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LaRC DESIGN ANALYSIS REPORT

FOR

NATIONAL TRANSONIC FACILITY

FOR

304 STAINLESS STEEL TUNNEL SHELL

FINITE ELEMENT ANALYSIS OF PLENUM REGION INCLUDING SIDE ACCESS REINFORCEMENT, SIDE ACCESS DOOR AND ANGLE OF ATTACK PENETRATION

VOL. 3S

BY

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Formal Documentation of Design Analyses to Obtain Code Approval of Fabricated National Transonic Facility

16. Abstract

This report contains the results of extensive computer (finite element, finite difference and numerical integration), thermal, fatigue, and special analyses of critical portions of a large pressurized, cryogenic wind tunnel (National Transonic Facility). The computer models, loading and boundary conditions are described. Graphic capability was used to display model geometry, section properties, and stress results. A stress criteria is presented for evaluation of the results of the analyses. Thermal analyses were performed for major critical and typical areas. Fatigue analyses of the entire tunnel circuit is presented.

The major computer codes utilized are: SPAR - developed by Engineering Information Systems, Inc. under NASA Contracts NAS8-30536 and NAS1-13977; SALORS - developed by Langley Research Center and described in NASA TN D-7179; and SRA - developed by Structures Research Associates under NASA Contract NAS1-10091; "A General Transient Heat-Transfer Computer Program for Thermally Thick Walls" developed by Langley Research Center and described in NASA TM X-2058.

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NATIONAL TRANSONIC FACILITY

TUNNEL SHELL

NASA - LaRC

FINITE ELEMENT ANALYSIS
OF
PLENUM REGION
INCLUDING
SIDE ACCESS REINFORCEMENT,
SIDE ACCESS DOOR
AND
ANGLE OF ATTACK PENETRATION

304 STAINLESS STEEL

SEPTEMBER 1976

VOLUME 3S

LaRC CALCULATIONS

FOR THE

NATIONAL TRANSONIC FACILITY

TUNNEL SHELL

DATE: SEPTEMBER, 1976

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This report is one volume of a Design Analysis Report prepared by LaRC on portions of the pressure shell for the National Transonic Facility. This report is to be used in conjunction with reports prepared under NASA Contract NAS1-13535(c) by the Ralph M. Parsons Company (Job Number 5409-3 dated September 1976) and Fluidyne Engineering Corporation (Job Number 1060 dated September 1976). The volumes prepared by LaRC are listed below:

1. Finite Difference Analysis of Cone/Cylinder Junction (304 S.S.) Vol. 1, NASA TM X-73957-1.

2. Finite Element Analysis of Corners #3 and #4 (304 S.S.), Vol. 2S, NASA TM X-73957-2.

3. Finite Element Analysis of Plenum Region Including Side Access Reinforcement, Side Access Door and Angle of Attack Penetration (304 S.S.), Vol. 3S, NASA TM X73957-3.

4. Thermal Analysis (304 S.S.) Vol. 4S, NASA TM X73957-4.

5. Finite Element and Numerical Integration Analyses of the Bulkhead Region (304 S.S.), Vol. 5S, NASA TM X73957-5.

6. Fatigue Analysis (304 S.S.), Vol. 6S, NASA TM X73957-6.

7. Special Studies (304 S.S.), Vol. 7S, NASA TM X73957-7.

NTF DESIGN CRITERIA
FOR 304 STAINLESS STEEL

GENERAL

THE DESIGN OF THE PRESSURE SHELL REFLECTED IN THIS REPORT SATISFIES THE DESIGN REQUIREMENTS OF THE ASME BOILER AND PRESSURE VESSEL CODE, SECTION VIII, DIVISION 1. SINCE DIVISION 1 DOES NOT CONTAIN RULES TO COVER ALL DETAILS OF DESIGN, ADDITIONAL ANALYSES WERE PERFORMED IN AREAS HAVING COMPLEX CONFIGURATIONS SUCH AS THE CONE CYLINDER JUNCTIONS, THE GATE VALVE BULKHEADS, THE BULKHEAD-SHELL ATTACHMENTS, THE PLENUM ACCESS DOORS AND REINFORCEMENT AREAS, THE ELLIPTICAL CORNER SECTIONS, AND THE FIXED REGION (RING S8) OF THE TUNNEL. THE DIVISION 1 DESIGN CALCULATIONS, THE ADDITIONAL ANALYSES AND THE CRITERIA FOR EVALUATION OF THE RESULTS OF THE ADDITIONAL ANALYSES TO ENSURE COMPLIANCE WITH THE INTENT OF DIVISION 1 REQUIREMENTS ARE CONTAINED IN THE TEXT OF THIS REPORT. THE DESIGN ANALYSES AND ASSOCIATED CRITERIA CONSIDERED BOTH THE OPERATING AND HYDROSTATIC TEST CONDITIONS.

IN CONJUNCTION WITH THE DESIGN, A DETAILED FATIGUE ANALYSIS OF THE PRESSURE SHELL WAS ALSO PERFORMED UTILIZING THE METHODS OF THE ASME CODE, SECTION VIII, DIVISION 2.

MATERIAL

THE PRESSURE SHELL MATERIAL SHALL BE ASME, SA-240, GRADE 304 FOR PLATE AND SA-182, GRADE F304 FOR FORGINGS. THE MATERIAL PROPERTIES AT TEMPERATURES EQUAL TO OR BELOW 150°F ARE AS FOLLOWS:

(A) PLATE

YIELD = 30.0 KSI
ULTIMATE = 75.0 KSI

(B) WELDS (AUTOMATIC, SEMIAUTOMATIC, OR "STICK")

YIELD = 30.0 KSI
ULTIMATE = 75.0 KSI

OPERATING, DESIGN AND TEST CONDITIONS

THE OPERATING, DESIGN AND TEST CONDITIONS FOR THE TUNNEL PRESSURE SHELL AND ASSOCIATED SYSTEMS AND ELEMENTS ARE SUMMARIZED BELOW:

1. OPERATING MEDIUM

ANY MIXTURE OF AIR AND NITROGEN

2. DESIGN TEMPERATURE RANGE

MINUS 320 DEGREES FAHRENHEIT TO PLUS 150 DEGREES FAHRENHEIT, EXCEPT IN THE REGION OF THE PLENUM BULKHEADS AND GATE VALVES INSIDE A 23-FOOT, 4-INCH DIAMETER, FOR WHICH THE TEMPERATURE RANGE IS MINUS 320 DEGREES FAHRENHEIT TO PLUS 200 DEGREES FAHRENHEIT.

3. PRESSURE RANGE

	TUNNEL CONFIGURATION	OPERATING PRESSURE RANGE, PSIA	DESIGN PRESSURES PSID
A.	CONDITION I - PLENUM ISOLATION GATES OPEN AND TUNNEL OPERATING:		
	TUNNEL CIRCUIT EXCEPT PLENUM	8.3 to 130	A. 8 EXTERNAL B. 119 INTERNAL
	PLENUM (PLENUM PRESSURE IS LIMITED TO .4 TO 1 TIMES THE REMAINDER OF THE TUNNEL CIRCUIT	3.3 to 130	A. 15 EXTERNAL B. 119 INTERNAL
	BULKHEAD		56 (EXTERNAL TO PLENUM)
B.	CONDITION II - PLENUM ISOLATION GATES OPEN AND TUNNEL SHUTDOWN:		
	ENTIRE TUNNEL CIRCUIT	8.3 to 130	A. 8 EXTERNAL B. 119 INTERNAL
	BULKHEAD		0
C.	CONDITION III - PLENUM ISOLATION GATES AND ACCESS DOORS CLOSED:		
	TUNNEL CIRCUIT EXCEPT PLENUM	8.3 to 130	A. 8 EXTERNAL B. 119 INTERNAL

PLENUM (PLENUM OPERATING PRESSURE CAN EXCEED THE PRESSURE IN THE REMAINDER OF THE TUNNEL CIRCUIT BY 24 PSI, BUT DOES NOT EXCEED THE 130 PSIA MAXIMUM OPERATING PRESSURE)	0 to 130	A. 15 EXTERNAL B. 119 INTERNAL
BULKHEAD		A. 25 (INTERNAL TO PLENUM) B. 119 (EXTERNAL TO PLENUM) FOR MINUS 320 DEGREES FAHRENHEIT TO PLUS 150 DEGREES FAHRENHEIT *C. 115.7 (EXTERNAL TO PLENUM) FOR PLUS 151 DEGREES FAHRENHEIT TO PLUS 200 DEGREES FAHRENHEIT

*OPERATING PROCEDURES LIMIT PRESSURES TO THAT SHOWN.

D. CONDITION IV - PLENUM ISOLATION GATES CLOSED AND ACCESS DOORS OPEN:

TUNNEL CIRCUIT EXCEPT PLENUM	8.3 to 130	A. 8 EXTERNAL B. 119 INTERNAL
PLENUM	14.7	0
BULKHEAD		A. 119 (EXTERNAL TO PLENUM) FOR MINUS 320 DEGREES FAHRENHEIT TO PLUS 150 DEGREES FAHRENHEIT *B. 115.7 (EXTERNAL TO PLENUM) FOR PLUS 151 DEGREES FAHRENHEIT TO PLUS 200 DEGREES FAHRENHEIT

*OPERATING PROCEDURES LIMIT PRESSURES TO THAT SHOWN.

4. HYDROSTATIC TEST DESIGN CONDITIONS

THE PRESSURE SHELL WAS DESIGNED FOR HYDROSTATIC TEST IN ACCORDANCE WITH THE REQUIREMENTS OF THE ASME CODE, SECTION VIII, DIVISION 1. THE TEST PRESSURES SHALL BE AS FOLLOWS. PRESSURE SHELL TEMPERATURE SHALL BE EQUAL TO OR BELOW 100°F DURING HYDROSTATIC TESTS.

CONDITION (1) - MAXIMUM INTERNAL PRESSURE CONDITION FOR THE ENTIRE TUNNEL CIRCUIT

$$PH_1 = 1.5\ (119)\ \left(\frac{18.7}{18.2}\right) + \text{HYDROSTATIC HEAD}$$

$$= 183.4\ \text{PSI} + \text{HYDROSTATIC HEAD}$$

CONDITION (2) - MAXIMUM DIFFERENTIAL PRESSURE CONDITION ACROSS THE PLENUM BULKHEADS

$$PH_2 = 1.5\ \left(\frac{18.7}{18.2}\right)\ (119) + \text{HYDROSTATIC HEAD}$$

$$= 183.4 + \text{HYDROSTATIC HEAD}$$

$$PH_2{}^* = 1.5\ (115.7)\ \left(\frac{18.7}{17.7}\right) + \text{HYDROSTATIC HEAD}$$

$$= 183.4 + \text{HYDROSTATIC HEAD}$$

*TUNNEL OPERATION LIMITATIONS PRECLUDE PRESSURE DIFFERENTIALS ACROSS BULKHEADS IN EXCESS OF 115.7 PSI FOR BULKHEAD AND GATE TEMPERATURES IN EXCESS OF 150°F.

CONDITION (3) - MAXIMUM REVERSE DIFFERENTIAL PRESSURE CONDITION ACROSS THE PLENUM BULKHEADS

$$PH_3 = 1.5\ \left(\frac{18.7}{18.2}\right)\ (25) = 38.5\ \text{PSI}$$

THE PRESSURE SHELL EXCEPT FOR THE PLENUM SHALL BE PRESSURIZED TO 144.9 PSIG. THE PLENUM SHALL BE PRESSURIZED TO 183.4 PSIG.

PRESSURE SHELL STRESS EVALUATION CRITERIA

THIS CRITERIA ESTABLISHES THE BASIS FOR ANALYSIS AND DESIGN OF THE PRESSURE SHELL SO IT WILL MEET OR EXCEED ALL OF THE REQUIREMENTS OF SECTION VIII, DIVISION 1 OF THE ASME BOILER AND PRESSURE VESSEL CODE AND CAN BE STAMPED WITH A DIVISION 1 "U" STAMP.

1. SECTION VIII, DIVISION 1, DIRECT APPLICATION

(A) THE MAXIMUM ALLOWABLE STRESS (S)

$S = 18.2$ KSI (-320°F TO +150°F)

$S = 17.7$ KSI (-320°F TO +200°F)

(B) PRIMARY BENDING PLUS PRIMARY MEMBRANE STRESSES

THE LOCAL MEMBRANE STRESSES ARE NOT GENERALLY CONSIDERED IN SECTION VIII, DIVISION 1 DESIGNS. HOWEVER, FOR THE PURPOSE OF DESIGNING LOCAL REINFORCEMENT AT BRACKETS, RINGS OR PENETRATIONS NOT COVERED BY DESIGN BASED ON STRESS ANALYSIS, THE LOCAL SHELL MEMBRANE STRESS SHALL BE:

$$P_b + P_m \leq 1.5\ SE$$

NOTE: E IS JOINT EFFICIENCY

2. IN REGIONS OF THE PRESSURE SHELL WHERE DIVISION 1 DOES NOT CONTAIN RULES TO COVER ALL DETAILS OF DESIGN (REF. U-2(g)), ADDITIONAL ANALYSES WERE PERFORMED UTILIZING THE GUIDELINES OF THE ASME CODE, SECTION VIII, DIVISION 2, APPENDIX 4, "DESIGN BASED ON STRESS ANALYSIS." THE BASIC STRESS CRITERIA FOR DIVISION 2 IS REPRESENTED IN FIGURE 4-130.1 AND RESTATED BELOW INDICATING ANY MODIFICATIONS OR EXCESS REQUIREMENTS APPLIED TO IT TO REMAIN WITHIN THE INTENT OF DIVISION 1 AND TO OBTAIN A DIVISION 1 STAMP.

A. GENERAL PRINCIPAL MEMBRANE STRESS

MAXIMUM ALLOWABLE STRESS

$S = 18.2$ KSI (-320°F TO +150°F)

$S = 17.7$ KSI (-320°F TO +200°F)

MAXIMUM ALLOWABLE STRESS INTENSITY

$S_m = 20.0$ KSI (-320°F TO +300°F)

B. PRIMARY GENERAL MEMBRANE STRESS INTENSITY

$$P_m \leq S_m$$

AND IN ORDER TO COMPLY WITH DIVISION 1, THE MAXIMUM PRINCIPAL MEMBRANE STRESS MUST BE:

$$P_m^* \leq S$$

NOTE: THE * IS USED TO DENOTE THAT MAXIMUM PRINCIPAL STRESSES ARE TO BE COMPUTED FOR THE GIVEN LOADING CONDITION. THE INTENT IS TO DETERMINE THE STRESSES WHICH REPRESENT THE HOOP STRESSES AND MERIDIONAL STRESSES WHICH ARE THE STRESSES USED IN DIVISION 1 COMPUTATIONS.

C. DESIGN LOADS, PRIMARY LOCAL MEMBRANE STRESS INTENSITY

$$P_L \leq 1.5\ S_m$$

NOTE: LOCAL MEMBRANE STRESS INTENSITY IS DEFINED IN ACCORDANCE WITH DIVISION 2, APPENDIX 4-112(i). THE TOTAL MERIDIONAL LENGTH IS CONSIDERED TO BE 1.0 $\sqrt{RT}$.

D. DESIGN LOADS, PRIMARY LOCAL MEMBRANE PLUS PRIMARY BENDING STRESS INTENSITY

$$P_L + P_b \leq 1.5\ S_m$$

E. OPERATING LOADS, PRIMARY PLUS SECONDARY STRESS INTENSITY

$$P_L + P_b + Q \leq 3\ S_m$$

3. A FATIGUE ANALYSIS WAS CONDUCTED IN ACCORDANCE WITH SECTION VIII, DIVISION 2 WITHOUT MODIFICATION.

4. HYDROSTATIC TEST CONDITION DESIGN CONSIDERATIONS

A. PRESSURE SHELL

IN ACCORDANCE WITH DIVISION 1 OF THE ASME CODE, DESIGN ANALYSIS OF THE PRESSURE SHELL FOR THE HYDROSTATIC TEST CONDITION IS NOT REQUIRED. HOWEVER, IN ORDER TO PROVIDE A SATISFACTORY ENGINEERING DESIGN FOR THE PRESSURE SHELL SPECIAL EMPHASIS WAS GIVEN, AS PROMPTED BY NOTE (1) OF SECTION VIII, DIVISION 1 OF THE ASME CODE, TO FLANGES OF GASKETED JOINTS OR OTHER APPLICATIONS WHERE SLIGHT AMOUNTS OF DISTORTION CAN CAUSE LEAKAGE OR MALFUNCTION. EXAMPLES OF THESE AREAS ARE THE PLENUM, PLENUM ACCESS DOORS, PLENUM ACCESS DOOR REINFORCEMENT, THE BULKHEADS, AND BULKHEAD FLANGES.

B. SUPPORT RINGS

DESIGN OF THE PRESSURE SHELL SUPPORT RINGS, INCLUDING

THE CORNER RINGS, FOR THE HYDROSTATIC TEST CONDITION, COMPLIES WITH THE FOLLOWING:

(A) THE COMBINED VALUE OF THE SHELL CIRCUMFERENTIAL PRESSURE STRESS, S_1 AND SHELL

BENDING STRESS S_2, RESULTING FROM ACTION OF A

PORTION OF THE SHELL AS AN INNER FLANGE OF THE RING, SHALL NOT EXCEED 0.8 WELD YIELD STRESS:

$S_1 + S_2 \leq 0.8$ WELD YIELD STRESS,

WHERE, FOR SUPPORT RINGS NOT ANALYZED BY FINITE ELEMENT TECHNIQUES,

$S_1 = P_H \left(\frac{R}{T}\right) + .6\ P_H$; P_H INCLUDES HYDROSTATIC

HEAD CORRECTION, AND

S_2 = RING BENDING STRESS AT INNER FLANGE, BASED

ON AN EFFECTIVE WIDTH OF THE PRESSURE SHELL ACTING AS AN INNER FLANGE OF THE RING OF 1.1 MULTIPLIED BY THE SQUARE ROOT OF D_O T.

(B) THE BENDING STRESS, S_{2F} ON THE OUTSIDE FLANGE

SHALL NOT EXCEED .9 WELD YIELD STRESS. (IN THE COMPUTER ANALYSIS ALL LOADING CONDITIONS ARE LIMITED TO .9 S_Y ON THE OUTER FLANGE.)

(C) BRACKETS AND SUPPORT PAD WELDMENTS

THE DESIGN FOR ALL LOADING CONDITIONS INCLUDING THE HYDROSTATIC TEST CONDITION OF THOSE PORTIONS OF BRACKETS AND SUPPORT PAD WELDMENTS WHICH ARE ATTACHED TO THE PRESSURE SHELL BUT NOT ON THE SURFACE OF THE SHELL SHALL COMPLY WITH THE REQUIREMENTS OF THE AISC CODE, I.E. MAXIMUM STRESS IN TENSION EQUALS .6 S_Y, ETC.

Vol. 3S

Finite Element Analyses of Plenum Region Including the Side Access Reinforcement, Side Access Door and Angle of Attack Penetration

Table of Contents

Part 1 Plenum

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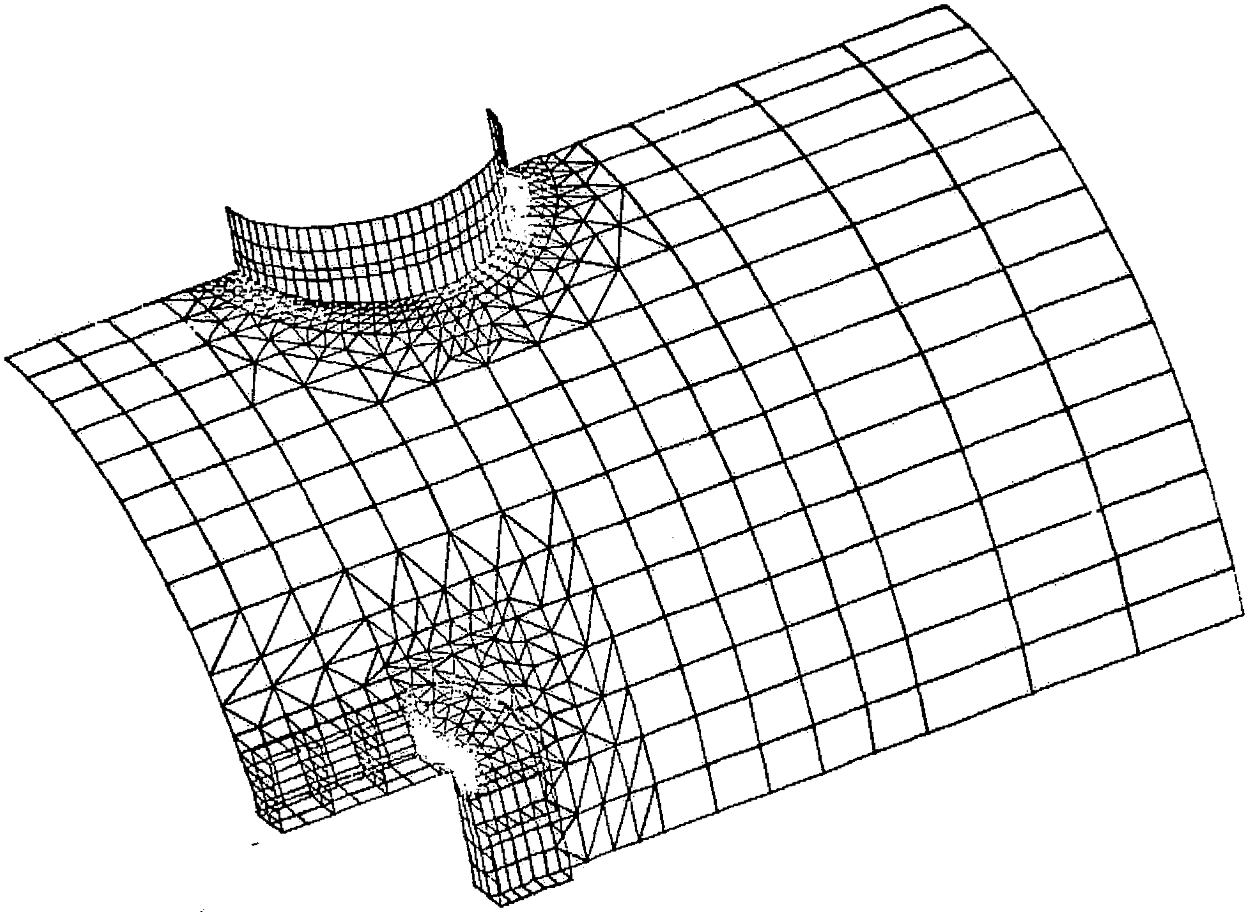


SPEC
1.1

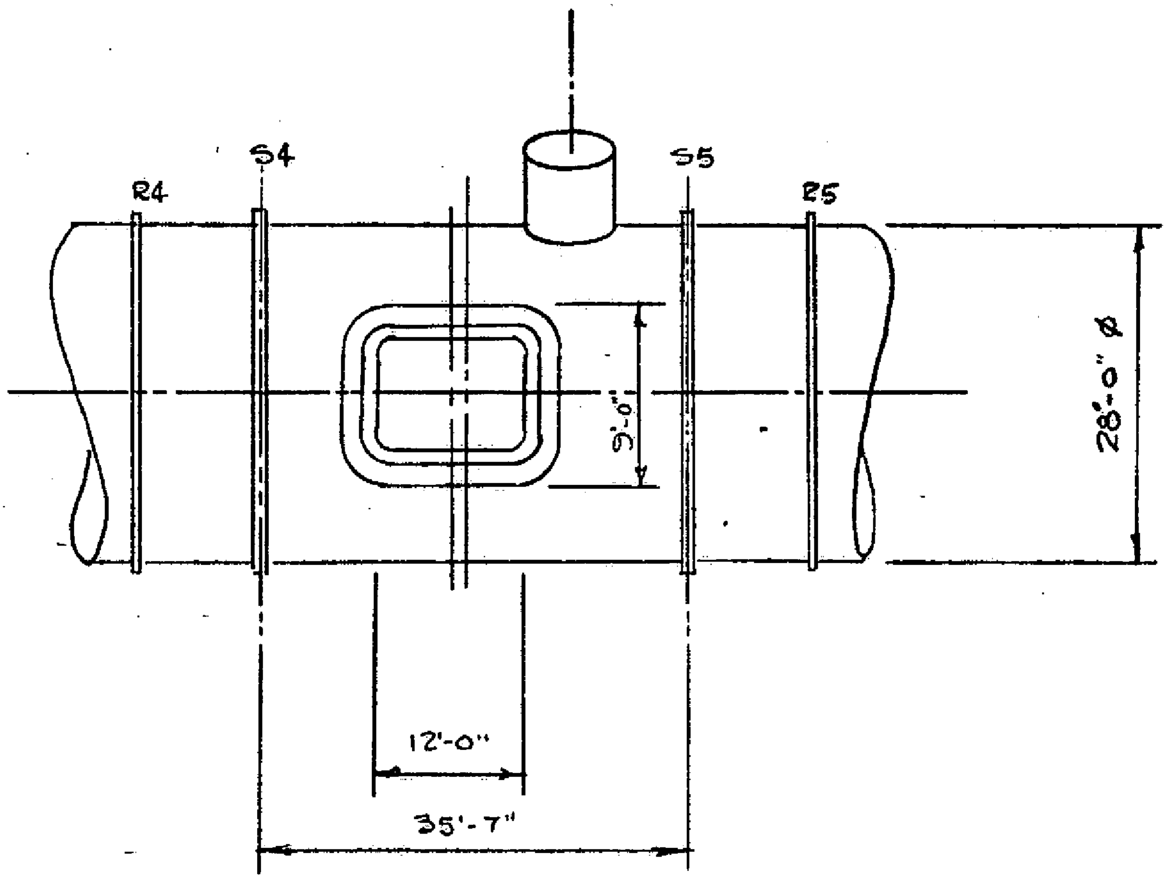
NTF 9 X 12 ACCESS OPENING

0 64
SCALE

BY ______ DATE ______ SUBJECT UTF SHEET NO. 1 OF ______
CHKD. BY ______ DATE ______ FINITE ELEMENT ANALYSES JOB NO. ______
OF ACCESS DOOR REINFORCEMENT

(Plenum)

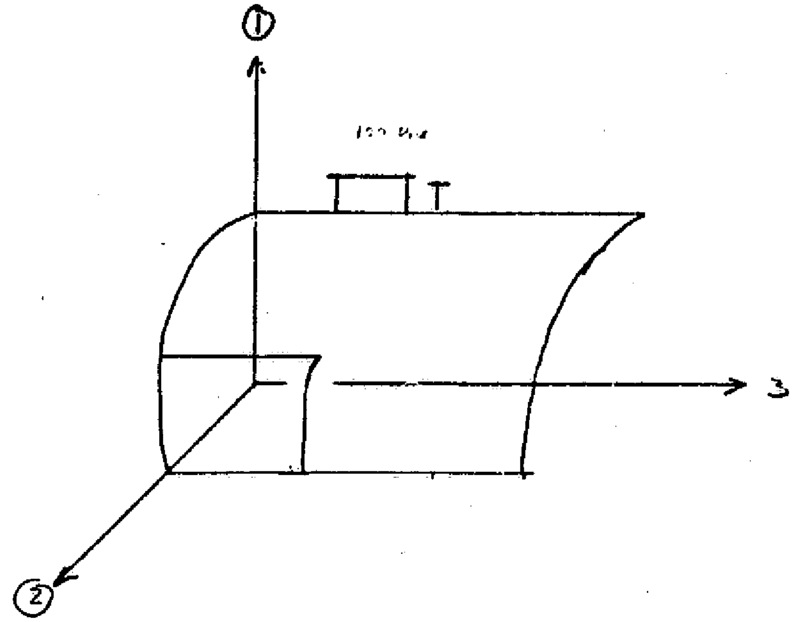
REFERENCE DRAWING NO. LE-9444315



BY .... DATE	SUBJECT	SHEET NO. 2 OF ......
CHKD. BY .... DATE		JOB NO. ....

SPAR (a finite element computer code developed & maintained by Engineering Information System, Inc. under NASA contract NAS8-30536 and NAS1-13977) was used to analyse this region of the pressure shell. The region was modeled using, triangular and quadrilateral, membrane plus bending flat aeolotropic elements. The "T" ring + flange was modeled with general beam elements.

A 90° segment of the pressure shell (Plenum) was modeled from the ℄ of the access opening to beyond the support ring S5. A plane thru the access opening perpendicular to the axis of the shell is a plane of symmetry.
Horizontal + vertical planes thru the axis of the shell are also planes of symmetry.



Plane of symmetry 1-2 plane
1-3 plane
2 3 plane

A computer plot of the model is shown in fig 1. The model consist of 1092 joints with 6 DOF per joint except where boundary conditions were applied and rotation about an axis ⊥ to a plate element was restricted.

BY____ DATE____ SUBJECT____ SHEET NO. 4 OF____
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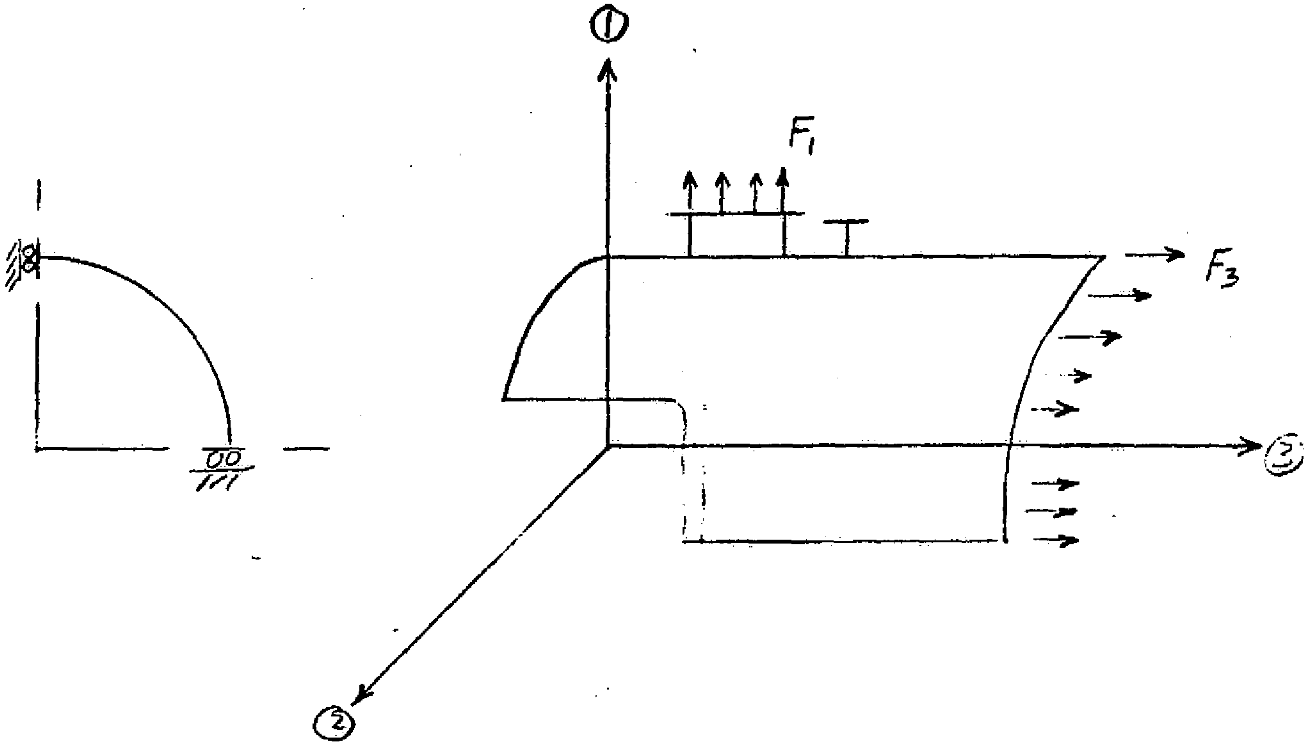
The joint numbers for the model are shown in Fig 2 thru 10

The shell section properties (plate thickness) are shown in Fig 11 thru 19

Shell Section Property	Thickness
1	2.00
2	2.60
3	1.30
4	5.85
5	2.60
6	3.00
7	2.00
8	4.25
9	1.30
10	3.75
11	2.875

Boundary Conditions



1 2 plane is a plane of symmetry

1 3 plane is a plane of symmetry

2 3 plane is a plane of symmetry

on boundary of cylinder and pipe - restrict rotation about θ & z axes (cy. cord.)

BY ____ DATE ____ SUBJECT ____ SHEET NO. 6 OF ____
CHKD. BY ____ DATE ____ JOB NO. ____

Boundary Forces

Cylinder

$$F = (\pi R^2)(P) = \pi(169^2)(119) = 1067,516 \text{ lbs.}$$

For $\frac{1}{4}$ model

$$F_3 = \frac{F}{4} = 10677516 \text{ lbs.}$$

$$F_3 = 2669379 \text{ lbs.}$$

This force was applied uniformly around 1/4 cylinder model

on Joint 1 + 16 – 88979.2 lbs.

2 thru 15 – 177957.3 lbs.

Pipe

$$F = (\pi R^2)(P) = \pi(50^2)\,119 = 934623.8 \text{ lbs.}$$

For $\frac{1}{2}$ model of pipe

$$F_1 = \frac{F}{2} = \frac{934623.8}{2} \text{ lbs}$$

$$F_1 = 467311.9 \text{ lbs.}$$

This force was applied uniformly around ½ pipe model

Joint 1056 + 1092 - 6490 lb
1057 thru 1091 - 12980 lbs

9' X 12' - opening

Forced displacements obtained from combining the Door and Plenum models were applied to the 9' X 12' opening. See discussion on combined runs (p. 9)

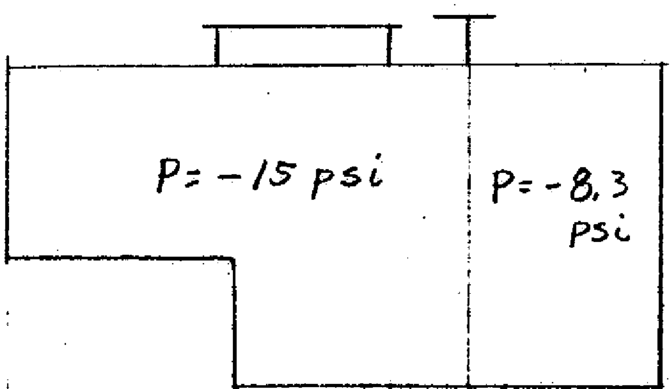
Loading

Internal Pressure

P= 119psi (design pressure) was applied as nodal pressure to the joints of the pressure surface.

External Pressure

Nodal pressure was applied to the joints of the pressure surface according to the following sketch.



Combined Door & Plenum Analyses

see Finite Element Analyses of Side Access Door

To determine the interaction of the door and plenum, a combined reduced stiffness matrix from the 2 models (Plenum and Door) was generated. From this the relative displacement between the door and plenum, (sealing surfaces) was determined for internal pressure. Nodal displacements from the combined run were used as boundary conditions at the sealing surfaces of the Door and Plenum to compute the final stress in each model.

For vacuum condition, the dog loads and relative displacement between the door & plenum (sealing surfaces) was determined.

Results

Nodal stresses are presented in Fig 20 thru 67

The max principal stress (PS1) or min principal stress (PS2) are given for the mid-surface (surface 0), the inside surface (surface 1), and outside surface (surface 2).

The stresses plotted are for joint 1 of the element. As an example (reference Fig 2), for the element defined by joints 17, 18, 34, 33 joint 1 for that element is 17.

