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LIGHTWEIGHT TOWED HOWITZER DEMONSTRATOR PHASE 1 AND
 PARTIAL PHASE 2 VOLUM (U) FMC CORP MINNEAPOLIS MINN
 NORTHERN ORDNANCE DIV R RATHE ET AL APR 87

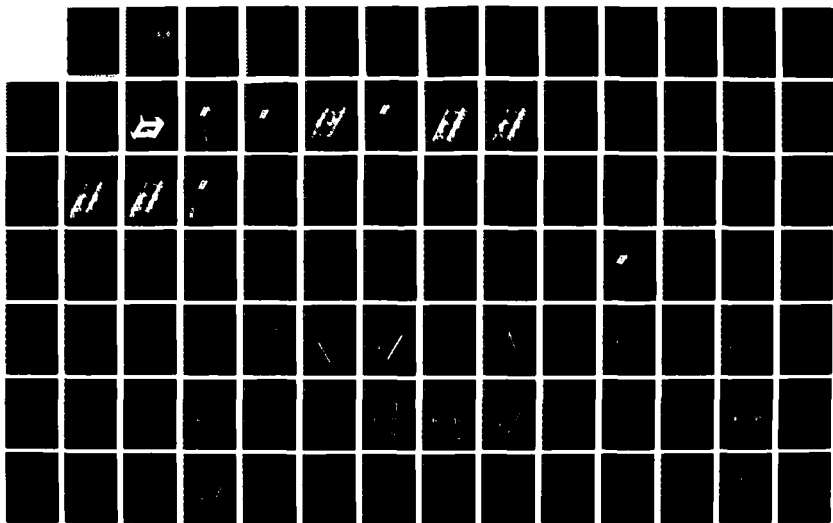
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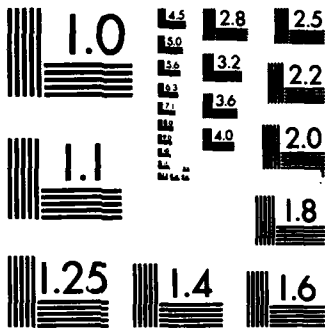
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Lightweight Towed Howitzer Demonstrator

Final Report

Volume D3 - Part I

Structural Analysis of System

April 1987

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Contract Number DAAA21-86-C-0047

FMC CORPORATION
Northern Ordnance Division
4800 East River Road
Minneapolis, Minnesota 55421

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The LTHD (Lightweight Towed Howitzer Demonstrator) was to be a 9,000 lb equivalent to the M198, transportable via Blackhawk helicopter, with reduced emplacement time using fewer personnel. The FMC design achieved weight reduction via a mortar-like configuration, composites structure, and hydraulic actuators. Recovery of power from the recoil system, in turn, facilitated crew reduction via hydraulic emplacement, four-way joystick tube lay, and power ramming. FMC completed Concept Development (Ph I) and two-thirds of Detailed Design (Ph II) prior to funds running out. <i>Keywords:</i>		

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D3/100

STRUCTURAL ANALYSIS OF SYSTEM

PART NUMBER(S):
(NOT APPLICABLE)

DESCRIPTION:

STRUCTURAL ANALYSIS OF SYSTEM

STATUS:

The howitzer system consists of several major structural elements including the gimbal, platform, spade, trails, gun tube, and cradle. Also included are the major interconnections that tie the major structures together.

The goal of the structural analysis was to predict the forces exerted on the major components for the dynamic firing forces of recoil and rifling torque. This information would be employed by the component designers. Therefore, it was important that the dynamics of the structure be modeled correctly. Secondary goals were to predict approximate stresses and the important deflections (e.g. barrel recoil and lift, trail lift, etc.) The model should be formulated so that it may serve as an iterative tool that could be changed easily to reflect design changes or alternative designs.

The analysis was done for proof (limit) load cases which consisted of a simultaneous recoil (79,000#) and rifling torque (42,000 ft-#) loads. These were transient (dynamic) input as forces vs time. A static case was also processed to check the validity of the transient cases and to determine the amplification/deamplification effects. Transportation loads were not considered. Since it was not obvious which orientation was most severe, the model was processed for four orientations consisting of 0° and 72° elevation and 0° and 22.5° traverse. The structural analysis was conducted at CEL. This ANSYS model soon became too large and unwieldy to support design iterations. NOD's function was to provide input to the analysis and to audit modeling and results techniques. In all, four transient and one static cases were processed. A log of reports and memos is given on [D3/I/100 pg 5].

The finite element model description will be limited to major items. These include:

1. The model represents the howitzer geometry as was true of the October - November time frame.

AUTHOR:
Larry Libhardt

2. The ANSYS FEM model includes:
 - a. Platform (quite detailed)
 - b. Gimbal (quite detailed)
 - c. Spade (quite detailed)
 - d. Trail (approximate)
 - e. Cradle (very approximate)
 - f. Barrel (approximate)
 - g. Cables approximate)
 - h. Interconnections (approximate)

These are represented by a few thousand plate and beam elements. Major inertia affects are modeled as mass elements.

3. Rifling torque was input equally to the barrel at both front and rear manifolds locations. Recoil force was applied to the front manifold location only.
4. Total model weight was about 8,100# (a little low). Rotational inertia effects were also included but are probably low also.
5. The model was restrained at the spade rigidly (to represent "hard" soil conditions). Soft springs were attached to the front of the trails to give stability.
6. Numerous geometry plots are contained in the memos. Particularly relevant memos for geometry and assumption information are:
 - a. The Dec. 19, 1986 memo. [D3/I/130]
 - b. The Dec. 22, 1986 memo. [D3/I/140]
 - c. The Jan. 7, 1987 memo. [D3/I/180]
7. The model was good for predicting dynamic stresses in the gimbal and platform and key deflections. It was less useful for other information required (e.g. forces on major components). It is necessary to select time(s) to predict stresses.

Results of the analysis are numerous and include:

1. Von Mises stress plots of the platform, gimbal and spade (at a particular time).
2. Displacement of key locations (as a function of time).

The reader should review the major reports for details of results. A report exists for each of the four transient analyses and the static analysis. There is also a summary of results for the four

orientations in the January 26, 1987 memo [D3/II/200]. The results indicate that stress levels and deflections appear reasonable for the design. Unfortunately forces for the major components were not obtained. The static analysis verified the dynamic analyses and indicated that deamplification was occurring (i.e. dynamic stress less than static stress).

Further analysis was planned to update the model to the latest configuration and to process for the worst orientation (22.5 traverse and 72° elevation). The trails, cradle and platform/gimbal interface would require the most model updating.

LOG - ORTLOFF REPORTS/MEMOS - LTHD

	<u>DATE</u>	<u>TITLE</u>	<u>FIGURES</u>
A	10-3-86	Summary of Progress	None
1	11-25-86	Static-Comp. Cradle-proof load	1-81
2	12-8-86	Static-Comp. Cradle-proof load	82-143
3	12-16-86	Element-Node-Comp Cradle	144-192
4	12-17-86	Stress in Plat + Gimbal	193-272
		Dynamic 0° - 0°	
4A	12-19-86	Progress Report: 12-5 to 12-18	None
5	12-22-86	Request for Infor: Description of FEM - Thermal + Moisture Loads	264A-269
6	12-29-86	Stress for 0° - 72°	270 - 384
6A	12-29-86	Progress Report to 12-28	None
7	12-30-86	Response to Color Graphic	Misc
8	1-7-87	Delivery of Requested Material	Misc
9	1-8-87	Stress/Stability 22.5 - 0°	385-466
10	1-14-87	Est. of Thermal Expansion-Cradle	467-496
11	1-26-87	Stress/Stability 22.5 - 72°	497-601
12	1-28-87	Remaining Tasks	None
13	2-12-87	Static Analysis (22.5° and 72°)	602-623

D3/110

CEL MEMO: OCTOBER 3, 1986

REC'D 10/21/86

Jim → Larry → Dave L. → Jim

FMC Central Engineering Laboratories
Santa Clara

✓
10/21/86

Interoffice

To R. Rathe

From C. R. Ortloff

Subject SUMMARY OF CEL/NORTHERN ORDNANCE PROGRESS
ON THE LWHD PHASE II LWHD PROJECT

Date October 3, 1986

cc J. Alexander
A. Amberg
B. Anderson
J. Ries
E. Thuse
B. Zierwick
P. Carroll

This memo summarizes the phone conversation (CRO to RR) made on 10/5, and incorporates additional "state of the LWHD" commentary:

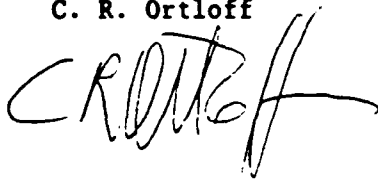
- o A P.O. has been issued for the initial \$20K of AM analysis work; a follow-on P.O. for the full amount is to be issued shortly. A P.O. for CEL materials work will be issued separately to MEL in C.C. Chen's name. The total to CEL is on the order of \$165K.
- o The CEL FE model has been modified to resemble closely the NOD scale model. Because no final detailed drawings of any LWHD part have been received to date, calculations are proceeding with the "best available" configuration represented by the scale model. These calculations have to date uncovered high dynamic stress areas which give insight into the types of materials that must be used in certain zones of the LWHD. Because the FE model is evolving (as unnecessary weight is pared away from the structure and the stress consequences examined) it is providing insight into how to create a composite structure that meets weight and strength requirements under dynamic loading conditions. Some of these recommendations have already worked themselves into modifications of the NOD design (viz., the aluminum platform base plate segment) while other suggestions are being considered for incorporation. Since the original aluminum honeycomb core area of the platform is viewed negatively by ARDEC and is a "last resort" construction method for the lower platform, it is hoped that some of the suggestions made at the last CEL/NOD meeting (sketches left with B. Zierwick) as to how to construct the lower to upper platform region will be incorporated into the next design iteration. These "suggestions" are backed up by many hours of FE calculations to prove their worth in creating a safe, weight efficient structural design.

CRO/01/861003

- o Since the NOD version of the LWHD is based on functionality, some modification of the model should be anticipated as the weight/stress considerations assume a greater role. At present, I have an 1,800 lbf requirement for the structure (excepting the slide tube); the present FE model (for the same parts) shows a weight of 2,300 lbf with safe stress levels. This weight can be reduced somewhat with further design iterations. In short, the CEL and NOD designs are close, and as the CEL design recommendations are further incorporated, our "functional" and "stress-weight" designs will coalesce. You (RR) indicated that more weight will be made available to the structure as the hydraulics is simplified - this will lessen the need to remove more material and thus create hard-to-manufacture "sculptured" shapes. I believe we are very close to a workable design.
- o The CPU time per run has been reduced to about 3.2 CPU hrs. by new wave fronting techniques - this permits design iterations to be performed rapidly as new considerations arise.
- o A FE model has been created with a rotated (22.5°) gimbal that resembles the model gimbal shape. I am retaining the slightly curved sideplates as they are much stronger torsionally under firing torque loads than flat plates. When the slide tube drawing is ready, a separate file can be made and appended to the main FE model at any QE angle so as to compute forces, deflections and stresses at any firing position with these models the 15 load cases can be calculated rapidly.
- o Wing Cheng will be aiding me shortly in the trail-wheel assembly design (when this drawing becomes available). We will use Don Cronquist's road obstacle loads generated in Phase I to help define the loads on the structure. As Wing has helped develop the filament wound structure optimizer model, his work will be of importance in designing lightweight trails.
- o I have run FE calculations of stress distributions in the LWHD with the trail spades "free". There is a lot of rocking motion, as might be expected, and some new stress highs within the structure (which can be dealt with by local thickening of gimbal parts). Stress in the gimbal bearing is high and this reinforces my idea to use a cup-cone lower platform-gimbal connection for extra safety margin if the lower bearing should fail.

- 4
- o The new dynamic load conditions (proof-loads) have been written into a file for incorporation into all new FE calculations. It is expected that some yielding will occur locally as a result of this "once-only" load. The regular load cases will still be the basis for the design, however.
 - o The FE model has had additions to allow for force predictions necessary for "free body" diagram force-time histories to be generated. At the very least, one can work with the stress distributions and part geometry to estimate the forces that produce the stresses.
 - o It appears that a cooperative effort between CEL and NOD is evolving along with the LWHD design. This project will succeed if we make a special effort to understand each other's concerns.
 - o At present, we are probably behind schedule in all design areas. This is understandable based on recent changes forced by ARDEC on the LWHD design. With these out of the way, we can now begin the "optimization" process.

C. R. Ortloff



D3/120

PLOTS FROM CEL

LTHD Ortloff

Note: Not sure
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OCT 30 1986

9-31-14

PLOT NO. 1

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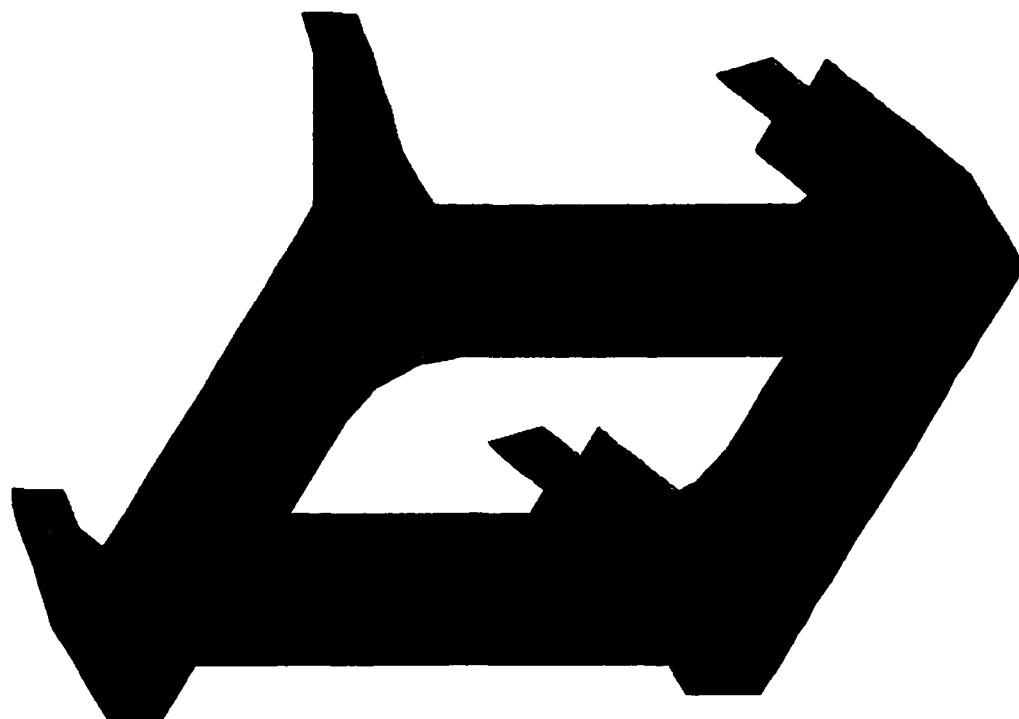
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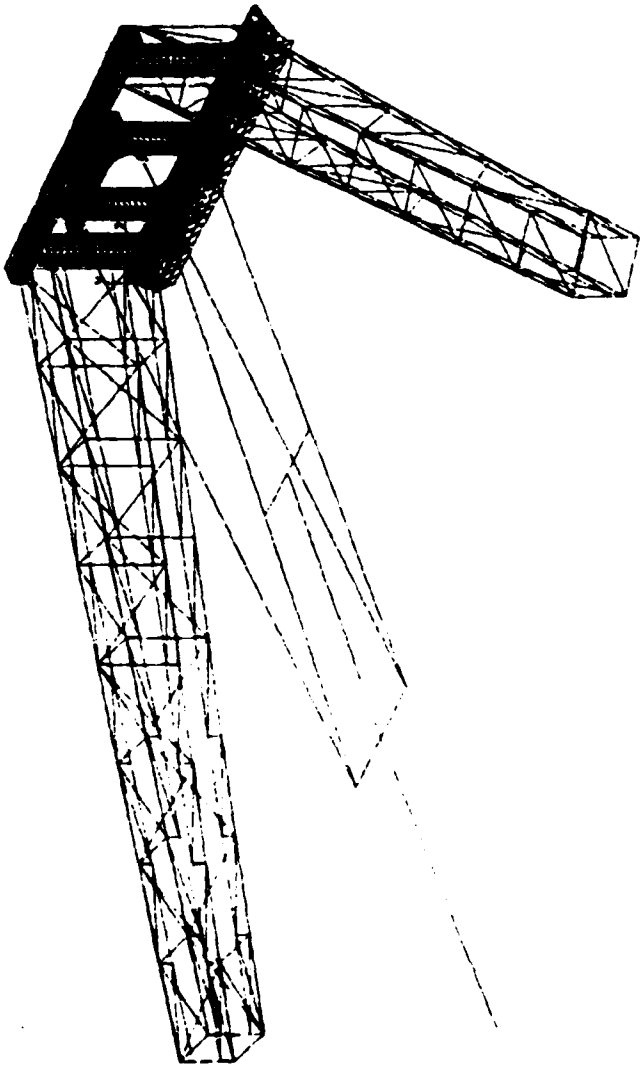
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1 LTHD - GIMBALL DESIGN ANALYSIS (10-27-86 M.W.C.)

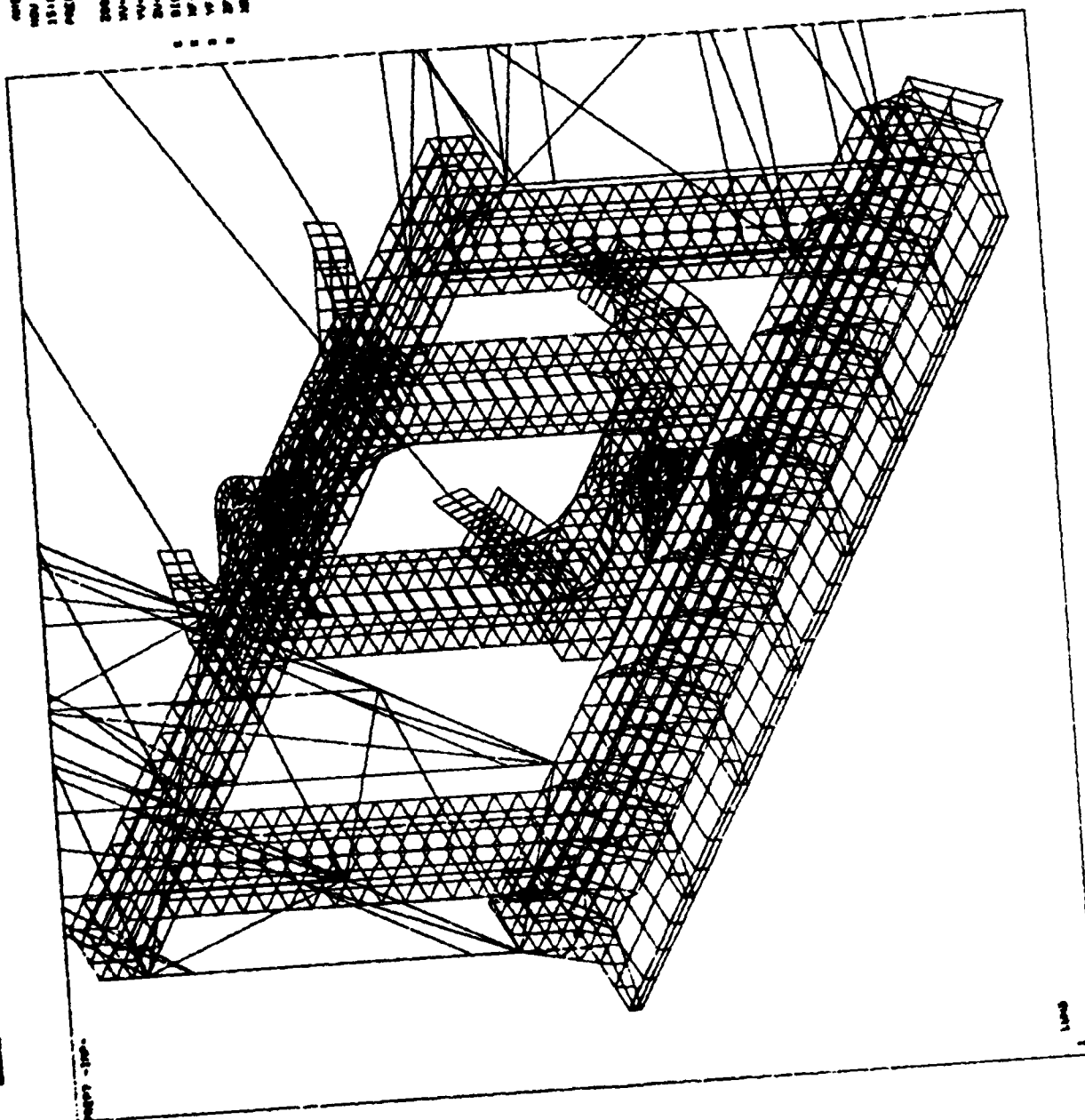
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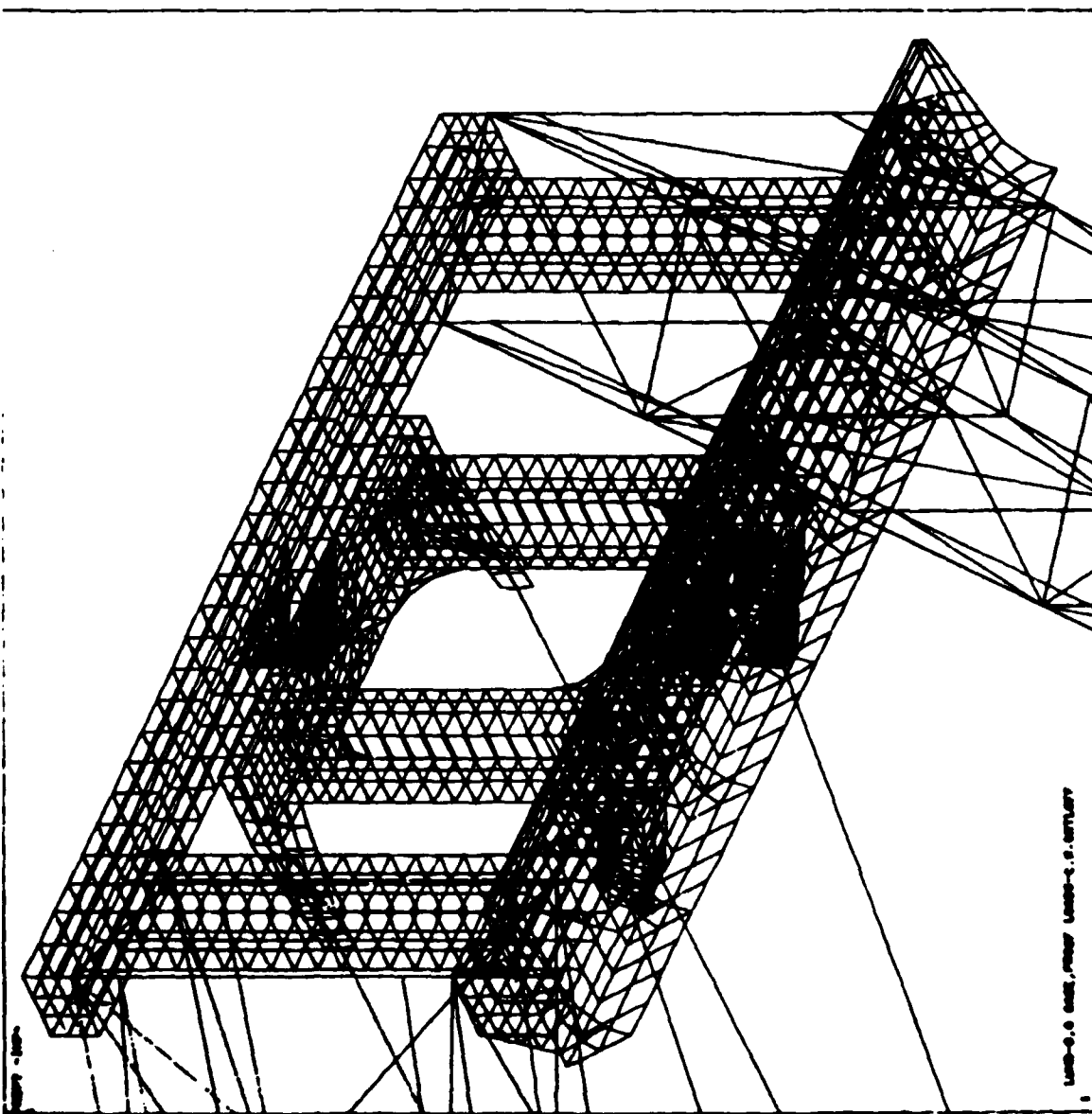
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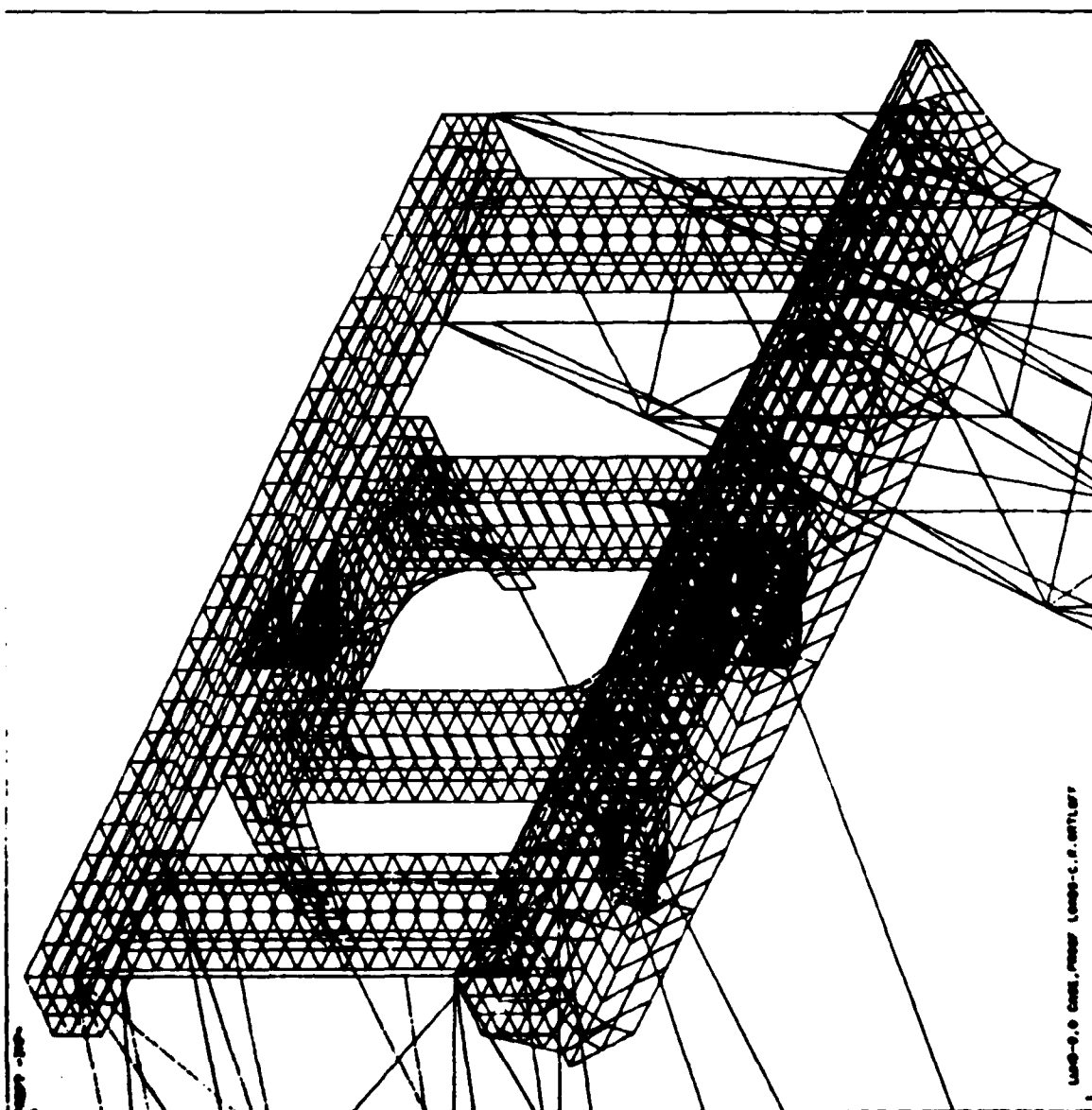
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D3/130

CEL MEMO: DECEMBER 19, 1986

FMC Central Engineering Laboratories
Santa Clara

Interoffice

To R. Rathe

From C. R. Ortloff

Subject **PROGRESS REPORT ON ASSIGNED TASKS**
LWHD PROJECT (12/5 TO 12/18)

Date Dec. 19, 1986

cc E. Thuse
R. Kazares
P. Carroll
J. Ries
B. Anderson
E. Alexander
B. Zierwick
L. Libhardt

TOTAL SYSTEM MODEL

A report on the dynamic motion and concomitant dynamic stress states of the total LWHD system (cradle, platform, gimbal, trails) was completed and forwarded to NOD (CRO to L. Libhardt, 12/16). This dynamic load case represented the 0° elevation, 0° gimbal rotation case (79 figures forwarded). Three further FE models (of 3,400 elements each) have been constructed for the 0° - 72°, 22.5° - 0°, 22.5° - 72° cases and are currently residing on the VAX queue for execution. Each case represents about 34 CPU hours of run and postprocessing time and requires about 400,000 blocks of file space to store results. Since the current available disk space is about 450,000 blocks, each run must be postprocessed and stored on tape before the next run can be effectively started. Turn-around time per run under current operating conditions is about 3-4 days.

During Christmas holidays when batch usage is low, I hope to run the remaining programs continuously to try to get most of these load cases done and postprocessed. Additional load cases remaining (LAPES, etc.) plus ones on the queue most likely total up to several hundred CPU hours remaining to fully analyze the LWHD under dynamic load conditions.

CRADLE

* The hardcopy output for the latest static cradle run was forwarded (12-16) in addition to element and node maps. Since recent work on the dynamic amplification factor indicates a value between 1 to 1.5, failure of the current design is likely (memo, CRO to R. Rathe, 12/8/86) in a number of different modes under proof loads. A possible suggestion you may wish to consider for a cradle design "fix" was included with this memo. Use of additional Gr/Ep layers in selected cradle regions can reinforce the current design to make it meet design allowables. Since the cradle design is going through another design iteration (memo, J. Reis to C. R. Ortloff, 12/5/86), it is unclear whether the work performed to date will be used. A decision on a design change from a filament-wound 14 layer foam-core sandwich to woven roving lay-up structure has not yet been transmitted to me as of 12/19. Regardless of the design choice, I can easily

R. Rathe
Progress Report on Assigned Tasks
LWHD Project (12/5 to 12/18)

Dec. 19, 1986
Page 2

modify the existing cradle program to accommodate new design changes and material properties. The CPU time per run is about 10-12 CPU hours so turnaround time is not excessive to compare "new" to "old" designs.

From this point forward, with your concurrence, any cradle runs will include thermal expansion induced stresses at "hot" conditions. An estimation of moisture absorption stresses is important as both the laminate stiffness and strength properties change primarily through changes in epoxy properties. I will perform a FPF analysis for hygrothermal effects for the laminate design you ultimately choose for $C = 1\%$ and $T = 160^{\circ}\text{F}$, based on one of the quadratic lamina failure criteria. Since this type of analysis is strongly dependent upon epoxy and fiber materials properties and ply stacking sequence, I will need an update on your latest design to perform this work. This effect may cause a significant change in either direction in laminate strength under hot, wet conditions depending on the final choice of the stacking sequence and load type. You may want to consider a test program to measure effects (upon your laminate design) to more precisely gage this effect (as this is the usual procedure for assessment of the hygrothermal stress effect).

do we
want
this?

2

Please keep me informed of recent design changes so that I can modify my (current) FE models and provide you with current results as quickly as possible.


C. R. Ortloff

FMC Central Engineering Laboratories
Santa Clara

Interoffice

To L. Libhardt*

Date Dec. 17, 1986

From C. R. Ortloff

cc E. Thuse
A. Amberg
R. Kazares
R. Rathe
E. Alexander
J. Ries
B. Anderson
T. Rudolf
B. Zierwick

Subject **STRESS LEVELS IN THE PLATFORM AND GIMBAL
UNDER DYNAMIC (PROOF) FIRING LOADS -
0° ELEVATION, 0° GIMBAL ROTATION CASE**

*one copy of original
figures only

79 Figures - ~~263~~ 272

An ANSYS finite element model of the platform, gimbal, spades and trails has been made. A representative beam-element model of the cradle-cable system has been added to this model with the correct mass and moment of inertia values. The model is then impulsively loaded with firing torque and recoil impulse loads and the dynamic motion and stress states (at given selected times) determined. The boundary conditions are:

- o no constraints on the trail ends
- o the spade lower edge is fixed
- o no vertical deflection of the horizontal plane of the lower plate of the platform, i.e. $U_Y = 0$ on the bottom horizontal plane adjacent to the spade. This condition corresponds to emplacement in "hard" soil.

what
w2.?
16 too?

} correct?

The input loads correspond to the proof load maximums and time durations previously specified. The dynamic deflection under impulse loads is shown at selected Master Degree of Freedom (MDOF) nodes in the structure and is shown in figures 197-217. The locations of these MDOF nodes is shown in figures 193-196. The trailing arm locations (figure 195) are seen to have a deflection time history (figure 208) indicating several inches of bounce. The trail model used consists of a foam-core sandwich upper plate (9 Gr/Ep lamina [0/45/-45/90/0/90/-45/45/0] over a 2 inch Rohacell core) with the metal matrix truss structure (Al/SiC) and Ti bulkhead reinforcing plates (after the Concept 3 Trail Drawing, 10-29-86 and 11-12-86, D. Langerud). Although the trail design is not yet fixed (as of 12-16-86), the free-end boundary condition reduces its importance as a load carrying member (over previous fixed-end trail configurations). The trails may then be designed to static load conditions with an appropriate safety factor (2).

what?

+transient
load?

As usual for Linear Transient Dynamic Analysis, peaks in deflection-time history (on the gimbal-platform) provide corresponding stress maximums in the structure. Several times are selected in the time interval from 0 to 1 second at which stress "snapshots" can be obtained for the structure by ANSYS stress-pass methods. Times selected are 0.013, 0.28 and 0.428 seconds and correspond to displacement peaks in several of the MDOF's on the main structure. The initial time is at the end of the firing torque input; the second time is slightly after the recoil impulse input. A damping value of (ANSYS) DAMP = 0.2E-2 is included to reduce later-time spurious dynamic peaks in the displacement-time histories. Once the final configuration/materials of the composite parts of the structure are decided and a damping value justified then a rerun can be made to include values of ALPHAD, BETAD for final production runs. As damping dissipates energy, present stress/deflection values are on the conservatively high side with respect to this effect.

* Figures 225-263 show Von Mises equivalent stress contours on the Ti gimbal/platform outer surface. Over most of the structure, stresses are well within the yield stress for Ti (60-80 ksi) under proof loads. Stress values in the connection tabs (figures 242, 247 for example) are near the yield stress locally. Also, gimbal upper and lower openings in the upper and lower box beams show high stress values (figures 248, 249, 250, 251, 252, 253, 259, 261, 262, 263). Since these bearing areas are undoubtedly to be reinforced locally (once bearing details are decided upon) these locally high stress values can be easily lowered by (locally) mounted reinforcing plates. * when? OK

Details of the bearing-tab-gimbal model are shown in figures 269-272. Beam elements (STIF 4) with the appropriate mass and inertia properties appropriate to the latest design are the vertical shafts shown. Rigid beam elements connect the shaft(s) to the tabs/gimbal openings as shown. Since the STIF 4 beam element has no torsional stiffness, a supplementary beam ties the gimbal to the platform to prevent relative motion between gimbal and platform under any torque loads. Since loads on the structure are on-axis along the centerline, no significant shaft rotation is expected and the load entering the shaft(s) is primarily directed to cause bending. To access the shaft bending stresses (in addition to other tension/compression effects present), recourse to figures 270 (bottom shaft) and 271 (upper shaft) is made. Reference to the ANSYS User's Manual, V. 1, p. 4.4.4, and figures 266-268 (at t = 0.28 sec after the recoil loads have been input into the system) indicate a bottom shaft outer fiber stress maximum of 6035 psi at node 3461. For the top shaft, the maximum stress is on the order to 22,000 psi. slight that initial what?

L. Libhardt
Stress Levels in the Platform and Gimbal
Under Dynamic (Proof) Firing Loads -
0° Elevation, 0° Gimbal Rotation Case

Dec. 17, 1986
Page 3

In all the above calculations, the mass and rotary inertia of the cradle are simulated with its CG approximately duplicated from the cradle model. Distributed masses are also included throughout by means of specifying the material density.

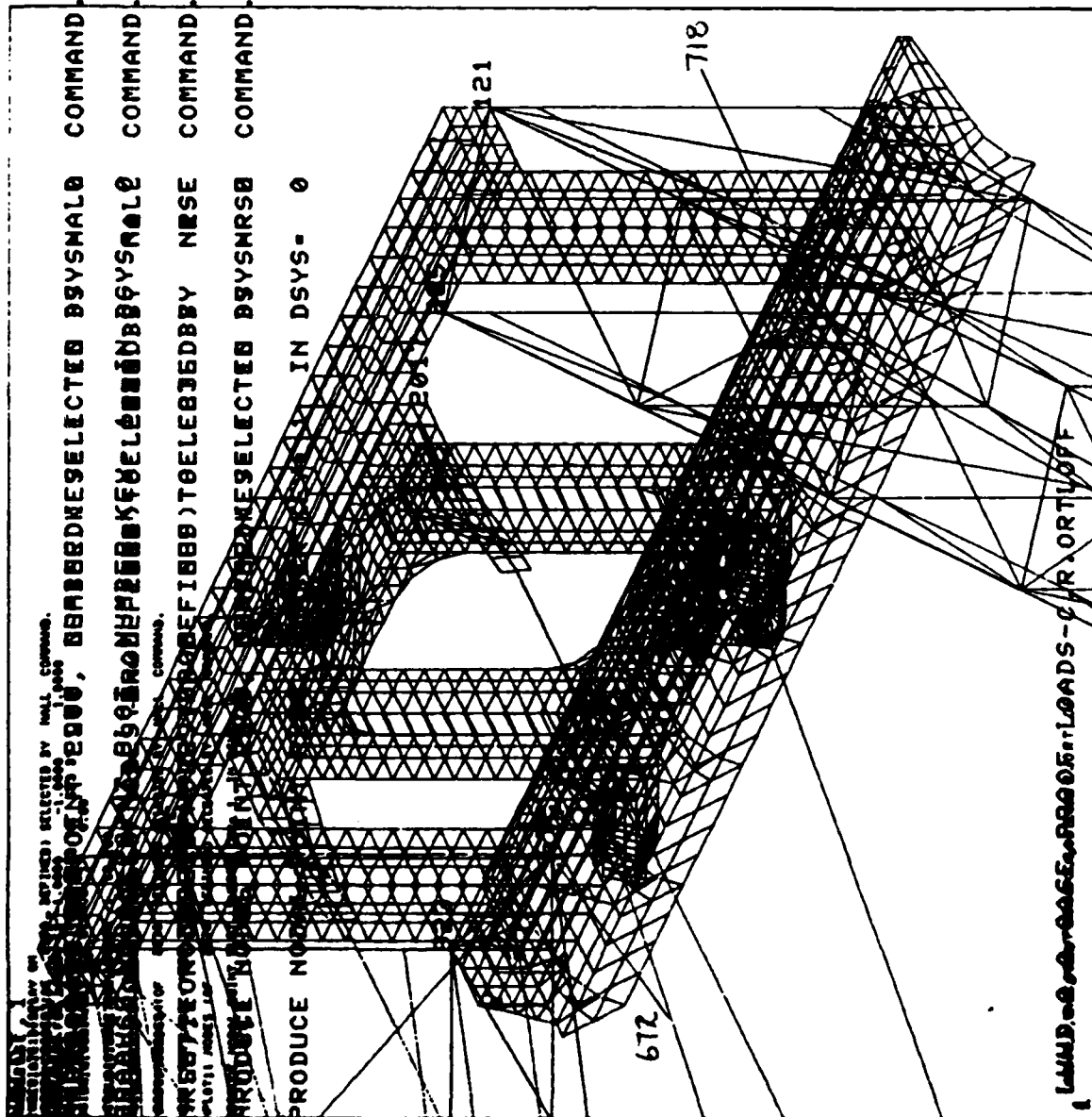
Conclusions

- o Except for some local zones around the bearings of the upper portion of the gimbal and the associated platform tab/upper shaft region, stresses under proof loads in both platform and gimbal appear to be much less than the 60-80 ksi Ti proportional limit stress (figures 225-263).
- o These zones may be easily reinforced by additional weld-on or bolt-on plates in the bearing areas on the box beam sections.
- o The upper shaft stress is about 20 ksi.
- o The system appears stable under dynamic loads in the 0° elevation, 0° gimbal rotation mode for the given set of boundary conditions, although it appears that the trail ends "lift off" the ground upon firing. It would probably be better to retain end stakes/claws on the trails to limit system "bounce" to a minimum.
- o In total, the stress analysis results look positive for the current design under proof firing loads with only minor changes required to reduce some local stresses to acceptable values.
- o CPU time for the current results set in 34 CPU hours. Inclusion of ALPHAD, BETAD damping will increase run time to over 42 cpu hours. With additional time related to post-processing, it is imperative that subsequent design changes be made in response to stress deficiencies as a matter of priority so that at least one "workable" design exists before further revisions are made.

Since original figures have been forwarded with all memos sent to date, it is imperative that they be stored in a cool, dark place to preserve them. When a final stress report is to be written, some of these figures will need to be sent back to me for inclusion into the final report.


C. R. Ortloff

**



ANSYS 4.80
DEC 5 1986
10:26:10
PREP7 ELEMENTS

ZOOM
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YU=-1
ZU=1
DIST=58.1
VF=79.7
ZF=52.5
XRT0=1:17

PREP7 NODES

ZOOM
XU=-1
YU=-1
ZU=1
DIST=58.1
VF=79.7
ZF=52.5
XRT0=1:17

PREP7 NODES

ZOOM
XU=-1
YU=-1
ZU=1
DIST=58.1
VF=79.7
ZF=52.5
XRT0=1:17

PREP7 NODES

ZOOM
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ZU=1
DIST=58.1
VF=79.7
ZF=52.5
XRT0=1:17

PREP7 NODES

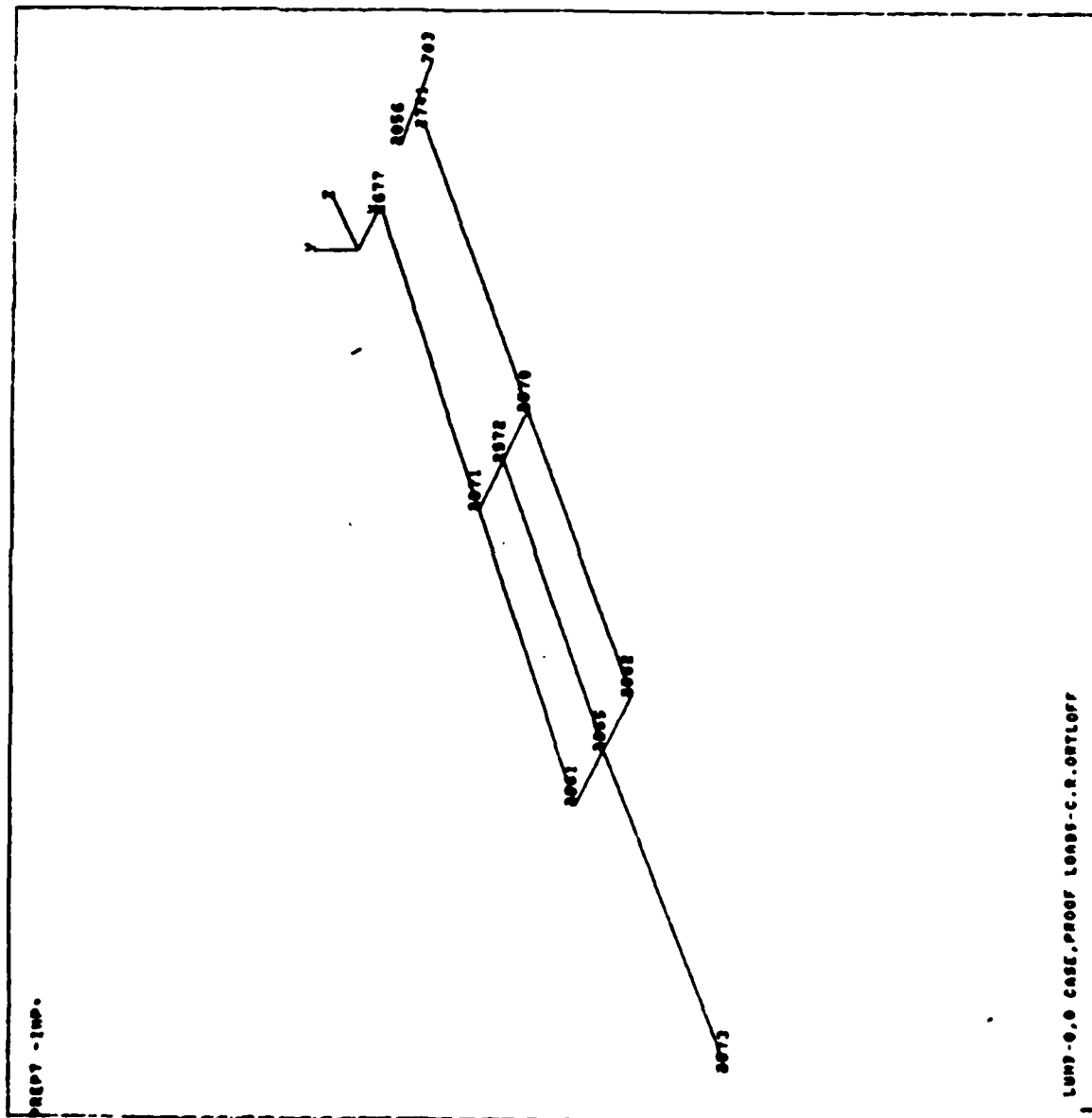
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YU=-1
ZU=1

MDOF
NODES

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 10101.47
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 VU--1
 ZU--1
 A157-814
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 YF-88.7
 ZF--184
 XRT0-1.37
 YRT0-1.17

MDOF
 NODES



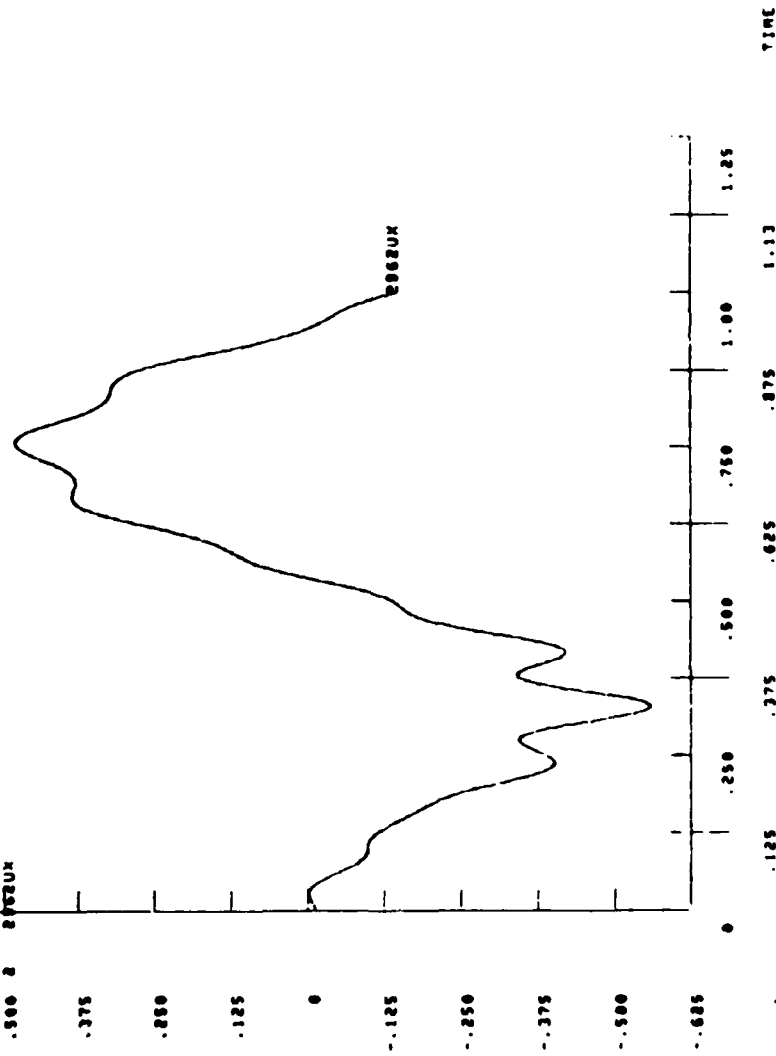
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 POSTAGE-IMP.
 PLUMB, 2

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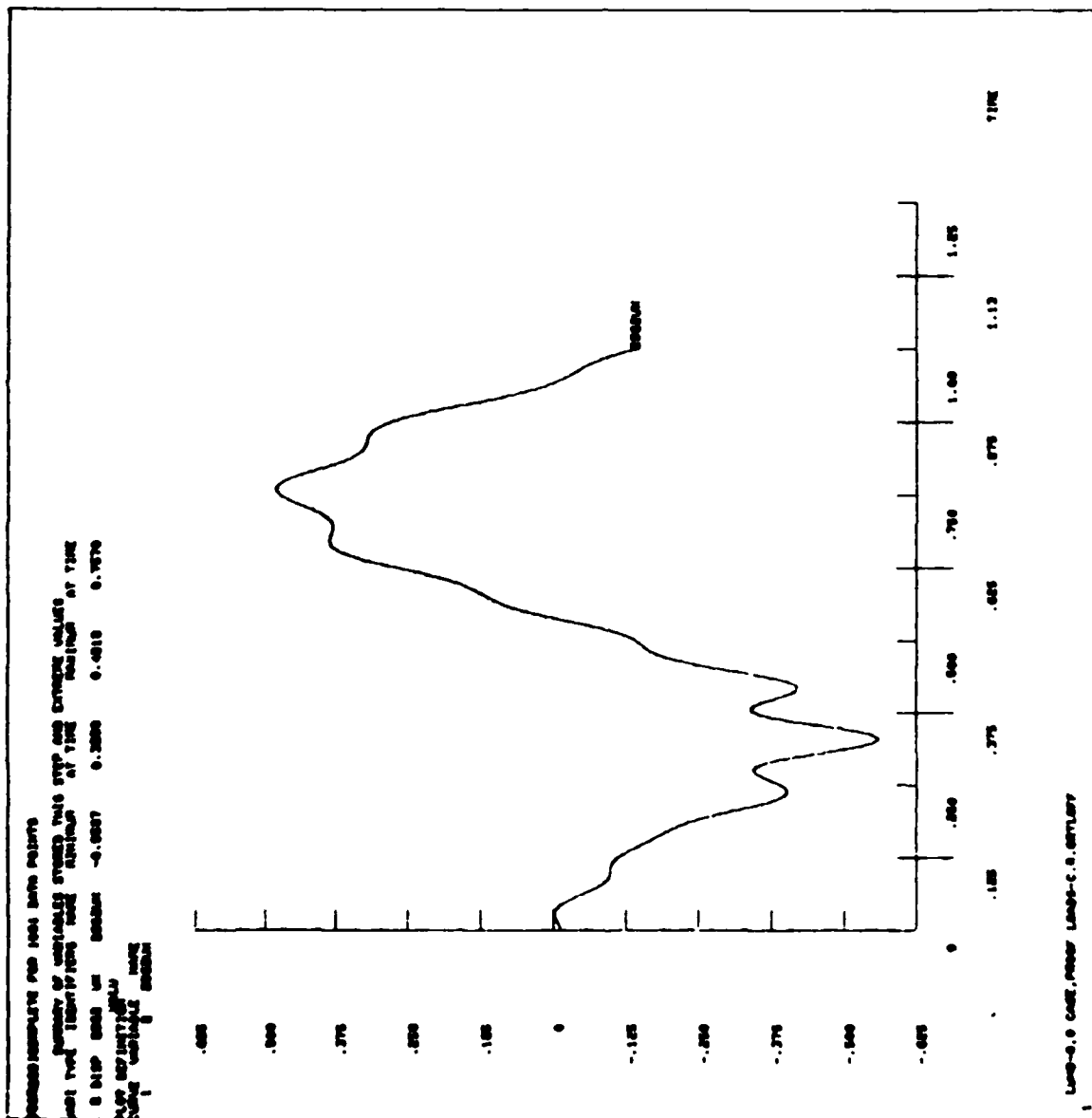
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 1 .500 2 2062UX

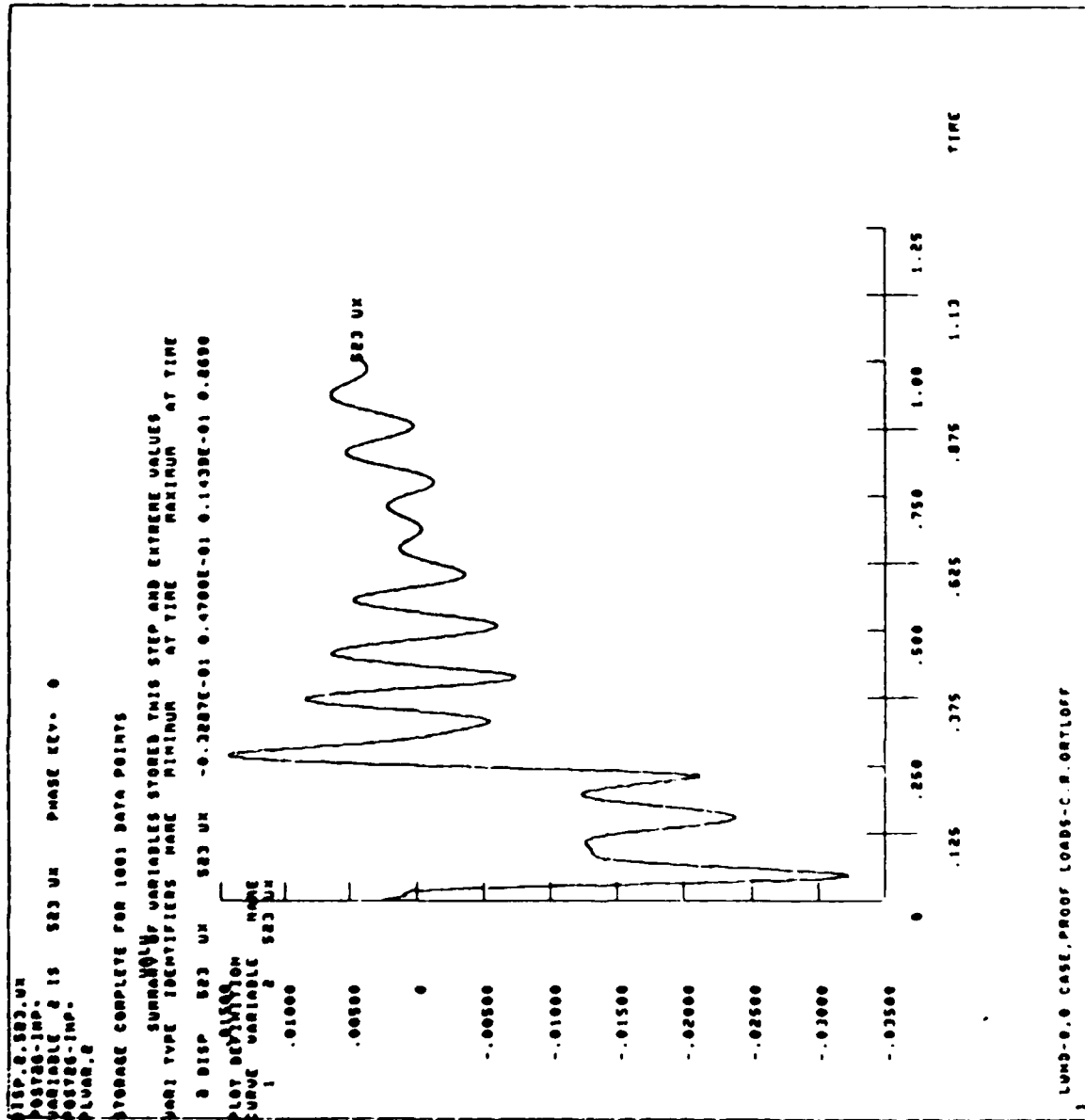


1 LUMB-0.0 CASE, PROOF LOADS-C. R. ORTLOFF

199

POSTER
20-1
0107-1.20



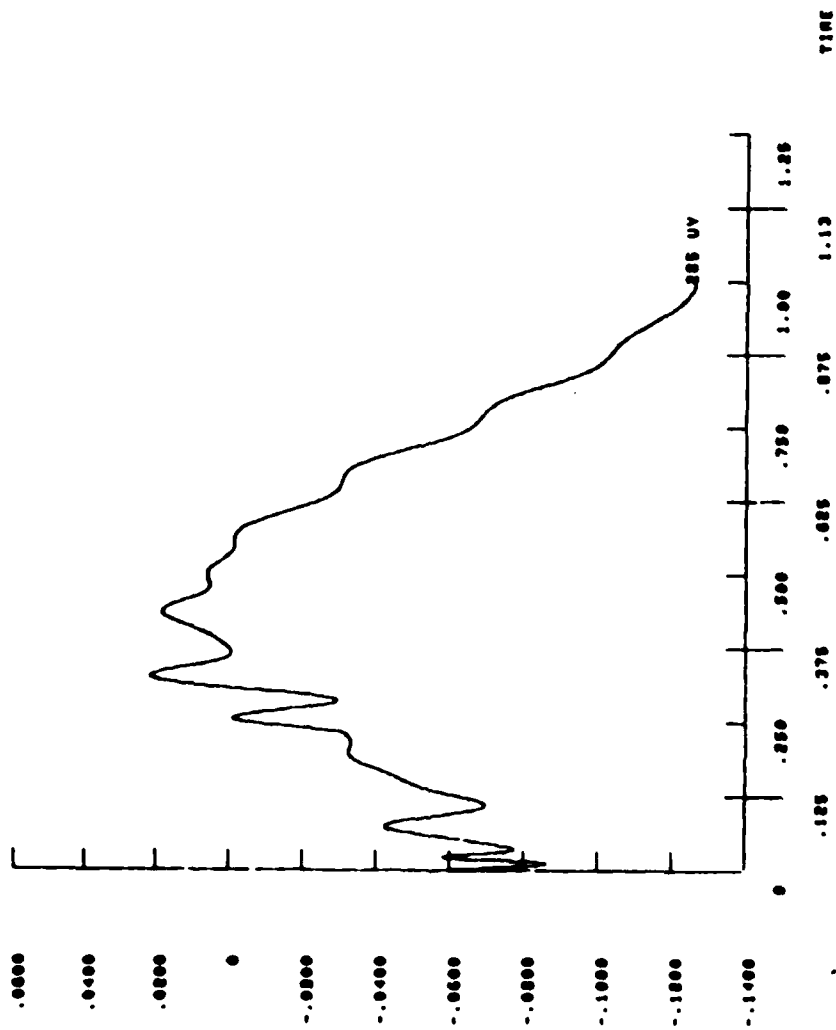


*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
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2 010P 288.0 UV 288 UV -0.1000 1.000 0.0100E-01 0.3870

PLOT DEFINITION
 CURVE VARIABLE NAME
 1 288 UV



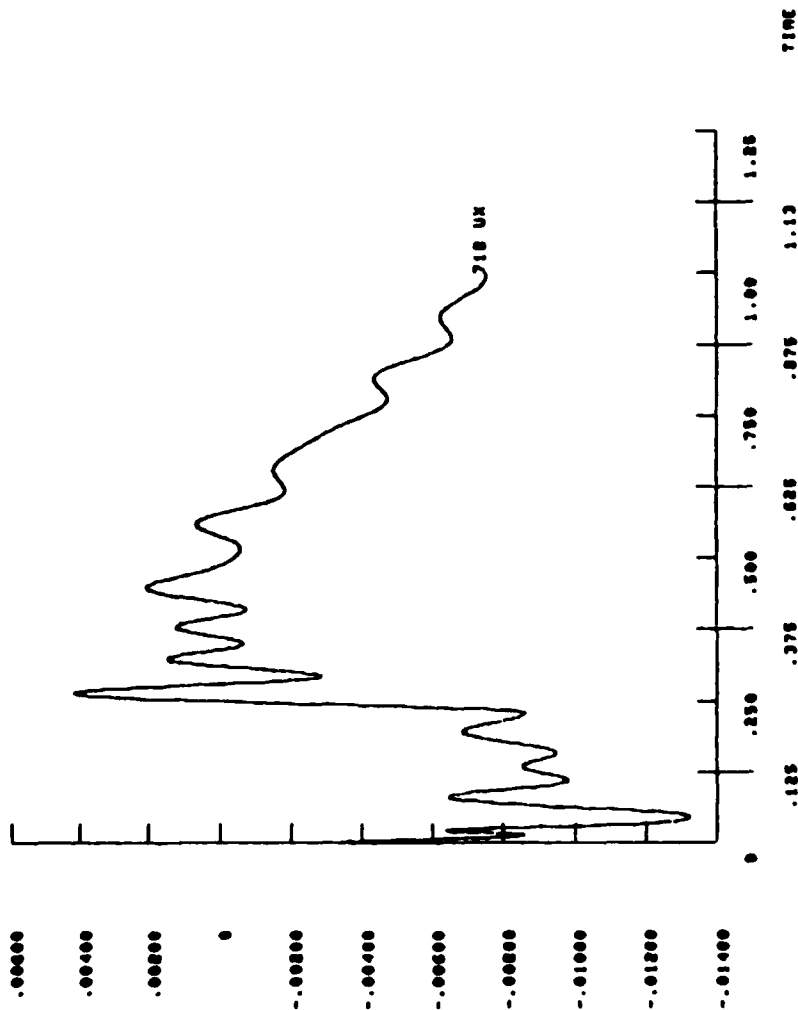
1 LWB-0.0 CASE, PROOF LOOPS-C.R.001077

*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 VARIABLE IDENTIFIER NAME MINIMUM AT TIME MAXIMUM AT TIME

8 DISP 710 UX 710 UX -0.1324E-01 0.4000E-01 0.4181E-02 0.0000

 PLOT DEFINITION
 1 NAME
 2 CURVE VARIABLE 710 UX



1 LUND-0.0 CASE, PROOF LOADS-C.B. ONTLOFF

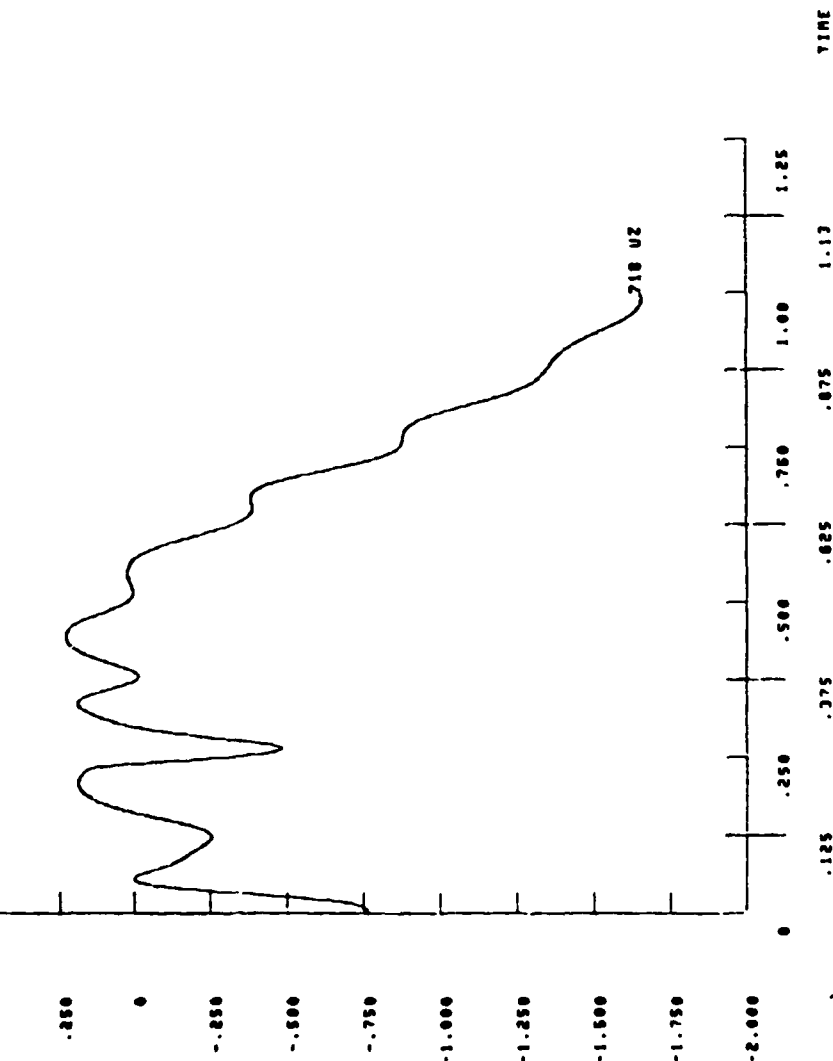
POORGEIDCOMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES

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2 DISP	W91W UZ	718 UZ	-1.635	0.9910	0.2319	0.4470

PLOT DEFINITION

CURVE	VARIABLE	NAME
1	718 UZ	718 UZ



1 LUMB-0.0 CASE, PROOF LOADS-C.R.ORTLOFF

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES

NAME	MINIMUM	AT TIME	MAXIMUM	AT TIME
101 UX	-9.174	1.000	1.000	0.4000
101 UY	-0.00010-01	0.4000	0.4000	0.4000
101 UZ	-0.3000	0.1000-01	0.3110	0.4000

NAME

101 UX

101 UY

101 UZ

101 UX

101 UY

101 UZ

101 UX

101 UY

101 UZ

101 UX

101 UY

101 UZ

101 UX

101 UY

101 UZ

101 UX

101 UY

101 UZ

101 UX

101 UY

101 UZ

101 UX

101 UY

101 UZ

101 UX

101 UY

101 UZ

101 UX

101 UY

101 UZ

121 UX
UY
UZ



101 UX 101 UY 101 UZ

INCOMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES

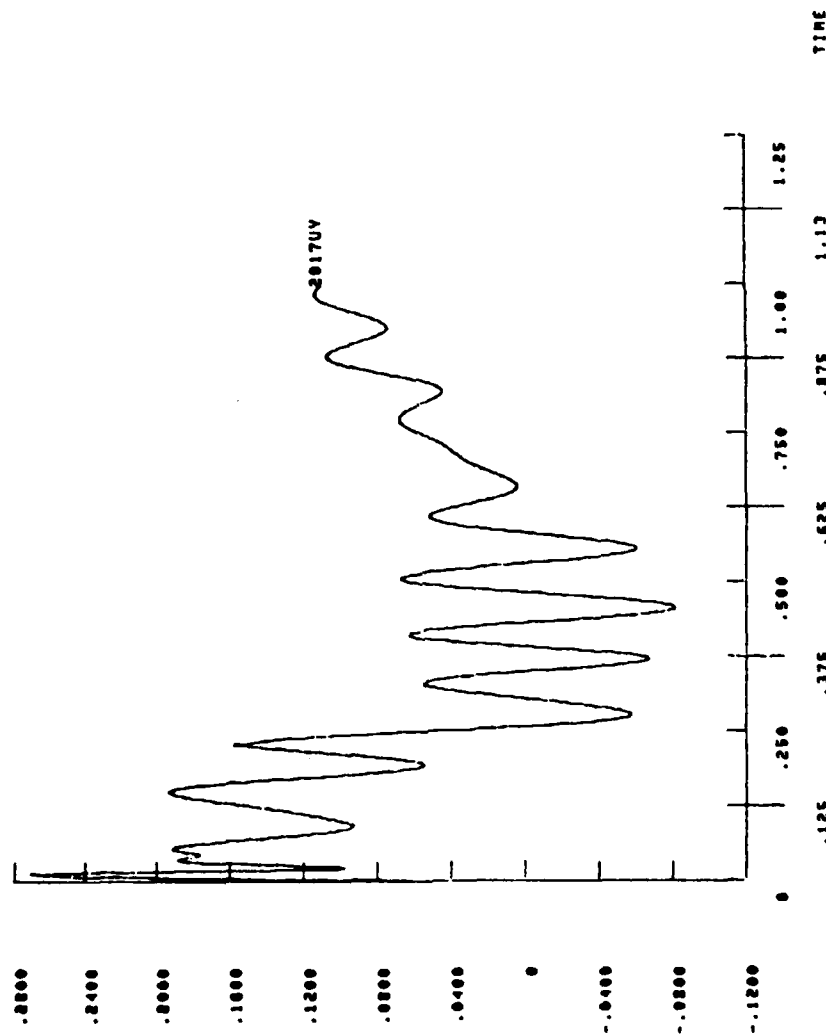
JOB1 TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME

2 DISP 2017UV 2017UV -0.8165E-01 0.4570 0.2712 0.1300E-01

PLOT DEFINITION

CURVE VARIABLE NAME

1 2017UV



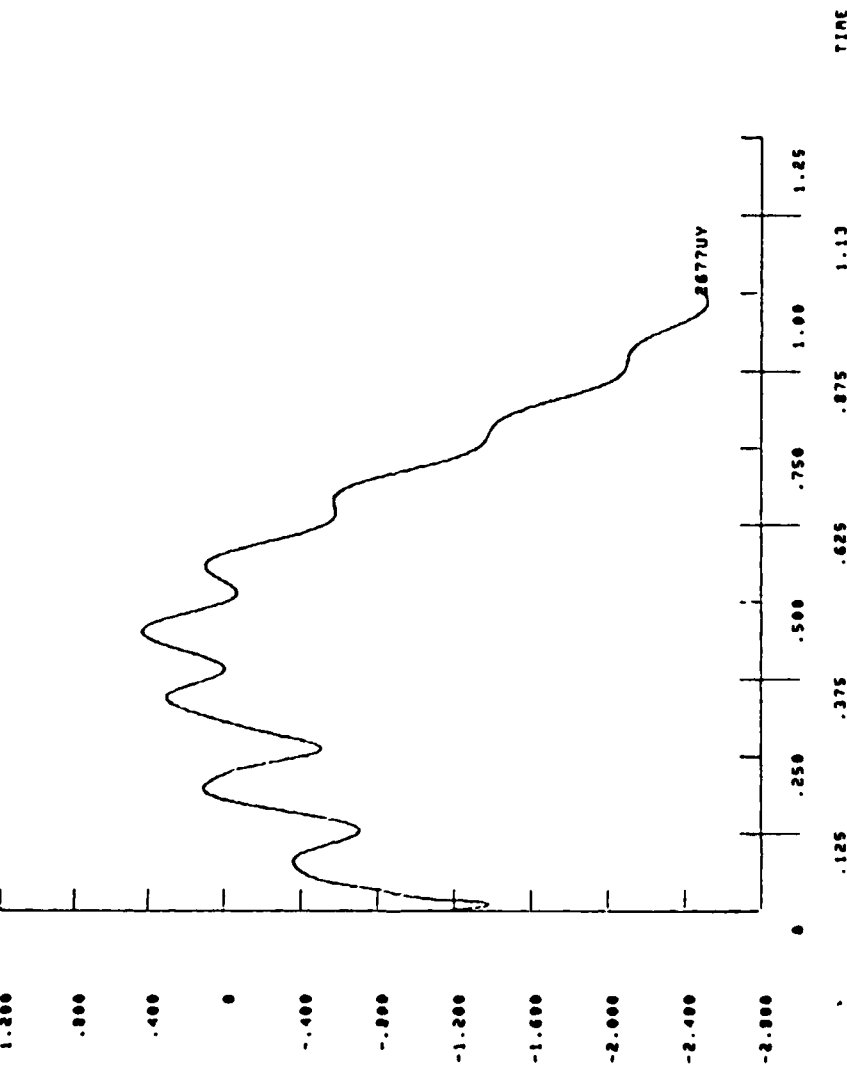
1 LUMP-0.0 CASE, PROOF LOADS-C.R. ORYLOFF

SOURCE: COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME

R DISP 8034 UV 2677UV -2.520 0.0870 0.4293 0.4500

PLOT DEFINITION
 CURVE VARIABLE NAME
 1 1.200 2677UV
 2 2677UV

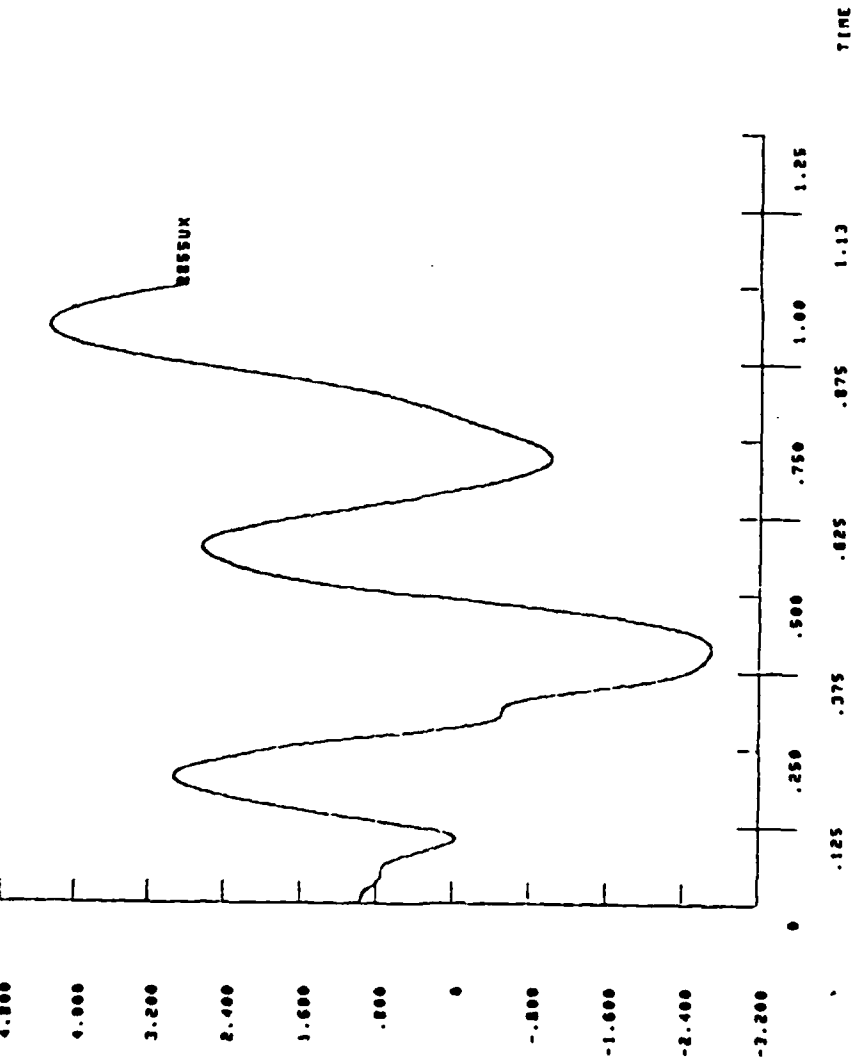


LUND-0.0 CASE, PROOF LOADS-C.R. ORTLOFF

*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
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PLOT DEFINITION
 CURVE VARIABLE NAME
 1 4.800 2085UX
 2

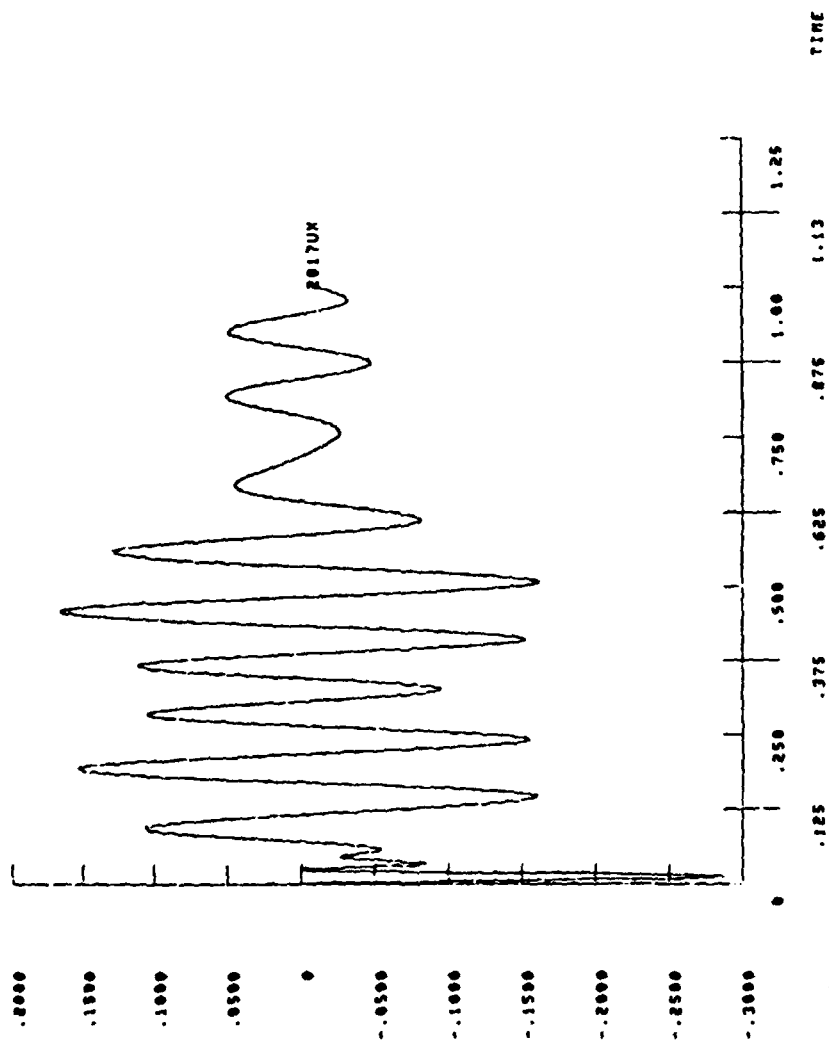


1 LUMB-0.0 CASE, PROOF LOADS-C.P. ORTLOFF

ON TRAILS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES				
WARD	TYPE	IDENTIFIERS	MADE	MINIMUM AT TIME MAXIMUM AT TIME
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1	CURVE	DEFINITION	NAME
1		VARIABLE	2017UX

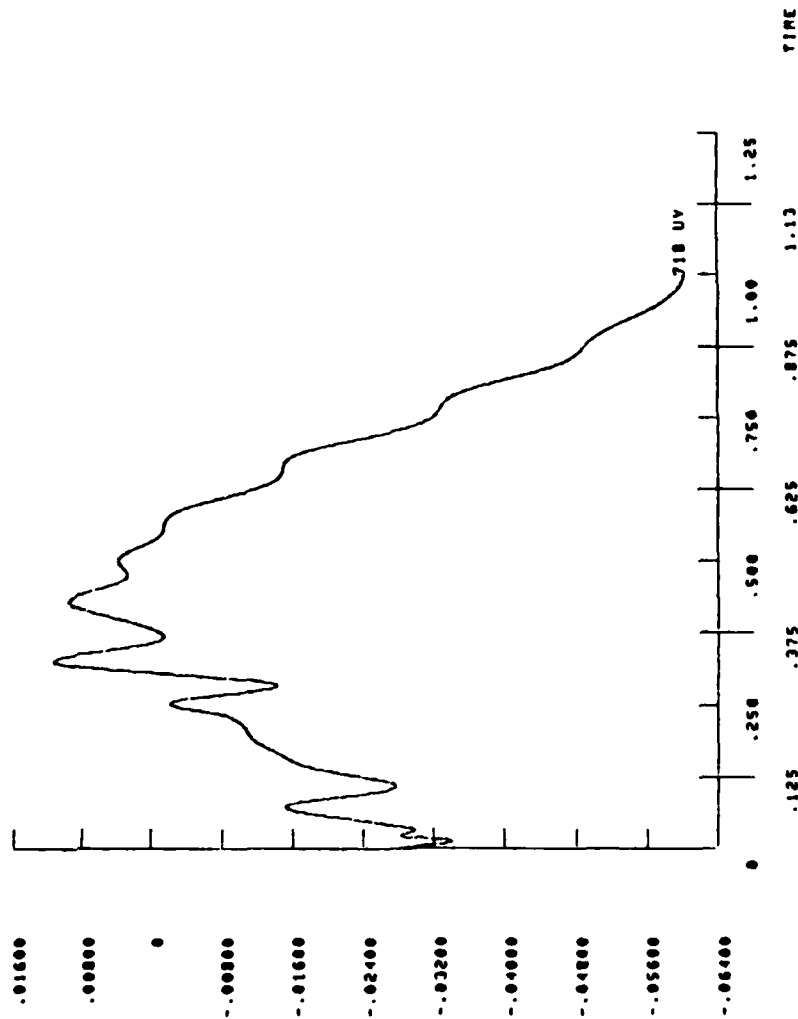


LUND-0.0 CASE, PROOF LOADS-C.A. ORTLOFF

POORERCOMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME
 2 DISP 718 UV 718 UV -0.6080E-01 1.000 0.1138E-01 0.3260

PLOT DEFINITION
 CURVE VARIABLE NAME
 1 2 718 UV

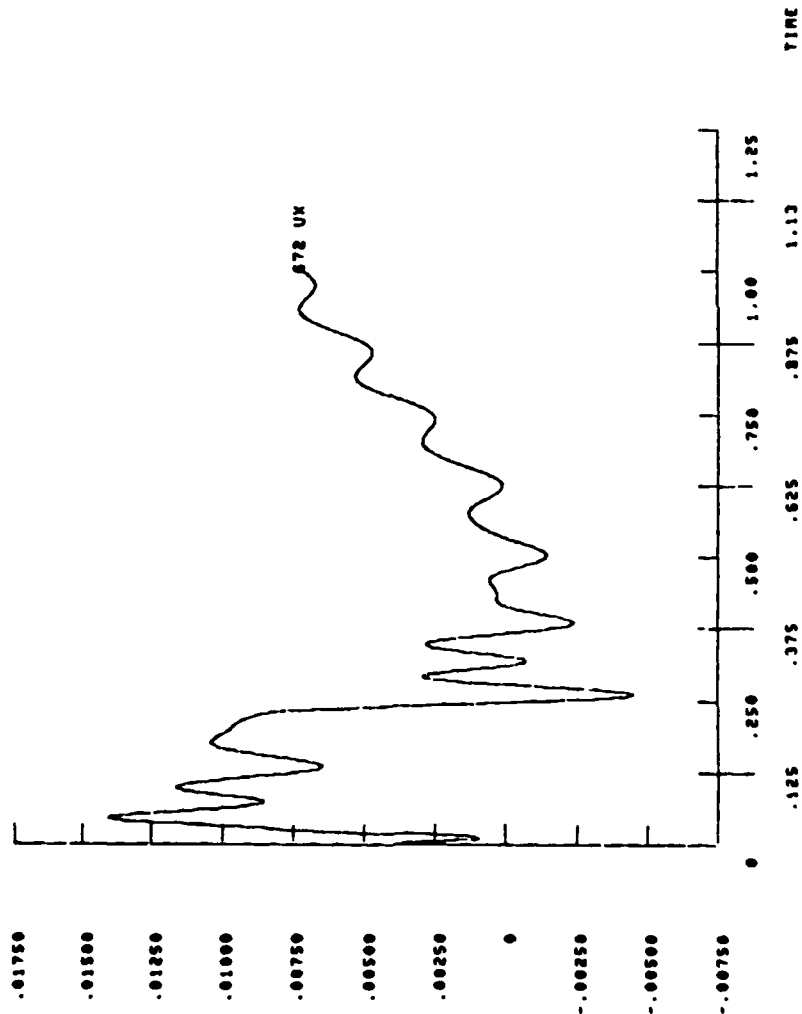


1 LUMB-0.0 CASE, PROOF LOADS-C.R.ORTLOFF

PROB001 COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME
 2 B1SP 672 UX 672 UX -0.4518E-02 0.2610 0.1403E-01 0.4500E-01

PLOT DEFINITION
 CURVE VARIABLE NAME
 1 672 UX



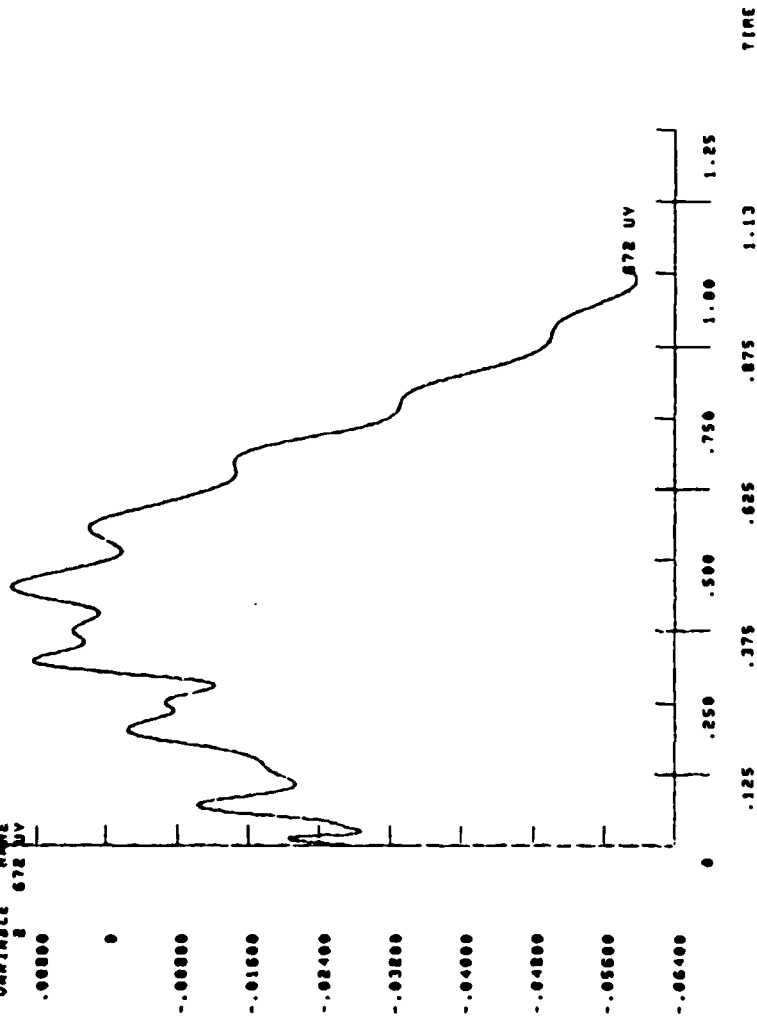
1 LUMB-0,8 CASE, PROOF LOADS-C.R.ORTLOFF

STEP 8.072 UV
POSTAGE-IMP.
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POSTAGE-IMP.
PLVAR.2

STORAGE COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
VARIABLE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME
2 81SP 672 UV 672 UV -0.0981E-01 0.0000 0.1101E-01 0.4510

PLOT DEFINITION
CURVE VARIABLE NAME
1 672 UV
2 672 UV



1 LUMB-0.8 CASE, PROOF LOADS-C.R. ORTLOFF

PROGRAM COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES

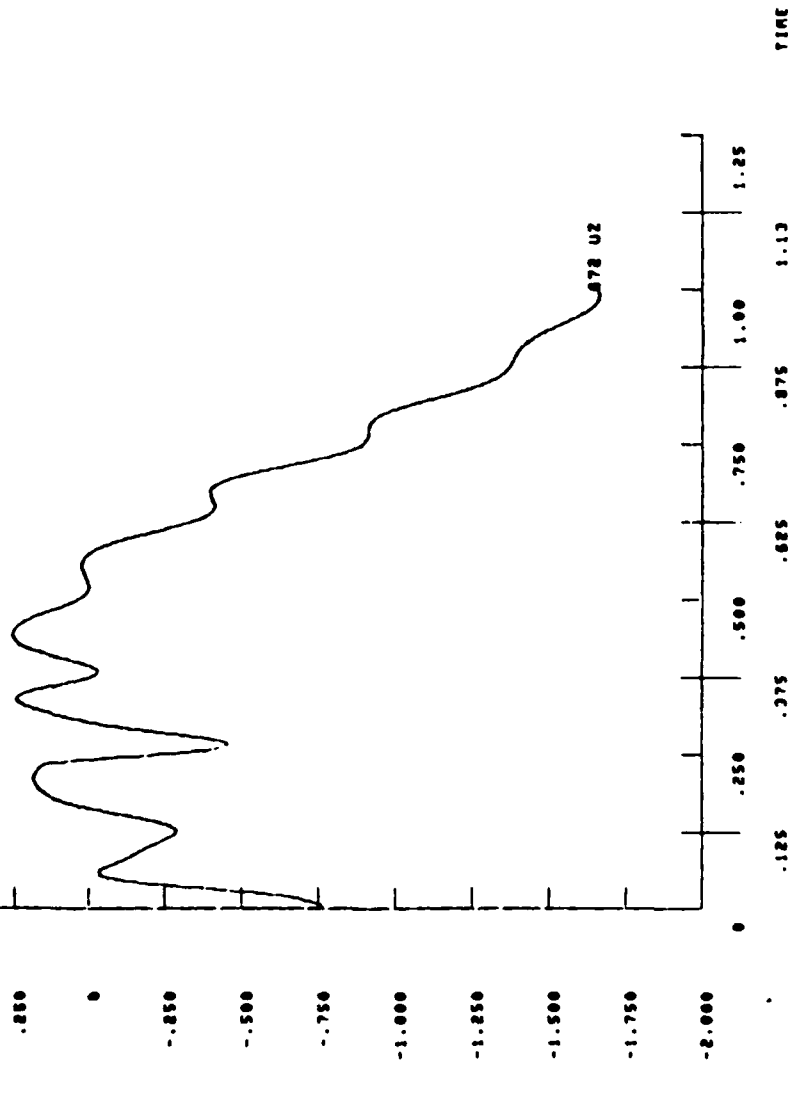
PART TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME

2 316P UZ 072 UZ -1.665 0.9900 0.8584 0.4410

PLOT DEFINITION

CURVE VARIABLE NAME

1 2 072 UZ



1 LUMB-0.0 CASE, PROOF LOADS-C.R.ORTLOFF

PROBATION COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES

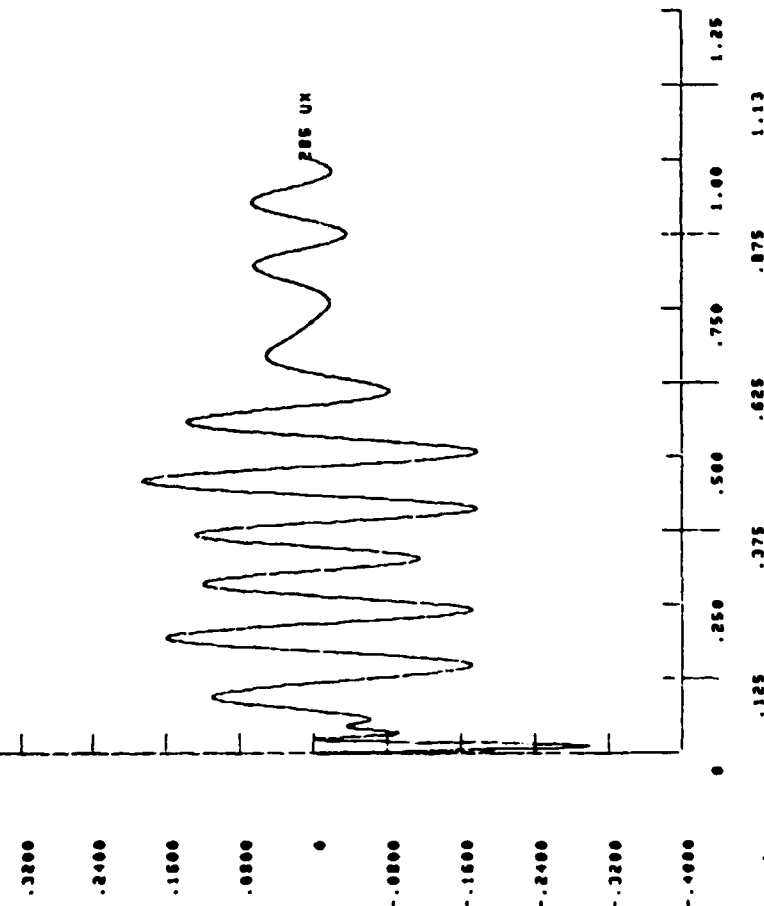
VARIABLE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME

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PLOT DEFINITION

CURVE VARIABLE NAME

1 285 UX



TIME

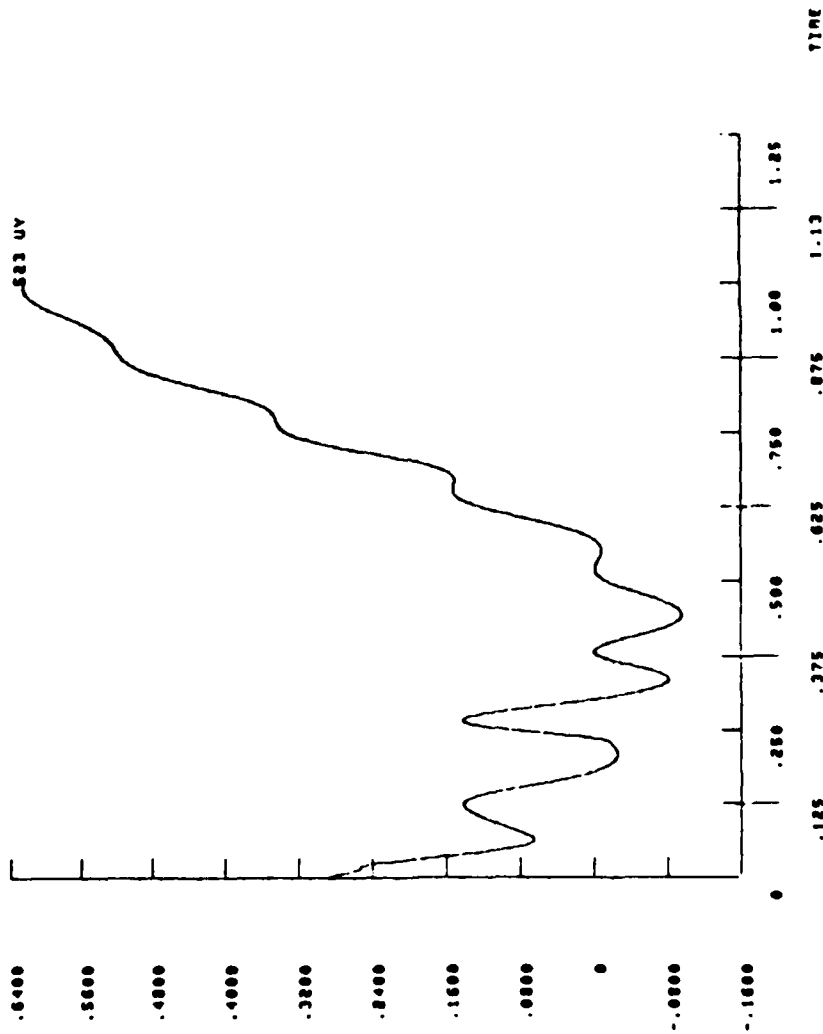
1 LUND-9.0 CASE, PROOF LOADS-C.R.ORTLOFF

POST26
ZU-1
0187-1.43

POORREIDCOMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 VARIABLE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME
 2 DISP VALU UV 523 UV -0.9548E-01 0.4430 0.0846 0.9910

PLOT DEFINITION
 CURVE VARIABLE NAME
 1 2 523 UV



1 LUND-0,0 CASE,PROOF LOADS-C.A.ORTLOFF

POST26
 ZU-1
 DISP-1.43

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POST26-IMP.

PLVAR,2

STORAGE COMPLETE FOR 1001 DATA POINTS

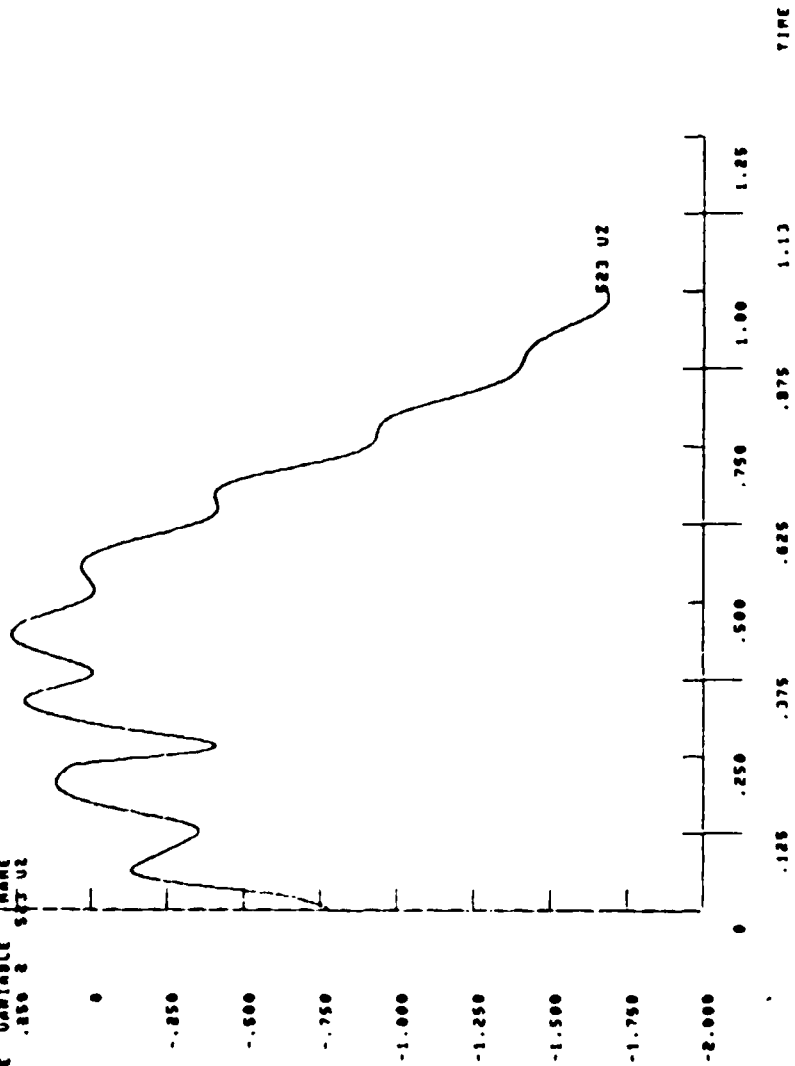
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PLOT DEFINITION

CURVE VARIABLE NAME

1 .250 2 523 UZ

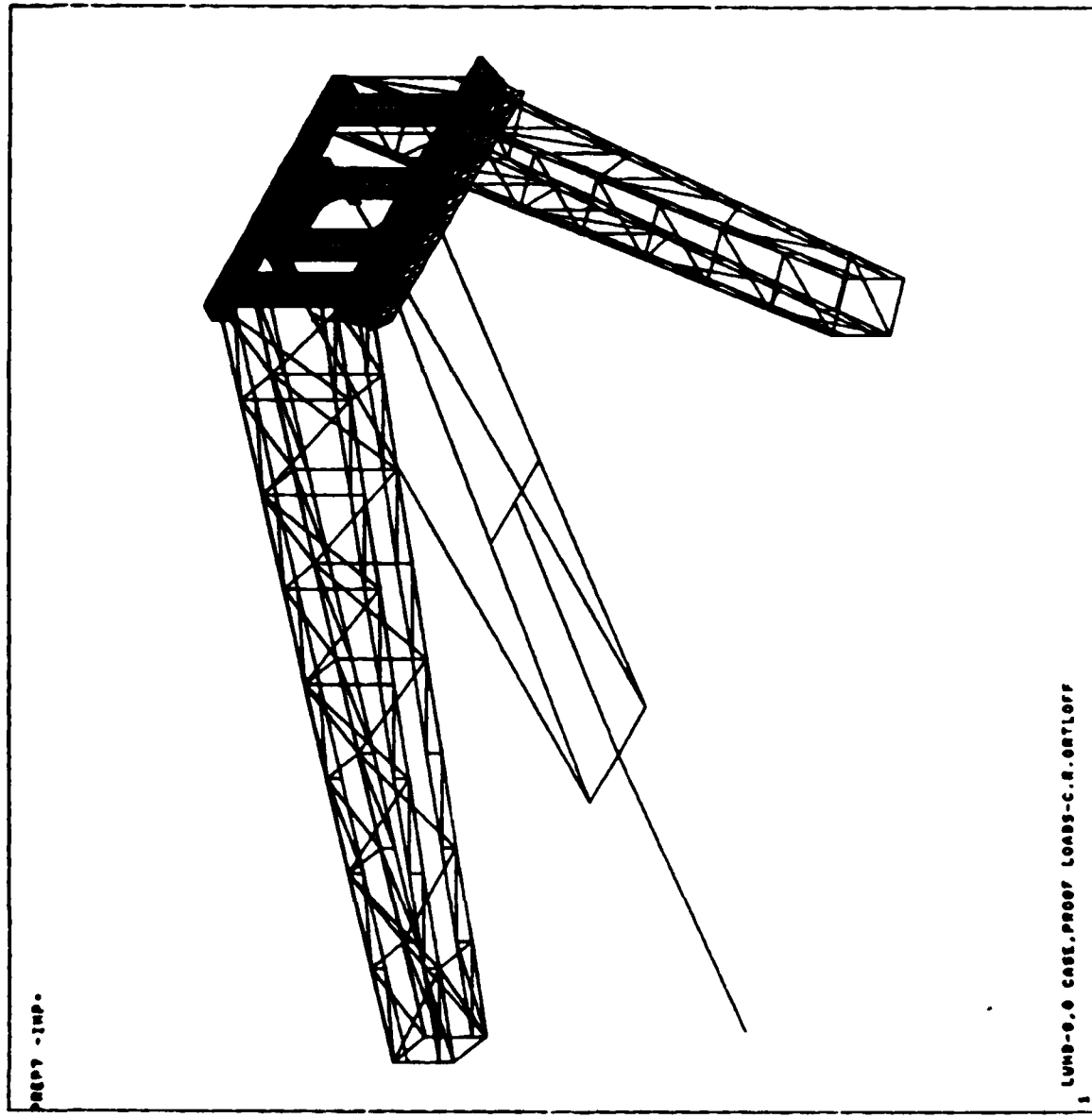


1 LUMB-0.0 CASE, PROOF LOADS-C.R.ORTLOFF

POST26
2U-1
0157-1.30

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 DEC 5 1988
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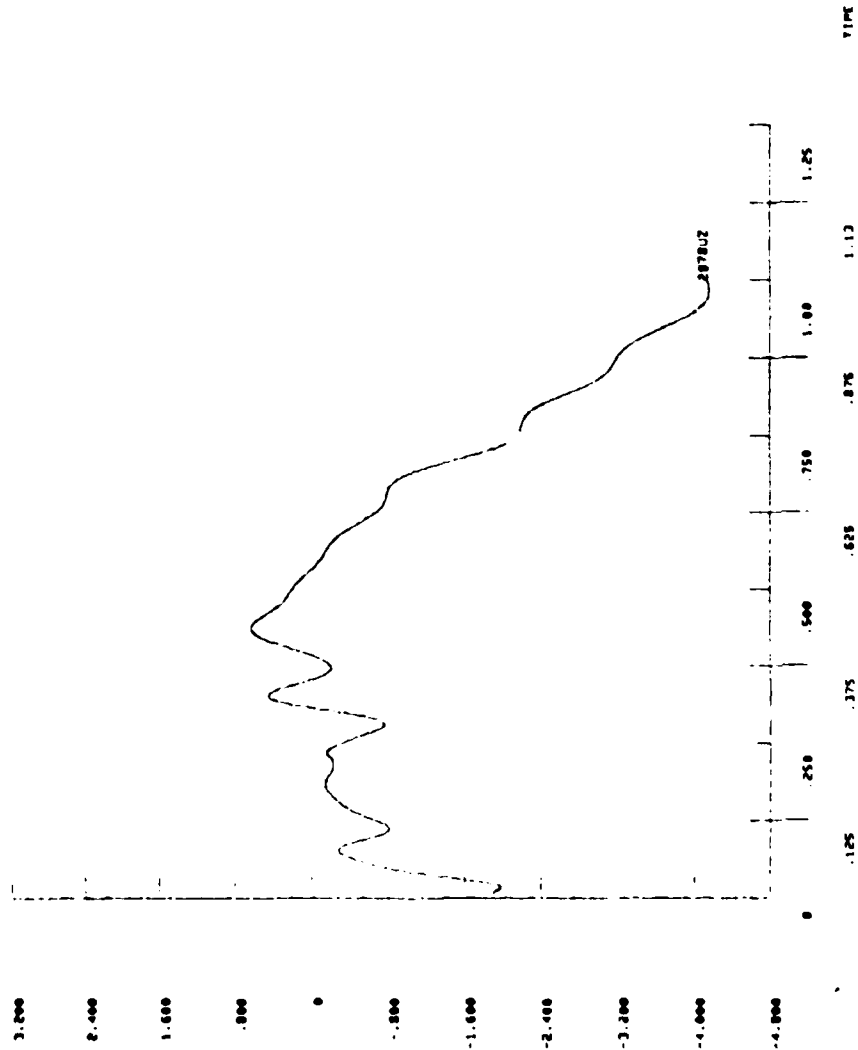


PREP7 -IMP.

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 Name
 Case 2
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Unit



Case 2, 100, 287802

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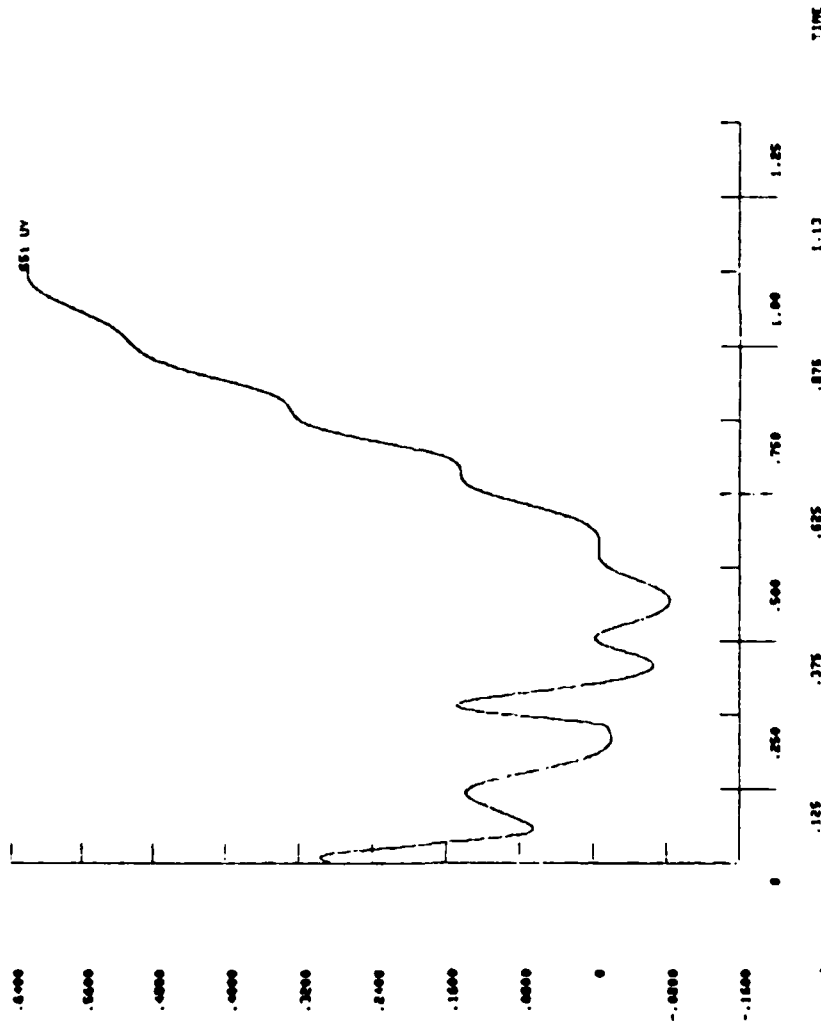
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POSTER-100
POSTER-100
POSTER-100

Summary of variables stored this step and extreme values
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Plot definition value
name variable name

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PLUMB-0, 0 CASE, PROOF LOADS-C.R. ORTLOFF

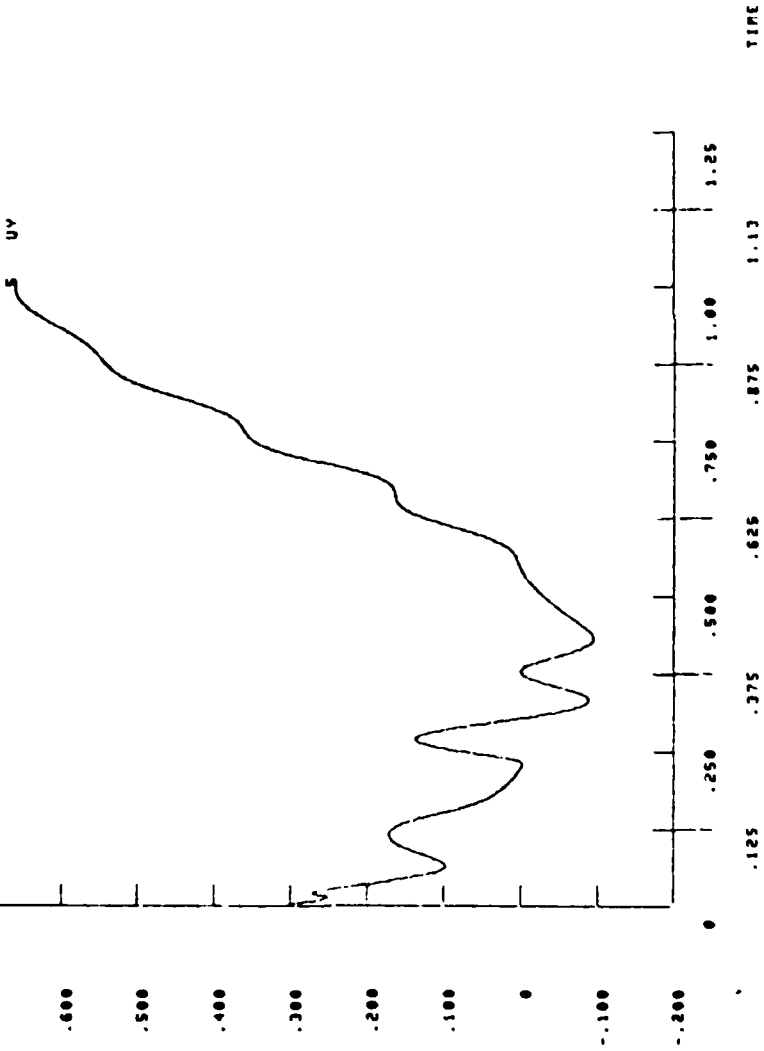
POSTER
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0107-1.43

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 POST26-IMP.
 PLVAR,2

STORAGE COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
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PLOT DEFINITION
 CURVE VARIABLE NAME
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1 LUMD-0.0 CASE, PROOF LOADS-C.R.ORTLOFF

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*****COMPLETE FOR 1001 DATA POINTS

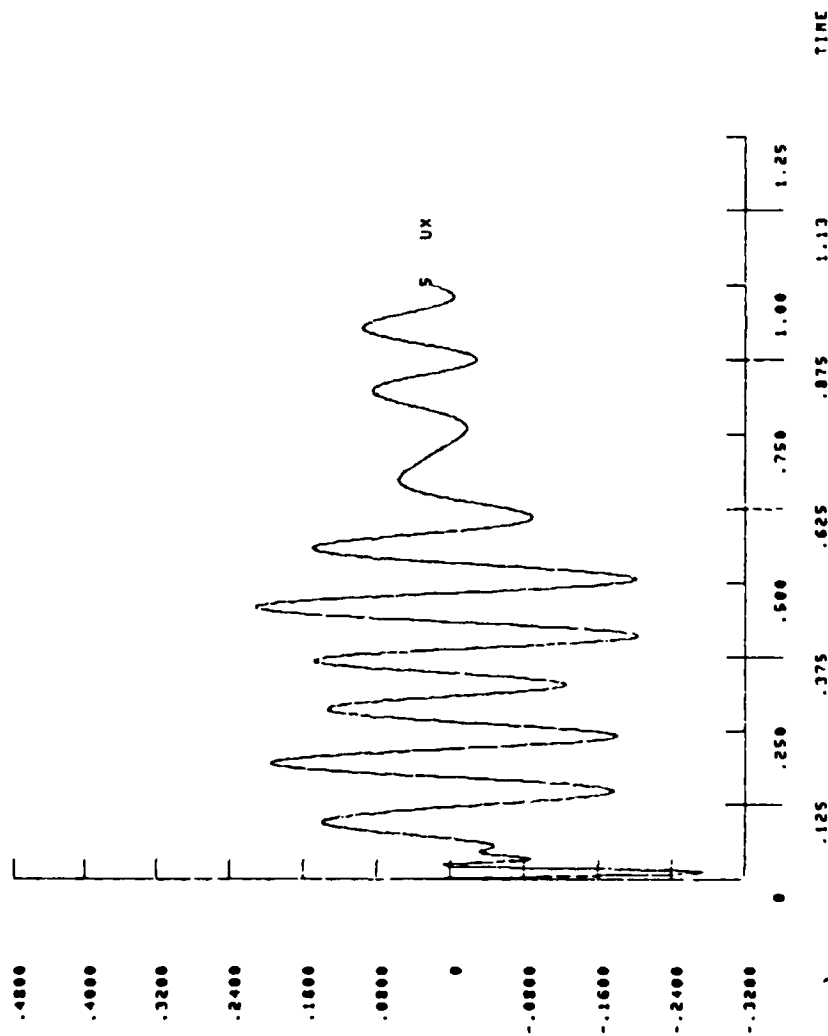
[illegible]

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			MINIMUM
			AT TIME
			MAXIMUM
			AT TIME

2 013P	$\mu\alpha_{2000}$	5	UX	-0.2760	0.1300E+01	0.2130	0.4580

PLOT	DEFINITION	NAME
CURVE	VARIABLE	UX
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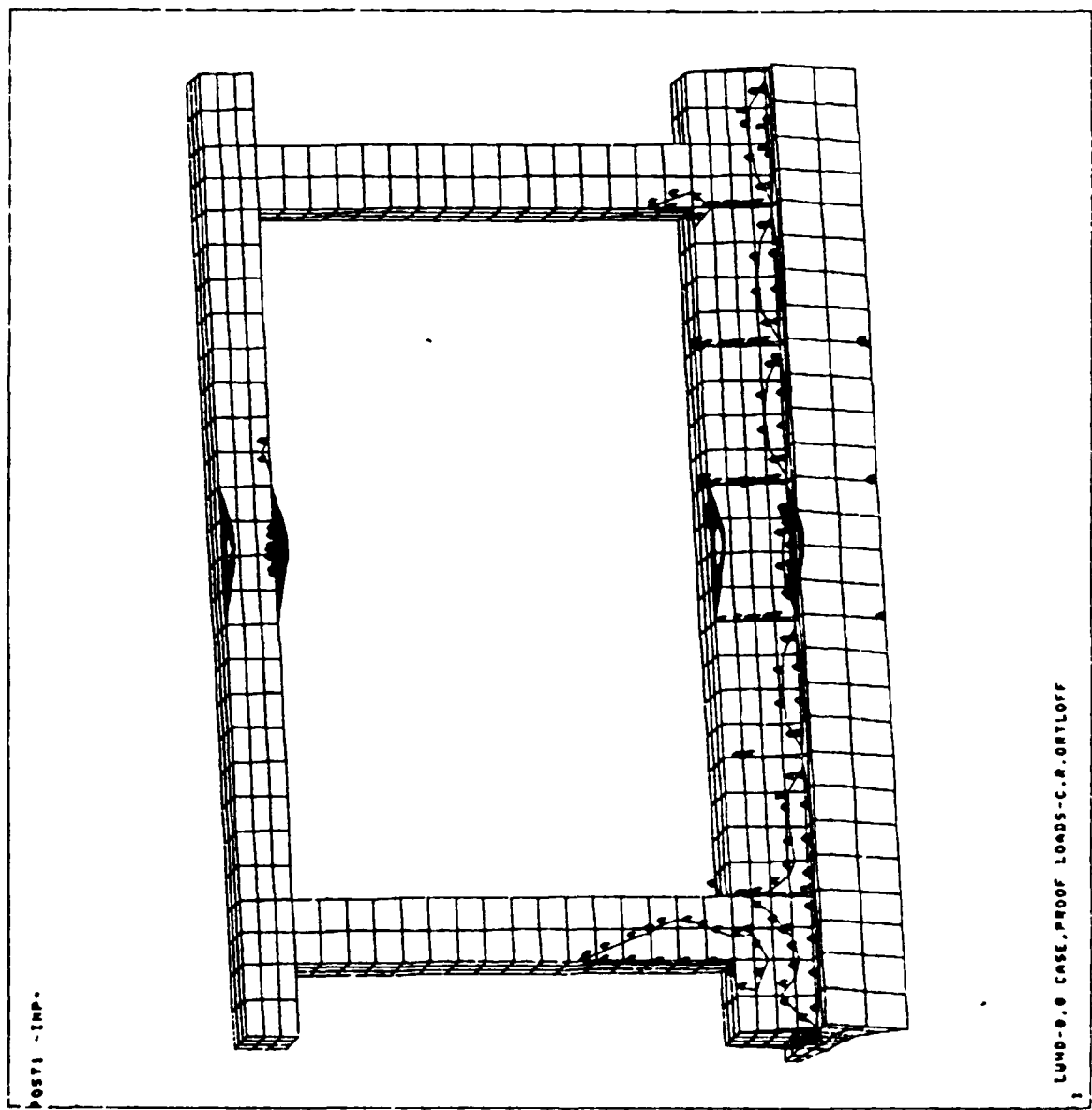
CURVE	VARIABLE	NAME

[illegible]

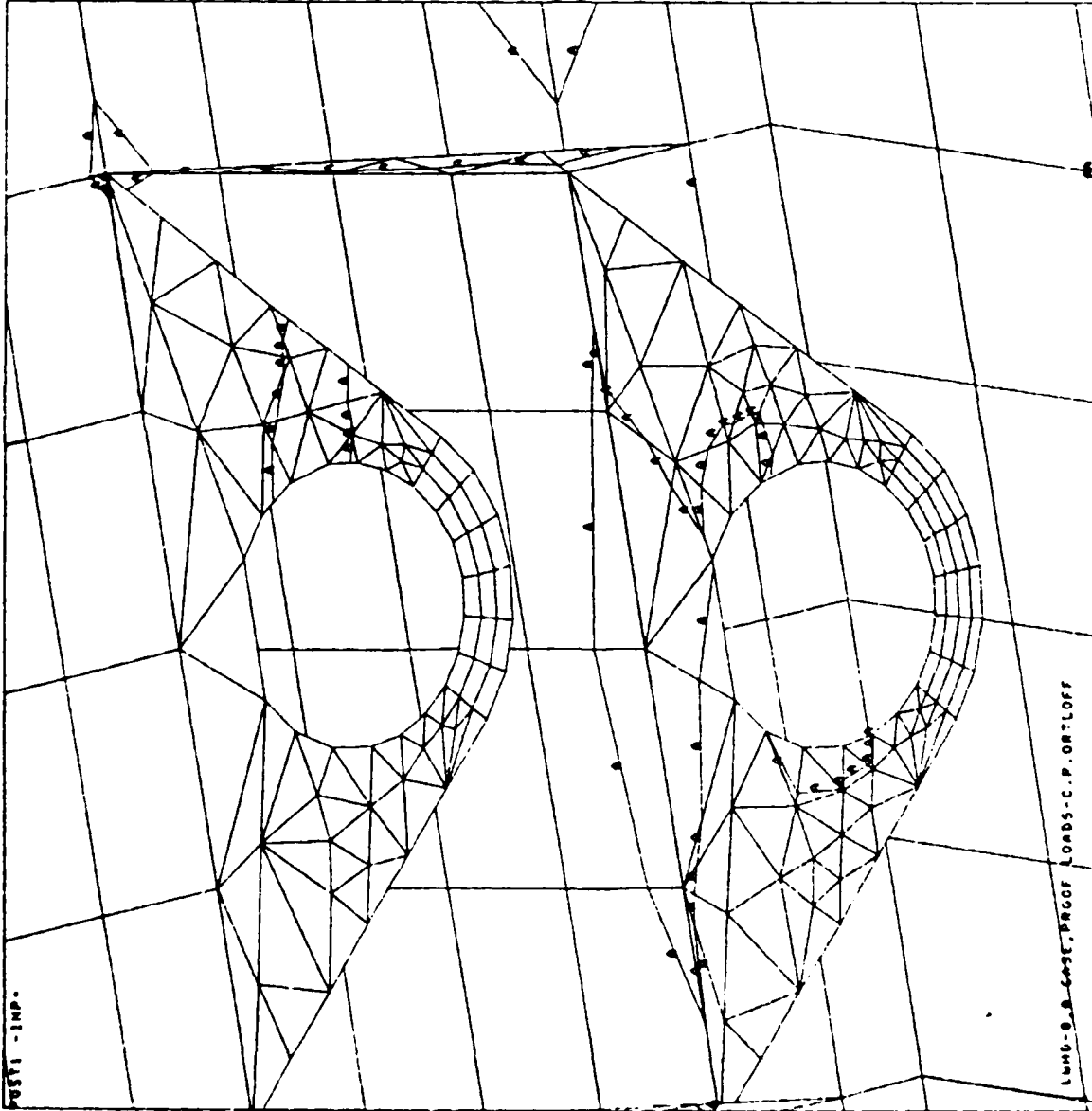
LUMB-O, O CASE, PROOF LOADS-C.R. ORYLOFF

POST 26
ZU-1
DIST-1.43

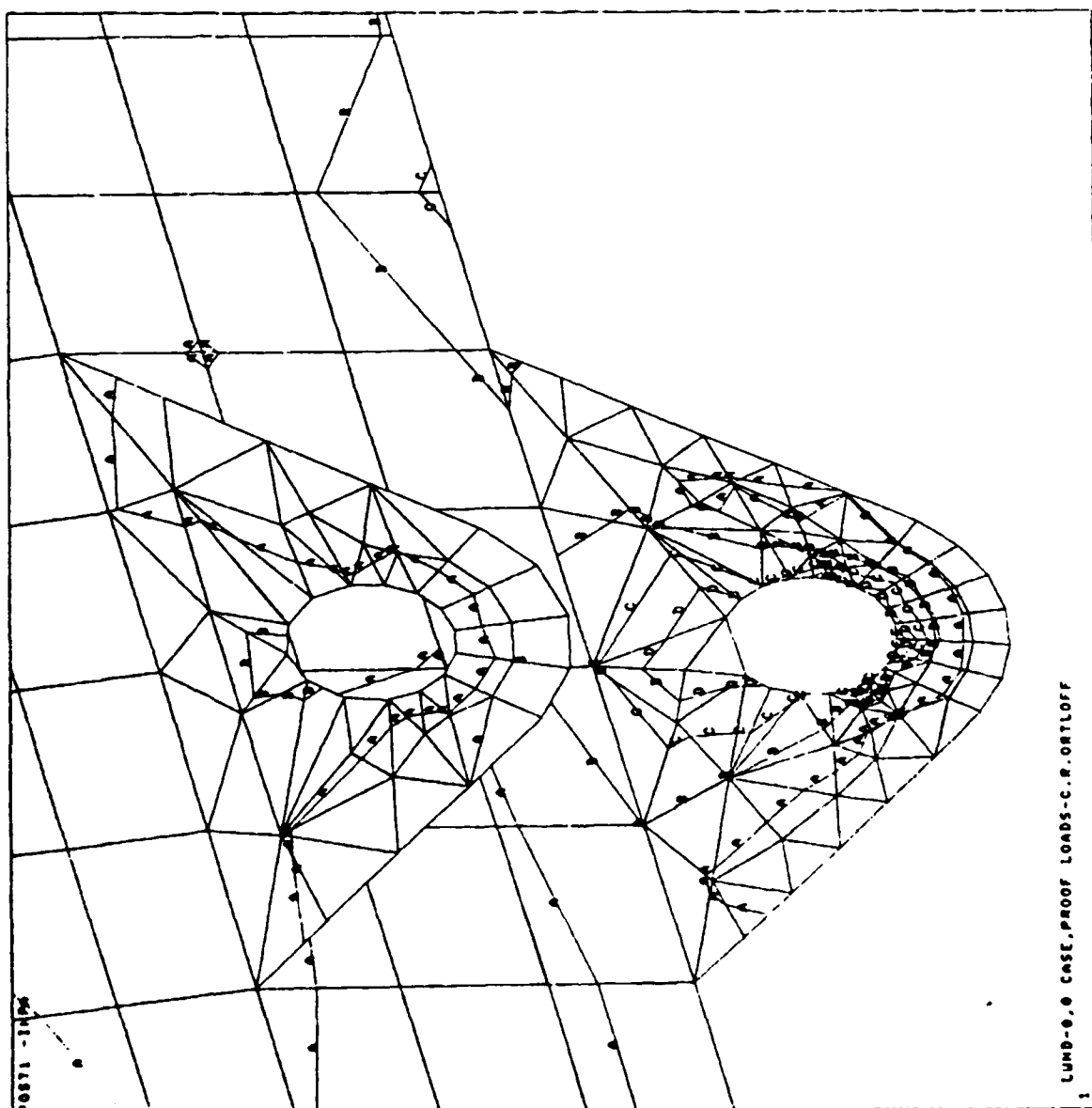
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 SICE
 TOP
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 VU=.3
 ZU=.1
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 XF=82.9
 VF=26.6
 ZF=6.46
 WIDEN
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 MY=59.9
 A=7162
 B=15466
 C=23170
 D=30874
 E=38578



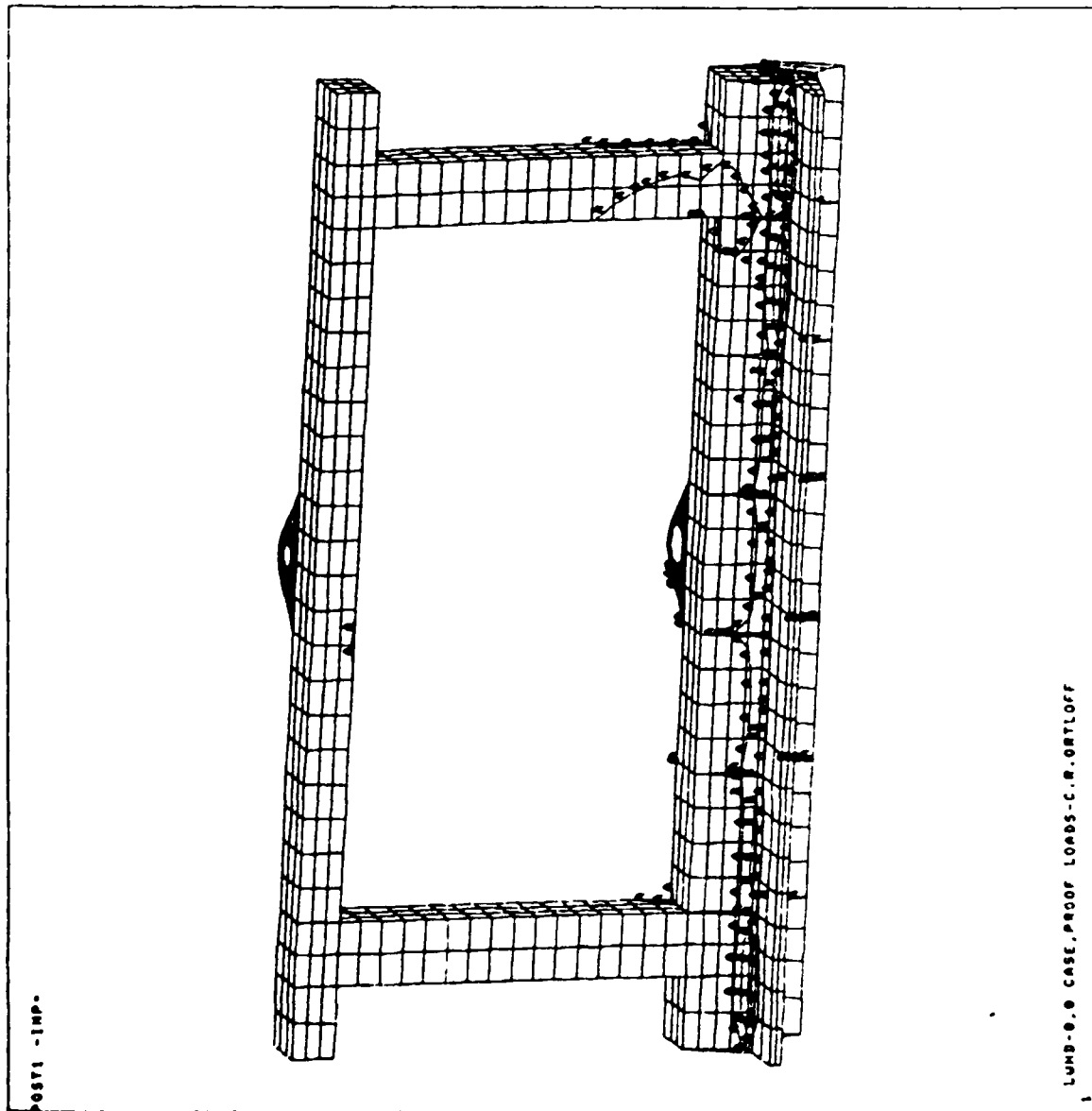
ANSV 4.28
 DEC 6 1986
 16:31:38
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 ITER=1
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 SICE
 TOP
 ZOOM
 XU=.2
 VU=1
 ZU=-1
 1 DIST=36.6
 2 XF=53.6
 3 VF=11.7
 4 ZF=-10.1
 XRT0=4.22
 VRT0=4.91
 HIDDEN
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 B=15466
 C=23170
 D=30874
 E=38578



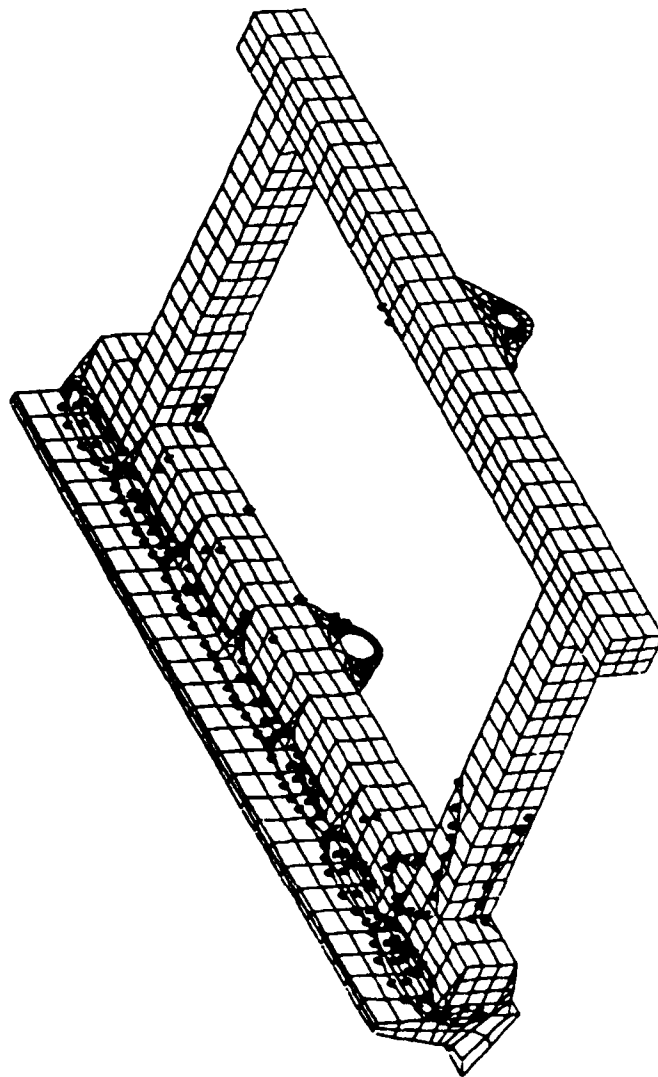
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 DEC 6 1986
 16137100
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.428
 SICE
 TOP
 ZOOM
 XU=.2
 YU=1
 ZU=-1
 Z DIST=54.6
 Z XF=47.2
 Z YF=42.7
 Z ZF=18.8
 XRT0=4.22
 YRT0=8.39
 HIDDEN
 MX=17334
 MY=0
 A=2947
 B=5836
 C=8725
 D=11614
 E=14593



ANSYS 4.28
 DEC 5 1986
 16:00:52
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.428
 SICE
 TOP
 ZOOM
 RV=.2
 VU=.3
 ZU=1
 DIST=72
 RF=52.4
 VF=27.3
 ZF=2.89
 XRT0=1.21
 HIDDEN
 RH=48280
 RM=50.0
 A=7762
 B=15466
 C=23170
 D=30874
 E=38578

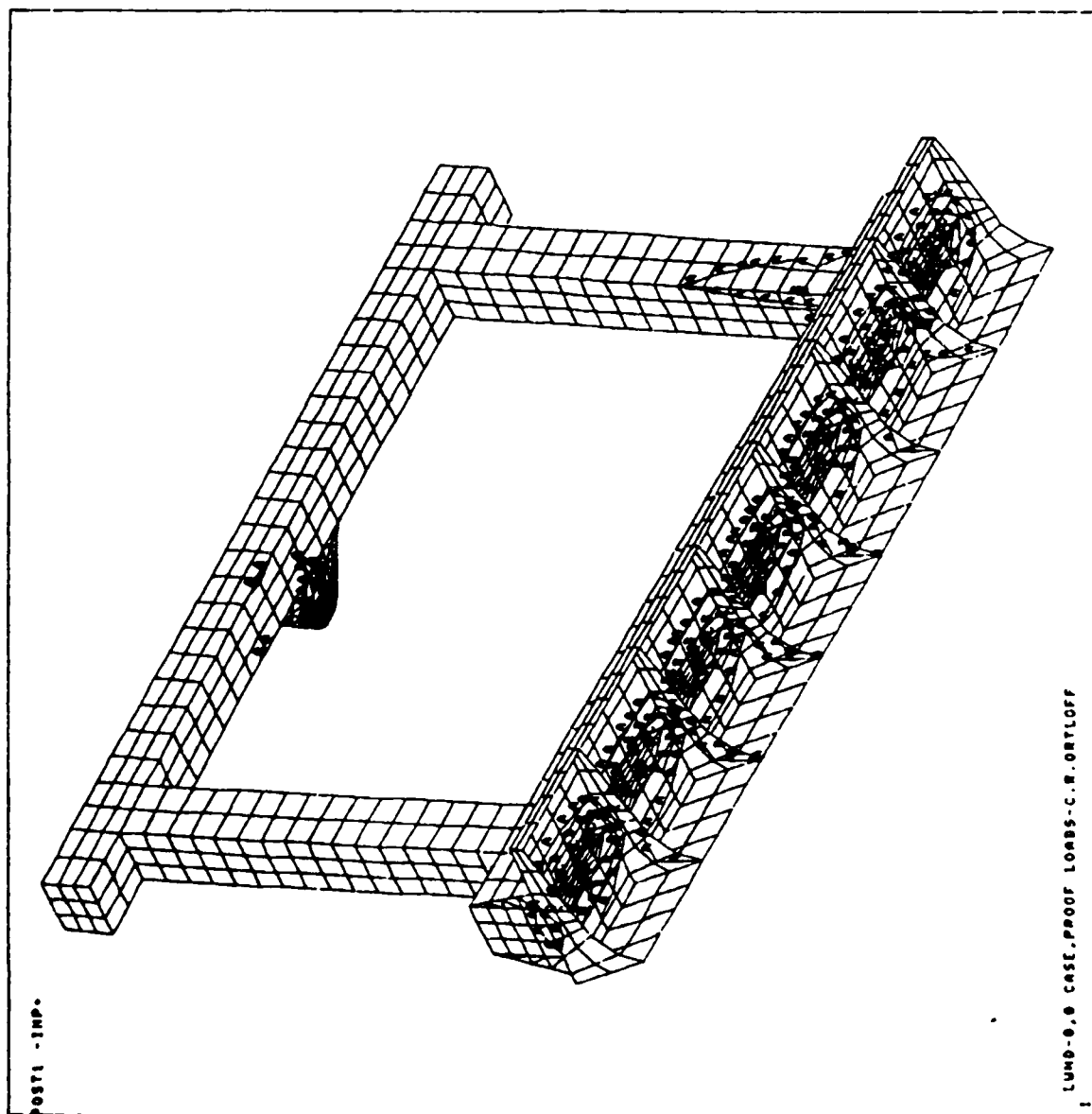


10-11-1964

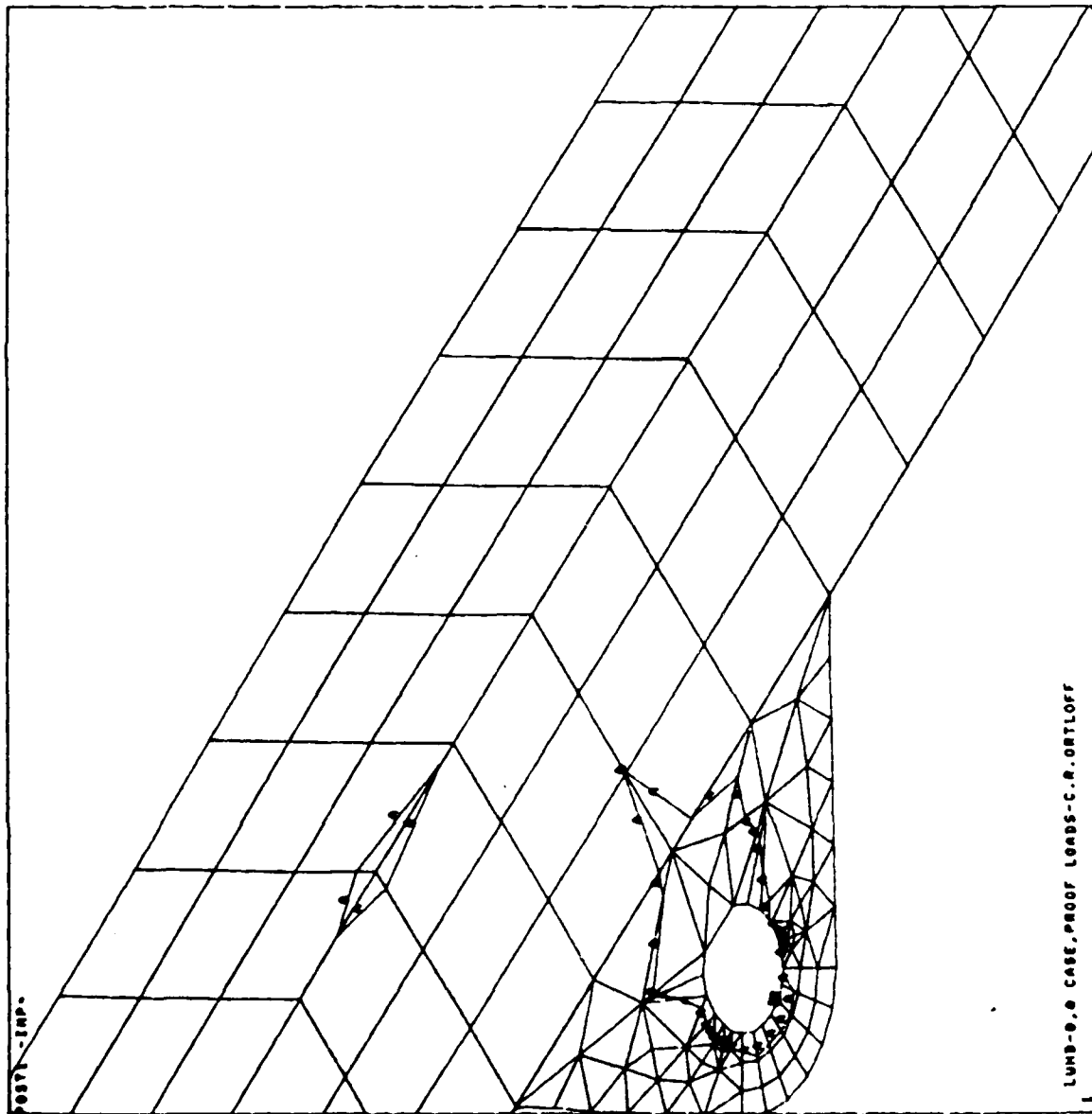


WFO-0,0 CASE, P0007 LONG-C. R. 0071077

ANSYS 4.08
 DEC 5 1986
 14100145
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.428
 SLICE
 TOP
 XU=-1
 VU=-1
 ZU=1
 DIST=59.2
 XF=54.2
 YF=26.4
 ZF=4.85
 HIDDEN
 MN=46280
 MM=59.9
 A=7782
 B=15466
 C=23170
 D=30874
 E=38578

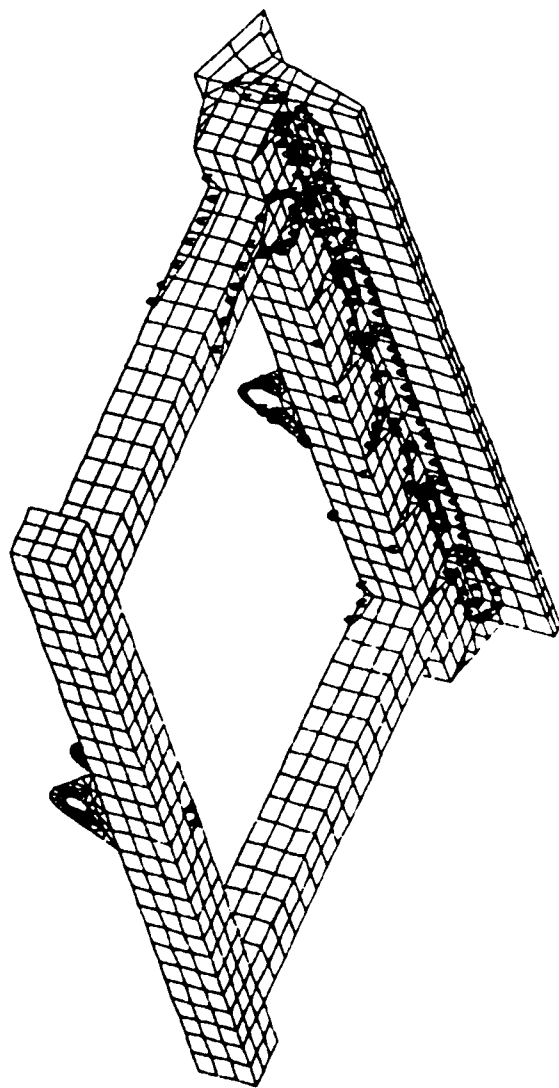


ANSYS 4.20
 DEC 5 1986
 14109146
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.428
 SICE
 TOP
 ZOOM
 KU=-1
 VU=-1
 ZU=1
 * BIST=11.6
 * XF=45.2
 * VF=47.9
 * ZF=17.3
 VRT0=1.06
 HIDDEN
 RX=17334
 RM=8
 A=7762
 B=15466



BOTTOM TAB

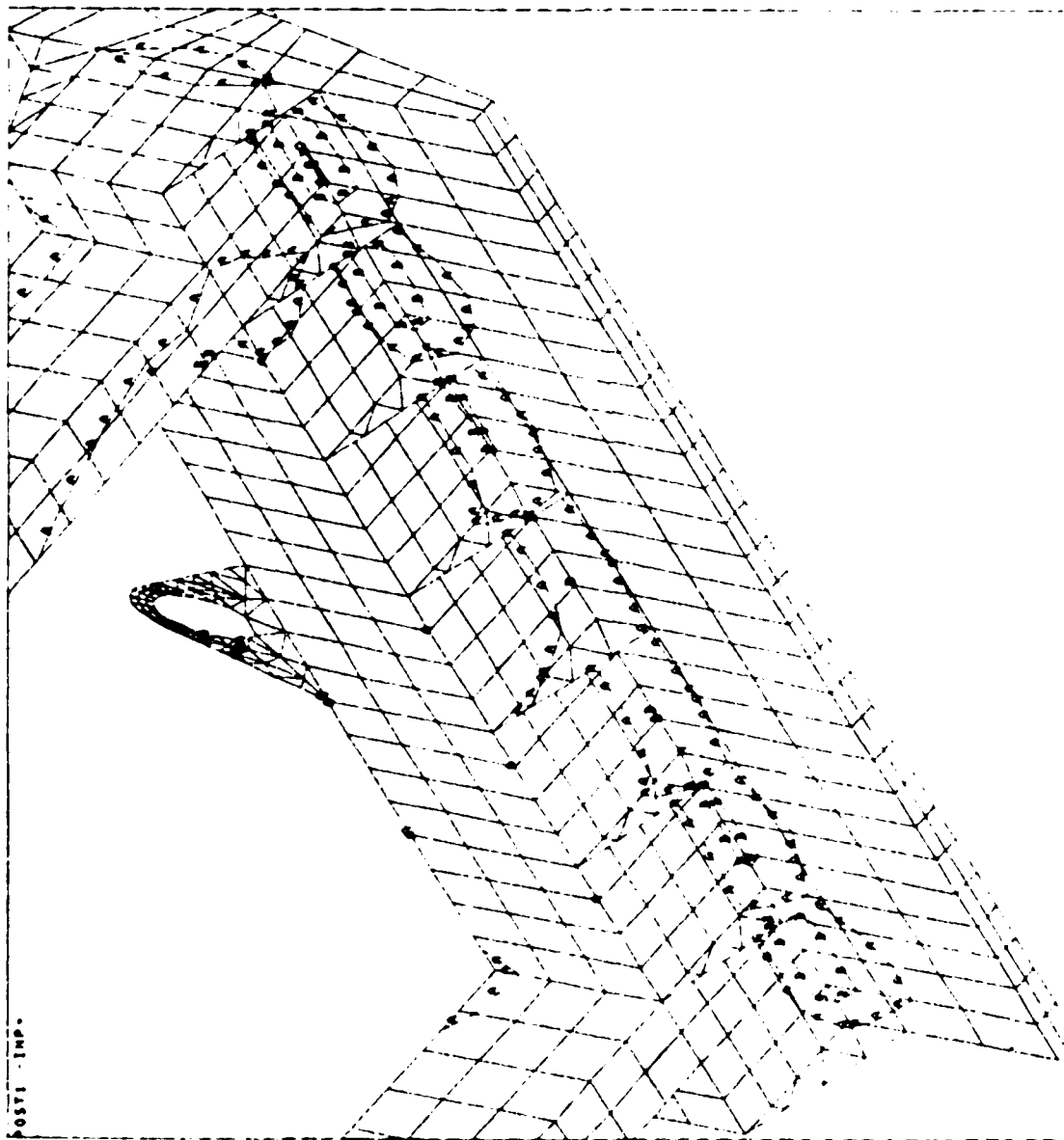
ANSYS 4.20
 DEC 5 1986
 14142131
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.488
 SICE
 TOP
 KU=1
 YU=.5
 ZU=.5
 D187=84.3
 HF=52.6
 VF=25.6
 ZF=5.21
 ANGL=60
 MIDDEN
 MX=46200
 MY=59.0
 A=7762
 B=15466
 C=23170
 D=30874
 E=38578



POST1 -IMP.

