) U1	00710000
	C		00720000
ISN 0113		130 CALL DEL95	00721000
ISN 0114		135 IF(NSPLIT,EW,0) GO TO 131	00721200
ISN 0116		IF(NTRG,SE,2) GO TO 131	00721300
ISN 0118		00 134 I=1,NTC	00721400
ISN 0119		EIG(I)=SIG(I)	00721500
ISN 0120		134 N(I)=0	00721600
ISN 0121		J=1	00721700
ISN 0122		00 132 I=1,50	00721800
ISN 0123		IF(XN(I),EQ,0) GO TO 133	00721900
ISN 0124		IF(ELC(I),LE,UMG2) GO TO 132	00722000
ISN 0127		N(I)=XN(I)+.00001	00722100
ISN 0128		J=J+1	00722200
ISN 0129		132 CONTINUE	00722300
ISN 0130		137 WRITE(6,302)	00722350
ISN 0131		CALL DLOADR(FORCE,I)	00722360
ISN 0132		CALL DLOADR(FORCE2,I)	00722370
ISN 0133		302 FURNA(I,1),10X,"THE FORCING FREQUENCY IS GREATER THAN ALL THE EIGENVALUES"	00722380
		INVALUES"	00722390
ISN 0134		GO TO 131	00722400
ISN 0135		133 IF(M(I),EW,0) GO TO 137	00722410
ISN 0137		READ 11P	00722420
ISN 0138		HEAD(11P)HTK,NTC	00722430
ISN 0139		00 139 I=1,250	00722440
ISN 0140		00 139 J=1,30	00722450
ISN 0141		139 XI(I,J)=0,	00722460
ISN 0142		GO TO 200	00722470
ISN 0143		131 CONTINUE	00722480
ISN 0144		IF(NDU3,EW,1)NFLG=1	00722490
ISN 0146		CALL DLOADR(GUL,1)	00722500
ISN 0147		NDU3=DU3IP+.1	00722510
ISN 0148		IF(NFLG,EW,1) NDU3=0	00722520
ISN 0150		JUMP=JXP+.001	00722530
ISN 0151		IF(JUMP,EW,1) GO TO 135	00722540
ISN 0153		IF(JUMP,EW,2)RETURN	00722550
ISN 0155		GO TO 130	00722560
ISN 0156		END	00722570

LEVEL 21.7 (N 73)

US/360 FORTMAN M

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COMPIER OPTIONS = NAMES MAIN,OPT202,1,ECNT=50,SIZE=00004,
SOURCE,EBDDIC,NOLIST,NUDECK,LOAD,MAP,NUEDIT,1D,NOXNEF
THIS ROUTINE DOES THE WORK ORDINARILY
DONE BY D96.
MEMBER=NAME DB2FRP
ADDED TO SMI ON 17M,APRIL,1969
SUBROUTINE DEE96
IMPLICIT REAL*8(A-M,O-Z)
REAL*4 T
1 DIMENSION AS(250),CI(30),ZFL(30),TEFF(30),EPA(30,30),
2 EIG(30),FURLE(250),FURCE2(250),G(250),
3 MAP(250),PHI(250,30),UI(250,30),RCUS(30),
4 RSIN(30),SK(30),SHOOT(30),TMP(250,30),
5 XI(30),XNI(30),YSP(30,30),ZA(30),T(2)
6 DIMENSION RESLT(215)
7 DIMENSION AAA(215),BBB(215)
8 COMMON /GEM/ AS,TE16,FURLE,FURCE2,SK,MAP,M14,NTC
9 COMMON /NMX/ EFM,PH,WI,6,NUU3,NSPL1T
10 COMMON /VJT/ UMG,DLO,FON,XJP,XNI,XI
11 COMMON /TUM/ MAP1(250),NDM
12 COMMON /TKU/ KU,REY,N1(30)
13 EQUIVALENCE (YSP(1,1),EFM(1,1)),(TMP(1,1),T(1,1))
14 C 900 FORMAT ( 1M, 35X, 'SCLAHNA - JACKSON', / 36X, '( DB2 ',
15 'PROGRAM ' / 22X, 'DAMPED FORCED RESPONSE ',
16 'OF COMPLEX STRUCTURE' / )
17 901 FORMAT (40X,5HINPUT/84(1M-))
18 902 FORMAT (9X,17H NUMBER OF ROWS =10/9X,20H NUMBER OF COLUMNS=18/
19 9X, 25H TAPE/LAND INPUT OPTION = F4.1 / )
20 903 FORMAT(/,18X, 'EIGENVECTIONS DESIGNED',/(28X,15))
21 904 FORMAT (1X,63(1M-)/25X,13H EIGENVALUES 9X,15H MODAL DAMPING
22 /(28X,E12.6,12X,E12.6))
23 906 FORMAT (39X,7H MASSES/(9X,5E14,6))
24 907 FORMAT (17X,24H FINAL EFFECTIVE MASS MATRIX /64(1M-))
25 909 FORMAT (29X,14H PSEUDO-VALUES /12X,2M L 12X,2M K 10X,2M
26 2X,5H SINE 2X,2M F 2X,4M COS /13X,4M EFF 38X,4M EFF 8X,
27 4M EFF )
28 910 FORMAT (9X,E13.6,12X,E13.6,2X,E13.6,2X,E13.6)
29 911 FORMAT (/32X,21H EXCITING FREQUENCY =F15.5,6H KAO/SEC/84(1M-))
30 912 FORMAT (/3X,54H NODE 2X,13H SINE COMPONENT 2X,10H COSINE COMPONENT 2X,03770000
31 /)
32 913 FORMAT (5X,13,1X,F15.6,1X,F15.6, 15,6,1X,F8.2,6X,F9.5 )
33 925 FORMAT (34X,13H MODAL MATRIX )
34 926 FORMAT (/3X,54H NODE 2X,13H SINE COMPONENT 2X,10H COSINE COMPONENT 2X,03770000
35 /)
36 930 FORMAT (25X,33H OSCILLATORY FORCES FOR THIS CASE /1X,84(1M-)/17X,
37 8M FORCE
38 11M COMPONENTS /9X,4M KUM 7X,5H SINE 7X,7M COSINE )
39 941 FORMAT (10X,13,5X,E13.6,2X,E13.6)
40 942 FORMAT (29X,14H PSEUDO-VALUES /8X,14H FORCING FREQ,2X,

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ISN 0030	1	23H AMPLIFICATION	PHASE 9X, 10H AMPLITUDE 726X,	00470000
ISN 0031	2	23H FACTOR	ANGLE (RAD))	00480000
ISN 0032	935	FORMAT (5X,4F15.6)		00490000
	940	FORMAT (30X, 15M SINE COMPONENT)		00500000
	941	FORMAT (30X, 17M COSINE COMPONENT)		00510000
	C			00520000
	C			00530000
ISN 0033		ABS(X)=DABS(X)		00531000
ISN 0034		COS(X)=DCOS(X)		00532000
ISN 0035		SIN(X)=DSIN(X)		00533000
ISN 0036		ATN(X,Y)=DATAN2(X,Y)		00534000
ISN 0037		SQRT(X)=USQRT(X)		00535000
ISN 0038		WRITE (11) EFM,DI		00536000
ISN 0039		DO 10 J=1,NTC		00540000
ISN 0040		CI(J) = 0.0		00550000
ISN 0041		EIG(J) = ABS(EIG(J))		00560000
ISN 0042		SQRT(J) = SQRT(EIG(J))		00570000
ISN 0043		10 CONTINUE		00580000
ISN 0044		NDLO=DLO+.001		00581000
ISN 0045		IF(ASPLIT.EQ.1) GO TO 300		00581100
ISN 0047		IF(XJP.EQ.1.) GO TO 12		00582000
ISN 0049		300 DO 11 J=1,250		00584000
ISN 0050		11 G(J)=0.0		00586000
ISN 0051		12 CONTINUE		00588000
ISN 0052		IF(KEY.GT.0) GO TO 7000		00590000
ISN 0054		WRITE(7,67)		00591100
ISN 0055		IF(NON.GI.0)WRITE(8,67)		00591200
ISN 0057		67 FORMAT(' CONSTRAINT DATA=IMPOSED DISPLACEMENTS')		00591300
ISN 0058		7000 CONTINUE		00591400
ISN 0059		WRITE (6,900)		00600000
ISN 0060		WRITE (6,901)		00610000
ISN 0061		WRITE (6,902) NTR,NTC,1E5T		00620000
ISN 0062		WRITE(6,903)(NI(J),J=1,NTC)		00630000
ISN 0063		WRITE (6,904) (EIG(J),XI(J),J=1,NTC)		00640000
ISN 0064		WRITE(6,1000)(SQRT(J),J=1,NTC)		00641000
ISN 0065		1000 FORMAT(25X,'NATURAL FREQ RAD/SEC',/,(26X,E12.6,/))		00642000
ISN 0066		WRITE (6,900)		00650000
ISN 0067		WRITE (6,901)		00660000
ISN 0068		DO 30 I=1,NTR		00670000
ISN 0069		30 G(I) = G(I) + AS(I)		00680000
ISN 0070		WRITE (6,906) (G(J),J=1,NTR)		00690000
	C			00700000
ISN 0071		WRITE (6,900)		00710000
ISN 0072		WRITE (6,925)		00720000
ISN 0073		CALL MATPHN(PH,NTR,NTC,250,30)		00730000
ISN 0074		DO 40 I=1,NTR		00740000
ISN 0075		DO 40 J=1,NTC		00750000
ISN 0076		40 IMP(I,J) = 0.0		00760000
	C			00770000
	C			00780000
	C			00790000
	C			00800000
		CALCULATE PH I M PH I		

154 0126	WRITE (6,900)	01300000
154 0127	WRITE (6,900)	01310000
154 0128	COUNT = 0	01320000
154 0129	140 CONTINUE	01330000
154 0130	COUNT = COUNT + 1	01340000
154 0131	WRITE (6,910) VSP(I,I),CI(I),ZK(I),EF(I),EFC(I)	01350000
154 0132	150 CONTINUE	01360000
154 0133	PA = 0.11	01364000
154 0134	MEAN(I) = EFC(I)	01365000
154 0135	MEAN(I) = 11	01365500
		01370000
154 0136	IF (NDUS, EQ, 0) GO TO 175	01372000
154 0137	MEAN(I) = 1	01373000
154 0138	DO 172 J=1,NTC	01374000
154 0139	172 WRITE(I) (PM(I,J), I=1,NTN)	01375000
154 0140	175 CONTINUE	01376000
154 0141	WRITE (6,910)	01377000
154 0142	IF (U-G, 0.0, 104E=SHOOT(NOLU))	01378000
154 0143		01379000
		01380000
154 0145	155 WRITE (6,900)	01390000
154 0146	WRITE (6,911) DME	01400000
154 0147	WRITE (6,940)	01410000
154 0148	WRITE (6,952)	01420000
154 0149	DO 155 I=1,NTN	01421000
154 0150	MSIN(I)=0.	01422000
154 0151	1555 RCUS(I)=0.	01423000
154 0152	DO 160 I=1,NTC	01430000
154 0153	IF (SHOOT(I), EQ, 0.) GO TO 160	01431000
154 0154	BETA = UME/SHOOT(I)	01440000
154 0155	PA = 1.-BETA*BETA	01450000
154 0156	MB = 2.*XI(I)*BETA	01460000
154 0157	XMU = 1./SUM(CA*PA+MB*MB)	01470000
154 0158	PMI = ATN(MB,PA)	01480000
154 0159	IF (ZK(I), EQ, 0.) GO TO 156	01485000
154 0160	M = XMU*EFC(I)/ZK(I)	01490000
154 0161	GO TO 157	01493000
154 0162	156 M=0.	01494000
154 0163	157 CONTINUE	01495000
154 0164	MSIN(I) = R*SIN(PMI)	01500000
154 0165	RCUS(I) = R*COS(PMI)	01510000
154 0166		01520000
154 0167		01530000
	WRITE OUT BETA,XMU,PMI,M	01540000
		01550000
154 0168	WRITE (6,935) BETA,XMU,PMI,M	01560000
154 0169	160 CONTINUE	01570000
154 0170	WRITE (6,900)	01580000
154 0171	WRITE (6,941)	01590000
154 0172	WRITE (6,932)	01600000
154 0173	DO 170 I=1,NTC	01610000
154 0174	IF (SHOOT(I), EQ, 0.) GO TO 170	01620000
154 0175	BETA = UME/SHOOT(I)	
154 0176	PA = 1.-BETA*BETA	
154 0177		

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15N 0178      RB = 2,XT(1),BETA      01630000
15N 0179      XMU = 1,SOHT(PA*PA+MB*MB)      01640000
15N 0180      PHI = ATN(MB,PA)      01650000
15N 0181      IF(ZK(1),EQ,0,0) GO TO 161      01655000
15N 0183      R = XMU*EPC(1)/ZK(1)      01660000
15N 0184      GO TO 162      01665000
15N 0185      161 R=0,0      01665000
15N 0186      162 CONTINUE      01669000
15N 0187      RCM(1) = MSIN(1) = K*COS(PHI)      01670000
15N 0188      RCOS(1) = PCOS(1) = R*SIN(PHI)      01670000
15N 0189      WRITE (6,933) BETA,XMU,PHI,R      01670000
15N 0190      170 CONTINUE      01700000
C
15N 0191      KOUNT = 0      01700000
15N 0192      WRITE (6,900)      01700000
15N 0193      00 200 I=1,NTH      01700000
15N 0194      A=0,0      01700000
15N 0195      B=0,0      01701000
15N 0196      C=0,0      01702000
15N 0197      GL=0,0      01703000
15N 0198      DO 180 J=1,NTC      01704000
15N 0199      A = A + PH(I,J)*MSIN(J)      01800000
15N 0200      B = B + PH(I,J)*RCOS(J)      01810000
15N 0201      PHZATNI(A,B)      01820000
15N 0202      IF(PH*LT,0) PHZ=PH*+6,2831852      01830000
15N 0203      PHZ=PH*+57,24574      01835000
15N 0205      IF (ARS(PH),GT,360,0) PHZ = PHZ+360,0      01840000
15N 0206      C = SRT(A*A+B*B)      01850000
15N 0208      IF (MOD3,EQ,1) RESLT(I)=C      01855000
15N 0209      GL = CAUNE*ONE/386,0      01860000
15N 0211      C      01870000
C
C      WRITE OUT AP,SIN,COS,C
C
15N 0212      IF (KOUNT,LE,45) GO TO 190      01890000
15N 0214      WRITE (6,900)      01900000
15N 0215      WRITE (6,912)      01910000
15N 0216      KOUNT = 0      01920000
15N 0217      190 CONTINUE      01930000
15N 0218      NN = MAP(I)      01935000
15N 0219      NNJ=MAP1(I)      01935000
15N 0220      T(1)=A      01931010
15N 0221      T(2)=B      01931020
15N 0222      IF (KEY,LT,0) GO TO 69      01931030
15N 0224      WRITE (7,901)(1),T(2),NN,NN1      01931100
15N 0225      IF (NDM,GT,0) WRITE (8,65)(1),T(2),NN,NN1      01931200
15N 0227      65 FCHMA(11H ,',1',',F14,7',',22',',F14,7',',15',',F',11)      01931300
15N 0228      69 CONTINUE      01931400
15N 0229      WRITE (6,913) NN,A,B,C,PHR,GL      01960000
15N 0230      AAA(I)=A      01961000
15N 0231      BBS(I)=B      01962000
15N 0232      200 KOUNT = KOUNT + 1      01970000

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--ISN 0233	NETKEY=9	01970100
ISN 0234	IKU=IKU+1	01970200
ISN 0235	WRITE(12)((AAA(I),I=1,NTR),(BBB(I),I=1,NTR))	01970300
--ISN 0236	IF(ND03.EQ.1) WRITE(1) (RESLT(J),J=1,NTR)	01970500
ISN 0238	UME = UME + DLO	01971000
ISN 0239	IF(OME.LE.FOM) GO TO 155	01972000
--ISN 0241	IF(ND03.EQ.1) REWIND 1	01973000
ISN 0243	WRITE(7,66)	01974000
ISN 0244	IF(ND03.GT.0) WRITE(8,60)	01975000
--ISN 0246	66 FORMAT(' END BLOCK INPUT',7,'END ASSEMBLY',7,'BEGIN ANALYSIS',7,7,7,'END ANALYSIS',7,7,7)	01976000
	1 PERFORM A SINGLE ASSEMBLY SAM ANALYSIS	01977000
	IF(ND03.GT.0) WRITE(8,60)	01977100
ISN 0247	IF(ND03.GT.0) WRITE(8,60)	01977200
--ISN 0249	68 FORMAT(' END OF ASTRA DECK')	01978000
ISN 0250	RETURN	01980000
ISN 0252	END	01990000
--ISN 0253		

LEVEL 21.7 IN 73)

05/360 FORTRAN M

COMPILER OPTIONS = NAME= MAINOPT=02,LIMCNT=54,SIZE=0000,
SOURCE,EMCOIC,NOLIST,MODECK,LOAD,MAP,NUEBIT,ID,NOXREF

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C      MEMBER NAME STAMESKT
C      SOURCE MEMBER NAME      D82RESKT
C
ISN 0002      SUMMUTINE RESORT (XRX)
ISN 0003      IMPLICIT REAL*8(A-H,O-Z)
C
ISN 0004      DIMENSION XRX(12,12),EXT(12,12),TEMP(12,12)
C
ISN 0005      DO 1 I=1,12
ISN 0006      DO 1 J=1,12
ISN 0007      1 EXT(I,J)=0.0
C
ISN 0008      EXT(1,1)=1.
ISN 0009      EXT(2,2)=1.
ISN 0010      EXT(3,3)=1.
ISN 0011      EXT(4,4)=1.
ISN 0012      EXT(5,5)=1.
ISN 0013      EXT(6,6)=1.
ISN 0014      EXT(7,7)=1.
ISN 0015      EXT(8,8)=1.
ISN 0016      EXT(9,9)=1.
ISN 0017      EXT(10,10)=1.
ISN 0018      EXT(11,11)=1.
ISN 0019      EXT(12,12)=1.
C
ISN 0020      DO 20 I=1,12
ISN 0021      DO 20 J=1,12
ISN 0022      TEMP(I,J)=0.0
ISN 0023      DO 20 K=1,12
ISN 0024      20 TEMP(I,J)=TEMP(I,J)+EXT(I,K)*XRX(K,J)
C
ISN 0025      DO 30 I=1,12
ISN 0026      DO 30 J=1,12
ISN 0027      XRX(I,J)=0.0
ISN 0028      DO 30 K=1,12
ISN 0029      30 XRX(I,J)=XRX(I,J)+TEMP(I,J)+TEMP(I,K)*EXT(J,K)
ISN 0030      RETURN
ISN 0031      END

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LEVEL 21.7 JAN 73)

US/360 FORTMAN M

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COMPILER OPTIONS = NAME=MAIN,OPT=02,LINECNT=54,SIZE=0000K,
SOURCE,BCDIC,NOLIST,NOVECK,LOAD,MAP,NOEDIT,ID,NOXREF
C MEMBER NAME S74APLOR
C SOURCE MEMBER NAME D8ZLOADR
C
ISN 0002 SUBROUTINE LOADM(ARRAY,NUDE)
ISN 0003 REAL*8 DUMY2,003TP
ISN 0004 COMMON /LINK/ DUMY(200),EVSAVE
ISN 0005 COMMON/VT/DUMY2(64),D03TP
ISN 0006 DIMENSION CARD(5),TITLE(19),ARRAY(1)
ISN 0007 GO TO (100,200),NUDE
ISN 0008 CONTINUE
ISN 0009 100 READ(5,101)NSUB,NOPC,CARD
ISN 0010 101 FORMAT(14,11,5E14,7)
ISN 0011 IF(NSUB)303,303,106
ISN 0012 IF(NOPC)303,303,107
ISN 0013 106 IF(NOPC=5)109,303,108
ISN 0014 107 IF(NOPC=8)102,111,112
ISN 0015 108 IF(NOPC=1)102,111,112
ISN 0016 109 DO 110 JCARD=1,NOPC
ISN 0017 JCARD=NSUB+JCARD-1
ISN 0018 110 ARRAY(JCARD)=CARD(JCARD)
ISN 0019 GO TO 105
ISN 0020 102 READ(5,103)TITLE
ISN 0021 103 FORMAT(16,17A4,A2)
ISN 0022 IF(TITLE(1))301,104,301
ISN 0023 104 NPAGE=0
ISN 0024 GO TO 105
ISN 0025 111 RETURN
ISN 0026 112 IF(D03TP.EQ.1.) STOP
ISN 0027 IF(EVSAVE.EQ.1.) STOP 13
ISN 0028 STOP 14
ISN 0029 200 NPAGE=NPAGE+1
ISN 0030 WRITE(6,201)(TITLE(N),N=2,19),NPAGE
ISN 0031 201 FORMAT(11,17A4,A2,6H PAGE ,15,77)
ISN 0032 RETURN
ISN 0033 301 WRITE(6,302)
ISN 0034 302 FORMAT(20H INVALID HEADER CARD)
ISN 0035 STOP
ISN 0036 303 WRITE(6,304)NSUB,NOPC,ARRAY
ISN 0037 304 FORMAT(19H INVALID DATA CARD ,14,11,5E14,7)
ISN 0038 STOP
ISN 0039 END
ISN 0040
0010000
0010200
0010400
0010500
0011000
0012000
0020000
0030000
0040000
0050000
0060000
0070000
0080000
0090000
0100000
0110000
0120000
0130000
0140000
0150000
0160000
0170000
0180000
0190000
0200000
0210000
0210400
0210500
0220000
0230000
0240000
0250000
0260000
0270000
0280000
0290000
0300000
0310000
0320000

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LEVEL 21.7 (IN 73)

OS/360 FORTRAN M

COMPILER OPTIONS = NAME= MAIN,OPT=02,LINECNT=54,SIZE=0000K,
SOURCE,ECCDIC,MOLIST,MUDECK,LOAD,MAP,MUEDIT,LD,NOXREF
C MEMBEN NAME S742UUT

ISN 0002	C	SURMUUT I E ZOUT (RU,IA,NN,NMAP)	00010000
ISN 0003	C	IMPLICIT REAL*8(A-M,O-Z)	00015000
ISN 0004	C	DIMENSION RD(I),NMAP(I)	00020000
ISN 0005	C	ABS(U)=DABS(U)	00025000
ISN 0006	C	DO 1 I =1A,NN	00030000
ISN 0007	C	IF ((ABS(MO(I))=1,E=1),LT,0.) RU(I)=0.0	00035000
ISN 0009	C	CONTINUE	00040000
ISN 0010	C	I=1A	00041000
ISN 0011	C	M=1	00045000
ISN 0012	C	M=0	00050000
ISN 0013	C	50 IF (RU(I),NE,0.) GO TO 20	00060000
ISN 0015	C	M=M+1	00070000
ISN 0016	C	IF (I,EG,NN) GO TO 10	00080000
ISN 0018	C	I=I+1	00090000
ISN 0019	C	GO TO 50	00100000
ISN 0020	C	10 RU(M)=FLOAT(MM)*1,E=6	00110000
ISN 0021	C	GO TO 60	00120000
ISN 0022	C	20 IF (MM,EQ,0) GO TO 21	00130000
ISN 0024	C	RO(M)=FLOAT(MM)*1,E=6	00140000
ISN 0025	C	M=M+1	00150000
ISN 0026	C	RO(M)=RO(I)	00160000
ISN 0027	C	GO TO 60	00170000
ISN 0028	C	21 RO(M)=RO(I)	00180000
ISN 0029	C	60 IF (I,EG,NN) GO TO 70	00190000
ISN 0031	C	I=I+1	00200000
ISN 0032	C	M=M+1	00210000
ISN 0033	C	M=0	00220000
ISN 0034	C	GO TO 50	00230000
ISN 0035	C	70 NMAP(NN)=M	00240000
ISN 0036	C	RETURN	00250000
ISN 0037	C	END	00260000

LEVEL 21.7 AM 73 J

US/360 FORTRAN M

COMPILER OPTIONS		NAME=	MAIN,OPT=027,INECNT=54,SIZE=0000K,
		SOURCE,ERRCUC,NOLIST,NOUECK,LOAD,MAP,NOEDIT,IO,NOAREF	
C	MEMBER NAME	S74SRCH	
C			
ISN 0002	SUBROUTINE SEARCH (MAP,NI,NORET,NTOTAL,NBOU,II)		00010000
ISN 0003	IMPLICIT REAL*8(A-H,O-Z)		00015000
			00020000
			00025000
			00030000
		LOOK-UP FOR II (START OF THE NODE IN MAP, RET OR RED)	00040000
			00050000
ISV 0004	DIMENSION MAP(1500)		00060000
ISN 0005	II=0		00070000
ISN 0006	IF (NBOU,NE,2) GO TO 3		00080000
ISV 0008	DO 1 I =1,NORET		00090000
ISN 0009	IF (NI,NE,MAP(I)) GO TO 1		00100000
ISN 0011	II=I		00110000
ISN 0012	GO TO 2		00120000
ISN 0013	1 CONTINUE		00130000
ISN 0014	GO TO 2		00140000
ISV 0015	3 J=NORET+1		00150000
ISN 0016	IF (NORET,II,NTOTAL) GO TO 2		00160000
ISN 0018	DO 4 I =J,NTOTAL		00170000
ISN 0019	IF (NI,NE,MAP(I)) GO TO 4		00180000
ISN 0021	II=I		00190000
ISN 0022	GO TO 2		00200000
ISN 0023	4 CONTINUE		00210000
ISN 0024	2 RETURN		00220000
ISN 0025	END		00230000

LEVEL 21.7 IAN 73)

OS/360 FORTRAN M

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COMPILER OPTIONS = NAMES NATN,OPT=02,LIRECNT=50,SIZE=0000K,
SOURCE,ERCOIC,MULLST,NUDECK,LOAD,MAP,MUEDIT,ID,NOXHEF
C MEMBER NAME SP7TRAFER
C
ISN 0002 SUBROUTINE TRAFER (NODE,MAP,NONET,NTOTAL,JU,NUNE,NTWO,ROW,ROW2,
1 VTYPE )
ISN 0003 1 IMPLICIT REAL*8(A-H,D-Z)
TRANSFER VARIABLES
C
ISN 0004 DIMENSION MAP(3000),NORE(250),NTWO(250),ROW(3000),ROW2(12),KK(6)
C
C UNPACK DUF NO.
C
ISN 0005 CALL UNPACK (NORE(NODE),NTWO(NODE),KK)
C
C FIND NODE IN MAP
C
ISN 0006 DO 5 I =1,2
C
C TO LOCATE NODE IN MAP WE CALL SEARCH,
C IN ORDER TO GET II (WHICH IS THE START OF THE NODE)
C NODE IN MAP RET. OR RED. PORTION)
ISN 0007 CALL SEARCH (MAP,NODE,NONET,NTOTAL,1 ,II)
ISN 0008 IF (II.EQ.0) GO TO 5
TRANSFER FROM ROW2 TO ROW
C
ISN 0010 DO 6 J =1,6
ISN 0011 IF (KK(J).NE.1) GO TO 6
ISN 0013 IF ((NTYPE.NE.4).AND.(J.GI.3)) GO TO 5
ISN 0015 J=JU+J
ISN 0016 ROW(II)=ROW2(JE)+ROW(II)
ISN 0017 II=II+1
ISN 0018 6 CONTINUE
ISN 0019 5 CONTINUE
ISN 0020 RETURN
ISN 0021 END

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LEVEL 21.7 IAN 73 J

US/360 PUMTRAN H

COMPILER OPTIONS: NAME= MAINTOP1=02,LINECNT=54,SIZE=0000K,
SOURCE,ERCOIC,NOLIST,MODECA,LOAD,MAP,NOEDIT,10,NOXREF

C	MEMBER NAME	SYMBOL	
C			
ISN 0002	SUBROUTINE UNPACK (NUNE,NTWU,KA)		00010000
ISN 0003	IMPLICIT REAL*8(A-H,O-Z)		00015000
ISN 0004	DIMENSION KK(1)		00020000
ISN 0005	KK(1)=NUNE/100		00025000
ISN 0006	KK(2)=(NUNE-100*KK(1))/10		00030000
ISN 0007	KK(3)=NUNE-100*KK(1)-10*KK(2)		00040000
ISN 0008	KK(4)=TWU/100		00050000
ISN 0009	KK(5)=(TWU-100*KK(4))/10		00060000
ISN 0010	KK(6)=TWU-100*KK(4)-10*KK(5)		00070000
ISN 0011	RETURN		00080000
ISN 0012	END		00090000
			00100000
			00110000

LEVEL 21,7 'AN 73)

09/360 FORTRAN M

COMPILER OPTIONS = NAMES MAIN,OPT=02,LINECNT=54,SIZE=0000K,

SOURCE,EBDCIC,NOLIST,NODECK,LUAD,MAP,NOEDIT,ID,NOXREF

C MEMBER NAME 974SETUP

ISN 0002	C	SUBROUTINE SETUP(NTYPE,N1,N2,N3,E,TEMP,X,Y,Z,NONE,NTMU,XBK,IZ, 1 CF1,CF2)	00010000
ISN 0003	C	IMPLICIT REAL*8(A-H,D-Z)	00015000
ISN 0004	C	DIMENSION XBK(12,12),X(250),Y(250),Z(250),NUNL(4),NINU(4),TEMP(4)	00020000
ISN 0005	C	DO 100 I = 1,12	00021000
ISN 0006	C	DO 100 J = 1,12	00025000
ISN 0007	C	100 XBK(I,J)=0.0	00030000
ISN 0008	C	IF(NTYPE,NE,2) GO TO 24	00035000
ISN 0010	C	CALL STRING(X(N1),Y(N1),Z(N1),X(N2),Y(N2),Z(N2),E,TEMP(1), 1 XBK,CF1,CF2)	00040000
ISN 0011	C	IZ=6	00100000
ISN 0012	C	GO TO 30	00110000
ISN 0013	C	24 IF(NTYPE,NE,3) GO TO 25	00115000
ISN 0015	C	6ZE/12,*(1,TEMP(1))	00120000
ISN 0016	C	CALL SKIN (X(N1),Y(N1),Z(N1),X(N2),Y(N2),Z(N2),X(N3),Y(N3),Z(N3), E,G,TEMP(2),TEMP(3),TEMP(4),XBK,CF1,CF2)	00130000
ISN 0017	C	IZ=9	00140000
ISN 0018	C	GO TO 30	00150000
ISN 0019	C	25 IF(NTYPE,NE,4) GO TO 26	00160000
ISN 0021	C	CALL BEAM (X(N1),Y(N1),Z(N1),X(N2),Y(N2),Z(N2),X(N3),Y(N3),Z(N3), 1 E,TEMP(1),TEMP(2),TEMP(3),TEMP(4),XBK,CF1,CF2)	00170000
ISN 0022	C	IZ=12	00180000
ISN 0023	C	GO TO 30	00190000
ISN 0024	C	26 WRITE (6,10)	00200000
ISN 0025	C	10 FORMAT(4X,35MNTYPE NO. IN COLUMN 4 IS NOT 2,3OR4)	00210000
ISN 0026	C	30 CONTINUE	00220000
ISN 0027	C	RETURN	00230000
ISN 0028	C	END	00240000
			00250000
			00260000
			00270000
			00280000
			00290000
			00300000
			00310000
			00320000
			00330000
			00340000
			00350000
			00360000
			00370000
			00380000
			00390000
			00400000
			00410000

LEVEL 21.7 (AN 73)

US/360 FORTRAN M

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COMPILER OPTIONS = NAME= MAIN,OPT=02,LINENR=54,SIZE=0000N,
SOURCE,ECODIC,NOLIST,MODECM,LOAD,MAP,NOLDIT,IO,NOMREF
C MEMBER NAME 9748EAM
ISN 0002 SUBROUTINE BEAM(X1,Y1,Z1,X2,Y2,Z2,X3,Y3,Z3,E,AMU,Y1,XJ,AM,BMAT,
1 CF1,CF2)
ISN 0003 IMPLICIT REAL*8(A-H,O-Z)
ISN 0004 DIMENSION BMAT(12,12),UMF(6,12),BK(6,6),TEMP(6,12),D(3,3)
ISN 0005 DOUBLE PRECISION L1,T1,T17MU
C
ISN 0006 SORT(X) = USORT(X)
ISN 0007 ABS(X) = DABS(X)
ISN 0008 MU=AMU
ISN 0009 X31=X3-X1
ISN 0010 Y31=Y3-Y1
ISN 0011 Z31=Z3-Z1
ISN 0012 X12=X1-X2
ISN 0013 Y12=Y1-Y2
ISN 0014 Z12=Z1-Z2
ISN 0015 X13=X1-X3
ISN 0016 Y13=Y1-Y3
ISN 0017 Z13=Z1-Z3
ISN 0018 SU1=(1./Y1)
ISN 0019 SU3=(2./Y3)
C
ISN 0020 I1ZYI
ISN 0021 ASAM
ISN 0022 JISAJ
C
ISN 0023 SL= SORT(X12+Z3Y12+Z2+Z12+X2)
ISN 0024 G=Z/12.*Y1,AMU)
ISN 0025 S=0.
ISN 0026 IF(A.EQ.0.) GO TO 105
ISN 0027 S=0.12.*E+11)/(S+ASL+2)
ISN 0028 105 F=(0.*E+11)/(SL+0.1*(1.+SA))
C
C
C FORM 6X6 MATRIX BK
ISN 0030 DO 5 I=1,6
ISN 0031 DO 6 J=1,6
ISN 0032 6 BK(I,J)=0.
ISN 0033 5 CONTINUE
ISN 0034 BK(1,1)=2.*F+0.5*CF1/(5.*SL)
ISN 0035 BK(3,1)=SL*F-CF1/10.
ISN 0036 BK(4,1)=2.*F
ISN 0037 BK(6,1)=SL*F
C
ISN 0038 BK(2,2)=0.5*J/SL
ISN 0039 BK(5,2)=-(0.5*J)/SL

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ISV 0040	BK(I,J)=SU3*SL**2+P*(1,SA/4,)*Z,SL*CF1/15,	00500000
ISV 0041	BK(4,3)=SL*P	00510000
ISV 0042	BK(6,3)=SU3*SL**2+P*(1,SA/2,)	00520000
ISV 0043	BK(4,4)=2,PF+6,CF2/(5,SL)	00530000
ISV 0044	BK(6,4)=SL*P+CF2/10,	00540000
ISV 0045	BK(5,5)=6*J1/SL	00550000
ISV 0046	BK(6,6)=SU3*SL**2+P*(1,SA/4,)*Z,SL*CF2/15,	00560000
ISV 0047	DO I=1,6	00570000
ISV 0048	DO J=1,6	00580000
ISV 0049	BK(I,J)=P*(J,I)	00590000
ISV 0050	BK(4,1)=BK(4,1)-6,CF1/15,SL	00600000
ISV 0051	BK(1,4)=BK(1,4)-6,CF2/(5,SL)	00610000
ISV 0052	BK(6,1)=BK(6,1)-CF1/10,	00620000
ISV 0053	BK(1,6)=BK(1,6)-CF2/10,	00630000
ISV 0054	BK(4,5)=BK(4,5)+CF1/10,	00640000
ISV 0055	BK(3,4)=BK(3,4)+CF2/10,	00650000
ISV 0056	BK(6,5)=BK(6,5)-SL*CF1/30,	00660000
ISV 0057	BK(3,6)=BK(3,6)-SL*CF2/50,	00670000
	C CALCULATE DIRECTION COSINES	00680000
ISV 0058	X21=X2-X1	00690000
ISV 0059	Y21=Y2-Y1	00700000
ISV 0060	Z21=Z2-Z1	00710000
ISV 0061	UX=SU3*(X21**2+Y21**2+Z21**2)	00720000
ISV 0062	UX=X21/UX	00730000
ISV 0063	UY=X21/UY	00740000
ISV 0064	UZ=X21/UZ	00750000
ISV 0065	DO 100 J=1,3	00760000
ISV 0066	100 U(J,1)=1,	00770000
ISV 0067	U(1,2)=Y1	00780000
ISV 0068	U(2,2)=Y2	00790000
ISV 0069	U(3,2)=Y3	00800000
ISV 0070	U(2,3)=Z2	00810000
ISV 0071	U(1,3)=Z1	00820000
ISV 0072	U(3,3)=Z3	00830000
ISV 0073	CALL DET (0,A)	00840000
ISV 0074	DO 101 J=1,3	00850000
ISV 0075	101 U(J,2)=1,	00860000
	C	00870000
		00880000
		00890000
		00900000
		00910000
		00920000
		00930000

ISN 0076	D(1,1)=X1	00940000
ISN 0077	D(2,1)=X2	00950000
ISN 0078	D(3,1)=X3	00960000
ISN 0079	C CALL DET (D,B)	00970000
ISN 0080	C	00980000
ISN 0081	DO 102 J=1,3	00990000
	102 D(J,3)=1.	01000000
ISN 0082	C	01010000
ISN 0083	D(1,2)=Y1	01020000
ISN 0084	D(2,2)=Y2	01030000
ISN 0085	D(3,2)=Y3	01040000
ISN 0086	C	01050000
ISN 0087	C CALL DET (D,C)	01060000
ISN 0088	C	01070000
ISN 0089	BD=SQRT(A**2+B**2+C**2)	01080000
ISN 0090	XBY=A/BD	01090000
ISN 0091	YBY=B/BD	01100000
ISN 0092	ZBY=C/BD	01110000
ISN 0093	C	01120000
ISN 0094	XBZ=(YBX*ZBY)-(YBY*ZBX)	01130000
ISN 0095	YBZ=(XBY*ZBX)-(XBX*ZBY)	01140000
ISN 0096	ZBZ=(XBX*YBY)-(XBY*YBX)	01150000
ISN 0097	C	01160000
ISN 0098	DO 9 I=1,6	01170000
ISN 0099	DO 10 J=1,12	01180000
ISN 0100	10 OME(I,J)=0.0	01190000
ISN 0101	9 CONTINUE	01200000
ISN 0102	C	01210000
ISN 0103	OME(1,1)=XBZ	01220000
ISN 0104	OME(1,2)=YBZ	01230000
ISN 0105	OME(1,3)=ZBZ	01240000
ISN 0106	C	01250000
ISN 0107	OME(4,4)=XBZ	01260000
ISN 0108	OME(4,5)=YBZ	01270000
ISN 0109	OME(4,6)=ZBZ	01280000
ISN 0110	C	01290000
ISN 0111	OME(2,7)=XBZ	01300000
ISN 0112	OME(3,7)=YBZ	01310000
ISN 0113	OME(2,8)=YBX	01320000
ISN 0114	OME(3,8)=YBY	01330000
ISN 0115	OME(2,9)=ZBX	01340000
ISN 0116	OME(3,9)=ZBY	01350000
ISN 0117	C	01360000
ISN 0118	OME(5,10)=XBZ	01370000
ISN 0119	OME(5,11)=YBZ	01380000
ISN 0120	OME(5,12)=ZBX	01390000
ISN 0121	C	01400000
ISN 0122	OME(6,10)=XBZ	01410000
ISN 0123	OME(6,11)=YBZ	01420000
ISN 0124	OME(6,12)=ZBY	01430000
ISN 0125	C	01440000
ISN 0126		01450000

ISN 0115	C		01260000
ISN 0116		DO 3 I = 1,6	01470000
ISN 0117		DO 3 J = 1,12	01480000
		TEMP(I,J)=0.0	01490000
ISN 0118	C		01500000
ISN 0119		DO 3 K = 1,6	01510000
		3 TEMP(I,J)=TEMP(I,J)+BK(I,K)*OME(K,J)	01520000
ISN 0120	C		01530000
ISN 0121		DO 11 I = 1,12	01540000
ISN 0122		DO 11 J = 1,12	01550000
ISN 0123		BMAT(I,J)=0.0	01560000
		DO 13 K = 1,6	01570000
ISN 0124	C		01580000
ISN 0125		13 BMAT(I,J)=BMAT(I,J)+OME(K,I)*TEMP(K,J)	01590000
ISN 0126		IF (ABS(BMAT(I,J)).GT.1) GO TO 11	01600000
ISN 0127		BMAT(I,J)=0.0	01610000
ISN 0128	C	11 CONTINUE	01620000
ISN 0129		RETURN	01630000
ISN 0130		END	01640000
			01650000

LEVEL 21,7 JAN 73)

US/560 FORTRAN M

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COMPILER OPTIONS = NAME= MAIN,OPT=02,CTHRCNT=54,SIZE=0000K,
SOURCE,EBCDIC,NOLIST,NOUECR,LUAD,MAP,NOLDIT,ID,NOXHEF
C MEMBER NAME S74SHIFT
ISN 0002 SUBROUTINE SHIFT (N1,N2,N3,JJ,XBK)
ISN 0003 IMPLICIT REAL*8(A-M,U-Z)
ISN 0004 DIMENSION XBK(12,12),EXT(9,9),TEMP(9,9)
ISN 0005 DO 1 I=1,9
ISN 0006 DO 1 J=1,9
ISN 0007 1 EXT(I,J)=0.0
ISN 0008 IF ((N2.EQ.JJ).OR.(N3.EQ.JJ)) GO TO 2
ISN 0010 RETURN
ISN 0011 2 IF (N2.NE.JJ) GO TO 3
ISN 0013 DO 4 I=1,3
ISN 0014 J=1+3
ISN 0015 EXT(I,J)=I.
ISN 0016 4 EXT(J,I)=I.
ISN 0017 DO 5 I=7,9
ISN 0018 5 EXT(I,I)=1.
ISN 0019 18=N1
ISN 0020 N1=N2
ISN 0021 N2=18
ISN 0022 GO TO 10
ISN 0023 3 IF (N3.NE.JJ) GO TO 100
ISN 0025 DO 6 I=1,5
ISN 0026 J=1+6
ISN 0027 EXT(I,J)=I.
ISN 0028 6 EXT(J,I)=I.
ISN 0029 DO 7 I=7,9
ISN 0030 7 EXT(I,I)=I.
ISN 0031 18=N1
ISN 0032 N1=N3
ISN 0033 N3=18
ISN 0034 10 DO 11 I=1,9
ISN 0035 DO 11 J=1,9
ISN 0036 TEMP(I,J)=0.0
ISN 0037 DO 11 K=1,9
ISN 0038 11 TEMP(I,J)=TEMP(I,J)+EXT(I,K)*XBK(K,J)

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00010000
00015000
00020000
00025000
00030000
00040000
00050000
00060000
00070000
00080000
00090000
00100000
00110000
00120000
00130000
00140000
00150000
00160000
00170000
00180000
00190000
00200000
00210000
00220000
00230000
00240000
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00340000
00350000
00360000
00370000
00380000
00390000
00400000
00410000
00420000
00430000
00440000
00450000
00460000
00470000
00480000

ISN 0039	C	DO 12 I = 1,9	00490000
ISN 0040		DO 12 J = 1,9	00500000
ISN 0041	C	XBA(1,J)=0,0	00510000
ISN 0042	C	DO 12 K = 1,9	00520000
ISN 0043		12 XBA(I,J)=XBA(I,J)+TEMP(I,K)*EXT(J,K)	00530000
ISN 0044	C	100 RETURN	00540000
ISN 0045		END	00550000
			00560000
			00570000
			00580000
			00590000

