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DEVELOPMENT AND EXPERIMENTAL VERIFICATION OF PROCEDURES TO DETERMINE NONLINEAR LOAD-DEFLECTION CHARACTERISTICS OF HELICOPTER SUBSTRUCTURES SUBJECTED TO CRASH FORCES. VOLUME II. TEST DATA AND DESCRIPTION OF REFINED PROGRAM 'KRASH', INCLUDING A USER'S GUIDE AND SAMPLE CASE

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The results of a study to develop simplified design procedures for determining nonlinear load-deflection characteristics for helicopter airframe structures are presented. A literature survey is performed in which 60 technical reports and papers are evaluated with regard to their applicability to crashworthiness analysis and designer-oriented procedures.

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4. Continued.
TEST DATA AND DESCRIPTION OF REFINED PROGRAM "KRASH", INCLUDING A USER'S GUIDE AND SAMPLE CASE

20. Continued

Studies using an existing 31 lumped mass model of the UH-1H helicopter are performed to determine the sensitivity of responses to changes in the load-deflection representation for the engine and transmission mounts, landing gear and fuselage. Simplified techniques are used to predict the load-deflection curve for the crushing of a segment of the lower fuselage under impact conditions. The predictions include elastic behavior, failure load and post-failure behavior. The structural segment selected for analysis and test is a section supported on four edges, representative of the transmission pylon support.

Twelve specimens were fabricated. The specimens are 46 inches long by 18 inches wide by 6.125 inches to 12.125 inches deep. The 6.125-inch-deep specimens are approximately half the size (except for thickness) and are varied in detail design (number of angles, spacing of angles, lightening holes). Static and dynamic tests were performed. The predicted load-deflection curves are compared to the test load-deflection curves and show good agreement with regard to peak failure load, failure point, energy absorbed, and shape. The results of the tests show that for this type of typical fuselage structure, static tests provide load-deflection data which is similar to data that can be obtained from dynamic tests, but more economically.

Program KRASH is refined to facilitate its use by designers. In particular, the input data is reordered, some inputs are standardized and more general load-deflection curve characteristics are possible. The capacity of the program is increased to 80 lumped masses, 100 internal beams and 120 load-deflection tables. The refined program was run to demonstrate capability to treat a three-dimensional impact velocity, mass penetration into an occupiable space, and simplified rotor blade contact. Specimen test data is also used to refine the 31 mass UH-1H model.

The analytical techniques developed herein are presented in the form of design charts, nomographs, curves, tables and equations and form the basis of a structural crashworthiness design manual. The design procedures are outlined in a step-by-step process including examples.

Volume II contains supporting analytical and test data and a literature matrix categorization. A description of refined program KRASH is provided which shows the new input-output format, a listing, and sample problems.

EUSTIS DIRECTORATE POSITION STATEMENT

The Eustis Directorate technical monitor for this effort was Mr. G. T. Singley III of the Military Operations Technology Division.

The conclusions submitted by the contractor are considered to be valid.

The report is divided into two volumes. Volume I contains a description of the survey of technical publications, investigation of the sensitivity of the simulated structural response to load-deflection variations, substructure test program, refinement of KRASH, structural crashworthiness design procedures, and results obtained. Volume II contains abstracts of literature reviewed, supporting analytical and test data, a description of the refined KRASH computer program, and a user's guide for the computer program.

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This volume contains test and analysis data in support of the detailed discussions presented in Volume I. The 60 technical reports and publications reviewed during the study are briefly summarized and then tabulated in a Literature Survey Subject Index. The test data is presented in the form of recorded load, deflection, strain and accelerometer readings versus scan (time). The refinements of program KRASH to facilitiate its usage are described. Included in the writeup for program KRASH is the refined input-output format, user's guide, listing, and two sample problems. Also included in the section on program KRASH are the energy balance equations and the sample format for the energy data.

LITERATURE SURVEY AND SYNOPSIS

1. Wittlin, G., Gamon, M.A., EXPERIMENTAL PROGRAM FOR THE DEVELOPMENT OF IMPROVED HELICOPTER STRUCTURAL CRASHWORTHINESS ANALYTICAL AND DESIGN TECHNIQUES, Lockheed-California Company; USAAMRDL Technical Report 72-72A,-72B, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, May 1973, AD 764985.

   This report presents the results of a four-phase study to develop improved rotary-wing aircraft structural crashworthiness analytical and design techniques. A digital computer program, designated KRASH, was developed and shown to be capable of accurately predicting responses during a crash in which multidirectional forces are present. The program was verified using controlled test data obtained on the same program via a combined vertical-lateral velocity impact using a fully instrumented UH-1H helicopter. Parameter studies were performed to ascertain the effect on the response of the structure and the occupants due to changes in structural element load deflection characteristics. A consistent design approach is presented, and the results of the parameter study are used to illustrate its application in a crash analysis. The study also included a detailed accident investigation, a literature survey and evaluation, substructure test, and analysis.

2. Turnbow, J.W., Carroll, D.F., Haley, J.L., Jr., Robertson, S.N., CRASH SURVIVAL DESIGN GUIDE, Dynamic Science; USAAMRDL Technical Report 71-22, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, October 1971, AD 733358.

   This report is a design guide that has been assembled to provide the engineer with an understanding of the basic problems associated with the development of crashworthy U.S. Army aircraft. Where possible, solutions to specific problems are indicated. In areas in which little design data are available, only the general philosophy appropriate to the problem solution is presented; the details of such solutions as well as the degree of crashworthiness to be achieved must be left, at present, to the ingenuity of the designer.

   This guide presents, in a condensed form, the data, design techniques, and criteria that are presently available in eight areas: (1) aircraft crash kinematic and survival envelope, (2) airframe crashworthiness design criteria, (3) aircraft seat design criteria (crew and troop/passenger), (4) restraint system design criteria (crew, troop/passenger, and cargo), (5) occupant environment design criteria, (6) aircraft ancillary equipment stowage design criteria, (7) emergency escape provisions, and (8) postcrash fire design criteria.

   It is intended that both airframe and component designers and manufacturers use this guide to extend the "region of survivability" in aircraft accidents to a maximum level.

3. Reed, William H., Avery, James P., Ph.D, PRINCIPLES FOR IMPROVING STRUCTURAL CRASHWORTHINESS FOR STOL AND CTOL AIRCRAFT, Aviation Safety Engineering and Research; USAAVLABS Technical Report 66-39, U.S. Army Aviation Materiel Laboratories, Fort Eustis, Virginia, June 1966, AD 637133.

   In this report the crash behavior of aircraft structures is investigated. The investigation begins with the definition of two indices of crashworthiness of basic aircraft structures and the analysis of the influence of several general types of structural modifications upon these two indices. This analysis, using fundamental principles of mechanics, contains several simplifying assumptions, which are explained as they are introduced.

   Design concepts to improve the ability of the "protective container" to maintain living space for occupants during a crash or to attenuate the accelerations experienced by occupants during a crash are developed for crash conditions which are either primarily longitudinal in nature or primarily vertical in nature. Analytical methods are then provided to show how and when to apply these design concepts to any particular aircraft. Principles are presented which are considered to be suitable for use during design of new aircraft as well as modifications of existing aircraft.

   The results are presented from three full-scale crash tests of small twin-engine airplanes which were conducted as a part of this investigation.

   Among the pertinent conclusions of the report are: (1) improvements in crashworthiness can be achieved via minor changes in structural design or modification of existing structure, (2) vertical and longitudinal impact environments offer significantly different problems in designing for improved crashworthiness, and (3) analysis of aircraft behavior is hampered by the lack of adequate knowledge of the relationships which apply to the determination of the reaction force which decelerates the aircraft upon contact with the ground.

4. Greer, D.L., et al, DESIGN STUDY AND MODEL STRUCTURES TEST PROGRAM TO IMPROVE FUSELAGE CRASHWORTHINESS, General Dynamics, Convair; FAA Report DS-67-20, Federal Aviation Administration, Washington, D.C., October 1967, AD 666816.

   This report presents the results of a study to evaluate methods to improve crashworthiness by retaining transport cabin integrity during crash impact loadings.

   The study includes analyses of the effects of strengthening, redistribution of bending material, and incorporation of energy dissipating features on the ability of the fuselage to provide a protective shell around the occupants. Analytical results were substantiated by a test program.

The test program included compression tests of plate-stringer panels and drop tests of representative fuselage structure. Tests were made on three 100-inch-diameter cylindrical sections dropped axially, four segments of 100-inch-diameter cylinders dropped laterally, and a structurally comple' nose section of a jet transport dropped in a 10-degree nose-down attit.de.

The requirement for a plastically deforming structure is important for both axial and vertical collapse characteristics of a fuselage. Plastic collapse provides the most efficient energy-absorbing capability and also reduces the possibility of excessive tearing or complete disintegration of the structure.

Both energy-absorbing capacity and failure mode are important for vertical crushing conditions. The recommended manner of reinforcement for the fuselage lower frame segments strengthens the bottom centerline portion and the floor beam to frame area. No significant weight or cost penalty is involved since the crash requirement reinforcement occurs at the most critical areas for existing design conditions.

5. Saczalski, K.J., and Park, K.C., TRANSIENT RESPONSE OF INELASTICALLY CONSTRAINED RIGID BODY SYSTEMS, to appear in the Journal of Engineering for Industry, A.S.M.E. Transactions, 1974.

An energy rate balance is employed to develop the incremental equations of motion for a shock-loaded, inelastically constrained, rigid-body structural system. Lagrangian multipliers provide the coupling mechanism necessary to reduce the overall system of equations to a set of modified rigid-body equations which include the nonlinear geometric and structural material effects. Kinematic material hardening and a modified yield criteria are used. Examples illustrate the technique and are compared with experimental results.

6. Massonnet, C.E., and Save, M.A., PLASTIC ANALYSIS AND DESIGN, VOL. I, BEAMS AND FRAMES; Blusdell, New York, 1965.

This book deals with the analysis and design of beams and frames made of a ductile material on the basis of the ultimate load. With the second volume, which is concerned with more complicated structures such as plates and shells, it aims at giving a broad (if not exhaustive) coverage of plastic analysis and design methods. These methods essentially apply to mild steel structures, but may also be used, with adequate caution, for reinforced and prestressed concrete structures.

Presently, the first volume is the most important for practical applications. The so-called simple plastic theory of beams and frames is presented in Volume II, which is now being finalized.

The material has been considered as an engineering problem and not as applied mathematics. Much attention and extensive treatment have been given to plastic buckling and to design of joints. The influence of details of construction (machining, drilling, punching, etc.) is also considered.

7. Roark, R.J., FORMULAS FOR STRESS AND STRAIN, McGraw-Hill, New York, 1965.

This book provides a compact, complete summary of the formulas, facts, and principles pertaining to strength of materials. It is intended primarily as a reference book and represents an attempt to meet what is believed to be a present need of the design engineer.

Presented are certain general principles. Included are brief descriptions of analytical and experimental methods of stress analysis and information concerning the behavior of material under stress. The behavior of structural elements under various conditions of loading is discussed, and extensive tables of formulas for the calculation of stress, strain, and strength are given. Derivations and detailed explanations are omitted. However, examples are included to illustrate the application of the various formulas and methods.

8. Ayre, Robert S., Shock and Vibration Handbook, Chap. 8, Vol. 1, TRANSIENT RESPONSE TO STEP AND PULSE FUNCTIONS, McGraw-Hill, 1961.

Hoppmann, W.K., Shock and Vibration Handbook, Chap. 9, Vol. 1, EFFECTS OF IMPACT ON STRUCTURES, McGraw-Hill, New York, 1961.

Chapter 8 deals briefly with methods of analysis for obtaining the response spectrum from the time history, and includes in graphical form certain significant spectra for various regular step- and pulse-type excitations. The usual concept of the response spectrum is based upon the single-degree-of-freedom system, usually considered linear and undamped although useful information sometimes can be obtained by introducing nonlinearity or damping. The single-degree-of-freedom system is considered to be subjected to the shock or transient vibration, and its response is determined.

The response spectrum is a graphical presentation of a reflected quantity in the response taken with reference to a quantity in the excitation. It is plotted as a function of a dimensionless parameter that includes the natural period of the responding system and a significant period of the excitation. The excitation may be defined in terms of various physical quantities, and the response spectrum likewise may depict various characteristics of the response.

Chapter 9 discusses a particular phenomenon in the general field of shock and vibration usually referred to as impact. An impact occurs when two or more bodies collide. An important characteristic of an impact is the generation of relatively large forces at points of contact for relatively short periods of time. Such forces sometimes are referred to as impulse-type forces.

Three general classes of impact are considered in this chapter: (1) impact between spheres or other rigid bodies, where a body is considered to be rigid if its dimensions are large relative to the wavelengths of the elastic stress waves in the body; (2) impact of a rigid body against a beam or plate that remains substantially elastic during the impact; and (3) impact involving yielding of structures.

9. Timoshenko, S. Woinowsky-Krieger, S., THEORY OF PLATES AND SHELLS, McGraw-Hill Publishers, New York, 1959.

This book deals with the three regions of plate and shell theory: (1) thin plates with small deflections; (2) thin plates with large deflections; (3) thick plates. The book considers problems with membrane stresses and the case with clamped edges. Simplifications are given for special cases of deformation to the shape of a developable surface. The thick plate theory presented considers the problem as a three-dimensional problem of elasticity.

10. Tulk, F.D., BUCKLING OF CIRCULAR CYLINDRICAL SHELLS UNDER DYNAMICALLY APPLIED AXIAL LOADS, UTIAS report 160, 1972.

A theoretical and experimental study was made of the buckling characteristics of perfect and imperfect circular cylindrical shells subjected to dynamic axial loading.

The tests were performed on a specially designed dynamic testing machine which was capable of producing controlled ramp-type loads at rates ranging from the quasi-static up to higher than 200,000 pounds/second. Ten shell specimens were tested, including two near-perfect shells, seven shells with axisymmetric sinusoidal imperfections of a variety of amplitudes and wavelengths, and one shell with quasi-random axisymmetric imperfections. The shells were produced from a photoelastic epoxy plastic using a spin-casting technique. The imperfection profiles were machined into the shell walls using a high-precision hydraulic tracing apparatus. For three of the shells with sinusoidal imperfections, imperfection profiles were cut on the inner surface alone; while for the remaining four shells with sinusoidal imperfections and for the shell with quasi-random imperfections, a special manufacturing procedure was adopted which produced shells with matching inner and outer profiles, thus providing effectively constant thickness walls.

Experimental data included dynamic buckling loads (124 data points), high-speed photographs of the buckling mode shapes, and observations of the dynamic stability of shells subjected to rapidly applied subcritical loads.

A mathematical model is developed to describe the dynamic behavior of perfect and imperfect shells. This model is based on the Donnell-von Karman compatibility and equilibrium equations and has a wall deflection function incorporating five separate modes of deflection. Close agreement between theory and experiment is found for both dynamic buckling strength and buckling mode shapes.

11. Stricklin, J.E., et al, LARGE DEFLECTION ELASTIC-PLASTIC DYNAMIC RESPONSE OF STIFFENED SHELLS OF REVOLUTION, TEES-RPT-72-25 and SLA-73-0128, 1972.

This report presents the formulation and check-out problems for a computer code DYNAPLAS, which analyzes the large deflection elastic-plastic dynamic response of stiffened shells of revolution. The formulation is by the finite element method, with finite differences being used for the evaluation of the pseudo forces due to material and geometric nonlinearities. Time integration is by the Houbolt method. The stiffness may be due to concentrated or distributed eccentric rings and spring supports at arbitrary angles around the circumference of the elements. Check-out problems include the comparison of solutions from DYNAPLAS with experimental and other computer calculations for rings, conical and cylindrical shells, and a curved panel. A hypothetical submarine including stiffeners and missile tube is studied under a combination of hydrostatic and dynamically applied asymmetrical pressure loadings.

12. Becker, H., and Gerard G., HANDBOOKS OF STRUCTURAL STABILITY, PARTS I-V, NACA Technical Notes 3781-3785, 1957.

The local buckling of stiffener sections and the buckling of plates with angle stiffeners are reviewed, and the results are summarized in charts and tables. Numerical values of buckling coefficients are presented for longitudinally compressed stiffener sections of various shapes, and for stiffened cylinders loaded in torsion. Although the data presented consists primarily of elastic-buckling coefficients, the effects of plasticity are discussed for a few special cases.

13. Skogh, J., Stern, P., POSTBUCKLING BEHAVIOR OF A SECTION REPRESENTATIVE OF THE B-1 AFT INTERMEDIATE FUSELAGE, Lockheed Palto Alto Research Laboratory, AFFDL-TR-73-63, Air Force Flight Dynamics Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, May 1973.

A section of the B-1 aft intermediate fuselage consisting of a combination of flat and curved panels is analyzed for postbuckling strength under a combination of torque and axial loading. The analysis, which extends to load levels about ten times the load that produces the first buckle, was carried out rigorously by the use of the finite-difference computer code STAGS. The results show that the fuselage section does not collapse at the applied ultimate load. Shear stiffness values as a function of the applied load are calculated. These data can be used as inputs for a finite-element analysis of the fuselage section.

14. Atluri, S., PETROS 3: A FINITE-DIFFERENCE METHOD AND PROGRAM FOR THE CALCULATION OF LARGE ELASTIC-PLASTIC DYNAMICALLY-INDUCED DEFORMATIONS OF MULTILAYER VARIABLE THICKNESS SHELLS, BRL, U.S. Army Aberdeen Research & Development Center, Aberdeen Proving Ground, Maryland, Contract #DAAD05-68-C-0314, Nov. 1971.

The governing equations for the arbitrarily large-deformation elastic-plastic transient responses of variable-thickness, hard-bonded, multilayer, multimaterial, thin, Kirchhoff shells of any initial shape are formulated and solved by the finite-difference technique. The material is assumed to be initially isotropic and to exhibit elastic, strain-hardening, strain-rate-sensitive, and temperature-dependent behavior. The structure may be subjected to a variety of initial velocity distributions, transient mechanical loads, and/or transient thermal loads. These capabilities and features are contained in a computer program, PETROS 3, which has been applied to a variety of example problems.

Included is a FORTRAN IV listing and a description of PETROS 3 together with the data input and solution output for several example problems.

15. Haftka, R.T., A KOITER-TYPE METHOD FOR FINITE ELEMENT ANALYSIS OF NONLINEAR STRUCTURAL BEHAVIOR, AFFDL-TR-70-130, Vol. I, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio, Nov. 1970.

Koiter's method for the asymptotic analysis of post-buckling behavior is reformulated in finite element notation for application to structures idealized by finite element models. Originally restricted to the analysis either of structures exhibiting bifurcation buckling or of slightly imperfect versions of such structures, Koiter's method is therein adapted to a more general class of structures exhibiting the more common snap-through (limit point) type of buckling. This adaption of Koiter's method is referred to as the Modified Structure method. It is accomplished by modification of the actual energy functional to create a hypothetical modified structure having a strictly linear pre-buckling path along which buckling must be of the bifurcation type. The analysis of the actual structure is then accomplished by application of Koiter's method through consideration of the actual structure as an imperfect version of the modified structure.

In this way, the Modified Structure method operates within the theoretical framework established by Koiter, and the effects of prebuckling nonlinearity are approximated asymptotically. Various levels of approximation are considered. Additionally, the use of the Modified Structure method, in conjunction with direct methods of nonlinear analysis, is examined. A highly accurate finite element representation is employed in presenting a comprehensive numerical evaluation of the Modified Structure method of analysis on the basis of a number of planar frame problems. Collectively, these examples exhibit a broad spectrum of nonlinear behavior characteristics. Emphasis throughout is placed upon assessing the limitations and attributes of the Modified Structure method of analysis. Conclusions regarding applicability and performance emerge from detailed examination of the results obtained.

16. Stilwell, W.C., and Ball, R.E., A DIGITAL COMPUTER STUDY OF THE BUCKLING OF SHALLOW SPHERICAL CAPS AND TRUNCATED HEMISPHERES, NASA CR 1998, June 1972.

Several user-oriented digital computer programs for the static analysis of shells of revolution exist. A detailed discussion of most of these programs is given in Reference 1 of the report. Of particular interest here is the program developed by Ball (Reference 2) for the geometrically nonlinear analysis of arbitrarily loaded shells of revolution. This program is an equilibrium program; that is, it solves for the displacement and stress resultant fields for an arbitrary loading condition. Since geometric nonlinearities are included, the magnitude of load that leads to a condition of instability can be determined.

The utility of the program would be considerably enhanced if it could be used to determine bifurcation buckling loads and the behavior of the shell in the vicinity of the bifurcation load. This latter feature is often referred to as the imperfection sensitivity of the shell to the load. As a consequence, the objective of this study was to use the computer program to examine the buckling behavior of several shells subjected to axisymmetric and nearly axisymmetric loads. It was anticipated that an examination of the effects of the small asymmetric perturbations upon the stability of the shell would disclose the bifurcation buckling load and provide a quantitative evaluation of the imperfection sensitivity of the shell to the load.

17. Witmer, E.A., LARGE DYNAMIC DEFORMATIONS OF BEAMS, RINGS, PLATES AND SHELLS, AIAA Journal, Vol. I, No. 2, August 1963.

The axisymmetric responses of shells, plates, rings, and beams to impulsive or blast loading that produces large deformations involving both the elastic and plastic regions of material behavior are analyzed. A general numerical method that includes (1) elastic, (2) perfectly plastic, (3) elastic, strain-hardening, and/or (4) elastic, strain-hardening, strain-rate sensitive material behavior and large structural deflections is formulated and applied. In the timewise step-by-step numerical analysis, the increments in stress resultants and stress couples are determined by idealizing the shell thickness as consisting of n concentrated layers of materials separated by a material that cannot carry normal stresses but has infinite shear rigidity. The influences of the number of layers employed in the idealized model, as well as the aforementioned various types of material behavior, are demonstrated. Theoretical predictions of time-history responses and/or final structural deformations are compared with experimental data for impact-loaded spherical shells, for blast-loaded circular plates, and for explosively loaded circular rings and clamped beams.

18. Perrone, N., ON A SIMPLIFIED METHOD FOR SOLVING IMPULSIVELY LOADED STRUCTURES OF RATE-SENSITIVE MATERIALS, Office of Naval Research, Washington, D.C., Journal of Applied Mechanics, A.S.M.E., September 1965.

In an attempt to assess more completely rate-sensitivie material effects, two fundamental structural elements are analyzed: a wire with an impulsively loaded end mass, and an impulsively loaded ring. The ring and wire are made of perfectly plastic, rate-sensitive materials. In each case, exact and approximate solutions are obtained for an exponential rate-sensitivity law. The results suggest that very good approximations to the exact solutions may be found by utilizing a rate-insensitive material with constant yield stress equal to the initial dynamic yield stress.

19. Bodner, S.R., and Symonds, P.S., EXPERIMENTAL AND THEORETICAL INVESTIGATION OF THE PLASTIC DEFORMATION OF CANTILEVER BEAMS SUBJECTED TO IMPULSIVE LOADING, Brown University, Journal of Applied Mechanics, December 1962.

The experimental techniques and the results obtained in a program to evaluate the assumptions of dynamic, rigid-plastic theory of beams are presented. The experiments use steel and aluminum-alloy cantilever beams subjected to either a rapid velocity change at the base or to an impulsive load at the tip. A rigid-plastic theory that includes the strain-rate dependence of the yield stress and geometry changes is outlined for the case of the tip impulsive loading. Predictions of this theory are in satisfactory agreement with the experimental results.

20. Hibbit, H.D., et al, A FINITE ELEMENT FORUMLATION FOR PROBLEMS OF LARGE STRAIN AND LARGE DISPLACEMENT, Brown University, Int'l Journal of Solids and Structures, 1970, Vol 6, pp. 1069-1086.

An incremental and piecewise linear finite element theory is developed for the large-displacement, large-strain regime with particular reference to elastic-plastic behavior in metals. The resulting equations, though more complex, are in a similar form to those previously developed for large-displacement, small-strain problems, the only additional term being an initial load stiffness matrix which is dependent on current loads. This similarity in form means that existing nonlinear general-purpose programs may easily be extended to include finite strains. A large-displacement, small-strain formulation (as applicable to problems of structural stability) is obtained from this theory by assuming that changes in length of line elements and relative rotation of orthogonal line elements are negligible compared to unity. The simplified equations are in essential agreement with previous formulations in the literature. The only difference which is observed is the persistence of the initial load stiffness matrix, which may be significant in some cases.

21. Toridio, T.G., and Khozeimeh, K., INELASTIC RESPONSE OF FRAMES TO DYNAMIC LOADS, Journal of Engineering Mechanics, June 1971.

A procedure of analysis is presented for determining the elastic-inelastic response of framed structures under dynamic loads. Application of Hamilton's principle in conjunction with the finite-element method leads to the basic dynamic equation of the system incorporating the plastic effects in the form of equivalent nodal forces. This approach also allows the more accurate treatment of the distributed mass of the element than the usual geometrical method of lumping.

22. McDaniel, T.J., DYNAMICS OF STIFFENED CYLINDRICAL SHELLS WITH SPATIALLY VARYING CURVATURE, University of Dayton Research Institute, Air Force Materials Laboratory Report AFML-TR-72-134, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, July 1972.

This report presents the results of a theoretical study of the effects of spatially varying curvature on the dynamics of cylindrical panels and stiffened cylindrical shell structures. The first section of the report contains a brief discussion of the general problem area. Following this discussion, the analytical techniques for solving constant-curvature cylindrical panels and stiffened cylindrical shell problems by a transfer matrix approach are reviewed. These techniques are found to apply directly to the varying curvature shell analysis, provided the transfer matrix for this type of shell can be obtained. An analytical approach to obtaining the transfer matrix for a shell with varying curvature is explored. A solution to the transfer matrix for a cylindrical shell with exponentially varying curvature is obtained. In a following section, the preparation of this solution to obtain numerical transfer matrix is discussed. Several approximate and numerical procedures for obtaining a transfer matrix are explored. Finally, the dynamic responses of both single panels and stringer stiffened cylindrical structures with increasing and decreasing curvature are compared to similar structures with constant curvature.

23. Bendix Corp., Final Engineering Report, ENERGY ABSORBING CHARACTERISTICS OF CRUSHABLE ALUMINUM STRUCTURES IN A SPACE ENVIRONMENT, NASA-CR-65096, July 1965.

The research effort detailed in this report involves the basic objective of obtaining quantitative design data concerning the characteristics of aluminum honeycomb materials when used in high L/D ratio, crushable, energy-absorbing capsules. Nine configurations of honeycomb energy-absorbing capsules using alloy 5056 are evaluated. The nine basic configurations incorporate three cross-sectional shapes of high, medium, and low crush strength, each of which was fabricated with cell axes oriented at angles of 0, 15 and 30 degrees to the capsule longitudinal axis. The characteristics which are studied included specific energy, load onset rate, and rebound. Variations of these characteristics are investigated under controlled environmental conditions.

The capsules were subjected to both static and dynamic loads, impact velocities from 5 thru 20 feet per second, and impact weights varying from 760 thru 3750 pounds. The environmental extremes under which the specimens were tested spanned the temperature range from -260°F thru room temperature up to +300°F, and a vacuum of 3×10^{-1} TORR.

24. Kornhauser, M., STRUCTURAL EFFECTS OF IMPACT, Sparton Books, Inc., Baltimore, Md., 1964.

Mechanical impact has been treated traditionally, in the United States, as a subject which is variously appended to college textbooks on elasticity, strength of materials, engineering mechanics, or vibrations. The elasticity and strength of materials texts are generally concerned with local surface effects or with stress waves; the mechanics texts usually treat the whole-body motions on impact; and the vibrations texts are apt to consider impact a special case of unsteady vibrations and amplification factors. In the actual case of impact, all of these phenomena and effects come into play, and the significance of each effect must be emphasized relative to the purpose of the analysis.

In this book the emphasis is placed on go or no-go behavior, survivability, or failure. Loading and response must, or course, be analyzed. Nevertheless, wherever possible, the object is to permit estimates of failure directly in terms of the loading conditions. Impact is a complex process. Given the loading history of a structure (and assuming no interaction with the structure's response), it is, in general, impossible to trace the stress waves and their reflections throughout the structure, resulting in vibrations and permanent set or failure. Many solutions of loading and response, as well as theories of failure in terms of material properties, are available in the literature for various idealized conditions and configurations. What is desired by the practicing engineer are some relatively simple approaches to prediction of failure. This book is intended as a start in this direction.

In attempting to provide engineering answers to some very complex problems, liberal use has neen made of "engineering judgment" and idealizations. The soundness of each assumption is in proportion to the number of exact theoretical and experimental results available for very similar situations. For this reason it is anticipated that modifications of the approaches presented therein will be appropriate as the various disciplines produce more data.

The book is organized in three sections: "Loading Conditions", "Response and Failure of Structures", and "Effects of Impact." The section on response and failure is expository in nature, introducing the background theory and application of the sensitivity method of presenting and predicting inertial failure, as well as discussing low-speed and hypervelocity impact effects. Having accepted the approaches recommended in the second section, the practicing engineer may use the curves and tables of the first and third sections for prediction of impact effects in terms of the environmental input functions.

25. Fisher, L. J., Jr., LANDING-IMPACT-DISSIPATION SYSTEMS, NASA, Technical Note D-975, December 1961.

Analytical and experimental investigations are made to determine the landing-energy-dissipation characteristics for several types of earth-landing-impact systems having application to reentry vehicles. The areas of study are divided into three velocity regions: (1) those having primarily vertical velocity, (2) those having both moderate horizontal and moderate vertical velocity, and (3) those having primarily horizontal velocity. The impact systems discussed are braking rockets, gas-filled bags, frangible metal tubing, aluminum honeycomb, balsa wood, strain straps, and both skid and skid-rocker landings on hard-surface runways and on water.

The report states that it appears feasible to evaluate landing-gear systems for reentry vehicles by computational methods and free-body landing techniques with energy dissipation for an earth landing of such a vehicle. Some systems are more efficient than others, some package better than others, and a variety of promising systems are under study. Horizontal energy dissipation is simpler to deal with than vertical energy dissipation since translational friction is all that is involved; however, runout behavior becomes a factor. Vertical velocity can also be a big factor when high flight-path angles are associated with even moderate horizontal velocities. High-speed landings are particularly a problem, especially high-speed water landings, and indications are that if large horizontal velocities are involved in hard-surface landings, a selected site will be required.

26. McGehee, J. R., A PRELIMINARY EXPERIMENTAL INVESTIGATION OF AN ENERGY-ABSORPTION PROCESS EMPLOYING FRANGIBLE METAL TUBING, NASA Technical Note D-1477, 1962.

A highly efficient energy-absorption process, employing frangible metal tubing as the working element, is investigated. A preliminary experimental investigation is conducted to determine the variation of the average fragmenting stress of 2024-T3 aluminum-alloy tubing with the pertinent parameters of this process. Limited tests were made to determine the feasibility of employing this process in a landing-gear system. A 1/5-scale model of a proposed manned spacecraft with a landing gear incorporating this process is employed in these tests.

The results of this investigation show that the fragmenting process produces a fluctuating force with displacement, but for a fixed set of parameters, the force about which the fluctuation occurs is approximately constant. A large force which occurs when the process is started with the unaltered tube seated symmetrically in the die can be reduced most effectively by tapering the wall thickness over a short length at the die end of the tube. The average fragmenting stress, for 2024-T3 aluminum-alloy tubing and the range of parameters investigated, appears to be independent of the ratio of wall thickness to tube diameter, but varies as the cube of the ratio of the wall thickness to the radius of the forming die. The fragmenting stress obtained at 12,000 inches per minute was about 60 percent higher than those obtained at 1 inch per minute. The 2024-T3 aluminum-alloy tubing, when fragmenting on a die at 90 percent of the yield stress, is capable of absorbing 31,000 foot-pounds of energy per pound of material. This energy-absorption capability is greater than that of the most frequently considered processes; for example, the crushing of balsa wood, aluminum honeycomb, or pressurized thin-walled metallic cylinders. Model tests, employing frangible tubing as the working element in the landing gear, indicate that this process is suitable for use in a load-alleviation application.

27. Kroell, C. K., A SIMPLE, EFFICIENT, ONE SHOT ENERGY ABSORBER, General Motors Research Laboratory, Warren, Michigan, Shock, Vibration and Associated Environments, Part III, Bulletin No. 30, 1962.

This paper describes a single-shot expendable energy absorber which has been developed at the General Motors Research Laboratory. The device is inherently simple and is characterized by a rectangular force-displacement relationship and high specific energy absorption capacity. Both a qualitative discussion of the mechanics of the

plastic deformation process involved and a graphical summary of the experimental performance data which have been collected to date are presented.

28. Weinberg, L.W.T., and Turnbow, J.W., Ph.D., SURVIVABILITY SEAT DESIGN DYNAMIC TEST PROGRAM, Aviation Safety Engineering and Research, USAAVLABS Technical Report 65-43, U.S. Army Aviation Materiel Laboratories, Fort Eustis, Virginia, July 1965, AD 621718.

This report presents the results of a series of dynamic tests conducted with four different concepts of experimental crew seats.

The experimental seats were designed and constructed by four helicopter manufacturers. The seats were designed to withstand static load factors equivalent to those recommended in TRECOM Technical Report 63-4, "Crew Seat Design Criteria for Army Aircraft", dated February 1963.

The design load factors recommended in the above-referenced report are as follows: longitudinal - 45G for 0.10 second; lateral - 45G for 0.10 second; and vertical - 25G for 0.10 second.

Special kits for small-arms ballistic protection were also designed and installed in the seats tested.

These seats were designed exclusively using static load factors. No previous testing was conducted by any seat manufacturer prior to the conduct of these tests.

The four seats were tested under four load conditions. Two of the conditions involved simultaneous half loads on the seats in two different seat positions, and two of the conditions involved full loads in two different seat positions.

Only one of the four seats tested withstood the loads imposed for all four conditions. Three of the seats failed and were damaged beyond economical repair when each was subjected to the first full-load test condition.

This report also includes a detailed description of an acceleration device which was specifically designed and fabricated for this series of tests.

29. Langhaar, H. L., THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF THIN-WEBBED PLATE-GIRDER BEAMS, Transactions of the ASME, October 1943.

A simple, semirational theory for the design of webs and flange rivets of thin-webbed rectangular plate-girder shear beams is presented. Calculations of shear loads to cause web rupture and flange rivet failure are compared with test data from 27 beams.

30. Perry, D. J., AIRCRAFT STRUCTURES, McGraw Hill Book Co., New York, 1950.

In this book an attempt is made to emphasize basic structural theory which will not change as new materials and new construction methods are developed. Most of the theory is applicable for any design requirements and for any materials. The design engineer may then supplement this theory with the detail design specifications and the material properties which are applicable to his particular airplane.

Heavy emphasis is placed on the application of the elementary principles of mechanics to the analysis of aircraft structures.

31. Jones, N., et al, THE DYNAMIC PLASTIC BEHAVIOR OF SHELLS, MIT Report 71-6, 1971.

A survey is made of the literature published previously on the inelastic behavior of shells subjected to dynamic loads. An experimental investigation is also being undertaken to examine the behavior of various cylindrical shell panels which are loaded with an impulse on the inner surface. The panels are fully clamped along the two longitudinal edges and free on the other two. The initial kinetic energy of the dynamic loads is sufficiently large to cause inelastic behavior and to produce maximum permanent transverse deflections of up to nearly twice the corresponding panel thickness. Tests are conducted on mild steel and aluminum 6061-T6 panels which have various thicknesses and included angle of 90° approximately.

32. Mitchell, B., THE DYNASORB ENERGY ABSORBER, Lockheed Report LR 16735, March 1963.

This report introduces a method of absorbing energy while maintaining a constant load level. The tubular load-carrying member can support its full load capability and still be almost totally consumed by rolling up one end. The energy curves presented are typical and show excellent load consistency with efficiencies as high as 450,000 in.-lb/lb.

33. Mitchell, B., SHOCK ABSORPTION WITH ONE SLOT TUBES, Lockheed Report LR 16369, June 1963.

The work covered in this report is a follow-on of an independent research program that developed a very efficient method of absorbing energy by load control and end roll-up of tubes. This study investigates 12 different materials and improves the control rings to give a smooth, nearly rectangular, energy curve. The load level can be set, by suitable design, at any desired point within the column or local

strength limits of the tube. The maximum efficiency attained here with a 2-inch-diameter by .049 wall 4130 steel tube heat treated to 200,000 psi is 600,000 in.-lb per lb of tube weight. This represents a mean compressive stress of 189,000 psi over the total 6 inches of travel.

34. Mitchell, B., DESIGN NOTES FOR THE DYNASORB ENERGY ABSORBER, Lockheed Report LR 17201, December 1963.

The Dynasorb Energy Unit, developed in the Lockheed Engineering Laboratory, is adaptable to many applications as a shock absorber or load limiter. Design procedures based on previously reported data are described, and several typical installations are illustrated.

This report is submitted in fulfillment of the reporting requirements of a 1963 Independent Development Project, "Energy Absorption Products."

35. Mitchell, B., ENERGY ABSORPTION AT HIGH SPEED VERTICAL LANDING, Lockheed Report LR 21023, November 1967.

This report describes the use of the Lockheed Dynasorb energy absorber in landing impact tests of a 3400-lb simulated vehicle structure. The structure, released from a helicopter and tethered by parachute, impacted at a velocity of 112 feet per second.

36. Perrone, N., RESPONSE OF RATE SENSITIVE FRAMES TO IMPULSIVE LOAD, <u>ASME Journal of Applied Mechanics</u>, February 1971, pp. 49-62.

A relatively convenient method is presented herein to determine the plastic response of rate-sensitive frameworks. The technique represents a significant extension of usual limit analysis type approaches as well as similar efforts applied to rate insensitive structures.

The method consists of assuming a modal deformation pattern for the structure in question, determination of the initial modal velocity utilizing the appropriate criteria, and integration in some form of the equations of motion after estimating the magnitude of the dynamic yield moments at the rate-sensitive plastic hinge locations. It is recommended that an effective hinge length of the order of three beam depths should suffice in estimating the strain rate magnitude. For the perfectly plastic case, the dynamic yield moment is assumed to be a constant with time.

A square portal frame made of a solid rectangular cross-section and loaded under a horizontal impulsive load is considered in some detail. It is shown that a critical initial velocity exists.

The effects of strain hardening and pulse load application are considered. Minor modifications of the impulsively loaded, perfectly plastic situation are necessary to accommodate these extensions.

The usual limitations should be noted. It is assumed that buckling will not occur, that the median surface or membrane effects are negligible, and that elastic effects are negligibly small relative to plastic flow because the former are omitted.

Portal frame experiments under high intensity loading similar to those conducted at Brown University on cantilever beams would be most welcome. Most of the experiments performed to date have been in a much lower load range where elastic and plastic effects are of comparable order. The true limiting strength of the framework could be more completely assessed only if larger loads are applied. Other tests have been reported, and hopefully these results will soon be available.

37. Jones, N., INFLUENCE OF STRAIN-HARDENING AND STRAIN-RATE SENSITIVITY ON THE PERMANENT DEFORMATION OF IMPULSIVELY LOADED RIGID PLASTIC BEAMS, International Journal of Mechanical Science, 1967, Vol. 9, pp. 777-796.

A simple method is presented for estimating the combined influence of strain-hardening and strain-rate sensitivity on the permanent deformation of rigid-plastic structures loaded dynamically. A study is made of the particular case of a beam supported at the ends by immovable frictionless pins and loaded with a uniform impulse. The results of this work indicate that, when stress-hardening or strain-rate sensitivity are considered, permanent deformations are experienced which are similar to those predicted by an analysis retaining both effects simultaneously.

38. Ni, C. M., IMPACT RESPONSE OF CURVED BOX BEAM-COLUMNS WITH LARGE GLOBAL AND LOCAL DEFORMATIONS, General Motors Research Laboratory, Warren, Michigan, AIAA Paper 73-401.

A numerical approach based on a lumped-mass model is developed for investigating the impact response of curved box beam-columns with large global and local deformations. An empirical formula which relates the changes of depth and bending angle of a beam cross-section is obtained to take into account the local deformations of the cross-sections. The strain-hardening and the strain-rate properties of the material are considered in this analysis. The correlation between the present analysis and test results is very good. The results obtained indicate that the strain-wave propagations due to the impact and the strain-rate sensitivity of the material play the key roles in increasing the energy-absorbing capacity of the structure when subjected to high-speed impact.

39. O'Bryan, T.C., and Hatch, H.G., Jr., LIMITED INVESTIGATION OF CRUSHABLE STRUCTURES FOR ACCELERATION PROTECTION OF OCCUPANTS OF VEHICLES AT LOW IMPACT SPEEDS, NASA Technical Note D-158, 1958.

A limited investigation is made to determine the characteristics of three materials to see how they can be applied for human protection against accelerations encountered at low impact speeds. As a result, if given man's physiological tolerance to abrupt acceleration, which has not yet been well-defined, an alleviation system can be designed.

Foamed plastics require considerable depth to provide a given stopping distance for impact alleviation, and their use will require some control of rebound. They can be made soft enough to obtain the low onset of acceleration that may be necessary for man where depth is not limited.

Aluminum honeycomb is an efficient material for impact load alleviation from the standpoint of usable material depth, and it exhibits very little rebound. The stiffness of the material results in a very high initial onset rate of acceleration. For many installations this may be controlled by reducing the initial loading area of contact to get the material to start failing.

40. Jones, Norman, THE INFLUENCE OF LARGE DEFLECTION ON THE BEHAVIOR OF RIGID-PLASTIC CYLINDRICAL SHELLS LOADED IMPULSIVELY, Journal of Applied Mechanics, ASME, June 1970, pp. 417-425.

In order to gain some insight into the importance and influence of finite deflections on the response of shells loaded dynamically, this article studies theoretically the behavior of a cylindrical shell subjected to a uniform axisymmetric impulsive pressure. The cylindrical shell is assumed to be made from a rigid, perfectly plastic material, and the external energy imparted to the shell is much greater than the total strain-energy which can be absorbed elastically. The results of the investigation indicate that geometry changes are important and should be retained when studying the behavior of cylindrical shells loaded dynamically.

41. D'Amato, R., STATIC POST-FAILURE STRUCTURAL CHARACTERISTICS OF MULTI-WEB BEAMS, WADC TR 59-112, February 1959.

The structural behavior of aircraft components is discussed in relationship to the general lethality problem, the concept of post-failure restoring force for built-up structures of multiweb beams is considered, and a relatively simple analysis is developed to compute the static post-failure behavior of multiweb beams in pure bending. An experimental investigation is conducted to examine the validity of the analysis and, within the range of parameters considered, agreement between experiment and theory is satisfactory. Both the theoretical analysis and the experimental results indicated that an arbitrary extrapolation of post-failure data on the basis of ultimate strength can be very misleading.

42. Rawlings, B. ENERGY ABSORPTION OF DYNAMICALLY AND STATICALLY TESTED MILD STEEL BEAMS UNDER CONDITIONS OF GROSS DEFORMATION, International Journal of Mechanical Science, Pergamon Press, Ltd., 1967, Vol. 9, pp. 633-649. Printed in Great Britain.

An account is given of dynamic and static tests on mild steel members deformed under conditions of gross geometry change. An evaluation is made of the rigid-plastic theory, taking account of change of geometry, and also the elastic-plastic theory, assuming deformation to occur in the static mode, in predicting the behavior of the members.

43. Thompson, J.E., VEHICLE CRUSH PREDICTION USING FINITE-ELEMENT TECHNIQUES, Chrysler Corp., SAE Paper 73-157, January 1973.

The principal objective of this investigation is to develop analytical tools in the form of computer programs which will permit the automobile designer to predict the crush characteristics of a given car structure due to forces generated in a variety of impact modes.

The predictive or control capability is embodied in two large computer programs. "TELSAP" forms, reduces, and inverts the vehicle structure mass matrix expressed relative to a datum coordinate system and writes the mass matrix and its inversion onto a file for reading by the "CRUSH" program. "CRUSH" is a general matrix structural analysis program which calculates the large, plastic, rate-sensitive response of an interconnected beam structure due to known dynamic boundary displacement inputs. The theoretical bases and assumptions employed in developing these programs are described along with a detailed discussion of how the automobile design engineer might use them to develop a new vehicle structure.

Experimental correlation with the computer models is given for a vehicle-to-vehicle 90-degree intersection collision between a special rigid moving barrier and an intermediate-size four-door sedan. The structural model is further correlated with a laboratory test of a clamped-clamped beam struck at its center by an impact pendulum. The correlation indicates general agreement between experimental and analytical results.

By using the computer programs developed in this investigation, the automobile designer is able to reduce the amount of testing required to prove his design, and is able to identify the benefits of a particular structural reinforcement with a minimum of development time and expense.

44. Burgmann, J. B., and Rawlings, B., DYNAMIC PLASTIC ANALYSIS OF PIN-JOINTED FRAMES, International Journal of Mechanical Science, Pergamon Press, 1968, Vol. 10, pp. 967-980, Printed in Great Britain. (Revised 30 July 1968).

The paper presents an analysis of a pin-jointed frame subjected to dynamic or impulsive overload, of sufficient magnitude to cause permanent deformation. Rigid-plastic behavior of tensile members is assumed and, as a first approximation, a similar behavior of compressive members is assumed, although modifications to account for other characteristics are also discussed.

The behavior is considered in terms of the kinematic conditions, dynamic conditions, and the load-deformation characteristics assumed for the members.

45. Martin, J.B., MODE APPROXIMATION FOR IMPULSIVELY LOADED STRUCTURES IN THE INELASTIC RANGE, Proceedings of the Southampton 1969 Civil Engineering Material Conference.

A convergence approximation technique, based on the uniqueness proof, is reviewed for impulsively loaded rigid plastic and rigid viscoplastic structures. Emphasis is given to the use of mode or quasi-mode solutions and their usefulness in establishing a general approximating procedure and in providing insight into the important aspects of the gross structural response.

46. Jensen, W.R., Flaby, W.E., and Prince, N., MATRIX ANALYSIS METHODS FOR ANISOTROPIC INELASTIC STRUCTURES, AFFDL-TR-65-220, April 1966.

Most aerospace structural materials exhibit some degree of anisotropic strain-hardening. During the past few years, several methods have appeared in the literature for introducing inelastic isotropic material behavior effects into existing matrix analysis procedures using the incremental theory of plasticity. A review is presented of these methods and a step-by-step routine known as the "Constant Strain" method is selected for the development of an anisostropic inelastic procedure.

47. Isaakson, G., Armen, H., Jr., and Pipko, A., DISCRETE ELEMENT METHODS FOR THE PLASTIC ANALYSIS OF STRUCTURES, NASA CR 803, October 1967.

This study deals with the extension of finite-element methods to provide analytical means for determining the failure loads of aeronautical structures. Two areas are considered as related to predicting failure loads: inelastic stress analysis in the presence of load cycling, and plastic buckling of the bifurcation type.

Finite-element inelastic stress analysis methods are extended to take into account the Bauschinger effect for biaxial stress states using a plasticity theory based on Ziegler's modification to Prager's kinematic hardening theory. This methodology is applied to several structures representative of aeronautical construction, including a notched plate, a shear lag specimen, and a swept wing. Good correlation is obtained between analytical and experimental results for the strains at the root of the notched plate subjected to load cycling in the plastic range.

Finite-element buckling methods are also extended to consider plastic buckling using Stowell's formulation for implementing a deformation plasticity theory into the buckling theory. Sample calculations are carried out for the plastic buckling of a flat plate with various geometries and edge conditions.

48. Stricklin, J.A., et al, NONLINEAR DYNAMIC ANALYSIS OF SHELLS OF REVOLUTION BY MATRIX DISPLACEMENT METHOD, AIAA Journal, Vol. 9, No. 4, April 1971, p. 629.

A formulation and computer program is developed for the geometrically nonlinear dynamic analysis of shells of revolution under symmetric loads. The nonlinear strain energy expression is evaluated using linear functions for all displacements. Five different procedures are examined for solving the equations of equilibrium, with Houbolt's method proving to be the most suitable. Solutions are presented for the symmetrical and asymmetrical buckling of shallow caps under step pressure loadings and a wide variety of other problems, including some highly nonlinear ones.

49. Owens, R. H., and Symonds, P.S., PLASTIC DEFORMATIONS OF A FREE RING UNDER CONCENTRATED DYNAMIC LOADING, ASME Journal of Applied Mechanics, December 1955, p. 524.

A concentrated time-dependent force acts on an unsupported thin ring along a diameter. The problem considered in this paper is to determine the deformations of the ring when the force magnitudes are such that plastic strains occur which are large compared to the elastic strains. By neglecting elastic strains and assuming ideally plastic behavior, approximations to the final deformations of the ring are obtained. The analysis is developed for force pulses of arbitrary shape, but numerical results are obtained only in the special case of a rectangular force pulse. A criterion is stated for conditions when this type of analysis can be expected to provide satisfactory results.

50. Lee, H., and Symonds, P.S., LARGE PLASTIC DEFORMATIONS OF BEAM UNDER TRANSVERSE IMPACT, ASME Journal of Applied Mechanics, September 1952, p. 308.

A comparatively simple method of analysis is developed to determine the deformations in a beam subjected to lateral impact of such a magnitude that plastic strains occur which are large compared with elastic strains. A useful approximation to the motion then can be obtained by neglecting elastic strains and considering rigid-body motion of segments of the beam joined at plastic hinges where the

entire deformation takes place. A method of analyzing such a situation is described and applied to a beam subjected to central impact. The approximate final permanent deformation is obtained; this includes deformation during application of the load, and plastic flow which continues afterward when the kinetic energy of the motion generated by the impact is transformed into additional plastic deformation. A criterion is given for conditions when this type of theory can be expected to provide a satisfactory analysis. The method of solution provides an interesting analogy to the concept of static determinacy which has been used in the analysis of quasi-static plastic-flow problems.

51. Prager, W., A NEW METHOD OF ANALYZING STRESSES AND STRAINS IN WORK-HARDENING PLASTIC SOLIDS, ASME Journal of Applied Mechanics, December 1956, p. 493.

For work-hardening plastic solids, segment-wise linear yield conditions and the associated flow rules constitute a reasonable compromise between the mathematically convenient but physically unsound total stress-strain laws and the physically sound but mathematically inconvenient incremental laws. They allow total stress-strain laws to be used in the small, but retain the characteristic features of the incremental laws in the large. The use of a segmentwise linear yield condition and the associated flow rule is illustrated by the analysis of the bending moments and deflections of a simply supported circular plate that is made of a work-hardening material and subjected to a uniformly distributed transverse load.

52. Morino, L., Leech, J.W., and Witmer, E.A., AN IMPROVED NUMERICAL CALCULATION TECHNIQUE FOR LARGE ELASTIC-PLASTIC TRANSIENT DEFORMATIONS OF THIN SHELLS, Part 1, ASME Journal of Applied Mechanics, June 1971, p. 423.

In this paper, the governing differential relations which describe the large-deflection elastic-plastic dynamic responses of arbitrarily shaped thin Kirchhoff shells are given, including recent improvements. These relations are then cast into finite-difference form for numerical solutions. These finite-difference relations are employed in a computer program, PETROS 2, which has been applied to evaluate the "analysis improvements" by comparing PETROS 2 predictions with those of the earlier analysis and with experimental results.

53. Pifko, A. Issakson, A FINITE-ELEMENT METHOD FOR THE PLASTIC BUCKLING ANALYSIS OF PLATES, Grumman Aerospace Corporation, Bethpage, N.Y., AIAA Journal of Applied Mechanics, Vol. 7, No. 10, October 1969.

An existing finite-element technique for elastic buckling of plates is extended to include the case of plastic buckling. The Stowell theory for the plastic buckling of flat plates is used in conjunction with the finite-element technique. Application is made to rectangular

plates, and results are presented for a variety of boundary support conditions and several different edge loading conditions.

54. Armen, H., Jr., Pifko, A., and Levine, H.S., FINITE ELEMENT ANALYSIS OF STRUCTURES IN THE PLASTIC RANGE, NASA CR 1649, February 1971.

The present report is concerned with the development of finite-element methods for the treatment of the nonlinear behavior of complex structures. It represents an extension of a previous study reported in NASA Contractor's Report CR-803. The nonlinearity may be of two types - material nonlinearity associated with plastic deformation, and geometric nonlinearity associated with the changing geometry of the structure as it deforms - or it may involve a combination of the two. Effects due to creep and other time-dependent material properties are neglected.

The methods developed are applicable to loading conditions that cause membrane stress states or pure bending, or both in combination. The Prager-Ziegler kinematic hardening theory of plasticity is incorporated in the finite-element methods to allow for consideration of the plastic response of structures subjected to realistic loading conditions, including cyclic loadings that cause stress reversals into the plastic range. Ideally, plastic behavior is also included to provide capability for predicting the collapse load of structures. The plasticity theory is implemented in the finite-element analysis by using an incremental approach in conjunction with the initial strain concept, with plastic strains interpreted as initial strains.

The treatment of geometric nonlinearity requires use of an incremental technique in which the internal forces and configuration of the structure are continuously updated to account for its changing geometry.

The methods developed are applied to a number of sample structures. For membrane stress states alone, the analysis employs a triangular finite element in which stress and strain vary linearly. This element is used for the plastic analysis of a variety of structures characterized by regions of rapid stress variation and subjected to cyclic loading resulting in reversed plasticity. Comparisons of the results of the analysis and experimental data indicate good correlation.

Plastic analyses are also performed for a variety of beam and plate structures. These problems make use of refined rectangular and triangular finite elements. Among the problems considered are rectangular, circular, and annular plates with various boundary conditions. Once again, comparisons with results of other available analyses are favorable.

Problems of combined bending and stretching of plates are also considered. Results are obtained for rectangular and circular plates. Results for combined geometric and material nonlinearity are presented for beams and arches.

55. Mallett, R. H., AUTOMATED METHOD FOR THE LARGE DEFLECTION AND INSTABILITY ANALYSIS OF THREE-DIMENSIONAL TRUSS AND FRAME ASSEMBLIES, AFFDL-TR-66-102, December 1966.

The computer program presented in this report was developed to predict large deflection behavior of three-dimensional truss and frame assemblies. The solutions are obtained by the direct minimization of the total potential energy with respect to the displacement variables rather than by solving nonlinear matrix equations. Sample problems are presented to demonstrate the analysis capability developed. Instructions for the preparation of the input data and the FORTRAN IV source program listing are included.

56. Przemieniecki, J.S., MATRIX METHODS IN STRUCTURAL MECHANICS, AFFDL-TR-66-80, Conference held October 26-28, 1965.

The Conference on Matrix Methods in Structural Mechanics held at Wright-Patterson Air Force Base on 26-28 October 1965 was sponsored jointly by the Air Force Flight Dynamics Laboratory, Research and Technology Division, Air Force Systems Command, and the Air Force Institute of Technology, Air University. The purpose of the conference was to discuss the recent developments in the field of matrix methods of structural analysis and design of aerospace vehicles.

57. Berke, L., PROCEEDINGS OF THE SECOND CONFERENCE ON MATRIX METHODS IN STRUCTURAL MECHANICS, AFFDL-TR-68-150, Conference held October 15-17, 1968.

The Second Conference on Matrix Methods in Structural Mechanics, sponsored by the Air Force Institute of Technology (AFIT), Air University, and the Air Force Flight Dynamics Laboratory (AFFDL), Air Force Systems Command, was held on 15-17 October 1968. The purpose of the conference is to discuss the recent developments in matrix structural analysis and design of structural systems. This volume contains all the papers presented at the conference.

Forty papers were presented at the conference in seven sessions, entitled Structural Weight Optimization, Dynamics, General Elements, Curved Elements, Applications, General Methods, and Nonlinear Analysis. The papers covered practically all major aspects of recent research and development work on matrix methods in structural mechanics.

58. Symonds, P.S., SURVEY OF TECHNICAL METHODS OF ANALYSIS FOR PLASTIC DEFORMATION OF STRUCTURES UNDER DYNAMIC LOADING, BU/NSRDC/1-67, Brown University, Providence, R.I., 1967.

This survey attempts to make a critical study of methods described in the literature for the analysis of metal structures under dynamic loading to plastic deformation.

Analyses have now appeared in the literature of a considerable variety of structures of engineering interest. They include beams (under many conditions of loading, support, and materials), rings, arches, frames, (simple rectangular bents), plates (circular and rectangular), membranes (i.e., plates with deflections greatly exceeding the thickness), and shells (axially symmetric loading on cylinders, spheres, and spherical caps). Most of these have been obtained by a rigid-plastic type of analysis (in which strain rates are assumed zero unless a yield condition is satisfied). A few have been obtained by wholly numerical approaches of finite-difference type.

Experiments reported in the literature have, in most cases, shown that the actual permanent deflections are smaller than those predicted on the basis of plastic properties determined by quasi-static tests, the predictions often being in error by as much as 100 percent or more for mild steel, with smaller discrepancies for other metals, such as aluminum alloys or high-strength steels. Strengthening under conditions of rapid straining has been considered the principal cause of such discrepancies; when it has been possible to modify the analysis to take account of the increase of yield and flow stresses at high strain rates, much better agreement has, in most cases,been obtained.

59. Semonian, J.W., and Anderson, P.A., AN ANALYSIS OF THE STABILITY AND ULTIMATE BENDING STRENGTH OF MULTIWEB BEAMS WITH FORMED CHANNEL WEBS, NACA Technical Note TN 3232, 1954.

Design curves and procedures are presented for calculating the stresses for instability and failure of multiweb beams with formed-channel webs. The ultimate bending strength of this type of construction is shown to depend upon the deflectional stiffness of the web attachment flanges. A simple criterion is also given for predicting whether a multiweb beam with a given attachment-flange design will be susceptible to a wrinkling instability or will buckle as if the webs are integrally joined to the cover skins.

The criteria for predicting buckling and failure stresses are compared with experimental data. These criteria are sensitive to the offset, pitch, and diameter of the rivets used on the web attachment flanges, and the riveting specification is, therefore, emphasized as an important design consideration.

60. Semonian, J.W., and Peterson, J.P., AN ANALYSIS OF THE STABILITY AND ULTIMATE COMPRESSIVE STRENGTH OF SHORT SHEET-STRINGER PANELS WITH SPECIAL REFERENCE TO THE INFLUENCE OF THE RIVETED CONNECTION BETWEEN SHEET AND STRINGER, NACA Technical Report TR 1255, 1956.

A method of strength analysis of short sheet-stringer panels subjected to compression is presented which takes into account the effect that the riveted attachments between the plate and the stiffeners have on the strength of panels. An analysis of experimental data shows that panel strength is highly influenced by rivet pitch, diameter, and location and that the degree of influence for a given riveting depends on the panel configuration and panel material.

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Experimental Data	●			●		●	●			●	●		
Static Test	●			●									
Dynamic Test	●		●	●	●					●			
Load-Deflection Curves	●			●		●						●	
Airframe Structure	●	●		●		●	●	●					
Frame Structure					●	●	●						●
Beam Elements	●			●	●	●	●	●					
Columns, Bars, Tubes							●	●					●
Plates, Shells, Cylinders	●			●		●		●	●	●	●	●	
Composite Elements				●		●	●						
Large Displacements	●				●				●		●		
Design Procedures/Guidelines	●	●				●	●					●	
Simplified Analytical Techniques					●	●	●		●			●	
Inertia Effect	●							●					
Strain Rate Effects					●								
Energy Absorption	●	●	●	●									
Load-Limiting Devices		●											
Failure Modes	●			●					●			●	●

B

TABLE I. LITERATURE MATRIX CATEGORIZATION

3	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
	●	●	●	●	●		●	●	●														●	●	●		●	●	●	●			
				●								●					●		●	●	●	●			●			●					
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●												●																					

C

CATEGORIZATION

27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
									●	●	●		●	●	●	●				●	●		●	●	●	●	●		●	●	●		●
			●		●	●	●	●			●			●										●	●		●	●	●			●	
		●		●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●		●
			●	●					●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●		●	●	●
		●	●			●								●			●			●	●					●			●		●	●	●
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		●				●								●				●										●	●		●	●	
				●					●	●	●		●		●	●	●	●	●	●	●	●	●	●	●	●	●		●	●			●
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●	●	●		●	●	●		●			●	●		●	●	●									●		●		●			●	●
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●			●		●	●		●			●				●		●												●	●			●
			●	●									●	●						●	●			●	●	●	●		●	●			●
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		●	●				●																										
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											●		●			●							●	●	●		●		●				
				●					●	●	●		●		●	●		●	●	●				●					●				●
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					●	●	●	●				●			●																		

TEST DATA

DYNAMIC TEST INSTALLATION

The dynamic test setup uses existing components. The drop carriage assembly is the same one that was utilized during the drop test of the fuselage bumper, the results of which are reported in Reference 1. Between the test specimen support and the ground are installed six load cells (two each along the north and south edges of the support and one each along the east and west edge of the support). The load cells are used for tests 7 and 8. In the previous dynamic tests (4, 5, 6), the specimen support is grouted to the concrete slab ground. The installation provides sufficient free-fall clearance (14 ft) to perform 30-ft/sec impact tests. The setup has the flexibility of performing higher impact velocity drop tests by adding additional frames, thus increasing the available free-fall distance. Figure 1 shows a layout of the test installation and notes the various items and assemblies that form a part of the complete installation.

TEST SPECIMENS

A complete description of the test specimen overall dimensions, bulkhead and end beam web thicknesses, number and thickness of angles, design configuration, nominal weight, and type of test performed for each specimen is shown in Volume I, Table XVII. A complete set of drawings for the various design configurations is presented herein as described in Table II below:

Table II. SPECIMEN DRAWING IDENTIFICATION

Figure	Applicable Specimen	Drawing X-16628A
2	1	-1
3	2,3,4	-2
4	5,6	-3
5	7,8,9	-4
6	10,11,12	-5

RECORDED SCAN (TIME) HISTORIES

A complete set of pertinent recorded test data is presented in Figures 7 through 80. Load-deflection curves for each of the test specimens are presented in Volume I in the section entitled Substructure Test Program.

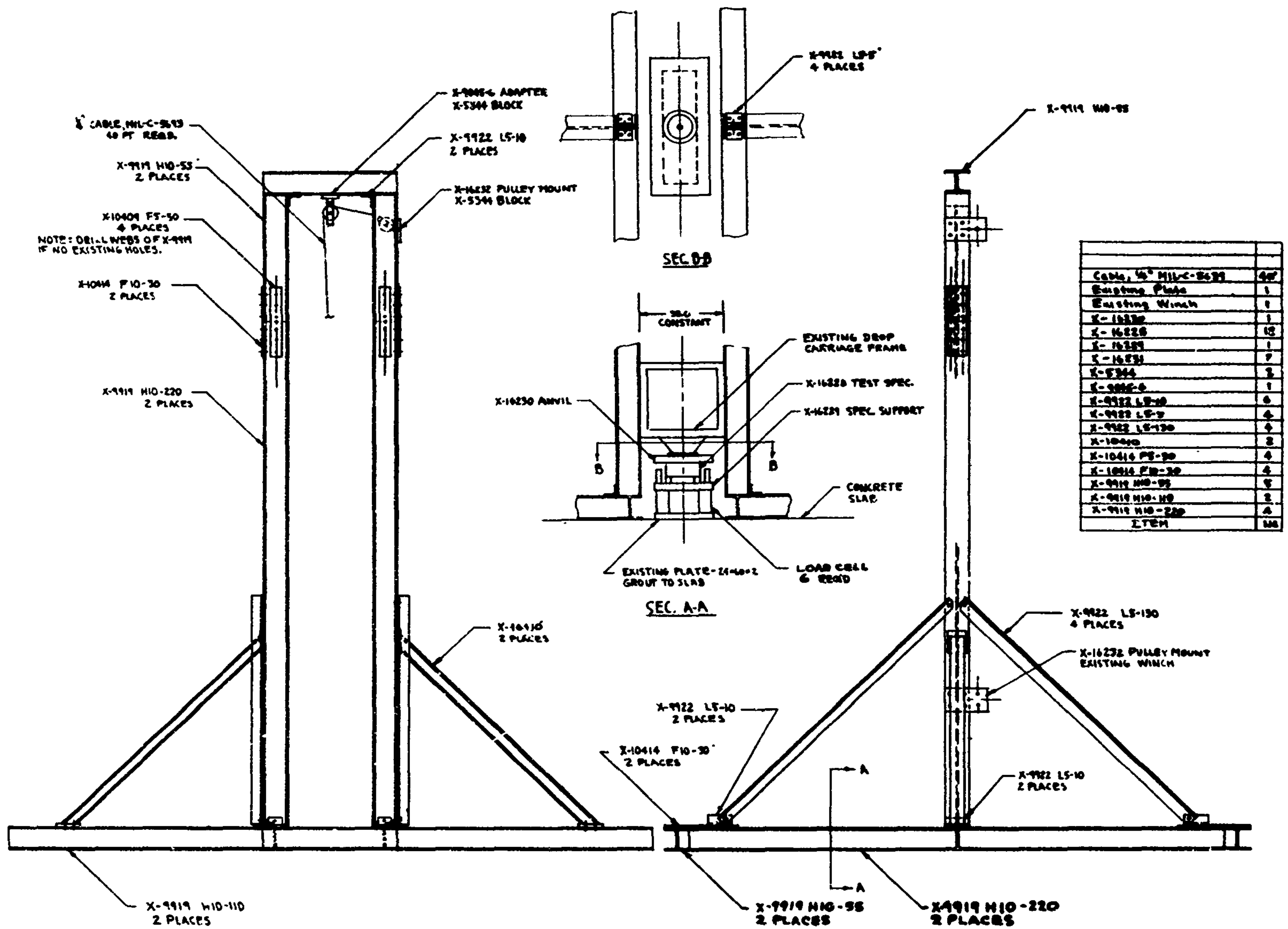

Figure 1. Dynamic Test Installation.

A

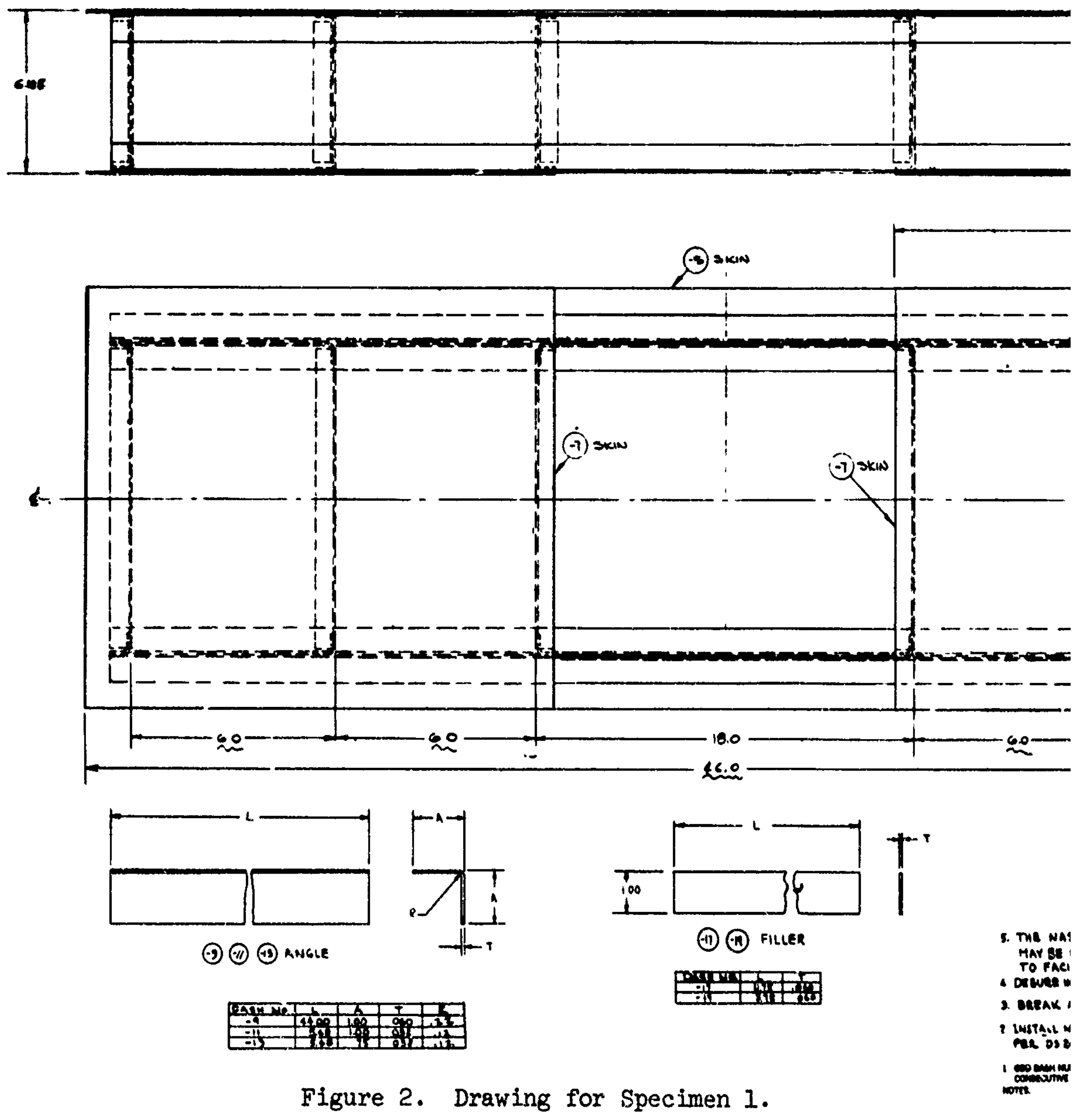

Figure 2. Drawing for Specimen 1.

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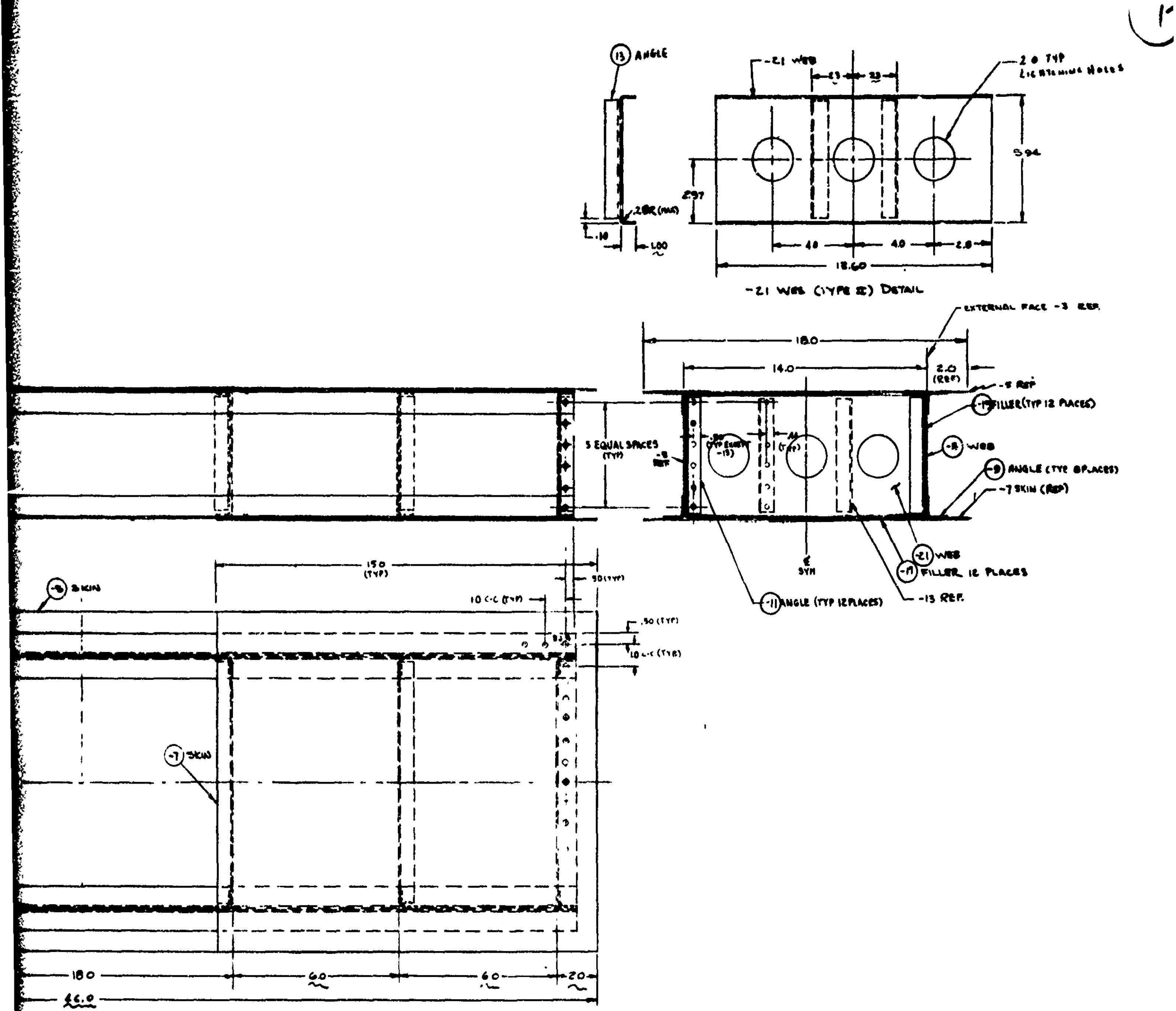
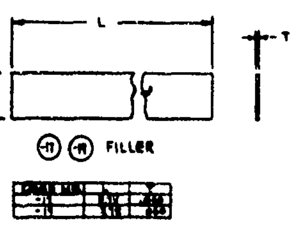




5 THE NAS 1738B4( ) RIVETS MAY BE INSTALLED AT ANY LOCATION TO FACILITATE FABRICATION
4 DEBURR HOLES BEFORE ASS'Y
3 BREAK ALL SHARP EDGES
2 INSTALL NAS 1738E4-( ) RIVETS PER D3 2493
1 ODD DASH NUMBER SHOWN, NEXT HIGHER CONSECUTIVE EVEN DASH NUMBER OPPOSITE.
NOTES:

QUANTITY REQ'D PER SPECIMEN NO.	SYMBOL	NOMENCLATURE OR DESCRIPTION	CODE IDENT	PART OR IDENTIFYING NO.	MATERIAL SPECIFICATION	MATERIAL OR NOTES	SIZE OR SHAPE	UNIT WT	ZONE	HEAT TREAT
AR		RIVETS		MS20470AD4 [redacted]						
6		WEB		-21	CLAD	7075-T6	.025 x 8 x 14			
12		FILLER		-19		7075-T6	.040 x 1.0 x 1.75			
12		FILLER		-17		7075-T6	.040 x 1.0 x 12			
12		ANGLE		-13		2024-T3	.125 x 1/2 x	5.8		
12		ANGLE		-11		2024-T3	.125 x 2 x	5.8		
8		ANGLE		-9		2024-T3	.060 x 1 x 1 x	44		
2		SKIN		-7		2024-T3	.125 x 18 x 15			
1		SKIN		-5		2024-T3	.032 x 18 x 46			
2		WEB		-3	CLAD	7075-T6	.032 x 5.87 x 44			
		ASSY								
1										

LIST OF MATERIALS OR PARTS LIST

cimen 1.

A

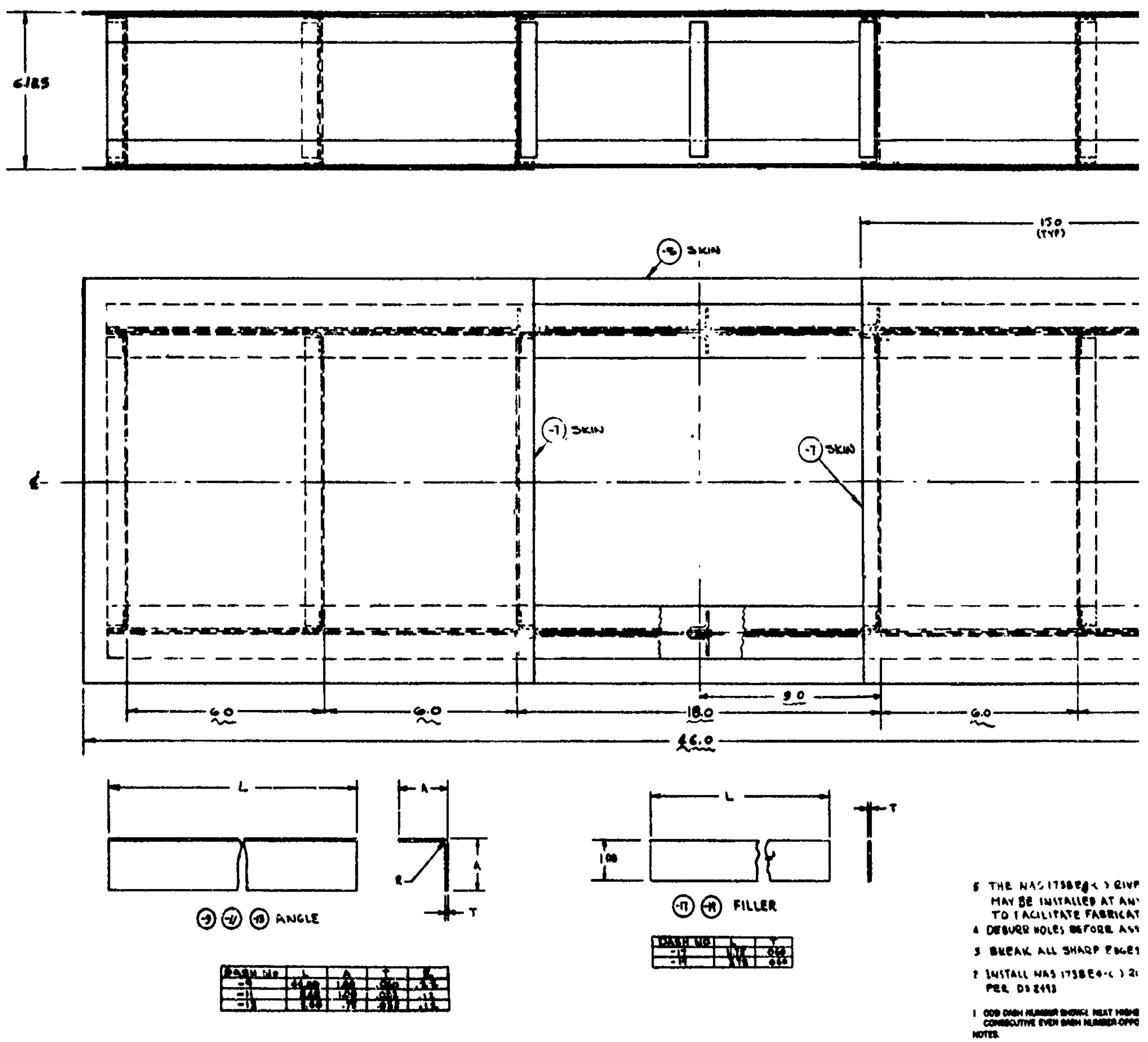
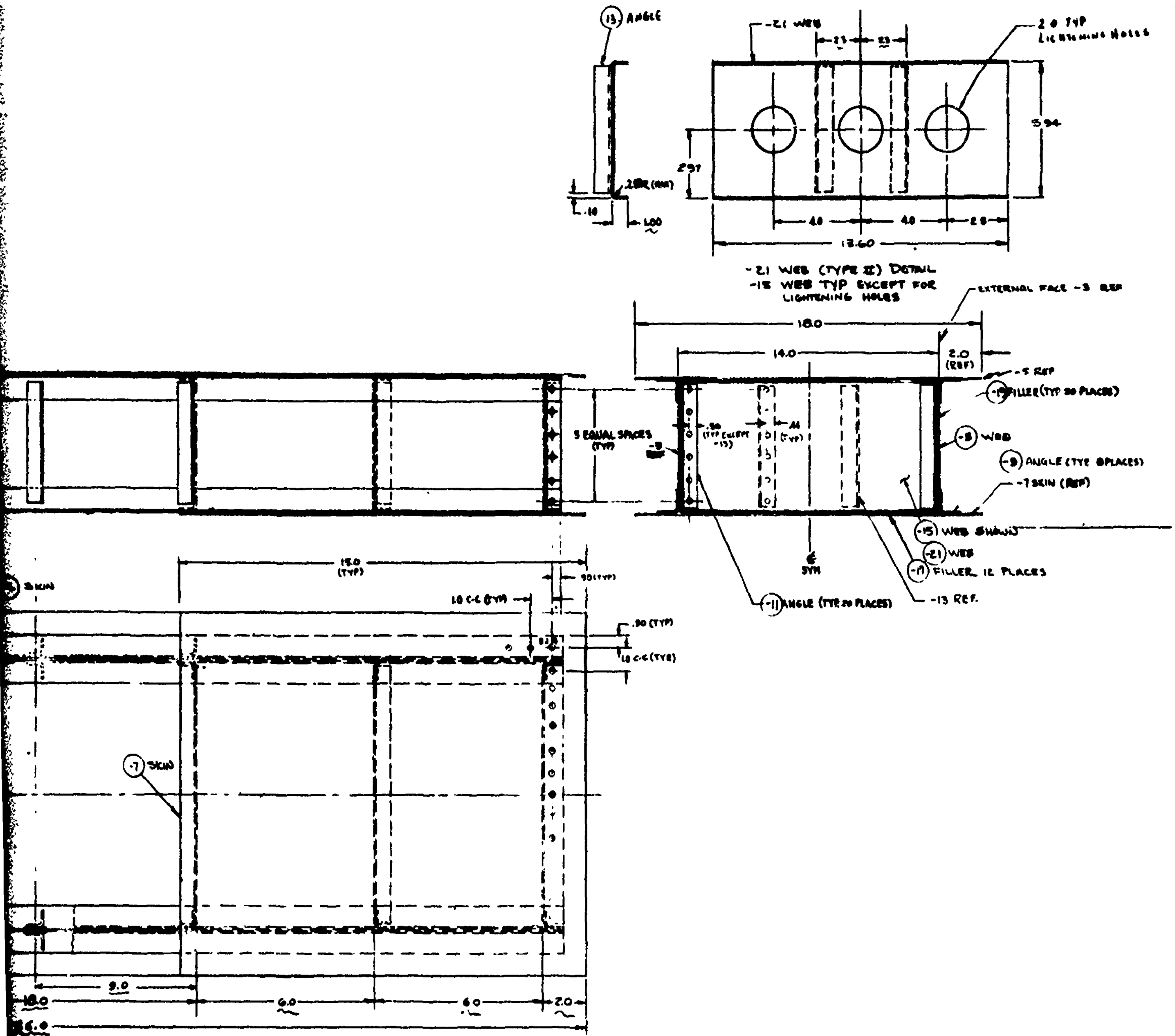
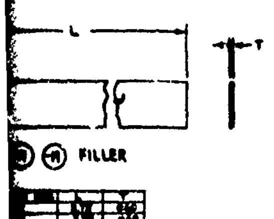


Figure 3. Drawing for Specimens 2, 3, and 4.

B





5. THE NAS 1738B( ) RIVETS MAY BE INSTALLED AT ANY LOCATION TO FACILITATE FABRICATION
4. DEBURR HOLES BEFORE ASSY
3. BREAK ALL SHARP EDGES
2. INSTALL NAS 1738B4-( ) RIVETS PER D32493
1. ODD DASH NUMBER SHOWN NEXT HIGHER CONSECUTIVE EVEN DASH NUMBER OPPOSITE.

NOTES:

	#4	#3	#2		RIVETS		MS20470AD4 [redacted]						
	6	6			WEB		-21	CLAD	7075-T6	.025 x 6 x 14			
	20	20	20		FILLER		-19		7075-T6	.064 x 1.0 x 1.75			
	12	12	12		FILLER		-17		7075-T6	.064 x .5 x .2			
			6		WEB		-15		7075-T6	.025 x 6 x 14			
	12	12	12		ANGLE		-13		2024-T3	.032 x 1/2 x	5.8		
	20	20	20		ANGLE		-11		2024-T3	.032 x 2 x	5.8		
	8	8	8		ANGLE		-9		2024-T3	.040 x 1 x 1 x	6.4		
	2	2	2		SKIN		-7		2024-T3	.032 x 18 x 15			
	1	1	1		SKIN		-5		2024-T3	.032 x 18 x 46			
	2	2	2		WEB		-3	CLAD	7075-T6	.032 x 5.87 x 46			
					ASSY								
QUANTITY REQD PER SPECIMEN NO	#4	#3	#2	SYMBOL	NOMENCLATURE OR DESCRIPTION	CODE IDENT	PART OR IDENTIFYING NO	MATERIAL SPECIFICATION	MATERIAL OR NOTES	SIZE OR SHAPE	UNIT WT	ZONE	HEAT TREAT
					LIST OF MATERIALS OR PARTS LIST								

, 3, and 4.

A

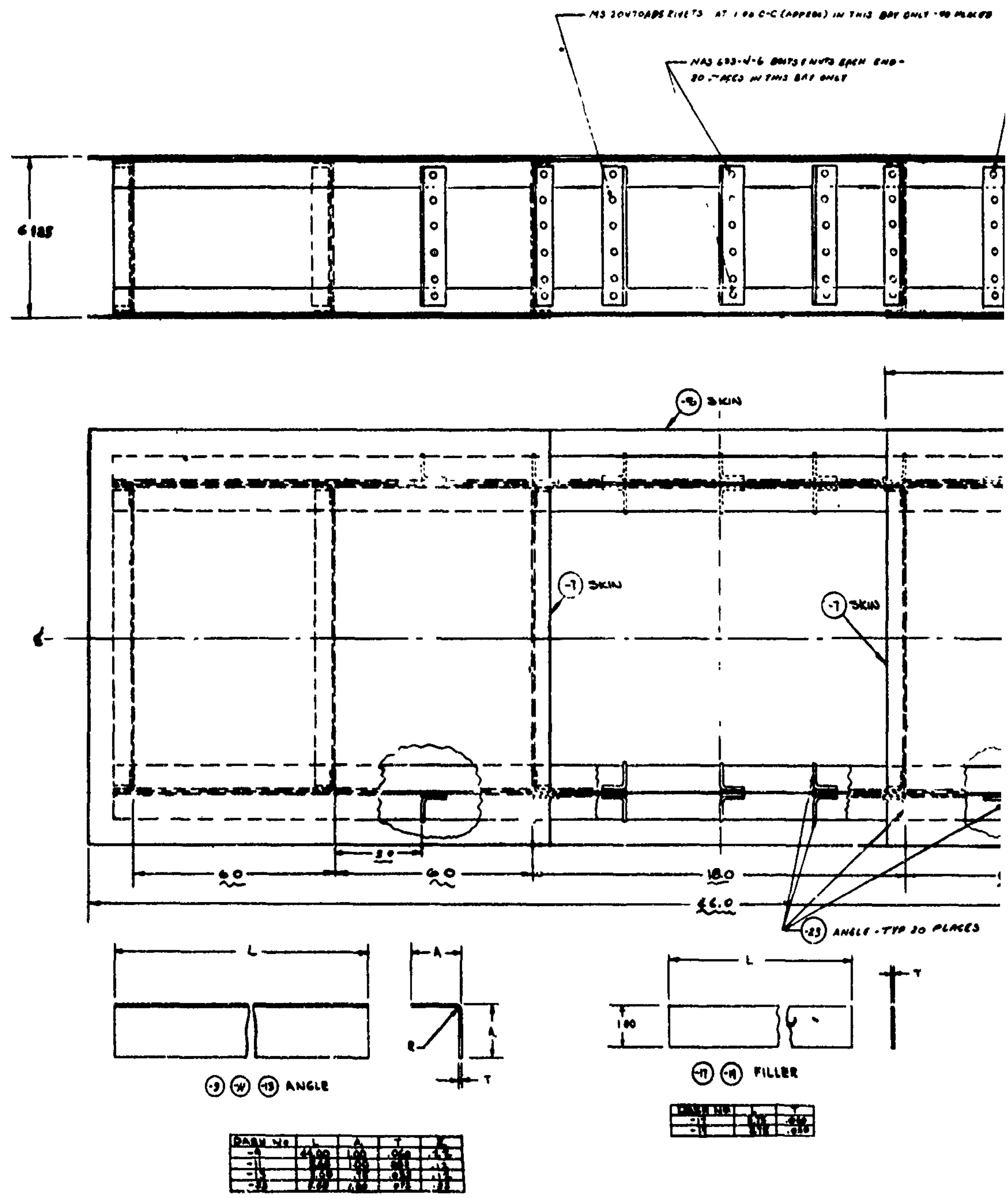


Figure 4. Drawing for Specimens 5 and 6.

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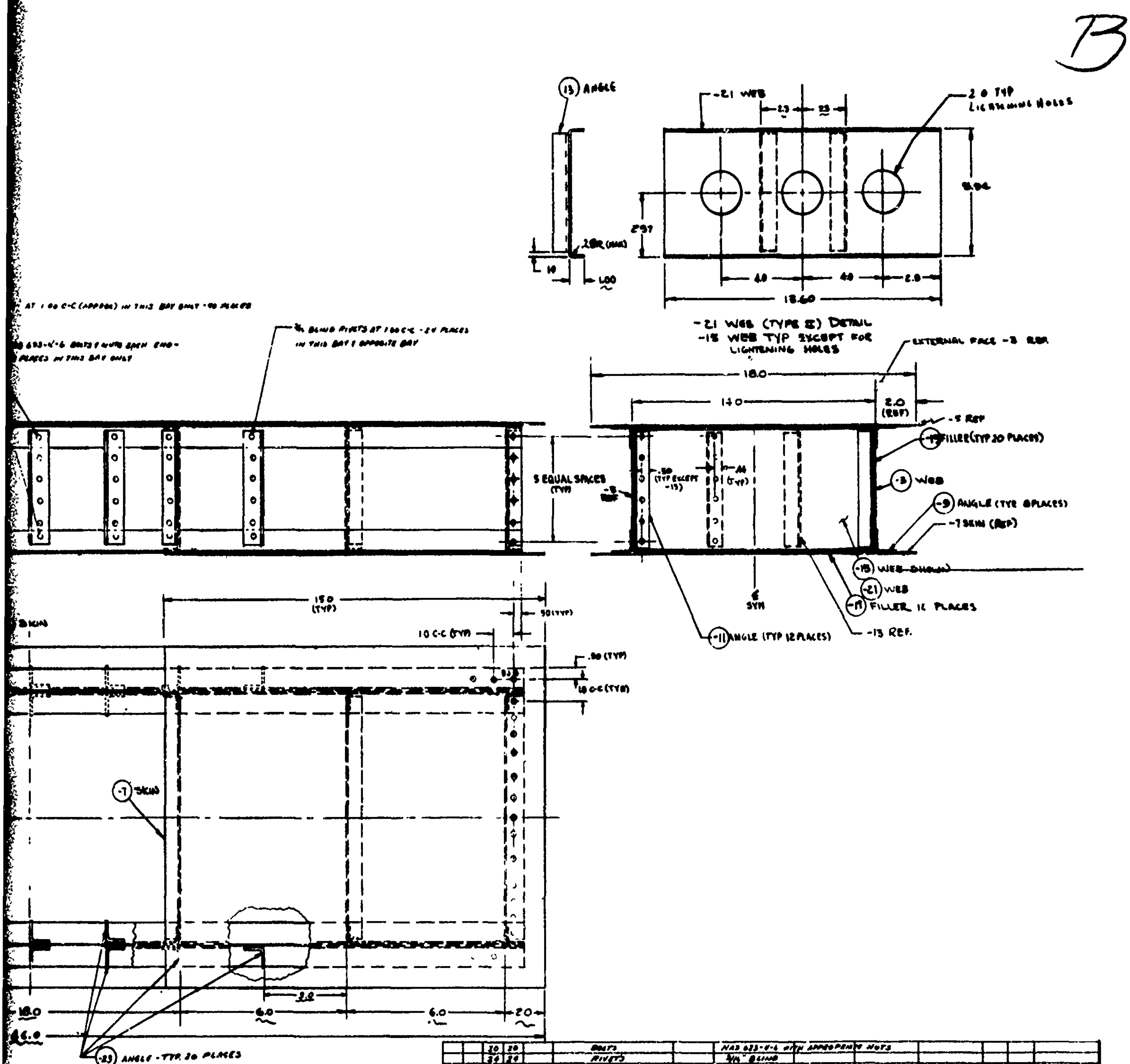
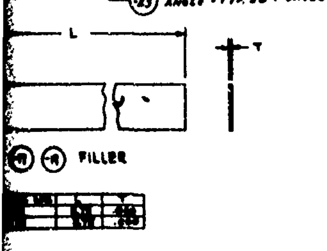
B





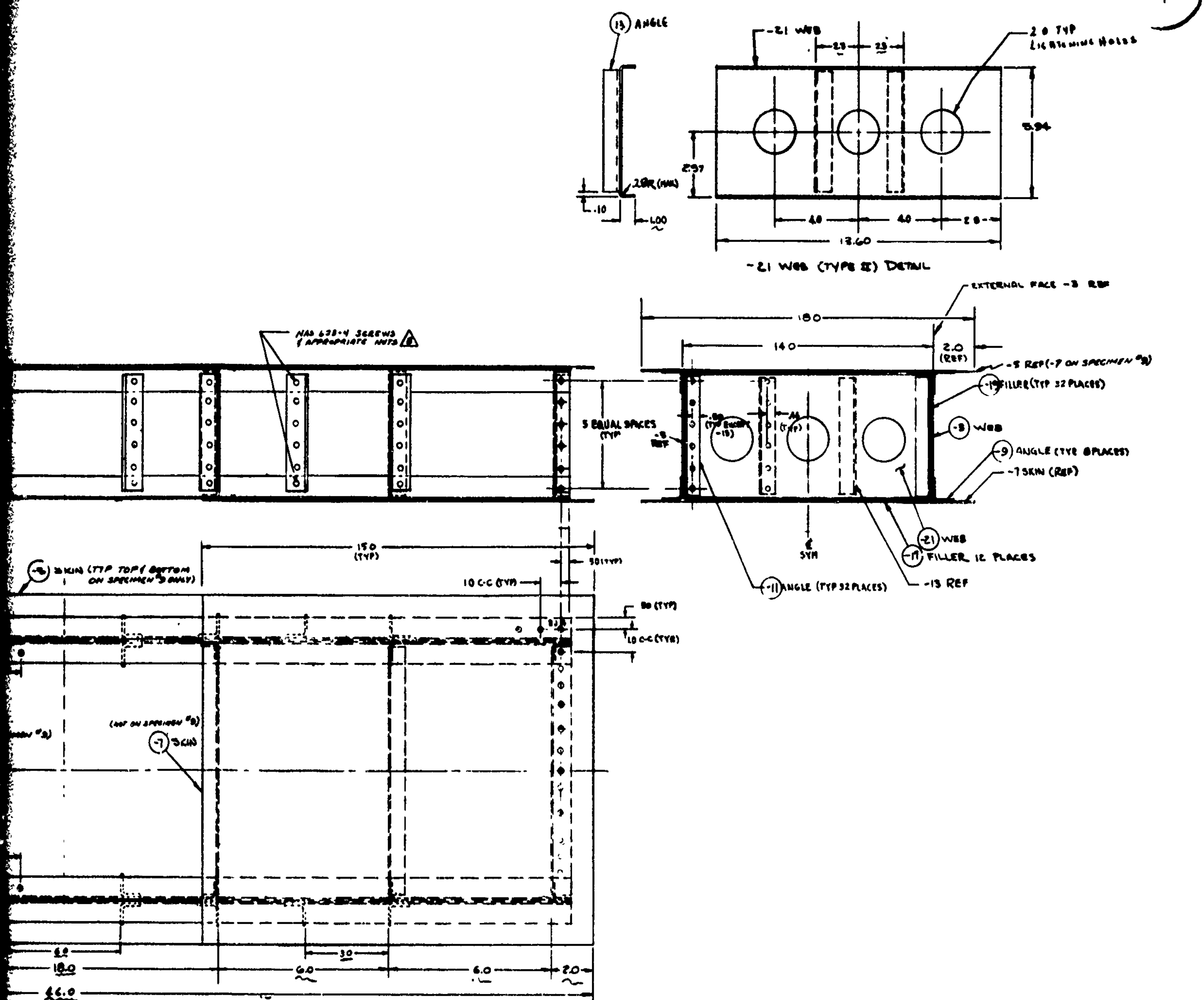
5 and 6.

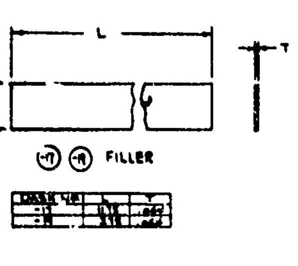
5. THE NAS 1738E4-( ) RIVETS MAY BE INSTALLED AT ANY LOCATION TO FACILITATE FABRICATION
4. DEBURR HOLES BEFORE ASS'Y.
3. BREAK ALL SHARP EDGES
2. INSTALL NAS 1738E4-( ) RIVETS PER DS 2493
1. ODD DASH NUMBER SHOWN. NEXT HIGHER CONSECUTIVE EVEN DASH NUMBER OPPOSITE.