1 LUMB=0.0 CASE, PROOF LOADS-C.R. DRYLOFF

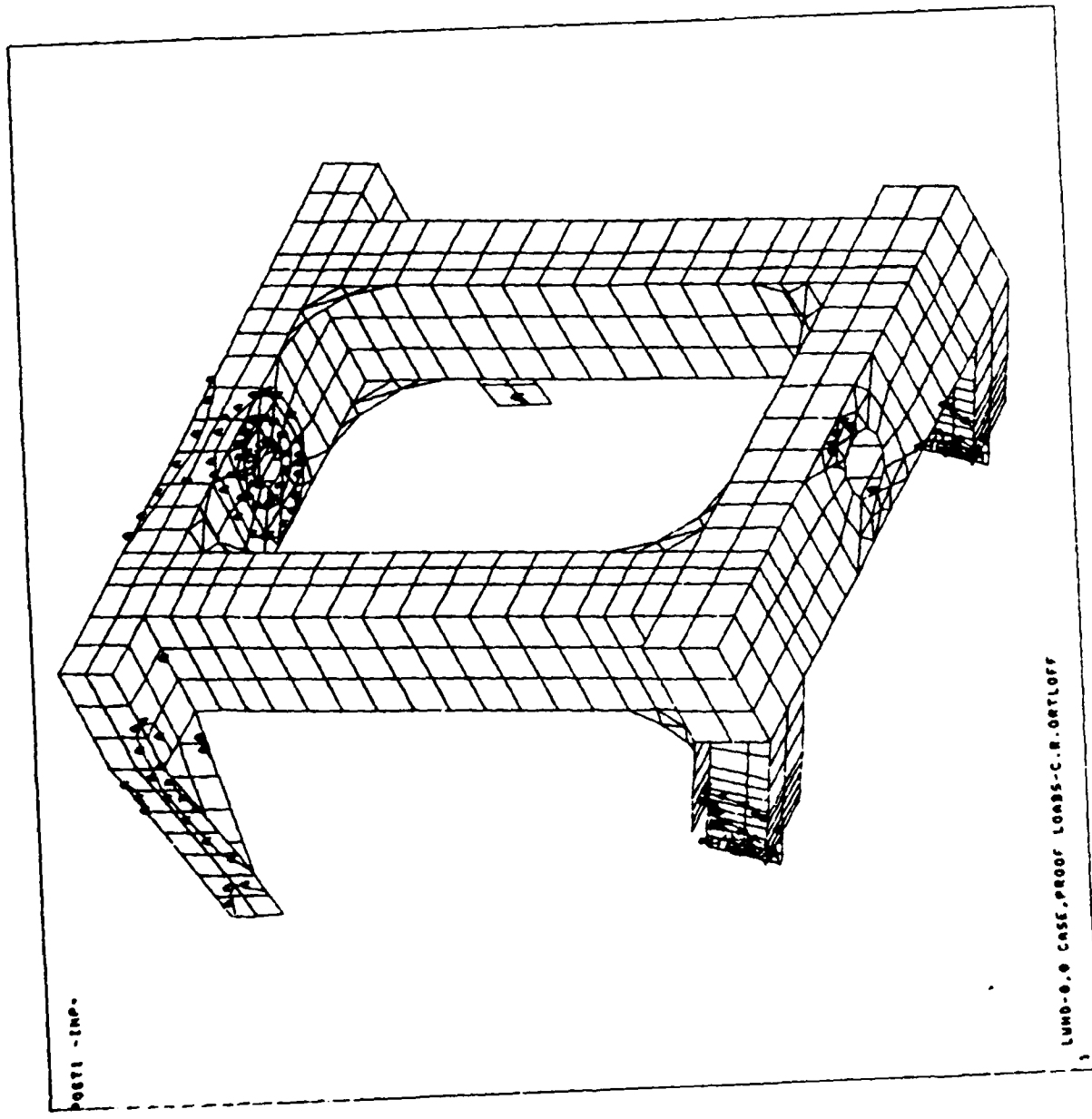
ANSYS 4.20
 DEC 5 1986
 14142131
 POST1 STRESS
 STEP=1
 TIME=1
 TIME=1.428
 SICE
 YOP
 ZOOM
 KU=1
 VU=.5
 ZU=.5
 DIST=34.4
 KF=59.8
 VF=4.68
 ZF=11.8
 ANGL=60
 VRTO=1.65
 MIDDEN
 RK=46280
 RM=0
 A=7762
 B=15456
 C=23170
 D=20874
 E=20578



LUND-0.0 CASE.PRCOF LOADS-C.D.ORTLOFF

ANSYS 4.20
 DEC 5 1980
 14132158
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.420
 SLOE
 TOP
 KU=-1
 YU=-1
 ZU=1
 DIST=32.7
 XF=51.5
 YF=35.2
 ZF=-8.87
 MIDDLEM
 RK=48474
 RM=220
 A=7112
 B=14006
 C=20000
 D=27794
 E=34088
 F=41582

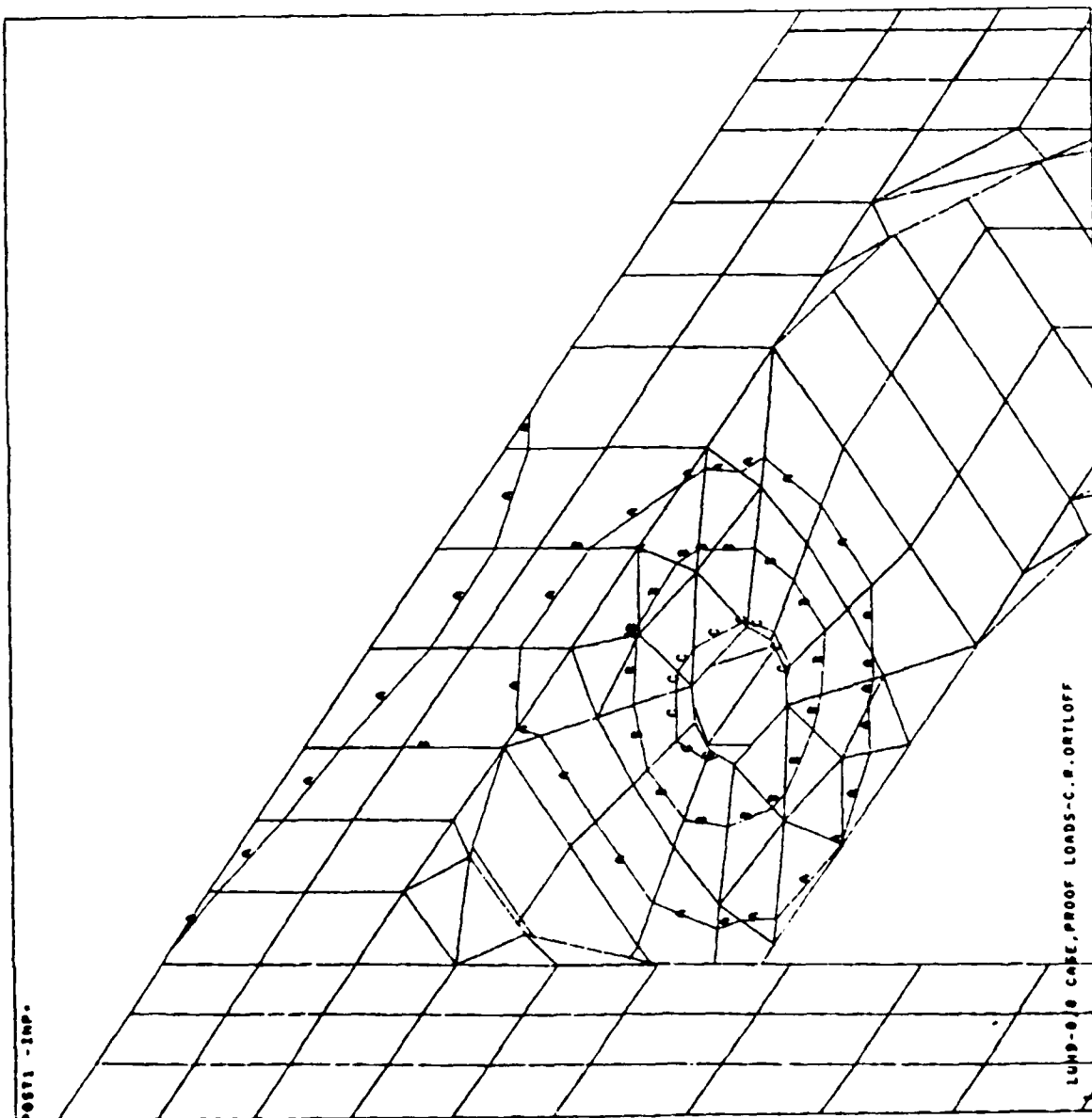
GIMBAL



POST1 -IMP.

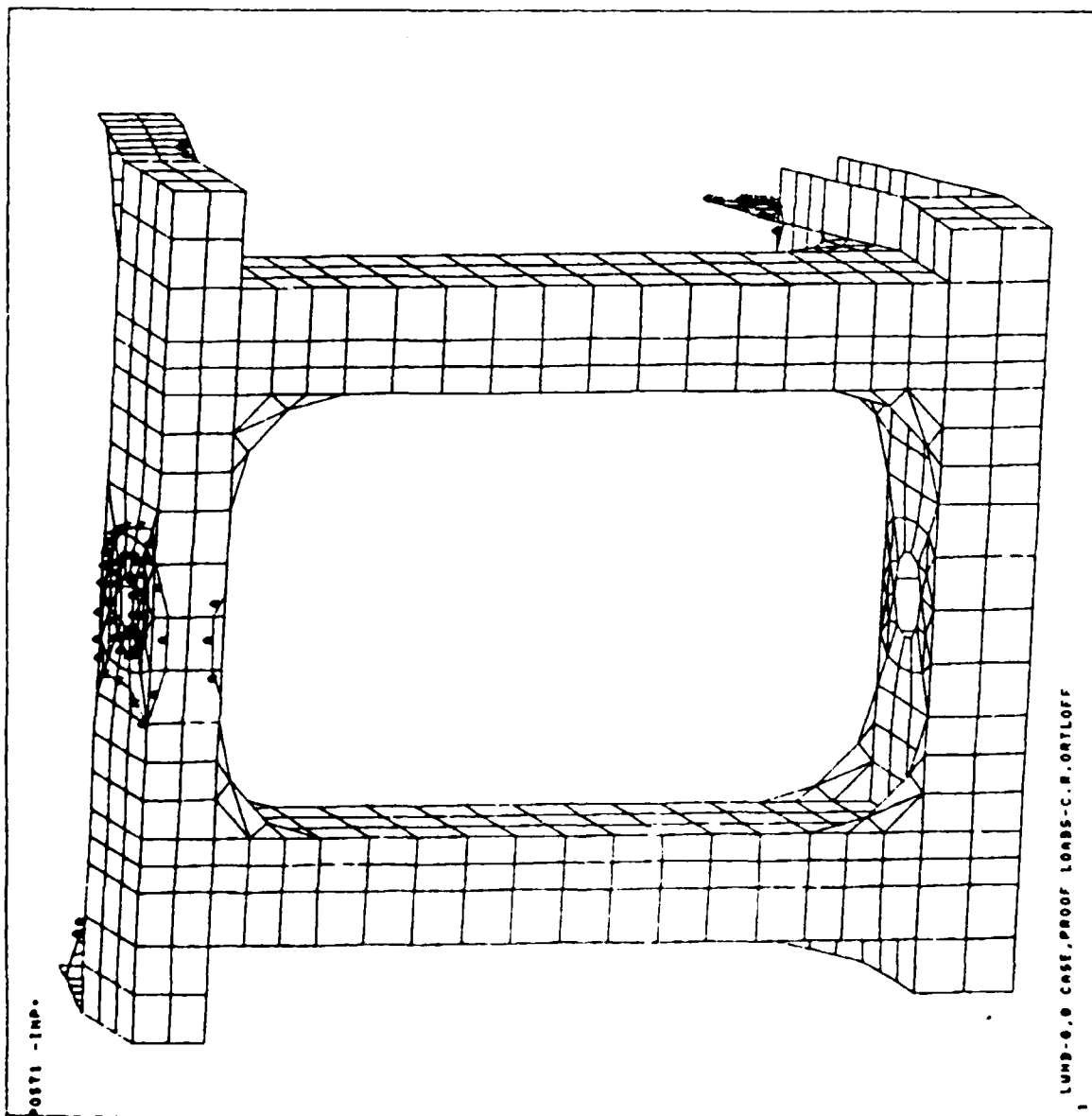
LUND-0.0 CASE,PROOF LOADS-C.R.ORTLOFF

ANSYS 4.20
 DEC 5 1986
 14:32:52
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.488
 \$JOE
 TOP
 ZOOM
 KU=-1
 VU=-1
 ZU=-1
 F DIST=10.0
 F MF=49.2
 F VF=50.0
 C TF=4.58
 VRT0=1.2
 MIDDEN
 MN=28230
 MN=0
 A=7112
 B=14006
 C=20900
 D=27794

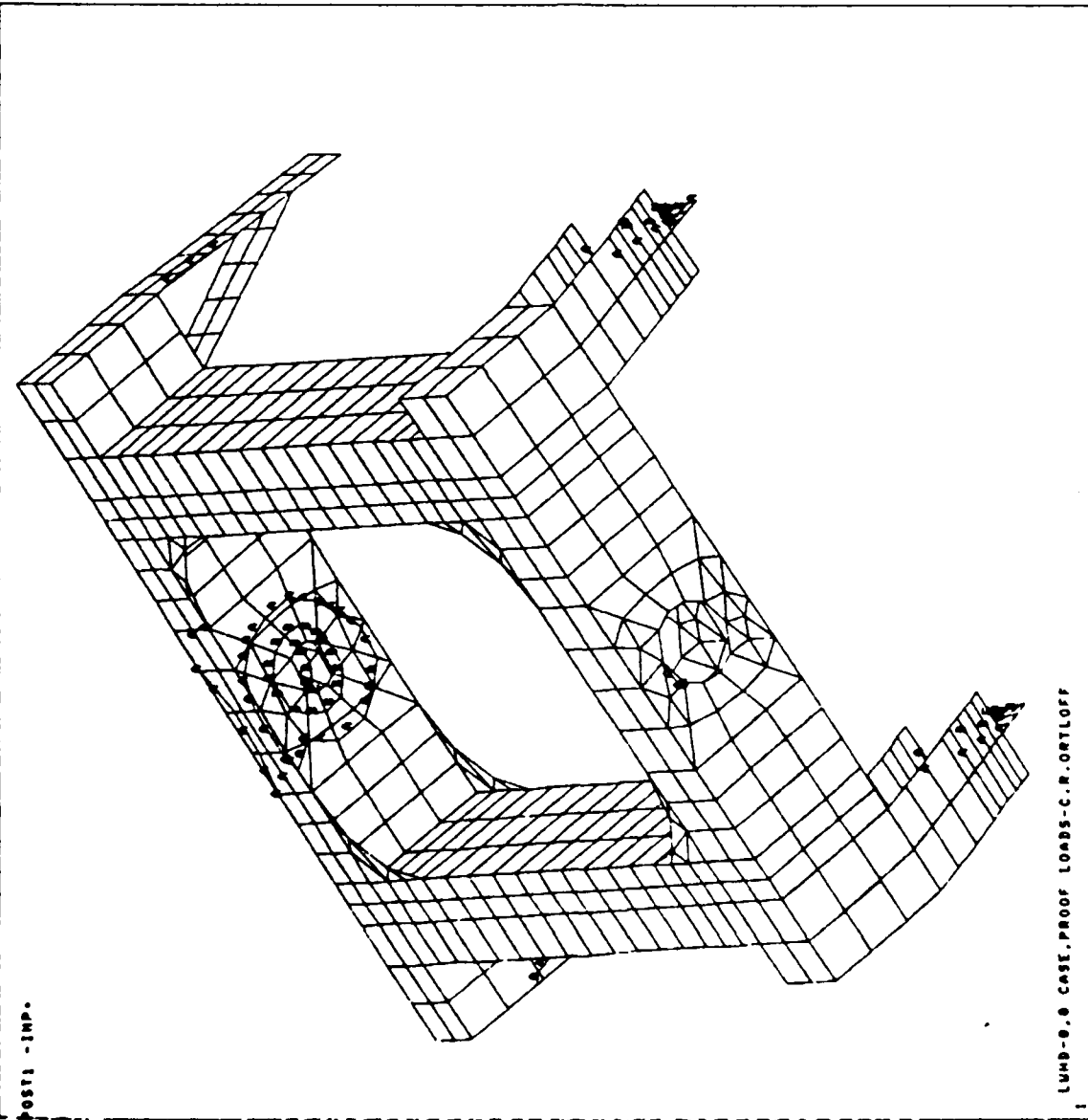


TOP
 GIMBAL

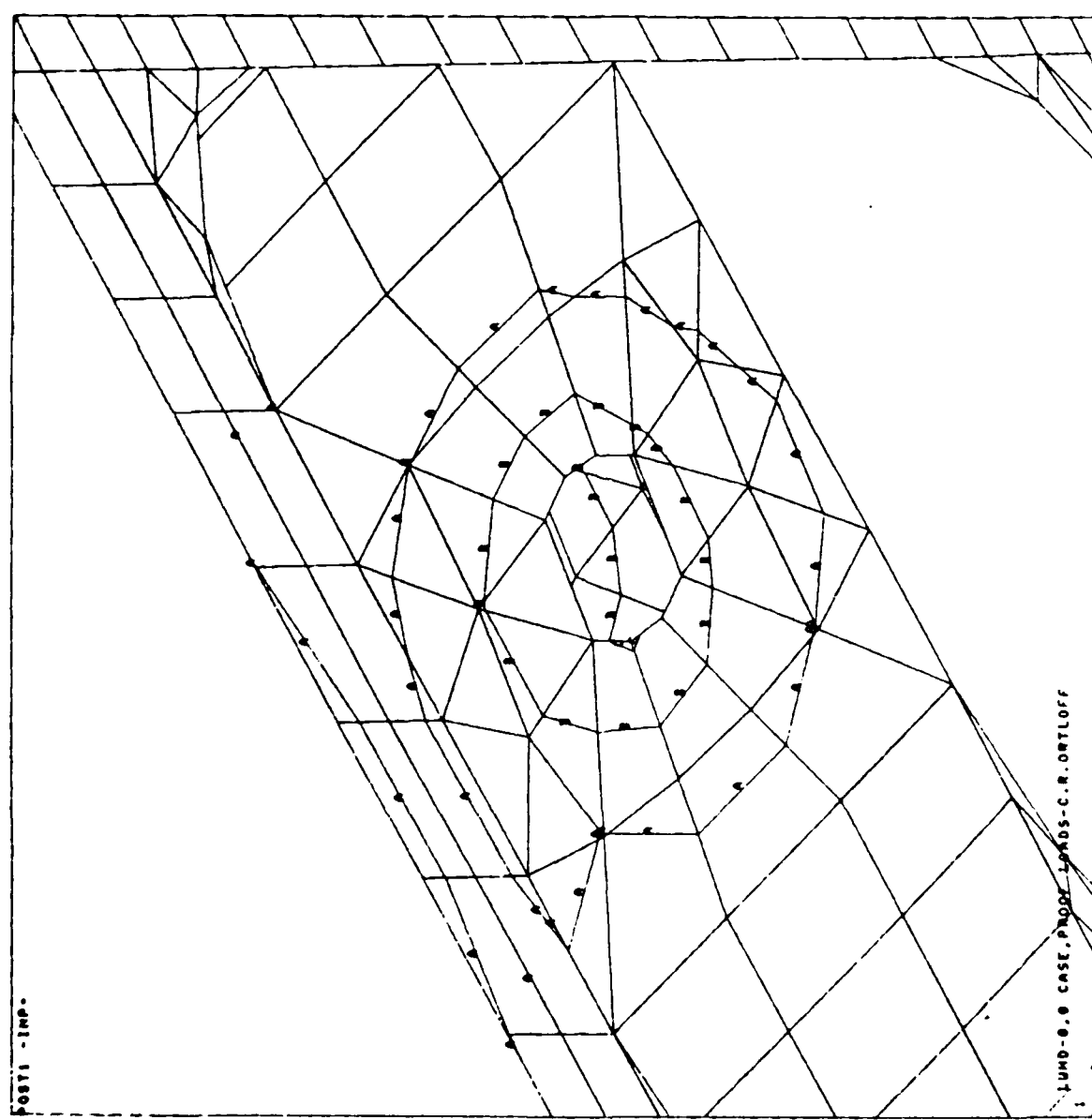
AMSVS 4.28
 DEC 5 1986
 15:20:49
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.428
 SICE
 TOP
 XV=.2
 YV=.3
 ZU=1
 DIST=28.1
 XF=53.3
 YF=31.9
 ZF=-8.53
 MIDDEN
 MX=48474
 MY=220
 A=8261
 B=16384
 C=24347
 D=32380
 E=48433



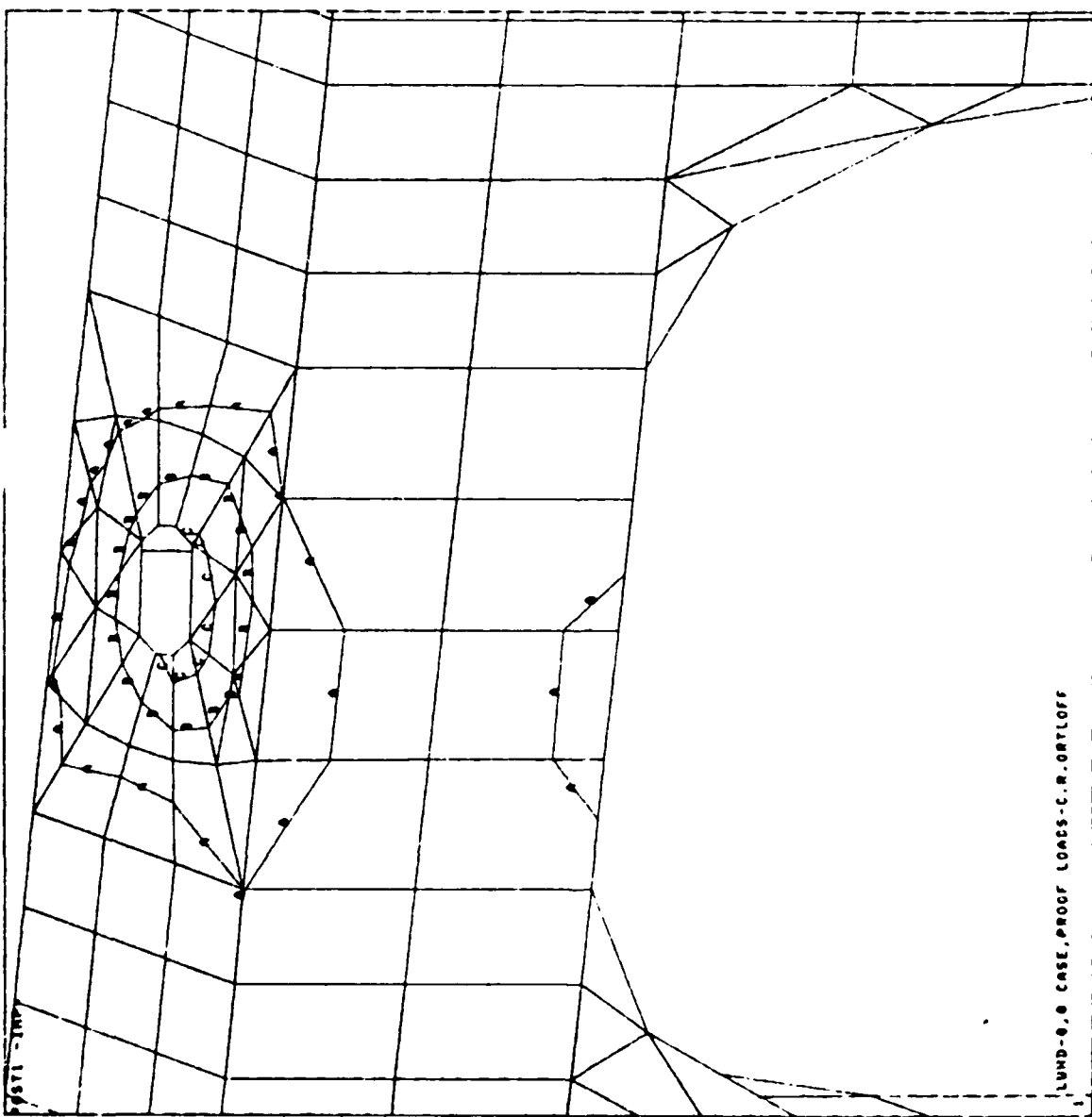
ANSYS 4.28
 DEC 5 1985
 15:43:40
 POST1 STRESS
 STEP=1
 LAYER=1
 TIME=.428
 SICE
 TOP
 XU=.3
 VU=-1
 ZU=.4
 DIST=30.2
 XF=54.6
 YF=33.1
 ZF=-7.74
 MIDDLEM
 MX=48474
 MY=220
 MZ=8861
 B=16384
 C=24347
 D=32380
 E=40433



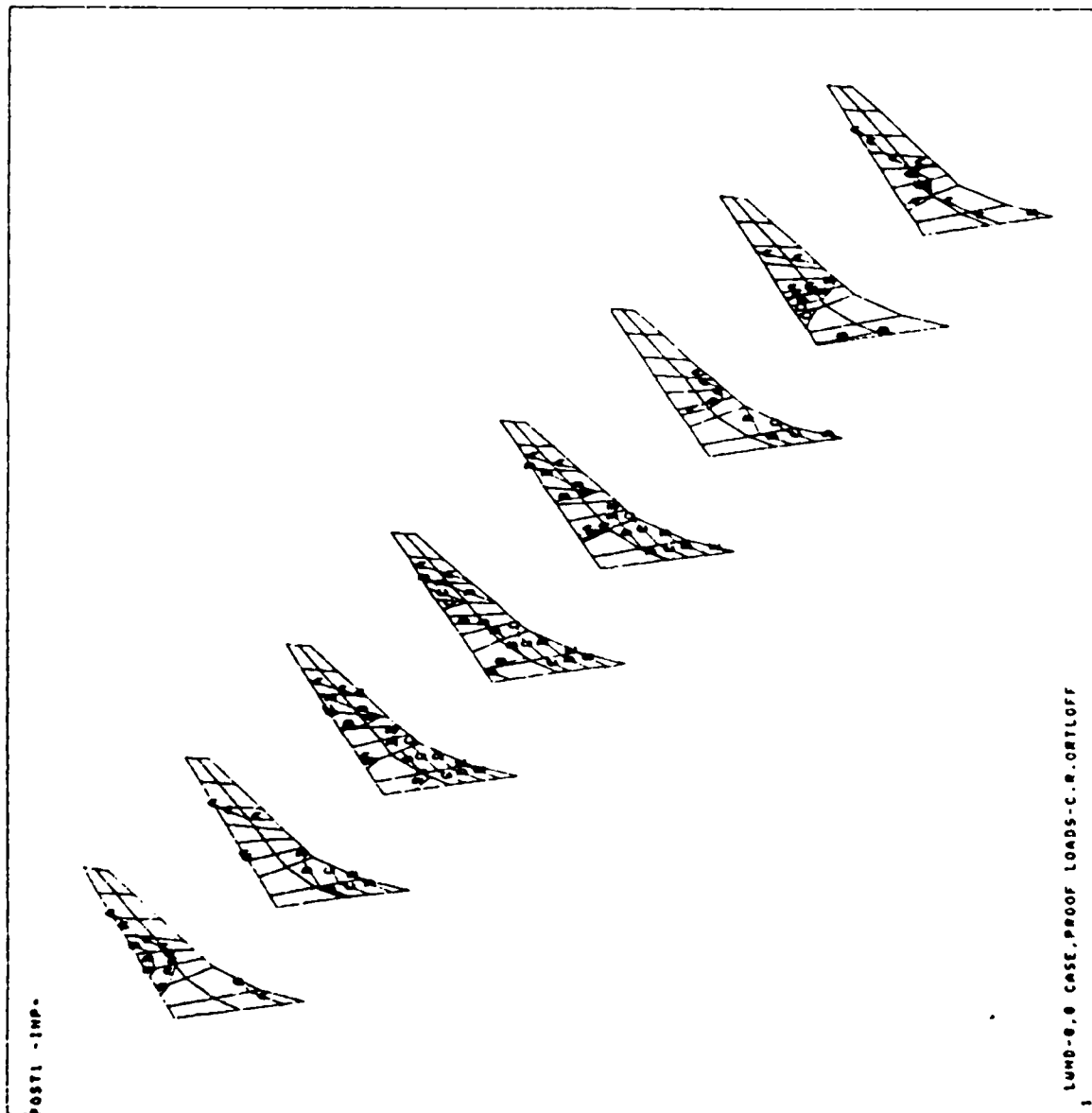
ANSYS 4.20
 DEC 5 1986
 15:43:40
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.428
 SICE
 TOP
 ZOOM
 KU=.3
 VU=-1
 ZU=.4
 8 DIST=9.47
 8 XF=57.7
 8 YF=38.7
 8 ZF=3.92
 XRT0=1.21
 HIDDEN
 RK=29230
 RH=0
 A=8261
 B=16304
 C=24347



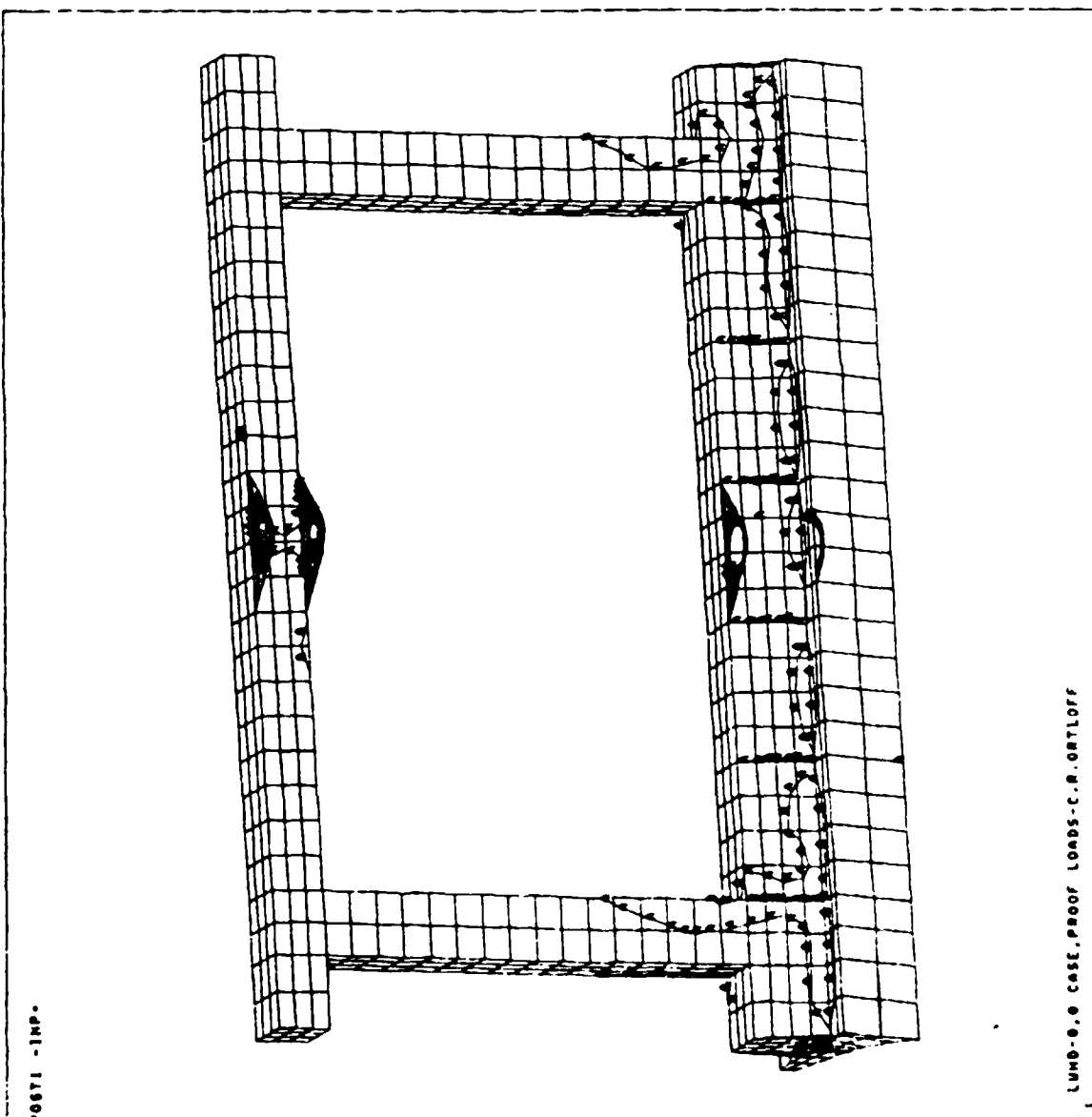
ANSYS 4.80
 DEC 6 1986
 15:20:40
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.428
 SICE
 TOP
 ZOOM
 NU=.2
 VU=.3
 ZU=1
 E DIST=11.4
 E XF=51.4
 E VF=48.3
 E ZF=-13.4
 VRTG=1.9
 MIDDLE
 MX=28230
 MY=0
 A=8261
 B=16304
 C=24347



ANSYS 4.28
 DEC 5 1986
 15:04:54
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.428
 SICE
 TOP
 ZOOM
 XU=-1
 YU=-1
 ZU=-1
 DIST=52.8
 WF=54.1
 VF=-2.93
 ZF=4.93
 VRT0=1.65
 MIDDEN
 RA=22061
 RH=181
 A=3827
 B=7474
 C=11121
 D=14768
 E=18415



ANSYS 4.23
 DEC 8 1986
 10:49:36
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.013
 SICE
 TOP
 XU=.2
 YU=.3
 ZU=-1
 DIST=59.3
 XF=62.8
 YF=25.6
 ZF=6.46
 HIDDEN
 NA=159893
 AN=176
 A=26784
 B=53414
 C=80034
 D=106654
 E=133274



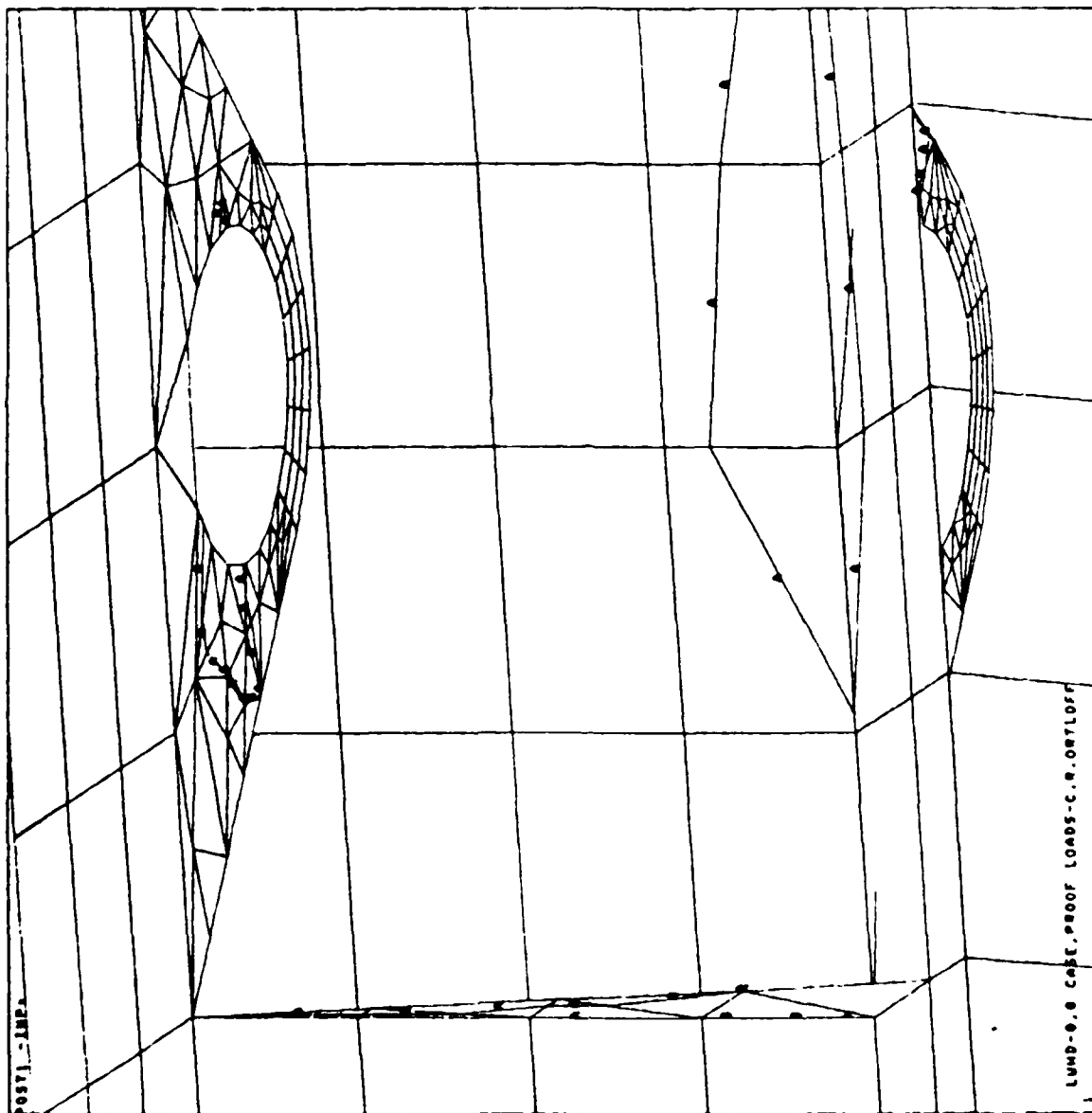
POST 1 - IMP.

LUND-0.0 CASE, PROOF LOADS-C.R.ORTLOFF

LUND-0.0 CASE, PROOF LOADS-C.R.-ORTLOFF

TOP PLATFORM

ANSYS 4.20
 DEC 8 1986
 11:01:00
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.013
 SLOE
 TOP
 ZOOM
 XU=.2
 VU=.3
 ZU=-1
 B DIST=8.61
 B KF=54.5
 B VF=3.62
 B ZF=.17
 XRTD=1.19
 VRTD=1.28
 MIDDLE
 RK=124272
 RM=0
 A=26794
 B=53414
 C=80034
 D=106654

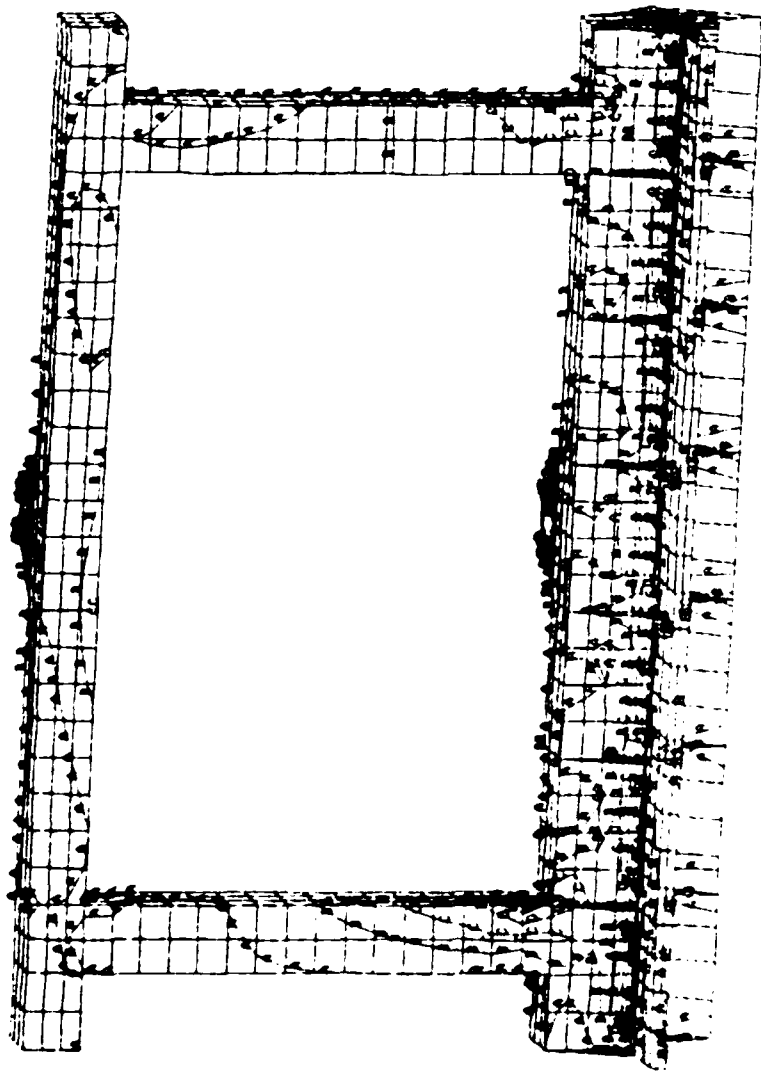


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PLATFORM
 BOTTOM

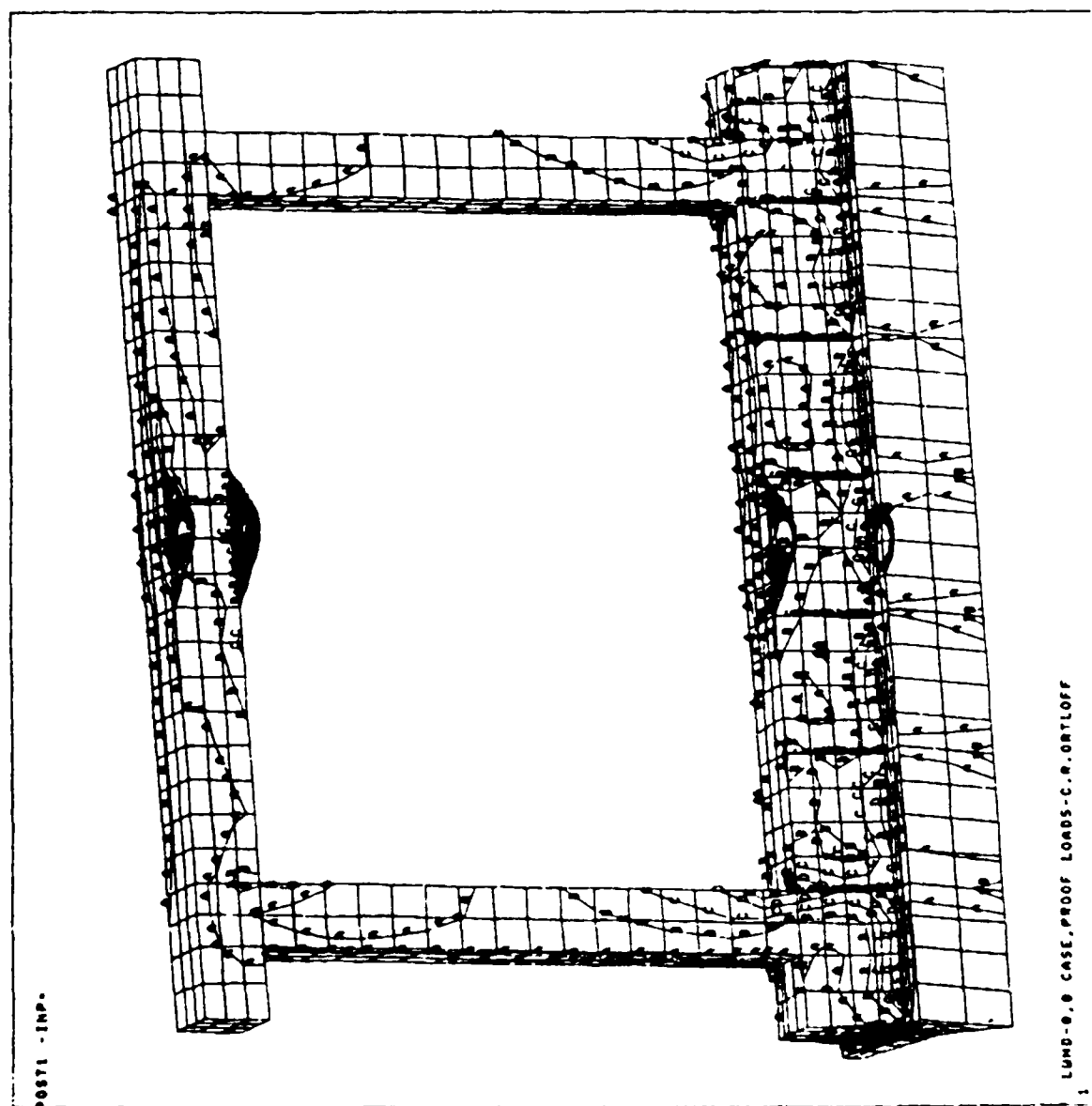
ANSYS 4.28
 DEC 8 1986
 11:14:33
 POST1 STRESS
 STEP=1
 ITEM=1
 TIME=.013
 SICE
 TOP
 XU=.2
 YU=.3
 ZU=.1
 DIST=59.3
 XF=52.4
 YF=27.3
 ZF=2.89
 MIDDEN
 RM=150893
 RM=176
 A=10153
 B=20136
 C=30119
 D=40102
 E=50085
 F=60068
 G=70051
 H=80034
 I=90017
 J=100000
 K=109983
 L=119966
 M=129949
 N=139932
 O=149915

POST1 -IMP.

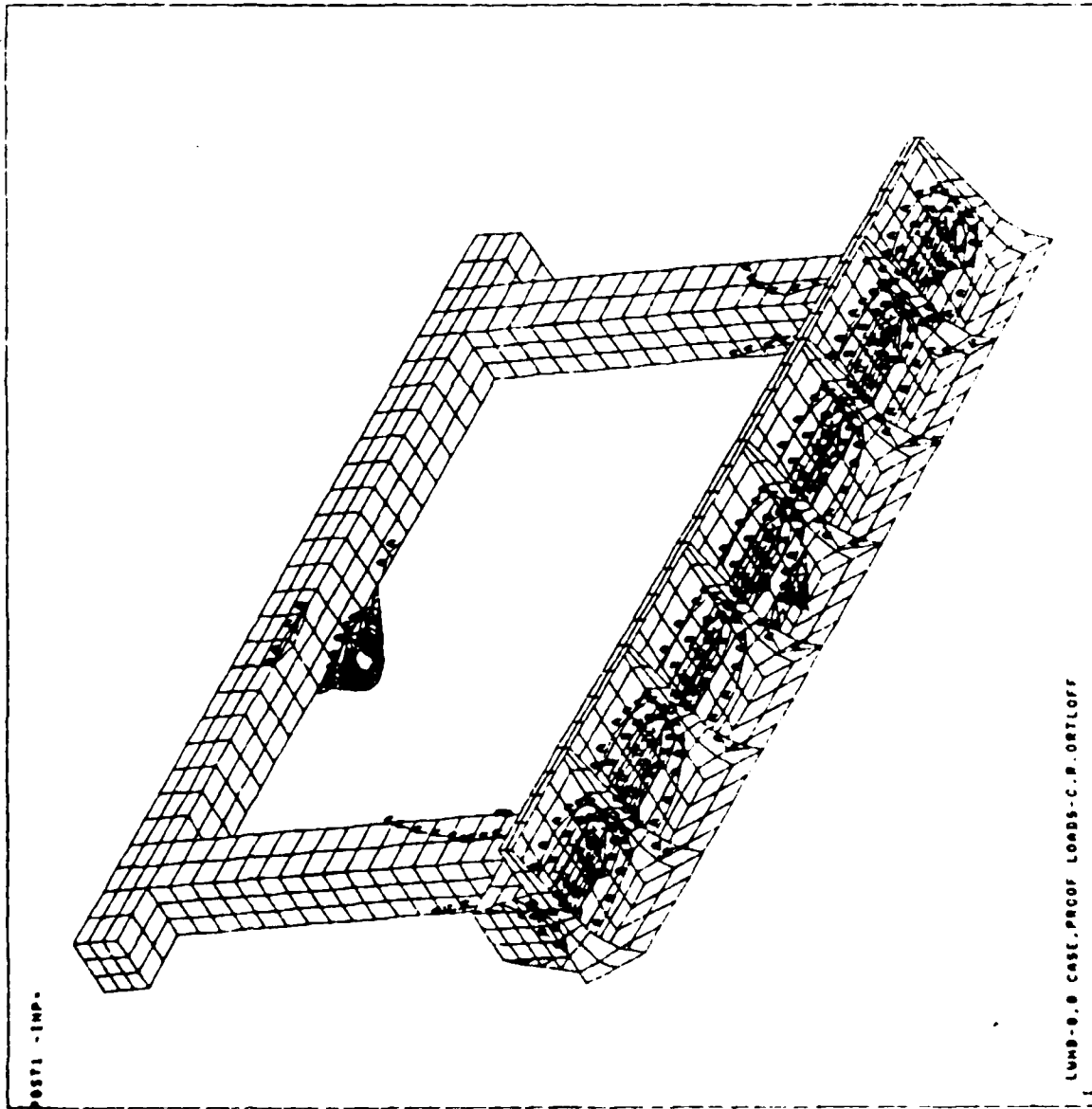


LUMP=0.0 CASE,PROOF LOADS-C.R.ORTLCFF

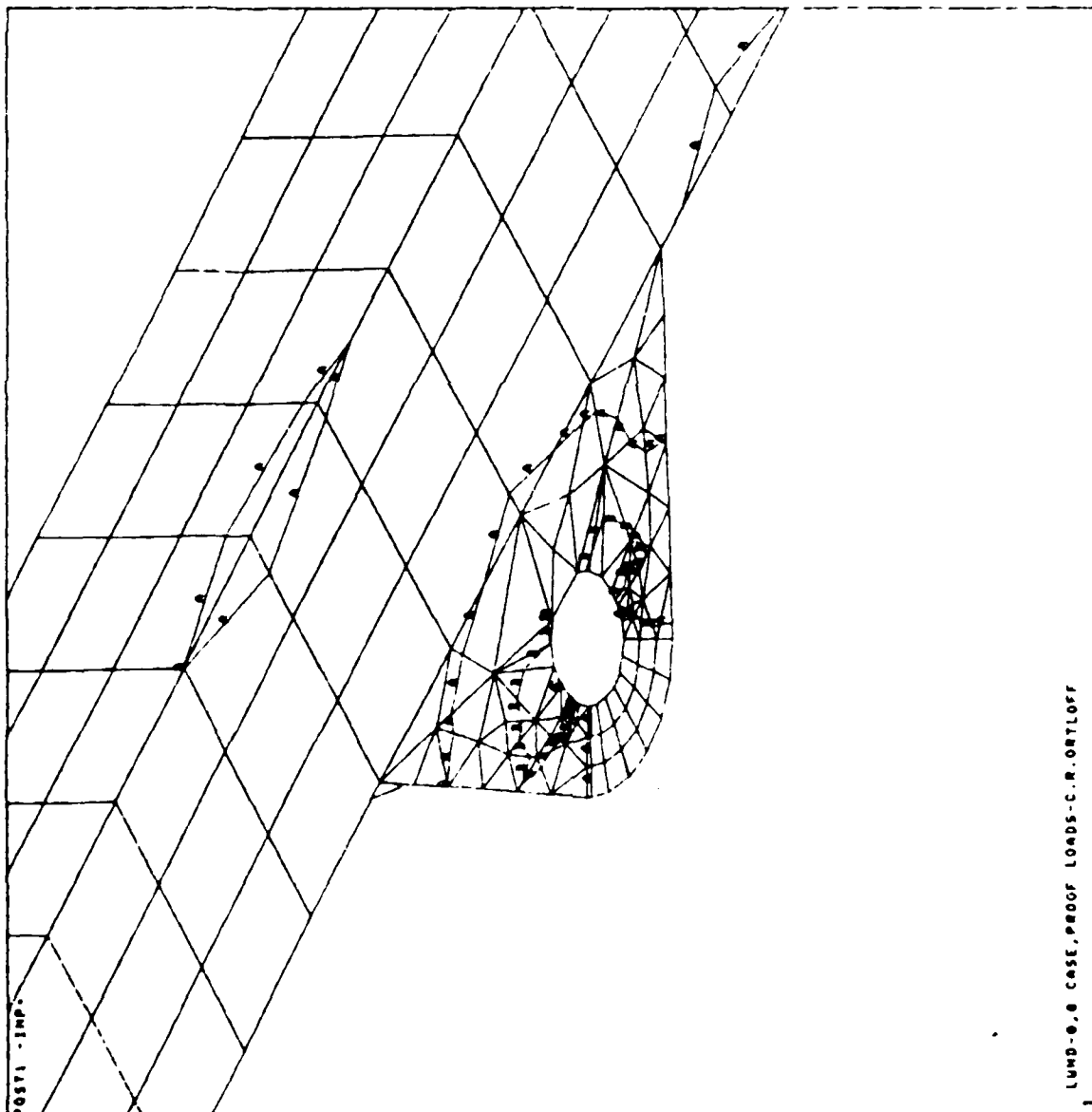
ANSYS 4.2D
 DEC 8 1988
 11:01:09
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.013
 SICE
 TOP
 ZOOM
 XU=.2
 YU=.3
 VU=-1
 DIST=59.3
 MF=82.8
 VF=25.6
 ZF=6.46
 VRTD=1.28
 WIDEN
 MX=158803
 MY=176
 A=10153
 B=20136
 C=30119
 D=40102
 E=50085
 F=60068
 G=70051
 H=80034
 I=90017
 J=100000
 K=109983
 L=119966
 M=129949
 N=139932
 O=149915



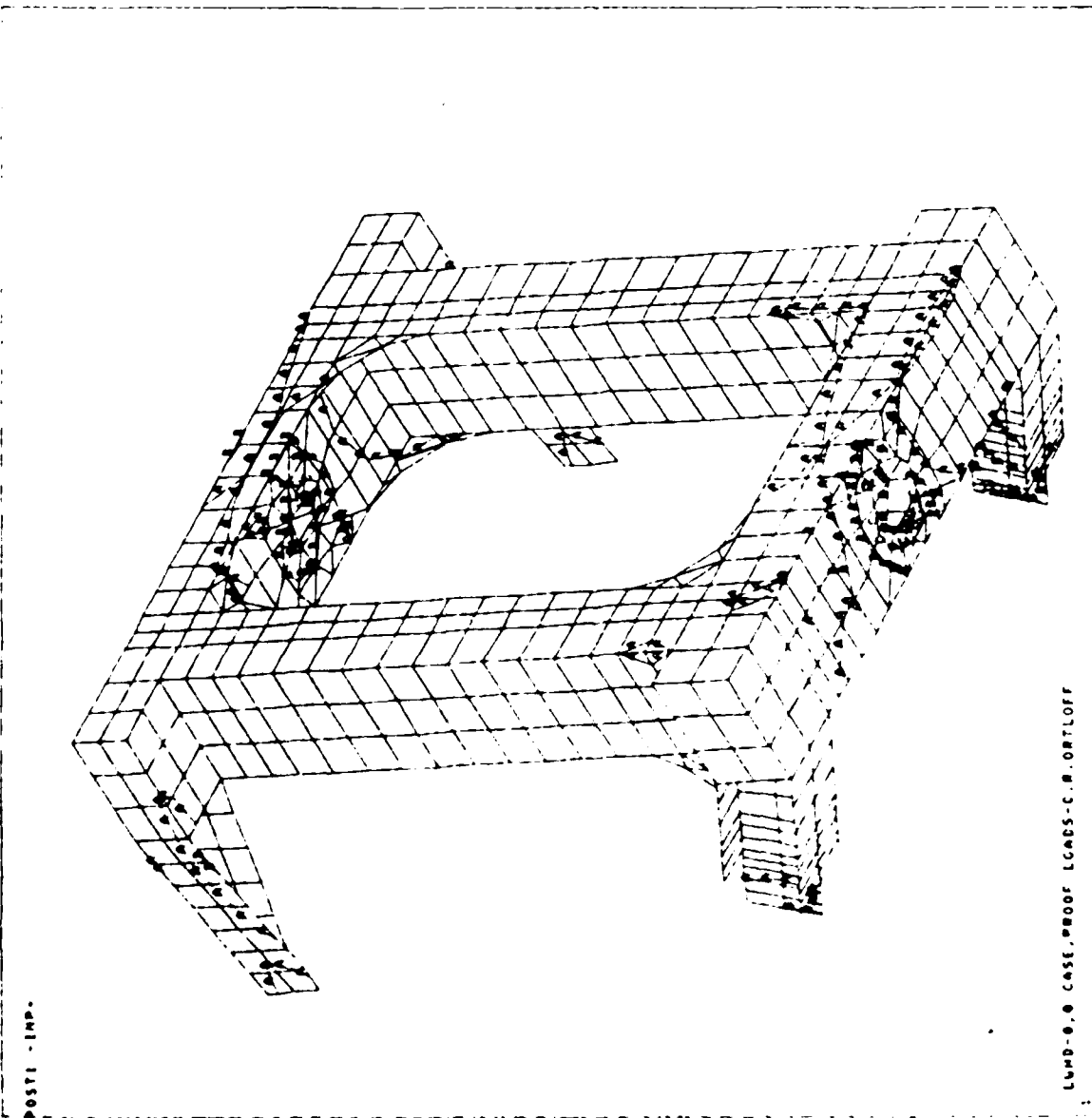
ANALYS 4.00
 DEC 8 1986
 10:37:10
 POST1 STRESS
 STEP=1
 ITEM=1
 TIME=.013
 SICE
 TOP
 XU=-1
 YU=-1
 ZU=-1
 DIST=58.2
 XF=54.2
 YF=26.4
 ZF=4.86
 HIDDEN
 RH=158893
 RM=176
 A=26794
 B=53414
 C=80034
 D=106654
 E=133274



ANSYS 4.20
 DEC 8 1986
 10:33:19
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.013
 SICE
 TOP
 ZOOM
 XU=-1
 YU=-1
 VU=-1
 ZU=-1
 DIST=12.3
 ZF=49.8
 VF=44.7
 ZF=9.77
 XRAY=1.11
 HIDDEN
 HA=82893
 HA=0
 A=26784
 B=53414
 C=80034

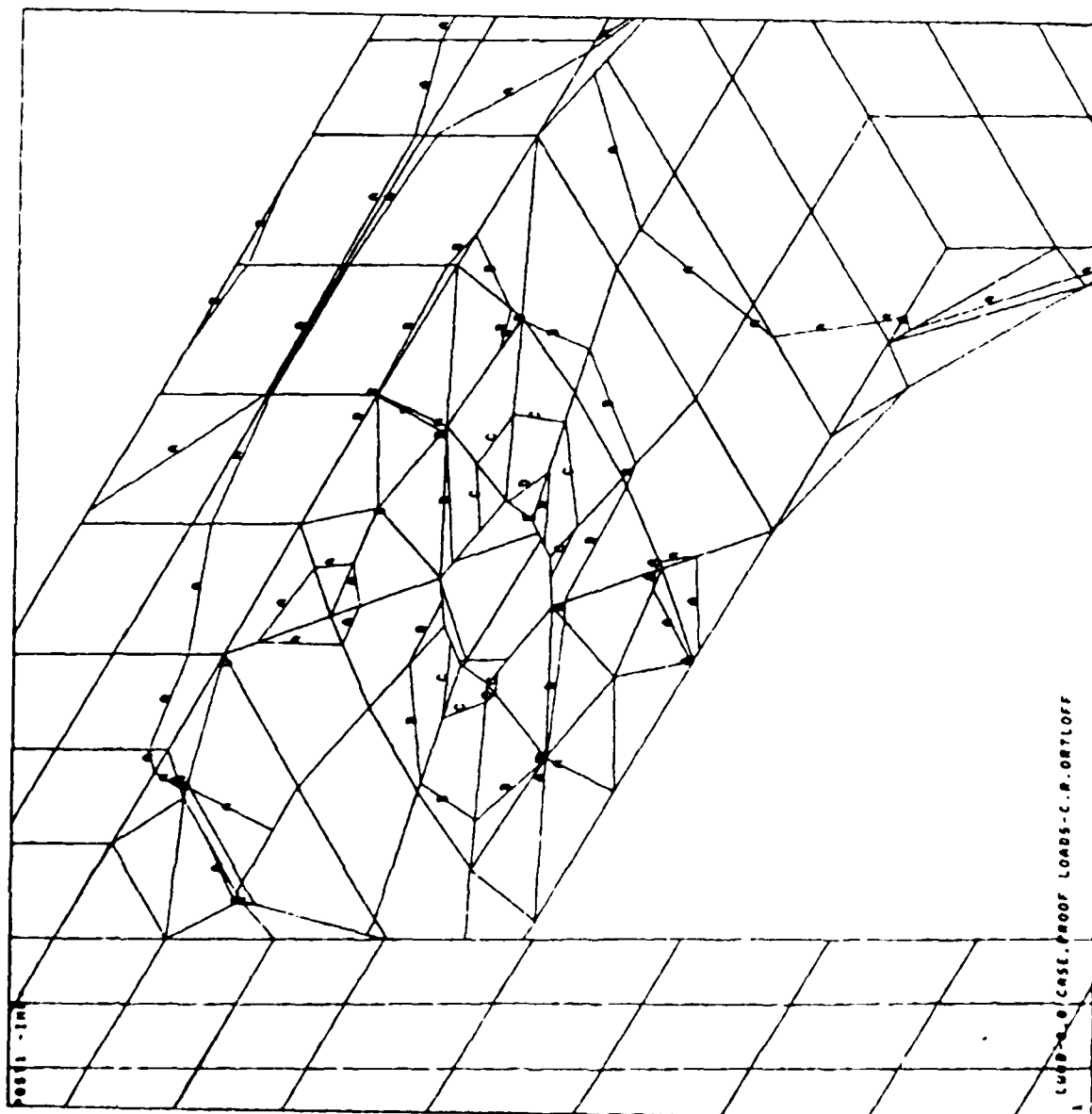


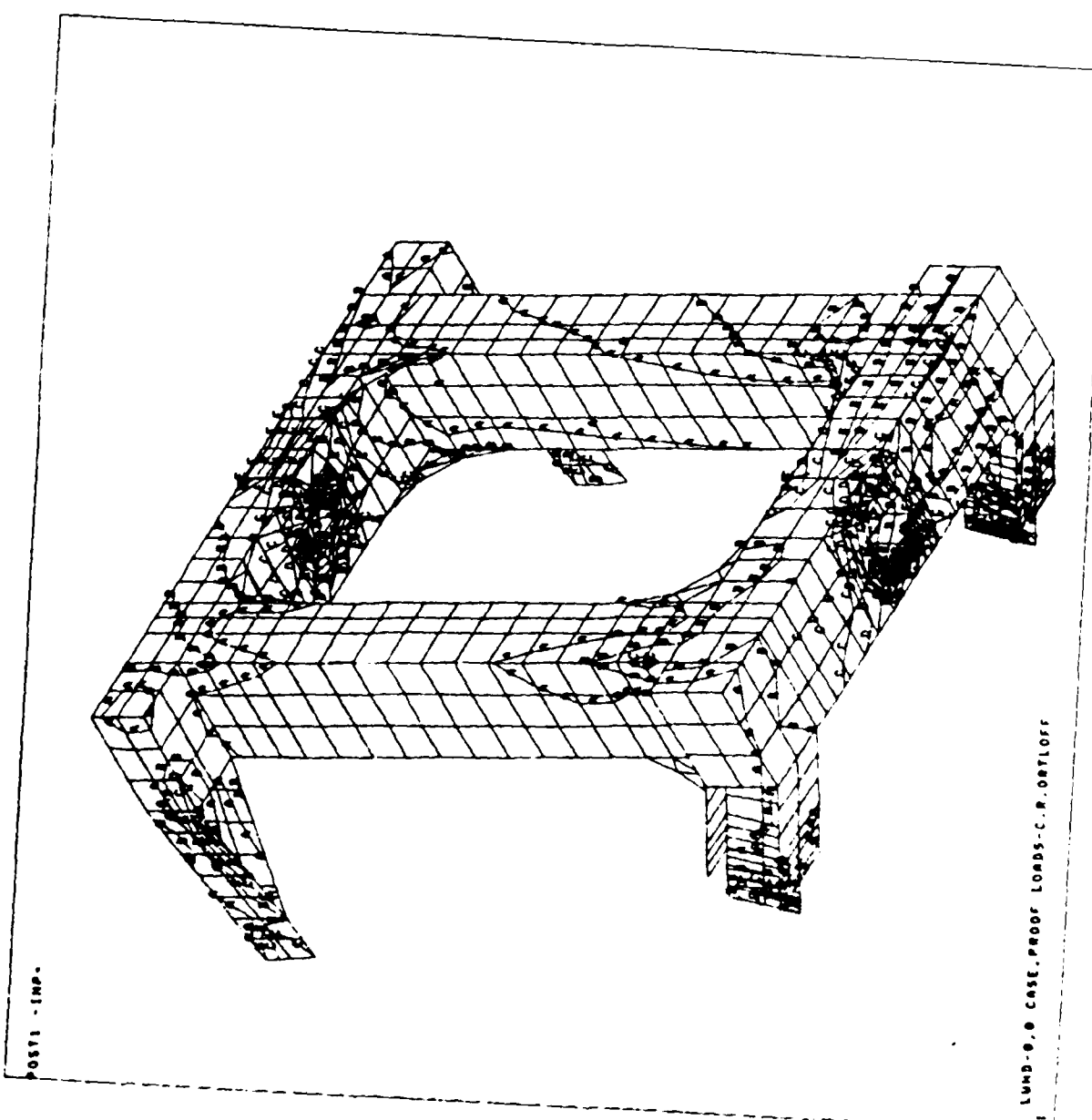
ANSYS 4.28
 BEC 8 1986
 11-27-86
 POST1 STRESS
 STEP=1
 TIME=1
 TIME=.013
 SLOC
 TOP
 KU=-1
 VU=-1
 ZU=1
 DIST=32.7
 KF=51.6
 VF=35.2
 ZF=8.57
 MIDDLEM
 RM=118834
 RM=1361
 A=20940
 B=40519
 C=64008
 D=79677
 E=99256



Top

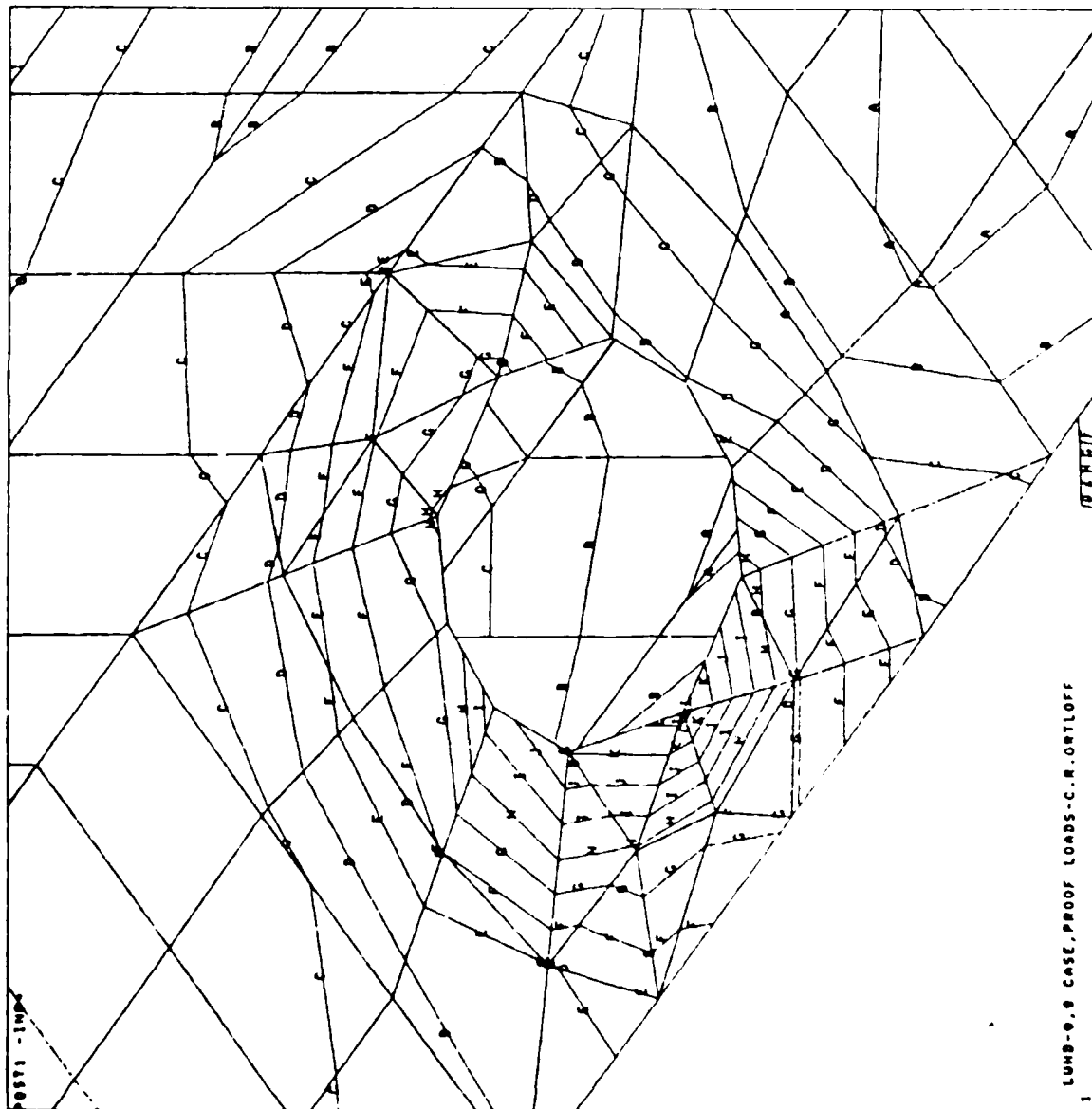
ANSYS 4.20
 DEC 8 1986
 11:27:35
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.013
 SICE
 TOP
 ZOOM
 XU=-1
 YU=-1
 ZU=1
 DIST=8.14
 WF=48.8
 VF=47.2
 ZF=.527
 VRTO=1.03
 HIDDEN
 PK=103282
 MN=8
 A=20840
 B=49319
 C=60898
 D=79677
 E=99256



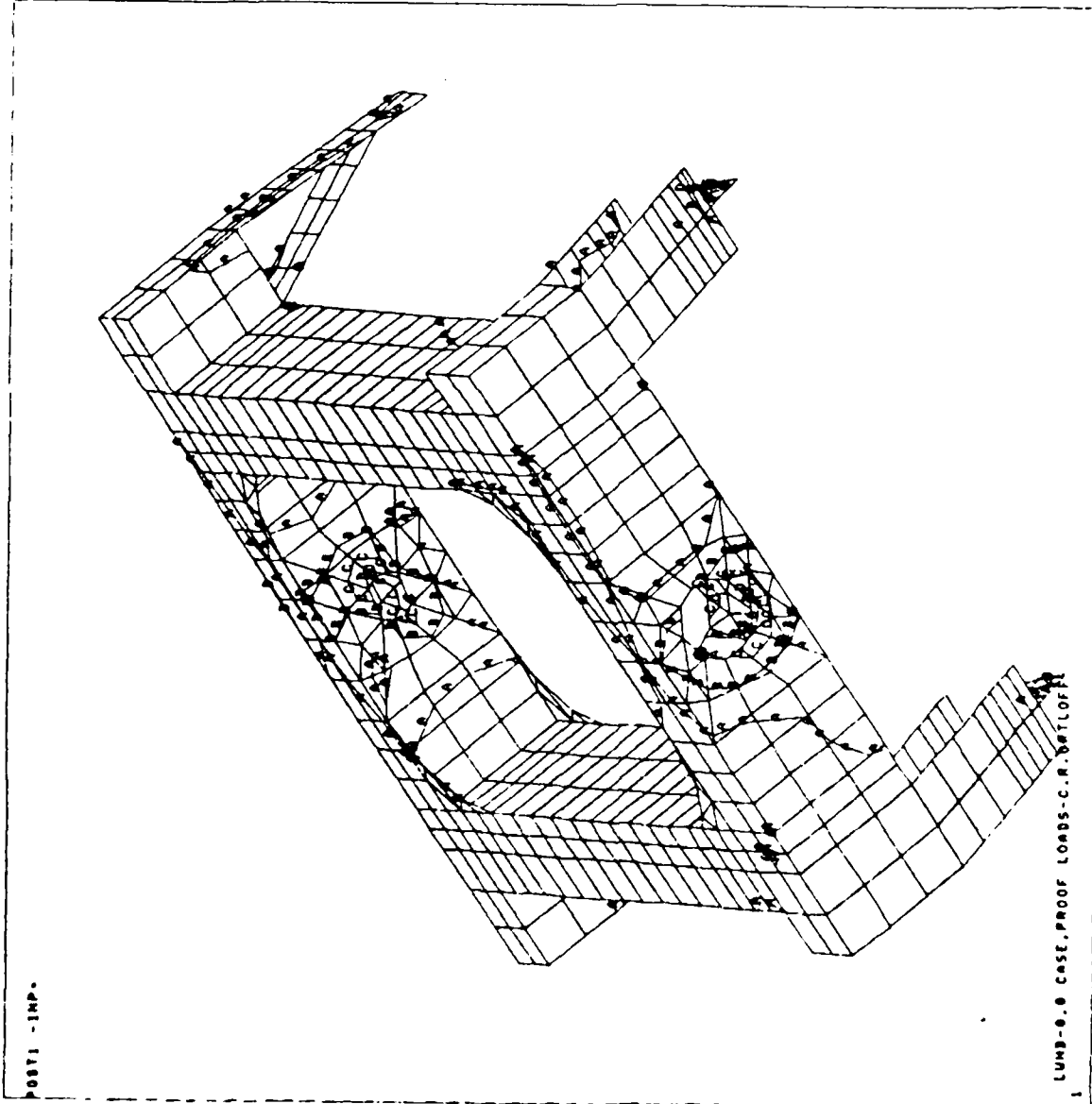


ANSYS 4.20
 DEC 8 1988
 11:38:21
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.013
 SICE
 TOP
 ZOOM
 XU=-1
 YU=-1
 ZU=-1
 DIST=33.7
 XF=51.6
 YF=35.2
 ZF=-8.57
 VRT0=1.03
 HIDDEN
 MX=118834
 MY=1361
 MZ=8697
 B=16640
 C=23383
 D=38726
 E=38069
 F=45412
 G=52755
 H=60008
 I=67491
 J=74784
 K=82127
 L=89470
 M=96813
 N=104156
 O=111409

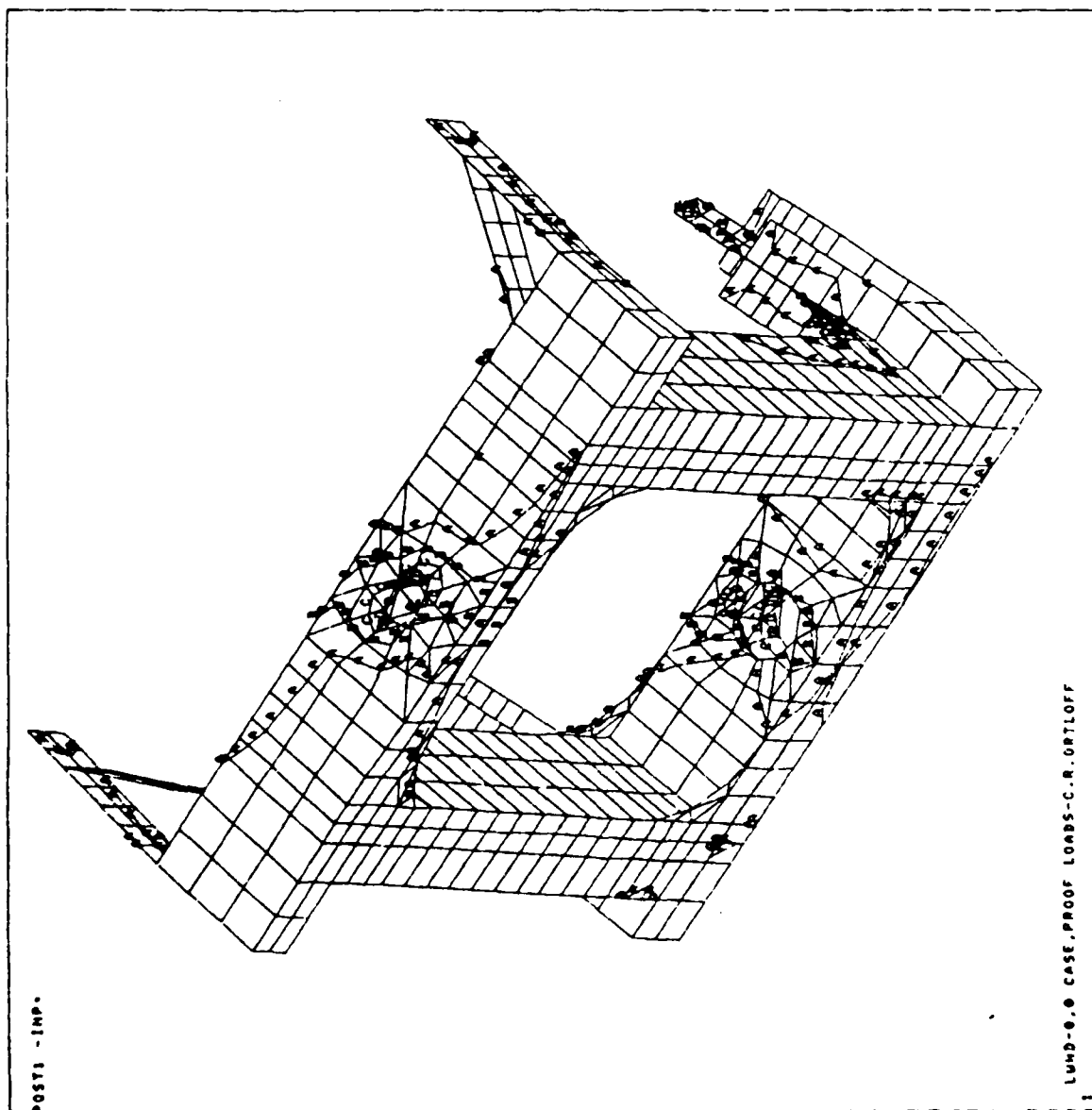
ANSYS 4.20
 DEC 8 1986
 11/36:21
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.013
 SICE
 TOP
 ZOOM
 RV=-1
 VU=-1
 ZU=1
 DIST=5.93
 XF=62.7
 VF=19.2
 ZF=-13.5
 VRT0=1.26
 MIDDLEM
 MX=118834
 MN=0
 A=8897
 B=16040
 C=23383
 D=30726
 E=38069
 F=45412
 G=52755
 H=60098
 I=67441
 J=74784
 K=82127
 L=89470
 M=96813
 N=104156
 O=111499



ANSYS 4.28
 DEC 8 1986
 11:46:11
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.013
 SICE
 TOP
 XU=.3
 VU=.1
 ZU=.4
 DIST=30.2
 XF=54.6
 YF=33.1
 ZF=7.74
 MIDDLE
 MN=118834
 MA=1361
 A=20940
 B=40510
 C=60098
 D=79677
 E=98256



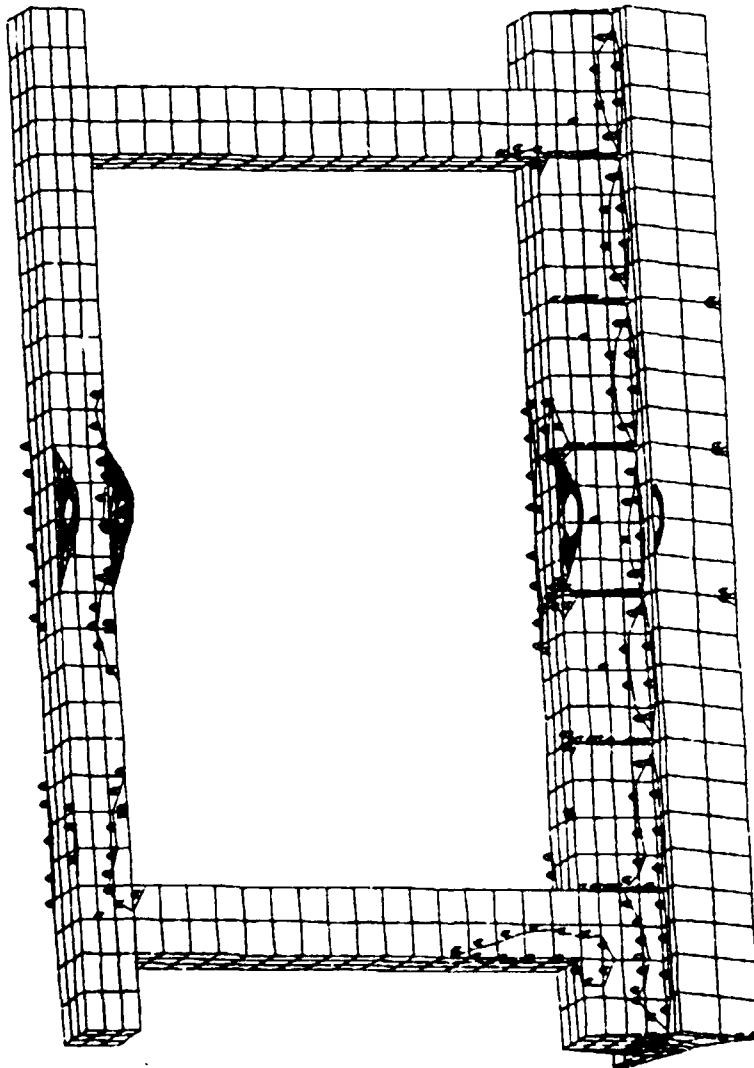
ANSYS 4.2B
 DEC 8 1986
 11:51:47
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.013
 SICE
 TOP
 XU=.3
 YU=1
 ZU=.4
 DIST=31.7
 XF=53.7
 YF=35.2
 ZF=-8.97
 MIDDLE
 MX=118034
 MY=1361
 A=20940
 B=40510
 C=60000
 D=79677
 E=99256



ANSYS 4.2B
 DEC 8 1986
 13157122
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.28
 SICE
 TOP

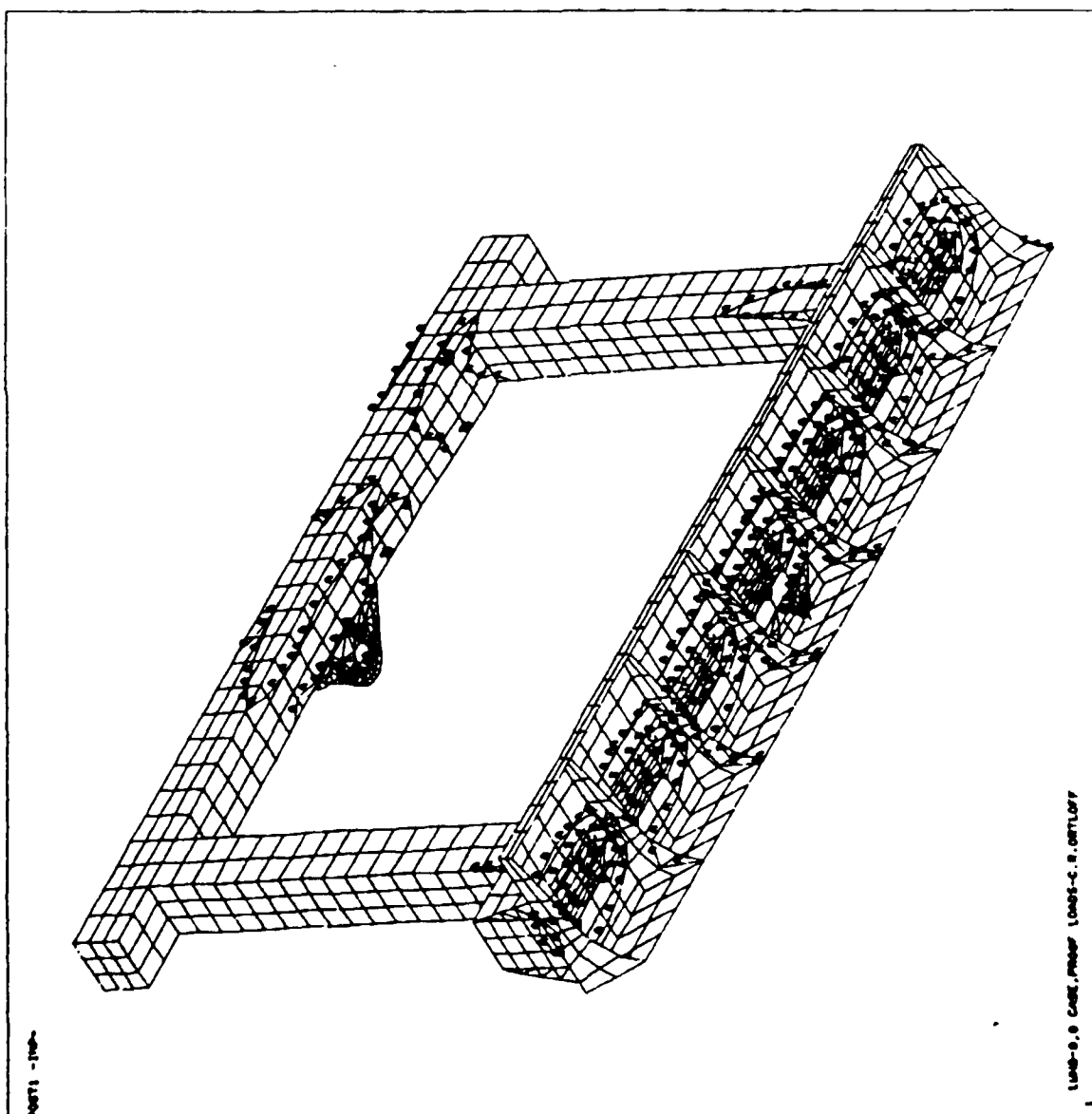
XU=.2
 VU=.3
 ZU=.1
 DIST=59.3
 XF=52.9
 YF=25.6
 ZF=6.48
 MIDDEN
 RK=67714
 RM=248
 A=11491
 B=22736
 C=33981
 D=45226
 E=56471

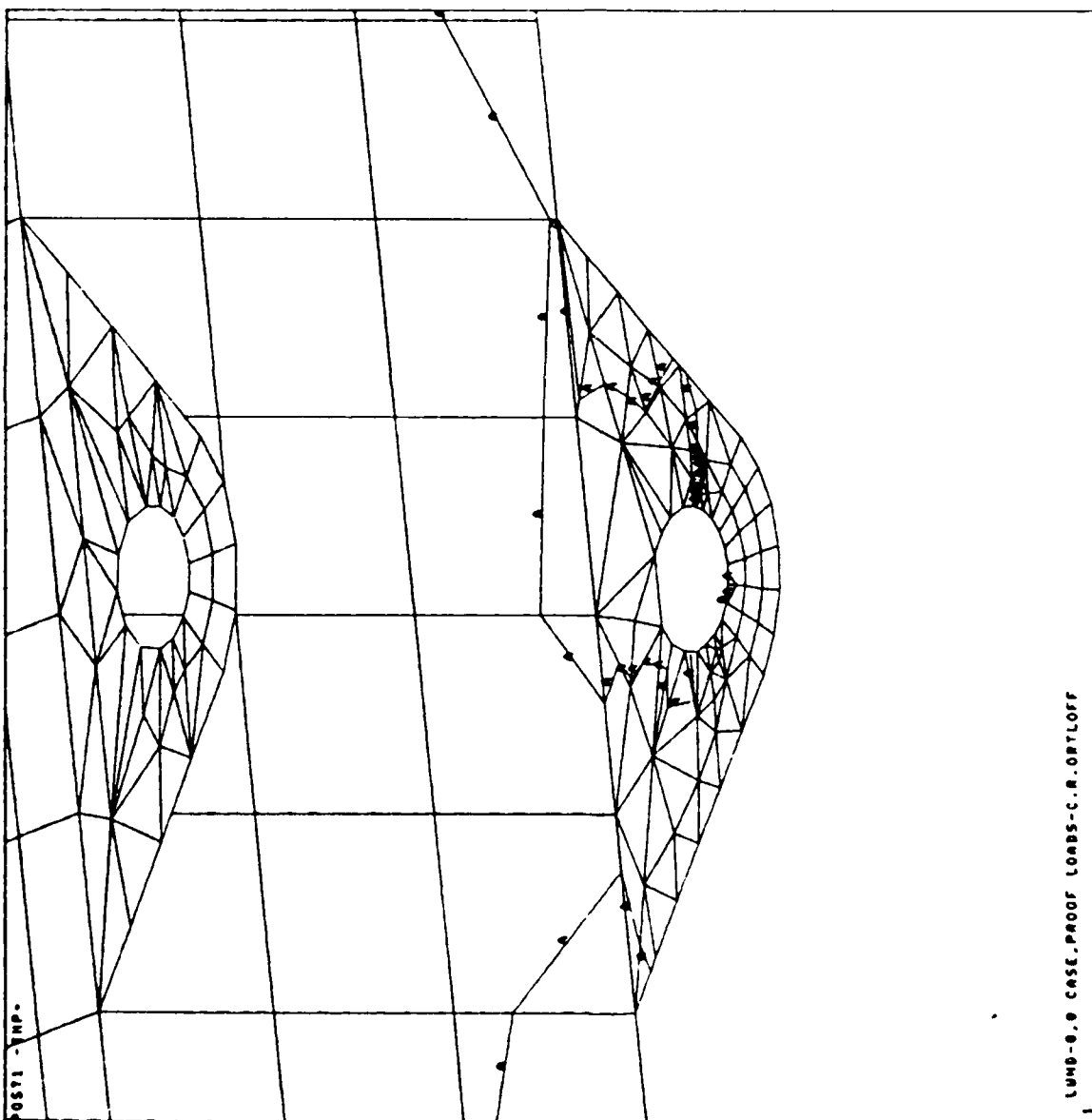
POST1 -IMP.



1 LUMD=0.0 CASE,PROOF LOADS-C.R.ORTLOFF

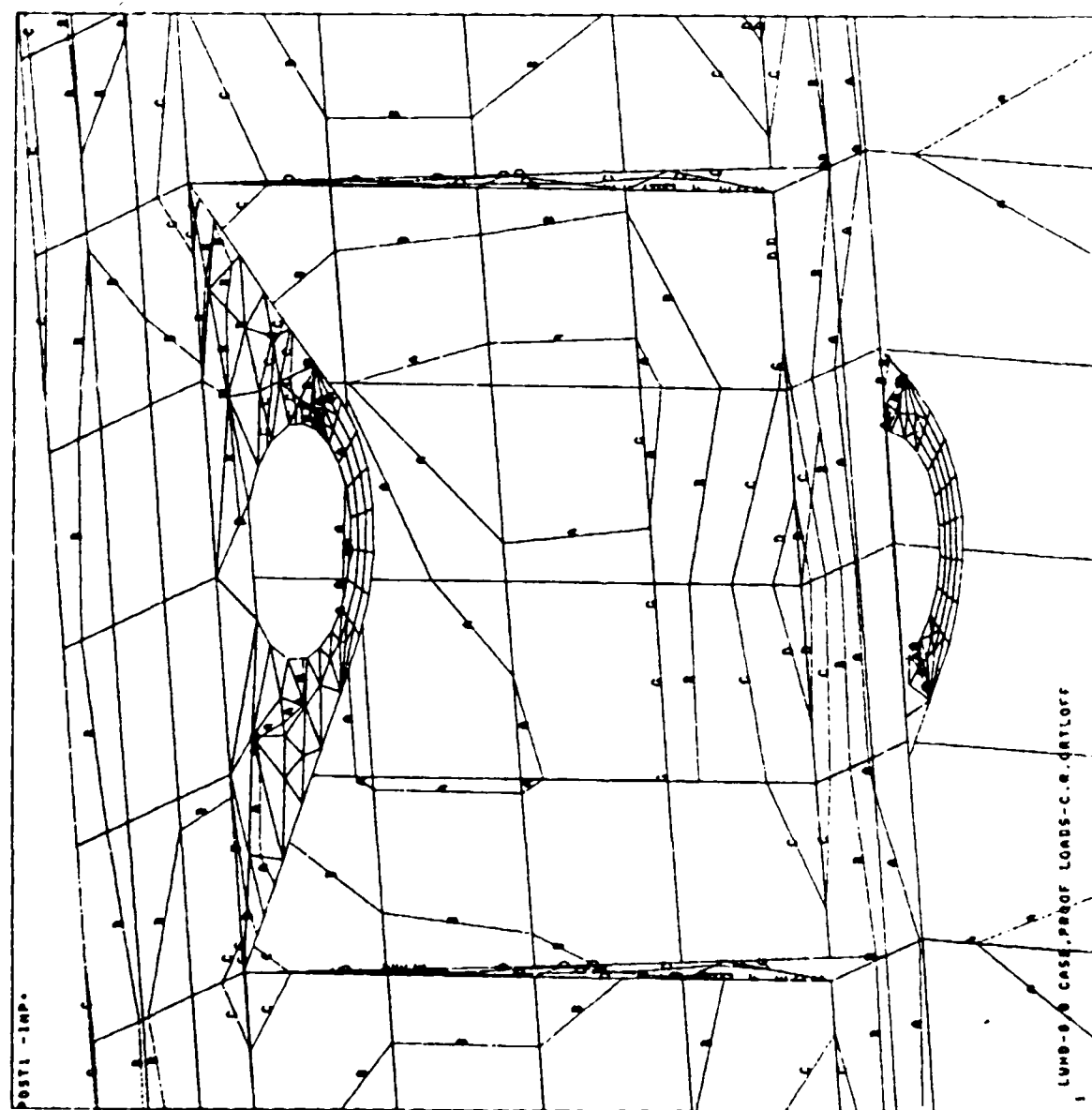
000015 4.20
 DEC 8 1986
 13:48:06
 POST1, STRESS
 STEP=1
 ITER=1
 TIME=.20
 SLOPE
 TOP
 AU=1
 WU=1
 DU=1
 DIST=88.8
 XF=64.2
 YF=88.4
 ZF=4.85
 M1896M
 RM=6771.6
 WM=248
 SM=11.081
 B=22728
 C=33081
 D=45226
 E=56471





ANSYS 4.20
 DEC 8 1986
 13:57:22
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.28
 SICE
 TOP
 ZOOM
 XU=.2
 YU=.3
 ZU=-1
 DIST=10.4
 XP=49.2
 YP=83.1
 ZP=14
 VRT0=1.70
 HIDDEN
 MX=24645
 MY=0
 A=11491
 B=22736

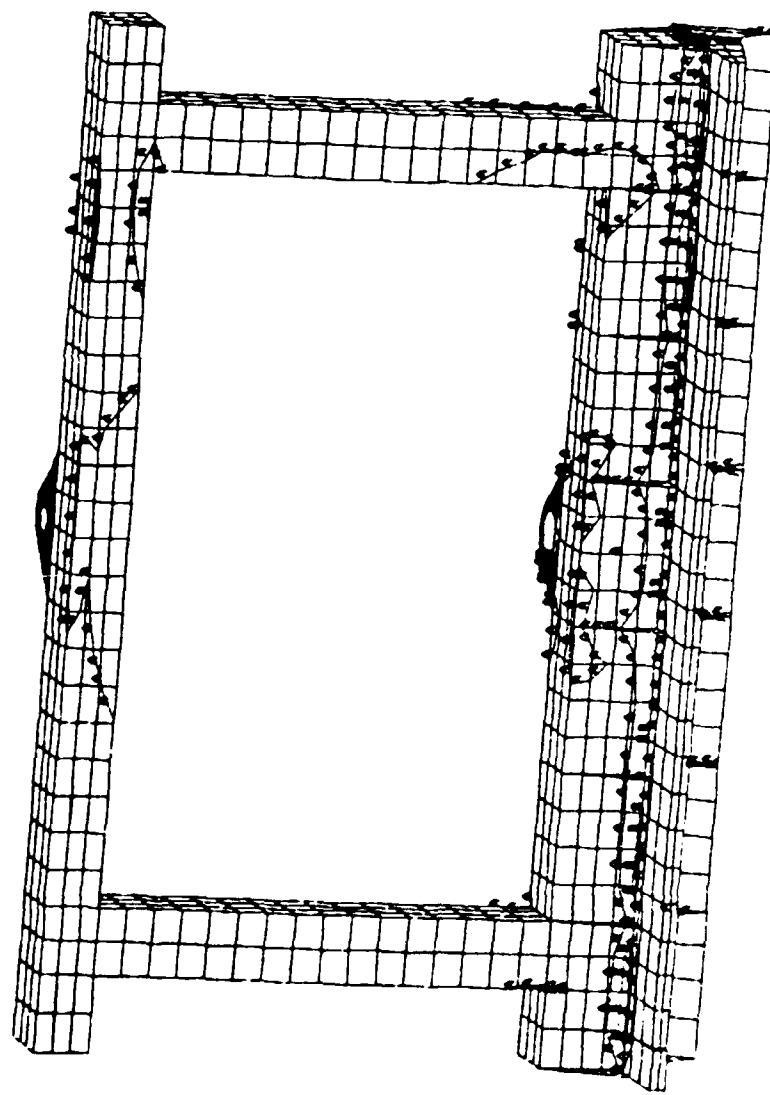
ARSVS 4.28
 DEC 8 1986
 14113101
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.28
 SLOC
 TOP
 ZOOM
 KU=.2
 VU=.3
 ZU=.1
 1 DIST=13.6
 2 XF=52.6
 3 VF=3.5
 4 ZF=-.25
 XRT0=1.31
 VRT0=1.78
 MIDDEN
 MX=57128
 MN=0
 A=4462
 B=8679
 C=12896
 D=17113
 E=21330
 F=25547
 G=29764
 H=33981
 I=38198
 J=42415
 K=46632
 L=50849
 M=55066



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 PLATFORM
 BOTTOM

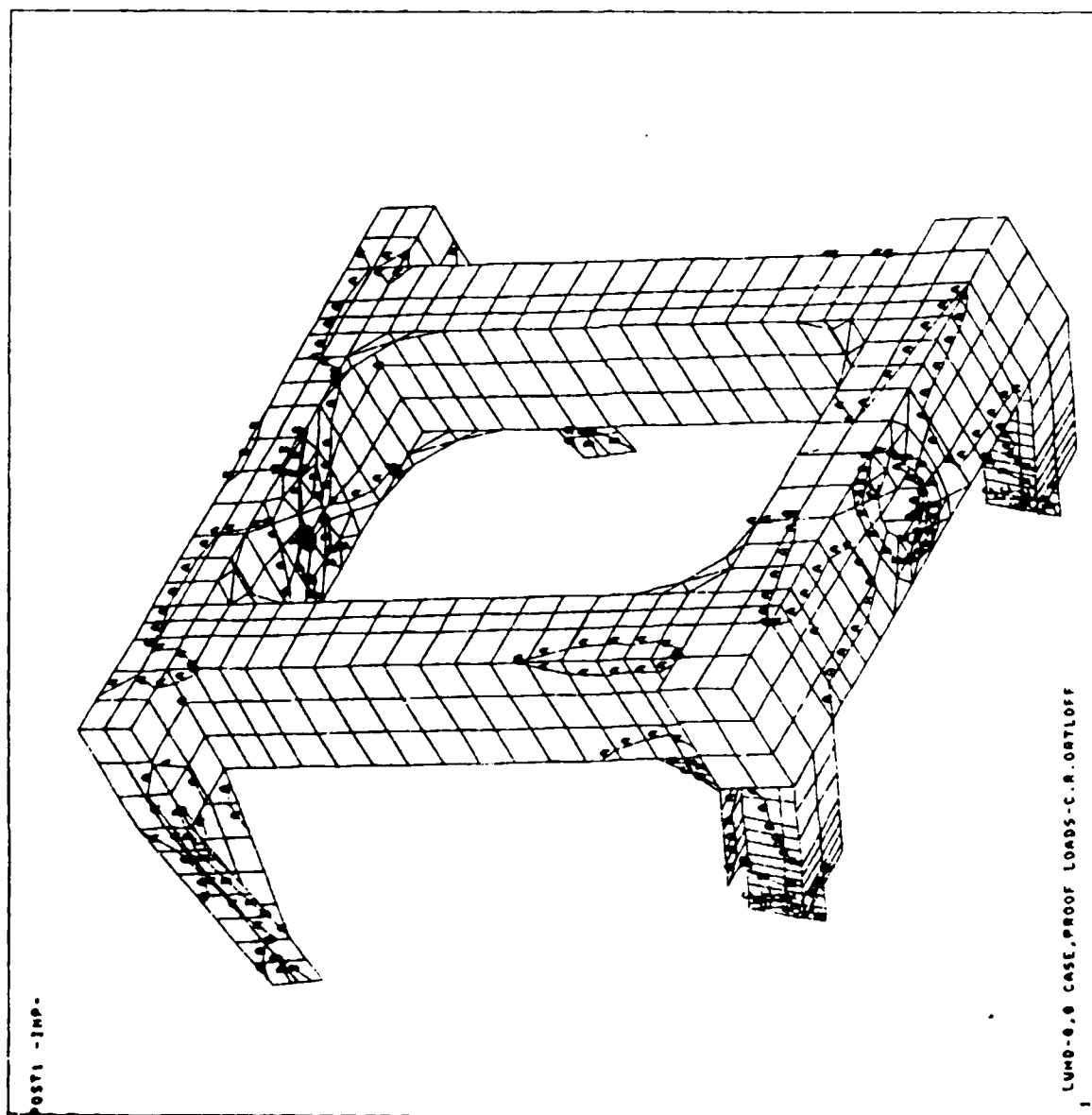
POSTIVE STRESS
POSTIVE -IMP.



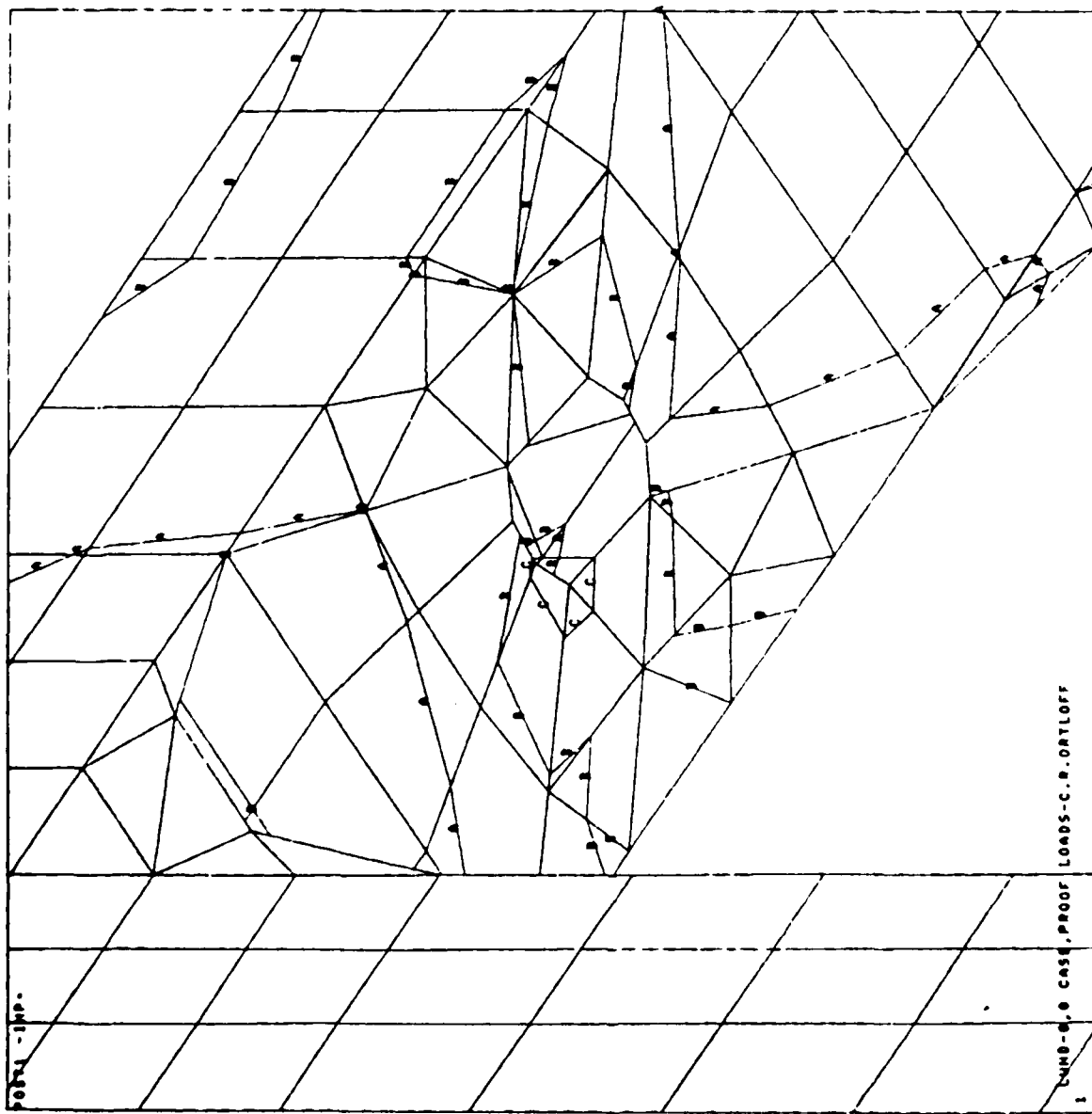
LUND-0.0 CASE, PROOF LOADS-C.R.ORTLOFF

STEP-1
ITER-1
TIME-.28
SLICE
TOP
XU-.2
VU-.4
ZU-1
DIST-59.3
XF-58.4
VF-27.7
ZF-3.15
HIDDEN
MX-67714
MY-248
A-11491
B-22736
C-33981
D-45226
E-56471

ANSYS 4.28
 DEC 8 1986
 14:38:50
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.28
 SICE
 TOP
 RV=-1
 VU=-1
 ZU=1
 DIST=22.7
 RF=51.6
 VF=35.2
 ZF=-8.57
 MIDDEN
 MX=66819
 MY=523
 M=11588
 D=22655
 C=33721
 D=44787
 E=55853

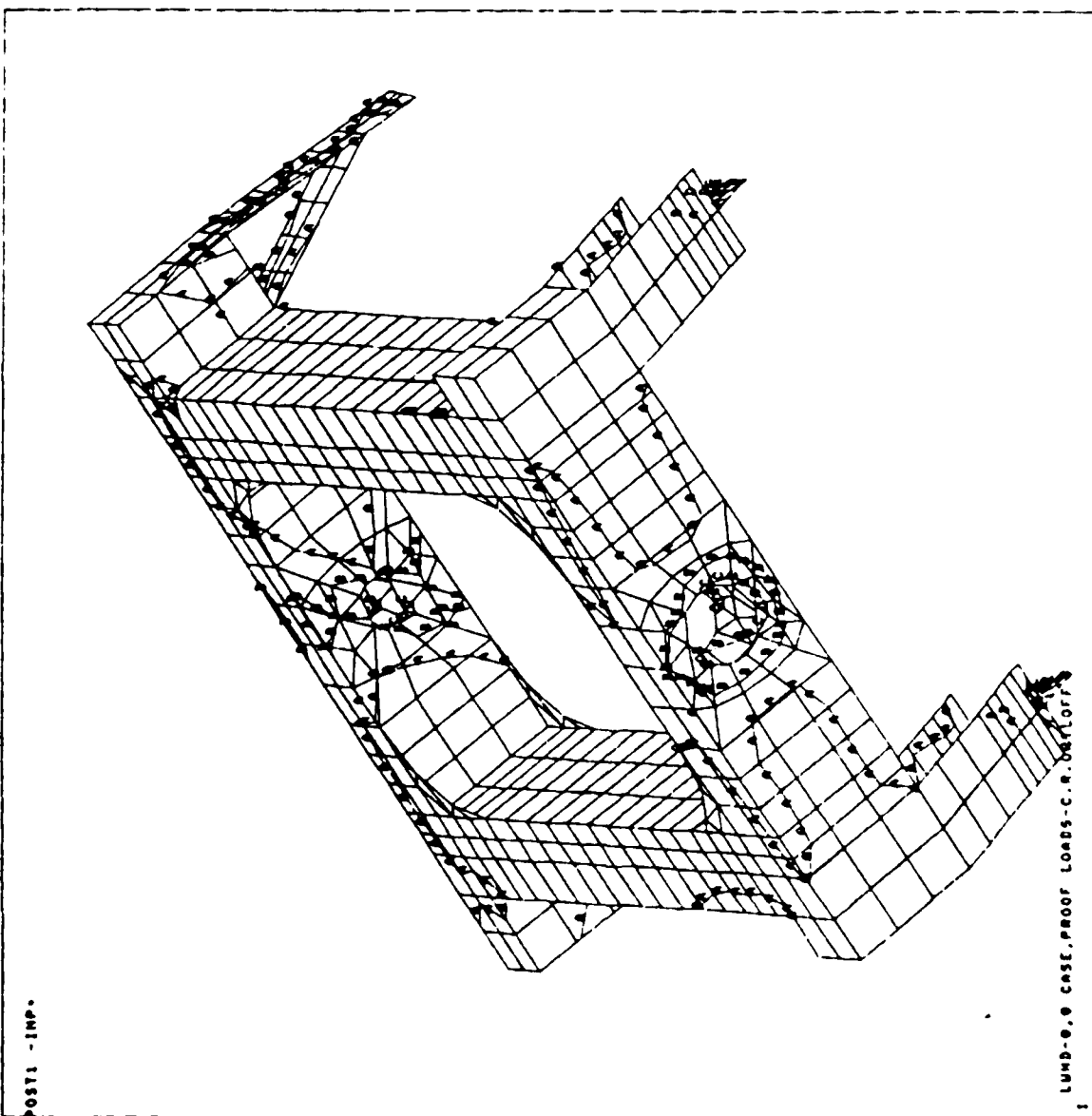


ANSYS 4.20
 DEC 8 1986
 14138159
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=1.28
 SICE
 TOP
 ZOOM
 KU=1
 VU=1
 ZU=1
 8 DIST=7.82
 8 XF=47.4
 8 VF=48.2
 8 ZF=117
 VRT0=1.18
 HIDDEN
 RM=38080
 RM=0
 A=11589
 B=22655
 C=33721

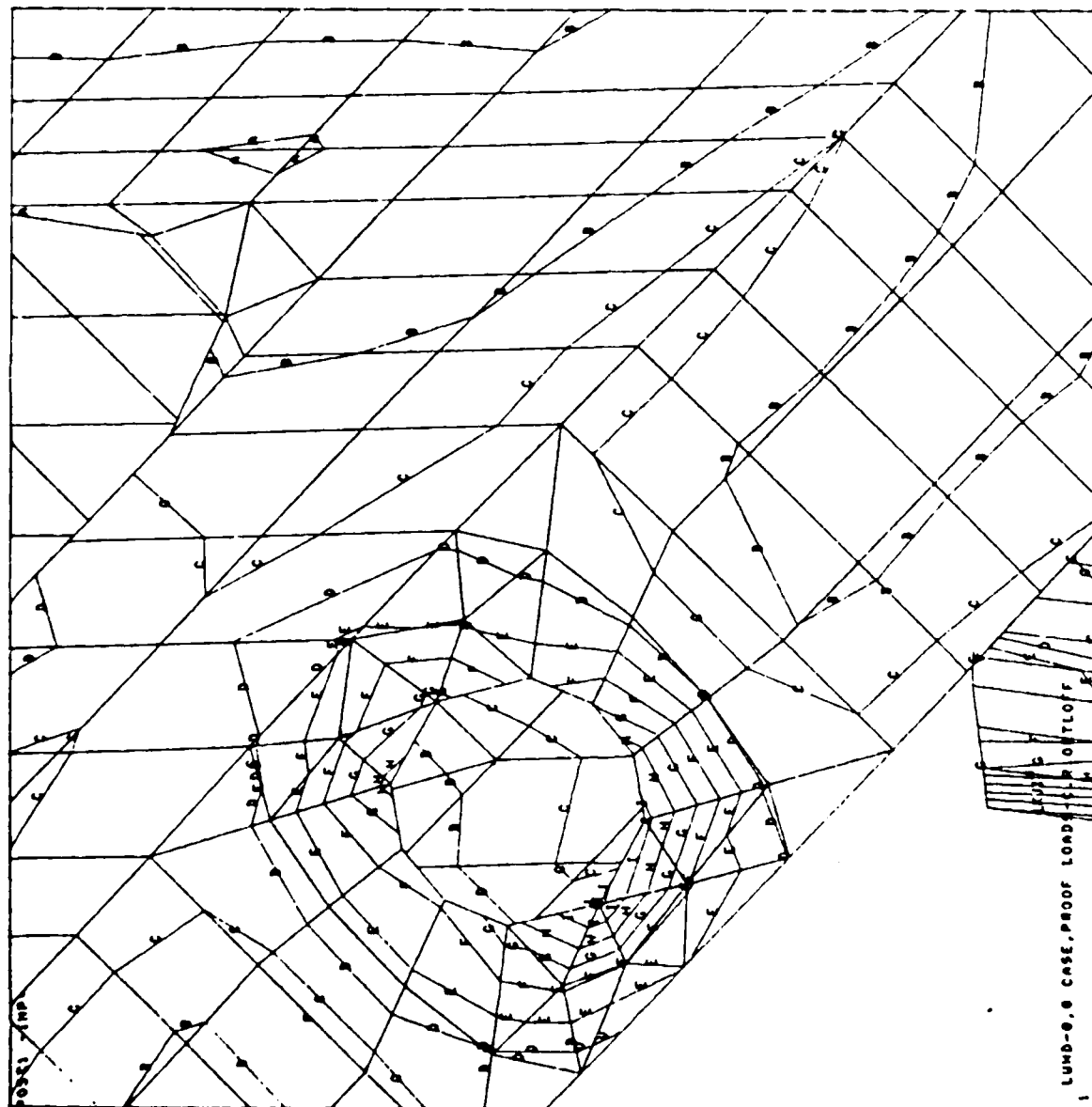


1 LUND-0 CASE, PROOF LOADS-C.R. OUTFLOW

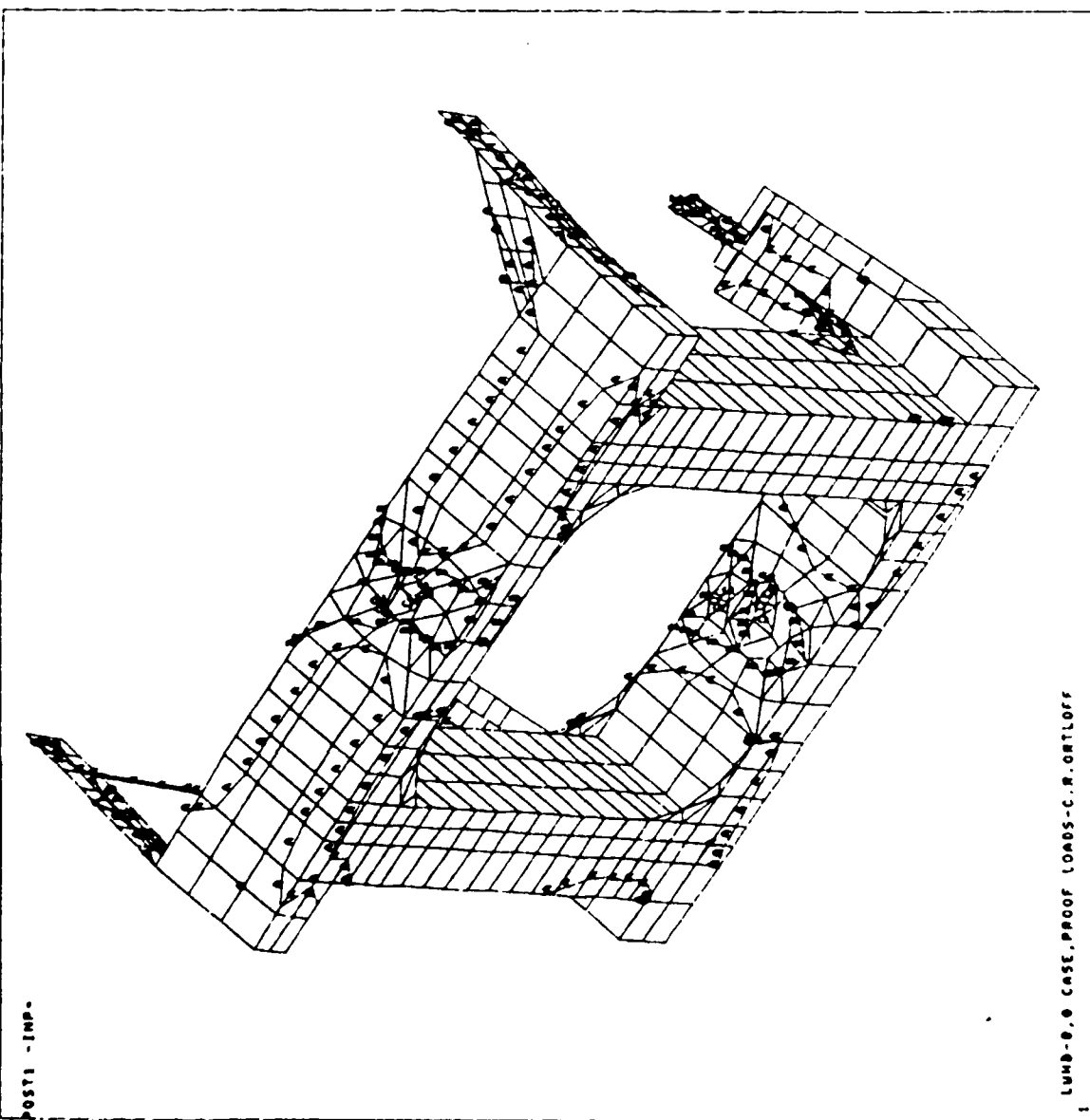
ANSYS 4.20
 DEC 8 1986
 14147120
 POST1, STRESS
 STEP=1
 TIME=1
 TIME=.28
 SIZE
 TOP
 XU=.3
 YU=-1
 ZU=.4
 DIST=30.2
 XF=54.6
 YF=33.1
 ZF=7.74
 MIDDLE
 RM=66010
 RM=523
 A=11509
 B=22655
 C=33721
 D=44787
 E=55853



ANSYS 4.20
 DEC 8 1986
 14143140
 POST1 STRESS
 STEP=1
 ITER=1
 VIME=.28
 SLOC
 TOP
 ZOOM
 KU=-1
 VU=-1
 ZU=1
 1 DIST=9.88
 1 XF=65.9
 1 VF=18.1
 1 ZF=11.3
 VRT0=1.64
 MIDDEN
 MX=57721
 MY=6
 A=4671
 B=8821
 C=12971
 D=17121
 E=21271
 F=25421
 G=28571
 H=33721
 I=37871
 J=42021
 K=46171
 L=50321
 M=54471

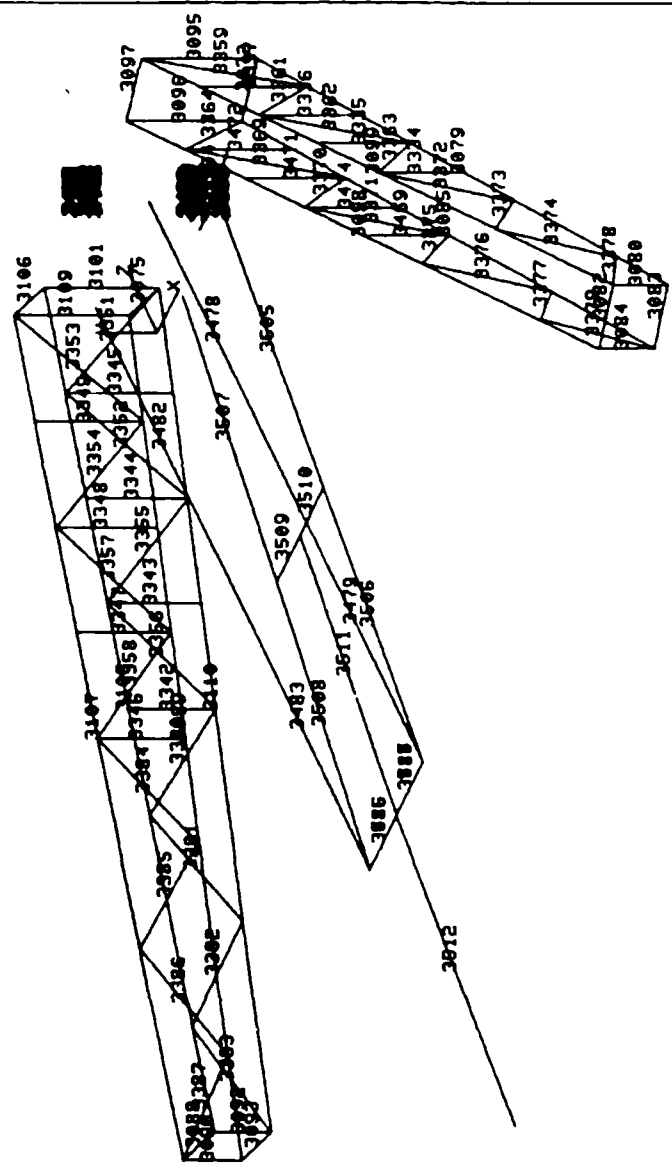


ANSYS 4.20
 DEC 8 1986
 14:51:34
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.28
 SICE
 TOP
 NU=.3
 VU=1
 ZU=.4
 DIST=31.7
 XF=53.7
 YF=35.2
 ZF=-8.97
 HIDDEN
 MM=66910
 MN=523
 A=11589
 B=22655
 C=33721
 D=44787
 E=55853



ANSYS 4.82
 DEC 9 1986
 13:08:02
 PREP7 ELEMENTS
 ENUM=1
 XU=-1
 YU=-1
 ZU=1
 DIST=241
 XF=51.9
 YF=31.8
 ZF=-166
 KRT0=1.37
 VRT0=1.17

PREP7 -IMP.
 ELIST,3478
 LIST SELECTED ELEM. IN RANGE 3478 TO 3478 BY 1 (LIST NODES)
 ELEM MAT TYP REL NODES
 3478 37 7 37 2813 2963 0
 PREP7 -IMP.



1 LUND-9.0 CASE, PROOF LOADS-C.R.ORTLOFF

t = 0.28 sec

PRINFOR

PRINT REACTION FORCES PER NODE

***** POST1 REACTION FORCE LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.28000 LOAD CASE= 1

THE FOLLOWING X,Y,Z FORCES ARE IN MODAL COORDINATES

MODE	FX	FY	FZ	MX	MY	MZ
856	-2950.					
857	-6749.					
858	-7033.					
859	-5772.					
860	-2501.					
861	-6371.					
862	-6323.					
863	-2468.					
864	-6265.					
865	-6826.					
866	-3279.					
867	-6992.					