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US/360 FORTRAN M

COMPILER OPTIONS - NAMES=MAINTCOT=02,LINECT=54,SIZE=0000K,
SUDCT=80000,MODLIST=NUDECA,LOAD,MAP,MODL17,1D,NOXREF

ISN	MEMBER NAME	SYNOPSIS	ADDRESS
ISN 0002	C	SUBROUTINE STRING(X1,Y1,Z1,X2,Y2,Z2,E,A,SMAT,CHI,C*2)	00010000
ISN 0003	C	IMPLICIT REAL*8(A-M-Z)	00015000
ISN 0004	C	DOUBLE PRECISION LAM,MO,NU,L	00020000
ISN 0005	C	DISPOSITION SMAT(12,12)	00025000
ISN 0006	C	SMAT(6)=SUSMT(6)	00030000
ISN 0007	C	L=SMAT((X2=X1)*2+(-2=Y1)*2+(Z2=Z1)*2)	00035000
ISN 0008	C	LAM=(X2=X1)/L	00040000
ISN 0009	C	MO=(Y2=Y1)/L	00045000
ISN 0010	C	NU=(Z2=Z1)/L	00050000
ISN 0011	C	SMAT(1,1)=LAM**2	00055000
ISN 0012	C	SMAT(2,2)=MO**2	00060000
ISN 0013	C	SMAT(3,3)=NU**2	00065000
ISN 0014	C	SMAT(4,4)=SMAT(1,1)	00070000
ISN 0015	C	SMAT(5,5)=SMAT(2,2)	00075000
ISN 0016	C	SMAT(6,6)=SMAT(3,3)	00080000
ISN 0017	C	SMAT(1,2)=MO*LAM	00085000
ISN 0018	C	SMAT(1,3)=MO*LAM	00090000
ISN 0019	C	SMAT(1,4)=(-LAM)*2	00095000
ISN 0020	C	SMAT(1,5)=(-MO*LAM)	00100000
ISN 0021	C	SMAT(1,6)=(-MO*LAM)	00105000
ISN 0022	C	SMAT(2,3)=MO*NU	00110000
ISN 0023	C	SMAT(2,4)=LAM*NU	00115000
ISN 0024	C	SMAT(2,5)=(-MO)*2	00120000
ISN 0025	C	SMAT(2,6)=(-MO)*2	00125000
ISN 0026	C	SMAT(3,4)=LAM*NU	00130000
ISN 0027	C	SMAT(3,5)=MO*NU	00135000
ISN 0028	C	SMAT(3,6)=(-NU)*2	00140000
ISN 0029	C	SMAT(4,5)=MO*LAM	00145000
ISN 0030	C	SMAT(4,6)=LAM*NU	00150000
ISN 0031	C	SMAT(5,6)=MO*NU	00155000
ISN 0032	C	DO 100 I=1,6	00160000
ISN 0033	C	DO 100 J=1,6	00165000
ISN 0034	C	100 SMAT(I,J)=SMAT(I,J)	00170000
ISN 0035	C	DO 105 I=1,6	00175000
ISN 0036	C	DO 105 J=1,6	00180000
ISN 0037	C	105 SMAT(I,J)=(A+E)/L*SMAT(I,J)	00185000
ISN 0038	C	XI=CHI/L	00190000
ISN 0039	C	XI2=CF2/L	00195000
ISN 0040	C	SMAT(1,1)=SMAT(1,1)+(1=LAM*LAM)*XI	00200000
ISN 0041	C	SMAT(1,2)=SMAT(1,2)-LAM*MO*XI	00205000
ISN 0042	C	SMAT(1,3)=SMAT(1,3)-LAM*NU*XI	00210000

LEVEL 21.7 JAN 73)

US/360 FORTRAN H

LC-PILER OPTIONS = NAME= MAIN,OPT=02,LTRECN=53,SIZE=00000,

SOURCE=ECCLIC,NOLIST,NODECK,LOAD,MAP,NODEIT,IO,NODEF

MEMBER NAME: STASKIN

ISN 0002	C	SUBROUTINE SKIN (X1,Y1,Z1,X2,Y2,Z2,X3,Y3,Z3,E6,I9,IY,XMU,IMAT)	00010000
ISN 0003	C	IMPLICIT REAL*8(A-M,U=Z)	00015000
ISN 0004		DIMENSION TRAT(12,12),D(3,3),DME(9,9),TBK(6,6),TEMP(6,9),XX(9),X(6)	00020000
ISN 0005		DOUBLE PRECISION MU	00025000
ISN 0006	C	DO=SQRT((X2-X1)**2+(Y2-Y1)**2+(Z2-Z1)**2)	00030000
ISN 0007		ABS(X)=DSORT(X)	00040000
ISN 0008		ABS(X)=DABS(X)	00050000
ISN 0009		MU=DMU	00060000
ISN 0010		DO=SQRT((X2-X1)**2+(Y2-Y1)**2+(Z2-Z1)**2)	00070000
ISN 0011		COS2DME=(X2-X1)/DO	00080000
ISN 0012	C	COS2DME=(X2-X1)/DO	00090000
ISN 0013		I=1	00100000
ISN 0014		DO 5 J=1,3	00110000
ISN 0015	C	5 D(J,1)=1.	00120000
ISN 0016		D(1,2)=Y1	00130000
ISN 0017		D(2,2)=Y2	00140000
ISN 0018		D(3,2)=Y3	00150000
ISN 0019		D(1,3)=Z1	00160000
ISN 0020		D(2,3)=Z2	00170000
ISN 0021	C	D(3,3)=Z3	00180000
ISN 0022	C	CALL DET (D,A1)	00190000
ISN 0023	C		00200000
ISN 0024		D(1,1)=X1	00210000
ISN 0025	C	D(2,1)=X2	00220000
ISN 0026		D(3,1)=X3	00230000
ISN 0027		I=2	00240000
ISN 0028	C	DO 6 J=1,3	00250000
ISN 0029	C	6 D(J,1)=1.	00260000
ISN 0030		CALL DET (D,B)	00270000
ISN 0031	C		00280000
ISN 0032		I=3	00290000
ISN 0033		DO 7 J=1,3	00300000
ISN 0034	C	7 D(J,1)=1.	00310000
ISN 0035		D(1,2)=Y1	00320000
ISN 0036	C	D(2,2)=Y2	00330000
ISN 0037		D(3,2)=Y3	00340000
ISN 0038	C	CALL DET (D,C)	00350000
ISN 0039	C		00360000
ISN 0040			00370000
ISN 0041			00380000
ISN 0042			00390000
ISN 0043			00400000
ISN 0044			00410000
ISN 0045			00420000
ISN 0046			00430000
ISN 0047			00440000
ISN 0048			00450000
ISN 0049			00460000


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C
ISN 0037      C      U1=SU-T(A1)*2*H**2-C**2)
ISN 0038      COSXZ=A1/G1
ISN 0039      COSYH=H/G1
ISN 0040      COSZN=C/G1
C
ISN 0041      C      COSXNY=COSYH*Z+COSZHX=COSYHX+COSZHZ
ISN 0042      COSYH=COSZHZ+COSYHX=COSZHX+COSYHZ
ISN 0043      COSZNY=COSXZ+COSYH*Z=COSXHZ+COSYHZ
C
C      *** FOUR 6x9 MATRIX UME ***
C
C      DO 8 I=1,8
C      DO 9 J=1,9
C      9  UME(I,J)=0.0
C      8  CONTINUE
C
ISN 0044      C      UME(1,1)=COSXHX
ISN 0045      UME(1,2)=COSYHX
ISN 0046      UME(1,3)=COSZHX
ISN 0047      UME(2,1)=COSXHY
ISN 0048      UME(2,2)=COSYHY
ISN 0049      UME(2,3)=COSZHY
ISN 0050      UME(3,1)=COSXHX
ISN 0051      UME(3,2)=COSYHX
ISN 0052      UME(3,3)=COSZHX
ISN 0053      UME(4,1)=COSXHY
ISN 0054      UME(4,2)=COSYHY
ISN 0055      UME(4,3)=COSZHY
ISN 0056      UME(5,1)=COSXHX
ISN 0057      UME(5,2)=COSYHX
ISN 0058      UME(5,3)=COSZHX
ISN 0059      UME(6,1)=COSXHY
ISN 0060      UME(6,2)=COSYHY
ISN 0061      UME(6,3)=COSZHY
ISN 0062      UME(7,1)=COSXHX
ISN 0063      UME(7,2)=COSYHX
ISN 0064      UME(7,3)=COSZHX
ISN 0065      UME(8,1)=COSXHY
ISN 0066      UME(8,2)=COSYHY
ISN 0067      UME(8,3)=COSZHY
C
C      *** FOUR 6x6 MATRIX BA ***
C
ISN 0068      C      BA(1)=X1
ISN 0069      BA(2)=Y1
ISN 0070      BA(3)=Z1
ISN 0071      BA(4)=X2
ISN 0072      BA(5)=Y2
ISN 0073      BA(6)=Z2

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ISN 0072	XX(7)=Z3	00900000
ISN 0073	XX(8)=Y3	01000000
ISN 0074	XX(9)=Z3	01010000
		01020000
ISN 0075	DO 70 I = 1,6	01030000
ISN 0076	X(1)=0,0	01040000
ISN 0077	GO 70 J = 1,9	01050000
ISN 0078	70 X(1)=X(1)+0.5*(J,J) *XX(J)	01060000
ISN 0079	X(2)=X(1)-X(3)	01070000
ISN 0080	X(3)=X(1)-X(5)	01080000
ISN 0081	X(2)=X(2)	01090000
ISN 0082	X(3)=X(3)-X(5)	01100000
ISN 0083	X(3)=X(3)	01110000
ISN 0084	X(2)=X(5)-X(3)	01120000
ISN 0085	Y(2)=X(2)-X(4)	01130000
ISN 0086	Y(3)=X(2)-X(6)	01140000
ISN 0087	Y(2)=Y(2)	01150000
ISN 0088	Y(3)=Y(3)	01160000
ISN 0089	Y(3)=X(4)-X(6)	01170000
ISN 0090	Y(2)=Y(2)	01180000
		01190000
		01200000
ISN 0091	A=5*(X(2)+Y(3)-Y(2)+X(5))	01210000
ISN 0092	GO 150/(A,A)	01220000
		01230000
ISN 0093	GX=0	01240000
ISN 0094	GY=0	01250000
ISN 0095	IF(TX,EO,0) GO 10 105	01260000
ISN 0097	GY=0.5 *Y/Y	01270000
		01280000
ISN 0098	105 IF(TX,LT,TV) GO 10 50	01290000
		01300000
ISN 0100	GX=0	01310000
ISN 0101	IF(TX,EO,0) GO 10 200	01320000
ISN 0103	GX=0.5 *Y/Y	01330000
ISN 0104	200 GY=0	01340000
		01350000
ISN 0105	50 CONTINUE	01360000
		01370000
ISN 0106	TX=TX*(1+0.5*GX)	01380000
ISN 0107	TX=TX*(1+0.5*GX)	01390000
		01400000
ISN 0108	BK(1,1)=TX*(23+2+0.5*X(2)+2	01410000
ISN 0109	BK(2,1)=Y(2)+X(2)*(Y+0.5)	01420000
ISN 0110	BK(3,1)=TX*(31+Y(23+0.5*X(2)+2	01430000
ISN 0111	BK(4,1)=TX*(Y+X(3)+Y(23+0.5*X(2)+2	01440000
ISN 0112	BK(5,1)=TX*(12+Y(23+0.5*X(2)+2	01450000
ISN 0113	BK(6,1)=TX*(Y+X(21+Y(23+0.5*X(2)+2	01460000
		01470000
ISN 0114	BK(2,2)=TX*(32+2+0.5*Y(23+2	01480000
ISN 0115	BK(3,2)=TX*(6+Y(31+X(2)+0.5*X(3)+Y(23	01490000
ISN 0116	BK(4,2)=TX*(3+X(32+0.5*Y(31+Y(23	01500000

```

1SN 0117-----BK(5,2)=EX*GX*Y12*X32+G0*X21*Y23-----01070000
1SN 0118-----BK(7,2)=EY*X21*X32+G0*Y12*Y23-----01000000
C-----01000000
1SN 0119-----BK(3,3)=EX*Y31*X2+G0*X13*X2-----01500000
1SN 0120-----BK(4,3)=EY*GX*X13*Y31+G0*Y31*X13-----01510000
1SN 0121-----BK(5,3)=EX*Y12*Y31+G0*X21*X13-----01520000
1SN 0122-----BK(6,3)=EY*GX*X21*Y31+G0*Y12*X13-----01530000
C-----01540000
1SN 0123-----BK(4,4)=EX*X13*X2+G0*Y31*X2-----01550000
1SN 0124-----BK(5,4)=EX*GX*X13*Y12+G0*X21*Y31-----01560000
1SN 0125-----BK(6,4)=EY*X21*X13+G0*Y12*Y31-----01570000
C-----01580000
1SN 0126-----BK(5,5)=EX*Y12*X2+G0*X21*X2-----01590000
1SN 0127-----BK(6,5)=EY*X21*Y12*(EY*GX+G0)-----01600000
C-----01610000
1SN 0128-----BK(6,6)=EY*X21*X2+G0*Y12*X2-----01620000
C-----01630000
1SN 0129-----DO 100 I=1,9-----01640000
1SN 0130-----DO 100 J=1,9-----01650000
1SN 0131-----100 BK(I,J)=BK(J,I)-----01660000
1SN 0132-----DO 10 I=1,9-----01670000
1SN 0133-----DO 10 J=1,9-----01680000
1SN 0134-----TEMP(I,J)=0.0-----01690000
1SN 0135-----DO 10 K=1,9-----01700000
C-----01710000
1SN 0136-----10 TEMP(I,J)=TEMP(I,J)+BK(I,K)*OME(K,J)-----01720000
C-----01730000
1SN 0137-----DO 11 I=1,9-----01740000
1SN 0138-----DO 11 J=1,9-----01750000
1SN 0139-----TEMP(I,J)=0.0-----01760000
1SN 0140-----DO 5 K=1,9-----01770000
C-----01780000
1SN 0141-----5 TEMP(I,J)=TEMP(I,J)+OME(K,I)*TEMP(K,J)-----01790000
1SN 0142-----IF (ABS(TEMP(I,J)),GT,.1) GO TO 11-----01800000
1SN 0143-----TEMP(I,J)=0.0-----01810000
1SN 0144-----11 CONTINUE-----01820000
1SN 0145-----RETURN-----01830000
1SN 0146-----END-----01840000
1SN 0147

```

11

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00051000
00007000
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00029000
00025000

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02070000

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05/360 FUMIKAWA H

[illegible]

ISN 0036	DO 40 I=1,N	00673000
ISN 0037	ISN=N=NMAP(NNN)	00675000
ISN 0038	HEAD(NTAPEA) (MU(K),K=1,ISEND)	00677000
ISN 0039	ISEND=NNN	00679000
ISN 0040	CALL ZINCRO,1,ISEND,ISEND)	00680000
ISN 0041	WRITE(NTAPEB) (MU(J),J=1,NNR)	00681000
ISN 0042	40 NNR=NNN-1	00683000
ISN 0043	60 NNR=NNN-1	00685000
ISN 0044	60 NNR=NNN-1	00687000
ISN 0045	60 NNR=NNN-1	00689000
	GO TO 500	00690000
		00692000
		00694000
		00696000
		00698000
		00699000
ISN 0046	61 CONTINUE	00700000
ISN 0047	CALL REDUCE(FIN,N,NH,NTAPEA,NTAPEB,MU,NMAP,NUNET)	00702000
		00704000
		00706000
		00708000
		00710000
		00712000
		00714000
		00716000
		00718000
		00720000
		00722000
		00724000
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		00728000
		00730000
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		00762000
		00764000
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		00780000
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		00796000
		00798000
		00800000
		00802000
		00804000
		00806000
		00808000
		00810000
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		00842000
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		00864000
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		00868000
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		00872000
		00874000
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		00878000
		00880000
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		00888000
		00890000
		00892000
		00894000
		00896000
		00898000
		00900000
		00902000
		00904000
		00906000
		00908000
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		00954000
		00956000
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		00990000
		00992000
		00994000
		00996000
		00998000
		00999000

LEVEL 21. JAN 73)

US/360 FORTRAN H

COMPILER OPTIONS = NAME= NAIN,OPT=02,CIRECT=54,SIZE=0000K,
SOURCE,EBCDIC,NOLIST,MODECK,LOAD,MAP,MODED11,ID,NOKREF

C MEMBER NAME 374REDC

C

ISN 0002	SUBROUTINE REDUCE(FIX,N,N,N,NTAPEA,NTAPEB,MO,NMAP,NORET)	00010000
ISN 0003	IMPLICIT REAL*8(S=8,O=2)	00020000
ISN 0004	DIMENSION MO(1),FIX(1),NMAP(1)	00030000
ISN 0005	A=FIX(NN)	00040000
ISN 0006	NN=N	00050000
ISN 0007	WRITE(NORET,1)	00060000
ISN 0008	DO 9 I=1,N	00070000
ISN 0009	ISEND=NMAP(NN)	00080000
ISN 0010	READ(NTAPEA) (RO(K),K=1,ISEND)	00090000
ISN 0011	IF(FIX(NN).EQ.0..AND,NN,NE,NK1) GO TO 78	00100000
ISN 0012	ISEND=NN	00110000
ISN 0013	CALL ZIN(RO,1,ISEND,IBEND)	00120000
ISN 0014	II=1	00130000
ISN 0015	N=FIX(NN)	00140000
ISN 0016	AA=6/A	00150000
ISN 0017	DO 11 J=1,NN	00160000
ISN 0018	MO(1)=RO(1)=FIX(J)*AA	00170000
ISN 0019	11 II=II+1	00180000
ISN 0020	IF(NN.EQ,NK1) GO TO 88	00190000
ISN 0021	CALL ZOUT2(RO,1,IBD8,NMAP)	00200000
ISN 0022	78 IBD8=NMAP(NN)	00210000
ISN 0023	88 WRITE(NTAPEB) (MO(L),L=1,IBD8)	00220000
ISN 0024	9 NN=NN-1	00230000
ISN 0025	RETURN	00240000
ISN 0026	END	00250000
ISN 0027		00260000
ISN 0028		00270000
ISN 0029		00280000

LEVEL 21,7 JAN 73)

US/360 FORTIAN H

COMPILEH OPTIONS - NAMES=MAIN,OPT=02,LINECNT=50,SIZE=0000K,
SOURCE=EMEDIC,NOLIST,NUDECK,LOAD,MAP,NODEIT,ID,NODEF

	C	MEMBER NAME	370ZIN	
ISN 0002	C	SUBROUTINE ZIN	(K0,ISST,ISEND,ISEND)	00010000
ISN 0003		IMPLICIT REAL*8(A-H,D=2)		00015000
ISN 0004		DIMENSION KO(1)		00020000
ISN 0005		ABS(A)=DABS(X)		00025000
ISN 0006		50 IF (ABS(KO(ISEND)),GT,1,D=2) GO TO 40		00030000
ISN 0008	C	NK5=K0(ISEND)*1.06+.1		00031000
ISN 0009	C	DO 20 I=1,NK5		00040000
ISN 0010	C	KO(ISEND)=0.0		00050000
ISN 0011		IF (1.E0,NK5) GO TO 30		00060000
ISN 0013	C	20 ISEND=ISEND+1		00070000
ISN 0014	C	40 KO(ISEND)=K0(ISEND)		00080000
ISN 0015	C	30 IF (ISEND.EQ,ISST) RETURN		00090000
ISN 0017	C	ISEND=ISEND+1		00100000
ISN 0018		ISEND=ISEND+1		00110000
ISN 0019		GO TO 50		00120000
ISN 0020	C	END		00130000
				00140000
				00150000
				00160000
				00170000
				00180000
				00190000
				00200000
				00210000
				00220000
				00230000
				00240000

LEVEL 21.7 JAN 75)

OS/360 FORTRAN M

COMPILER OPTIONS = NAME= WATN,DPT=02,LINECNT=54,SIZE=0000K,

SOURCE,EBCCIC,NULIST,NODECK,LUARD,MAP,MUCDIT,IO,NOXREF

C SOURCE MEMBER NAME ORZ2OU12

C SOURCE MEMBER S74ZOU12

SUBROUTINE ZOUT2(HQ,IA,NN,NMAP)

IMPLICIT REAL*8(A-H,O-Z)

DIMENSION MO(1),NMAP(1)

ABS(X)=DABS(X)

FLUAT(L)=DFLUAT(L)

M=IA

M=MO

DO 10 I = 1,NN

IF(ABS(RC(I)).GT.D.IU) GO TO 5

MP = MM+1

GO TO 10

5 IF(MM.EQ.0) GO TO 7

RC(M) = FLUAT(MM)*1.D=6

M = M + 1

7 RC(M) = RC(I)

M = M+1

MM = 0

10 CONTINUE

IF(CMM.EQ.0)MM=M-1

IF(CMM.NE.0) RC(M)=FLUAT(MM)*1.D=6

NMAP(MN)=M-IA+1

RETURN

END

00010000
00020000
00030000
00040000
00050000
00060000
00070000
00080000
00090000
00100000
00110000
00120000
00130000
00140000
00150000
00160000
00170000
00180000
00190000
00200000
00210000
00220000
00230000
00240000
00250000

LEVEL 21, JAN 73)

REF ID: A66564

```

C      COMPILER OPTIONS -RANKS MAIN,OPTIMIZE=5,SIZE=000K,
      SOURCE,BUGOIC,NOLIST,NODECK,LOAD,MAP,MUEDIR,IU,NOXMF
      C      MEMHEN NAME S74AD

```

```

C-----
C      MEMBER NAME S74d
C-----
C      EIGENVALUES & EIGENVECTORS BY USING ROUTINES
C      EIGEN & GELS FROM THE SSP.
C-----
C      00010000
C      00050000
C      00040000

```

000700000
000600000
000600000
000900000

VERBEX=NAME U8240
ADDED TO SWI ON 10TH, MARCH, 1969

```

J
ISN 0002
SUBROUTINE ABLNK3
0010000
00120000

```

```

1  ISN 0003      DOUBLE PRECISION DSROUT,IMASS,IROUT,SCALF,RODRI,ROD,TESE,SUM2,
2  1 SURT,TIME,DARK,TOP,SUM,SKP,RHS,HGB,EPS,DAF,AUX,ABS,XM,XK,TI,R,
3  2 NORM,ON,XISUM,RODOUTS,PHK,PHIK,DARK1,X
4  COMMON /LINKA/ LAP(250),
5  ISN 0004

```

```

COMMON /CARRY/ CARRY(3),
1 XNOD0,XNOD1,XNOD2,XNOD3,XNOD4,XNOD5,XNOD6,XNOD7,XNOD8,XNOD9,XNOD10,XNOD11,XNOD12,XNOD13,
2 XNWSV,ANGLG,XNMAS6,SCALE,EVSAVE,XSAVE,XNSPEC,
3 CAS,FSD,MST,DUM,UN,MUNE,IJUV,DUM(S),MUNMM

```

```

ISN 0005      COMM - /LINNA1/NTOTAL,NOREF,TAPPE
              C
ISN 0006      DIMENSION AUX(250),DARK(250,3),MGB(30),MAP(250),PACK(8),
              RMS(250),NDUTK(250),IMASS(6),MURU(2),XH(250),
              XK(2305),PMJK(3)
              1
              2
00170000
00200000
00210000
00220000
00230000
00240000

```

```

C
ISN 0007
EQUIVALENCE (LAP(1),MAP(1))
00280000
00270000

```

ISN 0038
901 FORMATTING, 20%, AND SIGNAL ENERGY VIBRATION OPTIMIZATION, 1M, 50X, 90303000
PROGRAM 9-73, 1M, 25%, CONTRACT NO. DAMC04-71-C-0048, 1M, 30%, 5000369000
AIAA/MURTIQUEZ, 1M, 25%, BUETING COMPANY VENTURE, 1M, 30%, 90321000
902 FINANCIAL AND AIRCRAFT STRESS ANALYSIS, 1M, 30%, 90350000
TEN 0039

```

      *****DEFORMATION ANALYSIS*****
      902 FWRITE( IHO, 27X, 'RETAINED STIFFNESS MATRIX' ) //
      903 FWRITE( IHO, 27X, 'FLEXIBILITY MATRIX' ) //
      904 FWRITE( 1X, 80(IH=1) )
      906 FWRITE( 14I, 1E10, 0.246)
      907 FWRITE( 2X, 15I, 0.511, 0.1X, 2A6)
      908 FWRITE( 1X, 80(IH=1) ) // 30X 13M EIGENVALUES )
      910 FWRITE( 20X, 11F EIGENVALUE=15.0, 13M ASSUMED ZEROS )
      911 FWRITE( / 30X, 'EIGENVALUES' // 23X E20.1 // 50X, 'EIGENVECTORS' ) //
      912 FWRITE( / 40X, 'EIGENVALUES' // 23X E20.7 // 40X, 'EIGENVECTORS' ) //
      914 FWRITE( / 50X, 'EIGENVALUES' // 23X E20.7 // 50X, 'EIGENVECTORS' ) //
      914 FWRITE( 7X, 'RUN', 7X, 'STOP')
    END
  END

```

ISN 0019		914	FORMAT (7X, 'RUM', 7X, 'AUDE?')	00450000
ISN 0020		915	FORMAT (21X, 5X \$20.7)	00460000
ISN 0021		916	FORMAT (18X, 21X NATURAL FREQUENCIES)	00470000
ISN 0022		917	FORMAT (18X, 17H NEG. EIGENVALUE = E15.6)	00480000
ISN 0023		918	FORMAT (1X, E17.6, 2X, 7X MOD/SEC, 5X, 15H EIGENVALUE = E16.6, 1 3X SMPS = E13.6)	00490000
				00500000

ISN 0024
...
919 FORMAT / HL,10X, 'SUBROUTINE GELS +ANNING = ', /// 10X
00510000
00500000

```

1  'ERROR PARAMETER IER'=' ' DOES NOT NECESSAR',
2  'ILY MPAN', / 10X, ' THAT THE MATRIX IS SING',
3  'ULAK, AS ONLY MAIN DIAGONAL', / 10X, 'ELEMENTS',
4  ' ARE USED AS PIVOT ELEMENTS', )
ISN 0025  920 FORMAT ( 1M1,10X, 'SUBROUTINE BELS MANNING = ', // 10X
1  10X, 'WITH IER =',13, ' IN THE CASE OF A WELL-',
2  ' SCALED MATRIX', / 10X, 'AND APPROPRIATE TOLERANCE',
3  ' EPS, IT MAY BE INTERPRETED', / 10X,
4  ' THAT THE MATRIX WAS MANN',13, ' )
ISN 0026  924 FORMAT ( 14X,14,5X,14,5X,15,6 )
ISN 0027  925 FORMAT( 1M1, // 20X, 'EFFECTIVE MASS =',E15,6 )
ISN 0028  926 FORMAT ( // 20X, 'TOTAL EFFECTIVE', /
1  12X, 'STRAIN ENERGY =',E15,6 )
ISN 0029  927 FORMAT ( // 20X, 'EFFECTIVE STRAIN', /
1  12X, 'ENERGY RESIDUAL =',E15,6 )
ISN 0030  928 'FORMAT( // 10X, 'THIS APPLIES TO EIGENVALUES NO.',13 )
ISN 0031  929 FORMAT ( 1M1, // 14X, ' (THE AN MATRIX WAS SINGULAR FOR THIS CASE', )
ISN 0032  930 FORMAT(1M1, // 14X, 'A TOOK ON THE ILLEGAL VALUE OF ',17 )
ISN 0033  932 FORMAT ( 1M1, 51X, 'OFF-DIAGONAL STRAIN', / 50X,
1  'CONTINUATIONS', // 10X, 'NODE', 5X, 'MODE',
2  5X, 'ROW', 5X, 'COLUMN', 7X, 'ELEMENT', / )
ISN 0034  933 FORMAT ( 10X, 15, 4X, 15, 4X, 15, 4X, 15, 6 )
ISN 0035  935 FORMAT( // 30X, 'EIGENVECTORS NORMALIZED WITH RESPECT TO ROW ',13 )
ISN 0036  936 FORMAT( // 25X, 'EIGENVECTORS NORMALIZED WITH RESPECT TO THE MAXIMUM',13 )
ISN 0037  937 FORMAT( // 20X, 'EFFECTIVE MASS (',11, ') =',E15,6 /
1  / 20X, 'EFFECTIVE STIFFNESS (',11, ') =',E15,6 )

C
C  NOMASV= NUMBER OF MASS VARIATIONS FOR STUDY
C  XREIG= NUMBER OF EIGENVECTIOR WANTED
C  NOMASG= NUMBER OF MASS GROUPS
C  SCALE = SCALE FACTOR
C
ISN 0038  ABS(X)=DABS(X)
ISN 0039  SORT(X)=DSORT(X)
ISN 0040  SCALE = 1.
ISN 0041  SCALE = SCALE
ISN 0042  NOMASV=XNOMASV
ISN 0043  NMAX=MOMXN+1
ISN 0044  NMAX=XREIG
ISN 0045  NOMASG=XNOMASG
ISN 0046  IF (NOMASV,EN,6) NOMASV=1
ISN 0047  N=XREIG
ISN 0048  NSU = N* (N+1)/2
ISN 0049  M=1 = N* (N+1)/2
ISN 0050  M=1 = N* (N+1)/2
ISN 0051  M=1 = N* (N+1)/2
ISN 0052  M=1 = N* (N+1)/2
ISN 0053  M=1 = N* (N+1)/2
ISN 0054  M=1 = N* (N+1)/2
ISN 0055  M=1 = N* (N+1)/2

```

ISN 0056	J2 = J* CJ172	01010000
ISN 0057	J1 = J2-J +1	01020000
ISN 0058	HEAD (NTAPE) (XK(J),J=J1,J2)	01030000
ISN 0059	WRITE(12)(XK(J),J=J1,J2)	01031000
ISN 0060	10 CONTINUE	01040000
ISN 0061	REWIND NTAPE	01050000
ISN 0062	NRIX = 1	01060000
ISN 0063	IF (NRIX.EQ.1.) GO TO 30	01070000
ISN 0065	20 CALL LOADER(FLP,2)	01080000
ISN 0066	WRITE (6,901)	01090000
ISN 0067	IF (NRIX.EQ.1) WRITE(6,902)	01100000
ISN 0069	IF (NRIX.EQ.2) WRITE(6,903)	01110000
ISN 0071	CALL MROUT (NRIX,XK,N,N,1,50780,1,6)	01120000
ISN 0072	30 IF (NRIX.EQ.2) GO TO 80	01130000
ISN 0074	IF (NUMASG.EQ.0) GO TO 40	01140000
ISN 0076	REWIND NTAPE	01150000
ISN 0077	WRITE (3) (XK(1),1=1,NSU)	01160000
ISN 0078	REWIND 3	01170000
ISN 0079	IF (CINV.ME.17) GO TO 60	01180000
ISN 0081	HEAD (3) (AK(1),1=1,NSU)	01190000
ISN 0082	REWIND 3	01200000
ISN 0083	NRIX=2	01210000
ISN 0084	CALL LQVA(XK,N,1EM)	01220000
ISN 0085	IF (1EM=1) 40,20,50	01230000
ISN 0086	40 WRITE (6,929)	01240000
ISN 0087	GO TO 20	01250000
ISN 0088	50 WRITE (6,930) N	01260000
ISN 0089	GO TO 20	01270000
C		
ISN 0090	60 HEAD (3) (XK(1),1=1,NSU)	01280000
ISN 0091	REWIND 3	01290000
ISN 0092	10 = 1	01300000
ISN 0093	NRUNT=1	01310000
ISN 0094	70 HEAD (5,906) NODE,THASS,NORD	01320000
C		
ISN 0095	80 72 J=1,250	01330000
ISN 0096	IF (MAP(J),NE,NODE) GO TO 72	01340000
ISN 0098	10=J	01350000
ISN 0099	GO TO 75	01360000
ISN 0100	72 CONTINUE	01370000
ISN 0101	75 80 80 1=1,6	01380000
ISN 0102	IF (THASS(1).EQ.0) GO TO 90	01390000
ISN 0104	XA(1R) = THASS(1)	01400000
ISN 0105	80 10 = 10 +1	01410000
ISN 0106	90 IF (COUNT,GE,NUMASG) GO TO 100	01420000
ISN 0108	COUNT=COUNT+1	01430000
ISN 0109	GO TO 70	01440000
C		
ISN 0110	100 CALL SUB(XK,XP,SCALF,N)	01450000
ISN 0111	REWIND 1	01460000
ISN 0112	WRITE (1) (XK(1),1=1,NSU)	01470000
ISN 0113	CALL LOADER (SKP,2)	01480000

```

ISN 0113 WRITE (6,900)
ISN 0115 WRITE (6,900)
ISN 0116 CALL EIGEN(M,N,1)
ISN 0117 DO 120 I=1,N
ISN 0118 IS = I*(I+1)/2
ISN 0119 ROOTR(I) = X(IIS)
ISN 0120 120 CONTINUE
C ***** PUT EIGENVALUES IN ASCENDING ORDER *****
C
ISN 0121 DO 130 I=1,M
ISN 0122 130 ROOTR(IP)=ROOTR(I)* SCALF
C
ISN 0123 DO 150 I=1,M
ISN 0124 DO 140 J=1,M
ISN 0125 IF (ROOTR(J).GT.ROOTR(I)) GO TO 140
ISN 0127 11=ROOTR(I)
ISN 0128 ROOTR(I)=ROOTR(J)
ISN 0129 ROOTR(J)=11
ISN 0130 140 CONTINUE
ISN 0131 150 CONTINUE
ISN 0132 DO 500 I=1,M
ISN 0133 IF (ROOTR(I).GT.0.0) GO TO 510
ISN 0135 WRITE(6,917) ROOTR(I)
ISN 0136 GO TO 500
ISN 0137 510 ROOTS = SORT(ROOTR(I))
ISN 0138 DROOTS = ROOTS / 6.28316
ISN 0139 WRITE(6,918) ROOTS,ROOTR(I),DROOTS
ISN 0140 500 CONTINUE
C ***** START OF FINDING EIGENVECTORS *****
C
ISN 0141 L=0
ISN 0142 WRITE (6,900)
ISN 0143 IF (M.LE.0) GO TO 400
ISN 0145 170 L=L+1
C
ISN 0146 IF (ROOTR(L).GT.WONE) GO TO 180
ISN 0148 WRITE (6,910) ROOTR(L)
ISN 0149 GO TO 170
ISN 0150 180 REAL=0
ISN 0151 READ (1) (XK(I),I=1,NSU)
ISN 0152 READ 1
C
ISN 0153 K=0
ISN 0154 MKN=3
ISN 0155 12=0
ISN 0156 190 CONTINUE
ISN 0157 IF ((M-K).LE.2) MKN=M-K

```

```

15N 0159 DO 330 KMT,MKN 02100000
15N 0160 READ (1) (XK(1),I=1,NSU) 02110000
15N 0161 REMIND 1 02120000
15N 0162 DO 200 I=1,I2 02130000
15N 0163 IS = 1 + MKT 02140000
15N 0164 RMS(I) = -XK(IS) 02150000
15N 0165 200 CONTINUE 02160000
15N 0166 K=K+1 02170000
15N 0167 DO 210 I = 1,I2 02180000
15N 0168 IS = I*(I+1)/2 02190000
15N 0169 210 XK(IS) = XK(IS)-ROUTR(L) 02200000
15N 0170 HGBCK = ROUTR(L) 02210000
C 02220000
C 02230000
15N 0171 EPS = 1.0E-07 02240000
15N 0172 CALL GELS (RMS,XK,I2,IERS,IER,AUX) 02250000
15N 0173 IF (IER) 220,240,230 02260000
15N 0174 220 WRITE (6,919) 02270000
15N 0175 WRITE (6,928) L 02280000
15N 0176 GO TO 240 02290000
15N 0177 230 WRITE (6,920) IER,IER 02300000
15N 0178 WRITE (6,928) L 02310000
15N 0179 240 RMS(N) = 1.0 02320000
15N 0180 SUM = 0.0 02330000
15N 0181 DO 250 I=1,N 02340000
15N 0182 RMS(I) = RMS(I)*XK(I) 02350000
15N 0183 250 SUM = SUM + RMS(I)**2 02360000
15N 0184 SUM=SUM/(SUM) 02370000
C 02380000
C 02390000
15N 0185 DO 260 I =1,N 02400000
15N 0186 RMS(I) = RMS(I)/SUM 02410000
15N 0187 DO 270 I=1,N 02420000
15N 0188 270 DAK(I,KN) = RMS(I) 02430000
C 02440000
15N 0189 IF (EVSAVE.NE.1.) GO TO 280 02450000
15N 0191 WRITE (5) (RMS(I),I=1,N) 02460000
C 02470000
C 02480000
15N 0192 280 CONTINUE 02490000
15N 0193 SUM = 0 02500000
15N 0194 SUM2 = 0 02510000
15N 0195 TUP = -1.0E+10 02520000
15N 0196 HEAD (1) (XK(1),I=1,NSU) 02530000
15N 0197 REMIND 1 02540000
15N 0198 DO 290 I=1,N 02550000
15N 0199 J = I*(I+1)/2 02560000
15N 0200 XI = RMS(I) 02570000
15N 0201 DAK1 = XI / (XK(I)*XK(I)) 02580000
15N 0202 DAM = XI * DAM1 02590000
15N 0203 TESE=XK(J)*XI*XI 02600000
15N 0204 IF (TUP,LT,TESE) TUP = TESE 02610000
15N 0206 SUM = SUM + DAM 02620000
15N 0207 SUM2 = SUM2 + TESE 02630000

```

ISV 0208	290 CONTINUE	02690000
ISV 0209	600 WRITE(6,925) SUM	02700000
ISV 0210	TESE = SUM*ROOTR(LL)	02710000
ISV 0211	WRITE(6,926) TESE	02720000
ISV 0212	PHIK(44) = TESE	02730000
ISV 0213	SUM2 = TESE - SUM2	02740000
ISV 0214	WRITE(6,927) SUM2	02750000
ISV 0215	325 I=I+1	02760000
ISV 0216	330 L=L+1	02770000
ISV 0217	NLEL=NN	02780000
ISV 0218	KLEL=1	02790000
ISV 0219	CALL LOADER(FLIP,2)	02800000
ISV 0220	WRITE(6,901)	02810000
ISV 0221	GO TO (340,350,360), NKN	02820000
ISV 0222	340 WRITE(6,911) (ROOTR(LL),LLENL,K1)	02830000
ISV 0223	GO TO 370	02840000
ISV 0224	350 WRITE(6,912) (MUWIN(LL),LLENL,K1)	02850000
ISV 0225	GO TO 370	02860000
ISV 0226	360 WRITE(6,913) (MOUTR(LL),LLENL,K1)	02870000
ISV 0227	370 WRITE(6,910)	02880000
ISV 0228	DO 380 I=1,N	02890000
ISV 0229	380 WRITE(6,915) (LAP(I),(DARK(I,KN),KN=1,IN)	02900000
ISV 0230	IF(NKN=0,END) GO TO 387	02910000
ISV 0231	DO 388 I=1,IN	02920000
ISV 0232	IF(MUWIN,GT,XNORET) GO TO 381	02930000
ISV 0233	KJ=KJ+DARK(NKN=0,I)	02940000
ISV 0234	GO TO 383	02950000
ISV 0235	381 KJ=KJ+DARK(I,I)	02960000
ISV 0236	DO 382 I=2,N	02970000
ISV 0237	382 IF(ABS(DARK(M,I))>.6T,ABS(ROWNT)) ROWN=DARK(M,I)	02980000
ISV 0238	383 DO 385 JJ=1,N	02990000
ISV 0239	385 DARK(JJ,I)=DARK(JJ,I)/ROWN	03000000
ISV 0240	386 PHIK(I)=PHIK(I)/ROWN+2	03010000
ISV 0241	CALL LOADER(FLIP,2)	03020000
ISV 0242	WRITE(6,901)	03030000
ISV 0243	IF(MUWIN,GT,XNORET) GO TO 384	03040000
ISV 0244	WRITE(6,935) NKN=0	03050000
ISV 0245	GO TO 349	03060000
ISV 0246	384 WRITE(6,936)	03070000
ISV 0247	389 WRITE(6,914)	03080000
ISV 0248	DO 386 I=1,N	03090000
ISV 0249	386 WRITE(6,915) (LAP(I),(DARK(I,KN),KN=1,IN)	03100000
ISV 0250	CALL LOADER(DUM,2)	03110000
ISV 0251	DO 395 LLL=1,IN	03120000
ISV 0252	SUM=0	03130000
ISV 0253	DO 396 JJ=1,N	03140000
ISV 0254	X=DARK(J,LLL)+2	03150000
ISV 0255	DREX(I,KN(J),KN(J))	03160000
ISV 0256	396 SUM=SUM+X	03170000
ISV 0257	395 WRITE(6,937) LLL,SUM,LLL,PHIK(LLL)	03180000
ISV 0258	387 IF(N,NE,NH) GO TO 190	03190000

