IN-18
p. 105

NASA Technical Memorandum 109059

Langley's CSI Evolutionary Model: Phase II

Lucas G. Horta, Mercedes C. Reaves, Kenny B. Elliott, W. Keith Belvin, and John E. Teter
Langley Research Center, Hampton, Virginia

October 1995

National Aeronautics and
Space Administration
Langley Research Center
Hampton, Virginia 23681-0001

Table of Contents

1. Introduction

The Phase 2 testbed is part of a sequence of laboratory models, developed at NASA Langley Research Center, to enhance understanding on how to model, control, and design structures for space applications. A key problem with structures that must perform in space is unwanted vibrations during operations. Instruments, designed independently by different scientists, must share the same vehicle causing interactions with each other. Once in space, these problems are difficult to correct and therefore prediction via analysis, design, and experiments is very important. Examples of these unwanted vibrations were evident in the Hubble Space Telescope and Upper Atmosphere Remote Satellite (UARS). Vibrations, although not crippling, can curtail the satellite effectiveness and data quality. The Phase 2 laboratory model is designed to fill a gap between theory and practice and to aid understanding of important aspects in modeling, sensor and actuator technology, ground testing techniques, and space control design issues. This report documents the Phase 2 structural properties, instrumentation, analytical and experimental models, and the suspension system.

Phase-2 is among the most sophisticated laboratory testbeds ever assembled to study spacecraft dynamics problems. Among the problems studied are actuator/sensor placement, dynamic modeling and testing of large flexible structures, use of active suspension for large structural testing, structure/control interaction of precision pointing instruments, application of modern control design methodology to large structures, and many others. The ability to construct an accurate mathematical model for dynamic response prediction is a critical technology area for future flight experiments. To develop some of the needed tools, a significant amount of time was spent on experimental validation of analytical models. Phase 1 truss design methodology was reported in Ref. [1] , actuator and sensor descriptions are found in Ref. [2].

An outline of this document is as follows. Section 2 provides a description of the truss structure and its main components. Section 3 describes the structural models along with corresponding modal testing results and a detailed description of the gimbal models, and control electronics. Finally, a brief summary of the results and some concluding remarks are given in Section 4.

2. Testbed Description

2.1. Structure

The Phase-2 CSI Evolutionary Model (CEM), shown in Fig. 1, consists of a three-dimensional aluminum truss 620 inch long constructed from 10 inch cubical bays. The truss has a 62 bay long center truss, four 2 x 5 bay horizontal suspension trusses, an 11 bay vertical laser tower, and a four bay vertical reflector tower. There are three two axis-gimbals mounted on the main bus. Also a 17 inch diameter reflector is mounted at the top of the vertical tower on the aft end of the structure. All the main components are labeled in Fig. 1. Four cables support the structure from the ceiling, each cable is in series with a pneumatic magnetic suspension system. Active suspension allows all six suspension modes to have a frequency less than 0.2 Hz. The following sections contain a detailed description of the main structural components.

2.1.1. Truss

The truss consists of 117 ten inch cubical bays constructed from five different types of strut elements. There are four different longerons sizes, as indicated in Table 1, but all battens and diagonals are the same size. These strut sizes are used to construct four types of bays distributed throughout the structure as shown in Fig. 2. A close-up view of the truss, Fig. 3, shows a typical truss lacing pattern. The lacing pattern used in the main truss and vertical towers has six or seven struts intersecting at the node ball. Each horizontal suspension appendage is 2 bays wide and has five, eight, or eleven struts intersecting at a given node ball.

2.1.2. Struts

Figures 4 and 5 show the design features and nomenclature for a typical truss member. Notice that a repeatable element of the truss is considered to be the strut tube and two half node balls at each end, but is shown equivalently as having one full node ball at one end. First, a standoff is fastened to the node ball using a steel screw and then the standoff is connected to the strut tube by fastening the nut onto the threaded section of the strut tube. This joint connection allows removal of strut tubes without disassembling others struts in a given bay. The strut length, indicated in Table 1, includes an established stackup tolerance of ±10 mils to facilitate truss assembly. Joint components such as node balls, standoffs, screws, and nuts are the same for all of the strut sizes. Strut development and testing results are documented in Ref. [3].

2.1.3. Reflector

An important component of the global line-of-sight (LOS) pointing subsystem is the reflector. The reflector, shown in detail in Fig. 6, is a 17 inch diameter 0.375 inch thick aluminum plate with a 10 inch diameter 0.25 inch thick mirror mounted on its surface. A steel circular plate 1.25 inches thick and 16.5 inches in diameter is mounted on the back of the aluminum plate to stiffen and add mass to the structural appendage. A tapered truss bay on the upper part of the aft truss tower supports the reflector at a 39.1 degree inclined position.

To monitor the LOS pointing accuracy, a laser mounted on the forward vertical truss tower is pointed towards the reflector and the laser beam reflection is measured by a photo-diode array over 600 inches above the reflector. This laser-reflector-detector system allows laser position measurements to within 3/10 in. Laser position is sampled and forwarded to the main computer at a maximum rate of 50 Hz. Although this signal is available to the control system, it has been used primarily to monitor the effectiveness of different control schemes.

2.1.4. Gimbals

To simulate interaction of instruments mounted on a spacecraft and the spacecraft control system, three two axis gimbal systems were fabricated and installed on the model. A typical gimbal system, known as a Science Instruments Simulator (SIS), is shown in Fig. 3. Each gimbal system is capable of slewing or pointing to a fixed point on earth with a pointing accuracy of less than 2 arc-seconds. Angular measurements are obtained using an Optical Sensor System (OSS) mounted on the floor underneath the gimbals, see Fig. 3. All OSS were designed and fabricated for use with the model.

Figure 7 shows a photograph of the gimbal system without a payload. The gimbal structure consists of two pivoting aluminum rings that are coplanar and concentric when in the null position. Axes associated with the interior and exterior gimbal rings have been named the "inner" and "outer" axis, respectively. The inner and outer gimbal rings have diameters 8.5 and 10 inches, respectively. Each ring has a motor module on one end and a sensor module at the other end. Each motor module includes a torquer and a cable wrap-up mechanism. The sensor module includes an optical encoder, interpolation electronics, electromagnetic brakes, and a cable wrap-up for the payload and inner gimbal sensor module.

The gimbals are controlled with a STD Bus 386SX computer that reads encoder pulses, and commands the gimbal torque motors. During gimbal operation, this computer provides commands to control gimbal brakes, motor, and also provides status information to maintain communications with the main computer. All software is written in C language and is executed at 1000 samples per second. Communication of the SIS with the control system is via ARCNET Ref. [4] digital data link.

To test the gimbal with a realistic inertia and payload, a dummy payload is mounted in the two axis gimbal. The dummy payload assembly, shown in Fig. 8, consists of two steel quarter sections, a top aluminum plate with a mirror and plate bracket, a bottom aluminum plate with a laser mounting clamp, a laser, and a mounting ring. The payload is tailored to have a higher mass moment of inertia about the inner axis than the outer axis to counter the smaller outer axis inertia, see Table 2. A removable payload top allows for the inertia and weight to be easily increased if desired. Slotted mounts between the steel quarter sections and the inner ring mount allow some adjustment for balancing purposes. A laser source is clamped to the bottom plate and is pointed towards the Optical Scoring System.

2.1.5. Suspension System

The model is suspended from four points on the ceiling of the laboratory, see Fig. 9. Four pneumatic-magnetic suspension devices are used to provide a near zero-g suspension, Fig. 10a. Attached to these devices are 66.75 foot long 0.170 inch diameter Kevlar cables. All cables are terminated in a Y configuration consisting of two 1/8" 7x19 braided stainless steel cables which attach to the top of two node balls on the model, Fig. 10b. The Y raised the pivot point of the model slightly above the center of gravity (cg.) to produce a desired roll mode of 0.2 Hz.

One goal of the suspension system is to have the frequencies of all 6 suspension modes of the model below 0.2 Hz. This separates the suspension modes from the flexible body modes. The pendulum action of the model hanging from 66.75 ft. cables determined the x, y and yaw modes. The stiffness of the pneumatic suspension system and the geometry of the structure determined the z, roll and pitch modes.

2.2. Instrumentation

Instrumentation for the testbed had to fulfill a number of different purposes, namely instrumentation for model validation, controller performance verification, controller design, and safety. In the following sections, highlights of the different sensors and/or actuators available are discussed.

2.2.1. Accelerometers

The model is instrumented with 51 Sundstrand model QA-900 servo accelerometers, 8 Sundstrand model QA-1400 servo accelerometers, and 129 PCB 330A piezo-film accelerometers. Sensor distribution is shown in Fig. 11 with coordinates given in Table 3. The servo accelerometers provide low-frequency acceleration measurements. Eight of the servo accelerometers are collocated with the air thrusters, and they are generally used as sensors during structural control experiments. The piezo-film accelerometers are used for structural identification tests at frequencies above 1 Hz.

2.2.2. Inertial Measurement Units

To measure angular rates, four Guidance Instrument Clusters GIC-100 units were purchased from Rockwell International. Each instrument cluster unit (size 5.85" x 5.85" x 1.978") provides angular rates and translational accelerations in three orthogonal directions. These units, which are commonly used in missiles, have a serial communication interface via an RS-422. The units are configured with a fixed sample-rate of 600 Hz. Angular rates are measured with a nominal least significant bit (LSB) of +/- 16.45 arc-sec/sec and for acceleration the LSB is 0.177 in/s^2. A significant amount of noise is introduced into the rate measurement due to the gyro bearing noise which can be anywhere between 200 and 600 arc-sec/sec. After initial testing, the units were modified to reduce noise. All units are rated for 150 deg/sec and 15 g's with a corresponding bandwidth of 90 and 60 Hz, respectively. By internal scaling of the signals and a bandwidth reduction, noise levels were reduced by a factor of 2 for rates and 3 for accelerations.

2.2.3. Optical Scoring System

Figure 12 shows a diagram of the OSS and Fig. 3 shows a photograph of the gimbal and OSS station for the CEM. The purpose of the OSS is to measure the relative angle between an incoming laser beam and the optical axis of the OSS. This measurement is independent of the laser beam translations allowing the CEM tests to simulate a real spacecraft where linear motions have a small impact on image degradation. To remove translation effects, a collimated laser beam is focused into a two axis photo-detector placed in the effective focal plane of the OSS optics. The photo-detector output is proportional to the angle that the laser beam enters the OSS optics. The detector electronics is housed in an annular circuit board and communicates with the OSS computer via an RS-422 high speed serial data link. The OSS computer samples the angular motions and communicates this data at 1000 samples per second via an ARCNET data link.

The OSS has a field of view (FOV) greater than 1000 arc-seconds and accepts laser beam translations up to 6.0 inches. To accommodate the large translation, two six-inch diameter clear aperture objective lenses (focal length = 12 inches) are located in front of the OSS. The FOV is limited by the spot traversing off the detector which is dependent on the effective focal length. For a FOV of 1200 arc-seconds, the required effective focal length is 36 inches. Two small concave lenses achieve this focal length and focus the beam at the photo-detector. When the OSS is mounted toward the ceiling lights, an optical filter reduces detector output noise caused by ambient light.

2.2.4 Air Thrusters

There are 16 air thrusters operating in pairs at eight locations, shown in Fig. 11. The thrusters are linear, bi-directional devices designed and built by Boeing Aerospace Ref. [5]. Each thurster will produce a peak force of 2.2 lbs. The thruster's dynamics is described in Ref. [2].

2.2.5 Shakers

Up to eight long-stroke electrodynamic shakers are available to apply excitations at most points on the structure. Details of the shakers can be found in Ref. [2]. Four of these shakers were used during the modal survey. The shakers were mounted to provide forces at 45 degrees angles relative to the global coordinate system, as shown in Fig. 11. Moreover, servo accelerometers are placed at these skewed locations to measure drive point frequency response functions. Thread mounted PCB 208 force gauges are also used to measure input excitation force at all shaker drive points and Nylon quills (1/4" diameter) are used to transmit shaker excitation.

2.3 Control and Data Acquisition System

The control and data acquisition system (DAS) is centered around two separate data acquisition systems. One system is used for structural dynamics testing, and the another system is used for control experiments. The structural test system is based on a ZONIC SYSTEM 7000 DAS. This system is a commercial general purpose data acquisition and signal processing system. The ZONIC 7000 provides 256 channels of simultaneous data acquisition and 8 channels of excitation. The system can be configured to acquire either time domain or frequency domain data, and this data can be saved in either ASCII or SDRC's ADF (associated data file) data formats. Figure 13 shows the configuration of the system during the modal test. The system is configured to receive analog signals from the accelerometers and force gages and output analog command signals to the shaker amplifiers.

The control system is custom based on the CAMAC (Computer Automated Measurement and Control) standard, see Ref. [9]. The CAMAC system is composed of modules that are mounted in a 'crate' or chassis. These modules interface an external process to a bus , located in the crate, called a dataway. Modules are available to provide analog input and output, communication interfaces (such as ARCnet), and computer interfaces. The system is flexible, and it can be re-configured to meet the experimenter's need. A typical control system configuration is shown in Fig. 14. In this case, four crates are configured to perform control experiments using a centralized or distributed architecture. Three of the crates are used to control each of the gimbals. These crates are equipped with two controllers: one controller is linked to a central computer to provide centralized control of the gimbals, while the other controller is linked to an internal single board real-time computer to provide local control of the gimbals. Gimbal communications are provided via a point-to-point ARCNet network. The fourth crate is configured to provide control of the structure using the air-thrusters as actuators and collocated servo-accelerometers or IMU units as sensors. All the crates are configured to receive data from the optical scoring system via a separate ARCNet network.

3.0 Analytical and Experimental Models

Analytical and/or experimental models have been developed for the main truss structure, Science Instrument Simulators, and the active suspension system. In most cases these models are validated with experimental data and experimentally derived model properties are obtained via heuristic approaches. Models and experimental results are discussed in the following sections.

3.1. Finite Element Model : Test and Analysis

3.1.1. Finite Element Analysis

A Finite Element Model (FEM) of the Phase-2 Evolutionary Model was constructed using MSC/NASTRAN. A static analysis including gravity preload effects was conducted followed by a normal mode analysis. Static preloading modifies the stiffness matrices used in the vibration analysis. NASTRAN input data deck listings for the static and dynamic analyses are given in Appendix A.

The FEM, shown in Fig. 9, has 664 grid points with 3984 degrees of freedom. Some grid point locations are shown in Fig. 9 and detailed grid point locations are included in Table 4. Beam elements are used to model the struts. Square aluminum-honeycomb core sandwich plates, used to support thrusters, laser, and gimbal controller are modeled using CTRIA3 triangular elements, 4 elements per plate. CQUAD4 elements are used to model the gimbal support plates. The reflector plate geometry is modeled using 8 CTRIA3. All concentrated masses are modeled using CONM2 including the laser, node balls, reflector mirror, instrumentation, and thrusters. In addition, CELAS2 elastic elements are used to model the effects of the thruster air hoses stiffness on the structure. Each pneumatic/magnetic suspension system is modeled as a spring-lumped mass system. A vertical suspension stiffness value of 0.7 lb_f/in and a suspension carriage moving mass of 0.186 slugs, determined experimentally, are incorporated into the FEM. Each of the four Kevlar cables supporting the structure is represented by 5 CROD elements. For the static differential stiffness computation, the suspension system model has all degrees-of-freedom constrained to avoid excessive deflections during initial loading. Constraints are removed for vibration analyses, allowing displacement of the lumped masses and stretching of the suspension springs.

The geometry of the gimbal rings is modeled by forming CBEAM elements polygons inscribed within 8.5 inches inner and 11 inches outer diameter circles. Motor and sensor shafts as well as the vertical posts supporting the gimbal system are also modeled using CBEAM elements. Lump mass elements, CONM2, including mass moments of inertia properties, are used to model the payload, motor, and sensor units. For modeling purposes, the payload at the center of the inner ring is connected to the ring using four steel beams 1 in^2 cross-sectional area. Stiffening of the inner ring due to the payload rigidity is approximated by steel beams.

A complete summary of the element type, element identification number, property identification number, and element locations on the structure are included in Table 5. The material and physical properties of the elements based on the property identification numbers are given in Table 6.

3.1.2. Experimental Set-up and Procedures

A modal test was performed on the Phase-2 CEM in its suspended configuration. Natural frequencies and damping values for six pendulum modes are measured using free decay data. Pure bandpass burst random excitation is employed to excite the 0 to 15 Hz frequency range. Flexible modes are identified from frequency response functions for all sensors described in the following section. Flexible modal parameters are determined using the polyreference complex exponential technique, Ref. [7], on SDRC I-DEAS Test™.

Pretest analysis - 34 iterations using the Lanzcos method yielded 66 modes in the 0 - 30 Hz bandwidth. Sensor and actuator locations are chosen by evaluating their effective independence, see Ref. [8], using mode shape influence coefficients. Appendix B shows an implementation of the algorithm, written using the commercially available program MATLAB. Sensor and actuator locations are described in Sections 2.2.1 and 2.2.5.

Two normal mode solutions are computed, one using all degrees-of-freedom, and a second solution using Guyan reduction which retains only degrees of freedom at locations where sensors are placed. Natural frequencies and eigenvectors cross orthogonality are compared for the full and reduced order models. Results indicated that the reduced inertia properties are well preserved and suitable for test-analysis correlation. Frequencies and corresponding mode shapes excluding cable modes are shown in figures 15 through 49. The first six modes are pendulum modes from 0.14 to 0.27 Hz while the first structural mode appears at 1.72 Hz. A number of cable modes appeared throughout the frequency range analyzed.

<u>Test procedure and modal identification</u>- Natural frequency and damping values for the first six rigid body modes are estimated using free decay data. Specifically, damped natural frequencies are determined by computing the auto spectrum of the response and locating the frequency at which resonance occurred. Damping values are determined by fitting a line to the decaying response in logarithmic space. Five measurements, using 10 servo accelerometers for each measurement, are made for each mode with the thruster air hoses both connected and disconnected. Undamped natural frequencies are then determined from the second order relation:

$$f_n = \frac{f_d}{\sqrt{1-\zeta^2}}$$

where :

f_n = natural frequency

f_d = frequency of damped oscillation

ζ = damping ratio

Flexible modes are identified from frequency response function measurements. Time history data and frequency response functions are acquired for all sensors chosen in the pretest analysis. Pure bandpass burst random excitation is employed and the modal parameters in terms of natural frequency, damping, and mode shapes are determined using the polyreference technique.

3.1.3. Test/Analysis Correlation Results

<u>Mode Shape Correlation</u> - Analytical and experimental mode frequencies and damping values are compared in Table 7. Also shown are results for cases with and without hoses. Note that thruster air hoses significantly increase the damping of the x-y plane, x-z plane, and y-z plane pendulum modes. Also showing a slight increase in damping are bounce and roll modes, although they are most affected by the suspension system damping. A maximum difference of 5% is observed between analytical and experimental frequencies for the range 0 - 15 Hz with cable modes excluded. In addition, Modal Assurance Criteria (MAC) values show good correlation between test and analysis mode shapes.

After updating the FEM model with new weight information, results between the modal test and analysis showed lower correlation values for all third bending modes than the previous model. Apparently, the weight distribution for cables and other support equipment mounted on the model have a significant effect on the coupling between higher bending and torsional modes.

Transfer Function Correlation - For control design, transfer functions between the control actuators and sensors are very important. In most cases, air thrusters are used as control actuators and their collocated accelerometers as control sensors. Using the first 95 structural modes, predicted by NASTRAN, Figs. 50 to 53 shows a comparison of the analysis transfer function with test. Figure 50-a shows thruster 1 to its collocated accelerometer 1, and Fig. 50-b shows data for thruster 2 and accelerometer 2. Included structural modes covered a frequency range up to 58 Hz. All analysis modes have assumed modal damping values of 0.1 %. Results compared well in the 0 to 10 Hz range where frequency errors are less than 5 %. Beyond 10 Hz the correlation is not as good. Thruster dynamic is assumed to be first order with a pole at 276.42 rad/sec and a gain of 111.3 lb_f/volt. For controller performance comparison the line-of-sight measured using the OSS is used. Since there are eight thrusters and six OSS angles, a multi-input multi-output frequency response function, shown in Fig. 54, is compared to test in terms of maximum singular values of the thruster to OSS.

3.2. Gimbal Modeling and Test Results

A description of the SIS gimbals was given in Section 2.1.4. Modeling of gimbal system includes the supporting structure and the control system electronics. Both aspects are discussed in the following sections along with experimental results.

Gimbal system - As mentioned earlier, the gimbals are constructed using two concentric rings actuated by torque motors. Support brackets connect the motors to an aluminum base plate which serves as an interface to the truss structure, shown in Fig. 3. MSC/NASTRAN is used for structural modeling and vibration analyses. The inner and outer rings are free to rotate about the global x and y axes. Figure 55 shows axes orientation and gimbal geometry while mounted on the platform. To study gimbal dynamics independently of the truss structure, one gimbal system is bolted to ground and analyzed in that configuration. Inner and outer axes are allowed to rotate in the FEM model to evaluate ring inertia and structural flexibility. Figures 56-60 show the first five gimbal modes. The first two modes are inner and outer ring rigid body modes and the first ring bending mode appeared at 47.32 Hz. Mode number four, which appeared at

108.01 Hz, is an in-plane collapsing of both inner and outer rings. To correlate model with test, hammer tests of the gimbal system were performed to determine resonance frequencies. A proving accelerometer was mounted at various points on the inner and outer ring. The strongest response appeared at a frequency 44 Hz and it is belief to be the first ring mode. To examine the effect of payload inertia, the payload was removed and a hammer test showed a frequency increase of 10 Hz., i.e., the first ring mode is now at 54 Hz. Both these conditions are simulated with the NASTRAN model. Based on analysis the first ring mode without payload was predicted at 53.8 Hz and with payload at 47.3 Hz. In order to match the first mode frequency without payload of the NASTRAN model, the connection between the motor shaft and ring stiffness had to be reduced to 70 % of its ideal value. Although the frequency prediction without payload is good, the total frequency change with the payload is not predicted. Payload inertias computed based on a solid model are 0.0854 lb_f-sec^2-ft for outer axis and 0.1344 lb_f-sec^2-ft for inner axis. In addition to the payload inertia, the estimated outer and inner ring inertias are 0.192 and 0.00314 lb_f-sec^2-ft. Although these values are not used directly in NASTRAN, one can compare them to those obtained from the vibration analysis. NASTRAN estimated the total outer axis inertia to be 0.4127 lb_f-sec^2-ft and the total inner inertia to be 0.1384 lb_f-sec^2-ft. Over 30% discrepancy is noted in the outer axis inertia, whereas, the inner axis showed less that 0.1 %.

<u>Gimbal Controller</u> - To maintain precision pointing of the gimbal system, a digital control loop is made active using a 386SX computer. A block diagram of the control system is shown in Fig. 61. Operations represented by the discrete transform Gc(z) are implemented digitally at 1000 Hz. Data from the optical encoder θ_e are internally represented in terms of 1/64 of an arc-second. Furthermore, reference commands to the gimbal must be given in terms of 1/64 of an arc-second. All gains in the controller loops are scaled to accept angle information in 1/64 arc-sec increments. A complete model of the gimbal with control electronics is assembled in MATLAB to simulate the closed-loop system. Gimbal controller coefficients and filter settings are also included in Fig. 61.

With the gimbal system bolted to the floor, a transfer function from gimbal commands to the encoder angle is shown in Fig. 62; outer axis at the top, inner axis at the bottom. The predicted corner frequency for the outer axis is 12 % lower than test. This is consistent with the inertia overprediction from the NASTRAN model. Inner axis results showed excellent agreement. For the case shown in Fig. 62, the controller parameter k_e is set to be 0.025 for both outer/inner axes. During bench testing, the controller loop gains were adjusted to prevent instabilities. Without payload, the loop gain is reduced to 0.01 for outer and 0.001 for inner axis. These gains do not correspond to the stability margin of the controller but are a good experimental compromise.

3.3. Suspension Dynamics and Test Results

Pneumatic-magnetic suspension devices, designed and built by CSA Engineering, are the heart of the suspension system. Each device, shown in Figures 63 and 64 --CSA Model 60350-D--, can lift up to 350 pounds with a stroke of +/-3 inches. The devices are controlled from a control panel on the floor which regulates air pressure and electrical commands. Each device has one hose supplying 60 psi air to the air bearings, a second hose supplying regulated air to the air pistons, and one cable supplying power and control commands.

Operating Principle : The pneumatic-magnetic suspension device uses two parallel subsystems: one passive pneumatic subsystem and one active electromagnetic subsystem, schematic shown in Fig. 65. The passive pneumatic subsystem consists of a clean, dry, air supply, a precision regulator, a 60 gallon accumulator tank and two air pistons. The regulated air balances the load in the air pistons and lifts the payload. The active electromagnetic subsystem consists of an LVDT position sensor, a controller, power amplifier, and a voice coil actuator. Once the controller senses the position of the air piston, commands are sent to the voice coil actuator to keep the payload centered. Without active control, the payload would drift from the center because there would be no restoring force.

Apparent stiffness of each suspension device can be varied independently. It has two components, a pneumatic stiffness and an active stiffness. The pneumatic stiffness is a function of the payload and increases as the load increases. Active stiffness is controlled manually from the control panel and can be varied from 0.05 lb_f/in to over 2.0 lb_f/in. For all testing the active stiffness is set to 0.5 lb_f/in and the pneumatic stiffness is 0.212 lb_f/in for a total stiffness of 0.712 lb_f/in.

4.0 Concluding Remarks

This document describes the Phase-2 CSI Evolutionary Model testbed and characterization. A number of different aspects of this testbed have been discussed in the paper. Instrumentation, control computer, advanced science instrument simulator, and structural modeling are but a few of the unique elements of this testbed. Because of its short life, only limited testing and correlation of most of the analytical models are available. However, the finite element model results in the 0 - 10 Hz frequency range showed good correlation between test and analysis. Also studied, are the effects of air hoses connections on suspension modes. Results indicated significant increase in damping values for pendulum modes.

Modeling of the Science Instrument Simulators (SIS) has proven to be an interesting challenge because of unexplained discrepancies and instabilities observed during testing which are still unresolved. Since these instruments will continue to be used, further modeling work would be required. Nevertheless, the SIS have provided unprecedented accuracy for angular measurements and are a good representation of science instruments flying in spacecrafts today.

A new pneumatic-magnetic suspension system was installed and tested. Although some initial failures occurred, after minor modifications the suspension devices have operated for extended periods of time without any problems. They have proven to be reliable and effective devices for testing large structures under near zero gravity conditions.

This document is a compilation of results generated for this testbed and some of the efforts to resolve discrepancies in our modeling techniques.

5.0 References

1- Maghami, P. G., et. al., "Experimental Validation of an Integrated Controls-Structures Design Methodology for a Class of Flexible Space Structures," NASA Technical Paper 3462, Nov. 1994.

2- Belvin, W.K., Elliott, K.B., Horta, L.G., Bailey, J.P., Bruner, A.M., Sulla, J.L., Won, J., and Ugoletti, R.M., " Langley's CSI Evolutionary Model: Phase 0," NASA TM 104165.

3- Gronet, M.J., Davis., D.A., Kintis, D.H., Brillhart, R.D., and Atkins, E.M., " Design and Testing of the Phase 1 CSI Evolutionary Model Erectable Truss," NASA CR 4461, Aug. 1992.

4- ZT 89CT90, STD ARCNET Interface Operating Manual Revision 0. Ziatech Corp., Jan. 1991.

5- Jacot, A.D., Bushnell, G.S., and Anderson, T.M., "Bi-directional Thruster Development and Test Report," NASA CR-182013, Feb. 1990.

6- Model 3843-J4A 1K to 16K-word FIFO Buffer Instruction Manual. Kinetic Systems Corporation, April 1990.

7- I-DEAS Test™ User's Guide. Structural Dynamics Research Corporation , 1990, pp. B-33 - B-42.

8- Kammer, D., "Sensor Placement for On-Orbit Modal Identification and Correlation of Large Space Structures, " *Journal of Guidance Control, and Dynamics*, Vol. 14, No. 2, 1991, pp. 251-259.

9- Anonymous, CAMAC Instrumentation and Interface Standards, The Institute of Electrical and Electronics Engineers, Inc., New York, NY, 1982.

Table 1. Truss struts mass and stiffness properties

Strut Description	Strut Lenght (in)	Actual OD/ID	Effective Area (in^2)	Strut Weight (lbs)	Node Ball Weight (lbs)
S1 longeron	10.000	0.876/0.376	0.3326	0.467	0.159
S2 longeron	10.000	0.586/0.500	0.0991	0.223	0.159
S3 longeron	10.000	0.660/0.500	0.1747	0.271	0.159
S4 longeron	10.000	0.786/0.500	0.2640	0.353	0.159
Batten	10.000	0.574/0.500	0.0974	0.220	0.159
Diagonal	14.142	0.578/0.500	0.0831	0.245	0.159

- Strut lenght includes node ball (center-to-center)
- Effective area and strut weight include standoffs, nuts and screws and node balls
- Effective area assumes E=10.E+6 lb/in^2

Table 2. Gimbal Assembly and Payload Inertia Properties

	I outer in-lbf-sec^2	I inner in-lbf-sec^2
Gimbal assembly (no payload)	2.3031	0.03764
Payload	0.98165	1.5687

Table 3. Actuator and sensor locations

Servo Accelerometers

No.	X	Y	Z	Direction	Grid No.
1	0.000	5.000	-5.000	Z	4
2	0.000	5.000	-5.000	Y	4
3	0.000	5.000	-5.000	X	4
4	160.000	-5.000	115.000	Z	311
5	160.000	-5.000	115.000	Y	311
6	160.000	-5.000	115.000	X	311
7	120.000	-55.000	-5.000	Z	352
8	120.000	-55.000	-5.000	Y	352
9	120.000	-55.000	-5.000	X	352
10	120.000	55.000	-5.000	Z	348
11	120.000	55.000	-5.000	Y	348
12	120.000	55.000	-5.000	X	348
13	620.000	-5.000	-5.000	Z	251
14	620.000	-5.000	-5.000	Y	251
15	620.000	-5.000	-5.000	X	251
16	620.000	-5.000	35.000	Z	263
17	620.000	-5.000	35.000	Y	263
18	620.000	-5.000	35.000	X	263
19	560.000	55.000	-5.000	Z	431
20	560.000	55.000	-5.000	Y	431
21	560.000	55.000	-5.000	X	431
22	560.000	-55.000	-5.000	Z	435
23	560.000	-55.000	-5.000	Y	435
24	560.000	-55.000	-5.000	X	435
25	60.000	5.000	-5.000	Z	28
26	60.000	5.000	-5.000	Y	28
27	120.000	5.000	-5.000	Z	52
28	120.000	5.000	-5.000	Y	52
29	160.000	5.000	-5.000	Z	68
30	160.000	5.000	-5.000	Y	68
31	250.000	5.000	-5.000	Z	104
32	250.000	5.000	-5.000	Y	104
33	330.000	5.000	-5.000	Z	136
34	330.000	5.000	-5.000	Y	136
35	450.000	5.000	-5.000	Z	184
36	450.000	5.000	-5.000	Y	184
37	560.000	5.000	-5.000	Z	228
38	560.000	5.000	-5.000	Y	228
39	0.000	-5.000	-5.000	Z	3
40	60.000	-5.000	-5.000	Z	27
41	120.000	-5.000	-5.000	Z	51

Table 3. Actuator and sensor locations (Continued)

Servo Accelerometers (Continued)

No.	X	Y	Z	Direction	Grid No.
42	160.000	-5.000	-5.000	Z	67
43	250.000	-5.000	-5.000	Z	103
44	330.000	-5.000	-5.000	Z	135
45	450.000	-5.000	-5.000	Z	183
46	560.000	-5.000	-5.000	Z	227
47	620.000	5.000	-5.000	Z	252
48	140.000	55.000	-5.000	Z	370
49	140.000	-55.000	-5.000	Z	372
50	540.000	55.000	-5.000	Z	454
51	540.000	-55.000	-5.000	Z	456

PCB Structcel Accelerometers

No.	X	Y	Z	Direction	Grid No.
1	140.000	-5.000	-5.000	Z	59
2	140.000	-5.000	-5.000	Y	59
3	140.000	-5.000	-5.000	X	59
4	140.000	5.000	-5.000	Z	60
5	140.000	5.000	-5.000	Y	60
6	140.000	5.000	-5.000	X	60
7	190.000	-5.000	-5.000	Z	79
8	190.000	-5.000	-5.000	Y	79
9	190.000	-5.000	-5.000	X	79
10	190.000	5.000	-5.000	Z	80
11	190.000	5.000	-5.000	Y	80
12	190.000	5.000	-5.000	X	80
13	220.000	-5.000	-5.000	Z	91
14	220.000	-5.000	-5.000	Y	91
15	220.000	-5.000	-5.000	X	91
16	220.000	5.000	-5.000	Z	92
17	220.000	5.000	-5.000	Y	92
18	220.000	5.000	-5.000	X	92
19	280.000	-5.000	-5.000	Z	115
20	280.000	-5.000	-5.000	Y	115
21	280.000	-5.000	-5.000	X	115
22	280.000	5.000	-5.000	Z	116
23	280.000	5.000	-5.000	Y	116
24	280.000	5.000	-5.000	X	116
25	310.000	-5.000	-5.000	Z	127
26	310.000	-5.000	-5.000	Y	127
27	310.000	-5.000	-5.000	X	127

Table 3. Actuator and sensor locations (Continued)

PCB Structcel Accelerometers (Continued)

No.	X	Y	Z	Direction	Grid No.
28	310.000	5.000	-5.000	Z	128
29	310.000	5.000	-5.000	Y	128
30	310.000	5.000	-5.000	X	128
31	360.000	-5.000	-5.000	Z	147
32	360.000	-5.000	-5.000	Y	147
33	360.000	-5.000	-5.000	X	147
34	360.000	5.000	-5.000	Z	148
35	360.000	5.000	-5.000	Y	148
36	360.000	5.000	-5.000	X	148
37	390.000	-5.000	-5.000	Z	159
38	390.000	-5.000	-5.000	Y	159
39	390.000	-5.000	-5.000	X	159
40	390.000	5.000	-5.000	Z	160
41	390.000	5.000	-5.000	Y	160
42	390.000	5.000	-5.000	X	160
43	420.000	-5.000	-5.000	Z	171
44	420.000	-5.000	-5.000	Y	171
45	420.000	-5.000	-5.000	X	171
46	420.000	5.000	-5.000	Z	172
47	420.000	5.000	-5.000	Y	172
48	420.000	5.000	-5.000	X	172
49	480.000	-5.000	-5.000	Z	195
50	480.000	-5.000	-5.000	Y	195
51	480.000	-5.000	-5.000	X	195
52	480.000	5.000	-5.000	Z	196
53	480.000	5.000	-5.000	Y	196
54	480.000	5.000	-5.000	X	196
55	510.000	-5.000	-5.000	Z	207
56	510.000	-5.000	-5.000	Y	207
57	510.000	-5.000	-5.000	X	207
58	510.000	5.000	-5.000	Z	208
59	510.000	5.000	-5.000	Y	208
60	510.000	5.000	-5.000	X	208
61	540.000	-5.000	-5.000	Z	219
62	540.000	-5.000	-5.000	Y	219
63	540.000	-5.000	-5.000	X	219
64	540.000	5.000	-5.000	Z	220
65	540.000	5.000	-5.000	Y	220
66	540.000	5.000	-5.000	X	220
67	590.000	-5.000	-5.000	Z	239
68	590.000	-5.000	-5.000	Y	239

Table 3. Actuator and sensor locations (Continued)

PCB Structcel Accelerometers (Continued)

No.	X	Y	Z	Direction	Grid No.
69	590.000	-5.000	-5.000	X	239
70	590.000	5.000	-5.000	Z	240
71	590.000	5.000	-5.000	Y	240
72	590.000	5.000	-5.000	X	240
73	620.000	-5.000	15	Z	255
74	620.000	-5.000	15	Y	255
75	620.000	-5.000	15	X	255
76	620.000	5.000	15	Z	256
77	620.000	5.000	15	Y	256
78	620.000	5.000	15	X	256
79	620.000	5.000	35	Z	264
80	620.000	5.000	35	Y	264
81	620.000	5.000	35	X	264
82	160.000	-5.000	55	Z	287
83	160.000	-5.000	55	Y	287
84	160.000	-5.000	55	X	287
85	160.000	5.000	55	Z	288
86	160.000	5.000	55	Y	288
87	160.000	5.000	55	X	288
88	160.000	-5.000	85	Z	299
89	160.000	-5.000	85	Y	299
90	160.000	-5.000	85	X	299
91	160.000	5.000	85	Z	300
92	160.000	5.000	85	Y	300
93	160.000	5.000	85	X	300
94	160.000	5.000	115	Z	312
95	160.000	5.000	115	Y	312
96	160.000	5.000	115	X	312
97	0.000	-5.000	-5.000	Y	3
98	0.000	-5.000	-5.000	X	3
99	60.000	-5.000	-5.000	Y	27
100	60.000	-5.000	-5.000	X	27
101	120.000	-5.000	-5.000	Y	51
102	120.000	-5.000	-5.000	X	51
103	160.000	-5.000	-5.000	Y	67
104	160.000	-5.000	-5.000	X	67
105	250.000	-5.000	-5.000	Y	103
106	250.000	-5.000	-5.000	X	103
107	330.000	-5.000	-5.000	Y	135
108	330.000	-5.000	-5.000	X	135
109	450.000	-5.000	-5.000	Y	183

Table 3. Actuator and sensor locations (Continued)

PCB Structcel Accelerometers (Continued)

No.	X	Y	Z	Direction	Grid No.
110	450.000	-5.000	-5.000	X	183
111	560.000	-5.000	-5.000	Y	227
112	560.000	-5.000	-5.000	X	227
113	620.000	5.000	-5.000	Y	252
114	620.000	5.000	-5.000	X	252
115	140.000	55.000	-5.000	Y	370
116	140.000	55.000	-5.000	X	370
117	140.000	-55.000	-5.000	Y	372
118	140.000	-55.000	-5.000	X	372
119	540.000	55.000	-5.000	Y	454
120	540.000	55.000	-5.000	X	454
121	540.000	-55.000	-5.000	Y	456
122	540.000	-55.000	-5.000	X	456
123	60.000	5.000	-5.000	X	28
124	120.000	5.000	-5.000	X	52
125	160.000	5.000	-5.000	X	68
126	250.000	5.000	-5.000	X	104
127	330.000	5.000	-5.000	X	136
128	450.000	5.000	-5.000	X	184
129	560.000	5.000	-5.000	X	228

Thrusters Servo accelerometers

No.	X	Y	Z	Direction	Grid No.
1	5.000	5.000	0.000	Y	492
2	5.000	0.000	5.000	Z	489
3	325.000	5.000	0.000	Y	501
4	325.000	0.000	5.000	Z	498
5	620.000	0.000	40.000	X	503
6	615.000	5.000	40.000	Y	502
7	160.000	0.000	100.000	X	494
8	155.000	5.000	100.000	Y	493

Shakers Driving Points Servo Accelerometers

No.	X	Y	Z	Direction	Grid No.
1	0.000	-5.000	-5.000	X	901
2	320.000	-5.000	-5.000	X	902
3	140.000	-55.000	-5.000	X	903
4	540.000	-55.000	-5.000	X	904

Table 4. Summary of FEM grid numbers

Truss Coordinate Information

Grids	No.	Location	X	Y	Z
1 - 252	252	main truss	0,620	5,-5	5,-5
253 - 268	16	reflector truss	610,620	5,-5	15,45
269-312	44	tower truss	150,160	5,-5	15,115
313 - 372	60	forward suspension truss	120,140	55,-55	5,-5
397 - 456	60	back suspension truss	540,560	55,-55	5,-5
485 - 488	4	reflector support bracket	610,620	5,-5	52.06,60.16
489 -492	4	forward thruster	5	5,-5	5,-5
493 - 496	4	tower thruster	150,160	5,-5	100
497	1	laser	155	0	155
498 - 501	4	middle thruster	325	5,-5	5,-5
502 - 505	4	reflector truss thruster	610,620	5,-5	40
508 - 516	9	front suspension cable & spring, +Y	130	45,55	6.78,803.5
518 - 526	9	front suspension cable & spring, -Y	130	-45,-55	6.78,803.5
528 - 536	9	back suspension cable & spring, +Y	550	45,55	6.78,803.5
538 - 546	9	back suspension cable & spring, -Y	550	-45,-55	6.78,803.5
550 - 602	53	gimbal #1	115,140	10,-10	12.71,18.71
650 - 702	53	gimbal #2	175,200	10,-10	12.71,18.71
750 - 802	53	gimbal #3	535,560	10,-10	12.71,18.71
605	1	gimbal #1 controller plate	140	0.00	0.00
705	1	gimbal #2 controller plate	200	0.00	0.00
805	1	gimbal #3 controller plate	560	0.00	0.00
901 - 904	4	shakers	0,540	-5,-55	-5

Reflector, Cylindrical Coordinates

Grids	No.	Location	R, in	Theta, deg.	Z, in
851,858	8	base plate	8.15	0, 322.16	0.811
859	1	plate center	0.00	0.00	0.811

truss grids	=	655
reflector grids	=	9
total grids	**=**	**664**

Table 5. Summary of FEM element numbers

Truss Elements Information

Element	EID's	No.	PID	Location
CBEAM	1 - 80	80	101	main truss, S1 longerons
CBEAM	81 - 248	168	401	main truss, S4 longerons
CBEAM	249 - 332	84	102	main truss, S1 battens
CBEAM	333 - 500	168	402	main truss, S4 battens
CBEAM	501 - 521	21	103	main truss, S1 batten diagonals
CBEAM	522 - 563	40	403	main truss, S4 batten diagonals
CBEAM	566 - 603	34	103	main truss, S1 top and bottom diagonals
CBEAM	604 -687	80	403	main truss, S4 top and bottom diagonals
CBEAM	690 - 727	38	103	main truss, S1 side diagonals
CBEAM	728 - 811	82	403	main truss, S4 side diagonals
CBEAM	812 - 855	44	301	tower truss, S3, longerons
CBEAM	856 - 899	44	302	tower truss, S3, battens
CBEAM	900 - 909	10	303	tower truss, S3 batten diagonals
CBEAM	911 - 932	20	303	tower truss, S3, front and back diagonals
CBEAM	933 - 954	20	303	tower truss, S3, side diagonals
CBEAM	955 - 970	16	201	reflector truss, S2, longerons
CBEAM	971 - 986	16	202	reflector truss, S2, battens
CBEAM	987 - 990	4	203	reflector truss,S2, batten diagonals
CBEAM	991 - 996	6	203	reflector truss, S2, side diagonals
CBEAM	999 - 1004	6	203	reflector truss, S2, front and back diagonals
CBEAM	1007 - 1036	30	201	front suspension truss, S2 longerons, +Y
CBEAM	1037 - 1066	30	201	front suspension truss, S2 longerons, -Y
CBEAM	1072 - 1106	35	202	front suspension truss, S2 battens, +Y
CBEAM	1112 - 1146	35	202	front suspension truss, S2 battens, -Y
CBEAM	1167 - 1176	10	203	front suspension truss, S2 batten diagonals, +Y
CBEAM	1177 - 1186	10	203	front suspension truss, S2 batten diagonals, -Y
CBEAM	1187 - 1201	15	203	front suspension truss, S2 front and back diagonals,+Y
CBEAM	1207 - 1221	15	203	front suspension truss, S2 front and back diagonals,-Y
CBEAM	1227 - 1246	20	203	front suspension truss, S2 top and bottom diagonals,+Y
CBEAM	1247 - 1266	20	203	front suspension truss, S2 top and bottom diagonals,-Y
CBEAM	1267 - 1296	30	201	back suspension truss, S2 longerons, +Y
CBEAM	1307 - 1336	30	201	back suspension truss, S2 longerons, -Y
CBEAM	1347 - 1381	35	202	back suspension truss, S2 battens, +Y
CBEAM	1387 - 1421	35	202	back suspension truss, S2 battens, -Y
CBEAM	1427 - 1436	10	203	back suspension truss, S2 batten diagonals, +Y
CBEAM	1437 - 1446	10	203	back suspension truss, S2 batten diagonals, -Y
CBEAM	1447 - 1461	15	203	back suspension truss, S2 front and back diagonals,+Y
CBEAM	1467 - 1481	15	203	back suspension truss, S2 front and back diagonals,-Y
CBEAM	1487 - 1506	20	203	back suspension truss, S2 top and bottom diagonals,+Y
CBEAM	1507 - 1526	20	203	back suspension truss, S2 top and bottom diagonals,-Y
CBEAM	1531 - 1534	4	27	reflector support bracket beams

Table 5. Summary of FEM element numbers (Continued)

Truss Elements Information (continued)

Element	EID's	No.	PID	Location
CBEAM	1535 - 1540	6	28	reflector support bracket beams
CBEAM	1541 - 1542	2	29	reflector support bracket beams

Suspension, gimbals, reflector and thrusters elements

Element	EID's	No.	PID	Location
CROD	1551 - 1555	5	14	front suspension kevlar cable, +Y
CROD	1556 - 1557	2	13	front suspension short stainless steel cable, +Y
CBEAM	1558 - 1559	2	12	front suspension cable standoff, +Y
CROD	1561 - 1565	5	14	front suspension cable, -Y
CROD	1566 - 1567	2	13	front suspension short stainless steel cable, -Y
CBEAM	1568 - 1569	2	12	front suspension cable standoff, -Y
CROD	1571 - 1575	5	14	back suspension cable, +Y
CROD	1576 - 1577	2	13	back suspension short stainless steel cable, +Y
CBEAM	1578 - 1579	2	12	back suspension cable standoff, +Y
CROD	1581 - 1585	5	14	back suspension cable, -Y
CROD	1586 - 1587	2	13	back suspension short stainless steel cable, -Y
CBEAM	1588 - 1589	2	12	back suspension cable standoff, -Y
CBEAM	1601 - 1608	8	502	gimbal #1 support beams
CBEAM	1609 - 1646	38	4	gimbal #1 1/2"X1" ring
CBEAM	1647 - 1648	2	5	gimbal #1 3"X3" posts
CBEAM	1651 - 1654	4	11	support for gimbal #1 laser
CBEAM	1661 - 1672	12	17	weightless back-up beams for gimbal #1 plate
CQUAD4	1681 - 1688	8	1	gimbal #1 plate
CTRIA3	1691 - 1694	4	15	gimbal #1 controller (IMU) board plate
CBEAM	1695 - 1698	4	17	weightless back-up beams for gimbal #1 IMU plate
CBEAM	1701 - 1708	8	502	gimbal #2 support beams
CBEAM	1709 - 1746	38	4	gimbal #2 1/2"X1" ring
CBEAM	1747 - 1748	2	5	gimbal #2 3"X3" posts
CBEAM	1751 - 1754	4	11	support for gimbal #2 laser
CBEAM	1761 - 1772	12	17	weightless back-up beams for gimbal #2 plate
CQUAD4	1781 - 1788	8	1	gimbal #2 plate
CTRIA3	1791 - 1794	4	15	gimbal #2 controller (IMU) board plate
CBEAM	1795 - 1798	4	17	weightless back-up beams for gimbal #2 IMU plate
CBEAM	1801 - 1808	8	502	gimbal #3 support beams
CBEAM	1809 - 1846	38	4	gimbal #3 1/2"X1" ring
CBEAM	1847 - 1848	2	5	gimbal #3 3"X3" posts
CBEAM	1851 - 1854	4	11	support for gimbal #3 laser
CBEAM	1861 - 1872	12	17	weightless back-up beams for gimbal #3 plate
CQUAD4	1881 - 1888	8	1	gimbal #3 plate
CTRIA3	1891 - 1894	4	15	gimbal #3 controller (IMU) board plate
CBEAM	1895 - 1898	4	17	weightless back-up beams for gimbal #3 IMU plate

Table 5. Summary of FEM element numbers (Continued)

Suspension, gimbals, reflector and thrusters elements (continued)

Element	EID's	No.	PID	Location
CQUAD4	1900	1	40	front end steel plate
CTRIA3	1901 - 1916	16	15	forward thruster plate
CTRIA3	1921 - 1936	16	15	tower thruster plate
CTRIA3	1941 - 1956	16	15	middle thruster plate
CTRIA3	1961 -1976	16	15	reflector truss thruster plate
CTRIA3	1981 - 1984	4	15	laser plate
CQUAD4	1991 - 1992	2	15	thruster controller board plate
CBEAM	2000 - 2007	8	17	weightless back-up beams for forward thruster
CBEAM	2010 - 2019	10	17	weightless back-up beams for tower thruster
CBEAM	2020 - 2027	8	17	weightless back-up beams for middle thruster
CBEAM	2030 - 2037	8	17	weightless back-up beams for reflector tower thruster
CBEAM	2040 - 2043	4	17	weightless back-up beams for reflector plate
CBEAM	2045 - 2048	4	12	reflector plate connectors to reflector truss
CTRIA3	2051 - 2058	8	25	reflector plate
CELAS2	2201 - 2204	4		suspension springs
CELAS2	2241 - 2252	12		air tubing stiffness at thrusters

Lumped mass elements

Element	EID's	No.	Location
CONM2	3001 - 3372	372	joint lumped mass
CONM2	3393 - 3452	60	joint lumped mass
CONM2	3453 - 3464	12	suspension cable mass
CONM2	3465 - 3476	12	gimbal encoder, decoder mass
CONM2	3477 - 3479	3	gimbal laser mass
CONM2	3481 -3492	12	half node balls at ends of gimbal support beams
CONM2	3501 - 3562	62	instrumentation mass
CONM2	3563 - 3569	7	thruster air hose mass
CONM2	3770	1	thruster air hose mass
CONM2	3570 - 3577	8	thruster controller mass
CONM2	3578 - 3589	12	air supply bracket and tubing mass
CONM2	3590 - 3605	16	thruster mass
CONM2	3606	1	laser mass
CONM2	3610 - 3615	6	thruster controller board signal cable mass
CONM2	3621 - 3632	12	gimbal controller board
CONM2	3633 - 3635	3	MU at controller board
CONM2	3636 - 3639	4	mass at suspension springs

Table 5. Summary of FEM element numbers (Continued)

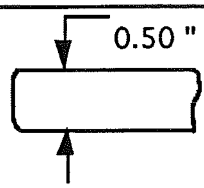
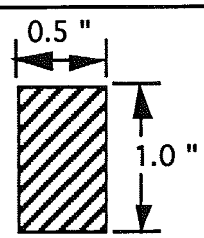
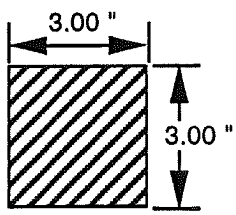
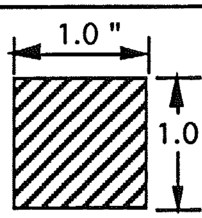
Elements removed from truss

Element	EID's	No.	PID	Location
CBEAM	526	-1	403	batten diagonal in the way of controller plate
CBEAM	542	-1	403	batten diagonal in the way of controller plate
CBEAM	588	-1	103	top, bottom diagonal in the way of gimbal #1
CBEAM	589	-1	103	top, bottom diagonal in the way of gimbal #1
CBEAM	600	-1	103	top, bottom diagonal in the way of gimbal #2
CBEAM	601	-1	103	top, bottom diagonal in the way of gimbal #2
CBEAM	672	-1	103	top, bottom diagonal in the way of gimbal #3
CBEAM	673	-1	103	top, bottom diagonal in the way of gimbal #3

Total number of elements

CBEAM	1687
CROD	28
CTRIA3	88
CQUAD4	27
CELAS2	16
CONM2	603

Table 6. FEM Physical Section Properties

PID	Dimension	Sections	Elements	Property of sections	Material property
1	t= 0.500"		CQUAD4 gimbal plate	t= 0.500"	E =1.0E+07 ν = 0.333 ρ = 3.8E–04
4	1/2" X 1"		CBEAM gimbal ring	A= 0.500 I1= 0.041667 I2= 0.010417 J= 0.02861	E = 1.0E+07 ν = 0.333 ρ = 2.62E–4
5	3" X 3"		CBEAM gimbal posts	A= 9.00 I1= 6.75 I2= 6.75 J=11.407	E = 1.0E+07 ν = 0.333 ρ = 0.000
11 , 12	1" X 1"		CBEAM support beams for gimbal laser, suspension cable standoff, rfl plate	A= 1.00 I1= 0.08333 I2= 0.08333 J= 0.166667	E = 3.0E+07 G = 1.1538E+07 ρ = 0.000

where,

A is the cross sectional area in units of in^2
J is the bending moment of inertia in units of in^4
I is the torsional moment of inertia in units of in^4
E is the Young's Modulus in units of lb_f / in^2
G is the Shear Modulus in units of lb_f / in^2
ν is Poisson's ratio
ρ is the mass density in units of $lb_f\text{-}sec^2 / in$

Table 6. FEM Physical Section Properties (Continued)

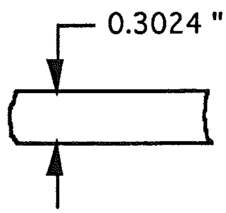
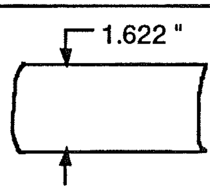
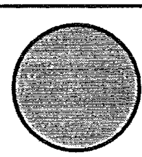
PID	Dimension	Sections	Elements	Property of sections	Material property
13	O.D.= 0.125"	 O.D.= 0.125"	CROD suspension short stainless steel cables	A= 0.012272 J= 0.000	E = 3.0E+07 G = 1.1538E+07 ρ = 7.332E–04
14	O.D.= 0.170"	 O.D.= 0.170"	CROD suspension kevlar cable	A= 0.022698 J= 0.000	E = 5.0E+06 ρ = 1.01E–04
15	t= 0.3024"		CTRIA3 thruster, laser, and gimbal, controller board (IMU) plates	t= 0.3024"	E = 1.0E+07 ν = 0.333 ρ = 0.000
17	N/A	N/A	CBEAM wtless back-up beams for thruster, rfl., gimbal and IMU board plates	A= 0.001 I1= 0.0001 I2= 0.0001 J= 0.0002	E = 1.0E+07 ν = 0.333 ρ = 0.000
25	t= 1.622"		CTRIA3 reflector plate	t= 1.622"	E = 3.0E+07 G = 1.1538E+07 ρ = 7.332E–04
27	O.D.= 0.75"	 O.D.= 0.75"	CBEAM reflector support bracket beams	A= 0.4418 I1= 0.0155 I2= 0.0155 J = 0.031	E = 1.0E+07 G = 3.7509E+06 ρ = 2.5390E–04