MORE (YES, NO OR CONTINUOUS) C

***** POST1 REACTION FORCE LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.28000 LOAD CASE= 1

THE FOLLOWING X,Y,Z FORCES ARE IN MODAL COORDINATES

MODE	FX	FY	FZ	MX	MY	MZ
891	-6481.					
892	-2636.					
893	-6031.					
894	-7232.					
895	-3038.					
896	-7087.					
897	-3081.					
898	-8030.					
899	-6936.					
900	642.6	3121.	-822.5			
901	1270	879.3	-353.1			
902	454.9	1714.	-739.7			

***** POST1 REACTION FORCE LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.28000 LOAD CASE= 1

THE FOLLOWING X,Y,Z FORCES ARE IN MODAL COORDINATES

MODE	FX	FY	FZ	MX	MY	MZ
1284	775.0	0.1278E+05	3414.			
1285	1700.	1846.	-726.0			
1286	345.0	0.1428E+05	5980.			
1287	-134.0	1860.	-718.4			
1288	478.6	631.3	-255.4			
1289	1007.	1210.	-461.9			
1290	134.4	0.1334E+05	7613.			
1291	756.0	1058.	-325.1			

1298	123.4	80.40	-41.07
1299	442.9	295.4	-100.9
1300	-240.8	0.1485E+05	7050.
1301	-184.1	331.2	-93.16

***** POST1 REACTION FORCE LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.28000 LOAD CASE= 1

THE FOLLOWING X,Y,Z FORCES ARE IN MODAL COORDINATES

MODE	FX	FY	FZ	MX	MY	MZ
1306	63.88	91.95	-26.60			
1307	357.7	929.1	-339.6			
1308	-385.3	0.1262E+05	4658.			
1309	-806.5	1086.	-410.2			
1310	-885.1	518.4	-216.2			
1311	-265.6	1336.	-516.4			
1312	-678.5	0.1179E+05	1171.			
1313	-911.8	1412.	-542.0			
1314	-234.5	930.2	-377.0			
1315	636.2	2513.	-986.6			
1316	-954.5	1366.	-541.2			
1317	-1841.	2492.	-990.4			

***** POST1 REACTION FORCE LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.28000 LOAD CASE= 1

THE FOLLOWING X,Y,Z FORCES ARE IN MODAL COORDINATES

MODE	FX	FY	FZ	MX	MY	MZ
1332	-707.7	9823.	849.0			
1333	233.0	3221.	-1338.			
TOTAL	1067.	1907.	0.1074E+05			
00E+00			0.0000E+00			
POST1 -IMP.			0.0000E+00			

AD-A183 993

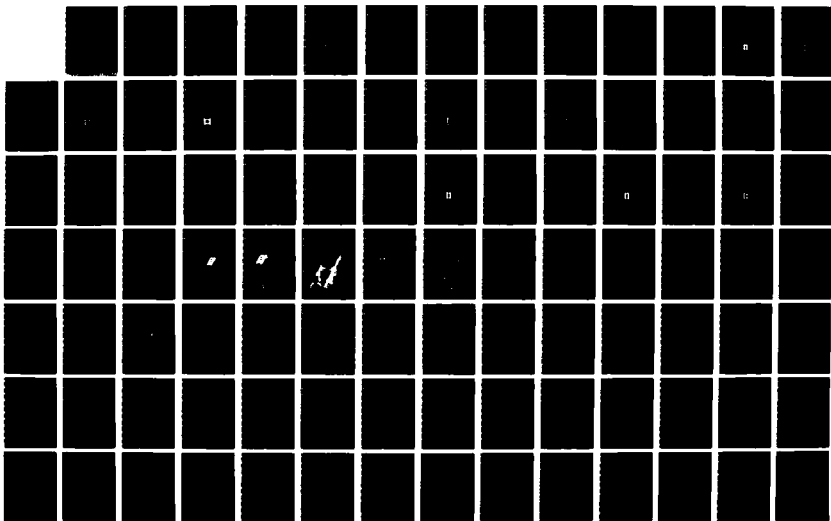
LIGHTWEIGHT TOWED HOWITZER DEMONSTRATOR PHASE 1 AND
PARTIAL PHASE 2 VOLUM (U) FNC CORP MINNEAPOLIS MINN
NORTHERN ORDNANCE DIV R RATHE ET AL APR 87
FNC-E-3841-VOL-D3-PT-1 DAAA21-86-C-8847

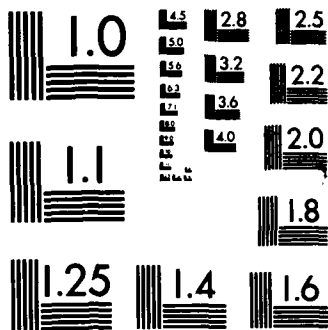
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UNCLASSIFIED

F/G 19/6

NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

$t = 0.20 \text{ sec}$

POINT ELEMENT STRESS ITEMS PER ELEMENT

SESS POST1 ELEMENT STRESS LISTING SESS
TIME: 0.20000

LOAD STEP 1 ITERATION: 1									
LOAD CASE: 1									
ELEM	FX	FY	FZ	SDR	SESS	SESS	SESS	SESS	SESS
3340	179.30	17.429	07.876	-483.41	1159.5	886.19	886.19	886.19	886.19
3341	-431.41	-1340.5	-110.240	51.419	886.19	886.19	886.19	886.19	886.19
3342	300.753	110.240	51.419	886.19	886.19	886.19	886.19	886.19	886.19
3343	1640.8	1.0205	-0.0311	-4217.8	886.19	886.19	886.19	886.19	886.19
3344	-3317.8	318.91	3.1407	886.19	886.19	886.19	886.19	886.19	886.19
3345	31.138	-149.37	52.304	886.19	886.19	886.19	886.19	886.19	886.19
3346	376.45	103.07	-131.21	886.19	886.19	886.19	886.19	886.19	886.19
3347	318.91	3.1407	886.19	886.19	886.19	886.19	886.19	886.19	886.19
3348	517.15	-105.53	-53.982	886.19	886.19	886.19	886.19	886.19	886.19
3349	-121.0	423.106	5.7681	-11143.	886.19	886.19	886.19	886.19	886.19
3350	-1143.	423.106	5.7681	-11143.	886.19	886.19	886.19	886.19	886.19
3351	-1143.	423.106	5.7681	-11143.	886.19	886.19	886.19	886.19	886.19
3352	-1143.	423.106	5.7681	-11143.	886.19	886.19	886.19	886.19	886.19
3353	-1143.	423.106	5.7681	-11143.	886.19	886.19	886.19	886.19	886.19
3354	-1143.	423.106	5.7681	-11143.	886.19	886.19	886.19	886.19	886.19
3355	-1143.	423.106	5.7681	-11143.	886.19	886.19	886.19	886.19	886.19
3356	-1143.	423.106	5.7681	-11143.	886.19	886.19	886.19	886.19	886.19
3357	-1143.	423.106	5.7681	-11143.	886.19	886.19	886.19	886.19	886.19
3358	-1143.	423.106	5.7681	-11143.	886.19	886.19	886.19	886.19	886.19
3359	-1143.	423.106	5.7681	-11143.	886.19	886.19	886.19	886.19	886.19
3360	-1143.	423.106	5.7681	-11143.	886.19	886.19	886.19	886.19	886.19

END OF CONTINUOUS

SESS POST1 ELEMENT STRESS LISTING SESS

TIME: 0.20000

LOAD STEP 1 ITERATION: 1									
LOAD CASE: 1									
ELEM	FX	FY	FZ	SDR	SESS	SESS	SESS	SESS	SESS
3361	1676.0	10.851	10.933	-4410.2	886.19	886.19	886.19	886.19	886.19
3362	-410.2	-813.23	886.19	-51.146	886.19	886.19	886.19	886.19	886.19
3363	198.52	8.8688	51.146	-522.44	886.19	886.19	886.19	886.19	886.19
3364	-618.9	8.8688	51.146	11882.	886.19	886.19	886.19	886.19	886.19
3365	-114.25	0.55059	-0.0220	886.19	886.19	886.19	886.19	886.19	886.19
3366	1506.4	11.712	-5.2901	-4172.0	886.19	886.19	886.19	886.19	886.19
3367	107.45	-14.45	25.748	-284.17	886.19	886.19	886.19	886.19	886.19
3368	107.45	-14.45	25.748	-284.17	886.19	886.19	886.19	886.19	886.19
3369	107.45	-14.45	25.748	-284.17	886.19	886.19	886.19	886.19	886.19
3370	107.45	-14.45	25.748	-284.17	886.19	886.19	886.19	886.19	886.19
3371	107.45	-14.45	25.748	-284.17	886.19	886.19	886.19	886.19	886.19
3372	107.45	-14.45	25.748	-284.17	886.19	886.19	886.19	886.19	886.19
3373	107.45	-14.45	25.748	-284.17	886.19	886.19	886.19	886.19	886.19
3374	107.45	-14.45	25.748	-284.17	886.19	886.19	886.19	886.19	886.19
3375	107.45	-14.45	25.748	-284.17	886.19	886.19	886.19	886.19	886.19
3376	107.45	-14.45	25.748	-284.17	886.19	886.19	886.19	886.19	886.19
3377	107.45	-14.45	25.748	-284.17	886.19	886.19	886.19	886.19	886.19
3378	107.45	-14.45	25.748	-284.17	886.19	886.19	886.19	886.19	886.19
3379	107.45	-14.45	25.748	-284.17	886.19	886.19	886.19	886.19	886.19
3380	107.45	-14.45	25.748	-284.17	886.19	886.19	886.19	886.19	886.19

END OF CONTINUOUS

SESS POST1 ELEMENT STRESS LISTING SESS

TIME: 0.20000

LOAD STEP 1 ITERATION: 1									
LOAD CASE: 1									
ELEM	FX	FY	FZ	SDR	SESS	SESS	SESS	SESS	SESS
3381	-83.959	14.167	0.5636	45.206	886.19	886.19	886.19	886.19	886.19
3382	-83.959	14.167	0.5636	45.206	886.19	886.19	886.19	886.19	886.19
3383	-83.959	14.167	0.5636	45.206	886.19	886.19	886.19	886.19	886.19
3384	-83.959	14.167	0.5636	45.206	886.19	886.19	886.19	886.19	886.19
3385	-83.959	14.167	0.5636	45.206	886.19	886.19	886.19	886.19	886.19
3386	-83.959	14.167	0.5636	45.206	886.19	886.19	886.19	886.19	886.19
3387	-83.959	14.167	0.5636	45.206	886.19	886.19	886.19	886.19	886.19
3388	-83.959	14.167	0.5636	45.206	886.19	886.19	886.19	886.19	886.19
3389	-83.959	14.167	0.5636	45.206	886.19	886.19	886.19	886.19	886.19
3390	-83.959	14.167	0.5636	45.206	886.19	886.19	886.19	886.19	886.19

LOAD STEP 1 ITERATION: 1									
LOAD CASE: 1									
ELEM	FX	FY	FZ	SDR	SESS	SESS	SESS	SESS	SESS
3391	-197.107	81.840	11.034	373.00	886.19	886.19	886.19	886.19	886.19
3392	-197.107	81.840	11.034	373.00	886.19	886.19	886.19	886.19	886.19
3393	-197.107	81.840	11.034	373.00	886.19	886.19	886.19	886.19	886.19
3394	-197.107	81.840	11.034	373.00	886.19	886.19	886.19	886.19	886.19
3395	-197.107	81.840	11.034	373.00	886.19	886.19	886.19	886.19	886.19
3396	-197.107	81.840	11.034	373.00	886.19	886.19	886.19	886.19	886.19
3397	-197.107	81.840	11.034	373.00	886.19	886.19	886.19	886.19	886.19
3398	-197.107	81.840	11.034	373.00	886.19	886.19	886.19	886.19	886.19
3399	-197.107	81.840	11.034	373.00	886.19	886.19	886.19	886.19	886.19
3400	-197.107	81.840	11.034	373.00	886.19	886.19	886.19	886.19	886.19

END OF CONTINUOUS

SESS POST1 ELEMENT STRESS LISTING SESS

TIME: 0.20000

LOAD STEP 1 ITERATION: 1									
LOAD CASE: 1									
ELEM	FX	FY	FZ	SDR	SESS	SESS	SESS	SESS	SESS
3401	-601.81	30.804	-85.137	1135.5	886.19	886.19	886.19	886.19	886.19
3402	-601.81	30.804	-85.137	1135.5	886.19	886.19	886.19	886.19	886.19
3403	-601.81	30.804	-85.137	1135.5	886.19	886.19	886.19	886.19	886.19
3404	-601.81	30.804	-85.137	1135.5	886.19	886.19	886.19	886.19	886.19
3405	-601.81	30.804	-85.137	1135.5	886.19	886.19	886.19	886.19	886.19
3406	-601.81	30.804	-85.137	1135.5	886.19	886.19	886.19	886.19	886.19
3407	-601.81	30.804	-85.137	1135.5	886.19	886.19	886.19	886.19	886.19
3408	-601.81	30.804	-85.137	1135.5	886.19	886.19	886.19	886.19	886.19
3409	-601.81	30.804	-85.137	1135.5	886.19	886.19	886.19	886.19	886.19
3410	-601.81	30.804	-85.137	1135.5	886.19	886.19	886.19	886.19	886.19

END OF CONTINUOUS

SESS POST1 ELEMENT STRESS LISTING SESS

TIME: 0.20000

LOAD STEP 1 ITERATION: 1									
LOAD CASE: 1									
ELEM	FX	FY	FZ	SDR	SESS	SESS	SESS	SESS	SESS
3411	-813.23	8.8688	-0.0220	886.19	886.19	886.19	886.19	886.19	886.19
3412	-813.23	8.8688	-0.0220	886.19	886.19	886.19	886.19	886.19	886.19
3413	-813.23	8.8688	-0.0220	886.19	886.19	886.19	886.19	886.19	886.19
3414	-813.23	8.8688	-0.0220	886.19	886.19	886.19	886.19	886.19	886.19
3415	-813.23	8.8688	-0.0220	886.19	886.19	886.19	886.19	886.19	886.19
3416	-813.23	8.8688	-0.0220	886.19	886.19	886.19	886.19	886.19	886.19
3417	-813.23	8.8688	-0.0220	886.19	886.19	886.19	886.19	886.19	886.19
3418	-813.23	8.8688	-0.0220	886.19	886.19	886.19	886.19	886.19	886.19
3419	-813.23	8.8688	-0.0220	886.19	886.19	886.19	886.19	886.19	886.19
3420	-813.23	8.8688	-0.0220	886.19	886.19	886.19	886.19	886.19	886.19

END OF CONTINUOUS

SESS POST1 ELEMENT STRESS LISTING SESS

TIME: 0.20000

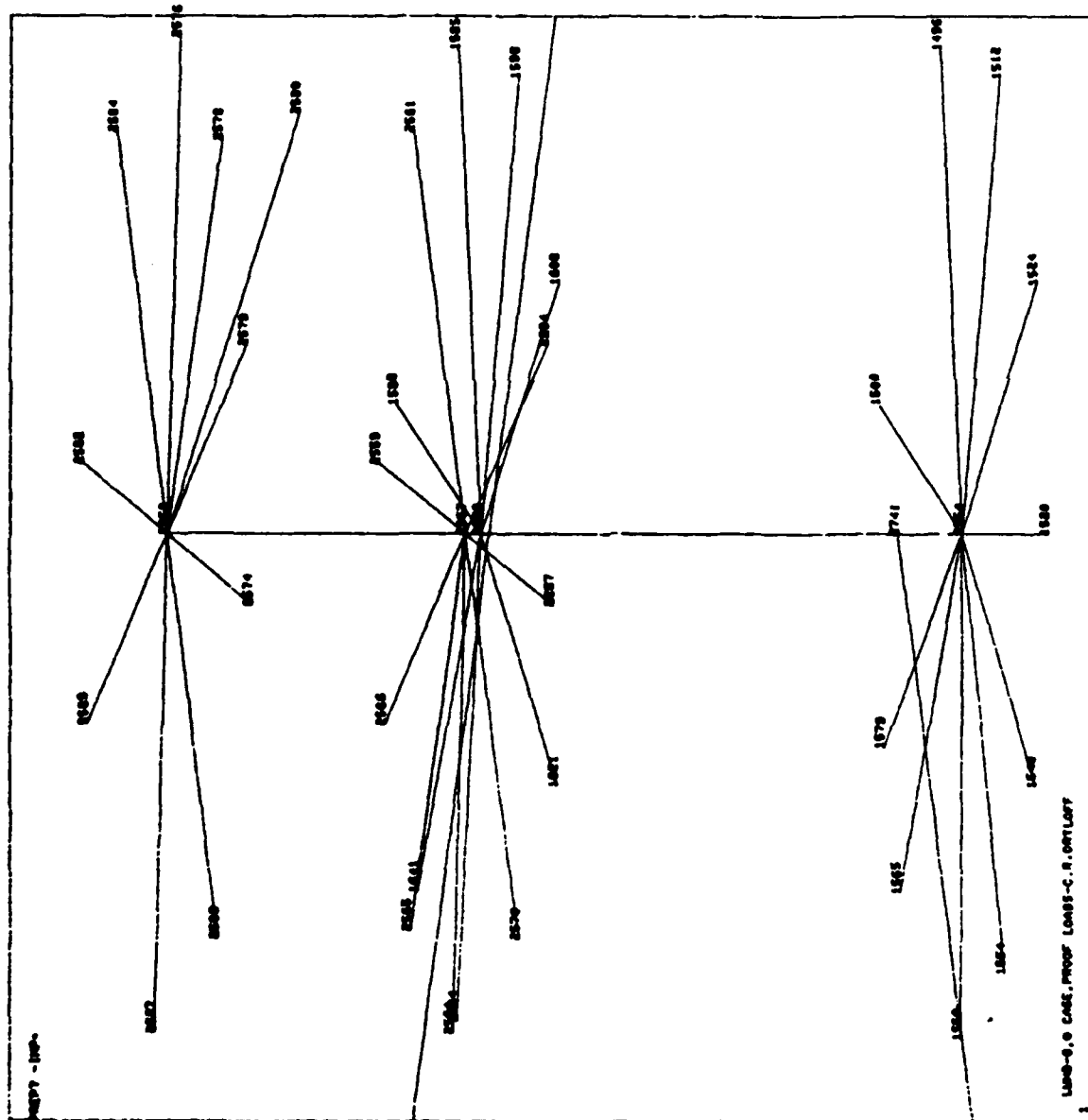
LOAD STEP 1 ITERATION: 1									
LOAD CASE: 1									
ELEM	FX	FY	FZ	SDR	SESS	SESS	SESS	SESS	SESS
3421	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3422	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3423	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3424	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3425	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3426	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3427	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3428	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3429	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3430	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3431	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3432	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3433	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3434	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3435	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3436	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3437	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3438	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3439	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3440	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3441	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3442	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3443	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3444	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3445	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3446	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3447	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3448	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3449	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3450	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3451	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3452	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3453	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3454	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3455	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3456	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3457	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3458	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3459	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3460	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3461	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3462	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3463	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3464	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3465	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3466	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3467	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3468	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3469	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
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3471	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3472	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3473	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3474	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3475	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3476	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3477	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
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3479	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
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3525	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3526	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3527	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3528	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3529	-133.23	-8.7159	5499.5	-333.83	886.19	886.19	886.19	886.19	886.19
3530	-133.23	-8.7159	5499.5	-333.83	886.19</				

$$t = 0.28 \text{ sec}$$

267

77

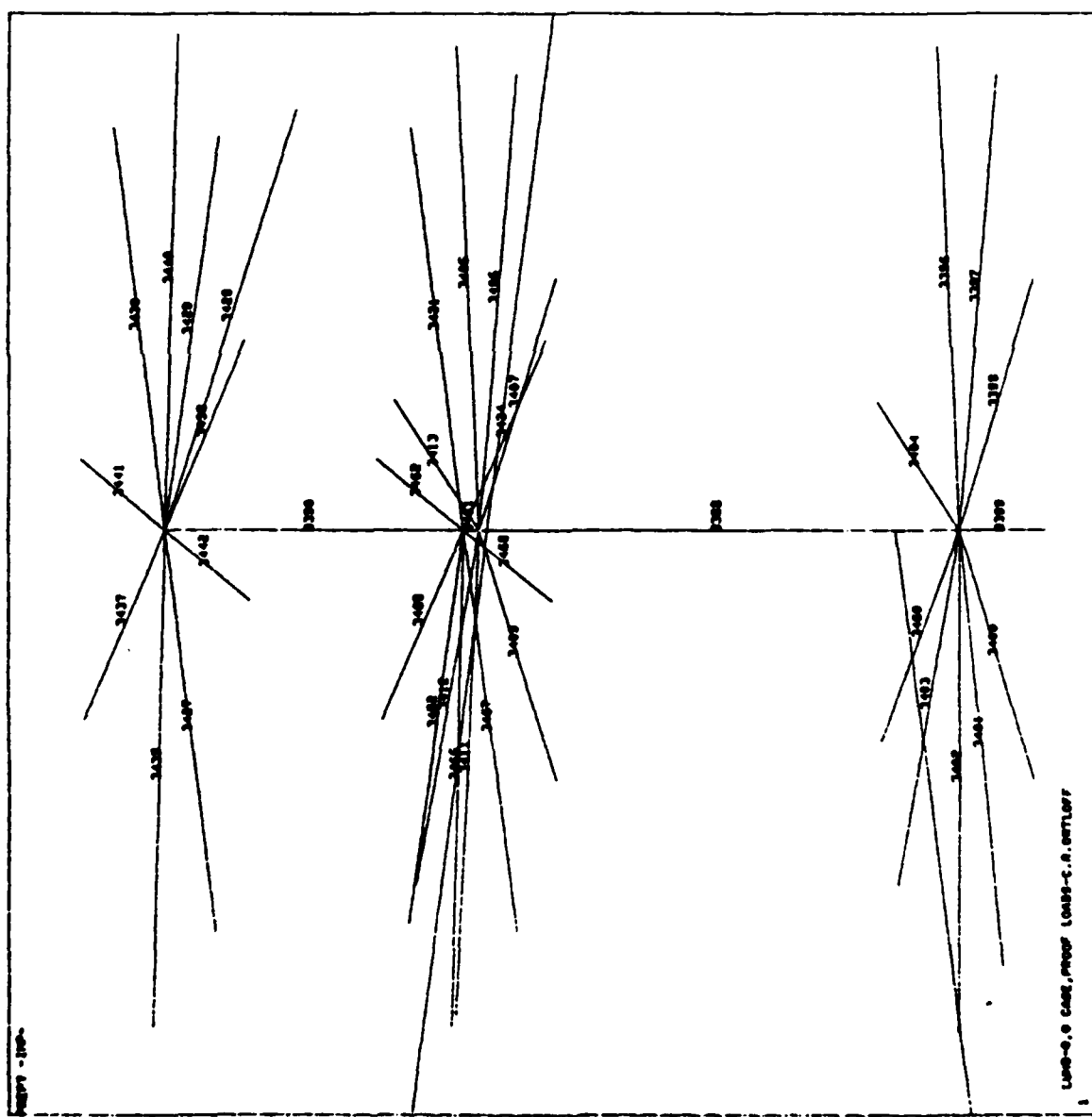
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 000-1
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 0 07-00.4
 0 07-00.6
 0000-1.30
 0000-1.32



1. LAMB-0.0 CASE, PROOF LOADS-C, R, ORTL, ORT

BOTTOM

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 DEC 8 1965
 17102144
 PNEU7 ELEMENTS
 (PNEU7-1)
 20000
 W-1
 V-1
 20-1
 0 0101-10.0
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 0 01-100.4
 0 01-05.0
 0 01-01.30
 0 01-01.30



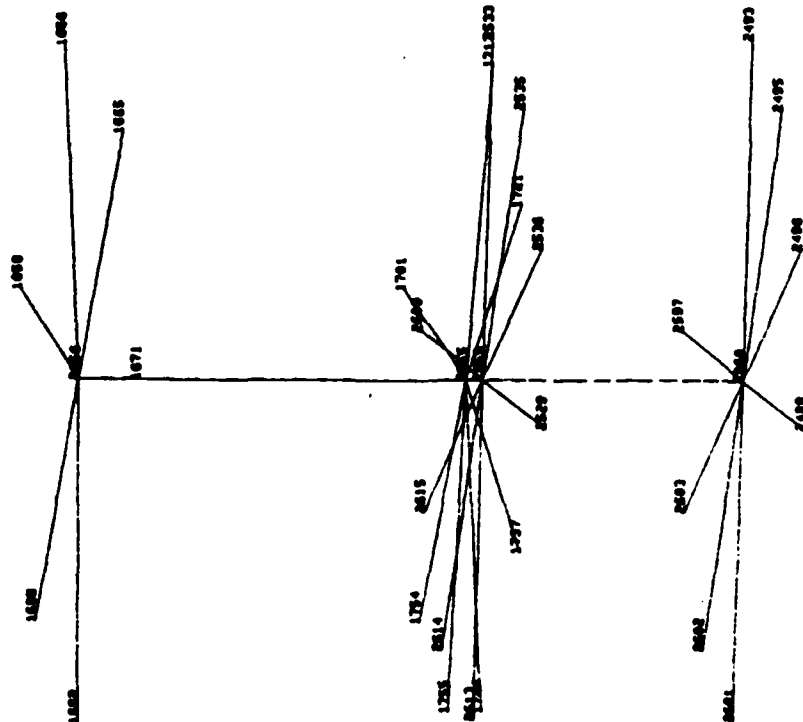
BOTTOM

0011-6233

10/10/2000

WFO-1.17

100-3-88



LINE-0.0 CASE, PROOF LOSS-C.A. OFF

To Q

FMC Central Engineering Laboratories Santa Clara

Interoffice

To	L. Libhardt*	Date	January 14, 1987
From	C. R. Ortloff	cc	A. Amberg E. Thuse R. Kazares J. Ries B. Rathe B. Zierwick B. Anderson *(29 figures)
Subject	ESTIMATES OF THERMAL EXPANSION STRESSES IN THE LTHD CRADLE		

Although the composite cradle design is currently undergoing design revision in geometry, materials selection, and fabrication method, nevertheless it is instructive to determine the order of magnitude of thermally induced stress on an earlier cradle model. This earlier cradle version has many similarities to the proposed later version and represents a fall-back design should later design not prove adequate.

The wall model in the sandwich plate used for the present cradle analysis is the [0/45/-45/90/-45/45/0]_s Gr/Ep filament wound laminate for which thermal expansion coefficients (TEC) have been provided (LL to CR0). The provided (TEC) value has been cross-checked with results from the UCLA Seminar Notes "Design Technology and Applications of Composites Engr. 847.34, P. K122, K162-165, 1982) and found to be in reasonable agreement for the given stacking sequence. Results for a 100°F temperature excursion over ambient (70°F) are summarized below. The nomenclature used to describe the cradle lamina sequence as given in a previous memo (CR0 to R. Rathe, 8-Dec-86) is used. As before, the ANSYS analysis program is the basis of reported results.

- o Maximum thermal expansion stresses exceeding 10 ksi in the fiber direction appear in: lamina 3 (-45°, Figure 475); lamina 7 (0°, Figure 483); lamina 8 (45°, Figure 484); lamina 9 (-45°, Figure 486); lamina 10 (90°, Figure 488); lamina 11 (-45°, Figure 490) and lamina 12 (45°, Figure 493). Of these, the lamina 10 stress (16 ksi) is the largest (Figure 488).
- o While many high stress regions occur around the manifold to inner Gr/Ep layer interface zones (Figure 486, for example), high stresses over 10 ksi occur over most of the cradle for lamina 10 (90°, Figure 488). The selection of a proper clearance value between the second manifold and the inner Gr/Ep layer should help to relieve the locally high contact stress levels. The first manifold joint, however, appears to experience high (16.9 ksi) stress due to the mismatch between Ti

L. Libhardt
Estimates of Thermal Expansion Stresses
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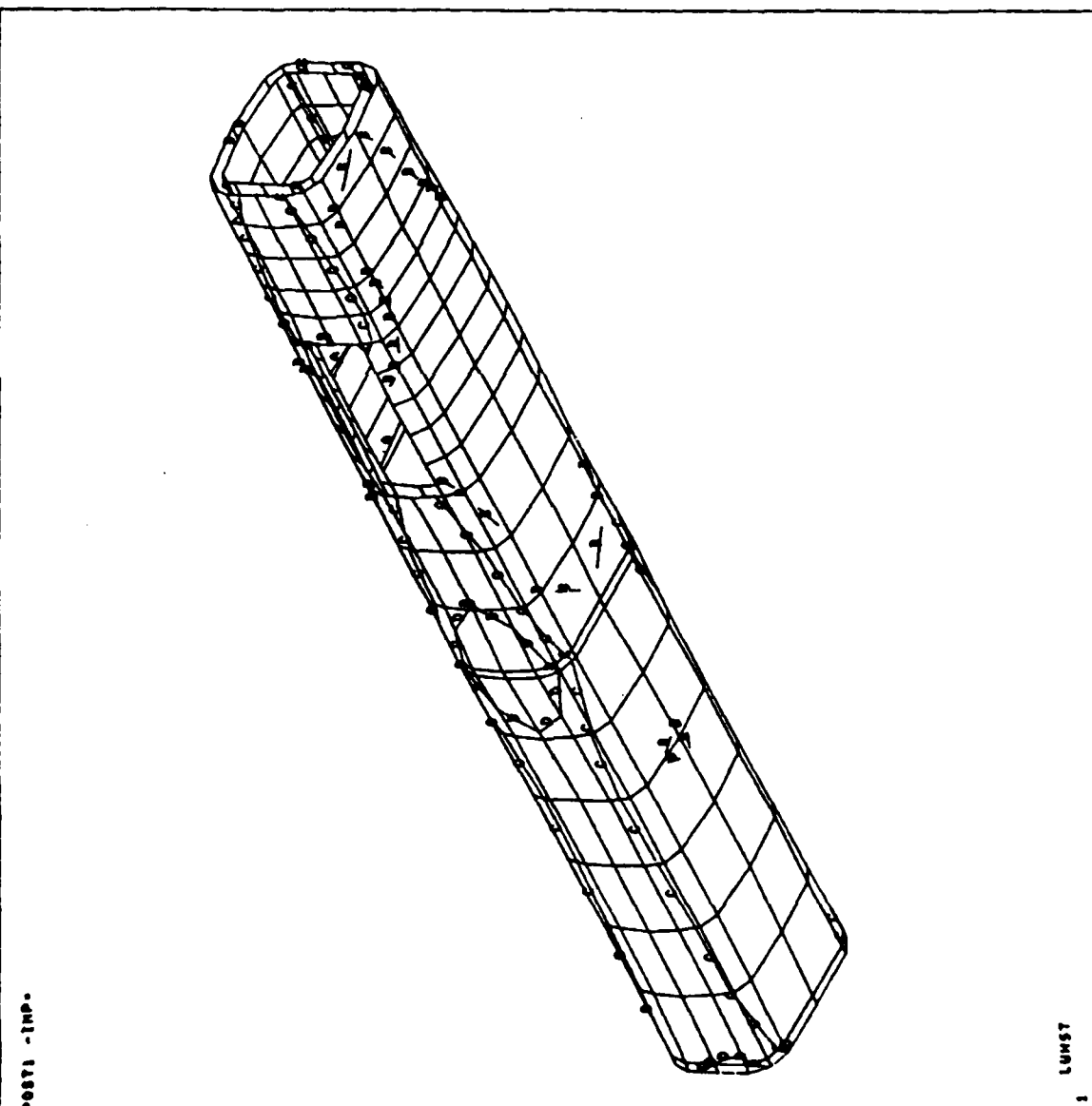
and Gr/Ep thermal expansion coefficients (3 to 4X). These additional thermal stresses should be taken into account for the forward joint design as the joint interface may not show much Gr yielding under dynamic loading and undergo brittle failure. The joint needs special design considerations and possible use of buffer strips. Stresses are large in the vicinity of the cradle cut-outs for certain lamina (see, for example, Figures 475, 484, 486, 488 and 493).

- o A rough calculation of compressional fiber buckling stress using the CMAP equivalent modulus in the load direction indicates that there may be local fiber buckling or crippling near the first manifold joint under the proof impulse loads (for the "old" filament wound cradle design). A layered beam column FE model under compressive impulse loads would be constructive to investigate local stability. Although buckling stress or load prediction is very approximate, nonetheless, this forward joint zone should be analyzed with local FE detailed models.
- A comparison of the University of Delaware CMAP thermal stress program results (Memo: CRO to L. Libhardt 22-Dec-86) to present detailed thermal stress ANSYS results confirms that thermal stresses as high as 15 ksi may occur within the cradle laminate. The presence of hygrothermal (moisture absorption loads) is not considered in the present analysis but can result in a reduction in modulus (10-15%), softening of the epoxy resulting in a lowering of failure criteria epoxy stress values and induced stress (due to swelling) within the laminate. These stresses can be on the order of several thousand psi as indicated by the CMAP results.
- o Decreases in temperature may cause contractions and local curvature changes in the Gr/Ep cradle laminate such as to bind the second manifold to the interior wall of the cradle. The sliding motion of the manifold will therefore be impeded if the clearance is too small. A FE model analysis can predict temperature contraction effects to decide the appropriate Gr/Ep inner wall-to-manifold plate clearance.
- o Use of layered Gr/Ti sheets to compose cradle end joints (to connect to the gimbal) should be analyzed for thermal expansion layer stress as the CTE for each material differs widely.



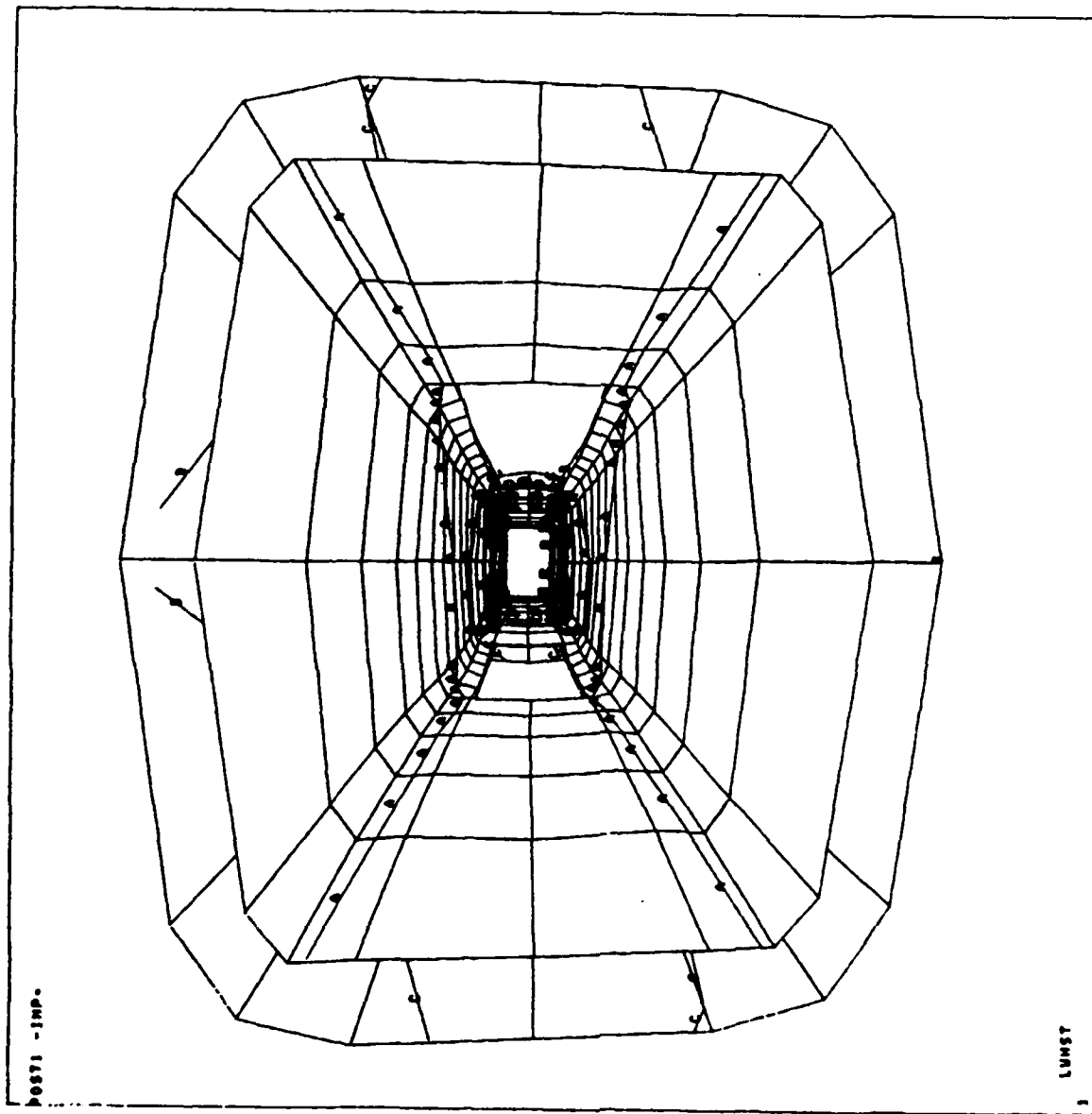
C. R. Ortloff

ANSYS 4.20
 JAN 13 1987
 15128140
 POST1 STRESS
 STEP=1
 LAYER=1
 SKE
 XU=-1
 YU=-1
 ZU=1
 DIST=104
 ZF=116
 HIDDEN
 RK=8146
 RN=4306
 A=-2232
 B=-156
 C=1020
 D=3096
 E=8072

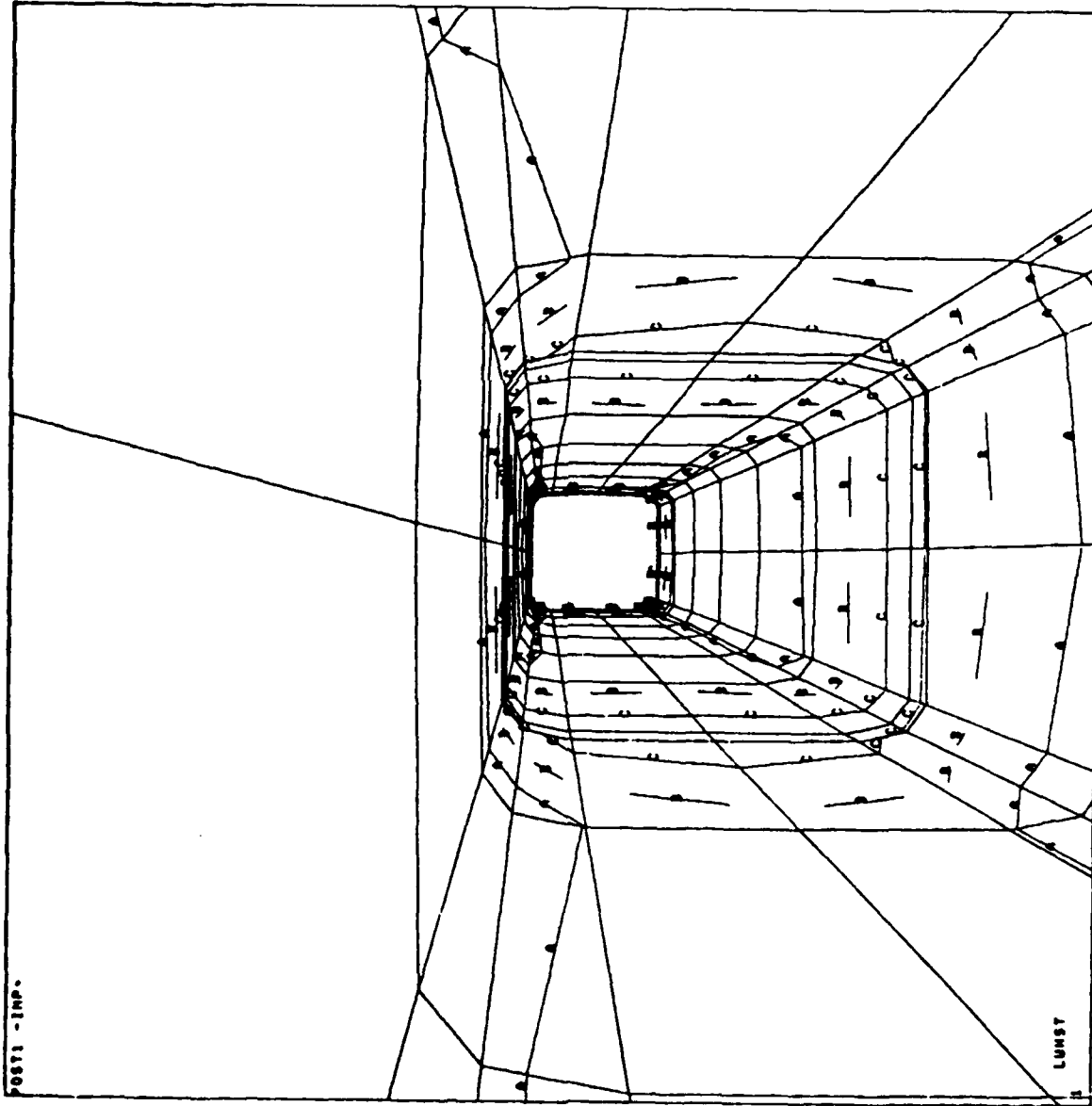


THERMAL STRESSES
 $\Delta T = 100^{\circ}F$
 FIBER DIRECTION
 LAMINA 1
 "OLD DESIGN"
 CRADLE -29
 LAYERS; WALL
 $[0/45/-45/90/-45/45/0]_S$
 GR/EP FILAMENT
 WOUND STRUCTURE

ANSYS 4.20
JAN 13 1987
15:38:34
POST1 STRESS
STEP=1
ITER=1
SX1
ZU=1
BIST=136
ZF=116
CONE=45
HIDDEN
RX=8146
RN=4308
A=-2232
B=-156
C=1920
D=2096
E=6072

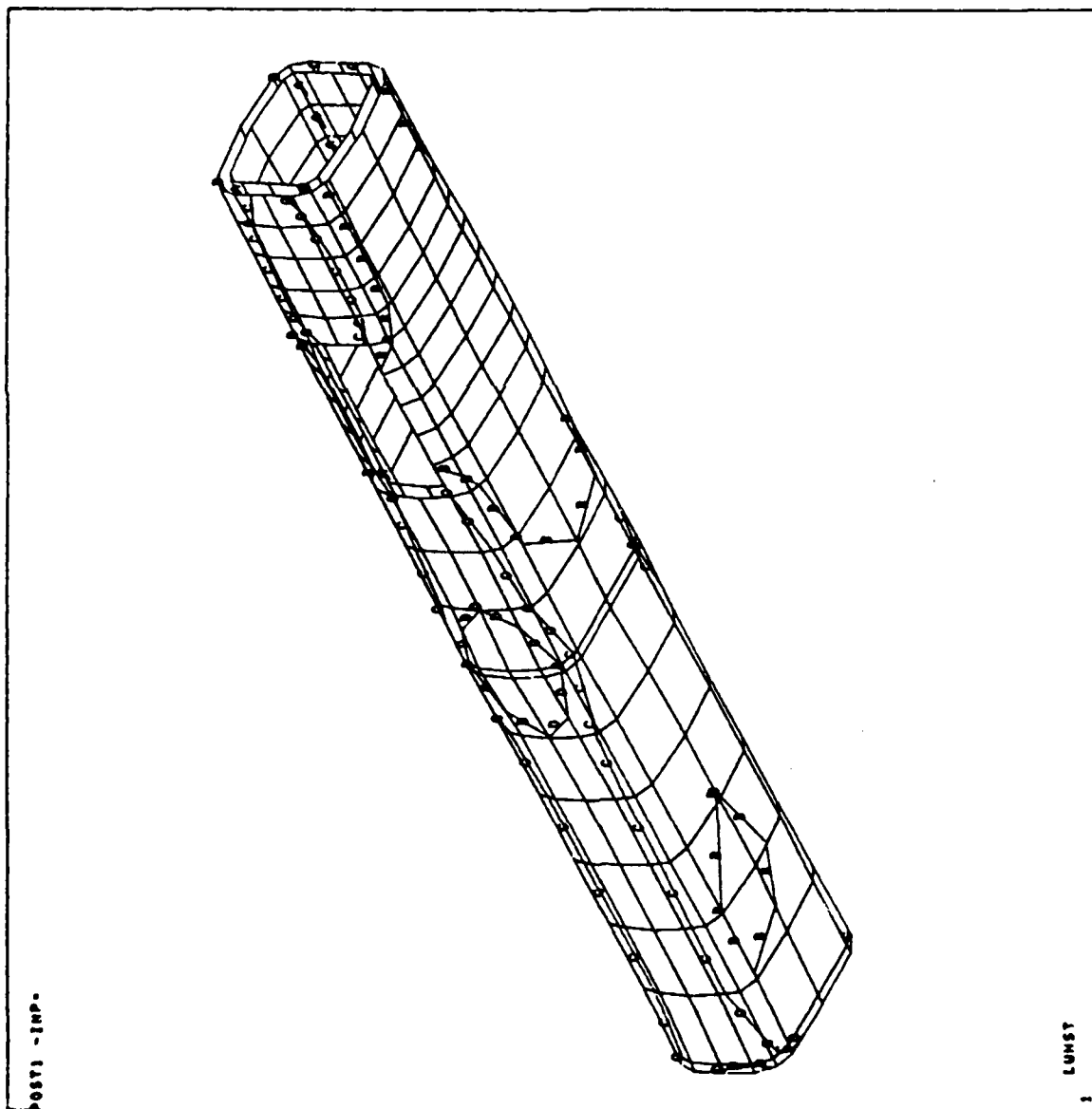


ANSYS 4.28
 JAN 13 1987
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 POST1 STRESS
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 ITER=1
 SNI
 ZOOM
 ZU=1
 1 DIST=36.2
 2 XF=-.87
 3 VF=8.35
 4 ZF=116
 CONE=45
 VROT=1.84
 MIDDEN
 RX=8146
 RN=-4386
 A=-2232
 B=-156
 C=1920
 D=3986
 E=6072



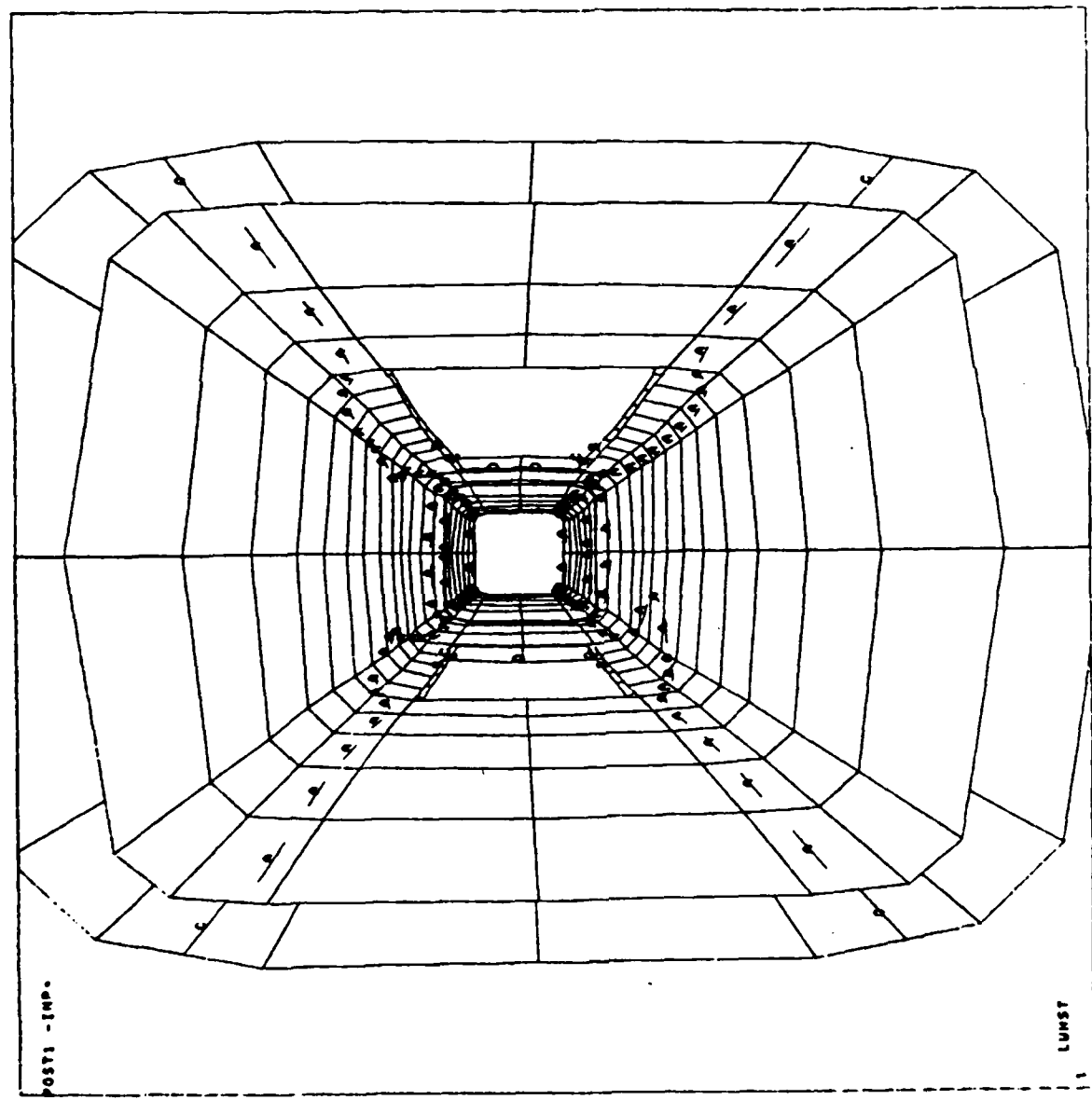
ANSYS 4.28
 JAN 12 1987
 15:33:48
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 ITER=1
 SVI
 XU=-1
 YU=-1
 ZU=1
 DIST=104
 ZF=116
 HIDDEN
 MM=1119
 MM=109
 A=20
 B=240
 C=460
 D=680
 E=900

NORMAL FIBER
 DIRECTION

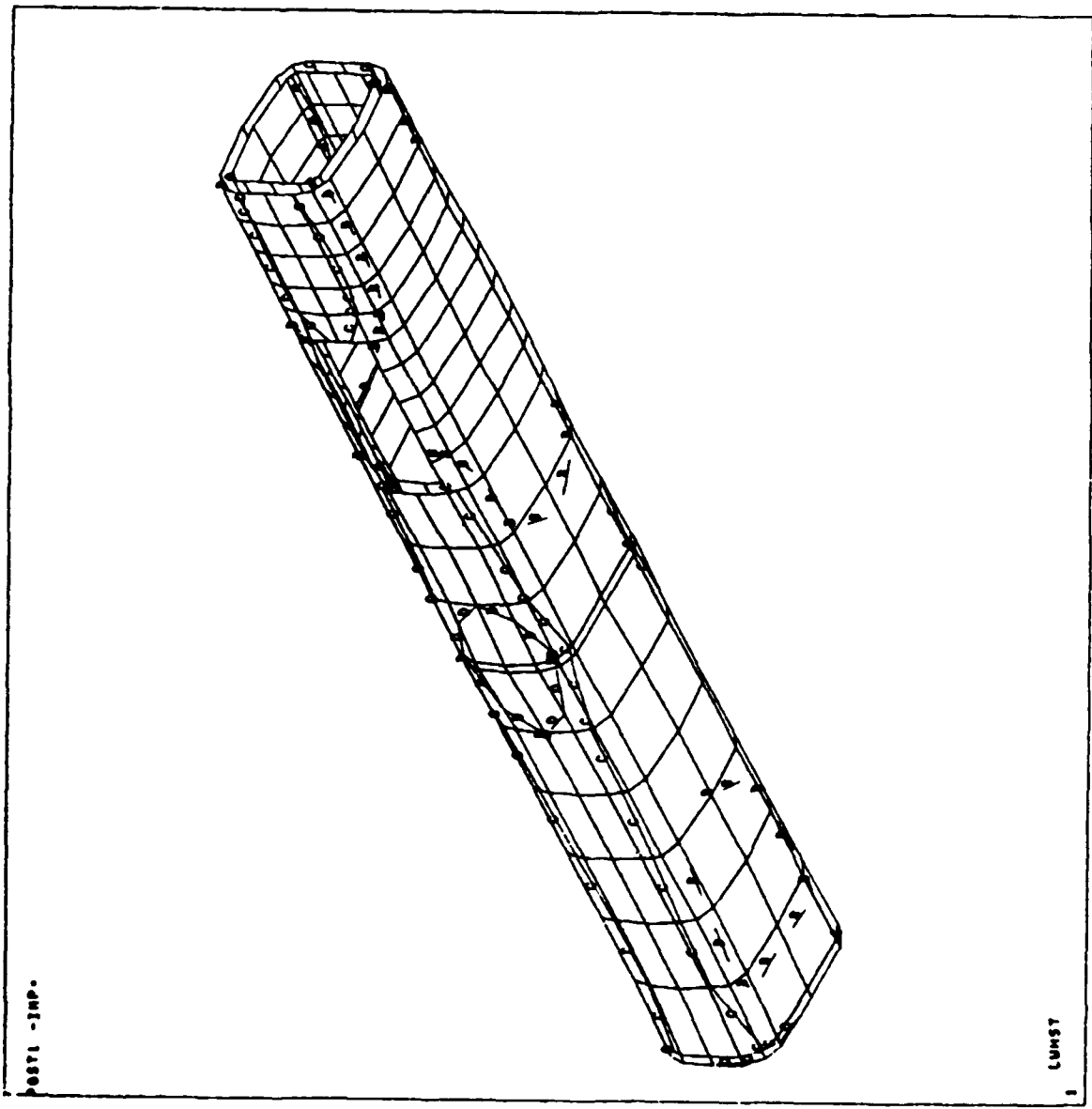


ANSYS 4.2D
JAN 13 1987
15:40:25
POST1 STRESS
STEP=1
ITER=1
SKYL
ZOOM
ZU=1
DIST=143
ZF=116
CONE=40
VROT=1.84
MIDEN
MX=713
MY=156
A=-11.3
B=134
C=270
D=424
E=569

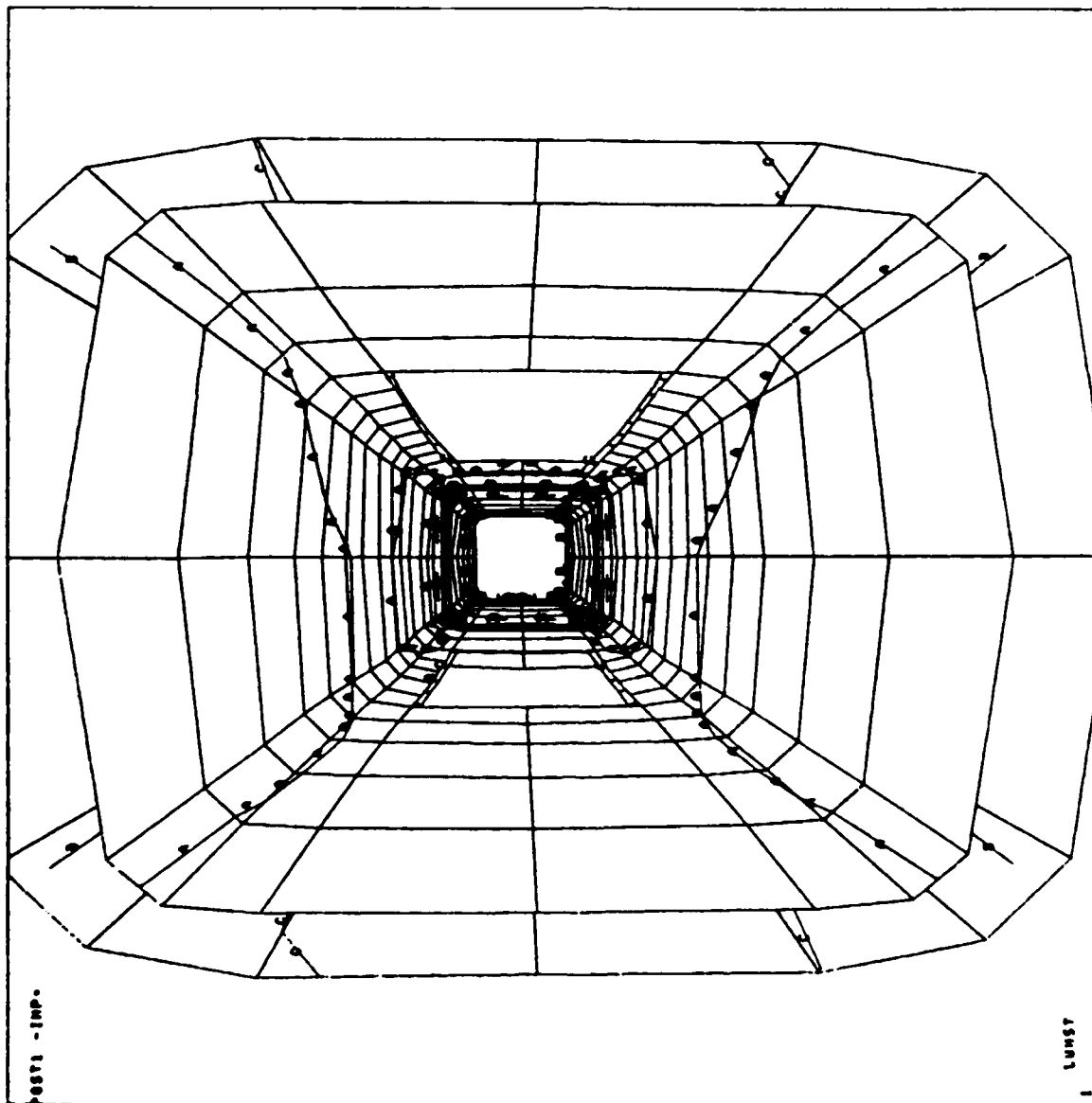
IN PLANE
SHEAR
STRESS



ANSYS 4.28
JAN 13 1987
15:30:18
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ITER=1
SHE
KX=1
KY=1
KZ=1
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ZF=118
WIDEN
HX=8095
HY=4297
A=2233
B=167
C=1899
D=3965
E=6031



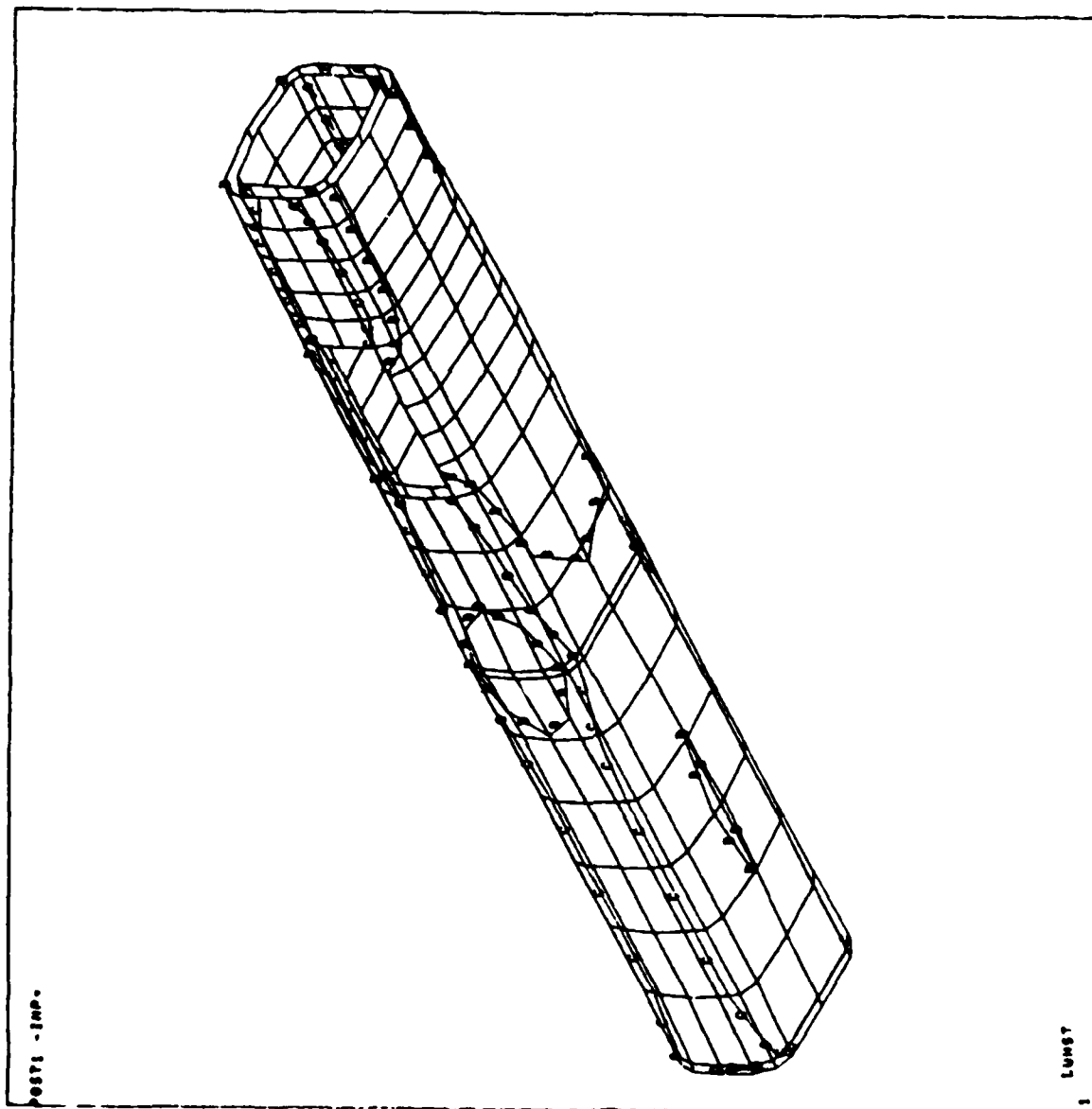
ANSYS 4.28
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 SK2
 ZOOM
 ZU=1
 0187.193
 2F-116
 CONE-40
 VRT0-1.84
 MIDDLEM
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 RM-4287
 A--2233
 B--167
 C-1899
 D-3965
 E-8831



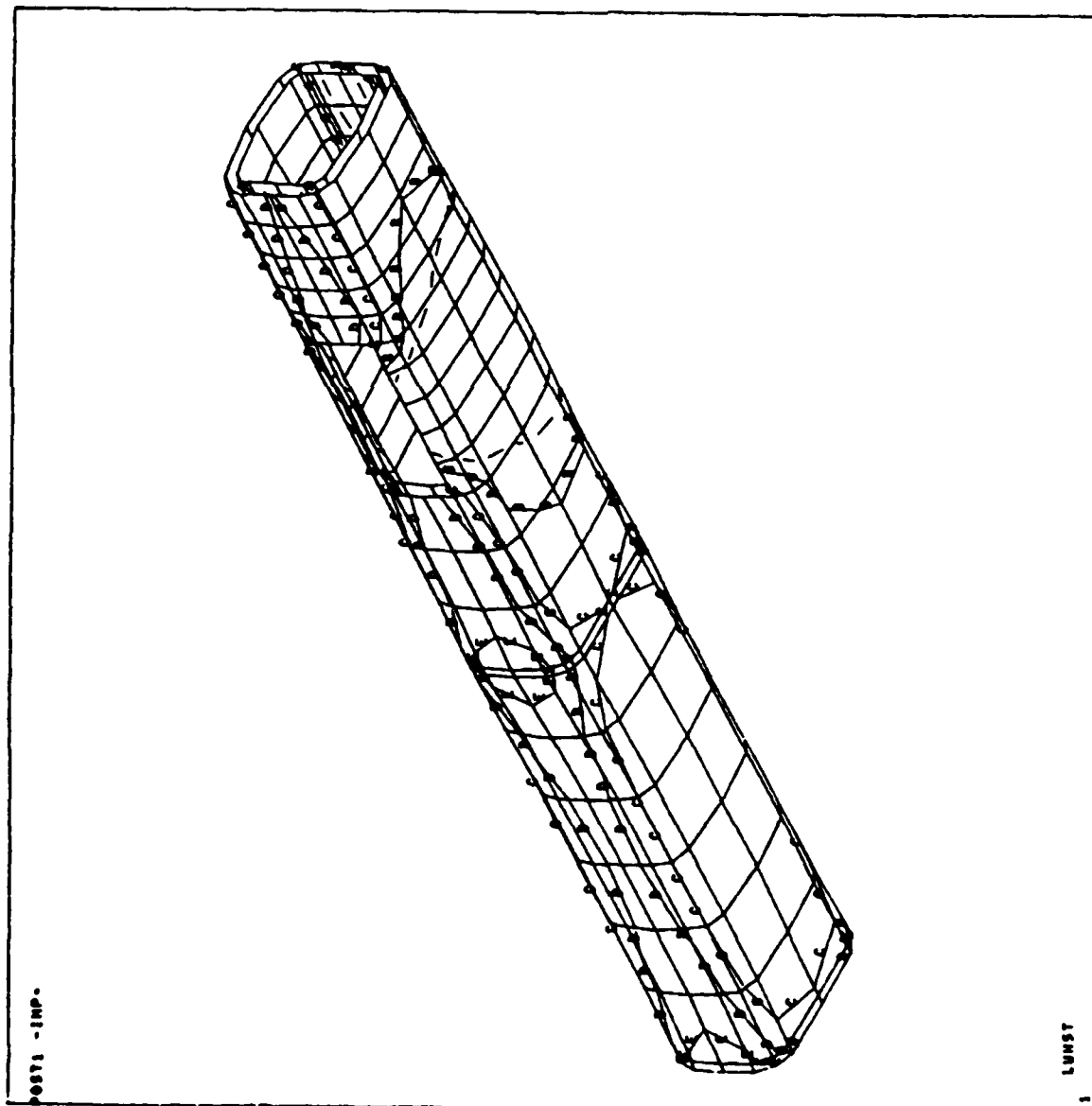
POST1 -IMP.

LUNST

ANSYS 4.80
 JAN 13 1987
 15125127
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 ITER=1
 SVE
 MU=-1
 VU=-1
 ZU=1
 DIST=104
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 RM=1100
 MM=-202
 A=15.6
 B=235
 C=454
 D=673
 E=892

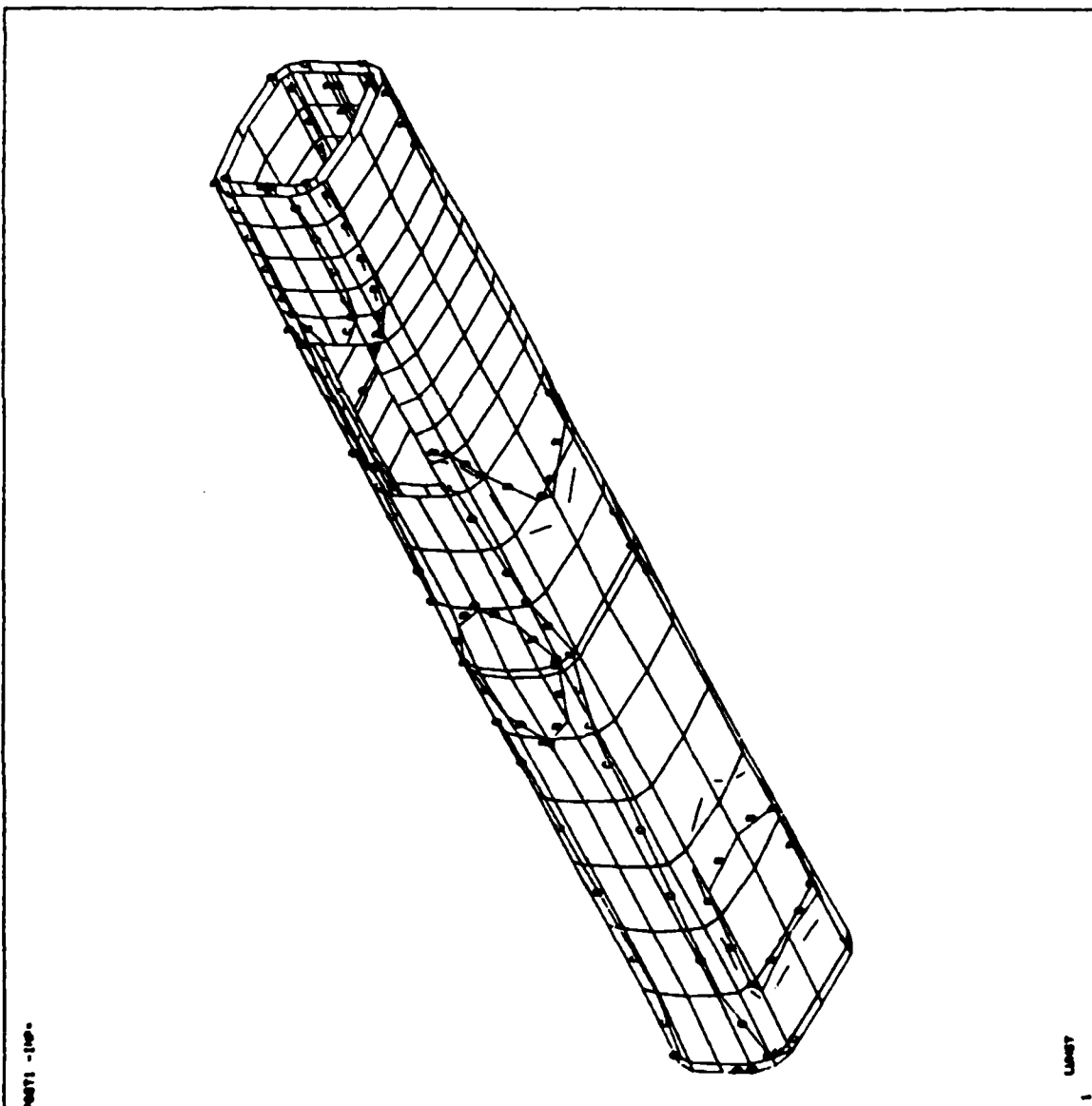


ANSYS 4.2B
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 VU=-1
 ZU=1
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 ZF=116
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 RN=-5305
 A=-8639
 B=1820
 C=4497
 D=7765
 E=11033



3
475

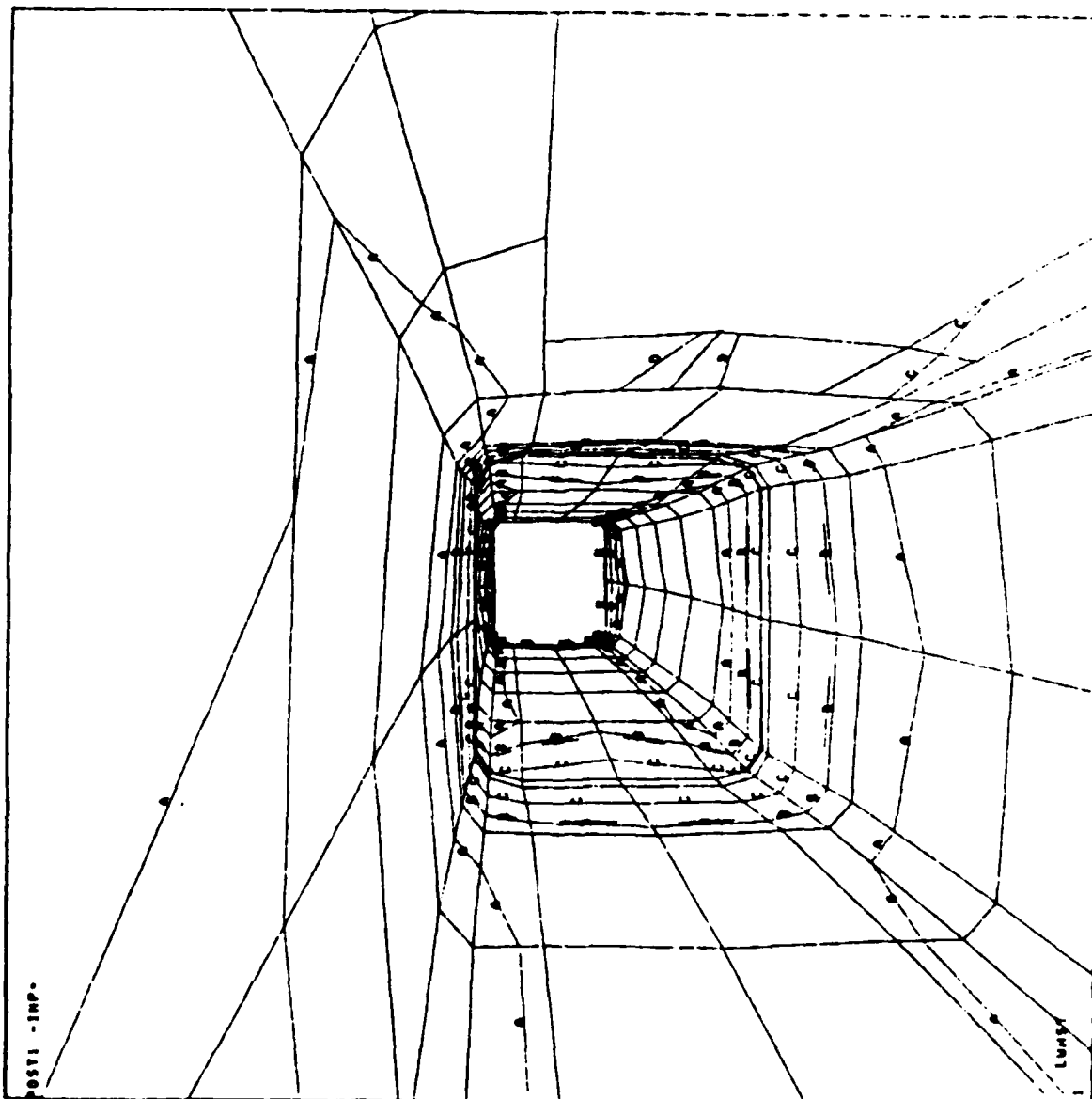
ANALYSIS 4.25
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ITER-1
END
NO.-1
VNO.-1
ZU.-1
DIST-104
27-116
M10007
PC-7007
PC-4344
A-2201
B-205
C-1701
D-2027
E-8003



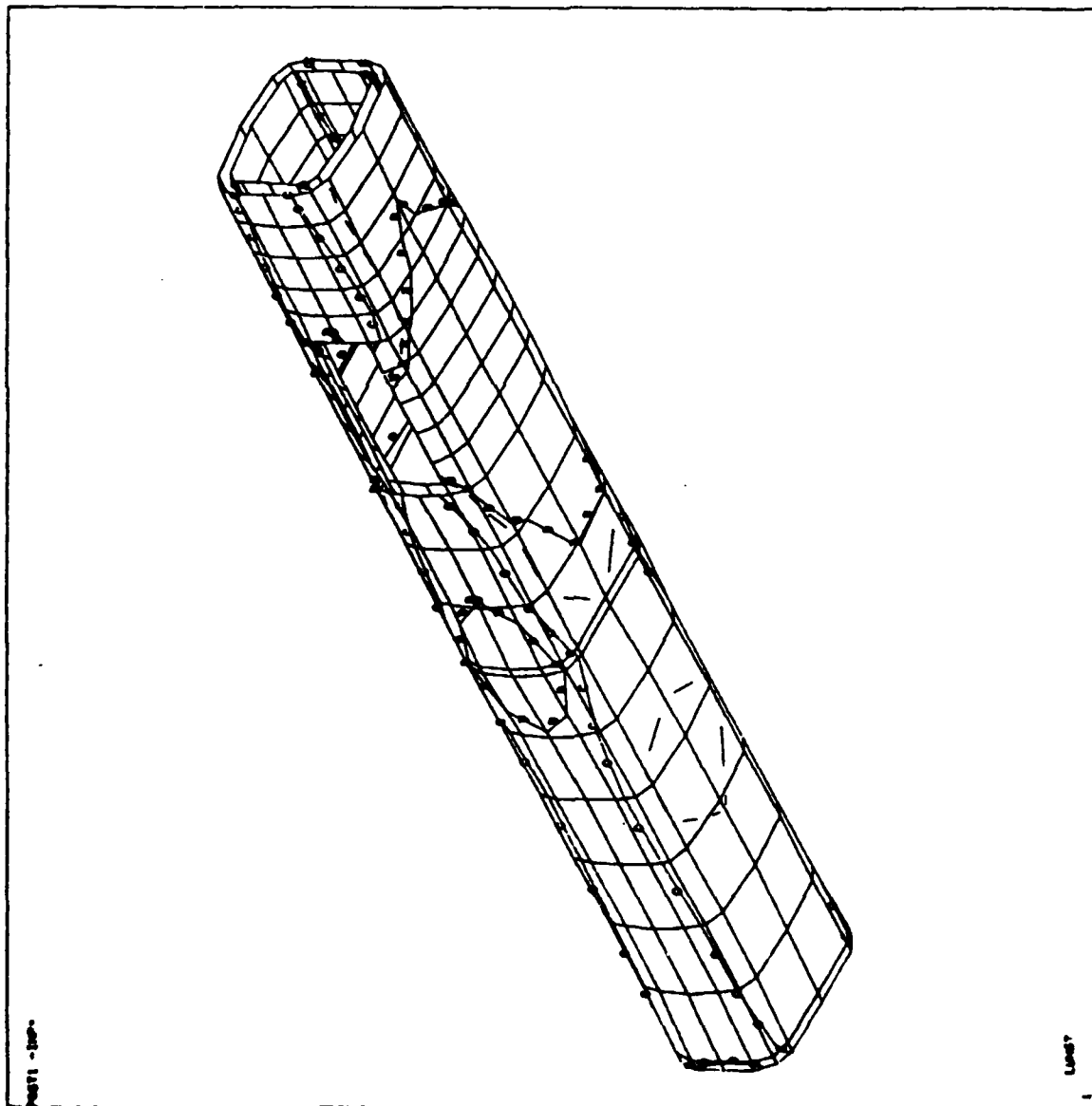
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 ITER=1
 SK1

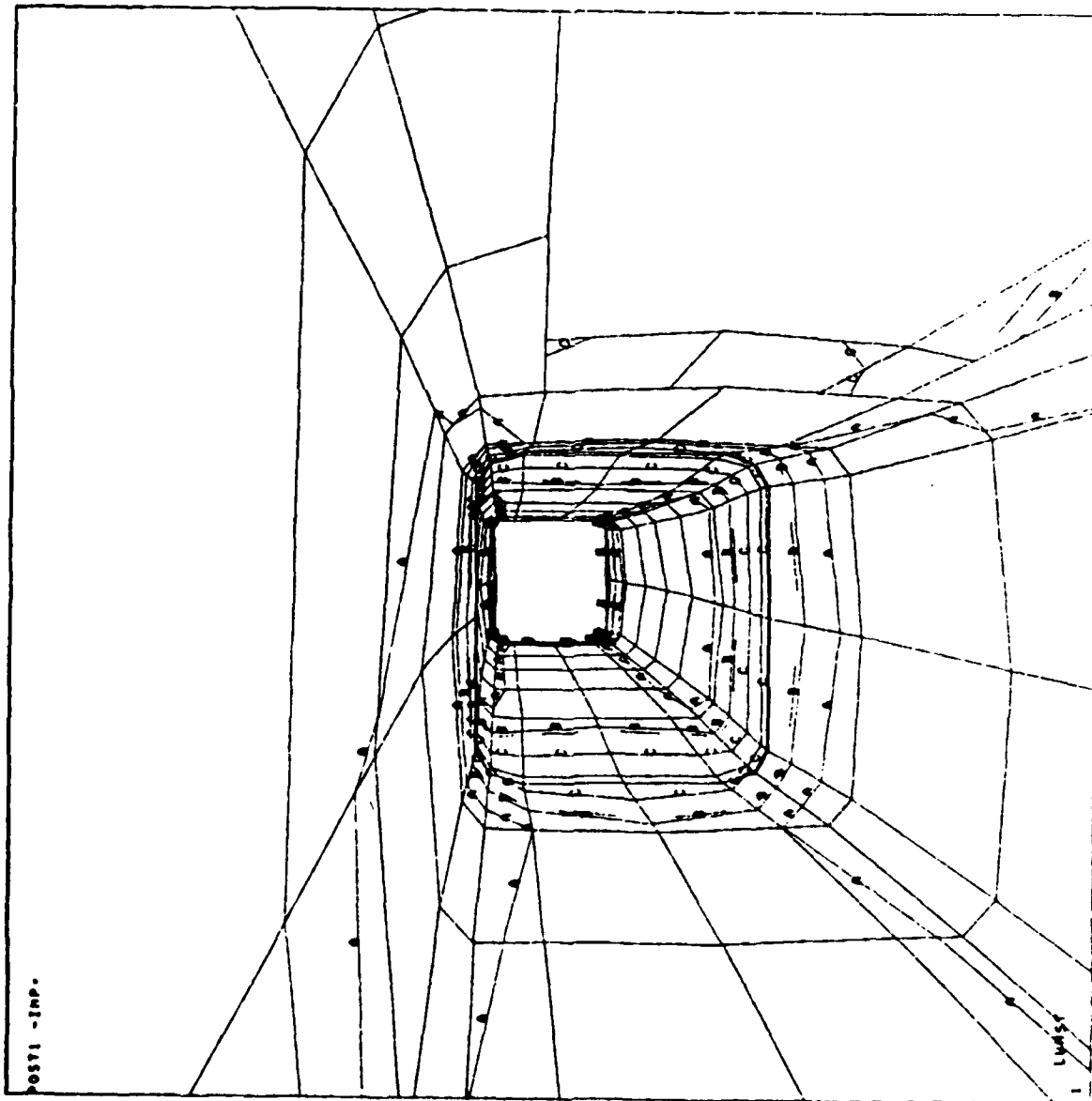
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 YF=11.2
 ZF=116
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 MX=7927
 MY=4344
 MZ=2301
 B=255
 C=1791
 D=3837
 E=5883



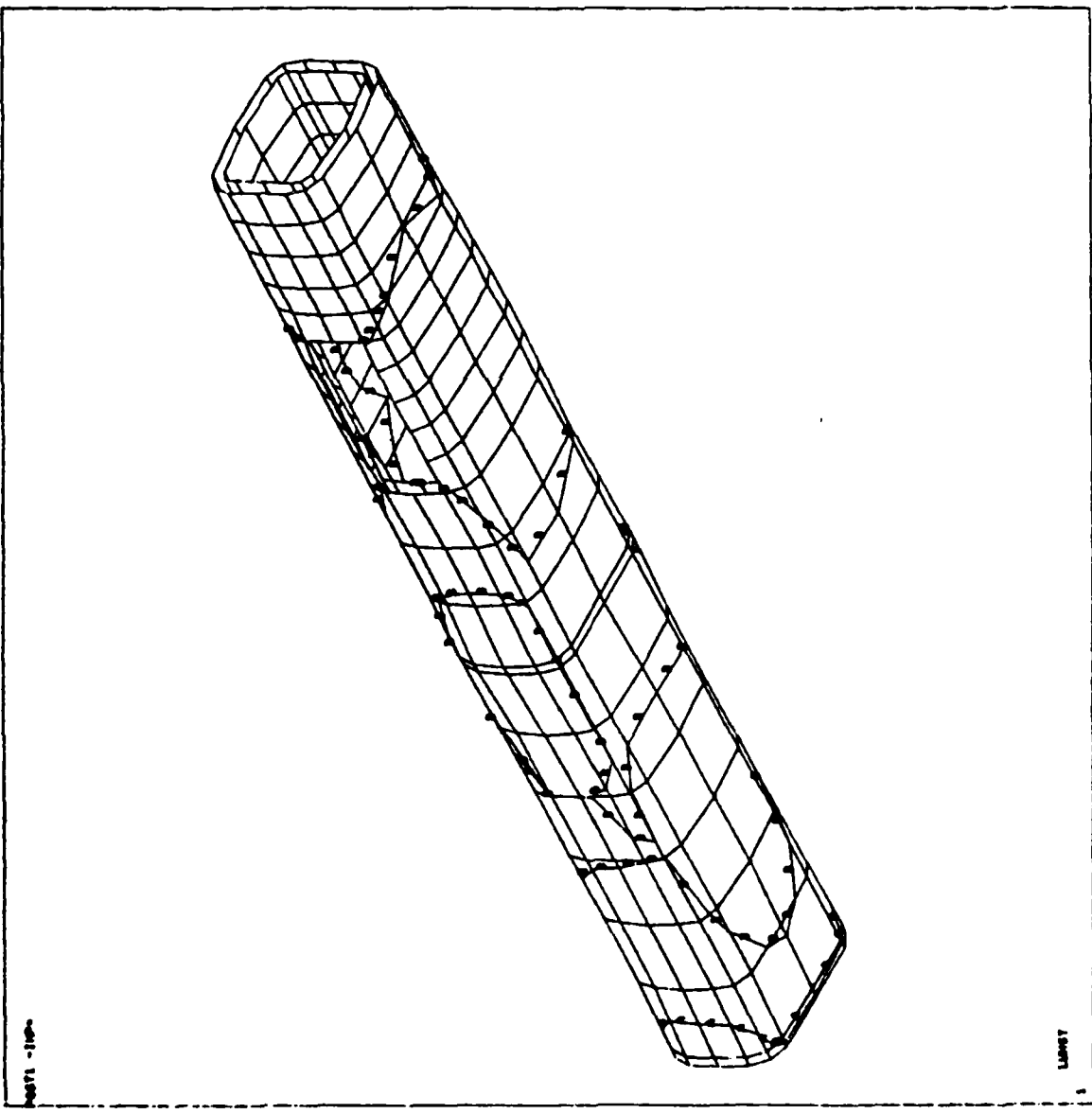
AUGUS 4.20
 JAN 13 1987
 15112-00
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 IYER=1
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 10--1
 20--1
 315--104
 35--116
 418024
 60-7018
 80--4204
 8--4751
 9--317
 C-1717
 D-3761
 E-9785



ANSYS 4.20
 JAN 13 1987
 16:50:48
 POST1 STRESS
 STEP=1
 ITER=1
 SHS
 ZOOM
 ZU=1
 1 DIST=55.5
 2 XF=6.16
 3 VF=11.2
 4 ZF=116
 CONE=40
 VRTO=1.48
 HIDDEN
 RM=7818
 RM=-4284
 A=-2351
 B=-317
 C=1717
 D=3751
 E=5785



ADVIS 4.20
JAN 12 1987
10114077
POST1 STRESS
STEP=1
ITER=1
END
N000=1
N001=1
N002=1
N003=104
N004=116
N005=1
N006=7078
N007=6023
A=-0300
B=-0066
C=0200
D=0312
E=0700



AMSVS 4.28

JAN 13 1987

16:49:31

POST1 STRESS

STEP=1

ITER=1

SK6

ZOOM

ZU=1

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1 XF=6.16

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1 VETO=1.48

1 MIDDLE

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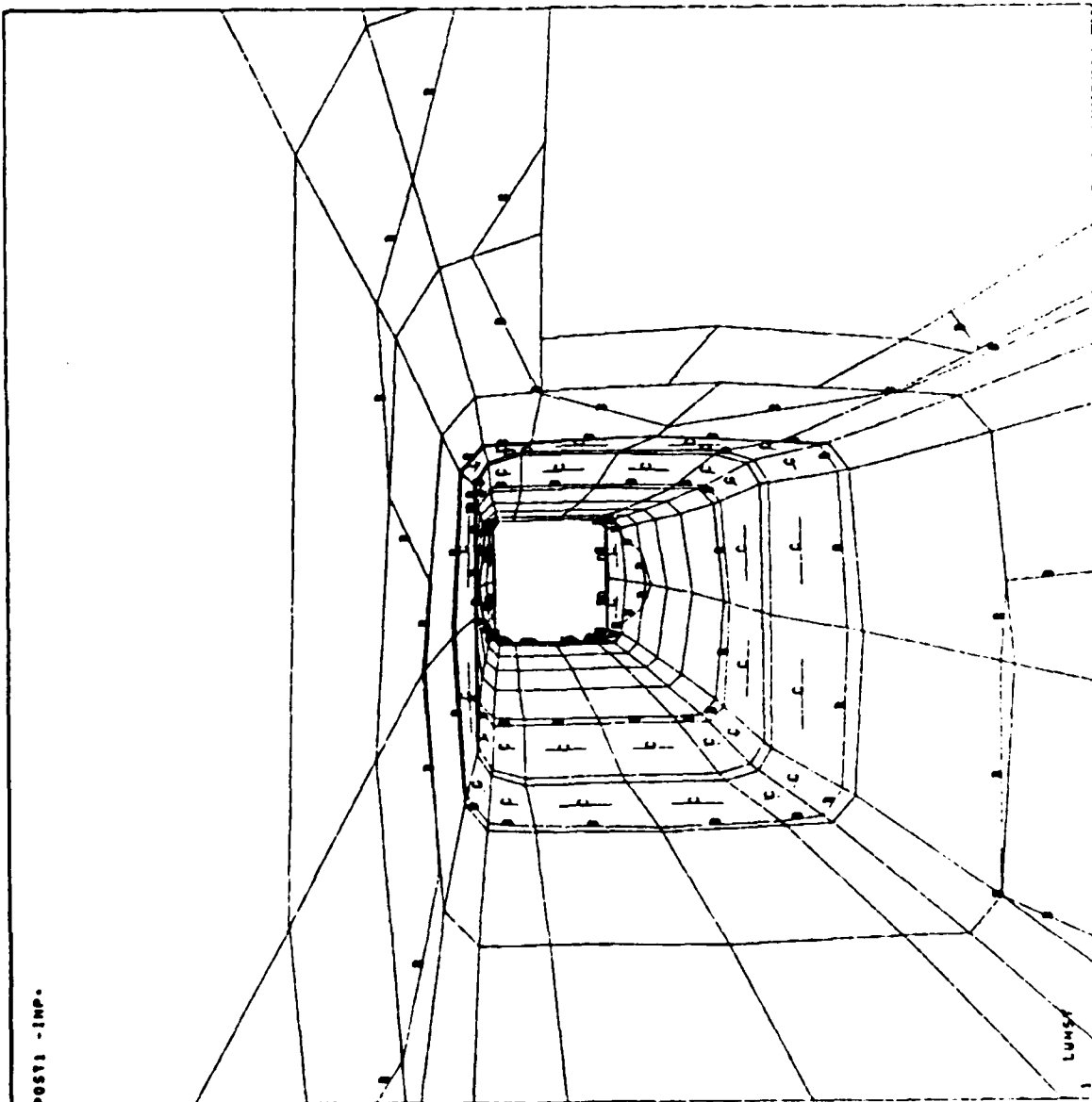
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1 C=228

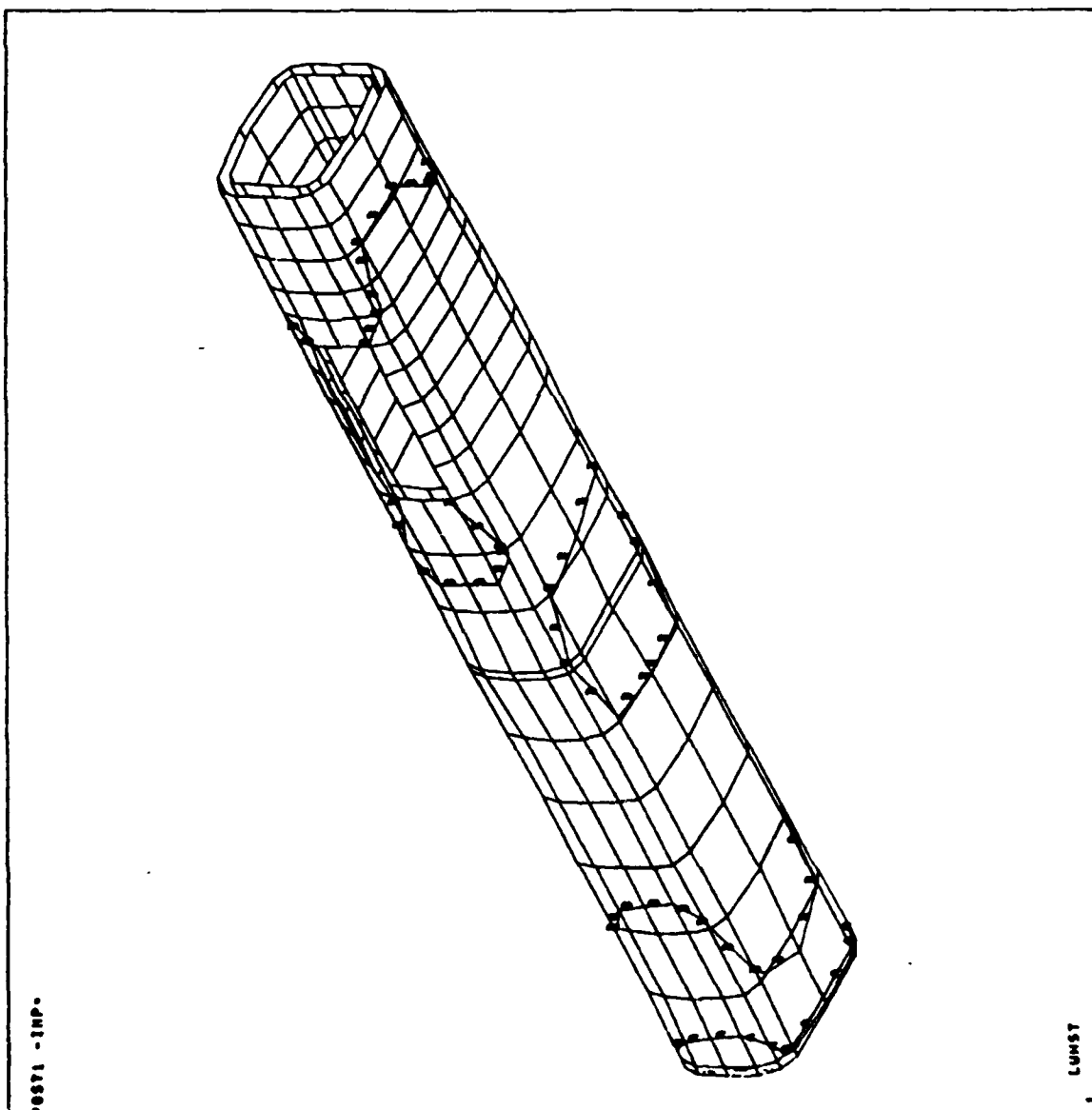
1 D=2512

1 E=4796

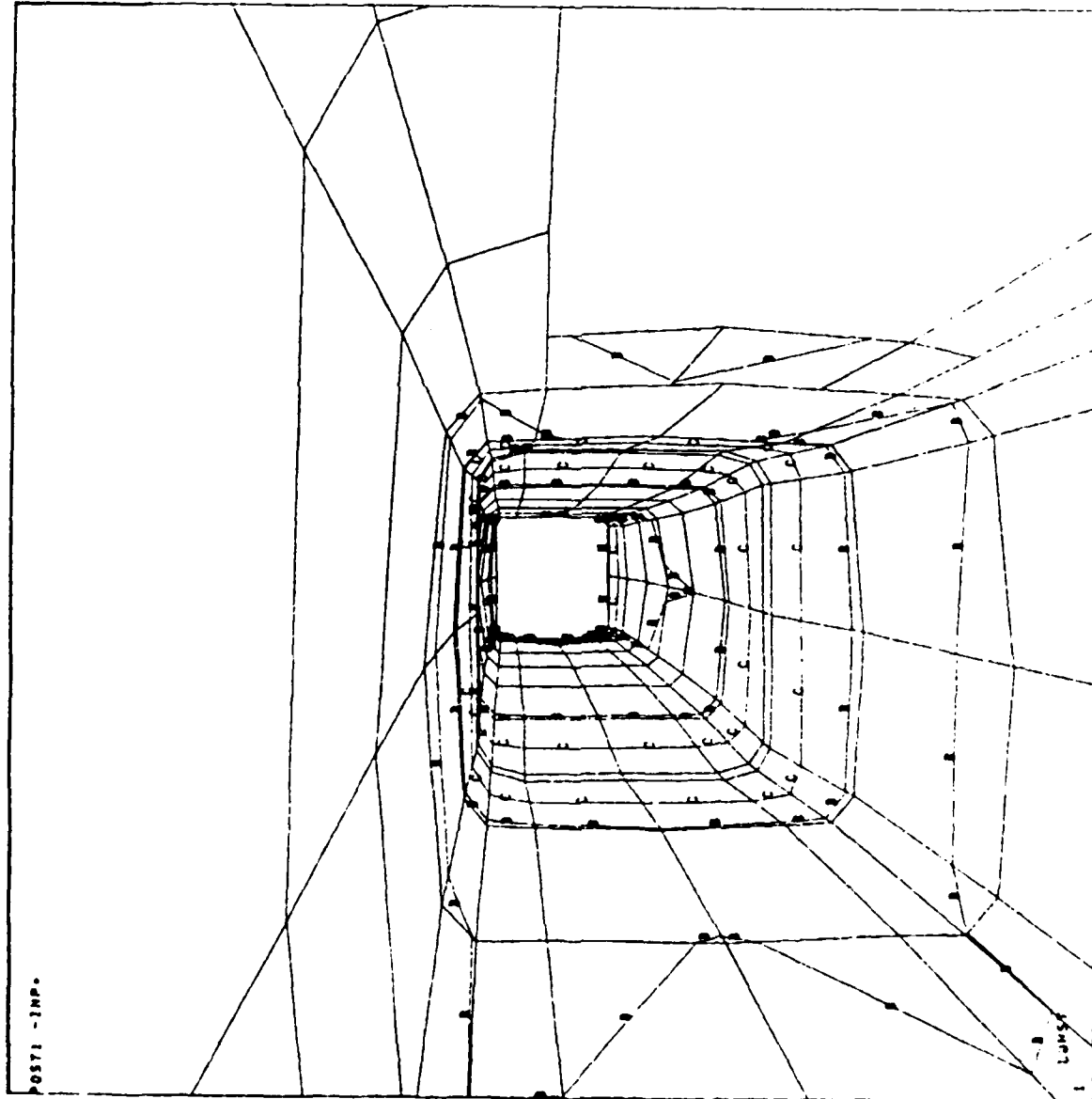
POST1 -IMP.



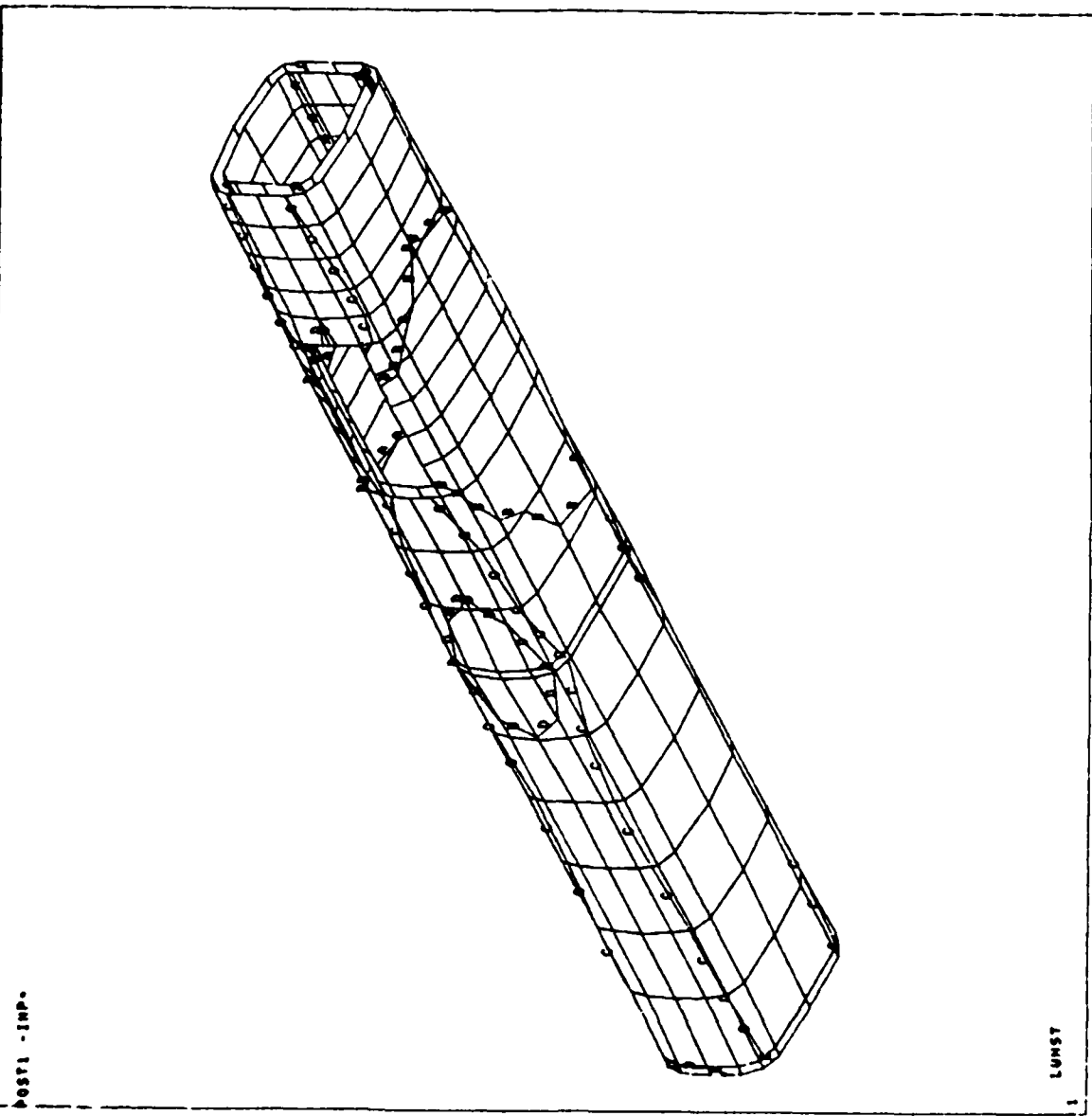
ANSYS 4.28
 JAN 12 1987
 16:16:00
 POST1 STRESS
 STEP=1
 ITER=1
 Sx7
 NU=1
 VU=1
 ZU=1
 DIST=104
 ZP=116
 HTDEM
 MX=18847
 MM=-930
 A=1388
 B=3858
 C=5954
 D=8852
 E=10550



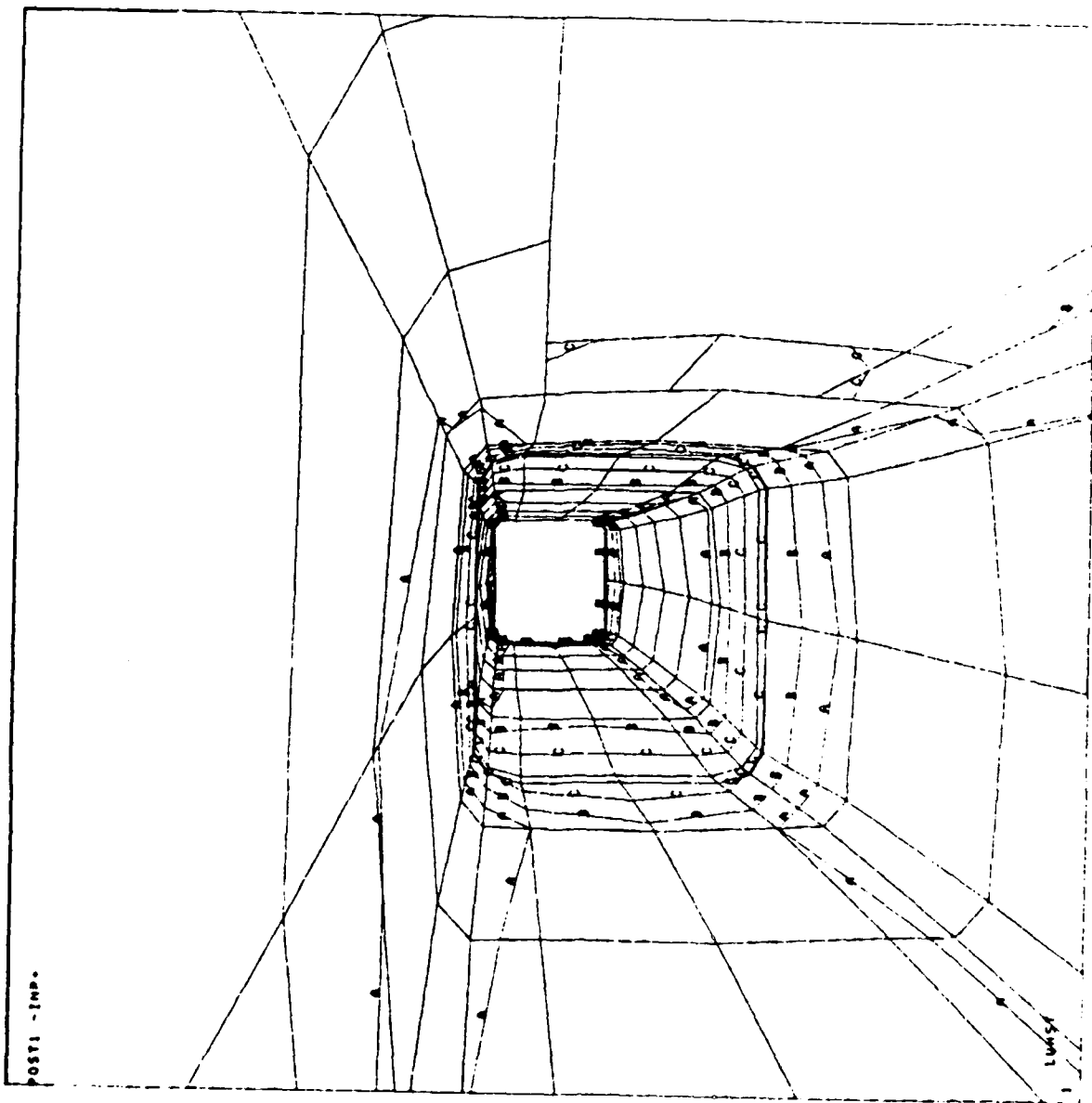
ANSYS 4.20
 JAN 13 1987
 16:48:12
 POST1 STRESS
 STEP=1
 ITER=1
 SNT
 ZOOM
 ZU=1
 Z DIST=56.5
 Z MF=6.16
 Z VF=11.2
 Z ZF=116
 COME=40
 VERTO=1.48
 MIDDLEM
 MX=12847
 MY=-939
 A=1358
 B=3656
 C=5954
 D=8252
 E=10550



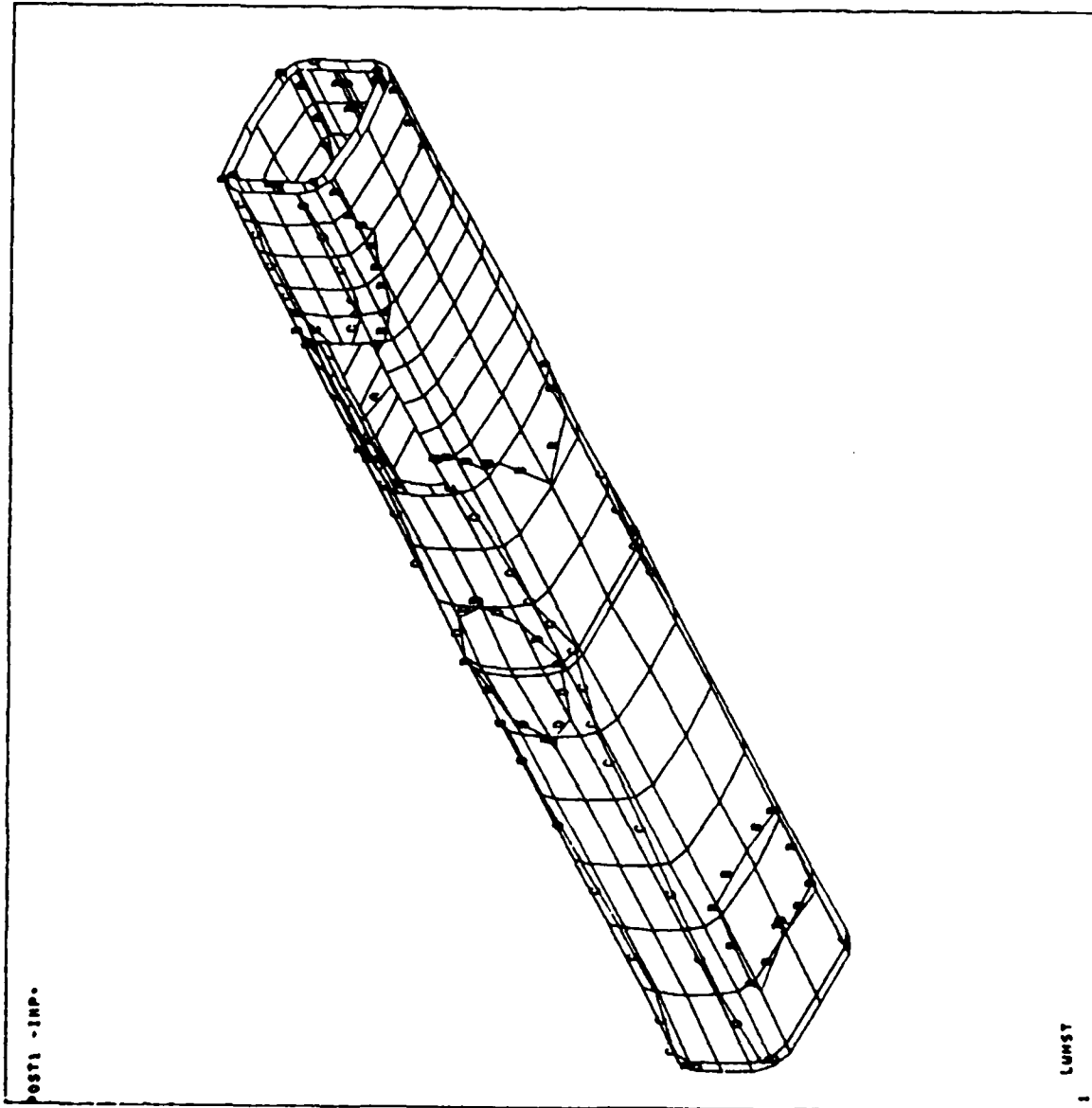
ANSYS 4.20
 JAN 13 1987
 16:18:31
 POST1 STRESS
 STEP=1
 ITER=1
 9x8
 XU=-1
 YU=-1
 ZU=1
 DIST=104
 ZF=116
 MIDDEN
 MX=13454
 MY=1251
 A=3366
 B=5384
 C=7482
 D=8428
 E=11438



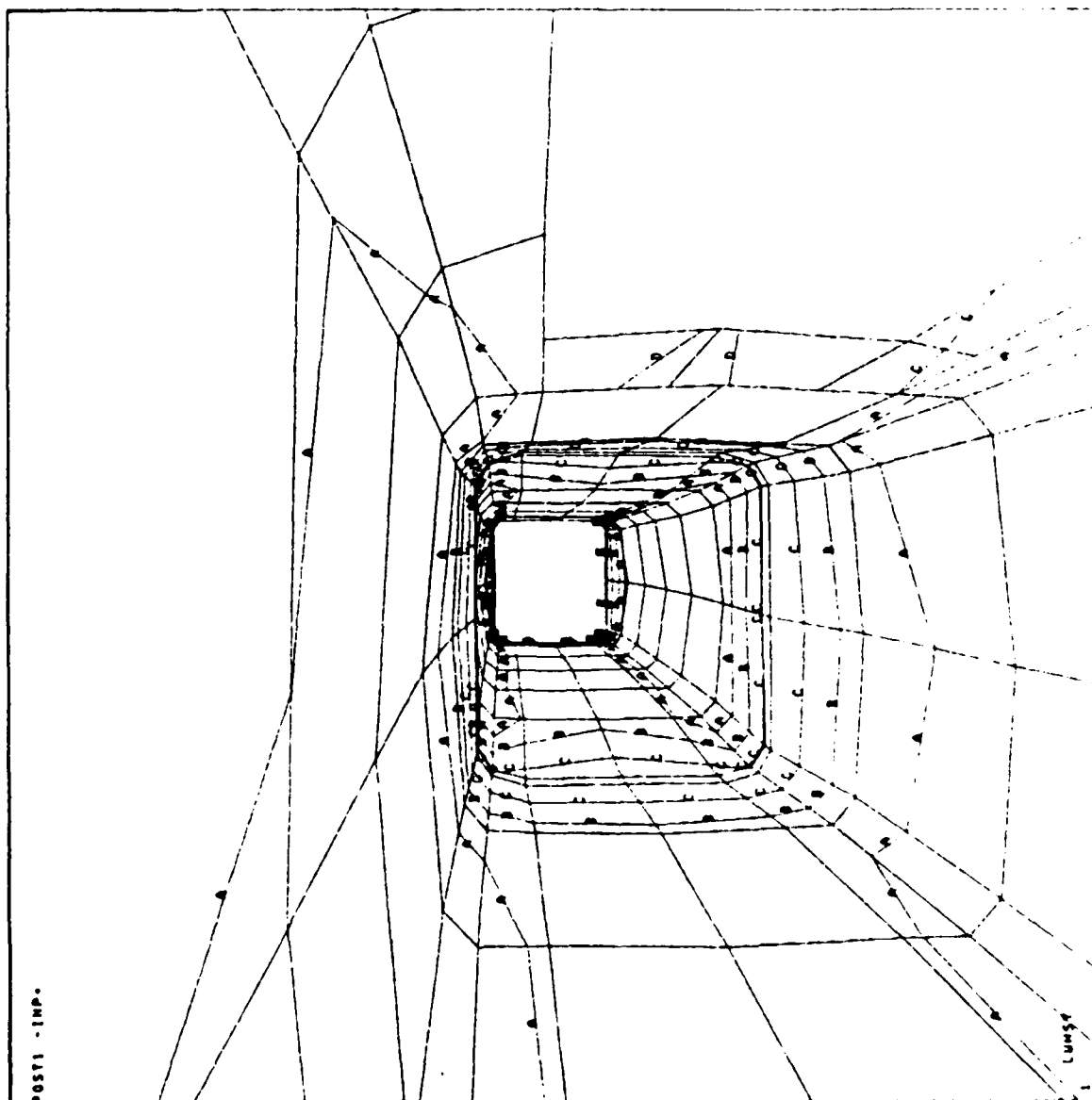
ANSYS 4.28
 JAN 13 1987
 16146145
 POST1 STRESS
 STEP=1
 ITER=1
 S48
 ZOOM
 ZU=1
 2 DIST=55.5
 3 KP=6.16
 4 VP=11.2
 5 ZF=116
 6 COME=40
 VRTO=1.48
 HIDDEN
 MX=13454
 MN=0
 A=3366
 B=5384
 C=7402
 D=9420
 E=11438



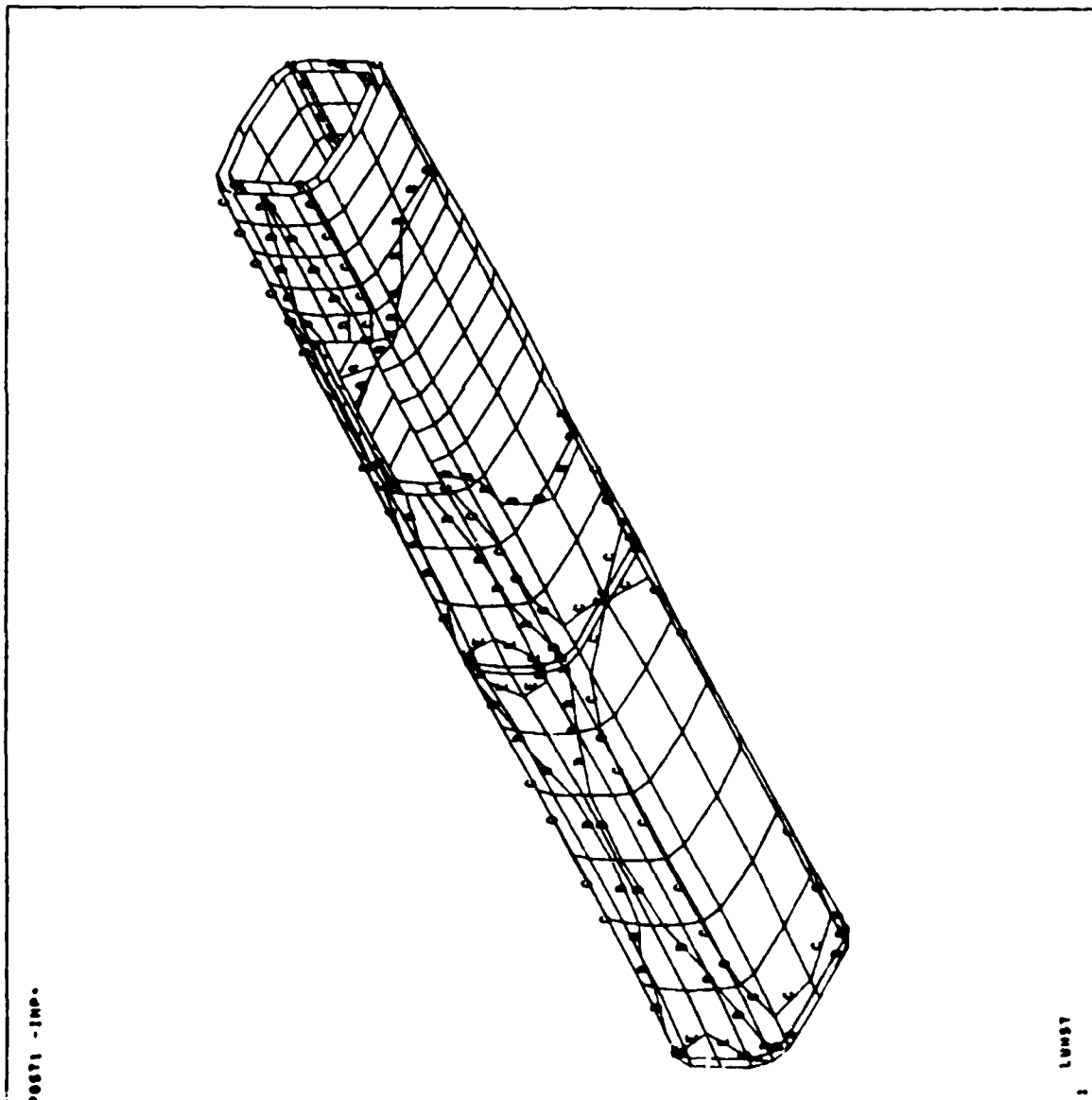
ANSYS 4.20
 JAN 13 1987
 16/20/21
 POST1 STRESS
 STEP=1
 ITER=1
 SSB
 KU=-1
 VU=-1
 ZU=1
 DIST=104
 ZF=116
 HIDDEN
 NH=13606
 NH=1346
 A=3367
 B=5305
 C=7423
 D=8451
 E=11479



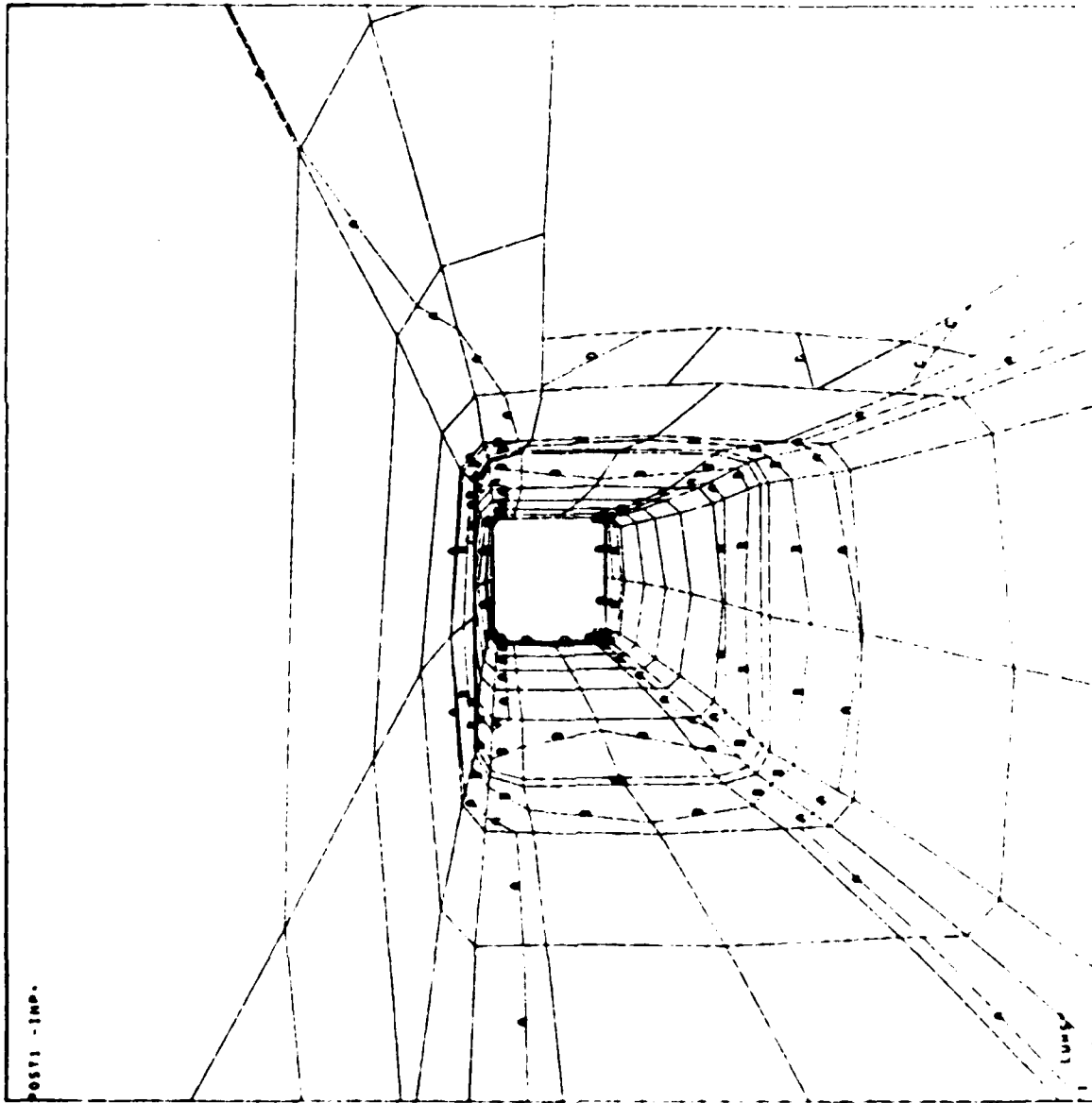
ANSYS 4.29
 JAN 13 1987
 16144127
 POST1 STRESS
 STEP=1
 ITER=1
 SLD
 ZOOM
 ZU=1
 DIST=55.6
 KF=6.16
 VF=11.2
 ZF=116
 CONE=40
 VRTO=1.48
 MIDDEN
 RK=13506
 RM=9
 A=3367
 B=5395
 C=7423
 D=9451
 E=11479



ANSYS 4.20
 JAN 13 1987
 16:22:10
 POST1, STRESS
 STEP=1
 ITER=1
 SK10
 NU=1
 VU=1
 ZU=1
 DIST=104
 ZF=118
 MIDDLEM
 MX=20036
 MY=-30.6
 A=3313
 B=6888
 C=10003
 D=13348
 E=18693

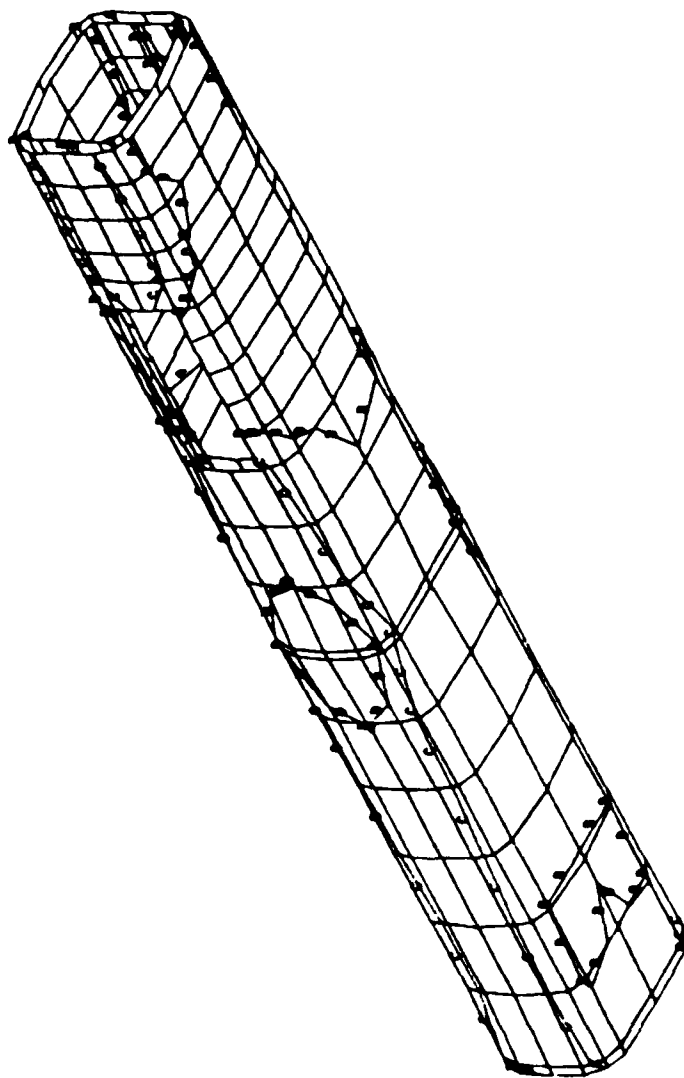


ANSYS 4.20
 JAN 13 1987
 16:42:27
 POST1, STRESS
 STEP=1
 ITER=1
 SX10
 ZOOM
 ZU=1
 1 D1S1=56.5
 2 XF=6.16
 3 VF=11.2
 4 ZF=116
 5
 6 COME=40
 7 VETO=1.48
 8
 9 HIDDEN
 10 MX=20036
 11 MN=0
 12 A=3313
 13 B=6658
 14 C=10003
 15 D=13348
 16 E=16693



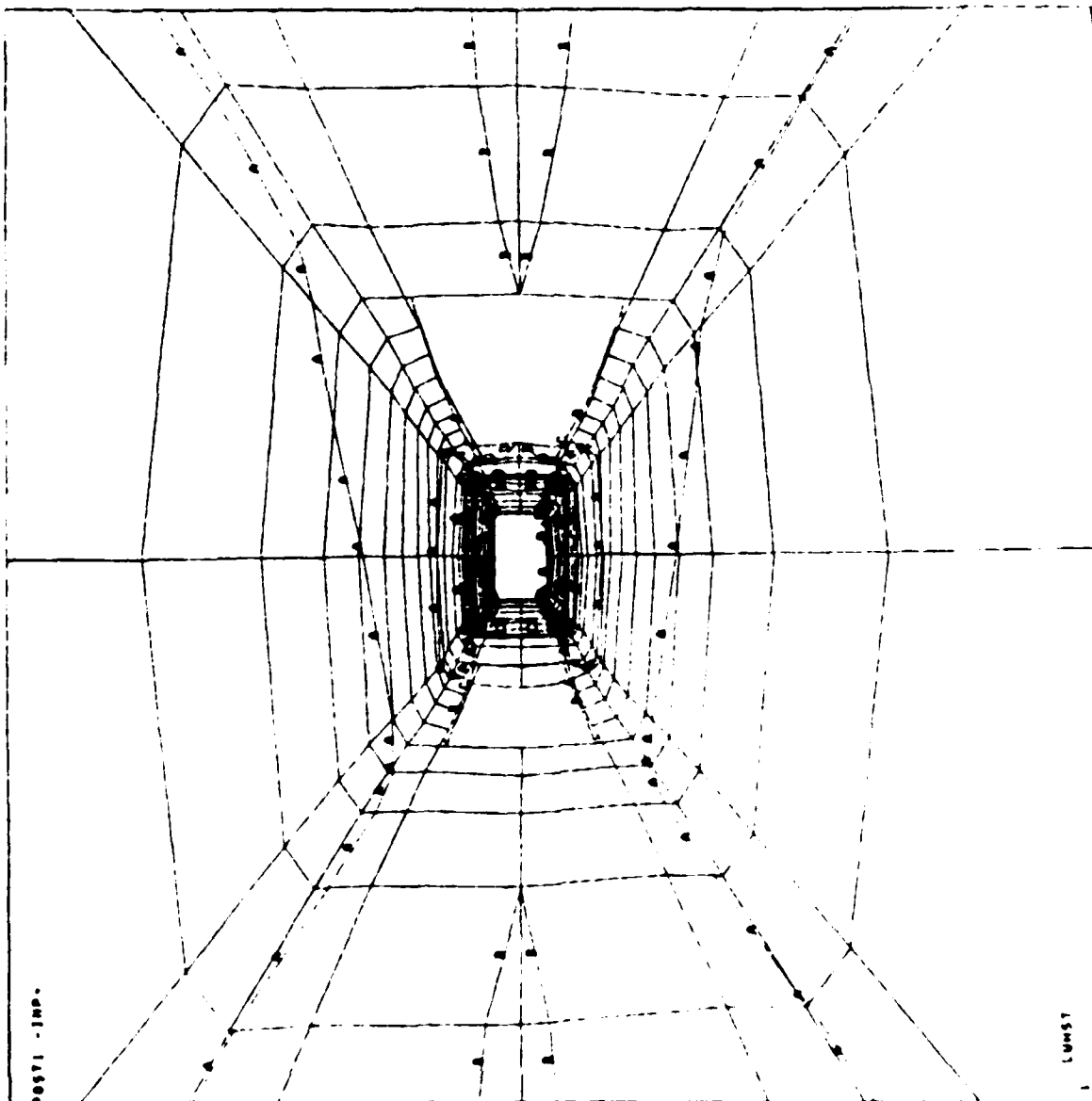
ANSYS 4.28
 JAN 13 1987
 16:24:43
 POST1 STRESS
 STEP=1
 1720=1
 8111
 XU=-1
 VU=-1
 ZU=-1
 8197=104
 26=116
 MIDDLE
 71=13424
 71=1200
 A=2244
 B=5280
 C=7216
 D=9352
 E=11388

POST1 -IMP.

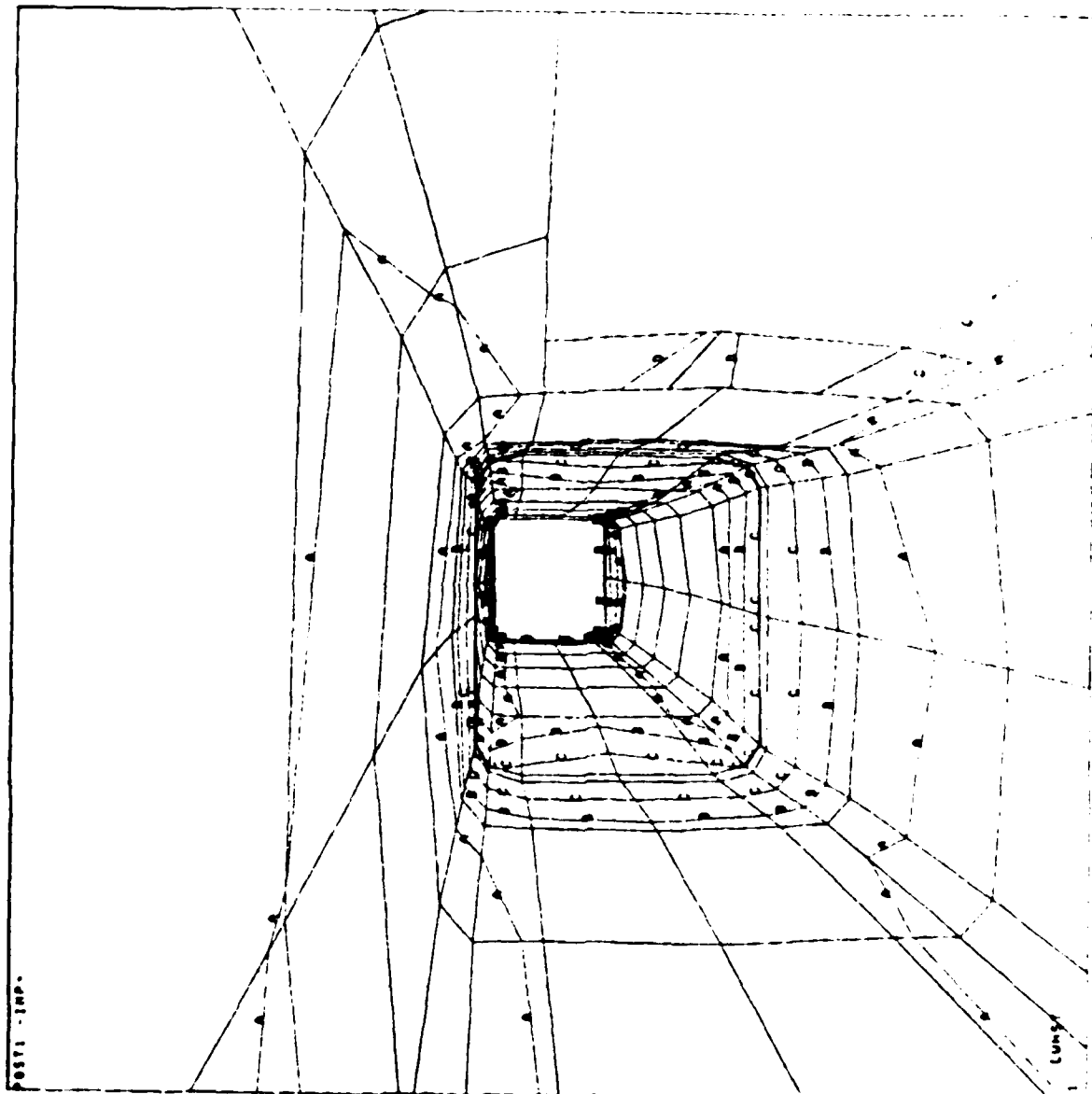


1720=1

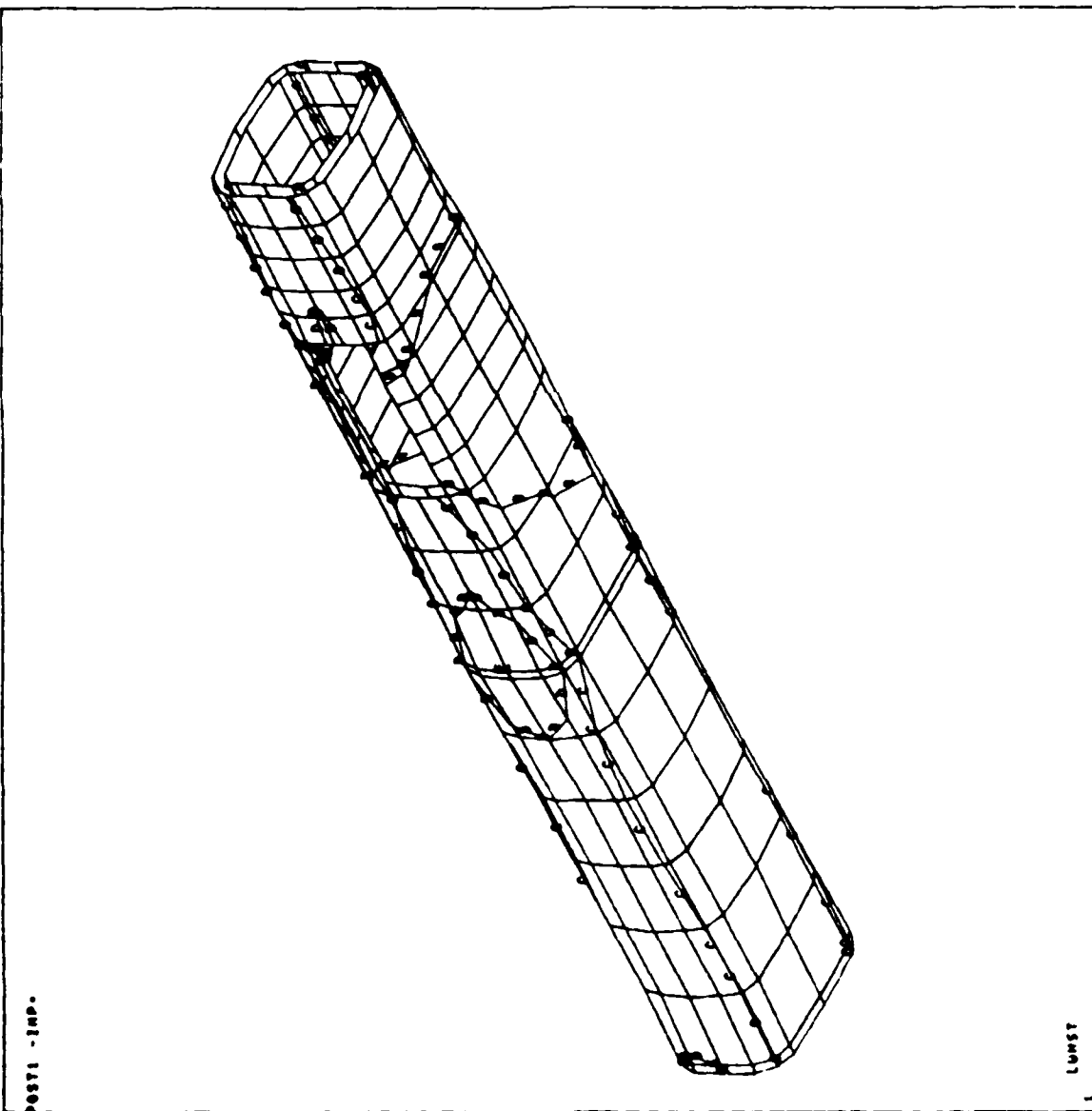
ANSYS 4.20
 JAN 13 1987
 16:39:04
 POST1 STRESS
 STEP=1
 LAYER=1
 SALL
 20:1
 8 3157-127
 1 26-116
 CONE=40
 HIDDEN
 MX=13424
 MY=0
 A=3244
 B=5200
 C=7316
 D=8352
 E=11388



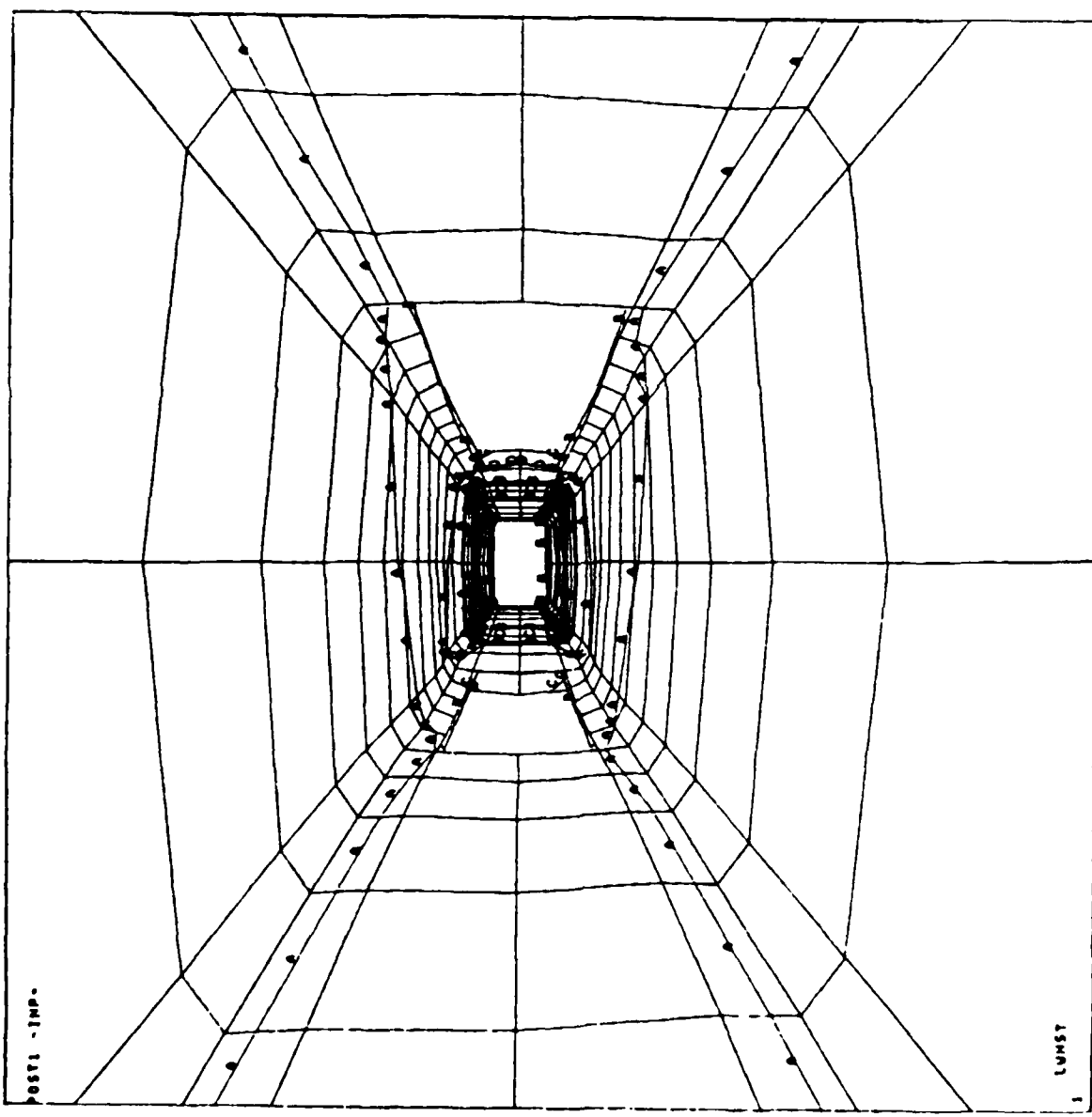
ANSYS 4.28
 JAN 13 1987
 16:39:04
 POST1 STRESS
 STEP=1
 ITER=1
 SALL
 ZOOM
 ZU=1
 DIST=55.5
 KF=6.16
 VF=11.2
 ZF=116
 CONE=40
 VRTO=1.48
 MIDDLE
 RX=13424
 RM=0
 A=3244
 B=5280
 C=7316
 D=9352
 E=11380



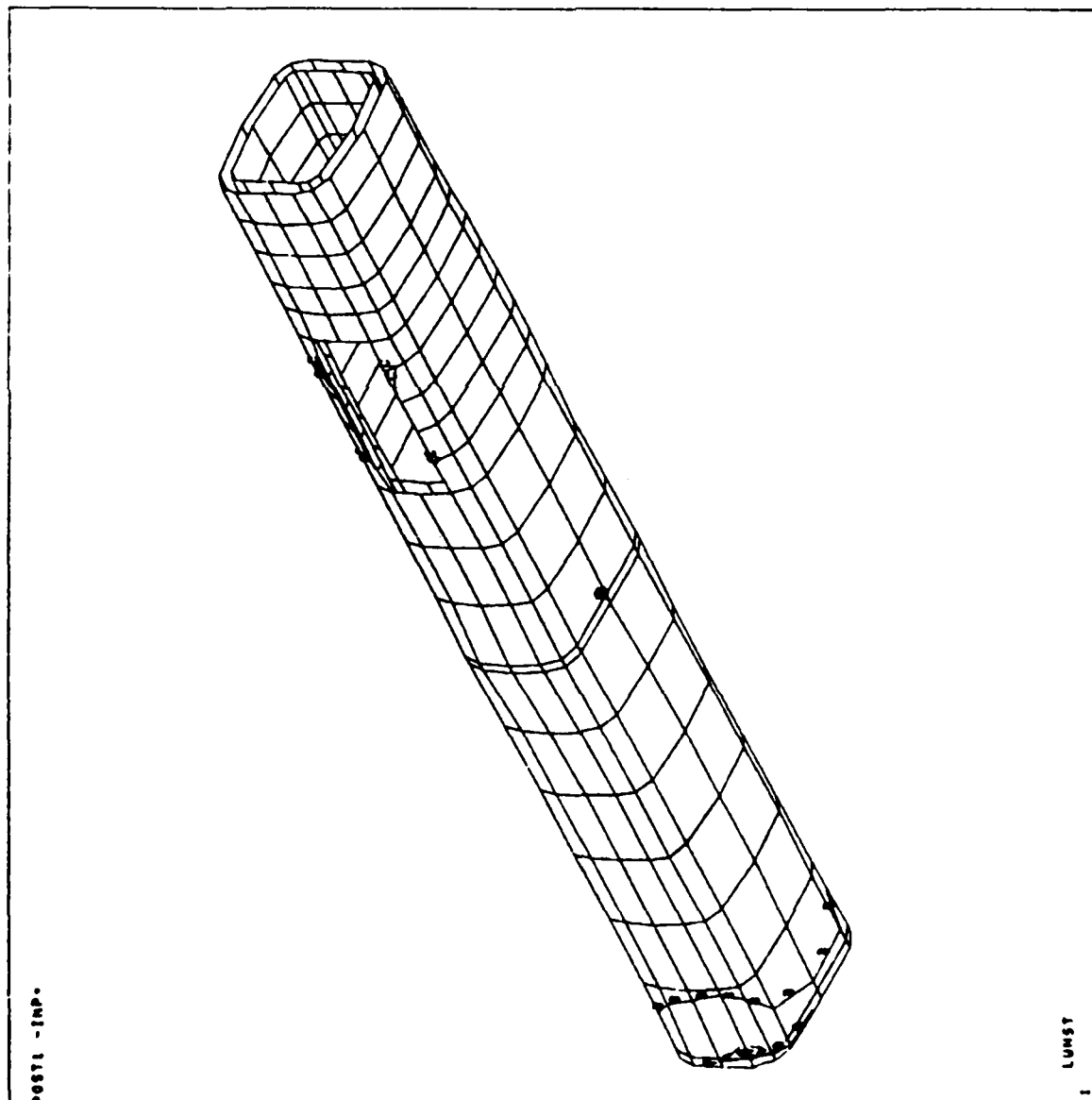
ANSYS 4.28
 JAN 13 1987
 16:26:50
 POST1 STRESS
 STEP=1
 ITER=1
 SN12
 NU=-1
 VU=-1
 ZU=1
 B157-104
 ZF-116
 M1000
 MM-13102
 MM-1002
 A-2078
 D-5095
 C-7112
 D-9129
 E-11146



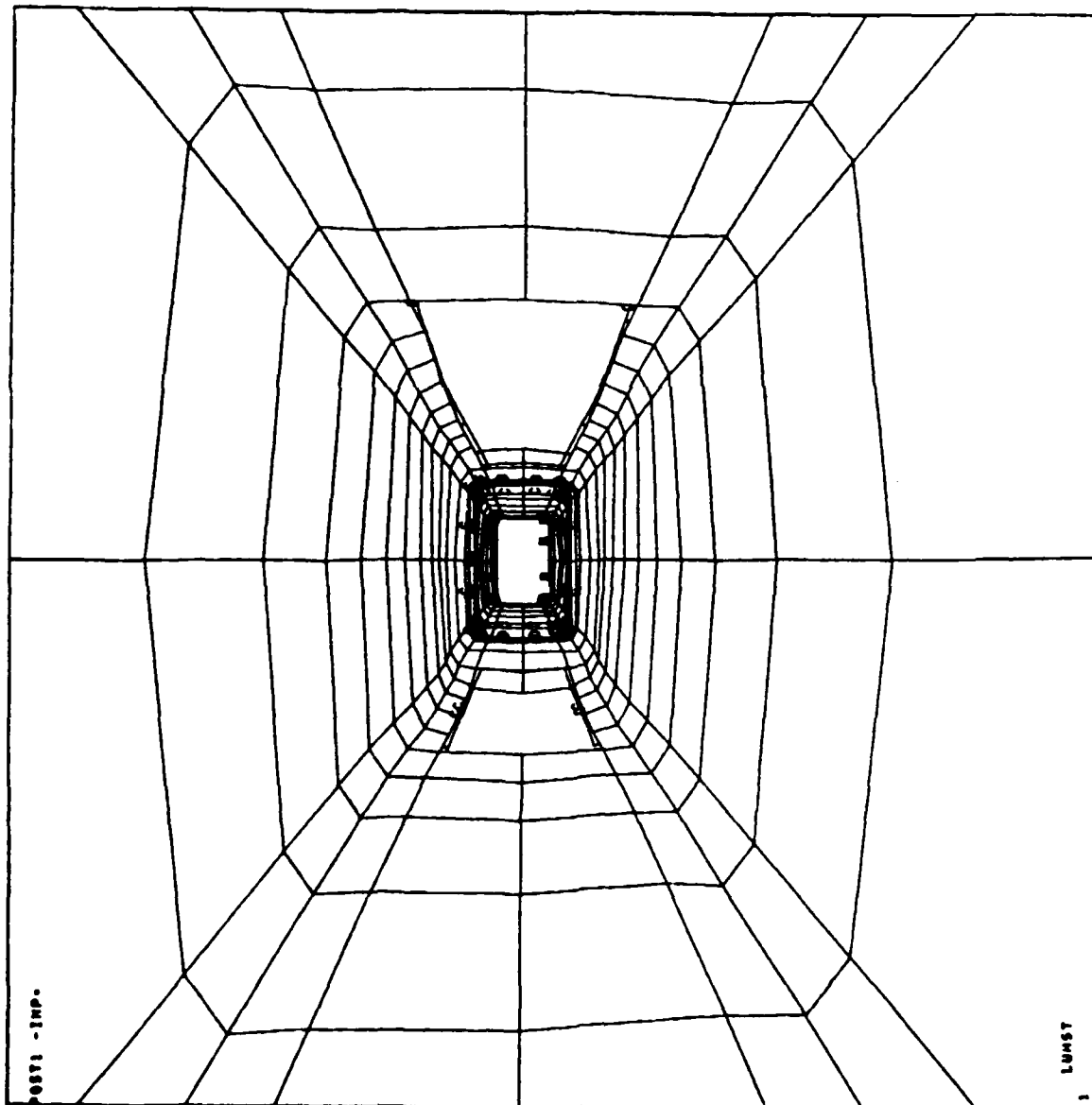
ANSYS 4.20
 JAN 13 1987
 161371.31
 POST1 STRESS
 STEP=1
 ITER=1
 SX12
 ZU=1
 1 DIST=127
 2 ZF=116
 3 COME=40
 4 MIDDEN
 5 RN=13162
 6 RN=0
 7 A=2078
 8 B=5095
 9 C=7112
 10 D=9129
 11 E=11146



ANSYS 4.20
 JAN 13 1987
 16130101
 POST1 STRESS
 STEP=1
 ITER=1
 SKI3
 KU=-1
 VU=-1
 ZV=1
 DIST=104
 ZF=116
 MIDDEN
 MX=18549
 MY=-3040
 A=-440
 B=2151
 C=4751
 D=7351
 E=9951



ANSYS 4.20
 JAN 13 1987
 16135117
 POST1 STRESS
 STEP=1
 ITER=1
 SX13
 20-1
 8 DIST-187
 8 2F-118
 8 CONE-40
 MIDDLE
 MX-18540
 MM-3048
 A--448
 B-8151
 C-4751
 D-7351
 E-9851



D3/140

CEL MEMO: DECEMBER 22, 1986

2

FMC Central Engineering Laboratories
Santa Clara

Interoffice

To L. Libhardt**

Date Dec. 22, 1986

From C. R. Ortloff

cc E. Thuse
R. Kazares
A. Amberg
R. Rathe
E. Alexander
B. Zierwick

Subject REQUEST FOR INFORMATION: DESCRIPTION OF
THE FINITE ELEMENT MODEL(S) - LWHD PROGRAM
& FURTHER INFORMATION OF THERMAL & MOISTURE
STRESS LOADS

**one copy of original
figures only
264-269

Shown in figures 264-269** is the total system model used for dynamic studies and stress analysis. This information was requested by L. Libhardt on 19 Dec 86 for purposes of having presentation materials available for ARDEC presentations on finite element analysis by NOD staff.

The ANSYS model (3400 elements) consists of rectangular STIF 43 elements and triangular STIF 48 elements for the gimbal and platform structure (Figure 265). A separate file was made for the gimbal so that it could be added to the platform file in rotated positions (representing the 22.5° off-axis rotation cases). Appropriate density values and material properties for Ti are specified for platform, gimbal and spade.

Representations of trailing arms are made in the form of a foam core sandwich upper plate (9 Gr/Ep lamina [0/45/-45/90/0/90/-45/45/0]) over a 2-inch Rohacell core with a metal matrix truss structure (Al/SiC) and Ti bulkhead reinforcing plates (after the Concept 3 Trail Drawing, 10/29/86 and 11/12/86, D. Langerud). ANSYS STIF 53 elements were used for the composite part of the trail structure. The section properties of the hollow cross-section beams were input together with appropriate materials and geometry properties. Since I have had no update on details of this part, I am using the most current model. The trail ends (toward the platform) are connected to nodes on the platform. A STIF 4 beam representation of the cradle is next input into the model and connected to the appropriate lower gimbal mount points. This beam model is made rigid (no attempt is made to model the cradle X, Y, Z, ROTX, ROTY, ROTZ stiffnesses) and the appropriate mass distribution and rotational moment of inertia is duplicated. The CG location of the cradle is duplicated approximately also. Beam elements (STIF 4) or STIF 10 cable elements are used to model the cable attachment to the gimbal. This latter element has a bilinear stiffness matrix, i.e., the stiffness is made zero if the element goes into compression. No bending or torsional stiffness is associated with this element. For

L h m n ?

*Figures are numbered consecutively in sequent memos to avoid reference difficulties when referring to figures in different memos.

Libhardt
Memo

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Page 2

cases for which the STIF 4 element is used, EI is made small to duplicate the negligible bending stiffness of the cable. Reference to ANSYS Manual, V. 1, 4.10.1-4 provides a description of this element. This latter element is incorporated into later dynamic runs.

The upper and lower shaft arrangement is shown in figures 267 to 269. Beam elements (STIF 4) with appropriate geometry, inertia and materials properties are input for upper and lower shafts. Those shafts connect the gimbal to the platform. Since the STIF 4 elements have no rotational stiffness, this simulates the torque-free action of gimbal on the platform connection, i.e., no torque is transmitted through the connecting shafts between gimbal and platform.