ISN 0264	CALL LOADEN(FLIP,2)	03090000
ISN 0265	WRITE (6,901)	03100000
ISN 0266	WRITE (6,916)	03110000
ISN 0267	DO 400 L = 1, N	03120000
ISN 0268	IF (KOUTR(L),GT,0.7) GO TO 390	03130000
		03140000
		03150000
ISN 0270	WRITE (6,917) KOUTH(L)	03160000
ISN 0271	GO TO 400	03170000
ISN 0272	390 SROUT=SQRT(KOUTR(L))	03180000
ISN 0273	USROUT=SQRT(6.28316	03190000
ISN 0274	WRITE (6,918) SROUT,ROUTR(L),DSROUT	03200000
ISN 0275	400 CONTINUE	03210000
ISN 0276	IF (EVSARE,EU,1.) GO TO 410	03220000
		03230000
		03240000
ISN 0278	NOASV=NUMASV-1	03250000
ISN 0279	IF (NUMASV,EU,0) GO TO 440	03260000
ISN 0281	REIND 3	03270000
ISN 0282	REIND 1	03280000
ISN 0283	WRITE (6,904)	03290000
ISN 0284	GO TO 60	03300000
ISN 0285	410 DO 415 I=1,N	03310000
ISN 0286	TUP = AM(I)	03320000
ISN 0287	AM(I) = SCALF / (TUP+TUP)	03330000
ISN 0288	415 CONTINUE	03340000
ISN 0289	WRITE (3) MAP,XM,MGB	03350000
ISN 0290	DO 420 I=1,512	03360000
ISN 0291	420 AM(I) = 500000000	03370000
ISN 0292	DO 430 J=1,5	03380000
ISN 0293	430 WRITE (3) (AM(I),I=1,512)	03390000
ISN 0294	440 CONTINUE	03400000
ISN 0295	RETURN	03410000
ISN 0296	END	03420000


```

COMPILER OPTIONS = NAMES = MAIN,OPT=02,LINECT=24,SIZE=0000K,
SOURCE,EBASIC,NOLIST,NOBACK,LOAD,MAP,NOEDIT,IO,NOXREF
C
C THIS ROUTINE FORMS THE SYMMETRIC EQUIVALENT
C OF THE DYNAMIC MATRIX.
C
C MEMBER NAME ST4SJB
C
C ADDED TO SM1 UN 23RD. JAN., 1969
C
TSV 0002 SUBROUTINE SUB(XM,XM,WF,N)
TSV 0003 IMPLICIT REAL*8(A-H,O-Z)
C
TSV 0004 DIMENSION XM(1),XM(1)
C
TSV 0005 SUBT(X)=DSUBT(X)
TSV 0006 NN = N*(N+1)/2
TSV 0007 DO 10 I=1,N
TSV 0008 XM(I) = SUBT(WF/XM(I))
TSV 0009 10 CONTINUE
TSV 0010 JB = 1
TSV 0011 IE = 1
TSV 0012 IS = 1
TSV 0013 DO 50 I=1,N
TSV 0014 20 XM(JM) = XM(IS)*XM(IE)*XM(JB)
TSV 0015 IF (IS=IE) 30,40,50
TSV 0016 30 IS = IS + 1
TSV 0017 JB = JB + 1
TSV 0018 GO TO 20
TSV 0019 40 IE = IE + 1
TSV 0020 IS = 1
TSV 0021 JB = JB + 1
TSV 0022 50 CONTINUE
TSV 0023 RETURN
TSV 0024 END
00010000
00020000
00030000
00040000
00050000
00060000
00070000
00080000
00090000
00100000
00110000
00120000
00130000
00140000
00150000
00160000
00170000
00180000
00190000
00200000
00210000
00220000
00230000
00240000
00250000
00260000
00270000
00280000
00290000
00300000

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LEVEL 21.7 JAN 73 J

US/360 FORTRAN H

COMPILER OPTIONS - NAMES MAIN,OPT=02,LINELNT=54,SIZE=0000K,
SOURCE=EBCDIC,NOLIST,MODECA,LOAD,MAP,NOEDIT,10,NOXREF

C	MEMBER NAME 'S74UCI'	00010000
C		00020000
ISN 0002	SUBROUTINE LOC(1,J,IX,N,M,MS)	00030000
ISN 0003	IMPLICIT REAL*8(A-H,O-Z)	00040000
ISN 0004	IX=1	00050000
ISN 0005	JX=J	00060000
ISN 0006	IF(MS-1)10,20,30	00070000
ISN 0007	10 IX=IX*(JX-1)+1X	00080000
ISN 0008	GO TO 36	00090000
ISN 0009	20 IF(IX-JX)22,24,24	00100000
ISN 0010	22 IX=IX*(JX-JX-JX)/2	00110000
ISN 0011	GO TO 36	00120000
ISN 0012	24 IX=JX*(IX-IX-IX)/2	00130000
ISN 0013	GO TO 36	00140000
ISN 0014	30 IX=0	00150000
ISN 0015	IF(IX-JX)36,32,36	00160000
ISN 0016	32 IX=IX	00170000
ISN 0017	36 IX=IX	00180000
ISN 0018	RETURN	00190000
ISN 0019	END	00200000

IAN 73)

US/560 FURTHAN H

COMPILE OPTIONS = NAME3=ATW,OPT502,LINCNT=54,SIZE=000K,
SOURCE=ZBCULC,NOLISI,NODECK,LOAD,MAP,NODEIT,ID,NOMREF

ISN	0002	MEMBER NAME '3741PRD	00010000
ISN 0003	SUBROUTINE IPKD(A,B,K,N,M,MSA,MSB,L)	00020000	
ISN 0004	IMPLICIT REAL*8 (A-H,O-Z)	00030000	
ISN 0005	DIMENSION A(1),B(1),M(1)	00040000	
ISN 0006	MS=MSA*10+MSB	00050000	
ISN 0007	IF(MS=22)50,10,30	00060000	
ISN 0008	10 DO 20 I=1,N	00070000	
ISN 0009	20 M(I)=A(I)*B(I)	00080000	
ISN 0010	RETURN	00090000	
ISN 0011	30 IH=1	00100000	
ISN 0012	DO 90 J=1,L	00110000	
ISN 0013	DO 90 J=1,M	00120000	
ISN 0014	M(IH)=0.	00130000	
ISN 0015	DO 80 I=1,N	00140000	
ISN 0016	IF(MS)40,60,70	00150000	
ISN 0017	40 CALL LUC1(I,J,IA,N,M,MSA)	00160000	
ISN 0018	CALL LUC1(I,K,IB,N,L,MSB)	00170000	
ISN 0019	IF(IA)50,80,50	00180000	
ISN 0020	50 IF(10)70,80,70	00190000	
ISN 0021	60 IA=IA*(J-1)+1	00200000	
ISN 0022	IB=IB*(K-1)+1	00210000	
ISN 0023	70 M(IH)=M(IH)+A(IA)*B(IB)	00220000	
ISN 0024	80 CONTINUE	00230000	
ISN 0025	90 IH=IH+1	00240000	
ISN 0026	RETURN	00250000	
ISN 0027	END	00260000	

LEVEL 21.7 AN. 73)

OS/360 FORTRAN M

COMPILER OPTIONS = NAME= FAIN,OPT=02,LINENT=50,SIZE=0000K,
SOURCE,ECDCIC,MULIST,MODECK,LOAD,MAP,MUEDIT,ID,NOXHEF
SUBROUTINE LOC(1,J,IX,N,N,MS)
MEMBER NAME ST4LOC

ISN 0002	C	PURPOSE	00010000
	C	COMPUTE A VECTOR SUBSCRIPT FOR AN ELEMENT IN A MATRIX OF SPECIFIED STORAGE MODE	00010001
	C	DESCRIPTION OF PARAMETERS	00020000
	C	I = ROW NUMBER OF ELEMENT	00030000
	C	J = COLUMN NUMBER OF ELEMENT	00040000
	C	IR = RESULTANT VECTOR SUBSCRIPT	00050000
	C	N = NUMBER OF ROWS IN MATRIX	00060000
	C	M = NUMBER OF COLUMNS IN MATRIX	00070000
	C	MS = ONE DIGIT NUMBER FOR STORAGE MODE OF MATRIX	00080000
	C	0 = GENERAL	00090000
	C	1 = SYMMETRIC	00100000
	C	2 = DIAGONAL	00110000
	C		00120000
ISN 0003		IX = I	00130000
ISN 0004		JX = J	00140000
ISN 0005		IF (MS = 1) 10,20,30	00150000
ISN 0006		10 IX = N * (JX - 1) + IX	00160000
ISN 0007		GO TO 30	00170000
ISN 0008		20 IF (IX = JX) 22,20,24	00180000
ISN 0009		22 IX = IX + (JX + JX * JX)/2	00190000
ISN 0010		GO TO 30	00200000
ISN 0011		24 IX = JX + (IX + JX * JX)/2	00210000
ISN 0012		GO TO 30	00220000
ISN 0013		30 IX = 0	00230000
ISN 0014		IF (IX = JX) 36,32,36	00240000
ISN 0015		32 IX = IX	00250000
ISN 0016		36 IX = IX	00260000
ISN 0017		RETURN	00270000
ISN 0018		END	00280000

ISN 0002
ISN 0003

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TSN 0004      DIMENSION 2(1),B(8)
C
ISN 0005      901 FORMAT ( 1M1, 5X, 7M1M1X, 15,6X,13,5M 1M1S,6X,13,
      1      8M 1COLUMNS,6X,13M1STORAGE MODE ,11,6X,5M1PAGE ,12, / )
ISN 0006      902 FORMAT ( 12X,8M1COLUMNS , 7(2X,13,10X) )
ISN 0007      903 FORMAT ( 1F )
ISN 0008      904 FORMAT ( 1F, 7X, 4M1ROX, 13, 7(11,6) )
ISN 0009      905 FORMAT ( 1F, 7X, 4M1ROX, 13, 7(11,6) )
ISN 0010      906 FORMAT ( //5X, 7M1M1X, 15,6X,13,5M 1M1S,6X,13,
      1      8M 1COLUMNS,6X,13M1STORAGE MODE ,11,6X,5M1PAGE ,12, / )
C
ISN 0011      J = 1
C
C      WRITE HEADING
C
ISN 0012      NEND=IPUS/16 -1
ISN 0013      LEND=(LIMS/ISP)*2
ISN 0014      IPAGE = 1
ISN 0015      WRITE(NOUT,906) 'ICODE',N,M,MS,IPAGE
ISN 0016      LSTMT = 1
ISN 0017      GO TO 25
ISN 0018      10 LSTMT = 1
ISN 0019      20 WRITE (NOUT,901) ICODE,N,M,MS,IPAGE
ISN 0020      25 JMT = J+NEND-1
ISN 0021      IPAGE = IPAGE+1
ISN 0022      50 IF (JMT=M) 50,50,40
ISN 0023      40 JMT = N
ISN 0024      50 CONTINUE
ISN 0025      WRITE (NOUT,902) (JCM,JCM=J,JMT)
ISN 0026      IF (ISP-1) 60,60,70
ISN 0027      60 WRITE (NOUT,903)
ISN 0028      70 LEND = LSTMT+LEND-1
ISN 0029      DO 150 L=LSTMT,LEND
C
C      FORM OUTPUT ROW LINE
C
ISN 0030      DO 100 K=1,LEND
ISN 0031      KK = K
ISN 0032      JT = J+K-1
ISN 0033      CALL LOC(L,JT,IJMT,N,M,MS)
ISN 0034      B(K) = 0.0
ISN 0035      IF (IJMT) 40,90,60
ISN 0036      80 B(K) = A(IJMT)
ISN 0037      90 CONTINUE
C
C      CHECK IF LAST COLUMN, IF YES GO TO 110
C
ISN 0038      IF (JT=M) 100,110,110
ISN 0039      100 CONTINUE
C
C      END OF LINE, NOW WRITE
C

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ISN 0040	110 IF (ISP,1) 120,120,130	00980000
ISN 0041	120 WRITE (NOUT,904) L,(8(JM),JWSI,KK)	00990000
ISN 0042	GO TO 140	01000000
ISN 0043	130 WRITE (NOUT,905) L,(8(JM),JWSI,KK)	01010000
	C	01020000
	C IF END OF ROWS, GO CHECK COLUMNS	01030000
	C	01040000
ISN 0044	140 IF (N-L) 160,160,150	01050000
ISN 0045	150 CONTINUE	01060000
	C	01070000
	C END OF PAGE, NOW CHECK FOR MORE OUTPUT	01080000
	C	01090000
ISN 0046	LSMT 2 LSTRT+LEND	01100000
ISN 0047	GO TO 20	01110000
	C	01120000
	C END OF COLUMNS, THEN RETURN	01130000
	C	01140000
ISN 0048	160 IF (JT-M) 170,180,180	01150000
ISN 0049	170 JSJT+1	01160000
ISN 0050	GO TO 10	01170000
ISN 0051	180 RETURN	01180000
ISN 0052	END	01190000

US/360 FUKI HAN H

355

C	STATEMENT WHICH FOLLOWS,	00510000
C	DOUBLE PRECISION A,R,ANORM,ANMMX,IMR,X,Y,SINX,SINX2,COSX,	00520000
C	1 COSX2,SINCS	00530000
C		00540000
C	THE C MUST ALSO BE REMOVED FROM DOUBLE PRECISION STATEMENTS	00550000
C	APPEARING IN OTHER ROUTINES USED IN CONJUNCTION WITH THIS	00560000
C	ROUTINE.	00570000
C		00580000
C	THE DOUBLE PRECISION VERSION OF THIS SUBROUTINE MUST ALSO	00590000
C	CONTAIN DOUBLE PRECISION FUNCTION FUNCTIONS, SORT IN STATEMENTS	00600000
C	40, 68, 75, AND 78 MUST BE CHANGED TO DSORT, ABS IN STATEMENT	00610000
C	62 MUST BE CHANGED TO DABS.	00620000
C		00630000
C		00640000
C		00650000
C	*****	00660000
C	GENERATE IDENTITY MATRIX	00670000
C		00680000
C	ABS(X)=DABS(X)	00690000
C	DSORT(X)=DSORT(X)	00700000
C	IF(XV=1) 10,25,10	00710000
C	10 10=1	00720000
C	DO 20 J=1,N	00730000
C	10=10+1	00740000
C	DO 20 I=1,N	00750000
C	10=10+1	00760000
C	IF(I=J) 20,15,20	00770000
C	15 M(IJ)=1.0	00780000
C	20 CONTINUE	00790000
C	*****	00800000
C	COMPUTE INITIAL AND FINAL NORMS (ANORM AND ANORMX)	00810000
C		00820000
C	25 ANORM=0.0	00830000
C	DO 35 I=1,N	00840000
C	00 35 J=1,N	00850000
C	IF(I=J) 30,35,35	00860000
C	30 IA=1+(J+J-1)/2	00870000
C	ANORM=ANORM+AA(IA)*A(IA)	00880000
C	35 CONTINUE	00890000
C	IF(ANORM) 165,165,40	00900000
C	40 ANORM=1.0/ANORM	00910000
C	ANORMX=ANORM*1.00-12/FLOAT(N)	00920000
C	*****	00930000
C	INITIALIZE INDICATORS AND COMPUTE THRESHOLD, TH	00940000
C		00950000
C	TH=0	00960000
C	THRESH=TH/FLOAT(N)	00970000
C	45 THRESH=TH/FLOAT(N)	00980000
C	50 L=1	00990000
C	55 MEL=1	01000000

```

C      COMPUTE SIN AND COS
C
ISN 0032      60 MU=(M*M*M)/2      01010000
ISN 0033      LU=(L-L-L)/2      01020000
ISN 0034      LML+MU      01030000
ISN 0035      62 IF (ABS(A(LM))-THR) 130,65,65 01040000
ISN 0036      65 INDE1      01050000
ISN 0037      LL=L+LU      01060000
ISN 0038      MM=LU+U      01070000
ISN 0039      X=0.5*(A(LL)-A(MM))      01080000
ISN 0040      68 Y=A(LM)/SQR(A(LM)*A(LM)*X*X)      01090000
ISN 0041      70 Y=Y      01100000
ISN 0042      75 SIN=X/SQRT(2.0*(1.0+(SQR(1.0-Y*Y))))      01110000
ISN 0043      SIN=X/SINX      01120000
ISN 0044      COS=X/SQRT(1.0-SINX2)      01130000
ISN 0045      COSX2=COSX*COSX      01140000
ISN 0046      SINX2=SINX*SINX      01150000
ISN 0047      C      ROTATE L AND M COLUMNS      01160000
C
ISN 0048      ILQ=M*(L-1)      01170000
ISN 0049      IMQ=N*(M-1)      01180000
ISN 0050      DO 125 I=1,N      01190000
ISN 0051      IU=(I+1-I)/2      01200000
ISN 0052      IF(I-L) 80,115,60      01210000
ISN 0053      80 IF(I-M) 85,115,90      01220000
ISN 0054      85 I=I+M      01230000
ISN 0055      90 IM=I+U      01240000
ISN 0056      95 IF(I-L) 100,105,105      01250000
ISN 0057      100 IL=I+U      01260000
ISN 0058      105 IL=I+U      01270000
ISN 0059      110 X=A(IL)*COSX-A(IM)*SINX      01280000
ISN 0060      A(IM)=A(IL)*SINX+A(IM)*COSX      01290000
ISN 0061      A(IL)=X      01300000
ISN 0062      115 IF(M=N) 120,125,120      01310000
ISN 0063      120 IL=IL+1      01320000
ISN 0064      IM=IM+1      01330000
ISN 0065      X=A(IL)*COSX-R(IM)*SINX      01340000
ISN 0066      R(IM)=X      01350000
ISN 0067      R(IL)=A(IL)*SINX-R(IM)*COSX      01360000
ISN 0068      R(IL)=X      01370000
ISN 0069      125 CONTINUE      01380000
ISN 0070      X=2.0*(L)*SINX      01390000
ISN 0071      Y=A(LL)*COSX2+A(MM)*SINX2=X      01400000
ISN 0072      X=A(LL)*SINX2+A(MM)*COSX2=X      01410000
ISN 0073      A(LM)=A(LL)-A(MM)*SINX2      01420000
ISN 0074      A(LL)=Y      01430000
ISN 0075      A(MM)=X      01440000
ISN 0076      C      TESTS FOR COMPLETION      01450000
C
ISN 0077      01500000
ISN 0078      01510000
ISN 0079      01520000

```

C				01530000
C		TEST FOR M = LAST COLUMN		01540000
C				01550000
ISN 0077		150 IF(M=1) 135,140,135		01560000
ISN 0078		135 M=M+1		01570000
ISN 0079		GO TO 60		01580000
C				01590000
C		TEST FOR L = SECOND FROM LAST COLUMN		01600000
C				01610000
ISN 0080		140 IF(L=(N-1)) 145,150,145		01620000
ISN 0081		145 L=L+1		01630000
ISN 0082		GO TO 55		01640000
ISN 0083		150 IF(L=1) 160,155,160		01650000
ISN 0084		155 L=L-1		01660000
ISN 0085		GO TO 50		01670000
C				01680000
C		COMPARE THRESHOLD WITH FINAL NORM		01690000
C				01700000
ISN 0086		160 IF(NORM-ANR) 165,165,45		01710000
C				01720000
C		SORT EIGENVALUES AND EIGENVECTORS		01730000
C				01740000
ISN 0087		165 IS=N		01750000
ISN 0088		DO 185 I=1,N		01760000
ISN 0089		IG=IG+N		01770000
ISN 0090		LL=1+(I-1)/2		01780000
ISN 0091		JG=JG+(I-2)		01790000
ISN 0092		DO 185 J=1,N		01800000
ISN 0093		JG=JG+N		01810000
ISN 0094		MMSJ=(J+J)/2		01820000
ISN 0095		IF(A(LL)-A(MM)) 185,185,176		01830000
ISN 0096		170 XZA(LL)		01840000
ISN 0097		A(LL)=A(MM)		01850000
ISN 0098		A(MM)=A		01860000
ISN 0099		IF(MM=1) 175,185,175		01870000
ISN 0100		175 DO 180 K=1,N		01880000
ISN 0101		IG=IG+K		01890000
ISN 0102		JG=JG+N		01900000
ISN 0103		XK(ILK)		01910000
ISN 0104		R(ILK)=R(IMR)		01920000
ISN 0105		180 R(IMR)=X		01930000
ISN 0106		185 CONTINUE		01940000
ISN 0107		RETURN		01950000
ISN 0108		END		01960000

```

LEVEL 21.  JAN 73 )      09/569  FORTRAN M
-----
COMPILER OPTIONS = NAME= MATN,OPT=02,LINENCT=50,SIZE=000DK,
SOURCE=EBCCIC,NOLIST,NOECHK,LOAD,MAR,MURDIT,IO,NORREF
C      A IS THE SQUARE MATRIX, OF ORDER IO,
C      TO BE INVERTED.
C      IEM IS AN ERROR MESSAGE INDICATOR
C      0 MEANS 'AP' IS SINGULAR
C      1 MEANS A NORMAL RETURN
C      2 MEANS IO WAS INVALID.
C
C      MEMBER NAME 9741MVA      ADDED TO SM1 ON 6TH, FEB., 1969
C
ISN 0002      SUBROUTINE INVA(A,I0,IEM)
ISN 0003      IMPLICIT REAL*8(A-H,O-Z)
C
ISN 0004      DIMENSION A(I),COL(250)
C
ISN 0005      IF (I0-1) 160,150,10
ISN 0006      10 IF(I0-250) 20,20,160
C
C      --- INVERSE OF A 2X2 MATRIX
C
ISN 0007      20 C = A(I)/A(3)*A(2)*A(2)
ISN 0008      IF (C) 30,140,30
ISN 0009      30 A(2) = -A(2)/C
ISN 0010      COL(1) = A(1)/C
ISN 0011      A(1) = A(3)/C
ISN 0012      A(3) = COL(1)
ISN 0013      IF (I0-2) 160,120,40
ISN 0014      40 K = 1
ISN 0015      10 K = I0-1
ISN 0016      DO 120 L=2,M
ISN 0017      K = K+L
C
C      L--H OF SYMMETRIC MATRIX COLUMN
C
ISN 0018      N = 0
ISN 0019      DO 50 I=1,L
ISN 0020      50 COL (I) = 0
ISN 0021      DO 70 I=1,L
ISN 0022      70 IA = I+1
ISN 0023      DO 70 J=1,I
ISN 0024      N = N+1
ISN 0025      COL(J)=COL(J)+A(N)*A(IA)
ISN 0026      IF (J-1) 60,70,160
ISN 0027      60 IM = K+J
ISN 0028      COL(1)=COL(1)+A(N)*A(IM)
ISN 0029      70 CONTINUE
C
C      COMPUTE      822
C
00010000
00020000
00030000
00040000
00050000
00060000
00070000
00080000
00090000
00100000
00110000
00120000
00130000
00140000
00150000
00160000
00170000
00180000
00190000
00200000
00210000
00220000
00230000
00240000
00250000
00260000
00270000
00280000
00290000
00300000
00310000
00320000
00330000
00340000
00350000
00360000
00370000
00380000
00390000
00400000
00410000
00420000
00430000
00440000
00450000
00460000
00470000
00480000
00490000

```

ISV 0030	C = 0	00500000
ISV 0031	DO 80 I=1,L	00510000
ISV 0032	IA = K+I	00520000
ISV 0033	80 C = C + A(IA)*COL(I)	00530000
ISV 0034	IA = IA+1	00540000
ISV 0035	C = A(IA)-C	00550000
ISV 0036	IF (C) 90,140,90	00560000
ISV 0037	90 C = 1.0/C	00570000
ISV 0038	A(IA) = C	00580000
		00590000
		00600000
		00610000
	COMPUTE 821	00620000
ISV 0039	DO 100 I=1,L	00630000
ISV 0040	IA = K+I	00640000
ISV 0041	100 A(IA) = -C*COL(I)	00650000
		00660000
		00670000
		00680000
	COMPUTE 811	00690000
ISV 0042	N = 0	00700000
ISV 0043	DO 110 I=1,L	00710000
ISV 0044	DC 110 J=1,I	00720000
ISV 0045	N = N+1	00730000
ISV 0046	IA = K+J	00740000
ISV 0047	110 A(N)=A(N)-A(IA)*COL(I)	00750000
ISV 0048	120 CONTINUE	00760000
ISV 0049	130 IER = 1	00770000
ISV 0050	RETURN	00780000
ISV 0051	140 IER = 0	00790000
ISV 0052	RETURN	00800000
ISV 0053	150 A(1) = 1.07*A(1)	00810000
ISV 0054	GO TO 130	00820000
ISV 0055	160 IER = 2	00830000
ISV 0056	RETURN	00840000
ISV 0057	END	

ISW 0001	LEL=11	00490000
ISW 0002	LELL=1	00500000
ISW 0003	IF(L=LM)12,10,11	00510000
ISW 0004	10 A(LL)=A(LST)	00520000
ISW 0005	IM=A(L)	00530000
ISW 0006	GO TO 13	00540000
ISW 0007	11 LEL=LT	00550000
ISW 0008	12 IM=A(LL)	00560000
ISW 0009	A(LL)=A(L)	00570000
ISW 0010	13 AUX(I)=TB	00580000
ISW 0011	14 A(L)=PIV1*TB	00590000
ISW 0012	A(LST)=LT	00600000
ISW 0013	PIV = 0.00	00610000
ISW 0014	LST=LST	00620000
ISW 0015	LT=0	00630000
ISW 0016	DO 18 I=K,LEND	00640000
ISW 0017	PIV1=AUX(I)	00650000
ISW 0018	LELL=1	00660000
ISW 0019	LELL=1	00670000
ISW 0020	DO 15 LLO=11,LEND	00680000
ISW 0021	LELL=LLD	00690000
ISW 0022	LELL=LT	00700000
ISW 0023	15 A(L)=A(L)+PIV1*A(LL)	00710000
ISW 0024	LST=LST+1	00720000
ISW 0025	LST=LST	00730000
ISW 0026	18 A(L)=A(LR)	00740000
ISW 0027	12 (18-PIV)17,17,16	00750000
ISW 0028	16 PIV=TB	00760000
ISW 0029	17 DO 18 L=K,NM,M	00770000
ISW 0030	J=11+1	00780000
ISW 0031	LELL=LT	00790000
ISW 0032	18 M(LL)=R(LL)+PIV1*R(LR)	00800000
ISW 0033	19 IF(LEND)24,23,20	00810000
ISW 0034	20 11=N	00820000
ISW 0035	DO 22 I=2,M	00830000
ISW 0036	LST=LST+1	00840000
ISW 0037	I=11-1	00850000
ISW 0038	LEA(LST)+500	00860000
ISW 0039	DO 22 J=11,NM,M	00870000
ISW 0040	IM=M(J)	00880000
ISW 0041	LELL=1	00890000
ISW 0042	LELL=1	00900000
ISW 0043	DO 21 LT=11,LEND	00910000
ISW 0044	LELL=1	00920000
ISW 0045	LELL=1	00930000
ISW 0046	21 TB=TB+A(K)*M(LL)	00940000
ISW 0047	K=J+1	00950000
ISW 0048	R(J)=R(K)	00960000
ISW 0049	22 M(K)=TB	00970000
ISW 0050	23 RETURN	00980000
ISW 0051	24 IER=1	00990000
ISW 0052		01000000

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TSN 0093      RETURN      01010000
TSN 0094      END         01020000

```

LEVEL 21.7 / 31.73) US/360 FORTRAN M

COMPILER OPTIONS = NAME=MAIN,OPT=2,LINEN=750,SIZE=0000N,
SOURCE,EBCDIC,NULIST,NODECK,LOAD,MAP,NULDIT,IO,NOXHEF

TSN	LINE	CODE	MEMBER NAME	ADDRESS
TSN 0003	100	CONTINUE	SUBROUTINE DLOADH(ARRAY,MODE)	00010000
TSN 0003	101	IMPLICIT REAL*8(A-H,O-S,U-Z)		00015000
TSN 0004	102	DIMENSION CARD(5),TITLE(19),ARRAY(1)		00020000
TSN 0005	103	GO TO (100,200),MODE		00025000
TSN 0006	104	CONTINUE		00030000
TSN 0007	105	HEAD(5,10)INSUB,NOPC,CARD		00040000
TSN 0008	106	FORMAT(14,11,5E14,7)		00050000
TSN 0009	107	IF(NSUB)303,303,106		00060000
TSN 0010	108	IF(NOPC)303,303,107		00070000
TSN 0011	109	IF(NOPC-6)109,303,108		00080000
TSN 0012	110	IF(NOPC-8)102,111,112		00090000
TSN 0013	111	DO 110 JCARD=1,NOPC		00100000
TSN 0014	112	JARRAY=NSUB+JCARD-1		00110000
TSN 0015	113	ARRAY(JARRAY)=CARD(JCARD)		00120000
TSN 0016	114	GO TO 105		00130000
TSN 0017	115	HEAD(5,103)ITLF		00140000
TSN 0018	116	FORMAT(16,1744,A2)		00150000
TSN 0019	117	IF(TITLE(11)301,106,301		00160000
TSN 0020	118	NPAGE=0		00170000
TSN 0021	119	GO TO 105		00180000
TSN 0022	120	RETURN		00190000
TSN 0023	121	STOP		00200000
TSN 0024	200	NPAGE=NPAGE+1		00210000
TSN 0025	201	WRITE(6,2012)(TITLE(I),I=2,19),NPAGE		00220000
TSN 0026	202	FORMAT(1M,1744,A2,6M PAGE,13,1)		00230000
TSN 0027	203	RETURN		00240000
TSN 0028	301	WRITE(6,302)		00250000
TSN 0029	302	FORMAT(20M INVALID HEADER CARD)		00260000
TSN 0030	303	STOP		00270000
TSN 0031	304	WRITE(6,304)INSUB,NOPC,ARRAY		00280000
TSN 0032	305	FORMAT(19M INVALID DATA CARD,14,11,5E14,7)		00290000
TSN 0033	306	STOP		00300000
TSN 0034	307	END		00310000

LEVEL 21.7 AN 73)

US/360 FORTRAN M

```

COMPILER OPTIONS = NAME= MAY,OPT=02,LINECT=54,SIZE=0000K,
SOURCE,EHCIC,NOLIST,NOCHECK,LOAD,NAP,NOEDIT,10,NOXREF
C MEMBER NAME STMT1PH
C MATRIX PRINT=OUT SUBROUTINE = CF, 096MATPR
C
ISN 0002 SUBROUTINE MATPRN (A,NIR,NTC,MR,MC)
ISN 0003 IMPLICIT REAL*8(A-M,D-Z)
C
ISN 0004 DIMENSION A(1)
C
ISN 0005 1 FORMAT (8HDCOLUMNS 18, 4116 77H RDN)
ISN 0006 2 FORMAT (1M,17, 5E15.8)
ISN 0007 3 FORMAT (1M1,
1/ 37X, '(S-74 PROGRAM)')
C
ISN 0008 ICUS=0
ISN 0009 NCUS=5
ISN 0010 NR = 1
ISN 0011 NC = 5
ISN 0012 NOUT = 6
ISN 0013 10 IF (MC,LE,NTC) GO TO 11
ISN 0015 NCUS=NTC-NCUS+ICUS
ISN 0016 NC=NTC
ISN 0017 NOUT = 6
ISN 0018 11 WRITE (NOUT,1) (J80,J80=NR,NC)
ISN 0019 ICUS=ICUS+1
ISN 0020 KOUNT = 0
ISN 0021 K1=NR*NC
ISN 0022 NCUS=NCUS+NR
ISN 0023 GO 13 1=1,NTR
ISN 0024 IF (KOUNT,LE,40) GO TO 12
ISN 0026 WRITE (NOUT,3)
ISN 0027 WRITE (NOUT,1) (J80,J80=NR,NC)
ISN 0028 KOUNT=0
ISN 0029 12 K1=K1-NCUS+1
ISN 0030 WRITE (NOUT,2) 1,(A(K),K=K1,K17,MK)
ISN 0031 13 KOUNT=KOUNT+1
C
ISN 0032 IF (MC,EQ,NTC) GO TO 14
ISN 0034 NR = NR + 5
ISN 0035 NC = NC + 5
ISN 0036 WRITE (NOUT,3)
ISN 0037 GO TO 10
C
ISN 0038 14 RETURN
ISN 0039 END
00010000
00020000
00030000
00040000
00050000
00060000
00065000
00070000
00080000
00090000
00100000
00110000
00120000
00130000
00151000
00140000
00150000
00160000
00170000
00180000
00190000
00194000
00195000
00200000
00201000
00210000
00220000
00221000
00230000
00240000
00250000
00260000
00310100
00310200
00310300
00310400
00320000
00330000
00340000
00350000
00360000
00370000
00380000
00390000
00400000

```

LEVEL 21, 7 JAN 75)

[illegible]

LEVEL 21.7 AM 73)

03/360 FORTAN M

COMPILER OPTIONS = NAMES= NAJNTOPT=02,LINECHT=50,SIZE=000K,
SOURCE,ENCODIC,NOLIST,MODECK,LOAD,MAP,NUEDIT,ID,NORREF

```

C
C
C      MEMBER NAME S74A6LNS
      SUBROUTINE A6LNS
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*4 NS,NC
      COMMON/IKU/IKU,KEY
      COMMON/LINKA/INTOTAL,NORET,NTAPE
      DIMENSION X(25005)
      DIMENSION AAA(215),BBB(215),K(215),K9(215,20),KC(215,20)
      REWIND 12
      DO 10 I=1,NORET
        J=NORET-I+1
        J2=J*(J+1)/2
        J1=J2-J+1
        DO 20 I=1,IKU
          READ(12)((AAA(J),J=1,NORET),(BBB(J),J=1,NORET))
          CALL IPRU(X,AAA,R,NORET,NORET,1,0,1)
          DO 30 K=1,NORET
            NS(K,1)=H(K)
            CALL IPRU(X,BBB,H,NORET,NORET,1,0,1)
            DO 40 K=1,NORET
              KC(K,1)=H(K)
              WRITE(6,3001)
            300 FORMAT(1H,24X,'ARD=S-747/19X,'VIBRATORY INTERNAL LOADS',
1//,27X,'CASE ',I2)
            WRITE(6,100)
            100 FORMAT(//,6X,'SINE',1X,'SINE',13X,'COSINE',12X,'COSINE',
1//,5X,'DEFLECTIONS',10X,'LOADS',10X,'DEFLECTIONS',10X,
2//,5X,'INCHES',7X,'LBS & IN-LBS',9X,
3//,5X,'INCHES',7X,'LBS & IN-LBS',7X,'(A)',14X,
4//,5X,'(B)',14X,'(C)',14X,'(RC)',14X)
            WRITE(6,200)(AAA(L),NS(L,1),BBB(L),KC(L,1),L=1,NORET)
            200 FORMAT(1X,F13.8,5X,F13.4,5X,F13.8,5X,F13.4)
          20 CONTINUE
          REWIND 12
          IKU2=IKU+2
          IF(KY.EQ.1) IKU2=-IKU2
          WRITE(12)NORET,IKU2
          DO 50 I=1,IKU
            WRITE(12)(NS(J,1),J=1,NORET)
            50 WRITE(12)(KC(J,1),J=1,NORET)
          REWIND 12
          RETURN
        END
      END

```

APPENDIX F

LISTING OF COMPUTER PROGRAM FOR USE WITH NASTRAN, LEVEL 16, TO TAKE PUNCHED STRAIN ENERGY OUTPUT FROM RIGID FORMAT 1 TO SORT AND ANALYZE

FORTRAN IV G LEVEL	C1	DATA	DATE = 7/24/5	12/17/20	PAGE 0001
0001		PIMENSION CARD(20),CARD1(20),CARD2(20),CARD3(20),CARD4(20),			
0002	1	CARD5(20),CARD(20),IM1(10000),A1A(10000),B1B(10000),			
0003	1	MINENSION SCARD1(20),SCARD2(20),SCARD3(20),SCARD4(20),			
0004	1	SCARD5(20),SCARD6(20)			
0005	300	DATA TEST,7451177			
0006	300	FORMAT(1X,84HINDEX			
0007	1	ACCUMULATED			
0008	3	71X,77H NO.			
0009	15	IF (CASE,RE.0) GO TO 35			
0010	15	IF (CASE,RE.0) GO TO 35			
0011	15	IF (CASE,RE.0) GO TO 35			
0012	15	IF (CASE,RE.0) GO TO 35			
0013	20	IF (CASE,RE.0) GO TO 35			
0014	20	IF (CASE,RE.0) GO TO 35			
0015	20	IF (CASE,RE.0) GO TO 35			
0016	20	IF (CASE,RE.0) GO TO 35			
0017	20	IF (CASE,RE.0) GO TO 35			
0018	20	IF (CASE,RE.0) GO TO 35			
0019	20	IF (CASE,RE.0) GO TO 35			
0020	25	IF (CASE,RE.0) GO TO 35			
0021	25	IF (CASE,RE.0) GO TO 35			
0022	25	IF (CASE,RE.0) GO TO 35			
0023	25	IF (CASE,RE.0) GO TO 35			
0024	25	IF (CASE,RE.0) GO TO 35			
0025	25	IF (CASE,RE.0) GO TO 35			
0026	25	IF (CASE,RE.0) GO TO 35			
0027	25	IF (CASE,RE.0) GO TO 35			
0028	25	IF (CASE,RE.0) GO TO 35			
0029	25	IF (CASE,RE.0) GO TO 35			
0030	25	IF (CASE,RE.0) GO TO 35			
0031	25	IF (CASE,RE.0) GO TO 35			
0032	25	IF (CASE,RE.0) GO TO 35			
0033	25	IF (CASE,RE.0) GO TO 35			
0034	25	IF (CASE,RE.0) GO TO 35			
0035	25	IF (CASE,RE.0) GO TO 35			
0036	25	IF (CASE,RE.0) GO TO 35			
0037	25	IF (CASE,RE.0) GO TO 35			
0038	25	IF (CASE,RE.0) GO TO 35			
0039	25	IF (CASE,RE.0) GO TO 35			
0040	25	IF (CASE,RE.0) GO TO 35			
0041	25	IF (CASE,RE.0) GO TO 35			
0042	25	IF (CASE,RE.0) GO TO 35			
0043	25	IF (CASE,RE.0) GO TO 35			
0044	25	IF (CASE,RE.0) GO TO 35			
0045	25	IF (CASE,RE.0) GO TO 35			
0046	25	IF (CASE,RE.0) GO TO 35			
0047	25	IF (CASE,RE.0) GO TO 35			

```

0048 90 INQ = 0
0049 101 = IK - 2
0050 10 50 101,IK1
0051 IF (ERR(I).GE.RRP(1+1)) GO TO 50
0052 102 = 1
0053 SWAP1 = AA(I)
0054 SWAP2 = EBR(I)
0055 ISWAP = IM(I)
0056 AAR(I) = AA(I+1)
0057 EBR(I) = EBR(I+1)
0058 IM(I) = IM(I+1)
0059 AAR(I+1) = SWAP1
0060 EBR(I+1) = SWAP2
0061 IM(I+1) = ISWAP
0062 50 CONTINUE
0063 IF (INQ.EQ.1) GO TO 40
0064 SUM = 0.0
0065 100 101 = 1
0066 10 60 101,IKK
0067 SUM = SUM + EBR(J)
0068 WRITE(6,70) SUM(I),AA(I),EBR(I),SUM
0069 70 FORMAT(1X,15,5X,19,5X,F10.5,7X,F10.5,F10.5)
0070 KK = KK + 1
0071 IF (KK.LT.61) GO TO 60
0072 WRITE(6,10) SCARD1
0073 WRITE(6,10) SCARD2
0074 WRITE(6,10) SCARD3
0075 WRITE(6,10) SCARD4
0076 WRITE(6,10) SCARD5
0077 WRITE(6,10) SCARD6
0078 WRITE(6,300)
0079 PK = 10
0080 60 CONTINUE
0081 IF (IS.EQ.1) GO TO 100
0082 KK = 10
0083 10 101
0084 GO TO 10
0085 30 WRITE(6,45)
0086 40 FORMAT(10X,10X) 1000 CARDS WERE INPUT JOB ABORTED
0087 80 10 = 1
0088 GO TO 40
0089 100 CALL EXIT
0090 END

```

APPENDIX G

LISTING OF COMPUTER PROGRAM FOR USE WITH NASTRAN, LEVEL 16, TO REFORMAT RIGID FORMAT 3 PUNCHED EIGENVECTOR OUTPUT, FOR EXECUTION WITH RIGID FORMAT 1 AS SPC CARDS STRAIN ENERGY CALCULATIONS

```

DIMENSION CARD(18),COM(6)
DIMENSION FILLER(4),G(2)
DIMENSION CONT(2)
DIMENSION SPC(2),DUM(2)
DATA SPCS,SPCD,ASTER,BLANK /4HSPC*,4HSPCD,4H* ,4H
DATA BAD /4HBAD /
DATA TEST1 /4HSUBC/
DATA TEST2 /4HTITL/
IRK = 0
SPC(1) = SPCS
SPC(2) = BLANK
KOUNT = 0
REVIND 8
5 READ(5,10,END=100) CARD,INTX
10 FORMAT(18A4,I8)
KOUNT = KOUNT + 1
12 IF (INTX.NE.KOUNT) GO TO 60
IF (CARD(1).NE.TEST1) GO TO 5
READ(0,15) FILLER,ID
15 FORMAT(4A4,I8)
READ(5,10) CARD,INTX
KOUNT = KOUNT + 1
17 READ(5,10,END=100) CARD,INTX
KOUNT = KOUNT + 1
IF (INTX.NE.KOUNT) GO TO 70
19 READ(0,20) IGRID,G,COM(1),COM(2),COM(3),INTX
20 FORMAT(I10,2A4,5X,1PE13.6,5X,1PE13.6,5X,1PE13.6,I8)
33 READ(5,10,END=100) CARD,INTX
KOUNT = KOUNT + 1
IF (INTX.NE.KOUNT) GO TO 27
READ(0,25) CONT,COM(4),COM(5),COM(6),INTX
25 FORMAT(2A4,15X,1PE13.6,5X,1PE13.6,5X,1PE13.6,I8)
37 DO 40 I=1,6
IF (COM(I).NE.0.0) WRITE(6,30) SPC,ID,IGRID,I,COM(I)
IF (COM(I).NE.0.0) WRITE(7,21) SPC,ID,IGRID,I,COM(I)
IF (COM(I).NE.0.0.AND.IRK.EQ.0) WRITE(8,21) SPC,ID,IGRID,I,COM(I)
30 FORMAT(1X,2A4,I4,12X,I4,12X,I1,15) 1PE13.6)
21 FORMAT(2A4,I4,12X,I4,12X,I1,15X,I1 13.6)
40 CONTINUE
READ(5,10,END=100) CARD,INTX
KOUNT = KOUNT + 1
IF (INTX.NE.KOUNT) GO TO 70
IF (CARD(1).EQ.TEST2.AND.IRK.EQ.0) GO TO 50
IF (CARD(1).EQ.TEST2) GO TO 5
GO TO 19

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60  WRITE(6,80) CARD,INTX
80  FORMAT(10X,'THIS CARD OUT OF SEQUENCE ',18A4,I8)
    KOUNT = KOUNT + 1
    GO TO 5
70  WRITE(6,80) CARD,INTX
    DO 83 I=1,6
    COM(I) = BAD
    WRITE(6,32) SPC,ID,IGRID,I,COM(I)
    WRITE(7,65) SPC,ID,IGRID,I,COM(I)
83  CONTINUE
    KOUNT = KOUNT + 1
    GO TO 17
27  READ(8,20) IGRD, G,COM1,COM2,COM3,INTX
    WRITE(6,80) CARD,INTX
    COM(4) = PAD
    COM(5) = BAD
    COM(6) = BAD
    DO 72 I=1,3
    IF (COM(I).NE.0.0) WRITE(6,30) SPC,ID,IGRID,I,COM(I)
72  CONTINUE
    DO 82 I=4,6
    WRITE(6,32) SPC,ID,IGRID,I,COM(I)
32  FORMAT(1X,2A4,I4,12X,I4,12X,I1,15X,A4)
    WRITE(7,65) SPC,ID,IGRID,I,COM(I)
65  FORMAT(2A4,I4,12X,I4,12X,I1,15X,1PE13.6)
82  CONTINUE
    IGRID = IGRD
    COM(1) = COM1
    COM(2) = COM2
    COM(3) = COM3
    KOUNT = KOUNT + 1
    GO TO 33
50  SPC(1) = SPCD
    SPC(2) = ASTER
    END FILE 8
    REWIND 8
    IRK = 1
55  READ(8,21,END=5) DUM,ID,IGRID,I,COMA
    WRITE(6,30) SPC,ID,IGRID,I,COMA
    WRITE(7,21) SPC,ID,IGRID,I,COMA
    GO TO 55
100 CALL EXIT
    END

```

APPENDIX H

LISTING OF PROGRAM TO IDENTIFY AREAS OF HIGH STRAIN ENERGY DENSITY FOR SHAFTING (S-68)