NOTES:

QUANTITY REQ'D PER SPECIMEN NO.		-5	-6	SYMBOL	NOMENCLATURE OR DESCRIPTION	CODE IDENT	PART OR IDENTIFYING NO.	MATERIAL SPECIFICATION	MATERIAL OR NOTES	SIZE OR SHAPE	UNIT WT	ZONE	ITEM WEIGHT
		20	20		BOLTS		NAS 623-4-6 WITH APPROPRIATE NUTS						
		24	24		RIVETS		3/16" BLIND						
		80	80		RIVETS		MS 20470AD6						
		20	20		ANGLE		-23	CLAD	2024-T3	[illegible]			
		A/R	A/R		RIVETS		MS 20470 AD4 or [redacted]						
		6			WEB		-21	CLAD	7075-T6	.025 x 8 x 14			
		20	20		FILLER		-19		7075-T6	.040 x 1.0 x 1.75			
		12	12		FILLER		-17		7075-T6	.040 x 1.0 x 12			
			6		WEB		-15		7075-T6	.025 x 8 x 14			
		12	12		ANGLE		-13		2024-T3	.032 x 1 1/2 x	5.5		
		12	12		ANGLE		-11		2024-T3	.032 x 2 x	5.5		
		8	8		ANGLE		-9		2024-T3	.040 x 1.5 x	6.4		
		2	2		SKIN		-7		2024-T3	.032 x 18 x 15			
		1	1		SKIN		-5		2024 T3	.032 x 18 x 46			
		2	2		WEB		-3	CLAD	7075-T6	.012 x 5.87 x 46			
					ASSY								

LIST OF MATERIALS OR PARTS LIST





⚠ 8 ATTACHMENTS AT ENDS OF ALL -11 ANGLES SHALL BE NAS 623-4 SCREWS AND APPROPRIATE NUTS

⚠ 7 NAS 1738EV-( ) RIVETS USED IN LOCATION NOTED 'X' FOR SPECIMEN #9

6. RIVETS THRU SKINS TO BE ADV. ALL OTHER RIVETS TO BE ADS

5. REMOVED

4 DEBURR HOLES BEFORE ASSY

3 BREAK ALL SHARP EDGES

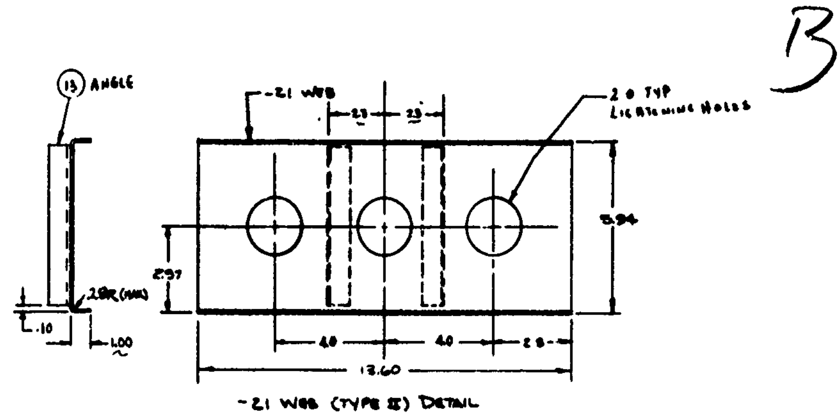
2 REMOVED

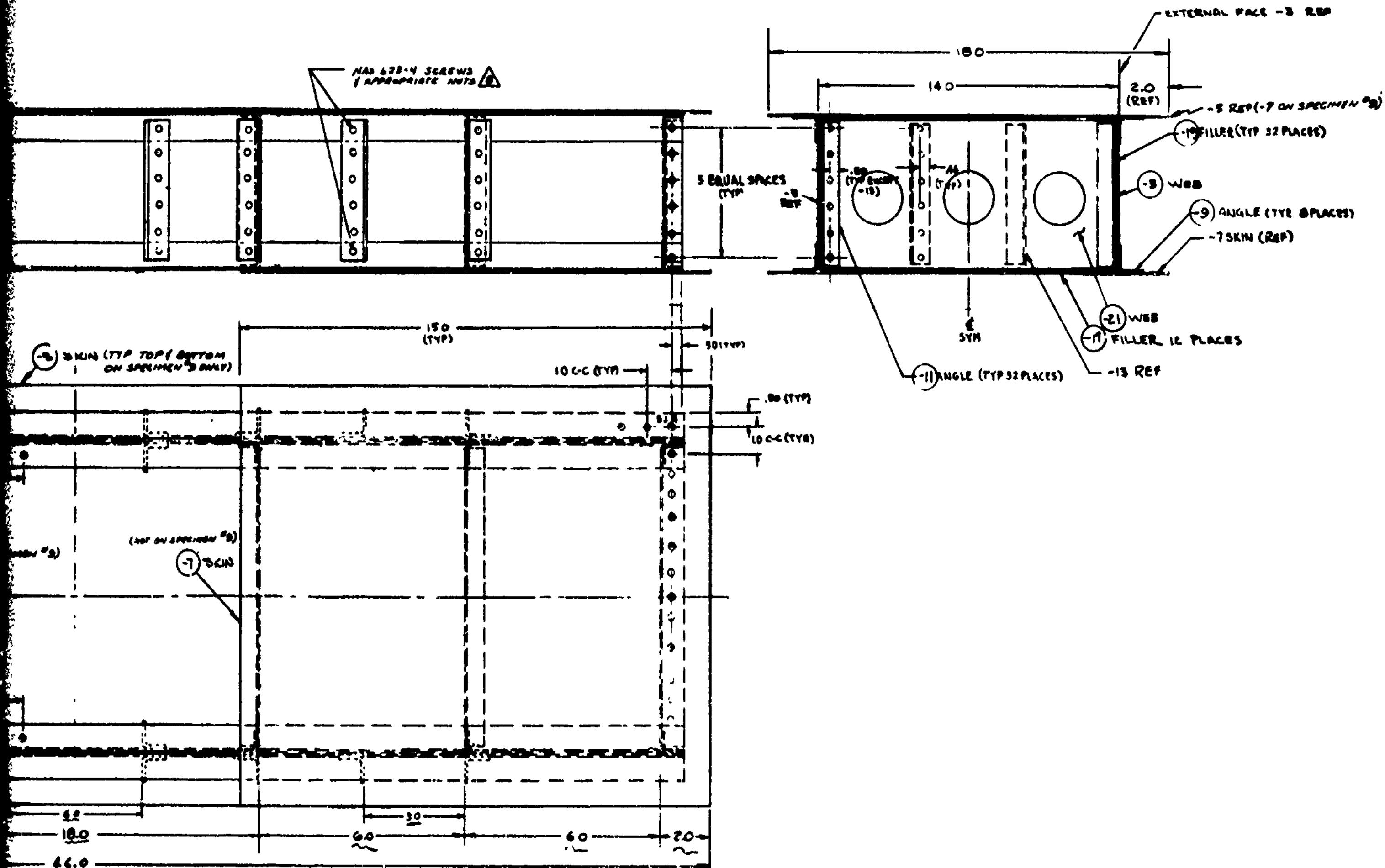
1 ODD DASH NUMBER SHOWN NEXT HIGHER CONSECUTIVE EVEN DASH NUMBER OPPOSITE

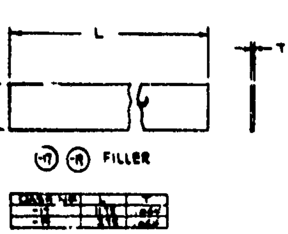
NOTES:

	10			RIVETS		NAS 1738EV ( )	BLIND RIVETS					
A/R	A/R	A/R		BOLTS		NAS 625 V AND APPROPRIATE NUTS						
A/R	A/R	A/R		RIVETS		MS20470AD5						
A/R	A/R	A/R		RIVETS		MS20470AD4						
6	6	6		WEB		-21	CLAD	7075-T6	[illegible]			
32	32	32		FILLER		19		7075-T6	.040 X 1.0 X 1.75			
12	12	12		FILLER		-17		7075-T6	.040 X 1.0 X 12			
12	12	12		ANGLE		-13		2024-T3	[illegible] X 5.94			
32	32	32		ANGLE		-11		2024-T3	[illegible] X 2 X 5.94			
8	8	8		ANGLE		-9		2024-T3	.040 X 1 X 1 X 6.6			
	2	2		SKIN		-7		2024-T3	.032 X 18 X [illegible]			
2	1	1		SKIN		-5		2024-T3	.032 X 18 X 46			
2	2	2		WEB		-3	CLAD	7075-T6	.064 X 5.87 X 46			
				ASSY								
#8	#9	#7	SYMBOL	NOMENCLATURE OR DESCRIPTION	CODE IDENT	PART OR IDENTIFYING NO.	MATERIAL SPECIFICATION	MATERIAL OR NOTES	SIZE OR SHAPE	UNIT WT	[illegible]	HEAT TREAT
QUANTITY REQD PER SPECIMEN NO				LIST OF MATERIALS OR PARTS LIST								

7, 8, and 9.







NOTES:

7. ATTACHMENTS AT ENDS OF ALL -11 ANGLES SHALL BE NAS 623-4 SCREWS AND APPROPRIATE NUTS

7. NAS 1738EV-( ) RIVETS USED IN LOCATION NOTED 'X' FOR SPECIMEN #9

6. RIVETS THRU SKINS TO BE ADV. ALL OTHER RIVETS TO BE ADS

5. REMOVED

4. DEBURR HOLES BEFORE ASSY

3. BREAK ALL SHARP EDGES

2. REMOVED

1. ODD DASH NUMBER SHOWN NEXT HIGHER CONSECUTIVE EVEN DASH NUMBER OPPOSITE

#8	#9	#7	SYMBOL	NOMENCLATURE OR DESCRIPTION	CODE IDENT	PART OR IDENTIFYING NO.	MATERIAL SPECIFICATION	MATERIAL OR NOTES	SIZE OR SHAPE	UNIT WT	ZONE	HEAT TREAT
	10			RIVETS		NAS 1738EV ( )	BLIND RIVETS					
A/R	A/R	A/R		BOLTS		NAS 623-4 AND APPROPRIATE NUTS						
A/R	A/R	A/R		RIVETS		MS20426AD						
A/R	A/R	A/R		RIVETS		MS20470AD6						
6	6	6		WEB		-21	CLAD	7075-T6	.063 SH			
32	32	32		FILLER		19		7075-T6	.060X1.0X1.75			
12	12	12		FILLER		-17		7075-T6	.060X1.0X12			
12	12	12		ANGLE		-13		2024-T3	[illegible]	5		
32	32	32		ANGLE		-11		2024-T3	[illegible]	5		
8	8	8		ANGLE		-9		2024-T3	.060X1X1X	44		
	2	2		SKIN		-7		2024-T3	.032X18X			
2	1	1		SKIN		-5		2024-T3	.032X18X46			
2	2	2		WEB		-3	CLAD	7075-T6	.064X5.87X44			
				ASSY								

QUANTITY REQD PER SPECIMEN NO

LIST OF MATERIALS OR PARTS LIST

7, 8, and 9.

A

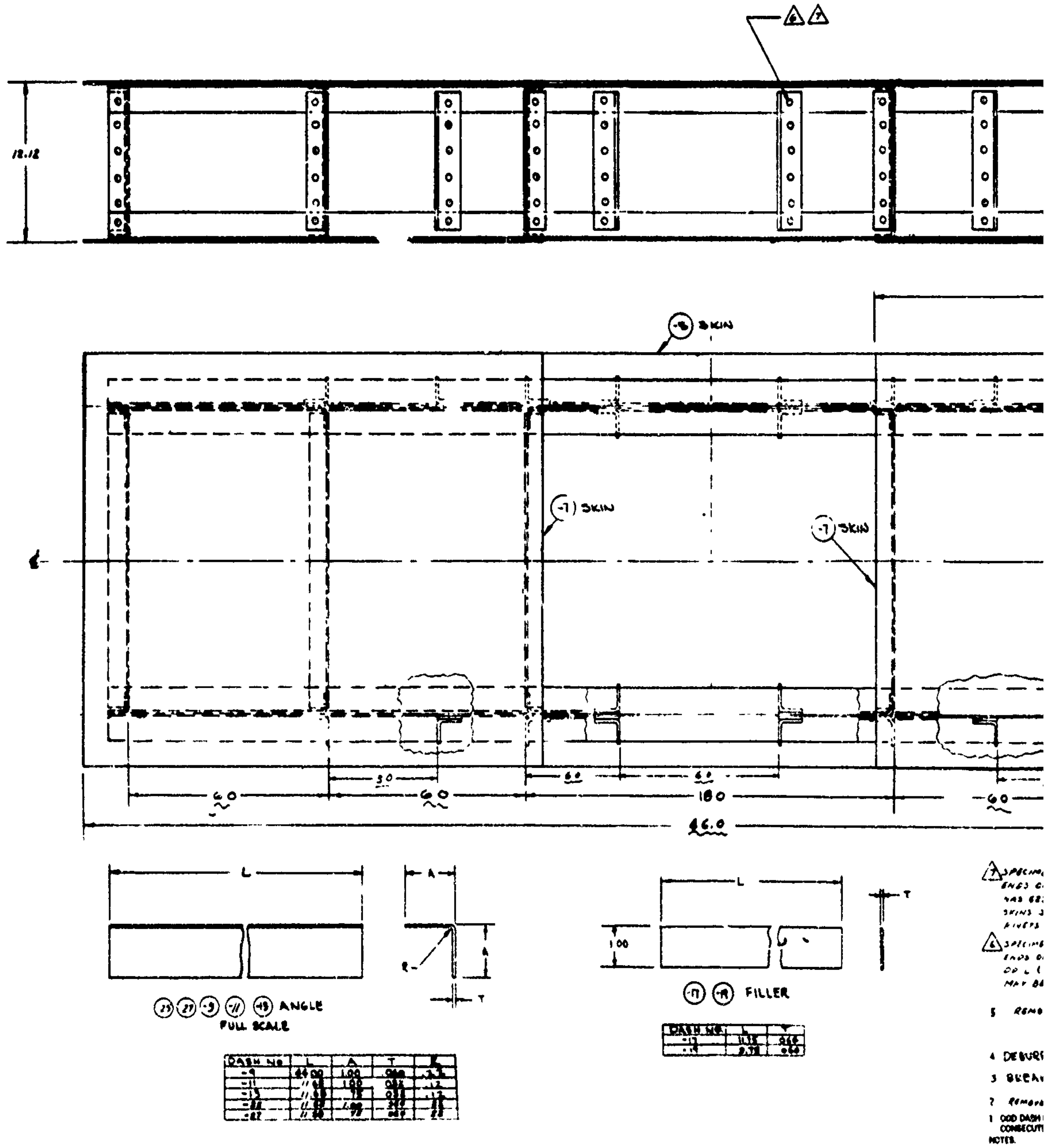


Figure 6. Drawing for Specimens 10, 11, and 12.

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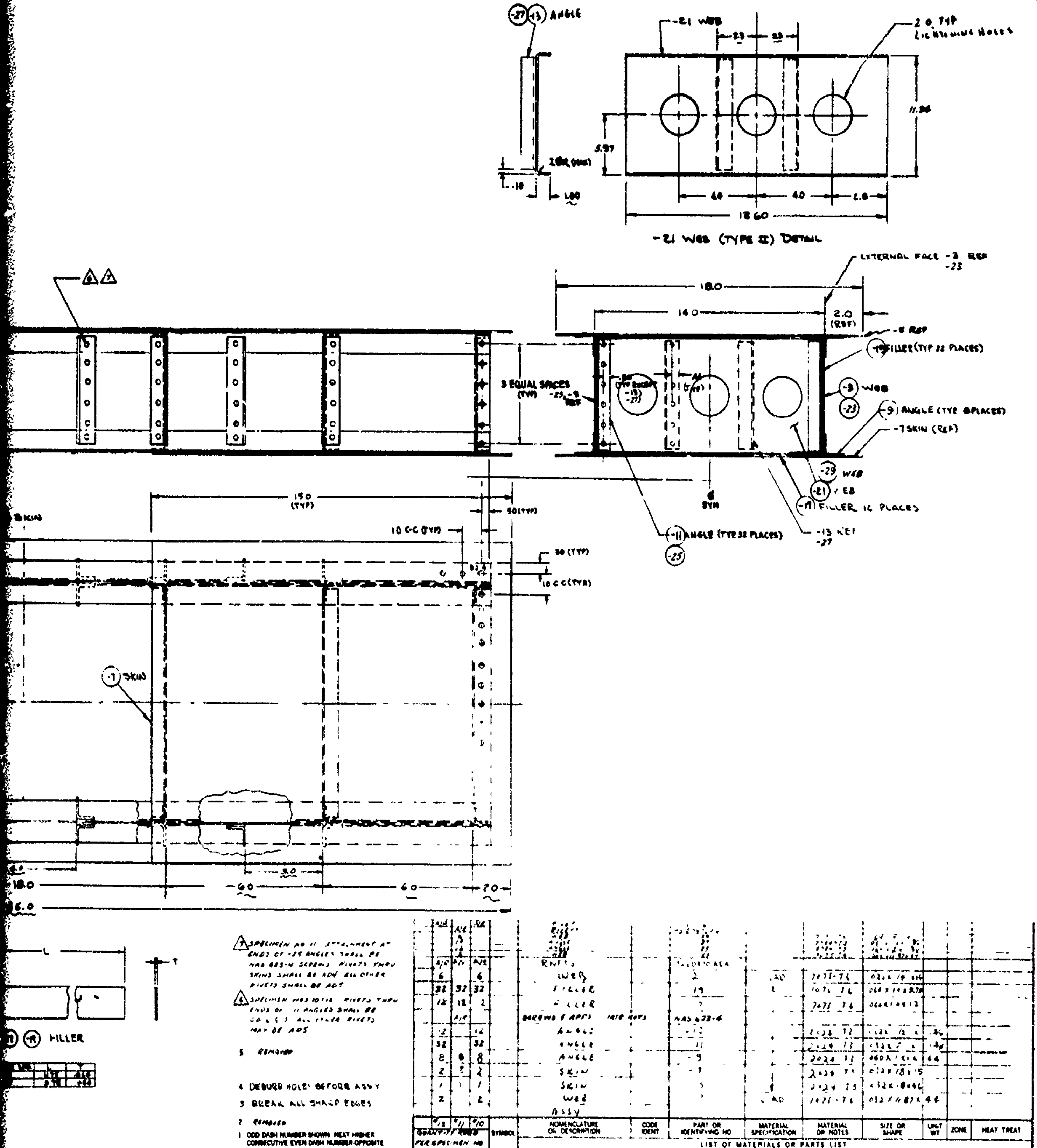

-21 WEB
2.0 TYP LIGHTENING HOLES
11.86
5.97
18.60
-21 WEB (TYPE II) DETAIL
EXTERNAL FACE -3 REF -23
18.0
14.0
2.0 (REF)
3 EQUAL SPACES (TYP)
ANGLE (TYP 8 PLACES)
-7 SKIN (REF)
WEB
FILLER 12 PLACES
ANGLE (TYP 32 PLACES)
15.0 (TYP)
10 C-C (TYP)
.50 (TYP)
10 C-C (TYP)
-7 SKIN
18.0
6.0
6.0
7.0
3.0
FILLER
4 DEBURR HOLES BEFORE ASSY
3 BREAK ALL SHARP EDGES
1 ODD DASH NUMBER SHOWN. NEXT HIGHER CONSECUTIVE EVEN DASH NUMBER OPPOSITE
NOTES
QUANTITY REQD PER SPECIMEN NO
SYMBOL
NOMENCLATURE OR DESCRIPTION
CODE IDENT
PART OR IDENTIFYING NO
MATERIAL SPECIFICATION
MATERIAL OR NOTES
SIZE OR SHAPE
UNIT WT
ZONE
HEAT TREAT
LIST OF MATERIALS OR PARTS LIST

11, and 12.

The data in this section includes load, deflection, acceleration (tests 4-8) and strain versus scan plots. Table III shows the test data available in the section for each specimen.

The sampling rate for test 4 is 750 scans/second. The sampling rate for tests 5 through 8 is 1500 scans/second; thus for the dynamic tests the time in seconds can be obtained by dividing the abscissa scale (scan) by 750 for test 4 and by 1500 for tests 5 through 8. Positive strain is compression for tests 1, 2, 3, 9, 10, 11, 12 and tension for tests 4, 5, 6, 7 and 8.

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Table III. TEST DATA IDENTIFICATION

Data Item	Test Specimen											
	1	2	3	4	5	6	7	8	9	10	11	12
Load	X	X	X				X	X	X	X	X	X
Deflection	X	X	X	X	X	X	X	X	X	X	X	X
Strain Gage 1A	X	X	X	X	X	X	X	X	X	X	X	X
Strain Gage 1B	X	X	X	X	X	X	X	X	X	X	X	X
Strain Gage 2	X	X	X	X	X	X						
Strain Gage 3	X	X	X									
Strain Gage 4	X	X	X									
Strain Gage 5	X	X	X									
Strain Gage 6	X	X	X	X	X	X						
Acceleration				X	X	X	X	X				
Applicable Figures	7 thru 13	14 thru 20	21 thru 29	30 thru 38	39 thru 44	45 thru 50	51 thru 60	61 thru 68	69 thru 71	72 thru 74	75 thru 77	78 thru 80

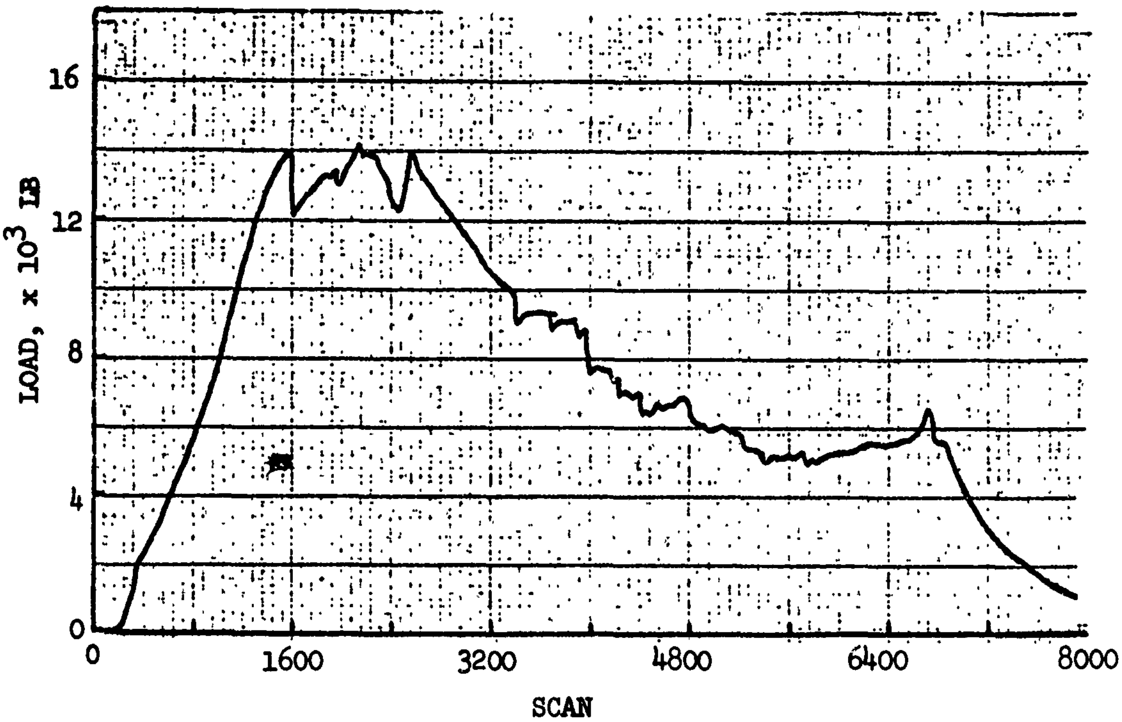


Figure 7. Load Versus Scan, Test Specimen 1.

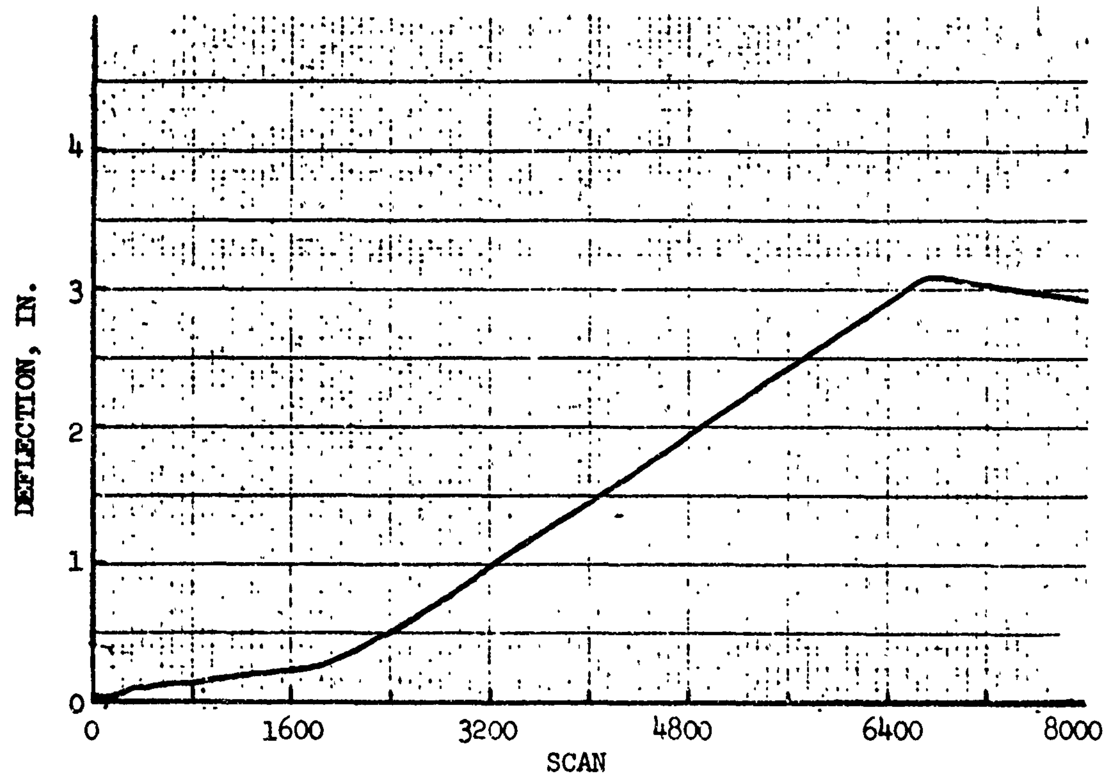


Figure 8. Deflection Versus Scan, Test Specimen 1.

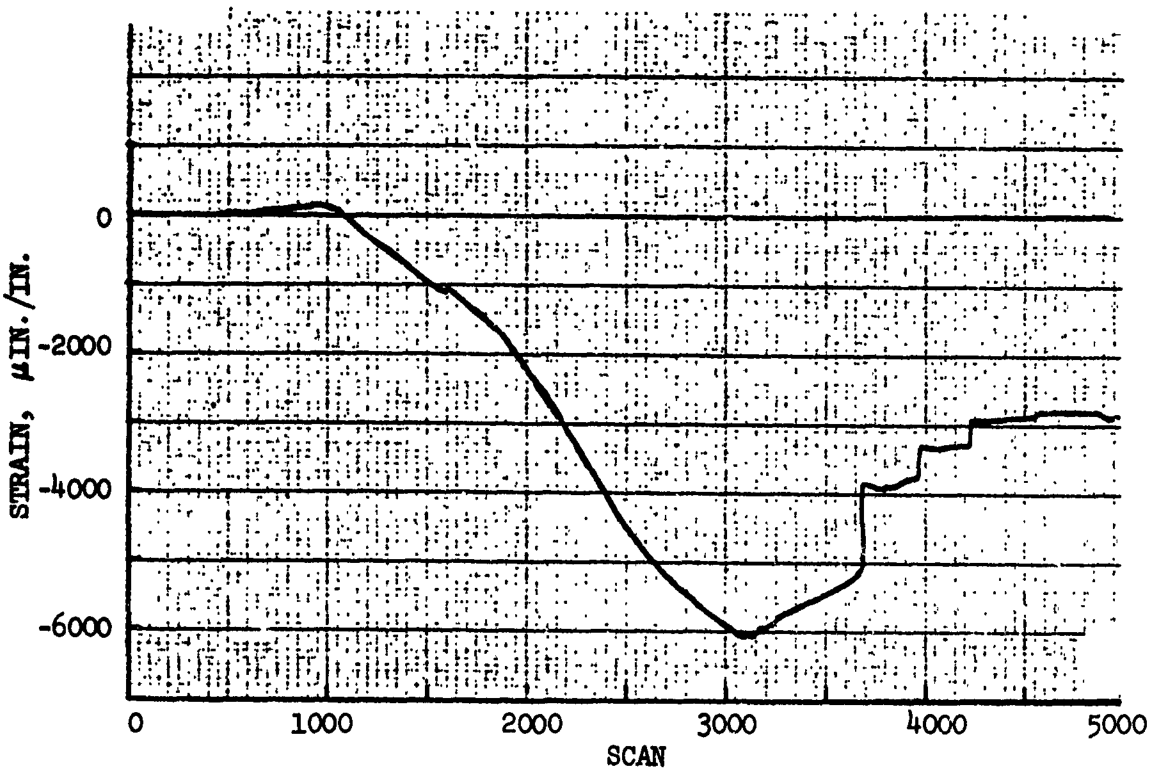


Figure 9. Strain Gage 1A Versus Scan, Test Specimen 1.

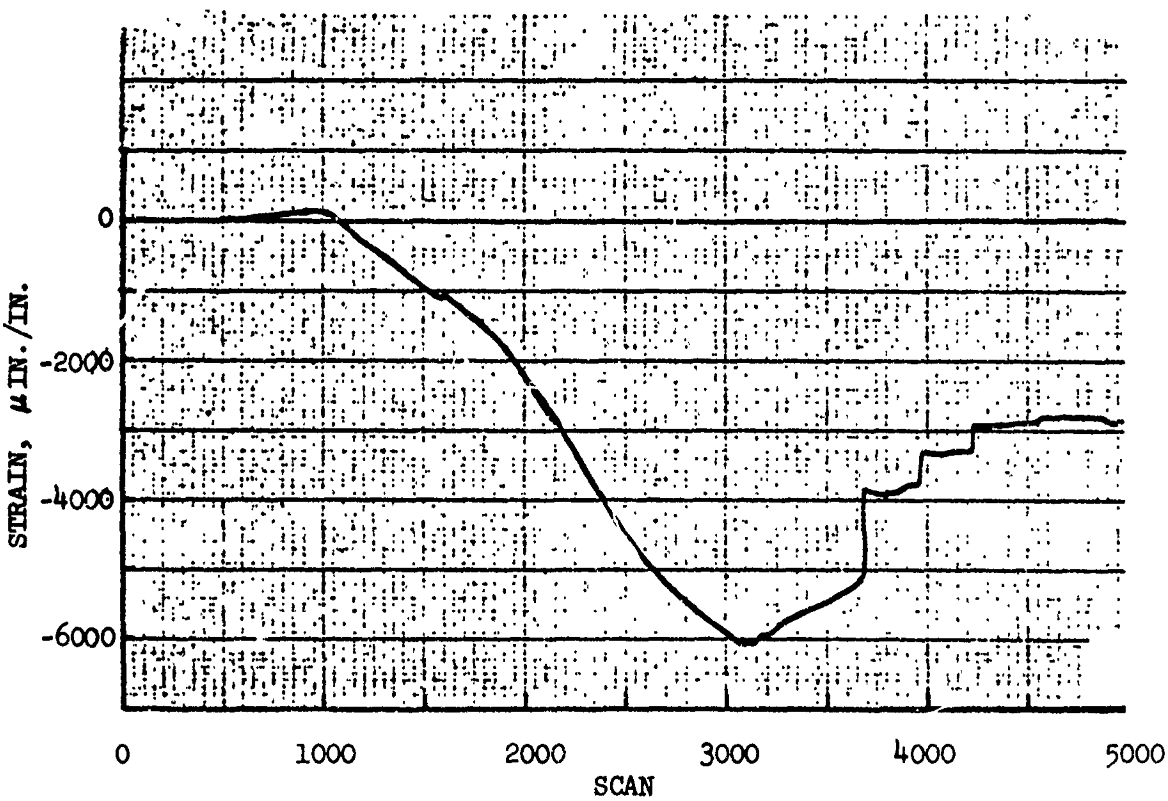


Figure 10. Strain Gage 1B Versus Scan, Test Specimen 1.

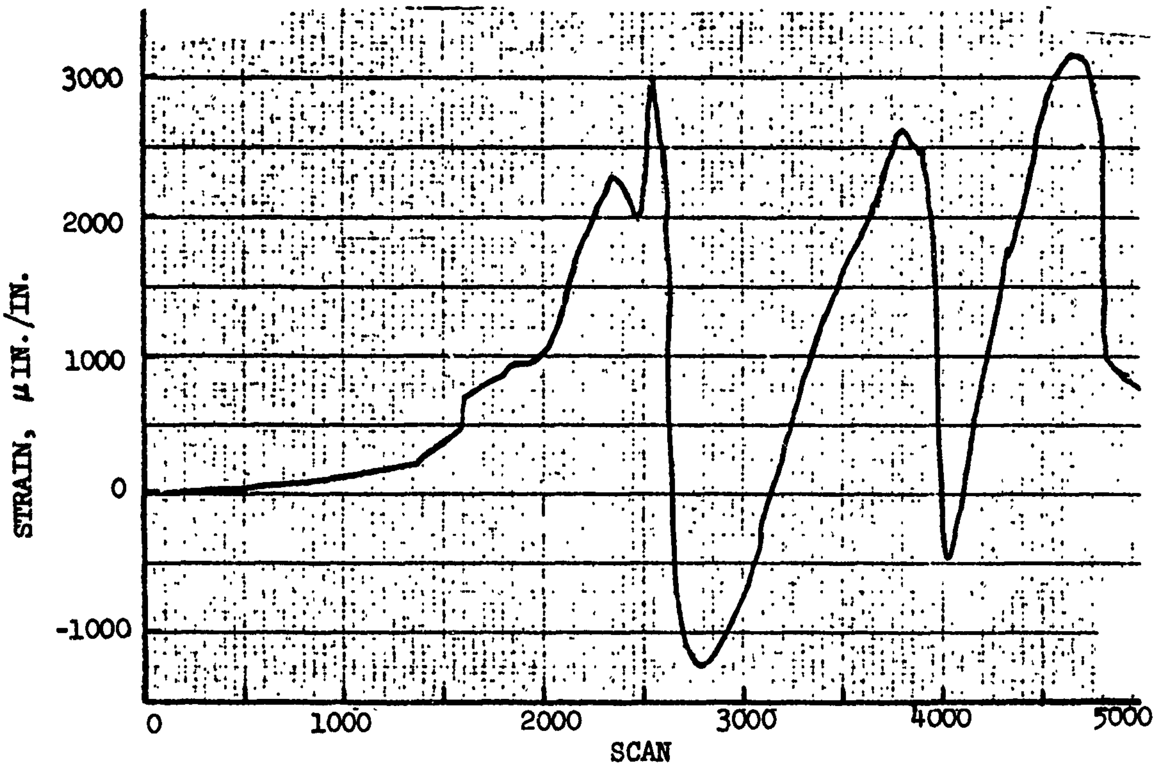


Figure 11. Strain Gage 2 Versus Scan, Test Specimen 1.

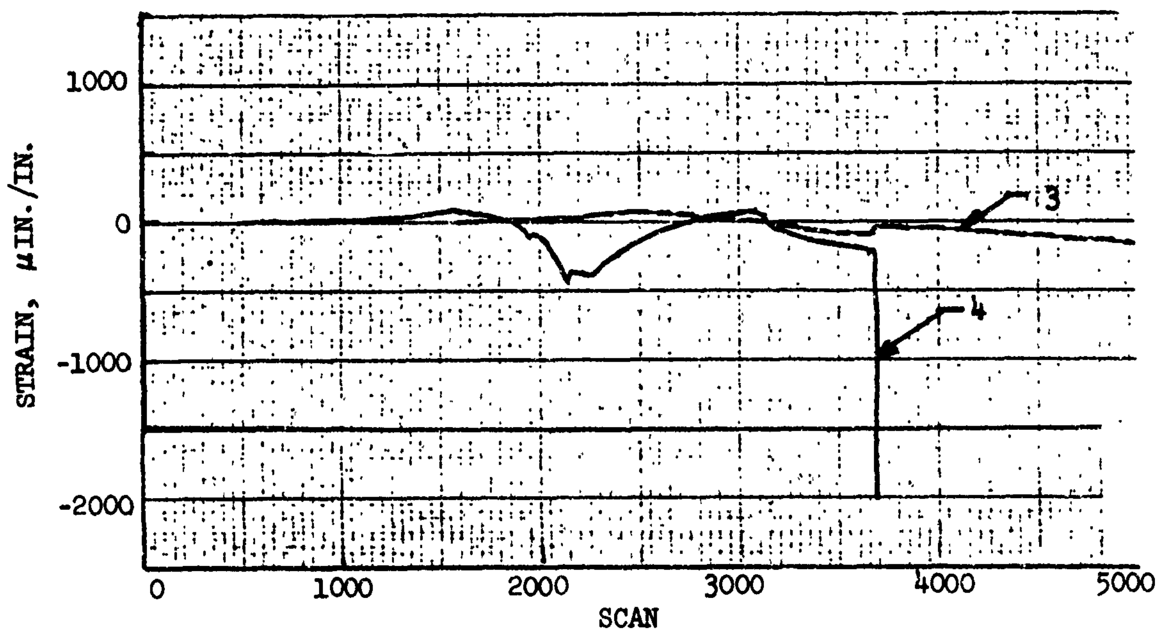


Figure 12. Strain Gages 3 and 4 Versus Scan, Test Specimen 1.

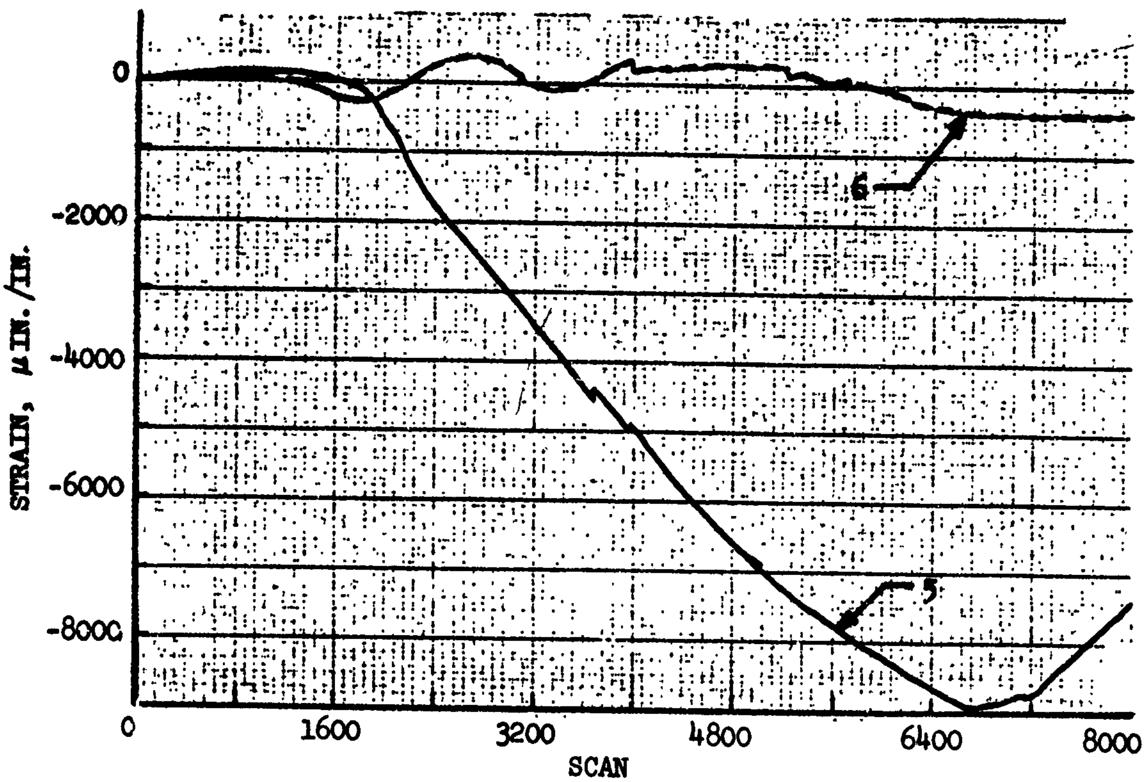


Figure 13. Strain Gages 5 and 6 Versus Scan, Test Specimen 1.

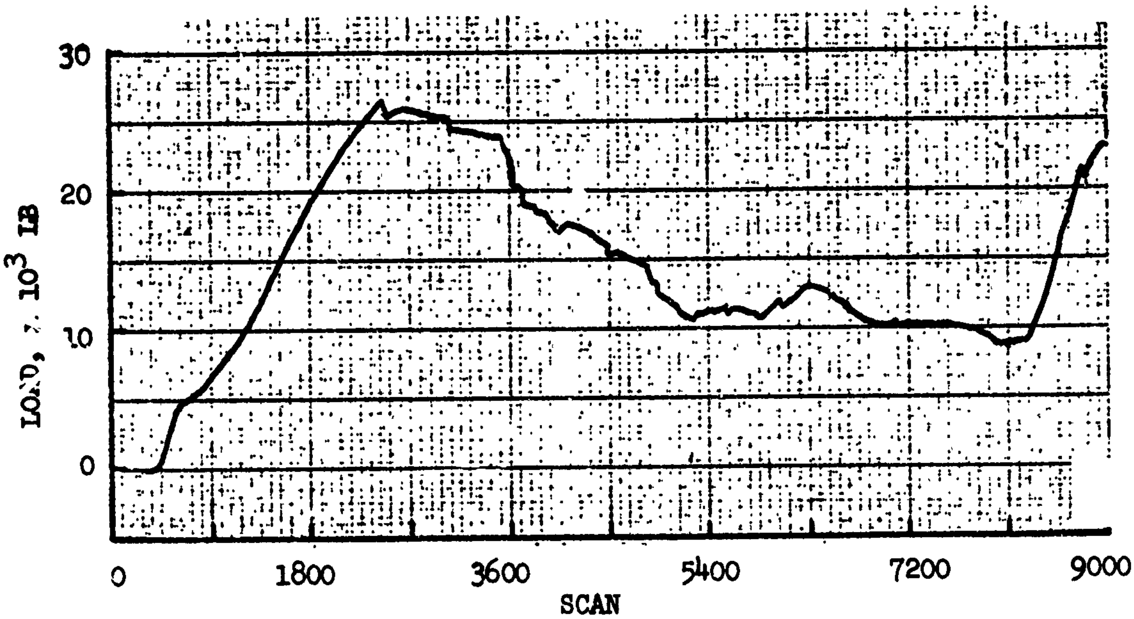


Figure 14. Load Versus Scan, Test Specimen 2.

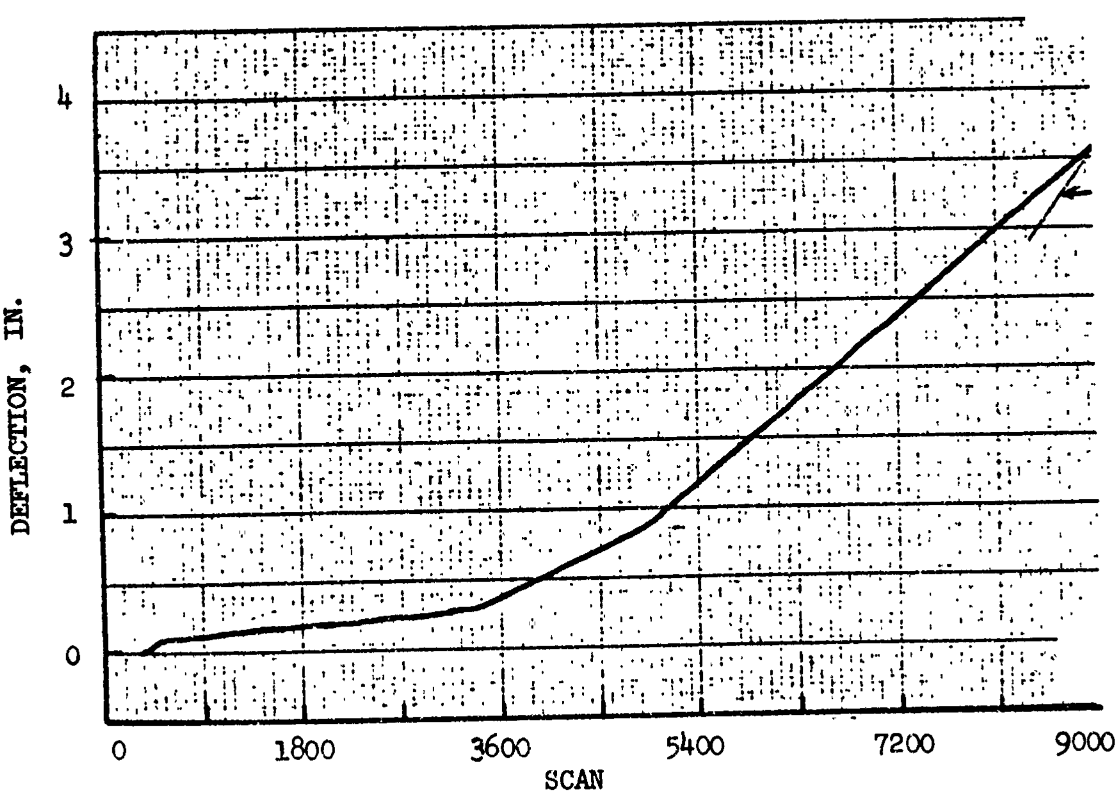


Figure 15. Deflection Versus Scan, Test Specimen 2.

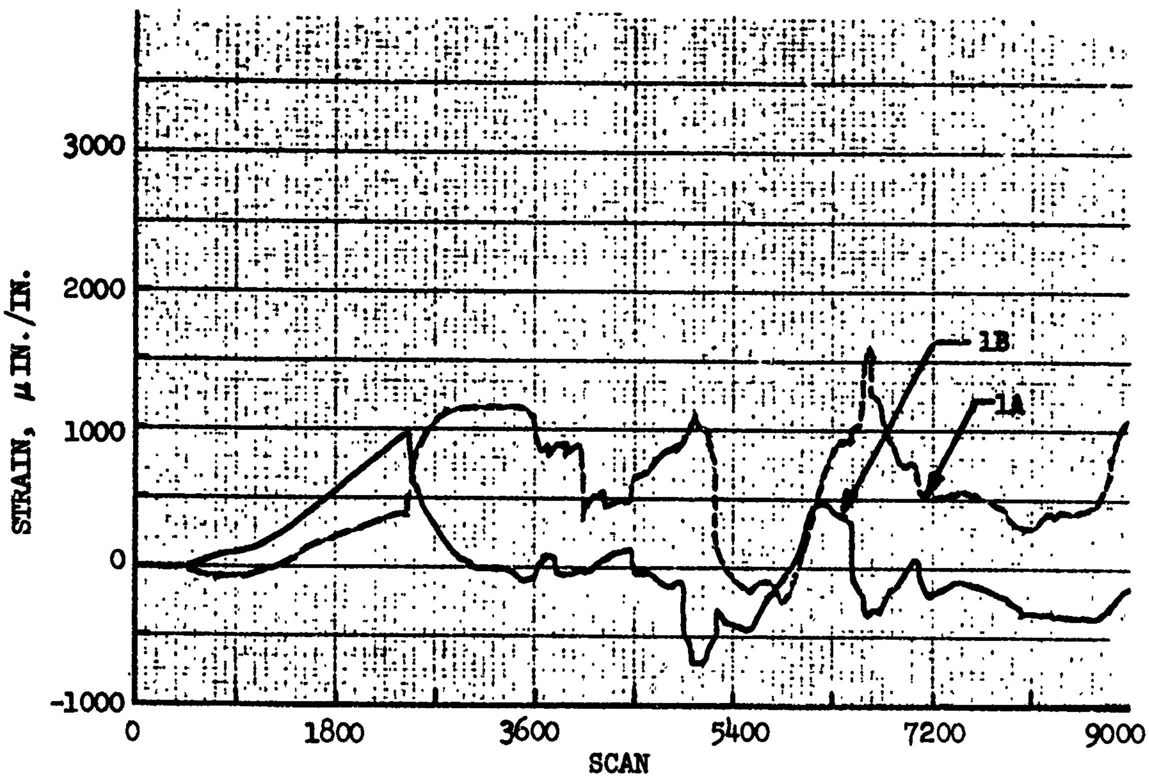


Figure 16. Strain Gages 1A and 1B Versus Scan, Test Specimen 2.

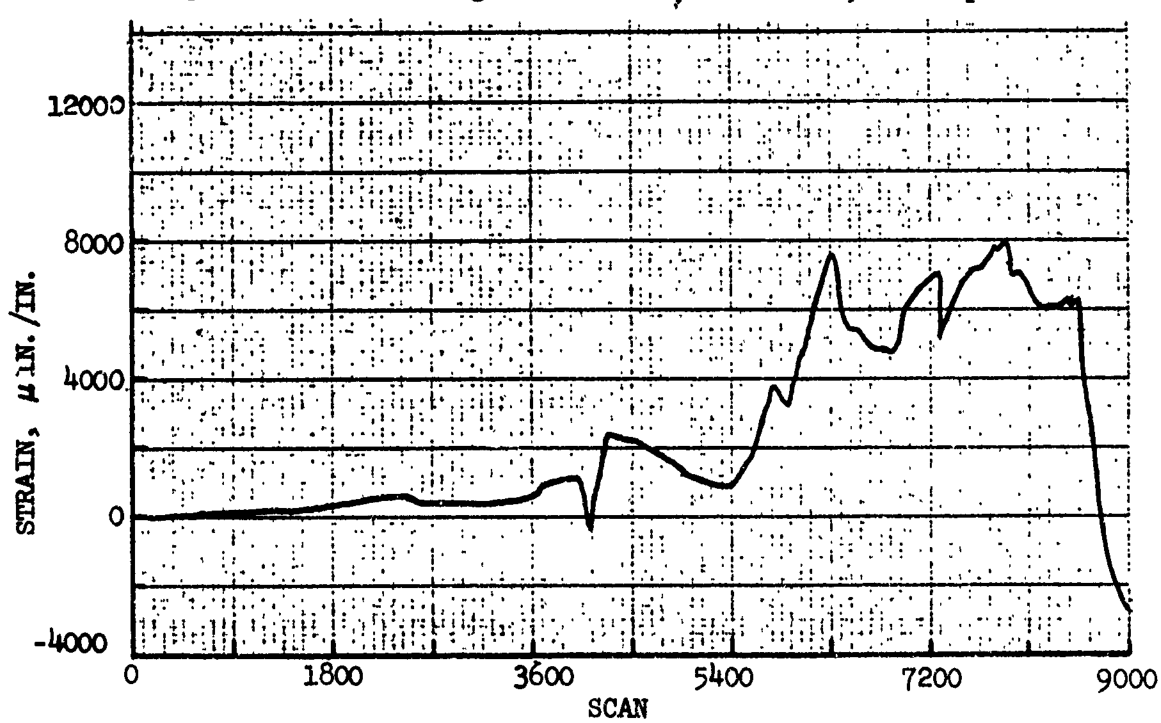


Figure 17. Strain Gage 2 Versus Scan, Test Specimen 2.

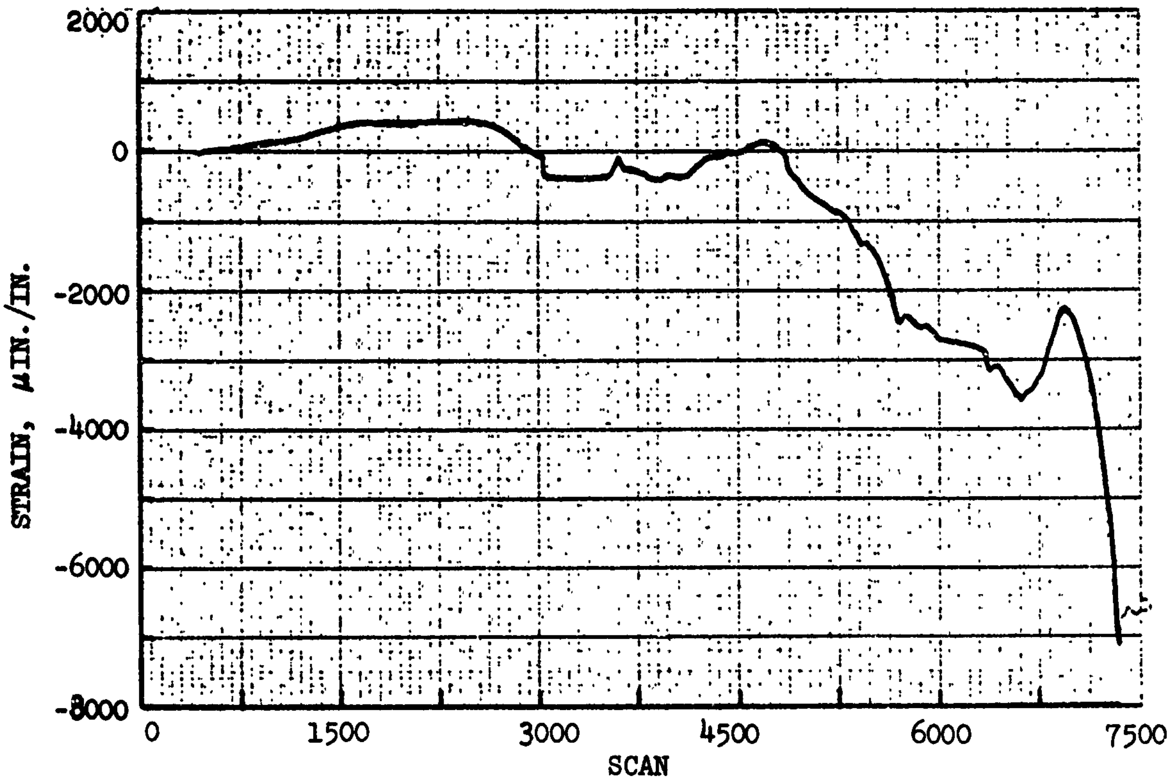


Figure 18. Strain Gage 3 Versus Scan, Test Specimen 2.

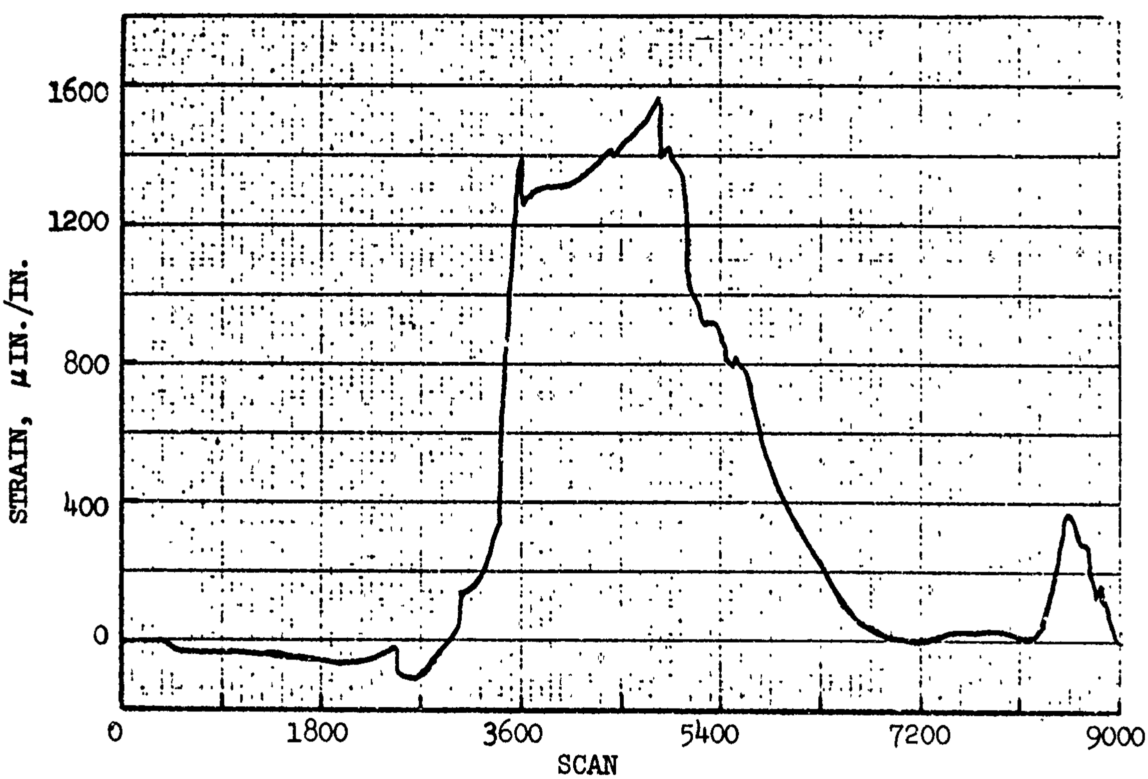


Figure 19. Strain Gage 4 Versus Scan, Test Specimen 2.

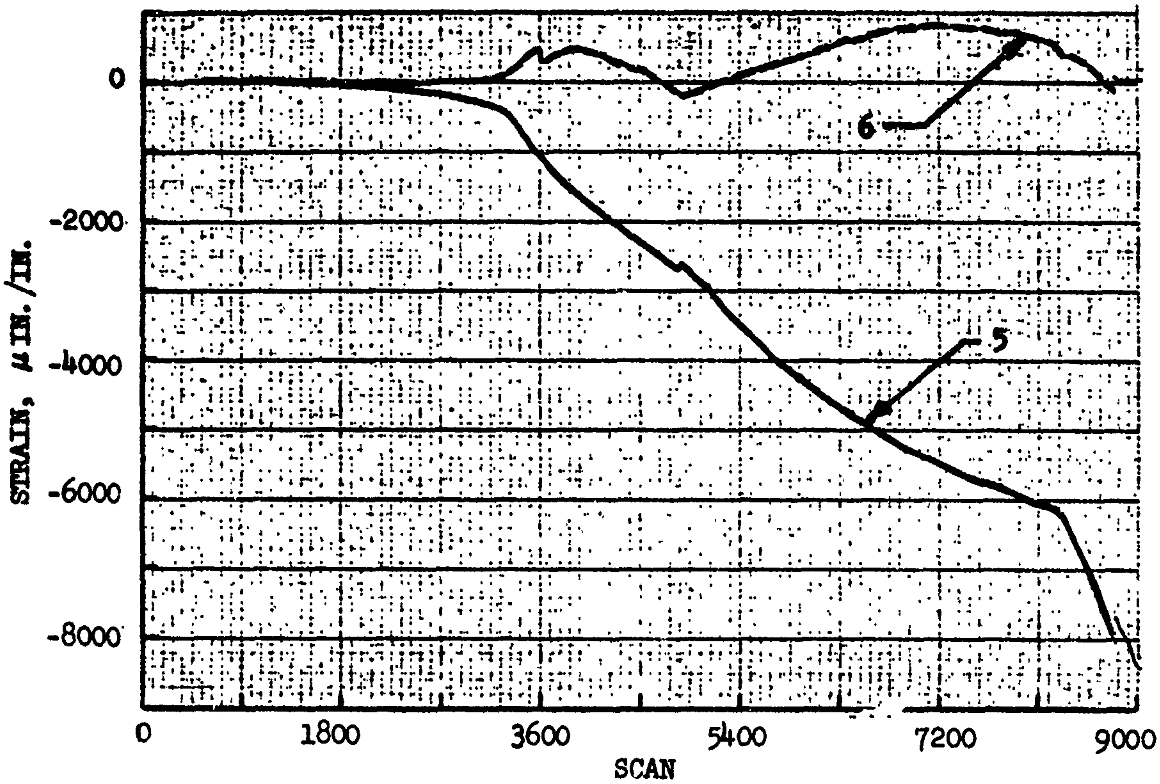


Figure 20. Strain Gages 5 and 6 Versus Scan, Test Specimen 2.

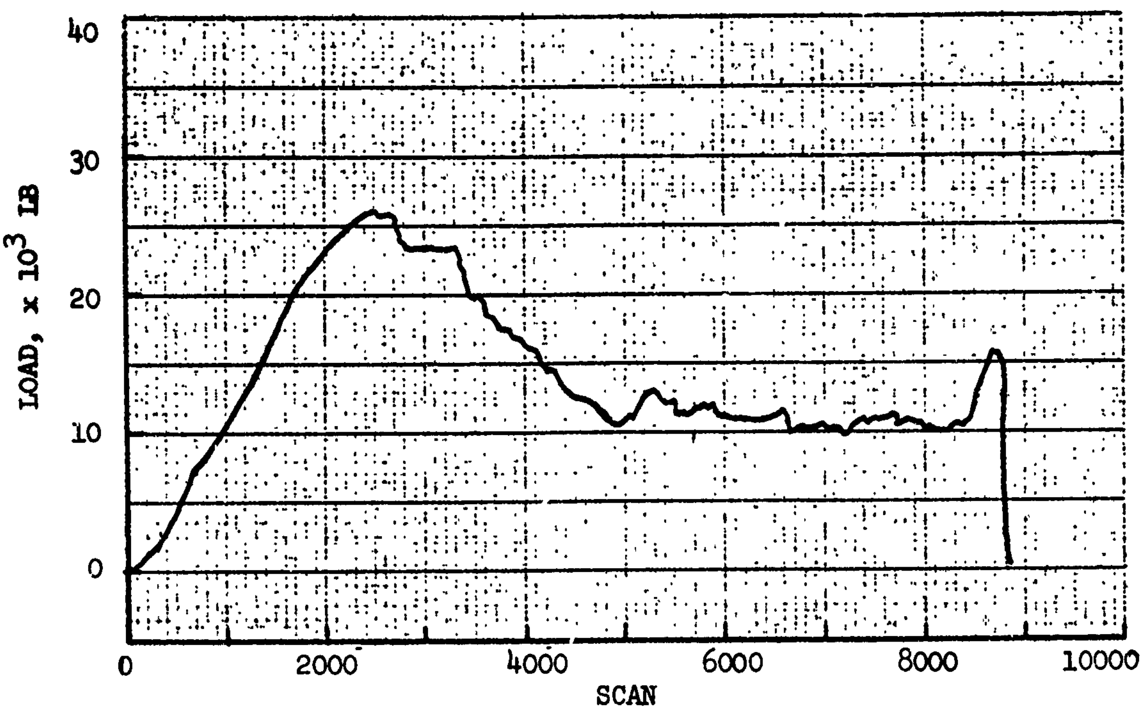


Figure 21. Load Versus Scan, Test Specimen 3.

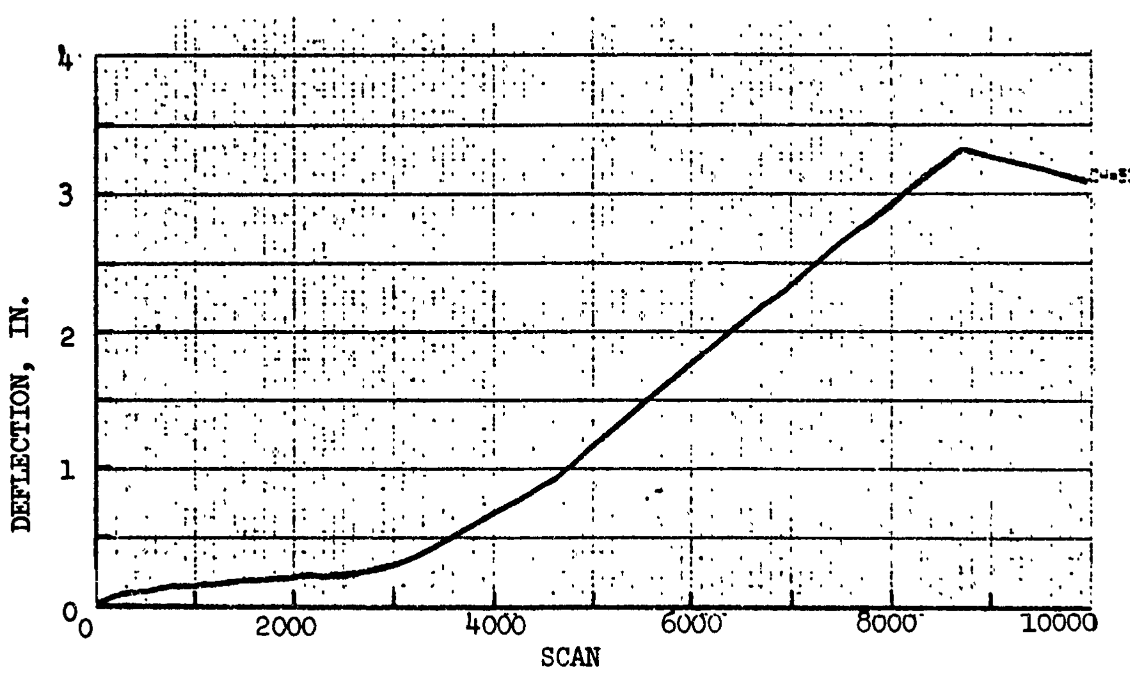


Figure 22. Deflection Versus Scan, Test Specimen 3.

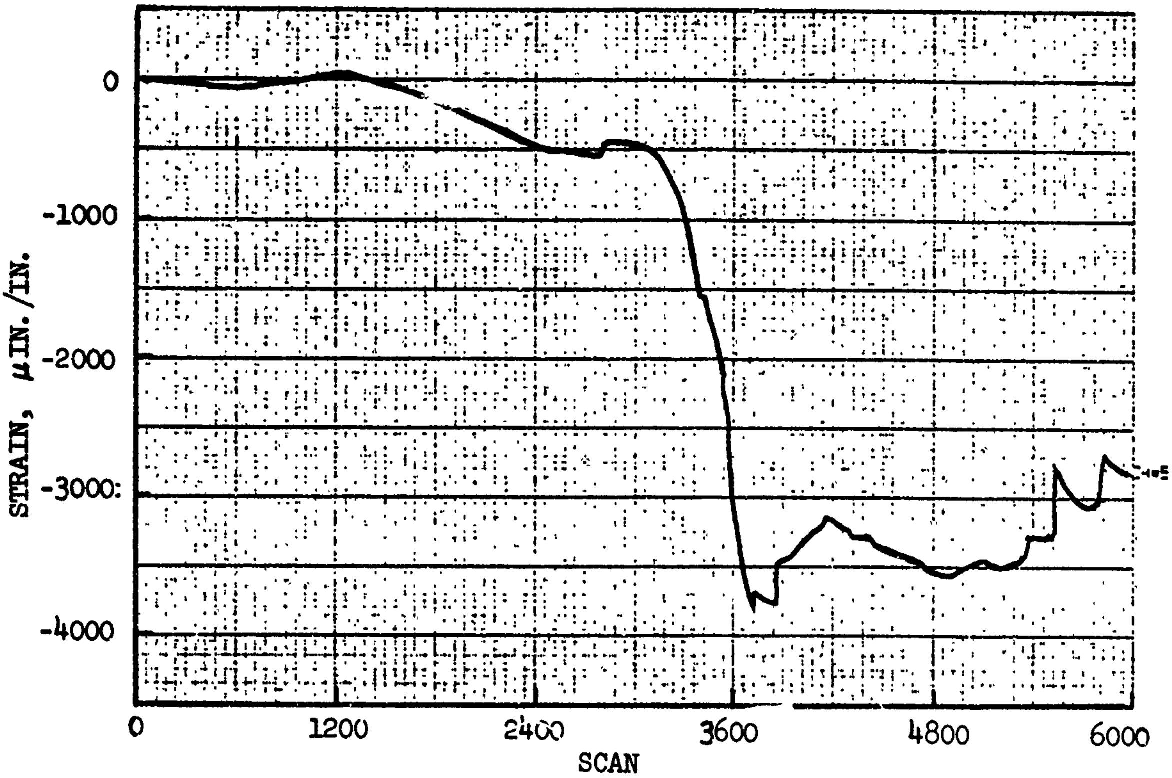


Figure 23. Strain Gage 1A Versus Scan, Test Specimen 3.

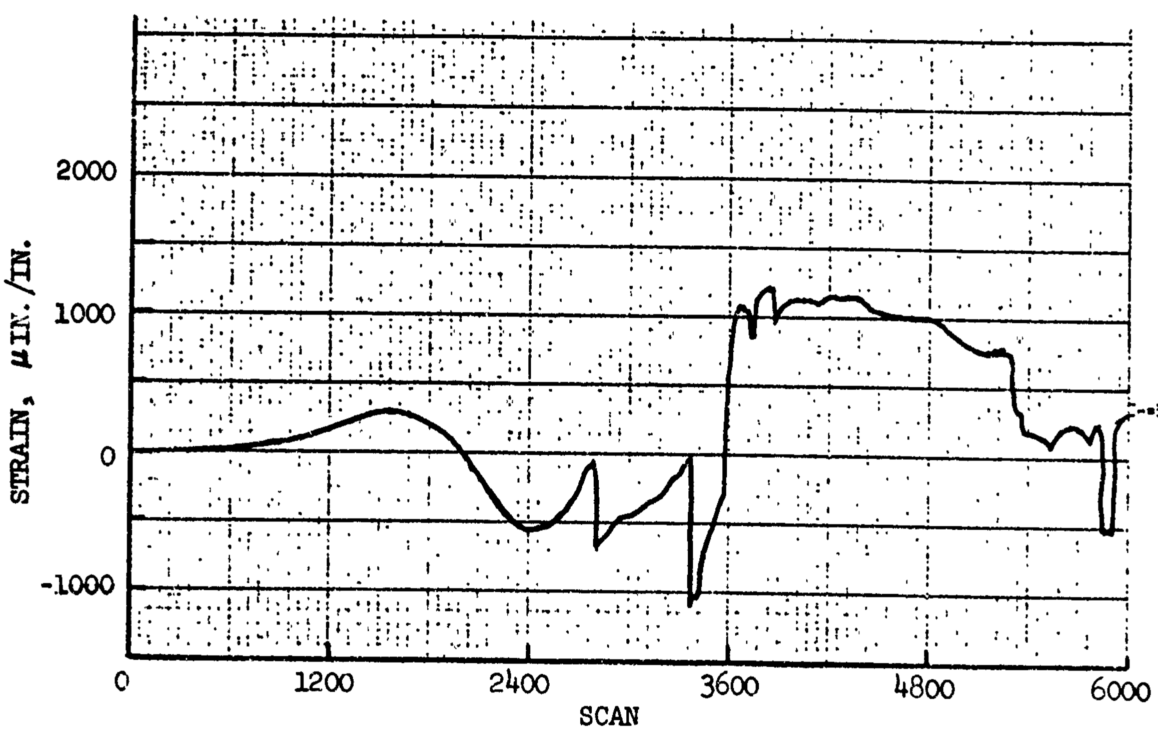


Figure 24. Strain Gage 1B Versus Scan, Test Specimen 3.

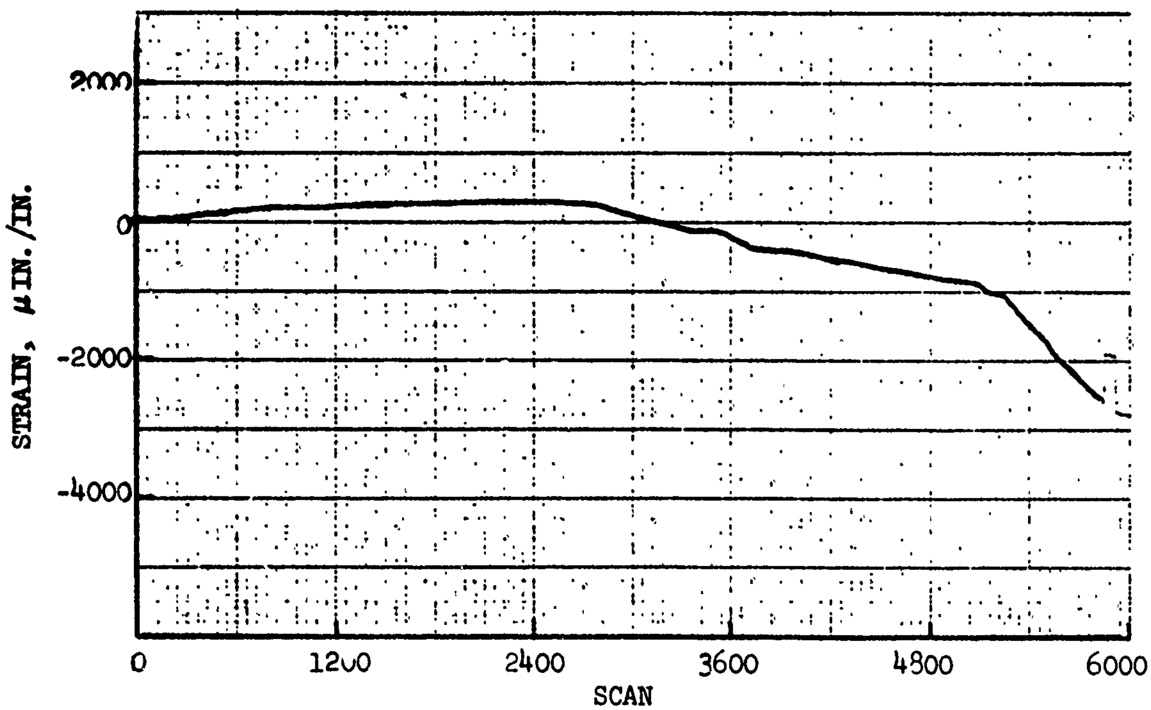


Figure 25. Strain Gage 2 Versus Scan Test Specimen 3.

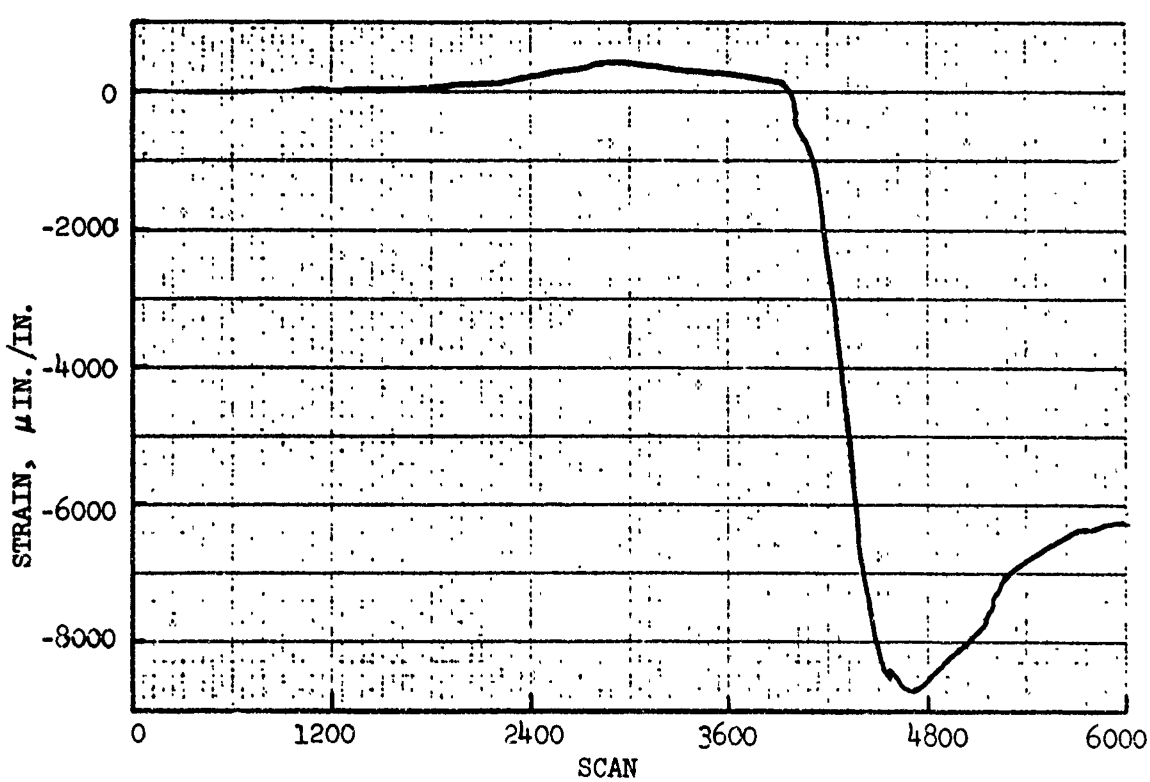


Figure 26. Strain Gage 3 Versus Scan, Test Specimen 3.

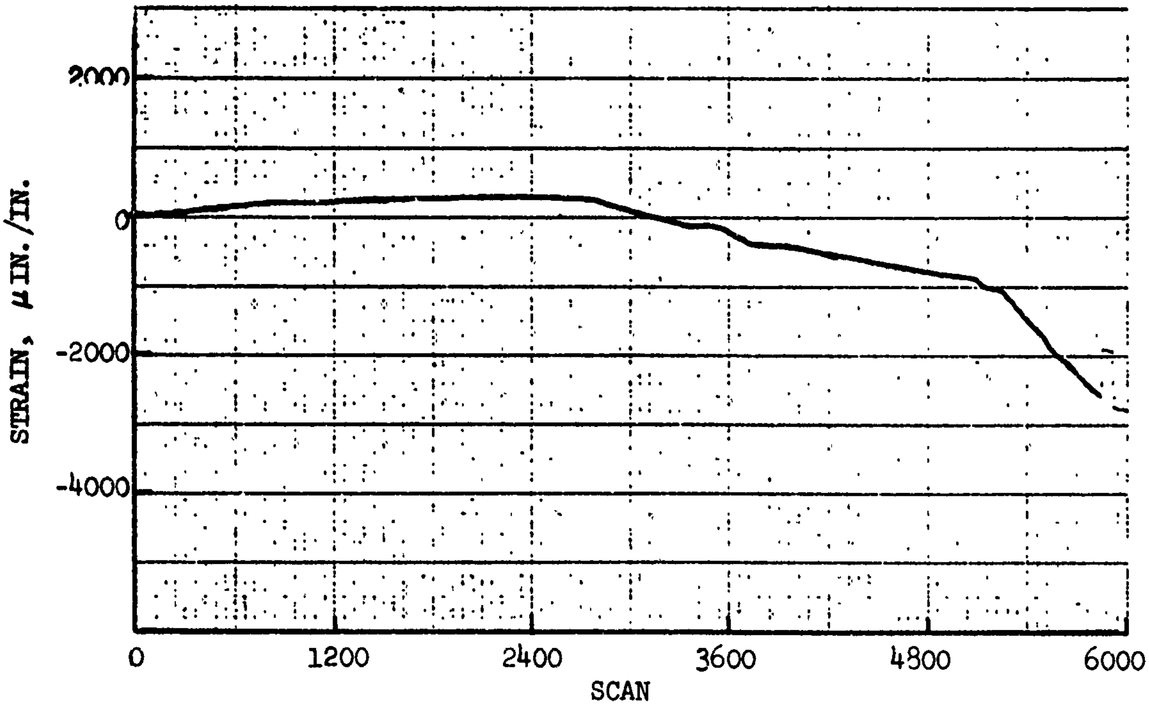


Figure 25. Strain Gage 2 Versus Scan, Test Specimen 3.

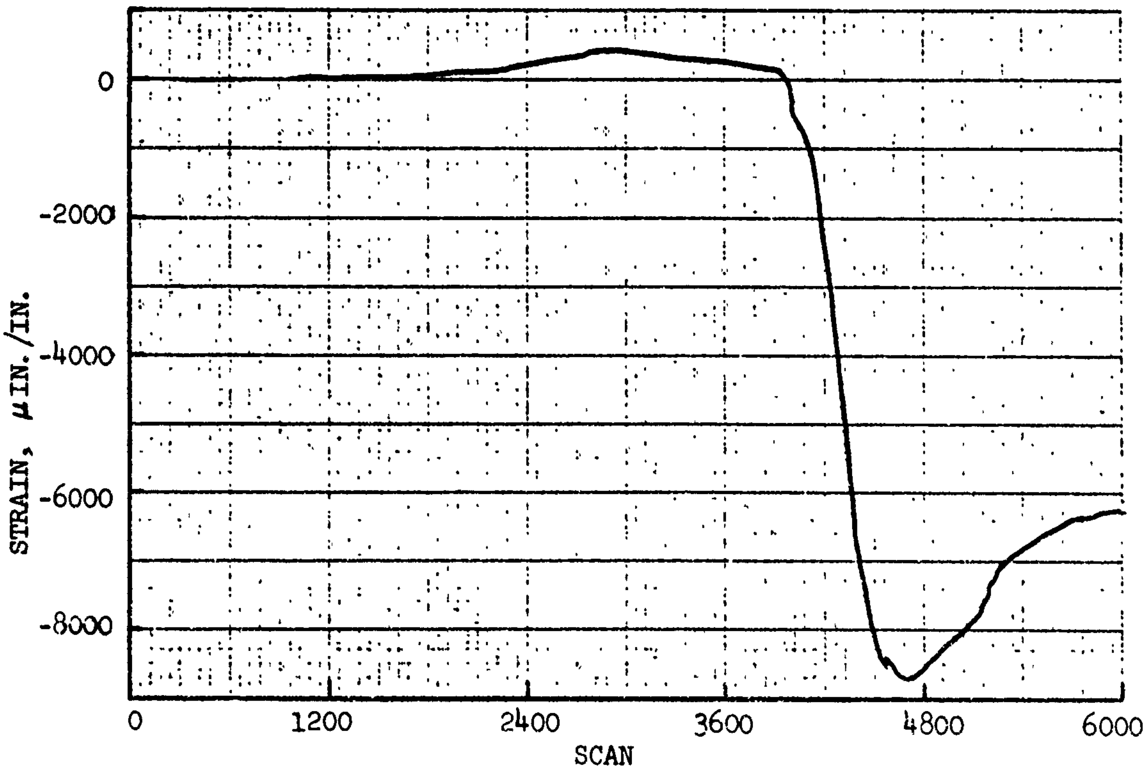


Figure 26. Strain Gage 3 Versus Scan, Test Specimen 3.

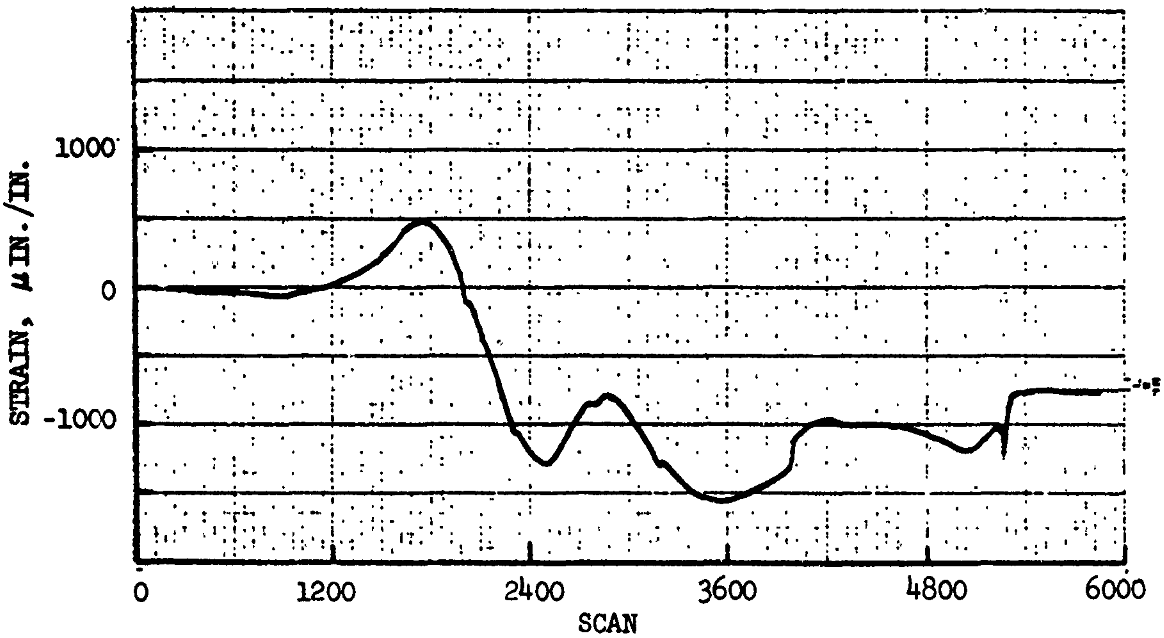


Figure 27. Strain Gage 4 Versus Scan, Test Specimen 3.

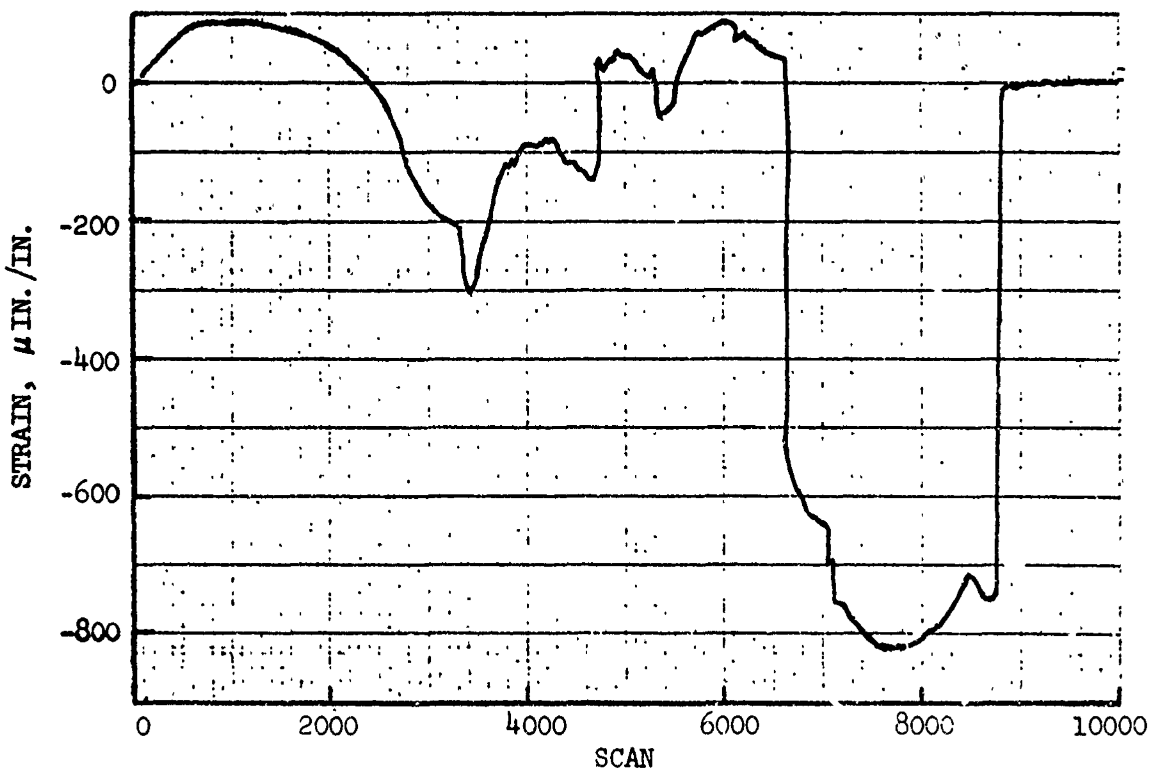


Figure 28. Strain Gage 5 Versus Scan, Test Specimen 3.

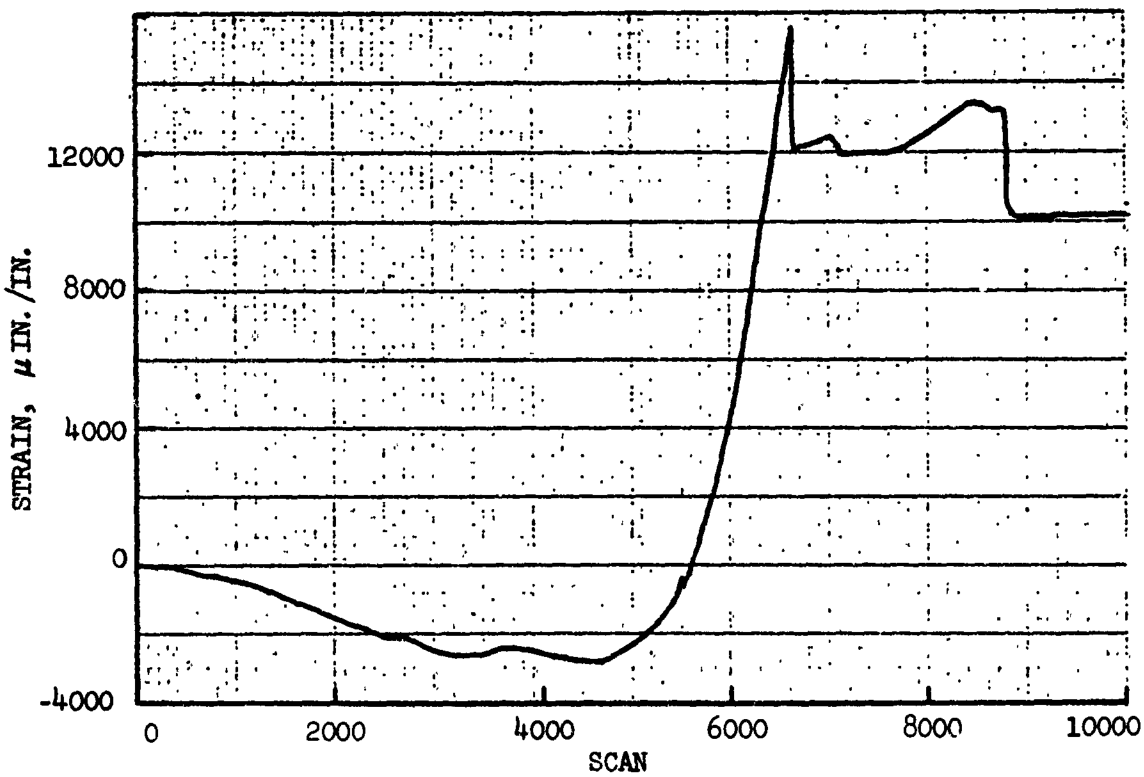


Figure 29. Strain Gage 6 Versus Scan, Test Specimen 3.

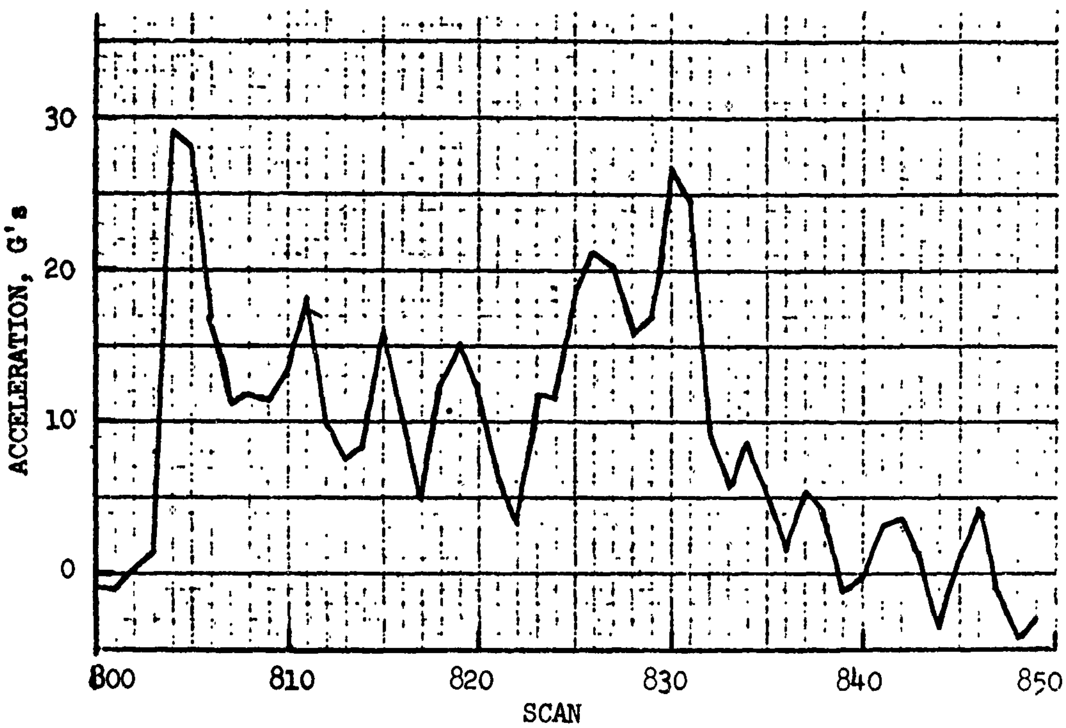


Figure 30. Acceleration Versus Scan, Test Specimen 4.

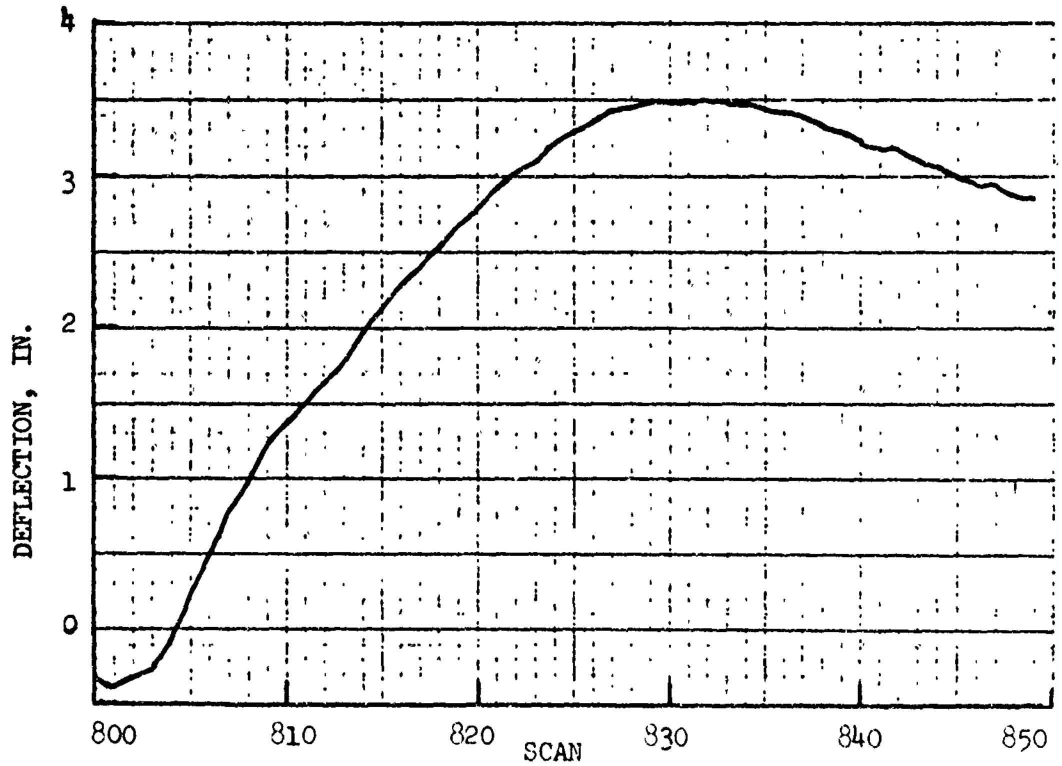


Figure 31. Deflection Versus Scan, Test Specimen 4.

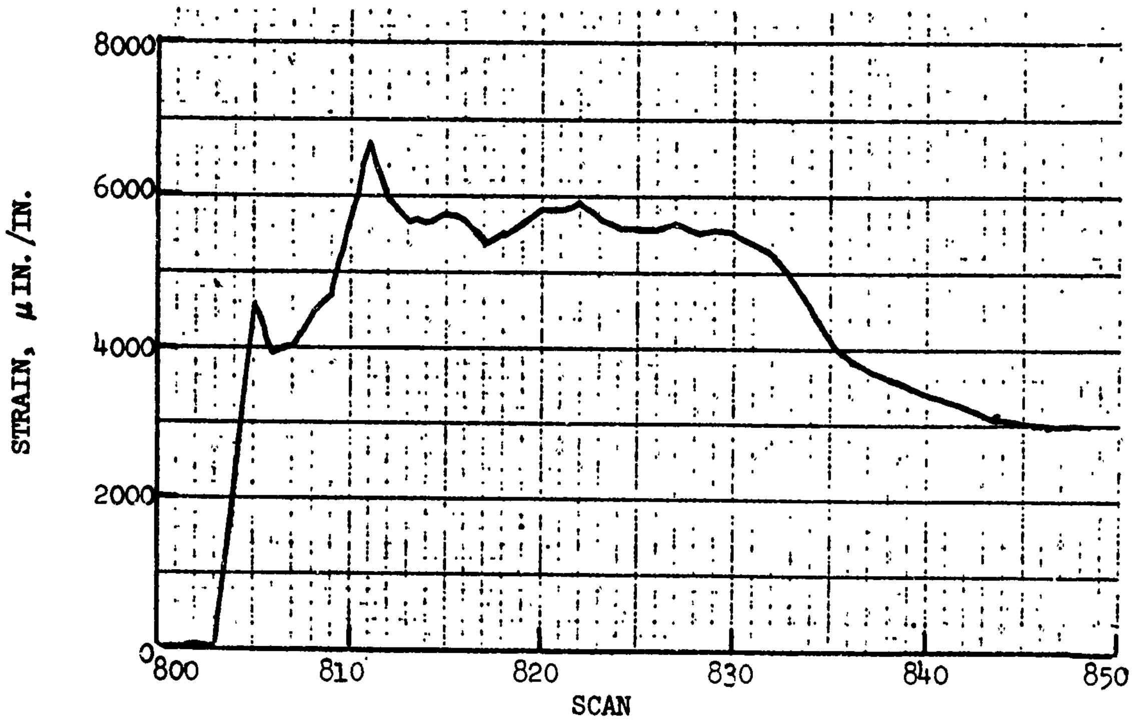


Figure 32. Strain Gage 1A Versus Scan, Test Specimen 4.