Nodal stresses for one joint are given from 4 elements (for quadrilateral elements). If any discrepancies exist in the stresses for a joint, the largest value is used in the interpretation of the results.

The displacement of the sealing surfaces for the Door and plenum for an internal P= 119 psi is given in table 1.

The sealing surfaces of the Door and Plenum remained in contact. (the relative displacements of the sealing surfaces was minus)

TABLE 1

$P = 119$ psi

*CONNECT POINT NO.	DISPLACEMENTS AT SEALING SURFACES		RELATIVE DISPLACEMENTS
	PLENUM	DOOR	
1	.0726	.0736	−.00109
2	.0657	.0666	−.00092
3	.0512	.0521	−.00086
4	.0329	.0329	−.00003
5	.0196	.0197	−.00008
6	.0123	.0128	−.00049
7	.0123	.0126	−.00034
8	.0122	.0127	−.00051
9	.0114	.0118	−.00035
10	.0113	.0115	−.00014

* SEE FIGURE

ALL RELATIVE DISPLACEMENTS ARE NEGATIVE
∴ ALL POINTS ALONG SEALING SURFACES OF DOOR AND PLENUM REMAIN IN CONTACT.

RELATIVE DISPLACEMENTS X STIFFNESS (1.0×10^{8}) RESULTS IN A TOTAL DOOR FORCE OF 480,539 lb.

The displacement and relative displacement of the sealing surfaces of the Door and Plenum for vacuum conditions (external pressure = 15 psi) are given in table 2.

The dog loads for vacuum conditions are also given in Table 2.

BY______________ DATE__________ SUBJECT 304 S.S. SHEET NO. 14 OF______
CHKD. BY_______ DATE__________ JOB NO.__________

TABLE 2

VACUUM PRESSURE

* CONNECT POINT NO.	DISPLACEMENTS AT SEALING SURFACES		RELATIVE DISPLACEMENTS
	PLENUM	DOOR	
1	−.00464	−.0214	.01676
2	−.00386	−.0194	.01550
3	−.00214	−.0155	.01338
4	−.00018	−.0101	.00991
5	.00227	−.0123	.01458
6	.00379	−.0165	.02032
7	.00380	−.0194	.02321
8	.00380	−.0217	.02546
9	.00413	−.0229	.02709
10	.00416	−.0234	.02756

* SEE FIGURE

CONNECT POINTS 1-4 ARE DOG LOCATIONS AND ARE THE ONLY POINTS CONSIDERED TO BE TIED TOGETHER DURING VACUUM CONDITIONS.

FORCES AT DOGS

*	RELATIVE DISPLACEMENT	X DOG STIFFNESS	= FORCE
1	.01676	.63 E+6	10558.8 #
2	.01550	.63 E+6	9763.1
3	.01338	.63 E+6	8430.0
4	.00991	3.21 E+6	31820.1

TOTAL = 60572.0 #

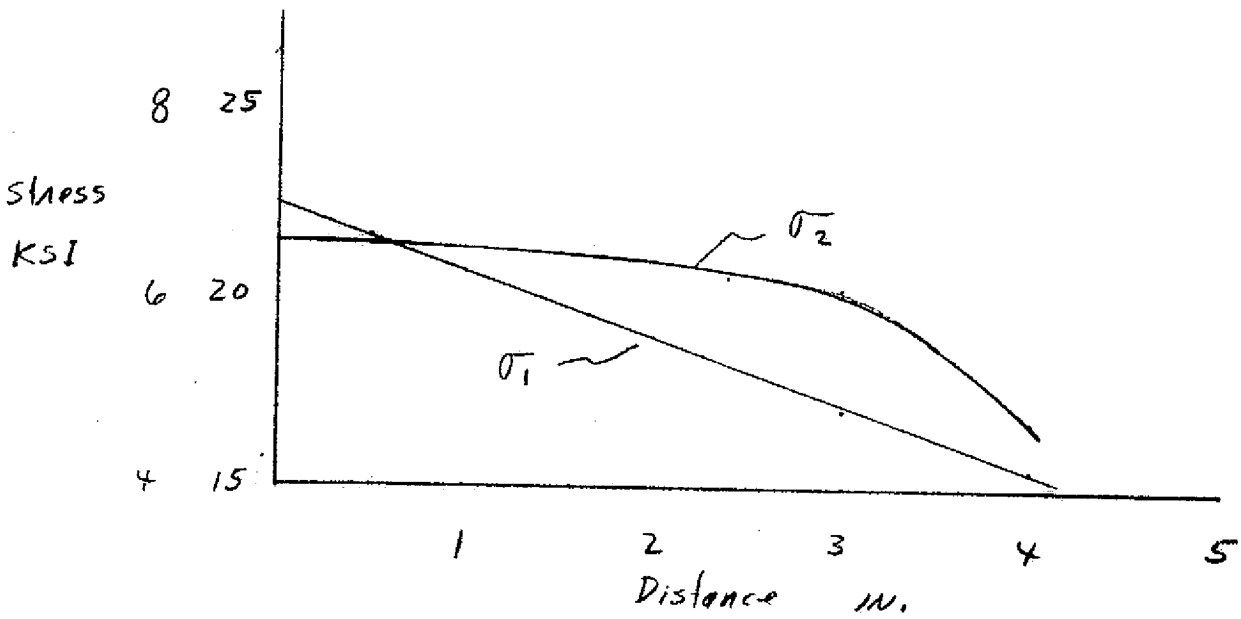
Region around the 9' X 12' Opening

Max membrane stress occures in the cornes

See fig. 44.

The max. stress intensity is at group 4 index 17

Since stress for surface 0 is at the centroid of triangular element, the stress is projected to edge of plate



$\sigma_1 = 22.4$ KSI

$\sigma_2 = 7.40$ KSI

$\sigma_3 = -.\frac{119}{2} = -.06$ KSI

$S_{12} = 22.4 - 7.40 = 15.0$ KSI

$S_{23} = 7.40 - (-.06) = 7.46$ KSI

$S_{31} = -.06 - 22.4 = -22.46$ KSI

$P_L = \left| -22.46 \right| = 22.46$ KSI

$P_L \leq 1.5\, S_m$

$22.46 < 1.5(20) = 30$ KSI

This stress is local membrane stress near a nozzle.

∴ The region meets the criteria for Local primary stress intensity

General Membrane Stress Intensity

away from opening

See fig 20 (1/99/120)

$\sigma_1 = 10.58$ KSI

$\sigma_2 = 4.97$ KSI

$\sigma_3 = -\frac{.119}{2} = -.06$ KSI

$S_{12} = 10.58 - 4.97 = 5.61$ KSI

$S_{23} = 4.97 - (-.06) = 5.03$ KSI

$S_{31} = -.06 - 10.58 = -10.64$ KSI

$P_m = |-10.64| = 10.64$ KSI

$P_m \leq S_m$

$10.64 < 20$ KSI O.K.

General Principle Membrane Stress

$\sigma_1 = 10.58$

$\sigma_1 \leq S$

$10.58 < 18.2$ KSI

∴ The general principle membrane stress and the general membrane stress intensity for the plenum region meets the stress evaluation criteria.

Primary Plus Secondary Stress Intensity

Inside Surface (See Fig 46)

Max stress intensity at

4/20/518

To correct for stress at the edge

add 22.4 − 21.55 = .85 KSI of σ_1

add 7.4 − 7.4 = 0 of σ_2

σ_1 = 32.4 + .85 = 33.25 KSI

σ_2 = 16.7 + 0 = 16.7 KSI

σ_3 = −.119 KSI

S_{12} = 33.25 − 16.7 = 16.55 KSI

S_{23} = 16.7 − (−.12) = 16.82 KSI

S_{31} = −.12 − 33.25 = −33.37 KSI

$$P_L + P_b + Q = |-33.37| = 33.37 \text{ KSI}$$

$$P_L + P_b + Q \leq 3S_m$$

$$33.37 < 3(20) = 60 \text{ KSI} \qquad \text{O.K.}$$

Outside Surface

See Fig 45

Max at. 4/16/518

Apply same correction as before

$$\sigma_1 = 18.98 + 0.35 = 19.83 \text{ KSI}$$

$$\sigma_2 = -.37 + 0 = -.37 \text{ KSI}$$

$$\sigma_3 = 0$$

$$S_{12} = 19.83 - (-.37) = 20.20 \text{ KSI}$$

$$S_{23} = -.37 - 0 = -.37 \text{ KSI}$$

$$S_{31} = 0 - 19.83 = -19.83 \text{ KSI}$$

$$P_L + P_b + Q = |20.20| = 20.20 \text{ KSI}$$

$$P_L + P_b + Q \leq 3 S_m$$

$$20.20 < 3(20) = 60 \text{ KSI} \qquad \text{o.k.}$$

The primary plus secondary stress intensity for the region around the 9' X 12' opening meets the stress evaluation criteria.

Inside Stiffner Ring

See Fig 32 and 38

Max at 6/36/591

Membrane stress

$\sigma_1 = 19.80$ KSI

$\sigma_2 = -4.15$ KSI

$\sigma_3 = -\frac{.119}{2} = -.06$ KSI

$S_{12} = 19.80 - (-4.15) = 23.95$ KSI

$S_{23} = -4.15 - (-.06) = 4.09$ KSI

$S_{31} = -.06 - 19.80 = -19.86$ KSI

$P_L = |23.95| = 23.95$ KSI

$P_L \leq 1.5\ S_m$

$23.95 < 1.5(20) = 30$ KSI

O.K.

The stress is local stress at a nozzle

$\therefore$ This region meets the criteria for local membrane stress intensity.

Primary plus Secondary Stress Intensity

The max stress intensity is on the non-pressure side of the inside stiffner See Fig. 36 + 42

6/28/582

$\sigma_1 = 5.66$ KSI

$\sigma_2 = -21.12$ KSI

$\sigma_3 = 0$ KSI

$S_{12} = 5.66 - (-21.12) = 26.78$ KSI

$S_{23} = -21.12 - 0 = -21.12$ KSI

$S_{31} = 0 - 5.66 = 5.66$ KSI

$P_L + P_b + Q = |26.78| = 26.78$ KSI

$P_L + P_b + Q \leq 3 S_m$

$26.78 < 3(20) = 60$ KSI

$\therefore$ This region meets the criteria for primary plus secondary stress intensity

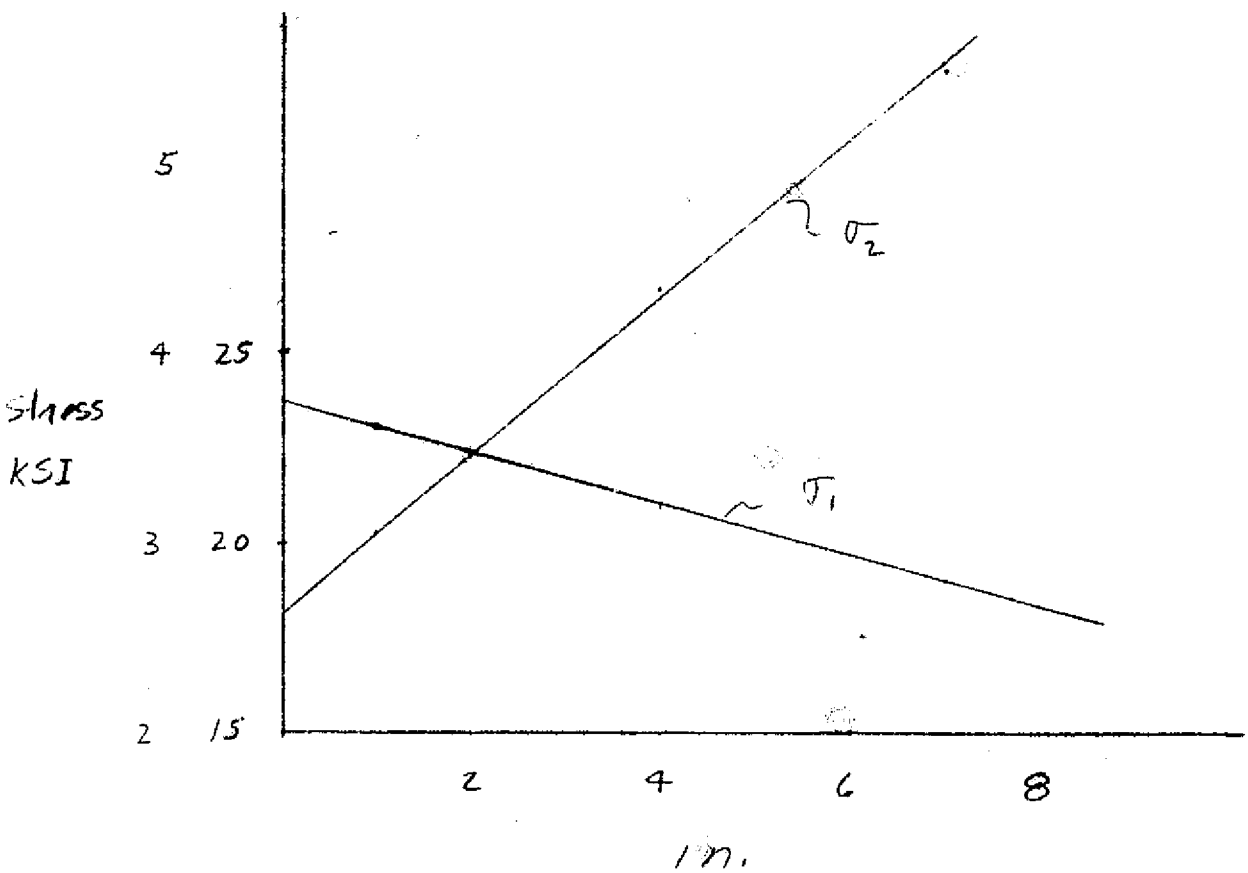
BY ________ DATE ________ SUBJECT ________ SHEET NO. 25 OF ____
CHKD. BY ________ DATE ________ JOB NO. ________

Region the 8.33' dia circular hole

Ref. Fig. 50

Max membrane stress intensity at 6/71

Since stress at surface 0 is for centroid of triangular element, the stress is projected to edge of plate.



$\sigma_1 = 23.8$ KSI

$\sigma_2 = 2.62$ KSI

$\sigma_3 = -\frac{.119}{2} = -.06$ KSI

$S_{12} = 23.8 - 2.62 = 26.42$ KSI

$S_{23} = 2.62 - (-.06) = 2.68$ KSI

$S_{31} = -.06 - 23.8 = -22.86$ KSI

$P_L = |-22.86| = 22.86$ KSI

$P_L \leq 1.5\ S_m$

$22.86 < 1.5(20) = 60$ KSI O.K

This stress intensity is local stress intensity near a nozzle

∴ This region meets the criteria for local membrane stress intensity

Primary Plus Secondary Stress Intensity

Outside Surface

ref. Fig. 51

Max at 6/71/795

To correct for stresses at edge of plate

add 23.8 − 23.13 = .67 KSI

add 2.62 − 3.03 = −.41 KSI

$\sigma_1 = 24.21 + .67 = 24.88$ KSI

$\sigma_2 = 12.85 + (-.41) = 12.43$ KSI

$\sigma_3 = 0$

$S_{12} = 24.88 - 12.45 = 12.43$ KSI

$S_{23} = 12.43 - 0 = 12.43$ KSI

$S_{31} = 0 - 24.88 = -24.88$ KSI

$P_L + P_b + Q = |-24.88| = 24.88$ KSI

$P_L + P_b + Q \leq 3S_m$

$24.88 < 3(20) = 60$ KSI O.K.

Inside Surface 6/71/795

See Fig. 52

To correct stress for edge of plate, apply the same correction as above.

$\sigma_1 = 22.62 + 0.64 = 22.62$ KSI

$\sigma_2 = -8.85 + (-.42) = -9.27$ KSI

$\sigma_3 = 0$

$S_{12} = 22.62 - (-9.27) = 31.89$ KSI

$S_{23} = -9.27 - 0 = -9.27$ KSI

$S_{31} = 0 - 22.62 = -22.62$ KSI

$P_L + P_b + Q = |31.89| = 31.89$ KSI

$P_L + P_B + Q < 3S_m$

$31.89 < 3(20) = 60$ KSI O.K.

∴ The primary plus secondary stress intensity for this region meets the stress evaluation criteria.

The holes size in this analyses is 8.33' dia. The thickness of the reinforcement around the hole is 3.75 The hole shown on drawing LE 9444295 is 6.0' dia. The thickness of the reinforcement around the hole is 4.25.

Since the larger dia & smaller reinforcing thickness meets the stress evaluation criteria, the 6.0' dia hole was not analyses. It was assumed to also meet the criteria

BY............ DATE........ SUBJECT.. SHEET NO........ OF......
CHKD. BY...... DATE........ JOB NO...................

Buckling of Plenum

A finite element analysis for the 304 S.S. design was not performed. The thicknesses are greater than the 9% Ni. design with only slight change in Mod. of elasticity (28×10^6 psi for 304 vs 29×10^6 for 9% Ni)

The critical load factor for 304 S.S will be larger than 9% Ni design

From 9% Ni analysis

The critical load factor for plenum region at a pressure of -15 psi is 12.0.

Buckling occured at the center of the plenum.

See Fig 69

Model check points

axial & hoop stress in section of shell

$$S_H = \frac{Pr}{t} = \frac{(119)(169)}{1.3} = 15.47 \text{ KSI}$$

$$S_a = \frac{Pr}{2t} = \frac{(119)(169)}{2(1.3)} = 7.73 \text{ KSI}$$

Stress at surface O

$$S_1 = 15.32 \text{ KSI}$$

$$S_2 = 7.76 \text{ KSI}$$

∴ stresses on section of cylinder check with hand calculations

Model check - Buckling

Ref. Theory of Elastic Stability
Timoshenko & Gere
Second Edition
p. 495 to 497

Buckling under Combined Axial and Uniform Lateral Pressure

Assume shell to be simply supported.
and a uniform cylinder with
$t = 1.75$ $R = 168.875"$ $L = 427"$
$E = 29 \times 10^6$ psi $\mu = 0.3$
The critical pressure is 122.5 psi
The critical load factor for
15 psi is 8.2

Ref: Stress in Shell
W. Flügge
Second Printing
p. 432 to 434

For External Pressure only

Assume edges clamped and a uniform cylinder with $t = 1.75$

$R = 168.75$ $L = 427''$ $E = 29 \times 10^6$ psi

$\mu = 0.3$

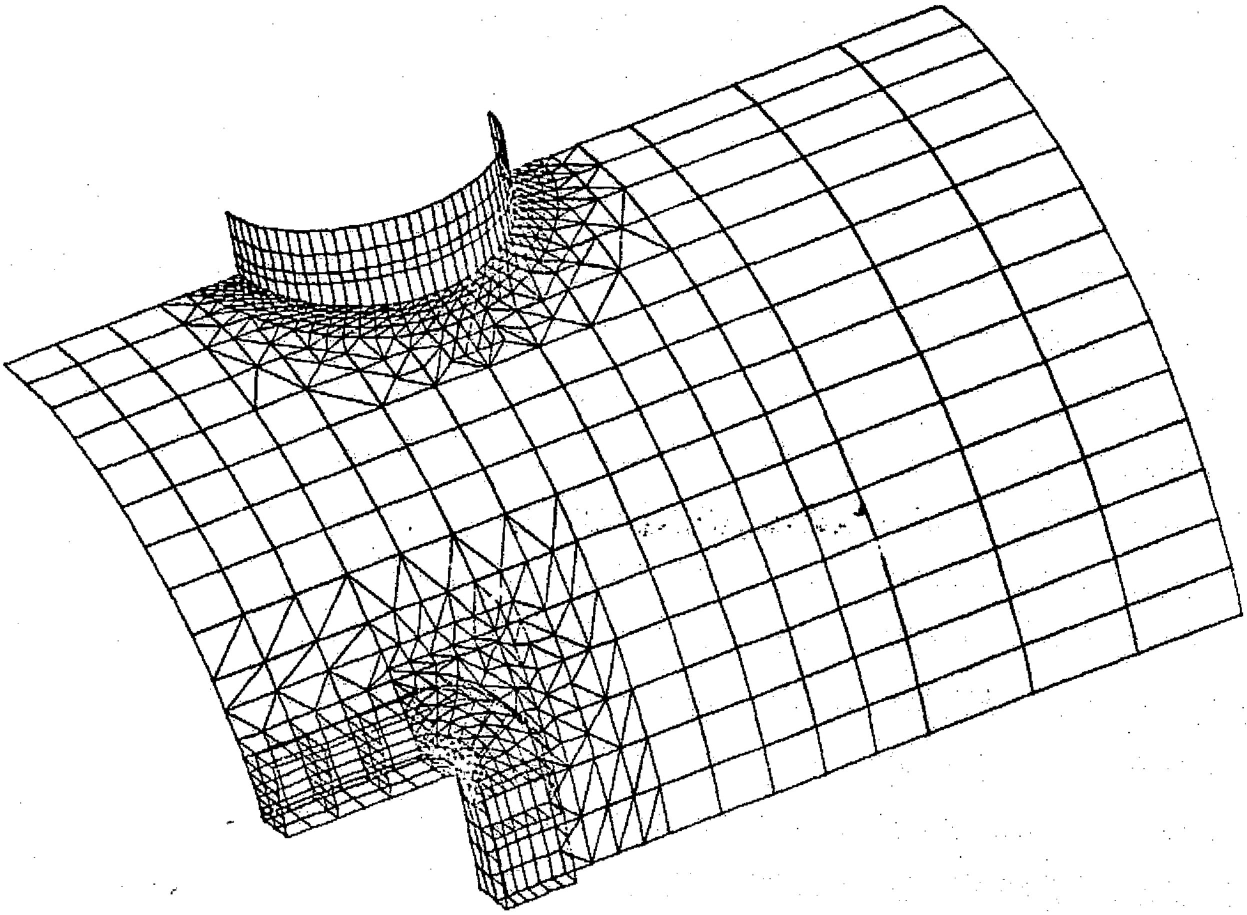
The critical pressure is 123.9 psi

The critical load factor for 15 psi is 8.3

Timoshenk & Flügge yield critical load factor lower than the finite element solution (8.3 vs 12.0)

This, can be explain by the fact part of the shell in the finite element solution is 2" thick and the heavy reinforcing provided around the openings.

∴ Model is O.K.