MEMBER NAME AXIAL681	
SUBROUTINE AXIAL	00010000
COMMON /BLOCK5/ ITEMP(68)	00060000
DIMENSION ITEMP(68)	00070000
COMMON /BLOCK2/	00080000
101(24,24),U2(24,24),U3(24,24),U4(24,24),U5(24,24),U6(24,24),	00090000
207(24,24),NODE(4)	00100000
DIMENSION INDEX(4)	00110000
EQUIVALENCE (ITEMP(1),ITEMP(1))	00120000
NODE(1)=ITEMP(2)	00150000
NODE(2)=ITEMP(3)	00160000
AXAREA=ITEMP(4)	00170000
CF=ITEMP(5)	00180000
X1=ITEMP(6)	00190000
Y1=ITEMP(7)	00200000
Z1=ITEMP(8)	00210000
X2=ITEMP(9)	00220000
Y2=ITEMP(10)	00230000
Z2=ITEMP(11)	00240000
CALL UNPAK2(ITEMP(12),NX(1))	00260000
CALL UNPAK2(ITEMP(13),NX(7))	00270000
INDEX(1)=ITEMP(14)	00280000
INDEX(2)=ITEMP(15)	00290000
DO 1 J=1,12	00310000
DO 2 I=1,12	00320000
STRESS(1,J)=0.0	00330000
3 STIFFK(1,J)=0.	00340000
ALENTH=SQRT((X1-X2)**2+(Y1-Y2)**2+(Z1-Z2)**2)	00370000
ELEMK=AXAREA*CF/ALENTH	00380000
VOLUME=ALENTH*AXAREA	00390000
DCXX=(Z2-X1)/ALENTH	00430000
DCYY=(Y2-Y1)/ALENTH	00440000
DCZY=(Z2-Z1)/ALENTH	00450000
A=ELEMK*DCXX**2	00460000
B=ELEMK*DCXX*DCYY	00470000
C=ELEMK*DCXX*DCZY	00480000
D=ELEMK*DCYY**2	00490000
E=ELEMK*DCYY*DCZY	00500000
F=ELEMK*DCZY**2	00510000
CONST=SQRT((AXAREA*ALENTH)/(2.*CF))	00600000
STRESS(1,10)=(ELEMK*DCXX/AXAREA)*CONST	00610000
STRESS(1,11)=(ELEMK*DCYY/AXAREA)*CONST	00620000
STRESS(1,12)=(ELEMK*DCZY/AXAREA)*CONST	00630000
STRESS(1,4)=-STRESS(1,10)	00640000
STRESS(1,5)=-STRESS(1,11)	00650000
STRESS(1,6)=-STRESS(1,12)	00660000
STIFFK(4,4)=A	00670000
STIFFK(4,5)=B	00680000
STIFFK(4,6)=C	00690000
STIFFK(4,10)=-A	00700000
STIFFK(4,11)=-B	00710000
STIFFK(4,12)=-C	00720000
STIFFK(5,4)=B	00730000
STIFFK(5,5)=D	00740000
STIFFK(5,6)=E	00750000
STIFFK(5,10)=-B	00760000
STIFFK(5,11)=-D	00770000
STIFFK(5,12)=-E	00780000
STIFF(6,4)=C	00790000

MEMBER NAME AXIAL681

STIFFK(5,5)=E	00800000
STIFFK(6,6)=E	00810000
STIFFK(6,10)=E	00820000
STIFFK(6,11)=E	00830000
STIFFK(6,12)=E	00840000
STIFFK(10,4)=E	00850000
STIFFK(10,5)=E	00860000
STIFFK(10,6)=E	00870000
STIFFK(10,10)=E	00880000
STIFFK(10,11)=E	00890000
STIFFK(10,12)=E	00900000
STIFFK(11,4)=E	00910000
STIFFK(11,5)=E	00920000
STIFFK(11,6)=E	00930000
STIFFK(11,10)=E	00940000
STIFFK(11,11)=E	00950000
STIFFK(11,12)=E	00960000
STIFFK(12,4)=E	00970000
STIFFK(12,5)=E	00980000
STIFFK(12,6)=E	00990000
STIFFK(12,10)=E	01000000
STIFFK(12,11)=E	01010000
STIFFK(12,12)=E	01020000
CALL DANDS(STIFFK,STRESS,12,1,NX,INDEX,NODE,VOLUME)	01050000
RETURN	01060000
CND	01070000

MEMBER NAME PLANK681

SUBROUTINE PLANK	00010000
COMMON /BLOCKS/ ITEMP(68)	00020000
COMMON /BLOCK2/ NX(24),STRESS(24,24),STIFFK(24,24),	00070000
1AMFIAT(24,24),AMFIDAI(24,24),U1(24,24),U2(24,24),U3(24,24),U4(24,24)	00080000
2,U5(24,24),NODE(4)	00090000
COMMON /COMMON/ALINTE,F,BIYY,AYY,G,BI7Z,AZZ,NF1X1,NF1X2,NF1X3,	00100000
1NF1X4,NF1X5,NF1X6,BJ,AKAREA	00110000
DIMENSION ITEMP(68)	00120000
DIMENSION INDEX(4)	00130000
EQUVALENCE (ITEMP(1),ITEMP(1))	00140000
DATA ISPLANK /1H /	00150000
NODE(1)=ITEMP(12)	00160000
NODE(2)=ITEMP(13)	00190000
NODE(3)=ITEMP(14)	00200000
NODE(4)=ITEMP(15)	00210000
AKAREA=ITEMP(16)	00220000
BIYY=ITEMP(17)	00230000
AYY=ITEMP(18)	00240000
BI7Z=ITEMP(19)	00250000
AZZ=ITEMP(20)	00260000
BJ=ITEMP(21)	00270000
NF1X1=ITEMP(22)	00280000
NF1X2=ITEMP(23)	00290000
NF1X3=ITEMP(24)	00300000
NF1X4=ITEMP(25)	00310000
NF1X5=ITEMP(26)	00320000
NF1X6=ITEMP(27)	00330000
F=ITEMP(28)	00340000
G=ITEMP(29)	00350000
X1=ITEMP(30)	00360000
Y1=ITEMP(31)	00370000
Z1=ITEMP(32)	00380000
X2=ITEMP(33)	00390000
Y2=ITEMP(34)	00400000
Z2=ITEMP(35)	00410000
X3=ITEMP(36)	00420000
Y3=ITEMP(37)	00430000
Z3=ITEMP(38)	00440000
XA3=ITEMP(39)	00450000

YAS=TEMP(30)	00460000
ZAS=TEMP(31)	00470000
CALL UNPAK2(ITEMP(32), NX(1))	00490000
CALL UNPAK2(ITEMP(33), NX(7))	00500000
IND(X(1))=ITEMP(34)	00510000
IND(X(2))=ITEMP(35)	00520000
DO 50 J=1,12	00540000
DO 50 I=1,12	00550000
STIFFK(I,J)=0.	00560000
STRESS(I,J)=0.	00570000
AMBDAT(I,J)=0.	00580000
50 AMBDA(I,J)=0.	00590000
IF (MCONF.EQ.1B(ANK)) GO TO 70	00610000
65 Y3=XAS	00620000
Y3=YAS	00630000
Z3=ZAS	00640000
70 ALENTH=SQRT((X1-X2)**2+(Y1-Y2)**2+(Z1-Z2)**2)	00650000
CALL BEMFEM(SIIFEK)	00660000
A=Y2+73*Y1+72*Z1+Y3-(Y2+Z1+Y3+Z2+Y1+Z3)	00730000
B=X1+73+Z2+X3+Z1+Y2-(X3+Z1+X1+Z2+X2+73)	00740000
C=X1+Y2+Y1+X3+X2+Y3-(X3+Y2+X1+Y3+X2+Y1)	00750000
GG=SQRT(A**2+B**2+C**2)	00760000
AMBDA(1,1)=(X2-Y1)/ALENTH	00790000
AMBDA(1,2)=(Y2-Y1)/ALENTH	00800000
AMBDA(1,3)=(Z2-Z1)/ALENTH	00810000
AMBDA(3,1)=A/GG	00820000
AMBDA(3,2)=B/GG	00830000
AMBDA(3,3)=C/GG	00840000
AMRDA(2,1)=AMBDA(3,2)*AMBDA(1,3)-AMBDA(1,2)*AMBDA(3,3)	00850000
AMRDA(2,2)=AMBDA(3,3)*AMBDA(1,1)-AMBDA(1,3)*AMBDA(3,1)	00860000
AMRDA(2,3)=AMBDA(3,1)*AMBDA(1,2)-AMBDA(1,1)*AMBDA(3,2)	00870000
DO 15 JK=4,10,3	00890000
DO 15 J=1,3	00900000
JKPLJ=JK+J-1	00910000
DO 15 I=1,3	00920000
JKPLI=JK+I-1	00930000
15 AMBDA(IKPLI,JKPLJ)=AMBDA(I,J)	00940000
DO 16 J=1,12	00960000
DO 16 I=1,12	00970000
16 AMBDAT(I,J)=AMBDA(I,J)	00980000
VOLUME = ALENTH * AZZ	00990000
CALL MATMU2(STIFFK,AMBDAT,STRESS,12,12,12)	01010000
CALL MATMU2(AMBDAT,STRESS,STIFFK,12,12,12)	01020000
TEMP(1) = SQRT(ALENTH/(2.*G*BJ))	01110000
TEMP(2) = SQRT(ALENTH/(6.*E*BIYY))	01120000
TEMP(3) = SQRT(ALENTH/(6.*F*BTZZ))	01130000
TEMP(4) = 1./AYAREA	01140000
TEMP(5) = SQRT(ALENTH/(2.*G*AZZ))	01150000
TEMP(6) = SQRT(ALENTH/(2.*G*AYY))	01160000
JK = 1	01170000
JL = JK	01180000
86 DO 87 I=JK,12,6	01190000
DO 87 J=1,12	01200000
IF (TEMP(JL).EQ.0.) GO TO 87	01210000
STRESS(I,J) = STRESS(I,J) + TEMP(JL)	01220000
87 CONTINUE	01230000
JL = JL + 1	01240000
JK = JL	01250000
IF (JL.LE.6) GO TO 86	01260000
DO 20 J=1,12	01280000
STRESS(4,J)=STRESS(5,J)	01290000
STRESS(5,J)=STRESS(6,J)	01300000
STRESS(6,J)=STRESS(8,J)	01310000
STRESS(7,J)=STRESS(9,J)	01320000
20 STRESS(8,J)=STRESS(10,J)	01330000
CALL DANDS(STIFFK,STRESS,12,8,NX,INLX,NODE,VOLUME)	01340000
RETURN	01350000
END	01360000

MEMBER NAME	OPEN/81	
SUBROUTINE	MEMFRM(STIFFK)	00010000
DIMENSION	STIFFK(24,24)	00020000
COMMON/COMMON/ALENTH,E,BIYY,AXY,G,BI22,A22,NFIX1,NFIX2,NFIX3,		00030000
1NFIX4,NFIX5,NFIX6,BJ,AXAREA		00040000
TERM1=ALENTH/(3.*E*BIYY)		00060000
TERM2=1./((AXY+G*ALENTH)		00070000
TERM3=ALENTH/(3.*E*BI22)		00080000
TFPM4=1./((A22+G*ALENTH)		00090000
TAAZ=TERM1+TERM2		00100000
TARY=TERM2-.5*TERM1		00120000
TBAZ=TARY		00130000
TBDY=TAAZ		00140000
TAAZ=TERM3+TERM4		00160000
TAPZ=TFPM4-.5*TERM3		00170000
TBAZ=TAPZ		00180000
TBDZ=TAAZ		00190000
C117 = 0.		00200000
C122 = 0.		00210000
C222 = 0.		00220000
C11Y = 0.		00230000
C12Y = 0.		00240000
C22Y = 0.		00250000
IF((NFIX2.EQ.1).AND.(NFIX5.EQ.0))GO TO 1		00260000
IF((NFIX2.EQ.0).AND.(NFIX5.EQ.1))GO TO 2		00270000
IF((NFIX2.EQ.1).AND.(NFIX5.EQ.1))GO TO 4		00280000
DENOM = TAAZ + TARY - TABY + 2		00300000
C11Y = TARY/DENOM		00320000
C12Y = -TARY/DENOM		00330000
C22Y = TAAZ/DENOM		00340000
GO TO 4		00350000
1 C22Y = 1./TARY		00360000
GO TO 4		00380000
2 C11Y = 1./TAAZ		00390000
4 IF((NFIX3.EQ.1).AND.(NFIX6.EQ.0))GO TO 5		00400000
IF((NFIX3.EQ.0).AND.(NFIX6.EQ.1))GO TO 6		00410000
IF((NFIX3.EQ.1).AND.(NFIX6.EQ.1))GO TO 8		00420000
DENOM = TAAZ + TBDZ - TABZ ** 2		00450000
C117 = TBDZ / DENOM		00460000
C122 = -TABZ / DENOM		00470000
C222 = TAAZ / DENOM		00480000
GO TO 8		00490000
5 C222 = 1./TBDZ		00500000
GO TO 8		00510000
6 C117 = 1./TAAZ		00520000
8 IF((NFIX1.EQ.1).AND.(NFIX4.EQ.1))GO TO 9		00530000
STIFFK(1,1)=BJ*G/ALENTH		00540000
GO TO 10		00550000
9 STIFFK(1,1)=0.		00560000
10 STIFFK(1,7)=-STIFFK(1,1)		00570000
STIFFK(7,1)=-STIFFK(1,1)		00580000
STIFFK(7,7)=STIFFK(1,1)		00590000
STIFFK(4,4)=AXY*PEA+E/ALENTH		00600000
STIFFK(4,10)=-STIFFK(4,4)		00610000
STIFFK(10,4)=-STIFFK(4,4)		00620000
STIFFK(10,10)=STIFFK(4,4)		00630000
STIFFK(2,2)=C11Y		00640000
STIFFK(2,6)=C22Y		00650000
STIFFK(2,6)=-((C11Y+C12Y)/ALENTH		00660000
STIFFK(6,2)=STIFFK(2,6)		00670000
STIFFK(2,12)=-STIFFK(2,6)		00680000
STIFFK(12,2)=-STIFFK(2,6)		00690000
STIFFK(6,8) = -(C12Y+C22Y)/ALENTH		00700000
STIFFK(8,6) = STIFFK(6,8)		00710000
STIFFK(8,12)=-STIFFK(6,8)		00720000
STIFFK(12,8)=-STIFFK(6,8)		00730000
STIFFK(5,5) = (C117+2.*C122 +C222) *ALENTH+2)		00740000
STIFFK(5,11)=-STIFFK(5,5)		00750000
STIFFK(11,5)=-STIFFK(5,5)		00760000
STIFFK(11,11)=STIFFK(5,5)		00770000
STIFFK(12,8)=C22Y		00780000

STIFFK(8,2)=C12Y	00790000
STIFFK(3,7)=C11Z	00800000
STIFFK(9,9)=C22Z	00810000
STIFFK(3,5)=(C11Z+C12Z)/ALENTH	00820000
STIFFK(5,3)=STIFFK(3,5)	00830000
STIFFK(3,11)=-STIFFK(3,5)	00840000
STIFFK(11,3)=-STIFFK(3,5)	00850000
STIFFK(5,9)=(C12Z + C22Z)/ALENTH	00860000
STIFFK(9,5)=STIFFK(5,9)	00870000
STIFFK(11,7)=-STIFFK(5,9)	00880000
STIFFK(9,11)=-STIFFK(5,9)	00890000
STIFFK(6,6)=1C11Y + 2.0 C12Y + C22Y/(ALENTH**2)	00900000
STIFFK(6,12)=-STIFFK(6,6)	00910000
STIFFK(12,6)=-STIFFK(6,6)	00920000
STIFFK(12,12)=STIFFK(6,6)	00930000
STIFFK(3,9)=C12Z	00940000
STIFFK(9,3)=C12Z	00950000
RETURN	00960000
END	00970000

MEMBER NAME CORR1	
SUBROUTINE CORR1	00010000
DIMENSION LT(999),NOS(3),E(3),U(3),HOLD(80),G(3)	00020000
DIMENSION H1(999),MAP(300),MDOF(300)	
COMMON/JUNE/ KOP,LAC,LT,NIN,NOUT,NPCH,E,U,HOLD,G,JN,MAP,MDOF,MT,MM	00030000
EQUIVALENCE(10,NOS(1)),(ND1,NOS(2)),(ND2,NOS(3))	00040000
901 FORMATT(1,3,213,X,11,E10,5)	00050000
902 FORMAT(101,214,5X,8A1,46X,5A1)	00060000
10 READ(0,901)NOS,MC,AEL	00070000
WRITE(2,901)NOS,MC,AEL	00070010
IF(10.NE.2)GO TO 30	00080000
IF(MC.FR.0)MC=1	00090000
ND1=1(ND1)	00100000
ND2=1(ND2)	00110000
WRITE(0,700)AEL,E(MC)	00130000
100 FORMAT(2HE11,3,2PE9,1)	00140000
RF(0,101)HOLD	00140010
101 FORMAT(80A1)	00140020
WRITE(NPCH,902)ND1,ND2,HOLD(2),HOLD(3),(HOLD(11,1-5,9),HOLD(11,1-5,9))	00150000
HOLD(13),HOLD(14),HOLD(16),HOLD(17),HOLD(20)	00160000
30 RETURN	00170000
END	00180000

MEMBER NAME CORR1	
SUBROUTINE CORR1	00010000
DIMENSION LT(999),NTH(3),NEC(6),NDL(3),HOLD(80),E(3),U(3),G(3)	00090000
DIMENSION SL(999),MAP(300)	00100000
DIMENSION MDOF(300),MT(999)	00110000
COMMON/JUNE/ KOP,LAC,LT,NIN,NOUT,NPCH,E,U,HOLD,G,JN,MAP,MDOF,MT,MM	00120000
DATA XSGN/1.0/	00130000
DATA PSIGN/1.0/	00140000
DATA AZEPD/2F0404040/	00150000
EQUIVALENCE(NTH(1),NEC(1)),(NDL(1),NEC(4))	00160000
MM=0	00170000
JN = 0	00180000
90110 JN=1,300	00190000
110 MAP(J) = 0	00200000
100 READ(NIN,101)NDN,X,Y,Z,NEC,11	00210000
WRITE(2,101)NDN,X,Y,Z,NEC,11	00210100

	IF(X.EQ.0.9) X=0.00001	00211000
101	FORMAT(13,3F10.4,6I1,32X,11)	00220000
	DO 120 J=1,6	00260000
	IF(NEC(J).NE.2) GO TO 120	00270000
	JN = JN + 1	00280000
	MAP2JN1 = NON	00290000
	POOF(JN) = J	00300000
120	CONTINUE	00310000
	MM=MM+1	00370000
	LT(NON)=MM	00380000
	MT(MM) = NON	00390000
	DO 200 J=1,6	00430000
	IF(MEC(J).GE.1) GO TO 150	00440000
	MFC(J)=1	00450000
	GO TO 200	00460000
150	MFC(J)=0	00470000
200	CONTINUE	00480000
	WRITE(6,220)X,Y,Z	00520000
220	FORMAT('F10.4,2X,F10.4,2X,F10.4,2X')	00540000
	READ(6,201)HOLD	00540010
201	FORMAT(60A1)	00540020
	DO 250 J=2,26,12	00550000
	N=J+3	00590000
	DO 250 I=J,N	00600000
	IF(POLO(I).EQ.XSIGN.OR.HOLD(I).EQ.PSIGN)GO TO 300	00610000
250	CONTINUE	00620000
	GO TO 350	00630000
300	HOLD(I-1)=HOLD(I)	00640000
	HOLD(I)=AZERO	00650000
350	CONTINUE	00660000
	WRITE(NPCH,361) MM,(HOLD(I),I=1,5),(HOLD(I),I=7,17),	00710000
	1(HOLD(I),I=19,29),(HOLD(I),I=31,36),NDL,NTH	00720000
361	FORMAT(14,1X,53A1,611)	00730000
	IF(11.NF.9)GO TO 100	00740000
	WRITE(NPCH,361)	00750000
361	FORMAT(180X)	00760000
	RETURN	00770000
	END	00780000

MEMBER NAME HANDS621

	SUBROUTINE HANDS(STIFF,STRESS,NRECS,NRISH,NX,1D4NODE,VOLUME)	
	COMMON NELREC, PRECS, NREC11, LSTCON, NBAND, MXBAND,	00020000
1	MXLCHD, MXHDS, NBASE, NSTIEF, NSTRES, LIN,	00030000
2	NSFREC, HOGO, NSTRPS, KNTLOS, MUDDY1, MUDDY2	00040000
	COMMON/RCNT/JNCS	00050000
	COMMON/JULY/IDNO	00060000
	EQUIVALENCE (NUMREC,JRECS)	00070000
	DIMENSION STIFF(24,24),STRESS(24,24),NX(24),EXTR1(24,24)	00080000
	1,SAVE(24,24),EXTR2(24,24),NODE1(1,1D191,NID14)	00090000
	DIMENSION NEWNY(20),STRES2(24,24),NNODE(4),NSTIEF(4),NSTRES(4)	00100000
	1,IND(24),INI(24)	00100500
	DO 2 J=1,24	00120000
	GO 2 J=1,24	00130000
	EXTR1(I,J)=0.	00140000
	STRES2(I,J)=0.	00150000
	SAVE(I,J)=0.	00160000
2	EXTR2(I,J)=0.	00170000
	LL=0	00220000
	DO 99 I=1,NPLDCK	00230000
	NSTIEF(I)=0	00240000
	LL=LL+6	00250000
	L=LL-5	00260000
	DO 99 M=L,LL	00270000
	IF(NX(M).EQ.0)NSTIEF(I)=NSTIEF(I)+1	00280000
99	CONTINUE	00290000
	NGRLAT=MODE(1)	00340000
	DO 10 J=2,NPLDCK	00350000

IF (NODE(1).GT.NGREAT)NGREAT=NODE(1)	00360000
10 CONTINUE	00370000
NLEAST=NODE(1)	00430000
DO 11 I=2,NBLOCK	00440000
IF (NODE(I).LT.NLEAST)NLEAST=NODE(I)	00460000
11 CONTINUE	00470000
KK=0	00500000
DO 12 J=1,NBLOCK	00510000
IF (NODE(J).NE.NGREAT)GO TO 18	00530000
NNODE(1)=NODE(I)	00540000
NID(1)=ID(I)	00550000
DO 14 K=1,6	00560000
NSTRES(1)=NSTIFF(I)	00570000
KKK=K+KK	00580000
NEWNX(K)=NX(KKK)	00590000
DO 14 J=1,NRISM	00610000
14 STR(S2(J,K))=STRESS(J,KKK)	00620000
GO TO 20	00630000
18 KK=KK+6	00640000
12 CONTINUE	00670000
20 LL=0	00710000
DO 30 I=1,NBLOCK	00720000
IF (NODE(I).NE.NLEAST)GO TO 29	00740000
NNODE(2)=NODE(I)	00750000
NID(2)=ID(I)	00760000
NSTRES(2)=NSTIFF(I)	00770000
DO 24 L=1,6	00790000
LLL=L+LL	00800000
NEWNX(L+6)=NX(LLL)	00810000
DO 24 J=1,NRISM	00830000
24 STR(S2(J,L+6))=STRESS(J,LLL)	00840000
GO TO 31	00850000
22 LL=LL+6	00870000
30 CONTINUE	00890000
31 IF (NBLOCK.EQ.2)GO TO 51	00920000
MM=0	00940000
DO 40 I=1,NBLOCK	00960000
IF (NODE(I).EQ.NGREAT)GO TO 39	00970000
IF (NODE(I).EQ.NLEAST)GO TO 39	00980000
NNODE(3)=NODE(I)	01000000
NID(3)=ID(I)	01010000
NSTRES(3)=NSTIFF(I)	01020000
DO 34 M=1,6	01040000
MMM=M+MM	01050000
NEWNX(M+12)=NX(MMM)	01060000
DO 34 J=1,NRISM	01080000
34 STR(S2(J,M+12))=STRESS(J,MMM)	01090000
GO TO 41	01100000
39 MM=MM+6	01110000
40 CONTINUE	01120000
41 IF (NBLOCK.EQ.3)GO TO 51	01130000
NN=0	01150000
DO 50 I=1,NBLOCK	01170000
IF (NODE(I).EQ.NGREAT)GO TO 49	01180000
IF (NODE(I).EQ.NLEAST)GO TO 49	01190000
IF (NODE(I).EQ.NNODE(3))GO TO 49	01200000
NNODE(4)=NODE(I)	01220000
NID(4)=ID(I)	01230000
NSTRES(4)=NSTIFF(I)	01240000
DO 44 N=1,6	01260000
NNN=N+NN	01270000
NEWNX(N+18)=NX(NNN)	01280000
DO 44 J=1,NRISM	01290000
44 STR(S2(J,N+18))=STRESS(J,NNN)	01300000
GO TO 51	01310000
49 NN=NN+6	01320000
50 CONTINUE	01330000
51 CONTINUE	01340000
IND(1)=1	01360000
JVC=1	01370000

INK = 1	01370100
IN1(1) = 1	01370200
DO 750 I1 = 2, NCOLS	01380000
I1M1 = I1 - 1	01390000
IF (NWX(I1M1), EQ, 0) INC = 0	01400000
IND(I1) = IND(I1M1) + INC	01410000
INC = 1	01420000
IF (NWX(I1M1), EQ, 0) INK = 0	01420100
IN1(I1) = IN1(I1M1) + INK	01420200
INK = 1	01420300
750 CONTINUE	01430000
DO 770 J1 = 1, NCOLS	01440000
DO 770 J1 = 1, NCOLS	01450000
EXTP2(IND(I1), IND(J1)) = STIFF(I1, J1)	01460000
770 STRES2(I1, IN1(J1)) = STRES2(I1, J1)	01470000
INDLST = IND(NCOLS)	01470010
INILST = IN1(NCOLS)	01470020
IF (NWX(NCOLS), EQ, 0) INDLST = INDLST + 1	01470021
IF (NWX(NCOLS), EQ, 0) INILST = INILST + 1	01470025
IF (INDLST, GT, NCOLS) GO TO 778	01470029
DO 775 I1 = INDLST, NCOLS	01470030
DO 775 J1 = 1, NCOLS	01470040
EXTP2(J1, I1) = 0.	01470041
775 EXTP2(I1, J1) = 0.	01470050
778 IF (INILST, GT, NCOLS) GO TO 782	01470055
DO 780 J1 = INILST, NCOLS	01470060
DO 780 I1 = 1, NRISM	01470070
780 STRES2(I1, J1) = 0.	01470090
782 CONTINUE	01470095
JA = 0	01470100
DO 211 I = 1, NCOLS	01620000
IF (NWX(I), GT, 0) GO TO 211	01630000
JA = JA + 1	01640000
EXTP2(I, JA) = 1.0	01650000
211 CONTINUE	01660000
WRITE(9) NUMREC, NBLOCK, NRISM, (IND(I), I = 1, NDBLOCK),	01690000
(INODE(I), I = 1, NDBLOCK), (NSTRES(I), I = 1, NDBLOCK), JA,	01700000
2((STRES2(I, J), J = 1, JA), I = 1, NRISM), IDNO, VOLUME	01710000
NRREC = NRREC + 1	01720000
MROWL = 0	01750000
DO 301 I = 1, NDBLOCK	01760000
MROWL = MROWL + NSTIFF(I)	01770000
MROWF = MROWL - NSTIFF(I) + 1	01780000
MCOLL = 0	01790000
DO 301 J = 1, NDBLOCK	01800000
IF (NSTIFF(I), EQ, 0.0, OR, NSTIFF(J), EQ, 0.0) GO TO 301	01810000
MCOLL = MCOLL + NSTIFF(J)	01820000
MCOLE = MCOLL - NSTIFF(J) + 1	01830000
WRITE(9) 'DATA', ID(I), NSTIFF(I), NSTIFF(J), ((EXTP2(M, N), N = MCOLE,	01860000
1, MCOLL), M = MROWF, MROWL)	01870000
NSFREC = NSFREC + 1	01880000
301 CONTINUE	01900000
RETURN	01910000
END	01920000
MEMBER NAME DATA(61)	
SUBROUTINE DATA	00010000
DIMENSION LT(999), NCG(10), E(3), U(3), HOLD(40), G(3)	
DIMENSION MAP(300), WIL(250), WHASS(6), C(250), FH(250, 10),	
MDOF(300), FOR(250, 10), OP(6), MT(999)	
DIMENSION DATA(26)	00090100
COMMON / JUNE / KOP, LAC, LT, NIN, NOUT, NPCH, F, U, HOLD, G, IN, MAP, MDOF, MI, MM	00100000
COMMON / PART / TITLE(20)	00120000
NPCH = 5	00130000
NIN = 15	00140000
CALL LOADER(DATA, 1)	00150000
POS = DATA(1)	00160000
NIR = DATA(3)	00170000
NTC = DATA(14)	00180000
IPT = DATA(17)	00190000
NSTIFF = DATA(18)	00200000

MSTRES=DATA(26)	00210000
WRITE(NPCH,1002) (TITLE(I),I=1,20)	00220000
1002 FORMAT(20A4)	00230000
WRITE(NPCH,1003) MSTIFF,MSTRES	00240000
1003 FORMAT(214)	00250000
WRITE(NPCH,1004) WJSD,NTC	00260000
1004 FORMAT('0001',I4,'0000',I4,'00000000')	00270000
DO 1050 I=1,3	00280000
F(I)=DATA(I+6)	00290000
U(I)=DATA(I+9)	00300000
G(I)=F(I)/(2.0*(1.0+U(I)))	00310000
1050 CONTINUE	00320000
CALL COORD	00390000
WRITE(14) MM, (MT(I),I=1,MM)	00400000
1100 READ(NIN,21720) HOLD	00450000
READ(10,1120)NT,JJ	00460000
1120 FORMAT(I3,68X,I1)	00470000
NT=NT+1	00510000
GO TO(1400,1200,1300,1400,1500),NT	00530000
1200 CONTINUE	00540000
WRITE(6,1270)	00550000
1270 FORMAT(IHO 'ERRONEOUS CARD IN INPUT DATA')	00560000
CALL EXIT	00570000
1300 CALL CD	00580000
GO TO 1610	00590000
1400 CALL NF	00600000
GO TO 1610	00610000
1500 CALL FF	00620000
1610 IF(JJ.NE.9)GO TO 1100	00630000
WRITE(NPCH,10001)	00640000
10001 FORMAT(ROX)	00650000
DO 11010 J=1,250	
11010 WT(J) = 0.0	00710000
11000 READ(NIN,11001) NODE,(WMASS(I),I=1,6), NC	00720000
11001 FORMAT(I4,6E10.0,15X,I1)	00730000
NN = 0	00740000
DO 11200 L=1,6	00750000
IF(WMASS(L).EQ.0.) GO TO 11300	00760000
IF(NN.GT.0) GO TO 11150	00770000
NN = 1	00780000
JJ = 0	00790000
11100 JJ = JJ + 1	00800000
IF(MAP(JJ).NE.NONE) GO TO 11100	00810000
GO TO 11200	00820000
11150 JJ = JJ + 1	00830000
11200 WT(JJ) = WMASS(I)	00840000
11300 IF(NC.NE.9) GO TO 11000	00850000
IF(IPT.(0.1)GO TO 20000	01010000
READ(12,19000)MSQ,LRA	01020000
19000 FORMAT(214)	01030000
IF(NTR.LE.MSQ)GO TO 19100	01040000
WRITE(16,20010)MSQ,NTR	01050000
NTR=MSQ	01060000
19100 I=(NTR.LE.LRA)GO TO 19200	01070000
WRITE(16,20060)I,LRA,NTC	01080000
NTR=LRA	01090000
19200 READ(12,19300)NR,NC,(C(ID),ID=1,5)	01100000
19300 FORMAT(13,12,5C15.0)	01110000
IF(NR.LL.0)GO TO 20300	01120000
DO 19400 ID=1,5	01130000
PHC(NR,NC)=C(ID)	01140000
19400 NC=NC+1	01150000
GO TO 19200	01160000
20000 REWIND 3	01170000
READ(13) MSQ,LRA	01180000
IF(NTR.LE.MSQ)GO TO 20050	01190000
WRITE(16,20010)MSQ,NTR	01200000
20010 FORMAT(IHO, 4HMSG=,16,20X, 4HNTR=,16)	01210000
NTR=MSQ	01220000
20050 IF(NTR.LE.LRA)GO TO 20100	01230000
WRITE(16,20060)LRA,NTC	01240000
20060 FORMAT(IHO, 4HLRA=,16,20X, 4HNTC=,16)	01250000
NTC = LRA	01260000

20100	DO 20150 J=1,NTR	01270000
	READ(3) (C(MN),NN=1,NTR)	01280000
	DO 20150 NN=1,NTR	01290000
20150	PH(MN,J) = C(MN)	01300000
20300	DO 21000 J=1,NTR	01330000
	DO 21000 K=1,NTR	01340000
	FOR(J,K)=VT(J)*PH(J,K)+10000	01350000
21000	CONTINUE	01350400
	DO 21000 J=1,NTR	01410000
	KP = 1	01450000
	DO 21800 JJ=1,NTR	01460000
	NO = HAP(JJ)	01470000
	DO 21500 K=KP+6	01520000
	IF(K.EQ.MDOF(JJ)) GO TO 21550	01530000
	OP(K) = 0	01540000
21500	CONTINUE	01550000
	GO TO 21600	01560000
21550	OP(K) = FOR(JJ,K)	01570000
21600	IF(HAP(JJ+1).EQ.NO) GO TO 21750	01580000
	KO = K+1	01590000
	DO 21650 KK=KO+6	01600000
	OP(KK) = 0	01610000
21650	CONTINUE	01620000
	KP = 1	01630000
	WRITE(10,21700)LT(NO),1,OP(4),OP(5),OP(6),OP(1),OP(2),OP(3)	01680000
21700	FORMAT(214,6PG12,0)	01690000
	READ(10,21720)HOLD	01690100
	WRITE(NPCH, 21720) HOLD	01700000
21720	FORMAT(80A1)	01710000
	GO TO 21800	01720000
21750	KP = K + 1	01730000
21800	CONTINUE	01740000
21900	CONTINUE	01750000
	WRITE(NPCH,21901)	01760000
21901	FORMAT(80X)	01770000
	REWIND 5	01780000
	RETURN	01790000
	END	01800000

MEMBER NAME DL6A1

	SUBROUTINE DE	00010000
	DIMENSION LT(299),MGR(3),NOS(4),TPC(3),HOLD(40),E(3),U(3),G(3)	00020000
	DIMENSION MT(995),HAP(300),MDOF(360)	
	COMMON/JUNK/ KOP,LAC,LT,NIN,NOUT,NPCH,E,U,HOLD,G,JN,HAP,MDOF,MT,HMO	00030000
	EQUIVALENCE (10,NOS(1)),(ND1,NOS(2)),(ND2,NOS(3)),(ND3,NOS(4)),	00040000
	(MGR(1),NOS(2))	00050000
901	FORMAT(13,315,11,3F10.5)	00060000
902	FORMAT('04',314,4X,31A1)	00070000
10	READ(10,901)NOS,MC,TPC	00080000
	WRITE(2,901)NOS,MC,TPC	00080010
	IF(10.NF.0.AND.10.NE.3)GO TO 30	00090000
	IF(TPC(1).EQ.0)MC=1	00100000
	IF(TPC(2).NE.0.0)GO TO 21	00110000
	IF(TPC(3).NE.0.0)GO TO 21	00120000
	TPC(2)=TPC(1)	00130000
	TPC(3)=TPC(1)	00140000
21	ND1=LT(ND1)	00150000
	ND2=LT(ND2)	00160000
	ND3=LT(ND3)	00170000
	NRLCK=NCOLS/6	00180000
	WRITE(10,100)TPC,E(MC),G(MC)	00190000
100	FORMAT(1PE10.3,1PE10.3,1PE10.3,2PE9.1,2PE9.1)	00200000
	READ(10,101)HOLD	00200010
101	FORMAT(80A1)	00200020
	WRITE(NPCH,902)MGR,HOLD(2),(HOLD(1),I=4,8),HOLD(10),HOLD(12),	00210000
	(HOLD(1),I=14,18),HOLD(20),HOLD(22),(HOLD(1),I=24,28),HOLD(30),	00220000
	2HOLD(32),HOLD(33),HOLD(35),HOLD(36),HOLD(38),HOLD(41),HOLD(42),	00230000
	3HOLD(44),HOLD(45),HOLD(48)	00240000
30	RETURN	00250000
	END	00260000

MEMBER NAME	GETGRI	
SUBROUTINE	FE	00010000
DIMENSION	REL(4),L1(99),NOS(4),I(3),UC(3),HOLD(40),G(3)	00020000
DIMENSION	MT(99),JAF(360),MUOF(360)	
COMMON	JULY/KR,LAC,LI,NIN,NOUT,NPCH,,U,HOLD,G,JH,MAP,MUOF,M1,MH	00030000
EQUIVALENCE	(L1,I(1)),(N(1),NOS(2)),(N(2),NOS(3)),	00040000
	(N(3),NOS(4)),(L2Z,BEL(1)),(P,BEL(2)),(L2Z,BEL(3))	00050000
901	FORMAT(13,113,11,3F10.5)	00060000
903	FORMAT(1007,314,25X,24A1,16,10A1)	00070000
10	READ(6,901)NOS,RC,BEL	00080000
	WRITE(2,903)NOS,RC,BEL	00080010
	NUMBER=10010	00090000
	IF(L1,BL,4)GO TO 30	00100000
	IF(PI,FG,0)PC=1	00110000
	IF(P,FG,0)NUMBER=110110	00120000
	ND1=L1(L1)	00130000
	ND2=L1(ND1)	00140000
	ND3=L1(ND2)	00150000
	WRITE(10,100)SZZ,AZZ,P,EIMC1,G(MC)	00170000
100	FORMAT(2PF11.3,2PF11.3,2PF11.3,2PF4.1,2PF0.1)	00180000
	READ(6,101)HOLD	00180010
101	FORMAT(80A1)	00180020
	WRITE(803,903)ND1,ND2,ND3,HOLD(2),HOLD(3),HOLD(1),I=5,9)	00190000
	HOLD(11),HOLD(13),HOLD(14),(HOLD(1),I=16,26),HOLD(22),	00200000
	HOLD(34),HOLD(25),(HOLD(1),I=27,31),HOLD(33),NUMBER,HOLD(35),	00210000
	HOLD(36),HOLD(38),HOLD(39),HOLD(42),HOLD(44),	00220000
	HOLD(45),HOLD(47),HOLD(48),HOLD(51)	00230000
30	RETURN	00290000
	END	00250000

MEMBER NAME	GETGRI	
SUBROUTINE	CENTIF	00010000
COMMON	NELREC, NPLCS, NPEC11, LSTCON, KHAND, KXPAND,	00040000
1	KXLOND, MYHODS, NBASE, MSTIFF, NSTRES, LIN,	00050000
2	ISEPEC, HCGO, NSTEPS, KNTLDS, MUDDY1, MUDDY2	00060000
COMMON	ELLOCKE/ITEMP(48)	00070000
COLLOC	ELLOCKE/2/ NXL(24),S11(24,24),S12(24,24),ALLDA1(24,24)	00080000
1	AKPDA(24,24),AKP21(24,24),AK12(24,24),AKINV(24,24),AK(24,24),	00090000
	PDMA(24,24),NODE(4)	00100000
COMMON	PCNT/JRECS	00110000
COMMON	JULY/JRNO	00120000
DIMENSION	TEMP(60)	00130000
EQUIVALENCE	(TEMP(1),ITEMP(1))	00140000
	NSPEC = 0	00150000
	PREC = 0	00160000
	JRECS = 0	00170000
	REWIND 4	00180000
	REWIND 11	00190000
1	IF(JRECS.EQ.NELREC)GO TO 11	00200000
	READ(4)(ITEMP(1),I=1,68)	00210000
	JRECS=JRECS+1	00220000
	IDN=ITEMP(1)	00230000
	GO TO (2,3,4,5,6,7,8,9,10),IDNO	00240000
2	CALL AXIAL	00250000
	GO TO 1	00260000
3	CALL PEAK	00270000
	GO TO 1	00280000
4	CONTINUE	00290000
5	CALL TRIANG	00310000
	GO TO 1	00320000
6	CONTINUE	00330000
7	CONTINUE	00442100
8	CONTINUE	00442200
9	CONTINUE	00442300
10	CONTINUE	00442400
11	CONTINUE	00450000
	REWIND 4	00460000
	LARR = 9700	00470000
	NZERO = NSTEPS	00480000
	WRITE(9),NZERO,NZERO,NZERO,LARR,NZERO,	00490000

1	NEIFEC, NRECS, NREC11, LSTCON, NREND, MXRAND,	00500000
1	MXLCND, MXNODS, NRIASE, NSTIFF, MSTRLS, LIN,	00510000
2	NSREFC, NRGD, NSTRPS, KNILDS, MUDDY1, MUDDY2	00520000
	REWIND 8	00530000
	REWIND 9	00540000
	CALL EXIT	00550000
	RETURN	00560000
	END	00570000

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MEMBER NAME HQRWZLRO
  TITLE *SUBROUTINE HQRWZERO ** U C S P R O P R I E T A R Y ** UN022575
  * * * * *
  * THIS SUBROUTINE SOURCE LISTING IS * DN100374
  * - R C S P R O P R I E T A R Y - * DN100374
  * * * * * DN100374
  * DN100374
  * BCS READWRITE LOGICAL FORTRAN UNIT ZERO
  * FOR INTERNAL CONVERSION BY FORMAT CODES
  * VERSION 2 LEVEL RELEASE 21.6, AUGUST 1972
  * REVISED BY NORMAN MENZIE WICHITA DISTRICT
  * THIS ASSUMES THAT THE EXTENDED ERROR FACILITY IS SYSGEN
  * OPTION
  *
  * BUFFERS VALID READ (VR) READ NON ZERO UNIT
  * /CONVRT/ INTERNAL CONVERSION BUFFER (ICE)
  *
HQRWZERO START
  ENTRY FIOCSH 00001100
  EXRN HQRZIGES
  ENTRY ZRGERR 00001300
  ENTRY HQRVEN
  ENTRY HQRWER
  RUEPTRS EQU X'114' LOCATION IN INCOM CONTAINING BUFFER, LENGTH
  DSRNLOC EQU X'3C' SAVED DSRN UNIT IN INCOM FOR MESSAGES
  SAVELOC EQU X'7C' SAVE LOCATION IN INCOM TH ALLOW NEXT I/O
  INIT EQU X'00' 00001500
  USING 0,1 00001600
  FIOCSH EQU 0 00001700
  ZZZ STM 4,15,SAVE 00001800
  PROP 1 00001900
  LR 11,1 00002000
  USING ZZZ,11 00002100
  L 1,ADFIOCS 00002300
  CLI DISABLE,X'FF'
  IF XIT GO DIRECT TO FIOCSH WITHOUT FURTHER CHECKS
  USING CONVRT,12
  L 12,CONVRTAD SET UP CONVRT BUFFER
  LP 4,0 00002200
  LP 5,2 00002400
  CLI 0(4),X'03' CHECK FOR A CONTROL I/O STATEMENT 00002500
  PHL SETOFF YES---CANCEL BUFFERS IF UNIT IS SAME AS VR 00002600
  CLI 0(4),INIT NO CHECK FOR INITIALIZATION CALL 00002700
  PNE WORK NO 00002800
  SR 6,6
  ST 6,XODE ASSUME NO ERRORS
  LA 7,CHECKZ SET FOR DSRN CHECK
  TH 0(5),X'0F' YES CHECK FOR READ-PUNCH TYPE 00002900
  FZ DSRN NO 00003000
  HI 19,0 YES 00003100
  " YIT 00003200
  SETOFF EQU 0 00004000
  CLI 0(4),X'04' IS IT A CLOSE ALL DATA SETS
  RF CLOSFA YES
  PAL 7,DSRN
  CLI 3(5),0 IS IT ZERO DSRN
  IF SETERR YES