The shafts are mounted to the appropriate gimbal and platform tabs and bearing surfaces by means of rigid beam elements so as to transmit bending and tension/compression loads. These loads are converted to shaft stresses by means of methods described in the ANSYS Manual, V. 1, 4.4.1-5. A lower connecting beam from the shaft bottom provides additional support to prevent Y translation of the lower shaft. A further beam is attached between gimbal and platform (Sketch L. Libhardt to CRO 11/15/86) to prevent relative gimbal/platform rotation about the shafts under load cases for which torque is transmitted to the gimbal. The FE models are sufficiently detailed to use as design tools for component stress analysis. Use of a smaller number of elements in a "simplified" model for this complex assembly will give erroneous global stiffness values for all components and thereby misrepresent the dynamic motion and concomitant stress states. (Note the tab detail in figure 267, for example). For metal parts, SIGE stresses are sufficient on the outer surface. For composite parts, STRESS commands up to level 3 must be issued before the SET command to store lamina stress data.

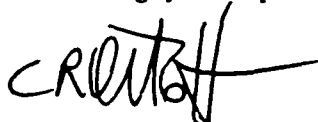
Use of /PREP6 preprocessor methodology is employed to construct the impulse force vs. time curves representing proof load recoil and firing torque loads. This .F23 file is edited to the .F27 file and run as a restart to obtain dynamic motion of the system. Output from the 30 CPU hour run consists of dynamic motion history of some 200 key Master Degree of Freedom points throughout the structure. At appropriate peaks of these curves, a stress pass can be performed to get a stress "snapshot" at any time of the entire structure (see for example, memo CRO to L. Libhardt, 12/17/86). Use of Linear Transient Dynamic Methods (KAN,5) are employed (V. 1, ANSYS Manual) to obtain a solution. Integration time steps of 0.001 sec. are used together with ramped loading between time steps to avoid numerical instabilities connected with the zero stiffness (under compression) cable elements. Use of coupling equations in all degrees of freedom

L. Libhardt
Memo

4
Dec. 22, 1986
Page 3

(except X rotation) at the cradle end-gimbal mount is made to allow for relative rotation of the cradle at these bearing points. (You may wish to rigidly pin this joint at some later time to prevent cable creep and dynamic stress effects typical of Kevlar cables under dynamic load. This will prevent resetting of the firing angles between shots and improve gun pointing accuracy). For off-axis firing, a local coordinate system is used for the combined gimbal-cradle system so as to input both firing torques and constraint/coupling equations correctly. The system is loaded with lg at all times during analysis time steps to provide a "restoring force" to the structure. The spades are pinned at their lower edge and have UY=0 constraints on the bottom horizontal surface at nodes between the vertical spade separator plates. The trail ends are not fixed. Use of UX=0 constraints on these separator plates is also made for the 22.5-0, 22.5-72 firing cases to limit side thrust travel on the spades and model the plate stress distributions correctly. Postprocessing of the computer solution is made with /POST1 and /POST26 routines.

Preliminary runs have been made with CMAP to estimate the thermal expansion and moisture loads on a typical [0/45/-45/90/-45/45/0] Gr/Ep composite face sheet for AS-3501/5 for 2% moisture and a temperature difference of 100°F (hot, wet conditions). Stresses as high as 15 ksi may be encountered in the 90° layers. These values are to be superimposed upon load induced stresses (Memo, CRO to J. Ries, 12/8/86). Although the CMAP results are preliminary (and will be updated by a further ANSYS cradle analysis with those effects included, they indicate additional problems for the original cradle design. It is suggested that in light of the dynamic amplification factor of 1 to 1.5 and the additional thermal expansion and moisture stresses (plus a not unreasonable safety factor of 1.5 to allow for manufacturing errors and defects plus residual curing stresses) that a redesign be considered along the lines suggested in the memo (CRO to R. Rathe, 12/8/86) if filament winding is to be retained. If a woven roving design is to be used, please forward your redesign to me at your earliest convenience so that I may modify my model accordingly and perform analyses. *



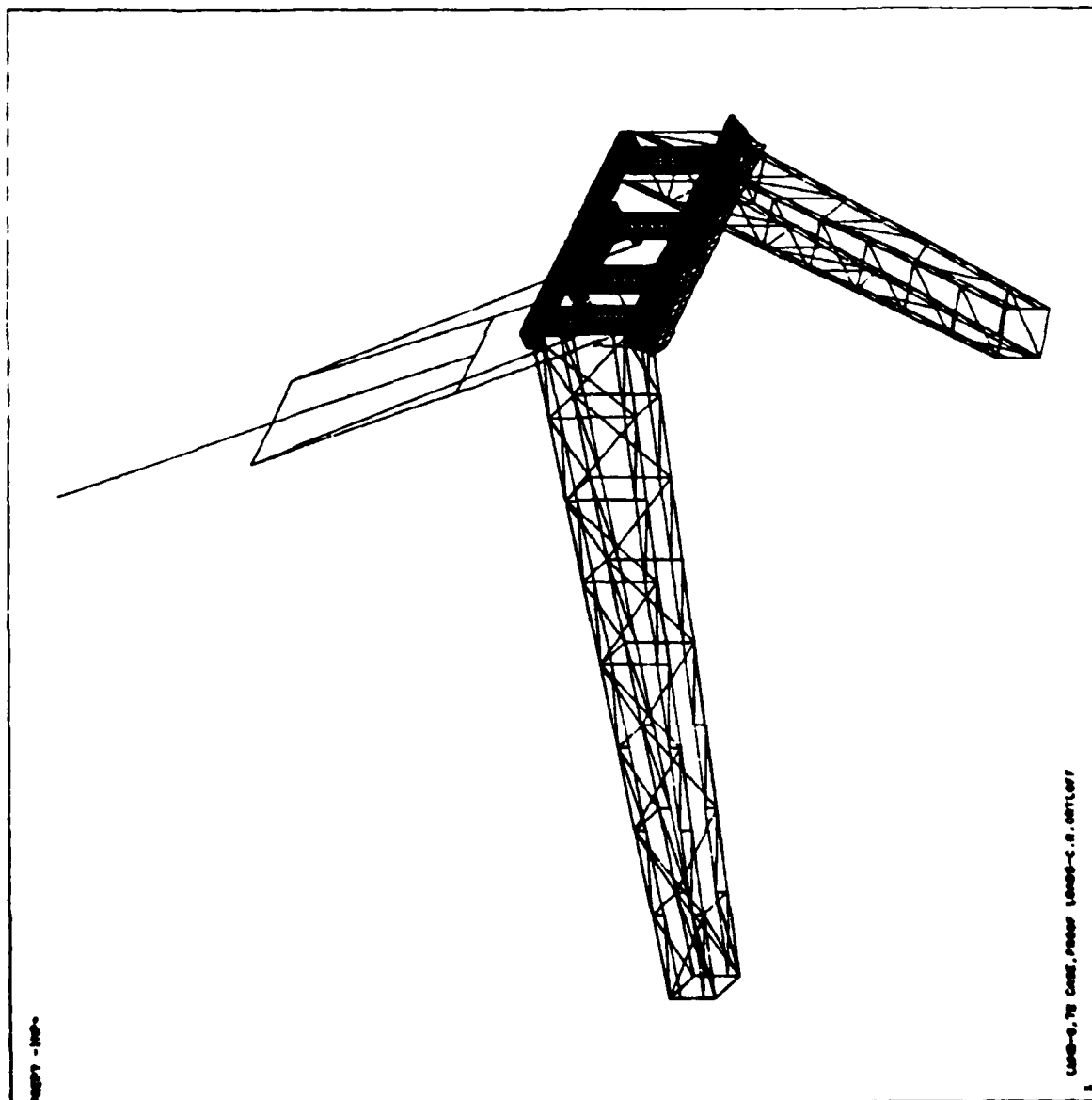
C. R. Ortloff

The 0°-72° case has been postprocessed and will be sent to Larry Libhardt on December 29.

001000 4.00
 DEC 8 1996
 15118121
 PRCPT ELEMENTS

RU--1
 WU--1
 ZU--1
 DIS-270
 M-24.1
 W-120
 ZV--134
 MTO-1.37
 VTO-1.17

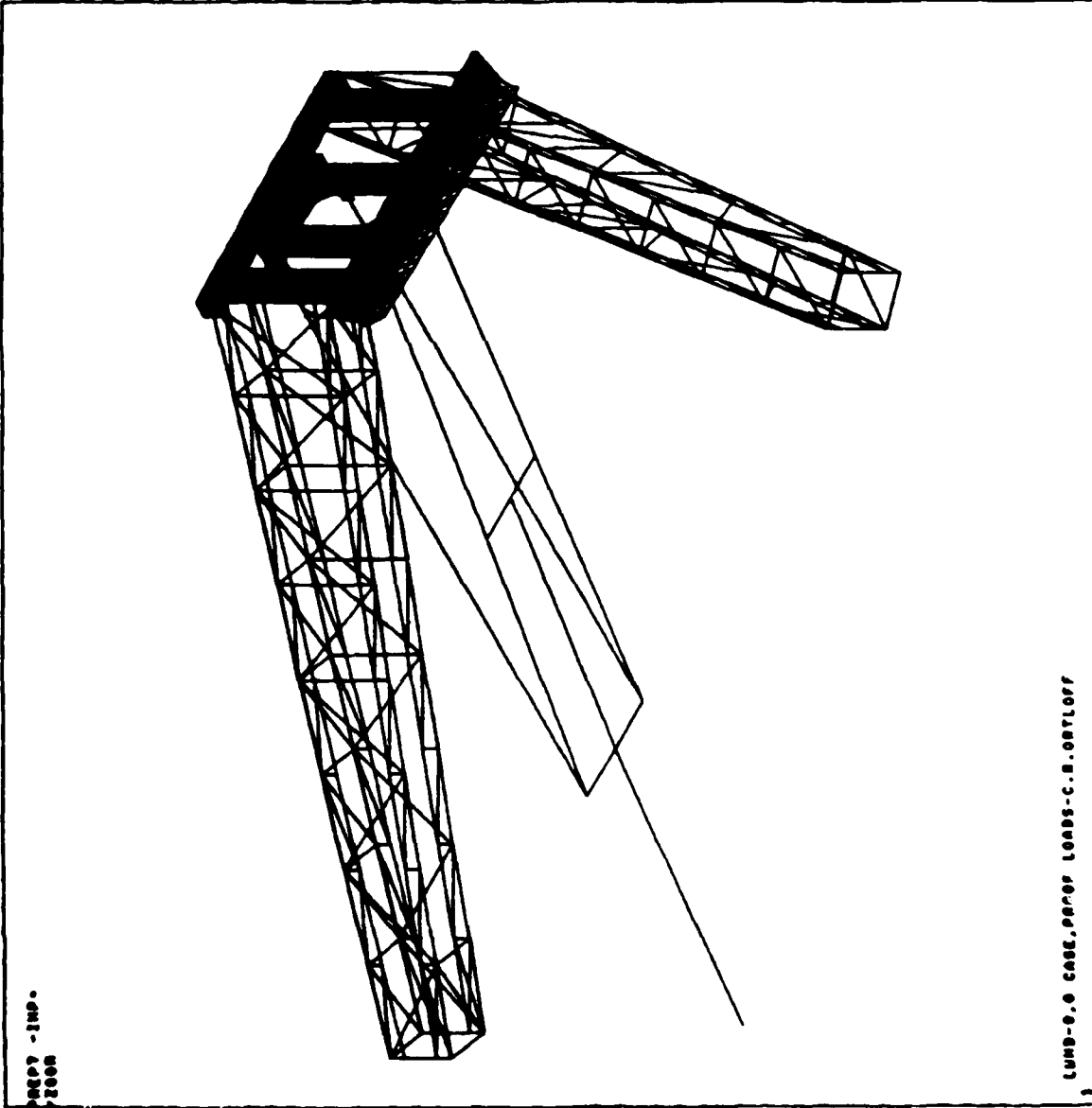
0,72° case-



0000 4.20
 DEC 5 1988
 10120104
 PREP7 ELEMENTS

20--1
 20--1
 20--1
 20--1
 20--1
 20--1
 20--1

0°-0° CASE

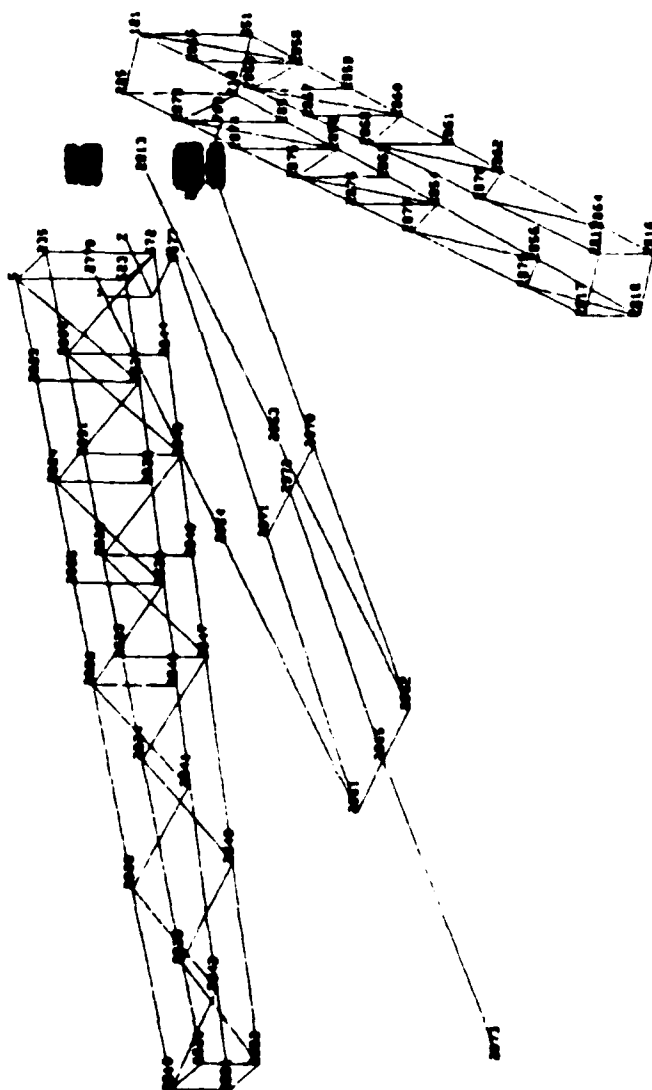


0000 4.20
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 10120104
 PREP7 ELEMENTS

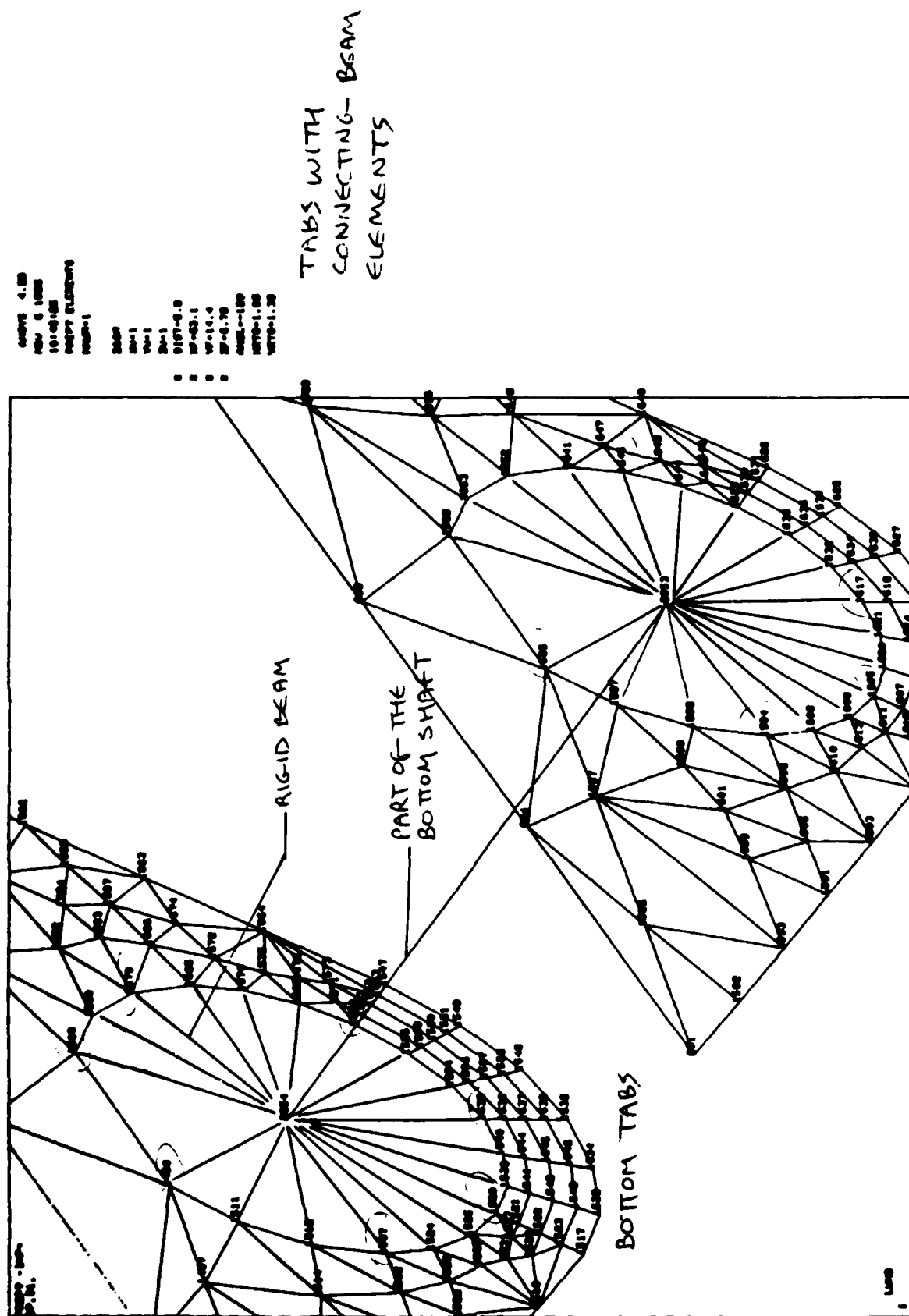
0000 4.20

三、

BEAM REPRESENTATIONS
OF CRADLE AND TRAILS
(TRAILS CONTAIN
COMPOSITE STIFF
ELEMENTS ON TOP FACE)
0° - 0° CASE



LEAD-0,0 CASE, PAPER LEADS-C. B. OFFICE



10000 4.00
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 10000 22.6000
 10000 25.7000
 10000 28.8000
 10000 31.9000
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 10000 84.6000
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D3/150

CEL MEMO: DECEMBER 29, 1986

FMC Central Engineering Laboratories
Santa Clara

Interoffice

To Larry Libhardt Date Dec. 29, 1986

From C. R. Ortloff cc E. Thuse
A. Amberg
R. Kazares
J. Ries
R. Rathe
E. Alexander
B. Zierwick

Subject STRESS RESULTS FOR THE 0° ROTATION,
72° ELEVATION LWHD CONFIGURATION (GIMBAL,
PLATFORM SPADE, TRAILS) UNDER PROOF LOADS.
(114 FIGURES ATTACHED)

Attached are figures 270-384 showing dynamic deflection histories at MDOF nodes on the LWHD structure. Locations of many of these MDOF points have been previously given (Memo: CRO to L. Libhardt, 17 Dec 86). Boundary conditions for these runs are those of a fixed lower spade edge and UY=0 on the horizontal plate resting on the ground (hard ground emplacement assumption). The cradle is free to rotate about its gimbal mount point in the (vector) x-direction with only the cable providing a restraint against rotation. The model has been described in detail in a prior memo (Memo: CRO to L. Libhardt, 22 Dec 86).

Scales of figures 271-273, 275-277 and 281-288 should be normalized to zero deflection at zero time. The deflection scale normalization is necessary due to the fact that separate files (and coordinate systems) were appended to the cradle/gimbal file to form the total system model.

Figures 271-273 show a deflection-time history for a node (N 2915) on the cable (figure 270). The cable has a small EI value to insure its flexibility; this will produce a conservative deflection effect as the cable is not allowed to contribute any resistance to compressive bending effects along its length. The modulus is correctly chosen, however, to account for stretching effects under tension loads. Results indicate about a maximum of 0.5 inch UZ deflection (global coordinates), a maximum of 0.65 inch UY deflection and a maximum 0.07 inch UX deflection under load indicating that the cable/cradle system is stable for times between 0 and 1 second (the calculation time range). Since the masses of the cradle and cables are duplicated as well as the rotary moment of inertia of the cradle, the dynamic motion of the cradle/cable system can (at least) be estimated. Since the stiffness matrix of the cradle has not been exactly duplicated in the current FE model, the bending, twisting and compression effects of the cradle on the cable motion are not exact. Use of beam elements (figure 270) with high rigidity comprise the cradle and allow for limited flexibility in all coordinate directions. In final analysis, the cable/cradle system appears stable during and after firing and torque loads have been applied with the current approximate representation of the cradle/cable.

Figure 274 represents the UY (vertical) deflection of a node on the trails (see figure 270). This part has been modeled after the 12

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Nov 86 drawing. As of 28 Dec 86 no drawings have been received of the trails to permit an upgrade in the FE model over the version described in the Memo: CRO to L. Libhardt, 22 Dec 86. Deflection in the UY direction indicates about a 0.25 inch "springback" liftoff of the trail and subsequent relaxation to a rest position, i.e., trail motion is stable under 0°-72° firing loads. Note that "rest" deflection asymptotes in all figures reflect the 1g gravity load static deflection.

gun w → Figures 275-277 show the motion of N2976 on the cable (figure 270). In general, the same conclusions regarding the cable motion and its stability can be drawn from these figures as for those discussed earlier. Figure 278 and 279 represent further trail MDOF nodes. The deflection stability at these nodes can be seen from the figures. Figures 287-288 represent the motion of the gun barrel tip. Again, the stiffness matrix of the cradle represented by near rigid beam elements only estimates cradle bending and deflection effects approximately but does allow for its "rigid body" motion due to the correct representation of mass and rotary inertia effects. The gun barrel tip motion is therefore only approximate. Also, the barrel moves in the Z direction with time, further rendering the estimates for barrel tip motion less valid with increasing time. Nevertheless, the estimates provided give an indication of stability of the system under dynamic firing loads. As can be seen from these figures, maximum vertical deflection of the barrel tip appears to be about 2 inches while maximum X deflection is about 0.5 inches. While most oscillations are sufficiently damped after one second using DAMP=0.2%, an upgrade on the Kevlar cable damping values will provide further detailed information on the effect of the cable on system stability. Better representation of the dynamics of the cradle/cable system await final design decisions on the redesign of the original cradle configuration in order to represent its stiffness matrix more correctly. Estimates of the motion of the barrel tip, with approximate representations of the dynamic properties of the cradle/cable system, nevertheless reveal a stable system with acceptable barrel travel dynamics. Presumably, the redesign of the cradle will be slanted toward a stiffer system than presently exists rendering the current approximate FE model of the cradle closer to the next design stage.

The remaining figures detail dynamic deflection histories for MDOFs on the platform/gimbal system. Locations of many of these nodes are detailed in the Memo: CRO to L. Libhardt, 22 Dec 86. The dynamic deflections are generally less than 1.0 inches in all (global) coordinate directions. From these figures, times at which maximum

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dynamic deflection amplifications exist (here chosen as 0.046, 0.031 and 0.258 sec.) correspond to maximum stress states in the gimbal and platform.

For the 0.046 second case, figures 307-331 give Von Mises equivalent stress results on the outside Ti surfaces of the gimbal and platform. Results are summarized below.

- o Zones around the shaft connection openings in the gimbal fail locally as stresses exceed 80 ksi. This holds true for the two openings on the top box beam as well as the two bottom box beam elements. This type of local failure was also observed for the 0°-0° case (Memo CRO to L. Libhardt, 17 Dec 86) under proof loads. These zones can be easily reinforced with weld-on or bolt-on plates around the gimbal shaft openings.
- o The lower gimbal-cradle attachment arms have local stresses exceeding yield stress (figure 310 for example). The reinforcement weld-ons appear to fail as stresses exceed yield stress by 40 ksi. These reinforcements need to be modified significantly to sustain the 0°-72° firing loads without failure.
- o The upper gimbal-cable arms appear to be adequate to sustain firing loads (together with the gravity load).
- o Triangular reinforcing plates (figures 316-318) appear overstressed especially in the central portion of the platform. Stresses are about 80 ksi maximum (figure 316) and indicate local yielding is probable.
- o Stresses in both top and bottom platform shaft tabs (figures 319, 320) appear to be sufficiently low to not fail under load.
- o Stresses in the upper box beam of the platform are very close to yield stress for Ti (figure 324). The upper box beam needs to be reinforced (additional thickness is sufficient) to lower these values. The presence of a welded box beam structure introduces the need for a reasonable safety factor to account for weld defects and the concomitant local stress concentration factors.
- o Maximum bottom shaft stress is 29800 psi at Node 3388 from figures 329-330.
- o Top shaft stress is about 40 ksi.

Results at 0.258 second are as follows:

- o Stresses in the top gimbal to cradle arms again exceed yield

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stress (similar to results from the 0.046 sec case). (See figure 342, 348 for example.) These upper arms need to be reinforced as well as the local connecting structure (figure 349, 350 for example) on the gimbal.

- o Global vertical UY deflection of the gimbal appears large (figure 360) in the region of the lower arms corroborating the high stress values in these zones. Remaining UZ and UX deflections are small.
- o Bottom shaft stress is about 10 ksi, top shaft stress is about 40 ksi (figures 366-377).

Results from the 0.031 second run are as follows:

- o Stresses for both upper and lower gimbal arms exceed yield stress under proof loads (figure 376 for example). These arms need reinforcement as indicated by this and the prior two time cases.
- o The gimbal upper and lower box beam shaft openings similarly exceed yield stresses and need reinforcement (see figure 376 for example). Without reinforcement in these zones, gimbal failure is imminent as yield stresses are exceeded by as much as 20-40 ksi (see figure 378 for example).
- o Bottom shaft stress is about 21 ksi; top shaft stress is about 40 ksi (see figures 381-382).

General conclusions for the 0°-72° load case:

- o The upper and lower gimbal arms appear to fail under dynamic load as stresses can exceed yield stress by 20-40 ksi.
- o The gimbal shaft openings for both upper and lower box beams fail locally around the opening zone. Local reinforcement in the form of weld-on or bolt-on box beams is required to prevent part failure.
- o In general, both platform and gimbal in regions away from local failure zones exhibit stresses that can be as high as half of the yield stress. In that a welded box beam Ti structure is used for both platform and gimbal, a reasonable safety factor must be used to allow for weld defects causing local stress concentrations.

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- o The total system appears stable under firing loads and no overturning or "gun whip" excursions appear to exist. The cable seems to induce vibrational (rigid body) oscillations into the cradle (figures 271-273 for example) which may be very damaging to gun pointing accuracy if the oscillations are not sufficiently damped before the next firing.
- o Shaft stress for all times indicated are less than 40 ksi.

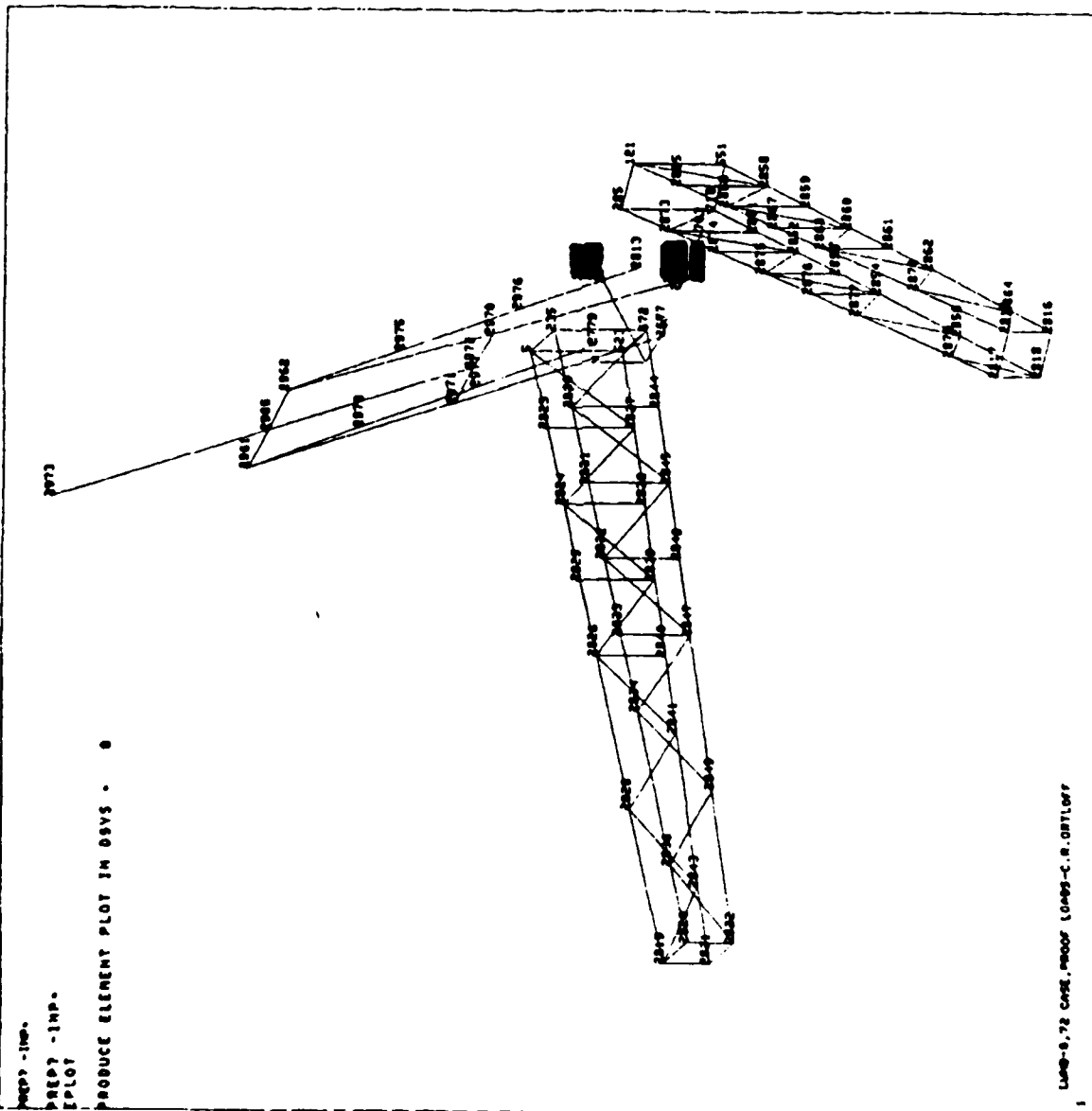
Results of the 0°-72° case confirm some prior findings of the 0°-0° case (Memo: CRO to L. Libhardt, 22 Dec 86) in that reinforcement of the gimbal upper and lower shaft attachment zones is called for to reduce local stresses. The additional result for the 0°-72° case shown in the present memo is that the gimbal upper and lower arms need also to be reinforced to prevent failure. Since these changes require additional thickening and/or bolt-on plates, the current design can be modified to achieve the necessary strength margins. Since the 22.5°-72° case has also been completed, it is suggested that results from this case be examined before new structural revisions are made in order to judge the sum total of all failure zones.