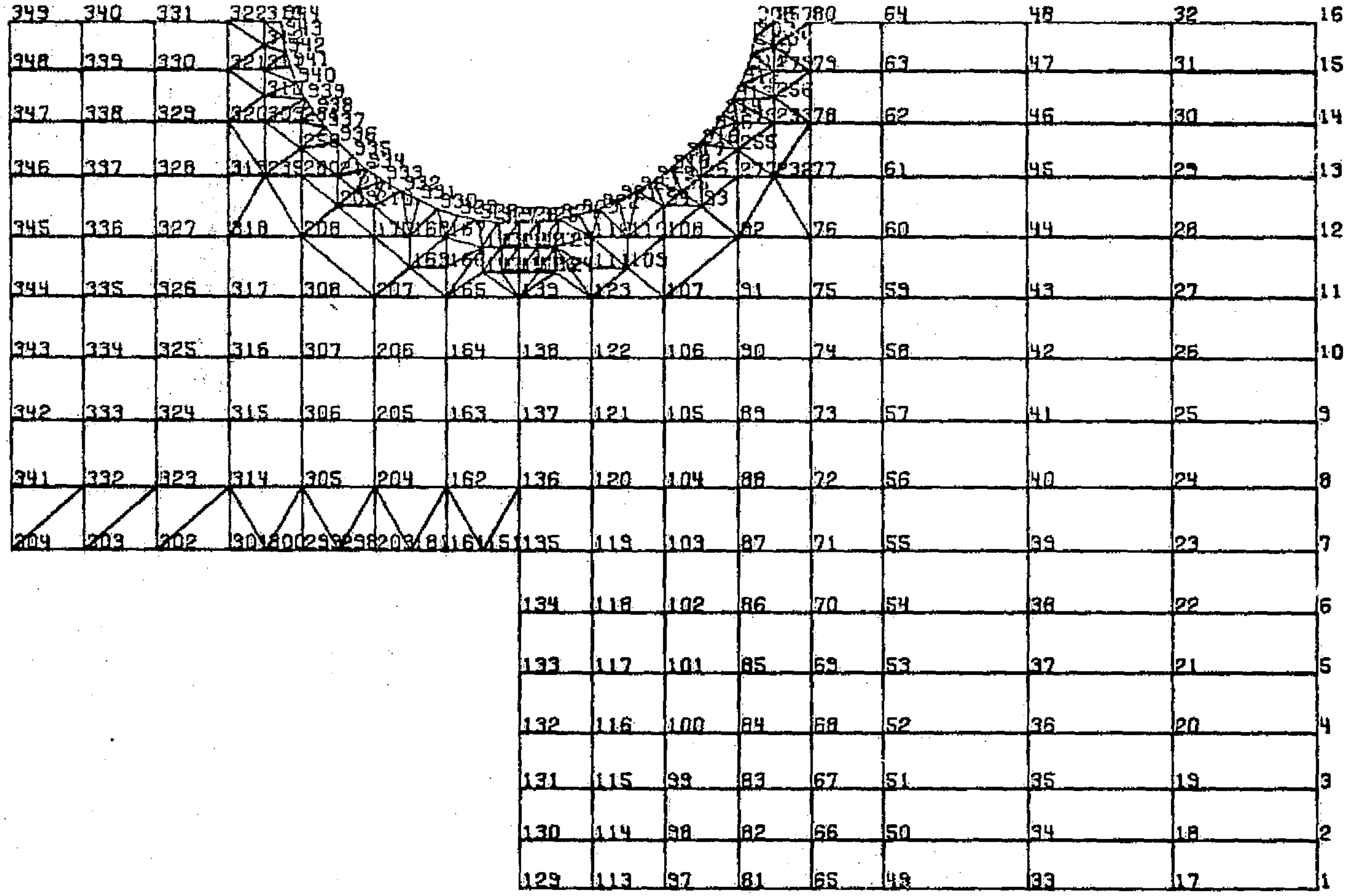
SPEC
1.1

NTF 9 X 12 ACCESS OPENING

0 64
SCALE

Figure 1

Figure 2



SPEC 3.1

NTF 9 X 12 ACCESS OPENING SHELL

0 55 SCALE

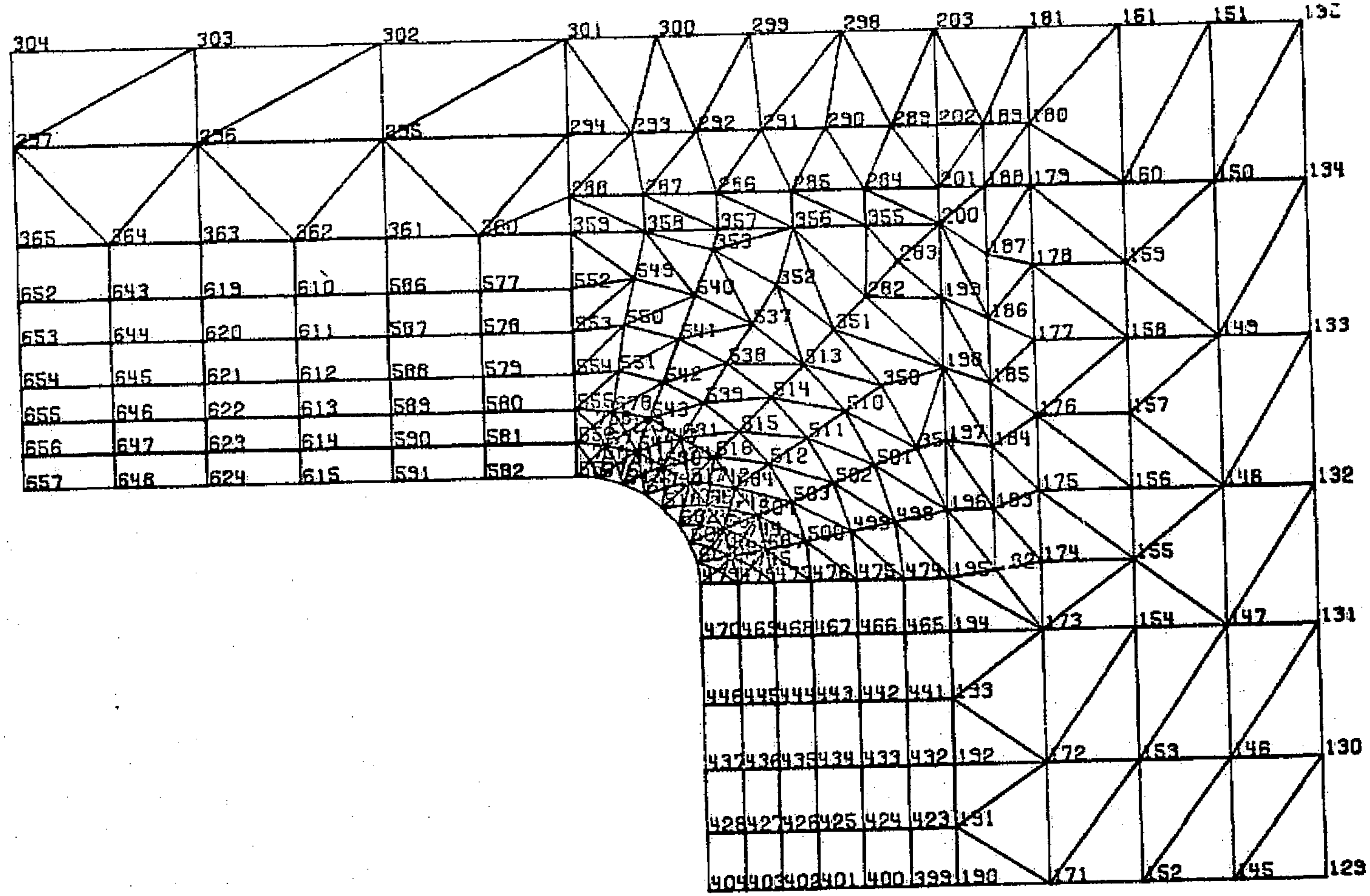


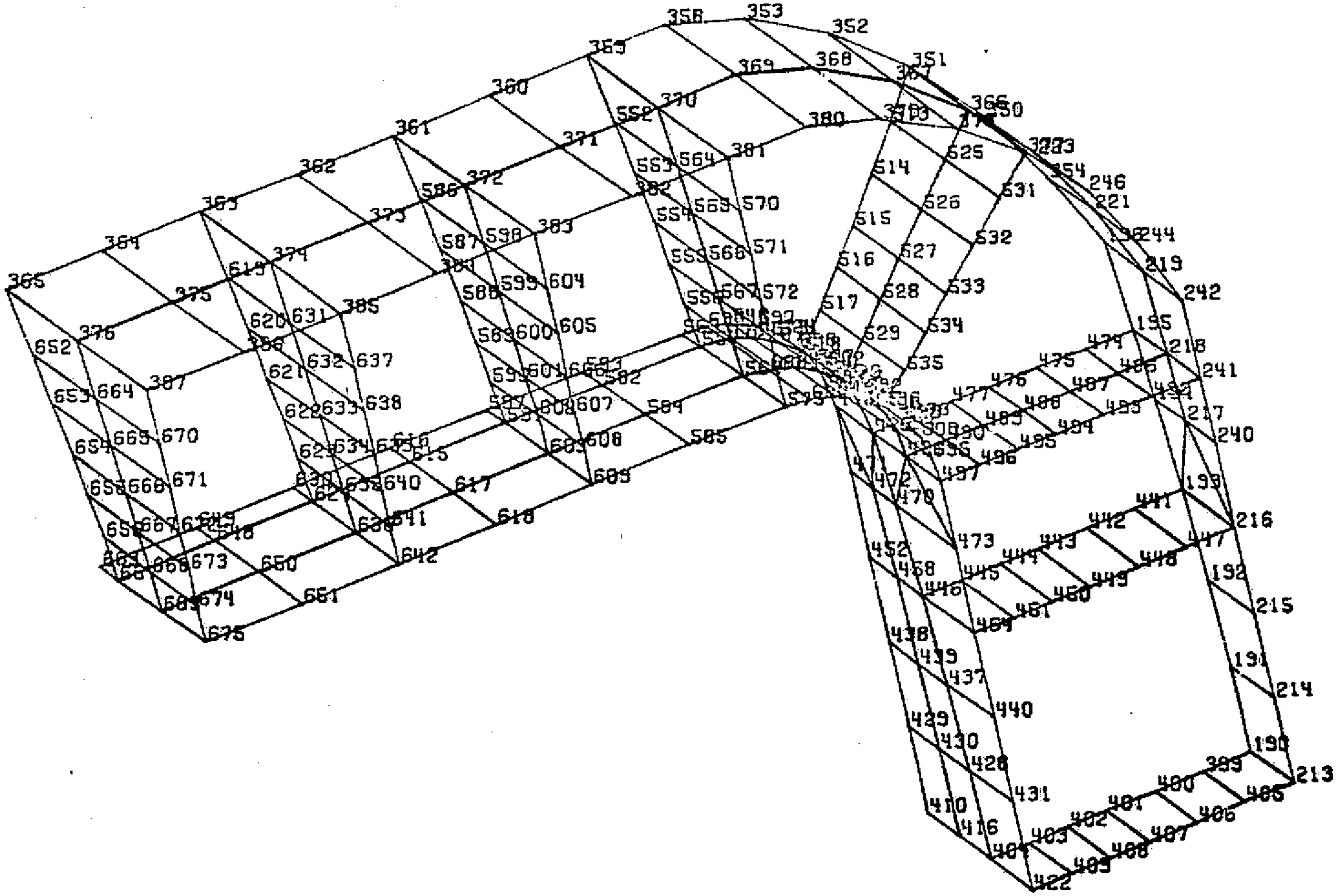
Figure 3

SPEC 4.1

NTF 9 X 12 ACCESS OPENING
SHELL

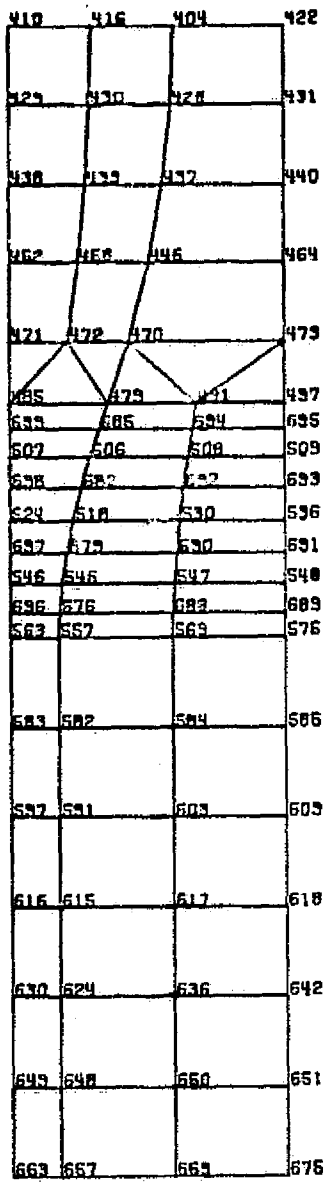
0 21
SCALE

Figure 4



SPEC 5.1 NTF 9X12 ACESS OPENING GUSSET

0 18 SCALE

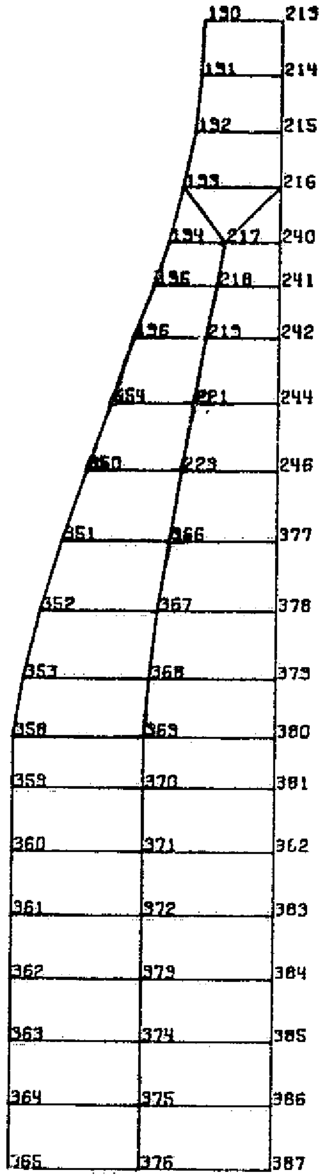


SPEC
6.1

NTF 9X12 REINF.
INNER RING

0
SCALE

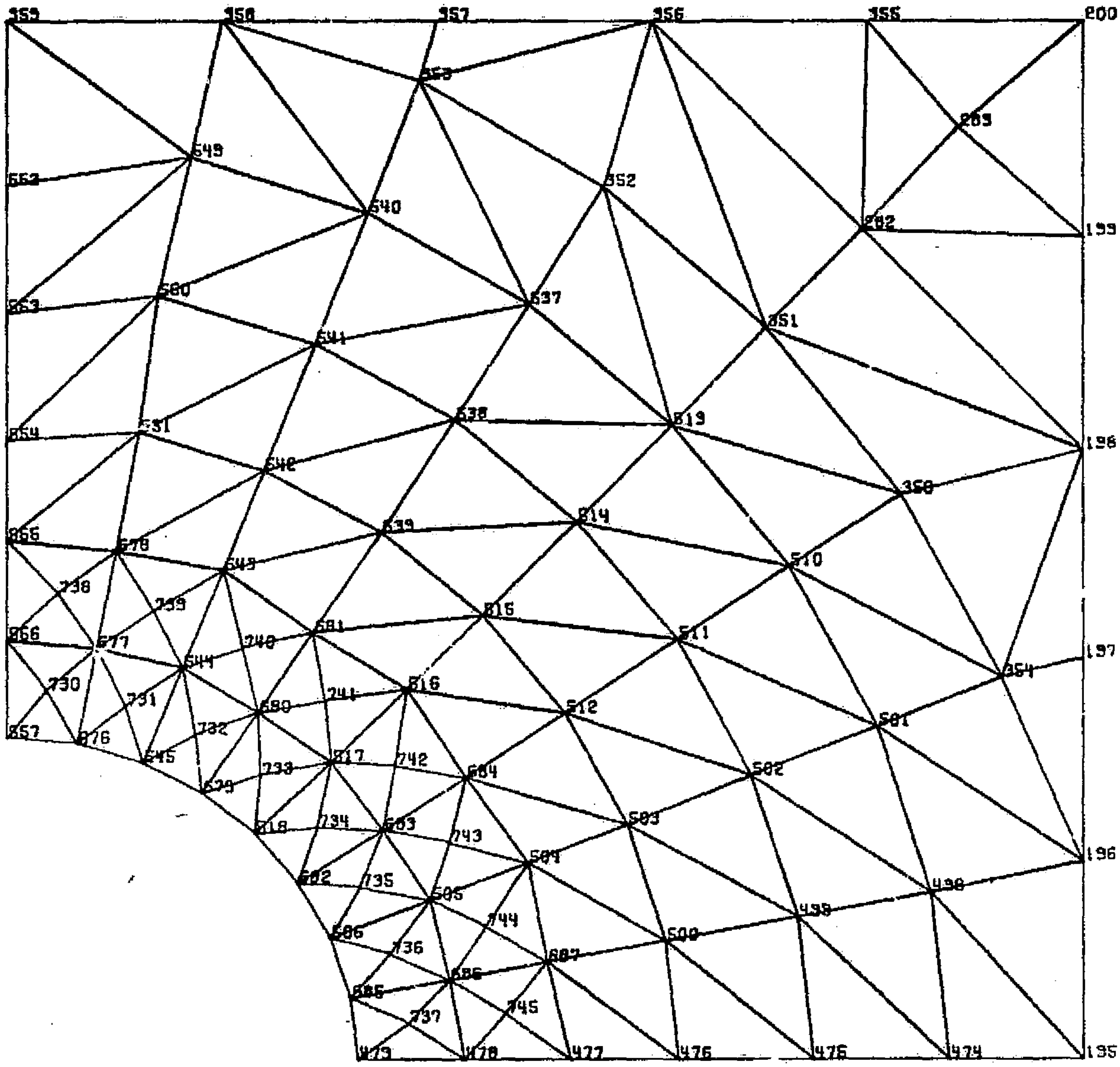
Figure 5



SPEC 7.1 NTF 9X12 DOOR REINF. OUTER RING

0 19 SCALE

Figure 6



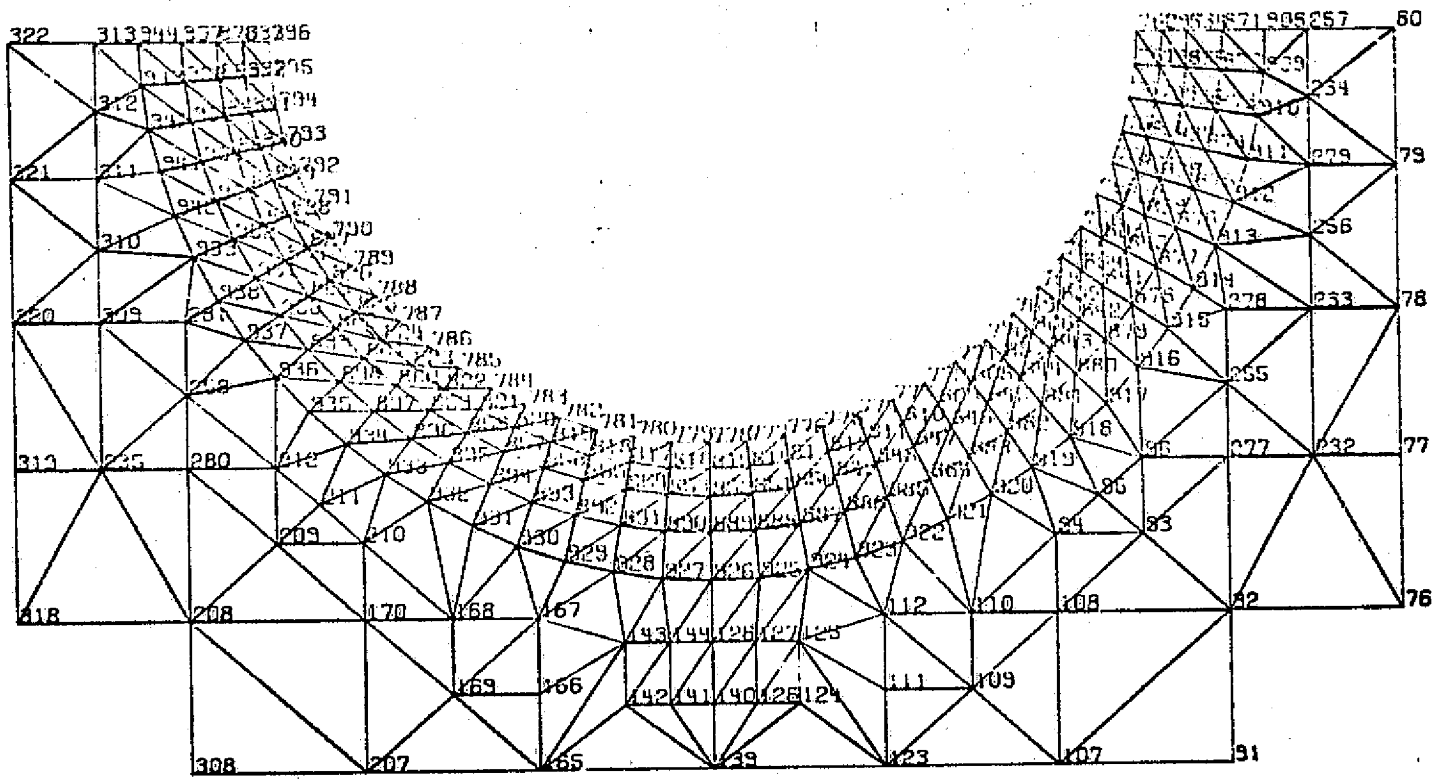
SPEC 8.1

NTF 9 X 12 REINF
CENTER TRIANGLES

0 6
SCALE

Figure 7

Figure 8



SPEC 9.1   9 X 12 REINF WITH 9 FT HOLE
TRIANGLES AROUND 9 FT HOLE

0   24
SCALE

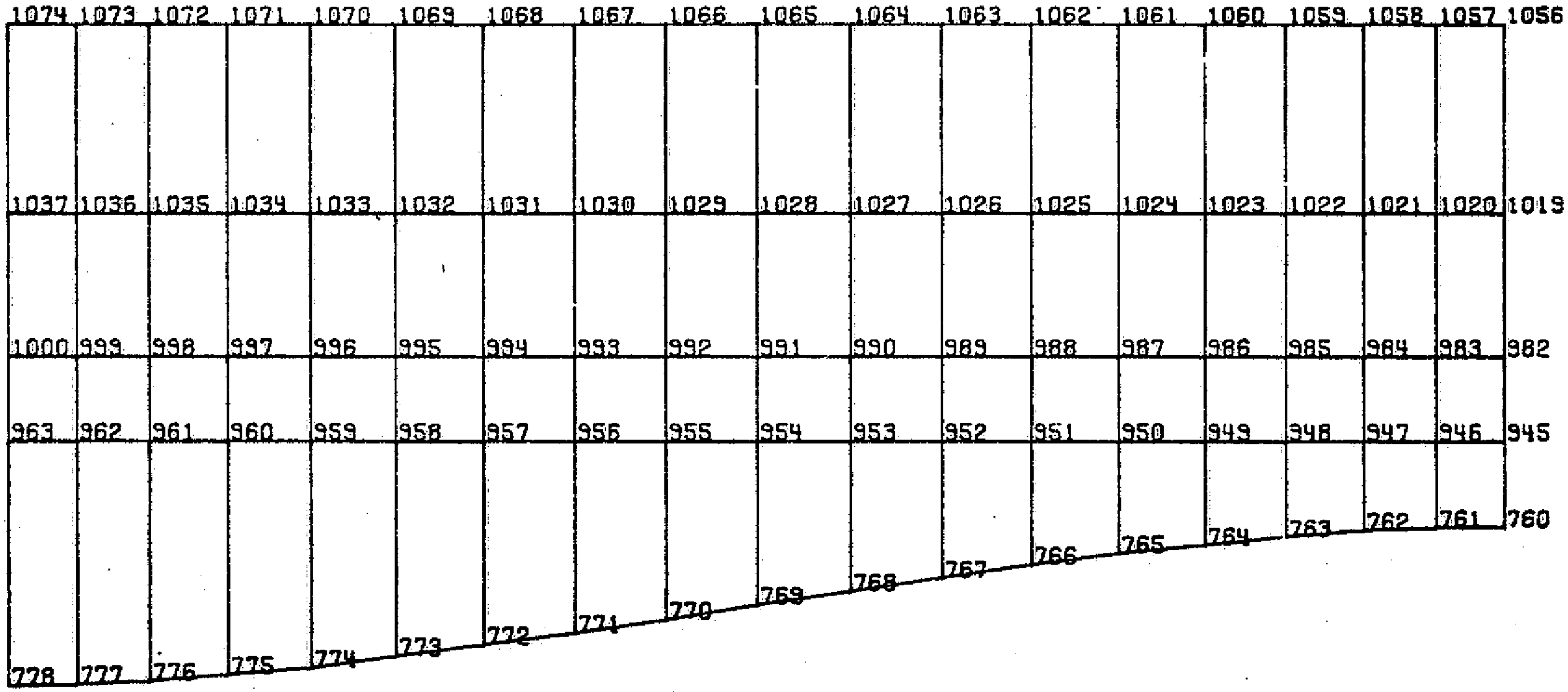
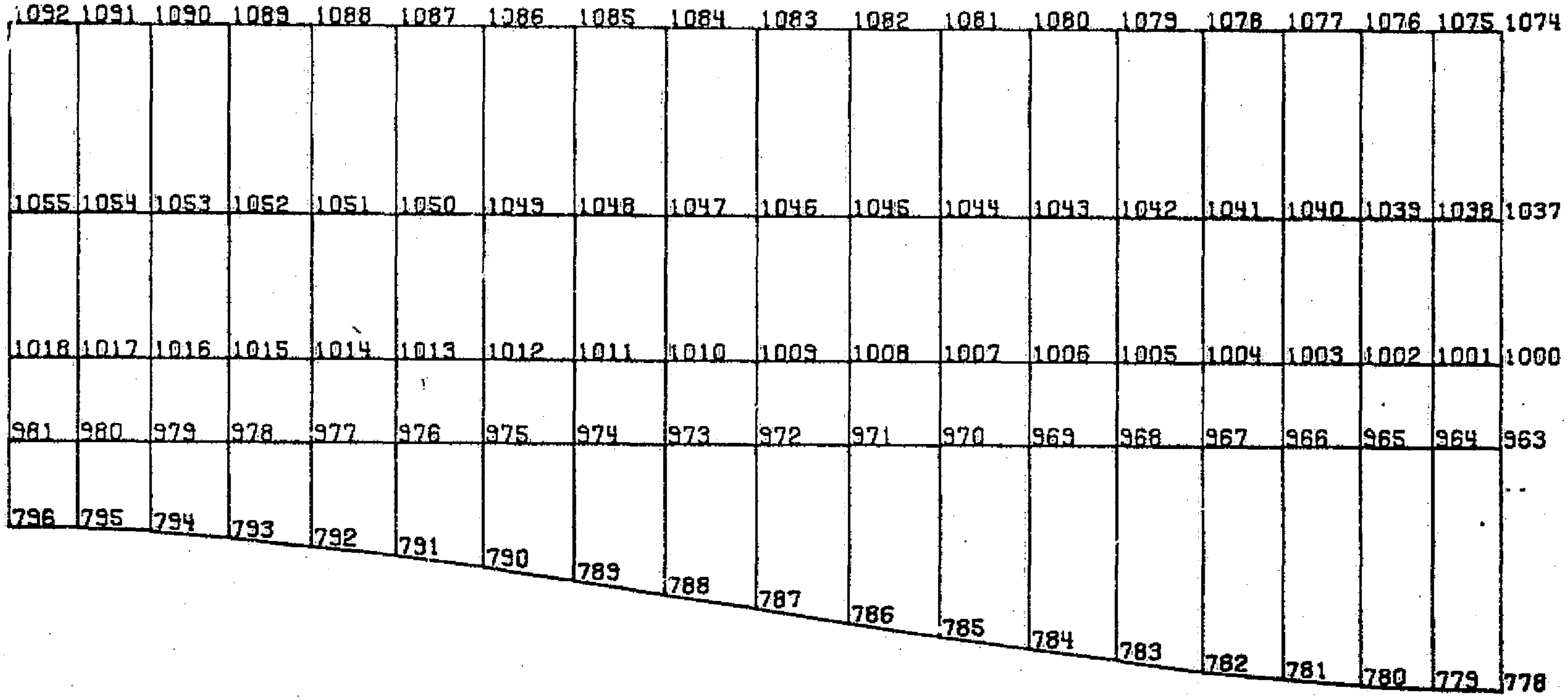


Figure 9

SPEC 10.1 9 X 12 REINF WITH 9 FT HOLE
9 FT PIPE SECTION 1

0 11 SCALE

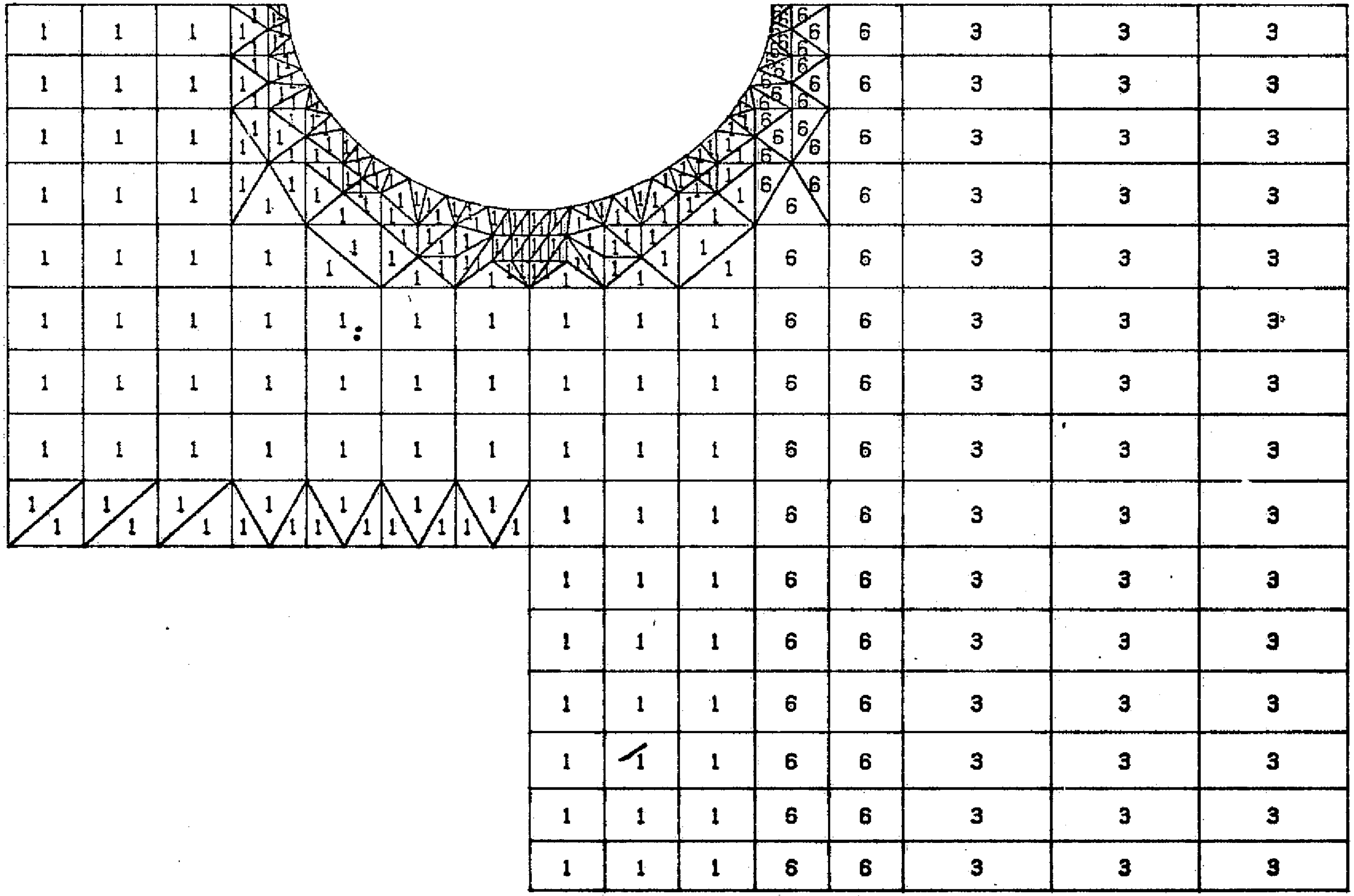
Figure 10



SPEC 11.1

9 X 12 REINF WITH 9 FT HOLE
9 FT PIPE SECTION 2

0 11
SCALE



ELEMENT SECTION PROPERTY GROUPS

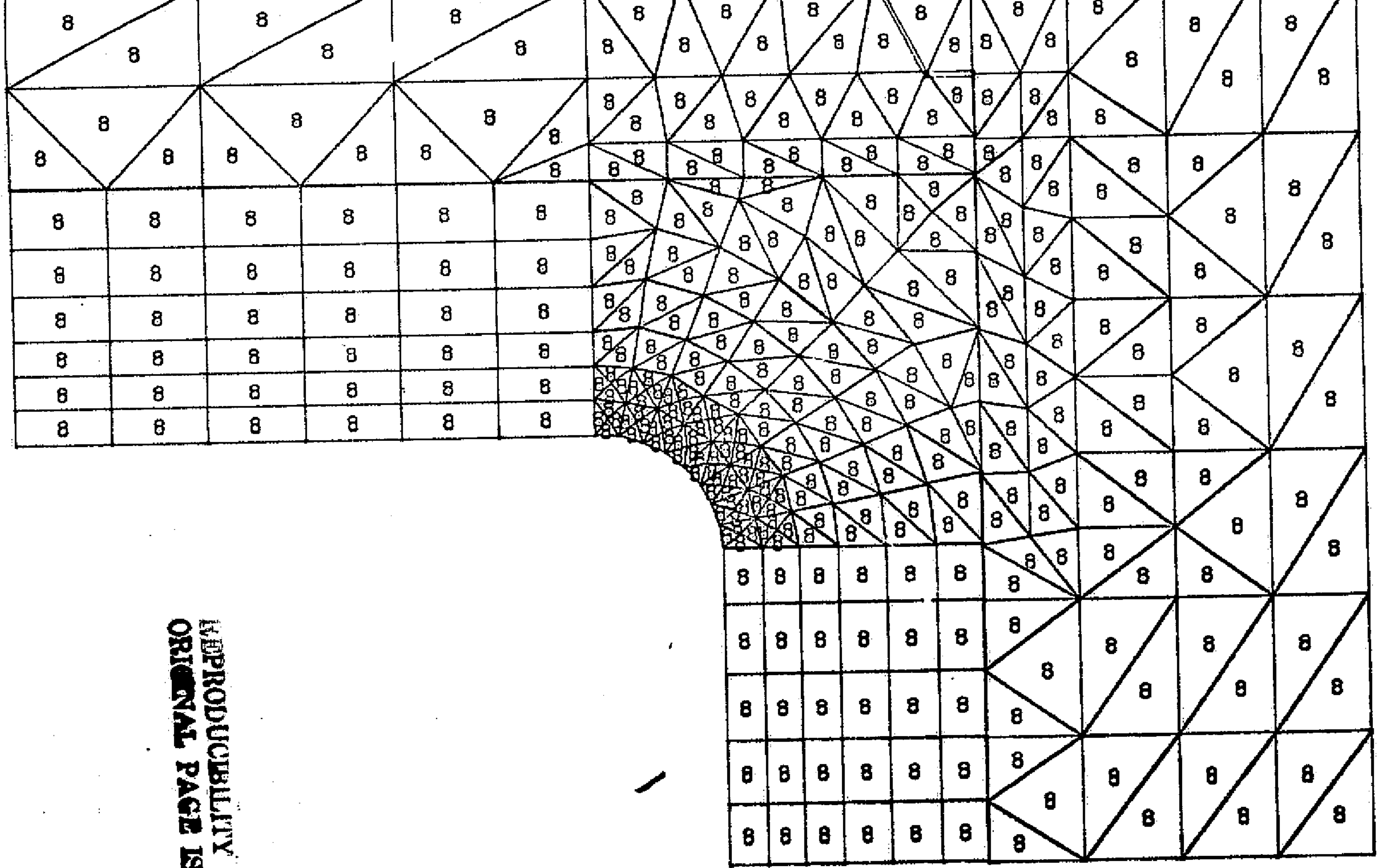
Figure 11

SPEC
3.1

NTF 9 X 12 ACCESS OPENING
SHELL

0 55
SCALE

Figure 12

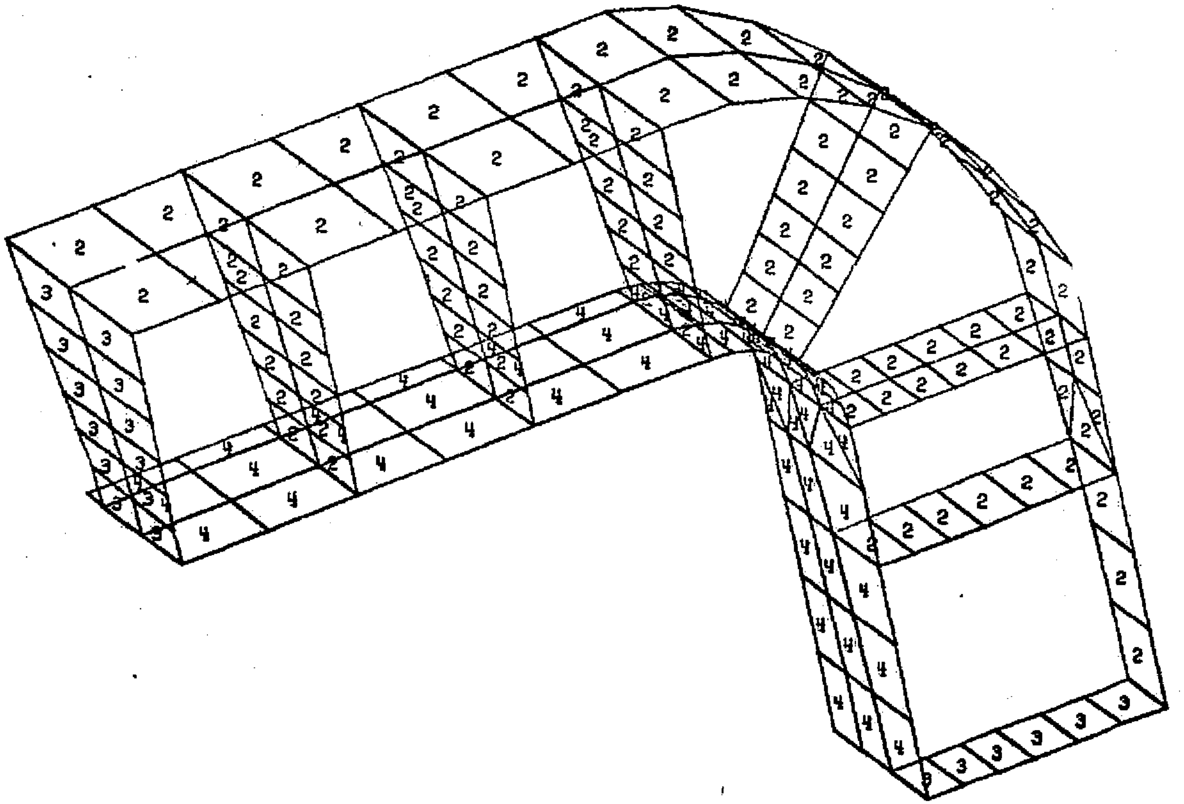


SPEC
4.1

NTF 9 X 12 ACCESS OPENING
SHELL

0 SCALE 2

ELEMENT SECTION PROPERTY GROUPS



SPEC
5.1

NTF 9X12 ACESS OPENING
GUSSET

0 18
SCALE

:PERTY GROUPS

Figure. 13

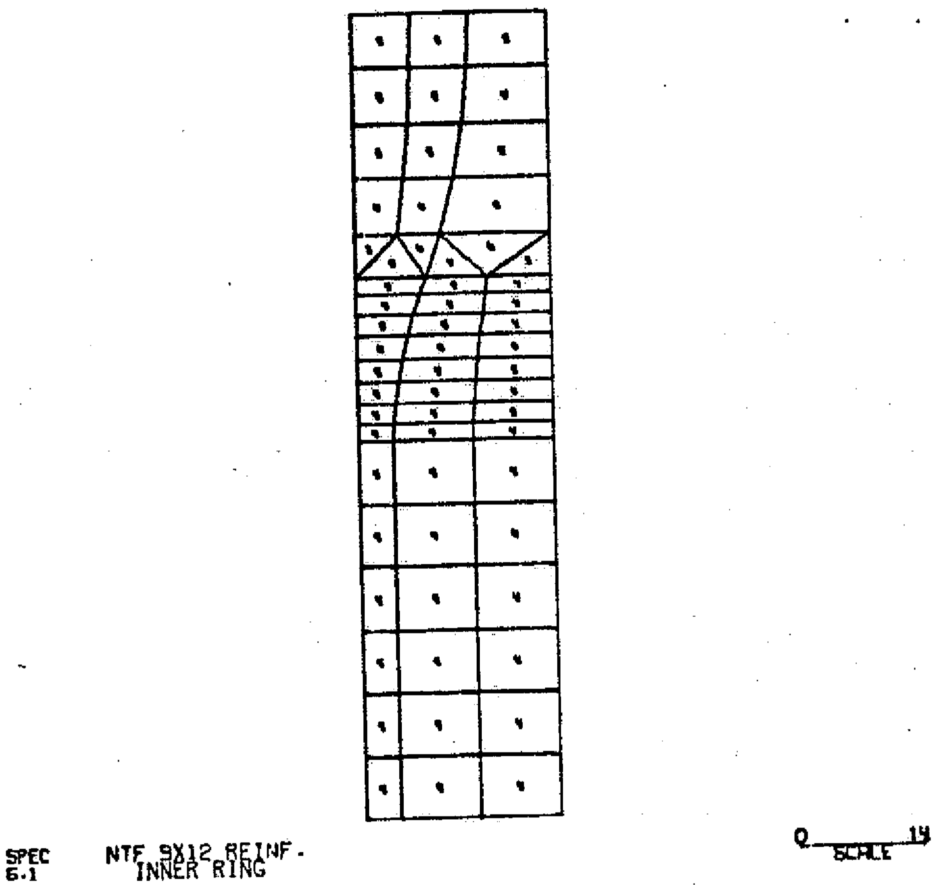
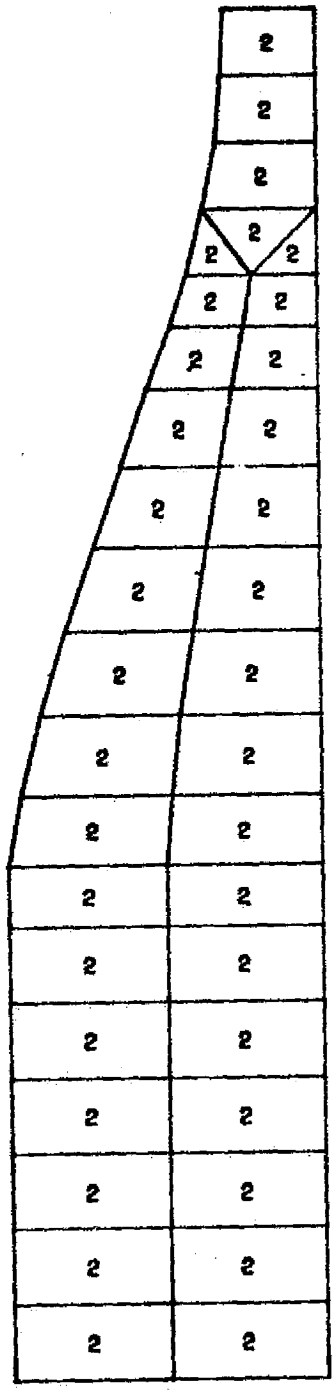


Figure 14



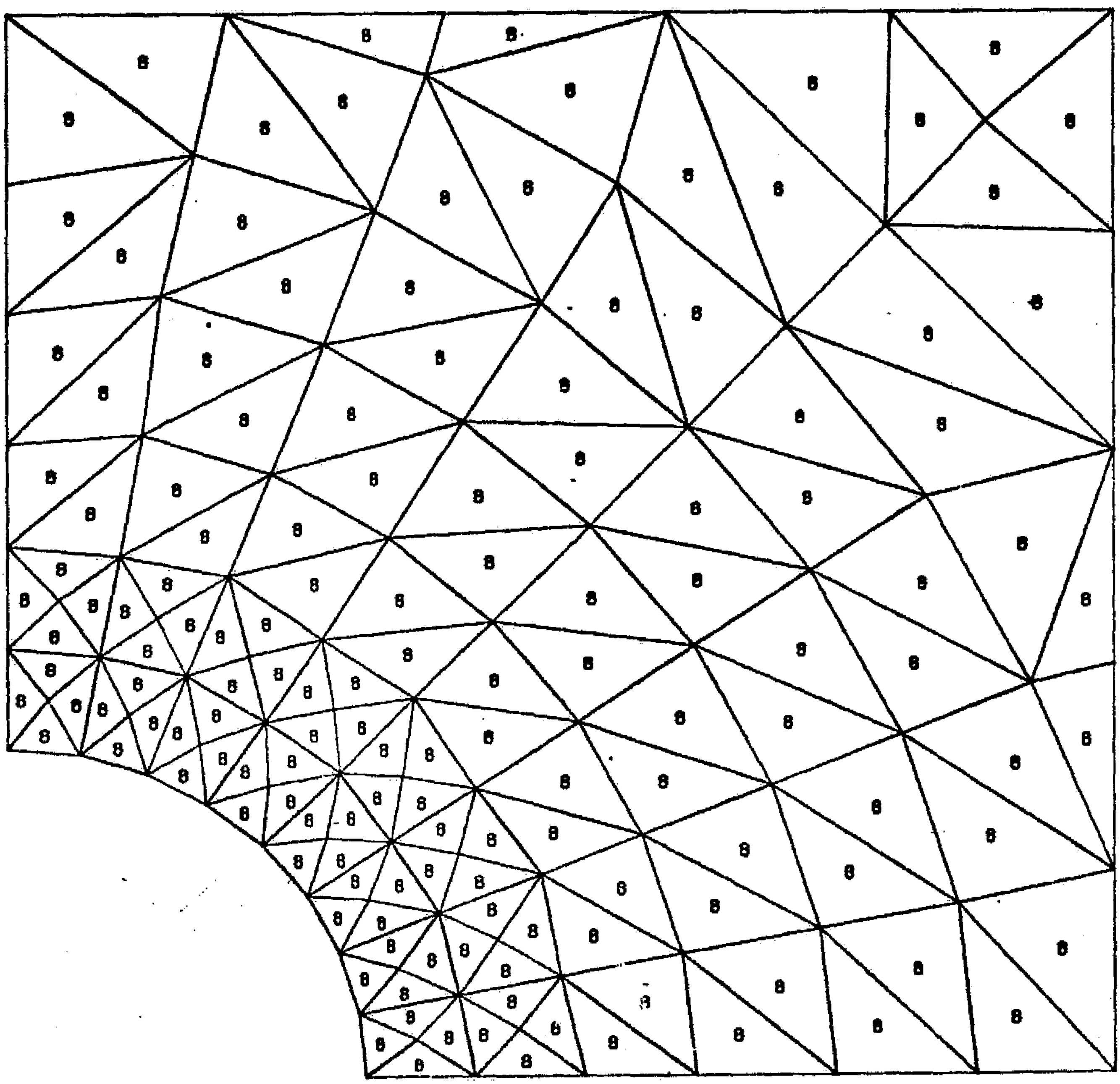
ELEMENT SECTION PROPERTY GROUPS

SPEC
7 '