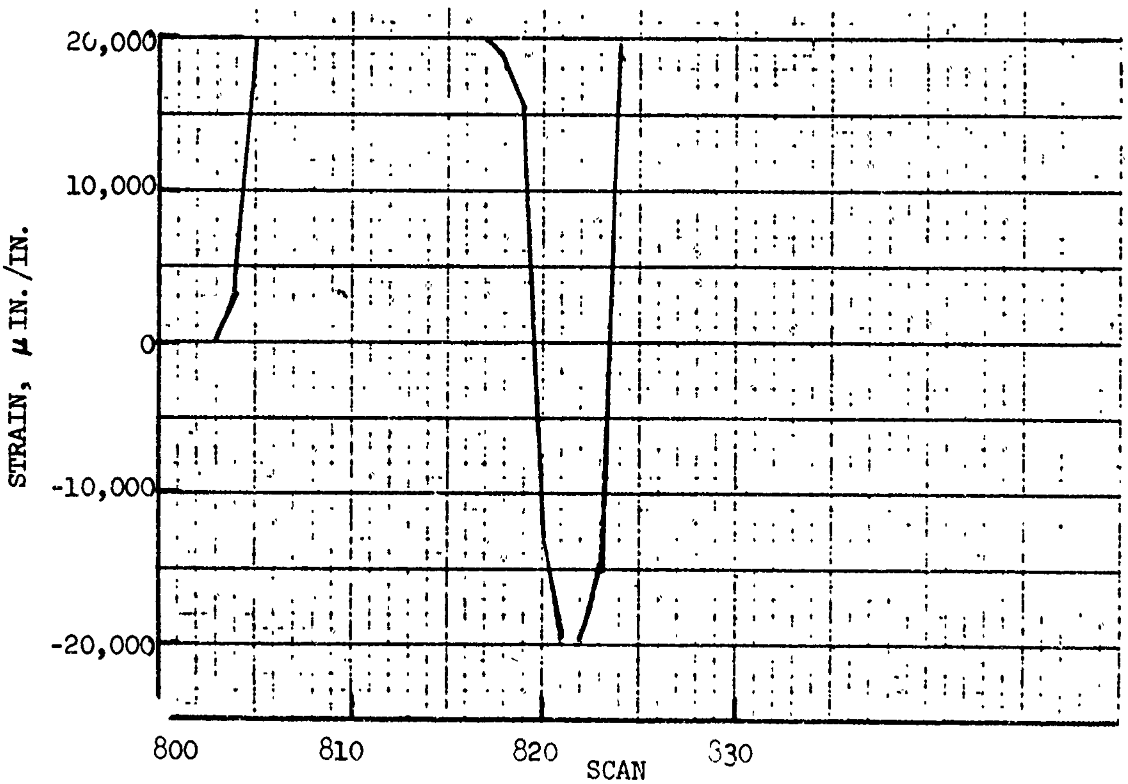


Figure 33. Strain Gage 1B Versus Scan, Test Specimen 4.

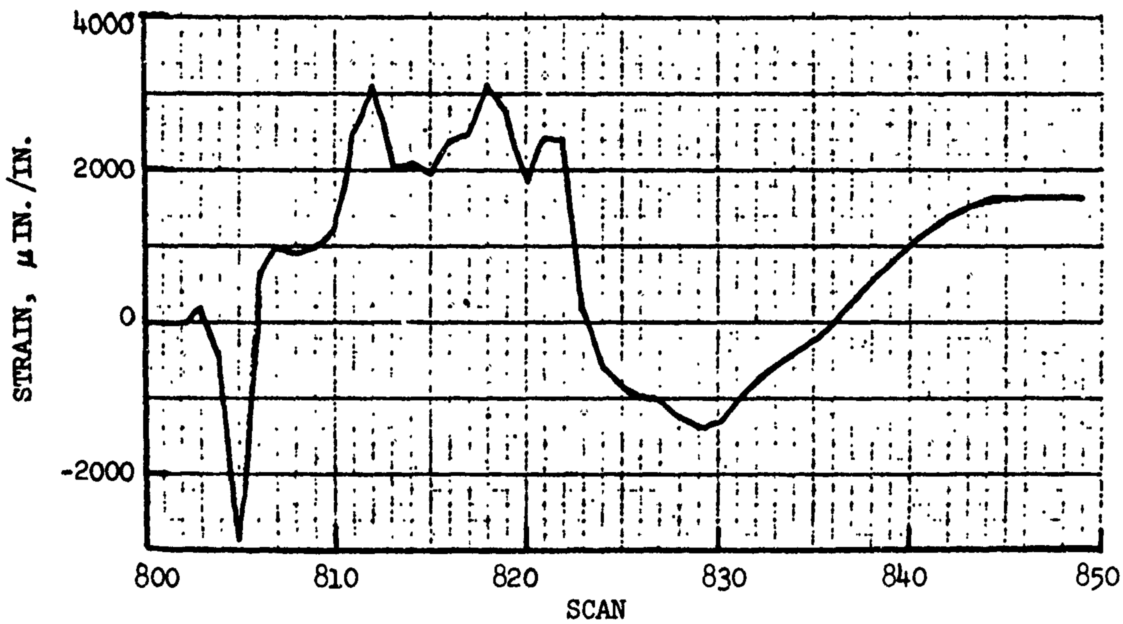


Figure 34. Strain Gage 2 Versus Scan, Test Specimen 4.

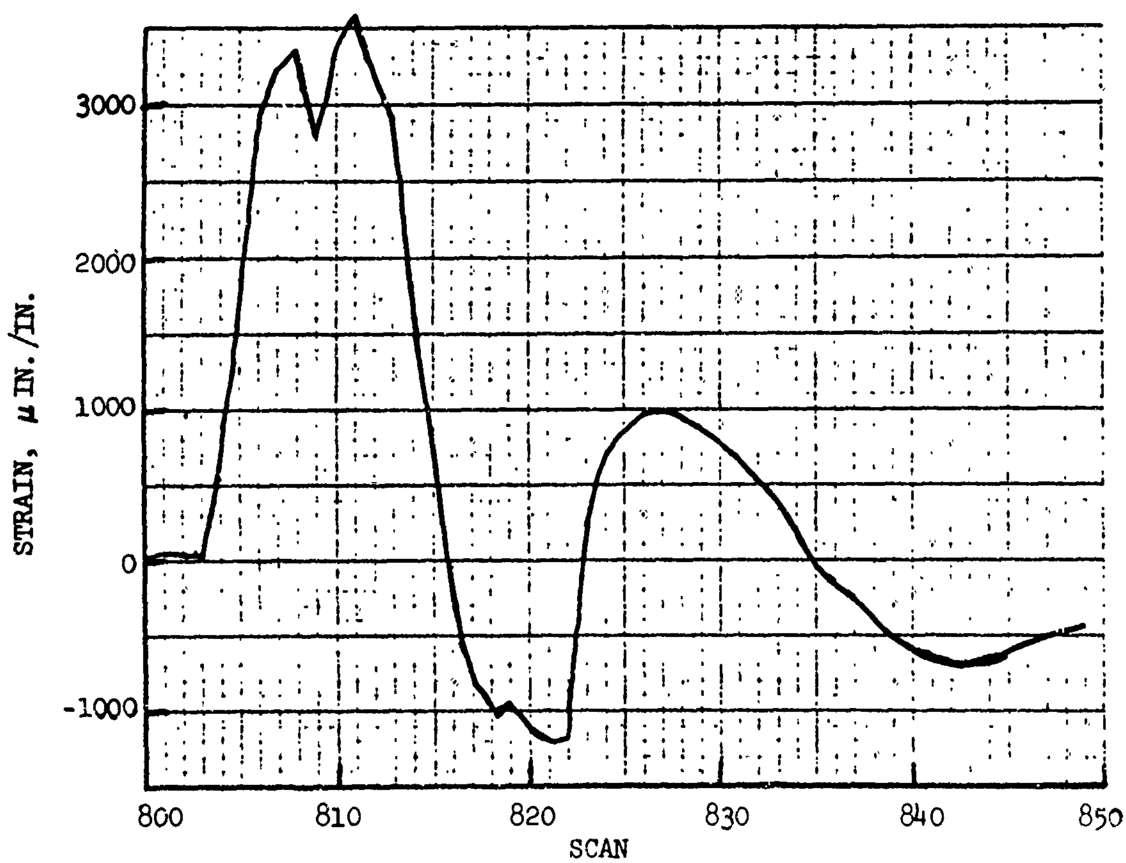


Figure 35. Strain Gage 3 Versus Scan, Test Specimen 4.

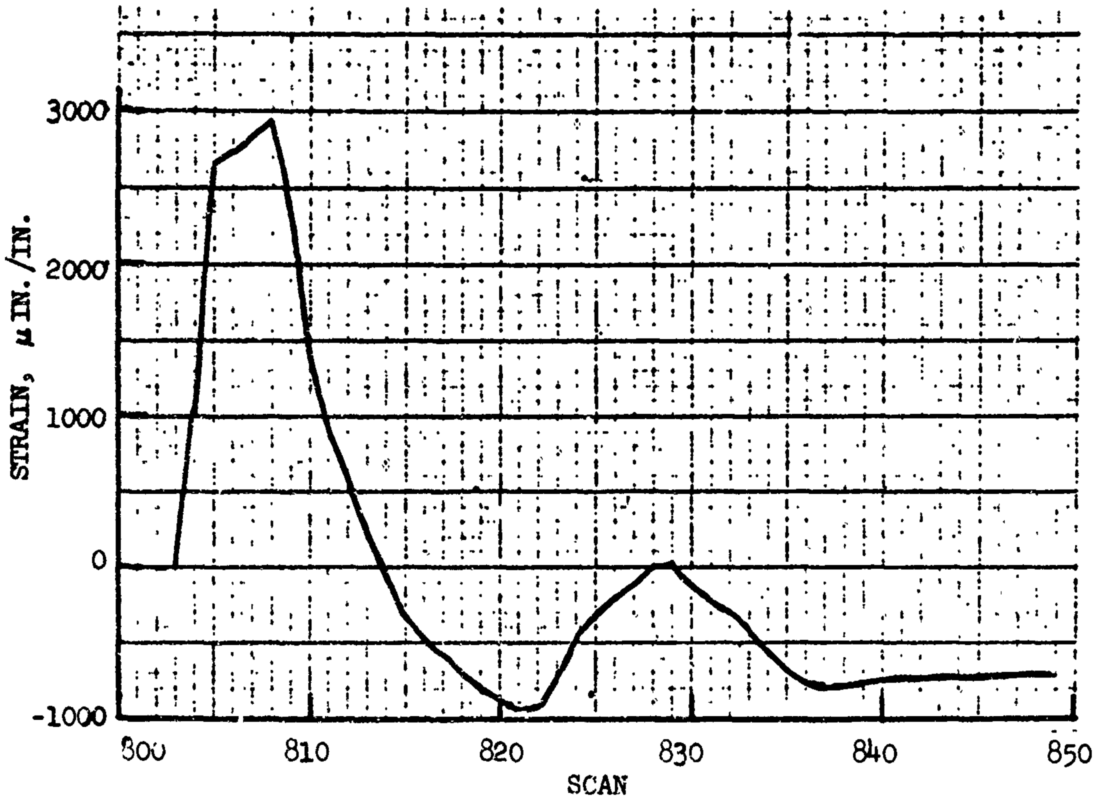


Figure 36. Strain Gage 4 Versus Scan, Test Specimen 4.

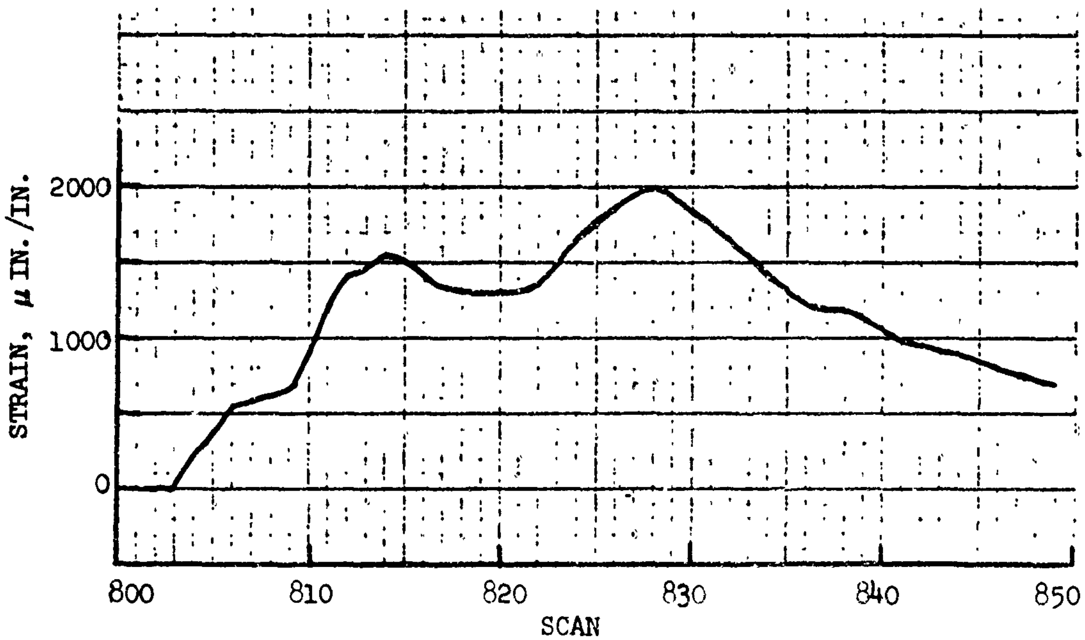


Figure 37. Strain Gage 5 Versus Scan, Test Specimen 4.

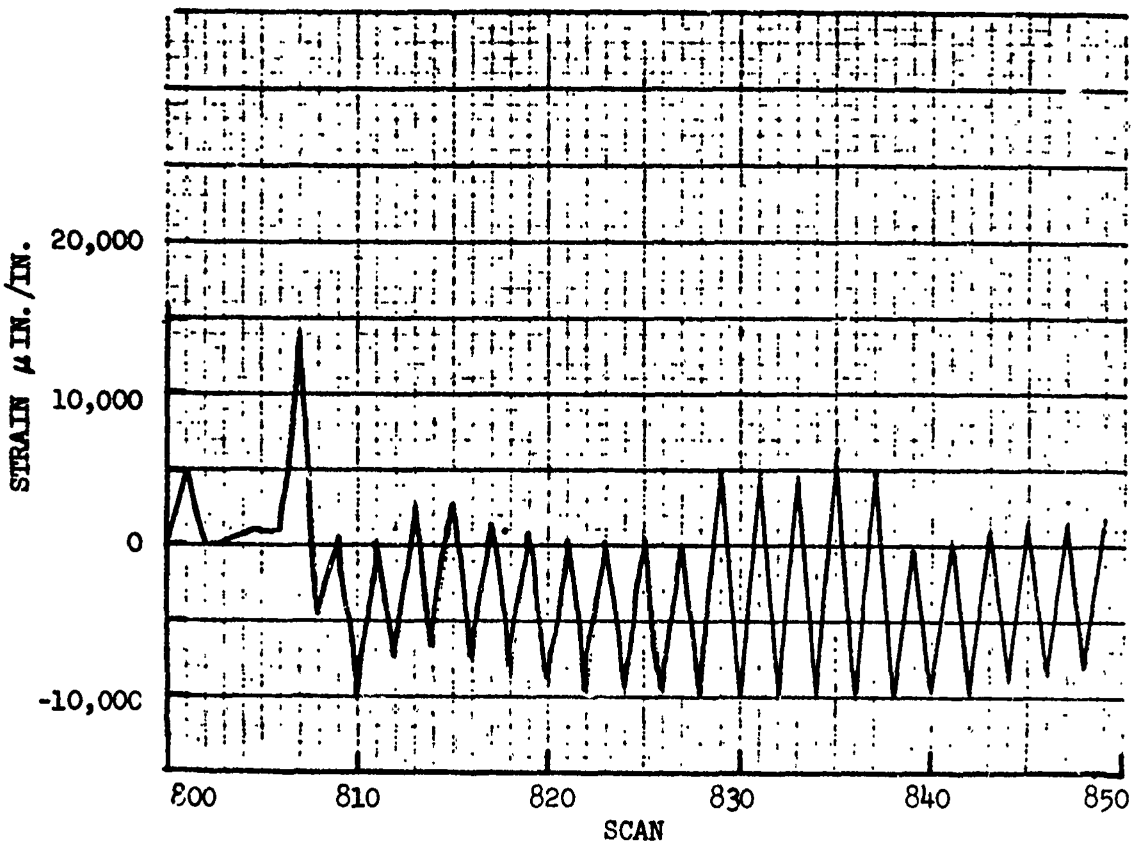


Figure 38. Strain Gage 6 Versus Scan, Test Specimen 4.

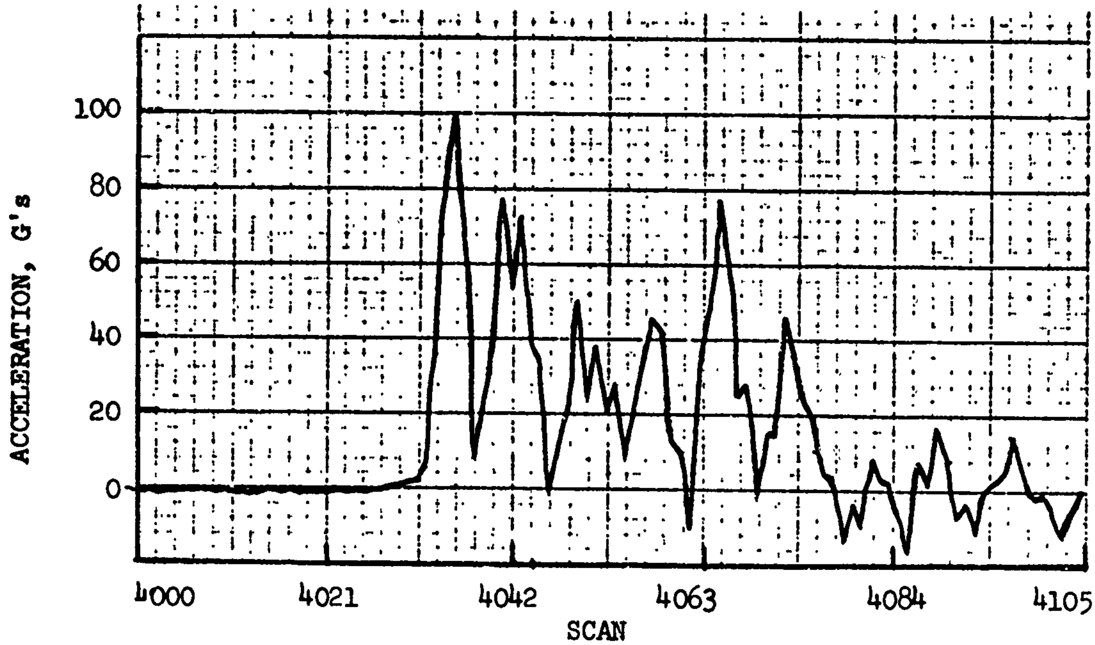


Figure 39. Acceleration Versus Scan, Test Specimen 5.

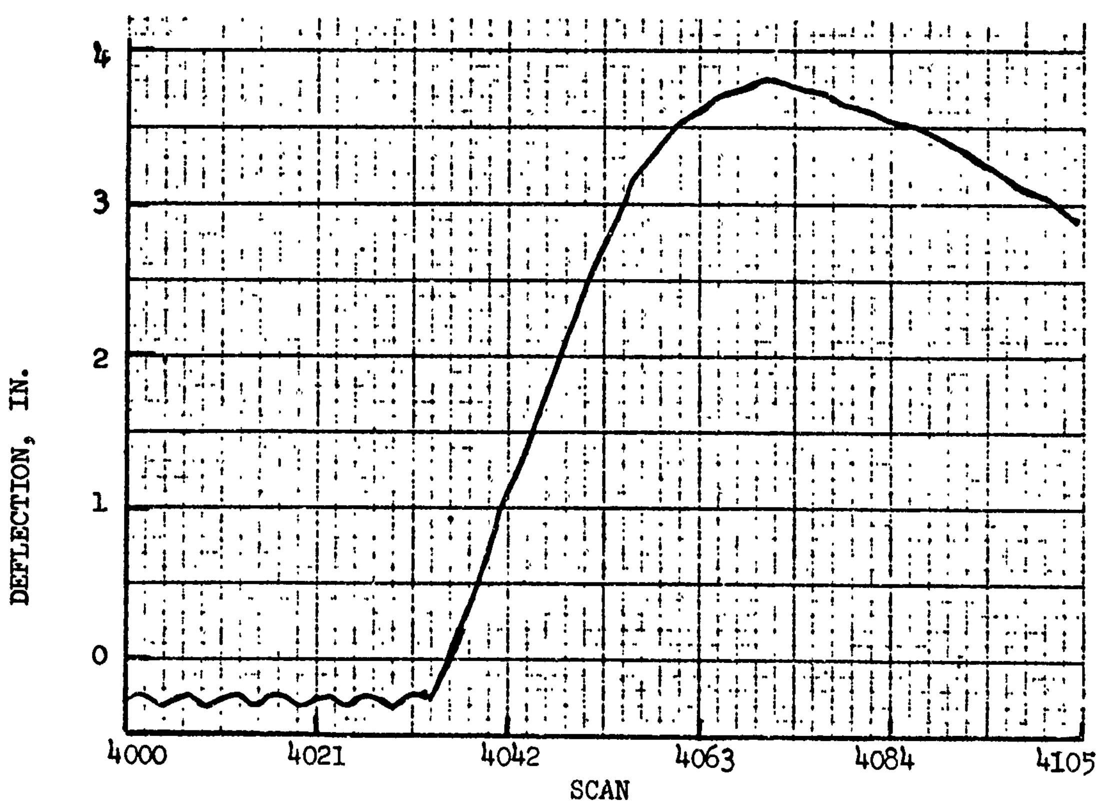


Figure 40. Deflection Versus Scan, Test Specimen 5.

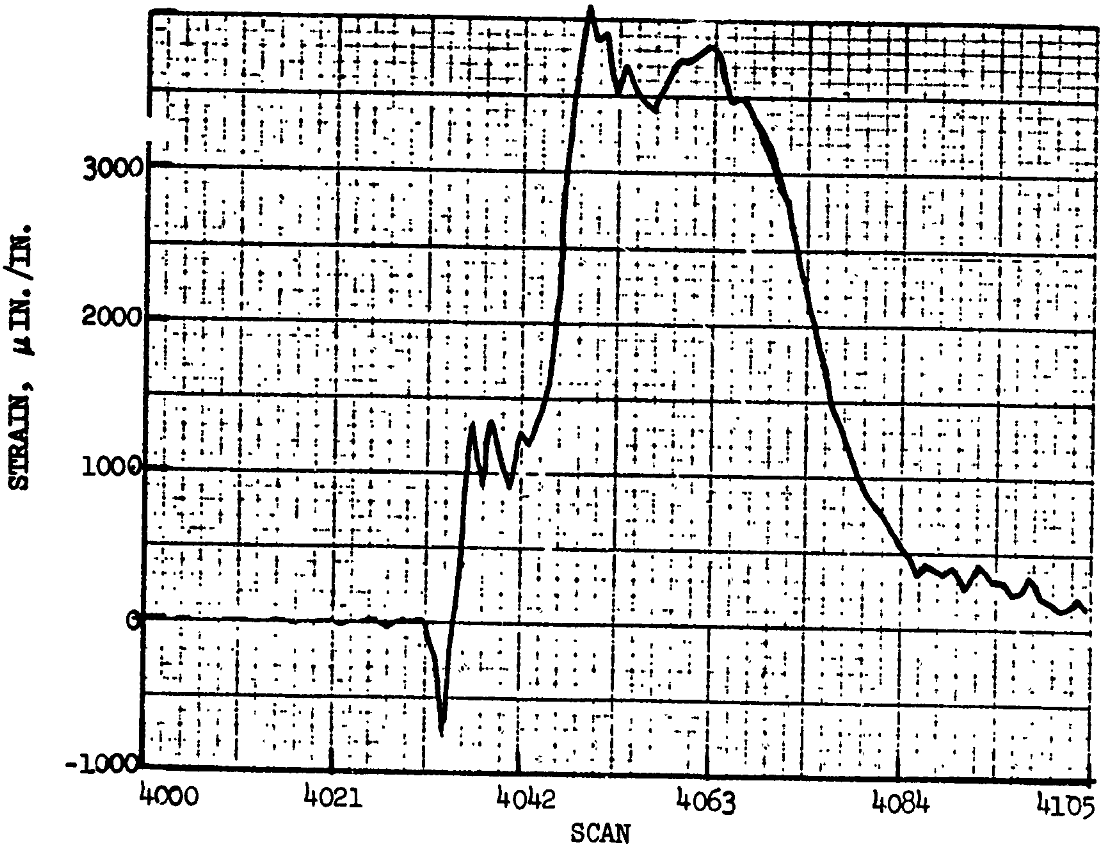


Figure 41. Strain Gage 1A Versus Scan, Test Specimen 5.

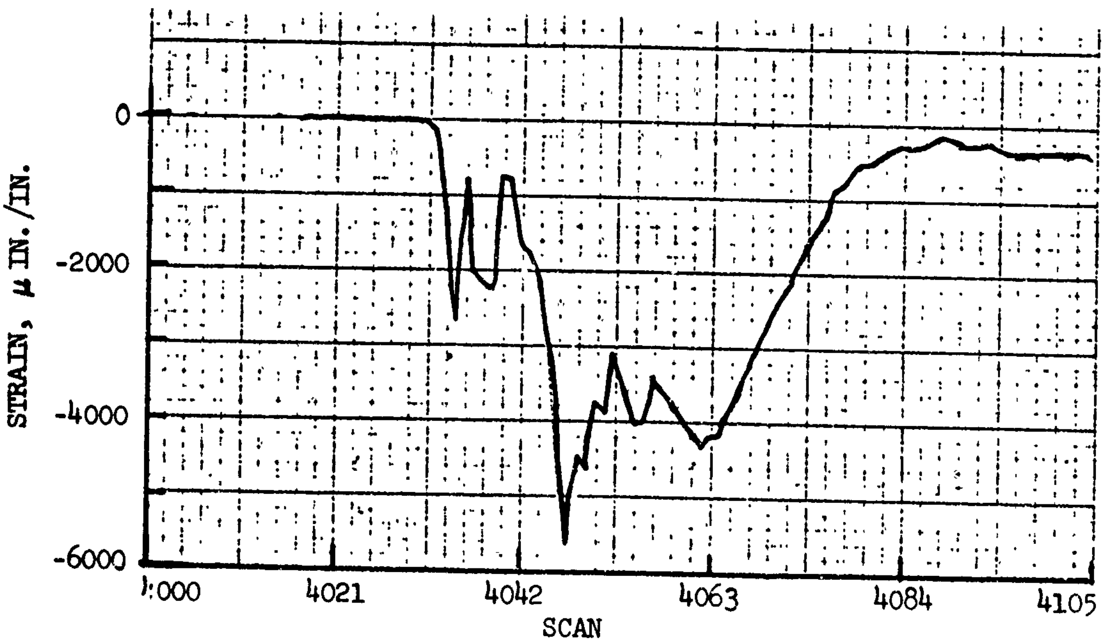


Figure 42. Strain Gage 1B Versus Scan, Test Specimen 5.

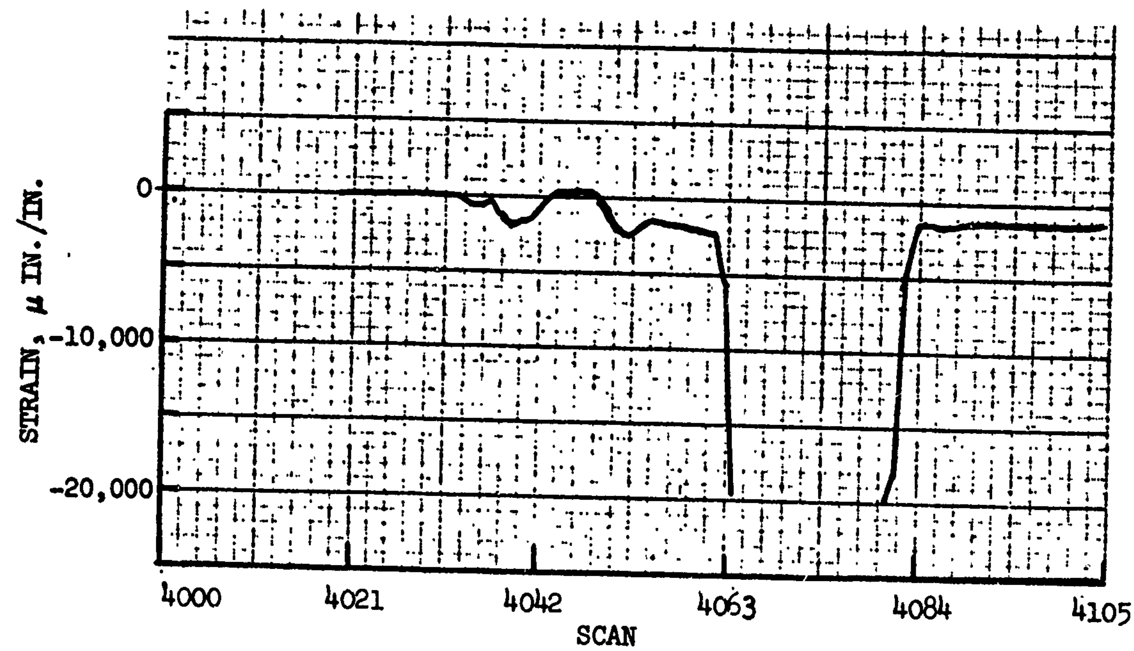


Figure 43. Strain Gage 2 Versus Scan, Test Specimen 5.

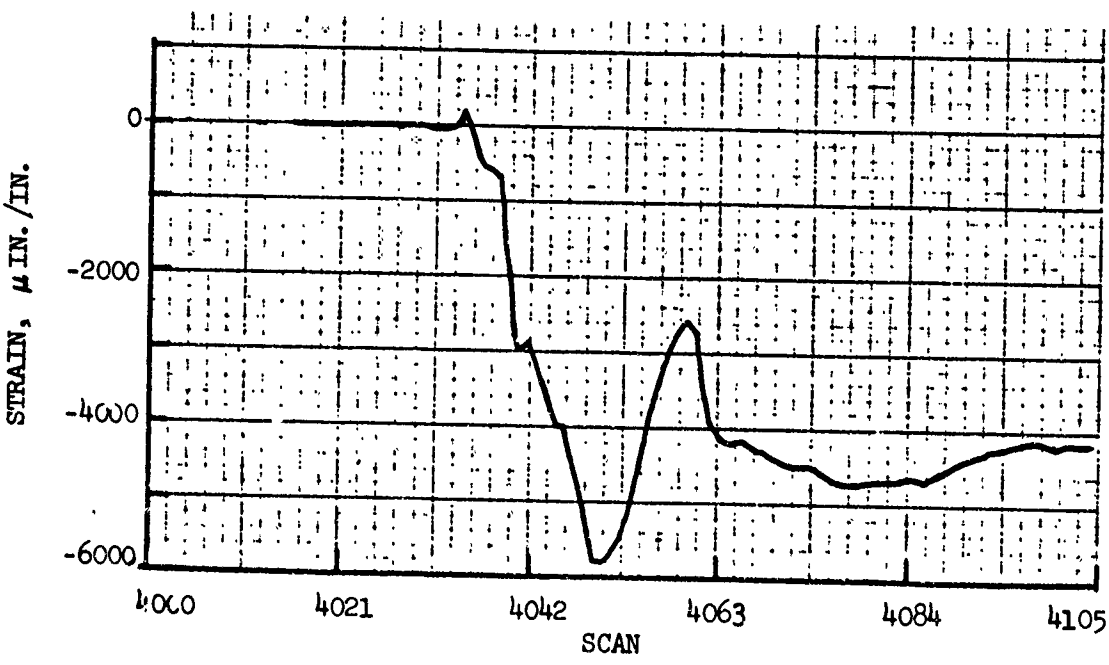


Figure 44. Strain Gage 4 Versus Scan, Test Specimen 5.

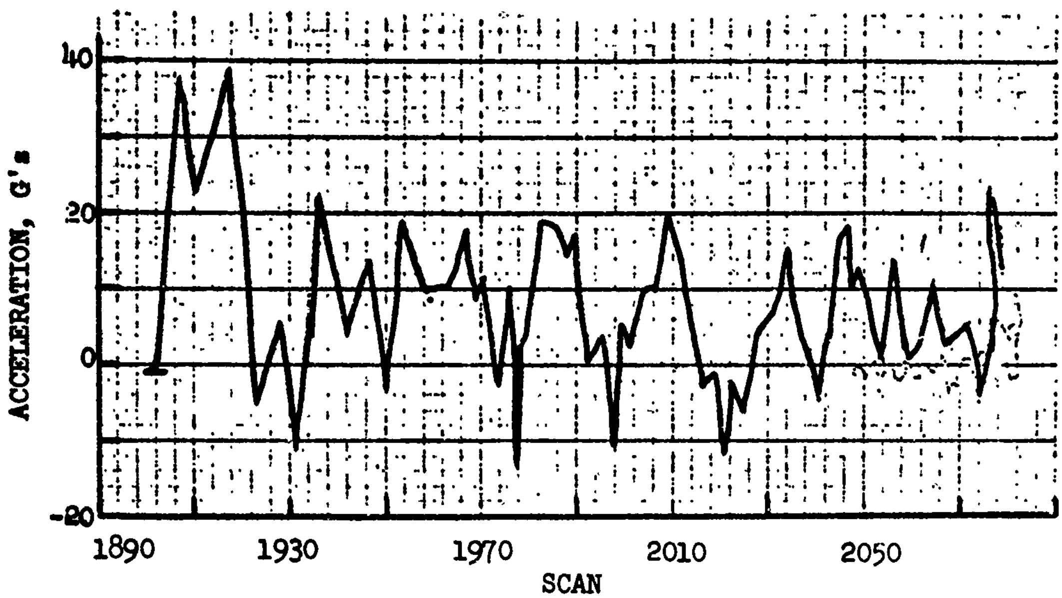


Figure 45. Acceleration Versus Scan, Test Specimen 6.

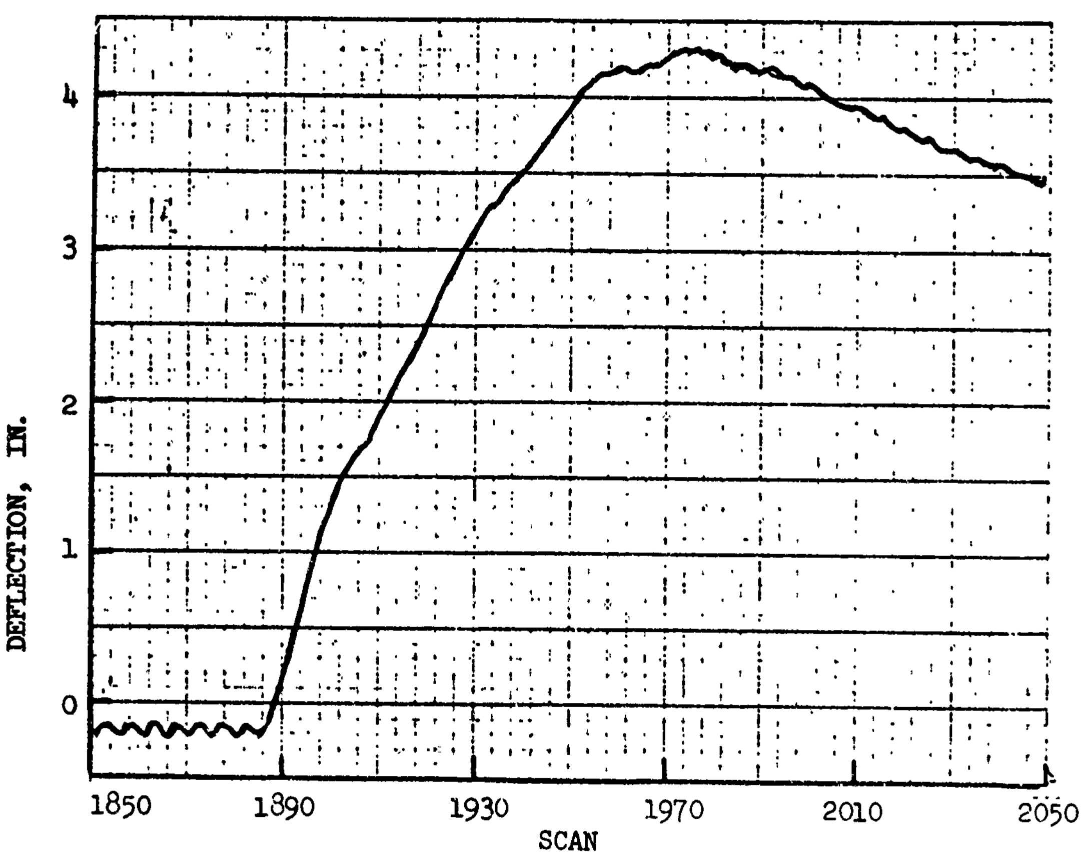


Figure 46. Deflection Versus Scan, Test Specimen 6.

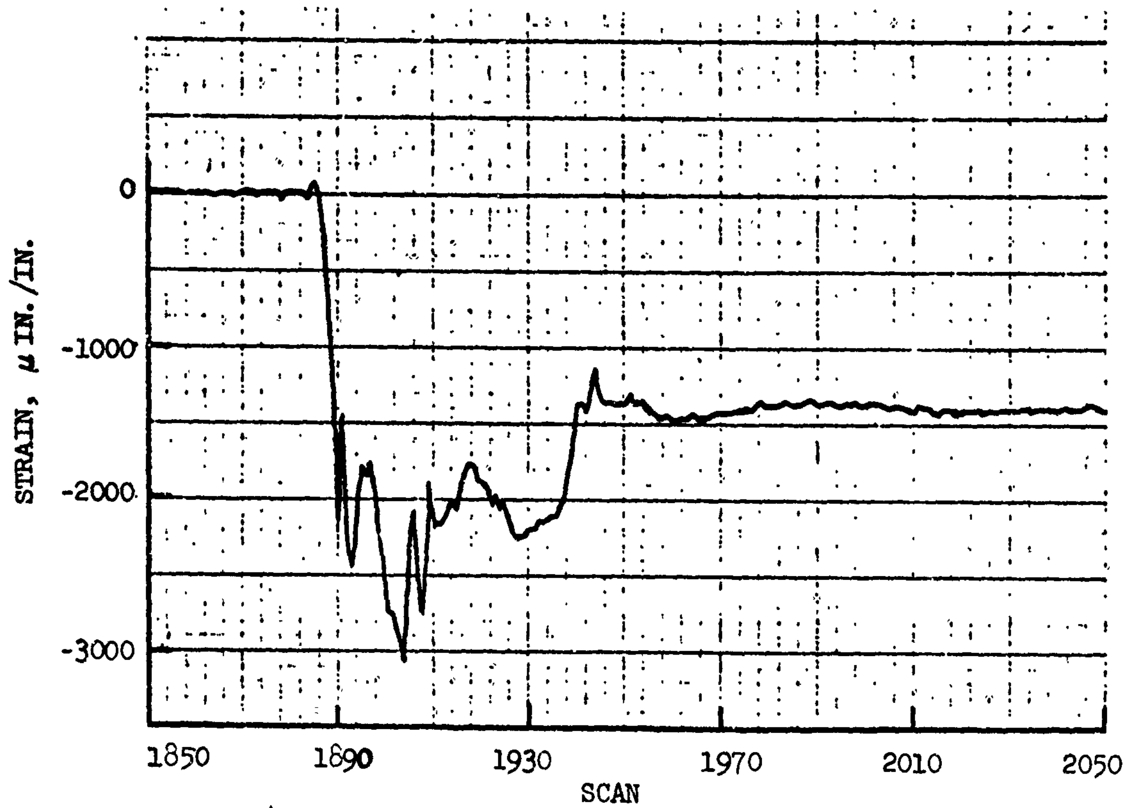


Figure 47. Strain Gage 1A Versus Scan, Test Specimen 6.

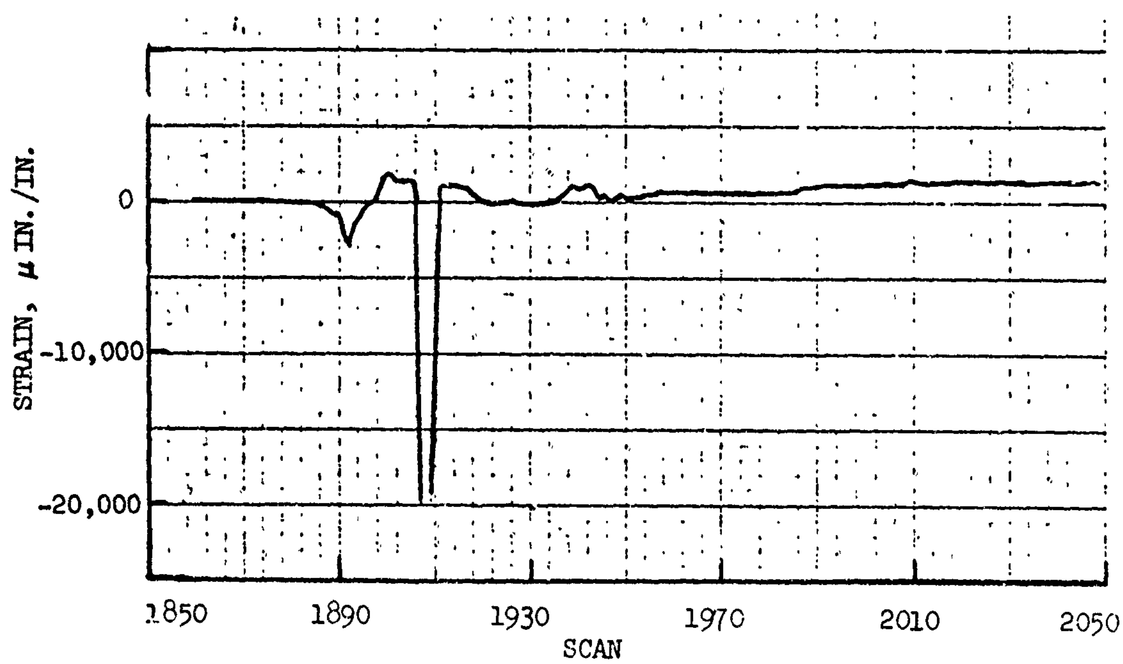


Figure 48. Strain Gage 1B Versus Scan, Test Specimen 6.

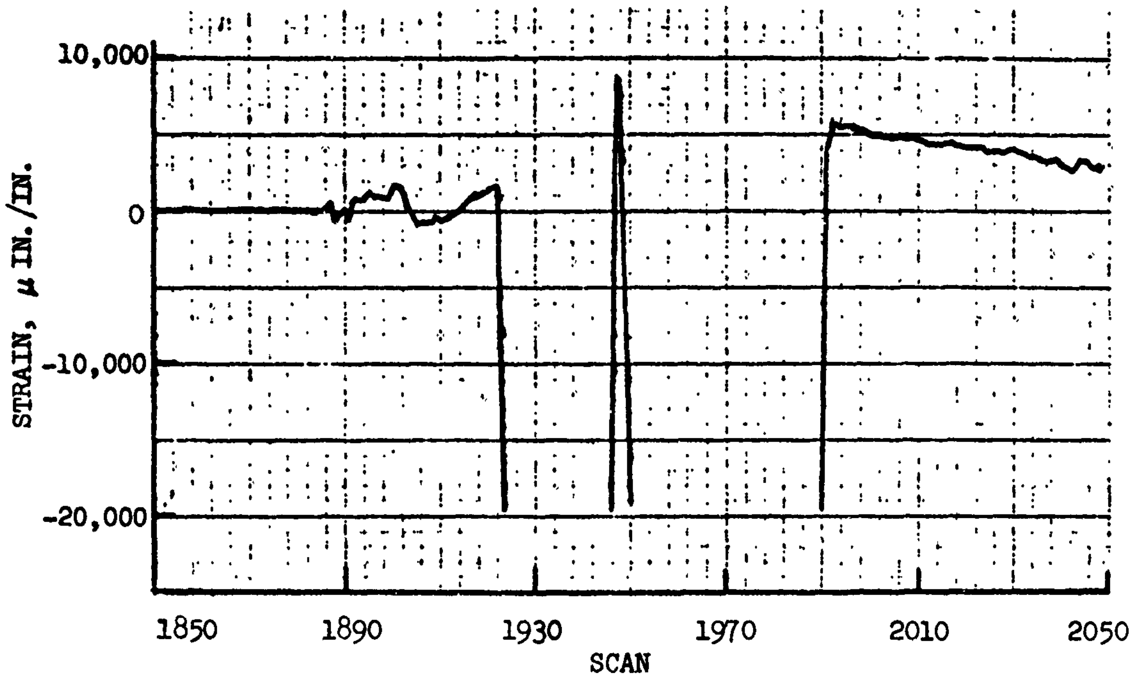


Figure 49. Strain Gage 2 Versus Scan, Test Specimen 6.

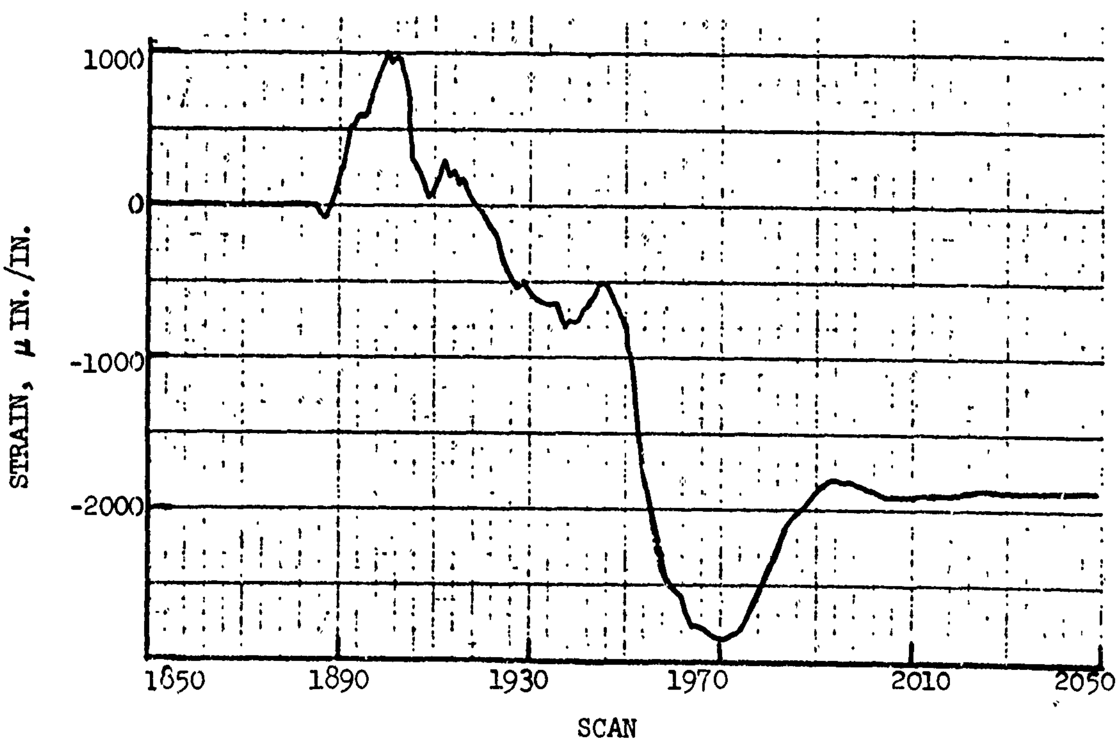


Figure 50. Strain Gage 6 Versus Scan, Test Specimen 6.

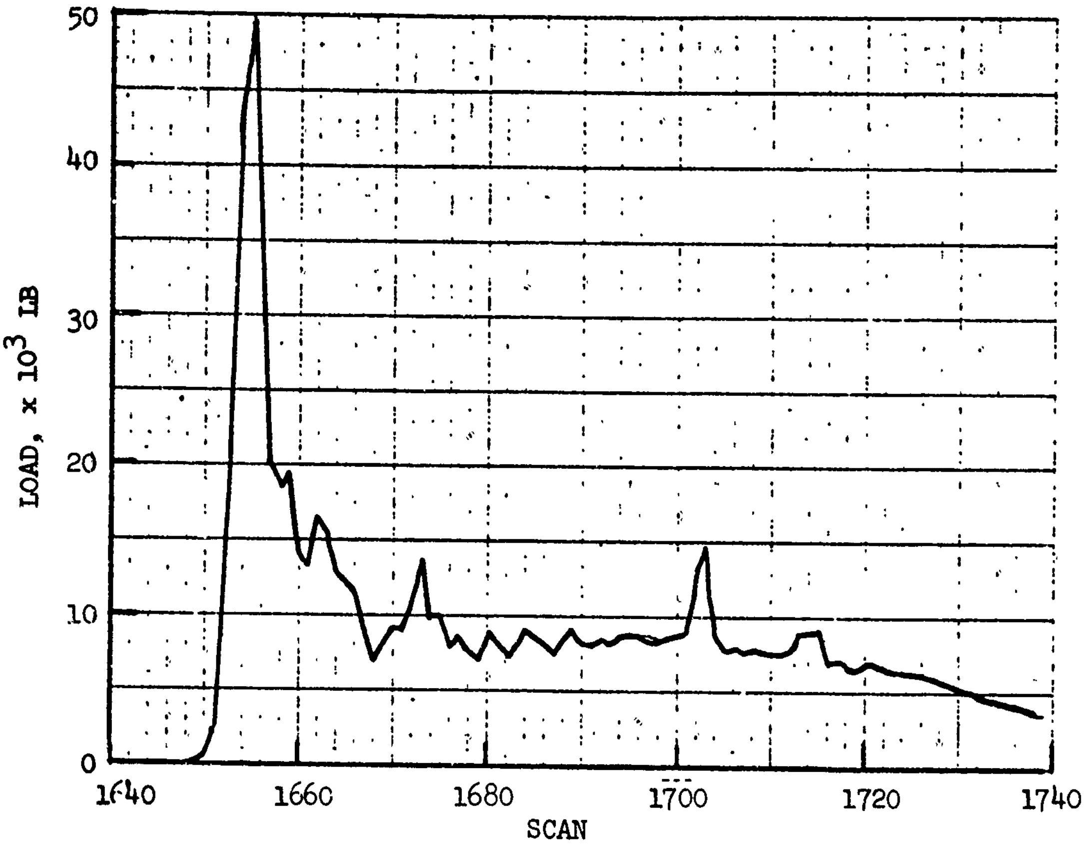


Figure 51. Load Cell (North) Versus Scan, Test Specimen 7.

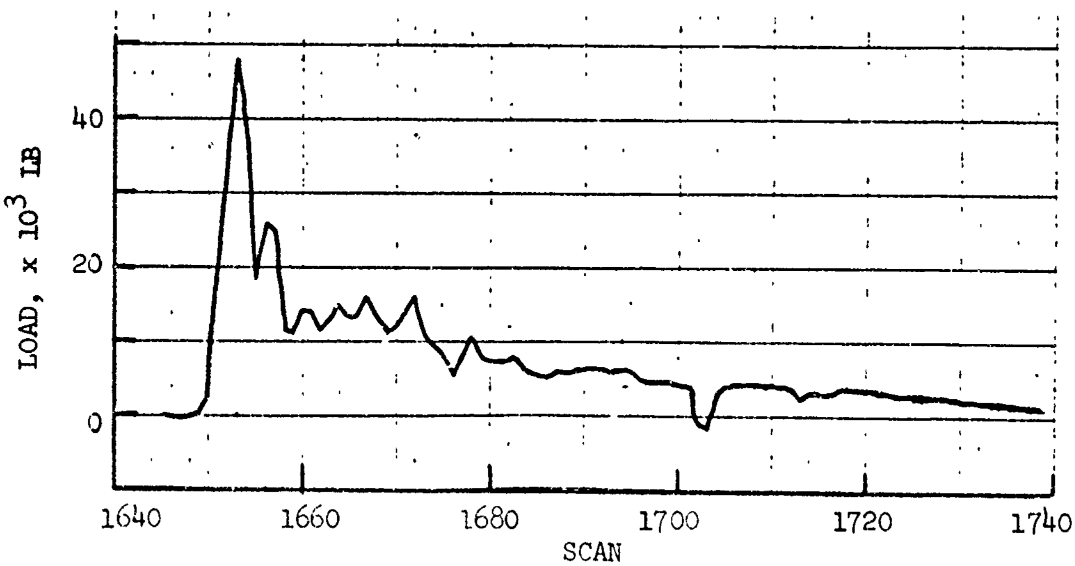


Figure 52. Load Cell (South) Versus Scan, Test Specimen 7.

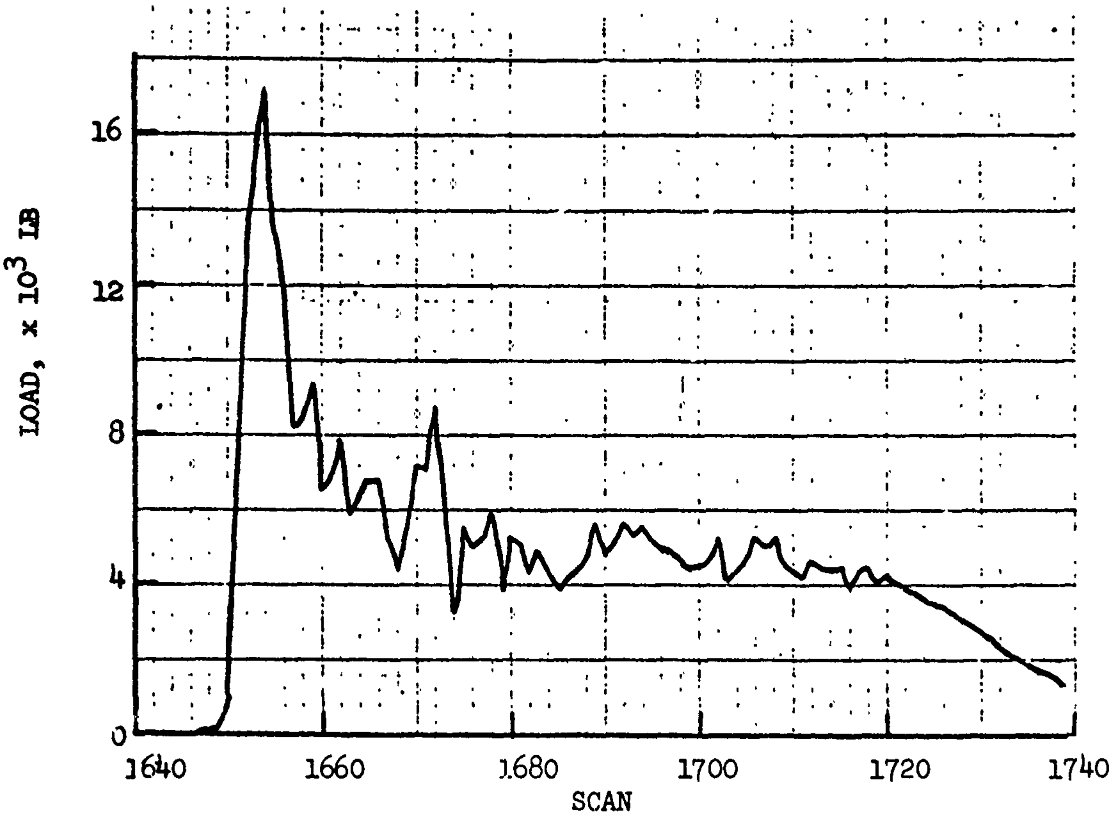


Figure 53. Load Cell (East) Versus Scan, Test Specimen 7.

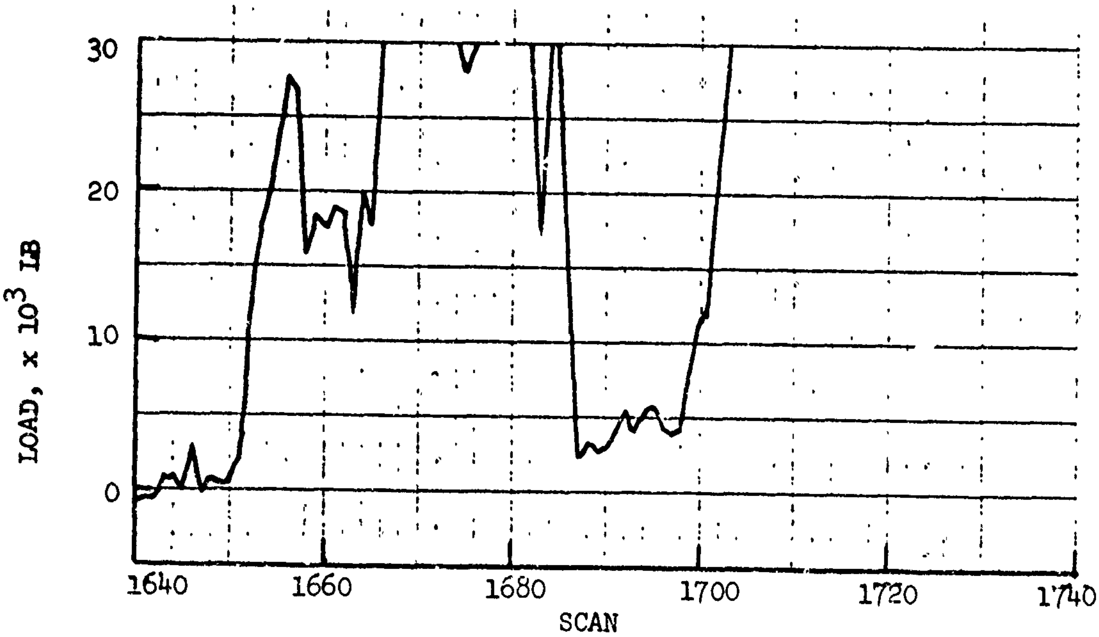


Figure 54. Load Cell (West) Versus Scan, Test Specimen 7.

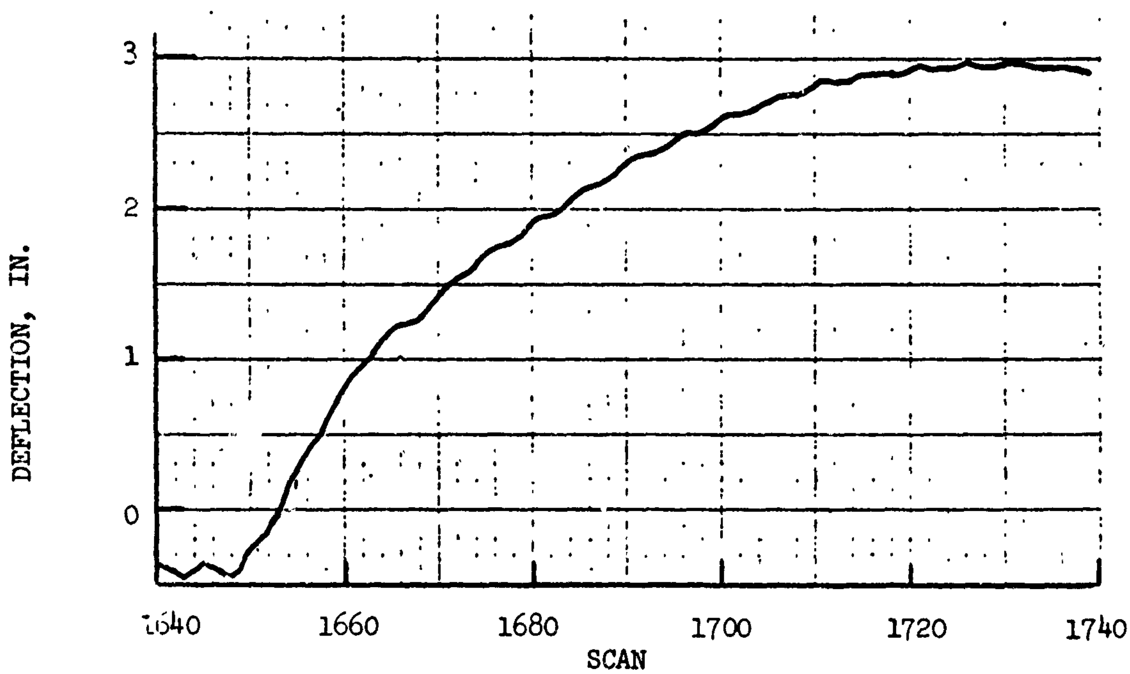


Figure 55. Deflection Versus Scan, Test Specimen 7.

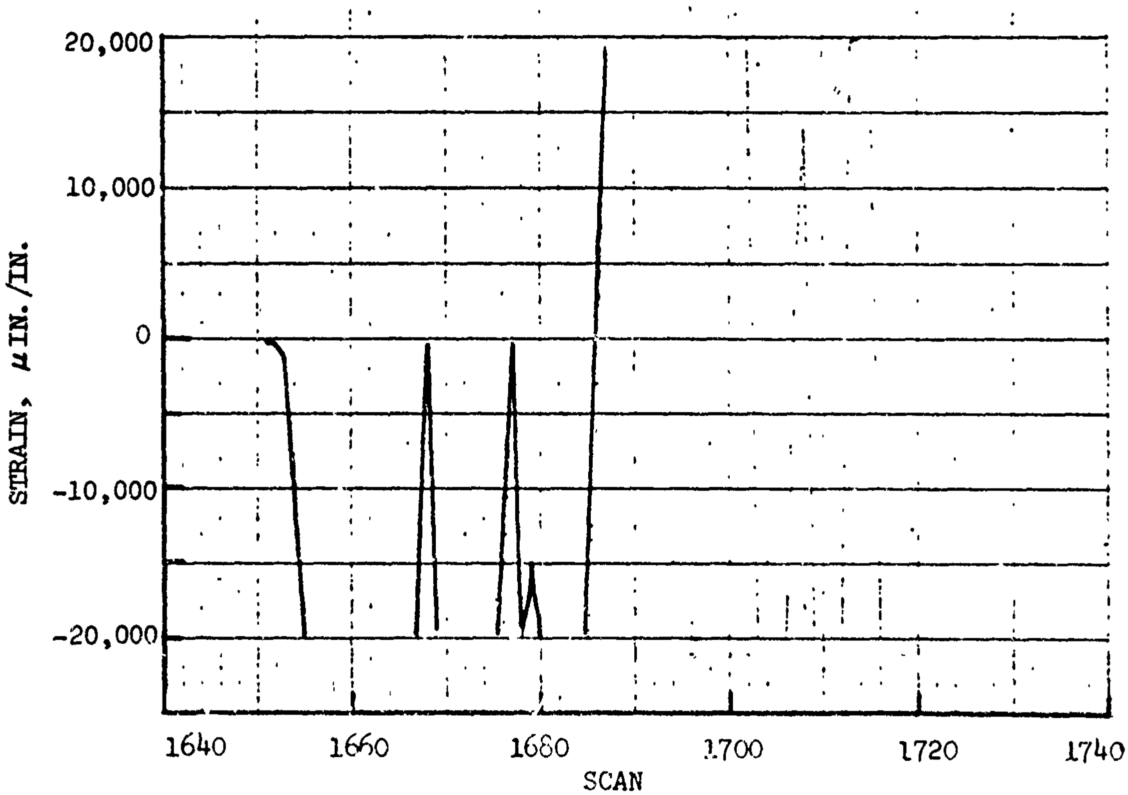


Figure 56. Strain Gage 1A Versus Scan, Test Specimen 7.

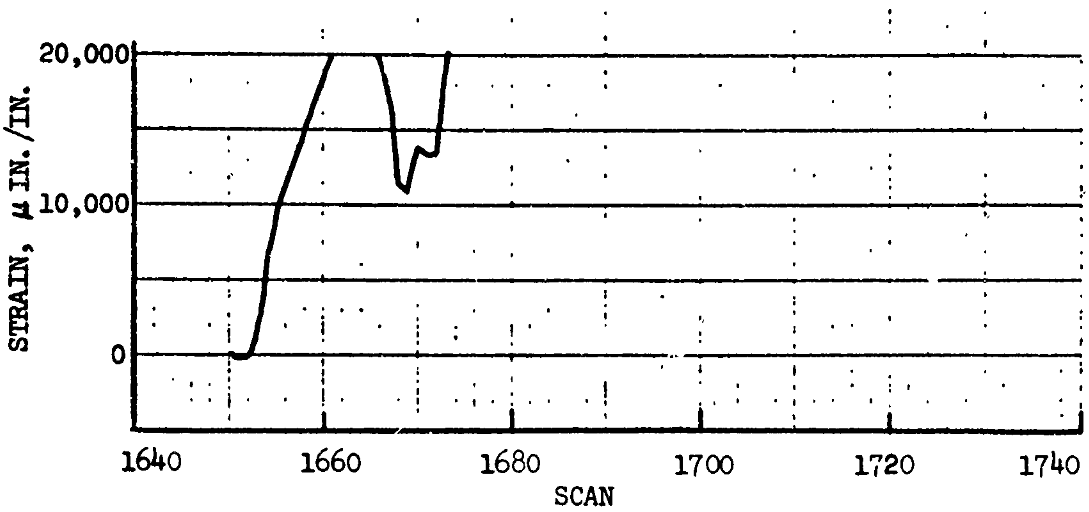


Figure 57. Strain Gage 1B Versus Scan, Test Specimen 7.

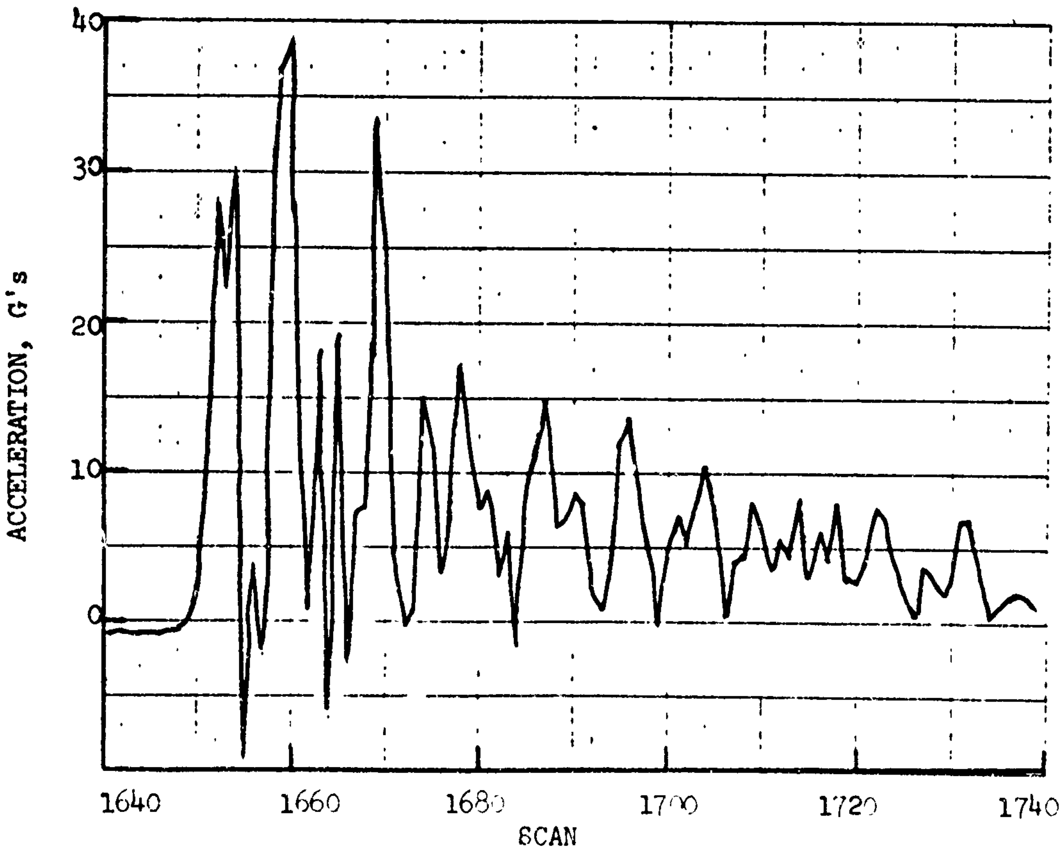


Figure 58. Acceleration (East) Versus Scan, Test Specimen 7.

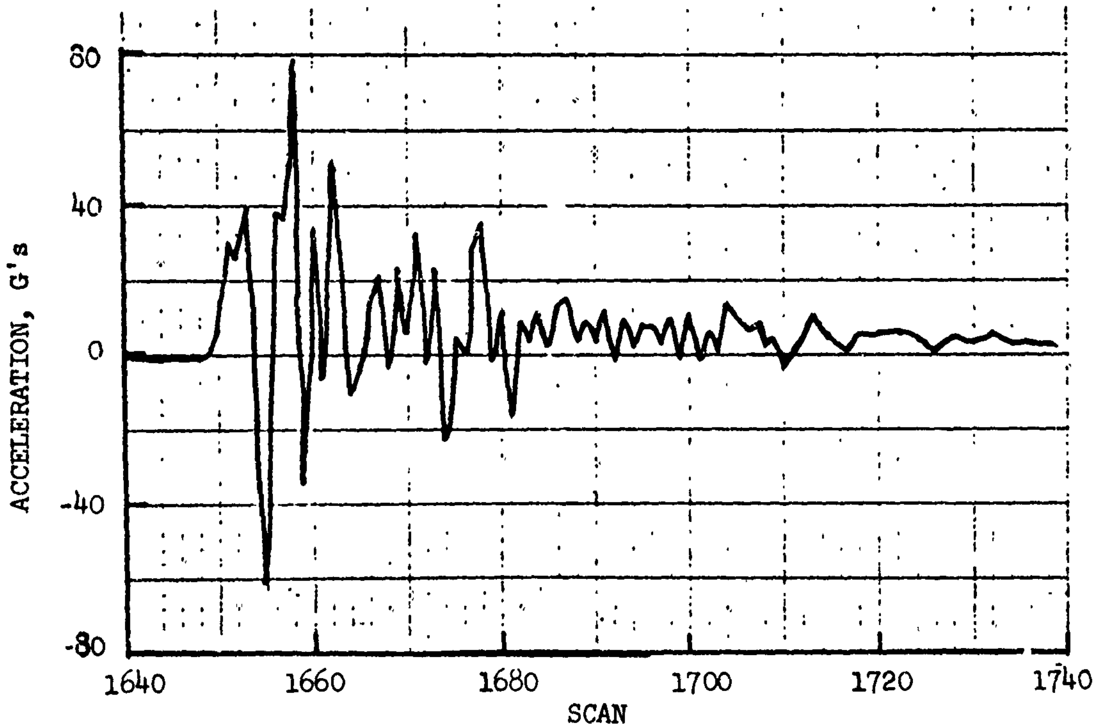


Figure 59. Acceleration (Center) Versus Scan, Test Specimen 7

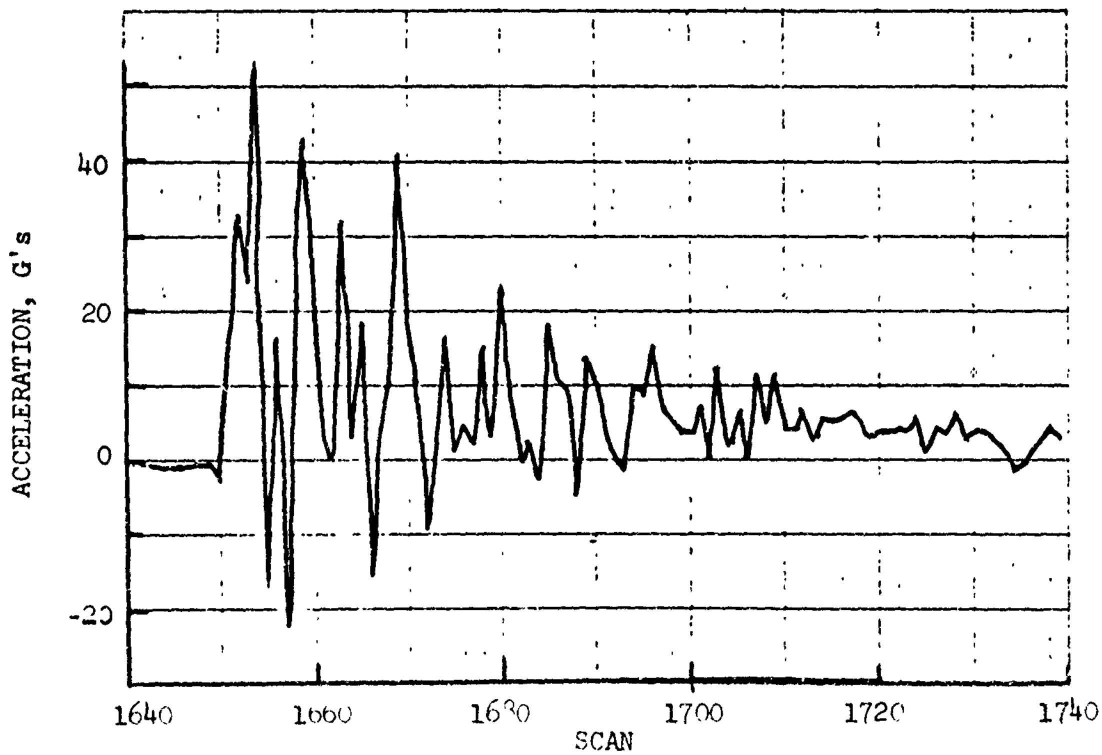


Figure 60. Acceleration (West) Versus Scan, Test Specimen 7.

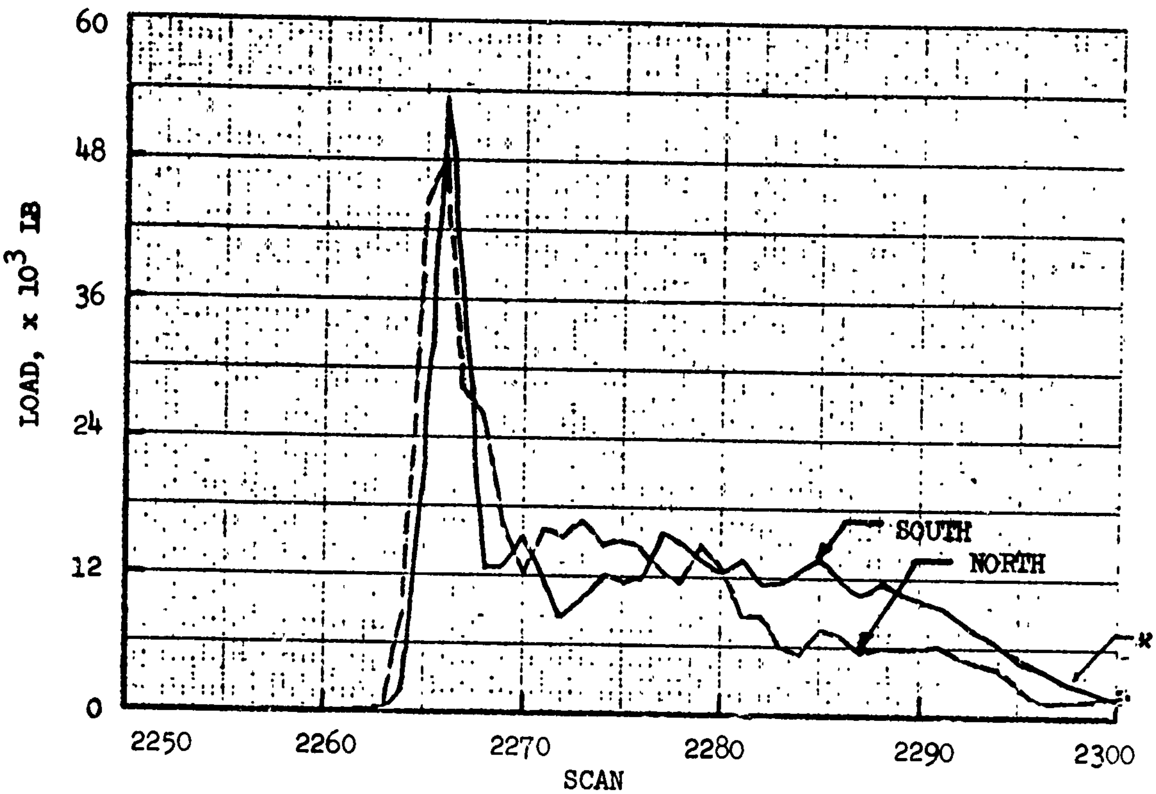


Figure 61. Load Cells (North and South) Versus Scan, Test Specimen 8.

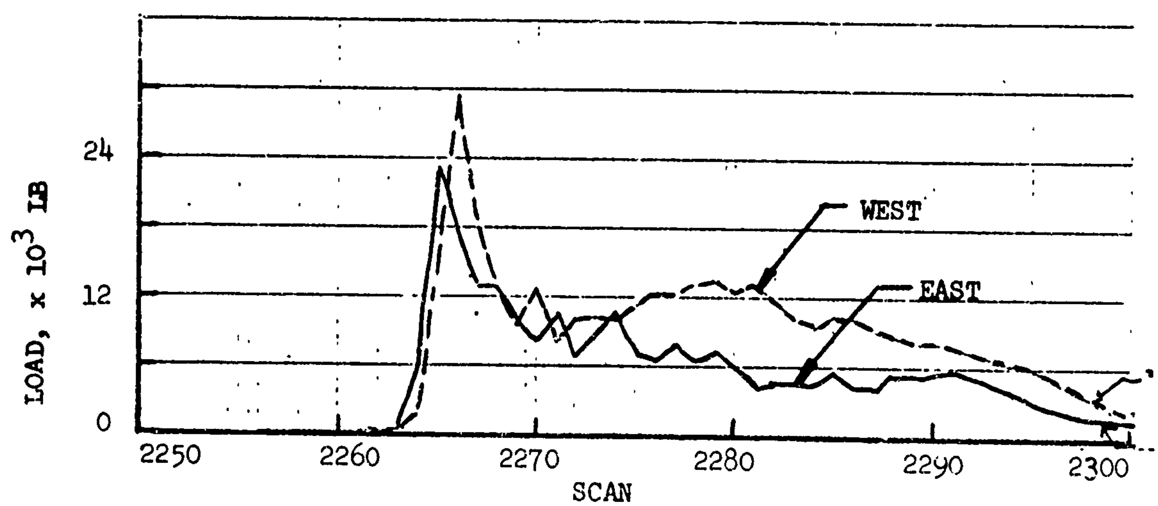


Figure 62. Load Cells (East and West) Versus Scan, Test Specimen 8.

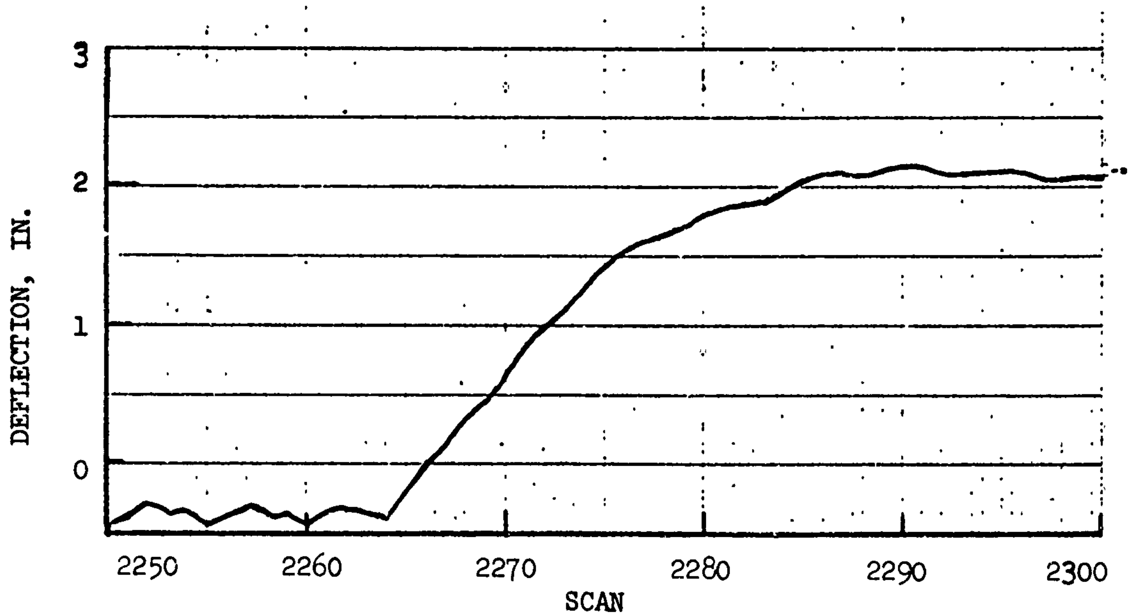


Figure 63. Deflection Versus Scan, Test Specimen 8.

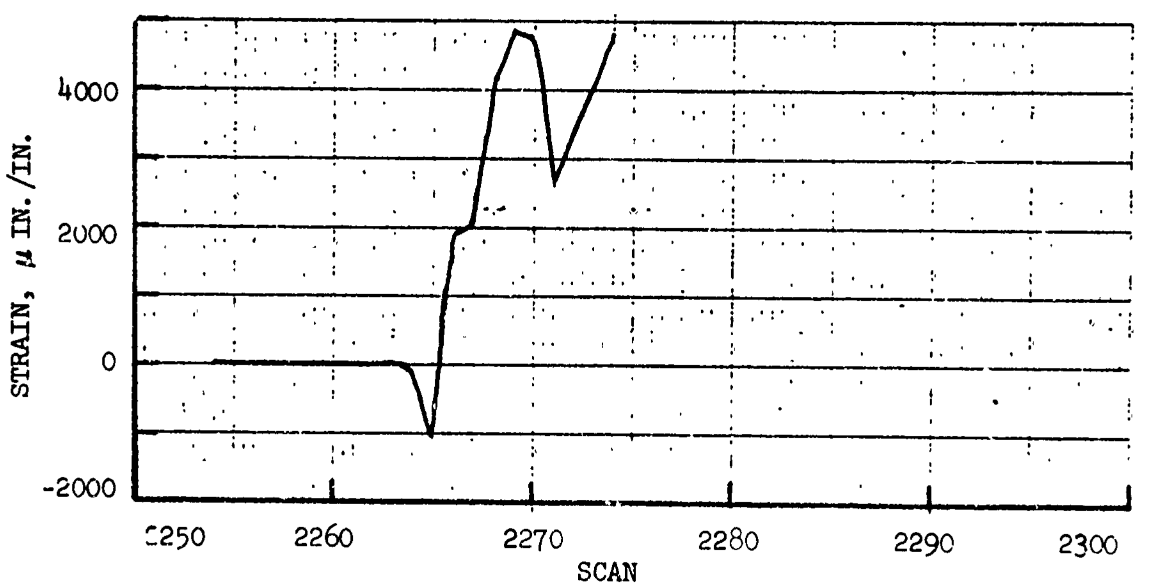


Figure 64. Strain Gage 1A Versus Scan, Test Specimen 8.

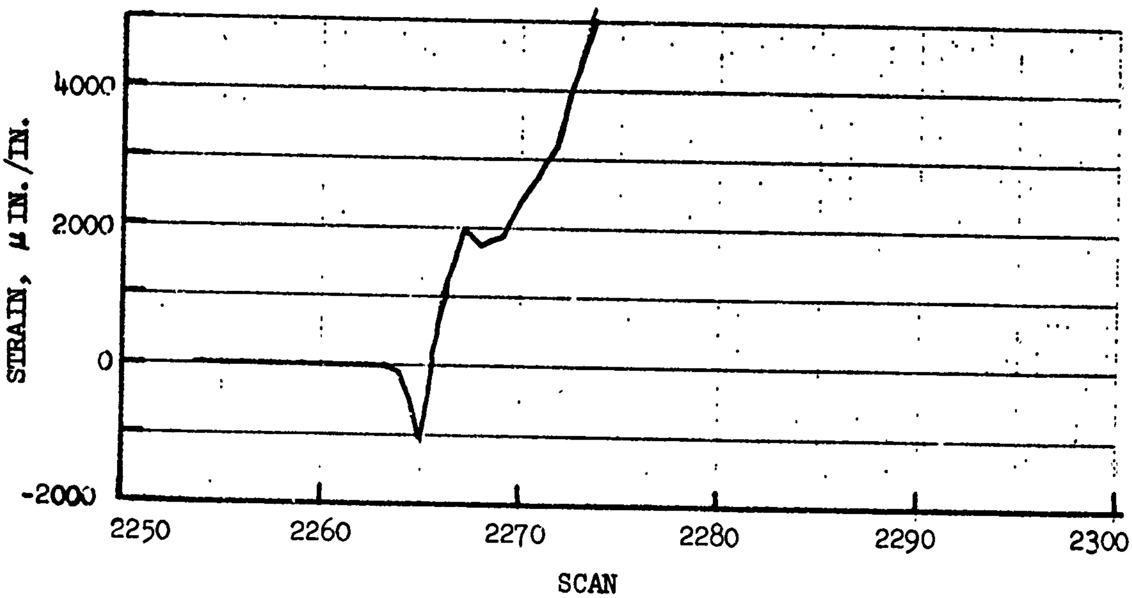


Figure 65. Strain Gage 1B Versus Scan, Test Specimen 8.

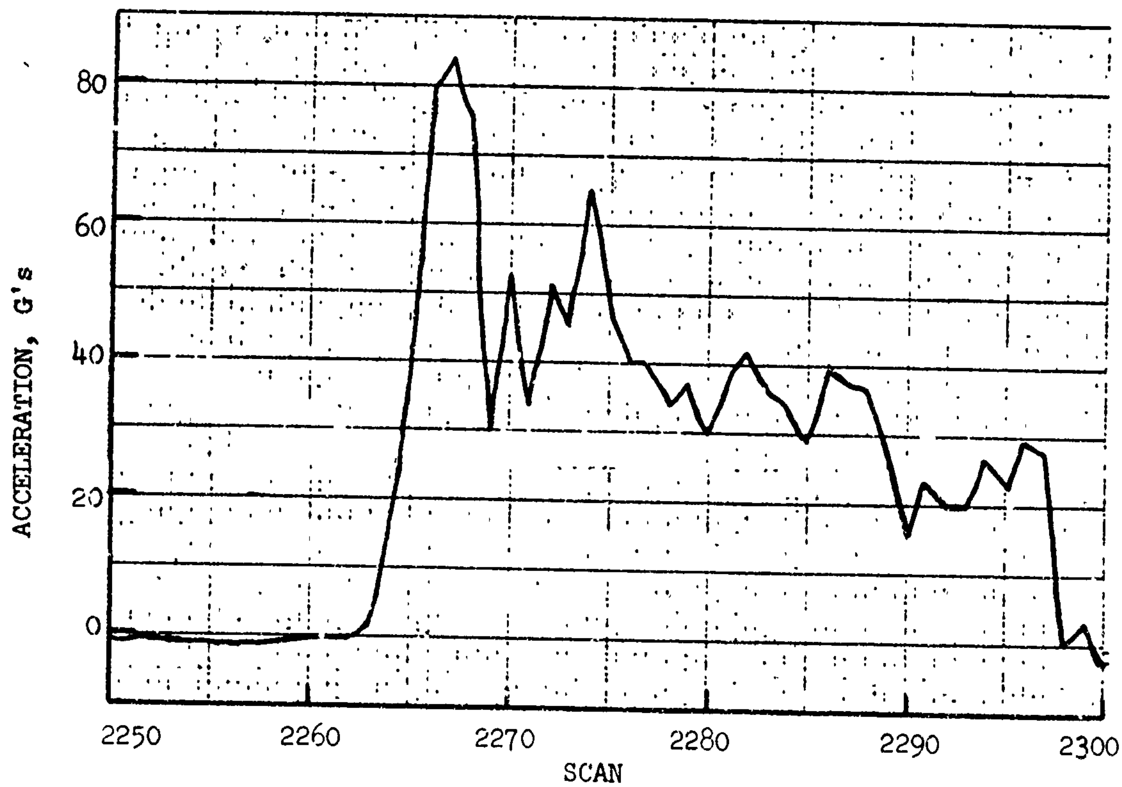


Figure 66. Acceleration (East) Versus Scan, Test Specimen 8.

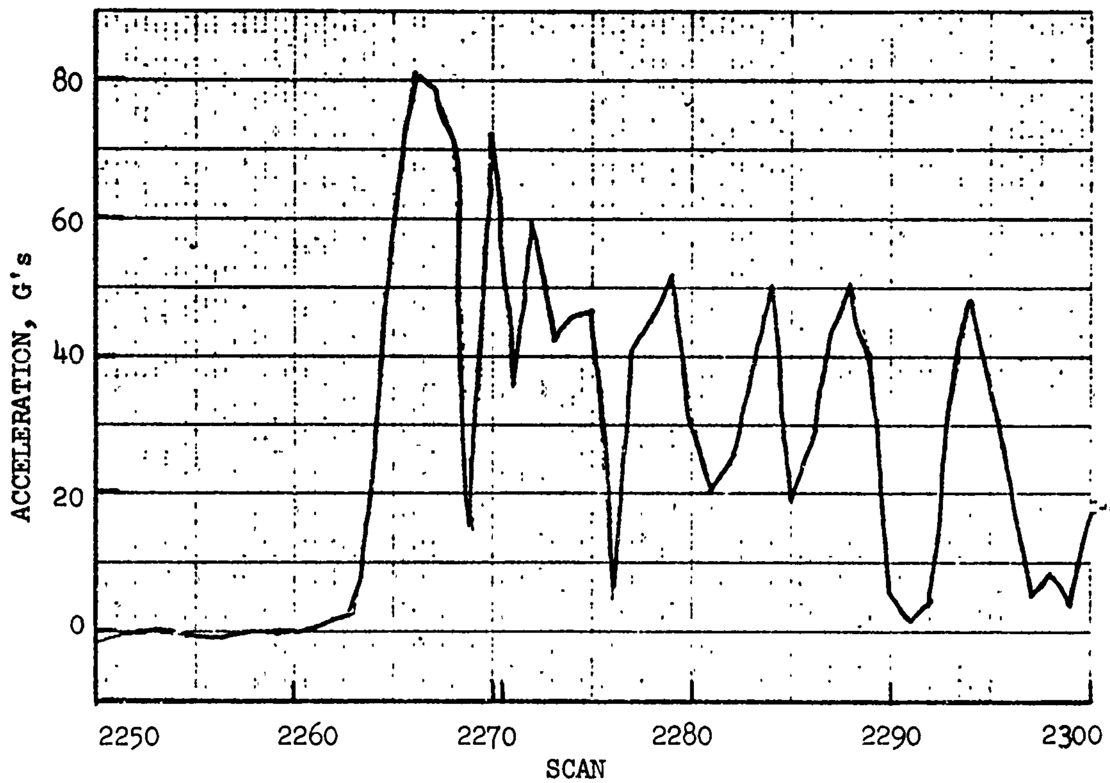


Figure 67. Acceleration (Center) Versus Scan, Test Specimen 8.

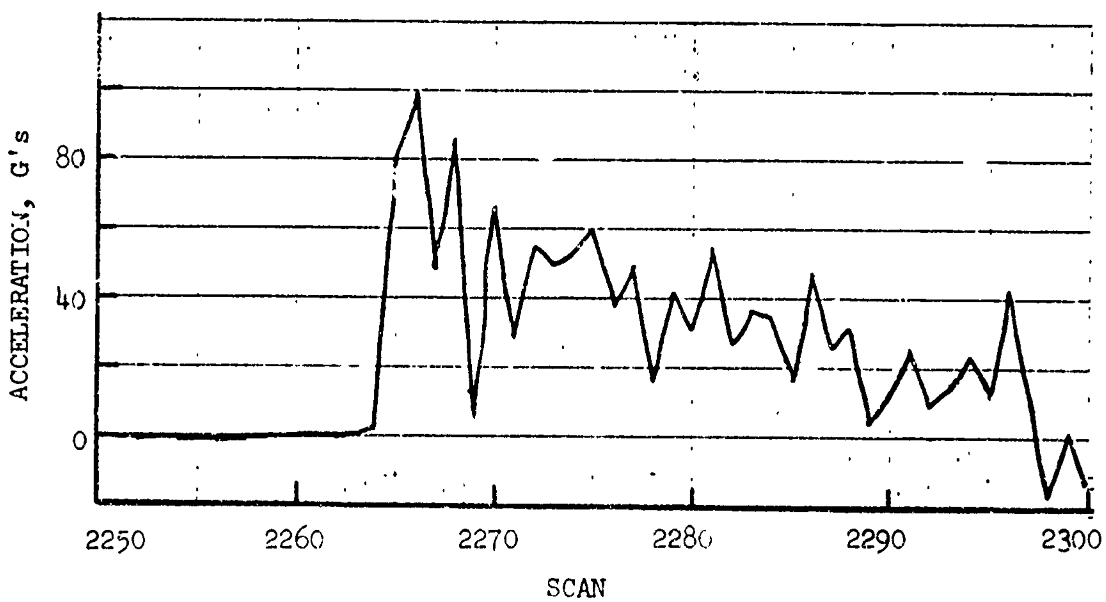


Figure 68. Acceleration (West) Versus Scan, Test Specimen 8.

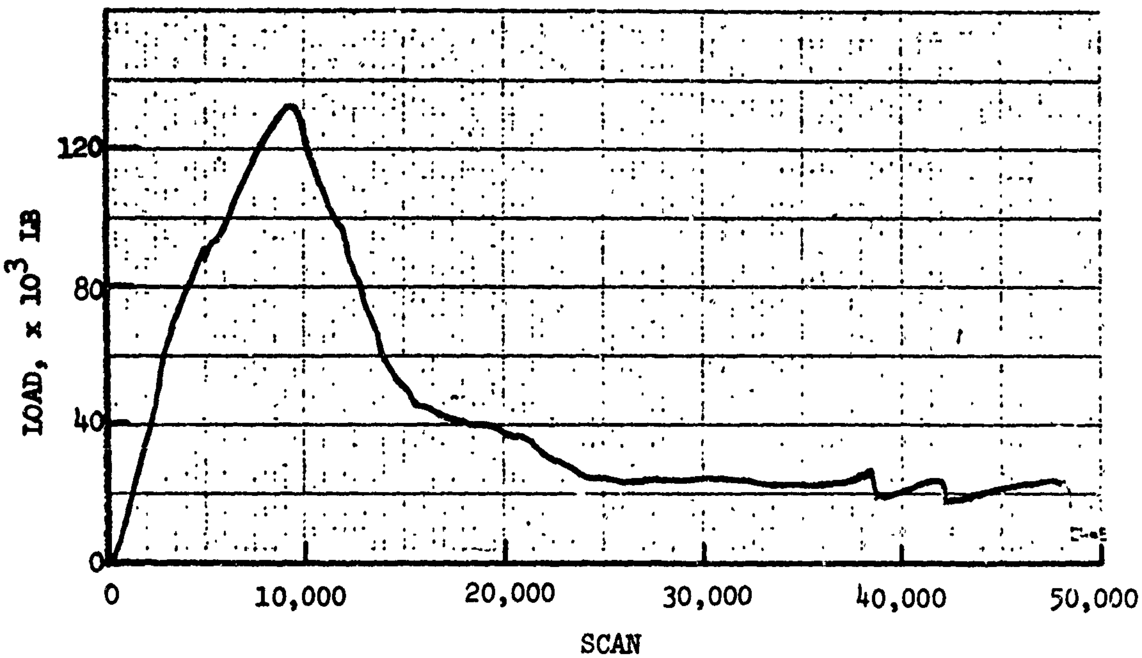


Figure 69. Load Versus Scan, Test Specimen 9.

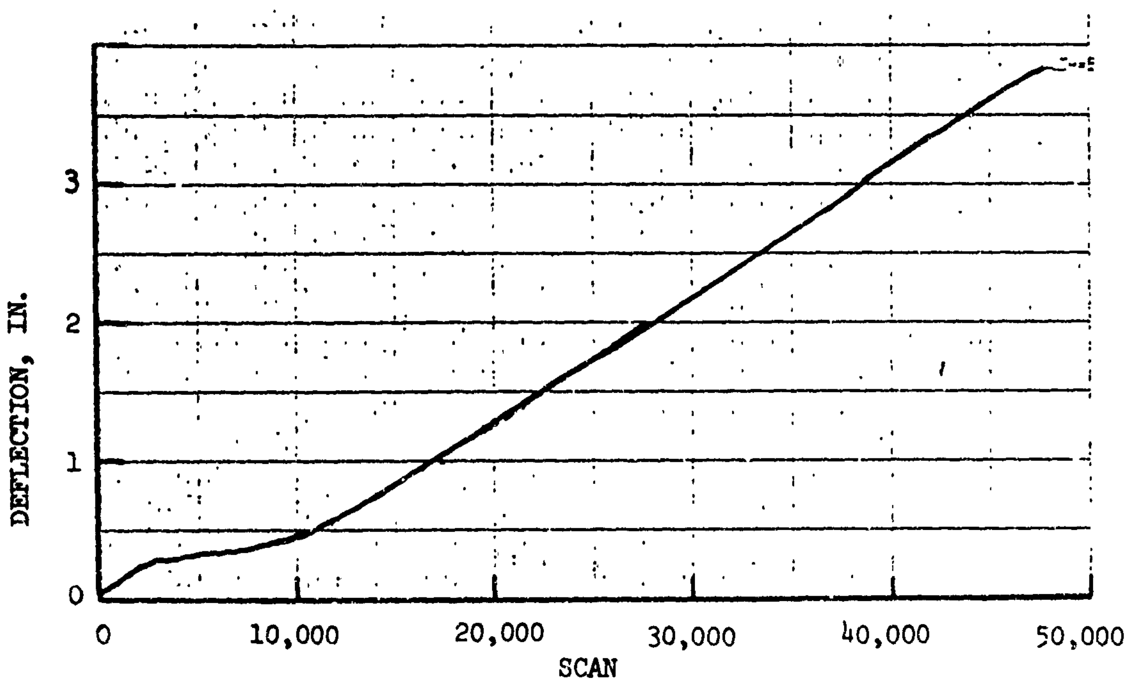


Figure 70. Deflection Versus Scan, Test Specimen 9.