Table 6. FEM Physical Section Properties (Continued)

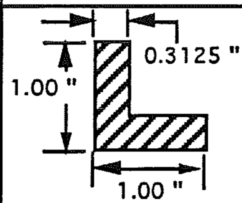
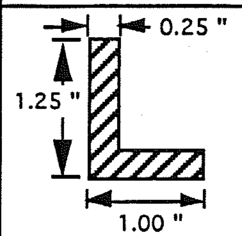
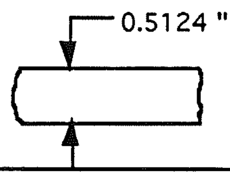
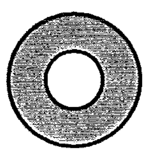
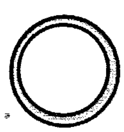
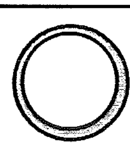
PID	Dimension	Sections	Elements	Property of sections	Material property
28	1 X 1 X 5/16"		CBEAM aluminum angle for rfl support	A= 0.3390 I1= 0.0300 I2= 0.0300 J= 0.00439	E = 1.0E+07 G = 3.7509E+06 ρ = 2.5390E–04
29	1 X 1.25 X 1/4"		CBEAM aluminum angle cross members, rfl support	A= 0.500 I1= 0.0397 I2= 0.0397 J= 0.071	E = 1.0E+07 G = 3.7509E+06 ρ = 2.5390E–04
40	t= 0.512367"		CQUAD4 front end steel plate	t= 0.512367"	E = 3.0E+07 G = 1.1538E+07 ρ = 7.332E–04
101	O.D.= 0.876" I.D.= 0.376"	 O.D.= 0.876" I.D.= 0.376"	CBEAM S1 longerons	A= 0.333 I1= 0.027803 I2= 0.027803 J= 0.055607	E = 1.0E+07 ν = 0.333 ρ = 3.6358E–04
102, 202, 302, 402, 502	O.D.= 0.574" I.D.= 0.500"	 O.D.= 0.574" I.D.= 0.500"	CBEAM S1 battens S2 battens S3 battens S4 battens gimbal support	A=0.0974 I1= 0.002335 I2= 0.002335 J= 0.00467	E = 1.0E+07 ν = 0.333 ρ = 5.8464E–04
201	O.D.= 0.586" I.D.= 0.500"	 O.D.= 0.586" I.D.= 0.500"	CBEAM S2 longerons	A= 0.0991 I1= 0.00276 I2= 0.00276 J= 0.00552	E = 1.0E+07 ν = 0.333 ρ = 5.8206E–04

Table 6. FEM Physical Section Properties (Continued)

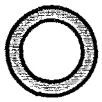
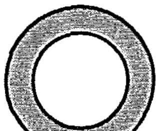
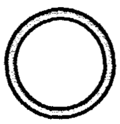
PID	Dimension	Sections	Elements	Property of sections	Material property
301	O.D.= 0.660" I.D.= 0.500"	 O.D.= 0.660" I.D.= 0.500"	CBEAM S3 longerons	A=0.1750 I1= 0.006303 I2= 0.006303 J= 0.012605	E = 1.0E+07 ν = 0.333 ρ = 4.0156E–04
401	O.D.= 0.786" I.D.= 0.500"	 O.D.= 0.786" I.D.= 0.500"	CBEAM S4 longerons	A= 0.2640 I1= 0.01576 I2= 0.01576 J= 0.031525	E = 1.0E+07 ν = 0.333 ρ = 3.4581E–04
103, 203, 303, 403,	O.D.= 0.578" I.D.= 0.500"	 O.D.= 0.578" I.D.= 0.500"	CBEAM S1 diagonals S2 diagonals S3 diagonals S4 diagonals	A=0.0831 I1= 0.002449 I2= 0.002449 J= 0.004897	E = 1.0E+07 ν = 0.333 ρ = 5.3917E–04

Table 7. Phase - 2 CEM analytical and experimental mode frequencies and damping

Mode No.	Test Frequency with hoses (Hz)	Analysis Frequency with hoses (Hz)	With Hose Test-Analysis MAC Value	Test Damping with hoses %	Test Damping without hoses %	Description
1	0.136	0.139		3.658	0.607	Y-Pendulum
2	0.135	0.140		4.576	0.471	X-Pendulum
3	0.132	0.149		5.503	0.448	Yaw
4	0.180	0.161		5.807	5.086	Bounce (Node Near Laser Tower)
5	0.192	0.164		5.885	4.585	Bounce (Node Near Reflector Tower)
6	0.344	0.276		2.420	1.910	Roll
7	1.780	1.725	0.997	0.181	0.181	1st Torsion
8	2.434	2.400	0.998	0.181	0.146	1st X,Z Bending
9	3.049	2.967	0.998	0.291	0.184	1st X,Y Bending
10	5.689	5.486	0.997	0.183	0.147	2nd X,Z Bending
11	6.137	5.850	0.998	0.175	0.131	Refl Appendage Rocking
12	6.577	6.421	0.964	0.202	0.514	Refl Appendage Rocking
13		6.444				
14		6.509				
15	6.451	6.533	0.555	0.575	0.407	
16	7.218	6.923	0.730	0.195	0.204	Cable
17		6.955				
18		7.014				
19		7.046				
20	7.777	7.684	0.998	0.236	0.143	Laser Tower X,Z Bending
21	8.719	8.405	0.993	0.25	0.221	2nd X,Y Bending
22	9.146	9.002	0.995	0.177	0.177	2nd X,Z Bending
23	10.212	10.042	0.996	0.206	0.191	Laser Tower Y,Z Bending
24		12.241				
25		12.287				

Table 7. Phase - 2 CEM analytical and experimental mode frequencies and damping (Continued)

Mode No.	Test Frequency with hoses (Hz)	Analysis Frequency with hoses (Hz)	With Hose Test-Analysis MAC Value	Test Damping with hoses %	Test Damping without hoses %	Description
26		12.374				
27		12.419				
28		12.679				
29		13.203				
30		13.264				
31		13.343				
32		13.404				
33	13.628	13.551	0.860	0.341	0.335	3rd X,Z Bending
34	13.087	13.635	0.954	0.057	0.061	3rd X,Y Bending
35		14.088				
36	14.578	14.267	0.866	0.077	0.446	Cable
37		15.054				
38		15.668				
39	14.32	16.302	0.596	0.254	0.227	Cable
40		16.926				
41		16.987				
42		17.028				
43		17.089				
44		17.817				
45		18.164				
46		18.246				
47		18.329				
48		18.361				
49		18.446				
50		18.739				

Table 7. Phase - 2 CEM analytical and experimental mode frequencies and damping (Continued)

Mode No.	Test Frequency with hoses (Hz)	Analysis Frequency with hoses (Hz)	With Hose Test-Analysis MAC Value	Test Damping with hoses %	Test Damping without hoses %	Description
51		19.974				
52		20.012				
53		20.046				
54		20.084				
55		20.921				
56		21.542				
57		21.578				
58		21.640				
59		21.677				
60		23.185				
61		23.910				
62		24.825				
63		25.752				
64		27.575				
65		28.433				
66		28.984				

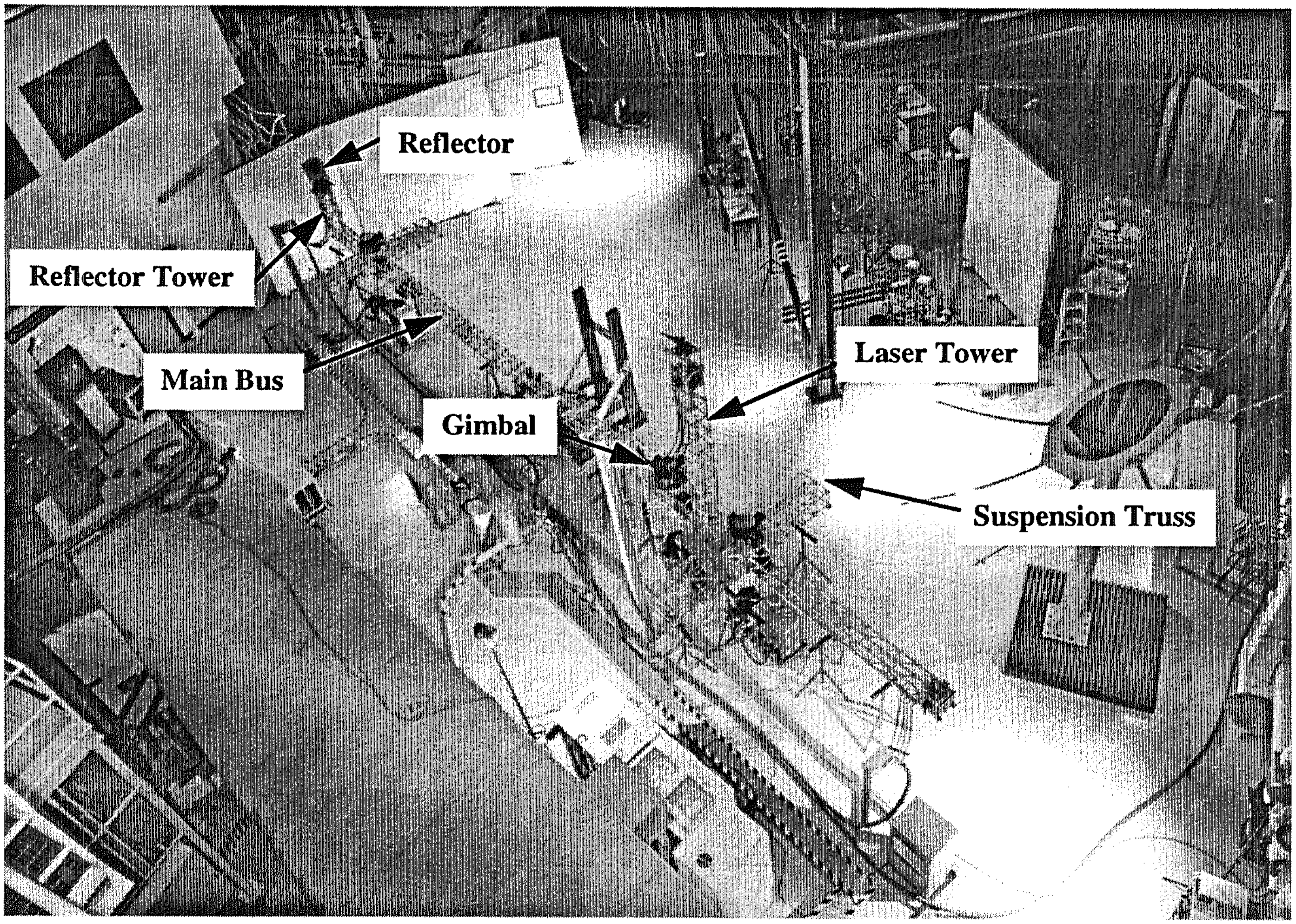


Figure 1. Phase-2 CSI Evolutionary Model (CEM)