C. R. Ortloff


```

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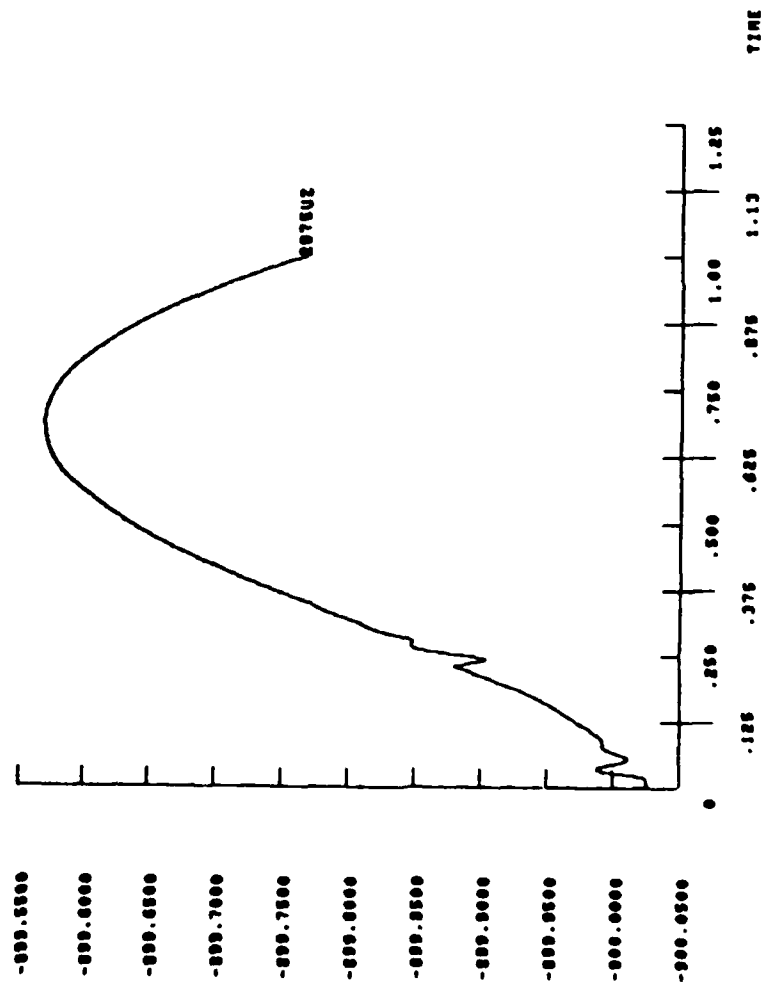
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1 LUMB-0.72 CASE, PROOF LOADS-C.B. ONTLOFF

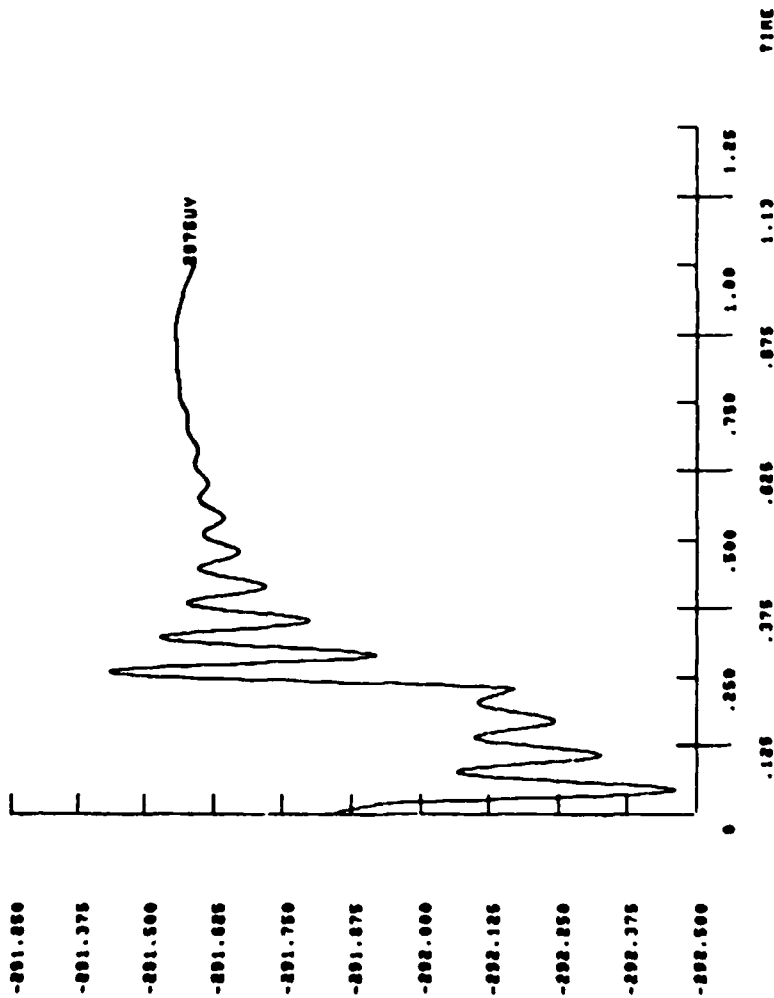
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PLOT DEFINITIONALLY
CURVE VARIABLE NAME
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*****COMPLETE FOR 1001 DATA POINTS

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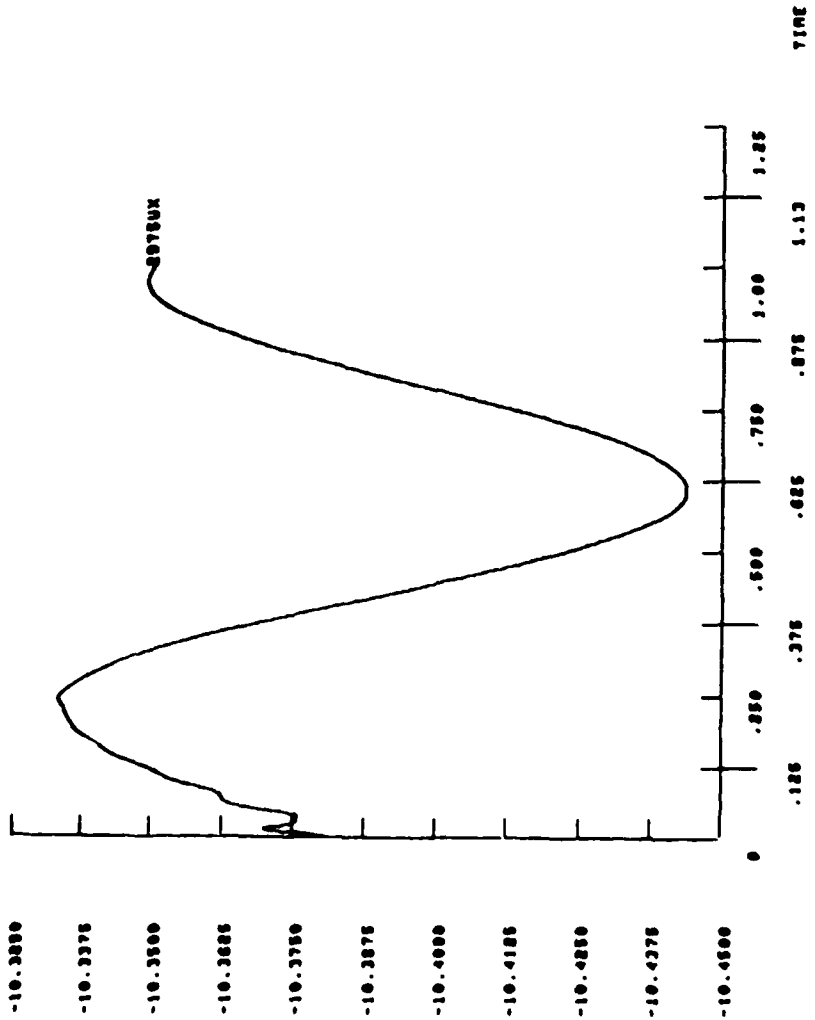
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PL0Y DEFINITIVE

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1 LUMB-0.72 CASE, PROOF LOADS-C.B.ORTLOFF

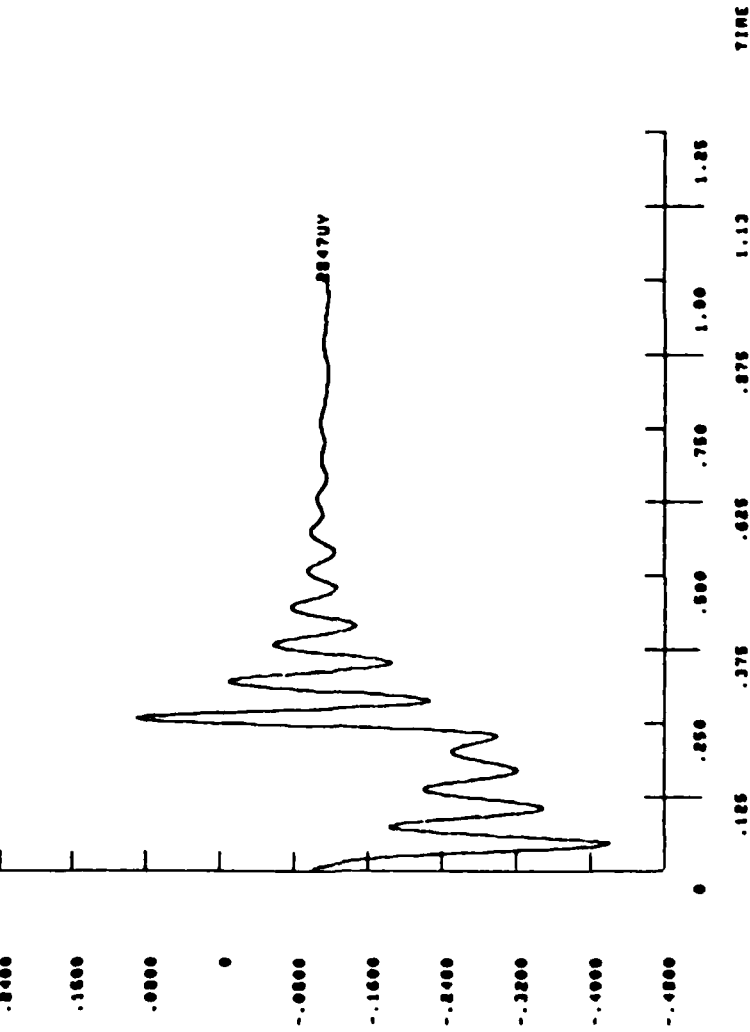
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 VARIABLE 2 IS 2847 UV PHASE REV. 0
 POSTER-IMP.
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2 0102 2847 UV 2847UV -0.4818 0.4700E-01 0.2877E-01 0.2880

PLOT DEFINITION
 CURVE VARIABLE NAME
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1 LUND-0.72 CASE, PROOF LOADS-C.R. ONTLOFF

*****COMPLETE FOR 1001 DATA POINTS

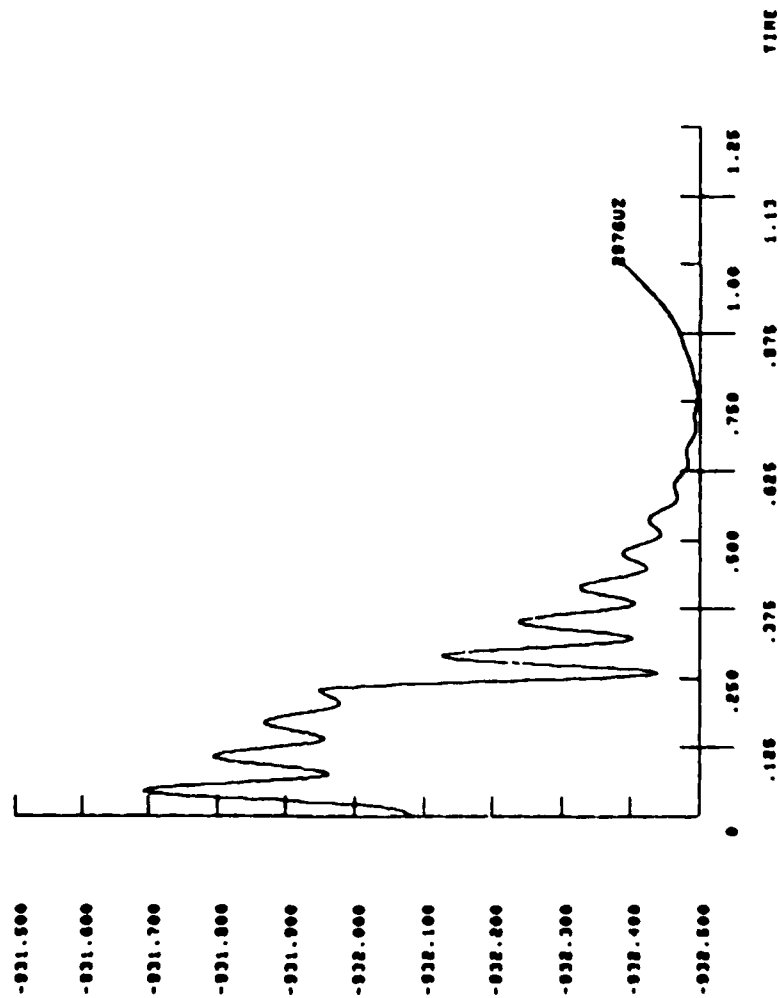
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PLOT DEFINITION

CURVE VARIABLE NAME

1 2076U2



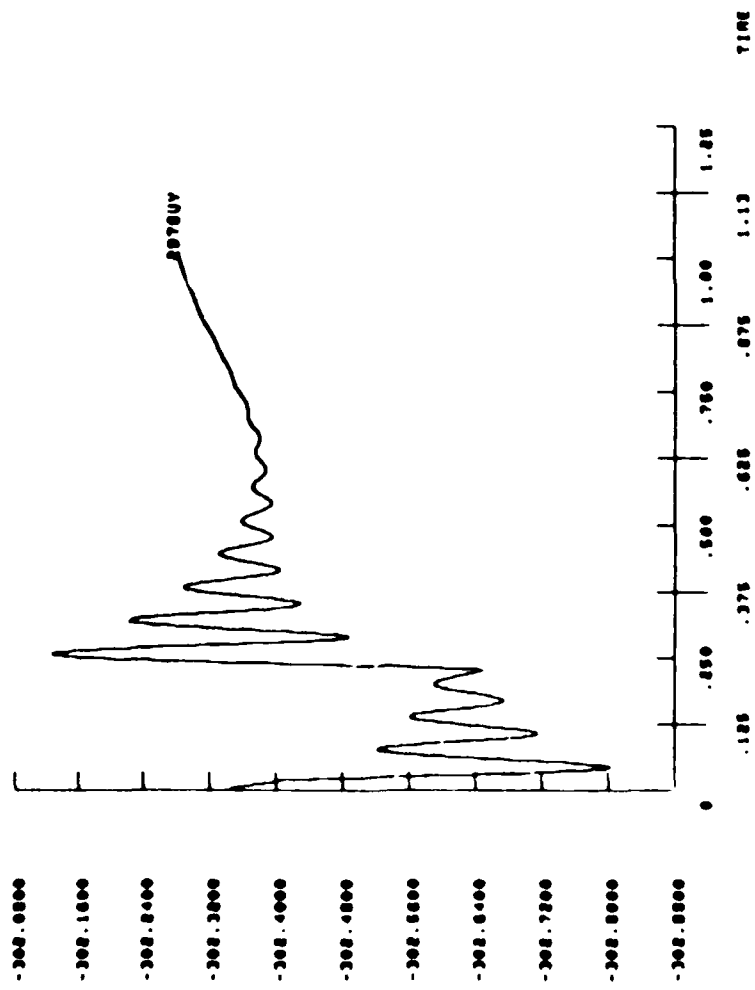
1 LUMB-0.72 CASE, PROOF LOADS-C.D. ONTLOFF

*****INCOMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
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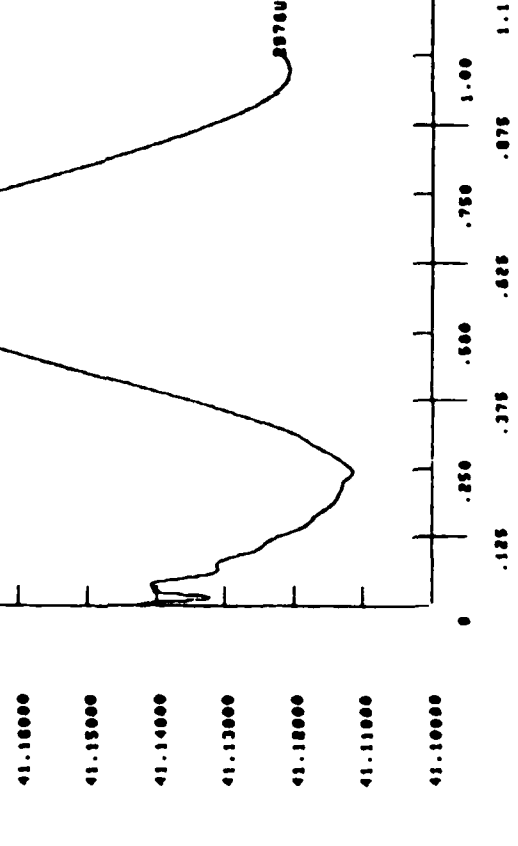
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 POST700-IMP.
 PLOT 0.2070, UN

POSTS WARNING- 0005 DIR- UN IS NOT A MASTER D.O.P.
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 POST700-IMP.
 PLOT 0

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PLOT OF VARIABLE
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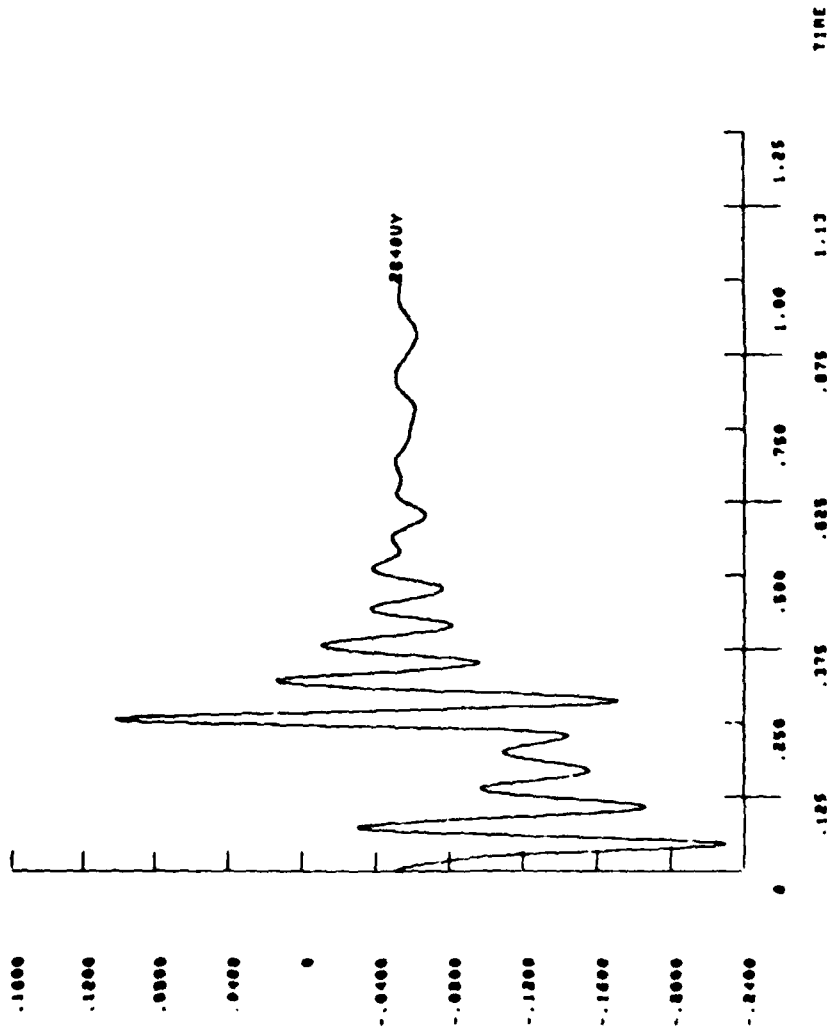


1 LUND-0.72 CASE, PROOF LOADS-C.R. OUTLOFF

*****COMPLETE FOR 1001 DATA POINTS

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PLOT DEFINITION
 CURVE VARIABLE NAME
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1 LUMB-0.72 CASE, PROOF LOADS-C.B. ONTLOFF

INCOMPLETE FOR 1001 DATA POINTS

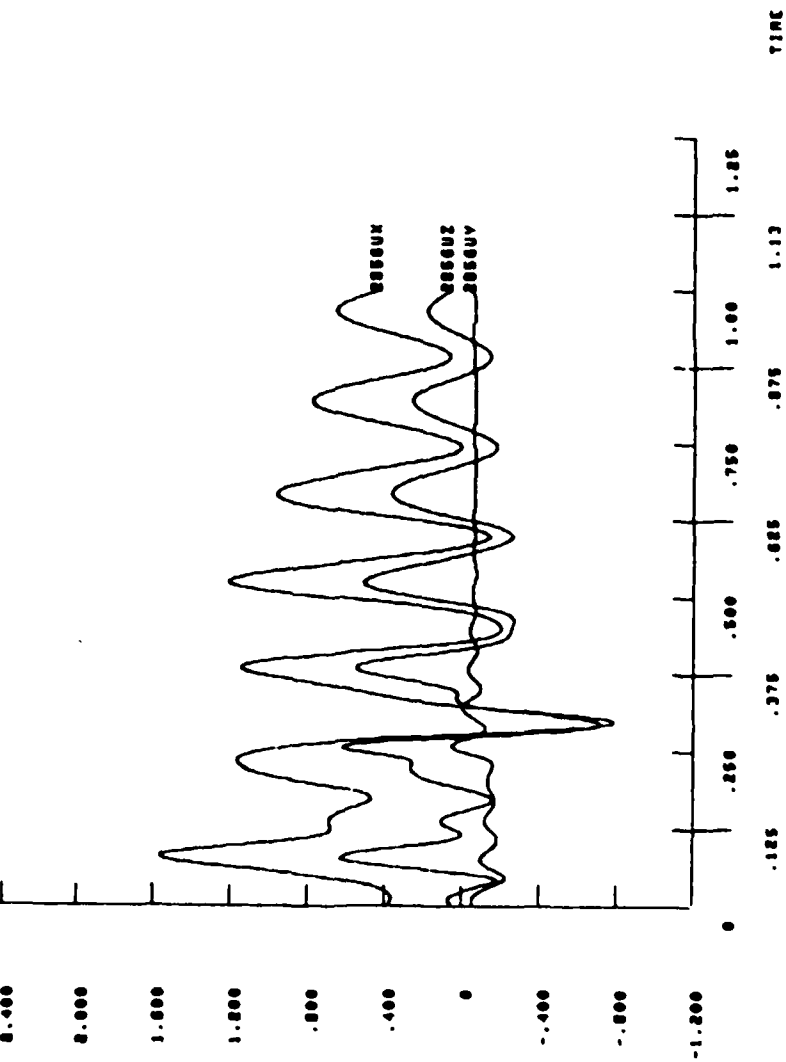
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2	DISP	205W	UY	2050UY	-0.2800	0.4000E-01	0.0000E-01	0.2500
3	DISP	206W	UZ	2050UZ	-0.7100	0.2000	0.0000	0.7000E-01

PLOT DEFINITION

SUBJECT VARIABLE

NAME
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2050UY
2050UZ



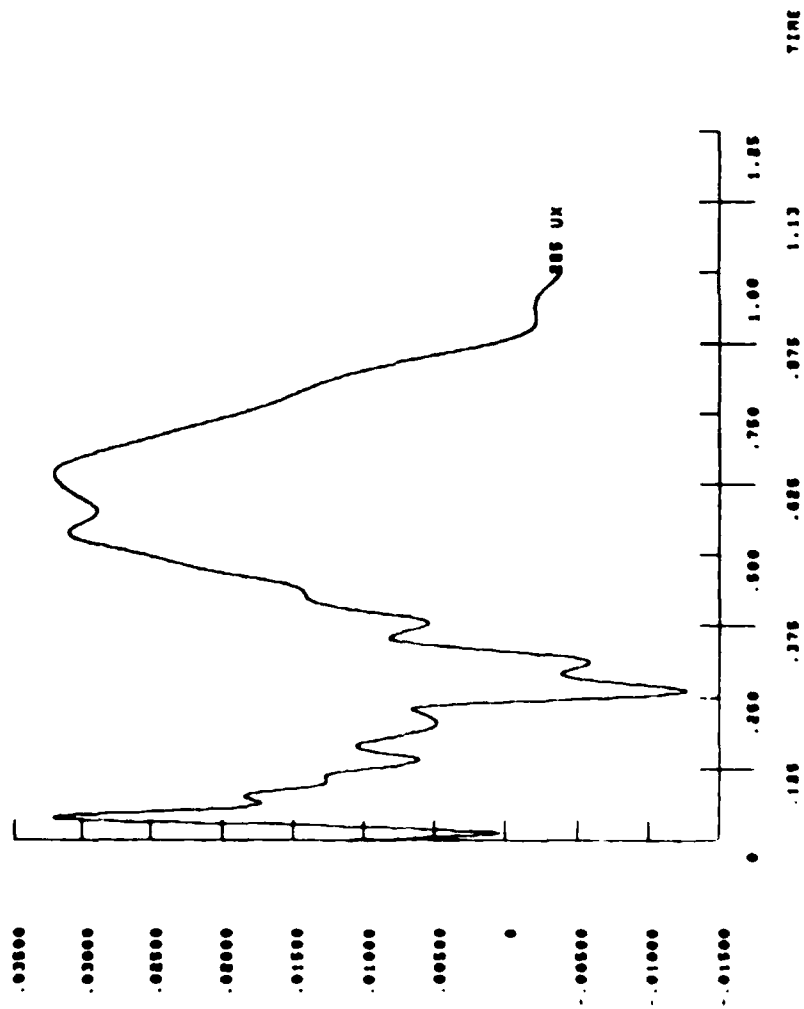
1 LUND-9.72 CASE, PROOF LOADS-C.R. ONTLOFF

*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 LAST TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME

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PLOT DEFINITION
 CURVE VARIABLE NAME
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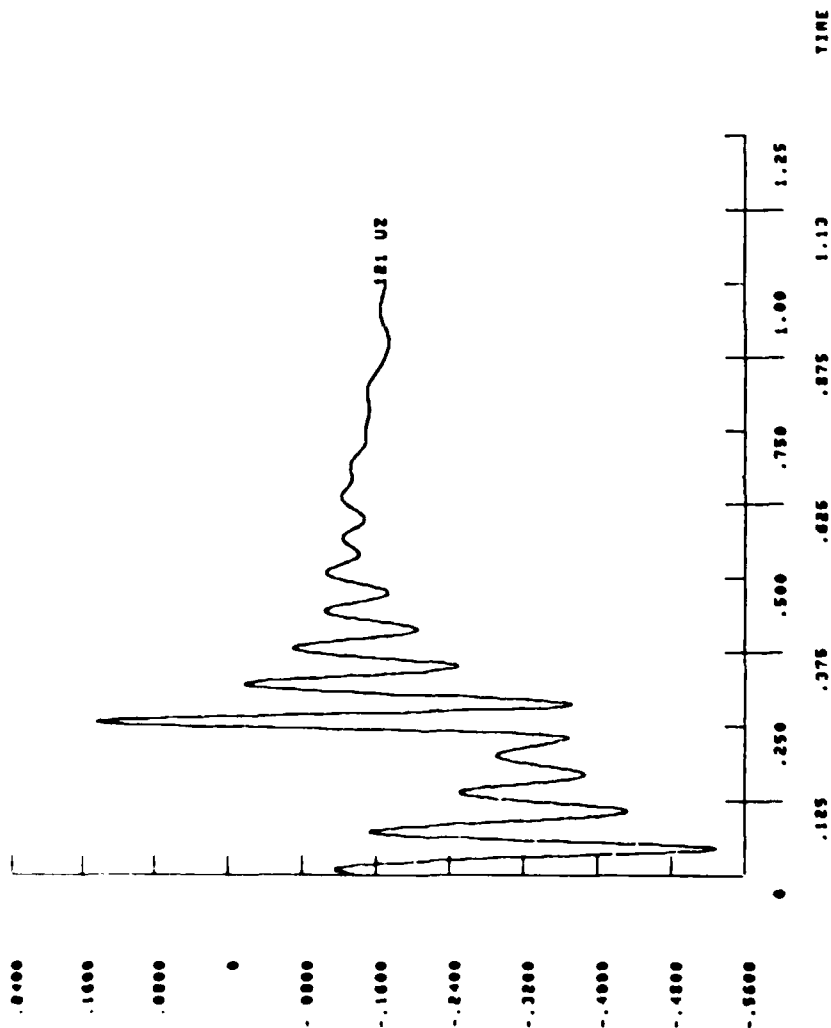


1 1000-0.72 CASE, PROOF LOADS-C.B. ONLY 077

*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
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PLOT DEFINITION
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1 LUND-0.72 CASE, PROOF LOADS-C.R.ORTLOFF

INCOMPLETE FOR 1001 DATA POINTS

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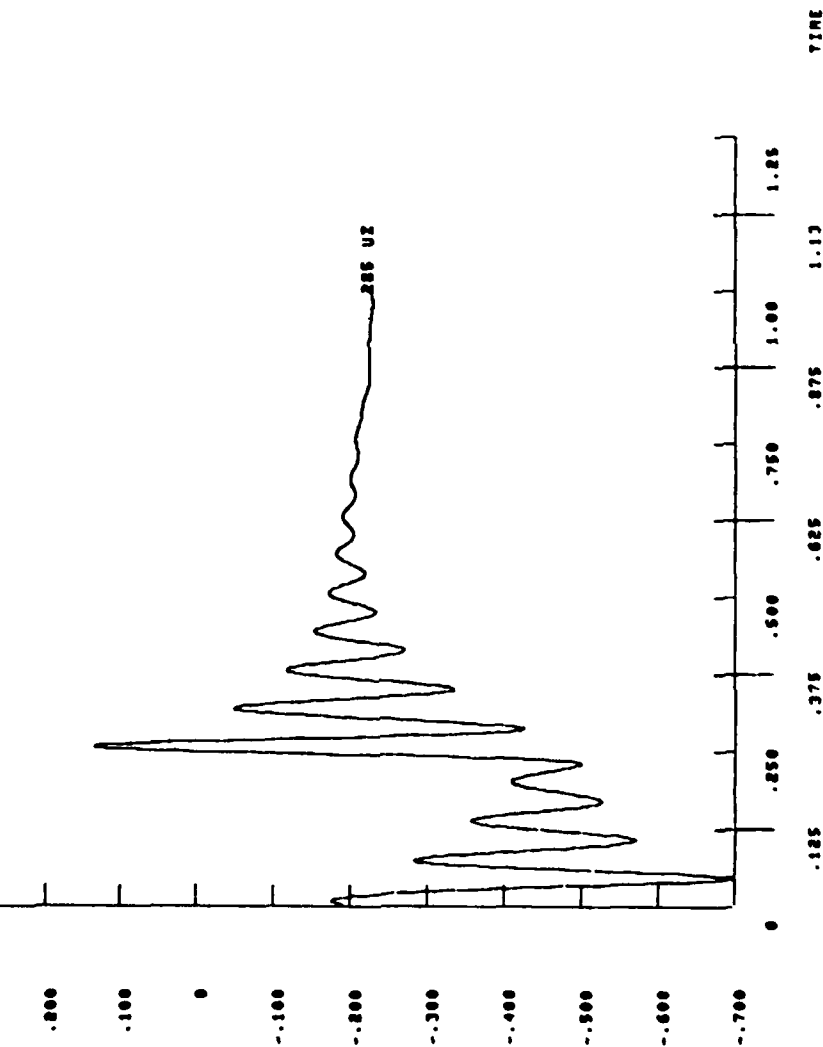
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PLOT DEFINITION

CURVE VARIABLE NAME

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1 LUND-0.72 CASE, PROOF LOADS-C.R.ORTLOFF

INCOMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES

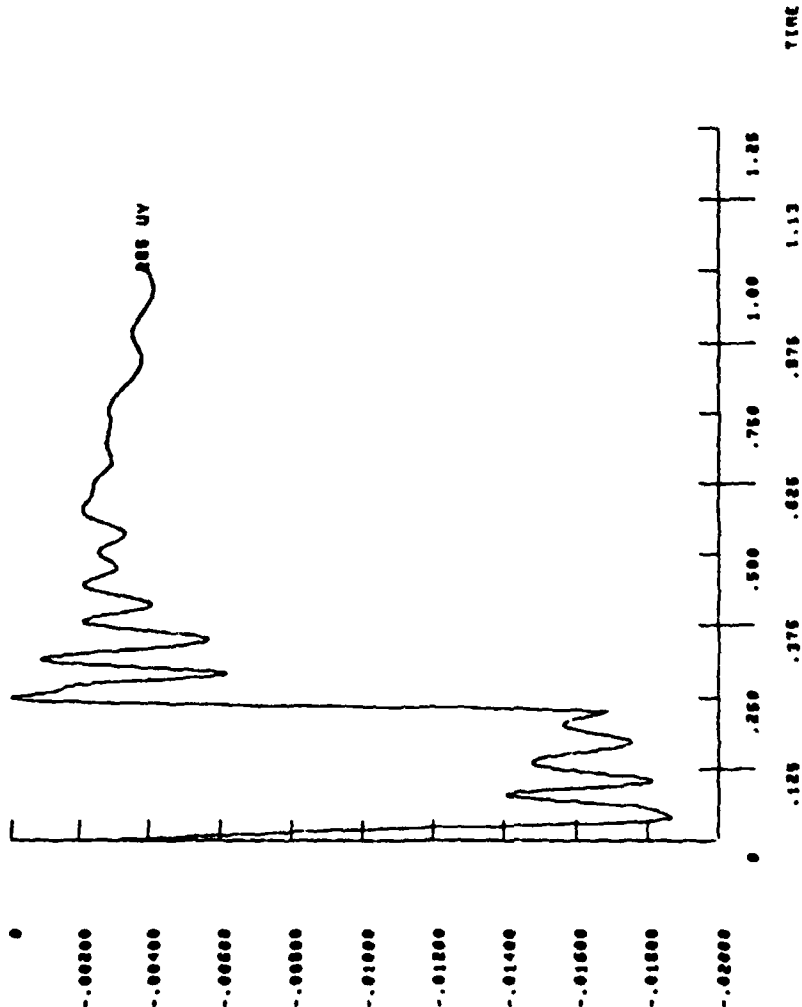
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PLOT DEFINITION

CURVE VARIABLE NAME

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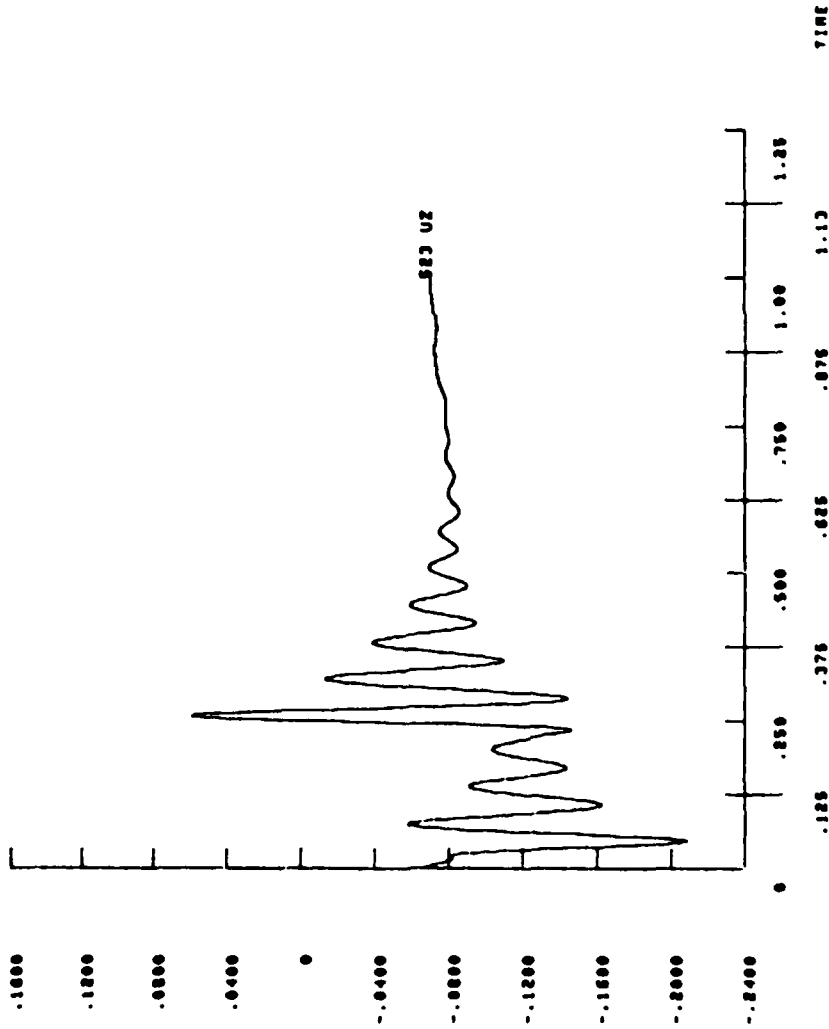
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*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 VARIABLE IDENTIFIERS HAVE MINIMUM AT TIME MAXIMUM AT TIME

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PLOT DEFINITION
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1 LUMD-0.72 CASE, PROOF LOADS-C.R.ORTLOFF

*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES

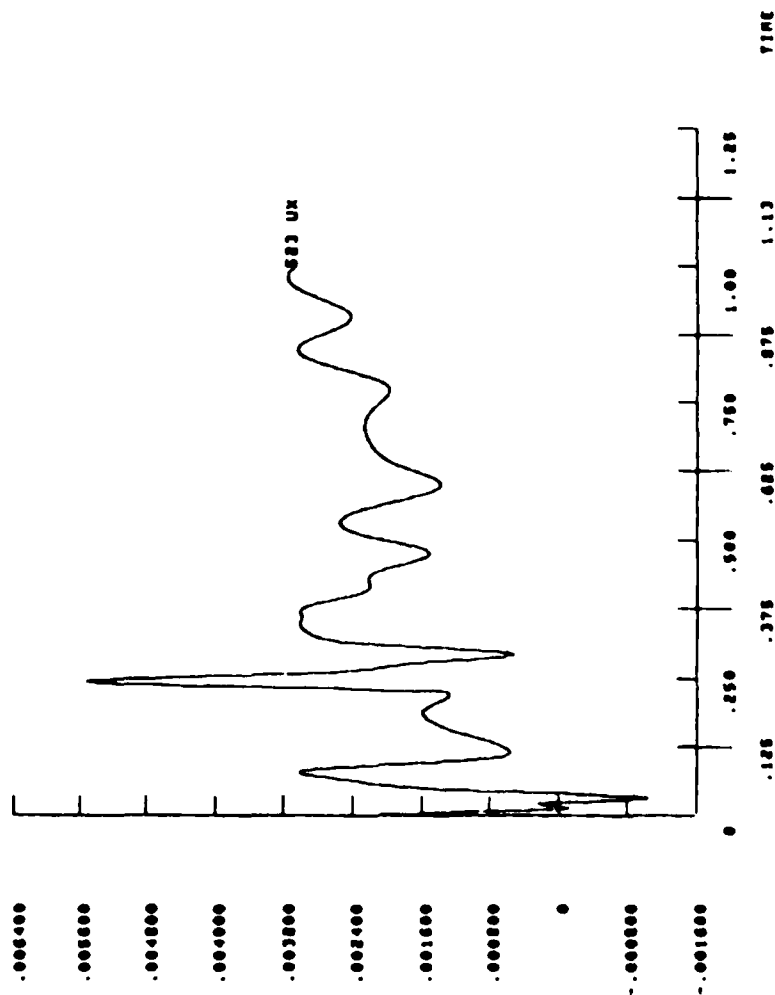
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PLOT DEFINITION

CURVE VARIABLE NAME

1 823 UX

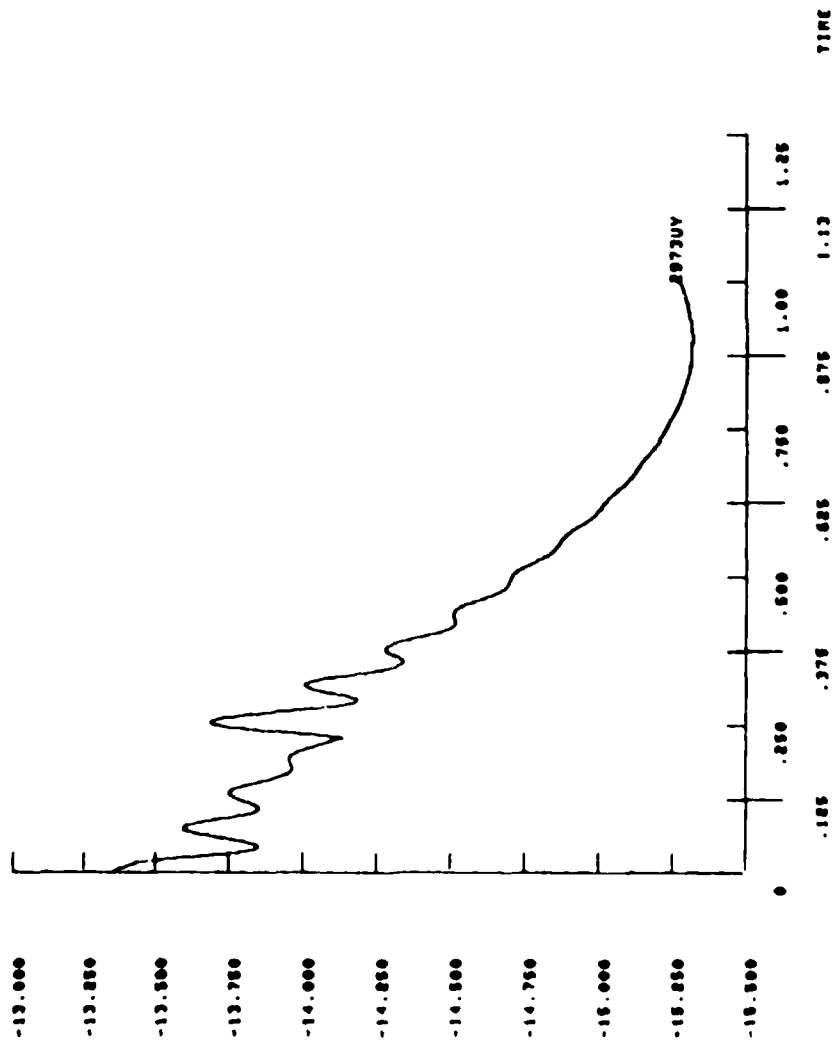


1 LUMP-0.72 CASE, PROOF LOADS-C.R. ONTLOFF

*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIER NAME MINIMUM AT TIME MAXIMUM AT TIME
 0 STOP 0027UV 0073UV -15.31 0.0040 -13.36 0.8000E-08

PLOT DEFINITION
 1 VARIABLE NAME
 2 0073UV

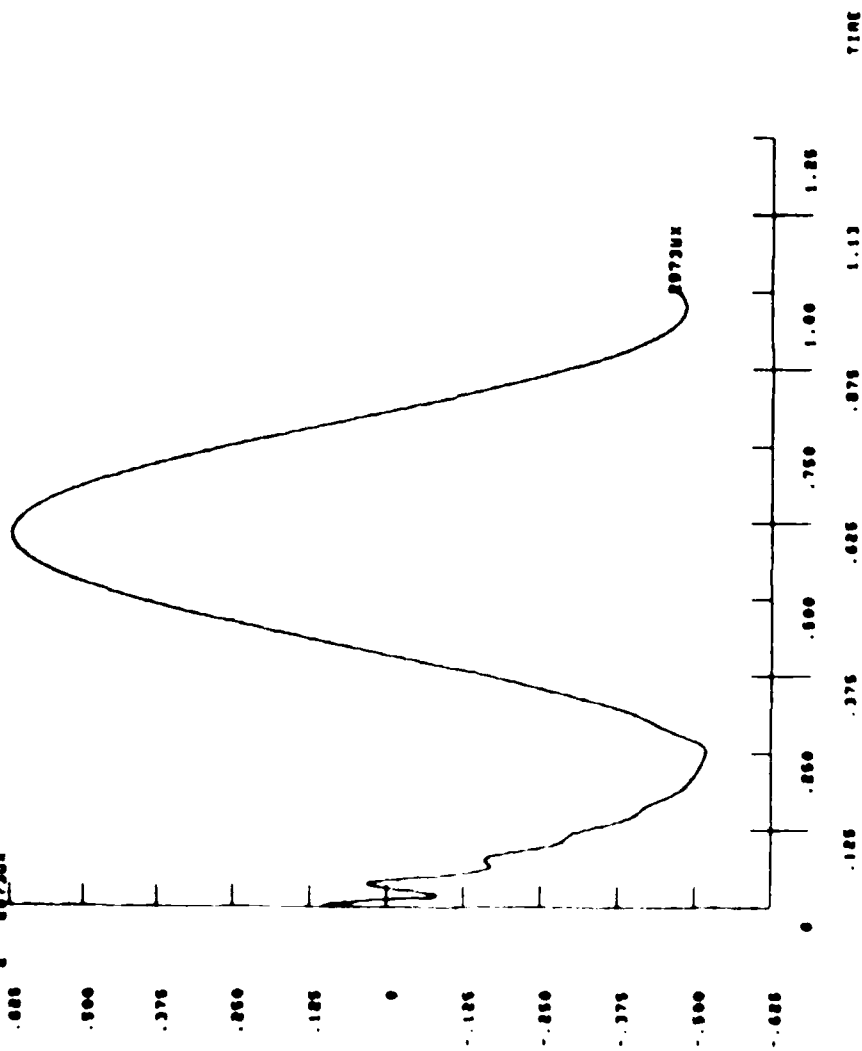


1.000E-072 CASE,0000F LOADS-C.R.0071OFF

*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME
 1 DISP 1001 00730X -0.0107 0.0010 0.0020 0.0040

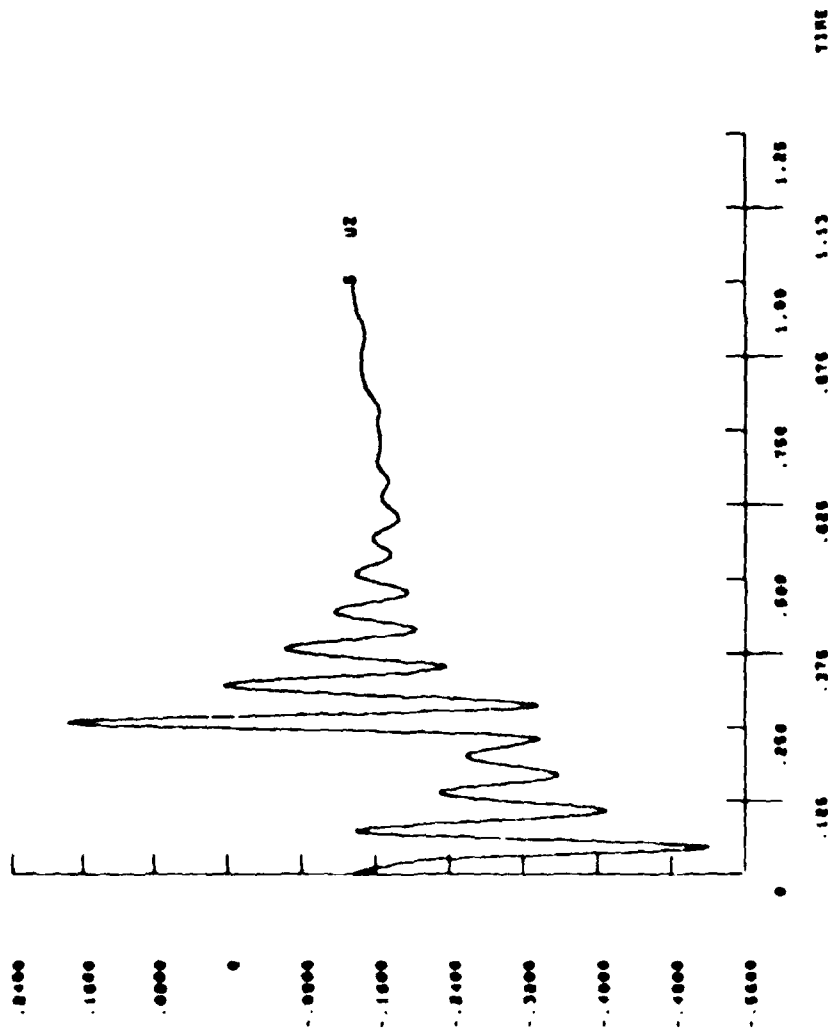
PLOT DERIVATION
 CURVE VARIABLE NAME
 1 00730X



1 LUMB-0.72 CASE, PROOF LOADS-C.D. OUTLOFF

*****COMPLETE FOR 1001 DATA POINTS
 SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIER NAME MINIMUM AT TIME MAXIMUM AT TIME
 S STOP S UZ S UZ -0.5816 0.4000E-01 0.1771 0.0000

PLOT DEFINITION
 PLOT VARIABLE NAME
 1 S UZ

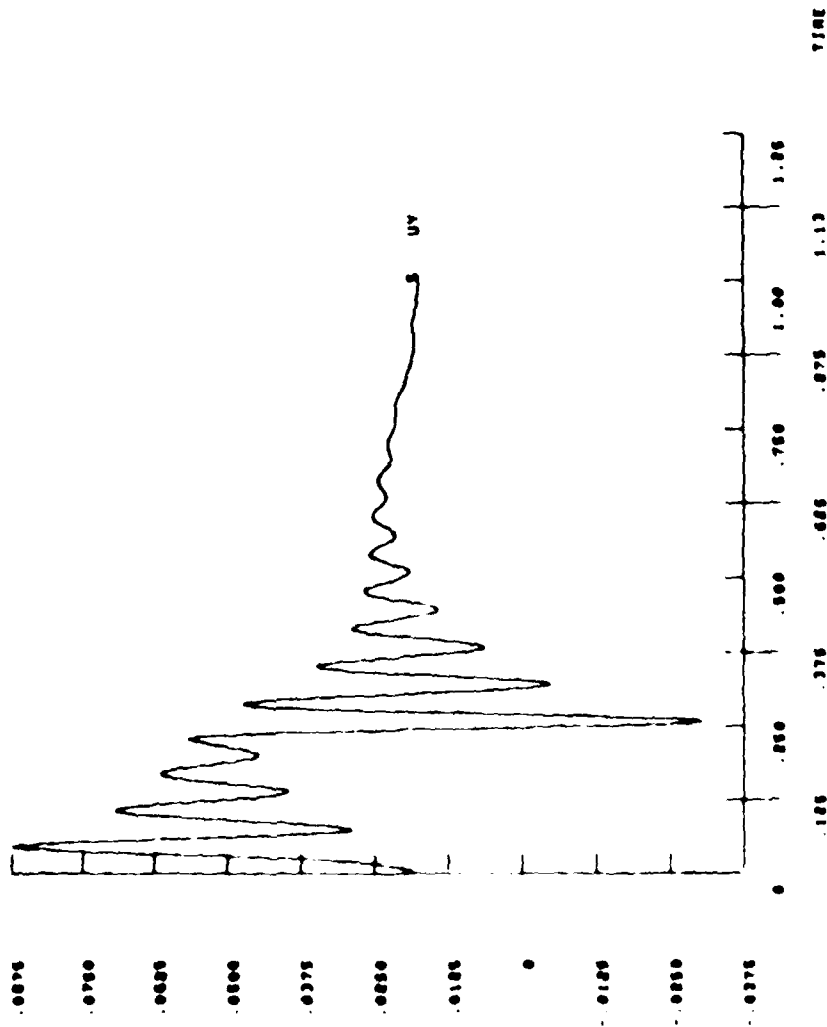


1 LUND-0.72 CASE, PROOF LOADS-C.6.00TLOFF

===== COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIER NAME MINIMUM AT TIME MAXIMUM AT TIME
 A 0100 WAVELENGTH S UV -0.00000000 0.00000000 0.00000000 0.00000000

Plot description
 Name variable S UV



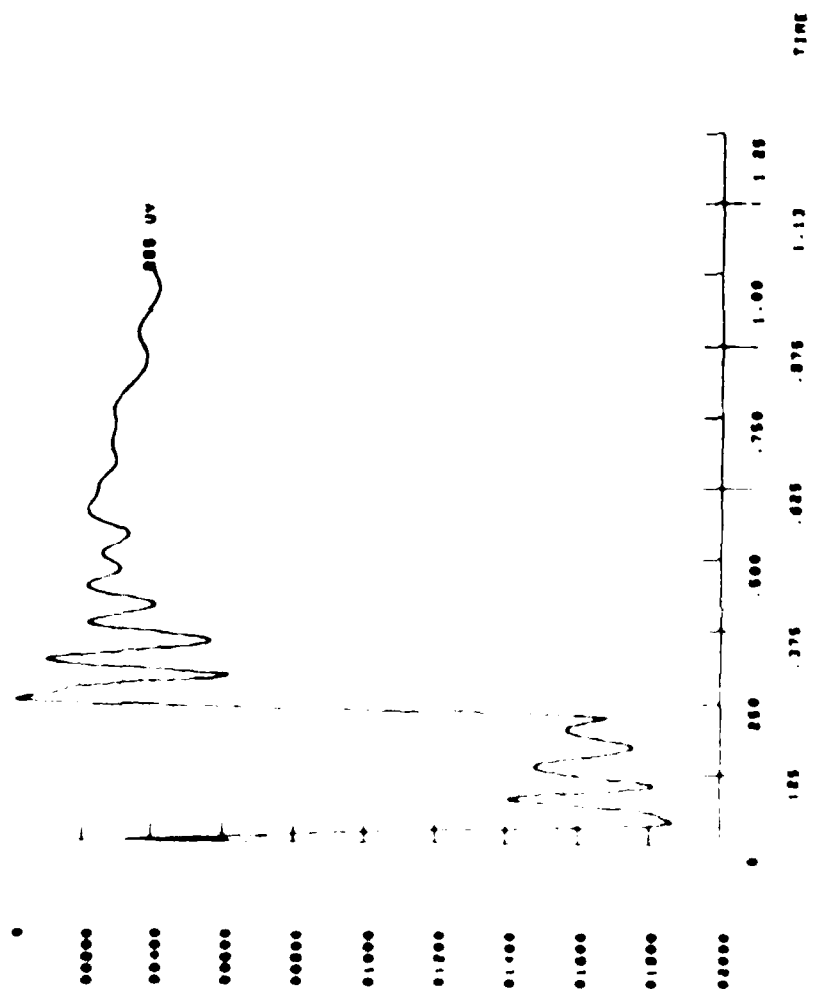
===== 1000-0.78 CASE.00000000 1000-0.00000000

*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREMUM VALUES
 NAME IDENTIFIED NAME MINIMUM AT TIME MAXIMUM AT TIME

0.0100 000 UV 000 UV -0.1007E-01 0.0000E-01 0.0000E-01 0.0000E-01 0.0000

PLAY DEFINITION
 NAME VARIABLE NAME
 0 000 UV



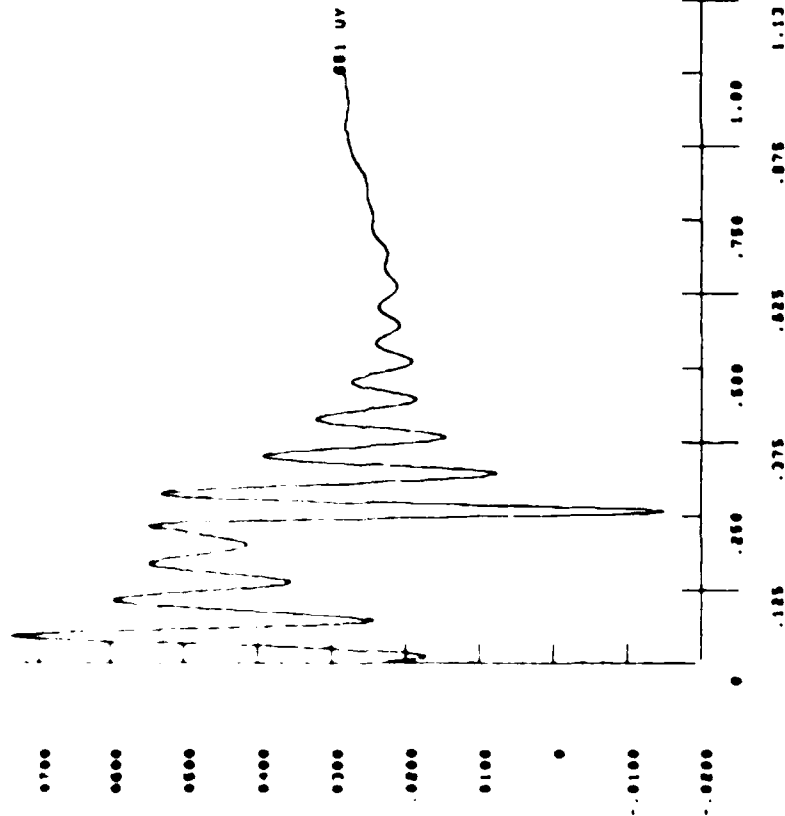
*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED INTO STEP AND SAVING VALUES

NAME OF VARIABLE STORED INTO STEP AND SAVING VALUES

NAME OF VARIABLE STORED INTO STEP AND SAVING VALUES

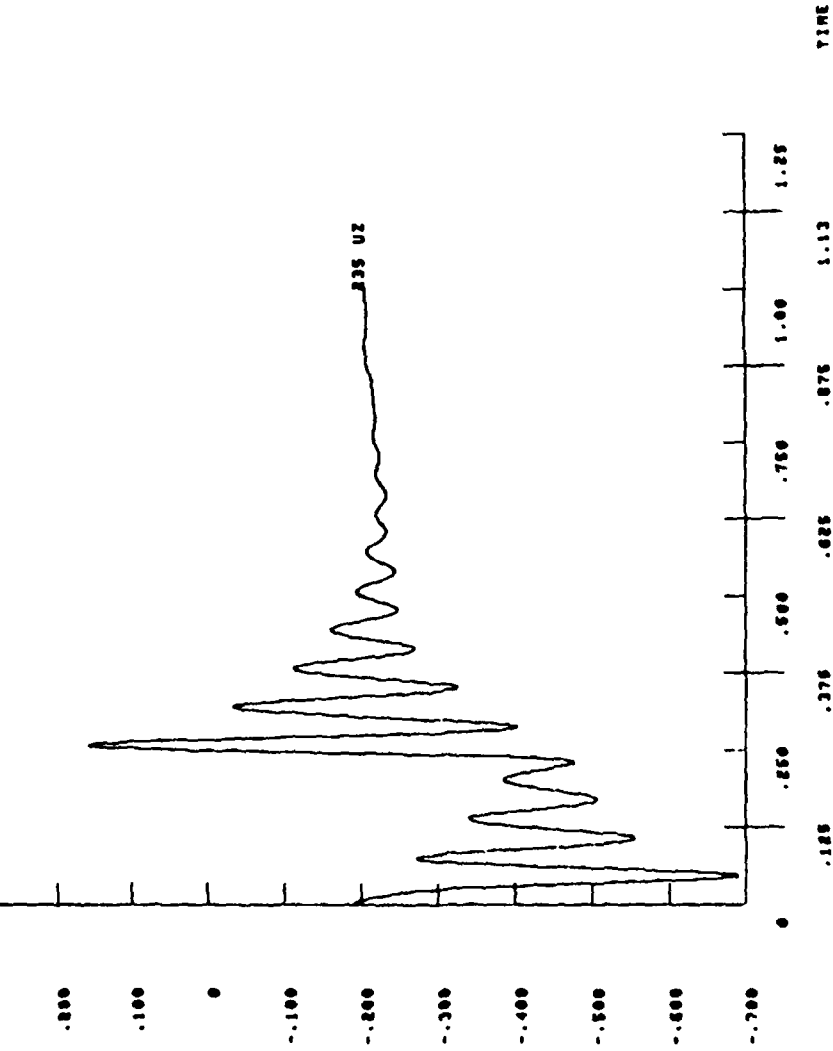
NAME



000001 COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIED NAME MINIMUM AT TIME MAXIMUM AT TIME
 0 0100 V058 UZ 038 UZ -0.0003 0.4000E-01 0.1500 0.0000

PLOT DEFINITION
 CURVE VARIABLE NAME
 1 038 UZ
 2 038 UZ



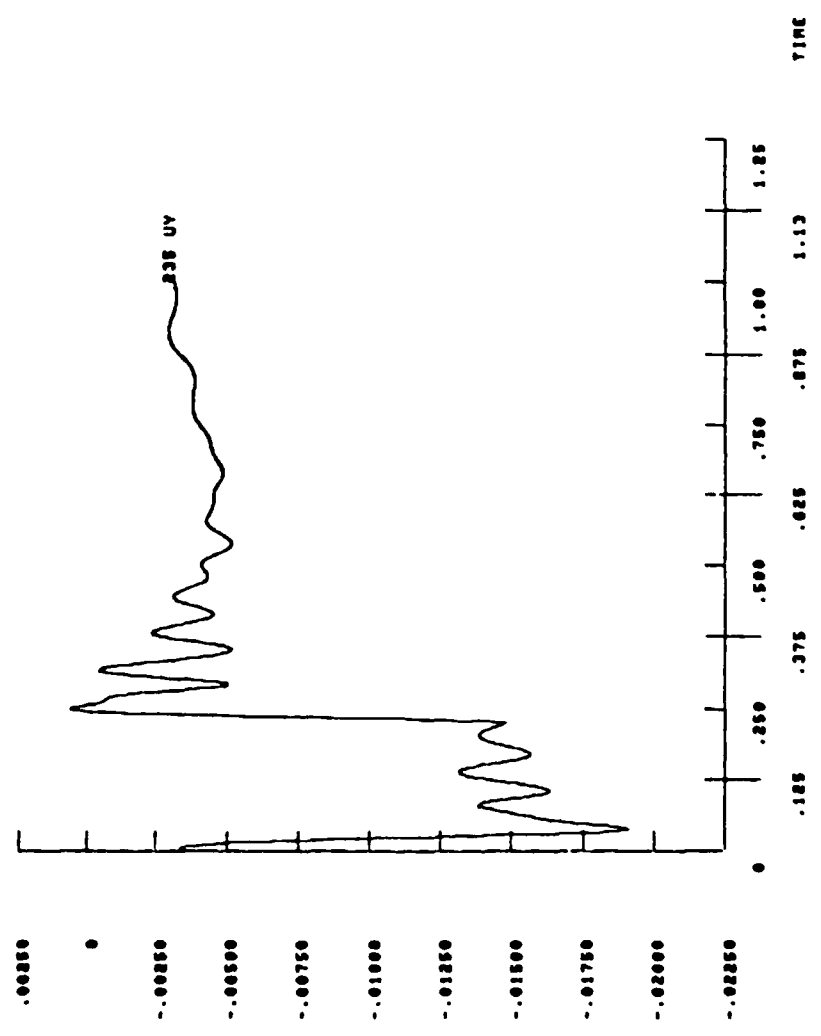
1 LUMB-0.72 CASE, PROOF LOSS-C.R.08710FF

INCOMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 PART TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME

2 DISP 835 UV 835 UV -0.1808E-01 0.3800E-01 0.0806E-03 0.0400

PLOT DEFINITION
 CURVE VARIABLE 1 835 UV



1 LUMB-0.72 CASE, PROOF LOADS-C.R. ORTLOFF

*****COMPLETE FOR 1001 DATA POINTS

NAME	TYPE	IDENTIFIERS NAME	MINIMUM	AT TIME	EXTREME VALUES	MAXIMUM	AT TIME
SUMMARY OF VARIABLES STORED THIS STEP							

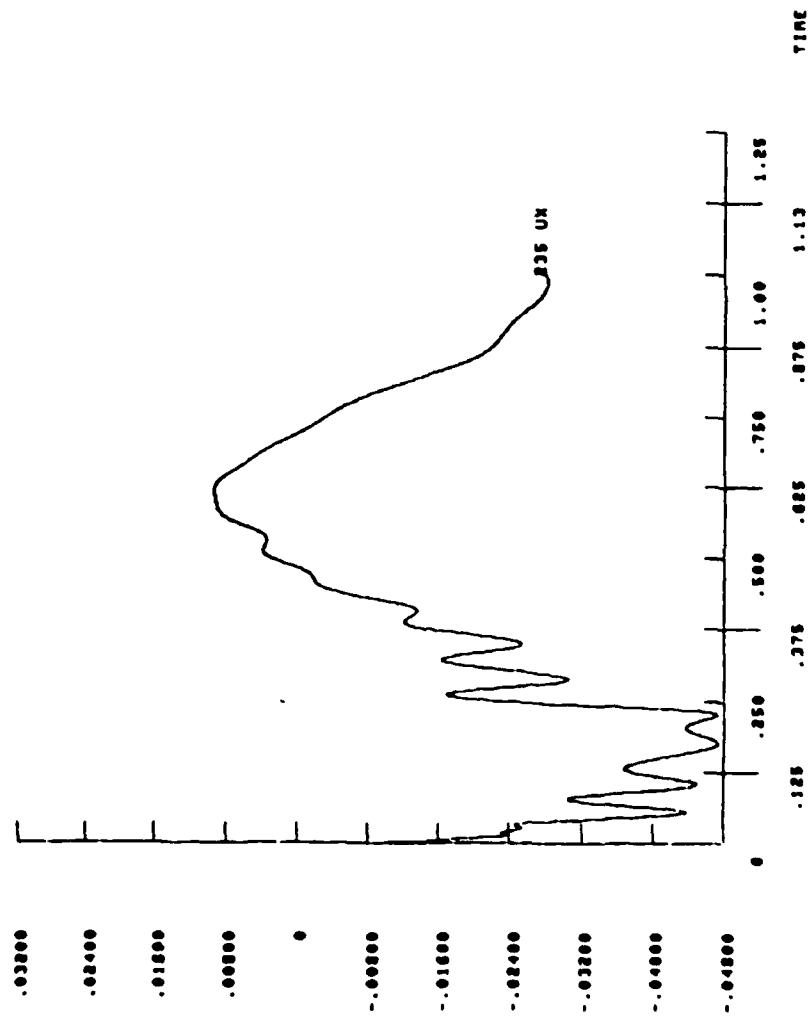
[illegible]

8 D18P	835	WY	835	WY	-0.4738E-01	0.1700	0.3439E-02	0.8170

0768-2199

NAME	DATE	TIME	LOCATION	REMARKS
...	...	...	...	...

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1



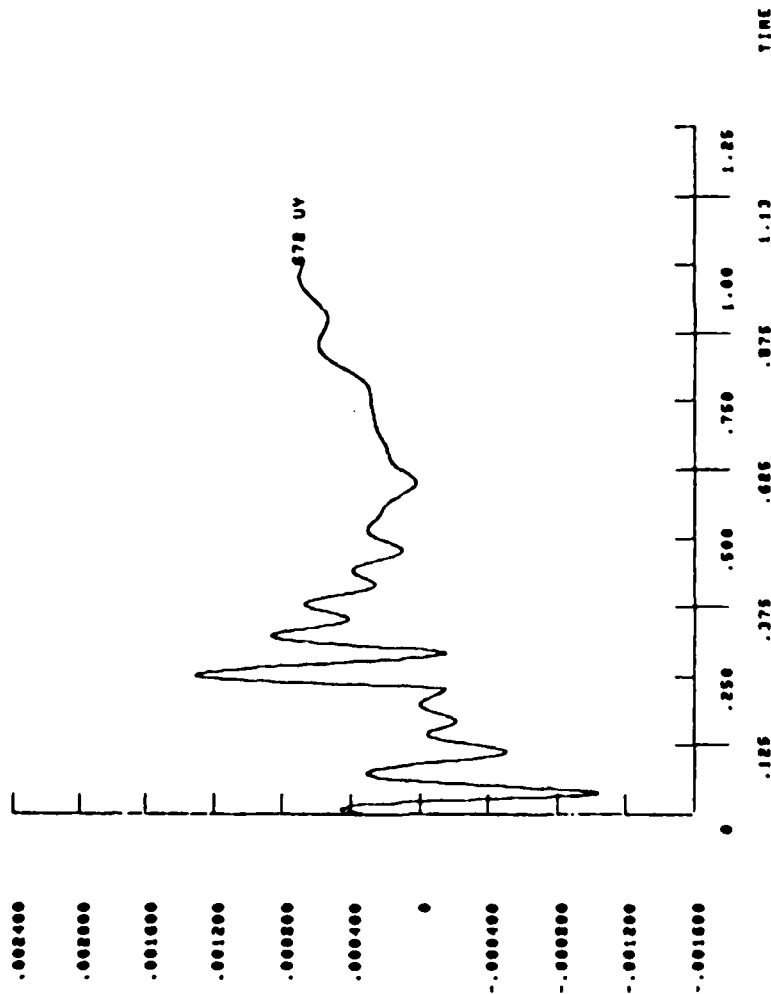
LUND-0,72 CASE, PROOF LOADS-C.R. ORYLOFF

*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME

8 B10P 878 UV 878 UV -0.1040E-02 0.3700E-01 0.1300E-02 0.2510

PLOT DEFINITIONALLY
 CURVE VARIABLE NAME
 1 8 878 UV

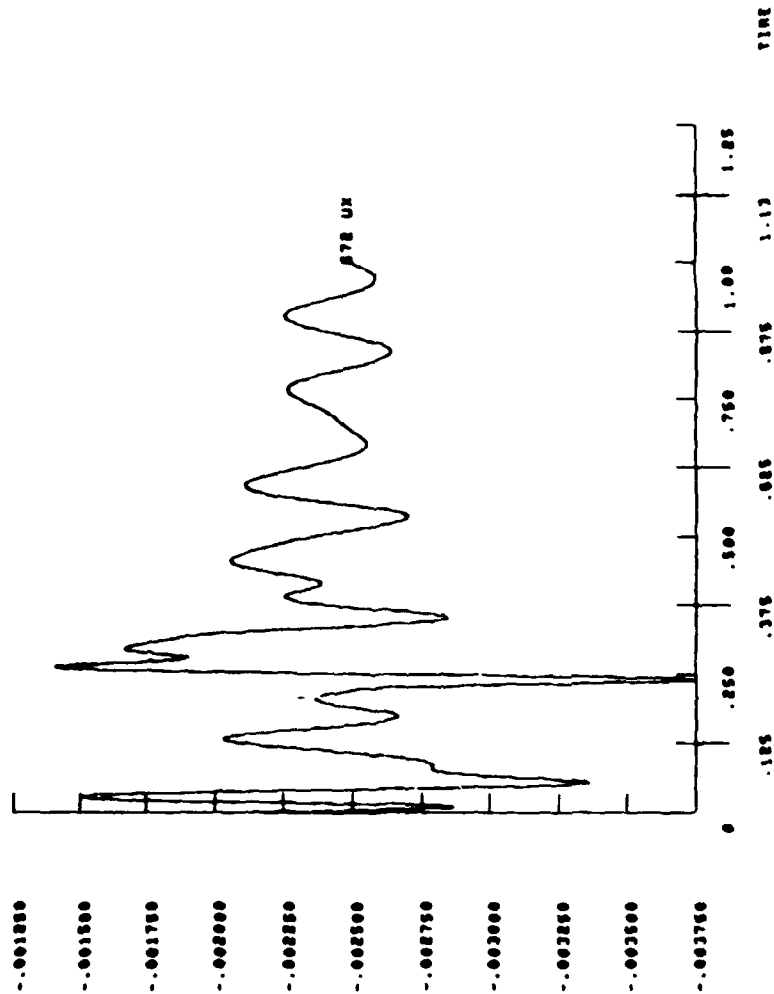


1) LUMB-0.72 CASE, PROOF LOADS-C.R. ON TLOFF

*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 VAR1 TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME
 2 DISP 878 UN 878 UN -0.3739E-08 0.8330 -0.1407E-08 0.8830

PLOT DEFINITIONALLY
 CURVE VARIABLE NAME
 1 878 UN



1 LUND-0.78 CASE, PROOF LOADS-C.R. 00710FF

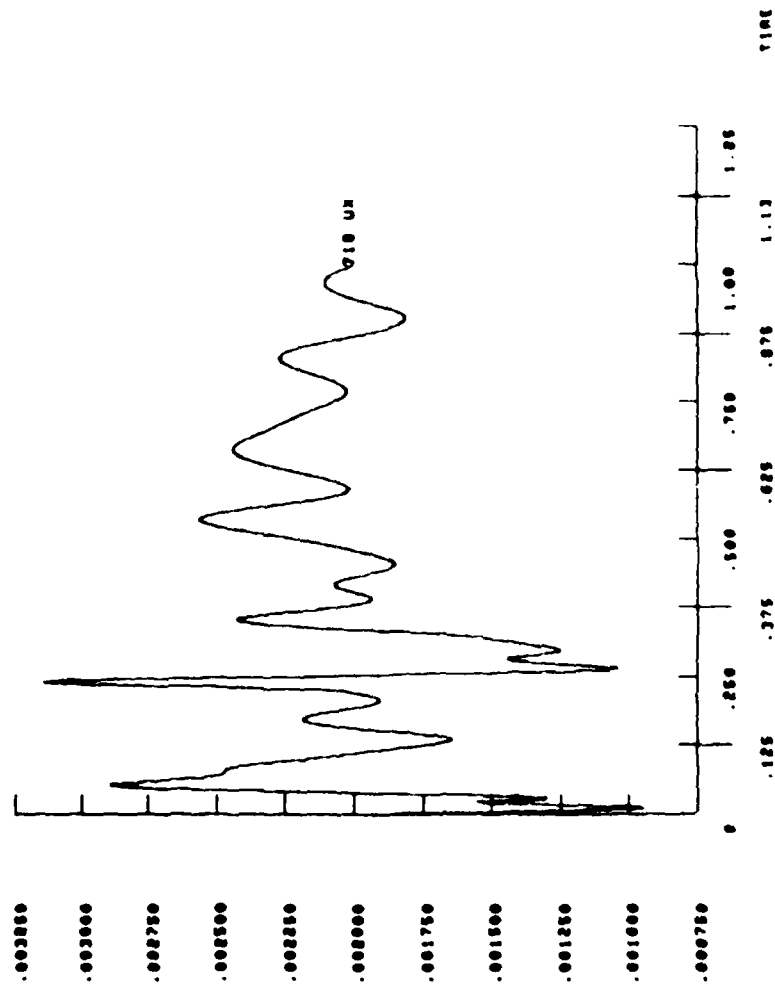
000780
 20-1

===== COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 PART TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME

2 01SP 710 UN 710 UN 0.000000-03 0.100000-01 0.210000-00 0.0000

PLOT DEFINITIONALLY
 CURVE VARIABLE NAME
 1 0 710 UN



LUND-0.72 CASE, PROOF LOADS-C.B. ONTLOFF

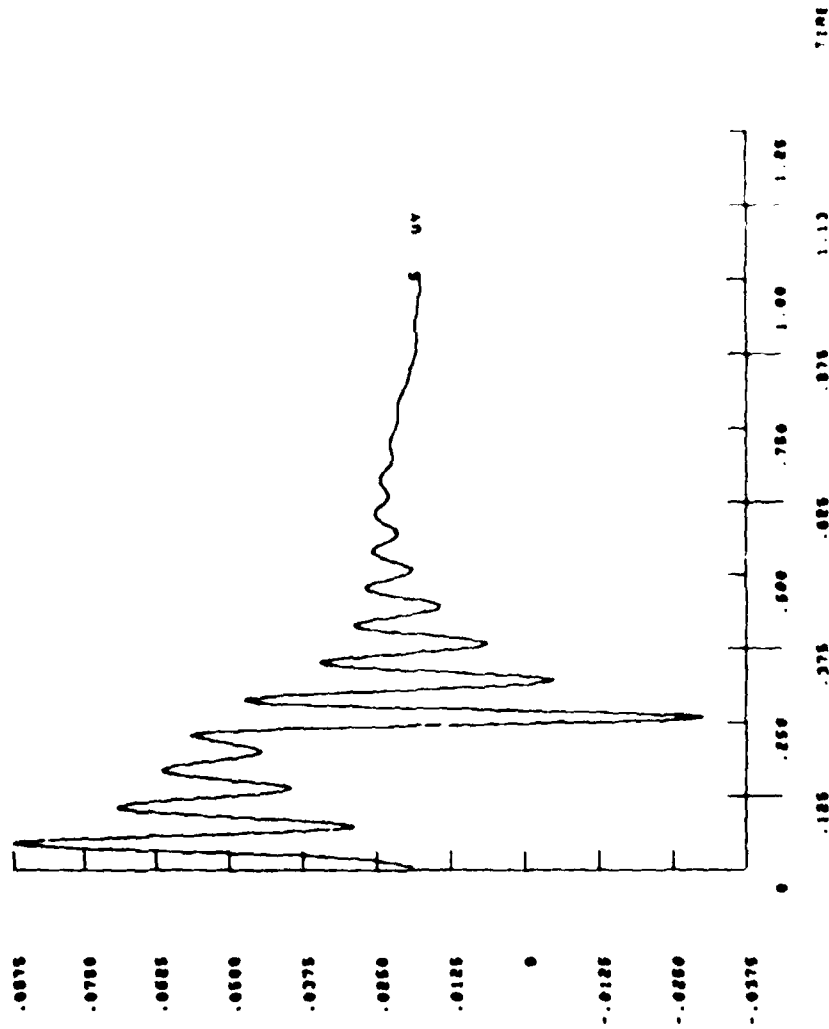
000700
 20-1
 0187-1.00

*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME

A STEP WAVE UV S UV -0.3037E-01 0.2500 0.0740E-01 0.0000E-01

Plot description
 CURVE VARIABLE NAME
 1 2 S UV



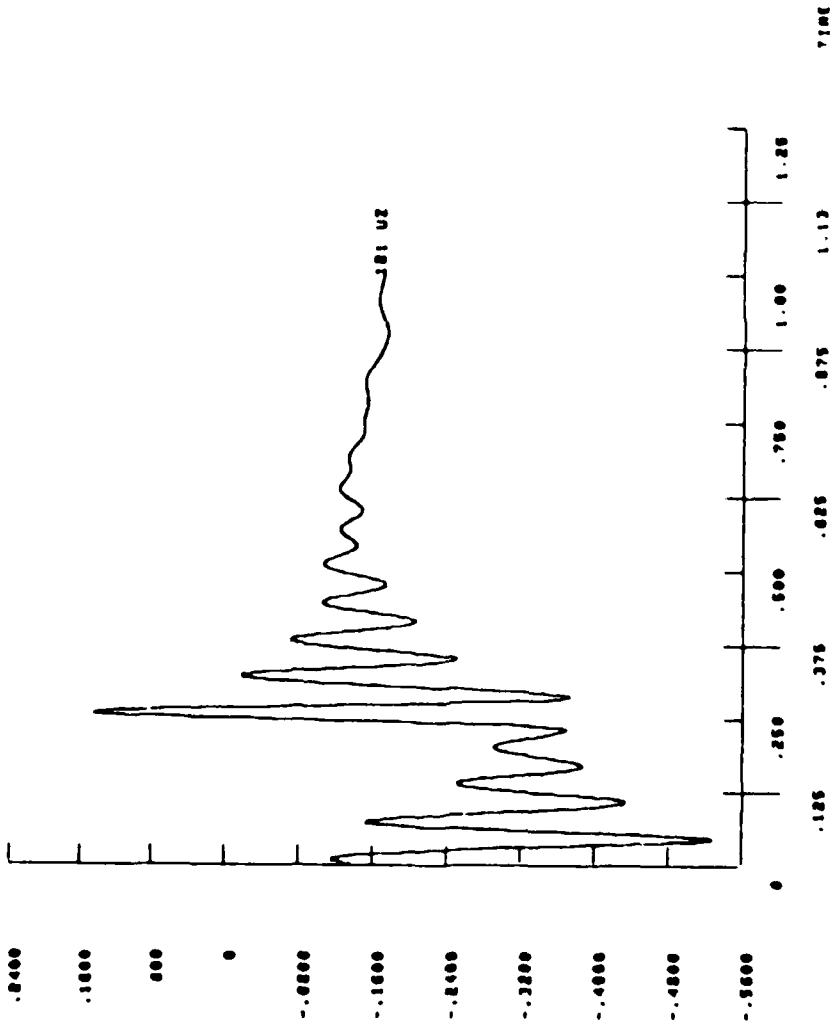
1 LUMP-0.72 CASE, PROOF LOADS-C.B. OUTLOPP

POSTAGE
 20-1
 0107-1 03

*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME
 0 0100 VALU UZ 101 UZ -0.5000 0.00000E+01 0.1402 0.0000

PLOT DEFINITION
 CURVE VARIABLE NAME
 1 101 UZ



1 LUMB-0.72 CASE, PROOF LOADS-C.R.00TLOFF

003706
 20-1
 0107-1.43

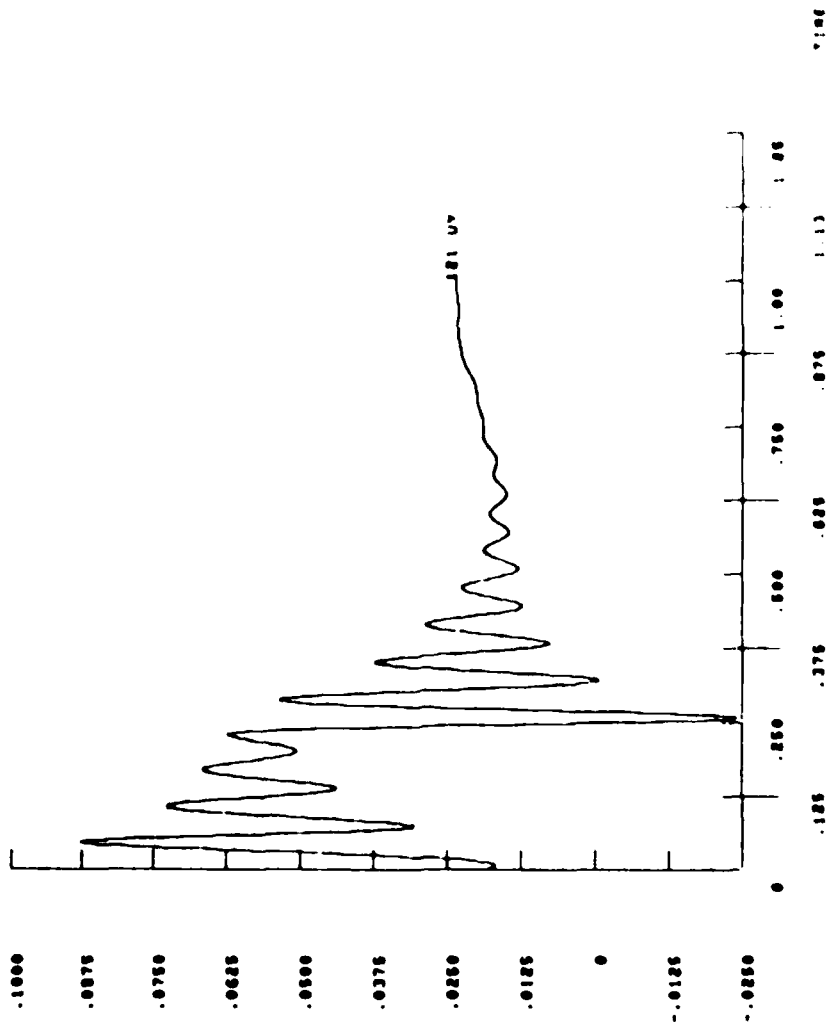
PERIODICITY FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTENDING VALUES

NAME TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME

2 DISP WAVE UV 181 UV -0.2410E-01 0.0000 0.0701E-01 0.4000E-01

PLOT DEFINITION
CURVE VARIABLE NAME
181 UV



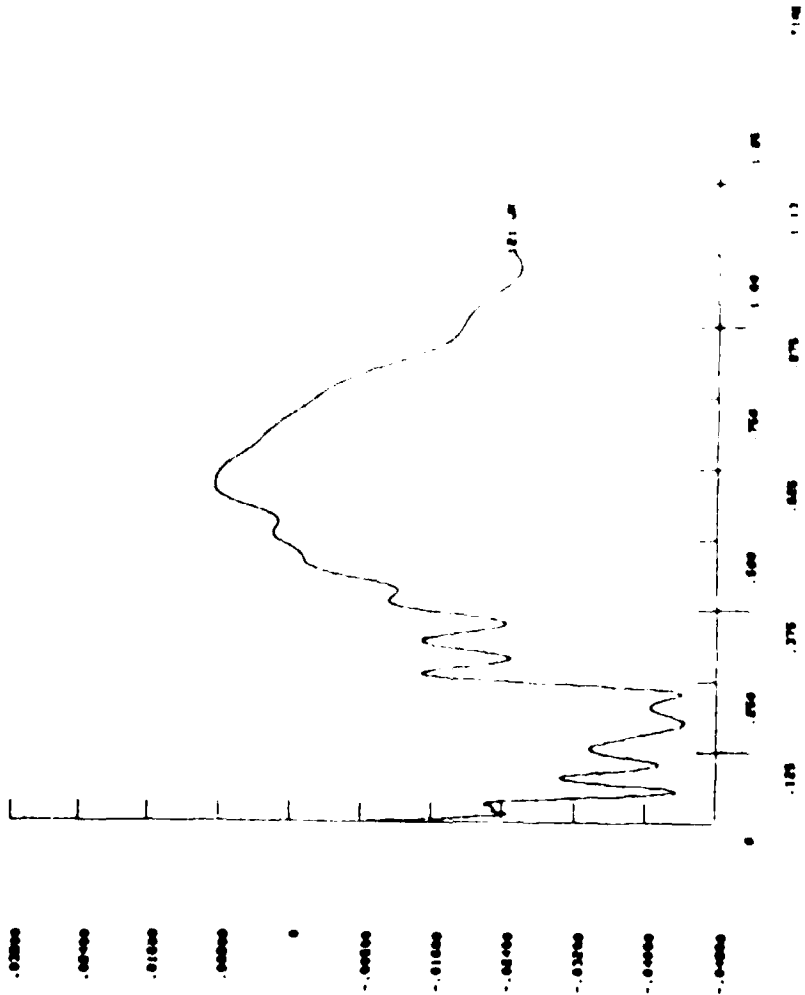
1 LUMB-0.72 CASE, PROOF LOADS-C.M.0071077

POSTED
7-1
8107-1 43

100-100-
FBI COMPLIANCE 100: DATA POINTS

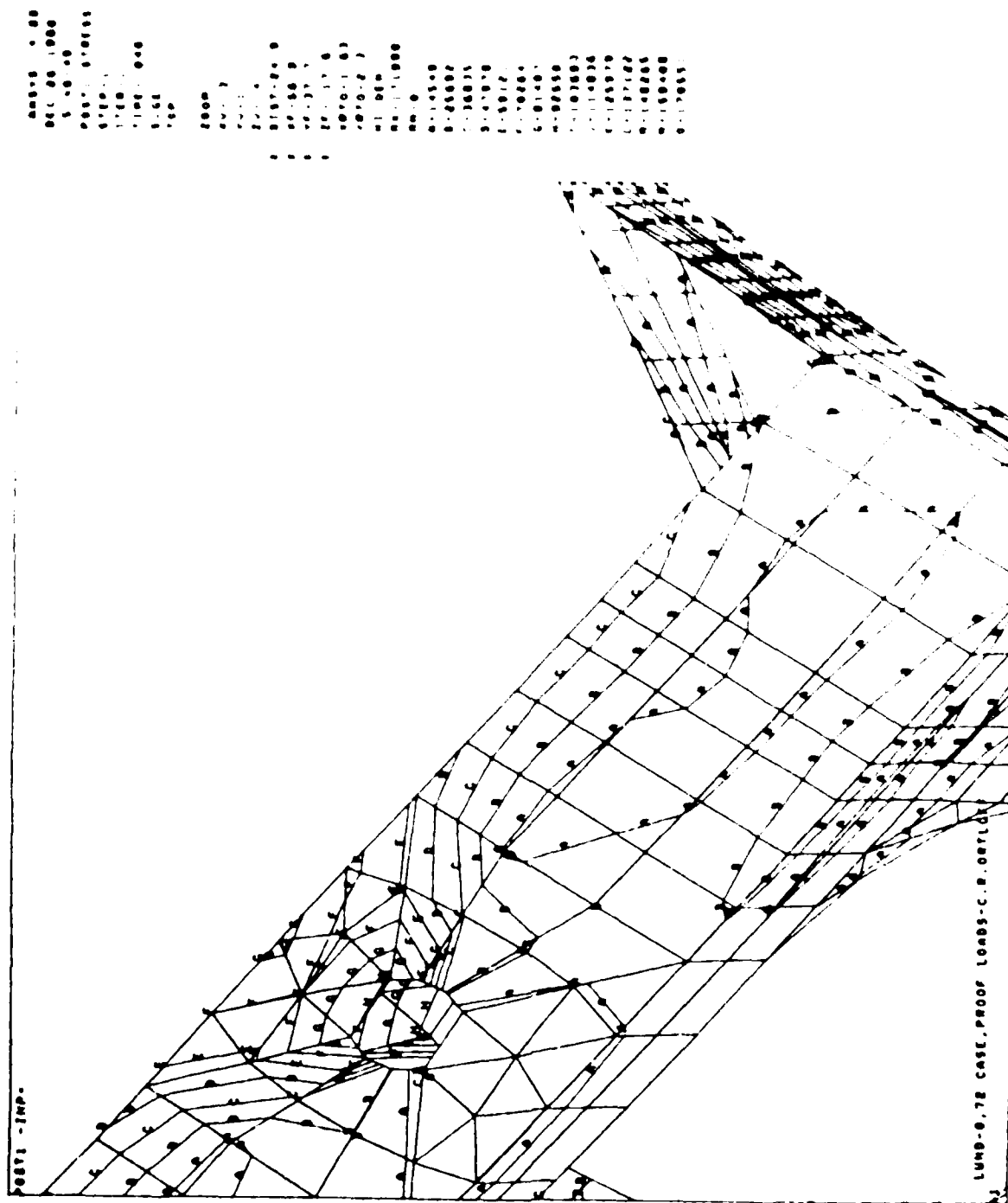
DATE	DESCRIPTION	AMOUNT	BALANCE
10/1/00	OPENING BALANCE	0.0000	0.0000
10/1/00	SALES	10.0000	10.0000
10/1/00	COGS	(5.0000)	5.0000
10/1/00	ADVERTISING	(1.0000)	4.0000
10/1/00	RENT	(0.5000)	3.5000
10/1/00	UTILITIES	(0.2500)	3.2500
10/1/00	DEPRECIATION	(0.2500)	3.0000
10/1/00	WAGES	(1.5000)	1.5000
10/1/00	INVENTORY	(0.2500)	1.2500
10/1/00	CLOSING BALANCE	1.2500	1.2500

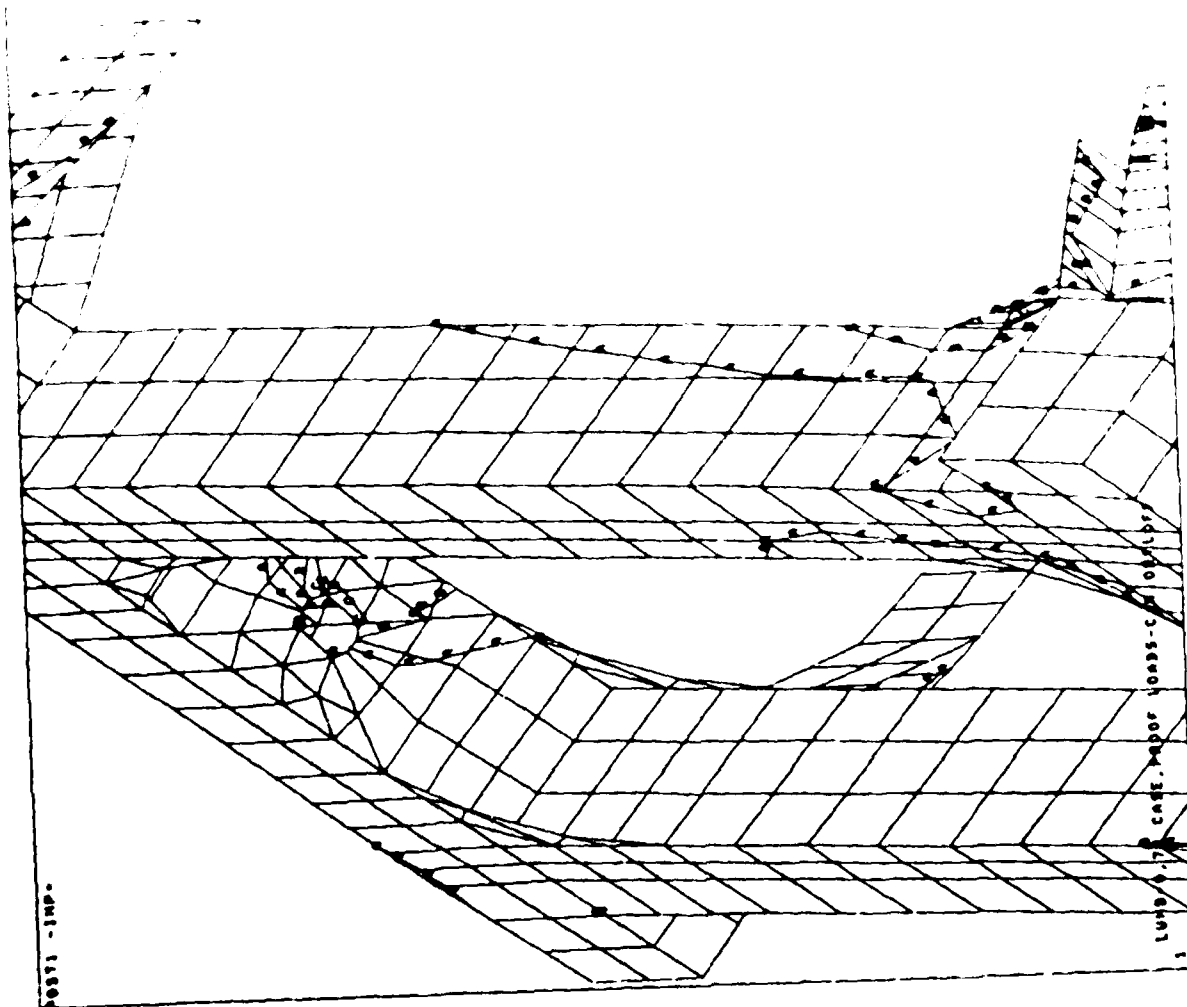
EXHIBIT



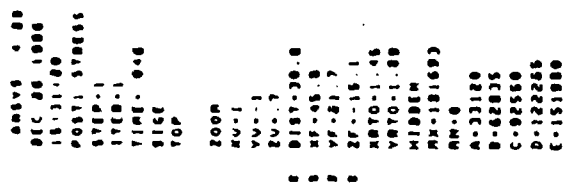
1000-0, 70 CAL. PUMP 1000-C. A. 0071001

100



[illegible]

LUMB-0,72 CASE, PROOF LOADS-C.N. OBTLOFF



AD-A183 993

LIGHTWEIGHT TOWED HOWITZER DEMONSTRATOR PHASE 1 AND
PARTIAL PHASE 2 VOLUM (U) FMC CORP MINNEAPOLIS MINN
NORTHERN ORDNANCE DIV R RATHE ET AL APR 87

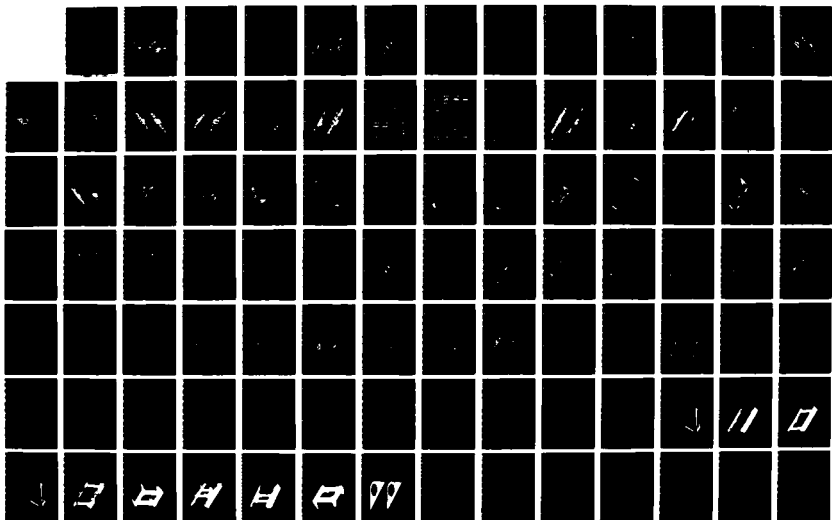
3/5

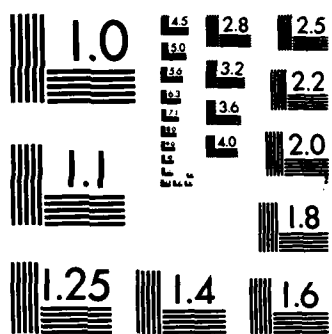
UNCLASSIFIED

FMC-E-3041-VOL-D3-PT-1 DAAA21-86-C-0047

F/G 19/6

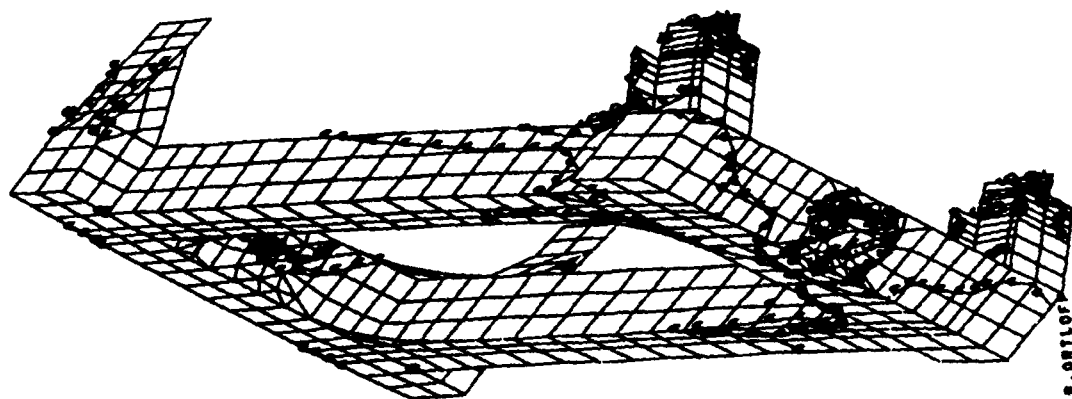
NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ANSYS 4.84
 DEC 26 1986
 16131120
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.046
 SICE
 TOP
 ZOOM
 RV=1
 VU=-1
 ZU=.7
 DIST=84
 KP=54.7
 VF=35
 ZF=-8.78
 VRT0=1.89
 M100EN
 MX=181693
 MN=3408
 A=33120
 B=82825
 C=92558
 D=122245
 E=151980

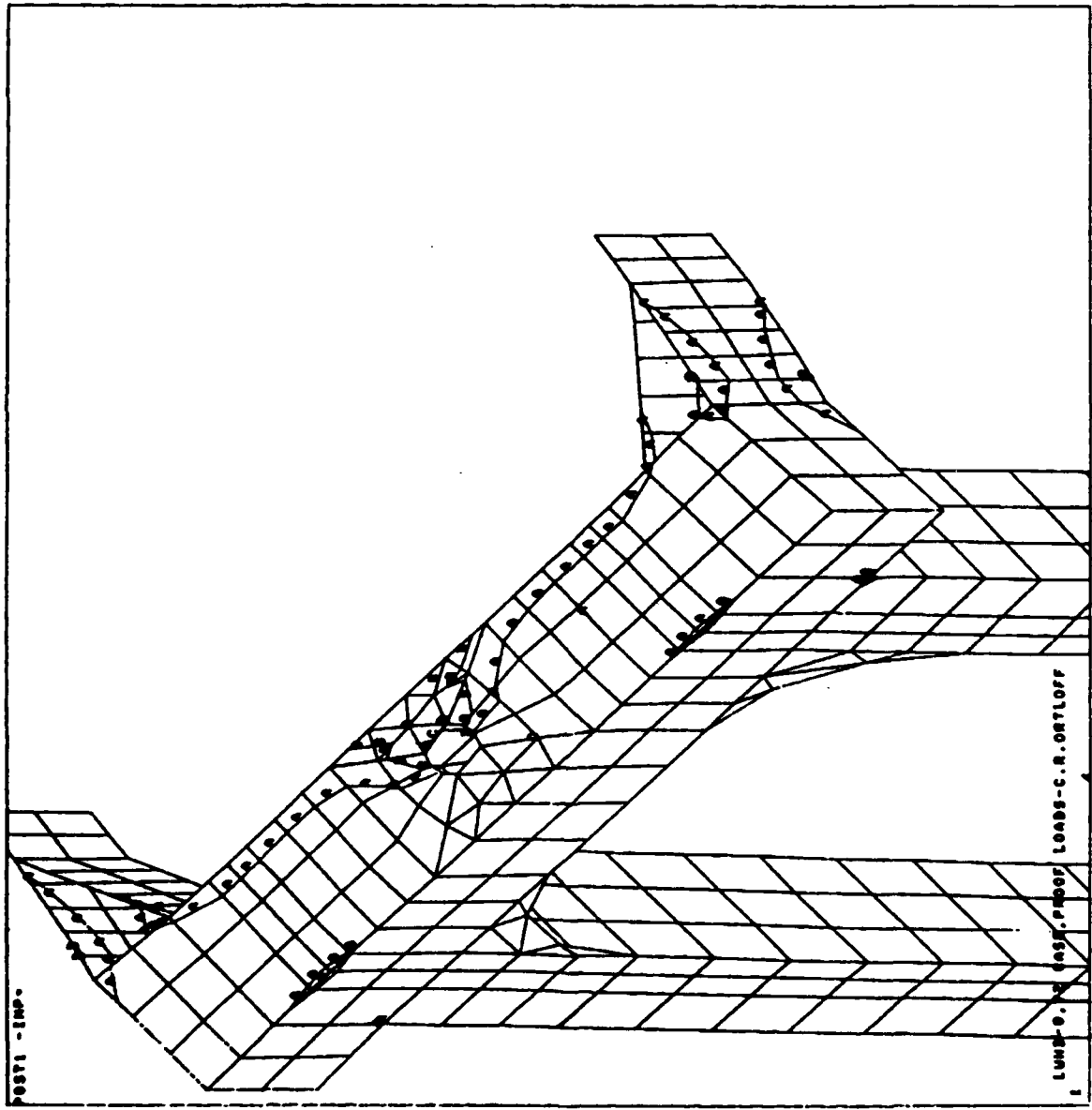


POST1 -IMP
 ZOOM

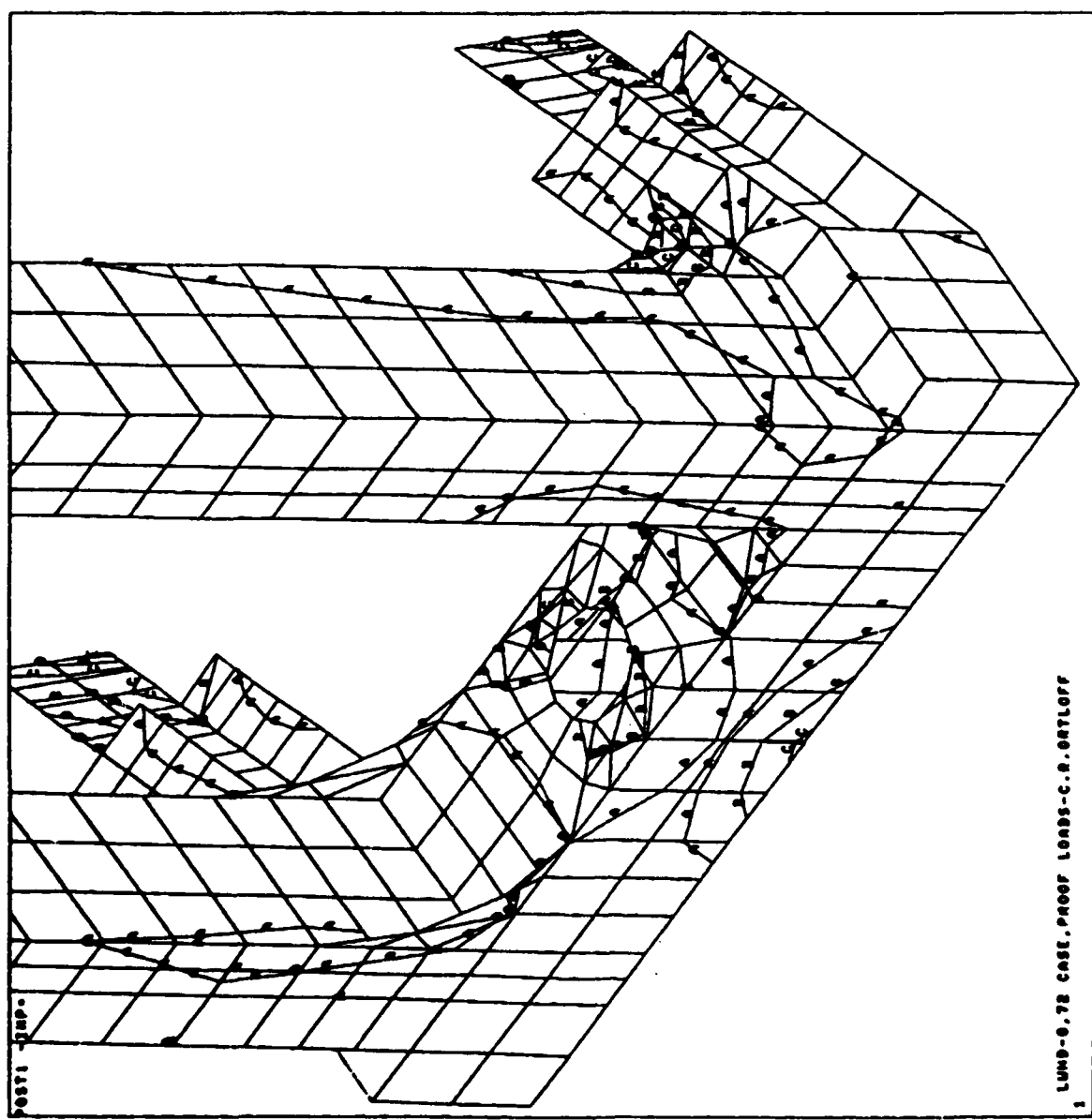
LUNB-0.72 CASE,PROOF LOADS-C.R.ORTLOF

1

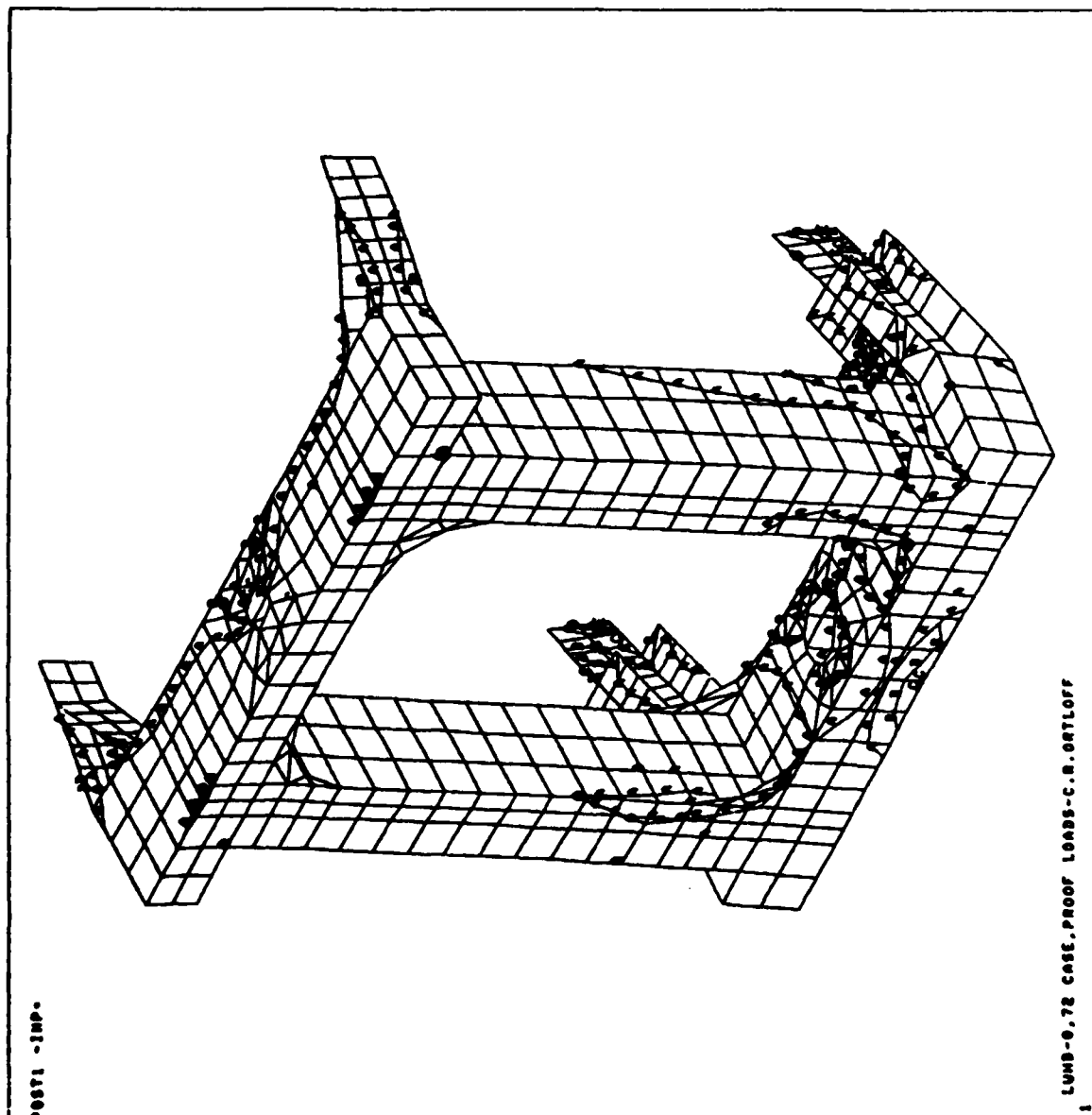
ANSYS 4.28
 DEC 26 1986
 15123110
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.045
 SICE
 TOP
 ZOOM
 KU=1
 VU=1
 ZU=1
 S ST-20.6
 S XF=54
 S VF=46.7
 S ZF=19.9
 VRTD=1.89
 HIDDEN
 RX=131137
 RM=6
 A=23120
 B=62835
 C=92550
 D=122255



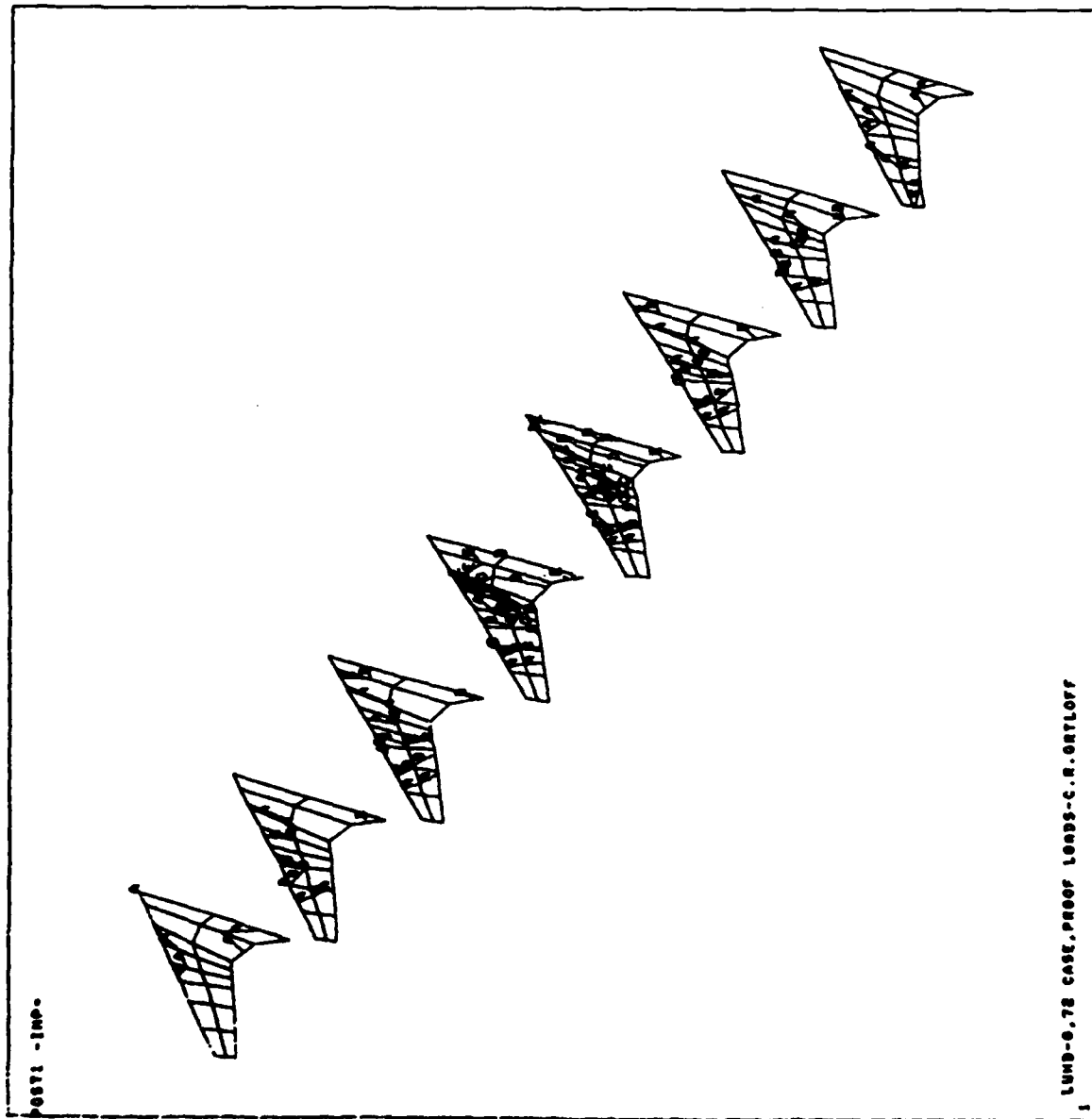
ANSYS 4.20
 DEC 26 1986
 15:10:14
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.046
 SIQE
 TOP
 ZOOM
 XZ=1
 YZ=1
 ZU=1
 Z DIST=21.4
 Z XF=61
 Z VF=21.1
 Z ZF=-1.34
 VRTD=1.33
 HIDDEN
 RM=101803
 RM=0
 A=33120
 B=62835
 C=92550
 D=122265
 E=151980



ANSYS 4.20
 DEC 26 1986
 1519114
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.046
 SLOC
 TOP
 20=1
 20=1
 20=1
 2187-34.2
 27-54.9
 27-32.9
 27-5.01
 HIDDEN
 MM=101093
 MM=3406
 0-33120
 0-62026
 C-92550
 D-122265
 E-151000



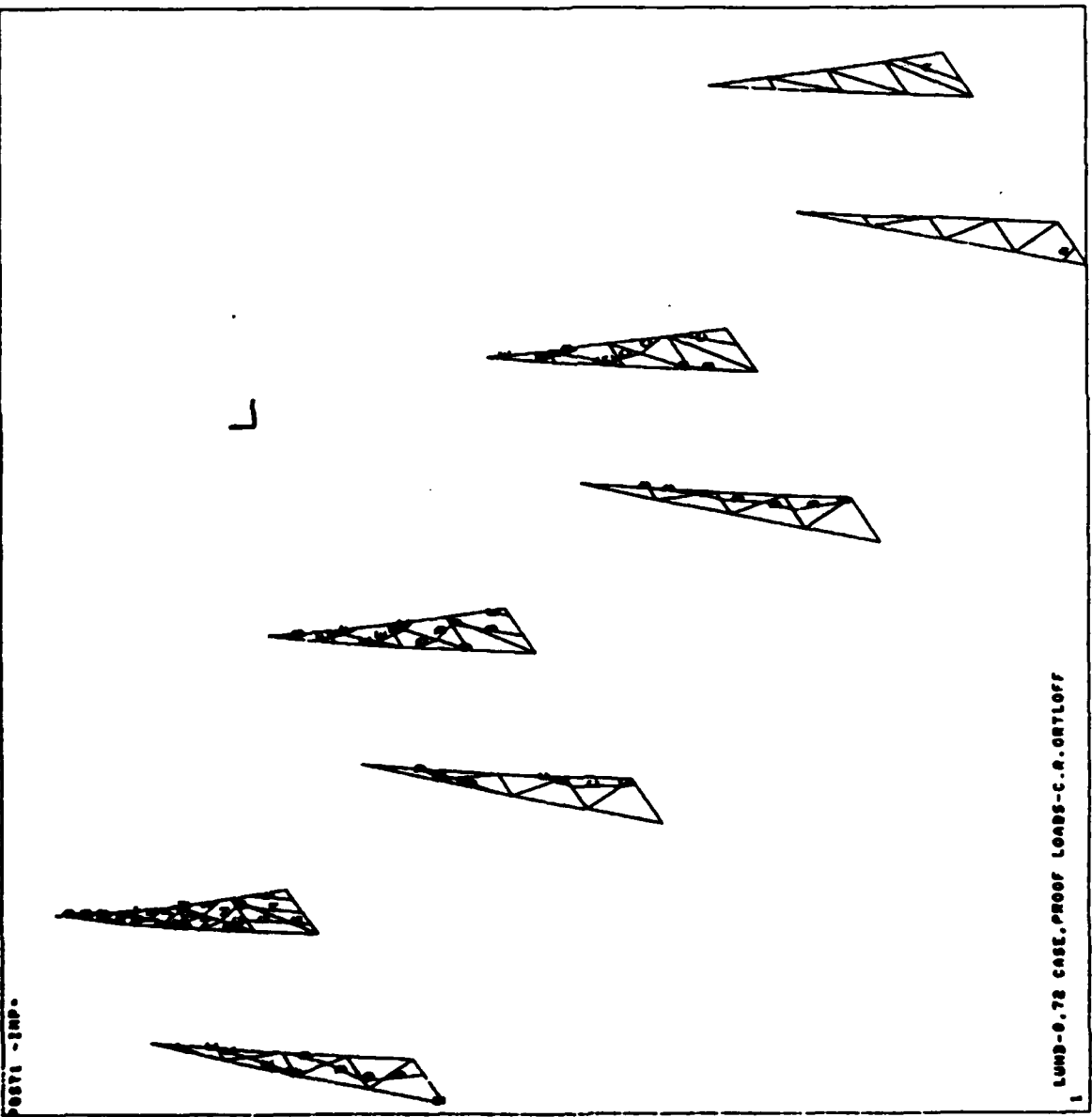
ANSYS 4.08
 DEC 26 1986
 15115184
 POST1, STRESS
 STEP=1
 LTEMP=1
 TIME=.046
 SIZE
 TOP
 ZOOM
 NU=1
 VU=1
 ZU=1
 DIST=63.8
 XF=52.3
 YF=-1.67
 ZF=5.33
 HRT0=1.3
 VRT0=1.02
 HIDDEN
 MX=33779
 MY=528
 A=6070
 B=11612
 C=17154
 D=22696
 E=28238



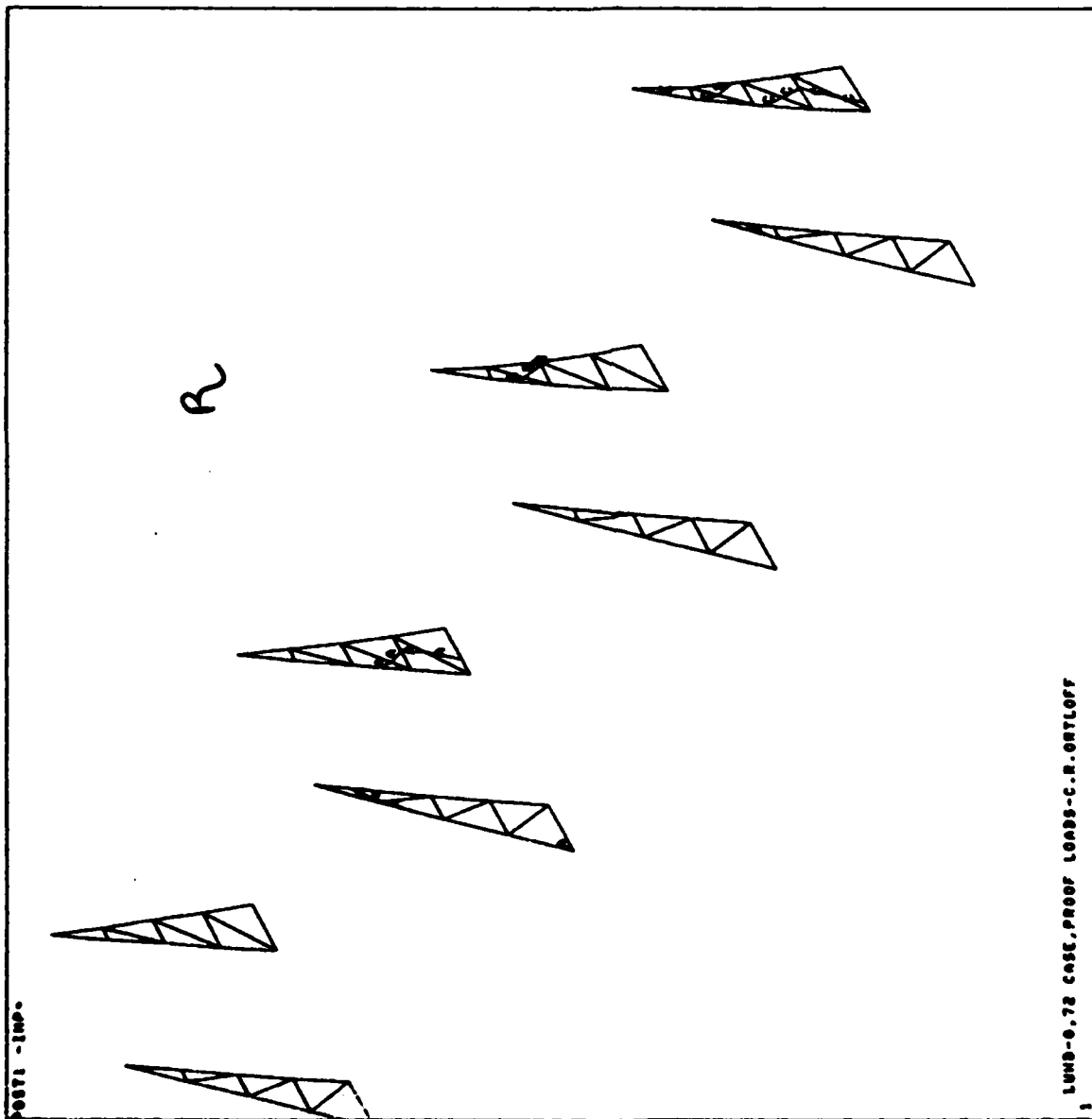
POST1 -IMP-

LUND-0.72 CASE,PROOF LOADS-C.R.ORTLOFF

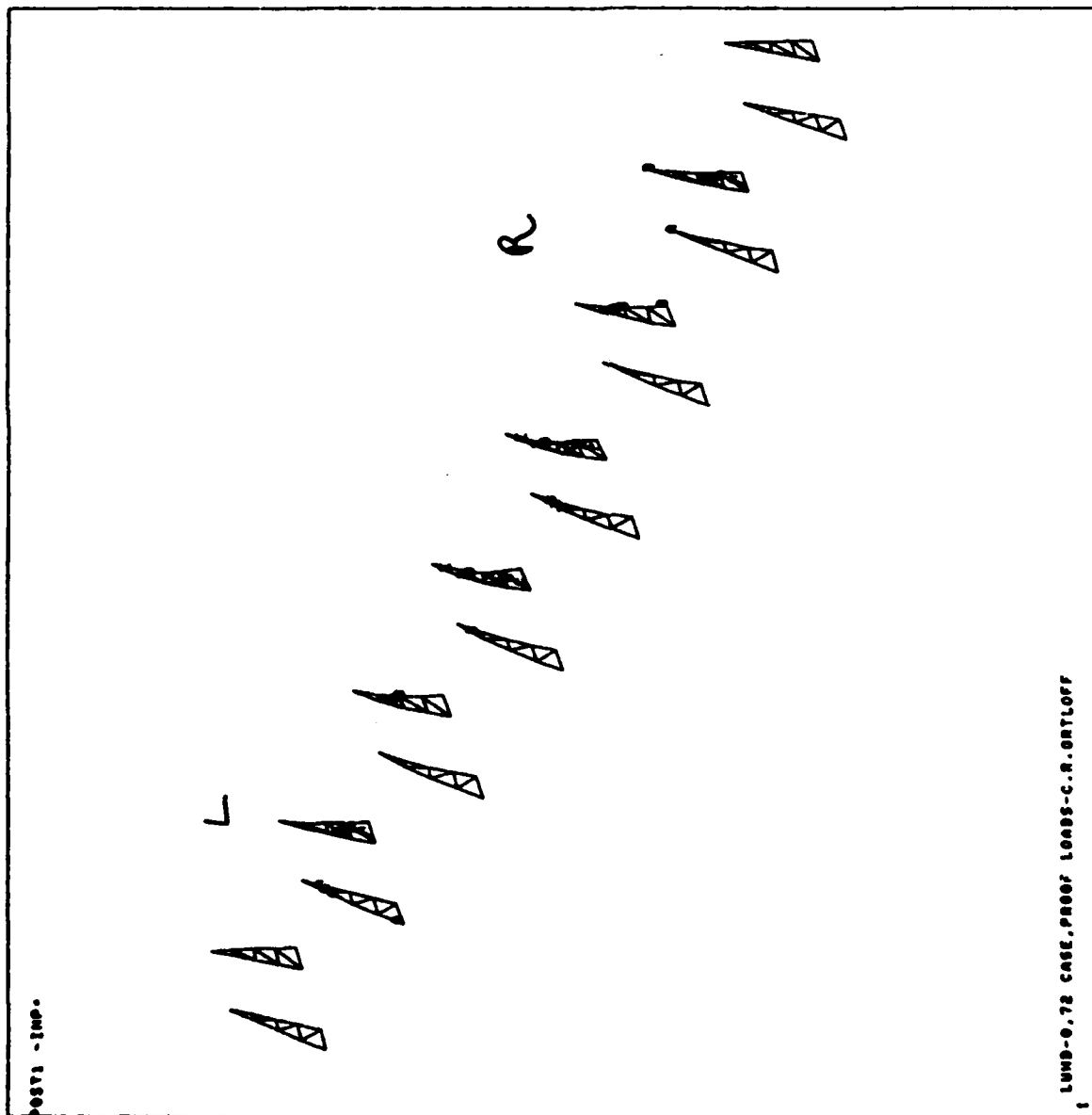
ANSYS 4.28
 DEC 26 1988
 18114139
 POST1 STRSS
 STEP=1
 TYPE=1
 TIME=.048
 SIZE
 TOP
 ZOOM
 KU=1
 VU=1
 ZV=1
 2 0161-28
 3 1F-73.8
 4 1F-5.39
 5 2F--8.11
 6 X870-1.3
 7 X870-1.82
 8 HIDDEN
 9 HX-88033
 10 HX-1888
 11 A-5863
 12 B-11141
 13 C-16419
 14 D-21897
 15 E-26875
 16 F-32853
 17 G-37521