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MEMBER NAME	ADDRESS	DESCRIPTION	VALUE
	CLC 2(2,5),USRNVR	IS IT SAME UNIT AS FOR -VR-	
	INX YIT	NO	
CLOSEA	EQU *		
	LH 6,SV2	RESET LENGTH	
	ST 6,SV2	AND	
	L 6,CONVERTAD	BUFFER	
	ST 6,SV1		
	YC 199,199		
	L XIL		
SETER53	EQU *		
	LA 6,3	INDICATE CONTROL OF	
SETER8	EQU *		
	ST 6,KOBI	ON OSRN (0)	
	STC 6,KOPEFF	STORE CODE INTO FORMAT	
	LA 6,1		
	AN 6,ERRCOUNT		
	STH 6,ERRCOUNT	CURRENT COUNT OF ERRORS	
	CH 6,ERRLIMIT	HAVE WE REACHED A MAXIMUM	
	PNP LEAVE	NO	
	STAE 0	NULLIFY FORTRAN STAF	
	OL K00FF1,X1FF0*	ADD ZONE TO II	
	L 6,VUATIL		
	LH 7,0(6)	GET THE ERROR UNIT	
	STH 7,ERRUNIT+2		
	L 15,VIPCOM		
	PVI SAVELOC(15),X'FF*	SAVE LOC IN IPCOM--TO ALLOW NEXT I/O	
	CNOP 0,4		
	HAL 14,4(15)	GO TO IRCON WITH FORMAT CALL	
ERRUNIT	CC F'0*	LOGICAL UNIT	
	CC A(FORMAT)	FORMAT LOCATION	
	HAL 10,16(15)	END THE LIST FOR THIS OUTPUT	
	AREND 993,DUMP		
VIPCOM	CC V(IRCONH)		
VUATIL	CC V(ICHUATIL)		
FORMAT	CC X'021A2F0*		
	CC C'INCORRECT USE OF READ/WRITE ZERO CODE= *		
KOPEFF	CC X'0022*	END OF THE FORMAT	
USRN	TH 2(5),X'01*	IS IT VARIABLE	00003400
	BZ NOTVAR	NO	00003500
	L 5,0(5)		00003600
NOTVAR	EQU *		00003700
	BR 7		
CHECKZ	EQU *		
	CLJ 3(5),0	IS IT UNIT ZERO	
	BE EYDASS1	YES	00003200
	YC 199(2),199	ZERO TWO FLAG BYTES	
	CLJ 1(4),Y'F0*	IS IT FORMATTED INPUT	00004200
	SNR WORK	NO	00004300
	PVI 199+1,X'FF*	SET INPUT FLAG	00004400
WORK	EQU *		00004500
	TH 199,X'FF*	WAS IT A ZERO USRN	00004600
	PO BYPASS	YES	00004700
	PVC ARG,0(4)		00004800
	BLR 0,1	GO TO FLOSH	00004900
ARG	DS CLP		00005000
	R LEAVE2	EXTENDED ERROR IN REL 15/16	00005100
	CLC ARG,EXTREAD	NORMAL RETURN	00005200
	PI SAVPTR	SAVE BUFFER POINTER AND LENGTH	00005300
	CLJ 199+1,X'FF*		00005400
	SNR LEAVE		00005500
SAVPTR	EQU *	2 CONTAINS THE BUFFER LOCATION	00005600
	STH 2,SV1	3 CONTAINS THE BUFFER LENGTH	00005700
	PVI 199+2,X'FF*	INDICATE VR BUFFER	
	PVI 199+3,X'FF*	INDICATE THERE IS A BUFFER AVAILABLE	
	PVC USRNVR,2(5)	SAVE THE LAST -VR- UNIT	
	L LEAVE		00005800
		VALID READ OVERRIDES ANY OTHER BUFFER POINTER	
LEAVE2	LA 1,2(4)	ERROR RETURN AT CALLS IN IRCON	00005900
	YIT	RESTORE AND RETURN	00006000
BYPASS1	CLJ 1(4),Y'FF*	IS IT A WHITE ZERO	
	PO BYPASS	NO	
	CLJ 199+2,X'FF*	DO WE HAVE A ZROBER TO USE	
	BL BYPASS2	YES	

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CUU SV2*2(2),K132      IS VR LENGTH LONGER THAN ICH
DH BYPASS              YES
LN 6,K132              GET ICE LENGTH
ST 6,SV2              RESET THE COUNTERS
MVC SV1,(CONVRTAD
XC DSRNVR,DSRNVR      ZERO OUT THE LAST UNIT NUMBER
MVI 199*2,0
BYPASS2 MVI 199*3,X'FF'  INDICATE THERE IS A BUFFER AVAILABLE
BYPASS LGU *          BYPASS FIOCS 00006100
I 4,DSRNVR          LOAD ADDRESS IN IBCOM TO INDICATE *0* DSRN
XC DSRNLOC(4,6),DSRNLOC(6) SET IT FOR AN IHC212 MESSAGE
LN 2,3,SV1          BUFFER AND LENGTH--WHY LOAD IT EVERYTIME 00006200
STB 2,3,IBDTPS(6)   SAVE THESE IN IBCOM FOR IRRMON
GI 199,X'FF'
LN 199*3,X'FF'      DO WE HAVE A BUFFER AVAILABLE
PRD SETFFB          NO
LEAVE IA 1,F(4)      NORMAL RETURN TO IBCOM 00006400
XIT LN 4,15,SAVE
PCP 199          THIS ASSUMES REG *0* IS MAINTAINED THRU PROGRAM
                     FOR FIOCS'S RETURN ADDRESS
GETERR1 IA 4,1      INDICATE THERE IS NO BUFFER FOR READ *0*
P SETERR
*ZPOFFER EQU *      DEFINE USER BUFFER WITH LENGTH
USING ZROFFER,15
ZROFFER SAVE (14,12),**
LN 4,5,0(1)
ST 4,SV1
L 5,0(15)
ST 5,SV2
XC DSRNVR,DSRNVR      ZERO OUT THE LAST UNIT NUMBER
MVI 199*2,X'FF'      INDICATE THERE IS A BUFFER AVAILABLE
MVI 199*2,X'0F'      INDICATE BUFFER USED
RETURN (14,12) 00007400
HGRWFH EQU *      TURN OFF/ON ALL ENTRIES TO R-W ZERO
USING HGRWFH,15
HGRWFH SAVE (0,2),**
L 2,0(1) GET PARM *1*
L 2,0(2)
MI DISABLE,X'00' I.NE.D ENABLE R-W ZERO
LTR 2,2 WAS 1=0
ORZ HGRWFH1 NO
OI DISABLE,X'FF' I.EQ.0 DISABLE R-W ZERO
HGRWFH1 RETURN (0,2)
USING HGRWFH,15
HGRWFH2 SAVE (0,2),**
L 2,0(1) GET THE NEW ERROR LIMIT
L 2,0(2)
STB 2,(ERRLIMIT LIMIT OF ERRORS BEFORE ABEND
RETURN (0,2),1
SAVE DS 12F
DSRNFTR EQU VIBCOM
ADFI0CS SC A(HGRZIOCS)
199 DC F'0' 00007700
*
* BYTE 1 *FF* SET AT BYPASS IF DSRN IS ZIPO
* 2 FF IMMUT (LORETAILED)
* 3 *00* ICE BUFFER *FF* VR BUFFER
* 3 *0F* ZROFFER
* 4 *00* NO BUFFER SET FOR READ *0*
* 4 *FF* BUFFER HAS BEEN SET FOR *0*
SV1 DC V(CONVRT) SET DEFAULT BUFFER
SV2 DC F'132' SET DEFAULT LENGTH
CONVRTAD DC V(CONVRT)
FMTREAD DC XL2'00F0' 00008100
ERRCOUNT DC H'0' ERROR COUNT
ERRLIMIT DC H'5' ERROR LIMIT BEFORE ABEND--DEFAULT 5
K132 DC H'132'
DSRNVG DC H'0' BUFFER UNIT ON VR
DISABLE DC X'00' DEFAULT TO *0* WHICH INDICATES *ON*
SPACE 2
CONVRT CSSECT
DS 33F
KODE DS F
END 00008200

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MEMBER NAME INPUTER1
SUBROUTINE INPUT
COMMON DELP(1), NRECS, NREC11, LSTCON, NBASE, NXPAND,
1 PXLOND, NPNODS, NBASE, NSTIFF, NSTRES, LIN,
2 NUSEREC, NMOD, NSTRES, KNTLDS, MUDDY1, MUDDY2
DIMENSION X(1500), Y(1500), Z(1500), XA(1500), YA(1500), ZA(1500)
1100 DUMMY(20), INDEX(1500), KONEQ(1500)
DIMENSION I1YPE(3), J1YPE(2)
DIMENSION ITEMP(60), ITEMP(60), INFOCN(6)
DIMENSION KOND(155)
DATA SIGN/1, SIGN/1, END/1, END/1
EQUIVALENCE (ITEMP(1), ITEMP(1))
LOGO = 0
PCARD = 0
NPLANC = 0
NXPAND = 200
NBASE = 0
IN = 5
PXLOND = 100
NPNODS = 1500
NREC11 = 0
ITEMP = 0
KONT = 52
DO 1111 I = 1, NPNODS
X(I) = 0.
Y(I) = 0.
Z(I) = 0.
XA(I) = 0.
YA(I) = 0.
ZA(I) = 0.
KK = 0
K = 0
KONEQ(I) = 0
1111 INDEX(I) = 0
DO 1112 I = 1, 13
1112 DUMMY(I) = 0.
INDEX(I) = 1
READ(5, 130) (ITEMP(I), I = 1, 20)
WRITE(6, 132) (ITEMP(I), I = 1, 20)
DATA IPLANK, /IN, /
DATA IA, /IHA, /
READ(5, 131) NSTIFF, NSTRES
131 FORMAT(2I4)
READ(5, 100) NBASE, NPNODS, NMODS, LSTCON, MUDDY2, MUDDY1
WRITE(6, 500)
NPNODS = NPNODS
IF (MUDDY1 .EQ. 1) IN = 5
WRITE(6, 501) NBASE, NPNODS, NMODS, LSTCON
WRITE(6, 505)
WRITE(6, 507)
1103 FORMAT(I4, 10A4)
103 FORMAT(A1, 3F11.6, 16)
1 READ(5, 1103) NMOD, (DUMMY(I), I = 1, 19)
IF (DUMMY(1) .EQ. END .OR. NMOD .EQ. 0) GO TO 1203
WRITE(6, 91476) (DUMMY(I), I = 1, 19)
91476 FORMAT(15A4)
READ(6, 103) ILOF, XDUM, YDUM, ZDUM, KONDUM
GO TO 7
1203 WRITE(6, 1213) (DUMMY(I), I = 1, 19)
5 IF (K .EQ. NPNODS) GO TO 6
WRITE(6, 101) K
NMOD = 1
6 IF (KK .EQ. NPNODS) GO TO 3
WRITE(6, 102) KK
NMOD = 1
3 CONTINUE
DO 5001 I = 1, NPNODS
DO 5001 J = 1, NPNODS
IF (J .EQ. I) GO TO 5000
IF (X(J) .NE. X(I)) GO TO 5000
IF (Y(J) .NE. Y(I)) GO TO 5000
IF (Z(J) .NE. Z(I)) GO TO 5000
NMOD = 1
WRITE(6, 5010) J, I

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5010	FORMAT(//25X,4HNODE,15,24H HAS THE SAME COORDS. AS NODE,15//)	00770000
5000	IF(X(J).NE.YA(I))GO TO 5001	00790000
	IF(Y(J).NE.YA(I))GO TO 5001	00800000
	IF(Z(J).NE.ZA(I))GO TO 5001	00810000
	NOGO=1	00820000
	WRITE(6,5011)J,I	00830000
5011	FORMAT(//25X,4HNODE,15,31H HAS THE SAME COORDS. AS A-NODE,15//)	00840000
5001	CONTINUE	00850000
	DO 5020 K=1,NANODES	00860000
	CO 5020 L=1,NANODES	00870000
	IF(X(K).EQ.0.1 GO TO 5020	00880000
	IF(YA(K).EQ.0.1 GO TO 5020	00890000
	IF(YA(K).NE.YA(L)) GO TO 5020	00900000
	IF(YA(K).NE.YA(L)) GO TO 5020	00910000
	IF(ZA(K).NE.ZA(L)) GO TO 5020	00920000
	NOGO=1	00930000
	WRITE(6,5021)K,L	00940000
5021	FORMAT(//25X,4HA-NODE,15,31H HAS THE SAME COORDS. AS A-NODE,15//)	00950000
5020	CONTINUE	00960000
	LIN=INDEX(NSTNDS+1)	00970000
	IF(NOGO.EG.1) GO TO 1214	00990000
	L47 = 155	01060000
	L47 = 2600	01070000
	LX = LSTNDS + 1	01080000
	I1 = LY	01090000
	J2 = L47	01100000
705	CONTINUE	01110000
	I2 = I1 - 1	01120000
	I1 = I1 - L47	01130000
	IF(I1.GE.1) GO TO 710	01140000
	I1=1	01150000
	J2=I2	01160000
710	CONTINUE	01170000
	DO 720 I =1,J2	01180000
	LX = LX-1	01190000
	KOUM(I) = KONEQ(LX)	01200000
720	CONTINUE	01210000
	LARR = LARR-1	01220000
	WRITE(//NSTNDS,I1,I2,LARR,J2,(KOUM(I),I=1,J2)	01230000
	IF(I1.NE.1)GO TO 705	01240000
	WRITE(6,5087)	01250000
	GO TO 1214	01260000
7	N = NNODE - NPAST + 1	01280000
	KONT = KONT - 2	01290000
	IF(ICODE.EQ.1HANK) GO TO 11	01300000
10	K=K+1	01340000
	XAC(I) = XDUM	01350000
	YAC(I) = YDUM	01360000
	ZAC(I) = ZDUM	01370000
	IF(KONT) 730,730,731	01370100
730	WRITE(6,129)	01370200
	WRITE(6,507)	01370300
	KONT = 52	01370400
731	WRITE(6,566) NUGC, ICODE, XA(N), YA(N), ZA(N)	01380000
	GO TO 1	01390000
11	KK=KK+1	01420000
	IF((I-NTMP).EG.1)GO TO 4	01430000
	NOGO=1	01440000
	WRITE(6,9450)	01450000
9450	FORMAT(//42H A NODE NUMBER SEQUENCE BREAK HAS OCCURRED//)	01460000
4	NTMP=1	01470000
	Y(I) = YDUM	01480000
	ENT 4 22 52 236 15 10 0.	
	ENT 4 22 52 236 15 11 0.	
	Y(I) = YDUM	01490000
	Z(I) = ZDUM	01500000
	KONEQ(I) = KONDUM	01510000
	CALL UNPAK (KONEQ(N), INECON, KEEP)	01520000
	INDEX(N+1) = INDEX(N) + KEEP	01530000
	IF(KONT) 732,732,733	01530100

735 WRITE(6,123)	01539200
WRITE(6,507)	01530400
POINT = 52	01539600
735 WRITE(6,510) NODM,X(N),Y(N),Z(N),CINQCN(11),I1=1,6,INDEX(N+1)	01540000
GO TO 1	01550000
1212 WRITE(6,1213) DUMMY(1),I=1,20	01570050
1213 FORMAT(1H1,2Y,2F47.7)	01575000
1214 K1 = 1	01575100
K2 = 1	01575200
K4 = 1	01575300
K5 = 1	01575400
K6 = 1	01575500
K7 = 1	01575600
K8 = 1	01575700
LINES = 2	01575800
12 READ(5,111) IEND, (DUMMY(I), I=1,20)	01580000
WRITE(6,91477) (DUMMY(I), I=1,20)	01580100
91477 FORMAT(119A4.2)	01580110
IF(DUMMY(1).EQ.5EGM) GO TO 1212	01585000
IF(IEND.EQ.0) GO TO 2300	01590000
17 NCARD = NCARD + 1	01600000
REIREC = REIREC + 1	01610000
C	01615000
C DATA IS NOW DIRECTED TO APPROPRIATE PART OF PROGRAM ACCORDING TO	01615001
C WHICH TYPE OF ELEMENT IT IS.	01615002
GO TO (13,12,13,200,200), IEND	01620000
13 READ(5,112) NODE1, NODE2, NODE3, MCODE, AXAREA, BIYY, AYY, BIZZ, AZZ, BJ,	02560000
IFIX1, IFIX2, IFIX3, IFIX4, IFIX5, IFIX6, L, G	02570000
IF(IEND.EQ.1) GO TO 4000	02572000
IF(K2.EQ.1) GO TO 4002	02573000
WRITE(6,127)	02574000
4002 WRITE(6,120) IEND, IEND, NODE1, NODE2, NODE3, MCODE, AXAREA, BIYY, AYY,	02580000
BIZZ, AZZ, G, IFIX1, IFIX2, IFIX3, IFIX4, IFIX5, IFIX6, L, G	02590000
K2 = K2 + 1	02590500
GO TO 126	02591000
4000 IF(K1.EQ.1) GO TO 4004	02592000
WRITE(6,123)	02593000
4004 WRITE(6,125) NCARD, IEND, NODE1, NODE2, AXAREA, L	02594000
K1 = K1 + 1	02597000
126 IF(LINES.EQ.23) LINES = 1	02597500
IF(LINES.EQ.1) GO TO 4006	02598000
WRITE(6,4007)	02598500
GO TO (4010, 4020, 4020, 4020), IEND	02598600
4010 WRITE(6,123)	02598700
GO TO 4006	02598800
4020 WRITE(6,127)	02599000
4007 FORMAT(1H1)	02599200
4006 IF(TOLO.EQ.1, OR, IEND.EQ.2) GO TO 4008	02599500
LINES = LINES + 1	02599600
4008 LINES = LINES + 1	02599700
NODE1 = NODE1 - NPAGE + 1	02600000
NODE2 = NODE2 - NPAGE + 1	02610000
NODE3 = NODE3 - NPAGE + 1	02620000
IF(X(NODE1).EQ.0) GO TO 8419	02630000
IF(X(NODE2).EQ.0) GO TO 8419	02640000
IF(NODE1.LT.0) GO TO 8401	02650000
IF(NODE2.LT.0) GO TO 8401	02660000
IF(AXAREA.LT.0) GO TO 8404	02670000
IF(BIYY.LT.0) GO TO 8405	02680000
IF(AYY.LT.0) GO TO 8406	02690000
IF(BIZZ.LT.0) GO TO 8407	02700000
IF(AZZ.LT.0) GO TO 8408	02710000
IF(G.LT.0) GO TO 8409	02720000
IF(L.LT.0) GO TO 8416	02730000
IF(C.LT.0) GO TO 8417	02740000
NSMALL = MIN0(NODE1, NODE2)	02740000
NLARGE = MAX0(NODE1, NODE2)	02750000
NR1 = INDEX(NLARGE+1) - INDEX(NSMALL)	02800000
IF(NODE1.NLARGE).EQ.11111111 CALL UNPAK(YONI,0(NSMALL), INEQCN, NR1)	02800500
IF(X(NODE1).EQ.11111111) CALL UNPAK(XONI,0(NSMALL), INEQCN, NR1)	02800600

IF (P1.LF.NE.AND) GO TO 60	02810000
IF (P1.LF.NE.AND) GO TO 51	02820000
NOGO=1	02830000
WRITE (6,115) INCARD	02840000
GO TO 60	02850000
51 DBALD=1	02860000
60 CONTINUE	02870000
IF (IDNO.EQ.1) GO TO 219	02900000
IF (CODE1.EQ.1) GO TO 67	02910000
66 IF (CODE1.NE.1) GO TO 8421	02920000
67 IF (FIX1.NE.FIX4) GO TO 8422	02930000
IF (IYY.NE.0) GO TO 72	02940000
IF (IYY.NE.0) GO TO 8423	02950000
IF (FIX2.NE.1) GO TO 8423	02960000
IF (FIX4.NE.1) GO TO 8423	02970000
72 IF (I22.NE.0) GO TO 76	02980000
IF (I22.NE.0) GO TO 8424	02990000
IF (FIX3.NE.1) GO TO 8424	03000000
IF (FIX6.NE.1) GO TO 8424	03010000
76 IF (I3.II.0) GO TO 79	03020000
IF (FIX1.NE.1) GO TO 8427	03030000
IF (FIX4.NE.1) GO TO 8427	03040000
79 CONTINUE	03050000
IF (IDNO.LF.2) GO TO 219	03070000
IF (XACODE11.EQ.0) GO TO 8419	03090000
IF (XACODE21.EQ.0) GO TO 8419	03100000
IF (NOGO-1) 217,12,217	03360000
8401 WRITE (6,9401)	03380000
NOGO=1	03390000
GO TO 12	03400000
8404 WRITE (6,9404)	03410000
NOGO=1	03420000
GO TO 12	03430000
8405 WRITE (6,9405)	03440000
NOGO=1	03450000
GO TO 12	03460000
8406 WRITE (6,9406)	03470000
NOGO=1	03480000
GO TO 12	03490000
8407 WRITE (6,9407)	03500000
NOGO=1	03510000
GO TO 12	03520000
8408 WRITE (6,9408)	03530000
NOGO=1	03540000
GO TO 12	03550000
8409 WRITE (6,9409)	03560000
NOGO=1	03570000
GO TO 12	03580000
8416 WRITE (6,9416)	03590000
NOGO=1	03600000
GO TO 12	03610000
8417 WRITE (6,9417)	03620000
NOGO=1	03630000
GO TO 12	03640000
8419 WRITE (6,9419)	03680000
NOGO=1	03690000
GO TO 12	03700000
8421 WRITE (6,9421)	03710000
NOGO=1	03720000
GO TO 12	03730000
8422 WRITE (6,9422)	03740000
NOGO=1	03750000
GO TO 12	03760000
8423 WRITE (6,9423)	03770000
NOGO=1	03780000
GO TO 12	03790000
8424 WRITE (6,9424)	03800000
NOGO=1	03810000
GO TO 12	03820000
8427 WRITE (6,9427)	03830000

NOGO=1	03840000
CO TO 12	03850000
8438 WRITE(6,9438)	03920000
NOGO=1	03930000
CO TO 12	03940000
8446 WRITE(6,9446)	03950000
NOGO=1	03960000
CO TO 12	03970000
200 IF(ABO,114) NODE1,NODE2,NODE3,NODE4,IS,IX,IY,E,G	04020000
IF(CERO.EC.4) GO TO 7001	04022000
IF(K5.EE.1) GO TO 7006	04023000
WRITE(6,7004)	04024000
7004 WRITE(6,122) NCARD, IDNO, NODE1, NODE2, NODE3, NODE4, IS, IX, IY, E, G	04030000
K5 = K5 + 1	04030500
*NODE1 = NODE1 - NBASE + 1	04030510
*NODE2 = NODE2 - NBASE + 1	04030520
*NODE3 = NODE3 - NBASE + 1	04030530
*NODE4 = NODE4 - NBASE + 1	04030540
GO TO 7005	04031000
7001 IF(K4.EE.1) CO TO 7003	04032000
WRITE(6,7002)	04033000
7003 WRITE(6,7000) NCARD, IDNO, NODE1, NODE2, NODE3, IS, IX, IY, E, G	04034000
K4 = K4 + 1	04035000
7004 IF(LINES.GE.23) LINES = 1	04036000
IF(LINES.EE.1) CO TO 7008	04037000
WRITE(6,4007)	04038000
CO TO (7008,7009,7008,7010,7020), IDNO	04038200
7010 WRITE(6,7002)	04038400
CO TO 7008	04038600
7020 WRITE(6,7004)	04038800
7008 IF(IDNO.EC.4) GO TO 7009	04039000
LINES = LINES + 1	04039200
7009 LINES = LINES + 1	04039400
NODE1=NODE1-NBASE+1	04040000
NODE2=NODE2-NBASE+1	04050000
NODE3=NODE3-NBASE+1	04060000
IF(NODE1.LE.0) GO TO 8401	04070000
IF(NODE2.LE.0) GO TO 8401	04080000
IF(NODE3.LE.0) GO TO 8401	04090000
IF(CI.LI.0) GO TO 8438	04100000
IF(IX.LI.0) GO TO 8438	04110000
IF(IY.LI.0) GO TO 8438	04120000
IF(LE.LE.0) GO TO 8416	04130000
IF(GE.LE.0) GO TO 8417	04140000
IF(X(NODE1).LE.0) GO TO 8419	04150000
IF(X(NODE2).LE.0) GO TO 8419	04160000
IF(X(NODE3).LE.0) GO TO 8419	04170000
NSMALL = MIN(NODE1,NODE2,NODE3)	04180000
NLARGE = MAX(NODE1,NODE2,NODE3)	04190000
IF(IDNO.EC.4) GO TO 210	04200000
NODE4=NODE4-NBASE+1	04210000
IF(NODE4.EC.0) GO TO 8446	04220000
IF(X(NODE4).LE.0) GO TO 8419	04230000
IF(NODE4.LI.NSMALL) NSMALL = NODE4	04240000
IF(NODE4.GI.NLARGE) NLARGE = NODE4	04250000
210 CONTINUE	04260000
NP1 = INDEX(NLARGE+1) - INDEX(NSMALL)	04270000
IF(NP1.LE.NRAND) GO TO 213	04280000
IF(NP1.LE.NXPAND) GO TO 211	04290000
NOGO = 1	04300000
WRITE(6,115) NCARD	04310000
CO TO 213	04320000
211 NBRAND = NP1	04330000
213 IF(IDNO.LO.4) GO TO 216	04340000
IF(NOGO-1) 215,12,215	04350000

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MEMBER NAME INPUT
215 IF (NODG,LO,1) GO TO 12 04610000
WRITE (4) IDNO, NODE1, NODE2, NODE3, TS, TX, TY, LG, X(NODE1), 04620000
1Y(NODE1), Z(NODE1), Y(NODE2), X(NODE2), Z(NODE2), X(NODE3), Y(NODE3), 04630000
2Y(NODE3), Y(NODE4), Y(NODE4), Z(NODE4), 04640000
7KONEQ(NODE1), KONEQ(NODE2), KONEQ(NODE3), KONEQ(NODE4), INDEX(NODE1), 04650000
9 INDEX(NODE2), INDEX(NODE3), INDEX(NODE4), (ITMP(I), I=31,68) 04660000
GO TO 12 04670000
216 IF (NODG,LO,1) GO TO 12 04690000
WRITE (4) IDNO, NODE1, NODE2, NODE3, TS, TX, TY, LG, X(NODE1), Y(NODE1), 04700000
1Y(NODE1), Y(NODE2), Y(NODE2), Z(NODE2), X(NODE3), Y(NODE3), Z(NODE3), 04710000
2KONEQ(NODE1), KONEQ(NODE2), KONEQ(NODE3), INDEX(NODE1), INDEX(NODE2), 04720000
3 INDEX(NODE3), (ITMP(I), I=25,68) 04730000
GO TO 12 04740000
217 IF (NODG,LO,1) GO TO 12 04760000
WRITE (4) IDNO, NODE1, NODE2, AXAREA, ELY, AYY, RIZZ, AZZ, HJ, NFIX1, NFIX2, 04770000
1EJY3, NEJY4, NEJY5, NFIX6, E, G, X(NODE1), Y(NODE1), Z(NODE1), X(NODE1), 04780000
2Y(NODE1), Z(NODE1), Y(NODE2), Y(NODE2), Z(NODE2), X(NODE2), Y(NODE2), YA(NODE2) 04790000
3, Z(NODE2), KONEQ(NODE1), KONEQ(NODE2), INDEX(NODE1), INDEX(NODE2), 04800000
4 (ITMP(I), I=34,68) 04810000
GO TO 12 04820000
218 IF (NODG,LO,1) GO TO 12 04840000
IF (NODE3,LT,0) GO TO 8401 04850000
WRITE (4) IDNO, NODE1, NODE2, NODE3, NCODE, AXAREA, ELY, AYY, RIZZ, AZZ, HJ, 04860000
1EJY3, NEJY4, NEJY5, NFIX6, E, G, X(NODE1), Y(NODE1), Z(NODE1), X(NODE1), 04870000
2, X(NODE2), Y(NODE2), Z(NODE2), X(NODE3), Y(NODE3), Z(NODE3), YA(NODE3), 04880000
3YA(NODE3), Z(NODE3), 04890000
4 KONEQ(NODE1), KONEQ(NODE2), INDEX(NODE1), INDEX(NODE2), 04900000
5 (ITMP(I), I=36,68) 04910000
GO TO 12 04920000
219 IF (NODG,LO,1) GO TO 12 04940000
WRITE (4) IDNO, NODE1, NODE2, AXAREA, F, X(NODE1), Y(NODE1), Z(NODE1), 04950000
1X(NODE2), Y(NODE2), Z(NODE2), 04960000
7KONEQ(NODE1), KONEQ(NODE2), INDEX(NODE1), INDEX(NODE2), (ITMP(I), I= 04970000
3 16,68) 04980000
GO TO 12 04990000
130 FORMAT(2X,10A4,A2) 05000000
135 FORMAT(2X,10A4,A2,////,25X,*** INPUT LISTING ***, 05000100
1/////////) 05001000
127 FORMAT(1H) 05010000
100 FORMAT(6I4) 05020000
500 FORMAT(//25X,*** CONTROL INPUT ***,//) 05030000
501 FORMAT(20X,30HLOWEST NODE NUMBER DESIGNATION, 7X,13// 05040000
120X,26HNUMBER OF STRUCTURAL NODES,10X,14// 05050000
220X,17HNUMBER OF A-NODES,19X,14// 05060000
320X,21HNUMBER OF LOAD CONDS.,15X,14) 05070000
505 FORMAT(1H1,45X,*** COORDINATE INPUT ***,//) 05080000
507 FORMAT(11Y,8HNODE NO.,19X,1HX,15X,1HY,15X,1HZ,12X,'EQUATION CONTR 05090000
1L',10X,5HINDEX,/) 05095000
101 FORMAT(1H1//10X,45H R R O R - THE NUMBER OF A-NODE CARDS READ, 05100000
13H 15,14) 05110000
102 FORMAT(1H1//10X,45H R R O R - THE NUMBER OF STRUCTURAL NODE , 05120000
113HCARDS READ 15,14) 05130000
107 FORMAT(3F11,6) 05140000
506 FORMAT( 115,1X,A1,12X,3F16,5,/) 05150000
508 FORMAT(1H1,45X,*** ELEMENT INPUT ***,//) 05152000
509 FORMAT(1H1,45X,*** LOADS INPUT ***,//) 05154000
510 FORMAT(115,14X,5E16,5,4X,6(2X,11),10X,15,/) 05160000
111 FORMAT(12,15A4,A2) 05170000
112 FORMAT(314,A1,6(9,3,6)1,2E5,1) 05180000
120 FORMAT(217,1X,215,2X,A1,2X,6E10,3,2X,611,2X,2E12,3) 05190000
127 FORMAT (//,3X,'ELCM NO',2X,'ID',3X,'N1',3X,'H2',3X,'N3',9X,'AREA', 05192000
17X,'IY',9X,'AY',9X,'I2',9X,'AZ',9X,'J',9X,'PINS',10X,'E',11X,'G') 05193000
123 FORMAT (//,3X,'ELCM NO',2X,'ID',3X,'N1',3X,'N2',14X,'AREA',18X, 05194000
1'E2) 05195000
125 FORMAT(217,1X,215,11X,'10,3,11X,'12,3) 05196000
121 FORMAT(20X,50H15,114,7) 05200000
9401 FORMAT(//10X,35HONE OF THE NODE NUMBERS IS IN ERROR/) 05210000
9404 FORMAT(//10X,26HTHE TOTAL AREA IS IN ERROR/) 05220000
9405 FORMAT(//10X,15HYY IS NEGATIVE/) 05230000
9406 FORMAT(//10X,15HYY IS NEGATIVE/) 05240000

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9407 FORMAT(/10X,15H1ZZ IS NEGATIVE//)	05250000
9408 FORMAT(/10X,15H1ZZ IS NEGATIVE//)	05260000
9409 FORMAT(/10X,14H1 IS NEGATIVE//)	05270000
9416 FORMAT(/10X,13H1 IS NEGATIVE//)	05280000
9417 FORMAT(/10X,13H1 IS NEGATIVE//)	05290000
9418 FORMAT(/10X,41HONE OF THE X COORDINATES IS EQUAL TO ZERO//)	05310000
9421 FORMAT(/10X,40HTHERE IS AN ILLEGAL CHARACTER IN COL. 15//)	05320000
9422 FORMAT(/10X,37HTHE FIXITY CONTROLS FOR X ARE UNEQUAL//)	05330000
9423 FORMAT(/10X,43H1XX AND 1YY MUST BE POSITIVE OR THE FIXITY	05340000
124HCONTROLS FOR Y MUST BE 1//)	05350000
9424 FORMAT(/10X,43H1ZZ AND 1ZZ MUST BE POSITIVE OR THE FIXITY	05360000
124HCONTROLS FOR Z MUST BE 1//)	05370000
9427 FORMAT(/10X,45HIF J=0 THE FIXITY CONTROLS FOR X MUST EQUAL 1)	05380000
9430 FORMAT(/10X,31H1X, 1X, AND 1Y MUST BE POSITIVE//)	05410000
9446 FORMAT(/10X,23H1NODE 4 IS EQUAL TO ZERO//)	05420000
114 FORMAT(14,3E7,3,2E5,1)	05430000
122 FORMAT(/217,1X,415,5X,E10.3,10X,E10.3,10X,E10.3,5X,2E10.3)	05440000
7000 FORMAT(/217,1X,315,10X,E10.3,10X,E10.3,10X,E10.3,5X,2E10.3)	05441000
7002 FORMAT (/7,3X,'1LEM NO',2X,'1D',3X,'N1',3X,'N2',3X,'N3',15X,'1S',	05442000
118X,'1TX',18X,'1TY',15X,'1E',9X,'1G')	05443000
7004 FORMAT (/7,3X,'1LEM NO',2X,'1D',3X,'N1',3X,'N2',3X,'N3',3X,'N4',	05444000
110X,'1S',18X,'1TX',18X,'1TY',15X,'1E',9X,'1G')	05445000
115 FORMAT(/5X,10H*****3X,27HTHE SEPARATION ON CARD NO. ,15,	05450000
113H IS TOO LARGE//)	05460000
DIMENSION ARLDS(6)	05500000
2000 WRITE(6,509)	05510000
2266 FORMAT(13X, BH, NODE,5X,4HCOND,91X,8HCARD NO.//)	05530000
WRITE(6,2266)	05540000
2001 READ(JN,1105) NOPEE,(DUMMY(I),I=1,19)	05550000
IF(1000E,NE,0) GO TO 3300	05560000
WRITE(6,1215) (DUMMY(I),I=1,19)	05570000
GO TO 2200	05570100
3300 WRITE(6,91476)(DUMMY(I),I=1,19)	05570300
READ(JN,2002) KONDNO,ARLDS	05570310
2002 FORMAT(14,612.0)	05570400
NREC11 = NREC11 + 1	05580000
IF((NODEE,LE,NPASF).AND.(NODEE,LE,(INSTNDS+NPASF)).AND.	05590000
1(KONDNO,GE,1).AND.(KONDNO,LE,LSTCON)) GO TO 2100	05600000
NOCU = 1	05610000
6602 FORMAT(1X 11H** IPROR **,219,6E15.6,19)	05620000
WRITE(6,6602) NOPEE, KONDNO, ARLDS, NREC11	05630000
GO TO 2001	05640000
2100 WRITE(6,6601) NOPEE, KONDNO, ARLDS, NREC11	05650000
NOPEE = NOPEE - NPASF + 1	05660000
IF(NOCU,GE,1) GO TO 2001	05670000
WRITE(11) NOPEE, KONDNO, ARLDS	05680000
6601 FORMAT(12X219,6E15.6,19)	05690000
GO TO 2001	05700000
2200 IF(NOCU,NE,1) WRITE(6,2202)	05710000
2202 FORMAT (/5X24H10 ERRORS IN LOADS CARDS.//)	05720000
RETURN	05730000
END	05740000

MEMBER NAME: LOADGR1	
SUBROUTINE: LOADER (ARRAY, MODE)	00010000
DIMENSION CARD(4), ARRAY(1), AREA(20)	00050000
COMMON / PART / TITLE(20)	00060000
GO TO (100, 200), MODE	00080000
100 READ(15, 401) AREA	00090000
401 FORMAT(20A4)	00090100
WRITE(2, 401) AREA	00090200
READ(10, 101) NSUB, NOPC, CARD	00090300
101 FORMAT(I4, L1, 5L14, 7)	00100000
IF (NSUB.LI.0) GO TO 303	00110000
IF (NOPC.LI.0) GO TO 303	00120000
IF (NOPC.EQ.1) GO TO 102, 303, 108	00130000
102 IF (NOPC.EQ.8) GO TO 111, 112	00140000
108 DO 110 JCARD=1, NOPC	00150000
JARRAY=NSUB + JCARD - 1	00160000
110 ARRAY(JARRAY) = CARD(JCARD)	00170000
GO TO 100	00180000
102 READ(15, 401) AREA	00190000
WRITE(2, 401) AREA	00190100
READ(10, 103) TITLE	00190200
103 FORMAT(20A4)	00200000
104 NPAGE = 0	00230000
GO TO 100	00240000
111 RETURN	00250000
112 STOP	00260000
200 NPAGE = NPAGE + 1	00270000
WRITE(6, 201) ((TITLE(N), N=1, 20), NPAGE)	00280000
201 FORMAT(1H1, 20A4, 10X, 6H PAGE, I3, //)	00290000
RETURN	00300000
303 WRITE(6, 304) NSUB, NOPC, ARRAY	00310000
304 FORMAT(19H INVALID DATA CARD, I4, L1, 5L14, 7)	00320000
STOP	00330000
END	00340000

MEMBER NAME: MAINGR1	
COMMON: NPEEC, ARECS, NPEC11, LSTCON, NUAND, MXRAND,	00040000
1 MXICND, MXNODS, NBASE, NSTIFF, NSTRES, LIN,	00050000
2 NCFREC, NGCD, NSTRES, KNILDS, MUDDY1, MUDDY2	00060000
COMMON/UNIT/UPRCS	00070000
COMMON/JULY/IONC	00090000
COMMON/ELECK5/LITEMP(68)	00100000
CALL FPRSET(200, 300, -1)	00120000
2 REWIND 4	00130000
REWIND 8	00140000
REWIND 9	00150000
REWIND 11	00160000
CALL DATA	00170000
CALL INPUT	00180000
REWIND 11	00190000
CALL GENRIN	00210000
CALL EXIT	00220000
END	00280000

MEMBER NAME: DIMU2GR1	
SUBROUTINE: MATHU2 (A, B, C, NRA, NCA, NCH)	00010000
DIMENSION A(24, 24), B(24, 24), C(24, 24), TEMP(24)	00020000
DOUBLE PRECISION D, E, F	00030000
DO 3 I=1, NRA	00040000
DO 2 J=1, NCH	00050000
F=0.	00060000
DO 1 K=1, NCA	00070000
F=A(I, K)	00080000
F=B(K, J)	00090000
1 D=C(K, I)	00100000
2 TEMP(J)=D	00110000
DO 3 KK=1, NCH	00120000
3 C(I, KK)=TEMP(KK)	00130000
RETURN	00140000
END	00150000

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MEMBER NAME: TRANSFORM
SUBROUTINE TRANSFORM
COMMON /BLOCKS/ ITEMP(60)
COMMON /BLOCKS/ NX(24,5),S1(24,24),S2(24,24),TRANS(24,24)
1 TRANS(24,24)=0, U1(24,24),U2(24,24),U3(24,24),U4(24,24),U5(24,24)
2,NODE(4)
DIMENSION ITEMP(60),TRANS(3,3)
DIMENSION INDEX(4)
EQUIVALENCE (ITEMP(1),ITEMP(1))
NODE(1)=ITEMP(2)
NODE(2)=ITEMP(3)
NODE(3)=ITEMP(4)
IS=ITEMP(5)
IX=ITEMP(6)
IY=ITEMP(7)
E=ITEMP(8)
G=ITEMP(9)
X1=ITEMP(10)
Y1=ITEMP(11)
Z1=ITEMP(12)
X2=ITEMP(13)
Y2=ITEMP(14)
Z2=ITEMP(15)
X3=ITEMP(16)
Y3=ITEMP(17)
Z3=ITEMP(18)
CALL UNPAK2(ITEMP(19),NX(1))
CALL UNPAK2(ITEMP(20),NX(7))
CALL UNPAK2(ITEMP(21),NX(13))
INDEX(1)=ITEMP(22)
INDEX(2)=ITEMP(23)
INDEX(3)=ITEMP(24)
DO 20 J=1,24
  DO 20 I=1,24
    S1(I,J)=0.
    S2(I,J)=0.
    TRANS2(I,J)=0.
20 TRANS3(I,J)=0.
  DO 24 J=1,3
    DO 24 I=1,3
      TRANS(I,J)=0.
24 DELTA=Y2+Z3+Y1+Z2+Y1+Y3-(Y2+Z1+Y3+Z2+Y1+Z3)
  DELTH=X1+Z3+Z2+X2+Z1+X2-(X3+Z1+Y1+Z2+X2+Z3)
  DETC=X1+Y2+Y1+X2+X2+Y3-(X3+Y2+Y3+X1+X2+Y1)
  GG=SQRT(DELTA**2+DELTH**2+DETC**2)
  D=DOT((X2-X1)**2+(Y2-Y1)**2+(Z2-Z1)**2)
  TRANS(1,3)=DETA/GG
  TRANS(2,3)=DETH/GG
  TRANS(3,3)=DETC/GG
  TRANS(1,1)=(Y2-X1)/D
  TRANS(2,1)=(Y2-Y1)/D
  TRANS(3,1)=(Z2-Z1)/D
  TRANS(1,2)=TRANS(2,3)+TRANS(3,1)-TRANS(2,1)+TRANS(3,3)
  TRANS(2,2)=TRANS(3,3)+TRANS(1,1)-TRANS(3,1)+TRANS(1,3)
  TRANS(3,2)=TRANS(1,3)+TRANS(2,1)-TRANS(1,1)+TRANS(2,3)
  PX1=X1+TRANS(1,1)+Y1+TRANS(2,1)+Z1+TRANS(3,1)
  PY1=X1+TRANS(1,2)+Y1+TRANS(2,2)+Z1+TRANS(3,2)
  PZ1=X1+TRANS(1,3)+Y1+TRANS(2,3)+Z1+TRANS(3,3)
  PX2=X2+TRANS(1,1)+Y2+TRANS(2,1)+Z2+TRANS(3,1)
  PY2=X2+TRANS(1,2)+Y2+TRANS(2,2)+Z2+TRANS(3,2)
  PZ2=X2+TRANS(1,3)+Y2+TRANS(2,3)+Z2+TRANS(3,3)
  PX3=X3+TRANS(1,1)+Y3+TRANS(2,1)+Z3+TRANS(3,1)
  PY3=X3+TRANS(1,2)+Y3+TRANS(2,2)+Z3+TRANS(3,2)
  PZ3=X3+TRANS(1,3)+Y3+TRANS(2,3)+Z3+TRANS(3,3)
  ISG=ISAG
  X12=PX3-PX2
  Y12=PY3-PY2
  Z12=PZ3-PZ2
  Y21=PX2-PX1
  Y23=PY2-PY3
  Y31=PY3-PY1
  Y12=PY1-PY2
  ONE/2A=1./((Y1+X12+PY2+X13+BY3+X21)
  AKU = ((/2.*G)) - 1.
  GX = AKU