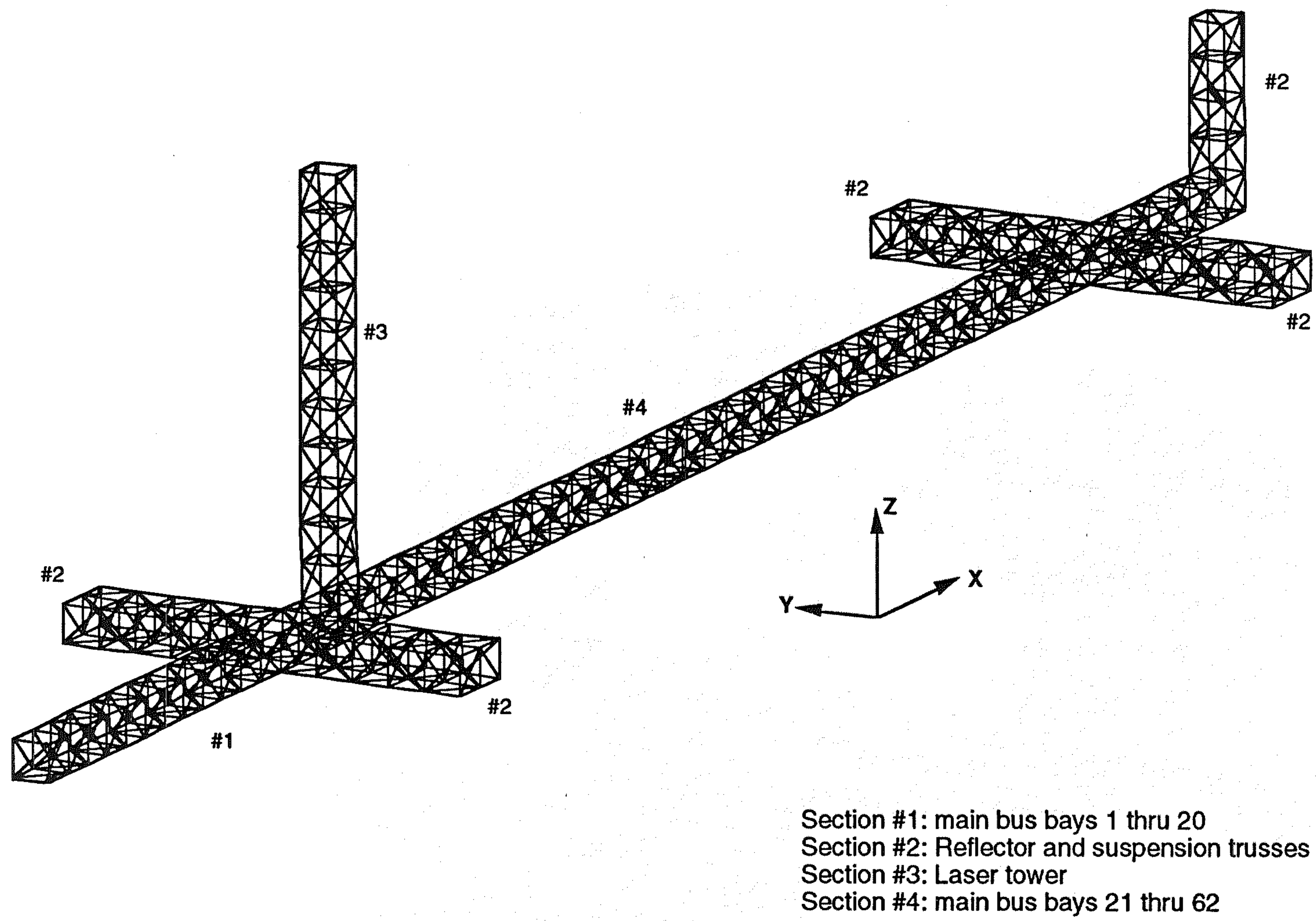


Figure 2. Phase-2 CEM truss sections

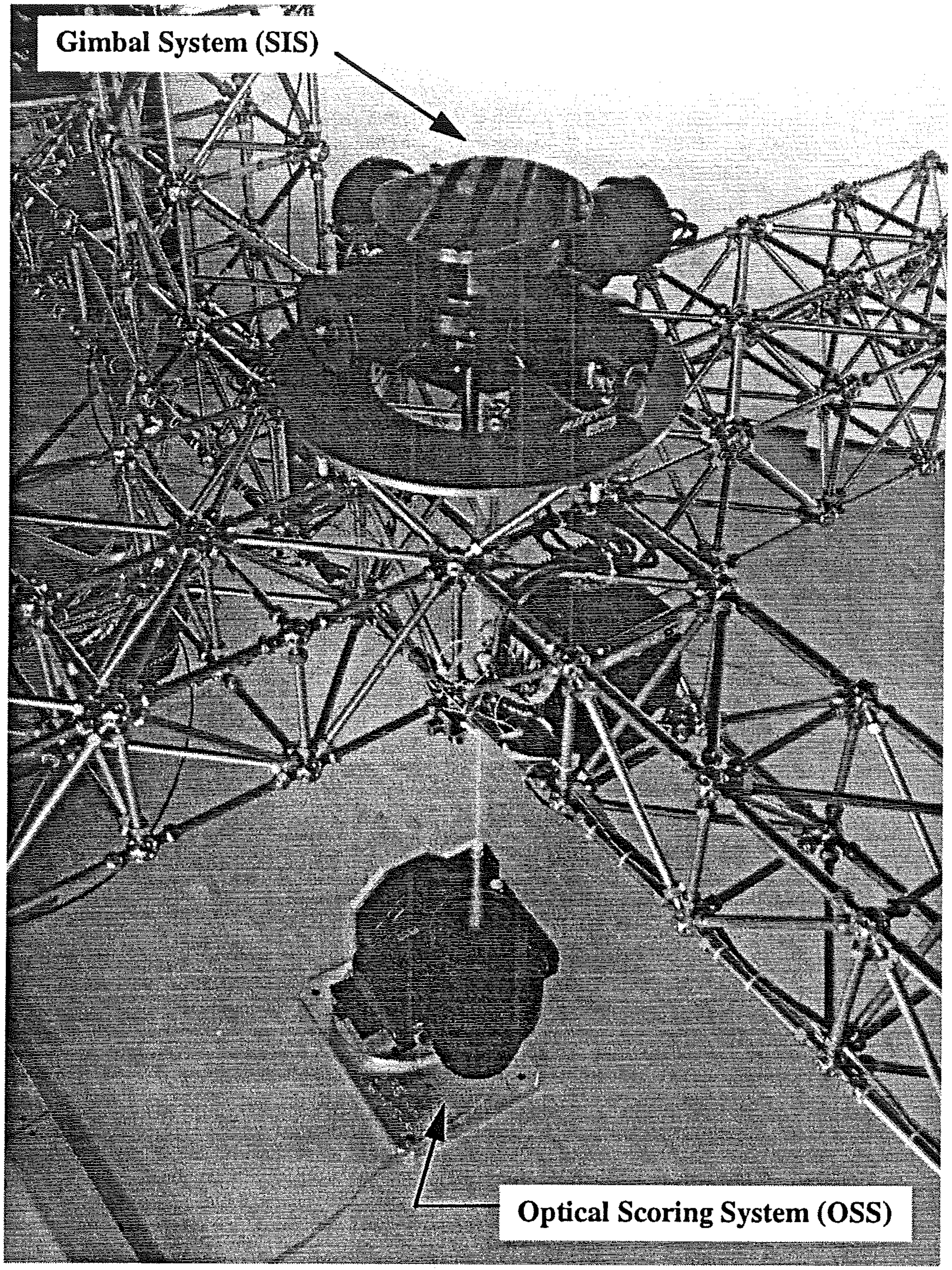


Figure 3. Closed-up of truss lacing and science instrument simulator

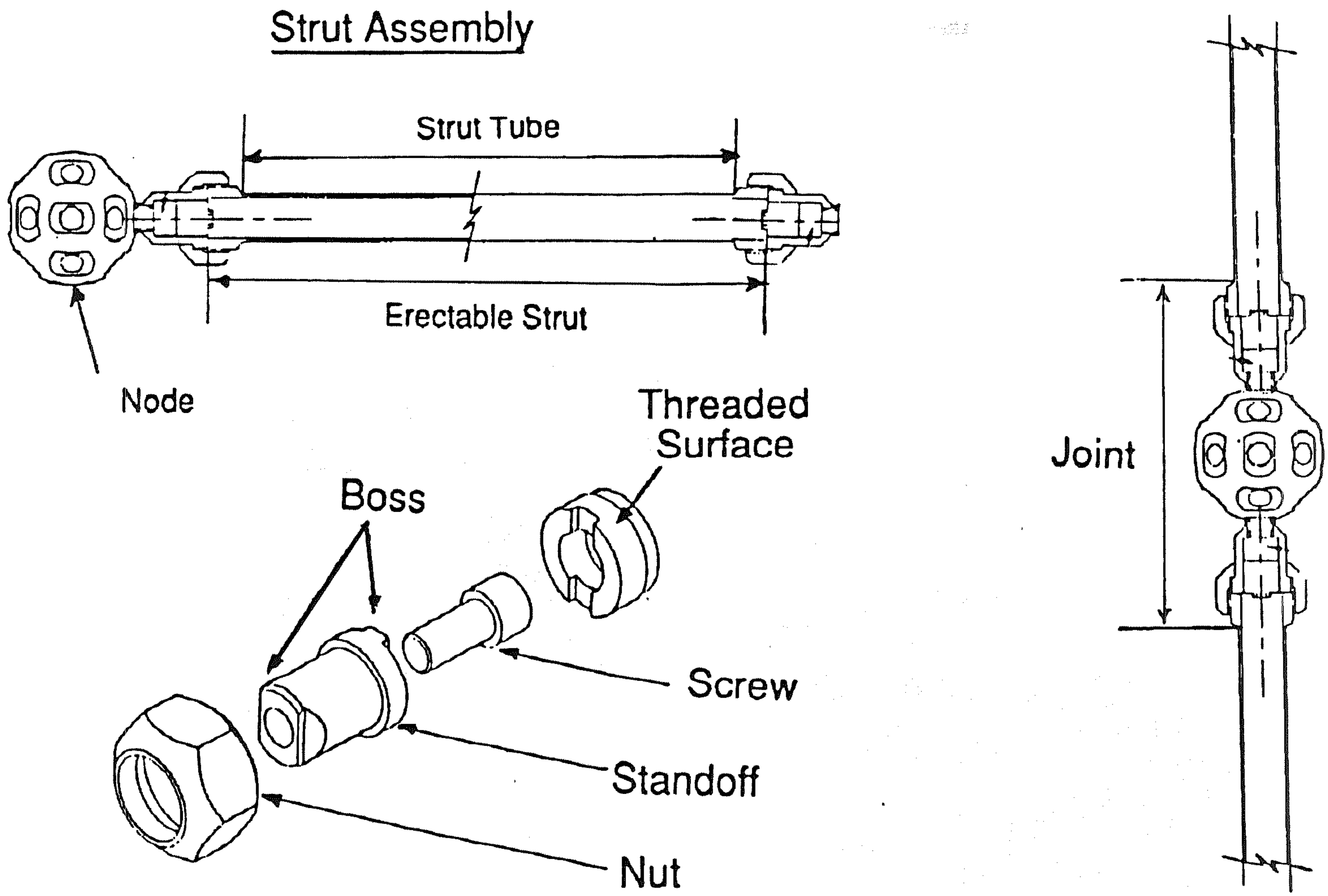


Figure 4. Phase-2 Strut design features and nomenclature

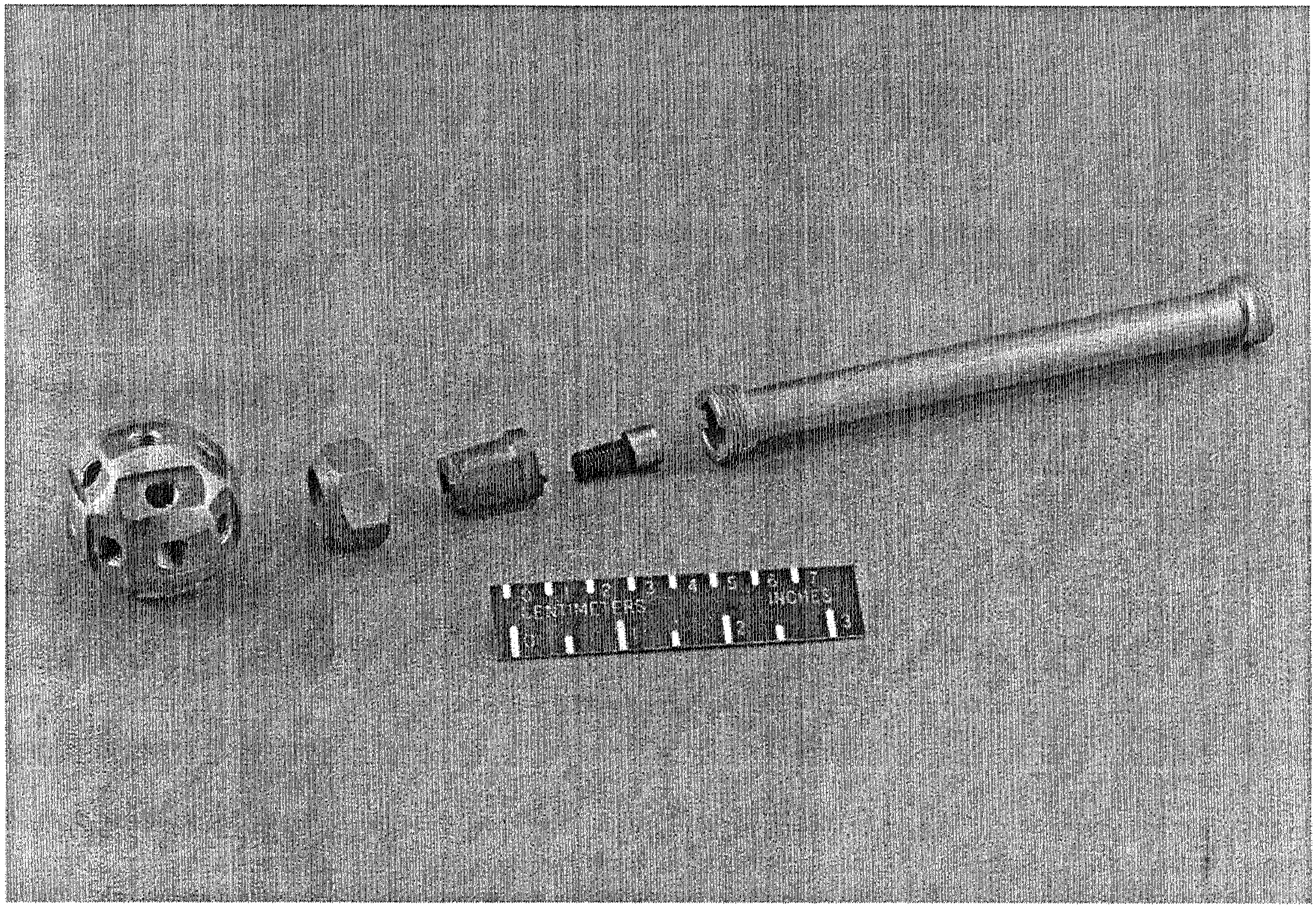


Figure 5. Strut and node ball hardware

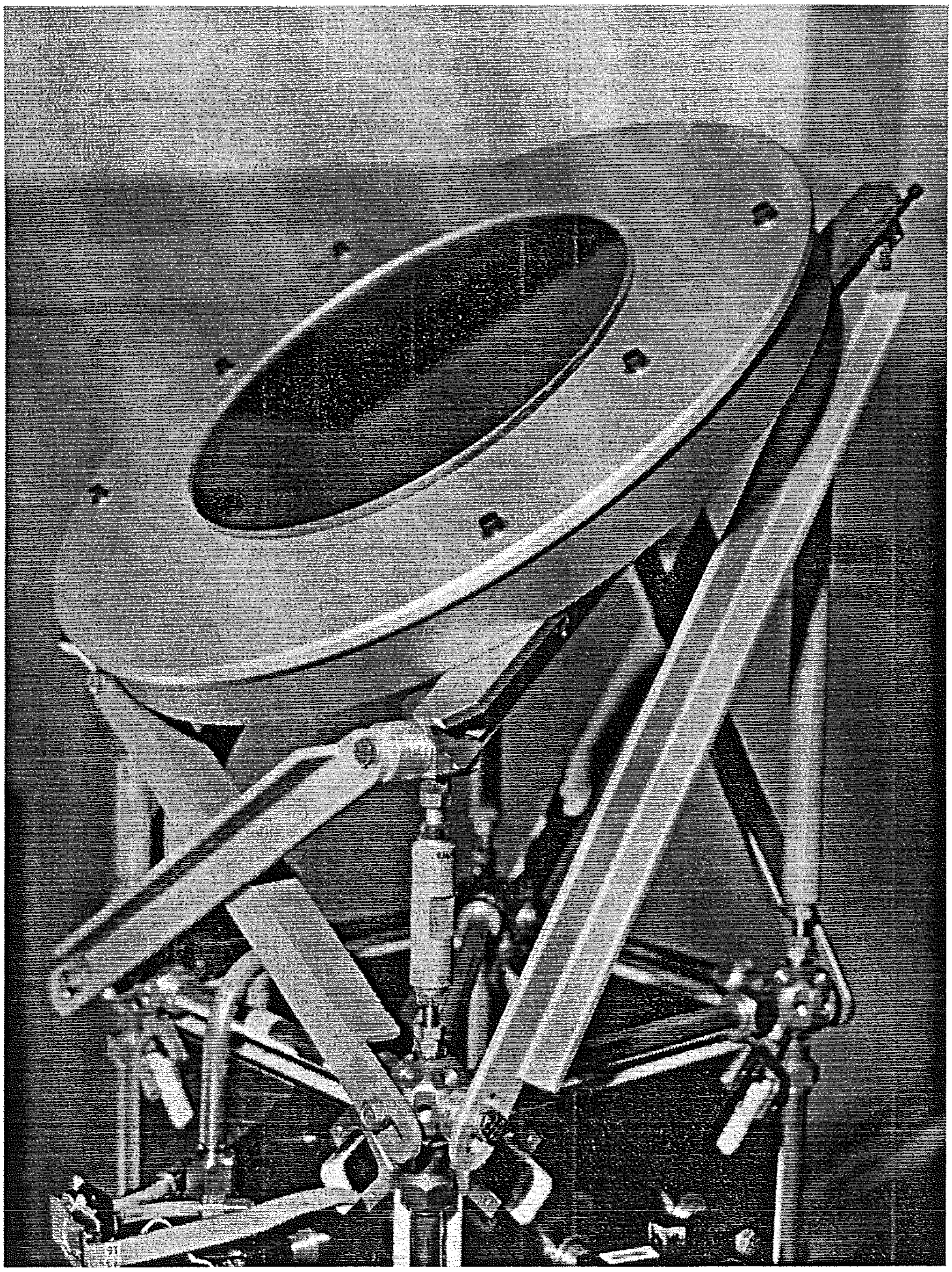


Figure 6. Phase-2 CEM reflector

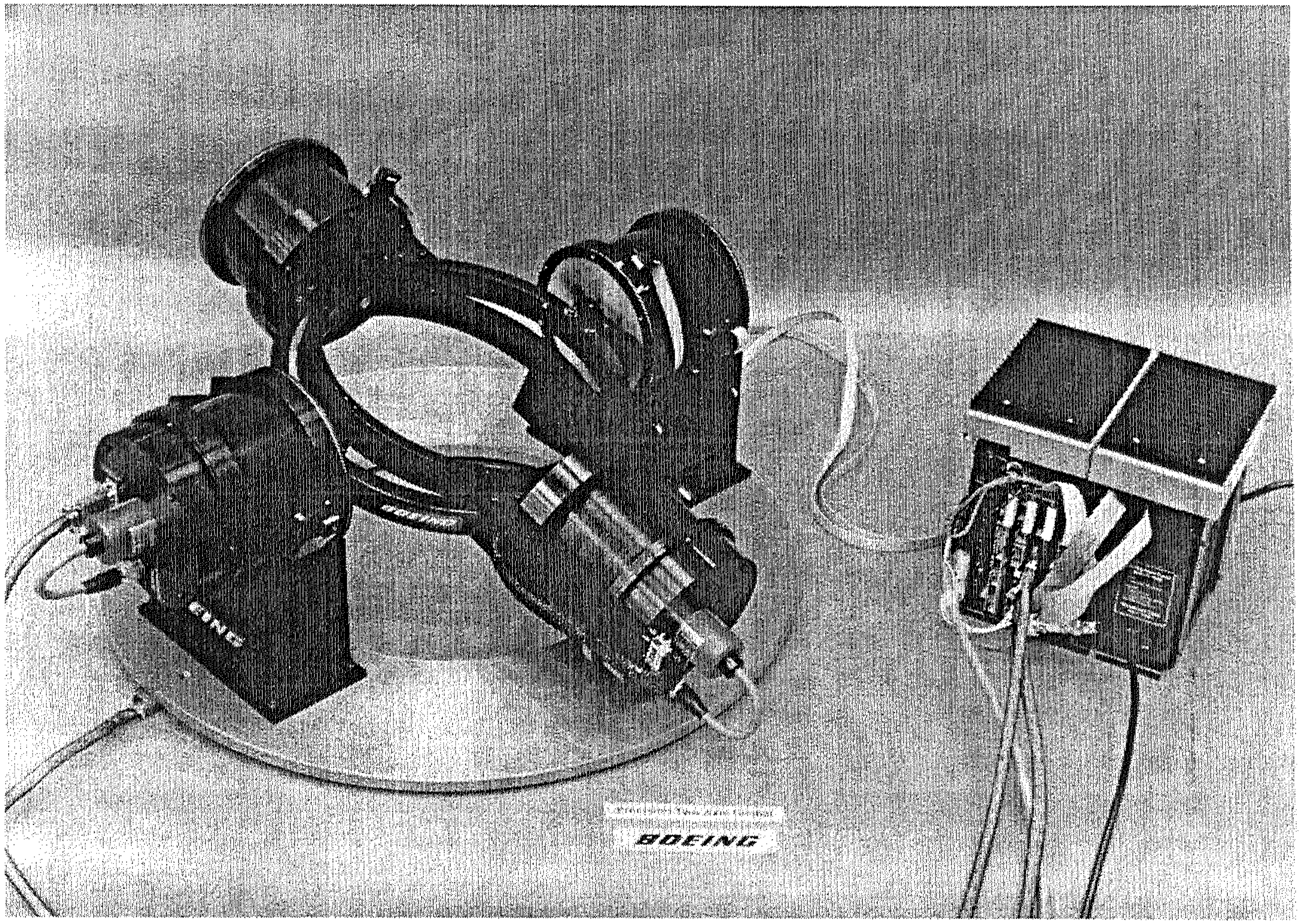


Figure 7. Gimbal system (SIS) without payload

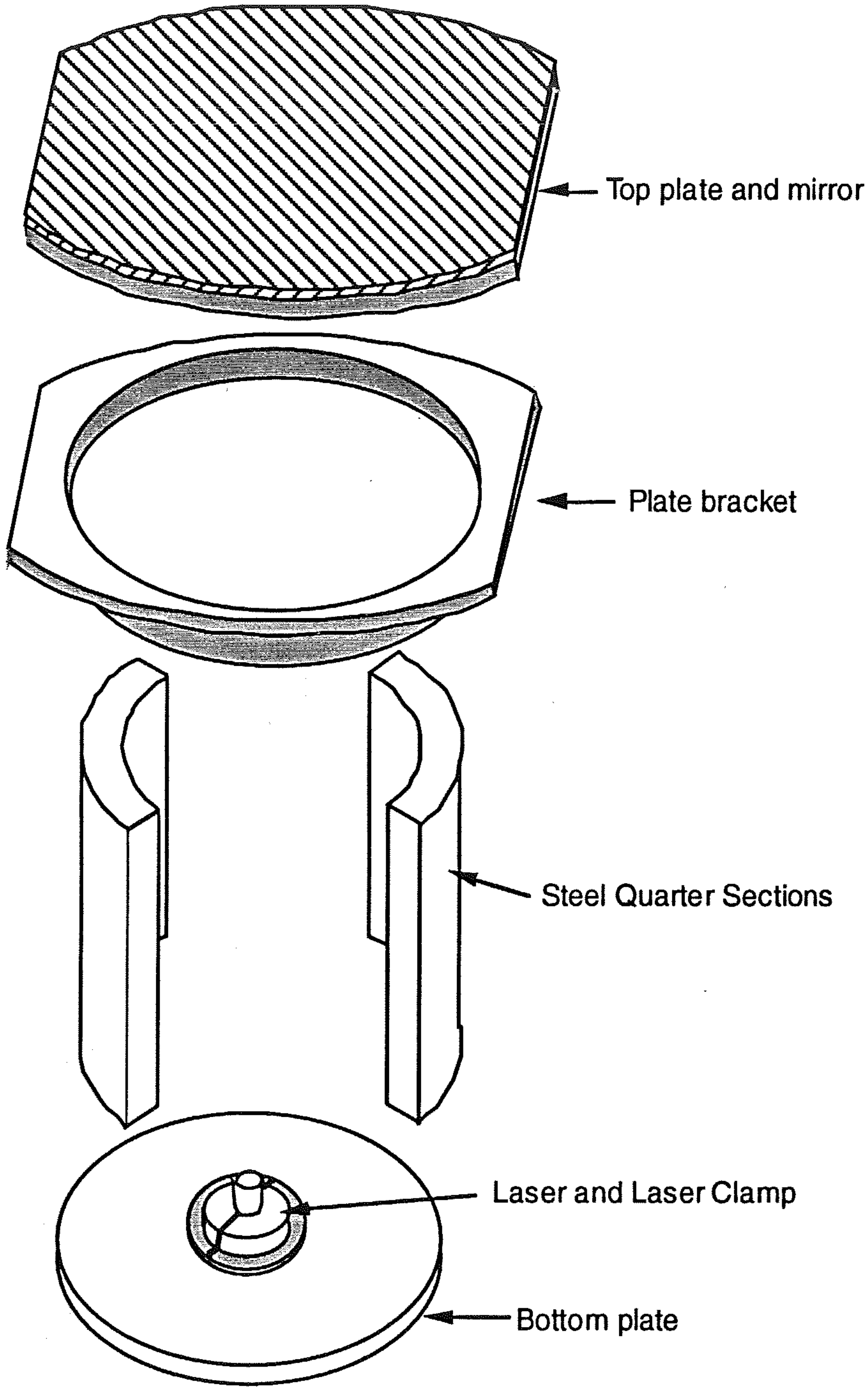


Figure 8. Payload assembly

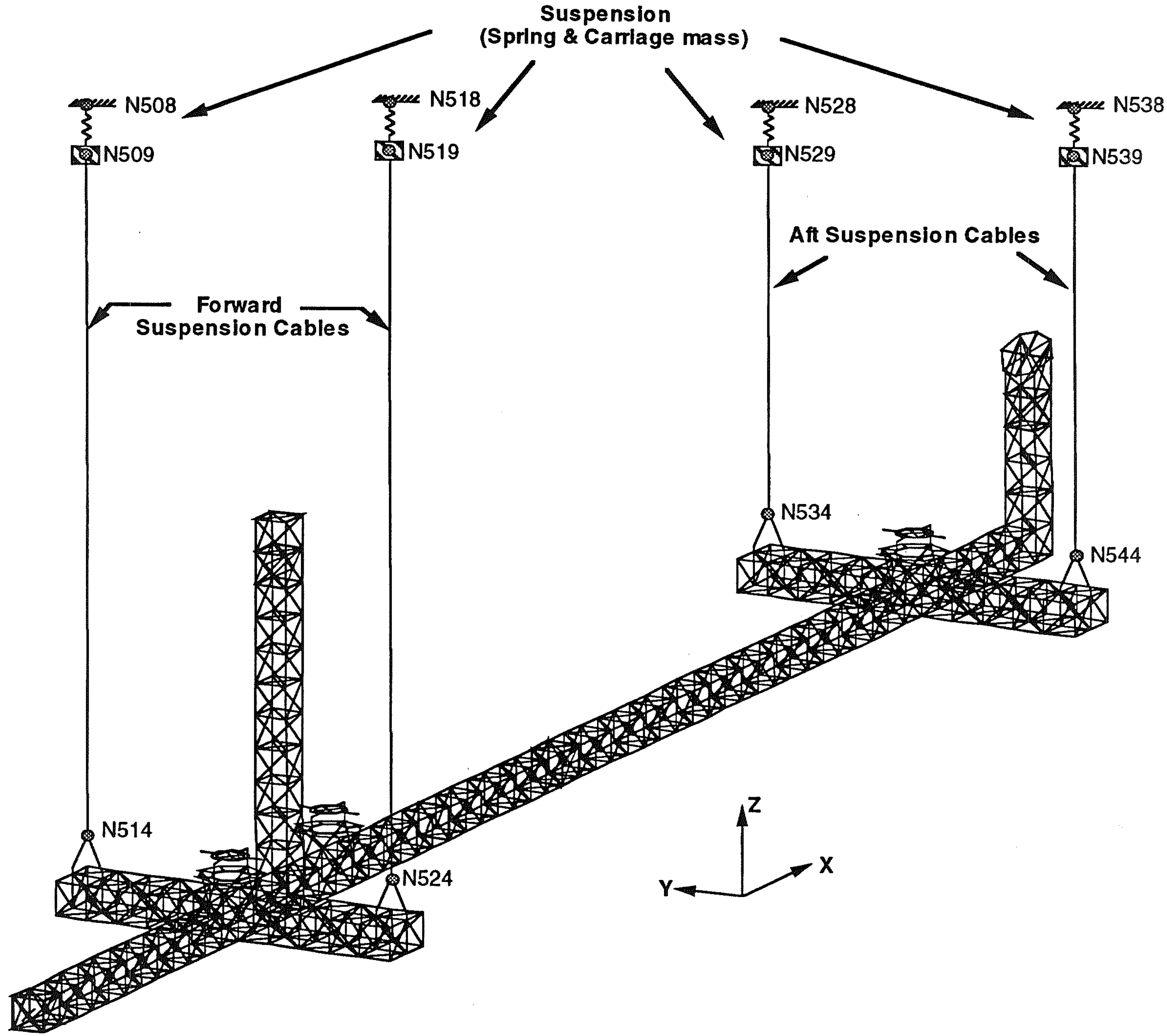


Figure 9. Schematic of CEM Phase2 suspension

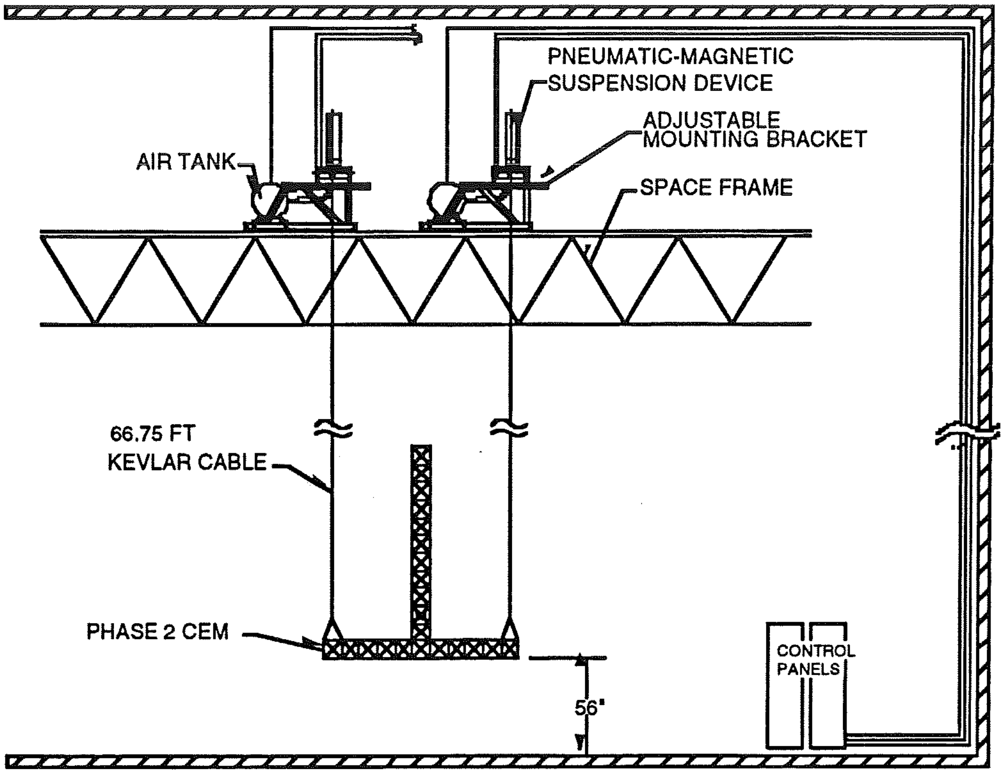


Figure 10a. Schematic of suspension system arrangement in laboratory

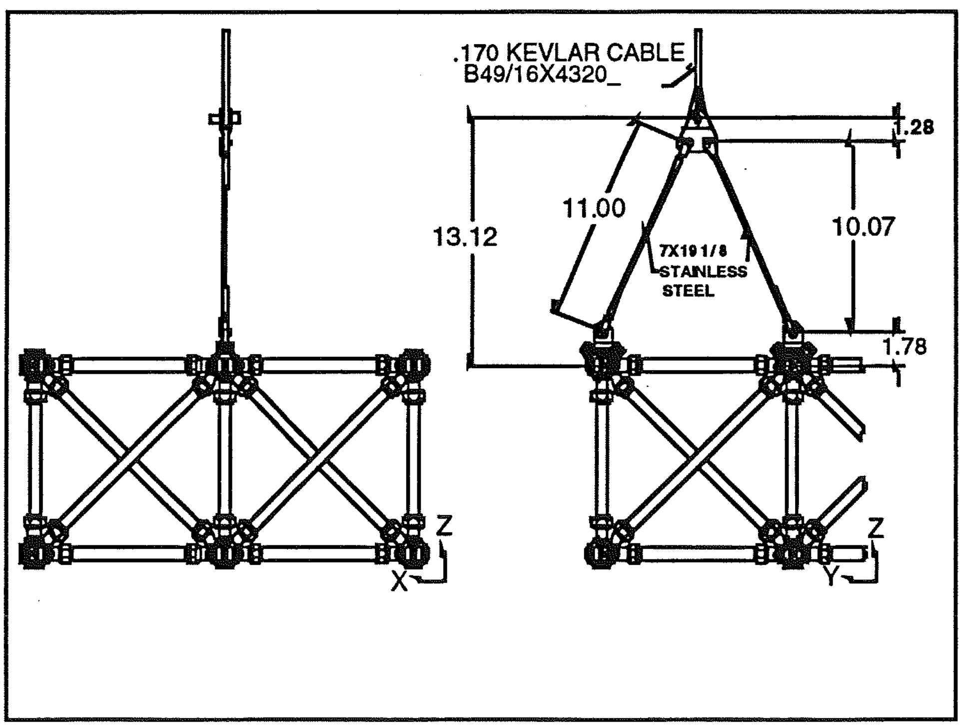


Figure 10b. Cable attachment to truss structure

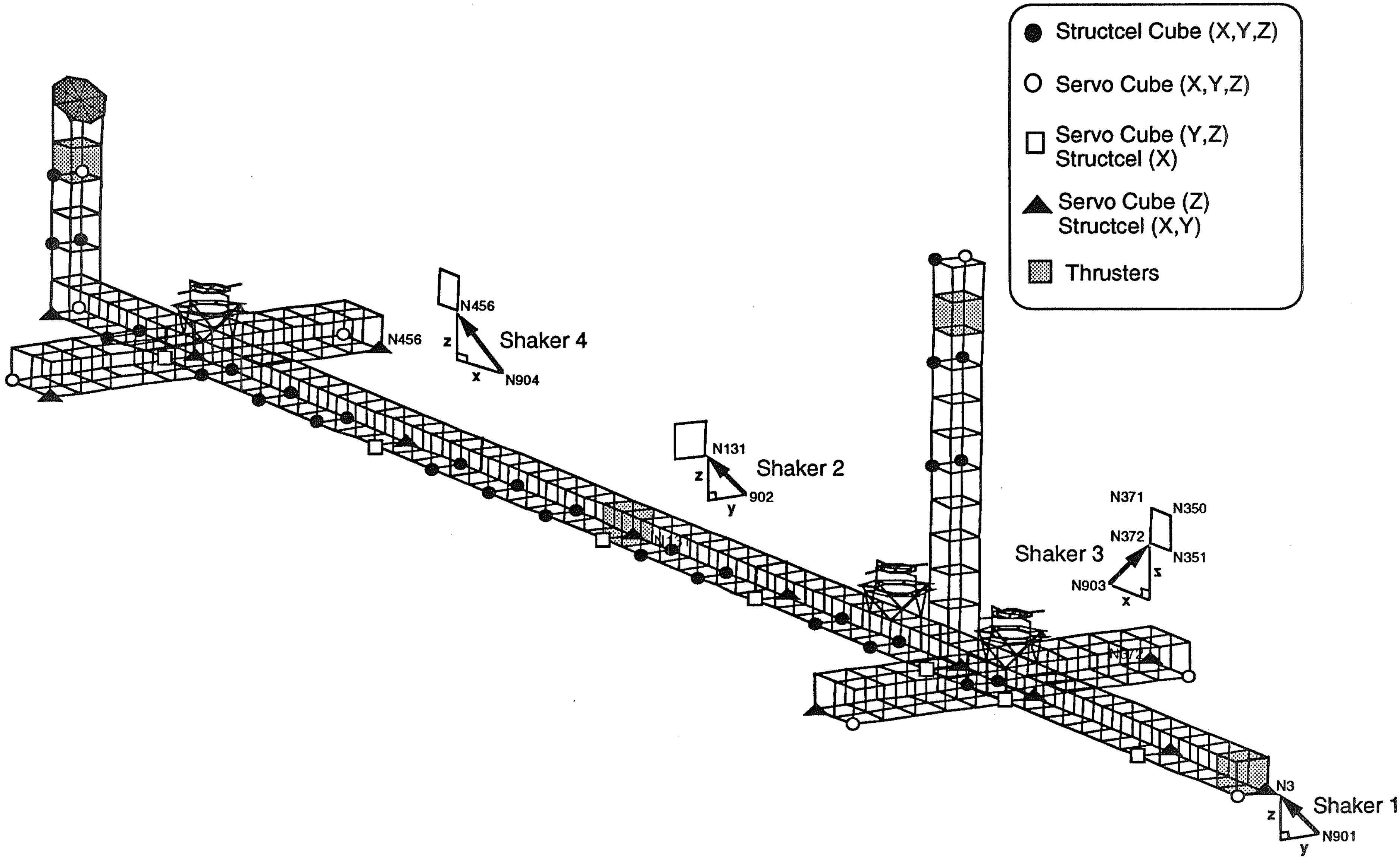


Figure 11. Phase2 CEM sensors and actuators locations

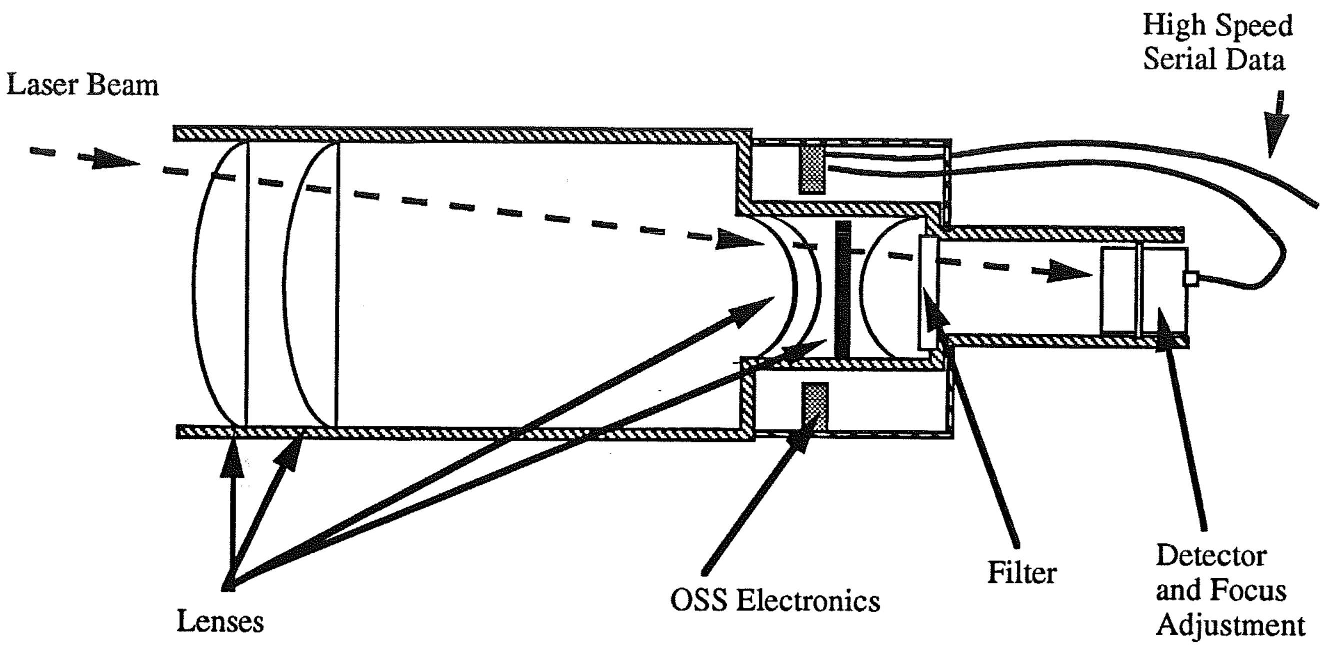


Figure 12. Optical Scoring System (OSS) diagram

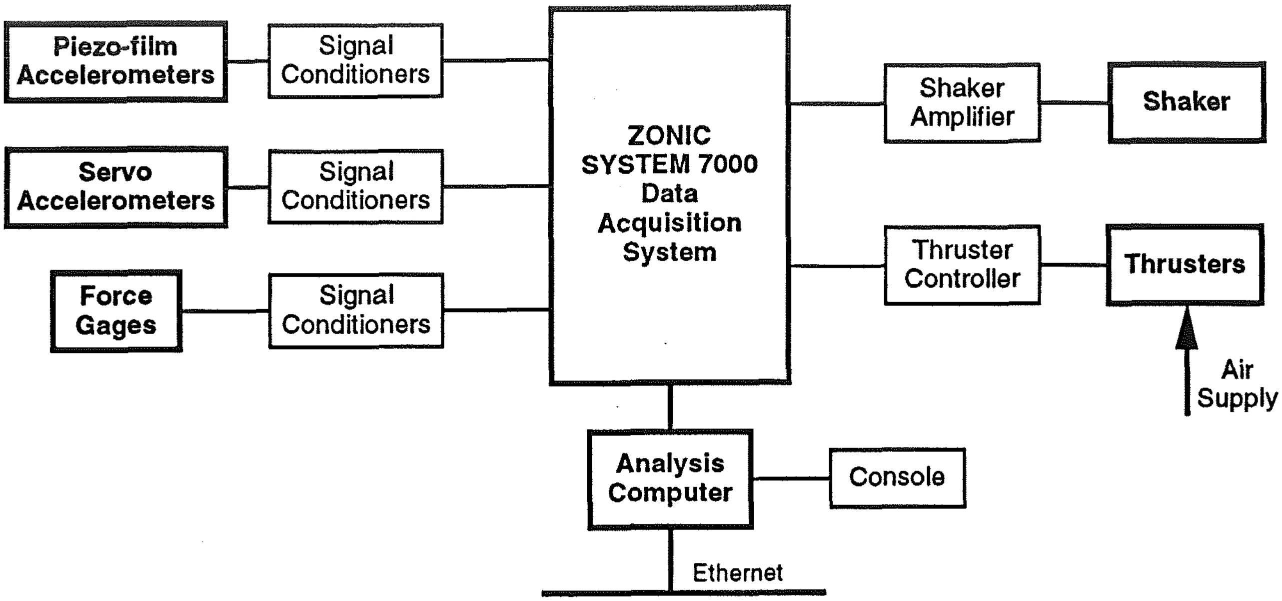


Figure 13. Data acquisition system configuration

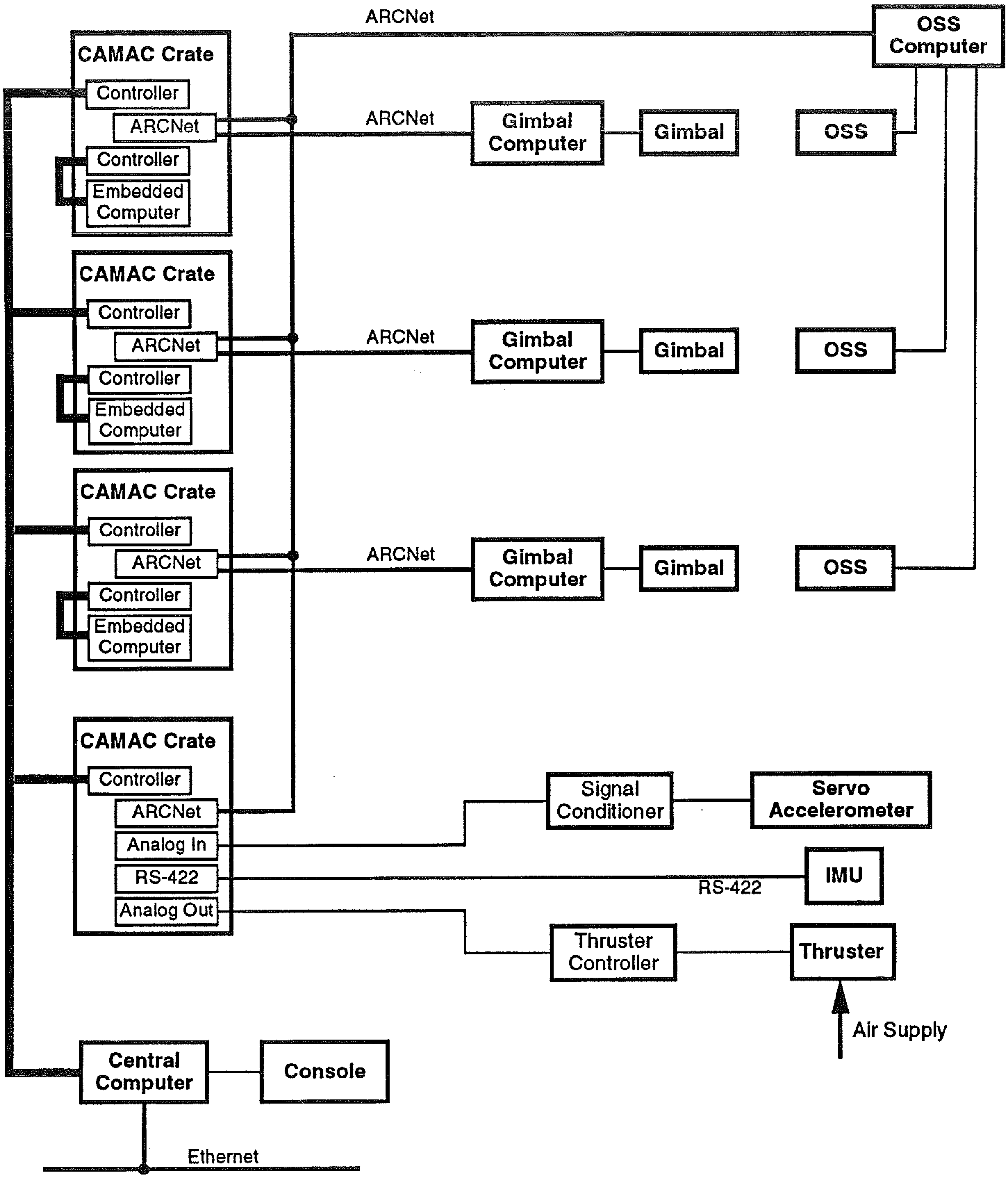


Figure 14. Control computer configuration

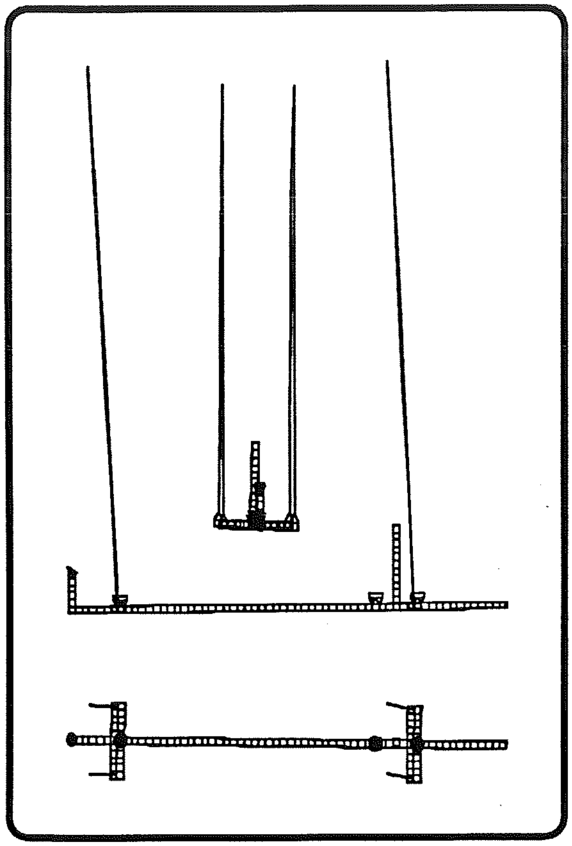


Figure 15. Mode 1, f=0.1393 Hz

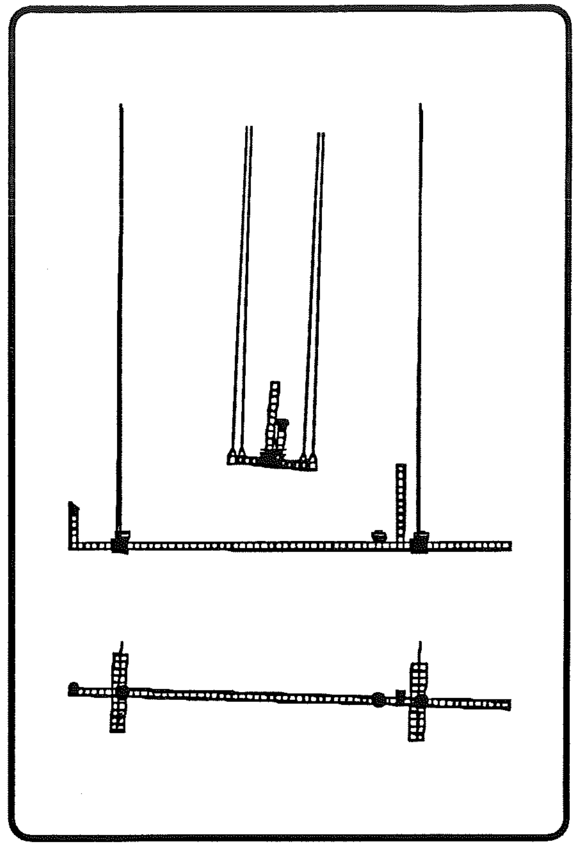


Figure 16. Mode 2, f=0.1404 Hz

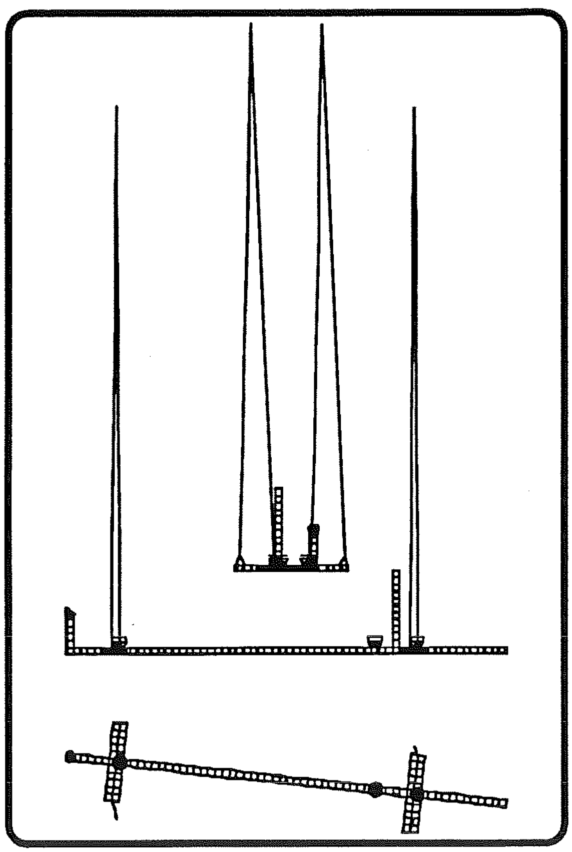


Figure 17. Mode 3, f=0.1492 Hz

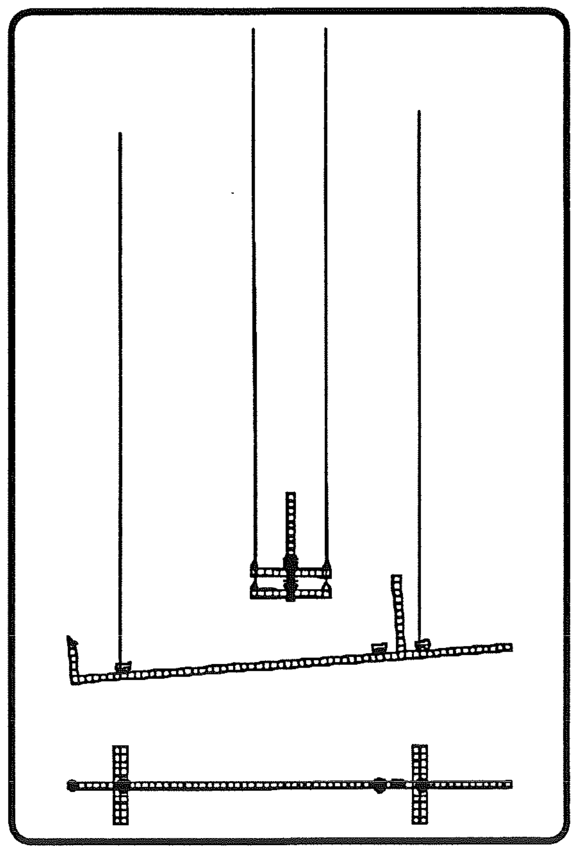


Figure 18. Mode 4, f=0.1609 Hz

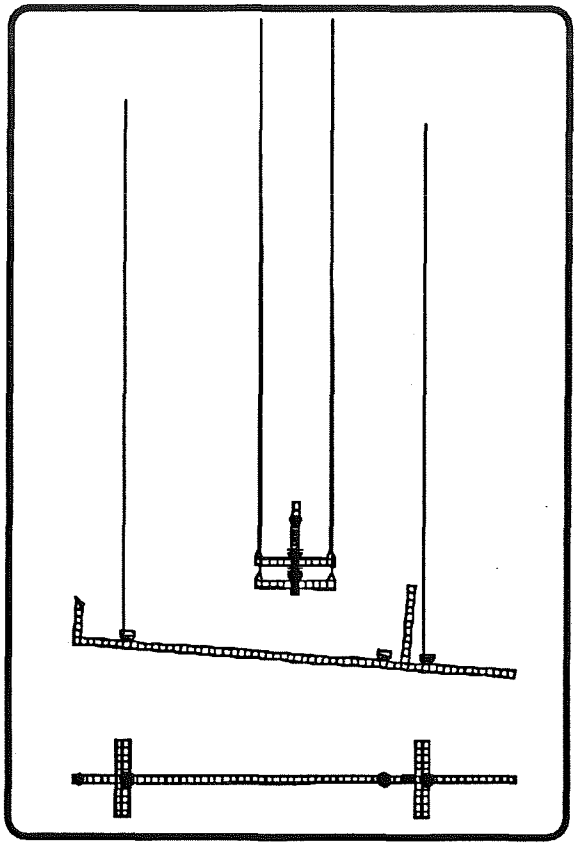


Figure 19. Mode 5, f=0.1643 Hz

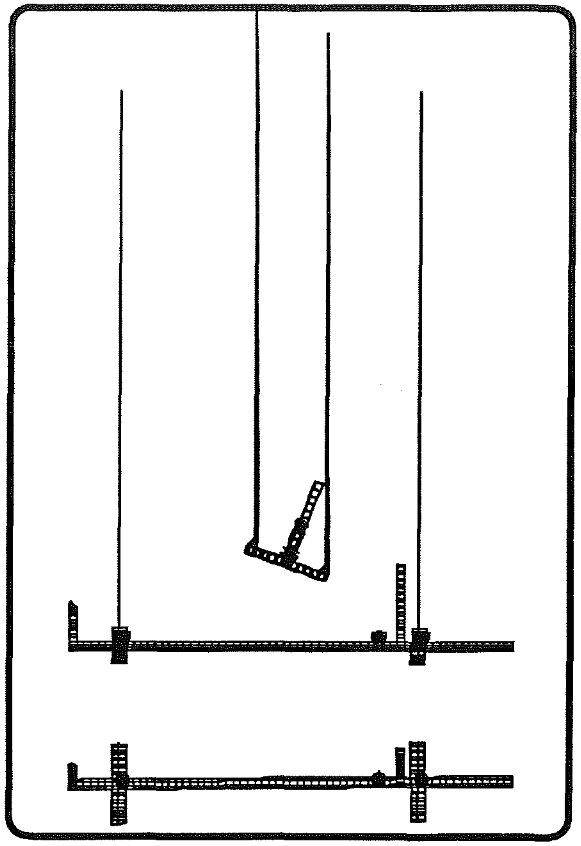


Figure 20. Mode 6, f=0.2760 Hz

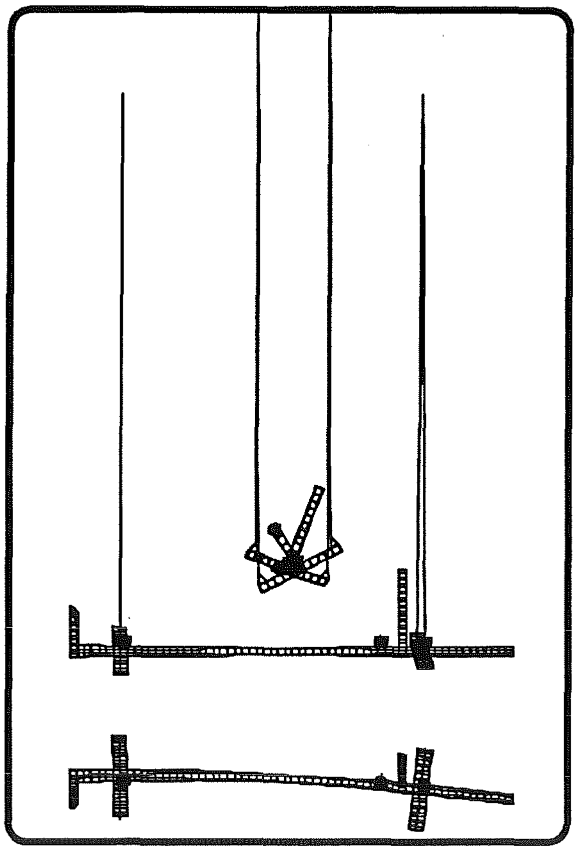


Figure 21. Mode 7, f=1.7247 Hz

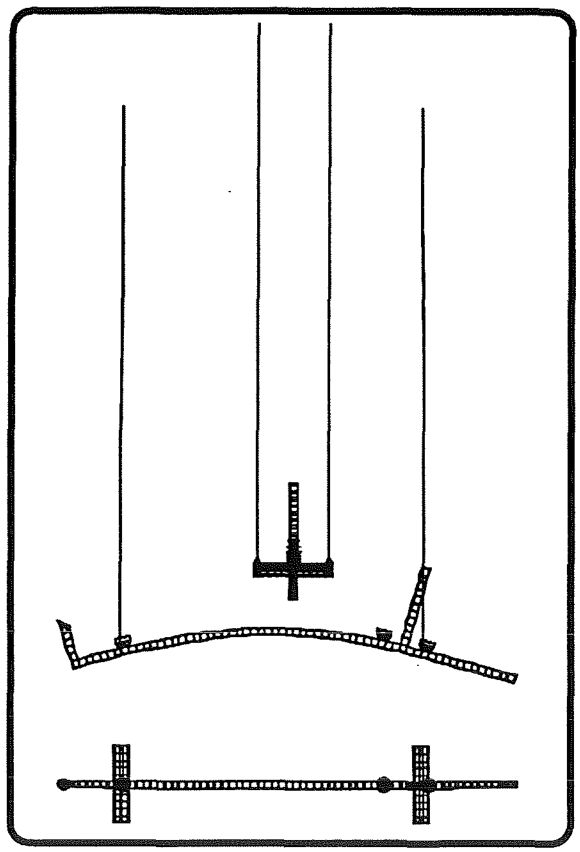


Figure 22. Mode 8, f=2.4000 Hz

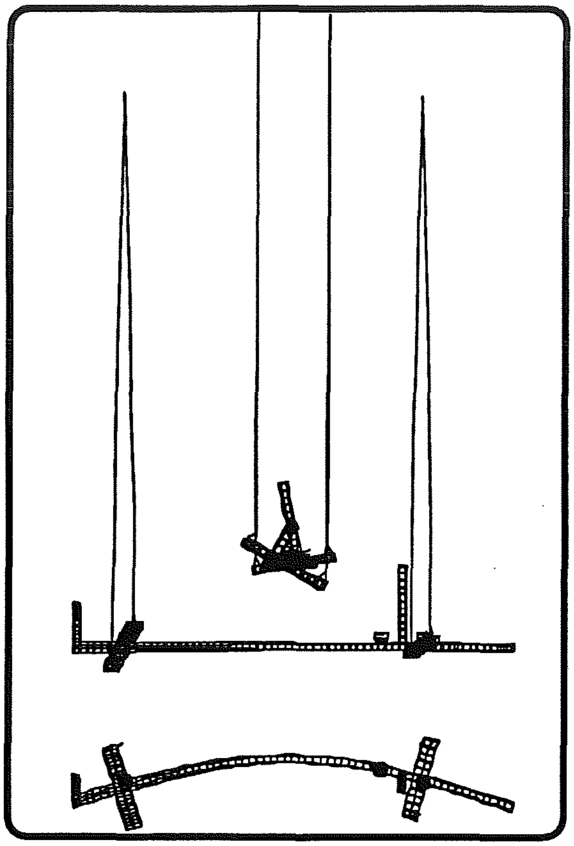


Figure 23. Mode 9, f=2.9673 Hz

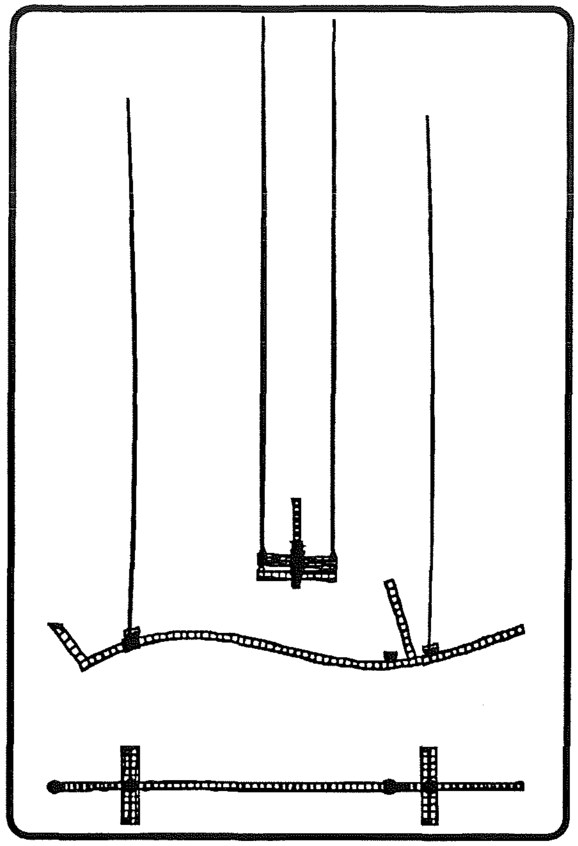


Figure 24. Mode10, f=5.4863 Hz

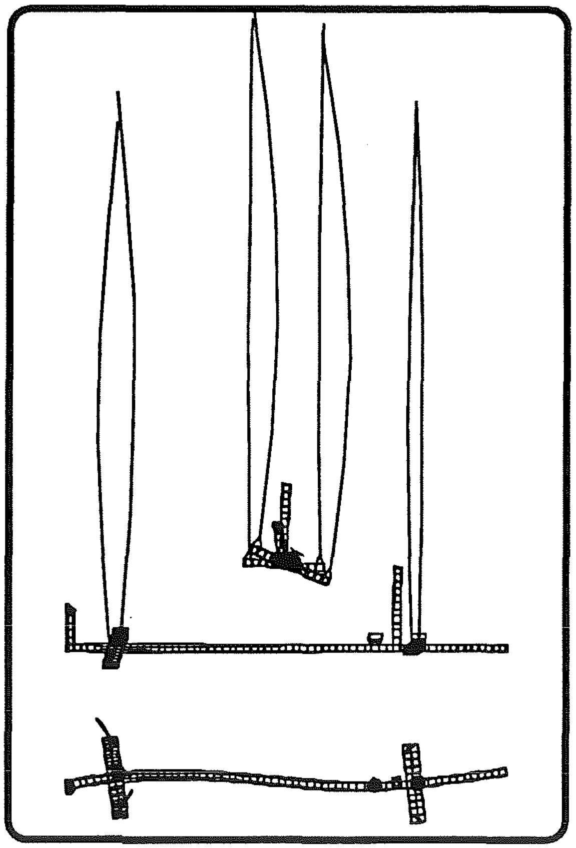


Figure 25. Mode 11, f=5.8503 Hz

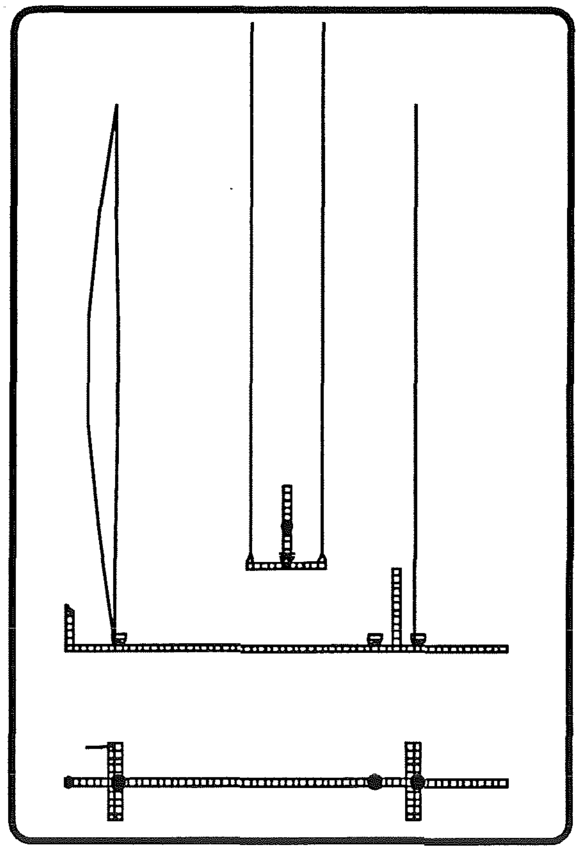


Figure 26. Mode 12, f=6.4208 Hz

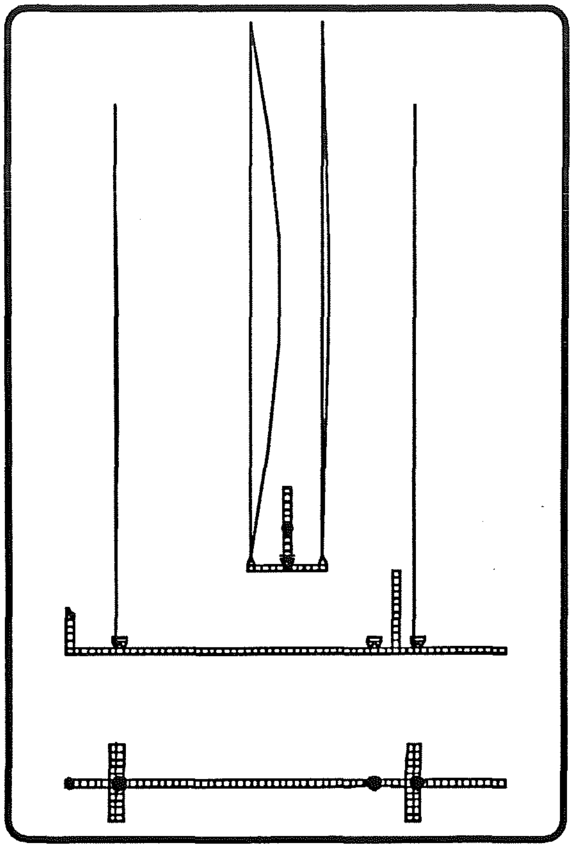


Figure 27. Mode 15, f=6.5335 Hz

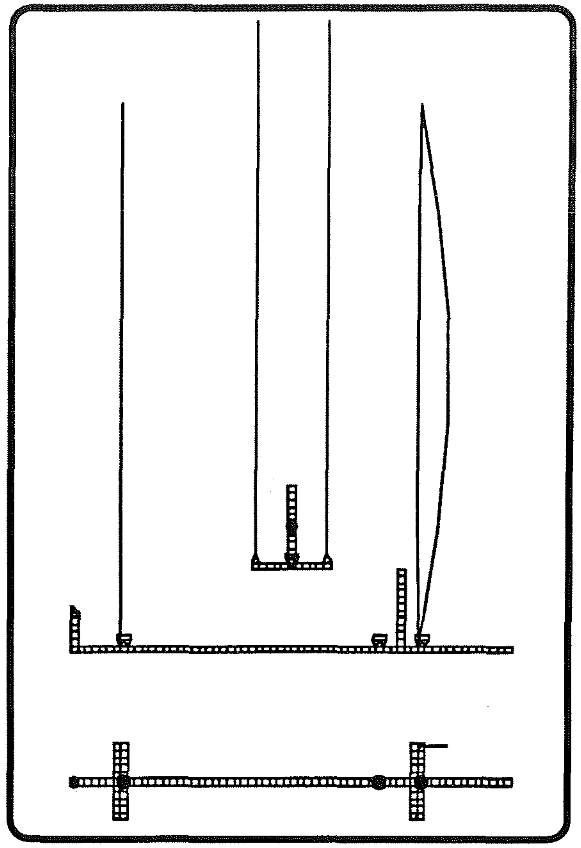


Figure 28. Mode 16, f=6.9233 Hz

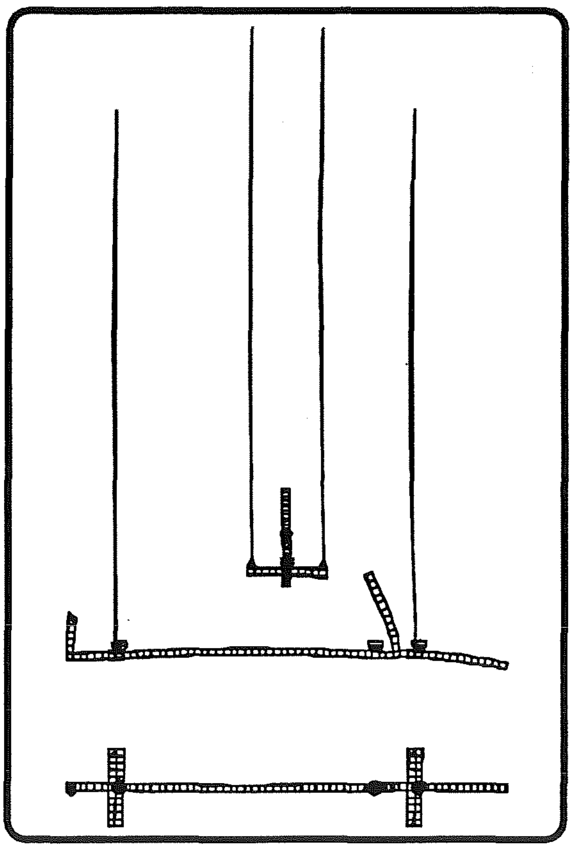


Figure 29. Mode 20, f=7.6844 Hz

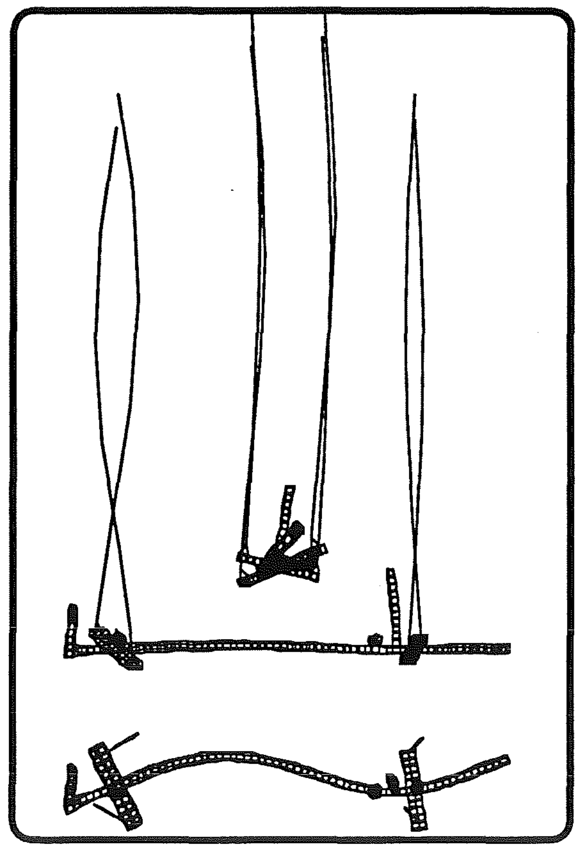


Figure 30. Mode 21, f=8.4046 Hz

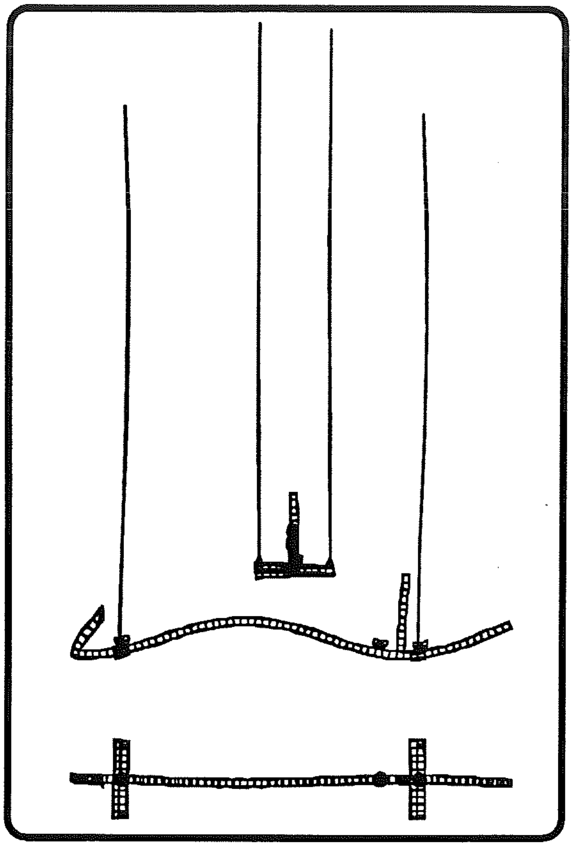


Figure 31. Mode 22, f=9.0020 Hz

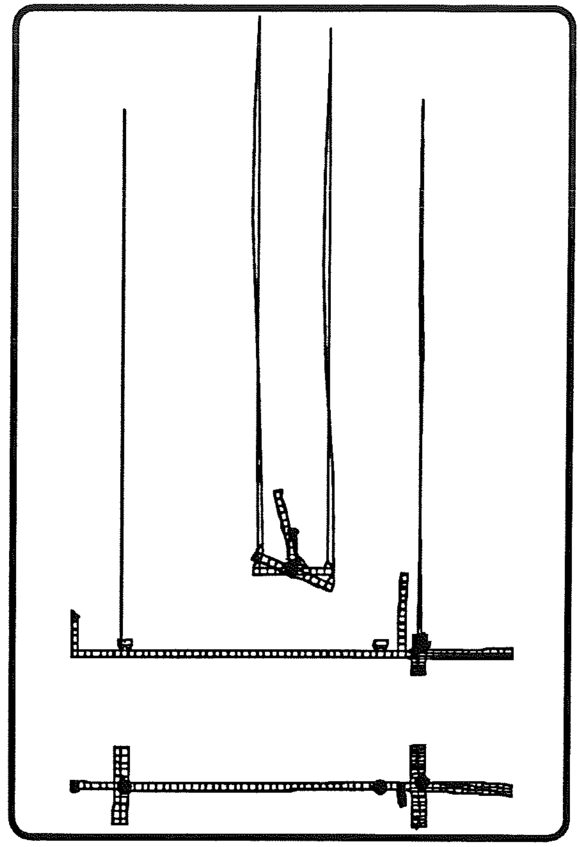


Figure 32. Mode 23, f=10.0418 Hz

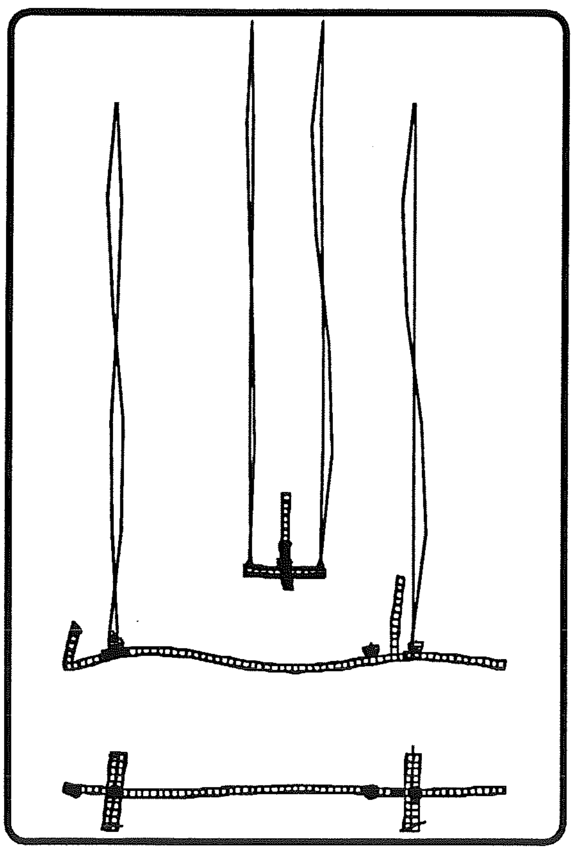


Figure 33. Mode 33, f=13.5509 Hz

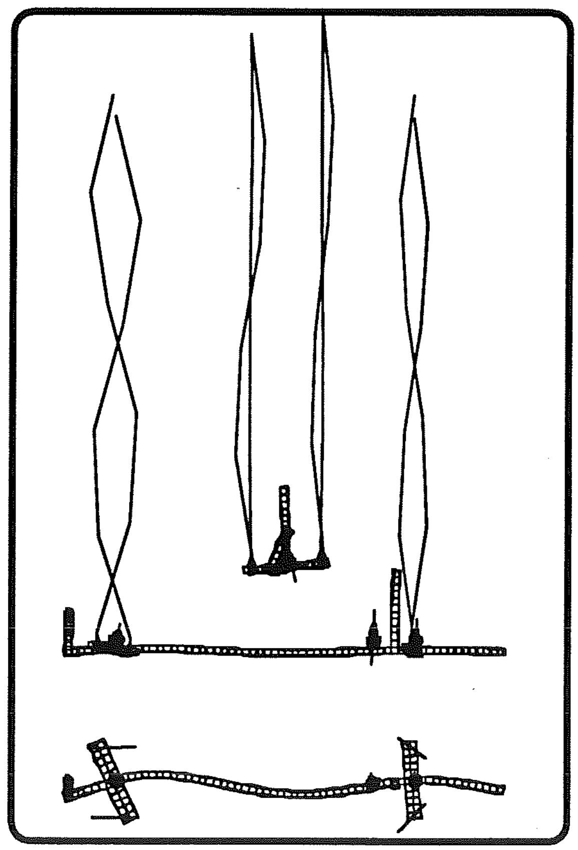


Figure 34. Mode 34, f=13.6346 Hz

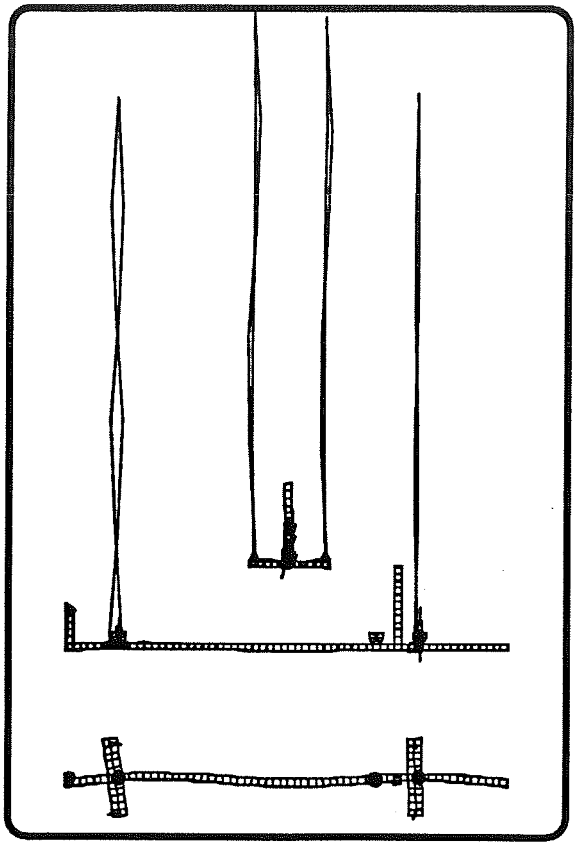


Figure 35. Mode 36, f=14.2675 Hz

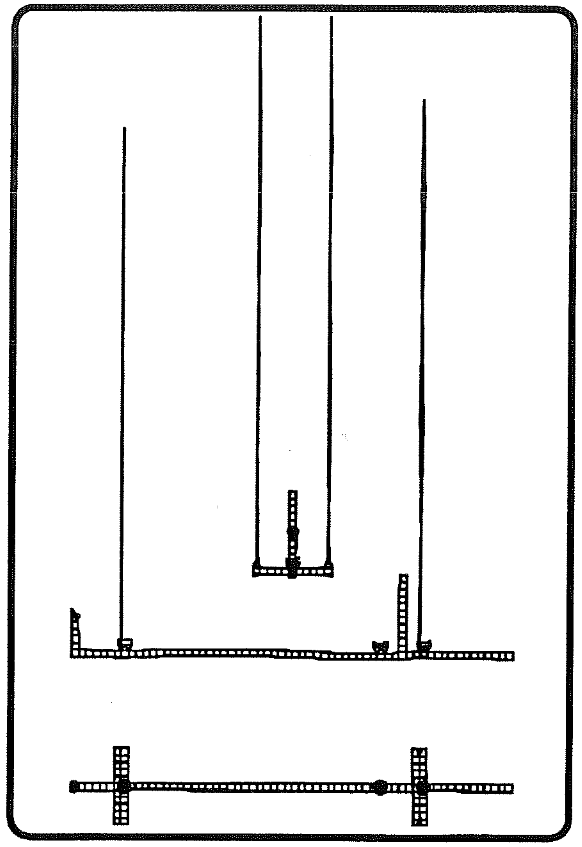