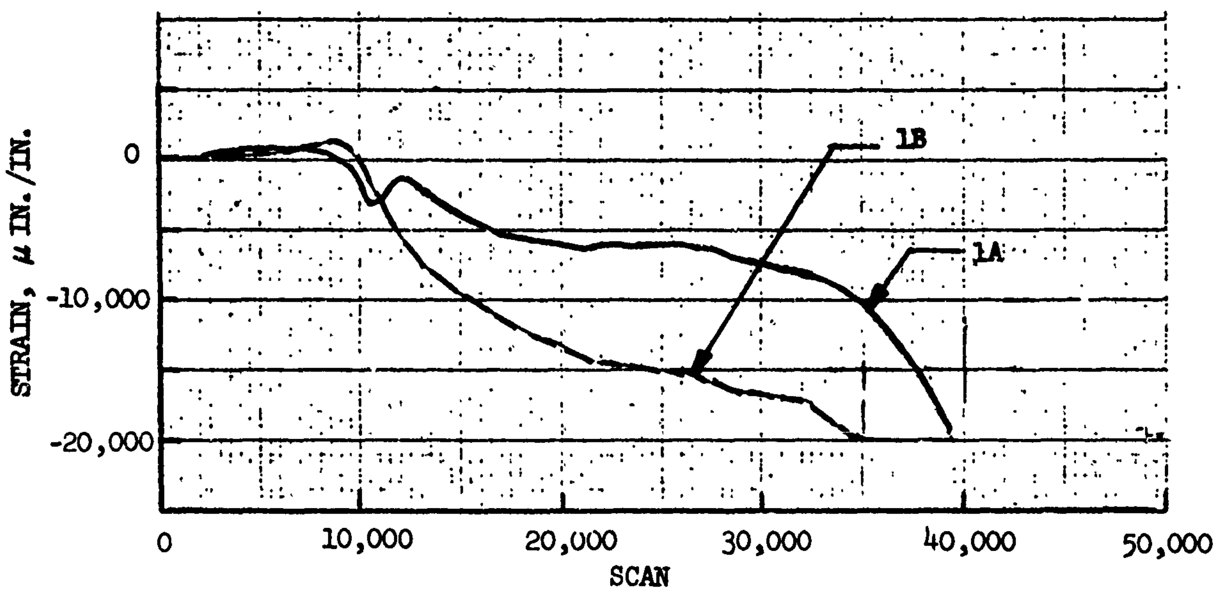


Figure 71. Strain Gages 1A and 1B Versus Scan, Test Specimen 9.

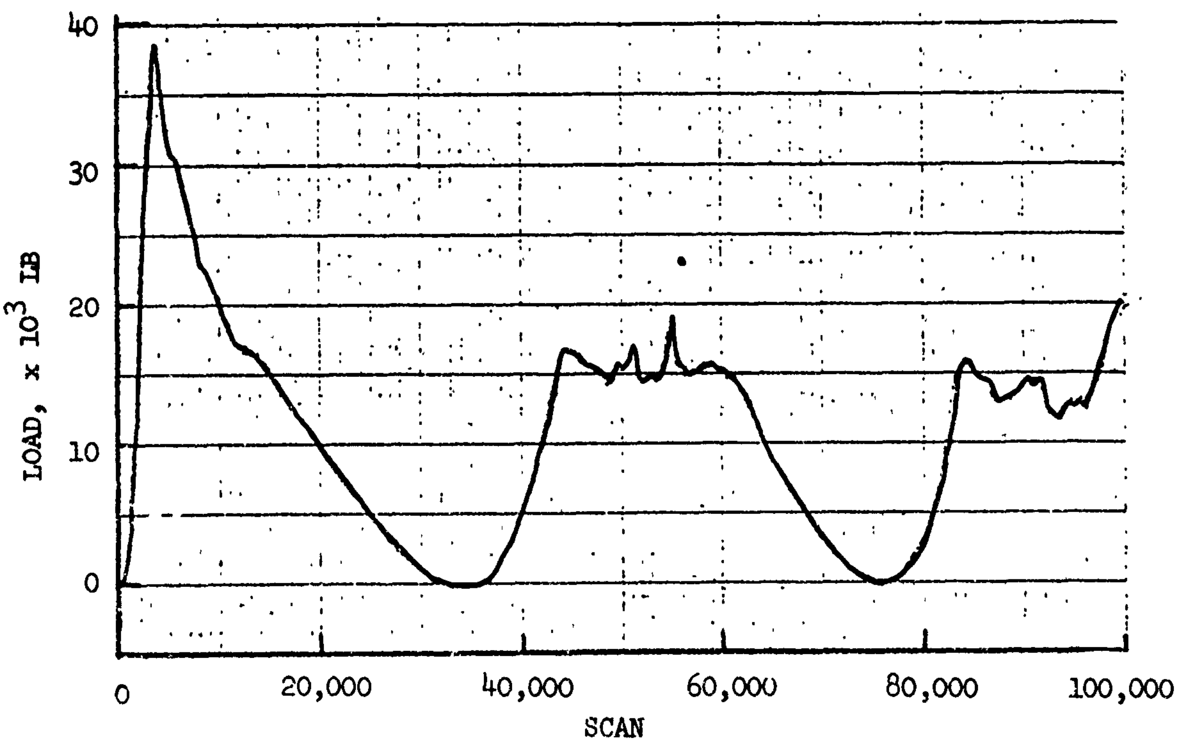


Figure 72. Load Versus Scan, Test Specimen 10.

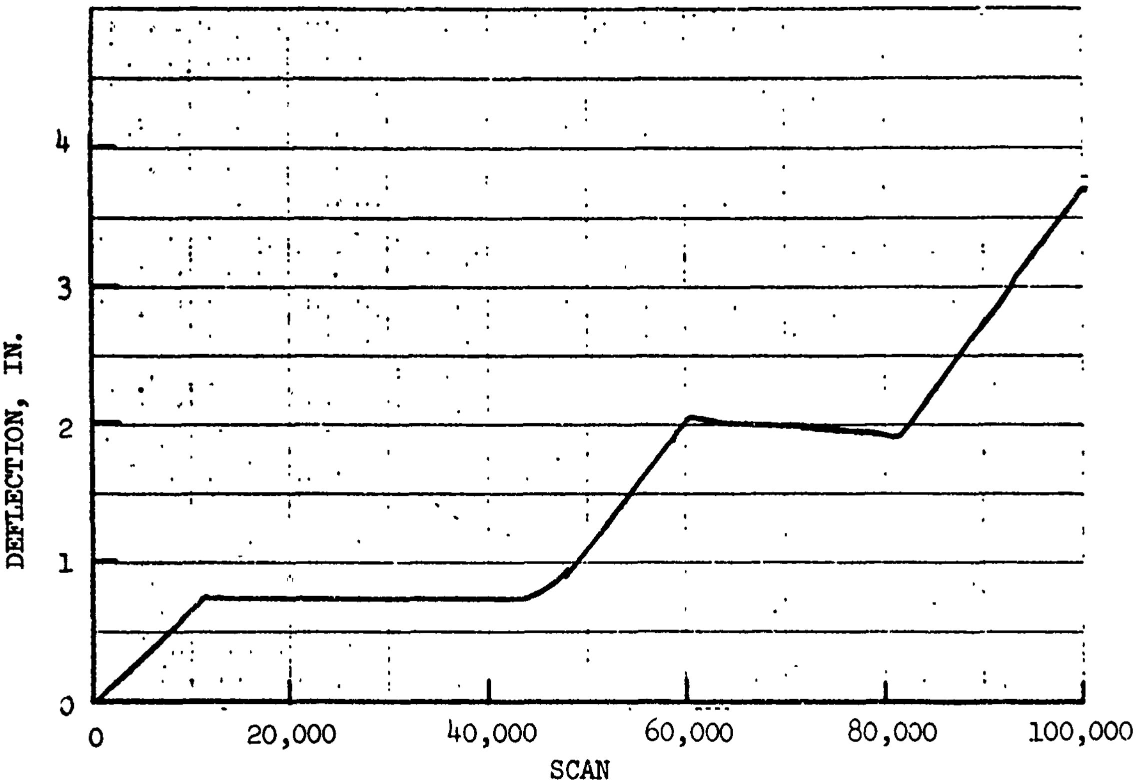


Figure 73. Deflection Versus Scan, Test Specimen 10.

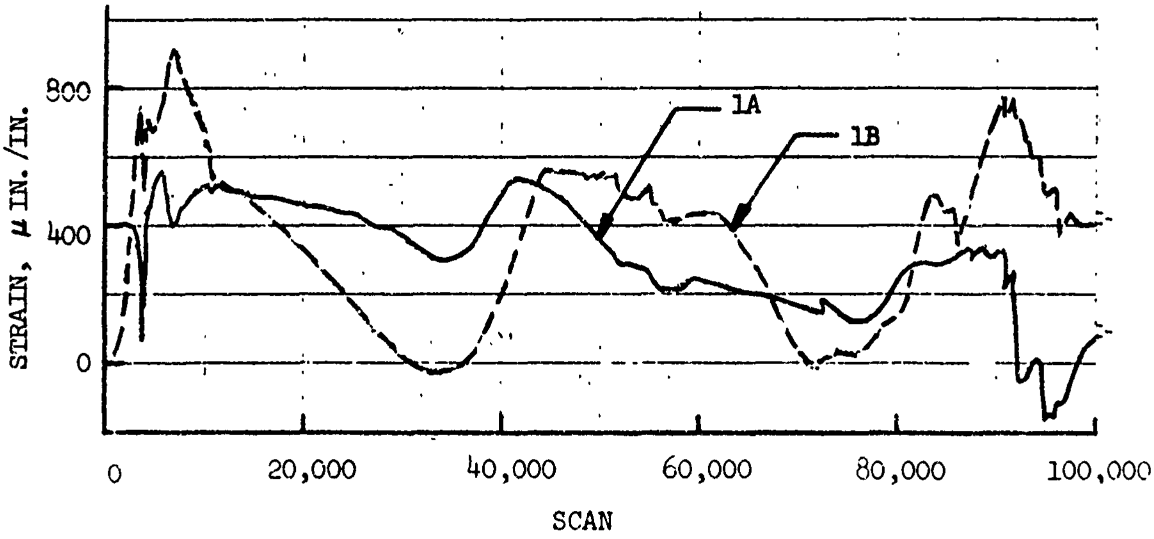


Figure 74. Strain Gages 1A and 1B Versus Scan, Test Specimen 10.

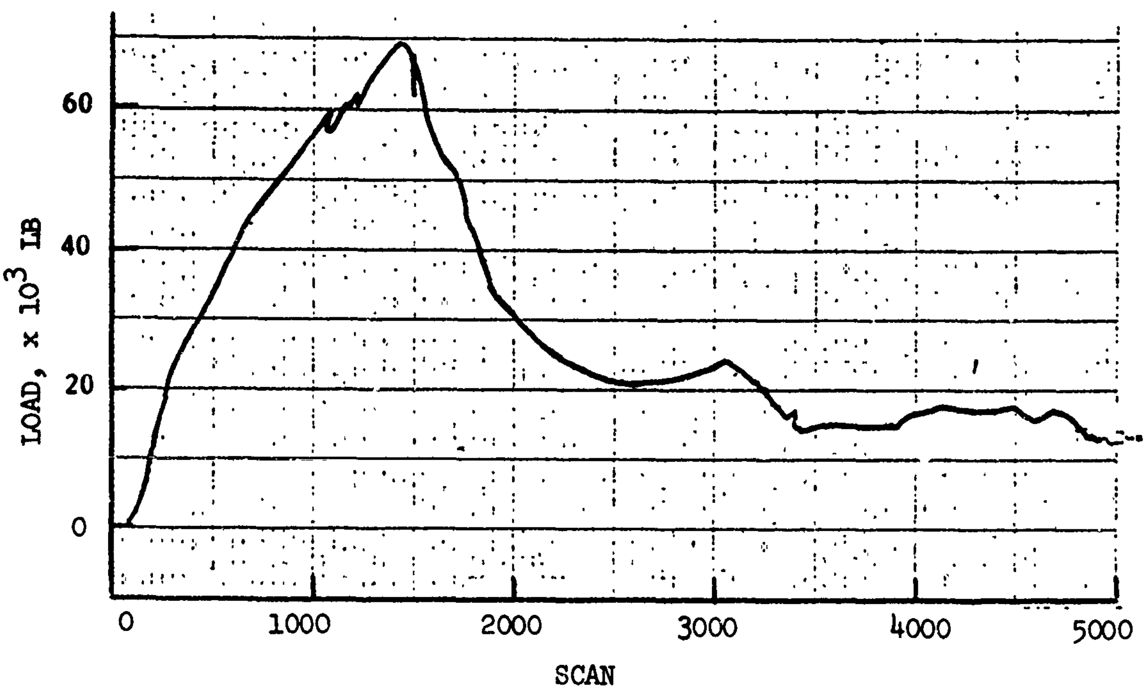


Figure 75. Load Versus Scan, Test Specimen 11.

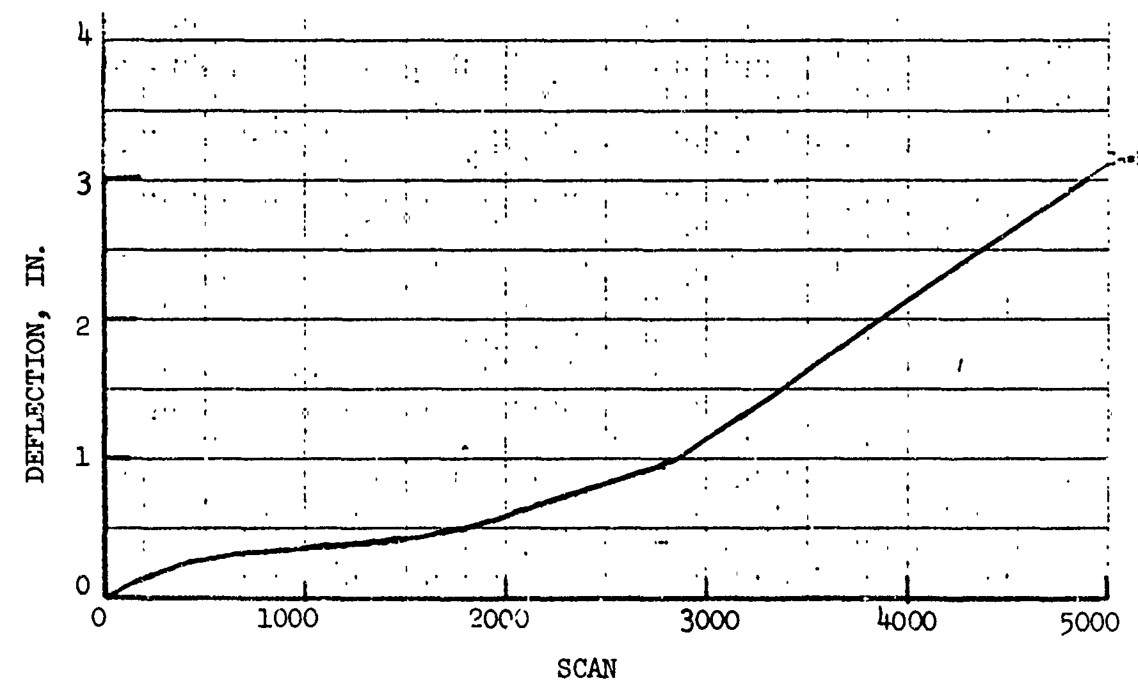


Figure 76. Deflection Versus Scan, Test Specimen 11.

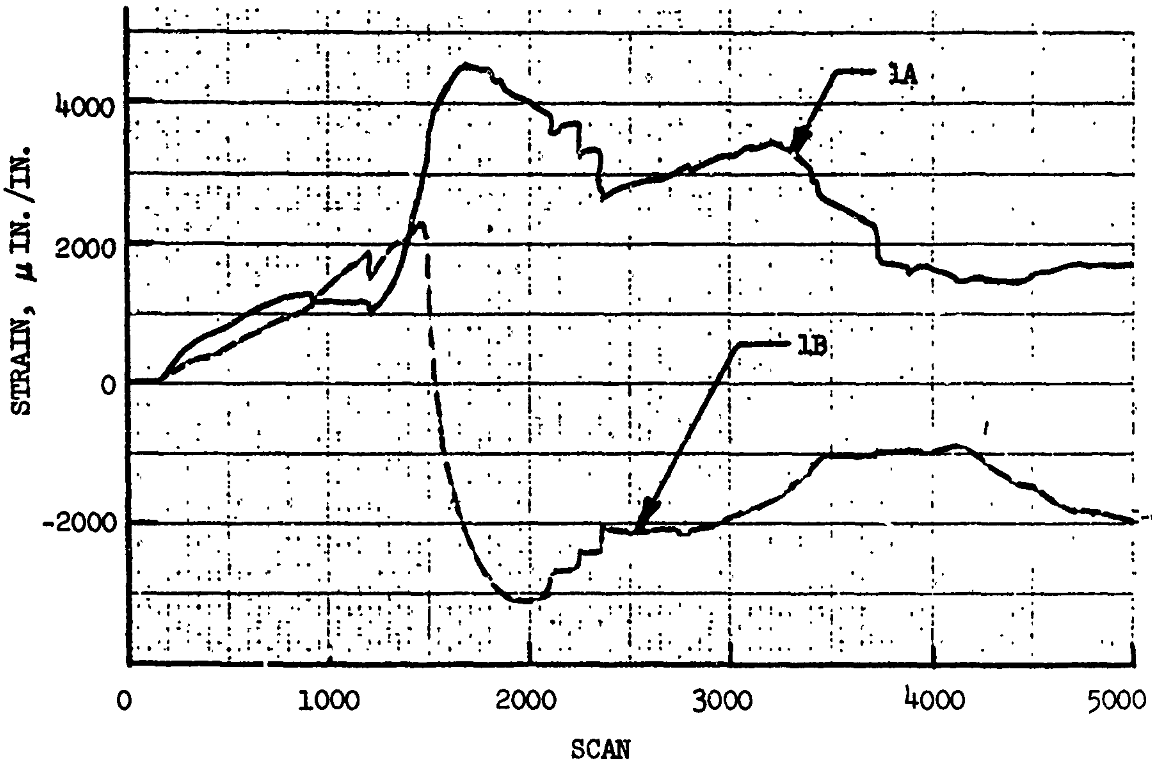


Figure 77. Strain Gages 1A and 1B Versus Scan, Test Specimen 11.

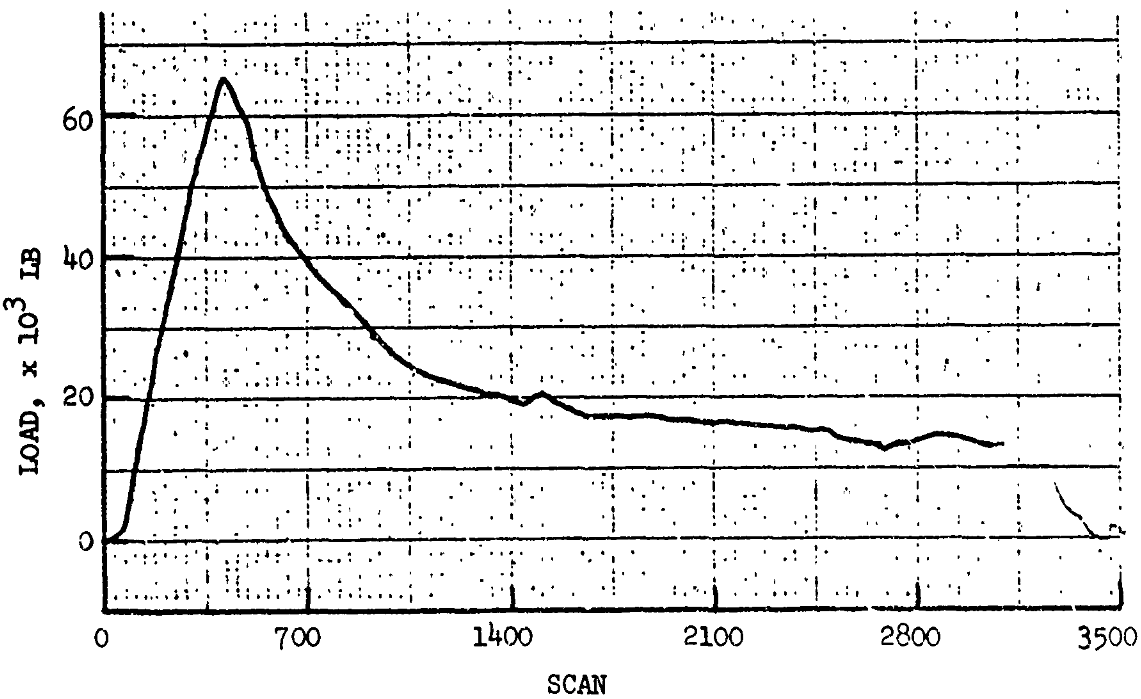


Figure 78. Load Versus Scan, Test Specimen 12.

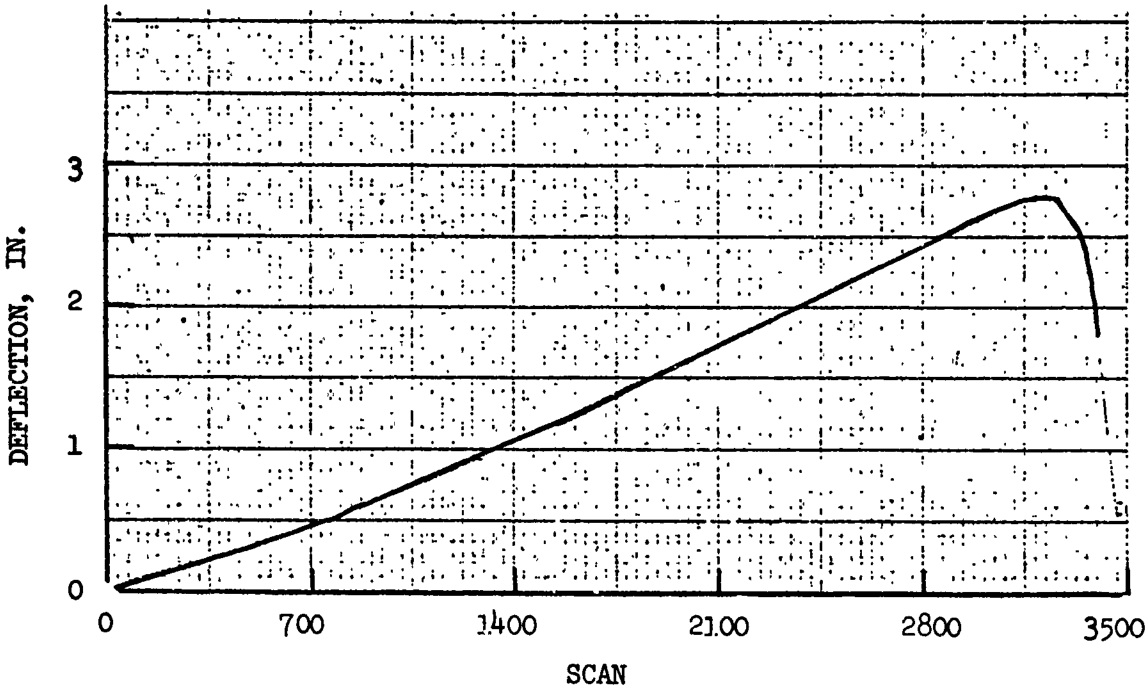


Figure 79. Deflection Versus Scan, Test Specimen 12.

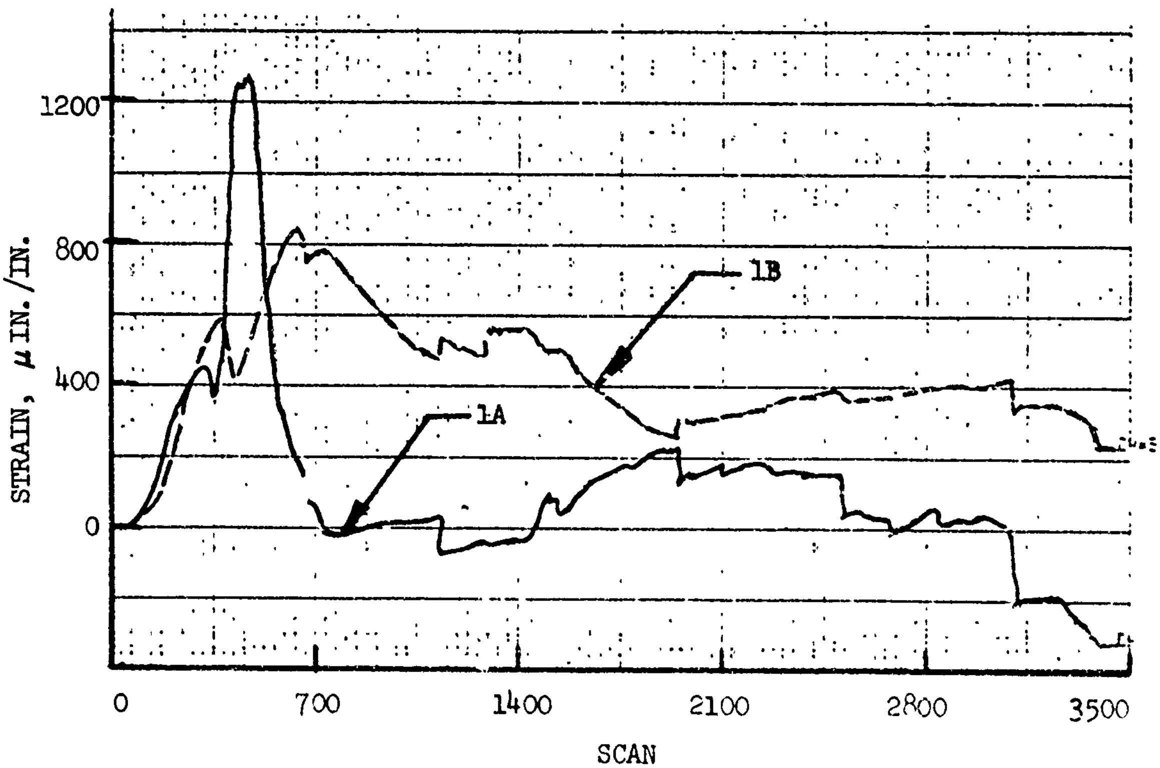


Figure 80. Strain Gages 1A and 1B Versus Scan, Test Specimen 12.

PROGRAM "KRASH" REFINEMENT

GENERAL

Program KRASH was developed as an analytical tool to be used during preliminary phases of design. In Reference 1 the results of a parametric study were integrated into an iterative design procedure by which a tradeoff between potential incremental cost and/or weight versus incremental improvements in crashworthiness capability could be accomplished. The results of that study and a subsequent study for the U.S. Army (Reference 106) showed the potential benefits that could be achieved for designers using a comprehensive but unsophisticated analytical approach. However, as is the situation with rapidly developed advances in the state-of-the-art analytical techniques, there are generally areas which can be simplified for users not thoroughly familiar with the approach.

In an effort to facilitate a designer's usage of program KRASH and to incorporate the results of the literature survey, load sensitivity study, substructure analysis, and tests, the program was revised. In particular, the input data format was changed for ease of data input and subsequent data changes, as would be required during parameter tradeoff studies. In addition, flexibility was added by the manner in which the Stiffness Reduction factors (KR's) are input. The revised program was run for the following conditions:

- Correlation case 31-52 from Reference 1 (to demonstrate that the revised program format was compatible with previous results: 23-ft/sec vertical velocity combined with 18.5-ft/sec lateral velocity impact).
- Three-dimensional velocity (~ 40 ft/sec combined velocity impact - 27.5 ft/sec longitudinal, 23 ft/sec vertical, 18.5 ft/sec lateral).
- Upper mass penetration into a specified occupiable volume.
- Simplified blade contact.
- Utilization of load-deflection data obtained from the 12 substructure tests, performed during the study, and related to actual fuselage structure size.

PROGRAM "KRASH" INPUT FORMAT REVISIONS

The input format changes are divided into three categories:

- Reordered data.
- Standardization of certain inputs.
- Allowance for more general KR curves.

First, the input data is rearranged so that all mass associated data (subscript i) is in one block, followed by all external spring data (subscript ik) and then all internal beam data (subscript ij). Next, standard values are assigned to certain input data items unless otherwise specified. Thus, much repetitive data input is eliminated. The following quantities are given standard values unless otherwise specified:

Quantity	Symbol	Standard Value
Angular Momenta	He_i	0
Euler Angles	$\phi''_i, \theta''_i, \psi''_i$	0
Aerodynamic Lift	lc_i	0
Stiffness Reduction Factors	KR_{ij}	1
Failure Deflection	$\upsilon_{max_{ijl}}$	100

Thus, the angular momenta of the masses (He_i) and the aerodynamic lift (lc_i) are normally zero, as are the Euler angles ϕ'', θ'', ψ''_i, relating mass body-fixed axes to airplane c.g. axes. For linear internal beam elements, KR = 1 for the entire run, so only nonlinear KR data need be input. Similarly, υ_{max}'s need only be input for those elements where rupture is expected to occur; for elements not specified, a failure deflection of 100 inches and rotation of 100 radians are assumed. Thus, the nonspecified beams will not rupture during the run.

The input has also been revised to allow more general KR (stiffness reduction factor) curves. Previously, each KR curve could have only six data points, equally spaced. Now each curve can have up to 15 data points, with any desired spacing. This greatly facilitates modeling more complex load-deflection relationships. However, the load-sensitivity study results indicate that for many structural elements a very simple KR representation is adequate. The KR representation for the various load-deflection categories is discussed in Volume I (Design Procedures).

The relationship between the number of masses, internal beam elements and KR tables is governed by the following expression:

Total number of bytes = 235,136 + 1244 x number of lumped masses (n) + 1372 x Internal Beam Elements (IBE) + 198 x number of KR tables

e.g. N = 80
IBE = 100
KR = 120

Bytes = 235136 + 260,480 = 495616 = 484K

where 1K = 1024 bytes.

Thus, program KRASH has some flexibility with regard to the size of problems to which it can be applied. Depending on the type of vehicle that is being analyzed the program can be redimensionalized to provide the most practical and economical solution.

The three-dimensional impact mass penetration, simplified rotor blade contact and updated load-deflection data cases are described in Volume I under the section entitled Program KRASH Refinement.

ENERGY BALANCE EQUATIONS

The primary objective of a crash analysis in the preliminary design phase is to determine how to absorb the initial vehicle kinetic energy while maintaining a livable environment for the occupants. This task is greatly facilitated if information regarding the spatial distribution of the energy flow through the vehicle is available. With the objective in mind, energy balance equations are developed. These equations do not alter the existing computational procedures or results; they merely provide additional information to assist in understanding how the initial kinetic energy is absorbed.

The total system energy at any time is given by the following expression:

$$E_{TOT} = KE + PE + SE + DE + CE \qquad (1)$$

where E_{TOT} = Total system energy

KE = Total kinetic energy

PE = Total potential energy

SE = Total strain energy absorbed

DE = Total damping energy dissipated

CE = Total crash spring (external spring) energy absorbed.

The total system energy E_{TOT} remains constant during the analysis. The total kinetic and potential energies for each mass over the number of masses (N) are shown in Equation (2).

$$KE = \sum_{i=1}^{N} KE_i \qquad PE = \sum_{i=1}^{N} PE_i \qquad (2)$$

The total strain and damping energies are obtained by summing the strain and damping energy for each interval beam element (ij pair) over the M ij pairs.

$$SE = \sum_{ij=1}^{M} SE_{ij} \qquad DE = \sum_{ij=1}^{M} DE_{ij} \tag{3}$$

SE_{ij} results from the elastic-plastic behavior of the beam, and DE_{ij} results from its damping properties. The total crash spring energy results from summing the energies for all the individual crash springs (ik pairs) over all the P ik pairs.

$$CE = \sum_{ik=1}^{P} CE_{ik} \tag{4}$$

Referring to Equation (1), at time zero all energies are zero except KE, PE and E_{TOT}. The potential energy is referenced to the ground plane.

After impact with the ground, the kinetic and potential energies decrease; damping, strain and crash spring energies all increase to keep E_{TOT} constant.

In Equation (3), the summations over the ij pairs exclude those ij pairs that are identified in the input as DRI elements, which are described in Reference 1, page 73. This is done because these ij beams and their masses are isolated from the rest of the system; the forces in DRI beam ij drive mass j but not mass i. Also, the summations in Equation (2) for the kinetic and potential energies exclude mass j in a DRI ij pair, since this mass is isolated from the system. Thus, if ij pairs 6-9 and 11-15 are defined as DRI elements, the summations for SE and DE will exclude these ij pairs and the summations for KE and PE will exclude masses 9 and 15.

The kinetic energy for each mass, including translational and rotational components, is simply

$$KE_i = \frac{1}{2} \left|vel_i\right|^T \left[M_i\right] \left\{vel_i\right\} \tag{5}$$

where

$$\left[M_i\right] = \begin{bmatrix} M_i & & & & & \\ & M_i & & & & \\ & & M_i & & & \\ & & & I_{xi} & I_{xyi} & I_{xzi} \\ & & & I_{xyi} & I_{yi} & I_{yzi} \\ & & & I_{xzi} & I_{yzi} & I_{zi} \end{bmatrix}$$

and

$$\{vel_i\} = \begin{Bmatrix} u_i \\ v_i \\ w_i \\ p_i \\ q_i \\ r_i \end{Bmatrix}$$

$[M_i]$ is the 6 x 6 inertia matrix for mass i, and $\{vel_i\}$ is a six-element vector of the linear and angular velocity components of mass i in body-fixed axes.

The i^{th} mass potential energy, referenced to the ground plane, is given by

$$PE_i = w_i \; z_i \tag{6}$$

Note that z_i is positive downward, measured from the ground plane.

The strain energy in internal beam ij is computed as a continuous summation of the incremental energy contributions from each integration interval.

$$\left(SE_{ij}\right)_{current} = \left(SE_{ij}\right)_{previous} + \sum_{\ell=1}^{6} F_{ij\ell} \, \Delta vb_{ij\ell} \tag{7}$$

$F_{ij\ell} \, \Delta vb_{ij\ell}$ is the internal beam force (or moment) in the ℓ^{th} direction, multiplied by the incremental beam deflection (or rotation) in the ℓ^{th} direction; this is the incremental strain energy for the integration interval being considered. This straightforward formulation automatically accounts for the complexities of nonlinear, coupled deflections and unloading-reloading behavior, since these are considered in the calculation of F_{ij}.

The damping energy dissipated in internal beam ij is computed in a similar manner:

$$\left(DE_{ij}\right)_{current} = \left(DE_{ij}\right)_{previous} + \sum_{\ell=1}^{6} FD_{ij\ell} \, \Delta vb_{ij\ell} \tag{8}$$

$FD_{ij\ell}$ is the internal beam damping force (or moment) in the ℓ^{th} direction.

The crash spring energy is also computed as a summation of incremental energy changes. The crash spring energy resulting from all the ik springs attached to mass i is

$$\left(CE_i\right)_{current} = \left(CE_i\right)_{previous} - \left|X_{Ci}\ Y_{Ci} \cdots,\ N_{Ci}\right| \begin{Bmatrix} \Delta x'_i \\ \Delta y'_i \\ \Delta z'_i \\ \Delta inp_i \\ \Delta inq_i \\ \Delta inr_i \end{Bmatrix} \tag{9}$$

X_{Ci}, Y_{Ci}, ..., N_{Ci} are the six forces and moments acting on mass i in body-fixed axes, resulting from all ik external springs attached to mass i. These are given by Equations (66) in Reference 1, page 61. The vector $\left\{\Delta x'_i, \Delta y'_i, \Delta z'_i, \Delta inp_i, \Delta inr_i\right\}$ is made up of the six incremental deflections and rotations of mass m_i, in the same body-fixed axes. The first three terms of this vector are given by a simple rotation transformation of the incremental deflections in ground axes, which are obtained directly from numerical integration of the equations of motion.

$$\begin{Bmatrix} \Delta x'_i \\ \Delta y'_i \\ \Delta z'_i \end{Bmatrix} = \left|A_i\right|^T \begin{Bmatrix} \Delta x_i \\ \Delta y_i \\ \Delta z_i \end{Bmatrix} \tag{10}$$

The last three terms of the incremental displacement vector in Equation (9) are the incremental changes in the integrals of the angular velocities of mass m_i, p_i, q_i, r_i. These are the incremental rotations of mass m_i in body-fixed axes for the integration interval being considered.

The negative sign in Equation (9) results from the fact that the forces acting on mass m_i rather than the forces within the ik springs are being considered. A positive deflection of spring ik results in a negative force on mass m_i. The energy calculated in Equation (9) includes the energy dissipated by the sliding of spring ik on the ground with a friction coefficient; hence the forces in that equation include the ground drag loads due to friction.

The crash spring energies in Equation (9) are not yet in the form desired; the crash spring energy due to each spring ik must be separated out of the total crash spring energy associated with mass m_i, CE_i. This is done simply by substituting Equations (66) of Reference 1 for the $\{X_{Ci}, Y_{Ci}, \ldots, N_{Ci}\}$ terms in Equation (9). This reformulates Equation (9) into a function of the individual crash spring forces FSP_{ijk}, where i and k refer to the ik spring and j refers to the direction of the forces on the ik spring. These forces are shown in Figure 10 on page 62 of Reference 1. The final equation for the crash spring energy associated with each spring ik is the following:

$$\left(CE_{ik}\right)_{current} = \left(CE_{ik}\right)_{previous} - \sum_{j=1}^{3} FSP_{ijk}\,\Delta vc_{ij} + TERM_{ik} \qquad (11)$$

where

$$\left\{\Delta vc_i\right\} = \begin{Bmatrix} \Delta x_i \\ \Delta y_i \\ \Delta z_i \end{Bmatrix}$$

and

$$TERM_{ik} = FSP_{i31}\,\ell_{i1}\,\Delta inq_i - FSP_{i2i}\,\ell_{i1}\,\Delta inr_i \qquad (k = 1)$$

$$TERM_{ik} = -FSP_{i32}\,\ell_{i2}\,\Delta inp_i + FSP_{i12}\,\ell_{i2}\,\Delta inr_i \qquad (k = 2)$$

$$TERM_{ik} = FSP_{i23}\,\ell_{i3}\,\Delta inp_i - FSP_{i13}\,\ell_{i3}\,\Delta inq_i \qquad (k = 3)$$

This is the crash spring energy to be used in Equation (4) to obtain the total crash spring energy, CE, for the entire vehicle. Note that CE could have been determined more directly by summing the CE_i from Equation (9) over all the masses m_i. However, the CE_{ik} associated with each spring ik is calculated so that it can be determined how much each external spring is contributing to CE.

ENERGY BALANCE DATA

The energy balance technique described in the preceding section and the information presented in the following paragraphs describe a type of format which can be of benefit to a designer during the preliminary stage of design.

The output format for the energy balance data is shown in Figures 81, 82 and 83. For a condition of 42-ft/sec vertical velocity impact and using program KRASH with the existing UH-1H helicopter math model consisting of 31 masses and 38 internal beam elements, Figure 81 shows that at time = 0.0 second only contributions to the energy term are kinetic and potential energies. The kinetic energy represents the $1/2\ MV^2$ terms while the potential energy is a function of the height the respective masses are above the ground at the initiation of impact. The internal beam energy contributions due to strain and damping are zero at this time, as is the external spring crushing energy. Figure 82 shows the energy data output during the run at time = .042 second after impact. At this time kinetic energy has decreased from 85.85% of the total energy to 58.6% of the total energy. Similarly, the potential energy has decreased from 14.15% to 8.96% of the total energy. At this time crushing energy, strain energy and damping energy as a percent of the total energy have increased to 9.8%, 7.5% and 15.2%, respectively. Furthermore, Figure 82 shows the following:

- distribution of kinetic energy and potential energy by mass item
- distribution of strain energy and damping energy by beam element
- distribution of crushing energy by external spring element

The negative terms in the damping energy output for beam elements 2 and 4 are of the order of less than .0003 percent of the total energy. The values are obviously insignificant and are considered to reflect damping inherent in the integration routine.

Figure 83 shows a summary of the energy data which is presented at the end of the computer run. The summary shows for each time increment the total energy and the amount and percentage contribution from kinetic, potential, strain damping and crushing. The data in the summary shown in Figure 83 indicates that for the illustrated case the vehicle rebounds at approximately .064 second after impact. The kinetic energy reduces from impact until .064 second after impact,then starts to increase again. The summary data presented in Figure 83 also shows that crushing energy reaches a maximum of 51.73% of the total energy at .062 second after impact and that strain energy reaches a maximum of 21.93% of the total energy at .076 second after impact.

TOTAL ENERGY *	KINETIC ENERGY	POTENTIAL ENERGY	STRAIN ENERGY	DAMPING ENERGY	CRUSHING ENERGY
3.2576D 06	2.79681D 06	4.6084D 05	0.0	0.0	0.0
PERCENT OF TOTAL ENERGY	85.853	14.147	0.0	0.0	0.0

MASS	KINETIC ENERGY	PER CENT	POTENTIAL ENERGY	PER CENT	INTERNAL BEAM IJ	I	J	STRAIN ENERGY	PER CENT	DAMPING ENERGY	PER CENT	EXTERNAL SPRING I	K	CRUSHING ENERGY	PER CENT
1	4.5736E 4	1.635	1.9706E 4	4.276											
2	2.7968E 4	1.000	6.9063E 3	1.499											
3	2.0400E 4	0.729	3.5185E 3	0.764											
4	5.6594E 4	2.024	8.2045E 3	1.780											
5	9.1472E 4	3.271	1.3260E 4	2.878											
	3.[illegible]E 5	10.965	4.4457E 4	9.647											
7	[illegible].4052E 5	8.600	6.4365E 4	13.967											
8	4.6459E 5	16.612	1.4014E 5	30.410											
9	2.9613E 4	1.059	6.8679E 3	1.490											
10	8.4562E 4	3.024	8.0315E 3	1.743											
11	5.9963E 5	21.447	5.6970E 4	12.362											
12	5.7581E 4	2.059	5.4689E 3	1.187											
13	5.7[illegible]1E 4	2.059	5.4689E 3	1.187											
14	7.8968E 3	0.282	5.4024E 1	0.012											
15	7.8966E 3	0.282	5.4024E 1	0.012											
16	3.1256E 5	11.176	2.9688E 4	6.442											
17	7.8[illegible]E 3	0.282	5.4024E 1	0.012											
18	7.8966E 3	0.282	5.4024E 1	0.012											
19	1.0101E 5	3.612	9.5940E 3	2.082											
20	1.0200E 4	0.365	2.6427E 3	0.573											
21	1.0200E 4	0.365	2.6427E 3	0.573											
22	5.4620E 4	1.953	5.1876E 3	1.126											
23	5.4620E 4	1.953	5.1876E 3	1.126											
24	9.3775E 3	0.335	2.4296E 3	0.527											
25	9.3775E 3	0.335	2.4296E 3	0.527											
26	1.8097E 4	0.647	2.2688E 3	0.492											
27	2.3032E 4	0.824	2.6875E 3	0.627											
28	3.9484E 4	1.412	6.1501E 3	1.335											
29	3.9484E 4	1.412	6.1501E 3	1.335											
30	0.0	0.0	0.0	0.0											
31	0.0	0.0	0.0	0.0											

* D Denote Double Precision

Figure 81. Energy Balance Data Output at t = 0.0 Second

TOTAL ENERGY	KINETIC ENERGY	POTENTIAL ENERGY	STRAIN ENERGY	DAMPING ENERGY	CRUSHING ENERGY
3.30[illegible]D 06	1.9357D 06 *	[illegible].3578D 05	[illegible].4685D 05	5.0[illegible]54D 05	3.2210D 05
PERCENT OF TOTAL ENERGY	58.665	[illegible].455	7.474	15.21[illegible]	9.752

MASS	KINETIC ENERGY	PER CENT	POTENTIAL ENERGY	PER CENT
1	[illegible]	[illegible]	1.[illegible]747E [illegible]	5.[illegible]
2	2.[illegible]	[illegible]	[illegible].11[illegible]E 3	1.7[illegible]
3	1.[illegible]	[illegible]	[illegible]E 3	[illegible].7[illegible]
4	[illegible]	[illegible]	[illegible].75[illegible]	1.[illegible]
5	[illegible]	[illegible]	[illegible].733[illegible] 3	[illegible]
6	[illegible]	[illegible]	[illegible]935 [illegible]	[illegible]
7	1.[illegible]	[illegible]	[illegible]F 4	[illegible]
8	3.2[illegible]	1[illegible]	1.1094E 5	37.5[illegible]
9	2.1220[illegible]	1.[illegible]	[illegible]41E 3	1.719
10	[illegible]3E [illegible]	2.493	2.985[illegible] 3	1.009
11	4.3014E [illegible]	[illegible]	[illegible]E 4	7.054

INTERNAL BEAM Ie	I	J	STRAIN ENERGY	PER CENT	DAMPING ENERGY	PER CENT
1	1	[illegible]	1.[illegible]5D 1	[illegible].008	1.[illegible]5D 1	0.004
[illegible]	[illegible]	[illegible]	[illegible]33D 1	[illegible].024	-2.[illegible]7D 1	-0.004
[illegible]	[illegible]	[illegible]	3.[illegible]D 1	0.013	1.8215D 0	0.000
[illegible]	[illegible]	[illegible]	[illegible].5794D 1	0.010	-[illegible].2497D [illegible]	-0.001
[illegible]	[illegible]	[illegible]	[illegible].1901D 1	0.021	1.7038D 1	0.003
[illegible]	[illegible]	[illegible]	[illegible].7513D 1	0.019	2.9828D 1	0.006
7	5	[illegible]	5.17[illegible]D 1	[illegible].021	2.4847D 1	0.005
8	5	20	1.0090D [illegible]	0.041	1.7220D 1	0.003
9	5	21	1.0068D 2	0.041	1.7223D 1	0.003
10	5	2[illegible]	7.0115D 2	0.284	1.2278D 2	0.024
11	5	23	7.0116D 2	0.284	1.2278D 2	0.024

EXTERNAL BEAM I	K	CRUSHING ENERGY	PER CENT
10	3	1.4764D 5	45.[illegible]
11	3	5.3878D 4	16.7[illegible]
12	3	4.0787D 3	1.2[illegible]
13	3	4.0809D 3	1.257
14	3	5.2955D 3	1.644
15	3	5.2958D 3	1.644
16	3	6.4115D 4	19.906
17	3	5.1023D 3	1.584
1[illegible]	3	5.1023D 3	1.584
22	3	1.3751D 4	4.269
23	3	1.3751D 3	4.269

* D Denote Double Precision

For Illustrative Purpose Only the Energy Associated with Masses and Structural Members 1 through 11 is shown

Figure 82. Energy Balance Data Output at t = 0.042 Second.

TIME	TOTAL ENERGY	PERCENT	KINETIC ENERGY	PERCENT	POTENTIAL ENERGY	PERCENT	STRAIN ENERGY	PERCENT	DAMPING ENERGY	PERCENT	CRUSHING ENERGY	PERCENT
0	3.256D6*	100.	2.796E6	85.85	4.608E5	14.15	0.0	0.0	0.0	0.0	0.0	0.0
.01	3.259D6	100.04	2.662E6	81.71	4.186E5	12.85	4.883E4	1.5	1.030E5	3.16	2.563E4	0.79
.02	3.269D6	100.35	2.458E6	75.21	2.781E5	11.57	1.145E5	3.6	2.603E5	8.57	3.741E4	1.14
.03	3.296D6	101.15	2.234E6	67.80	3.395E5	10.30	2.221E5	6.74	4.602E5	13.99	3.919E4	1.19
.04	3.303D6	101.39	2.038E6	61.66	3.028E5	9.17	2.432E5	7.38	5.011E5	15.17	2.189E5	6.63
.05	3.303D6	101.41	1.168E6	35.38	2.708E5	8.2	3.081E5	9.33	5.153E5	15.40	1.041E6	31.5
.06	3.303D6	101.4	2.622E5	7.94	2.533E5	7.67	5.231E5	16.84	5.584E5	16.90	1.706E6	51.65
.062	3.303D6	101.4	2.080E5	6.30	2.522E5	7.64	5.698E5	17.08	5.698E5	17.25	1.708E6	51.73
.064	3.303D6	101.47	2.017E5	6.11	2.520E5	7.63	5.815E5	18.24	5.815E5	17.61	1.665E6	50.42
.070	3.303D6	101.46	4.016E5	12.15	2.560E5	7.75	6.112E5	21.03	6.112E5	18.50	1.340E6	40.57
.076	3.305D6	101.46	8.053E5	24.36	2.659E5	8.04	6.298E5	21.93	6.298E5	19.06	8.795E6	26.61
.080	3.307D6	101.53	1.137E5	34.38	2.748E5	8.31	6.467E5	19.53	6.467E5	19.55	6.028E5	18.23

*) denotes double precision

Computer Printout is Every .002 Second. For Illustrative Purpose an Abbreviated Computer Printout is Shown

Figure 83. Energy Data Output Summary.

REVISED USER'S GUIDE

This section describes all the input necessary to run the program, and the output available from the program.

Input

The input data format is described in detail in this section and is shown in Figure 84. Unless otherwise specified, all quantities are input in inch, pound, second, and radian units. For cards 0102 and following the input format is 6E12.0 unless otherwise noted. Each card has 6 fields; each field is 12 columns wide. As an example of this format, the number 126.08 can be input in the following ways:

			1	2	6	.	0	8			
			1	2	6	.		8			

	1	.	2	6	0	8				E	2
	1	2	6	0	8	.			E	-	2

Blank columns are treated as zeros. When the E format is used, the exponent must be right justified in the field. Integer formats with field widths of 1, 2 or 3 are also used. The numbers in these locations must be right justified integers. Sequence numbers in columns 77 through 80 should be used corresponding to those shown in the input format to facilitate deck assembly and changes. All tabular input is linearly interpolated between input values and extrapolated beyond the two end values, if necessary.

Card 0100 - This card contains the title for the case being analyzed. All text material on card 0100 is reproduced at the top of every page of the output and on every plot.

Card 0101 - N is the total number of lumped masses. The maximum allowable number of masses is 80. ΔPrint/Δt is the integer multiple of Δt at which output is printed. Δt is the numerical integration time interval. t_{max} is the time span being analyzed.

Cards 0102 through 0104 - These cards contain the overall vehicle initial conditions. $\dot{x}_G$, $\dot{y}_G$, and $\dot{z}_G$ are the ground axes components of the initial c.g. velocity. p', q', and r' are the c.g. coordinate system components of the initial angular velocity of the vehicle. p' is the roll velocity, q' the pitch velocity, and r' the yaw velocity. ϕ', θ', and ψ' are the Euler angles relating the initial position of the vehicle to ground coordinates. ϕ' is the roll angle, θ' the pitch angle, and ψ' the yaw angle. z_G is the negative of the initial vehicle c.g. height above ground. If this input is zero (blank), the initial condition subroutine computes a value of z_G so that the lowest extremity of the vehicle is .1 inch above the ground.

Cards 0201 through 02XX - N of these cards are used to input the weights (not masses) of the N lumped masses.

Cards 0301 through 03XX - N of these cards are required. Each card inputs the six moments and products of inertia for the ith maxx, i = 1, 2, ..., N.

Cards 0401 through 04XX - N of these cards are used to input the coordinates of the N lumped masses. x_i'' is the Fuselage Station (increasing aft), y_i'' is the Butt Line (positive left), and z_i'' is the Water Line (increasing upward).

Card 0500 - NI is the number of masses having nonzero He_{xi}, He_{yi}, He_{zi} (angular momenta) or ϕ_i'', θ_i'', ψ_i'', which are the Euler angles relating the c.g. axes to the ith mass body fixed axes. The above quantities are normally zero, so only nonzero values are input on cards 050I through 05NI. i_1, i_2, ..., i_{NI} are the actual i's or mass numbers that have nonzero input data for any of the above quantities. NI and i through i_{NI} are input in integer format I2. If NI equals zero, cards 0501 through 05NI are not input; however, card 0500 is always required. If NI equals zero, a bland card for card 0500 is input.

Cards 0501 through 05NI - As noted above, these cards are used to input any nonzero values of He_{xi}, He_{yi} or ϕ_i'', θ_i'', ψ_i''. One card is used for each mass i having nonzero input. The masses are ordered according to the sequence specified on card 0500. He_{xi}, He_{yi}, and He_{zi} are the body axes components of the angular momenta of masses m_i, due to rotation of internal masses within m_i. These are normally zero. ϕ_i'', θ_i'', ψ_i'' are the Euler angles from the c.g. axes to the ith mass axes. If the ith mass body-fixed axes are parallel to the vehicle c.g. coordinate axes. which is usually the case, these are all zero. Note that if any nonzero values are input, then θ_{ij} and ψ_{ij} on cards 0901 through 090M must be input.

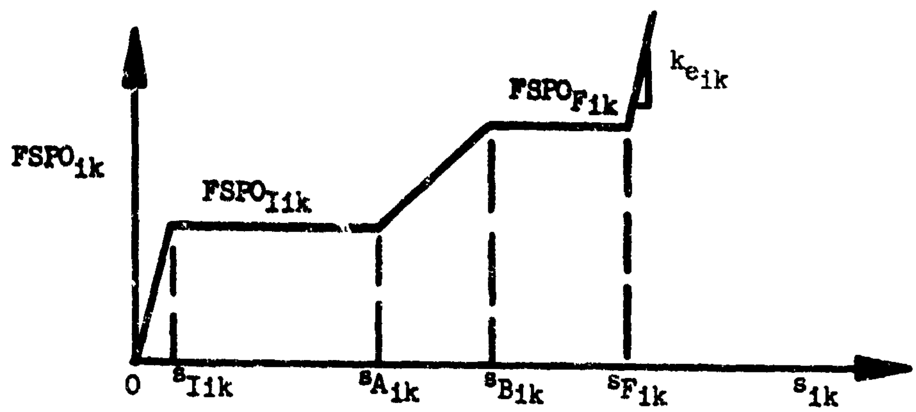
Cards 0600 through 06NI - NI is the number of masses having nonzero l_{c_i}, which are the aerodynamic lift constants used in Equation (5) on page 30 of Reference 1. i_1, i_2, ..., i_{NI} are the actual mass numbers having nonzero l_{c_i}: If all l_{c_i} are zero, card 0600 is input as a blank card and cards 0601 through 06NI are not input. One card is used for each nonzero l_{c_i} input, with the ordering defined on card 0600.

Cards 0701 through 070p - As many cards as necessary are used to input data for the external springs. The maximum allowable number of external springs is 50. Each spring is identified by an ik pair, where i defines the mass to which the spring is attached and k defines the direction of the spring. k = 1, 2 and 3 correspond to springs in the x, y and z directions, in mass i body-fixed axes. l_{ik} is the free length of the external spring ik. l_{ik} is positive if it radiates out from mass m_i in the positive direction of the ith mass body axes; l_{ik} is negative if it radiates in the opposite direction. Springs in both directions are not allowed. mu_{ik} is the friction coefficient between the ground and the end of the ik spring. ke_{ik} is the linear unloading stiffness and also the bottoming stiffness for the ik spring.

If no external springs are used, card 0701 is input blank and the next card input is 0901.

Card 07XX - A blank card in this location is required to terminate the above ik external spring list.

Cards 0801 through 080p - External spring load-deflection curve parameters are input on these cards, one card per ik spring, ordered as in the ik list on cards 0701 through 070p. The program is written so that a table of the following form is input:



This table is defined by six parameters S_{Iik}, S_{Aik}, S_{Bik}, S_{Fik}, $FSPO_{Iik}$, and $FSPO_{Fik}$, which are input on cards 0801 through 080p.

Cards 0901 through 090M - These cards contain the Euler angles ϕ_{ij}, θ_{ij}, and ψ_{ij} for all internal beams ij. The beam interconnections are defined by the i's and j's input. i must be less than j, but there is no other requirement on the ordering of the ij pairs. ϕ_{ij} is always input; θ_{ij} and ψ_{ij} need not be input if ϕ_i'', θ_i'' and ψ_i'' on cards 0501 through 05NI are all zero. In the latter case, θ_{ij} and ψ_{ij} are computed in initial conditions. ϕ_{ij} will normally be zero. The maximum allowable number of internal beams is 100.

Card 09XX - A blank card is required here to terminate the ij pair internal beam list.

Cards 1001 through 1006 - These six cards are used to input the 6 x 6 linear stiffness matrix $|K_{ij}|$ for the first ij beam, listed on card 0901. Each card inputs one row of the matrix.

Cards 1007 through 1XXX - As many cards as necessary are used to input all the remaining 6 x 6 $|K_{ij}|$ matrices. These matrices must be ordered the same as the ij pairs are ordered on cards 0901 through 090M.

Cards 2001 through 200M - These cards are used to input the $\bar{C}_{ij}$ for all the ij pairs defined on cards 0901 through 090M. $\bar{C}_{ij}$ is the damping ratio (damping/critical damping) for the isolated system consisting of masses m_i and m_j connected by beam ij. Values of $\bar{C}_{ij}$ between .01 and .05 are generally representative of the structural damping.

Cards 2101 through 210q - These cards are used to specify which beam elements (ij pairs) and directions (l) have nonlinear stiffness properties. l varies from 1 to 6 corresponding to the x, y, z, ϕ, θ, ψ, directions in beam axes. Only beam elements and directions having nonlinear properties (KR $\neq$ 1) are input. For each ijl combination listed, a table of KR (stiffness reduction factor) versus deflection is input on the following cards. The NP's are the number of points in the following tables. For all itjl combinations not listed, KR = 1 for the entire run. The maximum allowable number of ijl combinations (nonlinear KR tables) is 80. The maximum allowable number of points per table is 15. For a completely linear analysis, card 2101 is blank and the next card input is 3001.

Card 21XX - A blank card is required here to terminate the ijl list of nonlinear beam/direction combinations.

Cards 2201 through $22NP_1$ - These NP_1 cards are used to input the deflection (vb_{ijl}) versus KR_{ijl} table for the ijl combination listed on card 2101. KR_{ijl} normally starts at 1.0 zero deflection (or rotation), corresponding to linear behavior, and varies in any desired manner thereafter to define a general load-deflection curve. Note that KR is not the actual load, but rather the derivative of load with respect to deflection, i.e., the slope of the load-deflection curve.

Cards 22X1 through 2XXX - As many cards as necessary are used to input the KR_{ijl} vs. vb_{ijl} tables for the remaining ijl combinations listed on cards 2102 through 210q above. Note that each table can have a different number of data points NP_i.

Cards 3001 through 300r - These cards are used to identify which internal beam elements ij have nonstandard maximum deflections for rupture (v_{maxijl}). The standard deflections built into the program are 100 inches for deflections and 100 radians for rotations. These numbers were deliberately chosen to be very high so that rupture would not occur unless reasonable $v_{max's}$ were specified. If no nonstandard $v_{max's}$ are to be input, card 3001 is input blank, and the next card input is 5001.

Card 30XX - This blank card is required to terminate the preceding ij list for nonstandard v_{maxijl}.

Cards 3101 through 310r - These cards are used to input the nonstandard $v_{maxijl's}$, one card for each ij beam specified on cards 3001 through 300r. Each card inputs the six $v_{max's}$ for one ij beam, ordered x, y, z, ϕ, θ, ψ in beam axes. v_{maxijl} defines the maximum allowable deflection before rupture occurs. After rupture, all forces in beam ij go to zero, regardless of the direction in which the rupture occurred.

Cards 5001 through 5025 - These cards are used to specify the time history output plots desired. The only input for these cards is either a 1 or a blank. A 1 results in the output of a time history plot for the response quantity indicated; a blank results in no plot for that item. For example, a 1 in the 13th column of card 5003 specifies that a time history plot of z_{13} is to be generated. For cards 5001 through 5012, the column number in which the 1 is input indicates which mass i is desired. For cards 5013 through 5024, the column number in which the 1 is input indicates which ij pair is desired, where the ij pairs are ordered as on cards 0200 through 02XX.

Plots are available for the displacements, velocities and accelerations of all the lumped masses, all the external spring compressions S_{ik}, and all the beam ij total deflections/rotations (vb_{ij}) and forces/moments (F_{ij}). The latter two items are in beam ij axes. Also available are plots of the DRI (Dynamic Response Index). These are identified by the DRI ij element, as described on card 7000 below. The plot variables are labelled automatically, and the plot scales are chosen automatically. The user merely has to specify which plots are desired. Up to 150 plots can be requested per run. Thirty thousand data points are stored for plotting, with the plot time interval depending on run time and number of plots requested. Thus, if the maximum of 150 plots are requested, 200 points will be saved to generate each plot. If the maximum run time is .2 second, this will give one data point every .001 second. For the types of problems analyzed, this appears to be a marginally acceptable resolution. Requesting fewer plots automatically increases the number of points per plot and, hence, the resolution.

Card 6000 - P is the mass to be used to locate the mass penetration control volume. The format is I2. If no mass penetration calculations are required, this card is input blank and card 6001 is not required.

Card 6001 - xn, xp, yn, yp, zn, and zp are the six distances (all positive), measured from the control mass P to the six sides of the control volume. These are measured along the positive (p) and negative (n) body-fixed axes for mass mp.

Card 7000 - This card is used to specify which internal beam ij elements, if any, are to be treated as DRI (Dynamic Response Index) elements. For example, if the 15th ij pair listed on cards 0901 through 090M is to be a DRI element, then a 1 is input in column 15 of card 7000. For DRI beam elements, the forces in beam ij drive mass j but not mass i. To understand the physical significance of this, refer to Reference 1, page 73, which explains the concept of a DRI.

Cards 8000 and 8001 - Cards 8000 and 8001 are used to specify il (mass-direction) pairs for which it is desired to input a time history table of acceleration. Thus, any mass can be driven by a specified acceleration in any direction. The 6 directions are ordered x, y, z, ϕ, θ, ψ in mass i body-fixed axes. The format is 24 (I2I1), where the l is right justified in the field of 3 and the i is right justified in the left two columns of the field of 3. A maximum of 48 input tables are allowed. For example, driving mass 3 in the y direction would be specified as |032|.

When any acceleration table is input, that acceleration replaces the normally computed acceleration, so it becomes a driving force to the system. If less than 24 il pairs are specified, only card 8000 is required (omit 8001). If 24 or more il pairs are input, cards 8000 and 8001 are both required (if exactly 24 il pairs are input, card 8001 will be blank, but must be input).

Card 8010 - N_1 is the number of data points in the following acceleration time history table, applicable to the first il pair on card 8000. The maximum allowable value of N_1 is 50.

Cards 8011 through 801N_1 - N_1 cards are used to input the time history table of acceleration for the first il pair. Each card inputs one time and the corresponding acceleration.

Cards 8XX0 through 8XXN_q - The remaining acceleration time history tables are input on these cards, in the format described above. The tables are ordered according to the sequence of il pairs defined on cards 8000 and 8001.

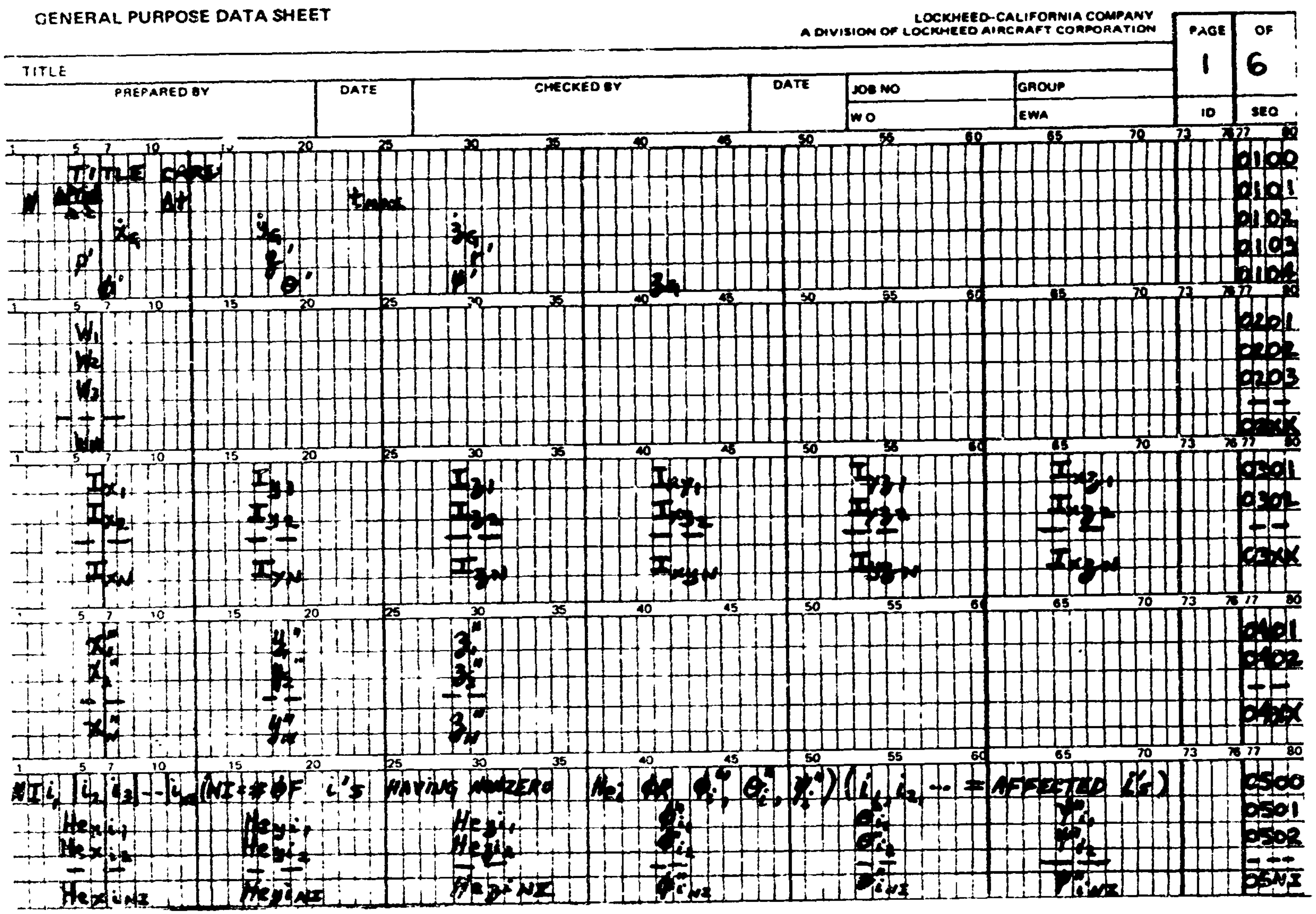


Figure [illegible]. Input Data Format.

GENERAL PURPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

TITLE:						PAGE 2	OF 6
PREPARED BY	DATE	CHECKED BY	DATE	JOB NO. / WO	GROUP / EWA	ID	SEQ

1–76	SEQ (77–80)
NI i_1 i_2 i_3 — i_N (NI = No. OF i's HAVING NONZERO ℓ_{ij} (i_1, i_2 — = AFFECTED i's)	0600
ℓ_{i_1}	0601
ℓ_{i_2}	0602
— —	— —
$\ell_{i_{NI}}$	06NI
i_1 k_1 ℓ_{ik_1} MU_{ik_1} K_{ik_1} (INPUT ik PAIRS DEFINING	0701
i_2 k_2 ℓ_{ik_2} MU_{ik_2} K_{ik_2} EXTERNAL SPRINGS)	0702
— — — — — — — — — —	— —
i_p k_p ℓ_{ik_p} MU_{ik_p} K_{ik_p}	070P
(BLANK CARD REQUIRED TO TERMINATE ik LIST)	07XX
SI_{ik_1} SA_{ik_1} SB_{ik_1} SF_{ik_1} $FSPO_{I\,ik_1}$ $FSPO_{\phi\,ik_1}$	0801
SI_{ik_2} SA_{ik_2} SB_{ik_2} SF_{ik_2} $FSPO_{I\,ik_2}$ $FSPO_{\phi\,ik_2}$	0802
— — — — — — — — — — — —	— —
SI_{ik_p} SA_{ik_p} SB_{ik_p} SF_{ik_p} $FSPO_{I\,ik_p}$ $FSPO_{\phi\,ik_p}$	080P
i_1 j_1 ϕ_{ij_1} θ_{ij_1} ψ_{ij_1}	0901
i_2 j_2 ϕ_{ij_2} θ_{ij_2} ψ_{ij_2} (INPUT ij PAIRS DEFINING	0902
— — — — — — — — INTERNAL BEAMS)	— —
i_m j_m ϕ_{ij_m} θ_{ij_m} ψ_{ij_m}	090M
(BLANK CARD REQUIRED TO TERMINATE ij LIST)	09XX
$K(ij)_{11}$ $K(ij)_{12}$ $K(ij)_{13}$ $K(ij)_{14}$ $K(ij)_{15}$ $K(ij)_{16}$	1001
$K(ij)_{21}$ $K(ij)_{26}$	1002
$K(ij)_{31}$ (INPUT 6×6 K MATRIX FOR 1ST ij INTERNAL BEAM) $K(ij)_{36}$	1003
$K(ij)_{41}$ $K(ij)_{46}$	1004
$K(ij)_{51}$ $K(ij)_{56}$	1005
$K(ij)_{61}$ $K(ij)_{62}$ $K(ij)_{63}$ $K(ij)_{64}$ $K(ij)_{65}$ $K(ij)_{66}$	1006

Figure 84. (Continued)

GENERAL PURPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
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TITLE						PAGE 3	OF 6
PREPARED BY	DATE	CHECKED BY	DATE	JOB NO / WO	GROUP / EWA	ID	SEQ

		SEQ
		1007
	(INPUT REMAINING 6x6 K MATRICES FOR EACH (ij) BEAM,	--
	6 CARDS PER MATRIX. ORDER MATRICES SAME AS (ij) ELEMENTS	--
	ARE ORDERED ON CARDS 0901–090M.)	--
		1XXX
C_{ij1}		2001
C_{ij2}		2002
--		--
C_{ijm}		200M
i_1 j_1 ℓ_1 NR_1	(THESE CARDS ARE USED TO SPECIFY WHICH BEAM ELEMENTS (ij) AND	2101
i_2 j_2 ℓ_2 NR_2	DIRECTIONS (ℓ) (x, y, z, ϕ, θ, or ψ) HAVE NONLINEAR STIFFNESS	2102
-- -- -- --	PROPERTIES (KR ≠ 1). ALL ijℓ COMBINATIONS NOT LISTED ARE LINEAR (KR=1)	--
i_g j_g ℓ_g NR_g	FOR ALL DEFLECTIONS. NR IS # OF POINTS IN FOLLOWING KR TABLE.)	210g
	(BLANK) CARD REQUIRED TO TERMINATE ijℓ LIST)	21XX
$vb(ij\ell_1)_1$	$KR(ij\ell_1)_1$ (DEFLECTION (vb) VERSUS STIFFNESS REDUCTION FACTOR (KR)	2201
$vb(ij\ell_1)_2$	$KR(ij\ell_1)_2$ TABLE INPUT FOR 1ST NONLINEAR ijℓ COMBINATION,	2202
--	-- USING NP CARDS	--
$vb(ij\ell_1)_{NP_1}$	$KR(ij\ell_1)_{NP_1}$	22NP
$vb(ij\ell_g)_1$	$KR(ij\ell_g)_1$	22X1
$vb(ij\ell_g)_2$	$KR(ij\ell_g)_2$ (vb VERSUS KR TABLES INPUT FOR REMAINING	22X2
--	-- ijℓ COMBINATIONS.)	--
$vb(ij\ell_g)_{NP_g}$	$KR(ij\ell_g)_{NP_g}$	22XX

Figure .. (Continued)

GENERAL PURPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

TITLE						PAGE 4	OF 6
PREPARED BY	DATE	CHECKED BY	DATE	JOB NO / W O	GROUP / EW	ID	SEQ

Cols 1–10	Cols 11–72	SEQ (77–80)
i_1 j_1	(THESE CARDS ARE USED TO SPECIFY WHICH BEAM ELEMENTS (ij)	3001
i_2 j_2	HAVE NON-STANDARD MAXIMUM DEFLECTIONS, INPUT ON FOLLOWING	3002
— —	CARD SET. STANDARD MAXIMUM DEFLECTION = 100 INCHES OR RADIANS.)	— —
i_r j_r		300r
		30XX

1–10	11–20	21–35	36–50	51–60	61–72	SEQ (77–80)
$v_{max}(ij1)_1$	$v_{max}(ij1)_2$	$v_{max}(ij1)_3$	$v_{max}(ij1)_4$	$v_{max}(ij1)_5$	$v_{max}(ij1)_6$	3101
$v_{max}(ij2)_1$	$v_{max}(ij2)_2$	$v_{max}(ij2)_3$	$v_{max}(ij2)_4$	$v_{max}(ij2)_5$	$v_{max}(ij2)_6$	3102
—	—	—	—	—	—	— —
$v_{max}(ijr)_1$	$v_{max}(ijr)_2$	$v_{max}(ijr)_3$	$v_{max}(ijr)_4$	$v_{max}(ijr)_5$	$v_{max}(ijr)_6$	310r

Figure . (Continued)

GENERAL PURPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
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PAGE	OF
5	6

TITLE:

PREPARED BY	DATE	CHECKED BY	DATE	JOB NO / W O	GROUP / WA	ID	SEQ

PLOT OUTPUT CARDS

1 in m^{th} column means plot that item for mass $i = m$

1 in n^{th} column means plot that item for n^{th} ij pair

65–70	SEQ (77–80)
xi	5001
yi	5002
zi	5003
xi	5004
yi	5005
zi	5006
[illegible]	5007
[illegible]	5008
[illegible]	5009
Si	5010
Si	5011
Si	5012
Vij	5013
Vij	5014
Vij	5015
Vij	5016
Vij	5017
Vij	5018
Fij	5019
Fij	5020
Fij	5021
Fij	5022
Fij	5023
Fij	5024
DRij	5025

Figure 8.. (Continued)

GENERAL PURPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

TITLE:						PAGE	OF
PREPARED BY	DATE	CHECKED BY	DATE	JOB NO.	GROUP	6	6
				W.O.	EWA	ID	SEQ

P

$\overline{x}_n$ $\overline{x}_p$ $\overline{y}_n$ $\overline{y}_p$ $\overline{z}_n$ $\overline{z}_p$

DRI ELEMENT SPECIFICATION

il_1 il_2 il_3

N_1 il_N

t_1 ACC_{11}

t_2 ACC_{12}

t_{N_1} ACC_{1N_1}

N_2

t_1 ACC_{21}

t_2 ACC_{22}

t_{N_2} ACC_{2N_2}

F . (Continued)

Print Output

First, all the input data is printed out, with self-explanatory identifying titles. Next, at each print time ($= \Delta Print/\Delta t \times \Delta t$), the data shown in Figure 85 is printed out. At the top of each page, the case identification data is printed out (from input card 0100). Then the current value of time t is printed.

Next, for each of the N masses, five lines of data are output. x_i, y_i, and z_i are the ground coordinates of m_i. $\dot{x}_i$, $\dot{y}_i$, and $\dot{z}_i$ are the ground axes components of the velocity of m_i. $\dot{u}_i$, $\dot{v}_i$, $\dot{w}_i$ are the time derivatives of u_i, v_i, and w_i. (These are not equal to the acceleration of m_i, as can be seen from Equation (81), Reference 1.) XACCEL, YACCEL, ZACCEL are the body axes components of the acceleration of m_i.

ϕ, θ, and ψ are the Euler angles defining the attitude of body m_i, in roll, pitch and yaw. $\dot{\phi}_i$, $\dot{\theta}_i$, and $\dot{\psi}_i$ are the time derivatives of ϕ_i, θ_i, and ψ_i. $\dot{p}_i$, $\dot{q}_i$, and $\dot{r}_i$ are the body axes components of the angular velocity of m_i; they are the velocities in roll, pitch, and yaw, respectively. p_i, q_i, and r_i are the body axes components of the angular acceleration of m_i.

Following that output, the running time sums of the internal forces $\left\{F_{ij}\right\}$ (Equation (27), Reference 1) are printed out; the six forces and moments for each ij pair are printed on a line preceded by the identifying i and j. Next, the running time sums of the beam deflections $\left\{\nu_{b_{ij}}\right\}$ (Equation (26), Reference 1) are printed out in the same format.

Finally, the external spring compressions s_{ik} (Equation (47), Reference 1) are printed out. Each line starts with the i, followed by the s_{ik} for $k = 1, 2, 3$. Only values of i for which a spring is input are shown.

During the course of the run, if any ruptures or control volume mass penetrations occur, the appropriate information is printed out. When a rupture occurs, the word RUPTURE is printed, followed by four items:

1. The ij pair that ruptured, where the numbering corresponds to the ordering of the ij pairs as input on cards 0200 through 02XX.

2. The l (from 1 to 6) indicating in which direction (in beam axes) the rupture occurred. These are ordered x, y, z, ϕ, θ, and ψ. See Figure 24 (Reference 1) for the directions of the beam axes.

3. The $\nu_{b_{ijl}}$ at the time of rupture. This is the total deflection, in beam axes, in the direction of the rupture.

4. The $\nu_{max_{ijl}}$ which defines the maximum allowable beam deflection in the l^{th} direction. This is an input constant.

If a control volume mass penetration occurs, the mass which penetrates and the time are printed out. At the end of the run, the ruptures and mass penetrations that occurred during the run are summarized in tables for ready reference.

Sample Cases

Two sample cases are presented. The first sample case represents a combined vertical and lateral impact condition. The vertical impact velocity is 23 ft/sec and the lateral impact velocity is 18.6 ft/sec. The mathematical model is the 31 mass representation shown in Volume I, Figure 6 and Table VI. The sample output for one time period is shown in Figure 85. The input data, which follows the User's Guide Input format (Figure 84), is presented in Figure 86.

Sample output plots are provided for the engine mass vertical velocity, engine mass vertical acceleration and engine mount support vertical deflection in Figures 87, 88 and 89, respectively. Figures 90, 91 and 92 provide similar sample plots for the lateral velocity, lateral acceleration and mount lateral displacement, respectively. Figures 93 and 94 show the forward and aft DRI plots, respectively, for the combined vertical and lateral impact velocity case. The engine vertical responses shown in Figures 87 (velocity), 88 (acceleration) and 89 (displacement) can be compared to Figures 17, 18 and 19 in Volume II, Reference 1 to show that the revised program KRASH performs in the same manner as the final submitted program KRASH from the previous study (Reference 1).

The second sample case provided in this section is the three-dimensional velocity impact condition. The initial c.g. velocity for this case is a combined 40 ft/sec velocity in which the velocity vector components are:

$$V_x = 27 \text{ ft/sec} \qquad V_y = 18.6 \text{ ft/sec} \qquad V_z = 23 \text{ ft/sec}$$

The initial vehicle attitude is flat (zero roll, pitch and yaw angles), and the initial angular velocities are zero. Figure 101 (page 140) in Volume I shows the mathematical model representation for this condition The model consists of 32 lumped masses. It is the same model used in the previous sample problem except for the extra mass location which represents the rotor blade during a potential mass penetration (of the upper cabin) condition. The input data for this sample problem is provided in Figure 95. A sample output for one time period is shown in Figure 96. Figures 97 through 99 show the engine mass vertical, lateral and longitudinal velocities, respectively. Figures 100 through 102 present the engine mass vertical, lateral and longitudinal accelerations, respectively. Figures 103 through 105 show the engine support mount vertical, lateral and longitudinal deflections, respectively. The forward and aft DRI's are presented in Figures 106 and 107.

Program Listing

A complete listing of the computer program KRASH, including subroutines, is presented in Figure 108.

RUN 31-52 DROP TEST CORRELATION 20G/18G ENGINE 100

TIME = 0.15000

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 1	-3.250560 02	-4.317090 01	-1.106250 02	-8.361200-02	9.347450-02	-1.601300-02
	-1.930260 02	-1.715540 02	1.702990 02	-1.276540 00	4.516750 00	1.657800 00
	-2.053190 02	-1.873710 02	1.357490 02	-1.431280 00	4.352960 00	2.043800 00
	-3.506280 02	1.497320 03	-5.605120 03	-5.452120 01	1.41[illegible]60 02	5.834700 01
	1.614580 00	3.295260 00	-1.1[illegible]1090 01			
MASS 2	-2.661260 02	-3.917940 01	-5.452410 01	-2.275900-02	5.227000-02	3.797920-02
	-1.446050 01	-7.145320 01	-2.025450 01	-3.938050-01	6.004730-01	-3.878030-[illegible]1
	-1.608150 01	-7.035360 01	-2.273050 01	-3.735440-01	6.091310-01	-3.73508[illegible]
	2.307880 03	3.825090 03	-7.145730 03	-5.934810 01	-3.199530 01	-4.206[illegible] [illegible]1
	5.675000 00	9.903130 00	-1.641880 01			
MASS 3	-1.023130 02	-3.2677[illegible]0 01	-3.726080 01	-1.929990-02	3.215990-02	3.293480-02
	-2.123310 00	-1.085600 02	-1.011980 02	6.164260-01	3.824960-01	-1.067390-02
	-2.439980 00	-1.064550 02	-1.034030 02	6.167690-01	3.826310-01	-3.284760-03
	9.054170 02	-6.119310 02	-6.050930 02	-2.245050 01	-3.372250 01	-7.738650 00
	2.242230 00	-1.420070 00	-2.253410 00			
MASS 4	-7.246160 01	-3.155460 01	-2.908360 01	-1.934330-02	2.62837D-02	3.047130-02
	1.497750 00	-1.130470 02	-1.120220 02	6.995640-01	3.579740-01	1.050750-01
	9.975790-01	-1.108520 02	-1.142000 02	6.967810-01	3.558600-01	1.127420-01
	5.765360 02	-5.147920 02	-5.828620 00	-1.785700 01	-1.984840 01	2.546640 00
	1.42[illegible]710 00	-1.127220 00	-2.161230-01			
MASS 5	-2.3[illegible]0 01	-3.011490 01	-3.033350 01	-1.938630-02	2.512670-02	2.876610-02
	9.2[illegible]840-01	-1.062580 02	-1.297590 02	7.008600-01	3.765770-01	1.790510-01
	1.132230 00	-1.037050 02	-1.318070 02	6.963610-01	3.730370-01	1.862610-01
	5.397[illegible]30 02	-3.576680 02	8.804820 02	-1.781500 01	-1.638310 01	3.840880 00
	1.320[illegible]0 00	-6.887080-01	2.092860 00			
MASS 6	-1[illegible]2410 00	-2.952470 01	-3.083570 01	-1.947340-02	2.079660-02	2.537870-02
	[illegible]1910-01	-1.012070 02	-1.353860 02	7.049810-01	4.611280-01	2.365620-[illegible]
	8.[illegible]-01	-9.845330 01	-1.413430 02	7.000620-01	4.564350-01	2.454450-[illegible]
	3.3[illegible]4740 [illegible]	-1.315000 02	1.068360 03	-1.806800 01	-4.855560-01	1.672730 01
	7.568[illegible]10 [illegible]1	-8.379550-02	2.588210 00			
MASS 7	-4.891240 01	-3.181350 01	-7.003260 01	-2.166540-02	2.590640-02	2.931840-02
	-1.326[illegible]70 01	-8.455370 01	-1.266060 02	6.222380-01	3.239300-01	1.580260-01
	-1.244[illegible] 01	-8.135820 01	-1.28[illegible]40 02	6.181440-01	3.204310-01	1.649530-01
	[illegible].722[illegible] 03	1.513070 02	9.466610 02	3.196940 01	-2.349160 01	8.335260 00
	4.39[illegible] 00	5.926710-01	2.332540 00			
MASS 8	2.420610 00	3.075200 01	-8.175580 01	-[illegible]300-02	1.066320-02	6.315720-02
	-3.882600 01	-3.027150 01	-1.460640 02	5.[illegible]3010-01	6.652860-01	4.513780 00
	-3.909440 01	-2.153480 01	-1.475330 02	5.281700-01	4.736310-01	4.537640 00
	-2.394060 03	-1.079560 02	1.010520 03	5.796460 01	5.832480 00	-1.574990 02
	-6.130110 00	-5.3744[illegible]0-01	2.636430 00			

Figure 85. Output Data Format.

