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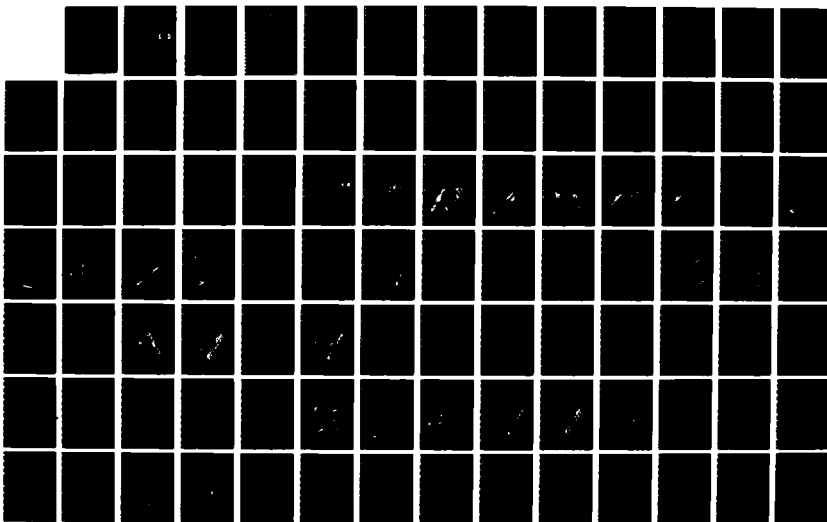
LIGHTWEIGHT TOWED HOWITZER DEMONSTRATOR PHASE 1 AND
PARTIAL PHASE 2 VOLUM (U) FMC CORP MINNEAPOLIS MINN
NORTHERN ORDNANCE DIV R RATHE ET AL APR 87
FMC-E-3041-VOL-D3-PT-2 DAAA21-86-C-0047

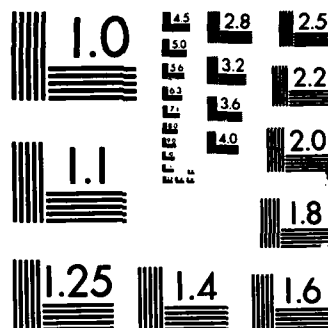
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Lightweight Towed Howitzer Demonstrator

Final Report

Volume D3 - Part II

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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1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A183994	3. RECIPIENT'S CATALOG NUMBER
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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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CEL MEMO: JANUARY 26, 1987

Interoffice

To R. Rathe* Date January 26, 1987

From C. R. Ortloff cc L. Libhardt
J. Ries
L. Langerud
B. Anderson
B. Zierwick
E. Thuse
R. Kazares
A. Amberg

Subject STRESS & STABILITY RESULTS FOR THE 22.5° GIMBAL
ROTATION, 72° GUN ELEVATION SYSTEM MODEL LWHD
UNDER PROOF IMPULSE LOADS
*(figures 497-601 attached)

This stress report summarizes results of the system FE model load case (22.5°-72°) under the assumption of "hard soil" spade emplacement, free trail ends, and proof dynamic loads. Previously, reports have been forwarded for the 0°-0° case (CRO to L. Libhardt, 17 Dec 86), the 0°-72° case (CRO to L. Libhardt, 29 Dec 86) and the 22.5°-0° case (CRO to L. Libhardt, 8 Jan 87). This report completes the cycle of specified load cases for the system model with free trail ends and hard soil spade emplacement for dynamic impulse loading. To date, 601 computer hard copy figures have been delivered on system stress results.

SUMMARY

The present load case (22.5°-72°) appears to be the limiting case of the 4 cases thus far computed. In addition to previously observed gimbal failure zones (viz., the lower cradle attachment arms and shaft attachment zones on both upper and lower box beams), this load case indicates a plastic hinge failure of the gimbal upper arms also. This load case also confirms that plastic deformation occurs on the horizontal spade plate attached to the lower box beam of the platform. The details of stress pass results at times equal to 0.084, 0.129, 0.237 and 0.304 sec. are summarized below as are stability results. Stresses shown in the accompanying plots are von Mises equivalent stress values.

DETAILS OF STRESS PASS RUNS

Shown in figures 498 to 515 are dynamic displacement-time histories for Master Degree of Freedom nodes (MDOF) located on the platform. The locations of these nodes has been shown in earlier memos of this sequence. Peak displacement times are selected from these plots for use in stress pass calculations (Figures 521 to 595). A damping value of 0.2% is incorporated into the runs; in that actual system damping values (ALPHAD, BETAD) are unknown, the decay envelope of the oscillatory displacement behavior (exhibited in Figures 498-515) past c.310 ms may vary depending on the damping constant chosen. Use of the 0.2% damping value is conservative past c.310ms in that

system stability is not dependent on an energy dissipation mechanism (which may not exist). Below c.310 ms, where loads are applied, damping plays a minor role in stress and deflection levels; note that the stress pass times are all below c.310 ms and that this time range contains all the displacement peaks.

Reference to Figures 519 and 520 shows the MDOF node locations for Figures 516-518. Node 3009 is located on the cradle forward manifold. Figure 516 indicates about a 5 inch lateral (UX) deflection peak at c.750 ms as well as a 4 inch vertical excursion at about the same time. In that the torque vector can be decomposed into components in the (global) x,y,z directions (Figure 520), then moments exist (acting on the cradle arm) to twist the cradle about the x,y, and z axes simultaneously. The beam model used for the cradle is constructed to roughly match the bending and rotational stiffness of the 10-86 cradle design so that UX, UY deflections (Figures 516, 517) roughly model the dynamic deflection effect of both cradle and cable deflection. It appears that for the 22.5°, 72° load case then that the cradle experiences reasonably large UX and UY deflections. Depending on cradle and cable damping values, it is unclear if the duration of the cradle oscillations will interfere with reloading/reaiming procedures under "rapid fire" conditions. Later cradle designs with higher stiffness components will undoubtedly reduce these deflections and vibration levels.

Figures 521-539 summarize results for the stress pass at 0.304 sec. The conclusions are summarized below: ←

- o The upper gimbal arms (Figures 527, 528, 529, 532 and 537) contain stresses far in excess of the 80 ksi yield stress. A plastic hinge appears to develop and cause arm failure. The attachment zone of upper arms to gimbal (Figure 530) also shows zones of plastic failure.
- o Upper and lower platform tabs (Figures 533-534) appear to be adequately designed.
- o The lower gimbal arms contain tip zones (Figure 535) at the 80 ksi yield stress; although the actual gimbal mount zone has not been modeled exactly, nevertheless high stresses are encountered close to the mount points.

Figures 540-558 summarize stress results for the 0.084 sec. stress pass. The conclusions are summarized below.

- o The gimbal lower box beam shaft mount openings (upper and lower) exhibit stresses in excess of yield stress (Figures 540, 541, 542). The upper gimbal box beam shaft openings are in the elastic range.

- o The platform (Figures 545-548) horizontal spade plate has zones between vertical reinforcing spacers that are in the plastic region. The moment (about the x-axis) and compressive force put on the lower platform box beam is substantial (considering that the spade horizontal plate is constrained by ground contact). This leads to stress concentration areas in the vicinity of the spade horizontal plate-lower box beam welded connection seams. As recommended in earlier memos, a possible fix to this recurring problem is to extend the triangular reinforcing tabs (front and rear) to the edge of the horizontal spade plate and/or use of several more of the extended reinforcing tabs in the open bays between the current tabs.
- o Upper (Figure 549) and lower (Figure 550) platform to gimbal shaft mounting tabs appear to be adequately designed as stresses do not exceed 30 ksi.
- o The lower gimbal arms (Figure 552) appear to have localized failure zones in the region of the cradle attachment points (here taken to be the central nodes denoted C_1 , C_2). Although the actual connecting bearing region has not been modeled, nevertheless stresses are over 80 ksi in regions away from the C_1 , C_2 nodes. Based on St. Venant's principle, the vertical plate part of the I-Beam lower arms will need to be thickened to reduce stress levels near the C_1 , C_2 nodes.
- o The gimbal lower arm reinforcing plates (Figure 554) contain stresses in the plastic regime and need to be thickened to reduce stress to acceptable levels.
- o The platform spade reinforcing spacers (Figures 555-557) appear adequate to absorb the side thrust loads as stresses shown are in the elastic range.

Figures 560-573 summarize stress results for the 0.237 sec. stress pass. The conclusions are summarized below.

- o Again, this stress pass case indicates stresses over yield on the top gimbal arms (Figure 561).
- o Stress on the lower gimbal box beam shaft opening (Figure 565) is at the yield value. This type of local failure has been observed for all the load cases and may be remedied by local reinforcement of the gimbal at all the box beam openings.
- o Stresses on the platform horizontal spade plate exceed yield stress (Figure 567-569) in the plate bays between triangular reinforcing plates by as much as 40 ksi. The overstressed zones occur both ahead (Figure 569) and behind (Figure 567) the lower platform box beam.

Figures 575-595 summarize stress results for the 0.129 sec. stress pass. The conclusions are summarized below.

- o Local yielding again occurs on the platform vertical spade plate (Figures 575-577). Stresses in the outer panel bays exceed yield by about 4 ksi.
- o Stresses in the lower gimbal box beam shaft opening (or both upper and lower surfaces) exceed yield stress (Figures 578-580) by about 6 ksi.
- o Stresses in the lower gimbal arms (Figure 583) have localized stress zones over yield stress in the web area near the gimbal-cradle attachment zone. This type of failure has been previously observed for all other stress pass times.

The values given below summarize maximum stress results for the upper and lower shafts (connecting the gimbal to the platform). These results proceed from the printed output associated with each stress pass case together with interpretative descriptive material from the ANSYS 4.2B, V. I Manual, pp. 4.4.1-4.2.5. Reference to Figure 596 (lower shaft nodes), Figure 597 (lower shaft elements), Figure 598 (upper shaft nodes) and Figure 599 (upper shaft elements) is used with printout results to obtain the maximum shaft stress values.

- o The maximum upper shaft stress (for all times considered) is 37 ksi; the maximum lower shaft stress is 32.4 ksi. These stresses are the maximum of the outer fiber stresses.
- o The maximum force in the connecting rod (element 3262) between gimbal and platform is 13,000 lbf. This rod is necessary to prevent gimbal rotation within the platform frame caused by the Y components of torque on the gimbal. Recall that the STIF4 shafts have zero torsional stiffness so that the connecting rod is necessary for gimbal stability.
- o A survey of forces on connecting nodes from trails to platform (4 connecting nodes per trail) indicates a maximum force of about 4000 lbf. The forces are obtained by observing the stress in the beam elements of the trails joining connecting nodes on the platform and multiplying by the beam area.

SUMMARY OF THE FOUR LOAD CASES

Since all four load cases have now been computed for the system model, some general observations can be made with respect to gimbal and platform stress levels. The 22.5°-72° case contains all of the previously noted structural failure mechanisms; however, the details of prior load cases should be reviewed for stress levels.

- The upper gimbal arms appear to have stresses in the plastic regime in the time period $0 < t < 400$ ms (Figure 529, 537, 561) and most likely form a plastic hinge. No allowance has been made for the apparent yield stress increase under large load rates; i.e., the 80 ksi yield stress value is used for dynamic load conditions. Note that stresses can be as high as $2.65 \times$ yield stress for the 0.304 sec. stress pass case.
- The lower gimbal arms likewise possess regions near the cradle mount zone that are over yield stress (Figures 540, 543, 552, 578). For many cases, stress levels are close to or exceed yield stress in the I-Beam web area as well as the triangular reinforcement plates connecting the arms to the gimbal box beams. Details of the maximum stress levels are obtainable from review of the totality of $0^\circ-0^\circ$, $0^\circ-72^\circ$, $22.5^\circ-0^\circ$ and $22.5^\circ-72^\circ$ load cases; this failure occurs for most of these load cases.
- The horizontal plate forming the top part of the spade is highly stressed. Since this plate lies on the ground and is constrained to move parallel to the ground, the lower platform box beam puts considerable moment and compressive force on the spade plate. The bay regions between vertical triangular reinforcement plates are in the plastic regime for most load cases. Several reinforcement ideas have been presented to strengthen this region.
- The upper and lower shaft opening zones on the gimbal, for both upper and lower box beams, are in the plastic regime. This result appears consistently in all the load cases and calls for local reinforcement of these gimbal areas.
- o The upper and lower gimbal-to-platform shafts appear to be adequate for all load cases. Stresses between 20-50 ksi are encountered for these shafts for all load cases.
- o The upper and lower platform to gimbal shaft mounting tabs appear to be adequate for all load cases as no stresses outside the elastic regime are encountered.
- o The vertical platform and gimbal box beams can be reduced in thickness somewhat (about 30%) to raise their dynamic stress levels. The weight saved can be put to use in providing local reinforcement plates or thickness increases of elements elsewhere in the structure.
- o Dynamic stability of the system exists for all load cases. The $22.5^\circ-72^\circ$ case appears to contain somewhat large horizontal and vertical amplitude displacements (about 4 inches) at low frequency (1-5 Hz) for the cradle. The high damping

characteristics of the composite slide tube and Kevlar cable may damp this motion out before the next firing event. More work needs to be done on the effect of material and geometric (structural) damping constants on system stability.

- o The spade appears adequate to absorb loads for the "hard soil" model for all load cases computed.



C. R. Ortloff

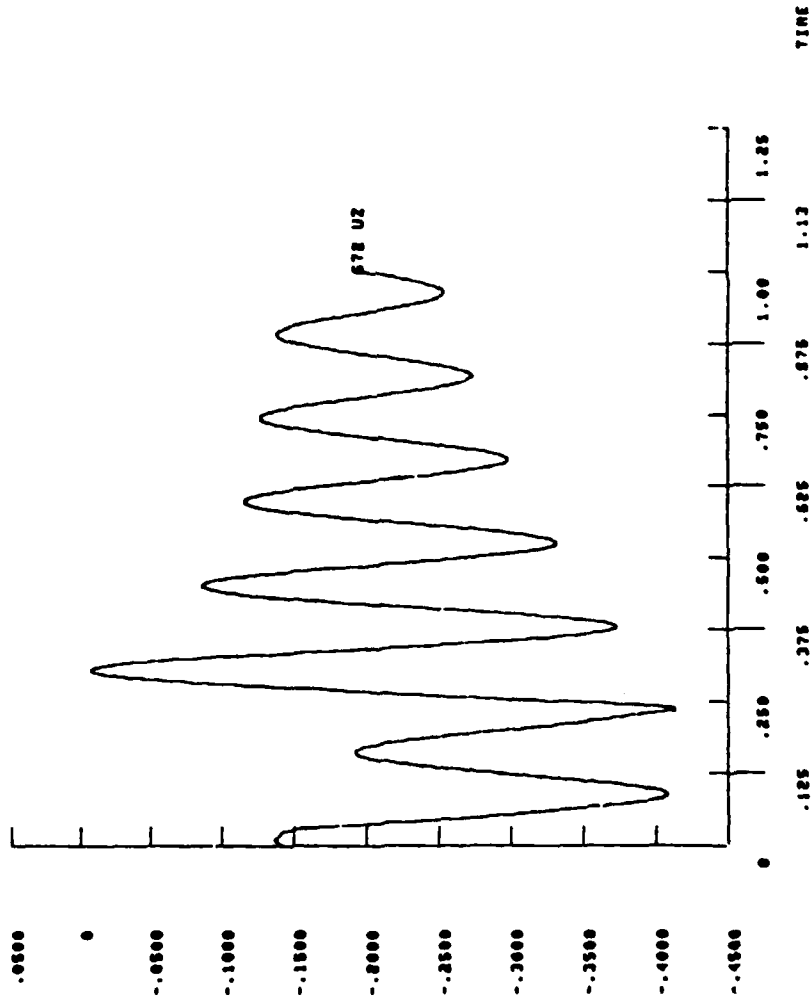
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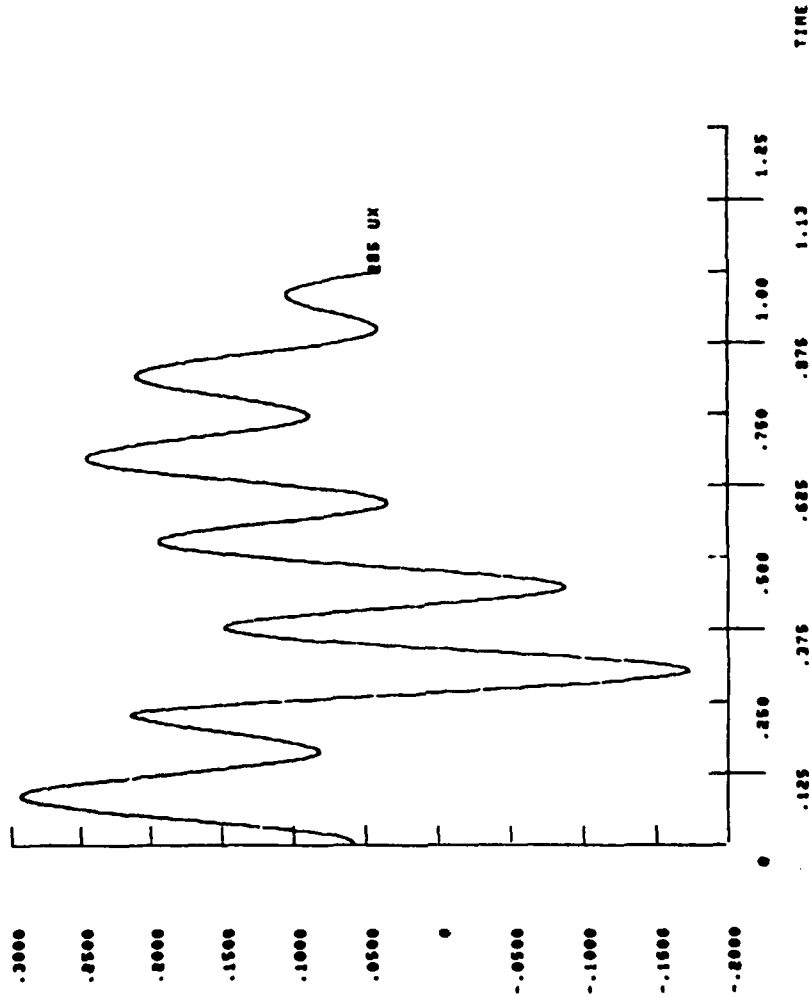
1 LYNB-22.5.72 CASE, PROOF LOADS

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1 LTMD-22.6.72 CASE PROOF LOADS

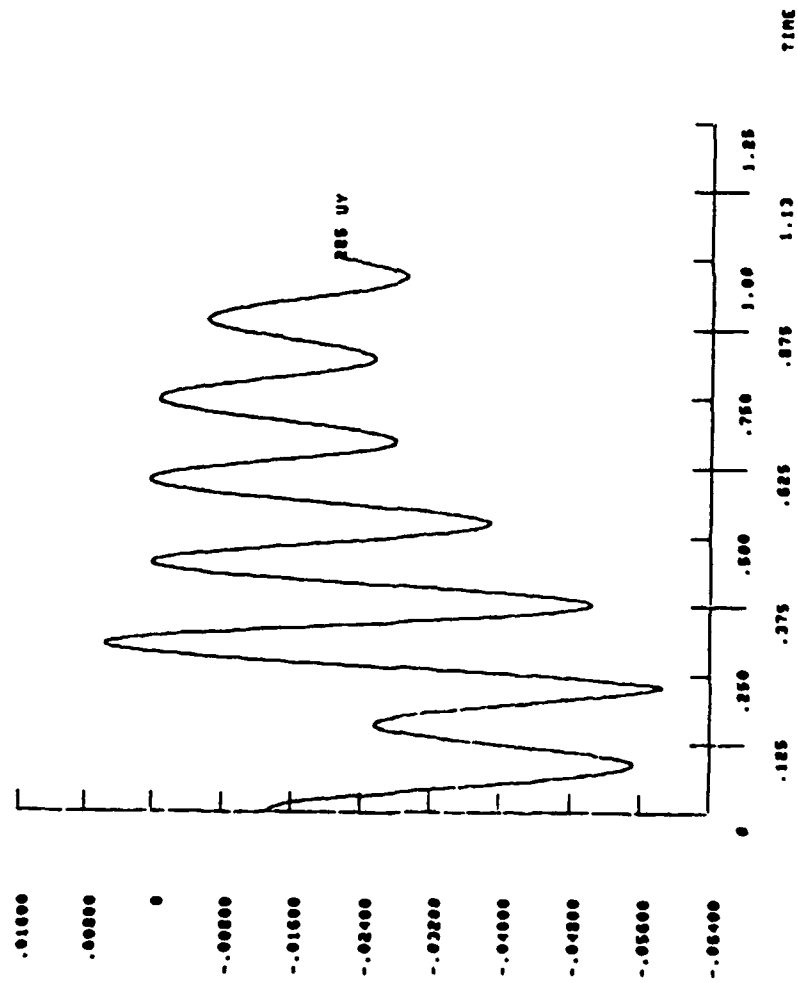
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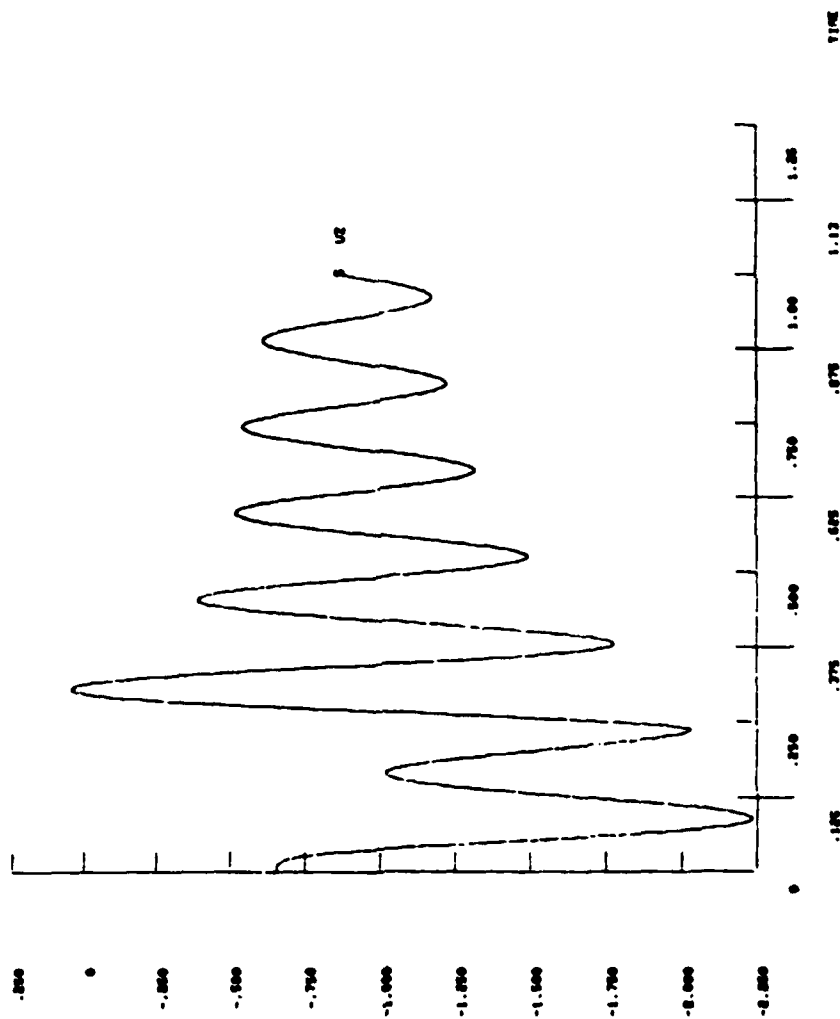
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Performance Results for 1GB Data Points

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1700-22.5, 72 CASE, POWER LEADS

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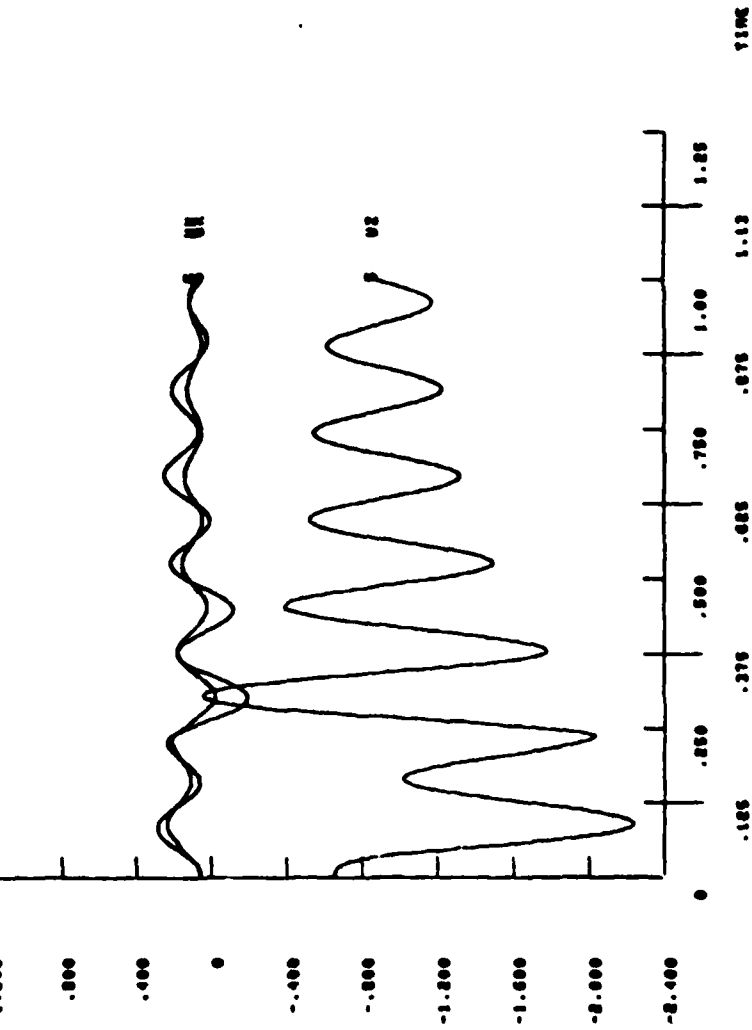
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3 STEP	VALY	VZ	0	0.1000	0.0000	0.04000E-01
4 STEP	VALY	WZ	-0.0000E-01	0.0000E-01	0.0000E-01	0.0000E-01

PLOT DEFINITION

CURVE IDENTIFIABLE	NAME
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4	WZ



LYND-28-0.72 CASE, PROOF LOADS

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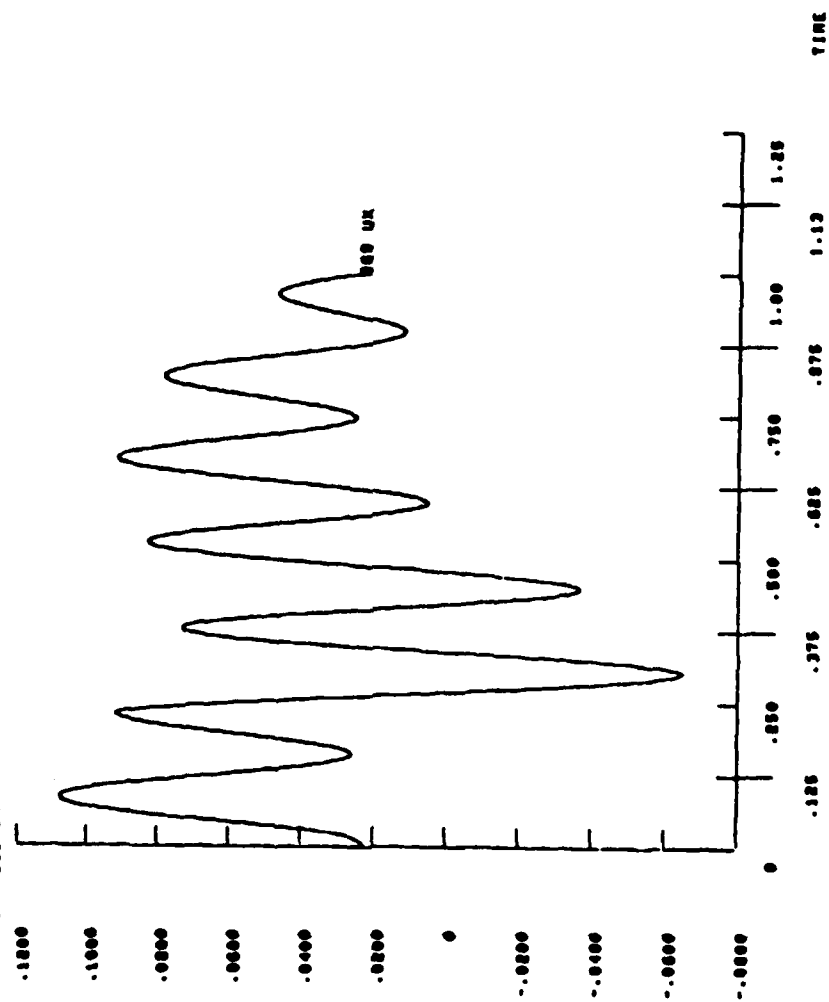
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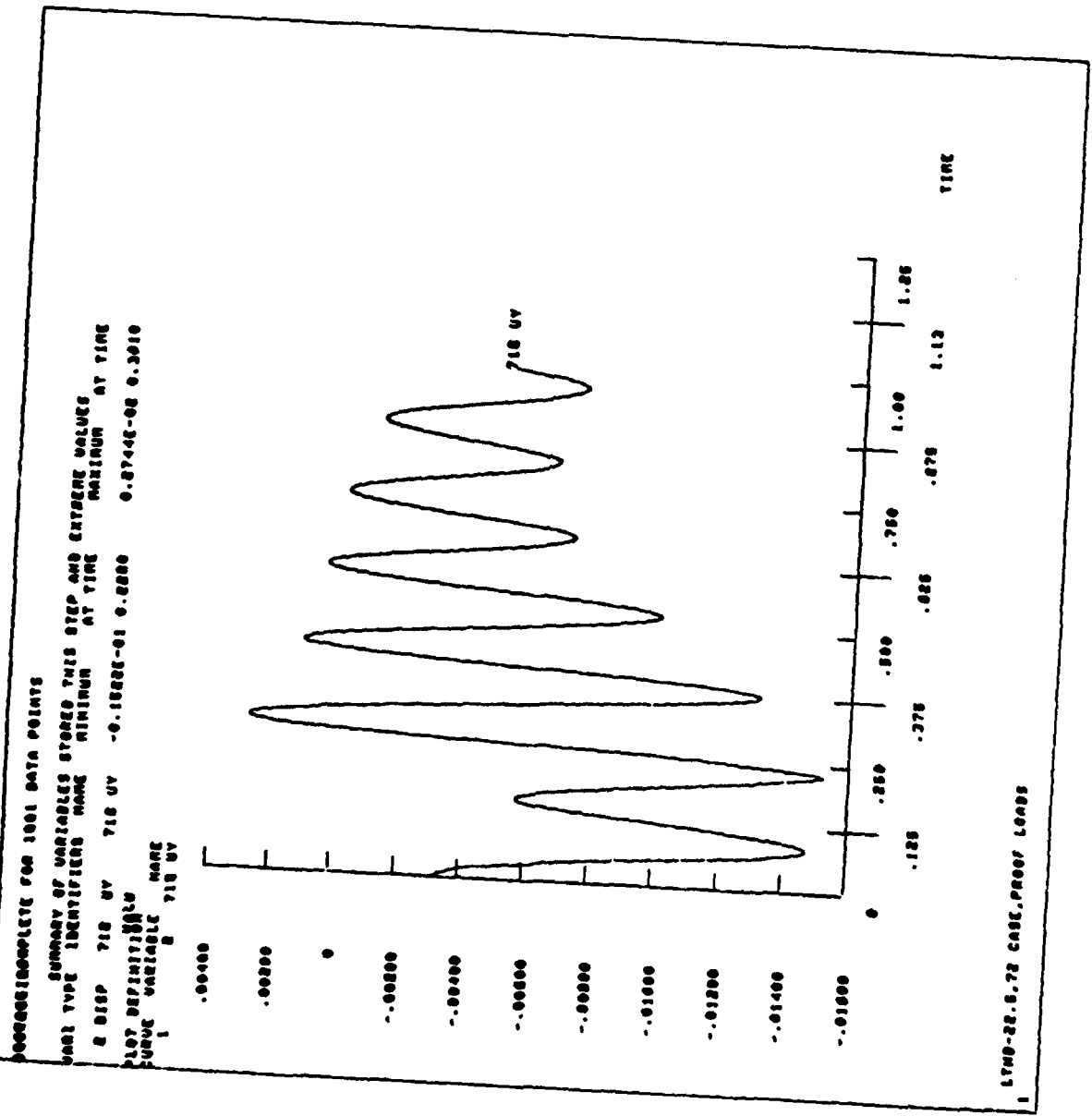
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U.S. AIR FORCE



LYND-88-6.72 CASE, PROOF LOADS



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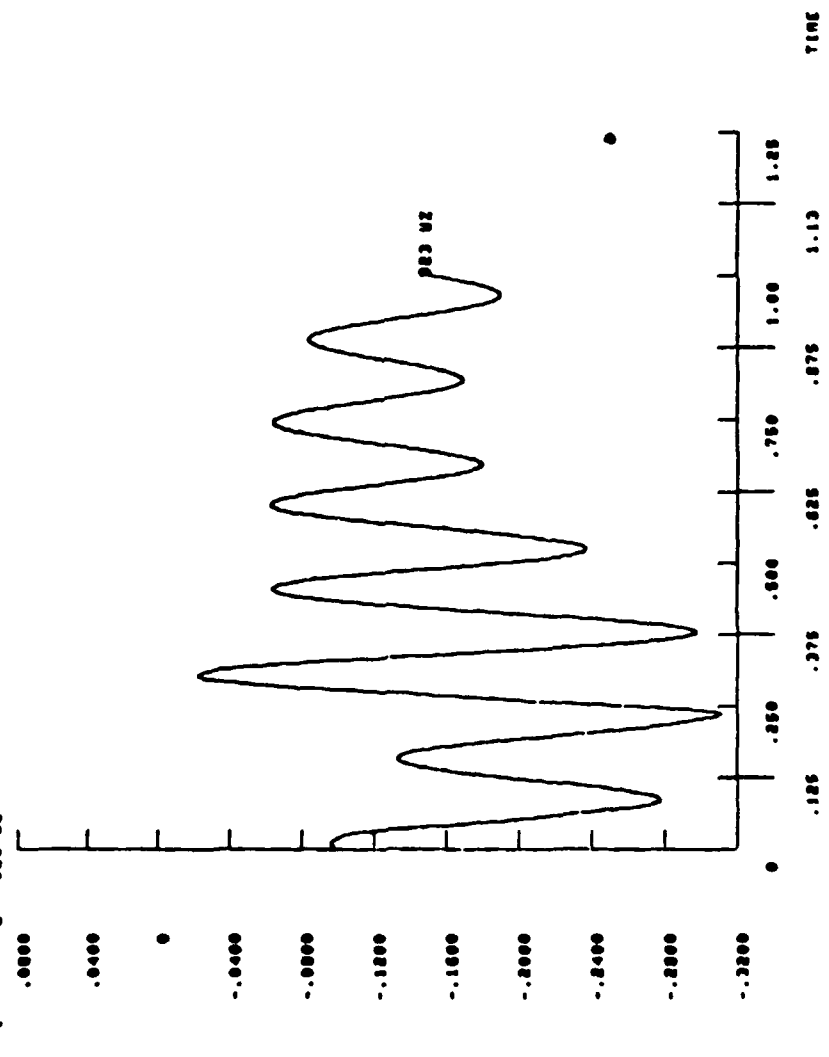
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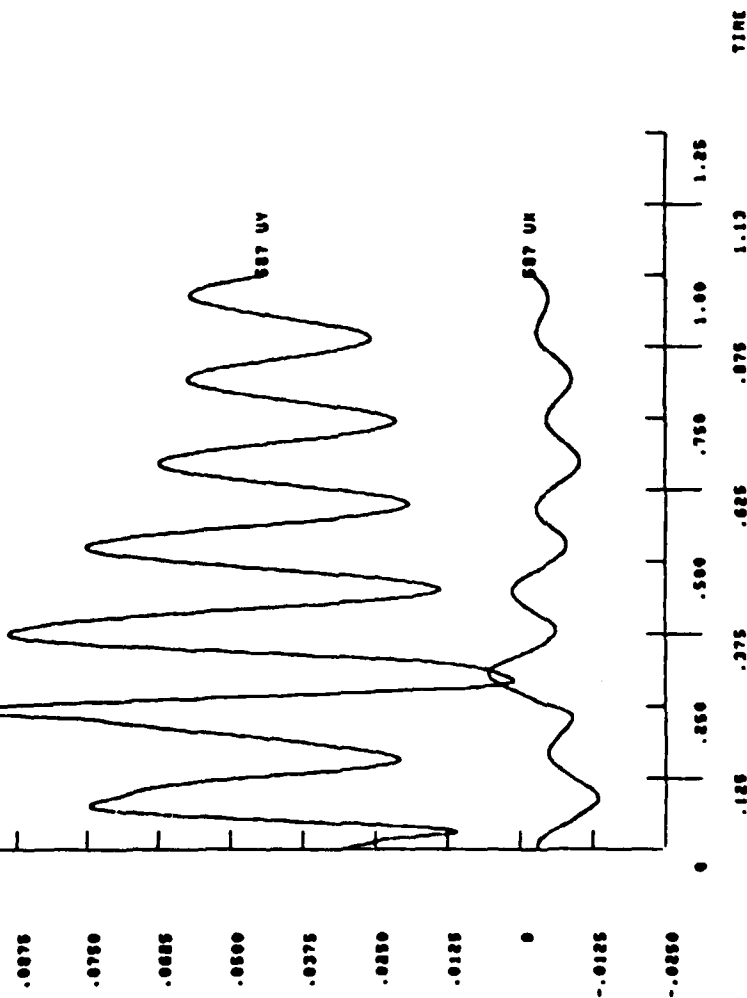


LTND-22.6.72 CASE, PROOF LOADS

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 NAME TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME
 1 010P 007 UV 007 UV -0.1330E-01 0.0100E-01 0.5340E-02 0.3000
 2 010P 007 UV 007 UV 0.0100E-03 0.0000 0.0000E-01 0.0430

PLOT DEFINITION
 CURVE VARIABLE NAME
 1 0100 0 007 UV
 2 0100 0 007 UV



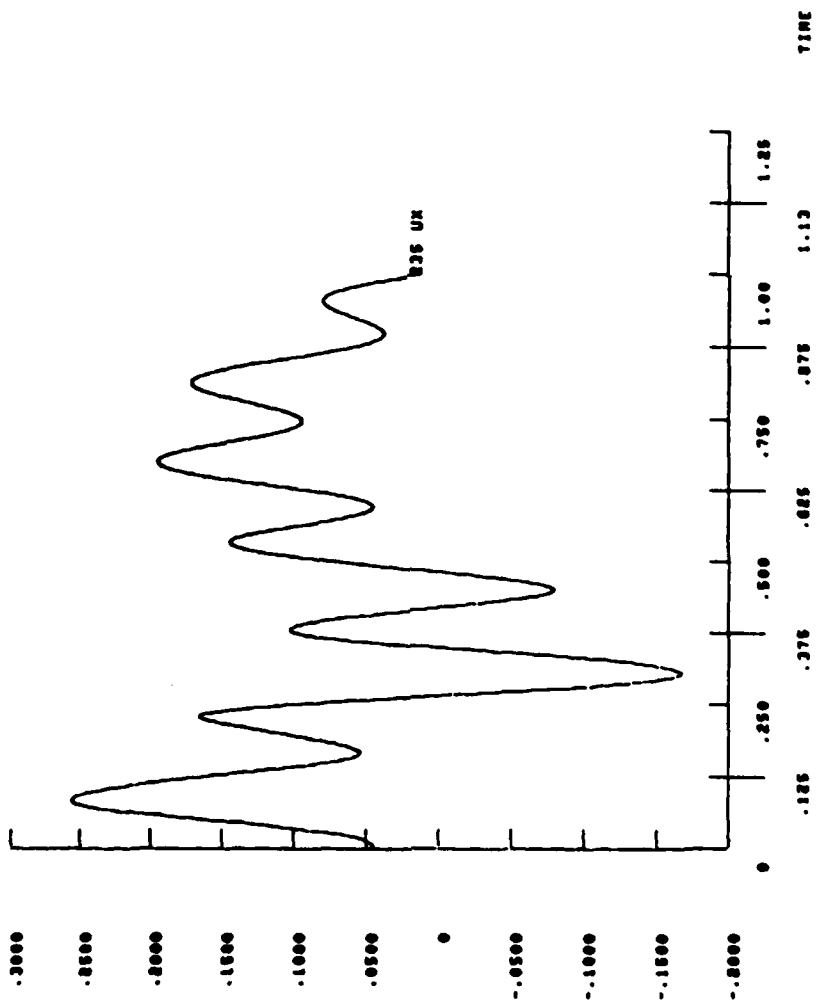
LTMB-22.5.75 CASE, PROOF LOADS

*****COMPLETE FOR 1001 DATA POINTS

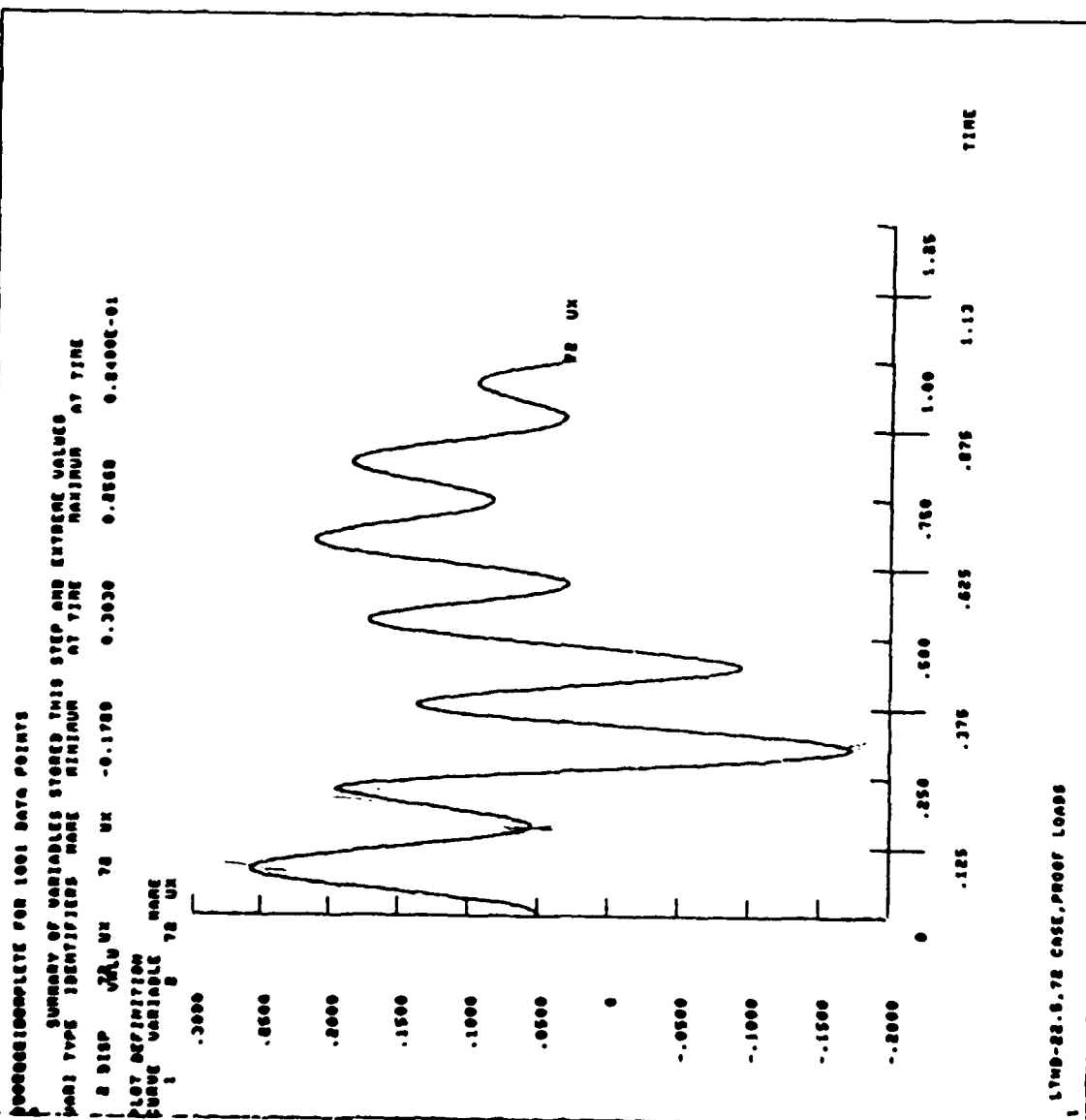
SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME

1 8 DISK QALU UX 235 UX -0.1672 0.3040 0.8555 0.8500E-01

PLOT DEFINITION
 CURVE VARIABLE NAME
 1 8 235 UX

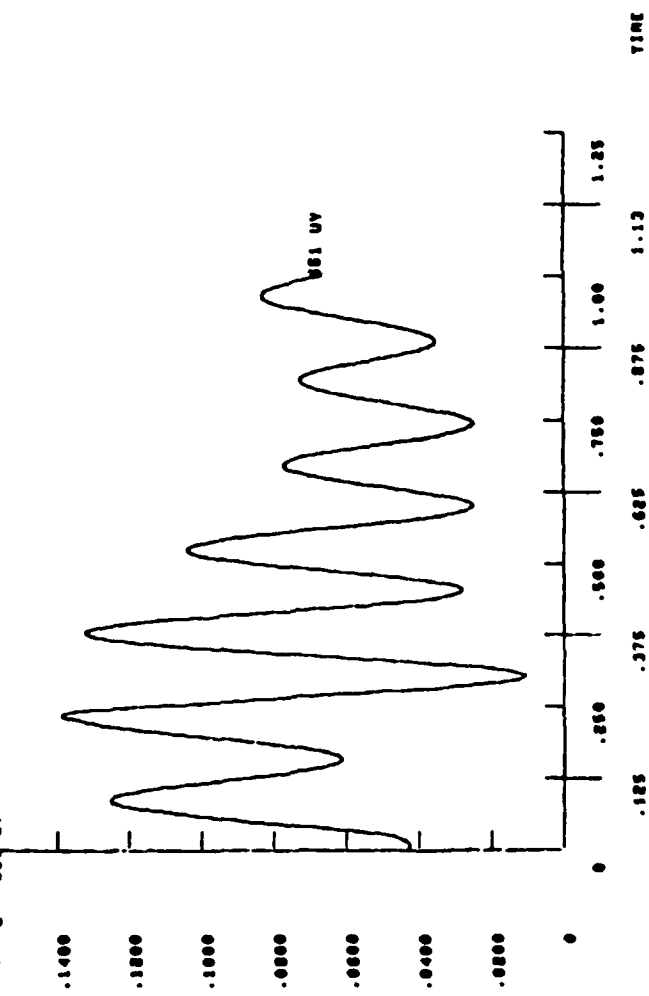


1 LTHD-22.5.72 CASE, PROOF LOADS



STEP 2.001 UV
 POSTER-IMP.
 SUCCESS WARNING- NONE 000 010- UZ IS NOT A MASTER D.O.F.
 BEGINNING 000
 NO DATA POINTS SAVED THIS STORAGE STEP CP. 100.0000 TIME- 13.33740
 VARIABLE 0 000 001 UV PHASE KEY. 0
 POSTER-IMP.
 PLUMB.0

STORAGE COMPLETE FOR 1000 DATA POINTS
 SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIER NAME MINIMUM AT TIME MAXIMUM AT TIME
 0 010000001 UV 001 UV 0.1003E-01 0.3030 0.1387 0.8350
 PLOT DEFINITION
 CURVE VARIABLE NAME
 1.10000 001 UV

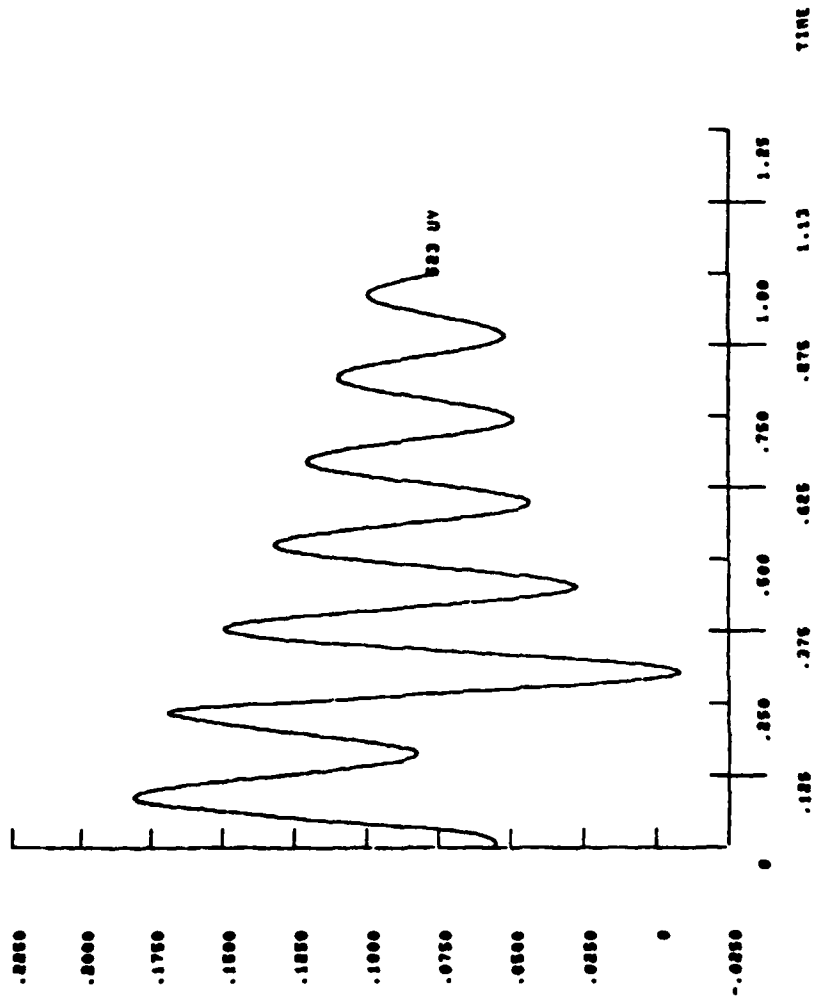


1 LTHD-88.8.78 CASE, PROOF LOADS

*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 POST TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME
 0 STEP VALU UV 003 UV -0.0000E-00 0.3000 0.1011 0.0000E-01