Figure 36. Mode 37, f=15.0536 Hz

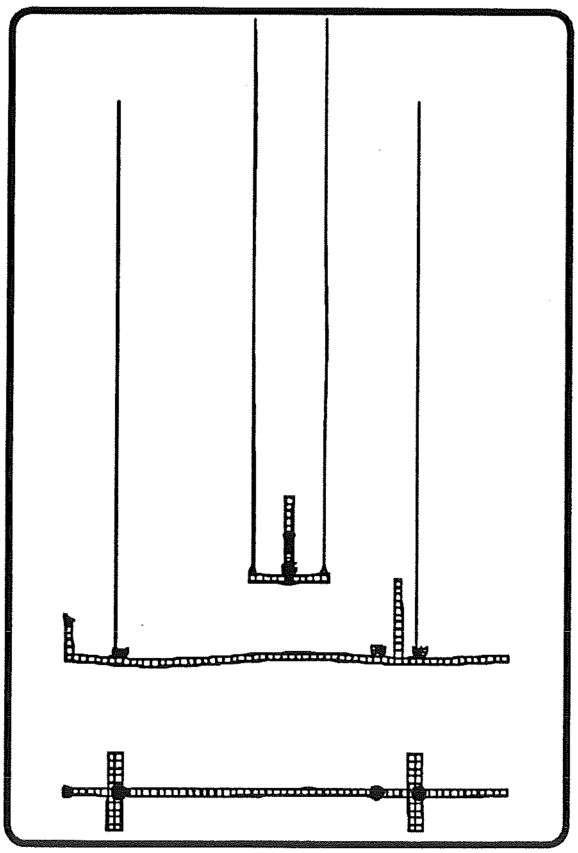


Figure 37. Mode 38, f=15.6685 Hz

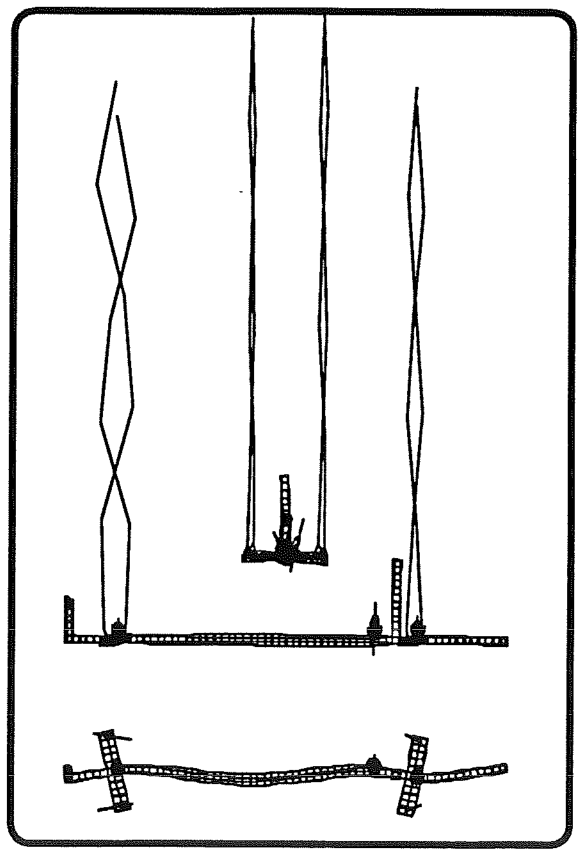


Figure 38. Mode 39, f=16.3021 Hz

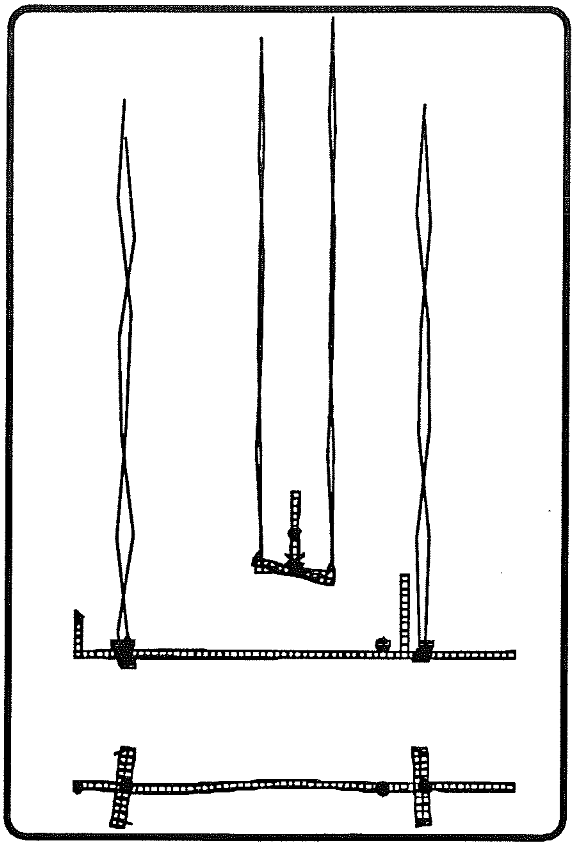


Figure 39. Mode 44, f=17.8175 Hz

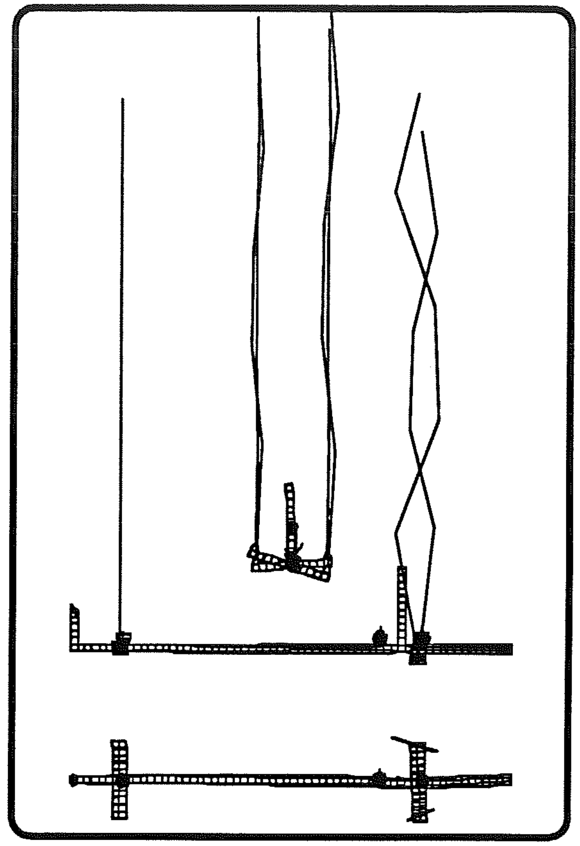


Figure 40. Mode 45, f=18.1644 Hz

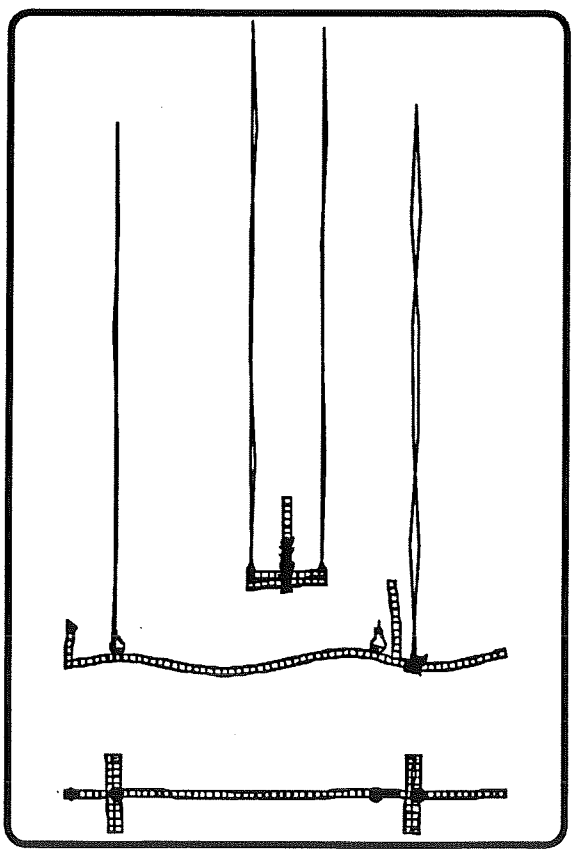


Figure 41. Mode 50, f=18.7388 Hz

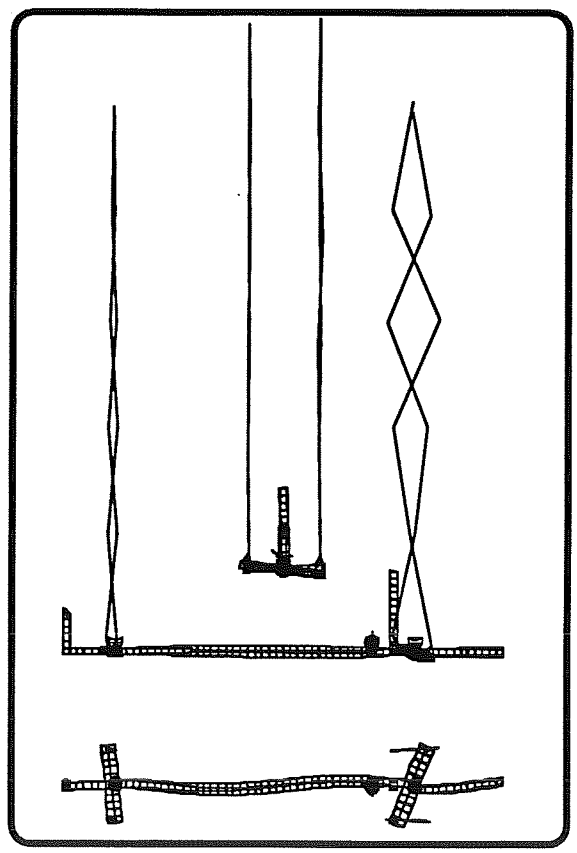


Figure 42. Mode 55, f=20.9209 Hz

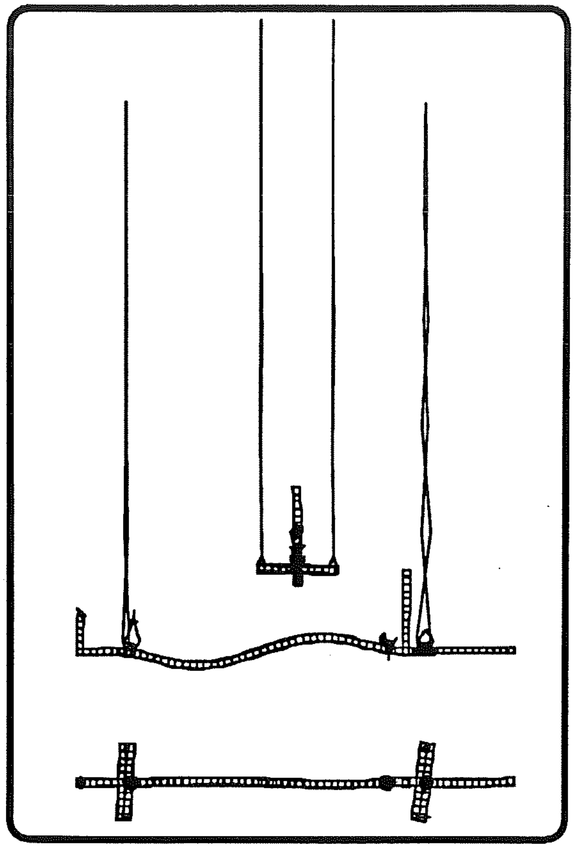


Figure 43. Mode 60, f=23.185 Hz

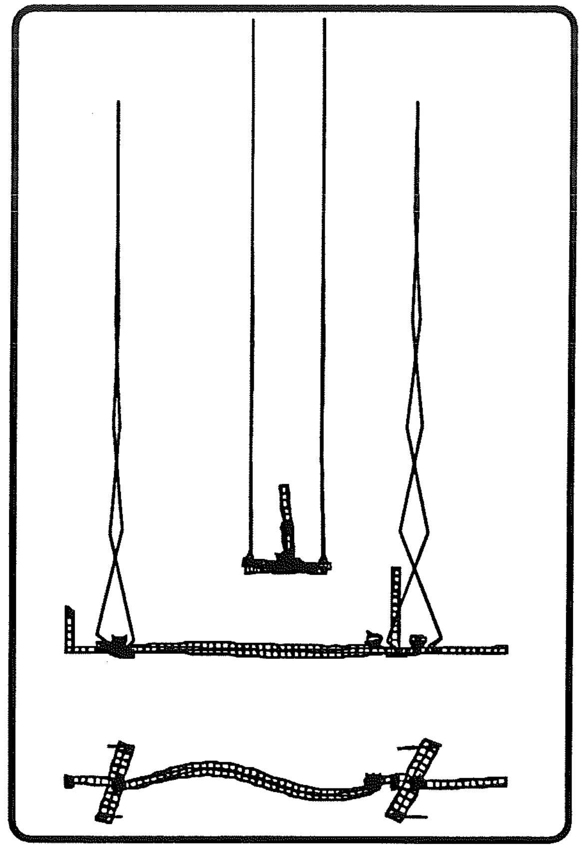


Figure 44. Mode 61, f=23.9101 Hz

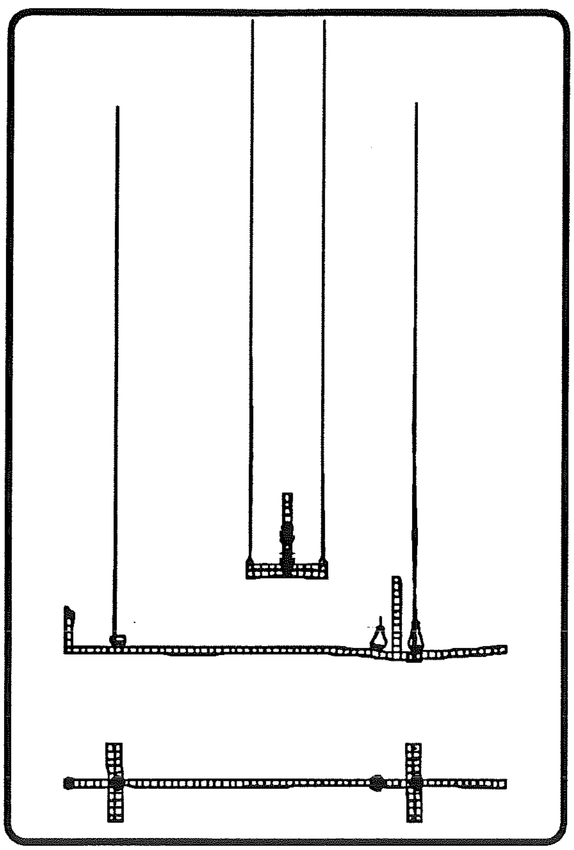


Figure 45. Mode 62, f=24.8246 Hz

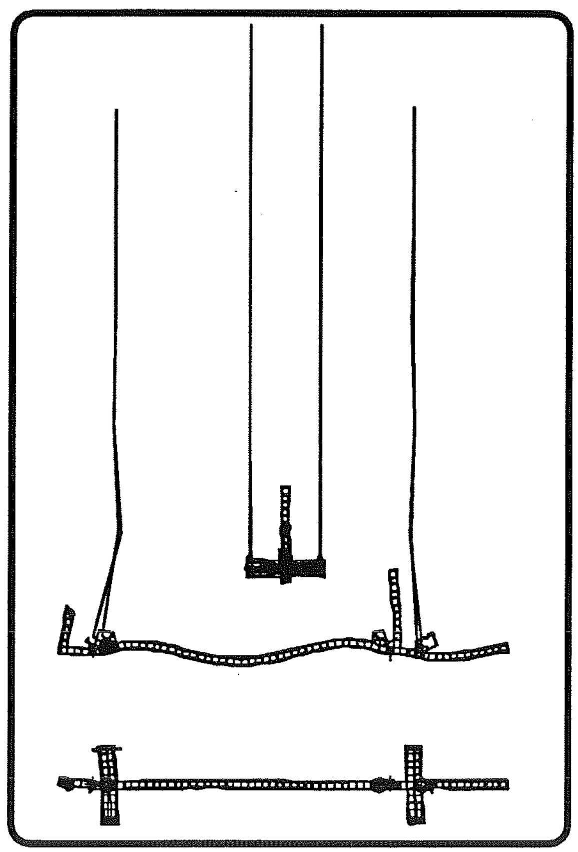


Figure 46. Mode 63, f=25.7520 Hz

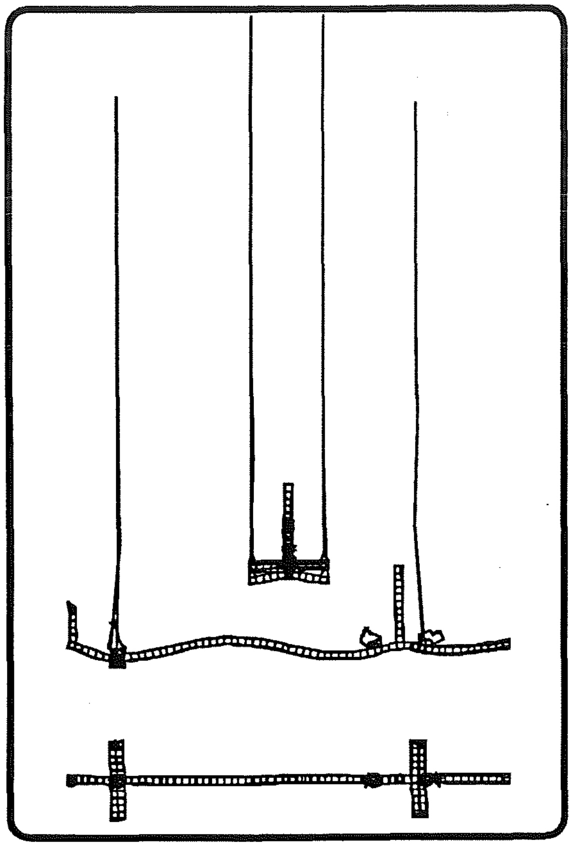


Figure 47. Mode 64, f=27.5750 Hz

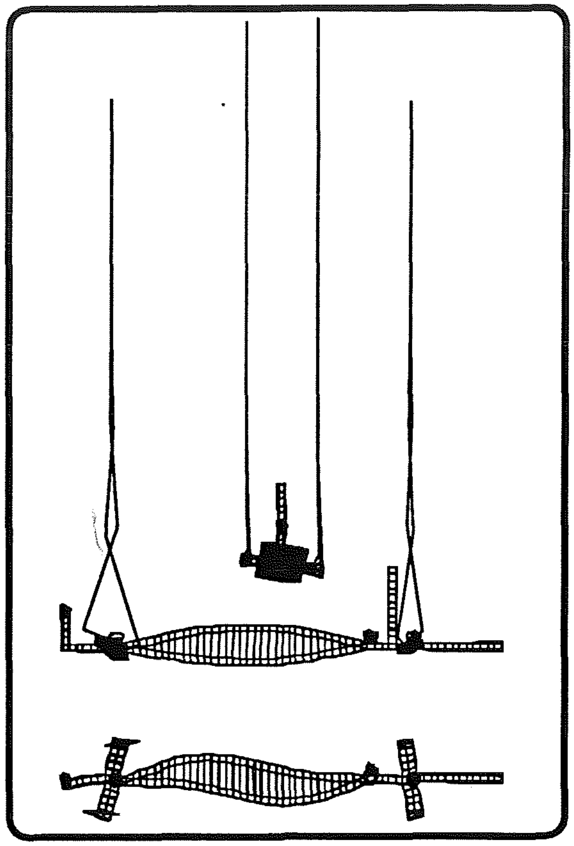


Figure 48. Mode 65, f=28.4333 Hz

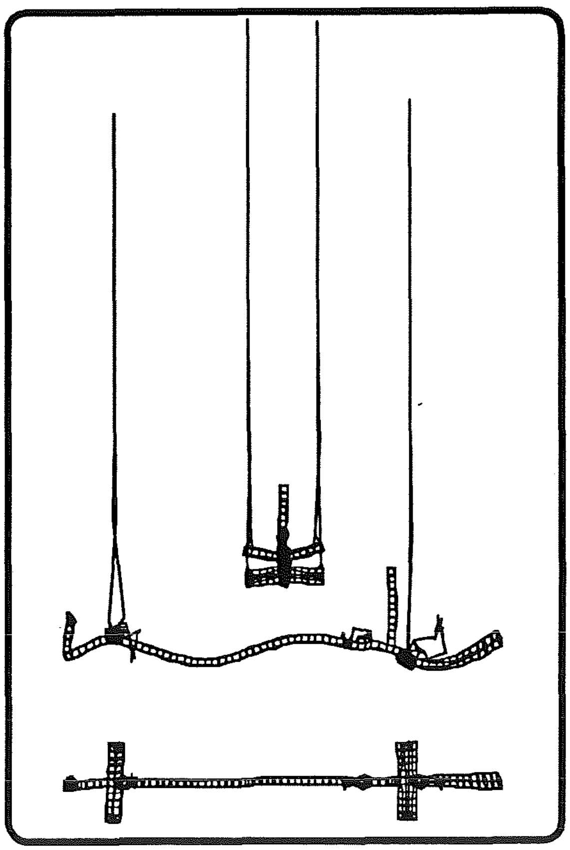


Figure 49. Mode 66, f=28.9849 Hz

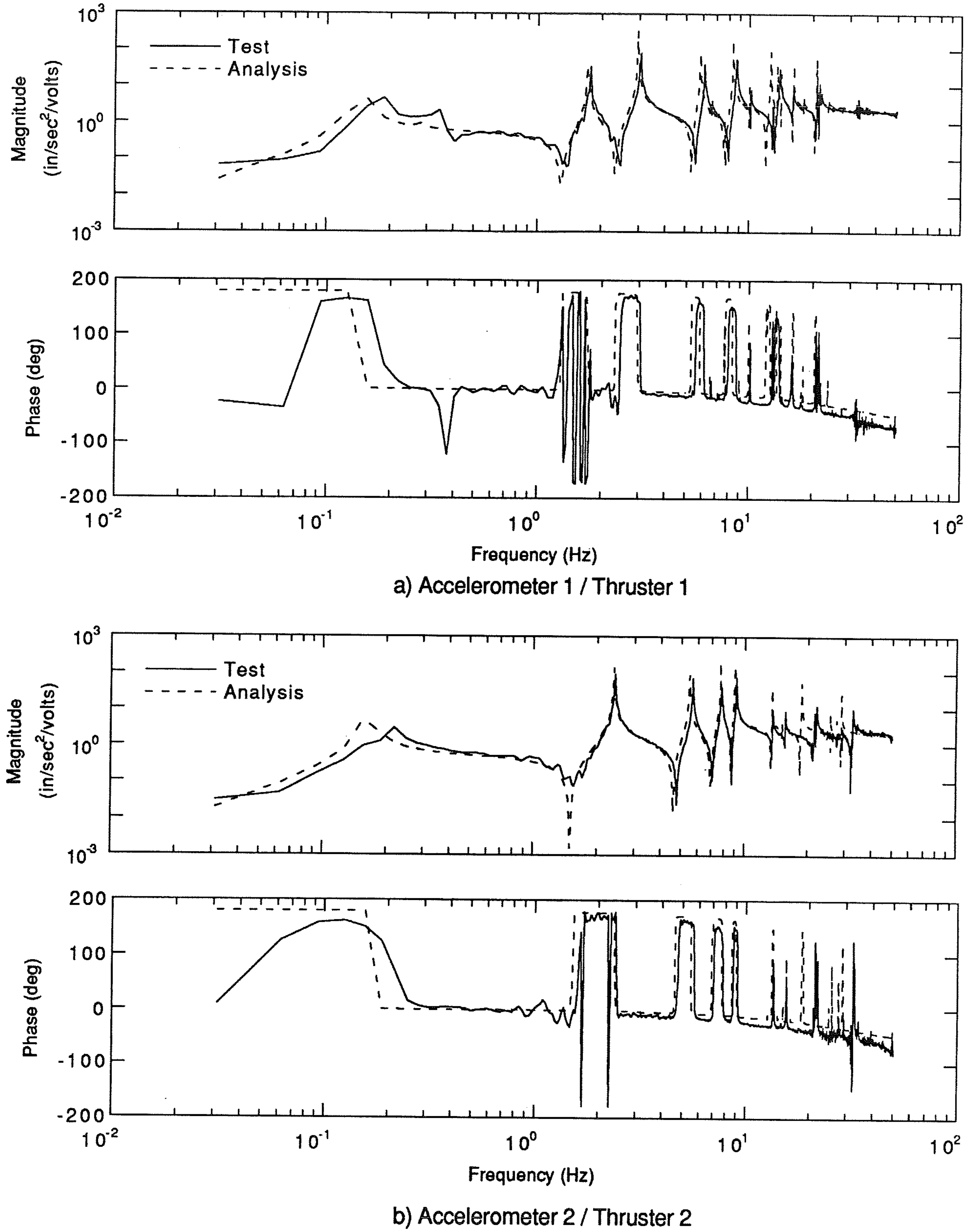
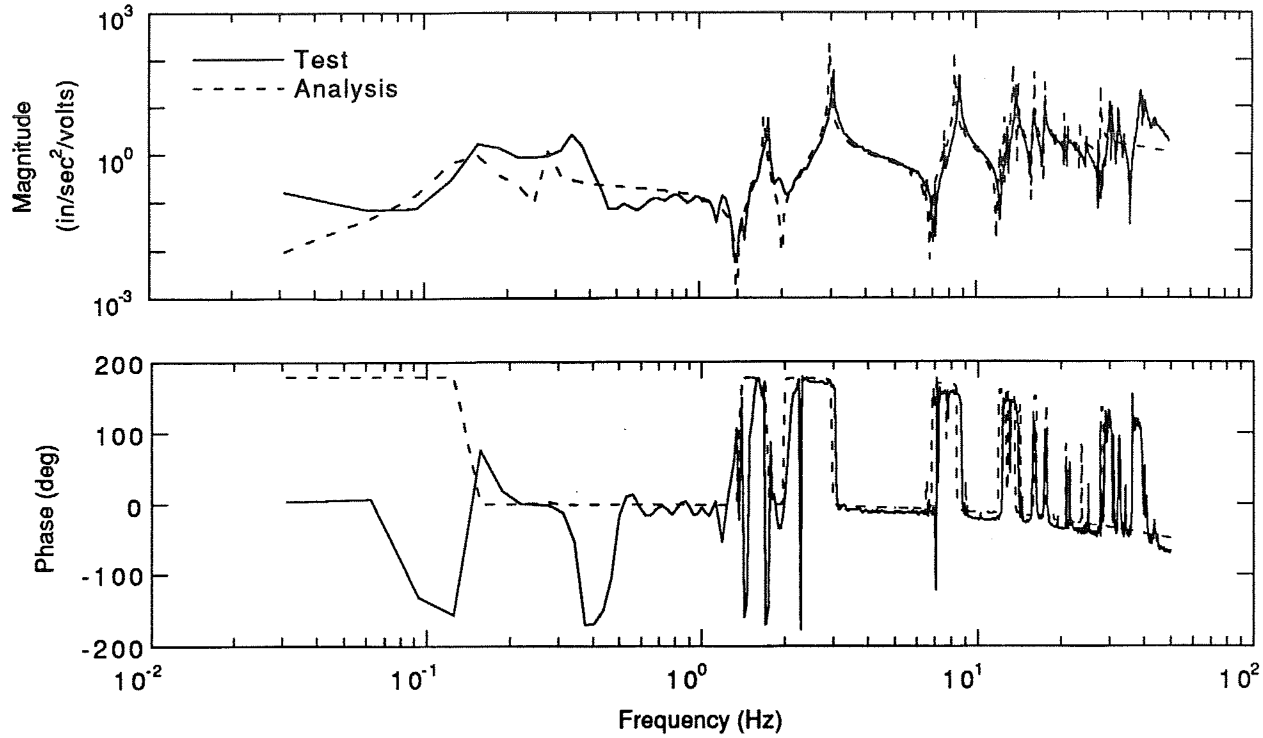
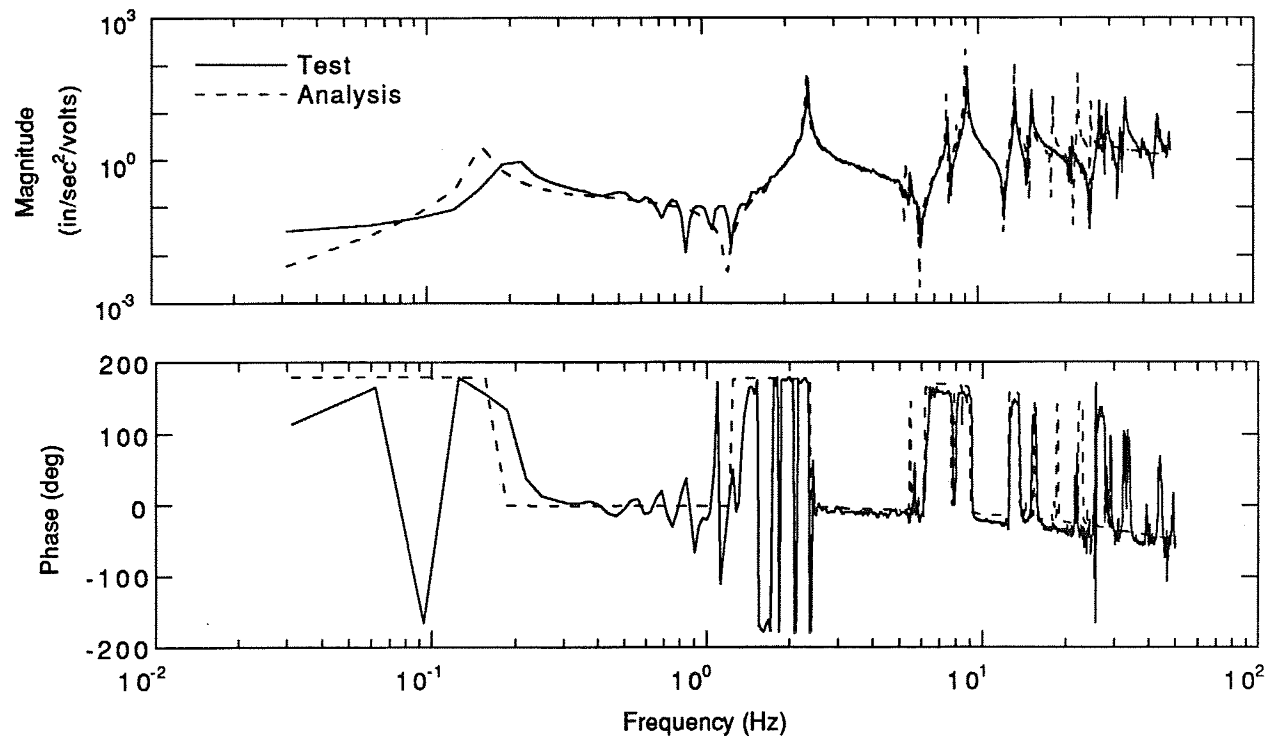


Figure 50. Transfer function for Accelerometer 1 / Thruster 1 and Accelerometer 2 / Thruster 2

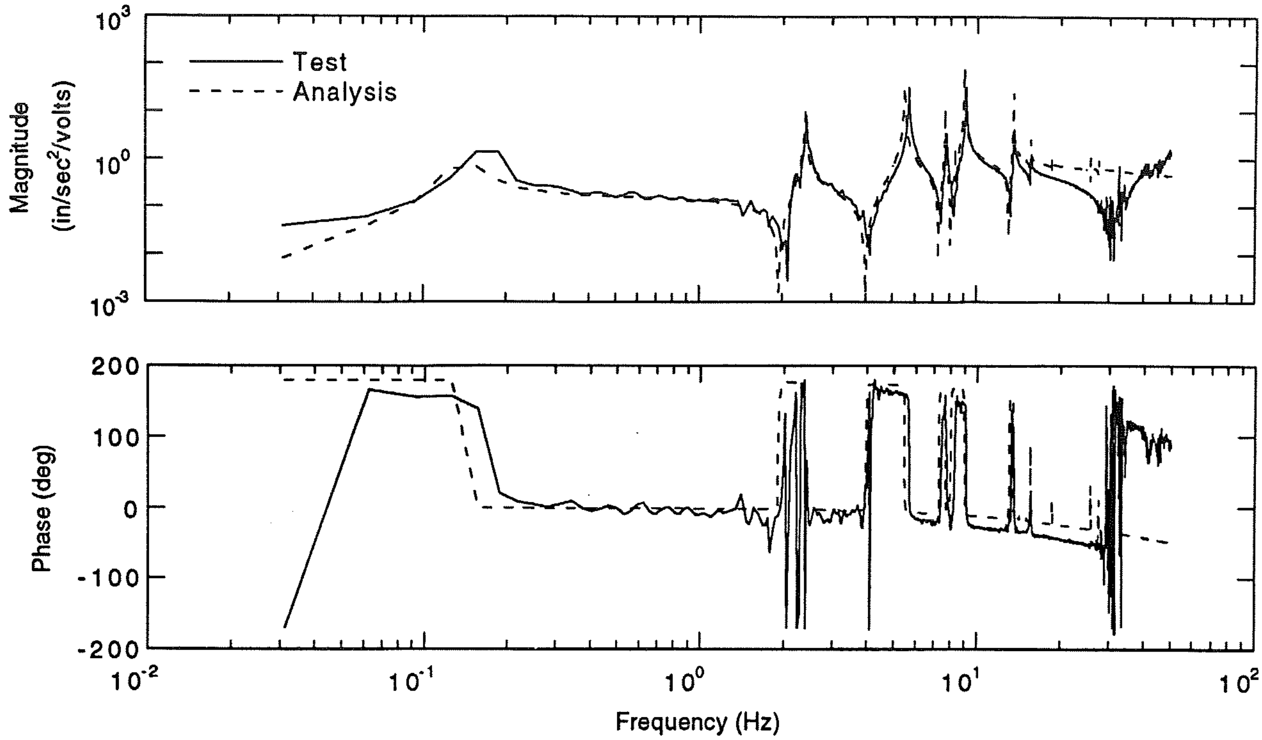


a) Accelerometer 3 / Thruster 3

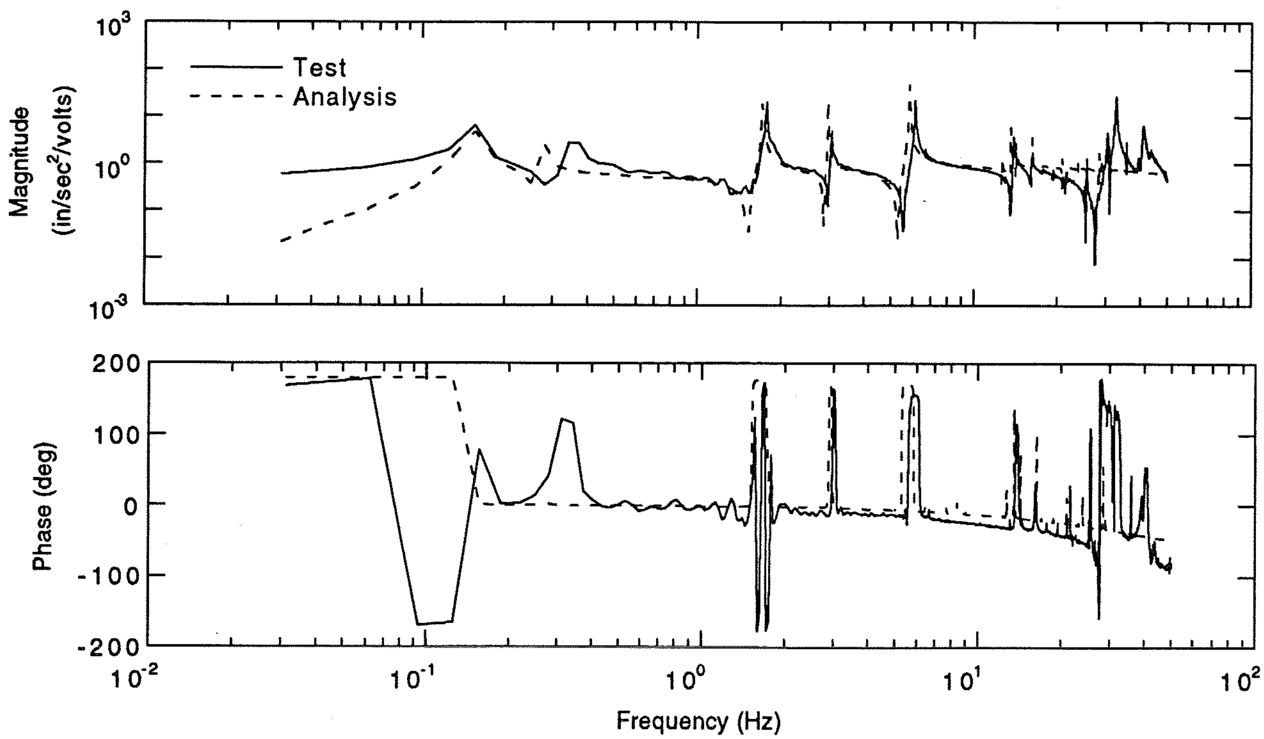


b) Accelerometer 4 / Thruster 4

Figure 51. Transfer function for Accelerometer 3 / Thruster 3 and Accelerometer 4 / Thruster 4



a) Accelerometer 5 / Thruster 5



b) Accelerometer 6 / Thruster 6

Figure 52. Transfer function for Accelerometer 5 / Thruster 5 and Accelerometer 6 / Thruster 6

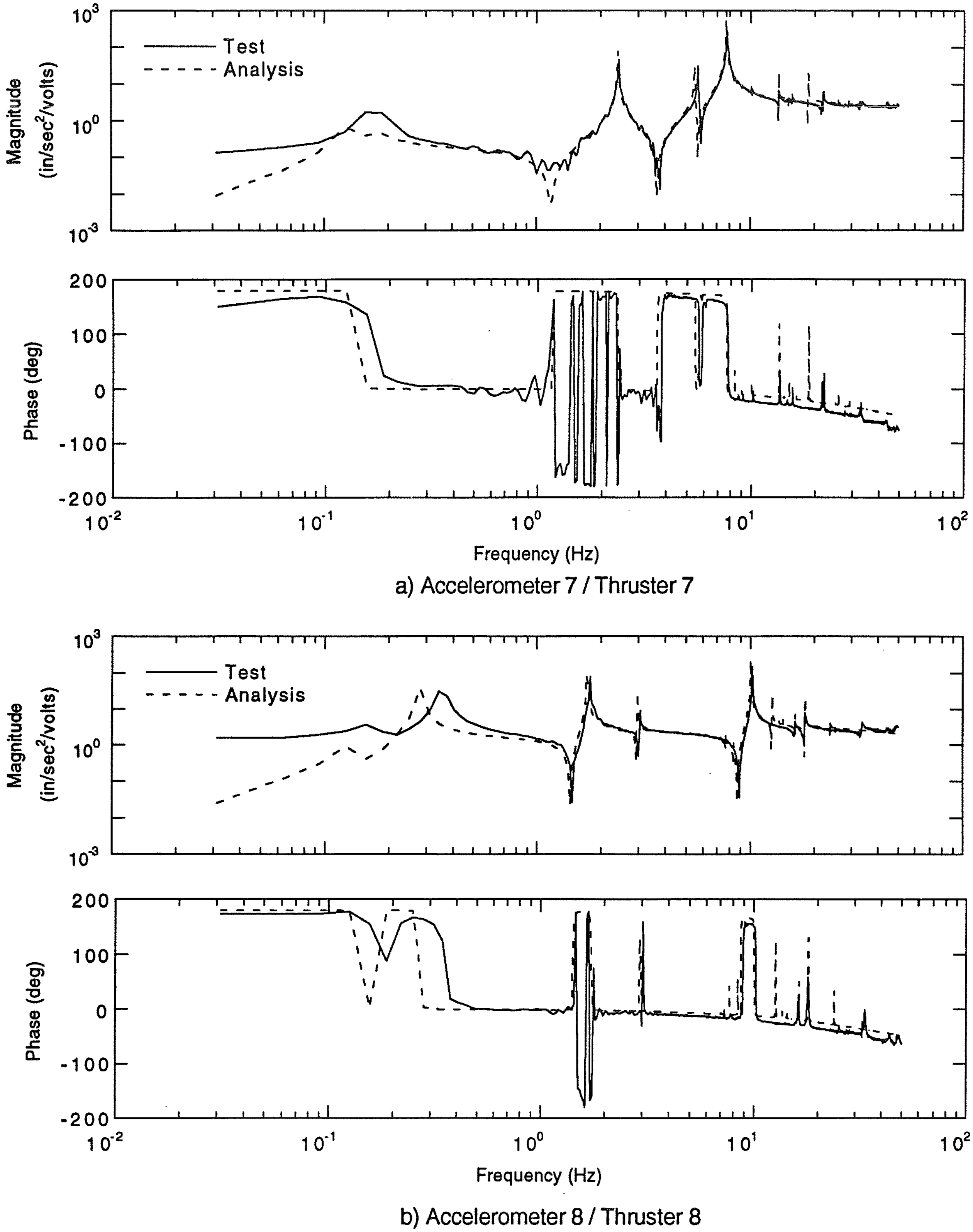


Figure 53. Transfer function for Accelerometer 7 / Thruster 7 and Accelerometer 8 / Thruster 8

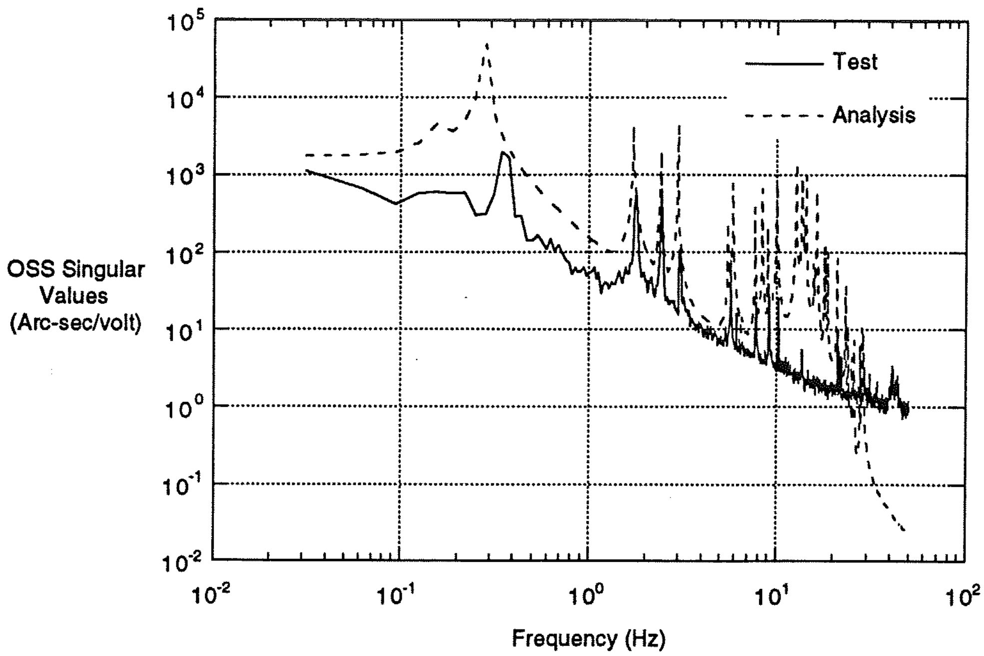


Figure 54. Comparison of maximum singular values of OSS / thruster transfer function

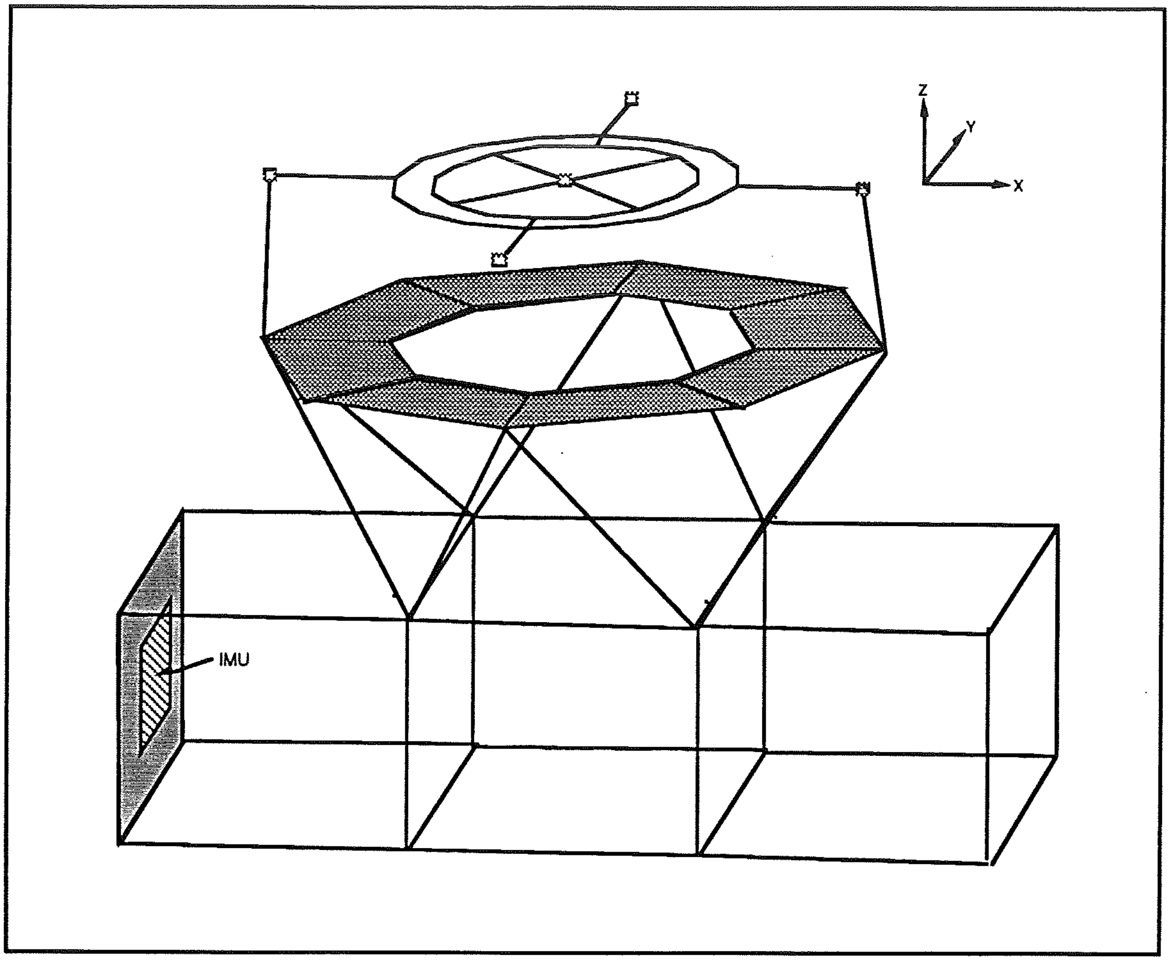


Figure 55. Gimbal and base on Phase-2 model

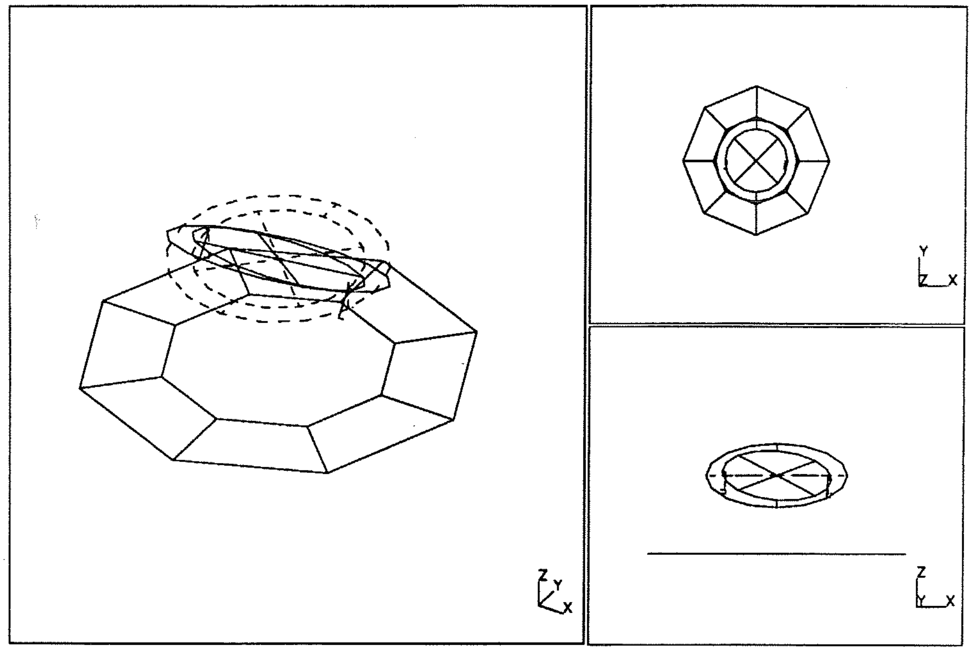


Figure 56. Gimbal mode 1, f= 3.6317E-06 Hz

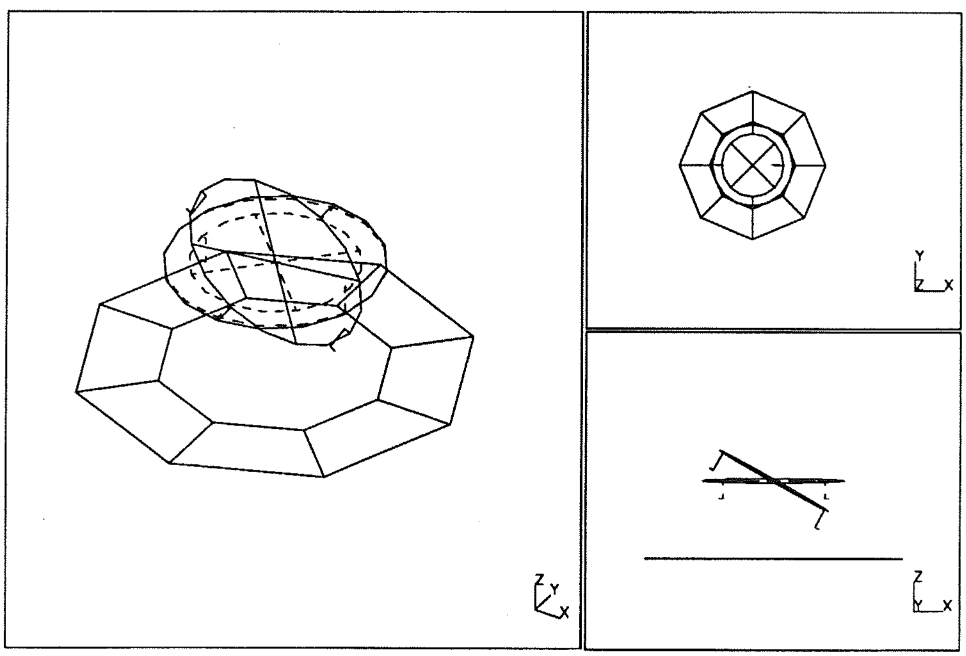


Figure 57. Gimbal mode 2, f= 8.1948E-06 Hz

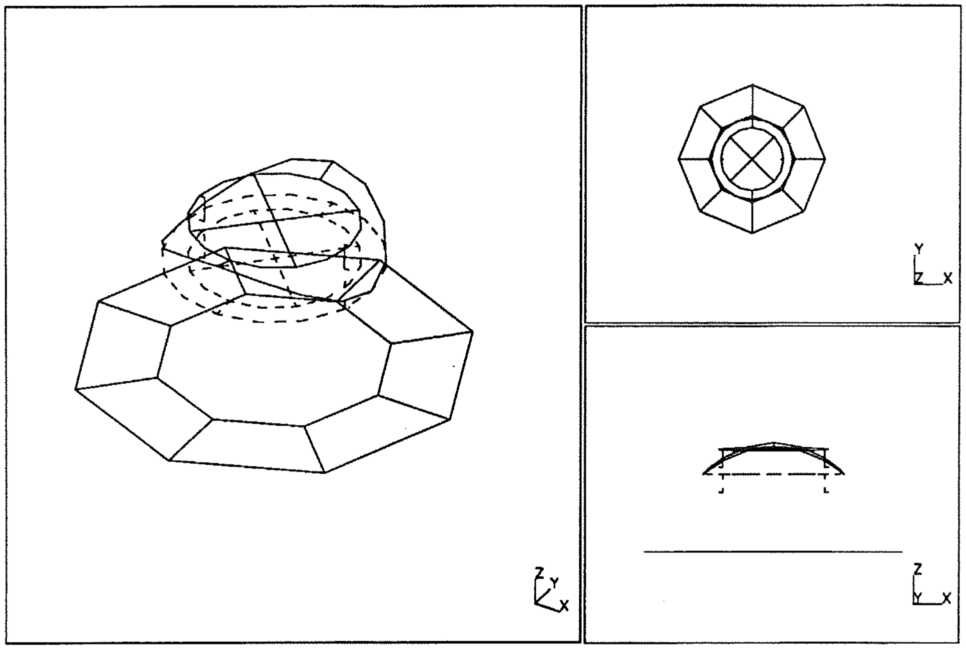


Figure 58. Gimbal mode 3, f= 47.3233 Hz

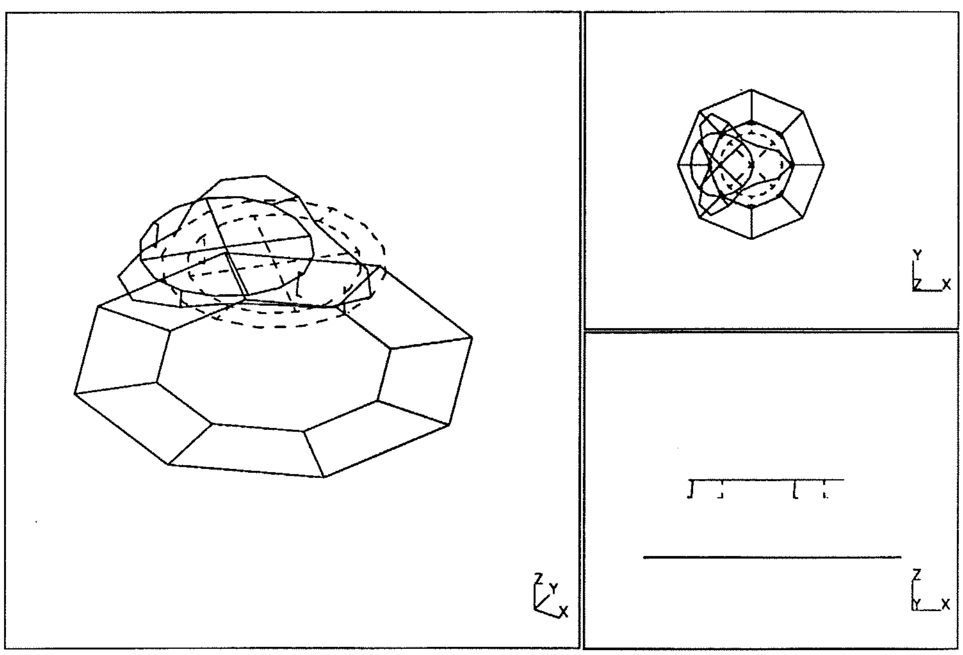


Figure 59. Gimbal mode 4, f= 108.0121 Hz

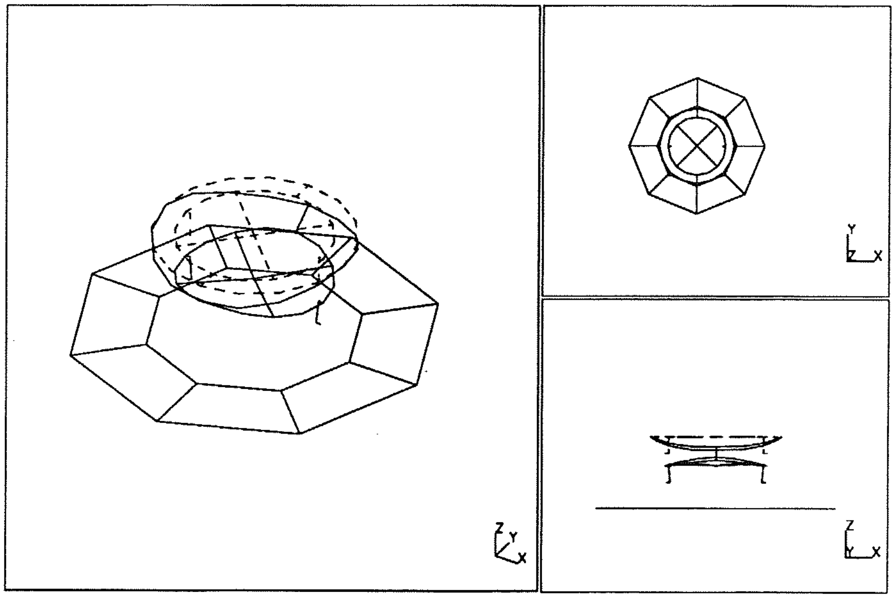
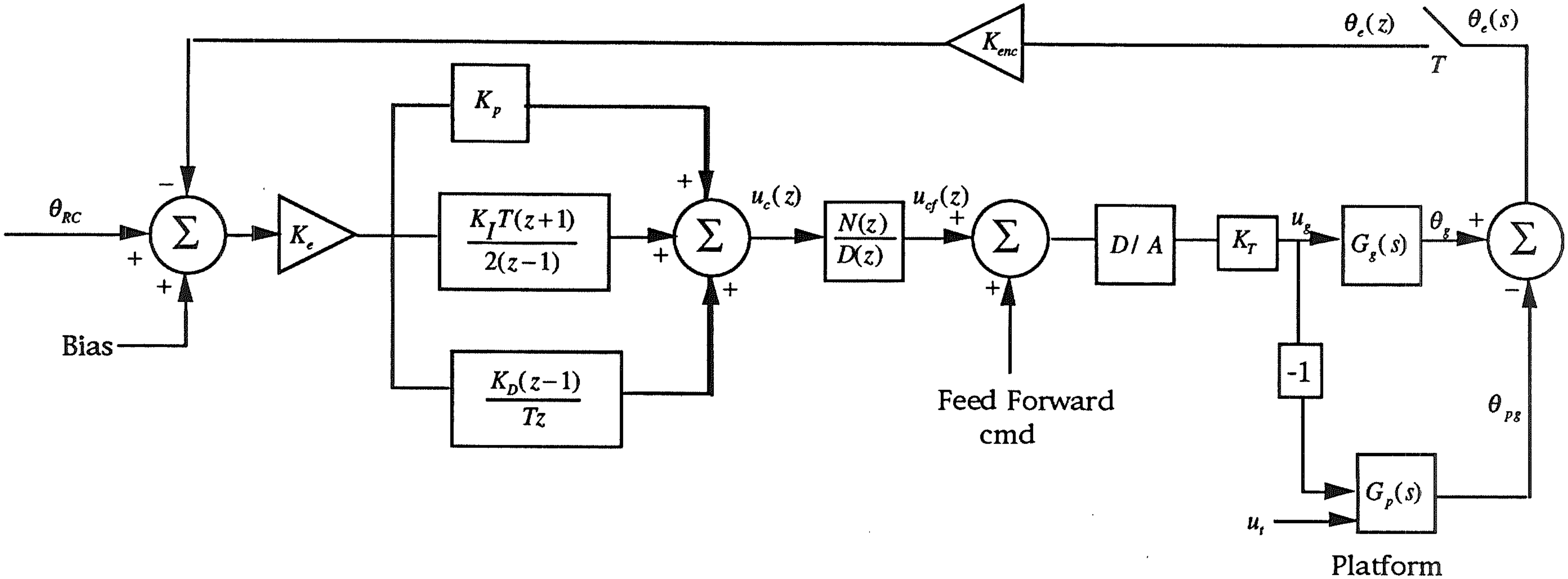


Figure 60. Gimbal mode 5, f= 117.5721 Hz



Constants

$K_p = 8$

$K_I = 32$

$K_D = 0.125$

$K_e = 0.05$ outer

$K_e = 0.052$ inner

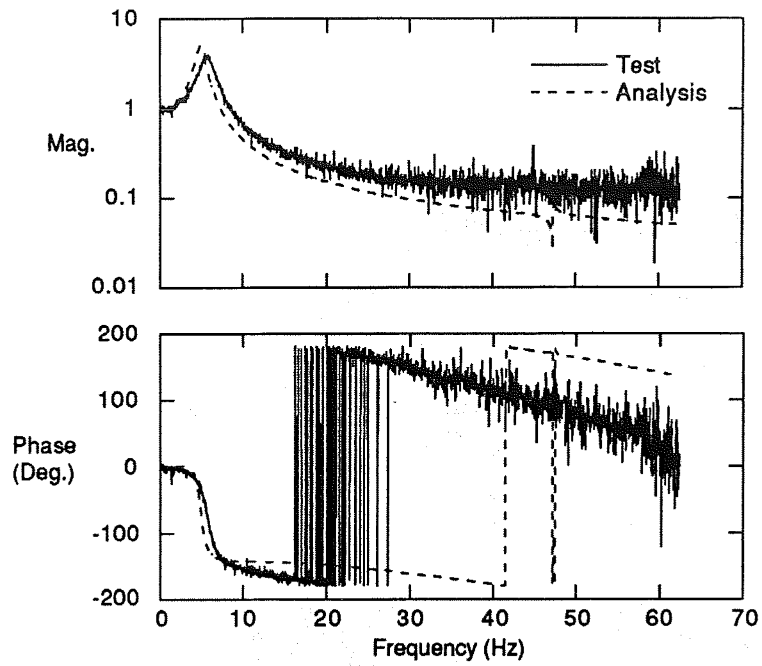
$K_T = 146.5\text{E-06}$ ft-lb/count

$K_{enc} = 132.0\text{E+05}$ counts

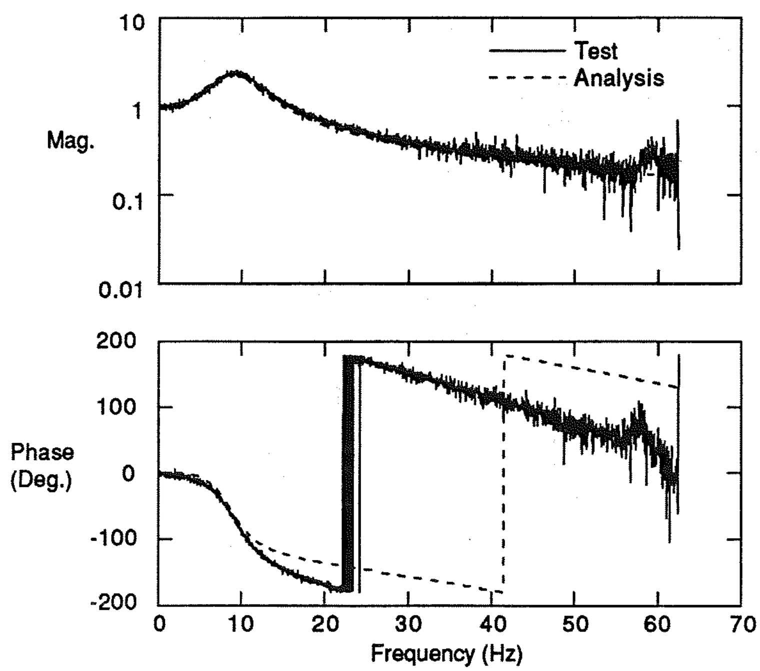
64 counts = 1 arc-sec

$$\frac{u_{cf}(z)}{u_c(z)} = \frac{0.0074z^4 + 0.0296z^3 + 0.0444z^2 + 0.0296z + 0.0074}{z^4 - 2.333z^3 + 2.386z^2 - 1.202z + 0.267}$$