RUN 31-52 DROP TEST CORRELATION 206/186 ENGINE 100

TIME = 0.16000

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 9	-2.246780 00	-3.024200 01	-5.943700 01	-2.916510-02	6.843480-03	2.781560-02
	-1.508220 01	-7.036700 01	-1.400950 02	1.375520 00	5.797620-01	6.234240-01
	-1.607430 01	-6.580190 01	-1.421880 02	1.371250 00	5.613360-01	6.400510-01
	-7.337330 02	-4.533550 02	1.203420 03	2.233270 00	5.829820 01	-6.552810-01
	-1.998530 03	-6.960330-01	2.907300 00			
MASS 10	-2.360240 01	-2.971910 01	-1.406110 01	-1.872680-02	1.204580-02	2.430870-02
	7.861460 00	-1.182090 02	-1.068850 02	5.719250-01	2.512350 00	3.508480-01
	6.273040 00	-1.163440 02	-1.090150 02	5.676990-01	2.505340 00	3.978060-01
	4.308890 02	2.924900 02	-1.324950 03	-3.101970 01	-4.414450 00	7.304090 00
	5.786340-01	9.245420-01	-3.644340 00			
MASS 11	-1.608210 00	-2.918580 01	-1.438820 01	-2.069040-02	1.628410-02	2.342370-02
	6.995640 00	-1.126740 02	-1.394260 02	7.104940-01	3.943200-01	9.124290-02
	6.624670 00	-1.099000 02	-1.416400 02	7.090080-01	3.022670-01	9.750740-02
	3.493150 02	-1.223560 02	1.040640 03	1.837500 01	6.261370 00	1.954090 01
	8.217710-01	-5.514580-02	2.488920 00			
MASS 12	6.487680 01	1.739160 01	-1.750720 01	-7.587180-02	5.052170-02	1.602980-02
	-3.061890 00	-1.150860 02	-2.251460 02	-3.959520 00	4.635010-01	1.345040-01
	6.470020 00	-9.762990 01	-2.331790 02	-3.966320 00	4.519850-01	1.690790-01
	-1.971370 03	1.142580 03	4.902580 02	2.466370 02	-3.456910 01	-.599440 01
	-5.337450 00	5.668720-01	2.265710 00			
MASS 13	6.87 040 01	-7.254030 01	-1.368730 01	-6.458330-02	4.210670-02	2.134310-02
	1.071970 01	-1.016340 02	4.693570 01	-8.345480-01	4.714490-01	-1.821620-03
	6.305120 00	-1.046720 02	4.057470 01	-8.344710-01	4.705840-01	2.861040-02
	-6.120580 02	1.276240 03	-5.114460 03	-7.663390 01	-5.813970 00	-4.439880 01
	-2.046550 00	3.394520 00	-1.303140 01			
MASS 14	-2.474030 01	3.352010 01	-5.710330 00	-2.394670-02	-2.083170-02	-4.393490-03
	-1.334810 00	-5.924960 01	-9.793830 01	9.730470 00	-3.449400-02	-3.882300-01
	-3.114330 00	-5.689390 01	-9.928550 01	9.722380 00	-2.319020-02	-3.888600-01
	2.766320 01	-9.757430 02	9.390280 02	3.213280-03	1.239040 00	3.700740-17
	2.083020-02	-2.393920-02	9.996960-01			
MASS 15	-2.310070 01	-1.129530 02	-1.527050 01	-3.879390-01	-3.685620-02	-2.027020-02
	1.846400 01	-4.042250 02	-1.378360 02	-7.200280 00	-1.355450-01	-4.214320-02
	2.317670 01	-3.953040 02	-3.114660 02	-7.201830 00	-1.095410-01	-9.025910-02
	1.578470 01	2.099300 03	-2.492380 03	3.240300-03	-2.130350-01	-1.480300-16
	3.684780-02	-3.780250-01	9.250620-01			
MASS 16	6.774830 01	-2.757710 01	-1.551980 01	-3.044230-02	4.960170-02	1.927090-02
	6.841040 00	-1.062290 02	-3.608440 01	-3.083130 00	1.261520-01	-6.180880-02
	6.575970 00	-1.052020 02	-3.902260 01	-3.080070 00	1.279720-01	-5.786450-02
	1.288980 02	1.239540 03	-5.010420 03	6.789490 01	-1.702950 02	1.945110 01
	3.052250-01	2.898880 00	-1.214310 01			

Figure 85. (Continued)

RUN 31-52 DROP TEST CORRELATION 206/186 ENGINE 100

TIME = 0.16000

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 17	6.68480D 01	3.77596D 01	-1.28183D 01	-8.29066D-01	5.11634D-02	1.50140D-02
	-4.73180D-01	-5.32664D 01	-1.48462D 02	-6.94834D 00	6.70484D-01	-1.65059D-01
	6.32130D 00	7.33895D 01	-1.39472D 02	-6.93965D 00	5.78028D-01	3.79748D-01
	8.47477D 01	6.81259D 02	7.73378D 02	1.25766D-01	1.50992D 00	-5.92119D-16
	-5.11410D-02	-7.36336D-01	6.74681D-01			
MASS 18	6.87150D 01	-8.78221D 01	-2.04878D 00	3.23397D-01	3.86992D-02	-7.82935D-03
	2.25660D 01	-2.03440D 02	-4.85934D 01	-5.31674D 00	9.98747D-01	-5.70132D-02
	2.60201D 01	-2.07854D 02	1.94392D 01	-5.31454D 00	9.28869D-01	-3.71409D-01
	4.42082D 01	2.89285D 01	-7.14763D 02	-1.97663D-01	-1.13093D 00	2.36848?-15
	-3.86895D-02	3.17552D-01	9.47451D-01			
MASS 19	1.16309D 02	-2.66344D 01	-1.77334D 01	-3.99789D-02	4.32992D-02	1.96153D-02
	5.05582D 00	-1.09918D 02	-6.90634D 01	-6.01265D 00	9.69677D-01	-6.31384D-02
	5.88565D 00	-1.07156D 02	-7.32146D 01	-6.00992D 00	9.71424D-01	-2.42729D-02
	1.25563D 02	2.26740D 03	7.97927D 02	1.80578D 02	-1.41096D 02	1.39748D 01
	1.34300D-01	4.73378D 00	3.72074D 00			
MASS 20	-2.08183D 01	1.42548D 01	-6.68404D 01	-1.64308D-02	-7.41853D-02	1.43641D-02
	2.93872D 01	-6.13268D 01	-9.92093D 01	6.51185D-01	-6.39363D-01	3.30912D-01
	2.07853D 01	-7.98547D 01	-1.02517D 02	6.75711D-01	-6.45336D-01	3.18162D-01
	-5.82089D 03	-1.06969D 03	7.69035D 02	-1.60706D 00	1.23495D 02	3.75026D 01
	-1.48428D 01	-2.57464D 00	1.88726D 00			
MASS 21	-1.95394D 01	-7.57241D 01	-6.70893D 01	-1.88847D-02	-6.25003D-02	1.66830D-02
	6.85950D 01	-8.75220D 01	-1.46938D 02	3.75702D-01	-8.46793D-01	6.26220D-01
	5.78167D 01	-8.57898D 01	-1.52491D 02	4.14815D-01	-8.58444D-01	6.08895D-01
	-3.57830D 03	-1.56643D 03	2.34453D 03	-3.58684D 01	1.04504D 02	2.82262D 01
	-8.79575D 00	-3.80303D 00	6.11030D 00			
MASS 22	-2.46526D 01	1.52534D 01	-1.49531D 01	-2.14918D-02	-6.93085D-02	2.40606D-02
	-1.19514D 01	-1.16749D 02	-9.39985D 01	4.78872D-01	-8.45470D-01	4.47846D-01
	-2.12210D 01	-1.14406D 02	-9.52315D 01	5.09887D-01	-8.54876D-01	4.28498D-01
	-1.23983D 02	-2.41413D 02	4.40880D 02	-1.27725D 01	8.35708D 01	4.29791D 01
	1.67131D-02	-5.23196D-01	9.44028D-01			
MASS 23	-2.27399D 01	-7.47686D 01	-1.31847D 01	-1.77436D-02	-5.79819D-02	1.80959D-02
	1.90967D 01	-1.16402D 02	-1.39093D 02	5.71247D-01	-9.24660D-01	1.79626D-01
	8.89835D 00	-1.14229D 02	-1.41893D 02	5.81657D-01	-9.27696D-01	1.62090D-01
	2.92023D 02	-3.24601D 02	1.27038D 03	-2.20849D 01	7.39764D 01	-9.80197D 00
	1.14576D 00	-6.23364D-01	3.14038D 00			
MASS 24	6.42481D 01	1.39783D 01	-7.13436D 01	-5.19136D-02	-.99874D-02	2.37253D-02
	-2.88459D 01	-1.82334D 02	-2.21479D 02	2.02543D 00	5.08636D-01	-1.35964D-02
	-2.20553D 01	-1.69790D 02	-2.31982D 02	2.02611D 00	5.08651D-01	1.29219D-02
	-4.84053D 02	2.90451D 03	9.43212D 02	-3.03175D 02	-2.21477D 01	7.50497D 00
	-1.55403D 00	8.74156D 00	1.58140D 00			

Figure 85. (Continued)

RUN 31-52 DROP TEST CORRELATION 20G/18G ENGINE 100

TIME = 0.16000

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 25	6.660340 01	-7.591430 01	-6.753460 01	-5.895890-02	4.171910-02	2.490420-02
	-1.466410 01	-1.660940 02	5.146460 01	-1.986510 00	5.186540-01	-2.285290-02
	-2.094560 01	-1.683720 02	4.078470 01	-1.985560 00	5.190980-01	7.768230-03
	-7.34738D 02	1.592620 03	-5.298070 03	1.579070 02	1.294380 00	-3.559680 00
	-1.845230 00	4.335330 00	-1.283130 01			
MASS 26	-2.370340 01	-2.990670 01	-2.385880 01	-2.139070-02	8.891090-03	2.200410-02
	-1.863460 01	-1.135900 02	-1.250880 02	5.221490-01	3.139160 00	1.042850-01
	-2.001630 01	-1.104470 02	-1.276630 02	5.212220-01	3.136210 00	1.714010-01
	6.087720 02	-6.628750 02	8.266570 02	4.907930 01	6.118920 01	7.141520 00
	5.889270-01	-1.553800 00	2.155090 00			
MASS 27	6.724060 01	-2.788650 01	-2.548030 01	-3.227090-02	5.655880-02	2.072320-02
	2.734080 00	-1.356300 02	-3.524180 01	-2.603510 00	1.208470 00	-1.576990-01
	1.915300 00	-1.344520 02	-3.954850 01	-2.594600 00	?.212930 00	-1.183730-01
	2.109680 03	1.798760 03	-5.253490 03	3.688530 01	-1.917910 02	-1.058730 01
	5.299980 00	4.393580 00	-1.271230 01			
MASS 28	-2.373880 01	-3.007900 01	-3.171600 01	-2.237010-02	6.561220-03	2.190770-02
	-4.413620 01	-1.115760 02	-1.844580 02	3.467860-01	3.344450 00	2.548860-02
	-4.535850 01	-1.064220 02	-1.871870 02	3.466190-01	3.343050 00	1.002910-01
	-1.010960 02	-5.931900 02	-5.922580 03	8.122920 01	7.816030 01	3.572040 00
	-1.855440 00	-1.380460 00	-1.504620 01			
MASS 29	6.671000 01	-2.818710 01	-3.501200 01	-3.293750-02	5.832960-02	2.212800-02
	-1.586140 01	-1.621940 02	-1.094040 02	-2.296150 00	1.689350 00	-6.244020-02
	-1.303530 01	-1.580810 02	-1.156200 02	-2.292510 00	1.690480 00	-6.6 ?240-03
	3.727900 03	1.969660 03	1.347160 03	4.205270 00	-1.726290 02	-1.732330 01
	9.146690 00	4.416280 00	4.486010 00			
MASS 30	-2.373770 01	-3.004410 01	-3.018080 01	-2.257820-02	6.992260-03	2.159860-02
	-3.951080 01	-1.115250 02	-1.576750 02	3.535020-01	3.378030 00	1.329320-02
	-4.080670 01	-1.070510 02	-1.604220 02	3.534090-01	3.376870 00	8.955300-02
	1.505480 02	-8.018650 02	-8.253480 03	8.524400 01	6.534030 01	4.482140 00
	-9.885700-01	-1.939960 00	-2.112310 01			
MASS 31	6.677720 01	-2.815190 01	-3.370860 01	-3.259830-02	5.872520-02	2.212480-02
	-1.452480 01	-1.590080 02	-1.262080 02	-2.293700 00	1.695710 00	-4.603280-02
	-1.060050 01	-1.544230 02	-1.321530 02	-2.290990 00	1.696300 00	9.338400-03
	3.574080 03	1.761180 03	-2.192790 03	-6.867590 00	-1.721900 02	-1.665390 01
	8.682260 00	3.778030 00	-4.717680 00			

IG(IJ),JG(IJ),SUMDF(1,IJ),SUMDF(2,IJ),SUMDF(3,IJ),'SUMDF(4,IJ),SUMDF(5,IJ),SUMDF(6,IJ)

1	2	-1.356560 03	9.422560 01	-4.297280 02	0.0	-6.998340 04	-1.735290 04
2	3	1.620810 02	1.420760 03	-3.063890 03	6 911040 03	-6.800300 05	-2.262900 05
3	4	-3.205860 02	1.535530 03	-2.662980 03	-2.643780 04	-8.040650 05	-2.634190 05
4	5	2.354140 02	5.672020 01	-6.737560 02	6.353610 04	-1.028930 06	-2.932140 05
4	7	-5.214160 02	-1.305070 03	2.124940 03	0.0	4.264330 04	-2.202220 04
5	6	4.684850 03	-9.189030 03	1.667720 04	-1.281430 05	-7.676130 05	-1.314530 05
5	7	3.529950 03	-1.799270 03	-1.790770 03	0.0	-2.614870 04	-4.482160 03
5	20	-3.248680 03	0.0	1.068330 03	0.0	3.322110 04	0.0
5	21	-7.616340 02	0.0	-7.413280 02	0.0	-3.085030 04	0.0
5	22	-4.725690 02	0.0	-7.830700 03	0.0	-1.770430 05	0.0

Figure 85. (Continued)

5	23	-1.20354D 04	0.0	[illegible]	0.0	-2.39273D 05	0.0
6	9	3.06176D 03	-3.96678D 03	9.16165D 03	-5.61331D 04	-1.63525D 05	-2.08246D 05
6	11	1.74979D 04	5.49727D 03	9.32375D 03	-1.66558D 05	-2.68395D 05	6.69139D 04
7	9	0.0	0.0	0.0	-1.71369D 04	0.0	0.0
8	9	3.85139D 03	1.97020D 03	8.62194D 03	-8.41786D 04	1.93635D 05	-1.73460D 05
10	11	1.62915D 03	4.15183D 03	-2.78042D 03	-4.76844D 03	2.95481D 02	-6.13953D 04
10	14	-1.34937D 03	-1.61285D 02	-9.45984D 02	7.00954D 03	1.88089D 05	2.47095D 03
10	15	-2.27221D 03	-5.40466D 02	-1.23499D 03	1.26773D 03	1.78630D 05	1.52115D 03
10	22	-5.72976D 02	-3.49166D 02	2.00029D 03	0.0	1.08264D 05	1.41834D 03
10	23	5.83720D 03	-1.65621D 03	5.61783D 03	0.0	1.39185D 05	8.81597D 03
11	16	7.66696D 02	-3.94270D 03	6.68522D 03	-7.20873D 03	3.09424D 05	-1.05955D 05
12	16	-2.57608D 03	-1.07066D 03	-8.58193D 03	1.03812D 03	-3.07660D 04	7.04336D 04
12	24	5.43726D 02	4.78421D 02	6.19261D 02	-2.31578D 03	3.04364D 03	1.80543D 04
13	16	-1.47775D 03	3.46930D 02	6.44413D 03	7.87020D 03	2.22618D 04	-2.46977D 04
13	25	-6.33075D 02	5.40920D 01	5.50794D 02	-1.05698D 03	-1.57574D 02	5.74120D 03
16	17	-1.07388D 04	4.54536D 01	-1.54174D 03	-5.40785D 02	6.56119D 04	-6.03902D 00
16	18	-9.14516D 03	-3.35619D 02	-7.45139D 02	2.40511D 03	9.17941D 04	-6.42475D 02
16	19	1.39666D 01	1.38939D 03	3.98859D 03	-1.02438D 04	-1.74917D 04	4.96372D 03
20	21	2.18345D 02	4.06634D 00	1.25766D 03	0.0	5.35874D 04	4.60846D 03
20	22	2.40153D 03	-4.68645D 02	-7.59145D 02	0.0	-5.75357D 03	5.64457D 04
21	23	5.67742D 02	1.65070D 03	-8.75012D 02	0.0	-9.44877D 03	-6.70096D 04
24	25	1.96612D 01	3.91656D 01	-3.58021D 02	5.52577D 02	-1.75696D 04	-4.69482D 02
10	26	-1.99971D 03	1.00185D 02	9.35485D 02	2.40589D 03	-2.97073D 04	-2.59889D 04
16	27	-6.51570D 02	6.01737D 02	-1.21864D 03	-1.52270D 03	6.79152D 04	-1.97089D 04
26	28	-2.63118D 03	-2.38661D 02	2.84217D 03	1.56744D 02	-2.01392D 04	-9.38070D 03
27	29	-5.51713D 02	1.94519D 03	4.72904D 02	-1.42643D 03	1.76344D 04	-9.36493D 03
26	30	-2.88971D 03	-1.70842D 01	1.70306D 03	4.56550D 02	-1.69294D 04	-1.16193D 04
27	31	-1.37896D 03	1.08051D 03	-7.36036D 01	-1.43408D 03	2.10007D 04	-5.13260D 03

IG(IJ),JG(IJ),VEE2(1,IJ),VEE2(2,IJ),VEE2(3,IJ),VEE2(4,IJ),VEE2(5,IJ),VEE2(6,IJ)

1	2	-1.10496D-02	-5.13914D-01	1.54478D 00	8.01663D-02	-4.26896D-02	-1.39368D-02
2	3	2.64514D-03	-3.10157D-01	1.31691D 00	2.80481D-03	-2.00488D-02	-5.84819D-03
3	4	-9.93140D-04	-3.69894D-02	8.86238D-02	-7.24521D-04	-5.82902D-03	-2.46959D-03
4	5	1.12049D-04	-4.10371D-02	2.66074D-02	7.75493D-07	-1.12386D-03	-1.72672D-03
4	7	-9.22864D-03	-1.96287D-01	2.74615D-02	-2.14842D-04	-3.60132D-04	-2.55350D-03
5	6	1.03077D-02	-4.36965D-02	4.99128D-02	-1.43593D-05	-4.26349D-03	-3.46974D-03
5	7	-5.83327D-03	-1.96767D-01	-3.43048D-02	6.79428D-04	7.77034D-04	-2.26852D-03
5	20	-2.03042D-02	-5.32173D 00	2.20492D-02	-6.56816D-02	-1.04433D-05	-7.58804D-02
5	21	-4.76021D-03	3.96851D 00	-4.51460D-05	7.60698D-02	-4.80877D-04	4.52255D-02
5	22	-2.69117D-03	-1.65051D-01	-1.94885D-01	-9.08477D-02	2.61239D-03	2.62266D-02
5	23	-6.85385D-02	-5.56477D-01	-1.65405D-01	7.36314D-02	9.49966D-04	-4.06649D-02
6	9	1.00716D-03	-1.51152D-01	2.30287D-01	-2.27082D-03	-1.36947D-02	-9.79987D-03
6	11	3.59617D-03	1.09798D-02	3.94831D-02	-2.03892D-03	-4.46969D-03	1.17672D-03
7	9	3.83313D-01	-5.27436D-02	-3.25849D-02	-7.82506D-03	-1.88066D-02	9.92646D-05
8	9	-5.75020D-01	-1.39609D-01	4.85580D-01	-3.73132D-02	-1.49294D-03	-6.87165D-03
10	11	2.96653D-03	-2.76449D-04	-6.20645D-02	-2.01370D-03	4.24096D-03	-8.00454D-04
10	14	-2.81411D-03	-1.27482D-01	-1.51038D 01	1.25171D-04	3.88199D-01	-2.73892D-03
10	15	-4.73871D-03	-7.32546D-01	-1.51030D 01	2.25567D-05	3.83881D-01	-2.16141D-02
10	22	-6.44568D-03	-5.39150D-02	-4.88412D-02	-8.13491D-02	2.84599D-03	-1.70355D-03
10	23	6.56114D-02	-2.43321D-01	2.97066D-02	6.99199D-02	5.75589D-04	-7.52778D-03
11	16	4.43176D-03	-1.61267D-02	-2.10420D-03	-9.60012D-03	3.35874D-02	-3.91361D-04
12	16	-1.44886D-03	4.00353D-02	-1.42248D 00	9.72932D-04	4.52625D-02	2.15312D-03
12	24	3.67136D-03	7.24734D-01	2.90166D-02	-7.76846D-03	-7.63703D-04	2.35668D-02
13	16	-8.31131D-04	-1.49319D-02	1.07341D 00	7.37601D-03	-3.42217D-02	-7.84778D-04
13	25	-4.27465D-03	1.57955D-01	3.01275D-02	-3.54574D-03	-8.39213D-04	5.47984D-03
16	17	-4.48009D-02	1.26541D-01	-1.51070D 01	-1.83693D-05	3.58208D-01	3.85022D-03
16	18	-3.81525D-02	-9.92862D-01	-1.51027D 01	8.13904D-05	3.81217D-01	-3.08071D-02
16	19	6.75950D-05	6.91439D-04	1.97339D-01	-9.55579D-03	-6.33076D-03	2.20407D-05
20	21	4.91214D-03	1.16141D-01	8.85390D-02	-1.16330D-02	-2.70415D-04	2.54864D-03
20	22	3.24224D-02	5.77680D-02	-1.84899D-01	9.76750D-03	4.68022D-03	2.36767D-03
21	23	7.66493D-03	-1.10949D-02	-1.88971D-01	1.48785D-03	4.49986D-03	-1.21295D-03
24	25	2.21160D-05	3.15674D-02	-8.55954D-01	8.43629D-03	-7.10826D-03	4.82549D-04
10	26	-1.99971D-01	-1.61317D-03	1.24501D-02	2.40589D-03	-3.09524D-03	-2.61502D-03
16	27	-2.17190D-02	4.08735D-03	-1.91696D-02	-1.52270D-03	6.98322D-03	-1.93002D-03
26	28	-2.14091D 00	-3.35826D-03	3.07430D-02	1.56744D-04	-2.32135D-03	-9.71653D-04
27	29	-4.48912D-01	1.87024D-02	2.99556D-03	-1.42643D-03	1.73348D-03	-7.49469D-04
26	30	-3.67647D 00	-1.34623D-03	1.89127D-02	4.58550D-04	-1.88206D-03	-1.17539D-03

Figure 85. (Continued)

```
 27  31     -1.754400D 00     1.039580D-02     -2.864750D-03     -1.434080D-03     2.128710D-03     -4.093020D-04
I,SC(I,1),SC(I,2),SC(I,3)
       10      0.0              0.0              2.935400D 00
       11      0.0              0.0              2.406820D 00
       12      0.0              C.0              4.211480D-03
       13      0.0              0.0              3.271890D 00
       14      0.0              0.0              2.108200D-03
       15      0.0              0.0              2.944230D-03
       16      0.0              0.0              1.453910D 00
       17      0.0              0.0              6.593940D-04
       18      0.0              0.0              8.759200D-02
       22      0.0              0.0              2.007490D 00
       23      0.0              0.0              3.791070D 00

MASS       DRI
 30       2.408090D 01
 31       1.149130D 01
     RUPTURE  SUMMARY

           I          J      TIME

          10         15    0.06786
          16         17    0.08624
          10         14    0.11572
          16         18    0.14320
```

Figure 85. (Continued)

```
RUN 31-52 DROP TEST CORRELATION  20G/18G ENGINE          100

MASSES = 31 CP/DT = 100 DT =0.00002 TMAX =  0.160
 XGDOT =  0.0           YGDOT = -2.232000 02  ZGDOT =  2.760000 02
    P' =  4.615000-01      Q' =  0.0             R' =  0.0
  PHI' = -1.746000-01 THETA' = -1.746000-02   PSI' =  0.0          ZG =  0.0

WEIGHTS
   1   1.390000 02
   2   8.500000 01
   3   6.200000 01
   4   1.720000 02
   5   2.760000 02
   6   9.320000 02
   7   7.310000 02
   8   1.412000 03
   9   9.000000 01
  10   2.570000 02
  11   1.823000 03
  12   1.750000 02
  13   1.750000 02
  14   2.400000 01
  15   2.400000 01
  16   9.500000 02
  17   2.400000 01
  18   2.400000 01
  19   3.070000 02
  20   3.100000 01
  21   3.100000 01
  22   1.660000 02
  23   1.660000 02
  24   2.850000 01
  25   2.850000 01
  26   5.500000 01
  27   7.000000 01
  28   1.200000 02
  29   1.200000 02
  30   1.200000 02
  31   1.200000 02

I,IX(I),IY(I),IZ(I),IXY(I),IYZ(I),IXZ(I)
   1   2.000000 02   1.730000 02   1.730000 02   0.0   0.0   0.0
   2   1.000000 01   2.050000 02   2.000000 02   0.0   0.0   0.0
   3   1.500000 01   1.470000 02   1.320000 02   0.0   0.0   0.0
   4   3.400000 01   3.400000 01   1.000000 01   0.0   0.0   0.0
   5   2.500000 02   2.500000 02   2.500000 02   0.0   0.0   0.0
   6   1.000000 03   1.000000 03   1.000000 03   0.0   0.0   0.0
   7   3.060000 02   6.030000 02   6.280000 02   0.0   0.0   0.0
   8   3.500000 03   3.563000 03   3.130000 02   0.0   0.0   0.0
   9   3.700000 01   4.700000 01   4.000000 01   0.0   0.0   0.0
  10   2.500000 02   2.500000 02   2.500000 02   0.0   0.0   0.0
  11   2.010000 03   5.082000 03   3.294000 03   0.0   0.0   0.0
  12   4.300000 01   2.500000 02   2.300000 02   0.0   0.0   0.0
  13   4.300000 01   2.500000 02   2.300000 02   0.0   0.0   0.0
  14   3.570000 01   3.570000 01   2.400000 01   0.0   0.0   0.0
  15   3.570000 01   3.570000 01   2.400000 01   0.0   0.0   0.0
  16   1.000000 03   1.100000 03   1.100000 03   0.0   0.0   0.0
  17   5.620000 01   5.620000 01   2.400000 01   0.0   0.0   0.0
  18   5.620000 01   5.620000 01   2.400000 01   0.0   0.0   0.0
  19   1.716000 02   2.476000 02   7.600000 01   0.0   0.0   0.0
  20   1.284000 02   1.290000 02   3.960000 01   0.0   0.0   0.0
  21   1.284000 02   1.290000 02   3.960000 01   0.0   0.0   0.0
  22   6.650000 01   7.000000 01   7.000000 01   0.0   0.0   0.0
```

Figure 86. Input Data, Combined Vertical and Lateral Impact Sample Case.

23	4.650000 01	7.000000 01	7.000000 01	0.0	0.0	0.0
24	1.358000 02	2.688000 02	1.565000 02	0.0	0.0	0.0
25	1.358000 02	2.688000 02	1.565000 02	0.0	0.0	0.0
26	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0
27	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0
28	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0
29	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0
30	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0
31	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0

I,X**(I),Y**(I),Z**(I)

1	4.587500 02	0.0	1.325200 02
2	4.042300 02	0.0	7.200000 01
3	2.412200 02	0.0	4.750000 01
4	2.116000 02	0.0	3.845000 01
5	1.630000 02	0.0	3.845000 01
6	1.410000 02	0.0	3.845000 01
7	1.870200 02	0.0	7.880000 01
8	1.365000 02	0.0	9.000000 01
9	1.410000 02	0.0	6.706000 01
10	1.630000 02	0.0	2.200000 01
11	1.410000 02	0.0	2.200000 01
12	7.163000 01	-4.500000 01	2.200000 01
13	7.163000 01	4.500000 01	2.200000 01
14	1.630000 02	-5.080000 01	-7.000000 00
15	1.630000 02	5.080000 01	-7.000000 00
16	7.162000 01	0.0	2.200000 01
17	7.162000 01	-5.080000 01	-7.000000 00
18	7.162000 01	5.080000 01	-7.000000 00
19	2.300000 01	0.0	2.200000 01
20	1.630000 02	-4.500000 01	7.600000 01
21	1.630000 02	4.500000 01	7.600000 01
22	1.630000 02	-4.500000 01	7.200000 01
23	1.630000 02	4.500000 01	7.200000 01
24	7.162000 01	-4.500000 01	7.600000 01
25	7.162000 01	4.500000 01	7.600000 01
26	1.630000 02	0.0	3.200000 01
27	7.162000 01	0.0	3.200000 01
28	1.630000 02	0.0	4.200000 01
29	7.162000 01	0.0	4.200000 01
30	1.630000 02	0.0	4.200000 01
31	7.162000 01	0.0	4.200000 01

THERE ARE 0 I'S HAVING NON-ZERO HE OR PHI**,THETA**,PSI**

THERE ARE 0 I'S HAVING NON-ZERO LC'S

I,K,LBAR(I,K),MU(I,K),KE(I,K)

10	3	1.700000 01	3.000000-01	3.300000 04
11	3	1.700000 01	3.000000-01	1.100000 04
12	3	1.700000 01	3.000000-01	1.100000 04
13	3	1.700000 01	3.000000-01	1.100000 04
14	3	2.250000 00	3.000000-01	2.200000 04
15	3	2.250000 00	3.000000-01	2.200000 04
16	3	1.700000 01	3.000000-01	3.300000 04
17	3	2.250000 00	3.000000-01	2.200000 04
18	3	2.250000 00	3.000000-01	2.200000 04
22	3	1.700000 01	3.000000-01	1.100000 04
23	3	1.700000 01	3.000000-01	1.100000 04

I,K,SI(I,K),SA(I,K),SB(I,K),SF(I,K),FSPOI(I,K),FSPOF(I,K)

10	3	1.000000-03	1.000000 00	2.000000 00	3.500000 00	1.650000 04	1.650000 04
11	3	1.000000-03	1.000000 00	2.000000 00	3.500000 00	5.500000 03	5.500000 03
12	3	1.000000-03	1.000000 00	2.000000 00	3.500000 00	5.500000 03	5.500000 03
13	3	1.000000-03	1.000000 00	2.000000 00	3.500000 00	5.500000 03	5.500000 03
14	3	2.000000-01	4.000000-01	6.000000-01	1.200000 00	4.400000 03	4.400000 03

Figure 86. (Continued).

15	3	2.000000D-01	4.000000D-01	6.000000D-01	1.200000 00	4.400000 03	4.400000 03
16	3	1.000000D-03	1.000000D 00	2.000000D 00	3.500000 00	1.650000 04	1.650000 04
17	3	2.000000D-01	4.000000D-01	6.000000D-01	1.200000 00	4.400000 03	4.400000 03
18	3	2.000000D-01	4.000000D-01	6.000000D-01	1.200000 00	4.400000 03	4.400000 03
22	3	1.000000D-03	1.000000 00	2.000000 00	3.500000 00	5.500000 03	5.500000 03
23	3	1.000000D-03	1.000000 00	2.000000 00	3.500000 00	5.500000 03	5.500000 03

IJ,I,J,PHI(I,J),THETA(I,J),PSI(I,J) (INTERNAL BEAMS)

1	1	2	0.0	0.0	0.0
2	2	3	0.0	0.0	0.0
3	3	4	0.0	0.0	0.0
4	4	5	0.0	0.0	0.0
5	4	7	0.0	0.0	0.0
6	5	6	0.0	0.0	0.0
7	5	7	0.0	0.0	0.0
8	5	20	0.0	0.0	0.0
9	5	21	0.0	0.0	0.0
10	5	22	0.0	0.0	0.0
11	5	23	0.0	0.0	0.0
12	6	9	0.0	0.0	0.0
13	6	11	0.0	0.0	0.0
14	7	9	0.0	0.0	0.0
15	8	9	0.0	0.0	0.0
16	10	11	0.0	0.0	0.0
17	10	14	0.0	0.0	0.0
18	10	15	0.0	0.0	0.0
19	10	22	0.0	0.0	0.0
20	10	23	0.0	0.0	0.0
21	11	16	0.0	0.0	0.0
22	12	16	0.0	0.0	0.0
23	12	24	0.0	0.0	0.0
24	13	16	0.0	0.0	0.0
25	13	25	0.0	0.0	0.0
26	16	17	0.0	0.0	0.0
27	16	18	0.0	0.0	0.0
28	16	19	0.0	0.0	0.0
29	20	21	0.0	0.0	0.0
30	20	22	0.0	0.0	0.0
31	21	23	0.0	0.0	0.0
32	24	25	0.0	0.0	0.0
33	10	26	0.0	0.0	0.0
34	16	27	0.0	0.0	0.0
35	26	28	0.0	0.0	0.0
36	27	29	0.0	0.0	0.0
37	26	30	0.0	0.0	0.0
38	27	31	0.0	0.0	0.0

I,J,K MATRIX FOR INTERNAL BEAM IJ

1 2

1.227700 05	0.0	0.0	0.0	0.0	0.0
0.0	1.754000 03	0.0	0.0	0.0	-7.143900 04
0.0	0.0	2.220000 03	0.0	9.040000 04	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	9.040000 04	0.0	4.910400 06	0.0
0.0	-7.143900 04	0.0	0.0	0.0	3.879400 06

2 3

6.127500 04	0.0	0.0	0.0	0.0	0.0
0.0	8.505000 03	0.0	0.0	0.0	-6.940000 05
0.0	0.0	9.663000 03	0.0	7.885000 05	0.0
0.0	0.0	0.0	2.464000 06	0.0	0.0
0.0	0.0	7.885000 05	0.0	8.579000 07	0.0
0.0	-6.940000 05	0.0	0.0	0.0	7.550000 07

3 4

3.228000 05	0.0	0.0	0.0	0.0	0.0
0.0	1.213000 06	0.0	0.0	0.0	-1.879000 07
0.0	0.0	1.634000 06	0.0	2.530000 07	0.0

Figure 86. (Continued).

```
   0.0          0.0          0.0          3.649000 07  0.0          0.0
   0.0          0.0          2.530000 07  0.0          5.226000 08  0.0
   0.0         -1.879000 07  0.0          0.0          0.0          3.881000 08
 4  5
   2.101000 06  0.0          0.0          0.0          0.0          0.0
   0.0          8.957000 05  0.0          0.0          0.0         -2.132000 07
   0.0          0.0          4.773000 06  0.0          1.136000 08  0.0
   0.0          0.0          0.0          8.193000 10  0.0          0.0
   0.0          0.0          1.136000 08  0.0          3.605000 09  0.0
   0.0         -2.132000 07  0.0          0.0          0.0          6.765000 08
 4  7
   5.650000 04  0.0          0.0          0.0          0.0          0.0
   0.0          1.120000 05  0.0          0.0          0.0         -2.640000 06
   0.0          0.0          1.120000 05  0.0          2.640000 06  0.0
   0.0          0.0          0.0          0.0          0.0          0.0
   0.0          0.0          2.640000 06  0.0          8.290000 07  0.0
   0.0         -2.640000 06  0.0          0.0          0.0          8.290000 07
 5  6
   4.545000 05  0.0          0.0          0.0          0.0          0.0
   0.0          1.665000 06  0.0          0.0          0.0         -1.832000 07
   0.0          0.0          5.531000 06  0.0          6.084000 07  0.0
   0.0          0.0          0.0          8.924000 09  0.0          0.0
   0.0          0.0          6.084000 07  0.0          8.923000 08  0.0
   0.0         -1.832000 07  0.0          0.0          0.0          2.686000 08
 5  7
   5.650000 04  0.0          0.0          0.0          0.0          0.0
   0.0          1.120000 05  0.0          0.0          0.0         -2.640000 06
   0.0          0.0          1.120000 05  0.0          2.640000 06  0.0
   0.0          0.0          0.0          0.0          0.0          0.0
   0.0          0.0          2.640000 06  0.0          8.290000 07  0.0
   0.0         -2.640000 06  0.0          0.0          0.0          8.290000 07
 5 20
   1.600000 05  0.0          0.0          0.0          0.0          0.0
   0.0          0.0          0.0          0.0          0.0          0.0
   0.0          0.0          4.918000 04  0.0          1.537000 06  0.0
   0.0          0.0          0.0          0.0          0.0          0.0
   0.0          0.0          1.537000 06  0.0          6.401000 07  0.0
   0.0          0.0          0.0          0.0          0.0          0.0
 5 21
   1.600000 05  0.0          0.0          0.0          0.0          0.0
   0.0          0.0          0.0          0.0          0.0          0.0
   0.0          0.0          4.918000 04  0.0          1.537000 06  0.0
   0.0          0.0          0.0          0.0          0.0          0.0
   0.0          0.0          1.537000 06  0.0          6.401000 07  0.0
   0.0          0.0          0.0          0.0          0.0          0.0
 5 22
   1.756000 05  0.0          0.0          0.0          0.0          0.0
   0.0          0.0          0.0          0.0          0.0          0.0
   0.0          0.0          6.498000 04  0.0          1.850000 06  0.0
   0.0          0.0          0.0          0.0          0.0          0.0
   0.0          0.0          1.850000 06  0.0          7.024000 07  0.0
   0.0          0.0          0.0          0.0          0.0          0.0
 5 23
   1.756000 05  0.0          0.0          0.0          0.0          0.0
   0.0          0.0          0.0          0.0          0.0          0.0
   0.0          0.0          6.498000 04  0.0          1.850000 06  0.0
   0.0          0.0          0.0          0.0          0.0          0.0
   0.0          0.0          1.850000 06  0.0          7.024000 07  0.0
   0.0          0.0          0.0          0.0          0.0          0.0
 6  9
   3.040000 06  0.0          0.0          0.0          0.0          0.0
   0.0          4.010000 05  0.0          0.0          0.0         -5.780000 06
   0.0          0.0          3.258000 05  0.0          4.690000 06  0.0
   0.0          0.0          0.0          2.560000 07  0.0          0.0
   0.0          0.0          4.690000 06  0.0          8.950000 07  0.0
   0.0         -5.780000 06  0.0          0.0          0.0          1.104000 08
```

Figure 86. (Continued).

6 11						
	4.863000 06	0.0	0.0	0.0	0.0	0.0
	0.0	4.227000 06	0.0	0.0	0.0	-3.477000 07
	0.0	0.0	3.424000 06	0.0	2.816000 07	0.0
	0.0	0.0	0.0	8.267000 07	0.0	0.0
	0.0	0.0	2.816000 07	0.0	3.088000 08	0.0
	0.0	-3.477000 07	0.0	0.0	0.0	3.813000 08
7 9						
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	2.190000 06	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
8 9						
	2.039000 06	0.0	0.0	0.0	0.0	0.0
	0.0	1.051000 05	0.0	0.0	0.0	-2.422000 06
	0.0	0.0	1.911000 04	0.0	4.404000 05	0.0
	0.0	0.0	0.0	2.256000 06	0.0	0.0
	0.0	0.0	4.404000 05	0.0	1.354000 07	0.0
	0.0	-2.422000 06	0.0	0.0	0.0	7.445000 07
10 11						
	5.455000 05	0.0	0.0	0.0	0.0	0.0
	0.0	4.869000 05	0.0	0.0	0.0	-5.355000 06
	0.0	0.0	1.803000 05	0.0	1.983000 06	0.0
	0.0	0.0	0.0	2.368000 06	0.0	0.0
	0.0	0.0	1.983000 06	0.0	2.909000 07	0.0
	0.0	-5.355000 06	0.0	0.0	0.0	7.855000 07
10 14						
	4.795000 05	0.0	0.0	0.0	0.0	0.0
	0.0	2.697000 03	0.0	0.0	0.0	-6.637000 04
	0.0	0.0	2.697000 03	0.0	6.637000 04	0.0
	0.0	0.0	0.0	5.587000 07	0.0	0.0
	0.0	0.0	6.637000 04	0.0	2.178000 06	0.0
	0.0	-6.637000 04	0.0	0.0	0.0	2.178000 06
10 15						
	4.795000 05	0.0	0.0	0.0	0.0	0.0
	0.0	2.697000 03	0.0	0.0	0.0	-6.637000 04
	0.0	0.0	2.697000 03	0.0	6.637000 04	0.0
	0.0	0.0	0.0	5.587000 07	0.0	0.0
	0.0	0.0	6.637000 04	0.0	2.178000 06	0.0
	0.0	-6.637000 04	0.0	0.0	0.0	2.178000 06
10 22						
	8.889000 04	0.0	0.0	0.0	0.0	0.0
	0.0	2.239000 04	0.0	0.0	0.0	-5.037000 05
	0.0	0.0	1.317000 05	0.0	2.963000 06	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	2.963000 06	0.0	8.889000 07	0.0
	0.0	-5.037000 05	0.0	0.0	0.0	1.511000 67
10 23						
	8.889000 04	0.0	0.0	0.0	0.0	0.0
	0.0	2.239000 04	0.0	0.0	0.0	-5.037000 05
	0.0	0.0	1.317000 05	0.0	2.963000 06	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	2.963000 06	0.0	8.889000 07	0.0
	0.0	-5.037000 05	0.0	0.0	0.0	1.511000 07
11 16						
	1.730000 05	0.0	0.0	0.0	0.0	0.0
	0.0	1.545000 06	0.0	0.0	0.0	-5.359000 07
	0.0	0.0	5.749000 03	0.0	1.994000 05	0.0
	0.0	0.0	0.0	7.509000 05	0.0	0.0
	0.0	0.0	1.994000 05	0.0	9.225000 06	0.0
	0.0	-5.359000 07	0.0	0.0	0.0	2.479000 09
12 16						
	1.778000 06	0.0	0.0	0.0	0.0	0.0
	0.0	1.275000 05	0.0	0.0	0.0	-2.348000 06

Figure 86. (Continued).

0.0	0.0	2.123000 04	0.0	4.776000 05	0.0
0.0	0.0	0.0	1.067000 06	0.0	0.0
0.0	0.0	4.776000 05	0.0	1.433000 07	0.0
0.0	-2.868000 06	0.0	0.0	0.0	8.604000 07
12 24					
1.481000 05	0.0	0.0	0.0	0.0	0.0
0.0	5.411000 03	0.0	0.0	0.0	-1.461000 05
0.0	0.0	7.377000 04	0.0	1.992000 06	0.0
0.0	0.0	0.0	2.981000 05	0.0	0.0
0.0	0.0	1.992000 06	0.0	7.170000 07	0.0
0.0	-1.461000 05	0.0	0.0	0.0	5.259000 06
13 16					
1.778000 06	0.0	0.0	0.0	0.0	0.0
0.0	1.275000 05	0.0	0.0	0.0	-2.868000 06
0.0	0.0	2.123000 04	0.0	4.776000 05	0.0
0.0	0.0	0.0	1.067000 06	0.0	0.0
0.0	0.0	4.776000 05	0.0	1.433000 07	0.0
0.0	-2.868000 06	0.0	0.0	0.0	8.604000 07
13 25					
1.481000 05	0.0	0.0	0.0	0.0	0.0
0.0	5.411000 03	0.0	0.0	0.0	-1.461000 05
0.0	0.0	7.377000 04	0.0	1.992000 06	0.0
0.0	0.0	0.0	2.981000 05	0.0	0.0
0.0	0.0	1.992000 06	0.0	7.170000 07	0.0
0.0	-1.461000 05	0.0	0.0	0.0	5.259000 06
16 17					
2.397000 05	0.0	0.0	0.0	0.0	0.0
0.0	1.429000 03	0.0	0.0	0.0	-3.516000 04
0.0	0.0	1.429000 03	0.0	3.516000 04	0.0
0.0	0.0	0.0	2.946000 07	0.0	0.0
0.0	0.0	3.516000 04	0.0	1.154000 06	0.0
0.0	-3.516000 04	0.0	0.0	0.0	1.154000 06
16 18					
2.397000 05	0.0	0.0	0.0	0.0	0.0
0.0	1.429000 03	0.0	0.0	0.0	-3.516000 04
0.0	0.0	1.429000 03	0.0	3.516000 04	0.0
0.0	0.0	0.0	2.946000 07	0.0	0.0
0.0	0.0	3.516000 04	0.0	1.154000 06	0.0
0.0	-3.516000 04	0.0	0.0	0.0	1.154000 06
16 19					
2.057000 05	0.0	0.0	0.0	0.0	0.0
0.0	8.933000 06	0.0	0.0	0.0	-2.172000 08
0.0	0.0	9.188000 04	0.0	2.234000 06	0.0
0.0	0.0	0.0	1.072000 06	0.0	0.0
0.0	0.0	2.234000 06	0.0	7.240000 07	0.0
0.0	-2.172000 08	0.0	0.0	0.0	7.039000 09
20 21					
4.445000 04	0.0	0.0	0.0	0.0	0.0
0.0	2.800000 03	0.0	0.0	0.0	-1.260000 05
0.0	0.0	1.647000 04	0.0	7.410000 05	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	7.410000 05	0.0	4.445000 07	0.0
0.0	-1.260000 05	0.0	0.0	0.0	7.550000 06
20 22					
7.407000 04	0.0	0.0	0.0	0.0	0.0
0.0	7.621000 04	0.0	0.0	0.0	-2.058000 06
0.0	0.0	1.296000 04	0.0	3.498000 05	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	3.498000 05	0.0	1.259000 07	0.0
0.0	-2.058000 06	0.0	0.0	0.0	7.407000 07
21 23					
7.407000 04	0.0	0.0	0.0	0.0	0.0
0.0	7.621000 04	0.0	0.0	0.0	-2.058000 06
0.0	0.0	1.296000 04	0.0	3.498000 05	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	3.498000 05	0.0	1.259000 07	0.0

Figure 86. (Continued).

```
   0.0          -2.05800D 06   0.0           0.0           0.0           7.40700D 07
24 25
   8.89000D 05   0.0           0.0           0.0           0.0           0.0
   0.0           3.98000D 03   0.0           0.0           0.0          -1.79200D 05
   0.0           0.0           3.04500D 02   0.0           1.37000D 04   0.0
   0.0           0.0           0.0           6.55000D 04   0.0           0.0
   0.0           0.0           1.37000D 04   0.0           8.22000D 0[illegible]   0.0
   0.0          -1.79200D 05   0.0           0.0           0.0           1.07500D 07
10 26
   1.00000D 04   0.0           0.0           0.0           0.0           0.0
   0.0           1.00000D 05   0.0           0.0           0.0          -1.00000D 05
   0.0           0.0           1.00000D 05   0.0           1.00000D 05   0.0
   0.0           0.0           0.0           1.00000D 06   0.0           0.0
   0.0           0.0           1.00000D 05   0.0           1.00000D 07   0.0
   0.0          -1.00000D 05   0.0           0.0           0.0           1.00000D 07
16 27
   3.00000D 04   0.0           0.0           0.0           0.0           0.0
   0.0           1.00000D 05   0.0           0.0           0.0          -1.00000D 05
   0.0           0.0           1.00000D 05   0.0           1.00000D 05   0.0
   0.0           0.0           0.0           1.00000D 06   0.0           0.0
   0.0           0.0           1.00000D 05   0.0           1.00000D 07   0.0
   0.0          -1.00000D 05   0.0           0.0           0.0           1.00000D 07
26 28
   1.22900D 03   0.0           0.0           0.0           0.0           0.0
   0.0           1.00000D 05   0.0           0.0           0.0          -1.00000D 05
   0.0           0.0           1.00000D 05   0.0           1.00000D 05   0.0
   0.0           0.0           0.0           1.00000D 06   0.0           0.0
   0.0           0.0           1.00000D 05   0.0           1.00000D 07   0.0
   0.0          -1.00000D 05   0.0           0.0           0.0           1.00000D 07
27 29
   1.22900D 03   0.0           0.0           0.0           0.0           0.0
   0.0           1.00000D 05   0.0           0.0           0.0          -1.00000D 05
   0.0           0.0           1.00000D 05   0.0           1.00000D 05   0.0
   0.0           0.0           0.0           1.00000D 06   0.0           0.0
   0.0           0.0           1.00000D 05   0.0           1.00000D 07   0.0
   0.0          -1.00000D 05   0.0           0.0           0.0           1.00000D 07
26 30
   7.86000D 02   0.0           0.0           0.0           0.0           0.0
   0.0           1.00000D 05   0.0           0.0           0.0          -1.00000D 05
   0.0           0.0           1.00000D 05   0.0           1.00000D 05   0.0
   0.0           0.0           0.0           1.00000D 06   0.0           0.0
   0.0           0.0           1.00000D 05   0.0           1.00000D 07   0.0
   0.0          -1.00000D 05   0.0           0.0           0.0           1.00000D 07
27 31
   7.86000D 02   0.0           0.0           0.0           0.0           0.0
   0.0           1.00000D 05   0.0           0.0           0.0          -1.00000D 05
   0.0           0.0           1.00000D 05   0.0           1.00000D 05   0.0
   0.0           0.0           0.0           1.00000D 06   0.0           0.0
   0.0           0.0           1.00000D 05   0.0           1.00000D 07   0.0
   0.0          -1.00000D 05   0.0           0.0           0.0           1.00000D 07

IJ,I,J,CBAR(I,J)
  1  1  2      5.00000D-02
  2  2  3      5.00000D-02
  3  3  4      5.00000D-02
  4  4  5      5.00000D-02
  5  4  7      5.00000D-02
  6  5  6      5.00000D-02
  7  5  7      5.00000D-02
  8  5 20      5.00000D-02
  9  5 21      5.00000D-02
 10  5 22      1.00000D-01
 11  5 23      1.00000D-01
 12  6  9      5.00000D-02
 13  6 11      1.00000D-01
 14  7  9      5.00000D-02
```

Figure 86. (Continued).

```
15  8  9     5.000000D-02
16 10 11     1.000000D-01
17 10 14     1.000000D-01
18 10 15     1.000000D-01
19 10 22     1.000000D-01
20 10 23     1.000000D-01
21 11 16     1.000000D-01
22 12 16     1.000000D-01
23 12 24     5.000000D-02
24 13 16     1.000000D-01
25 13 25     5.000000D-02
26 16 17     1.000000D-01
27 16 18     1.000000D-01
28 16 19     1.000000D-01
29 20 21     5.000000D-02
30 20 22     5.000000D-02
31 21 23     5.000000D-02
32 24 25     5.000000D-02
33 10 26     5.000000D-02
34 16 27     5.000000D-02
35 26 28     2.470000D-01
36 27 29     2.380000D-01
37 26 30     1.818000D-01
38 27 31     1.752000D-01

KR TABLE SPECS, I,J,L,NP
   2    3    2    6
   2    3    3    6
   2    3    5    6
   2    3    6    6
   4    7    1    6
   4    7    2    6
   4    7    3    6
   4    7    4    6
   4    7    5    6
   4    7    6    6
   5    7    1    6
   5    7    2    6
   5    7    3    6
   5    7    4    6
   5    7    5    6
   5    7    6    6
   8    9    1    6
   8    9    2    6
   8    9    3    6
   8    9    4    6
   8    9    5    6
   8    9    6    6
  10   14    1    6
  10   14    2    6
  10   14    3    6
  10   14    4    6
  10   14    5    6
  10   14    6    6
  10   15    1    6
  10   15    2    6
  10   15    3    6
  10   15    4    6
  10   15    5    6
  10   15    6    6
  16   17    1    6
  16   17    2    6
  16   17    3    6
  16   17    4    6
  16   17    5    6
  16   17    6    6
```

Figure 86. (Continued).

```
  16   18    1    6
  16   18    2    6
  16   18    3    6
  16   18    4    6
  16   18    5    6
  16   18    6    6

 KR TABLE FOR I,J,L =     2    3    2
   1     0.0              1.00000E 00
   2     2.00000E 00      1.00000E 00
   3     4.00000E 00     -1.00000E 00
   4     6.00000E 00     -1.00000E 00
   5     8.00000E 00     -1.00000E 00
   6     1.00000E 01     -1.00000E 00

 KR TABLE FOR I,J,L =     2    3    3
   1     0.0              1.00000E 00
   2     2.00000E 00      1.00000E 00
   3     4.00000E 00     -1.00000E 00
   4     6.00000E 00     -1.00000E 00
   5     8.00000E 00     -1.00000E 00
   6     1.00000E 01     -1.00000E 00

 KR TABLE FOR I,J,L =     2    3    5
   1     0.0              1.00000E 00
   2     1.00000E 00      1.00000E 00
   3     2.00000E 00      0.0
   4     3.00000E 00     -1.00000E 00
   5     4.00000E 00     -1.00000E 00
   6     5.00000E 00     -1.00000E 00

 KR TABLE FOR I,J,L =     2    3    6
   1     0.0              1.00000E 00
   2     1.00000E 00      1.00000E 00
   3     2.00000E 00      0.0
   4     3.00000E 00     -1.00000E 00
   5     4.00000E 00     -1.00000E 00
   6     5.00000E 00     -1.00000E 00

 KR TABLE FOR I,J,L =     4    7    1
   1     0.0              1.00000E 00
   2     1.00000E-01      1.00000E 00
   3     2.00000E-01     -7.00000E-01
   4     3.00000E-01     -7.00000E-01
   5     4.00000E-01      0.0
   6     5.00000E-01      0.0

 KR TABLE FOR I,J,L =     4    7    2
   1     0.0              1.00000E 00
   2     6.67000E-02      1.00000E 00
   3     1.33400E-01      1.00000E 00
   4     2.00100E-01      1.00000E 00
   5     2.66800E-01      0.0
   6     3.33500E-01      0.0

 KR TABLE FOR I,J,L =     4    7    3
   1     0.0              1.00000E 00
   2     6.67000E-02      1.00000E 00
   3     1.33400E-01      1.00000E 00
   4     2.00100E-01      1.00000E 00
   5     2.66800E-01      0.0
   6     3.33500E-01      0.0

 KR TABLE FOR I,J,L =     4    7    4
   1     0.0              1.00000E 00
   2     1.00000E-01      1.00000E 00
```

Figure 86. (Continued).

```
   3     2.00000E-01     1.00000E 00
   4     3.00000E-01     1.00000E 00
   5     4.00000E-01     0.0
   6     5.00000E-01     0.0

 KR TABLE FOR I,J,L =      4     7     5
   1     0.0             1.00000E 00
   2     1.00000E-01     1.00000E 00
   3     2.00000E-01     1.00000E 00
   4     3.00000E-01     1.00000E 00
   5     4.00000E-01     0.0
   6     5.00000E-01     0.0

 KR TABLE FOR I,J,L =      4     7     6
   1     0.0             1.00000E 00
   2     1.00000E-01     1.00000E 00
   3     2.00000E-01     1.00000E 00
   4     3.00000E-01     1.00000E 00
   5     4.00000E-01     0.0
   6     5.00000E-01     0.0

 KR TABLE FOR I,J,L =      5     7     1
   1     0.0             1.00000E 00
   2     1.00000E-01     1.00000E 00
   3     2.00000E-01    -7.00000E-01
   4     3.00000E-01    -7.00000E-01
   5     4.00000E-01     0.0
   6     5.00000E-01     0.0

 KR TABLE FOR I,J,L =      5     7     2
   1     0.0             1.00000E 00
   2     6.67000E-02     1.00000E 00
   3     1.33400E-01     1.00000E 00
   4     2.00100E-01     1.00000E 00
   5     2.66800E-01     0.0
   6     3.33500E-01     0.0

 KR TABLE FOR I,J,L =      5     7     3
   1     0.0             1.00000E 00
   2     6.67000E-02     1.00000E 00
   3     1.33400E-01     1.00000E 00
   4     2.00100E-01     1.00000E 00
   5     2.66800E-01     0.0
   6     3.33500E-01     0.0

 KR TABLE FOR I,J,L =      5     7     4
   1     0.0             1.00000E 00
   2     1.00000E-01     1.00000E 00
   3     2.00000E-01     1.00000E 00
   4     3.00000E-01     1.00000E 00
   5     4.00000E-01     0.0
   6     5.00000E-01     0.0

 KR TABLE FOR I,J,L =      5     7     5
   1     0.0             1.00000E 00
   2     1.00000E-01     1.00000E 00
   3     2.00000E-01     1.00000E 00
   4     3.00000E-01     1.00000E 00
   5     4.00000E-01     0.0
   6     5.00000E-01     0.0

 KR TABLE FOR I,J,L =      5     7     6
   1     0.0             1.00000E 00
   2     1.00000E-01     1.00000E 00
   3     2.00000E-01     1.00000E 00
   4     3.00000E-01     1.00000E 00
```

Figure 86. (Continued).

```
   5    4.00000E-01    0.0
   6    5.00000E-01    0.0

 KR TABLE FOR I,J,L =     8     9     1
   1    0.0            7.85000E-03
   2    4.80000E-01    7.85000E-03
   3    9.60000E-01    1.00000E 00
   4    1.44000E 00    1.00000E 00
   5    1.92000E 00    0.0
   6    2.40000E 00    0.0

 KR TABLE FOR I,J,L =     8     9     2
   1    0.0            1.00000E 00
   2    2.00000E-01    1.00000E 00
   3    4.00000E-01    1.00000E 00
   4    6.00000E-01    1.00000E 00
   5    8.00000E-01    0.0
   6    1.00000E 00    0.0

 KR TABLE FOR I,J,L =     8     9     3
   1    0.0            1.00000E 00
   2    2.00000E-01    1.00000E 00
   3    4.00000E-01    1.00000E 00
   4    6.00000E-01    1.00000E 00
   5    8.00000E-01    0.0
   6    1.00000E 00    0.0

 KR TABLE FOR I,J,L =     8     9     4
   1    0.0            1.00000E 00
   2    1.00000E-01    1.00000E 00
   3    2.00000E-01    1.00000E 00
   4    3.00000E-01    1.00000E 00
   5    4.00000E-01    0.0
   6    5.00000E-01    0.0

 KR TABLE FOR I,J,L =     8     9     5
   1    0.0            1.00000E 00
   2    5.00000E-03    1.00000E 00
   3    1.00000E-02    1.00000E 00
   4    1.50000E-02    1.00000E 00
   5    2.00000E-02    0.0
   6    2.50000E-02    0.0

 KR TABLE FOR I,J,L =     8     9     6
   1    0.0            1.00000E 00
   2    1.00000E-01    1.00000E 00
   3    2.00000E-01    1.00000E 00
   4    3.00000E-01    1.00000E 00
   5    4.00000E-01    0.0
   6    5.00000E-01    0.0

 KR TABLE FOR I,J,L =    10    14     1
   1    0.0            1.00000E 00
   2    5.00000E-01    1.00000E 00
   3    1.00000E 00    1.00000E 00
   4    1.50000E 00    1.00000E 00
   5    2.00000E 00   -3.33000E 00
   6    2.50000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =    10    14     2
   1    0.0            1.00000E 00
   2    4.00000E 00    1.00000E 00
   3    8.00000E 00    1.00000E 00
   4    1.20000E 01    1.00000E 00
   5    1.60000E 01   -3.32000E 00
   6    2.00000E 01   -3.32000E 00
```

Figure 86. (Continued).

```
KR TABLE FOR I,J,L =   10   14    3
   1    0.0              1.00000E 00
   2    4.00000E 00      1.00000E 00
   3    8.00000E 00      1.00000E 00
   4    1.20000E 01      1.00000E 00
   5    1.60000E 01     -3.33000E 00
   6    2.00000E 01     -3.33000E 00

KR TABLE FOR I,J,L =   10   14    4
   1    0.0              1.00000E 00
   2    2.00000E-01      1.00000E 00
   3    4.00000E-01      1.00000E 00
   4    6.00000E-01      1.00000E 00
   5    8.00000E-01     -3.33000E 00
   6    1.00000E 00     -3.33000E 00

KR TABLE FOR I,J,L =   10   14    5
   1    0.0              1.00000E 00
   2    2.00000E-01      1.00000E 00
   3    4.00000E-01      1.00000E 00
   4    6.00000E-01      1.00000E 00
   5    8.00000E-01     -3.33000E 00
   6    1.00000E 00     -3.33000E 00

KR TABLE FOR I,J,L =   10   14    6
   1    0.0              1.00000E 00
   2    2.00000E-01      1.00000E 00
   3    4.00000E-01      1.00000E 00
   4    6.00000E-01      1.00000E 00
   5    8.00000E-01     -3.33000E 00
   6    1.00000E 00     -3.33000E 00

KR TABLE FOR I,J,L =   10   15    1
   1    0.0              1.00000E 00
   2    5.00000E-01      1.00000E 00
   3    1.00000E 00      1.00000E 00
   4    1.50000E 00      1.00000E 00
   5    2.00000E 00     -3.33000E 00
   6    2.50000E 00     -3.33000E 00

KR TABLE FOR I,J,L =   10   15    2
   1    0.0              1.00000E 00
   2    4.00000E 00      1.00000E 00
   3    8.00000E 00      1.00000E 00
   4    1.20000E 01      1.00000E 00
   5    1.60000E 01     -3.33000E 00
   6    2.00000E 01     -3.33000E 00

KR TABLE FOR I,J,L =   10   15    3
   1    0.0              1.00000E 00
   2    4.00000E 00      1.00000E 00
   3    8.00000E 00      1.00000E 00
   4    1.20000E 01      1.00000E 00
   5    1.60000E 01     -3.33000E 00
   6    2.00000E 01     -3.33000E 00

KR TABLE FOR I,J,L =   10   15    4
   1    0.0              1.00000E 00
   2    2.00000E-01      1.00000E 00
   3    4.00000E-01      1.00000E 00
   4    6.00000E-01      1.00000E 00
   5    8.00000E-01     -3.33000E 00
   6    1.00000E 00     -3.33000E 00

KR TABLE FOR I,J,L =   10   15    5
```

Figure 86. (Continued).

```
   1     0.0            1.00000E 00
   2     2.00000E-01    1.00000E 00
   3     4.00000E-01    1.00000E 00
   4     6.00000E-01    1.00000E 00
   5     8.00000E-01   -3.33000E 00
   6     1.00000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =    10   15    6
   1     0.0            1.00000E 00
   2     2.00000E-01    1.00000E 00
   3     4.00000E-01    1.00000E 00
   4     6.00000E-01    1.00000E 00
   5     8.00000E-01   -3.33000E 00
   6     1.00000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =    16   17    1
   1     0.0            1.00000E 00
   2     5.00000E-01    1.00000E 00
   3     1.00000E 00    1.00000E 00
   4     1.50000E 00    1.00000E 00
   5     2.00000E 00   -3.33000E 00
   6     2.50000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =    16   17    2
   1     0.0            1.00000E 00
   2     4.00000E 00    1.00000E 00
   3     8.00000E 00    1.00000E 00
   4     1.20000E 01    1.00000E 00
   5     1.60000E 01   -3.33000E 00
   6     2.00000E 01   -3.33000E 00

 KR TABLE FOR I,J,L =    16   17    3
   1     0.0            1.00000E 00
   2     4.00000E 00    1.00000E 00
   3     8.00000E 00    1.00000E 00
   4     1.20000E 01    1.00000E 00
   5     1.60000E 01   -3.33000E 00
   6     2.00000E 01   -3.33000E 00

 KR TABLE FOR I,J,L =    16   17    4
   1     0.0            1.00000E 00
   2     2.00000E-01    1.00000E 00
   3     4.00000E-01    1.00000E 00
   4     6.00000E-01    1.00000E 00
   5     8.00000E-01   -3.33000E 00
   6     1.00000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =    16   17    5
   1     0.0            1.00000E 00
   2     2.00000E-01    1.00000E 00
   3     4.00000E-01    1.00000E 00
   4     6.00000E-01    1.00000E 00
   5     8.00000E-01   -3.33000E 00
   6     1.00000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =    16   17    6
   1     0.0            1.00000E 00
   2     2.00000E-01    1.00000E 00
   3     4.00000E-01    1.00000E 00
   4     6.00000E-01    1.00000E 00
   5     8.00000E-01   -3.33000E 00
   6     1.00000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =    16   18    1
   1     0.0            1.00000E 00
   2     5.00000E-01    1.00000E 00
```

Figure 86. (Continued).

```
   3    1.00000E 00    1.00000E 00
   4    1.50000E 00    1.00000E 00
   5    2.00000E 00   -3.33000E 00
   6    2.50000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =   16   18    2
   1    0.0            1.00000E 00
   2    4.00000E 00    1.00000E 00
   3    8.00000E 00    1.00000E 00
   4    1.20000E 01    1.00000E 00
   5    1.60000E 01   -3.33000E 00
   6    2.00000E 01   -3.33000E 00

 KP TABLE FOR I,J,L =   16   18    3
   1    0.0            1.00000E 00
   2    4.00000E 00    1.00000E 00
   3    8.00000E 00    1.00000E 00
   4    1.20000E 01    1.00000E 00
   5    1.60000E 01   -3.33000E 00
   6    2.00000E 01   -3.33000E 00

 KR TABLE FOR I,J,L =   16   18    4
   1    0.0            1.00000E 00
   2    2.00000E-01    1.00000E 00
   3    4.00000E-01    1.00000E 00
   4    6.00000E-01    1.00000E 00
   5    8.00000E-01   -3.33000E 00
   6    1.00000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =   16   18    5
   1    0.0            1.00000E 00
   2    2.00000E-01    1.00000E 00
   3    4.00000E-01    1.00000E 00
   4    6.00000E-01    1.00000E 00
   5    8.00000E-01   -3.33000E 00
   6    1.00000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =   16   18    6
   1    0.0            1.00000E 00
   2    2.00000E-01    1.00000E 00
   3    4.00000E-01    1.00000E 00
   4    6.00000E-01    1.00000E 00
   5    8.00000E-01   -3.33000E 00
   6    1.00000E 00   -3.33000E 00

 IJ,I,J,VMAX( I,J,1-6)
   1  1  2    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   2  2  3    1.000000D 01   6.000000D 00   6.000000D 00   1.000000D 01   1.000000D 01   1.000000D 01
   3  3  4    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   4  4  5    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   5  4  7    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   6  5  6    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   7  5  7    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   8  5 20    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   9  5 21    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  10  5 22    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  11  5 23    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  12  6  9    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  13  6 11    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  14  7  9    1.000000D 00   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  15  8  9    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  16 10 11    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  17 10 14    1.000000D 01   1.000000D 01   1.510000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  18 10 15    1.000000D 01   1.000000D 01   1.510000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  19 10 22    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
  20 10 23    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
```

Figure 86. (Continued).

```
21 11 16   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
22 12 16   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
23 12 24   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
24 13 16   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
25 13 25   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
26 16 17   1.000000D 01   1.000000D 01   1.510000D 01   1.000000D 01   1.000000D 01   1.000000D 01
27 16 18   1.000000D 01   1.000000D 01   1.510000D 01   1.000000D 01   1.000000D 01   1.000000D 01
28 16 19   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
29 20 21   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
30 20 22   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
31 21 23   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
32 24 25   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
33 10 26   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
34 16 27   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
35 26 28   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
36 27 29   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
37 26 30   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
38 27 31   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01

                          PLOT CARDS WHICH ARE NOT ALL BLANK

              1         2         3         4         5         6         7         8
     12345678901234567890123456789012345678901234567890123456789012345678901234567890

   5       11 1     1                                                            5005
   6       11 1     1                                                            5006
   8       11 11    1                                                            5008
   9       11 11    1         11  11                                             5009
  12          1111  1      11                                                    5012
  13     1 1       1                     11                                      5013
  14     1 1       1                                                             5014
  15     1 1       1                                                             5015
  25                                     11                                      5025

 INDP =  0

                               DRI(IJ) INDICATORS

              1         2         3         4         5         6         7         8
     12345678901234567890123456789012345678901234567890123456789012345678901234567890

                                         11                                      7000

 IJ,THEIJ(IJ),PSIIJ(IJ)
    1   -8.375070-01    0.0
    2   -1.491810-01    0.0
    3   -2.965290-01    0.0
    4    0.0            0.0
    5    1.023660 00    0.0
    6    0.0            0.0
    7    2.107750 00    0.0
    8    6.953940-01    1.570800 00
    9    6.953940-01   -1.570800 00
   10   -3.504650-01    1.570800 00
   11   -3.504650-01   -1.570800 00
   12    1.570800 00    0.0
   13   -1.570800 00    0.0
   14   -2.497790-01    0.0
   15   -1.764500 00    0.0
   16    0.0            0.0
   17   -5.187220-01    1.570800 00
   18   -5.187220-01   -1.570800 00
   19    0.0            1.570800 00
   20    0.0           -1.570800 00
   21    0.0            0.0
   22    0.0           -1.570570 00
```

Figure 86. (Continued).

23	1.570610 00	0.0
24	0.0	1.570570 00
25	1.570610 00	0.0
26	-5.187220-01	1.570800 00
27	-5.187220-01	-1.570800 00
28	0.0	0.0
29	0.0	-1.570800 00
30	-1.570800 00	0.0
31	-1.570800 00	0.0
32	0.0	-1.570800 00
33	1.570800 00	0.0
34	1.570800 00	0.0
35	1.570800 00	0.0
36	1.570800 00	0.0
37	1.570800 00	0.0
38	1.570800 00	0.0

Figure 86. (Continued).

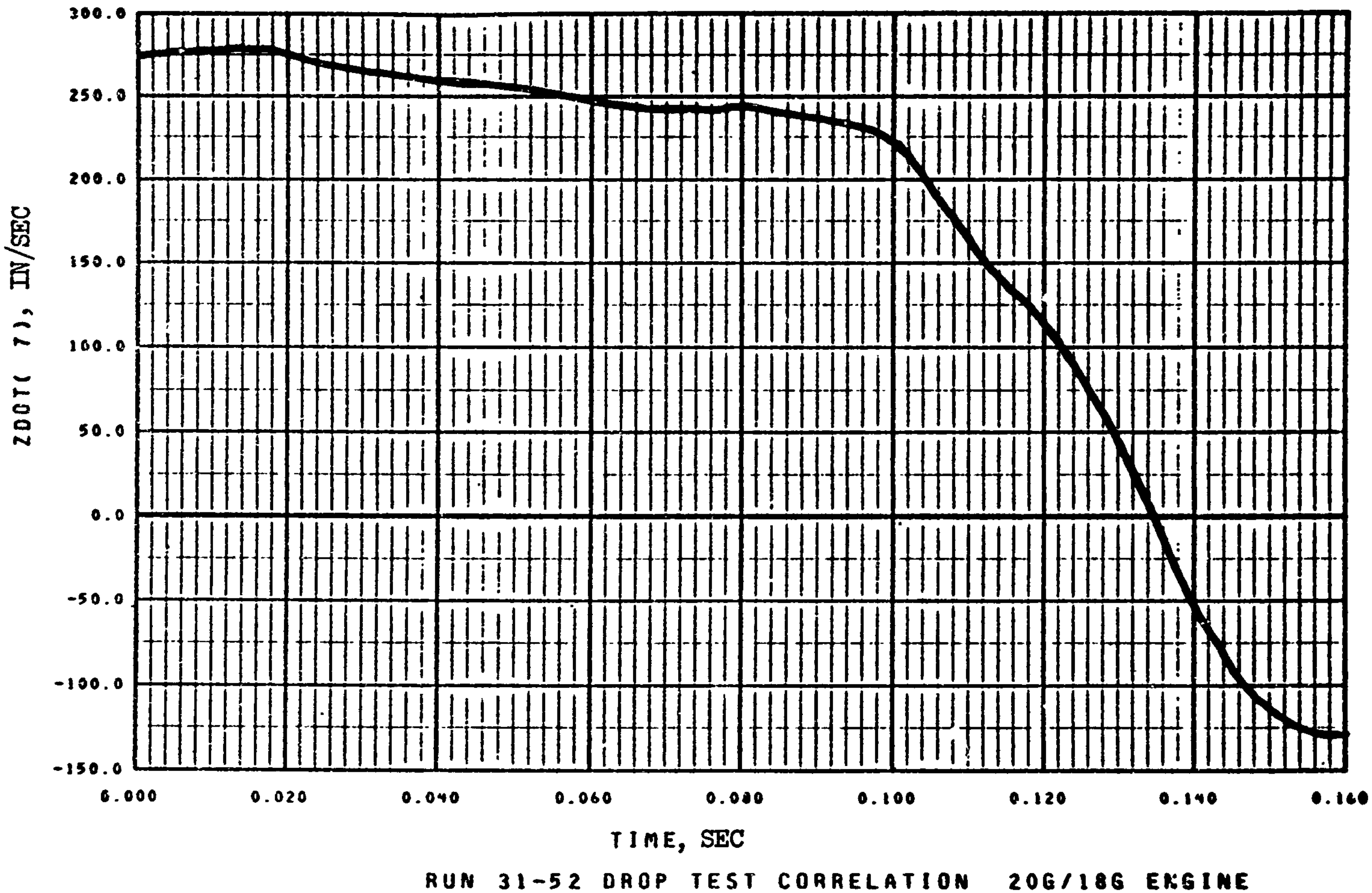


Figure 87. Engine Mass Vertical Velocity Time History Plot, Combined Vertical and Lateral Impact Sample Case.

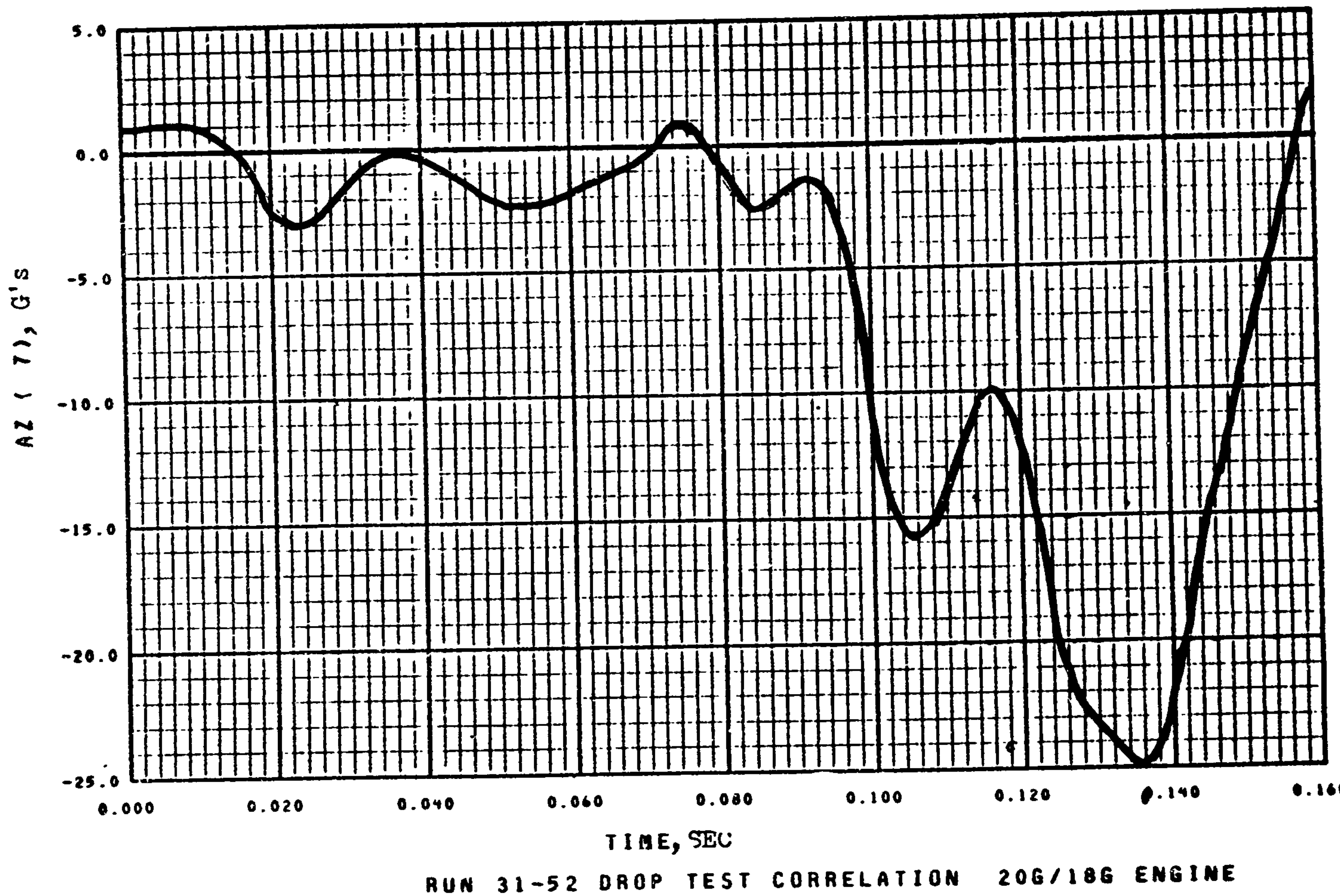


Figure 88. Engine Mass Vertical Acceleration Time History Plot, Combined Vertical and Lateral Impact Sample Case.

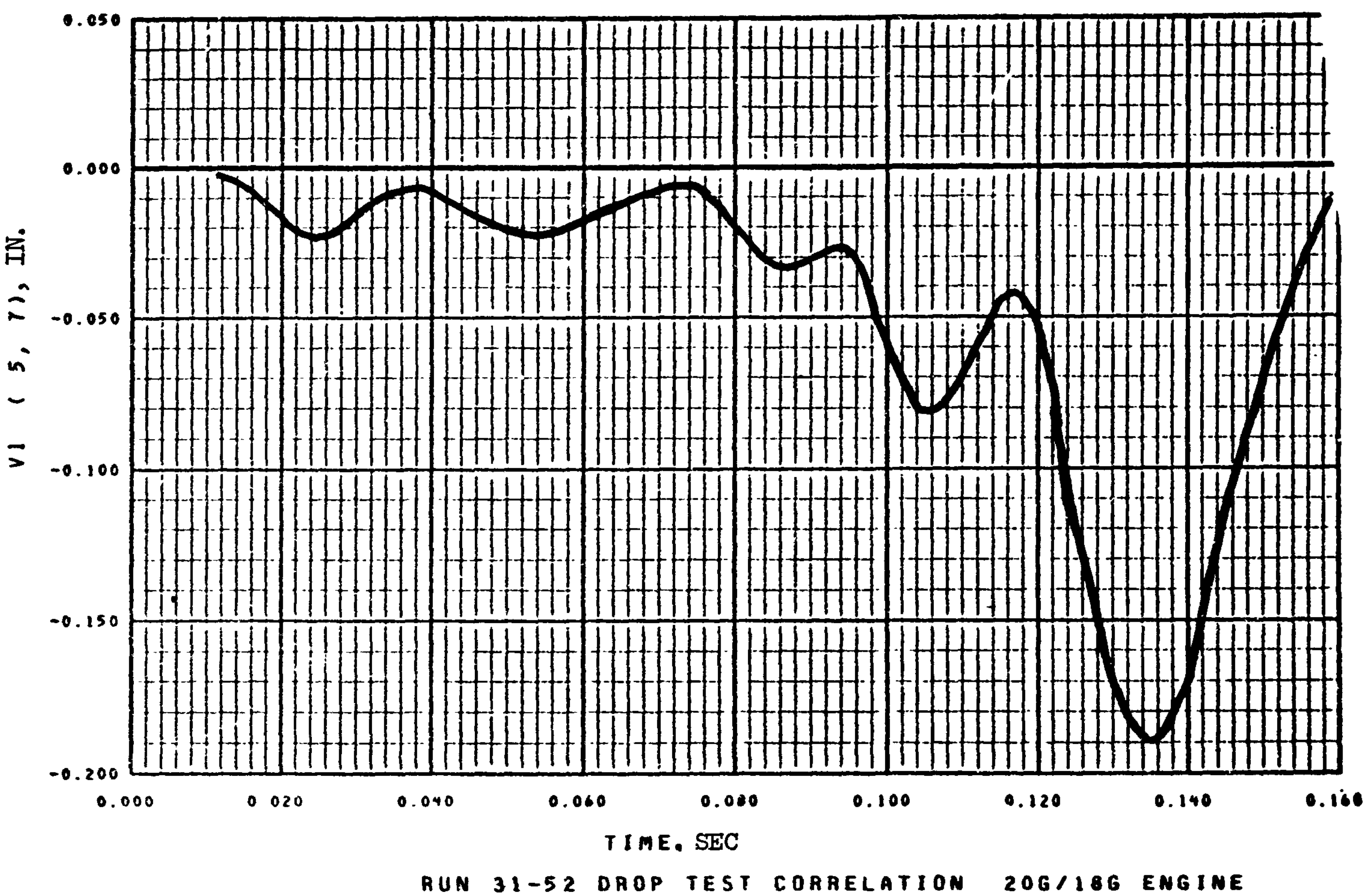


Figure 89. Engine Mount Vertical Deflection Time History Plot, Combined Vertical and Lateral Impact Sample Case.

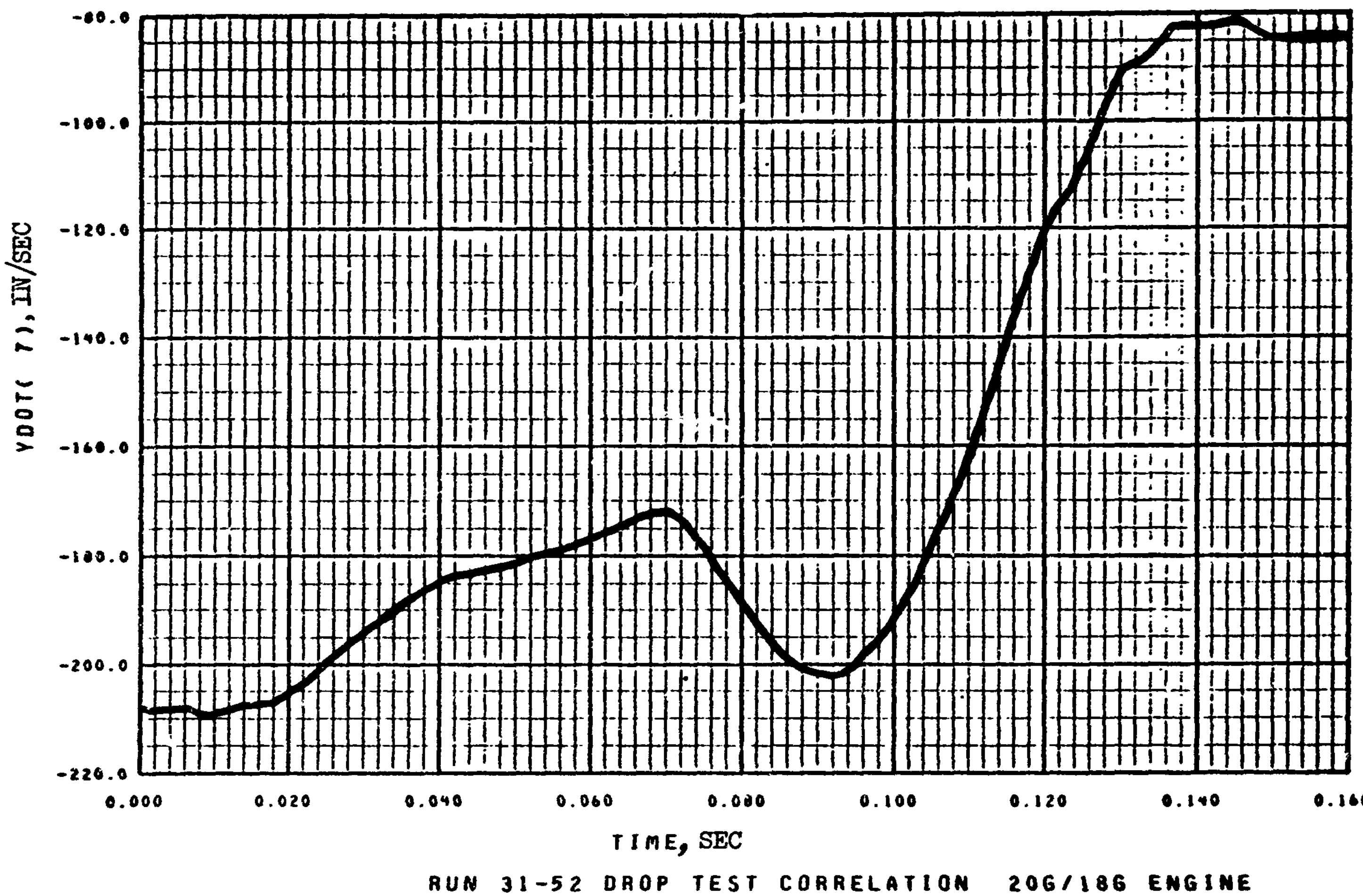


Figure 90. Engine Mass Lateral Velocity Time History Plot, Combined Vertical and Lateral Impact Sample Case.

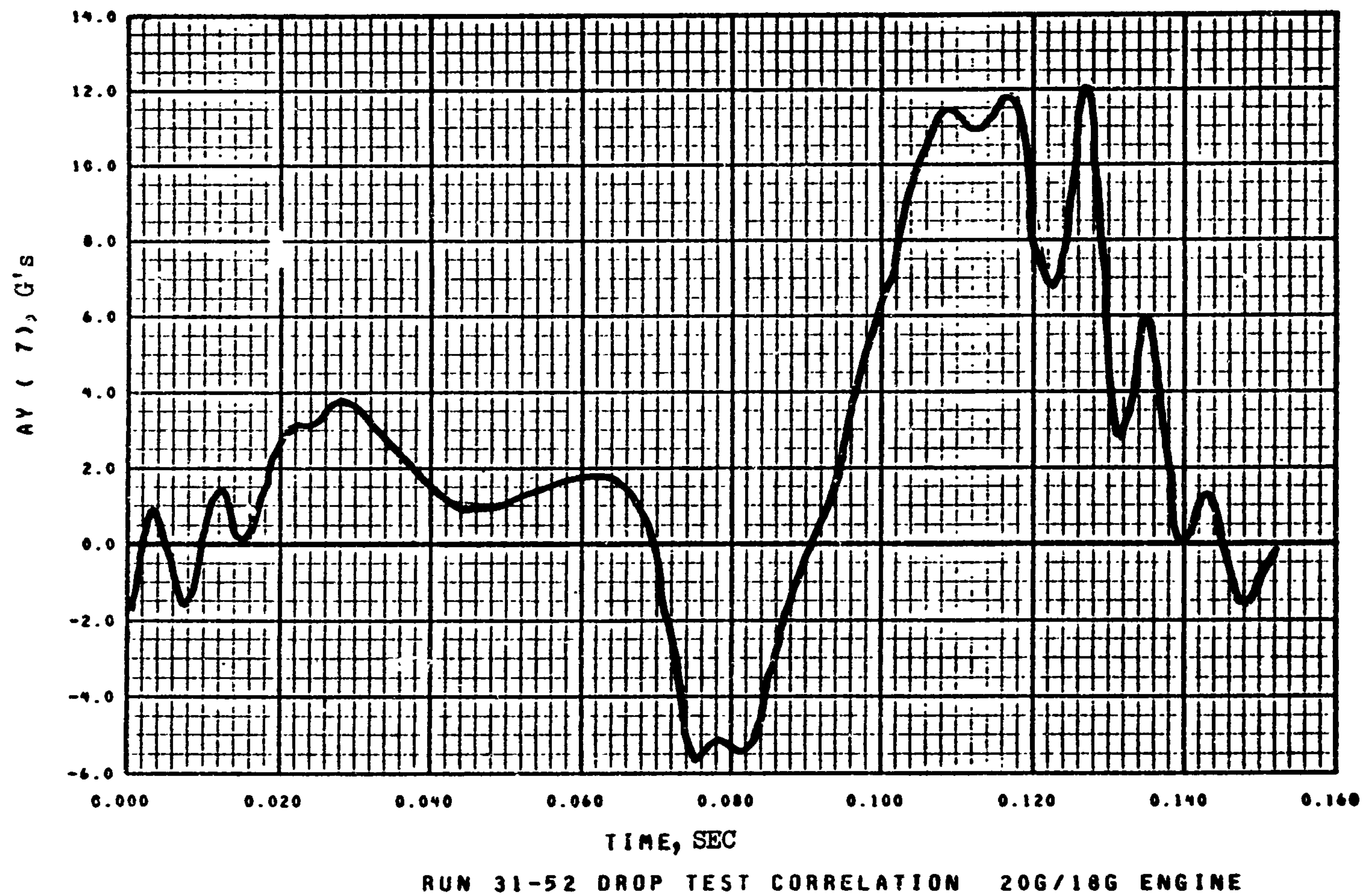


Figure 91. Engine Mass Lateral Acceleration Time History Plot, Combined Vertical and Lateral Impact Sample Case.

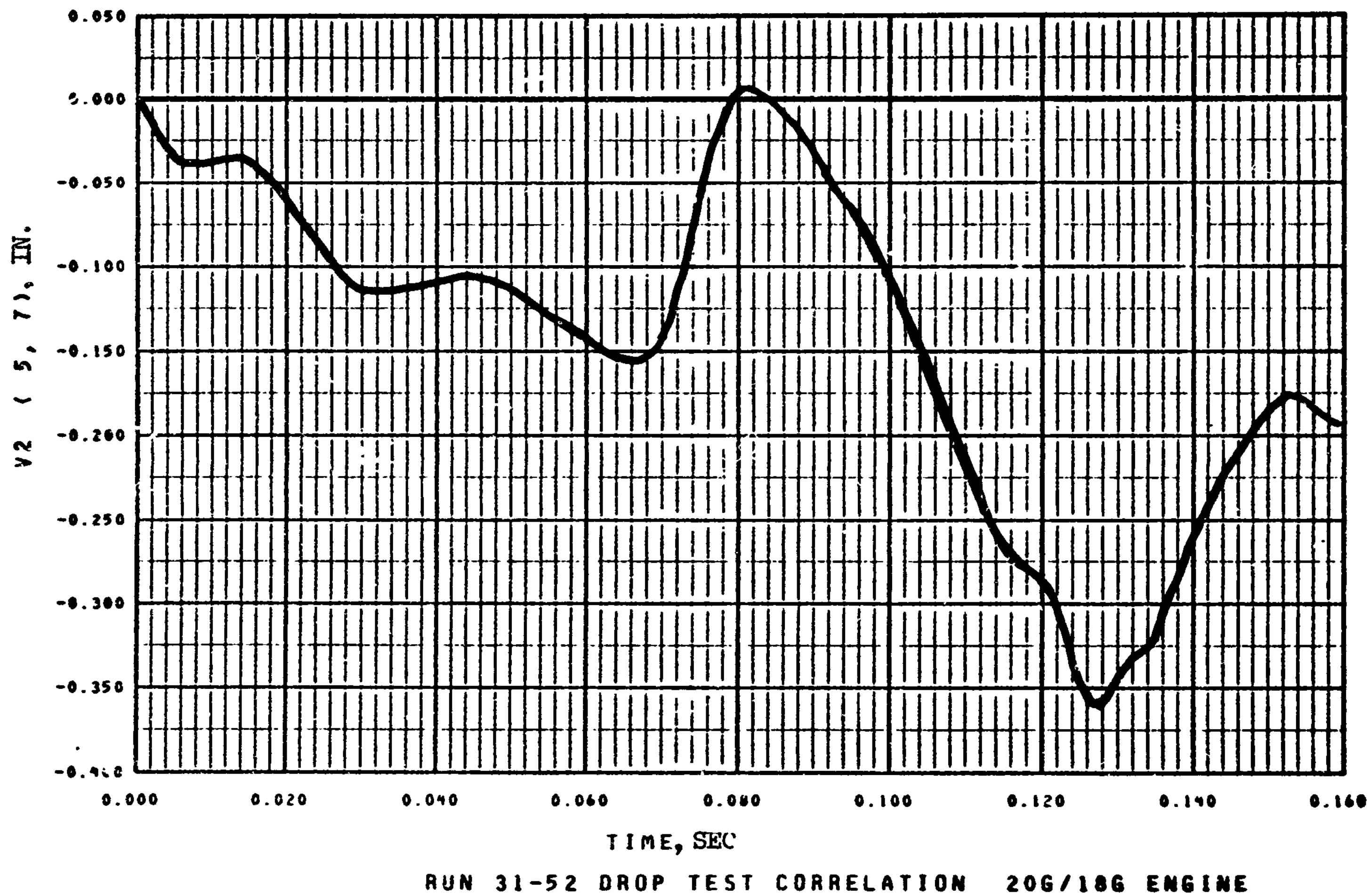


Figure 92. Engine Mount Lateral Deflection Time History Plot, Combined Vertical and Lateral Impact Sample Case.

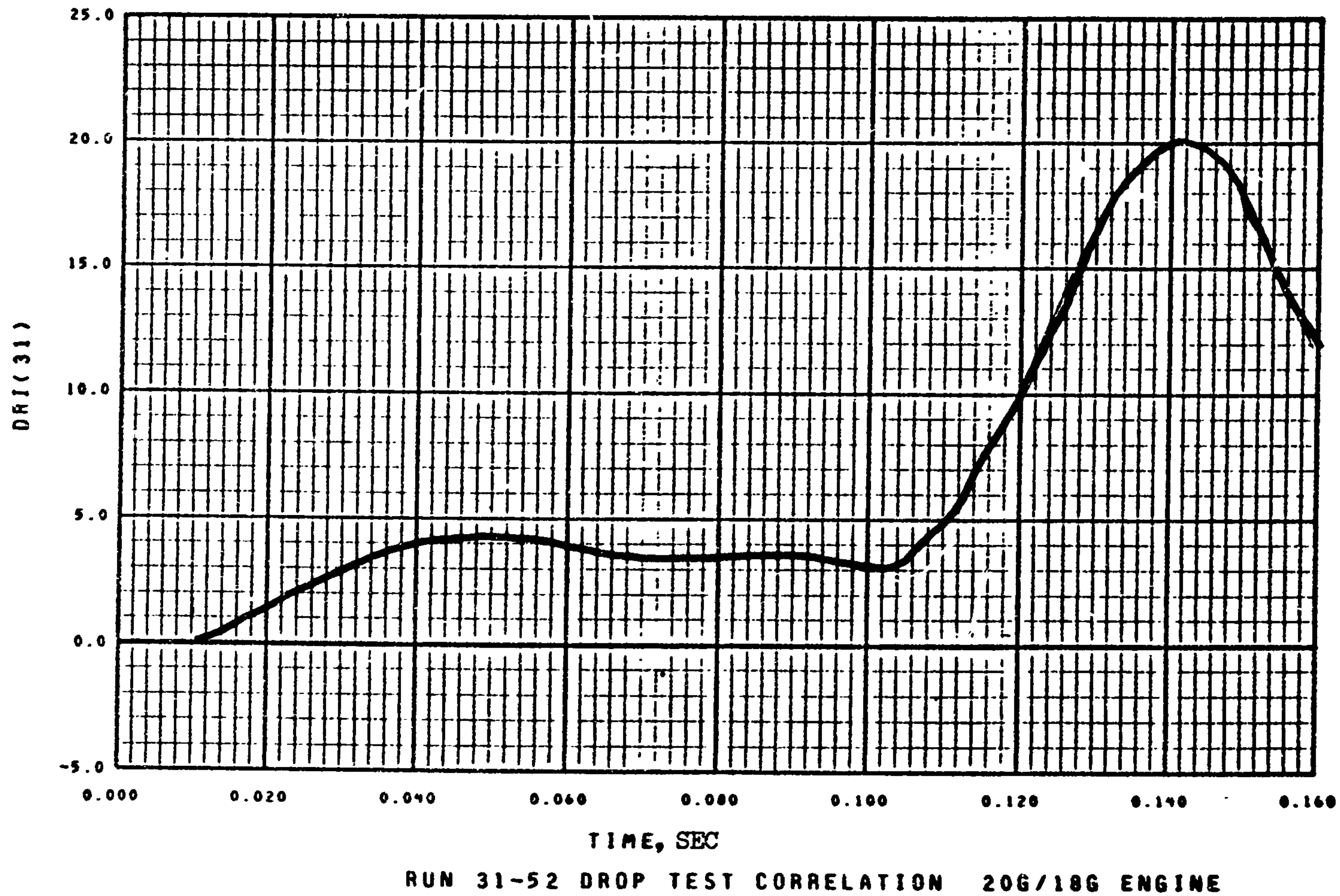


Figure 93. Forward DRI Time History Plot, Combined Vertical and Lateral Impact Sample Case.

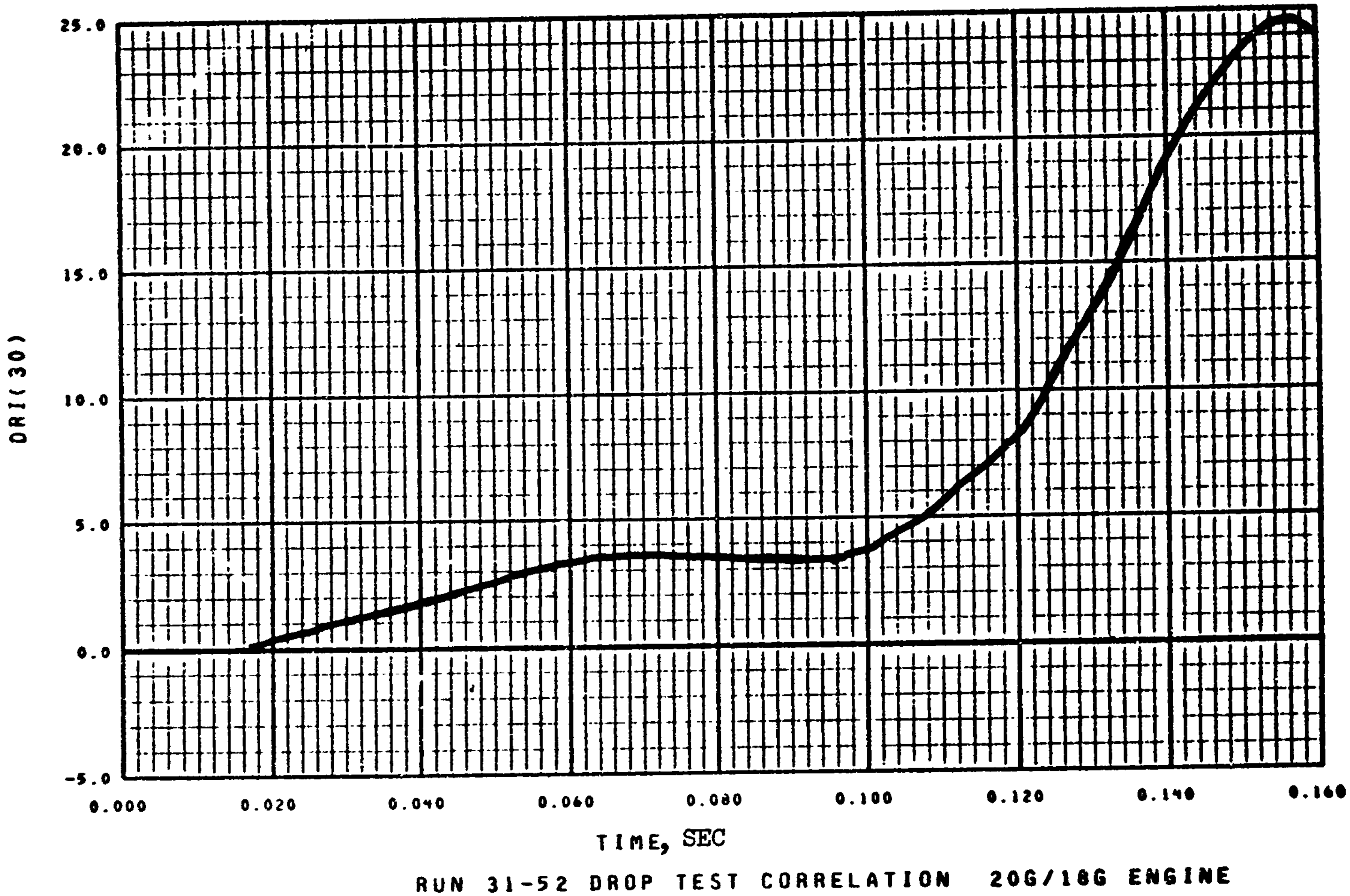


Figure 94. Aft DRI Time History Plot, Combined Vertical and Lateral Impact Sample Case.

RUN SE-31-100 COMBINED VEL. IMPACT 0100

MASSES = 32 DP/DT = 100 DT =0.00002 TMAX = 0.100
XGDOT = 3.240000 02 YGDOT = -2.232000 02 ZGDOT = 2.760000 02
P' = 0.0 Q' = 0.0 R' = 0.0
PHI' = 0.0 THETA' = 0.0 PSI' = 0.0 ZG = 0.0

WEIGHTS

1	1.390000 02
2	8.500000 01
3	6.200000 01
4	1.720000 02
5	2.780000 02
6	9.320000 02
7	7.310000 02
8	1.212000 03
9	9.000000 01
10	2.570000 02
11	1.823000 03
12	1.750000 02
13	1.750000 02
14	2.400000 01
15	2.400000 01
16	9.500000 02
17	2.400000 01
18	2.400000 01
19	3.070000 02
20	3.100000 01
21	3.100000 01
22	1.660000 02
23	1.660000 02
24	2.850000 01
25	2.850000 01
26	5.500000 01
27	7.000000 01
28	1.200000 02
29	1.200000 02
30	1.200000 02
31	1.200000 02
32	2.00000[illegible]

I,IX(I),IY(I),IZ(I),IXY(I),IYZ(I),IXZ(I)

1	2.000000 02	1.730000 02	1.730000 02	0.0	0.0	0.0
2	1.000000 01	2.056000 02	2.000000 02	0.0	0.0	0.0
3	1.500000 01	1.470000 02	1.320000 02	0.0	0.0	0.0
4	3.400000 01	3.400000 01	1.000000 01	0.0	0.0	0.0
5	2.500000 02	2.500000 02	2.500000 02	0.0	0.0	0.0
6	1.000000 03	1.000000 03	1.000000 03	0.0	0.0	0.0
7	3.060000 02	6.030000 02	6.280000 02	0.0	0.0	0.0
8	3.500000 03	3.563000 03	3.130000 02	0.0	0.0	0.0
9	3.700000 01	4.700000 01	4.000000 01	0.0	0.0	0.0
10	2.500000 02	2.500000 02	2.500000 02	0.0	0.0	0.0
11	[illegible].010000 03	5.082000 03	3.294000 03	0.0	0.0	0.0
12	4.300000 01	2.500000 02	2.300000 02	0.0	0.0	0.0
13	4.300000 01	2.500000 02	2.300000 02	0.0	0.0	0.0
14	3.570000 01	3.570000 01	2.400000 01	0.0	0.0	0.0
15	3.570000 01	3.570000 01	2.400000 01	0.0	0.0	0.0
16	1.000000 03	1.100000 03	1.100000 03	0.0	0.0	0.0
17	5.620000 01	5.620000 01	2.400000 01	0.0	0.0	0.0
18	5.620000 01	5.620000 01	2.400000 01	0.0	0.0	0.0
19	1.716000 02	2.476000 02	7.600000 01	0.0	0.0	0.0
20	1.284000 02	1.290000 02	3.960000 01	0.0	0.0	0.0
21	1.284000 02	1.290000 02	3.960000 01	0.0	0.0	0.0
22	4.650000 01	7.000000 01	7.000000 01	0.0	0.0	0.0

Figure 95. Input Data, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

23	4.650000 01	7.000000 01	7.000000 01	0.0	0.0	0.0
24	1.358000 02	2.688000 02	1.565000 02	0.0	0.0	0.0
25	1.358000 02	2.688000 02	1.565000 02	0.0	0.0	0.0
26	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0
27	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0
28	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0
29	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0
30	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0
31	1.800000 02	1.800000 02	1.800000 02	0.0	0.0	0.0
32	2.000000 01	2.000000 02	2.000000 02	0.0	0.0	0.0

I,X**(I),Y**(I),Z**(I)

1	4.587500 02	0.0	1.325200 02
2	4.042300 02	0.0	7.200000 01
3	2.412200 02	0.0	4.750000 01
4	2.116000 02	0.0	3.845000 01
5	1.630000 02	0.0	3.845000 01
6	1.410000 02	0.0	3.845000 01
7	1.870700 02	0.0	7.860000 01
8	1.356000 02	0.0	9.490000 01
9	1.410000 02	0.0	6.706000 01
10	1.630000 02	0.0	2.200000 01
11	1.410000 02	0.0	2.200000 01
12	7.163000 01	-4.500000 01	2.200000 01
13	7.163000 01	4.500000 01	2.200000 01
14	1.630000 02	-5.080000 01	-7.000000 00
15	1.630000 02	5.080000 01	-7.000000 00
16	7.162000 01	0.0	2.200000 01
17	7.162000 01	-5.080000 01	-7.000000 00
18	7.162000 01	5.080000 01	-7.000000 00
19	2.300000 01	0.0	2.200000 01
20	1.630000 02	-4.500000 01	7.600000 01
21	1.630000 02	4.500000 01	7.600000 01
22	1.630000 02	-4.500000 01	2.200000 01
23	1.630000 02	4.500000 01	2.200000 01
24	7.162000 01	-4.500000 01	7.600000 01
25	7.162000 01	4.500000 01	7.600000 01
26	1.630000 02	0.0	3.200000 01
27	7.162000 01	0.0	3.200000 01
28	1.630000 02	0.0	4.200000 01
29	7.162000 01	0.0	4.200000 01
30	1.630000 02	0.0	4.200000 01
31	7.162000 01	0.0	4.200000 01
32	5.000000 01	0.0	7.780000 01

THERE ARE 0 I'S HAVING NON-ZERO HE OR PHI**,THETA**,PSI**

THERE ARE 0 I'S HAVING NON-ZERO LC'S

I,K,LBAR(I,K),MU(I,K),KE(I,K)

10	3	1.700000 01	3.000000-01	3.300000 04
11	3	1.700000 01	3.000000-01	1.100000 04
12	3	1.700000 01	3.000000-01	1.100000 04
13	3	1.700000 01	3.000000-01	1.100000 04
14	3	2.250000 00	3.000000-01	2.200000 04
15	3	2.250000 00	3.000000-01	2.200000 04
16	3	1.700000 01	3.000000-01	3.300000 04
17	3	2.250000 00	3.000000-01	2.200000 04
18	3	2.250000 00	3.000000-01	2.200000 04
22	3	1.700000 01	3.000000-01	1.100000 04
23	3	1.700000 01	3.000000-01	1.100000 04

I,K,SI(I,K),SA(I,K),SB(I,K),SF(I,K),FSPDI(I,K),FSPDF(I,K)

10	3	1.000000-03	1.000000 00	2.000000 00	3.500000 00	1.550000 04	1.650000 04
11	3	1.000000-03	1.000000 00	2.000000 00	3.500000 00	5.500000 03	5.500000 03
12	3	1.000000-03	1.000000 00	2.000000 00	3.500000 00	5.500000 03	5.500000 03

Figure 95. (Continued).

13	3	1.000000D-03	1.000000 00	2.000000 00	3.500000 00	5.500000 03	5.500000 03
14	3	2.000000D-01	4.000000D-01	6.000000D-01	1.200000 00	4.400000 03	4.400000 03
15	3	2.000000D-01	4.000000D-01	6.000000D-01	1.200000 00	4.400000 03	4.400000 03
16	3	1.000000D-03	1.000000 00	2.000000 00	3.500000 00	1.650000 04	1.650000 04
17	3	2.000000D-01	4.000000D-01	6.000000D-01	1.200000 00	4.400000 03	4.400000 03
18	3	2.000000D-01	4.000000D-01	6.000000D-01	1.200000 00	4.400000 03	4.400000 03
22	3	1.000000D-03	1.000000 00	2.000000 00	3.500000 00	5.500000 03	5.500000 03
23	3	1.000000D-03	1.000000 00	2.000000 00	3.500000 00	5.500000 03	5.500000 03

IJ,I,J,PHI(I,J),THETA(I,J),PSI(I,J) (INTERNAL BEAMS)

1	1	2	0.C	0.0	0.0
2	2	3	0.0	0.0	0.0
3	3	4	0.0	0.0	0.0
4	4	5	0.0	0.0	0.0
5	4	7	0.0	0.0	0.0
6	5	6	0.0	0.0	0.0
7	5	7	0.0	0.0	0.0
8	5	20	0.0	0.0	0.0
9	5	21	0.0	0.0	0.0
10	5	22	0.0	0.0	0.0
11	5	23	0.0	0.0	0.0
12	6	9	0.0	0.0	0.0
13	6	11	0.0	0.0	0.0
14	7	9	0.0	0.0	0.0
15	8	9	0.0	0.0	0.0
16	10	11	0.0	0.0	0.0
17	10	14	0.0	0.0	0.0
18	10	15	0.0	0.0	0.0
19	10	22	0.0	0.0	0.0
20	10	23	0.0	0.0	0.0
21	11	16	0.0	0.0	0.0
22	12	16	0.0	0.0	0.0
23	12	24	0.0	0.0	0.0
24	13	16	0.0	0.0	0.0
25	13	25	0.0	0.0	0.0
26	16	17	0.0	0.0	0.0
27	16	18	0.0	0.0	0.0
28	16	19	0.0	0.0	0.0
29	20	21	0.0	0.0	0.0
30	20	22	0.0	0.0	0.0
31	21	23	0.0	0.0	0.0
32	24	25	0.0	0.0	0.0
33	10	26	0.0	0.0	0.0
34	16	27	0.0	0.0	0.0
35	26	28	0.0	0.0	0.0
36	27	29	0.0	0.0	0.0
37	26	30	0.0	0.0	0.0
38	27	31	0.0	0.0	0.0
39	8	32	0.0	0.0	0.0

I,J,K-MATRIX FOR INTERNAL BEAM IJ

1 2

1.227700 05	0.0	0.0	0.0	0.0	0.0
0.0	1.754000 03	0.0	0.0	0.0	-7.143900 04
0.0	0.0	2.220000 03	0.0	9.040000 04	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	9.040000 04	0.0	4.910600 06	0.0
0.0	-7.143900 04	0.0	0.0	0.0	3.879400 06

2 3

6.127500 04	0.0	0.0	0.0	0.0	0.0
0.0	8.505000 03	0.0	0.0	0.0	-6.940000 05
0.0	0.0	9.663000 03	0.0	7.885000 05	0.0
0.0	0.0	0.0	2.464000 06	0.0	0.0
0.0	0.0	7.885000 05	0.0	8.579000 07	0.0
0.0	-6.940000 05	0 0	0.0	0.0	7.550000 07

3 4

Figure 95. (Continued).