PLOT DEFINITION
 CURVE VARIABLE NAME
 1 003 UV



1 17M0-00.5.70 CASE, PROOF LOADS

RECORDS: COMPLETE FOR 1001 DATA POINTS

USER TYPE IDENTIFIERS NAME	MINIMUM	AT TIME	STORING THIS STEP AND	EXTREME VALUES	MAXIMUM	AT TIME
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						

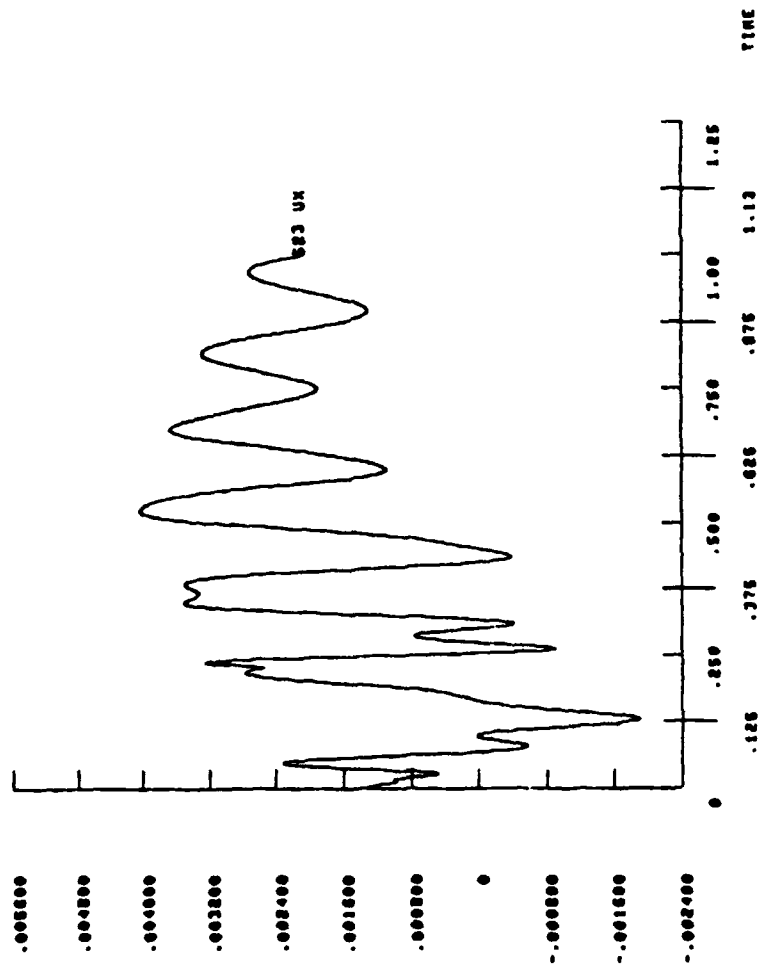
BOARD TYPE	IDENTIFIERS	NAME	MINIMUM	AT TIME	MAXIMUM	AT TIME
2 01SP	523	UH	523	UH	0.4039E-02	0.5210

018P	523	UX	-0.1823E-02	0.1290	0.4038E-02	0.5210
018P	523	UX				

! CURVE VARIABLE VALUE
PLOT DEFINITION

BY REFLECTIONS ON THE

UNCLAS

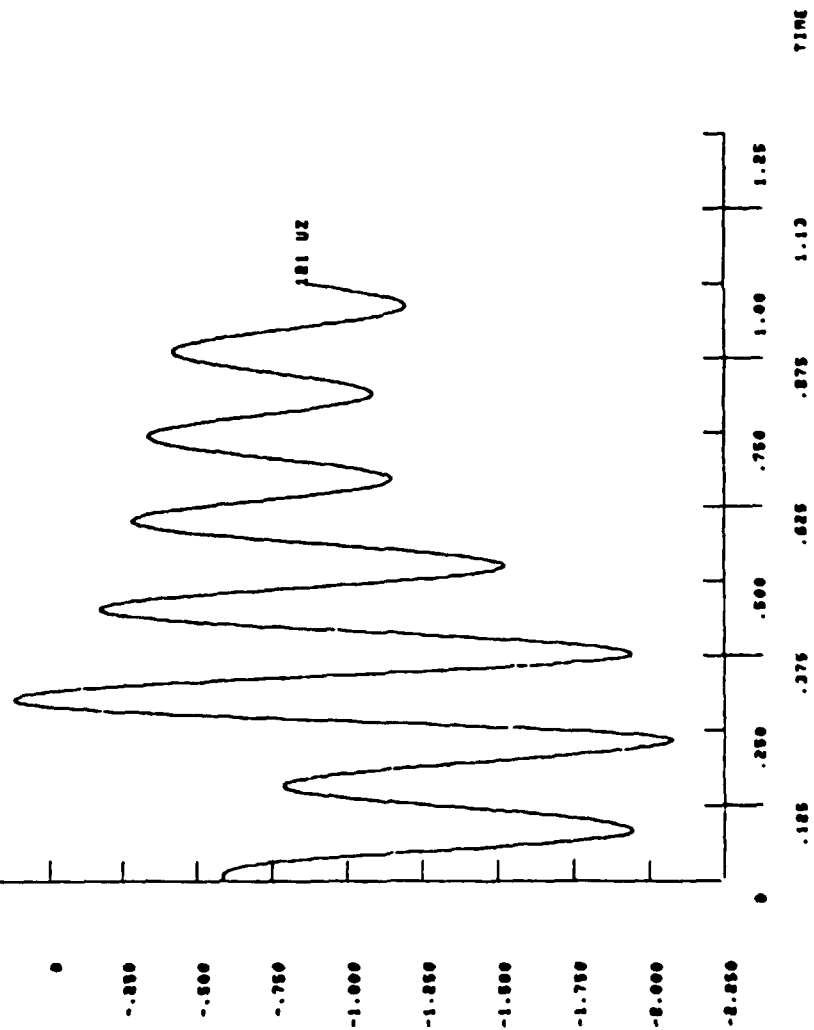


LYND-22.5.72 CASE, PROOF LOADS

INCOMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME
 1 01SP V014 UZ 101 UZ -2.976 0.2300 0.1224 0.3030

PLOT DEFINITION
 CURVE VARIABLE NAME
 1 101 UZ



LYND-22.9.72 CASE, PROOF LOADS

RECORDS COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES

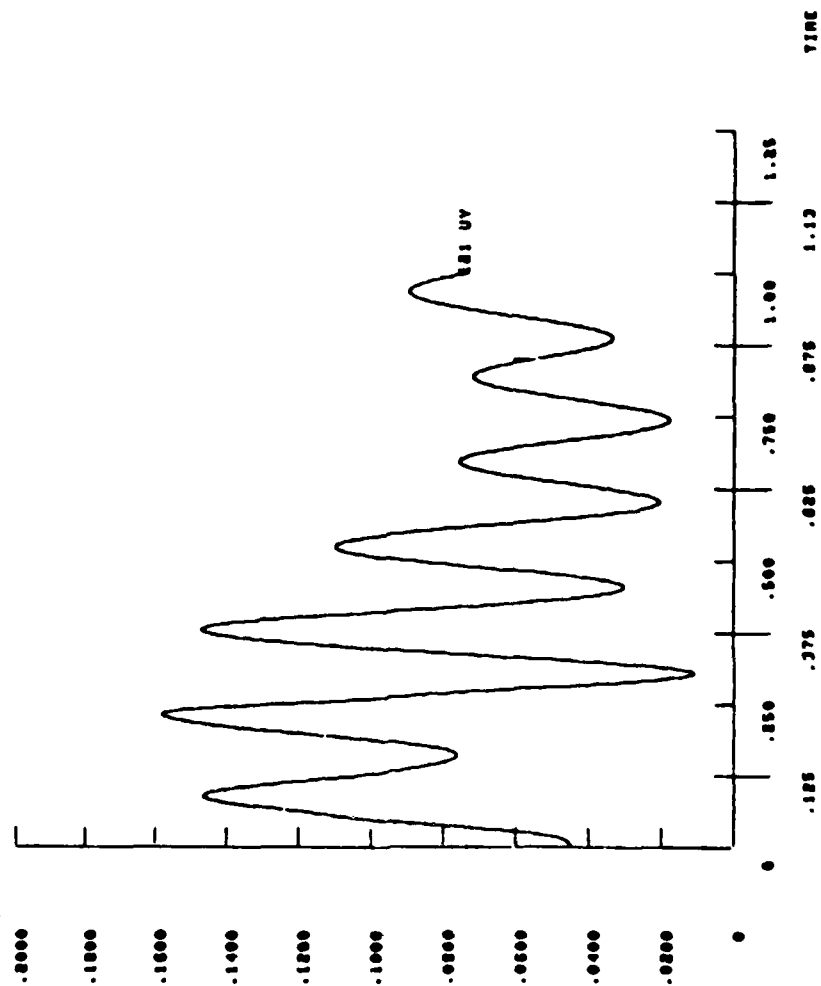
NAME TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME

0 STEP VALU UV 181 UV 0.1120E-01 0.3040 0.1880 0.2310

PLOT DEFINITION

CURVE VARIABLE NAME

1 181 UV



LYND-22-5.72 CASE, PROOF LOADS

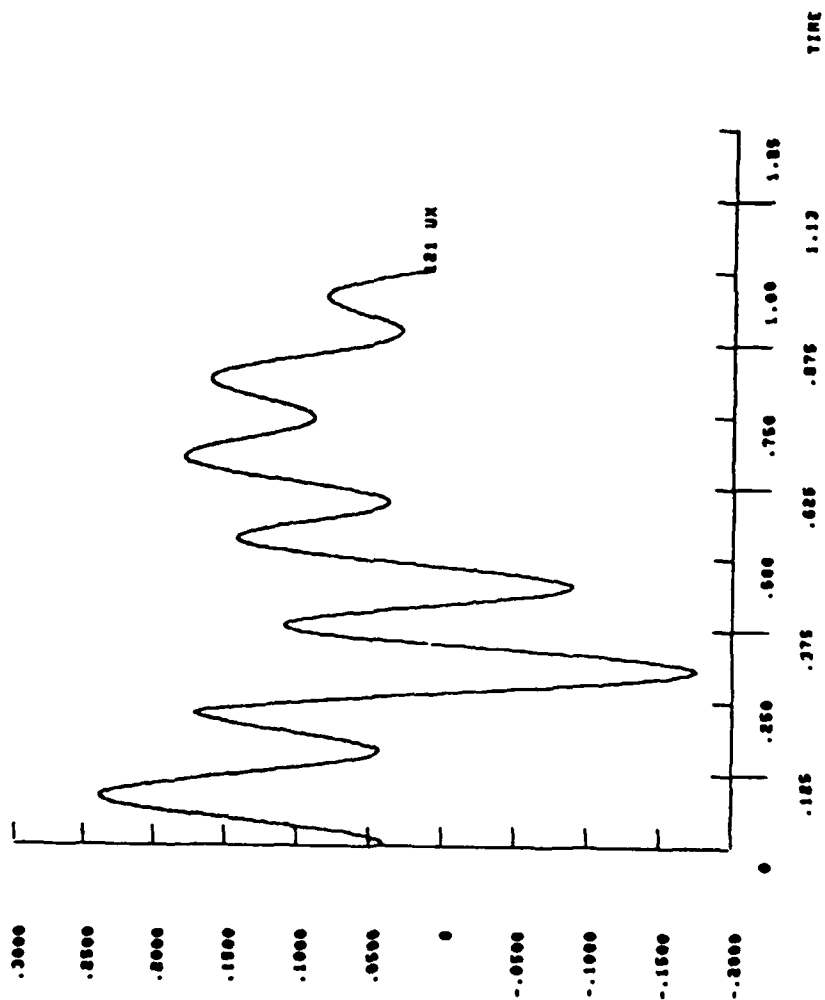
*****COMPLETE FOR 1001 DATA POINTS

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES

DATA TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME

2 0100 101 UN -0.1781 0.3040 0.2308 0.0400E-01

PLOT DEFINITION
CURVE VARIABLE 101 UN



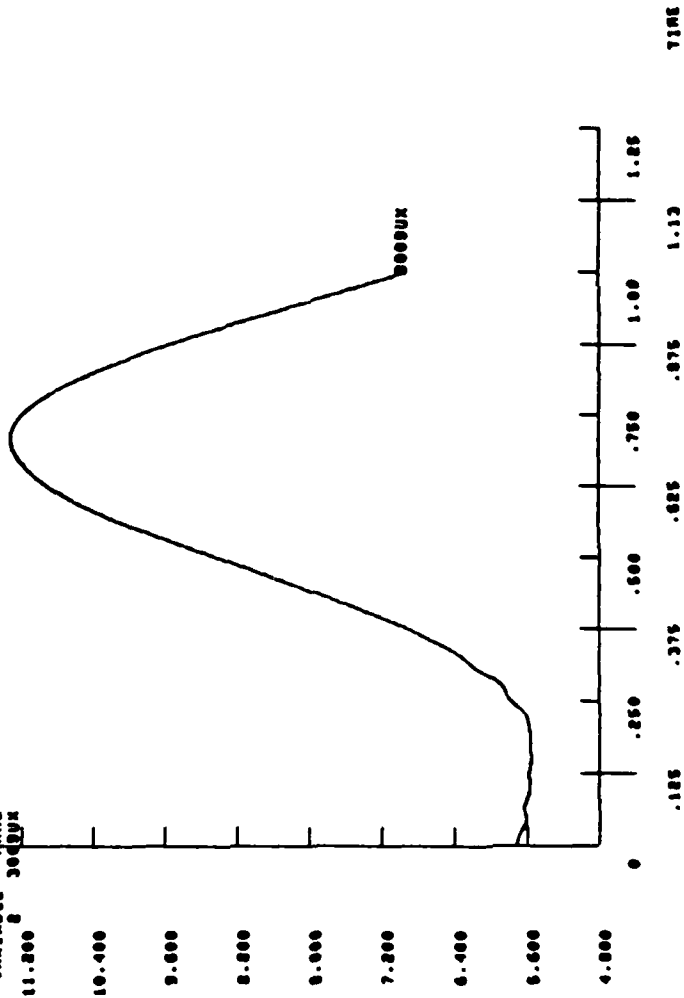
LTND-22.5.72 CASE, PROOF LOADS

POSTER
20-1

POSTPROCESSING- NODE 3016 DIS- UV IS NOT A MASTER D.O.F.
 DISP. 2.3016 UX
 POSTPROCESSING- 222
 NO DATA POINTS SAVED THIS STORAGE STEP CP- 307.0000 TIME- 13.07000
 VARIABLE 2 VALU 3000 UX PHASE KEY- 0
 POSTER-IMP. PLVA.2

STORAGE COMPLETE FOR 1001 DATA POINTS

IS A SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES
 NAME TYPE IDENTIFIERS NAME MINIMUM AT TIME MAXIMUM AT TIME
 2 DISP. 3000 UX 3000UX 5.500 0.1550 11.31 0.7000
 11.000
 PLOT DEFINITION NAME
 CURVE VARIABLE 3000UX
 1 11.000 2 3000UX



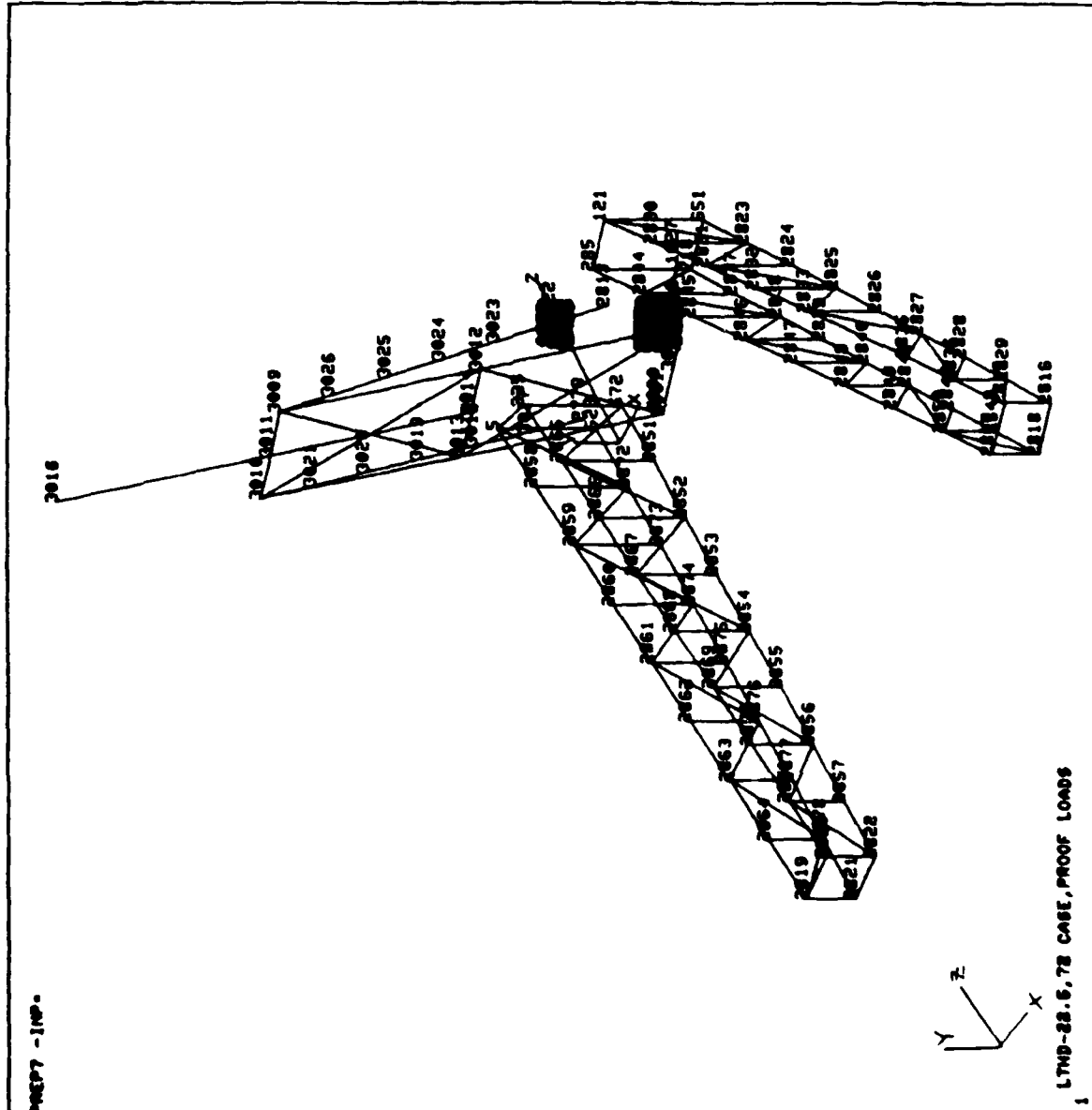
1 LTWD-22.9.72 CASE, PROOF LOADS

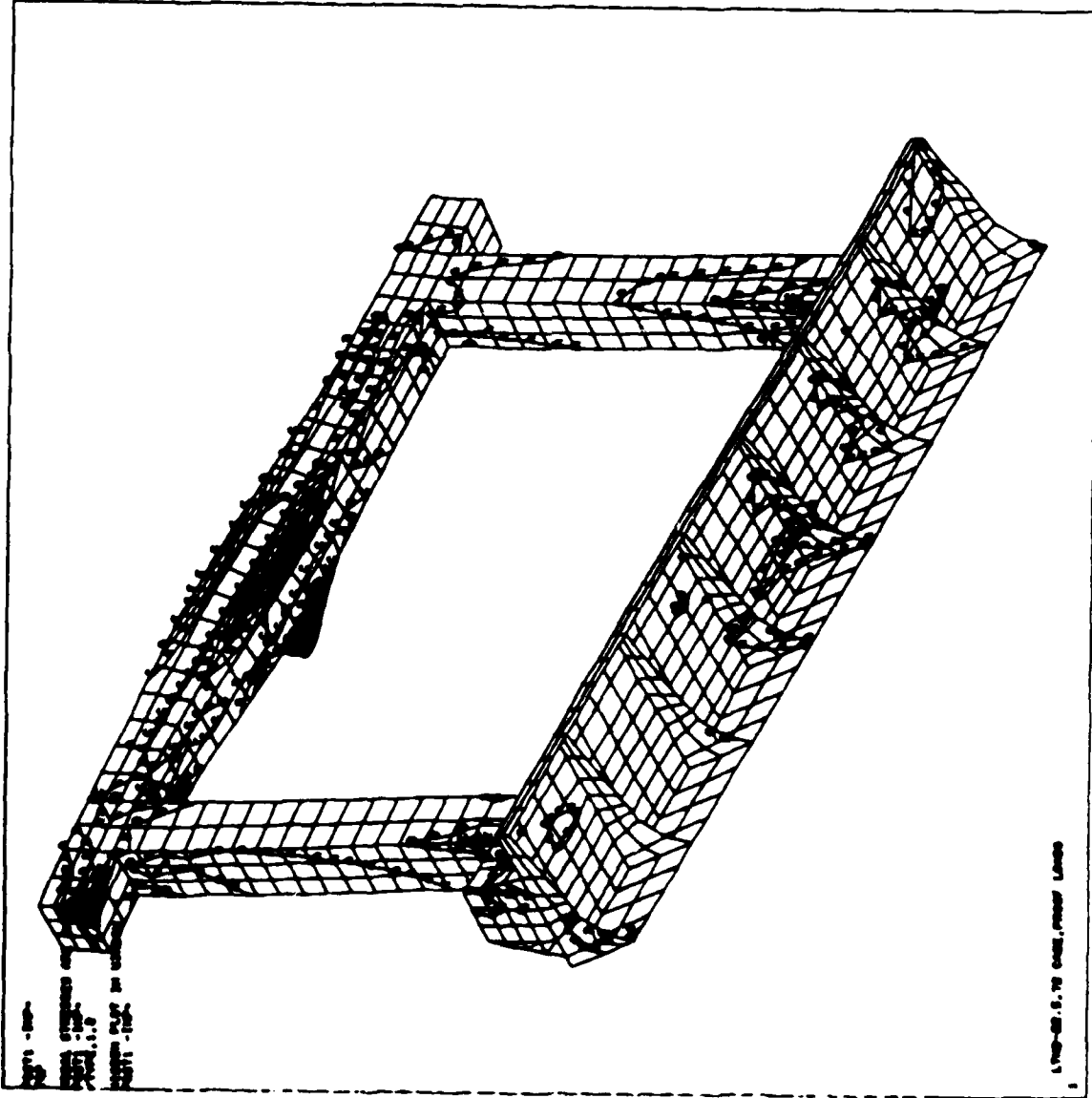
CRADLE FORWARD
 END MDOF NODE
 (SIDE-TO-SIDE MOTION)

SUMMARY OF VARIABLES STORED THIS STEP AND EXTREME VALUES				
DEPT	TYPE	IDENTIFIERS MADE	MINIMUM AT TIME MAXIMUM AT TIME	
2	DEPT	30000000	-10.30 0.0700	-5.985 0.00000000

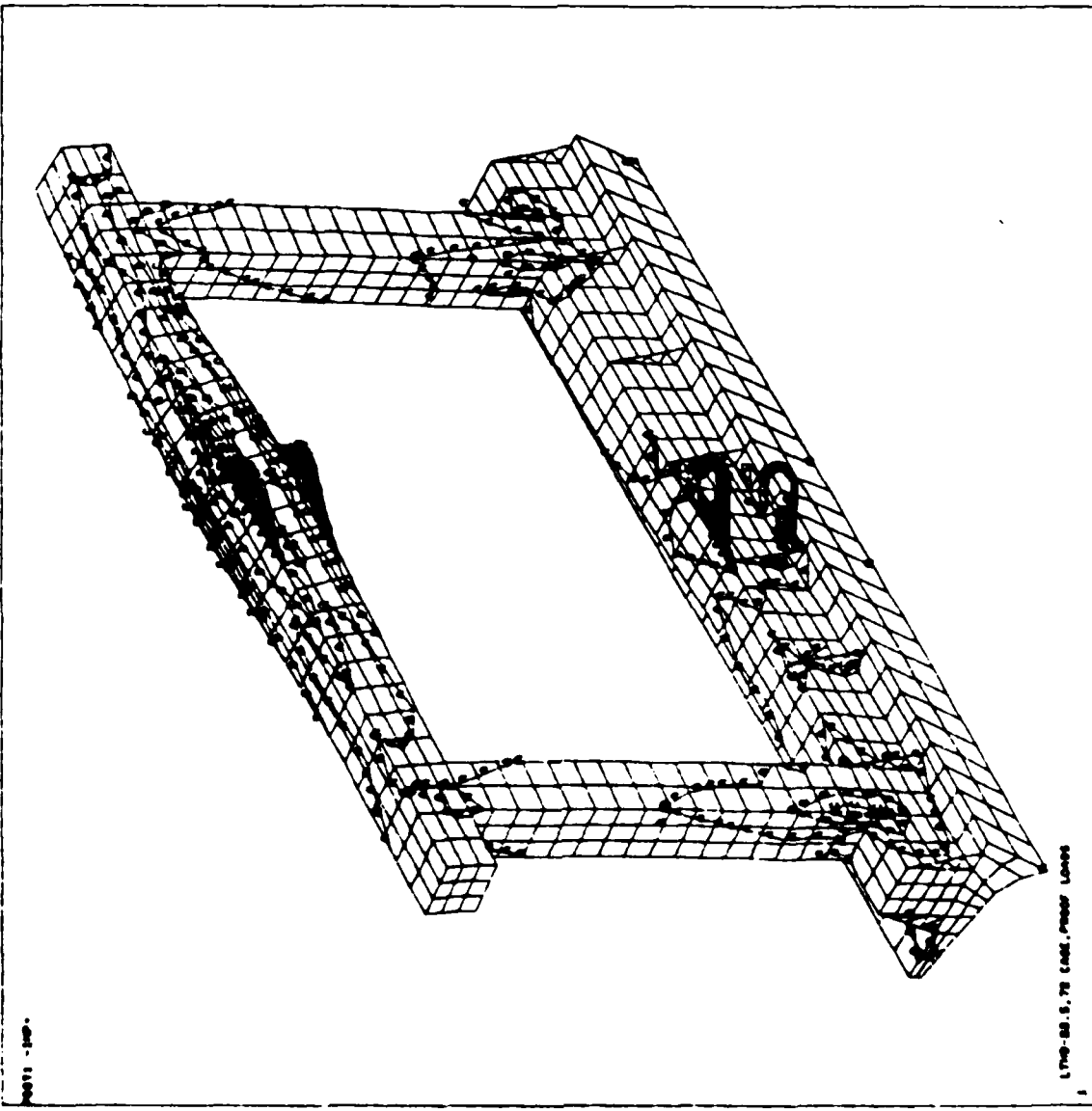
CRADLE FORWARD
END MDOF NODE

ANDVS 4.28
 JAN 19 1987
 13130122
 PREP7 ELEMENTS
 MHUM-1
 XU--1
 VU--1
 ZU-1
 DIST-811
 XF-69.4
 YF-132
 ZF--129
 XRT0-4.06
 YRT0-3.64



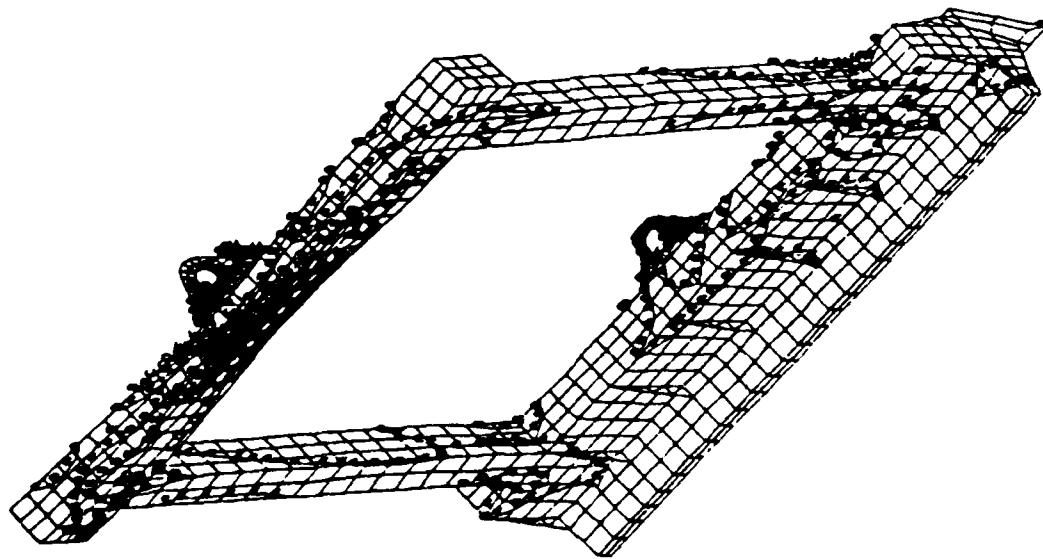
[illegible]

00071 0.00
 Jan 10 1987
 16:22:10
 00071 070000
 0700-1
 0700-1
 1100-1 204
 0700
 1100
 0700-1
 0700-1
 2000-1
 0700-100.8
 0700-100.2
 0700-100.4
 0700-100.6
 0700-100.8
 0700-101.0
 0700-101.2
 0700-101.4
 0700-101.6
 0700-101.8
 0700-102.0
 0700-102.2
 0700-102.4
 0700-102.6
 0700-102.8
 0700-103.0



PLATFORM

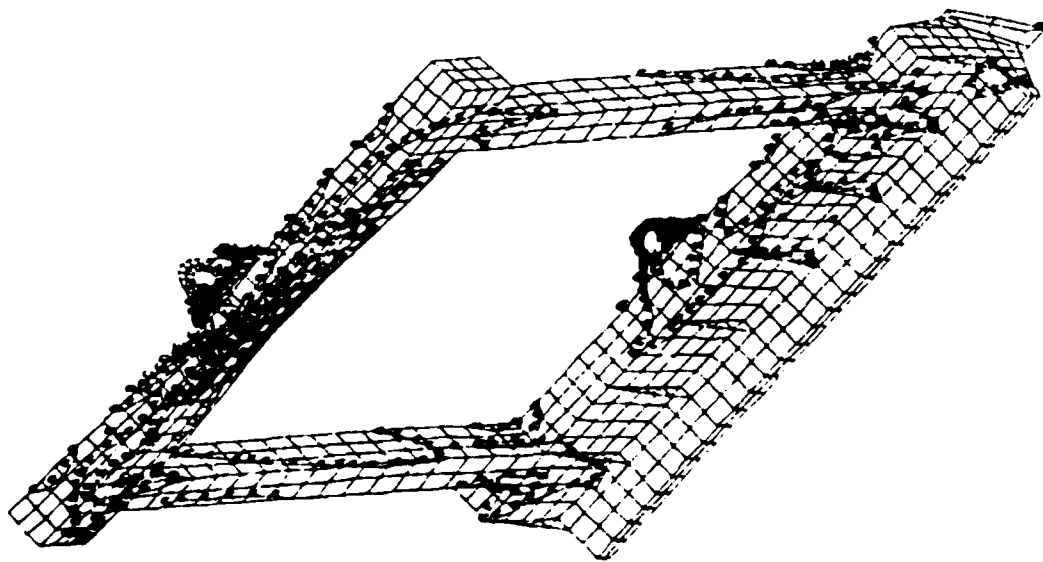
ANSYS 4.20
 JAN 10 1987
 15:28:46
 POST1 BYRESS
 STEP=1
 170-1
 TIME=.304
 SIDE
 TOP
 ZOOM
 ZV=1
 ZU=1
 ZW=1
 0.157-93.3
 XZ=51.2
 YZ=27.7
 ZF=9.37
 V870-1.05
 M180EM
 MX=29163
 MY=121
 A=4960
 B=8801
 C=14642
 D=19483
 E=24324



POST1 -IMP.

1749-22.5, 72 CASE, PROOF LOADS

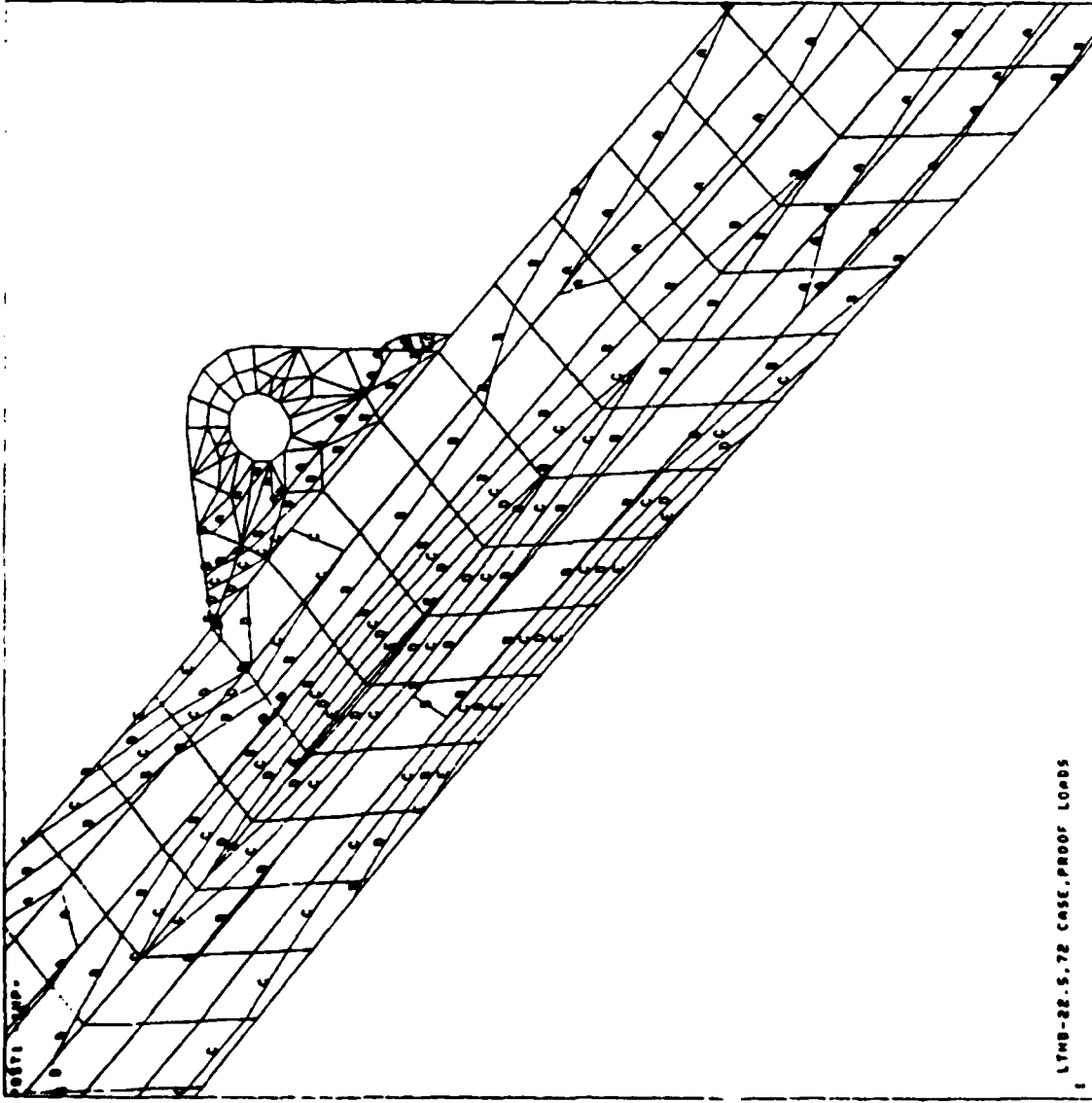
ANSYS 4.20
 JAN 10 1987
 15:28:46
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.304
 SIZE
 TOP
 ZOOM
 KU=1
 YU=1
 ZU=1
 DIST=93.3
 WF=51.2
 VF=27.7
 ZF=4.17
 VATO=1.65
 MID8CM
 RM=20163
 RM=121
 A=4960
 B=9801
 C=14642
 D=19403
 E=24324



POST1 -IMP.
 ZOOM

LTMC-22.5.72 CASE PROOF LOADS

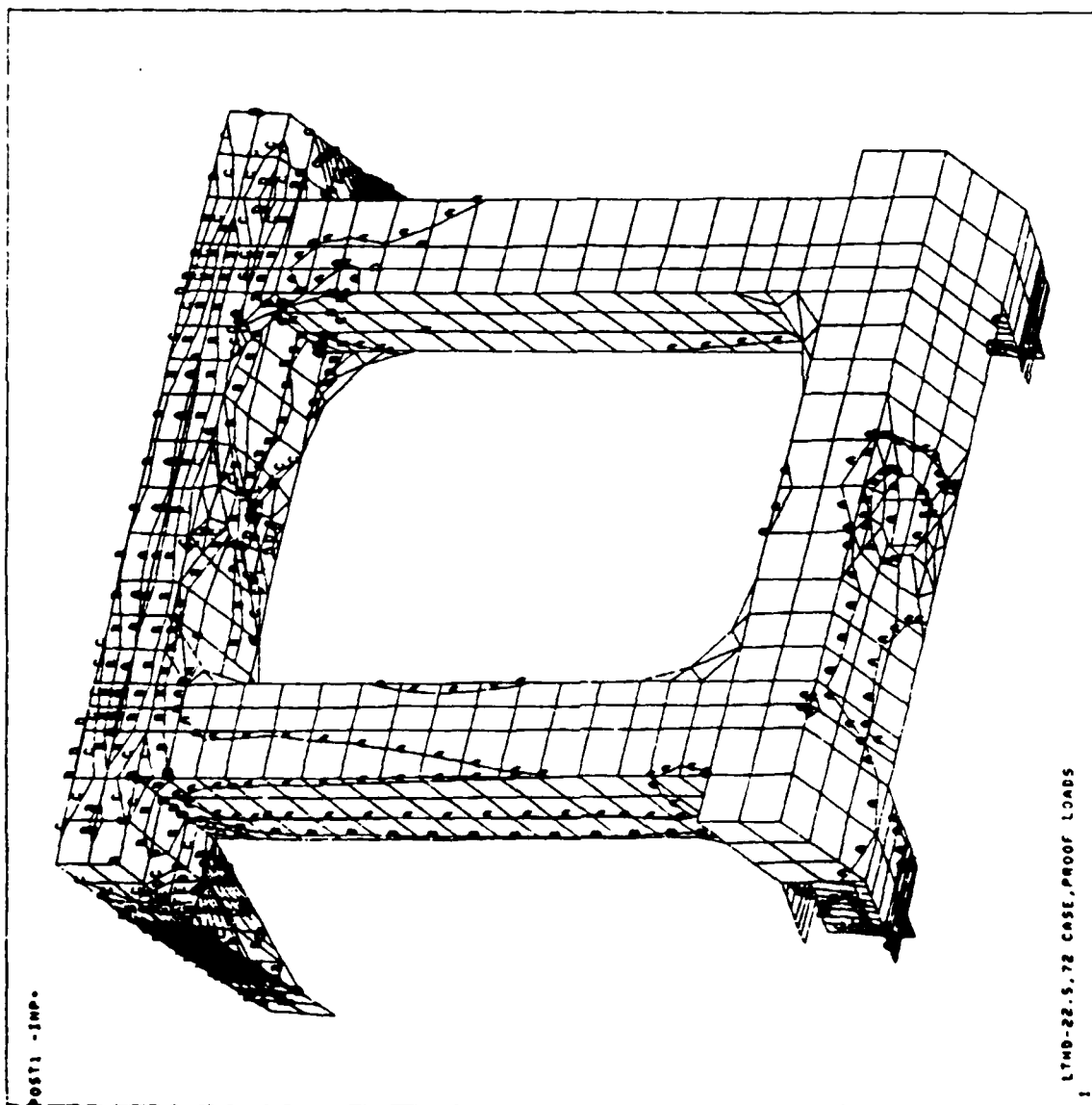
ANSYS 4.20
 JAN 19 1987
 15:28:46
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.304
 SICE
 TOP
 ZOOM
 RU=1
 VU=1
 ZU=1
 2 DIST=24.2
 3 XP=41.9
 4 YP=47.1
 5 ZP=-5.86
 6 XSTO=1.12
 7 YSTO=1.65
 8 HIDDEN
 9 HX=28180
 10 HX=0
 11 A=4960
 12 B=8801
 13 C=14642
 14 D=19483
 15 E=24324



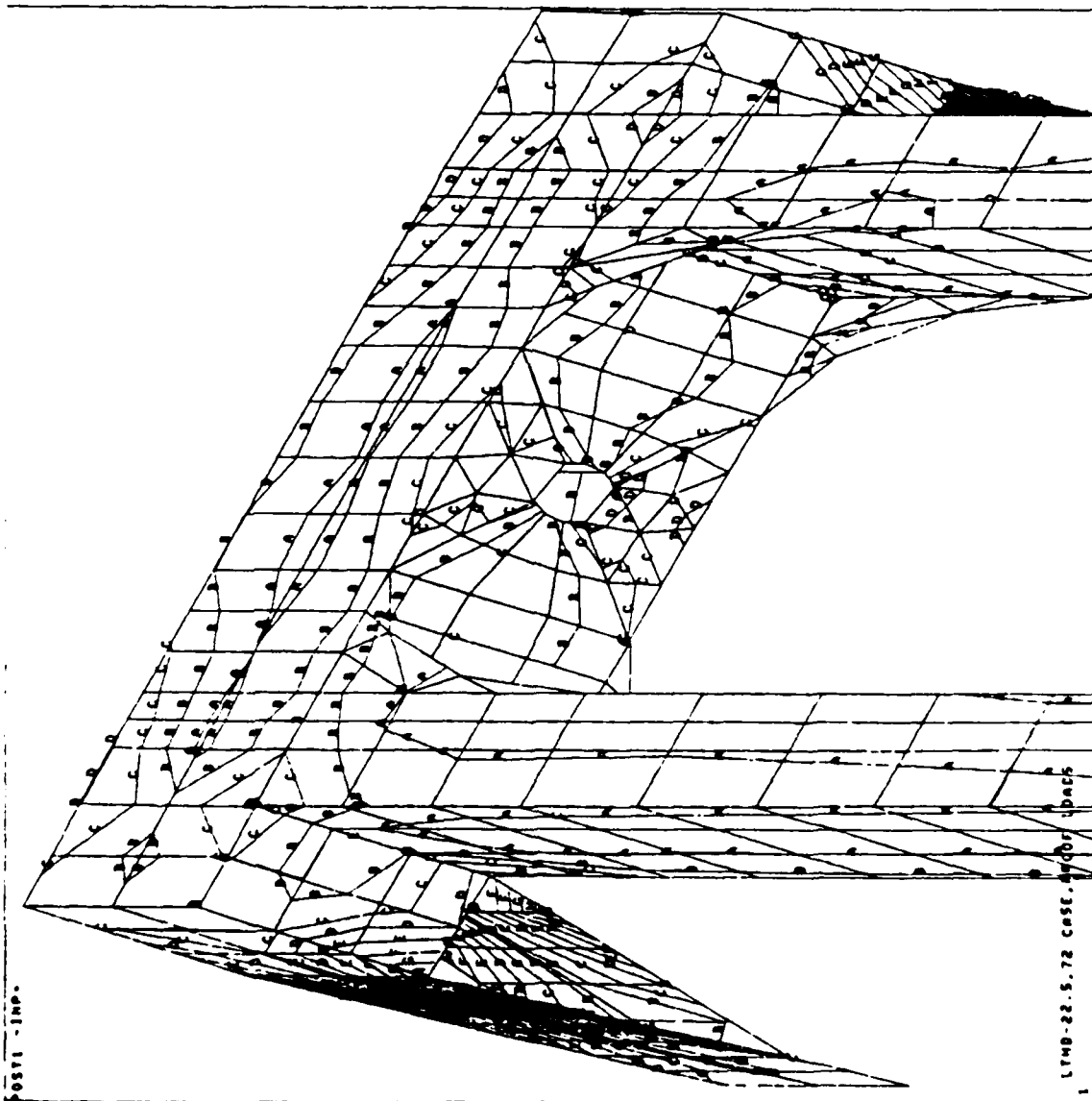
LTMB-22.5.72 CASE, PROOF LOADS

PLATFORM
 UPPER BOX
 BEAM

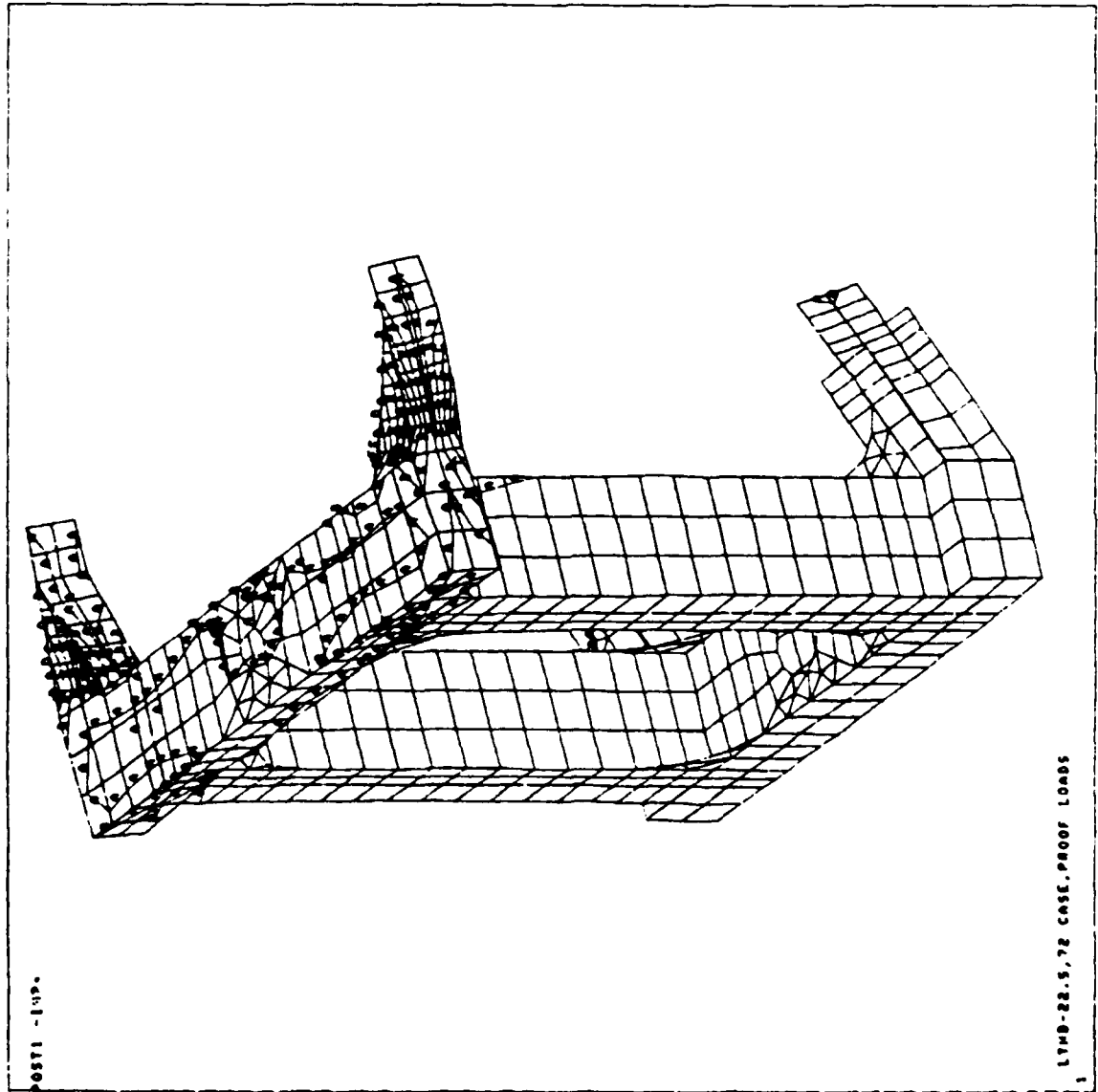
AMSYS 4.20
 JAN 19 1987
 15140153
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.304
 SIZE
 TOP
 KU=-1
 VU=-1
 ZU=1
 DIST=88.7
 KF=53.8
 VF=35
 ZF=-7.83
 MIDDLE
 RM=235105
 RM=660
 A=15311
 B=29964
 C=44617
 D=59278
 E=73923
 F=88576
 G=103229
 H=117882
 I=132535
 J=147188
 K=161841
 L=176494
 M=191147
 N=205800
 O=220453