Figure 61. Gimbal controller



a) Outer gimbal



b) Inner gimbal

Figure 62. Bench test results for gimbal system with FEM model

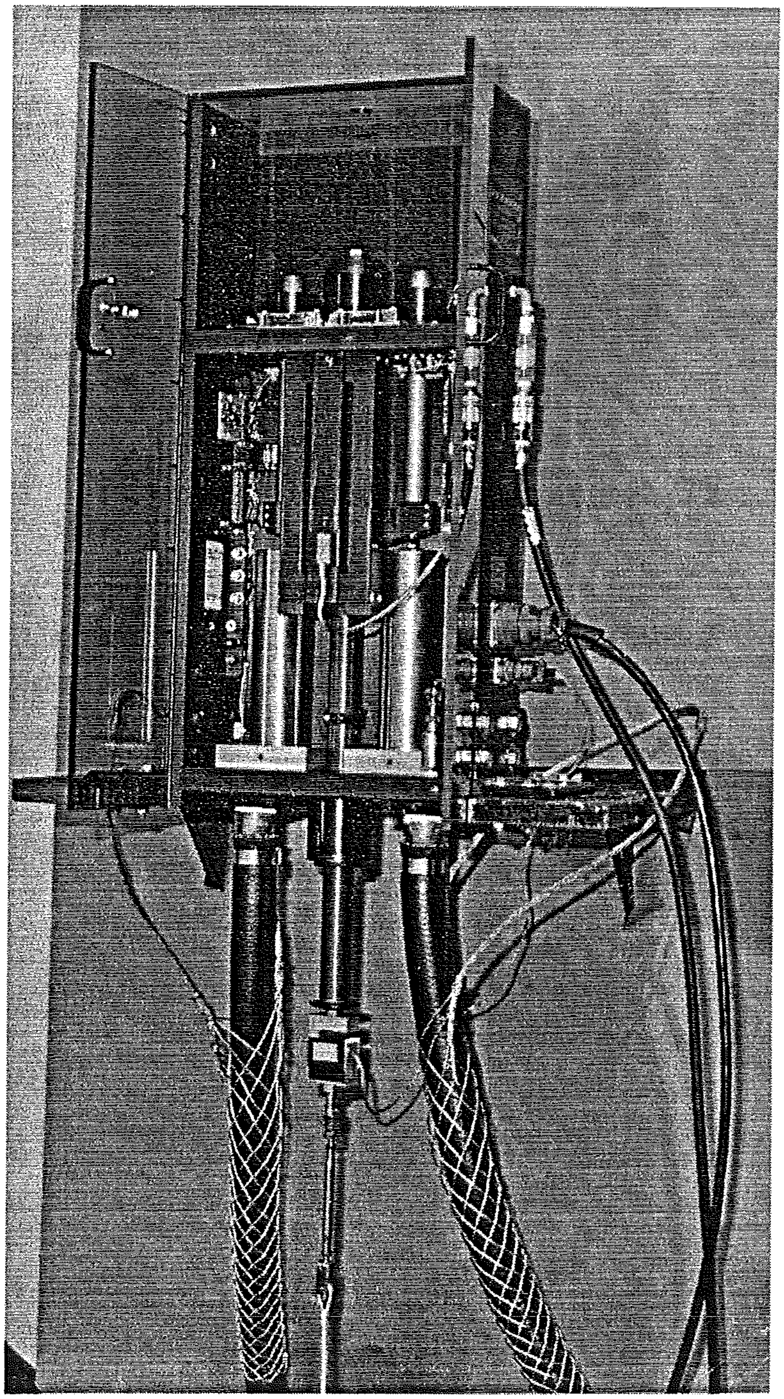


Figure 63. Photograph of suspension mechanism

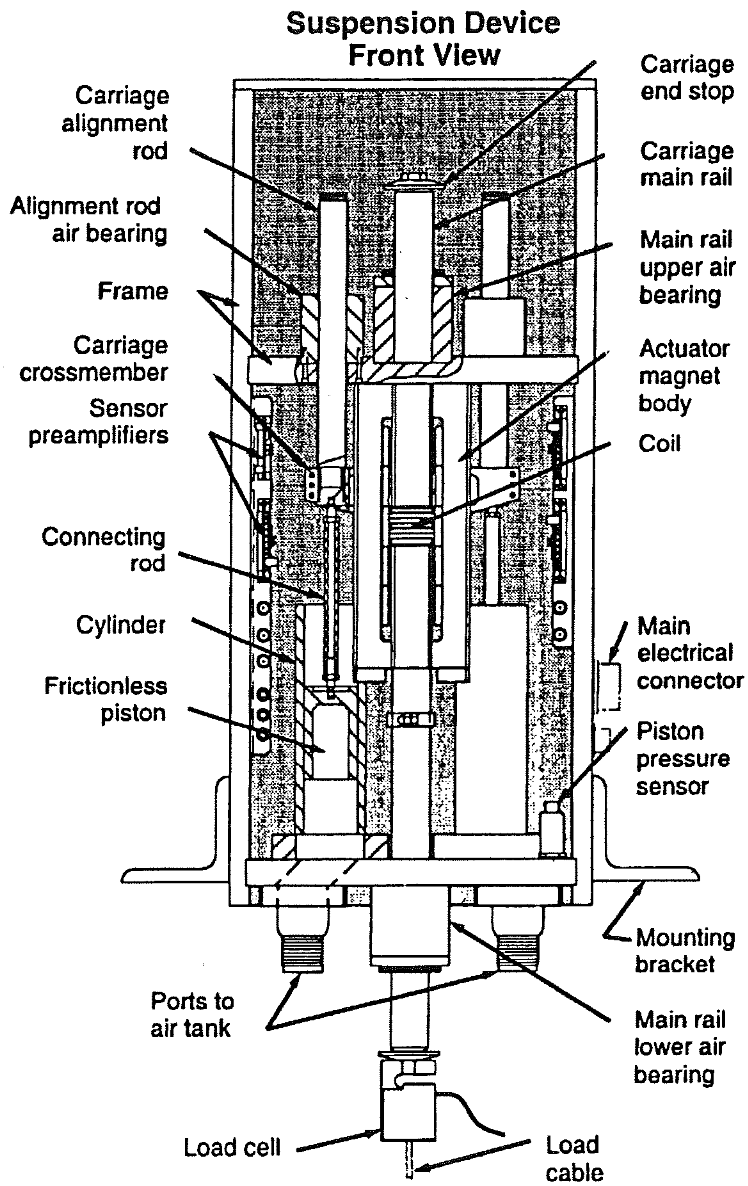


Figure 64. Schematic of suspension systrem device

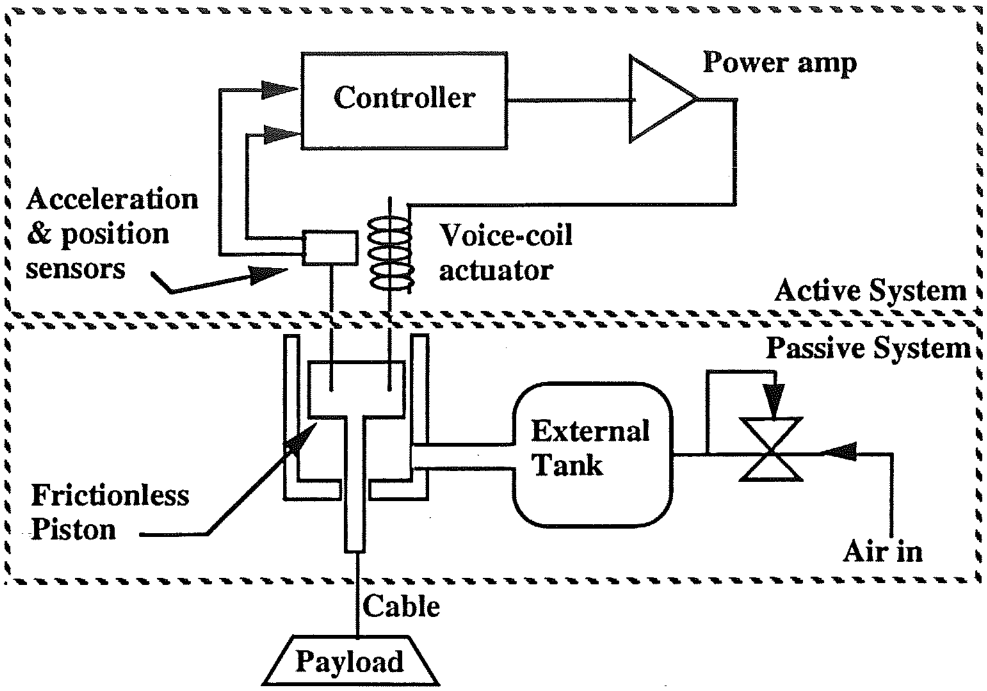


Figure 65. Suspension device operating principle

Appendix A

The following data is the NASTRAN runstream for the Phase-2 CEM model used to compute the mass matrix and the stiffness matrix including differential stiffness due to gravity preload. This data runs under MSC/NASTRAN Version 66, Rigid Format 66.

```
NASTRAN REAL=0, HICORE=1000000
ID PHASE-TWO, CSI EVOLUTIONARY FEM
APP DISPLACEMENT
SOL 66
TIME 12000
CEND
TITLE = CSI GROUND TEST BEAM, P2JULY2693 (july 26,1993)
SUBTITLE = SOL 66
ECHO=UNSORT
LINE = 35
SPC = 100
MPC = 1
SEALL=ALL
LOAD = 200
NLPARM = 100
OUTPUT(PLOT)
 CSCALE=1.8
 PLOTTER NAST
 SET 1 = 1 THRU 500,812 THRU 899,955 THRU 986,1007 THRU 1166,
      1267 THRU 1426,1527 THRU 1550, 1590 THRU 2048,
      2051 THRU 2058
 AXES = X,Y,Z
 VIEW = 214.27,23.17,0.
 FIND SCALE ORIGIN 1 SET 1
 PLOT SET 1 ORIGIN 1
 PLOT STATIC DEFORMATION SET 1 ORIGIN 1 SHAPE
$
$ 4 REDESIGNED AREAS OF THE TRUSS.
$ AREA # 1 - MAIN TRUSS BAYS 1 THRU 20
$ AREA # 2 - THE FWD & AFT SUSPENSION TRUSS, + RFL TRUSS
$ AREA # 3 - THE LASER TOWER
$ AREA # 4 - MAIN TRUSS BAYS 21 THRU 62
$ ALL BATTENS HAVE THE SAME A(eff) and MASS DENSITY 91/12/07
$ ALL DIAGONALS HAVE THE SAME A(eff) and MASS DENSITY 91/12/07
$ UPDATED TRUSS STRUT AREAS AND DENSITIES FROM LOCKHEED TESTS 92/03/11
$ CONSTRAINED BOTTOM OF SPRING
$ THRUSTER AIR TUBING SPRINGS ARE ON
$ PUT SPC ON PLATES WITHOUT NORMAL RESTRAINTS
$ TOOK J OFF SUSPENSION CABLES
$ SUSPENSION CABLE BROKEN INTO 5 ELEMENTS 92/04/14
$ ADDED WEIGHTLESS BEAMS BEHIND THRUSTER PLATES CBEAM 1700 T 1737
$ UPDATE 92/07/25
$ UPDATE 92/08/17
$ UPDATE 92/09/01 ADDED IMU MASS
$ CORRECTED RFL PLATE GRID DISPL COORD 92/09/03
$ ADDED 6 LB MASS AT BOTTOM OF SUSPENSION SPRING 92/09/09
$ CORRECTED DIAGONALS 672 AND 674 92/09/09
BEGIN BULK
$
CORD2C      3      0  615.00 0.00000  56.110  590.22 0.00000  86.707+CS    3
+CS   3  645.60 0.00000  80.885
PARAM,LGDISP,1
NLPARM,100,4,,SEMI,1,30,
PARAM,GRDPNT,0
PARAM,MAXRATIO,1.E+8
```

```
PARAM,COUPMASS,1
GRAV,200,0,386.,0.,0.,-1.
$
SPC1   100   123456 508   509   518   519
SPC1   100   123456 528   529   538   539
SPC1   100   456    510   511   512   513   514
SPC1   100   456    520   521   522   523   524
SPC1   100   456    530   531   532   533   534
SPC1   100   456    540   541   542   543   544
$ Multipoint Constraint for Skewed Shaker Locations
$MPC     1    901   2   1.0   3     2   -0.707    +CS  7
$+CS  7      3     3  -0.707
$MPC     1    901   3   1.0   3     2    0.707    +CS  8
$+CS  8      3     3  -0.707
$MPC     1    902   2   1.0   131   2   -0.707    +CS  9
$+CS  9      131   3  -0.707
$MPC     1    902   3   1.0   131   2    0.707    +CT  1
$+CT  1      131   3  -0.707
$MPC     1    903   1   1.0   372   1   -0.707    +CT  2
$+CT  2      372   3   0.707
$MPC     1    903   3   1.0   372   1   -0.707    +CT  3
$+CT  3      372   3  -0.707
$MPC     1    904   1   1.0   456   1   -0.707    +CT  4
$+CT  4      456   3   0.707
$MPC     1    904   3   1.0   456   1   -0.707    +CT  5
$+CT  5      456   3  -0.707

$ MAIN TRUSS GRID POINTS
GRID,  1, 0,  0.0000,  5.0000,  5.0000
GRID,  2, 0,  0.0000, -5.0000,  5.0000
GRID,  3, 0,  0.0000, -5.0000, -5.0000
GRID,  4, 0,  0.0000,  5.0000, -5.0000
GRID,  5, 0, 10.0000,  5.0000,  5.0000
GRID,  6, 0, 10.0000, -5.0000,  5.0000
GRID,  7, 0, 10.0000, -5.0000, -5.0000
GRID,  8, 0, 10.0000,  5.0000, -5.0000
GRID,  9, 0, 20.0000,  5.0000,  5.0000
GRID, 10, 0, 20.0000, -5.0000,  5.0000
GRID, 11, 0, 20.0000, -5.0000, -5.0000
GRID, 12, 0, 20.0000,  5.0000, -5.0000
GRID, 13, 0, 30.0000,  5.0000,  5.0000
GRID, 14, 0, 30.0000, -5.0000,  5.0000
GRID, 15, 0, 30.0000, -5.0000, -5.0000
GRID, 16, 0, 30.0000,  5.0000, -5.0000
GRID, 17, 0, 40.0000,  5.0000,  5.0000
GRID, 18, 0, 40.0000, -5.0000,  5.0000
GRID, 19, 0, 40.0000, -5.0000, -5.0000
GRID, 20, 0, 40.0000,  5.0000, -5.0000
GRID, 21, 0, 50.0000,  5.0000,  5.0000
GRID, 22, 0, 50.0000, -5.0000,  5.0000
GRID, 23, 0, 50.0000, -5.0000, -5.0000
GRID, 24, 0, 50.0000,  5.0000, -5.0000
GRID, 25, 0, 60.0000,  5.0000,  5.0000
GRID, 26, 0, 60.0000, -5.0000,  5.0000
GRID, 27, 0, 60.0000, -5.0000, -5.0000
GRID, 28, 0, 60.0000,  5.0000, -5.0000
GRID, 29, 0, 70.0000,  5.0000,  5.0000
GRID, 30, 0, 70.0000, -5.0000,  5.0000
GRID, 31, 0, 70.0000, -5.0000, -5.0000
GRID, 32, 0, 70.0000,  5.0000, -5.0000
GRID, 33, 0, 80.0000,  5.0000,  5.0000
GRID, 34, 0, 80.0000, -5.0000,  5.0000
GRID, 35, 0, 80.0000, -5.0000, -5.0000
GRID, 36, 0, 80.0000,  5.0000, -5.0000
GRID, 37, 0, 90.0000,  5.0000,  5.0000
GRID, 38, 0, 90.0000, -5.0000,  5.0000
GRID, 39, 0, 90.0000, -5.0000, -5.0000
GRID, 40, 0, 90.0000,  5.0000, -5.0000
GRID, 41, 0,100.0000,  5.0000,  5.0000
GRID, 42, 0,100.0000, -5.0000,  5.0000
GRID, 43, 0,100.0000, -5.0000, -5.0000
GRID, 44, 0,100.0000,  5.0000, -5.0000
GRID, 45, 0,110.0000,  5.0000,  5.0000
GRID, 46, 0,110.0000, -5.0000,  5.0000
GRID, 47, 0,110.0000, -5.0000, -5.0000
GRID, 48, 0,110.0000,  5.0000, -5.0000
GRID, 49, 0,120.0000,  5.0000,  5.0000
GRID, 50, 0,120.0000, -5.0000,  5.0000
GRID, 51, 0,120.0000, -5.0000, -5.0000
GRID, 52, 0,120.0000,  5.0000, -5.0000
GRID, 53, 0,130.0000,  5.0000,  5.0000
GRID, 54, 0,130.0000, -5.0000,  5.0000
GRID, 55, 0,130.0000, -5.0000, -5.0000
GRID, 56, 0,130.0000,  5.0000, -5.0000
GRID, 57, 0,140.0000,  5.0000,  5.0000
GRID, 58, 0,140.0000, -5.0000,  5.0000
GRID, 59, 0,140.0000, -5.0000, -5.0000
GRID, 60, 0,140.0000,  5.0000, -5.0000
GRID, 61, 0,150.0000,  5.0000,  5.0000
GRID, 62, 0,150.0000, -5.0000,  5.0000
GRID, 63, 0,150.0000, -5.0000, -5.0000
GRID, 64, 0,150.0000,  5.0000, -5.0000
GRID, 65, 0,160.0000,  5.0000,  5.0000
GRID, 66, 0,160.0000, -5.0000,  5.0000
GRID, 67, 0,160.0000, -5.0000, -5.0000
GRID, 68, 0,160.0000,  5.0000, -5.0000
GRID, 69, 0,170.0000,  5.0000,  5.0000
GRID, 70, 0,170.0000, -5.0000,  5.0000
GRID, 71, 0,170.0000, -5.0000, -5.0000
GRID, 72, 0,170.0000,  5.0000, -5.0000
GRID, 73, 0,180.0000,  5.0000,  5.0000
```

```
GRID, 74, 0,180.0000, -5.0000, 5.0000
GRID, 75, 0,180.0000, -5.0000, -5.0000
GRID, 76, 0,180.0000, 5.0000, -5.0000
GRID, 77, 0,190.0000, 5.0000, 5.0000
GRID, 78, 0,190.0000, -5.0000, 5.0000
GRID, 79, 0,190.0000, -5.0000, -5.0000
GRID, 80, 0,190.0000, 5.0000, -5.0000
GRID, 81, 0,200.0000, 5.0000, 5.0000
GRID, 82, 0,200.0000, -5.0000, 5.0000
GRID, 83, 0,200.0000, -5.0000, -5.0000
GRID, 84, 0,200.0000, 5.0000, -5.0000
GRID, 85, 0,210.0000, 5.0000, 5.0000
GRID, 86, 0,210.0000, -5.0000, 5.0000
GRID, 87, 0,210.0000, -5.0000, -5.0000
GRID, 88, 0,210.0000, 5.0000, -5.0000
GRID, 89, 0,220.0000, 5.0000, 5.0000
GRID, 90, 0,220.0000, -5.0000, 5.0000
GRID, 91, 0,220.0000, -5.0000, -5.0000
GRID, 92, 0,220.0000, 5.0000, -5.0000
GRID, 93, 0,230.0000, 5.0000, 5.0000
GRID, 94, 0,230.0000, -5.0000, 5.0000
GRID, 95, 0,230.0000, -5.0000, -5.0000
GRID, 96, 0,230.0000, 5.0000, -5.0000
GRID, 97, 0,240.0000, 5.0000, 5.0000
GRID, 98, 0,240.0000, -5.0000, 5.0000
GRID, 99, 0,240.0000, -5.0000, -5.0000
GRID, 100, 0,240.0000, 5.0000, -5.0000
GRID, 101, 0,250.0000, 5.0000, 5.0000
GRID, 102, 0,250.0000, -5.0000, 5.0000
GRID, 103, 0,250.0000, -5.0000, -5.0000
GRID, 104, 0,250.0000, 5.0000, -5.0000
GRID, 105, 0,260.0000, 5.0000, 5.0000
GRID, 106, 0,260.0000, -5.0000, 5.0000
GRID, 107, 0,260.0000, -5.0000, -5.0000
GRID, 108, 0,260.0000, 5.0000, -5.0000
GRID, 109, 0,270.0000, 5.0000, 5.0000
GRID, 110, 0,270.0000, -5.0000, 5.0000
GRID, 111, 0,270.0000, -5.0000, -5.0000
GRID, 112, 0,270.0000, 5.0000, -5.0000
GRID, 113, 0,280.0000, 5.0000, 5.0000
GRID, 114, 0,280.0000, -5.0000, 5.0000
GRID, 115, 0,280.0000, -5.0000, -5.0000
GRID, 116, 0,280.0000, 5.0000, -5.0000
GRID, 117, 0,290.0000, 5.0000, 5.0000
GRID, 118, 0,290.0000, -5.0000, 5.0000
GRID, 119, 0,290.0000, -5.0000, -5.0000
GRID, 120, 0,290.0000, 5.0000, -5.0000
GRID, 121, 0,300.0000, 5.0000, 5.0000
GRID, 122, 0,300.0000, -5.0000, 5.0000
GRID, 123, 0,300.0000, -5.0000, -5.0000
GRID, 124, 0,300.0000, 5.0000, -5.0000
GRID, 125, 0,310.0000, 5.0000, 5.0000
GRID, 126, 0,310.0000, -5.0000, 5.0000
GRID, 127, 0,310.0000, -5.0000, -5.0000
GRID, 128, 0,310.0000, 5.0000, -5.0000
GRID, 129, 0,320.0000, 5.0000, 5.0000
GRID, 130, 0,320.0000, -5.0000, 5.0000
GRID, 131, 0,320.0000, -5.0000, -5.0000
GRID, 132, 0,320.0000, 5.0000, -5.0000
GRID, 133, 0,330.0000, 5.0000, 5.0000
GRID, 134, 0,330.0000, -5.0000, 5.0000
GRID, 135, 0,330.0000, -5.0000, -5.0000
GRID, 136, 0,330.0000, 5.0000, -5.0000
GRID, 137, 0,340.0000, 5.0000, 5.0000
GRID, 138, 0,340.0000, -5.0000, 5.0000
GRID, 139, 0,340.0000, -5.0000, -5.0000
GRID, 140, 0,340.0000, 5.0000, -5.0000
GRID, 141, 0,350.0000, 5.0000, 5.0000
GRID, 142, 0,350.0000, -5.0000, 5.0000
GRID, 143, 0,350.0000, -5.0000, -5.0000
GRID, 144, 0,350.0000, 5.0000, -5.0000
GRID, 145, 0,360.0000, 5.0000, 5.0000
GRID, 146, 0,360.0000, -5.0000, 5.0000
GRID, 147, 0,360.0000, -5.0000, -5.0000
GRID, 148, 0,360.0000, 5.0000, -5.0000
GRID, 149, 0,370.0000, 5.0000, 5.0000
GRID, 150, 0,370.0000, -5.0000, 5.0000
GRID, 151, 0,370.0000, -5.0000, -5.0000
GRID, 152, 0,370.0000, 5.0000, -5.0000
GRID, 153, 0,380.0000, 5.0000, 5.0000
GRID, 154, 0,380.0000, -5.0000, 5.0000
GRID, 155, 0,380.0000, -5.0000, -5.0000
GRID, 156, 0,380.0000, 5.0000, -5.0000
GRID, 157, 0,390.0000, 5.0000, 5.0000
GRID, 158, 0,390.0000, -5.0000, 5.0000
GRID, 159, 0,390.0000, -5.0000, -5.0000
GRID, 160, 0,390.0000, 5.0000, -5.0000
GRID, 161, 0,400.0000, 5.0000, 5.0000
GRID, 162, 0,400.0000, -5.0000, 5.0000
GRID, 163, 0,400.0000, -5.0000, -5.0000
GRID, 164, 0,400.0000, 5.0000, -5.0000
GRID, 165, 0,410.0000, 5.0000, 5.0000
GRID, 166, 0,410.0000, -5.0000, 5.0000
GRID, 167, 0,410.0000, -5.0000, -5.0000
GRID, 168, 0,410.0000, 5.0000, -5.0000
GRID, 169, 0,420.0000, 5.0000, 5.0000
GRID, 170, 0,420.0000, -5.0000, 5.0000
GRID, 171, 0,420.0000, -5.0000, -5.0000
GRID, 172, 0,420.0000, 5.0000, -5.0000
GRID, 173, 0,430.0000, 5.0000, 5.0000
GRID, 174, 0,430.0000, -5.0000, 5.0000
GRID, 175, 0,430.0000, -5.0000, -5.0000
GRID, 176, 0,430.0000, 5.0000, -5.0000
GRID, 177, 0,440.0000, 5.0000, 5.0000
GRID, 178, 0,440.0000, -5.0000, 5.0000
GRID, 179, 0,440.0000, -5.0000, -5.0000
GRID, 180, 0,440.0000, 5.0000, -5.0000
GRID, 181, 0,450.0000, 5.0000, 5.0000
GRID, 182, 0,450.0000, -5.0000, 5.0000
GRID, 183, 0,450.0000, -5.0000, -5.0000
GRID, 184, 0,450.0000, 5.0000, -5.0000
GRID, 185, 0,460.0000, 5.0000, 5.0000
GRID, 186, 0,460.0000, -5.0000, 5.0000
GRID, 187, 0,460.0000, -5.0000, -5.0000
GRID, 188, 0,460.0000, 5.0000, -5.0000
GRID, 189, 0,470.0000, 5.0000, 5.0000
GRID, 190, 0,470.0000, -5.0000, 5.0000
GRID, 191, 0,470.0000, -5.0000, -5.0000
GRID, 192, 0,470.0000, 5.0000, -5.0000
GRID, 193, 0,480.0000, 5.0000, 5.0000
GRID, 194, 0,480.0000, -5.0000, 5.0000
GRID, 195, 0,480.0000, -5.0000, -5.0000
GRID, 196, 0,480.0000, 5.0000, -5.0000
GRID, 197, 0,490.0000, 5.0000, 5.0000
GRID, 198, 0,490.0000, -5.0000, 5.0000
GRID, 199, 0,490.0000, -5.0000, -5.0000
GRID, 200, 0,490.0000, 5.0000, -5.0000
GRID, 201, 0,500.0000, 5.0000, 5.0000
```

```
GRID, 202, 0,500.0000, -5.0000,  5.0000
GRID, 203, 0,500.0000, -5.0000, -5.0000
GRID, 204, 0,500.0000,  5.0000, -5.0000
GRID, 205, 0,510.0000,  5.0000,  5.0000
GRID, 206, 0,510.0000, -5.0000,  5.0000
GRID, 207, 0,510.0000, -5.0000, -5.0000
GRID, 208, 0,510.0000,  5.0000, -5.0000
GRID, 209, 0,520.0000,  5.0000,  5.0000
GRID, 210, 0,520.0000, -5.0000,  5.0000
GRID, 211, 0,520.0000, -5.0000, -5.0000
GRID, 212, 0,520.0000,  5.0000, -5.0000
GRID, 213, 0,530.0000,  5.0000,  5.0000
GRID, 214, 0,530.0000, -5.0000,  5.0000
GRID, 215, 0,530.0000, -5.0000, -5.0000
GRID, 216, 0,530.0000,  5.0000, -5.0000
GRID, 217, 0,540.0000,  5.0000,  5.0000
GRID, 218, 0,540.0000, -5.0000,  5.0000
GRID, 219, 0,540.0000, -5.0000, -5.0000
GRID, 220, 0,540.0000,  5.0000, -5.0000
GRID, 221, 0,550.0000,  5.0000,  5.0000
GRID, 222, 0,550.0000, -5.0000,  5.0000
GRID, 223, 0,550.0000, -5.0000, -5.0000
GRID, 224, 0,550.0000,  5.0000, -5.0000
GRID, 225, 0,560.0000,  5.0000,  5.0000
GRID, 226, 0,560.0000, -5.0000,  5.0000
GRID, 227, 0,560.0000, -5.0000, -5.0000
GRID, 228, 0,560.0000,  5.0000, -5.0000
GRID, 229, 0,570.0000,  5.0000,  5.0000
GRID, 230, 0,570.0000, -5.0000,  5.0000
GRID, 231, 0,570.0000, -5.0000, -5.0000
GRID, 232, 0,570.0000,  5.0000, -5.0000
GRID, 233, 0,580.0000,  5.0000,  5.0000
GRID, 234, 0,580.0000, -5.0000,  5.0000
GRID, 235, 0,580.0000, -5.0000, -5.0000
GRID, 236, 0,580.0000,  5.0000, -5.0000
GRID, 237, 0,590.0000,  5.0000,  5.0000
GRID, 238, 0,590.0000, -5.0000,  5.0000
GRID, 239, 0,590.0000, -5.0000, -5.0000
GRID, 240, 0,590.0000,  5.0000, -5.0000
GRID, 241, 0,600.0000,  5.0000,  5.0000
GRID, 242, 0,600.0000, -5.0000,  5.0000
GRID, 243, 0,600.0000, -5.0000, -5.0000
GRID, 244, 0,600.0000,  5.0000, -5.0000
GRID, 245, 0,610.0000,  5.0000,  5.0000
GRID, 246, 0,610.0000, -5.0000,  5.0000
GRID, 247, 0,610.0000, -5.0000, -5.0000
GRID, 248, 0,610.0000,  5.0000, -5.0000
GRID, 249, 0,620.0000,  5.0000,  5.0000
GRID, 250, 0,620.0000, -5.0000,  5.0000
GRID, 251, 0,620.0000, -5.0000, -5.0000
GRID, 252, 0,620.0000,  5.0000, -5.0000
$ REFLECTOR TRUSS
GRID, 253, 0,610.0000,  5.0000, 15.0000
GRID, 254, 0,610.0000, -5.0000, 15.0000
GRID, 255, 0,620.0000, -5.0000, 15.0000
GRID, 256, 0,620.0000,  5.0000, 15.0000
GRID, 257, 0,610.0000,  5.0000, 25.0000
GRID, 258, 0,610.0000, -5.0000, 25.0000
GRID, 259, 0,620.0000, -5.0000, 25.0000
GRID, 260, 0,620.0000,  5.0000, 25.0000
GRID, 261, 0,610.0000,  5.0000, 35.0000
GRID, 262, 0,610.0000, -5.0000, 35.0000
GRID, 263, 0,620.0000, -5.0000, 35.0000
GRID, 264, 0,620.0000,  5.0000, 35.0000
GRID, 265, 0,610.0000,  5.0000, 45.0000
GRID, 266, 0,610.0000, -5.0000, 45.0000
GRID, 267, 0,620.0000, -5.0000, 45.0000
GRID, 268, 0,620.0000,  5.0000, 45.0000
$ TOWER TRUSS
GRID, 269, 0,150.0000,  5.0000, 15.0000
GRID, 270, 0,150.0000, -5.0000, 15.0000
GRID, 271, 0,160.0000, -5.0000, 15.0000
GRID, 272, 0,160.0000,  5.0000, 15.0000
GRID, 273, 0,150.0000,  5.0000, 25.0000
GRID, 274, 0,150.0000, -5.0000, 25.0000
GRID, 275, 0,160.0000, -5.0000, 25.0000
GRID, 276, 0,160.0000,  5.0000, 25.0000
GRID, 277, 0,150.0000,  5.0000, 35.0000
GRID, 278, 0,150.0000, -5.0000, 35.0000
GRID, 279, 0,160.0000, -5.0000, 35.0000
GRID, 280, 0,160.0000,  5.0000, 35.0000
GRID, 281, 0,150.0000,  5.0000, 45.0000
GRID, 282, 0,150.0000, -5.0000, 45.0000
GRID, 283, 0,160.0000, -5.0000, 45.0000
GRID, 284, 0,160.0000,  5.0000, 45.0000
GRID, 285, 0,150.0000,  5.0000, 55.0000
GRID, 286, 0,150.0000, -5.0000, 55.0000
GRID, 287, 0,160.0000, -5.0000, 55.0000
GRID, 288, 0,160.0000,  5.0000, 55.0000
GRID, 289, 0,150.0000,  5.0000, 65.0000
GRID, 290, 0,150.0000, -5.0000, 65.0000
GRID, 291, 0,160.0000, -5.0000, 65.0000
GRID, 292, 0,160.0000,  5.0000, 65.0000
GRID, 293, 0,150.0000,  5.0000, 75.0000
GRID, 294, 0,150.0000, -5.0000, 75.0000
GRID, 295, 0,160.0000, -5.0000, 75.0000
GRID, 296, 0,160.0000,  5.0000, 75.0000
GRID, 297, 0,150.0000,  5.0000, 85.0000
GRID, 298, 0,150.0000, -5.0000, 85.0000
GRID, 299, 0,160.0000, -5.0000, 85.0000
GRID, 300, 0,160.0000,  5.0000, 85.0000
GRID, 301, 0,150.0000,  5.0000, 95.0000
GRID, 302, 0,150.0000, -5.0000, 95.0000
GRID, 303, 0,160.0000, -5.0000, 95.0000
GRID, 304, 0,160.0000,  5.0000, 95.0000
GRID, 305, 0,150.0000,  5.0000,105.0000
GRID, 306, 0,150.0000, -5.0000,105.0000
GRID, 307, 0,160.0000, -5.0000,105.0000
GRID, 308, 0,160.0000,  5.0000,105.0000
GRID, 309, 0,150.0000,  5.0000,115.0000
GRID, 310, 0,150.0000, -5.0000,115.0000
GRID, 311, 0,160.0000, -5.0000,115.0000
GRID, 312, 0,160.0000,  5.0000,115.0000
$ FORWARD SUSPENSION TRUSS
GRID, 313, 0,120.0000, 15.0000,  5.0000
GRID, 314, 0,130.0000, 15.0000,  5.0000
GRID, 315, 0,130.0000, 15.0000, -5.0000
GRID, 316, 0,120.0000, 15.0000, -5.0000
GRID, 317, 0,120.0000,-15.0000,  5.0000
GRID, 318, 0,130.0000,-15.0000,  5.0000
GRID, 319, 0,130.0000,-15.0000, -5.0000
GRID, 320, 0,120.0000,-15.0000, -5.0000
GRID, 321, 0,120.0000, 25.0000,  5.0000
GRID, 322, 0,130.0000, 25.0000,  5.0000
GRID, 323, 0,130.0000, 25.0000, -5.0000
GRID, 324, 0,120.0000, 25.0000, -5.0000
GRID, 325, 0,120.0000,-25.0000,  5.0000
GRID, 326, 0,130.0000,-25.0000,  5.0000
```

```
GRID, 327, 0,130.0000,-25.0000, -5.0000
GRID, 328, 0,120.0000,-25.0000, -5.0000
GRID, 329, 0,120.0000, 35.0000,  5.0000
GRID, 330, 0,130.0000, 35.0000,  5.0000
GRID, 331, 0,130.0000, 35.0000, -5.0000
GRID, 332, 0,120.0000, 35.0000, -5.0000
GRID, 333, 0,120.0000,-35.0000,  5.0000
GRID, 334, 0,130.0000,-35.0000,  5.0000
GRID, 335, 0,130.0000,-35.0000, -5.0000
GRID, 336, 0,120.0000,-35.0000, -5.0000
GRID, 337, 0,120.0000, 45.0000,  5.0000
GRID, 338, 0,130.0000, 45.0000,  5.0000
GRID, 339, 0,130.0000, 45.0000, -5.0000
GRID, 340, 0,120.0000, 45.0000, -5.0000
GRID, 341, 0,120.0000,-45.0000,  5.0000
GRID, 342, 0,130.0000,-45.0000,  5.0000
GRID, 343, 0,130.0000,-45.0000, -5.0000
GRID, 344, 0,120.0000,-45.0000, -5.0000
GRID, 345, 0,120.0000, 55.0000,  5.0000
GRID, 346, 0,130.0000, 55.0000,  5.0000
GRID, 347, 0,130.0000, 55.0000, -5.0000
GRID, 348, 0,120.0000, 55.0000, -5.0000
GRID, 349, 0,120.0000,-55.0000,  5.0000
GRID, 350, 0,130.0000,-55.0000,  5.0000
GRID, 351, 0,130.0000,-55.0000, -5.0000
GRID, 352, 0,120.0000,-55.0000, -5.0000
GRID, 353, 0,140.0000, 15.0000,  5.0000
GRID, 354, 0,140.0000, 15.0000, -5.0000
GRID, 355, 0,140.0000,-15.0000,  5.0000
GRID, 356, 0,140.0000,-15.0000, -5.0000
GRID, 357, 0,140.0000, 25.0000,  5.0000
GRID, 358, 0,140.0000, 25.0000, -5.0000
GRID, 359, 0,140.0000,-25.0000,  5.0000
GRID, 360, 0,140.0000,-25.0000, -5.0000
GRID, 361, 0,140.0000, 35.0000,  5.0000
GRID, 362, 0,140.0000, 35.0000, -5.0000
GRID, 363, 0,140.0000,-35.0000,  5.0000
GRID, 364, 0,140.0000,-35.0000, -5.0000
GRID, 365, 0,140.0000, 45.0000,  5.0000
GRID, 366, 0,140.0000, 45.0000, -5.0000
GRID, 367, 0,140.0000,-45.0000,  5.0000
GRID, 368, 0,140.0000,-45.0000, -5.0000
GRID, 369, 0,140.0000, 55.0000,  5.0000
GRID, 370, 0,140.0000, 55.0000, -5.0000
GRID, 371, 0,140.0000,-55.0000,  5.0000
GRID, 372, 0,140.0000,-55.0000, -5.0000
$ BACK SUSPENSION TRUSS
GRID, 397, 0,550.0000, 15.0000,  5.0000
GRID, 398, 0,560.0000, 15.0000,  5.0000
GRID, 399, 0,560.0000, 15.0000, -5.0000
GRID, 400, 0,550.0000, 15.0000, -5.0000
GRID, 401, 0,550.0000,-15.0000,  5.0000
GRID, 402, 0,560.0000,-15.0000,  5.0000
GRID, 403, 0,560.0000,-15.0000, -5.0000
GRID, 404, 0,550.0000,-15.0000, -5.0000
GRID, 405, 0,550.0000, 25.0000,  5.0000
GRID, 406, 0,560.0000, 25.0000,  5.0000
GRID, 407, 0,560.0000, 25.0000, -5.0000
GRID, 408, 0,550.0000, 25.0000, -5.0000
GRID, 409, 0,550.0000,-25.0000,  5.0000
GRID, 410, 0,560.0000,-25.0000,  5.0000
GRID, 411, 0,560.0000,-25.0000, -5.0000
GRID, 412, 0,550.0000,-25.0000, -5.0000
GRID, 413, 0,550.0000, 35.0000,  5.0000
GRID, 414, 0,560.0000, 35.0000,  5.0000
GRID, 415, 0,560.0000, 35.0000, -5.0000
GRID, 416, 0,550.0000, 35.0000, -5.0000
GRID, 417, 0,550.0000,-35.0000,  5.0000
GRID, 418, 0,560.0000,-35.0000,  5.0000
GRID, 419, 0,560.0000,-35.0000, -5.0000
GRID, 420, 0,550.0000,-35.0000, -5.0000
GRID, 421, 0,550.0000, 45.0000,  5.0000
GRID, 422, 0,560.0000, 45.0000,  5.0000
GRID, 423, 0,560.0000, 45.0000, -5.0000
GRID, 424, 0,550.0000, 45.0000, -5.0000
GRID, 425, 0,550.0000,-45.0000,  5.0000
GRID, 426, 0,560.0000,-45.0000,  5.0000
GRID, 427, 0,560.0000,-45.0000, -5.0000
GRID, 428, 0,550.0000,-45.0000, -5.0000
GRID, 429, 0,550.0000, 55.0000,  5.0000
GRID, 430, 0,560.0000, 55.0000,  5.0000
GRID, 431, 0,560.0000, 55.0000, -5.0000
GRID, 432, 0,550.0000, 55.0000, -5.0000
GRID, 433, 0,550.0000,-55.0000,  5.0000
GRID, 434, 0,560.0000,-55.0000,  5.0000
GRID, 435, 0,560.0000,-55.0000, -5.0000
GRID, 436, 0,550.0000,-55.0000, -5.0000
GRID, 437, 0,540.0000, 15.0000,  5.0000
GRID, 438, 0,540.0000, 15.0000, -5.0000
GRID, 439, 0,540.0000,-15.0000,  5.0000
GRID, 440, 0,540.0000,-15.0000, -5.0000
GRID, 441, 0,540.0000, 25.0000,  5.0000
GRID, 442, 0,540.0000, 25.0000, -5.0000
GRID, 443, 0,540.0000,-25.0000,  5.0000
GRID, 444, 0,540.0000,-25.0000, -5.0000
GRID, 445, 0,540.0000, 35.0000,  5.0000
GRID, 446, 0,540.0000, 35.0000, -5.0000
GRID, 447, 0,540.0000,-35.0000,  5.0000
GRID, 448, 0,540.0000,-35.0000, -5.0000
GRID, 449, 0,540.0000, 45.0000,  5.0000
GRID, 450, 0,540.0000, 45.0000, -5.0000
GRID, 451, 0,540.0000,-45.0000,  5.0000
GRID, 452, 0,540.0000,-45.0000, -5.0000
GRID, 453, 0,540.0000, 55.0000,  5.0000
GRID, 454, 0,540.0000, 55.0000, -5.0000
GRID, 455, 0,540.0000,-55.0000,  5.0000
GRID, 456, 0,540.0000,-55.0000, -5.0000
$ REFLECTOR SUPPORT BRACKETS
GRID, 485, 0,610.0000,  5.0000, 52.0600
GRID, 486, 0,610.0000, -5.0000, 52.0600
GRID, 487, 0,620.0000, -5.0000, 60.1600
GRID, 488, 0,620.0000,  5.0000, 60.1600
$ ADDED FOLLOWING GRID PTS. 90/11/28
$ THRUSTERS GRID POINTS
$ FORWARD THRUSTER
GRID, 489, 0,  5.0,  0.0,  5.0
GRID, 490, 0,  5.0, -5.0,  0.0
GRID, 491, 0,  5.0,  0.0, -5.0
GRID, 492, 0,  5.0,  5.0,  0.0
$ TOWER THRUSTER
GRID, 493, 0,155.0,  5.0,100.0
GRID, 494, 0,160.0,  0.0,100.0
GRID, 495, 0,155.0, -5.0,100.0
GRID, 496, 0,150.0,  0.0,100.0
$ LASER GRID POINT
GRID, 497, 0,155.0,  0.0,115.0

$ MIDDLE THRUSTER
```

```
GRID, 498, 0,325.0,  0.0,  5.0
GRID, 499, 0,325.0, -5.0,  0.0
GRID, 500, 0,325.0,  0.0, -5.0
GRID, 501, 0,325.0,  5.0,  0.0
$ REFLECTOR TRUSS THRUSTER
GRID, 502, 0,615.0,  5.0, 40.0
GRID, 503, 0,620.0,  0.0, 40.0
GRID, 504, 0,615.0, -5.0, 40.0
GRID, 505, 0,610.0,  0.0, 40.0
$ FRONT SUSPENSION CABLE, +Y
GRID, 508, 0,130.0000, 50.0000,803.5000
GRID, 509, 0,130.0000, 50.0000,777.0000
GRID, 510, 0,130.0, 50.0,625.
GRID, 511, 0,130.0, 50.0,473.
GRID, 512, 0,130.0, 50.0,321.
GRID, 513, 0,130.0, 50.0,169.
GRID, 514, 0,130.0, 50.0, 17.48
GRID, 515, 0,130.0, 45.0,  6.78
GRID, 516, 0,130.0, 55.0,  6.78
$ FRONT SUSPENSION CABLE, -Y
GRID, 518, 0,130.0000,-50.0000,803.5000
GRID, 519, 0,130.0000,-50.0000,777.0000
GRID, 520, 0,130.0,-50.0,625.
GRID, 521, 0,130.0,-50.0,473.
GRID, 522, 0,130.0,-50.0,321.
GRID, 523, 0,130.0,-50.0,169.
GRID, 524, 0,130.0,-50.0, 17.48
GRID, 525, 0,130.0,-45.0,  6.78
GRID, 526, 0,130.0,-55.0,  6.78
$ BACK SUSPENSION CABLE, +Y
GRID, 528, 0,550.0000, 50.0000,803.5000
GRID, 529, 0,550.0000, 50.0000,777.0000
GRID, 530, 0,550.0, 50.0,625.
GRID, 531, 0,550.0, 50.0,473.
GRID, 532, 0,550.0, 50.0,321.
GRID, 533, 0,550.0, 50.0,169.
GRID, 534, 0,550.0, 50.0, 17.48
GRID, 535, 0,550.0, 45.0,  6.78
GRID, 536, 0,550.0, 55.0,  6.78
$ BACK SUSPENSION CABLE, -Y
GRID, 538, 0,550.0000,-50.0000,803.5000
GRID, 539, 0,550.0000,-50.0000,777.0000
GRID, 540, 0,550.0,-50.0,625.
GRID, 541, 0,550.0,-50.0,473.
GRID, 542, 0,550.0,-50.0,321.
GRID, 543, 0,550.0,-50.0,169.
GRID, 544, 0,550.0,-50.0, 17.48
GRID, 545, 0,550.0,-45.0,  6.78
GRID, 546, 0,550.0,-55.0,  6.78
$ START GIMBAL GRIDS
$ GIMBAL#1 - FORWARD
GRID     550    0 125.000  10.000  12.707   0
GRID     551    0 125.000   5.875  12.707   0
GRID     552    0 132.071   7.071  12.707   0
GRID     553    0 129.154   4.154  12.707   0
GRID     554    0 135.000   0.000  12.707   0
GRID     555    0 130.875   0.000  12.707   0
GRID     556    0 132.071  -7.071  12.707   0
GRID     557    0 129.154  -4.154  12.707   0
GRID     558    0 125.000 -10.000  12.707   0
GRID     559    0 125.000  -5.875  12.707   0
GRID     560    0 117.929  -7.071  12.707   0
GRID     561    0 120.846  -4.154  12.707   0
GRID     562    0 115.000   0.000  12.707   0
GRID     563    0 119.125   0.000  12.707   0
GRID     564    0 117.929   7.071  12.707   0
GRID     565    0 120.846   4.154  12.707   0
GRID     566    0 125.000   5.500  18.707   0
GRID     567    0 125.000   4.250  18.707   0
GRID     568    0 127.105   5.081  18.707   0
GRID     569    0 126.626   3.926  18.707   0
GRID     570    0 128.889   3.889  18.707   0
GRID     571    0 128.005   3.005  18.707   0
GRID     572    0 130.081   2.105  18.707   0
GRID     573    0 128.926   1.626  18.707   0
GRID     574    0 130.500   0.000  18.707   0
GRID     575    0 129.250   0.000  18.707   0
GRID     576    0 130.081  -2.105  18.707   0
GRID     577    0 128.926  -1.626  18.707   0
GRID     578    0 128.889  -3.889  18.707   0
GRID     579    0 128.005  -3.005  18.707   0
GRID     580    0 127.105  -5.081  18.707   0
GRID     581    0 126.626  -3.926  18.707   0
GRID     582    0 125.000  -5.500  18.707   0
GRID     583    0 125.000  -4.250  18.707   0
GRID     584    0 122.895  -5.081  18.707   0
GRID     585    0 123.374  -3.926  18.707   0
GRID     586    0 121.111  -3.889  18.707   0
GRID     587    0 121.995  -3.005  18.707   0
GRID     588    0 119.919  -2.105  18.707   0
GRID     589    0 121.074  -1.626  18.707   0
GRID     590    0 119.500   0.000  18.707   0
GRID     591    0 120.750   0.000  18.707   0
GRID     592    0 119.919   2.105  18.707   0
GRID     593    0 121.074   1.626  18.707   0
GRID     594    0 121.111   3.889  18.707   0
GRID     595    0 121.995   3.005  18.707   0
GRID     596    0 122.895   5.081  18.707   0
GRID     597    0 123.374   3.926  18.707   0
GRID     598    0 134.500   0.000  18.707   0
GRID     599    0 115.500   0.000  18.707   0
GRID     600    0 125.000   9.500  18.707   0
GRID     601    0 125.000  -9.500  18.707   0
GRID     602    0 125.000   0.000  18.707   0
GRID     605    0 140.000   0.000   0.000   0
$ START GIMBAL#2
GRID     650    0 185.000  10.000  12.707   0
GRID     651    0 185.000   5.875  12.707   0
GRID     652    0 192.071   7.071  12.707   0
GRID     653    0 189.154   4.154  12.707   0
GRID     654    0 195.000   0.000  12.707   0
GRID     655    0 190.875   0.000  12.707   0
GRID     656    0 192.071  -7.071  12.707   0
GRID     657    0 189.154  -4.154  12.707   0
GRID     658    0 185.000 -10.000  12.707   0
GRID     659    0 185.000  -5.875  12.707   0
GRID     660    0 177.929  -7.071  12.707   0
GRID     661    0 180.846  -4.154  12.707   0
GRID     662    0 175.000   0.000  12.707   0
GRID     663    0 179.125   0.000  12.707   0
GRID     664    0 177.929   7.071  12.707   0
GRID     665    0 180.846   4.154  12.707   0
GRID     666    0 185.000   5.500  18.707   0
GRID     667    0 185.000   4.250  18.707   0
GRID     668    0 187.105   5.081  18.707   0
GRID     669    0 186.626   3.926  18.707   0
GRID     670    0 188.889   3.889  18.707   0
GRID     671    0 188.005   3.005  18.707   0
```

```
GRID    672   0 190.081  2.105 18.707   0
GRID    673   0 188.926  1.626 18.707   0
GRID    674   0 190.500  0.000 18.707   0
GRID    675   0 189.250  0.000 18.707   0
GRID    676   0 190.081 -2.105 18.707   0
GRID    677   0 188.926 -1.626 18.707   0
GRID    678   0 188.889 -3.889 18.707   0
GRID    679   0 188.005 -3.005 18.707   0
GRID    680   0 187.105 -5.081 18.707   0
GRID    681   0 186.626 -3.926 18.707   0
GRID    682   0 185.000 -5.500 18.707   0
GRID    683   0 185.000 -4.250 18.707   0
GRID    684   0 182.895 -5.081 18.707   0
GRID    685   0 183.374 -3.926 18.707   0
GRID    686   0 181.111 -3.889 18.707   0
GRID    687   0 181.995 -3.005 18.707   0
GRID    688   0 179.919 -2.105 18.707   0
GRID    689   0 181.074 -1.626 18.707   0
GRID    690   0 179.500  0.000 18.707   0
GRID    691   0 180.750  0.000 18.707   0
GRID    692   0 179.919  2.105 18.707   0
GRID    693   0 181.074  1.626 18.707   0
GRID    694   0 181.111  3.889 18.707   0
GRID    695   0 181.995  3.005 18.707   0
GRID    696   0 182.895  5.081 18.707   0
GRID    697   0 183.374  3.926 18.707   0
GRID    698   0 194.500  0.000 18.707   0
GRID    699   0 175.500  0.000 18.707   0
GRID    700   0 185.000  9.500 18.707   0
GRID    701   0 185.000 -9.500 18.707   0
GRID    702   0 185.000  0.000 18.707   0
GRID    705   0 200.000  0.000  0.000   0
$ START GIMBAL#3
GRID    750   0 545.000 10.000 12.707   0
GRID    751   0 545.000  5.875 12.707   0
GRID    752   0 552.071  7.071 12.707   0
GRID    753   0 549.154  4.154 12.707   0
GRID    754   0 555.000  0.000 12.707   0
GRID    755   0 550.875  0.000 12.707   0
GRID    756   0 552.071 -7.071 12.707   0
GRID    757   0 549.154 -4.154 12.707   0
GRID    758   0 545.000 -10.000 12.707  0
GRID    759   0 545.000 -5.875 12.707   0
GRID    760   0 537.929 -7.071 12.707   0
GRID    761   0 540.846 -4.154 12.707   0
GRID    762   0 535.000  0.000 12.707   0
GRID    763   0 539.125  0.000 12.707   0
GRID    764   0 537.929  7.071 12.707   0
GRID    765   0 540.846  4.154 12.707   0
GRID    766   0 545.000  5.500 18.707   0
GRID    767   0 545.000  4.250 18.707   0
GRID    768   0 547.105  5.081 18.707   0
GRID    769   0 546.626  3.926 18.707   0
GRID    770   0 548.889  3.889 18.707   0
GRID    771   0 548.005  3.005 18.707   0
GRID    772   0 550.081  2.105 18.707   0
GRID    773   0 548.926  1.626 18.707   0
GRID    774   0 550.500  0.000 18.707   0
GRID    775   0 549.250  0.000 18.707   0
GRID    776   0 550.081 -2.105 18.707   0
GRID    777   0 548.926 -1.626 18.707   0
GRID    778   0 548.889 -3.889 18.707   0
GRID    779   0 548.005 -3.005 18.707   0
GRID    780   0 547.105 -5.081 18.707   0
GRID    781   0 546.626 -3.926 18.707   0
GRID    782   0 545.000 -5.500 18.707   0
GRID    783   0 545.000 -4.250 18.707   0
GRID    784   0 542.895 -5.081 18.707   0
GRID    785   0 543.374 -3.926 18.707   0
GRID    786   0 541.111 -3.889 18.707   0
GRID    787   0 541.995 -3.005 18.707   0
GRID    788   0 539.919 -2.105 18.707   0
GRID    789   0 541.074 -1.626 18.707   0
GRID    790   0 539.500  0.000 18.707   0
GRID    791   0 540.750  0.000 18.707   0
GRID    792   0 539.919  2.105 18.707   0
GRID    793   0 541.074  1.626 18.707   0
GRID    794   0 541.111  3.889 18.707   0
GRID    795   0 541.995  3.005 18.707   0
GRID    796   0 542.895  5.081 18.707   0
GRID    797   0 543.374  3.926 18.707   0
GRID    798   0 554.500  0.000 18.707   0
GRID    799   0 535.500  0.000 18.707   0
GRID    800   0 545.000  9.500 18.707   0
GRID    801   0 545.000 -9.500 18.707   0
GRID    802   0 545.000  0.000 18.707   0
GRID    805   0 560.000  0.000  0.000   0
$ REFLECTOR 86.4# SPACER PLATE GRID POINTS
GRID,851, 3, 8.1500, 0.0000, 0.811, 0
GRID,852, 3, 8.1500,37.8428, 0.811, 0
GRID,853, 3, 8.1500, 90.0000, 0.811, 0
GRID,854, 3, 8.1500,142.1572, 0.811, 0
GRID,855, 3, 8.1500,180.0000, 0.811, 0
GRID,856, 3, 8.1500,217.8428, 0.811, 0
GRID,857, 3, 8.1500,270.0000, 0.811, 0
GRID,858, 3, 8.1500,322.1572, 0.811, 0
GRID,859, 3, 0.0000, 0.0000, 0.811, 0
$ SHAKER GRID POINTS ADDED (JWG 01/06/92)
GRID,901, 0, 0.0000, -5.000, -5.00
GRID,902, 0, 320.00, -5.000, -5.00
GRID,903, 0, 140.00, -55.000, -5.00
GRID,904, 0, 540.00, -55.000, -5.00
$ START ELEMENTS
$ MAIN TRUSS,20 BAYS,LONGERONS,PID 101
CBEAM,  1,101,  1,  5,0.,1.,1.
CBEAM,  2,101,  2,  6,0.,1.,1.
CBEAM,  3,101,  3,  7,0.,1.,1.
CBEAM,  4,101,  4,  8,0.,1.,1.
CBEAM,  5,101,  5,  9,0.,1.,1.
CBEAM,  6,101,  6, 10,0.,1.,1.
CBEAM,  7,101,  7, 11,0.,1.,1.
CBEAM,  8,101,  8, 12,0.,1.,1.
CBEAM,  9,101,  9, 13,0.,1.,1.
CBEAM, 10,101, 10, 14,0.,1.,1.
CBEAM, 11,101, 11, 15,0.,1.,1.
CBEAM, 12,101, 12, 16,0.,1.,1.
CBEAM, 13,101, 13, 17,0.,1.,1.
CBEAM, 14,101, 14, 18,0.,1.,1.
CBEAM, 15,101, 15, 19,0.,1.,1.
CBEAM, 16,101, 16, 20,0.,1.,1.
CBEAM, 17,101, 17, 21,0.,1.,1.
CBEAM, 18,101, 18, 22,0.,1.,1.
CBEAM, 19,101, 19, 23,0.,1.,1.
CBEAM, 20,101, 20, 24,0.,1.,1.
CBEAM, 21,101, 21, 25,0.,1.,1.
CBEAM, 22,101, 22, 26,0.,1.,1.
CBEAM, 23,101, 23, 27,0.,1.,1.
CBEAM, 24,101, 24, 28,0.,1.,1.
```

```
CBEAM,  25,101,  25,  29,0.,1.,1.
CBEAM,  26,101,  26,  30,0.,1.,1.
CBEAM,  27,101,  27,  31,0.,1.,1.
CBEAM,  28,101,  28,  32,0.,1.,1.
CBEAM,  29,101,  29,  33,0.,1.,1.
CBEAM,  30,101,  30,  34,0.,1.,1.
CBEAM,  31,101,  31,  35,0.,1.,1.
CBEAM,  32,101,  32,  36,0.,1.,1.
CBEAM,  33,101,  33,  37,0.,1.,1.
CBEAM,  34,101,  34,  38,0.,1.,1.
CBEAM,  35,101,  35,  39,0.,1.,1.
CBEAM,  36,101,  36,  40,0.,1.,1.
CBEAM,  37,101,  37,  41,0.,1.,1.
CBEAM,  38,101,  38,  42,0.,1.,1.
CBEAM,  39,101,  39,  43,0.,1.,1.
CBEAM,  40,101,  40,  44,0.,1.,1.
CBEAM,  41,101,  41,  45,0.,1.,1.
CBEAM,  42,101,  42,  46,0.,1.,1.
CBEAM,  43,101,  43,  47,0.,1.,1.
CBEAM,  44,101,  44,  48,0.,1.,1.
CBEAM,  45,101,  45,  49,0.,1.,1.
CBEAM,  46,101,  46,  50,0.,1.,1.
CBEAM,  47,101,  47,  51,0.,1.,1.
CBEAM,  48,101,  48,  52,0.,1.,1.
CBEAM,  49,101,  49,  53,0.,1.,1.
CBEAM,  50,101,  50,  54,0.,1.,1.
CBEAM,  51,101,  51,  55,0.,1.,1.
CBEAM,  52,101,  52,  56,0.,1.,1.
CBEAM,  53,101,  53,  57,0.,1.,1.
CBEAM,  54,101,  54,  58,0.,1.,1.
CBEAM,  55,101,  55,  59,0.,1.,1.
CBEAM,  56,101,  56,  60,0.,1.,1.
CBEAM,  57,101,  57,  61,0.,1.,1.
CBEAM,  58,101,  58,  62,0.,1.,1.
CBEAM,  59,101,  59,  63,0.,1.,1.
CBEAM,  60,101,  60,  64,0.,1.,1.
CBEAM,  61,101,  61,  65,0.,1.,1.
CBEAM,  62,101,  62,  66,0.,1.,1.
CBEAM,  63,101,  63,  67,0.,1.,1.
CBEAM,  64,101,  64,  68,0.,1.,1.
CBEAM,  65,101,  65,  69,0.,1.,1.
CBEAM,  66,101,  66,  70,0.,1.,1.
CBEAM,  67,101,  67,  71,0.,1.,1.
CBEAM,  68,101,  68,  72,0.,1.,1.
CBEAM,  69,101,  69,  73,0.,1.,1.
CBEAM,  70,101,  70,  74,0.,1.,1.
CBEAM,  71,101,  71,  75,0.,1.,1.
CBEAM,  72,101,  72,  76,0.,1.,1.
CBEAM,  73,101,  73,  77,0.,1.,1.
CBEAM,  74,101,  74,  78,0.,1.,1.
CBEAM,  75,101,  75,  79,0.,1.,1.
CBEAM,  76,101,  76,  80,0.,1.,1.
CBEAM,  77,101,  77,  81,0.,1.,1.
CBEAM,  78,101,  78,  82,0.,1.,1.
CBEAM,  79,101,  79,  83,0.,1.,1.
CBEAM,  80,101,  80,  84,0.,1.,1.
CBEAM,  81,401,  81,  85,0.,1.,1.
$ MAIN TRUSS,42 BAYS,LONGERONS,PID 401
CBEAM,  82,401,  82,  86,0.,1.,1.
CBEAM,  83,401,  83,  87,0.,1.,1.
CBEAM,  84,401,  84,  88,0.,1.,1.
CBEAM,  85,401,  85,  89,0.,1.,1.
CBEAM,  86,401,  86,  90,0.,1.,1.
CBEAM,  87,401,  87,  91,0.,1.,1.
CBEAM,  88,401,  88,  92,0.,1.,1.
CBEAM,  89,401,  89,  93,0.,1.,1.
CBEAM,  90,401,  90,  94,0.,1.,1.
CBEAM,  91,401,  91,  95,0.,1.,1.
CBEAM,  92,401,  92,  96,0.,1.,1.
CBEAM,  93,401,  93,  97,0.,1.,1.
CBEAM,  94,401,  94,  98,0.,1.,1.
CBEAM,  95,401,  95,  99,0.,1.,1.
CBEAM,  96,401,  96, 100,0.,1.,1.
CBEAM,  97,401,  97, 101,0.,1.,1.
CBEAM,  98,401,  98, 102,0.,1.,1.
CBEAM,  99,401,  99, 103,0.,1.,1.
CBEAM, 100,401, 100, 104,0.,1.,1.
CBEAM, 101,401, 101, 105,0.,1.,1.
CBEAM, 102,401, 102, 106,0.,1.,1.
CBEAM, 103,401, 103, 107,0.,1.,1.
CBEAM, 104,401, 104, 108,0.,1.,1.
CBEAM, 105,401, 105, 109,0.,1.,1.
CBEAM, 106,401, 106, 110,0.,1.,1.
CBEAM, 107,401, 107, 111,0.,1.,1.
CBEAM, 108,401, 108, 112,0.,1.,1.
CBEAM, 109,401, 109, 113,0.,1.,1.
CBEAM, 110,401, 110, 114,0.,1.,1.
CBEAM, 111,401, 111, 115,0.,1.,1.
CBEAM, 112,401, 112, 116,0.,1.,1.
CBEAM, 113,401, 113, 117,0.,1.,1.
CBEAM, 114,401, 114, 118,0.,1.,1.
CBEAM, 115,401, 115, 119,0.,1.,1.
CBEAM, 116,401, 116, 120,0.,1.,1.
CBEAM, 117,401, 117, 121,0.,1.,1.
CBEAM, 118,401, 118, 122,0.,1.,1.
CBEAM, 119,401, 119, 123,0.,1.,1.
CBEAM, 120,401, 120, 124,0.,1.,1.
CBEAM, 121,401, 121, 125,0.,1.,1.
CBEAM, 122,401, 122, 126,0.,1.,1.
CBEAM, 123,401, 123, 127,0.,1.,1.
CBEAM, 124,401, 124, 128,0.,1.,1.
CBEAM, 125,401, 125, 129,0.,1.,1.
CBEAM, 126,401, 126, 130,0.,1.,1.
CBEAM, 127,401, 127, 131,0.,1.,1.
CBEAM, 128,401, 128, 132,0.,1.,1.
CBEAM, 129,401, 129, 133,0.,1.,1.
CBEAM, 130,401, 130, 134,0.,1.,1.