	3.228000 05	0.0	0.0	0.0	0.0	0.0
	0.0	1.213000 06	0.0	0.0	0.0	-1.879000 07
	0.0	0.0	1.634000 06	0.0	2.530000 07	0.0
	0.0	0.0	0.0	3.649000 07	0.0	0.0
	0.0	0.0	2.530000 07	0.0	5.226000 08	0.0
	0.0	-1.879000 07	0.0	0.0	0.0	3.881000 08
4 5						
	2.101000 06	0.0	0.0	0.0	0.0	0.0
	0.0	8.957000 05	0.0	0.0	0.0	-2.132000 07
	0.0	0.0	4.773000 06	0.0	1.136000 08	0.0
	0.0	0.0	0.0	8.193000 10	0.0	0.0
	0.0	0.0	1.136000 08	0.0	3.605000 09	0.0
	0.0	-2.132000 07	0.0	0.0	0.0	6.765000 08
4 7						
	5.650000 04	0.0	0.0	0.0	0.0	0.0
	0.0	1.120000 05	0.0	0.0	0.0	-2.640000 06
	0.0	0.0	1.120000 05	0.0	2.640000 06	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	2.640000 06	0.0	8.290000 07	0.0
	0.0	-2.640000 06	0.0	0.0	0.0	8.290000 07
5 6						
	4.545000 05	0.0	0.0	0.0	0.0	0.0
	0.0	1.665000 06	0.0	0.0	0.0	-1.832000 07
	0.0	0.0	5.531000 06	0.0	6.084000 07	0.0
	0.0	0.0	0.0	8.924000 09	0.0	0.0
	0.0	0.0	6.084000 07	0.0	8.923000 08	0.0
	0.0	-1.832060 07	0.0	0.0	0.0	2.686000 08
5 7						
	5.650000 04	0.0	0.0	0.0	0.0	0.0
	0.0	1.120000 05	0.0	0.0	0.0	-2.640000 06
	0.0	0.0	1.120000 05	C.0	2.640000 06	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	2.640000 06	0.0	8.290000 07	0.0
	0.0	-2.640000 06	0.0	0.0	0.0	8.290000 07
5 20						
	1.600000 05	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	4.918000 04	0.0	1.537000 06	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	1.537000 06	0.0	6.401000 07	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
5 21						
	1.600000 05	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	4.918000 04	0.0	1.537000 06	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	1.537000 06	0.0	6.401000 07	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
5 22						
	1.756000 05	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	6.498000 04	0.0	1.850000 06	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	1.850000 06	0.0	7.024000 07	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
5 23						
	1.756000 05	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	6.498000 04	0.0	1.850000 06	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	1.850000 06	0.0	7.024000 07	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
6 9						
	3.040000 06	0.0	0.0	0.0	0.0	0.0
	0.0	4.010000 05	0.0	0.0	0.0	-5.780000 06
	0.0	0.0	3.258000 05	0.0	4.690000 06	0.0

Figure 95. (Continued).

0.0	0.0	0.0	2.560000 07	0.0	0.0
0.0	0.0	4.690000 06	0.0	8.950000 07	0.0
0.0	-5.780000 06	0.0	0.0	0.0	1.104000 08
6 11					
4.863000 06	0.0	0.0	0.0	0.0	0.0
0.0	4.227000 06	0.0	0.0	0.0	-3.477000 07
0.0	0.0	3.424000 06	0.0	2.816000 07	0.0
0.0	0.0	0.0	8.267000 07	0.0	0.0
0.0	0.0	2.816000 07	0.0	3.089000 08	0.0
0.0	-3.477000 07	0.0	0.0	0.0	3.813000 08
7 9					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	2.190000 06	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
8 9					
2.039000 06	0.0	0.0	0.0	0.0	0.0
0.0	1.051000 05	0.0	0.0	0.0	-2.422000 06
0.0	0.0	1.911000 04	0.0	4.404000 05	0.0
0.0	0.0	0.0	2.256000 06	0.0	0.0
0.0	0.0	4.404000 05	0.0	1.354000 07	0.0
0.0	-2.422000 06	0.0	0.0	0.0	7.445000 07
10 11					
5.455000 05	0.0	0.0	0.0	0.0	0.0
0.0	4.869000 05	0.0	0.0	0.0	-5.355000 06
0.0	0.0	1.803000 05	0.0	1.983000 06	0.0
0.0	0.0	0.0	2.368000 06	0.0	0.0
0.0	0.0	1.983000 06	0.0	2.909000 07	0.0
0.0	-5.355000 06	0.0	0.0	0.0	7.855000 07
10 14					
4.795000 05	0.0	0.0	0.0	0.0	0.0
0.0	2.697000 03	0.0	0.0	0.0	-6.637000 04
0.0	0.0	2.697000 03	0.0	6.637000 04	0.0
0.0	0.0	0.0	5.587000 07	0.0	0.0
0.0	0.0	6.637000 04	0.0	2.178000 04	0.0
0.0	-6.637000 04	0.0	0.0	0.0	2.178000 06
10 15					
4.795000 05	0.0	0.0	0.0	0.0	0.0
0.0	2.697000 03	0.0	0.0	0.0	-6.637000 04
0.0	0.0	2.697000 03	0.0	6.637000 04	0.0
0.0	0.0	0.0	5.587000 07	0.0	0.0
0.0	0.0	6.637000 04	0.0	2.178000 06	0.0
0.0	-6.637000 04	0.0	0.0	0.0	2.178000 06
10 22					
8.889000 04	0.0	0.0	0.0	0.0	0.0
0.0	2.239000 04	0.0	0.0	0.0	-5.037000 05
0.0	0.0	1.317000 05	0.0	2.963000 06	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	2.963000 06	0.0	8.889000 07	0.0
0.0	-5.037000 05	0.0	0.0	0.0	1.511000 07
10 23					
8.889000 04	0.0	0.0	0.0	0.0	0.0
0.0	2.239000 04	0.0	0.0	0.0	-5.037000 05
0.0	0.0	1.317000 05	0.0	2.963000 06	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	2.963000 06	0.0	8.889000 07	0.0
0.0	-5.037000 05	0.0	0.0	0.0	1.511000 07
11 16					
1.730000 05	0.0	0.0	0.0	0.0	0.0
0.0	1.545000 06	0.0	0.0	0.0	-5.359000 07
0.0	0.0	5.749000 03	0.0	1.994000 05	0.0
0.0	0.0	0.0	7.509000 05	0.0	0.0
0.0	0.0	1.994000 05	0.0	9.225000 06	0.0
0.0	-5.359000 07	0.0	0.0	0.0	2.479000 09

Figure 95. (Continued).

```
12 16
   1.778000 04   0.0           0.0           0.0           0.0           0.0
   0.0           1.275000 05   0.0           0.0           0.0          -2.868000 06
   0.0           0.0           2.123000 04   0.0           4.776000 05   0.0
   0.0           0.0           0.0           1.067000 06   0.0           0.0
   0.0           0.0           4.776000 05   0.0           1.433000 07   0.0
   0.0          -2.868000 06   0.0           0.0           0.0           8.604000 07
17 24
   1.481000 05   0.0           0.0           0.0           0.0           0.0
   0.0           5.411000 03   0.0           0.0           0.0          -1.461000 05
   0.0           0.0           7.377000 04   0.0           1.992000 06   0.0
   0.0           0.0           0.0           2.981000 05   0.0           0.0
   0.0           0.0           1.992000 06   0.0           7.170000 07   0.0
   0.0          -1.461000 05   0.0           0.0           0.0           5.259000 06
13 16
   1.778000 04   0.0           0.0           0.0           0.0           0.0
   0.0           1.275000 05   0.0           0.0           0.0          -2.868000 06
   0.0           0.0           2.123000 04   0.0           4.776000 05   0.0
   0.0           0.0           0.0           1.067000 06   0.0           0.0
   0.0           0.0           4.776000 05   0.0           1.433000 07   0.0
   0.0          -2.868000 06   0.0           0.0           0.0           8.604000 07
13 25
   1.481000 05   0.0           0.0           0.0           0.0           0.0
   0.0           5.411000 03   0.0           0.0           0.0          -1.461000 05
   0.0           0.0           7.377000 04   0.0           1.992000 06   0.0
   0.0           0.0           0.0           2.981000 05   0.0           0.0
   0.0           0.0           1.992000 06   0.0           7.170000 07   0.0
   0.0          -1.461000 05   0.0           0.0           0.0           5.259000 06
16 17
   2.397000 05   0.0           0.0           0.0           0.0           0.0
   0.0           1.429000 03   0.0           0.0           0.0          -3.516000 04
   0.0           0.0           1.429000 03   0.0           3.516000 04   0.0
   0.0           0.0           0.0           2.946000 07   0.0           0.0
   0.0           0.0           3.516000 04   0.0           1.154000 06   0.0
   0.0          -3.516000 04   0.0           0.0           0.0           1.154000 06
16 18
   2.397000 05   0.0           0.0           0.0           0.0           0.0
   0.0           1.429000 03   0.0           0.0           0.0          -3.516000 04
   0.0           0.0           1.429000 03   0.0           3.516000 04   0.0
   0.0           0.0           0.0           2.946000 07   0.0           0.0
   0.0           0.0           3.516000 04   0.0           1.154000 06   0.0
   0.0          -3.516000 04   0.0           0.0           0.0           1.154000 06
16 19
   2.057000 05   0.0           0.0           0.0           0.0           0.0
   0.0           8.933000 06   0.0           0.0           0.0          -2.172000 08
   0.0           0.0           9.188000 04   0.0           2.234000 06   0.0
   0.0           0.0           0.0           1.072000 06   0.0           0.0
   0.0           0.0           2.234000 06   0.0           7.240000 07   0.0
   0.0          -2.172000 08   0.0           0.0           0.0           7.039000 09
20 21
   4.445000 04   0.0           0.0           0.0           0.0           0.0
   0.0           2.800000 03   0.0           0.0           0.0          -1.260000 05
   0.0           0.0           1.647000 04   0.0           7.410000 05   0.0
   0.0           0.0           0.0           0.0           0.0           0.0
   0.0           0.0           7.410000 05   0.0           4.445000 07   0.0
   0.0          -1.260000 05   0.0           0.0           0.0           7.550000 06
20 22
   7.407000 04   0.0           0.0           0.0           0.0           0.0
   0.0           7.621000 04   0.0           0.0           0.0          -2.058000 06
   0.0           0.0           1.296000 04   0.0           3.498000 05   0.0
   0.0           0.0           0.0           0.0           0.0           0.0
   0.0           0.0           3.498000 05   0.0           1.259000 07   0.0
   0.0          -2.058000 06   0.0           0.0           0.0           7.407000 07
21 23
   7.407000 04   0.0           0.0           0.0           0.0           0.0
   0.0           7.621000 04   0.0           0.0           0.0          -2.058000 06
```

Figure 95. (Continued).

```
       0.0           0.0           1.296000 04   0.0           3.498000 05   0.0
       0.0           0.0           0.0           0.0           0.0           0.0
       0.0           0.0           3.498000 05   0.0           1.259000 07   0.0
       0.0          -2.058000 06   0.0           0.0           0.0           7.407000 07
  24 25
     8.840000 05     0.0           0.0           0.0           0.0           0.0
       0.0           3.980000 03   0.0           0.0           0.0          -1.792000 05
       0.0           0.0           3.045000 02   0.0           1.370000 04   0.0
       0.0           0.0           0.0           6.550000 04   0.0           0.0
       0.0           0.0           1.370000 04   0.0           8.220000 05   0.0
       0.0          -1.792000 05   0.0           0.0           0.0           1.075000 07
  10 26
     1.000000 04     0.0           0.0           0.0           0.0           0.0
       0.0           1.000000 05   0.0           0.0           0.0          -1.000000 05
       0.0           0.0           1.000000 05   0.0           1.000000 05   0.0
       0.0           0.0           0.0           1.000000 06   0.0           0.0
       0.0           0.0           1.000000 05   0.0           1.000000 07   0.0
       0.0          -1.000000 05   0.0           0.0           0.0           1.000000 07
  16 27
     3.000000 04     0.0           0.0           0.0           0.0           0.0
       0.0           1.000000 05   0.0           0.0           0.0          -1.000000 05
       0.0           0.0           1.000000 05   0.0           1.000000 05   0.0
       0.0           0.0           0.0           1.000000 06   0.0           0.0
       0.0           0.0           1.000000 05   0.0           1.000000 07   0.0
       0.0          -1.000000 05   0.0           0.0           0.0           1.000000 07
  26 28
     1.229000 03     0.0           0.0           0.0           0.0           0.0
       0.0           1.000000 05   0.0           0.0           0.0          -1.000000 05
       0.0           0.0           1.000000 05   0.0           1.000000 05   0.0
       0.0           0.0           0.0           1.000000 06   0.0           0.0
       0.0           0.0           1.000000 05   0.0           1.000000 07   0.0
       0.0          -1.000000 05   0.0           0.0           0.0           1.000000 07
  27 29
     1.229000 03     0.0           0.0           0.0           0.0           0.0
       0.0           1.000000 05   0.0           0.0           0.0          -1.000000 05
       0.0           0.0           1.000000 05   0.0           1.000000 05   0.0
       0.0           0.0           0.0           1.000000 06   0.0           0.0
       0.0           0.0           1.000000 05   0.0           1.000000 07   0.0
       0.0          -1.000000 05   0.0           0.0           0.0           1.000000 07
  26 30
     7.860000 02     0.0           0.0           0.0           0.0           0.0
       0.0           1.000000 05   0.0           0.0           0.0          -1.000000 05
       0.0           0.0           1.000000 05   0.0           1.000000 05   0.0
       0.0           0.0           0.0           1.000000 06   0.0           0.0
       0.0           0.0           1.000000 05   0.0           1.000000 07   0.0
       0.0          -1.000000 05   0.0           0.0           0.0           1.000000 07
  27 31
     7.860000 02     0.0           0.0           0.0           0.0           0.0
       0.0           1.000000 05   0.0           0.0           0.0          -1.000000 05
       0.0           0.0           1.000000 05   0.0           1.000000 05   0.0
       0.0           0.0           0.0           1.000000 06   0.0           0.0
       0.0           0.0           1.000000 05   0.0           1.000000 07   0.0
       0.0          -1.000000 05   0.0           0.0           0.0           1.000000 07
   8 32
     1.000000 05     0.0           0.0           0.0           0.0           0.0
       0.0           8.000000 03   0.0           0.0           0.0          -4.000000 05
       0.0           0.0           8.000000 03   0.0           4.000000 05   0.0
       0.0           0.0           0.0           1.000000 06   0.0           0.0
       0.0           0.0           4.000000 05   0.0           2.667000 07   0.0
       0.0          -4.000000 05   0.0           0.0           0.0           2.667000 07

IJ,I,J,CBAR(I,J)
   1   1   2     5.000000-02
   2   2   3     5.000000-02
   3   3   4     5.000000-02
   4   4   5     5.000000-02
```

Figure 95. (Continued).

5	4	7	5.000000-02
6	5	6	5.000000-02
7	5	7	5.000000-02
8	5	20	5.000000-02
9	5	21	5.000000-02
10	5	22	1.000000-01
11	5	23	1.000000-01
12	6	9	5.000000-02
13	6	11	1.000000-01
14	7	9	5.000000-02
15	8	9	5.000000-02
16	10	11	1.000000-01
17	10	14	1.000000-01
18	10	15	1.000000-01
19	10	22	1.000000-01
20	10	23	1.000000-01
21	11	16	1.000000-01
22	12	16	1.000000-01
23	12	24	5.000000-02
24	13	16	1.000000-01
25	13	25	5.000000-02
26	16	17	1.000000-01
27	16	18	1.000000-01
28	16	19	1.000000-01
29	20	21	5.000000-02
30	20	22	5.000000-02
31	21	23	5.000000-02
32	24	25	5.000000-02
33	10	26	5.000000-02
34	16	27	5.000000-02
35	26	28	2.470000-01
36	27	29	2.380000-01
37	26	30	1.818000-01
38	27	31	1.752000-01
39	8	32	5.000000-02

KR TABLE SPECS, I,J,L,NP

2	3	2	6
2	3	3	6
2	3	5	6
2	3	6	6
4	7	1	6
4	7	2	6
4	7	3	6
4	7	4	6
4	7	5	6
4	7	6	6
5	7	1	6
5	7	2	6
5	7	3	6
5	7	4	6
5	7	5	6
5	7	6	6
8	9	1	6
8	9	2	6
8	9	3	6
8	9	4	6
8	9	5	6
8	9	6	6
10	14	1	6
10	14	2	6
10	14	3	6
10	14	4	6
10	14	5	6
10	14	6	6
10	15	1	6

Figure 95. (Continued).

```
   10   15    2    6
   10   15    3    6
   10   15    4    6
   10   15    5    6
   10   15    6    6
   16   17    1    6
   16   17    2    6
   16   17    3    6
   16   17    4    6
   16   17    5    6
   16   17    6    6
   16   18    1    6
   16   18    2    6
   16   18    3    6
   16   18    4    6
   16   18    5    6
   16   18    6    6
 KR TABLE FOR I,J,L =    2    3    2
   1     0.0               1.00000E 00
   2     2.00000E 00       1.00000E 00
   3     4.00000E 00      -1.00000E 00
   4     6.00000E 00      -1.00000E 00
   5     8.00000E 00      -1.00000E 00
   6     1.00000E 01      -1.00000E 00

 KR TABLE FOR I,J,L =    2    3    3
   1     0.0               1.00000E 00
   2     2.00000E 00       1.00000E 00
   3     4.00000E 00      -1.00000E 00
   4     6.00000E 00      -1.00000E 00
   5     8.00000E 00      -1.00000E 00
   6     1.00000E 01      -1.00000E 00

 KR TABLE FOR I,J,L =    2    3    5
   1     0.0               1.00000E 00
   2     1.00000E 00       1.00000E 00
   3     2.00000E 00       0.0
   4     3.00000E 00      -1.00000E 00
   5     4.00000E 00      -1.00000E 00
   6     5.00000E 00      -1.00000E 00

 KR TABLE FOR I,J,L =    2    3    6
   1     0.0               1.00000E 00
   2     1.00000E 00       1.00000E 00
   3     2.00000E 00       0.0
   4     3.00000E 00      -1.00000E 00
   5     4.00000E 00      -1.00000E 00
   6     5.00000E 00      -1.00000E 00

 KR TABLE FOR I,J,L =    4    7    1
   1     0.0               1.00000E 00
   2     1.00000E-01       1.00000E 00
   3     2.00000E-01      -7.00000E-01
   4     3.00000E-01      -7.00000E-01
   5     4.00000E-01       0.0
   6     5.00000E-01       0.0

 KR TABLE FOR I,J,L =    4    7    2
   1     0.0               1.00000E 00
   2     6.67000E-02       1.00000E 00
   3     1.33400E-01       1.00000E 00
   4     2.00100E-01       1.00000E 00
   5     2.66800E-01       0.0
   6     3.33500E-01       0.0
```

Figure 95. (Continued).

```
KR TABLE FOR I,J,L =     4     7     3
   1      0.0              1.00000E 00
   2      6.67000E-02      1.00000E 00
   3      1.33400E-01      1.00000E 00
   4      2.00100E-01      1.00000E 00
   5      2.66800E-01      0.0
   6      3.33500E-01      0.0

KR TABLE FOR I,J,L =     4     7     4
   1      0.0              1.00000E 00
   2      1.00000E-01      1.00000E 00
   3      2.00000E-01      1.00000E 00
   4      3.00000E-01      1.00000E 00
   5      4.00000E-01      0.0
   6      5.00000E-01      0.0

KR TABLE FOR I,J,L =     4     7     5
   1      0.0              1.00000E 00
   2      1.00000E-01      1.00000E 00
   3      2.00000E-01      1.00000E 00
   4      3.00000E-01      1.00000E 00
   5      4.00000E-01      0.0
   6      5.00000E-01      0.0

KR TABLE FOR I,J,L =     4     7     6
   1      0.0              1.00000E 00
   2      1.00000E-01      1.00000E 00
   3      2.00000E-01      1.00000E 00
   4      3.00000E-01      1.00000E 00
   5      4.00000E-01      0.0
   6      5.00000E-01      0.0

KR TABLE FOR I,J,L =     5     7     1
   1      0.0              1.00000E 00
   2      1.00000E-01      1.00000E 00
   3      2.00000E-01     -7.00000E-01
   4      3.00000E-01     -7.00000E-01
   5      4.00000E-01      0.0
   6      5.00000E-01      0.0

KR TABLE FOR I,J,L =     5     7     2
   1      0.0              1.00000E 00
   2      6.67000E-02      1.00000E 00
   3      1.33400E-01      1.00000E 00
   4      2.00100E-01      1.00000E 00
   5      2.66800E-01      0.0
   6      3.33500E-01      0.0

KR TABLE FOR I,J,L =     5     7     3
   1      0.0              1.00000E 00
   2      6.67000E-02      1.00000E 00
   3      1.33400E-01      1.00000E 00
   4      2.00100E-01      1.00000E 00
   5      2.66800E-01      0.0
   6      3.33500E-01      0.0

KR TABLE FOR I,J,L =     5     7     4
   1      0.0              1.00000E 00
   2      1.00000E-01      1.00000E 00
   3      2.00000E-01      1.00000E 00
   4      3.00000E-01      1.00000E 00
   5      4.00000E-01      0.0
   6      5.00000E-01      0.0

KR TABLE FOR I,J,L =     5     7     5
   1      0.0              1.00000E 00
```

Figure 95. (Continued)

```
 2    1.00000E-01    1.00000E 00
 3    2.00000E-01    1.00000E 00
 4    3.00000E-01    1.00000E 00
 5    4.00000E-01    0.0
 6    5.00000E-01    0.0

KR TABLE FOR I,J,L =    5    7    6
 1    0.0            1.00000E 00
 2    1.00000E-01    1.00000E 00
 3    2.00000E-01    1.00000E 00
 4    3.00000E-01    1.00000E 00
 5    4.00000E-01    0.0
 6    5.00000E-01    0.0

KR TABLE FOR I,J,L =    8    9    1
 1    0.0            7.85000E-03
 2    4.80000E-01    7.85000E-03
 3    9.60000E-01    1.00000E 00
 4    1.44000E 00    1.00000E 00
 5    1.92000E 00    0.0
 6    2.40000E 00    0.0

KR TABLE FOR I,J,L =    8    9    2
 1    0.0            1.00000E 00
 2    2.00000E-01    1.00000E 00
 3    4.00000E-01    1.00000E 00
 4    6.00000E-01    1.00000E 00
 5    8.00000E-01    0.0
 6    1.00000E 00    0.0

KR TABLE FOR I,J,L =    8    9    3
 1    0.0            1.00000E 00
 2    5.00000E-02    1.00000E 00
 3    1.00000E-0.    1.00000E 00
 4    1.50000E-01    1.00000E 00
 5    2.00000E-01    0.0
 6    2.50000E-01    0.0

KR TABLE FOR I,J,L =    8    9    4
 1    0.0            1.00000E 00
 2    1.00000E-01    1.00000E 00
 3    2.00000E-01    1.00000E 00
 4    3.00000E-01    2.00000E 00
 5    4.00000E-01    0.0
 6    5.00000E-01    0.0

KR TABLE FOR I,J,L =    8    9    5
 1    0.0            1.00000E 00
 2    1.00000E-03    1.00000E 00
 3    2.00000E-03    1.00000E 00
 4    3.00000E-03    1.00000E 00
 5    4.00000E-03    0.0
 6    5.00000E-03    0.0

KR TABLE FOR I,J,L =    8    9    6
 1    0.0            1.00000E 00
 2    1.00000E-01    1.00000E 00
 3    2.00000E-01    1.00000E 00
 4    3.00000E-01    1.00000E 00
 5    4.00000E-01    0.0
 6    5.00000E-01    0.0

KR TABLE FOR I,J,L =   10   14    1
 1    0.0            1.00000E 00
 2    5.00000E-01    1.00000E 00
 3    1.00000E 00    1.00000E 00
```

Figure 95. (Continued).

```
  4    1.50000E 00    1.00000E 00
  5    2.00000E 00   -3.33000E 00
  6    2.50000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =    10   14     2
  1    0.0            1.00000E 00
  2    4.00000E 00    1.00000E 00
  3    8.00000E 00    1.00000E 00
  4    1.20000E 01    1.00000E 00
  5    1.60000E 01   -3.33000E 00
  6    2.00000E 01   -3.33000E 00

 KR TABLE FOR I,J,L =    10   14     3
  1    0.0            1.00000E 00
  2    4.00000E 00    1.00000E 00
  3    8.00000E 00    1.00000E 00
  4    1.20000E 01    1.00000E 00
  5    1.60000E 01   -3.33000E 00
  6    2.00000E 01   -3.33000E 00

 KR TABLE FOR I,J,L =    10   14     4
  1    0.0            1.00000E 00
  2    2.00000E-01    1.00000E 00
  3    4.00000E-01    1.00000E 00
  4    6.00000E-01    1.00000E 00
  5    8.00000E-01   -3.33000E 00
  6    1.00000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =    10   14     5
  1    0.0            1.00000E 00
  2    2.00000E-01    1.00000E 00
  3    4.00000E-01    1.00000E 00
  4    6.00000E-01    1.00000E 00
  5    8.00000E-01   -3.33000E 00
  6    1.00000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =    10   14     6
  1    0.0            1.00000E 00
  2    2.00000E-01    1.00000E 00
  3    4.00000E-01    1.00000E 00
  4    6.00000E-01    1.00000E 00
  5    8.00000E-01   -3.33000E 00
  6    1.00000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =    10   15     1
  1    0.0            1.00000E 00
  2    5.00000E-01    1.00000E 00
  3    1.00000E 00    1.00000E 00
  4    1.50000E 00    1.00000E 00
  5    2.00000E 00   -3.33000E 00
  6    2.50000E 00   -3.33000E 00

 KR TABLE FOR I,J,L =    10   15     2
  1    0.0            1.00000E 00
  2    4.00000E 00    1.00000E 00
  3    8.00000E 00    1.00000E 00
  4    1.20000E 01    1.00000E 00
  5    1.60000E 01   -3.33000E 00
  6    2.00000E 01   -3.33000E 00

 KR TABLE FOR I,J,L =    10   15     3
  1    0.0            1.00000E 00
  2    4.00000E 00    1.00000E 00
  3    8.00000E 00    1.00000E 00
  4    1.20000E 01    1.00000E 00
  5    1.60000E 01   -3.33000E 00
```

Figure 95. (Continued).

```
   6    2.00000E 01    -3.33000E 00

 KR TABLE FOR I,J,L =    10   15    4
   1    0.0             1.00000E 00
   2    2.00000E-01     1.00000E 00
   3    4.00000E-01     1.00000F 00
   4    6.00000E-01     1.00000E 00
   5    8.00000E-01    -3.33000E 00
   6    1.00000E 00    -3.33000E 00

 KR TABLE FOR I,J,L =    10   15    5
   1    0.0             1.00000E 00
   2    2.00000E-01     1.00000E 00
   3    4.00000E-01     1.00000E 00
   4    6.00000E-01     1.00000E 00
   5    8.00000E-01    -3.33000E 00
   6    1.00000E 00    -3.33000E 00

 KR TABLE FOR I,J,L =    10   15    6
   1    0.0             1.00000E 00
   2    2.00000E-01     1.00000E 00
   3    4.00000E-01     1.00000E 00
   4    6.00000E-01     1.00000E 00
   5    8.00000E-01    -3.33000E 00
   6    1.00000E 00    -3.33000E 00

 KR TABLE FOR I,J,L =    16   17    1
   1    0.0             1.00000E 00
   2    5.00000E-01     1.00000E 00
   3    1.00000E 00     1.00000E 00
   4    1.50000E 00     1.00000E 00
   5    2.00000E 00    -3.33000E 00
   6    2.50000E 00    -3.33000E 00

 KR TABLE FOR I,J,L =    16   17    2
   1    0.0             1.00000E 00
   2    4.00000E 00     1.00000E 00
   3    8.00000E 00     1.00000E 00
   4    1.20000E 01     1.00000E 00
   5    1.60000E 01    -3.33000E 00
   6    2.00000E 01    -3.33000E 00

 KR TABLE FOR I,J,L =    16   17    3
   1    0.0             1.00000E 00
   2    4.00000E 00     1.00000E 00
   3    8.00000E 00     1.00000E 00
   4    1.20000E 01     1.00000E 00
   5    1.60000E 01    -3.33000E 00
   6    2.00000E 01    -3.33000E 00

 KR TABLE FOR I,J,L =    16   17    4
   1    0.0             1.00000E 00
   2    2.00000E-01     1.00000E 00
   3    4.00000E-01     1.00000E 00
   4    6.00000E-01     1.00000E 00
   5    8.00000E-01    -3.33000E 00
   6    1.00000E 00    -3.33000E 00

 KR TABLE FOR I,J,L =    16   17    5
   1    0.0             1.00000E 00
   2    2.00000E-01     1.00000E 00
   3    4.00000E-01     1.00000E 00
   4    6.00000E-02     1.00000E 00
   5    8.00000E-01    -3.33000E 00
   6    1.00000E 00    -3.33000E 00
```

Figure 95. (Continued).

```
KR TABLE FOR I,J,L =    16   17    6
   1     0.0              1.00000E 00
   2     2.00000E-01      1.00000E 00
   3     4.00000E-01      1.00000E 00
   4     6.00000E-01      1.00000E 00
   5     8.00000E-01     -3.33000E 00
   6     1.00000E 00     -3.33000E 00

KR TABLE FOR I,J,L =    16   18    1
   1     0.0              1.00000E 00
   2     5.00000E-01      1.00000E 00
   3     1.00000E 00      1.00000E 00
   4     1.50000E 00      1.00000E 00
   5     2.00000E 00     -3.33000E 00
   6     2.50000E 00     -3.33000E 00

KR TABLE FOR I,J,L =    16   18    2
   1     0.0              1.00000E 00
   2     4.00000E 00      1.00000E 00
   3     8.00000E 00      1.00000E 00
   4     1.20000E 01      1.00000E 00
   5     1.60000E 01     -3.33000E 00
   6     2.00000E 01     -3.33000E 00

KR TABLE FOR I,J,L =    16   18    3
   1     0.0              1.00000E 00
   2     4.00000E 00      1.00000E 00
   3     8.00000E 00      1.00000E 00
   4     1.20000E 01      1.00000E 00
   5     1.60000E 01     -3.33000E 00
   6     2.00000E 01     -3.33000E 00

KR TABLE FOR I,J,L =    16   18    4
   1     0.0              1.00000E 00
   2     2.00000E-01      1.00000E 00
   3     4.00000E-01      1.00000E 00
   4     6.00000E-01      1.00000E 00
   5     8.00000E-01     -3.33000E 00
   6     1.00000E 00     -3.33000E 00

KR TABLE FOR I,J,L =    16   18    5
   1     0.0              1.00000E 00
   2     2.00000E-01      1.00000E 00
   3     4.00000E-01      1.00000E 00
   4     6.00000E-01      1.00000E 00
   5     8.00000E-01     -3.33000E 00
   6     1.00000E 00     -3.33000E 00

KR TABLE FOR I,J,L =    16   18    6
   1     0.0              1.00000E 00
   2     2.00000E-01      1.00000E 00
   3     4.00000E-01      1.00000E 00
   4     6.00000E-01      1.00000E 00
   5     8.00000E-01     -3.33000E 00
   6     1.00000E 00     -3.33000E 00

IJ,I,J,VMAX(I,J,1-6)
   1  1  2    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   2  2  3    1.000000D 01   6.000000D 00   6.000000D 00   1.000000D 01   1.000000D 01   1.000000D 01
   3  3  4    1.000000D 01   1.000000D 01   1.600000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   4  4  5    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   5  4  7    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   6  5  6    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   7  5  7    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   8  5 20    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
   9  5 21    1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01   1.000000D 01
```

Figure 95. (Continued).

10	5	22	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
11	5	23	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
12	6	9	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
13	6	11	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
14	7	9	1.000000D 00	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
15	8	9	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
16	10	11	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
17	10	14	1.000000D 01	1.000000D 01	1.510000D 01	1.000000D 01	1.000000D 01	1.000000D 01
18	10	15	1.000000D 01	1.000000D 01	1.510000D 01	1.000000D 01	1.000000D 01	1.000000D 01
19	10	22	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
20	10	23	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
21	11	16	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
22	12	16	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
23	12	24	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
24	13	16	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
25	13	25	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
26	16	17	1.000000D 01	1.000000D 01	1.510000D 01	1.000000D 01	1.000000D 01	1.000000D 01
27	16	18	1.000000D 01	1.000000D 01	1.510000D 01	1.000000D 01	1.000000D 01	1.000000D 01
28	16	19	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
29	20	21	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
30	20	22	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
31	21	23	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
32	24	25	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
33	10	26	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
34	16	27	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
35	26	28	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
36	27	29	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
37	26	30	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01
38	27	31	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01	1.000000D 01

PLOT CARDS WHICH ARE NOT ALL BLANK

```
             1         2         3         4         5         6         7         8
    12345678901234567890123456789012345678901234567890123456789012345678901234567890

  5       11 1     1                                                            5005
  6       11 1     1                                                            5006
  8       11 11    1                                                            5008
  9       11 11    1         11  11                                             5009
 12          1111  1     11                                                     5012
 13     1 1       1                     11                                      5013
 14     1 1       1                                                             5014
 15     1 1       1                                                             5015
 25                                     11                                      5025
```

INDP = 9

XN-,XP-,YN-,YP-,ZN-,ZP-

2.200000 01 9.500000 01 4.500000 01 4.500000 01 9.000000D 00 4.500000 01

DRI(IJ) INDICATORS

```
             1         2         3         4         5         6         7         8
    12345678901234567890123456789012345678901234567890123456789012345678.0

                                        11                                      7000
```

IJ,THEIJ(IJ),PSIIJ(IJ)		
1	-8.375070D-01	0.0
2	-1.491810D-01	0.0
3	-2.965290D-01	0.0
4	0.0	0.0
5	1.023660D 00	0.0
6	0.0	0.0
7	2.107750D 00	0.0
8	6.953940D-01	1.570800D 00
9	6.953940D-01	-1.570800D 00

Figure 95. (Continued).

10	-3.50465D-01	1.57080D 00
11	-3.50465D-01	-1.57080D 00
12	1.57080D 00	0.0
13	-1.57080D 00	0.0
14	-2.49779D-01	0.0
15	-1.76228D 00	0.0
16	0.0	0.0
17	-5.18722D-01	1.57080D 00
18	-5.18722D-01	-1.57080D 00
19	0.0	1.57080D 00
20	0.0	-1.57080D 00
21	0.0	0.0
22	0.0	-1.57057D 00
23	1.57061D 00	0.0
24	0.0	1.57057D 00
25	1.57061D 00	0.0
26	-5.18722D-01	1.57080D 00
27	-5.18722D-01	-1.57080D 00
28	0.0	0.0
29	0.0	-1.57080D 00
30	-1.57080D 00	0.0
31	-1.57080D 00	0.0
32	0.0	-1.57080D 00
33	1.57080D 00	0.0
34	1.57080D 00	0.0
35	1.57080D 00	0.0
36	1.57080D 00	0.0
37	1.57080D 00	0.0
38	1.57080D 00	0.0
39	-1.97171D-01	0.0

Figure 95. (Continued).

RUN SE-31-100 COMBINED VEL. IMPACT 0100

TIME = 0.10000

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 1	-2.937840 02	-2.316690 01	-1.174970 02	-5.511000-03	2.080480-02	5.725200-03
	1.946840 02	-2.549870 02	1.451010 02	-4.027280-01	-6.040580-01	4.400620-01
	1.901610 02	-2.569160 02	1.476760 02	-4.118820-01	-6.064740-01	4.366310-01
	-6.978250 03	-1.062200 03	-6.921680 03	-1.076730 01	6.801120 01	1.321820 01
	-1.801980 01	-2.379130 00	-1.735890 01			
MASS 2	-2.375200 02	-2.239830 01	-5.816520 01	-1.791600-02	2.471600-02	6.511870-03
	2.211050 02	-2.058480 02	1.165370 02	-4.662490-01	1.418340 00	4.396890-01
	2.168120 02	-2.094340 02	1.181990 02	-4.771150-01	1.410240 00	4.648930-01
	-2.440930 03	2.973460 03	-1.087260 04	-8.732060 01	3.664120 00	-7.684490 00
	-5.639570 00	8.110500 00	-2.870070 01			
MASS 3	-7.416460 01	-2.100660 01	-3.654810 01	-2.525740-02	5.745380-03	4.108720-03
	2.368780 02	-1.480060 02	-4.076820 01	-4.702050-01	1.015370-01	-3.348400-03
	2.364990 02	-1.479350 02	-4.315590 01	-6.702660-01	1.015890-01	-7.830010-04
	-3.405020 03	3.800050 03	-1.059310 04	-1.312800 01	-7.182070 00	-1.192670 01
	-8.632960 00	9.765130 00	-2.724860 01			
MASS 4	-4.453600 01	-2.066340 01	-2.758970 01	-2.579440-02	-3.068300-04	3.444990-03
	2.349190 02	-1.441310 02	-3.824520 01	-7.020200-01	-3.108780-01	-1.560390-01
	2.344050 02	-1.439030 02	-4.204110 01	-7.020690-01	-3.067510-01	-1.640020-01
	-3.626750 03	3.508930 03	-1.042150 04	-7.968380 00	-1.148460 01	-1.617430 01
	-9.449350 00	8.914430 00	-2.655080 01			
MASS 5	4.057450 00	-2.050660 01	-2.755320 01	-2.578290-02	-1.469680-03	2.715100-03
	2.347350 02	-1.532330 02	-2.180100 01	-7.017320-01	-3.671850-01	-2.138810-01
	2.342860 02	-1.532480 02	-2.610480 01	-7.020470-01	-3.615490-01	-2.232760-01
	-3.618240 03	2.723020 03	-9.788530 03	-7.960110 00	-1.382020 01	-1.459480 01
	-9.437880 00	6.871470 00	-2.486070 01			
MASS 6	2.603260 01	-2.047380 01	-2.745040 01	-2.578280-02	-7.089530-03	1.065000-03
	2.331710 02	-1.583460 02	-1.259640 01	-7.018310-01	-4.645500-01	-2.337330-01
	2.329070 02	-1.581750 02	-1.833170 01	-7.034880-01	-4.583700-01	-2.456250-01
	-3.512770 03	2.391010 03	-9.664160 03	[illegible]160 00	-3.526050 00	-1.775990 01
	-9.179320 00	6.012700 00	-2.447180 01			
MASS 7	-1.987720 01	-2.163480 01	-6.773270 01	-2.646260-02	-1.847090-03	3.754710-03
	2.470380 02	-1.741180 02	-3.397900 01	-6.001630-01	-2.478090-01	-3.296300-01
	2.463190 02	-1.740720 02	-3.905360 01	-6.007710-01	-2.390000-01	-3.360710-01
	-1.826840 03	2.234770 03	-1.161130 04	-2.732810 01	-5.717350 01	-2.960240 01
	-4.860130 00	5.514320 00	-2.965760 01			
MASS 8	3.326430 01	-2.201850 01	-8.290960 01	-2.316350-02	-5.404550-02	-7.325020-03
	3.149710 02	-2.046640 02	4.280530 00	-9.634440-01	-1.925680 00	-4.059980-01
	3.162310 02	-2.020000 02	-1.750400 01	-1.853760-01	-1.915780 00	-4.498980-01
	3.534950 00	1.516210 03	-9.348230 03	-2.648300 01	-7.801950 01	-1.367260 01
	-1.394060-01	3.514740 00	-2.213300 01			

Figure 96. Typical Output, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

RUN SE-31-100 COMBINED VEL. IMPACT 0100

TIME = 0.10000

	X / XDOT / U / UDOT / XACCEL	Y / YDOT / V / VDOT / YACCEL	Z / ZDOT / W / WDOT / ZACCEL	PHI / PHIDOT / P / PDOT	THETA / THETADOT / Q / QDOT	PSI / PSIDOT / R / RDOT
MASS 9	2.631900 01	-2.124670 01	-5.603770 01	-2.777980-02	-1.305530-02	2.154960-04
	2.502520 02	-1.800170 02	-1.232710 01	-6.101590-01	-6.704870-01	-2.682480-01
	2.500310 02	-1.795690 02	-2.058830 01	-8.136610-01	-6.627780-01	-2.867450-01
	-3.079220 03	2.109720 03	-9.760600 03	-1.318430 01	-1.755510 01	-2.178370 01
	-8.075290 00	5.236470 00	-2.447920 01			
MASS 10	3.838520 00	-2.002530 01	-1.179550 01	-2.427930-02	-5.937590-02	-6.419530-03
	2.228440 02	-1.419830 02	-3.304940 01	-5.489590-01	-1.854530 00	-3.819760-01
	2.223940 02	-1.393770 02	-4.972640 01	-5.716260-01	-1.844730 00	-4.262130-01
	-3.495640 03	2.649330 03	-8.041380 03	1.516740 01	8.103670 01	1.102760 01
	-8.972830 00	6.544350 00	-1.956340 01			
MASS 11	2.588350 01	-2.006660 01	-1.100750 01	-2.427840-02	-1.054170-02	1.702580-03
	2.235340 02	-1.470470 02	-1.257960 01	-6.881470-01	-6.745840-01	-1.750500-01
	2.231380 02	-1.470220 02	-1.850720 01	-6.899930-01	-6.701360-01	-1.913650-01
	-3.333560 03	2.656790 03	-9.707520 03	-2.505020 01	2.912140 01	-1.556550 01
	-8.676930 00	6.739170 00	-2.449880 01			
MASS 12	9.527820 01	2.499980 01	-1.400310 01	-2.891720-02	-2.280660-02	-6.181390-04
	2.266400 02	-1.603340 02	-9.271710 00	1.229310 00	-3.258560-01	-9.554570-02
	2.264680 02	-1.597100 02	-1.906570 01	1.227130 00	-3.279580-01	-1.049020-01
	-5.006610 03	1.540520 03	-9.092420 03	-3.282150 01	-3.329300 01	7.507000 01
	-1.299850 01	3.990040 00	-2.387370 01			
MASS 13	9.534950 01	-6.498400 01	-1.258250 01	-4.716330-03	-2.825570-02	4.051550-04
	2.006530 02	-1.610610 02	-4.142760 01	7.657660-01	-8.744670-01	-7.259600-01
	1.993370 02	-1.608220 02	-4.815930 01	7.452560-01	-8.695730-01	-7.315270-01
	-4.778590 03	1.413050 03	-1.270400 04	1.131230 02	-2.257860 01	-3.346760 01
	-1.257610 01	3.375970 00	-3.277330 01			
MASS 14	1.045600-01	4.233390 01	-4.441950 00	-7.468000-03	-1.385490-01	1.404430-01
	3.073910 02	-7.569720 01	-8.247360 01	9.888910 00	-1.753590 00	-2.459680-01
	2.795630 02	-1.170650 02	-1.231320 02	9.854540 00	-1.751730 00	-2.566990-01
	-1.323350 02	-1.144560 03	1.046240 03	1.473700-01	8.290800-01	0.0
	1.381070-01	-7.396370-03	9.903900-01			
MASS 15	4.660220-01	-8.796720 01	-7.974130 00	8.565930-02	-1.243250-01	-1.346580-01
	2.842070 02	-4.055270 02	-1.549410 02	-6.958410 00	-1.707130 00	-1.114420 00
	3.214200 02	-3.723940 02	-1.650590 02	-7.096610 00	-1.795480 00	-9.557120-01
	1.074070 02	1.511310 03	-2.838220 03	5.623730-01	-2.222770 00	0.0
	1.240050-01	8.489430-02	9.886430-01			
MASS 16	9.529940 01	-1.998520 01	-1.281440 01	-1.999330-02	2.629910-03	1.806230-03
	2.203560 02	-1.609680 02	-3.347960 01	-2.106050-01	-1.036510 00	-1.375380-01
	2.201530 02	-1.606760 02	-3.612020 01	-2.102430-01	-1.033550 00	-1.582320-01
	-3.070180 03	1.488960 03	-9.603640 03	8.186020 01	-2.020510 01	-1.090700 01
	-7.922990 00	3.747540 00	-2.420290 01			

Figure 96. (Continued).

RUN SE-31-100 COMBINED VEL. IMPACT 0100

TIME = 0.10000

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 17	9.073610 01	4.219210 01	-3.925540 00	-3.424670-01	-5.72654D-02	1.79543D-01
	2.758320 02	-7.079260 01	-7.751980 01	1.45786D 00	-3.77241D-01	1.558490 00
	2.538950 02	-8.104470 01	-1.267810 02	1.547060 00	-8.778380-01	1.338900 00
	-1.977110 02	-6.654890 02	2.654900 02	-6.73415D-01	-1.186790 00	-1.480300-16
	5.72341D-02	-3.352620-01	9.403850-01			
MASS 18	9.201220 01	-8.412170 01	-4.36356D 00	3.631290-01	-4.761730-02	-1.486860-01
	2.811690 02	-3.399290 02	-8.345280 01	-6.012290-01	-2.394360-01	-1.456400 00
	3.240790 02	-3.104820 02	1.208030 01	-6.705520-01	-7.405490-01	-1.274830 00
	4.231330 02	5.419990 02	-8.777110 01	5.409120-01	-4.897850-01	-1.480300-16
	4.759930-02	3.547980-01	9.337310-01			
MASS 19	1.439320 02	-1.989250 01	-1.286090 01	-1.979850-02	4.429600-05	1.944670-03
	2.194150 02	-1.675610 02	6.817230 00	-6.464570-01	-7.118480-01	-1.336440-01
	2.190930 02	-1.680860 02	3.668010 00	-6.464510-01	-7.092100-01	-1.470010-01
	-2.990810 03	9.466110 02	-7.514200 03	1.072260 01	-6.081680 01	-1.109890 01
	-7.818970 00	2.375070 00	-1.678280 01			
MASS 20	8.572190 00	2.351700 01	-6.635600 01	-2.832640-02	-9.907300-02	1.333570-02
	5.090570 02	-1.794130 02	-4.351070 01	-7.665010-01	-6.038080 00	1.028230 00
	4.998310 02	-1.834650 02	-9.864330 01	-6.647970-01	-6.064640 00	9.517640-01
	7.077550 03	2.313510 03	-1.174470 04	1.797730 01	-2.244830 02	-8.672980 00
	2.029030 01	6.926610 00	-2.225770 01			
MASS 21	9.346010 00	-6.632250 01	-6.414730 01	-2.217940-02	-1.398640-01	1.059540-02
	5.663140 02	-1.647780 02	2.891730 01	-1.024550 00	-8.567780 00	1.209550 00
	5.628460 02	-1.896110 02	-5.425510 01	-8.559320-01	-8.592240 00	1.007430 02
	1.001570 04	7.993010 02	-1.302690 04	-3.895870 01	-2.048300 02	4.190420 01
	2.765000 01	3.419410 00	-3.079920 01			
MASS 22	3.143030 00	2.498460 01	-1.272870 01	-2.844200-02	-9.469050-02	1.677870-02
	2.323640 02	-1.423020 02	-6.048320 01	-8.139680-01	-4.645470 00	2.334520-01
	2.231950 02	-1.437910 02	-8.607710 01	-7.918950-01	-4.650200 00	1.002040-01
	-2.059860 03	2.566300 03	-9.270970 03	-7.214520 00	-1.101120 02	-2.913230 01
	-4.262120 00	6.561600 00	-2.103420 01			
MASS 23	2.410910 00	-6.517550 01	-1.073640 01	-1.479790-02	-1.316370-01	-4.086180-02
	1.534200 02	-1.453660 02	-1.321850 01	-5.724160-02	-7.242200 00	-2.106830 00
	1.561180 02	-1.384610 02	-3.605720 01	-3.337790-01	-7.210500 00	-2.195540 00
	-2.205510 03	2.382060 03	-1.033520 04	3.733050 01	-2.395240 02	4.074940 01
	-5.838130 00	5.251970 00	-2.373910 01			
MASS 24	9.651260 01	2.372440 01	-6.797220 01	-2.031270-02	-2.229180-02	3.384820-03
	2.411310 02	-1.684390 02	-6.562360 00	-2.019890 00	-2.236300-01	1.074480-04
	2.403090 02	-1.689360 02	-1.735720 01	-2.019890 00	-2.235860-01	-4.434840-03
	-3.384420 03	8.841320 03	-9.845910 03	1.660690 02	-2.975700 01	2.197530 01
	-8.759820 00	2.281140 01	-2.448430 01			

Figure 96. (Continued).

RUN SE-31-100 COMBINED VEL. IMPACT 0100

TIME = 0.10000

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDCT W WDOT ZACCEL	PHI PHIDOT P PDOT	THETA THETADOT Q QDOT	PSI PSIDOT R RDOT
MASS 25	9.681900 01	-6.626370 01	-6.654630 01	-3.087490-02	-2.612220-02	3.785710-03
	2.442640 02	-1.697780 02	-4.104110 01	-1.992380-01	-8.160850-01	-9.844010-04
	2.424640 02	-1.691570 02	-5.263720 01	-1.992630-01	-8.156660-01	-2.617610-02
	-2.484000 03	8.522940 03	-1.295300 04	5.036990 01	-6.400890 01	8.198300-01
	-6.335470 00	2.203650 01	-3.295740 01			
MASS 26	4.422960 00	-2.027120 01	-2.137960 01	-2.198670-02	-6.197930-02	1.317860-03
	2.436950 02	-1.470280 02	-1.911640 01	-7.237350-01	-4.116860 00	-3.364610-01
	2.416560 02	-1.465620 02	-1.739320 01	-7.445750-01	-4.108480 00	-4.262430-01
	-3.714180 03	3.269430 03	-9.198680 03	-6.427370 01	1.251380 02	-2.355050 01
	-9.386080 00	8.130830 00	-2.097390 01			
MASS 27	9.527400 01	-2.019180 01	-2.264940 01	-2.013100-02	6.714790-03	3.903830-03
	2.298580 02	-1.640320 02	-3.307460 01	-5.582300-01	-1.112520 00	1.514070-04
	2.294330 02	-1.642600 02	-3.484830 01	-5.582310-01	-1.112300 00	-2.224330-02
	-2.432110 03	2.245180 03	-1.079660 04	1.832070 01	-1.050300 02	-8.334890 00
	-6.209850 00	5.752920 00	-2.707220 01			
MASS 28	4.902730 00	-2.045210 01	-2.954740 01	-2.034260-02	-5.886640-02	4.642210-03
	2.760930 02	-1.510370 02	4.106620 01	-5.880990-01	-5.395370 00	-1.372740-01
	2.773280 02	-1.527900 02	2.168580 01	-5.961750-01	-5.391460 00	-2.467560-01
	-4.174880 03	2.983440 03	-1.055930 04	-1.301050 02	5.794400 01	-3.006610 01
	-1.121640 01	7.585330 00	-2.324620 01			
MASS 29	9.521080 01	-2.036510 01	-3.119200 01	-1.935730-02	9.122070-03	4.526060-03
	2.386530 02	-1.672510 02	6.472440 01	-6.388680-01	-1.079190 00	5.306500-02
	2.372940 02	-1.695930 02	6.362100 01	-6.393520-01	-1.080020 00	3.216390-02
	-1.359100 03	2.299520 03	-9.408310 03	-3.057440 01	-1.344620 02	-6.610210 00
	-3.684870 00	6.082450 00	-2.342900 01			
MASS 30	4.873610 00	-2.043920 01	-2.866850 01	-2.015460-02	-5.945500-02	5.014220-03
	2.719780 02	-1.501370 02	6.468630 01	-6.070120-01	-5.638580 00	-1.140920-01
	2.745670 02	-1.524440 02	4.539300 01	-6.137920-01	-5.635140 00	-2.275030-01
	-4.221650 03	3.122630 03	-9.383910 03	-1.340270 02	5.747200 01	-3.075680 01
	-1.168940 01	8.000050 00	-2.005960 01			
MASS 31	9.521560 01	-2.035880 01	-3.081090 01	-1.906960-02	9.176380-03	4.632700-03
	2.387210 02	-1.668240 02	7.636220 01	-6.607170-01	-1.100970 00	5.700310-02
	2.372350 02	-1.693950 02	7.532600 01	-6.612400-01	-1.101850 00	3.599660-02
	-1.395150 03	2.312020 03	-7.052960 03	-4.811210 01	-1.347730 02	-6.716970 00
	-3.813600 00	6.140850 00	-1.730450 01			
MASS 32	1.178450 02	-2.213580 01	-6.128670 01	-2.197020-02	-5.296760-02	-5.291830-03
	2.737740 02	-2.177610 02	1.672420 02	-9.781160-01	-2.037890 00	-3.372820-01
	2.833960 02	-2.196060 02	1.476630 02	-9.959730-01	-2.030000 00	-3.814970-01
	-5.228550 02	2.018220 02	-5.893110 03	-3.576140 01	2.891950 01	-2.578610 01
	-2.348160 00	6.237730-01	-1.321010 01			

IG(IJ)	JG(IJ)	SUMDF(1,IJ)	SUMDF(2,IJ)	SUMDF(3,IJ)	SUMDF(4,IJ)	SUMDF(5,IJ)	SUMDF(6,IJ)
1	2	-3.508070 03	-4.867180 02	2.902240 02	0.0	1.658580 04	2.919290 04
2	3	-3.663970 03	4.428450 01	-3.601350 03	-1.877770 04	-6.997490 05	-3.526330 04
3	4	-5.381350 03	6.952490 02	-5.735750 03	-2.697240 04	-8.784010 05	-7.184110 04
4	5	-1.321090 04	6.246730 03	-2.792160 04	8.899380 04	-1.695270 06	-2.770870 05
4	7	-6.711760 03	-1.169140 03	1.275840 04	0.0	2.687940 05	1.846660 04

Figure 96. (Continued).

5	6	-1.122360 04	-1.488650 04	4.659290 04	-6.408060 04	-7.312060 05	4.354610 04
5	7	-6.335520 03	-2.028840 02	-9.782660 03	0.0	-2.388770 05	-1.813680 04
5	20	1.112600 04	0.0	-9.267770 02	0.0	6.358850 03	0.0
5	21	6.835870 03	0.0	-6.469450 03	0.0	-1.405360 05	0.0
5	22	-1.187400 04	0.0	-2.658140 04	0.0	-7.241340 05	0.0
5	23	-3.379850 04	0.0	-3.470700 04	0.0	-8.435860 05	0.0
6	9	-3.325750 04	-2.810000 03	-6.682090 02	2.578300 04	-1.431080 05	-1.381070 04
6	11	-6.929000 03	-1.786060 04	1.104960 04	4.553700 04	-1.768190 05	2.966050 03
7	9	0.0	0.0	0.0	-4.928820 03	0.0	0.0
8	9	-3.023290 04	2.964540 03	4.888310 03	2.082070 04	1.231230 05	-1.793510 04
10	11	2.872950 04	5.418070 03	2.864780 03	7.769940 02	3.855230 05	1.222390 05
10	14	1.536540 03	2.838690 03	-2.213690 03	3.654780 03	1.466110 05	7.481030 03
10	15	-3.190440 03	-2.561170 03	-6.393380 02	8.024240 03	1.916040 05	4.459730 03
10	22	1.383050 03	3.151910 03	3.263720 04	0.0	7.853880 05	1.280240 04
10	23	1.532740 04	-5.977430 03	2.174440 04	0.0	6.245060 05	-9.541440 02
11	16	2.156990 03	1.325020 04	-1.197000 04	3.220260 03	-3.847760 05	-1.683020 05
12	16	7.478390 02	-3.603310 02	1.897490 03	-2.696270 04	7.508100 04	7.409350 04
12	24	-3.764680 02	2.815720 02	4.243070 01	-1.192090 03	5.439040 03	3.822210 03
13	16	-1.154660 03	8.458610 02	7.636390 03	3.293080 04	2.238240 05	2.089470 04
13	25	-1.311980 03	-1.450160 03	-7.537790 02	-1.019090 03	1.675750 04	7.531660 03
16	17	1.879440 03	1.900590 03	-5.781720 02	-6.151950 03	9.727850 04	-8.951820 03
16	18	-2.147740 03	-1.606720 03	-5.624490 02	5.990040 03	9.786600 04	9.517850 03
16	19	2.564150 03	7.243780 03	1.710040 03	1.279850 03	-5.218640 03	-4.239170 03
20	21	-5.814620 03	-8.160610 01	-7.533790 02	0.0	3.028160 04	-3.621860 03
20	22	-8.766020 03	1.027010 03	-2.646910 03	0.0	-5.796670 04	-3.115780 04
21	23	-9.764240 03	3.278190 03	-4.453820 03	0.0	-9.136250 04	-1.003570 05
24	25	-9.113660 02	7.096900 01	-2.671580 02	2.500860 02	-1.418970 04	-2.257000 03
10	26	-3.950490 03	-1.181300 03	1.310950 03	-7.578920 03	-2.599900 04	2.921590 04
16	27	-4.883720 03	-9.800980 02	4.054110 02	-2.178620 03	4.041480 04	-4.620680 02
26	28	-2.232060 03	-3.423850 02	-2.427600 03	-3.364940 03	2.772880 04	1.874530 04
27	29	-1.788690 03	-1.819080 02	-4.109400 02	-6.682070 02	2.329570 04	7.798610 03
26	30	-1.961590 03	-5.709920 02	-1.167240 03	-3.719300 03	2.309440 04	2.110870 04
27	31	-1.443570 03	-3.492940 02	-1.704960 02	-7.745710 02	2.405530 04	1.080740 04
8	32	9.945050 02	1.609790 02	-1.785610 02	1.686810 03	-2.053020 03	3.644190 03

IG(IJ),JG(IJ),VEE2(1,IJ),VEE2(2,IJ),VEE2(3,IJ),VEE2(4,IJ),VEE2(5,IJ),VEE2(6,IJ)

1	2	-2.657430-02	1.160180-01	-2.716120-02	-7.802220-03	3.877940-03	9.661560-03
2	3	-5.979560-02	-1.316530-01	1.171460 00	-7.620810-03	-1.892350-02	-1.677230-03
3	4	-1.667080-02	-9.176360-03	8.990920-02	-7.391730-04	-6.033500-03	-6.293870-04
4	5	-6.287920-03	-1.110700-02	2.136940-02	1.086220-06	-1.143640-03	-7.596270-04
4	7	-1.256550-01	-2.080610-02	1.503340-01	-5.814190-04	-1.545100-03	-4.398270-04
5	6	-2.469430-02	-2.868610-02	6.975280-02	-7.180710-06	-5.575440-03	-1.794630-03
5	7	-1.765680-01	-2.794580-02	-7.790400-02	-[illegible].349350-04	-4.096090-04	-1.108730-03
5	20	6.953730-02	-4.577220 00	-8.794910-02	-8.024330-02	2.211160-03	-5.655780-02
5	21	4.272420-02	5.110360 00	-2.521600-01	1.036350-01	3.859310-03	9.206760-02
5	22	-6.761940-02	3.691200-01	-4.619740-01	-8.393250-02	1.858170-03	4.292400-02
5	23	-1.924740-01	-1.743100 00	-7.683210-01	1.054590-01	8.226210-03	-5.778540-02
6	9	-1.094000-02	-3.590960-02	8.285270-02	1.007150-03	-5.940640-03	-2.005150-03
6	11	-1.424840-03	-1.665130-02	3.174180-02	5.508280-04	-3.467370-03	-1.510620-03
7	9	1.608160-01	-9.259530-02	-1.738530-01	-2.250600-03	-1.109630-02	-3.392970-03
8	9	-5.940810-01	9.050850-02	2.059550-01	9.229030-03	4.078800-02	2.703510-03
10	11	5.266630-02	1.128720-01	-5.189210-01	3.281220-04	4.862640-02	9.251010-03
10	14	3.208640-03	4.546780 00	-1.510060 01	6.790780-05	3.693720-01	1.419700-01
10	15	-6.653680-03	-3.595580 00	-1.510380 01	1.431340-04	3.898030-01	-1.074740-01
10	22	1.555910-02	6.391780-01	1.960820-01	-3.591540-02	2.299440-03	2.215460-02
10	23	1.724320-01	-1.073290 00	2.816420-02	7.152560-02	6.086790-03	-3.584190-02
11	16	1.269940-02	2.486820-02	-2.538710 00	4.288540-03	1.316460-02	4.696990-04
12	16	4.206070-04	6.612700-02	-1.138620-01	-2.526960-02	9.034290-03	3.065390-03
12	24	-2.541990-03	2.867590-01	-5.897680-03	-3.998970-03	2.397100-04	8.693230-03
13	16	-6.495390-04	4.834950-02	7.127420-02	3.086290-02	1.324380-02	1.854500-03
13	25	-8.858730-03	-9.177080-01	-6.617010-02	-3.418630-03	2.072080-03	-2.406270-02
16	17	7.840820-03	4.550260 00	-1.510230 01	-2.091440-04	3.860080-01	1.308440-01
16	18	-8.960120-03	-3.680620 00	-1.510010 01	2.029000-04	3.866610-01	-1.038580-01
16	19	1.246550-02	3.188340-03	8.153920-02	1.193890-03	-2.588080-03	9.777930-05
20	21	-1.308120-01	-2.037390-01	-3.055910-01	4.070020-02	5.775580-03	-3.879860-03
20	22	-1.183750-01	8.476900-03	-3.197450-01	3.548620-03	4.279690-03	-1.851260-04
21	23	-1.318240-01	2.574080-02	-5.909600-01	-5.082220-02	9.162470-03	-6.396930-04

Figure 96. (Continued).

24	25	-1.025160-03	3.358790-02	-4.025800-01	3.818110-03	-1.055270-02	3.499490-04
10	26	-3.950490-01	-8.981210-03	1.566810-02	-7.578920-03	-2.758590-03	2.831780-03
16	27	-1.627910-01	-9.946660-03	1.275840-05	-2.178620-03	4.041350-03	-1.456730-04
26	28	-1.816160 00	-1.564970-03	-2.732210-02	-3.364940-03	3.046100-03	1.858880-03
27	29	-1.455400 00	-1.049720-03	-6.504010-03	-6.682070-04	2.394610-03	7.693640-04
26	30	-2.495640 00	-3.635400-03	-1.412300-02	-3.719300-03	2.450670-03	2.074520-03
27	31	-1.836600 00	-2.436560-03	-4.152020-03	-7.745710-04	2.447050-03	1.096380-03
8	32	9.945050-03	1.077770-01	-7.365710-02	1.686810-03	1.030740-03	1.753090-03

I,SC(I,1),SC(I,2),SC(I,5)

10	0.0	0.0	5.180160 00
11	0.0	0.0	5.988650 00
12	0.0	0.0	2.987370 00
13	0.0	0.0	4.412220 00
14	0.0	0.0	1.037320-03
15	0.0	0.0	1.674310-03
16	0.0	0.0	4.182980 00
17	0.0	0.0	1.653420-04
18	0.0	0.0	1.043750-03
22	0.0	0.0	4.208850 00
23	0.0	0.0	6.168710 00

MASS	DR*
30	1.634660 01
31	1.202970 01

Figure 96. (Continued).

RUPTURE SUMMARY

I	J	TIME
10	15	0.05676
10	14	0.06142
16	18	0.06284
16	17	0.06510

Figure 96. (Continued).

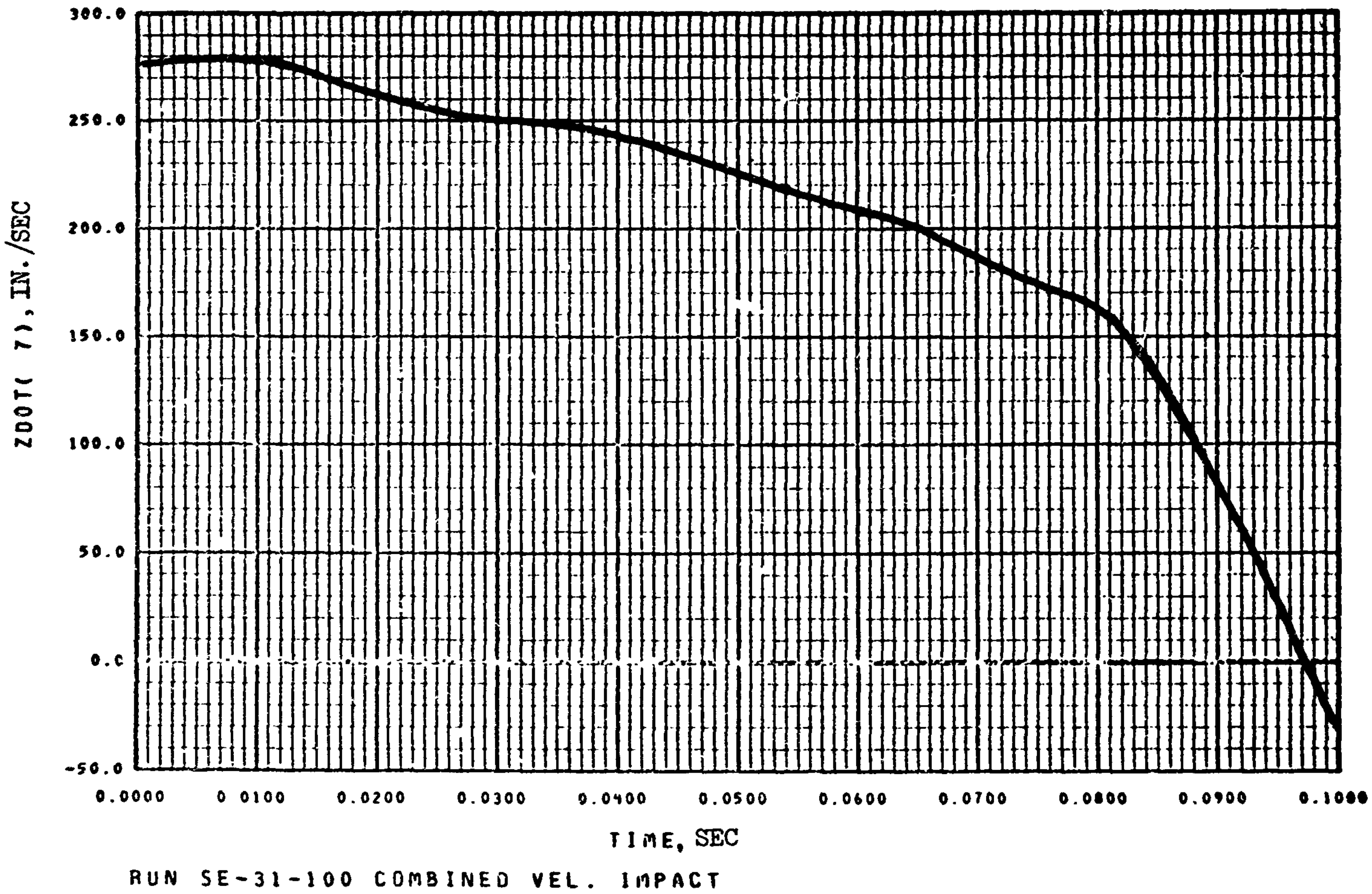


Figure 97. Engine Mass Vertical Velocity, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

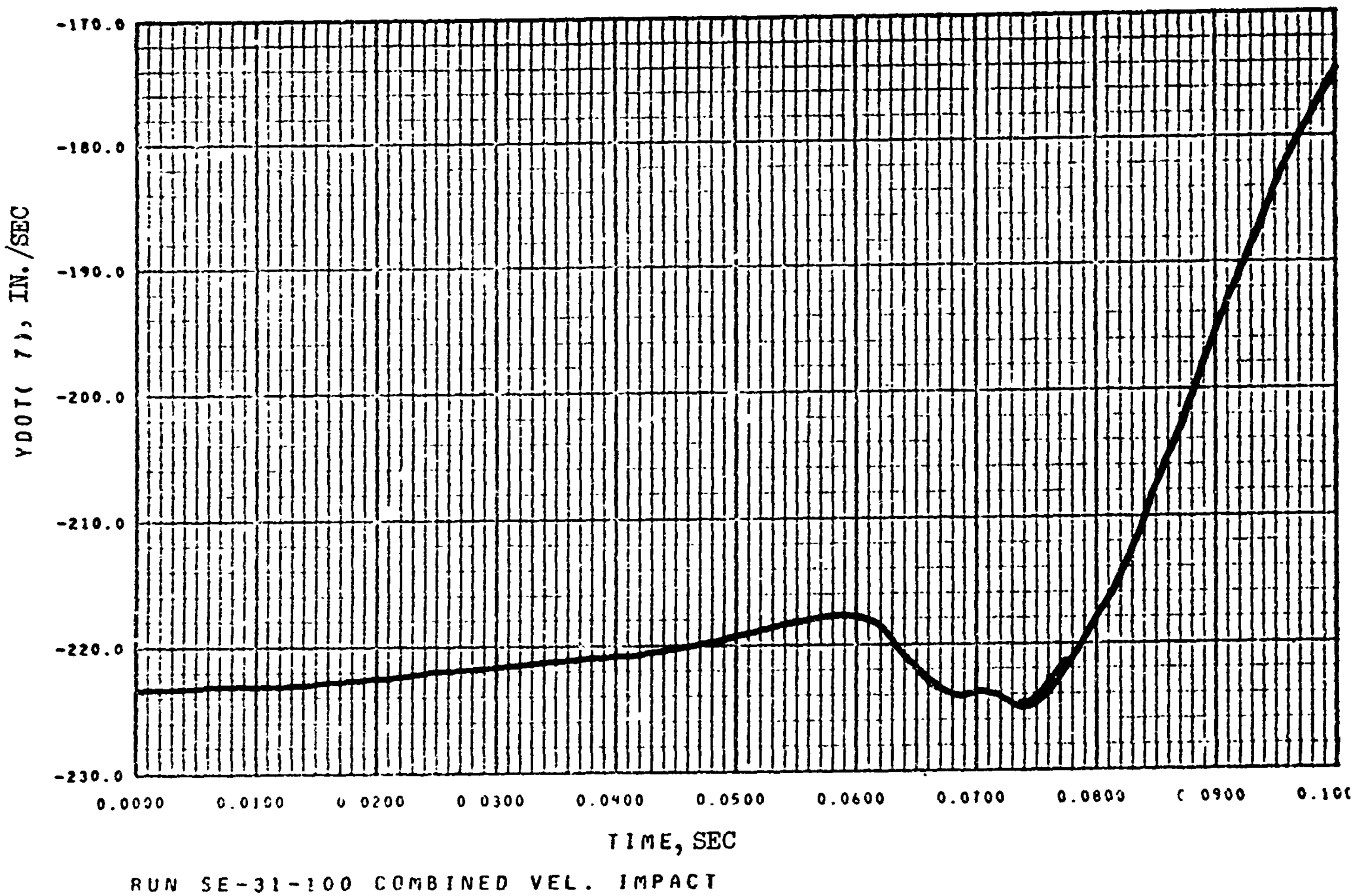
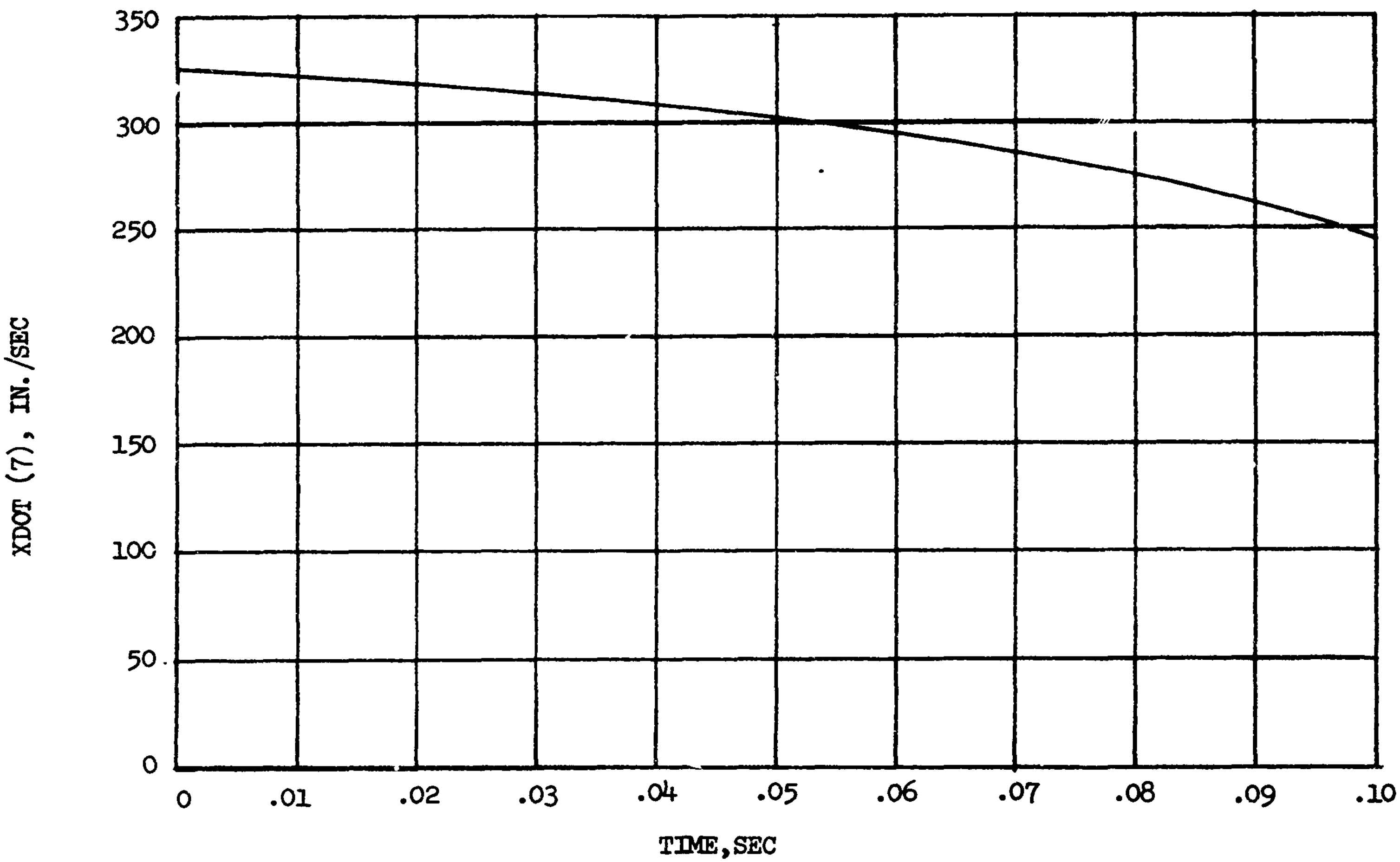


Figure 98. Engine Mass Lateral Velocity, Combined Vertical, Lateral and Longitudinal Impact Sample Case.



RUN SE-31-100 COMBINED VELOCITY IMPACT

Figure 99. Engine Mass Longitudinal Velocity, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

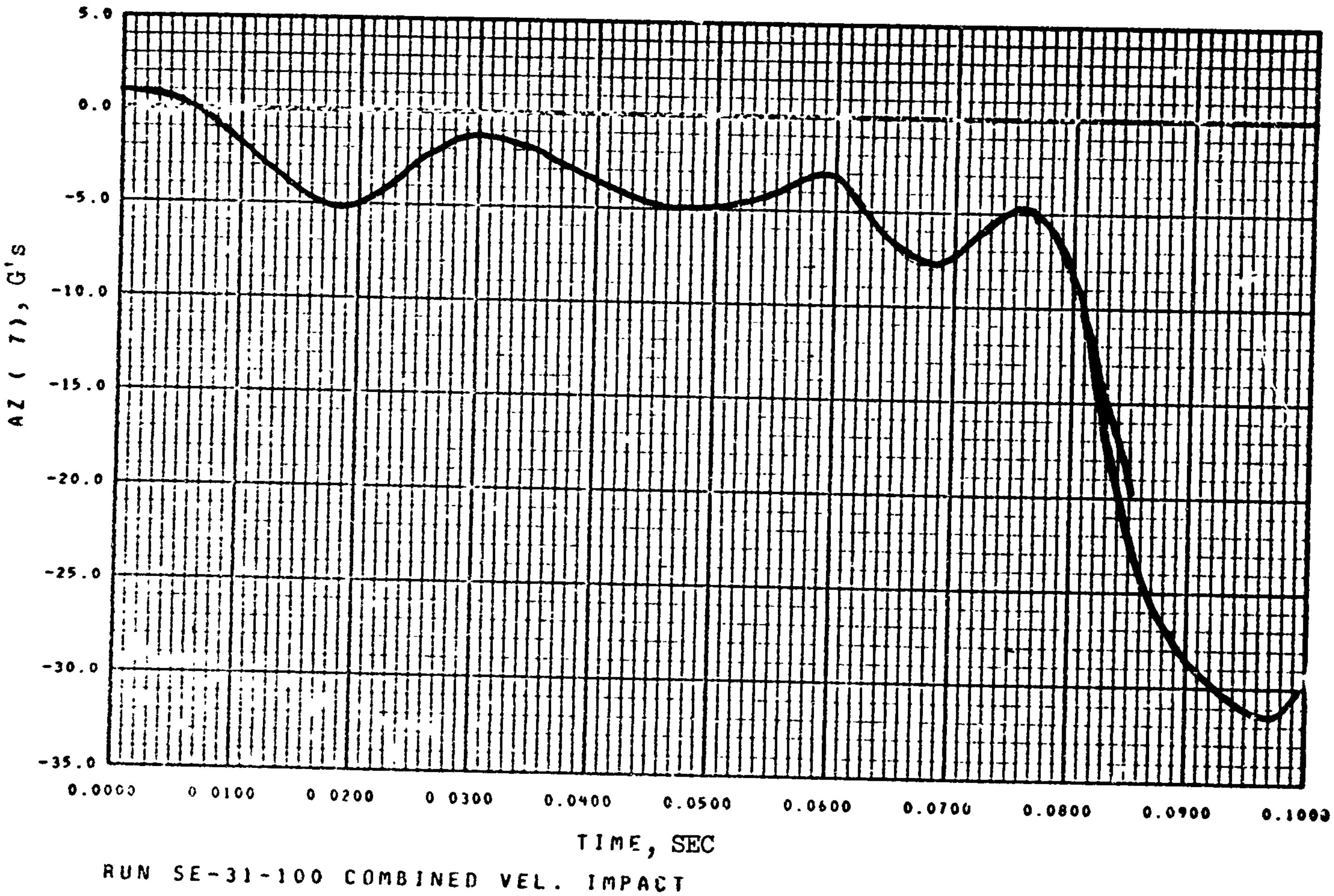


Figure 100. Engine Mass Vertical Acceleration, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

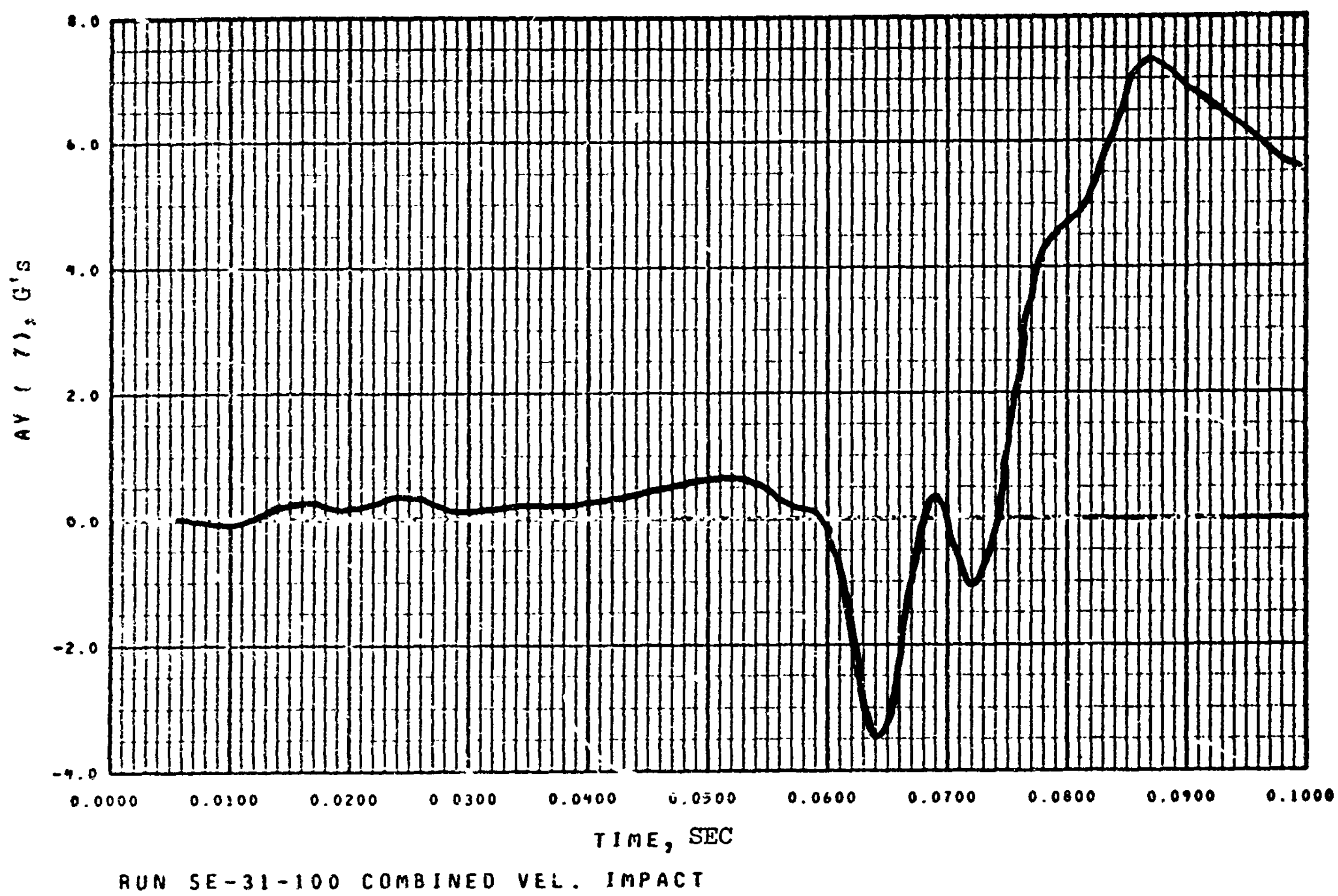


Figure 101. Engine Mass Lateral Acceleration, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

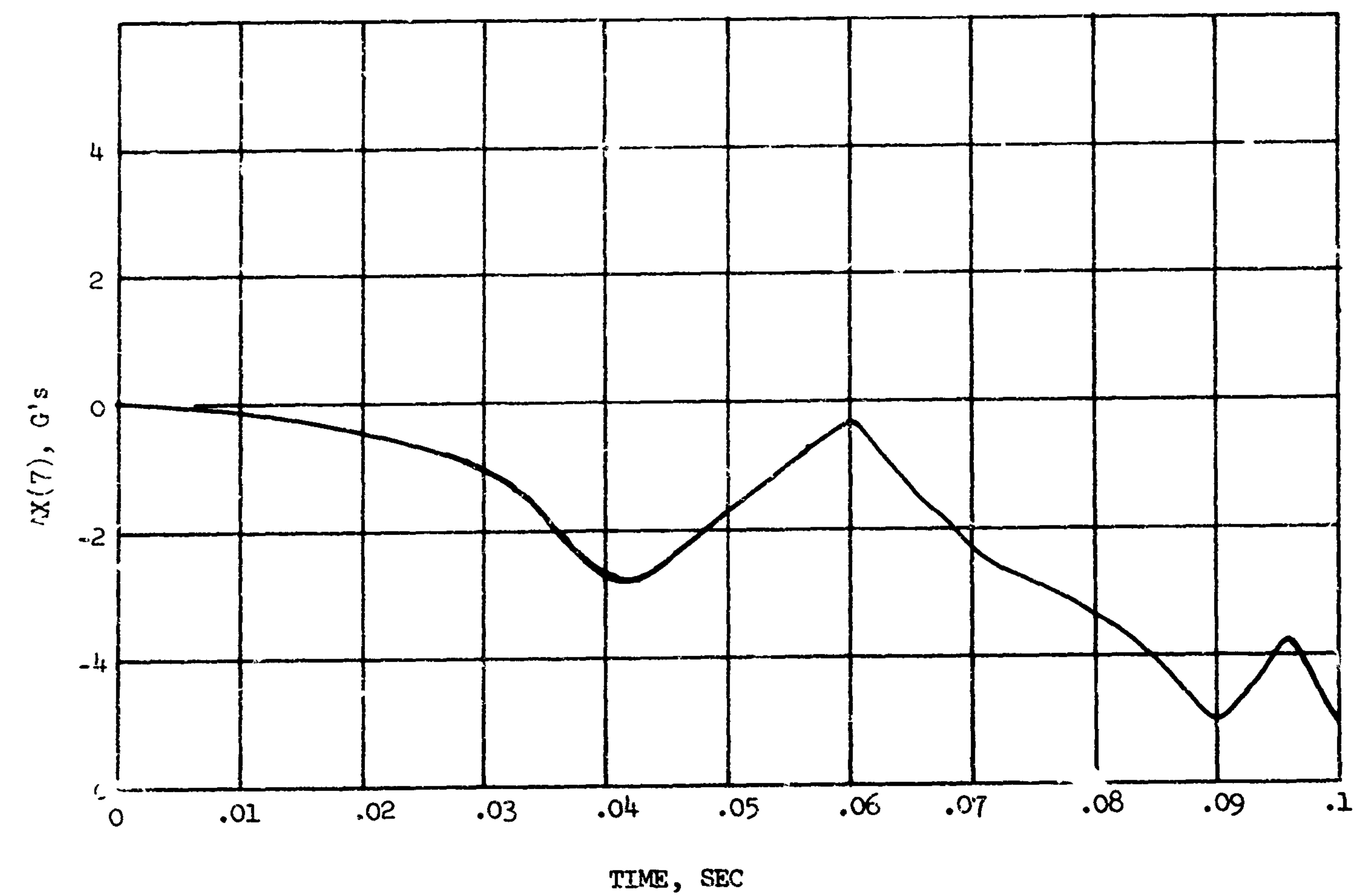


Figure 102. Engine Mass Longitudinal Acceleration, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

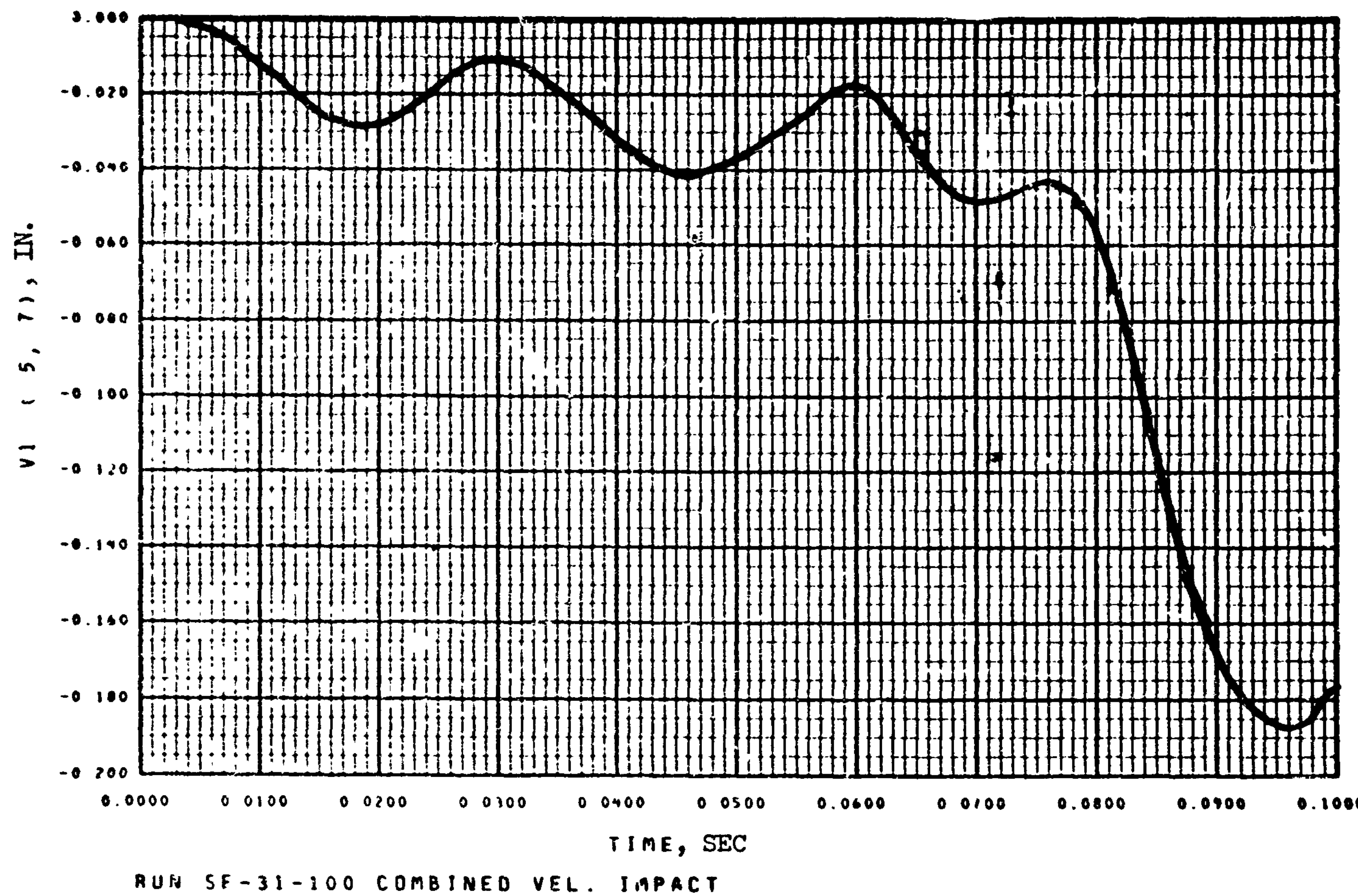


Figure 103. Engine Mount Vertical Deflection, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

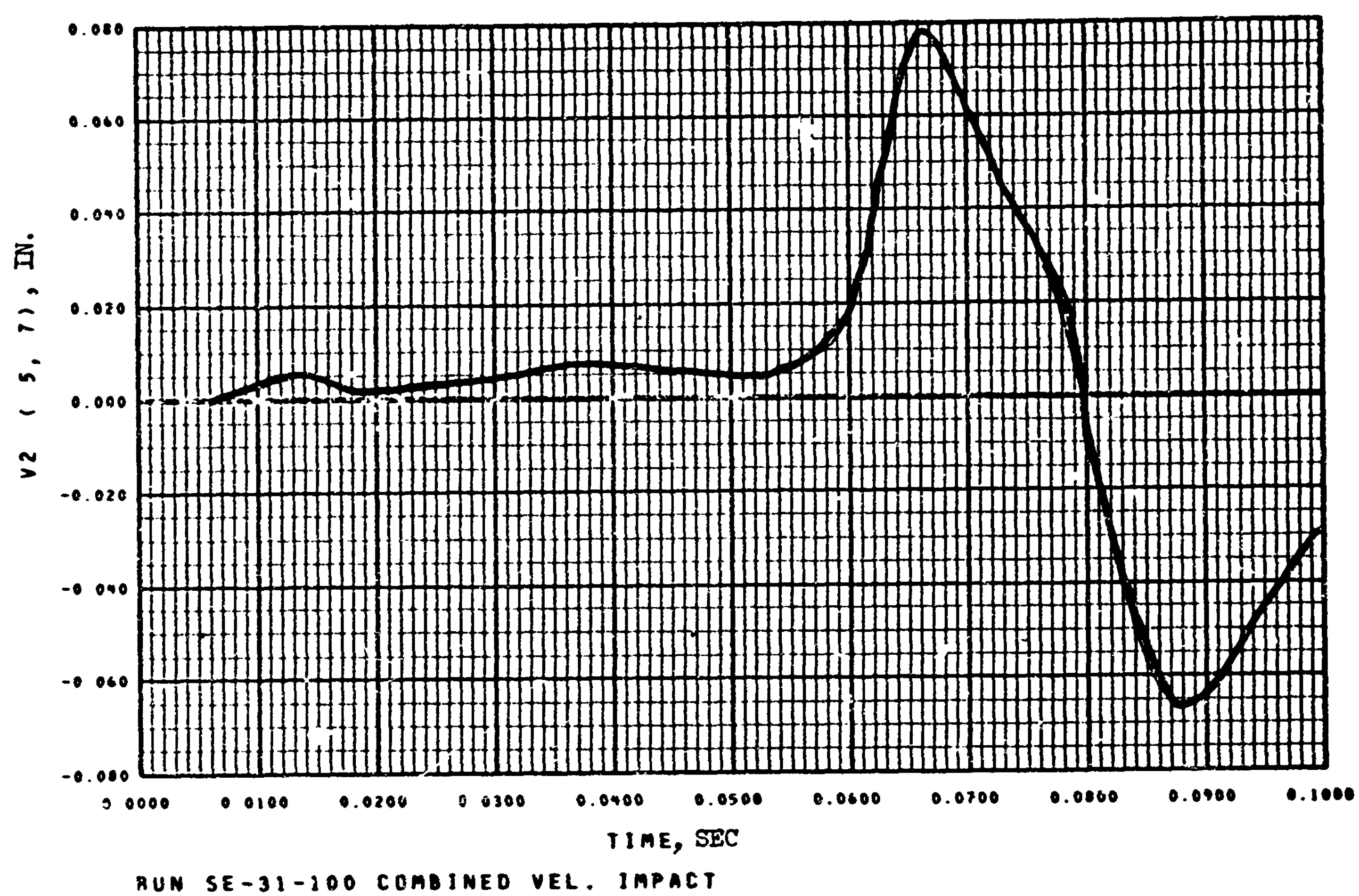


Figure 104. Engine Mount Lateral Deflection, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

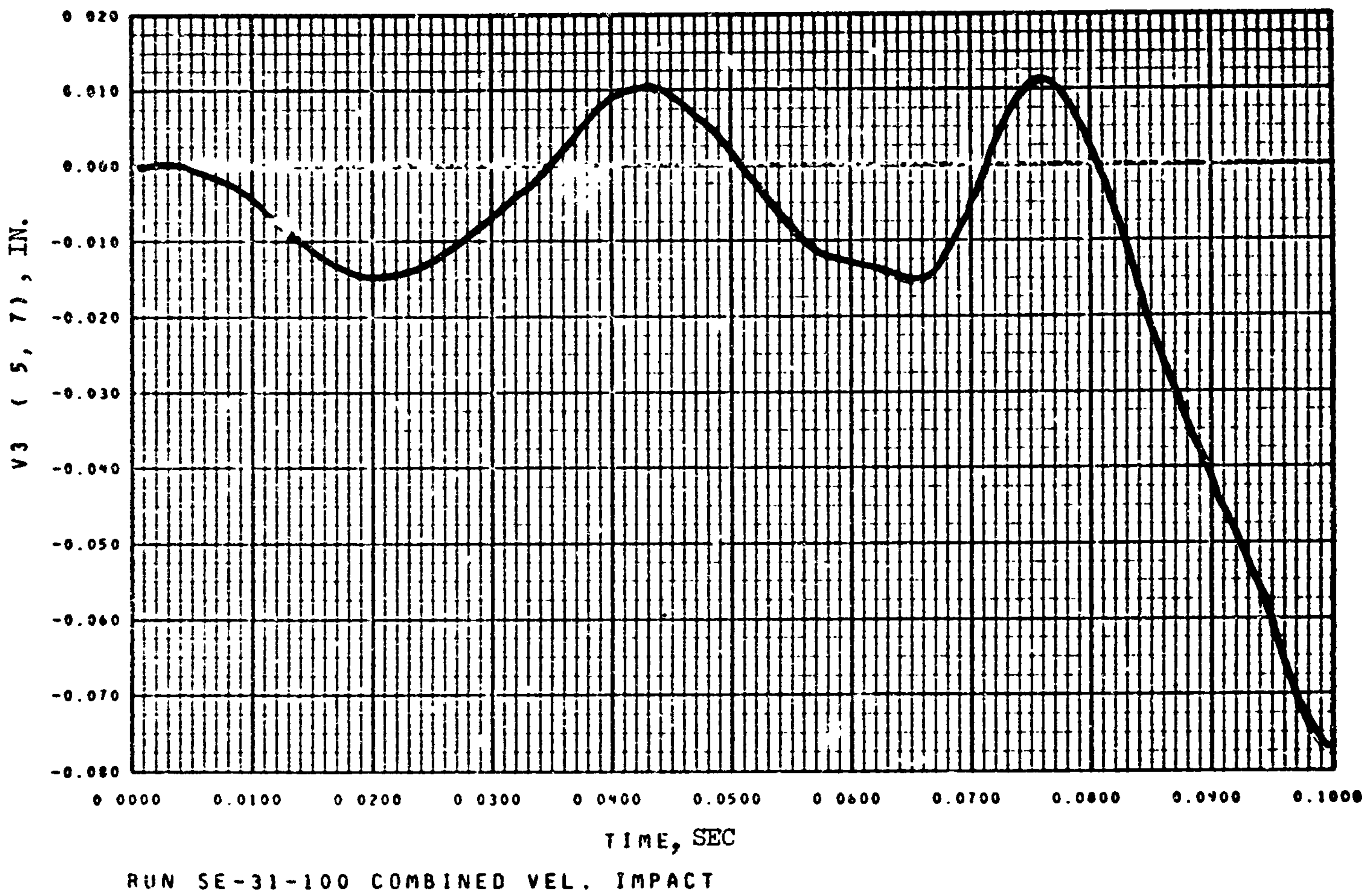


Figure 105. Engine Mount Longitudinal Deflection, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