 18 H-42809
 19 I-48887
 20 J-53365
 21 K-58643
 22 L-63821
 23 M-69195
 24 N-74477
 25 O-79755



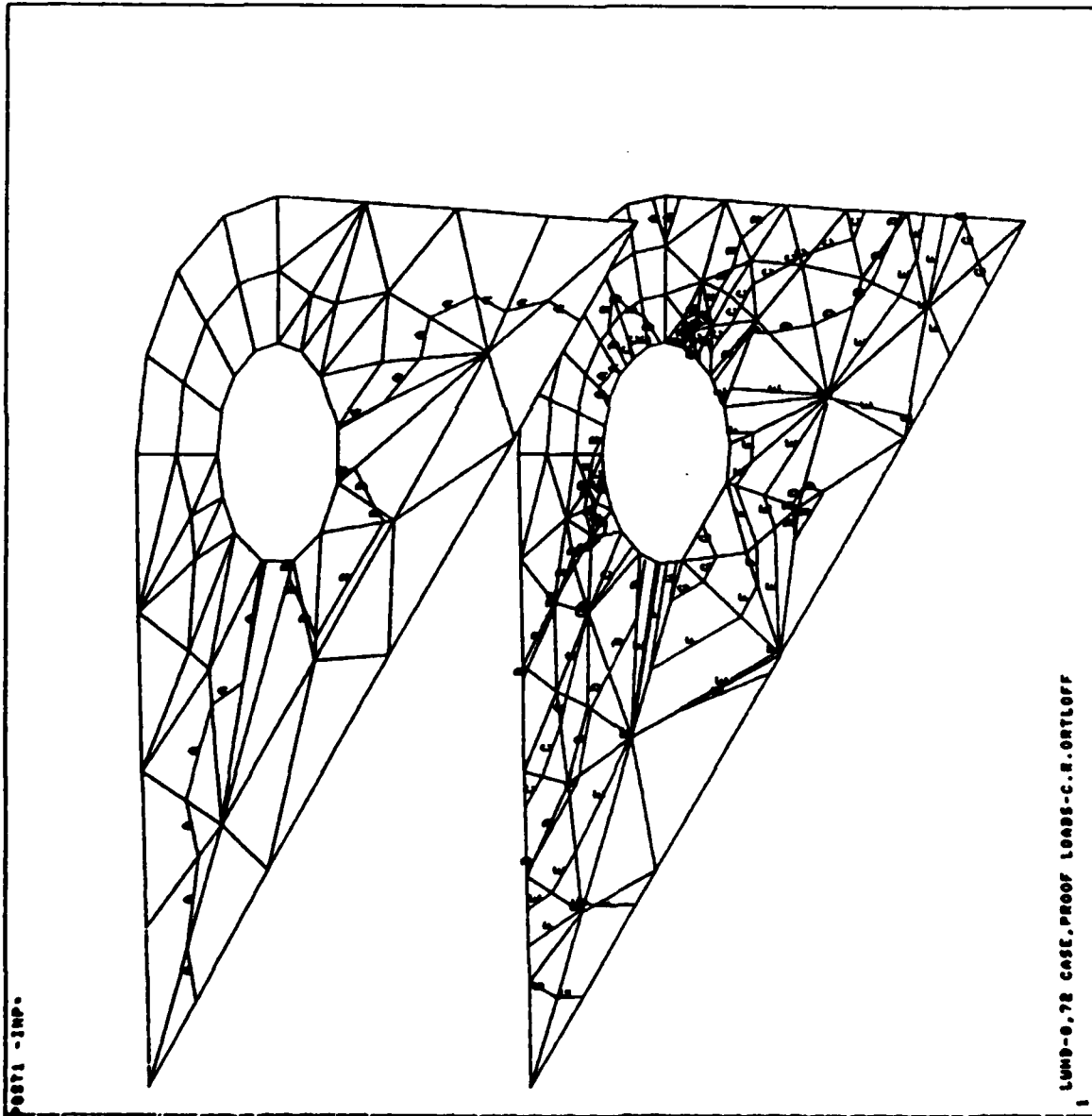
ANSYS 4.2B
 DEC 26 1988
 15:12:59
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.046
 SIDE
 TOP
 ZOOM
 XU=1
 YU=1
 ZU=1
 2 DIST=27.4
 2 KF=34
 2 VF=13
 2 ZF=12.6
 KATO=1.2
 VATO=1.56
 MIDDLE
 RK=2337
 RM=585
 A=14658
 B=28734
 C=42808
 D=56884
 E=70858



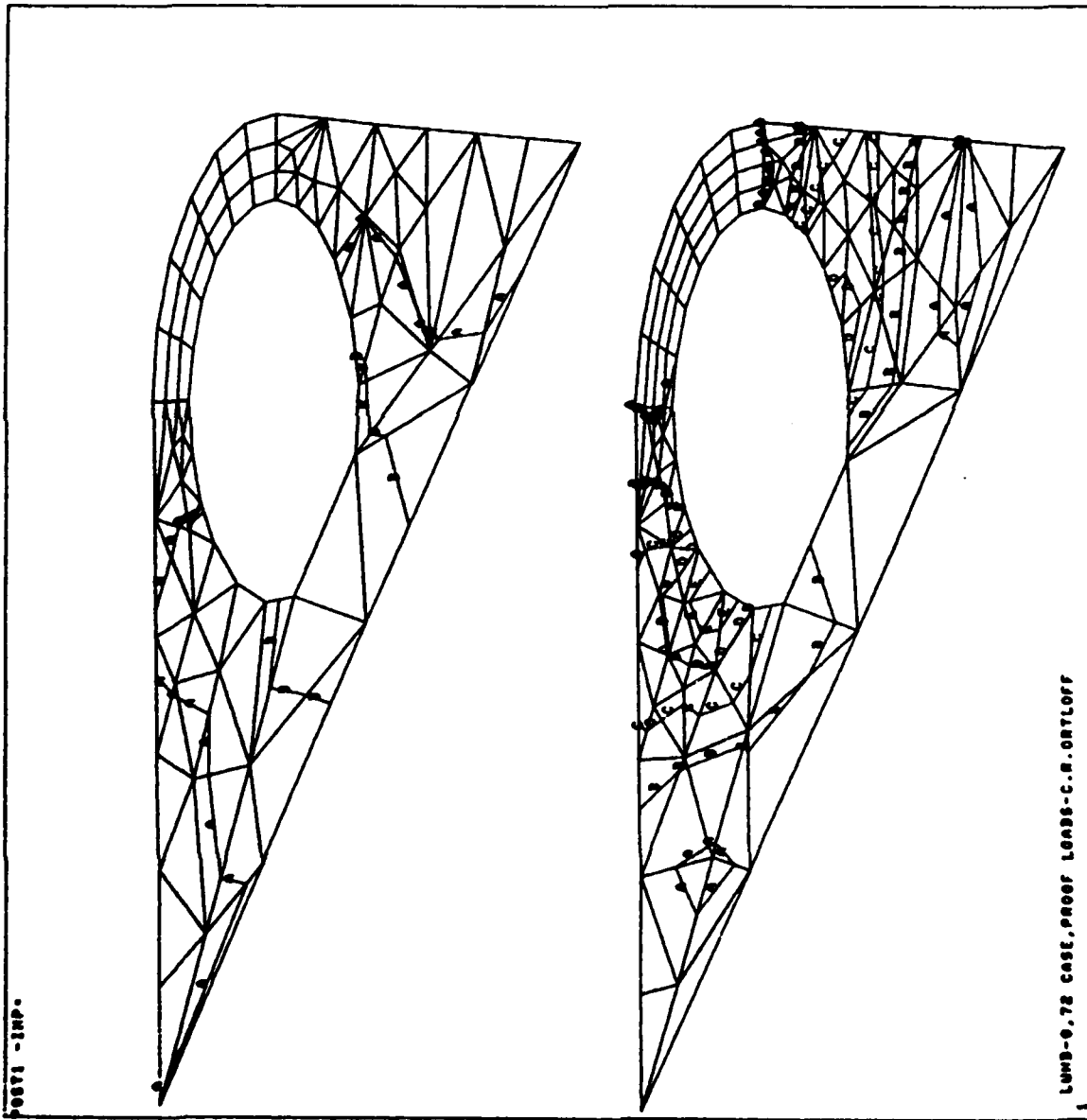
ANSYS 4.20
 DEC 26 1986
 15:18:59
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.046
 SICE
 TOP
 ZOOM
 XU=1
 YU=1
 ZU=1
 DIST=59.7
 WF=62.8
 VP=3.85
 ZP=3.3
 XRT0=1.3
 YRT0=1.29
 MIDDEN
 RX=88033
 MY=585
 A=14850
 B=20724
 C=42809
 D=56204
 E=70950



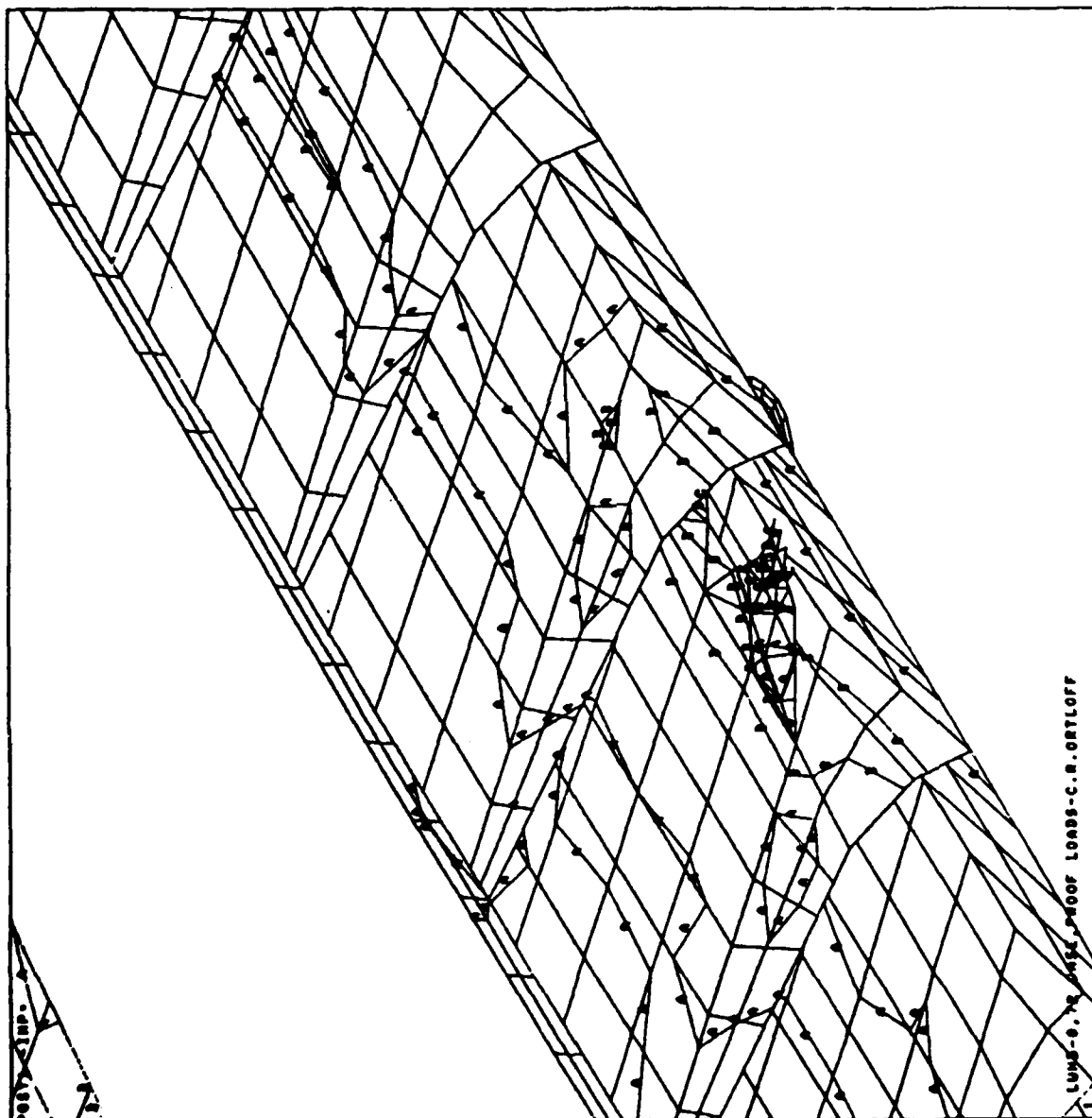
ANSYS 4.20
 DEC 26 1986
 15110157
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.046
 SLOC
 TOP
 ZOOM
 KU=1
 VU=1
 ZU=1
 DIST=8.08
 XF=44.3
 VF=88.8
 ZF=-11
 KATO=1.3
 VATO=1.29
 M100EM
 MX=28576
 MY=1803
 A=4367
 B=7833
 C=11299
 D=14765
 E=18231
 F=21697
 G=25163



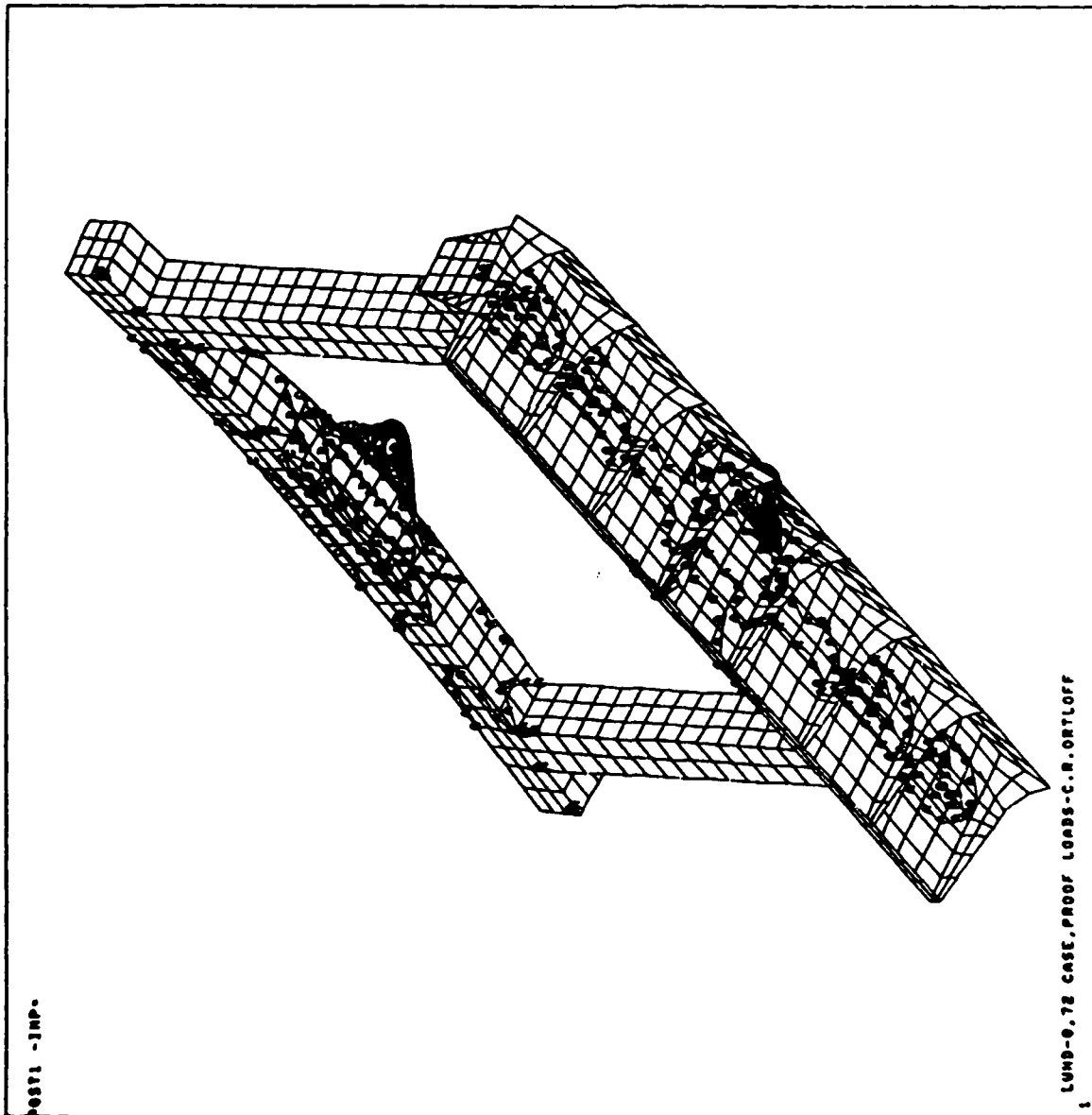
ANSYS 4.20
 DEC 26 1986
 15:09:30
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.046
 SLOC
 TOP
 ZOOM
 X0=1
 Y0=1
 Z0=1
 * DLIST=8,68
 * KP=62,1
 * VF=14,1
 * ZF=8,97
 XRT0=1,3
 HIDDEN
 MM=56356
 MM=803
 A=10143
 B=19386
 C=28629
 D=37872
 E=47115



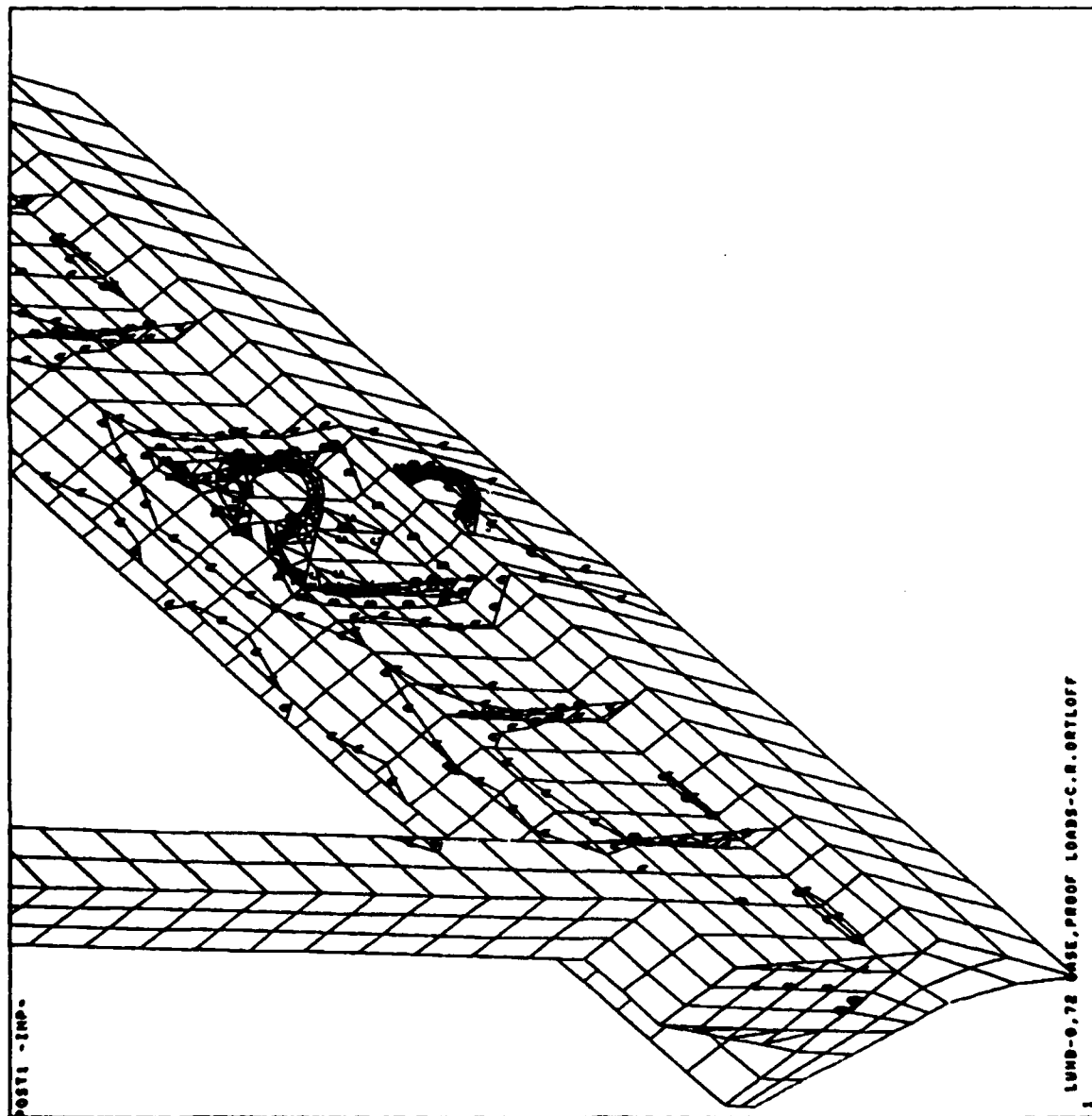
ANSYS 4.20
 DEC 26 1986
 14145107
 POST1 STRESS
 STEP=1
 ITEM=1
 TIME=.046
 SECT
 TOP
 ZOOM
 XU=1
 VU=-1
 ZU=.7
 2 8197-23.6
 2 XF-46.7
 2 VF-14.8
 2 ZF-5.61
 XRT0=1.49
 HIDDEN
 RX=67985
 RM=0
 A=11896
 B=23114
 C=34332
 D=45550
 E=56768



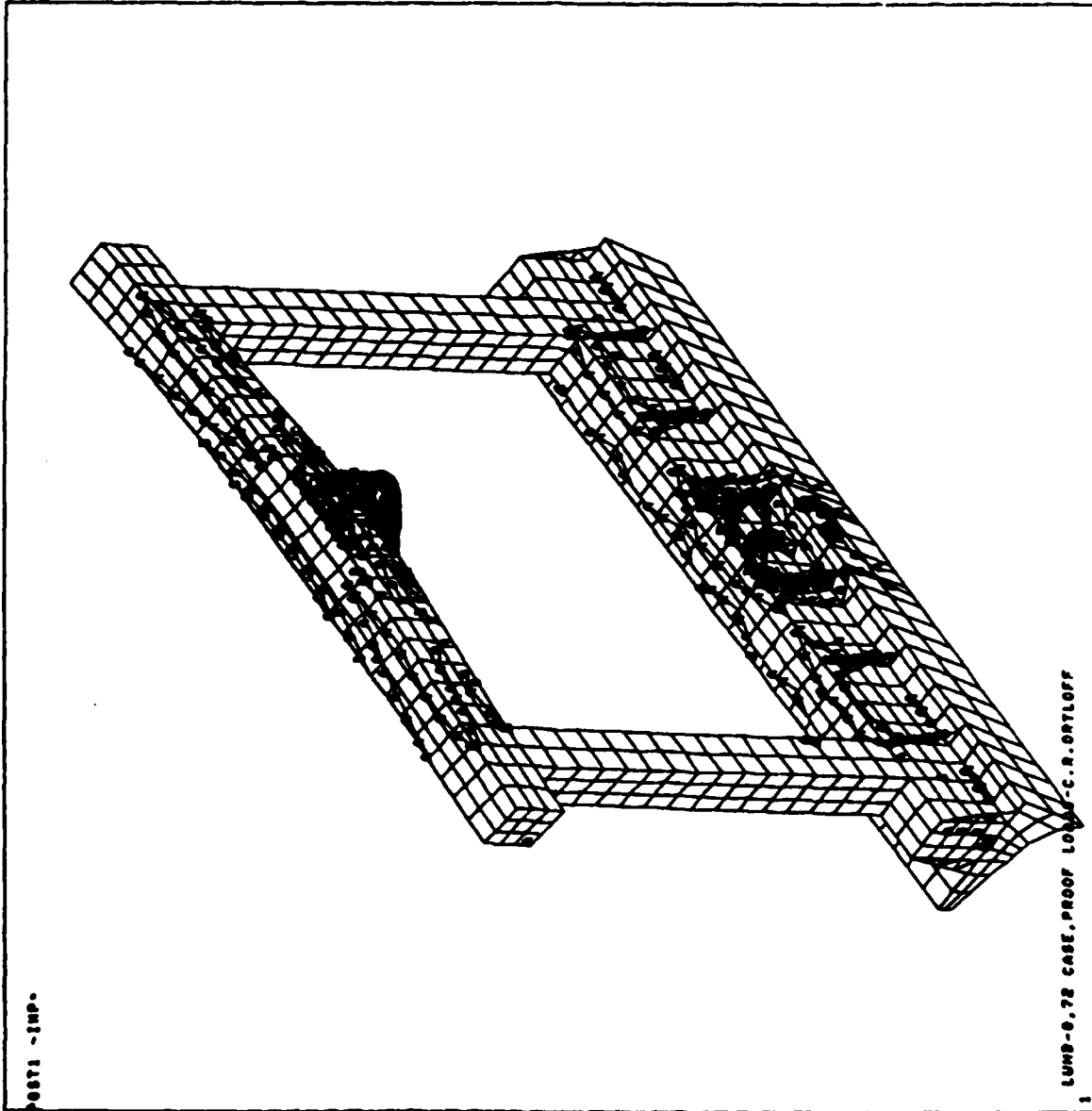
ANSYS 4.20
 DEC 26 1986
 14145107
 HOST1 STRESS
 STEP=1
 ITER=1
 TIME=.046
 SIZE
 TOP
 NU=1
 VU=-1
 ZU=.7
 2 3187-68.7
 2 37-51.4
 2 37-56.9
 2 27-4.88
 MIDDEN
 RM-6788
 RM-680
 A-11896
 B-23114
 C-24332
 D-46550
 E-56768



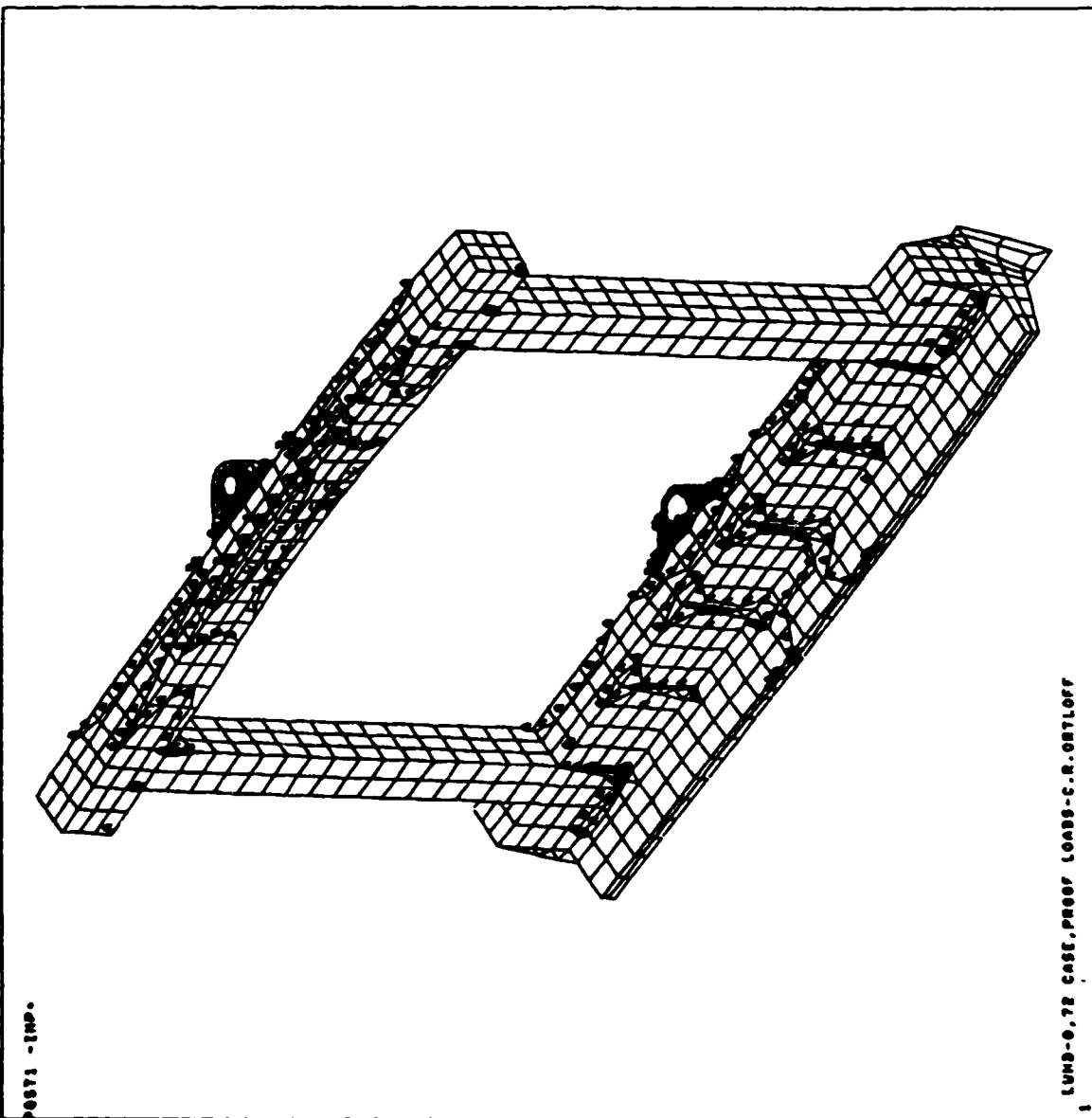
ANSYS 4.20
 DEC 26 1986
 14120150
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.046
 SIZE
 TOP
 ZOOM
 XU=1
 VU=1
 ZU=-1
 Z 2187.65.4
 Z KF=65.3
 Z VF=1.50
 Z ZF=-8.84
 XRT0=1.18
 VRT0=2.38
 MDOEN
 RK=67985
 RM=0
 A=11896
 B=23114
 C=34332
 D=45550
 E=56768



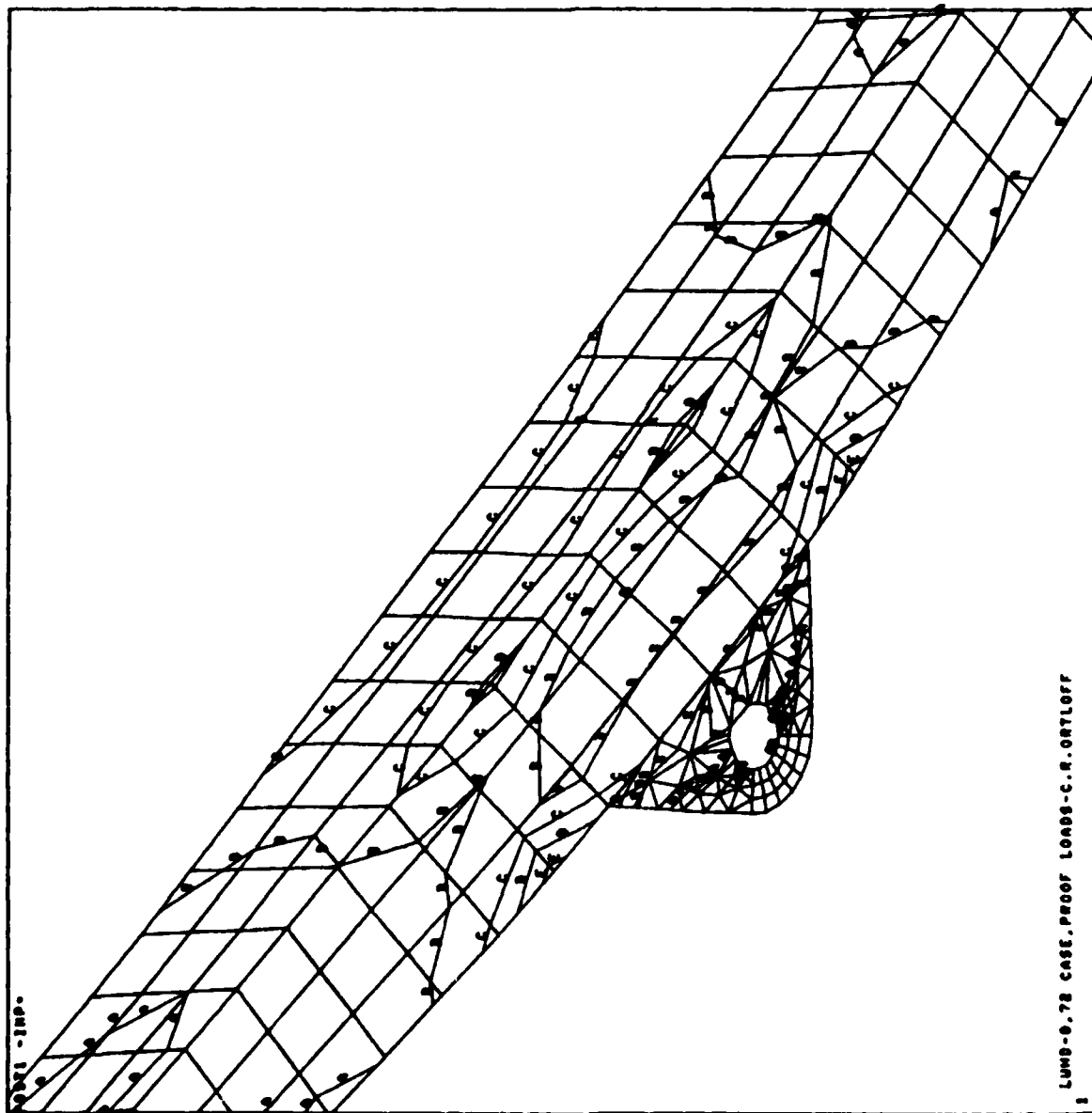
ANSYS 4.20
 DEC 26 1986
 14180150
 POST1 STRESS
 STEP=1
 FREQ=1
 TIME=.046
 SLOC
 TOP
 ZOOM
 MU=1
 VU=1
 VU=1
 20--1
 8 DISP=73.8
 8 XF=81.8
 8 VF=87.7
 8 ZF=4.17
 VARY=1.3
 HIDDEN
 RM=87005
 RM=880
 A=11896
 B=23114
 C=34332
 D=45550
 E=56768



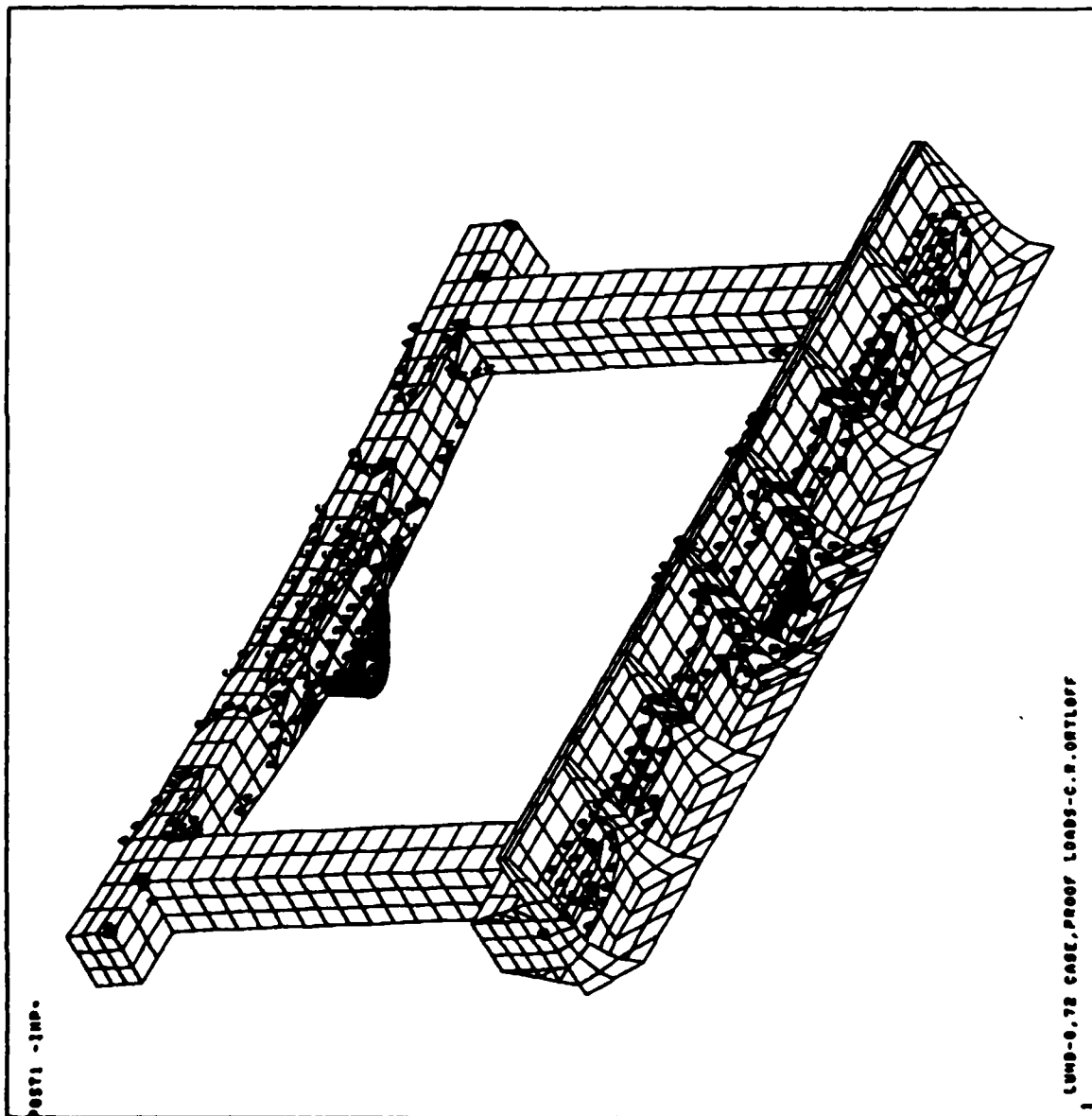
ANSYS 4.20
 DEC 26 1986
 14112168
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.046
 SIZE
 TOP
 ZOOM
 KU=1
 VU=1
 ZU=1
 1 DIST=72.8
 2 MF=51.2
 3 VF=27.7
 4 2F=4.17
 5 VRT0=1.3
 WIDEN
 RH=67886
 RH=680
 A=11806
 B=23114
 C=34332
 D=45550
 E=56768



ANSYS 4.20
 DEC 26 1986
 13:58:54
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.048
 SLOC
 TOP
 ZOOM
 XU=-1
 VU=-1
 ZU=-1
 5 DIST=22.7
 5 XF=41.2
 5 VF=47.1
 5 ZF=12.6
 VRT0=1.3
 HIDDEN
 RK=63157
 RM=0
 A=11896
 B=23114
 C=34332
 D=46560
 E=58768

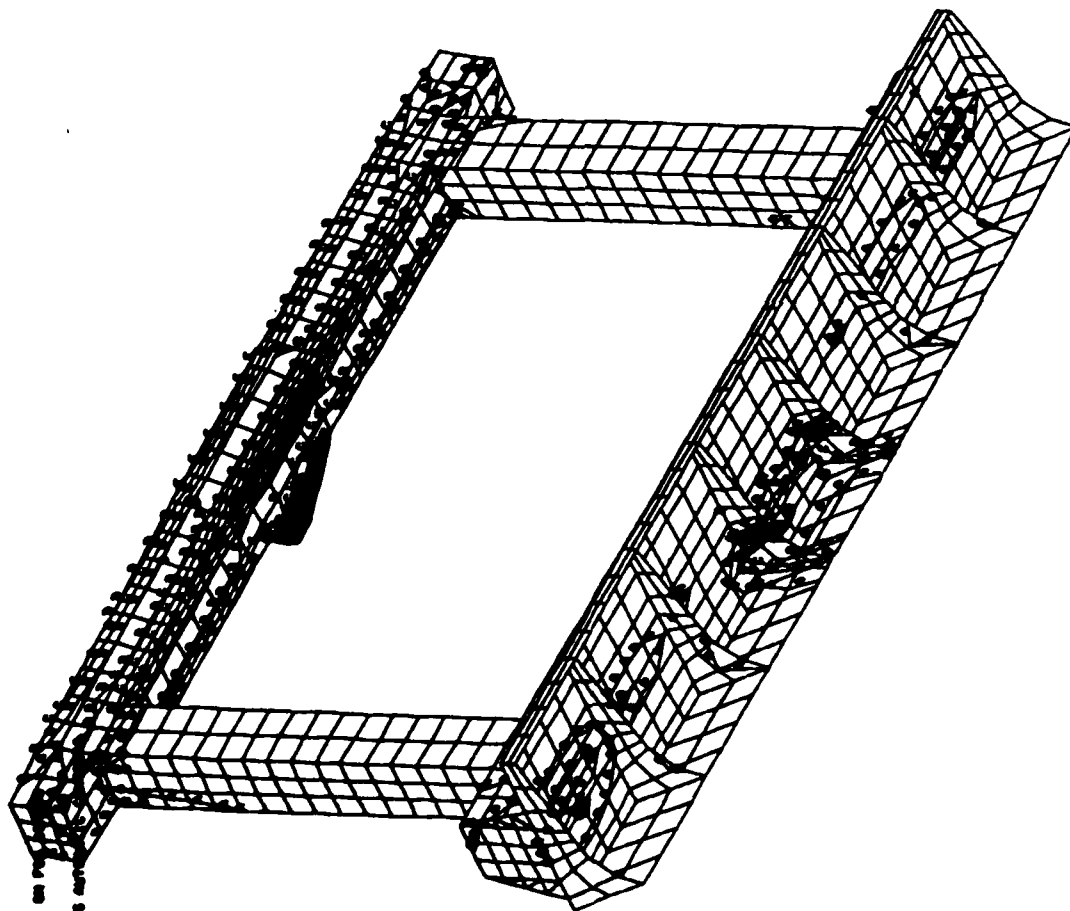


ANSYS 4.20
 DEC 26 1986
 1316154
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.048
 SLOC
 TOP
 NU=-1
 VU=-1
 ZU=1
 8 S1S7=50.8
 8 XF=54.2
 8 YF=26.4
 8 ZF=4.85
 MIDDEN
 RH=67085
 RH=680
 A=11896
 B=83114
 C=34338
 D=46850
 E=98768



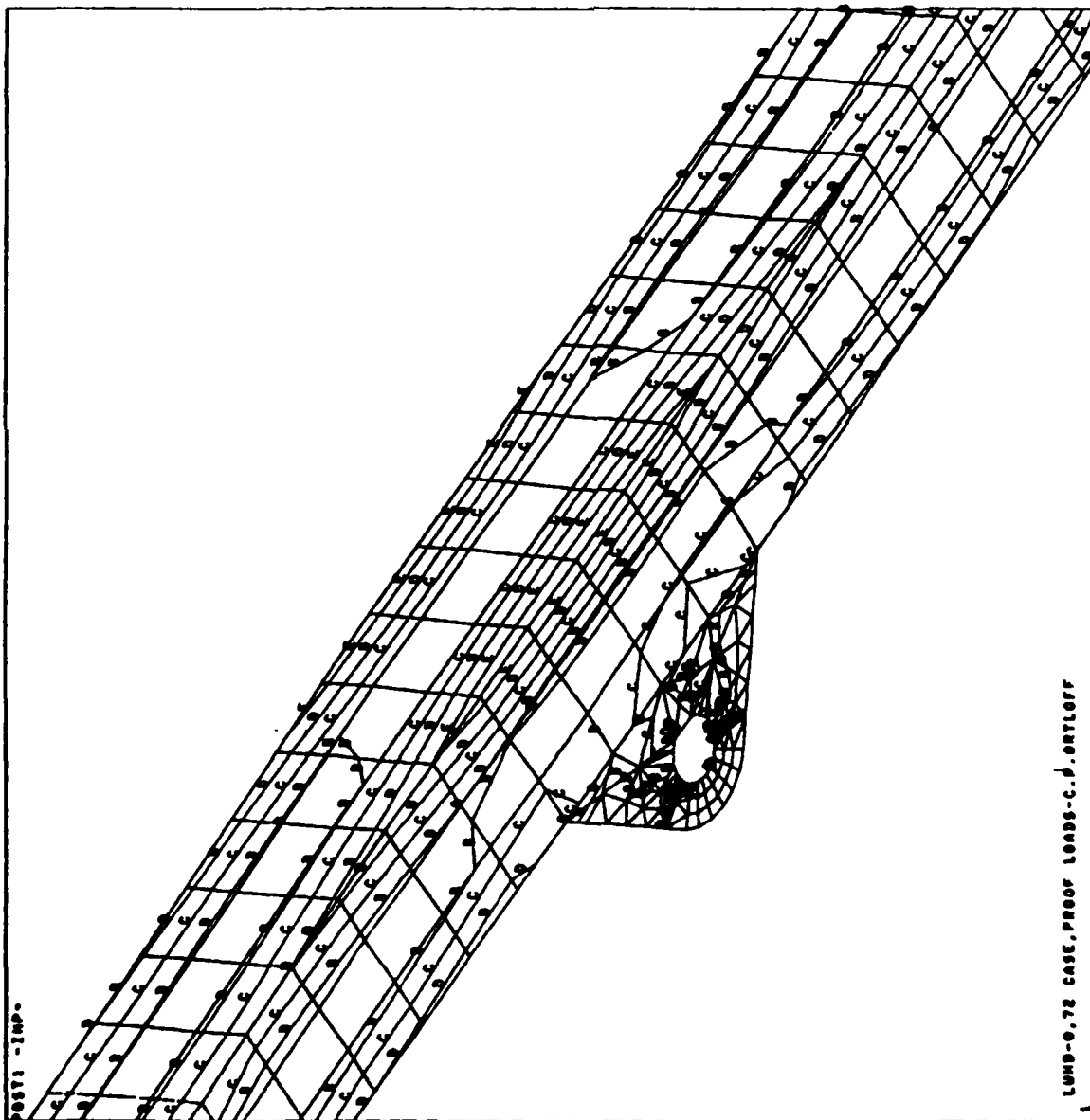
[illegible]

1951-1952
CLASS 1.1

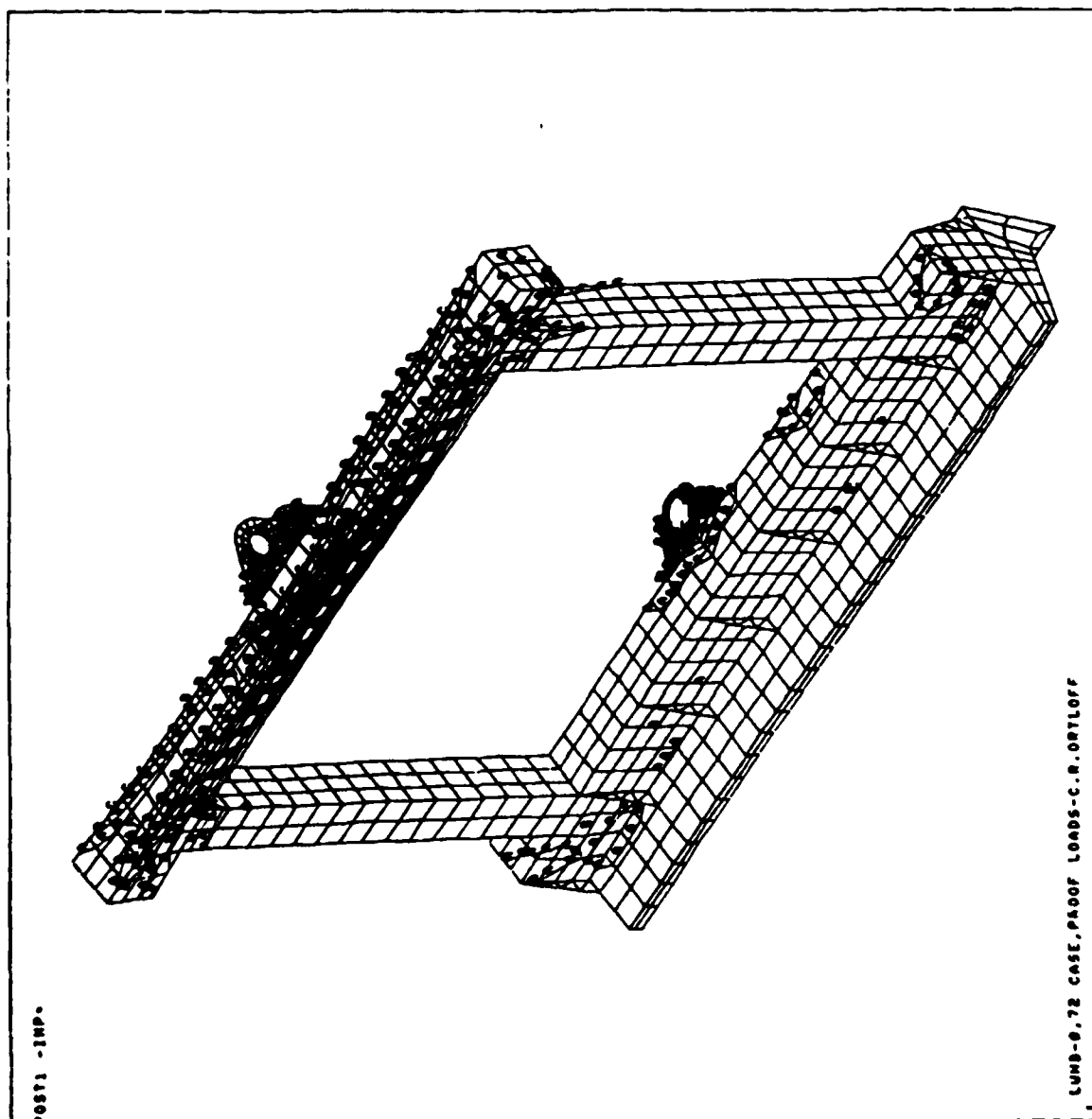


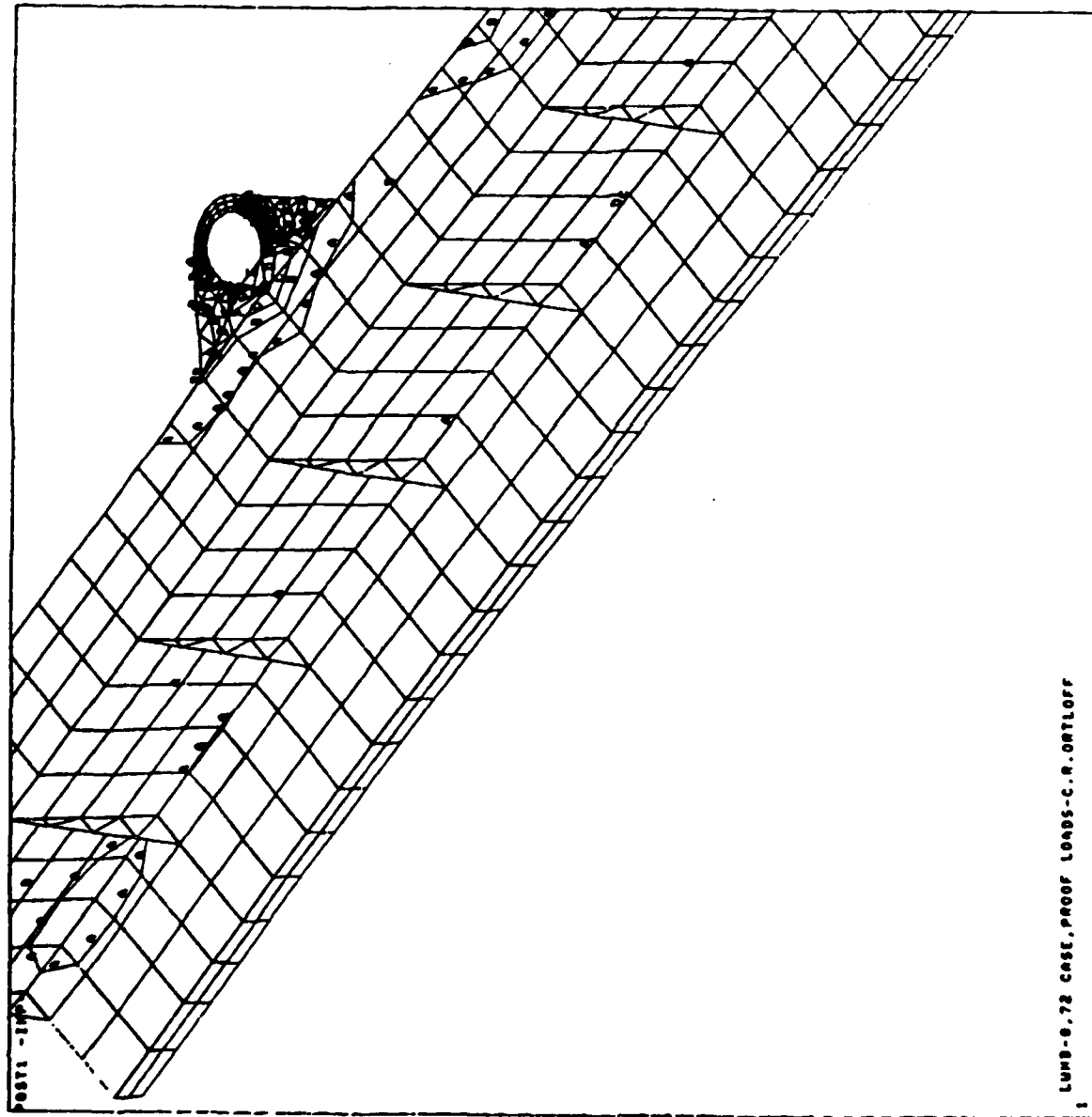
LA00-0,78 CASE, FROM LA00-C.0.0.071009

ANSYS 4.80
 DEC 20 1980
 1314519
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.280
 SICE
 TOP
 ZOOM
 RV=-1
 VU=-1
 ZU=1
 2 DIST=22
 2 XF=43.7
 2 YF=48.8
 2 ZF=16.8
 VRT0=1.81
 HIDDEN
 RM=18431
 RM=0
 A=3178
 B=6220
 C=9280
 D=12331
 E=15382



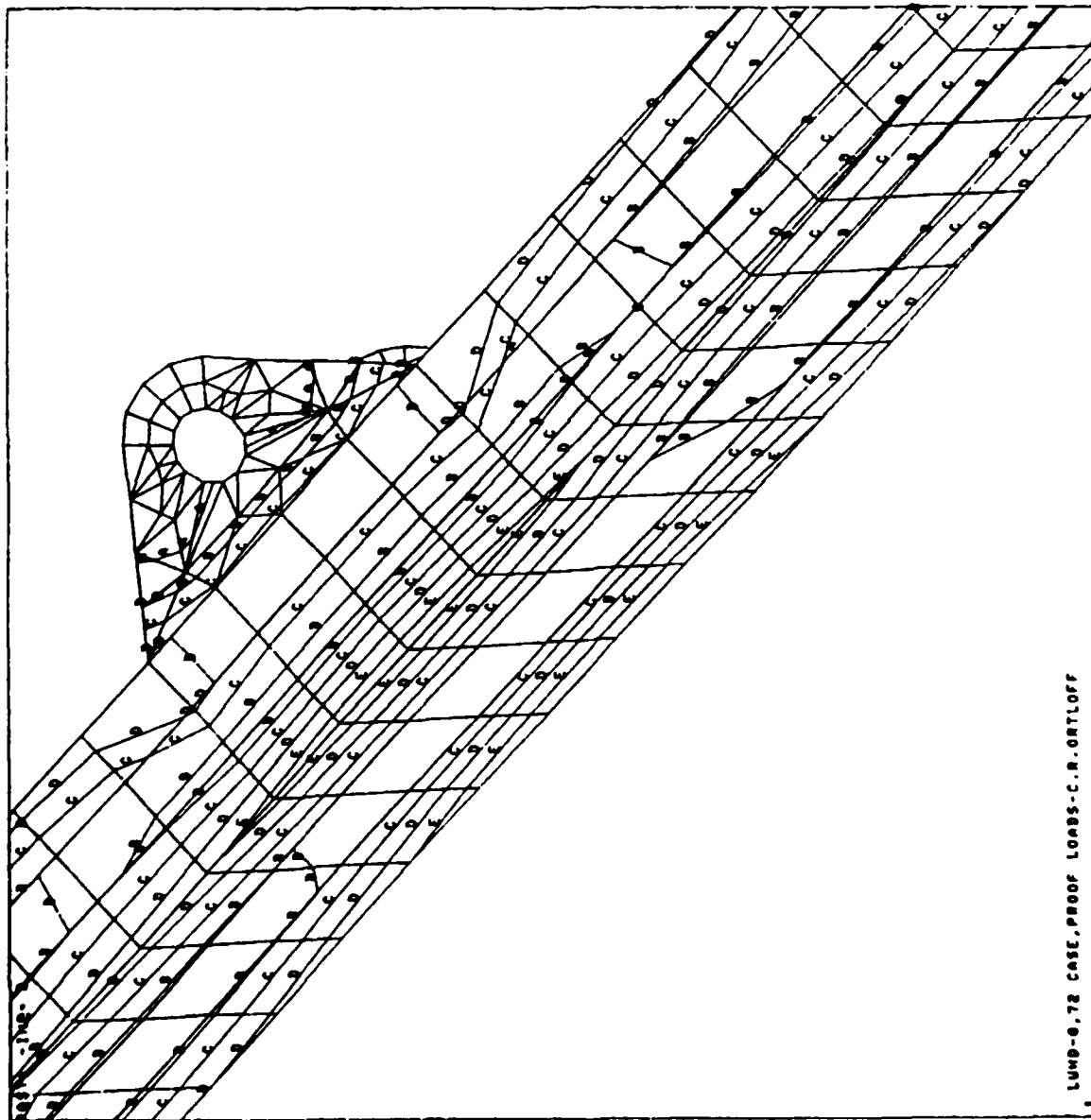
ANSYS 4.28
 DEC 28 1986
 13:58:58
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.258
 SICE
 TOP
 ZOOM
 XZ=1
 YZ=1
 ZU=1
 1 DIST=68.7
 2 XF=51.2
 3 YF=27.7
 4 ZF=4.17
 VRT0=1.21
 MIDEN
 MN=10431
 MN=128
 A=3178
 B=6229
 C=9280
 D=12321
 E=15382



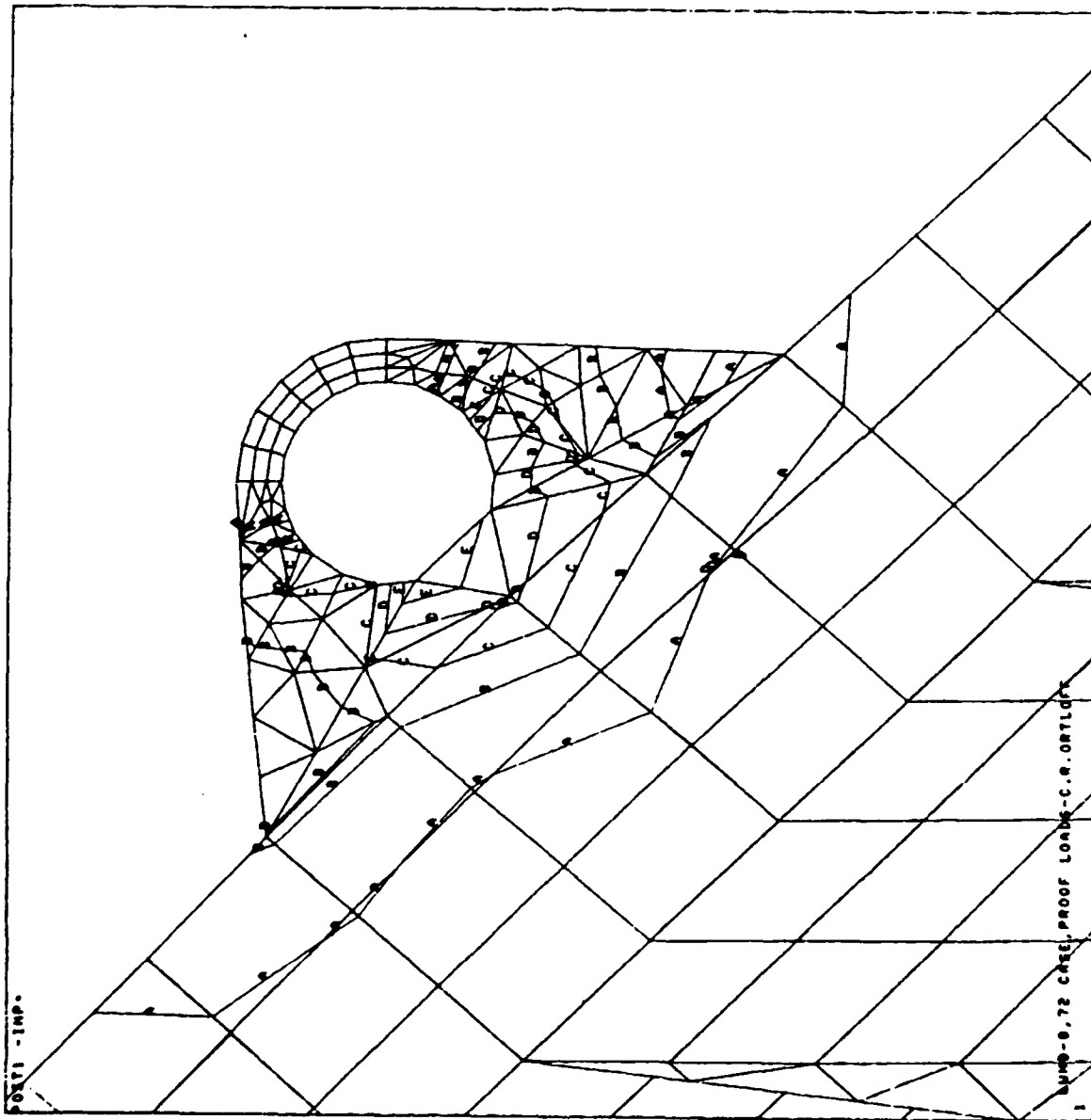


ANSYS 4.00
 DEC 28 1986
 13158150
 POST1 STRESS
 STCP=1
 ITER=1
 TIME=.358
 SICE
 TOP
 ZOOM
 XU=1
 VU=1
 ZU=1
 1 8187-33.3
 2 8 XF-53.6
 3 8 VF-5.13
 4 26-24.2
 5 VRTD-1.34
 MIDDEN
 RM-17588
 RM-6
 A-3178
 B-6229
 C-9280
 D-12331
 E-15382

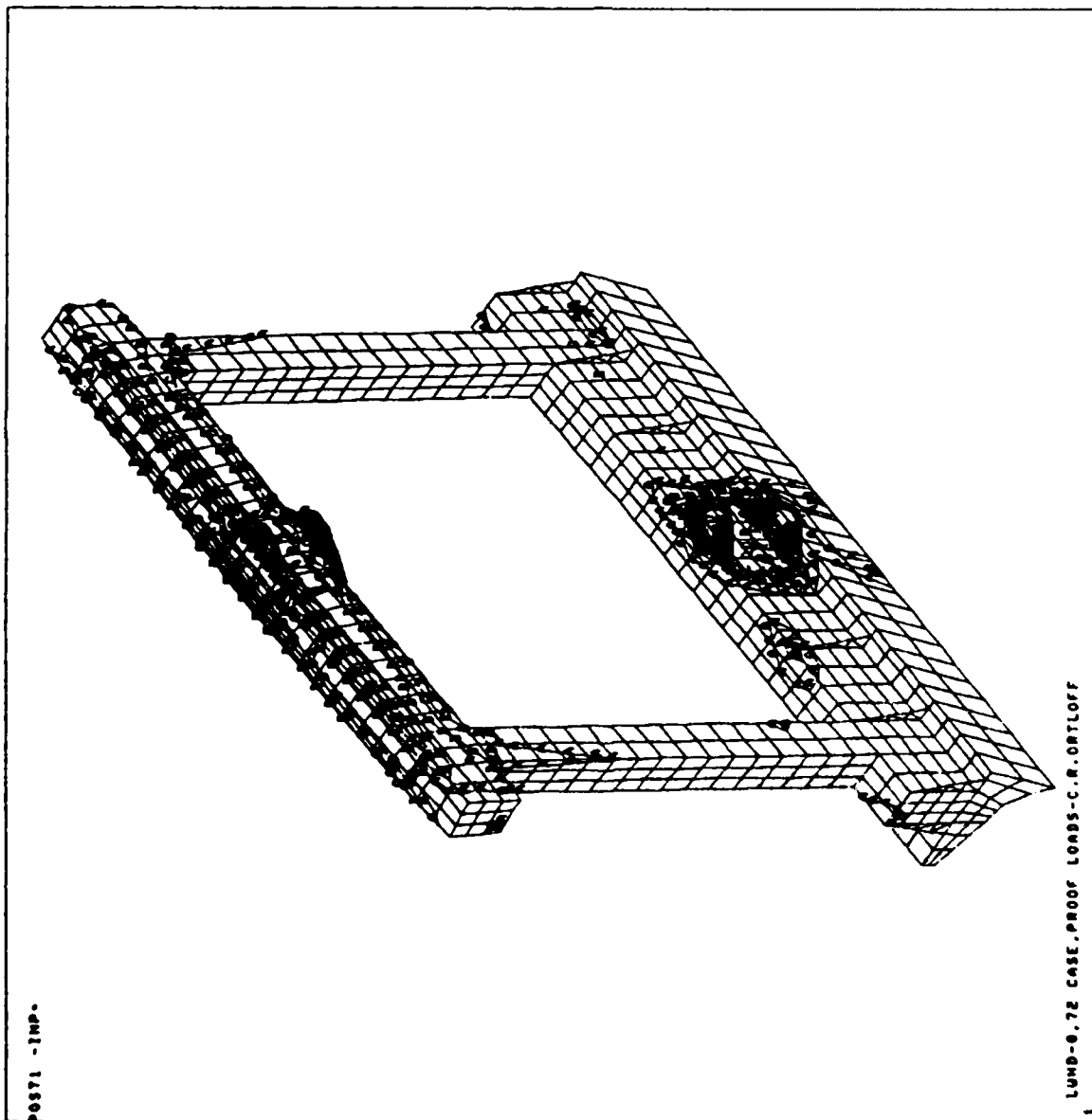
ANSYS 4.2B
 DEC 28 1986
 1410312
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.858
 SICE
 TOP
 200H
 XU=1
 YU=1
 ZU=1
 1 DIST=20.1
 2 XF=42.8
 3 YF=46.6
 4 ZF=6.39
 VRT0=1.81
 MIBDEM
 MX=18431
 MY=0
 A=3178
 B=6229
 C=9280
 D=12331
 E=15382



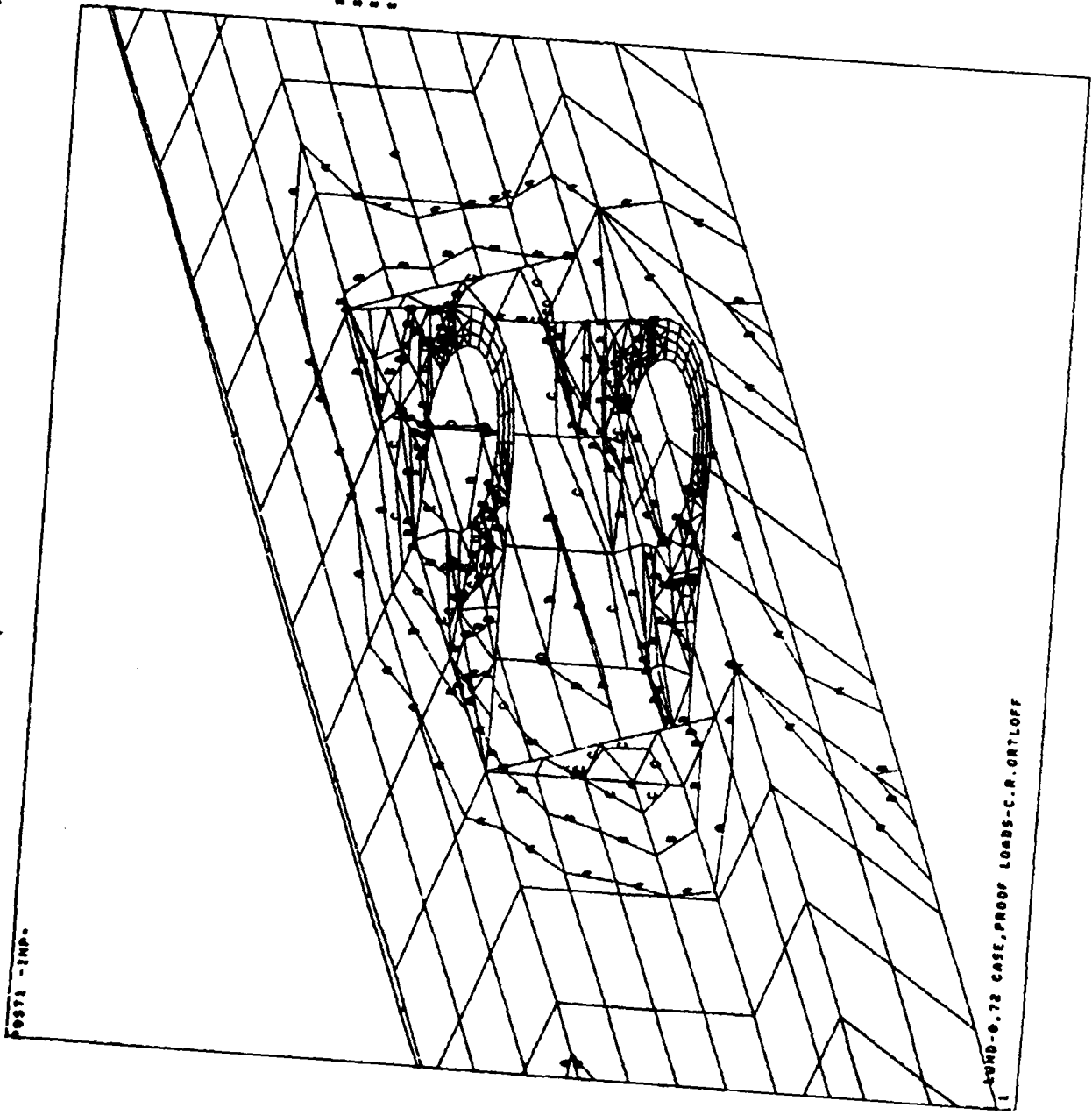
ANSYS 4.20
 DEC 20 1986
 14122117
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.250
 SICE
 TOP
 ZOOM
 KU=1
 VU=1
 ZU=1
 8 DIST=12.3
 8 XF=60.6
 8 YF=15.5
 8 ZF=6.94
 VRT0=1.84
 WIDEN
 RM=17599
 RM=6
 A=3178
 B=6220
 C=9280
 D=12331
 E=15382



ANSYS 4.28
 DEC 28 1986
 14149142
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.258
 SIZE
 TOP
 ZOOM
 KU=1
 VU=1
 ZU=-1
 DIST=232
 XC=54.2
 YF=26.4
 ZF=4.86
 XRT0=2.77
 YRT0=4
 HIDDEN
 RX=18431
 RM=129
 A=3178
 B=6229
 C=9280
 D=12331
 E=15382



POST1 -IMP.

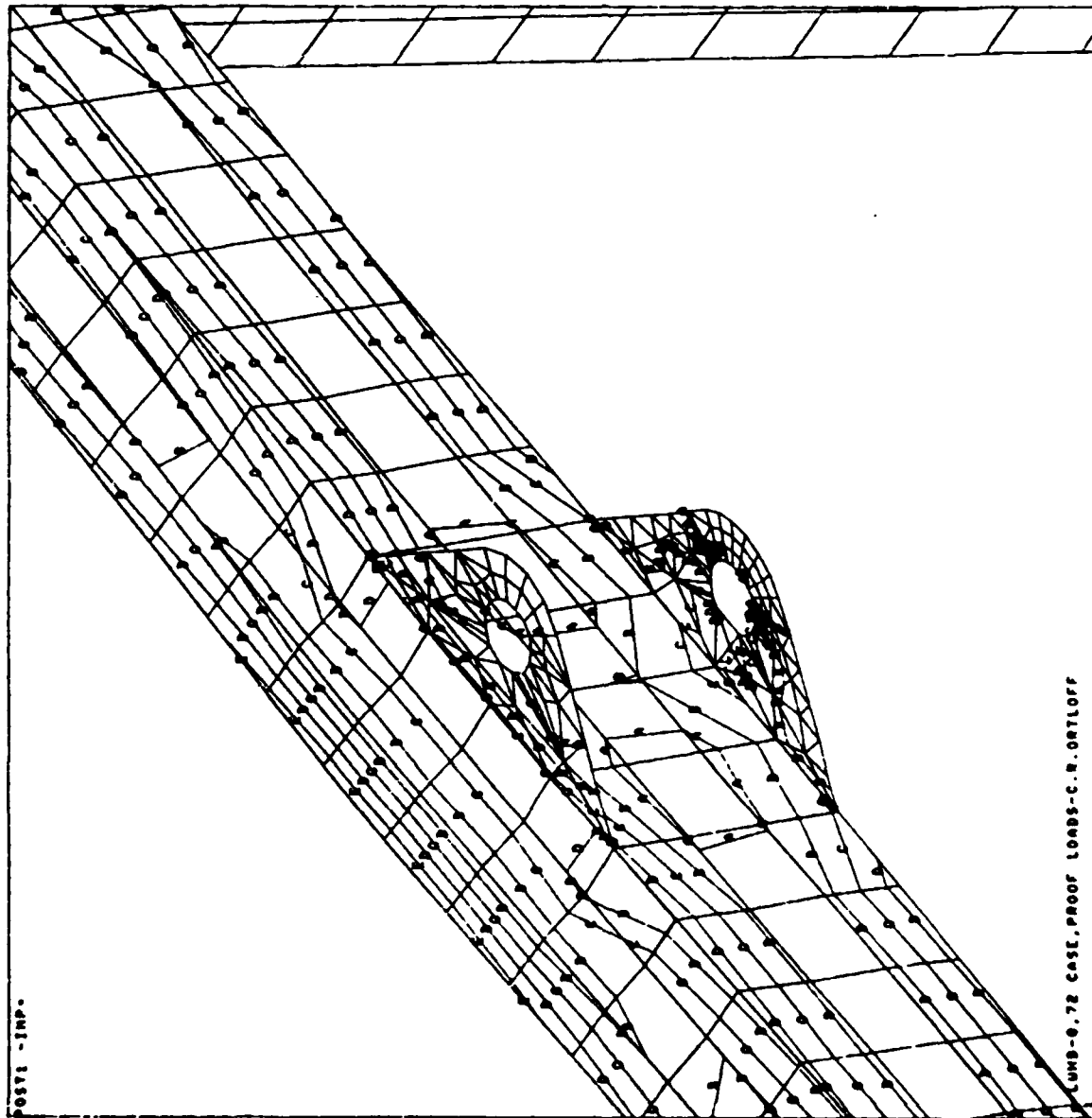


1 SUBD-0.72 CASE, PROOF LOADS-C.R. OUTFLOW

ANSYS 4.28
DEC 28 1986
1413113
POST1 STRESS
STEP=1
ITER=1
TIME=.000
SIZE
TOP
ZOOM
NU=1
VU=1
ZU=-1
1 DIST=34.2
2 XF=59.7
3 VF=9.58
4 ZF=-6.37
KATO=2.77
VATO=1.84
HIDDEN
RX=17588
RY=0
A=3178
B=6229
C=9280
D=12331
E=15382

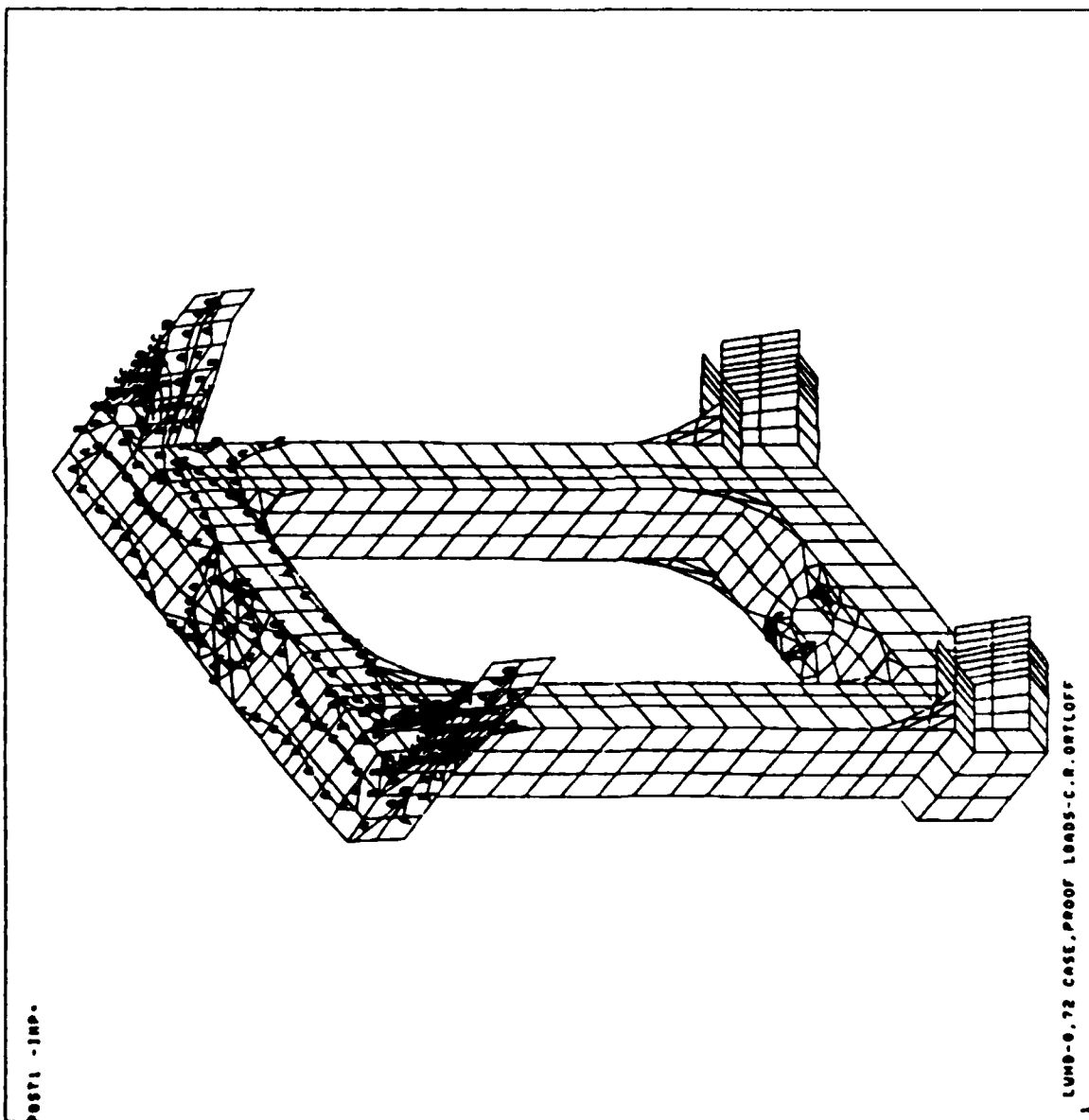
BOTTOM

ANSYS 4.20
 DEC 28 1986
 14:41:07
 POST1 STRESS
 STEP=1
 LAYER=1
 TIME=.250
 SICE
 TOP
 ZOOM
 XU=1
 VU=1
 ZU=-1
 1 BIST-56.4
 2 XF-37.9
 3 VF-49.8
 4 ZF-11.9
 5 XRTQ-2.77
 6 VRTQ-4
 7 MISEN
 8 MX-18431
 9 MN-9
 10 A-3178
 11 B-6229
 12 C-9280
 13 D-12331
 14 E-15382

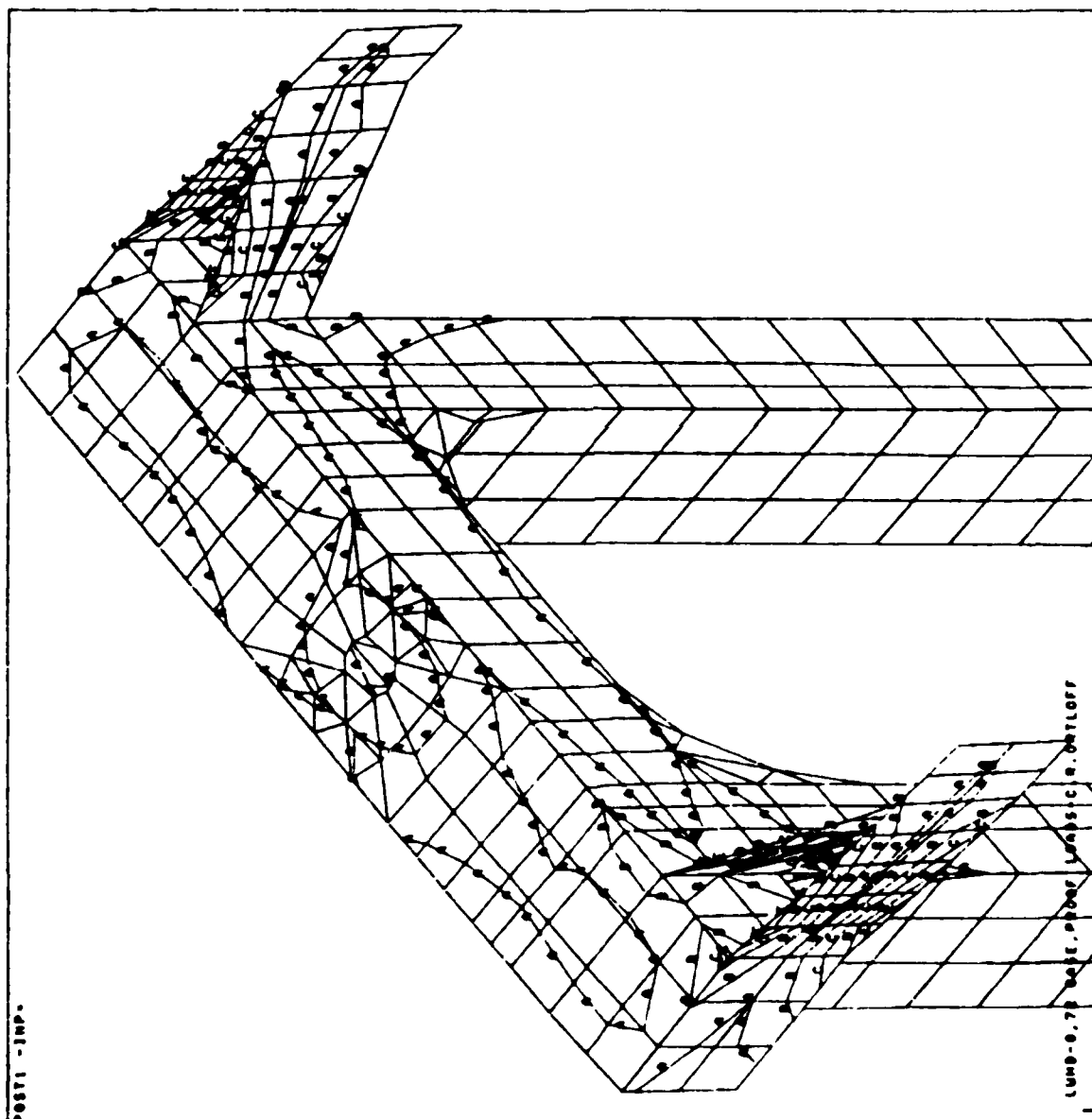


TOP

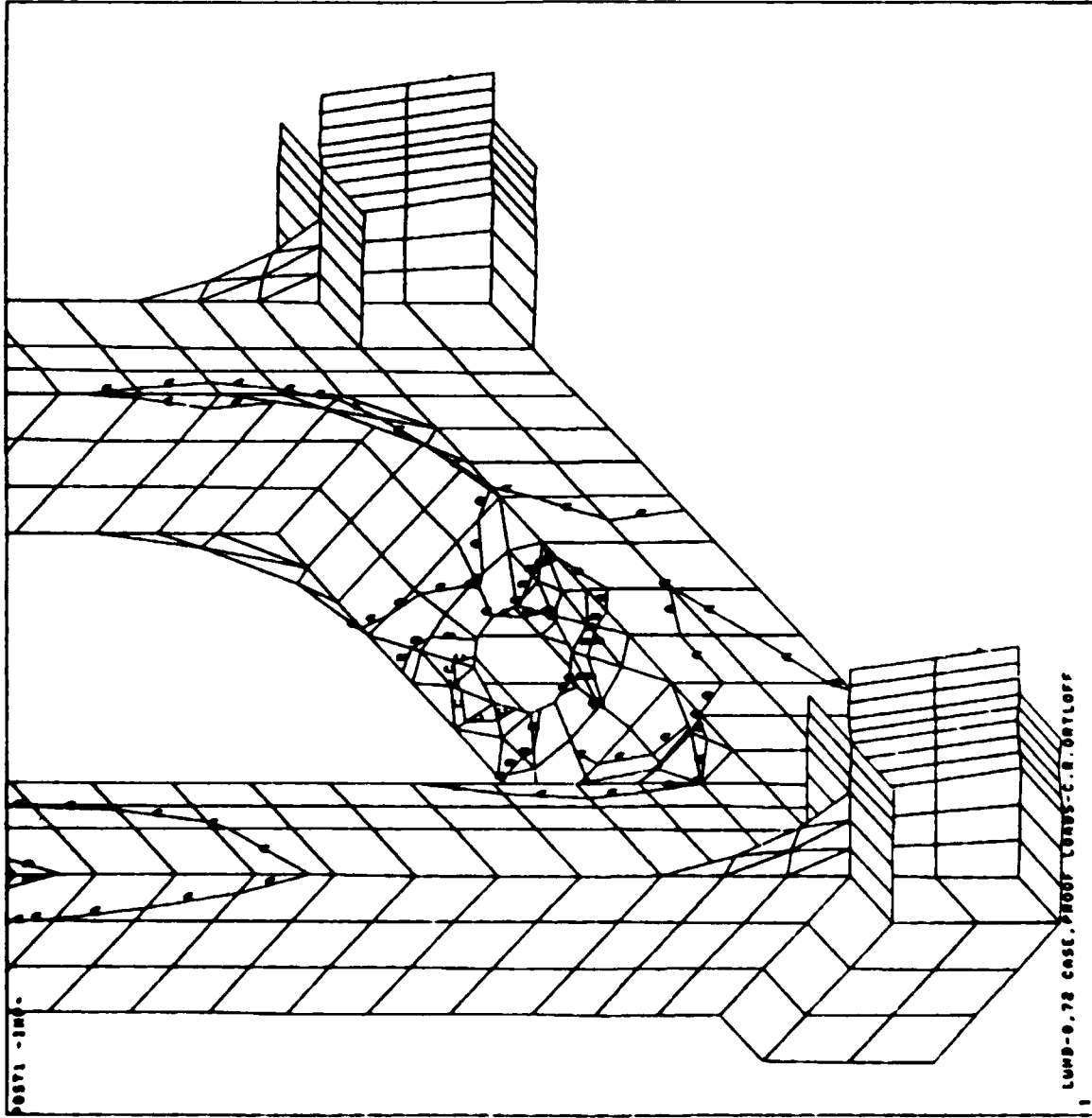
ANSYS 4.20
 DEC 28 1986
 14157126
 POST1 STRESS
 STEP=1
 LAYER=1
 TIME=.258
 SIZE
 TOP
 ZOOM
 KU=1
 VU=1
 ZU=-1
 DIST=131
 XF=51.6
 YF=35.8
 ZF=-8.57
 XRT0=2.77
 YRT0=4
 HIDDEN
 NX=192039
 NY=127
 A=32111
 B=64087
 C=96083
 D=128069
 E=160065



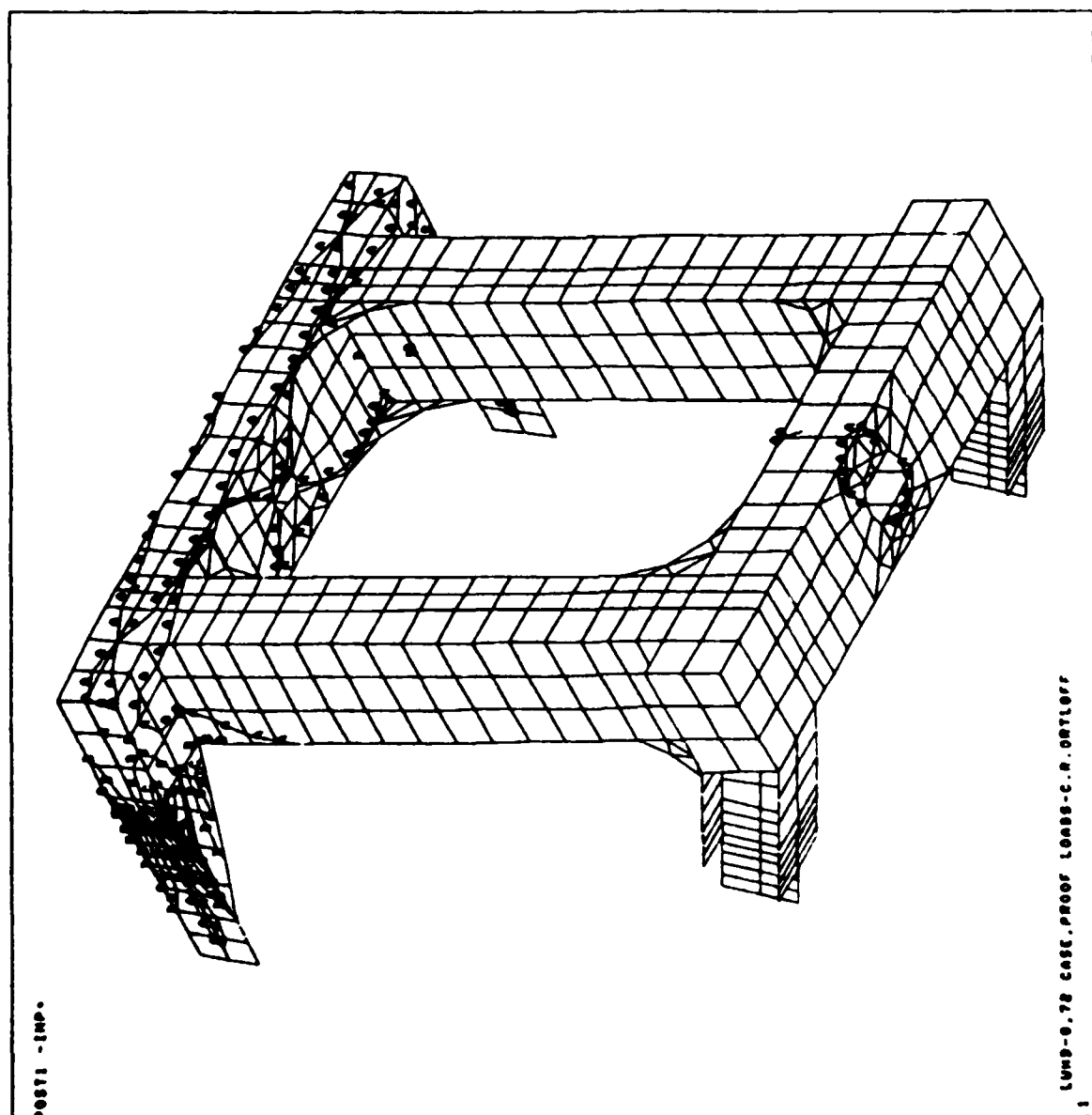
ANSYS 4.20
 DEC 28 1986
 14157136
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.258
 SIGC
 TOP
 ZOOM
 KU=1
 VU=1
 ZU=1
 1 DIST=66.9
 2 XF=46.8
 3 VF=46.8
 4 ZF=2.64
 KRYO=2.77
 VRYO=4.13
 MIDDEN
 AK=192030
 RM=0
 A=32111
 B=64007
 C=96003
 D=128009
 E=160055



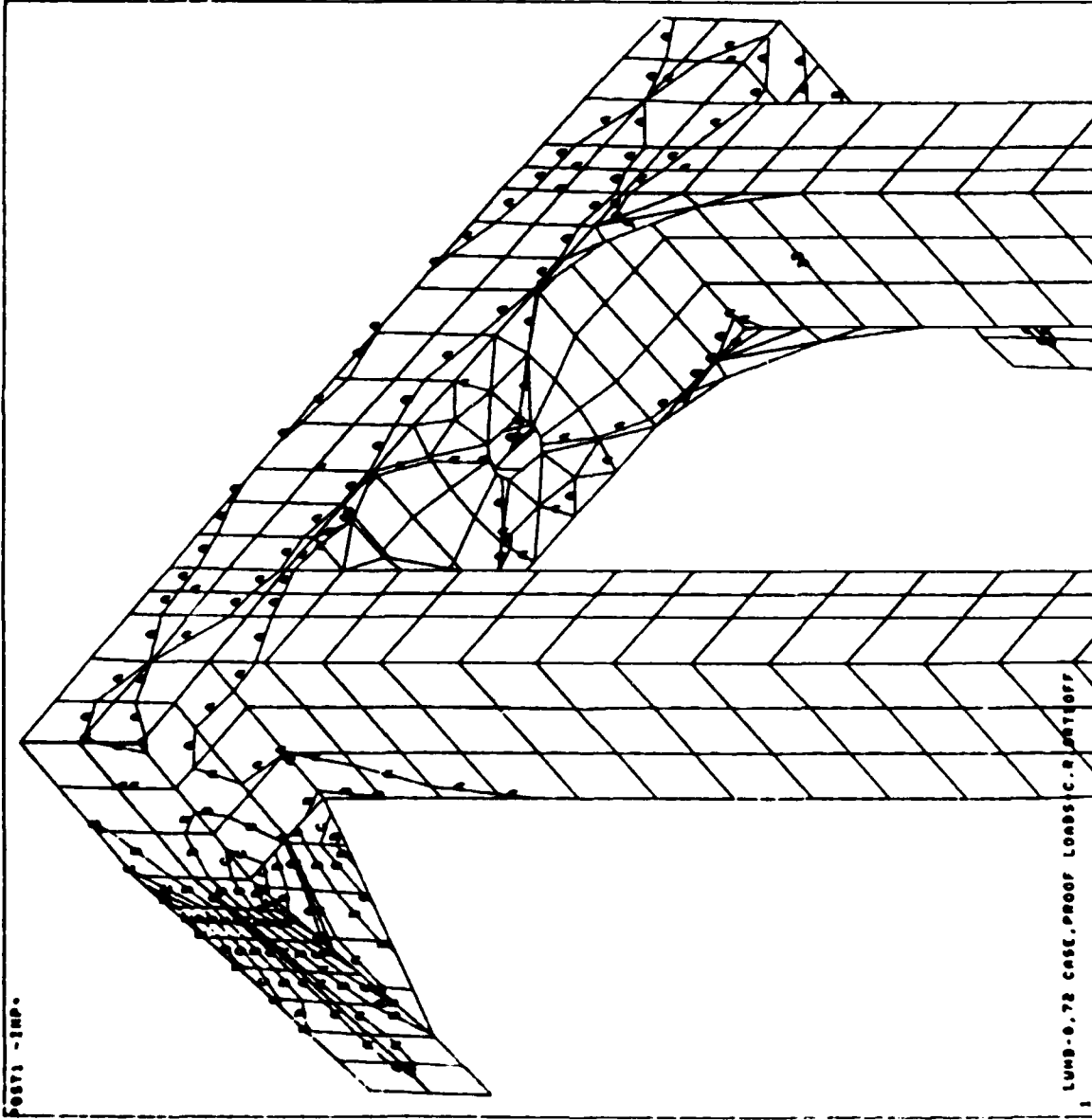
ANSYS 4.20
 DEC 20 1988
 15:03:59
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.298
 SISE
 TOP
 ZOOM
 KU=1
 VU=1
 ZU=-1
 * BIST-64.5
 * KF=58.5
 * VF=22.1
 * ZF=-14.8
 * KATO=2.77
 * VETO=4.47
 * HIDDEN
 * KX=52420
 * MN=0
 * A=13118
 * B=24113
 * C=36108
 * D=48102



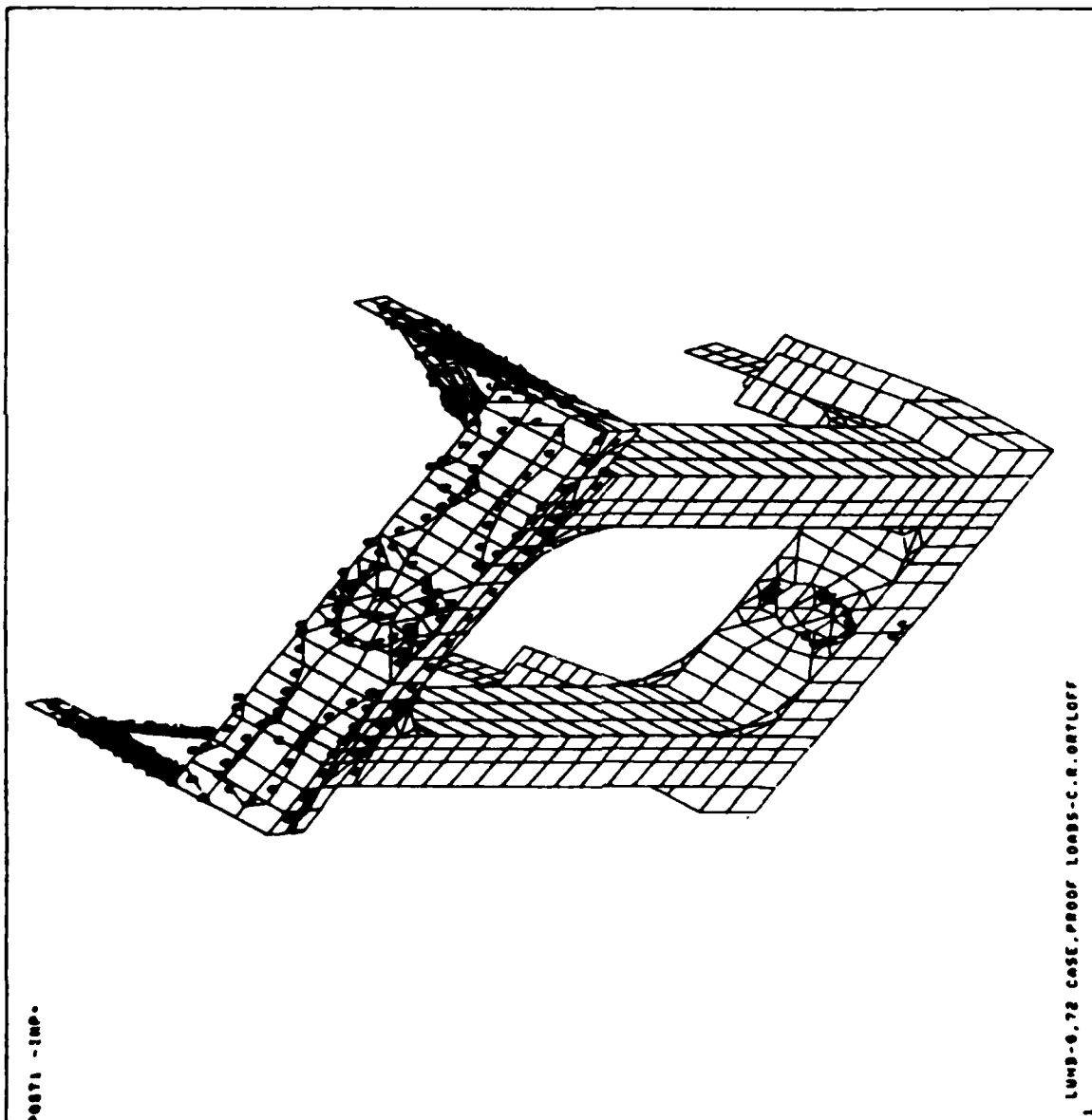
ANSYS 4.20
 DEC 20 1986
 15:10:25
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.250
 SLOC
 TOP
 NU=1
 VU=1
 20=1
 S1S7=32.7
 SF=51.6
 VF=35.8
 ZF=-8.57
 MIDEN
 ME=102030
 MN=127
 A=32111
 B=64097
 C=06083
 D=128069
 E=160055



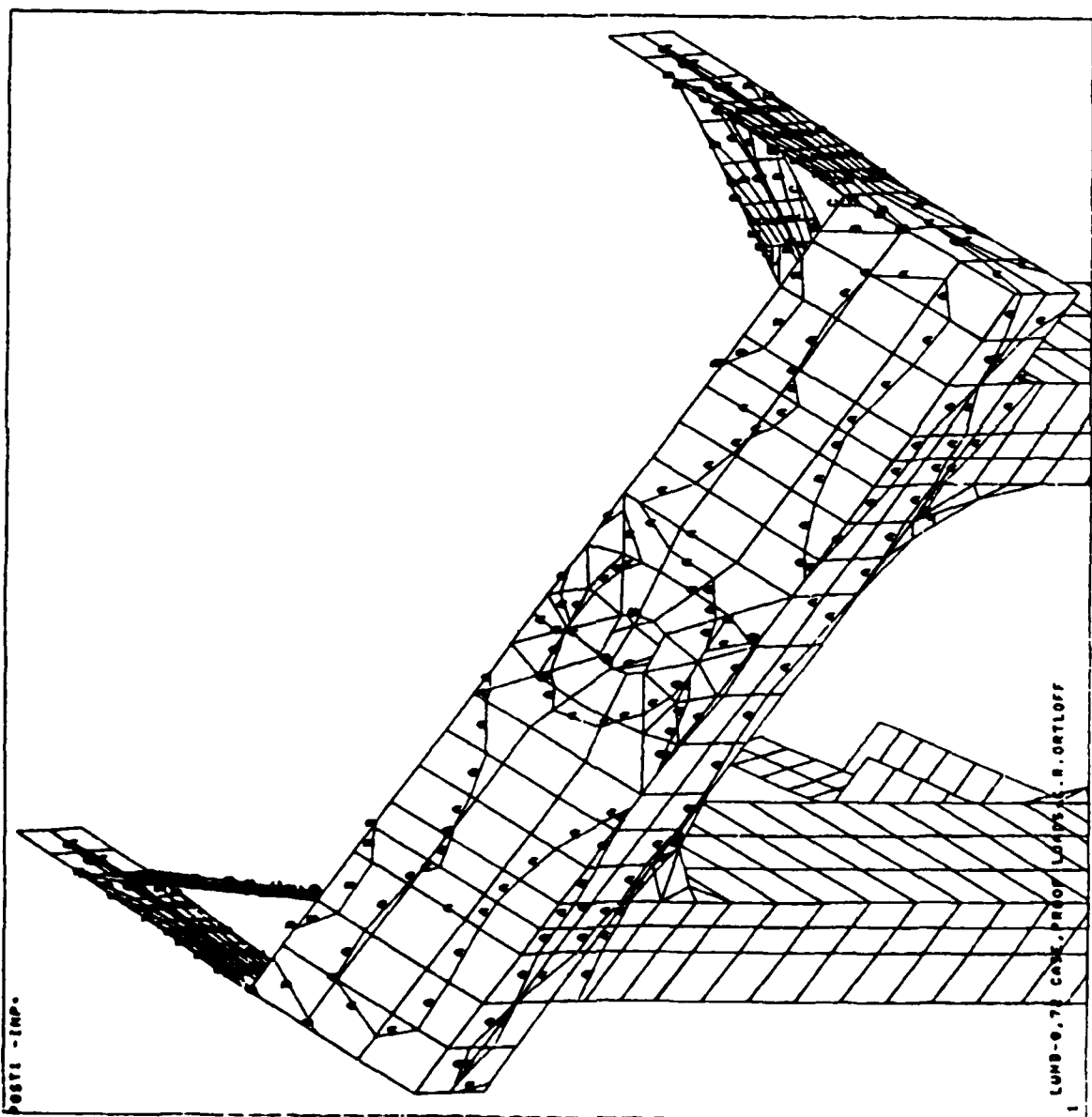
ANSYS 4.20
 DEC 20 1986
 15:10:25
 POST1, STRESS
 STEP=1
 ITER=1
 TIME=.250
 SLOC
 TOP
 2004
 NU=-1
 NU=-1
 20=1
 3157=24
 37=45.4
 37=47.4
 37=-2.6
 VARY=1.55
 U100EN
 EX=102030
 MY=0
 A=32111
 B=64097
 C=80083
 D=120060
 E=160055



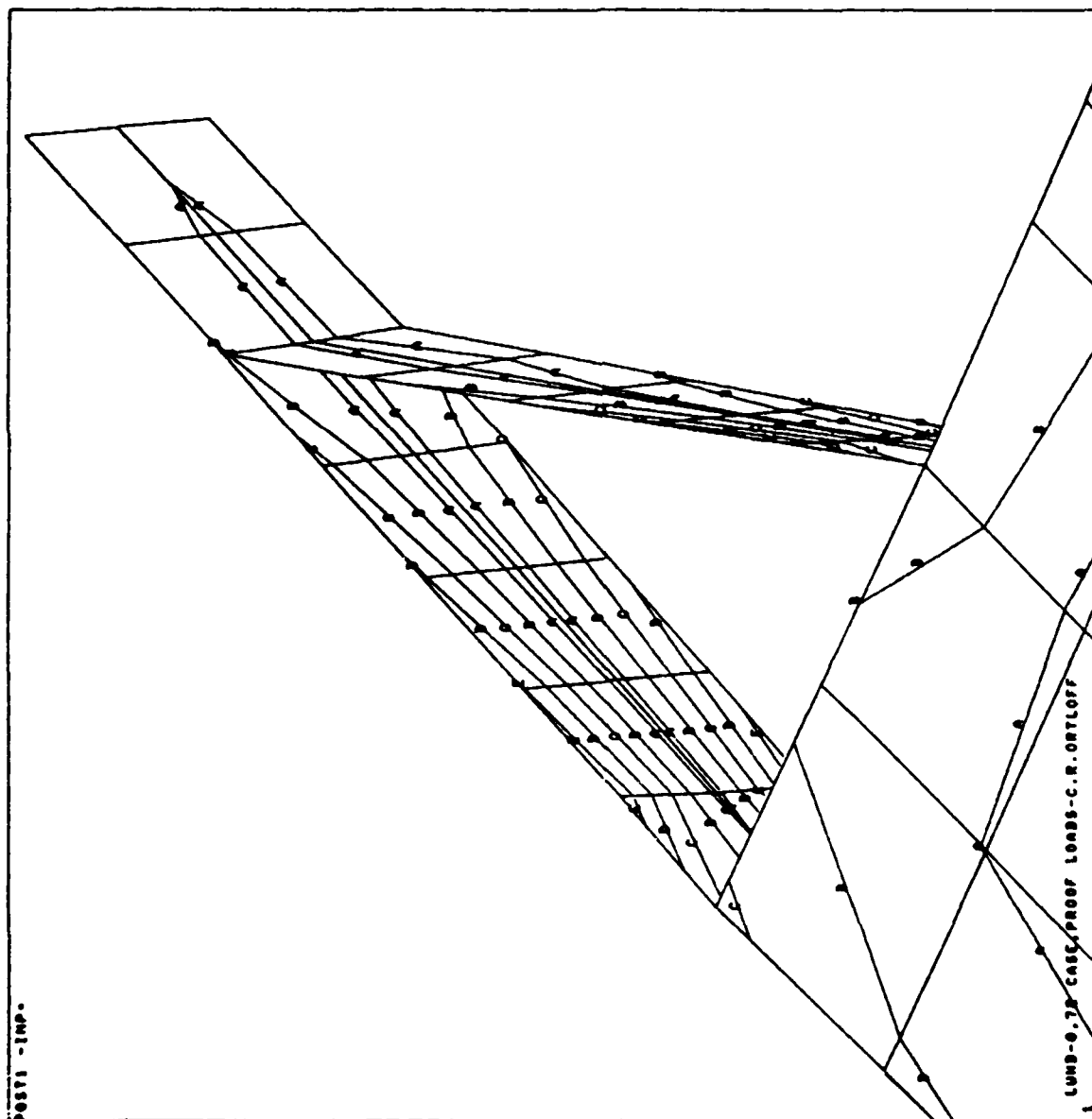
ANSYS 4.20
 DEC 20 1986
 15:17:17
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.888
 SICE
 TOP
 ZOOM
 RV=.4
 VU=1
 ZU=.6
 D187=50.8
 XF=54.2
 VF=35.1
 ZF=9.2
 VHT0=1.56
 M188EN
 M2=192039
 MH=127
 A=32111
 B=64007
 C=86003
 D=128069
 E=160055



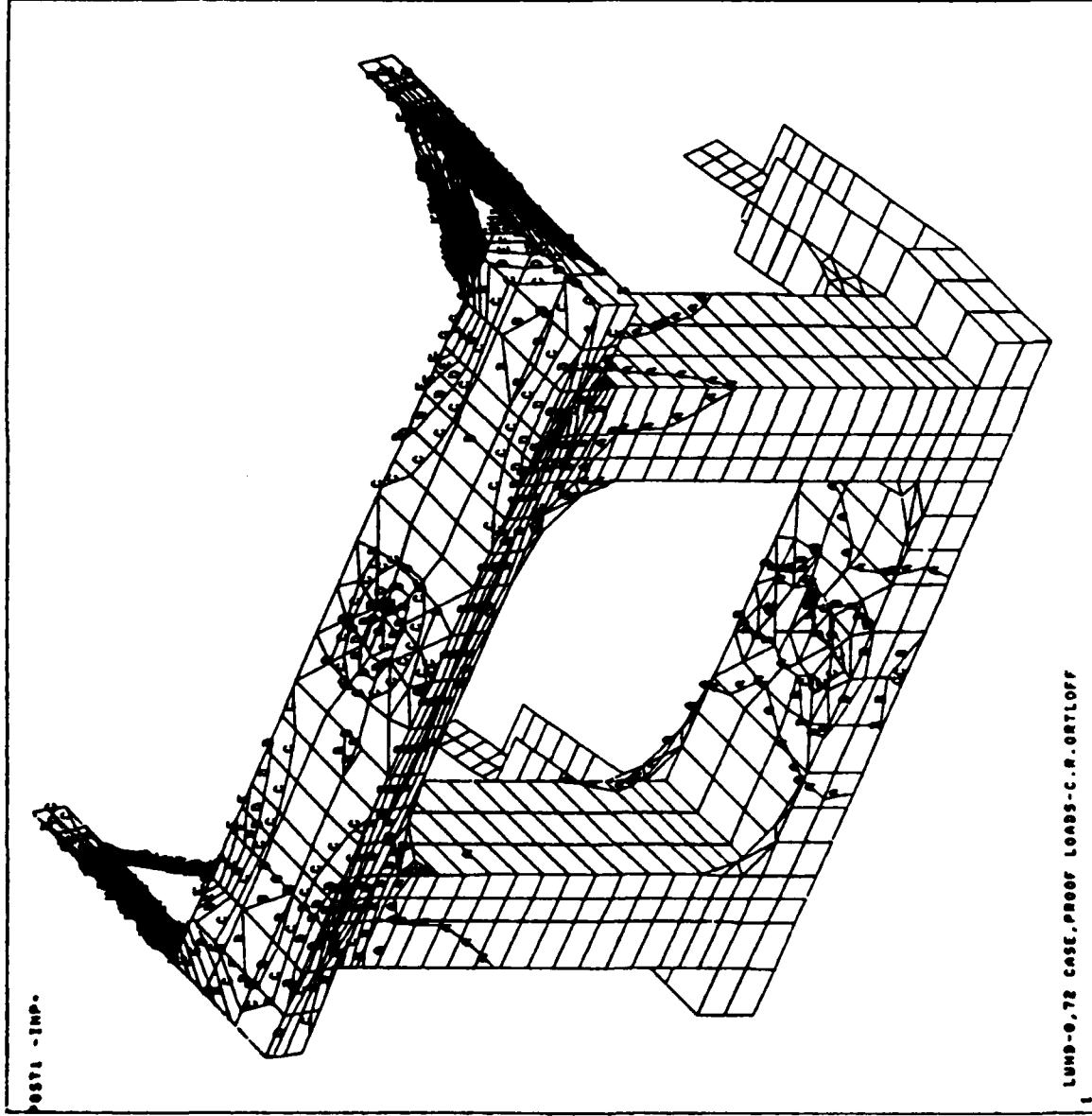
ANSYS 4.28
 DEC 28 1986
 15:17:17
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.888
 SICE
 TOP
 ZOOM
 XU=.4
 VU=.1
 ZU=.6
 2 DIST=28.5
 5 XF=48.3
 5 VF=42.6
 5 ZF=16.7
 XRT0=1.13
 VRT0=1.56
 MIBDEN
 RH=192039
 RH=6
 A=22131
 B=64987
 C=86023
 D=128069
 E=160055



ANSYS 4.20
 DEC 28 1986
 15127140
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.050
 SIZE
 TOP
 ZOOM
 XU=.4
 YU=1
 VU=.6
 ZU=.6
 DIST=9.75
 XF=29.4
 YF=49.5
 ZF=15.6
 XRT0=1.87
 YRT0=1.56
 WIDEN
 RH=105315
 RH=0
 A=32111
 B=64007
 C=96003
 D=128009
 E=160005



ANSYS 4.23
 DEC 28 1986
 15120111
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.250
 SICE
 TOP
 ZOOM
 XU=.4
 YU=1
 ZU=.6
 DIST=50.8
 XP=54.2
 YP=36.1
 ZP=-8.8
 XRTD=1.87
 YRTD=1.56
 WIDEN
 RX=192030
 RM=127
 A=12118
 B=24113
 C=36108
 D=48103
 E=60098
 F=72093
 G=84088
 H=96083
 I=108078
 J=120073
 K=132068
 L=144063
 M=156058
 N=168053
 O=180048



POST1 -IMP.

PLABEL,1,1

CONTOUR LABELING ON FOR WINDOW 1
NUMBER OF CONTOURS SET TO 10. USE /CONTOUR TO
SET DIFFERENT NUMBER OF CONTOURS (MAX. OF 24)

POST1 -IMP.

/CONTOUR,1,6

WINDOW 1 HAS 6 AUTOMATIC CONTOURS

POST1 -IMP.

PLNSTR,SIZE

PRODUCE STRESS PLOT, LABEL= SIZE AT TOP

ANSYS 4.20

DEC 28 1986

15:23:11

POST1 STRESS

STEP=1

ITER=1

TIME=.258

SIGE

TOP

ZOOM

KU=.4

VU=1

ZU=.6

8 DIST=13.6

8 XF=67.3

8 YF=37

8 ZF=-20.1

8 XROT=1.88

8 YROT=1.56

8 MIDBCH

8 X=192030

8 Y=0

8 A=12118

8 B=24113

8 C=36108

8 D=48103

8 E=60098

8 F=72093

8 G=84088

8 H=96083

8 I=108078

8 J=120073

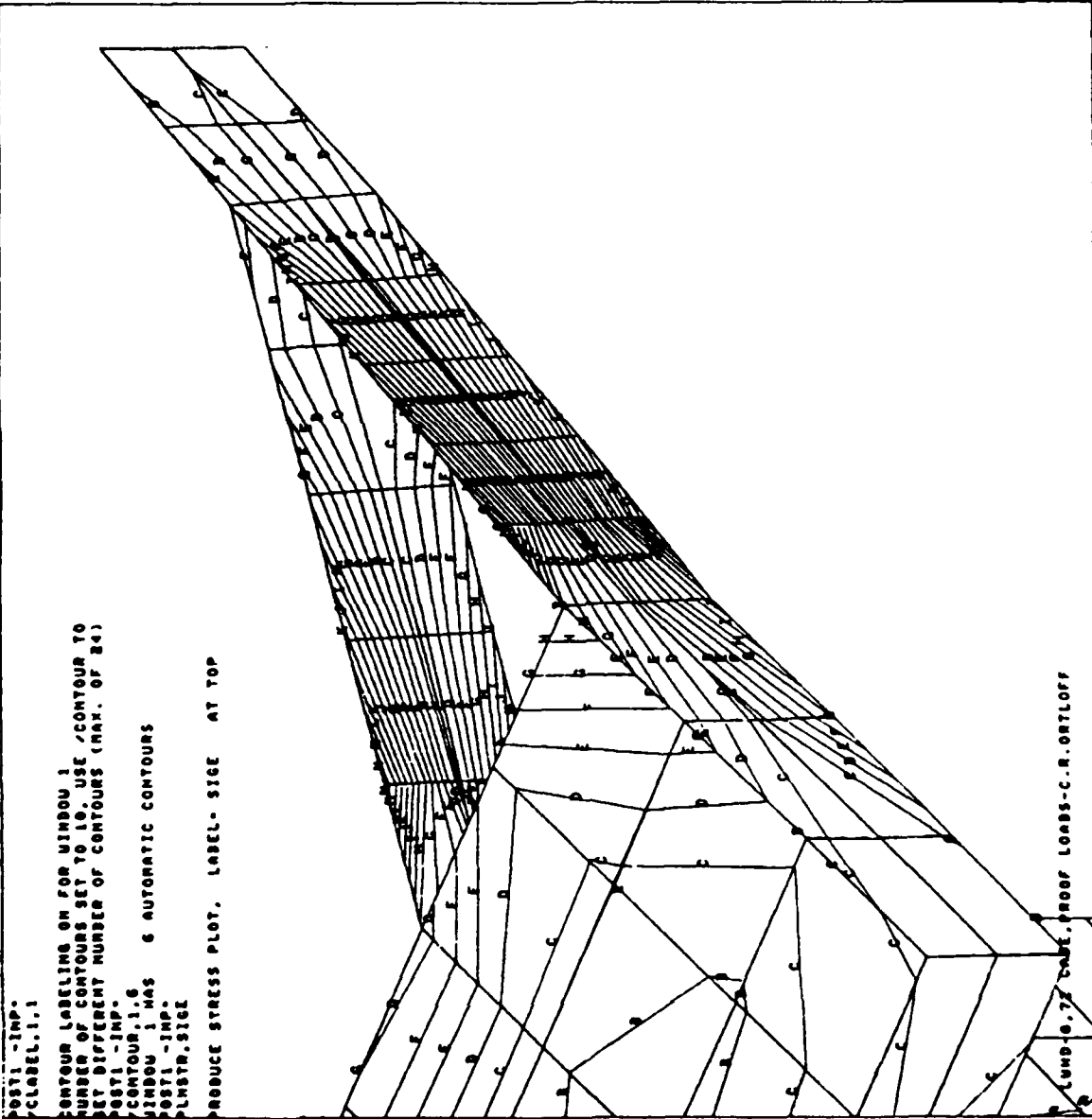
8 K=132068

8 L=144063

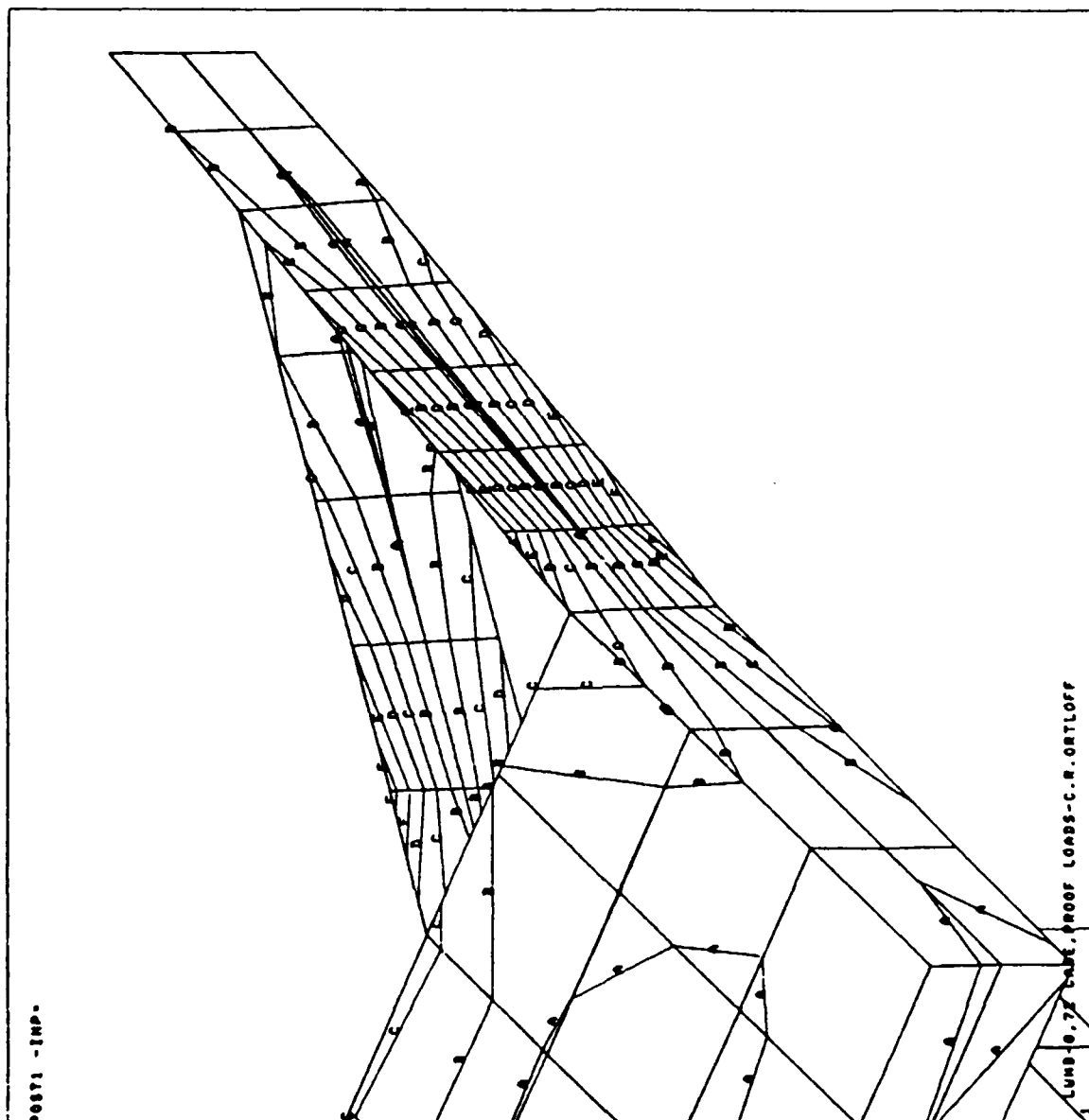
8 M=156058

8 N=168053

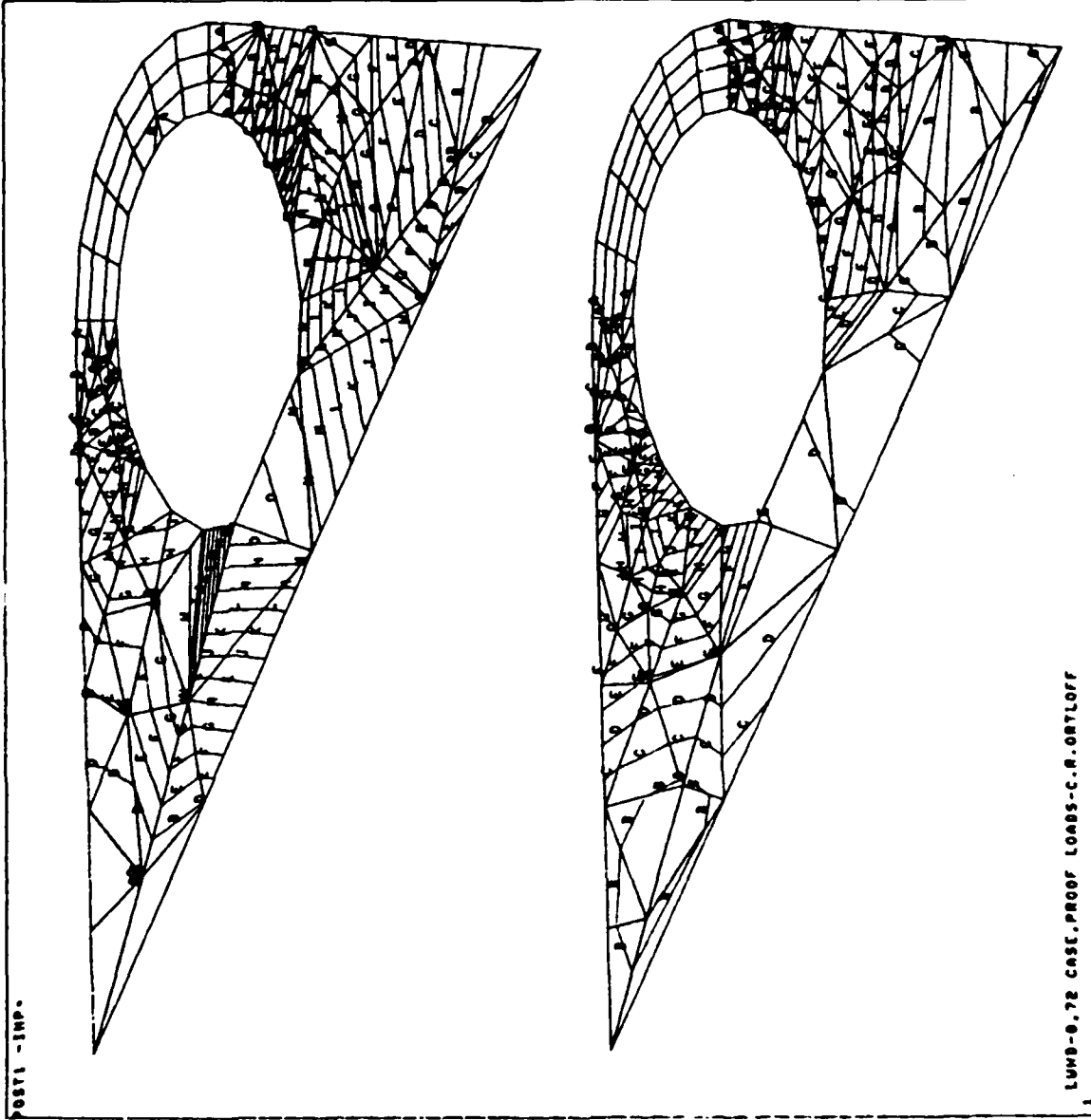
8 O=180048



ANSYS 4.28
 DEC 28 1986
 15132150
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.258
 SICE
 TOP
 ZOOM
 XU=.4
 VU=1
 ZU=.6
 2 DIST=13.5
 2 XF=67.3
 2 VF=37
 2 ZF=29.1
 XRT0=1.88
 YRT0=1.56
 HIDDEN
 RX=192039
 RM=0
 A=27541
 B=54958
 C=82376
 D=169792
 E=137209
 F=164626



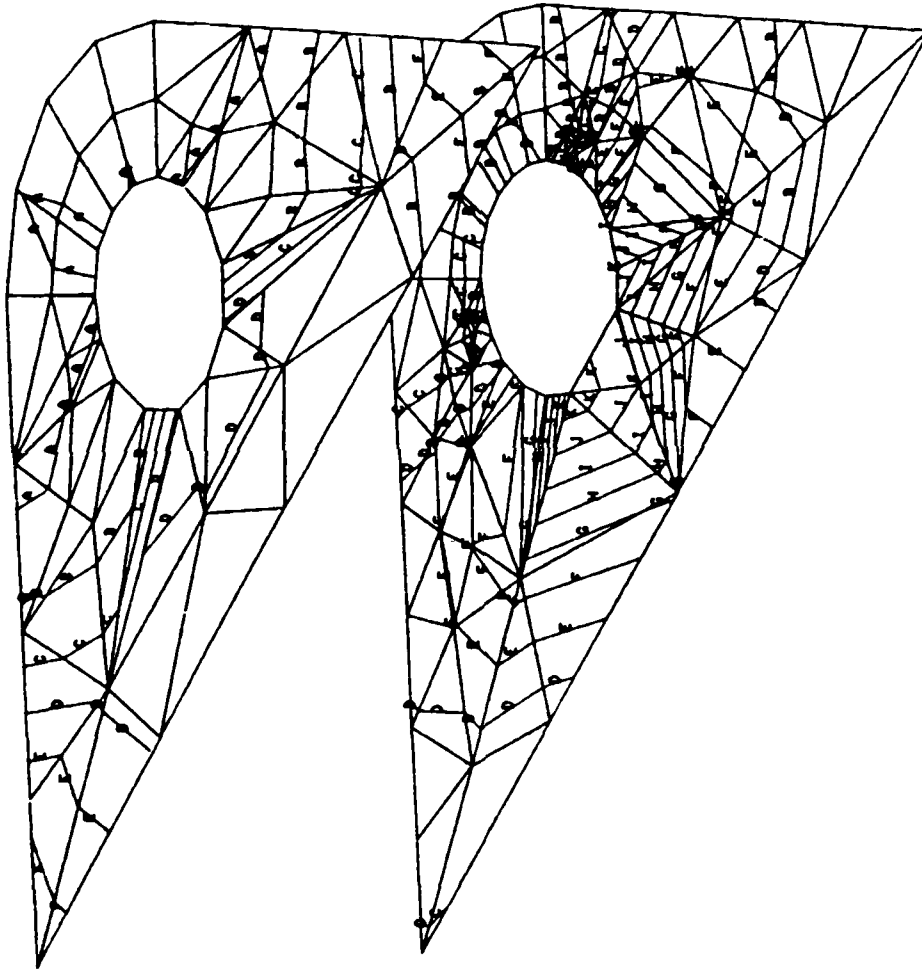
ANSYS 4.20
 DEC 20 1986
 15:34:25
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.288
 SICE
 TOP
 ZOOM
 X0=1
 Y0=1
 Z0=1
 DIST=11.7
 X1=61.8
 Y1=13.6
 Z1=8.93
 X2=0.196
 Y2=0.156
 HIDDEN
 MM=17599
 MM=120
 A=1220
 B=2312
 C=2494
 D=4496
 E=5588
 F=6680
 G=7772
 H=8864
 I=9956
 J=11048
 K=12140
 L=13232
 M=14324
 N=15416
 O=16508



352
 BOTTOM TABS

POST1 -IMP.

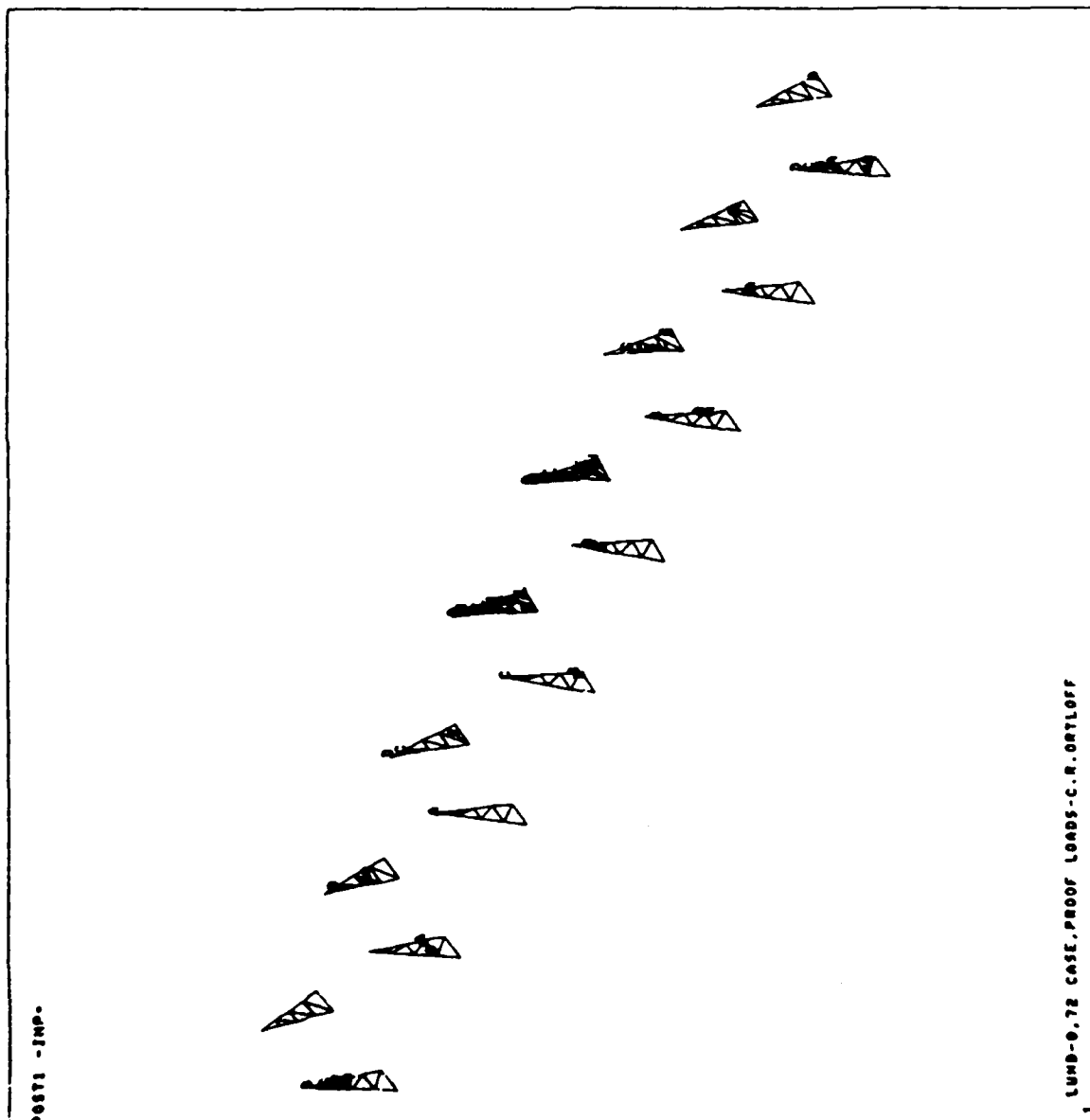
ANVS 4.20
DEC 28 1986
15:36:05
POST1 STRESS
STEP=1
ITER=1
TIME=.250
SLOE
TOP
ZOOM
XU=1
VU=1
ZU=1
B187=13.4
B=42.4
VF=50.5
ZF=9.65
H870=1.86
V870=1.88
HIDDEN
MX=13004
MH=672
A=1220
B=2312
C=3494
D=4456
E=5528
F=6680
G=7772
H=8864
I=9956
J=11048
K=12140



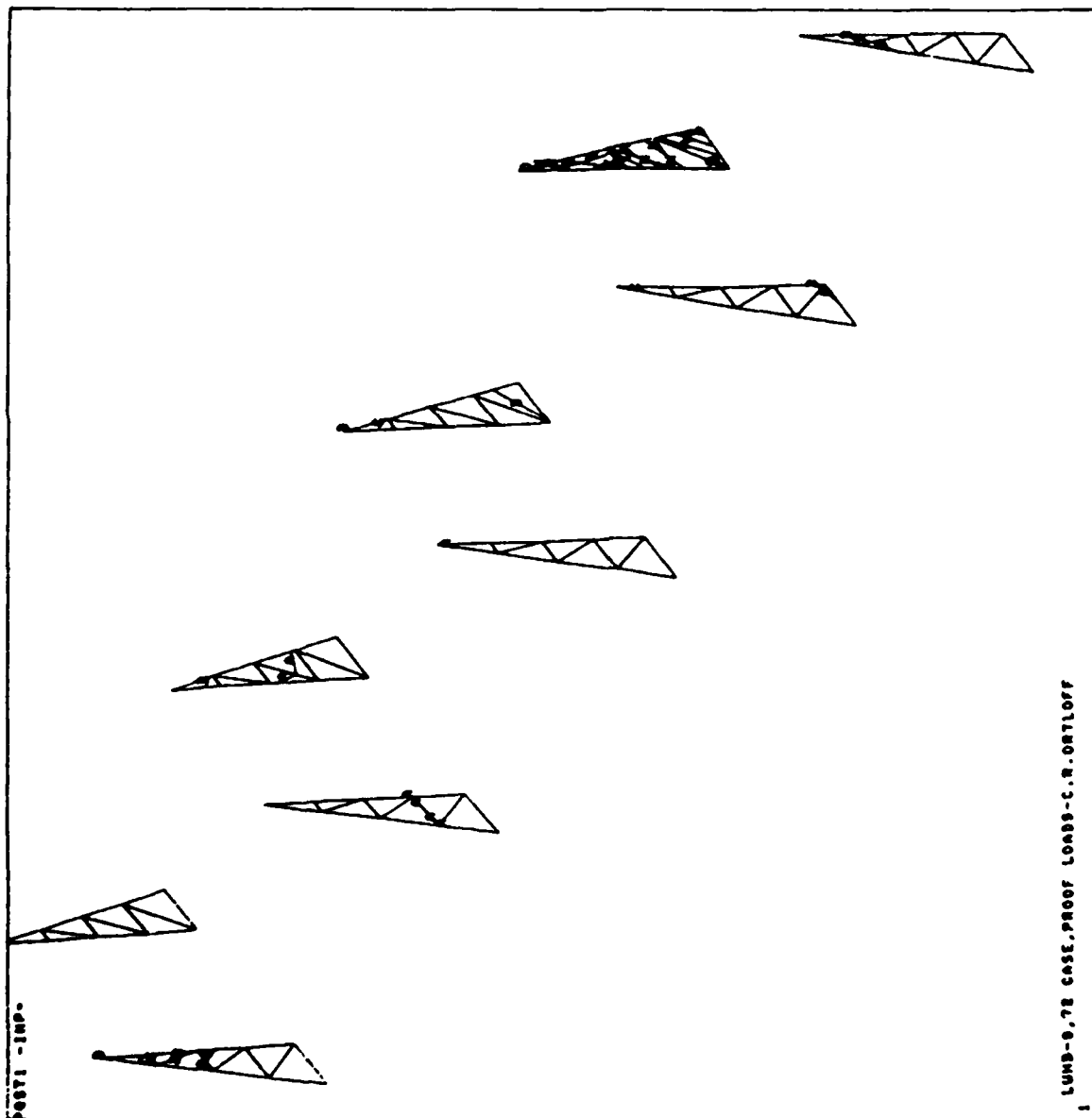
1 LUMB=0.72 CASE,PROOF LOADS-C.R.ORTLOFF

TOP

ANSYS 4.20
 DEC 28 1986
 15:38:00
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.888
 SICE
 TOP
 ZOOM
 KU=1
 VU=1
 2U=1
 DIST=88.6
 XF=88.8
 VF=2.55
 ZF=2.2
 KRT0=1.96
 VRT0=1.88
 HIDDEN
 RM=11829
 MM=219
 A=800
 B=1588
 C=2877
 D=2866
 E=2655
 F=4244
 G=5033
 H=5722
 I=6411
 J=7100
 K=7789
 L=8478
 M=9167
 N=9856
 O=10545



ANSYS 4.20
 DEC 20 1986
 15:38:00
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.000
 QLOC
 TOP
 ZOOM
 MU=1
 VU=1
 ZU=1
 0 DISY=46.3
 0 WF=36.6
 0 VF=9.58
 0 ZF=14.6
 XRT0=1.98
 VRT0=2.47
 MIDDEN
 RX=11289
 RH=351
 A=809
 B=1500
 C=2277
 D=2066
 E=3655
 F=4344
 G=5033
 H=5722
 I=6411
 J=7100
 K=7780
 L=8470
 M=9167
 N=9856
 O=10545



ANSYS 4.20
 DEC 20 1986
 15:38:44
 POST1 STRESS

STEP=1
 ITER=1
 TIME=.280
 SLOC
 TOP

ZOOM
 KU=1
 YU=1
 ZU=1

0 0107-42.8
 1 XF-72.5
 2 YF-6.41
 3 ZF-7.48

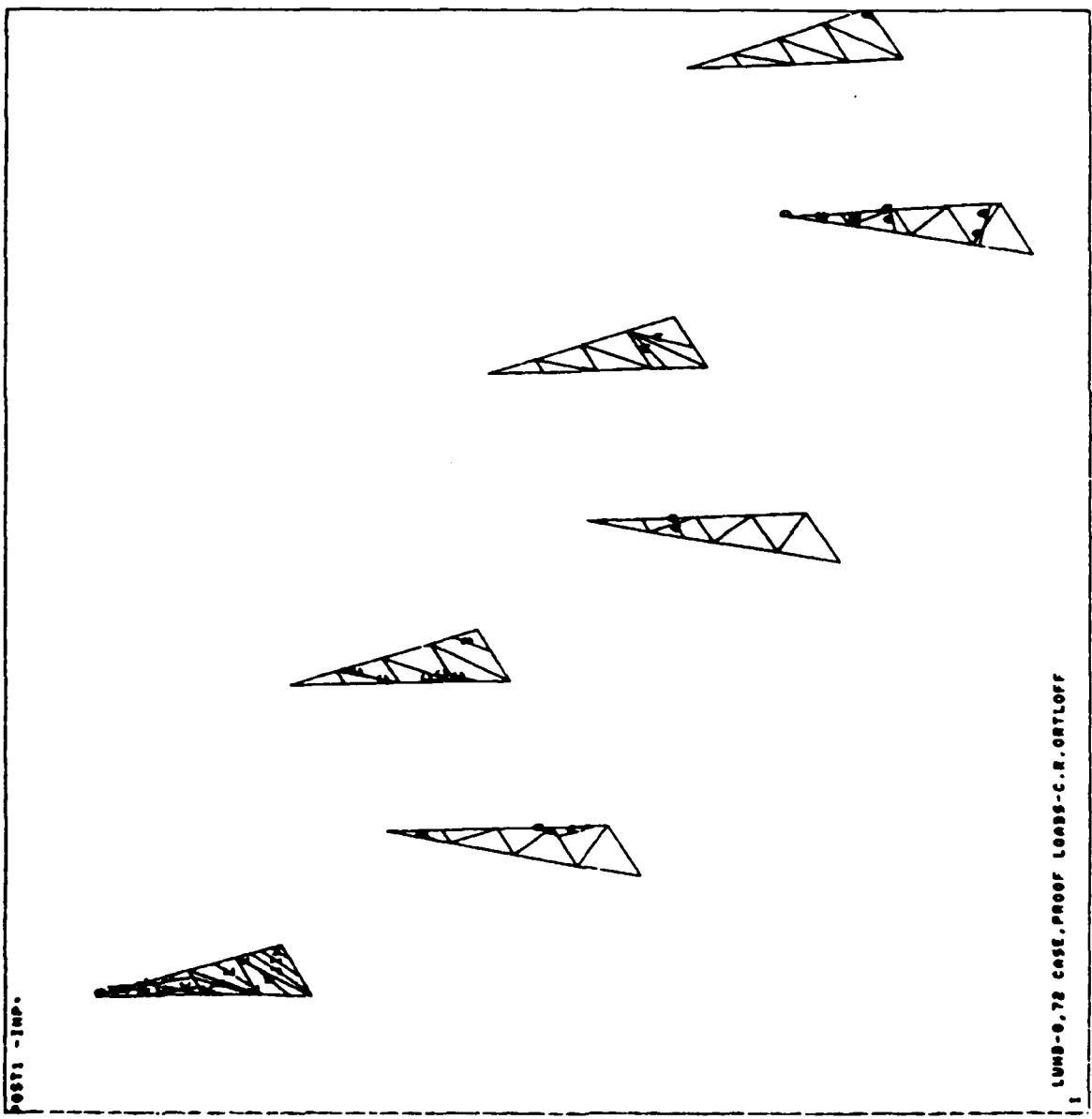
XRT0-2.20
 VRT0-2.47
 MIBDEM
 RM-10000
 RM-215

A-899
 B-1588
 C-2277
 D-2866
 E-2655

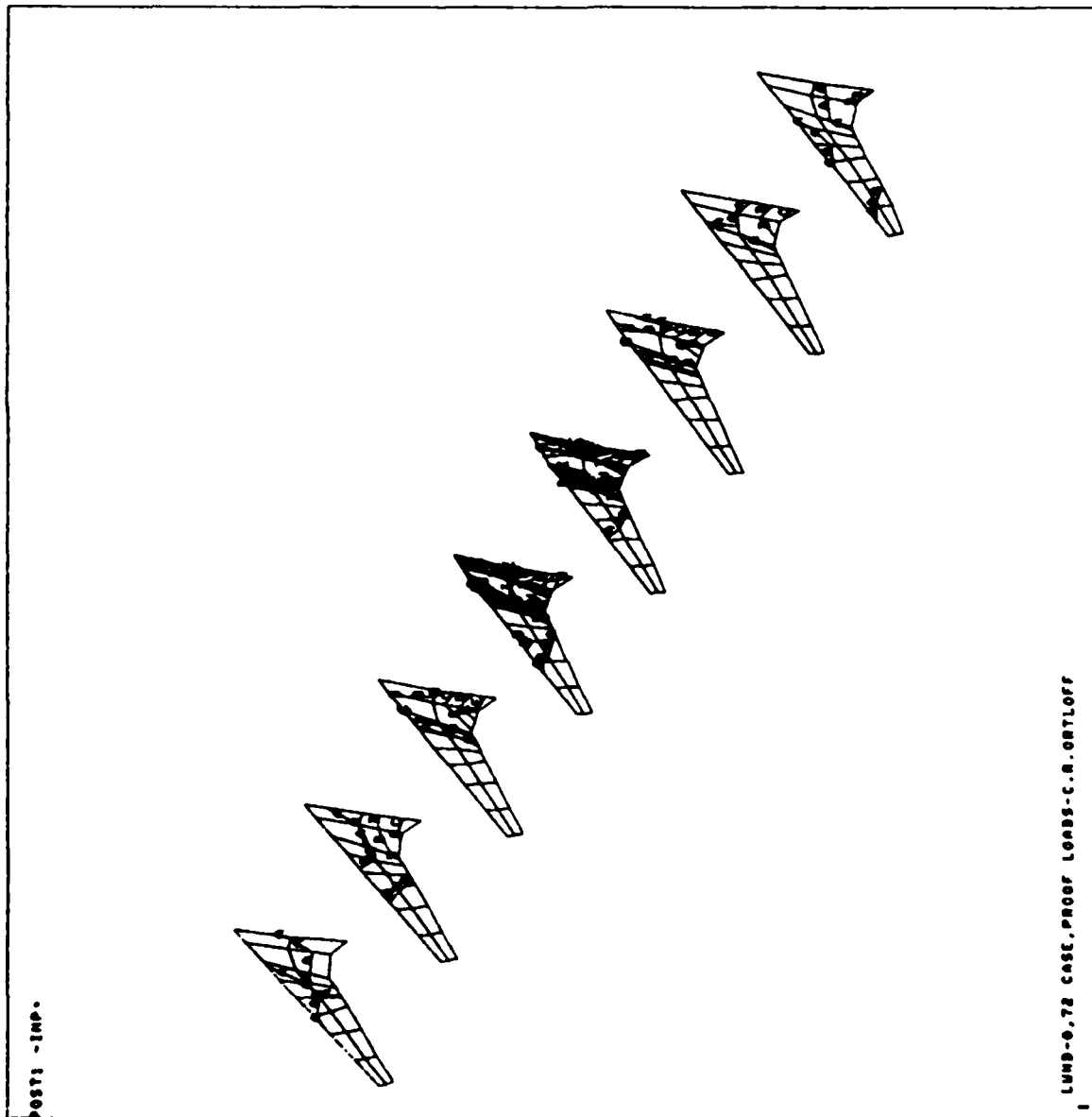
F-4244
 G-5033
 H-5722
 I-6411
 J-7100

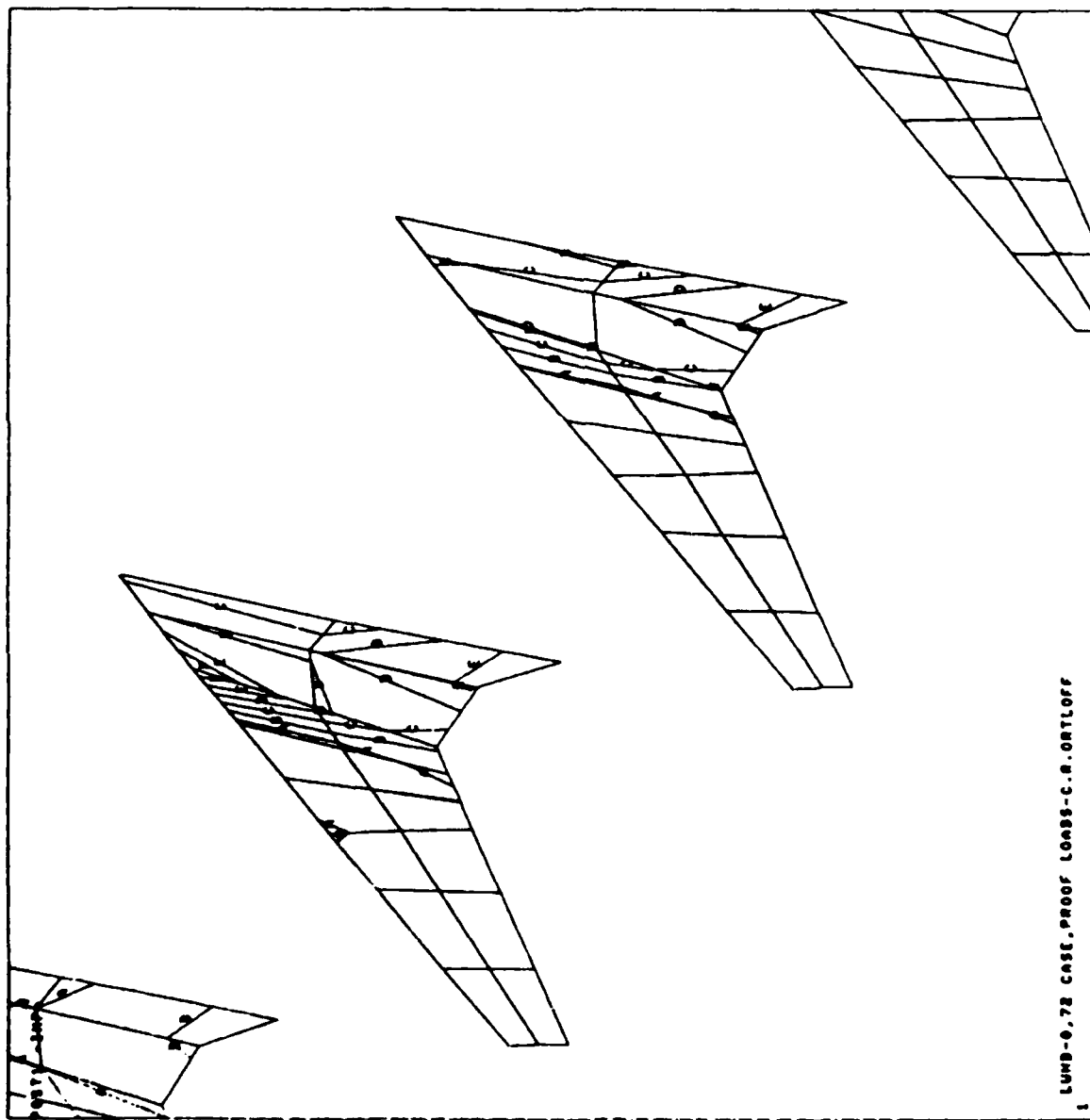
K-7789
 L-8478
 M-9167
 N-9856

O-10545



ANSYS 4.20
 DEC 20 1986
 15:40:03
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.250
 SICE
 TOP
 ZOOM
 ZU=1
 VU=1
 ZU=1
 DIST=112
 XF=58.3
 VF=-1.67
 ZF=5.33
 XRT0=2.20
 VRT0=2.47
 HIDDEN
 RM=18719
 RM=202
 A=1355
 B=2513
 C=3671
 D=4020
 E=5987
 F=7145
 G=8303
 H=9451
 I=10619
 J=11777
 K=12935
 L=14093
 M=15251
 N=16409
 O=17567



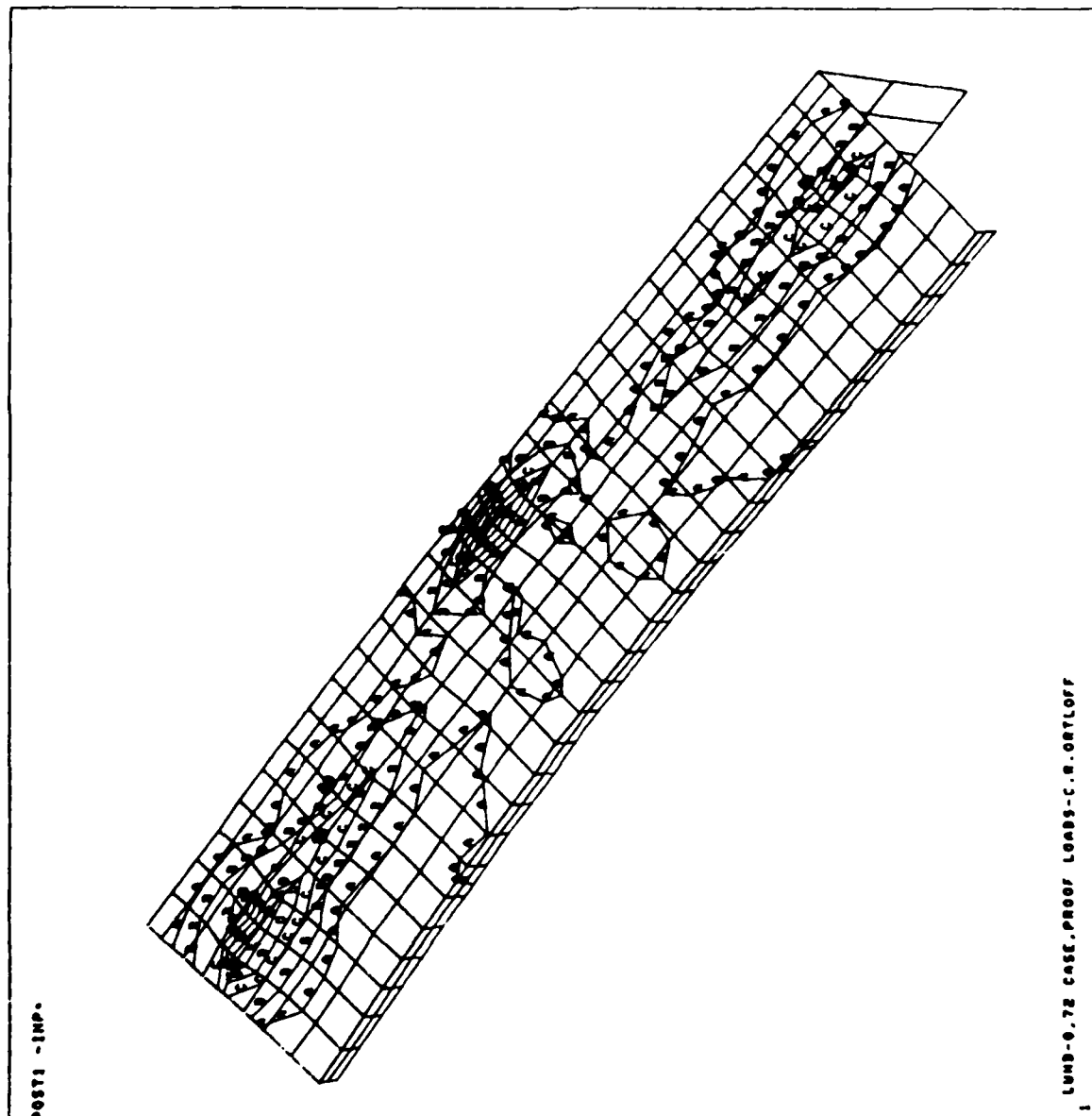