NTF 9X12 DOOR REINF.
OUTER RING

0 SCALE 19

Figure 15



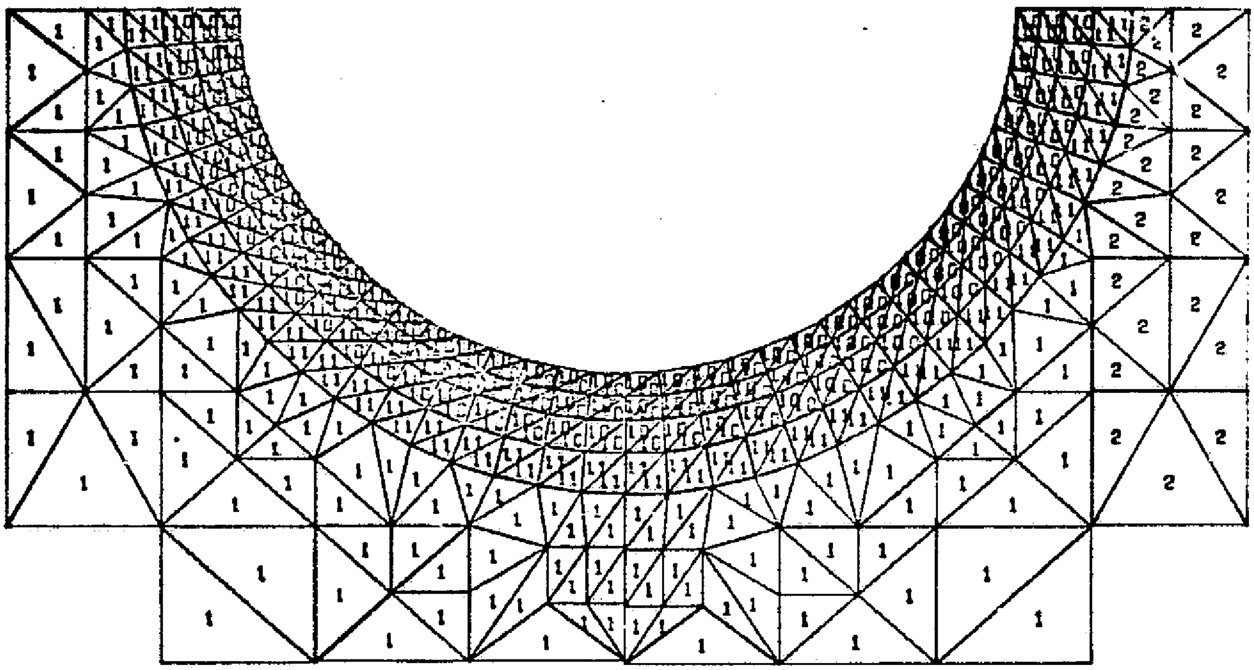
SPEC
8.1

NTF 9 X 12 REINF
CENTER TRIANGLES

0 SCALE

ELEMENT SECTION PROPERTY GROUPS

Figure 16



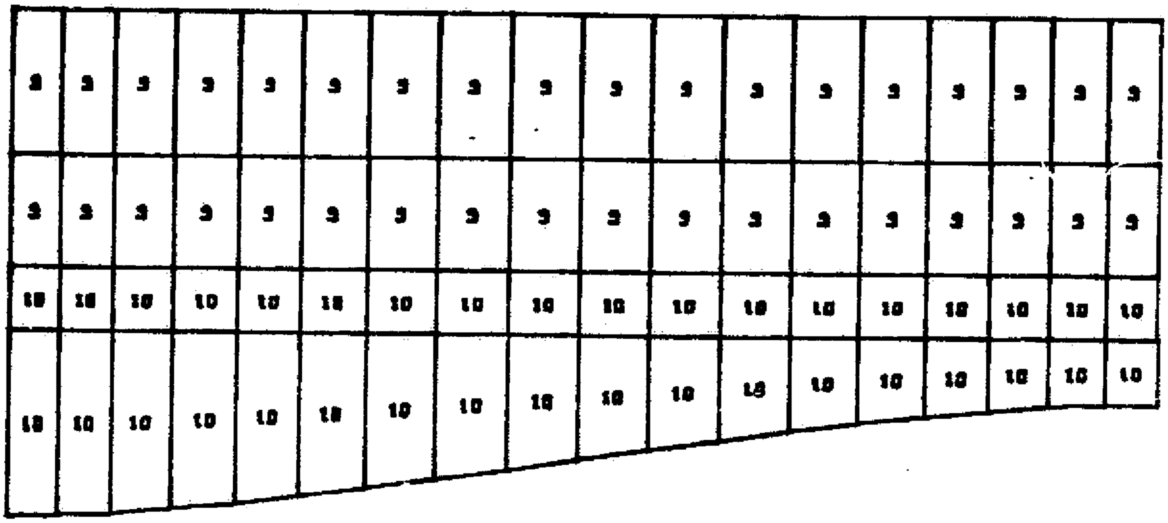
SPEC 9.1

9 X 12 REINF WITH 9 FT HOLE
TRIANGLES AROUND 9 FT HOLE

0 24 SCALE

ELEMENT SECTION PROPERTY GROUPS

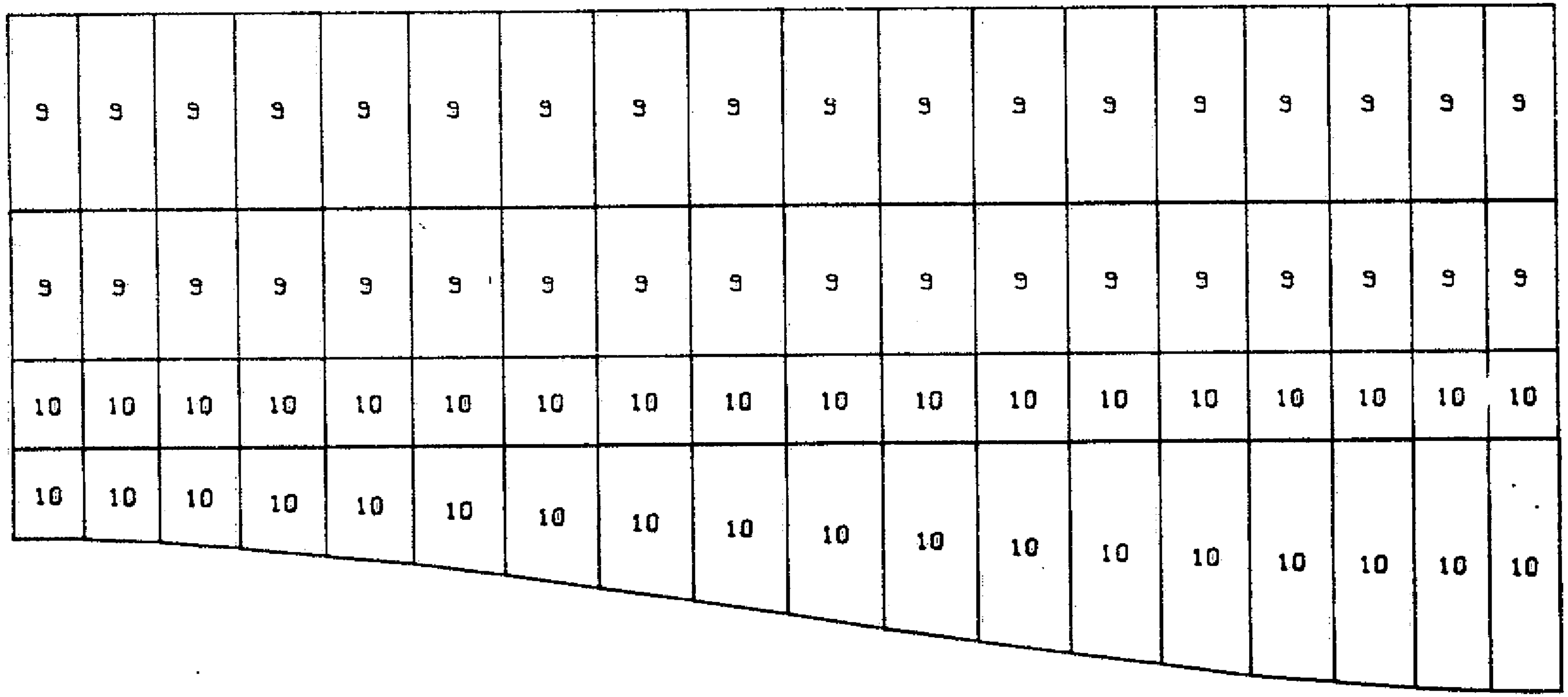
Figure 17



SPEC 9 X 12 REINF WITH 9 FT HOLE
10.1 9 FT PIPE SECTION I

0 SCALE 11

Figure 18



ELEMENT SECTION PROPERTY GROUPS

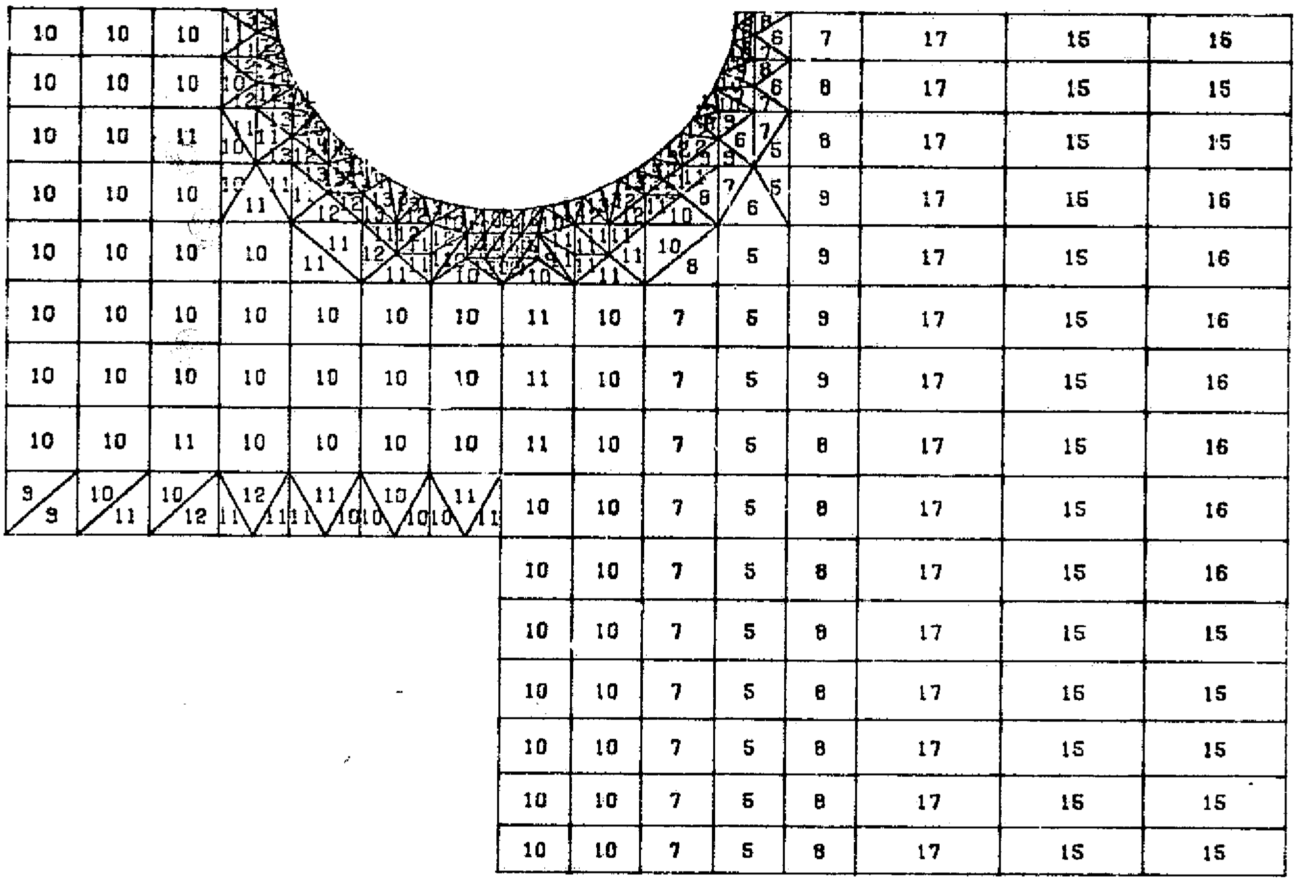
Figure 19

SPEC 11.1

9 X 12 REINF WITH 9 FT HOLE
9 FT PIPE SECTION 2

0 11
SCALE

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 0 10/1/1



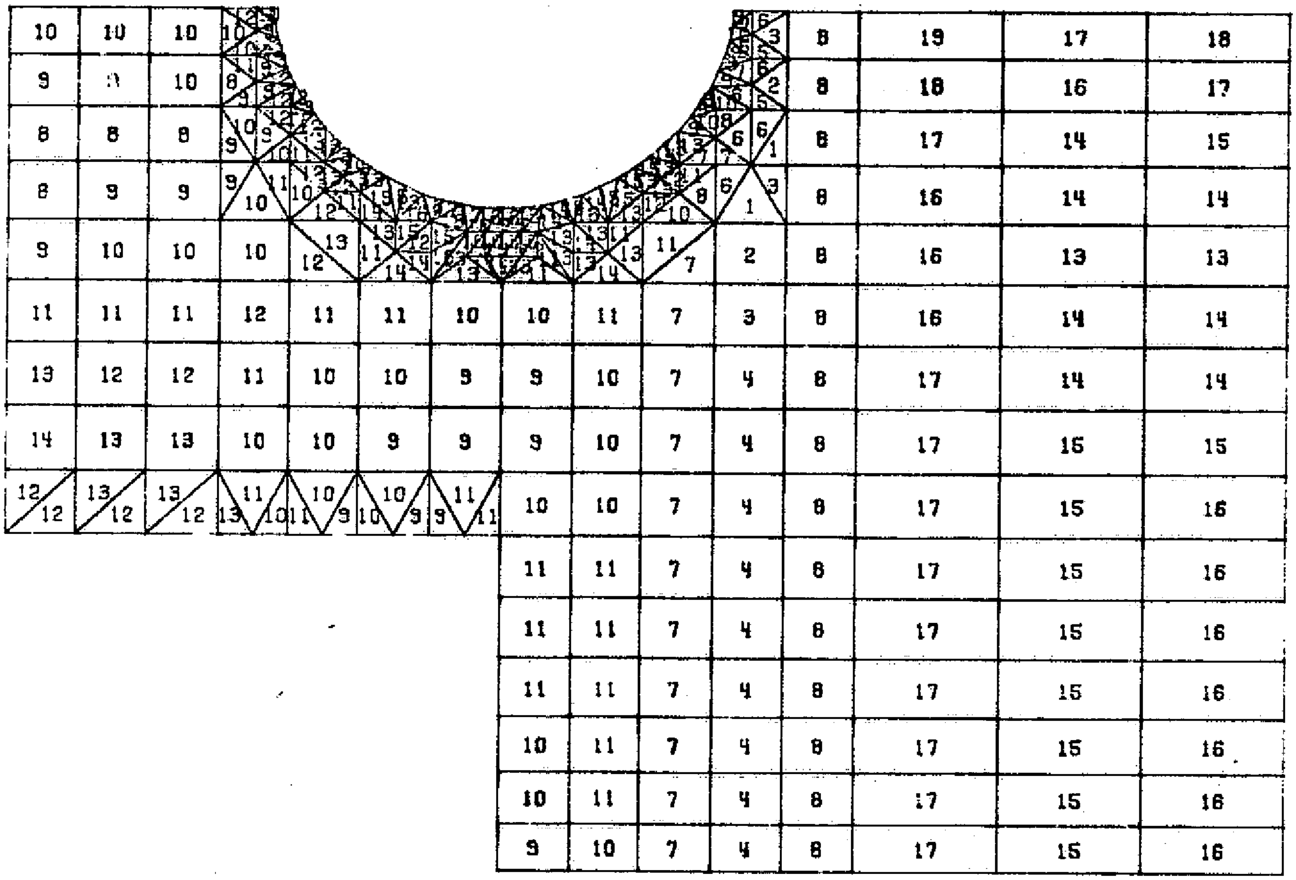
SPEC
.1

NTF 9 X 12 ACCESS OPENING
SHELL

0 55
SCALE

Figure 20

DISPLAY= PS1 /1000 , NODE= 1 , SURFACE= 1 10/1/1



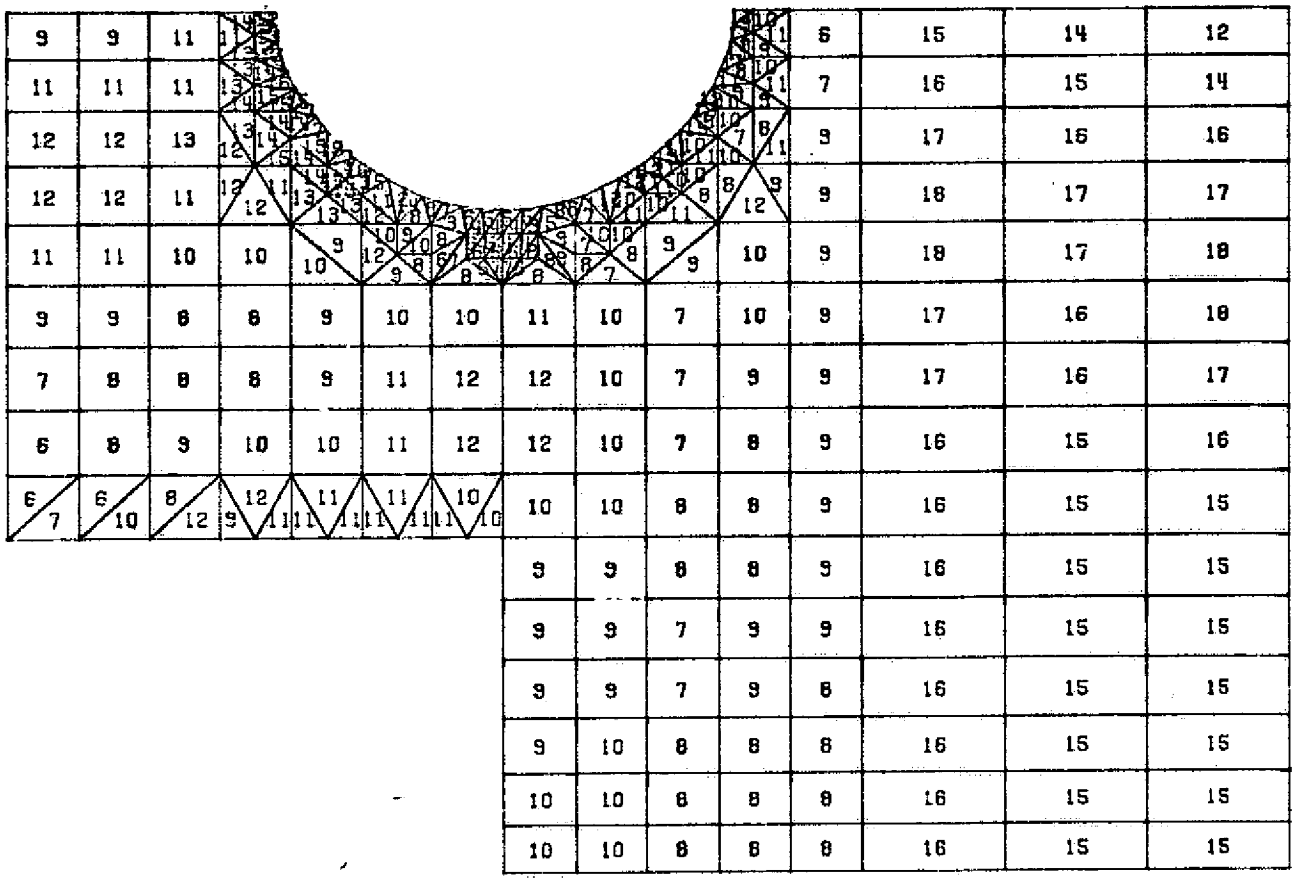
EC
5.1 NTF 9 X 12 ACCESS OPENING
SHELL

0 55
SCALE

Figure 21

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 2

10/1/1



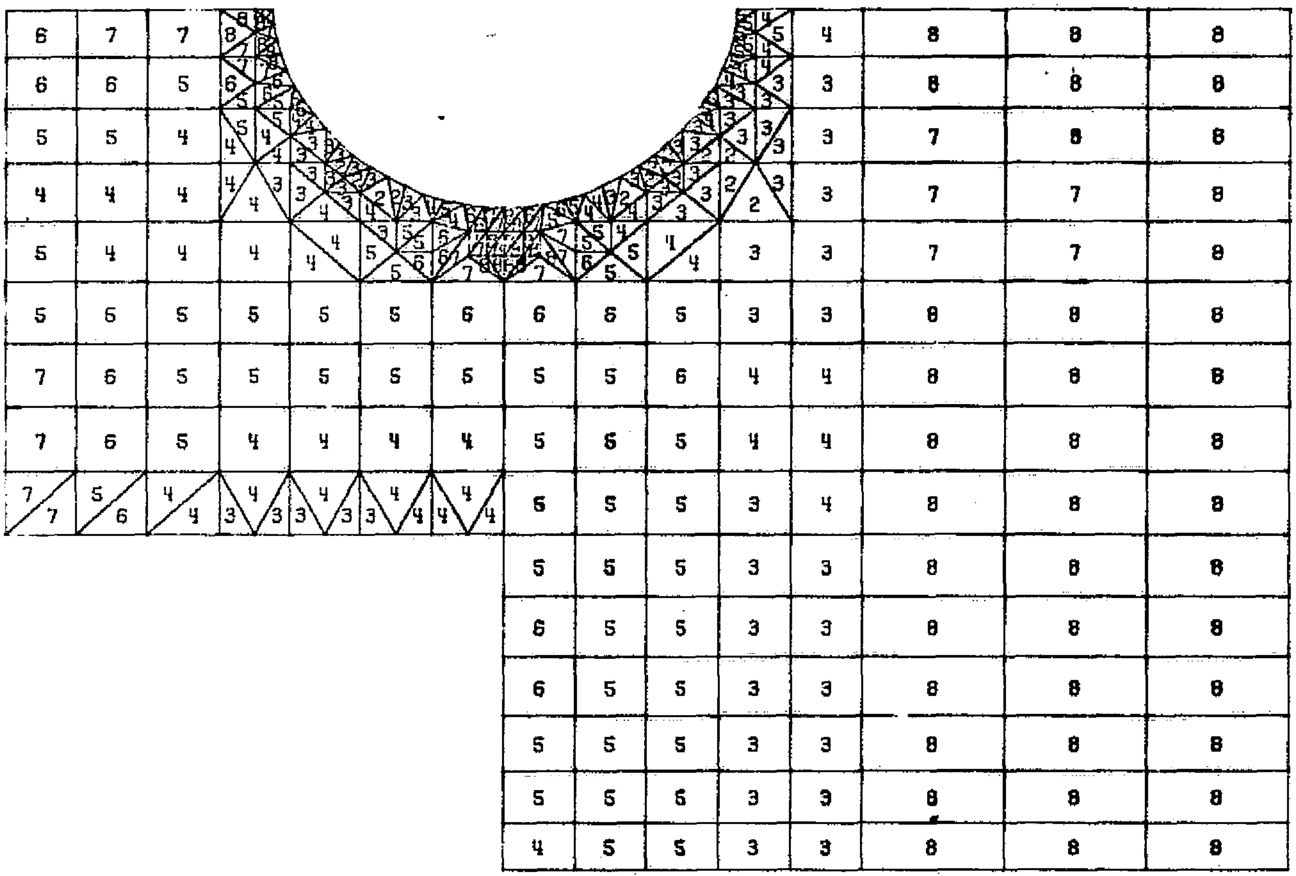
SPEC 3.1

NTF 9 X 12 ACCESS OPENING SHELL

0 55 SCALE

Figure 22

DISPLAY= PS2 /1000 , NODE= 1, SURFACE= 0



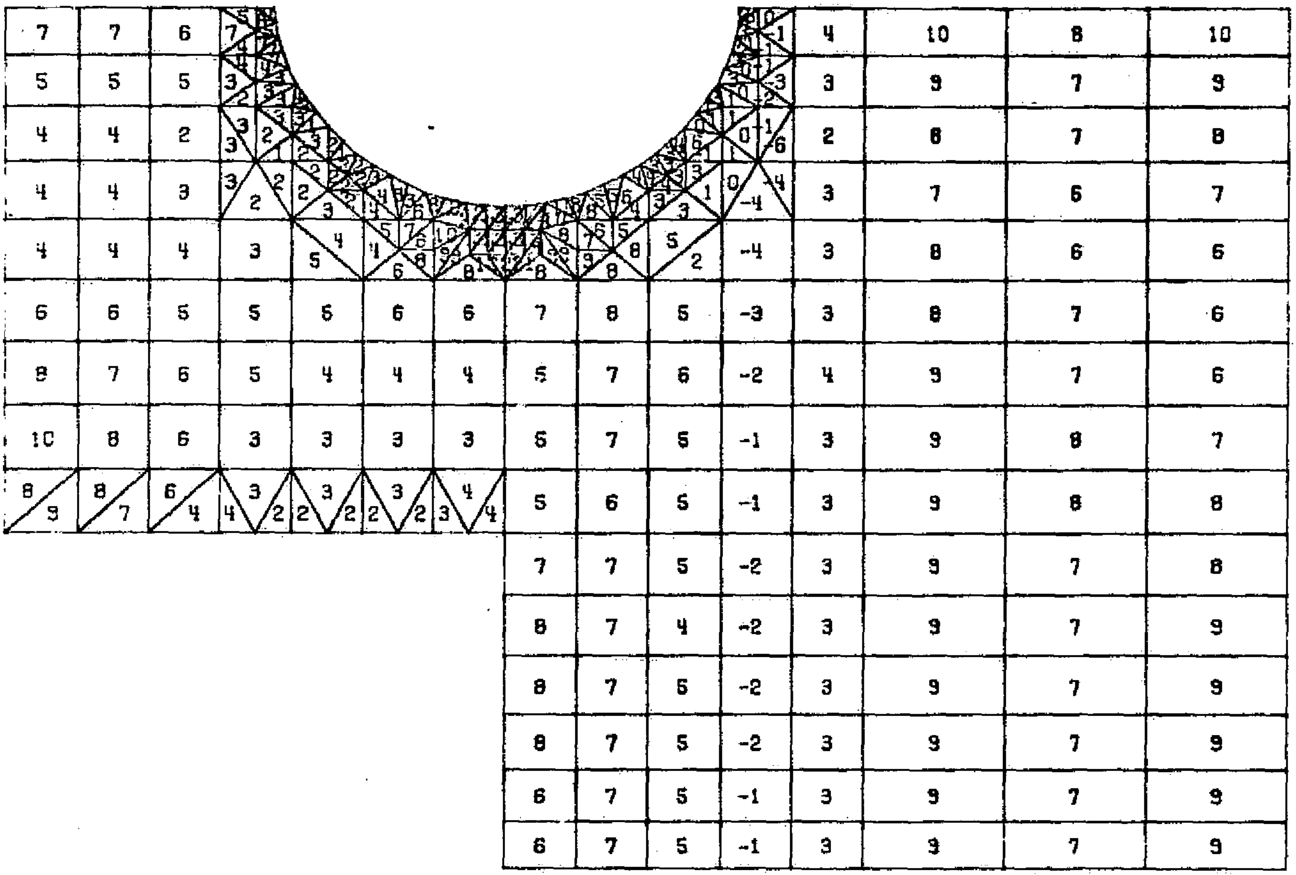
SPEC 3.1 NTF 9 X 12 ACCESS OPENING SHELL

0 55 SCALE

Figure 23

DISPLAY= PS2 /1000 , NODE= 1, SURFACE= 1

10/1/1



SPEC 3.1

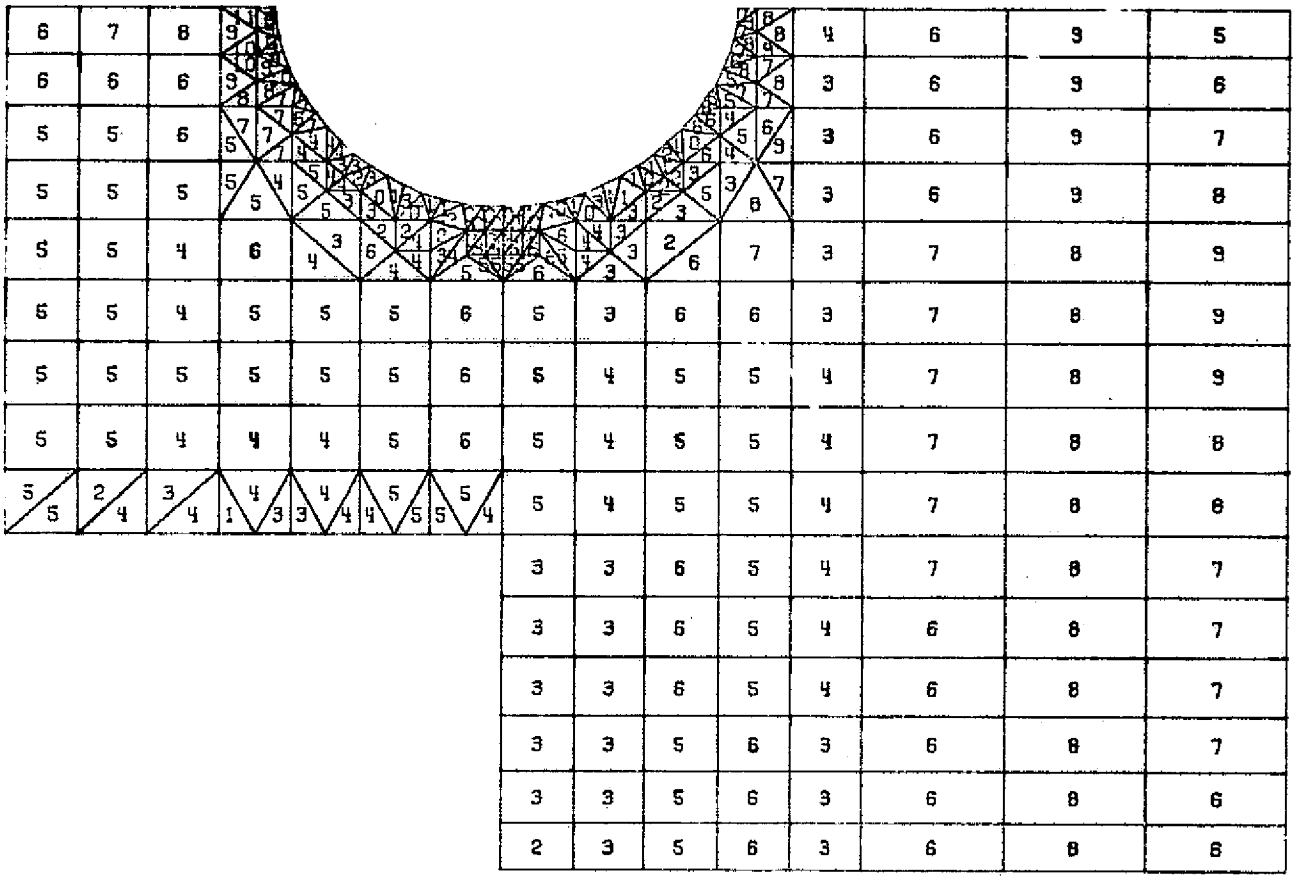
NTF 9 X 12 ACCESS OPENING SHELL

0 SCALE

Figure 24

DISPLAY= PS2 /1000 , NODE= 1, SURFACE= 2

10/1/1



SPEC 3.1

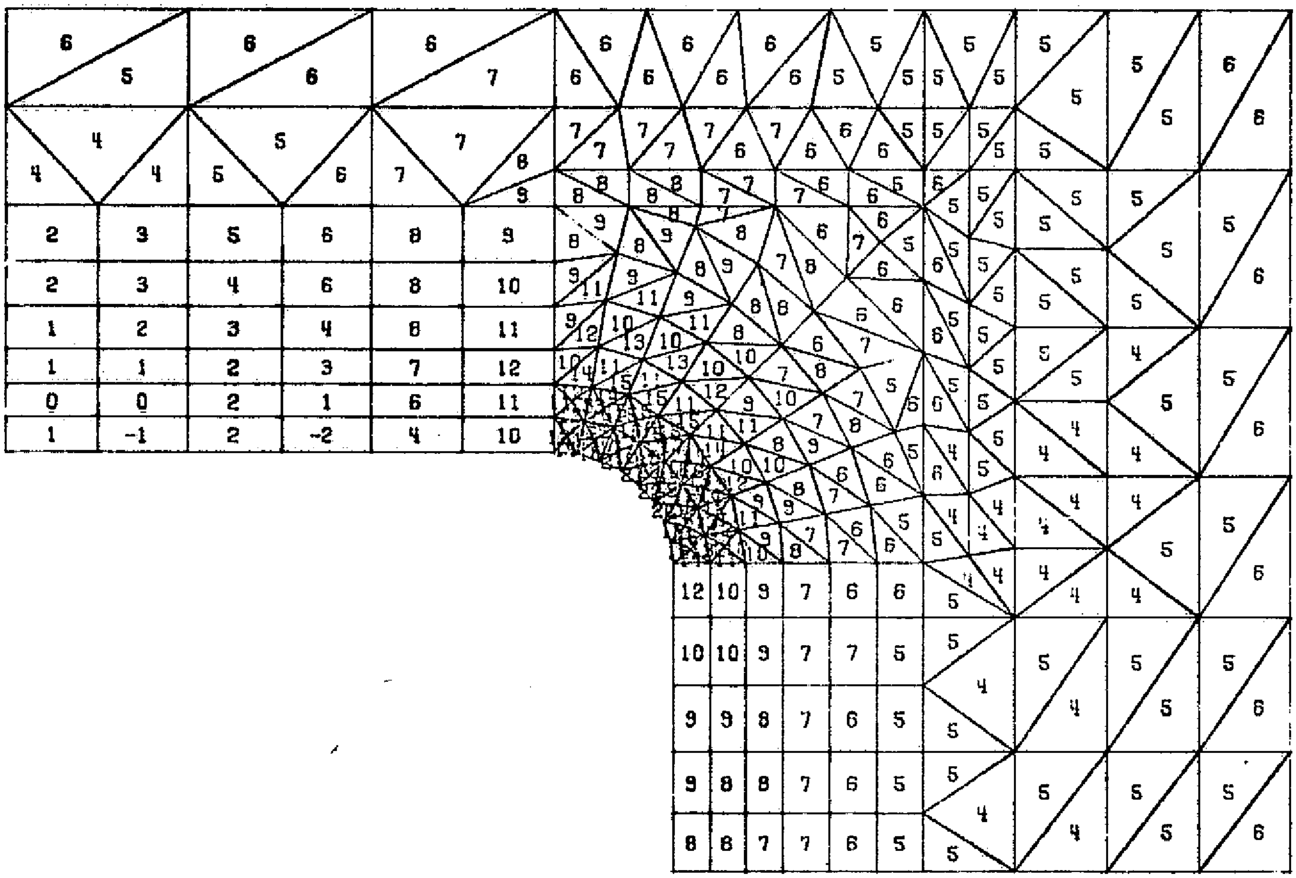
NTF 9 X 12 ACCESS OPENING
SHELL

0 55
SCALE

Figure 25

10/1/1

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 0



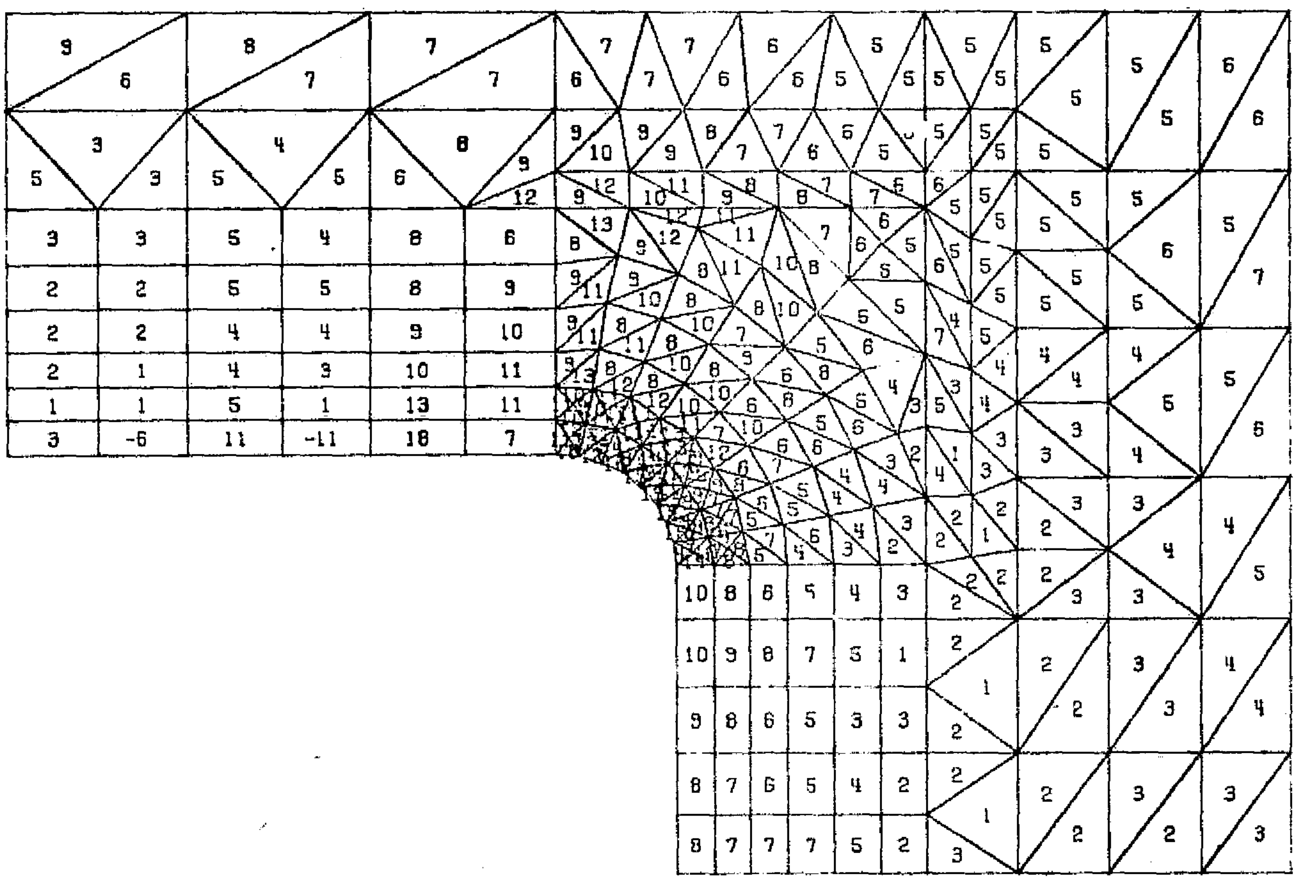
SPEC 4,1 NTF 9 X 12 ACCESS OPENING SHELL