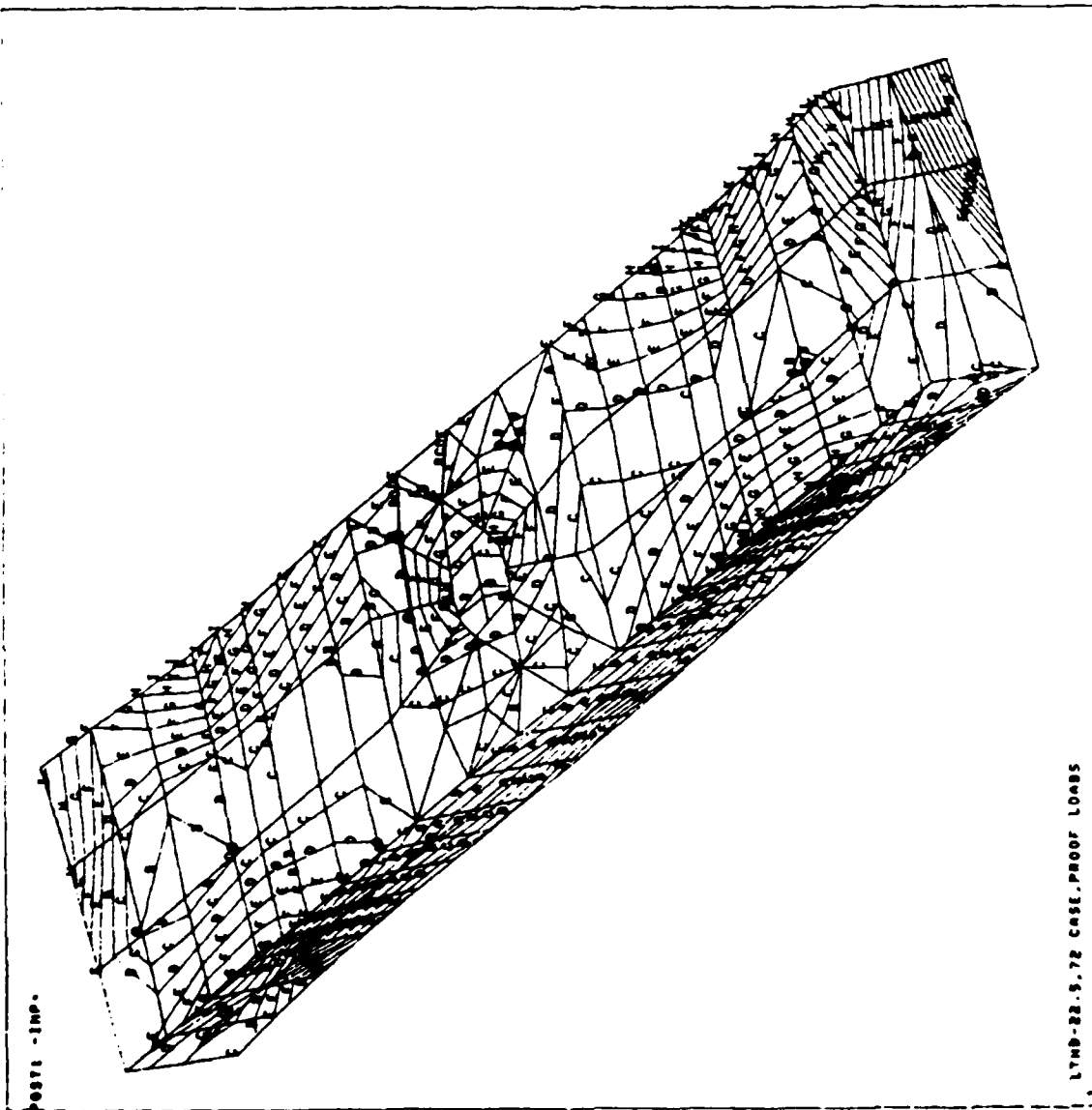
ANSYS 4.20
 JAN 19 1987
 15140158
 POST1 STRESS
 STEP=1
 LAYER=1
 TIME=.204
 SLOC
 TOP
 ZOOM
 XU=-1
 VU=-1
 ZU=1
 # DIST=24.8
 # XF=46.6
 # VF=48
 # ZF=-1.81
 VRTO=2.45
 MIDDLE
 RK=235105
 RN=6
 A=15311
 B=20964
 C=44617
 D=59270
 E=73923
 F=98576
 G=103229
 H=117882
 I=132535
 J=147100
 K=161841
 L=176494
 M=191147
 N=205800
 O=220453



ANSYS 4.20
 JAN 10 1987
 15:50:54
 POST1 STRESS
 STEP=1
 L100=1
 TIME=.304
 SICE
 TOP
 NU=1
 VU=1
 ZU=1
 D167-34.0
 XF-57.3
 YF-32.9
 ZF--7.62
 MIDELH
 MN-235105
 MN-660
 A-39732
 B-78807
 C-117802
 D-156857
 E-106032

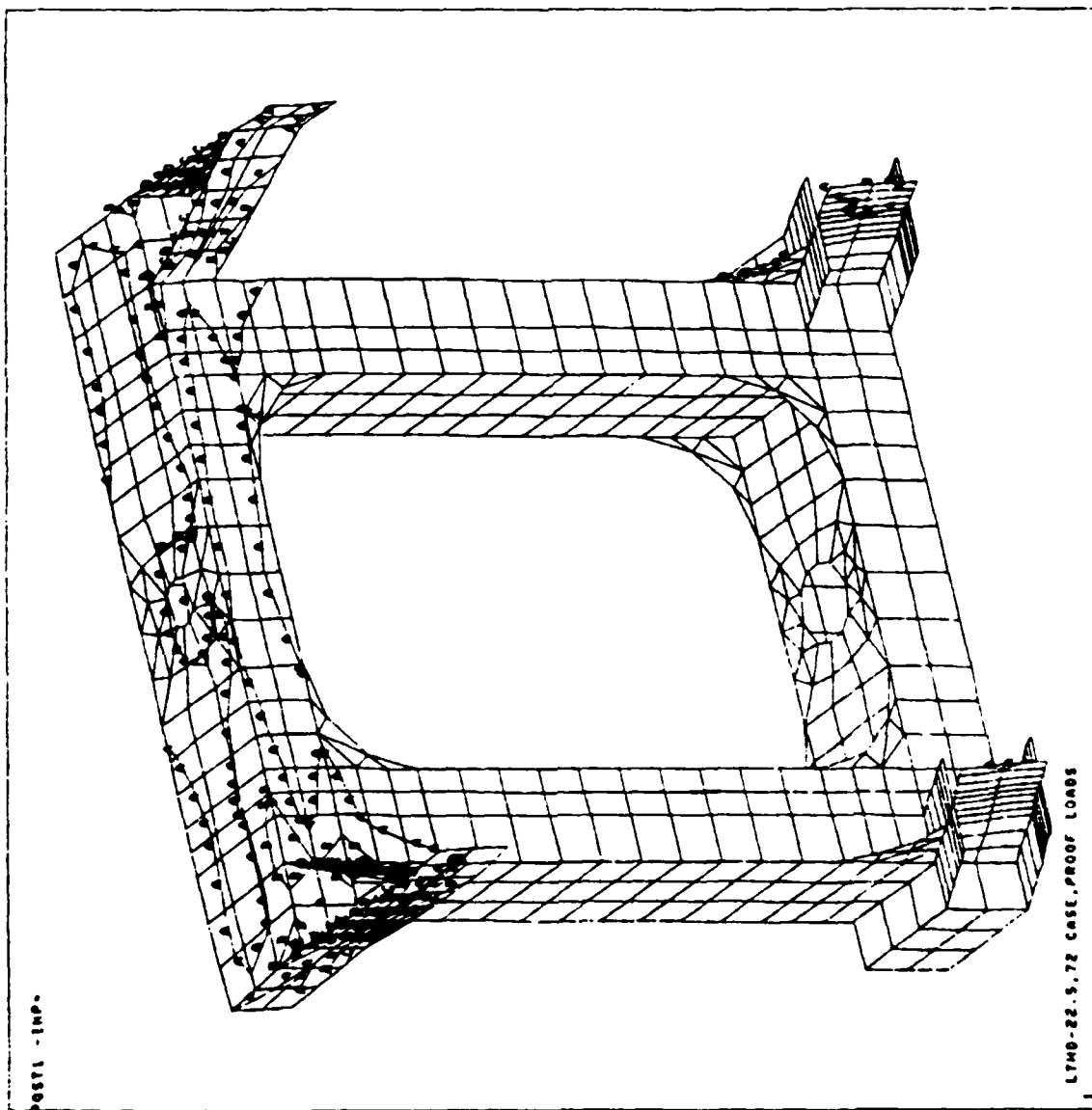


ANSYS 4.20
 JAN 19 1987
 16:07:06
 POST1 STRESS
 STEP=1
 LREQ=1
 TIME=.304
 SICE
 TOP
 ZOOM
 XU=1
 YU=1
 ZU=1
 BIST=16.8
 XF=53
 VF=54.7
 ZF=-3.5
 XROT=1.23
 YROT=1.08
 MIBDEM
 MN=121964
 MN=9161
 A=16205
 B=23256
 C=30307
 D=37358
 E=44400
 F=51460
 G=58511
 H=65562
 I=72613
 J=79664
 K=86715
 L=93766
 M=100817
 N=107868
 O=114919

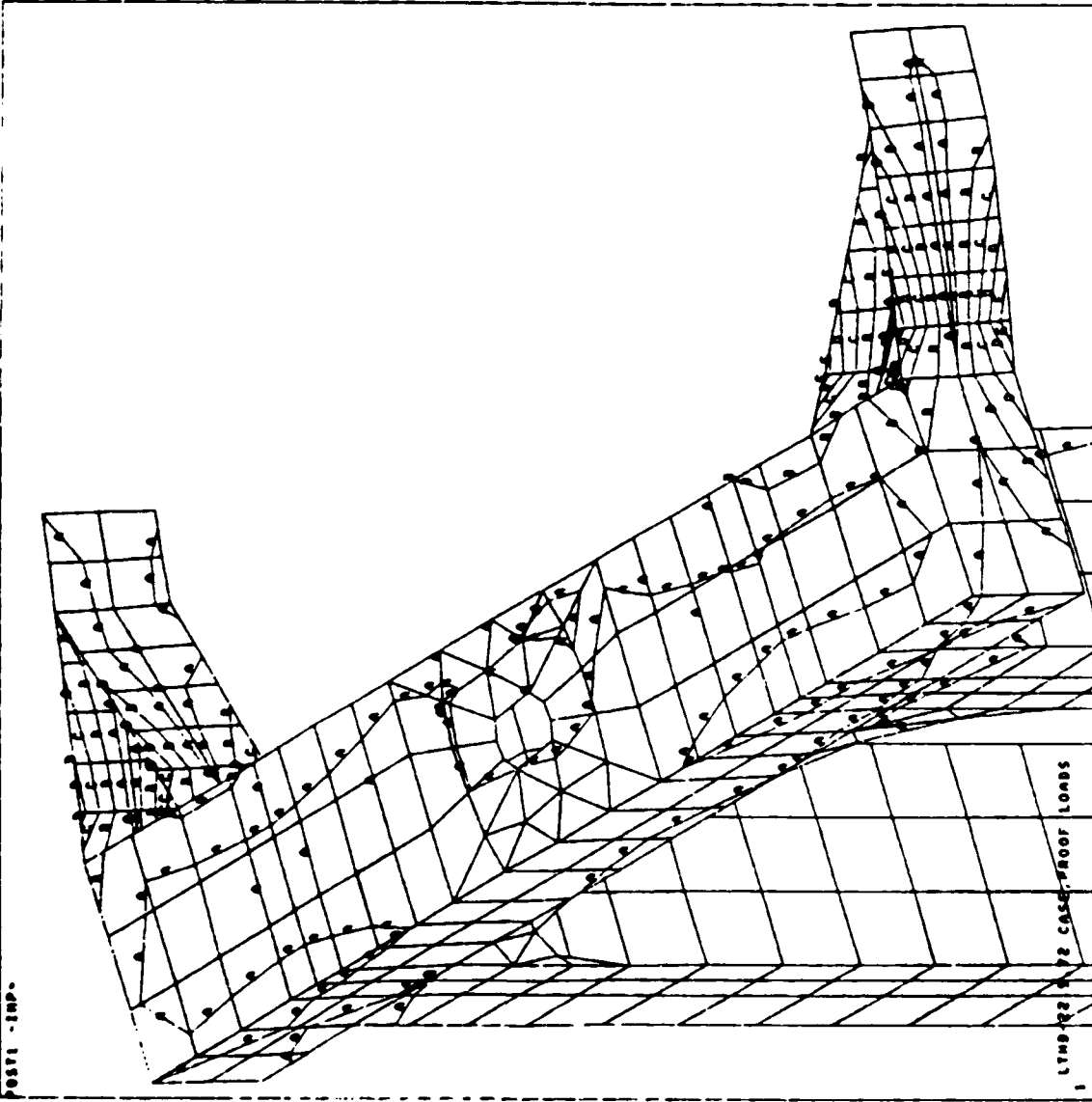


UPPER G-WIBAL
 BOX BEAM

ANSYS 4.28
 JAN 19 1987
 16:34:24
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.304
 SICE
 TOP
 NU=1
 VU=1
 ZU=-1
 DIST=28.7
 WF=52.9
 VF=35
 ZF=-7.93
 MIDDLEM
 RN=235105
 RN=669
 A=38732
 B=78807
 C=117882
 D=156957
 E=196932

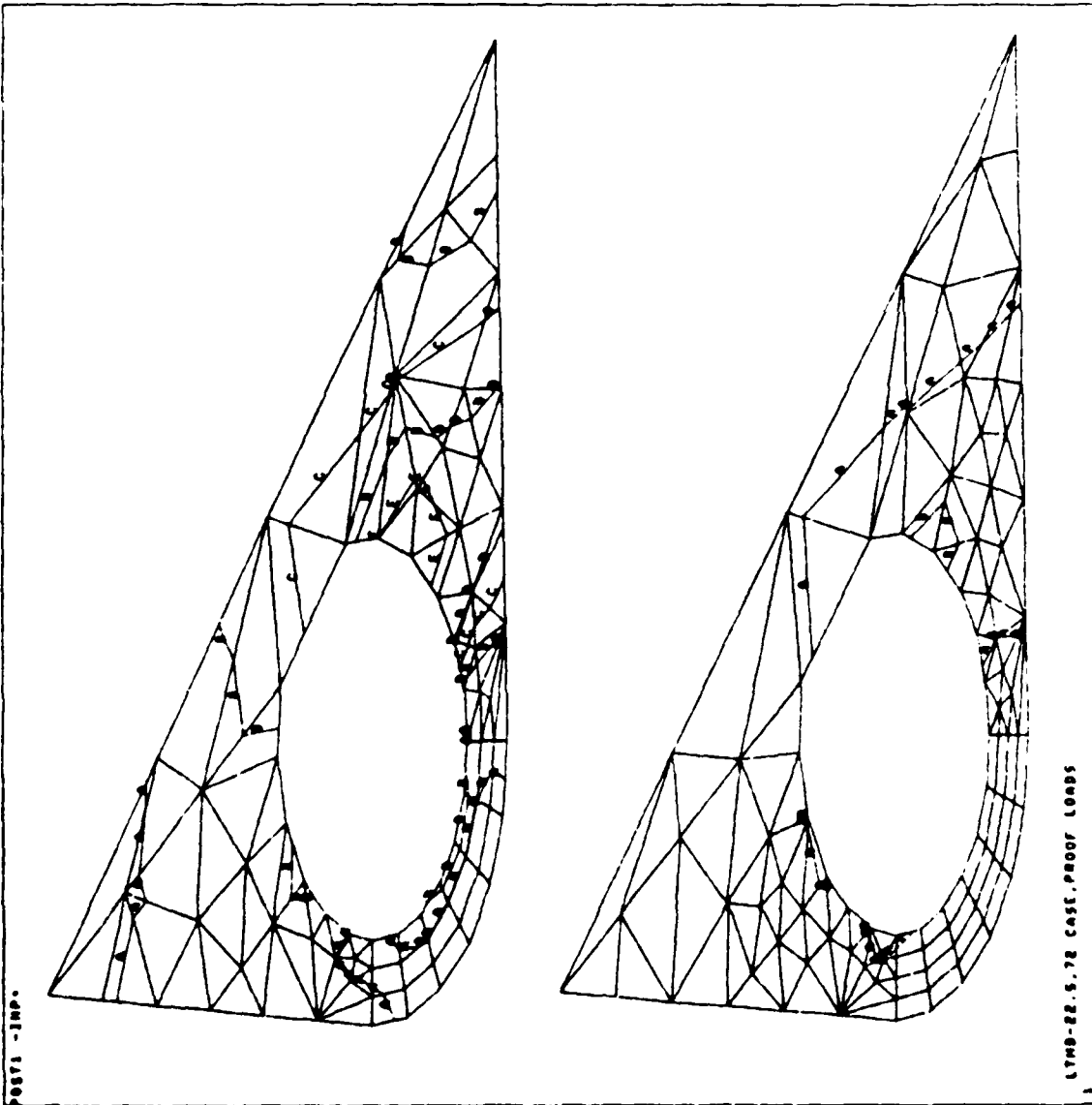


ANSYS 4.20
 JAN 19 1987
 15:50:54
 POST1 STRESS
 STEP=1
 ITEM=1
 TIME=...304
 SLC
 TOP
 ZOOM
 KU=1
 VU=1
 ZU=1
 8 DIST=10
 8 KF=48.0
 8 VF=48.0
 8 ZF=15.1
 VRT0=1.21
 MIDDLE
 RK=235105
 RM=0
 A=20732
 B=70807
 C=117002
 D=156957
 E=106032

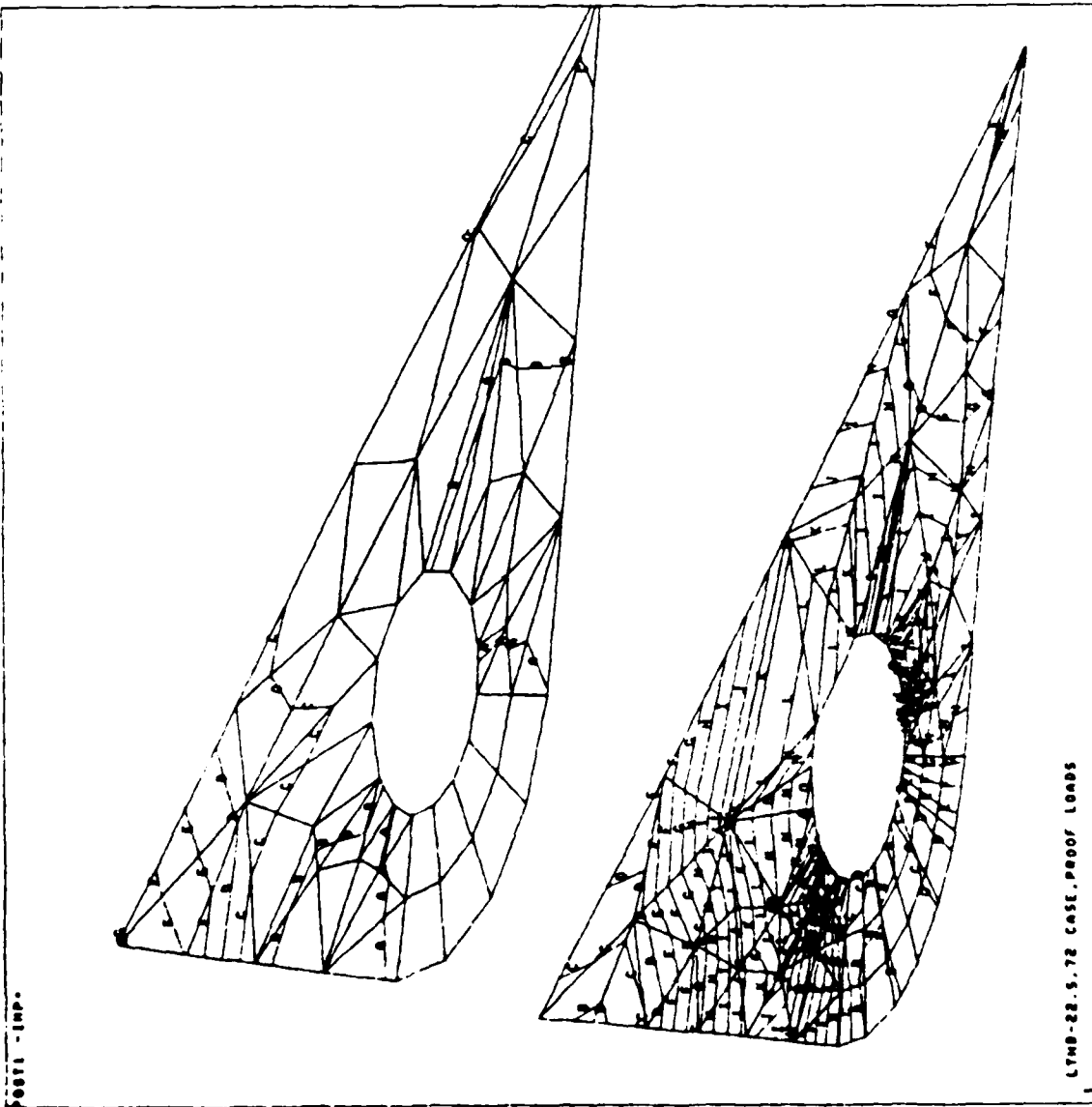


ANSYS 4.20
 JAN 19 1987
 15:58:40
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=1.004
 SLOC
 TOP

ZOOM
 RV=1
 VU=1
 ZU=1
 1 0187-7.56
 2 07-61.0
 3 07-13.2
 4 27-0.58
 5 0187-1.23
 MIDDLE
 RM-29163
 RM-121
 A-4960
 B-0001
 C-14648
 D-10403
 E-24324



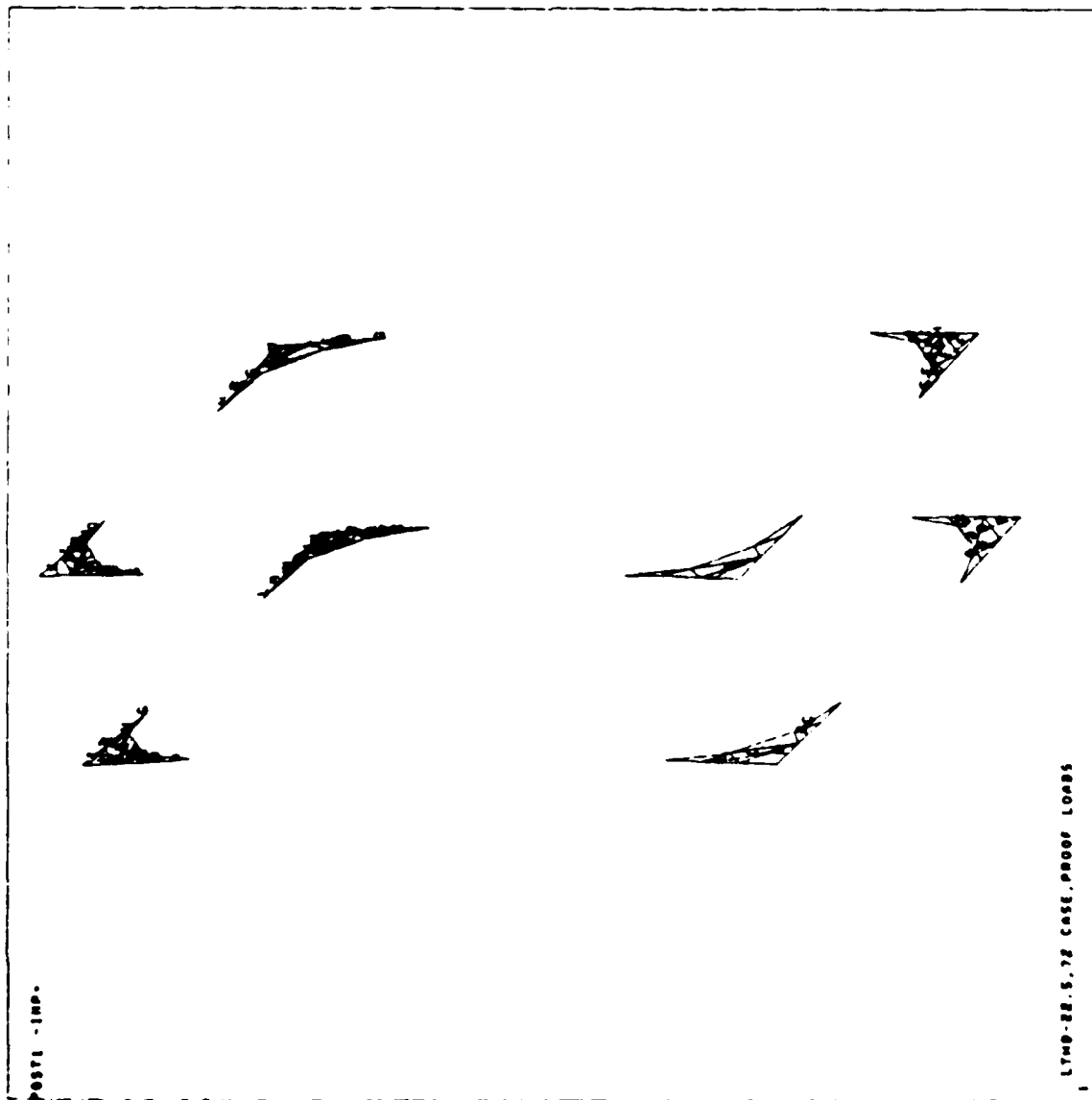
ANSYS 4.28
 JAN 19 1987
 16:00:49
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.394
 SICE
 TOP
 ZOOM
 RV=-1
 VU=-1
 ZU=1
 1 0.187-7.47
 2 22-42.4
 3 VF-61.5
 4 ZF-8.18
 5 XRT0-1.23
 6 VRT0-1.08
 7 MIDDLE
 8 RK-27874
 9 RM-718
 10 A-1930
 11 B-2746
 12 C-5562
 13 D-2378
 14 E-9194
 15 F-11910
 16 G-12826
 17 H-14642
 18 I-16458
 19 J-18274
 20 K-20090
 21 L-21906
 22 M-23722
 23 N-25530
 24 O-27354



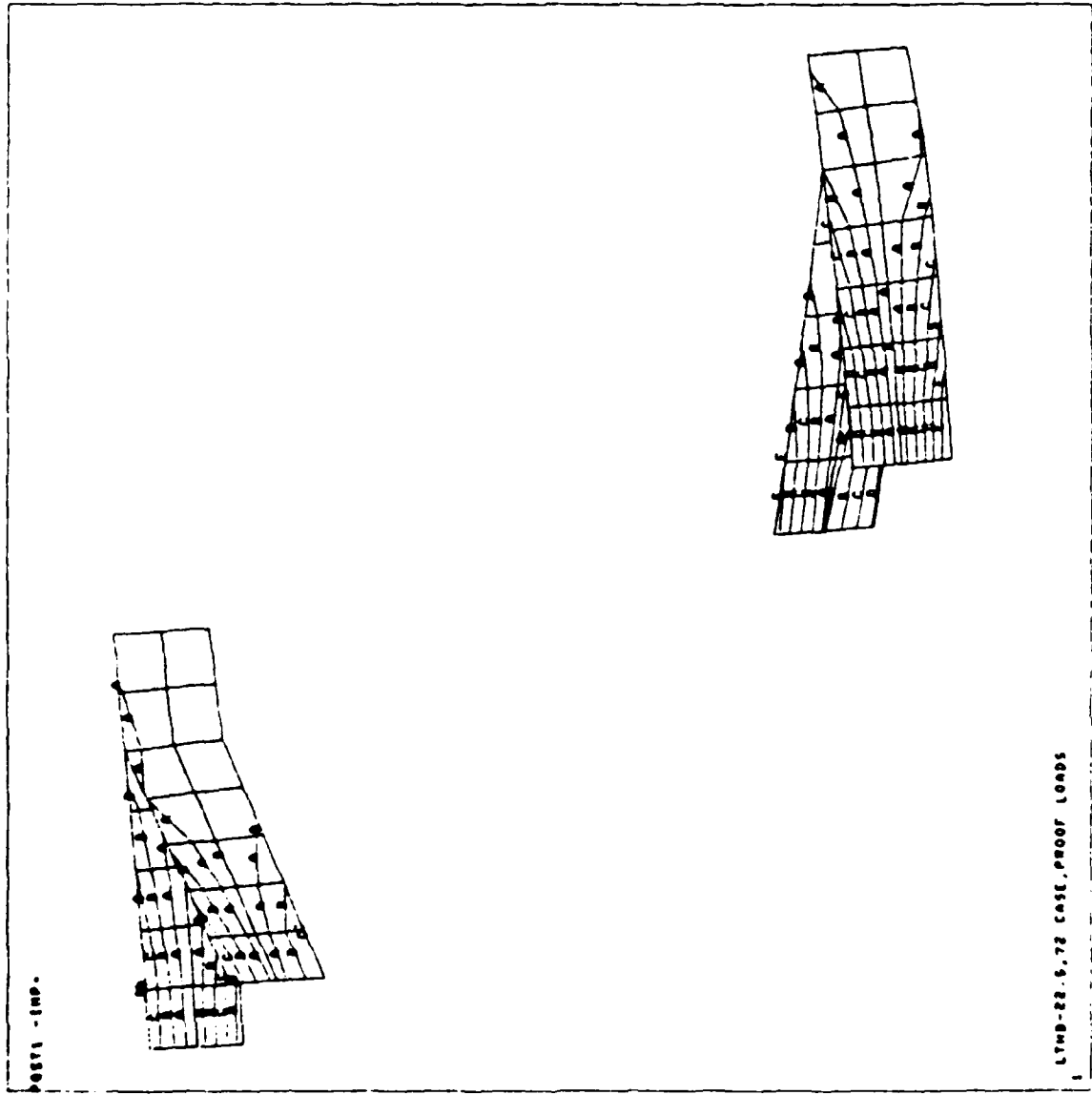
LYMB-22.5.72 CASE, PROOF LOADS

ANSYS 4.80
 JAN 19 1987
 16:00:27
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.304
 SICE
 TOP
 ZOOM
 RV=1
 VU=1
 20=1
 DIST=86.8
 SF=53
 VF=23.6
 ZF=-3.5
 WOTO=1.23
 WOTO=1.08
 MIDELM
 ME=98794
 ME=3461
 A=6290
 B=8124
 C=11858
 D=14792
 E=17626
 F=20450
 G=23294
 H=26128
 I=28962
 J=31786
 K=34630
 L=37464
 M=40288
 N=43132
 O=45966

GIMBAL REINFORCEMENTS

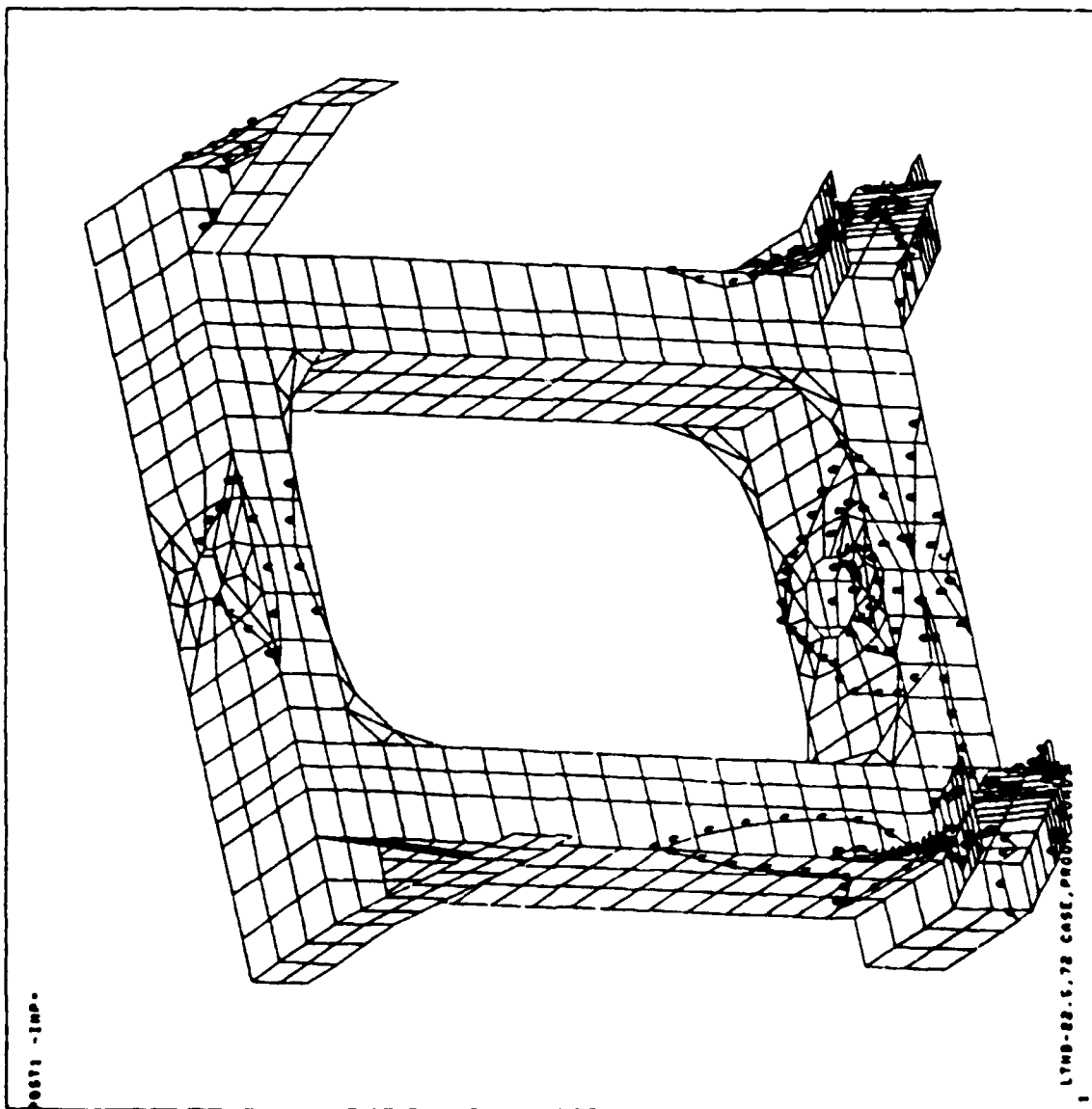


ANSYS 4.20
 JAN 19 1987
 16118116
 POST1 STRESS
 STEP=1
 ZEP=1
 TIME=.304
 SLOC
 TOP
 ZOOM
 KU=1
 VU=1
 ZU=1
 DISP=19.4
 XF=57.1
 YF=53.3
 ZF=-13.8
 XRTD=1.23
 YRTD=1.08
 MI00EN
 RM=251001
 RM=17469
 A=66556
 B=95603
 C=134720
 D=173817
 E=212004

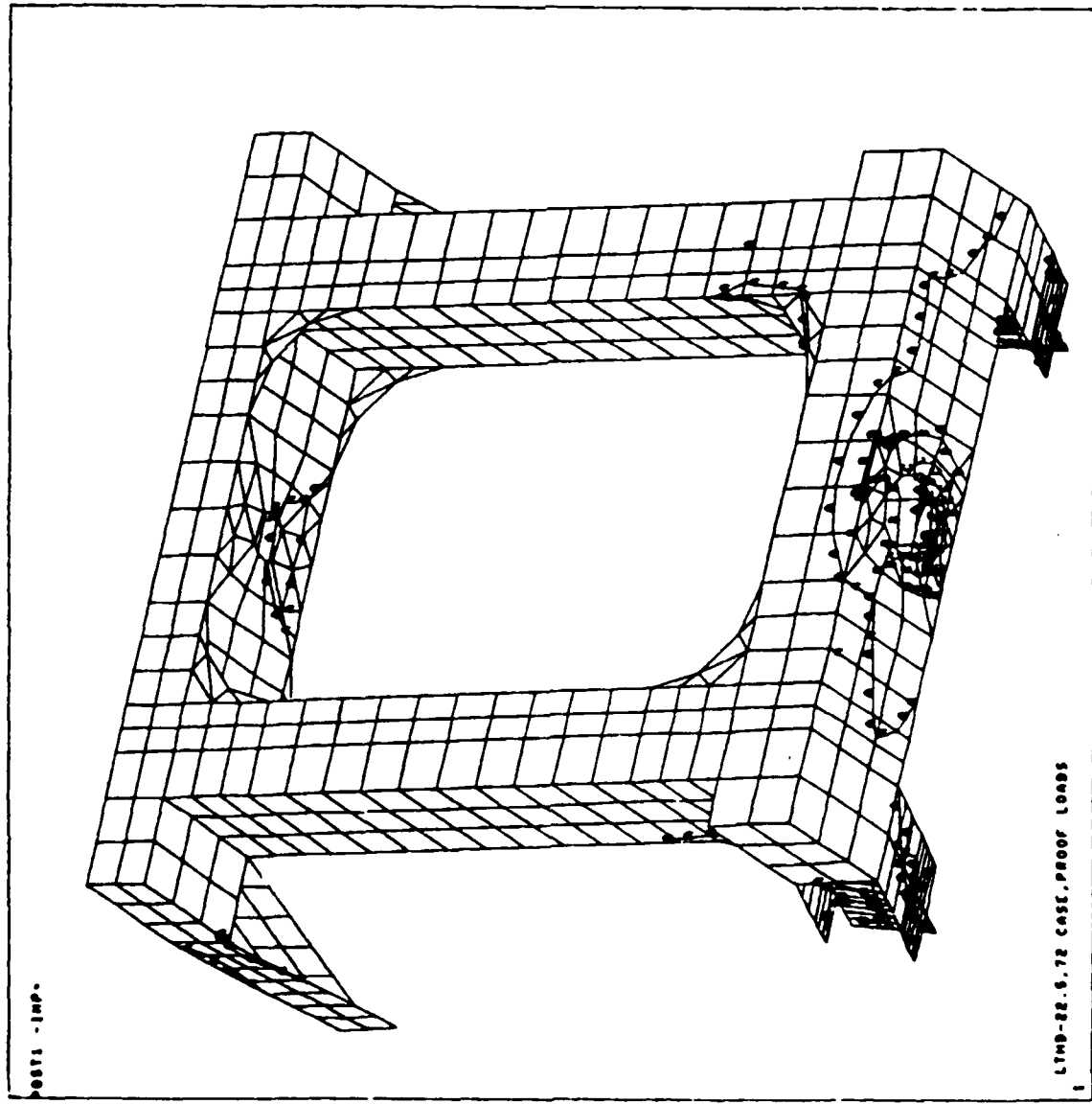


UPPER GIMBAL
MOUNTS

ANSYS 4.80
 JAN 20 1987
 17:09164
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.004
 SICE
 TOP
 NU=1
 VU=1
 ZU=-1
 DIST=88.7
 XF=53.8
 YF=35
 ZF=-7.83
 MIDDLE
 RX=165002
 MY=284
 A=27735
 B=55188
 C=82843
 D=110097
 E=137551

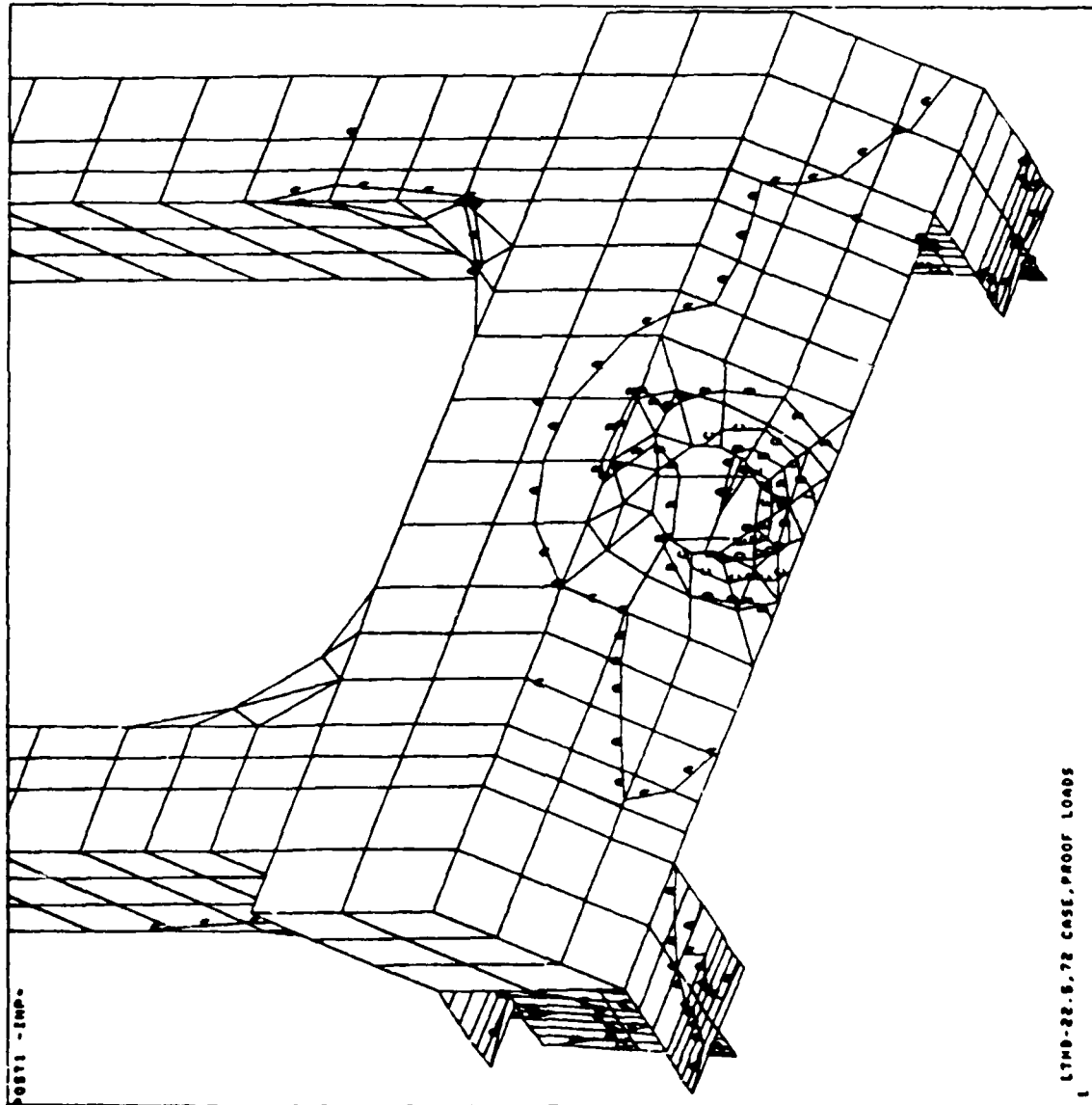


ANSYS 4.08
 JAN 20 1987
 16:25:07
 POST1 STRSS
 STEP=1
 ITEM=1
 TIME=.084
 SECT
 TOP
 KU=-1
 VU=-1
 ZU=1
 S1S7=25.7
 XF=63.9
 YF=26
 ZF=-7.93
 M100EM
 RM=165003
 RM=284
 A=27726
 B=56109
 C=22643
 D=110097
 E=137551



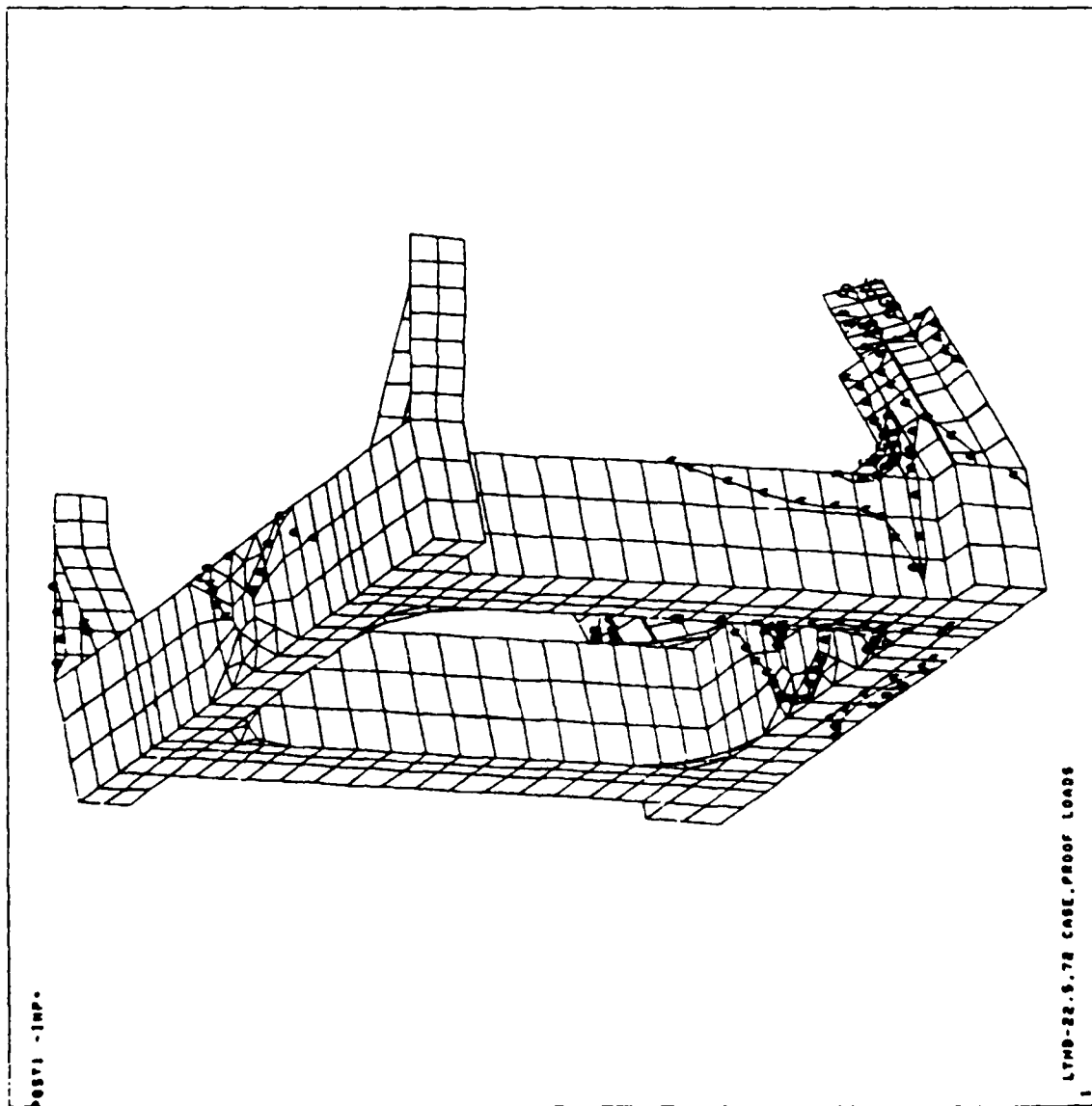
POST1 -IMP.