```

      ANSYS      4.20
      DEC 26 1986
      15:00:37
      POST1 STRESS
      STEP=1
      ITER=1
      TIME=.208
      SLOC
      TOP
      ZOOM
      KU=1
      VU=1
      ZU=1
      1 DIS=38.2
      2 KP=64.2
      3 VP=-2.95
      4 ZF=-.73
      5 KATO=2.28
      6 VATO=3.18
      MDOCM
      MX=18719
      MY=0
      A=2546
      B=5492
      C=3138
      D=10784
      E=13430
      F=15076

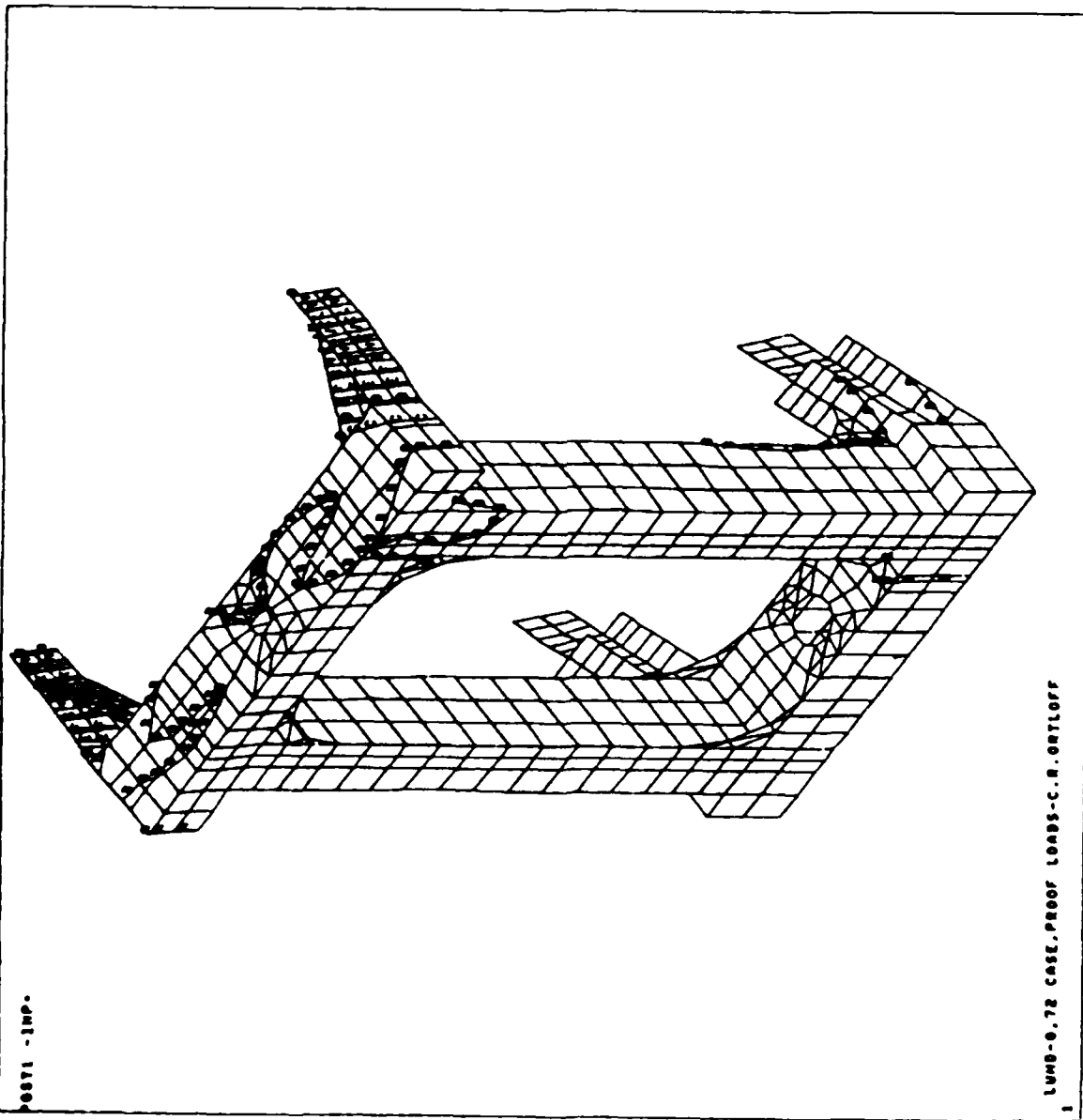
```

ANSYS 4.20
 DEC 28 1988
 15:42:05
 POST1 STRLESS
 STEP=1
 ITER=1
 TIME=.250
 SLOC
 TOP
 ZOOM
 NU=1
 VU=1
 ZU=1
 DIS1=112
 WF=62.3
 VF=-1.67
 ZF=5.33
 HOTO=2.20
 VOTO=3.18
 HIDDEN
 MX=10351
 MM=220
 A=1908
 B=3597
 C=5286
 D=6975
 E=8684



ANSYS 4.20
 DEC 20 1986
 15:40:42
 POST1 STRSS
 STEP=1
 ITER=1
 TIME=.008
 UV
 01891 NODAL

 ZOOM
 ZU=1
 VU=1
 ZV=1
 DIST=100
 XF=54.9
 YF=33.9
 ZF=-8.01
 XRTG=8.29
 YRTG=3.18
 WIDEN
 RM=1.12
 RM=-.00223
 A=0
 B=.08
 C=.16
 D=.24
 E=.32
 F=.4
 G=.48
 H=.56
 I=.64
 J=.72
 K=.8
 L=.88
 M=.96
 N=1.04
 O=1.12



```

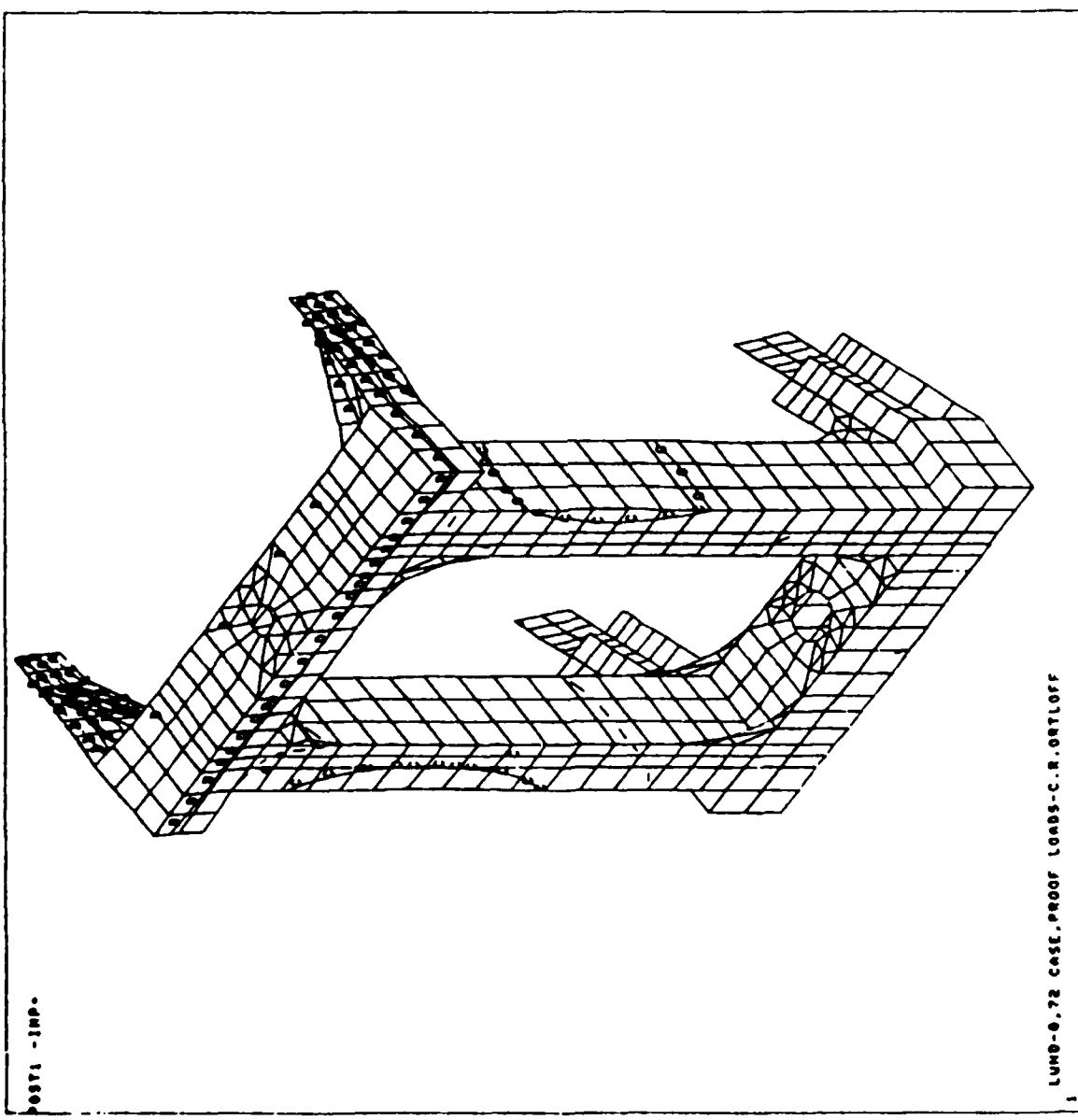
ANSYS 4.20
DEC 20 1986
15:40:10
POST1, STRESS
STEP=1
ITER=1
TIME=.258
U2
DISPL MODAL

```

```

ZOOM
XU=1
VU=1
ZU=1
DISP=100
KF=54.0
VF=23.0
ZF=8.01
KATO=2.20
VATO=3.10
MIDSETH
MX=.166
MY=0.302
A=0.210
B=0.110
C=0.0170
D=0.0022

```

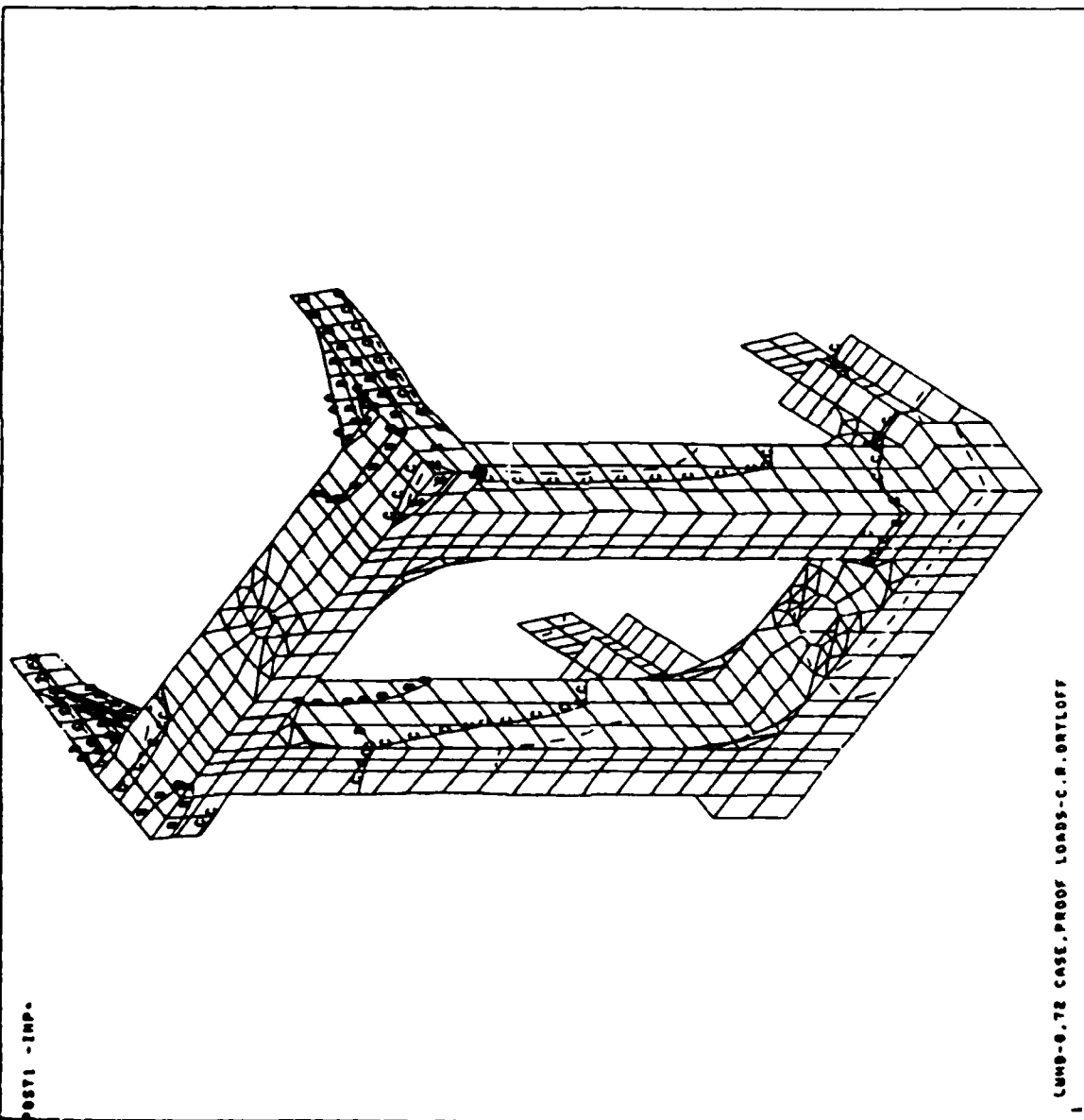


POST1 -IMP.

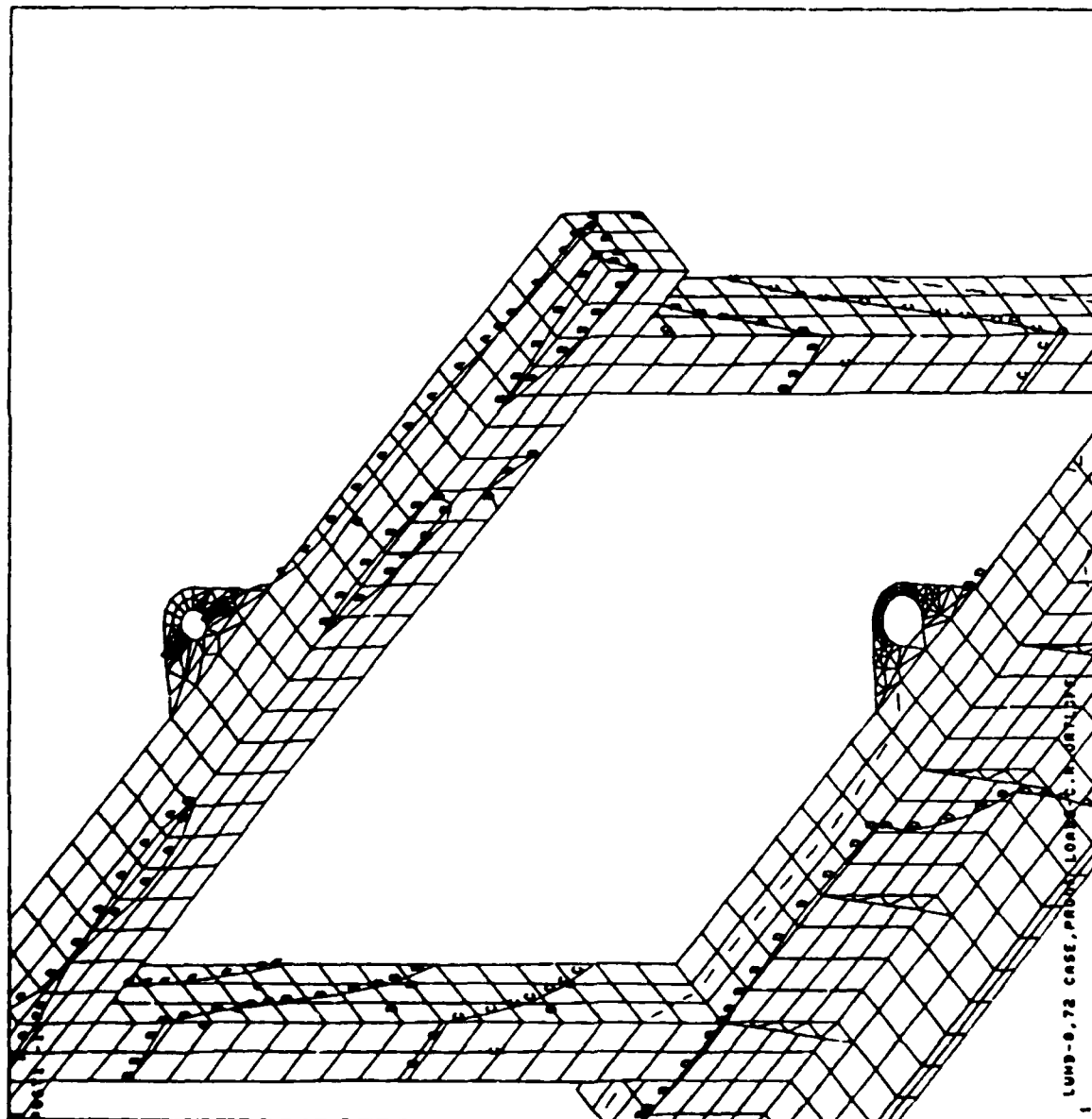
1 LUND-0.72 CASE, PROOF LOADS-C.R.ORTLOFF

ANSYS 4.2B
 DEC 28 1985
 15:03:20
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.388
 UN
 DISPL MODAL

ZOOM
 KU=1
 VU=1
 WU=1
 ZU=1
 Z 8157.109
 Z 8 KF=54.9
 Z 8 VF=33.9
 Z 8 ZF=-8.01
 KATO=2.89
 VATO=3.18
 MIDDEN
 MX=-.0201
 MY=-.0512
 AZ=-.0456
 B=-.0255
 C=-.00556
 D=-.0144

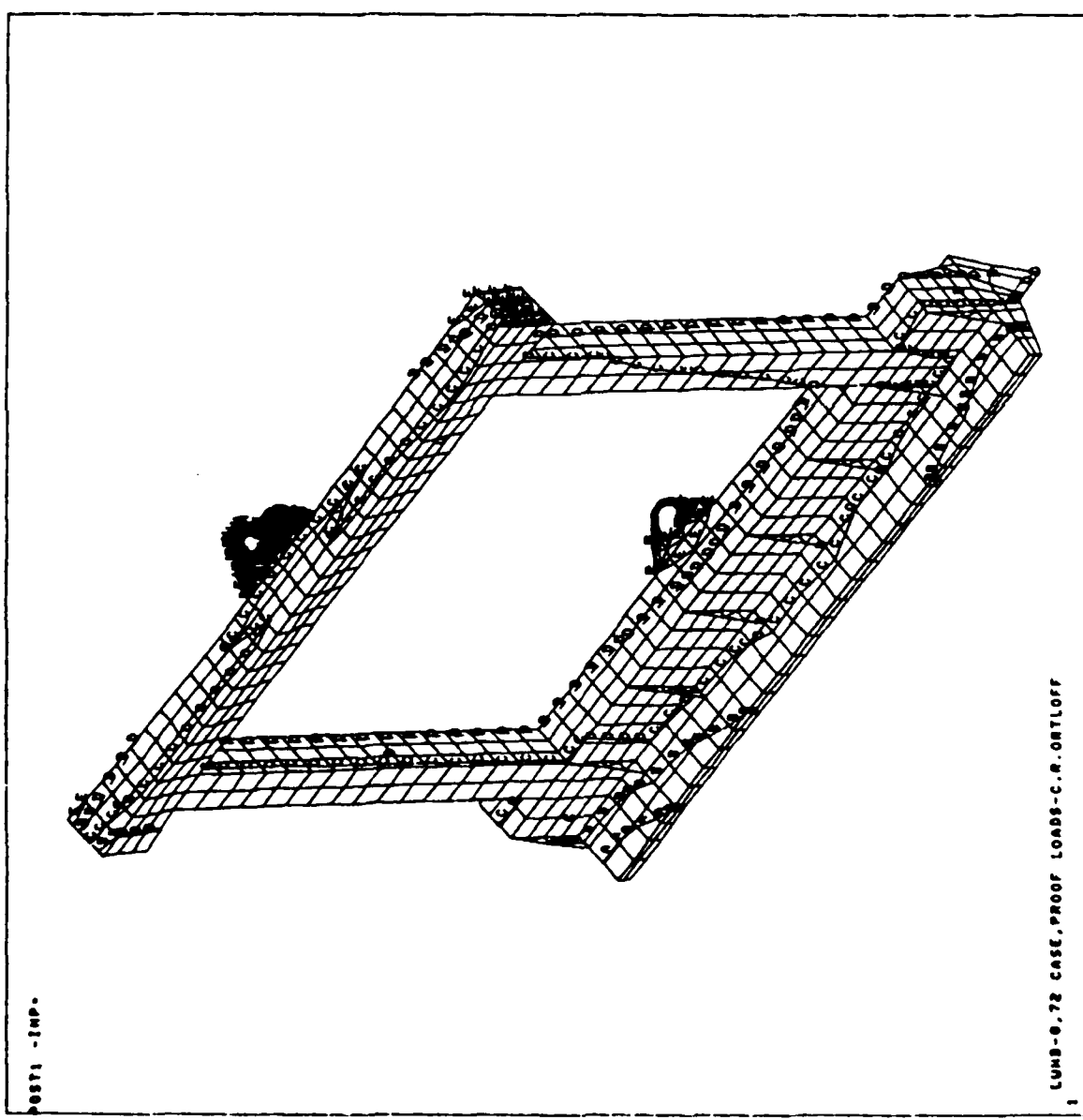


ANSYS 4.28
 DEC 28 1986
 15157106
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.858
 UX
 DISPL NODAL
 ZOOM
 XU=1
 YU=1
 ZU=1
 0 DISPL=100
 0 MF=54.8
 0 VF=33.8
 0 ZF=8.01
 XRT0=8.29
 YRT0=3.18
 M189EN
 RM=.00787
 RM=-.0218
 A=-.0158
 B=-.0089
 C=-.0039
 D=-.0021



100
36A

ANSYS 4.20
DEC 20 1986
16:03:00
POST1 STRESS
STEP=1
ITER=1
TIME=.000
UV
DISPL NODAL
ZOOM
XU=1
YU=1
ZU=1
DIST=100
XF=51.2
YF=27.7
ZF=4.17
XRT0=2.29
YRT0=3.18
HIDDEN
MX=-.142
MY=-.0459
MZ=-.0361
S=-.0241
C=-.0121
D=-.00013
E=.0119
F=.0239
G=.0359
H=.0479
I=.0599
J=.0719
K=.0839
L=.0959
M=.108
N=.12
O=.132

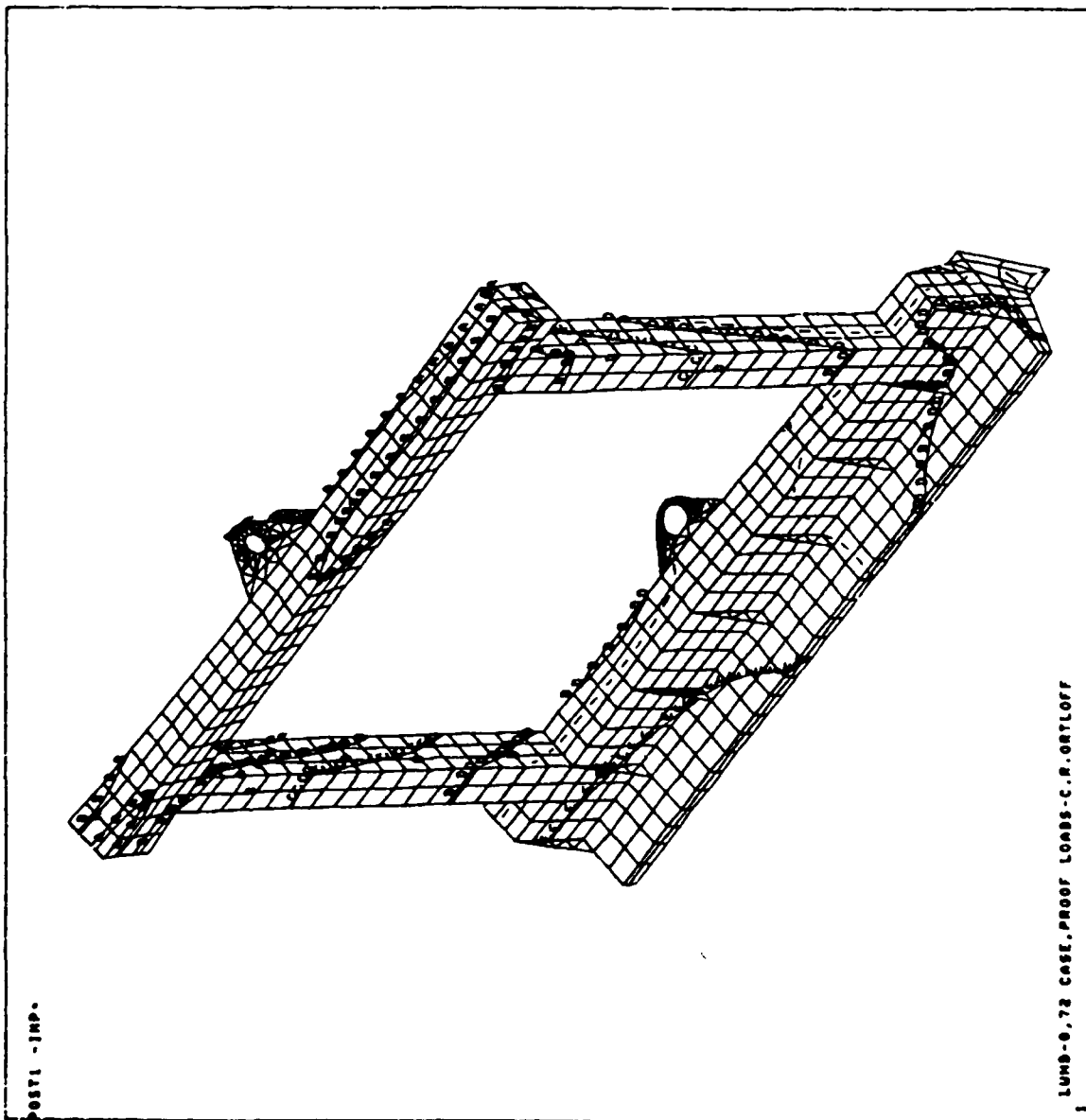


POST1 -IMP.

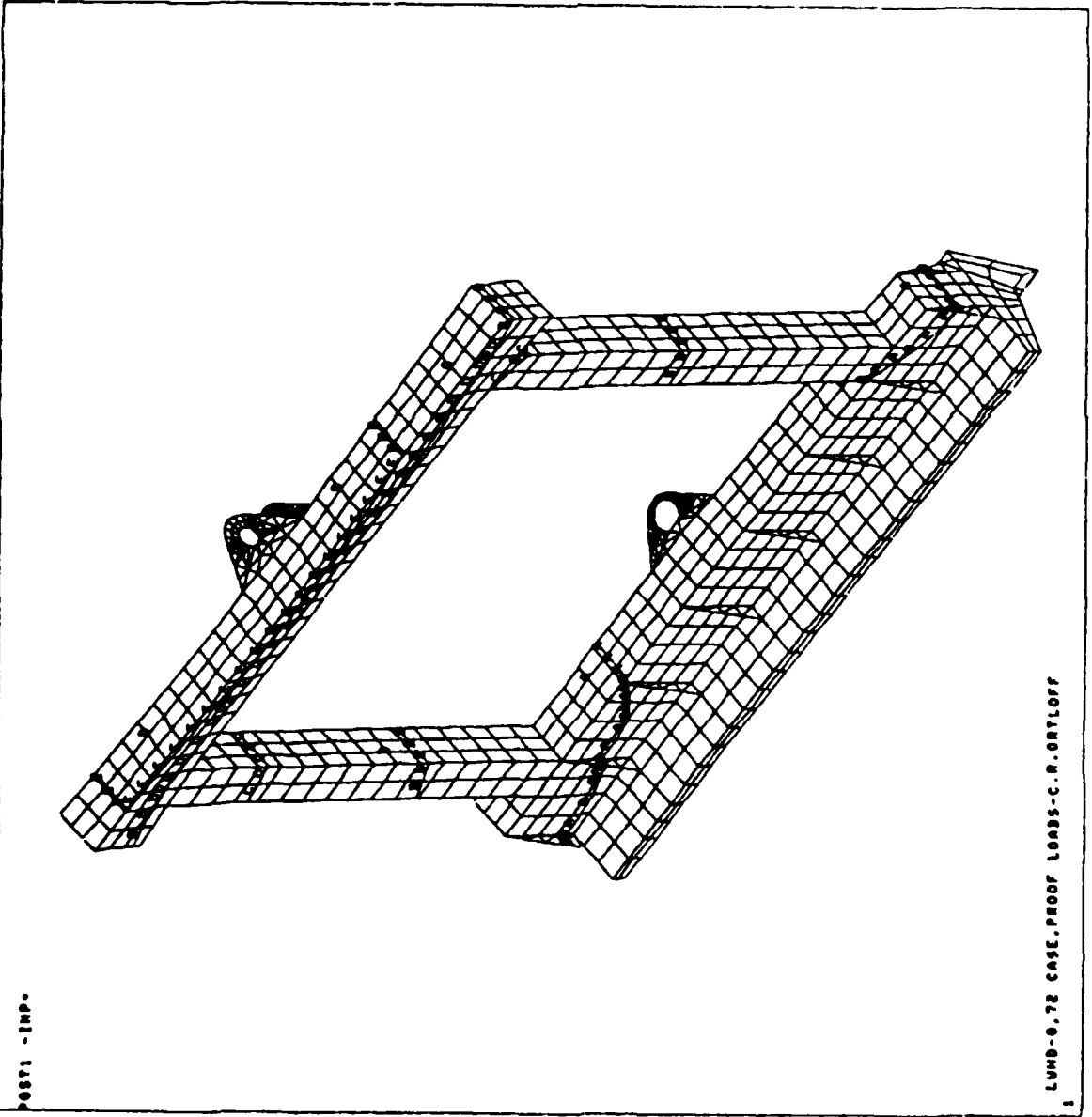
1 LUMB-0.72 CASE, PROOF LOADS-C.R. ONTLOFF

[illegible]

ANSYS 4.20
 DEC 28 1986
 16123120
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.250
 UX
 DISPL MODAL
 ZOOM
 MU=1
 VU=1
 ZU=1
 Z DIST=100
 Z XF=51.2
 Z VF=27.7
 Z ZF=4.17
 XRT0=2.20
 VRT0=3.18
 HIDDEN
 RX=.00004
 RM=.0218
 A=-.0169
 B=-.0119
 C=-.0059
 D=-.0019
 E=.0031



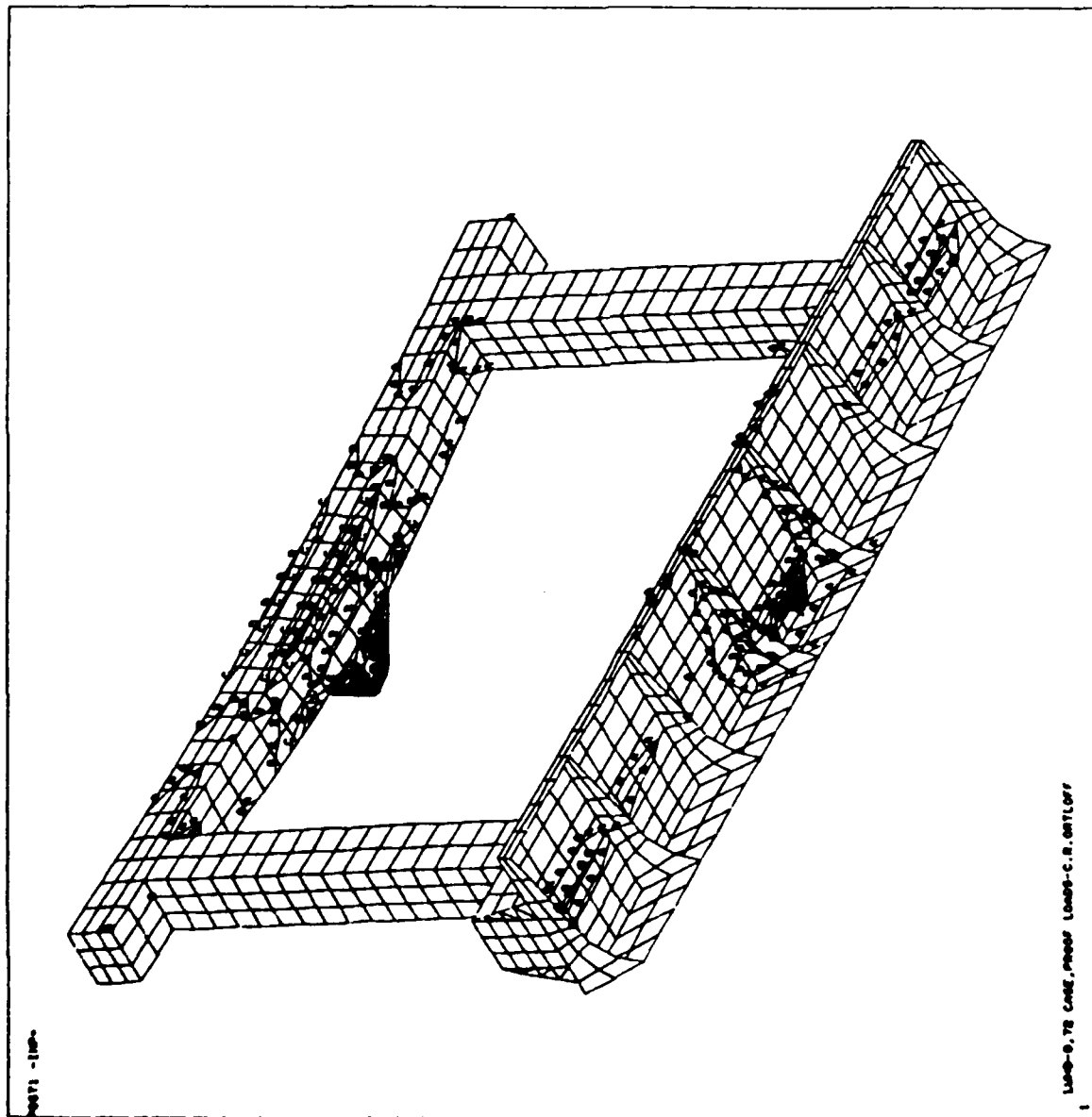
ANSYS 4.20
 DEC 28 1986
 1615183
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.850
 UZ
 DISPL NODAL
 ZOOM
 KU=1
 YU=1
 VU=1
 ZU=1
 1 DISPL=100
 2 XF=51.2
 3 YF=27.7
 4 ZF=4.17
 HOTO=2.29
 VOTO=3.18
 MIBDEM
 MX=.267
 MY=0
 MZ=.0337
 B=.0837
 C=.134
 D=.184
 E=.234



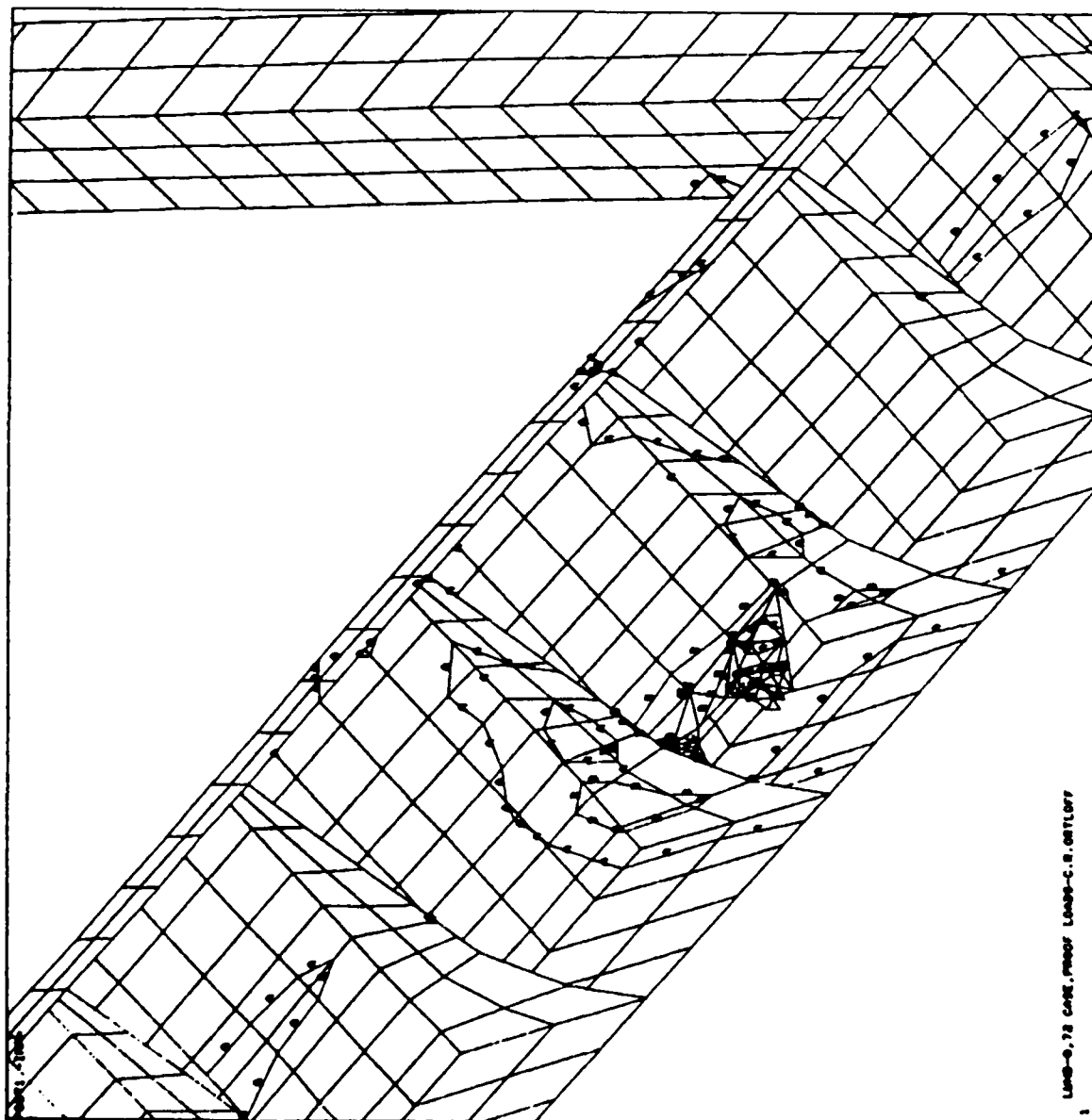
POST1 -IMP.

1 LUMB=0.72 CASE,PROOF LOADS-C.R.ORTLOFF

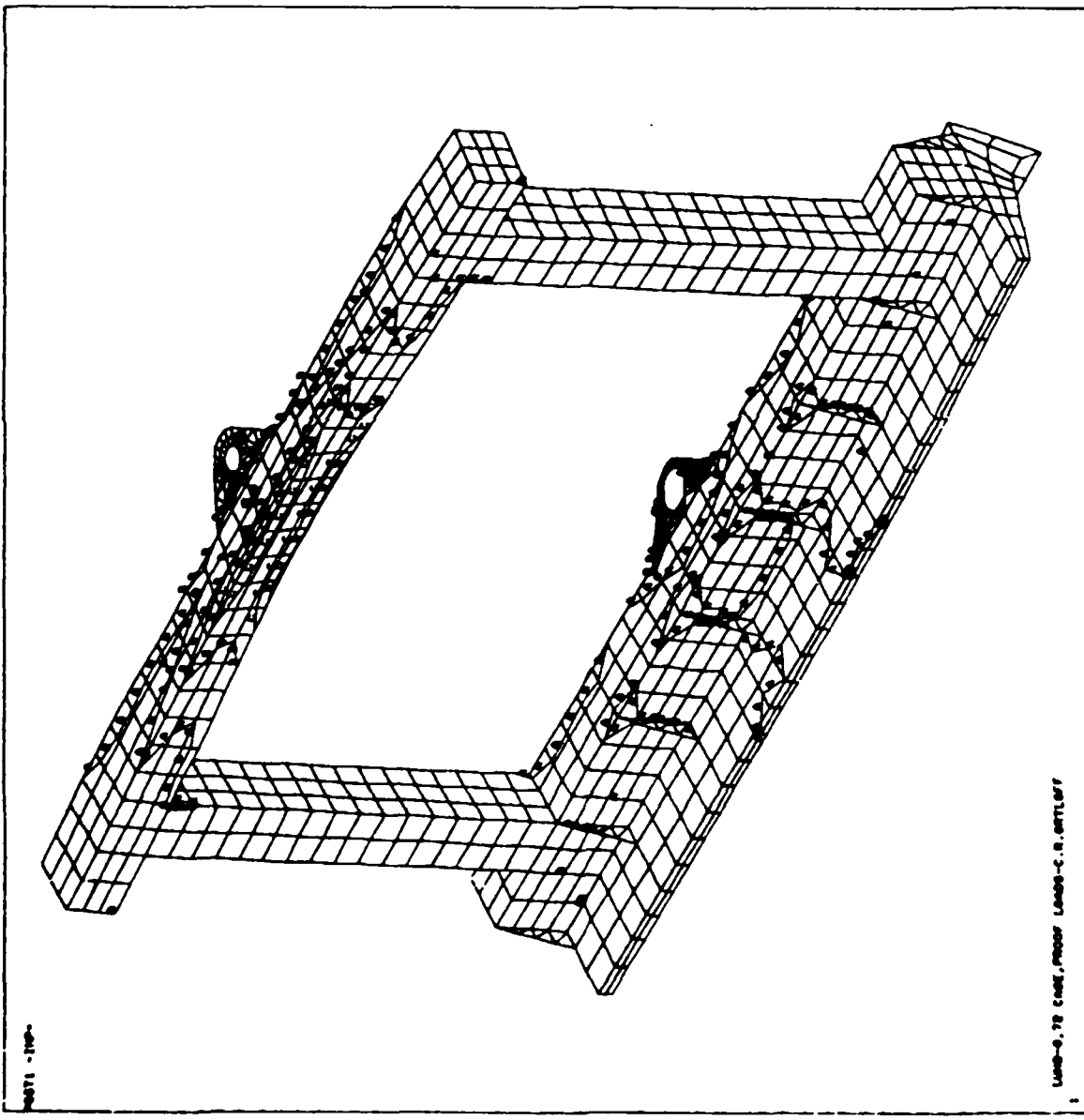
00101 4.00
 DEC 20 1966
 01471.00
 POSTS STRESS
 STEP=1
 ITER=1
 TIME=.031
 0100
 TOP
 10--1
 10--1
 20--1
 0151-55.2
 10-54.2
 10-55.4
 22-4.05
 110000
 00-54.16
 00-345
 A-0023
 B-17702
 C-25381
 D-26400
 E-03720



000000 4.00
DEC 88 1000
9.43.169
POSTAL STRESS
STED-1
1734.1
TIME .031
100



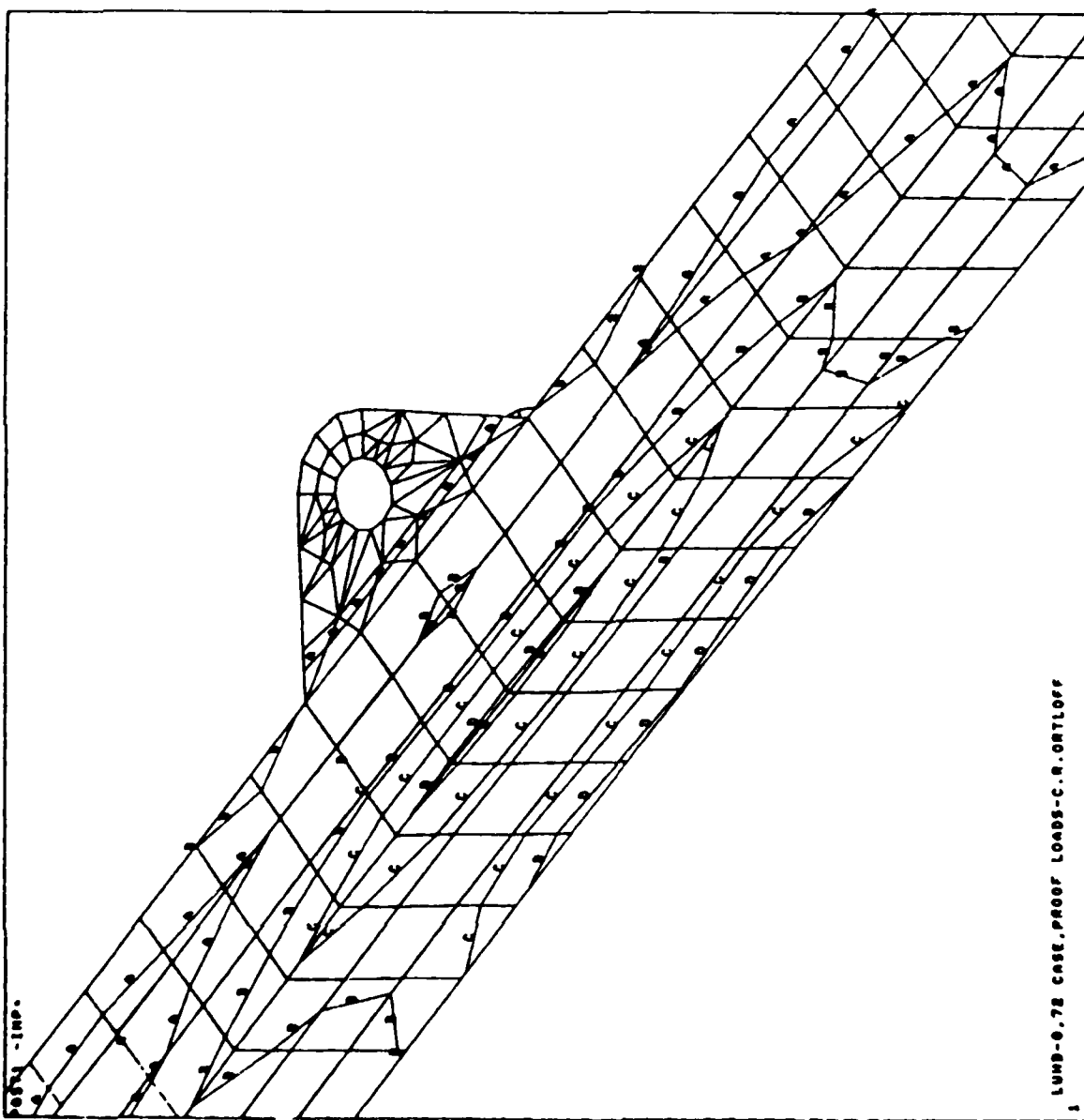
00010 4.30
 DEC 20 1966
 10100.17
 00071 010000
 STEP=1
 ITER=1
 TIME=.031
 SIZE
 TOP
 100=1
 100=1
 200=1
 0101-00.6
 07-01.2
 07-07.7
 20-4.17
 010000
 00-00010
 00-300
 0-0007
 0-17700
 0-00001
 0-30000
 0-07700



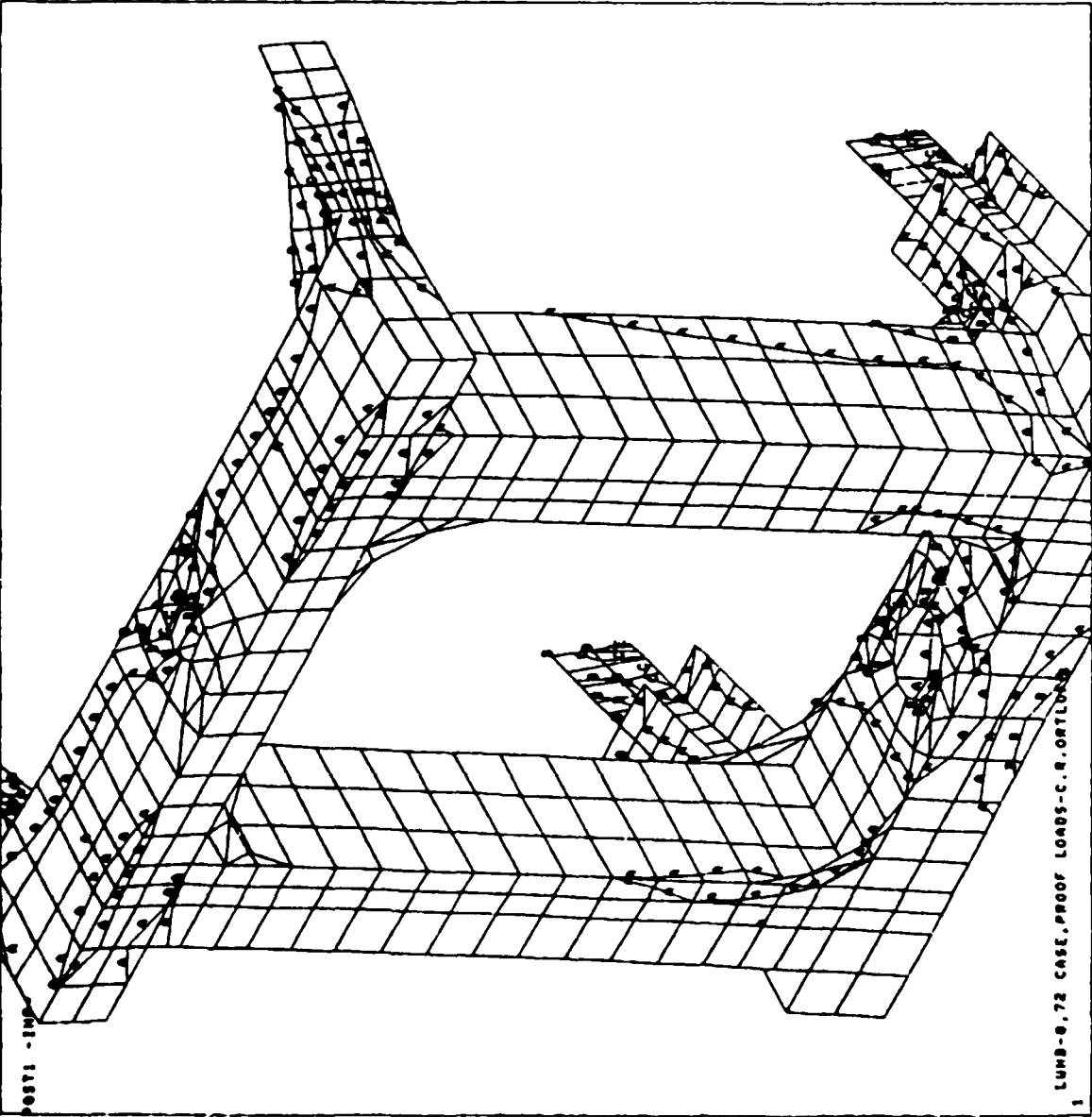
00071 -100-

LOAD=9, 70 CASE, PROOF LOADS-C. R. BENTLEY

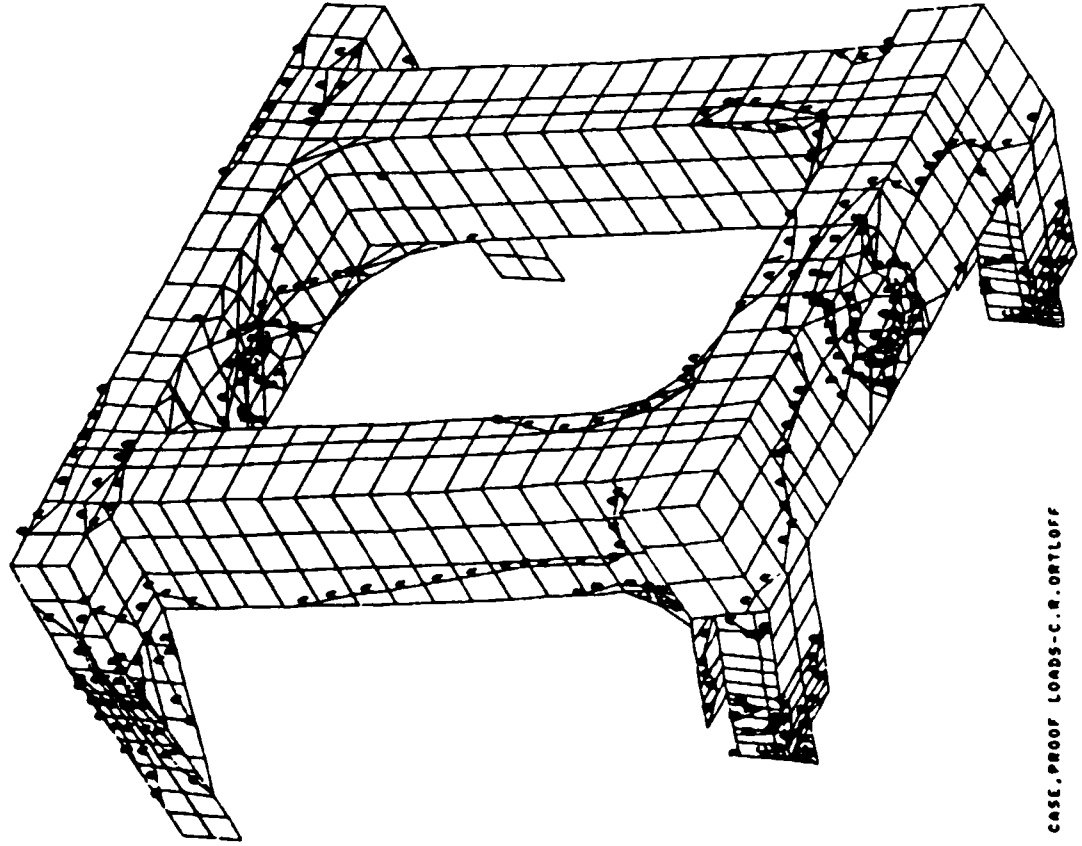
ANSYS 4.20
 DEC 20 1986
 10100:17
 POST1 STRESS
 STEP=1
 LAYER=1
 VINC=.031
 SLOC
 TOP
 ZOOM
 KU=1
 VU=1
 ZU=1
 1 DISY=20.8
 2 KF=03.9
 3 VF=48.3
 4 ZF=-10.8
 VRT0=1.36
 WIDEN
 MX=49942
 MY=0
 A=9023
 B=17702
 C=26381
 D=35060
 E=43730



ANSYS 4.20
DEC 20 1985
10:33:00
POST1 STRESS
STEP=1
TYPE=1
TIME=.031
SIDE
TOP
XU=1
YU=1
ZU=1
S 1187.26.3
S 27.53
S 27.32.8
S 27.10.3
MIDNEN
RM=155611
A=27994
B=53518
C=79042
D=104566
E=130990



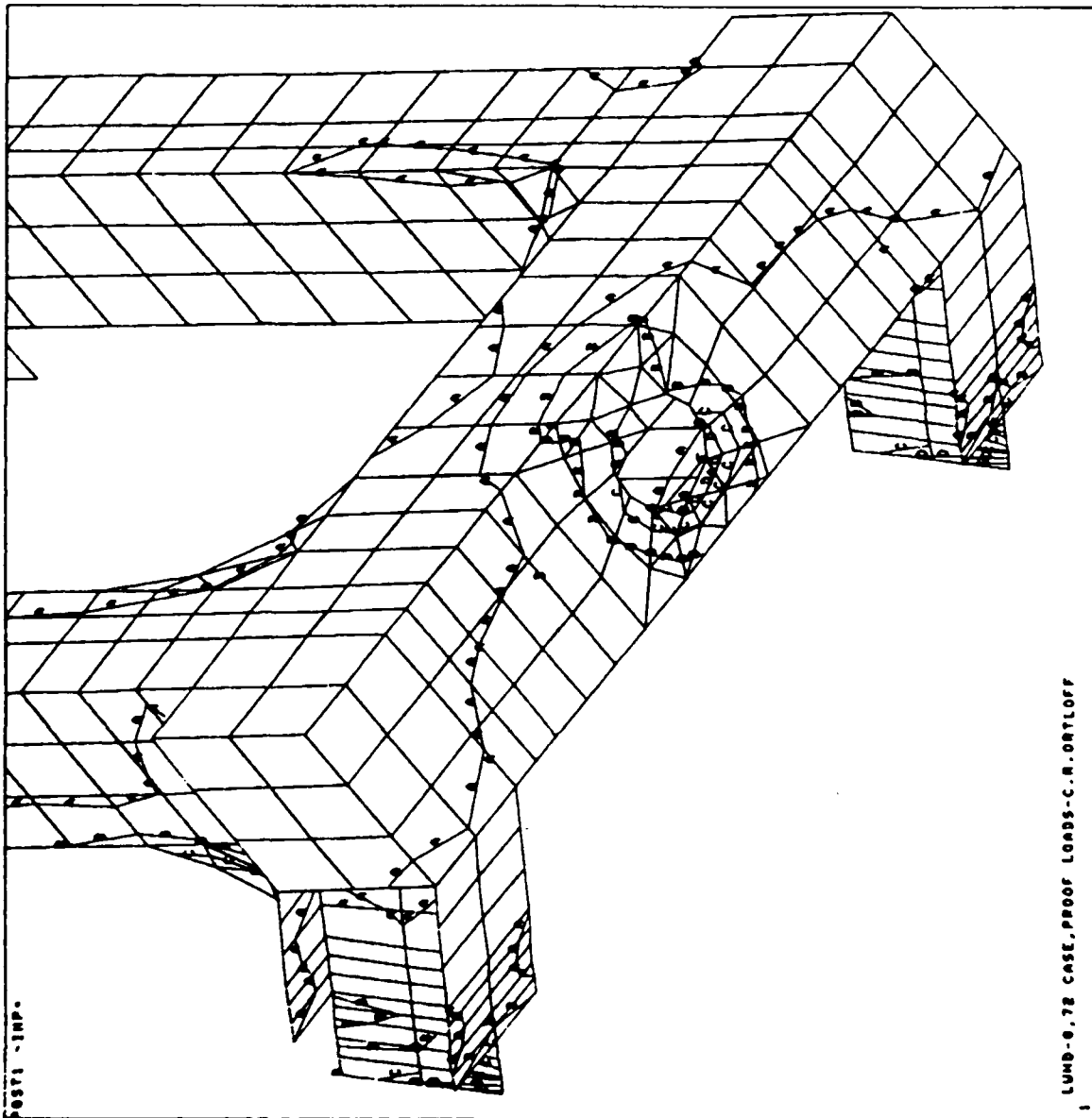
ANSYS 4.80
DEC 20 1986
10:38:00
POST1 STRESS
STEP=1
ITER=1
TIME=.031
SIZE
TOP
XU=-1
VU=-1
ZU=-1
DIST=32.7
XF=51.8
VF=36.8
ZF=-8.87
HIDDEN
MX=185811
MY=2472
M=27994
S=53518
C=78942
D=104566
E=130886



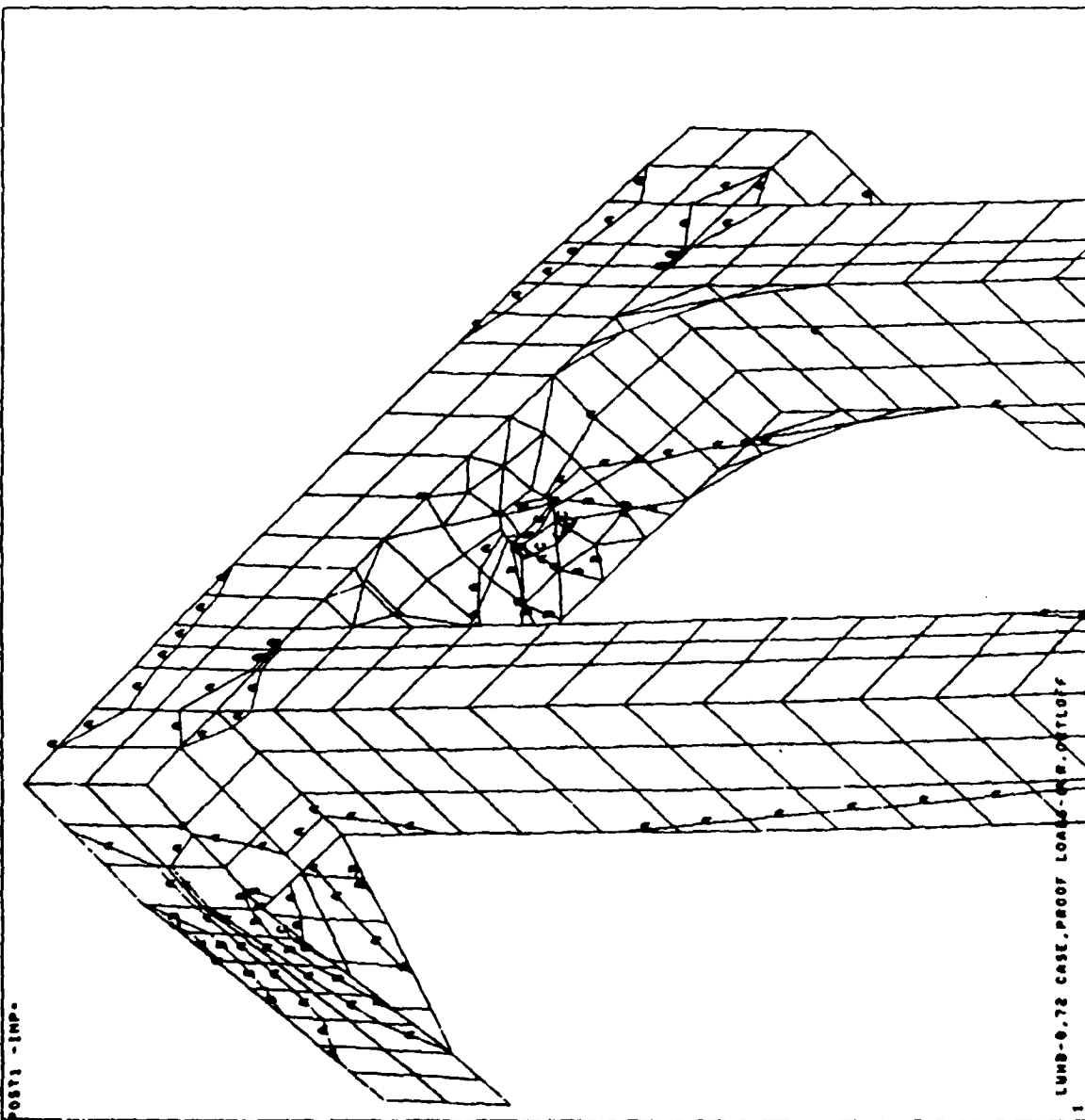
POST1 - ENP.

1 LUMB=0.72 CASE, PROOF LOADS-C.R.ORTLOFF

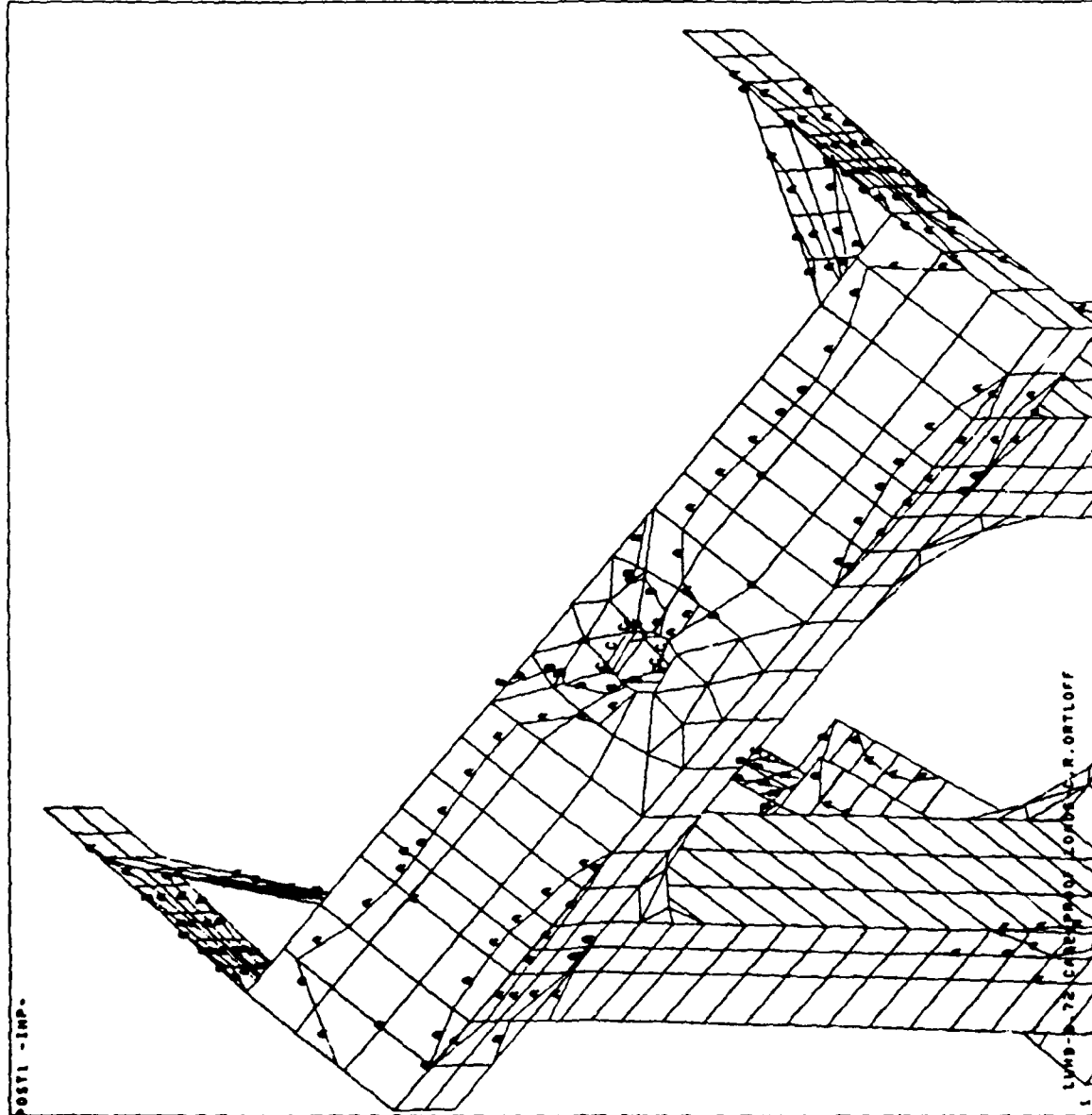
ANSYS 4.20
 DEC 20 1986
 10130100
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.031
 SICE
 TOP
 ZOOM
 KU=-1
 VU=-1
 ZU=1
 DIST=21.4
 KF=58.7
 VF=21.2
 ZF=-15.5
 VRT0=1.4
 MIDDEN
 RX=155611
 RM=0
 A=27894
 B=53518
 C=79042
 D=104566
 E=130000



ANSYS 4.20
 DEC 29 1986
 10:43:05
 POST1, STRESS
 STEP=1
 LAYER=1
 TIME=.031
 SICE
 TOP
 ZOOM
 KU=-1
 VU=-1
 ZU=-1
 2 DIST=26.4
 2 WF=46.2
 2 VF=46.6
 2 ZF=2.5
 VATO=1.78
 HIDDEN
 MX=94376
 MY=6
 A=27994
 B=53518
 C=78942



ANSYS 4.20
 DEC 29 1986
 18148157
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.031
 SICE
 TOP
 ZOOM
 XU=.4
 VU=1
 ZU=.5
 8 DIST=34.0
 8 XE=48.5
 8 VE=42.3
 8 ZE=17.8
 XRT0=1.42
 YRT0=1.78
 MIDDEN
 MX=145769
 MY=0
 A=27884
 B=53518
 C=79842
 D=184566
 E=130080



PRINT ELEMENT STRESS ITEMS PER ELEMENT

8888 POST1 ELEMENT STRESS LISTING 8888

LOAD STEP	1	ITERATION	1	SECTION	1
TIME	0.31000E-01	LOAD CASE	1		
ELEM	SDIR	SBZ	SBVI	SBZ2	
3078	149.62	1478.4	353.66	-339.58	
3079	445.58	1433.5	359.55	-787.77	
3080	6049.2	-318.79	-212.91	180.38	
3081	-2727.1	-109.24	1807.1	-32.309	
3082	-226.66	45.056	-867.75	-75.778	
3083	1198.2	-56.221	-1446.6	31.046	
3084	418.48	53.446	1139.8	186.86	
3085	9885.8	-205.58	-208.19	65.821	
3086	-268.04	-46.994	1488.2	-60.563	
3089	6171.1	-266.93	804.42	89.629	
3090	-2585.6	116.83	-1773.8	-294.74	
3092	398.07	314.15	-1671.5	-84.811	
3093	1242.7	-15.369	1803.7	-82.344	
3095	3978.4	634.20	323.62	-663.90	

MORE (YES, NO OR CONTINUOUS).

Y

8888 POST1 ELEMENT STRESS LISTING 8888

LOAD STEP	1	ITERATION	1	SECTION	1
TIME	0.31000E-01	LOAD CASE	1		
ELEM	SDIR	SBZ	SBVI	SBZ2	
3096	-5208.2	-120.28	548.30	422.83	
3097	-1631.7	1609.2	-673.75	-962.76	
3098	-8270.7	-186.03	-576.64	479.43	
3099	-2663.5	304.19	-151.16	-89.250	
3101	-5524.2	370.20	-1688.8	-69.092	
3106	-1580.1	-859.82	1646.3	1695.4	
3107	-3418.9	317.34	143.65	-102.70	
3108	-8285.3	486.71	274.40	-176.32	
3109	4087.6	661.66	-357.39	-700.09	
3110	9735.2	-167.53	274.45	47.817	
3134	-247.27	0.80786E-01	85.434	43.750	
3135	-370.70	3.7816	68.338	32.046	
3136	-390.93	0.11386	4.9224	-29.345	
3137	-84.841	104.48	4.2766	1.6341	

MORE (YES, NO OR CONTINUOUS).

Y

8888 POST1 ELEMENT STRESS LISTING 8888

LOAD STEP	1	ITERATION	1	SECTION	1
TIME	0.31000E-01	LOAD CASE	1		
ELEM	SDIR	SBZ	SBVI	SBZ2	
3142	-153.98	56.075	-5.7105	3.3457	
3143	-327.00	0.73415E-02	-57.418	-28.807	
3144	-81.580	5.2846	-5.6923	2.7478	
3145	-331.00	0.34046	-123.81	-103.81	
3146	-611.00	-0.11152	-84.834	-31.924	
3147	-380.81	30.980	-5.7041	7.1466	
3148	-368.45	0.99504E-01	9.1267	-41.220	
3149	-119.91	104.84	-4.0216	1.7616	

3351	2335.1	-448.71	-83.841	-317.02
3352	-2134.8	358.79	168.80	223.13
3353	-1149.7	924.09	39.435	-7.6389
3354	1888.3	-131.87	-192.88	-88.38
3355	2822.8	-193.65	-134.14	-347.14
3356	-2148.7	432.65	47.489	85.680

MORE (YES, NO OR CONTINUOUS).

Y

8888 POST1 ELEMENT STRESS LISTING 8888

LOAD STEP	1	ITERATION	1	SECTION	1
TIME	0.31000E-01	LOAD CASE	1		
ELEM	SDIR	SBZ	SBVI	SBZ2	
3357	-1107.0	385.47	120.63	68.725	
3358	1988.9	-65.381	-56.798	-159.42	
3359	-1141.2	939.87	-38.669	-10.825	
3361	1046.6	-132.17	107.04	-284.87	
3362	-938.52	330.43	-121.68	74.606	
3363	1941.4	-77.082	26.898	-169.14	
3364	2232.0	-428.52	16.112	-336.50	
3369	-8000.3	358.18	-172.18	238.31	
3379	2777.9	-196.82	134.39	-378.35	
3371	-2098.9	478.72	-45.091	78.136	
3372	-2004.8	230.63	161.71	-75.380	
3373	2392.2	-41.134	129.84	100.44	
3374	-3413.4	-142.26	70.959	-10.181	
3375	3630.0	-214.55	47.884	-107.38	

MORE (YES, NO OR CONTINUOUS).

Y

8888 POST1 ELEMENT STRESS LISTING 8888

LOAD STEP	1	ITERATION	1	SECTION	1
TIME	0.31000E-01	LOAD CASE	1		
ELEM	SDIR	SBZ	SBVI	SBZ2	
3376	-3922.1	138.18	254.45	-87.112	
3377	4442.7	-104.96	73.470	306.71	
3378	3969.2	117.61	-211.85	268.73	
3379	-6860.5	-205.53	-66.388	-449.45	
3380	3530.5	-191.07	-20.544	-115.90	
3381	-3510.9	142.57	-215.67	-61.367	
3382	4376.5	-111.62	-72.850	373.45	
3383	-6812.7	-273.38	-48.102	-475.45	
3384	-1216.7	339.08	-125.36	-66.200	
3385	8639.4	-29.164	-70.978	167.53	
3386	-3823.9	-142.89	-82.237	-55.118	
3387	3542.4	82.210	69.907	216.30	
3388	-4793.1	31709	-364.76	-16035	
3389	191.73	4934.2	0.00000E+00	10787	

MORE (YES, NO OR CONTINUOUS).

Y

Y
 3434 -5972.2 -113.02 -10.493 -0.96353E-03
 3437 1375.0 70.465 7.4923 0.13040E-03
 3438 1689.7 17.009 -1.4474 0.24086E-04
 3439 4111.9 -3.8289 13.059 0.60283E-04
 MORE (YES, NO OR CONTINUOUS).
 Y

3434 POST1 ELEMENT STRESS LISTING 8888
 LOAD STEP 1 ITERATION-01 LOAD CASE-1
 TIME-0.31000E-01
 ELEM SB1R SB2 SBV1 SBV2
 3434 1174.0 30.507 -7.7116 0.10058E-03
 3437 820.47 83.544 12.257 0.14123E-03
 3438 2013.0 -11.712 -16.896 0.05131E-06
 3439 135.16 11.566 8.3613 0.22843E-03
 3440 240.66 11.838 -1.1878 0.18153E-03
 3441 -100.06 11.879 22.934 0.69871 0.21112E-03
 3442 188.01 8.5088 -10.564 0.20283E-03
 3443 404.04 9.8921 5.9546 0.26757E-03
 3444 301.85 9.6862 -3.0899 0.20642E-03
 3445 -48.589 13.141 0.37149 0.20278E-03
 3446 -109.89 -0.16036 -1.0321 0.77888E-04
 3447 117.93 1.5852 0.20241 0.87849E-04
 3448 113.46 -5.8373 -0.39138 0.50614E-06
 MORE (YES, NO OR CONTINUOUS).
 Y

3434 POST1 ELEMENT STRESS LISTING 8888
 LOAD STEP 1 ITERATION-01 LOAD CASE-1
 TIME-0.31000E-01
 ELEM SB1R SB2 SBV1 SBV2
 3434 -74.850 -2.2257 2.2669 0.84006E-06
 3437 -35.580 -3.2770 0.54724 0.27523E-04
 3438 -181.82 3.6580 0.4698 -0.52308E-04
 3439 -31.999 10.885 -2.7913 0.45211E-04
 3440 -118.07 2.5323 -2.9121 0.52132E-04
 3441 -6151.3 57.576 -26.857 0.21075E-04
 3442 -771.07 27172.4 -1332.4 28336.
 3443 -1135.8 -83.563 10.129 -0.58337E-03
 3444 -709.12 -42.485 3.0112 -0.33174E-03
 3445 -704.12 -47.027 2.5602 -0.34284E-03
 3446 -2548.8 -56.579 12.059 -0.56593E-03
 3447 -1134.9 -12.901 29.715 -0.23794E-04
 3448 -4033.4 -11.909 -20.431 -0.65528E-03
 MORE (YES, NO OR CONTINUOUS).
 Y

Y
 3434 POST1 ELEMENT STRESS LISTING 8888
 LOAD STEP 1 ITERATION-01 LOAD CASE-1
 TIME-0.31000E-01
 ELEM SB1R SB2 SBV1 SBV2
 3434 -2855.8 85108. -1402.1 2575.5
 3437 1708.7 41073. -9337.4 8575.5
 3438 3419.6 36270. 0.00000E+00 32811.
 3439 -913.91 38.380 20.094 0.11530E-03
 3440 1811.6 62.542 25.215 0.18470E-04
 3441 -841.53 45.504 5.8004 0.36724E-05
 3442 86.082 555.94 -15.082 0.27855E-05
 3443 69.082 3.7564 -0.14883 0.32813E-06
 3444 76.089 7.1407 -0.90281E-01 0.31800E-06
 3445 -218.75 38.759 0.89656 0.12107E-05
 3446 -1679.6 53.104 -10.363 0.57713E-05
 3447 -1468.4 0.39088E-04 26.415 51.427
 3448 -397.94 -40.670 23.032 -0.04964E-03
 3449 139.20 -28.691 12.121 -0.00580E-04
 MORE (YES, NO OR CONTINUOUS).
 Y

3434 POST1 ELEMENT STRESS LISTING 8888
 LOAD STEP 1 ITERATION-01 LOAD CASE-1
 TIME-0.31000E-01
 ELEM SB1R SB2 SBV1 SBV2
 3434 741.95 -30.827 0.69934 -0.80995E-04
 3437 -118.21 -9.3236 -0.35337 -0.37349E-05
 3438 92.493 -3.9951 0.53499 -0.37167E-05
 3439 -326.42 -3.7478 -8.4745 -0.86470E-04
 3440 -750.12 -35.660 -24.894 -0.84856E-04
 3441 1301.2 21.024 -40.833 -0.43403E-05
 3442 2824.4 -11.609 13.271 -0.14282E-03
 3443 1877.4 -24.852 -1.7377 -0.85177E-05
 3444 -222.01 -8.9372 -2.4055 -0.75001E-06
 3445 -113.94 -5.9283 1.7590 -0.49203E-05
 3446 301.17 -11.326 2.3413 -0.86478E-05
 3447 1475.5 -25.986 -2.9825 -0.23830E-04
 3448 -62.19 3.7166 5.9277 -0.40707E-04
 3449 114.14 -3.3969 0.43104 -0.24631E-04
 MORE (YES, NO OR CONTINUOUS).
 Y

3434 POST1 ELEMENT STRESS LISTING 8888
 LOAD STEP 1 ITERATION-01 LOAD CASE-1
 TIME-0.31000E-01
 ELEM SB1R SB2 SBV1 SBV2
 3434 37.835 -408.83 0.00000E+00 0.85427E-03
 3437 13.579 -2.3734 1.0526 -0.22890E-05
 3438 97.392 -2.7859 -0.42507 -0.22250E-04
 3439 -472.37 4.0809 -5.6573 -0.52918E-04
 3440 2027.5 -23.523 27.223 0.14720E-04
 3441 4598.2 69.541 -12.840 0.10498E-03
 3442 901.41 2.3267 -2.3997 0.70188E-04
 3443 1023.5 2.8434 -17.151 -0.38443E-04
 3444 1380.2 -110.77 -15.422 -0.37072E-03
 3445 -1135.8 -42.486 3.0112 -0.33174E-03
 MORE (YES, NO OR CONTINUOUS).
 Y

20000 POST1 ELEMENT STRESS LISTING 20000

LOAD STEP 1 ITERATION 1 SECTION 1

TIME 0.31000E-01 Load CASE 1

ELEM	SDIR	SDZ	SDV1	SDZ2
3400	-100.40	50.000	0.1027	3.0400
3471	-100.70	1.2000	4.7014	2.7641
3472	-317.00	0.3404	134.88	-86.935
3474	-318.04	0.82034	37.193	-63.130
3494	-826.00	-3.4301	-1.4031	0.23174
3506	-1019.0	-0.10037	-228.45	31.000
3507	-990.27	40.404	20.000	65.117
3508	-1781.0	0.36166E-01	78.774	87.100
3509	-1135.0	61.300	-49.935	59.707
3510	83.704	-14.728	300.55	93.651
3511	94.840	83.045	130.21	45.380
3512	-812.20	18.407	-11.959	118.72
3513	-850.07	844.04	0.20007E-13	0.00000E+00
3515	-10.027	-4.0020	68.020	-43.780

NOTE (YES,NO OR CONTINUOUS).

20000 POST1 ELEMENT STRESS LISTING 20000

LOAD STEP 1 ITERATION 1 SECTION 1

TIME 0.31000E-01 Load CASE 1

ELEM	SDIR	SDZ	SDV1	SDZ2
3516	-24.360	-12.794	49.017	-11.106
3523	5293.6	-0.14511E+07	0.10404E+06	0.30528E+07
3524	4691.5	0.31056E+07	0.20705E+06	0.16000E+07
3525	4707.8	-0.16000E+07	0.15501E+06	0.14511E+07
3526	4853.7	0.32007E+07	24814.	-0.18974E+07
3529	4865.4	-0.12974E+07	18008.	-0.13050E+07
3530	5017.1	-0.13050E+07	-12932.	0.28648E+07
3531	766.86	1.0000	-2.2342	-1.8168
3532	-1307.0	-8.0823	-8.8761	-0.18480E-08

POST1 -IMP.

PRINT REACTION FORCES PER NODE

***** POST1 REACTION FORCE LISTING *****
 LOAD STEP 1 ITERATION-1 SECTION-1
 TIME- 0.31000E-01 LOAD CASE-1
 THE FOLLOWING X,Y,Z FORCES ARE IN NODAL COORDINATES

NODE	PX	PY	PZ	RX	RY	RZ
856	-918.5					
859	-8453.					
863	-2043.					
867	-1733.					
868	-558.6					
869	-1166.					
871	-835.0					
876	-64.43					
877	-52.18					
883	15.88					
884	513.0					
885	60.01					

MORE (YES, NO OR CONTINUOUS)-

***** POST1 REACTION FORCE LISTING *****
 LOAD STEP 1 ITERATION-1 SECTION-1
 TIME- 0.31000E-01 LOAD CASE-1
 THE FOLLOWING X,Y,Z FORCES ARE IN NODAL COORDINATES

NODE	PX	PY	PZ	RX	RY	RZ
891	-36.56					
892	-67.77					
893	-831.1					
898	-1151.					
900	-531.4					
901	-1707.					
906	-884.0					
907	-2027.					
911	-2454.					
1278	-704.8	273.5	470.8			
1279	-1108.	426.2	-188.6			
1280	-1484.	308.3	-161.1			

***** POST1 REACTION FORCE LISTING *****
 LOAD STEP 1 ITERATION-1 SECTION-1
 TIME- 0.31000E-01 LOAD CASE-1
 THE FOLLOWING X,Y,Z FORCES ARE IN NODAL COORDINATES

NODE	PX	PY	PZ	RX	RY	RZ
1284	-1352.	3016.	-78.06			
1285	-865.0	1025.	-400.5			
1288	-1114.	3601.	-977.3			
1289	-1757.	1339.	-541.8			
1290	-1285.	1154.	-464.8			
1291	-793.6	1946.	-773.1			
1296	81.42	0.1039E+05	-3286.			
1297	-1186.	2666.	-1074.			

***** POST1 REACTION FORCE LISTING *****
 LOAD STEP 1 ITERATION-1 SECTION-1
 TIME- 0.31000E-01 LOAD CASE-1
 THE FOLLOWING X,Y,Z FORCES ARE IN NODAL COORDINATES

NODE	PX	PY	PZ	RX	RY	RZ
1306	183.4	6383.	-2474.			
1307	1051.	6016.	-3202.			
1318	1320.	3706.	-799.1			
1313	-1396.	6351.	-2536.			
1314	326.3	3083.	-1804.			
1315	1479.	8533.	-1080.			
1380	1414.	3693.	-108.7			
1381	989.4	1874.	-744.8			
1382	1445.	1116.	-447.8			
1383	1029.	1442.	-581.7			
1388	1170.	442.6	-180.7			
1389	818.8	1161.	-453.9			

***** POST1 REACTION FORCE LISTING *****
 LOAD STEP 1 ITERATION-1 SECTION-1
 TIME- 0.31000E-01 LOAD CASE-1
 THE FOLLOWING X,Y,Z FORCES ARE IN NODAL COORDINATES

NODE	PX	PY	PZ	RX	RY	RZ
1332	737.4	-115.1	386.0			
1333	1441.	234.7	-85.57			
1435	-586.7					
1440	-187.6					
2810		1101.				
2818		1487.				
2821		1116.				
2822		1441.				

TOTAL 1726. 0.9814E+05-0.3115E+05 0.0000E+00 0.0000E+00 0.00
 00E+00
 POST1 -IMP.

D3/160

CEL MEMO: DECEMBER 29, 1986 (PROGRESS)

FMC Central Engineering Laboratories
Santa Clara

Interoffice

To R. Rathe

From C. R. Ortloff

Subject **PROGRESS REPORT TO 28 DEC 86
AND RESULTS TO DATE SUMMARY**

Date Dec. 29, 1986

cc E. Thuse
A. Amberg
R. Kazares
E. Alexander
B. Anderson
J. Ries
L. Libhardt
B. Zierwick
P. Carroll

A brief summary of expenditures and progress to date is given to summarize CEL results on the LWHD Phase II project.

- o Of the \$1.4MM awarded to Northern Ordnance, \$60K is now scheduled for CEL Applied Mechanics and \$15K to MEL. Expenditures to date are: Applied Mechanics \$33K, MEL \$0K. Original budget of \$120K for Applied Mechanics was reduced to \$60K (10/86) with no reduction in expected work or schedule times. 2 m. later put
- o Design analysis and deliverables have been forwarded to Northern Ordnance for the most current available version of the cradle. Work to date includes a static analysis of the 27 layer foam core Gr/Ep sandwich structure under firing load maximums. Work performed by M. Rodamaker (ANSYS consultant) on the dynamic behavior of a simplified FE model of the cradle provided dynamic amplification factors between 1 to 1.5 used to modify the static results for an approximation to the dynamic stress state. The current cradle design apparently fails by a number of composite failure mechanisms (Memo: C. R. Ortloff to R. Rathe, 8 Dec 86) and is presently under redesign. Suggestions were forwarded with the above memo for a redesign of the filament wound structure with additional layers to produce a workable design. As yet, no response on the new design (woven roving layup) or acceptance of the suggested modified filament wound structure has been received for further analysis (as of 28 Dec 86). Hard copy of the static analysis was also forwarded (C. R. Ortloff to L. Libhardt, 16 Dec 86) as requested. 29 not sure
- o Dynamic analysis of the 0°-0° load case has been performed and results forwarded (Memo: CRO to L. Libhardt, 17 Dec 86). Analysis showed that the gimbal shaft attachment zones were overstressed and needed local reinforcement. The system appeared to be stable under dynamic firing loads.
- o Dynamic analysis of the 0°-72° load case has been performed and results forwarded (Memo: CRO to L. Libhardt, 28 Dec 86). Results indicate local failure of the gimbal upper and lower

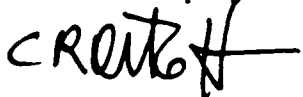
arms in addition to local failure of the shaft attachment zones in the gimbal. These parts may be reinforced to meet strength requirements as outlined in the memo. In total, some 384 pages of computer hard copy output on stress results have been forwarded with these memos.

- o A description of the model, loads and boundary conditions (and accompanying hard copy) was sent (Memo: CRO to L. Libhardt, 22 Dec 86) by request in order to provide materials to NOD staff for ARDEC presentations. Further color transparencies were sent (Memo: CRO to L. Libhardt, 29 Dec 86) with additional descriptive material to add to the materials previously sent.
- o Estimates of the effects of thermal expansion and moisture absorption stresses were made (Memo: CRO to L. Libhardt, 22 Dec 86) for the cradle by the University of Delaware CMAP program.
- o The 22.50-720, 22.50-00 FE models are finished (3600 elements each). The 22.50-720 dynamic stress analysis case has been run and is currently in postprocessing. Each run is 32 CPU hours.
- o About \$30K work of CEL computer resources has been devoted to the project to date. Remaining load cases (LAPES loads, various soil models for the spade to react to, further design iterations, etc.) remain. It is estimated that several hundred CPU hours will be expended before the project is completed.
- o Investigations on thermal expansion stresses under hot, wet conditions for the cradle are underway (in the run queue). Further investigations of cradle buckling are being set up for a run in early January. Buckling effects may dominate survivability considerations for the cradle.
- o Considerable overtime (not charged to the project) has been devoted to accomplish the project's schedule and cost goals.
- o Numerous changes in FE models have been made throughout the history of the project. It is estimated that 10 major revisions and/or new models were made in the course of the project to keep up with the "current design" and provide stress results. Once the design was stabilized in December, stress reports ensued rapidly (5 reports in the month of December, for example). As of 28 Dec 86, no new design updates have been received for the trails or cradle. Once these are received, FE models will be revised quickly and rerun to test new design fixes.

R. Rathe
Progress Report to 28 Dec 86 and
Results to Date Summary

29 Dec. 86
Page 3

- o The computer loading for work to date has been high. Problems occurred with disk space available (450K blocks) compared to necessary disk space to run a problem (400K blocks). Use of M. Rodamaker's computer system alleviated the problem of running multiple problems simultaneously and permitted rapid progress to be made. It is recommended that 700K blocks be held in reserve for problems of this size and complexity. Fees for M. Rodamaker's work are to be taken out of the CEL budget at NOD's request.
- o In the spirit of cooperation, I ask for all current design updates to be sent to me as soon as possible so that I may modify the FE models and report results of the next design iteration. The more rapidly this process can occur, the more design iterations can be performed and the better the final design will be.
- o Four trips have been taken to NOD (CRO) and NOD personnel have visited CEL twice to discuss progress on the project. To date, no invitation to present FEA results or to visit ARDEC has been made to CEL to upgrade our understanding of latest developments on the project.


C. R. Ortloff

D3/170

CEL MEMO: DECEMBER 30, 1986

FMC Central Engineering Laboratories
Santa Clara

Interoffice

To	Larry Libhardt	Date	Dec. 30, 1986
From	C. R. Ortloff	cc	E. Thuse A. Amberg R. Kazares J. Ries R. Rathe E. Alexander
Subject	RESPONSE TO REQUEST FOR COLOR GRAPHICS PLOTS FOR THE NOD/ARDEC PRESENTATION (9 FIGURES) IN JANUARY		

Enclosed are color transparencies showing the FEA model (0°-72° case) and various components of the full model. Also shown are some stress color fill plots representing the stress states at a given time during dynamic loading. I trust that these plots plus the several hundred B+W stress plots supplied with earlier memos will give you sufficient material to answer any questions at the design review meeting. Please contact me if you need any additional presentation or descriptive material before your meeting.

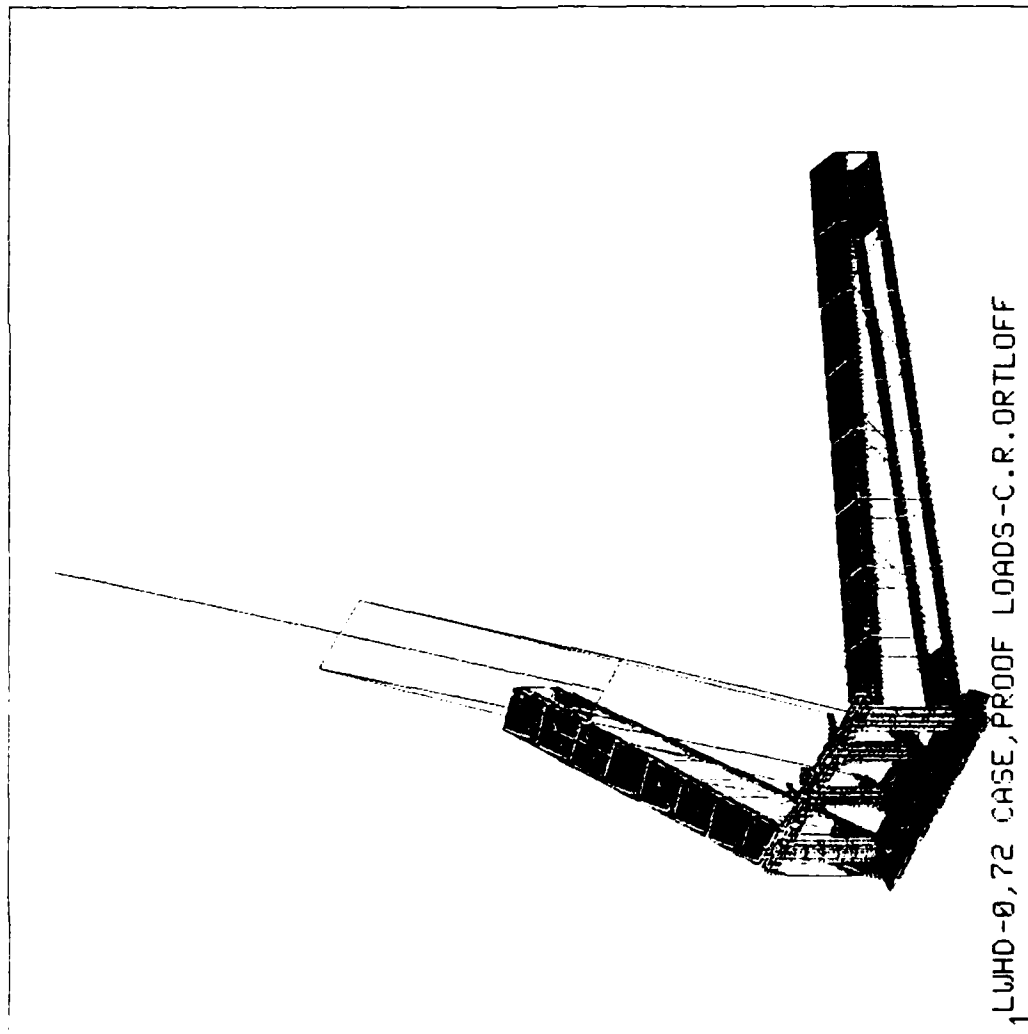
Please store all original hard copy material in a cool, dry place (or xerox as required) as these originals will darken with exposure to light. At some later time, I may request some of these originals to be returned for inclusion in the final stress report.

C. R. Ortloff

C. R. Ortloff

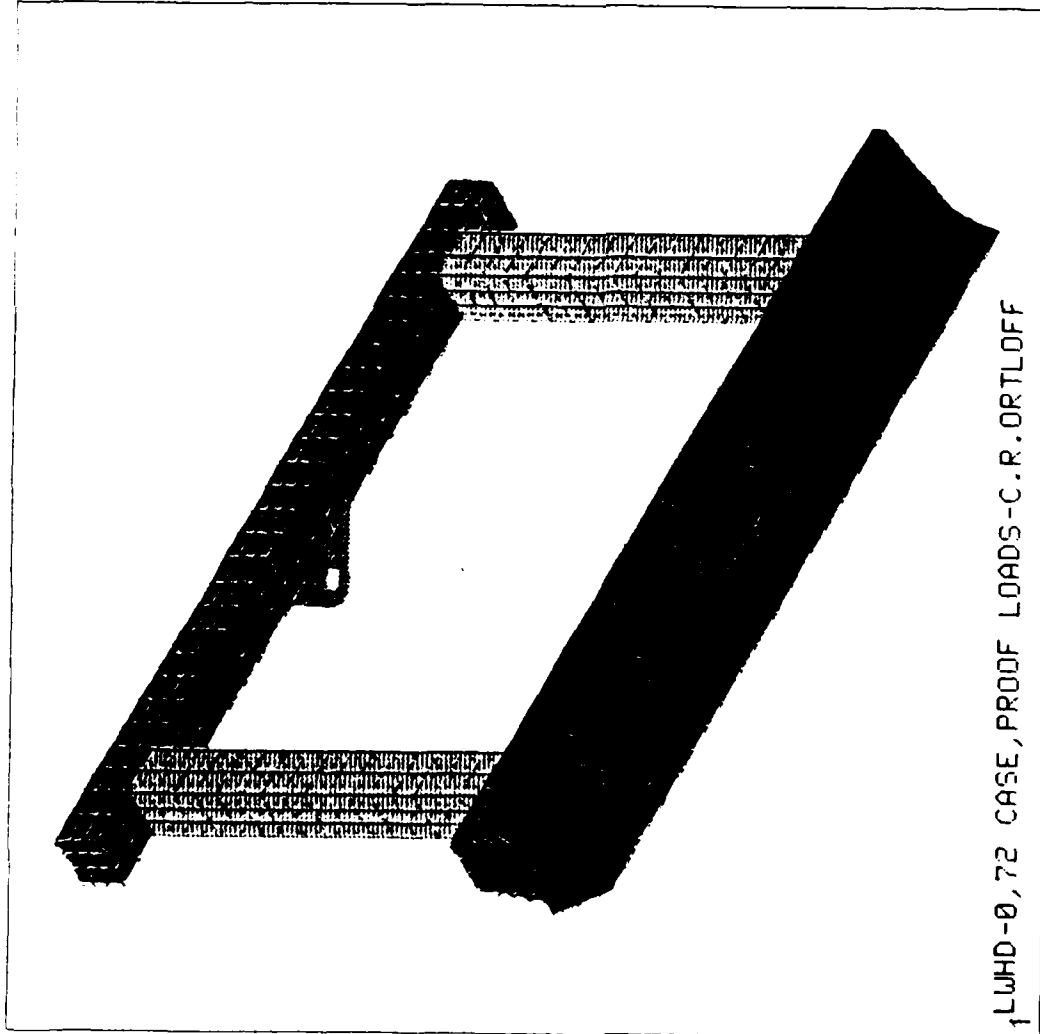
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DEC 29 1986
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XU=1
YU=1
ZU=1
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* XF=43.2
* YF=127
* ZF=-172
HIDDEN



ANSYS 4.28
DEC 29 1986
15:00:56
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RNUM=1

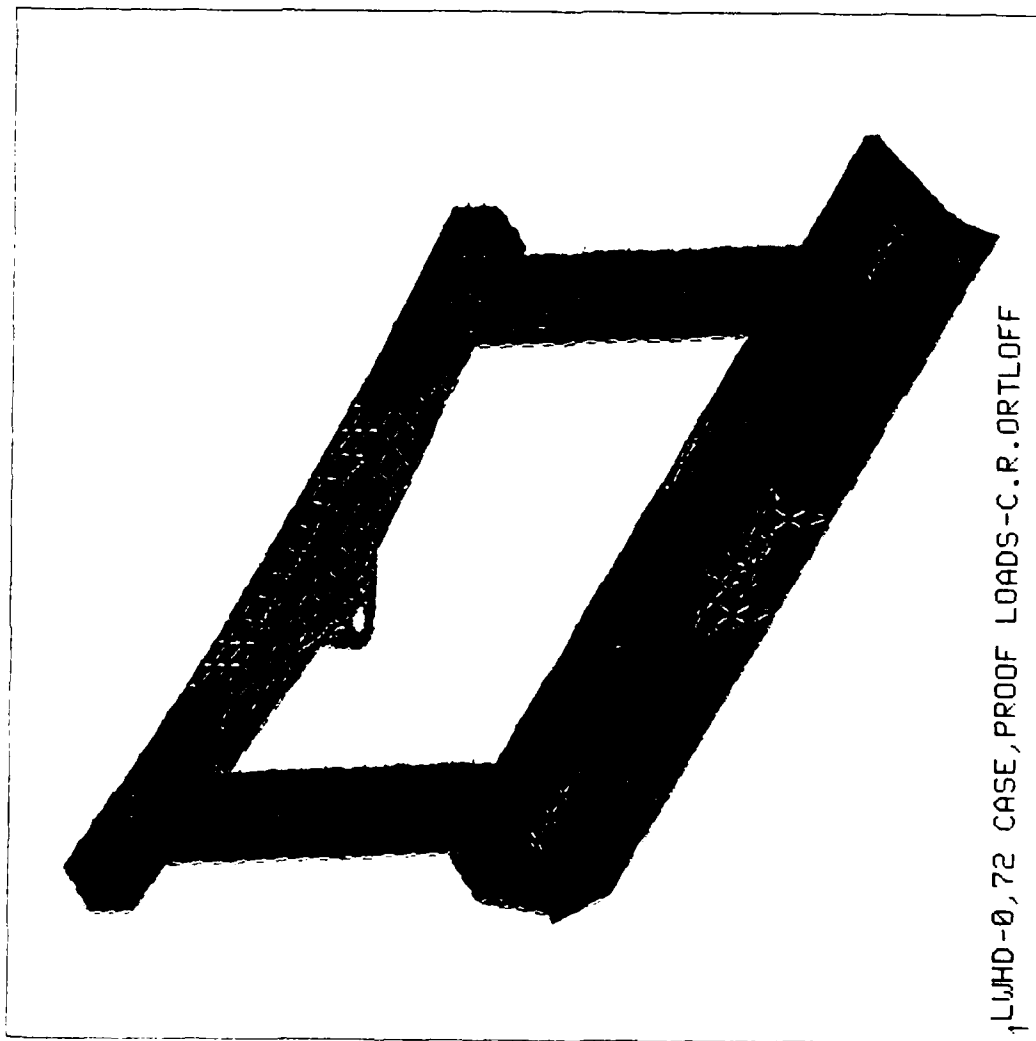
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YU=-1
ZU=1
* DIST=58.2
* XF=54.2
* YF=26.4
* ZF=4.85
HIDDEN



1LWHD-0,72 CASE,PROOF LOADS-C.R.ORTLOFF

ANSYS 4.28
 DEC 29 1986
 13:59:00
 PDST1 STRESS
 STEP=1
 ITER=1
 TIME=.031
 SIGE
 TDP

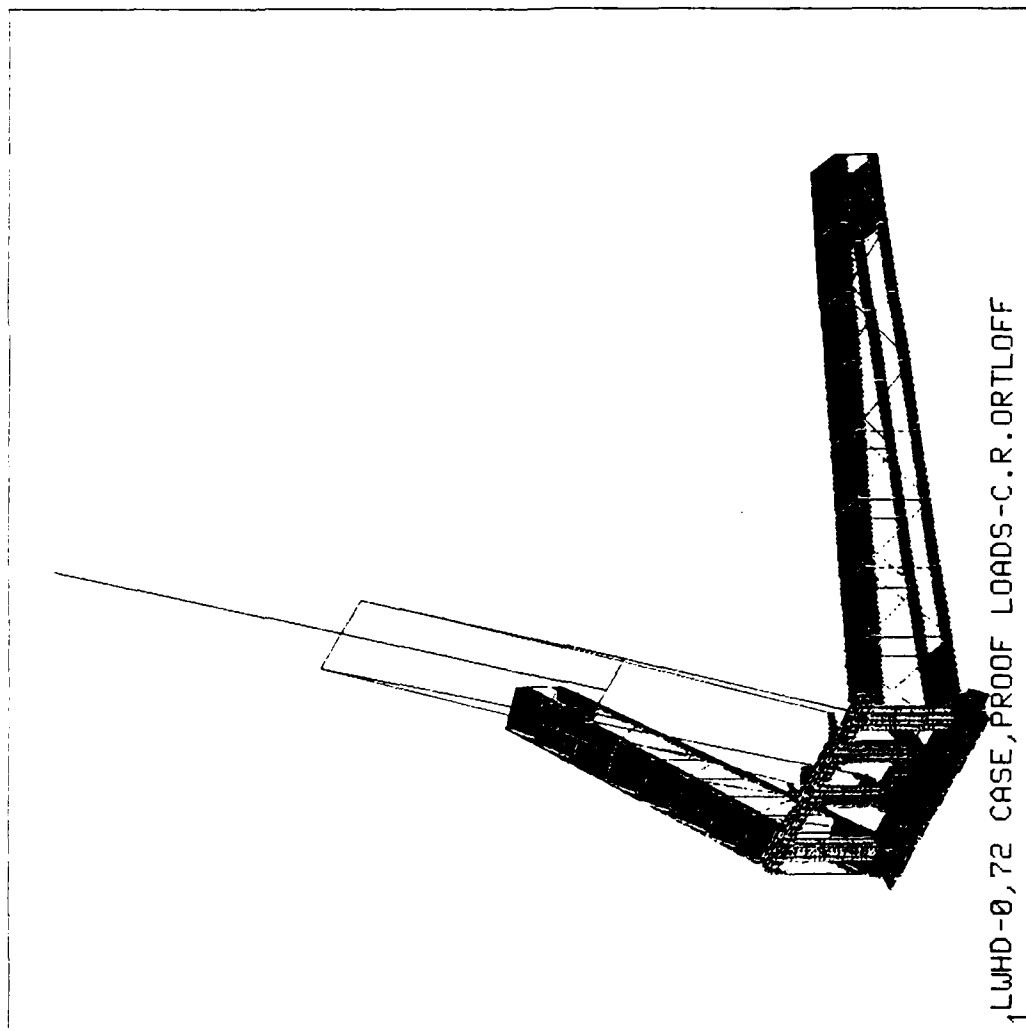
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 ZU=1
 DIST=58.2
 XF=54.2
 YF=26.4
 ZF=4.85
 HIDDEN
 MX=52416
 MN=345
 6854
 13363
 19372
 26331
 32390
 39399
 45988
 52417



1LWHD-0,72 CASE, PROOF LOADS-C.R.ORTLOFF

ANSYS 4.2B
DEC 29 1986
16:30:56
PREP7 ELEMENTS
RNUM=1

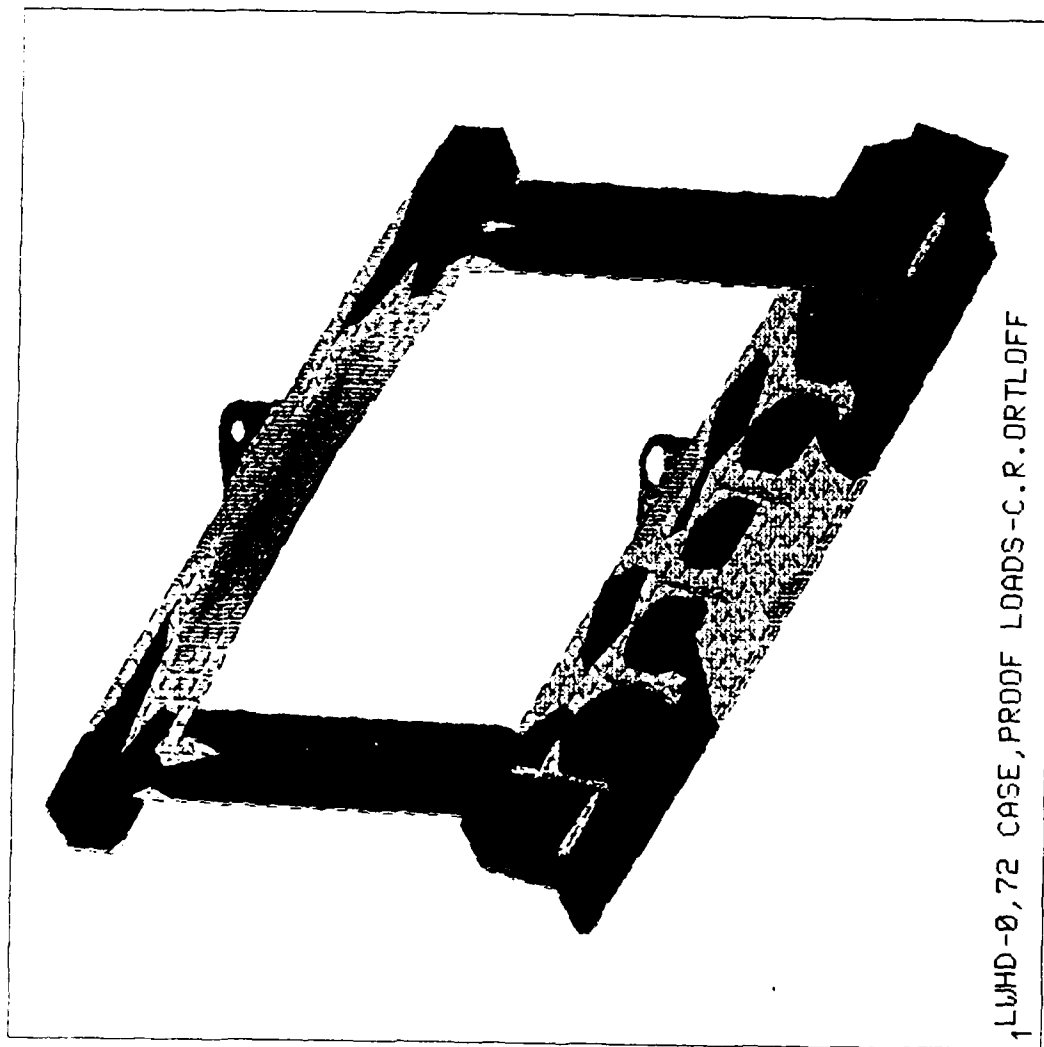
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ZU=1
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* YF=127
* ZF=-172
HIDDEN



ANSYS 4.2B
DEC 29 1986
14:18:24
POST1 STRESS
STEP=1
ITER=1
TIME=.031
SIGE
TOP

XU=1
YU=1
ZU=1
DIST=56.6
XF=51.2
YF=27.7
ZF=4.17
HIDDEN
MX=52416
MN=345
6854

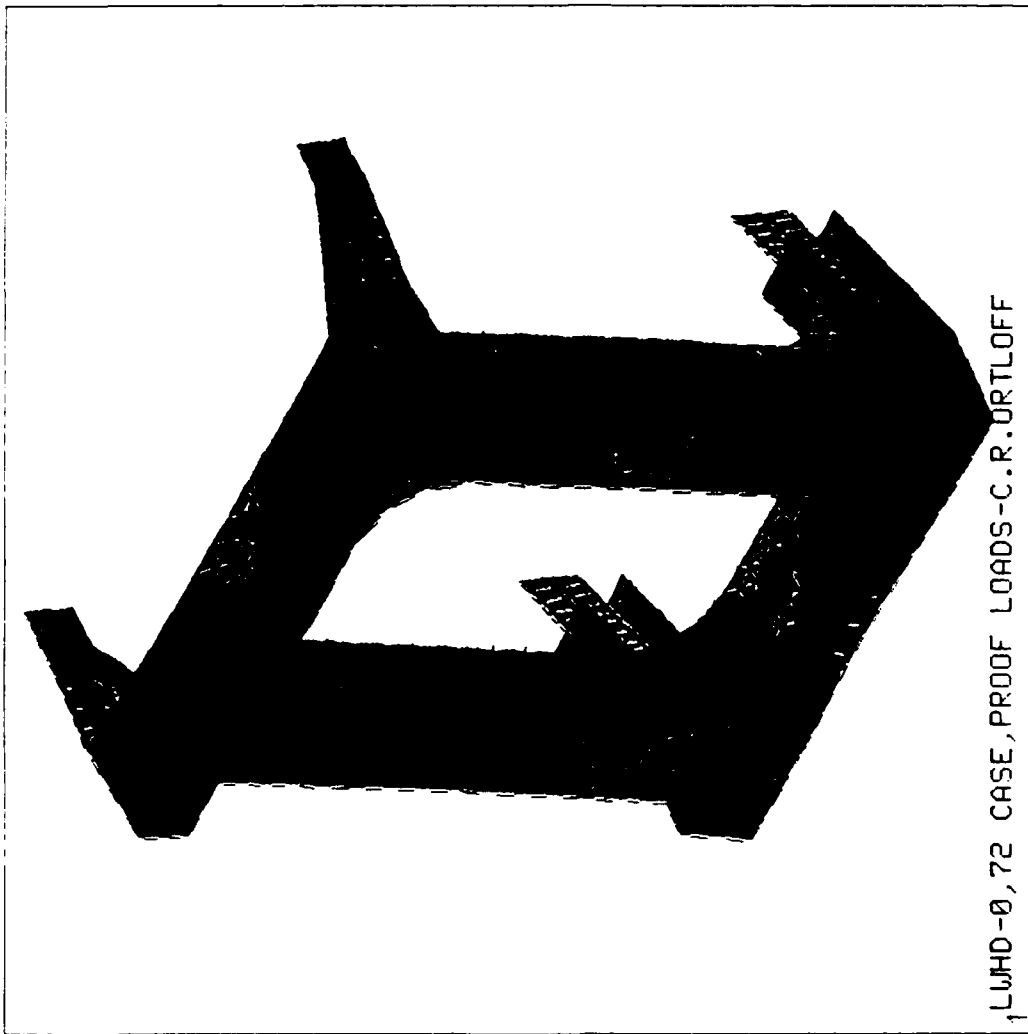
10000
26331
32390
39399
45908
52417



1 LUHD-0,72 CASE,PROOF LOADS-C.R.ORTLOFF

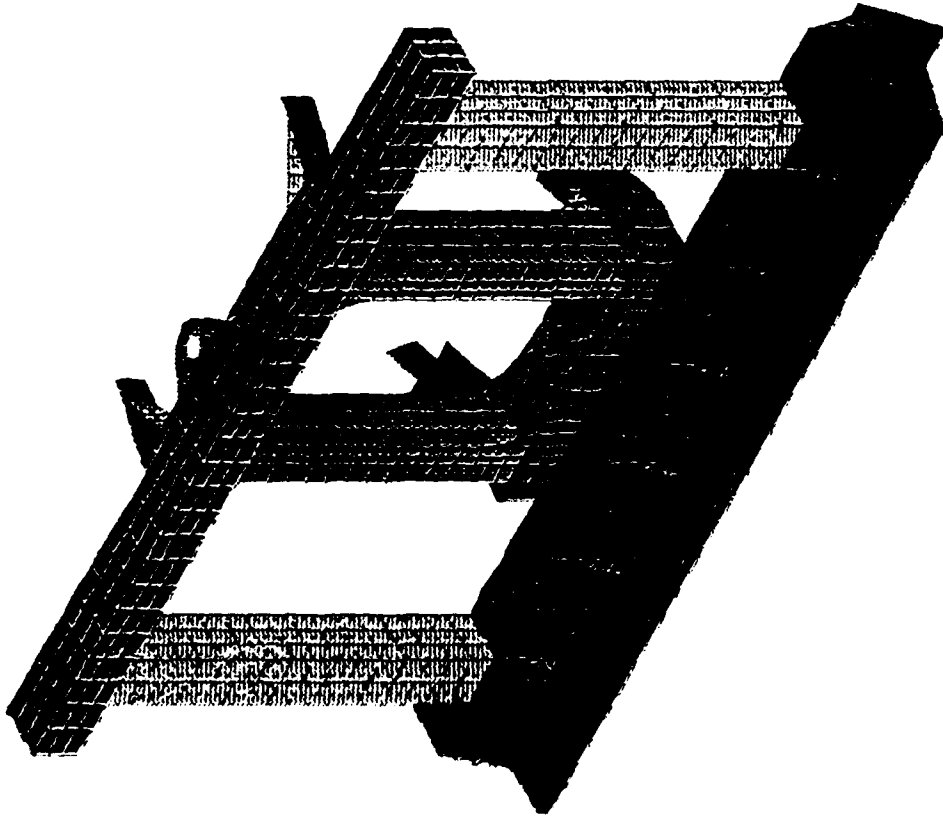
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DEC 29 1986
13:46:25
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ITER=1
TIME=.031
SIGE
TOP

XU=1
YU=1
ZU=1
DIST=34.2
XF=54.9
YF=33.9
ZF=-8.01
HIDDEN
MX=155611
MN=2472
21613
40756
59399
79042
98185
117323
131451
155614



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DEC 29 1986
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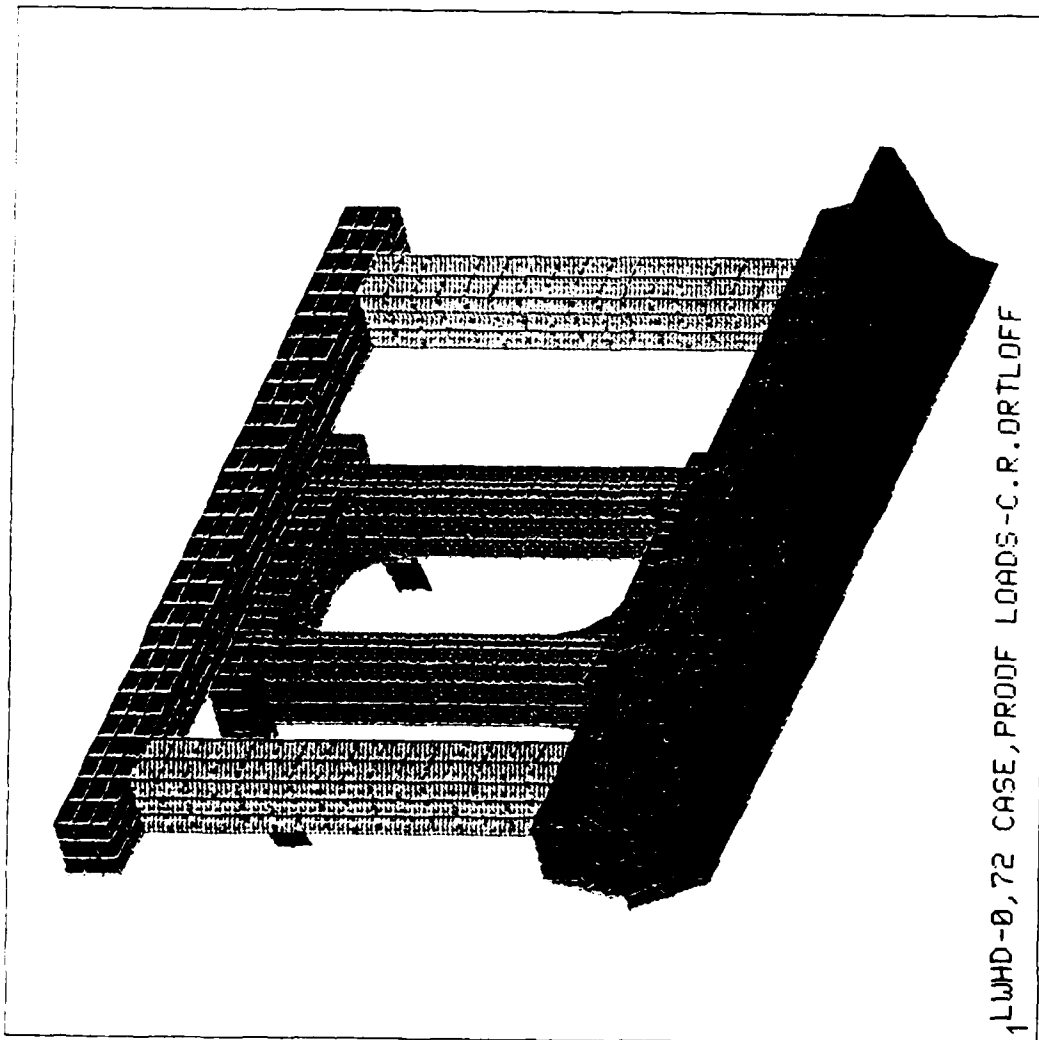
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ZF=4.17
HIDDEN



1,LUHD-0,72 CASE,PROOF LOADS-C.R.ORTLOFF

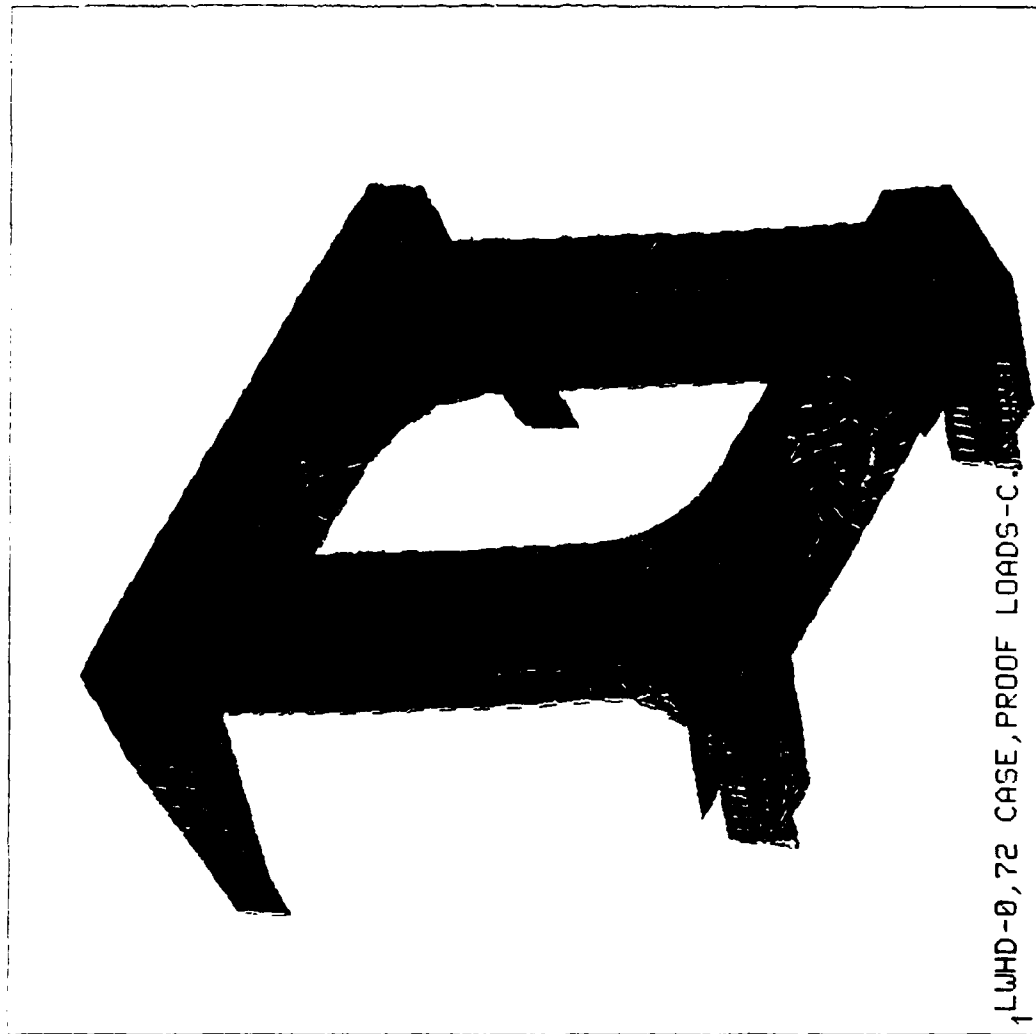
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XF=53.4
YF=26.1
ZF=5.66
HIDDEN



ANSYS 4.2B
DEC 29 1986
13:26:32
POST1 STRESS
STEP=1
ITER=1
TIME=.031
SIGE
TOP

XU=-1
YU=-1
ZU=1
DIST=32.7
XF=51.6
YF=35.2
ZF=-8.57
HIDDEN
MX=155611
MN=2472
21613
40756
59899
79042
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155614



ANSYS 4.28
DEC 29 1986
14:40:21
POST1 STRESS
STEP=1
ITER=1
TIME=.031
SIGE
TOP

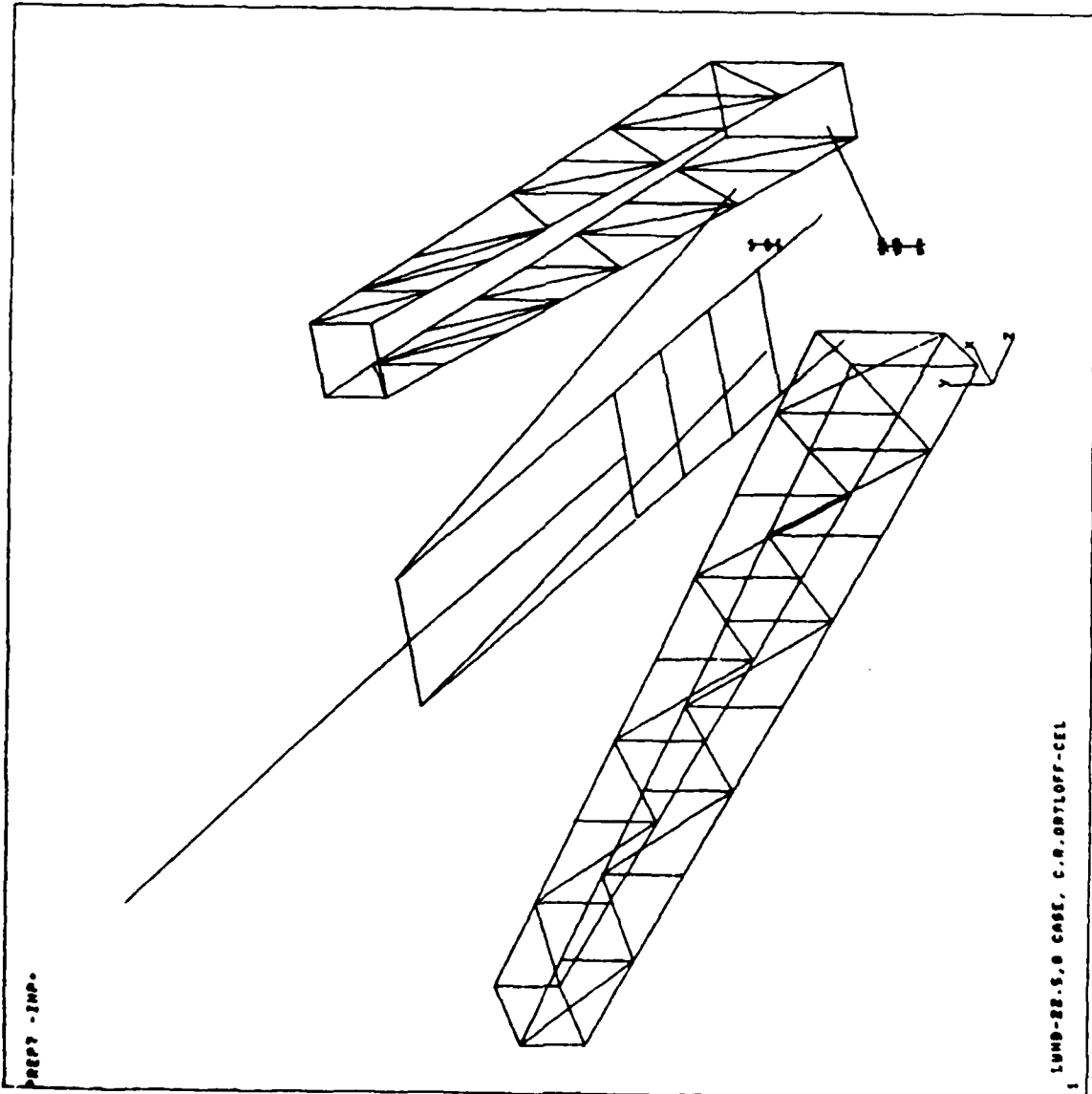
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YU=1
ZU=1
* DIST=7.31
* XF=62.4
* YF=13.3
* ZF=8.63
XRTD=1.16
HIDDEN
MX=45606
MN=695
5682
10673
15664
20655
30637
35628
40619
45610



1LWHD-0,72 CASE,PROOF LOADS-C.R.ORTLOFF

ANSYS 4.20
JAN 7 1987
13167133
PREP7 ELEMENTS

ZOOM
XU=-1
VU=1
ZU=1
DIST=167
XP=114
VP=81.5
ZF=-174
KSTO=1.24



STF 4
BEAM ELEMENTS

D3/180

CEL MEMO: JANUARY 7, 1987

FMC Central Engineering Laboratories
Santa Clara

Interoffice

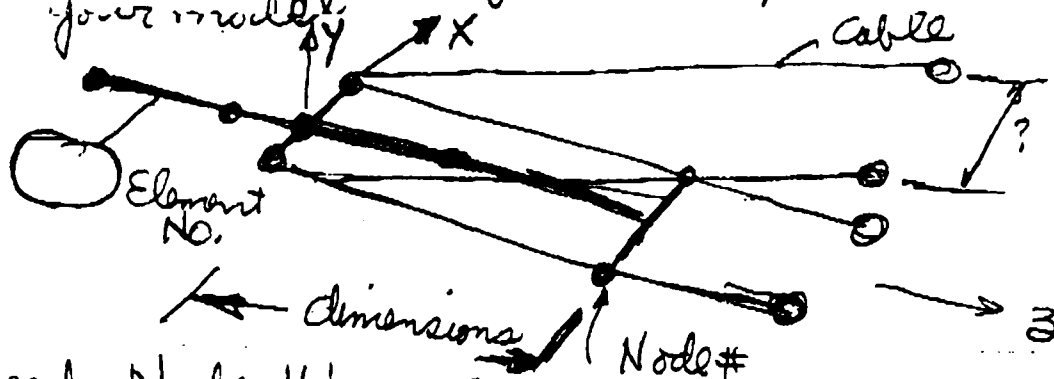
To	L. Libhardt	Date	January 7, 1987
From	C. R. Ortloff	cc	R. Rathe R. Kazares J. Ries E. Thuse
Subject	DELIVERY OF REQUESTED MATERIAL		

Pursuant to our 7 January 87 telecall, I am forwarding three requested items immediately. I will forward additional color transparencies tomorrow as requested. The 22.5°-0° system load case is done and a memo will be forwarded to you before 9 January 87.


C. R. Ortloff

1/7/87

We need a sketch of the finite element representation of the Gun/Cradle used in your model.



Need Node #'s

Need Weights / Masses & rotary Inertias

Need Dimensions

Element #'s & types of elements

Beam Properties for gun, cradle, cables

E values

A.

LWHD

BOUNDARY CONDITIONS

HARD SOIL EMPLACEMENT

- FIXED LOWER EDGE OF SPADE ($U_X = U_Y = U_Z = 0$)
- CONSTRAINTS ON VERTICAL DISPLACEMENT OF THE HORIZONTAL PLATE PART OF THE SPADE ($U_Y = 0$ AT SELECTED NODES ON THE PLATE)
- FREE TRAIL ENDS

SOFT SOIL EMPLACEMENT

- "EQUIVALENT" SPRING (MATCHING SOIL ELASTICITY) ATTACHED BETWEEN SPADE AND GROUND IN HORIZONTAL, VERTICAL DIRECTIONS
- FREE TRAIL ENDS

B.

LUMPED MASSED

- MASS OF BARREL, CRADLE INPUT AS LUMPED MASS IN TOTAL SYSTEM FINITE ELEMENT MODEL
- ALL OTHER MASS INPUT AS DISTRIBUTED MASS (I.E., DENSITY PRESCRIBED FOR ALL MATERIALS USED)

AD-A183 993	LIGHTWEIGHT TOWED HOWITZER DEMONSTRATOR PHASE 1 AND PARTIAL PHASE 2 VOLUM (U) FMC CORP MINNEAPOLIS MINN NORTHERN ORDNANCE DIV R RATH E AL APR 87	4/5
UNCLASSIFIED	FMC-E-3041-VOL-D3-PT-1 DAA421-86-C-0047 F/G 19/6	NL

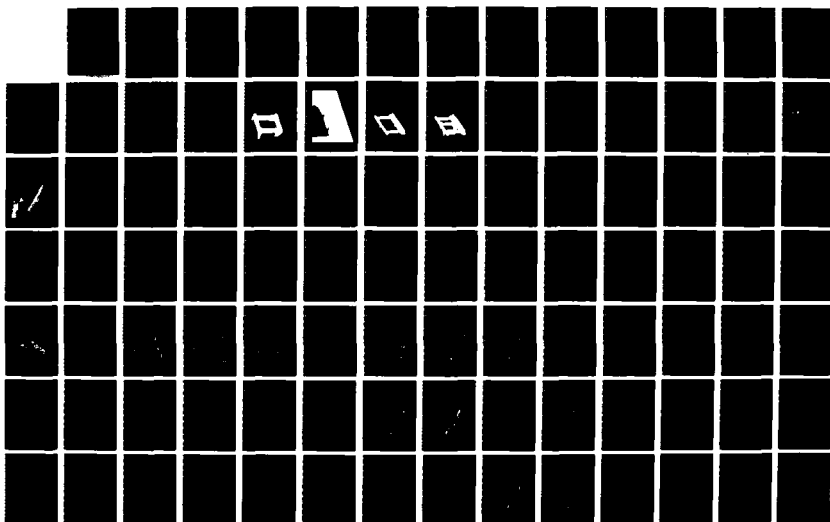
LIGHTWEIGHT TOWED HOWITZER DEMONSTRATOR PHASE 1 AND
 PARTIAL PHASE 2 VOLUM (U) FNC CORP MINNEAPOLIS MINN
 NORTHERN ORDNANCE DIV R RATHE ET AL APR 87
 FNC-E-3041-VOL-D3-PT-1 DAAA21-86-C-0047 E/G 19/6

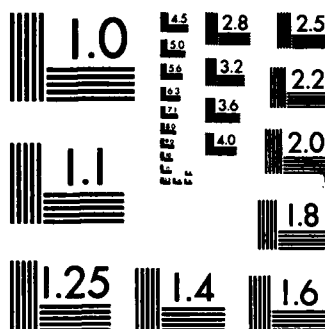
4/5

UNCLASSIFIED

F/G 19/6

NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

c. WHAT/WHAT NOT CONSIDERED (WHAT)

- 3600 ELEMENT FE MODEL
- CRADLE FREE TO ROTATE ON GIMBAL BEARINGS (ROTX NOT FIXED IN LOCAL COORDINATE SYSTEM)
- CABLES HAVE LOW EI TO PREVENT COMPRESSIVE STIFFNESS AND CORRECT E TO ALLOW FOR TENSIONAL EXTENSION
- ALL MASS REPRESENTED AS EITHER CONCENTRATED OR DISTRIBUTED MASS
- GRAVITY LOADS CONTINUOUSLY APPLIED
- GIMBAL IF FREE TO ROTATE WITHIN PLATFORM (ATTACHMENT SHAFTS HAVE ZERO TORSIONAL RESISTANCE BUT HAVE BENDING STIFFNESS)
- A LIMITER BEAM BETWEEN GIMBAL AND PLATFORM LIMITS GIMBAL ROTATION
- CRADLE MODEL (IN SYSTEM FE MODEL) REPRESENTED BY A BEAM ELEMENT FRAME APPROXIMATING BENDING AND TORSIONAL RESISTANCE OF CRADLE
- LINEAR TRANSIENT DYNAMIC LOADING OF THE SYSTEM MODEL
- FORCES AT TRAIL/PLATFORM CONNECTIONS
- ROTARY MOMENT OF INERTIA OF CRADLE REPRESENTED

C. WHAT/WHAT NOT CONSIDERED
(WHAT NOT)

- NONLINEAR EFFECTS OF THE SOIL MODEL / SPADE INTERACTION UNDER FIRING LOADS
- CABLE NONLINEARITIES (LARGE DEFLECTION, BILINEAR BEHAVIOR)
- FULL FE MODEL FOR CRADLE (29 LAYER G R / EP FOAM CORE STRUCTURE) APPENDED TO SYSTEM MODEL (ONLY A REPRESENTATIVE BEAM ELEMENT MODEL OF THE CRADLE USED)
- STATIONARY BARREL POSITION DURING FIRING

◦

D. MANNER OF LOADING

- FORCE vs. TIME DYNAMIC LOADING CURVES FOR RECOIL AND TORQUE FORCES INPUT INTO ANSYS LINEAR TRANSIENT DYNAMIC ANALYSIS (BY /PREP6 ROUTINES (PROOF LOAD LEVELS))
- TIME STEP: 0.001 SEC
LOADS ~~BY~~ RAMPED BETWEEN TIME STEPS
TIME OF ANALYSIS 0 TO 1 SECOND
- 1 G GRAVITY LOAD CONTINUOUSLY APPLIED DURING LOADING

E.

WORST ENVIRONMENT

- HOT, WET CONDITIONS FOR COMPOSITE CRADLE (1-2% MOISTURE, 150°F)
- HARD GROUND EMPLACEMENT
- PROOF LOAD DYNAMIC FORCE-TIME HISTORIES AS INPUT LOADS
- FREE TRAIL ENDS

F. STRESS REDUCTION IMPROVEMENTS PLAN

EXAMINATION OF STRESS RESULTS FOR THE 0°-0°, 0°-72°, 22.5°-0° CASES INDICATES THE FOLLOWING CHANGES TO BE MADE TO THE TOTAL SYSTEM STRUCTURE

- REINFORCE GIMBAL/CRADLE MOUNT ARMS (UPPER AND LOWER)
- REINFORCE (LOCALLY) THE GIMBAL SHAFT ZONES IN BOTH UPPER AND LOWER BOX BEAMS
- REDUCE THICKNESS OF THE PLATFORM AND GIMBAL VERTICAL BOX BEAMS (WEIGHT SAVING)
- REINFORCE TRIANGULAR ELEMENTS BETWEEN LOWER PLATFORM BOX BEAM AND SPADE HORIZONTAL PLATE IN CENTER SECTION
- THICKEN THE REAR PLATE OF THE UPPER GIMBAL AND PLATFORM BOX BEAMS

LIST SELECTED MODES IN THE RANGE 2007 TO 2007 BY 1 DAYS. 0				
MODE	X	Y	Z	
2007	215.00	10.175	-400.00	
2007 - 3HP.				
2008				
				MODE
				2007
				2008
				2009
				2010
				2011
				2012
				2013
				2014
				2015
				2016
				2017
				2018
				2019
				2020
				2021
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				2024
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				2093
				2094
				2095
				2096
				2097
				2098
				2099
				2100
				2101
				2102
				2103
				2104
				2105
				2106
				2107
				2108
				2109