0 21 SCALE

Figure 26

10/1/1

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 1



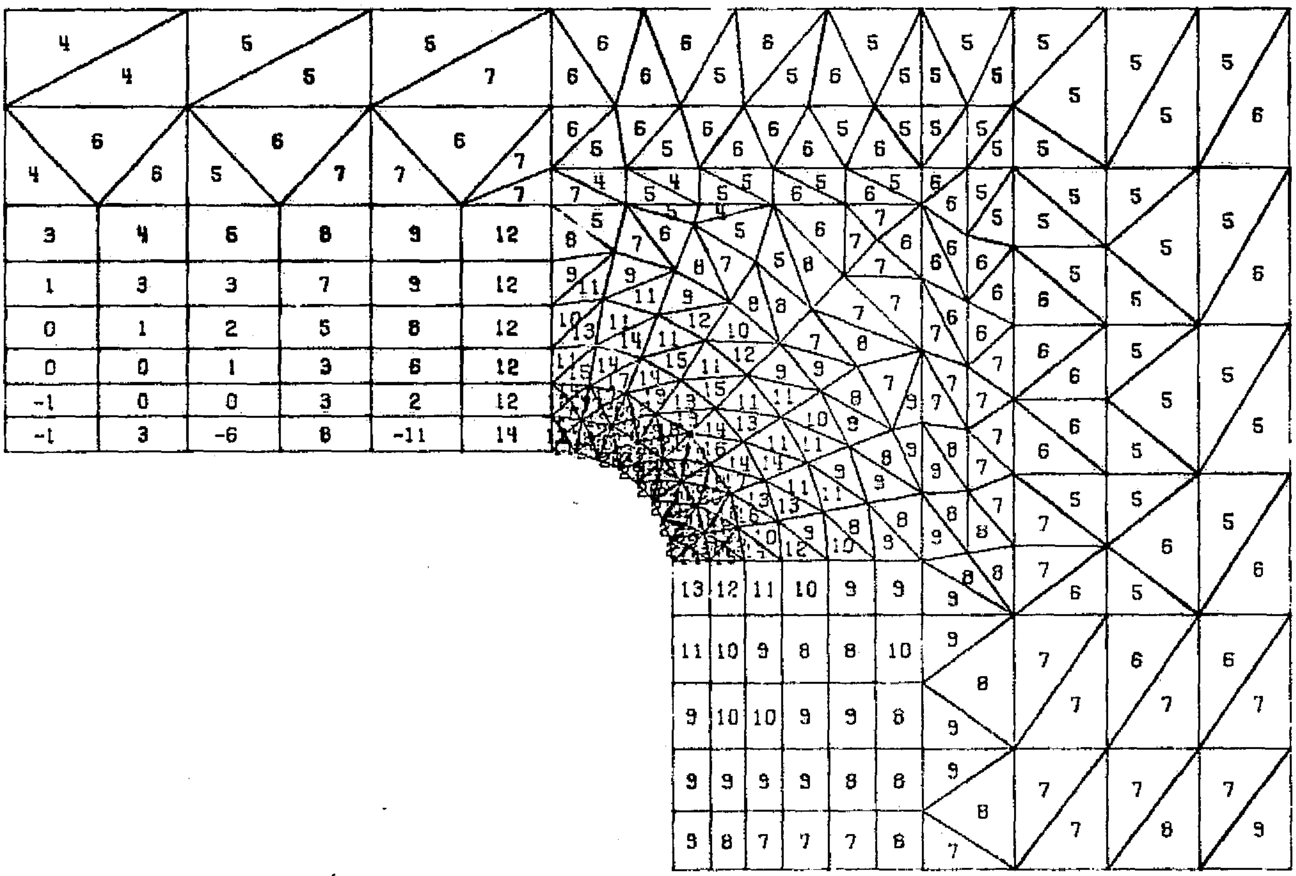
SPEC 4.1 NTF 9 X 12 ACCESS OPENING SHELL

0 21 SCALE

Figure 27

10/1/1

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 2



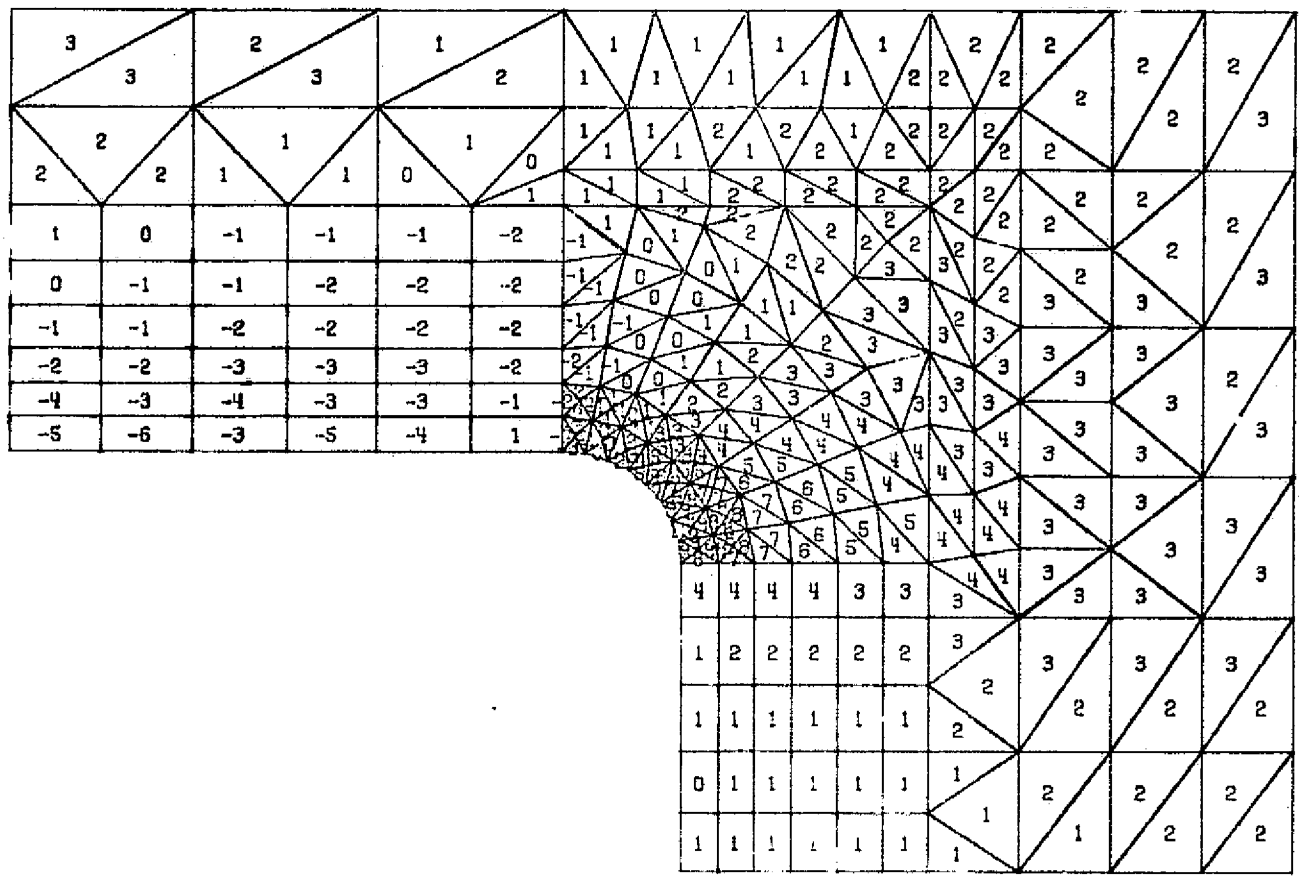
SPEC 4.1 NTF 9 X 12 ACCESS OPENING SHELL