LTMP-22.5.72 CASE, PROOF LOADS



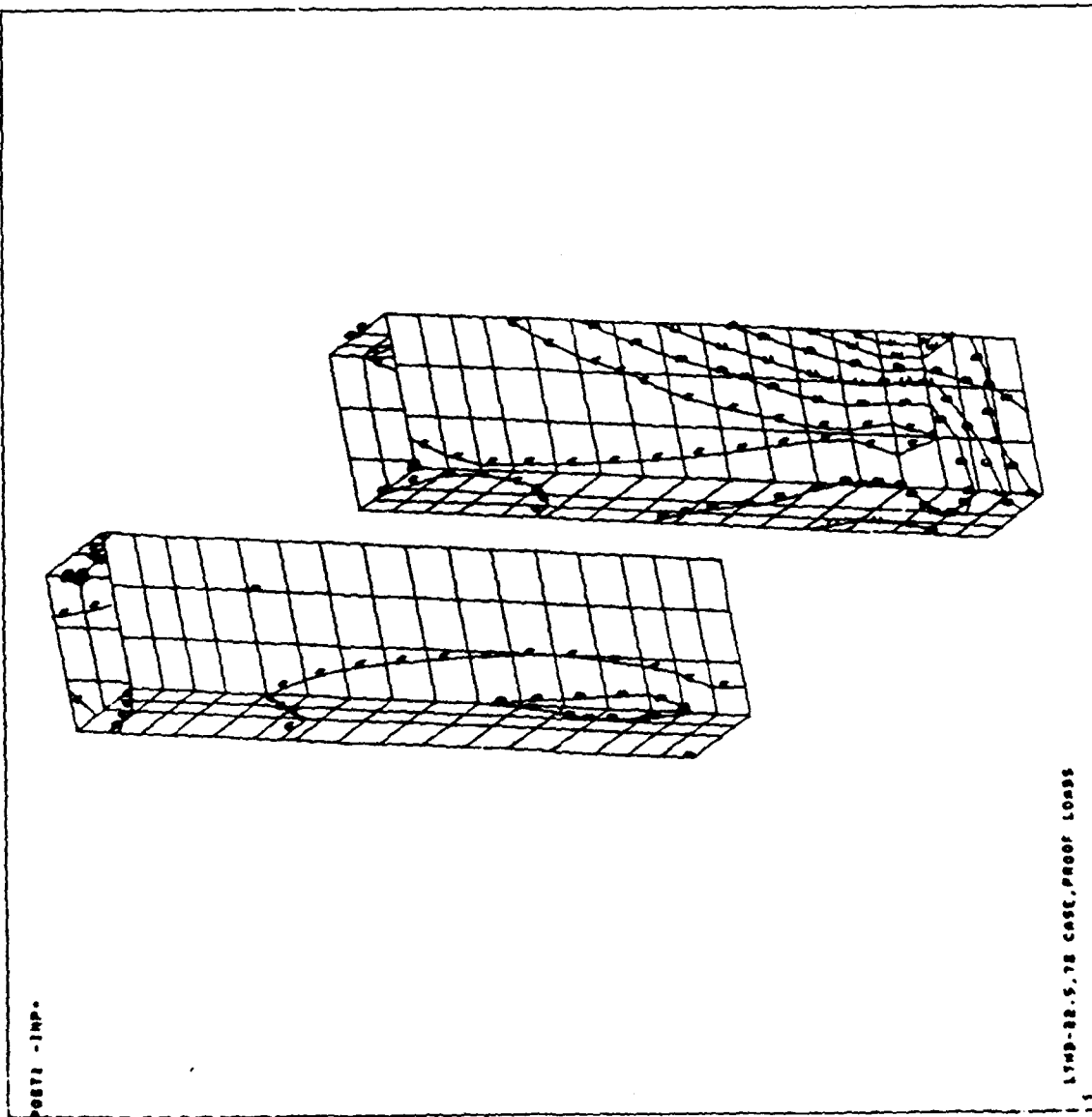
ANSYS 4.80
 JAN 20 1987
 10125107
 POST1 STRSS
 STEP=1
 ITER=1
 TIME=.004
 SICE
 TOP
 ZOOM
 MU=-1
 VU=-1
 ZU=1
 * D157-22.2
 * MF-60.3
 * VF-22.4
 * ZF--14.2
 VRT0=1.00
 MIDELM
 MX=165003
 MY=0
 A=27735
 B=55100
 C=82643
 D=110097
 E=137551

ANSYS 4.20
 JAN 20 1987
 17105134
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.004
 SICE
 TOP
 KU=1
 VU=1
 ZU=1
 DIST=34.9
 WF=57.3
 VF=33.9
 ZF=-7.62
 MIDDEN
 MX=165003
 MY=284
 A=27735
 B=55189
 C=82643
 D=110097
 E=137551

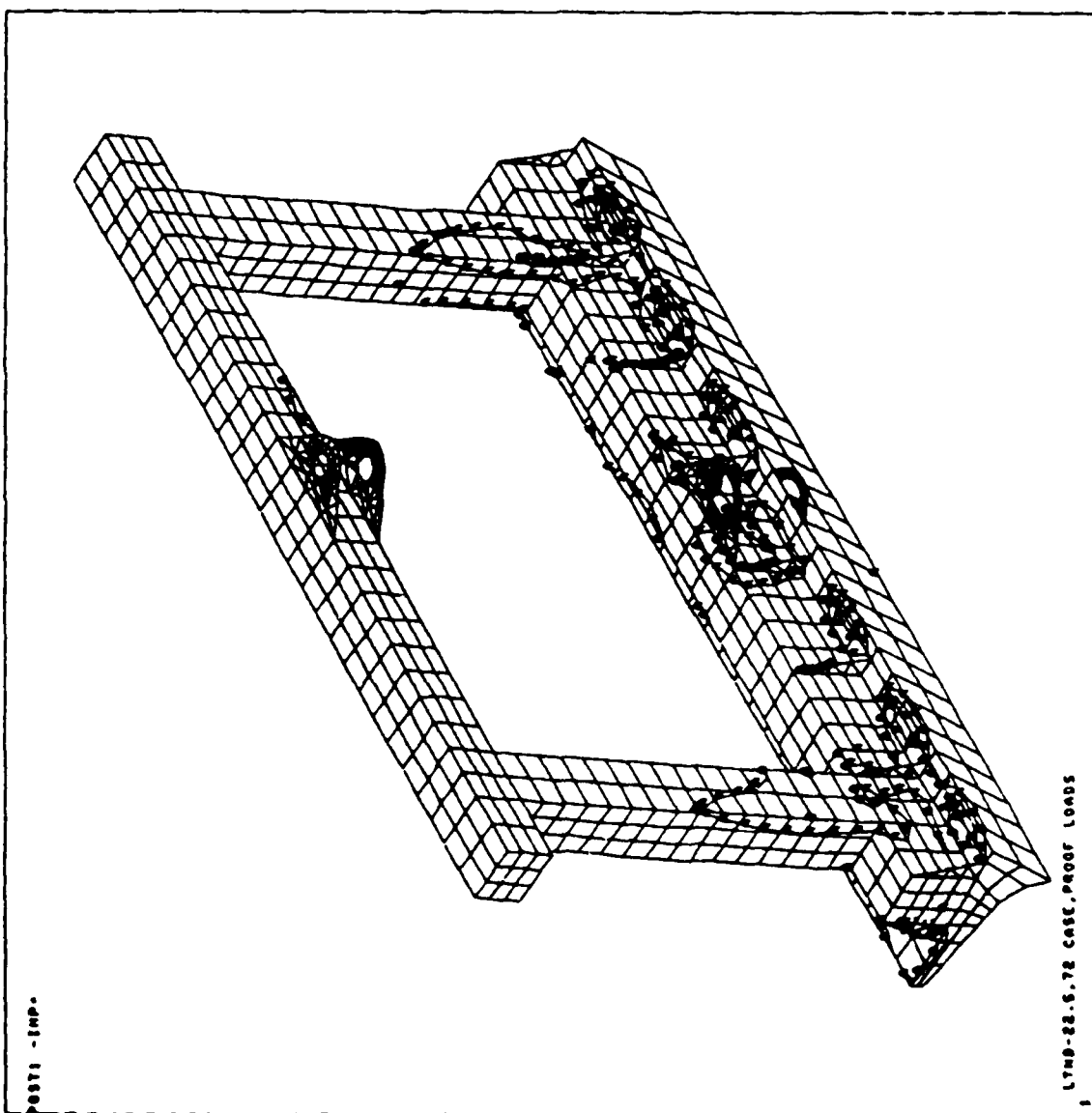


ANSYS 4.88
 JAN 29 1987
 17:30:12
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.004
 SLOC
 TOP
 ZOOM
 KU=1
 VU=1
 ZU=1
 D157=32.2
 KF=53
 VF=33.8
 ZF=-3.5
 KRT0=1.18
 VRT0=1.14
 M188CM
 RK=51658
 RM=2747
 A=9738
 B=16719
 C=23786
 D=38693
 E=37680
 F=44687

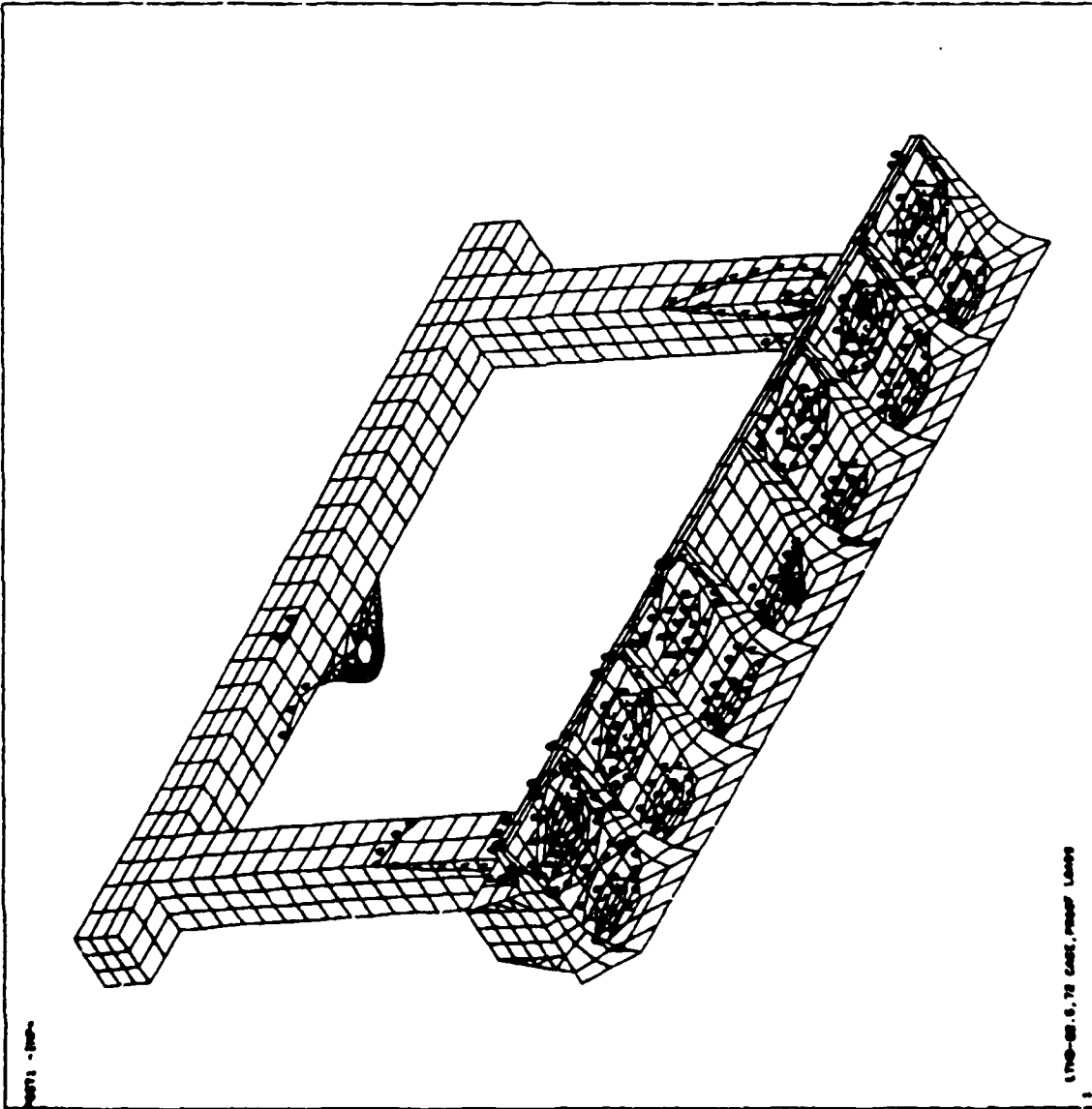
GIMBAL
 VERTICAL
 BOX BEAMS



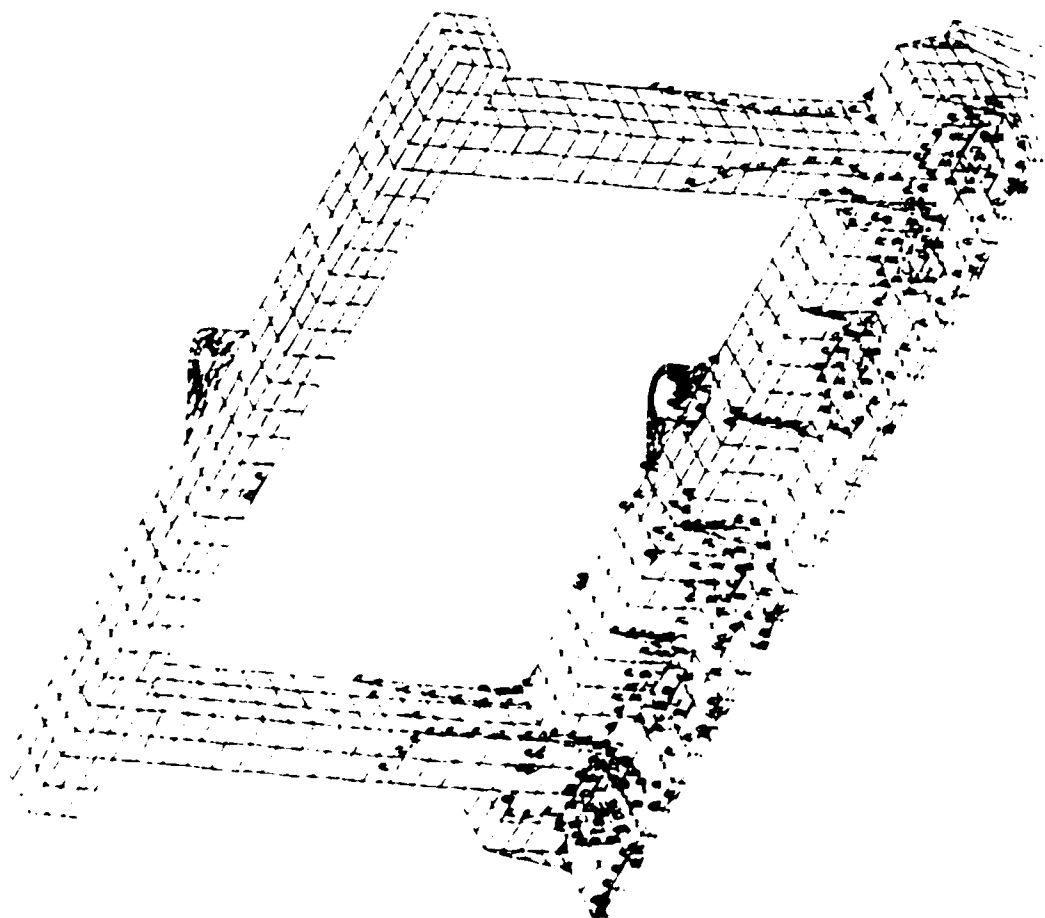
ANSYS 4.28
 JAN 20 1987
 17112152
 POST1 STRESS
 STEP=1
 TIME=1
 TIME=0.004
 SLOC
 TOP
 KU=1
 VU=1
 ZU=-1
 9187-88.2
 XF-54.2
 YF-26.4
 ZF-4.85
 MIDDLE
 RX-149027
 RM=400
 A=25170
 B=48042
 C=74714
 D=99486
 E=124258



ADP75	4.25
JAN 06 1987	
16:11:00	
PAGE1	0.00E+00
STEP=1	
TIME=1	
TIME=0.004	
SIE	
TOP	
MU=-1	
VU=-1	
ZV=-1	
DIST=0.0	
W=50.2	
VF=50.4	
ZF=4.19	
HISZIN	
MC1=0.0007	
MM=0.00	
B=0.5179	
C=0.00	
C=0.714	
E=0.0002	
S=1.2456	



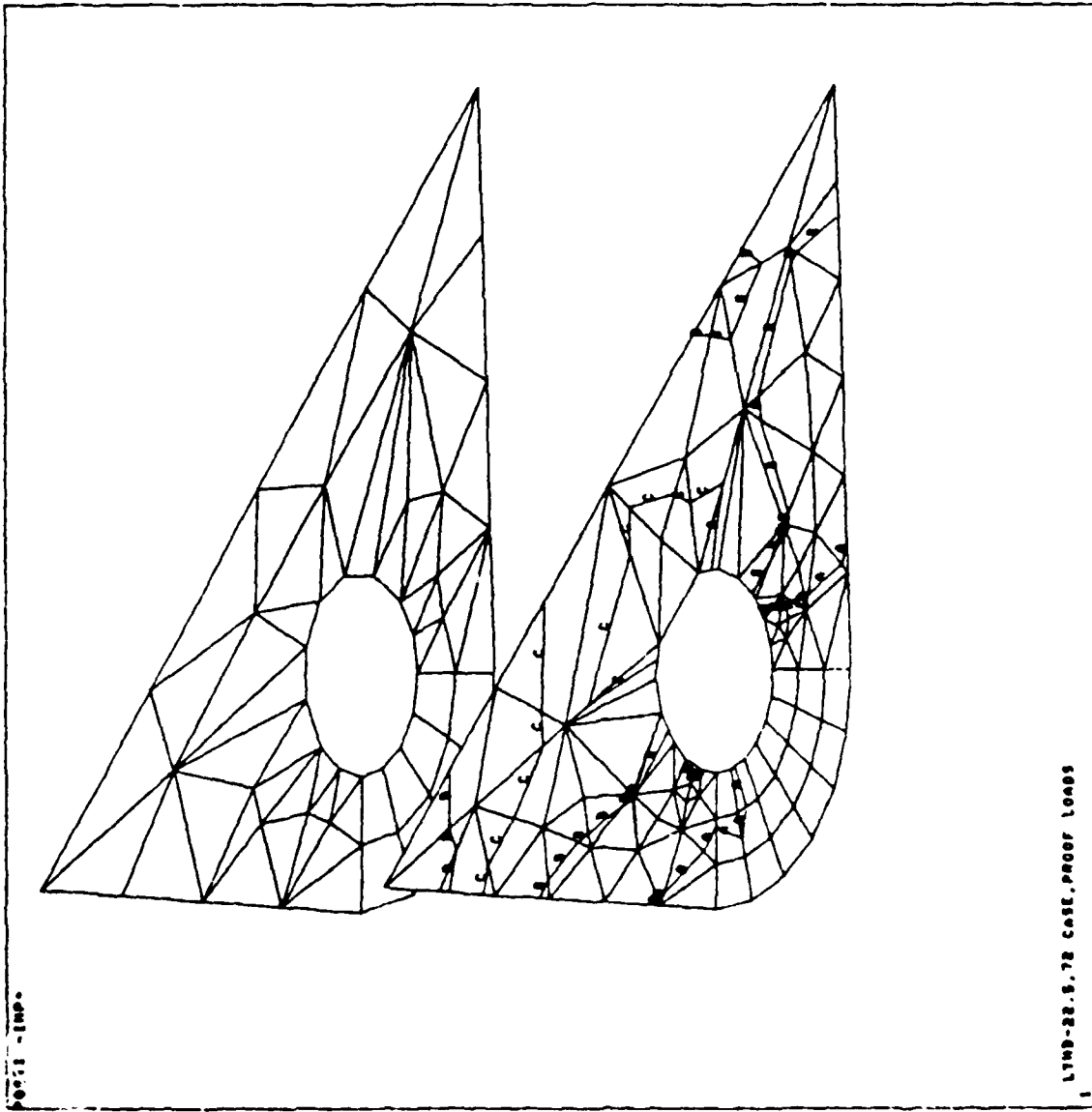
ARVLS 4.20
 JAN 20 1987
 16:12:27
 POST1 STRESS
 STEP=1
 TIME=1
 TIME= .004
 SIZE
 TOP
 RU=1
 VU=1
 ZU=1
 DIS=56.6
 SF=51.2
 VF=27.7
 ZI=4.17
 MIDDLE
 PK=149027
 RM=400
 A=25170
 B=40042
 C=74714
 D=99486
 E=124258



POST1 -IMP.

LTNG=22.5, 72 CASE, PRCL, LINES

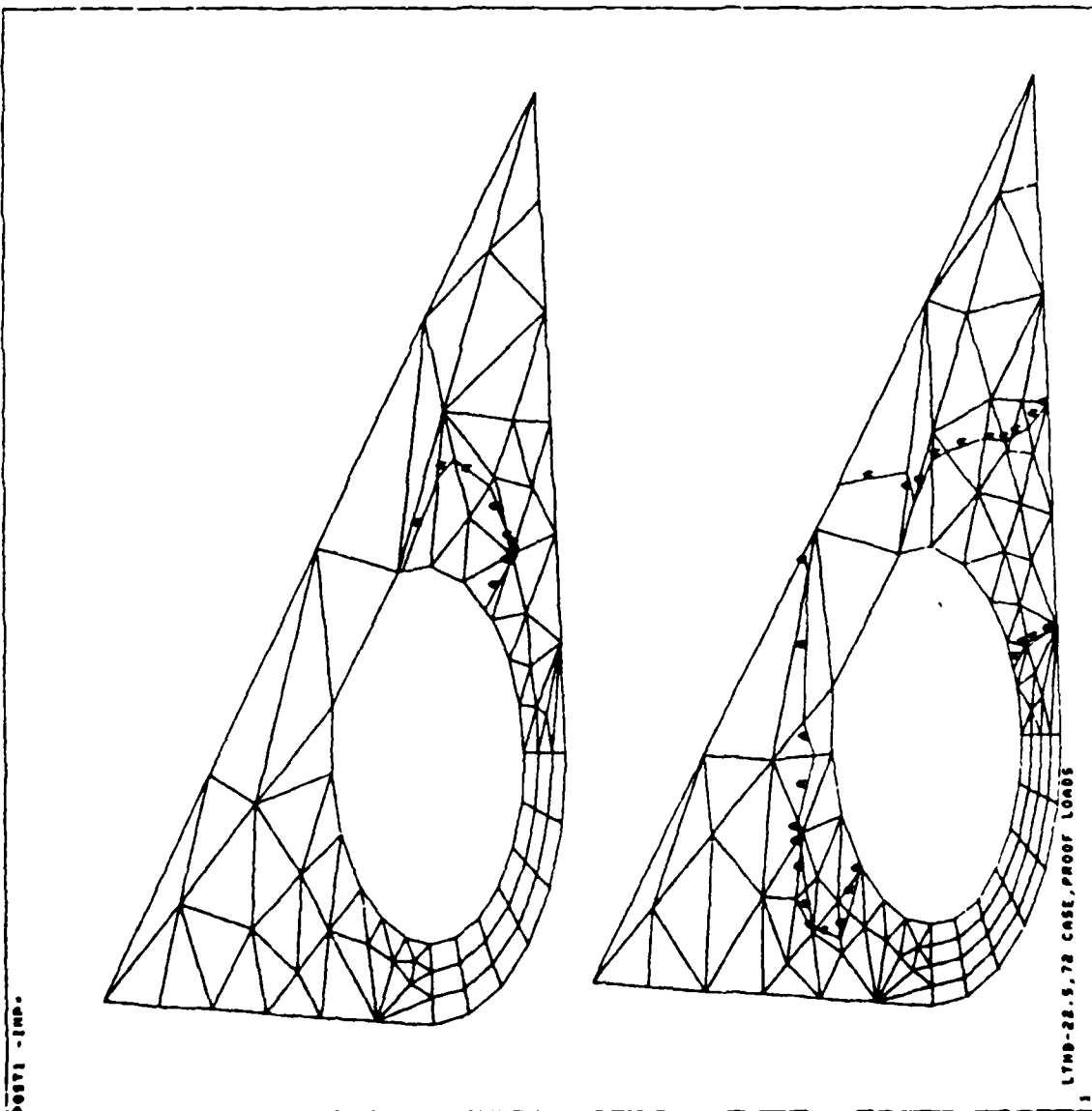
ANSYS 4.20
 JAN 20 1987
 17:24:23
 POST1 STRSS
 STEP=1
 IYEA=1
 TIME=.004
 SICE
 TOP
 ZOOM
 RV=-1
 VU=-1
 ZU=1
 DIST=8.74
 RF=3.4
 VF=48
 ZF=7.66
 XRT0=1.18
 YRT0=1.14
 HIDDEN
 NH=16884
 NH=519
 A=2816
 B=7316
 C=10716
 D=14116



TOP TABS

549

ANSYS 4.20
 JAN 20 1987
 17:28:47
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.004
 SIZE
 TOP
 ZOOM
 RU=-1
 VU=-1
 20=1
 DIST=7.73
 8 MP=65.8
 8 VP=17.6
 8 ZF=-13.5
 H870=1.18
 HIDDEN
 RH=54913
 RH=1980
 A=27726



BOTTOM
 TABS

550

(11)

ANSWER 4.20
JAN 06 1907
1.272160
POSTAL STRESS
STEP-1
ITER-1
TIME=0.084
SIC
TOP
200M
XU-1
VO-1
20-1
DIST-18.7
HF-57.1
VF-57.3
ZF-13.8
VHTO-1.18
VHTO-1.14
MINI00CM
MM-4816
MM-484
a-7180
a-7185
C-80706
E-87634
E-34472
F-41310

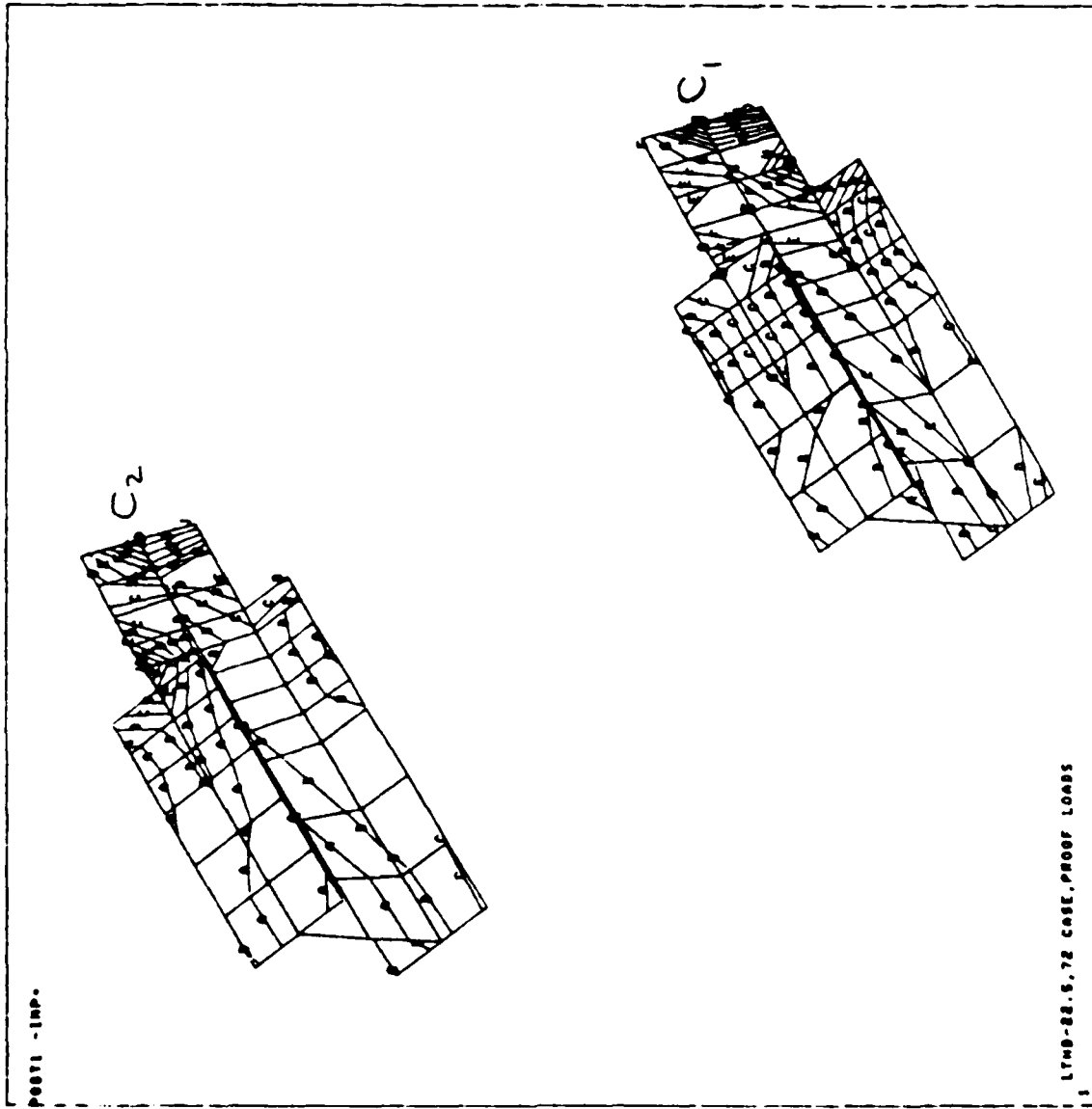


TOP ARMS,
GIMBAL

155

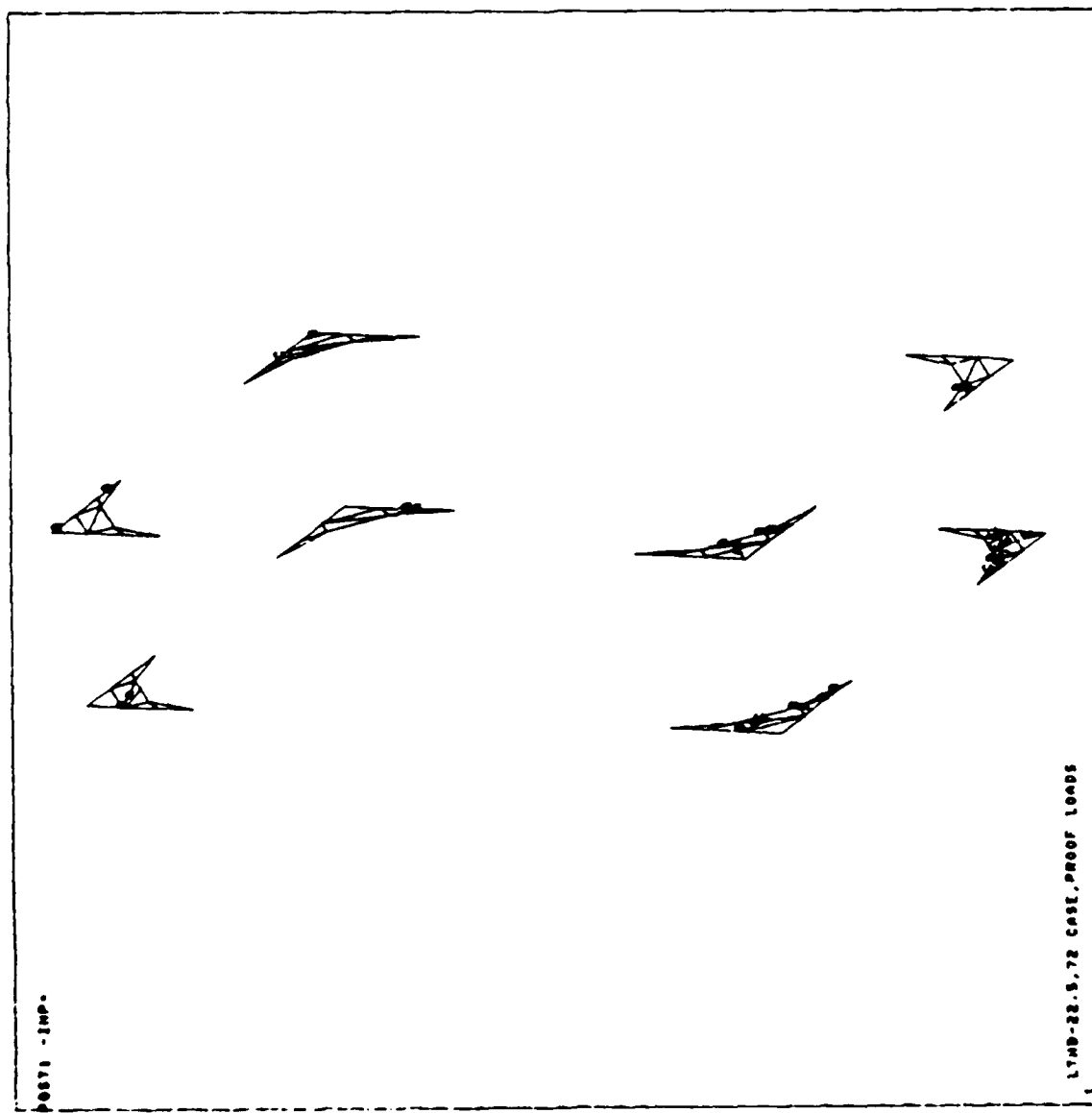
59

ANSYS 4.00
 JAN 20 1987
 17126100
 POST11 STRESS
 STEP=1
 ITER=1
 TIME=.004
 SLOC
 TOP
 ZOOM
 XU=1
 YU=1
 ZU=1
 B157.80
 XF=57.3
 YF=14.2
 ZF=-12.7
 XRT0=1.18
 YRT0=1.14
 MIDDEN
 MM=163566
 MM=6289
 A=15458
 B=24666
 C=33872
 D=43070
 E=52286
 F=61493
 G=70700
 H=79907
 I=89114
 J=98321
 K=107520
 L=116735
 M=125942
 N=135140
 O=144356



LOWER
 GIMBAL
 ARMS

ANSYS 4.20
 JAN 20 1987
 17:28:36
 POST1, STRESS
 STEP=1
 ITER=1
 TIME=.004
 S10E
 TOP
 ZOOM
 RU=1
 VU=1
 VU=1
 0167-28.5
 VF=53
 VF=33.6
 ZF=-3.5
 MISO=1.18
 MISO=1.14
 MISOEN
 MISO=45780
 MISO=3249
 A=8408
 B=15473
 C=21537
 D=27601
 E=23655
 F=38728



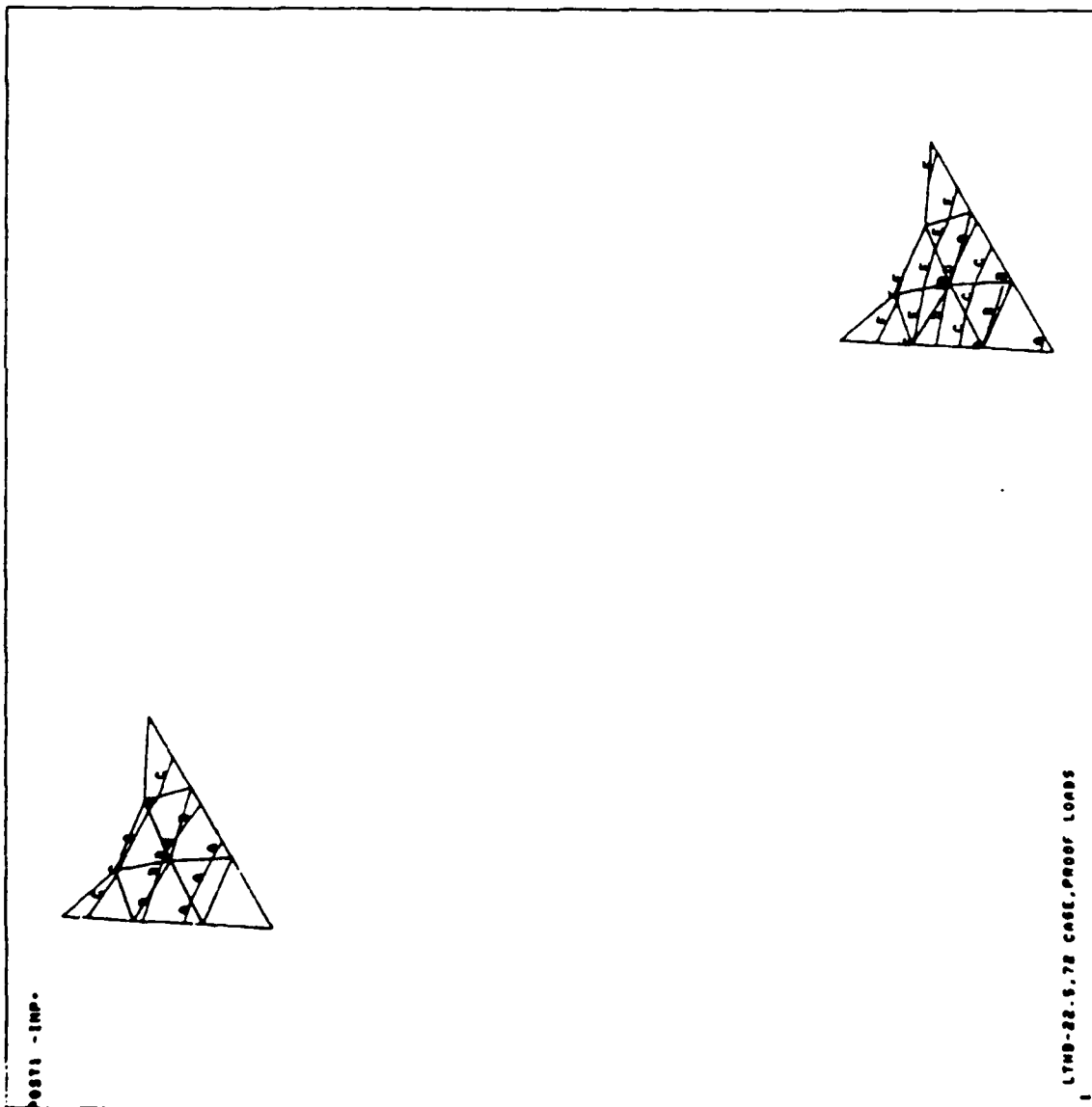
POST1, -IMP-

1, LTHB-22.5.72 CASE, PROOF LOADS

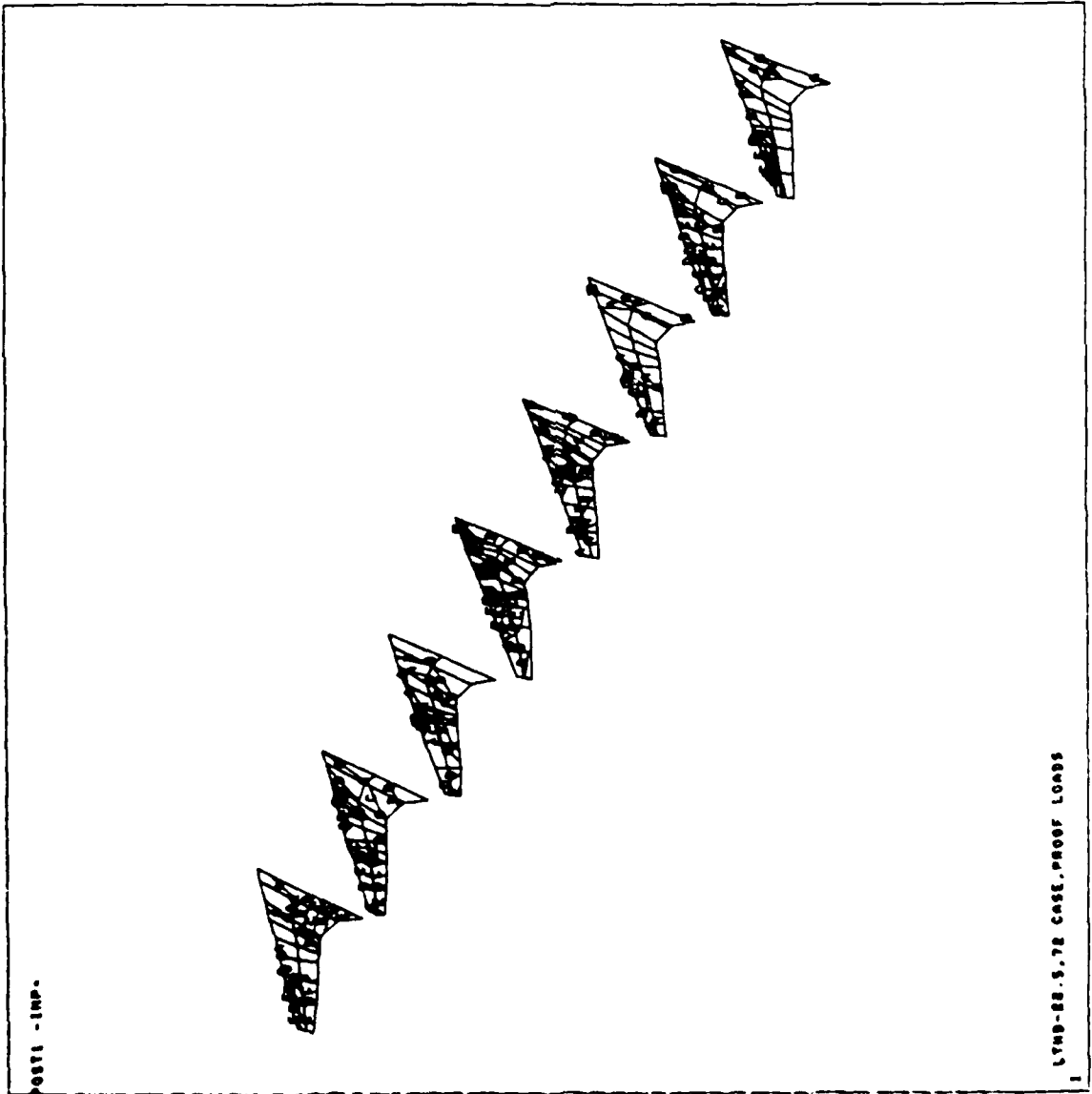
GIMBAL
 REINFORCING-
 TABS

ANSYS 4.20
 JAN 20 1987
 17132107
 POST1 STRESS
 STEP=1
 TIME=1
 TIME=.084
 SIZE
 TOP
 ZORR
 RU=1
 VU=1
 ZU=1
 D187-14.8
 XF-56.8
 YF-17.4
 ZF-8.97
 WRT0-1.18
 VRT0-1.14
 MIDDE
 MM-110534
 MM-18647
 A-31772
 B-44000
 C-58027
 D-71154
 E-84281
 F-97402

GIMBAL
 LOWER
 ARM
 REINFORCING
 TABS

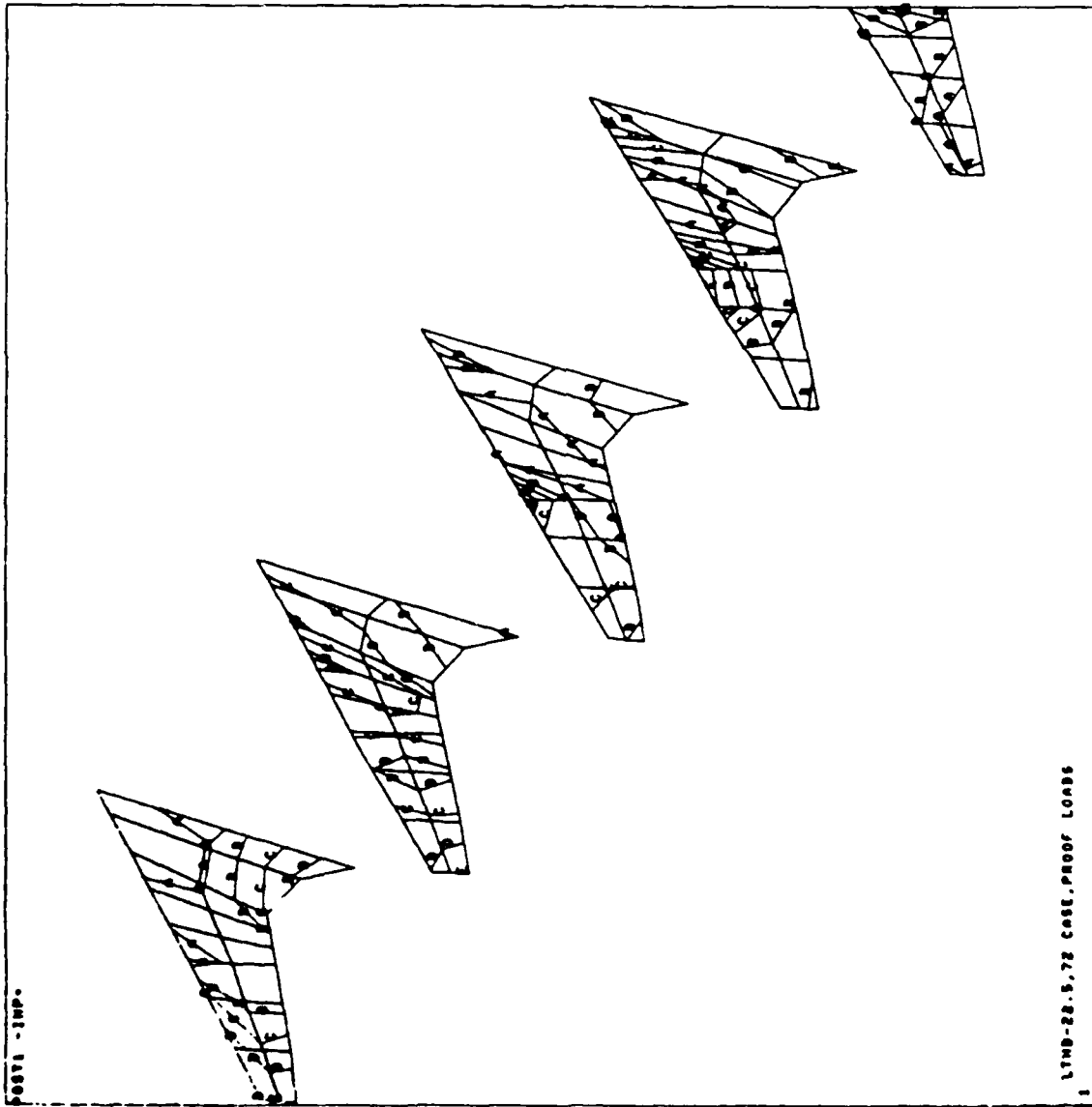


ANSYS 4.20
 JAN 20 1987
 17:38:22
 POST1, STESS
 STEP=1
 ITER=1
 TIME=.004
 SLOC
 TOP
 ZOOM
 XU=1
 YU=1
 ZU=1
 D167=57.8
 X7=52.3
 Y7=-1.87
 Z7=5.33
 KATO=1.18
 VATO=1.14
 MIBEN
 RM=44078
 MM=8488
 A=8487
 B=14369
 C=20311
 D=28253
 E=32195
 F=38137

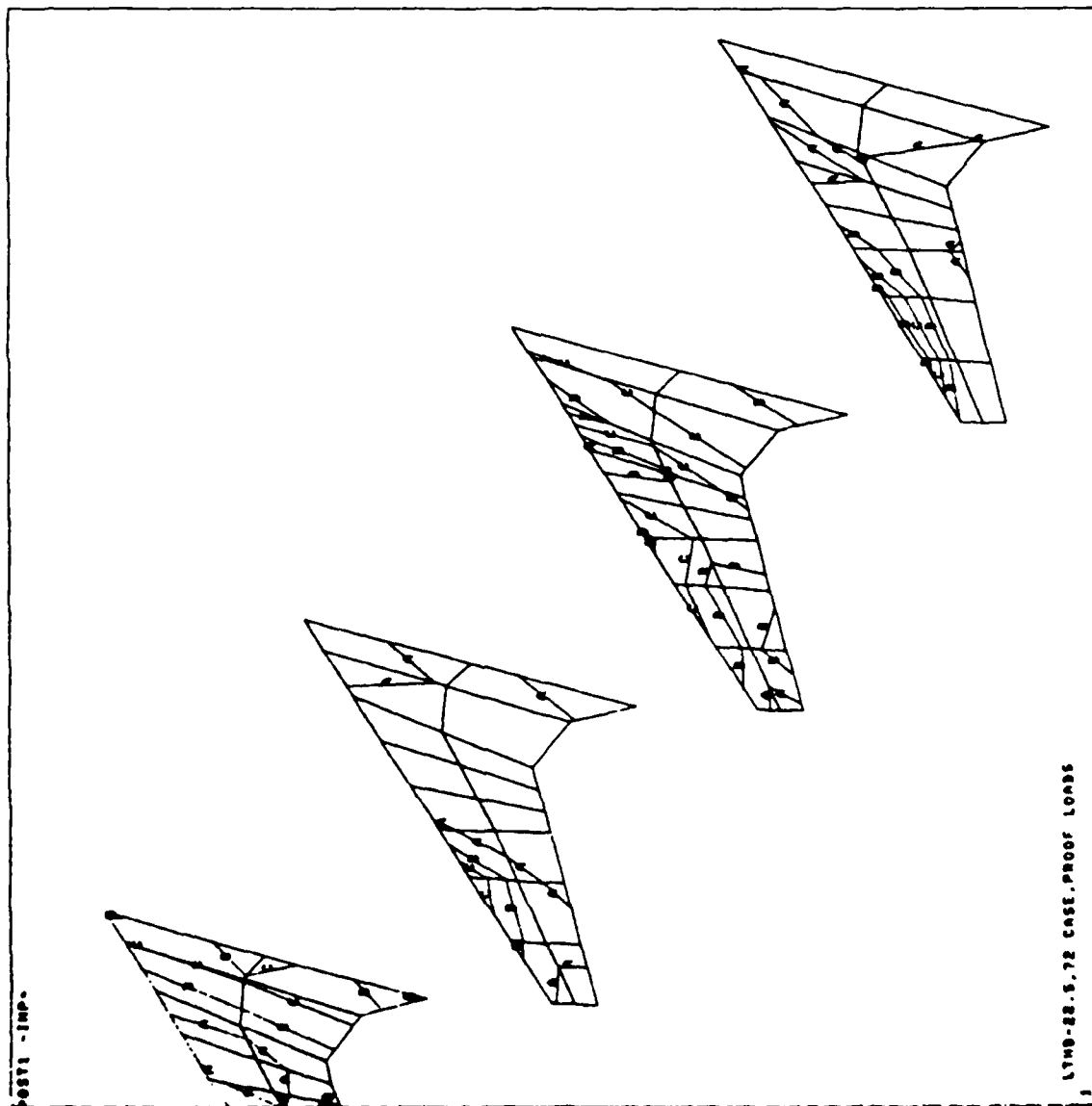


PLATFORM
 SPADE
 REINFORCING-
 VERTICAL
 ELEMENTS

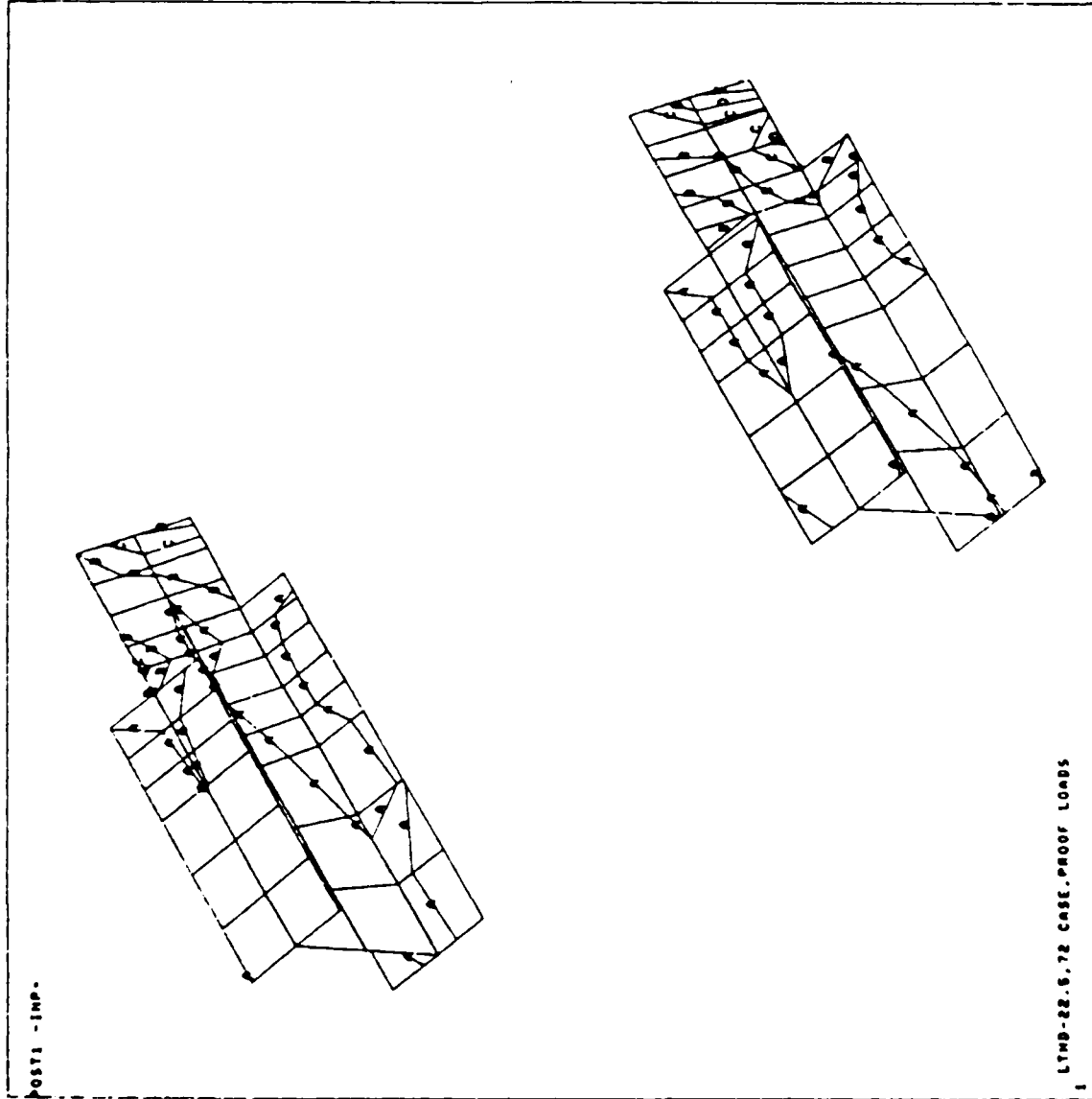
ANSYS 4.80
 JAN 20 1987
 17:38:33
 POST1 STRESS
 STEP=1
 ITEM=1
 TIME=.084
 SLOE
 TOP
 ZOOM
 KU=1
 VU=1
 ZU=1
 0 DIST=49.8
 8 XF=35.1
 8 VF=8.11
 8 ZF=14.8
 XRTQ=1.95
 VRTQ=2.4
 MIDSEN
 MK=44676
 MM=0
 A=9418
 B=16350
 C=22282
 D=30214
 E=37146



ANSYS 4.20
 JAN 20 1987
 17:37:21
 POST1 STRESS
 STEP=1
 ITEM=1
 TIME=.004
 SICE
 TOP
 ZOOM
 KU=1
 VU=1
 ZU=1
 0 DIS=39.4
 0 KF=75.4
 0 VF=-11.8
 0 ZF=-8.17
 XRTG=1.95
 YRTG=2.41
 MIBDEN
 MM=20179
 MM=2489
 A=9418
 B=18350
 C=22282
 D=30214
 E=31145