CBEAM, 131,401, 131, 135,0.,1.,1.
CBEAM, 132,401, 132, 136,0.,1.,1.
CBEAM, 133,401, 133, 137,0.,1.,1.
CBEAM, 134,401, 134, 138,0.,1.,1.
CBEAM, 135,401, 135, 139,0.,1.,1.
CBEAM, 136,401, 136, 140,0.,1.,1.
CBEAM, 137,401, 137, 141,0.,1.,1.
CBEAM, 138,401, 138, 142,0.,1.,1.
CBEAM, 139,401, 139, 143,0.,1.,1.
CBEAM, 140,401, 140, 144,0.,1.,1.
CBEAM, 141,401, 141, 145,0.,1.,1.
CBEAM, 142,401, 142, 146,0.,1.,1.
CBEAM, 143,401, 143, 147,0.,1.,1.
CBEAM, 144,401, 144, 148,0.,1.,1.
CBEAM, 145,401, 145, 149,0.,1.,1.
CBEAM, 146,401, 146, 150,0.,1.,1.
CBEAM, 147,401, 147, 151,0.,1.,1.
CBEAM, 148,401, 148, 152,0.,1.,1.
CBEAM, 149,401, 149, 153,0.,1.,1.
CBEAM, 150,401, 150, 154,0.,1.,1.
CBEAM, 151,401, 151, 155,0.,1.,1.
```

```
CBEAM, 152,401, 152, 156,0.,1.,1.
CBEAM, 153,401, 153, 157,0.,1.,1.
CBEAM, 154,401, 154, 158,0.,1.,1.
CBEAM, 155,401, 155, 159,0.,1.,1.
CBEAM, 156,401, 156, 160,0.,1.,1.
CBEAM, 157,401, 157, 161,0.,1.,1.
CBEAM, 158,401, 158, 162,0.,1.,1.
CBEAM, 159,401, 159, 163,0.,1.,1.
CBEAM, 160,401, 160, 164,0.,1.,1.
CBEAM, 161,401, 161, 165,0.,1.,1.
CBEAM, 162,401, 162, 166,0.,1.,1.
CBEAM, 163,401, 163, 167,0.,1.,1.
CBEAM, 164,401, 164, 168,0.,1.,1.
CBEAM, 165,401, 165, 169,0.,1.,1.
CBEAM, 166,401, 166, 170,0.,1.,1.
CBEAM, 167,401, 167, 171,0.,1.,1.
CBEAM, 168,401, 168, 172,0.,1.,1.
CBEAM, 169,401, 169, 173,0.,1.,1.
CBEAM, 170,401, 170, 174,0.,1.,1.
CBEAM, 171,401, 171, 175,0.,1.,1.
CBEAM, 172,401, 172, 176,0.,1.,1.
CBEAM, 173,401, 173, 177,0.,1.,1.
CBEAM, 174,401, 174, 178,0.,1.,1.
CBEAM, 175,401, 175, 179,0.,1.,1.
CBEAM, 176,401, 176, 180,0.,1.,1.
CBEAM, 177,401, 177, 181,0.,1.,1.
CBEAM, 178,401, 178, 182,0.,1.,1.
CBEAM, 179,401, 179, 183,0.,1.,1.
CBEAM, 180,401, 180, 184,0.,1.,1.
CBEAM, 181,401, 181, 185,0.,1.,1.
CBEAM, 182,401, 182, 186,0.,1.,1.
CBEAM, 183,401, 183, 187,0.,1.,1.
CBEAM, 184,401, 184, 188,0.,1.,1.
CBEAM, 185,401, 185, 189,0.,1.,1.
CBEAM, 186,401, 186, 190,0.,1.,1.
CBEAM, 187,401, 187, 191,0.,1.,1.
CBEAM, 188,401, 188, 192,0.,1.,1.
CBEAM, 189,401, 189, 193,0.,1.,1.
CBEAM, 190,401, 190, 194,0.,1.,1.
CBEAM, 191,401, 191, 195,0.,1.,1.
CBEAM, 192,401, 192, 196,0.,1.,1.
CBEAM, 193,401, 193, 197,0.,1.,1.
CBEAM, 194,401, 194, 198,0.,1.,1.
CBEAM, 195,401, 195, 199,0.,1.,1.
CBEAM, 196,401, 196, 200,0.,1.,1.
CBEAM, 197,401, 197, 201,0.,1.,1.
CBEAM, 198,401, 198, 202,0.,1.,1.
CBEAM, 199,401, 199, 203,0.,1.,1.
CBEAM, 200,401, 200, 204,0.,1.,1.
CBEAM, 201,401, 201, 205,0.,1.,1.
CBEAM, 202,401, 202, 206,0.,1.,1.
CBEAM, 203,401, 203, 207,0.,1.,1.
CBEAM, 204,401, 204, 208,0.,1.,1.
CBEAM, 205,401, 205, 209,0.,1.,1.
CBEAM, 206,401, 206, 210,0.,1.,1.
CBEAM, 207,401, 207, 211,0.,1.,1.
CBEAM, 208,401, 208, 212,0.,1.,1.
CBEAM, 209,401, 209, 213,0.,1.,1.
CBEAM, 210,401, 210, 214,0.,1.,1.
CBEAM, 211,401, 211, 215,0.,1.,1.
CBEAM, 212,401, 212, 216,0.,1.,1.
CBEAM, 213,401, 213, 217,0.,1.,1.
CBEAM, 214,401, 214, 218,0.,1.,1.
CBEAM, 215,401, 215, 219,0.,1.,1.
CBEAM, 216,401, 216, 220,0.,1.,1.
CBEAM, 217,401, 217, 221,0.,1.,1.
CBEAM, 218,401, 218, 222,0.,1.,1.
CBEAM, 219,401, 219, 223,0.,1.,1.
CBEAM, 220,401, 220, 224,0.,1.,1.
CBEAM, 221,401, 221, 225,0.,1.,1.
CBEAM, 222,401, 222, 226,0.,1.,1.
CBEAM, 223,401, 223, 227,0.,1.,1.
CBEAM, 224,401, 224, 228,0.,1.,1.
CBEAM, 225,401, 225, 229,0.,1.,1.
CBEAM, 226,401, 226, 230,0.,1.,1.
CBEAM, 227,401, 227, 231,0.,1.,1.
CBEAM, 228,401, 228, 232,0.,1.,1.
CBEAM, 229,401, 229, 233,0.,1.,1.
CBEAM, 230,401, 230, 234,0.,1.,1.
CBEAM, 231,401, 231, 235,0.,1.,1.
CBEAM, 232,401, 232, 236,0.,1.,1.
CBEAM, 233,401, 233, 237,0.,1.,1.
CBEAM, 234,401, 234, 238,0.,1.,1.
CBEAM, 235,401, 235, 239,0.,1.,1.
CBEAM, 236,401, 236, 240,0.,1.,1.
CBEAM, 237,401, 237, 241,0.,1.,1.
CBEAM, 238,401, 238, 242,0.,1.,1.
CBEAM, 239,401, 239, 243,0.,1.,1.
CBEAM, 240,401, 240, 244,0.,1.,1.
CBEAM, 241,401, 241, 245,0.,1.,1.
CBEAM, 242,401, 242, 246,0.,1.,1.
CBEAM, 243,401, 243, 247,0.,1.,1.
CBEAM, 244,401, 244, 248,0.,1.,1.
CBEAM, 245,401, 245, 249,0.,1.,1.
CBEAM, 246,401, 246, 250,0.,1.,1.
CBEAM, 247,401, 247, 251,0.,1.,1.
CBEAM, 248,401, 248, 252,0.,1.,1.
$ MAIN TRUSS,20 BAYS,BATTENS,PID 102
CBEAM, 249,102,  1,  2,1.,0.,1.
CBEAM, 250,102,  2,  3,1.,0.,1.
CBEAM, 251,102,  3,  4,1.,0.,1.
CBEAM, 252,102,  4,  1,1.,0.,1.
CBEAM, 253,102,  5,  6,1.,0.,1.
CBEAM, 254,102,  6,  7,1.,0.,1.
CBEAM, 255,102,  7,  8,1.,0.,1.
CBEAM, 256,102,  8,  5,1.,0.,1.
CBEAM, 257,102,  9, 10,1.,0.,1.
CBEAM, 258,102, 10, 11,1.,0.,1.
CBEAM, 259,102, 11, 12,1.,0.,1.
CBEAM, 260,102, 12,  9,1.,0.,1.
CBEAM, 261,102, 13, 14,1.,0.,1.
CBEAM, 262,102, 14, 15,1.,0.,1.
CBEAM, 263,102, 15, 16,1.,0.,1.
CBEAM, 264,102, 16, 13,1.,0.,1.
CBEAM, 265,102, 17, 18,1.,0.,1.
CBEAM, 266,102, 18, 19,1.,0.,1.
CBEAM, 267,102, 19, 20,1.,0.,1.
CBEAM, 268,102, 20, 17,1.,0.,1.
CBEAM, 269,102, 21, 22,1.,0.,1.
CBEAM, 270,102, 22, 23,1.,0.,1.
CBEAM, 271,102, 23, 24,1.,0.,1.
CBEAM, 272,102, 24, 21,1.,0.,1.
CBEAM, 273,102, 25, 26,1.,0.,1.
CBEAM, 274,102, 26, 27,1.,0.,1.
CBEAM, 275,102, 27, 28,1.,0.,1.
CBEAM, 276,102, 28, 25,1.,0.,1.
CBEAM, 277,102, 29, 30,1.,0.,1.
CBEAM, 278,102, 30, 31,1.,0.,1.
```

```
CBEAM, 279,102, 31, 32,1.,0.,1.
CBEAM, 280,102, 32, 29,1.,0.,1.
CBEAM, 281,102, 33, 34,1.,0.,1.
CBEAM, 282,102, 34, 35,1.,0.,1.
CBEAM, 283,102, 35, 36,1.,0.,1.
CBEAM, 284,102, 36, 33,1.,0.,1.
CBEAM, 285,102, 37, 38,1.,0.,1.
CBEAM, 286,102, 38, 39,1.,0.,1.
CBEAM, 287,102, 39, 40,1.,0.,1.
CBEAM, 288,102, 40, 37,1.,0.,1.
CBEAM, 289,102, 41, 42,1.,0.,1.
CBEAM, 290,102, 42, 43,1.,0.,1.
CBEAM, 291,102, 43, 44,1.,0.,1.
CBEAM, 292,102, 44, 41,1.,0.,1.
CBEAM, 293,102, 45, 46,1.,0.,1.
CBEAM, 294,102, 46, 47,1.,0.,1.
CBEAM, 295,102, 47, 48,1.,0.,1.
CBEAM, 296,102, 48, 45,1.,0.,1.
CBEAM, 297,102, 49, 50,1.,0.,1.
CBEAM, 298,102, 50, 51,1.,0.,1.
CBEAM, 299,102, 51, 52,1.,0.,1.
CBEAM, 300,102, 52, 49,1.,0.,1.
CBEAM, 301,102, 53, 54,1.,0.,1.
CBEAM, 302,102, 54, 55,1.,0.,1.
CBEAM, 303,102, 55, 56,1.,0.,1.
CBEAM, 304,102, 56, 53,1.,0.,1.
CBEAM, 305,102, 57, 58,1.,0.,1.
CBEAM, 306,102, 58, 59,1.,0.,1.
CBEAM, 307,102, 59, 60,1.,0.,1.
CBEAM, 308,102, 60, 57,1.,0.,1.
CBEAM, 309,102, 61, 62,1.,0.,1.
CBEAM, 310,102, 62, 63,1.,0.,1.
CBEAM, 311,102, 63, 64,1.,0.,1.
CBEAM, 312,102, 64, 61,1.,0.,1.
CBEAM, 313,102, 65, 66,1.,0.,1.
CBEAM, 314,102, 66, 67,1.,0.,1.
CBEAM, 315,102, 67, 68,1.,0.,1.
CBEAM, 316,102, 68, 65,1.,0.,1.
CBEAM, 317,102, 69, 70,1.,0.,1.
CBEAM, 318,102, 70, 71,1.,0.,1.
CBEAM, 319,102, 71, 72,1.,0.,1.
CBEAM, 320,102, 72, 69,1.,0.,1.
CBEAM, 321,102, 73, 74,1.,0.,1.
CBEAM, 322,102, 74, 75,1.,0.,1.
CBEAM, 323,102, 75, 76,1.,0.,1.
CBEAM, 324,102, 76, 73,1.,0.,1.
CBEAM, 325,102, 77, 78,1.,0.,1.
CBEAM, 326,102, 78, 79,1.,0.,1.
CBEAM, 327,102, 79, 80,1.,0.,1.
CBEAM, 328,102, 80, 77,1.,0.,1.
CBEAM, 329,102, 81, 82,1.,0.,1.
CBEAM, 330,102, 82, 83,1.,0.,1.
CBEAM, 331,102, 83, 84,1.,0.,1.
CBEAM, 332,102, 84, 81,1.,0.,1.
$ MAIN TRUSS,42 BAYS,BATTENS,PID 402
CBEAM, 333,402, 85, 86,1.,0.,1.
CBEAM, 334,402, 86, 87,1.,0.,1.
CBEAM, 335,402, 87, 88,1.,0.,1.
CBEAM, 336,402, 88, 85,1.,0.,1.
CBEAM, 337,402, 89, 90,1.,0.,1.
CBEAM, 338,402, 90, 91,1.,0.,1.
CBEAM, 339,402, 91, 92,1.,0.,1.
CBEAM, 340,402, 92, 89,1.,0.,1.
CBEAM, 341,402, 93, 94,1.,0.,1.
CBEAM, 342,402, 94, 95,1.,0.,1.
CBEAM, 343,402, 95, 96,1.,0.,1.
CBEAM, 344,402, 96, 93,1.,0.,1.
CBEAM, 345,402, 97, 98,1.,0.,1.
CBEAM, 346,402, 98, 99,1.,0.,1.
CBEAM, 347,402, 99, 100,1.,0.,1.
CBEAM, 348,402, 100, 97,1.,0.,1.
CBEAM, 349,402, 101, 102,1.,0.,1.
CBEAM, 350,402, 102, 103,1.,0.,1.
CBEAM, 351,402, 103, 104,1.,0.,1.
CBEAM, 352,402, 104, 101,1.,0.,1.
CBEAM, 353,402, 105, 106,1.,0.,1.
CBEAM, 354,402, 106, 107,1.,0.,1.
CBEAM, 355,402, 107, 108,1.,0.,1.
CBEAM, 356,402, 108, 105,1.,0.,1.
CBEAM, 357,402, 109, 110,1.,0.,1.
CBEAM, 358,402, 110, 111,1.,0.,1.
CBEAM, 359,402, 111, 112,1.,0.,1.
CBEAM, 360,402, 112, 109,1.,0.,1.
CBEAM, 361,402, 113, 114,1.,0.,1.
CBEAM, 362,402, 114, 115,1.,0.,1.
CBEAM, 363,402, 115, 116,1.,0.,1.
CBEAM, 364,402, 116, 113,1.,0.,1.
CBEAM, 365,402, 117, 118,1.,0.,1.
CBEAM, 366,402, 118, 119,1.,0.,1.
CBEAM, 367,402, 119, 120,1.,0.,1.
CBEAM, 368,402, 120, 117,1.,0.,1.
CBEAM, 369,402, 121, 122,1.,0.,1.
CBEAM, 370,402, 122, 123,1.,0.,1.
CBEAM, 371,402, 123, 124,1.,0.,1.
CBEAM, 372,402, 124, 121,1.,0.,1.
CBEAM, 373,402, 125, 126,1.,0.,1.
CBEAM, 374,402, 126, 127,1.,0.,1.
CBEAM, 375,402, 127, 128,1.,0.,1.
CBEAM, 376,402, 128, 125,1.,0.,1.
CBEAM, 377,402, 129, 130,1.,0.,1.
CBEAM, 378,402, 130, 131,1.,0.,1.
CBEAM, 379,402, 131, 132,1.,0.,1.
CBEAM, 380,402, 132, 129,1.,0.,1.
CBEAM, 381,402, 133, 134,1.,0.,1.
CBEAM, 382,402, 134, 135,1.,0.,1.
CBEAM, 383,402, 135, 136,1.,0.,1.
CBEAM, 384,402, 136, 133,1.,0.,1.
CBEAM, 385,402, 137, 138,1.,0.,1.
CBEAM, 386,402, 138, 139,1.,0.,1.
CBEAM, 387,402, 139, 140,1.,0.,1.
CBEAM, 388,402, 140, 137,1.,0.,1.
CBEAM, 389,402, 141, 142,1.,0.,1.
CBEAM, 390,402, 142, 143,1.,0.,1.
CBEAM, 391,402, 143, 144,1.,0.,1.
CBEAM, 392,402, 144, 141,1.,0.,1.
CBEAM, 393,402, 145, 146,1.,0.,1.
CBEAM, 394,402, 146, 147,1.,0.,1.
CBEAM, 395,402, 147, 148,1.,0.,1.
CBEAM, 396,402, 148, 145,1.,0.,1.
CBEAM, 397,402, 149, 150,1.,0.,1.
CBEAM, 398,402, 150, 151,1.,0.,1.
CBEAM, 399,402, 151, 152,1.,0.,1.
CBEAM, 400,402, 152, 149,1.,0.,1.
CBEAM, 401,402, 153, 154,1.,0.,1.
CBEAM, 402,402, 154, 155,1.,0.,1.
CBEAM, 403,402, 155, 156,1.,0.,1.
CBEAM, 404,402, 156, 153,1.,0.,1.
CBEAM, 405,402, 157, 158,1.,0.,1.
```

```
CBEAM, 406,402, 158, 159,1.,0.,1.
CBEAM, 407,402, 159, 160,1.,0.,1.
CBEAM, 408,402, 160, 157,1.,0.,1.
CBEAM, 409,402, 161, 162,1.,0.,1.
CBEAM, 410,402, 162, 163,1.,0.,1.
CBEAM, 411,402, 163, 164,1.,0.,1.
CBEAM, 412,402, 164, 161,1.,0.,1.
CBEAM, 413,402, 165, 166,1.,0.,1.
CBEAM, 414,402, 166, 167,1.,0.,1.
CBEAM, 415,402, 167, 168,1.,0.,1.
CBEAM, 416,402, 168, 165,1.,0.,1.
CBEAM, 417,402, 169, 170,1.,0.,1.
CBEAM, 418,402, 170, 171,1.,0.,1.
CBEAM, 419,402, 171, 172,1.,0.,1.
CBEAM, 420,402, 172, 169,1.,0.,1.
CBEAM, 421,402, 173, 174,1.,0.,1.
CBEAM, 422,402, 174, 175,1.,0.,1.
CBEAM, 423,402, 175, 176,1.,0.,1.
CBEAM, 424,402, 176, 173,1.,0.,1.
CBEAM, 425,402, 177, 178,1.,0.,1.
CBEAM, 426,402, 178, 179,1.,0.,1.
CBEAM, 427,402, 179, 180,1.,0.,1.
CBEAM, 428,402, 180, 177,1.,0.,1.
CBEAM, 429,402, 181, 182,1.,0.,1.
CBEAM, 430,402, 182, 183,1.,0.,1.
CBEAM, 431,402, 183, 184,1.,0.,1.
CBEAM, 432,402, 184, 181,1.,0.,1.
CBEAM, 433,402, 185, 186,1.,0.,1.
CBEAM, 434,402, 186, 187,1.,0.,1.
CBEAM, 435,402, 187, 188,1.,0.,1.
CBEAM, 436,402, 188, 185,1.,0.,1.
CBEAM, 437,402, 189, 190,1.,0.,1.
CBEAM, 438,402, 190, 191,1.,0.,1.
CBEAM, 439,402, 191, 192,1.,0.,1.
CBEAM, 440,402, 192, 189,1.,0.,1.
CBEAM, 441,402, 193, 194,1.,0.,1.
CBEAM, 442,402, 194, 195,1.,0.,1.
CBEAM, 443,402, 195, 196,1.,0.,1.
CBEAM, 444,402, 196, 193,1.,0.,1.
CBEAM, 445,402, 197, 198,1.,0.,1.
CBEAM, 446,402, 198, 199,1.,0.,1.
CBEAM, 447,402, 199, 200,1.,0.,1.
CBEAM, 448,402, 200, 197,1.,0.,1.
CBEAM, 449,402, 201, 202,1.,0.,1.
CBEAM, 450,402, 202, 203,1.,0.,1.
CBEAM, 451,402, 203, 204,1.,0.,1.
CBEAM, 452,402, 204, 201,1.,0.,1.
CBEAM, 453,402, 205, 206,1.,0.,1.
CBEAM, 454,402, 206, 207,1.,0.,1.
CBEAM, 455,402, 207, 208,1.,0.,1.
CBEAM, 456,402, 208, 205,1.,0.,1.
CBEAM, 457,402, 209, 210,1.,0.,1.
CBEAM, 458,402, 210, 211,1.,0.,1.
CBEAM, 459,402, 211, 212,1.,0.,1.
CBEAM, 460,402, 212, 209,1.,0.,1.
CBEAM, 461,402, 213, 214,1.,0.,1.
CBEAM, 462,402, 214, 215,1.,0.,1.
CBEAM, 463,402, 215, 216,1.,0.,1.
CBEAM, 464,402, 216, 213,1.,0.,1.
CBEAM, 465,402, 217, 218,1.,0.,1.
CBEAM, 466,402, 218, 219,1.,0.,1.
CBEAM, 467,402, 219, 220,1.,0.,1.
CBEAM, 468,402, 220, 217,1.,0.,1.
CBEAM, 469,402, 221, 222,1.,0.,1.
CBEAM, 470,402, 222, 223,1.,0.,1.
CBEAM, 471,402, 223, 224,1.,0.,1.
CBEAM, 472,402, 224, 221,1.,0.,1.
CBEAM, 473,402, 225, 226,1.,0.,1.
CBEAM, 474,402, 226, 227,1.,0.,1.
CBEAM, 475,402, 227, 228,1.,0.,1.
CBEAM, 476,402, 228, 225,1.,0.,1.
CBEAM, 477,402, 229, 230,1.,0.,1.
CBEAM, 478,402, 230, 231,1.,0.,1.
CBEAM, 479,402, 231, 232,1.,0.,1.
CBEAM, 480,402, 232, 229,1.,0.,1.
CBEAM, 481,402, 233, 234,1.,0.,1.
CBEAM, 482,402, 234, 235,1.,0.,1.
CBEAM, 483,402, 235, 236,1.,0.,1.
CBEAM, 484,402, 236, 233,1.,0.,1.
CBEAM, 485,402, 237, 238,1.,0.,1.
CBEAM, 486,402, 238, 239,1.,0.,1.
CBEAM, 487,402, 239, 240,1.,0.,1.
CBEAM, 488,402, 240, 237,1.,0.,1.
CBEAM, 489,402, 241, 242,1.,0.,1.
CBEAM, 490,402, 242, 243,1.,0.,1.
CBEAM, 491,402, 243, 244,1.,0.,1.
CBEAM, 492,402, 244, 241,1.,0.,1.
CBEAM, 493,402, 245, 246,1.,0.,1.
CBEAM, 494,402, 246, 247,1.,0.,1.
CBEAM, 495,402, 247, 248,1.,0.,1.
CBEAM, 496,402, 248, 245,1.,0.,1.
CBEAM, 497,402, 249, 250,1.,0.,1.
CBEAM, 498,402, 250, 251,1.,0.,1.
CBEAM, 499,402, 251, 252,1.,0.,1.
CBEAM, 500,402, 252, 249,1.,0.,1.
$ MAIN TRUSS,20 BAYS,BATTEN
DIAGONALS,PID 103
CBEAM, 501,103,  1,  3,1.,0.,1.
CBEAM, 502,103,  6,  8,1.,0.,1.
CBEAM, 503,103,  9, 11,1.,0.,1.
CBEAM, 504,103, 14, 16,1.,0.,1.
CBEAM, 505,103, 17, 19,1.,0.,1.
CBEAM, 506,103, 22, 24,1.,0.,1.
CBEAM, 507,103, 25, 27,1.,0.,1.
CBEAM, 508,103, 30, 32,1.,0.,1.
CBEAM, 509,103, 33, 35,1.,0.,1.
CBEAM, 510,103, 38, 40,1.,0.,1.
CBEAM, 511,103, 41, 43,1.,0.,1.
CBEAM, 512,103, 46, 48,1.,0.,1.
CBEAM, 513,103, 49, 51,1.,0.,1.
CBEAM, 514,103, 54, 56,1.,0.,1.
CBEAM, 515,103, 57, 59,1.,0.,1.
CBEAM, 516,103, 62, 64,1.,0.,1.
CBEAM, 517,103, 65, 67,1.,0.,1.
CBEAM, 518,103, 70, 72,1.,0.,1.
CBEAM, 519,103, 73, 75,1.,0.,1.
CBEAM, 520,103, 78, 80,1.,0.,1.
CBEAM, 521,103, 81, 83,1.,0.,1.
$ MAIN TRUSS,42 BAYS,BATTEN
DIAGONALS,PID 403
CBEAM, 522,403, 86, 88,1.,0.,1.
CBEAM, 523,403, 89, 91,1.,0.,1.
CBEAM, 524,403, 94, 96,1.,0.,1.
CBEAM, 525,403, 97, 99,1.,0.,1.
$CBEAM, 526,403, 102, 104,1.,0.,1.
CBEAM, 527,403, 105, 107,1.,0.,1.
CBEAM, 528,403, 110, 112,1.,0.,1.
CBEAM, 529,403, 113, 115,1.,0.,1.
```

```
CBEAM, 530,403, 118, 120,1.,0.,1.
CBEAM, 531,403, 121, 123,1.,0.,1.
CBEAM, 532,403, 126, 128,1.,0.,1.
CBEAM, 533,403, 129, 131,1.,0.,1.
CBEAM, 534,403, 134, 136,1.,0.,1.
CBEAM, 535,403, 137, 139,1.,0.,1.
CBEAM, 536,403, 142, 144,1.,0.,1.
CBEAM, 537,403, 145, 147,1.,0.,1.
CBEAM, 538,403, 150, 152,1.,0.,1.
CBEAM, 539,403, 153, 155,1.,0.,1.
CBEAM, 540,403, 158, 160,1.,0.,1.
CBEAM, 541,403, 161, 163,1.,0.,1.
$CBEAM, 542,403, 166, 168,1.,0.,1.
CBEAM, 543,403, 169, 171,1.,0.,1.
CBEAM, 544,403, 174, 176,1.,0.,1.
CBEAM, 545,403, 177, 179,1.,0.,1.
CBEAM, 546,403, 182, 184,1.,0.,1.
CBEAM, 547,403, 185, 187,1.,0.,1.
CBEAM, 548,403, 190, 192,1.,0.,1.
CBEAM, 549,403, 193, 195,1.,0.,1.
CBEAM, 550,403, 198, 200,1.,0.,1.
CBEAM, 551,403, 201, 203,1.,0.,1.
CBEAM, 552,403, 206, 208,1.,0.,1.
CBEAM, 553,403, 209, 211,1.,0.,1.
CBEAM, 554,403, 214, 216,1.,0.,1.
CBEAM, 555,403, 217, 219,1.,0.,1.
CBEAM, 556,403, 222, 224,1.,0.,1.
CBEAM, 557,403, 225, 227,1.,0.,1.
CBEAM, 558,403, 230, 232,1.,0.,1.
CBEAM, 559,403, 233, 235,1.,0.,1.
CBEAM, 560,403, 238, 240,1.,0.,1.
CBEAM, 561,403, 241, 243,1.,0.,1.
CBEAM, 562,403, 246, 248,1.,0.,1.
CBEAM, 563,403, 249, 251,1.,0.,1.
$ MAIN TRUSS ,20 BAYS,TOP AND BOTTOM
DIAGONALS,PID 103
CBEAM, 566,103, 6, 9,1.,0.,1.
CBEAM, 567,103, 8, 11,1.,0.,1.
CBEAM, 568,103, 9, 14,1.,0.,1.
CBEAM, 569,103, 11, 16,1.,0.,1.
CBEAM, 570,103, 14, 17,1.,0.,1.
CBEAM, 571,103, 16, 19,1.,0.,1.
CBEAM, 572,103, 17, 22,1.,0.,1.
CBEAM, 573,103, 19, 24,1.,0.,1.
CBEAM, 574,103, 22, 25,1.,0.,1.
CBEAM, 575,103, 24, 27,1.,0.,1.
CBEAM, 576,103, 25, 30,1.,0.,1.
CBEAM, 577,103, 27, 32,1.,0.,1.
CBEAM, 578,103, 30, 33,1.,0.,1.
CBEAM, 579,103, 32, 35,1.,0.,1.
CBEAM, 580,103, 33, 38,1.,0.,1.
CBEAM, 581,103, 35, 40,1.,0.,1.
CBEAM, 582,103, 38, 41,1.,0.,1.
CBEAM, 583,103, 40, 43,1.,0.,1.
CBEAM, 584,103, 41, 46,1.,0.,1.
CBEAM, 585,103, 43, 48,1.,0.,1.
CBEAM, 586,103, 46, 49,1.,0.,1.
CBEAM, 587,103, 48, 51,1.,0.,1.
$CBEAM, 588,103, 49, 54,1.,0.,1.
$CBEAM, 589,103, 51, 56,1.,0.,1.
CBEAM, 590,103, 54, 57,1.,0.,1.
CBEAM, 591,103, 56, 59,1.,0.,1.
CBEAM, 592,103, 57, 62,1.,0.,1.
CBEAM, 593,103, 59, 64,1.,0.,1.
CBEAM, 594,103, 62, 65,1.,0.,1.
CBEAM, 595,103, 64, 67,1.,0.,1.
CBEAM, 596,103, 65, 70,1.,0.,1.
CBEAM, 597,103, 67, 72,1.,0.,1.
CBEAM, 598,103, 70, 73,1.,0.,1.
CBEAM, 599,103, 72, 75,1.,0.,1.
$CBEAM, 600,103, 73, 78,1.,0.,1.
$CBEAM, 601,103, 75, 80,1.,0.,1.
CBEAM, 602,103, 78, 81,1.,0.,1.
CBEAM, 603,103, 80, 83,1.,0.,1.
$ MAIN TRUSS,42 BAYS,TOP AND BOTTOM
DIAGONALS,PID 403
CBEAM, 604,403, 81, 86,1.,0.,1.
CBEAM, 605,403, 83, 88,1.,0.,1.
CBEAM, 606,403, 86, 89,1.,0.,1.
CBEAM, 607,403, 88, 91,1.,0.,1.
CBEAM, 608,403, 89, 94,1.,0.,1.
CBEAM, 609,403, 91, 96,1.,0.,1.
CBEAM, 610,403, 94, 97,1.,0.,1.
CBEAM, 611,403, 96, 99,1.,0.,1.
CBEAM, 612,403, 97, 102,1.,0.,1.
CBEAM, 613,403, 99, 104,1.,0.,1.
CBEAM, 614,403, 102, 105,1.,0.,1.
CBEAM, 615,403, 104, 107,1.,0.,1.
CBEAM, 616,403, 105, 110,1.,0.,1.
CBEAM, 617,403, 107, 112,1.,0.,1.
CBEAM, 618,403, 110, 113,1.,0.,1.
CBEAM, 619,403, 112, 115,1.,0.,1.
CBEAM, 620,403, 113, 118,1.,0.,1.
CBEAM, 621,403, 115, 120,1.,0.,1.
CBEAM, 622,403, 118, 121,1.,0.,1.
CBEAM, 623,403, 120, 123,1.,0.,1.
CBEAM, 624,403, 121, 126,1.,0.,1.
CBEAM, 625,403, 123, 128,1.,0.,1.
CBEAM, 626,403, 126, 129,1.,0.,1.
CBEAM, 627,403, 128, 131,1.,0.,1.
CBEAM, 630,403, 134, 137,1.,0.,1.
CBEAM, 631,403, 136, 139,1.,0.,1.
CBEAM, 632,403, 137, 142,1.,0.,1.
CBEAM, 633,403, 139, 144,1.,0.,1.
CBEAM, 634,403, 142, 145,1.,0.,1.
CBEAM, 635,403, 144, 147,1.,0.,1.
CBEAM, 636,403, 145, 150,1.,0.,1.
CBEAM, 637,403, 147, 152,1.,0.,1.
CBEAM, 638,403, 150, 153,1.,0.,1.
CBEAM, 639,403, 152, 155,1.,0.,1.
CBEAM, 640,403, 153, 158,1.,0.,1.
CBEAM, 641,403, 155, 160,1.,0.,1.
CBEAM, 642,403, 158, 161,1.,0.,1.
CBEAM, 643,403, 160, 163,1.,0.,1.
CBEAM, 644,403, 161, 166,1.,0.,1.
CBEAM, 645,403, 163, 168,1.,0.,1.
CBEAM, 646,403, 166, 169,1.,0.,1.
CBEAM, 647,403, 168, 171,1.,0.,1.
CBEAM, 648,403, 169, 174,1.,0.,1.
CBEAM, 649,403, 171, 176,1.,0.,1.
CBEAM, 650,403, 174, 177,1.,0.,1.
CBEAM, 651,403, 176, 179,1.,0.,1.
CBEAM, 652,403, 177, 182,1.,0.,1.
CBEAM, 653,403, 179, 184,1.,0.,1.
CBEAM, 654,403, 182, 185,1.,0.,1.
CBEAM, 655,403, 184, 187,1.,0.,1.
CBEAM, 656,403, 185, 190,1.,0.,1.
CBEAM, 657,403, 187, 192,1.,0.,1.
```

```
CBEAM, 658,403, 190, 193,1.,0.,1.
CBEAM, 659,403, 192, 195,1.,0.,1.
CBEAM, 660,403, 193, 198,1.,0.,1.
CBEAM, 661,403, 195, 200,1.,0.,1.
CBEAM, 662,403, 198, 201,1.,0.,1.
CBEAM, 663,403, 200, 203,1.,0.,1.
CBEAM, 664,403, 201, 206,1.,0.,1.
CBEAM, 665,403, 203, 208,1.,0.,1.
CBEAM, 666,403, 206, 209,1.,0.,1.
CBEAM, 667,403, 208, 211,1.,0.,1.
CBEAM, 668,403, 209, 214,1.,0.,1.
CBEAM, 669,403, 211, 216,1.,0.,1.
CBEAM, 670,403, 214, 217,1.,0.,1.
CBEAM, 671,403, 216, 219,1.,0.,1.
$CBEAM, 672,403, 217, 222,1.,0.,1.
$CBEAM, 673,403, 219, 224,1.,0.,1.
CBEAM, 674,403, 222, 225,1.,0.,1.
CBEAM, 675,403, 224, 227,1.,0.,1.
CBEAM, 676,403, 225, 230,1.,0.,1.
CBEAM, 677,403, 227, 232,1.,0.,1.
CBEAM, 678,403, 230, 233,1.,0.,1.
CBEAM, 679,403, 232, 235,1.,0.,1.
CBEAM, 680,403, 233, 238,1.,0.,1.
CBEAM, 681,403, 235, 240,1.,0.,1.
CBEAM, 682,403, 238, 241,1.,0.,1.
CBEAM, 683,403, 240, 243,1.,0.,1.
CBEAM, 684,403, 241, 246,1.,0.,1.
CBEAM, 685,403, 243, 248,1.,0.,1.
CBEAM, 686,403, 246, 249,1.,0.,1.
CBEAM, 687,403, 248, 251,1.,0.,1.
$ MAIN TRUSS,20 BAYS,SIDE DIAGONALS,
PID 103
CBEAM, 690,103, 7, 10,0.,1.,1.
CBEAM, 691,103, 5, 12,0.,1.,1.
CBEAM, 692,103, 10, 15,0.,1.,1.
CBEAM, 693,103, 12, 13,0.,1.,1.
CBEAM, 694,103, 15, 18,0.,1.,1.
CBEAM, 695,103, 13, 20,0.,1.,1.
CBEAM, 696,103, 18, 23,0.,1.,1.
CBEAM, 697,103, 20, 21,0.,1.,1.
CBEAM, 698,103, 23, 26,0.,1.,1.
CBEAM, 699,103, 21, 28,0.,1.,1.
CBEAM, 700,103, 26, 31,0.,1.,1.
CBEAM, 701,103, 28, 29,0.,1.,1.
CBEAM, 702,103, 31, 34,0.,1.,1.
CBEAM, 703,103, 29, 36,0.,1.,1.
CBEAM, 704,103, 34, 39,0.,1.,1.
CBEAM, 705,103, 36, 37,0.,1.,1.
CBEAM, 706,103, 39, 42,0.,1.,1.
CBEAM, 707,103, 37, 44,0.,1.,1.
CBEAM, 708,103, 42, 47,0.,1.,1.
CBEAM, 709,103, 44, 45,0.,1.,1.
CBEAM, 710,103, 47, 50,0.,1.,1.
CBEAM, 711,103, 45, 52,0.,1.,1.
CBEAM, 712,103, 50, 55,0.,1.,1.
CBEAM, 713,103, 52, 53,0.,1.,1.
CBEAM, 714,103, 55, 58,0.,1.,1.
CBEAM, 715,103, 53, 60,0.,1.,1.
CBEAM, 716,103, 58, 63,0.,1.,1.
CBEAM, 717,103, 60, 61,0.,1.,1.
CBEAM, 718,103, 63, 66,0.,1.,1.
CBEAM, 719,103, 61, 68,0.,1.,1.
CBEAM, 720,103, 66, 71,0.,1.,1.
CBEAM, 721,103, 68, 69,0.,1.,1.
CBEAM, 722,103, 71, 74,0.,1.,1.
CBEAM, 723,103, 69, 76,0.,1.,1.
CBEAM, 724,103, 74, 79,0.,1.,1.
CBEAM, 725,103, 76, 77,0.,1.,1.
CBEAM, 726,103, 79, 82,0.,1.,1.
CBEAM, 727,103, 77, 84,0.,1.,1.
$ MAIN TRUSS ,42 BAYS,SIDE DIAGONALS,
PID 403
CBEAM, 728,403, 82, 87,0.,1.,1.
CBEAM, 729,403, 84, 85,0.,1.,1.
CBEAM, 730,403, 87, 90,0.,1.,1.
CBEAM, 731,403, 85, 92,0.,1.,1.
CBEAM, 732,403, 90, 95,0.,1.,1.
CBEAM, 733,403, 92, 93,0.,1.,1.
CBEAM, 734,403, 95, 98,0.,1.,1.
CBEAM, 735,403, 93, 100,0.,1.,1.
CBEAM, 736,403, 98, 103,0.,1.,1.
CBEAM, 737,403, 100, 101,0.,1.,1.
CBEAM, 738,403, 103, 106,0.,1.,1.
CBEAM, 739,403, 101, 108,0.,1.,1.
CBEAM, 740,403, 106, 111,0.,1.,1.
CBEAM, 741,403, 108, 109,0.,1.,1.
CBEAM, 742,403, 111, 114,0.,1.,1.
CBEAM, 743,403, 109, 116,0.,1.,1.
CBEAM, 744,403, 114, 119,0.,1.,1.
CBEAM, 745,403, 116, 117,0.,1.,1.
CBEAM, 746,403, 119, 122,0.,1.,1.
CBEAM, 747,403, 117, 124,0.,1.,1.
CBEAM, 748,403, 122, 127,0.,1.,1.
CBEAM, 749,403, 124, 125,0.,1.,1.
CBEAM, 750,403, 127, 130,0.,1.,1.
CBEAM, 751,403, 125, 132,0.,1.,1.
CBEAM, 754,403, 135, 138,0.,1.,1.
CBEAM, 755,403, 133, 140,0.,1.,1.
CBEAM, 756,403, 138, 143,0.,1.,1.
CBEAM, 757,403, 140, 141,0.,1.,1.
CBEAM, 758,403, 143, 146,0.,1.,1.
CBEAM, 759,403, 141, 148,0.,1.,1.
CBEAM, 760,403, 146, 151,0.,1.,1.
CBEAM, 761,403, 148, 149,0.,1.,1.
CBEAM, 762,403, 151, 154,0.,1.,1.
CBEAM, 763,403, 149, 156,0.,1.,1.
CBEAM, 764,403, 154, 159,0.,1.,1.
CBEAM, 765,403, 156, 157,0.,1.,1.
CBEAM, 766,403, 159, 162,0.,1.,1.
CBEAM, 767,403, 157, 164,0.,1.,1.
CBEAM, 768,403, 162, 167,0.,1.,1.
CBEAM, 769,403, 164, 165,0.,1.,1.
CBEAM, 770,403, 167, 170,0.,1.,1.
CBEAM, 771,403, 165, 172,0.,1.,1.
CBEAM, 772,403, 170, 175,0.,1.,1.
CBEAM, 773,403, 172, 173,0.,1.,1.
CBEAM, 774,403, 175, 178,0.,1.,1.
CBEAM, 775,403, 173, 180,0.,1.,1.
CBEAM, 776,403, 178, 183,0.,1.,1.
CBEAM, 777,403, 180, 181,0.,1.,1.
CBEAM, 778,403, 183, 186,0.,1.,1.
CBEAM, 779,403, 181, 188,0.,1.,1.
CBEAM, 780,403, 186, 191,0.,1.,1.
CBEAM, 781,403, 188, 189,0.,1.,1.
CBEAM, 782,403, 191, 194,0.,1.,1.
CBEAM, 783,403, 189, 196,0.,1.,1.
CBEAM, 784,403, 194, 199,0.,1.,1.
CBEAM, 785,403, 196, 197,0.,1.,1.
```

```
CBEAM, 786,403, 199, 202,0.,1.,1.
CBEAM, 787,403, 197, 204,0.,1.,1.
CBEAM, 788,403, 202, 207,0.,1.,1.
CBEAM, 789,403, 204, 205,0.,1.,1.
CBEAM, 790,403, 207, 210,0.,1.,1.
CBEAM, 791,403, 205, 212,0.,1.,1.
CBEAM, 792,403, 210, 215,0.,1.,1.
CBEAM, 793,403, 212, 213,0.,1.,1.
CBEAM, 794,403, 215, 218,0.,1.,1.
CBEAM, 795,403, 213, 220,0.,1.,1.
CBEAM, 796,403, 218, 223,0.,1.,1.
CBEAM, 797,403, 220, 221,0.,1.,1.
CBEAM, 798,403, 223, 226,0.,1.,1.
CBEAM, 799,403, 221, 228,0.,1.,1.
CBEAM, 800,403, 226, 231,0.,1.,1.
CBEAM, 801,403, 228, 229,0.,1.,1.
CBEAM, 802,403, 231, 234,0.,1.,1.
CBEAM, 803,403, 229, 236,0.,1.,1.
CBEAM, 804,403, 234, 239,0.,1.,1.
CBEAM, 805,403, 236, 237,0.,1.,1.
CBEAM, 806,403, 239, 242,0.,1.,1.
CBEAM, 807,403, 237, 244,0.,1.,1.
CBEAM, 808,403, 242, 247,0.,1.,1.
CBEAM, 809,403, 244, 245,0.,1.,1.
CBEAM, 810,403, 247, 250,0.,1.,1.
CBEAM, 811,403, 245, 252,0.,1.,1.
$ TOWER TRUSS, LONGERONS, PID 301
CBEAM, 812,301,  61, 269,1.,1.,0.
CBEAM, 813,301,  62, 270,1.,1.,0.
CBEAM, 814,301,  66, 271,1.,1.,0.
CBEAM, 815,301,  65, 272,1.,1.,0.
CBEAM, 816,301, 269, 273,1.,1.,0.
CBEAM, 817,301, 270, 274,1.,1.,0.
CBEAM, 818,301, 271, 275,1.,1.,0.
CBEAM, 819,301, 272, 276,1.,1.,0.
CBEAM, 820,301, 273, 277,1.,1.,0.
CBEAM, 821,301, 274, 278,1.,1.,0.
CBEAM, 822,301, 275, 279,1.,1.,0.
CBEAM, 823,301, 276, 280,1.,1.,0.
CBEAM, 824,301, 277, 281,1.,1.,0.
CBEAM, 825,301, 278, 282,1.,1.,0.
CBEAM, 826,301, 279, 283,1.,1.,0.
CBEAM, 827,301, 280, 284,1.,1.,0.
CBEAM, 828,301, 281, 285,1.,1.,0.
CBEAM, 829,301, 282, 286,1.,1.,0.
CBEAM, 830,301, 283, 287,1.,1.,0.
CBEAM, 831,301, 284, 288,1.,1.,0.
CBEAM, 832,301, 285, 289,1.,1.,0.
CBEAM, 833,301, 286, 290,1.,1.,0.
CBEAM, 834,301, 287, 291,1.,1.,0.
CBEAM, 835,301, 288, 292,1.,1.,0.
CBEAM, 836,301, 289, 293,1.,1.,0.
CBEAM, 837,301, 290, 294,1.,1.,0.
CBEAM, 838,301, 291, 295,1.,1.,0.
CBEAM, 839,301, 292, 296,1.,1.,0.
CBEAM, 840,301, 293, 297,1.,1.,0.
CBEAM, 841,301, 294, 298,1.,1.,0.
CBEAM, 842,301, 295, 299,1.,1.,0.
CBEAM, 843,301, 296, 300,1.,1.,0.
CBEAM, 844,301, 297, 301,1.,1.,0.
CBEAM, 845,301, 298, 302,1.,1.,0.
CBEAM, 846,301, 299, 303,1.,1.,0.
CBEAM, 847,301, 300, 304,1.,1.,0.
CBEAM, 848,301, 301, 305,1.,1.,0.
CBEAM, 849,301, 302, 306,1.,1.,0.
CBEAM, 850,301, 303, 307,1.,1.,0.
CBEAM, 851,301, 304, 308,1.,1.,0.
CBEAM, 852,301, 305, 309,1.,1.,0.
CBEAM, 853,301, 306, 310,1.,1.,0.
CBEAM, 854,301, 307, 311,1.,1.,0.
CBEAM, 855,301, 308, 312,1.,1.,0.
$ TOWER TRUSS, BATTENS, PID 302
CBEAM, 856,302, 269, 270,1.,0.,1.
CBEAM, 857,302, 270, 271,1.,0.,1.
CBEAM, 858,302, 271, 272,1.,0.,1.
CBEAM, 859,302, 272, 269,1.,0.,1.
CBEAM, 860,302, 273, 274,1.,0.,1.
CBEAM, 861,302, 274, 275,1.,0.,1.
CBEAM, 862,302, 275, 276,1.,0.,1.
CBEAM, 863,302, 276, 273,1.,0.,1.
CBEAM, 864,302, 277, 278,1.,0.,1.
CBEAM, 865,302, 278, 279,1.,0.,1.
CBEAM, 866,302, 279, 280,1.,0.,1.
CBEAM, 867,302, 280, 277,1.,0.,1.
CBEAM, 868,302, 281, 282,1.,0.,1.
CBEAM, 869,302, 282, 283,1.,0.,1.
CBEAM, 870,302, 283, 284,1.,0.,1.
CBEAM, 871,302, 284, 281,1.,0.,1.
CBEAM, 872,302, 285, 286,1.,0.,1.
CBEAM, 873,302, 286, 287,1.,0.,1.
CBEAM, 874,302, 287, 288,1.,0.,1.
CBEAM, 875,302, 288, 285,1.,0.,1.
CBEAM, 876,302, 289, 290,1.,0.,1.
CBEAM, 877,302, 290, 291,1.,0.,1.
CBEAM, 878,302, 291, 292,1.,0.,1.
CBEAM, 879,302, 292, 289,1.,0.,1.
CBEAM, 880,302, 293, 294,1.,0.,1.
CBEAM, 881,302, 294, 295,1.,0.,1.
CBEAM, 882,302, 295, 296,1.,0.,1.
CBEAM, 883,302, 296, 293,1.,0.,1.
CBEAM, 884,302, 297, 298,1.,0.,1.
CBEAM, 885,302, 298, 299,1.,0.,1.
CBEAM, 886,302, 299, 300,1.,0.,1.
CBEAM, 887,302, 300, 297,1.,0.,1.
CBEAM, 888,302, 301, 302,1.,0.,1.
CBEAM, 889,302, 302, 303,1.,0.,1.
CBEAM, 890,302, 303, 304,1.,0.,1.
CBEAM, 891,302, 304, 301,1.,0.,1.
CBEAM, 892,302, 305, 306,1.,0.,1.
CBEAM, 893,302, 306, 307,1.,0.,1.
CBEAM, 894,302, 307, 308,1.,0.,1.
CBEAM, 895,302, 308, 305,1.,0.,1.
CBEAM, 896,302, 309, 310,1.,0.,1.
CBEAM, 897,302, 310, 311,1.,0.,1.
CBEAM, 898,302, 311, 312,1.,0.,1.
CBEAM, 899,302, 312, 309,1.,0.,1.
$ TOWER TRUSS, BATTEN DIAGONALS, PID 303
CBEAM, 900,303, 270, 272,1.,0.,1.
CBEAM, 901,303, 273, 275,1.,0.,1.
CBEAM, 902,303, 278, 280,1.,0.,1.
CBEAM, 903,303, 281, 283,1.,0.,1.
CBEAM, 904,303, 286, 288,1.,0.,1.
CBEAM, 905,303, 289, 291,1.,0.,1.
CBEAM, 906,303, 294, 296,1.,0.,1.
CBEAM, 907,303, 297, 299,1.,0.,1.
CBEAM, 908,303, 302, 304,1.,0.,1.
CBEAM, 909,303, 305, 307,1.,0.,1.
```

```
$ TOWER TRUSS, FRONT AND BACK
DIAGONALS, PID 303
CBEAM, 911,303, 61, 272,0.,1.,1.
CBEAM, 912,303, 66, 270,0.,1.,1.
CBEAM, 913,303, 270, 275,0.,1.,1.
CBEAM, 914,303, 272, 273,0.,1.,1.
CBEAM, 915,303, 275, 278,0.,1.,1.
CBEAM, 916,303, 273, 280,0.,1.,1.
CBEAM, 917,303, 278, 283,0.,1.,1.
CBEAM, 918,303, 280, 281,0.,1.,1.
CBEAM, 919,303, 283, 286,0.,1.,1.
CBEAM, 920,303, 281, 288,0.,1.,1.
CBEAM, 921,303, 286, 291,0.,1.,1.
CBEAM, 922,303, 288, 289,0.,1.,1.
CBEAM, 923,303, 291, 294,0.,1.,1.
CBEAM, 924,303, 289, 296,0.,1.,1.
CBEAM, 925,303, 294, 299,0.,1.,1.
CBEAM, 926,303, 296, 297,0.,1.,1.
CBEAM, 927,303, 299, 302,0.,1.,1.
CBEAM, 928,303, 297, 304,0.,1.,1.
$ BAY BREAK FOR THRUSTER
CBEAM, 931,303, 307, 310,0.,1.,1.
CBEAM, 932,303, 305, 312,0.,1.,1.
$ TOWER TRUSS, SIDE DIAGONALS, PID 303
CBEAM, 933,303, 62, 269,1.,0.,1.
CBEAM, 934,303, 65, 271,1.,0.,1.
CBEAM, 935,303, 269, 274,1.,0.,1.
CBEAM, 936,303, 271, 276,1.,0.,1.
CBEAM, 937,303, 274, 277,1.,0.,1.
CBEAM, 938,303, 276, 279,1.,0.,1.
CBEAM, 939,303, 277, 282,1.,0.,1.
CBEAM, 940,303, 279, 284,1.,0.,1.
CBEAM, 941,303, 282, 285,1.,0.,1.
CBEAM, 942,303, 284, 287,1.,0.,1.
CBEAM, 943,303, 285, 290,1.,0.,1.
CBEAM, 944,303, 287, 292,1.,0.,1.
CBEAM, 945,303, 290, 293,1.,0.,1.
CBEAM, 946,303, 292, 295,1.,0.,1.
CBEAM, 947,303, 293, 298,1.,0.,1.
CBEAM, 948,303, 295, 300,1.,0.,1.
CBEAM, 949,303, 298, 301,1.,0.,1.
CBEAM, 950,303, 300, 303,1.,0.,1.
$ BAY BREAK FOR THRUSTER
CBEAM, 953,303, 306, 309,1.,0.,1.
CBEAM, 954,303, 308, 311,1.,0.,1.
$ REFLECTOR TRUSS, LONGERONS, PID 201
CBEAM, 955,201, 245, 253,1.,1.,0.
CBEAM, 956,201, 246, 254,1.,1.,0.
CBEAM, 957,201, 250, 255,1.,1.,0.
CBEAM, 958,201, 249, 256,1.,1.,0.
CBEAM, 959,201, 253, 257,1.,1.,0.
CBEAM, 960,201, 254, 258,1.,1.,0.
CBEAM, 961,201, 255, 259,1.,1.,0.
CBEAM, 962,201, 256, 260,1.,1.,0.
CBEAM, 963,201, 257, 261,1.,1.,0.
CBEAM, 964,201, 258, 262,1.,1.,0.
CBEAM, 965,201, 259, 263,1.,1.,0.
CBEAM, 966,201, 260, 264,1.,1.,0.
CBEAM, 967,201, 261, 265,1.,1.,0.
CBEAM, 968,201, 262, 266,1.,1.,0.
CBEAM, 969,201, 263, 267,1.,1.,0.
CBEAM, 970,201, 264, 268,1.,1.,0.
$ REFLECTOR TRUSS, BATTENS, PID 202
CBEAM, 971,202, 253, 254,1.,0.,1.
CBEAM, 972,202, 254, 255,1.,0.,1.
CBEAM, 973,202, 255, 256,1.,0.,1.
CBEAM, 974,202, 256, 253,1.,0.,1.
CBEAM, 975,202, 257, 258,1.,0.,1.
CBEAM, 976,202, 258, 259,1.,0.,1.
CBEAM, 977,202, 259, 260,1.,0.,1.
CBEAM, 978,202, 260, 257,1.,0.,1.
CBEAM, 979,202, 261, 262,1.,0.,1.
CBEAM, 980,202, 262, 263,1.,0.,1.
CBEAM, 981,202, 263, 264,1.,0.,1.
CBEAM, 982,202, 264, 261,1.,0.,1.
CBEAM, 983,202, 265, 266,1.,0.,1.
CBEAM, 984,202, 266, 267,1.,0.,1.
CBEAM, 985,202, 267, 268,1.,0.,1.
CBEAM, 986,202, 268, 265,1.,0.,1.
$ REFLECTOR TRUSS, BATTEN DIAGONALS,
PID 203
CBEAM, 987,203, 253, 255,1.,0.,1.
CBEAM, 988,203, 258, 260,1.,0.,1.
CBEAM, 989,203, 261, 263,1.,0.,1.
CBEAM, 990,203, 266, 268,1.,0.,1.
$ REFLECTOR TRUSS, SIDE DIAGONALS, PID 203
CBEAM, 991,203, 245, 256,0.,1.,1.
CBEAM, 992,203, 250, 254,0.,1.,1.
CBEAM, 993,203, 256, 257,0.,1.,1.
CBEAM, 994,203, 254, 259,0.,1.,1.
CBEAM, 995,203, 257, 264,0.,1.,1.
CBEAM, 996,203, 259, 262,0.,1.,1.
$ REFLECTOR TRUSS, FRONT AND BACK
DIAGONALS, PID 203
CBEAM, 999,203, 246, 253,1.,0.,1.
CBEAM, 1000,203, 249, 255,1.,0.,1.
CBEAM, 1001,203, 253, 258,1.,0.,1.
CBEAM, 1002,203, 255, 260,1.,0.,1.
CBEAM, 1003,203, 258, 261,1.,0.,1.
CBEAM, 1004,203, 260, 263,1.,0.,1.
$ FRONT SUSPENSION TRUSS, LONGERONS, +Y,
PID 201
CBEAM, 1007,201, 49, 313,1.,0.,1.
CBEAM, 1008,201, 53, 314,1.,0.,1.
CBEAM, 1009,201, 56, 315,1.,0.,1.
CBEAM, 1010,201, 52, 316,1.,0.,1.
CBEAM, 1011,201, 313, 321,1.,0.,1.
CBEAM, 1012,201, 314, 322,1.,0.,1.
CBEAM, 1013,201, 315, 323,1.,0.,1.
CBEAM, 1014,201, 316, 324,1.,0.,1.
CBEAM, 1015,201, 321, 329,1.,0.,1.
CBEAM, 1016,201, 322, 330,1.,0.,1.
CBEAM, 1017,201, 323, 331,1.,0.,1.
CBEAM, 1018,201, 324, 332,1.,0.,1.
CBEAM, 1019,201, 329, 337,1.,0.,1.
CBEAM, 1020,201, 330, 338,1.,0.,1.
CBEAM, 1021,201, 331, 339,1.,0.,1.
CBEAM, 1022,201, 332, 340,1.,0.,1.
CBEAM, 1023,201, 337, 345,1.,0.,1.
CBEAM, 1024,201, 338, 346,1.,0.,1.
CBEAM, 1025,201, 339, 347,1.,0.,1.
CBEAM, 1026,201, 340, 348,1.,0.,1.
CBEAM, 1027,201, 57, 353,1.,0.,1.
CBEAM, 1028,201, 60, 354,1.,0.,1.
CBEAM, 1029,201, 353, 357,1.,0.,1.
CBEAM, 1030,201, 354, 358,1.,0.,1.
CBEAM, 1031,201, 357, 361,1.,0.,1.
CBEAM, 1032,201, 358, 362,1.,0.,1.
```

```
CBEAM, 1033,201, 361, 365,1.,0.,1.
CBEAM, 1034,201, 362, 366,1.,0.,1.
CBEAM, 1035,201, 365, 369,1.,0.,1.
CBEAM, 1036,201, 366, 370,1.,0.,1.
$ FRONT SUSPENSION TRUSS, LONGERONS, -Y,
PID 201
CBEAM, 1037,201,  58, 355,1.,0.,1.
CBEAM, 1038,201,  59, 356,1.,0.,1.
CBEAM, 1039,201, 355, 359,1.,0.,1.
CBEAM, 1040,201, 356, 360,1.,0.,1.
CBEAM, 1041,201, 359, 363,1.,0.,1.
CBEAM, 1042,201, 360, 364,1.,0.,1.
CBEAM, 1043,201, 363, 367,1.,0.,1.
CBEAM, 1044,201, 364, 368,1.,0.,1.
CBEAM, 1045,201, 367, 371,1.,0.,1.
CBEAM, 1046,201, 368, 372,1.,0.,1.
CBEAM, 1047,201,  50, 317,1.,0.,1.
CBEAM, 1048,201,  54, 318,1.,0.,1.
CBEAM, 1049,201,  55, 319,1.,0.,1.
CBEAM, 1050,201,  51, 320,1.,0.,1.
CBEAM, 1051,201, 317, 325,1.,0.,1.
CBEAM, 1052,201, 318, 326,1.,0.,1.
CBEAM, 1053,201, 319, 327,1.,0.,1.
CBEAM, 1054,201, 320, 328,1.,0.,1.
CBEAM, 1055,201, 325, 333,1.,0.,1.
CBEAM, 1056,201, 326, 334,1.,0.,1.
CBEAM, 1057,201, 327, 335,1.,0.,1.
CBEAM, 1058,201, 328, 336,1.,0.,1.
CBEAM, 1059,201, 333, 341,1.,0.,1.
CBEAM, 1060,201, 334, 342,1.,0.,1.
CBEAM, 1061,201, 335, 343,1.,0.,1.
CBEAM, 1062,201, 336, 344,1.,0.,1.
CBEAM, 1063,201, 341, 349,1.,0.,1.
CBEAM, 1064,201, 342, 350,1.,0.,1.
CBEAM, 1065,201, 343, 351,1.,0.,1.
CBEAM, 1066,201, 344, 352,1.,0.,1.
$ FRONT SUSPENSION TRUSS, BATTENS, +Y,
PID 202
CBEAM, 1072,202, 314, 353,0.,1.,1.
CBEAM, 1073,202, 353, 354,0.,1.,1.
CBEAM, 1074,202, 354, 315,0.,1.,1.
CBEAM, 1075,202, 322, 357,0.,1.,1.
CBEAM, 1076,202, 357, 358,0.,1.,1.
CBEAM, 1077,202, 358, 323,0.,1.,1.
CBEAM, 1078,202, 330, 361,0.,1.,1.
CBEAM, 1079,202, 361, 362,0.,1.,1.
CBEAM, 1080,202, 362, 331,0.,1.,1.
CBEAM, 1081,202, 338, 365,0.,1.,1.
CBEAM, 1082,202, 365, 366,0.,1.,1.
CBEAM, 1083,202, 366, 339,0.,1.,1.
CBEAM, 1084,202, 346, 369,0.,1.,1.
CBEAM, 1085,202, 369, 370,0.,1.,1.
CBEAM, 1086,202, 370, 347,0.,1.,1.
$ NEW
CBEAM, 1087,202, 313, 314,0.,1.,1.
CBEAM, 1088,202, 314, 315,0.,1.,1.
CBEAM, 1089,202, 315, 316,0.,1.,1.
CBEAM, 1090,202, 316, 313,0.,1.,1.
CBEAM, 1091,202, 321, 322,0.,1.,1.
CBEAM, 1092,202, 322, 323,0.,1.,1.
CBEAM, 1093,202, 323, 324,0.,1.,1.
CBEAM, 1094,202, 324, 321,0.,1.,1.
CBEAM, 1095,202, 329, 330,0.,1.,1.
CBEAM, 1096,202, 330, 331,0.,1.,1.
CBEAM, 1097,202, 331, 332,0.,1.,1.
CBEAM, 1098,202, 332, 329,0.,1.,1.
CBEAM, 1099,202, 337, 338,0.,1.,1.
CBEAM, 1100,202, 338, 339,0.,1.,1.
CBEAM, 1101,202, 339, 340,0.,1.,1.
CBEAM, 1102,202, 340, 337,0.,1.,1.
CBEAM, 1103,202, 345, 346,0.,1.,1.
CBEAM, 1104,202, 346, 347,0.,1.,1.
CBEAM, 1105,202, 347, 348,0.,1.,1.
CBEAM, 1106,202, 348, 345,0.,1.,1.
$ FRONT SUSPENSION TRUSS, BATTENS, -Y,
PID 202
CBEAM, 1112,202, 318, 355,0.,1.,1.
CBEAM, 1113,202, 355, 356,0.,1.,1.
CBEAM, 1114,202, 356, 319,0.,1.,1.
CBEAM, 1115,202, 326, 359,0.,1.,1.
CBEAM, 1116,202, 359, 360,0.,1.,1.
CBEAM, 1117,202, 360, 327,0.,1.,1.
CBEAM, 1118,202, 334, 363,0.,1.,1.
CBEAM, 1119,202, 363, 364,0.,1.,1.
CBEAM, 1120,202, 364, 335,0.,1.,1.
CBEAM, 1121,202, 342, 367,0.,1.,1.
CBEAM, 1122,202, 367, 368,0.,1.,1.
CBEAM, 1123,202, 368, 343,0.,1.,1.
CBEAM, 1124,202, 350, 371,0.,1.,1.
CBEAM, 1125,202, 371, 372,0.,1.,1.
CBEAM, 1126,202, 372, 351,0.,1.,1.
CBEAM, 1127,202, 317, 318,0.,1.,1.
CBEAM, 1128,202, 318, 319,0.,1.,1.
CBEAM, 1129,202, 319, 320,0.,1.,1.
CBEAM, 1130,202, 320, 317,0.,1.,1.
CBEAM, 1131,202, 325, 326,0.,1.,1.
CBEAM, 1132,202, 326, 327,0.,1.,1.
CBEAM, 1133,202, 327, 328,0.,1.,1.
CBEAM, 1134,202, 328, 325,0.,1.,1.
CBEAM, 1135,202, 333, 334,0.,1.,1.
CBEAM, 1136,202, 334, 335,0.,1.,1.
CBEAM, 1137,202, 335, 336,0.,1.,1.
CBEAM, 1138,202, 336, 333,0.,1.,1.
CBEAM, 1139,202, 341, 342,0.,1.,1.
CBEAM, 1140,202, 342, 343,0.,1.,1.
CBEAM, 1141,202, 343, 344,0.,1.,1.
CBEAM, 1142,202, 344, 341,0.,1.,1.
CBEAM, 1143,202, 349, 350,0.,1.,1.
CBEAM, 1144,202, 350, 351,0.,1.,1.
CBEAM, 1145,202, 351, 352,0.,1.,1.
CBEAM, 1146,202, 352, 349,0.,1.,1.
$ FRONT SUSPENSION TRUSS, BATTEN
DIAGONALS, +Y, PID 203
CBEAM, 1167,203, 313, 315,0.,1.,1.
CBEAM, 1168,203, 322, 324,0.,1.,1.
CBEAM, 1169,203, 329, 331,0.,1.,1.
CBEAM, 1170,203, 338, 340,0.,1.,1.
CBEAM, 1171,203, 345, 347,0.,1.,1.
CBEAM, 1172,203, 353, 315,0.,1.,1.
CBEAM, 1173,203, 322, 358,0.,1.,1.
CBEAM, 1174,203, 361, 331,0.,1.,1.
CBEAM, 1175,203, 338, 366,0.,1.,1.
CBEAM, 1176,203, 369, 347,0.,1.,1.
$ FRONT SUSPENSION TRUSS, BATTEN
DIAGONALS, -Y, PID 203
CBEAM, 1177,203, 318, 320,0.,1.,1.
CBEAM, 1178,203, 327, 325,0.,1.,1.
CBEAM, 1179,203, 334, 336,0.,1.,1.
```