0 21 SCALE

Figure 28

10/1/

DISPLAY= PS2 /100C , NODE= 1, SURFACE= 0



SPEC 4.1

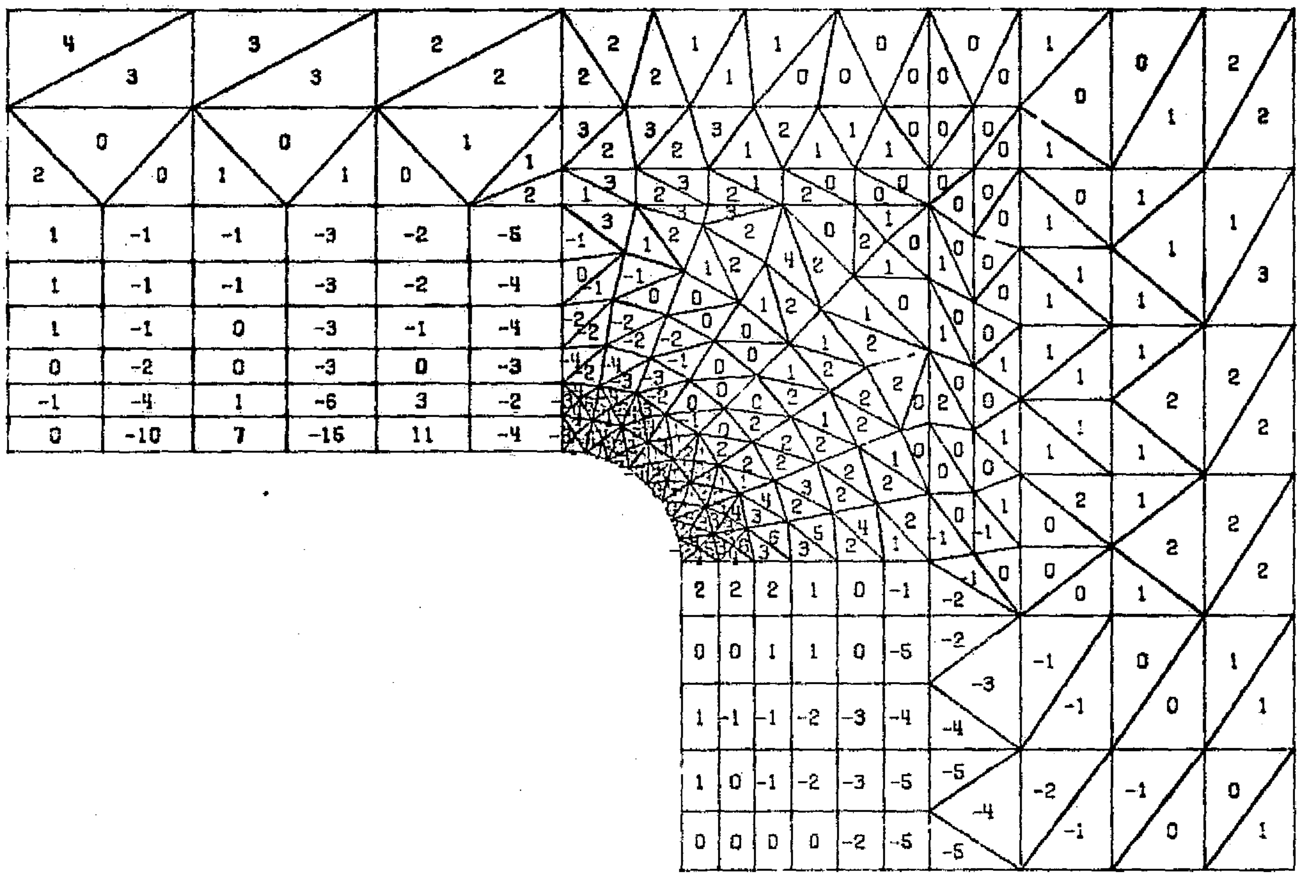
NTF 9 X 12 ACCESS OPENING SHELL

0 SCALE

Figure 29

DISPLAY= PS2 /1000 , NODE= 1, SURFACE= 1

10/1/1



SPEC 4.1

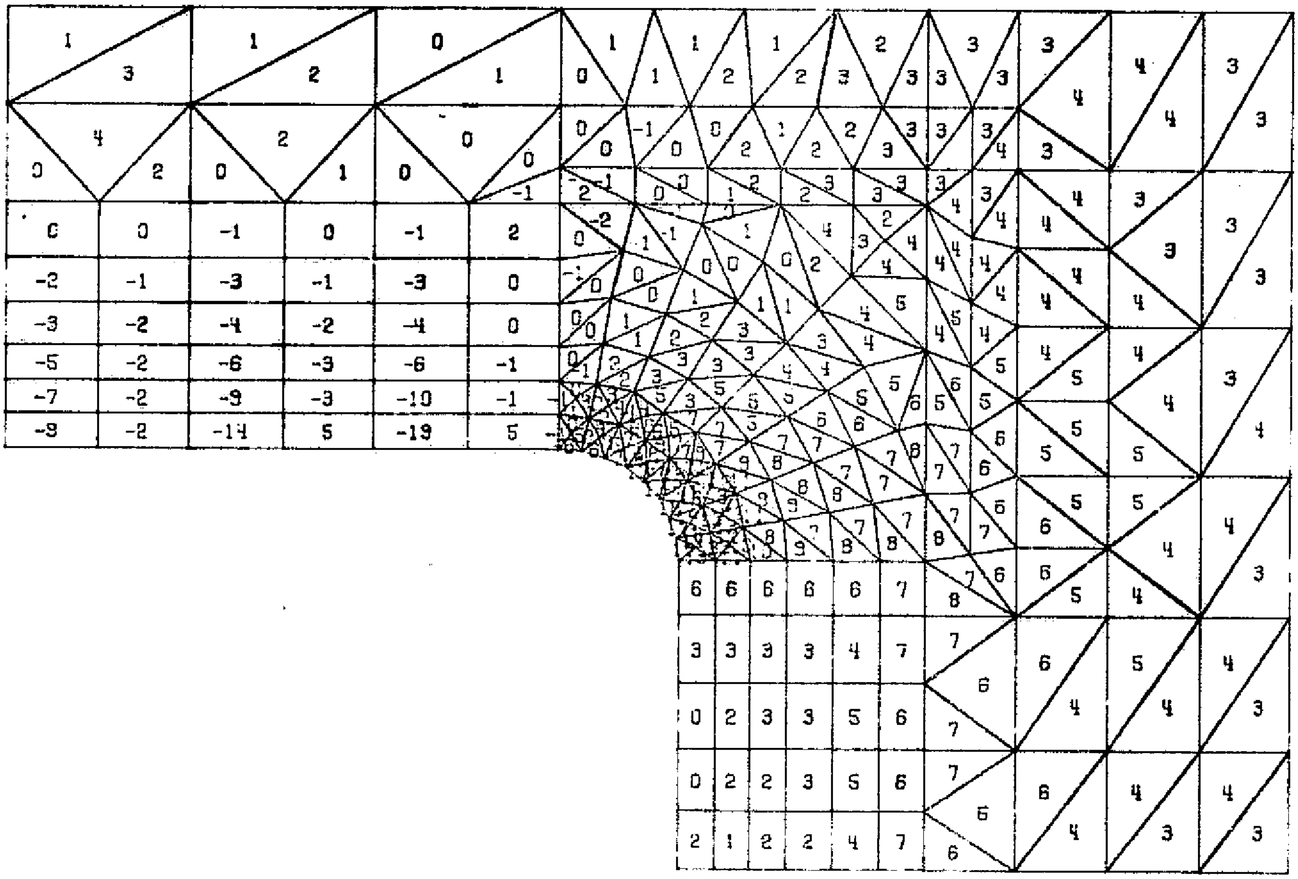
NTF 9 X 12 ACCESS OPENING
SHELL

0 2
SCALE

Figure 30

DISPLAY= PS2 /1000 , NODE= 1 , SURFACE= 2

10/1/1



SPEC 4.1

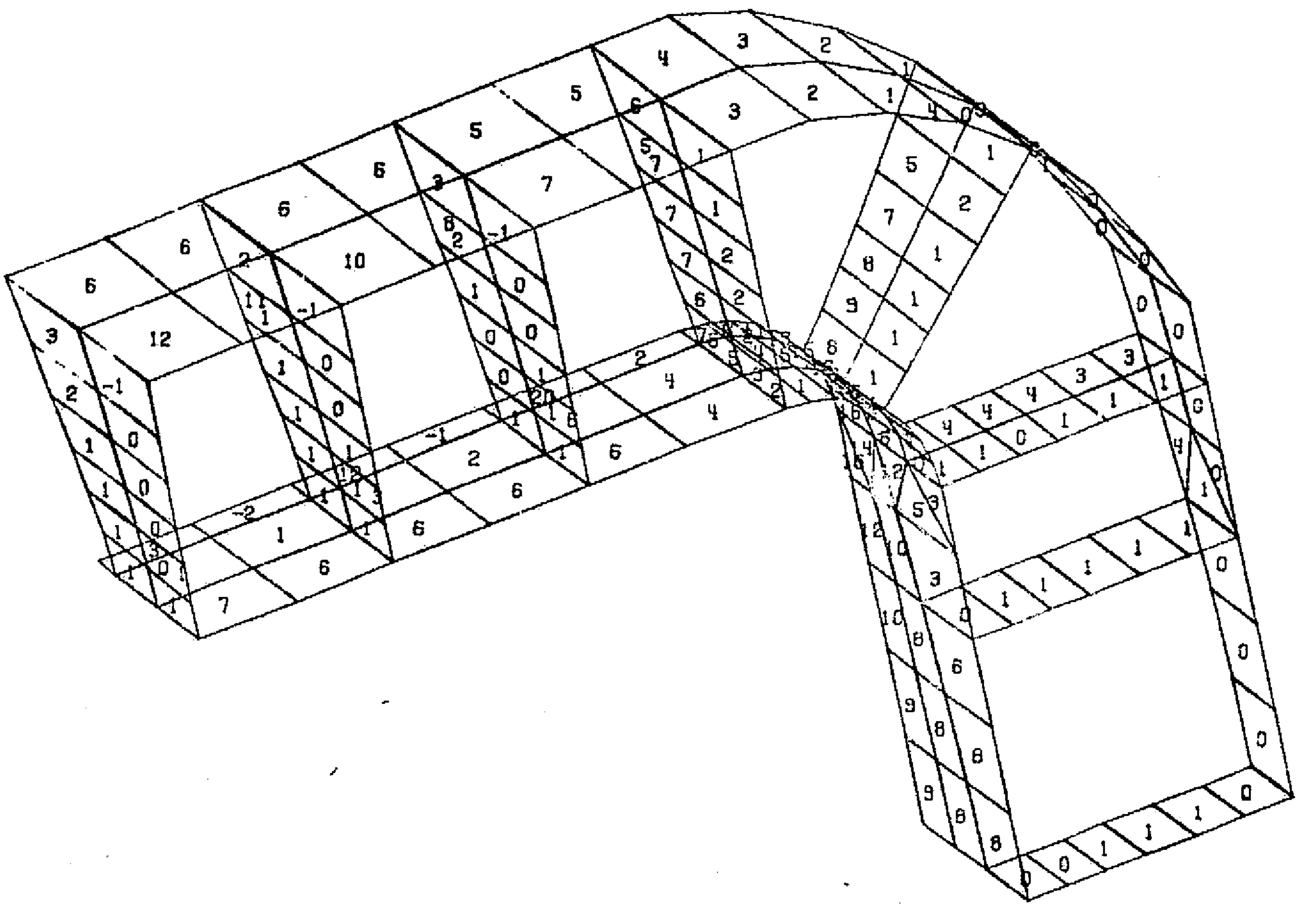
NTF 9 X 12 ACCESS OPENING SHELL

0 2 SCALE

Figure 31

10/1/1

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 0



SPEC
5.1

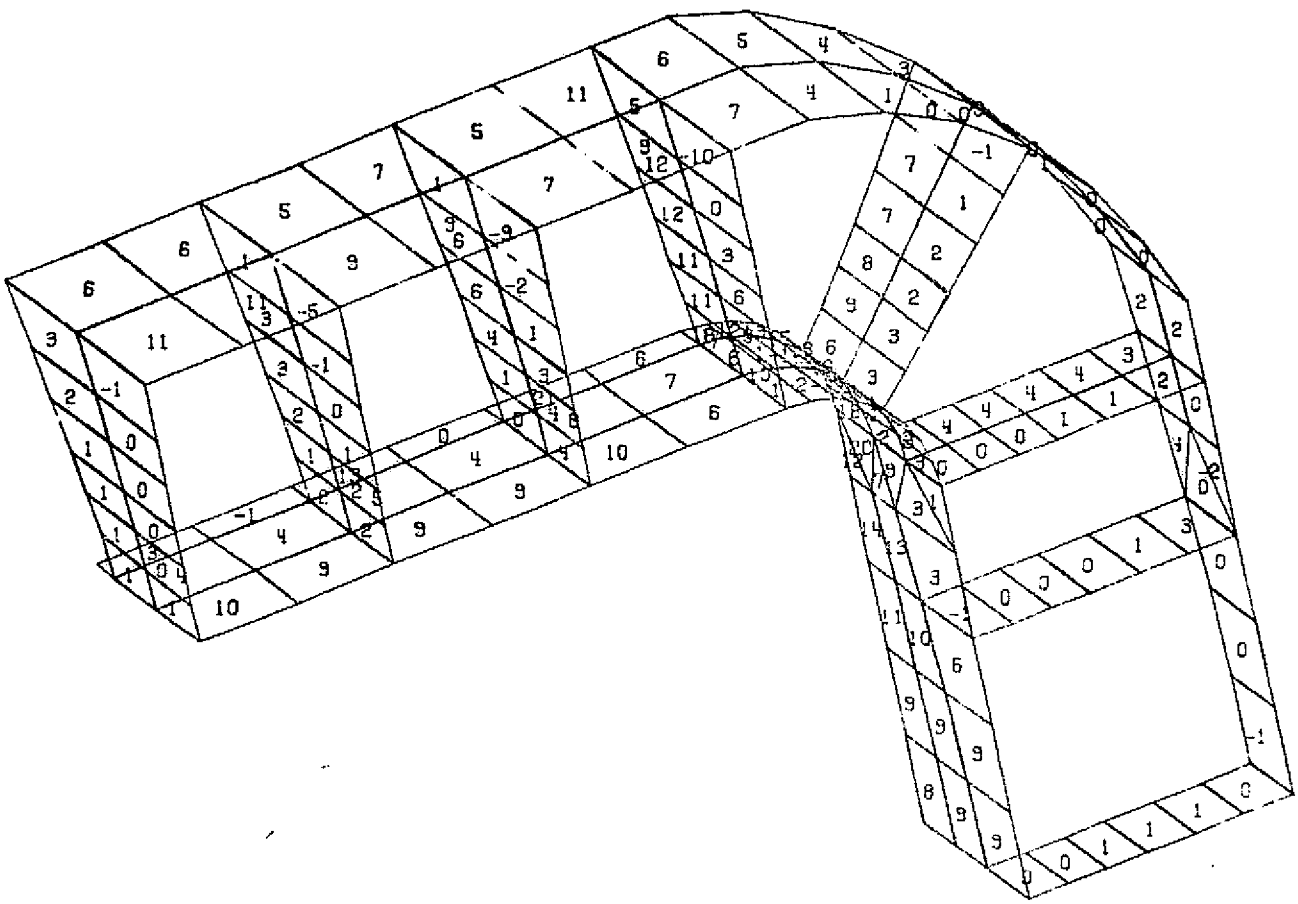
NTF 9X12 ACESS OPENING
GUSSET

0 18
SCALE

Figure 32

10/1/1

DISPLAY= PS1 /100C , NODE= 1, SURFACE= 1



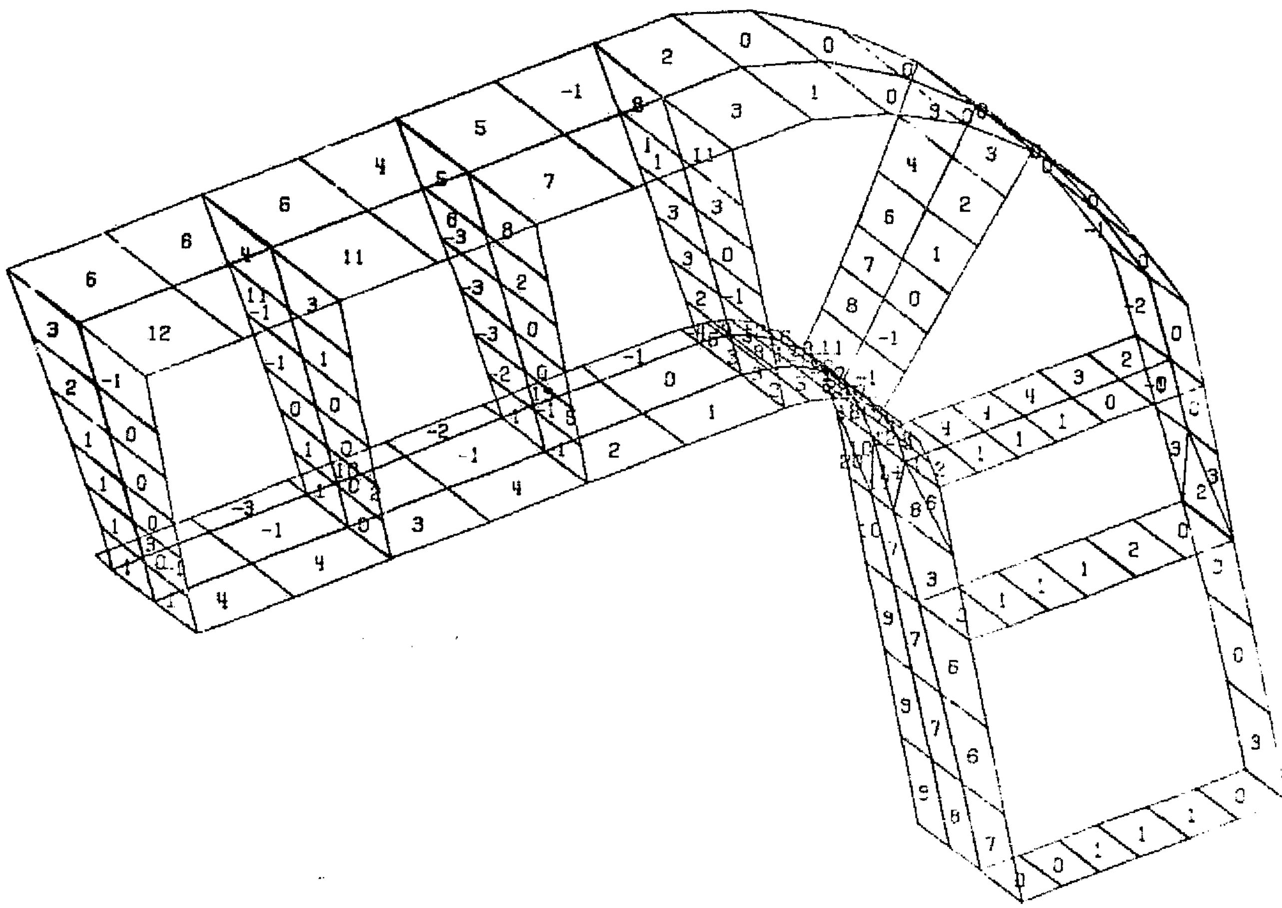
SPEC 5.1

NTF 9X12 ACESS OPENING GUSSET

0 18
SCALE

Figure 33

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 2 10/1/1



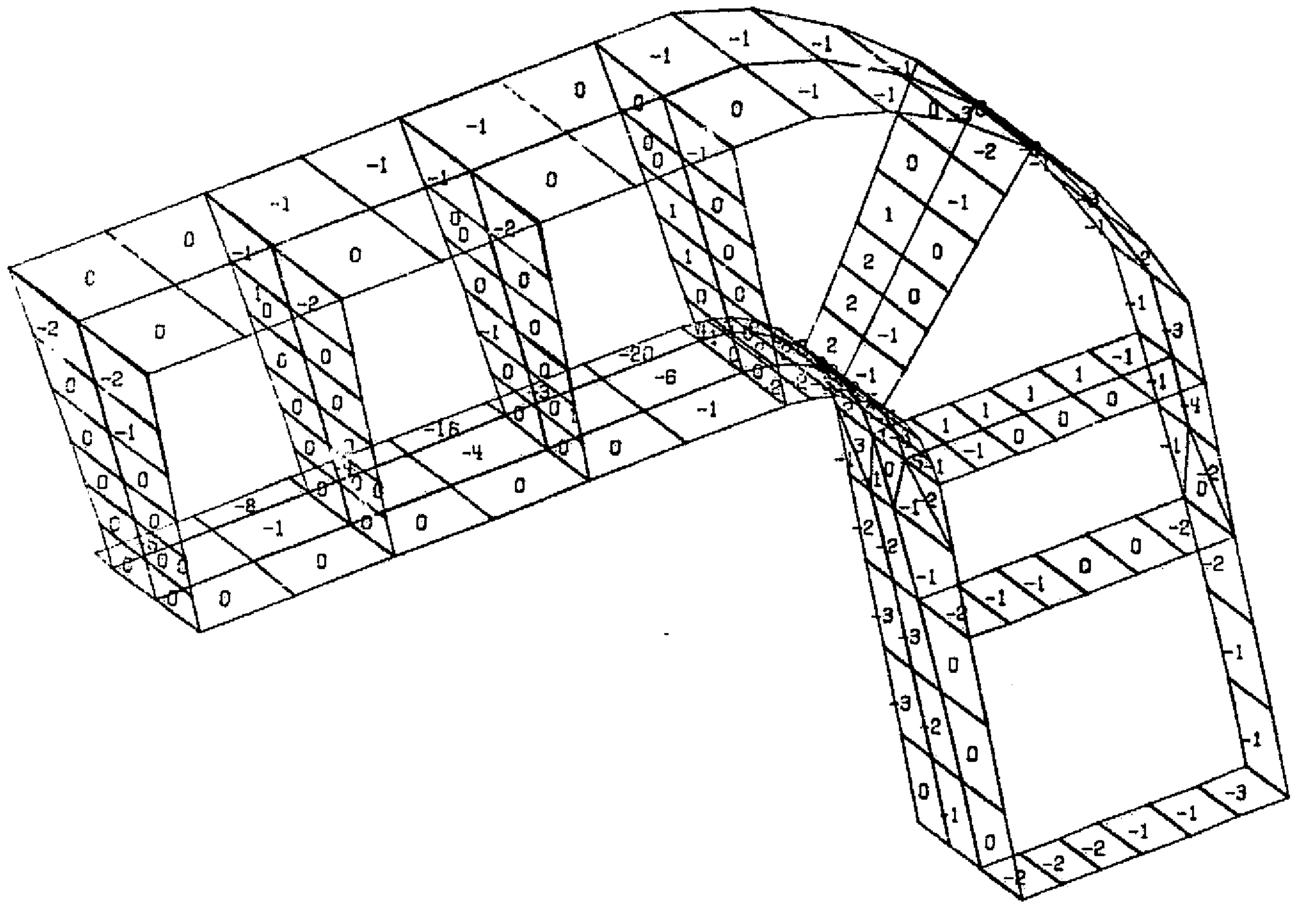
SPEC 5.1 NTF 9X12 ACESS OPENING GUSSET

0 18 SCALE

Figure 34

DISPLAY= PS2 /1000 , NODE= 1 , SURFACE= 0

10/1/



SPEC
S.1

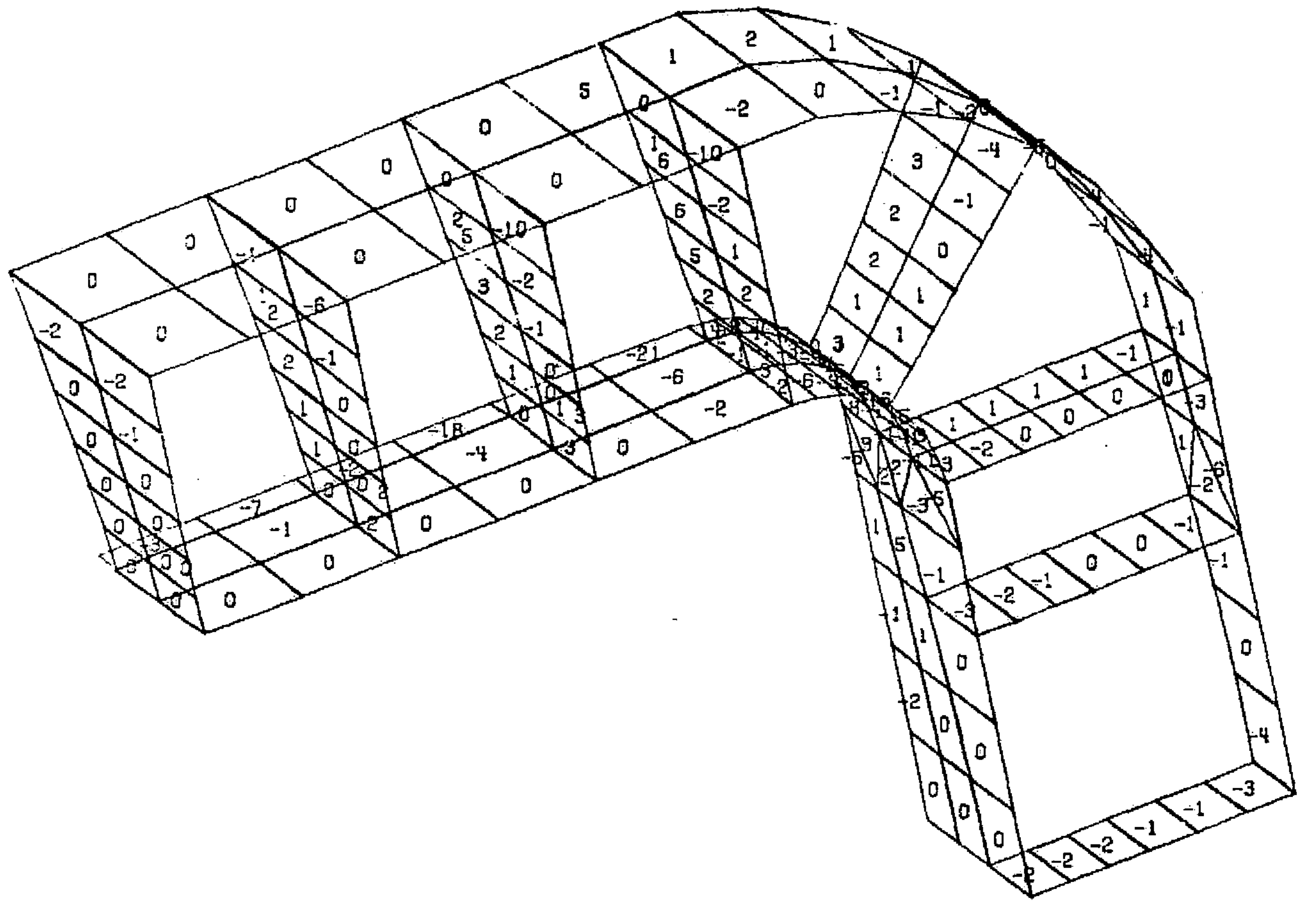
NTF 9X12 ACESS OPENING
GUSSET

0
SCALE

Figure 35

10/1/1

DISPLAY= PS2 /1000 , NODE= 1, SURFACE= 1



SPEC
5.1

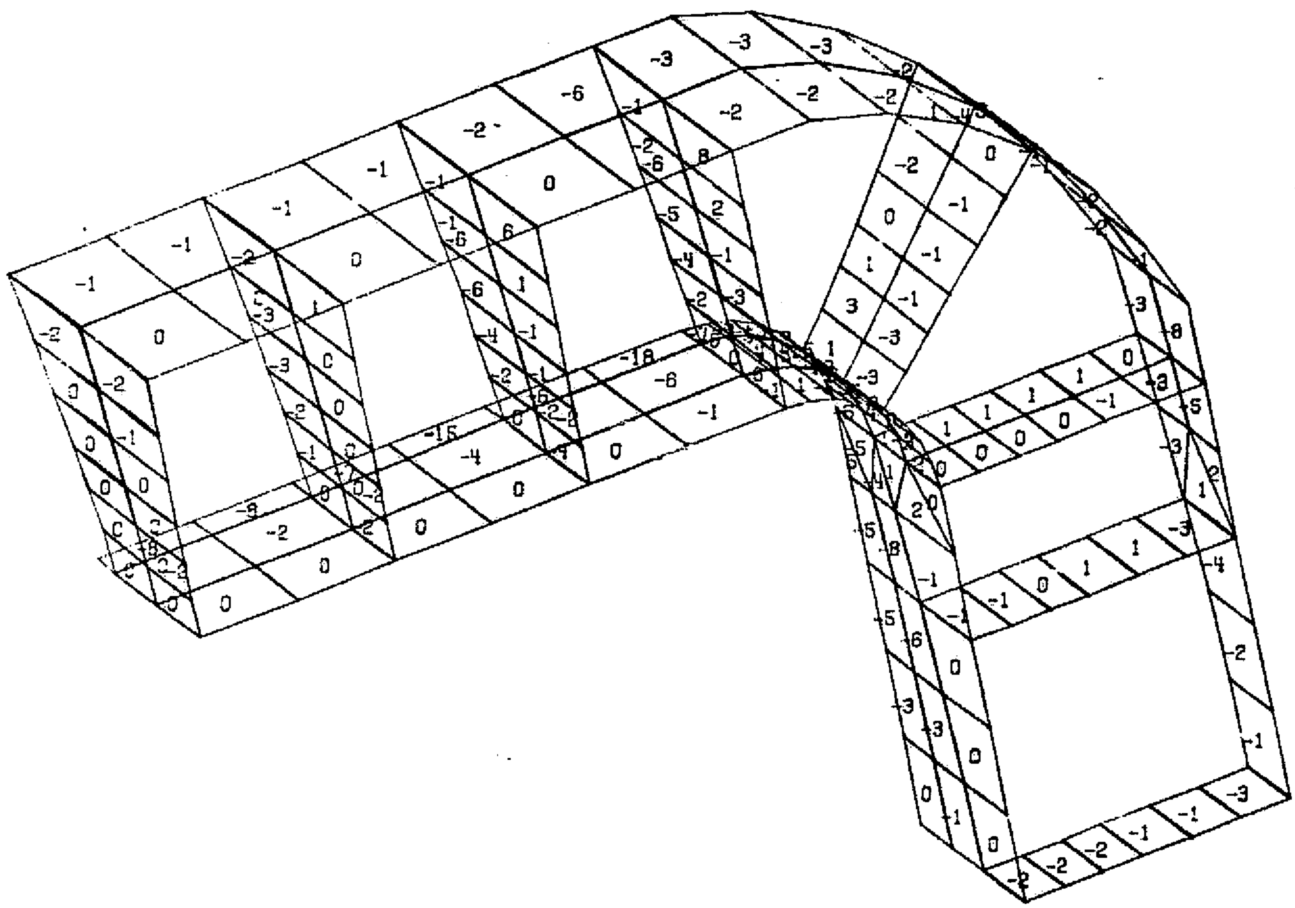
NTF 9X12 ACESS OPENING
GUSSET

0 SCALE

Figure 36

10/1/1

DISPLAY= PS2 /1000 , NODE= 1, SURFACE= 2



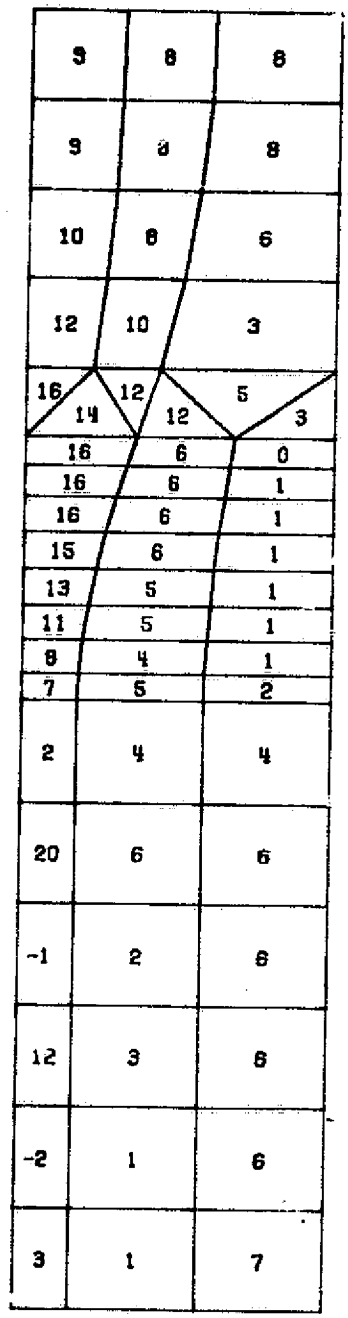
SPEC

NTF 9X12 ACESS OPENING
GUSSET

0 18
SCALE

Figure 37

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 0 10/1/1



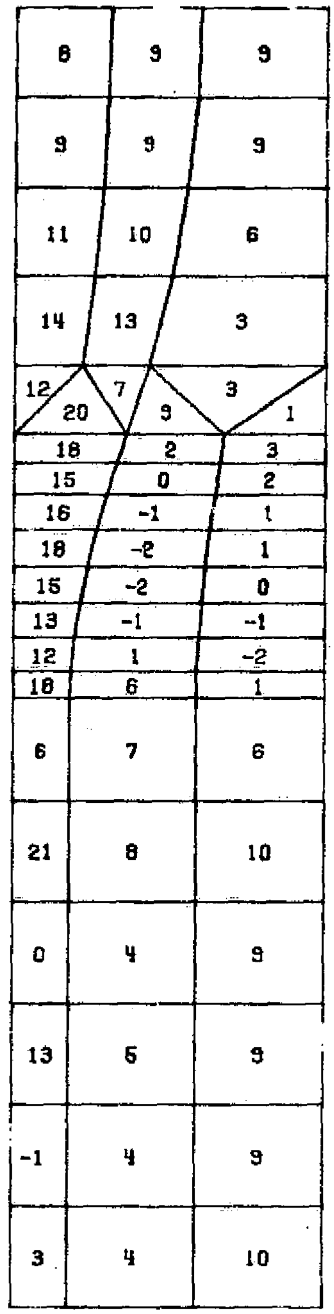
SPEC 6.1 NTF 9X12 REINF. INNER RING

0 .14 SCALE

Figure 38

10/1/1

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 1



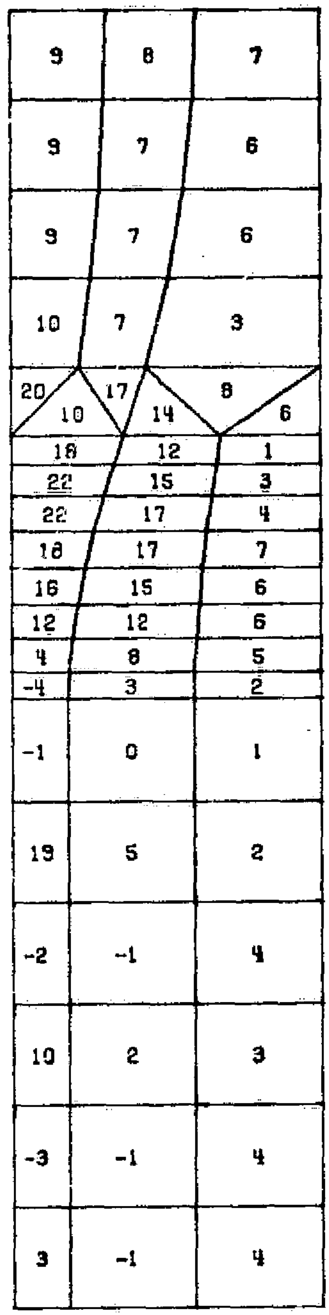
SPEC - NTF 9X12 REINF.
6.1 INNER RING

0 14
SCALE

Figure 39

10/1/

DISPLAY= PS1 /100C , NODE= 1, SURFACE= 2

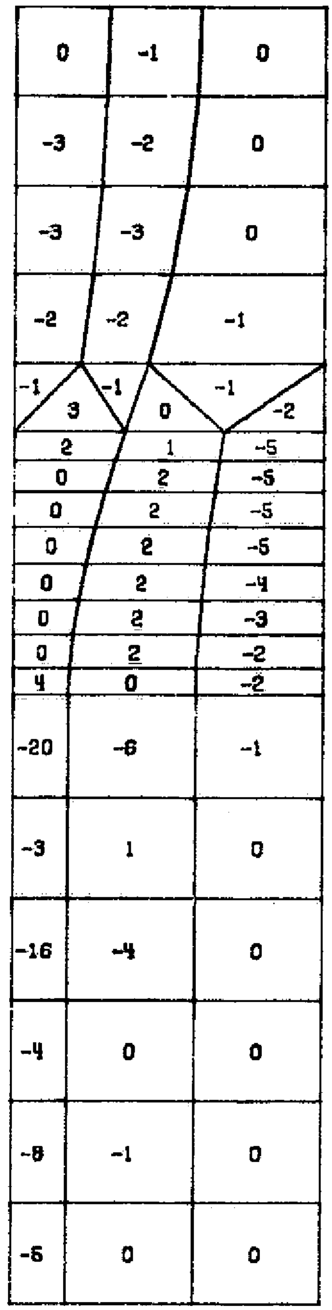


SPEC 6.1 NTF 9X12 REINF. INNER RING

0 SCALE

Figure 40

DISPLAY= PS2 /1000 , NODE= 1, SURFACE= 0

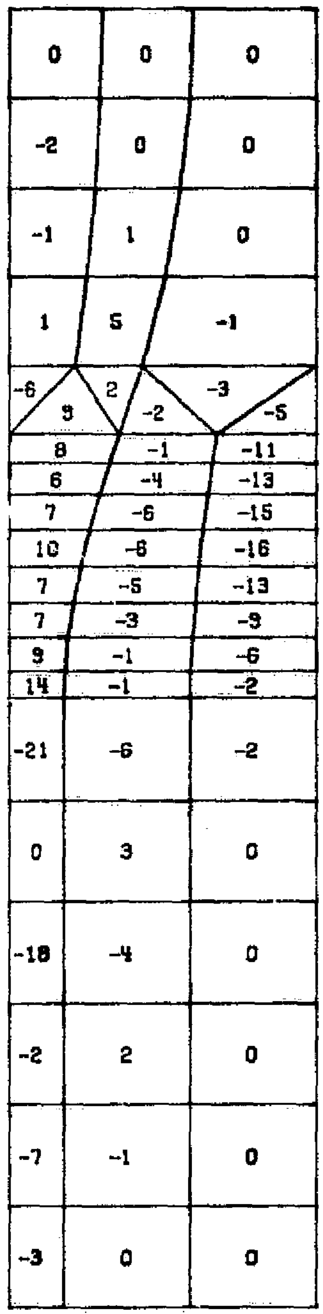


SPEC 6.1 NTF 9X12 REINF.
INNER RING

0 14
SCALE

Figure 41

DISPLAY= PS2 /1000 , NODE= 1, SURFACE= 1



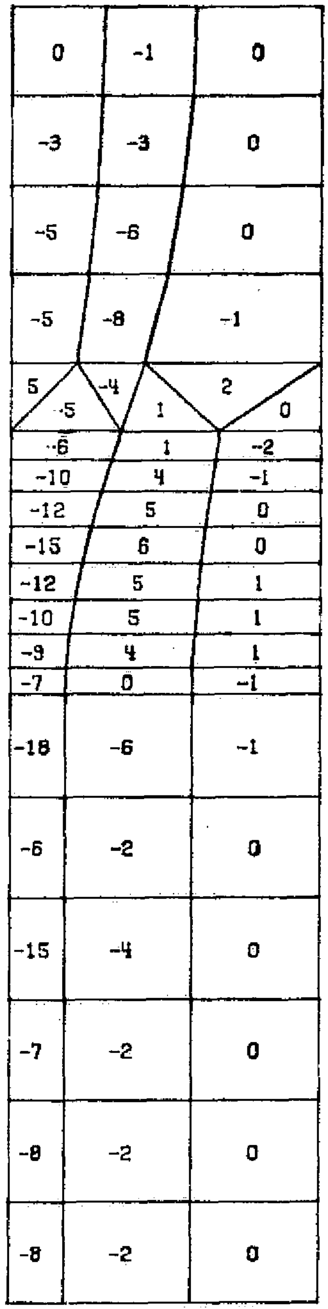
SPEC 6.1 NTF 9X12 REINF. INNER RING

0 1? SCALE

Figure 42

10/1/1

DISPLAY= PS2 /100C , NODE= 1, SURFACE= 2



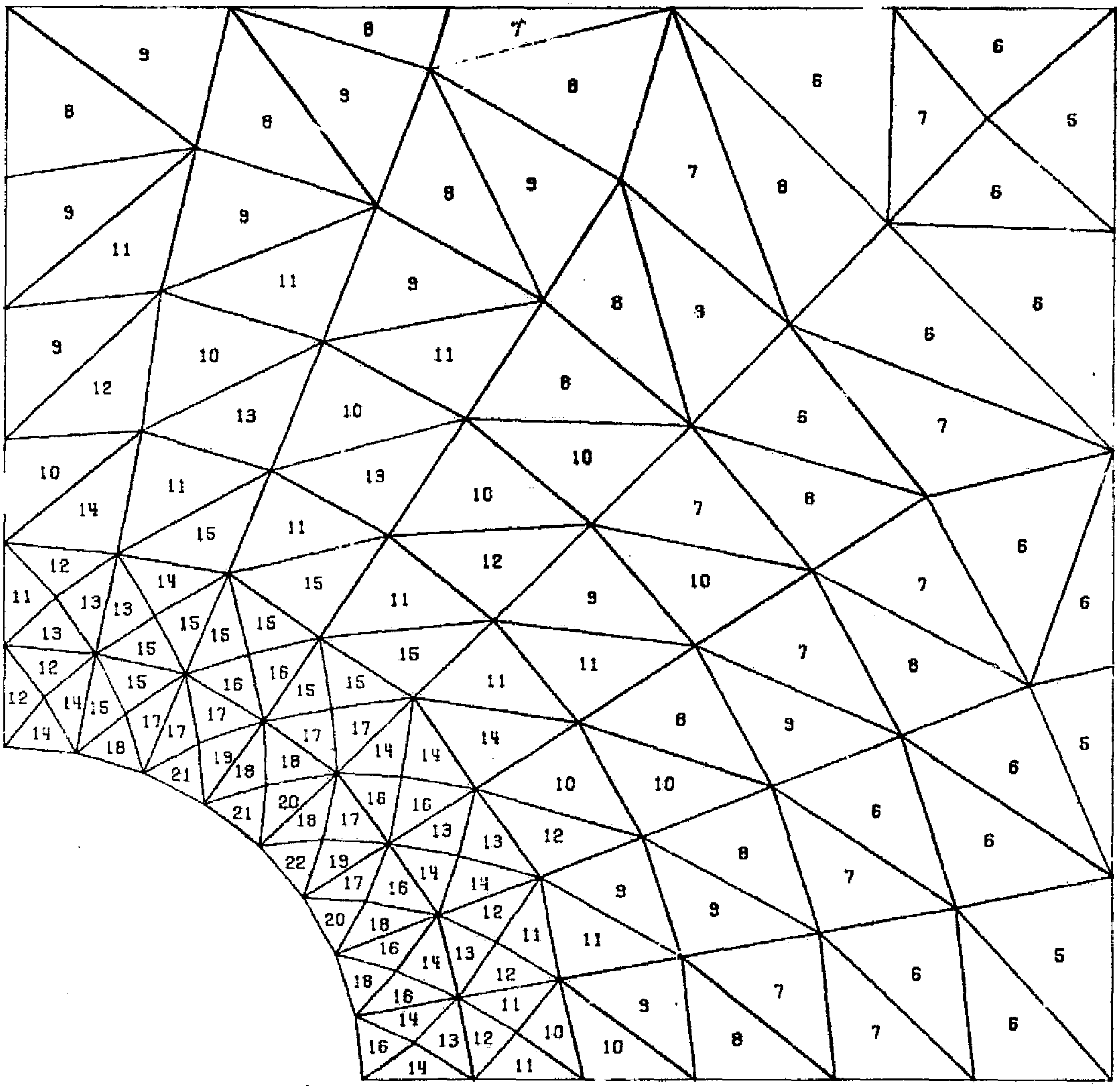
SPEC 6.1 NTF 9X12 REINF.
INNER RING

0 1 SCALE

Figure 43

10/1/1

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 0



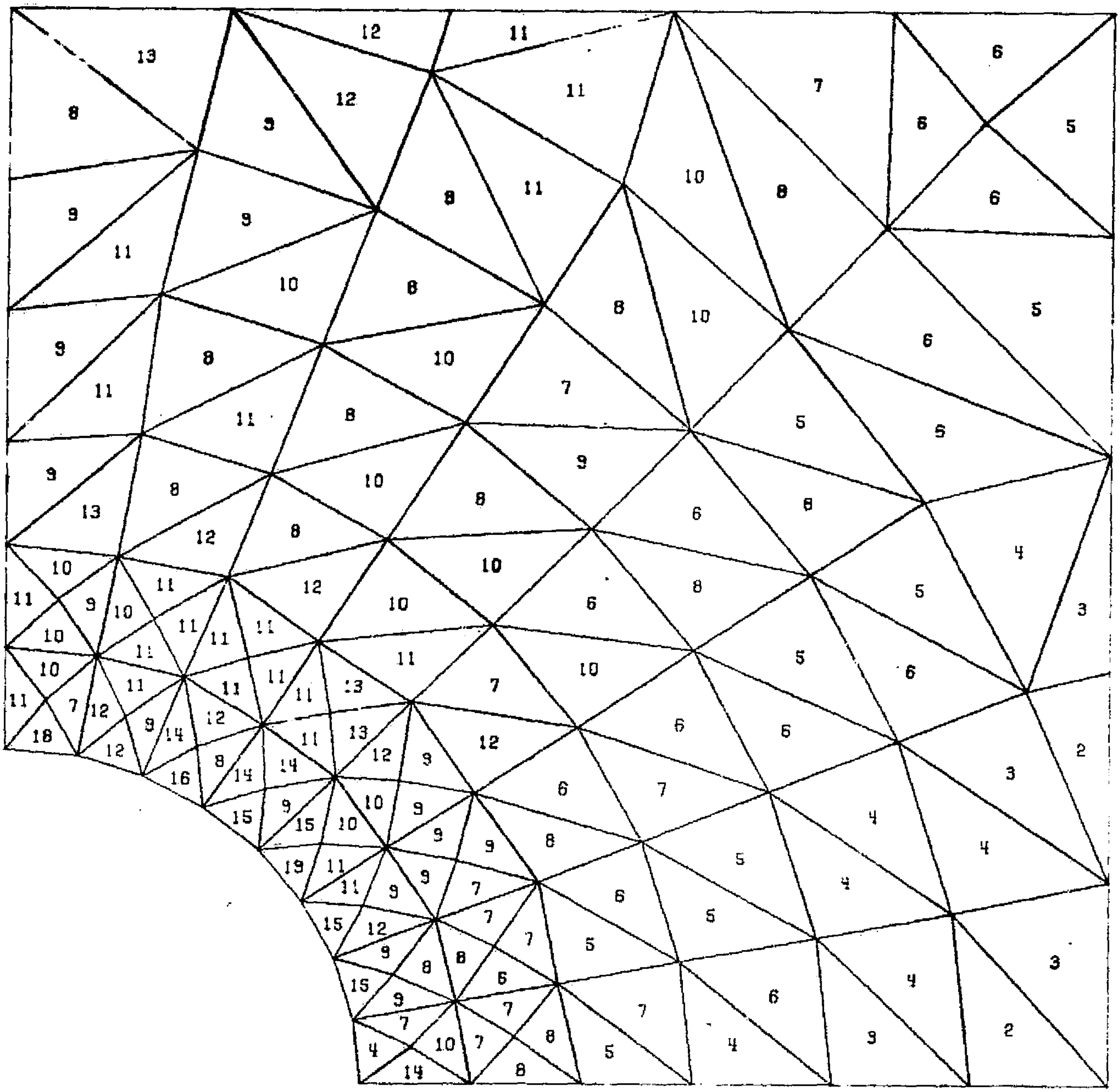
SPEC 3.1

NTF 9 X 12 REINF
CENTER TRIANGLES

0 6
SCALE

Figure 44

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 1 10/1/1