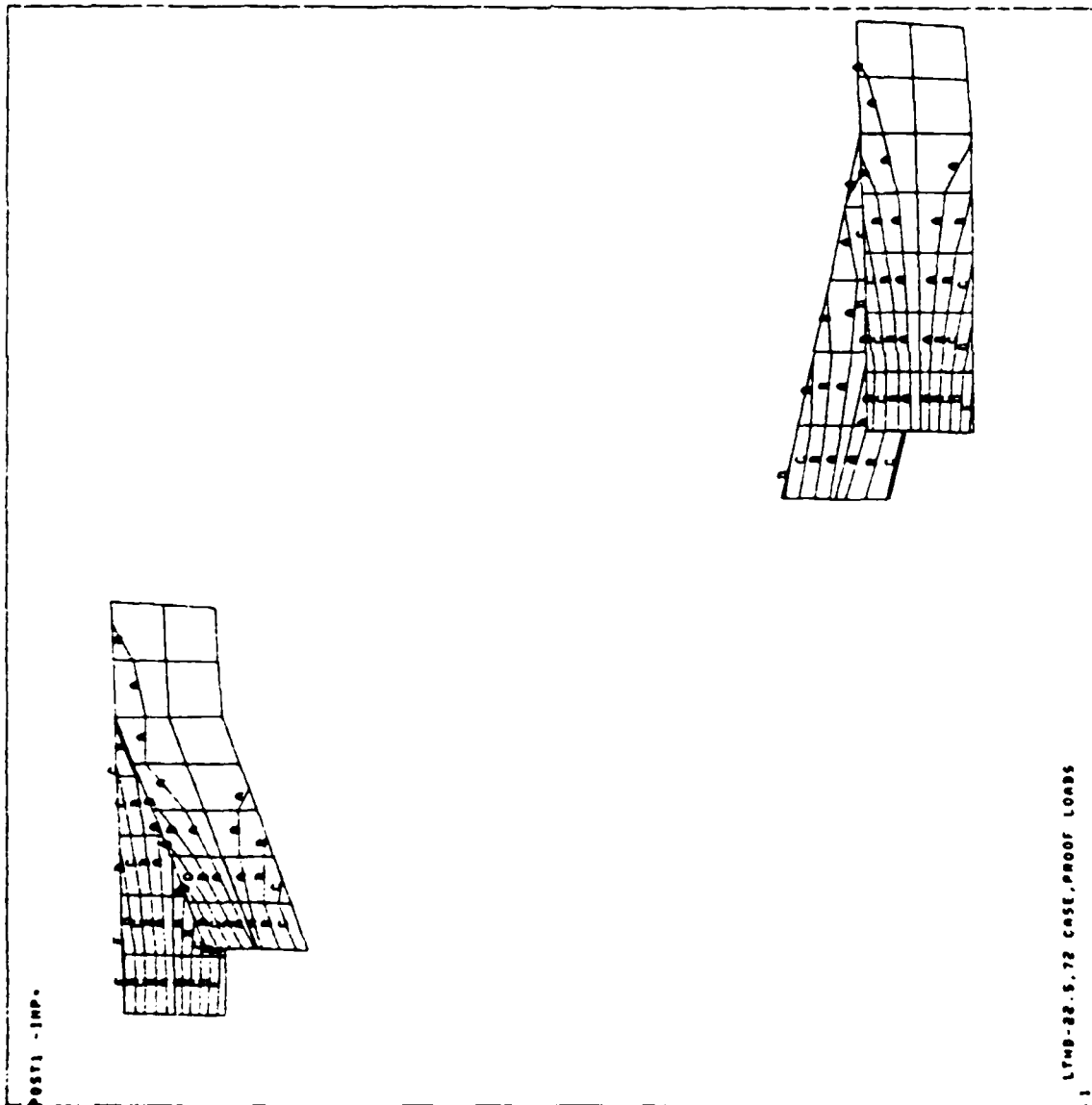


ANSYS 4.08
 JAN 21 1987
 1103110
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.237
 SDOF
 TOP
 ZOOM
 RV=1
 VU=1
 ZU=1
 DIST=21
 XF=57.3
 YF=14.2
 ZF=-12.7
 XROT=1.3
 YROT=1.2
 MIDDLE
 MX=76539
 MY=4261
 A=18306
 B=28353
 C=40400
 D=52447
 E=64494



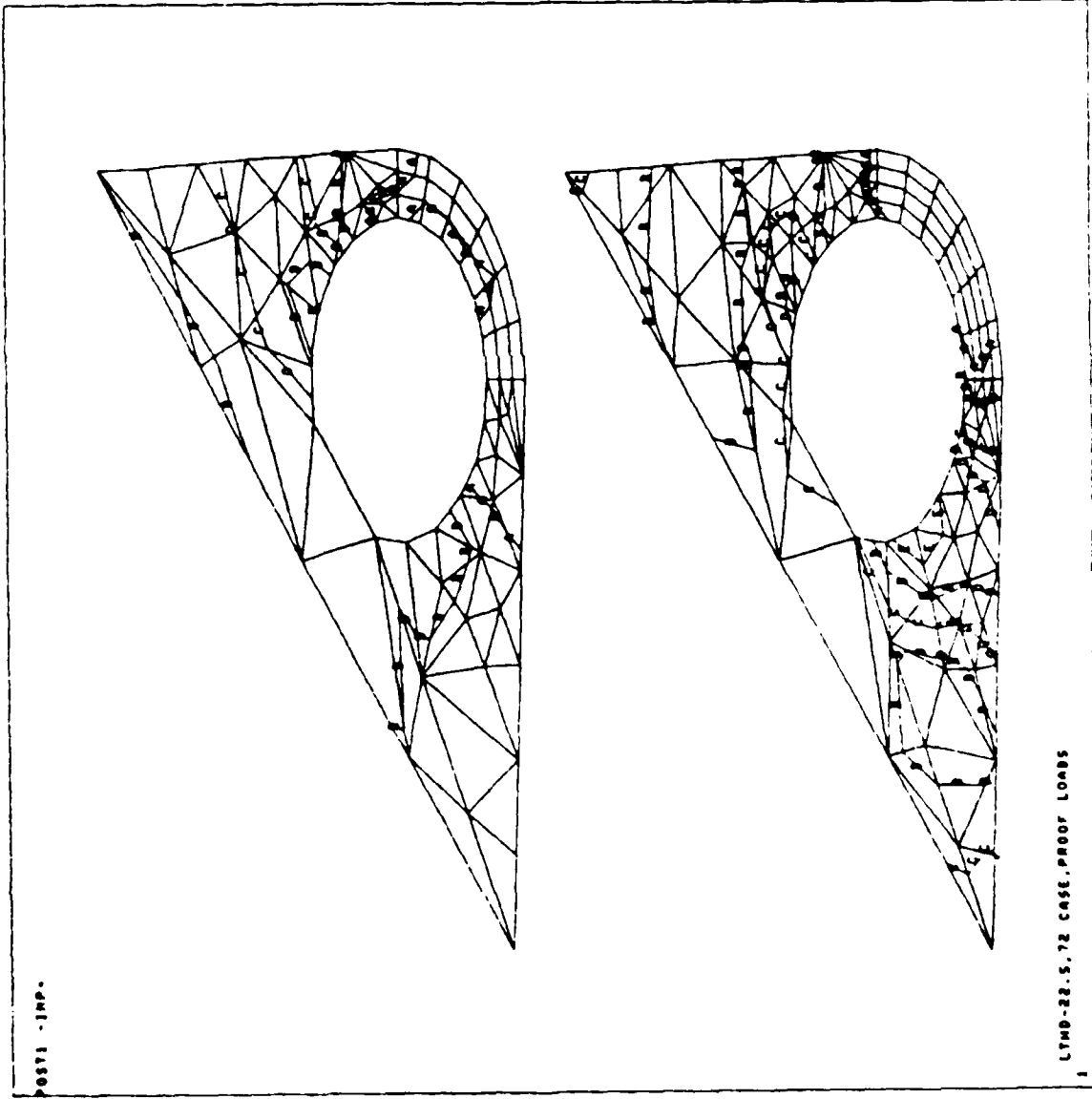
LOWER
 GIMBAL
 ARMS

ANSYS 4.20
 JAN 21 1987
 11:02:22
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.237
 SICE
 TOP
 2004
 XU=1
 YU=1
 ZU=1
 DIST=20.6
 XF=57.1
 YF=53.3
 ZF=13.2
 XRT0=1.3
 YRT0=1.2
 MIDEM
 PK=101923
 AN=8491
 A=2386
 B=39574
 C=55162
 D=70750
 E=86338



TOP
 GMBAL
 ARMS
 561

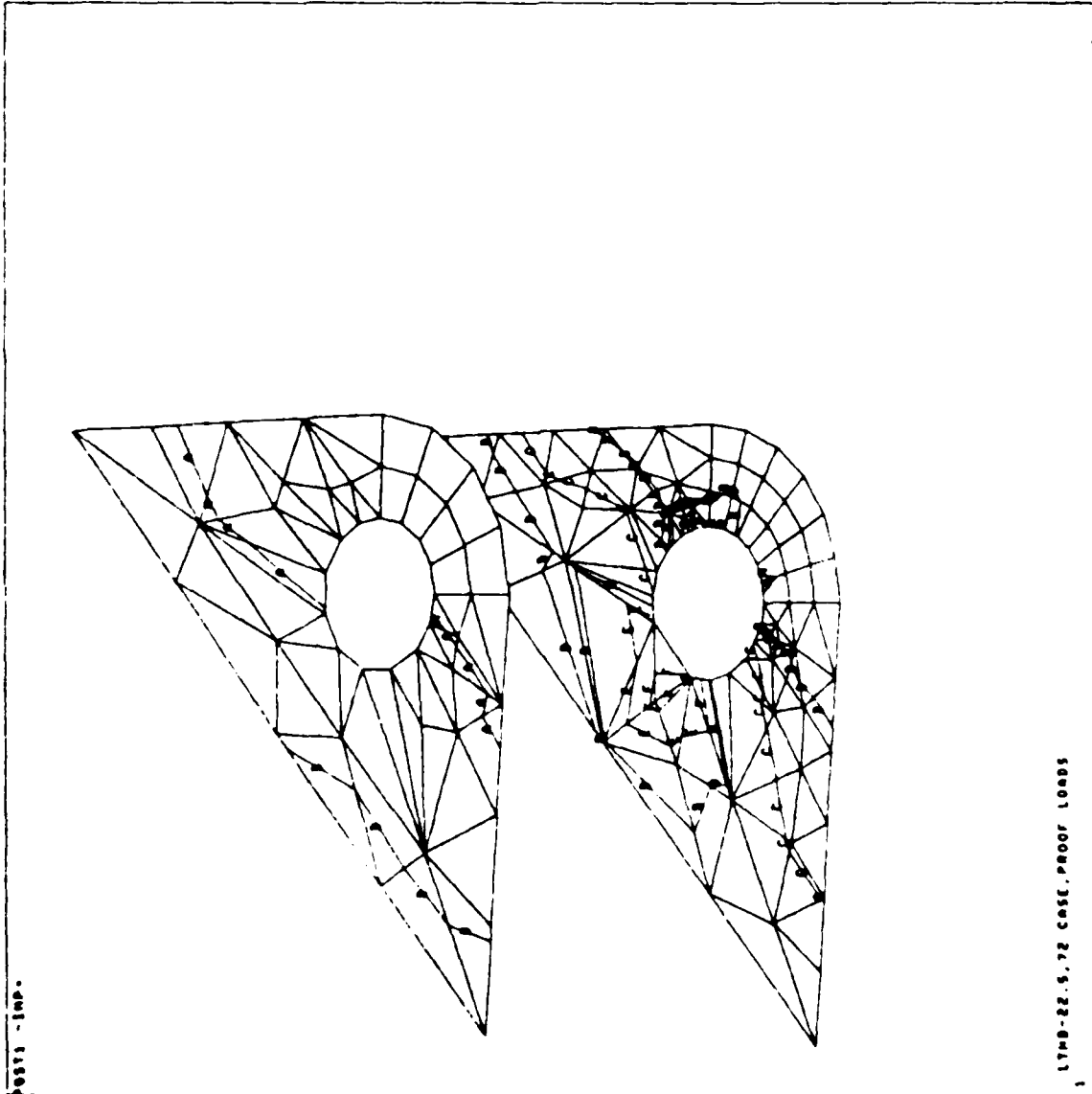
ANSYS 4.20
 JAN 21 1987
 10:59:40
 POST1 STRSS
 STEP=1
 ITER=1
 TIME=.237
 SLOC
 TOP
 ZOOM
 RU=1
 VU=1
 2U=-1
 F BIST-9.76
 F XF-62
 F VF-13.4
 F ZF-9.35
 XRTG-1.3
 VRTG-1.2
 MIDDEN
 RH-28018
 RH-1018
 A-4090
 B-9755
 C-14822
 D-19288
 E-24054



BOTTOM
 TABS

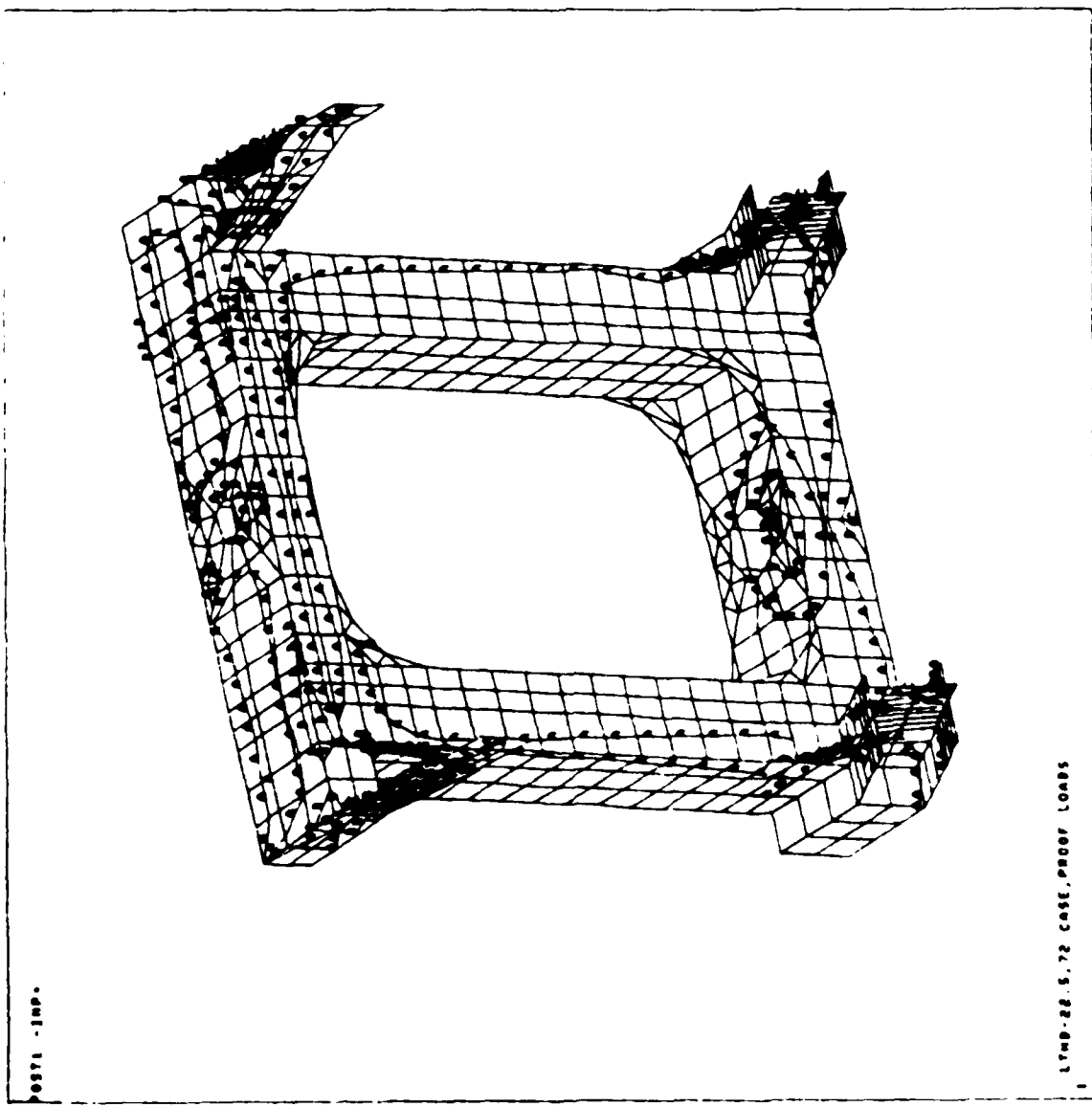
562

ANSYS 4.20
 JAN 21 1987
 10164104
 POST11 STRESS
 STEP=1
 ITER=1
 TIME=.237
 SICE
 TOP
 ZOOM
 RU=1
 VU=1
 ZU=-1
 0 0197-9.72
 0 01-41
 0 01-48.1
 0 01-4.46
 0 01-1.2
 0 01-11016
 0 01-227
 0 01-2013
 0 01-3000
 0 01-5587
 0 01-7374
 0 01-9161
 0 01-10040



TOP
 TABS
 5/2

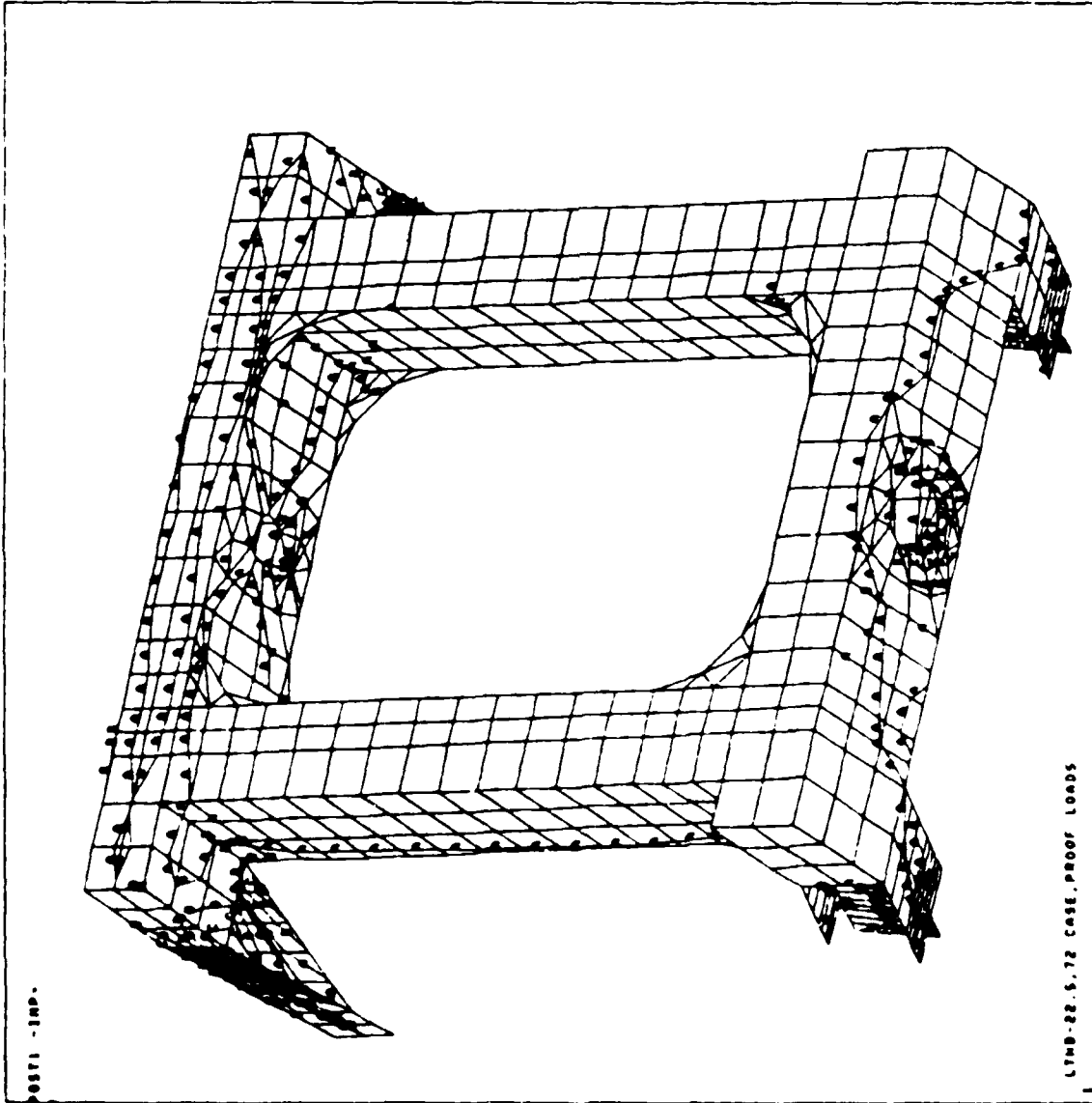
ANSYS 4.20
 JAN 21 1987
 10130115
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.237
 SICE
 TOP
 RV=1
 VU=1
 ZU=1
 E 8157-34.0
 C 46-67.3
 S 46-33.0
 E 26--7.62
 M100EN
 RM-95217
 RM-840
 A-16560
 B-22800
 C-48020
 D-03750
 E-79400



POST1 -IMP.

1 LTM9-22 5.72 CASE, PROOF LOADS

ANSYS 4.20
 JAN 21 1987
 0162154
 POST1 STRESS
 STEP=1
 LAYER=1
 TIME=.037
 SIZE
 TOP
 KU=-1
 VU=-1
 ZU=1
 0157-20.7
 XF=53.9
 VF=35
 ZF=-7.93
 MIDDEN
 RX=85217
 RM=840
 A=16568
 B=32200
 C=48020
 D=63758
 E=79400



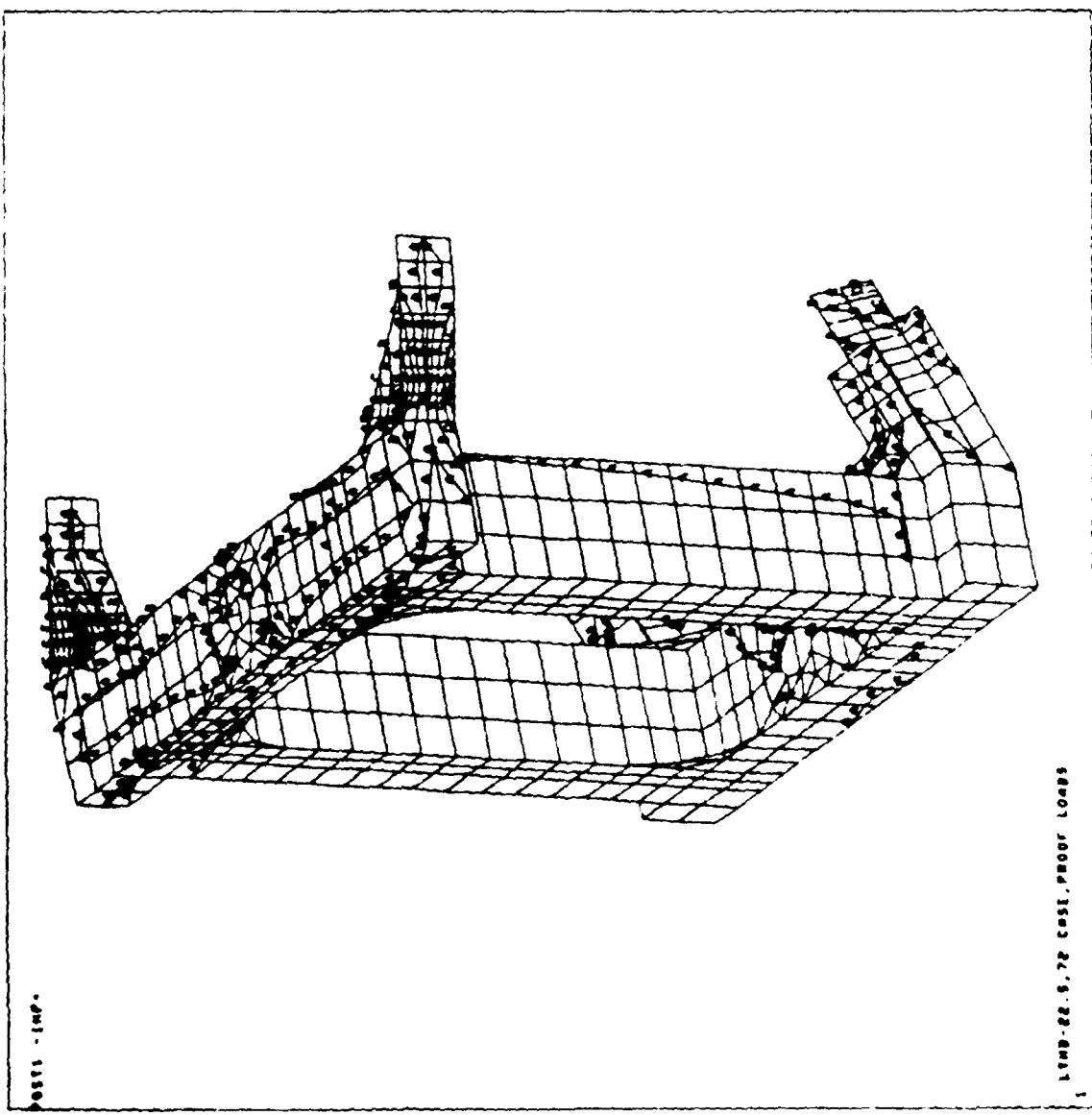
POST1 -IMP.

LTMB-22.5.72 CASE, PROOF LOADS

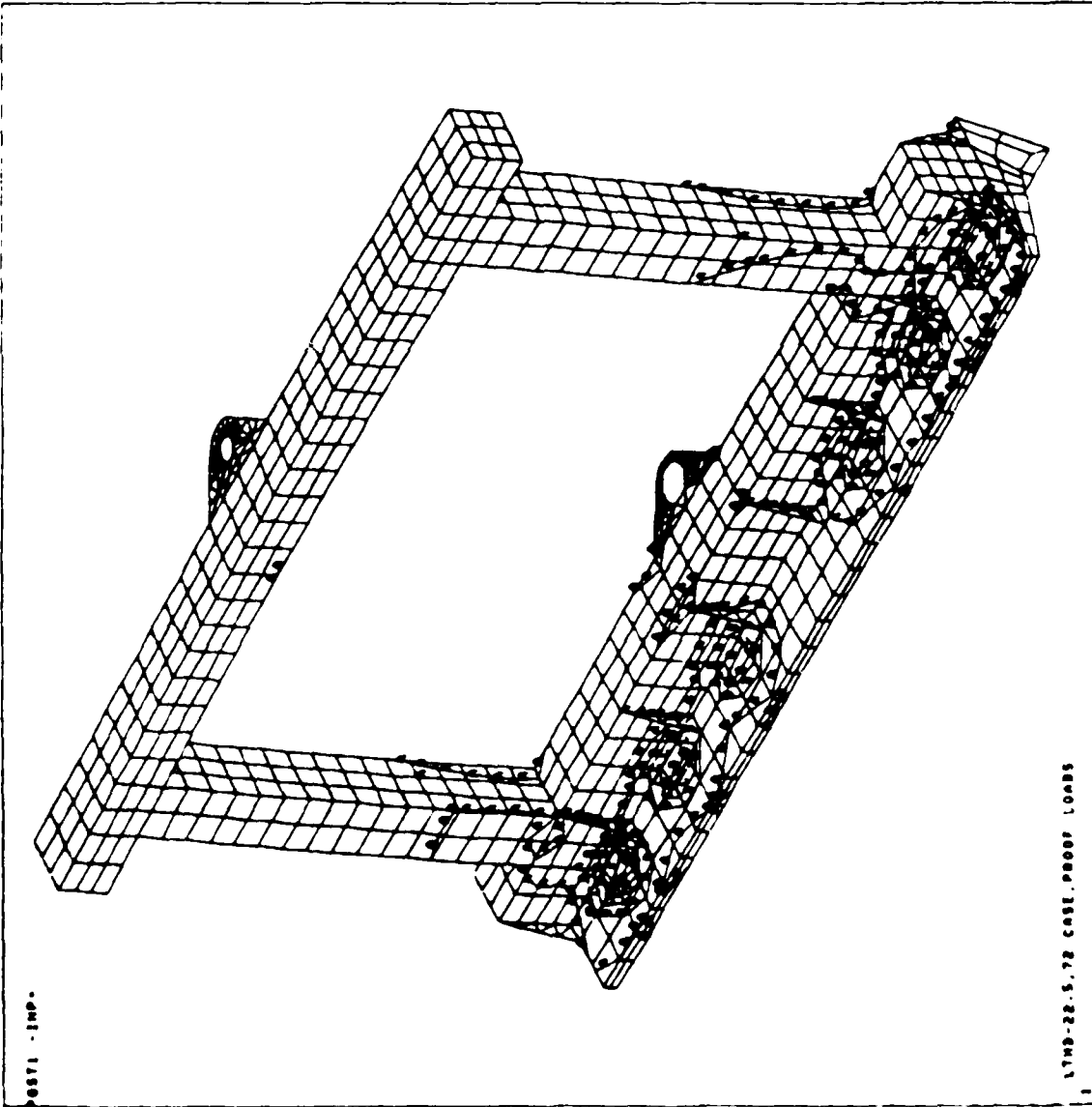
```

ANALYSIS 4.20
JAN 21 1987
8160101
PROBLEM 1
STEP=1
ITER=1
TIME=.237
SLOC
TOP
AV=1
VV=1
ZU=1
SLOC=24.0
AV=57.3
VV=32.0
ZU=1.62
W180CM
GA=08217
AN=040
N=15550
B=22000
C=40000
D=63750
E=79400

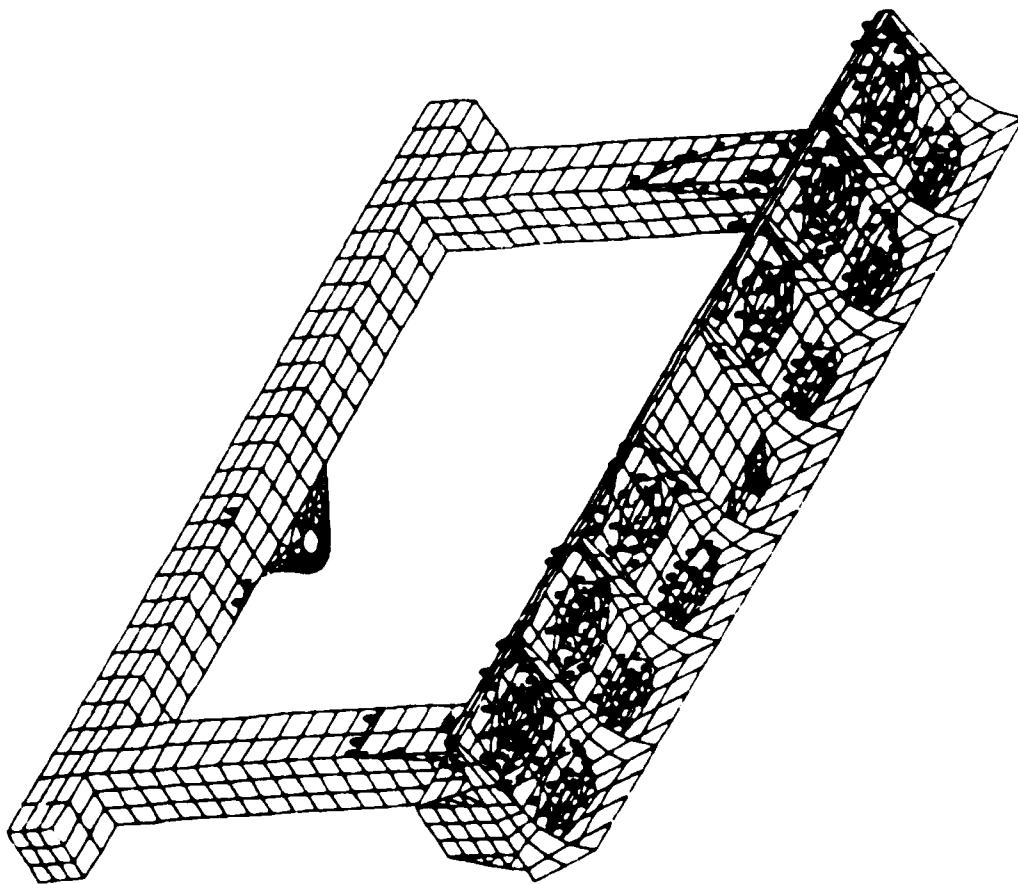
```



ANSYS 4.80
 JAN 21 1987
 10-10-02
 POST1 STRESS
 STEP=1
 TYPE=1
 TIME=.227
 SLOC
 TOP
 XU=1
 VU=1
 ZU=1
 DIS=56.6
 WF=51.2
 VF=27.7
 ZF=4.17
 MIDEL
 ME=140063
 MM=227
 A=86531
 B=40030
 C=73145
 D=87452
 E=121759



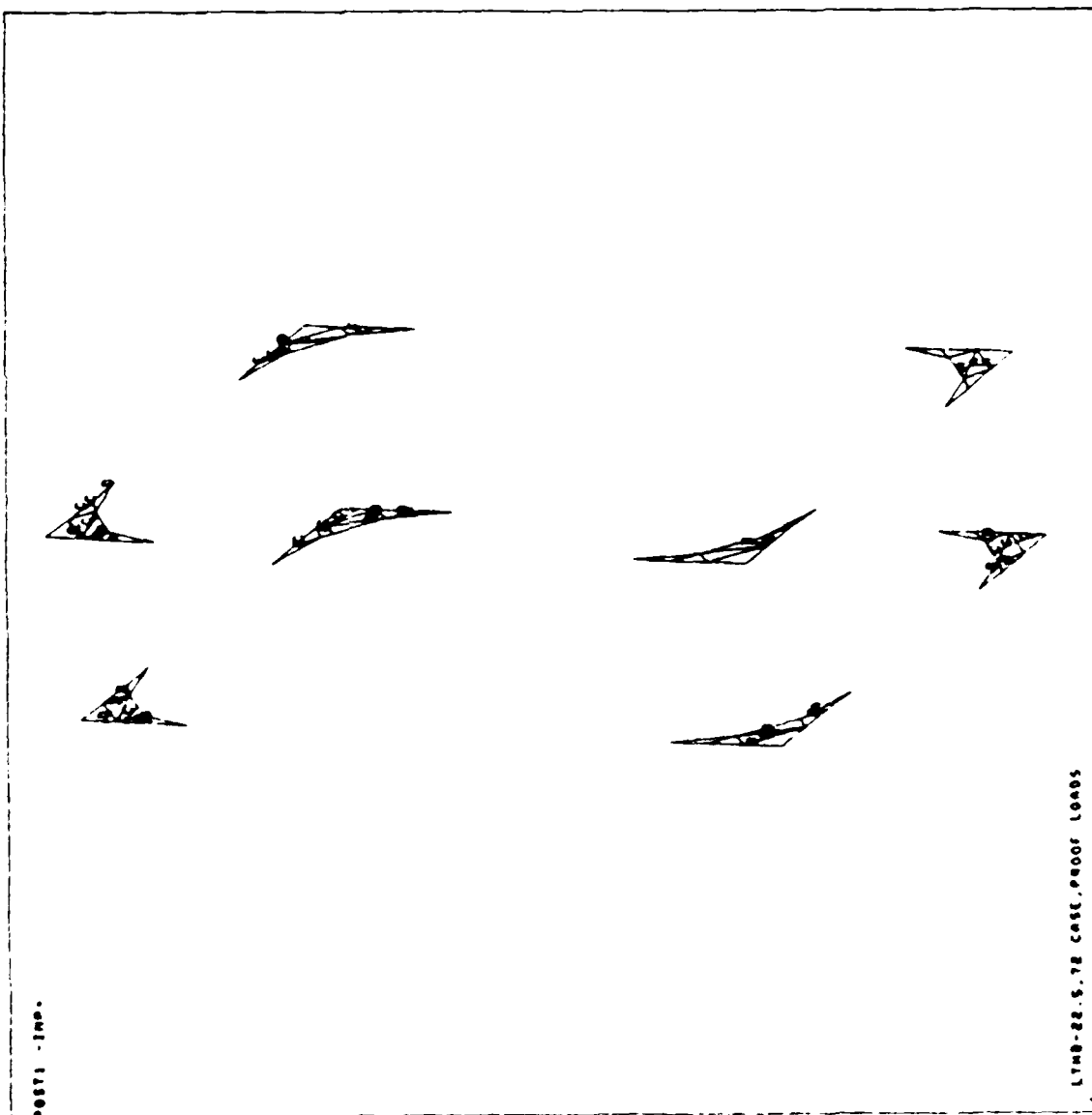
000000 1.00
 JUN 21 1967
 0.20 004
 POST1 570055
 STEP-1
 ITEM-1
 TIME-.007
 SLOC
 TOP
 RU-1
 VO-1
 ZO-1
 B157-68.2
 AF-65.2
 VF-26.4
 ZF-6.05
 M1000
 M1000
 AN-227
 AN-24321
 8-00020
 C-73145
 0-07458
 C-121759



00871 - IMP.

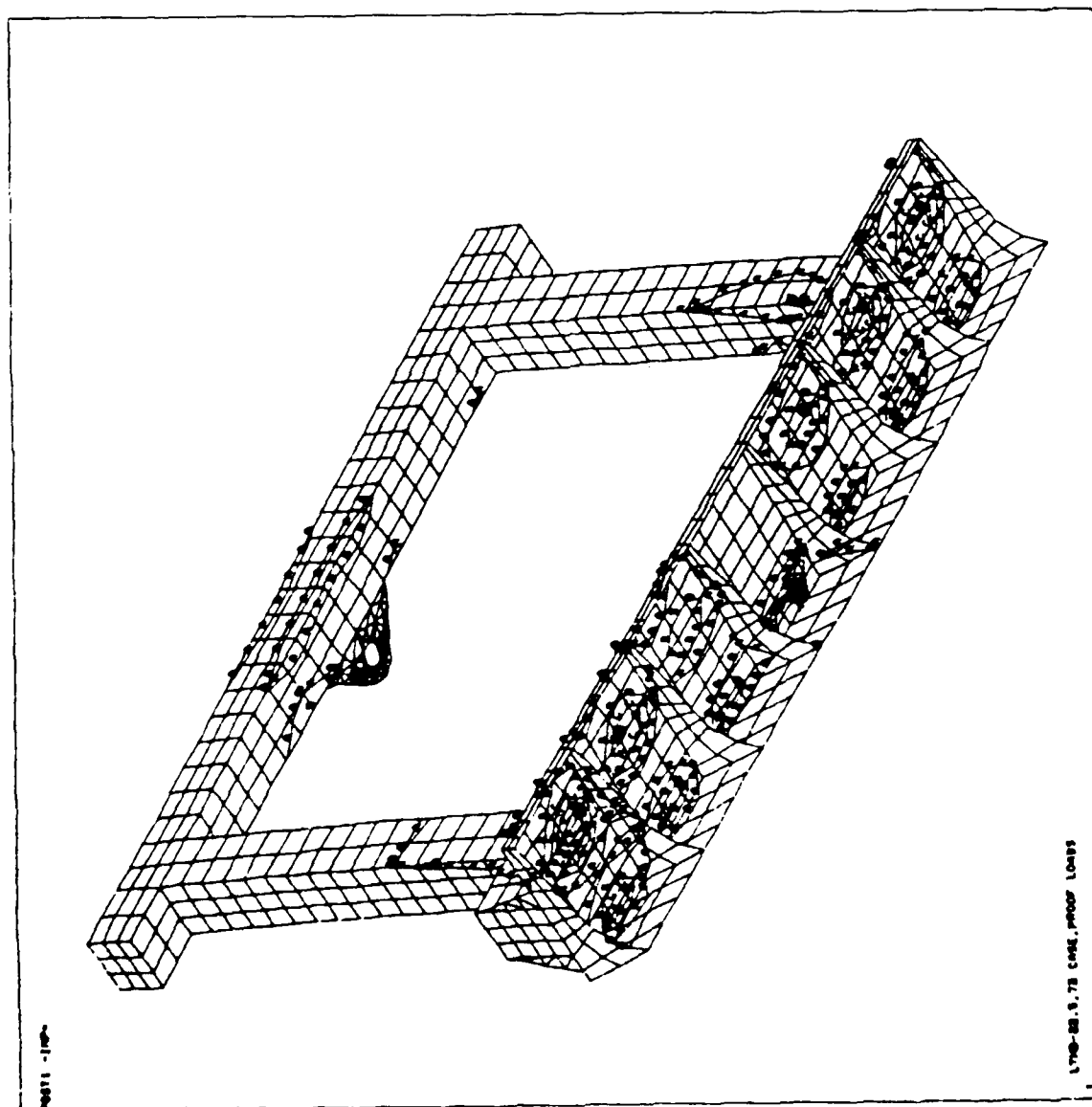
LYND-22 5.72 CASE, POOR LOADS

ANSYS 4.20
 JAN 21 1987
 11:04:11
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.837
 SICE
 TOP
 ZOOM
 X0=1
 Y0=1
 Z0=1
 D187=20
 XT=53
 YF=33.6
 ZF=3.5
 ROT0=1.3
 VRT0=1.2
 M18DEN
 M1=24078
 M1=2435
 A=6041
 B=9649
 C=13257
 D=16066
 E=20473



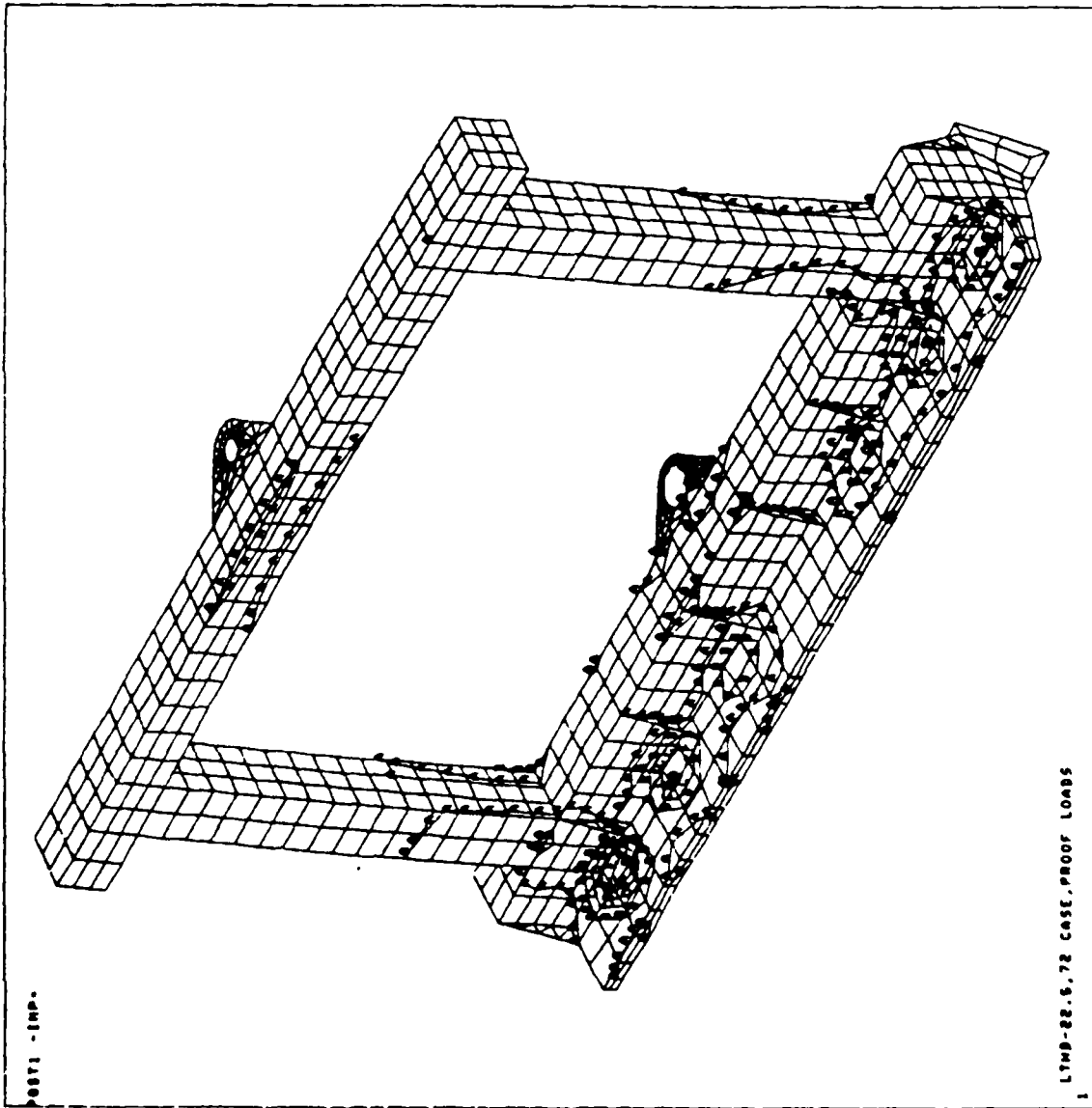
$t = 0.129 \text{ sec}$

44079 4.20
 JAN 81 1307
 13-07-100
 POST1, STRESS
 STEP=1
 ITER=1
 TIME=.129
 SLOC
 TOP
 NU=1
 VU=1
 ZU=1
 BIST=50.0
 W=51.8
 W=56.4
 ZF=4.55
 H100EN
 R8=101607
 R8=200
 A=17154
 B=34904
 C=54004
 D=57504
 E=84704

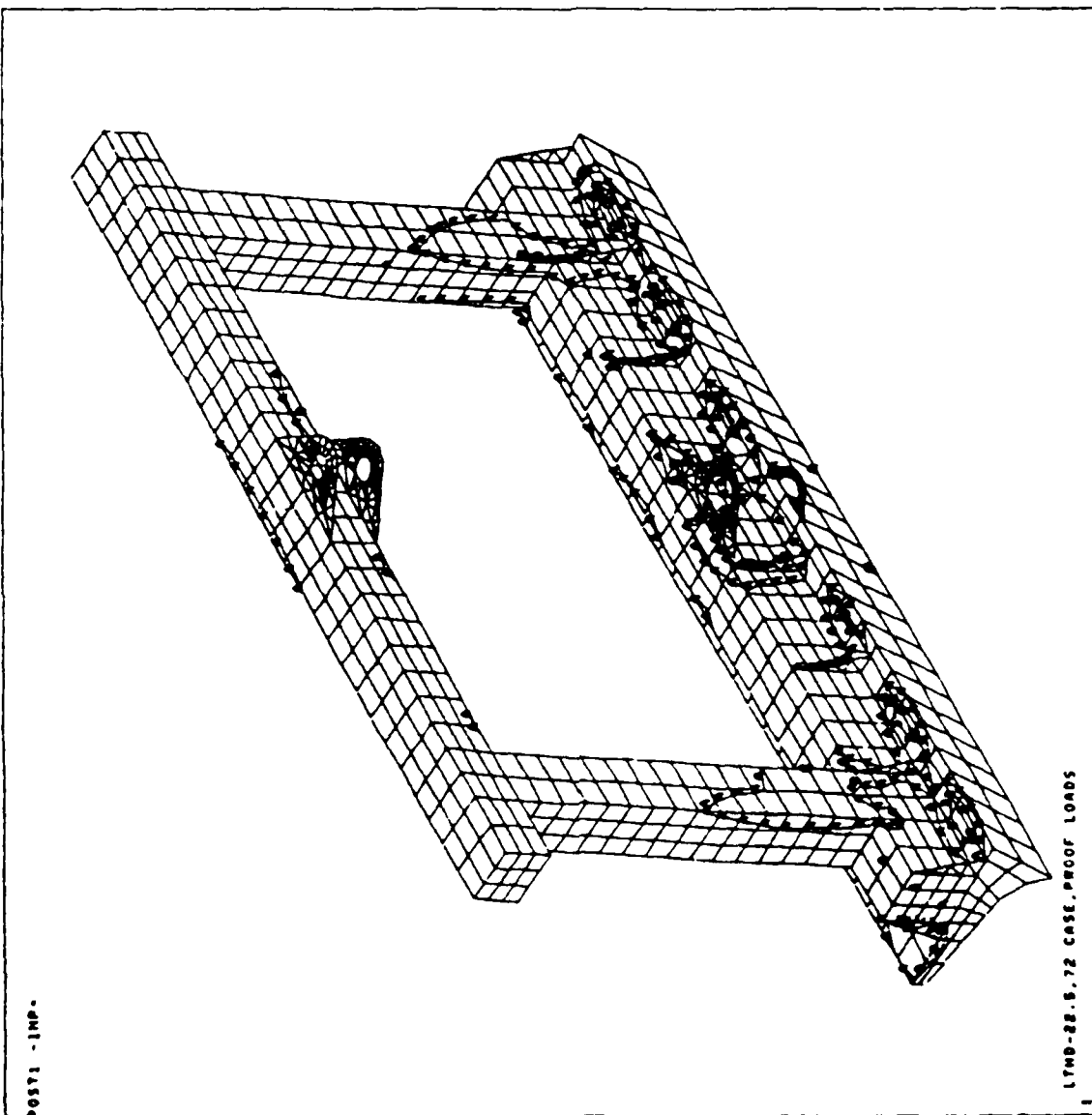


1700-50.5.75 CASE, PROOF LOADS

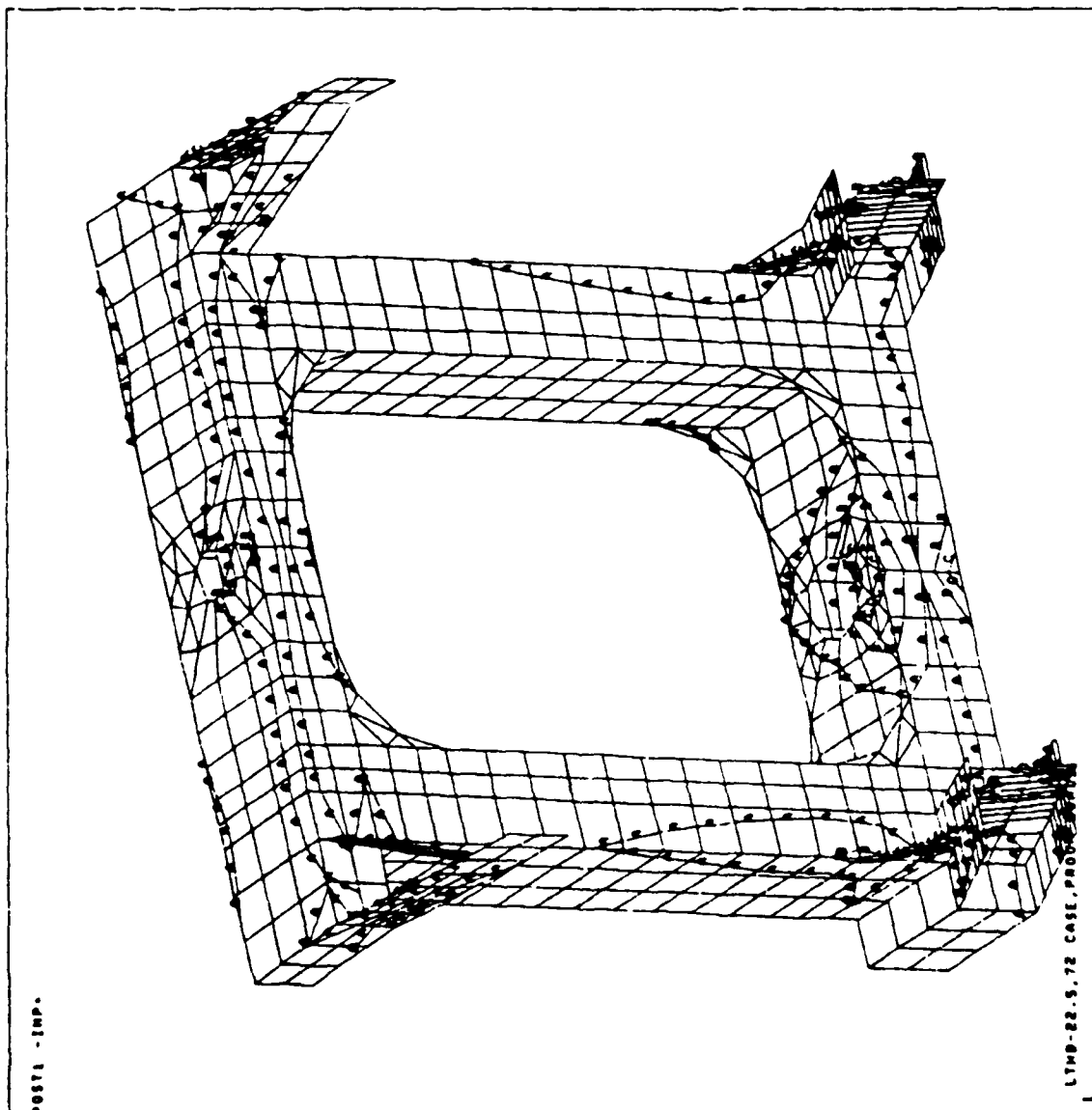
ANSYS 4.2D
 JAN 21 1987
 14-11-34
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.100
 SIZE
 TOP
 XU=1
 YU=1
 ZU=1
 BLST=66.6
 XF=51.2
 YF=27.7
 ZF=4.17
 MDOEN
 MX=101803
 MY=206
 MZ=17184
 B=34084
 C=50884
 D=67884
 E=84784