```

LIST SELECTED MODES IN THE RANGE 2002 TO 2008 BY 1 DAYS.
MODE      X      Y      Z      THW      THV      THZ
2002      137.17  10.175  -251.14  0.00  0.00  0.00
PRECT -TAP.
.3000

```

MODE	X	Y	Z	THW	THV	THZ
3000	45.086	18.175	-28.843	0.00	0.00	0.00
PREP -IMP.						
3006						

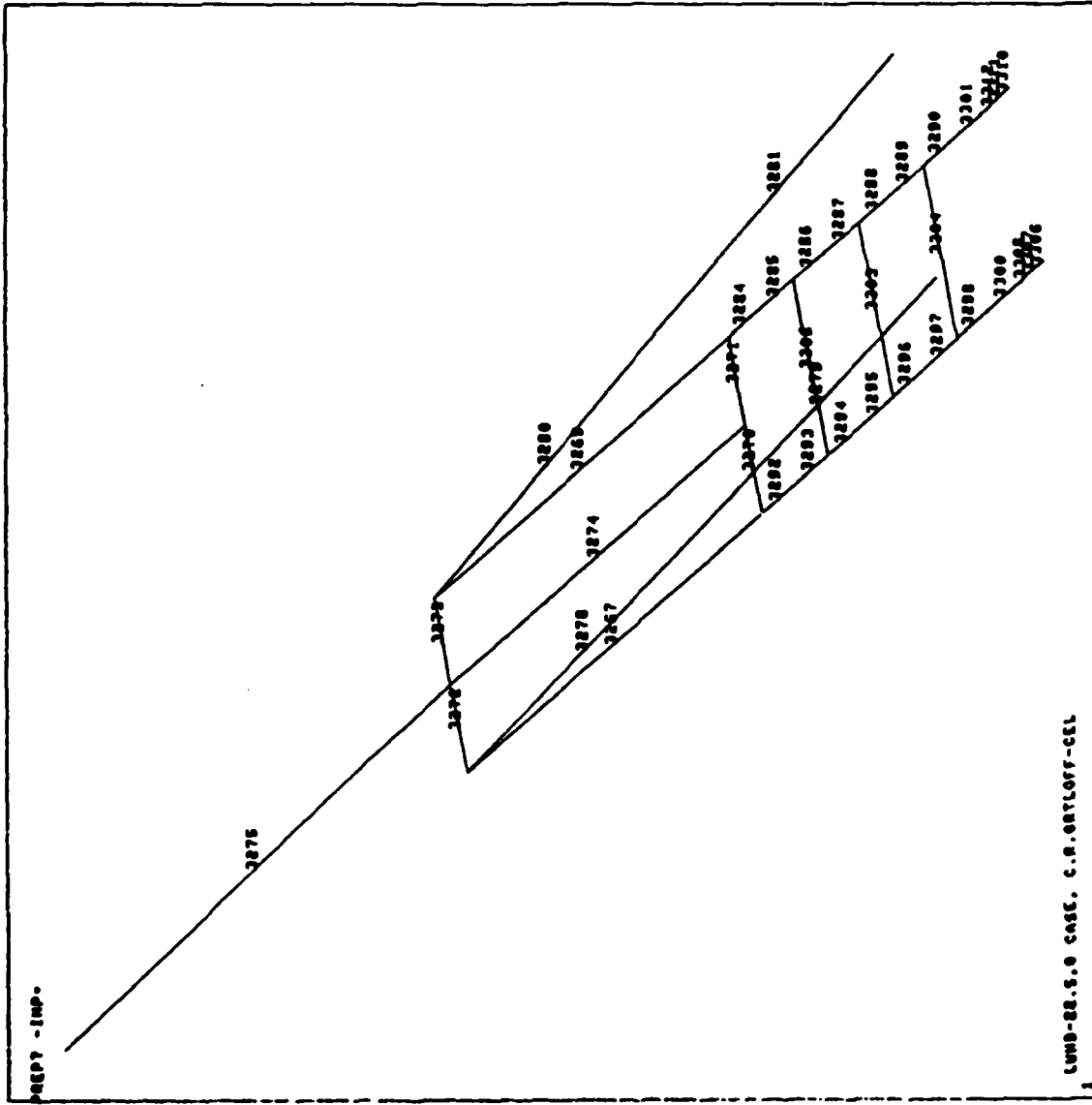
MODE	X	Y	THW	THVZ	THXZ
3006	70.500	18.175	-15.831	0.00	0.00
PREPT -IMP.					
2063					

MODE	X	Y	Z	TMV	TMV2	TMVZ
2863	90.485	18.175	-138.43	0.00	0.00	0.00
PRGP7	-IMP.					
						2779

MODE	X	Y	Z	TMXV	TMVZ
2770	39.142	51.775	-27.833	0.00	0.00
2771					
2772					
2773					
2774					
2775					
2776					
2777					
2778					
2779					
2780					
2781					
2782					
2783					
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2854					
2855					
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2859					
2860					
2861					
2862					
2863					
2864					
286					

KEY NODE POSITIONS

ANSYS 4.20
 JAN 7 1987
 13145116
 PREP7 ELEMENTS
 CHUN-1
 ZOOM
 KU--1
 VU-1
 ZU-1
 D187-123
 KF-136
 VF-25
 ZF--104
 XRT0-1.24



ELEMENTS

ELIST,3000

LIST SELECTED ELEM. IN RANGE 3000 TO 3000 BY 1 (LIST NODES)

ELER MAT TYP REL NODES

3000 27 6 27 2004 2001 0

PREP7 -IMP.
.3000

LIST SELECTED ELEM. IN RANGE 3000 TO 3000 BY 1 (LIST NODES)

ELER MAT TYP REL NODES

3000 27 6 27 2005 2004 0

PREP7 -IMP.
MPLIST,27

LIST MATERIALS 27 TO 27 BY 1

PROPERTY. ALL

PROPERTY TABLE EX MAT= 27 NUM. POINTS= 2
TEMPERATURE DATA TEMPERATURE DATA
0.00000E+00 0.30000E+08 2300.0 0.30000E+08

PROPERTY TABLE MUZY MAT= 27 NUM. POINTS= 2
TEMPERATURE DATA TEMPERATURE DATA
0.00000E+00 0.30000 2300.0 0.30000

PROPERTY TABLE BEMS MAT= 27 NUM. POINTS= 2
TEMPERATURE DATA TEMPERATURE DATA
0.00000E+00 0.50000E-07 2300.0 0.50000E-07

PREP7 -IMP.
ELIST,27

LIST REAL SETS 27 TO 27 BY 1

REAL CONSTANT SET 27 ITEMS 1 TO 6 4.0000 4.0000 0.00000E+00
10.000 500.00 500.00
PREP7 -IMP.

CRADLE
ELEMENTS
NOTE LARGE EI,
ie, FRAME IS
VERY STIFF. MASS
OF CRADLE IS ADDED
BY STIF 21 ELEMENT

LIST SELECTED ELEM. IN RANGE 3201 TO 3201 BY 1 (LIST MODES)

ELEM MAT TYP DEL MODES

3201 20 3 20 2001 2013 0
PROPERTY -IMP.
MPLIST,20

LIST MATERIALS 20 TO 20 BY 1
PROPERTY: ALL

PROPERTY TABLE EX MAT. 20 NUM. POINTS. 2
TEMPERATURE DATA TEMPERATURE DATA
0.00000E+00 0.12000E+08 2300.0 0.12000E+08

PROPERTY TABLE EV MAT. 20 NUM. POINTS. 2
TEMPERATURE DATA TEMPERATURE DATA
0.00000E+00 0.12000E+08 2300.0 0.12000E+08

PROPERTY TABLE MUZY MAT. 20 NUM. POINTS. 2
TEMPERATURE DATA TEMPERATURE DATA
0.00000E+00 0.30000 2300.0 0.30000

PROPERTY TABLE DENS MAT. 20 NUM. POINTS. 2
TEMPERATURE DATA TEMPERATURE DATA
0.00000E+00 0.10780E-03 2300.0 0.10780E-03

PROPERTY -IMP.
MPLIST,20

LIST REAL SETS 20 TO 20 BY 1

REAL CONSTANT SET 20 ITEMS 1 TO 6
2.0000 0.10000E-05 0.10000E-05 1.0000
PROPERTY -IMP.

1.0000 0.00000E+00

A IXX IYY TH1 TH2

15

CABLE

(NOTE THAT IXX, IYY
ARE SMALL SO THAT
EI IS SMALL (SMALL
E I IS SMALL (SMALL

ELIST.278

LIST SELECTED ELEMS. IN RANGE 3875 TO 3876 BY 1 (LIST MODES)

ELEM MAT TYP REL MODES

3875 27 0 27 2887 2888 0
PREPT -IMP.
MPLIST.27

LIST MATERIALS 27 TO 27 BY 1
PROPERTY. ALL

PROPERTY TABLE IN MAT. 27 NUM. POINTS. 2
TEMPERATURE DATA TEMPERATURE DATA
0.00000E+00 0.30000E+08 2300.0 0.30000E+08

PROPERTY TABLE NUMV MAT. 27 NUM. POINTS. 2
TEMPERATURE DATA TEMPERATURE DATA
0.00000E+00 0.30000 2300.0 0.30000

PROPERTY TABLE DENS MAT. 27 NUM. POINTS. 2
TEMPERATURE DATA TEMPERATURE DATA
0.00000E+00 0.00000E-07 2300.0 0.00000E-07

PREPT -IMP.
MPLIST.27

LIST REAL SETS 27 TO 27 BY 1

REAL CONSTANT SET 27 ITEMS 1 TO 6 4.0000 4.0000 0.00000E+00
10.000 500.00
PREPT -IMP.

BARREL
PROPERTIES
(NOTE BARREL
MASS IS ADDED
AS A CONCENTRATED

RLIST,30,30.1

LIST REAL SETS 30 TO 30 BY 1

REAL CONSTANT SET 30 ITEMS 1 TO 6

8.0000 8.0000 0.00000E+00 0.00000E+00 002.00

REAL CONSTANT SET 30 ITEMS 1 TO 6

7.0000 7.0000 0.00000E+00 0.00000E+00 10.000

ROTARY, Z-AXIS

MASS ACTS IN X, Y, Z DIRECTIONS SIMULTANEOUSLY

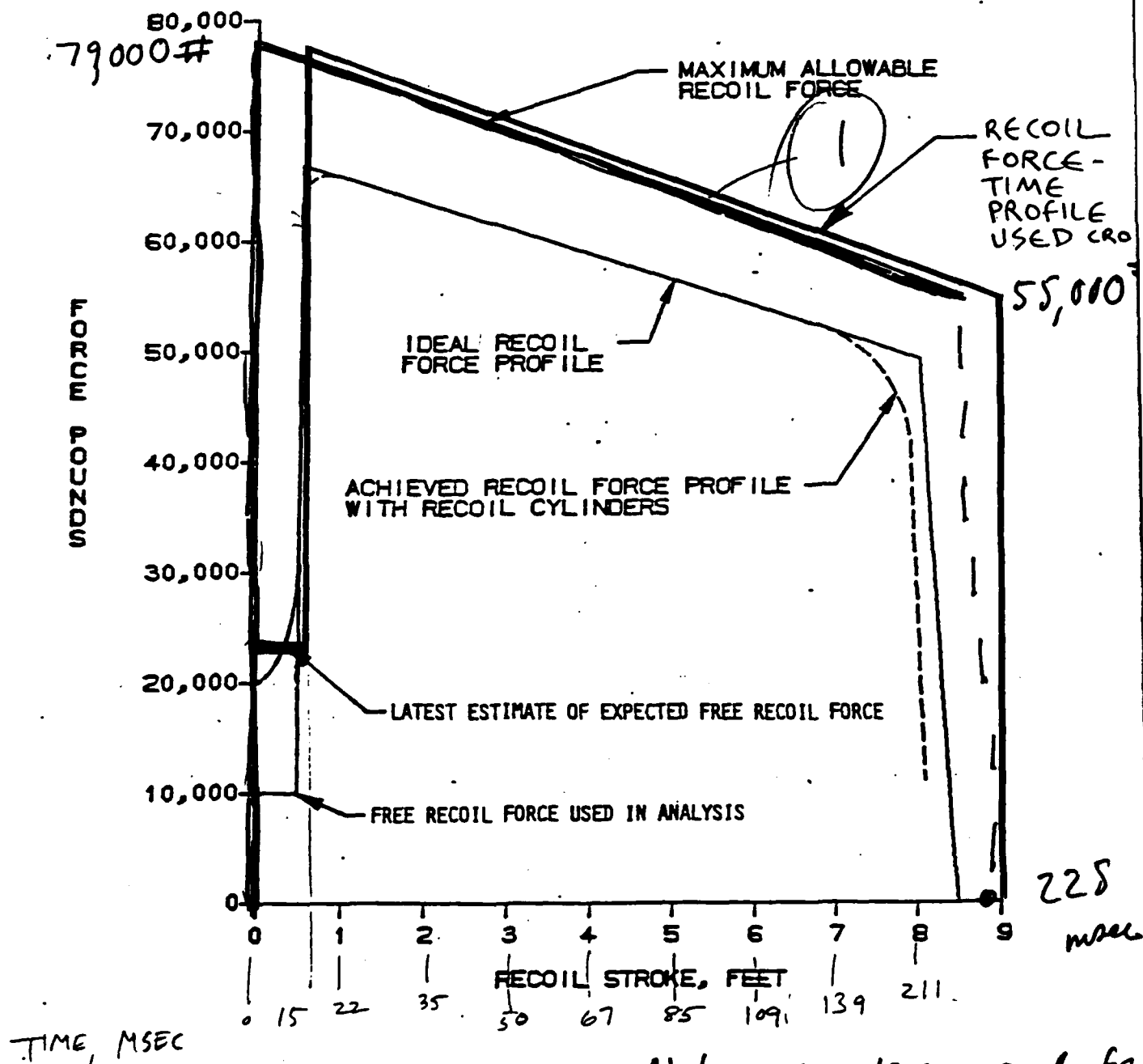
MULTIPLY ABOVE VALUES
BY 12(32.2) TO GET LBM
REMAINING UNITS IN
INCHES, SECONDS

1/7/87

Chuck: Use numbers in green.

TOTAL

RECOIL FORCE VS STROKE
WORST CASE



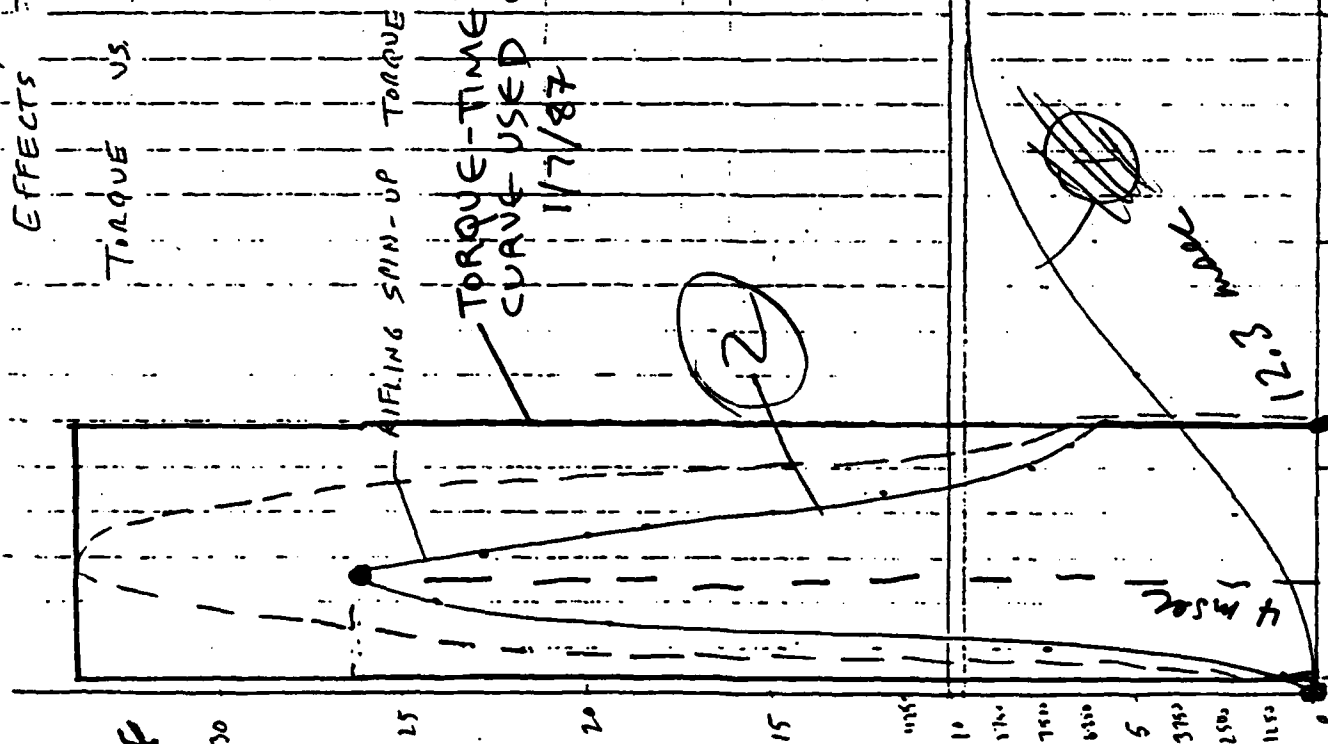
Note: Non-linear scale for time

Figure 4-2

48000 PROOF

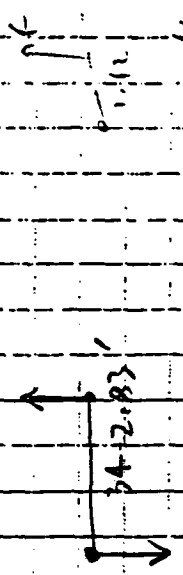
42,000
ft-# 25

Torque, FT-LB x 1000



EFFECTS OF TORQUE VS. RIFLING ON STABILITY TIME.

$$48,000 = 2.8 \times f, f =$$



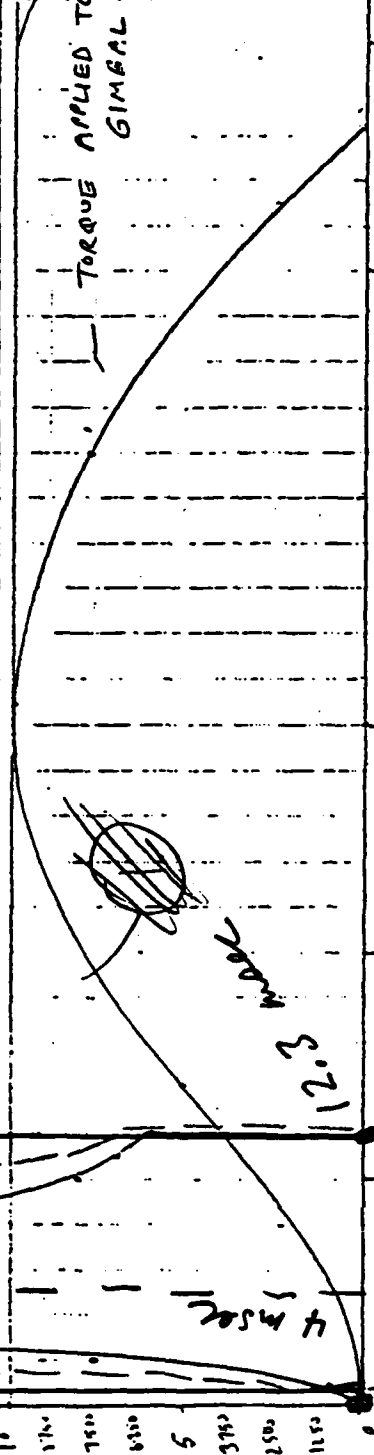
$$2(1.42)f = 410$$

STABILIZING MOMENTS OF SYSTEM W.T.

FLAT, GRADE

10% GRADE

TORQUE APPLIED TO GIMBAL



60

50 1/4, 13

40 21.55

30 1.48

20 1.01

10 1.19

RECOIL DIST. FT.

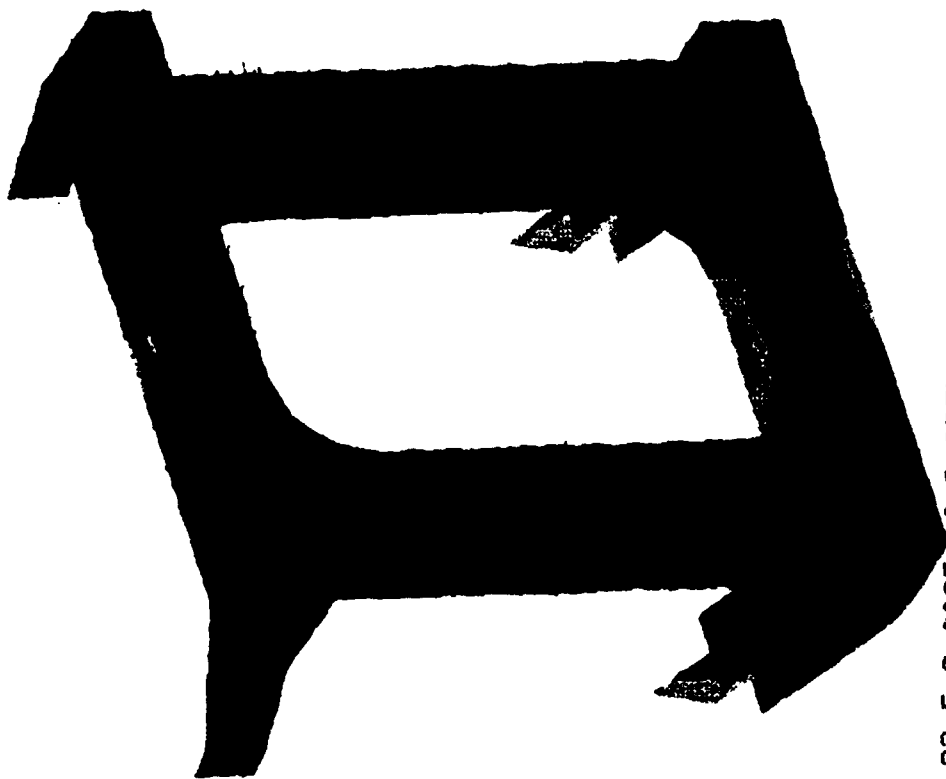
TIME, MSEC FROM START OF RIFLING

Additional
Transparencies

/VIEW, 1, -1, 1, 1
/ANGLE, 1, 0
CRO

ANSYS 4.28
 JAN 7 1987
 15:19:19
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.081
 SIGE
 TOP

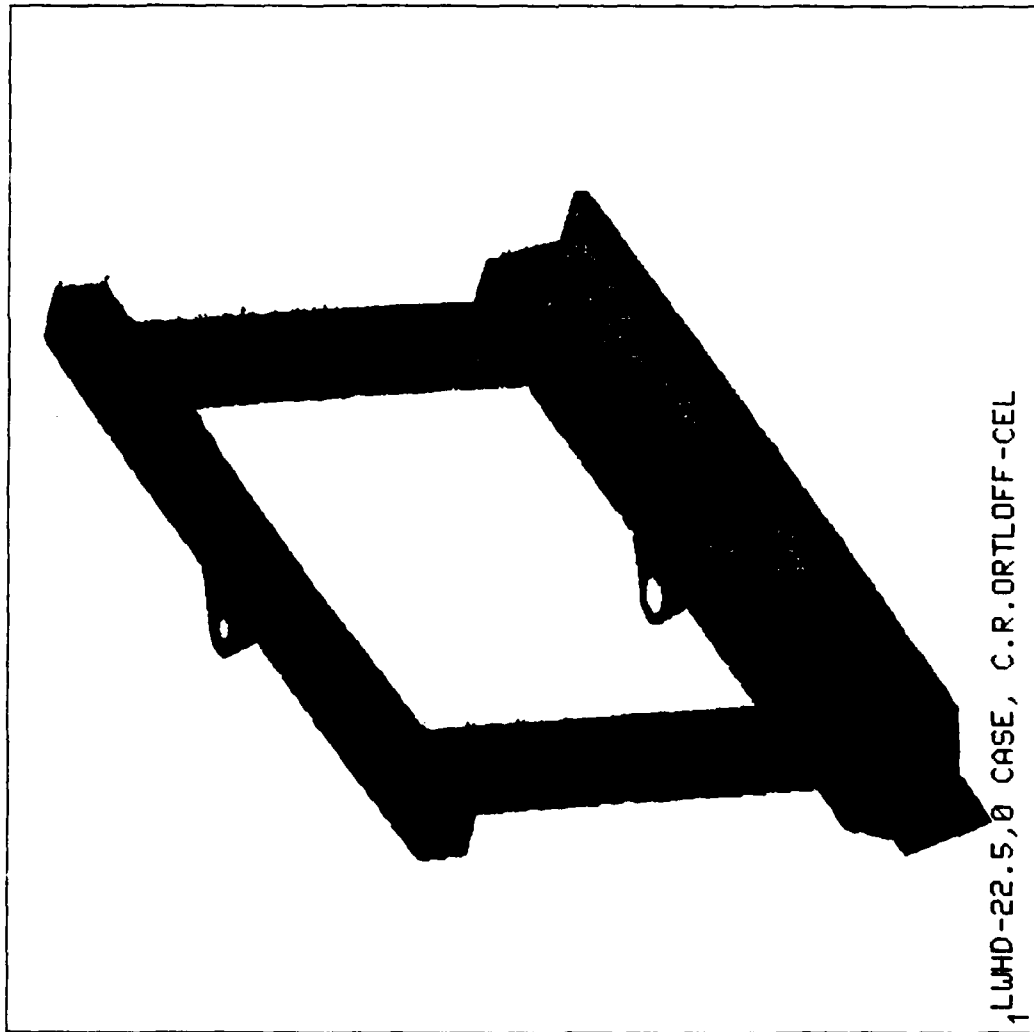
XU=-1.5
 YU=1
 ZU=1
 DIST=32.4
 XF=53.2
 YF=33.3
 ZF=-7.92
 HIDDEN
 MX=170685
 MY=756
 19634
 38516
 111014
 132926
 151808
 170690



1LUND-22.5,0 CASE, C.R.ORTLOFF-CEL

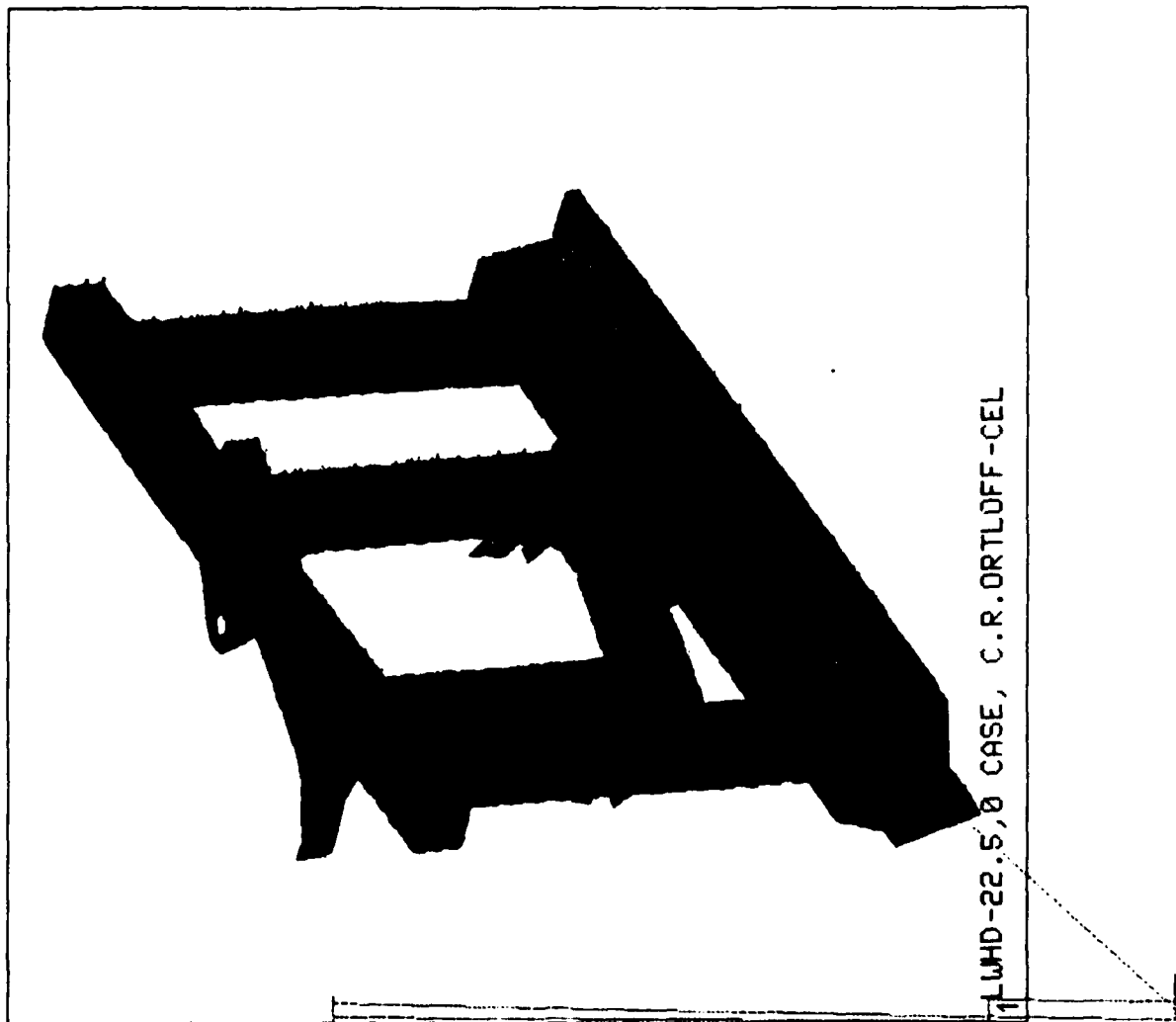


ANSYS 4.2B
 JAN 7 1987
 15:49:22
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.081
 SIGE
 TOP
 XU=-1.5
 YU=1
 ZU=1
 DIST=58.6
 XF=54.5
 YF=27.3
 ZF=4.98
 HIDDEN
 MX=132034
 MN=507
 15118
 29733
 44348
 58963
 73570
 88193
 102803
 117423
 132038



ANSYS 4.2B
JAN 7 1987
16:14:12
POST1 STRESS
STEP=1
ITER=1
TIME=.081
SIGE
TOP

XU=-1.5
YU=1
ZU=1
DIST=58.6
XF=54.5
YF=27.3
ZF=4.98
HIDDEN
MX=170685
MN=507
19415
33324
57000
76142
95051
113960
132869
151773
170687



D3/190

CEL MEMO: JANUARY 8, 1987

Interoffice

To	Larry Libhardt*	Date	January 8, 1987
From	C. R. Ortloff	cc	E. Thuse R. Kazares A. Amberg J. Ries R. Rathe B. Anderson *81 figures only
Subject	STRESS STABILITY RESULTS FOR THE LTHD 22.5° GIMBAL ROTATION, 0° ELEVATION CASE UNDER PROOF LOADS		

Figures 385-466 present the results for the 22.5°-0° total system FE model under proof dynamic firing loads. System weight for the trails, gimbal, platform, cradle plus internals is computed to be 7890.27 lbf. Additional weight (not included in the FE model) includes wheels and wheel mount/retraction structures and miscellaneous attachments to bring total weight up to 9000 lbf.

The main conclusions of the present study are given below. Stress passes have been performed for 0.318, 0.018 and 0.081 sec. times.

- o The cradle (at a node on the forward manifold) undergoes about a 4 inch vertical motion when subject to firing loads. Cable tension appears to go to zero after about 0.375 sec. after firing initiates. It appears that cradle rigid body oscillations then occur (the cradle is suspended on the cable) at about 0.8 Hz (figure 388). The amplitude of these oscillations will damp rapidly due to the high damping constant of the Kevlar cable. Total longitudinal compression (figure 387) is not too far off the values for the more exact 29 lamina cradle FE model indicating that the frame representation for the cradle approximately duplicates the compressional stiffness. Longitudinal vibrational frequency for the cradle appears to be on the order of 5.5 Hz (figure 390).
- o Barrel-tip deflection (if the barrel remained stationary (which it does not)) is shown in figures 394-396. A component of the firing torque vector along the x-axis present for the 22.5° gimbal rotation case accounts for the barrel "jump" and subsequent near-rigid-body vibration of the cradle (as the cradle is suspended by a flexible cable from the first manifold and has a hinge mounting at the gimbal attachment end).
- o Side to side (UX) motion (figure 395) is also stimulated by the component of the firing torque vector in the Y direction. The maximum amplitude of this motion appears to be about 0.75 inch.
- o Figures 396-415 represent dynamic displacements at MDOF nodes on the platform and gimbal. A damping value of 0.2% is used. Reference to figure 386 gives the location of the MDOF nodes. These curves determine the time value selection for subsequent stress passes.

Stress Results for 0.318 sec. Stress Pass

- o The lower shaft openings on the gimbal lower box beam have local stresses about at the 80 ksi yield value; this zone (figure 425) should be locally reinforced.
- o The lower platform base plate (figure 427 and 436) shows large stress values over the yield stress. While this may be a result of the $U_Y=0$ BC applied to a limited number of nodes on the bottom side of this plate, nevertheless, reference to figures 432-434 indicates that the lower box beam to lower horizontal plate connection zone is highly stressed. Stresses in the triangular supports can reach 66 ksi (figure 434) in this zone. The lower platform plate may undergo local yielding if vertical ground pressure on this plate is not uniform. Figure 428 reinforces the idea that the forward and trailing parts of the horizontal ground spade plate is overstressed and may require thickening to lower stress levels.
- o Top and bottom tabs (figures 429-430) indicate low stress levels and are adequately designed as are the corner gimbal reinforcing tabs (figure 431).
- o A $U_X=0$ condition has been applied to the spade reinforcing plates (figure 435) to limit side travel present for rotated gimbal firing cases. Stresses in these spade reinforcements are low.
- o The gimbal lower arms show stress levels about half of yield stress (figure 437).

Stress Results for the 0.018 sec. Stress Pass

- o Again the horizontal spade plate indicates high stress values (figure 442) past the yield stress. It may be advisable to increase both the number and extension of the triangular reinforcement plates on both sides of the lower platform box beam to eliminate stress concentrations in the unsupported panel areas on this plate.
- o Again the triangular reinforcements between lower platform box beam and horizontal spade plate are highly stressed (figures 447-449); reinforcing according to the above suggestion is recommended.
- o The top and bottom tabs (figures 450-451) are adequately designed.
- o Again the gimbal shaft opening in the lower box beam needs reinforcement as local stresses exceed yield stress (figures 453-455).

Stress Results for the 0.081 sec. Stress Pass

- o Local stresses in the lower gimbal arms exceed yield stress (figure 456).
- o Local stress in the lower gimbal box beam shaft opening are 75% over yield stress; this zone requires local reinforcing.
- o The horizontal spade plate has stresses over yield similar to results from the other two stress pass cases (figure 461).
- o Top and bottom tabs appear to be adequately designed (figures 462-463).

A table of results is given below for stress in the upper and lower shafts:

<u>Time</u> <u>(Sec)</u>	<u>Upper Shaft</u> <u>Max. Stress</u>	<u>Lower Shaft</u> <u>Max. Stress</u>
0.318	16 ksi	29 ksi
0.081	10.3 ksi	34.6 ksi

An estimate of dynamic forces on the trail-to-platform connecting pins indicates that for both times considered, a maximum of 2,500 lbf on each pin is a reasonable upper bound. This assumes a total of 4 connecting points for each trail to the platform.

Conclusions

Based on the results from the 0°-0°, 0°-72°, 22.5°-0° cases, the following recommendations are made:

- o Reinforce locally all the shaft opening zones on the gimbal and platform upper and lower box beams.
- o Reinforce the upper and lower gimbal arm sets.
- o Increase the number of triangular reinforcing plates connecting the lower box beam of the platform to the horizontal plate of the spade. An increase in size, number and thickness of these elements appears necessary.
- o Decrease the wall thickness of the vertical box beams in both gimbal and platform. The weight savings thus obtained can be redistributed to suggested reinforcements in other parts of the structure.
- o The present upper and lower gimbal to platform attachment shafts are structurally adequate as are the mount tabs.
- o The upper and lower shafts are adequately designed.

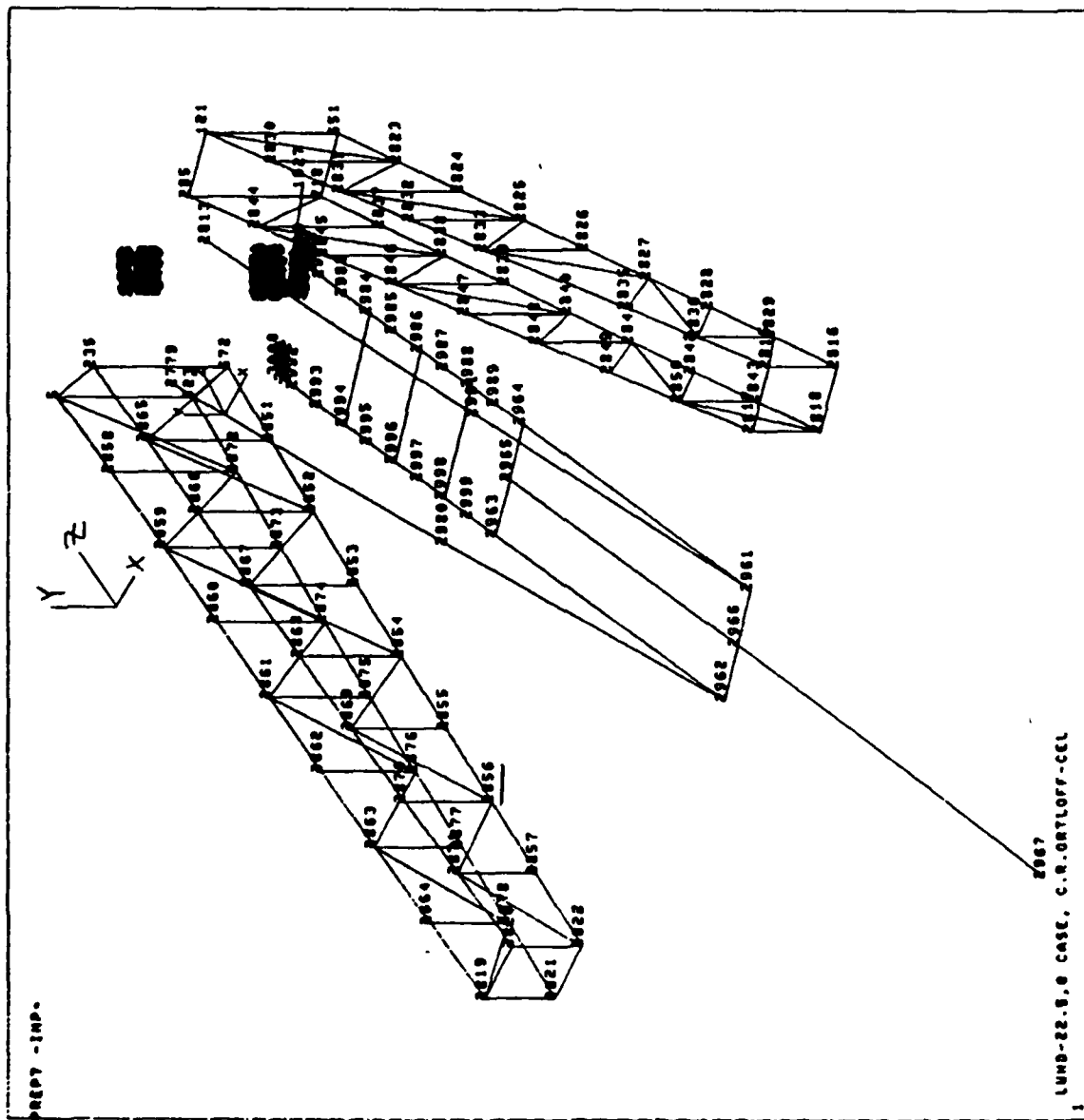
The degree to which reinforcement is necessary may be obtained by reference to the stress plots contained in previous memos (CRO to L. Libhardt, 17 Dec 86 and 29 Dec 86) and the maximum stresses for each case. As a "first approximation" rule the

stress may be changed linearly by varying the local thickness in the high stress region accordingly. For example, if maximum gimbal vertical box beam stress is 30 ksi, then a 50% reduction in wall thickness could be made with sufficient margin before yield stress values are encountered. This procedure may serve for redesign purposes on a first approximation level; however, a rerun of the modified FE model incorporating all the design changes is the best way to check that the desired lowering or redistribution of stress levels has been achieved.



C. R. Ortloff

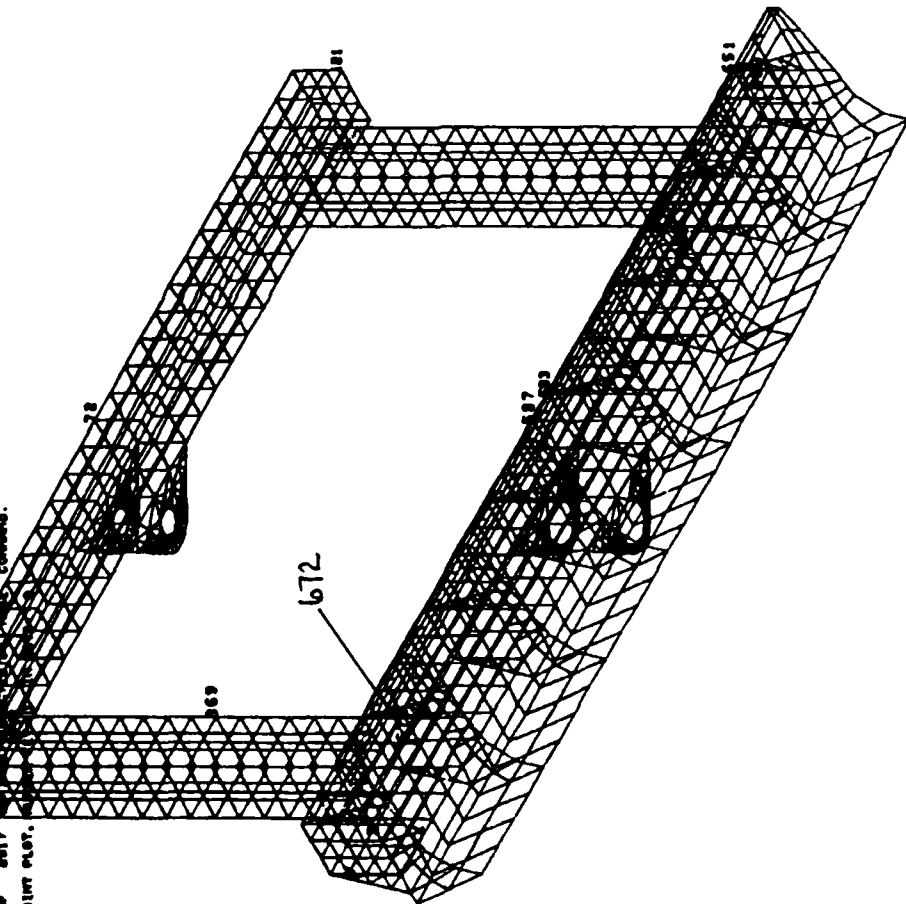
ANSYS 4.20
 JAN 5 1987
 0118116
 PREPT ELEMENTS
 NHUM=1
 NU=0.1
 VU=0.1
 0157-157
 NF=114
 VF=29.6
 ZF=174



NODE
 LISTING

100

100



1-0-1

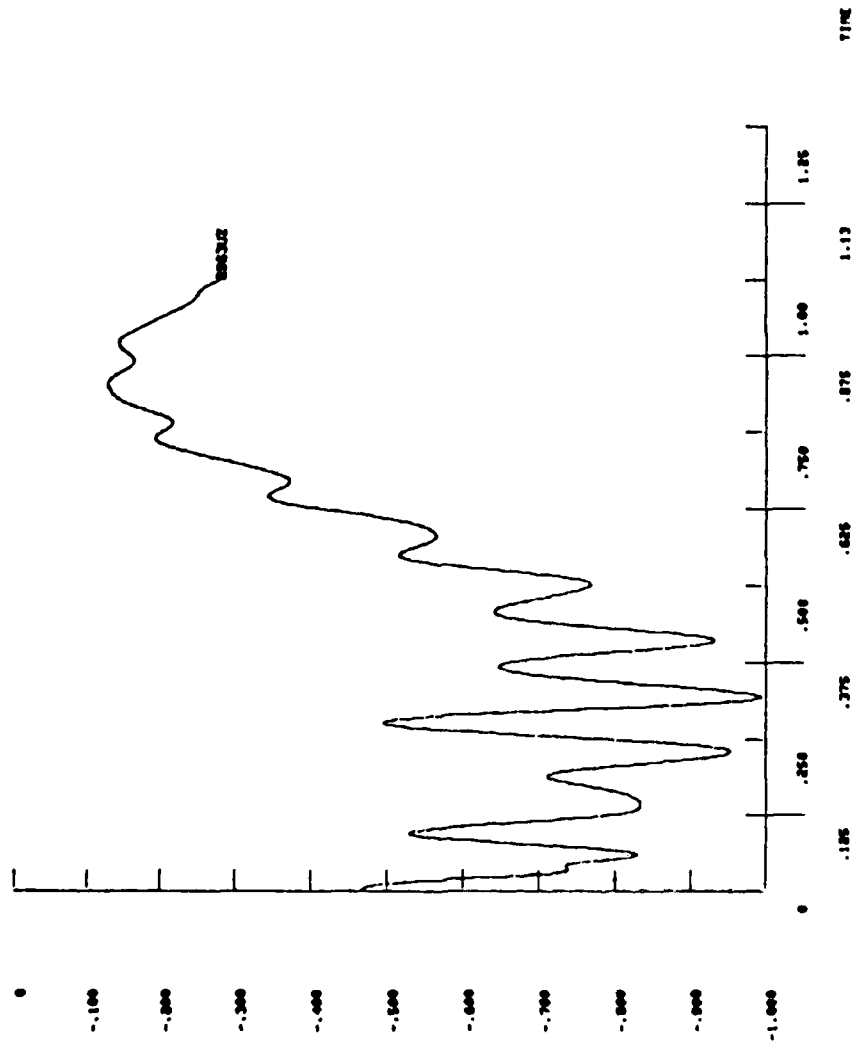
MDof
NODES

PERFORM COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 LAST TIME IDENTIFIED MAX MINIMUM AT TIME MAXIMUM AT TIME

0 316P 0003 UZ 000306 -0.0036 0.3180 -0.1076 0.0050

NOT IDENTIFIED
 LONG VARIABLE NAME 000306

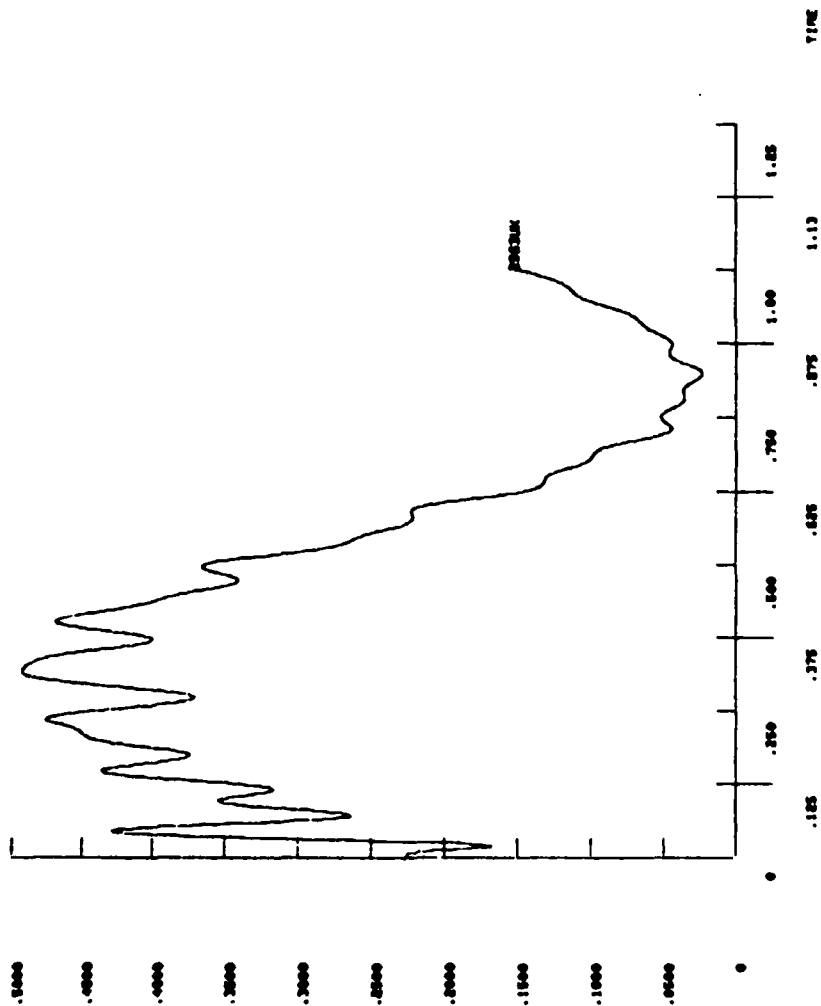


1 LUMP-22 5.0 CORN, C.R. OUTFLOW-CEL

POSTER
 20-1
 0107-1.30

DYNAMIC
 DISPLACEMENT-
 TIME HISTORY

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 LAST IDENTIFICATION NUMBER AT TIME MAXIMUM AT TIME
 2 310P 0043 IN 000300 0.0017E-01 0.0000 0.4001 0.3170
 LAST IDENTIFICATION
 SAME VARIABLE MAXIMUM
 000300



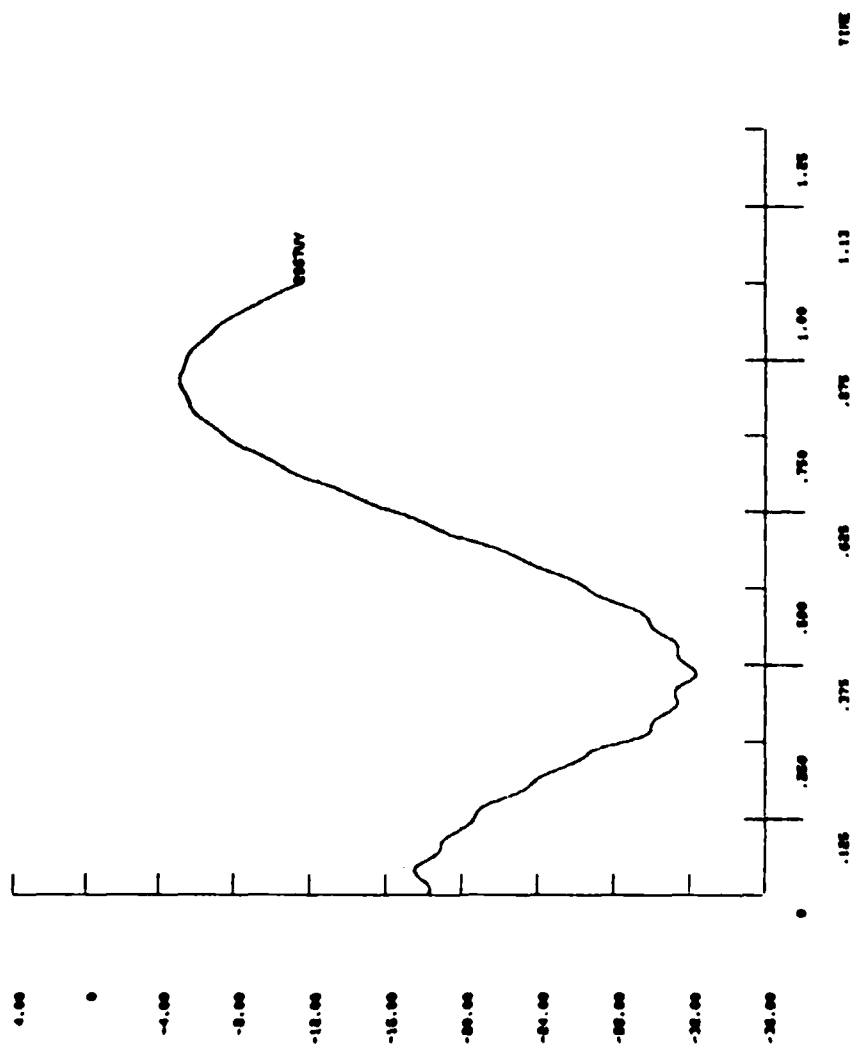
1. 1000-20.0.0 CODE, C.A. 001077-CEL

000300
 20-1
 0107-1.03

SECRET

DATE	AMOUNT OF DEBITED	STOCK THIS DATE	STOCK AT THE	ENDING VALUE
1910	100.00	100.00	100.00	100.00
1911	100.00	200.00	200.00	200.00
1912	100.00	300.00	300.00	300.00
1913	100.00	400.00	400.00	400.00
1914	100.00	500.00	500.00	500.00
1915	100.00	600.00	600.00	600.00
1916	100.00	700.00	700.00	700.00
1917	100.00	800.00	800.00	800.00
1918	100.00	900.00	900.00	900.00
1919	100.00	1000.00	1000.00	1000.00
1920	100.00	1100.00	1100.00	1100.00
1921	100.00	1200.00	1200.00	1200.00
1922	100.00	1300.00	1300.00	1300.00
1923	100.00	1400.00	1400.00	1400.00
1924	100.00	1500.00	1500.00	1500.00
1925	100.00	1600.00	1600.00	1600.00
1926	100.00	1700.00	1700.00	1700.00
1927	100.00	1800.00	1800.00	1800.00
1928	100.00	1900.00	1900.00	1900.00
1929	100.00	2000.00	2000.00	2000.00
1930	100.00	2100.00	2100.00	2100.00
1931	100.00	2200.00	2200.00	2200.00
1932	100.00	2300.00	2300.00	2300.00
1933	100.00	2400.00	2400.00	2400.00
1934	100.00	2500.00	2500.00	2500.00
1935	100.00	2600.00	2600.00	2600.00
1936	100.00	2700.00	2700.00	2700.00
1937	100.00	2800.00	2800.00	2800.00
1938	100.00	2900.00	2900.00	2900.00
1939	100.00	3000.00	3000.00	3000.00
1940	100.00	3100.00	3100.00	3100.00
1941	100.00	3200.00	3200.00	3200.00
1942	100.00	3300.00	3300.00	3300.00
1943	100.00	3400.00	3400.00	3400.00
1944	100.00	3500.00	3500.00	3500.00
1945	100.00	3600.00	3600.00	3600.00
1946	100.00	3700.00	3700.00	3700.00
1947	100.00	3800.00	3800.00	3800.00
1948	100.00	3900.00	3900.00	3900.00
1949	100.00	4000.00	4000.00	4000.00
1950	100.00	4100.00	4100.00	4100.00
1951	100.00	4200.00	4200.00	4200.00
1952	100.00	4300.00	4300.00	4300.00
1953	100.00	4400.00	4400.00	4400.00
1954	100.00	4500.00	4500.00	4500.00
1955	100.00	4600.00	4600.00	4600.00
1956	100.00	4700.00	4700.00	4700.00
1957	100.00	4800.00	4800.00	4800.00
1958	100.00	4900.00	4900.00	4900.00
1959	100.00	5000.00	5000.00	5000.00
1960	100.00	5100.00	5100.00	5100.00
1961	100.00	5200.00	5200.00	5200.00
1962	100.00	5300.00	5300.00	5300.00
1963	100.00	5400.00	5400.00	5400.00
1964	100.00	5500.00	5500.00	5500.00
1965	100.00	5600.00	5600.00	5600.00
1966	100.00	5700.00	5700.00	5700.00
1967	100.00	5800.00	5800.00	5800.00
1968	100.00	5900.00	5900.00	5900.00
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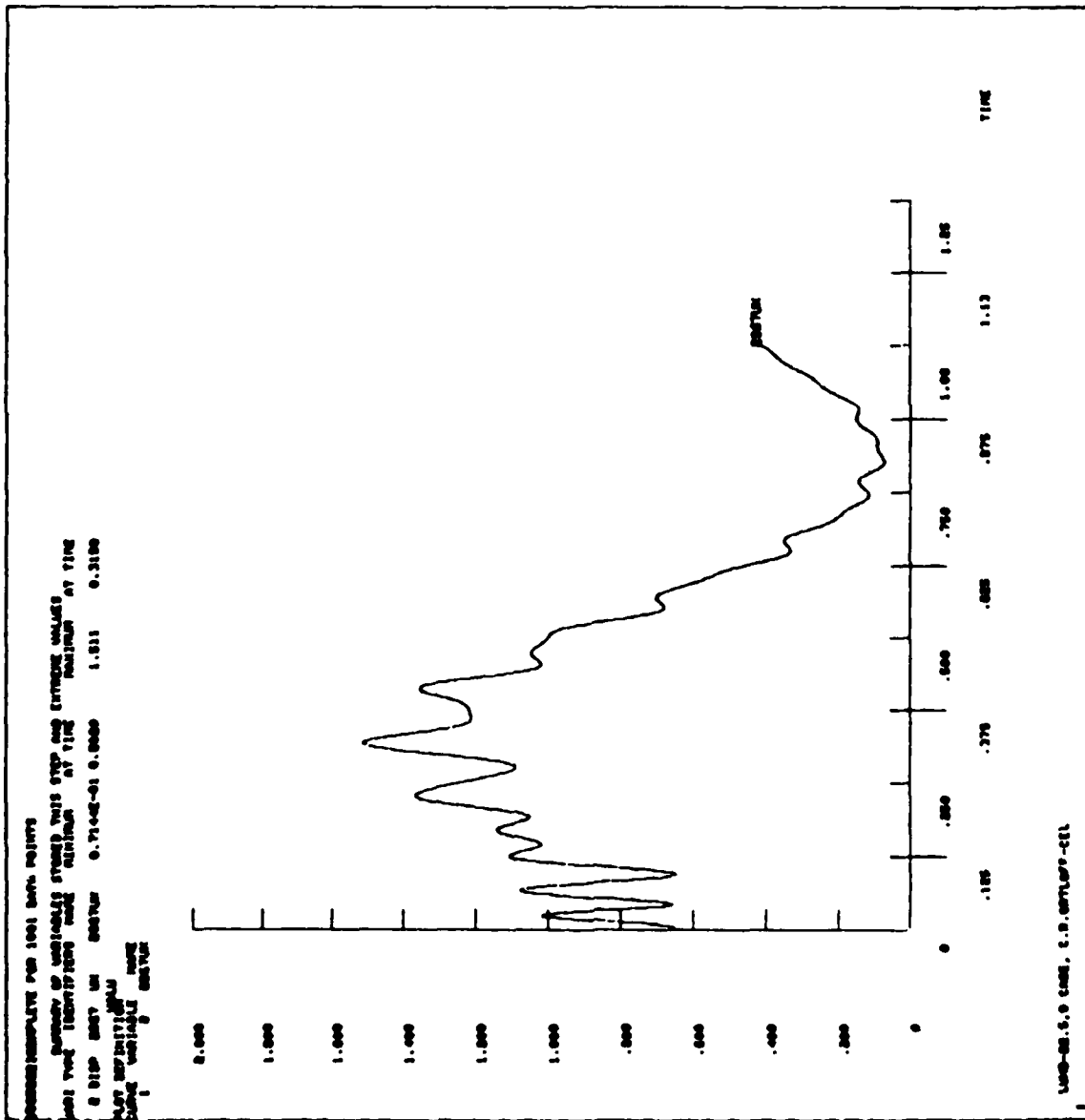
WASH-25,000 CASE, C. B. SMITHSON - 151

000720
ZV-1
0157-1.38

BARREL TIP

POSTER
 DIST=1
 DIST=1.20

POSTER
 DIST=1
 DIST=1.20



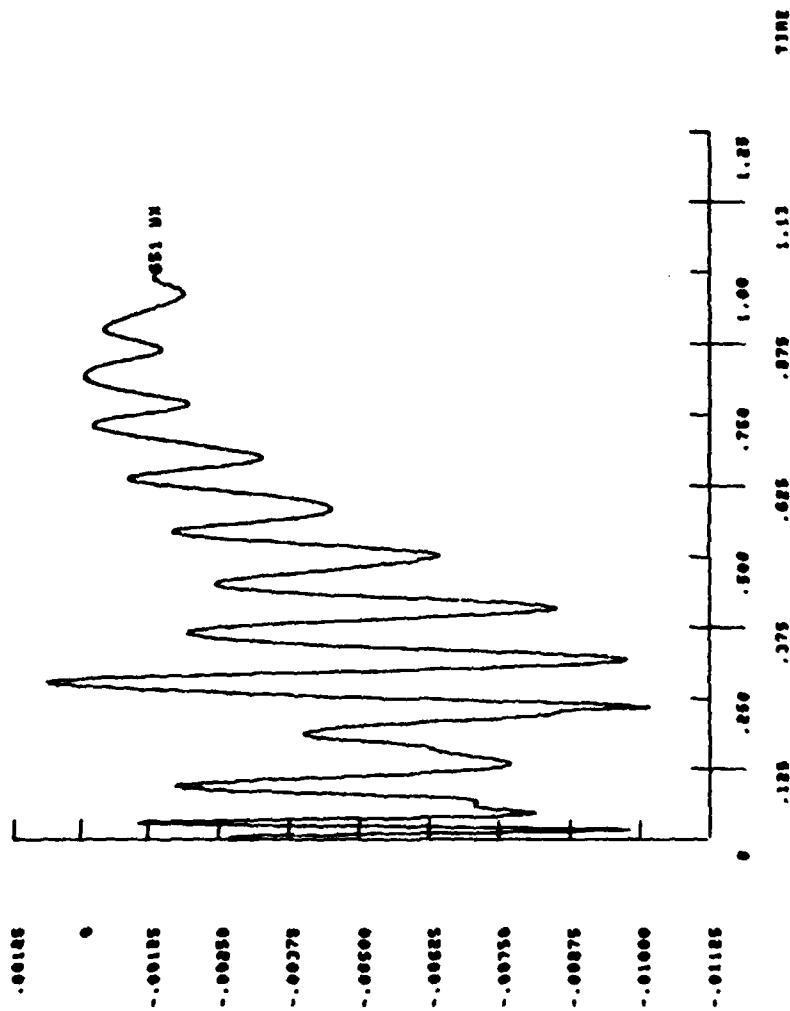
BARREL TIP

*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIER NAME MINIMUM AT TIME MAXIMUM AT TIME

0 0100 001 UN 001 UN -0.10100-01 0.0340 0.01000-03 0.0770

Plot DEFINITION
 CURVE VARIABLE NAME
 0 001 UN

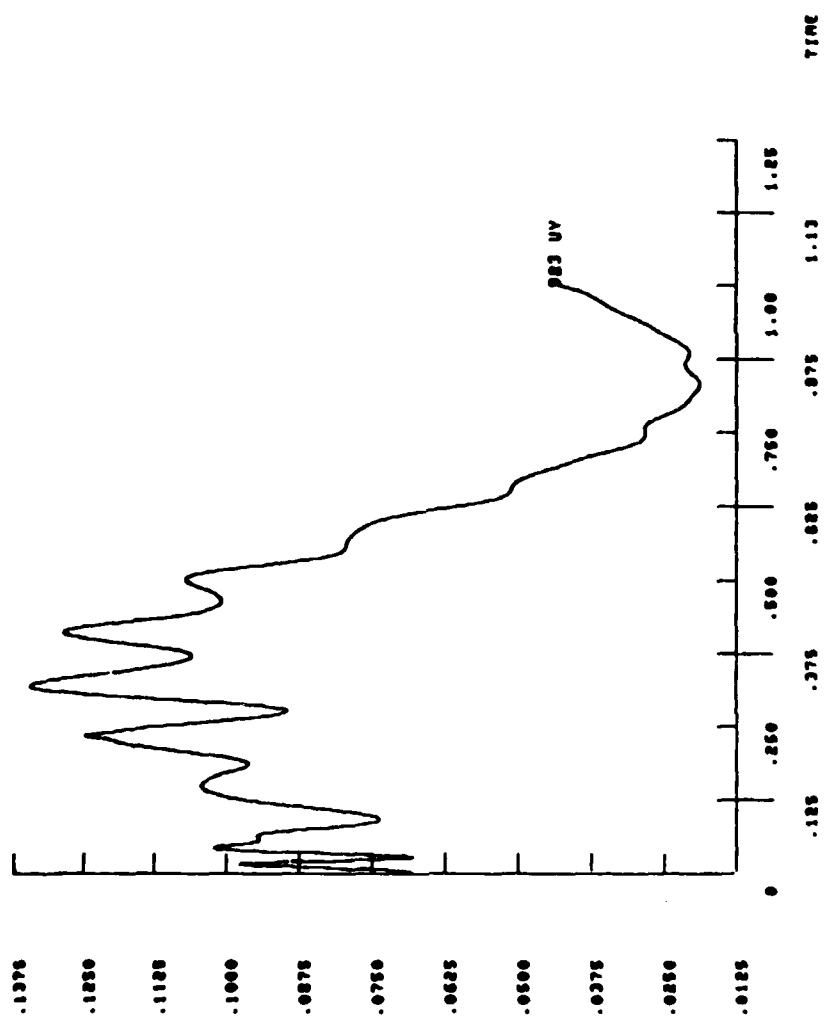


1 LUMP-22.0.0 CASE. C.R.001000-CEL

*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 1001 TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME
 2 818P 923 UV 923 UV 0.1885E-01 0.0310 0.1344 0.3180

PLOT DEFINITION
 CURVE VARIABLE NAME
 1 2 923 UV



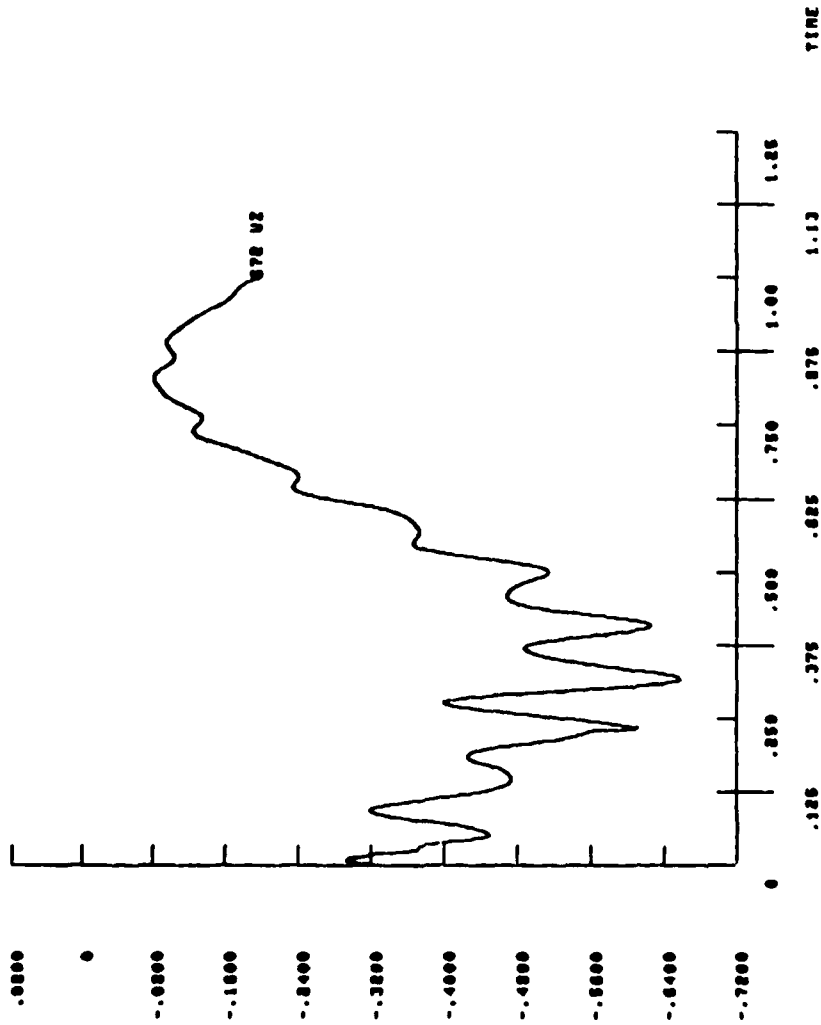
1 LUMB-22.5.0 CASE, C.R.ORTLOFF-CEL

UNRECORDED FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES

VAR	TYPE	IDENTIFIERS	MINIMUM	AT TIME	MAXIMUM	AT TIME
2	DISP	Q2A UZ	078 UZ	-0.6877	0.3180	-0.0187E-01 0.0280

PLOT DEFINITION
CURVE VARIABLE 2 078 UZ



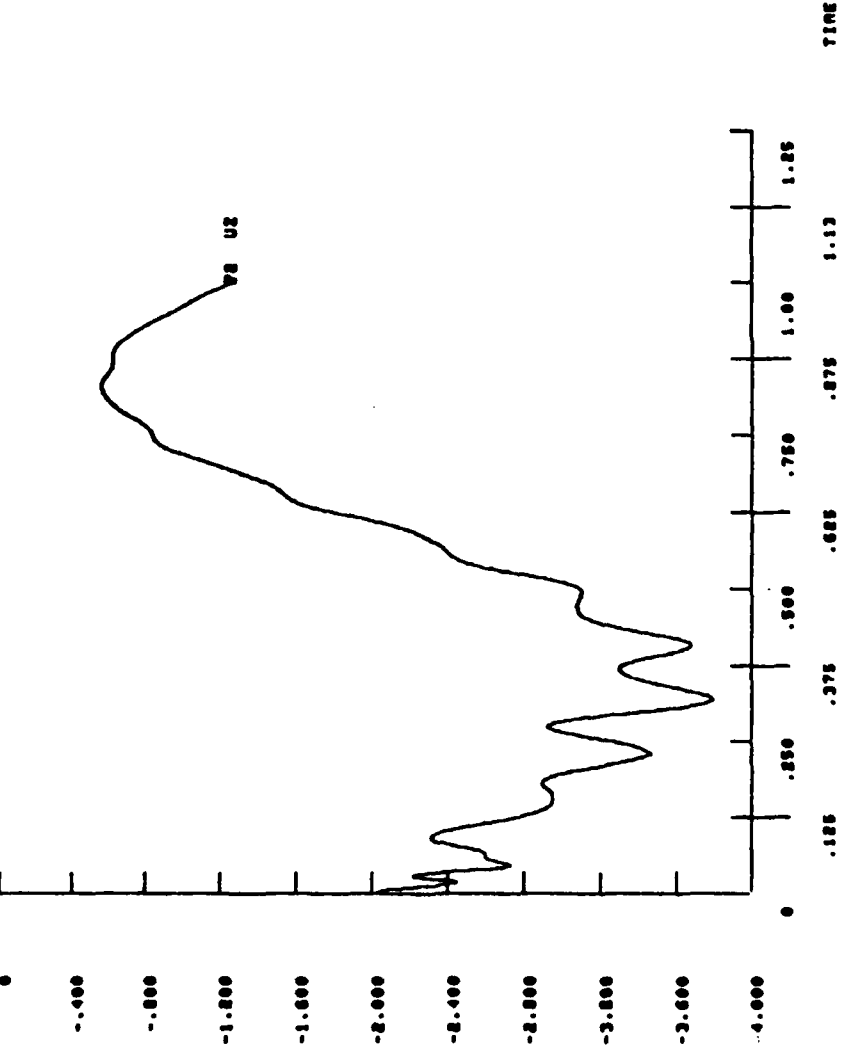
1 LUMB-82.5.0 CASE, C.R.ORTLOFF-CEL

1 LUMB-22.5.0 CASE, C.R.087LOFF-CEL

INCOMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME
 2 DISP VALD UZ 72 UZ -3.703 0.3100 -0.0506 0.0000

PLOT DEFINITION
 CURVE VARIABLE NAME
 1 2 72 UZ



1 LUND-22.5.0 CASE, C.R. ONTLOFF-CEL

*****COMPLETE FOR 1001 DATA POINTS

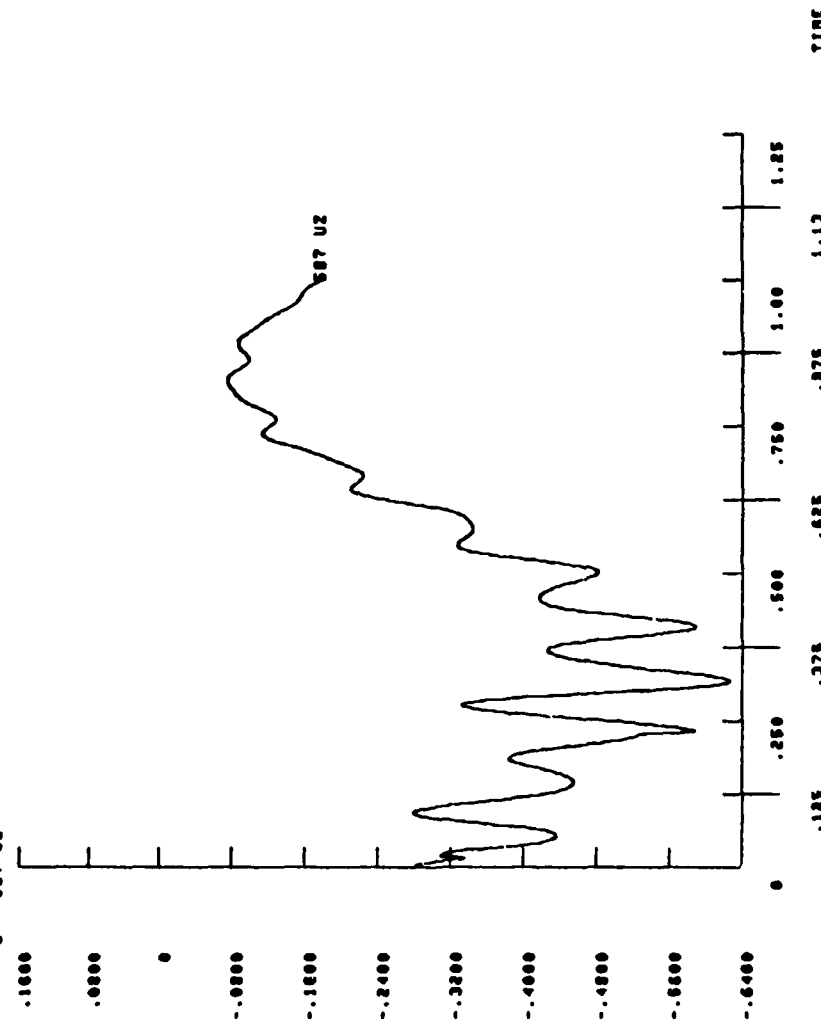
SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME

2 DISP VALU UZ 587 UZ -0.6282 0.3180 -0.7439E-01 0.8280

PLOT DEFINITION

CURVE VARIABLE NAME

1 CURVE VARIABLE 587 UZ

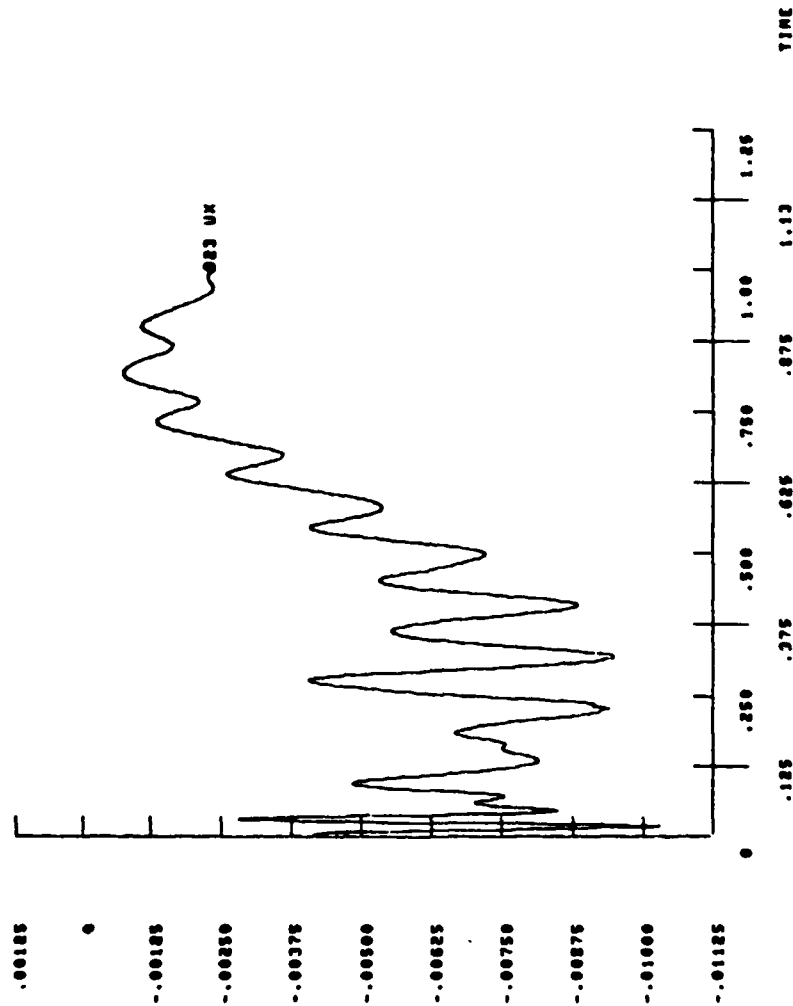


1 LUMB-22.5.0 CASE, C.R.ORTLOFF-CEL

POORER COMPLETE FOR 1001 DATA POINTS.

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 VAR1 TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME
 2 018P 003 UX 003 UX -0.1088E-01 0.1800E-01 -0.7344E-03 0.8160

PLOT DEFINITION
 CURVE VARIABLE NAME
 1 003 UX

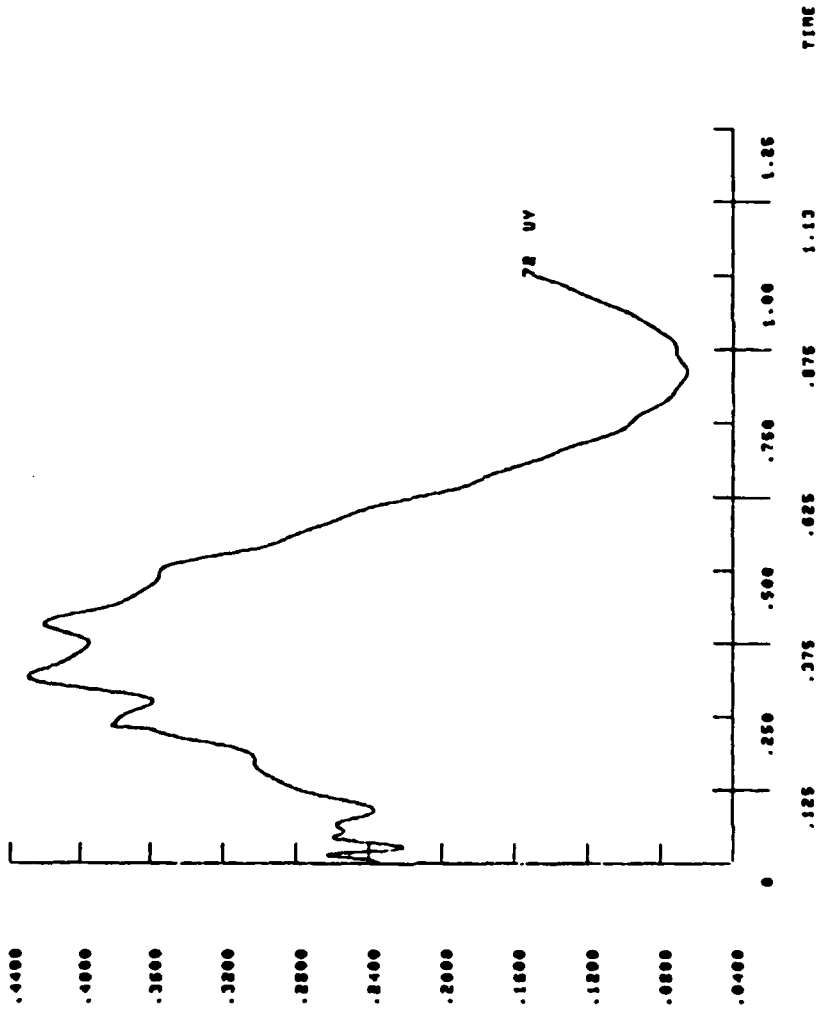


1 LUMB-22.5.0 CASE, C.R.ORTLOFF-CEL

PROGRAM COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME
 Z DISP ZALU UV 72 UV 0.00000E-01 0.0300 0.4201 0.3100

PLOT DEFINITION
 CURVE VARIABLE 72 UV



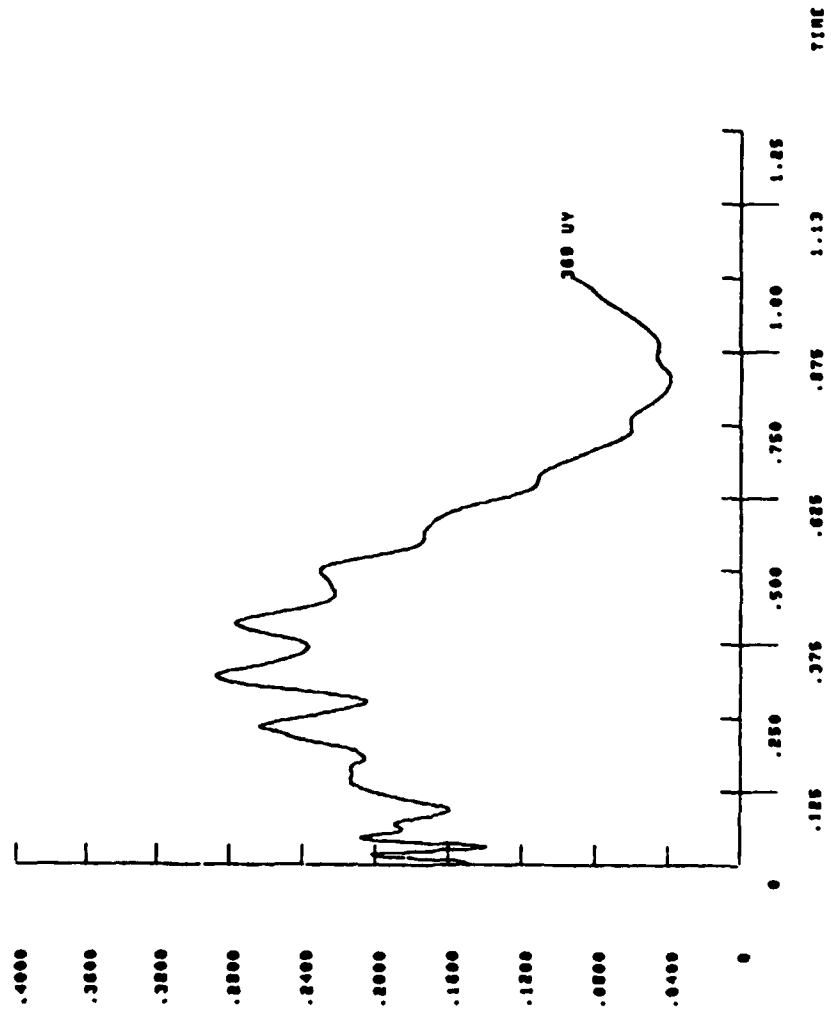
1 LMD-28.5.0 CASE, C.R.ORTLOFF-CEL

INCOMPLETE FOR 1001 DATA POINTS

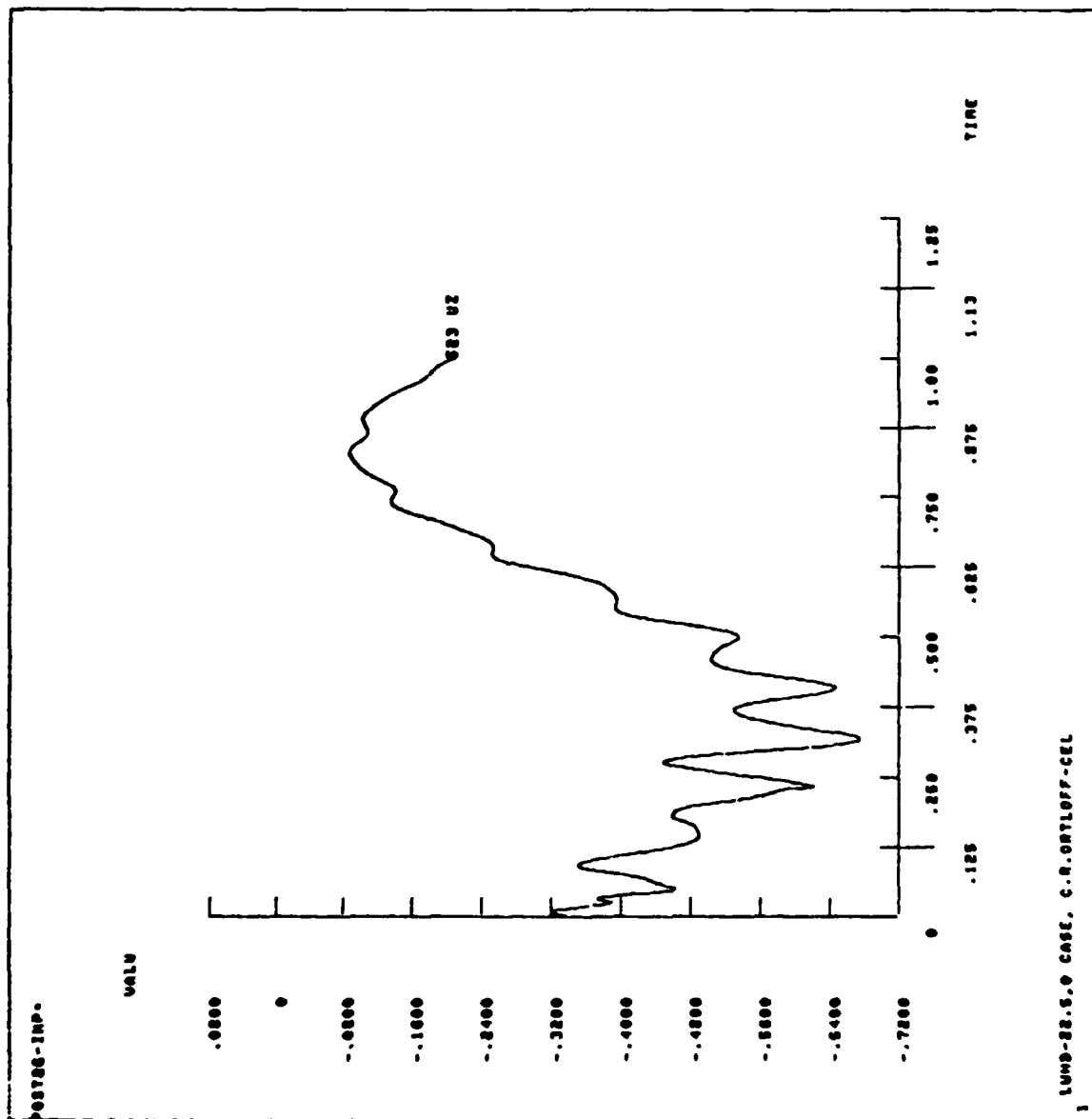
SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME

2 DISP 300 UV 300 UV 0.3884E-01 0.0000 0.8075 0.3100

PLAT DEFINITION
 CURVE VARIABLE NAME
 1 2 300 UV



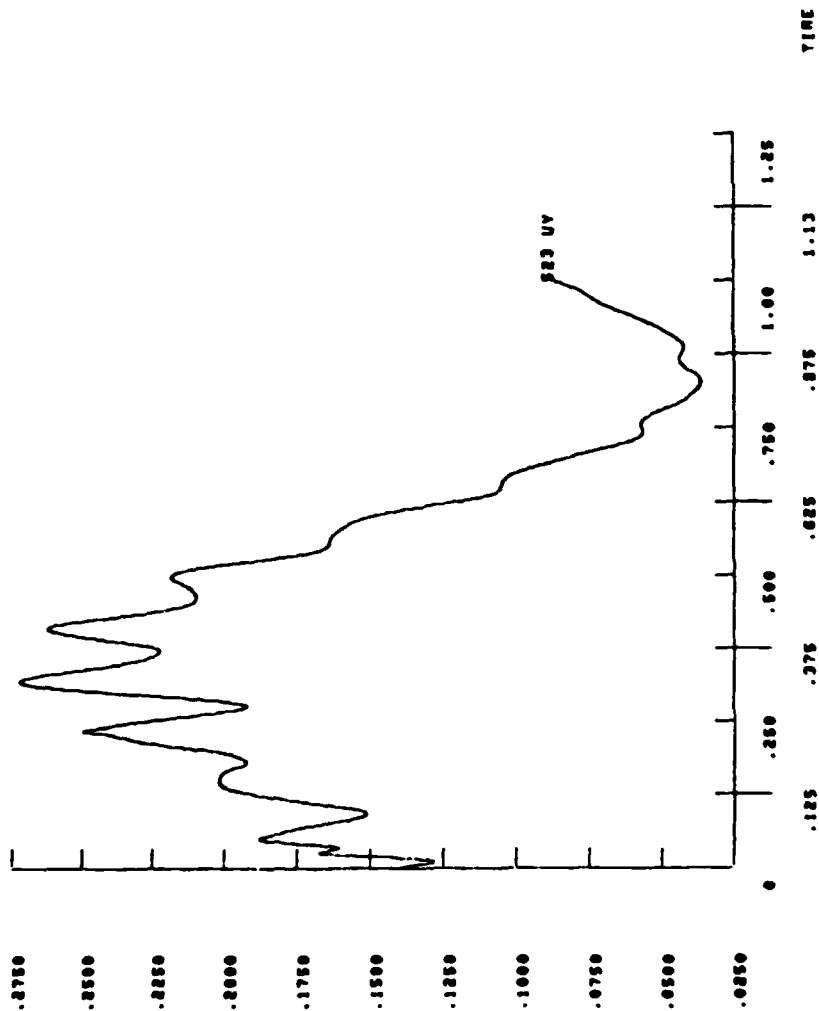
1 LUND-28.5.0 CASE, C.R.ORTLOFF-CEL



POSTER
24-1
DIST-1.43

POSTER-IMP.
 PLOT DEFINITION
 CURVE VARIABLE NAME
 1 3 823 UV

VALU



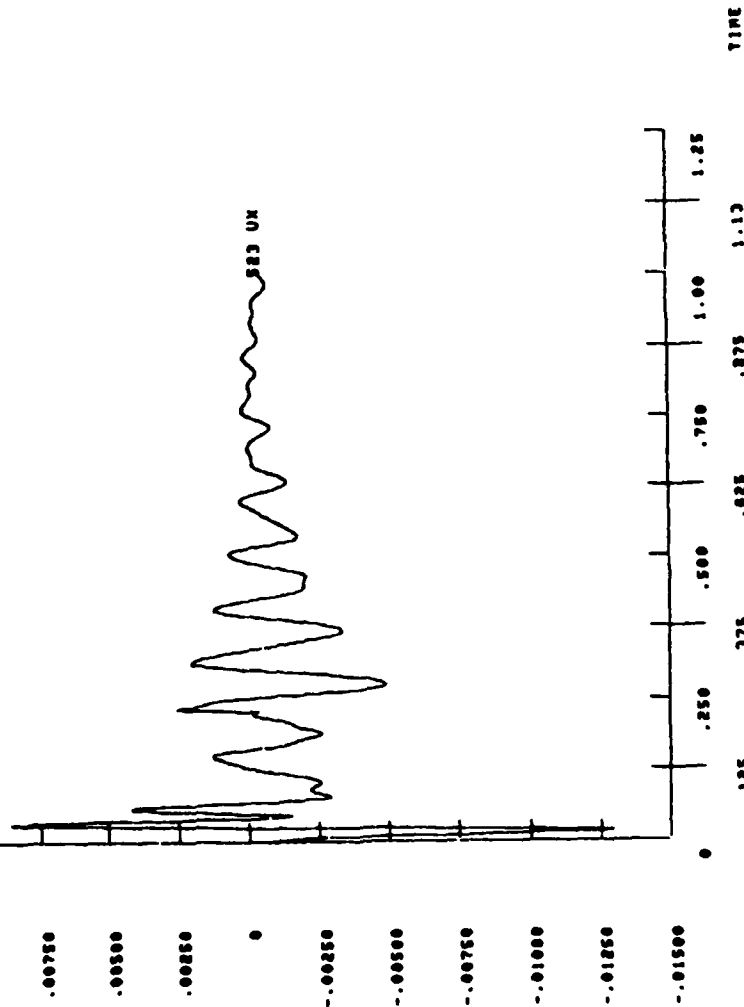
1 LUMP-22.5.0 CASE, C.R. ORTLOFF-CEL

POSTER
 20-1
 9157-1.43

DOES COMPLETE FOR 100! DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES							
JOB	TYPE	IDENTIFIERS	MINIMUM	AT TIME	MAXIMUM	AT TIME	
0	DISP	583	UN	-0.1815E-01	0.1000E-01	0.8875E-08	0.3100E-01
1	DISP	583	UN	-0.3633E-01	0.8270	0.8720	0.3180
2	DISP	583	UV	-0.6740	0.3150	-0.8720E-01	0.0280
4	DISP	583	UV	-0.6740	0.3150	-0.8720E-01	0.0280

PLAY DEFINITION	NAME
CURVE VARIABLE	523 JAX
1	01902

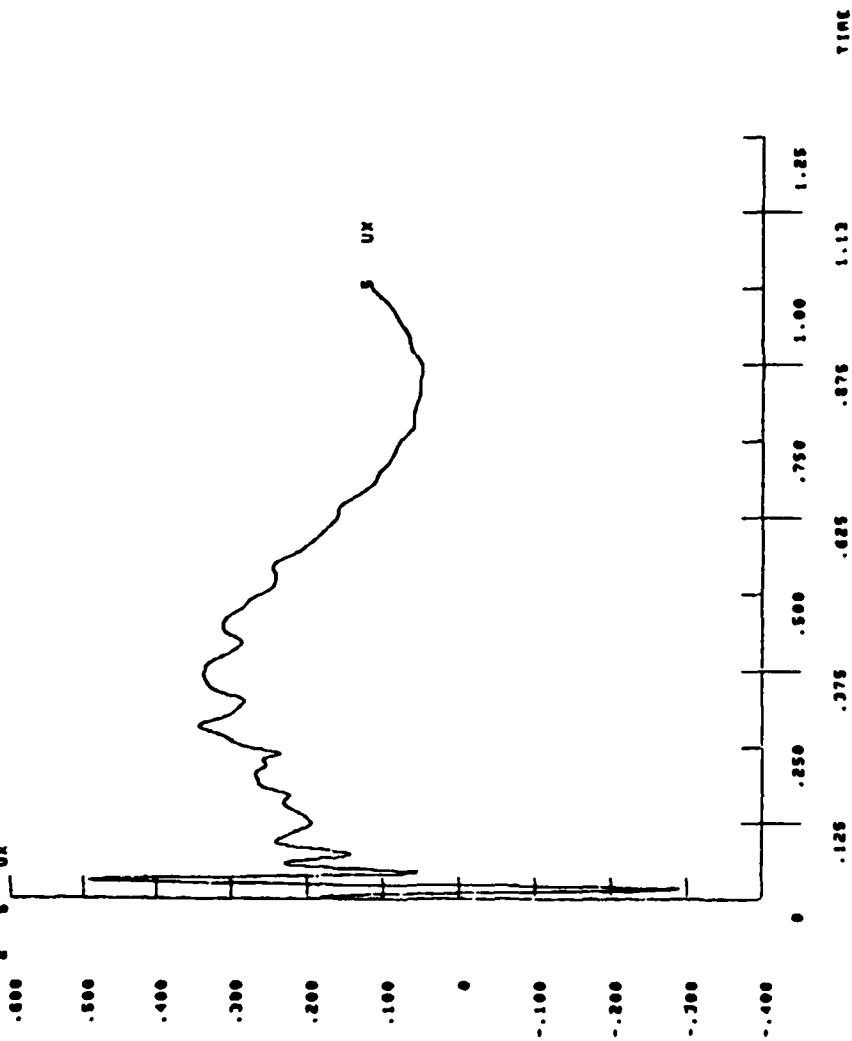


POSTED
ZU-1
0157-1.48

*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME
 2 DISP ONLY UX S UX -0.8897 0.1000E-01 0.4910 0.2000E-01

PLOT DESCRIPTION
 CURVE VARIABLE NAME
 1 2 S UX



1 LUMB-28.5.0 CASE, C.R.ORTLOFF-CEL

POST26
 20-1
 DIST-1.30

Chromatogram of a 100% methanol extract of a plant sample. The x-axis is labeled 'TIME' and ranges from 0 to 1.05 minutes. The y-axis represents intensity, ranging from 0 to 40,000. The chromatogram shows several peaks, with the most prominent ones occurring between 0.3 and 0.6 minutes. A small peak is visible at approximately 0.15 minutes, and another at 0.95 minutes.

U-9-52.1.0 CAG. C.2.07197-011

FOI704
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DIST-1.43

STUDY WITH THE BEST

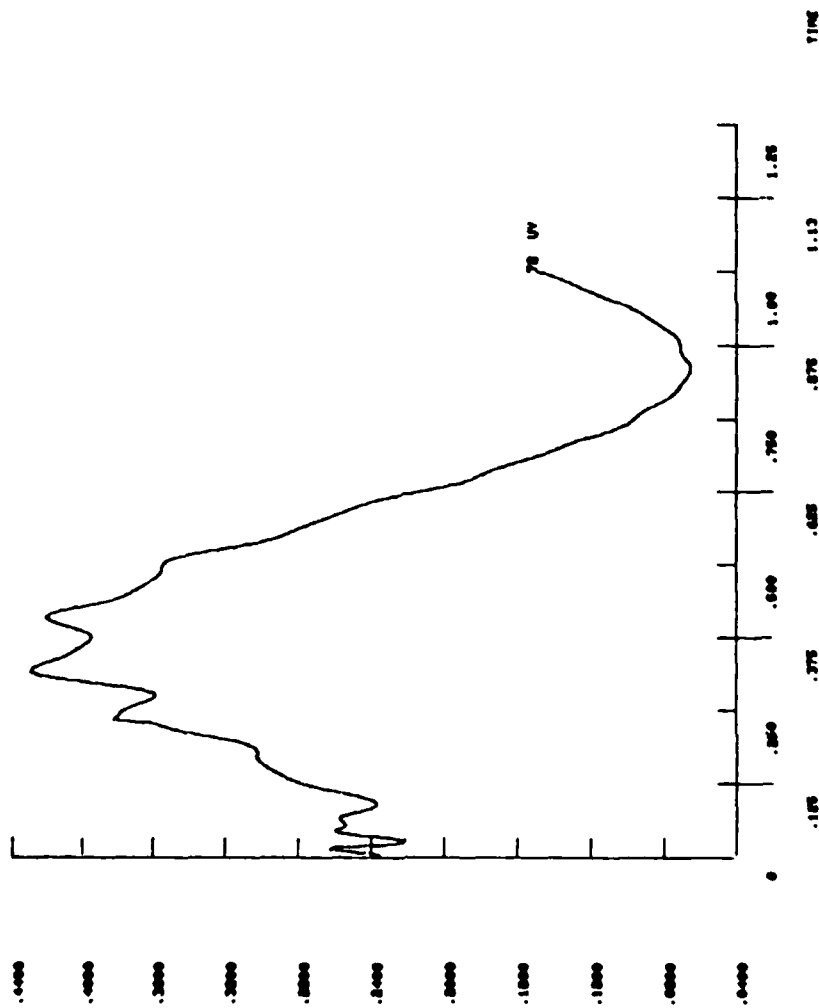
TABLE 1. SUMMARY OF VARIABILITY STUDIES THIS STEP AND EXTREME VALUES
OBTAINED FROM MONITORING RECORDS AT THE MINIMUM AT THE MAXIMUM AT THE

[illegible]

2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	1968	1967	1966	1965	1964	1963	1962	1961	1960	1959	1958	1957	1956	1955	1954	1953	1952	1951	1950	1949	1948	1947	1946	1945	1944	1943	1942	1941	1940	1939	1938	1937	1936	1935	1934	1933	1932	1931	1930	1929	1928	1927	1926	1925	1924	1923	1922	1921	1920	1919	1918	1917	1916	1915	1914	1913	1912	1911	1910	1909	1908	1907	1906	1905	1904	1903	1902	1901	1900	1899	1898	1897	1896	1895	1894	1893	1892	1891	1890	1889	1888	1887	1886	1885	1884	1883	1882	1881	1880	1879	1878	1877	1876	1875	1874	1873	1872	1871	1870	1869	1868	1867	1866	1865	1864	1863	1862	1861	1860	1859	1858	1857	1856	1855	1854	1853	1852	1851	1850	1849	1848	1847	1846	1845	1844	1843	1842	1841	1840	1839	1838	1837	1836	1835	1834	1833	1832	1831	1830	1829	1828	1827	1826	1825	1824	1823	1822	1821	1820	1819	1818	1817	1816	1815	1814	1813	1812	1811	1810	1809	1808	1807	1806	1805	1804	1803	1802	1801	1800	1799	1798	1797	1796	1795	1794	1793	1792	1791	1790	1789	1788	1787	1786	1785	1784	1783	1782	1781	1780	1779	1778	1777	1776	1775	1774	1773	1772	1771	1770	1769	1768	1767	1766	1765	1764	1763	1762	1761	1760	1759	1758	1757	1756	1755	1754	1753	1752	1751	1750	1749	1748	1747	1746	1745	1744	1743	1742	1741	1740	1739	1738	1737	1736	1735	1734	1733	1732	1731	1730	1729	1728	1727	1726	1725	1724	1723	1722	1721	1720	1719	1718	1717	1716	1715	1714	1713	1712	1711	1710	1709	1708	1707	1706	1705	1704	1703	1702	1701	1700	1699	1698	1697	1696	1695	1694	1693	1692	1691	1690	1689	1688	1687	1686	1685	1684	1683	1682	1681	1680	1679	1678	1677	1676	1675	1674	1673	1672	1671	1670	1669	1668	1667	1666	1665	1664	1663	1662	1661	1660	1659	1658	1657	1656	1655	1654	1653	1652	1651	1650	1649	1648	1647	1646	1645	1644	1643	1642	1641	1640	1639	1638	1637	1636	1635	1634	1633	1632	1631	1630	1629	1628	1627	1626	1625	1624	1623	1622	1621	1620	1619	1618	1617	1616	1615	1614	1613	1612	16

100-443887-100

3-2-1

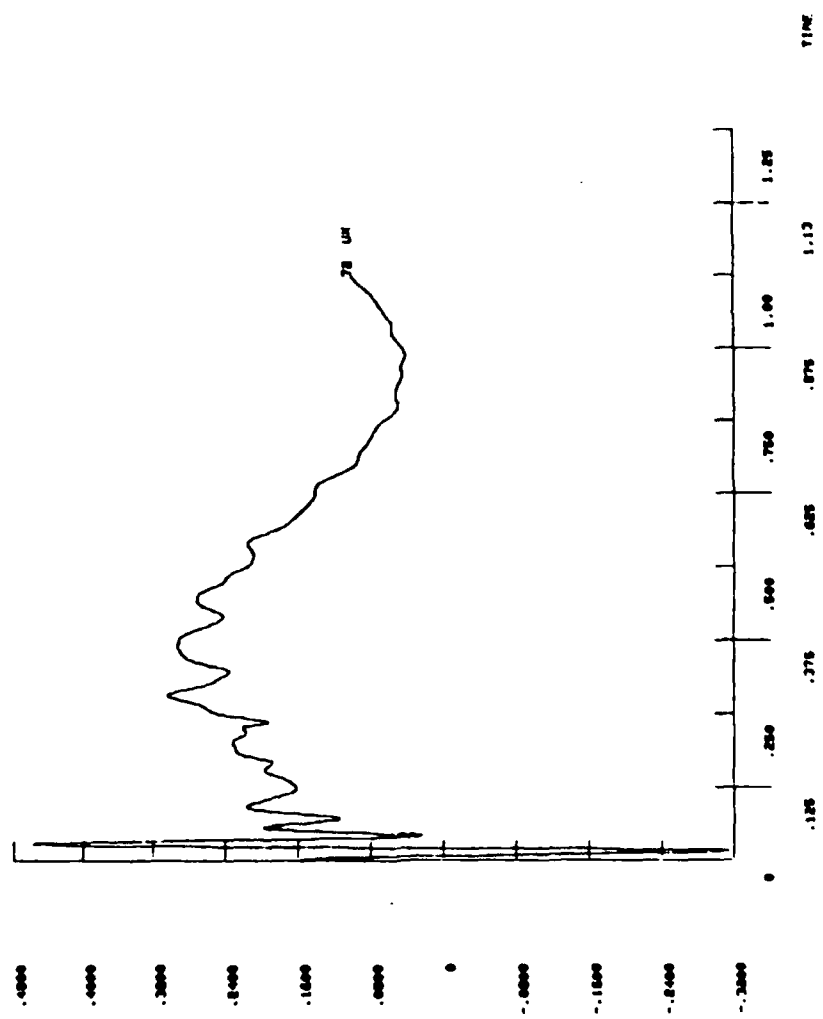


146-20.5.0 CASE, C.B. ENTLES/CIL

POSTED
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DIST-1.42

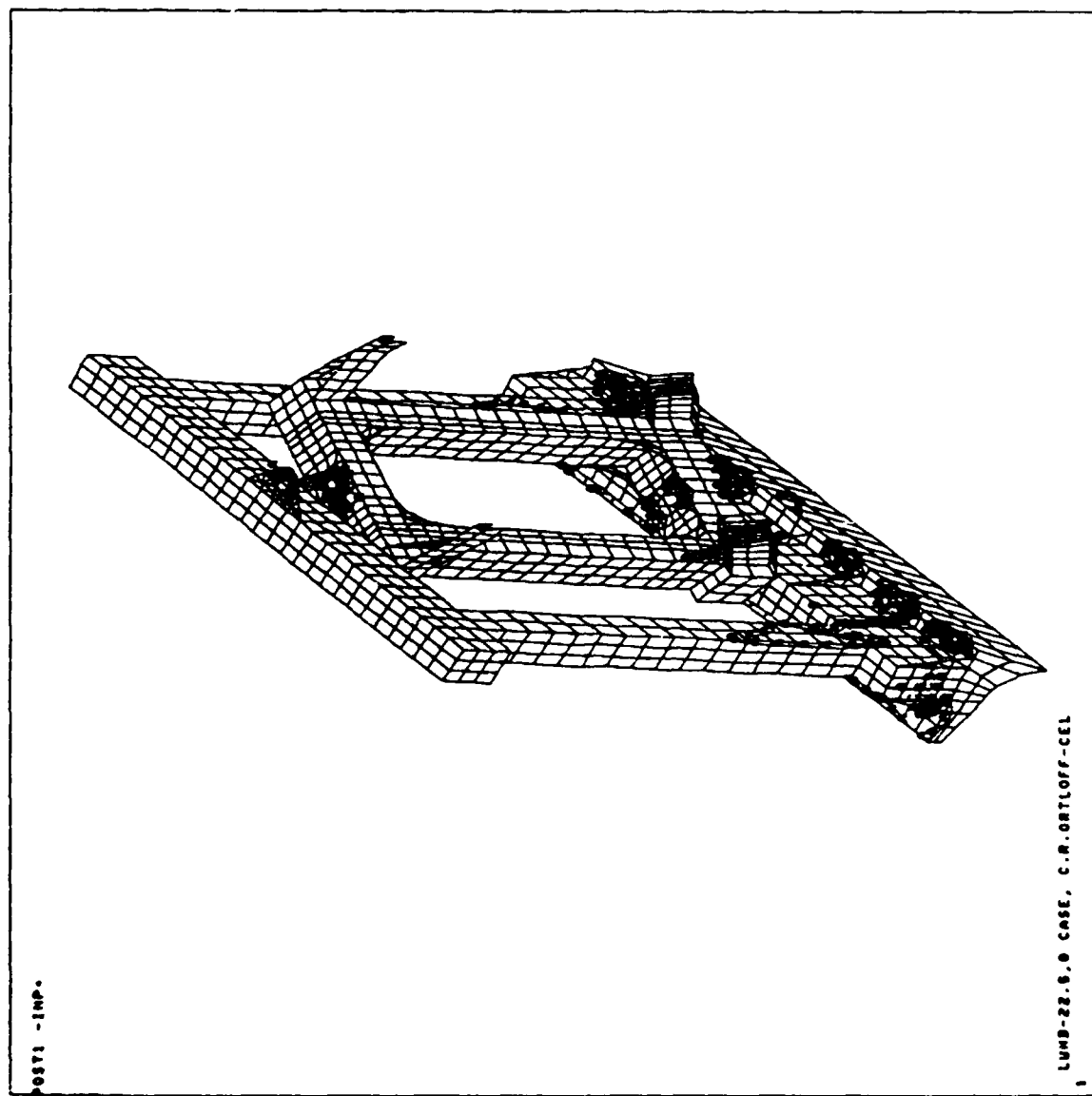
COMPLETION FOR 1001 DATA POINTS
 SUMMARY OF UNLOADED STORED THIS STEP AND EXTREME VALUES
 MAXIMUM AT TIME MINIMUM AT TIME
 0.015 78 UN 78 UN -0.3133 0.16000-01 0.4576 0.00000-01
 PLT DEFINITION VALUE
 SCALE UNIT 78 UN

POSTER
 20-1
 0187-1.43



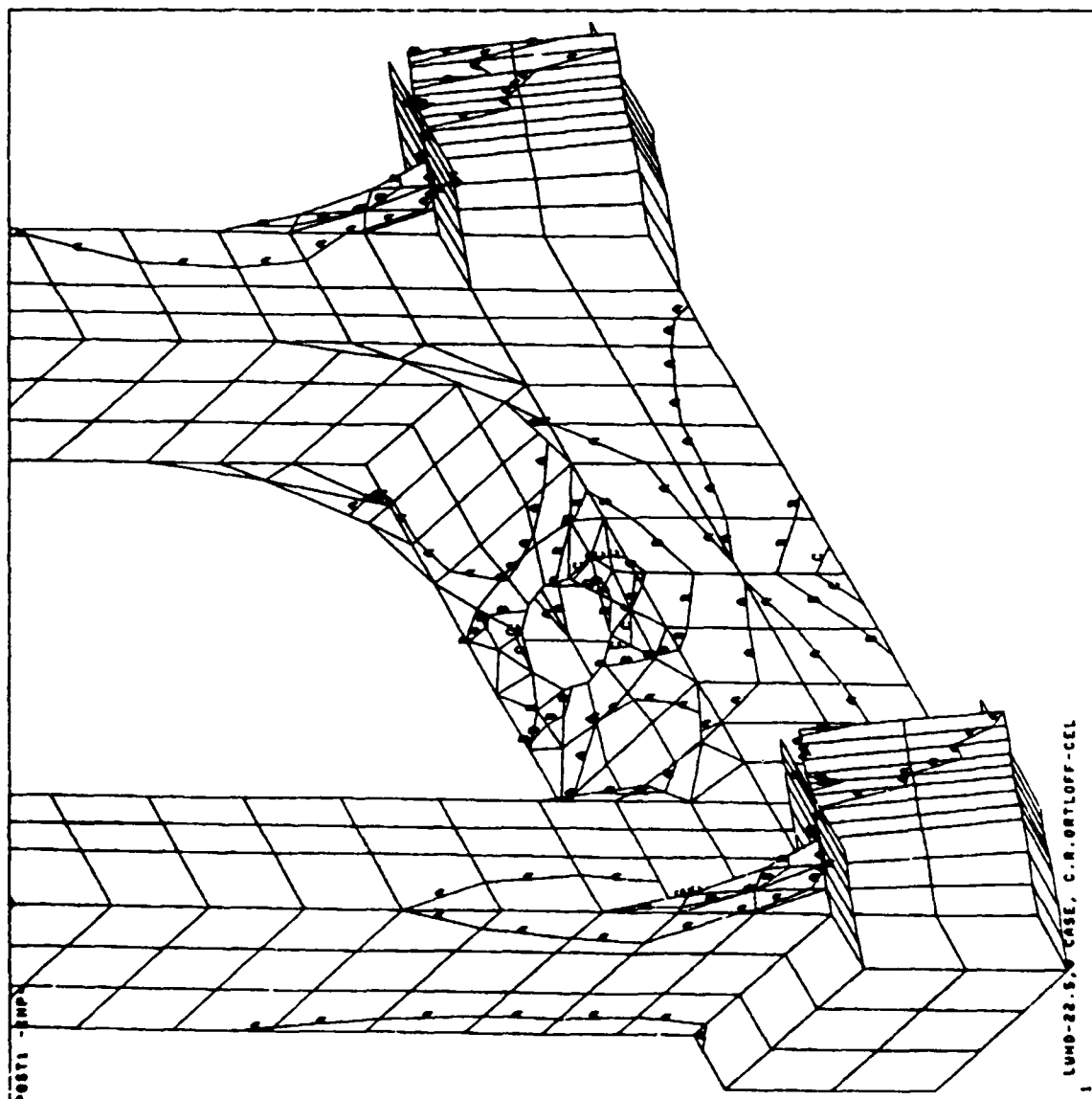
LAMP-DE 5.0 CASE, C.R. ANTILAMP-CELL

ANSYS 4.20
 JAN 5 1987
 12130114
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.318
 SLOC
 TOP
 ZOOM
 KU=1
 VU=.6
 ZU=-.6
 DIST=108
 XF=54
 VF=26.4
 ZF=5.26
 VRT0=1.71
 MIDDEN
 RX=232858
 RM=393
 A=39934
 B=77678
 C=116322
 D=154966
 E=193610



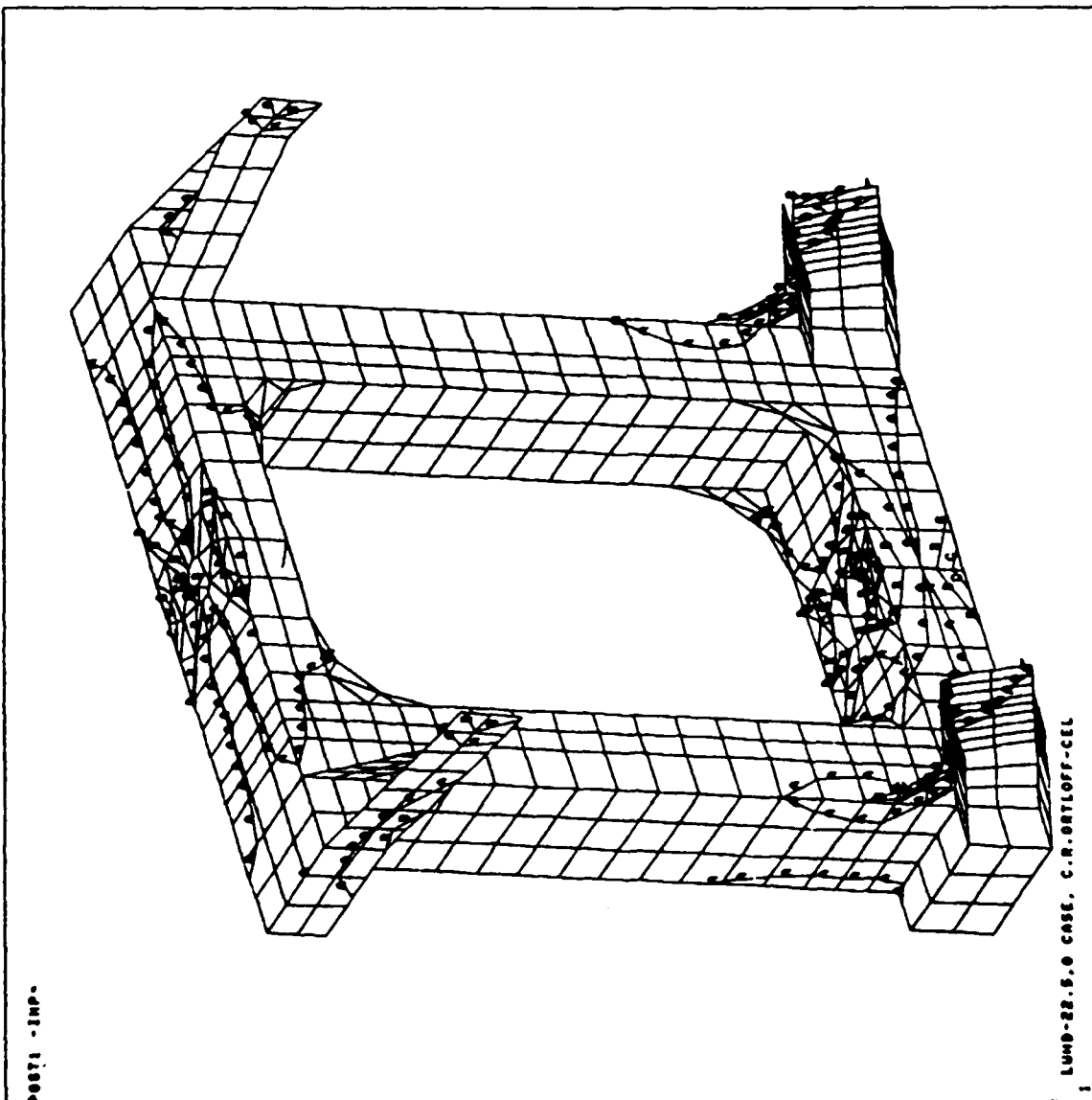
Von Mises
 Equivalent Stress

ANSYS 4.20
 JAN 6 1987
 12122137
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.318
 SICE
 TOP
 200R
 XU=1
 YU=.6
 ZU=-.6
 8 B167-28
 8 XF=61
 8 VF=20.6
 8 ZF=-12.3
 VSTD=1.71
 HIDDEN
 RX=95590
 RH=0
 A=15400
 B=32238
 C=48076
 D=63914
 E=79752

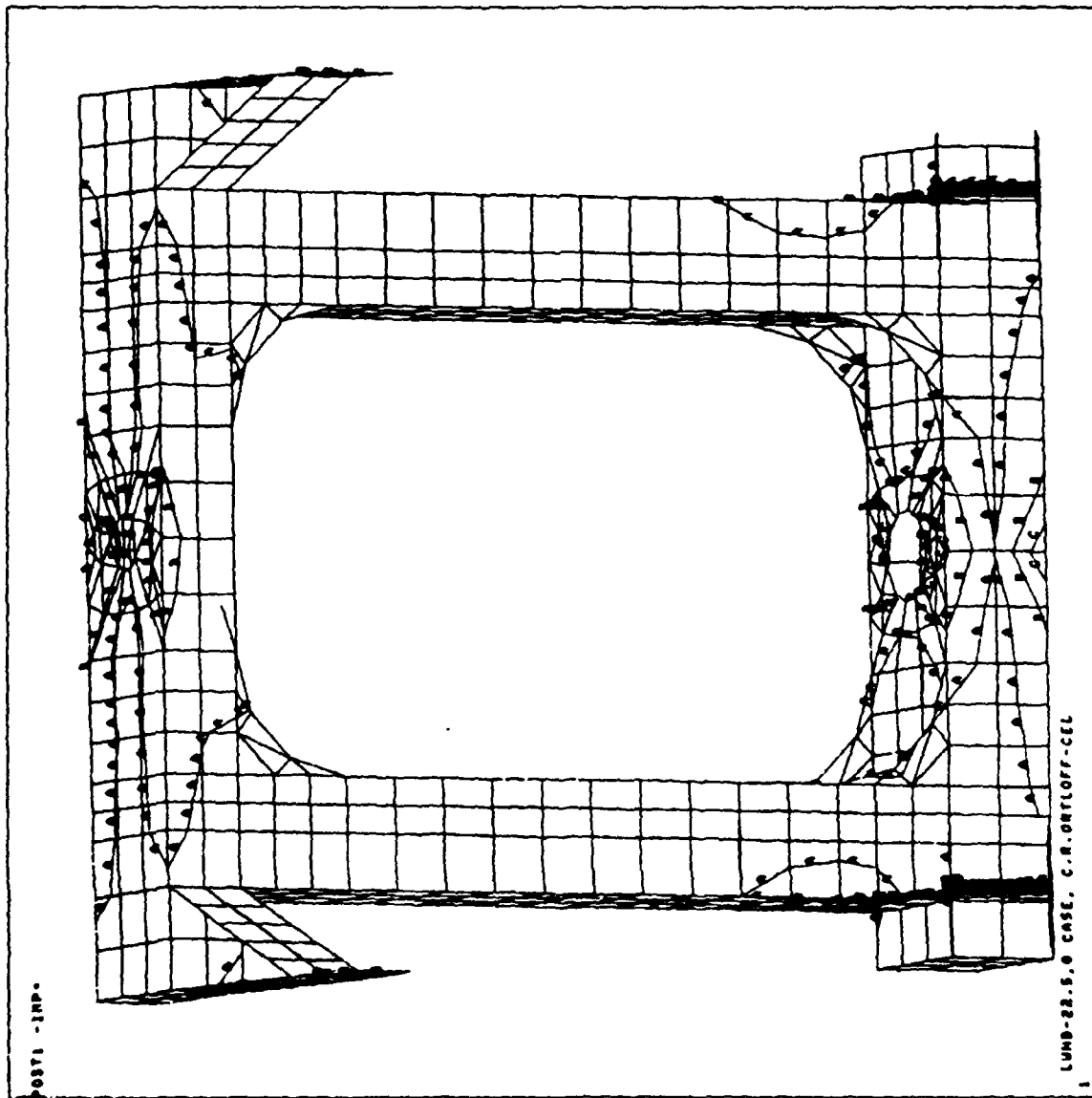


GIMBAL

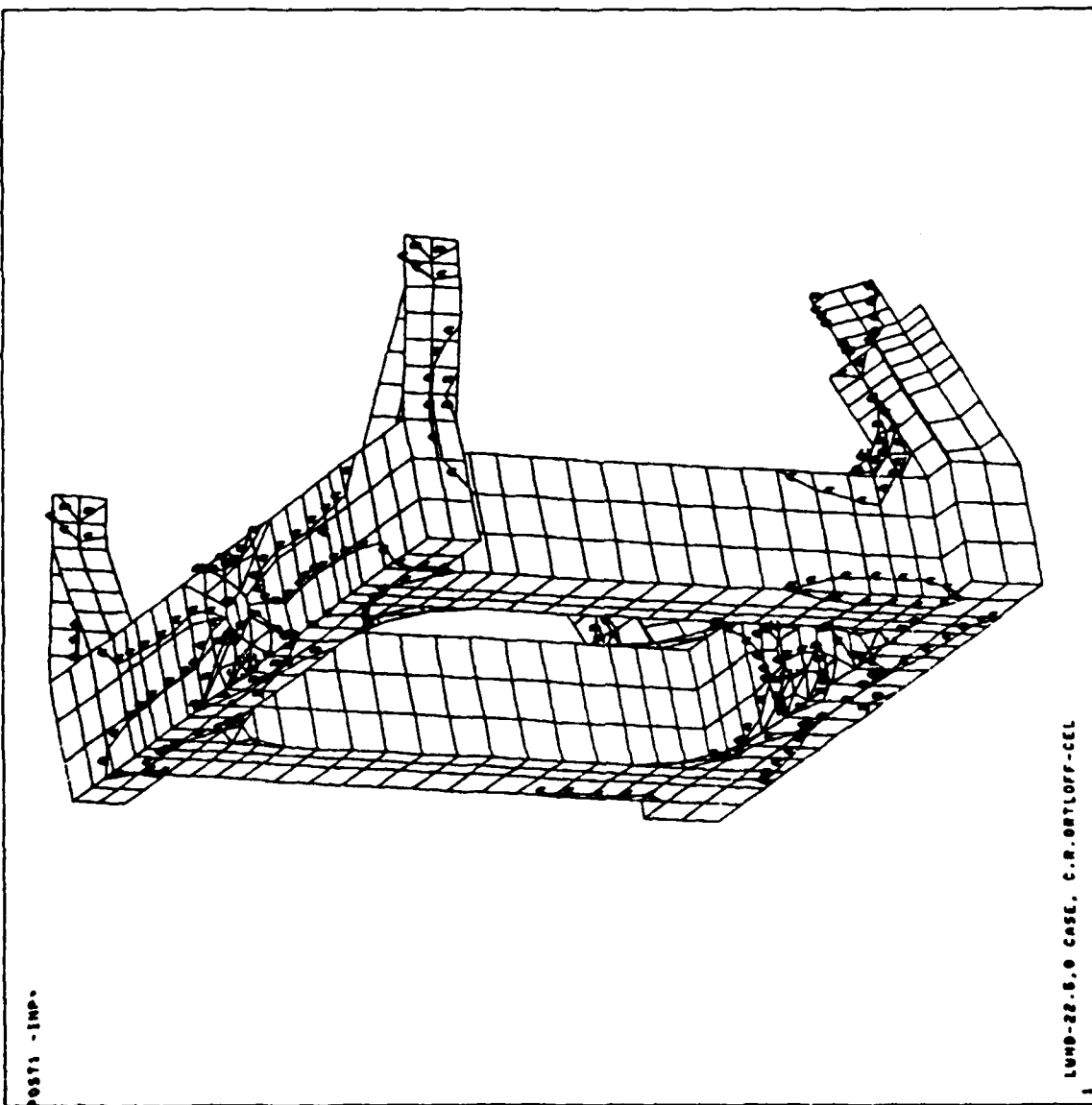
ANSYS 4.20
 JAN 5 1987
 18:22:37
 POST1 STRESS
 STEP=1
 TIME=1
 SICE
 TOP
 XU=1
 YU=6
 ZU=6
 BIST=31.3
 KF=54.4
 VF=35.2
 ZF=8.78
 MIBDEM
 MK=95590
 MN=563
 A=16400
 B=22238
 C=48076
 D=63814
 E=70752

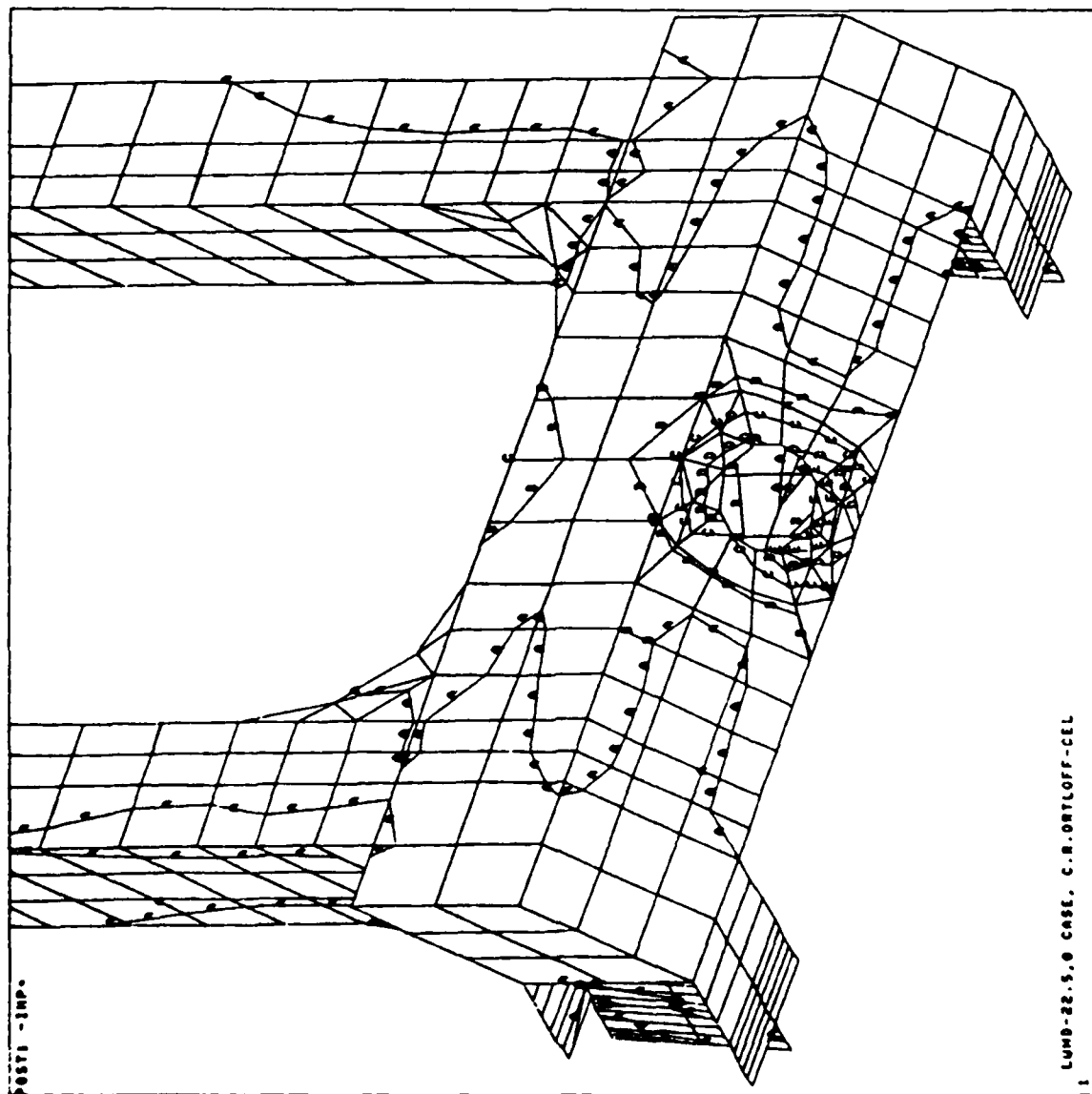


ANSYS 4.20
 JAN 5 1987
 12:19:23
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.318
 STOE
 TOP
 MU=.5
 VU=.5
 ZU=.1
 DIST=26.8
 KP=54.8
 VP=35.1
 ZP=-8.05
 MIDDLE
 MM=55590
 MM=563
 A=1600
 B=32238
 C=48076
 D=62914
 E=79752



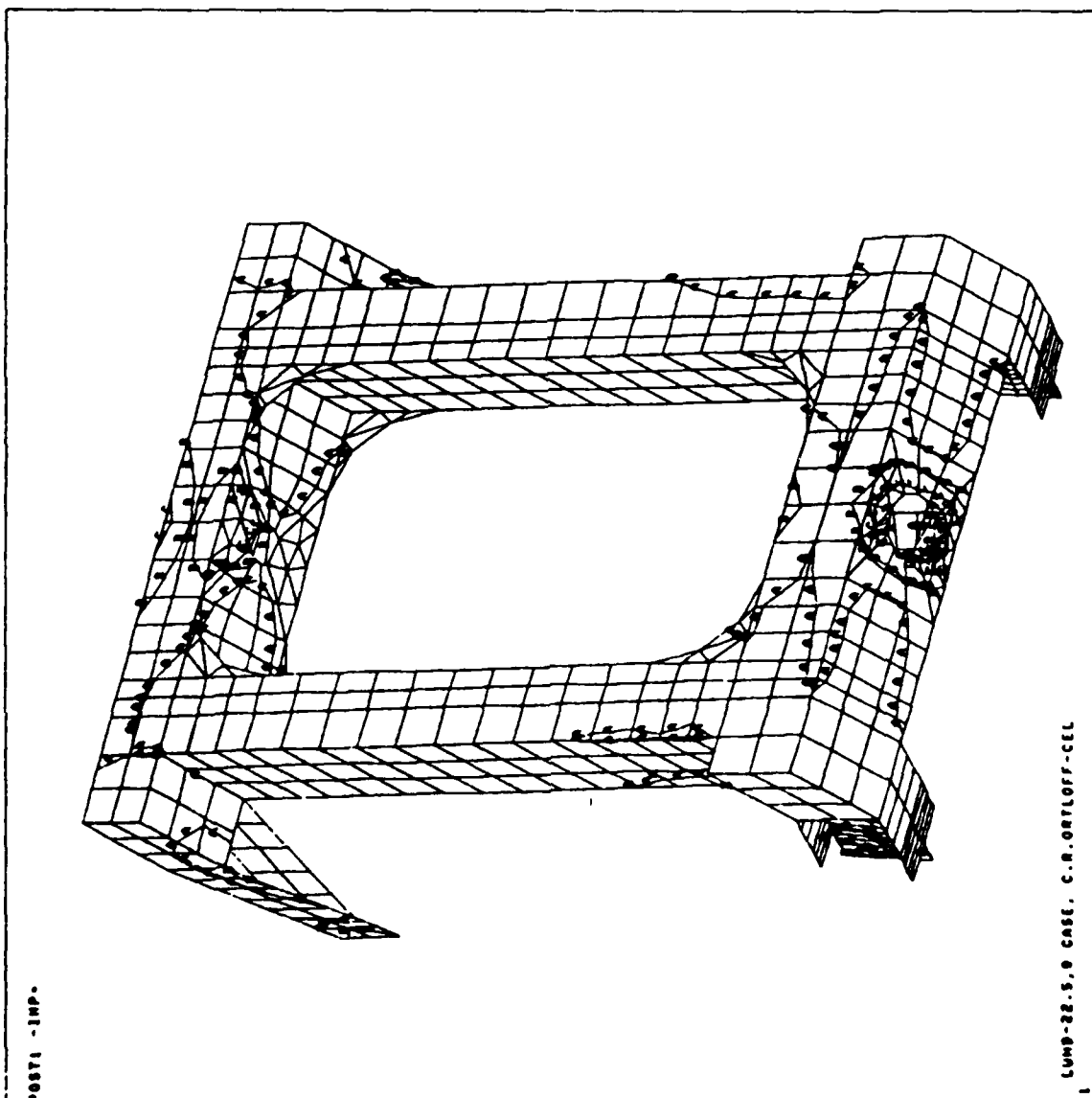
ARSYS 4.00
 JAN 5 1987
 12:18:28
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.318
 SICE
 TOP
 NU=1
 VU=1
 ZU=1
 DIST=34.8
 MF=57.3
 VF=33.9
 ZF=-7.62
 HIDDEN
 MN=95500
 MN=563
 A=10400
 D=32238
 C=48876
 D=63914
 E=70752



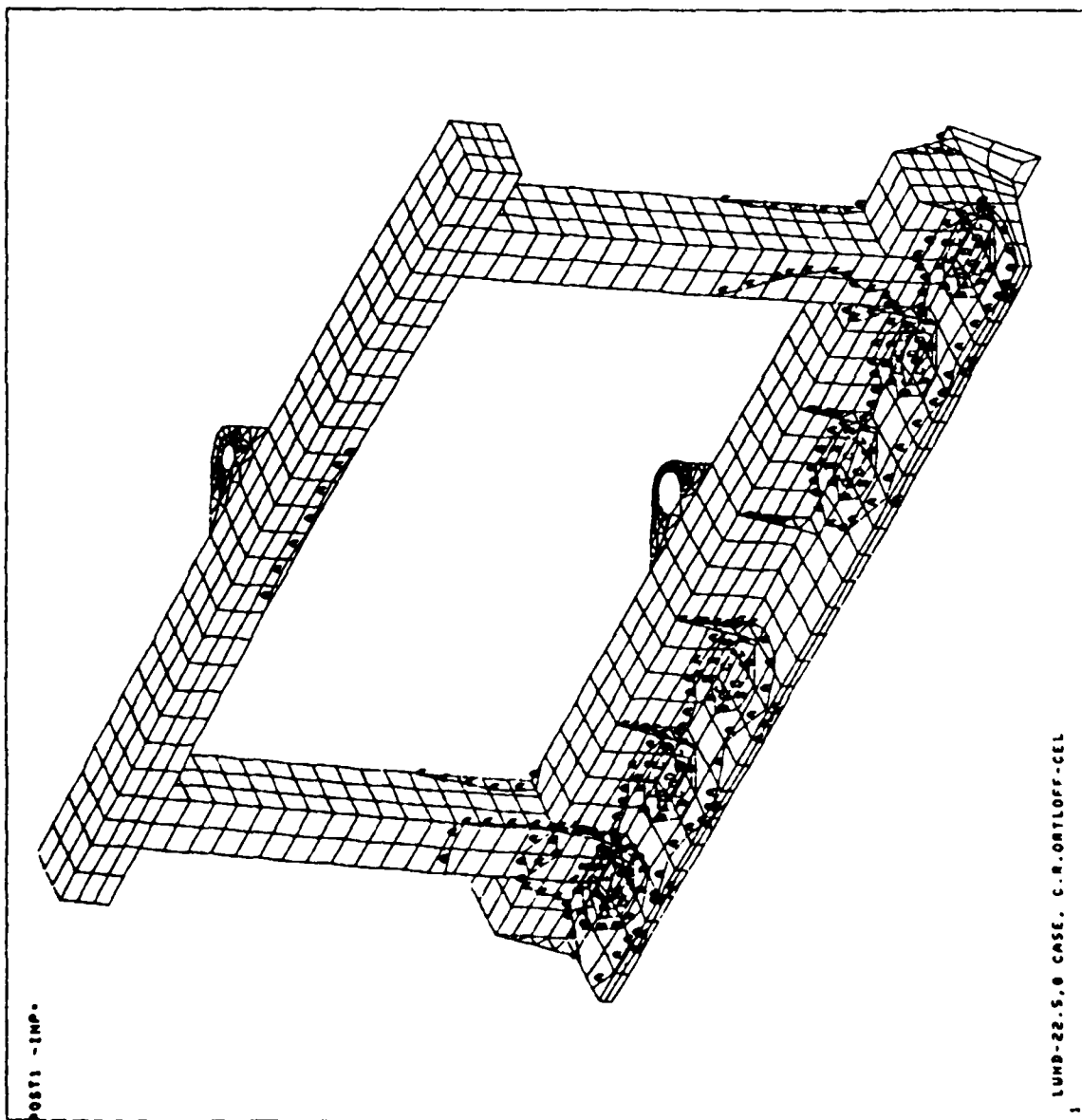


ANSYS 4.20
 JAN 5 1987
 12:05:46
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.318
 SICE
 TOP
 ZOOM
 XU=-1
 VU=-1
 ZU=1
 1 DIST=31.8
 2 RF=59.5
 3 VF=24
 4 ZF=13.4
 XRT0=1.43
 VRT0=2.18
 MIDDLE
 MX=95500
 MY=0
 A=14136
 B=27712
 C=41888
 D=54864
 E=68440
 F=82016

ANSYS 4.20
 JAN 5 1987
 12105146
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.310
 SIZE
 TOP
 ZOOM
 KU=-1
 YU=-1
 ZU=-1
 DIST=53.3
 MF=53.8
 VF=35
 ZF=-7.83
 XRTG 1.43
 VRTG=1.8
 HIDDEN
 M1=95590
 M1=562
 A=16400
 B=32238
 C=48076
 D=63914
 E=78752

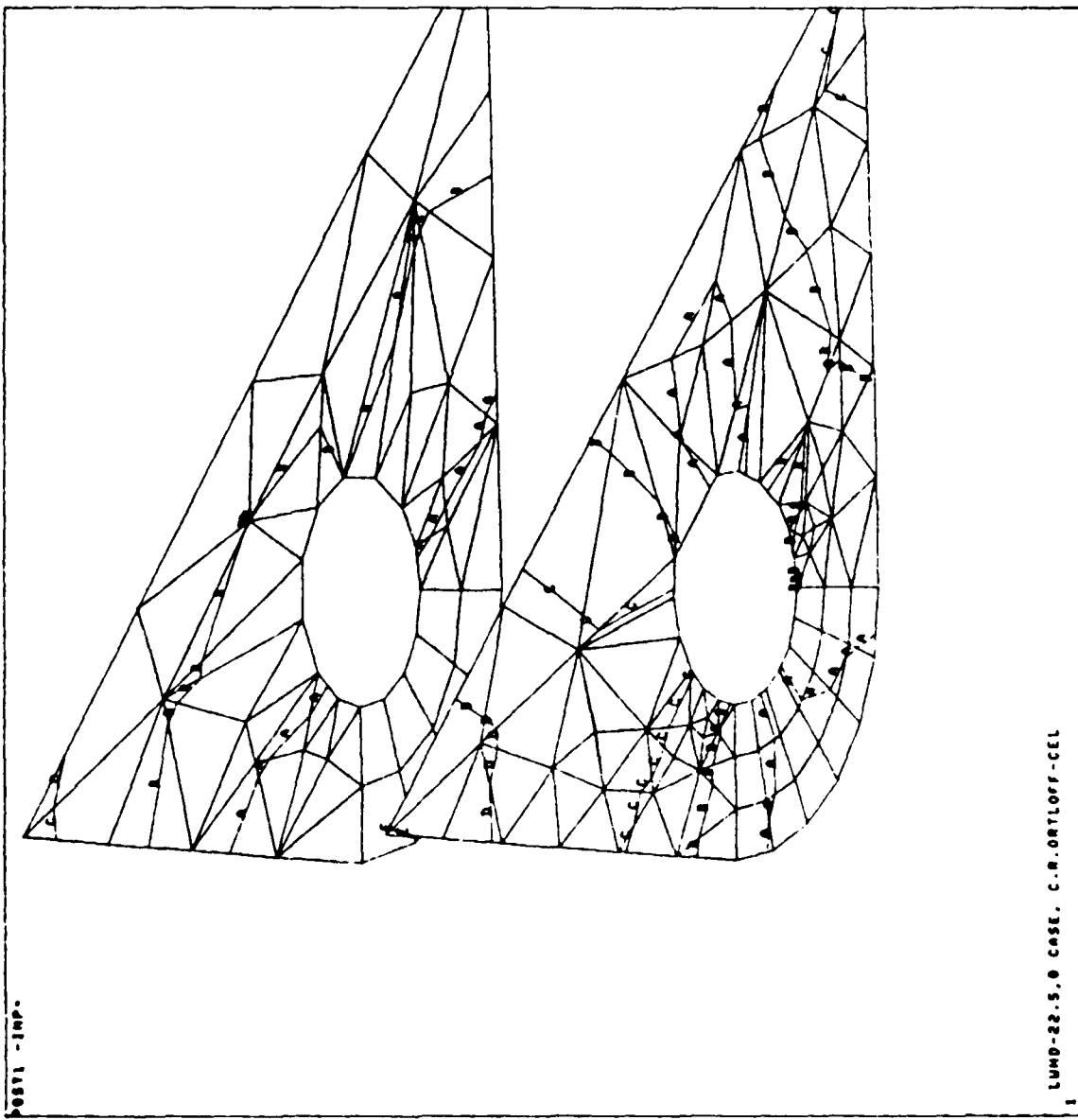


ANSYS 4.20
 JAN 5 1987
 11:41:00
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.318
 SICE
 TOP
 KU=1
 YU=1
 ZU=1
 DIST=56.6
 MF=51.2
 VF=27.7
 ZF=4.17
 MIDDEN
 MX=232252
 MY=393
 A=38934
 B=77678
 C=116322
 D=154066
 E=193610



100-225,000, C. O. 0071007-CEL

POST1 -IMP.



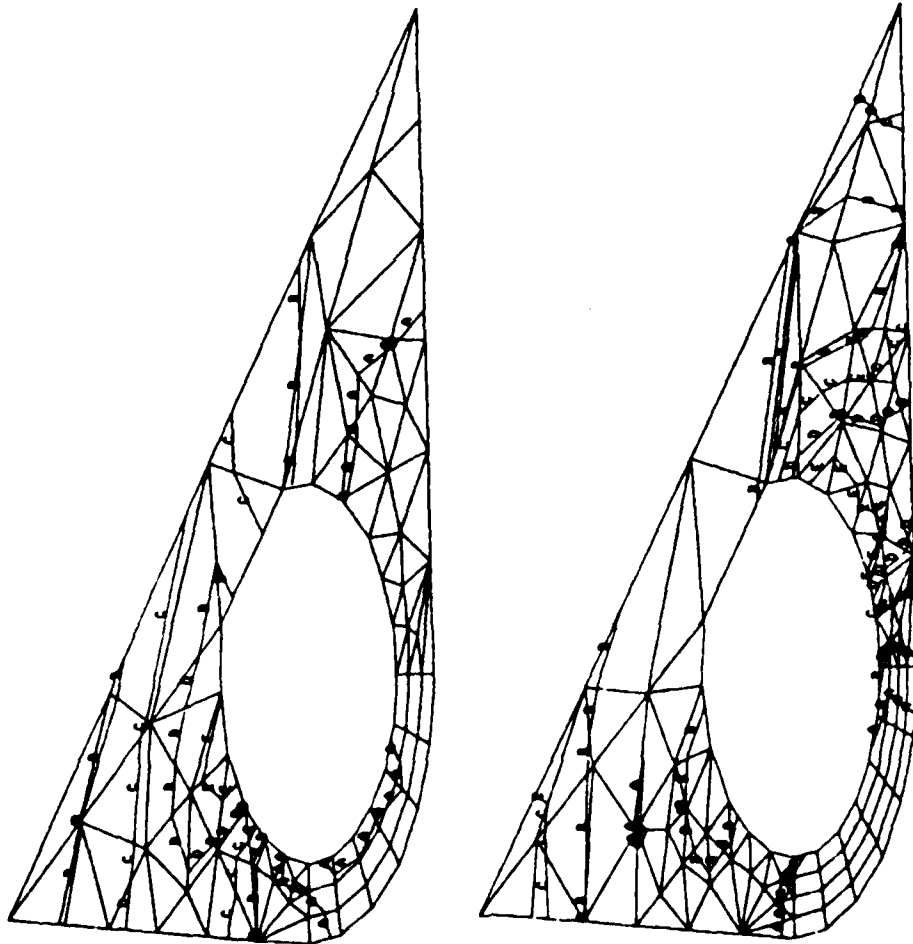
ANSYS 4.28
JAN 5 1987
11:51:22
POST1 STRESS
STEP=1
TYPE=1
TIME=.318
SIZE
TOP
ZOOM
XU=1
YU=1
ZU=1
DIST=7.14
KF=42.4
VF=48.2
ZF=6.95
KRT0=1.08
MIDEM
MX=20038
MY=283
A=437
B=8482
C=12527
D=16572
E=20617

TOP TABS

POST1 -IMP.
AUTO

FOR WINDOW 1 VIEW DISTANCE, FOCUS POINT, CONTOUR SPECIFICATIONS,
AND DISTORTION SCALING AUTOMATICALLY CALCULATED

POST1 -IMP.

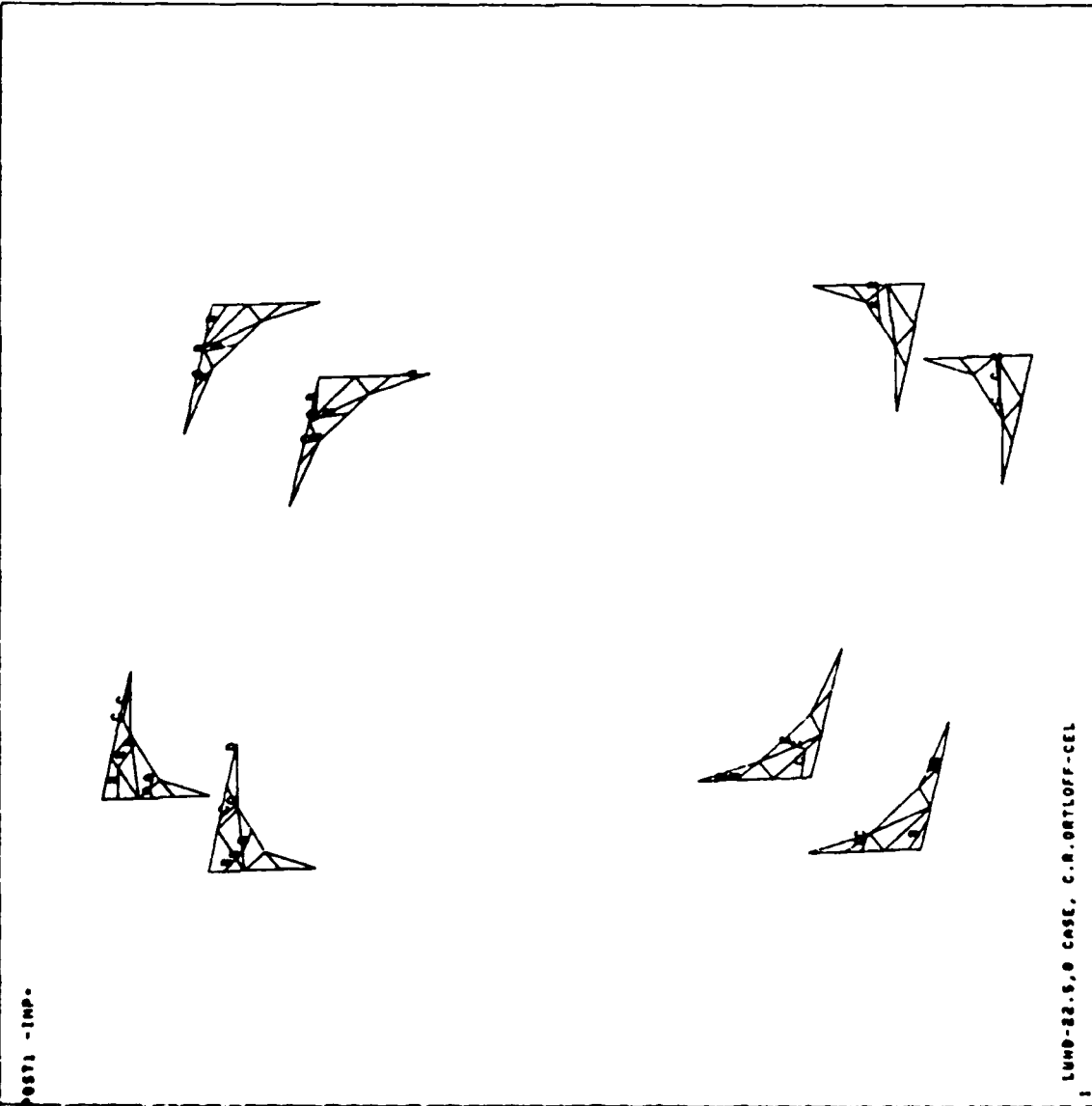


LUMB-22.5.0 CASE, C.R.ORTLOFF-CEL

ANSYS 4.20
JAN 5 1987
11:53:18
POST1 STRESS
STEP=1
ITER=1
TIME=.318
SIZE
TOP
ZOOM
XU=-1
YU=-1
ZU=1
E BIST-B.49
E MF-61.9
E VF-13.2
E ZF--8.83
XRT0-1.26
HIDDEN
NN-24661
NN-949
A-4437
B-8482
C-12527
D-16572
E-20617

BOTTOM TABS

ANSYS 4.28
 JAN 5 1987
 13104114
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.318
 SLOC
 TOP
 NU=-1
 VU=-1
 ZU=1
 8 D167-23.7
 8 MF-53
 8 VF-33.6
 8 SF-3.5
 MIDDEN
 MX-19820
 MY-2487
 A-5328
 B-16117
 C-14895
 D-18073



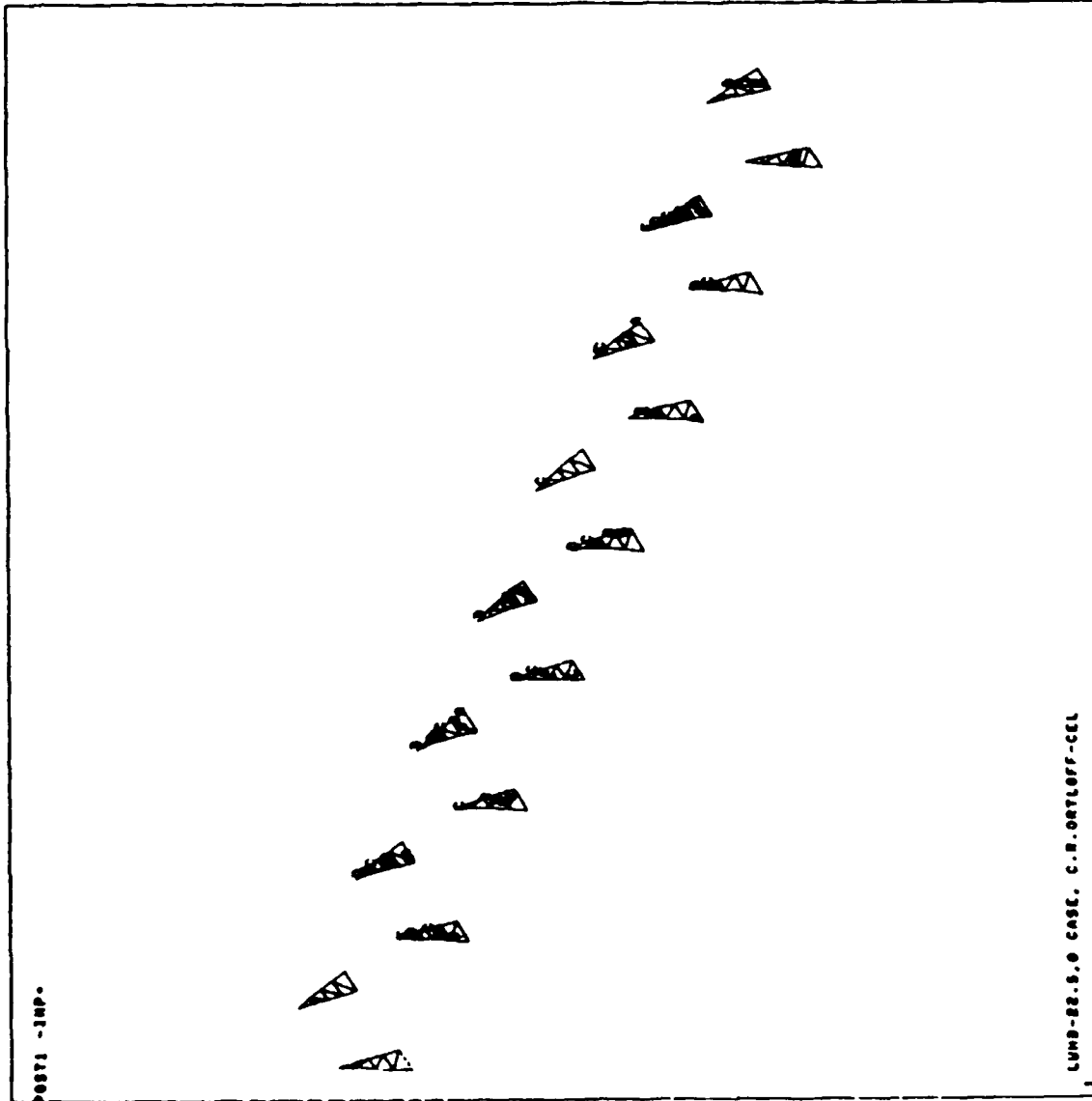
POST1 -IMP-

LUND-22.5.0 CASE, C.R. ORTLOFF-CEL

R,7

GIMBAL
CORNER
SUPPORTS

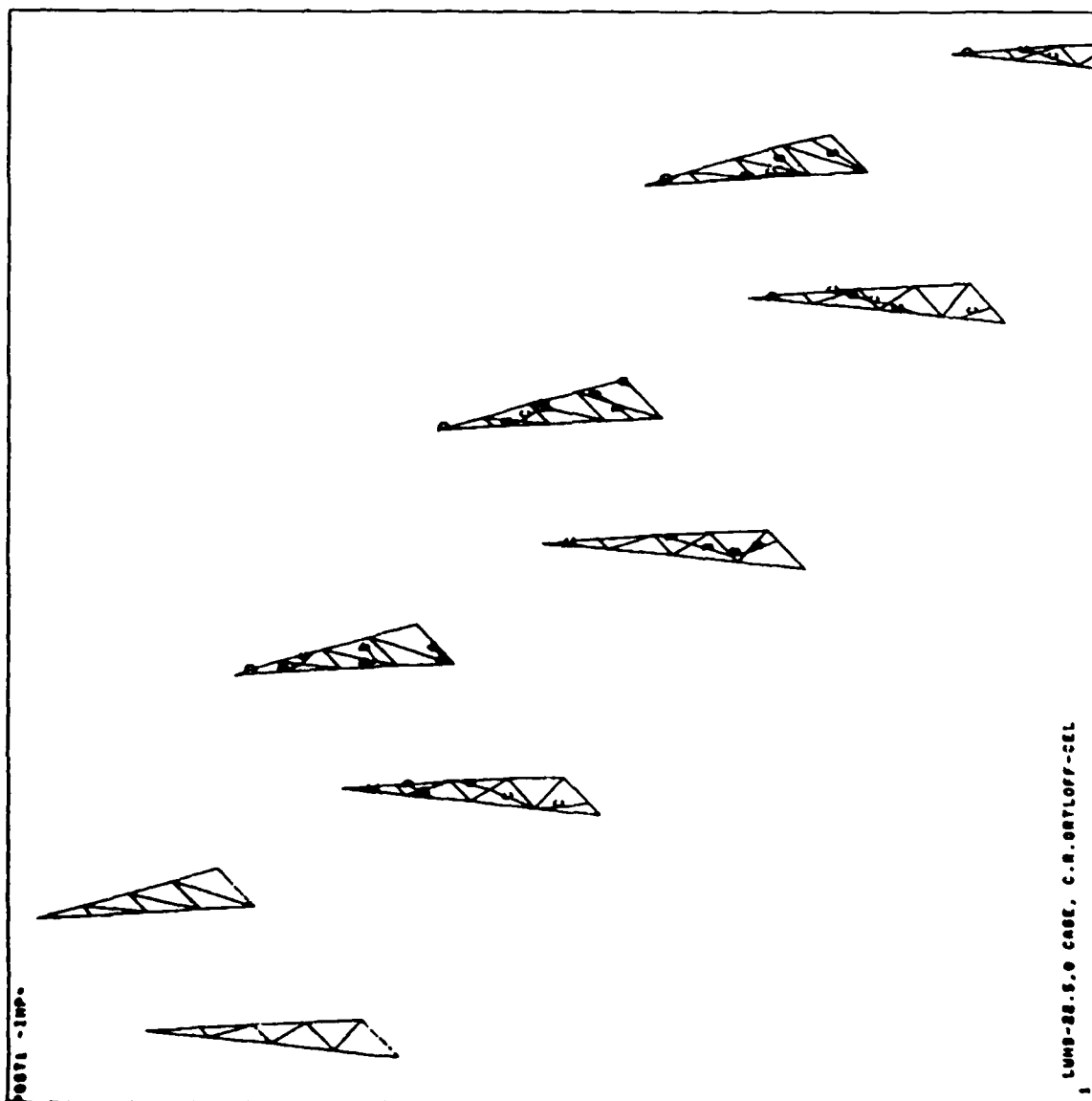
ARSVC 4.89
 JAN 5 1987
 11:50:40
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.318
 SLOC
 TOP
 ZOOM
 XU=-1
 YU=-1
 ZU=1
 DIST=57.6
 XF=82.8
 YF=3.95
 ZF=3.7
 XRT0=1.86
 HIDDEN
 RK=92444
 RW=1011
 A=10249
 B=31408
 C=46727
 D=61905
 E=77205



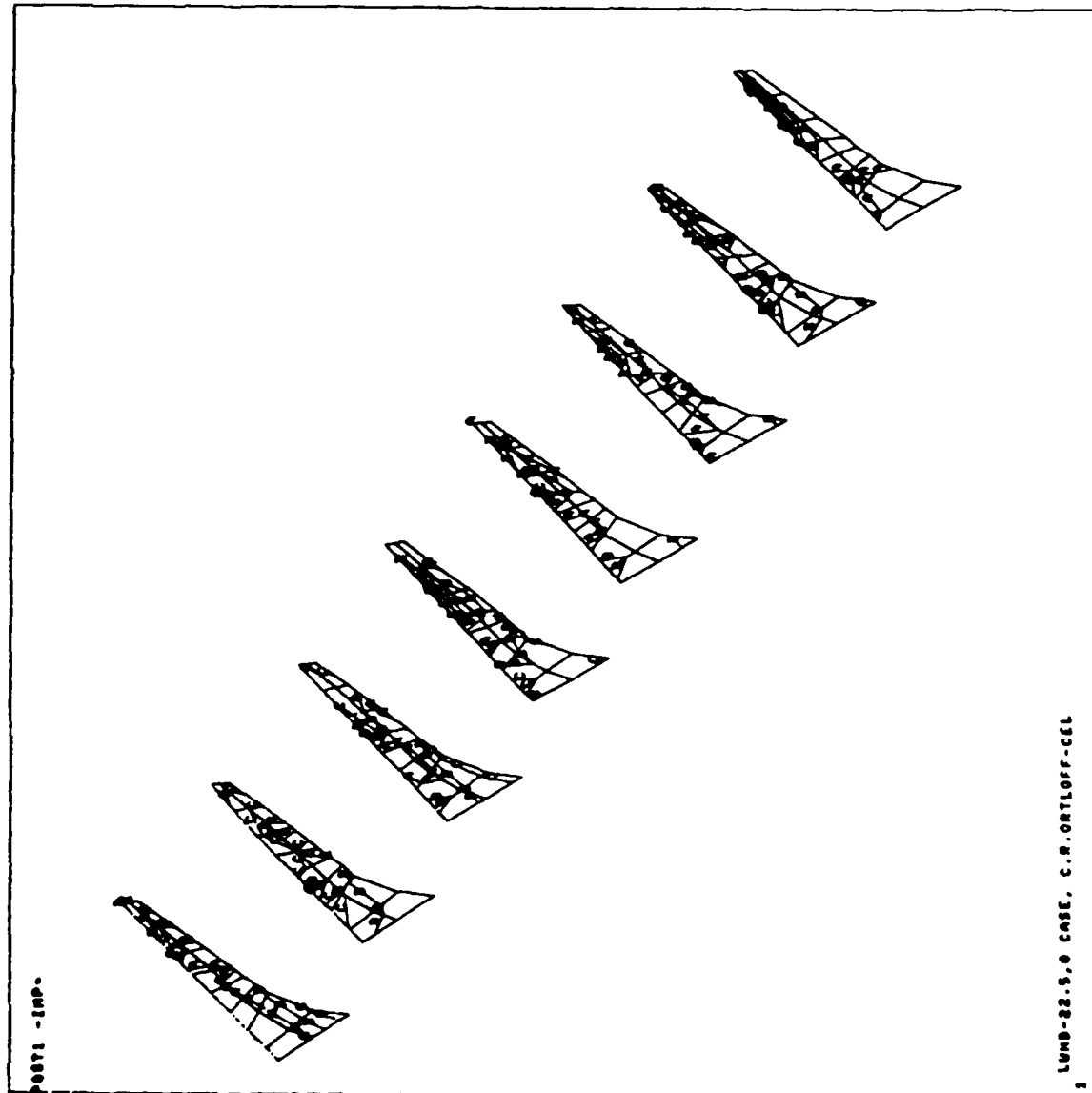
TRIANGULAR
 TAB REINFORCING-
 PLATES - PLATFORM
 LOWER BOX BEAM
 TO HORIZONTAL
 SPADE PLATE

ANSYS 4.80
JAN 9 1987
11:59:40
POST1 STRESS
VIEW=1
VIEW=1
TIME=.318
SIZE
TOP

ZOOM
RV=-1
VU=-1
20-1
S 16170.2
S VF-23.9
S VF-18.6
S 2-6.8
HOTO-1.86
VOTO-1.8
MIDLEN
MX-82444
MY-1811
A-18249
B-31488
C-46727
D-61806
E-77805

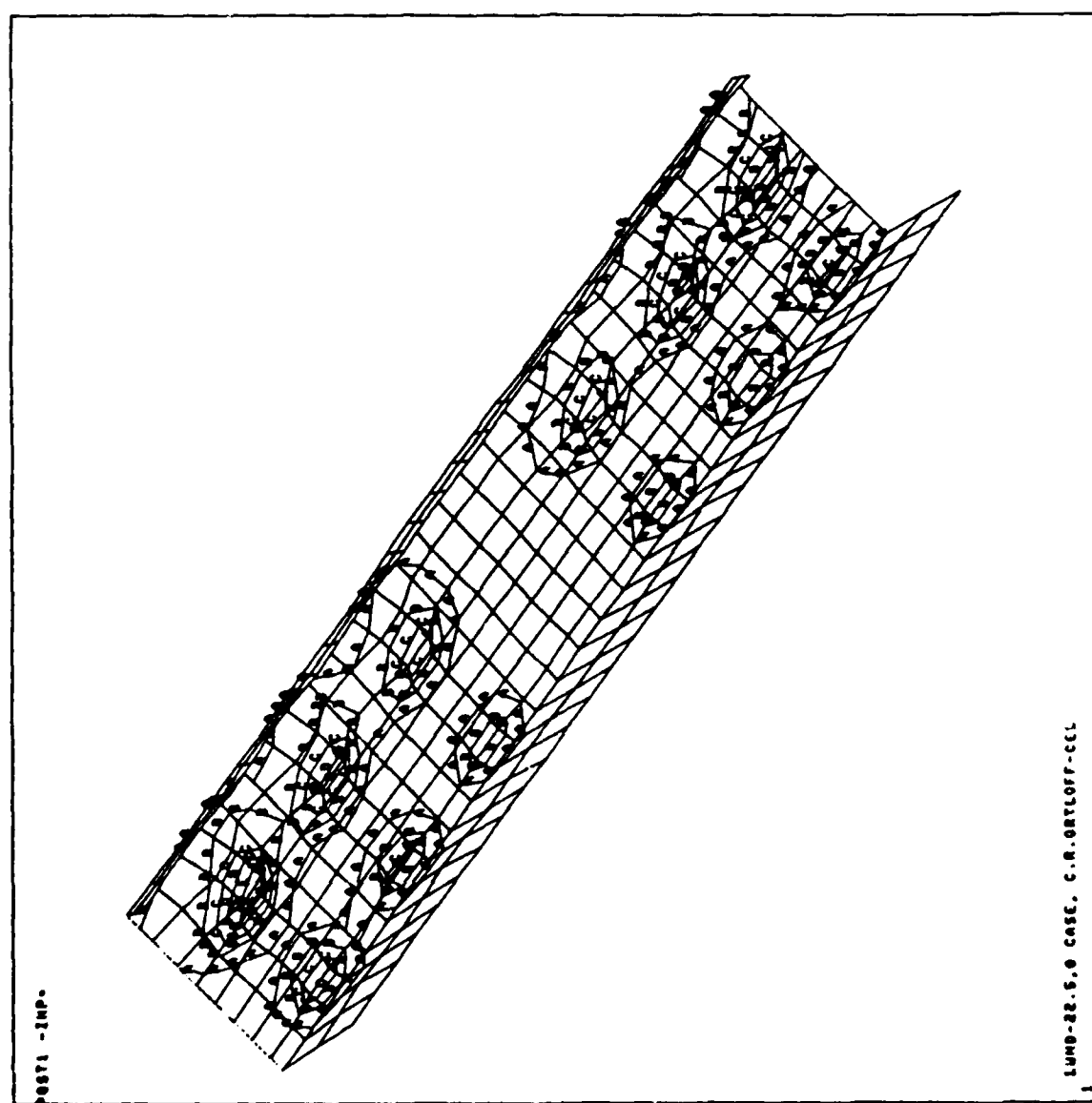


ANSYS 4.28
 JAN 5 1987
 18:08:34
 POST1 STRSS
 STEP=1
 ITER=1
 TIME=.318
 SLC
 TOP
 ZOOM
 XU=-1
 YU=-1
 ZU=1
 DIST=70.3
 XF=54.1
 YF=-8.93
 ZF=4.93
 MAT=1.43
 VRT=1.8
 HIDDEN
 MR=5400
 MM=4737
 A=13083
 B=21200
 C=29717
 D=30044
 E=46371



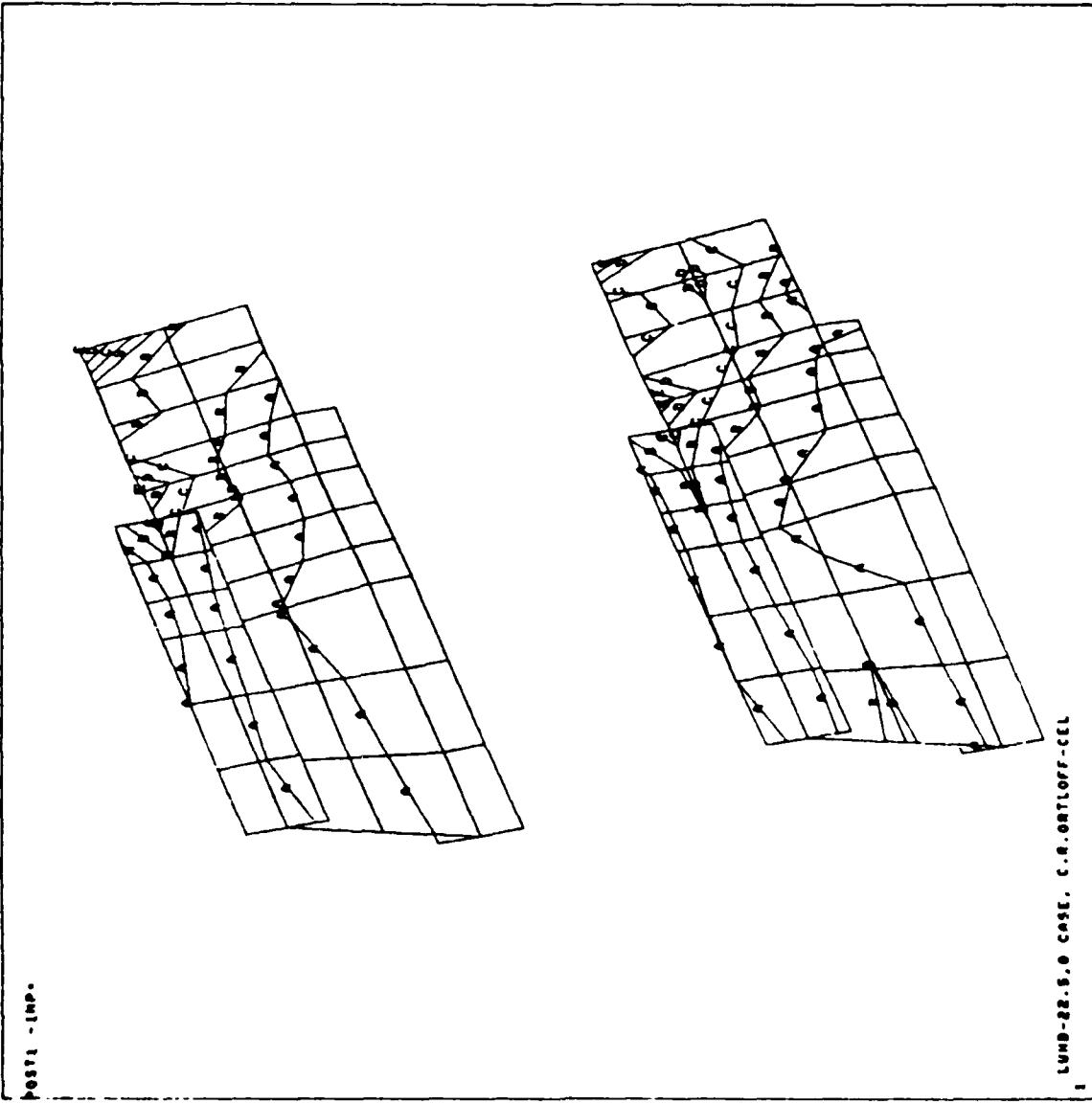
SPAD
 REINFORCING—
 PLATES

ANSYS 4.20
 JAN 5 1987
 12103146
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.310
 SIZE
 TOP
 ZOOM
 KU=-1
 VU=-1
 ZU=1
 DIST=70.3
 XF=54.1
 YF=-8.83
 ZF=4.03
 XRT0=1.43
 YRT0=1.8
 MIBDEN
 RM=232852
 RM=1673
 A=40102
 B=78532
 C=116962
 D=155202
 E=193822



LOWER
 HORIZONTAL
 SPADE PLATE

ANSYS 4.20
 JAN 5 1987
 13108140
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.318
 SIZE
 TOP
 XU=1
 VU=.5
 ZU=.5
 DIST=14.2
 WF=57.1
 VF=14.1
 ZF=13.5
 MIDDLE
 RM=42400
 RM=904
 A=7821
 B=14730
 C=21657
 D=28575
 E=35493



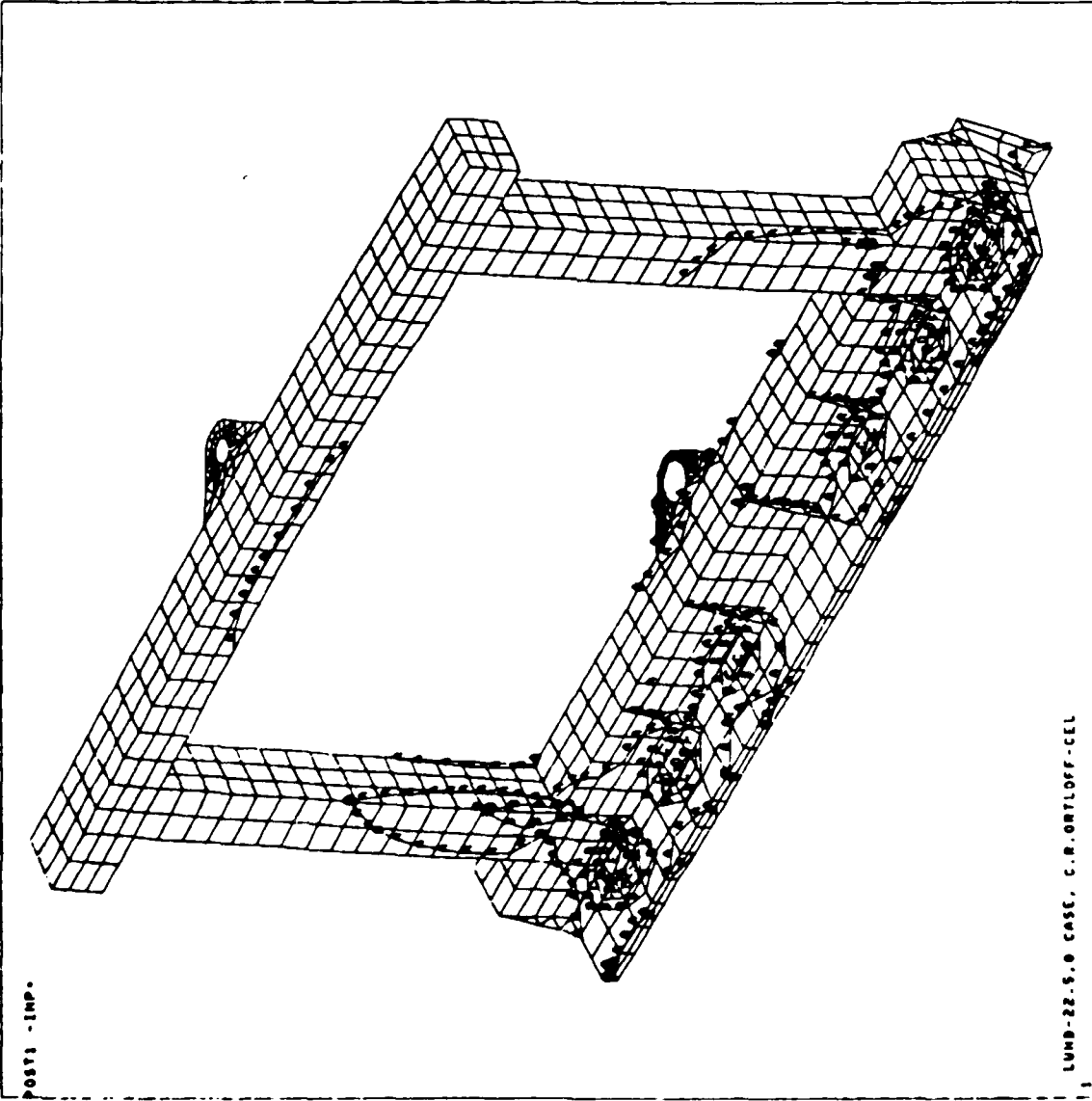
LOWER
 GIMBAL
 ARMS

LOAD STEP 1 ITERATION: 1 SECTION: 1
TIME: 0.31000 LOAD CASE: 1

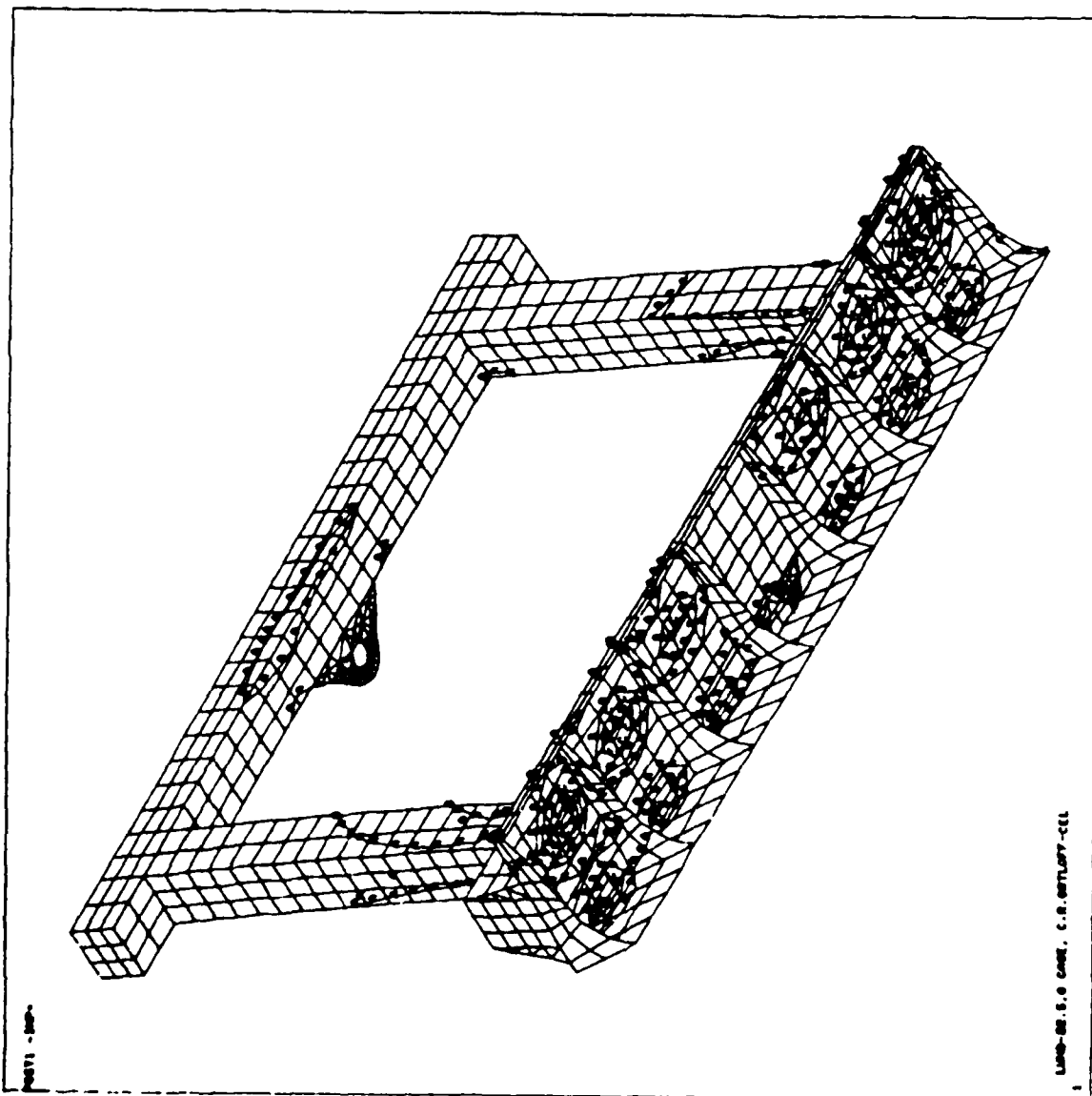
THE FOLLOWING X,Y,Z FORCES ARE IN NODAL COORDINATES

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1001	000.0					
1002	-244.0					
1003	000.0					
1004	000.0					
1005	000.0					
1006	-244.0					
1007	000.0					
1008	000.0					
1009	-244.0					
1010	000.0					
1011	000.0					
1012	000.0					
1013	000.0					
1014	000.0					
1015	000.0					
1016	000.0					
1017	000.0					
1018	000.0					
1019	000.0					
1020	000.0					
1021	000.0					
1022	000.0					
1023	000.0					
1024	000.0					
1025	000.0					
1026	000.0					
1027	000.0					
1028	000.0					
1029	000.0					
1030	000.0					
1031	000.0					
1032	000.0					
1033	000.0					
1034	000.0					
1035	000.0					
1036	000.0					
1037	000.0					
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1040	000.0					
1041	000.0					
1042	000.0					
1043	000.0					
1044	000.0					
1045	000.0					
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1047	000.0					
1048	000.0					
1049	000.0					
1050	000.0					
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1079	000.0					
1080	000.0					
1081	000.0					
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1083	000.0					
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1090	000.0					
1091	000.0					
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1108	000.0					
1109	000.0					
1110	000.0					
1111	000.0					
1112	000.0					
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1122	000.0					
1123	000.0					
1124	000.0					
1125	000.0					
1126	000.0					
1127	000.0					
1128	000.0					
1129	000.0					
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1176	000.0					
1177	000.0					
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1181	000.0					
1182	000.0					
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1185	000.0					
1186	000.0					
1187	000.0					
1188	000.0					
1189	000.0					
1190	000.0					
1191	000.0					
1192	000.0					
1193	000.0					
1194	000.0					
1195	000.0					
1196	000.0					
1197	000.0					
1198	000.0					
1199	000.0					
1200	000.0					
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1276	000.0					

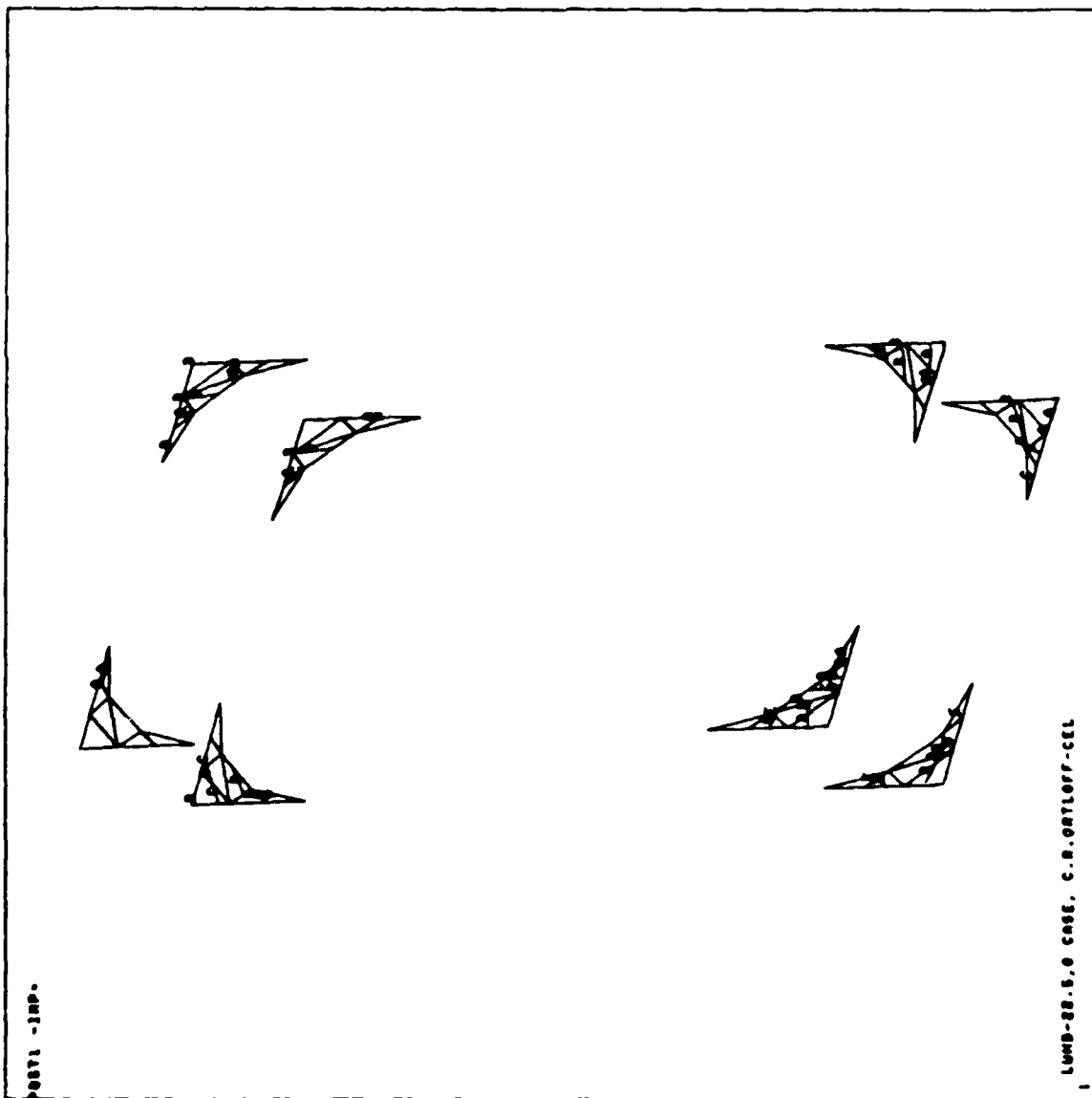
ANSYS 4.20
 JAN 6 1987
 9:47:20
 POST1 STRESS
 STEP=1
 LTR=1
 TIME=.018
 SIZE
 TOP
 KU=1
 VU=1
 ZU=1
 DIST=56.6
 XF=51.2
 YF=27.7
 ZF=4.17
 HIDDEN
 RK=127580
 RM=605
 A=21267
 B=42930
 C=64083
 D=95256
 E=106419



00010 4.20
 JAN 6 1987
 01-20-13
 00071 070000
 STEP-1
 STEP-1
 TIME-0.010
 SIZE
 TOP
 00-1
 00-1
 20-1
 0107-00.0
 07-04.0
 07-00.4
 27-04.00
 010000
 00-107000
 00-000
 0-01007
 0-00000
 0-00000
 0-00000
 0-00000

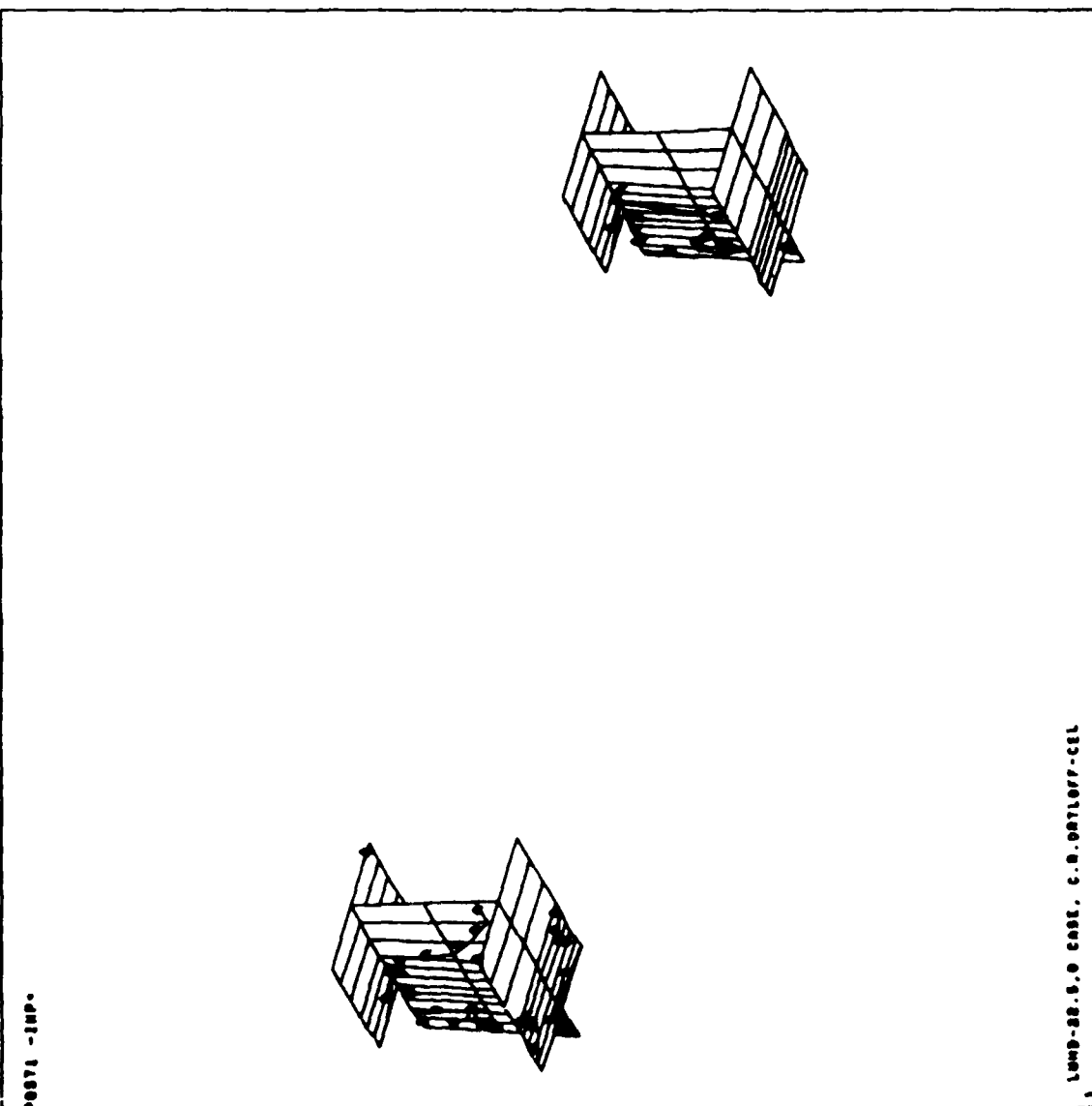


ARCS 4.00
 JAN 6 1987
 10130180
 POST1 STRSS
 STCD=1
 STED=1
 TIME=.010
 STOE
 TOP
 ZOOM
 X1=-1
 Y1=-1
 Z1=-1
 X2=31.0
 Y2=32.0
 Z2=3.0
 X3=1.00
 Y3=1.40
 Z3=1.40
 MIDEN
 MX=10343
 MY=2130
 MZ=8004
 B=7072
 C=10740
 D=13000
 E=10470



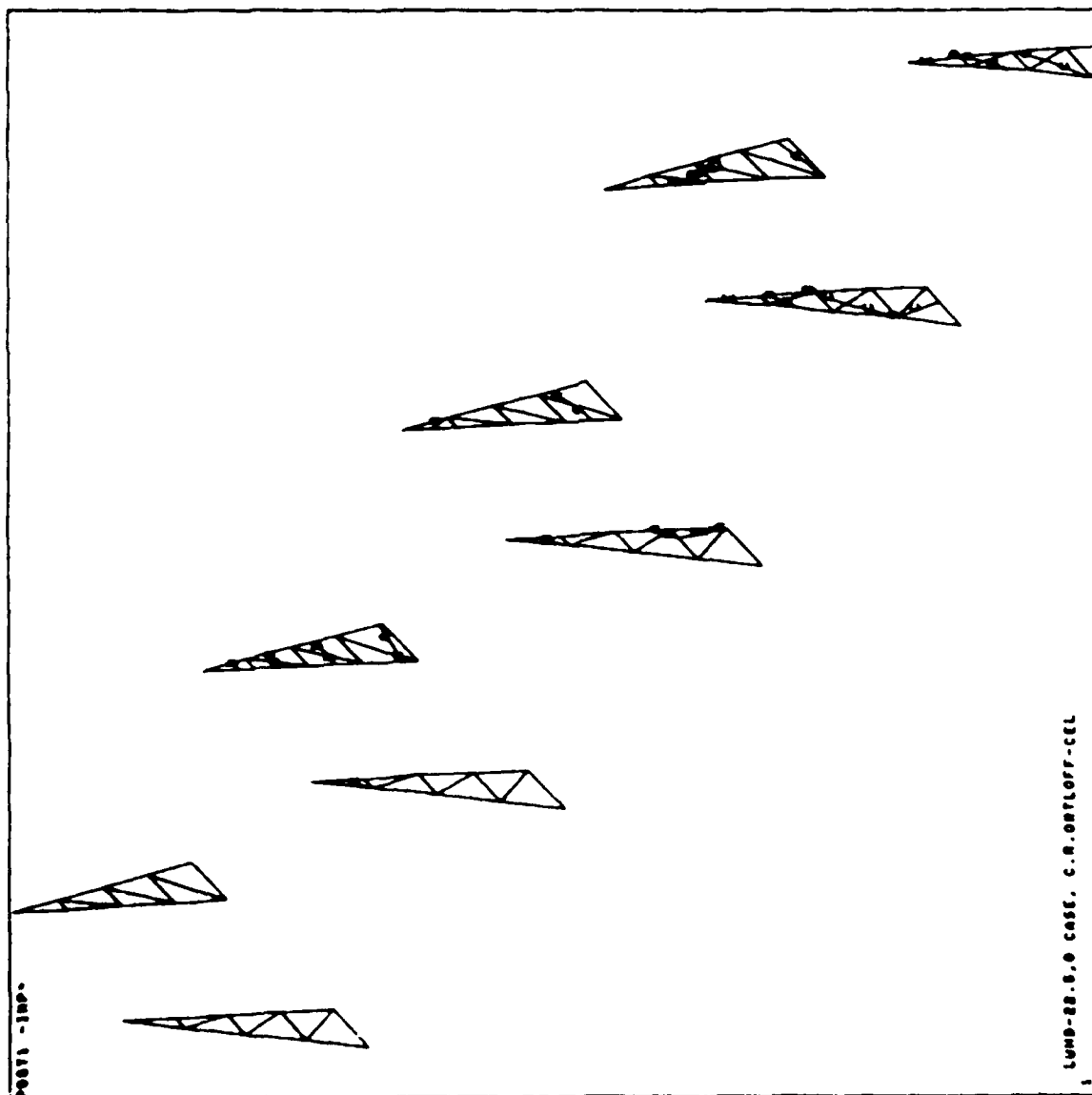
GIMBAL
 CORNER
 SUPPORTS

ANSYS 4.20
 JAN 6 1987
 10134146
 POST1 STRSS
 STEP=1
 1720=1
 TIME=.010
 SLOC
 700
 2004
 RU=1
 VU=1
 20=1
 0107-03.0
 RF=66.8
 VF=14.6
 ZF=18.6
 RT0=1.06
 VT0=1.48
 M100EN
 M1=134306
 M6=1100
 A=23207
 B=46607
 C=67707
 D=89907
 E=118107

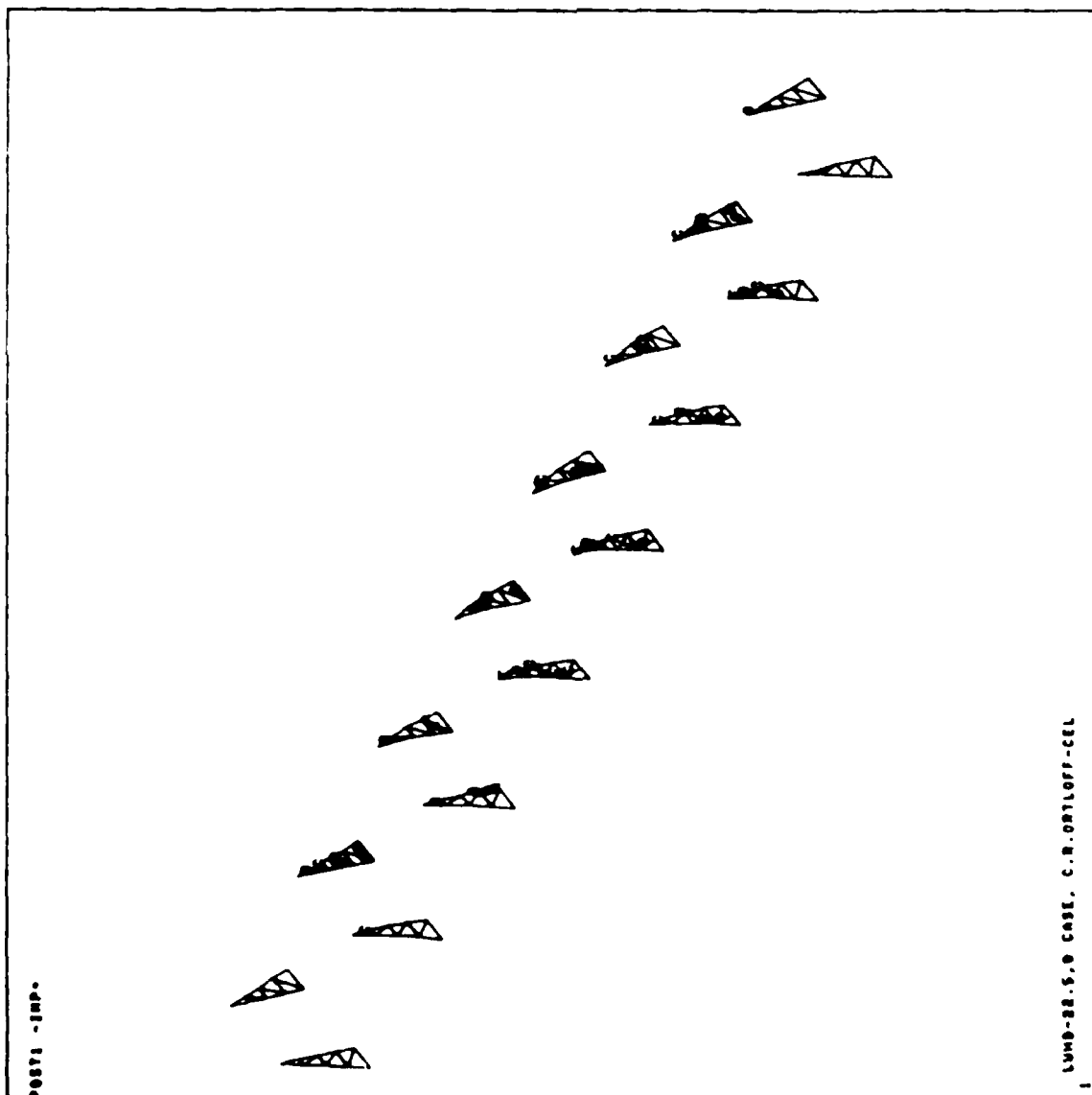


The diagrams illustrate the development of a ship's wake. The first diagram shows a simple V-shape. The second adds a small transverse wave across the V. The third adds more detail to the transverse wave. The fourth shows a more pronounced transverse wave. The fifth adds a second, smaller V-shape behind the first. The sixth adds a third V-shape. The seventh shows a complex pattern with multiple transverse waves and V-shapes. The eighth diagram shows a highly complex, multi-lobed wake pattern.

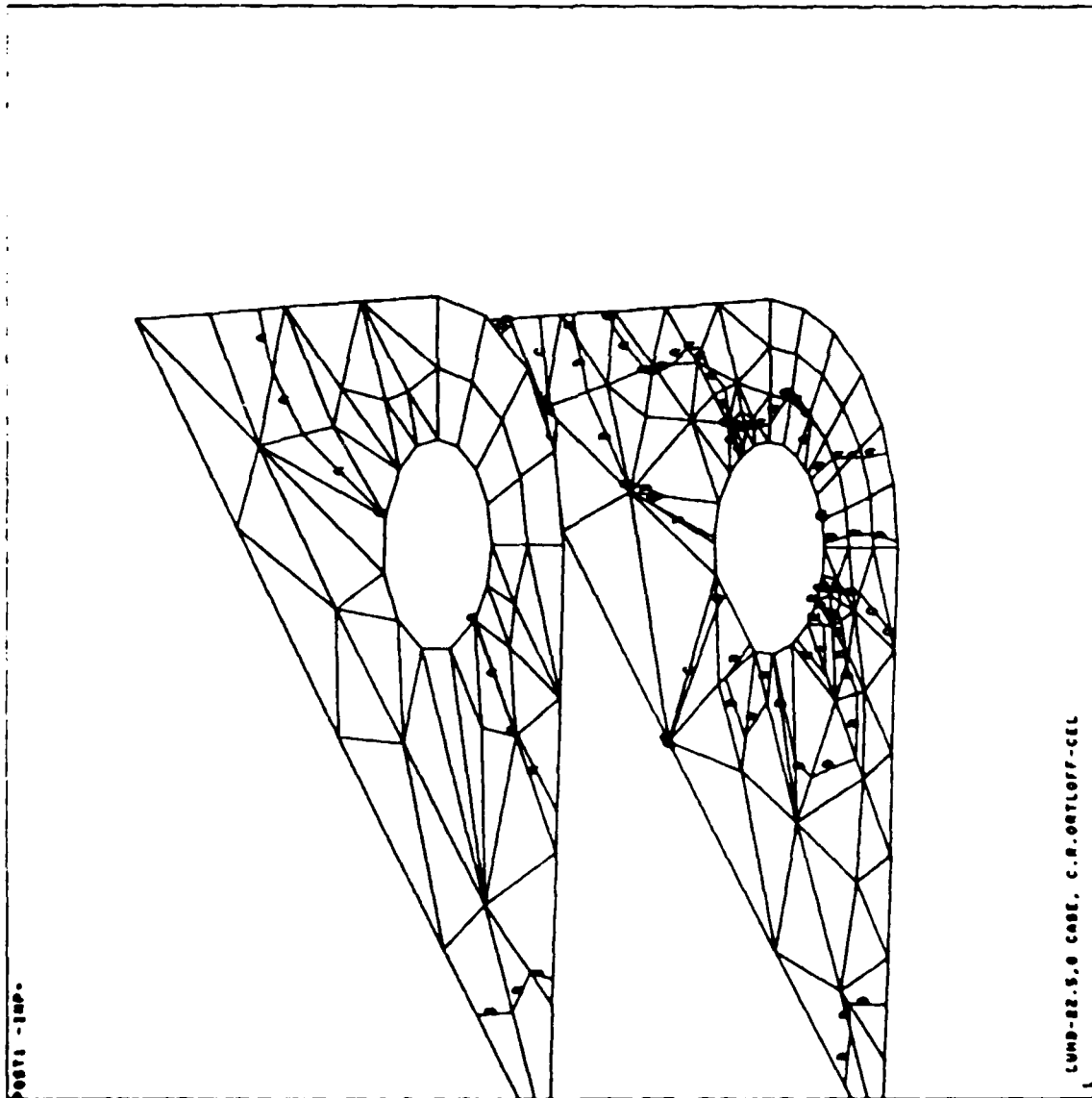
ANSYS 4.20
 JAN 6 1987
 10:04:18
 POST1 STRESS
 SECP-1
 ETEN-1
 TIME-.010
 SLOC
 TOP
 ZOOM
 ZN=-1
 VU=-1
 ZN=1
 S 107-24.3
 S 17-34.8
 S 17-11.7
 S 17-6.48
 V870-1.42
 H100EN
 RE-70200
 RE-1572
 A-13672
 B-25070
 C-20200
 D-50506
 E-62004



GROVS 4.88
 JAN 6 1967
 10:24:24
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.010
 SLOC
 TOP
 NV=-1
 VU=-1
 ZU=1
 DIST=45.8
 XF=22.8
 YF=3.55
 ZF=3.7
 HIDDEN
 MX=75100
 MY=1376
 M=13072
 D=25570
 C=30208
 S=50566
 E=62864



ANSYS 4.20
 JOB 8 1987
 10/21/87
 POST1, STRESS
 STEP=1
 ITEM=1
 TIME=.010
 SEQ
 TOP
 ZOOM
 XU=1
 YU=1
 ZU=-1
 0.187-0.57
 0.41.8
 0.48.8
 0.6.88
 0.70-1.82
 0.70-1.08
 MIDDLE
 0.18731
 0.005
 0.2888
 0.6730
 0.9809
 0.1879
 0.18948

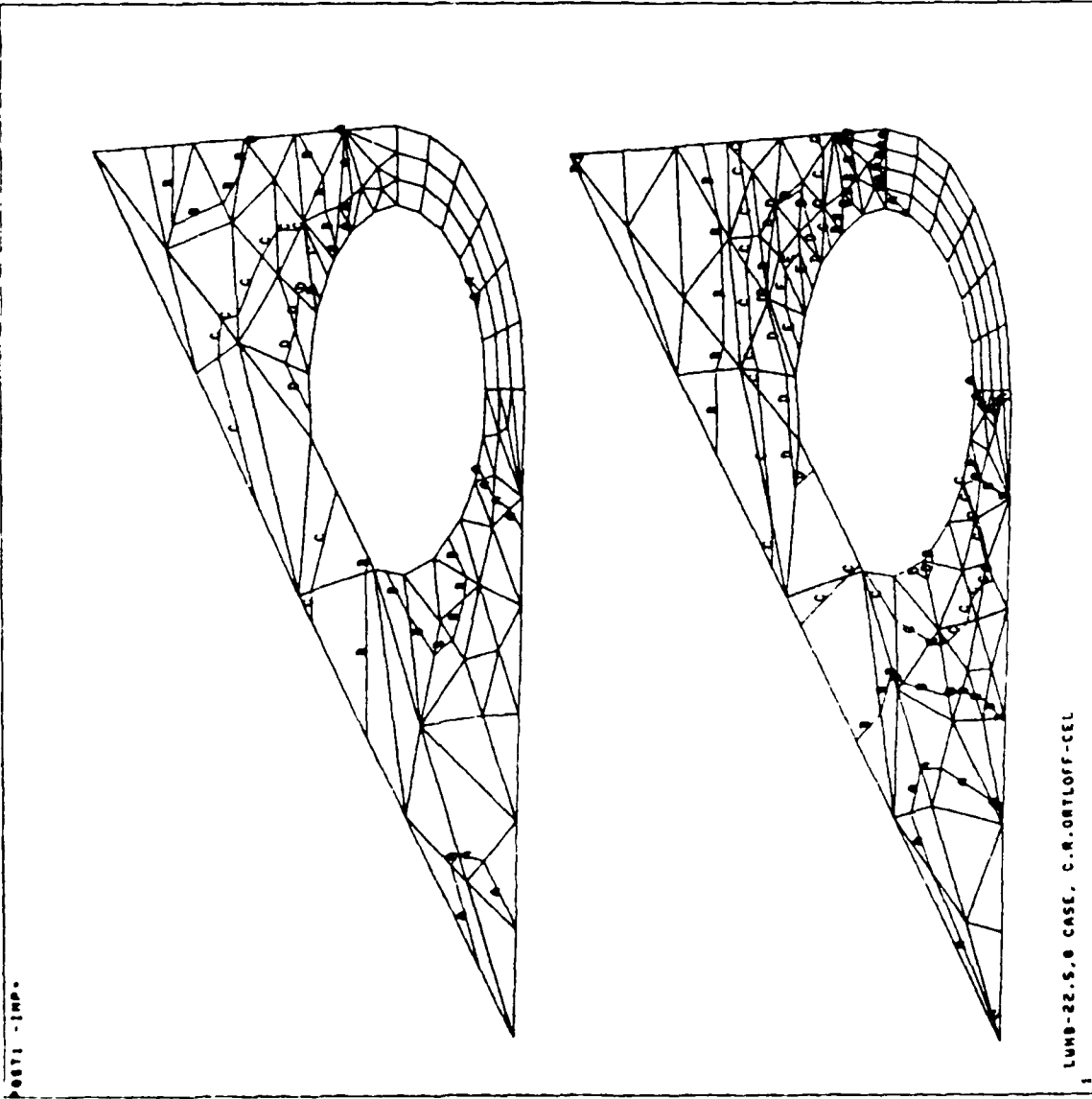


TOP TABS

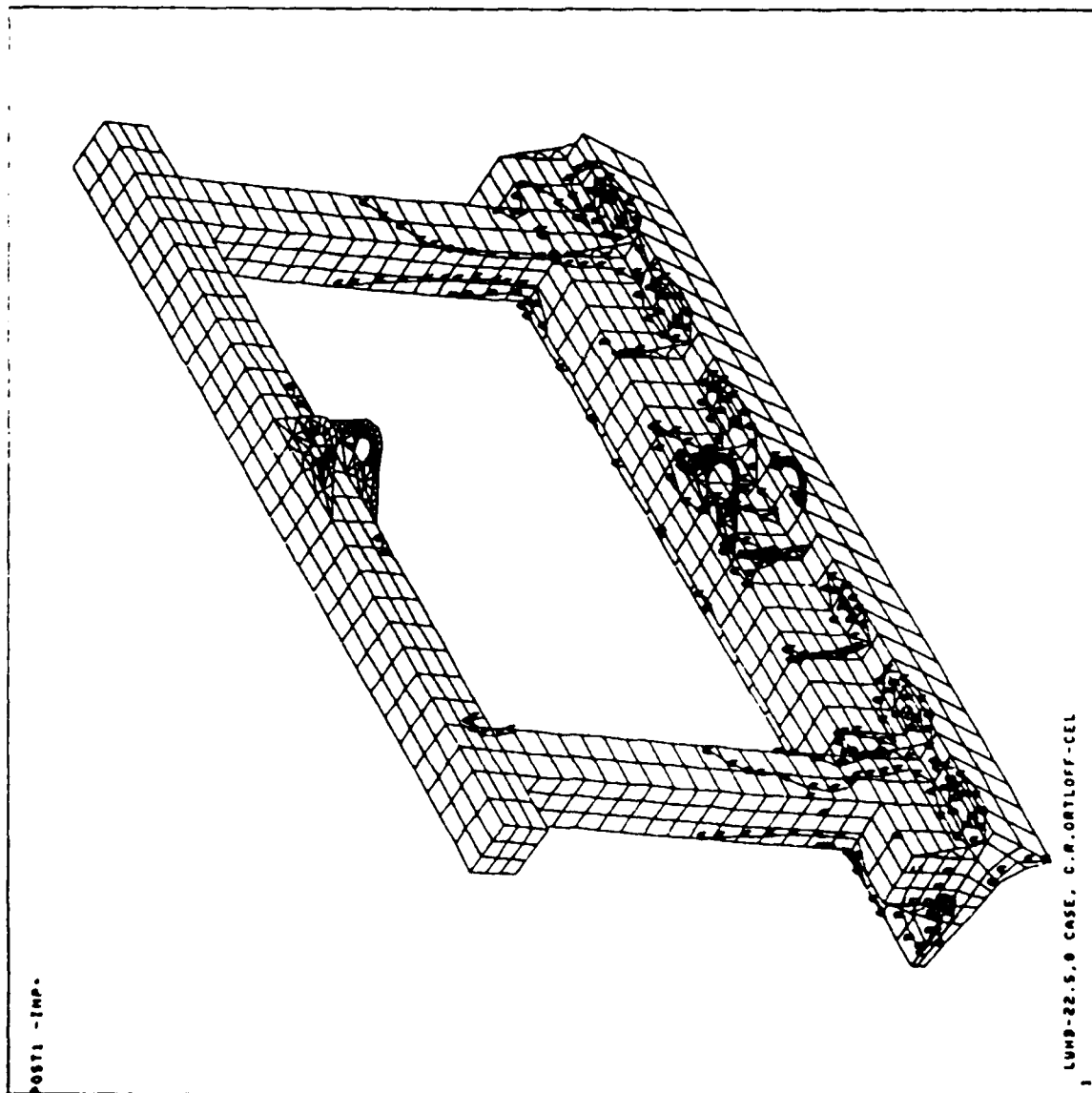
ANSYS 4.20
 JAN 6 1987
 10:10:32
 POST1 SYBSS
 STEP=1
 ITER=1
 TIME=.010
 SICE
 TOP
 ZOOM
 XU=1
 YU=1
 ZU=-1
 Z DIST=9.00
 Z XF=61.7
 Z YF=13.4
 Z ZF=-9.50
 XRT0=1.22
 HIDDEN
 MM=49712
 MM=1515
 A=8780
 B=16974
 C=25150
 D=33344
 E=41520

BOTTOM TABS

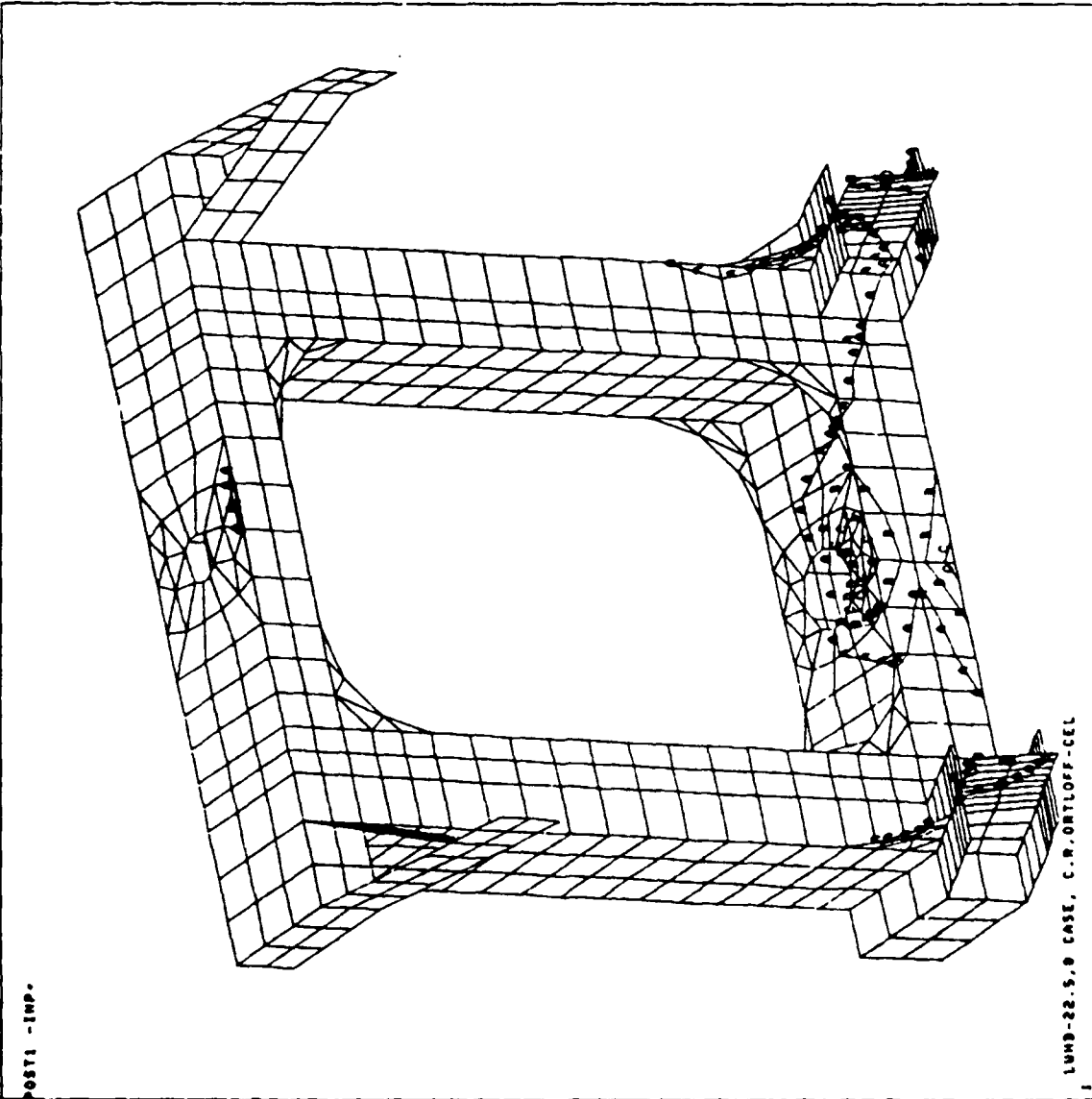
451



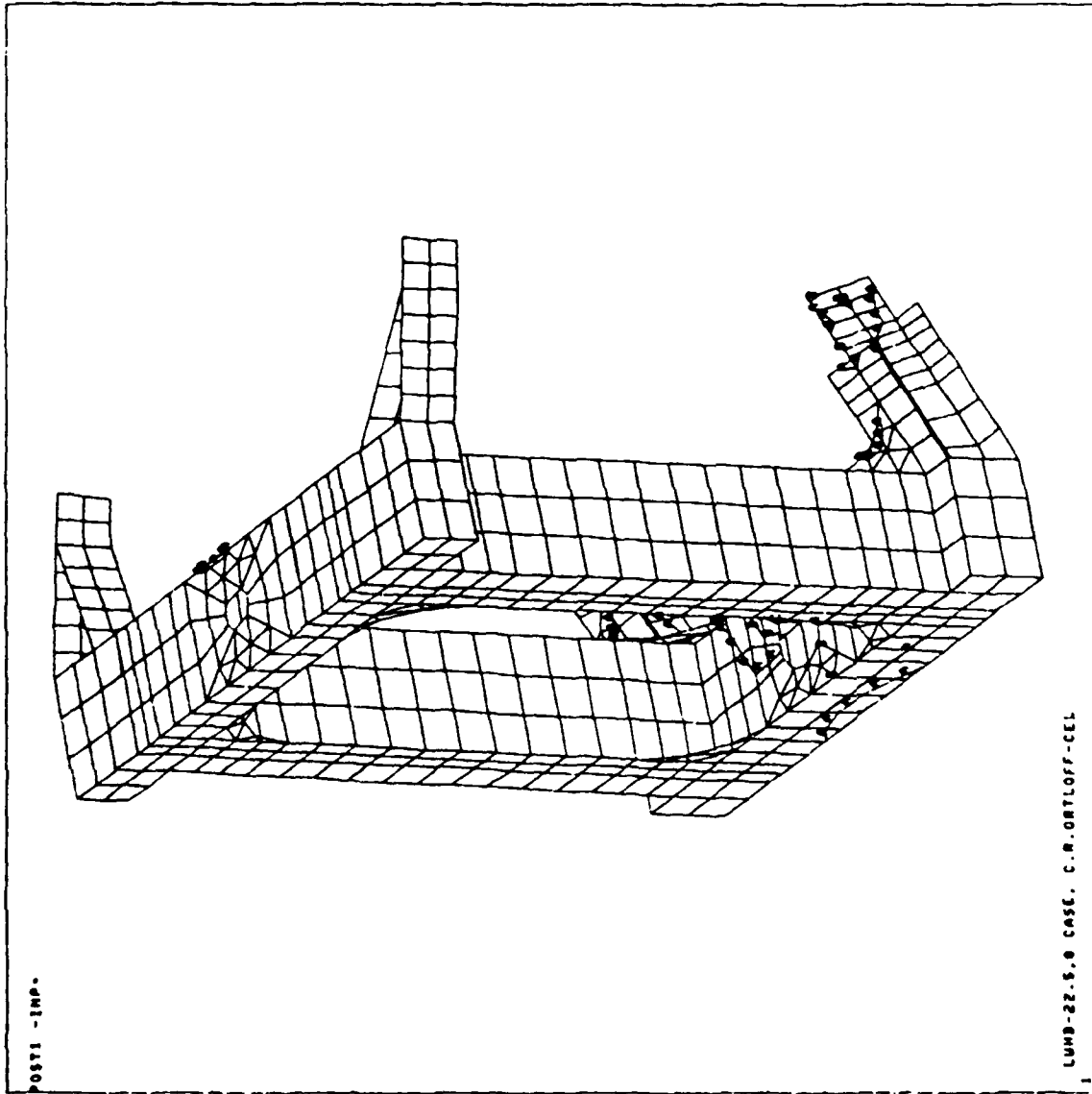
ANSYS 4.20
 JAN 6 1987
 10100130
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.010
 SLOC
 TOP
 NU=1
 VU=1
 ZU=-1
 B157-58-2
 XF-54-2
 YF-26-4
 ZF-4-85
 HIDDEN
 NA-127580
 MH-605
 A-21767
 B-42030
 C-84003
 D-85266
 E-106418



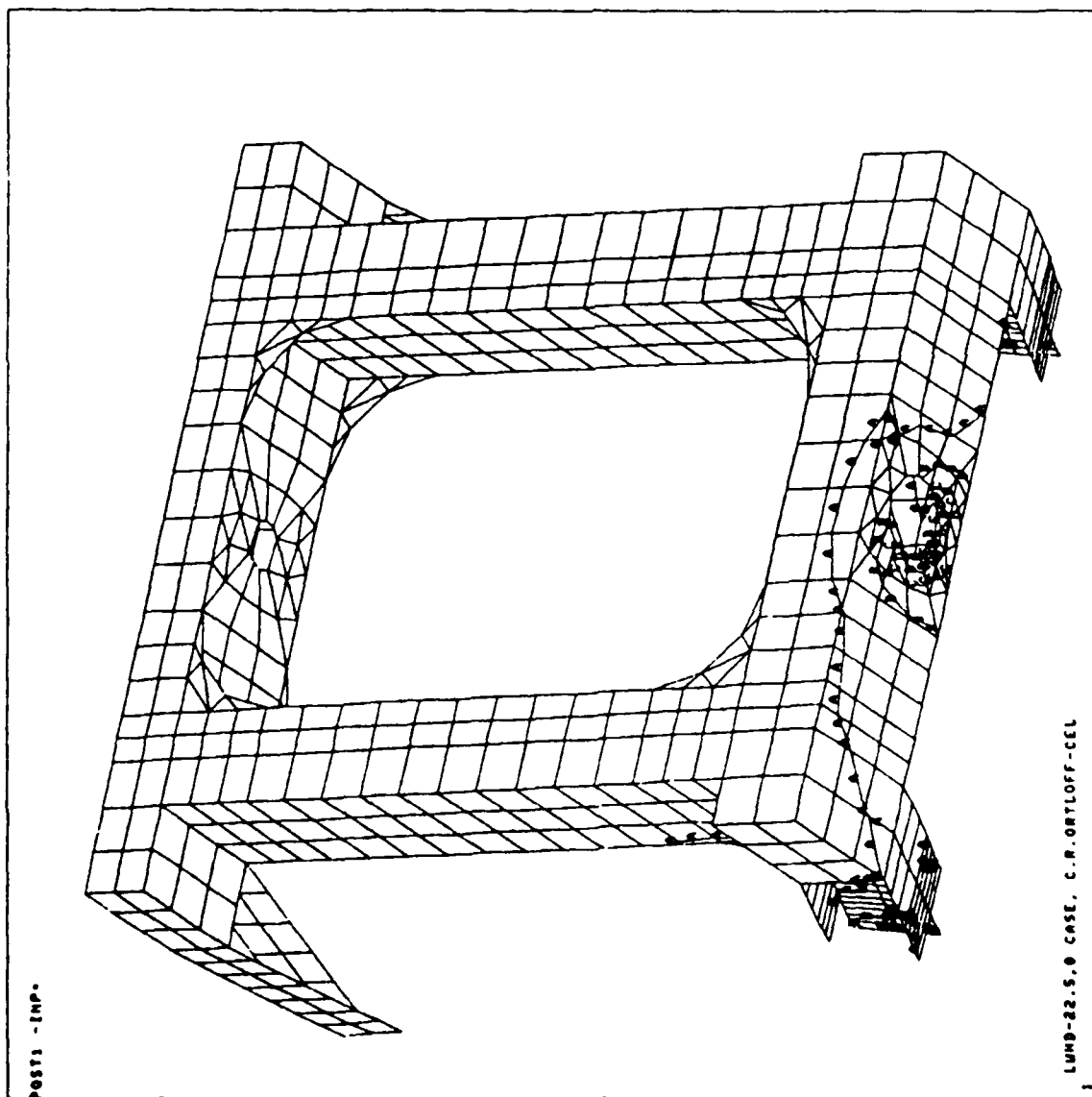
ANSYS 4.23
 JAN 6 1987
 10104137
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.010
 SLOC
 TOP
 XU=1
 VU=1
 ZU=-1
 DIST=28.7
 XF=63.9
 VF=35
 ZF=-7.93
 HIDDEN
 MX=155305
 MY=448
 A=26257
 B=58867
 C=77877
 D=103687
 E=188487



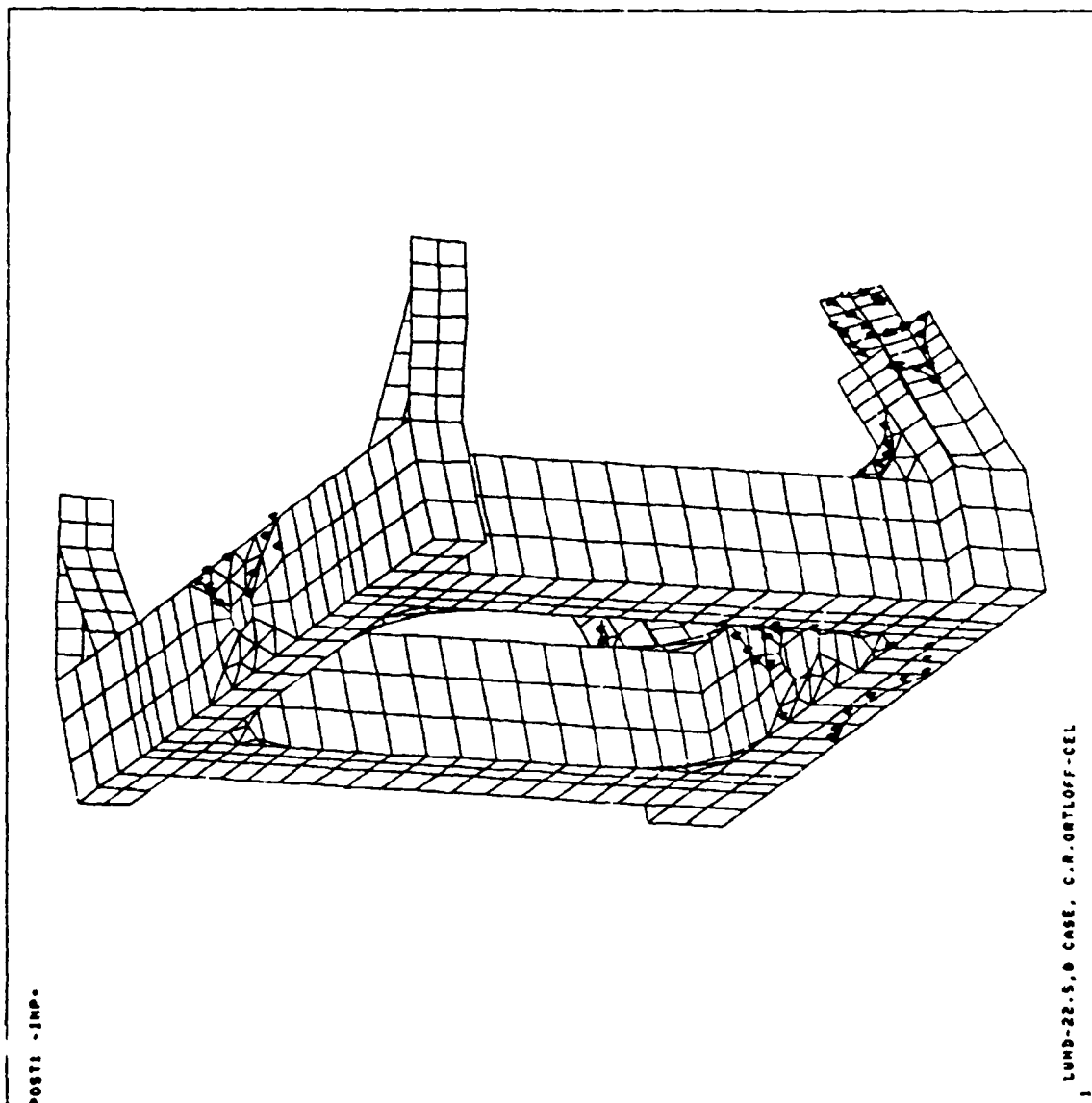
ANSYS 4.2D
 JAN 6 1987
 8:56:12
 POST1, STRESS
 STEP=1
 ITER=1
 TIME=.018
 SLICE
 TOP
 NU=1
 VU=1
 ZU=1
 DIST=34.9
 XF=57.3
 YF=23.9
 ZF=-7.62
 HIDDEN
 MX=155205
 MY=448
 MZ=26257
 D=52067
 C=17877
 B=102687
 E=129487



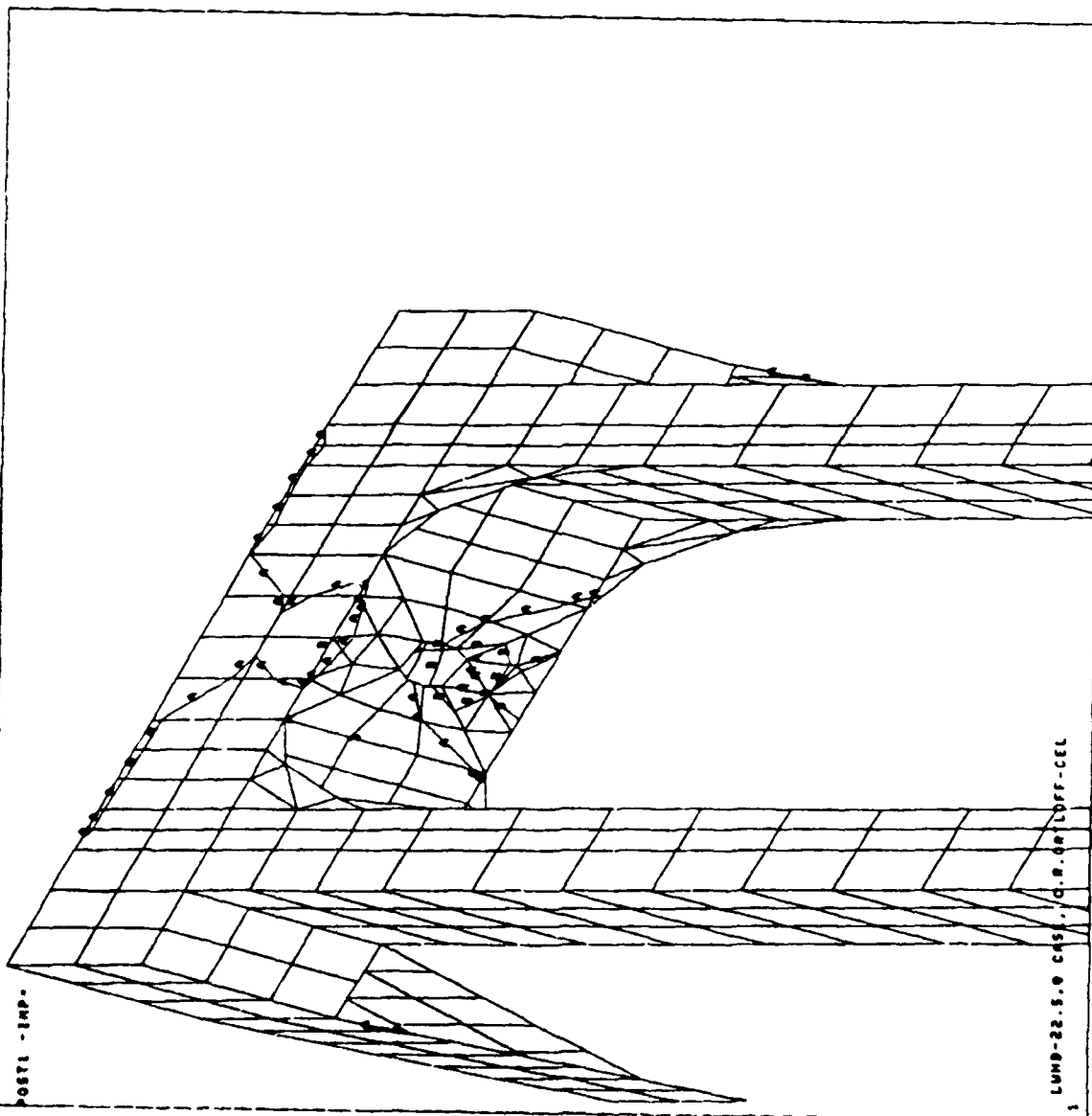
ANSYS 4.20
 JAN 6 1987
 10:01:00
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.010
 SLOC
 TOP
 NU=-1
 VU=-1
 ZU=1
 DIST=20.7
 MF=63.9
 VF=35
 ZF=-7.93
 MIDDLE
 MX=155305
 MY=448
 M=26257
 D=52067
 C=77877
 D=103687
 C=129487

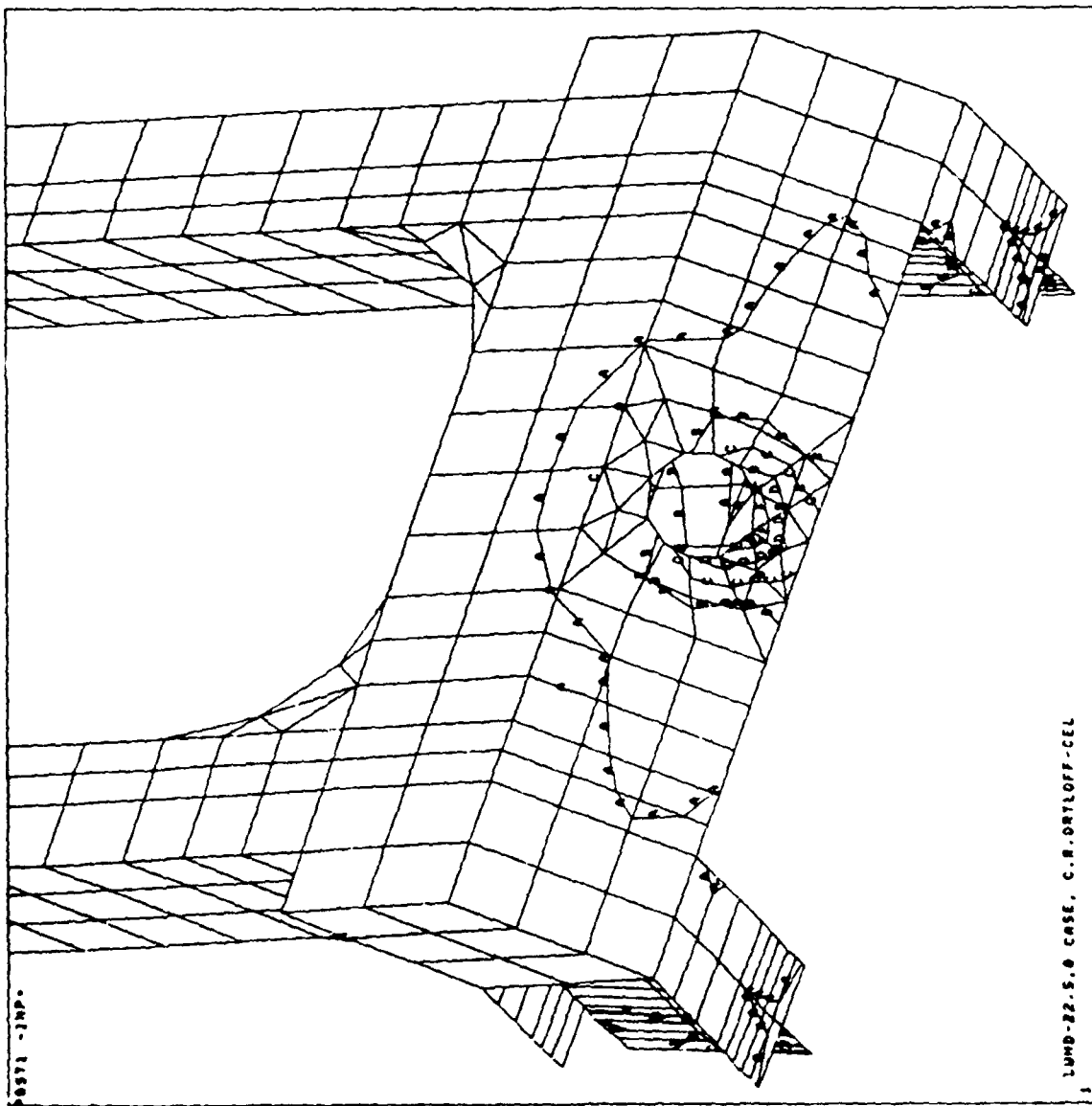


ARSYS 4.20
 JAN 6 1987
 14128117
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.081
 SICE
 TOP
 XU=1
 VU=1
 ZU=1
 DIST=34.9
 XF=57.3
 YF=32.8
 ZF=7.62
 MIDDEN
 RK=178685
 RM=756
 A=28077
 B=57389
 C=85721
 D=114043
 E=142365



ANSYS 4.20
 JAN 6 1987
 14110164
 POST1 STRSS
 STEP=1
 ITER=1
 TIME=.081
 SIZE
 TOP
 ZOOM
 ZU=-1
 ZV=-1
 ZW=1
 4 DIST=33.8
 5 XF=53.7
 6 YF=45.4
 7 ZF=2.27
 VRTD=2.63
 HIDDEN
 MX=43536
 MY=0
 MZ=0
 A=16200
 B=31649



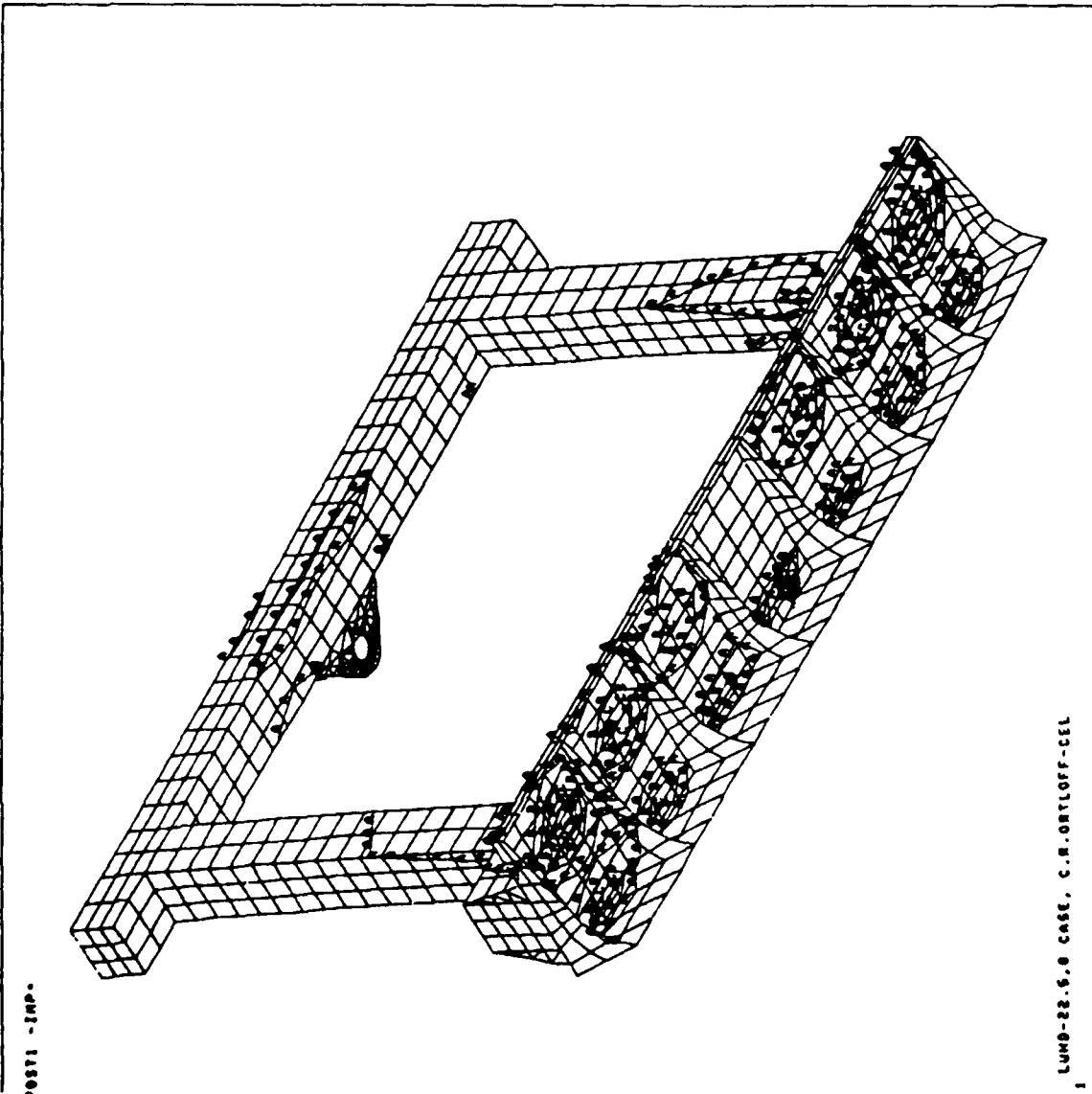


ANSYS 4.20
 JAN 6 1987
 14101.05
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.001
 SICE
 TOP
 ZOOM
 RV=-1
 VM=-1
 ZU=1
 BIST=22.0
 ZF=53.2
 VF=15
 ZF=-7.5
 VRTO=1.67
 HIDDEN
 RX=17000
 RM=0
 A=20077
 B=57300
 C=85721
 D=114043
 E=142366

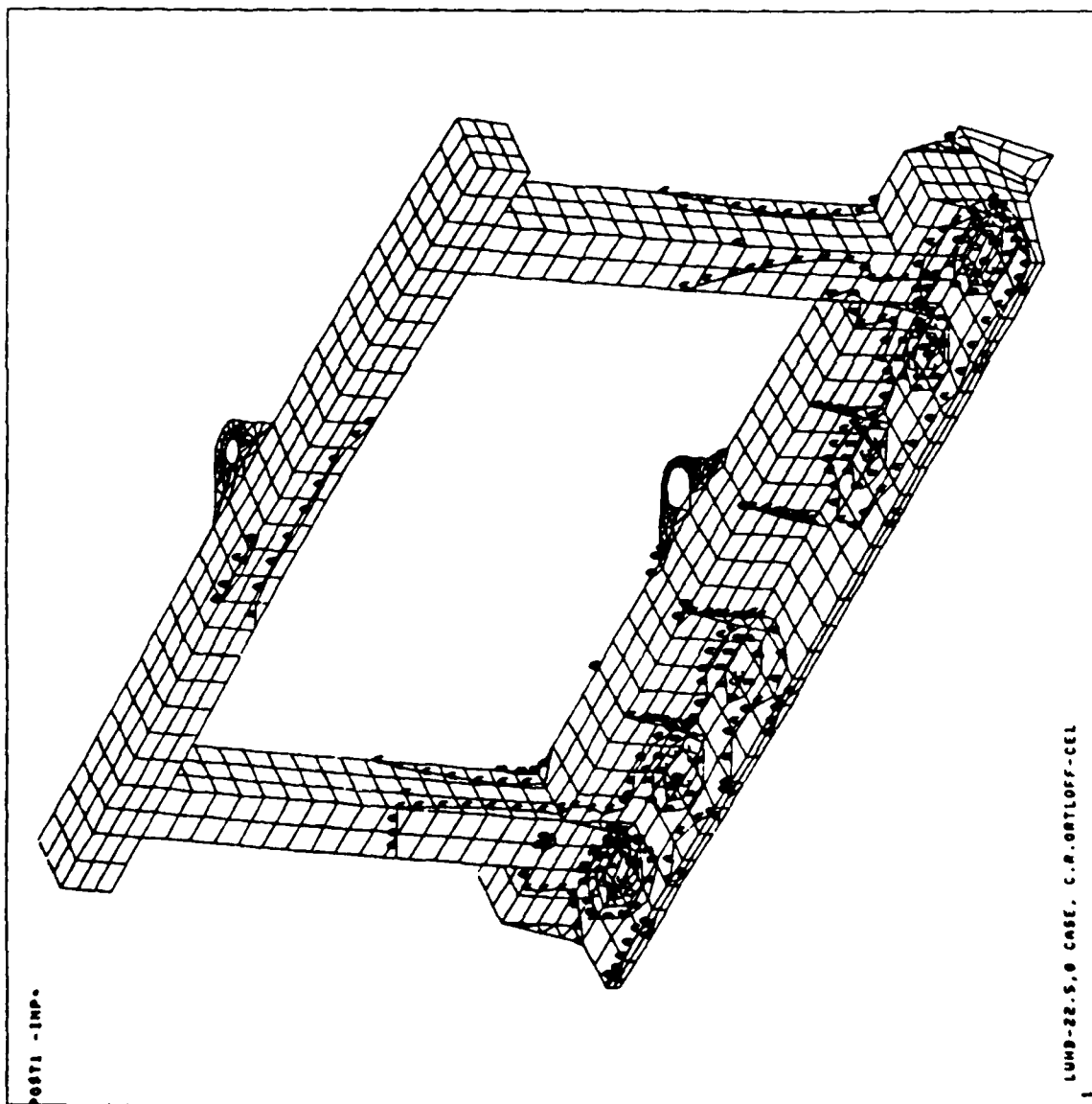
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ANSYS 4.20
JAN 6 1987
13:38:50
POST1 STRESS
STEP=1
ITER=1
TIME=.001
SIZE
TOP
KV=-1
VU=-1
ZU=-1
4 DIST=50.2
8 KF=54.8
5 VF=25.4
27=4.85
HIDDEN
RM=132034
RM=507
A=22427
B=44340
C=66271
D=88103
E=110115

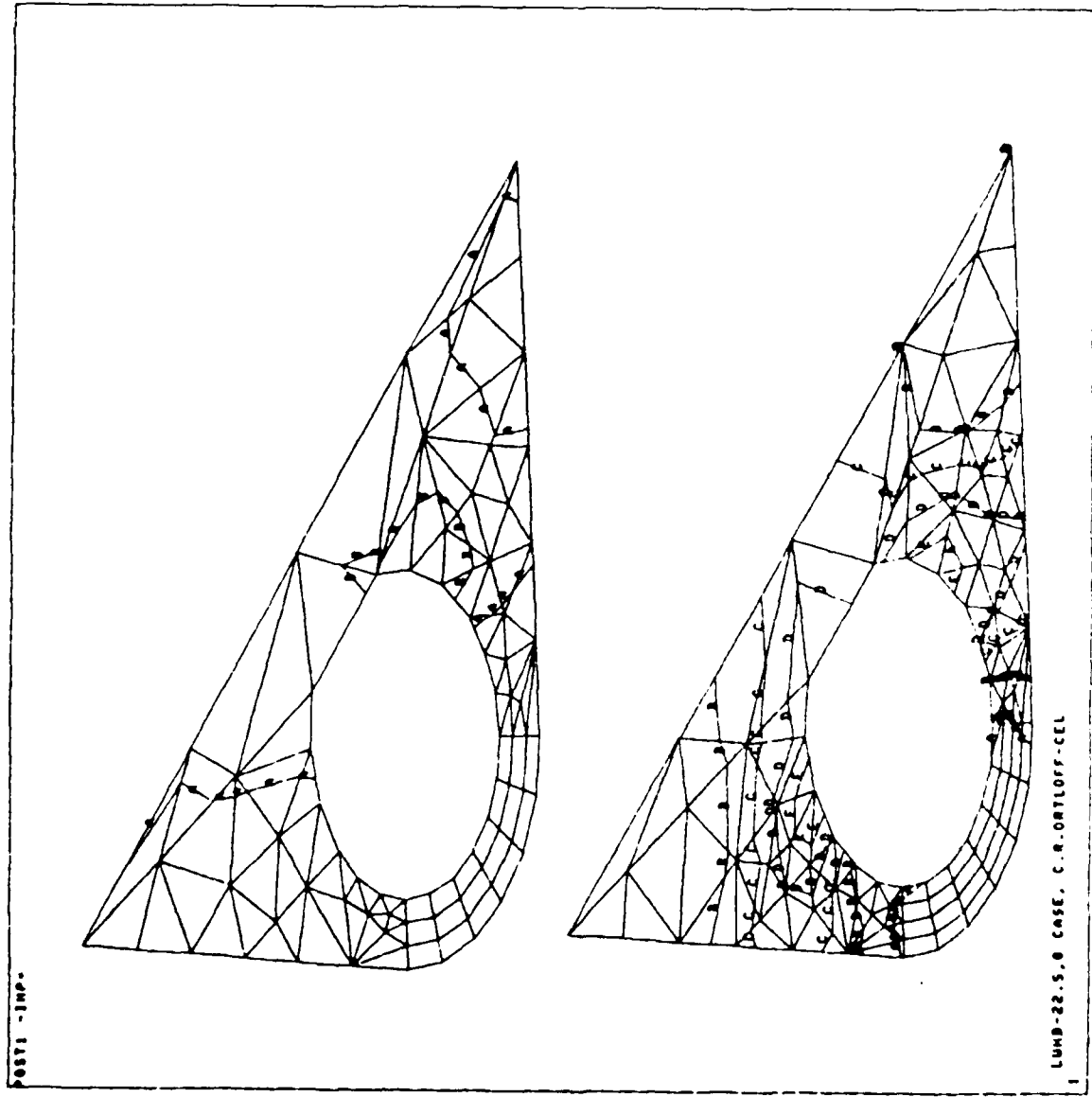
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ANSYS 4.20
 JAN 6 1987
 14119118
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.001
 SLOC
 TOP
 KU=1
 VU=1
 ZU=1
 B197=56.6
 XF=51.2
 YF=27.3
 ZF=4.17
 MIDDEN
 RN=138034
 RN=607
 A=82427
 B=44349
 C=66271
 D=88193
 E=110116



AREVS 4.20
 JAN 6 1987
 1973746
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.001
 SLOC
 TOP
 ZOOM
 KU=-1
 VU=-1
 ZU=-1
 9 DISP=7.72
 9 XF=62
 9 VF=13.3
 9 ZF=-9.37
 KNT0=1.04
 MIBEN
 MX=47211
 MY=507
 A=8881
 B=16075
 C=23858
 D=31643
 E=38427

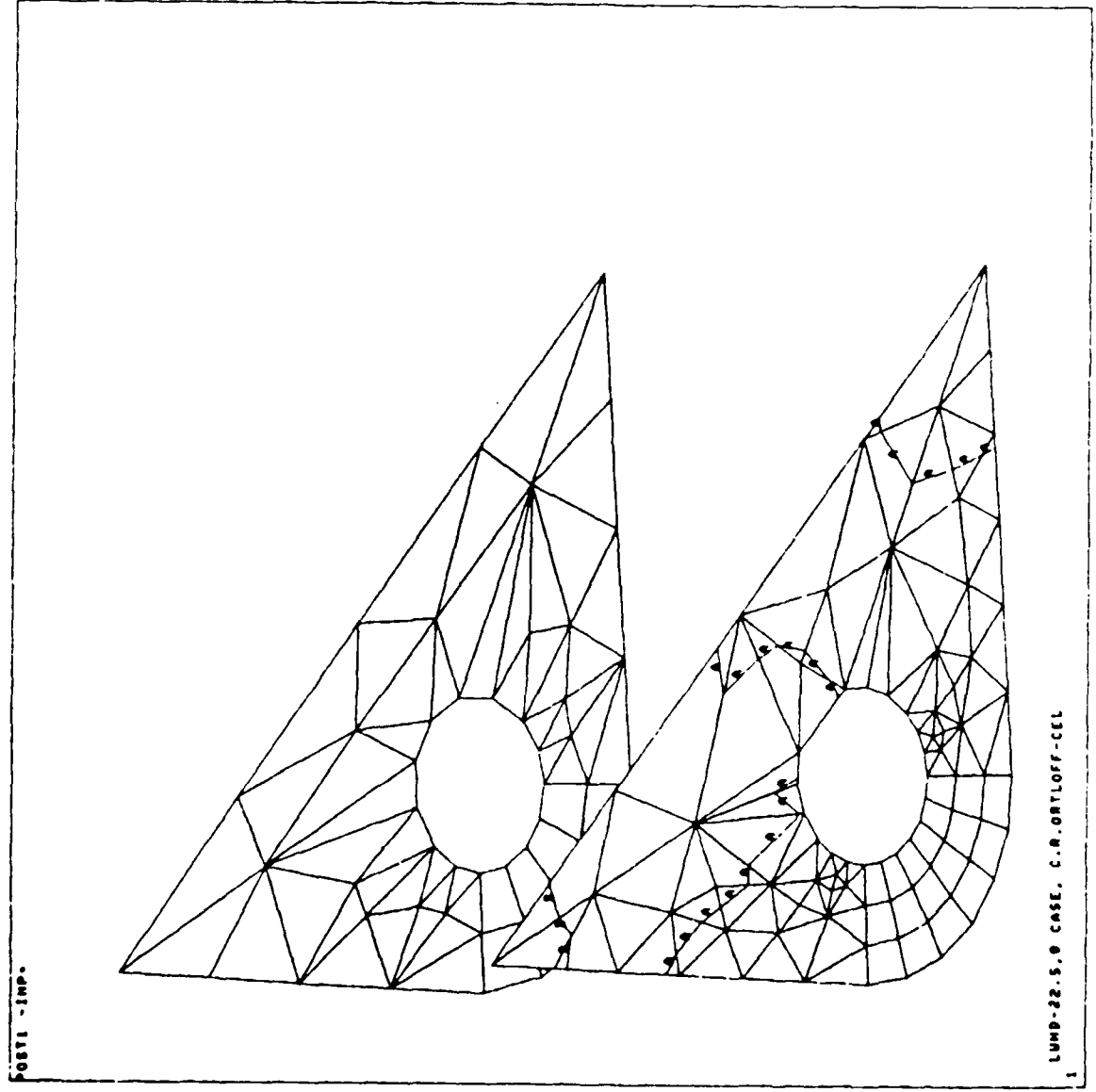


BOTTOM TABS

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ANSYS 4.20
JAN 6 1987
14726712
POST1 STRESS
STEP=1
TYPE=1
TIME=.001
SIZE
TOP
ZOOM
XU=-1
YU=-1
ZU=-1
* BIST=0.65
* KF=43.6
* VF=40.5
* ZF=0.36
XRT0=1.04
VRT0=1.28
MIDLEN
RE=18079
MM=980
A=0291
B=16075

```



TOP TABS

2010	1000.0	-1000.0	-34.000	-0.3400E-03	00.000
BASED POSTS ELEMENT STRESS LISTING BASED					
LOAD STEP		ITERATION=		SECTION=	
TIME		0.0000E-01		LOAD CASE=	
ELN	5010	5020	5030	5040	5050
1000	263.10	-100.0	604.00	-0.1633E-04	5070
2000	-234.00	-601.51	349.12	0.0790E-03	6000
3000	100.00	-341.29	-21.70	-0.0000E-01	7000
4000	184.07	6581.0	-440.00	-0.0000E-01	8000
5000	103.67	333.36	6499.0	-0.0000E-02	9000
6000	779.01	-158.48	6499.0	-0.0000E-01	0000.0
7000	1179.07	-100.00	6499.0	-0.0000E-01	1000.0
8000	1179.07	-100.00	6499.0	-0.0000E-01	2000.0
9000	2711.0	3249.5	6342.7	3.046E-1	3000.0
0000	-5540.7	3000.7	5096.1	-1.020E-2	4000.0
1000	-2304.1	2900.2	5096.1	0.0000E-03	5000.0
2000	-1704.2	182.50	607.01	0.0000E-03	6000.0
3000	-2300.0	100.00	607.01	0.0000E-03	7000.0
4000	-2300.0	100.00	607.01	0.0000E-03	8000.0
5000	-2300.0	100.00	607.01	0.0000E-03	9000.0
6000	-2300.0	100.00	607.01	0.0000E-03	0000.0
7000	-2300.0	100.00	607.01	0.0000E-03	1000.0
8000	-2300.0	100.00	607.01	0.0000E-03	2000.0
9000	-2300.0	100.00	607.01	0.0000E-03	3000.0
0000	-2300.0	100.00	607.01	0.0000E-03	4000.0
1000	-2300.0	100.00	607.01	0.0000E-03	5000.0
2000	-2300.0	100.00	607.01	0.0000E-03	6000.0
3000	-2300.0	100.00	607.01	0.0000E-03	7000.0
4000	-2300.0	100.00	607.01	0.0000E-03	8000.0
5000	-2300.0	100.00	607.01	0.0000E-03	9000.0
6000	-2300.0	100.00	607.01	0.0000E-03	0000.0
7000	-2300.0	100.00	607.01	0.0000E-03	1000.0
8000	-2300.0	100.00	607.01	0.0000E-03	2000.0
9000	-2300.0	100.00	607.01	0.0000E-03	3000.0
0000	-2300.0	100.00	607.01	0.0000E-03	4000.0
1000	-2300.0	100.00	607.01	0.0000E-03	5000.0
2000	-2300.0	100.00	607.01	0.0000E-03	6000.0
3000	-2300.0	100.00	607.01	0.0000E-03	7000.0
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5000	-2300.0	100.00	607.01	0.0000E-03	9000.0
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7000	-2300.0	100.00	607.01	0.0000E-03	1000.0
8000	-2300.0	100.00	607.01	0.0000E-03	2000.0
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3000	-2300.0	100.00	607.01	0.0000E-03	7000.0
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9000	-2300.0	100.00	607.01	0.0000E-03	3000.0
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4000	-2300.0	100.00	607.01	0.0000E-03	8000.0
5000	-2300.0	100.00	607.01	0.0000E-03	9000.0
6000	-2300.0	100.00	607.01	0.0000E-03	0000.0
7000	-2300.0	100.00	607.01	0.0000E-03	1000.0
8000	-2300.0	100.00	607.01	0.0000E-03	2000.0
9000	-2300.0	100.00	607.01	0.0000E-03	3000.0

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LIGHTWEIGHT TOWED HOWITZER DEMONSTRATOR PHASE 1 AND
PARTIAL PHASE 2 VOLUM (U) FMC CORP MINNEAPOLIS MINN
NORTHERN ORDNANCE DIV R RATHE ET AL APR 87

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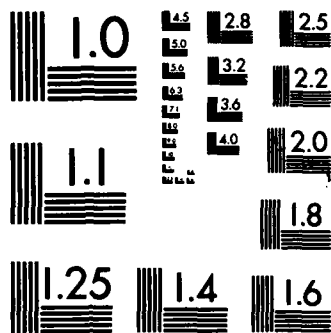
FMC-E-3041-VOL-D3-PT-1

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MICROCOPY RESOLUTION TEST CHART
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