SPEC
8.1

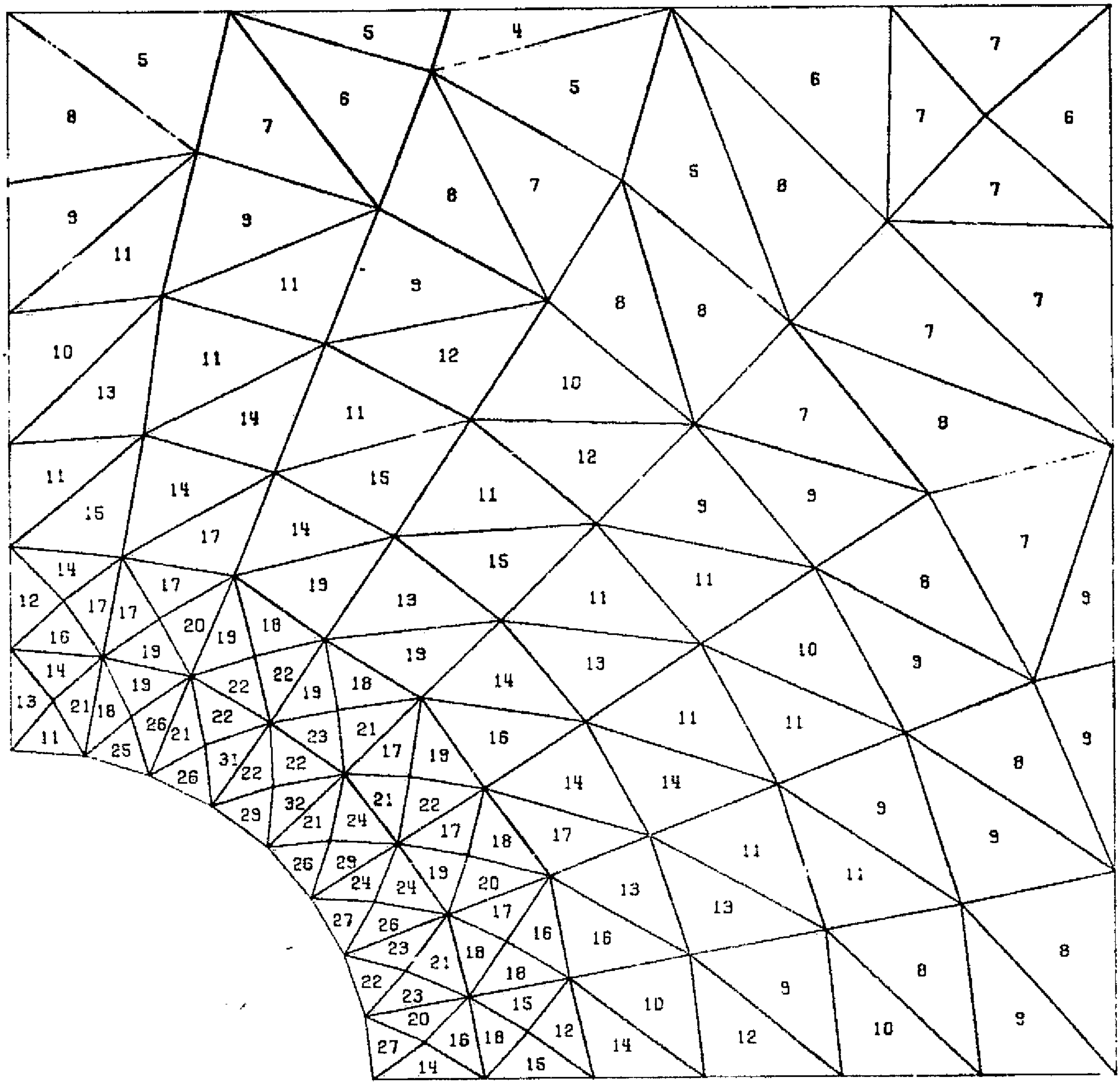
NTF 9 X 12 REINF
CENTER TRIANGLES

0 6
SCALE

Figure 45

10/1/1

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 2



SPEC 8.1

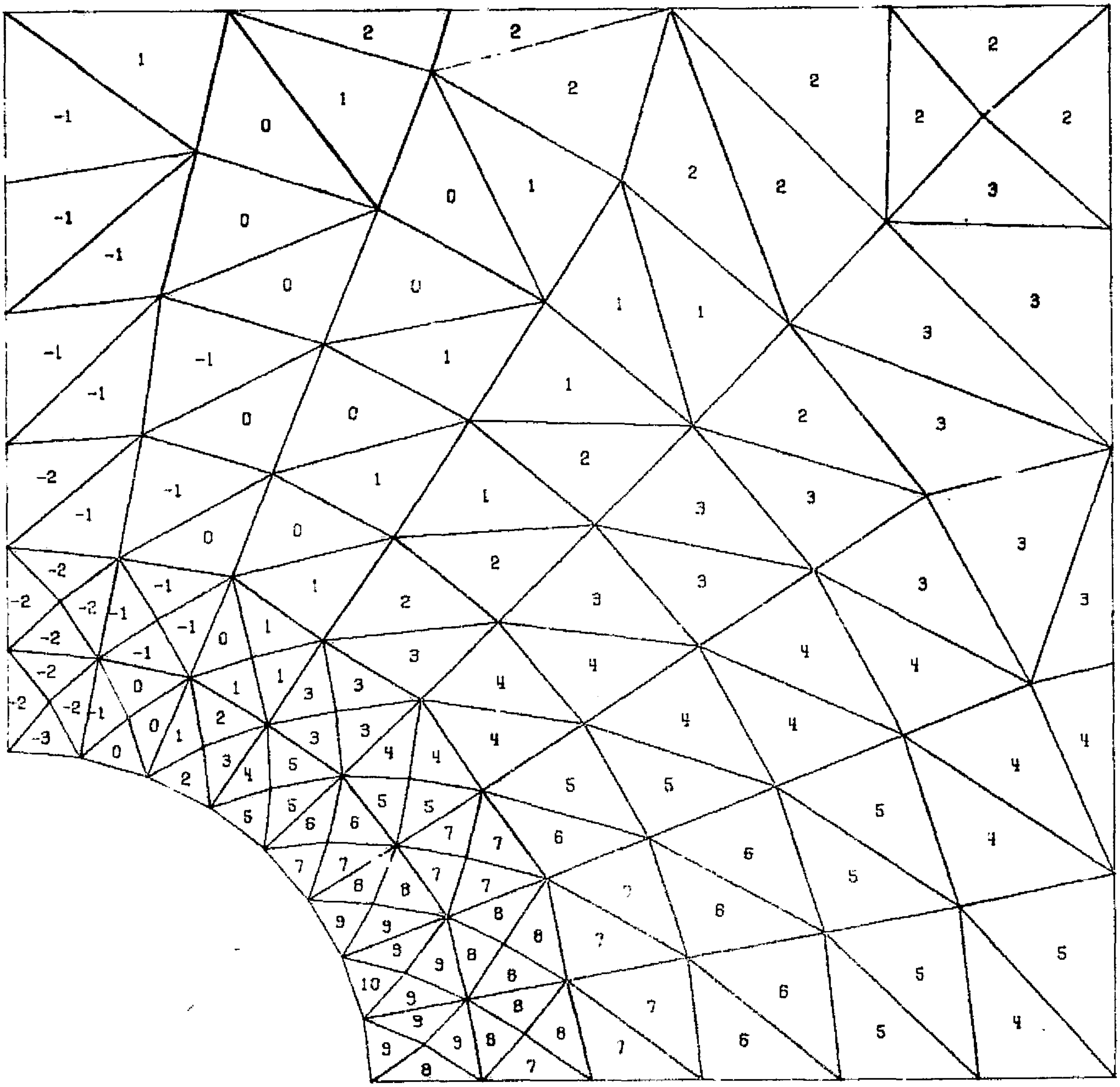
NTF 9 X 12 REINF
CENTER TRIANGLES

0 SCALE

Figure 46

10/1/1

DISPLAY= PS2 /100C , NODE= 1 , SURFACE= 0



SPEC
8.1

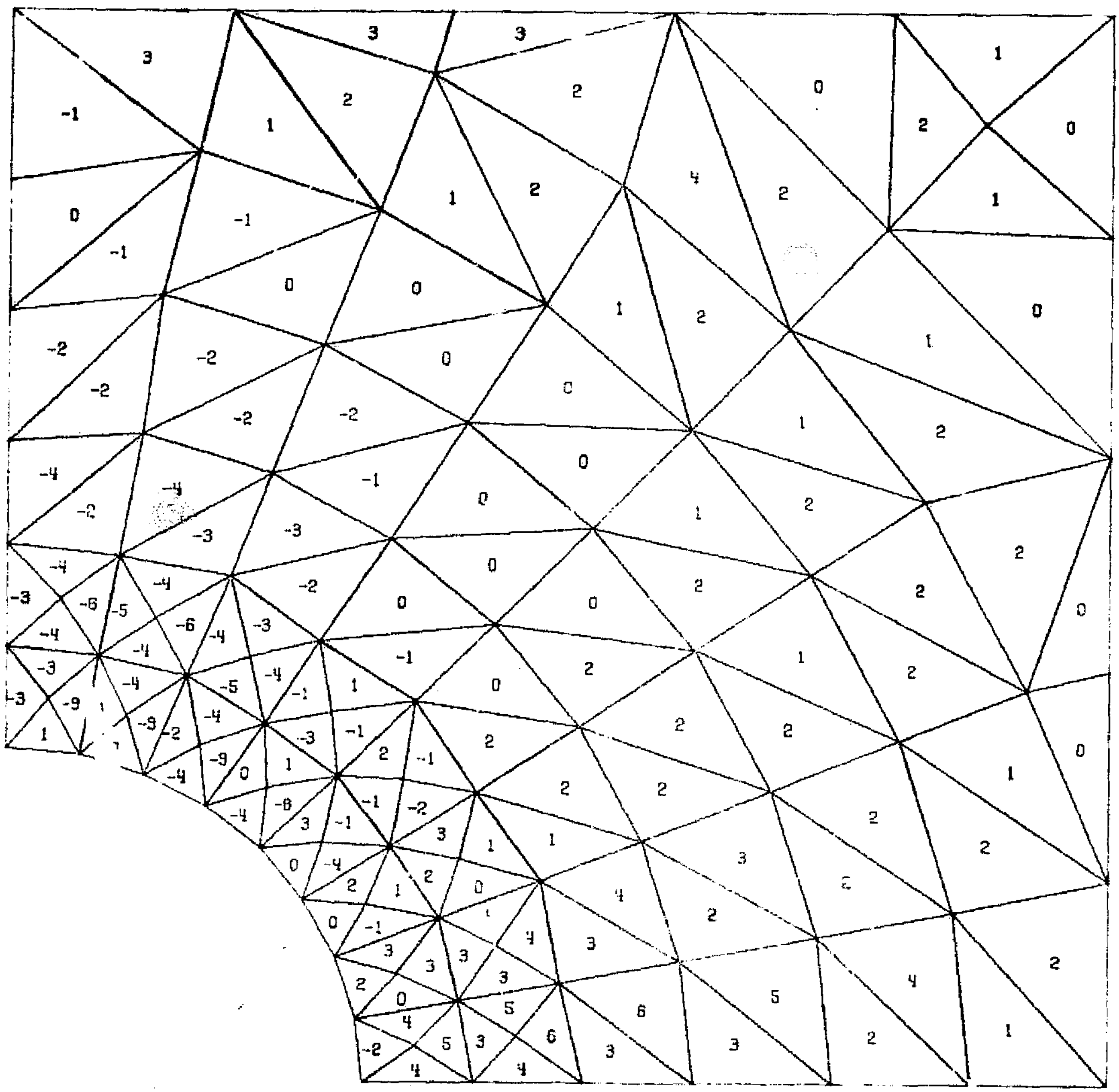
NTF 9 X 12 REINF
CENTER TRIANGLES

0 SCALE 6

Figure 47

10/1/1

DISPLAY= PS2 /1000 , NODE= 1 , SURFACE= 1



SPEC
8.1

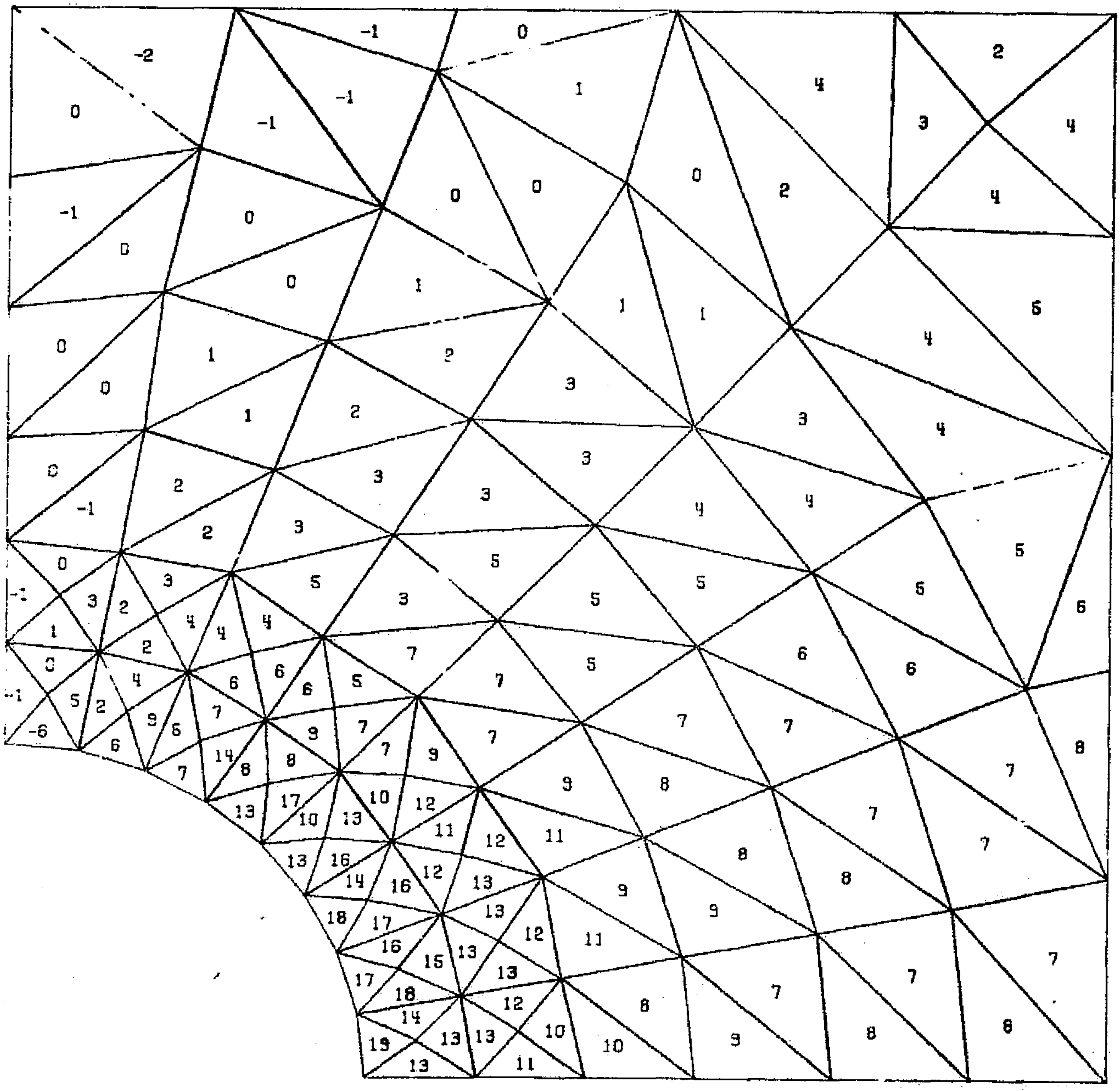
NTF 9 X 12 REINF
CENTER TRIANGLES

0
SCALE

Figure 48

10/1/1

DISPLAY= PS2 /1000, NODE= 1, SURFACE= 2



SPEC
8.1

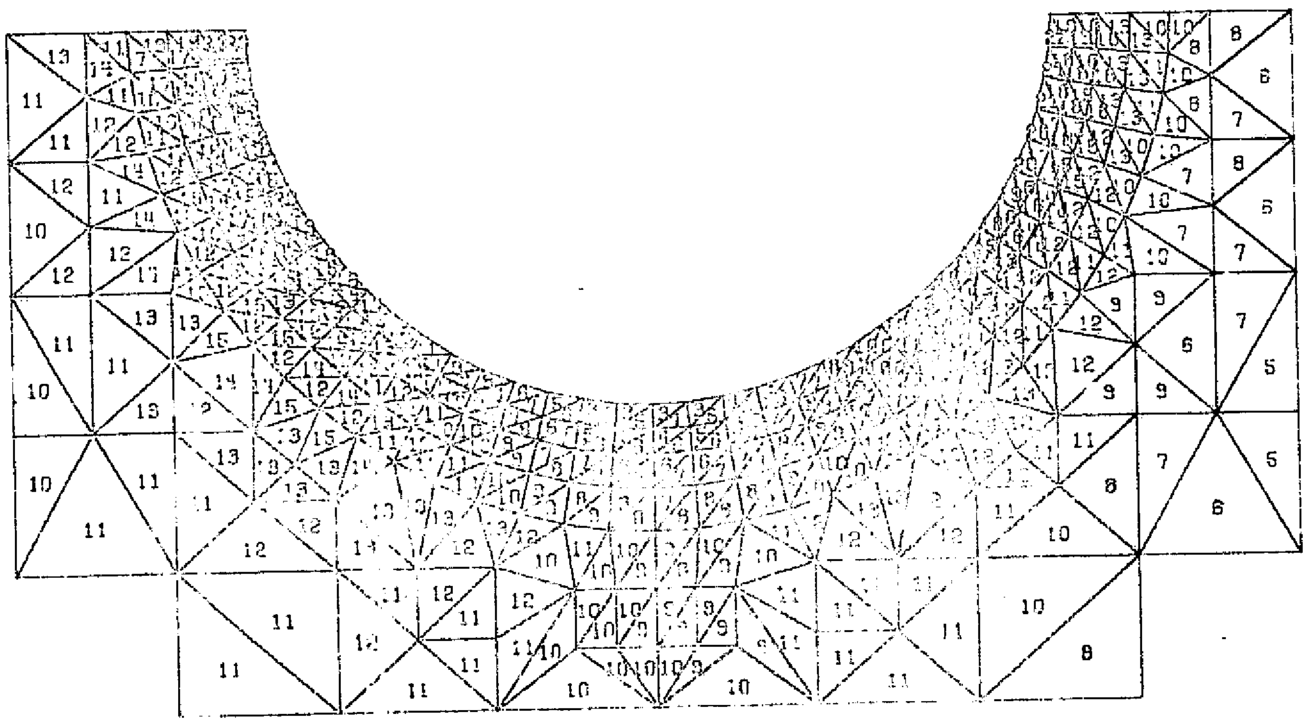
NTF 9 X 12 REINF
CENTER TRIANGLES

0 6
SCALE

Figure 49

10/1/1

SPLAY= PS1 /1000 , NODE= 1, SURFACE= 0



SPEC
2

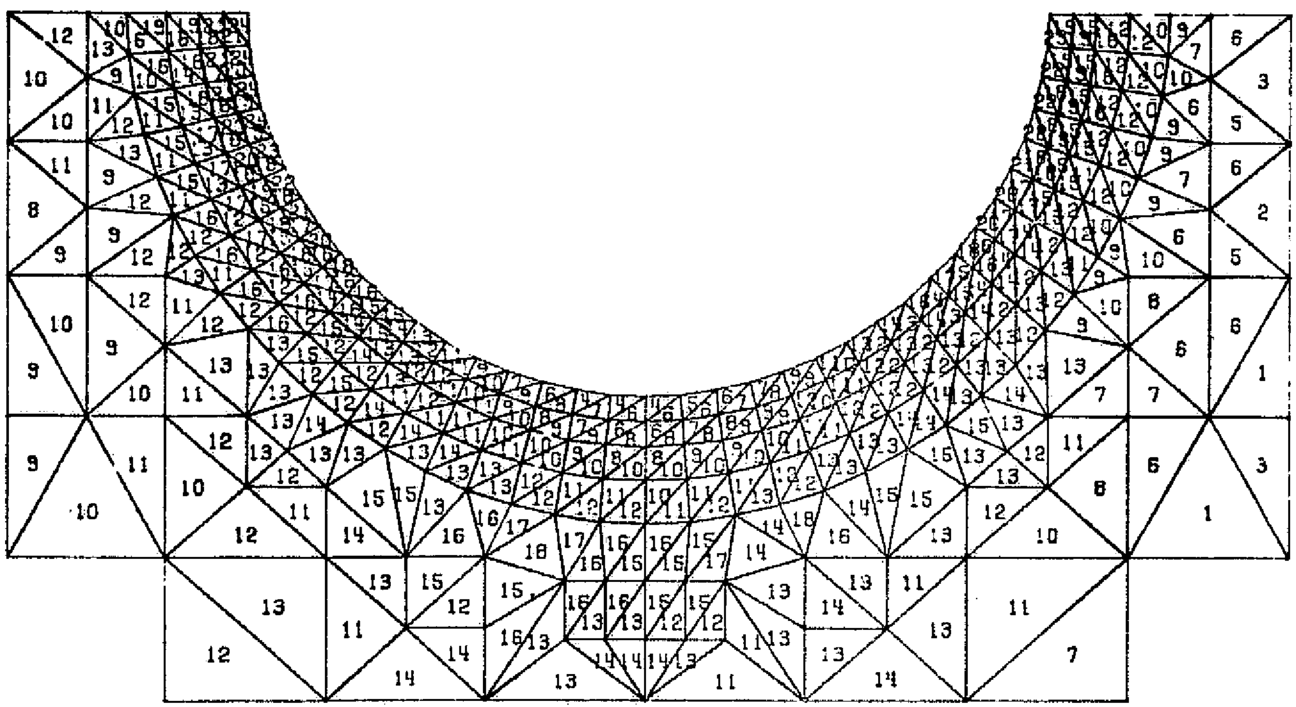
9 X 12 REINF WITH 9 FT HOLE
TRIANGLES AROUND 9 FT HOLE

0 SCALE 24

Figure [illegible]

10/1/1

DISPLAY= PS1 /1C00 , NODE= 1, SURFACE= 1



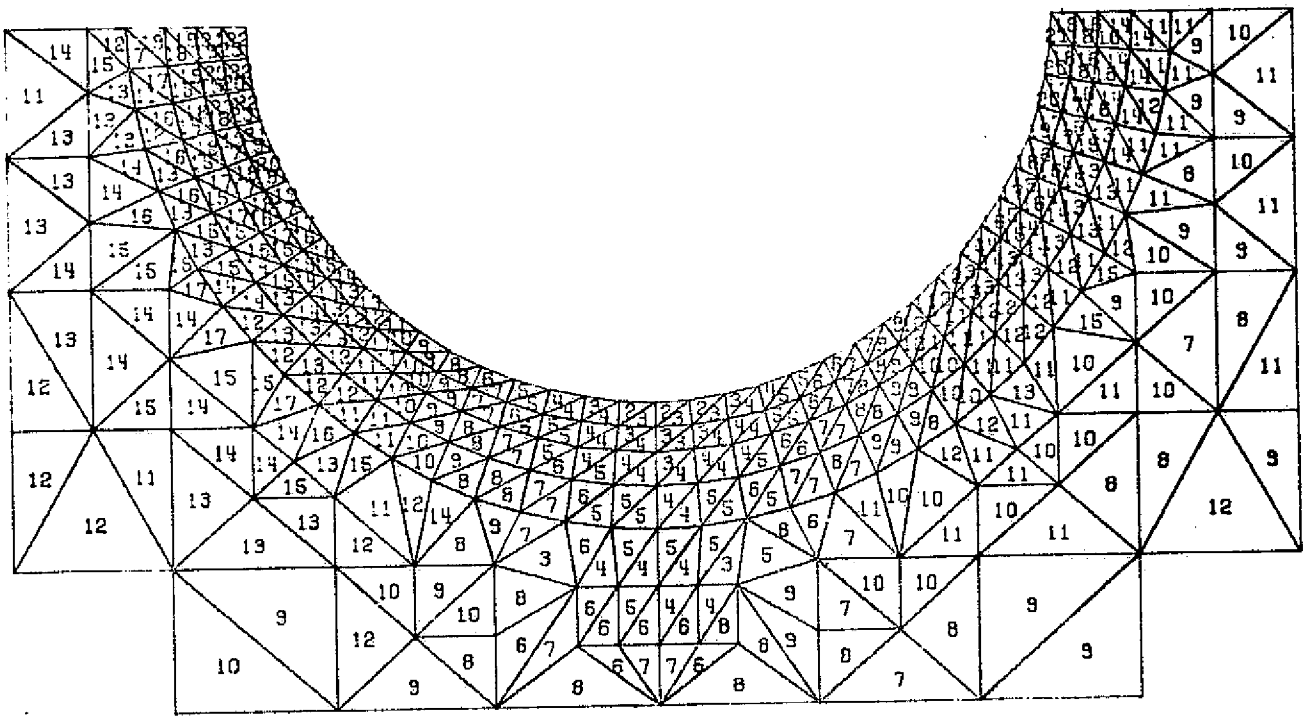
SPEC 9.1 9 X 12 REINF WITH 9 FT HOLE
TRIANGLES AROUND 9 FT HOLE

0 24 SCALE

Figure 51

10/1/1

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 2

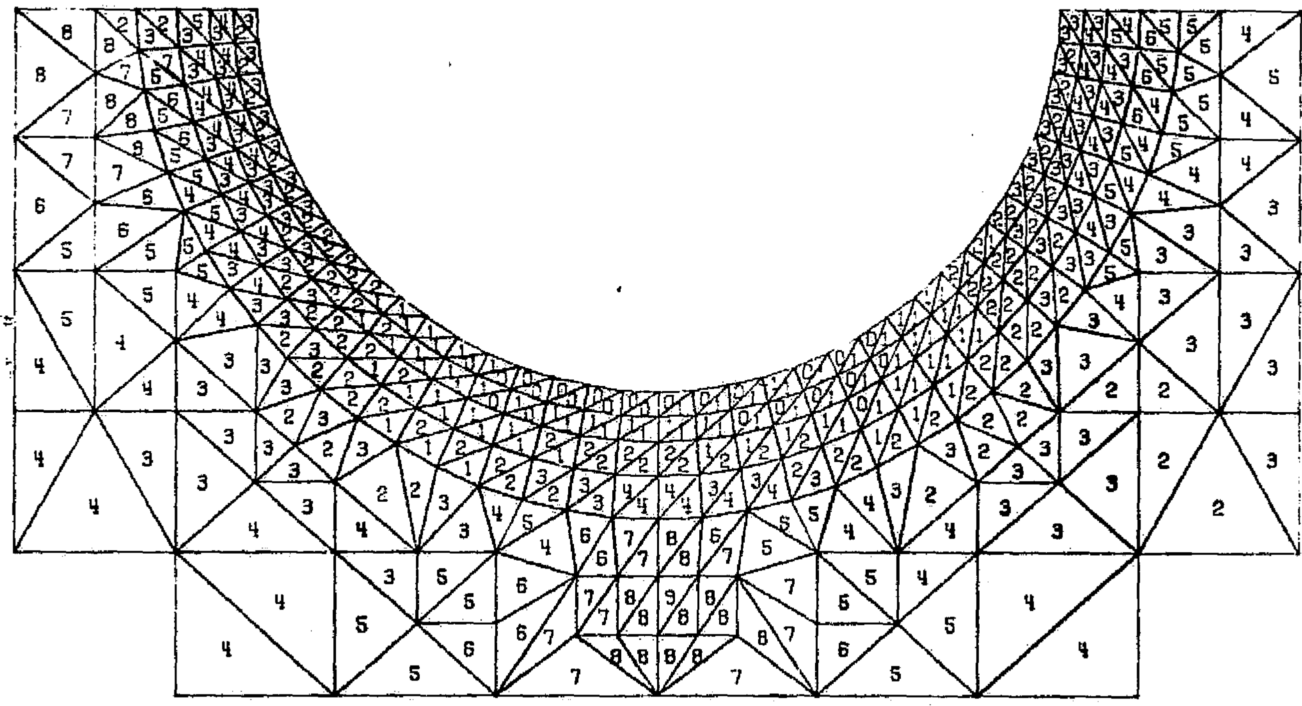


SPEC 9.1 9 X 12 REINF WITH 9 FT HOLE
TRIANGLES AROUND 9 FT HOLE

0 2
SCALE

Figure 52

DISPLAY= PS2 /1000 , NODE= 1, SURFACE= 0 10/

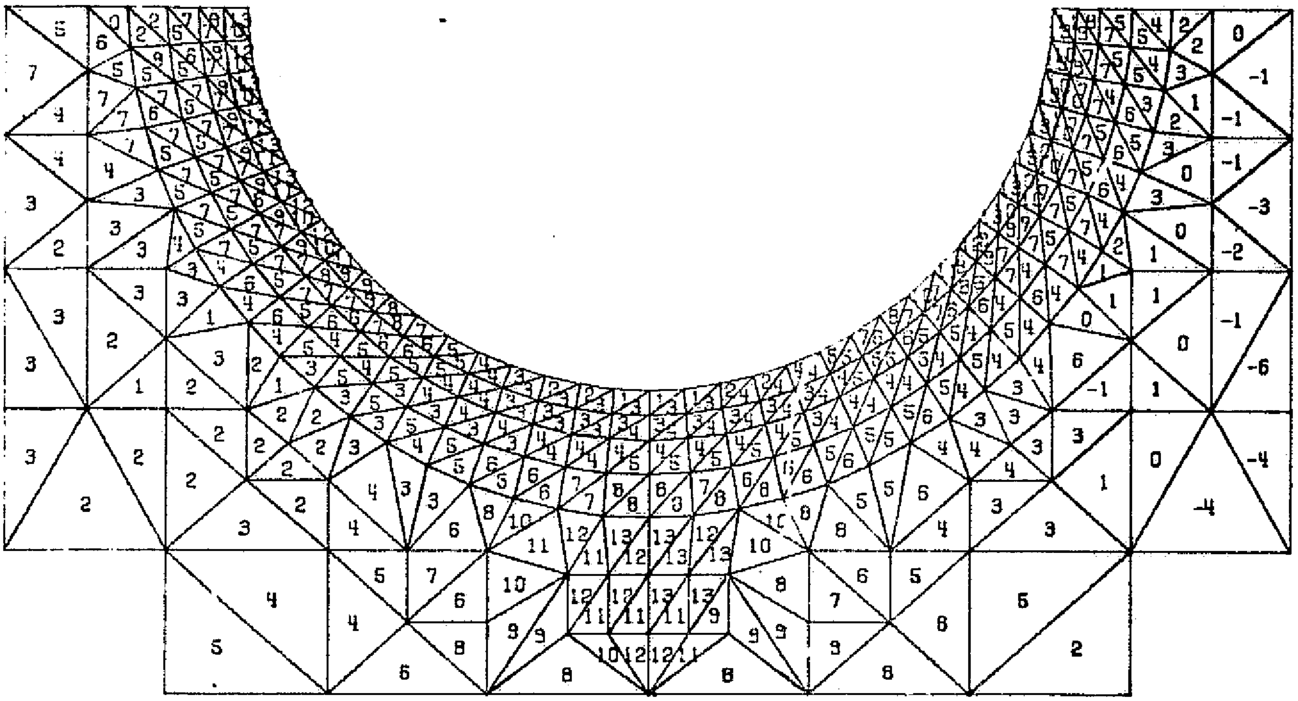


SPEC 9.1 9 X 12 REINF WITH 9 FT HOLE
TRIANGLES AROUND 9 FT HOLE

0 SCAL

Figure 53

DISPLAY= PS2 /1000 , NODE= 1, SURFACE= 1 10/1/1



SPEC 9.1

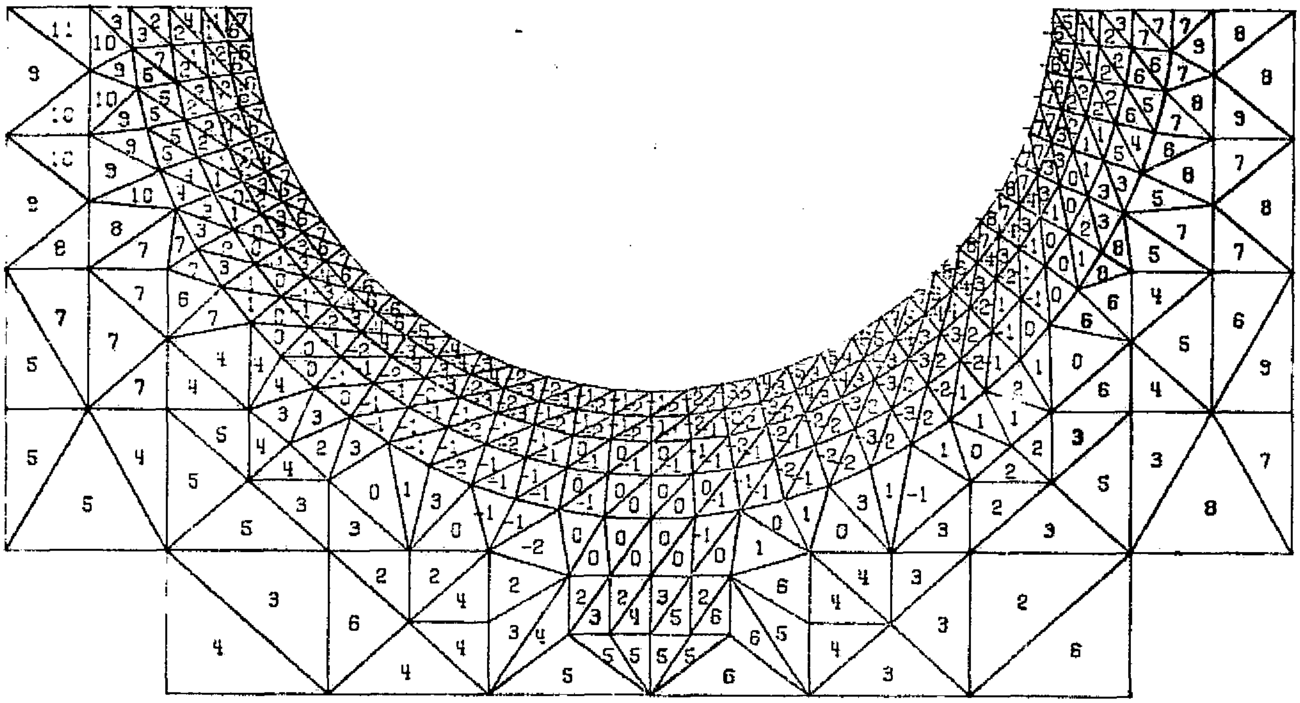
9 X 12 REINF WITH 9 FT HOLE
TRIANGLES AROUND 9 FT HOLE

0 24
SCALE

Figure 54

DISPLAY= PS2 /1000 , NODE= 1 , SURFACE= 2

10/1/1



SPEC
9.1

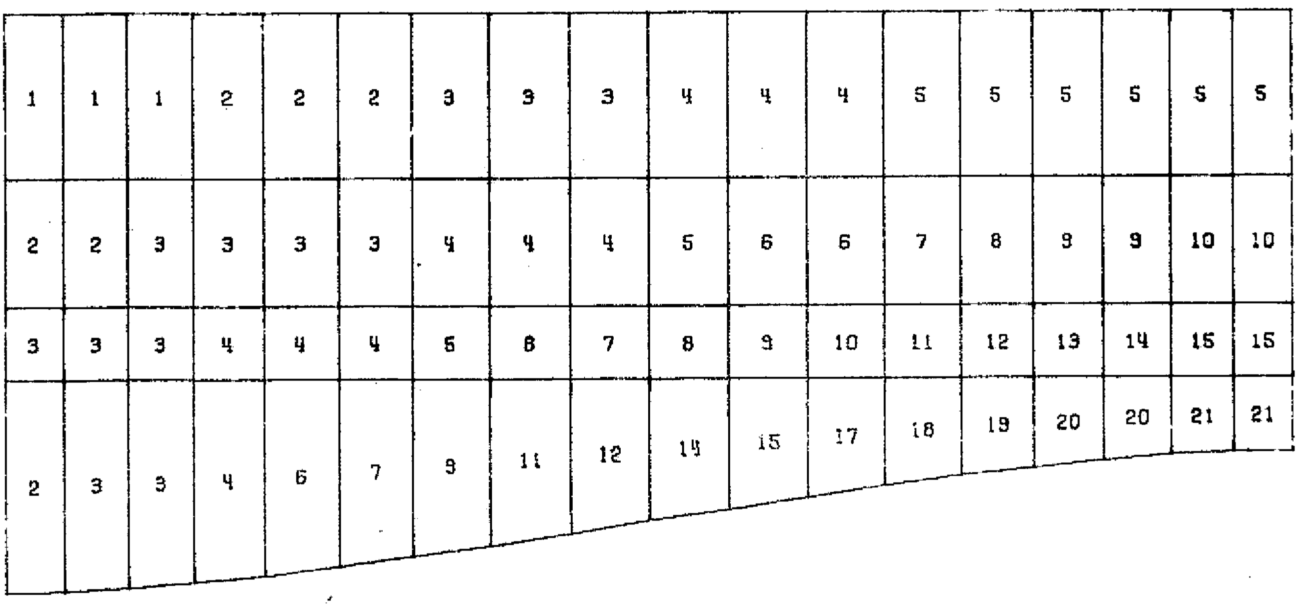
9 X 12 REINF WITH 9 FT HOLE
TRIANGLES AROUND 9 FT HOLE

0 24
SCALE

Figure 55

10/1/1

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 0



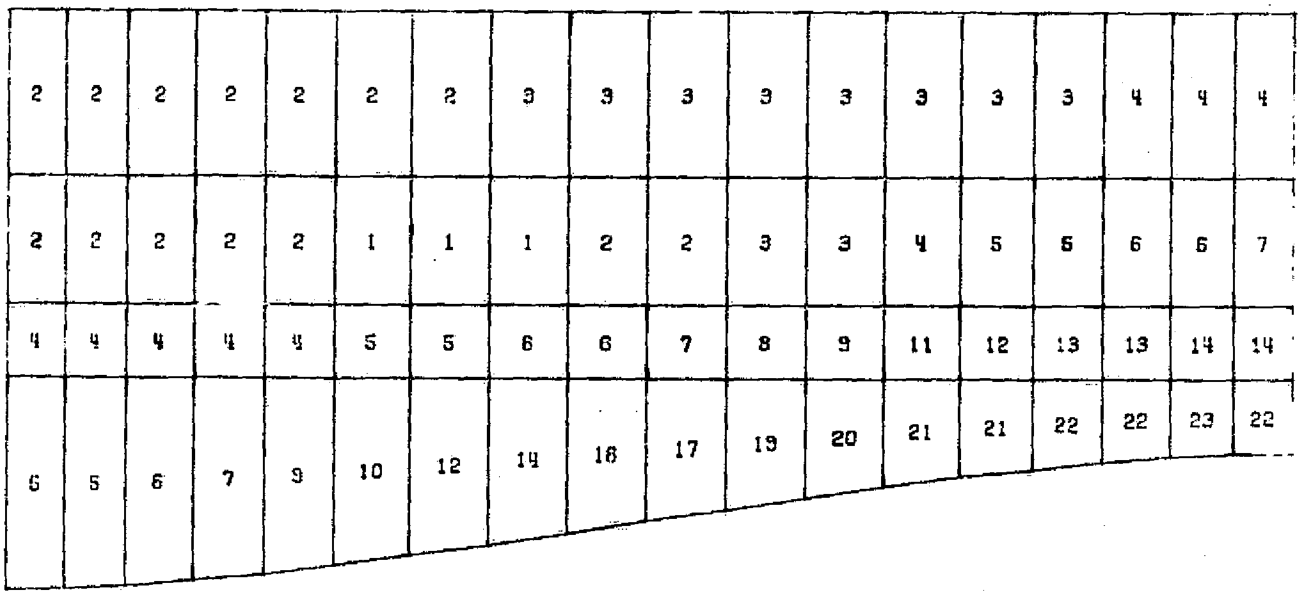
SPEC 9 X 12 REINE WITH 9 FT HOLE
?.1 9 FT PIPE SECTION 1

0 SCALE 11

Figure 56

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 1

10/1/1



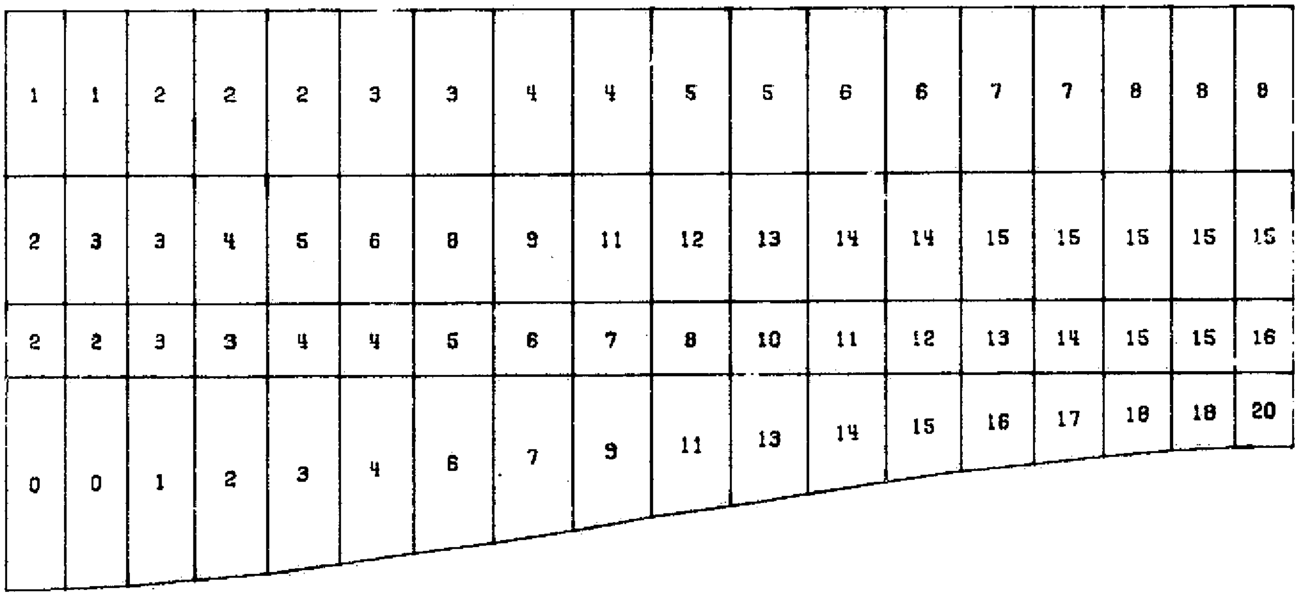
SPEC 9 X 12 REINF WITH 9 FT HOLE
10.1 9 FT PIPE SECTION 1

0 1
SCALE

Figure 57

10/1/

DISPLAY= PS1 /100C , NODE= 1, SURFACE= 2



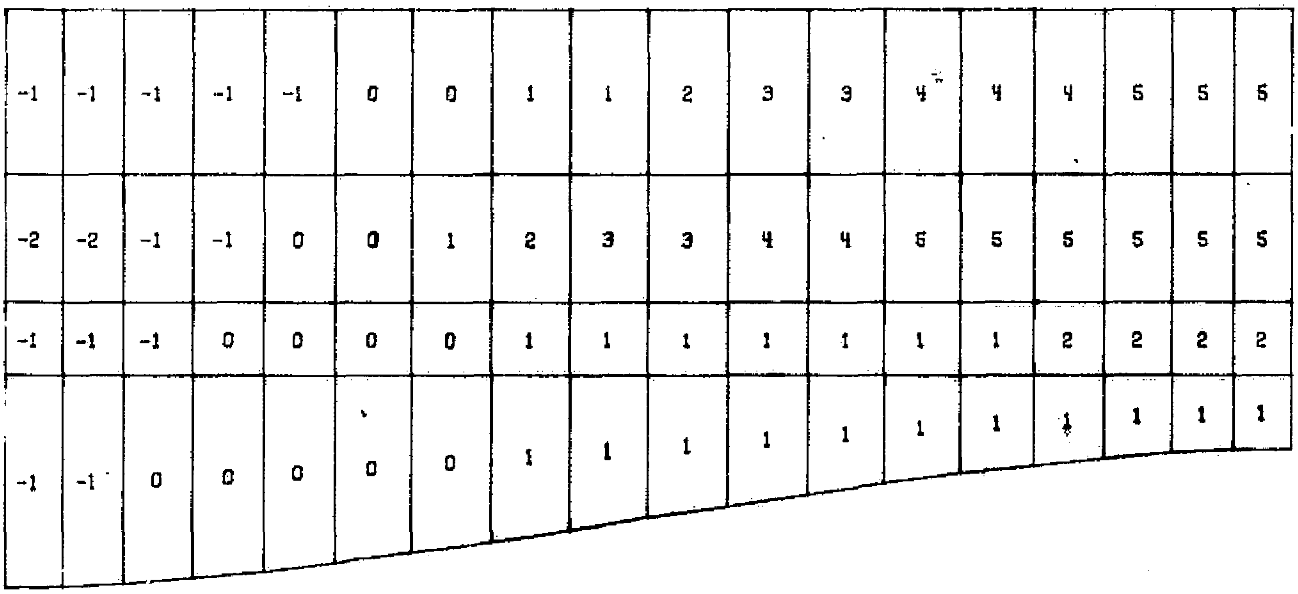
SPEC 10.1 9 X 12 REINF WITH 9 FT HOLE
9 FT PIPE SECTION 1

0 SCALE

Figure 58

DISPLAY= PS2 /1000 , NODE= 1, SURFACE= 0

10/1/1



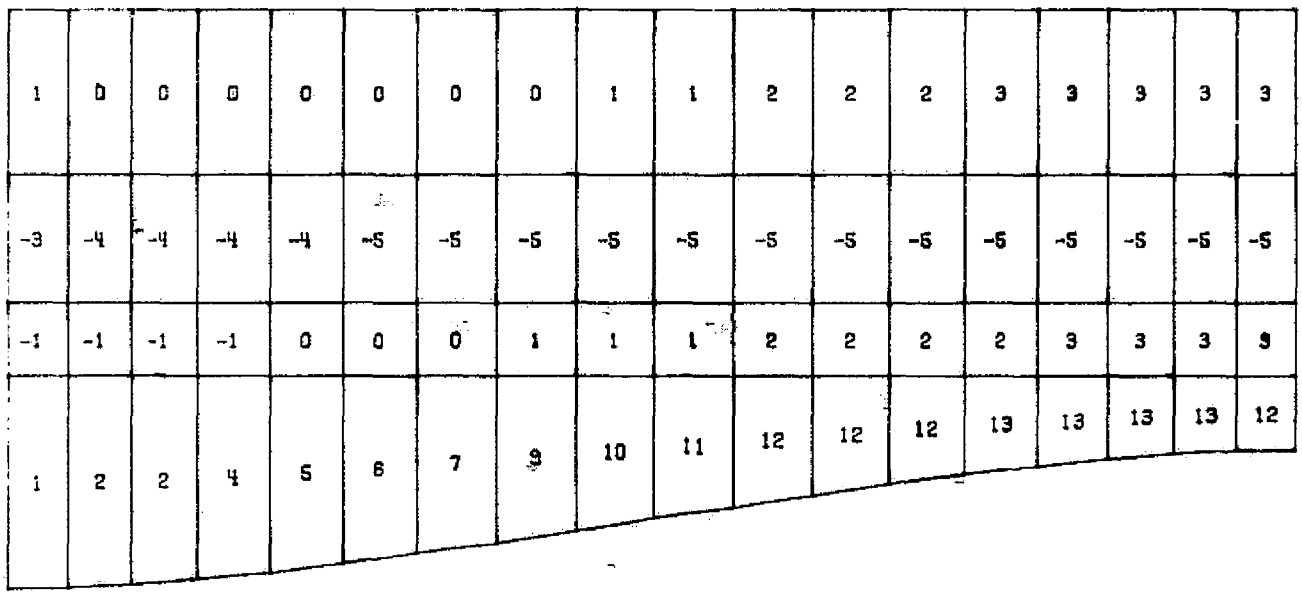
SPEC 9 X 12 REINF WITH 9 FT HOLE
10.1 9 FT PIPE SECTION 1