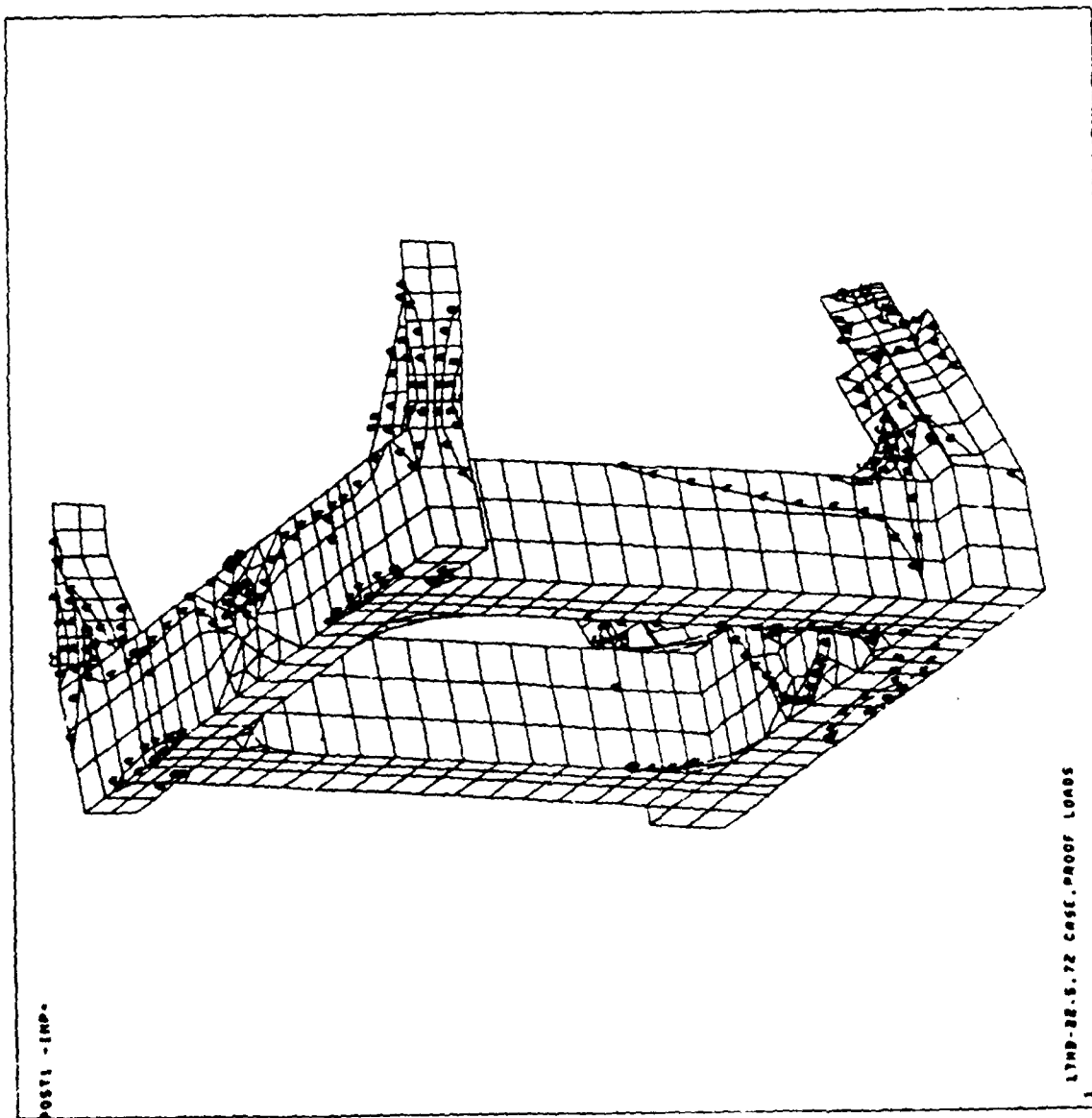
ANSYS 4.20
 JAN 21 1987
 14123103
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.120
 SIZE
 TOP
 KU=1
 VU=1
 ZU=-1
 DIST=58.2
 NF=54.2
 VF=26.4
 ZF=4.85
 MIBDEM
 MX=101603
 MY=206
 A=17184
 B=34004
 C=50004
 D=67004
 E=84704



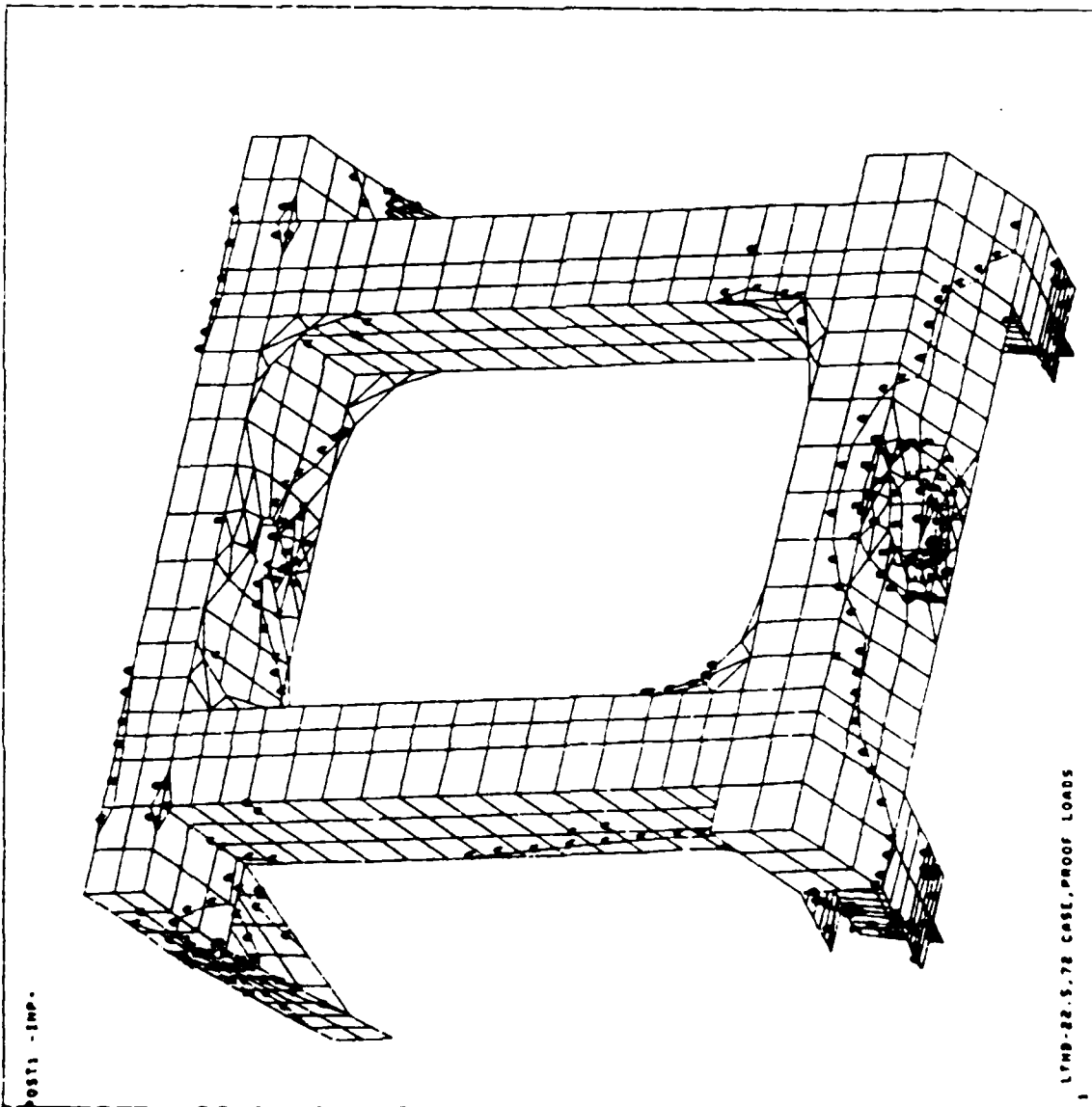
ANSYS 4.20
 JAN 21 1987
 14134107
 POST1, STRESS
 STEP=1
 ITER=1
 TIME=.129
 SIZE
 TOP
 KU=1
 VU=1
 20=1
 DIST=20.7
 XF=53.9
 YF=35
 ZF=-7.93
 MIDDLEM
 MM=188221
 MM=1739
 A=82818
 B=43899
 C=64999
 D=86061
 E=107142

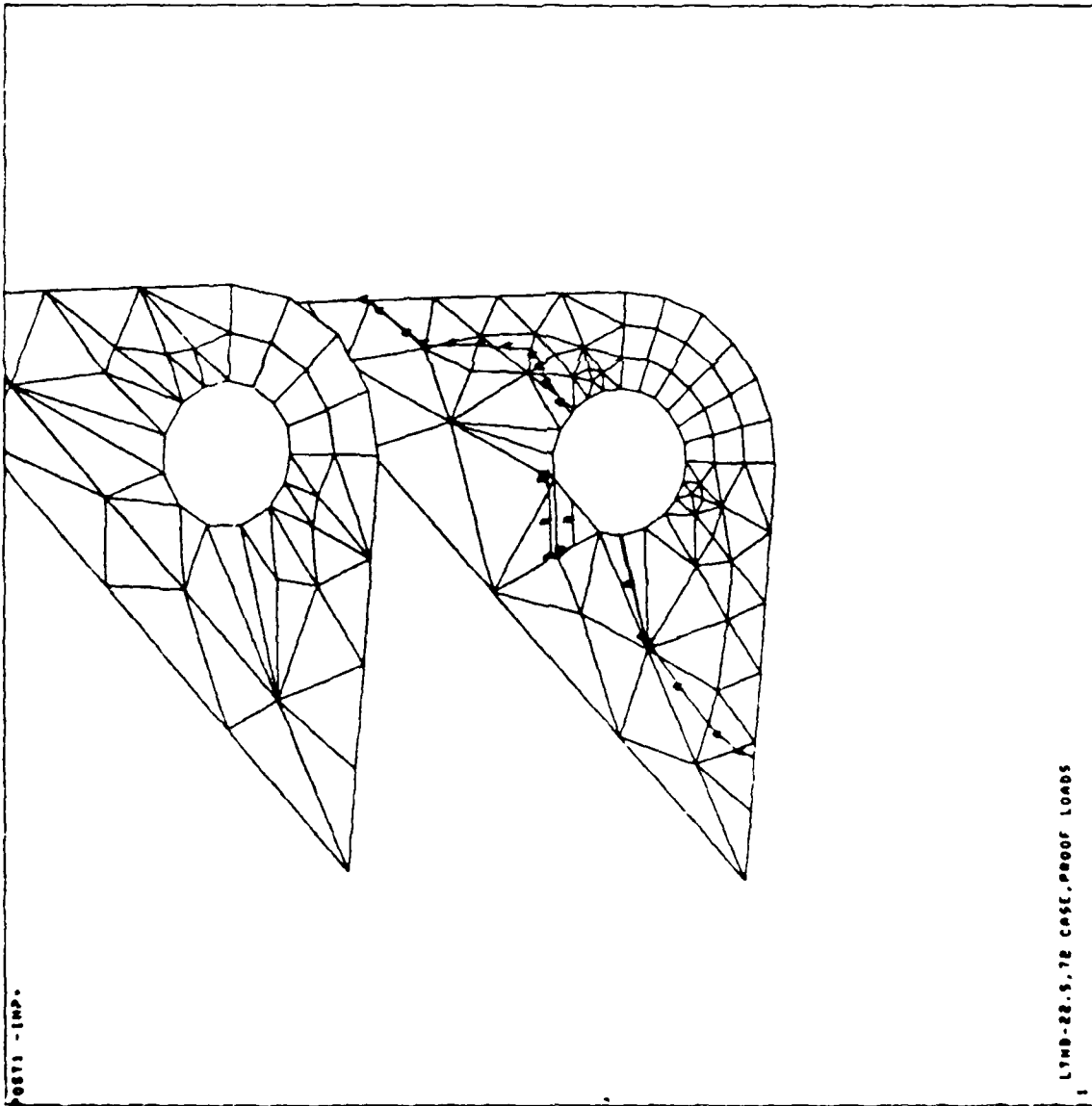


ABOVE 4.22
 JAN 21 1987
 14102133
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.100
 SICE
 TOP
 ZU=1
 YU=1
 ZU=1
 DIST=34.8
 XF=37.3
 YF=33.8
 ZF=-7.68
 MISOEM
 RM=128221
 CM=1136
 A=22818
 B=43880
 C=64880
 D=86861
 E=107142



ANSYS 4.20
 JAN 21 1987
 13158+27
 POST1, STRESS
 STEP=1
 TIME=1
 TIME=1.120
 SICE
 TOP
 RU=1
 VU=1
 ZU=1
 DIST=29.7
 XF=53.9
 YF=25
 ZF=7.93
 MIDDLE
 WK=128221
 WM=1730
 A=22810
 B=43800
 C=84980
 D=86061
 E=107142

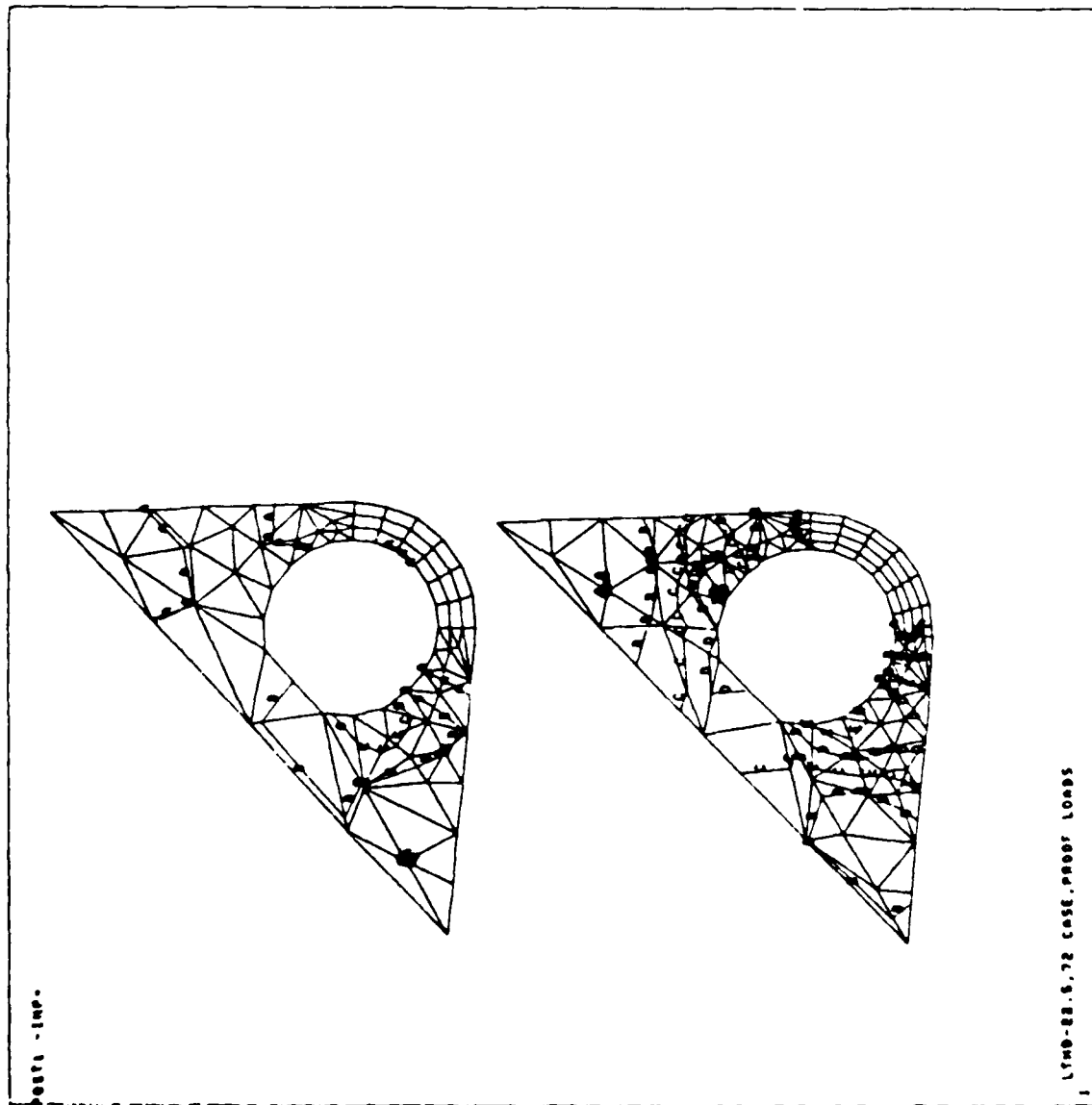




ANSYS 4.20
 JAN 21 1987
 14137146
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.180
 SLOC
 TOP
 ZOOM
 XU=1
 YU=1
 ZU=-1
 DIST=10.4
 XF=43.6
 YF=46.8
 ZF=5.75
 VRTO=1.54
 MIDDLE
 RM=14843
 MM=430
 Q=7380
 D=14181

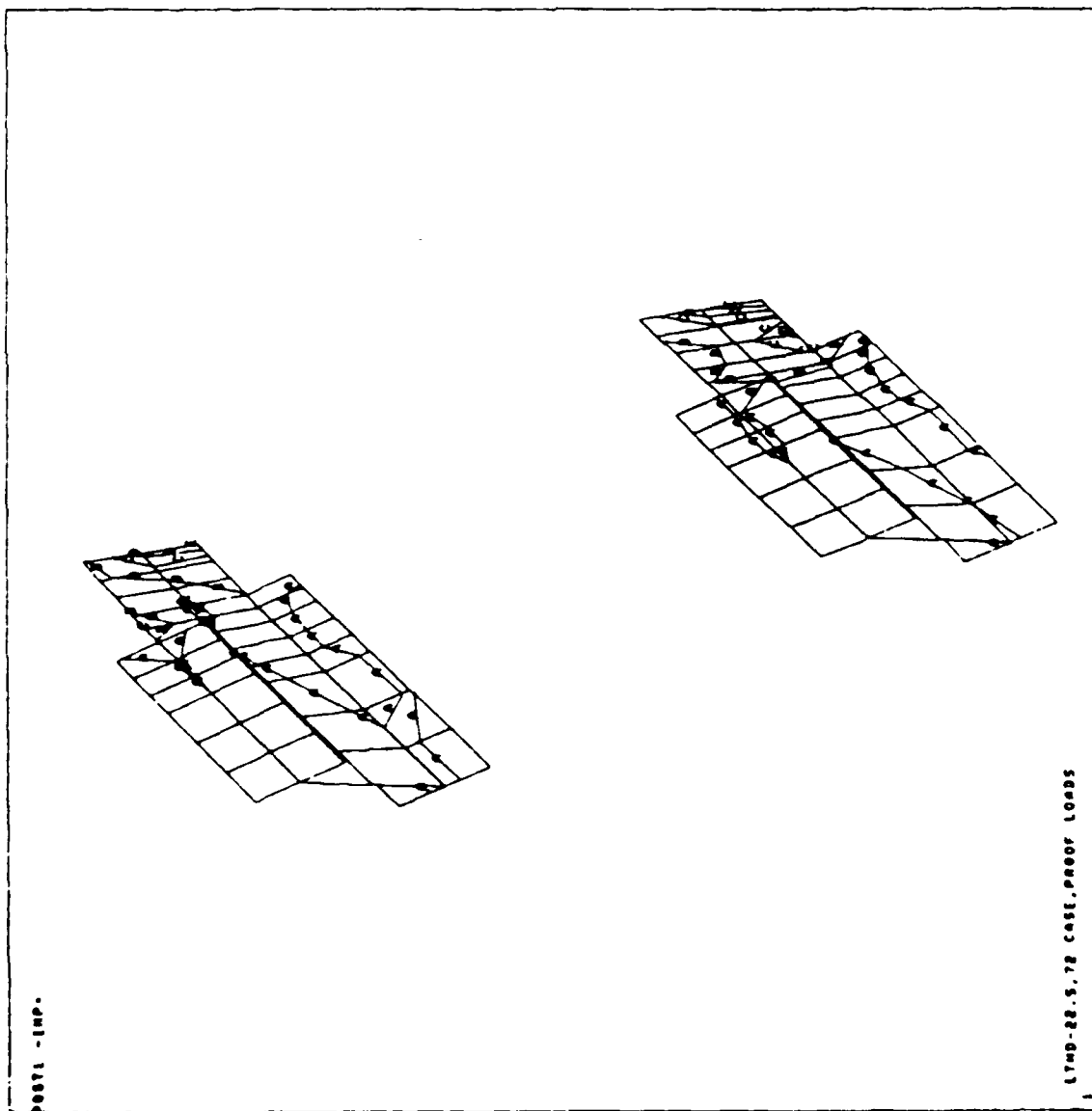
TOP TABS

ANSYS 4.02
 JAN 21 1987
 14146126
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.129
 SEQ
 TOP
 ZOOM
 KU=1
 VU=1
 ZU=-1
 DIST=14.1
 KF=89.4
 VF=12.4
 ZF=-12.9
 VRT0=1.67
 MIDDLE
 MX=41667
 MY=766
 A=7209
 B=14181
 C=21053
 D=27026
 E=34787



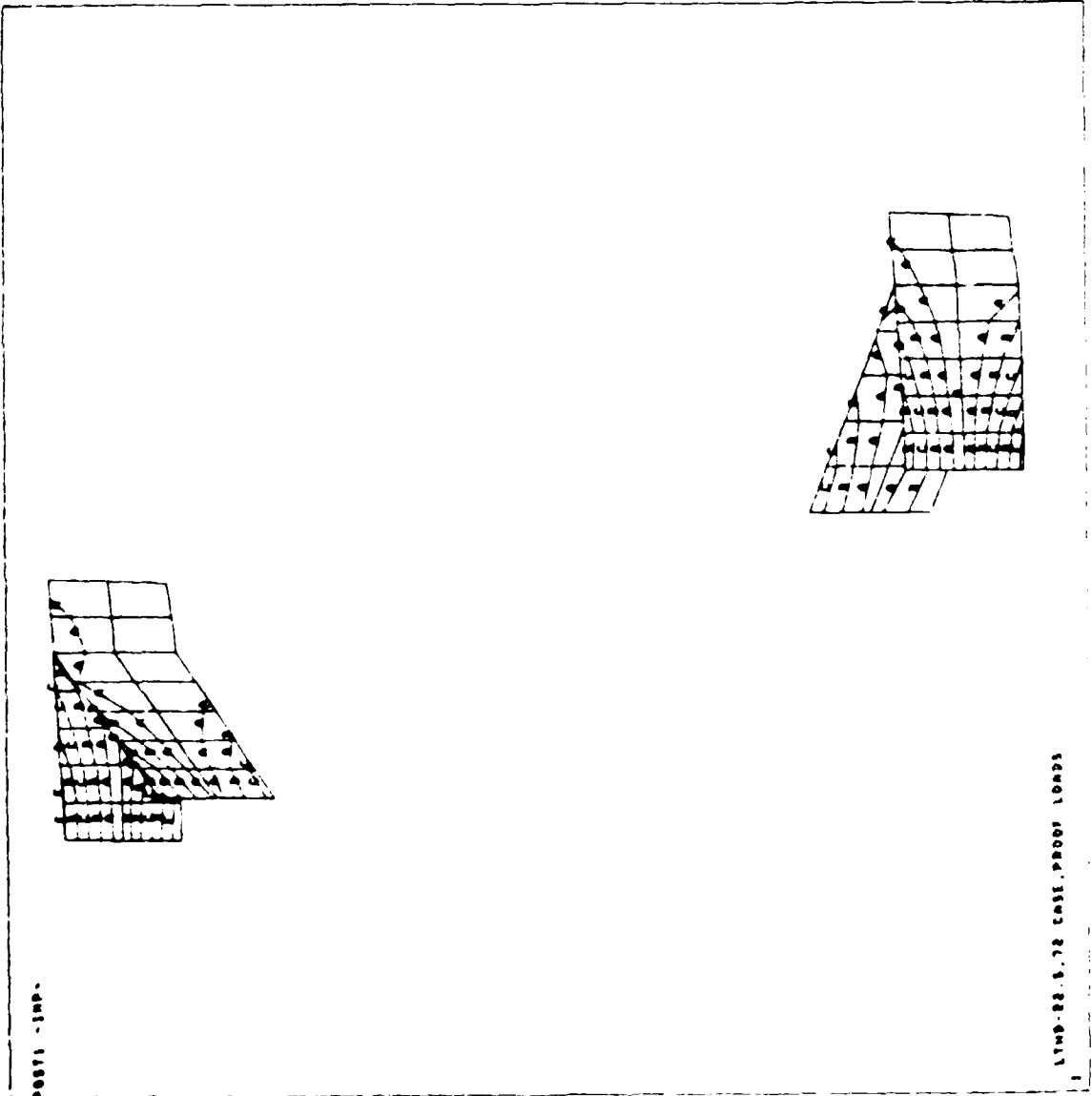
BOTTOM
TABS

ANSYS 4.20
 JAN 21 1987
 14143142
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=.120
 SIZE
 TOP
 ZOOM
 KU=1
 VU=1
 ZU=1
 0187.88.2
 KP=57.3
 VP=14.2
 ZF=-12.7
 V870=1.57
 MIDDLEM
 RA=124714
 RH=7700
 A=27205
 B=46771
 C=66257
 D=85743
 E=105229



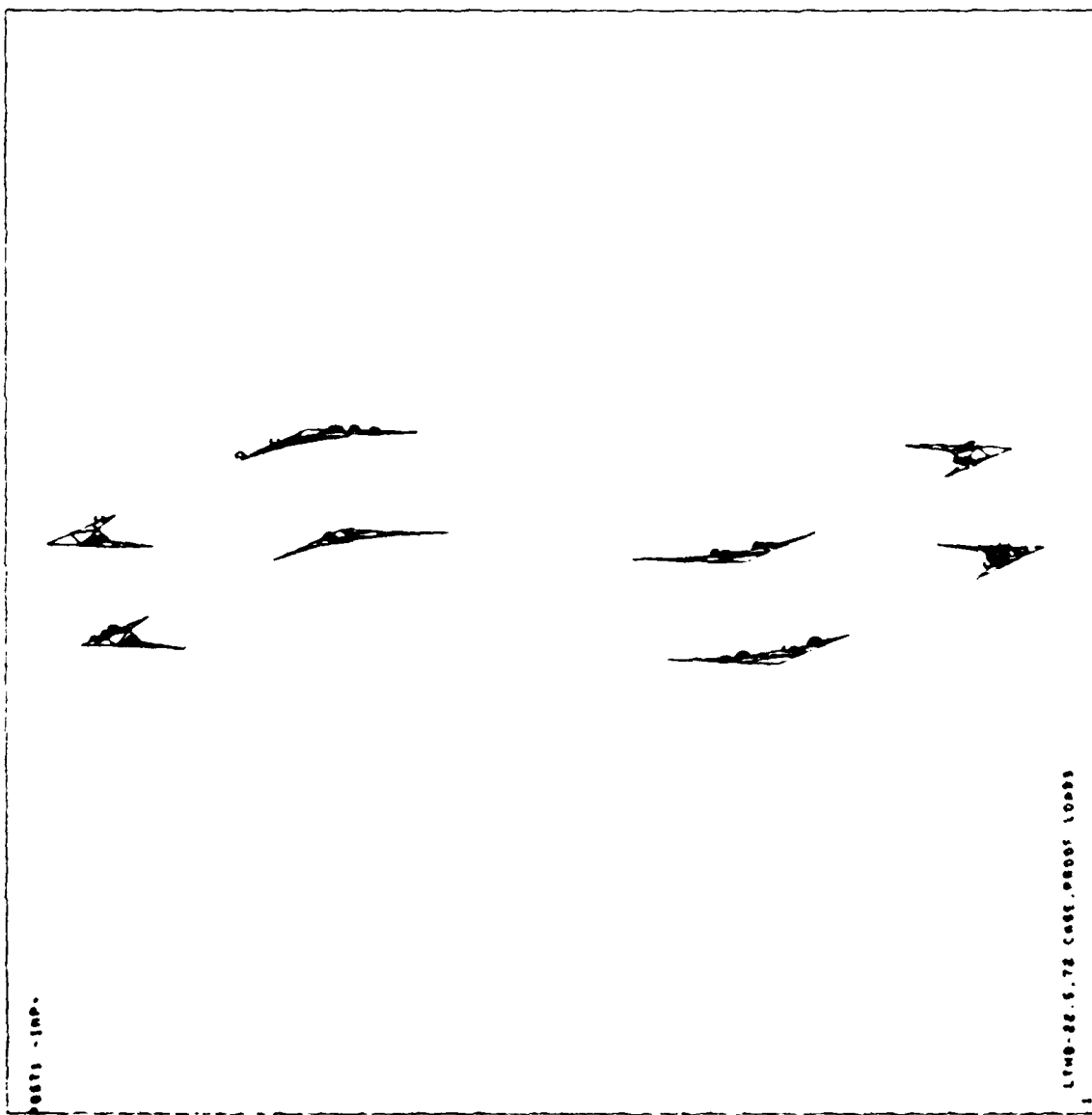
GIMBAL
 LOWER
 ARMS

ANSYS 4.20
 JAN 21 1987
 10145122
 POST1 STRESS
 STEP=1
 ITER=1
 TIME=1.00
 SICE
 TOP
 2004
 10-1
 20-1
 20-1
 0157.85
 27-57.1
 27-53.3
 27-12.2
 200-1.67
 11954
 22-77389
 22-8868
 2-18621
 2-30376
 2-42128
 2-52883
 2-65637



GIMBAL
 UPPER
 ARMS

ANSYS 4.20
 JAN 21 1987
 14145110
 POST1 STRSS
 STEP=1
 ITER=1
 TIME=1.00
 SICE
 TOP
 ZOOM
 RV=1
 VU=1
 ZU=1
 DIS=41.7
 WF=53
 VF=33.6
 ZF=3.5
 VRT=1.67
 M108CM
 MR=34610
 PR=3765
 A=8028
 D=14113
 C=19288
 D=24463
 E=28638



0.129 sec

PRINT ELEMENT STRESS ITEMS PER ELEMENT

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP	1	ITERATION	1	SECTION	1
TIME	0.12900		LOAD CASE	1	
ELEM	5010	502	50V1	5022	50V2
3069	42.720	-80.486	86.424	106.83	-109.26
3070	-18.506	-71.002	-416.54	-343.80	608.00
3071	46.720	-71.011	220.72	74.807	-330.34
3072	18302	-1671.31	-1671.31	1715.06	2573.0
3073	-8689.5	1087.8	3684.0	-1163.6	-4453.4
3074	1.4806	-306.62	-548.57	171.91	383.08
3075	-180.86	100.73	1927.0	186.88	-1121.0
3076	-16506	-821.72	-1624.0	1874.1	8816.4
3077	150.06	-31.197	-943.46	-81.733	809.00
3078	41.563	2544.0	1400.1	-8200.6	-1187.0
3079	117.72	-611.07	-688.46	401.02	608.62
3080	10.404	62.038	1436.7	-286.06	-1311.8
3081	5132.0	426.13	-508.73	537.30	713.87
3082	-228.55	9764.3	1866.8	-4686.5	-643.06

***** MORE IYES, NO OR CONTINUOUS *****

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP	1	ITERATION	1	SECTION	1
TIME	0.12900		LOAD CASE	1	
ELEM	5010	502	50V1	5022	50V2
3083	-9040.0	841.95	-328.39	-46.078	1070.8
3084	-1401.5	-302.03	383.21	433.96	-834.24
3085	401.31	676.89	-291.28	-657.82	800.28
3086	-71.536	-46.790	181.41	851.06	808.60
3087	-351.65	256.88	348.12	632.74	809.11
3088	3.5804	136.10	-178.00	-63.146	17.428
3089	212.13	-385.06	457.00	-377.00	647.58
3090	-39.378	-54.170	-84.127	187.07	204.28
3091	-204.05	496.17	689.56	510.28	580.16
3092	2.8844	48.166	-30.881	-33.789	18.765
3093	273.28	-282.56	312.25	-488.67	625.03
3094	-282.24	281.85	-264.01	386.89	-328.10
3100	168.05	-78.006	-144.10	-308.04	-644.10
3101	-380.53	360.20	-213.32	418.05	-288.88

***** MORE IYES, NO OR CONTINUOUS *****

AD-A183 994

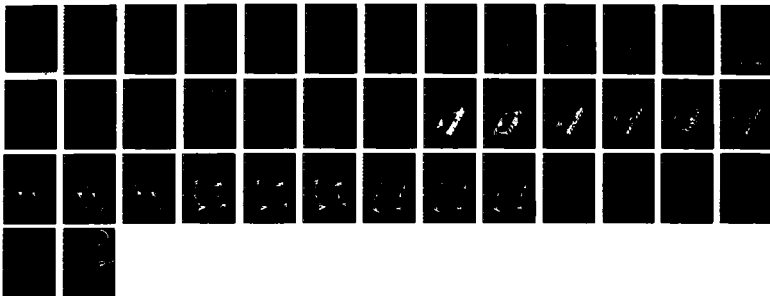
LIGHTWEIGHT TOWED HOWITZER DEMONSTRATOR PHASE 1 AND
PARTIAL PHASE 2 VOLUM (U) FMC CORP MINNEAPOLIS MINN
NORTHERN ORDNANCE DIV R RATHE ET AL APR 87
FMC-E-3041-VOL-D3-PT-2 DAAA21-86-C-0047

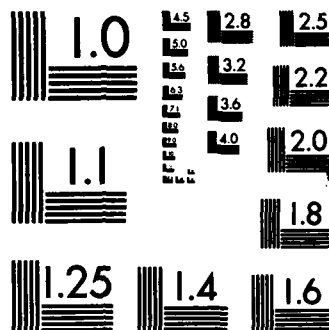
2/2

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NL





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

0000 POST1 ELEMENT STRESS LISTING 0000
 LOAD STEP 1 ITERATION-1 SECTION-1
 TIME 0.18000 LOAD CASE 1
 ELEM S101 S02 S01 S02 S01 S02
 2130 20.071 27.203 188.00 -48.532 -306.50
 2131 109.92 47.308 488.20 -1.5135 -48.600
 2132 5.6342 -56.060 301.70 30.793 -103.20
 2133 94.846 1.7101 81.621 -1.8023 -254.20
 2134 109.40 57.367 -105.70 -28.157 408.00
 2135 38.618 37.967 -843.10 -20.535 408.00
 2136 -857.93 34.800 117.42 57.908 328.21
 2137 7.7917 28.808 -150.42 -20.501 42.920
 2140 305.00 -61.856 170.83 -26.144 364.66
 2141 17.346 -25.385 -38.660 23.628 130.00
 2142 -344.73 17.651 325.76 74.809 383.00
 2143 8.8606 31.273 34.823 -24.065 -5.1631
 2144 352.43 -69.642 300.48 -24.281 321.14
 2145 -30.000 -37.875 85.710 32.240 -268.21
 MORE (YES, NO OR CONTINUOUS).
 Y

0000 POST1 ELEMENT STRESS LISTING 0000
 LOAD STEP 1 ITERATION-1 SECTION-1
 TIME 0.18000 LOAD CASE 1
 ELEM S101 S02 S01 S02 S01 S02
 2146 -321.00 34.834 485.00 41.926 100.72
 2147 5.4700 24.171 258.31 -20.315 -107.33
 2148 200.45 -45.247 237.42 14.224 -156.48
 2149 -57.060 -20.720 226.50 -1.5803 -480.00
 2150 -98.916 22.615 171.32 -68.923 -327.06
 2158 -328.37 974.46 -201.56 10145. 4360.2
 2159 -849.00 25594. 9427.4 23688. 8908.7
 2164 1182.7 35767. 10080. -7552.6 -3510.1
 2166 70.236 148.71 -269.87 0.79314E-03 -38.320
 2167 -6.1000 48.119 347.65 -0.33644E-02 251.47
 2168 -15.017 -61.267 319.36 0.17605E-02 99.516
 2169 -340.10 37.344 247.82 0.5510E-02 118.47
 2190 -64.630 98.000 -64.766 0.65742E-02 -129.70
 MORE (YES, NO OR CONTINUOUS).
 Y

0000 POST1 ELEMENT STRESS LISTING 0000

LOAD STEP 1 ITERATION 1 SECTION 1
TIME 0.10000 LOAD CASE 1

ELEM	SD18	SD2	SDV1	SD22	SDV2
3101	30.000	10.400	-376.10	0.87001E-03	-185.52
3102	-7.1100	41.017	-80.376	-0.30308E-04	-43.804
3103	-31.670	3600.9	64.90	0.89647E-01	835.66
3104	161.06	2313.1	-77.436	0.38101E-01	-107.70
3105	307.58	1699.5	-956.41	0.48040E-01	-482.73
3106	814.00	903.11	-3700.0	0.35323E-01	-1680.0
3107	500.00	1174.0	8000.1	0.42744E-01	1800.7
3108	346.03	1902.3	685.17	0.37820E-01	302.43
3109	60.000	2295.5	-152.03	0.30000E-01	-0.10000
3200	-01.600	2224.4	-944.02	0.10000E-01	-381.66
3201	-141.13	811.24	-893.08	0.10007E-01	-485.10
3202	-71.300	2040.0	-3466.8	0.12204E-01	-1827.2
3203	-200.14	-1.7349	8377.5	-0.10110E-01	905.00
3204	-011.00	-715.34	509.44	-0.46305E-02	317.75

NOTE (YES,NO OR CONTINUOUS).

0000 POST1 ELEMENT STRESS LISTING 0000

LOAD STEP 1 ITERATION 1 SECTION 1
TIME 0.10000 LOAD CASE 1

ELEM	SD18	SD2	SDV1	SD22	SDV2
3205	-100.00	-1153.0	-92.014	-0.05478E-03	26.051
3206	-12.107	-2326.7	-556.61	-0.20308E-02	-814.45
3207	-101.01	148.00	-85.671	0.80930E-01	-144.77
3208	408.01	-2466.7	6331.0	1004.6	-2023.6
3209	1694.6	4042.1	-7092.0	-0.42414E-01	-4908.1
3210	975.56	-1093.4	-1302.0	-0.50001E-03	-876.41
3211	813.20	-1236.2	1093.5	-0.59106E-04	357.97
3212	-100.52	-493.64	1002.0	0.20000E-04	368.24
3213	-226.05	-1070.4	-364.16	-0.00172E-03	-101.13
3214	378.01	-2207.5	-548.14	-0.03003E-03	-243.10
3215	400.74	6495.2	-4341.3	-0.001.0	2309.9
3216	1758.6	215.14	-3271.9	-0.72005E-02	-1522.5
3217	649.89	-857.70	7020.0	-0.20701E-01	3046.6
3218	702.70	-3166.4	-60.336	-0.55110E-02	116.56

NOTE (YES,NO OR CONTINUOUS).

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP	ITERATION	LOAD CASE	SECTION	1
TIME	0.10000			
EL60	1010	102	101	101
2000	1000	1000	1000	1000
2001	1001	1001	1001	1001
2002	1002	1002	1002	1002
2003	1003	1003	1003	1003
2004	1004	1004	1004	1004
2005	1005	1005	1005	1005
2006	1006	1006	1006	1006
2007	1007	1007	1007	1007
2008	1008	1008	1008	1008
2009	1009	1009	1009	1009
2010	1010	1010	1010	1010
2011	1011	1011	1011	1011
2012	1012	1012	1012	1012
2013	1013	1013	1013	1013
2014	1014	1014	1014	1014
2015	1015	1015	1015	1015
2016	1016	1016	1016	1016
2017	1017	1017	1017	1017
2018	1018	1018	1018	1018
2019	1019	1019	1019	1019
2020	1020	1020	1020	1020
2021	1021	1021	1021	1021
2022	1022	1022	1022	1022
2023	1023	1023	1023	1023
2024	1024	1024	1024	1024
2025	1025	1025	1025	1025
2026	1026	1026	1026	1026
2027	1027	1027	1027	1027
2028	1028	1028	1028	1028
2029	1029	1029	1029	1029
2030	1030	1030	1030	1030
2031	1031	1031	1031	1031
2032	1032	1032	1032	1032
2033	1033	1033	1033	1033
2034	1034	1034	1034	1034
2035	1035	1035	1035	1035
2036	1036	1036	1036	1036
2037	1037	1037	1037	1037
2038	1038	1038	1038	1038
2039	1039	1039	1039	1039
2040	1040	1040	1040	1040
2041	1041	1041	1041	1041
2042	1042	1042	1042	1042
2043	1043	1043	1043	1043
2044	1044	1044	1044	1044
2045	1045	1045	1045	1045
2046	1046	1046	1046	1046
2047	1047	1047	1047	1047
2048	1048	1048	1048	1048
2049	1049	1049	1049	1049
2050	1050	1050	1050	1050
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2052	1052	1052	1052	1052
2053	1053	1053	1053	1053
2054	1054	1054	1054	1054
2055	1055	1055	1055	1055
2056	1056	1056	1056	1056
2057	1057	1057	1057	1057
2058	1058	1058	1058	1058
2059	1059	1059	1059	1059
2060	1060	1060	1060	1060
2061	1061	1061	1061	1061
2062	1062	1062	1062	1062
2063	1063	1063	1063	1063
2064	1064	1064	1064	1064
2065	1065	1065	1065	1065
2066	1066	1066	1066	1066
2067	1067	1067	1067	1067
2068	1068	1068	1068	1068
2069	1069	1069	1069	1069
2070	1070	1070	1070	1070
2071	1071	1071	1071	1071
2072	1072	1072	1072	1072
2073	1073	1073	1073	1073
2074	1074	1074	1074	1074
2075	1075	1075	1075	1075
2076	1076	1076	1076	1076
2077	1077	1077	1077	1077
2078	1078	1078	1078	1078
2079	1079	1079	1079	1079
2080	1080	1080	1080	1080
2081	1081	1081	1081	1081
2082	1082	1082	1082	1082
2083	1083	1083	1083	1083
2084	1084	1084	1084	1084
2085	1085	1085	1085	1085
2086	1086	1086	1086	1086
2087	1087	1087	1087	1087
2088	1088	1088	1088	1088
2089	1089	1089	1089	1089
2090	1090	1090	1090	1090
2091	1091	1091	1091	1091
2092	1092	1092	1092	1092
2093	1093	1093	1093	1093
2094	1094	1094	1094	1094
2095	1095	1095	1095	1095
2096	1096	1096	1096	1096
2097	1097	1097	1097	1097
2098	1098	1098	1098	1098
2099	1099	1099	1099	1099
2100	1100	1100	1100	1100
2101	1101	1101	1101	1101
2102	1102	1102	1102	1102
2103	1103	1103	1103	1103
2104	1104	1104	1104	1104
2105	1105	1105	1105	1105
2106	1106	1106	1106	1106
2107	1107	1107	1107	1107
2108	1108	1108	1108	1108
2109	1109	1109	1109	1109
2110	1110	1110	1110	1110
2111	1111	1111	1111	1111
2112	1112	1112	1112	1112
2113	1113	1113	1113	1113
2114	1114	1114	1114	1114
2115	1115	1115	1115	1115
2116	1116	1116	1116	1116
2117	1117	1117	1117	1117
2118	1118	1118	1118	1118
2119	1119	1119	1119	1119
2120	1120	1120	1120	1120
2121	1121	1121	1121	1121
2122	1122	1122	1122	1122
2123	1123	1123	1123	1123
2124	1124	1124	1124	1124
2125	1125	1125	1125	1125
2126	1126	1126	1126	1126
2127	1127	1127	1127	1127
2128	1128	1128	1128	1128
2129	1129	1129	1129	1129
2130	1130	1130	1130	1130
2131	1131	1131	1131	1131
2132	1132	1132	1132	1132
2133	1133	1133	1133	1133
2134	1134	1134	1134	1134
2135	1135	1135	1135	1135
2136	1136	1136	1136	1136
2137	1137	1137	1137	1137
2138	1138	1138	1138	1138
2139	1139	1139	1139	1139
2140	1140	1140	1140	1140
2141	1141	1141	1141	1141
2142	1142	1142	1142	1142
2143	1143	1143	1143	1143
2144	1144	1144	1144	1144
2145	1145	1145	1145	1145
2146	1146	1146	1146	1146
2147	1147	1147	1147	1147
2148	1148	1148	1148	1148
2149	1149	1149	1149	1149
2150	1150	1150	1150	1150
2151	1151	1151	1151	1151
2152	1152	1152	1152	1152
2153	1153	1153	1153	1153
2154	1154	1154	1154	1154
2155	1155	1155	1155	1155
2156	1156	1156	1156	1156
2157	1157	1157	1157	1157
2158	1158	1158	1158	1158
2159	1159	1159	1159	1159
2160	1160	1160	1160	1160
2161	1161	1161	1161	1161
2162	1162	1162	1162	1162
2163	1163	1163	1163	1163
2164	1164	1164	1164	1164
2165	1165	1165	1165	1165
2166	1166	1166	1166	1166
2167	1167	1167	1167	1167
2168	1168	1168	1168	1168
2169	1169	1169	1169	1169
2170	1170	1170	1170	1170
2171	1171	1171	1171	1171
2172	1172	1172	1172	1172
2173	1173	1173	1173	1173
2174	1174	1174	1174	1174
2175	1175	1175	1175	1175
2176	1176	1176	1176	1176
2177	1177	1177	1177	1177
2178	1178	1178	1178	1178
2179	1179	1179	1179	1179
2180	1180	1180	1180	1180
2181	1181	1181	1181	1181
2182	1182	1182	1182	1182
2183	1183	1183	1183	1183
2184	1184	1184	1184	1184
2185	1185	1185	1185	1185
2186	1186	1186	1186	1186
2187	1187	1187	1187	1187
2188	1188	1188	1188	1188
2189	1189	1189	1189	1189
2190	1190	1190	1190	1190
2191	1191	1191	1191	1191
2192	1192	1192	1192	1192
2193	1193	1193	1193	1193
2194	1194	1194	1194	1194
2195	1195	1195	1195	1195
2196	1196	1196	1196	1196
2197	1197	1197	1197	1197
2198	1198	1198	1198	1198
2199	1199	1199	1199	1199
2200	1200	1200	1200	1200
2201	1201	1201	1201	1201
2202	1202	1202	1202	1202
2203	1203	1203	1203	1203
2204	1204	1204	1204	1204
2205	1205	1205	1205	1205
2206	1206	1206	1206	1206
2207	1207	1207	1207	1207
2208	1208	1208	1208	1208
2209	1209	1209	1209	1209
2210	1210	1210	1210	1210
2211	1211	1211	1211	1211
2212	1212	1212	1212	1212
2213	1213	1213	1213	

8888 POST1 ELEMENT STRESS LISTING 8888

LOAD STEP 1 ITERATION-1 SECTION-1
TIME-0.10000 LOAD CASE-1

ELN	8010	802	80V1	80V2
3000	-1037.0	-88.070	-80.03	-0.30330E-03
3001	-4000.0	-104.00	-110.41	-0.14130E-08
3002	-3314.0	-101.13	-10.911	-0.03300E-03
3003	-8046.0	104.00	36.300	-0.2301E-03
3004	10.100	-0.0001	-86.104	-0.00300E-04
3005	-1100.0	10.000	-5.0750	-0.70047E-05
3006	3040.0	-97.201	-0.01700	-0.00364E-04
3007	-907.43	-0.4004	130.50	-0.00140E-04
3008	-1010.0	-10.720	143.00	-0.10410E-02
3009	712.61	-84.014	-26.040	-0.00000E-03
3010	-0114.1	-70.305	64.500	-0.77000E-03
3011	-3314.0	-101.13	-10.911	-0.03300E-03
3012	-3046.0	-104.00	-10.900	-0.10700E-08
3013	1079.1	-70.007	1.1007	-0.00000E-03

NOTE (VES.NO ON CONTINUOUS).