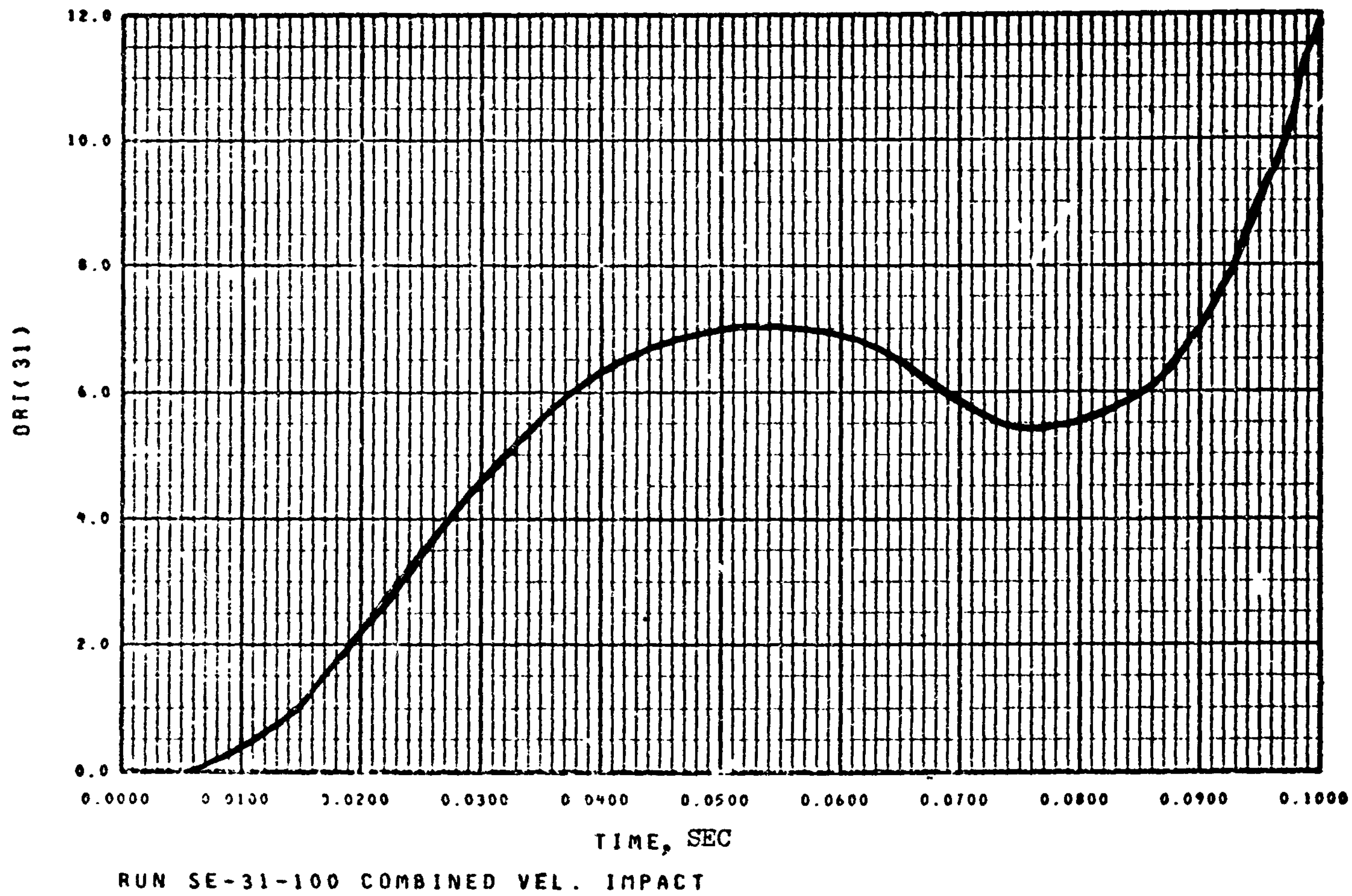


Figure 106. Forward DRI, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

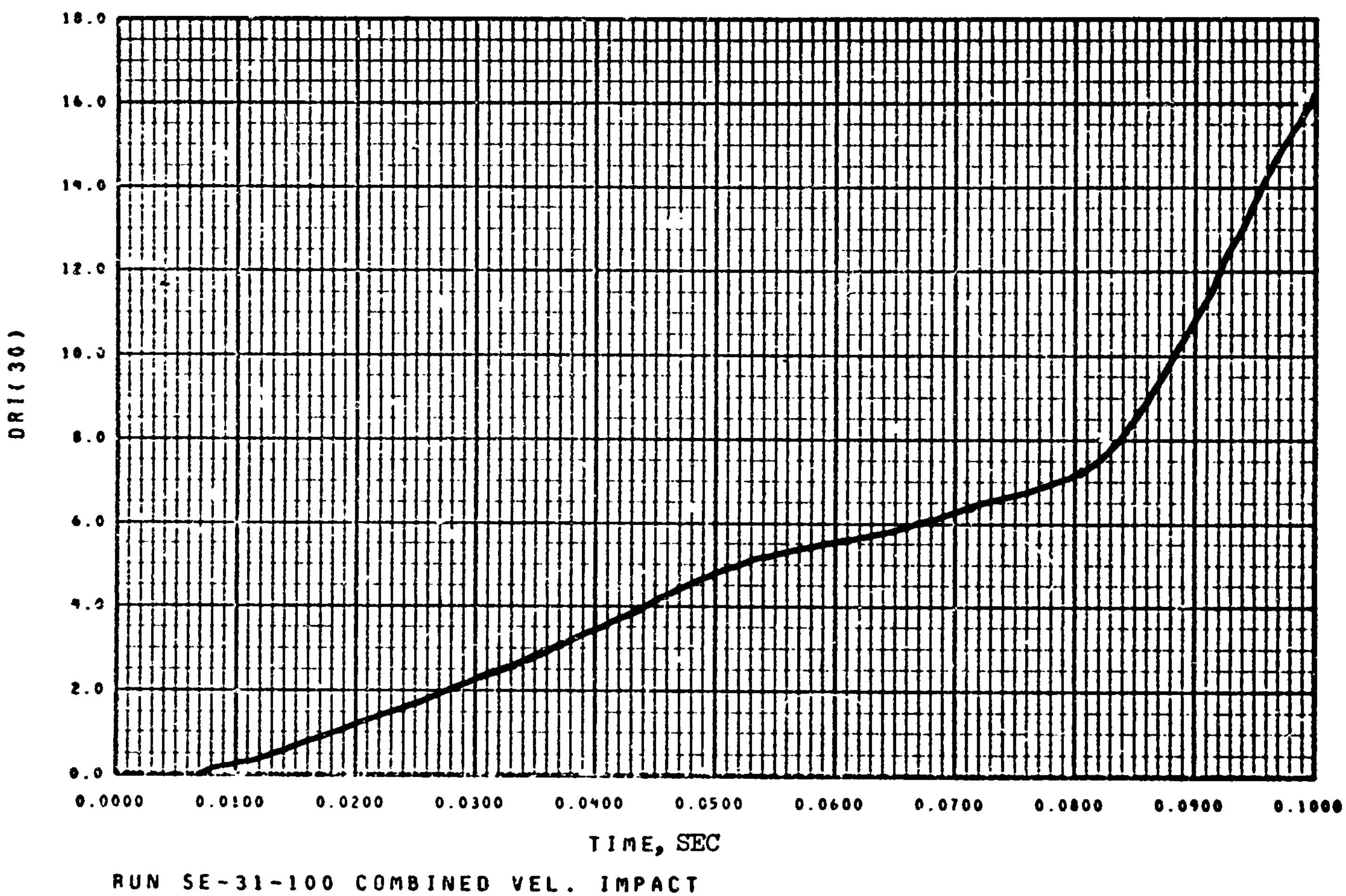


Figure 107. Aft DRI, Combined Vertical, Lateral and Longitudinal Impact Sample Case.

```
LEVEL 20.1 (MAY 71)                    OS/360  FORTRAN H                    DATE  73.298/10.02.22

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=56,SIZE=0000K,
                                SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
ISN 0002        IMPLICIT REAL*8 (A-H,O-Z)                                           CRS00000
ISN 0003        REAL*4 PLOT,ZAK,IMPLOT                                              CRS00010
ISN 0004        INTEGER*2      IOPLOT,N,N3,IJPF,ISP,        NN,IBS                  CRS00020
ISN 0005        DIMENSION DPHI(60),DTHETA(60),DPSI(60),              N3(60,6),      CRS00030
               1 VEE2(6,60),FM3(6,6,60),FMBAR3(6,6,80)                              CRS00040
ISN 0006        COMMON/MAINCF/IMAX,IPRINT,ITPLOT,IBS(60,3)                          CRS00050
ISN 0007        COMMON                      XX(60),XY(60),XZ(60),XL(60),XM(60),     CRS00060
               1 XN(60),DPX(60),DPY(60),DPZ(60),DPL(60),DPM(60),DPN(60),            CRS00070
               2 PIN(60),CIN(60),RIN(60),XI1(60),XI2(60),XI3(60),XI4(60),XI5(60),   CRS00080
               3 XI6(60),XXK(80),XYK(80),XZK(80),XLK(80),XMK(80),XNK(80),XXJ(80),   CRS00090
               4 XYJ(80),XZJ(80),XLJ(80),XMJ(80),XNJ(80),                           CRS00100
               5           DELI(60),POLD(60),QOLD(60),ROLD(60),UOLD(60),VOLD(60),   CRS00110
               6 WOLD(60),XOLD(60),YOLD(60),ZOLD(60),PINU(60),QINU(60),RINU(60),    CRS00120
               7 DXIJ(80),DYIJ(80),DZIJ(80),PHIOLD(60),THEOLD(60),PSIOLD(60),       CRS00130
               8 IPEN(80),IRUPT(80),DTHALF,                                         CRS00140
               9 IJKK,KPEN,KRUPT,IPEN(60),IRUPT(80),JPUPT(80)                       CRS00150
ISN 0008        COMMON/COMALL/ C(6,60),P(60),Q(60),R(60),U(60),V(60),W(60),X(60),   CRS00160
               1 Y(60),Z(60),AI(9),AJ(9),FM(2880),SC(60,3),XC(6),XK(2880),XI(60),   CRS00170
               2 YI(60),ZI(60),XYI(60),XZI(60),YZI(60),AIJ(9),BIJ(540),DIJ(720),    CRS00180
               3 DPI(60),UAI(540),VEE(480),WGT(60),PHI(60),THETA(60),PSI(60),       CRS00190
               4 PDOT(60),QDOT(60),RDOT(60),UDOT(60),VDOT(60),WDOT(60),XDOT(60),    CRS00200
               5 YDOT(60),ZDOT(60),PHIDOT(60),THEDOT(60),PSIDOT(60),TIME,DELTAT,    CRS00210
               6 XACC(60),YACC(60),ZACC(60),AITAJ(9),AIDOT(9),FMBAR(2880),          CRS00220
               7 PHIIJ(80),THEIJ(80),PSIIJ(80),SUMDF(6,60),TITLE(10),XLBAR(60,3),   CRS00230
               8 FSPBAR(60,3),VEEDOT(3,3),DX(60),DY(60),DZ(60),DPIN(60),DRIN(60),   CRS00240
               9 DQIN(60),SEIJ(80),DEIJ(80),CEIK(60,3),
               9ZAK(200),PLOT(30000),IMPLOT(500),                                   CRS00250
               ANM,IBS,  IOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(150),IG(80),JG(80),      CRS00260
               0 N(480),NN(60,3),ISP(60,3),IJPR(80),IOPLOT(150)                     CRS00270
ISN 0009        EQUIVALENCE (N(1),N3(1)),(VEE(1),VEE2(1)),(FM(1),FM3(1)),           CRS00290
               1 (FMBAR(1),FMBAR3(1))                                               CRS00300
ISN 0010        IPLSW = 0                                                           CRS00310
ISN 0011      1 CALL INPUT                                                          CRS00320
ISN 0012        IF(NM) 1000,1000,2                                                  CRS00330
ISN 0013      2 DT2 = 2.0*DELTAT                                                    CRS00340
ISN 0014        DTHALF = .5*DELTAT                                                  CRS00350
ISN 0015        KRUPT = 0                                                           CRS00360
ISN 0016        JPLOT = 0                                                           CRS00370
ISN 0017        KPEN=0                                                              CRS00380
           C (26)                                                                   CRS00390
ISN 0018        DO 130 I = 1,NM                                                     CRS00400
```


Figure 108. Program Listing.

```
ISN 0019          XI1(I) = YI(I)*ZI(I)-YZI(I)*YZI(I)                      CRS00410
ISN 0020          XI2(I) = XYI(I)*ZI(I)+XZI(I)*YZI(I)                     CRS00420
ISN 0021          XI3(I) = XYI(I)*YZI(I)+YI(I)*XZI(I)                     CRS00430
ISN 0022          XI4(I) = XI(I)*YZI(I)+XZI(I)*XYI(I)                     CRS00440
ISN 0023          XI5(I) = XI(I)*ZI(I)-XZI(I)*XZI(I)                      CRS00450
ISN 0024          XI6(I) = XI(I)*YI(I)-XYI(I)*XYI(I)                      CRS00460
ISN 0025      130 DELI(I) = 1.0/(XI(I)*XI1(I)-XYI(I)*XI2(I)-XZI(I)*XI3(I)) CRS00470
            C ZERO ARRAYS                                                  CRS00480
ISN 0026          TIME = 0.0                                               CRS00490
ISN 0027          NM9 = 9*NM                                               CRS00500
ISN 0028          DO 140 I = 1,NM9                                         CRS00510
ISN 0029      140 BIJ(I) = 0.0                                             CRS00520
ISN 0030          DO 150 I = 1,NM                                          CRS00530
ISN 0031          DX(I) = 0.0                                              CRS00540
ISN 0032          DY(I) = 0.0                                              CRS00550
ISN 0033          DZ(I) = 0.0                                              CRS00560
ISN 0034          DPHI(I) = 0.0                                            CRS00570
ISN 0035          DTHETA(I) = 0.0                                          CRS00580
ISN 0036          DPSI(I) = 0.0                                            CRS00590
ISN 0037          XX(I) = 0.0                                              CRS00600
ISN 0038          XY(I) = 0.0                                              CRS00610
ISN 0039          XZ(I) = 0.0                                              CRS00620
ISN 0040          XL(I) = 0.0                                              CRS00630
ISN 0041          XM(I) = 0.0                                              CRS00640
ISN 0042          XN(I) = 0.0                                              CRS00650
ISN 0043          DPX(I) = 0.0                                             CRS00660
ISN 0044          DPY(I) = 0.0                                             CRS00670
ISN 0045          DPZ(I) = 0.0                                             CRS00680
ISN 0046          DPL(I) = 0.0                                             CRS00690
ISN 0047          DPM(I) = 0.0                                             CRS00700
ISN 0048          DPN(I) = 0.0                                             CRS00710
ISN 0049          DPTH(I) = 0.0                                            CRS00720
ISN 0050          DOTN(I) = 0.0                                            CRS00730
ISN 0051          DRIN(I) = 0.0                                            CRS00740
ISN 0052          XACC(I)=0.0                                              CRS00750
ISN 0053          YACC(I)=0.0                                              CRS00760
ISN 0054          ZACC(I)=0.0                                              CRS00770
ISN 0055          DO 150 K = 1,3                                           CRS00780
ISN 0056          IBS(I,K) = 0                                             CRS00790
ISN 0057          NN(I,K) = 0                                              CRS00800
ISN 0058          SC(I,K) = 0.0                                            CRS00810
ISN 0059          CEIK(I,K) = 0.0
ISN 0060      150 FSPBAR(I,K) = 0.0                                        CRS00820
ISN 0061          DO 160 IJ = 1,IGS                                        CRS00830
ISN 0062          XXK(IJ) = 0.0                                            CRS00840
ISN 0063          XXJ(IJ) = 0.0                                            CRS00850
ISN 0064          XYK(IJ) = 0.0                                            CRS00860
ISN 0065          XYJ(IJ) = 0.0                                            CRS00870
ISN 0066          XZK(IJ) = 0.0                                            CRS00880
ISN 0067          XZJ(IJ) = 0.0                                            CRS00890
ISN 0068          XLK(IJ) = 0.0                                            CRS00900
ISN 0069          XLJ(IJ) = 0.0                                            CRS00910
ISN 0070          XMK(IJ) = 0.0                                            CRS00920
ISN 0071          XMJ(IJ) = 0.0                                            CRS00930
```

Figure 108. (Continued)

```
ISN 0072          XNK(IJ) = 0.0                               CRS00940
ISN 0073          XNJ(IJ) = 0.0                               CRS00950
ISN 0074          DXIJ(IJ) = 0.0                              CRS00960
ISN 0075          DYIJ(IJ) = 0.0                              CRS00970
ISN 0076          DZIJ(IJ) = 0.0                              CRS00980
ISN 0077          SEIJ(IJ) = 0.0
ISN 0078          DEIJ(IJ) = 0.0
ISN 0079          DO 160 L = 1,6                              CRS00990
ISN 0080          SUMUF(L,IJ) = 0.0                           CRS01000
ISN 0081          N3(IJ,L) = 0                                CRS01010
ISN 0082          VEEZ(L,IJ) = 0.0                            CRS01020
ISN 0083          DO 160 K = 1,6                              CRS01030
ISN 0084          FM3(L,K,IJ) = 0.0                           CRS01040
ISN 0085      160 FMEAR3(L,K,IJ) = 0.0                        CRS01050
ISN 0086          DO 165 J = 1,3                              CRS01060
ISN 0087          DO 165 K = 1,3                              CRS01070
ISN 0088      165 VELDOT(J,K) = 0.0                           CRS01080
            C DO INITIAL CONDITIONS                           CRS01090
ISN 0089          CALL IC                                     CRS01100
            C DO ALL THE (AIJ) INTO DIJ                       CRS01110
ISN 0090          CALL DUAIJ                                  CRS01120
ISN 0091          CALL LFKIV                                  CRS01130
ISN 0092          CALL PRINT                                  CRS01140
ISN 0093          IPC = 0                                     CRS01150
ISN 0094          IF(NPLOT.NE.0) CALL SAVE                    CRS01160
ISN 0096          DO 200 I = 1,NM                             CRS01170
            C PRESET OLD VALUES                               CRS01180
ISN 0097          PINO(I) = 0.0                               CRS01190
ISN 0098          QINO(I) = 0.0                               CRS01200
ISN 0099          RINO(I) = 0.0                               CRS01210
ISN 0100          XOLD(I) = X(I)                              CRS01220
ISN 0101          YOLD(I) = Y(I)                              CRS01230
ISN 0102          ZOLD(I) = Z(I)                              CRS01240
ISN 0103          PHIOLD(I) = PHI(I)                          CRS01250
ISN 0104          THEOLD(I) = THETA(I)                        CRS01260
ISN 0105          PSIOLD(I) = PSI(I)                          CRS01270
ISN 0106          POLD(I) = P(I)                              CRS01280
ISN 0107          QOLD(I) = Q(I)                              CRS01290
ISN 0108          ROLD(I) = R(I)                              CRS01300
ISN 0109          UOLD(I) = U(I)                              CRS01310
ISN 0110          VOLD(I) = V(I)                              CRS01320
ISN 0111          WOLD(I) = W(I)                              CRS01330
            C DO 1ST STEP EULER                               CRS01340
ISN 0112          DPIN(I) = DELTAT*P(I)                       CRS01350
ISN 0113          DQIN(I) = DELTAT*Q(I)                       CRS01360
ISN 0114          DRIN(I) = DELTAT*R(I)                       CRS01370
ISN 0115          PIN(I) = DPIN(I)                            CRS01380
ISN 0116          QIN(I) = DQIN(I)                            CRS01390
ISN 0117          RIN(I) = DRIN(I)                            CRS01400
ISN 0118          P(I) = P(I)+DELTAT*PDOT(I)                  CRS01410
ISN 0119          Q(I) = Q(I)+DELTAT*QDOT(I)                  CRS01420
ISN 0120          R(I) = R(I)+DELTAT*RDOT(I)                  CRS01430
ISN 0121          U(I) = U(I)+DELTAT*UDOT(I)                  CRS01440
ISN 0122          V(I) = V(I)+DELTAT*VDOT(I)                  CRS01450
```

Figure 108. (Continued)

```
ISN 0123          W(I) = W(I)+DELTAT*WDOT(I)                    CRS01460
ISN 0124          DX(I) = DELTAT*XDOT(I)                        CRS01470
ISN 0125          X(I) = X(I)+DX(I)                             CRS01480
ISN 0126          DY(I) = DELTAT*YDOT(I)                        CRS01490
ISN 0127          Y(I) = Y(I)+DY(I)                             CRS01500
ISN 0128          DZ(I) = DELTAT*ZDOT(I)                        CRS01510
ISN 0129          Z(I) = Z(I)+DZ(I)                             CRS01520
ISN 0130          DPHI(I) = DELTAT*PHIDOT(I)                    CRS01530
ISN 0131          PHI(I) = PHI(I)+DPHI(I)                       CRS01540
ISN 0132          DTHETA(I) = DELTAT*THEDOT(I)                  CRS01550
ISN 0133          THETA(I) = THETA(I)+DTHETA(I)                 CRS01560
ISN 0134          DPSI(I) = DELTAT*PSIDOT(I)                    CRS01570
ISN 0135          PSI(I) = PSI(I)+DPSI(I)                       CRS01580
ISN 0136      200 CONTINUE                                      CRS01590
ISN 0137      190 TIME = TIME+DELTAT                            CRS01600
ISN 0138          CALL DERIV                                    CRS01610
ISN 0139          IPC = IPC+1                                   CRS01620
ISN 0140          IF(IPC-IPRINT) 310,270,270                    CRS01630
ISN 0141      270 CALL PRINT                                    CRS01640
ISN 0142          IPC = 0                                       CRS01650
ISN 0143      310 IF(NPLOT.EQ.0) GO TO 280                      CRS01660
ISN 0145          IPLC = IPLC+1                                 CRS01670
ISN 0146          IF(IPLC.EQ.ITPLOT) CALL SAVE                  CRS01680
              C PREDICT, MOVE DOWN, AND DO DELTA'S              CRS01690
ISN 0148      280 DO 300 I = 1,NM                               CRS01700
ISN 0149          T = PINO(I)+DT2*P(I)                          CRS01710
ISN 0150          PINO(I) = PIN(I)                              CRS01720
ISN 0151          PIN(I) = T                                    CRS01730
ISN 0152          DPIN(I) = PIN(I)-PINO(I)                      CRS01740
ISN 0153          T = QINO(I)+DT2*Q(I)                          CRS01750
ISN 0154          QINO(I) = QIN(I)                              CRS01760
ISN 0155          QIN(I) = T                                    CRS01770
ISN 0156          DQIN(I) = QIN(I)-QINO(I)                      CRS01780
ISN 0157          T = RINO(I)+DT2*R(I)                          CRS01790
ISN 0158          RINO(I) = RIN(I)                              CRS01800
ISN 0159          RIN(I) = T                                    CRS01810
ISN 0160          DRIN(I) = RIN(I)-RINO(I)                      CRS01820
ISN 0161          T = XOLD(I)+DT2*XDOT(I)                       CRS01830
ISN 0162          XOLD(I) = X(I)                                CRS01840
ISN 0163          X(I) = T                                      CRS01850
ISN 0164          DX(I) = X(I)-XOLD(I)                          CRS01860
ISN 0165          T = YOLD(I)+DT2*YDOT(I)                       CRS01870
ISN 0166          YOLD(I) = Y(I)                                CRS01880
ISN 0167          Y(I) = T                                      CRS01890
ISN 0168          DY(I) = Y(I)-YOLD(I)                          CRS01900
ISN 0169          T = ZOLD(I)+DT2*ZDOT(I)                       CRS01910
ISN 0170          ZOLD(I) = Z(I)                                CRS01920
ISN 0171          Z(I) = T                                      CRS01930
ISN 0172          DZ(I) = Z(I)-ZOLD(I)                          CRS01940
ISN 0173          T = PHIOLD(I)+DT2*PHIDOT(I)                   CRS01950
ISN 0174          PHIOLD(I) = PHI(I)                            CRS01960
ISN 0175          PHI(I) = T                                    CRS01970
ISN 0176          DPHI(I) = PHI(I)-PHIOLD(I)                    CRS01980
ISN 0177          T = THEOLD(I)+DT2*THEDOT(I)                   CRS01990
```

Figure 108. (Continued)

```
ISN 0178          THEOLD(I) = THETA(I)                                    CRS02000
ISN 0179          THETA(I) = T                                            CRS02010
ISN 0180          DTHETA(I) = THETA(I)-THEOLD(I)                          CRS02020
ISN 0181          T = PSIOLD(I)+DT2*PSIDOT(I)                             CRS02030
ISN 0182          PSIOLD(I) = PSI(I)                                      CRS02040
ISN 0183          PSI(I) = T                                              CRS02050
ISN 0184          DPSI(I) = PSI(I)-PSIOLD(I)                              CRS02060
ISN 0185          T = POLD(I)+DT2*PDOT(I)                                 CRS02070
ISN 0186          POLD(I) = P(I)                                          CRS02080
ISN 0187          P(I) = T                                                CRS02090
ISN 0188          T = QOLD(I)+DT2*QDOT(I)                                 CRS02100
ISN 0189          QOLD(I) = Q(I)                                          CRS02110
ISN 0190          Q(I) = T                                                CRS02120
ISN 0191          T = ROLD(I)+DT2*RDOT(I)                                 CRS02130
ISN 0192          ROLD(I) = R(I)                                          CRS02140
ISN 0193          R(I) = T                                                CRS02150
ISN 0194          T = UOLD(I)+DT2*UDOT(I)                                 CRS02160
ISN 0195          UOLD(I) = U(I)                                          CRS02170
ISN 0196          U(I) = T                                                CRS02180
ISN 0197          T = VOLD(I)+DT2*VDOT(I)                                 CRS02190
ISN 0198          VOLD(I) = V(I)                                          CRS02200
ISN 0199          V(I) = T                                                CRS02210
ISN 0200          T = WOLD(I)+DT2*WDOT(I)                                 CRS02220
ISN 0201          WOLD(I) = W(I)                                          CRS02230
ISN 0202          W(I) = T                                                CRS02240
ISN 0203      300 CONTINUE                                                CRS02250
ISN 0204          IF(TIME-TMAX) 190,190,500                               CRS02260
ISN 0205      500 IF (KRUPT) 5500,5500,5000                               CRS02270
ISN 0206     5000 PRINT 2000                                              CRS02280
ISN 0207     2000 FORMAT(1H1,7X,15HRUPTURE SUMMARY,/)                     CRS02290
ISN 0208          PRINT 3000                                              CRS02300
ISN 0209     3000 FORMAT(1H ,9X,1HI,9X,1HJ,7X,4HTIME,/)                   CRS02310
ISN 0210          PRINT 4000,(IRUPT(KRT),JRUPT(KRT),TRUPT(KRT),KRT=1,KRUPT) CRS02320
ISN 0211     4000 FORMAT(1H ,2I10,F10.5)                                  CRS02330
ISN 0212     5500 IF (KPEN.LE.0)  GO TO 6000                              CRS02340
ISN 0214          PRINT 5501                                              CRS02350
ISN 0215     5501 FORMAT(1H1,7X,'CONTROL VOLUME PENETRATIONS' //)         CRS02360
ISN 0216          PRINT 5502                                              CRS02370
ISN 0217     5502 FORMAT(1H ,13X,'TIME',10X,'MASS' /)                     CRS02380
ISN 0218          PRINT 5503,(TPEN(K),IPEN(K),K=1,KPEN)                   CRS02390
ISN 0219     5503 FORMAT(1H ,10X,F10.5,I10)                               CRS02400
ISN 0220     6000 IF(NPLUT.NE.0) CALL TOLP                                CRS02410
ISN 0222          GO TO 1                                                 CRS02420
ISN 0223     1000 IF(IPLSW.NE.0) CALL EXITG(ZAR)                          CRS02430
ISN 0225          STOP                                                    CRS02440
ISN 0226          END                                                     CRS02450
```

Figure 108. (Continued)

```
COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=56,SIZE=0000K,
                   SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
ISN 0002     SUBROUTINE DERIV                                                    CRS02460
ISN 0003     IMPLICIT REAL*8 (A-H,O-Z)                                           CRS02470
ISN 0004     REAL*4 XKS,XKI,XKR,AXK,PLOT,ZAR,IMPLOT                              CRS02480
ISN 0005     INTEGER*2 NLSFLG,PTK*4,CHUG,     IDPLOT,N,IJPK,ISP,       NN,BLANKCRS02490
ISN 0006     DIMENSION IKUPSW(60),IPENSW(60),SINCOS(6),CIJ(540),DAI(9),DD(6),   CRS02500
            1 DF(6),D(6),AIAIJI(9),AP(9)                                         CRS02510
ISN 0007     COMMON/DERIN/ XNBAR,XPBAR,YNBAR,YPBAR,ZNBAR,ZPBAR                   CRS02515
ISN 0008     COMMON/DERIN/HFX(60),HFY(60),HFZ(60),ALIFT(60),VMAX(480),INDP       CRS02520
ISN 0009     COMMON/LINES/ XKS(1,60),XKI(1200),AKR(1,60),NLSFLG(480),CHUG(60)    CRS02530
ISN 0010     COMMON                        XX(60),XY(60),XZ(60),XL(60),XM(60),   CRS00060
            1 XN(60),LPX(60),DPY(60),DPZ(60),DPL(60),DPM(60),DPN(60),            CRS00070
            2 PIN(60),CIN(60),RIN(60),XI1(60),XI2(60),XI3(60),XI4(60),XI5(60),   CRS00080
            3 XI6(60),XXK(80),XYK(80),XZK(80),XLK(80),XMK(80),XNK(60),XXJ(80),   CRS00090
            4 XYJ(80),XZJ(80),XLJ(80),AMJ(80),XNJ(80),                           CRS00100
            5              DELI(60),POLD(60),QOLD(60),ROLD(60),UOLD(60),VOLD(60), CRS00110
            6 WOLD(60),XOLD(60),YOLD(60),ZOLD(60),PIND(60),CIND(60),RIND(60),    CRS00120
            7 DXIJ(60),DYIJ(60),DZIJ(60),PHIOLD(60),THEOLD(60),PSIOLD(60),       CRS00130
            8 IPEN(60),IKUPT(60),DTHALF,                                         CRS00140
            9 IJKK,KPEN,KKUPT,IPEN(60),IKUPT(60),JRUPT(80)                       CRS00150
ISN 0011     COMMON/COMALL/ C(6,60),P(60),Q(60),R(60),U(60),V(60),W(60),X(60),  CRS00160
            1 Y(60),Z(60),AI(9),AJ(9),FM(2880),SC(60,3),XC(6),XK(2880),XI(60),   CRS00170
            2 YI(60),ZI(60),XYI(60),XZI(60),YZI(60),AIJ(9),BIJ(540),DIJ(720),    CRS00180
            3 DKI(80),LAI(540),VEE(480),WGT(60),PHI(60),THETA(60),PSI(60),       CRS00190
            4 PDOT(60),QDOT(60),RDOT(60),UDOT(60),VDOT(60),WDOT(60),XDOT(60),    CRS00200
            5 YDOT(60),ZDOT(60),PHIDOT(60),THEDOT(60),PSIDOT(60),TIME,DELTAT,    CRS00210
            6 XACC(60),YACC(60),ZACC(60),AITAJ(9),AIDOT(9),FMBAR(2880),          CRS00220
            7 FMIIJ(20),THEIJ(80),PSIIJ(80),SUMDF(6,60),TITLE(10),XLBAR(60,3),   CRS00230
            8 FSPEAK(60,3),VEEDOT(5,3),DX(60),DY(60),DZ(60),DPIN(60),DRIN(60),   CRS00240
            8 DOIN(60),SEIJ(80),DFIJ(60),CEIK(60,3),
            9ZAR(200),PLOT(50000),IMPLOT(500),                                   CRS02730
            ANM,IGS,JPLOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(150),IG(80),JG(80),      CRS02740
            b NI(480),NN(60,3),ISP(60,3),IJPR(80),IDPLOT(150)                    CRS00270
ISN 0012     EQUIVALENCE (S1,SINCOS(1)),(C1,SINCOS(2)),(S2,SINCOS(3)),          CRS02770
            1            (C2,SINCOS(4)),(S3,SINCOS(5)),(C3,SINCOS(6))            CRS02780
ISN 0013     DATA BLANK/'  '/                                                    CRS02781
ISN 0014     SIN(X) = DSIN(X)                                                    CRS02790
ISN 0015     COS(X) = DCOS(X)                                                    CRS02800
ISN 0016     TT = .2D0                                                           CRS02810
ISN 0017     ET = .6D0                                                           CRS02820
ISN 0018     IF(TIME.NE.0.0) GO TO 60                                            CRS02830
ISN 0020     DO 70 IJ = 1,IGS                                                    CRS02840
```

Figure 108. (Continued)

```
ISN 0021          70 IFUPSW(IJ) = 0                                  CRS02850
ISN 0022             DO 72 I=1,NM                                    CRS02860
ISN 0023          72 IPENSW(I)=0                                     CRS02870
               C DO ALL THE (AI)((AJ))                               CRS02880
ISN 0024          60 DO 10 I = 1,NM                                  CRS02890
ISN 0025             ARG = PHI(I)                                    CRS02900
ISN 0026             S1 = SIN(ARG)                                   CRS02910
ISN 0027             C1 = COS(ARG)                                   CRS02920
ISN 0028             ARG = THETA(I)                                  CRS02930
ISN 0029             S2 = SIN(ARG)                                   CRS02940
ISN 0030             C2 = COS(ARG)                                   CRS02950
ISN 0031             ARG = PSI(I)                                    CRS02960
ISN 0032             S3 = SIN(ARG)                                   CRS02970
ISN 0033             C3 = COS(ARG)                                   CRS02980
ISN 0034             DO 40 J = 1,6                                   CRS02990
ISN 0035             T = SINCOS(J)                                   CRS03000
ISN 0036             IF(T) 45,40,50                                  CRS03010
ISN 0037          45 T = -T                                          CRS03020
ISN 0038          50 IF(T-1.E-10) 55,40,40                           CRS03030
ISN 0039          55 SINCOS(J) = 0.0                                 CRS03040
ISN 0040          40 CONTINUE                                        CRS03050
               C                                                     CRS03060
ISN 0041             J = 9*(I-1)                                     CRS03070
               C MOVE AI S TO OLD AI S                               CRS03080
ISN 0042             DO 4 JJ = 1,9                                   CRS03090
ISN 0043           4 OAI(J+JJ) = BIJ(J+JJ)                           CRS03100
ISN 0044             S1S2 = S1*S2                                    CRS03110
ISN 0045             C1S2 = C1*S2                                    CRS03120
ISN 0046             AI(1) = C2*C3                                   CRS03130
ISN 0047             BIJ(J+1) = AI(1)                                CRS03140
ISN 0048             AI(2) = C2*S3                                   CRS03150
ISN 0049             BIJ(J+2) = AI(2)                                CRS03160
ISN 0050             AI(3) = -S2                                     CRS03170
ISN 0051             BIJ(J+3) = AI(3)                                CRS03180
ISN 0052             AI(4) = -C1*S3+S1S2*C3                          CRS03190
ISN 0053             BIJ(J+4) = AI(4)                                CRS03200
ISN 0054             AI(5) = C1*C3+S1S2*S3                           CRS03210
ISN 0055             BIJ(J+5) = AI(5)                                CRS03220
ISN 0056             AI(6) = S1*C2                                   CRS03230
ISN 0057             BIJ(J+6) = AI(6)                                CRS03240
ISN 0058             AI(7) = S1*S3+C1S2*C3                           CRS03250
ISN 0059             BIJ(J+7) = AI(7)                                CRS03260
ISN 0060             AI(8) = -S1*C3+C1S2*S3                          CRS03270
ISN 0061             BIJ(J+8) = AI(8)                                CRS03280
ISN 0062             AI(9) = C1*C2                                   CRS03290
ISN 0063             BIJ(J+9) = AI(9)                                CRS03300
               C (27)                                                CRS03310
ISN 0064             PP = P(I)                                       CRS03320
ISN 0065             QQ = Q(I)                                       CRS03330
ISN 0066             RR = R(I)                                       CRS03340
ISN 0067             UU = U(I)                                       CRS03350
ISN 0068             VV = V(I)                                       CRS03360
ISN 0069             WW = W(I)                                       CRS03370
ISN 0070             XDOTI = XDOT(I)                                 CRS03380
```

Figure 108. (Continued)

```
ISN 0071        XDOT(I) = AI(1)*UU+AI(4)*VV+AI(7)*WW                    CRS03390
ISN 0072        YDOTI = YDOT(I)                                         CRS03400
ISN 0073        YDOT(I) = AI(2)*UU+AI(5)*VV+AI(8)*WW                    CRS03410
ISN 0074        ZDOTI = ZDOT(I)                                         CRS03420
ISN 0075        ZDOT(I) = AI(3)*UU+AI(6)*VV+AI(9)*WW                    CRS03430
          C (28),(29)                                                   CRS03440
ISN 0076        CS = S1/C2                                              CRS03450
ISN 0077        CC = C1/C2                                              CRS03460
ISN 0078        PHDOTI = PHIDOT(I)                                      CRS03470
ISN 0079        PHIDOT(I) = PP+QQ*CS*S2+RR*CC*S2                        CRS03480
ISN 0080        THDOTI = THEDOT(I)                                      CRS03490
ISN 0081        THEDOT(I) = QQ*C1-RR*S1                                 CRS03500
ISN 0082        PSDOTI = PSIDOT(I)                                      CRS03510
ISN 0083        PSIDOT(I) = QQ*CS+RR*CC                                 CRS03520
          C DO ABOUT NOW                                                CRS03530
ISN 0084        T = PSIDOT(I)*C2                                        CRS03540
ISN 0085        T1 = THEDOT(I)*S1-T*C1                                  CRS03550
ISN 0086        T2 = THEDOT(I)*C1+T*S1                                  CRS03560
ISN 0087        T3 = PHIDOT(I)-PSIDOT(I)*S2                             CRS03570
ISN 0088        CIJ(J+1)= -BIJ(J+4)*T1-BIJ(J+7)*T2                      CRS03580
ISN 0089        CIJ(J+4)=  BIJ(J+1)*T1+BIJ(J+7)*T3                      CRS03590
ISN 0090        CIJ(J+7)=  BIJ(J+1)*T2-BIJ(J+4)*T3                      CRS03600
ISN 0091        CIJ(J+2)= -BIJ(J+5)*T1-BIJ(J+8)*T2                      CRS03610
ISN 0092        CIJ(J+5)=  BIJ(J+2)*T1+BIJ(J+8)*T3                      CRS03620
ISN 0093        CIJ(J+8)=  BIJ(J+2)*T2-BIJ(J+5)*T3                      CRS03630
ISN 0094        CIJ(J+3)= -BIJ(J+6)*T1-BIJ(J+9)*T2                      CRS03640
ISN 0095        CIJ(J+6)=  BIJ(J+3)*T1+BIJ(J+9)*T3                      CRS03650
ISN 0096        CIJ(J+9)=  BIJ(J+3)*T2-BIJ(J+6)*T3                      CRS03660
ISN 0097        IF(TIME) 10,10,5                                        CRS03670
          C CORRECT X,Y,Z,PHI,THETA,PSI                                 CRS03680
ISN 0098      5 X(I) = TT*X(I)+ET*(XOLD(I)+DTHALF*(XDOT(I)+XDOTI))      CRS03690
ISN 0099        Y(I) = TT*Y(I)+ET*(YOLD(I)+DTHALF*(YDOT(I)+YDOTI))      CRS03700
ISN 0100        Z(I) = TT*Z(I)+ET*(ZOLD(I)+DTHALF*(ZDOT(I)+ZDOTI))      CRS03710
ISN 0101        PHI(I) = TT*PHI(I)+ET*(PHIOLD(I)+DTHALF*(PHIDOT(I)+PHDOTI))   CRS03720
ISN 0102        THETA(I) = TT*THETA(I)+ET*(THEOLD(I)+DTHALF*(THEDOT(I)+THDOTI))   CRS03730
ISN 0103        PSI(I) = TT*PSI(I)+ET*(PSIOLD(I)+DTHALF*(PSIDOT(I)+PSDOTI))   CRS03740
          C CLEAR THE DAMPING TERMS.                                    CRS03750
                                                                        CRS03760
ISN 0104        DPX(I) = 0.0                                            CRS03770
ISN 0105        DPY(I) = 0.0                                            CRS03780
ISN 0106        DPZ(I) = 0.0                                            CRS03790
ISN 0107        DPL(I) = 0.0                                            CRS03800
ISN 0108        DPM(I) = 0.0                                            CRS03810
ISN 0109        DPN(I) = 0.0                                            CRS03820
ISN 0110     10 CONTINUE                                                CRS03830
          C DO 1000 IS MAIN DO LOOP TO GET TOTAL INTERNAL FORCES AND MOMENTS   CRS03840
ISN 0111        ILAST = 0                                               CRS03850
ISN 0112        IJLIJ = 0                                               CRS03860
ISN 0113        IJKLIJ = -36                                            CRS03870
ISN 0114        DO 1000 IJ = 1,IGS                                      CRS03880
ISN 0115        IJKLIJ = IJKLIJ+36                                      CRS03890
ISN 0116        IJKK = IJKLIJ-6                                         CRS03900
ISN 0117        IJLIJ = IJLIJ+6                                         CRS03910
ISN 0118        IJL = IJLIJ                                             CRS03920
ISN 0119        IF(IRUPSW(IJ).NE.0) GO TO 1000
```

Figure 108. (Continued)

```
ISN 0121          I = IG(IJ)                                                    CRS03930
ISN 0122          J = JG(IJ)                                                    CRS03940
            C IF WE GET TO A NEW I WE MUST MOVE (AI) INTO AI AND (AIDOT) INTO AIDOT CRS03950
ISN 0123          IF(I-ILAST) 20,30,20                                          CRS03960
ISN 0124       20 ILAST = 1                                                     CRS03970
ISN 0125          IS = 9*(I-1)                                                  CRS03980
ISN 0126          DO 320 KS = 1,9                                               CRS03990
ISN 0127          IS = IS+1                                                     CRS04000
ISN 0128          AIDOT(KS) = CIJ(IS)                                           CRS04010
ISN 0129          DAI(KS) = DAI(IS)-BIJ(IS)                                     CRS04020
ISN 0130      320 AI(KS) = BIJ(IS)                                              CRS04030
ISN 0131       30 XIJ = X(J)-X(I)                                               CRS04040
ISN 0132          YIJ = Y(J)-Y(I)                                               CRS04050
ISN 0133          ZIJ = Z(J)-Z(I)                                               CRS04060
ISN 0134          XIJO = OXIJ(IJ)                                               CRS04070
ISN 0135          YIJO = OYIJ(IJ)                                               CRS04080
ISN 0136          ZIJO = OZIJ(IJ)                                               CRS04090
ISN 0137          OXIJ(IJ) = XIJ                                                CRS04100
ISN 0138          OYIJ(IJ) = YIJ                                                CRS04110
ISN 0139          OZIJ(IJ) = ZIJ                                                CRS04120
            C                                                                   CRS04130
ISN 0140          IS = 9*(J-1)                                                  CRS04140
ISN 0141          IJS = 9*(IJ-1)                                                CRS04150
ISN 0142          DO 310 KS = 1,9                                               CRS04160
ISN 0143          IS = IS+1                                                     CRS04170
ISN 0144          IJS = IJS+1                                                   CRS04180
ISN 0145          AIJ(KS) = DIJ(IJS)                                            CRS04190
ISN 0146      310 AJ(KS) = BIJ(IS)                                              CRS04200
            C (4)                                                               CRS04210
ISN 0147          T1 = DX(J)-DX(I)                                              CRS04220
ISN 0148          T2 = DY(J)-DY(I)                                              CRS04230
ISN 0149          T3 = DZ(J)-DZ(I)                                              CRS04240
            C (5)                                                               CRS04250
ISN 0150          T4= AI(1)*T1+AI(2)*T2+AI(3)*T3-DAI(1)*XIJO-DAI(2)*YIJO-DAI(3)*ZIJOCRS04260
ISN 0151          T5= AI(4)*T1+AI(5)*T2+AI(6)*T3-DAI(4)*XIJO-DAI(5)*YIJO-DAI(6)*ZIJOCRS04270
ISN 0152          T6= AI(7)*T1+AI(8)*T2+AI(9)*T3-DAI(7)*XIJO-DAI(8)*YIJO-DAI(9)*ZIJOCRS04280
ISN 0153          D(1) = AIJ(1)*T4+AIJ(2)*T5+AIJ(3)*T6                          CRS04290
ISN 0154          D(2) = AIJ(4)*T4+AIJ(5)*T5+AIJ(6)*T6                          CRS04300
ISN 0155          D(3) = AIJ(7)*T4+AIJ(8)*T5+AIJ(9)*T6                          CRS04310
            C (9)                                                               CRS04320
ISN 0156          AITAJ(1) = AI(1)*AJ(1)+AI(2)*AJ(2)+AI(3)*AJ(3)                CRS04330
ISN 0157          AITAJ(2) = AI(4)*AJ(1)+AI(5)*AJ(2)+AI(6)*AJ(3)                CRS04340
ISN 0158          AITAJ(3) = AI(7)*AJ(1)+AI(8)*AJ(2)+AI(9)*AJ(3)                CRS04350
ISN 0159          AITAJ(4) = AI(1)*AJ(4)+AI(2)*AJ(5)+AI(3)*AJ(6)                CRS04360
ISN 0160          AITAJ(5) = AI(4)*AJ(4)+AI(5)*AJ(5)+AI(6)*AJ(6)                CRS04370
ISN 0161          AITAJ(6) = AI(7)*AJ(4)+AI(8)*AJ(5)+AI(9)*AJ(6)                CRS04380
ISN 0162          AITAJ(7) = AI(1)*AJ(7)+AI(2)*AJ(8)+AI(3)*AJ(9)                CRS04390
ISN 0163          AITAJ(8) = AI(4)*AJ(7)+AI(5)*AJ(8)+AI(6)*AJ(9)                CRS04400
ISN 0164          AITAJ(9) = AI(7)*AJ(7)+AI(8)*AJ(8)+AI(9)*AJ(9)                CRS04410
ISN 0165          T1 = DPIN(J)                                                  CRS04420
ISN 0166          T2 = DQIN(J)                                                  CRS04430
ISN 0167          T3 = DRIN(J)                                                  CRS04440
ISN 0168          T4 = T1*AITAJ(1)+T2*AITAJ(4)+T3*AITAJ(7)-DPIN(I)              CRS04450
ISN 0169          T5 = T1*AITAJ(2)+T2*AITAJ(5)+T3*AITAJ(8)-DQIN(I)              CRS04460
```

Figure 108. (Continued)

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ISN 0170          T6 = T1*AITAJ(3)+T2*AITAJ(6)+T3*AITAJ(9)-DRIN(I)                CRS04470
            C (9R)                                                                 CRS04480
ISN 0171          D(4) = AIJ(1)*T4+AIJ(2)*T5+AIJ(3)*T6                             CRS04490
ISN 0172          D(5) = AIJ(4)*T4+AIJ(5)*T5+AIJ(6)*T6                             CRS04500
ISN 0173          D(6) = AIJ(7)*T4+AIJ(8)*T5+AIJ(9)*T6                             CRS04510
ISN 0174          DD(1) = D(1)/DELTAT
ISN 0175          DD(2) = D(2)/DELTAT
ISN 0176          DD(3) = D(3)/DELTAT
ISN 0177          T1 = P(J)                                                        CRS04610
ISN 0178          T2 = Q(J)                                                        CRS04620
ISN 0179          T3 = R(J)                                                        CRS04630
ISN 0180          T4 = T1*AITAJ(1)+T2*AITAJ(4)+T3*AITAJ(7)-P(I)                    CRS04640
ISN 0181          T5 = T1*AITAJ(2)+T2*AITAJ(5)+T3*AITAJ(8)-Q(I)                    CRS04650
ISN 0182          T6 = T1*AITAJ(3)+T2*AITAJ(6)+T3*AITAJ(9)-R(I)                    CRS04660
ISN 0183          DD(4) = T4*AIJ(1)+T5*AIJ(2)+T6*AIJ(3)                            CRS04670
ISN 0184          DD(5) = T4*AIJ(4)+T5*AIJ(5)+T6*AIJ(6)                            CRS04680
ISN 0185          DD(6) = T4*AIJ(7)+T5*AIJ(8)+T6*AIJ(9)                            CRS04690
ISN 0186          DO 270 K = 1,6                                                   CRS04700
ISN 0187      270 DD(K) = C(K,IJ)*DD(K)                                            CRS04710
            C*****DVSIGN IS NO LONGER USED.                                        CRS04720
            C*****FMBAR HAS VHBAR(I,J,K,L) IN IT NOW (7AUG1972)                    CRS04730
ISN 0188          DO 150 K = 1,6                                                   CRS04740
ISN 0189          IJKK = IJKK+6                                                    CRS04750
ISN 0190          IJKL = IJKK                                                      CRS04760
ISN 0191          IJL = IJL-6                                                      CRS04770
ISN 0192          DF(K) = 0.0                                                      CRS04780
ISN 0193          DO 150 L = 1,6                                                   CRS04790
ISN 0194          IJKL = IJKL+1                                                    CRS04800
ISN 0195          IJL = IJL+1                                                      CRS04810
ISN 0196          T = XR(IJKL)                                                     CRS04820
ISN 0197          IF(T) 160,150,160                                                CRS04830
ISN 0198      160 A = D(L)                                                         CRS04840
ISN 0199          B = A+VEE(IJL)                                                   CRS04850
ISN 0200          IF(A.GE.0.0.AND.B.GE.0.0.OR.A.LT.0.0.AND.B.LT.0.0) GO TO 210     CRS04860
            C SIGNS NOT SAME                                                       CRS04870
ISN 0202          IF(N(IJL)) 180,180,190                                           CRS04880
ISN 0203      180 N(IJL) = 1                                                       CRS04890
ISN 0204          FMBAR(IJKL) = DABS(VEE(IJL))                                     CRS04900
ISN 0205      190 DELFM = T*A                                                      CRS04910
ISN 0206          GO TO 220                                                        CRS04920
            C SIGNS THE SAME                                                       CRS04930
ISN 0207      210 VP = DABS(VEE(IJL))                                              CRS04940
ISN 0208          IF(VP.LE.FMBAR(IJKL)) GO TO 190                                  CRS04950
ISN 0210          N(IJL) = 0                                                       CRS04960
            C*****USE A TABLE IF PRESENT                                           CRS04970
ISN 0211          ITN = NLSFLG(IJL)                                                CRS04980
ISN 0212          IF(ITN.EQ.0) GO TO 190                                           CRS04990
ISN 0214          AXK = VP                                                         CRS05000
ISN 0215          PTR = CHGG(ITN)                                                  CRS05010
ISN 0216          IF(AXK.LT.XKR(PTR)) GO TO 110                                    CRS05020
ISN 0218          IF(AXK.GT.XKR(PTR+1)) GO TO 120                                  CRS05030
ISN 0220      140 DELFM = (XKS(PTR)*AXK+XKI(PTR))*T*A                              CRS05040
ISN 0221          GO TO 220                                                        CRS05050
            C*****REFER TO EXPLANATION IN SUBROUTINE INPUT FOR WHY THESE LOOPS     CRS05060
```

Figure 108. (Continued)

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                  C ARE SAFE TO BE SO TIGHT.                                      CRS05070
                  C*****CHUG DOWN                                                 CRS05080
      ISN 0222      110 PTR = PTR-1                                               CRS05090
      ISN 0223          IF(ARK.LT.XKR(PTR)) GO TO 110                             CRS05100
      ISN 0225      130 CHUG(IIN) = PTR                                           CRS05110
      ISN 0226          GO TO 140                                                 CRS05120
                  C*****CHUG UP                                                   CRS05130
      ISN 0227      120 PTR = PTR+1                                               CRS05140
      ISN 0228          IF(XK.GT.XKR(PTR+1)) GO TO 120                            CRS05150
      ISN 0230          GO TO 130                                                 CRS05160
      ISN 0231      220 FM(IJKL) = FM(IJKL)+DELFM                                 CRS05170
      ISN 0232          DF(K) = DF(K)+DELFM                                       CRS05180
      ISN 0233      150 CONTINUE                                                  CRS05190
      ISN 0234          DO 630 K = 1,6                                            CRS05200
      ISN 0235      630 SUMDF(K,IJ) = SUMDF(K,IJ)+DF(K)                           CRS05210
                  C*****COMPUTE THE ENERGY HERE BUT ADD IT AFTER 230 (NO RUPTURE)
      ISN 0236          SUMSE = 0.0
      ISN 0237          SUMDE = 0.0
                  C*****DON'T USE AN IJ IF IT'S A DRI ELEMENT
      ISN 0238          IF(IJPR(IJ).NE.BLANK) GO TO 632
      ISN 0240          DO 631 K = 1,6
      ISN 0241          SUMSE = SUMSE+SUMDF(K,IJ)*D(K)
      ISN 0242      631 SUMDE = SUMDE+DD(K)*D(K)
      ISN 0243          IF (IJ.NE.4) GO TO 632
      ISN 0245          PRINT 999, (DD(K),D(K),K=1,6)
      ISN 0246      999 FORMAT(1X,1P12E11.3)
      ISN 0247      632 IJL = IJL-6                                               CRS05220
      ISN 0248          DO 230 L = 1,6                                            CRS05230
      ISN 0249          IJL = IJL+1                                               CRS05240
      ISN 0250          T = VEE(IJL)+D(L)                                         CRS05250
      ISN 0251          VEE(IJL) = T                                              CRS05260
                  C MOVE DF TO D FOR (13) ETC.                                    CRS05270
      ISN 0252          D(L) = DF(L)                                              CRS05280
      ISN 0253          IF(T) 240,250,250                                         CRS05290
      ISN 0254      240 T = -T                                                    CRS05300
      ISN 0255      250 IF(T-VMAX(IJL)) 230,260,260                               CRS05310
      ISN 0256      260 IRUPSW(IJ) = 1                                            CRS05320
      ISN 0257          XX(I) = XX(I)-XXK(IJ)                                     CRS05330
      ISN 0258          XY(I) = XY(I)-XYK(IJ)                                     CRS05340
      ISN 0259          XZ(I) = XZ(I)-XZK(IJ)                                     CRS05350
      ISN 0260          XL(I) = XL(I)-XLK(IJ)                                     CRS05360
      ISN 0261          XM(I) = XM(I)-XMK(IJ)                                     CRS05370
      ISN 0262          XN(I) = XN(I)-XNK(IJ)                                     CRS05380
      ISN 0263          XX(J) = XX(J)-XXJ(IJ)                                     CRS05390
      ISN 0264          XY(J) = XY(J)-XYJ(IJ)                                     CRS05400
      ISN 0265          XZ(J) = XZ(J)-XZJ(IJ)                                     CRS05410
      ISN 0266          XL(J) = XL(J)-XLJ(IJ)                                     CRS05420
      ISN 0267          XM(J) = XM(J)-XMJ(IJ)                                     CRS05430
      ISN 0268          XN(J) = XN(J)-XNJ(IJ)                                     CRS05440
      ISN 0269          KRUPT = KRUPT+1                                           CRS05450
      ISN 0270          IRUPT(KRUPT) = I                                          CRS05460
      ISN 0271          JRUPT(KRUPT) = J                                          CRS05470
      ISN 0272          TRUPT(KRUPT) = TIME                                       CRS05480
      ISN 0273          PRINT 1040, IJ,L,VEE(IJL),VMAX(IJL)                       CRS05490
```

Figure 108. (Continued)

```
ISN 0274      1040 FORMAT(1H1'RUPTURE '2I5,1P2E15.6)                      CRS05500
ISN 0275           GO TO 1000                                             CRS05510
ISN 0276       230 CONTINUE                                               CRS05520
ISN 0277           SEIJ(IJ) = SEIJ(IJ)+SUMSE
ISN 0278           DEIJ(IJ) = DEIJ(IJ)+SUMDE
ISN 0279           IF (IJPR(IJ).NE.BLANK)  DRI(IJ) = -6.55D0*VEE(IJL-5)   CRS05530
ISN 0281           AIAIJT(1) = AI(1)*AIJ(1)+AI(4)*AIJ(2)+AI(7)*AIJ(3)     CRS05540
ISN 0282           AIAIJT(4) = AI(1)*AIJ(4)+AI(4)*AIJ(5)+AI(7)*AIJ(6)     CRS05550
ISN 0283           AIAIJT(7) = AI(1)*AIJ(7)+AI(4)*AIJ(8)+AI(7)*AIJ(9)     CRS05560
ISN 0284           AIAIJT(2) = AI(2)*AIJ(1)+AI(5)*AIJ(2)+AI(8)*AIJ(3)     CRS05570
ISN 0285           AIAIJT(5) = AI(2)*AIJ(4)+AI(5)*AIJ(5)+AI(8)*AIJ(6)     CRS05580
ISN 0286           AIAIJT(8) = AI(2)*AIJ(7)+AI(5)*AIJ(8)+AI(8)*AIJ(9)     CRS05590
ISN 0287           AIAIJT(3) = AI(3)*AIJ(1)+AI(6)*AIJ(2)+AI(9)*AIJ(3)     CRS05600
ISN 0288           AIAIJT(6) = AI(3)*AIJ(4)+AI(6)*AIJ(5)+AI(9)*AIJ(6)     CRS05610
ISN 0289           AIAIJT(9) = AI(3)*AIJ(7)+AI(6)*AIJ(8)+AI(9)*AIJ(9)     CRS05620
          C (13A)                                                         CRS05630
ISN 0290           T1 = AIAIJT(1)*D(1)+AIAIJT(4)*D(2)+AIAIJT(7)*D(3)      CRS05640
ISN 0291           T2 = AIAIJT(2)*D(1)+AIAIJT(5)*D(2)+AIAIJT(8)*D(3)      CRS05650
ISN 0292           T3 = AIAIJT(3)*D(1)+AIAIJT(6)*D(2)+AIAIJT(9)*D(3)      CRS05660
ISN 0293           D(1) = T1                                              CRS05670
ISN 0294           D(2) = T2                                              CRS05680
ISN 0295           D(3) = T3                                              CRS05690
          C (13B)                                                         CRS05700
ISN 0296           T1 = AIAIJT(1)*D(4)+AIAIJT(4)*D(5)+AIAIJT(7)*D(6)      CRS05710
ISN 0297           T2 = AIAIJT(2)*D(4)+AIAIJT(5)*D(5)+AIAIJT(8)*D(6)      CRS05720
ISN 0298           T3 = AIAIJT(3)*D(4)+AIAIJT(6)*D(5)+AIAIJT(9)*D(6)      CRS05730
ISN 0299           D(4) = T1                                              CRS05740
ISN 0300           D(5) = T2                                              CRS05750
ISN 0301           D(6) = T3                                              CRS05760
          C (17A)                                                         CRS05770
ISN 0302           DXX = -(AJ(1)*D(1)+AJ(2)*D(2)+AJ(3)*D(3))              CRS05780
ISN 0303           DXY = -(AJ(4)*D(1)+AJ(5)*D(2)+AJ(6)*D(3))              CRS05790
ISN 0304           DXZ = -(AJ(7)*D(1)+AJ(8)*D(2)+AJ(9)*D(3))              CRS05800
ISN 0305           XX(J) = XX(J)+DXX                                      CRS05810
ISN 0306           XY(J) = XY(J)+DXY                                      CRS05820
ISN 0307           XZ(J) = XZ(J)+DXZ                                      CRS05830
ISN 0308           XXJ(IJ) = XXJ(IJ)+DXX                                  CRS05840
ISN 0309           XYJ(IJ) = XYJ(IJ)+DXY                                  CRS05850
ISN 0310           XZJ(IJ) = XZJ(IJ)+DXZ                                  CRS05860
          C (17B)                                                         CRS05870
ISN 0311           DXL = -(AJ(1)*D(4)+AJ(2)*D(5)+AJ(3)*D(6))              CRS05880
ISN 0312           DXM = -(AJ(4)*D(4)+AJ(5)*D(5)+AJ(6)*D(6))              CRS05890
ISN 0313           DXN = -(AJ(7)*D(4)+AJ(8)*D(5)+AJ(9)*D(6))              CRS05900
ISN 0314           XL(J) = XL(J)+DXL                                      CRS05910
ISN 0315           XM(J) = XM(J)+DXM                                      CRS05920
ISN 0316           XN(J) = XN(J)+DXN                                      CRS05930
ISN 0317           XLJ(IJ) = XLJ(IJ)+DXL                                  CRS05940
ISN 0318           XMJ(IJ) = XMJ(IJ)+DXM                                  CRS05950
ISN 0319           XNJ(IJ) = XNJ(IJ)+DXN                                  CRS05960
ISN 0320           IF (IJPR(IJ).NE.BLANK)  GO TO 700                      CRS05970
          C (24B)                                                         CRS05980
ISN 0322           D(4) = D(4)-ZIJ*D(2)+YIJ*D(3)                          CRS05990
ISN 0323           D(5) = D(5)+ZIJ*D(1)-XIJ*D(3)                          CRS06000
ISN 0324           D(6) = D(6)-YIJ*D(1)+XIJ*D(2)                          CRS06010
```

Figure 108. (Continued)

```
                                                                                                PAGE 008
                        C (16A)                                                          CRS06020
ISN 0325                   DXX = AI(1)*D(1)+AI(2)*D(2)+AI(3)*D(3)                        CRS06030
ISN 0326                   DXY = AI(4)*D(1)+AI(5)*D(2)+AI(6)*D(3)                        CRS06040
ISN 0327                   DXZ = AI(7)*D(1)+AI(8)*D(2)+AI(9)*D(3)                        CRS06050
ISN 0328                   XX(I) = XX(I)+DXX                                             CRS06060
ISN 0329                   XY(I) = XY(I)+DXY                                             CRS06070
ISN 0330                   XZ(I) = XZ(I)+DXZ                                             CRS06080
ISN 0331                   XXK(IJ) = XXK(IJ)+DXX                                         CRS06090
ISN 0332                   XYK(IJ) = XYK(IJ)+DXY                                         CRS06100
ISN 0333                   XZK(IJ) = XZK(IJ)+DXZ                                         CRS06110
                        C (16B)                                                          CRS06120
ISN 0334                   DXL = AI(1)*D(4)+AI(2)*D(5)+AI(3)*D(6)                        CRS06130
ISN 0335                   DXM = AI(4)*D(4)+AI(5)*D(5)+AI(6)*D(6)                        CRS06140
ISN 0336                   DXN = AI(7)*D(4)+AI(8)*D(5)+AI(9)*D(6)                        CRS06150
ISN 0337                   XL(I) = XL(I)+DXL                                             CRS06160
ISN 0338                   XM(I) = XM(I)+DXM                                             CRS06170
ISN 0339                   XN(I) = XN(I)+DXN                                             CRS06180
ISN 0340                   XLK(IJ) = XLK(IJ)+DXL                                         CRS06190
ISN 0341                   XMK(IJ) = XMK(IJ)+DXM                                         CRS06200
ISN 0342                   XNK(IJ) = XNK(IJ)+DXN                                         CRS06210
                        C (6A)                                                           CRS06220
ISN 0343               700 CONTINUE                                                      CRS06230
ISN 0344                   T1 = AIAIJT(1)*DD(1)+AIAIJT(4)*DD(2)+AIAIJT(7)*DD(3)          CRS06240
ISN 0345                   T2 = AIAIJT(2)*DD(1)+AIAIJT(5)*DD(2)+AIAIJT(8)*DD(3)          CRS06250
ISN 0346                   T3 = AIAIJT(3)*DD(1)+AIAIJT(6)*DD(2)+AIAIJT(9)*DD(3)          CRS06260
ISN 0347                   DD(1) = T1                                                    CRS06270
ISN 0348                   DD(2) = T2                                                    CRS06280
ISN 0349                   DD(3) = T3                                                    CRS06290
                        C (6B)                                                           CRS06300
ISN 0350                   T1 = AIAIJT(1)*DD(4)+AIAIJT(4)*DD(5)+AIAIJT(7)*DD(6)          CRS06310
ISN 0351                   T2 = AIAIJT(2)*DD(4)+AIAIJT(5)*DD(5)+AIAIJT(8)*DD(6)          CRS06320
ISN 0352                   T3 = AIAIJT(3)*DD(4)+AIAIJT(6)*DD(5)+AIAIJT(9)*DD(6)          CRS06330
ISN 0353                   DD(4) = T1                                                    CRS06340
ISN 0354                   DD(5) = T2                                                    CRS06350
ISN 0355                   DD(6) = T3                                                    CRS06360
                        C (9A)                                                           CRS06370
ISN 0356                   DXX = -(AJ(1)*DD(1)+AJ(2)*DD(2)+AJ(3)*DD(3))                  CRS06380
ISN 0357                   DXY = -(AJ(4)*DD(1)+AJ(5)*DD(2)+AJ(6)*DD(3))                  CRS06390
ISN 0358                   DXZ = -(AJ(7)*DD(1)+AJ(8)*DD(2)+AJ(9)*DD(3))                  CRS06400
ISN 0359                   DPX(J) = DPX(J)+DXX                                           CRS06410
ISN 0360                   DPY(J) = DPY(J)+DXY                                           CRS06420
ISN 0361                   DPZ(J) = DPZ(J)+DXZ                                           CRS06430
                        C (9B)                                                           CRS06440
ISN 0362                   DXL = -(AJ(1)*DD(4)+AJ(2)*DD(5)+AJ(3)*DD(6))                  CRS06450
ISN 0363                   DXM = -(AJ(4)*DD(4)+AJ(5)*DD(5)+AJ(6)*DD(6))                  CRS06460
ISN 0364                   DXN = -(AJ(7)*DD(4)+AJ(8)*DD(5)+AJ(9)*DD(6))                  CRS06470
ISN 0365                   DPL(J) = DPL(J)+DXL                                           CRS06480
ISN 0366                   DPM(J) = DPM(J)+DXM                                           CRS06490
ISN 0367                   DPN(J) = DPN(J)+DXN                                           CRS06500
ISN 0368                   IF (IJPR(IJ).NE.BLANK)  GO TO 1000                            CRS06510
                        C (7)                                                            CRS06520
ISN 0370                   DD(4) = DD(4)-ZIJ*DD(2)+YIJ*DD(3)                             CRS06530
ISN 0371                   DD(5) = DD(5)+ZIJ*DD(1)-XIJ*DD(3)                             CRS06540
ISN 0372                   DD(6) = DD(6)-YIJ*DD(1)+XIJ*DD(2)                             CRS06550
```

Figure 108. (Continued)

```
                C (8A)                                                   CRS06560
ISN 0373              DXX = AI(1)*DD(1)+AI(2)*DD(2)+AI(3)*DD(3)          CRS06570
ISN 0374              DXY = AI(4)*DD(1)+AI(5)*DD(2)+AI(6)*DD(3)          CRS06580
ISN 0375              DXZ = AI(7)*DD(1)+AI(8)*DD(2)+AI(9)*DD(3)          CRS06590
ISN 0376              DPX(I) = DPX(I)+DXX                                CRS06600
ISN 0377              DPY(I) = DPY(I)+DXY                                CRS06610
ISN 0378              DPZ(I) = DPZ(I)+DXZ                                CRS06620
                C (8B)                                                   CRS06630
ISN 0379              DXL = AI(1)*DD(4)+AI(2)*DD(5)+AI(3)*DD(6)          CRS06640
ISN 0380              DXM = AI(4)*DD(4)+AI(5)*DD(5)+AI(6)*DD(6)          CRS06650
ISN 0381              DXN = AI(7)*DD(4)+AI(8)*DD(5)+AI(9)*DD(6)          CRS06660
ISN 0382              DPL(I) = DPL(I)+DXL                                CRS06670
ISN 0383              DPM(I) = DPM(I)+DXM                                CRS06680
ISN 0384              DPN(I) = DPN(I)+DXN                                CRS06690
ISN 0385         1000 CONTINUE                                           CRS06700
ISN 0386              IS=9*(INDP-1)                                      CRS06710
ISN 0387              DO 1010 KS=1,9                                     CRS06720
ISN 0388              IS=IS+1                                            CRS06730
ISN 0389         1010 AP(KS)=BIJ(IS)                                     CRS06740
                C FINISH COMPUTING DERIVATIVES                           CRS06750
ISN 0390              DO 2000 I = 1,NM                                   CRS06760
ISN 0391              IS = 9*(I-1)                                       CRS06770
ISN 0392              DO 330 KS = 1,9                                    CRS06780
ISN 0393              IS = IS+1                                          CRS06790
ISN 0394              AIDOT(KS) = CIJ(IS)                                CRS06800
ISN 0395          330 AI(KS) = BIJ(IS)                                   CRS06810
                C DO CRASH FORCES                                        CRS06820
ISN 0396              DO 340 K = 1,6
ISN 0397          340 XC(K) = 0.0
ISN 0398              IF(ISP(I,1).EQ.1 .OR.ISP(I,2).EQ.1.OR.ISP(I,3).EQ.1) CALL CFORCE
                C (20),(23),(24)                                         CRS06840
ISN 0400              XA = WGT(I)-ALIFT(I)                               CRS06850
ISN 0401              SX = XX(I)+XA*AI(3)+XC(1)+DPX(I)                   CRS06860
ISN 0402              SY = XY(I)+XA*AI(6)+XC(2)+DPY(I)                   CRS06870
ISN 0403              SZ = XZ(I)+XA*AI(9)+XC(3)+DPZ(I)                   CRS06880
ISN 0404              SL = XL(I)+XC(4)+DPL(I)                            CRS06890
ISN 0405              SM = XM(I)+XC(5)+DPM(I)                            CRS06900
ISN 0406              SN = XN(I)+XC(6)+DPN(I)                            CRS06910
                C GET P,Q,R,U,V,W                                        CRS06920
ISN 0407              PP = P(I)                                          CRS06930
ISN 0408              QQ = Q(I)                                          CRS06940
ISN 0409              RR = R(I)                                          CRS06950
ISN 0410              UU = U(I)                                          CRS06960
ISN 0411              VV = V(I)                                          CRS06970
ISN 0412              WW = W(I)                                          CRS06980
                C MASS                                                   CRS06990
ISN 0413              WGTI = 1.0/WGT(I)                                  CRS07000
ISN 0414              ZM = 386.0*WGTI                                    CRS07010
ISN 0415              XACC(I) = SX*WGTI                                  CRS07020
ISN 0416              YACC(I) = SY*WGTI                                  CRS07030
ISN 0417              ZACC(I) = SZ*WGTI                                  CRS07040
                C (25)                                                   CRS07050
ISN 0418              UDOTI = UDOT(I)                                    CRS07060
ISN 0419              UDOT(I) = SX*ZM-QQ*WW+RR*VV                        CRS07070
```

Figure 108. (Continued)

```
ISN 0420          VDOTI = VDOT(I)                                         CRS07080
ISN 0421          VDOT(I) = SY*ZM-RR*UU+PP*WW                             CRS07090
ISN 0422          WDOTI = WDOT(I)                                         CRS07100
ISN 0423          WDOT(I) = SZ*ZM-PP*VV+QQ*UU                             CRS07110
            C (26)                                                        CRS07120
ISN 0424          T1 = -XZI(I)*PP-YZI(I)*QQ+ZI(I)*RR+HEZ(I)               CRS07130
ISN 0425          T2 = XI(I)*PP-XYI(I)*QQ-XZI(I)*RR+HEX(I)                CRS07140
ISN 0426          T3 = -XYI(I)*PP+YI(I)*QQ-YZI(I)*RR+HEY(I)               CRS07150
ISN 0427          SL = SL-QQ*T1+RR*T3                                     CRS07160
ISN 0428          SM = SM-RR*T2+PP*T1                                     CRS07170
ISN 0429          SN = SN-PP*T3+QQ*T2                                     CRS07180
            C (25)                                                        CRS07190
ISN 0430          DEL = DELI(I)                                           CRS07200
ISN 0431          PDOTI = PDOT(I)                                         CRS07210
ISN 0432          PDOT(I) = DEL*(SL*XI1(I)+SM*XI2(I)+SN*XI3(I))           CRS07220
ISN 0433          QDOTI = QDOT(I)                                         CRS07230
ISN 0434          QDOT(I) = DEL*(SL*XI2(I)+SM*XI5(I)+SN*XI4(I))           CRS07240
ISN 0435          RDOTI = RDOT(I)                                         CRS07250
ISN 0436          RDOT(I) = DEL*(SL*XI3(I)+SM*XI4(I)+SN*XI6(I))           CRS07260
ISN 0437          IF(TIME) 2000,2000,300                                  CRS07270
ISN 0438      300 U(I) = TT*U(I)+ET*(UOLD(I)+DTHALF*(UDOT(I)+UDOTI))      CRS07280
ISN 0439          V(I) = TT*V(I)+ET*(VOLD(I)+DTHALF*(VDOT(I)+VDOTI))      CRS07290
ISN 0440          W(I) = TT*W(I)+ET*(WOLD(I)+DTHALF*(WDOT(I)+WDOTI))      CRS07300
ISN 0441          P(I) = TT*P(I)+ET*(POLD(I)+DTHALF*(PDOT(I)+PDOTI))      CRS07310
ISN 0442          Q(I) = TT*Q(I)+ET*(QOLD(I)+DTHALF*(QDOT(I)+QDOTI))      CRS07320
ISN 0443          R(I) = TT*R(I)+ET*(ROLD(I)+DTHALF*(RDOT(I)+RDOTI))      CRS07330
ISN 0444          PIN(I) = TT*PIN(I)+ET*(PINO(I)+DTHALF*(P(I)+POLD(I)))   CRS07340
ISN 0445          QIN(I) = TT*QIN(I)+ET*(QINO(I)+DTHALF*(Q(I)+QOLD(I)))   CRS07350
ISN 0446          RIN(I) = TT*RIN(I)+ET*(RINO(I)+DTHALF*(R(I)+ROLD(I)))   CRS07360
ISN 0447          IF ((IPENSW(I).NE.0).OR.(I.EQ.INDP).OR.(INDP.EQ.0))  GO TO 2000   CRS07370
            C                                                             CRS07380
            C        CONTROL VOLUME PENETRATION CALCULATIONS              CRS07390
            C                                                             CRS07400
ISN 0449          TP1=X(I)-X(INDP)                                        CRS07410
ISN 0450          TP2=Y(I)-Y(INDP)                                        CRS07420
ISN 0451          TP3=Z(I)-Z(INDP)                                        CRS07430
ISN 0452          XPI=AP(1)*TP1+AP(2)*TP2+AP(3)*TP3                       CRS07440
ISN 0453          YPI=AP(4)*TP1+AP(5)*TP2+AP(6)*TP3                       CRS07450
ISN 0454          ZPI=AP(7)*TP1+AP(8)*TP2+AP(9)*TP3                       CRS07460
ISN 0455          IF ((-XNBAR.GT.XPI).OR.(XPI.GT.XPBAR))  GO TO 2000      CRS07470
ISN 0457          IF ((-YNBAR.GT.YPI).OR.(YPI.GT.YPBAR))  GO TO 2000      CRS07480
ISN 0459          IF ((-ZNBAR.GT.ZPI).OR.(ZPI.GT.ZPBAR))  GO TO 2000      CRS07490
ISN 0461          KPEN=KPEN+1                                             CRS07500
ISN 0462          IPEN(KPEN)=I                                            CRS07510
ISN 0463          TPEN(KPEN)=TIME                                         CRS07520
ISN 0464          IPENSW(I)=1                                             CRS07530
ISN 0465          PRINT 1080, I,TIME                                      CRS07540
ISN 0466     1080 FORMAT(1H0,' CONTROL VOLUME PENETRATED BY MASS ',I2,', TIME=',   CRS07550
                 1 F10.5)                                                 CRS07560
ISN 0467     2000 CONTINUE                                                CRS07570
ISN 0468          RETURN                                                  CRS07580
ISN 0469          END                                                     CRS07590
```

Figure 108. (Continued)

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LEVEL 20.1 (MAY 71)                    OS/360  FORTRAN H                         DATE  73.298/10.02.52

        COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=56,SIZE=0000K,
                           SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
ISN 0002         SUBROUTINE DUAIJ                                                   CRS07600
ISN 0003         IMPLICIT REAL*8 (A-H,O-Z)                                          CRS07610
ISN 0004         INTEGER*2        IDPLOT,N,ISP,       NN,IGS                        CRS07620
ISN 0005         DIMENSION SINCOS(6),XIHOLD(9,2),XYZIJI(9),XYZIJJ(9),PROD(9),       CRS07630
                1 XIIJ(3),XK3(6,6,6),CBAR(80)                                        CRS07640
ISN 0006         COMMON/COMALL/ C(6,60),P(60),C(60),R(60),U(60),V(60),W(60),X(60),  CRS00160
                1 Y(60),Z(60),AI(9),AJ(9),FM(2880),SC(60,3),XC(6),XK(2880),XI(60),  CRS00170
                2 YI(60),ZI(60),XYI(60),XZI(60),YZI(60),AIJ(9),BIJ(540),DIJ(720),   CRS00180
                3 DKI(60),CAI(540),VLE(480),WGT(60),PHI(60),THETA(60),PSI(60),      CRS00190
                4 PDOT(60),QDOT(60),RDOT(60),UDOT(60),VDOT(60),WDOT(60),XDOT(60),   CRS00200
                5 YDOT(60),ZDOT(60),PHIDOT(60),THEDOT(60),PSIDOT(60),TIME,DELTAT,   CRS00210
                6 XACC(60),YACC(60),ZACC(60),AITAJ(9),AIDOT(9),FMBAR(2880),         CRS00220
                7 PHIIJ(60),THEIJ(60),PSIIJ(60),SUMDF(6,80),TITLE(10),XLBAR(60,3),  CRS00230
                8 FSPHAR(60,3),VEEDOT(3,3),DX(60),DY(60),DZ(60),DPIN(60),DRIN(60),  CRS00240
                8 DQIN(60),SEIJ(60),DLIJ(80),CLIK(60,3),
                9ZAR(700),PLOT(30000),IMPLOT(500),                                  CRS07740
                ANM,IGS,JPLOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(150),IG(60),JG(80),     CRS07750
                6 N(60),NN(60,3),ISP(60,3),IJPK(60),IDPLOT(150)                     CRS00270
ISN 0007         EQUIVALENCE (XIHOLD(1,1),XYZIJI(1)),(XIHOLD(1,2),XYZIJJ(1))         CRS07780
ISN 0008         EQUIVALENCE (S1,SINCOS(1)),(C1,SINCOS(2)),(S2,SINCOS(3))            CRS07790
ISN 0009         EQUIVALENCE (C2,SINCOS(4)),(S3,SINCOS(5)),(C3,SINCOS(6))            CRS07800
ISN 0010         EQUIVALENCE (XK(1),XK3(1,1,1))                                     CRS07810
ISN 0011         SIN(X) = DSIN(X)                                                   CRS07820
ISN 0012         COS(X) = DCOS(X)                                                   CRS07830
ISN 0013         SQRT(X) = DSQRT(X)                                                 CRS07840
ISN 0014         ARSIN(X) = DARSIN(X)                                               CRS07850
ISN 0015         ATAN2(Y,X) = DATAN2(Y,X)                                           CRS07860
ISN 0016         ICLD=0                                                             CRS07870
ISN 0017         DO 1100 I = 1,NM                                                   CRS07880
ISN 0018         ARG=PHI(I)                                                         CRS07890
ISN 0019         S1=SIN(ARG)                                                        CRS07900
ISN 0020         C1=COS(ARG)                                                        CRS07910
ISN 0021         ARG=THETA(I)                                                       CRS07920
ISN 0022         S2=SIN(ARG)                                                        CRS07930
ISN 0023         C2=COS(ARG)                                                        CRS07940
ISN 0024         ARG=PSI(I)                                                         CRS07950
ISN 0025         S3=SIN(ARG)                                                        CRS07960
ISN 0026         C3=COS(ARG)                                                        CRS07970
ISN 0027         DO 1085 J = 1,6                                                    CRS07980
ISN 0028         T=SINCOS(J)                                                        CRS07990
ISN 0029         IF (T) 1070,1085,1075                                              CRS08000
```

Figure 108. (Continued)

```
ISN 0030      1070 T=-T                                                CRS08010
ISN 0031      1075 IF(T-1.E-10) 1060,1085,1085                         CRS08020
ISN 0032      1060 SINCOS(J)=0.                                        CRS08030
ISN 0033      1085 CONTINUE                                            CRS08040
ISN 0034           J=9*(I-1)                                           CRS08050
                 C MOVE AI'S TO OLD AI'S                               CRS08060
ISN 0035           DO 1090 JJ = 1,9                                    CRS08070
ISN 0036      1090 OAI(J+JJ)=BIJ(J+JJ)                                 CRS08080
ISN 0037           S1S2=S1*S2                                          CRS08090
ISN 0038           C1S2=C1*S2                                          CRS08100
ISN 0039           BIJ(J+1)=C2*C3                                      CRS08110
ISN 0040           BIJ(J+2)=C2*S3                                      CRS08120
ISN 0041           BIJ(J+3)=-S2                                        CRS08130
ISN 0042           BIJ(J+4)=-C1*S3+S1S2*C3                             CRS08140
ISN 0043           BIJ(J+5)=C1*C3+S1S2*S3                              CRS08150
ISN 0044           BIJ(J+6)=S1*C2                                      CRS08160
ISN 0045           BIJ(J+7)=S1*S3+C1S2*C3                              CRS08170
ISN 0046           BIJ(J+8)=-S1*C3+C1S2*S3                             CRS08180
ISN 0047           BIJ(J+9)=C1*C2                                      CRS08190
ISN 0048      1100 CONTINUE                                            CRS08200
                 C                                                     CRS08210
ISN 0049           DO 1010 IJ = 1,IGS                                  CRS08220
ISN 0050           S1 = SIN(PHIIJ(IJ))                                 CRS08230
ISN 0051           C1 = COS(PHIIJ(IJ))                                 CRS08240
ISN 0052           S2 = SIN(THEIJ(IJ))                                 CRS08250
ISN 0053           C2 = COS(THEIJ(IJ))                                 CRS08260
ISN 0054           S3 = SIN(PSIIJ(IJ))                                 CRS08270
ISN 0055           C3 = COS(PSIIJ(IJ))                                 CRS08280
ISN 0056           DO 1040 J = 1,6                                     CRS08290
ISN 0057           T = SINCOS(J)                                       CRS08300
ISN 0058           IF (T) 1045,1040,1050                               CRS08310
ISN 0059      1045 T = -T                                              CRS08320
ISN 0060      1050 IF(T-1.E-10) 1055,1040,1040                         CRS08330
ISN 0061      1055 SINCOS(J) = 0.0                                     CRS08340
ISN 0062      1040 CONTINUE                                            CRS08350
ISN 0063           AIJ(1) = C2*C3                                      CRS08360
ISN 0064           AIJ(2) = C2*S3                                      CRS08370
ISN 0065           AIJ(3) = -S2                                        CRS08380
ISN 0066           AIJ(4) = -C1*S3+S1*S2*C3                            CRS08390
ISN 0067           AIJ(5) = C1*C3+S1*S2*S3                             CRS08400
ISN 0068           AIJ(6) = S1*C2                                      CRS08410
ISN 0069           AIJ(7) = S1*S3+C1*S2*C3                             CRS08420
ISN 0070           AIJ(8) = -S1*C3+C1*S2*S3                            CRS08430
ISN 0071           AIJ(9) = C1*C2                                      CRS08440
ISN 0072           I = 9*(IJ-1)                                        CRS08450
ISN 0073           DO 1015 J = 1,9                                     CRS08460
ISN 0074      1015 DIJ(I+J) = AIJ(J)                                   CRS08470
ISN 0075           CBIJ = CBAR(IJ)                                     CRS08480
ISN 0076           I = IG(IJ)                                          CRS08490
ISN 0077           J = JG(IJ)                                          CRS08500
ISN 0078           IF ((IOLD.NE.0).AND.(I.EQ.IOLD))  GO TO 1120        CRS08510
ISN 0080           IS=9*(I-1)                                          CRS08520
ISN 0081           DO 1110 JJ = 1,9                                    CRS08530
ISN 0082           IS=IS+1                                             CRS08540
```

Figure 108. (Continued)

```
ISN 0083      1110 AI(JJ)=BIJ(IS)                                               CRS08550
ISN 0084      1120 IOLD=1                                                       CRS08560
ISN 0085           IS=9*(J-1)                                                   CRS08570
ISN 0086           DO 1125 JJ = 1,9                                             CRS08580
ISN 0087           IS=IS+1                                                      CRS08590
ISN 0088      1125 AJ(JJ) = BIJ(IS)                                             CRS08600
ISN 0089           AITAJ(1)=AI(1)*AJ(1)+AI(2)*AJ(2)+AI(3)*AJ(3)                 CRS08610
ISN 0090           AITAJ(2)=AI(4)*AJ(1)+AI(5)*AJ(2)+AI(6)*AJ(3)                 CRS08620
ISN 0091           AITAJ(3)=AI(7)*AJ(1)+AI(8)*AJ(2)+AI(9)*AJ(3)                 CRS08630
ISN 0092           AITAJ(4)=AI(1)*AJ(4)+AI(2)*AJ(5)+AI(3)*AJ(6)                 CRS08640
ISN 0093           AITAJ(5)=AI(4)*AJ(4)+AI(5)*AJ(5)+AI(6)*AJ(6)                 CRS08650
ISN 0094           AITAJ(6)=AI(7)*AJ(4)+AI(8)*AJ(5)+AI(9)*AJ(6)                 CRS08660
ISN 0095           AITAJ(7)=AI(1)*AJ(7)+AI(2)*AJ(8)+AI(3)*AJ(9)                 CRS08670
ISN 0096           AITAJ(8)=AI(4)*AJ(7)+AI(5)*AJ(8)+AI(6)*AJ(9)                 CRS08680
ISN 0097           AITAJ(9)=AI(7)*AJ(7)+AI(8)*AJ(8)+AI(9)*AJ(9)                 CRS08690
          C                                                                     CRS08700
          C COMPUTE DAMPING COEFFICIENT MATRIX C                                CRS08710
ISN 0098           KKS=1                                                        CRS08720
ISN 0099           DO 1312 KS = 1,2                                             CRS08730
ISN 0100           IF (KS.EQ.2) KKS=J                                           CRS08740
ISN 0102           XTHOLD(1,KS)=XI(KKS)                                         CRS08750
ISN 0103           XTHOLD(2,KS)=XYI(KKS)                                        CRS08760
ISN 0104           XTHOLD(3,KS)=XZI(KKS)                                        CRS08770
ISN 0105           XTHOLD(4,KS)=XYI(KKS)                                        CRS08780
ISN 0106           XTHOLD(5,KS)=YI(KKS)                                         CRS08790
ISN 0107           XTHOLD(6,KS)=YZI(KKS)                                        CRS08800
ISN 0108           XTHOLD(7,KS)=XZI(KKS)                                        CRS08810
ISN 0109           XTHOLD(8,KS)=YZI(KKS)                                        CRS08820
ISN 0110      1312 XTHOLD(9,KS)=ZI(KKS)                                         CRS08830
          C                                                                     CRS08840
ISN 0111           PROD(1)=AITAJ(1)*XYZIJJ(1)+AITAJ(4)*XYZIJJ(2)+AITAJ(7)*XYZIJJ(3) CRS08850
ISN 0112           PROD(2)=AITAJ(2)*XYZIJJ(1)+AITAJ(5)*XYZIJJ(2)+AITAJ(8)*XYZIJJ(3) CRS08860
ISN 0113           PROD(3)=AITAJ(3)*XYZIJJ(1)+AITAJ(6)*XYZIJJ(2)+AITAJ(9)*XYZIJJ(3) CRS08870
ISN 0114           PROD(4)=AITAJ(1)*XYZIJJ(4)+AITAJ(4)*XYZIJJ(5)+AITAJ(7)*XYZIJJ(6) CRS08880
ISN 0115           PROD(5)=AITAJ(2)*XYZIJJ(4)+AITAJ(5)*XYZIJJ(5)+AITAJ(8)*XYZIJJ(6) CRS08890
ISN 0116           PROD(6)=AITAJ(3)*XYZIJJ(4)+AITAJ(6)*XYZIJJ(5)+AITAJ(9)*XYZIJJ(6) CRS08900
ISN 0117           PROD(7)=AITAJ(1)*XYZIJJ(7)+AITAJ(4)*XYZIJJ(8)+AITAJ(7)*XYZIJJ(9) CRS08910
ISN 0118           PROD(8)=AITAJ(2)*XYZIJJ(7)+AITAJ(5)*XYZIJJ(8)+AITAJ(8)*XYZIJJ(9) CRS08920
ISN 0119           PROD(9)=AITAJ(3)*XYZIJJ(7)+AITAJ(6)*XYZIJJ(8)+AITAJ(9)*XYZIJJ(9) CRS08930
          C                                                                     CRS08940
ISN 0120           XYZIJJ(1)=PROD(1)*AITAJ(1)+PROD(4)*AITAJ(4)+PROD(7)*AITAJ(7) CRS08950
ISN 0121           XYZIJJ(2)=PROD(2)*AITAJ(1)+PROD(5)*AITAJ(4)+PROD(8)*AITAJ(7) CRS08960
ISN 0122           XYZIJJ(3)=PROD(3)*AITAJ(1)+PROD(6)*AITAJ(4)+PROD(9)*AITAJ(7) CRS08970
ISN 0123           XYZIJJ(4)=PROD(1)*AITAJ(2)+PROD(4)*AITAJ(5)+PROD(7)*AITAJ(8) CRS08980
ISN 0124           XYZIJJ(5)=PROD(2)*AITAJ(2)+PROD(5)*AITAJ(5)+PROD(8)*AITAJ(8) CRS08990
ISN 0125           XYZIJJ(6)=PROD(3)*AITAJ(2)+PROD(6)*AITAJ(5)+PROD(9)*AITAJ(8) CRS09000
ISN 0126           XYZIJJ(7)=PROD(1)*AITAJ(3)+PROD(4)*AITAJ(6)+PROD(7)*AITAJ(9) CRS09010
ISN 0127           XYZIJJ(8)=PROD(2)*AITAJ(3)+PROD(5)*AITAJ(6)+PROD(8)*AITAJ(9) CRS09020
ISN 0128           XYZIJJ(9)=PROD(3)*AITAJ(3)+PROD(6)*AITAJ(6)+PROD(9)*AITAJ(9) CRS09030
ISN 0129           DO 1314 KS = 1,9                                             CRS09040
ISN 0130      1314 XYZIJI(KS)=XYZIJI(KS)+XYZIJJ(KS)                             CRS09050
ISN 0131           PROD(1)=XYZIJI(1)*AIJ(1)+XYZIJI(4)*AIJ(2)+XYZIJI(7)*AIJ(3)   CRS09060
ISN 0132           PROD(2)=XYZIJI(2)*AIJ(1)+XYZIJI(5)*AIJ(2)+XYZIJI(8)*AIJ(3)   CRS09070
ISN 0133           PROD(3)=XYZIJI(3)*AIJ(1)+XYZIJI(6)*AIJ(2)+XYZIJI(9)*AIJ(3)   CRS09080
```

Figure 108. (Continued)

```
ISN 0134          PROD(4)=XYZIJI(1)*AIJ(4)+XYZIJI(4)*AIJ(5)+XYZIJI(7)*AIJ(6)
ISN 0135          PROD(5)=XYZIJI(2)*AIJ(4)+XYZIJI(5)*AIJ(5)+XYZIJI(8)*AIJ(6)
ISN 0136          PROD(6)=XYZIJI(3)*AIJ(4)+XYZIJI(6)*AIJ(5)+XYZIJI(9)*AIJ(6)
ISN 0137          PROD(7)=XYZIJI(1)*AIJ(7)+XYZIJI(4)*AIJ(8)+XYZIJI(7)*AIJ(9)
ISN 0138          PROD(8)=XYZIJI(2)*AIJ(7)+XYZIJI(5)*AIJ(8)+XYZIJI(8)*AIJ(9)
ISN 0139          PROD(9)=XYZIJI(3)*AIJ(7)+XYZIJI(6)*AIJ(8)+XYZIJI(9)*AIJ(9)
            C
ISN 0140          XIIJ(1)=AIJ(1)*PROD(1)+AIJ(2)*PROD(2)+AIJ(3)*PROD(3)
ISN 0141          XIIJ(2)=AIJ(4)*PROD(4)+AIJ(5)*PROD(5)+AIJ(6)*PROD(6)
ISN 0142          XIIJ(3)=AIJ(7)*PROD(7)+AIJ(8)*PROD(8)+AIJ(9)*PROD(9)
ISN 0143          DO 1020 K = 1,3
ISN 0144     1020 C(K,IJ) = .101600*C6IJ*SQRT(XK3(K,K,IJ)*(WGT(I)+WGT(J)))
ISN 0145          DO 1030 K = 4,6
ISN 0146     1030 C(K,IJ)=2.*C8IJ*SQRT(XK3(K,K,IJ)*XIIJ(K-3))
ISN 0147     1010 CONTINUE
ISN 0148          RETURN
            C*********************************
            C*********************************
ISN 0149          ENTRY INPUT
            C*********************************
            C*********************************
ISN 0150          REAL*8 LEAF,MU,KF
ISN 0151          REAL*4 KR(15),SLOPE,XKS,XKI,XKR
ISN 0152          INTEGER*2 INBUF(80),II(81),KK(81),IR(81),JR(81),CHUG
ISN 0153          INTEGER*2 IO(81),JO(81),LO(81),NPO(81),NLSFLG,BLANK,IJPR
ISN 0154          DIMENSION XDP(60),YDP(60),ZDP(60),PHIDP(50),THEDP(60),PSIDP(60),
                 1 VMAX2(6,60)
            C*****THE FOLLOWING ARE ALSO USED BY CFORCE
ISN 0155          DIMENSION XMU(60,3),XKE(60,3),SI(60,3),SA(60,3),SH(60,3),
                 1 SF(60,3),FSPUI(60,3),FSPUF(60,3)
ISN 0156          COMMON/DERIN/ XNBAR,XFBAR,YNBAR,YPBAR,ZNBAR,ZPBAR
ISN 0157          COMMON/DERIN/HEX(60),HEY(60),HEZ(60),ALIFT(60),VMAX(480),INDP
ISN 0158          COMMON/LINES/ XKS(1200),XKI(1200),XKR(1200),NLSFLG(480),CHUG(80)
ISN 0159          EQUIVALENCE (VMAX(1),VMAX2(1))
ISN 0160          DATA BLANK/'  '/
ISN 0161          READ5100, TITLE
ISN 0162     5100 FORMAT(10A8)
ISN 0163          PRINT 5500, TITLE
ISN 0164     5500 FORMAT(1H1,10A8)
ISN 0165          READ5200,NM,IPRINT,DELTAT,TMAX
ISN 0166          PRINT 5501, NM,IPRINT,DELTAT,TMAX
ISN 0167     5501 FORMAT('0MASSES =',I3,' DP/DT =',I4,' DT =',F7.5,' TMAX =',F7.3)
ISN 0168          IF(DELTAT) 5017,5017,5018
ISN 0169     5017 NM = 0
ISN 0170          GO TO 5000
ISN 0171     5018 CONTINUE
ISN 0172          IF(NM) 5000,5000,5016
ISN 0173     5200 FORMAT(2I3,2E12.0)
ISN 0174     5016 READ5300, XGDOT,YGDOT,ZGDOT
ISN 0175          READ5300, PPR,QPR,RPR
ISN 0176          READ5300, PHIPR,THEPR,PSIPR,ZG
ISN 0177     5300 FORMAT(6E12.0)
ISN 0178          PRINT 5502, XGDOT,YGDOT,ZGDOT
ISN 0179     5502 FORMAT('  XGDOT =',1PE13.5,'  YGDOT =',E13.5,'  ZGDOT =',E13.5)
```

Figure 108. (Continued)