CBEAM, 1180,203, 341, 343,0.,1.,1.
CBEAM, 1181,203, 350, 352,0.,1.,1.
CBEAM, 1182,203, 318, 356,0.,1.,1.
CBEAM, 1183,203, 327, 359,0.,1.,1.
CBEAM, 1184,203, 334, 364,0.,1.,1.
CBEAM, 1185,203, 367, 343,0.,1.,1.
CBEAM, 1186,203, 350, 372,0.,1.,1.
$ FRONT SUSPENSION TRUSS, FRONT AND BACK DIAGONALS, +Y, PID 203
CBEAM, 1187,203, 49, 316,1.,0.,1.
CBEAM, 1188,203, 56, 314,1.,0.,1.
CBEAM, 1189,203, 316, 321,1.,0.,1.
CBEAM, 1190,203, 314, 323,1.,0.,1.
CBEAM, 1191,203, 321, 332,1.,0.,1.
CBEAM, 1192,203, 323, 330,1.,0.,1.
CBEAM, 1193,203, 332, 337,1.,0.,1.
CBEAM, 1194,203, 330, 339,1.,0.,1.
CBEAM, 1195,203, 337, 348,1.,0.,1.
CBEAM, 1196,203, 339, 346,1.,0.,1.
CBEAM, 1197,203, 57, 354,1.,0.,1.
CBEAM, 1198,203, 354, 357,1.,0.,1.
CBEAM, 1199,203, 357, 362,1.,0.,1.
CBEAM, 1200,203, 362, 365,1.,0.,1.
CBEAM, 1201,203, 365, 370,1.,0.,1.
$ FRONT SUSPENSION TRUSS, FRONT AND BACK DIAGONALS, -Y, PID 203
CBEAM, 1207,203, 51, 317,1.,0.,1.
CBEAM, 1208,203, 54, 319,1.,0.,1.
CBEAM, 1209,203, 317, 328,1.,0.,1.
CBEAM, 1210,203, 319, 326,1.,0.,1.
CBEAM, 1211,203, 328, 333,1.,0.,1.
CBEAM, 1212,203, 326, 335,1.,0.,1.
CBEAM, 1213,203, 333, 344,1.,0.,1.
CBEAM, 1214,203, 335, 342,1.,0.,1.
CBEAM, 1215,203, 344, 349,1.,0.,1.
CBEAM, 1216,203, 342, 351,1.,0.,1.
CBEAM, 1217,203, 59, 355,1.,0.,1.
CBEAM, 1218,203, 355, 360,1.,0.,1.
CBEAM, 1219,203, 360, 363,1.,0.,1.
CBEAM, 1220,203, 363, 368,1.,0.,1.
CBEAM, 1221,203, 368, 371,1.,0.,1.
$ FRONT SUSPENSION TRUSS, TOP AND BOTTOM DIAGONALS, +Y, PID 203
CBEAM, 1227,203, 49, 314,1.,0.,1.
CBEAM, 1228,203, 56, 316,1.,0.,1.
CBEAM, 1229,203, 314, 321,1.,0.,1.
CBEAM, 1230,203, 316, 323,1.,0.,1.
CBEAM, 1231,203, 321, 330,1.,0.,1.
CBEAM, 1232,203, 323, 332,1.,0.,1.
CBEAM, 1233,203, 330, 337,1.,0.,1.
CBEAM, 1234,203, 332, 339,1.,0.,1.
CBEAM, 1235,203, 337, 346,1.,0.,1.
CBEAM, 1236,203, 339, 348,1.,0.,1.
CBEAM, 1237,203, 57, 314,1.,0.,1.
CBEAM, 1238,203, 56, 354,1.,0.,1.
CBEAM, 1239,203, 314, 357,1.,0.,1.
CBEAM, 1240,203, 354, 323,1.,0.,1.
CBEAM, 1241,203, 357, 330,1.,0.,1.
CBEAM, 1242,203, 323, 362,1.,0.,1.
CBEAM, 1243,203, 330, 365,1.,0.,1.
CBEAM, 1244,203, 362, 339,1.,0.,1.
CBEAM, 1245,203, 365, 346,1.,0.,1.
CBEAM, 1246,203, 339, 370,1.,0.,1.
$ FRONT SUSPENSION TRUSS, TOP AND BOTTOM DIAGONALS, -Y, PID 203
CBEAM, 1247,203, 54, 317,1.,0.,1.
CBEAM, 1248,203, 51, 319,1.,0.,1.
CBEAM, 1249,203, 317, 326,1.,0.,1.
CBEAM, 1250,203, 319, 328,1.,0.,1.
CBEAM, 1251,203, 326, 333,1.,0.,1.
CBEAM, 1252,203, 328, 335,1.,0.,1.
CBEAM, 1253,203, 333, 342,1.,0.,1.
CBEAM, 1254,203, 335, 344,1.,0.,1.
CBEAM, 1255,203, 342, 349,1.,0.,1.
CBEAM, 1256,203, 344, 351,1.,0.,1.
CBEAM, 1257,203, 54, 355,1.,0.,1.
CBEAM, 1258,203, 59, 319,1.,0.,1.
CBEAM, 1259,203, 355, 326,1.,0.,1.
CBEAM, 1260,203, 319, 360,1.,0.,1.
CBEAM, 1261,203, 326, 363,1.,0.,1.
CBEAM, 1262,203, 360, 335,1.,0.,1.
CBEAM, 1263,203, 363, 342,1.,0.,1.
CBEAM, 1264,203, 335, 368,1.,0.,1.
CBEAM, 1265,203, 342, 371,1.,0.,1.
CBEAM, 1266,203, 368, 351,1.,0.,1.
$ START AFT SUSPENSION TRUSS
$ BACK SUSPENSION TRUSS, LONGERONS, +Y, PID 201
CBEAM, 1267,201, 221, 397,1.,0.,1.
CBEAM, 1268,201, 225, 398,1.,0.,1.
CBEAM, 1269,201, 228, 399,1.,0.,1.
CBEAM, 1270,201, 224, 400,1.,0.,1.
CBEAM, 1271,201, 397, 405,1.,0.,1.
CBEAM, 1272,201, 398, 406,1.,0.,1.
CBEAM, 1273,201, 399, 407,1.,0.,1.
CBEAM, 1274,201, 400, 408,1.,0.,1.
CBEAM, 1275,201, 405, 413,1.,0.,1.
CBEAM, 1276,201, 406, 414,1.,0.,1.
CBEAM, 1277,201, 407, 415,1.,0.,1.
CBEAM, 1278,201, 408, 416,1.,0.,1.
CBEAM, 1279,201, 413, 421,1.,0.,1.
CBEAM, 1280,201, 414, 422,1.,0.,1.
CBEAM, 1281,201, 415, 423,1.,0.,1.
CBEAM, 1282,201, 416, 424,1.,0.,1.
CBEAM, 1283,201, 421, 429,1.,0.,1.
CBEAM, 1284,201, 422, 430,1.,0.,1.
CBEAM, 1285,201, 423, 431,1.,0.,1.
CBEAM, 1286,201, 424, 432,1.,0.,1.
CBEAM, 1287,201, 217, 437,1.,0.,1.
CBEAM, 1288,201, 220, 438,1.,0.,1.
CBEAM, 1289,201, 437, 441,1.,0.,1.
CBEAM, 1290,201, 438, 442,1.,0.,1.
CBEAM, 1291,201, 441, 445,1.,0.,1.
CBEAM, 1292,201, 442, 446,1.,0.,1.
CBEAM, 1293,201, 445, 449,1.,0.,1.
CBEAM, 1294,201, 446, 450,1.,0.,1.
CBEAM, 1295,201, 449, 453,1.,0.,1.
CBEAM, 1296,201, 450, 454,1.,0.,1.
$ BACK SUSPENSION TRUSS, LONGERONS, -Y, PID 201
CBEAM, 1307,201, 222, 401,1.,0.,1.
CBEAM, 1308,201, 226, 402,1.,0.,1.
CBEAM, 1309,201, 227, 403,1.,0.,1.
CBEAM, 1310,201, 223, 404,1.,0.,1.
CBEAM, 1311,201, 401, 409,1.,0.,1.
CBEAM, 1312,201, 402, 410,1.,0.,1.
CBEAM, 1313,201, 403, 411,1.,0.,1.

CBEAM, 1314,201, 404, 412,1.,0.,1.
CBEAM, 1315,201, 409, 417,1.,0.,1.
CBEAM, 1316,201, 410, 418,1.,0.,1.
CBEAM, 1317,201, 411, 419,1.,0.,1.
CBEAM, 1318,201, 412, 420,1.,0.,1.
CBEAM, 1319,201, 417, 425,1.,0.,1.
CBEAM, 1320,201, 418, 426,1.,0.,1.
CBEAM, 1321,201, 419, 427,1.,0.,1.
CBEAM, 1322,201, 420, 428,1.,0.,1.
CBEAM, 1323,201, 425, 433,1.,0.,1.
CBEAM, 1324,201, 426, 434,1.,0.,1.
CBEAM, 1325,201, 427, 435,1.,0.,1.
CBEAM, 1326,201, 428, 436,1.,0.,1.
CBEAM, 1327,201, 218, 439,1.,0.,1.
CBEAM, 1328,201, 219, 440,1.,0.,1.
CBEAM, 1329,201, 439, 443,1.,0.,1.
CBEAM, 1330,201, 440, 444,1.,0.,1.
CBEAM, 1331,201, 443, 447,1.,0.,1.
CBEAM, 1332,201, 444, 448,1.,0.,1.
CBEAM, 1333,201, 447, 451,1.,0.,1.
CBEAM, 1334,201, 448, 452,1.,0.,1.
CBEAM, 1335,201, 451, 455,1.,0.,1.
CBEAM, 1336,201, 452, 456,1.,0.,1.
$ BACK SUSPENSION TRUSS, BATTENS, +Y, PID 202
CBEAM, 1347,202, 397, 398,0.,1.,1.
CBEAM, 1348,202, 398, 399,0.,1.,1.
CBEAM, 1349,202, 399, 400,0.,1.,1.
CBEAM, 1350,202, 400, 397,0.,1.,1.
CBEAM, 1351,202, 405, 406,0.,1.,1.
CBEAM, 1352,202, 406, 407,0.,1.,1.
CBEAM, 1353,202, 407, 408,0.,1.,1.
CBEAM, 1354,202, 408, 405,0.,1.,1.
CBEAM, 1355,202, 413, 414,0.,1.,1.
CBEAM, 1356,202, 414, 415,0.,1.,1.
CBEAM, 1357,202, 415, 416,0.,1.,1.
CBEAM, 1358,202, 416, 413,0.,1.,1.
CBEAM, 1359,202, 421, 422,0.,1.,1.
CBEAM, 1360,202, 422, 423,0.,1.,1.
CBEAM, 1361,202, 423, 424,0.,1.,1.
CBEAM, 1362,202, 424, 421,0.,1.,1.
CBEAM, 1363,202, 429, 430,0.,1.,1.
CBEAM, 1364,202, 430, 431,0.,1.,1.
CBEAM, 1365,202, 431, 432,0.,1.,1.
CBEAM, 1366,202, 432, 429,0.,1.,1.
CBEAM, 1367,202, 437, 397,0.,1.,1.
CBEAM, 1368,202, 400, 438,0.,1.,1.
CBEAM, 1369,202, 438, 437,0.,1.,1.
CBEAM, 1370,202, 441, 405,0.,1.,1.
CBEAM, 1371,202, 408, 442,0.,1.,1.
CBEAM, 1372,202, 442, 441,0.,1.,1.
CBEAM, 1373,202, 445, 413,0.,1.,1.
CBEAM, 1374,202, 416, 446,0.,1.,1.
CBEAM, 1375,202, 446, 445,0.,1.,1.
CBEAM, 1376,202, 449, 421,0.,1.,1.
CBEAM, 1377,202, 424, 450,0.,1.,1.
CBEAM, 1378,202, 450, 449,0.,1.,1.
CBEAM, 1379,202, 453, 429,0.,1.,1.
CBEAM, 1380,202, 432, 454,0.,1.,1.
CBEAM, 1381,202, 454, 453,0.,1.,1.
$ BACK SUSPENSION TRUSS, BATTENS, -Y, PID 202
CBEAM, 1387,202, 401, 402,0.,1.,1.
CBEAM, 1388,202, 402, 403,0.,1.,1.
CBEAM, 1389,202, 403, 404,0.,1.,1.
CBEAM, 1390,202, 404, 401,0.,1.,1.
CBEAM, 1391,202, 409, 410,0.,1.,1.
CBEAM, 1392,202, 410, 411,0.,1.,1.
CBEAM, 1393,202, 411, 412,0.,1.,1.
CBEAM, 1394,202, 412, 409,0.,1.,1.
CBEAM, 1395,202, 417, 418,0.,1.,1.
CBEAM, 1396,202, 418, 419,0.,1.,1.
CBEAM, 1397,202, 419, 420,0.,1.,1.
CBEAM, 1398,202, 420, 417,0.,1.,1.
CBEAM, 1399,202, 425, 426,0.,1.,1.
CBEAM, 1400,202, 426, 427,0.,1.,1.
CBEAM, 1401,202, 427, 428,0.,1.,1.
CBEAM, 1402,202, 428, 425,0.,1.,1.
CBEAM, 1403,202, 433, 434,0.,1.,1.
CBEAM, 1404,202, 434, 435,0.,1.,1.
CBEAM, 1405,202, 435, 436,0.,1.,1.
CBEAM, 1406,202, 436, 433,0.,1.,1.
CBEAM, 1407,202, 439, 401,0.,1.,1.
CBEAM, 1408,202, 404, 440,0.,1.,1.
CBEAM, 1409,202, 440, 439,0.,1.,1.
CBEAM, 1410,202, 443, 409,0.,1.,1.
CBEAM, 1411,202, 412, 444,0.,1.,1.
CBEAM, 1412,202, 444, 443,0.,1.,1.
CBEAM, 1413,202, 447, 417,0.,1.,1.
CBEAM, 1414,202, 420, 448,0.,1.,1.
CBEAM, 1415,202, 448, 447,0.,1.,1.
CBEAM, 1416,202, 451, 425,0.,1.,1.
CBEAM, 1417,202, 428, 452,0.,1.,1.
CBEAM, 1418,202, 452, 451,0.,1.,1.
CBEAM, 1419,202, 455, 433,0.,1.,1.
CBEAM, 1420,202, 436, 456,0.,1.,1.
CBEAM, 1421,202, 456, 455,0.,1.,1.
$ BACK SUSPENSION TRUSS, BATTEN DIAGONALS, +Y, PID 203
CBEAM, 1427,203, 398, 400,0.,1.,1.
CBEAM, 1428,203, 405, 407,0.,1.,1.
CBEAM, 1429,203, 414, 416,0.,1.,1.
CBEAM, 1430,203, 421, 423,0.,1.,1.
CBEAM, 1431,203, 430, 432,0.,1.,1.
CBEAM, 1432,203, 437, 400,0.,1.,1.
CBEAM, 1433,203, 405, 442,0.,1.,1.
CBEAM, 1434,203, 445, 416,0.,1.,1.
CBEAM, 1435,203, 421, 450,0.,1.,1.
CBEAM, 1436,203, 453, 432,0.,1.,1.
$ BACK SUSPENSION TRUSS, BATTEN DIAGONALS, -Y, PID 203
CBEAM, 1437,203, 401, 403,0.,1.,1.
CBEAM, 1438,203, 410, 412,0.,1.,1.
CBEAM, 1439,203, 417, 419,0.,1.,1.
CBEAM, 1440,203, 426, 428,0.,1.,1.
CBEAM, 1441,203, 433, 435,0.,1.,1.
CBEAM, 1442,203, 401, 440,0.,1.,1.
CBEAM, 1443,203, 443, 412,0.,1.,1.
CBEAM, 1444,203, 417, 448,0.,1.,1.
CBEAM, 1445,203, 451, 426,0.,1.,1.
CBEAM, 1446,203, 433, 456,0.,1.,1.
$ BACK SUSPENSION TRUSS, FRONT AND BACK DIAGONALS, +Y, PID 203
CBEAM, 1447,203, 224, 397,1.,0.,1.
CBEAM, 1448,203, 225, 399,1.,0.,1.
CBEAM, 1449,203, 397, 408,1.,0.,1.
CBEAM, 1450,203, 399, 406,1.,0.,1.
CBEAM, 1451,203, 408, 413,1.,0.,1.

```
CBEAM, 1452,203, 406, 415,1.,0.,1.
CBEAM, 1453,203, 413, 424,1.,0.,1.
CBEAM, 1454,203, 415, 422,1.,0.,1.
CBEAM, 1455,203, 424, 429,1.,0.,1.
CBEAM, 1456,203, 422, 431,1.,0.,1.
CBEAM, 1457,203, 217, 438,1.,0.,1.
CBEAM, 1458,203, 438, 441,1.,0.,1.
CBEAM, 1459,203, 441, 446,1.,0.,1.
CBEAM, 1460,203, 446, 449,1.,0.,1.
CBEAM, 1461,203, 449, 454,1.,0.,1.
$ BACK SUSPENSION TRUSS, FRONT AND BACK
DIAGONALS, -Y, PID 203
CBEAM, 1467,203, 222, 404,1.,0.,1.
CBEAM, 1468,203, 227, 402,1.,0.,1.
CBEAM, 1469,203, 404, 409,1.,0.,1.
CBEAM, 1470,203, 402, 411,1.,0.,1.
CBEAM, 1471,203, 409, 420,1.,0.,1.
CBEAM, 1472,203, 411, 418,1.,0.,1.
CBEAM, 1473,203, 420, 425,1.,0.,1.
CBEAM, 1474,203, 418, 427,1.,0.,1.
CBEAM, 1475,203, 425, 436,1.,0.,1.
CBEAM, 1476,203, 427, 434,1.,0.,1.
CBEAM, 1477,203, 219, 439,1.,0.,1.
CBEAM, 1478,203, 439, 444,1.,0.,1.
CBEAM, 1479,203, 444, 447,1.,0.,1.
CBEAM, 1480,203, 447, 452,1.,0.,1.
CBEAM, 1481,203, 452, 455,1.,0.,1.
$ BACK SUSPENSION TRUSS, TOP AND BOTTOM
DIAGONALS, +Y, PID 203
CBEAM, 1487,203, 225, 397,1.,0.,1.
CBEAM, 1488,203, 224, 399,1.,0.,1.
CBEAM, 1489,203, 397, 406,1.,0.,1.
CBEAM, 1490,203, 399, 408,1.,0.,1.
CBEAM, 1491,203, 406, 413,1.,0.,1.
CBEAM, 1492,203, 408, 415,1.,0.,1.
CBEAM, 1493,203, 413, 422,1.,0.,1.
CBEAM, 1494,203, 415, 424,1.,0.,1.
CBEAM, 1495,203, 422, 429,1.,0.,1.
CBEAM, 1496,203, 424, 431,1.,0.,1.
CBEAM, 1497,203, 217, 397,1.,0.,1.
CBEAM, 1498,203, 224, 438,1.,0.,1.
CBEAM, 1499,203, 397, 441,1.,0.,1.
CBEAM, 1500,203, 438, 408,1.,0.,1.
CBEAM, 1501,203, 441, 413,1.,0.,1.
CBEAM, 1502,203, 408, 446,1.,0.,1.
CBEAM, 1503,203, 413, 449,1.,0.,1.
CBEAM, 1504,203, 446, 424,1.,0.,1.
CBEAM, 1505,203, 449, 429,1.,0.,1.
CBEAM, 1506,203, 424, 454,1.,0.,1.
$ BACK SUSPENSION TRUSS, TOP AND BOTTOM
DIAGONALS, -Y, PID 203
CBEAM, 1507,203, 222, 402,1.,0.,1.
CBEAM, 1508,203, 227, 404,1.,0.,1.
CBEAM, 1509,203, 402, 409,1.,0.,1.
CBEAM, 1510,203, 404, 411,1.,0.,1.
CBEAM, 1511,203, 409, 418,1.,0.,1.
CBEAM, 1512,203, 411, 420,1.,0.,1.
CBEAM, 1513,203, 418, 425,1.,0.,1.
CBEAM, 1514,203, 420, 427,1.,0.,1.
CBEAM, 1515,203, 425, 434,1.,0.,1.
CBEAM, 1516,203, 427, 436,1.,0.,1.
CBEAM, 1517,203, 222, 439,1.,0.,1.
CBEAM, 1518,203, 219, 404,1.,0.,1.
CBEAM, 1519,203, 439, 409,1.,0.,1.
CBEAM, 1520,203, 404, 444,1.,0.,1.
CBEAM, 1521,203, 409, 447,1.,0.,1.
CBEAM, 1522,203, 444, 420,1.,0.,1.
CBEAM, 1523,203, 447, 425,1.,0.,1.
CBEAM, 1524,203, 420, 452,1.,0.,1.
CBEAM, 1525,203, 425, 455,1.,0.,1.
CBEAM, 1526,203, 452, 436,1.,0.,1.
$ START RFL SUPPORT BRACKET BEAMS
CBEAM, 1531,27, 265, 485,266
CBEAM, 1532,27, 266, 486,267
CBEAM, 1533,27, 267, 487,268
CBEAM, 1534,27, 268, 488,265
CBEAM, 1535,28, 267, 488,485
CBEAM, 1536,28, 268, 487,486
CBEAM, 1537,28, 265, 486,487
CBEAM, 1538,28, 266, 485,488
CBEAM, 1539,28, 265, 488,487
CBEAM, 1540,28, 266, 487,488
CBEAM, 1541,29, 485, 488,487
CBEAM, 1542,29, 486, 487,488
$ FORWARD SUSPENSION CABLE
$ .170 KELVAR CABLE, +Y
CROD, 1551,14, 509, 510
CROD, 1552,14, 510, 511
CROD, 1553,14, 511, 512
CROD, 1554,14, 512, 513
CROD, 1555,14, 513, 514
$ 7X19 .125 STAINLESS STEEL CABLE
CROD, 1556,13, 514, 515
CROD, 1557,13, 514, 516
$ CABLE STANDOFF
CBEAM, 1558, 12, 338, 515, 516
CBEAM, 1559, 12, 346, 516, 515
$ .170 KELVAR CABLE, -Y
CROD, 1561,14, 519, 520
CROD, 1562,14, 520, 521
CROD, 1563,14, 521, 522
CROD, 1564,14, 522, 523
CROD, 1565,14, 523, 524
$ 7X19 .125 STAINLESS STEEL CABLE
CROD, 1566,13, 524, 525
CROD, 1567,13, 524, 526
$ CABLE STANDOFF
CBEAM, 1568, 12, 342, 525, 526
CBEAM, 1569, 12, 350, 526, 525
$ AFT SUSPENSION CABLE
$ .170 KELVAR CABLE, +Y
CROD, 1571,14, 529, 530
CROD, 1572,14, 530, 531
CROD, 1573,14, 531, 532
CROD, 1574,14, 532, 533
CROD, 1575,14, 533, 534
$ 7X19 .125 STAINLESS STEEL CABLE
CROD, 1576,13, 534, 535
CROD, 1577,13, 534, 536
$ CABLE STANDOFF
CBEAM, 1578, 12, 421, 535, 536
CBEAM, 1579, 12, 429, 536, 535
$ .170 KELVAR CABLE, -Y
CROD, 1581,14, 539, 540
CROD, 1582,14, 540, 541
CROD, 1583,14, 541, 542
CROD, 1584,14, 542, 543
CROD, 1585,14, 543, 544
```

```
$ 7X19 .125 STAINLESS STEEL CABLE
CROD, 1586,13, 544, 545
CROD, 1587,13, 544, 546
$ CABLE STANDOFF
CBEAM, 1588, 12, 425, 545, 546
CBEAM, 1589, 12, 433, 546, 545
$ START GIMBAL#1
$ GIMBAL#1 SUPPORT BEAMS
CBEAM   1601  502  49   550  -0.707  0.707
CBEAM   1602  502  49   562   0.707 -0.707
CBEAM   1603  502  53   550  -0.707 -0.707
CBEAM   1604  502  53   554   0.707  0.707
CBEAM   1605  502  54   554  -0.707  0.707
CBEAM   1606  502  54   558   0.707 -0.707
CBEAM   1607  502  50   558   0.707  0.707
CBEAM   1608  502  50   562  -0.707 -0.707
$ 1/2" X 1" RINGS
CBEAM   1609  4  566  568  -0.195 -0.981
CBEAM   1610  4  568  570  -0.556 -0.831
CBEAM   1611  4  570  572  -0.831 -0.556
CBEAM   1612  4  572  574  -0.981 -0.195
CBEAM   1613  4  574  576  -0.981  0.195
CBEAM   1614  4  576  578  -0.831  0.556
CBEAM   1615  4  578  580  -0.556  0.831
CBEAM   1616  4  580  582  -0.195  0.981
CBEAM   1617  4  582  584   0.195  0.981
CBEAM   1618  4  584  586   0.556  0.831
CBEAM   1619  4  586  588   0.831  0.556
CBEAM   1620  4  588  590   0.981  0.195
CBEAM   1621  4  590  592   0.981 -0.195
CBEAM   1622  4  592  594   0.831 -0.556
CBEAM   1623  4  594  596   0.556 -0.831
CBEAM   1624  4  596  566   0.195 -0.981
CBEAM   1625  4  567  569  -0.195 -0.981
CBEAM   1626  4  569  571  -0.555 -0.832
CBEAM   1627  4  571  573  -0.832 -0.555
CBEAM   1628  4  573  575  -0.981 -0.195
CBEAM   1629  4  575  577  -0.981  0.195
CBEAM   1630  4  577  579  -0.832  0.555
CBEAM   1631  4  579  581  -0.555  0.832
CBEAM   1632  4  581  583  -0.195  0.981
CBEAM   1633  4  583  585   0.195  0.981
CBEAM   1634  4  585  587   0.555  0.832
CBEAM   1635  4  587  589   0.832  0.555
CBEAM   1636  4  589  591   0.981  0.195
CBEAM   1637  4  591  593   0.981 -0.195
CBEAM   1638  4  593  595   0.832 -0.555
CBEAM   1639  4  595  597   0.555 -0.832
CBEAM   1640  4  597  567   0.195 -0.981
CBEAM   1641  4  566  567   1.0
CBEAM   1642  4  582  583  -1.0
CBEAM   1643  4  574  598          1.0
CBEAM   1644  4  599  590          1.0
CBEAM   1645  4  600  566   1.0
CBEAM   1646  4  601  582  -1.0
$ 3" X 3" POSTS
CBEAM   1647  5  554  598          1.0
CBEAM   1648  5  562  599          1.0
$ BEAMS TO SUPPORT GIMBAL#1 LASER
CBEAM   1651  11  602  571  579
CBEAM   1652  11  602  579  587
CBEAM   1653  11  602  587  595
CBEAM   1654  11  602  595  571
$ START WEIGHTLESS BACK-UP BEAMS FOR
GIMBAL#1 PLATE
CBEAM   1661  17  553  551  561
CBEAM   1662  17  553  552  554
CBEAM   1663  17  553  555  561
CBEAM   1664  17  557  555  565
CBEAM   1665  17  557  556  558
CBEAM   1666  17  557  559  565
CBEAM   1667  17  561  559  553
CBEAM   1668  17  561  560  562
CBEAM   1669  17  561  563  553
CBEAM   1670  17  565  563  557
CBEAM   1671  17  565  564  550
CBEAM   1672  17  565  551  557
$ GIMBAL#1 PLATE
CQUAD4  1681  1  551  550  552  553
0.0
CQUAD4  1682  1  553  552  554  555
0.0
CQUAD4  1683  1  555  554  556  557
0.0
CQUAD4  1684  1  557  556  558  559
0.0
CQUAD4  1685  1  559  558  560  561
0.0
CQUAD4  1686  1  561  560  562  563
0.0
CQUAD4  1687  1  563  562  564  565
0.0
CQUAD4  1688  1  565  564  550  551
0.0
$ CONTROLLER BOARD PLATES (IMU UNIT
PLATE) FOR GIMBAL#1
CTRIA3  1691  15  57  605  58
CTRIA3  1692  15  58  605  59
CTRIA3  1693  15  59  605  60
CTRIA3  1694  15  60  605  57
$ START WEIGHTLESS BACK-UP BEAMS FOR
GIMBAL#1 CONTROLLER BOARD PLATE
CBEAM   1695  17  57  605  58
CBEAM   1696  17  58  605  59
CBEAM   1697  17  59  605  60
CBEAM   1698  17  60  605  57
$ START GIMBAL #2
$ GIMBAL#2 SUPPORT BEAMS
CBEAM   1701  502  73  650  -0.707  0.707
CBEAM   1702  502  73  662   0.707 -0.707
CBEAM   1703  502  77  650  -0.707 -0.707
CBEAM   1704  502  77  654   0.707  0.707
CBEAM   1705  502  78  654  -0.707  0.707
CBEAM   1706  502  78  658   0.707 -0.707
CBEAM   1707  502  74  658   0.707  0.707
CBEAM   1708  502  74  662  -0.707 -0.707
$ 1/2" X 1" RINGS
CBEAM   1709  4  666  668  -0.195 -0.981
CBEAM   1710  4  668  670  -0.556 -0.831
CBEAM   1711  4  670  672  -0.831 -0.556
CBEAM   1712  4  672  674  -0.981 -0.195
CBEAM   1713  4  674  676  -0.981  0.195
CBEAM   1714  4  676  678  -0.831  0.556
CBEAM   1715  4  678  680  -0.556  0.831
CBEAM   1716  4  680  682  -0.195  0.981
CBEAM   1717  4  682  684   0.195  0.981
CBEAM   1718  4  684  686   0.556  0.831
```

```
CBEAM   1719   4   686   688  0.831  0.556
CBEAM   1720   4   688   690  0.981  0.195
CBEAM   1721   4   690   692  0.981 -0.195
CBEAM   1722   4   692   694  0.831 -0.556
CBEAM   1723   4   694   696  0.556 -0.831
CBEAM   1724   4   696   666  0.195 -0.981
CBEAM   1725   4   667   669 -0.195 -0.981
CBEAM   1726   4   669   671 -0.555 -0.832
CBEAM   1727   4   671   673 -0.832 -0.555
CBEAM   1728   4   673   675 -0.981 -0.195
CBEAM   1729   4   675   677 -0.981  0.195
CBEAM   1730   4   677   679 -0.832  0.555
CBEAM   1731   4   679   681 -0.555  0.832
CBEAM   1732   4   681   683 -0.195  0.981
CBEAM   1733   4   683   685  0.195  0.981
CBEAM   1734   4   685   687  0.555  0.832
CBEAM   1735   4   687   689  0.832  0.555
CBEAM   1736   4   689   691  0.981  0.195
CBEAM   1737   4   691   693  0.981 -0.195
CBEAM   1738   4   693   695  0.832 -0.555
CBEAM   1739   4   695   697  0.555 -0.832
CBEAM   1740   4   697   667  0.195 -0.981
CBEAM   1741   4   666   667   1.0
CBEAM   1742   4   682   683  -1.0
CBEAM   1743   4   674   698          1.0
CBEAM   1744   4   699   690          1.0
CBEAM   1745   4   700   666   1.0 .
CBEAM   1746   4   701   682  -1.0
$ 3" X 3" POSTS
CBEAM   1747   5   654   698          1.0
CBEAM   1748   5   662   699          1.0
$ BEAMS TO SUPPORT GIMBAL#2 LASER
CBEAM   1751   11   702   671   679
CBEAM   1752   11   702   679   687
CBEAM   1753   11   702   687   695
CBEAM   1754   11   702   695   671
$ START WEIGHTLESS BACK-UP BEAMS FOR
GIMBAL#2 PLATE
CBEAM   1761   17   653   651   661
CBEAM   1762   17   653   652   654
CBEAM   1763   17   653   655   661
CBEAM   1764   17   657   655   665
CBEAM   1765   17   657   656   658
CBEAM   1766   17   657   659   665
CBEAM   1767   17   661   659   653
CBEAM   1768   17   661   660   662
CBEAM   1769   17   661   663   653
CBEAM   1770   17   665   663   657
CBEAM   1771   17   665   664   650
CBEAM   1772   17   665   651   657
$ GIMBAL#2 PLATES
CQUAD4   1781   1   651   650   652   653
0.0
CQUAD4   1782   1   653   652   654   655
0.0
CQUAD4   1783   1   655   654   656   657
0.0
CQUAD4   1784   1   657   656   658   659
0.0
CQUAD4   1785   1   659   658   660   661
0.0
CQUAD4   1786   1   661   660   662   663
0.0
CQUAD4   1787   1   663   662   664   665
0.0
CQUAD4   1788   1   665   664   650   651
0.0
$ CONTROLLER BOARD PLATES (IMU UNIT
PLATE) FOR GIMBAL#2
CTRIA3   1791   15   81   705   82
CTRIA3   1792   15   82   705   83
CTRIA3   1793   15   83   705   84
CTRIA3   1794   15   84   705   81
$ START WEIGHTLESS BACK-UP BEAMS FOR
GIMBAL#2 CONTROLLER BOARD PLATE
CBEAM   1795   17   81   705   82
CBEAM   1796   17   82   705   83
CBEAM   1797   17   83   705   84
CBEAM   1798   17   84   705   85
$ START GIMBAL #3
$ GIMBAL#3 SUPPORT BEAMS
CBEAM   1801   502   217   750 -0.707  0.707
CBEAM   1802   502   217   762  0.707 -0.707
CBEAM   1803   502   221   750 -0.707 -0.707
CBEAM   1804   502   221   754  0.707  0.707
CBEAM   1805   502   222   754 -0.707  0.707
CBEAM   1806   502   222   758  0.707 -0.707
CBEAM   1807   502   218   758  0.707  0.707
CBEAM   1808   502   218   762 -0.707 -0.707
$ 1/2" X 1" RINGS
CBEAM   1809   4   766   768 -0.195 -0.981
CBEAM   1810   4   768   770 -0.556 -0.831
CBEAM   1811   4   770   772 -0.831 -0.556
CBEAM   1812   4   772   774 -0.981 -0.195
CBEAM   1813   4   774   776 -0.981  0.195
CBEAM   1814   4   776   778 -0.831  0.556
CBEAM   1815   4   778   780 -0.556  0.831
CBEAM   1816   4   780   782 -0.195  0.981
CBEAM   1817   4   782   784  0.195  0.981
CBEAM   1818   4   784   786  0.556  0.831
CBEAM   1819   4   786   788  0.831  0.556
CBEAM   1820   4   788   790  0.981  0.195
CBEAM   1821   4   790   792  0.981 -0.195
CBEAM   1822   4   792   794  0.831 -0.556
CBEAM   1823   4   794   796  0.556 -0.831
CBEAM   1824   4   796   766  0.195 -0.981
CBEAM   1825   4   767   769 -0.195 -0.981
CBEAM   1826   4   769   771 -0.555 -0.832
CBEAM   1827   4   771   773 -0.832 -0.555
CBEAM   1828   4   773   775 -0.981 -0.195
CBEAM   1829   4   775   777 -0.981  0.195
CBEAM   1830   4   777   779 -0.832  0.555
CBEAM   1831   4   779   781 -0.555  0.832
CBEAM   1832   4   781   783 -0.195  0.981
CBEAM   1833   4   783   785  0.195  0.981
CBEAM   1834   4   785   787  0.555  0.832
CBEAM   1835   4   787   789  0.832  0.555
CBEAM   1836   4   789   791  0.981  0.195
CBEAM   1837   4   791   793  0.981 -0.195
CBEAM   1838   4   793   795  0.832 -0.555
CBEAM   1839   4   795   797  0.555 -0.832
CBEAM   1840   4   797   767  0.195 -0.981
CBEAM   1841   4   766   767   1.0
CBEAM   1842   4   782   783  -1.0
CBEAM   1843   4   774   798          1.0
CBEAM   1844   4   799   790          1.0
CBEAM   1845   4   800   766   1.0
```

```
CBEAM     1846    4    801    782   -1.0
$ 3" X 3" POSTS
CBEAM     1847    5    754    798          1.0
CBEAM     1848    5    762    799          1.0
$ BEAMS TO SUPPORT GIMBAL#3 LASER
CBEAM     1851    11   802    771    779
CBEAM     1852    11   802    779    787
CBEAM     1853    11   802    787    795
CBEAM     1854    11   802    795    771
$ START WEIGHTLESS BACK-UP BEAMS FOR
GIMBAL#3 PLATE
CBEAM     1861    17   753    751    761
CBEAM     1862    17   753    752    754
CBEAM     1863    17   753    755    761
CBEAM     1864    17   757    755    765
CBEAM     1865    17   757    756    758
CBEAM     1866    17   757    759    765
CBEAM     1867    17   761    759    753
CBEAM     1868    17   761    760    762
CBEAM     1869    17   761    763    753
CBEAM     1870    17   765    763    757
CBEAM     1871    17   765    764    750
CBEAM     1872    17   765    751    757
$ GIMBAL#3 PLATE
CQUAD4    1881    1    751    750    752    753
0.0
CQUAD4    1882    1    753    752    754    755
0.0
CQUAD4    1883    1    755    754    756    757
0.0
CQUAD4    1884    1    757    756    758    759
0.0
CQUAD4    1885    1    759    758    760    761
0.0
CQUAD4    1886    1    761    760    762    763
0.0
CQUAD4    1887    1    763    762    764    765
0.0
CQUAD4    1888    1    765    764    750    751
0.0
$ CONTROLLER BOARD PLATES (IMU UNIT
PLATE) FOR GIMBAL#3
CTRIA3    1891    15    225    805    226
CTRIA3    1892    15    226    805    227
CTRIA3    1893    15    227    805    228
CTRIA3    1894    15    228    805    225
$ START WEIGHTLESS BACK-UP BEAMS FOR
GIMBAL#3 CONTROLLER BOARD PLATE
CBEAM     1895    17    225    805    226
CBEAM     1896    17    226    805    227
CBEAM     1897    17    227    805    228
CBEAM     1898    17    228    805    229
$ 14.75# STEEL PLATE
CQUAD4, 1900, 40, 1, 2, 3, 4
$ THRUSTER PLATES FOLLOW
$ REVISED 90/11/28
$ MAIN TRUSS PLATES, FWD
CTRIA3, 1901, 15,  1, 5,489
CTRIA3, 1902, 15,  5, 6,489
CTRIA3, 1903, 15,  6, 2,489
CTRIA3, 1904, 15,  2, 1,489
CTRIA3, 1905, 15,  2, 6,490
CTRIA3, 1906, 15,  6, 7,490
CTRIA3, 1907, 15,  7, 3,490
CTRIA3, 1908, 15,  3, 2,490
CTRIA3, 1909, 15,  4, 8,491
CTRIA3, 1910, 15,  8, 7,491
CTRIA3, 1911, 15,  7, 3,491
CTRIA3, 1912, 15,  3, 4,491
CTRIA3, 1913, 15,  1, 5,492
CTRIA3, 1914, 15,  5, 8,492
CTRIA3, 1915, 15,  8, 4,492
CTRIA3, 1916, 15,  4, 1,492
$ TOWER TRUSS PLATES
CTRIA3, 1921, 15,305,308,493
CTRIA3, 1922, 15,308,304,493
CTRIA3, 1923, 15,304,301,493
CTRIA3, 1924, 15,301,305,493
CTRIA3, 1925, 15,308,307,494
CTRIA3, 1926, 15,307,303,494
CTRIA3, 1927, 15,303,304,494
CTRIA3, 1928, 15,304,308,494
CTRIA3, 1929, 15,307,306,495
CTRIA3, 1930, 15,306,302,495
CTRIA3, 1931, 15,302,303,495
CTRIA3, 1932, 15,303,307,495
CTRIA3, 1933, 15,306,305,496
CTRIA3, 1934, 15,305,301,496
CTRIA3, 1935, 15,301,302,496
CTRIA3, 1936, 15,302,306,496
$ MAIN TRUSS PLATES, MIDDLE
CTRIA3, 1941, 15,129,133,498
CTRIA3, 1942, 15,133,134,498
CTRIA3, 1943, 15,134,130,498
CTRIA3, 1944, 15,130,129,498
CTRIA3, 1945, 15,130,131,499
CTRIA3, 1946, 15,131,135,499
CTRIA3, 1947, 15,135,134,499
CTRIA3, 1948, 15,134,130,499
CTRIA3, 1949, 15,132,131,500
CTRIA3, 1950, 15,131,135,500
CTRIA3, 1951, 15,135,136,500
CTRIA3, 1952, 15,136,132,500
CTRIA3, 1953, 15,129,132,501
CTRIA3, 1954, 15,132,136,501
CTRIA3, 1955, 15,136,133,501
CTRIA3, 1956, 15,133,129,501
$ RFL TRUSS PLATES
CTRIA3, 1961, 15,265,268,502
CTRIA3, 1962, 15,268,264,502
CTRIA3, 1963, 15,264,261,502
CTRIA3, 1964, 15,261,265,502
CTRIA3, 1965, 15,268,267,503
CTRIA3, 1966, 15,267,263,503
CTRIA3, 1967, 15,263,264,503
CTRIA3, 1968, 15,264,268,503
CTRIA3, 1969, 15,266,267,504
CTRIA3, 1970, 15,267,263,504
CTRIA3, 1971, 15,263,262,504
CTRIA3, 1972, 15,262,266,504
CTRIA3, 1973, 15,266,265,505
CTRIA3, 1974, 15,265,261,505
CTRIA3, 1975, 15,261,262,505
CTRIA3, 1976, 15,262,266,505
$ LASER PLATE
CTRIA3, 1981, 15,310,311,497
CTRIA3, 1982, 15,311,312,497
CTRIA3, 1983, 15,312,309,497
```

```
CTRIA3, 1984, 15,309,310,497
$ THRUSTER CONTROLLER BOARD PLATES
90/09/25
CQUAD4, 1991, 15,101,102,103,104
CQUAD4, 1992, 15,165,166,167,168
$ START WEIGHLESS BACKUP BEAMS TO
THRUSTER PLATES
$ FORWARD THRUSTER
CBEAM,2000,17, 1,489,491
CBEAM,2001,17,489, 6,491
CBEAM,2002,17, 2,490,492
CBEAM,2003,17,490, 7,492
CBEAM,2004,17, 3,491,489
CBEAM,2005,17,491, 8,489
CBEAM,2006,17, 4,492,490
CBEAM,2007,17,492, 5,490
$ TOWER THRUSTER
CBEAM,2010,17,304,493,495
CBEAM,2011,17,493,307,495
CBEAM,2012,17,303,494,496
CBEAM,2013,17,494,306,496
CBEAM,2014,17,301,495,493
CBEAM,2015,17,495,306,493
CBEAM,2016,17,304,496,494
CBEAM,2017,17,496,304,494
CBEAM,2018,17,312,497,309
CBEAM,2019,17,497,310,309
$ MIDDLE THRUSTER
CBEAM,2020,17,129,498,500
CBEAM,2021,17,498,134,500
CBEAM,2022,17,130,499,501
CBEAM,2023,17,499,135,501
CBEAM,2024,17,131,500,498
CBEAM,2025,17,500,136,498
CBEAM,2026,17,132,501,499
CBEAM,2027,17,501,133,499
$ REFLECTOR TOWER THRUSTER
CBEAM,2030,17,265,502,504
CBEAM,2031,17,502,264,504
CBEAM,2032,17,268,503,505
CBEAM,2033,17,503,263,505
CBEAM,2034,17,267,504,502
CBEAM,2035,17,504,262,502
CBEAM,2036,17,266,505,503
CBEAM,2037,17,505,261,503
$ WTLESS BACKUP BEAMS FOR REFLECTOR
SPACER PLATE
CBEAM,2040,17,859,851,852
CBEAM,2041,17,859,853,854
CBEAM,2042,17,859,855,856
CBEAM,2043,17,859,857,858
$ REFLECTOR SPACER PLATE CONNECTORS TO
BRACKET TRUSS
CBEAM,2045,12,485,854,858
CBEAM,2046,12,486,856,852
CBEAM,2047,12,487,858,854
CBEAM,2048,12,488,852,856
$ REFLECTOR SPACER PLATE
CTRIA3    2051    25    851    852    859    0.
CTRIA3    2052    25    852    853    859    0.
CTRIA3    2053    25    853    854    859    0.
CTRIA3    2054    25    854    855    859    0.
CTRIA3    2055    25    855    856    859    0.
CTRIA3    2056    25    856    857    859    0.
CTRIA3    2057    25    857    858    859    0.
CTRIA3    2058    25    858    851    859    0.
$ SPRINGS AT TOP OF SUSPENSION CABLE
$ CHANGED 92/01/02
CELAS2, 2201, 0.5, 508, 3, 509, 3
CELAS2, 2202, 0.5, 518, 3, 519, 3
CELAS2, 2203, 0.5, 528, 3, 529, 3
CELAS2, 2204, 0.5, 538, 3, 539, 3
$ air tubing stiffness at thruster locations
CELAS2, 2241, .175,   1, 1
CELAS2, 2242, .127,   1, 2
CELAS2, 2243, .200,   1, 3
CELAS2, 2244, .175, 129, 1
CELAS2, 2245, .2606,129, 2
CELAS2, 2246, .200, 129, 3
CELAS2, 2247, .175, 265, 1
CELAS2, 2248, .2606, 265, 2
CELAS2, 2249, .200, 265, 3
CELAS2, 2250, .175, 309, 1
CELAS2, 2251, .127, 309, 2
CELAS2, 2252, .200, 309, 3
$ START JOINT LUMPED MASSES
$ joint mass = ball mass (4.12E-04 lb-s**2/in)
CONM2, 3001,  1, 0,4.12E-04
CONM2, 3002,  2, 0,4.12E-04
CONM2, 3003,  3, 0,4.12E-04
CONM2, 3004,  4, 0,4.12E-04
CONM2, 3005,  5, 0,4.12E-04
CONM2, 3006,  6, 0,4.12E-04
CONM2, 3007,  7, 0,4.12E-04
CONM2, 3008,  8, 0,4.12E-04
CONM2, 3009,  9, 0,4.12E-04
CONM2, 3010, 10, 0,4.12E-04
CONM2, 3011, 11, 0,4.12E-04
CONM2, 3012, 12, 0,4.12E-04
CONM2, 3013, 13, 0,4.12E-04
CONM2, 3014, 14, 0,4.12E-04
CONM2, 3015, 15, 0,4.12E-04
CONM2, 3016, 16, 0,4.12E-04
CONM2, 3017, 17, 0,4.12E-04
CONM2, 3018, 18, 0,4.12E-04
CONM2, 3019, 19, 0,4.12E-04
CONM2, 3020, 20, 0,4.12E-04
CONM2, 3021, 21, 0,4.12E-04
CONM2, 3022, 22, 0,4.12E-04
CONM2, 3023, 23, 0,4.12E-04
CONM2, 3024, 24, 0,4.12E-04
CONM2, 3025, 25, 0,4.12E-04
CONM2, 3026, 26, 0,4.12E-04
CONM2, 3027, 27, 0,4.12E-04
CONM2, 3028, 28, 0,4.12E-04
CONM2, 3029, 29, 0,4.12E-04
CONM2, 3030, 30, 0,4.12E-04
CONM2, 3031, 31, 0,4.12E-04
CONM2, 3032, 32, 0,4.12E-04
CONM2, 3033, 33, 0,4.12E-04
CONM2, 3034, 34, 0,4.12E-04
CONM2, 3035, 35, 0,4.12E-04
CONM2, 3036, 36, 0,4.12E-04
CONM2, 3037, 37, 0,4.12E-04
CONM2, 3038, 38, 0,4.12E-04
CONM2, 3039, 39, 0,4.12E-04
CONM2, 3040, 40, 0,4.12E-04
CONM2, 3041, 41, 0,4.12E-04
```