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GY = AMU * IX/IY	00843000
IF (IX.LY.IY) GO TO 30	00844000
GX = AMU * IY/IX	00845000
CY = AMU	00846000
30 CONTINUE	00847000
E = E / (1.-GX*CY)	00848000
AREA = (BY1 * X2 + BY2 * X13 + BY3 * X21)/2.	
VOLUME = IS * AREA	
CONST = SGRT((AREA*IX)/(2.*E))	00849100
S1(1,1)=E*Y23	00850000
S1(1,2)=E*GX*X32	00860000
S1(1,3)=E*Y31	00870000
S1(1,4)=E*GX*Y13	00880000
S1(1,5)=E*Y12	00890000
S1(1,6)=E*GX*X21	00900000
DO 40 I=1,6	00901000
40 S1(1,I) = S1(1,I) * CONST	00902000
CONST = SGRT((AREA*IY)/(2.*E))	00903000
S1(2,1)=E*GY*Y23	00910000
S1(2,2)=E*GX32	00920000
S1(2,3)=E*GY*Y31	00930000
S1(2,4)=E*X13	00940000
S1(2,5)=E*GY*Y12	00950000
S1(2,6)=E*X21	00960000
DO 50 I=1,6	00961000
50 S1(2,I) = S1(2,I) * CONST	00962000
CONST = SGRT((AREA*IS)/(2.*G))	00963000
S1(3,1)=G*X32	00970000
S1(3,2)=G*Y23	00980000
S1(3,3)=G*X13	00990000
S1(3,4)=G*Y31	01000000
S1(3,5)=G*Y21	01010000
S1(3,6)=G*Y12	01020000
DO 60 I=1,6	01021000
60 S1(3,I) = S1(3,I) * CONST	01022000
S1(4,1)=ISG*X32	01030000
S1(4,2)=ISG*Y23	01040000
S1(4,3)=ISG*Y13	01050000
S1(4,4)=ISG*Y31	01060000
S1(4,5)=ISG*X21	01070000
S1(4,6)=ISG*Y12	01080000
DO 1 J=1,6	01100000
DO 1 I=1,4	01110000
1 S1(I,J)=S1(I,J)+ONEQ2A	01120000
S2(1,1)=Y23**2*IX*E+X32**2*ISG	01170000
S2(2,1)=X32*Y23*(GY*Y+Y*E+ISG)	01180000
S2(2,2)=YX32**2*Y*E+Y23**2*ISG	01190000
S2(3,1)=Y31*Y23*Y*E+X13*X32*ISG	01200000
S2(3,2)=Y31*X32*GX*IX*E+X13*Y23*ISG	01210000
S2(3,3)=Y31**2*IX*E+Y13**2*ISG	01220000
S2(4,1)=Y13*Y23*GY*Y*E+Y31*X32*ISG	01230000
S2(4,2)=Y13*X32*Y*E+Y31*Y23*ISG	01240000
S2(4,3)=Y31*X13*(GY*Y*E+ISG)	01250000
S2(4,4)=Y13**2*Y*E+Y31**2*ISG	01260000
S2(5,1)=Y12*Y23*IX*E+X21*X32*ISG	01270000
S2(5,2)=Y12*X32*Y*E+Y21*Y23*ISG	01280000
S2(5,3)=Y12*Y31*IX*E+X21*X13*ISG	01290000
S2(5,4)=Y12*X13*GX*IX*E+X21*Y31*ISG	01300000
S2(5,5)=Y12**2*IX*E+X21**2*ISG	01310000
S2(6,1)=X21*Y23*GY*Y*E+Y12*Y32*ISG	01320000
S2(6,2)=X21*X32*Y*E+Y12*Y23*ISG	01330000
S2(6,3)=X21*Y31*GY*Y*E+Y12*X13*ISG	01340000
S2(6,4)=X21*X13*Y*E+Y12*Y31*ISG	01350000
S2(6,5)=X21*Y12*(GY*Y*E+ISG)	01360000
S2(6,6)=X21**2*Y*E+Y12**2*ISG	01370000
DO 2 J=7,6	01410000
K=J-1	01420000
DO 2 I=1,K	01430000
2 S2(I,J)=S2(I,J)	01440000
ONEQ4A=.5*ONEQ2A	01480000

DO 3 J=1,6	01490000
DO 3 I=1,6	01500000
3 TRANS2(1,4)=TRANS(1,1)	01510000
TRANS2(1,5)=TRANS(2,1)	01530000
TRANS2(1,6)=TRANS(3,1)	01540000
TRANS2(2,4)=TRANS(1,2)	01550000
TRANS2(2,5)=TRANS(2,2)	01560000
TRANS2(2,6)=TRANS(3,2)	01570000
TRANS2(3,10)=TRANS(1,1)	01580000
TRANS2(3,11)=TRANS(2,1)	01590000
TRANS2(3,12)=TRANS(3,1)	01600000
TRANS2(4,10)=TRANS(1,2)	01610000
TRANS2(4,11)=TRANS(2,2)	01620000
TRANS2(4,12)=TRANS(3,2)	01630000
TRANS2(5,16)=TRANS(1,1)	01640000
TRANS2(5,17)=TRANS(2,1)	01650000
TRANS2(5,18)=TRANS(3,1)	01660000
TRANS2(6,16)=TRANS(1,2)	01670000
TRANS2(6,17)=TRANS(2,2)	01680000
TRANS2(6,18)=TRANS(3,2)	01690000
DO 4 J=1,6	01700000
DO 4 I=1,18	01710000
4 TRANS3(I,J)=TRANS2(J,I)	01720000
CALL MATMUL(S1,TRANS2,S1,4,6,18)	01730000
CALL MATMUL(TRANS3,S2,TRANS3,18,6,6)	01740000
CALL MATMUL(TRANS3,TRANS2,TRANS3,18,6,18)	01750000
CALL DANDS(TRANS3,S1,18,4,NX,INDEX,NODE,VOLUME)	01760000
RETURN	01770000
END	01780000

MEMBER NAME UNPAK681	
SUBROUTINE UNPAK(NUMPKD,IUNPKD,KSAVE)	00010000
DIMENSION IUNPKD(6)	00020000
KSAVE=0	00030000
K=NUMPKD	00040000
DO 15 L=1,6	00050000
I=6-L	00060000
NED=10**I	00070000
IUNPKD(L)=K/NED	00080000
IF(IUNPKD(L).EQ.0) KSAVE=KSAVE+1	00090000
K=K-NED*IUNPKD(L)	00100000
15 CONTINUE	00110000
RETURN	00120000
END	00130000

MEMBER NAME UNPK7681	
SUBROUTINE UNPK7(NUMPKD,IUNPKD)	00010000
DIMENSION IUNPKD(6)	00020000
K=NUMPKD	00030000
DO 15 L=1,6	00040000
I=6-L	00050000
NED=10**I	00060000
IUNPKD(L)=K/NED	00070000
K=K-NED*IUNPKD(L)	00080000
15 CONTINUE	00090000
RETURN	00100000
END	00110000

MEMBER NAME ALD683	
SUBROUTINE ALD	00010000
DIMENSION KDUM(155)	00020000
DIMENSION SCOL(300,6),AELMTX(6,6),KONEQ(1500),	00030000
1 XYZ(100,6),XYZSUB(6), KONTRL(6)	00040000
COMMON NELREC, MRECS, NREC11, LSTCON, NBAND, MXBAND,	00050000
1 MXCLND, MXNODS, NBASE, MSTIFF, MSTRES, LIN,	00060000
2 NSFREC, NOGO, NSTRPS, KNTLOS, MUDDY1, MUDDY2	00070000
DIMENSION INFO(18)	00100000
EQUIVALENCE (INFO(1),NELREC)	00110000
READ (9) NZERO, NZERO, NZERO, LARR, NZERO, INFO	00130000
2 CONTINUE	00180000
READ(9) NSTINDS, I1, J2, LARR, J2, (KDUM(L),L=1,J2)	00190000
LX = J2 + 1	00200000
DO 4 L=1,J2	00210000
LX=LX-1	00220000
KONEQ(LX) = KDUM(L)	00230000
4 CONTINUE	00240000
IF(J1.NE.J2)GO TO 2	00250000
KOUNT = 100	00270000
MLINES = 54	00280000
KNTLOS = LIN - 1	00290000
6600 FORMAT(2H,10X,'PROGRAM CONTROL INFORMATION'///5X,	00300000
1'NO. OF STRUC. NODES = ',15/5X,'LOWEST NODE NO. = ',14/5X,	00310000
2'NO. OF LOAD CONDITIONS = ',14/5X,'BANDWIDTH = ',14/5X,	00320000
3'NO. OF STRUCTURAL ELEMENTS = ',16/5X,	00330000
4'ORDER OF STIFFNESS MATRIX IS ',16)	00330100
WRITE(6,6600) NSTINDS, NBASE, LSTCON, NBAND, MRECS, KNTLOS	00340000
IROW1 = 1	00490000
ITRI = 1	00500000
NSTRPS = 0	00510000
KIRECS = 0	00520000
NR10=NBAND+10	00530000
JJ=1	00540000
LCWEST=1	00550000
5 CONTINUE	00560000
DO 10 JJ=1,6	00610000
DO 10 I=1,NR10	00620000
10 SCOL(I,J) = 0.	00630000
JSAVE=JJ	00640000
IF(JSAVE.NE.1) GO TO 20	00650000
15 IF(KIRECS.EQ.NSFREC)GO TO(80,90),ITRI	00660000
KIRECS = KIRECS + 1	00680000
READ(8) I1, JJ, NROWS, NCOLS,((AELMTX(I1,J1),J1=1,NCOLS),	00700000
1 I1=1,NROWS)	00710000
20 IF(JJ.NE.JSAVE) GO TO (80,90),ITRI	00770000
IF(I1.GT.JSAVE.OR.I1.LT.LCWEST) GO TO 15	00810000
I=I1-LOWEST	00860000
DO 25 I1 = 1,NROWS	00870000
I = I + 1	00880000
DO 25 J = 1,NCOLS	00890000
25 SCOL(I,J) = SCOL(I,J) + AELMTX(I1,J)	00900000
NCOL = NCOLS	00910000
GO TO 15	00920000
80 CONTINUE	00960000
DO #5 K =1,MCOL	01000000
NSTRPS = NSTRPS + 1	01010000
IF(NSTRPS.LE.NBAND) ILOW = 1	01020000
WRITE(1)(SCOL(I,K),I=1LOW,NSTRPS)	01030000
ILOW=ILOW+1	01050000
IF(ILOW.GT.6) LOWEST = 2	01060000
85 CONTINUE	01070000
IF(NSTRPS.GE.NBAND) ITRI=2	01110000
IF(KIRECS.EQ.NSFREC)GO TO 150	01120000
GO TO 5	01130000
90 CONTINUE	01170000
IROW1=ILOW-LOWEST	01200000
DO 100 K = 1,MCOL	01210000
NSTRPS = NSTRPS +1	01220000
IFND = IROW1 + NBAND	01230000
IROW1 = IROW1 + 1	01240000

WRITE(1) (SFOL(1,K), I=1, ROW1+1, END)	01250000
100 CONTINUE	01270000
IF (NSFREC.EQ.KIRECS) GO TO 150	01280000
IFLOW=IFLOW+PCOL	01290000
LOW=ST=IFLOW-5	01300000
IF (LOWEST.LT.1) LOWEST=1	01310000
GO TO 5	01320000
150 CONTINUE	01390000
REWIND 8	01400000
REWIND 1	01410000
IND = 0	02090000
KNT = 0	02100000
NOD = 1	02110000
210 CONTINUE	02180000
DO 215 I1=1, LSTCON	02190000
DO 215 J1=1, 6	02200000
215 XYZ(I1, J1) = 0.	02210000
IF (KNT) 220, 220, 225	02220000
220 READ(11) NSUB, KSUB, XYZSUB	02240000
KNT = KNT + 1	02250000
225 CONTINUE	02280000
IF (NSUB.NE.NOD) GO TO 235	02290000
DO 230 J1=1, 6	02300000
230 XYZ(KSUB, J1) = XYZSUB(J1)	02310000
IF (KNT.LT.NREC11) GO TO 220	02320000
235 CONTINUE	02330000
CALL UNPAK2(KONEQ(NOD), KONTRL)	02340000
DO 240 I1=1, 6	02370000
IF (KONTRL(I1).NE.0) GO TO 240	02380000
IND = IND + 1	02390000
WRITE(3) IND, (XYZ(K, I1), K=1, LSTCON)	02400000
240 CONTINUE	02480000
NOD = NOD + 1	02490000
IF (KNT.LT.NREC11) GO TO 210	02500000
IF (IND.LT.NSTRPS) GO TO 210	02510000
REWIND 11	02520000
REWIND 3	02530000
RETURN	02540000
END	02550000

MEMBER NAME EXCHGR3

SUBROUTINE EXCH(NBAND)	00010000
COMMON/ATOS/S(42195), IROW, JY, JZ, KNT10	00050000
DO 110 J=2, NBAND	00060000
J2 = J+2	00070000
I1 = (J2 - 3 + J + 2)/2 + 1	00080000
I2 = (J2 - J)/2	00090000
DO 110 I = I1, I2	00100000
IJ = I + J	00110000
S(I) = S(IJ)	00120000
110 CONTINUE	00130000
READ(1) (S(I), I=JY, JZ)	00140000
KNT10 = KNT10 + 1	00150000
900 RETURN	00160000
END	00170000

MEMBER NAME KAYGR3

SUBROUTINE KAY	00010000
COMMON NPLREC, NRECS, NREC11, LSTCON, NBAND, MXBAND,	00020000
1 MXCLND, MXNODS, NBASE, MSTIFF, MSTRES, LJN,	00030000
2 NSFREC, NOGO, NSTRPS, KNTLDS, MUDDY1, MUDDY2	00040000
COMMON/ATOS/GJUNK(42195), IROW, JY, JZ, KNT10	
DOUBLE PRECISION SUM, TEMPA, TEMPD, TEMPC, TEMPD	00105000
DIMENSION YAK(290, 100), S(290), F(100)	00110000
EQUIVALENCE (GJUNK(1), YAK(1, 1)), (GJUNK(29001), S(1))	00115000
1 (GJUNK(29291), F(1))	00116000
DO203I = 1, LSTCON	00120000
DO203J = 1, NBAND	00130000
203 YAK(J, I) = 0.	00140000

	I = 0	00150000
	IBRNCH = 1	00160000
205	J = 1 + 1	00170000
	IF(I.EQ.NRAND)IBRNCH = 2	00180000
207	CONTINUE	00200000
	READ(4) (S(I2), I2=1, I)	00220000
	READ(3) MUD, (F(I3), I3=1, LSTCON)	00240000
	I1 = I - 1	00260000
	DO220 J = 1, LSTCON	00280000
	SUM = 0.	00290000
	IF(I1.LT.1) GO TO215	00310000
	DO210 L = 1, I1	00320000
	TEMPA = S(L)	00321000
	TEMPB = YAK(L, J)	00322000
210	SUM = SUM + TEMPA + TEMPB	00330000
H43 215	TEMPC = F(J)	00350000
	TEMPO = S(I)	00352000
	YAK(I, J) = (TEMPC - SUM)/ TEMPO	00354000
220	CONTINUE	00370000
	WRITE(10)MUD, (YAK(I, K), K=1, LSTCON)	00390000
223	IF(MUD.EQ.KNTLDS) GO TO250	00410000
	GO TO (205, 225), IBRNCH	00430000
225	CONTINUE	00450000
	DO240 M1 = 2, NRAND	00460000
	M2 = M1 - 1	00470000
	DO240 M3 = 1, LSTCON	00480000
240	YAK(M2, M3) = YAK(M1, M3)	00490000
	GO TO 207	00510000
250	CONTINUE	00530000
	REWIND 4	00550000
	REWIND 3	00560000
	REWIND 10	00570000
260	CONTINUE	00580000
	RETURN	00590000
	END	00600000

MEMBER NAME MAIN683

	COMMON NELREC, MRECS, NREC11, LSTCON, NBAND, MXBAND,	00010000
1	MXCLND, MXNODS, NBASE, MSTIFF, MSTRES, LIN,	00020000
2	NSRREC, NOGO, NSTRPS, KNTLDS, MUDDY1, MUDDY2	00030000
	REWIND 1	00110000
	REWIND 3	00130000
	REWIND 4	00170000
	REWIND 8	00070000
	REWIND 9	00050000
	REWIND 10	00190000
	REWIND 11	00090000
	REWIND 12	00150000
	CALL ALD	00230000
	CALL STFS	00270000
	CALL KAY	00310000
	CALL EXIT	00340000
	STOP 5	00350000
	END	00360000

MEMBER NAME STES683

	SUBROUTINE STFS	00010000
	COMMON NELREC, MRECS, NREC11, LSTCON, NBAND, MXBAND,	00070000
1	MXCLND, MXNODS, NBASE, MSTIFF, MSTRES, LIN,	00100000
2	NSRREC, NOGO, NSTRPS, KNTLDS, MUDDY1, MUDDY2	00110000
	COMMON/ATOS/S(42195), IROW, JY, JZ, KNT10	00120000
	DOUBLE PRECISION SUM, TEMPA, TEMPB, TEMPC, SCOMB	00125000
	DI*ENSION SDUM(290), TEMPN(3,3), KILT(290)	00130000
	NBAND1 = NBAND + 1	00150000
	NRM1 = NBAND - 1	00160000
	IROW = 1	00170000
	NGUY = 0	00176000
	KOUNTB = 50	00177000

CALL ERRSET(251,300,-1)	00180000
CALL ERRSET(261,300,-1)	00185000
I1 = 1	00210000
DO 20 N = 1, NBAND	00220000
I2 = I1 + N - 1	00230000
READ(1,)(S(I), I = I1, I2)	00240000
I1 = I1 + N	00250000
KILT(N) = 0	00255000
20 CONTINUE	00260000
JY = I1 - NBAND	00270000
JZ = I1 - 1	00280000
KNT10 = NBAND	00290000
NRAK = 1	00300000
S(I) = SQRT(S(I))	00340000
SDUM(I) = S(I)	00350000
K = 2	00360000
DO 25 I=2, NBAND	00370000
S(K) = S(K)/S(I)	00380000
SDUM(I) = S(K)	00390000
IF(SDUM(I).NE.0.) KILT(I)=1	00395000
K = K + 1	00400000
25 CONTINUE	00410000
WRITE(12) NRAK, (SDUM(I), I=1, NBAND)	00450000
NOGUY = (NRAK-1) / 3	00490100
NOGUY = (NRAK-1) - (NOGUY*3)	00490200
DO 40 L = 2, NRAK	00500000
ISUBL = ((L-(IROW-1))*2-(L-(IROW-1)))/2+1+L-IROW	00510000
L1 = L-1	00520000
DO 40 M = L, NRAK	00540000
ISUBLM = ((M-(IROW-1))*2-(M-(IROW-1)))/2+1+L-IROW	00540100
IF(KILT(M).EQ.1) GO TO 29	00540200
IF(S(ISUBLM)) 29,37,29	00550000
29 SUM = 0.	00560000
DO 30 K = 1, L1	00580000
ISUBKL = ((L-(IROW-1))*2-(L-(IROW-1)))/2+1+K-IROW	00590000
TEMPA = S(ISUBKL)	00595000
ISUBKM = ((M-(IROW-1))*2-(M-(IROW-1)))/2+1+K-IROW	00600000
TEMPB = S(ISUBKM)	00605000
SUM = SUM + TEMPA + TEMPB	00610000
30 CONTINUE	00620000
TEMPC = S(ISUBLM)	00630000
SCOMB = TEMPC - SUM	00640000
IF(L.NE.M) GO TO 35	00650000
NGUY = NGUY + 1	00650100
TEMPN(NGUY,1) = SCOMB	00650200
TEMPN(NGUY,2) = S(ISUBLM)	00650300
TEMPN(NGUY,3) = M	00650400
IF(NGUY.LT.3) GO TO 6969	00650500
IF(KOUNTR.LT.50) GO TO 6972	00650600
WRITE(6,6970)	00650700
KOUNTR = 1	00650800
6972 WRITE(6,6971)((TEMPN(NG,NU), NU=1,3), NG=1,2)	00650900
WRITE(6,4200)((TEMPN(3,NU), NU=1,3)	00650910
KOUNTR=KOUNTR+2	00651000
NGUY = 0	00651100
6969 IF((L.EQ.NRAK).AND.(NOGUY.GT.0)) WRITE(6,6971)((TEMPN(NG,NU), NU=1,3), NG=1, NOGUY)	00651200
S(ISUBLM) = DSQRT(SCOMB)	00651300
GO TO 38	00660000
35 TEMPA = S(ISUBL)	00670000
S(ISUBLM) = SCOMB/TEMPA	00680000
38 KILT(M) = 1	00680005
GO TO 40	00680010
37 S(ISUBLM) = 0.	00680020
40 CONTINUE	00680030
J1 = 1	00690000
DO 60 J1=1, NRAK	00730000
J2 = J1 + 1 - 1	00740000
WRITE(4) (S(J), J=J1, J2)	00750000
J1 = J1 + 1	00760000
60 CONTINUE	00770000
IF(KNT10.EQ.NSTRPS) GO TO 150	00780000
CALL EXCH(NRAND)	00790000
	00800000

M = NBRAND	00810000
NGUY = 0	00840100
KOUNTR = 50	00840200
100 CONTINUE	00850000
IROW = IROW + 1	00860000
M = M + 1	00870000
KILL = 0	00880010
IF (KNT10.LT.NSTRPS) GO TO 151	00880100
NOGUY = (M-NBRAND) / 3	00880200
NOGUY = (M-NBRAND) - (NOGUY*3)	00880300
151 CONTINUE	00880400
DO 115 L=IROW,M	00890000
ISUBLM=((M-(IROW-1))*2-(M-(IROW-1)))/2+1+L-IROW	00890010
IF (KILL.EQ.1) GO TO 103	00890020
IF (S(ISUBLM)) 103,112,103	00900000
103 SUM = 0.	00910000
L1 = L-1	00920000
IF (L1.LT.IROW) GO TO 108	00930000
DO 105 K = IROW,L1	00950000
ISURKL=((L-(IROW-1))*2-(L-(IROW-1)))/2+1+K-IROW	00960000
TEMPA = S(ISURKL)	00965000
ISURKM=((M-(IROW-1))*2-(M-(IROW-1)))/2+1+K-IROW	00970000
TEMPB = S(ISURKM)	00975000
SUM = SUM + TEMPA + TEMPB	00980000
105 CONTINUE	00990000
108 CONTINUE	01010000
TEMPC = S(ISUBLM)	01015000
SCOMB = TEMPC - SUM	01020000
IF (L.NE.M) GO TO 110	01030000
NGUY = NGUY + 1	01030100
TEMPN(NGUY,1) = SCOMB	01030200
TEMPN(NGUY,2) = S(ISUBLM)	01030300
TEMPN(NGUY,3) = M	01030400
IF (NGUY.LT.3) GO TO 7069	01030500
IF (KOUNTR.LT.50) GO TO 7072	01030600
WRITE(6,6970)	01030700
KOUNTR = 1	01030800
7072 WRITE(6,6971)((TEMPN(NG,NU),NU=1,3),NG=1,2)	01030900
WRITE(6,4200)((TEMPN(3,NU),NU=1,3)	01030910
KOUNTR=KOUNTR+2	01031000
NGUY = 0	01031100
7069 IF ((L.EQ.M).AND.(NOGUY.GT.0).AND.(KNT10.EQ.NSTRPS))WRITE(6,6971)	01040000
1((TEMPN(NG,NU),NU=1,3),NG=1,NOGUY)	01040100
S(ISUBLM) = DSORT(SCOMB)	01040200
GO TO 111	01050000
110 CONTINUE	01070000
ISUBLL=((L-(IROW-1))*2-(L-(IROW-1)))/2+1+L-IROW	01080000
TEMPA = S(ISUBLL)	01090000
S(ISUBLM) = SCOMB/TEMPA	01100000
111 KILL = 1	01100100
GO TO 115	01100200
112 S(ISUBLM) = 0.	01100300
115 CONTINUE	01110000
NBAK = NBAK + 1	01120000
K=1	01130000
DO 120 I=1,NBRAND	01140000
SDUM(I) = S(K)	01150000
K=K+1	01160000
120 CONTINUE	01170000
WRITE(12) NBAK, (SDUM(I),I=1,NBRAND)	01210000
WRITE(4) (S(K),K=J1,J2)	01250000
IF (KNT10.EQ.NSTRPS) GO TO 150	01260000
CALL EXCH(NBRAND)	01270000
GO TO 100	01280000
150 CONTINUE	01300000
DO 180 I=2,NBRAND	01340000
DO 175 J=1,NBRAND	01350000
I1 = (J+2-J)/2 + 1	01360000
175 SDUM(J) = S(I1)	01370000
NBAK = NBAK + 1	01390000

WRITE(12)NBAK,(SDUM(J1),J1=1,NBAND)	01400000
180 CONTINUE	01410000
6970 FORMAT(11,'BX','S112',13X,'A11',BX,'ROW',7X,'S112',13X,'A11',	01910100
18X,'ROW')	01410200
6971 FORMAT(1X,2(2E17.8,F5.0))	01410300
4206 FORMAT(1X,2(2E17.8,F5.0))	01410400
REWIND 4	01420000
REWIND 12	01430000
REWIND 1	01440000
RETURN	01450000
END	01460000

MEMBER NAME UNPK26R3	
SUBROUTINE UNPAK2(NUMPKD,IUNPKD)	00010000
DIMENSION IUNPKD(6)	00060000
K = NUMPKD	00070000
DO 15 L=1,6	00080000
I = 6 - L	00090000
NED = 10 ** I	00100000
IUNPKD(I) = K / NED	00110000
K = K - NED * IUNPKD(I)	00120000
15 CONTINUE	00130000
RETURN	00140000
END	00150000

MEMBER NAME DEFELE85	
SUBROUTINE DEFL	00010000
REAL*8 XSV	
DIMENSION INFO(18)	00080000
DIMENSION X(290,100),SC(290),YK(100)	
DIMENSION XSV(6,100),INEQCN(6),KDUM(155)	
DOUBLE PRECISION SUM,TEMPA,TEMPB,TEMPC,TEMPO	00105000
COMMON NELREC, MRECS, NREC11, LSTCON, NBRAND, MXBAND,	00110000
1 MXCLND, MXNODS, NBASE, MSTIFF, MSTRES, LIN,	00120000
2 NSEREC, NODG, NSTRES, KNTLDS, MUDDY1, MUDDY2	00130000
EQUIVALENCE (INFO(1),NELREC)	00140000
READ(9) NZERO, NZERO, NZERO, LARR, NZERO, INFO	00150000
NSINDS = NZERO	00160000
KNTLDS = LIN-1	00170000
NSTRPS = KNTLDS	00180000
6600 FORMAT(1JH1,10X,'PROGRAM CONTROL INFORMATION'///5X,	00190000
1'NO. OF STRUC. NODES = ',15/5X,'LOWEST NODE NO. = ',14/5X,	00200000
2'NO. OF LOAD CONDITIONS = ',14/5X,'BANDWIDTH = ',14/5X,	00210000
3'NO. OF STRESS PACKAGES = ',16/5X,	00220000
4'NO. OF STIFF ROWS (COLS) AND NO. OF LOADS ROWS = ',16)	00220100
WRITE(6,6600) NSINDS, NBASE, LSTCON, NBRAND, MRECS, KNTLDS	00230000
KOUNT=700	00240000
MLINES=600	00250000
DO 3 I = 1,LSTCON	00260000
DO 3 J = 1,NBRAND	00270000
3 X(J,I) = 0.	00280000
NUMDUM = LIN	00300000
IBRNCH = 1	00310000
I = 0	00320000
NODE = NSINDS + NBASE	00330000
JREAD = 1	00340000
GO TO 450	00380000
5 I = I + 1	00400000
IF(1.E0,NBAND)IBRNCH = 2	00410000

7	CONTINUE	00430000
	READ(12) MUD, (SC(12),I2=1,I)	00470000
	READ(10) MDU, (YK2(I3),I3=1,LSTCON)	00510000
	DO 20 J = 1,LSTCON	00530000
	SUM = 0.	00540000
	IF(I.EQ.1) GO TO 15	00550000
	DO 10 L = 2,I	00560000
	LI = I - L + 1	00570000
	TEMPA = SC(L)	00572000
	TEMPB = X(LI,J)	00574000
10	SUM = SUM + TEMPA + TEMPB	00580000
15	TEMPC = YK2(J)	00600000
	TEMPO = SC(1)	00602000
	X(I,J) = (TEMPC - SUM) / TEMPO	00604000
20	CONTINUE	00620000
	NUMDUM = NUMDUM - 1	00630000
	WRITE(4) NUMDUM, (X(I,J),J=1,LSTCON)	00670000
	NLINES = NLINES + 1	00680000
	IF(NLINES.NE.KEEPIT) GO TO 54	00690000
	DO 25 JK=1,6	00700000
	DO 25 JJ=1,LSTCON	00710000
25	XSV(JK,IJ) = 0.	00720000
	NSUB = I - KEEPIT	00730000
	DO 32 KK=1,6	00740000
	KKK = 7-KK	00750000
	IF(INEGN(KKK).GT.0)GO TO 32	00760000
	NSUB = NSUB + 1	00770000
	DO 30 JJ = 1,LSTCON	00780000
30	XSV(KKK,JJ) = X(NSUB,JJ)	00790000
32	CONTINUE	00800000
613	FORMAT(1H1,37X,J, 'SCLARRA',/)	00850000
1	24X,'FINITE ELEMENT METHODOLOGY',/	00851000
2	32X,'S-74 FINAL RESULTS',/	00852000
3	24X,'ROTATIONS(RADIANS) AND DEFLECTIONS')	00853000
611	FORMAT(//,2X,'NODE',I5,/,2X,'COND',4X,'ROTATION X',10X,	00870000
	1'ROTATION Y',10X,'ROTATION Z')	00880000
614	FORMAT(1X,'DEFLECTION X',8X,'DEFLECTION Y',8X,'DEFLECTION Z')	00880100
612	FORMAT(1X,I4,1PE17.7,1P2E20.7)	00890000
61212	FORMAT(1X,I4,1PE17.7,1P2E20.7)	
	KIN = 1	00900000
38	KEND = KIN + 40	00910000
	IF(KEND.GT.LSTCON) KEND = LSTCON	00920000
39	KOUNT = KOUNT + KEND - KIN + 6	00930000
	IF(KOUNT.LE.NLINES) GO TO 401	00940000
	KOUNT = 0	00950000
	WRITE(6,613)	00960000
	GO TO 39	00970000
401	CONTINUE	00980000
	WRITE(6,611) NODE	00990000
	DO 40 KK = KIN,KEND	01000000
	WRITE(6,612)KK,(XSV(KI,KK),K1=1,3)	01010000
	WRITE(11) NODE, KK,(XSV(KI,KK),K1 =1,6)	01011000
40	CONTINUE	01020000
	WRITE(6,614)	01020100
	DO 41 KK=KIN,KEND	01020200
	WRITE(6,61212)KK,(XSV(KI,KK),K1=4,6)	
41	CONTINUE	01020400
	KIN = KEND + 1	01030000
	IF(KIN.LE.LSTCON)GO TO 38	01040000
	IF(NUMDUM.EQ.1)GO TO 80	01050000
450	CONTINUE	01060000
	GO TO(455,460),IREAD	01100000
455	CONTINUE	01110000
	IREAD = 2	01120000

READ(9) NSTNDS, I1, I2, LARR, JAKE, (KDUH(JK), JK=1, JAKE)	01130000
LUG = 0	01140000
460 CONTINUE	01150000
LUG = LUG + 1	01160000
IF(LUG.GT.JAKE) GO TO 455	01200000
NODE = NODE - 1	01210000
CALL UNPAK(KDUH(LUG), INEQCN, KEEPIT)	01250000
IF(KEEPIT.LE.0) GO TO 460	01260000
NLINES=0	01270000
54 CONTINUE	01310000
GO TO(5, 55), IBRNCH	01320000
55 CONTINUE	01330000
DO 70 M1 = 2, NBAND	01370000
M2 = M1-1	01380000
DO 70 M3 = 1, LSTCON	01390000
70 X(M2, M3) = X(M1, M3)	01400000
GO TO 7	01410000
80 CONTINUE	01430000
REWIND 4	01440000
IF(I1.NE.1) READ(9) NSTNDS, I1, I2, LARR, JAKE, (KDUH(JK), JK=1, JAKE)	01445000
REWIND 10	01450000
REWIND 12	01460000
RETURN	01470000
END	01480000

MEMBER NAME FSTR685	
SURROUTINE FSTR	00020000
DIMENSION FSS(100, 28), STRESS(28, 48), X(290, 100)	00030000
1, OPMAX(28), OPMIN(28), KQNMAL(28), KONMIN(28)	00040000
2, NODEAR(8), KLSBLK(8), INDNOS(8)	00050000
COMMON NELREC, MRECS, NREC11, LSTCON, NBAND, MXBAND,	00060000
1 MXCLND, MXNODS, NBASE, MSTIFF, MSIRES, LIN1	00070000
2 NSFRECS, NOGO, NSTRPS, KNTLOS, MUDDY1, MUDDY2	00080000
DATA KMAX, KMIN /2HMX, 2HMM /	00100000
NSRECS = 0	00120000
NLINES = 54	00130000
MOST = MXBAND	00170000
LIN1 = LIN-1	00180000
IF(MXBAND.GT.LIN1) MOST = LIN1	00190000
DO 4 I = 1, MOST	00230000
4 READ(4) MUD, (X(I, J), J=1, LSTCON)	00240000
INDLOW = LIN - MOST	00250000
5 CONTINUE	00260000
READ(9) NUMREC, NBLKS, NRISM, (INDNOS(I1), I1=1, NBLKS), (NODEAR	00380000
1(I1), I1=1, NBLKS), (KLSBLK(I1), I1=1, NBLKS), KOLTTL,	00390000
2((STRESS(I1, J1), J1=1, KOLTTL), I1=1, NRISM), KIND, VOLUME	00400000
NSRECS = NSRECS + 1	00410000
IF(INDNOS(2).GE.INDLOW) GO TO 16	00450000
IDIF = INDLOW - INDNOS(2)	00490000
NEND = MOST - IDIF	00500000
DO 10 I = 1, MOST	00520000
IF(I.GT.NEND) GO TO 7	00530000
I1 = 1 + IDIF	00570000
DO 6 J = 1, LSTCON	00580000
6 X(I, J) = X(I1, J)	00590000
GO TO 10	00600000
7 CONTINUE	00610000
READ(4) MUD, (X(I, J1), J1=1, LSTCON)	00650000
10 CONTINUE	00670000
INDLOW = INDLOW - IDIF	00710000
16 CONTINUE	00730000
DO 18 I = 1, NRISM	00740000
OPMIN(I) = IE10	00750000
18 OPMAX(I) = -1.E10	00760000
DO 25 J=1, NBLKS	00840000

NODEAR(J) = NODEAR(J) + NBASE - 1	00850000
25 CONTINUE	00860000
LLIN = 1	00500000
LLFIN = MLINES-14	00910000
IF(LSTCON .LT. LLFIN)LLFIN = LSTCON	00920000
DO 10 K = 1, LSTCON	00930000
DO 50 L = 1, NRISM	00950000
SUM = 0.	00960000
J2 = 0	00970000
DO 30 I = 1, NBLKS	00990000
IF(KLSBLK(I).LT.0) GO TO 30	01000000
M1 = MOST - INDNOS(I) + INDLOW	01050000
J1 = J2 + 1	01060000
J2 = J2 + KLSBLK(I)	01070000
DO 20 J = J1, J2	01100000
SUM = SUM + STRESS(L,J) * X(M1,K)	01120000
M1 = M1-1	01130000
28 CONTINUE	01140000
30 CONTINUE	01160000
FSS(K,L) = SUM	01170000
IF(SUM.GT.OPMIN(L))GO TO 35	01210000
OPMIN(L) = SUM	01220000
KONMIN(L) = K	01230000
35 IF(SUM.LT.OPMAX(L)) GO TO 50	01250000
OPMAX(L) = SUM	01260000
KONMAX(L) = K	01270000
50 CONTINUE	01290000
70 CONTINUE	01310000
WRITE(13) NUMREC,KIND ,LSTCON,NRISM,((FSS(K,L),K=1,LSTCON),L=1,NRISM)	01320000
1SM),NODEAR,KONMAX,KONMIN,OPMAX,OPMIN,LLIN,LLFIN,KMAX,KMIN,VOLUME	01330000
IF(NRECS.GI.NSRECS) GO TO 5	01340000
END FILE 13	01350000
REWIND 13	01360000
RETURN	01370000
END	01380000

MEMBER NAME MAIN685	
COMMON NEIRLC, NRECS, NREC11, LSTCON, NRAND, MXRAND,	00110000
1 MXCLND, MXNODS, NBASE, MSTIFF, MSTRES, LIN,	00120000
2 NSFREC, NOGO, NSTRES, KNTLOS, MUDDY1, MUDDY2	00130000
REWIND 10	00170000
REWIND 12	00210000
REWIND 9	00250000
REWIND 4	00290000
CALL DEFL	00330000
REWIND 11	
CALL FSTR	
CALL EXIT	
STOP 7	00400000
END	00410000

MEMBER NAME UNPK685	
SUBROUTINE UNPAK(NUMPKD,IUNPKD,KSAYE)	00010000
DIMENSION IUNPKD(6)	00080000
KSAYE = 0	00090000
K = NUMPKD	00100000
DO 15 L = 1,6	00110000
I = 6 - L	00120000
NED = 10 ** I	00130000
IUNPKD(L) = K / NED	00140000
IF(IUNPKD(L).EQ.0) KSAYE = KSAYE + 1	00150000
K = K - NED * IUNPKD(L)	00160000
15 CONTINUE	00170000
RETURN	00180000
END	

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MEMBER NAME A3LNK68
SUBROUTINE A3LNK1(MS)
IMPLICIT REAL*8 (A-G,O-Z)
REAL*8 HMS
COMMON/LINKA1/NTOTAL,NORET,NTAPE
COMMON /LINKA/ LAP(150),
1 XNONOD,XNOSAT,XNORET,XNORED,XNOPROP,AXNOD,EE(3),XMU(3),
2 XNMAVS,XNEIG,XNMASS,SCALE,EVSAVE,XKSAVL,XNSPEC,
3 AS,FSM,RSM,DM,UH,WONE,OINV,FDEFL,FLOAD,OMEGA
DIMENSION WORDS(4),NODE1(2750),NODE2(2750),TEMP1(2750),
1 TEMP2(2750),TEMP3(2750),TEMP(4),
2 X(600),Y(600),Z(600),NONE(600),NTWO(600),
3 SHAP(1850),KK(6),DUM(4),
4 XPK(12,12),ROW(1850),ROW2(12)
DIMENSION TWOR(4),SEMP(4)
DIMENSION XMS(3000),HMS(6)
DIMENSION XX(12)
DIMENSION XIP(12)
DIMENSION XCON(2750)
DIMENSION VOLUM(2750)
DIMENSION OPTION(2),DATA(30),IOP(4)
DATA OPTION/'YES','NO'/
EQUIVALENCE(DATA(1),XNONOD)
DATA TWOR/4H 4H 4H 4H /
VOA=0.
VOB=0.
VOS=0.
NSPEC=XNSPEC
NONOD=XNONOD
NOSAT=XNOSAT
NORET=XNORET
NORED=XNORED
NOPROP=XNOPROP
MAXNOD=AXNOD
NMAVS=XNMAVS
NEIG=XNEIG
NMASS=XNMASS
NTOTAL=NORET+NORED
NN=NTOTAL
NOEFL=6*NONOD-NORET-NORED
DO 4629 I=1,4
4629 IOP(I)=DATA(I+19)
NOYE=2
IF(UH.EQ.1) NOYE=1
CALL LOADER (SKP,2)
WRITE(6,904) MS
904 FORMAT(20X,'**** MODE SHAPE NO. ',12,' ****',/)
999 FORMAT(1H0,29X,'ENERGY ANALYSIS PROGRAM'/22X,
1 C52 SCIARRA / SHAT2*77)
WRITE (6,999)
WRITE (6,985)NONOD,NOSAT,NORET,NORED,NOPROP,MAXNOD,NODEL,NTOTAL
1 ,NMAVS,NEIG,NMASS,SCALE
985 FORMAT (9X,15H NO. OF NODES = 16 / 9X,25H NO. OF STRUCTURAL ELEMENTS=16 / 9X,
1 4H TS = 16 / 9X,23H NO. OF RETAINED DOFS = 16 / 9X,
2 22H NO. OF REDUCED DOFS = 16 / 9X,16H NO. OF MATERIAL
3 13H PROPERTIES = 16 / 9X,21H MAX. NODE NO. USED = 16 / 9X,
4 22H NO. OF DELETED DOFS = 16 / 9X,20H FULL SIZE OF MATRIX
5 19H BEFORE REDUCTION = 16 / 9X,18H NO. OF VARIATION=16 / 9X,
6 21H NO. OF EIGENVECTORS=16 / 9X,20H NO. OF MASS GROUPS=16
7 / 9X * SCALE FACTOR='E15.6 ')
WRITE(6,4915) NSPEC
4915 FORMAT( 10X *NO. OF SPECIAL ELEMENTS='16 ')
WRITE(6,4916) FLOAD,FDEFL,OMEGA
4916 FORMAT( 10X *NO. OF LOAD CASES='F6.0 / 10X *NO. OF DEFLECTIONS='F6.0 /
1 F6.0 / 10X *EXCITING FREQUENCY='F6.0 )
WRITE(6,986) (EI(I),XMU(I),I=1,NOPROP)
986 FORMAT( / 19X 20H MATERIAL PROPERTIES /10X RMODULUS 19X 7HPOISSON
1 6H RATIO (/ 6X F15.2, 15X F10.4))
WRITE(6,9676) (OPTION(IOP(I)+1),I=1,4),OPTION(NOYE)
9676 FORMAT( / 15X *INPUT OPTIONS' / 10X *INPUT', 14X A4 / 10X *FULL K'
1 , 13X A4 / 10X *FINAL K', 12X A4 / 10X *DYNAMIC MATRIX', 5X A4 /
2 10X *UPPER HESSENBERG', 3X A4 / )
WRITE(6,9677) WONE