```
ISN 0160            PRINT 5503, FPR,CPR,RPR                                         CRS09620
ISN 0161       5503 FORMAT(5X,'P'' =',1PE13.5,5X,'Q'' =',E13.5,5X,'R'' =',E13.5)     CRS09630
ISN 0162            PRINT 5504, PHIPR,THEPR,PSIPR,ZG                                 CRS09640
ISN 0163       5504 FORMAT('   PHI'' =',1PE13.5,' THETA'' =',E13.5,'   PSI'' =',E13.5,CRS09650
                   1  5X,'ZG =',E13.5)                                               CRS09660
              C READ WEIGHTS                                                         CRS09670
ISN 0164            READ5600, (WGT(I),I=1,NM)                                        CRS09680
ISN 0165            PRINT 5505                                                       CRS09690
ISN 0166       5505 FORMAT('0WEIGHTS')                                               CRS09700
ISN 0167            PRINT 5506, (I,WGT(I),I=1,NM)                                    CRS09710
ISN 0168       5506 FORMAT(1H ,I3,1PE15.5)                                           CRS09720
              C READ MOMENTS AND INERTIA PRODUCTS                                    CRS09730
ISN 0189            READ5300, (XI(I),YI(I),ZI(I),XYI(I),YZI(I),XZI(I),I=1,NM)        CRS09740
ISN 0190            READ5700, (XDP(I),YDP(I),ZDP(I),I=1,NM)                          CRS09750
ISN 0191       5700 FORMAT(3E12.0)                                                   CRS09760
ISN 0192            PRINT 5507                                                       CRS09770
ISN 0193       5507 FORMAT('0I,IX(I),IY(I),IZ(I),IXY(I),IYZ(I),IXZ(I)')              CRS09780
ISN 0194            PRINT 5508, (I,XI(I),YI(I),ZI(I),XYI(I),YZI(I),XZI(I),I=1,NM)    CRS09790
ISN 0195       5508 FORMAT(1H ,I5,1P6E15.5)                                          CRS09800
ISN 0196            PRINT 5509                                                       CRS09810
ISN 0197       5509 FORMAT('0I,X''''(I),Y''''(I),Z''''(I)')                          CRS09820
ISN 0198            PRINT 5510, (I,XDP(I),YDP(I),ZDP(I),I=1,NM)                      CRS09830
ISN 0199       5510 FORMAT(1H ,I3,1P3E15.5)                                          CRS09840
              C*****CLEAR SOME ARRAYS WHICH ARE SPARSE                               CRS09850
ISN 0200            DO 5110 I = 1,NM                                                 CRS09860
ISN 0201            HEX(I) = 0.0                                                     CRS09870
ISN 0202            HEY(I) = 0.0                                                     CRS09880
ISN 0203            HEZ(I) = 0.0                                                     CRS09890
ISN 0204            PHIDP(I) = 0.0                                                   CRS09900
ISN 0205            THEDP(I) = 0.0                                                   CRS09910
ISN 0206            PSIDP(I) = 0.0                                                   CRS09920
ISN 0207       5110 ALIFT(I) = 0.0                                                   CRS09930
              C*****READ POINTERS TO NON-ZERO ANGULAR MOMENTUM CARDS                 CRS09940
ISN 0208            READ 5800, NI,(INBUF(I),I=1,NI)                                  CRS09950
ISN 0209            PRINT 5511, NI                                                   CRS09960
ISN 0210       5511 FORMAT('0THERE ARE',I3,' I''S HAVING NON-ZERO HE OR ',           CRS09970
                   1 'PHI''''',THETA'''',PSI'''''')                                  CRS09980
ISN 0211            IF(NI.EQ.0) GO TO 5533                                           CRS09990
ISN 0213            PRINT 5512                                                       CRS10000
ISN 0214       5512 FORMAT('0I,HEX(I),HEY(I),HEZ(I),PHI''''(I),THETA''''(I),'        CRS10010
                   1 ,'PSI''''(I)')                                                  CRS10020
              C*****NOW READ NON-ZERO CARDS                                          CRS10030
ISN 0215            DO 5120 I = 1,NI                                                 CRS10040
ISN 0216            J = INBUF(I)                                                     CRS10050
ISN 0217            READ 5300, HEX(J),HEY(J),HEZ(J),PHIDP(J),THEDP(J),PSIDP(J)       CRS10060
ISN 0218       5120 PRINT 5508, J,HEX(J),HEY(J),HEZ(J),PHIDP(J),THEDP(J),PSIDP(J)    CRS10070
              C*****READ POINTERS TO NON-ZERO AERODYNAMIC LIFTS                      CRS10080
ISN 0219       5533 READ 5800, NI,(INBUF(I),I=1,NI)                                  CRS10090
ISN 0220       5800 FORMAT(38I2)                                                     CRS10100
ISN 0221            PRINT 5513, NI                                                   CRS10110
ISN 0222       5513 FORMAT('0THERE ARE',I3,' I''S HAVING NON-ZERO LC''S')            CRS10120
ISN 0223            IF(NI.EQ.0) GO TO 5534                                           CRS10130
              C*****READ NON-ZERO LIFTS                                              CRS10140
ISN 0225            READ 5600, (ALIFT(INBUF(I)),I=1,NI)                              CRS10150
```

Figure 108. (Continued)

```
ISN 0226     5600 FORMAT(E12.0)                                          CRS10160
ISN 0227          PRINT 5514                                             CRS10170
ISN 0228     5514 FORMAT('0I,LC(I)')                                     CRS10180
ISN 0229          PRINT 5506, (INBUF(I),ALIFT(INBUF(I)),I=1,NI)          CRS10190
            C*****CLEAR EXTERNAL SPRING FLAGS (AND THE ASSOCIATED DATA ALTHO THIS   CRS10200
            C SHOULD NOT BE NECESSARY BECAUSE WE ONLY USE IT IF THE FLAG IS 1.      CRS10210
            C HOWEVER, THEY MUST BE CLEARED FOR THE SEARCH WHICH PRINTS THE INPUT.) CRS10220
ISN 0230     5534 DO 5130 K = 1,3                                        CRS10230
ISN 0231          DO 5130 I = 1,NN                                       CRS10240
ISN 0232          ISP(I,K) = 0                                           CRS10250
ISN 0233          XLBAR(I,K) = 0.0                                       CRS10260
ISN 0234          XMU(I,K) = 0.0                                         CRS10270
ISN 0235          XKE(I,K) = 0.0                                         CRS10280
ISN 0236          SI(I,K) = 0.0                                          CRS10290
ISN 0237          SA(I,K) = 0.0                                          CRS10300
ISN 0238          SB(I,K) = 0.0                                          CRS10310
ISN 0239          SF(I,K) = 0.0                                          CRS10320
ISN 0240          FSPOI(I,K) = 0.0                                       CRS10330
ISN 0241     5130 FSPOF(I,K) = 0.0                                       CRS10340
            C*****READ THE SPRING STUFF AND STORE IT.                    CRS10350
ISN 0242          IKCT = 1                                               CRS10360
ISN 0243          PRINT 5515                                             CRS10370
ISN 0244     5515 FORMAT('0I,K,LBAR(I,K),MU(I,K),KE(I,K)')               CRS10380
ISN 0245     5140 READ 5810, II(IKCT),KK(IKCT),LBAR,MU,KE                CRS10390
ISN 0246     5810 FORMAT(2I3,6X,3E12.0)                                  CRS10400
ISN 0247          I = II(IKCT)                                           CRS10410
ISN 0248          IF(I.EQ.0) GO TO 5150                                  CRS10420
ISN 0250          K = KK(IKCT)                                           CRS10430
ISN 0251          ISP(I,K) = 1                                           CRS10440
ISN 0252          XLBAR(I,K) = LBAR                                      CRS10450
ISN 0253          XMU(I,K) = MU                                          CRS10460
ISN 0254          XKE(I,K) = KE                                          CRS10470
ISN 0255          PRINT  5516, I,K,LBAR,MU,KE                            CRS10480
ISN 0256     5516 FORMAT(1H ,2I3,1P3E15.5)                               CRS10490
ISN 0257          IKCT = IKCT+1                                          CRS10500
ISN 0258          GO TO 5140                                             CRS10510
ISN 0259     5150 IKCT = IKCT-1                                          CRS10520
ISN 0260          IF(IKCT.EQ.0) GO TO 5535                               CRS10530
ISN 0262          PRINT 5517                                             CRS10540
ISN 0263     5517 FORMAT('0I,K,SI(I,K),SA(I,K),SB(I,K),SF(I,K),FSPOI(I,K),',  CRS10550
                 1 'FSPOF(I,K)')                                         CRS10560
            C*****READ SI,SA,SB,SF,FSPOI,FSPOF                           CRS10570
ISN 0264          DO 5160 J = 1,IKCT                                     CRS10580
ISN 0265          I = II(J)                                              CRS10590
ISN 0266          K = KK(J)                                              CRS10600
ISN 0267          READ 5300, SI(I,K),SA(I,K),SB(I,K),SF(I,K),FSPOI(I,K),FSPOF(I,K) CRS10610
ISN 0268     5160 PRINT 5518, I,K,SI(I,K),SA(I,K),SB(I,K),SF(I,K),FSPOI(I,K),  CRS10620
                 1 FSPOF(I,K)                                            CRS10630
ISN 0269     5518 FORMAT(1H ,2I3,1P6E15.5)                               CRS10640
ISN 0270     5535 IGS = 0                                                CRS10650
ISN 0271          PRINT 5519                                             CRS10660
ISN 0272     5519 FORMAT('0IJ,I,J,PHI(I,J),THETA(I,J),PSI(I,J) (INTERNAL BEAMS)')  CRS10670
            C READ THE I,J,PHIIJ,THEIJ,PSIIJ                             CRS10680
ISN 0273     5015 READ5400, I,J,PHIIN,THEIN,PSIIN                        CRS10690
```

Figure 108. (Continued)

```
ISN 0274      5400 FORMAT(2I3,3E12.0)                                            CRS10700
ISN 0275           IF(I) 5051,5051,5020                                          CRS10710
ISN 0276      5020 IGS = IGS+1                                                   CRS10720
ISN 0277           IG(IGS) = I                                                   CRS10730
ISN 0278           JG(IGS) = J                                                   CRS10740
ISN 0279           PHIIJ(IGS) = PHIIN                                            CRS10750
ISN 0280           THIJ(IGS) = THIN                                              CRS10760
ISN 0281           PSIIJ(IGS) = PSIIN                                            CRS10770
ISN 0282           PRINT 5539, IGS,I,J,PHIIN,THEIN,PSIIN                         CRS10780
ISN 0283      5539 FORMAT(1H ,3I3,1P6E15.5)                                      CRS10785
ISN 0284           GO TO 5015                                                    CRS10790
          C*****THESE K-MATRICES ARE STORED BY ROW, THUS THE THE L,K             CRS10800
ISN 0285      5051 READ(5,5010)(((XK3(L,K,IJ),L=1,6),K=1,6),IJ=1,IGS)            CRS10810
ISN 0286           PRINT 5520                                                    CRS10820
ISN 0287      5520 FORMAT('0I,J,K-MATRIX FOR INTERNAL BEAM I,J')                 CRS10830
ISN 0288           DO 5521 IJ = 1,IGS                                            CRS10840
ISN 0289           PRINT 5510, IG(IJ),JG(IJ)                                     CRS10850
ISN 0290      5521 PRINT 5522, ((XK3(L,K,IJ),L=1,6),K=1,6)                       CRS10860
ISN 0291      5522 FORMAT(1H ,1P6E15.5)                                          CRS10870
ISN 0292           READ5600, (CBAR(IJ),IJ=1,IGS)                                 CRS10880
ISN 0293           PRINT 5523                                                    CRS10890
ISN 0294      5523 FORMAT('0IJ,I,J,CBAR(I,J)')                                   CRS10900
ISN 0295           PRINT 5524, (IJ,IG(IJ),JG(IJ),CBAR(IJ),IJ=1,IGS)              CRS10910
ISN 0296      5524 FORMAT(1H ,3I3,1PE15.5)                                       CRS10920
          C*******KR TABLE INPUT                                                 CRS10930
          C IN DERIV, TO SEE IF THERE IS A TABLE FOR A PARTICULAR IJL, WE LOOK   CRS10940
          C AT NLSFLG(IJL) AND IF IT IS NON-ZERO, IT WILL BE THE TABLE NUMBER    CRS10950
          C FOR THAT IJL.  WE STILL USE SLOPES AND INTERCEPTS FOR THE            CRS10960
          C INTERPOLATION BUT WE MUST FIND WHICH INTERVAL IN X WE'RE IN.         CRS10970
          C THIS IS DONE BY KEEPING, FOR EACH TABLE, A POINTER TO THE LOWER X OF CRS10980
          C THE INTERVAL WE WERE IN AT THE LAST INTEGRATION STEP                 CRS10990
          C (INTEGER*2 CHUG(PC)) ON THE GROUNDS THAT WE'RE PROBABLY              CRS11000
          C STILL IN THAT INTERVAL.  IF WE'RE NOT IN THAT INTERVAL, WE CHECK     CRS11010
          C ONE BY ONE IN THE APPROPRIATE DIRECTION UNTIL WE FIND THE RIGHT      CRS11020
          C INTERVAL AND WE SAVE THAT IN CHUG AND DO THE INTERPOLATION.          CRS11030
          C X(1) AND XENPO FOR EACH TABLE ARE REPLACED BY VERY LARGE (E35)       CRS11040
          C NEGATIVE AND POSITIVE NUMBERS SO THAT WE NEED NEVER CHECK FOR BEING  CRS11050
          C OUT OF THE TABLE AND ALSO SO WE DON'T EVEN HAVE TO KNOW HOW MANY     CRS11060
          C POINTS IN THE TABLE.  (IF AN ARGUMENT EXCEEDS 1.E35 WE'LL BOMB       CRS11070
          C SOONER OR LATER). THIS ALLOWS VERY RAPID TABLE SEARCH AND            CRS11080
          C INTERPOLATION.                                                       CRS11090
          C*****CLEAR I,J,L NONLINEAR STIFFNESS FLAGS                            CRS11100
ISN 0297           DO 5010 I = 1,486                                             CRS11110
ISN 0298      5010 NLSFLG(I) = 0                                                 CRS11120
          C*****INPUT KR TABLE SPECS                                             CRS11130
ISN 0299           NO = 0                                                        CRS11140
          C*****GO TO # OF TABLES ALLOWED + 1*****C                              CRS11145
ISN 0300           DO 5090 I = 1,81                                              CRS11150
ISN 0301           READ5900, IO(I),JO(I),LO(I),NPO(I)                            CRS11160
ISN 0302      5900 FORMAT(4I3)                                                   CRS11170
ISN 0303           IF(IO(I).EQ.0) GO TO 5050                                     CRS11180
ISN 0305           NO = I                                                        CRS11190
          C*****HUNT FOR I,J PAIR SO WE CAN STORE NO IN NLSFLG                   CRS11200
ISN 0306           DO 5030 J = 1,IGS                                             CRS11210
```

Figure 108. (Continued)

```
ISN 0307          IF(IG(I).EQ.IG(J).AND.JG(I).EQ.JG(J)) GO TO 5040        CRS11220
ISN 0309     5030 CONTINUE                                                 CRS11230
           C*****NO SUCH I,J PAIR, ABORT                                   CRS11240
ISN 0310          PRINT5910, IO(I),JG(I)                                   CRS11250
ISN 0311          STOP                                                     CRS11260
ISN 0312     5910 FORMAT(1H1,'NON-EXISTENT I,J PAIR IN KR TABLE SPECS',2I5) CRS11270
           C*****FOUND IT                                                  CRS11280
ISN 0313     5040 NLSFLG(6*(J-1)+LO(I)) = NO                               CRS11290
ISN 0314     5090 CONTINUE                                                 CRS11300
           C*****TOO MANY KR TABLES, ABORT                                 CRS11310
ISN 0315          PRINT5920                                                CRS11320
ISN 0316          STOP                                                     CRS11330
ISN 0317     5920 FORMAT(1H1,'TOO MANY KR TABLES')                         CRS11340
           C*****PRINT KR TABLE SPECS                                      CRS11350
ISN 0318     5050 IF(NO.EQ.0) GO TO 5536                                   CRS11360
ISN 0320          PRINT 5930                                               CRS11370
ISN 0321     5930 FORMAT('CKR TABLE SPECS, I,J,L,NP')                      CRS11380
ISN 0322          PRINT5940,(IG(I),JG(I),LO(I),NPO(I),I=1,NO)              CRS11390
ISN 0323     5940 FORMAT(1H ,4I5)                                          CRS11400
           C*****LOOP TO READ IN A TABLE                                   CRS11410
ISN 0324          K = -14                                                  CRS11420
ISN 0325          DO 5070 I = 1,NO                                         CRS11430
ISN 0326          NP = NPL(I)                                              CRS11440
ISN 0327          IF(NP.LE.15) GO TO 5095                                  CRS11450
           C*****TOO MANY POINTS IN KR TABLE, ABORT                        CRS11460
ISN 0329          PRINT 5960, NP,I                                         CRS11470
ISN 0330          STOP                                                     CRS11480
ISN 0331     5980 FORMAT(1H1,I5,' POINTS IN KR TABLE',I3,' (MAX IS 15)')   CRS11490
           C*****SET CHUG TO 1,16,31,...                                   CRS11500
ISN 0332     5055 K = K+15                                                 CRS11510
ISN 0333          CHUG(I) = K                                              CRS11520
ISN 0334          ICH = CHUG(I)-1                                          CRS11530
ISN 0335          READ5950, (XKR(ICH+J),KR(J),J=1,NP)                      CRS11540
ISN 0336     5950 FORMAT(2E12.0)                                           CRS11550
           C*****PRINT TABLE                                               CRS11560
ISN 0337          PRINT5960,IG(I),JG(I),LO(I)                              CRS11570
ISN 0338     5960 FORMAT(1HC,'KR TABLE FOR I,J,L =',3I5)                   CRS11580
ISN 0339          PRINT5970, (J,XKR(ICH+J),KR(J),J=1,NP)                   CRS11590
ISN 0340     5970 FORMAT(1H ,I3,1P,E15.5)                                  CRS11600
           C*****COMPUTE SLOPES AND INTERCEPTS                             CRS11610
ISN 0341          NPM1 = NP-1                                              CRS11620
ISN 0342          DO 5080 J = 1,NPM1                                       CRS11630
ISN 0343          SLOPE = (KR(J)- KR(J+1))/(XKR(ICH+J)-XKR(ICH+J+1))       CRS11640
ISN 0344          XKS(ICH+J) = SLOPE                                       CRS11650
ISN 0345     5080 XKI(ICH+J) = KR(J)-SLOPE*XKR(ICH+J)                      CRS11660
           C*****MOVE ENDPOINTS 'WAY OUT                                   CRS11670
ISN 0346          XKR(ICH+1) = -1.E35                                      CRS11680
ISN 0347          XKR(ICH+NP) = 1.E35                                      CRS11690
ISN 0348     5070 CONTINUE                                                 CRS11700
           C*****STANDARD VMAX = 100                                       CRS11710
ISN 0349     5536 DO 5180 I = 1,460                                        CRS11720
ISN 0350     5180 VMAX(I) = 100.0                                          CRS11730
ISN 0351          PRINT 5525                                               CRS11740
ISN 0352     5525 FORMAT('0IJ,I,J,VMAX(I,J,1-6)')                          CRS11750
```

Figure 108. (Continued)

```
ISN 0353          IJCT = 0                                                CRS11760
ISN 0354     5170 IJCT = IJCT+1                                           CRS11770
ISN 0355          READ 5820, IR(IJCT),JR(IJCT)                            CRS11780
ISN 0356     5820 FORMAT(2I3)                                             CRS11790
ISN 0357          IF(IR(IJCT).NE.0) GO TO 5170                            CRS11800
ISN 0359          IJCT = IJCT-1                                           CRS11810
            C*****READ NON-STANDARD MAXIMUM DEFLECTIONS                   CRS11820
ISN 0360          IF(IJCT.EQ.0) GO TO 5537                                CRS11830
ISN 0362          DO 5190 K = 1,IJCT                                      CRS11840
ISN 0363          I = IR(K)                                               CRS11850
ISN 0364          J = JR(K)                                               CRS11860
            C*****HUNT FOR I,J PAIR (MUST HUNT)                           CRS11870
ISN 0365          DO 5210 L = 1,IGS                                       CRS11880
ISN 0366          IF(I.EQ.IG(L).AND.J.EQ.JG(L)) GO TO 5220                CRS11890
ISN 0368     5210 CONTINUE                                                CRS11900
            C*****NO SUCH PAIR, ABORT                                     CRS11910
ISN 0369          PRINT 5830, K,I,J                                       CRS11920
ISN 0370          STOP                                                    CRS11930
ISN 0371     5830 FORMAT(1H1,I3,'TH I,J PAIR(',2I3,') FOR VMAX DOES NOT EXIST.')  CRS11940
            C*****FOUND IT, READ A VMAX CARD                              CRS11950
ISN 0372     5220 READ 5300, (VMAX2(M,L),M=1,6)                           CRS11960
ISN 0373          PRINT 5539, (L,I,J,(VMAX2(M,L),M=1,6))                  CRS11970
ISN 0374     5190 CONTINUE                                                CRS11980
            C*****PRINT PLOT INDICATOR TITLES                             CRS11990
ISN 0375     5537 PRINT 5529                                              CRS12000
ISN 0376     5529 FORMAT(1H0,26X,'PLOT CARDS WHICH ARE NOT ALL BLANK',/)  CRS12010
ISN 0377          PRINT 5526                                              CRS12020
ISN 0378     5526 FORMAT(13X,'1',9X,'2',9X,'3',9X,'4',9X,'5',9X,'6',9X,'7',9X,'8')  CRS12030
ISN 0379          PRINT 5527                                              CRS12040
ISN 0380     5527 FORMAT(4X,'12345678901234567890123456789012345678901234567890',  CRS12050
                 1 '123456789012345678901234567890',/)                    CRS12060
            C READ PLOT INDICATORS                                        CRS12070
ISN 0381          NPLOT = 0                                               CRS12080
ISN 0382          JM = KM                                                 CRS12090
ISN 0383          DO 5035 I = 1,..                                        CRS12100
ISN 0384          IF(I.EQ.13) JM = IGS                                    CRS12110
ISN 0386          READ5926, INBUF                                         CRS12120
ISN 0387     5926 FORMAT(80A1)                                            CRS12130
ISN 0388          IANY = 0                                                CRS12140
ISN 0389          DO 5045 J = 1,JM                                        CRS12150
ISN 0390          IF (NPLOT.EQ.150)  GO TO 5035                           CRS12160
ISN 0392          IF(INBUF(J).EQ.BLANK) GO TO 5045                        CRS12170
ISN 0394          IANY = 1                                                CRS12180
ISN 0395          NPLOT = NPLOT+1                                         CRS12190
ISN 0396          IOPLOT(NPLOT) = I                                       CRS12200
ISN 0397          IPLOT(NPLOT) = J                                        CRS12210
ISN 0398     5045 CONTINUE                                                CRS12220
ISN 0399          IF(IANY.EQ.0) GO TO 5035                                CRS12230
            C*****GOT SOME 1'S IN THIS CARD SO PRINT IT.                  CRS12240
ISN 0401          PRINT 5528, I,INBUF                                     CRS12250
ISN 0402     5528 FORMAT(I3,1X,80A1)                                      CRS12260
ISN 0403     5035 CONTINUE                                                CRS12270
ISN 0404          READ5800,INDP                                           CRS12280
ISN 0405          PRINT 5538, INDP                                        CRS12290
```

Figure 108. (Continued)

```
ISN 0406     5538 FORMAT('OINDP =',I3)
ISN 0407          IF (INDP.EQ.0)  GO TO 5065                                 CRS12300
ISN 0409          READ5310, XNBAR,XPBAR,YNBAR,YPBAR,ZNBAR,ZPBAR               CRS12310
ISN 0410          PRINT 5530                                                 CRS12320
ISN 0411     5530 FORMAT('UXN-,XP-,YN-,YP-,ZN-,ZP-',/)                       CRS12330
ISN 0412          PRINT 5522, XNBAR,XPBAR,YNBAR,YPBAR,ZNBAR,ZPBAR             CRS12340
ISN 0413     5065 READ 5928, IJPR                                            CRS12350
ISN 0414          PRINT 5531                                                 CRS12360
ISN 0415     5531 FORMAT(1HO,34X,'URI(IJ) INDICATORS',/)                     CRS12370
ISN 0416          PRINT 5526                                                 CRS12380
ISN 0417          PRINT 5527                                                 CRS12390
ISN 0418          PRINT 5532, IJPR                                           CRS12400
ISN 0419     5532 FORMAT(4X,8GA1)                                            CRS12410
            C IF WE KNOW HOW MANY PLOTS WE WANT, WE CAN FIGURE OUT HOW MANY POINTS  CRS12420
            C PER PLOT WE CAN HAVE, ALTHO WE DON'T WANT MORE THAN 500, BECAUSE     CRS12430
            C WE COULDN'T NOTICE THE RESOLUTION ANYWAY.THE REST OF THIS FIGURES    CRS12440
            C OUT HOW OFTEN TO SAVE. A TRUNCATED ITPLOT WILL TRY TO SAVE TOO MUCH  CRS12450
            C AND THEN WE WOULDN'T GET TO TMAX, BUT IF WE WOULD ALMOST GET THERE   CRS12460
            C IT WILL NOT BE NOTICEABLE ON THE PLOT.                           CRS12470
ISN 0420          IF (NPLOT.EQ.0)  GO TO 5060                                CRS12480
ISN 0422          IP = 50000/NPLOT                                           CRS12490
ISN 0423          IF(IP.GT.500) IP = 500                                     CRS12500
ISN 0425          FITER = TMAX/DELTAT+2.0                                    CRS12510
ISN 0426          ITPLOT = FITER/IP                                          CRS12520
ISN 0427          IF(ITPLOT.EQ.0) ITPLOT = 1                                 CRS12530
ISN 0429          IF(FITER/(IP*ITPLOT).GT.1.002) ITPLOT = ITPLOT+1           CRS12540
ISN 0431     5060 CONTINUE                                                   CRS12550
ISN 0432     5000 RETURN                                                     CRS12560
            C********************************                                CRS12570
            C********************************                                CRS12580
ISN 0433          ENTRY CFORCE                                               CRS12590
            C********************************                                CRS12600
            C********************************                                CRS12610
ISN 0434          DIMENSION VA(3),VADOT(3),PBAR(3),XLNGTH(3),IISP(3),XXLBAR(3),  CRS12620
                 1 FSP(3,3),XVDC(3,3),C4(3),C5(3),VC3(3),S(3),SDOT(3),PL(3,3)  CRS12630
ISN 0435          DIMENSION OPCRIN(4),DXYZ(3),DXYZPR(3),TERM(6)               CRS12640
ISN 0436          COMMON/MAINCF/TMAX,IPRINT,ITPLOT,IHS(60,3)
ISN 0437          EQUIVALENCE (C4(1),DXYZ(1)),(C5(1),DXYZPR(1))              CRS12650
ISN 0438          VA(1) = X(I)
ISN 0439          VA(2) = Y(I)                                               CRS12660
ISN 0440          VA(3) = Z(I)                                               CRS12670
ISN 0441          VADOT(1) = XDOT(I)                                         CRS12680
ISN 0442          VADOT(2) = YDOT(I)                                         CRS12690
ISN 0443          VADOT(3) = ZDOT(I)                                         CRS12700
ISN 0444          PBAR(1) = P(I)                                             CRS12710
ISN 0445          PBAR(2) = Q(I)                                             CRS12720
ISN 0446          PBAR(3) = R(I)                                             CRS12730
            C INITIALIZE SOME MORE                                           CRS12740
ISN 0447          DO 910 K = 1,3                                             CRS12750
ISN 0448          XLNGTH(K) = 0.0                                            CRS12760
ISN 0449          IISP(K) = ISP(I,K)                                         CRS12770
ISN 0450          XXLBAR(K) = XLBAR(I,K)                                     CRS12780
ISN 0451          DO 915 JJ = 1,3                                            CRS12790
ISN 0452          FSP(JJ,K) = 0.0                                            CRS12800
                                                                             CRS12810
```

Figure 108. (Continued)

```
ISN 0453           915 XVDC(JJ,K) = 0.0                                     CRS12620
ISN 0454           910 CONTINUE                                              CRS12630
                 C LOOP G                                                    CRS12640
ISN 0455               DO 920 K = 1,3                                        CRS12650
ISN 0456               IF (IISP(K)) 925,920,925                              CRS12660
ISN 0457           925 ISUB = 3*K                                            CRS12670
ISN 0458               DVC = AI(ISUB)*XXLBAR(K)                              CRS12680
ISN 0459               DVCDOT = AIDOT(ISUB)*XXLBAR(K)                        CRS12690
ISN 0460               VC = VA(3)+DVC                                        CRS12900
ISN 0461               VCDOT = VADOT(3)+DVCDOT                               CRS12910
ISN 0462               C4(K) = VC/DVC                                        CRS12920
ISN 0463               C5(K) = (DVC*VCDOT-VC*DVCDOT)/(DVC*DVC)               CRS12930
ISN 0464               VC3(K) = VC                                           CRS12940
ISN 0465           920 CONTINUE                                              CRS12950
                 C LOOP H                                                    CRS12960
ISN 0466               DO 30 K = 1,3                                         CRS12970
ISN 0467               IF(IISP(K)) 35,30,35                                  CRS12980
ISN 0468            35 IF(VC3(K)) 30,30,40                                   CRS12990
ISN 0469            40 ISUB = 3*(K-1)                                        CRS13000
ISN 0470               BARL = XXLBAR(K)                                      CRS13010
ISN 0471               SUM = 0.0                                             CRS13020
ISN 0472               SUMD = 0.0                                            CRS13030
                 C LOOP J                                                    CRS13040
ISN 0473               DO 50 J = 1,3                                         CRS13050
ISN 0474               ISUB = ISUB+1                                         CRS13060
ISN 0475               DVC = AI(ISUB)*BARL                                   CRS13070
ISN 0476               DVCDOT = AIDOT(ISUB)*BARL                             CRS13080
ISN 0477               DVP = C4(K)*DVC                                       CRS13090
ISN 0478               DDP = C4(K)*DVCDOT+C5(K)*DVC                          CRS13100
ISN 0479               SUM = SUM+DVP*DVP                                     CRS13110
ISN 0480               SUMD = SUMD+DVP*DDP                                   CRS13120
ISN 0481            50 CONTINUE                                              CRS13130
ISN 0482               SK = SQRT(SUM)                                        CRS13140
ISN 0483               S(K) = SK                                             CRS13150
ISN 0484               SC(I,K) = SK                                          CRS13160
ISN 0485               SDOT(K) = SUMD/SK                                     CRS13170
                 C GET LENGTH                                                CRS13180
ISN 0486               IF(BARL) 55,60,60                                     CRS13190
ISN 0487            55 T = -BARL-SK                                          CRS13200
ISN 0488               IF(T) 65,65,70                                        CRS13210
ISN 0489            70 T = -1                                                CRS13220
ISN 0490               GO TO 65                                              CRS13230
ISN 0491            60 T = BARL-SK                                           CRS13240
ISN 0492               IF(T) 70,65,65                                        CRS13250
ISN 0493            65 XLNGTH(K) = T                                         CRS13260
ISN 0494            30 CONTINUE                                              CRS13270
ISN 0495               PL(1,1) = -SDOT(1)                                    CRS13280
ISN 0496               PL(2,2) = -SDOT(2)                                    CRS13290
ISN 0497               PL(3,3) = -SDOT(3)                                    CRS13300
ISN 0498               PL(2,1) = PBAR(3)*XLNGTH(1)                           CRS13310
ISN 0499               PL(3,1) = -PBAR(2)*XLNGTH(1)                          CRS13320
ISN 0500               PL(1,2) = -PBAR(3)*XLNGTH(2)                          CRS13330
ISN 0501               PL(3,2) = PBAR(1)*XLNGTH(2)                           CRS13340
ISN 0502               PL(1,3) = PBAR(2)*XLNGTH(3)                           CRS13350
```

Figure 108. (Continued)

```
ISN 0503          PL(2,3) = -PBAR(1)*XLNGTH(3)                          CRS13360
               C LOOP K                                                 CRS13370
ISN 0504          DO 75 JJ = 1,3                                        CRS13380
ISN 0505          ISUB = JJ-3                                           CRS13390
ISN 0506          VAD = VADOT(JJ)                                       CRS13400
               C LOOP L                                                 CRS13410
ISN 0507          DO 80 K = 1,3                                         CRS13420
ISN 0508          IF(IISP(K)) 85,80,85                                  CRS13430
ISN 0509       85 IF(VC3(K)) 80,80,90                                   CRS13440
ISN 0510       90 SUM = 0.0                                             CRS13450
               C LOOP M                                                 CRS13460
ISN 0511          DO 95 L = 1,3                                         CRS13470
ISN 0512          ISUB = ISUB+3                                         CRS13480
ISN 0513       95 SUM = SUM+AI(ISUB)*PL(L,K)                            CRS13490
ISN 0514          VEDOT(JJ,K) = VAD+SUM                                 CRS13500
ISN 0515       80 CONTINUE                                              CRS13510
ISN 0516       75 CONTINUE                                              CRS13520
               C LOOP N                                                 CRS13530
ISN 0517          DO 105 K = 1,3                                        CRS13540
ISN 0518          IF(IISP(K)) 110,105,110                               CRS13550
ISN 0519      110 IF(VC3(K)) 105,105,115                                CRS13560
ISN 0520      115 SK = S(K)                                             CRS13570
ISN 0521          SDIF = SK-SF(I,K)                                     CRS13580
ISN 0522          IF(SDIF) 120,120,125                                  CRS13590
ISN 0523      120 IF(IBS(I,K)) 130,130,135                              CRS13600
ISN 0524      125 IBS(I,K) = 1                                          CRS13610
ISN 0525      135 FSPU = FSPOF(I,K)+XKE(I,K)*SDIF                       CRS13620
ISN 0526          IF(FSPU) 140,190,190                                  CRS13630
ISN 0527      140 FSPU = 0.0                                            CRS13640
ISN 0528          GO TO 190                                             CRS13650
ISN 0529      130 SP = SK-FSPBAR(I,K)                                   CRS13660
               C FSPBAR = SHAR-FSPOBAR/KE                               CRS13670
ISN 0530          IF(SP) 150,155,155                                    CRS13680
ISN 0531      150 FSPO = 0.0                                            CRS13690
ISN 0532          GO TO 160                                             CRS13700
               C  COMPUTE FSPO PER NEW EXTERNAL SPRING LOAD-STROKE CURVES 7/25/72  CRS13710
ISN 0533      155 FSPU=FSPUF(I,K)                                       CRS13720
ISN 0534          IF (SP.GE.SR(I,K))  GO TO 160                         CRS13730
ISN 0536          IF (SP.GT.SA(I,K))  GO TO 157                         CRS13740
ISN 0538          FSPU=FSPUI(I,K)                                       CRS13750
ISN 0539          IF (SP.GE.SI(I,K))  GO TO 160                         CRS13760
ISN 0541          FSPO=FSPU*SP/SI(I,K)                                  CRS13770
ISN 0542          GO TO 160                                             CRS13780
ISN 0543      157 FSPO=FSPUI(I,K)+(SP-SA(I,K))*(FSPO-FSPOI(I,K))/(SB(I,K)-SA(I,K))  CRS13790
ISN 0544      160 IF(SDOT(K)) 165,165,170                               CRS13800
ISN 0545      170 NN(I,K) = 0                                           CRS13810
ISN 0546          GO TO 190                                             CRS13820
ISN 0547      165 IF(NN(I,K)) 190,175,190                               CRS13830
ISN 0548      175 NN(I,K) = 1                                           CRS13840
ISN 0549          FSPBAR(I,K) = SK-FSPU/XKE(I,K)                        CRS13850
               C (15A)                                                  CRS13860
ISN 0550      190 VX = AI(3*K)*FSPO                                     CRS13870
ISN 0551          XVOC(3,K) = VX                                        CRS13880
ISN 0552          VI = VFEDOT(1,K)                                      CRS13890
```

Figure 108. (Continued)

```
ISN 0553          V2 = VEEDOT(2,K)                                        CRS13900
ISN 0554          VBB = SQRT(V1*V1+V2*V2)                                 CRS13910
ISN 0555          IF(VBB) 210,210,200                                     CRS13920
ISN 0556      200 VX = XMU(I,K)*VX/VBB                                    CRS13930
ISN 0557          XVOL(1,K) = VX*VEEDOT(1,K)                              CRS13940
ISN 0558          XVOL(2,K) = VX*VEEDOT(2,K)                              CRS13950
ISN 0559      210 IS = 0                                                  CRS13960
          C LOOP C                                                        CRS13970
ISN 0560          DO 220 J = 1,3                                          CRS13980
ISN 0561          SUM = 0.0                                               CRS13990
          C LOOP R                                                        CRS14000
ISN 0562          DO 230 L = 1,3                                          CRS14010
ISN 0563          IS = IS+1                                               CRS14020
ISN 0564      230 SUM = SUM-AI(IS)*XVOL(L,K)                              CRS14030
ISN 0565      220 FSP(J,K) = SUM                                          CRS14040
          C END OF LOOP N                                                 CRS14050
ISN 0566      105 CONTINUE                                                CRS14060
          C CRASH FORCES                                                  CRS14070
ISN 0567          DO 240 J = 1,3                                          CRS14080
ISN 0568          SUM = 0.0                                               CRS14090
ISN 0569          DO 250 K = 1,3                                          CRS14100
ISN 0570      250 SUM = SUM+FSP(J,K)                                      CRS14110
ISN 0571      240 XC(J) = SUM                                             CRS14120
ISN 0572          DXYZ(1) = DX(1)
ISN 0573          DXYZ(2) = DY(1)
ISN 0574          DXYZ(3) = DZ(1)
ISN 0575          DPQRIN(1) = DLIN(1)
ISN 0576          DPQRIN(2) = DRIN(1)
ISN 0577          DPQRIN(3) = DPIN(1)
ISN 0578          DPQRIN(4) = DQIN(1)
ISN 0579          TERM(1) = FSP(3,1)*XLNGTH(1)
ISN 0580          TERM(2) = FSP(1,2)*XLNGTH(2)
ISN 0581          TERM(3) = FSP(2,3)*XLNGTH(3)
ISN 0582          TERM(4) = FSP(2,1)*XLNGTH(1)
ISN 0583          TERM(5) = FSP(3,2)*XLNGTH(2)
ISN 0584          TERM(6) = FSP(1,3)*XLNGTH(3)
          C CRASH MOMENTS                                                 CRS14130
ISN 0585          XC(4) = TERM(5)-TERM(3)
ISN 0586          XC(5) = TERM(6)-TERM(1)
ISN 0587          XC(6) = TERM(4)-TERM(2)
ISN 0588          CALL MATVEC(AI,DXYZ,DXYZPR,1)
ISN 0589          DO 260 K = 1,3
ISN 0590          IF(ISP(K).EQ.0) GO TO 260
ISN 0592          SUM = 0.0
ISN 0593          DO 270 J = 1,3
ISN 0594      270 SUM = SUM-FSP(J,K)*DXYZPR(J)
ISN 0595          CEIK(I,K) = CEIK(I,K)+SUM+TERM(K)*DPQRIN(K)-TERM(K+3)*DPQRIN(K+1)
ISN 0596      260 CONTINUE
          C                                                               CRS14170
ISN 0597          RETURN                                                  CRS14180
          C*******************************                                CRS14190
          C*******************************                                CRS14200
ISN 0598          ENTRY IC                                                CRS14210
          C*******************************                                CRS14220
```

Figure 108. (Continued)

```
                  C********************************                     CRS14230
      ISN 0599          DIMENSION XMPR(3),ABARPR(3,3),ANGDPR(3),DPR(3,3),AIDP(3,3),  CRS14240
                       1 AIC(3,3),ADPR(3,3),VJP(60,3),APR(3,3),VIP(3),XV(3)  CRS14250
      ISN 0600          EQUIVALENCE (PPR,XMPR(1)),(QPR,XMPR(2)),(RPR,XMPR(3)),  CRS14260
                       1 (PHIDPR,ANGDPR(1)),(THEDPR,ANGDPR(2)),(PSIDPR,ANGDPR(3))  CRS14270
      ISN 0601          WTOT = 0.0                                          CRS14280
      ISN 0602          DO 2010 I = 1,NM                                    CRS14290
      ISN 0603     2010 WTOT = WTOT+WGT(I)                                  CRS14300
      ISN 0604          XGDP = 0.0                                          CRS14310
      ISN 0605          YGDP = 0.0                                          CRS14320
      ISN 0606          ZGDP = 0.0                                          CRS14330
      ISN 0607          DO 2020 I = 1,NM                                    CRS14340
      ISN 0608          XGDP = XGDP+WGT(I)*XDP(I)                           CRS14350
      ISN 0609          YGDP = YGDP+WGT(I)*YDP(I)                           CRS14360
      ISN 0610     2020 ZGDP = ZGDP+WGT(I)*ZDP(I)                           CRS14370
      ISN 0611          XGDP = XGDP/WTOT                                    CRS14380
      ISN 0612          YGDP = YGDP/WTOT                                    CRS14390
      ISN 0613          ZGDP = ZGDP/WTOT                                    CRS14400
                  C APRIME AND ABARPRIME (3)                                CRS14410
      ISN 0614          CALL EULER(APR,PHIPR,THEPR,PSIPR)                   CRS14420
      ISN 0615          S1 = SIN(PHIPR)                                     CRS14430
      ISN 0616          C1 = COS(PHIPR)                                     CRS14440
      ISN 0617          S2 = SIN(THEPR)                                     CRS14450
      ISN 0618          C2 = COS(THEPR)                                     CRS14460
                  C NOW ABARPRIME (4)                                       CRS14470
      ISN 0619          ABARPR(1,1) = 1.0                                   CRS14480
      ISN 0620          ABARPR(2,1) = 0.0                                   CRS14490
      ISN 0621          ABARPR(3,1) = 0.0                                   CRS14500
      ISN 0622          ABARPR(1,2) = S1*S2/C2                              CRS14510
      ISN 0623          ABARPR(2,2) = C1                                    CRS14520
      ISN 0624          ABARPR(3,2) = S1/C2                                 CRS14530
      ISN 0625          ABARPR(1,3) = C1*S2/C2                              CRS14540
      ISN 0626          ABARPR(2,3) = -S1                                   CRS14550
      ISN 0627          ABARPR(3,3) = C1/C2                                 CRS14560
                  C ANGLE DOT PRIMES (6)                                    CRS14570
      ISN 0628          CALL MATVEC(ABARPR,XMPR,ANGDPR,0)                   CRS14580
                  C D PRIME (7)                                             CRS14590
      ISN 0629          DPR(1,1) = 0.0                                      CRS14600
      ISN 0630          DPR(1,2) = THEDPR*S1-PSIDPR*C1*C2                   CRS14610
      ISN 0631          DPR(1,3) = THEDPR*C1+PSIDPR*S1*C2                   CRS14620
      ISN 0632          DPR(2,1) = -DPR(1,2)                                CRS14630
      ISN 0633          DPR(2,2) = 0.0                                      CRS14640
      ISN 0634          DPR(2,3) = -PHIDPR-PSIDPR*S2                        CRS14650
      ISN 0635          DPR(3,1) = -DPR(1,3)                                CRS14660
      ISN 0636          DPR(3,2) = -DPR(2,3)                                CRS14670
      ISN 0637          DPR(3,3) = 0.0                                      CRS14680
                  C A DOT PRIME (8)                                         CRS14690
      ISN 0638          CALL MATMUL(APR,DPR,ADPR)                           CRS14700
      ISN 0639          ZCMAX = 0.0                                         CRS14710
                  C LOOP A                                                  CRS14720
      ISN 0640          DO 2040 I = 1,NM                                    CRS14730
                  C AI DOUBLE PRIME (9)                                     CRS14740
      ISN 0641          CALL EULER(AIDP,PHIDP(I),THEDP(I),PSIDP(I))         CRS14750
                  C AI (10)                                                 CRS14760
```

Figure 108. (Continued)

```
ISN 0642          CALL MATMUL(APR,AILP,AIC)                        CRS14770
ISN 0643          THETA(I) = -ARSIN(AIC(3,1))                      CRS14780
ISN 0644          CT = 1.0/COS(THETA(I))                           CRS14790
ISN 0645          PHI(I) = ARSIN(AIC(3,2)*CT)                      CRS14800
ISN 0646          PSI(I) = ARSIN(AIC(2,1)*CT)                      CRS14810
           C (12)                                                  CRS14820
ISN 0647          VJP(I,1) = XGDP-XDP(I)                           CRS14830
ISN 0648          VJP(I,2) = YGDP-YDP(I)                           CRS14840
ISN 0649          VJP(I,3) = ZGDP-ZDP(I)                           CRS14850
           C LOOP B                                                CRS14860
ISN 0650          DO 2050 K = 1,3                                  CRS14870
ISN 0651          IF(ISP(I,K)) 2060,2050,2060                      CRS14880
ISN 0652     2060 VC = AIC(3,K)*XL(BAR(I,K)                        CRS14890
ISN 0653          DO 2070 L = 1,3                                  CRS14900
ISN 0654     2070 VC = VC+APR(3,L)*VJP(I,L)                        CRS14910
ISN 0655          IF(VC-ZCMAX) 2050,2050,2080                      CRS14920
ISN 0656     2080 ZCMAX = VC                                       CRS14930
ISN 0657     2050 CONTINUE                                         CRS14940
           C END OF LOOP A                                         CRS14950
ISN 0658     2040 CONTINUE                                         CRS14960
ISN 0659          IF(ZC) 2220,2210,2220                            CRS14970
ISN 0660     2210 ZC = -ZCMAX-.01100                               CRS14980
           C SEE IF PHI'S, ETC. ARE ALL ZERO                       CRS14990
ISN 0661     2220 DO2100 I = 1,NM                                  CRS15000
ISN 0662          IF(PHIDP(I)) 2150,2110,2150                      CRS15010
ISN 0663     2110 IF(THEDP(I)) 2150,2120,2150                      CRS15020
ISN 0664     2120 IF(PSIDP(I)) 2150,2100,2150                      CRS15030
ISN 0665     2100 CONTINUE                                         CRS15040
           C IF WE GET HERE WE COMPUTE NEW THETA(I,J) AND PSI(I,J) CRS15050
ISN 0666          PI = 3.14159265358979324D0                       CRS15060
ISN 0667          PI2 = .500*PI                                    CRS15070
ISN 0668          DO 2160 IJ = 1,IGS                               CRS15080
ISN 0669          I = IG(IJ)                                       CRS15090
ISN 0670          J = JG(IJ)                                       CRS15100
ISN 0671          XIJP = VJP(J,1)-VJP(I,1)                         CRS15110
ISN 0672          YIJP = VJP(J,2)-VJP(I,2)                         CRS15120
ISN 0673          ZIJP = VJP(J,3)-VJP(I,3)                         CRS15130
ISN 0674          IF(YIJP) 2140,2130,2140                          CRS15140
ISN 0675     2130 IF(XIJP) 2180,2170,2180                          CRS15150
ISN 0676     2180 PSIIJ(IJ) = 0.0                                  CRS15160
ISN 0677          THEIJ(IJ) = -ATAN2(ZIJP,XIJP)                    CRS15170
ISN 0678          GO TO 2200                                       CRS15180
ISN 0679     2170 PSIIJ(IJ) = 0.0                                  CRS15190
ISN 0680          THEIJ(IJ) = -PI2                                 CRS15200
ISN 0681          IF(ZIJP) 2160,2200,2200                          CRS15210
ISN 0682     2160 THEIJ(IJ) = PI2                                  CRS15220
ISN 0683          GO TO 2200                                       CRS15230
ISN 0684     2140 PSIIJ(IJ) = ATAN2(YIJP,XIJP)                     CRS15240
ISN 0685          THEIJ(IJ) = -ATAN2(ZIJP,SQRT(XIJP*XIJP+YIJP*YIJP)) CRS15250
ISN 0686     2200 CONTINUE                                         CRS15260
           C LOOPC                                                 CRS15270
ISN 0687     2150 DO 2090 I = 1,NM                                 CRS15280
ISN 0688          VIP(1) = VJP(I,1)                                CRS15290
ISN 0689          VIP(2) = VJP(I,2)                                CRS15300
```

Figure 108. (Continued)

```
ISN 0690          VIP(3) = VJP(I,3)                                   CRS15310
            C (14)                                                     CRS15320
ISN 0691          CALL MATVEC(APR,VIP,XV,0)                            CRS15330
ISN 0692          XV(3) = XV(3)+ZG                                     CRS15340
ISN 0693          X(I) = XV(1)                                         CRS15350
ISN 0694          Y(I) = XV(2)                                         CRS15360
ISN 0695          Z(I) = XV(3)                                         CRS15370
            C (15)                                                     CRS15380
ISN 0696          CALL MATVEC(ADPR,VIP,XV,0)                           CRS15390
ISN 0697          XV(1) = XV(1)+XGDOT                                  CRS15400
ISN 0698          XV(2) = XV(2)+YGDOT                                  CRS15410
ISN 0699          XV(3) = XV(3)+ZGDOT                                  CRS15420
ISN 0700          XDOT(I) = XV(1)                                      CRS15430
ISN 0701          YDOT(I) = XV(2)                                      CRS15440
ISN 0702          ZDOT(I) = XV(3)                                      CRS15450
            C (16)                                                     CRS15460
ISN 0703          CALL MATVEC(AIC,XV,VIP,1)                            CRS15470
ISN 0704          U(I) = VIP(1)                                        CRS15480
ISN 0705          V(I) = VIP(2)                                        CRS15490
ISN 0706          W(I) = VIP(3)                                        CRS15500
            C (17)                                                     CRS15510
ISN 0707          CALL MATVEC(AIDP,XMPR,VIP,1)                         CRS15520
ISN 0708          P(I) = VIP(1)                                        CRS15530
ISN 0709          Q(I) = VIP(2)                                        CRS15540
ISN 0710          R(I) = VIP(3)                                        CRS15550
            C AIBAR (18)                                               CRS15560
ISN 0711          S1 = SIN(PHI(I))                                     CRS15570
ISN 0712          C1 = COS(PHI(I))                                     CRS15580
ISN 0713          S2 = SIN(THETA(I))                                   CRS15590
ISN 0714          C2 = COS(THETA(I))                                   CRS15600
ISN 0715          ABARPR(1,2) = S1*S2/C2                               CRS15610
ISN 0716          ABARPR(2,2) = C1                                     CRS15620
ISN 0717          ABARPR(3,2) = S1/C2                                  CRS15630
ISN 0718          ABARPR(1,3) = C1*S2/C2                               CRS15640
ISN 0719          ABARPR(2,3) = -S1                                    CRS15650
ISN 0720          ABARPR(3,3) = C1/C2                                  CRS15660
            C (19)                                                     CRS15670
ISN 0721          CALL MATVEC(ABARPR,VIP,XV,0)                         CRS15680
ISN 0722          PHIDOT(I) = XV(1)                                    CRS15690
ISN 0723          THEDOT(I) = XV(2)                                    CRS15700
ISN 0724          PSIDOT(I) = XV(3)                                    CRS15710
            C END LOOP C                                               CRS15720
ISN 0725     2090 CONTINUE                                             CRS15730
ISN 0726          PRINT 2301                                           CRS15740
ISN 0727     2301 FORMAT(1H0,'IJ,THEIJ(IJ),PSIIJ(IJ)' )                CRS15750
ISN 0728          PRINT 2300,(IJ,THEIJ(IJ),PSIIJ(IJ),IJ=1,IGS)         CRS15760
ISN 0729     2300 FORMAT (1H ,I5,1P2E15.5)                             CRS15770
ISN 0730          RETURN                                               CRS15780
            C********************************                          CRS15790
            C********************************                          CRS15800
ISN 0731          ENTRY PRINT                                          CRS15810
            C********************************                          CRS15820
            C********************************                          CRS15830
ISN 0732          REAL*4 KEI(60),PEI(60)
```

Figure 108. (Continued)

```
ISN 0733          DIMENSION VEE2(6,80)                                            CRS15840
ISN 0734          EQUIVALENCE (VEE(1),VEE2(1))                                    CRS15850
ISN 0735          ILINES = 60                                                     CRS15860
ISN 0736          IPL = 6                                                         CRS15870
ISN 0737          ITTL = 9                                                        CRS15880
            C FORCE NEW PAGE                                                      CRS15890
ISN 0738          NPK = 1000                                                      CRS15900
ISN 0739          DO 3099 I = 1,NM                                                CRS15910
ISN 0740          IF (ILINES-NPK-IPL) 3010,3020,3020                              CRS15920
ISN 0741     3010 PRINT 3100,TITLE                                                CRS15930
ISN 0742     3100 FORMAT(1H1,10A6,/)                                              CRS15940
ISN 0743          PRINT 3200,TIME                                                 CRS15950
ISN 0744     3200 FORMAT(1H ,6HTIME =,F9.5,/)                                     CRS15960
ISN 0745          PRINT 3300                                                      CRS15970
ISN 0746          PRINT 400                                                       CRS15980
ISN 0747          PRINT 500                                                       CRS15990
ISN 0748          PRINT 600                                                       CRS16000
ISN 0749          PRINT 900                                                       CRS16010
ISN 0750     3300 FORMAT(1H ,16X,1HX,14X,1HY,14X,1HZ,13X,3HPHI,11X,5HTHETA,       CRS16020
                1  11X,3HPSI)                                                     CRS16030
ISN 0751      400 FORMAT(1H ,17X,4HXDOT,11X,4HYDOT,11X,4HZDOT,10X,6HPHIDOT,       CRS16040
                1  8X,8HTHETADOT,8X,6HPSIDOT)                                     CRS16050
ISN 0752      500 FORMAT(1H ,16X,1HU,14X,1HV,14X,1HW,14X,1HP,14X,1HQ,14X,1HR)     CRS16060
ISN 0753      600 FORMAT(1H ,17X,4HUDOT,11X,4HVDOT,11X,4HWDOT,11X,4HPDOT,11X,     CRS16070
                1  4HQDOT,11X,4HRDOT)                                             CRS16080
ISN 0754      900 FORMAT (1H ,16X,6HXACCEL,9X,6HYACCEL,9X,6HZACCEL,/)             CRS16090
ISN 0755          NPK = ITTL                                                      CRS16100
ISN 0756     3020 NPK = NPK+IPL                                                   CRS16110
ISN 0757          PRINT 700, I,X(I),Y(I),Z(I),PHI(I),THETA(I),PSI(I)              CRS16120
ISN 0758          PRINT 800, XDOT(I),YDOT(I),ZDOT(I),PHIDOT(I),THEDOT(I),PSIDOT(I) CRS16130
ISN 0759          PRINT 800, U(I),V(I),W(I),P(I),Q(I),R(I)                        CRS16140
ISN 0760          PRINT 800, UDOT(I),VDOT(I),WDOT(I),PDOT(I),QDOT(I),RDOT(I)      CRS16150
ISN 0761          PRINT 800, XACC(I),YACC(I),ZACC(I)                              CRS16160
ISN 0762          PRINT 800                                                       CRS16170
ISN 0763      700 FORMAT(1H ,5HMASS ,I2,2X,1P6E15.5)                              CRS16180
ISN 0764      800 FORMAT(1H ,5X,1P6E15.5)                                         CRS16190
ISN 0765     3099 CONTINUE                                                        CRS16200
ISN 0766          PRINT 830                                                       CRS16210
ISN 0767      830 FORMAT(1H ,'IG(IJ),JG(IJ),SUMDF(1,IJ),SUMDF(2,IJ),SUMDF(3,IJ),'  CRS16220
                :  'SUMDF(4,IJ),SUMDF(5,IJ),SUMDF(6,IJ)')                         CRS16230
ISN 0768          PRINT 810,(IG(IJ),JG(IJ),(SUMDF(K,IJ),K=1,6),IJ=1,IGS)          CRS16240
ISN 0769          PRINT 831                                                       CRS16250
ISN 0770      831 FORMAT(1H ,'IG(IJ),JG(IJ),VEE2(1,IJ),VEE2(2,IJ),VEE2(3,IJ),VEE2(4,CRS16260
                1IJ),VEE2(5,IJ),VEE2(6,IJ)' )                                     CRS16270
ISN 0771          PRINT 810,(IG(IJ),JG(IJ),(VEE2(K,IJ),K=1,6),IJ=1,IGS)           CRS16280
ISN 0772      810 FORMAT (1H ,1X,I2,2X,I2,2X,1P6E15.5)                            CRS16290
ISN 0773          PRINT 832                                                       CRS16300
ISN 0774      832 FORMAT(1H ,'I,SC(I,1),SC(I,2),SC(I,3)' )                        CRS16310
ISN 0775          DO 3040 I = 1,NM                                                CRS16320
ISN 0776          DO 3050 J = 1,3                                                 CRS16330
ISN 0777          IF(ISP(I,J).NE.0) GO TO 3060                                    CRS16340
ISN 0779     3050 CONTINUE                                                        CRS16350
ISN 0780          GO TO 3040                                                      CRS16360
ISN 0781     3060 PRINT 820, I,(SC(I,J),J=1,3)                                    CRS16370
```

Figure 108. (Continued)

```
ISN 0762        820 FORMAT(1H ,I7,2X,1P3E15.5)                                 CRS16380
ISN 0763       3040 CONTINUE                                                   CRS16390
ISN 0764            ISET=0                                                     CRS16400
ISN 0765            DO 3070 I = 1,IGS                                          CRS16410
ISN 0766            IF(IJPR(I).EQ.BLANK) GO TO 3070                            CRS16420
ISN 0768            IF (ISET.EQ.1)  GO TO 3065                                 CRS16430
ISN 0790            PRINT 821                                                  CRS16440
ISN 0791        821 FORMAT(1H //1X,'MASS',7X,'DRI')                            CRS16450
ISN 0792            ISET=1                                                     CRS16460
ISN 0793       3065 PRINT 822, JG(I),DRI(I)                                    CRS16470
ISN 0794       3070 CONTINUE                                                   CRS16480
ISN 0795        822 FORMAT(1H ,1X,I2,3X,1PE15.5)                               CRS16490
ISN 0796            SUMKEI = 0.0
ISN 0797            SUMPEI = 0.0
ISN 0798            SUMSEI = 0.0
ISN 0799            SUMDEI = 0.0
ISN 0800            SUMCEI = 0.0
ISN 0801            DO 3400 I = 1,MM
               C*****DON'T USE AN I IF IT'S = TO A J OF A DRI I,J PAIR
ISN 0802            DO 3408 IJ = 1,IGS
ISN 0803            IF(IJPP(IJ).EQ.BLANK) GO TO 3408
ISN 0805            IF(I.NE.JG(IJ)) GO TO 3408
ISN 0807            PEI(I) = 0.0
ISN 0808            KEI(I) = 0.0
ISN 0809            GO TO 3400
ISN 0810       3408 CONTINUE
ISN 0811            PEI(I) = -WGT(I)*Z(I)
ISN 0812            SUMPEI = SUMPEI+PEI(I)
ISN 0813            KEI(I) = .5*(WGT(I)*(U(I)*U(I)+V(I)*V(I)+W(I)*W(I))/386.0
                   1 +P(I)*(P(I)* XI(I)+Q(I)*XYI(I)+R(I)*XZI(I))
                   2 +Q(I)*(P(I)*XYI(I)+Q(I)* YI(I)+R(I)*YZI(I))
                   3 +R(I)*(P(I)*XZI(I)+Q(I)*YZI(I)+R(I)* ZI(I)))
ISN 0814            SUMKEI = SUMKEI+KEI(I)
ISN 0815       3400 CONTINUE
ISN 0816            DO 3406 IJ = 1,IGS
ISN 0817            SUMSEI = SUMSEI+SEIJ(IJ)
ISN 0818       3406 SUMDEI = SUMDEI+DEIJ(IJ)
ISN 0819            IF(IKCT.EQ.0) GO TO 3409
ISN 0821            DO 3407 IK = 1,IKCT
ISN 0822       3407 SUMCEI = SUMCEI+CLIN(II(IK),KK(IK))
ISN 0823       3409 ETOT = SUMKEI+SUMPEI+SUMSEI+SUMDEI+SUMCEI
ISN 0824            PRINT 3401
ISN 0825       3401 FORMAT(1H0,6X,'TOTAL',7X,'KINETIC',6X,'POTENTIAL',7X,'STRAIN',7X,
                   1 'DAMPING',7X,'CRUSHING',/6X,'ENERGY',5(8X,'ENERGY')/)
ISN 0826            PRINT 3402, ETOT,SUMKEI,SUMPEI,SUMSEI,SUMDEI,SUMCEI
ISN 0827       3402 FORMAT(1X,1P6E14.5)
ISN 0828            PCKE = SUMKEI/ETOT
ISN 0829            PCPE = SUMPEI/ETOT
ISN 0830            PCSE = SUMSEI/ETOT
ISN 0831            PCDE = SUMDEI/ETOT
ISN 0832            PCCE = SUMCEI/ETOT
ISN 0833            PRINT 3403, PCKE,PCPE,PCSE,PCDE,PCCE
ISN 0834       3403 FORMAT('0  PERCENT OF',2P5F14.3/3X,'TOTAL ENERGY')
ISN 0835            PRINT 3404
```

Figure 108. (Continued)

```
ISN 0836      3404 FORMAT('1',50X,'INTERNAL',46X,'EXTERNAL'/53X,'BEAM',49X,'SPRING'/
                  1 7X,'KINETIC',15X,'POTENTIAL',26X,'STRAIN',17X,'DAMPING',20X,
                  2 'CRUSHING'/' MASS   ENERGY      PER CENT      ENERGY      PER CENT   I
                  3J   I   J     ENERGY      PER CENT      ENERGY      PER CENT    I K      ENER
                  4GY      PER CENT'/)
ISN 0837           MAXEN = MAX0(NM,IGS,IKCT)
ISN 0838           IF(TIME.EQ.0.0) MAXEN = NM
ISN 0840           DO 3410 IO = 1,MAXEN
ISN 0841           IOPTR = 0
ISN 0842           IF(IO.GT.NM) GO TO 3411
ISN 0844           IOPTR = IOPTR+4
ISN 0845           PCKE = KEI(IO)/SUMKEI
ISN 0846           PCPE = PEI(IO)/SUMPEI
ISN 0847           IF(TIME.EQ.0.0) GO TO 3504
ISN 0849      3411 IF(IO.GT.IGS) GO TO 3412
ISN 0851           IOPTR = IOPTR+2
ISN 0852           PCSE = SEIJ(IO)/SUMSEI
ISN 0853           PCDE = DEIJ(IO)/SUMDEI
ISN 0854      3412 IF(IO.GT.IKCT) GO TO 3413
ISN 0856           IOPTR = IOPTR+1
ISN 0857           I = II(IO)
ISN 0858           K = KK(IO)
ISN 0859           CE = CEIK(I,K)
ISN 0860           PCCE = CE/SUMCEI
ISN 0861      3413 GO TO (3501,3502,3503,3504,3505,3506,3507), IOPTR
             C******ONLY CE
ISN 0862      3501 PRINT 3511,I,K,CE,PCCE
ISN 0863      3511 FORMAT(165X,I3,I2,1PE13.5,2PF9.3)
ISN 0864           GO TO 3410
             C******SE AND DE
ISN 0865      3502 PRINT 3512,IO,IG(IO),JG(IO),SEIJ(IO),PCSE,DEIJ(IO),PCDE
ISN 0866      3512 FORMAT(51X,3I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3)
ISN 0867           GO TO 3410
             C******SE, DE, CE
ISN 0868      3503 PRINT 3513,IO,IG(IO),JG(IO),SEIJ(IO),PCSE,DEIJ(IO),PCDE,I,K,CE,
                  1 PCCE
ISN 0869      3513 FORMAT(51X,3I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3,I4,I2,1PE13.5,2PF9.3)
ISN 0870           GO TO 3410
             C******KE AND PE
ISN 0871      3504 PRINT 3514,IO,KEI(IO),PCKE,PEI(IO),PCPE
ISN 0872      3514 FORMAT(1X,I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3)
ISN 0873           GO TO 3410
             C******KE, PE, CE
ISN 0874      3505 PRINT 3515,IO,KEI(IO),PCKE,PEI(IO),PCPE,I,K,CE,PCCE
ISN 0875      3515 FORMAT(1X,I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3,58X,2I2,1PE13.5,2PF9.3)
ISN 0876           GO TO 3410
             C******KE, PE, SE, DE
ISN 0877      3506 PRINT 3516,IO,KEI(IO),PCKE,PEI(IO),PCPE,IO,IG(IO),JG(IO),SEIJ(IO),
                  1 PCSE,DEIJ(IO),PCDE
ISN 0878      3516 FORMAT(1X,I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3,2X,3I3,1PE13.5,2PF9.3,
                  1 1PE14.5,2PF9.3)
ISN 0879           GO TO 3410
             C******KE, PE, SE, DE, CE
ISN 0880      3507 PRINT 3517,IO,KEI(IO),PCKE,PEI(IO),PCPE,IO,IG(IO),JG(IO),SEIJ(IO),
```

Figure 108. (Continued)

```
                1 PCSE,DEIJ(10),PCDE,I,K,CE,PCCE
ISN 0881   3517 FORMAT(1X,I3,1PE13.5,2PF9.3,1PE14.5,2PF9.3,2X,3I3,1PE13.5,2PF9.3,
               1 1PE14.5,2PF9.3,I4,I2,1PE13.5,2PF9.3)
ISN 0882   3410 CONTINUE
ISN 0883        RETURN                                                          CRS16500
           C*********************************                                   CRS16510
           C*********************************                                   CRS16520
ISN 0884        ENTRY SAVE                                                      CRS16530
           C*********************************                                   CRS16540
           C*********************************                                   CRS16550
ISN 0885        REAL*4 PLOT,ZAK,TMPLOT                                          CRS16560
ISN 0886        IPLC = 0                                                        CRS16570
ISN 0887        JPLOT = JPLOT+1                                                 CRS16580
ISN 0888        IF(JPLOT.GT.IP) RETURN                                          CRS16590
ISN 0890        TMPLOT(JPLOT) = TIME                                            CRS16600
ISN 0891        DO 39 I = 1,NPLOT                                               CRS16610
ISN 0892        IS = IPLOT(I)                                                   CRS16620
ISN 0893        ID = IDPLOT(I)                                                  CRS16630
ISN 0894        GO TO (1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,   CRS16640
               1     22,23,24,25), ID                                           CRS16650
ISN 0895      1 T = X(IS)                                                       CRS16660
ISN 0896        GO TO 39                                                        CRS16670
ISN 0897      2 T = Y(IS)                                                       CRS16680
ISN 0898        GO TO 39                                                        CRS16690
ISN 0899      3 T = Z(IS)                                                       CRS16700
ISN 0900        GO TO 39                                                        CRS16710
ISN 0901      4 T = XDOT(IS)                                                    CRS16720
ISN 0902        GO TO 39                                                        CRS16730
ISN 0903      5 T = YDOT(IS)                                                    CRS16740
ISN 0904        GO TO 39                                                        CRS16750
ISN 0905      6 T = ZDOT(IS)                                                    CRS16760
ISN 0906        GO TO 39                                                        CRS16770
ISN 0907      7 T = XACC(IS)                                                    CRS16780
ISN 0908        GO TO 39                                                        CRS16790
ISN 0909      8 T = YACC(IS)                                                    CRS16800
ISN 0910        GO TO 39                                                        CRS16810
ISN 0911      9 T = ZACC(IS)                                                    CRS16820
ISN 0912        GO TO 39                                                        CRS16830
ISN 0913     10 T = SC(IS,1)                                                    CRS16840
ISN 0914        GO TO 39                                                        CRS16850
ISN 0915     11 T = SC(IS,2)                                                    CRS16860
ISN 0916        GO TO 39                                                        CRS16870
ISN 0917     12 T = SC(IS,3)                                                    CRS16880
ISN 0918        GO TO 39                                                        CRS16890
ISN 0919     13 T = VEE2(1,IS)                                                  CRS16900
ISN 0920        GO TO 39                                                        CRS16910
ISN 0921     14 T = VEE2(2,IS)                                                  CRS16920
ISN 0922        GO TO 39                                                        CRS16930
ISN 0923     15 T = VEE2(3,IS)                                                  CRS16940
ISN 0924        GO TO 39                                                        CRS16950
ISN 0925     16 T = VEE2(4,IS)                                                  CRS16960
ISN 0926        GO TO 39                                                        CRS16970
ISN 0927     17 T = VEE2(5,IS)                                                  CRS16980
ISN 0928        GO TO 39                                                        CRS16990
```

Figure 108. (Continued)

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ISN 0929      18 T = VEE2(6,IS)                                  CRS17000
ISN 0930         GO TO 39                                        CRS17010
ISN 0931      19 T = SUMDF(1,IS)                                 CRS17020
ISN 0932         GO TO 39                                        CRS17030
ISN 0933      20 T = SUMDF(2,IS)                                 CRS17040
ISN 0934         GO TO 39                                        CRS17050
ISN 0935      21 T = SUMDF(3,IS)                                 CRS17060
ISN 0936         GO TO 39                                        CRS17070
ISN 0937      22 T = SUMDF(4,IS)                                 CRS17080
ISN 0938         GO TO 39                                        CRS17090
ISN 0939      23 T = SUMDF(5,IS)                                 CRS17100
ISN 0940         GO TO 39                                        CRS17110
ISN 0941      24 T = SUMDF(6,IS)                                 CRS17120
ISN 0942         GO TO 39                                        CRS17130
ISN 0943      25 T=DRI(IS)                                       CRS17140
ISN 0944      39 PLOT(IP*(I-1)+JPLOT) = T                        CRS17150
ISN 0945         RETURN                                          CRS17160
ISN 0946         END                                             CRS17170
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Figure 108. (Continued)

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LEVEL 20.1 (MAY 71)                    OS/360  FORTRAN H                    DATE  73.298/10.03.38

      COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=56,SIZE=0000K,
                         SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
ISN 0002          SUBROUTINE TCLP                                                  CRS17180
ISN 0003          IMPLICIT REAL*8 (A-H,O-Z)                                        CRS17190
ISN 0004          REAL*4 DELX,DELY,DLX,DLY,XFMT,YFMT,YMIN,YMAX,XMIN,XMAX           CRS17200
ISN 0005          REAL*4 PLOT,ZAR,TMPLOT                                           CRS17210
ISN 0006          INTEGER*2 IJPR,      IDPLOT,   ISP,   N,NN                       CRS17220
ISN 0007          DIMENSION IYCHAR(3),LIT(3),NAMES(25)                             CRS17230
ISN 0008          COMMON/COMALL/ C(6,60),P(60),Q(60),R(60),U(60),V(60),W(60),X(60), CRS00160
                 1 Y(60),Z(60),AI(9),AJ(9),FM(2880),SC(60,3),XC(6),XK(2880),XI(60), CRS00170
                 2 YI(60),ZI(60),XYI(60),XZI(60),YZI(60),AIJ(9),BIJ(540),OIJ(720),  CRS00180
                 3 DKS(60),UAI(540),VFF(480),WGT(60),PHI(60),THETA(60),PSI(60),    CRS00190
                 4 PDOT(60),QDOT(60),RDOT(60),UDOT(60),VDOT(60),WDOT(60),XDOT(60), CRS00200
                 5 YDOT(60),ZDOT(60),PHIDOT(60),THEDOT(60),PSIDOT(60),TIME,DELTAT, CRS00210
                 6 XACC(60),YACC(60),ZACC(60),AITAJ(9),AIDOT(9),FMBAR(2880),       CRS00220
                 7 PHIIJ(60),THEIJ(60),PSIIJ(60),SUMDF(6,60),TITLE(10),XLBAR(60,3), CRS00230
                 8 FSPBAR(60,3),VEEDOT(3,3),DX(60),DY(60),DZ(60),DPIN(60),DRIN(60), CRS00240
                 8 DOIN(60),SEIJ(60),CEIJ(60),CEIK(60,3),
                 9ZAR(200),PLOT(30000),TMPLOT(500),                                CRS17330
                 ANN,IGS,JPLOT,NPLOT,IPLSW,IP,IPLC,I,J,IPLOT(150),IG(80),JG(80),  CRS17340
                 B N(420),NN(60,3),ISP(60,3),IJPR(60),IDPLOT(150)                   CRS00270
ISN 0009          DATA LIT/'(   )',' (   ',',  )'/                                  CRS17370
ISN 0010          DATA NAMES/' X   ',' Y   ',' Z   ','XDOT','YDOT','ZDOT',         CRS17380
                 1            ' AX ',' AY ',' AZ ',' S1 ',' S2 ',' S3 ',            CRS17390
                 2            ' V1 ',' V2 ',' V3 ',' V4 ',' V5 ',' V6 ',            CRS17400
                 3            ' F1 ',' F2 ',' F3 ',' F4 ',' F5 ',' F6 ',            CRS17410
                 3            ' DRI'/                                                CRS17420
ISN 0011          IYCHAR(3) = LIT(3)                                               CRS17430
ISN 0012          IF(JPLOT.GT.IP) JPLOT = IP                                       CRS17440
ISN 0014          XMIN = TMPLOT(1)                                                 CRS17450
ISN 0015          XMAX = TMPLOT(JPLOT)                                             CRS17460
ISN 0016          IF(XMIN.EQ.XMAX) RETURN                                          CRS17470
               C IF 1ST TIME INITIALIZE                                            CRS17480
ISN 0018          IF(IPLSW.NE.0) GO TO 4005                                        CRS17490
ISN 0020          IPLSW = 1                                                        CRS17500
ISN 0021          CALL MODESG(ZAR,0)                                               CRS17510
ISN 0022          CALL SETSMG(ZAR,93,0.0)                                          CRS17520
ISN 0023          CALL SETSMG(ZAR,97,150.0)                                        CRS17530
ISN 0024          CALL SETSMG(ZAR,100,2.0)                                         CRS17540
ISN 0025     4005 IYCHAR(2) = LIT(1)                                               CRS17550
ISN 0026          NY = 8                                                           CRS17560
ISN 0027          DO 4010 I = 1,NPLOT                                              CRS17570
ISN 0028          IF (IDPLOT(I).EQ.25)  GO TO 4015                                 CRS17580
```

Figure 108. (Continued)

```
ISN 0030          IF(IDPLOT(I).LE.12) GO TO 4020                            CRS17590
ISN 0032          NY = 12                                                   CRS17600
ISN 0033          IYCHAR(2) = LIT(2)                                        CRS17610
ISN 0034          CALL FMTSG(ZAR,1,4,0,IG(IPLOT(I)),IBUF)                   CRS17620
ISN 0035          CALLGETCZZ(ZAR,IHOLD,3,IBUF)                              CRS17630
ISN 0036          CALLPUTCZZ(ZAR,IHOLD,3,IYCHAR(2))                         CRS17640
ISN 0037          CALLGETCZZ(ZAR,IHOLD,4,IBUF)                              CRS17650
ISN 0038          CALLPUTCZZ(ZAR,IHOLD,4,IYCHAR(2))                         CRS17660
ISN 0039          CALL FMTSG(ZAR,1,4,0,JG(IPLOT(I)),IBUF)                   CRS17670
ISN 0040          CALLGETCZZ(ZAR,IHOLD,3,IBUF)                              CRS17680
ISN 0041          CALLPUTCZZ(ZAR,IHOLD,2,IYCHAR(3))                         CRS17690
ISN 0042          CALLGETCZZ(ZAR,IHOLD,4,IBUF)                              CRS17700
ISN 0043          CALLPUTCZZ(ZAR,IHOLD,3,IYCHAR(3))                         CRS17710
ISN 0044          GO TO 4030                                                CRS17720
ISN 0045     4015 CALL FMTSG(ZAR,1,4,0,JG(IPLOT(I)),IBUF)                   CRS17730
ISN 0046          IYCHAR(2)=LIT(1)                                          CRS17740
ISN 0047          NY=8                                                      CRS17750
ISN 0048          GO TO 4025                                                CRS17760
ISN 0049     4020 CALL FMTSG(ZAR,1,4,0,IPLOT(I),IBUF)                       CRS17770
ISN 0050     4025 CALLGETCZZ(ZAR,IHOLD,3,IBUF)                              CRS17780
ISN 0051          CALLPUTCZZ(ZAR,IHOLD,2,IYCHAR(2))                         CRS17790
ISN 0052          CALLGETCZZ(ZAR,IHOLD,4,IBUF)                              CRS17800
ISN 0053          CALLPUTCZZ(ZAR,IHOLD,3,IYCHAR(2))                         CRS17810
ISN 0054     4030 IYCHAR(1) = NAMES(IDPLOT(I))                              CRS17820
ISN 0055          YMIN = PLOT(IP*(I-1)+1)                                   CRS17830
ISN 0056          YMAX = YMIN                                               CRS17840
ISN 0057          DO 4040 J = 2,JPLOT                                       CRS17850
ISN 0058          YMIN = AMIN1(YMIN,PLOT(IP*(I-1)+J))                       CRS17860
ISN 0059     4040 YMAX = AMAX1(YMAX,PLOT(IP*(I-1)+J))                       CRS17870
ISN 0060          IF (ABS(YMAX-YMIN).GT.1.E-7*ABS(YMAX))  GO TO 4050        CRS17880
ISN 0062          IF (ABS(YMAX).GT.1.E-7)  GO TO 4045                       CRS17890
ISN 0064          YMAX=1.                                                   CRS17900
ISN 0065          YMIN=-1.                                                  CRS17910
ISN 0066          GO TO 4050                                                CRS17920
ISN 0067     4045 YMAX=YMAX+0.1*YMAX                                        CRS17930
ISN 0068          YMIN=YMIN-0.1*YMIN                                        CRS17940
ISN 0069     4050 CONTINUE                                                  CRS17950
ISN 0070          CALL SUBJEG(ZAR,XMIN,YMIN,XMAX,YMAX)                      CRS17960
ISN 0071          CALL SETUPG(ZAR,1,DELX,DELY,IXTH,JYTH,DLX,DLY,XFMT,YFMT)  CRS17970
ISN 0072          DO 4060 J = 106,109                                       CRS17980
ISN 0073     4060 ZAR(J) = 0.0                                              CRS17990
ISN 0074          CALL GRIDG(ZAR,DELX,DELY,IXTH,JYTH)                       CRS18000
ISN 0075          CALL SETSMG(ZAR,45,1.0)                                   CRS18010
ISN 0076          CALL LABELG(ZAR,0,DLX,0,XFMT)                             CRS18020
ISN 0077          CALL LABELG(ZAR,1,DLY,0,YFMT)                             CRS18030
ISN 0078          CALL SETSMG(ZAR,45,1.5)                                   CRS18040
ISN 0079          CALL TITLEG(ZAR,14,14HTIME (SECONDS),NY,IYCHAR,70,TITLE)  CRS18050
ISN 0080          CALL LINESG(ZAR,JPLOT,TMPLOT,PLOT(IP*(I-1)+1))            CRS18060
            C NEW FRAME                                                     CRS18070
ISN 0081          CALL PAGEG(ZAR,0,1,1)                                     CRS18080
ISN 0082     4010 CONTINUE                                                  CRS18090
ISN 0083          RETURN                                                    CRS18100
ISN 0084          END                                                       CRS18110
```

Figure 108. (Continued)

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LEVEL 20.1 (MAY 71)                    OS/360  FORTRAN H                         DATE  73.298/10.03.44

        COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=56,SIZE=0000K,
                          SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
  ISN 0002        SUBROUTINE EULER(A,PHI,THETA,PSI)                              CRS18120
  ISN 0003        IMPLICIT REAL*8 (A-H,O-Z)                                      CRS18130
  ISN 0004        DIMENSION A(9)                                                 CRS18140
  ISN 0005        SIN(X) = DSIN(X)                                               CRS18150
  ISN 0006        COS(X) = DCOS(X)                                               CRS18160
  ISN 0007        S1 = SIN(PHI)                                                  CRS18170
  ISN 0008        C1 = COS(PHI)                                                  CRS18180
  ISN 0009        S2 = SIN(THETA)                                                CRS18190
  ISN 0010        C2 = COS(THETA)                                                CRS18200
  ISN 0011        S3 = SIN(PSI)                                                  CRS18210
  ISN 0012        C3 = COS(PSI)                                                  CRS18220
  ISN 0013        A(1) =  C2*C3                                                  CRS18230
  ISN 0014        A(2) =  C2*S3                                                  CRS18240
  ISN 0015        A(3) = -S2                                                     CRS18250
  ISN 0016        A(4) = -C1*S3+S1*S2*C3                                         CRS18260
  ISN 0017        A(5) =  C1*C3+S1*S2*S3                                         CRS18270
  ISN 0018        A(6) =  S1*C2                                                  CRS18280
  ISN 0019        A(7) =  S1*S3+C1*S2*C3                                         CRS18290
  ISN 0020        A(8) = -S1*C3+C1*S2*S3                                         CRS18300
  ISN 0021        A(9) =  C1*C2                                                  CRS18310
  ISN 0022        RETURN                                                         CRS18320
  ISN 0023        END                                                            CRS18330
```

Figure 108. (Continued)

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LEVEL 20.1 (MAY 71)                 OS/360  FORTRAN H                         DATE  73.298/10.03.54

        COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=56,SIZE=0000K,
                          SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
  ISN 0002             SUBROUTINE MATMUL(A,B,C)                            CRS18340
  ISN 0003             IMPLICIT REAL*8 (A-H,O-Z)                           CRS18350
  ISN 0004             DIMENSION A(3,3),B(3,3),C(3,3)                      CRS18360
                C A*B TO C                                                 CRS18370
  ISN 0005             DO 10 I = 1,3                                       CRS18380
  ISN 0006             DO 10 J = 1,3                                       CRS18390
  ISN 0007             SUM = 0.0                                           CRS18400
  ISN 0008             DO 20 K = 1,3                                       CRS18410
  ISN 0009          20 SUM = SUM+A(I,K)*B(K,J)                             CRS18420
  ISN 0010          10 C(I,J) = SUM                                        CRS18430
  ISN 0011             RETURN                                              CRS18440
  ISN 0012             END                                                 CRS18450
```

Figure 108. (Continued)

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LEVEL 20.1 (MAY 71)                 OS/360  FORTRAN H                          DATE  73.296/10.04.05

COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=56,SIZE=0000K,
                   SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,XREF
 ISN 0002          SUBROUTINE MATVEC(A,V,P,ISW)                          CRS18460
 ISN 0003          IMPLICIT REAL*8 (A-H,O-Z)                             CRS18470
 ISN 0004          DIMENSION A(3,3),V(3),P(3)                            CRS18480
             C A*V TO P IF ISW = 0, ELSE AT*V TO P                       CRS18490
 ISN 0005          DO 10 I = 1,3                                         CRS18500
 ISN 0006          SUM = 0.0                                             CRS18510
 ISN 0007          DO 20 K = 1,3                                         CRS18520
 ISN 0008          IF(ISW) 40,30,40                                      CRS18530
 ISN 0009       30 SUM = SUM+A(I,K)*V(K)                                 CRS18540
 ISN 0010          GO TO 20                                              CRS18550
 ISN 0011       40 SUM = SUM+A(K,I)*V(K)                                 CRS18560
 ISN 0012       20 CONTINUE                                              CRS18570
 ISN 0013       10 P(I) = SUM                                            CRS18580
 ISN 0014          RETURN                                                CRS18590
 ISN 0015          END                                                   CRS18600
```

Figure 108. (Continued)

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LIST OF SYMBOLS

SUBSTRUCTURE ANALYSIS

A	area; for stiffened panel, area of stiffener plus area of sheet corresponding to stiffener spacing, $in.^2$
a	plate length, in.
A_s	area of stiffener, $in.^2$
A_w	area of web, $in.^2$
b_s	width of skin, in.
b_w	width of stiffener web, in.
C	constant (= 3.0)
c	number of cuts
d	rivet diameter, in.
E	modulus of elasticity, psi
e, e_o	distance to neutral axis, in.
f	number of flanges
f_{cr}	crush strength, lb
f_w	effective rivet off-set, in.
G	acceleration level
g	gravity term = 386.2 $in./sec^2$
H	distance, in.
I	moment of inertia, $in.^4$
I_o	moment of inertia about c.g., $in.^4$
K	eccentricity factor
KE	kinetic energy, in.-lb
K_w	wrinkling coefficient
L, ℓ	one-half column length, in.
L'	effective length $= L/\sqrt{C}$, in.
M	effective moment, in.-lb

SUBSTRUCTURE ANALYSIS

M_p	plastic hinge moment, in.-lb
N/A	neutral axis
N	effective axial force, lb
N_p	plastic hinge axial force, lb.
p	rivet pitch, in.
P	applied axial force, lb
P_f	monolithic failure load, lb
P_{f_w}	wrinkling failure load, lb
q	distributed load, lb/in.
S	stopping distance, core radius of given cross section, in.
s	distance from midcross-section of skin to neutral axis of stiffener, in.
T	ratio of σ/σ_{cy}
T_{cr}	ratio of critical stress (σ_{cr}) to yield stress (σ_{cy})
t_c	minimum core thickness, in.
t_s	skin thickness, in.
$\bar{t}_w$	stiffener thickness, in.
V	impact velocity, in./sec
W	weight, lb
w_e	effective half width of skin, in.
y	lateral deflection
Z	function of column length and end shortening, in.
α	defined in equation 51
η	plasticity reduction factor
$\bar{\eta}$	cladding reduction factor
π	P_i = 3.14
θ	$\tan^{-1} Z$
ρ	radius of gyration $= \sqrt{I/A}$, in.
γ	partial derivative

δu	incremental displacement
δ, Δ, u	displacement, end shortening
ν	Poisson's ratio
x	distance to c.g., in.
σ	compressive stress, psi
σ_b	stress at outermost fiber of sheet skin, psi
σ_{co}	column buckling stress, psi
σ_{cr}	buckling stress, psi
σ_{cy}	compressive yield stress, psi
$\bar{\sigma}_{cy}$	effective compressive yield stress, psi
σ_{cy_w}	effective compressive yield stress for stiffener web, psi
σ_{cy_s}	effective compressive yield stress for skin, psi
σ_e	Euler stress, psi
σ_f	crippling (or failure) stress, psi
σ_{fr}	failure stress of riveted panel, psi
σ_w	failure stress due to wrinkling mode, psi
σ_{zo}	buckling stress at $L'/\rho = 20$

Subscripts:

b	bending
f	filler
i	i^{th} segment
max.	maximum
min.	minimum
p	plastic state
s	skin or sheet
w	stiffener web

SUBSTRUCTURE ANALYSIS (Continued)

Constants (function of stiffened panel configuration)

β_f

β_g

g

m

n

PROGRAM "KRASH"

$[A_i]$	rotational transformation matrix from body axes to ground axes
$[A_i]^T$	transpose of A_i matrix
CE	total crash spring (external spring) energy absorbed
DE	total damping energy dissipated
DRI	dynamic response index
E_{TOT}	total system energy
$FD_{ij\ell}$	internal beam damping force (or moment) for the ij^{th} beam in the ℓ^{th} direction
FSP_{ijk}	crash spring forces; spring ij in the k^{th} direction
$F_{ij\ell}$	force (or moment) at point j due to beam ij, in the ℓ^{th} direction
I_{xi}, I_{yi}, I_{zi}	moments of inertia of lumped mass m_i about i^{th} body fixed axes
I_{xyi}, I_{yzi}, I_{zxi}	product of inertia of lumped mass m_i about i^{th} body axes
KE	total kinetic energy
ℓ_{ik}	length of vector from m_i to ground contact point C'_{ik}
m_i	i^{th} lumped mass
N	number of lumped masses
PE	total potential energy
SE	total strain energy absorbed
$TERM_{ij}$	term in expression for crash spring energy

W_i	weight of i^{th} lumped mass
x_i, y_i, z_i	ground coordinates of m_i
u_i, v_i, w_i	i^{th} body axes component of absolute translational velocity vector of mass i
p_i, q_i, r_i	i^{th} body axes components of absolute angular velocity vector of mass i
$\begin{Bmatrix} X_{ci}, Y_{ci}, Z_{ci} \\ L_{ci}, M_{ci}, N_{ci} \end{Bmatrix}$	crash (external) forces and moments, i^{th} body axes
$\Delta x_i', \Delta y_i', \Delta z_i'$	$= \{\Delta vc_i\}$, incremental displacement of point i, i^{th} body axes
$\Delta inp_i, \Delta inq_i, \Delta inr_i$	incremental rotation of point i, i^{th} body axes
$\Delta vb_{ij\ell}$	incremental displacement vector of point j with respect to point i, due to deformation of beam ij, in the ℓ^{th} direction

USER'S GUIDE AND REFERENCE 1 TERMS

A_i, B_i, C_i	Terms used in Euler's equations of motion
$[A_i]$	Rotation transformation matrix from body axes to ground axes
$[\bar{A}_i]$	Matrix relating $(\dot{\phi}_i, \dot{\theta}_i, \dot{\psi}_i)$ to (p_i, q_i, r_i) in equation (92)
$[\dot{A}_i]$	Time derivative of $[A_i]$
$[A_i'']$	Rotation transformation matrix from ith body axes to c.g. axes
$[A_{ij}]$	Rotation transformation matrix from beam ij axes to body i axes
$[A']$	Rotation transformation matrix from c.g. axes to ground axes
$[\bar{A}']$	Matrix relating $(\dot{\phi}', \dot{\theta}', \dot{\psi}')$ to (p', q', r') in equation (88)
C_{ik}	End point of kth spring on ith mass
C'_{ik}	Ground contact point of kth spring on ith mass
dvc_{ijk}	Ground axes components of vector from m_i to C_{ik}
dvc'_{ijk}	Ground axes components of vector for C'_{ik} to C_{ik}
$[D_i]$	Derivative matrix
$[D']$	Derivative matrix
FM_{ijkl}	Running time sum of ΔFM_{ijkl}
$\overline{FM}_{ijkl}$	Value of FM_{ijkl} at time of loading reversal
FSP_{ijk}	Body i axes components of spring force at ground contact point C'_{ik}
$FSPO_{ik}$	Axial compressive force in kth spring on ith mass
$\overline{FSPO}_{ik}$	Value of $FSPO_{ik}$ at time of loading reversal

USER'S GUIDE AND REFERENCE 1 TERMS

$FSPO_{Fik}$	Final value of $FSPO_{ik}$ in input table of s_{ik} vs. $FSPO_{ik}$
G	Center-of-gravity of total vehicle
H	Origin of helicopter coordinate system (F.S.0, B.L.0, W.L.0)
He_{xi}, He_{yi}, He_{zi}	Angular momenta of mi due to rotation of masses internal to m_i
I_{xi}, I_{yi}, I_{zi}	Moments of inertia of lumped mass mi, about ith body fixed axes
I_{xyi}, I_{yzi}, I_{zxi}	Products of inertia of lumped mass m_i, about ith body fixed axes
ke_{ik}	Linear unloading stiffness for kth spring
$[K_{ij}]$	Six by six linear stiffness matrix for beam ij
$[KR_{ij}]$	Six by six diagonal stiffness reduction matrix for beam ij
l_{ik}	Length of vector from m_i to ground contact point C'_{ik}
$\bar{l}_{xi}$, $\bar{l}_{yi}$, $\bar{l}_{zi}(\bar{l}_{ik})$	Free length of kth spring on ith mass
l_{ci}	Aerodynamic lift constant
$LIFT_i$	Aerodynamic lift on m_i, positive up, in ground axes
m_i	ith lumped mass
mu_{ik}	Ground-spring friction coefficient for kth spring on ith mass
N	Total number of lumped masses
$\bar{n}_{ik}$	Unit vector triad fixed in ith body coordinate system
$\bar{n}_x$, $\bar{n}_y$, $\bar{n}_z$	Unit vector triad fixed in ground coordinate system
O	Origin of ground coordinate system

USER'S GUIDE AND REFERENCE 1 TERMS

p_i, q_i, r_i	ith body axes components of absolute angular velocity vector of mass i
p', q', r'	c.g. axes components of initial(t=0) vehicle angular velocity vector
$[pl_i]$	Contact point velocity matrix used in equation (60)
s_{ik}	Axial external spring compression, kth spring on ith mass
$\bar{s}_{ik}$	Value of s_{ik} at time of loading reversal
sF_{ik}	Final value of s_{ik} in input table of s_{ik} vs. $FSPO_{ik}$
s'_{ik}	kth spring axial compression measured relative to current load stroke curve origin
s''_{ik}	Horizontal shift of s'_{ik} coordinates with respect to S_{ik} coordinates
t	Time
$[T_{ij}]$	Static balance matrix used in equation (30b)
u_i, v_i, w_i	Body i axes components of absolute translational velocity vector of point m_i
va_{ij}	x_i, y_i, z_i
vb_{ij}	Running time sum of Δvb_{ij}
$\overline{vb}_{ijl}$	Value of vb_{ijl} at time of loading reversal
$\bar{v}_{ik}$	Magnitude of ground plane contact point velocity
vb'_{ijl}	lth total beam deflection measured relative to current load-stroke curve origin
vb''_{ijl}	Horizontal shift of vb'_{ijl} coordinates with respect to vb_{ijl} coordinates
vc_{ijk}	Ground coordinates of point C_{ik}

$\dot{vcp}_{ijk}$	Ground axes components of absolute velocity of ground contact point C'_{ik}
$\overset{m_i \rightarrow c'}{V}$	Velocity vector of C'_{ik} with respect to m_i
$\overset{o \rightarrow c'}{V}$	Velocity vector of C'_{ik} with respect to ground
$\overset{o \rightarrow m_i}{V}$	Velocity vector of m_i with respect to ground
W_i	Weight of ith lumped mass
W_{TOT}	Total vehicle weight
xb_{ij}, yb_{ij}, zb_{ij}	Beam ij coordinates
x_G, y_G, z_G (vg_j)	Ground coordinates of initial (t = o) c.g. position
$\dot{x}_G$, $\dot{y}_G$, $\dot{z}_G$	Ground axes components of initial (t = o) c.g. velocity vector
x''_G, y''_G, z''_G ($vgpp_{ij}$)	Helicopter axes coordinates of vehicle c.g. (point G)
x_i, y_i, z_i (vm_{ij})	Ground coordinates of m_i
x'_i, y'_i, z'_i (vip_{ij})	Coordinates of m_i in center-of-gravity coordinate system
x''_i, y''_i, z''_i ($vipp_{ij}$)	Coordinates of m_i in helicopter coordinate system
x_{ij}, y_{ij}, z_{ij}	Ground coordinates of vector from point i to point j
x'_{ij}, y'_{ij}, z'_{ij}	ith body coordinates of vector from point i to point j
$\begin{pmatrix} X'_{ij}, & Y'_{ij}, & Z'_{ij} \\ L'_{ij}, & M'_{ij}, & N'_{ij} \end{pmatrix}$	Total (summed over time) internal forces and moments at point i due to beam ij, i^{th} body axes
$\begin{pmatrix} X'_{ji}, & Y'_{ji}, & Z'_{ji} \\ L'_{ji}, & M'_{ji}, & N'_{ji} \end{pmatrix}$	Total (summed over time) internal forces and moments at point j due to beam ij, j^{th} body axes

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$\begin{pmatrix} X_i, & Y_i, & Z_i \\ L_i, & M_i, & N_i \end{pmatrix}$	Total forces and moments on mass i, in ith body axes
X_{Ai} Y_{Ai}, Z_{Ai}	Aerodynamic forces, i^{th} body axes
$\begin{pmatrix} X_{Ci}, & Y_{Ci}, & Z_{Ci} \\ L_{Ci}, & M_{Ci}, & N_{Ci} \end{pmatrix}$	Crash (external) forces and moments, i^{th} body axes
X_{Gi}, Y_{Gi}, Z_{Gi}	Gravity forces, i^{th} body axes
$\begin{pmatrix} X_{Ii}, & Y_{Ii}, & Z_{Ii} \\ L_{Ii}, & M_{Ii}, & N_{Ii} \end{pmatrix}$	Internal forces and moments, i^{th} body axes
$XVOC_{ijk}$	Ground axes components of spring force at ground contact point C'_{ik}, positive up, left and aft
zc_{MAX}	Vertical distance from c.g. to lowest C'_{ik}
Δi	Determinate expression used in equation (68)
ΔF_{ijk}	Incremental forces and moments at point j due to beam ij
ΔFM_{ijkl}	kth incremental load due to lth incremental deflection for beam ij
$\Delta\phi b_{ij}$, $\Delta\theta b_{ij}$, $\Delta\psi b_{ij}$	Incremental rotations of point j with respect to point i, in beam ij axes
$\Delta\phi_i$, $\Delta\theta_i$, $\Delta\psi_i$	Incremental change in ith mass Euler angles
Δt	Numerical integration time interval
Δvb_{ij}	Six element vector made up of Δxb_{ij}, Δyb_{ij}, Δzb_{ij}, $\Delta\phi b_{ij}$, $\Delta\theta b_{ij}$, $\Delta\psi b_{ij}$
$\overrightarrow{\Delta vb_{ij}}$	Incremental displacement vector of point j with respect to point i, due to deformation of beam ij
$\overrightarrow{\Delta vd_{ij}}$	Incremental displacement vector of point j with respect to point i

$\overrightarrow{\Delta vr}_{ij}$	Incremental displacement vector of point j with respect to point i, due to rotation of mass i
$\Delta xb_{ij}, \Delta yb_{ij}, \Delta zb_{ij}$	Coordinates of $\overrightarrow{\Delta vb}_{ij}$ in beam ij axes
$\Delta x_i, \Delta y_i, \Delta z_i$	Incremental displacement of point i, ground axes
$\Delta x_{ij}, \Delta y_{ij}, \Delta z_{ij}$	Incremental displacement of point j with respect to point i in ground axes
$\begin{pmatrix} \Delta X_{ij}, \Delta Y_{ij}, \Delta Z_{ij} \\ \Delta L_{ij}, \Delta M_{ij}, \Delta N_{ij} \end{pmatrix}$	Incremental internal forces and moments at point j due to beam ij, in beam ij axes (elements of ΔF_{ij} vector)
$\begin{pmatrix} \Delta X^o_{ij}, \Delta Y^o_{ij}, \Delta Z^o_{ij} \\ \Delta L^o_{ij}, \Delta M^o_{ij}, \Delta N^o_{ij} \end{pmatrix}$	Incremental internal forces and moments at point j due to beam ij, ground axes
$\begin{pmatrix} \overline{\Delta X^o_{ij}}, \overline{\Delta Y^o_{ij}}, \overline{\Delta Z^o_{ij}} \\ \overline{\Delta L^o_{ij}} \; \overline{\Delta M^o_{ij}} \; \overline{\Delta N^o_{ij}} \end{pmatrix}$	Incremental internal forces and moments at point i due to beam ij ,ground axes
$\begin{pmatrix} \Delta X'_{ij}, \Delta Y'_{ij}, \Delta Z'_{ij} \\ \Delta L'_{ij}, \Delta M'_{ij}, \Delta N'_{ij} \end{pmatrix}$	Incremental internal forces and moments at point i due to beam ij, i^{th} body axes
$\begin{pmatrix} \Delta X'_{ji}, \Delta Y'_{ji}, \Delta Z'_{ji} \\ \Delta L'_{ji}, \Delta M'_{ji}, \Delta N'_{ji} \end{pmatrix}$	Incremental internal forces and moments at point j due to beam ij, j^{th} body axes
ϕ_i, θ_i, ψ_i	Euler angles from ground axes to body axes (time varying)
$\phi_{ij}, \theta_{ij}, \psi_{ij}$	Euler angles from ith body axes to beam ij axes (constant)
ϕ', θ', ψ'	Euler angles from ground axes to c.g. axes (constant); initial (t=o) attitude of vehicle
$\phi''_i, \theta''_i, \psi''_i$	Euler angles from c.g. axes to ith body axes (constant)

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