CONM2, 3042, 42, 0,4.12E-04
CONM2, 3043, 43, 0,4.12E-04
CONM2, 3044, 44, 0,4.12E-04
CONM2, 3045, 45, 0,4.12E-04
CONM2, 3046, 46, 0,4.12E-04
CONM2, 3047, 47, 0,4.12E-04
CONM2, 3048, 48, 0,4.12E-04
CONM2, 3049, 49, 0,4.12E-04
CONM2, 3050, 50, 0,4.12E-04
CONM2, 3051, 51, 0,4.12E-04
CONM2, 3052, 52, 0,4.12E-04
CONM2, 3053, 53, 0,4.12E-04
CONM2, 3054, 54, 0,4.12E-04
CONM2, 3055, 55, 0,4.12E-04
CONM2, 3056, 56, 0,4.12E-04
CONM2, 3057, 57, 0,4.12E-04
CONM2, 3058, 58, 0,4.12E-04
CONM2, 3059, 59, 0,4.12E-04
CONM2, 3060, 60, 0,4.12E-04
CONM2, 3061, 61, 0,4.12E-04
CONM2, 3062, 62, 0,4.12E-04
CONM2, 3063, 63, 0,4.12E-04
CONM2, 3064, 64, 0,4.12E-04
CONM2, 3065, 65, 0,4.12E-04
CONM2, 3066, 66, 0,4.12E-04
CONM2, 3067, 67, 0,4.12E-04
CONM2, 3068, 68, 0,4.12E-04
CONM2, 3069, 69, 0,4.12E-04
CONM2, 3070, 70, 0,4.12E-04
CONM2, 3071, 71, 0,4.12E-04
CONM2, 3072, 72, 0,4.12E-04
CONM2, 3073, 73, 0,4.12E-04
CONM2, 3074, 74, 0,4.12E-04
CONM2, 3075, 75, 0,4.12E-04
CONM2, 3076, 76, 0,4.12E-04
CONM2, 3077, 77, 0,4.12E-04
CONM2, 3078, 78, 0,4.12E-04
CONM2, 3079, 79, 0,4.12E-04
CONM2, 3080, 80, 0,4.12E-04
CONM2, 3081, 81, 0,4.12E-04
CONM2, 3082, 82, 0,4.12E-04
CONM2, 3083, 83, 0,4.12E-04
CONM2, 3084, 84, 0,4.12E-04
CONM2, 3085, 85, 0,4.12E-04
CONM2, 3086, 86, 0,4.12E-04
CONM2, 3087, 87, 0,4.12E-04
CONM2, 3088, 88, 0,4.12E-04
CONM2, 3089, 89, 0,4.12E-04
CONM2, 3090, 90, 0,4.12E-04
CONM2, 3091, 91, 0,4.12E-04
CONM2, 3092, 92, 0,4.12E-04
CONM2, 3093, 93, 0,4.12E-04
CONM2, 3094, 94, 0,4.12E-04
CONM2, 3095, 95, 0,4.12E-04
CONM2, 3096, 96, 0,4.12E-04
CONM2, 3097, 97, 0,4.12E-04
CONM2, 3098, 98, 0,4.12E-04
CONM2, 3099, 99, 0,4.12E-04
CONM2, 3100, 100, 0,4.12E-04
CONM2, 3101, 101, 0,4.12E-04
CONM2, 3102, 102, 0,4.12E-04
CONM2, 3103, 103, 0,4.12E-04
CONM2, 3104, 104, 0,4.12E-04
CONM2, 3105, 105, 0,4.12E-04
CONM2, 3106, 106, 0,4.12E-04
CONM2, 3107, 107, 0,4.12E-04
CONM2, 3108, 108, 0,4.12E-04
CONM2, 3109, 109, 0,4.12E-04
CONM2, 3110, 110, 0,4.12E-04
CONM2, 3111, 111, 0,4.12E-04
CONM2, 3112, 112, 0,4.12E-04
CONM2, 3113, 113, 0,4.12E-04
CONM2, 3114, 114, 0,4.12E-04
CONM2, 3115, 115, 0,4.12E-04
CONM2, 3116, 116, 0,4.12E-04
CONM2, 3117, 117, 0,4.12E-04
CONM2, 3118, 118, 0,4.12E-04
CONM2, 3119, 119, 0,4.12E-04
CONM2, 3120, 120, 0,4.12E-04
CONM2, 3121, 121, 0,4.12E-04
CONM2, 3122, 122, 0,4.12E-04
CONM2, 3123, 123, 0,4.12E-04
CONM2, 3124, 124, 0,4.12E-04
CONM2, 3125, 125, 0,4.12E-04
CONM2, 3126, 126, 0,4.12E-04
CONM2, 3127, 127, 0,4.12E-04
CONM2, 3128, 128, 0,4.12E-04
CONM2, 3129, 129, 0,4.12E-04
CONM2, 3130, 130, 0,4.12E-04
CONM2, 3131, 131, 0,4.12E-04
CONM2, 3132, 132, 0,4.12E-04
CONM2, 3133, 133, 0,4.12E-04
CONM2, 3134, 134, 0,4.12E-04
CONM2, 3135, 135, 0,4.12E-04
CONM2, 3136, 136, 0,4.12E-04
CONM2, 3137, 137, 0,4.12E-04
CONM2, 3138, 138, 0,4.12E-04
CONM2, 3139, 139, 0,4.12E-04
CONM2, 3140, 140, 0,4.12E-04
CONM2, 3141, 141, 0,4.12E-04
CONM2, 3142, 142, 0,4.12E-04
CONM2, 3143, 143, 0,4.12E-04
CONM2, 3144, 144, 0,4.12E-04
CONM2, 3145, 145, 0,4.12E-04
CONM2, 3146, 146, 0,4.12E-04
CONM2, 3147, 147, 0,4.12E-04
CONM2, 3148, 148, 0,4.12E-04
CONM2, 3149, 149, 0,4.12E-04
CONM2, 3150, 150, 0,4.12E-04
CONM2, 3151, 151, 0,4.12E-04
CONM2, 3152, 152, 0,4.12E-04
CONM2, 3153, 153, 0,4.12E-04
CONM2, 3154, 154, 0,4.12E-04
CONM2, 3155, 155, 0,4.12E-04
CONM2, 3156, 156, 0,4.12E-04
CONM2, 3157, 157, 0,4.12E-04
CONM2, 3158, 158, 0,4.12E-04
CONM2, 3159, 159, 0,4.12E-04
CONM2, 3160, 160, 0,4.12E-04
CONM2, 3161, 161, 0,4.12E-04
CONM2, 3162, 162, 0,4.12E-04
CONM2, 3163, 163, 0,4.12E-04
CONM2, 3164, 164, 0,4.12E-04
CONM2, 3165, 165, 0,4.12E-04
CONM2, 3166, 166, 0,4.12E-04
CONM2, 3167, 167, 0,4.12E-04
CONM2, 3168, 168, 0,4.12E-04
CONM2, 3169, 169, 0,4.12E-04

CONM2, 3170, 170, 0,4.12E-04
CONM2, 3171, 171, 0,4.12E-04
CONM2, 3172, 172, 0,4.12E-04
CONM2, 3173, 173, 0,4.12E-04
CONM2, 3174, 174, 0,4.12E-04
CONM2, 3175, 175, 0,4.12E-04
CONM2, 3176, 176, 0,4.12E-04
CONM2, 3177, 177, 0,4.12E-04
CONM2, 3178, 178, 0,4.12E-04
CONM2, 3179, 179, 0,4.12E-04
CONM2, 3180, 180, 0,4.12E-04
CONM2, 3181, 181, 0,4.12E-04
CONM2, 3182, 182, 0,4.12E-04
CONM2, 3183, 183, 0,4.12E-04
CONM2, 3184, 184, 0,4.12E-04
CONM2, 3185, 185, 0,4.12E-04
CONM2, 3186, 186, 0,4.12E-04
CONM2, 3187, 187, 0,4.12E-04
CONM2, 3188, 188, 0,4.12E-04
CONM2, 3189, 189, 0,4.12E-04
CONM2, 3190, 190, 0,4.12E-04
CONM2, 3191, 191, 0,4.12E-04
CONM2, 3192, 192, 0,4.12E-04
CONM2, 3193, 193, 0,4.12E-04
CONM2, 3194, 194, 0,4.12E-04
CONM2, 3195, 195, 0,4.12E-04
CONM2, 3196, 196, 0,4.12E-04
CONM2, 3197, 197, 0,4.12E-04
CONM2, 3198, 198, 0,4.12E-04
CONM2, 3199, 199, 0,4.12E-04
CONM2, 3200, 200, 0,4.12E-04
CONM2, 3201, 201, 0,4.12E-04
CONM2, 3202, 202, 0,4.12E-04
CONM2, 3203, 203, 0,4.12E-04
CONM2, 3204, 204, 0,4.12E-04
CONM2, 3205, 205, 0,4.12E-04
CONM2, 3206, 206, 0,4.12E-04
CONM2, 3207, 207, 0,4.12E-04
CONM2, 3208, 208, 0,4.12E-04
CONM2, 3209, 209, 0,4.12E-04
CONM2, 3210, 210, 0,4.12E-04
CONM2, 3211, 211, 0,4.12E-04
CONM2, 3212, 212, 0,4.12E-04
CONM2, 3213, 213, 0,4.12E-04
CONM2, 3214, 214, 0,4.12E-04
CONM2, 3215, 215, 0,4.12E-04
CONM2, 3216, 216, 0,4.12E-04
CONM2, 3217, 217, 0,4.12E-04
CONM2, 3218, 218, 0,4.12E-04
CONM2, 3219, 219, 0,4.12E-04
CONM2, 3220, 220, 0,4.12E-04
CONM2, 3221, 221, 0,4.12E-04
CONM2, 3222, 222, 0,4.12E-04
CONM2, 3223, 223, 0,4.12E-04
CONM2, 3224, 224, 0,4.12E-04
CONM2, 3225, 225, 0,4.12E-04
CONM2, 3226, 226, 0,4.12E-04
CONM2, 3227, 227, 0,4.12E-04
CONM2, 3228, 228, 0,4.12E-04
CONM2, 3229, 229, 0,4.12E-04
CONM2, 3230, 230, 0,4.12E-04
CONM2, 3231, 231, 0,4.12E-04
CONM2, 3232, 232, 0,4.12E-04
CONM2, 3233, 233, 0,4.12E-04
CONM2, 3234, 234, 0,4.12E-04
CONM2, 3235, 235, 0,4.12E-04
CONM2, 3236, 236, 0,4.12E-04
CONM2, 3237, 237, 0,4.12E-04
CONM2, 3238, 238, 0,4.12E-04
CONM2, 3239, 239, 0,4.12E-04
CONM2, 3240, 240, 0,4.12E-04
CONM2, 3241, 241, 0,4.12E-04
CONM2, 3242, 242, 0,4.12E-04
CONM2, 3243, 243, 0,4.12E-04
CONM2, 3244, 244, 0,4.12E-04
CONM2, 3245, 245, 0,4.12E-04
CONM2, 3246, 246, 0,4.12E-04
CONM2, 3247, 247, 0,4.12E-04
CONM2, 3248, 248, 0,4.12E-04
CONM2, 3249, 249, 0,4.12E-04
CONM2, 3250, 250, 0,4.12E-04
CONM2, 3251, 251, 0,4.12E-04
CONM2, 3252, 252, 0,4.12E-04
CONM2, 3253, 253, 0,4.12E-04
CONM2, 3254, 254, 0,4.12E-04
CONM2, 3255, 255, 0,4.12E-04
CONM2, 3256, 256, 0,4.12E-04
CONM2, 3257, 257, 0,4.12E-04
CONM2, 3258, 258, 0,4.12E-04
CONM2, 3259, 259, 0,4.12E-04
CONM2, 3260, 260, 0,4.12E-04
CONM2, 3261, 261, 0,4.12E-04
CONM2, 3262, 262, 0,4.12E-04
CONM2, 3263, 263, 0,4.12E-04
CONM2, 3264, 264, 0,4.12E-04
CONM2, 3265, 265, 0,4.12E-04
CONM2, 3266, 266, 0,4.12E-04
CONM2, 3267, 267, 0,4.12E-04
CONM2, 3268, 268, 0,4.12E-04
CONM2, 3269, 269, 0,4.12E-04
CONM2, 3270, 270, 0,4.12E-04
CONM2, 3271, 271, 0,4.12E-04
CONM2, 3272, 272, 0,4.12E-04
CONM2, 3273, 273, 0,4.12E-04
CONM2, 3274, 274, 0,4.12E-04
CONM2, 3275, 275, 0,4.12E-04
CONM2, 3276, 276, 0,4.12E-04
CONM2, 3277, 277, 0,4.12E-04
CONM2, 3278, 278, 0,4.12E-04
CONM2, 3279, 279, 0,4.12E-04
CONM2, 3280, 280, 0,4.12E-04
CONM2, 3281, 281, 0,4.12E-04
CONM2, 3282, 282, 0,4.12E-04
CONM2, 3283, 283, 0,4.12E-04
CONM2, 3284, 284, 0,4.12E-04
CONM2, 3285, 285, 0,4.12E-04
CONM2, 3286, 286, 0,4.12E-04
CONM2, 3287, 287, 0,4.12E-04
CONM2, 3288, 288, 0,4.12E-04
CONM2, 3289, 289, 0,4.12E-04
CONM2, 3290, 290, 0,4.12E-04
CONM2, 3291, 291, 0,4.12E-04
CONM2, 3292, 292, 0,4.12E-04
CONM2, 3293, 293, 0,4.12E-04
CONM2, 3294, 294, 0,4.12E-04
CONM2, 3295, 295, 0,4.12E-04
CONM2, 3296, 296, 0,4.12E-04
CONM2, 3297, 297, 0,4.12E-04

C-2

CONM2, 3298, 298, 0,4.12E-04
CONM2, 3299, 299, 0,4.12E-04
CONM2, 3300, 300, 0,4.12E-04
CONM2, 3301, 301, 0,4.12E-04
CONM2, 3302, 302, 0,4.12E-04
CONM2, 3303, 303, 0,4.12E-04
CONM2, 3304, 304, 0,4.12E-04
CONM2, 3305, 305, 0,4.12E-04
CONM2, 3306, 306, 0,4.12E-04
CONM2, 3307, 307, 0,4.12E-04
CONM2, 3308, 308, 0,4.12E-04
CONM2, 3309, 309, 0,4.12E-04
CONM2, 3310, 310, 0,4.12E-04
CONM2, 3311, 311, 0,4.12E-04
CONM2, 3312, 312, 0,4.12E-04
CONM2, 3313, 313, 0,4.12E-04
CONM2, 3314, 314, 0,4.12E-04
CONM2, 3315, 315, 0,4.12E-04
CONM2, 3316, 316, 0,4.12E-04
CONM2, 3317, 317, 0,4.12E-04
CONM2, 3318, 318, 0,4.12E-04
CONM2, 3319, 319, 0,4.12E-04
CONM2, 3320, 320, 0,4.12E-04
CONM2, 3321, 321, 0,4.12E-04
CONM2, 3322, 322, 0,4.12E-04
CONM2, 3323, 323, 0,4.12E-04
CONM2, 3324, 324, 0,4.12E-04
CONM2, 3325, 325, 0,4.12E-04
CONM2, 3326, 326, 0,4.12E-04
CONM2, 3327, 327, 0,4.12E-04
CONM2, 3328, 328, 0,4.12E-04
CONM2, 3329, 329, 0,4.12E-04
CONM2, 3330, 330, 0,4.12E-04
CONM2, 3331, 331, 0,4.12E-04
CONM2, 3332, 332, 0,4.12E-04
CONM2, 3333, 333, 0,4.12E-04
CONM2, 3334, 334, 0,4.12E-04
CONM2, 3335, 335, 0,4.12E-04
CONM2, 3336, 336, 0,4.12E-04
CONM2, 3337, 337, 0,4.12E-04
CONM2, 3338, 338, 0,4.12E-04
CONM2, 3339, 339, 0,4.12E-04
CONM2, 3340, 340, 0,4.12E-04
CONM2, 3341, 341, 0,4.12E-04
CONM2, 3342, 342, 0,4.12E-04
CONM2, 3343, 343, 0,4.12E-04
CONM2, 3344, 344, 0,4.12E-04
CONM2, 3345, 345, 0,4.12E-04
CONM2, 3346, 346, 0,4.12E-04
CONM2, 3347, 347, 0,4.12E-04
CONM2, 3348, 348, 0,4.12E-04
CONM2, 3349, 349, 0,4.12E-04
CONM2, 3350, 350, 0,4.12E-04
CONM2, 3351, 351, 0,4.12E-04
CONM2, 3352, 352, 0,4.12E-04
CONM2, 3353, 353, 0,4.12E-04
CONM2, 3354, 354, 0,4.12E-04
CONM2, 3355, 355, 0,4.12E-04
CONM2, 3356, 356, 0,4.12E-04
CONM2, 3357, 357, 0,4.12E-04
CONM2, 3358, 358, 0,4.12E-04
CONM2, 3359, 359, 0,4.12E-04
CONM2, 3360, 360, 0,4.12E-04
CONM2, 3361, 361, 0,4.12E-04
CONM2, 3362, 362, 0,4.12E-04
CONM2, 3363, 363, 0,4.12E-04
CONM2, 3364, 364, 0,4.12E-04
CONM2, 3365, 365, 0,4.12E-04
CONM2, 3366, 366, 0,4.12E-04
CONM2, 3367, 367, 0,4.12E-04
CONM2, 3368, 368, 0,4.12E-04
CONM2, 3369, 369, 0,4.12E-04
CONM2, 3370, 370, 0,4.12E-04
CONM2, 3371, 371, 0,4.12E-04
CONM2, 3372, 372, 0,4.12E-04
CONM2, 3393, 397, 0,4.12E-04
CONM2, 3394, 398, 0,4.12E-04
CONM2, 3395, 399, 0,4.12E-04
CONM2, 3396, 400, 0,4.12E-04
CONM2, 3397, 401, 0,4.12E-04
CONM2, 3398, 402, 0,4.12E-04
CONM2, 3399, 403, 0,4.12E-04
CONM2, 3400, 404, 0,4.12E-04
CONM2, 3401, 405, 0,4.12E-04
CONM2, 3402, 406, 0,4.12E-04
CONM2, 3403, 407, 0,4.12E-04
CONM2, 3404, 408, 0,4.12E-04
CONM2, 3405, 409, 0,4.12E-04
CONM2, 3406, 410, 0,4.12E-04
CONM2, 3407, 411, 0,4.12E-04
CONM2, 3408, 412, 0,4.12E-04
CONM2, 3409, 413, 0,4.12E-04
CONM2, 3410, 414, 0,4.12E-04
CONM2, 3411, 415, 0,4.12E-04
CONM2, 3412, 416, 0,4.12E-04
CONM2, 3413, 417, 0,4.12E-04
CONM2, 3414, 418, 0,4.12E-04
CONM2, 3415, 419, 0,4.12E-04
CONM2, 3416, 420, 0,4.12E-04
CONM2, 3417, 421, 0,4.12E-04
CONM2, 3418, 422, 0,4.12E-04
CONM2, 3419, 423, 0,4.12E-04
CONM2, 3420, 424, 0,4.12E-04
CONM2, 3421, 425, 0,4.12E-04
CONM2, 3422, 426, 0,4.12E-04
CONM2, 3423, 427, 0,4.12E-04
CONM2, 3424, 428, 0,4.12E-04
CONM2, 3425, 429, 0,4.12E-04
CONM2, 3426, 430, 0,4.12E-04
CONM2, 3427, 431, 0,4.12E-04
CONM2, 3428, 432, 0,4.12E-04
CONM2, 3429, 433, 0,4.12E-04
CONM2, 3430, 434, 0,4.12E-04
CONM2, 3431, 435, 0,4.12E-04
CONM2, 3432, 436, 0,4.12E-04
CONM2, 3433, 437, 0,4.12E-04
CONM2, 3434, 438, 0,4.12E-04
CONM2, 3435, 439, 0,4.12E-04
CONM2, 3436, 440, 0,4.12E-04
CONM2, 3437, 441, 0,4.12E-04
CONM2, 3438, 442, 0,4.12E-04
CONM2, 3439, 443, 0,4.12E-04
CONM2, 3440, 444, 0,4.12E-04
CONM2, 3441, 445, 0,4.12E-04
CONM2, 3442, 446, 0,4.12E-04
CONM2, 3443, 447, 0,4.12E-04
CONM2, 3444, 448, 0,4.12E-04
CONM2, 3445, 449, 0,4.12E-04

```
CONM2, 3446, 450, 0,4.12E-04
CONM2, 3447, 451, 0,4.12E-04
CONM2, 3448, 452, 0,4.12E-04
CONM2, 3449, 453, 0,4.12E-04
CONM2, 3450, 454, 0,4.12E-04
CONM2, 3451, 455, 0,4.12E-04
CONM2, 3452, 456, 0,4.12E-04
$ end joint mass
$ start suspension cable mass
CONM2, 3453, 514, 0,2.59E-04
CONM2, 3454, 515, 0,2.59E-04
CONM2, 3455, 516, 0,2.59E-04
CONM2, 3456, 524, 0,2.59E-04
CONM2, 3457, 525, 0,2.59E-04
CONM2, 3458, 526, 0,2.59E-04
CONM2, 3459, 534, 0,2.59E-04
CONM2, 3460, 535, 0,2.59E-04
CONM2, 3461, 536, 0,2.59E-04
CONM2, 3462, 544, 0,2.59E-04
CONM2, 3463, 545, 0,2.59E-04
CONM2, 3464, 546, 0,2.59E-04
$ GIMBAL ENCODER, DECODER MASS
CONM2, 3465, 598, 0,.03148
CONM2, 3466, 599, 0,.02643
CONM2, 3467, 600, 0,.02267
CONM2, 3468, 601, 0,.01943
CONM2, 3469, 698, 0,.03148
CONM2, 3470, 699, 0,.02643
CONM2, 3471, 700, 0,.02267
CONM2, 3472, 701, 0,.01943
CONM2, 3473, 798, 0,.03148
CONM2, 3474, 799, 0,.02643
CONM2, 3475, 800, 0,.02267
CONM2, 3476, 801, 0,.01943
$ .082902 GIMBAL LASER MASS (32 lbm)
CONM2, 3477, 602, 0,8.290E-2, 0., 0., 0.
,.05, ,.1, , ,0.
CONM2, 3478, 702, 0,8.290E-2, 0., 0., 0.
,.05, ,.1, , ,0.
CONM2, 3479, 802, 0,8.290E-2, 0., 0., 0.
,.05, ,.1, , ,0.
$ .000206 HALF A NODE BALL AT ENDS OF
GIMBAL SUPPORT
CONM2, 3481, 550, 0,2.06E-4
CONM2, 3482, 554, 0,2.06E-4
CONM2, 3483, 558, 0,2.06E-4
CONM2, 3484, 562, 0,2.06E-4
CONM2, 3485, 650, 0,2.06E-4
CONM2, 3486, 654, 0,2.06E-4
CONM2, 3487, 658, 0,2.06E-4
CONM2, 3488, 662, 0,2.06E-4
CONM2, 3489, 750, 0,2.06E-4
CONM2, 3490, 754, 0,2.06E-4
CONM2, 3491, 758, 0,2.06E-4
CONM2, 3492, 762, 0,2.06E-4
$ INSTRUMENTATION MASS
$ SERVO BLOCK        - .000979
$ STRUTCELL BLOCK        - .000135
$ STRUTCELL BLOCK + 3 STRUTCELL ACC
CONM2,  3501,    59, 0,.000201
CONM2,  3502,    60, 0,.000201
CONM2,  3503,    79, 0,.000201
CONM2,  3504,    80, 0,.000201
CONM2,  3505,    91, 0,.000201
CONM2,  3506,    92, 0,.000201
CONM2,  3507,   115, 0,.000201
CONM2,  3508,   116, 0,.000201
CONM2,  3509,   127, 0,.000201
CONM2,  3510,   128, 0,.000201
CONM2,  3511,   147, 0,.000201
CONM2,  3512,   148, 0,.000201
CONM2,  3513,   159, 0,.000201
CONM2,  3514,   160, 0,.000201
CONM2,  3515,   171, 0,.000201
CONM2,  3516,   172, 0,.000201
CONM2,  3517,   195, 0,.000201
CONM2,  3518,   196, 0,.000201
CONM2,  3519,   207, 0,.000201
CONM2,  3520,   208, 0,.000201
CONM2,  3521,   219, 0,.000201
CONM2,  3522,   220, 0,.000201
CONM2,  3523,   239, 0,.000201
CONM2,  3524,   240, 0,.000201
CONM2,  3525,   255, 0,.000201
CONM2,  3526,   256, 0,.000201
CONM2,  3527,   264, 0,.000201
CONM2,  3528,   287, 0,.000201
CONM2,  3529,   288, 0,.000201
CONM2,  3530,   299, 0,.000201
CONM2,  3531,   300, 0,.000201
CONM2,  3532,   312, 0,.000201
$ SERVO BLOCK + 3 SERVO ACCELEROMETERS
CONM2,  3533,     4, 0,.002176
CONM2,  3534,   311, 0,.002176
CONM2,  3535,   352, 0,.002176
CONM2,  3536,   348, 0,.002176
CONM2,  3537,   251, 0,.002176
CONM2,  3538,   263, 0,.002176
CONM2,  3539,   431, 0,.002176
CONM2,  3540,   435, 0,.002176
$ SERVO BLOCK + 2 SERVO ACC + 1 STRUTCELL
ACC
CONM2,  3541,    28, 0,.001799
CONM2,  3542,    52, 0,.001799
CONM2,  3543,    68, 0,.001799
CONM2,  3546,   104, 0,.001799
CONM2,  3547,   136, 0,.001799
CONM2,  3548,   184, 0,.001799
CONM2,  3549,   228, 0,.001799
$ SERVO BLOCK + 1 SERVO ACC + 2 STRUTCELL
ACC
CONM2,  3550,     3, 0,.001422
CONM2,  3551,    27, 0,.001422
CONM2,  3552,    51, 0,.001422
CONM2,  3553,    67, 0,.001422
CONM2,  3554,   103, 0,.001422
CONM2,  3555,   135, 0,.001422
CONM2,  3556,   183, 0,.001422
CONM2,  3557,   227, 0,.001422
CONM2,  3558,   252, 0,.001422
CONM2,  3559,   370, 0,.001422
CONM2,  3560,   372, 0,.001422
CONM2,  3561,   454, 0,.001422
CONM2,  3562,   456, 0,.001422
$.0021660 THRUSTER AIR HOSE MASS (379.24 gms)
CONM2,  3563,     8, 0,.0021660
CONM2,  3564,    12, 0,.0021660
CONM2,  3565,   136, 0,.0021660
```

```
CONM2, 3566,  140, 0,.0021660
CONM2, 3567,  257, 0,.0021660
CONM2, 3568,  260, 0,.0021660
CONM2, 3569,  297, 0,.0021660
CONM2, 4770,  300, 0,.0021660
$ .0038050 mass for thruster controller
CONM2, 3570,  167, 0,.0038050
CONM2, 3571,  168, 0,.0038050
CONM2, 3572,  165, 0,.0038050
CONM2, 3573,  166, 0,.0038050
$ .0038860 mass for thruster controller
CONM2, 3574,  101, 0,.0038860
CONM2, 3575,  104, 0,.0038860
CONM2, 3576,  103, 0,.0038860
CONM2, 3577,  102, 0,.0038860
$ .0066800 air supply bracket and tubing mass
CONM2, 3578,    8, 0,.0066800
CONM2, 3579,   12, 0,.0066800
CONM2, 3580,  136, 0,.0066800
CONM2, 3581,  140, 0,.0066800
CONM2, 3582,  257, 0,.0066800
CONM2, 3583,  257, 0,.0066800
CONM2, 3584,  260, 0,.0066800
CONM2, 3585,  260, 0,.0066800
CONM2, 3586,  297, 0,.0066800
CONM2, 3587,  297, 0,.0066800
CONM2, 3588,  300, 0,.0066800
CONM2, 3589,  300, 0,.0066800
$ .0096030 THRUSTER MASS (1681.3 gms)
CONM2, 3590,  489, 0,.0096030
CONM2, 3591,  496, 0,.0096030
CONM2, 3592,  499, 0,.0096030
CONM2, 3593,  491, 0,.0096030
CONM2, 3594,  495, 0,.0096030
CONM2, 3595,  492, 0,.0096030
CONM2, 3596,  493, 0,.0096030
CONM2, 3597,  494, 0,.0096030
CONM2, 3598,  490, 0,.0096030
CONM2, 3599,  498, 0,.0096030
CONM2, 3600,  503, 0,.0096030
CONM2, 3601,  501, 0,.0096030
CONM2, 3602,  502, 0,.0096030
CONM2, 3603,  505, 0,.0096030
CONM2, 3604,  504, 0,.0096030
CONM2, 3605,  500, 0,.0096030
$ .0133650 LASER MASS (2340 gms)
CONM2, 3606,  497, 0,.0133650
$ .000858 & .000429 THRUSTER CONTROLLER
BOARD SIGNAL CABLE MASS
CONM2, 3610,   97, 0,.000858
CONM2, 3611,   98, 0,.000858
CONM2, 3612,  161, 0,.000429
CONM2, 3613,  162, 0,.000429
CONM2, 3614,  166, 0,.000429
CONM2, 3615,  169, 0,.000429
$ .007772 GIMBAL CONTROLLER BOARD (3# AT
EACH CORNER)
CONM2, 3621, 57, 0, .007772
CONM2, 3622, 58, 0, .007772
CONM2, 3623, 59, 0, .007772
CONM2, 3624, 60, 0, .007772
CONM2, 3625, 81, 0, .007772
CONM2, 3626, 82, 0, .007772
CONM2, 3627, 83, 0, .007772
CONM2, 3628, 84, 0, .007772
CONM2, 3629,225, 0, .007772
CONM2, 3630,226, 0, .007772
CONM2, 3631,227, 0, .007772
CONM2, 3632,228, 0, .007772
$ IMU AT CONTROLLER BOARD 1735 gms.
CONM2, 3633,605, 0, .009912
CONM2, 3634,705, 0, .009912
CONM2, 3635,805, 0, .009912
$ MASS AT SUSPENSION SPRING 6 lbm
CONM2, 3636,509, 0, .015544
CONM2, 3637,519, 0, .015544
CONM2, 3638,529, 0, .015544
CONM2, 3639,539, 0, .015544
$ GIMBAL PLATE
MAT1, 1, 1.E+07, ,.333, .000380
$ GIMBAL RING
MAT1, 4, 1.E+07, ,.333, .000262
$ GIMBAL POSTS, WEIGHLESS
MAT1, 5, 1.E+07, ,.333, .000000
$ GIMBAL LASER SUPPORT - WEIGHLESS
MAT1,11, .30E+08,.11538+8, ,0.
$ SUSPENSION CABLE STANDOFF
MAT1,12, .30E+08,.11538+8, ,.0007332
$ 7X19 1/8" STAINLESS STEEL CABLE
MAT1,13, .30E+08,.11538+8, ,.0007332
$ SUSPENSION KEVLAR CABLE
MAT1,14, 5.E+06, ,.333, .000101, 0.
$ THRUSTER PLATES
MAT1,15, 1.E+07, ,.333, 0.
$ REFLECTOR SPACER PLATE SUPPORT BEAMS -
WEIGHLESS
MAT1,17, .10E+08, ,.333,0.
$ REFLECTOR SPACER PLATE
MAT1,25, .30E+08,.11538+8, ,.0007332
$ 3/4" DIAMETER ROD - REFLECTOR SUPPORT
MAT1,27, .10E+08,.37509+7, ,.0002539
$ ALUMINUM ANGLE - REFLECTOR SUPPORT
MAT1,28, .10E+08,.37509+7, ,.0002539
$ ALUMINUM ANGLE - REFLECTOR SUPPORT
MAT1,29, .10E+08,.37509+7, ,.0002539
$ BOLTS FOR REFLECTOR FIX
MAT1,30, .30E+08,.11538+8, ,.0007332
$ STEEL PLATE
MAT1,40, .30E+08,.11538+8, ,.0007332
$ TRUSS MAT1 CARDS, updated densities 92/7/28
$ SECTION#1 LONGERONS,BATTENS AND
DIAGONALS
MAT1,101, 1.E+07, ,.333333,3.6358-4, 0.
MAT1,102, 1.E+07, ,.333333,5.8464-4, 0.
MAT1,103, 1.E+07, ,.333333,5.3917-4, 0.
$ SECTION#2 LONGERONS,BATTENS AND
DIAGONALS
MAT1,201, 1.E+07, ,.333333,5.8206-4, 0.
MAT1,202, 1.E+07, ,.333333,5.8464-4, 0.
MAT1,203, 1.E+07, ,.333333,5.3917-4, 0.
$ SECTION#3 LONGERONS,BATTENS AND
DIAGONALS
MAT1,301, 1.E+07, ,.333333,4.0156-4, 0.
MAT1,302, 1.E+07, ,.333333,5.8464-4, 0.
MAT1,303, 1.E+07, ,.333333,5.3917-4, 0.
$ SECTION#4 LONGERONS,BATTENS AND
DIAGONALS
MAT1,401, 1.E+07, ,.333333,3.4581-4, 0.
```

```
MAT1,402, 1.E+07, ,.333333,5.8464-4, 0.
MAT1,403, 1.E+07, ,.333333,5.3917-4, 0.
$ GIMBAL SUPPORT BEAMS
MAT1,502, 1.E+07, ,.333333,5.8464-4, 0.
$ GIMBAL PLATE
PSHELL, 1, 1, .50, 1
$ GIMBAL 1/2"X1" RING
PBCOMP, 4, 4, .50,.0416667,.0104167, 0.,.0286098, 0.
,0.,0.
$ GIMBAL 3"X3" POST
PBCOMP, 5, 5, 9.0, 6.750, 6.750, 0., 11.407, 0.
,0.,0.
$ GIMBAL LASER SUPPORT
PBCOMP,11,11, 1., .083333, .083333, 0., .166667, 0.
,0.,0.
$ SUSPENSION CABLE STANDOFFS
PBCOMP,12,12, 1., .083333, .083333, 0., .166667, 0.
,0.,0.
$ 7X19 1/8" STAINLESS STEEL CABLE
PROD,13, 13, .012272
$ .170" KELVAR CABLE
PROD,14, 14, .022698
$ THRUSTER & LASER PLATE
PSHELL,15, 15, .3024, 15
$ WEIGHTLESS BEAM BACKING UP REFLECTOR
SPACER PLATE
PBCOMP,17,17, .001, .0001, .0001, 0., .0002, 0.
,0.,0.
$ SPACER PLATE
PSHELL,25,25,1.622,25
$ 3/4" DIAM ROD - REFLECTOR SUPPORT
PBCOMP,27,27, .4418, 1.55E-02, 1.55E-02, 0., 3.1E-02,
0.
,0.,0.
$ 1 X 1 X 5/16" AL ANGLE CROSS MEMBERS
PBCOMP,28,28, 0.339, 3.E-02, 3.E-02, 0., .00439, 0.
,0.,0.
$ 1 X 1 1/4 X 1/4" AL ANGLE THAT SUPPORTS
BASE PLATE
PBCOMP,29,29, .5, 3.97E-02 ,7.10E-02, 0., .1107, 0.
,0.,0.
$ PBAR 30 IS A 3/8" DIAM. STEEL MEMBER FOR
REFLECTOR FIX
PBCOMP,30,30, .06627, .000971, .000971, 0., .001942,
0.0
,0.,0.
$ STEEL PLATE, UPDATED 90/10/02
PSHELL,40,40, .512367,40
$ truss pid cards, updated 92/7/28
$ SECTION#1
PBCOMP,101,101,.333000,.027803,.027803,0.,.055607,
0.
,0.,0.
PBCOMP,102,102,.097400,.002335,.002335,0.,.004670,
0.
,0.,0.
PBCOMP,103,103,.083100,.002449,.002449,0.,.004897,
0.
,0.,0.
$ SECTION#2
PBCOMP,201,201,.099100,.002760,.002760,0.,.005520,
0.
,0.,0.
PBCOMP,202,202,.097400,.002335,.002335,0.,.004670,
0.
,0.,0.
PBCOMP,203,203,.083100,.002449,.002449,0.,.004897,
0.
,0.,0.
$ SECTION#3
PBCOMP,301,301,.175000,.006303,.006303,0.,.012605,
0.
,0.,0.
PBCOMP,302,302,.097400,.002335,.002335,0.,.004670,
0.
,0.,0.
PBCOMP,303,303,.083100,.002449,.002449,0.,.004897,
0.
,0.,0.
$ SECTION#4
PBCOMP,401,401,.264000,.015763,.015763,0.,.031525,
0.
,0.,0.
PBCOMP,402,402,.097400,.002335,.002335,0.,.004670,
0.
,0.,0.
PBCOMP,403,403,.083100,.002449,.002449,0.,.004897,
0.
,0.,0.
$ GIMBAL SUPPORT BEAMS
PBCOMP,502,502,.097400,.002335,.002335,0.,.004670,
0.
,0.,0.
$
ENDDATA
```

The following NASTRAN runstream uses the mass and stiffness matrices stored in the data base DBALL to calculate eigenvalues and eigenvectors. Note the constraints are changed to reflect the true boundary conditions. This runstream runs under MSC version 66, rigid format 63.

```
NASTRAN REAL=0, HICORE=1000000
RESTART VERSION=1 KEEP
ID PHASE-TWO SUSPENDED FROM KELVAR CABLES
APP DISPLACEMENT
SOL 63
TIME 200
DIAG 16
COMPILE SOL63 SOUIN=MSCSOU NOLIST NOREF $
```

```
$ALTER TO PUT DYNAMIC OUTPUT ON OUTPUT2 TAPE FOR IDEAS
RFALTER RF63D66
$ALTER FOR RECOVERING kG FROM SOL66
RFALTER RF63D89
ENDALTER
CEND
LINE=36
METHOD=33
SEALL=ALL
SPC=101
MPC=1
DISPLACEMENT=ALL
OUTPUT(PLOT)
 CSCALE=1.8
 SET 1 = ALL
 SET 2 = 550 THRU 602, 650 THRU 702, 750 THRU 802
 SET 30 = 1 THRU 500, 812 THRU 899, 955 THRU 986,
        1007 THRU 1146, 1267 THRU 1421, 1531 THRU 1589,
        1601 THRU 1893, 2051 THRU 2058
 PLOTTER NAST
 AXES X,Y,Z
 VIEW = 180.,0.,0.
 PTITLE = FRONT VIEW
 FIND SCALE, ORIGIN 1, SET 30
PLOT MODAL DEFORMATION,SET 30,ORIGIN 1,SHAPE
AXES Y,X,Z
 VIEW = 180.,0.,0.
 PTITLE = SIDE VIEW
 FIND ORIGIN 1
PLOT MODAL DEFORMATION,SET 30,ORIGIN 1,SHAPE
 AXES Z,X,Y
 VIEW = 0.,0.,180.
 PTITLE = TOP VIEW
  FIND ORIGIN 1
PLOT MODAL DEFORMATION,SET 30,ORIGIN 1,SHAPE
$
BEGIN BULK
$2345678$2345678$2345678$2345678$2345678$
SPC1    101     123456  508     518     528     538
SPC1    101     12456   509     519     529     539
PARAM,LGDISP,1
PARAM,LOOPID,4
PARAM,POST,-2
PARAM,OUNIT2,13
PARAM,OQG,NO
PARAM,OUG,YES
PARAM,OEF,NO
PARAM,OES,NO
PARAM,OEE,NO
PARAM,OGPS,NO
PARAM,OCMP,NO
PARAM,OESE,NO
PARAM,OUMU,NO
PARAM,OGPF,NO
EIGRL, 33, 0., 30.
ENDDATA
```

Appendix B

The following is a MATLAB routine to evaluate effective independance based on maximum modal amplitude .

```
function        [limit,trac,deter,cond,fdof,efi,order,fphi]=itindep(x,cdof)
%
%ITINDEP        [limit,trac,deter,cond,fdof,efi,order,fphi]=itindep(x,cdof)
%
%               Iteratively computes effective independence and rank
%               degrees of freedom
%
%               x       = Input mode shape partitions in numerical order
%               cdof    = Input containing dof ID numbers in numerical order
%                         ie. 8000-1 = 8000.1 etc
%
%               limit   = EFI value for highest ranked dof to be truncated
%                         during each iteration
%               trac    = Trace of Ao = PHI'*PHI
%               deter   = Determinant of Ao
%               cond    = Condition number of Ao
%               fdof    = Final list of sensor dof ID numbers
%               EFI     = Final effective independence ranking
%               order   = Final EFI sorted by descending magnitude
%               fphi    = Final partioned mode set
%
%       Input Number of Sensors
%
sen = input('    Enter Number of Sensors: ');
%
%       Set Number of dof to be Truncated Per Iteration
ntk = 1;
%
%       Set Number of Iterations
%
nit = fix(max(size(cdof))-sen/ntk);
%
disp(' ');
disp('    E F F E C T I V E   I N D E P E N D E N C E');
disp(' ');
disp(['    Number of Sensors                 : ',num2str(sen)]);
disp(['    Number of DOF Truncated/Iteration : ',num2str(ntk)]);
disp(['    Number of Iterations              : ',num2str(nit)]);
disp(' ');
junk = input('    RETURN to Continue');
disp(' ');
disp('    Iterating . . . Please Wait');
%
%       Calculate Initial Matrix Measures and Ranking
%       --------------------------------------------
%
t1      = clock;
a       = x'*x;
fphi    = x;
```

```
fdof     = cdof;
trac(1)  = trace(a);
deter(1) = det(a);
cond(1)  = rcond(a);
[p,l]    = eig(a);
e        = fphi*p;
e2       = e.^2;
efd      = e2*(inv(l));
[m,n]    = size(fphi);
add      = ones(n,1);
efi      = efd*add;
[y,I]    = sort(-efi);
order    = -y;
%
%        Loop Over Iterations
%        --------------------
%
for i = 1:nit,
         j        = i+1;
         [m,n]    = size(fphi);
      format short e
         limit(i) = order(m-ntk+1);
         one      = ones(m-ntk,1);
         i1       = cumsum(one);
         id       = I(i1);
         iext     = sort(id);
         fphi     = fphi(iext,:);
         fdof     = fdof(iext);
         a        = fphi'*fphi;
%
         trac(j)  = trace(a);
         deter(j) = det(a);
         cond(j)  = rcond(a);
         [p,l]    = eig(a);
         e        = fphi*p;
         e2       = e.^2;
         efd      = e2*inv(l);
         add      = ones(n,1);
         efi      = efd*add;
         [y,I]    = sort(-efi);
         order    = -y;
%
end;
%
t2 = clock;
Etime=etime(t2,t1);
trac=trac';
deter=deter';
cond=cond';
[yy,II] = sort(I);
end;
disp(' ');
disp(['    Elapsed Wall Clock Time (Sec): ',num2str(Etime)]);
format short;
```

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October 1995	Technical Memorandum

4. TITLE AND SUBTITLE
Langley's CSI Evolutionary Model: Phase II

5. FUNDING NUMBERS
WU 233-01-01-03

6. AUTHOR(S)
Lucas G. Horta, Mercedes C. Reaves, Kenny B. Elliott, W. Keith Belvin, John E. Teter

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
NASA Langley Research Center
Hampton, VA 23681-0001

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, DC 20546-0001

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
NASA TM-109059

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Unclassified - Unlimited
Subject Category - 18

Availability: NASA CASI, (301) 621-0390

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Phase II testbed is part of a sequence of laboratory models, developed at NASA Langley Research Center, to enhance our understanding on how to model, control, and design structures for space applications. A key problem with structures that must perform in space is the appearance of unwanted vibrations during operations. Instruments, design independently by different scientists, must share the same vehicle causing them to interact with each other. Once in space, these problems are difficult to correct and therefore, prediction via analysis design, and experiments is very important. Phase II laboratory model and its predecessors are designed to fill a gap between theory and practice and to aid in understanding important aspects in modeling, sensor and actuator technology, ground testing techniques, and control design issues. This document provides detailed information on the truss structure and its main components, control computer architecture, and structural models generated along with corresponding experimental results.

14. SUBJECT TERMS
modal testing, vibration, finite elements, test methods

15. NUMBER OF PAGES
104

16. PRICE CODE
A06

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified		

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102