8888 POST1 ELEMENT STRESS LISTING 8888

LOAD STEP 1 ITERATION-1 SECTION-1
TIME-0.10000 LOAD CASE-1

ELN	8010	802	80V1	80V2
3000	0014.1	-11.100	10.007	1.0001
3001	-1.400	977.00	0.00000E+00	1348.0
3002	-1.000	-030.00	0.00000E+00	-3147.0
3003	0.07000E-01	700.03	0.00000E+00	-070.32
3004	-0.00037E-01	004.00	0.00000E+00	-700.03
3005	-0.00070	-120.10	0.00000E+00	100.00
3006	-1.0720	003.33	0.00000E+00	-1200.0
3007	0.10003	-130.00	0.00000E+00	100.70
3008	0.00035	1000.0	0.00000E+00	-0100.7
3009	0.00037	-0217.1	0.00000E+00	1000.3
3010	0.00003	-1027.1	0.00000E+00	1000.0
3011	-0.23030E-01	-113.57	0.00000E+00	100.00
3012	0.02000	1010.0	0.00000E+00	-774.00
3013	0.02000	-774.00	0.00000E+00	-12700.

NOTE (VES.NO ON CONTINUOUS).

0000 POST1 ELEMENT STRESS LISTING 0000

LOAD STEP 1 ITERATION 1 SECTION 1
TIME 0.10000 LOAD CASE 1

ELEM	SO18	SO2	SOV1	SO28	SOV2
3300	0.16307E-10	-0.53500E-06	0.00000E+00	0.18000E-00	0.00000E+00
3301	-1.0000E	-77.000	0.00000E+00	00.200	0.00000E+00
3302	0.24123	-140.14	0.00000E+00	130.93	0.00000E+00
3303	-0.00001	907.84	0.00000E+00	-8030.0	0.00000E+00
3304	-0.57620	-1375.8	0.00000E+00	800.18	0.00000E+00
3305	75.330	-108.23	104.91	400.42	-833.14
3306	88.014	587.36	-850.18	-152.38	40.830
3307	80.804	789.10	-300.13	-80.303	10.401
3308	-45.426	500.74	-187.46	-500.86	820.66
3309	-80.043	87.000	-4.0306	-300.46	181.88
3310	-201.73	147.00	101.40	-300.93	-800.07
3311	-200.04	-800.36	-606.04	800.86	-1793.0
3312	0.3007	103.04	80.430	-80.718	-80.374

NOTE 1YES,NO OR CONTINUOUS).

0000 POST1 ELEMENT STRESS LISTING 0000

LOAD STEP 1 ITERATION 1 SECTION 1
TIME 0.10000 LOAD CASE 1

ELEM	SO18	SO2	SOV1	SO28	SOV2
3313	170.16	-95.774	-104.68	200.88	207.64
3314	200.87	-205.47	-823.17	186.56	100.00
3315	400.36	-100.10	-804.78	340.86	420.76
3316	811.06	-407.30	-374.30	132.90	182.38
3317	705.10	-104.64	-104.18	100.30	355.46
3318	800.04	-349.87	-317.23	60.000	800.16
3319	800.73	-51.816	-72.704	95.857	10.100
3320	-214.18	821.12	1024.8	-1377.0	-800.83
3321	-882.44	47.050	546.00	6.3012	255.00
3322	-224.44	109.13	-56.718	-257.00	304.80
3323	-800.33	326.24	-316.81	-172.77	170.00
3324	-100.64	807.41	-150.27	-400.00	376.08
3325	-87.941	467.40	-300.60	-866.67	808.30
3326	-110.76	62.592	-32.823	-98.878	70.807

NOTE 1YES,NO OR CONTINUOUS).

0000 POST1 ELEMENT STRESS LISTING 0000
 LOAD STEP 1 ITERATION- 1 SECTION- 1
 TIME 0.10000 LOAD CASE 1

ELEM	S01R	S02	S01I	S02I	S01R	S02R	S01I	S02I
3267	8.0043	111.86	-40.824	-07.300	-40.824	-07.300	-40.824	-07.300
3268	83.084	-800.00	86.301	170.03	86.301	170.03	86.301	170.03
3269	-846.37	534.10	-284.08	146.28	-284.08	146.28	-284.08	146.28
3270	-850.31	401.24	-186.00	-260.80	-186.00	-260.80	-186.00	-260.80
3271	-1350.0	607.46	-375.05	-64.10	-375.05	-64.10	-375.05	-64.10
3272	-1352.8	250.20	-85.085	-21.00	-85.085	-21.00	-85.085	-21.00
3273	-8100.0	407.37	-800.00	-81.00	-800.00	-81.00	-800.00	-81.00
3274	-2111.1	77.000	13.010	-300.80	13.010	-300.80	13.010	-300.80
3275	-8003.7	510.01	-80.306	-400.30	-80.306	-400.30	-80.306	-400.30
3276	-850.06	1000.0	61.008	-805.08	61.008	-805.08	61.008	-805.08
3277	-877.10	914.04	86.549	-801.06	86.549	-801.06	86.549	-801.06
3278	-800.05	501.05	-84.024	-600.00	-84.024	-600.00	-84.024	-600.00
3279	-1407.1	1074.0	-22.103	-132.10	-22.103	-132.10	-22.103	-132.10
3281	-1400.1	717.05	47.001	-810.74	47.001	-810.74	47.001	-810.74

 NONE 1YES,NO OR CONTINUOUS)

0000 POST1 ELEMENT STRESS LISTING 0000
 LOAD STEP 1 ITERATION- 1 SECTION- 1
 TIME 0.10000 LOAD CASE 1

ELEM	S01R	S02	S01I	S02I	S01R	S02R	S01I	S02I
3270	-1051.4	1035.6	-59.000	-305.70	-59.000	-305.70	-59.000	-305.70
3271	-1053.0	800.44	41.004	-1085.0	41.004	-1085.0	41.004	-1085.0
3272	-6000.3	635.08	-188.06	-4410.0	-188.06	-4410.0	-188.06	-4410.0
3273	79.054	-344.82	-88.005	680.44	-88.005	680.44	-88.005	680.44
3274	80.058	-705.75	-297.06	300.44	-297.06	300.44	-297.06	300.44
3275	97.708	-300.30	-83.102	685.67	-83.102	685.67	-83.102	685.67
3276	101.70	-1042.4	-142.00	405.06	-142.00	405.06	-142.00	405.06
3277	150.45	-400.50	-103.42	1040.0	-103.42	1040.0	-103.42	1040.0
3278	857.25	-1140.3	-804.68	613.60	-804.68	613.60	-804.68	613.60
3281	334.66	30.830	176.33	-120.80	176.33	-120.80	176.33	-120.80
3282	613.44	1412.2	-82.835	-800.80	-82.835	-800.80	-82.835	-800.80
3283	400.38	715.15	-28.104	-80.306	-28.104	-80.306	-28.104	-80.306
3284	400.64	610.73	9.0003	-507.75	9.0003	-507.75	9.0003	-507.75
3285	452.70	1422.4	-7.7020	-936.10	-7.7020	-936.10	-7.7020	-936.10

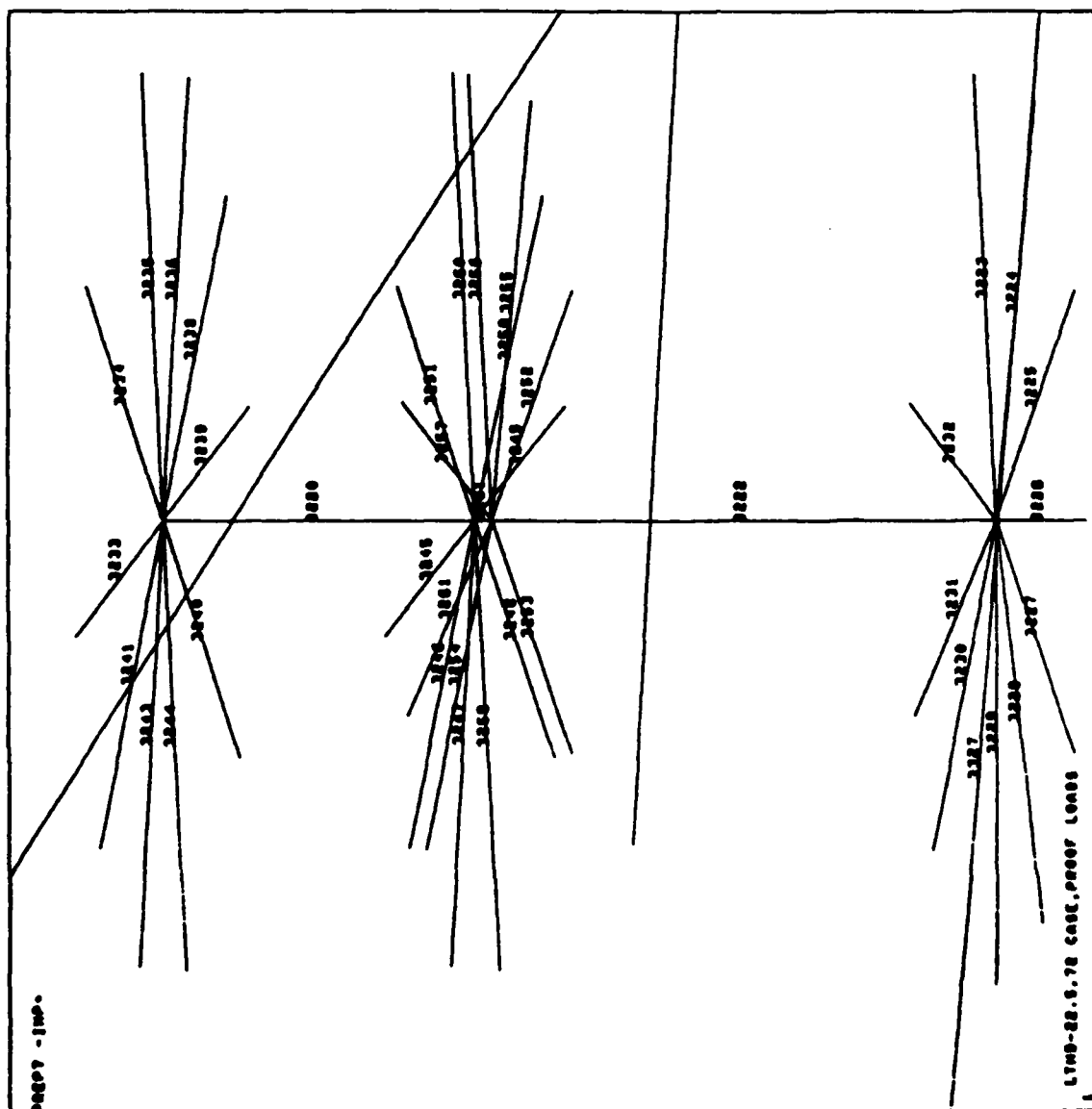
 NONE 1YES,NO OR CONTINUOUS)

[illegible]

BESS POST ELEMENT STRESS LISTING 2020									
LOAD STEP 1		ITERATION-		1 SECTION- 1					
TIME. 0.12000		LOAD CASE. 1							
		992	991	992	992				
ELN	3018.7	0.05500E+00	-0.2728E+00	0.00000E+00	-0.2550E+07	0.3550E+07			
3004	3770.3	0.00400E+07	-0.3050E+00	-0.2313E+00	0.0754E+07				
3006	3770.3	0.00400E+07	-0.3050E+00	-0.2313E+00	0.0754E+07				
3008	3771.4	-0.2213E+00	0.0754E+00	-0.2309E+00	0.1600E+07				
3007	3770.4	0.00000E+00	0.1600E+00	-0.1751E+00	0.0000E+07				
3008	4073.0	0.0181E+00	0.2024E+00	0.0000E+07	-0.4007E+07				
3009	4073.4	0.0000E+07	-0.4007E+00	0.0000E+07	-0.1814E+00				
3010	4073.0	-0.2334E+00	0.1214E+00	-0.2000E+00	0.1700E+00				
3011	4077.2	-0.2000E+00	0.1700E+00	-0.2647E+00	0.1700E+00				
3013	4079.6	-0.0647E+00	0.1700E+00	-0.1400E+00	-0.7400E+07				
3016	4079.0	0.1400E+00	-0.7400E+07	0.0000E+00	-0.2000E+00				

200H
XV--1
VV--1
ZV-1
010Y-32.0
XF-142
VF-06.0
ZF--02.0
WV0-12.0
VW0-4.10

LOWER
SHAFT
ELEMENTS

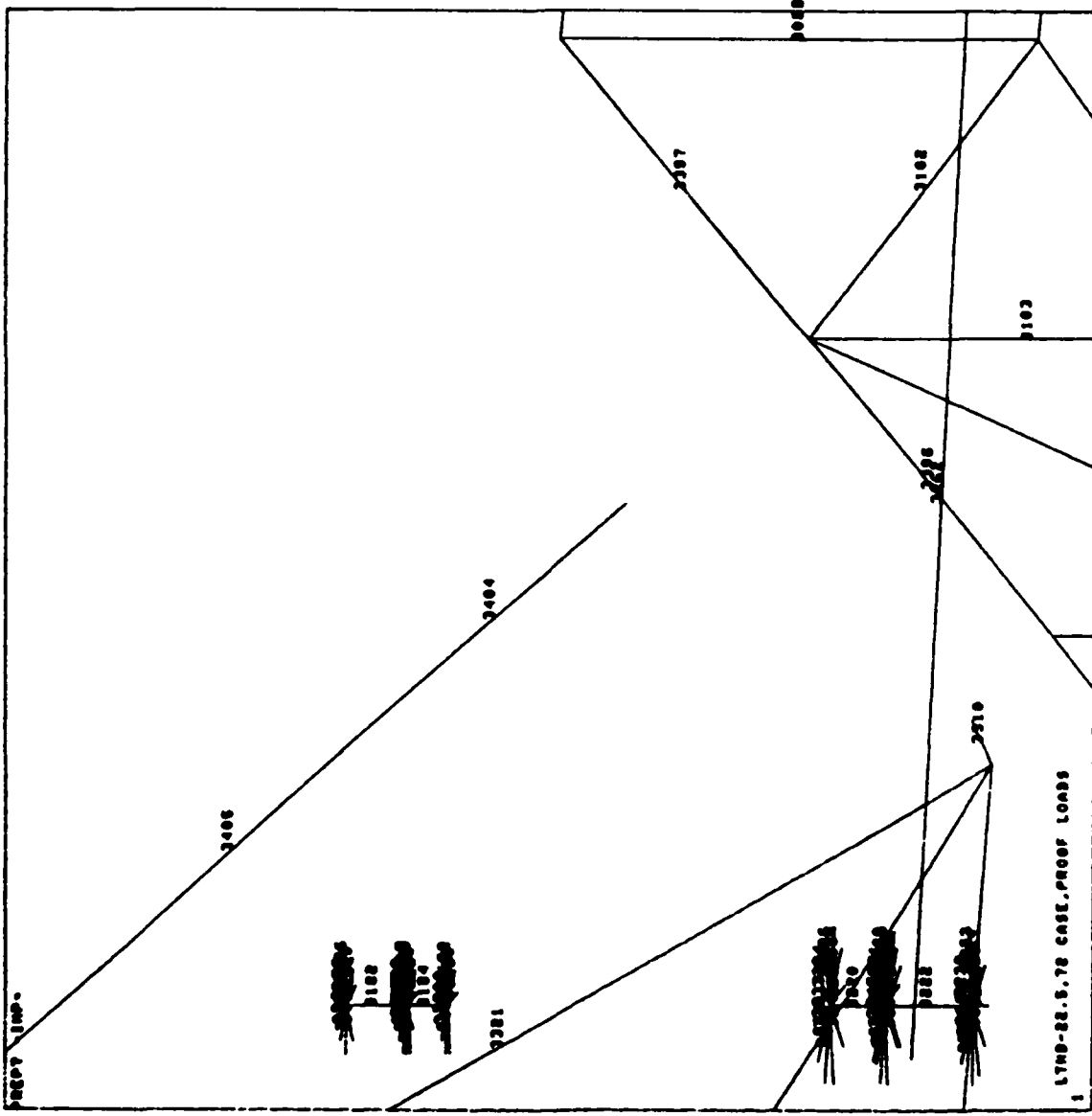


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 0 07-125
 0 07-120
 0 07-75.0
 0 070-10.4
 0 070-6.51

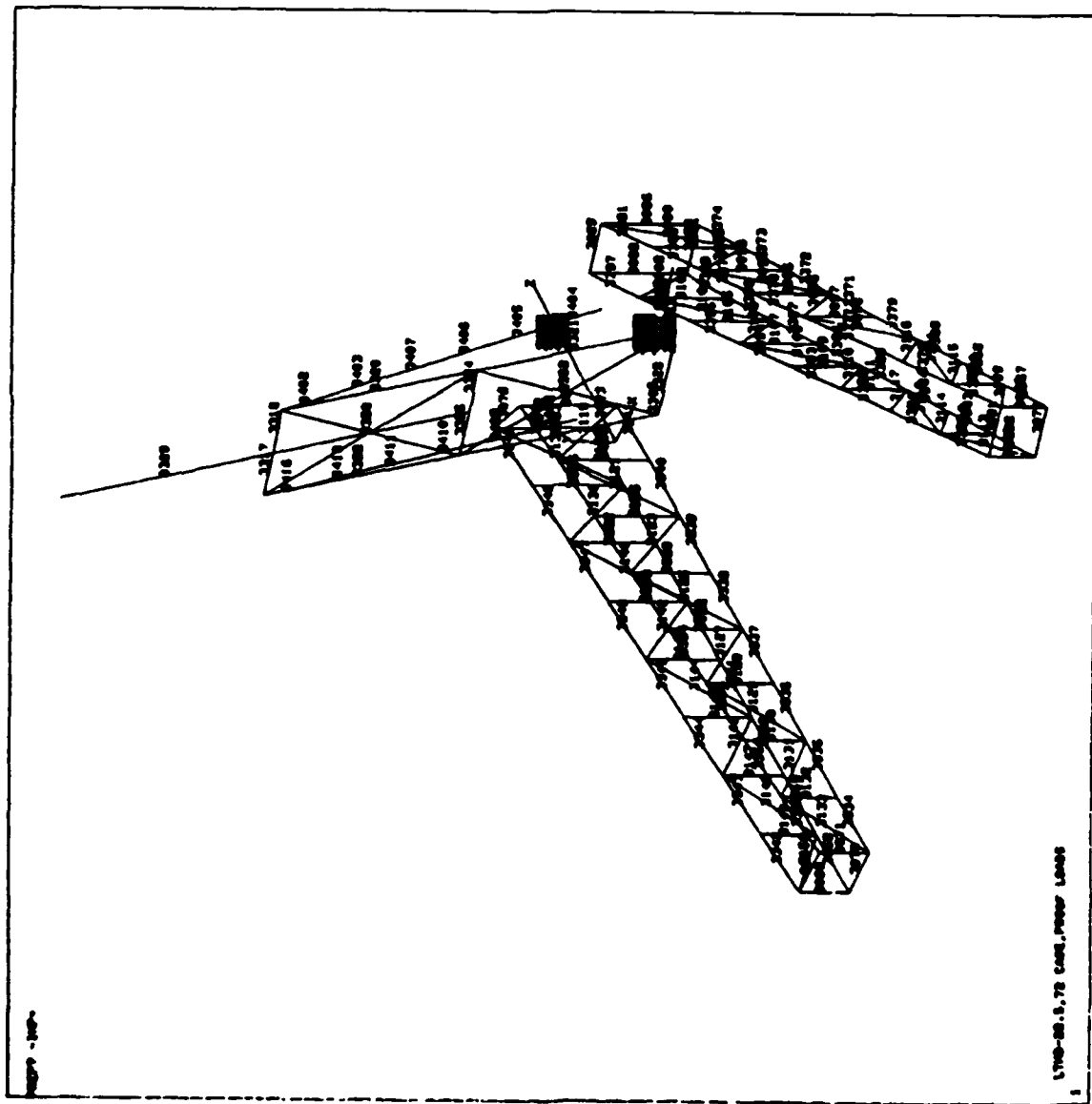
LYND-28.6.72 CASE PROOF LOADS

ANSYS 4.20
 JAN 23 1987
 11:15:44
 PREPT ELEMENTS
 ENUR-1

200N
 XV--1
 YU--1
 ZV--1
 0 D157-805
 0 XF-130
 0 YF-120
 0 ZF--72
 XRTD-19.4
 YRTD-6.51



00000 4.00
 JUN 03 1987
 11:10:04
 PREP7 ELEMENTS
 EXPR=1
 100--1
 100--1
 20--1
 0107-011
 07-00-0
 10-130
 07--100
 0070-4.00
 0070-3.00



D3/210

CEL MEMO: JANUARY 28, 1987

FMC Central Engineering Laboratories
Santa Clara

Interoffice

To J. Ries Date Jan. 28, 1987

From C. R. Ortloff cc E. Thuse
A. Amberg
R. Kazares
R. Rathe
L. Libhardt

Subject REMAINING TASKS ON THE LVHD PROJECT -
COST/BENEFIT ANALYSIS FOR SEVERAL PROPOSED TASK

To date (1-28-87) about \$43K out of \$65K authorized has been expended for labor charges on system analysis tasks. Allowing for a \$15K expenditure by M. Rodemaker for cradle analysis tasks, and a \$5K recapture from C. C. Chen, about \$12K remains, without consideration of computer charges. Retroactive computer charges starting 1-1-87 essentially reduce the remaining budget to a few thousand dollars. Further clarification is needed on the start date for these charges as well as an understanding on final management agreements on general issues regarding computer charges past 1-28-87. *

From a phone conversation with you (JR) on 1-28-87, the request was made to list important analysis tasks remaining together with cost estimates (including labor and computer charges). Accordingly, these tasks are listed below:

1. Computation of the effects of a "soft soil" model on system stress levels and stability. Linear springs will be input between the spade and ground to model the rearward motion of the system as the spade compresses the "soft soil" under recoil and torque impulse loads applied to the cradle.

*No
geom.
change.*

The 0°-0° or 22.5°-0° FE system model will be used as the rearward reaction force is largest for these cases. Stress contour plots for the gimbal and platform for "soft soil" and "hard soil" spade emplacement will be made and compared to assess the magnitude of the difference. Results will determine the amplification/diminition effect of the soil model on stress levels. Results will be reported in memo form.

*one - lum
- no
instab. h*

Labor: (Set-up, Report & Postprocessing time) 25 hours = \$2,000
Computer charges: 30 CPU hours @ \$125/hour = \$3,750
Total: \$5,750

2. Modification of the existing FE system model to incorporate the next design iteration in the platform and gimbal structure (plus a possible update in trail and cradle "beam" representations). The magnitude of this task depends on the degree of FEM modification required. An estimate of (say) one week (labor) for model modification and a computer run for the "worst load case" is as follows:

*need
form
out*

J. Ries
Remaining Tasks on the LVHD Project
Cost/Benefit Analysis for Several Proposed Tasks

January 28, 1987
Page 2

*probably
more
than
this*

Labor: (Model Modification, Report & Postprocessing) 54 hrs. = \$4,400
Computer Charges: 50 CPU hours @ \$125/hour = \$6,250
(includes average of interactive and batch run times)
Total: \$10,400

Totals for this task may be higher if FE model changes are very significant (or lower if only local thickness changes are prescribed).

3. Computation of static 16g LAPES loads on a system model with folded trails.

*old
geometry*

Labor: (Model Modification, Postprocessing & Final Memo) 30 hours = \$2,400
Computer Charges: 30 CPU hours @ \$125/hour = \$3,750
Total: \$6,150

No

For the above, a run involving towing loads could be substituted for the same cost.

4. Final report (includes results of Item 2)

Labor: 60 hours = \$5,000

yes

*old
geom*

5. Detailed multilamina FE model of the new cradle design and layer-by-layer analysis of stresses, deflections and failure mechanisms. This run will be a static analysis and dynamic amplification factors from M. Rodamaker's analysis will be used to obtain maximums of the dynamic stress state. Use of part of these computed results can be used in an inertial buckling analysis to determine cradle stability under impulse loads. The new FE model will be for the current cradle geometry, cable mount and (new) materials selection.

No.

Labor: (includes new FE model, postprocessing time and final memo) 60 hours = \$ 4,800
Computer charges: 60 CPU/hours @ \$125/hour = \$ 7,500
Total \$12,300

The above tasks 1, 2 and 4 total \$11,400 for labor and \$12,000 for computer charges and probably constitute the minimum work package necessary to assure that the new system design is adequate. Tasks 3 and 5 are optional but serve to increase confidence in the adequacy of the design.

C. R. Ortloff

C. R. Ortloff

CRO/870128/01

*Recommend do 2, and 4.
My estimate*

~ \$17K

Have 2 due about mid-Feb

As an addendum to this memo, a few additional comments on Task 5 are in order. As in prior cradle analyses, a detailed FE model needs to be made for this task. Use of ANSYS STIF 53 (3 node composite elements) and STIF 45 (8 node isoparametric elements) will reduce run times considerably. Use of the maximum stress failure criteria will be continued for the following reason: Since the Tsai-Hill failure ellipse lies within the maximum stress rectangle in stress space, if the structure fails based on maximum stress criteria, it will certainly fail based on Tsai-Hill criteria. Thus, use of the maximum stress criteria gives some margin of conservatism in the design. *

One remaining concern with the cradle is local buckling (or crippling) of the edge-loaded Gr/Ep sandwich structure near the forward manifold under proof impulse loads. Some computer work can be done in this task to investigate this effect. Certainly, this problem should be addressed in the test phase of future work on the cradle. Since ARDEC appears interested in tests/calculations that are at hot, wet composite conditions, the analysis tasks can easily include these effects and uncover problems that may be missed in the test phase unless environmental test chambers are used. Additional tasks related to thermal expansion deformation and stress levels can also be addressed by this task item.

Carroll

D3/220

CEL MEMO: FEBRUARY 12, 1987

Interoffice

To: L. Libhardt*

From: C. R. Ortloff

Subject: **STATIC PROOF LOAD ANALYSIS OF
THE LWED SYSTEM MODEL (22.5°-72° LOAD CASE)**

Date: Feb. 12, 1987

cc: E. Thuse
A. Amberg
R. Kazares
D. Langerud
R. Rathe
J. Ries

Attached are Figures 602-623* detailing the equivalent stress and UX, UY, UZ deflections of the gimbal and platform under statically applied proof loads. The recoil and firing torque maximum load vectors are decomposed into X, Y and Z components and applied at their normal point(s) of application on the beam representation of the cradle. In this manner, the subsidiary effects of the cradle "moment arm" are preserved with respect to load transmittal into the gimbal/platform and spade. For the present run, the trail ends are subject to a UY=0 constraint based on the fact that these ends rest on the ground while static loads are applied. An additional 1g gravity load is applied uniformly to all discrete and continuously distributed masses in the model. The spade is fixed at its lower edge while the horizontal spade plate is subject to UY=0 constraints.

Stresses shown are for the TOP (outside), MIDDLE and BOTTOM (inside) surface planes of STIF 43 plate elements used to compose the FE model. The SIGE stress follows the definition

$$\sigma_E = \frac{1}{\sqrt{2}} \sqrt{(\sigma_{xx} - \sigma_{zz})^2 + (\sigma_{xx} - \sigma_{yy})^2 + (\sigma_{yy} - \sigma_{zz})^2 + 6(\tau_{xy}^2 + \tau_{xz}^2 + \tau_{yz}^2)}$$

where σ_{ij} denotes normal stress and τ_{ij} denotes shear stress. The plasticity criteria used is $\sigma_E = 120$ ksi; this value denotes the boundary between elastic and plastic regions (for which $\sigma_E > 120$ ksi). The coordinate system used is shown in Figure 609. All displacements are with respect to global axes. Note that some of the UZ displacements toward the top part of the platform are large. As the lower arms of the gimbal absorb all of the proof recoil loads, a large moment (M_x) is input into the platform causing bending in the -Z direction. Note also that deflections are calculated on the basis of linear elasticity even though stresses may exceed the yield stress value. Actual deflections, calculated on the basis of plasticity theory, would be larger than elastic values shown (although stresses would be less than those shown).

Comparison of results from this load case to that run on the basis of dynamic input load (Memo: CRO to R. Rathe, 1-26-87) gives some indication as to dynamic amplification factor for stress and deflection levels.

L. Libhardt
Static Proof Load Analysis of
the LVHD System Model (22.5₀-72⁰ Load Case)

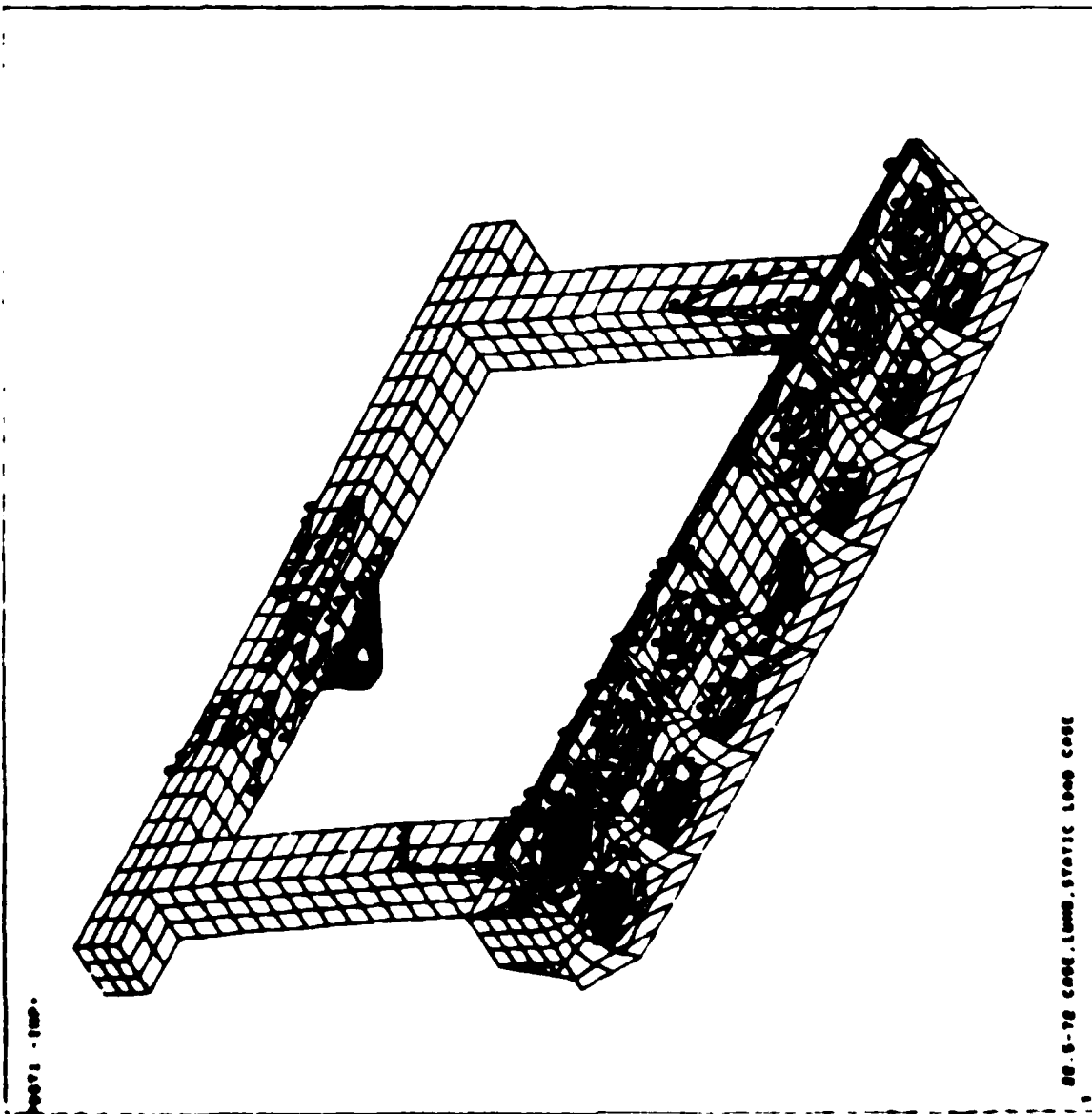
Feb. 12, 1987
Page 2

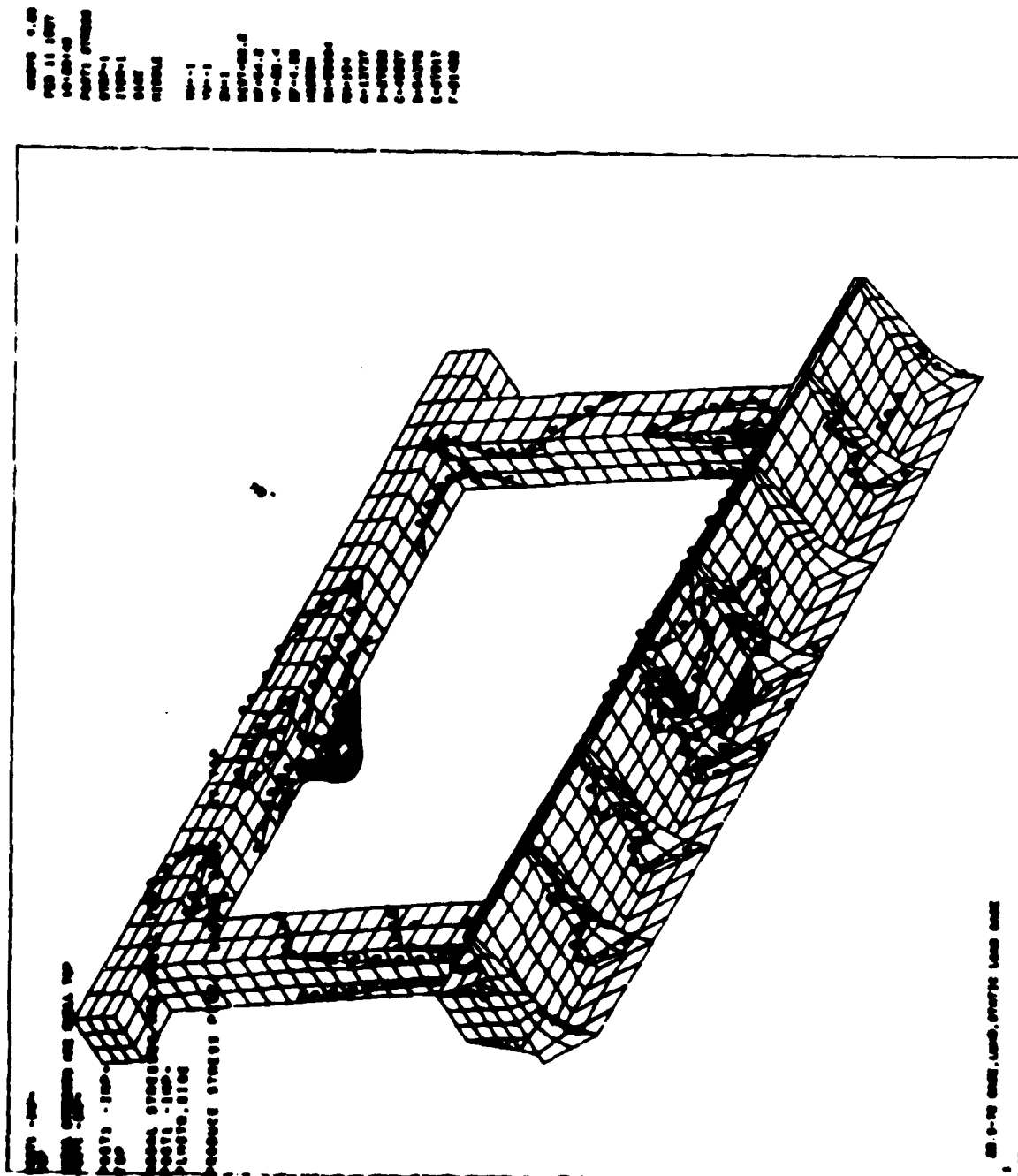
As a further note on thermal expansion effects in the Gr/Ep cradle, it should be noted that the "through the thickness" thermal expansion coefficient can be 20-50X the in-plane thermal expansion coefficient. It may be important to include these effects and examine stress and deflection results in the vicinity of ply-drop-off regions and fillet regions where the Gr/Ep layers transition into "thick walls."



C. R. Ortloff

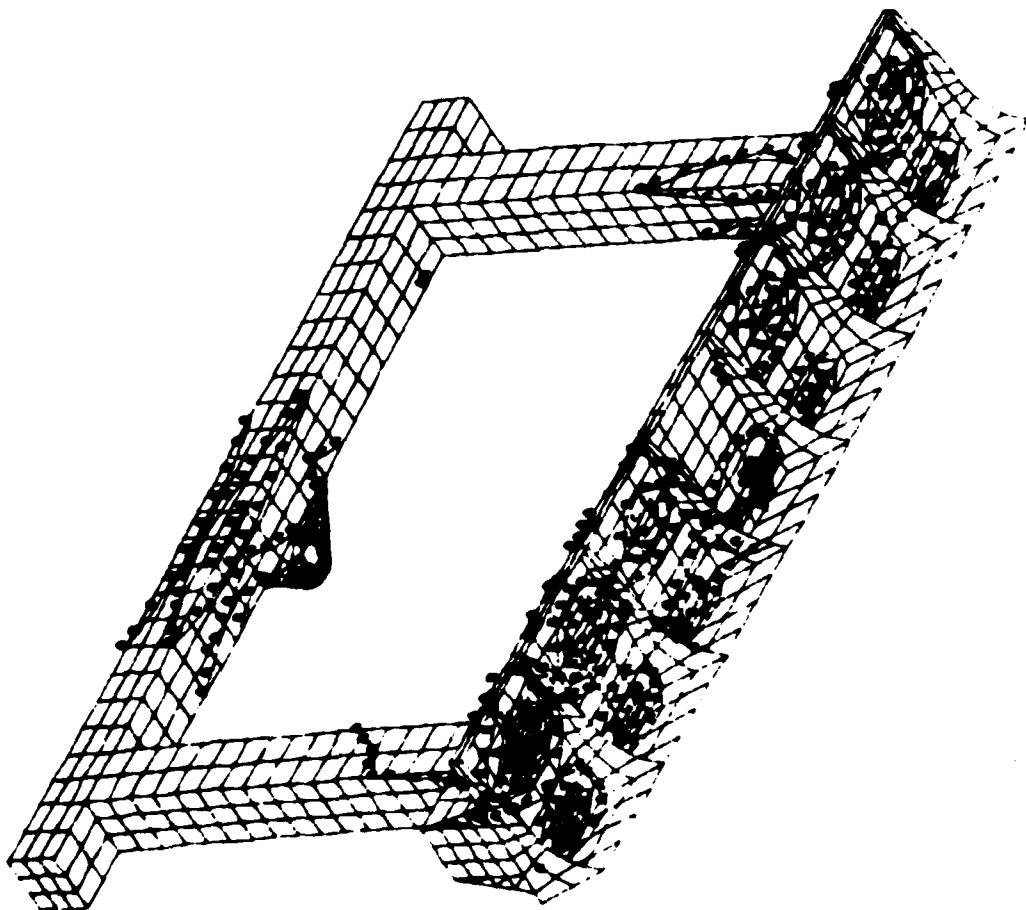
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 1700-1
 0100
 700
 20-1
 30-1
 20-1
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 27-00.0
 27-00.0
 27-00.0
 27-00.0
 010000
 01-170000
 00-000
 0-00000
 0-01700
 0-17000
 0-100000
 0-100000
 0-100000
 0-100000





Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100
1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	

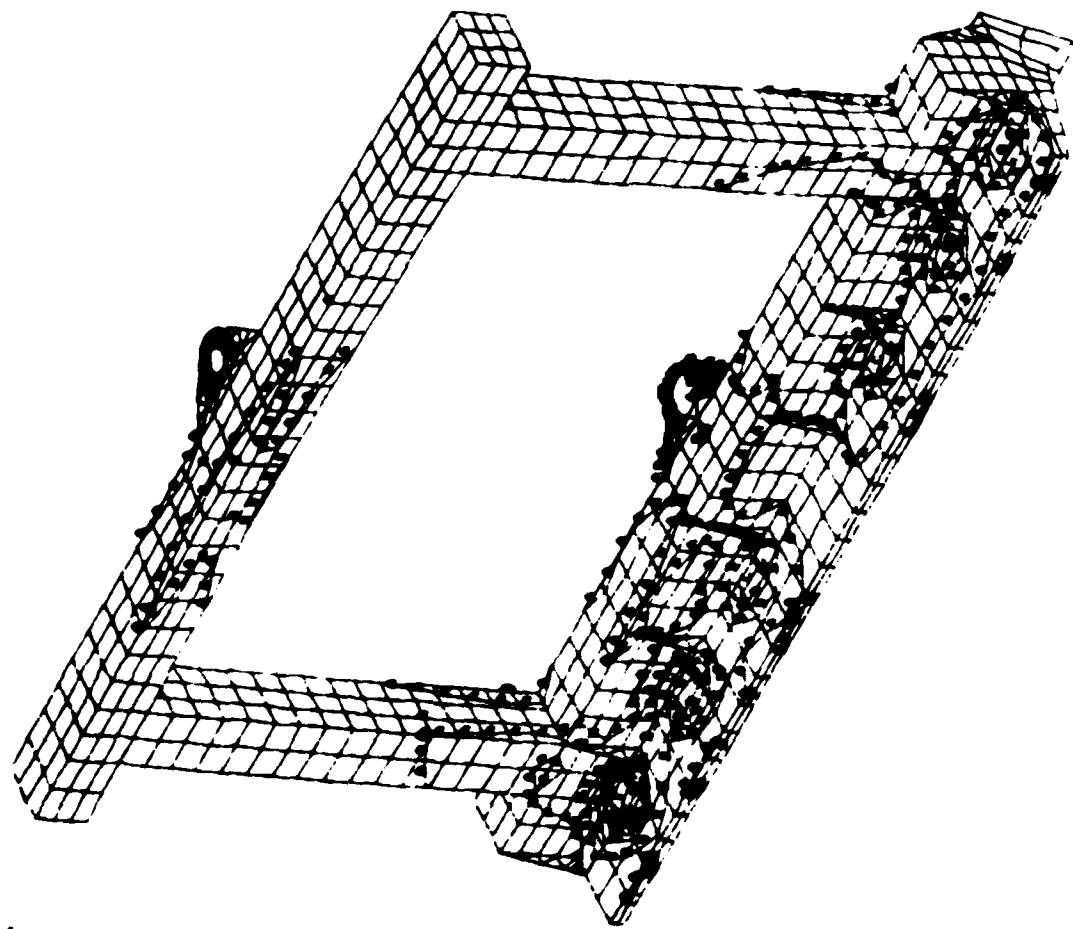
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 MU=1
 VU=1
 20=1
 0101-00.2
 WF-04.2
 VF-06.4
 27-04.05
 MIDDLE
 MM-10104
 MM-556
 0-00453
 0-00352
 C-70261
 0-104150
 E-120040
 F-155040



POST1 - IMP.

22.5-72 CASE, LUMP, STATIC LOAD CASE

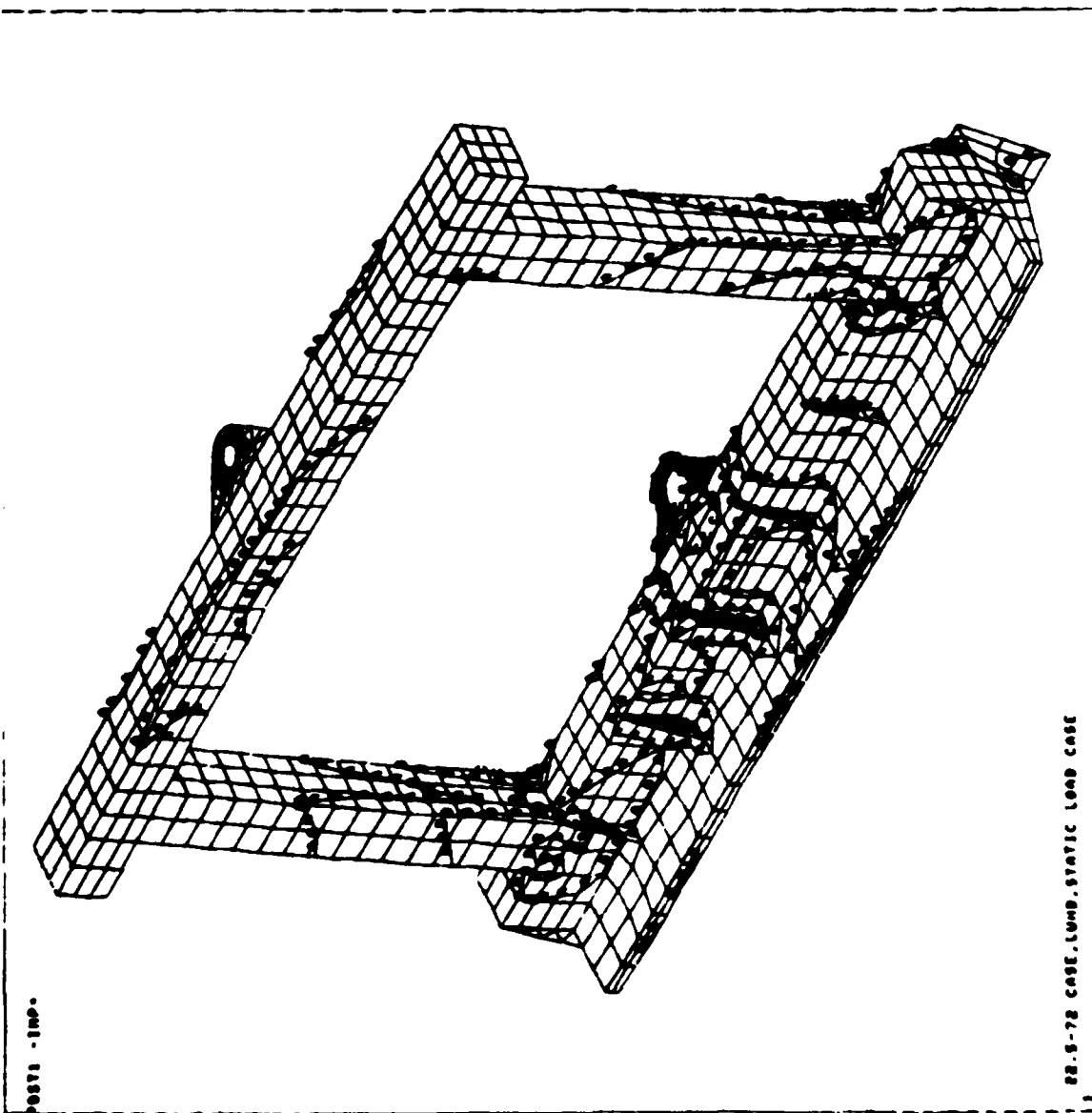
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 FEB 11 1987
 11:04:30
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 STEP=1
 ITER=1
 STRESS
 TOP
 20=1
 20=1
 20=1
 5157-55.8
 27-51.2
 27-27.7
 27-4.17
 MIDDLE
 22=170004
 22=464
 22=26004
 22=51726
 22=77358
 22=102000
 22=120622
 22=154854



POST1 -IMP-

82.5-72 CASE.LUMP,STATIC LOAD CASE

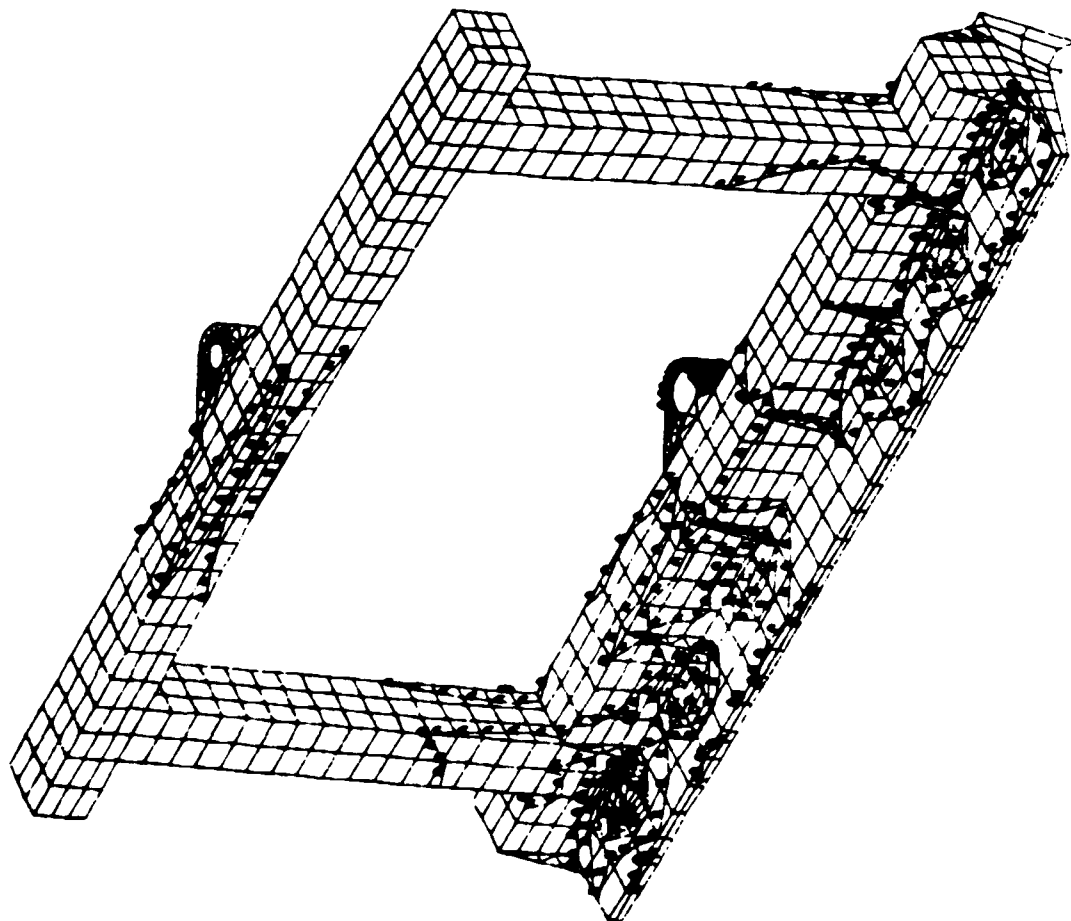
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 11:18:00
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 SLOC
 MIDDLE
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 37-51.8
 39-87.7
 39-4.17
 MIDDLE
 22-55004
 22-194
 4-13737
 8-27882
 8-40827
 8-54372
 8-87817
 8-81482



POST1 -IMP-

22.5-72 CASE, LUMB, STATIC LOAD CASE

ANSYS 4.80
 FEB 11 1987
 11:29:34
 POST1 STRESS
 STEP=1
 ITEM=1
 SLOC
 BOTTOM
 ZU=1
 VU=1
 ZU=1
 DIST=56.6
 XF=51.2
 YF=27.7
 ZF=4.17
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 F=155948



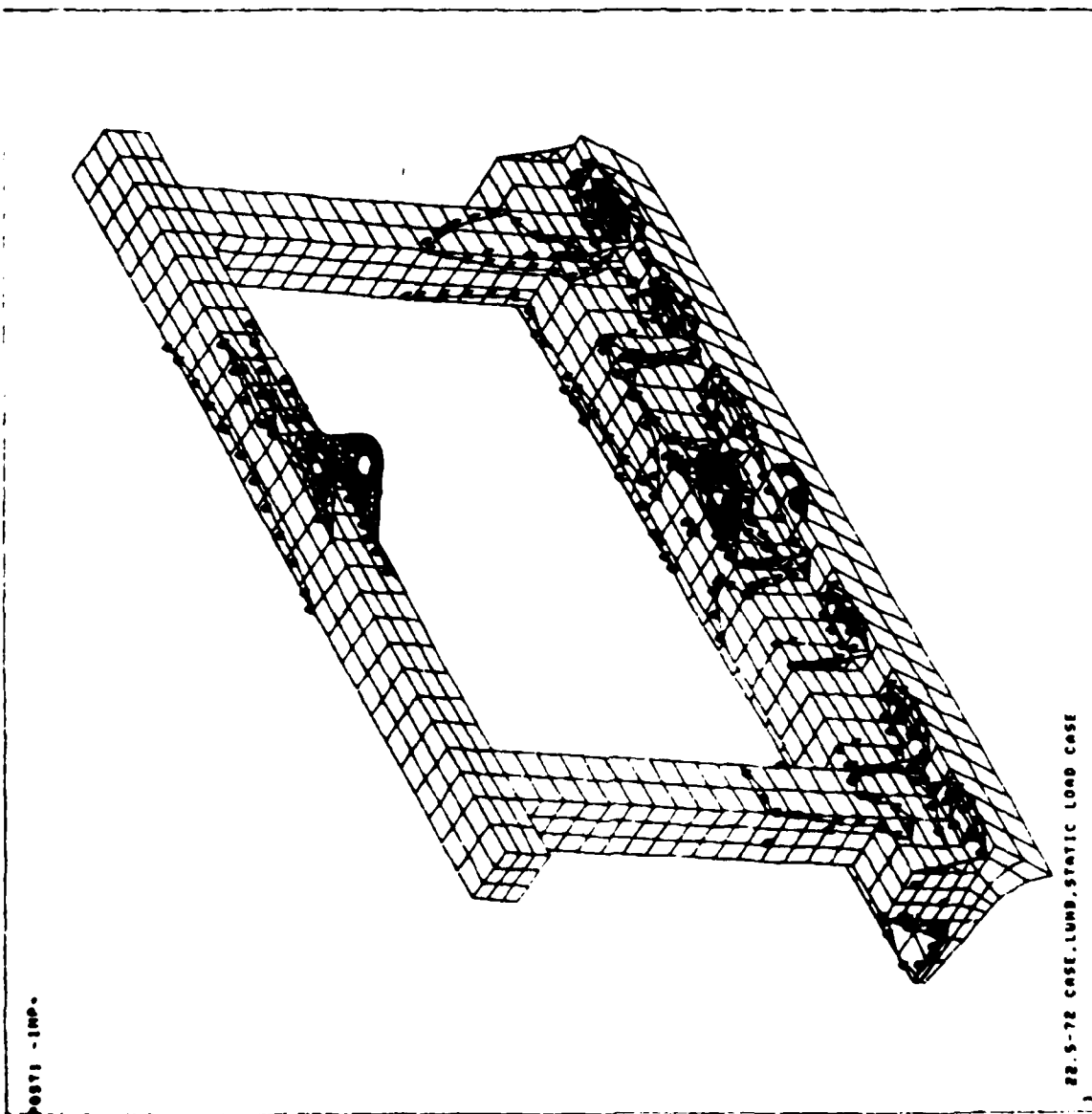
POST1 -IMP.