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9677 FORMAT (10X, 'EIGENVECTORS CALCULATED FOR EIGENVALUES GREATER THAN', F13.6)
100, F13.6)
IF (AS.EQ.1.) GO TO 686
ICOUNT=1
KOUNT=0
CALL LOADER (SKP,2)
WRITE (6,904) MS
987 FORMAT (32X,14H ACTION TABLE /1X,80(1H-)/
1 3X 'NODE', 7X 'X', 11X 'Y', 9X 'Z', 6X 'NONE', 3X 'NTWO' / )
WRITE (6,987)
686 CONTINUE
JJ=1
DO 1 I=1,NONOD
READ (5,800) NODE,X(NODE),Y(NODE),Z(NODE),NONE(NODE),NTWO(NODE),
1 (DUM(IJ),IJ=1,4)
IF (AS.EQ.1.) GO TO 687
IF (ICOUNT.NE.51) GO TO 9
CALL LOADER (SKP,2)
WRITE (6,904) MS
WRITE (6,987)
ICOUNT=0
9 ICOUNT=ICOUNT+1
800 FORMAT (13,3E10.0,2I3,4A 6)
WRITE (6,998) NODE,I,X(NODE),Y(NODE),Z(NODE),NONE(NODE),NTWO(NODE),
1 (DUM(IJ),IJ=1,4)
998 FORMAT (1H,13,14,2X,3F11.4,3X,13,3X,13,2X,4A6)
687 CALL UNPACK (NONE(NODE),NTWO(NODE),KK)
DO 700 L=1,6
MAP(JJ)=NODE
JJ=JJ+1
700 CONTINUE
1 CONTINUE
DO 50 I=1,3000
50 XMS(I)=0.
30 READ (11,END=90) NODE,LL,(HMS(I),I=1,6)
IF (LL.NE.MS) GO TO 30
M=6*NODE
DO 70 K=1,3
XMS(M-3+K)=HMS(K)
70 XMS(M-6+K)=HMS(K+3)
GO TO 30
90 CONTINUE
CALL LOADER (SKP,2)
WRITE (6,904) MS
989 FORMAT (1X,80(1H-)/ 18X,'MAP'// (3X,16I4))
NOW=NONOD+6
WRITE (6,989) (MAP(I),I=1,NOW)
911 FORMAT (1X,80(1H-))
WRITE (6,911)
150 IF (AS.EQ.1.) GO TO 688
CALL LOADER (FLIP,2)
WRITE (6,904) MS
688 MAXIAL=0
NSKIN=0
NREAM=0
6066 NAP=NOSAT+NSPEC
I=0
DO 11 INDEX=1,NAP
IF (INDEX.GT.NSPEC) GO TO 9065
DO 20 LS=1,4
20 WORDS(LS)=TWOR(LS)
NM=0
MO=0
READ (5,5055) NTYP,LN1,LN2,LN3,LN4,MC,(SEMP(L),L=1,4)
5055 FORMAT (5I3,11,4E10.0)
WRITE (6,2371) NTYP, LN1,LN2,LN3,LN4,MC,(SEMP(L),L=1,4)
2371 FORMAT (1X,80(1H-)/ 21X 'SPECIAL ELEMENT' / ' TYPE =',I4,
1 ' LN1 =',I4, ' LN2 =',I4, ' LN3 =',I4, ' LN4 =',I4 /
2 ' PROPERTIES =',I2,4( ' ',I4,5))
IF (NTYP.NE.5) GO TO 3035

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781	N1=LN1	01389200
	N2=LN2	01389300
	N3=LN3	01389400
	IF(NM.EQ.1) GO TO 5631	01389500
	NTYPE=2	01389600
	TEMP(1)=SEMP(4)	01389700
	TEMP(2)=0.	01389800
	TEMP(3)=0.	01389900
	NM=1	01389910
	GO TO 7777	01389920
5631	NTYPE=4	01389930
	DO 6181 J=1,3	01389940
6181	TEMP(J)=SEMP(J)	01389950
	NM=0	01389960
	GO TO 7777	01389970
3035	IF(NTYPE.NE.6) GO TO 4045	01390000
RR1	IF(MO.GT.2) GO TO 3611	01391000
	NTYPE=3	01392000
	N3=LN4	01393000
	DO 6212 J=1,3	01394000
6212	TEMP(J)=SEMP(1)	01395000
	IF(MO.EQ.2) GO TO 3711	01396000
	N1=LN1	01397000
	N2=LN2	01398000
	MO=2	01399000
	GO TO 7777	01399100
3711	N1=LN2	01399200
	N2=LN3	01399300
	MO=3	01399400
	GO TO 7777	01399500
3611	NTYPE=2	01399600
	N3=0	01399700
	TEMP(2)=0.	01399800
	TEMP(3)=0.	01399900
	IF(MO.EQ.4) GO TO 3811	01399910
	N1=LN1	01399920
	N2=LN2	01399930
	TEMP(1)=SEMP(2)	01399940
	MO=4	01399950
	GO TO 7777	01399960
3811	N1=LN3	01399970
	N2=LN4	01399980
	TEMP(1)=SEMP(3)	01399990
	MO=0	01400000
	GO TO 7777	01401000
4045	WRITE(6,7227)	01402000
7227	FORMAT(' // 5X *INCORRECT IDENTIFICATION FOR SPECIAL ELEMENT*')	01403000
	CALL EXIT	01404000
9065	READ(5,R01) NTYPE,N1,N2,N3,MC,(TEMP(J),J=1,3),(WORDS(J2),J2=1,4)	01408000
801	FORMAT(2X,I1,3I3,I1, 3E10.0,4A6)	01410000
	GO TO 8777	01411000
7777	NOSAT=NOSAT+1	01511000
8777	I=I+1	01512000
	IF(NTYPE.EQ.0) NTYPE=3	01520000
	IF(MC.EQ.0) MC=1	01530000
	IF((NTYPE.NE.3).OR.(TEMP(2).NE.0.)) GO TO 100	01550000
	TEMP(2)=TEMP(1)	01560000
	TEMP(3)=TEMP(1)	01570000
100	CONTINUE	01580000
	IF(NTYPE.NE.2) GO TO 101	01620000
	IF(AS.EQ.1.) GO TO 681	01651000
	WRITE(6,992) N1,N2,MC,TEMP(1),(WORDS(J),J=1,4)	01660000
992	FORMAT(1X80(1H-)/21X14H AXIAL ELEMENT/2X3HN1=14,2X3HN2=14,2X,	01670000
1	14HMATERIAL CODE=12,2X, 5HAREA=E12.5,2X,4A6)	01680000
681	NAXIAL=NAXIAL+1	01690000
	NOEF1(I)=N1+100+10*NTYPE+MC	01700000
	NODE2(I)=N2+1000+N3	01710000
	TEMP1(I)=TEMP(1)	01720000
	TEMP2(I)=TEMP(2)	01730000
	TEMP3(I)=TEMP(3)	01740000

GO TO 10	01750000
101 IF (NTYPE.NE.3) GO TO 102	01770000
IF(AS.EQ.1.) GO TO 682	01801000
WRITE (6,993)	01810000
993 FORMAT (1X 80(1H-)/24X 25H TRIANGULAR SKIN ELEMENT)	01820000
WRITE (6,994) N1,N2,N3,MC,(TEMP(J),J=1,3),(WORDS(J),J=1,4)	01830000
994 FORMAT (2X, 3HN1=14, 2X,	01840000
1 3HN2=14,2X,3HN3=14,2X,14HMATERIAL CODE=12,2X,3HTS=F7.4,2X,	01850000
2 3HTX=F7.4/2X 3HTY=F7.4, 2X 4A6)	01860000
682 NSKIN=NSKIN+1	01870000
NODE1(1)=N1+100+10*NTYPE*MC	01890000
NODE2(1)=N2+1000+N3	01900000
TEMP1(1)=TEMP(1)	01910000
TEMP2(1)=TEMP(2)	01920000
TEMP3(1)=TEMP(3)	01930000
GO TO 10	01940000
102 IF (NTYPE.NE.4) GO TO 103	01960000
IF(AS.EQ.1.) GO TO 683	01991000
WRITE (6,995)	02000000
995 FORMAT (1X 80(1H-)/ 21X 14H BEAM ELEMENT)	02010000
954 FORMAT (2X, 3HN1=14, 2X,	02020000
1 3HN2=14,2X,3HN3=14,2X,14HMATERIAL CODE=12,2X,3HTY=E12.5,2X	02030000
2 3HTX=E12.5/2X3HTY=E12.5, 2X 4A6)	02040000
WRITE (6,954) N1,N2,N3,MC,(TEMP(J),J=1,3),(WORDS(L),L=1,4)	02050000
683 NBEAM=NBEAM+1	02060000
NODE1(1)=N1+100+10*NTYPE*MC	02070000
NODE2(1)=N2+1000+N3	02080000
TEMP1(1)=TEMP(1)	02090000
TEMP2(1)=TEMP(2)	02100000
TEMP3(1)=TEMP(3)	02110000
103 CONTINUE	02170000
10 IF (INDEX.GT.NSPEC) GO TO 11	02180000
IF(NM.EQ.1) GO TO 781	02181000
IF(MO.NE.0) GO TO 881	02182000
11 CONTINUE	02183000
WRITE (6,911)	02190000
NTOT=NAXIAL+NSKIN+NBEAM	02200000
WRITE (6,977) NTOT,NAXIAL,NSKIN,NBEAM	02300000
977 FORMAT (9X,37H TOTAL NUMBER OF STRUCTURAL ELEMENTS 16/9X,	02310000
1 23H NO. OF AXIAL ELEMENTS 16 /9X,	02320000
2 23H NO. OF SKIN ELEMENTS 16/9X,	02330000
3 23H NO. OF BEAM ELEMENTS 16/)	02340000
CALL LOADER (SKP,2)	02510100
WRITE(6,904) MS	
DO 42 J =1,NOSAT	02520000
N1=NODE1(J)/100	02540000
N2=NODE2(J)/1000	02550000
N3=NODE2(J)-1000*N2	02560000
NO1=N1	02570000
NTYPE=(NODE1(J)-100*NO1)/10	02590000
45 MC=NODE1(J)-100*NO1-10*NTYPE	02760000
E=E1(MC)	02770000
TEMP(1)=XMU(MC)	02780000
IF (NTYPE.EQ.2) TEMP(1)=TEMP1(J)	02790000
TEMP(2)=TEMP1(J)	02800000
TEMP(3)=TEMP2(J)	02810000
TEMP(4)=TEMP3(J)	02820000
DO 76 N=1,12	02828001
76 XX(N)=0.	02828010
DO 72 M=1,NOW	02828020
IF(MAP(M).EQ.N1)GO TO 74	02828030
72 CONTINUE	02828040
74 DO 73 N=1,3	02828050
XX(N)=XMS(M+N-1)	02828060
IF(NTYPE.EQ.4)XX(N+3)=XMS(M+N+2)	02828070
73 CONTINUE	02828080
DO 89 M=1,NOW	02828090
IF(MAP(M).EQ.N2)GO TO 81	02829010
89 CONTINUE	02829020
81 DO 82 N=4,6	02829030

IF (NTYPE.EQ.4) GO TO 77	02829031
XX(N)=XMS(M+N-4)	02829033
GO TO 82	02829035
77 XX(N+3)=XMS(M+N-4)	02829037
XX(N+6)=XMS(M+N-1)	02829039
82 CONTINUE	02829040
IF (NTYPE.NE.3) GO TO 84	02829041
DO 86 M=1,NOW	02829043
IF (MAP(M).EQ.N3) GO TO 85	02829045
86 CONTINUE	02829047
85 DO 87 N=7,9	02829049
87 XX(N)=XMS(M+N-7)	02829050
84 CONTINUE	02829052
79 FORMAT(1H0,3E14.7)	02829056
900 FORMAT(1H0,7I8)	02860200
CALL SETUP(NTYPE,N1,N2,N3,E,TEMP,X,Y,Z,NONE,NTWO,XBK,I2,V0)	02870000
IF (NTYPE.EQ.4) CALL RESORT (XBK)	02880000
94 FORMAT(1H0,6E14.7)	02880200
DO 96 K=1,12	02880300
XIP(K)=0.	02880400
DO 96 I=1,12	02880500
96 XIP(K)=XX(I)-XBK(I,K)+XIP(K)	02880510
XIP(I)=XIP(I)+XX(I)	02880520
DO 97 I=2,12	02880530
97 XIP(I)=XIP(I)+XX(I)+XIP(I-1)	02880540
XCON(J)=XIP(I2)	02880541
IF (NTYPE.NE.2) GO TO 300	02880542
WRITE(6,992)N1,N2,MC,TEMP(1)	02880544
V0A=V0+V0A	02880546
VOLUM(J)=V0	02880547
GO TO 302	02880549
300 IF (NTYPE.NE.4) GO TO 301	02880550
WRITE(6,995)	02880552
WRITE(6,954)N1,N2,N3,MC,(TEMP(N),N=2,4)	02880553
V0B=V0+V0B	02880555
VOLUM(J)=V0	02880557
GO TO 302	02880559
301 WRITE(6,993)	02880560
WRITE(6,994)N1,N2,N3,MC,(TEMP(N),N=2,4)	02880561
V0S=V0+V0S	02880562
VOLUM(J)=V0	02880565
302 CONTINUE	02880570
WRITE(6,901)XIP(12),V0	02880572
901 FORMAT(1H ,10X,'STRAIN ENERGY = ',E15.7,3X,'VOLUME = ',E15.7)	02880573
902 FORMAT(1H ,10X,'TOTAL VOLUME = ',E15.7/11X,	
1'TOTAL AXIAL VOLUME = ',E15.7/11X,	02880575
2'TOTAL BEAM VOLUME = ',E15.7/11X,'TOTAL SKIN VOLUME = ',E15.7)	02880576
42 CONTINUE	03250000
REWIND 8	
TSE=0.0	
DO 17 N=1,NOSAT	
TSE=TSE+XCON(N)	
STD=XCON(N)/VOLUM(N)	
WRITE(R) STD,NODE1(N),NODE2(N),TEMP1(N),TEMP2(N),TEMP3(N)	
17 CONTINUE	
WRITE(6,903) TSE	
903 FORMAT(//1H ,10X,'TOTAL STRAIN ENERGY = ',E15.7)	
S=0	
N=0	
WRITE(R) S,N,N,S,S,S	
NOSAT=NOSAT-1	03250010
DO 12 N=1,NOSAT	03250100
IP1=N+1	03250110
IP1=IP1,NOSAT	03250120
IF (XCON(N).LE.XCON(IP1)) GO TO 12	03250130
SORT=XCON(N)	03250140
XCON(N)=XCON(IP1)	03250150
XCON(IP1)=SORT	03250152
SORT=VOLUM(N)	03250154
VOLUM(N)=VOLUM(IP1)	03250155
VOLUM(IP1)=SORT	03250156

NORT=NODE1(N)	03250161
NODE1(K)=NODE1(K)	03250162
NODE1(K)=NORT	03250163
NORT=NODE2(N)	03250164
NODE2(N)=NODE2(K)	03250165
NODE2(K)=NORT	03250166
SORT=TEMP1(N)	03250170
TEMP1(N)=TEMP1(K)	03250171
TEMP1(K)=SORT	03250172
SORT=TEMP2(N)	03250173
TEMP2(N)=TEMP2(K)	03250174
TEMP2(K)=SORT	03250175
SORT=TEMP3(N)	03250176
TEMP3(N)=TEMP3(K)	03250177
TEMP3(K)=SORT	03250178
12 CONTINUE	03250179
REWIND 9	
WRITE(9) TVOL,VOA,VOB,VOS,NOSAT,MS	
WRITE(9) (XCON(I),I=1,NOSAT)	
WRITE(9) (VOLUM(I),I=1,NOSAT)	
WRITE(9) (NODE1(I),I=1,NOSAT)	
WRITE(9) (NODE2(I),I=1,NOSAT)	
WRITE(9) (TEMP1(I),I=1,NOSAT)	
WRITE(9) (TEMP2(I),I=1,NOSAT)	
WRITE(9) (TEMP3(I),I=1,NOSAT)	
RETURN	
ENTRY ASLNK?	
REWIND 8	
REWIND 9	
READ(9) TVOL,VOA,VOB,VOS,NOSAT,MS	
READ(9) (XCON(I),I=1,NOSAT)	
READ(9) (VOLUM(I),I=1,NOSAT)	
READ(9) (NODE1(I),I=1,NOSAT)	
READ(9) (NODE2(I),I=1,NOSAT)	
READ(9) (TEMP1(I),I=1,NOSAT)	
READ(9) (TEMP2(I),I=1,NOSAT)	
READ(9) (TEMP3(I),I=1,NOSAT)	
TVOL=VOA+VOS	03250180
WRITE(6,902) TVOL,VOA,VOB,VOS	03250181
DO 13 ML=1,2	03250182
CALL LOADER (SKP,2)	03250184
WRITE(6,904) MS	
DO 13 ML=1,NOSAT	03250188
N=NOSAT-ML+1	03250190
IF (ML.EQ.2) READ(8) STD,NODE1(N),NODE2(N),TEMP1(N),TEMP2(N),	
TEMP3(N)	
1 N1=NODE1(N)/100	03250210
N2=NODE2(N)/1000	03250220
N3=NODE2(N)-1000*N2	03250240
N01=N1	03250250
NTYPE=(NODE1(N)-100*N01)/10	03250260
MC=NODE1(N)-100*N01-10*NTYPE	03250270
E=EF(MC)	03250280
TEMP(1)=XNU(MC)	03250290
IF (NTYPE.EQ.2) TEMP(1)=TEMP1(N)	03250300
TEMP(2)=TEMP1(N)	03250310
TEMP(3)=TEMP2(N)	03250320
TEMP(4)=TEMP3(N)	03250330
IF (NTYPE.NE.2) GO TO 14	03250340
WRITE(6,992) N1,N2,MC,TEMP(1)	03250350
IF (ML.EQ.2) WRITE(6,1003) STD	03250352
1003 FORMAT(1H ,25X,'STRAIN DENSITY = ',E14.7)	03250353
IF (ML.EQ.2) GO TO 15	03250354
VOA=VOLUM(N)/TVOL	03250355
VOAA=VOLUM(N)/VOA	03250356
WRITE(6,1002) XCON(N),VOAA,VOAT	03250357
1002 FORMAT(1H ,25X,'STRAIN ENERGY = ',E15.7,'/3X,	03250358
1*EL. VOL. / GROUP VOL.=',E15.7,'2X,'EL. VOL. / TOTAL VOL.= ',E15.7)	03250359
GO TO 15	03250360
14 IF (NTYPE.NE.4) GO TO 16	03250370

WRITE(6,995)	03250372
WRITE(6,994)N1,N2,N3,MC,(TEMP(K),K=2,4)	03250380
IF(ML.EQ.2)WRITE(6,1004)STD	03250381
IF(ML.EQ.2)GO TO 15	03250383
VOAT=VOLUM(N)/TVOL	03250385
VOAB=VOLUM(N)/VOB	03250387
WRITE(6,1005)XCON(N),VOAB,VOAT	03250388
GO TO 15	03250390
16 WRITE(6,993)	03250392
WRITE(6,994)N1,N2,N3,MC,(TEMP(K),K=2,4)	03250400
IF(ML.EQ.2)WRITE(6,1004)STD	03250401
100A FORMAT(1H+,25X,'STRAIN DENSITY = ',E14.7)	03250402
IF(ML.EQ.2)GO TO 15	03250403
VOAT=VOLUM(N)/TVOL	03250404
VOAS=VOLUM(N)/VOS	03250405
WRITE(6,1005)XCON(N),VOAS,VOAT	03250406
1005 FORMAT(1H+,25X,'STRAIN ENERGY = ',E15.7,/3X,	03250407
1'EL. VOL. / GROUP VOL.=',E15.7,2X,'EL. VOL. / TOTAL VOL.= ',E15.7)	03250408
15 CONTINUE	03250410
13 CONTINUE	03250430
500 RETURN	03710000
END	03720000

MEMBER NAME BEAM689

SLROUTINE BEAM(X1,Y1,Z1,X2,Y2,Z2,X3,Y3,Z3,E,XMU,Y1,XJ,AW,BMAT,VO100020000	
IMPLICIT REAL*8 (A-H,O-Z)	
DIMENSION BMAT(12,12),OME(6,12),BK(6,6),TEMP(6,12),G(3,3)	00030000
DOUPLF PRECISION L1,I1,J1,MU	
SOPT(X) = DSORT(X)	
ABS(X) = DABS(X)	
MU=XMU	
X31=X3-X1	00070000
Y31=Y3-Y1	00080000
Z31=Z3-Z1	00100000
X12=X1-X2	00120000
Y12=Y1-Y2	00170000
Z12=Z1-Z2	00180000
X13=X1-X3	00190000
Y13=Y1-Y3	00200000
Z13=Z1-Z3	00210000
SU1=(1./3.)	00220000
SU3=(2./3.)	00230000
I1=Y1	00240000
A=AW	00260000
J1=XJ	00270000
SL=SOPT(X12**2+Y12**2+Z12**2)	00280000
VO=A*SL	00300000
G=E/(2.*(1.+MU))	00300010
SA=0.	00310000
IF(A.EQ.0.) GO TO 105	00311000
SA=(12.*E*I1)/(G*A*SL**2)	00312000
105 F=(6.*E*I1)/(SL**3*(1.+SA))	00320000
DO 5 I=1,6	00330000
DO 6 J=1,6	00380000
6 BK(I,J)=0.0	00390000
5 CONTINUE	00400000
BK(1,1)=2.*F	00410000
BK(3,1)=-SL*F	00420000
BK(4,1)=-2.*F	00430000
BK(6,1)=-SL*F	00440000
BK(2,2)=G*J1/SL	00450000
BK(5,2)=-G*J1/SL	00470000
BK(3,3)=SU3*SL**2*F*(1.+SA/4.)	00480000
BK(4,3)=SL*F	00500000
BK(6,3)=SU1*SL**2*F*(1.-SA/2.)	00510000
BK(4,4)=2.*F	00520000
BK(6,4)=SL*F	00540000
BK(5,5)=G*J1/SL	00550000
	00570000

	BK(6,6)=SU3*SL**2*F*(1.+SA/4.)	00590000
	DO 8 I =1,6	00610000
	DO 8 J =1,6	00620000
8	BK(I,J)=BK(J,I)	00630000
	X21=X2-X1	00690000
	Y21=Y2-Y1	00700000
	Z21=Z2-Z1	00710000
	DX=SQRT(X21**2+Y21**2+Z21**2)	00730000
	XPX=X21/DX	00740000
	YPX=Y21/DX	00750000
	ZPX=Z21/DX	00760000
	DO 100 J =1,3	00780000
100	D(J,1)=1.	00790000
	D(1,2)=Y1	00810000
	D(2,2)=Y2	00820000
	D(3,2)=Y3	00830000
	D(2,3)=Z2	00850000
	D(1,3)=Z1	00860000
	D(3,3)=Z3	00870000
	CALL DET (D,A)	00890000
	DO 101 J =1,3	00910000
101	D(J,2)=1.	00920000
	D(1,1)=X1	00940000
	D(2,1)=X2	00950000
	D(3,1)=X3	00960000
	CALL DET (D,R)	00980000
	DO 102 J =1,3	01000000
102	D(J,3)=1.	01010000
	D(1,2)=Y1	01030000
	D(2,2)=Y2	01040000
	D(3,2)=Y3	01050000
	CALL DET (D,C)	01070000
	RD=SQRT(A**2+R**2+C**2)	01090000
	XBY=A/RD	01100000
	YBY=R/RD	01110000
	ZBY=C/RD	01120000
	XBZ=(YBX*ZBY)-(YBY*ZBX)	01140000
	YPZ=-(XBY*ZRX)-(XPX*ZBY)	01150000
	ZRZ=(XBX*YBY)-(XBY*YBX)	01160000
	DO 9 I =1,6	01180000
	DO 10 J =1,12	01190000
10	OME(I,J)=0.0	01200000
9	CONTINUE	01210000
	OME(1,1)=XBZ	01230000
	OME(1,2)=YRZ	01240000
	OME(1,3)=ZBZ	01250000
	OME(4,4)=YBZ	01270000
	OME(4,5)=YRZ	01280000
	OME(4,6)=ZBZ	01290000
	OME(2,7)=XBX	01310000
	OME(3,7)=XBY	01320000
	OME(2,8)=YBX	01330000
	OME(3,8)=YBY	01340000
	OME(2,9)=ZBX	01350000
	OME(3,9)=ZBY	01360000
	OME(5,10)=XPX	01380000
	OME(5,11)=YBX	01390000
	OME(5,12)=ZBX	01400000
	OME(6,10)=XBY	01420000
	OME(6,11)=YBY	01430000
	OME(6,12)=ZBY	01440000
	DO 3 I =1,6	01470000
	DO 3 J =1,12	01480000
	TEMP(I,J)=0.0	01490000
	DO 3 K =1,6	01510000
3	TEMP(I,J)=TEMP(I,J)+BK(I,K)*OME(K,J)	01520000
	DO 11 I =1,12	01540000

DO 11 J = 1,12	01550000
BMAT(I,J)=0.0	01560000
DO 13 K = 1,6	01570000
13 BMAT(I,J)=BMAT(I,J)+OME(K,I)*TEMP(K,J)	01590000
IF (ABS(BMAT(I,J)).GT..1) GO TO 11	01600000
BMAT(I,J)=0.0	01610000
11 CONTINUE	01620000
RETURN	01640000
END	01650000

MEMBER NAME DET6R9	
SUBROUTINE DET (D,ANS)	00020000
IMPLICIT REAL*8 (A-H,O-Z)	
DIMENSION D(3,3)	00040000
ANS=D(1,1)*D(2,2)+D(3,3)+D(1,2)*D(2,3)+D(3,1)+D(1,3)+D(2,1)+D(3,2)	00060000
ANS=ANS-(D(3,1)+D(2,2)+D(1,3)+D(3,2)+D(2,3)+D(1,1)+D(3,3)+D(2,1)+	00070000
D(1,2))	00080000
RETURN	00100000
END	00110000

MEMBER NAME LOAD6R9	
SUBROUTINE LOADER (ARRAY,MODE)	
IMPLICIT REAL*8 (A-H,O-S,U-Z)	
DIMENSION CARD(5),TITLE(19),ARRAY(1)	
GO TO(100,200),MODE	
100 READ(5,101) NSUB,NOPC,CARD	
101 FORMAT(14,I1,5E14.7)	
IF(NSUB.LE.0) GO TO 303	
IF(NOPC.LE.0) GO TO 303	
IF(NOPC-6)109,303,108	
108 IF(NOPC-8)102,111,112	
109 DO 110 JCARD=1,NOPC	
JARRAY=NSUB + JCARD - 1	
110 ARRAY(JARRAY) = CARD(JCARD)	
GO TO 100	
102 READ(5,103) TITLE	
103 FORMAT(16,17A4,A2)	
104 NPAGE = 0	
GO TO 100	
111 RETURN	
112 STOP	
200 NPAGE = NPAGE + 1	
WRITE(6,201) (TITLE(N),N=2,19),NPAGE	
201 FORMAT(11H1,17A4,A2,6H PAGE ,I3,/))	
RETURN	
303 WRITE(6,304)NSUB,NOPC,CARD	
304 FORMAT(19H INVALID DATA CARD ,I4,I1,5E14.7)	
STOP	
END	

```

MEMBER NAME PATN689
IMPLICIT REAL*8 (A-H,O-Z)
DIMENSION MSS(20),DATA(30)
COMMON/LINKA/LAP(150),XNONOD,XNOSAT,XNORET,XNORED,XNOPOP,AXNON,
*EE(3),XMU(3),XNMA5V,XNEIG,XNMA5G,SCALE,EVSAVE,XKSAVE,XNSPEC,
*AS,FSM,RSM,DH,UH,WONE,OINV,FDEFL,FLOAD,OMEGA
COMMON/LINKA1/NTOTAL,NORET,NTAPE
EQUIVALENCE (DATA(1),XNONOD)
DO 40 I=1,30
40 DATA(I)=0.
500 CALL LOADER(DATA,1)
KILL=1
READ(2,1000)NMS
READ(2,2000)(MSS(I),I=1,NMS)
DO 600 I=1,NMS
MS=MSS(I)
REWIND 11
CALL A3LNK1(MS)
CALL SORTSD
CALL A3LNK2
REWIND 5
CALL LOADER(DATA,1)
600 CONTINUE
1000 FORMAT(I5)
2000 FORMAT(16I5)
END

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MEMBER NAME RESRT689
SUBROUTINE RESORT (XBK)
IMPLICIT REAL*8 (A-H,O-Z)
DIMENSION XBK(12,12),EXT(12,12),TEMP(12,12)
DO 1 I =1,12
DO 1 J =1,12
1 EXT(I,J)=0.0
EXT(1,1)=1.
EXT(2,2)=1.
EXT(3,3)=1.
EXT(4,7)=1.
EXT(5,8)=1.
EXT(6,9)=1.
EXT(7,4)=1.
EXT(8,5)=1.
EXT(9,6)=1.
EXT(10,10)=1.
EXT(11,11)=1.
EXT(12,12)=1.
DO 20 I =1,12
DO 20 J =1,12
TEMP(I,J)=0.0
DO 20 K =1,12
20 TEMP(I,J)=TEMP(I,J)+EXT(I,K)*XBK(K,J)
DO 30 I =1,12
DO 30 J =1,12
XBK(I,J)=0.0
DO 30 K =1,12
30 XBK(I,J)=XBK(I,J)+TEMP(I,K)*EXT(J,K)
RETURN
END

```

```

MEMBER NAME  SETUP689
SUBROUTINE SETUP (NTYPE,N1,N2,N3,E,TEMP,X,Y,Z,NONE,NTWO,XBK,IZ,VO)00010000
IMPLICIT REAL*8 (A-H,O-Z)
DIMENSION XBK(12,12),X(300 ),Y(300 ),Z(300 ),NONE(4),NTWO(4),TEMP(00040000
1      4)
00 166 I =1,12
00 166 J =1,12
166 XBK(I,J)=0.0
IF(NTYPE.NE.2) GO TO 24
CALL STRING (X(N1),Y(N1),Z(N1),X(N2),Y(N2),Z(N2),E,TEMP(1),XBK,VO)
IZ=6
GO TO 30
24 IF(NTYPE.NE.3) GO TO 25
G=E/(2.+(1.+TEMP(1)))
CALL SKIN (X(N1),Y(N1),Z(N1),X(N2),Y(N2),Z(N2),X(N3),Y(N3),Z(N3),
1      E,G,TEMP(2),TEMP(3),TEMP(4),TEMP(1),XBK,VO)
IZ=9
GO TO 30
25 IF(NTYPE.NE.4) GO TO 26
CALL BEAM (X(N1),Y(N1),Z(N1),X(N2),Y(N2),Z(N2),X(N3),Y(N3),Z(N3),
1      E,TEMP(1),TEMP(2),TEMP(3),TEMP(4),XBK,VO)
IZ=12
GO TO 30
26 WRITE (6,10)
10 FORMAT(9X,35HNTYPE NO. IN COLUMN 4 IS NOT 2,3OR4 )
30 CONTINUE
RETURN
END

```

```

MEMBER NAME  SKIN689
SUBROUTINE SKIN (X1,Y1,Z1,X2,Y2,Z2,X3,Y3,Z3,E,G,TS,TX,TY,XMU,
1      TMAT,VO)
IMPLICIT REAL*8 (A-H,O-Z)
DOUBLE PRECISION MU
SQRT(X)=DSQRT(X)
ABS(X)=DABS(X)
DIMENSION TMAT(12,12),D(3,3),ONE(9,9),RK(6,6),TEMP(6,9),XX(9),X(6)00050000
MU=XMU
DD=SQRT((X2-X1)**2+(Y2-Y1)**2+(Z2-Z1)**2)
COSXBX=(X2-X1)/DD
COSYBY=(Y2-Y1)/DD
COSZBX=(Z2-Z1)/DD
I=1
00 5 J =1,3
5 D(J,1)=1.
D(1,2)=Y1
D(2,2)=Y2
D(3,2)=Y3
D(1,3)=Z1
D(2,3)=Z2
D(3,3)=Z3
CALL DET (D,A1)
D(1,1)=X1
D(2,1)=X2
D(3,1)=X3
I=2
00 6 J =1,3
6 D(J,1)=1.
CALL DET (D,B)
I=3
00 7 J =1,3
7 D(J,1)=1.
D(1,2)=Y1
D(2,2)=Y2
D(3,2)=Y3
CALL DET (D,C)
G1=SQRT(A1**2+B**2+C**2)
COSXNZ=A1/G1

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	COSYBZ=C/G1	00550000
	COSZRZ=C/G1	00560000
	COSYBY=COSYBZ*COSZRX-COSYBX*COSZBZ	00590000
	COSYBY=COSZBZ*COSYBX-COSZBX*COSYBZ	00600000
	COSZBY=COSXBZ*COSYBX-COSXBX*COSYBZ	00610000
	DO 8 I = 1,6	00670000
	DO 9 J = 1,9	00680000
9	OME(1,J)=0.0	00690000
8	CONTINUE	00700000
	OME(1,1)=COSXBX	00720000
	OME(1,2)=COSYBX	00730000
	OME(1,3)=COSZBX	00740000
	OME(2,1)=COSXBY	00760000
	OME(2,2)=COSYBY	00770000
	OME(2,3)=COSZBY	00780000
	OME(3,4)=COSXBX	00800000
	OME(3,5)=COSYBX	00610000
	OME(3,6)=COSZBX	00820000
	OME(4,4)=COSXBY	00830000
	OME(4,5)=COSYBY	00840000
	OME(4,6)=COSZBY	00850000
	OME(5,7)=COSXBX	00870000
	OME(5,8)=COSYBX	00880000
	OME(5,9)=COSZBX	00890000
	OME(6,7)=COSXBY	00910000
	OME(6,8)=COSYBY	00920000
	OME(6,9)=COSZBY	00930000
	XX(1)=X1	00970000
	XX(2)=Y1	00980000
	XX(3)=Z1	00990000
	XX(4)=X2	01000000
	XX(5)=Y2	01010000
	XX(6)=Z2	01020000
	XX(7)=X3	01030000
	XX(8)=Y3	01040000
	XX(9)=Z3	01050000
	DO 70 I = 1,6	01070000
	X(I)=0.0	01080000
	DO 70 J = 1,9	01090000
70	X(I)=X(I)+OME(1,J)*XX(J)	01100000
	X12=X(1)-X(3)	01110000
	X15=X(1)-X(5)	01120000
	X21=-X12	01130000
	X23=X(3)-X(5)	01140000
	X31=-X13	01150000
	Y32=X(5)-X(3)	01160000
	Y12=X(2)-X(4)	01170000
	Y13=X(2)-Y(6)	01180000
	Y21=-Y12	01190000
	Y31=-Y13	01200000
	Y23=X(4)-X(6)	01210000
	Y32=-Y23	01220000
	A=.5*(X21*Y31-Y21*X31)	01250000
	VO=A*TS	01260000
	G0=TS*G/(4.*A)	01270000
	GX=MU	01290000
	GY=0.	01300000
	IF(TY.EQ.0.) GO TO 105	01310000
	GY=MU*TX/TY	01320000
105	IF(TX.LT.TY) GO TO 50	01340000
	GX=0.	01360000
	IF(TX.FQ.0.) GO TO 200	01370000
	GX=MU*TY/TX	01380000
200	GY=MU	01390000
50	CONTINUE	01410000
	EY=TY*(1/(4.*A*(1.-GX*GY)))	01430000
	EX=TX*(1/(4.*A*(1.-GX*GY)))	01440000
	PK(1,1)=EX*Y23+.2*G0*X32+.2	01460000
	PK(2,1)=Y23*X32*(EY*GY+G0)	01470000
	PK(3,1)=EX*Y31+Y23+G0*X13*X32	01480000

PK(4,1)=EY*GY*X13*Y23+G0*Y31*X32	01490000
RK(5,1)=EX*Y12*Y23+G0*X21*X32	01500000
RK(6,1)=EY*GY*X21*Y23+G0*Y12*X32	01510000
RK(2,2)=EY*X32**2+G0*Y23**2	01530000
RK(3,2)=EX*GX*Y31*X32+G0*X13*Y23	01540000
RK(4,2)=EY*X13*X32+G0*Y31*Y23	01550000
PK(5,2)=EY*GX*Y12*X32+G0*X21*Y23	01560000
RK(6,2)=EY*X21*X32+G0*Y12*Y23	01570000
RK(3,3)=EX*Y31**2+G0*X13**2	01590000
PK(4,3)=EY*GY*X13*Y31+G0*Y31*X13	01600000
PK(5,3)=EX*Y12*Y31+G0*X21*X13	01610000
PK(6,3)=EY*GY*X21*Y31+G0*Y12*X13	01620000
RK(4,4)=EY*X13**2+G0*Y31**2	01640000
RK(5,4)=EX*GX*X13*Y12+G0*X21*Y31	01650000
RK(6,4)=EY*X21*X13+G0*Y12*Y31	01660000
RK(5,5)=EX*Y12**2+G0*X21**2	01680000
PK(6,5)=X21*Y12*(EY*GY+G0)	01690000
PK(6,6)=EY*X21**2+G0*Y12**2	01710000
DO 100 I =1,6	01730000
DO 100 J =1,6	01740000
100 RK(I,J)=EK(J,I)	01750000
DO 10 I =1,6	01760000
DO 10 J =1,9	01770000
TEMP(I,J)=0.0	017A0000
DO 10 K =1,6	01790000
10 TEMP(I,J)=TEMP(I,J)+BK(I,K)*OME(K,J)	01810000
DO 11 I =1,9	01830000
DO 11 J =1,9	01840000
THAT(I,J)=0.0	01850000
DO 3 K =1,6	01860000
3 THAT(I,J)=THAT(I,J)+OME(K,I)*TEMP(K,J)	01880000
IF (ABS(THAT(I,J)).GT..1) GO TO 11	01890000
THAT(I,J)=0.0	01900000
11 CONTINUE	01910000
RETURN	01920000
END	01930000

MEMBER NAME SORT689	
SUBROUTINE SORTSD	
IMPLICIT REAL*8 (A-H,O-Z)	00010000
DIMENSION STD(2750),NODE1(2750),NODE2(2750),TEMP1(2750),	
1 TEMP2(2750),TEMP3(2750)	00040000
N=1	00050000
REWIND R	00060000
10 READ(R) STD(N),NODE1(N),NODE2(N),TEMP1(N),TEMP2(N),TEMP3(N)	00070000
IF (NODE1(N).EQ.0) GO TO 15	00080000
N=N+1	00100000
GO TO 10	00110000
15 N=N-1	00120000
20 N=N-1	00130000
DO 30 L=1,M	00140000
I=L+1	00150000
DO 30 K=I,N	00160000
IF (STD(L).GE.STD(K)) GO TO 30	00170000
SORT=STD(L)	00180000
STD(L)=STD(K)	00190000
STD(K)=SORT	00200000
NORT=NODE1(L)	00210000
NODE1(L)=NODE1(K)	00220000
NODE1(K)=NORT	00230000
NORT=NODE2(L)	00240000
NODE2(L)=NODE2(K)	00250000
NODE2(K)=NORT	00260000
SORT=TEMP1(L)	00270000
TEMP1(L)=TEMP1(K)	00280000
TEMP1(K)=SORT	00290000
SORT=TEMP2(L)	00300000
	00310000

	TEMP2(L)=TEMP2(K)	00320000
	TEMP2(K)=SORT	00330000
	SORT=TEMP3(L)	00340000
	TEMP3(L)=TEMP3(K)	00350000
	TEMP3(K)=SORT	00360000
30	CONTINUE	00400000
	REWIND 8	00410000
	DO 40 L=1,N	00420000
	WRITE(8) STD(L),NODE1(L),NODE2(L),TEMP1(L),TEMP2(L),TEMP3(L)	00430000
40	CONTINUE	00450000
	RETURN	00460000
	END	00470000

MEMBER NAME STRNG6R9		
	SUBROUTINE STRING (X1,Y1,Z1,X2,Y2,Z2,E,A,SMAT,VO)	00010000
	IMPLICIT REAL*8 (A-H,O-Z)	
	DOUBLE PRECISION LAM,MU,NU,L	
	DIMENSION SMAT(12,12)	00050000
	L=DSQRT((X2-X1)**2+(Y2-Y1)**2+(Z2-Z1)**2)	
	VO=A*L	00080000
	LAM=(X2-X1)/L	00090000
	MU=(Y2-Y1)/L	00100000
	NU=(Z2-Z1)/L	00110000
	SMAT(1,1)=LAM**2	00130000
	SMAT(2,2)=MU**2	00140000
	SMAT(3,3)=NU**2	00150000
	SMAT(4,4)=SMAT(1,1)	00160000
	SMAT(5,5)=SMAT(2,2)	00170000
	SMAT(6,6)=SMAT(3,3)	00180000
	SMAT(1,2)=MU*LAM	00200000
	SMAT(1,3)=NU*LAM	00210000
	SMAT(1,4)=-(LAM)**2	00220000
	SMAT(1,5)=-(MU*LAM)	00230000
	SMAT(1,6)=-(NU*LAM)	00240000
	SMAT(2,3)=NU*MU	00250000
	SMAT(2,4)=-LAM*MU	00260000
	SMAT(2,5)=-(MU)**2	00270000
	SMAT(2,6)=-NU*MU	00280000
	SMAT(3,4)=-LAM*NU	00300000
	SMAT(3,5)=-MU*NU	00310000
	SMAT(3,6)=-(NU)**2	00320000
	SMAT(4,5)=MU*LAM	00340000
	SMAT(4,6)=LAM*NU	00350000
	SMAT(5,6)=MU*NU	00370000
	DO 100 I=1,6	00390000
	DO 100 J=1,6	00400000
100	SMAT (J,I)=SMAT(I,J)	00410000
	DO 105 I=1,6	00420000
	DO 105 J=1,6	00430000
105	SMAT(I,J)=(A+E)/L*SMAT(I,J)	00440000
	RETURN	00500000
	END	00510000

MEMBER NA UNPCK6R9		
	SUBROUTINE UNPACK (NONE,NTWO,KK)	00010000
	IMPLICIT REAL*8 (A-H,O-Z)	
	DIMENSION KK(1)	00040000
	KK(1)=NONE/100	00050000
	KK(2)=(NONE-100*KK(1))/10	00060000
	KK(3)=NONE-100*KK(1)-10*KK(2)	00070000
	KK(4)=NTWO/100	00080000
	KK(5)=(NTWO-100*KK(4))/10	00090000
	KK(6)=NTWO-100*KK(4)-10*KK(5)	00100000
	RETURN	00110000
	END	00120000

APPENDIX I

LISTING OF PROGRAM TO IDENTIFY AREAS OF HIGH STRAIN ENERGY DENSITY FOR HOUSINGS (S-83)

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MEMBER NAME S-83PLAT2
C MEMBERNAME S-83PLAT2 00000010
  REAL*8 HEADR(8),EST 00000020
  REAL*8 TREF,BEND,TYPE,BLANK,XMODE 00000030
  REAL*8 TIME 00000040
  COMMON/NOU10/10UT 00000050
  COMMON/STASRT/1210(200),DDUM(600),STE,STMU 00000060
  DIMENSION IDP(12853),JPLT(60) 00000070
  DIMENSION S2(12853) 00000080
  EQUIVALENCE (S2(1),REC2(1)) 00000090
  COMMON IREC1(146),REC2(12853),SIGMA(650,8,8),S1(1803), 00000100
  1LOADCS,ITYPE,IOEF1,SIGMS(650,16),IDELM(650),IXCLUD(50),NELEM, 00000110
  2JPLT(10,6),NEID,DPTH(650),ITIME 00000120
  COMMON/MODE/XMODE 00000130
  EQUIVALENCE (IDP(1),REC2(1)) 00000140
  NAMELIST/DATAX/JPLT 00000150
  NAMELIST /OMIT/IXCLUD 00000160
  REAL*8 NAME(4),NAMEIT,GPL,FILES(5),FILEF(5) 00000170
  DATA GPL/'GPL'/'/' 00000180
  DATA FILES/8HOESF1,8HOESC1,8HOESC2,8HOES1,8HOES2/'/' 00000190
  DATA FILEF/8HOEFB1,8HOEFC1,8HOEFC2,8HOEF1,8HOEF2/'/' 00000200
  DATA HEADR/'NORMAL-X','NORMAL-Y','SHEAR-XY','MAJOR','MINOR'/'/' 00000210
  1'SHEAR','THETA','CASE'/'/' 00000220
  DATA EST/'EST'/'/' 00000230
  DATA JPLT/6,7,8,9,15,16,17,18,19,63,3,17,8,17,8,3,17,8,4,5,2,6,5, 00000240
  13,6,9,2,7,3,7,3,3,9,3,4,12,2,16,12,3,16,2,25,21,30,26,21,26,32, 00000250
  226/'/' 00000260
  DATA BLANK/0H/'/' 00000270
  DATA BEND/0HENDING/'/' 00000280
C 00000290
C THIS PROGRAM CALCULATES CENTERLINE STRESSES FOR NASTRAN PLATE ELEMENTS 00000300
C ONLY AND FORMULATES A MAX/MIN ARRAY FOR THE CENTERLINE STRESSES. TH00000310
C GRAM REQUIRES THAT THE NASTRAN DATA BLOCKS OES1 AND DEF1 EXIST ON A 00000320
C TAPE. MULTIPLE SUBROUTINES ARE USED AND THEIR FUNCTIONS ARE AS FOLLO00000330
C 1) READS - READS STRESS DATA FROM OES1 AND COPIES IT INTO SIG00000340
C ARRAY. 00000350
C 2) READF - READS PLATE FORCES FROM DEF1 FOR TYPE AND LOAD CAS00000360
C FLAGGED FROM (1). DATA IS LEFT IN WORKING VECTOR 00000370
C 3) STRESS - CALCULATES CENTERLINE STRESSES AND ASSOCIATED PRIN00000380
C STRESSES. 00000390
C 4) LOADMM - LOADS THE MAX/MIN TABLE AS APPROPRIATE. 00000400
C 5) RITE - WRITES HEADER FOR STRESS OUTPUT 00000410
C 6) PRTOVR - PRINTS OVER MAX/MIN TERMS IN SIGMA ARRAY. 00000420
C 00000430
C 00000440
C READ IN 00000450
C 1) ELEMENT FORCE FLAG (IOEF1). IF IOEF1 IS 6, NO ELEMENT FORCE00000460
C WILL BE PROCESSED. IF IOEF1 EQ -1, THE FIRST FIBRE DISTANC00000470
C FROM THE PROPERTY CARD WILL BE USED. OTHERWISE, THE SECON00000480
C WILL BE USED. 00000490
C 2) NAMES OF NASTRAN DATA FILES (AND UNIT NUMBER ON WHICH FILE 00000500
C RE WRITTEN) CONTAINING STRESSES AND FORCES IN THE ORDER TH00000510
C APPEAR ON CHECKPOINT TAPE. 00000520
C 3) THE LOAD CASE ID NUMBERS TO BE EXCLUDED FROM CONSIDERATION 00000530
C THE MAX/MIN ROUTINE. VARIABLE IS IXCLUD WITH UP TO 50 EXCLU00000540
C POSSIBLE. NAMELIST INPUT IS USED. LIST IS TERMINATED WITH00000550
C 00000560
C WRITE(6,DATAX) 00000570
  READ(5,20)(NAME(I),I=1,4),TREF,IOEF1,TYPE,XMODE,STE,STMU 00000580
  20 FORMAT(5(48),18(48),48,2(8,0)) 00000590
C MEMPRATE THICKNESS 00000600
  TFLAG=-1. 00000610
C BENDING THICKNESS 00000620
  IF(TREF.EQ.BEND) TFLAG=1. 00000630
C SET THER FLAG 00000640

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ITIME=-1	00000650
IF (ITYE.NE.BLANK) ITIME=1	00000660
C ZERO TIMER	00000670
IF (ITIME.GT.0) CALL CLOCK(0,TIME)	00000680
DO 31 I=1,50	00000690
31 IXCLUD(I)=0	00000700
DO 32 J=1,5	00000710
DO 32 I=1,10	00000720
IA=10+J+1-10	00000730
32 IPLY(I,J)=JPLY(IA)	00000740
READ(5,OMIT,END=30,ERR=30)	00000750
30 CONTINUE	00000760
C INITIALIZE ARRAYS	00000770
DO 1 M=1,650	00000780
IDELM(M)=0	00000790
DO 1 MA=1,8	00000800
DO 1 MB=1,8	00000810
1 SIGMA(M,MA,MB)=0.0	00000820
DO 2 M=1,650	00000830
SIGMA(M,1,1)=-1.E60	00000840
SIGMA(M,2,2)=-1.E60	00000850
SIGMA(M,1,3)=+1.E60	00000860
SIGMA(M,2,4)=+1.E60	00000870
SIGMA(M,4,6)=-1.E60	00000880
SIGMA(M,5,7)=+1.E60	00000890
2 CONTINUE	00000900
ITYE = 0	00000910
C	00000920
C THE CHECKPOINT TAPE IS ASSUMED TO BE ON UNIT 10.	00000930
C	00000940
C COPY DATA BLOCKS ONTO SCRATCH TAPES	00000950
C	00000960
K=1	00000970
DO 3000 I=1,4	00000980
IOUT=I	00000990
REWIND I	00001000
NAMEIT=AF(I)	00001010
IF (NAMEIT.EQ.BLANK) GO TO 3004	00001020
CALL XFETCH(1803,NAMEIT,REC2,IX,IY,12853,K,S1,10,S2,ISUC,1,4)	00001030
IF (ISUC.GT.0) GO TO 3002	00001040
WRITE(6,3001) NAMEIT	00001050
3001 FORMAT(1H1,20(/),IX,120(' '),/,10X,'TROUBLE READING ',A6,' FROM RE	00001060
1 START TAPE--FATAL ERROR',//,1X,120(' '))	00001070
STOP	00001080
3002 K=0	00001090
REWIND I	00001100
3000 CONTINUE	00001110
3004 DO 3010 I=1,4	00001120
IF (NAME(I).EQ.EST) KEST=1	00001130
IF (NAME(I).EQ.GPL) KGPL=I	00001140
DO 3010 J=1,5	00001150
IF (NAME(I).EQ.FILES(J)) KSTR=J	00001160
IF (NAME(I).EQ.FILEF(J)) KFRC=J	00001170
3010 CONTINUE	00001180
CALL SORTID(KSTR)	00001190
CALL LODTHK(KEST,IFLAG)	00001200
C	00001210
C START READING DATA BLOCKS FROM SCRATCH TAPES.	00001220
C	00001230
50 CALL READS(KSTR,851)	00001240
IF (ITYE.EQ.9.OR.ITYE.EQ.16.OR.ITYE.EQ.63) GO TO 61	00001250
IF (ITYE.GT.0) GO TO 10	00001260
WRITE(6,11)	00001270
11 FORMAT(5X,'TROUBLE WITH DES1')	00001280
STOP	00001290
10 CONTINUE	00001300
IF (IOEFL.GE.0) CALL READF(KFRC)	00001310
C	00001320
C PLATE STRESSES ARE NOW CONTAINED IN THE ARRAY SIGMS, WITH ID CONTAIN	00001330
C IDELM. PLATE FORCES AND IO'S ARE CONTAINED IN TEMPORARY VECTOR REC	00001340

C		00001350
C		00001360
C	CALL THE ROUTINE STRESS FOR CALCULATING CENTERLINE STRESSES AND PERFORM	00001370
C	MAX/MIN SEARCH.	00001380
C		00001390
	61 CALL STRESS	00001400
	GO TO 50	00001410
	51 J=0	00001420
C	PRINT TABLE OF MAX/MIN DATA	00001430
	DO 60 M=1,NELEM	00001440
	J=J+1	00001450
	IF(J.EQ.1) WRITE(6,70)	00001460
	70 FORMAT(1H1,/,20X,'SUMMARY OF MAXIMUM AND MINIMUM STRESSES',/,40X,'(READ DATA SETS BY COLUMNS	00001470
	2))	00001480
	IF(J.EQ.3) J=0	00001490
	WRITE(6,71) IDELEM(M),DPTH(M)	00001500
	71 FORMAT(,/,45X,'ELEMENT NO.',10X,/,50X,'(THICKNESS=',F6.4,	00001510
	1)',/,17X,'MAXIMUM TENSION',13X,'MAXIMUM COMPRESSION',13X,	00001520
	2)'PRINCIPAL STRESSES',/,13X,'NORMAL-X',7X,'NORMAL-Y',7X,'NORMAL-X'	00001530
	3,7X,'NORMAL-Y',7X,'SHEAR-XY',9X,'MAJOR',10X,'MINOR',8X,'SHEAR',/)	00001540
	DO 72 MI=1,8	00001550
	IF(MI.EQ.6) GO TO 74	00001560
	WRITE(6,73) HEADR(MI),(SIGMA(M,MI,MJ),MJ=1,8)	00001570
	73 FORMAT(1X,A8,8(2X,E13.7))	00001580
C	PRINT OVER DIAGONAL TERMS	00001590
	CALL PRTOVR(M,MI)	00001600
	GO TO 72	00001610
	74 IF(MI.EQ.7) WRITE(6,75) HEADR(MI),(SIGMA(M,MI,MJ),MJ=1,8)	00001620
	75 FORMAT(1X,A8,8(6X,F9.4))	00001630
	IF(MI.EQ.8) WRITE(6,76) HEADR(MI),(SIGMA(M,MI,MJ),MJ=1,8)	00001640
	76 FORMAT(1X,A8,8(8X,F7.0))	00001650
	72 CONTINUE	00001660
	60 CONTINUE	00001670
	CALL ELCON(KEST,KGPL)	00001680
	STOP	00001690
	END	00001700
	SUBROUTINE SORTID(IUNIT)	00001710
	REAL*8 TIME,XMODE,XMDE	00001720
	REAL*8 FILEN	00001730
	COMMON/ROUTU/IOUT	00001740
	COMMON IREC1(146),REC2(12853),SIGMA(650,8,8),S1(1803),	00001750
	1LOADCS,ITYPE,IOEF1,SIGMS(650,16),IDELEM(650),IXCLUD(50),NELEM,	00001760
	2IPLT(10,6),NEID,DPTH(650),ITIME	00001770
	COMMON/MODE/XMDF	00001780
	DATA XMODE/'MODE' //	00001790
	DIMENSION IDP(12853)	00001800
	EQUIVALENCE (IDP(1),REC2(1))	00001810
	IF(ITIME.LT.0) GO TO 4001	00001820
	CALL CLOCK(1,TIME)	00001830
	TIM=(TIME*3.603)	00001840
	WRITE(6,1000) TIM	00001850
	4001 CONTINUE	00001860
	1000 FORMAT(1X,'ENTERING SORTID',F16.8)	00001870
C	THIS SUBROUTINE SCANS THE STRESS TABLE, BUILDS IDELEM ARRAY, AND THEN	00001880
C	IT IN ASCENDING ORDER.	00001890
	NELEM = 0	00001900
	KASFLG = -1	00001910
	99 READ(IUNIT,END=101)FILEN,JJ,L	00001920
	READ(IUNIT,END=101)(IREC1(IJ),IJ=1,L)	00001930
	READ(IUNIT,END=101)FILEN,JJ,L	00001940
	READ(IUNIT,END=101)(REC2(IJ),IJ=1,L)	00001950
C	CHECK FOR PLATE ELEMENT	00001960
	ITYPE=IREC1(3)	00001970
	DO 10 I=1,10	00001980
	IF(ITYPE.EQ.IPLT (I,1)) GO TO 98	00001990
	10 CONTINUE	00002000
	GO TO 99	00002010
	98 LOADCS=IREC1(4)	00002020
	IF(XMDE.EQ.XMODE)LOADCS=IREC1(5)	00002030
		00002040

C	SET FIRST LOAD CASE NUMBER	00002050
	IF(KASFLG.EQ.-1) LOAD1=LOADCS	00002060
	IF(LOADCS.GT.LOAD1) GO TO 101	00002070
	KASFLG=1	00002080
C	SET NUMBER OF ELEMENTS	00002090
	NEID=L/IPLT (1,2)	00002100
	DO 90 J=1,NEID	00002110
	K=NELEM+J	00002120
	JA=(J-1)*IPLT (1,2)+1	00002130
C	FILL UP ELEMENT ID ARRAY	00002140
	90 IDELEM(K)=(IDP(JA)-1)/10	00002150
	NELEM=NELEM+NEID	00002160
	GO TO 99	00002170
101	CONTINUE	00002180
C	SORT THE ID'S	00002190
	KX=NELEM	00002200
20	KN1=1	00002210
21	KO=KX-1	00002220
	LO=0	00002230
	DO 30 N=1,KO	00002240
	GO TO (22,23),KN1	00002250
22	I=N	00002260
	GO TO 24	00002270
23	I=KX-N	00002280
24	CONTINUE	00002290
	IF(IDELEM(I)-IDELEM(I+1)) 30,30,25	00002300
25	NARY=IDELEM(I)	00002310
	IDELEM(I)=IDELEM(I+1)	00002320
	IDELEM(I+1)=NARY	00002330
	LO=1	00002340
30	CONTINUE	00002350
	IF(LO) 40,40,35	00002360
35	IF(KN1-1) 45,45,20	00002370
45	KN1=2	00002380
	GO TO 21	00002390
40	CONTINUE	00002400
	REWIND UNIT	00002410
	ITYPE=0	00002420
	RETURN	00002430
100	WRITE(6,102)	00002440
102	FORMAT(1H1,10(/),1X,'TROUBLE IN SUBROUTINE SORTID---EXIT,')	00002450
	STOP	00002460
	END	00002470
	SUBROUTINE LODTHK(IUNIT,TFLAG)	00002480
	REAL*8 TIME	00002490
	DIMENSION IDP(12853)	00002500
	COMMON IREC1(146),REC2(12853),SIGMA(650,8,8),S1(1803),	00002510
	1LOADCS,ITYPE,IOEF1,SIGMS(650,16),IDELEM(650),IXCLUD(50),NELEM,	00002520
	2IPLT(10,6),NEID,DPH(650),ITIME	00002530
	EQUIVALENCE (IDP(1),REC2(1))	00002540
	REAL*8 FILE	00002550
	COMMON/ROUTU/1OUT	00002560
	1OUT=IUNIT	00002570
	IF(1TIME.LT.0) GO TO 4001	00002580
	CALL CLOCK(1,TIME)	00002590
4	TIM=(TIME*3.603)	00002600
5	WRITE(6,1000) TIM	00002610
4001	CONTINUE	00002620
1000	FORMAT(1X,'ENTERING LODTHK',F16.8)	00002630
C	THIS SUBROUTINE LOADS THE PLATE THICKNESSES	00002640
	42 READ(IUNIT,END=100) FILE,JJ,L	00002650
	IF(L.LE.6) RETURN	00002660
	READ(IUNIT,END=100) (REC2(I),I=1,L)	00002670
	J=IDP(1)	00002680
	GO 43 I=1,10	00002690
	IF(J.EQ.IPLT(1,1)) GO TO 50	00002700
43	CONTINUE	00002710
	GO TO 42	00002720
50	CONTINUE	00002730
	IECT= IPLT(1,3)	00002740

LEPT= IPLT(1,4)	00002750
IRCPD7=IPLT(1,5)	00002760
ITOT= IPLT(1,6)	00002770
C SET NUMBER OF ELEMENTS	00002780
NEID=(L-1)/10	00002790
C LOOP THROUGH ELEMENTS	00002800
DO 10 I=1,NEID	00002810
IR=(IA-1)*ITOT+2	00002820
ICD=IDP(IR)	00002830
IF(IEID,1,7,IDELEM(1)) GO TO 10	00002840
IF(IEID,6,IDELEM(NELEM)) GO TO 42	00002850
DO 20 J=1,NELEM	00002860
IF(IEID,NE,IDELEM(IC)) GO TO 20	00002870
DPIN(IC)=REC2(IR+IECT+1)	00002880
IF(J,EO,7,OR,J,EO,8,OR,J,EN,15) DPTH(IC)=REC2(IR+IECT+3)	00002890
IF(FLAG,LE,0) GO TO 20	00002900
IF(J,EO,6,OR,J,EO,19) DPTH(IC)=REC2(IR+IECT+5)	00002910
20 CONTINUE	00002920
10 CONTINUE	00002930
GO TO 42	00002940
100 RETURN	00002950
END	00002960
SUBROUTINE READS(IUNIT,*)	00002970
REAL*8 FILEN,XMODE,XMOD	00002980
REAL*8 TIME	00002990
COMMON/ROUTJ/IOUT	00003000
DIMENSION IDP(12853)	00003010
COMMON IREC1(146),REC2(12353),SIGMA(650,8,8),S1(1803),	00003020
LOADCS,ITYPE,DEF,SIGNS(650,16),IDELEM(650),IXCLUD(50),NELEM,	00003030
2IPLT(10,6),ICID,DP,H(650),TIME	00003040
COMMON/XMODE/XMODE	00003050
DATA XMODE/XMODE	00003060
EQUIVALENCE (IDP(1),REC2(1))	00003070
IOUT=IUNIT	00003080
IF(TIME,LT,0) GO TO 4001	00003090
CALL CLOCK(1,TIME)	00003100
TIME=(TIME*3.603)	00003110
WRITE(6,1000) TIME	00003120
4001 CONTINUE	00003130
1000 FORMAT(1X,'ENTERING READS',F16.8)	00003140
C BEGIN READING DATA FROM OES1	00003150
C	00003160
29 CONTINUE	00003170
READ(IUNIT,END=100) FILEN,JJ,L	00003180
IF(L,LT,100) RETURN 1	00003190
C WRITE(6,12) FILEN,JJ,L	00003200
12 FORMAT(1X,A9,2(4X,I8))	00003210
READ(IUNIT,END=100) (IREC1(II),II=1,L)	00003220
C WRITE(6,11) (IREC1(II),II=1,L)	00003230
11 FORMAT(1X,15I8)	00003240
READ(IUNIT,END=100) FILEN,JJ,L	00003250
READ(IUNIT,END=100) (REC2(II),II=1,L)	00003260
C WRITE(6,201) (REC2(II),II=1,L)	00003270
201 FORMAT(1X,8(F14.4,1X))	00003280
C CHECK FOR PLATE ELEMENTS	00003290
DO 10 I=1,10	00003300
IF(IREC1(3).EQ,IPLT(I,1)) GO TO 98	00003310
10 CONTINUE	00003320
GO TO 99	00003330
C	00003340
C PLATE ELEMENT FOUND, PROCEED	00003350
C	00003360
98 LOADCS=IREC1(4)	00003370
IF(XMODE,EO,XMODE)LOADCS=IREC1(5)	00003380
ITYPE=IREC1(3)	00003390
C SET NUMBER OF ELEMENTS IDS	00003400
NEID=L/IPLT(1,2)	00003410
DO 40 J=1,NEID	00003420
JA=(J-1)*IPLT(1,2)+1	00003430
ID=(IDP(JA)-1)/10	00003440

DO 91 K=1,NELEM	00003450
IF(ID.EQ.IDELEM(K)) GO TO 92	00003460
91 CONTINUE	00003470
92 IEND=IPLT(1,2)-1	00003480
C LOOP THROUGH ELEMENTS AND STORE IN SIGMS ARRAY.	00003490
C	00003500
86 DO 89 JD=1,IEND	00003510
89 SIGMS(K,JD)=REC2(JA+JD)	00003520
C WRITE(6,200) (SIGMS(K,M),M=1,16)	00003530
90 CONTINUE	00003540
RETURN	00003550
200 FORMAT(1X,8(F14.4,1X),/,1X,8(F14.4,1X))	00003560
100 CONTINUE	00003570
IF(10EF1.LT.0) RETURN 1	00003580
RETURN	00003590
STOP	00003600
END	00003610
SUBROUTINE READF(IUNIT)	00003620
REAL*8 FILEN	00003630
REAL*8 TIME	00003640
DIMENSION IDP(12853)	00003650
COMMON IREFC(196),REC2(12853),SIGMA(650,8,8),S1(1803),	00003660
1LOADCS,ITYPE,10EF1,SIGMS(650,16),IDELEM(650),IXCLUD(50),NELEM,	00003670
2IPLT(10,6),NFID,DPH(650),ITIME	00003680
EQUIVALENCE (IDP(1),REC2(1))	00003690
COMMON/ROUTU/ROUT	00003700
IF(ITIME.LT.0) GO TO 4001	00003710
CALL CLOCK(1,TIME)	00003720
TIM=(TIME*3.603)	00003730
WRITE(6,1000) TIM	00003740
4001 CONTINUE	00003750
1000 FORMAT(1X,'ENTERING READF',F16.8)	00003760
IOUT=JUNIT	00003770
NREWIND=-1	00003780
C	00003790
C COPY DEF1 FROM TAPE	00003800
C NREWIND= NUMBER OF REWINDS	00003810
98 NREWIND=NREWIND+1	00003820
99 CONTINUE	00003830
C WRITE(6,1) ITYPE,LOADCS	00003840
1 FORMAT(1X,20(' '),218)	00003850
READ(IUNIT,END=100) FILEN,JJ,L	00003860
C WRITE(6,12) FILEN,JJ,L	00003870
12 FORMAT(1X,A8,2(4X,18))	00003880
READ(IUNIT,END=100) (IREC1(I),II=1,L)	00003890
C WRITE(6,11) (IREC1(II),II=1,L)	00003900
11 FORMAT(1X,15A8)	00003910
READ(IUNIT,END=100) FILEN,JJ,L	00003920
READ(IUNIT,END=100) (REC2(II),II=1,L)	00003930
IF(NREWIND.GT.5) GO TO 110	00003940
DO 10 I=1,10	00003950
IF(IREC1(3).EQ.IPLT(1,1)) GO TO 102	00003960
10 CONTINUE	00003970
GO TO 99	00003980
C	00003990
C PLATE FOUND, PROCEED	00004000
C	00004010
102 IF(IREC1(3).NE.ITYPE.OR.IREC1(4).NE.LOADCS) GO TO 99	00004020
C ELEMENT TYPE AND LOAD CASE MATCH THOSE FROM 'READS' -- PROCEED.	00004030
RETURN	00004040
100 REWIND IUNIT	00004050
GO TO 98	00004060
110 WRITE(6,111)	00004070
111 FORMAT(1H1,20('/'),120(' '),//,2X,'THE UNIT CONTAINING DEF1 HAS BEEN	00004080
1 REWOUND 5 TIMES -- VERIFY THAT PLATE FORCES ARE ON TAPE',//,120('	00004090
2(' '))	00004100
STOP	00004110
END	00004120
SUBROUTINE STRESS	00004130
REAL*8 TIME	00004140
DIMENSION IDP(12853)	00004150

COMMON IREC1(146),RFC2(12853),SIGMA(650,8,8),SI(1803),	00004160
1LOADCS,ITYPE,IOEF1,SIGMS(650,16),IDELEM(650),XCLUD(50),NELEM,	00004170
2IPLY(10,6),HFID,OPTH(650),ITIME	00004180
EQUIVALENCE (IDP(1),REC2(1))	00004190
COMMON/START/1210(200),ZSIG1(200),ZSIG2(200),STOEN(200),STE,STMU	00004200
C LOOP THROUGH ELEMENTS	00004210
IF (ITIME.LT.0) GO TO 4001	00004220
CALL CLOCK(1,TIME)	00004230
TIM=(TIME+3.603)	00004240
WRITE(6,1000) TIM	00004250
4001 CONTINUE	00004260
1000 FORMAT(1X,'ENTERING STRESS',F16.8)	00004270
JC=0	00004280
J=1	00004290
C SET RECORD LENGTH	00004300
C	00004310
C IF ITYPE .EQ. 9,16,63, LNG=8	00004320
LNG=8	00004330
IF (ITYPE.EQ.9.OR.ITYPE.EQ.16.OR.ITYPE.EQ.63) GO TO 3	00004340
C IF IOEF1 .GE. 0, LNG=6	00004350
LNG=6	00004360
IF (IOEF1.GE.0) GO TO 3	00004370
C IF IOEF1 .LT. 0, LNG=17	00004380
LNG=17	00004390
3 DO 10 L=1,NEID	00004400
KK=(L-1)*LNG+1	00004410
ID=(IDP(KK)-1)/10	00004420
DO 91 I=1,NELEM	00004430
IF (ID.EQ.IDELEM(I)) GO TO 92	00004440
91 CONTINUE	00004450
WRITE(6,70) ID	00004460
70 FORMAT(1H1,20(/),120(*)),//,'NO ELEMENT HAS BEEN FOUND IN OEF1 FOR	00004470
1R THE CURRENT LOAD CASE AND ELEMENT',15,'. THIS ELEMENT IS IGNORED	00004480
2D.',//,120(*))	00004490
STOP	00004500
GO TO 10	00004510
92 CONTINUE	00004520
JC=JC+1	00004530
IF (JC.EQ.1) CALL RITE(ITYPE,LOADCS)	00004540
IF (JC.EQ.50) JC=0	00004550
IF (LNG.EQ.8) GO TO 99	00004560
IF (IOEF1.LT.0) GO TO 35	00004570
C CHECK FOR ZERO FIBRE DISTANCE.	00004580
J=1	00004590
IF (SIGMS(1,J).EQ.0.) GO TO 99	00004600
J=9	00004610
IF (SIGMS(1,J).EQ.0.) GO TO 99	00004620
J=1	00004630
IF (SIGMS(1,1).NE.(-SIGMS(1,9))) GO TO 5	00004640
C DATA IS FOUND FOR EQUAL DISTANCES FROM CENTERLINE, AVERAGE DATA.	00004650
SIGMS(1,J+1)=(SIGMS(1,J+1)+SIGMS(1,J+9))/2.	00004660
SIGMS(1,J+2)=(SIGMS(1,J+1)+SIGMS(1,J+10))/2.	00004670
GO TO 41	00004680
5 CONTINUE	00004690
C READ NONZERO FIBRE DISTANCE	00004700
FIBDIS=AMAX1(SIGMS(1,1),SIGMS(1,9))	00004710
IF (SIGMS(1,9).GT.SIGMS(1,1)) J=9	00004720
TSQ06=(2.*FIBDIS)**2/6.	00004730
40 CONTINUE	00004740
C IF YOU'RE HERE, YOU FOUND AN ELEMENT MATCH.	00004750
BENSTS=-REC2(KK+1)/TSQ06	00004760
IF (FIBDIS.LT.0.) BENSTS=-BENSTS	00004770
C STRESS IS POSITIVE IF TENSION.	00004780
SIGMS(1,J+1)=SIGMS(1,J+1)-BENSTS	00004790
BENSTS=-REC2(KK+2)/TSQ06	00004800
IF (FIBDIS.LT.0.) BENSTS=-BENSTS	00004810
SIGMS(1,J+2)=SIGMS(1,J+2)-BENSTS	00004820
C PRINCIPAL STRESSES	00004830
41 SIG1=(SIGMS(1,J+1)+SIGMS(1,J+2))/2.	00004840
SIG2=SQR1((SIGMS(1,J+1)-SIGMS(1,J+2))**2/4.+SIGMS(1,J+3)**2)	00004850

	SIG3=SIG1+SIG2	00004860
	SIG4=SIG1-SIG2	00004870
	SIGMS(I,J+5)=AMAX1(SIG3,SIG4)	00004880
	SIGMS(I,J+6)=AMIN1(SIG3,SIG4)	00004890
	SIGMS(I,J+4)=(ATAN(2.*SIGMS(I,J+3)/(SIGMS(I,J+2)-SIGMS(I,J+1))))	00004900
	1/2.*180./3.1416	00004910
I10	SIGPS(I,J+7)=ABS(SIG2)	00004920
	IF(SIGMS(I,J+4).GT.45..OR.SIGMS(I,J+4).LT.-45.)	00004930
	*SIGMS(I,J+4)=ABS(SIGMS(I,J+4))-90.	00004940
35	IF(10EFF1.LT.-1) J=9	00004950
99	JP1=J+1	00004960
	JP7=J+7	00004970
	WRITE(6,98) ID,(SIGMS(I,IJ),IJ=JP1,JP7),DPTH(I)	00004980
98	FORMAT(18,6X,3(E13.7,2X),F12.4, 3(2X, 13.7),7X,F6.4)	00004990
	IF(ITYPE.EQ.6)GO TO100	00005000
	IF(ITYPE.EQ.19)GO TO100	00005010
	IF(ITYPE.EQ.17)GO TO 100	00005020
	IF(ITYPE.EQ.18)GO TO 100	00005030
	GO TO 200	00005040
100	IZID(L)=ID	00005050
	ZSIG1(L)=SIGMS(I,JP7-2)	00005060
	ZSIG2(L)=SIGMS(I,JP7-1)	00005070
	STDEN(L)=.5*(ZSIG1(L)**2+ZSIG2(L)**2-2.*STHU*ZSIG1(L)*ZSIG2(L))/	00005080
	1STE	00005090
C	SKIP MAX/MIN IF LOAD CASE EXCLUDED	00005100
	ICLUD=0	00005110
200	DO 79 IXJ=1,50	00005120
	IF(IXCLUD(IXJ).EQ.0) GO TO 78	00005130
	IF(LOADCS.EQ.IXCLUD(IXJ))ICLUD=1	00005140
	IF(LOADCS.EQ.IXCLUD(IXJ)) GO TO 10	00005150
79	CONTINUE	00005160
78	CONTINUE	00005170
C	NOW FILL UP MAX/MIN ARRAY.	00005180
	IF(SIGMS(I,J+1).LE.SIGMA(1,1,1)) GO TO 80	00005190
	CALL LOADMH(I,1,J,I)	00005200
80	IF(SIGMS(I,J+1).GT.SIGMA(1,1,3)) GO TO 81	00005210
	CALL LOADMH(I,3,J,I)	00005220
81	IF(SIGMS(I,J+2).LE.SIGMA(1,2,2)) GO TO 82	00005230
	CALL LOADMH(I,2,J,I)	00005240
82	IF(SIGMS(I,J+2).GT.SIGMA(1,2,4)) GO TO 83	00005250
	CALL LOADMH(I,4,J,I)	00005260
83	IF(ABS(SIGMS(I,J+3)).LE.ABS(SIGMA(1,3,5))) GO TO 84	00005270
	CALL LOADMH(I,5,J,I)	00005280
84	IF(SIGMS(I,J+4).LE.SIGMA(1,4,6)) GO TO 85	00005290
	CALL LOADMH(I,6,J,I)	00005300
85	IF(SIGMS(I,J+5).GT.SIGMA(1,5,7)) GO TO 86	00005310
	CALL LOADMH(I,7,J,I)	00005320
86	IF(ABS(SIGMS(I,J+6)).LE.ABS(SIGMA(1,6,8))) GO TO 10	00005330
	CALL LOADMH(I,8,J,I)	00005340
10	CONTINUE	00005350
	IF(ICLUD.EQ.1)GO TO 300	00005360
	CALL STSOT	00005370
300	IF(ITYPE.LT.0)GO TO 4002	00005380
	CALL CLOCK(1,TIME)	00005390
	TIM=(TIME*3.603)	00005400
	WRITE(6,1001) TIM	00005410
4002	CONTINUE	00005420
1001	FORMAT(1X, 'LEAVING STRESS',F16.8)	00005430
	RETURN	00005440
	STOP	00005450
	END	00005460
	SUBROUTINE LOADMH(JDELEM,ICOL,J,KDELEM)	00005470
	DIMENSION IOP(12853)	00005480
	COMMON IREC1(146),REC2(12853),SIGMA(650,8,8),S1(1803),	00005490
	1LOADCS,ITYPE,10EFF1,SIGMS(650,16),IDelem(650),IXCLUD(50),NELEM,	00005500
	2IPLT(10,6),NFID,DPTH(650),ITIME	00005510
	EQUIVALENCE (IOP(1),REC2(1))	00005520
C		00005530
C	THIS SUBROUTINE LOADS THE ICOL COLUMN OF THE MAX/MIN ARRAY FOR THE	00005540
C	JDELEM ELEMENT.	00005550

C	SIGMA(KDELEM,1,ICOL)=SIGMS(JDELEM,J+1)	00005560
	SIGMA(KDELEM,2,ICOL)=SIGMS(JDELEM,J+2)	00005570
	SIGMA(KDELEM,3,ICOL)=SIGMS(JDELEM,J+3)	00005580
	SIGMA(KDELEM,4,ICOL)=SIGMS(JDELEM,J+5)	00005590
	SIGMA(KDELEM,5,ICOL)=SIGMS(JDELEM,J+6)	00005600
	SIGMA(KDELEM,6,ICOL)=SIGMS(JDELEM,J+7)	00005610
	SIGMA(KDELEM,7,ICOL)=SIGMS(JDELEM,J+4)	00005620
	SIGMA(KDELEM,8,ICOL)=LOADCS	00005630
	RETURN	00005640
	STOP	00005650
	END	00005660
	SUBROUTINE PRTOVR(I,J)	00005670
	DIMENSION IDP(12853)	00005680
	COMMON IREC1(146),REC2(12853),SIGMA(650,8,8),S1(1803),	00005690
	1LOADCS,ITYPE,IOEF1,SIGMS(650,16),IDELM(650),IXCLUD(50),NELEM,	00005700
	2IPLT(10,6),NEID,OPTH(650),ITIME	00005710
	EQUIVALENCE (IDP(1),REC2(1))	00005720
	GO TO(10,20,30,40,50,60),J	00005730
10	WRITE(6,11) SIGMA(I,J,1),SIGMA(I,J,3)	00005740
	WRITE(6,11) SIGMA(I,J,1),SIGMA(I,J,3)	00005750
11	FORMAT(1H+,10X,E13.7,17X,E13.7)	00005760
	RETURN	00005770
20	WRITE(6,21) SIGMA(I,J,2),SIGMA(I,J,4)	00005780
	WRITE(6,21) SIGMA(I,J,2),SIGMA(I,J,4)	00005790
21	FORMAT(1H+,25X,E13.7,17X,E13.7)	00005800
	RETURN	00005810
30	WRITE(6,31) SIGMA(I,J,5)	00005820
	WRITE(6,31) SIGMA(I,J,5)	00005830
31	FORMAT(1H+,70X,E13.7)	00005840
	RETURN	00005850
40	WRITE(6,41) SIGMA(I,J,6)	00005860
	WRITE(6,41) SIGMA(I,J,6)	00005870
41	FORMAT(1H+,85X,E13.7)	00005880
	RETURN	00005890
50	WRITE(6,51) SIGMA(I,J,7)	00005900
	WRITE(6,51) SIGMA(I,J,7)	00005910
51	FORMAT(1H+,100X,E13.7)	00005920
	RETURN	00005930
60	WRITE(6,61) SIGMA(I,J,8)	00005940
	WRITE(6,61) SIGMA(I,J,8)	00005950
61	FORMAT(1H+,115X,E13.7)	00005960
	RETURN	00005970
	STOP	00005980
	END	00005990
	SUBROUTINE RITE(ITYPE,LOADCS)	00006000
	WRITE(6,10)	00006010
10	FORMAT(1H1,/,30X,*,S T R E S S E S I N *)	00006020
	IF(ITYPE.EQ. 6) WRITE(6, 6)	00006030
	IF(ITYPE.EQ. 7) WRITE(6, 7)	00006040
	IF(ITYPE.EQ. 8) WRITE(6, 8)	00006050
	IF(ITYPE.EQ. 9) WRITE(6, 9)	00006060
	IF(ITYPE.EQ.15) WRITE(6,15)	00006070
	IF(ITYPE.EQ.16) WRITE(6,16)	00006080
	IF(ITYPE.EQ.17) WRITE(6,17)	00006090
	IF(ITYPE.EQ.18) WRITE(6,18)	00006100
	IF(ITYPE.EQ.19) WRITE(6,19)	00006110
	IF(ITYPE.EQ.63) WRITE(6,63)	00006120
	WRITE(6,20) LOADCS	00006130
20	FORMAT(1H+,70X,*,P L A T E S F O R C A S E*,18,/,)	00006140
6	FORMAT(1H+,54X,*,C T R I A 1 *)	00006150
7	FORMAT(1H+,54X,*,C T R B S C *)	00006160
8	FORMAT(1H+,54X,*,C T R P L T *)	00006170
9	FORMAT(1H+,54X,*,C T R M E M *)	00006180
15	FORMAT(1H+,54X,*,C Q D P L T *)	00006190
16	FORMAT(1H+,54X,*,C Q D M E M *)	00006200
17	FORMAT(1H+,54X,*,C T R I A 2 *)	00006210
18	FORMAT(1H+,54X,*,C Q U A D 2 *)	00006220
19	FORMAT(1H+,54X,*,C Q U A D 1 *)	00006230
63	FORMAT(1H+,54X,*,C Q D M E M 2*)	00006240
		00006250


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1 WRITE(6,40) 00006260
40 FORMAT(1X,'ELEMENT',10X,'STRESSES IN ELEMENT COORD SYSTEM',12X, 00006270
1'PRINCIPAL',11X,'PRINCIPAL STRESSES') 00006280
WRITE(6,50) 00006290
50 FORMAT(3X,'ID',10X,'NORMAL-X',7X,'NORMAL-Y',7X,'SHEAR-XY',5X, 00006300
1'STRESS ANGLE',8X,'MAJOR',10X,'MINOR',10X,'SHEAR',7X,'THICKNESS', 00006310
2//) 00006320
RETURN 00006330
END 00006340
SUBROUTINE ELCON(KEST,KGPL) 00006350
COMMON IREC1(146),REC2(12853),SIGMA(650,8,8),S1(1803), 00006360
1LOADCS,ITYPE,IOEF1,SIGMS(650,16),IDELM(650),IEXCLUD(50),NELEM, 00006370
2IPLT(10,6),NFID,DP1H(650),ITIME 00006380
DIMENSION ICON(650,7),IGPL(1300),JEST(10),IDP(12853) 00006390
REAL*8 FILEN,LNAME(12),NAME 00006400
EQUIVALENCE (ICON(1,1),SIGMS(1,1)),(IGPL(1),SIGMS(1,8)) 00006410
EQUIVALENCE (IDP(1),REC2(1)) 00006420
DATA JEST/4,3,2,4,3,3,4/ 00006430
DATA LNAME/8HCTRIA1,8HCTRBSC,8HCTRPLT,8HCTRHEM,8HCQDPLT, 00006440
8HCQDHEN,8HCTRIA2,8HCQUAD2,8HCQUAD1,8HCQDHEN2 / 00006450
REWIND KEST 00006460
C READ IN GPL TABLE 00006470
READ(KGPL) FILEN,J,L 00006480
READ(KGPL) (IGPL(I),I=1,L) 00006490
NL=0 00006500
C READ IN EST TABLE 00006510
19 READ(KEST,END=100) FILEN,J,L 00006520
READ(KEST,END=100) (REC2(I),I=1,L) 00006530
IF (IDP(1).GT.10.AND.IDP(1).LT.15) GO TO 19 00006540
IF (IDP(1).GT.19.AND.IDP(1).LT.31) GO TO 19 00006550
IF (L.E.6) GO TO 100 00006560
LTYPE=IDP(1) 00006570
C DETERMINE ELEMENT TYPE 00006580
DO 20 IA=1,10 00006590
IF (LTYPE.EQ.IPLT(IA,1)) GO TO 30 00006600
20 CONTINUE 00006610
GO TO 19 00006620
30 CONTINUE 00006630
LNG=IPLT(IA,6) 00006640
NELEM=L/LNG 00006650
NS=NL+1 00006660
NL=NL+NELEM 00006670
K=0 00006680
DO 40 I=NS,NL 00006690
K=K+1 00006700
IB=(K-1)*LNG+2 00006710
IC=JEST(IA) 00006720
ICON(I,1)=IDP(IB) 00006730
ICON(I,2)=IA 00006740
ICON(I,3)=IC 00006750
DO 41 J=1,IC 00006760
INGPL=(IDP(IB+J)+5)/6 00006770
41 ICON(I,J+3)=IGPL(INGPL) 00006780
40 CONTINUE 00006790
GO TO 19 00006800
C CONNECTION ARRAY IS COMPLETE, SORT IT 00006810
100 CONTINUE 00006820
NELEM=NL 00006830
CALL SORTCX(ICON,650,7,1) 00006840
C NOW PRINT IT 00006850
M=0 00006860
DO 50 I=1,NL 00006870
IF (M.EQ.0) WRITE(6,51) 00006880
51 FORMAT(1H1,/,40X,'E L E M E N T   C O N N E C T I O N   T A B L E', 00006890
1,/,7X,'ELEMENT',8X,'ELEMENT',1X,4(8X,'GRID',3X),/,9X,'ID',12X, 00006900
2'NAME',13X,'A',14X,'B',14X,'C',14X,'D',/) 00006910
NAME=LNAME(ICON(I,2)) 00006920
IC=ICON(I,3)+3 00006930
WRITE(6,60) ICON(I,1),NAME,(ICON(I,J),J=4,IC) 00006940
60 FORMAT(7X,16,9X,A8,2X,4(3X,16,6X)) 00006950
M=M+1 00006960

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MEMBER NAME	SA3PLAT	
	IF(M.GE.51) M=0	00006970
50	CONTINUE	00006980
	RETURN	00006990
	END	00007000
	SUBROUTINE SORTCX(ITEMP,L,M,ISEL)	00007010
	COMMON IREC(1140),REC2(12853),SIGMA(650,8,8),S1(1803),	00007020
	1LOADCS,ITYPE,IOCF1,SIGMS(650,16),IDELM(650),IXCLUD(50),NELEM,	00007030
	2IPLT(10,6),NEID,OPTH(650),ITIME	00007040
C		00007050
C		00007060
C	ITEMP IS THE ARRAY TO BE SORTED	00007070
C	L AND M ARE THE ADJUSTABLE DIMENSION VARIABLES FOR ITEMP	00007080
C		00007090
C		00007100
C	ISEL = THE NO. OF THE ROW OR COL. ON WHICH TO SORT	00007110
C		00007120
C		00007130
	DIMENSION ITEMP(L,M),NARY(650)	00007140
	EQUIVALENCE (NARY(1),IDELM(1))	00007150
	LL = NELEM	00007160
	MM = M	00007170
	IF(L.EQ.1.AND.M.EQ.1)GO TO 71	00007180
	KX = LL	00007190
20	KN1 = 1	00007200
21	KO = KX - 1	00007210
	LO = 0	00007220
	DO 30 N = 1,KO	00007230
	GO TO (22,23),KN1	00007240
22	J = N	00007250
	GO TO 24	00007260
23	I = KX - N	00007270
24	CONTINUE	00007280
	IF(ITEMP(I,ISEL)-ITEMP(I+1,ISEL)) 30,30,25	00007290
25	DO 60 II = 1,MM	00007300
	NARY(II) = ITEMP(I,II)	00007310
	ITEMP(I,II) = ITEMP(I+1,II)	00007320
	ITEMP(I+1,II) = NARY(II)	00007330
60	CONTINUE	00007340
	LO = 1	00007350
30	CONTINUE	00007360
	IF(LO)40,40,35	00007370
35	IF(KN1-1)45,45,20	00007380
45	KN1 = 2	00007390
	GO TO 21	00007400
40	CONTINUE	00007410
70	CONTINUE	00007420
71	RETURN	00007430
	END	00007440