28.5-72 CASE, LUMP, STATIC LOAD CASE

```

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POST1, STRESS
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ITER=1
SLOF
TOP
ZU=1
VU=1
ZU=-1
2157-88.2
27-54.2
VF-26.4
ZF-4.85
HIDDEN
RM=179884
RM=464
A=26094
B=51726
C=77358
D=102000
E=120282
F=154254

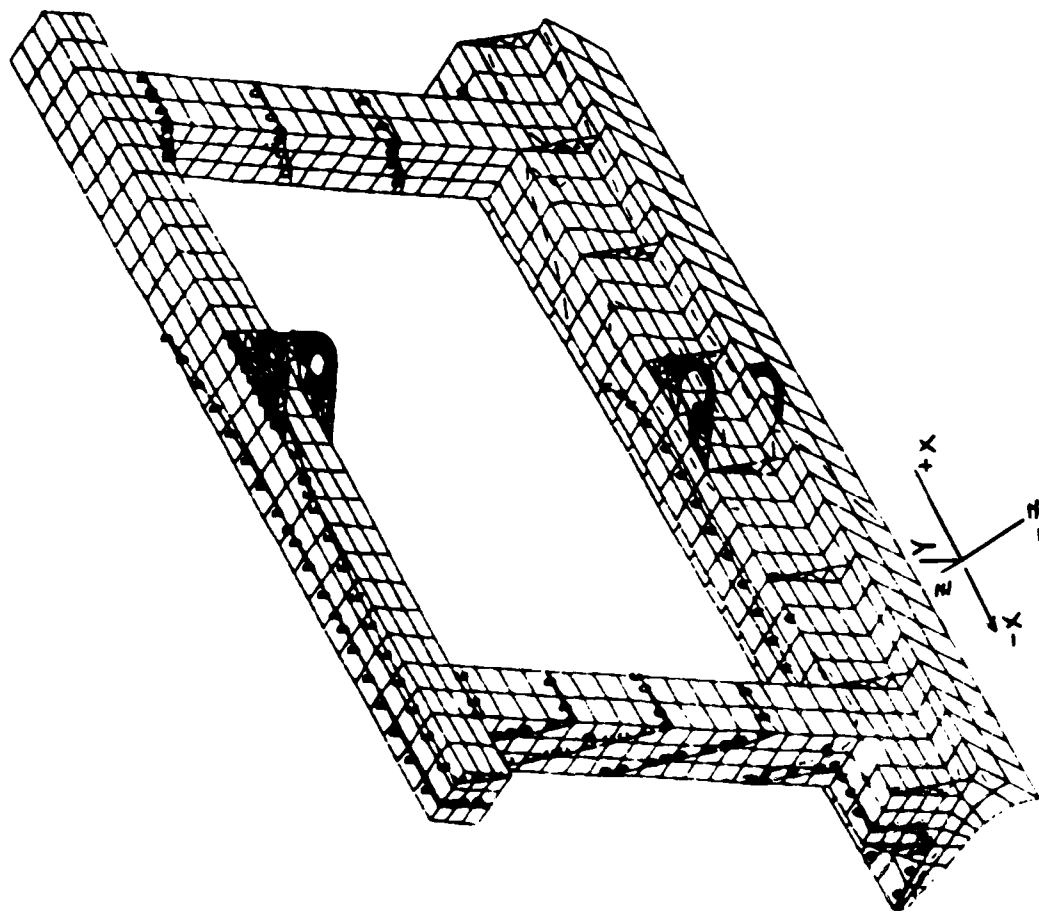
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UN
DISPL MODAL
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YU=1
ZU=1
20--1
DISP=60.8
XF=54.2
VF=86.4
ZF=4.85
MIDDM
MM=1.884
MM=1.888
MM=1.888
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B=1.000
C=1.000
D=1.141
E=1.191
F=1.241

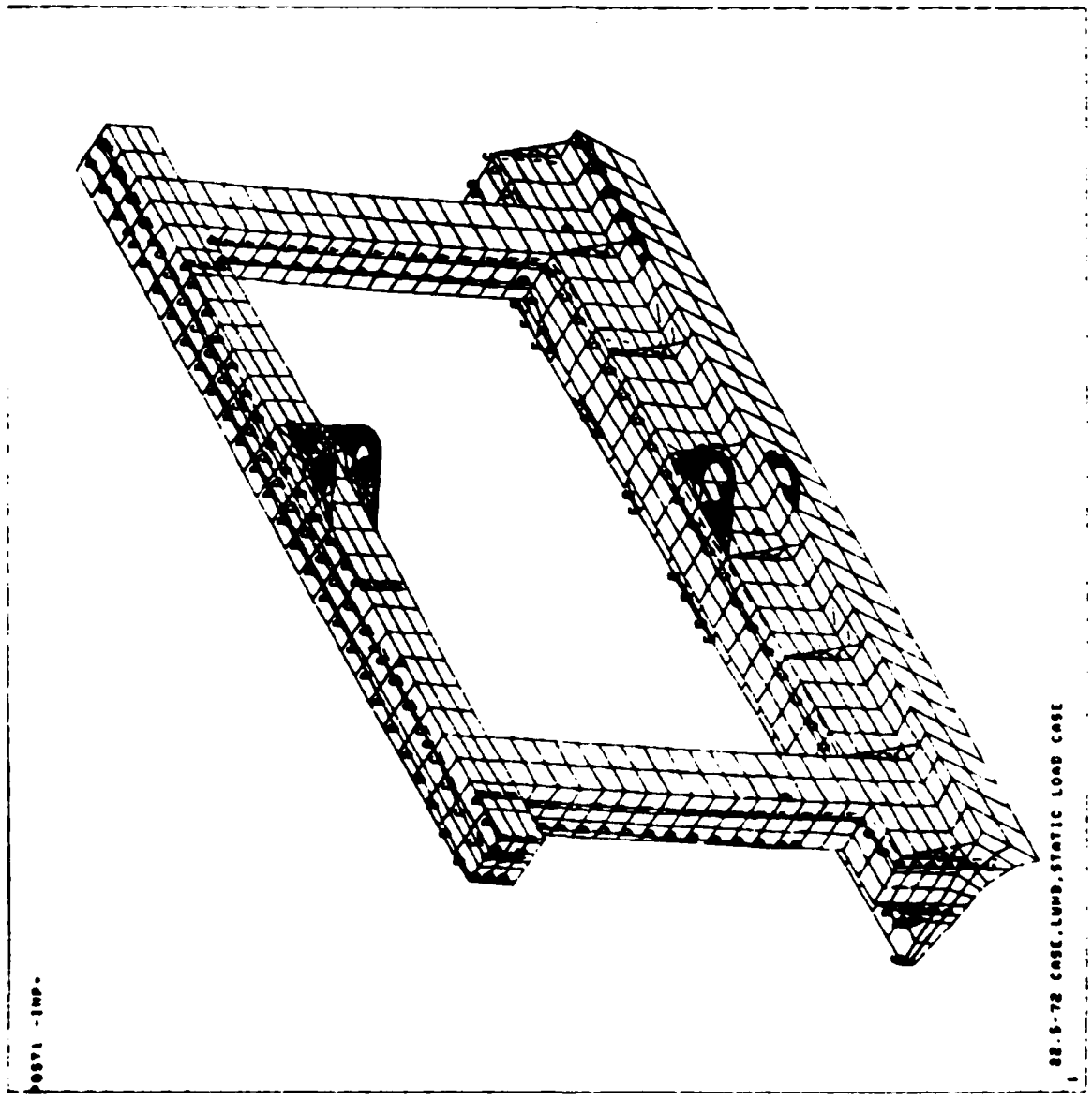
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POST1 -IMP.

22.9-72 CASE, LUMB, STATIC LOAD CASE

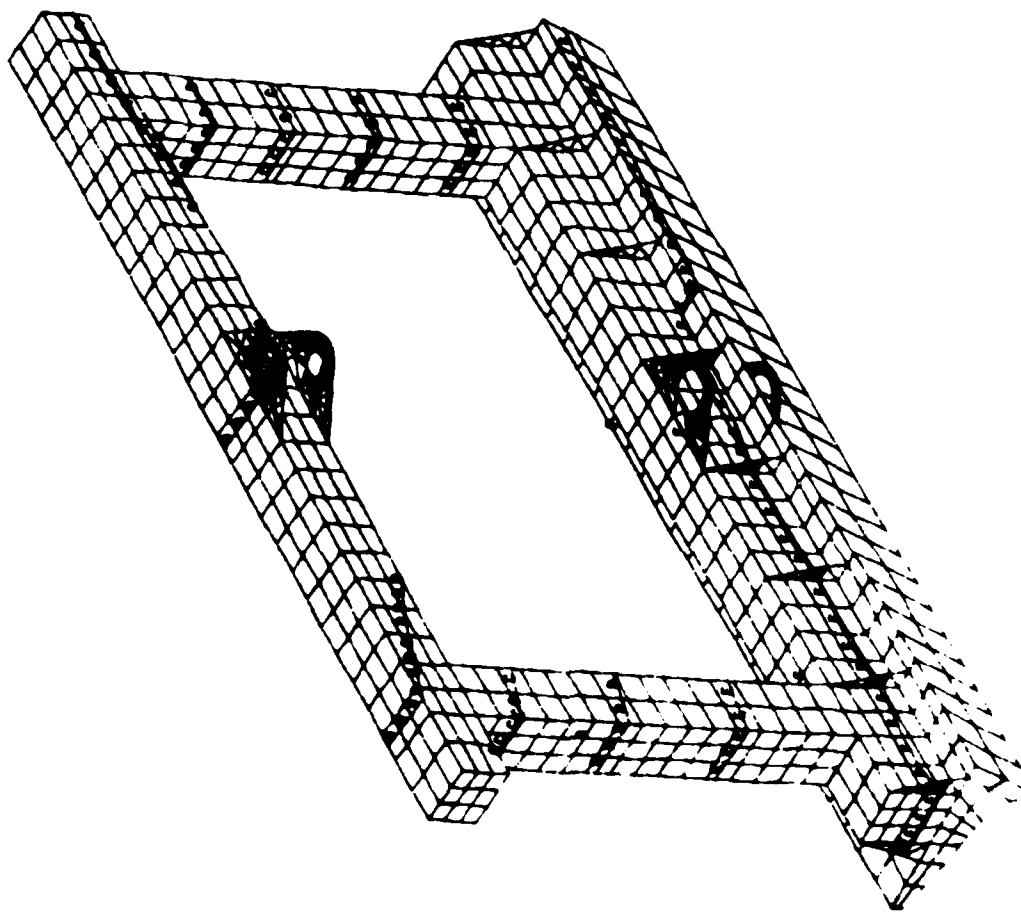
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 FEB 11 1987
 12:27:57
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 YZPL,1
 UN
 019PL MODEL
 NU=1
 VO=1
 ZV=1
 0197-68.8
 MF=64.2
 VF=20.4
 ZF=4.85
 MIDDLEM
 MX=.474
 MY=...308
 MZ=...817
 A=...0071
 C=...0000
 D=...143
 E=...863
 F=...383



```

00000 4.00
FEB 11 1987
12144147
POST1 STRESS
STEP=1
1788-1
U2
DISPL MODAL
NU=1
VU=1
20=-1
DISP=50.8
27=54.8
VF=20.4
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BB=-8.10
CC=-1.00
DD=-1.10
EE=-.90
F=-.10

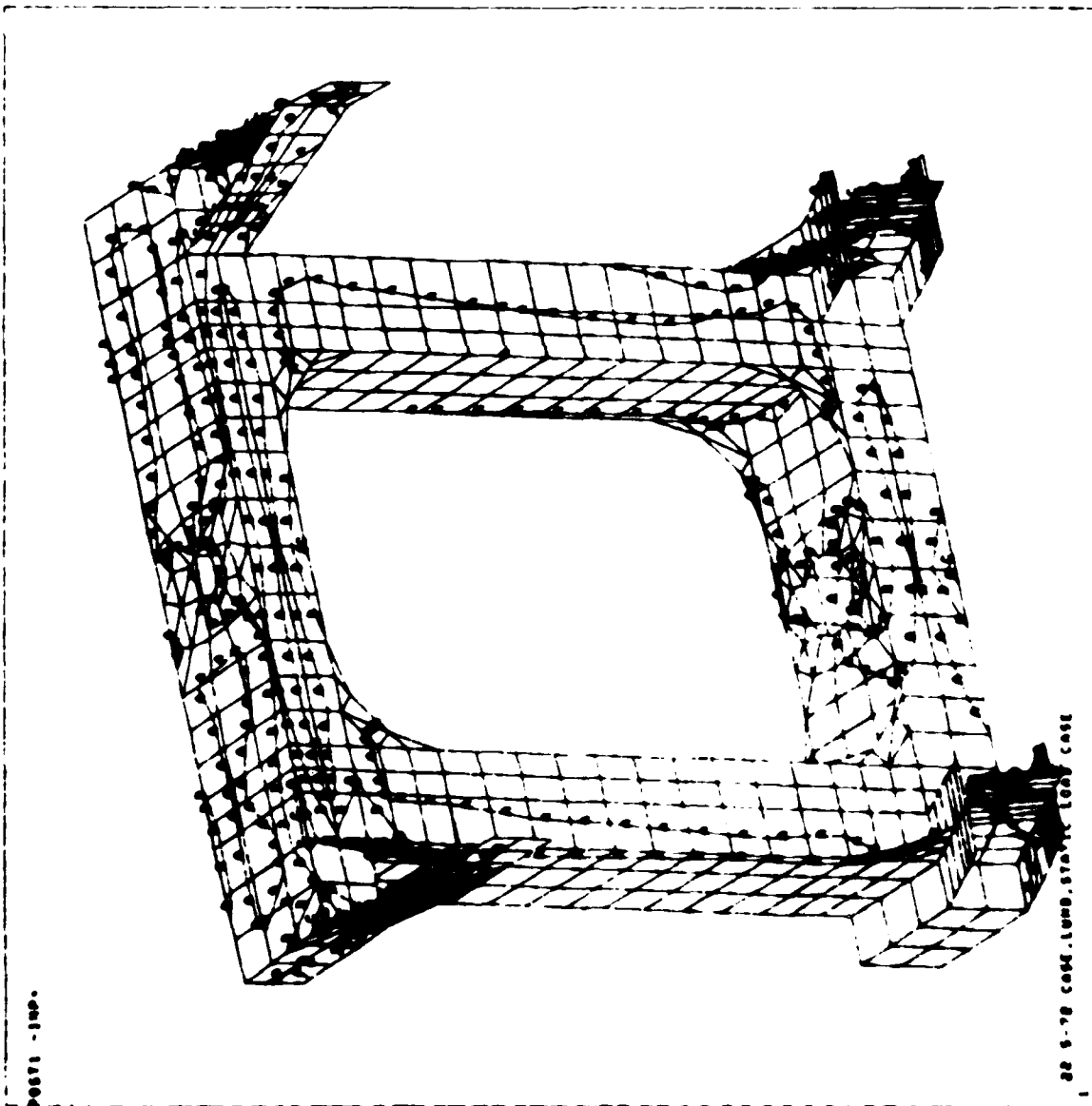
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POST1 -IMP.

22.8-72 CASE LUMP. STATIC LOAD CASE

ANSYS 4.80
 FEB 11 1987
 11:47:46
 POST1 STRESS
 STRESS
 1768-1
 SLOC
 TOP
 MU-1
 VU-1
 20-1
 0197-00.7
 00-03.0
 00-36
 20-7.03
 019040
 01-010302
 00-1070
 0-21020
 0-00007
 0-03300
 0-104100
 0-154004
 0-100003



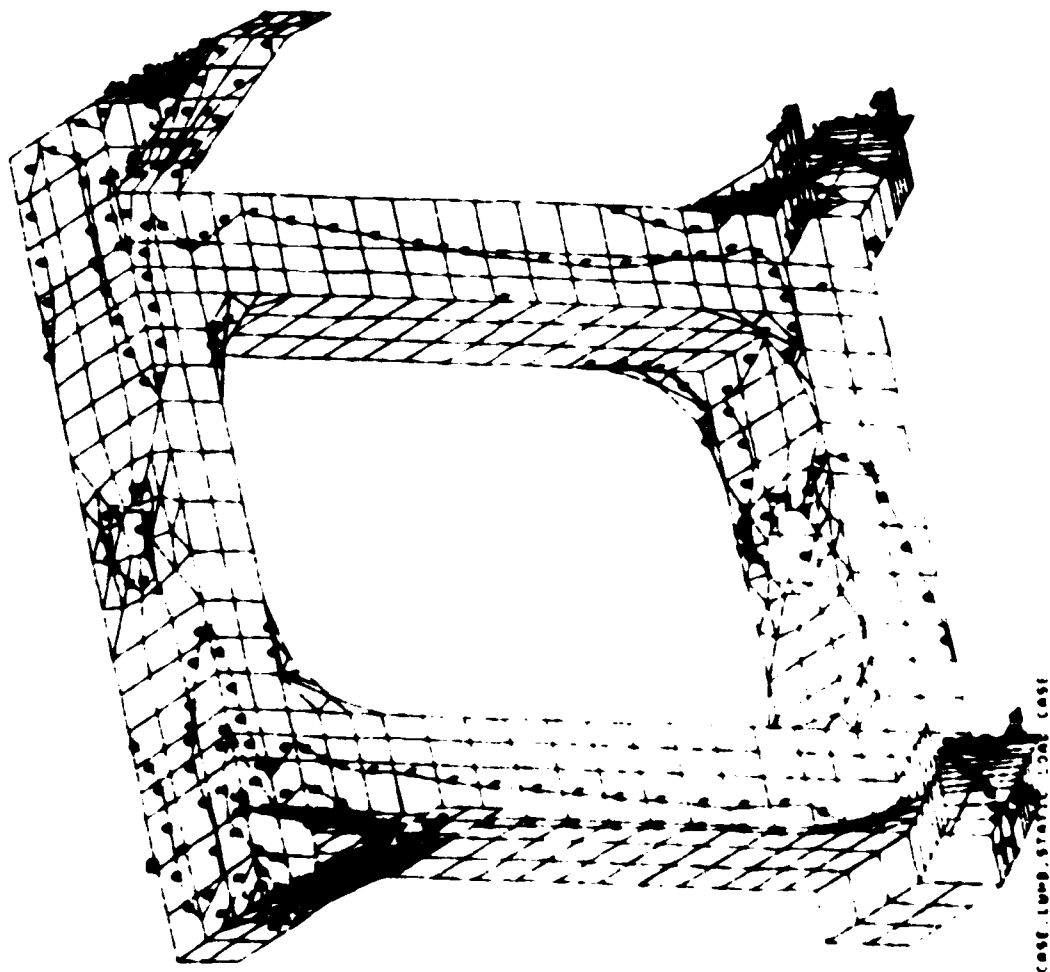
POST1 -IMP.

22 5-78 CODE LUMP,STATIC LOAD CASE

```

ANAL 1.00
END 11 1007
11-10014
POST1 SYMBL
STEP=1
1920-1
SIZE
MIDBLE
20-1
VAL
20-1
0187-20.7
10-53.0
17-36
27-17.03
MIDBLE
MID-210014
MID-1107
MID-22003
MID-22022
MID-22041
MID-22400
MID-15270
MID-10000

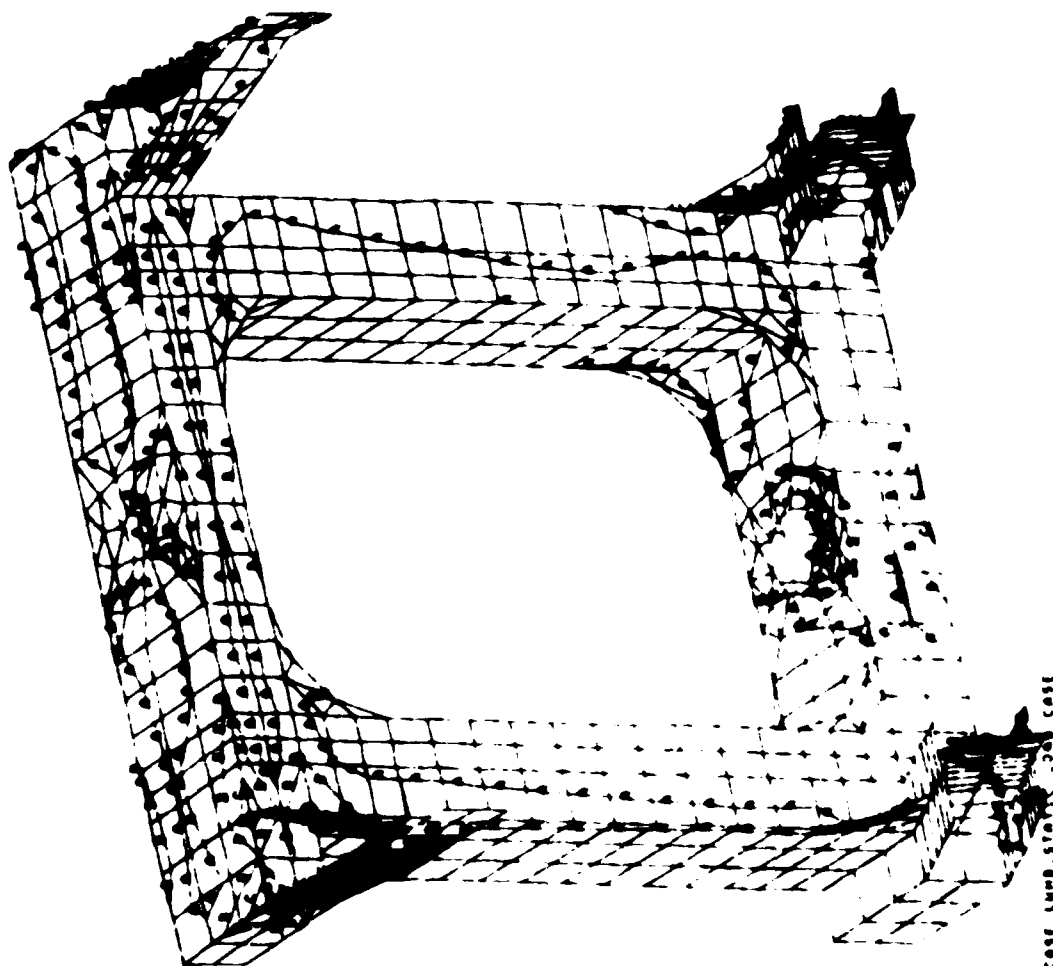
```



POST1 -140.

22 5-72 CASE LUMP. STIFF. CASE

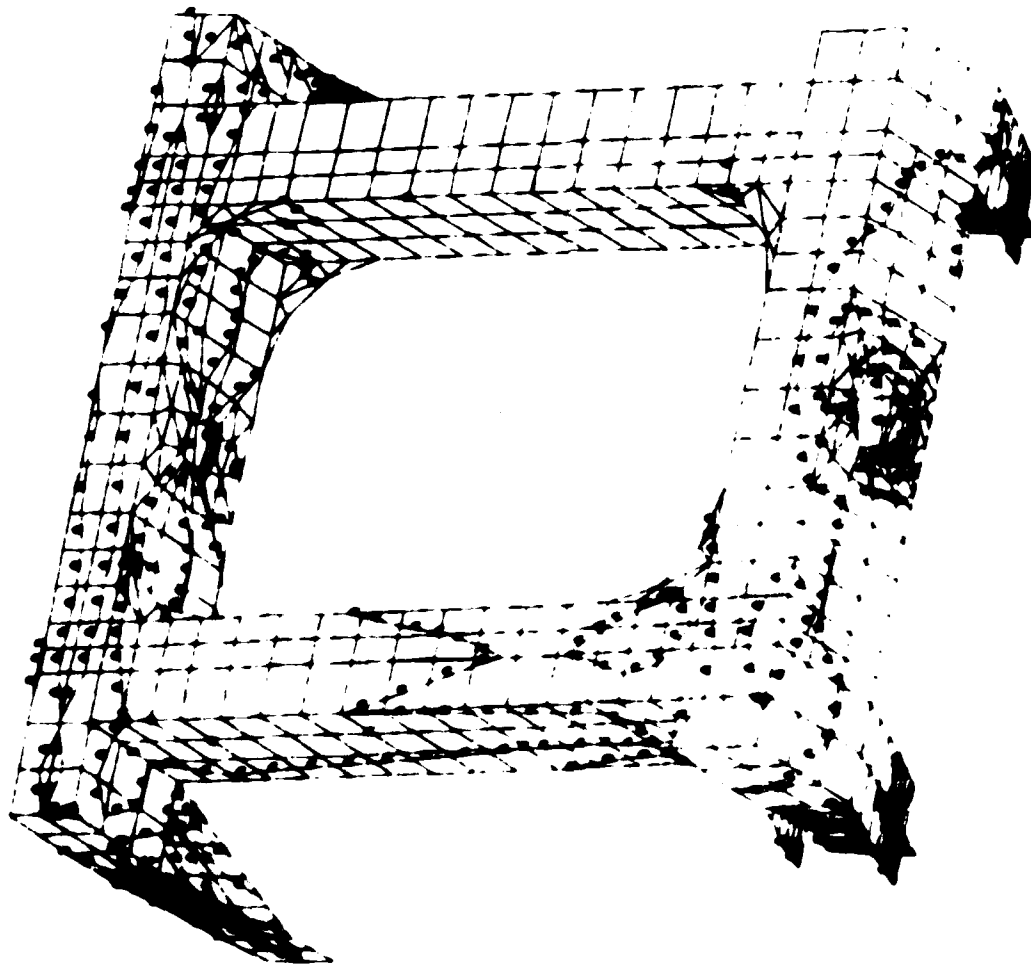
00000 0.00
 000 11 1007
 12-02-100
 00001 000000
 0000-1
 1000-1
 0100
 00000
 00-1
 00-1
 20-1
 0100-00.7
 00-03.0
 00-20
 20-17.00
 010000
 00-010000
 00-1000
 00-2000
 0-03000
 0-04100
 0-10000
 0-10000
 0-10000



00001 1000

22 0-72 CASE LUMB STAY 30 CASE

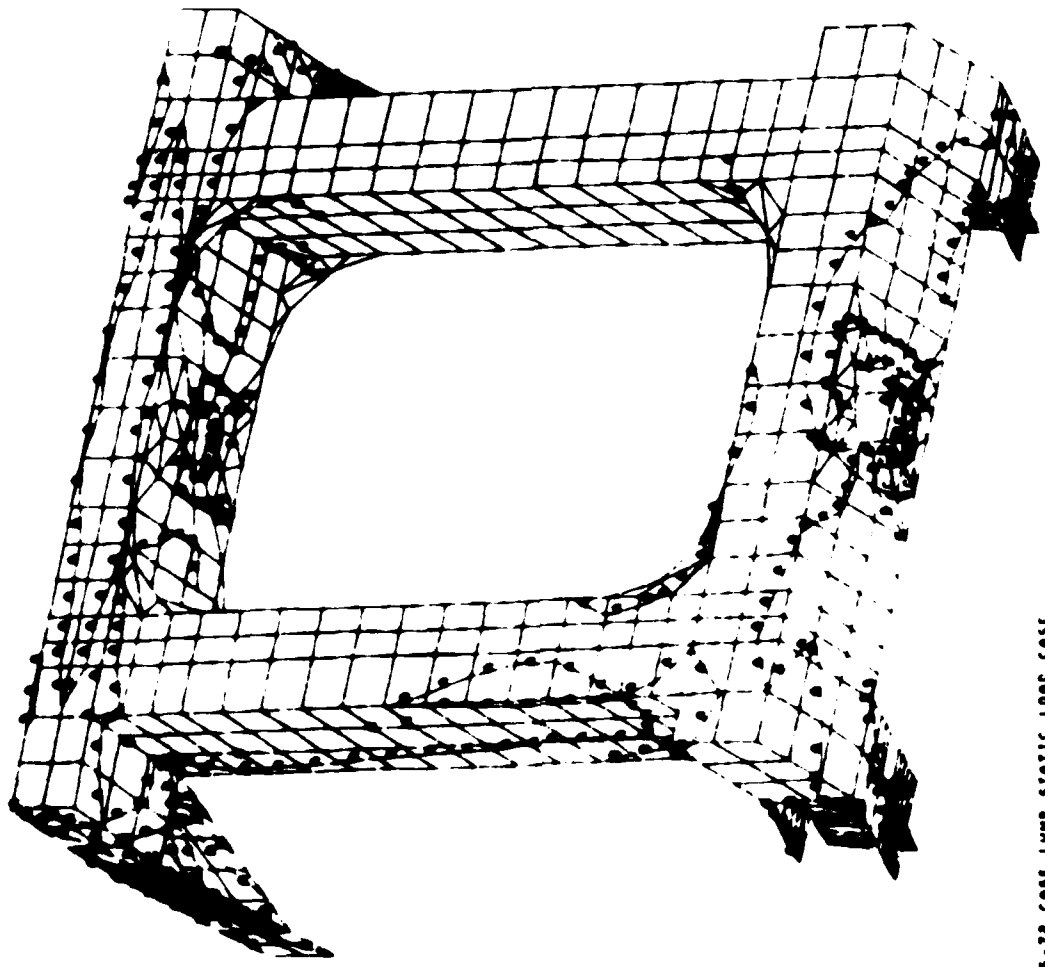
00515 1.20
 FEB 11 1965
 12-07-10
 00511 070155
 0701-1
 1700-1
 0154
 TOP
 000-1
 000-1
 20-1
 0151-09-7
 07-03-0
 07-05
 20-1-7-03
 01000
 00-210302
 00-1070
 0-31020
 0-00007
 0-03346
 0-100105
 0-150004
 0-100623



00511 100-

22 0 72 CODE LUMB. STATIC CODE CASE

00000 0.00
 00001 1.000
 00002 1.000
 00003 1.000
 00004 1.000
 00005 1.000
 00006 1.000
 00007 1.000
 00008 1.000
 00009 1.000
 00010 1.000
 00011 1.000
 00012 1.000
 00013 1.000
 00014 1.000
 00015 1.000
 00016 1.000
 00017 1.000
 00018 1.000
 00019 1.000
 00020 1.000
 00021 1.000
 00022 1.000
 00023 1.000
 00024 1.000
 00025 1.000
 00026 1.000
 00027 1.000
 00028 1.000
 00029 1.000
 00030 1.000
 00031 1.000
 00032 1.000
 00033 1.000
 00034 1.000
 00035 1.000
 00036 1.000
 00037 1.000
 00038 1.000
 00039 1.000
 00040 1.000
 00041 1.000
 00042 1.000
 00043 1.000
 00044 1.000
 00045 1.000
 00046 1.000
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 00091 1.000
 00092 1.000
 00093 1.000
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 00096 1.000
 00097 1.000
 00098 1.000
 00099 1.000
 00100 1.000



00001 - 1000

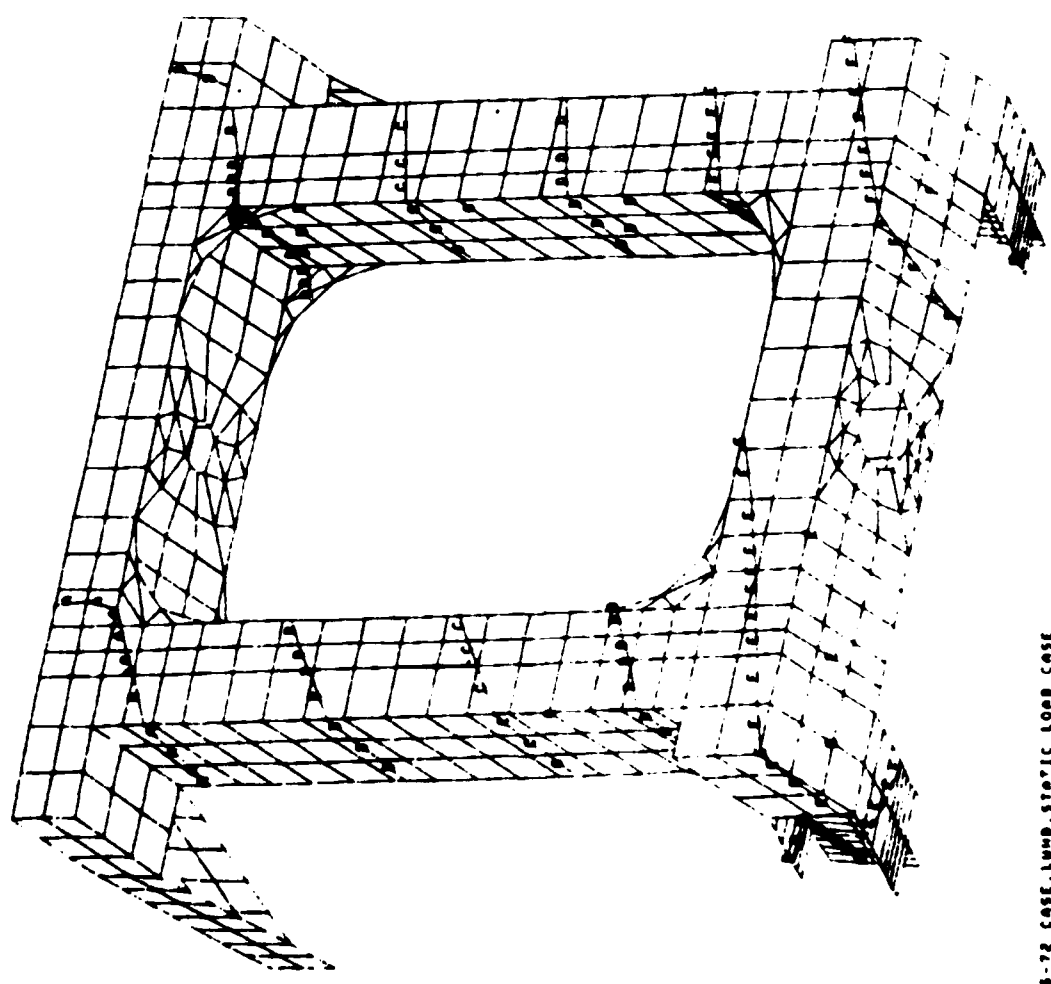
00001 - 1000


```

ANSYS 4.20
FEB 11 1987
12:20:25
POST1, STRESS
STEP=1
ITEM=1
U2
DISPL MODAL
MU=1
VU=1
ZU=1
DIST=29.7
NF=53.8
VF=35
ZF=7.83
HIDDEN
RM=3.11
RM=3.11
A=8.88
B=8.28
C=1.82
D=1.22
E=1.816
F=1.316

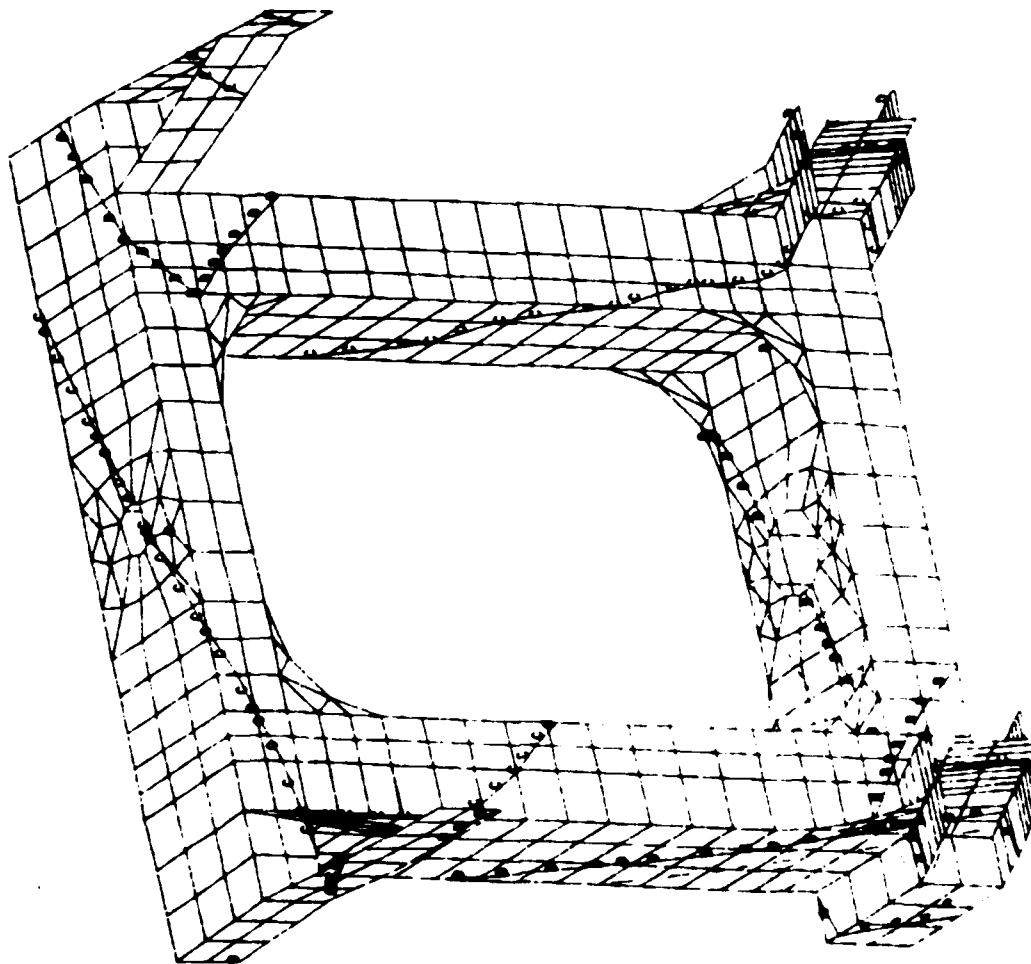
```

POST1 - 1200



22.5-72 CASE, LOAD, STATIC LOAD CASE

ANALYSIS 4.00
 CLO 11 1987
 12/23/01
 POST1 STRESS
 STEP=1
 1700=1
 UX
 DISPL NODAL
 NU=1
 VU=1
 20=1
 0157-80.7
 MF=83.9
 VF=35
 2F=7.93
 M1000M
 MX=.047
 MY=-.220
 MZ=-.141
 0-.050
 C-.350
 0-.450
 C-.050
 F-.050

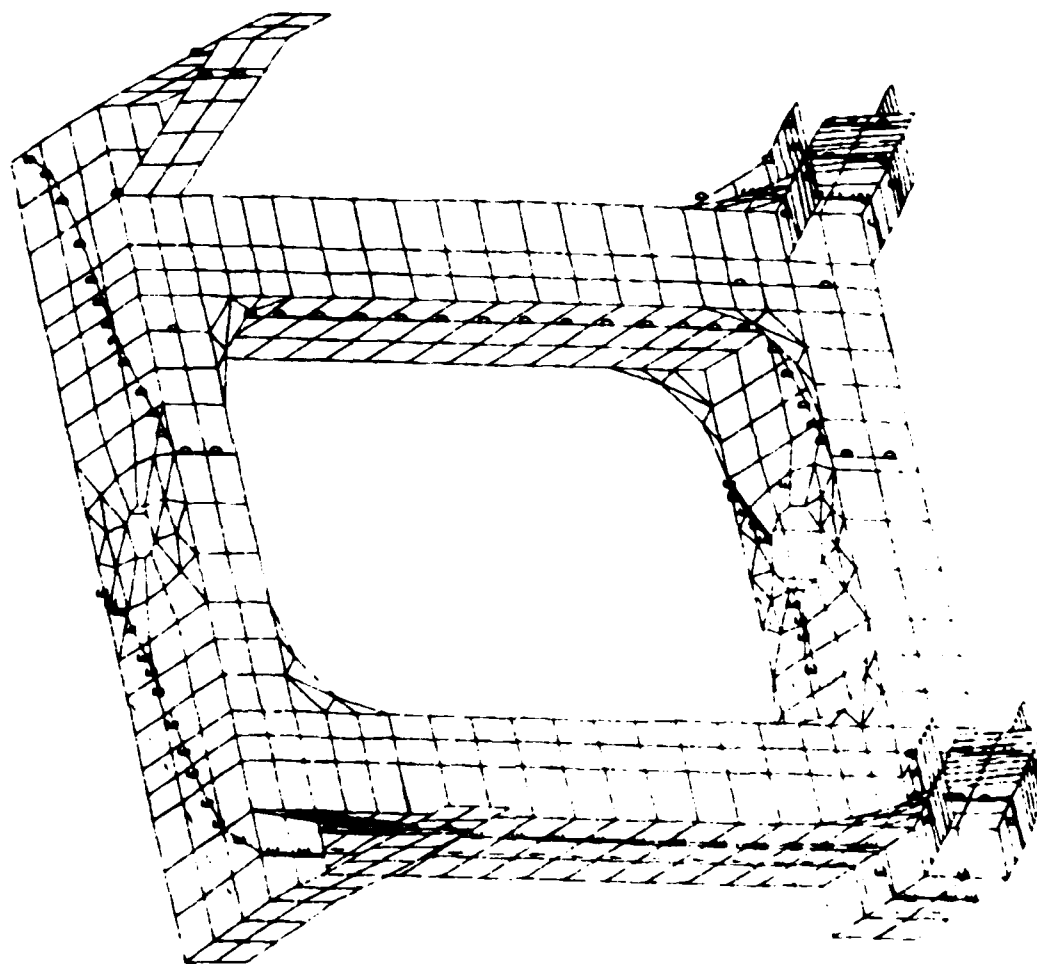


POST1 -IMP-

22.5-72 CASE, LUMB, STAYC, COMB CASE

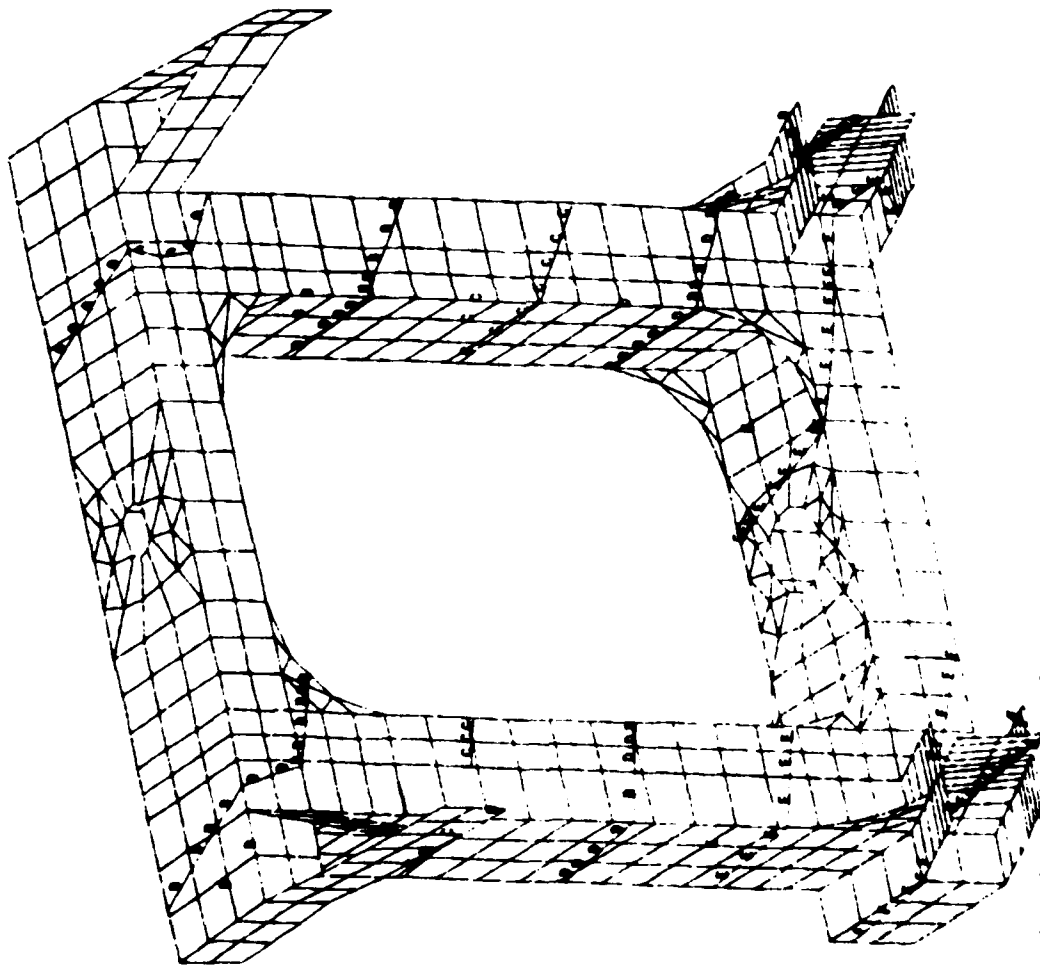
ANSYS 4.20
 FEB 11 1987
 12:25:13
 POST1 STRESS
 STEP=1
 ITER=1
 UY
 DISPL NODAL
 KU=1
 VD=1
 ZU=1
 DIST=29.7
 KP=53.9
 VP=36
 ZF=7.93
 MIDDLE
 RM=465
 PM=1.86
 A=1.7
 B=1.3
 C=808
 D=498
 E=8982
 F=302

POST1 -IMP.



22 5-72 CASE, LUND, STATIC LOAD CASE

ANSYS 4.20
 FEB 11 1987
 12:27:24
 POST1 STRESS
 STRESS
 1788.1
 1788.1
 UZ
 DISPL MODAL
 MU=1
 VU=1
 ZU=1
 0157-29.7
 MF=53.9
 VF=35
 ZF=7.93
 MIDDEM
 MM=0.0178
 MM=3.11
 A=8.82
 B=8.32
 C=1.82
 D=1.32
 E=0.815
 F=0.315



POST1 -IMP.

28.5-72 CASE, LUMB, STATIC LONG CASE

END

10-87

DTIC