0 SCALE

Figure 59

10/1/1

DISPLAY= PS2 /1000 , NODE= 1, SURFACE= 1

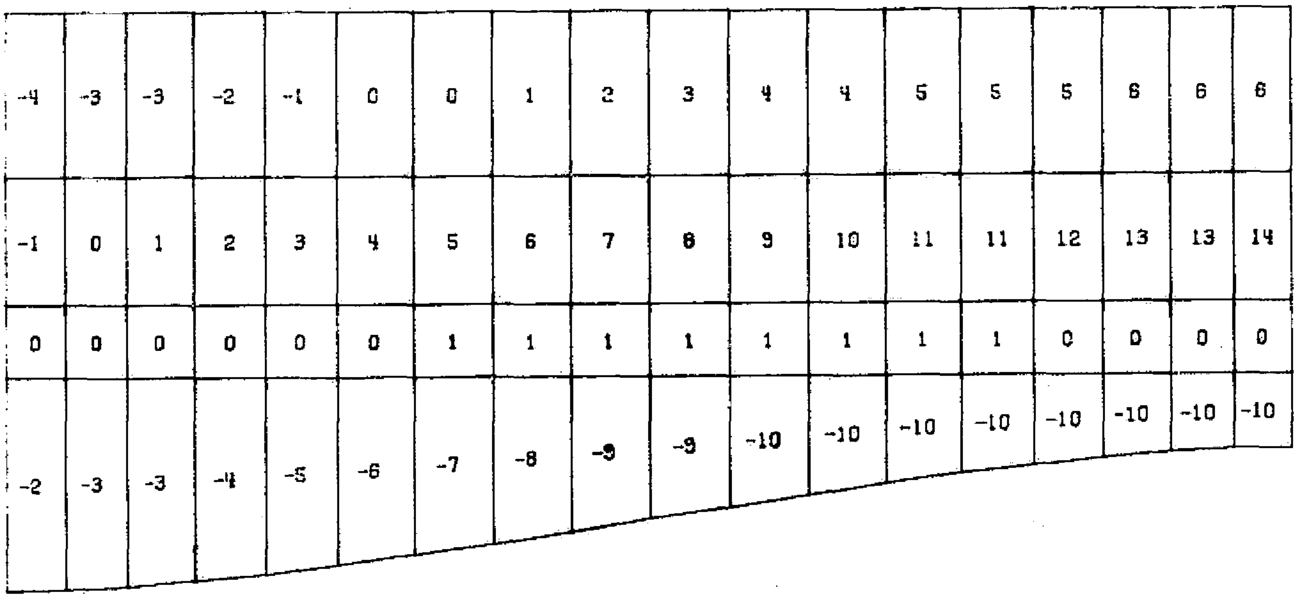


SPEC 9 X 12 REINF WITH 9 FT HOLE
10.1 9 FT PIPE SECTION 1

0 11
SCALE

Figure 60

DISPLAY= PS2 /100C , NODE= 1, SURFACE= 2



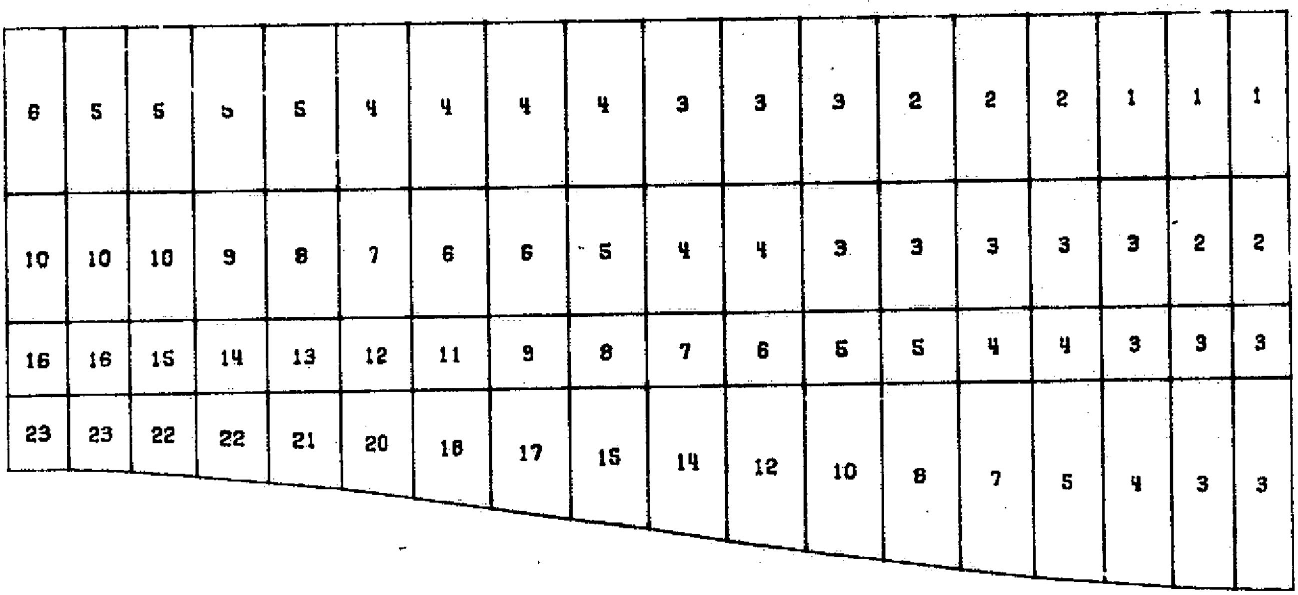
SPEC 9 X 12 REINF WITH 9 FT HOLE
10.1 9 FT PIPE SECTION 1

0 SCALE 11

Figure 61

10/1/1

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 0



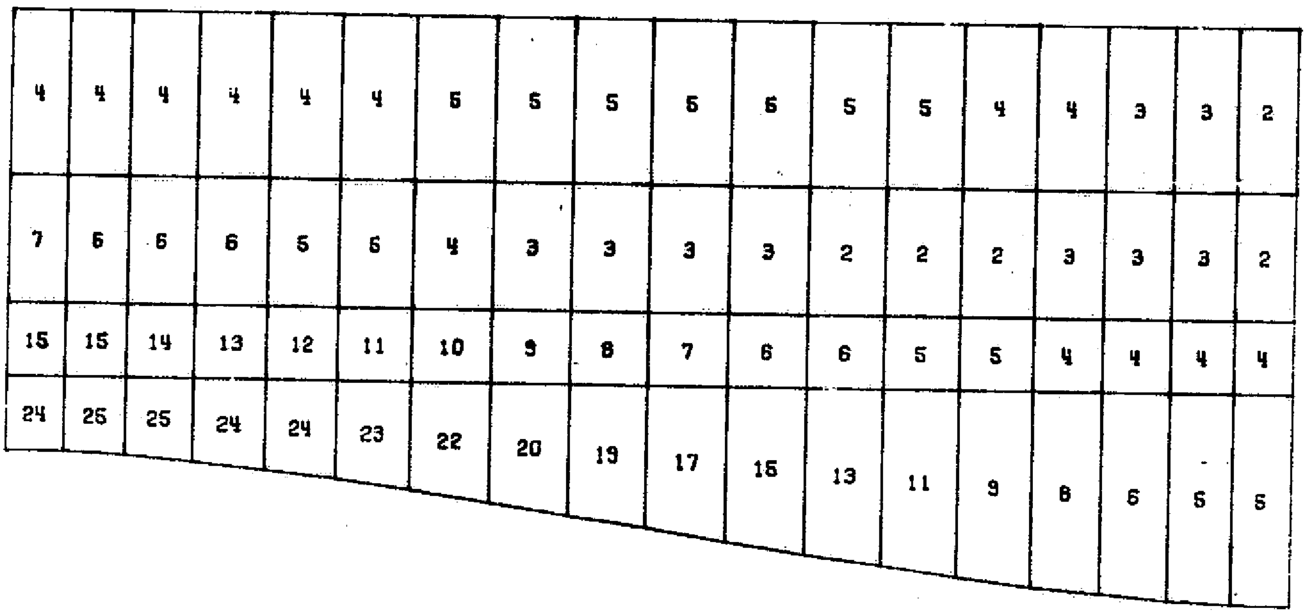
SPEC 1:1

9 X 12 REINF WITH 9 FT HOLE
9 FT PIPE SECTION 2

0 11
SCALE

Figure 62

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 1 10/1/1

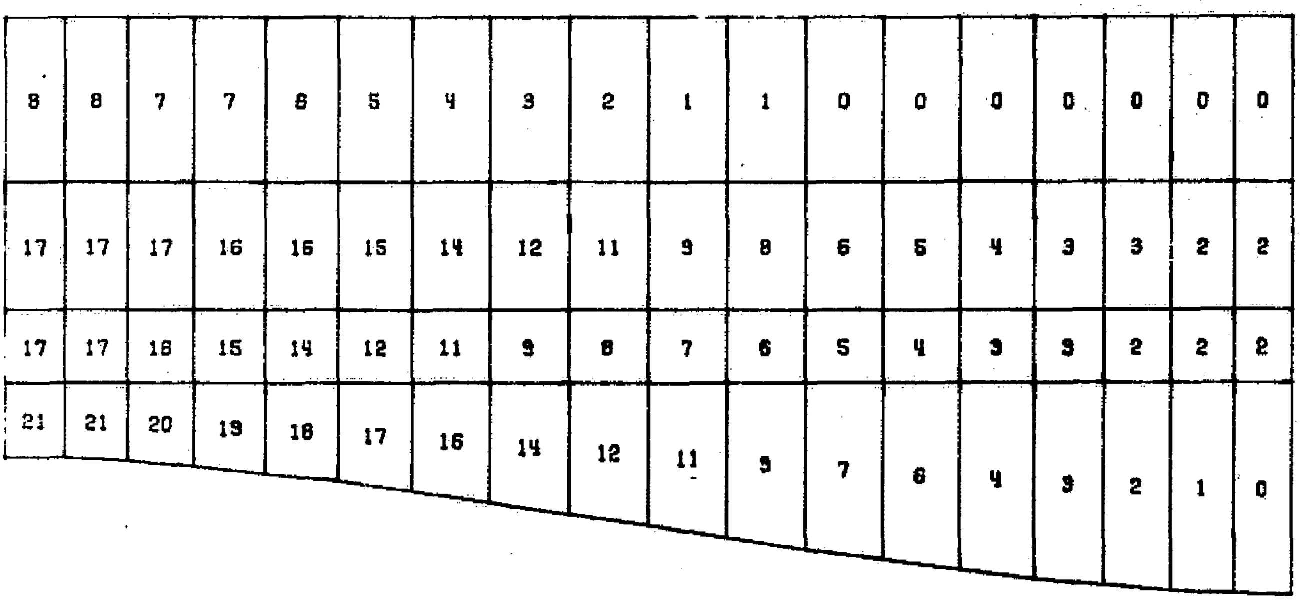


SPEC 11.1 9 X 12 REINF WITH 9 FT HOLE
9 FT PIPE SECTION 2

0 11
SCALE

Figure 63

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 2

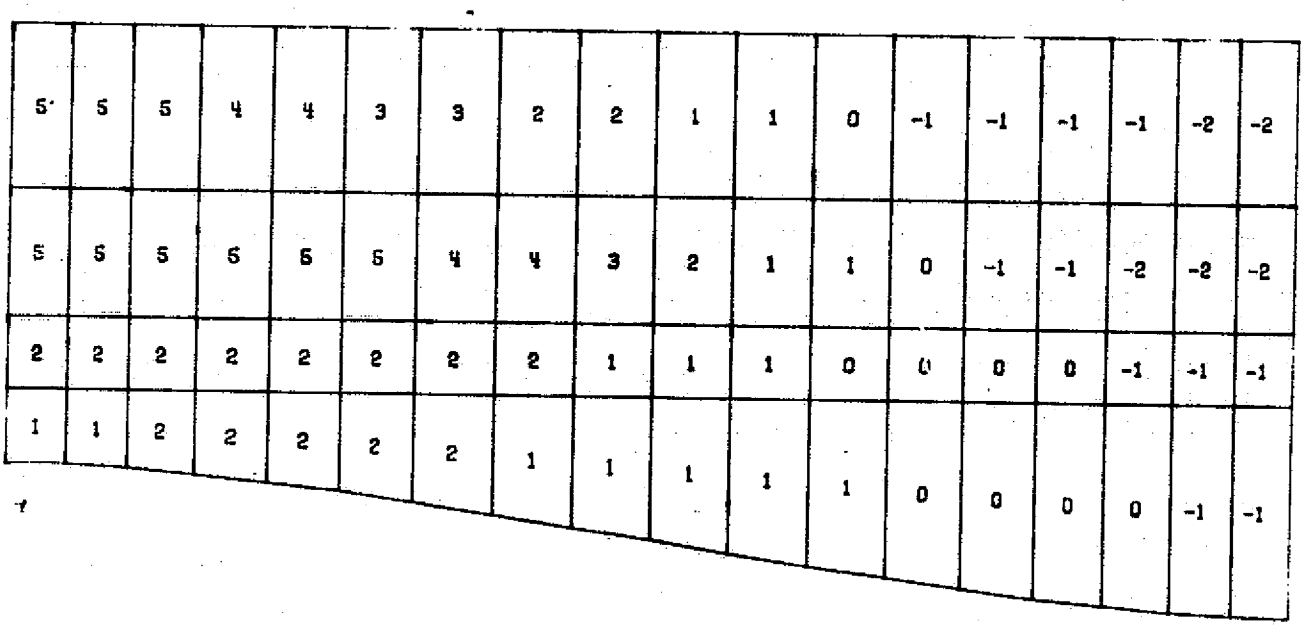


SPEC 11.1 9 X 12 REINF WITH 9 FT HOLE
9 FT PIPE SECTION 2

0 11
SCALE

Figure 64

DISPLAY= PS2 /100C , NODE= 1, SURFACE= 0 10/1/1

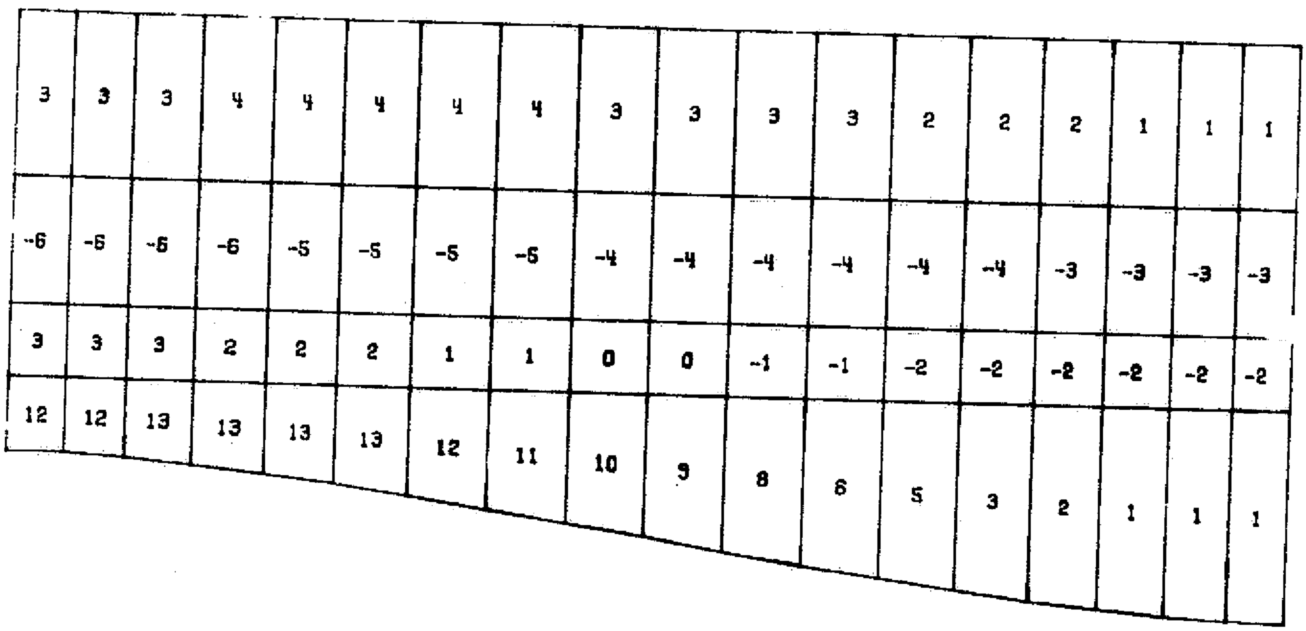


SPEC 11.1 9 X 12 REINF WITH 9 FT HOLE
9 FT PIPE SECTION 2

0 SCALE

Figure 65

DISPLAY= PS2 /1000 , NODE= 1, SURFACE= 1 10/1/1



SPEC 11.1

9 X 12 REINF WITH 9 FT HOLE
9 FT PIPE SECTION 2

0 SCALE 11

Figure 66

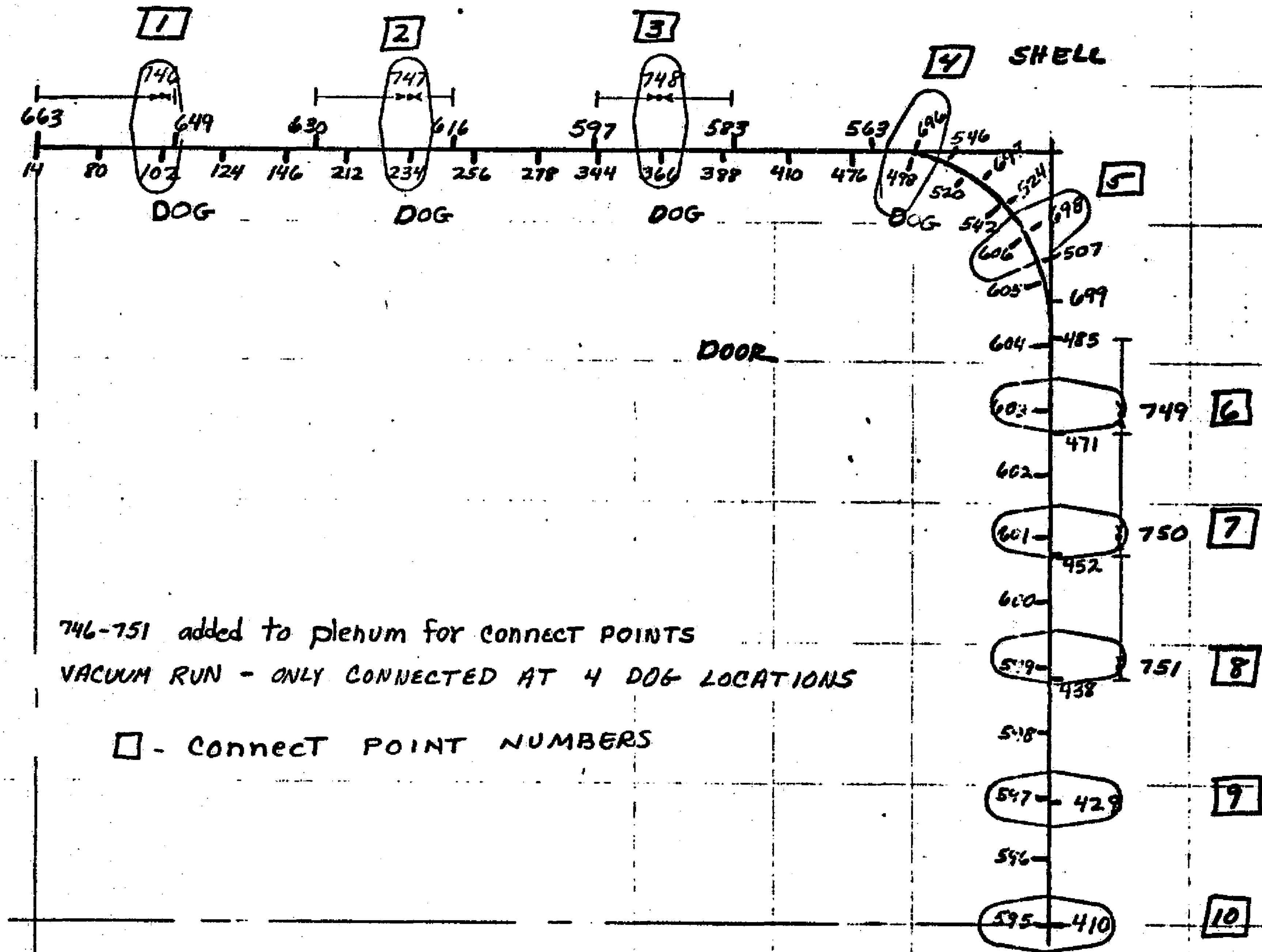
DISPLAY= PS2 /1000 , NODE= 1 , SURFACE= 2

6	6	5	5	4	3	2	1	0	-1	-2	-3	-3	-4	-4	-4	-4	-4
14	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	-1	-1
1	1	1	1	2	2	2	2	3	3	2	2	2	1	1	1	0	0
-10	-10	-10	-10	-10	-9	-9	-9	-8	-7	-6	-5	-4	-3	-3	-2	-2	-2

SPEC 9 X 12 REINF WITH 9 FT HOLE
11.1 9 FT PIPE SECTION 2

0 SCALE

Figure 67



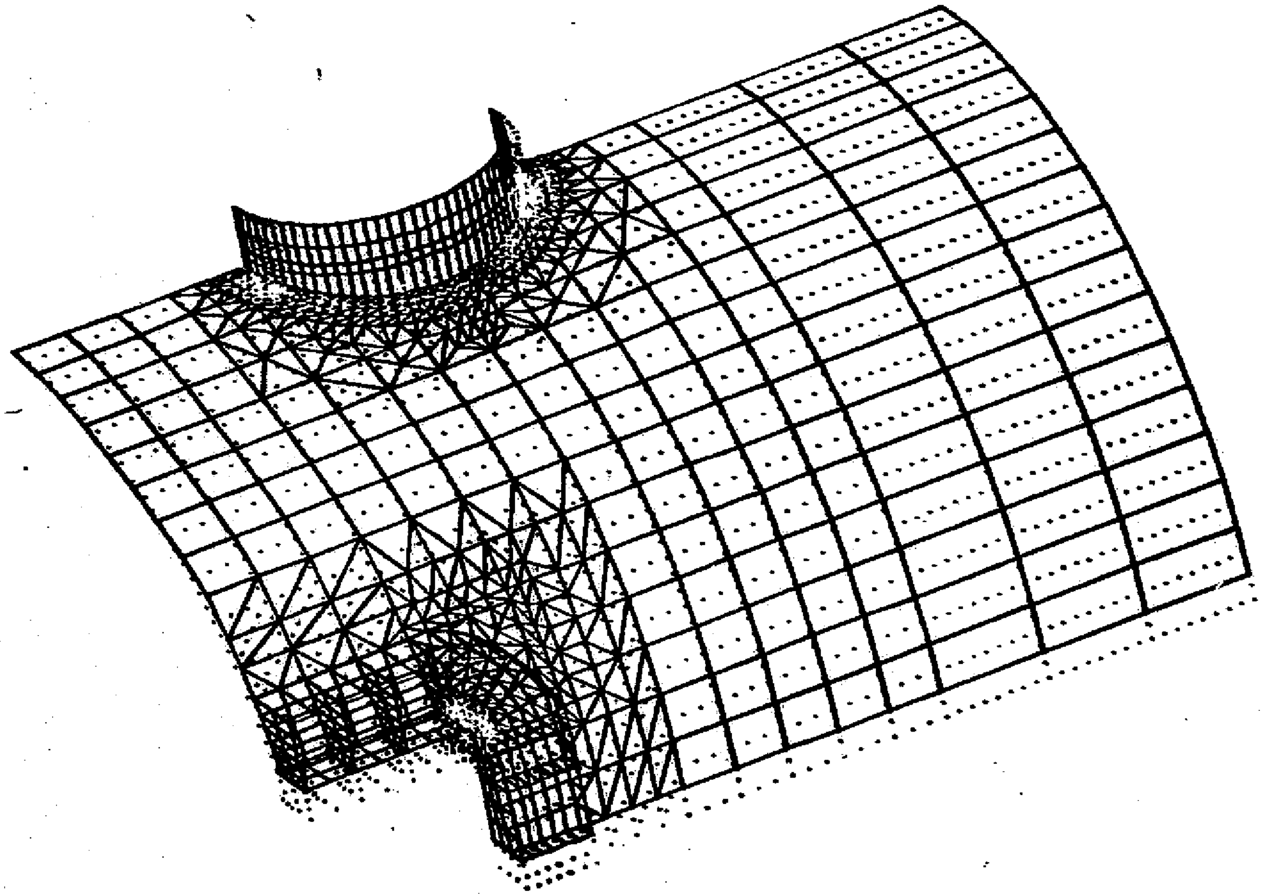
746-751 added to plenum for connect points

VACUUM RUN - ONLY CONNECTED AT 4 DOG LOCATIONS

□ - CONNECT POINT NUMBERS

FIGURE 68

BUCKLING MODE, CRITICAL LOAD .119357 X10 $^{+02}$ 1/7/1

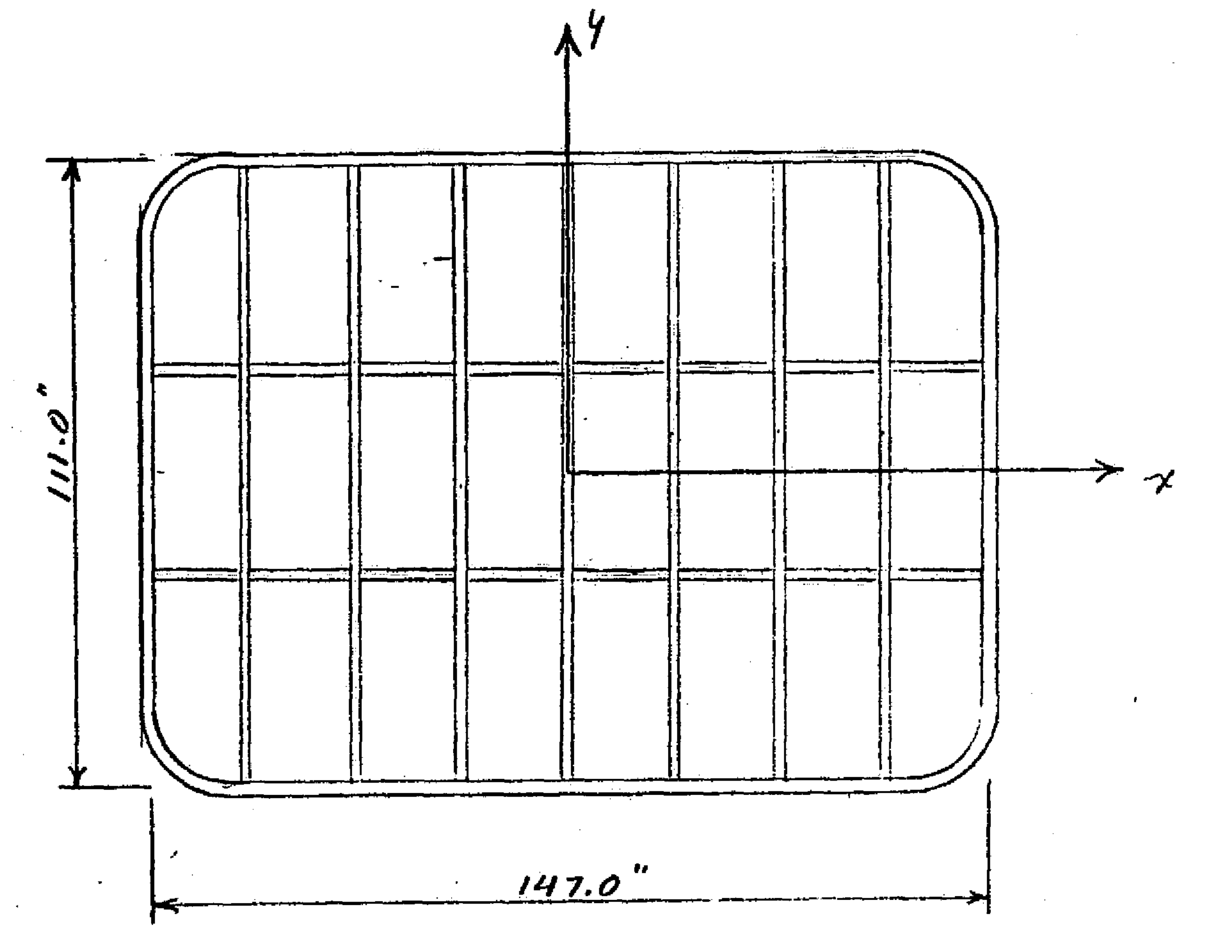


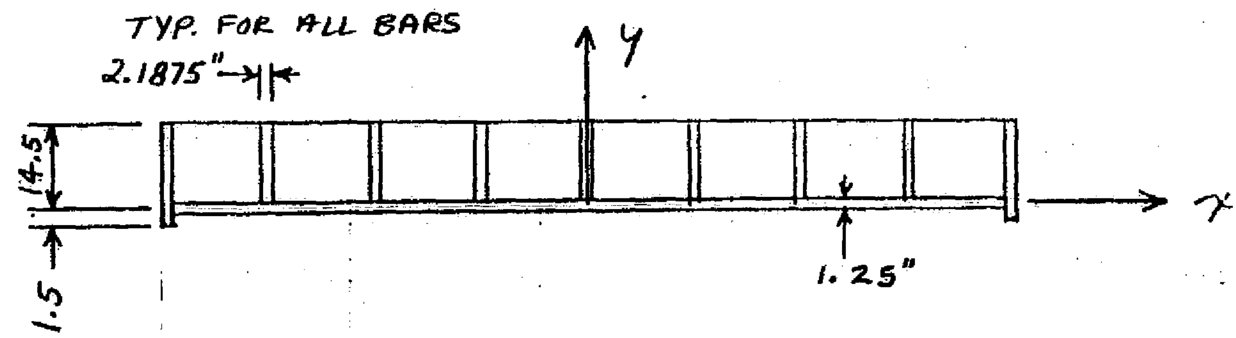
SPEC 1.1 NTF 9 X 12 ACCESS OPENING *Fig 69*

0 SCALE 67

Part 2

Reference Drawing LE 944471S





SPAR (a finite element computer code developed + maintained by Engineering Information System, Inc. under NASA contract NAS8-30536 and NAS1-13977) was used to analyse this region of the pressure shell. The region was modeled using, triangular and quadrilateral, membrane plus bending flat aeolotropic elements

The final configuration shown on LE is slightly different from the configuration modeled. The plate is now the sealing surface with all the stiffner hight above the plate (Total hight plate + stiffener = 17") rather that a 1.5" high stiffner for the sealing surface and 14.5" high stiffeners on opposite side of the plate.

The total height (sealing stiffner + plate + stiffner) is 17.0".

It was judged that these discreponcies would have min. effect on the Door / Plenum results.

One-quarter of the door was modeled. The horizontal and vertical ℄ of the door were planes of symmetry.

A computer plot of the door is show in Fig 1. The model consist of 606 joint with 6 DOF at each joint except where boundary condition were applied and rotation about an axis ⊥ to a plate element was restricted as required

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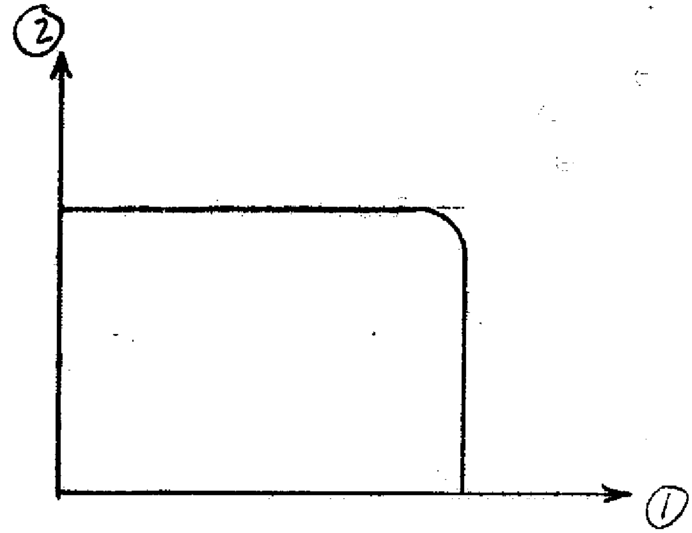
The joint numbers and shell section properties are shown in Fig 2 thru 11. The section properties and thicknesses are listed below

Shell Section Property	Thickness
1	1.25
2	2.1875
3	2.1875
4	1.0938
5	2.1875
6	2.1875
7	2.1875

Boundary Condition



Plane 1 3 is plane of symmetry
Plane 2 3 is plane of symmetry

Force displacements (in the 3 direction) obtained from combining the Door & Plenum models were applied to the edge of the Door
See discussion on combined runs (p.

Loading

P= 119 psi (design pressure) was applied as nodal pressure to the joints of the pressure surface.

For vacuum condition, -15 psi was applied as nodal pressure to the joints of the pressure surface.

Combined Door + Plenum Analyses

See discussion in Finite Element Analyses of Access Door Reinforcement (Plenum) (p. 9)

Results

Nodal stresses are presented in Fig 12 thru 69 .

The max principal stress (PS1) or min. principal stress (PS2) are given for the mid-surface (surface 0), the stiffner bar side of the plate (surface 1), and the sealing surface side of the plate (surface 2).

The stresses plotted are for joint 1 of the element. As an example (reference Fig 2), for the element defined by joint 1, 67, 66, 2. joint 1 for that element is 1

Nodal stresses for one joint are given from 4 elements (for quadrilateral elements). If any discrepancies exist in the stresses for a joint, the larges value is used in the evaluation of the results.

Membrane Stress in Plate (P = 119 psig)

Max. at joint 1 (Fig)

$\sigma_1 = 10.20$ KSI

$\sigma_2 = 1.00$ KSI

$\sigma_3 = -\frac{.119}{2} = -.06$ KSI

$S_{12} = 10.20 - 1.00 = 9.20$ KSI

$S_{23} = 1.00 - (-.06) = 9.94$ KSI

$S_{31} = -.06 - 10.20 = -10.26$ KSI

$P_m = |-10.26| = 10.26$ KSI

$P_m < S_m$

$10.26 < 20.0$ KSI O.K.

Bending stress in Plate ($P = 119$ psi)

Max at joint 233 (Not shown on plot)

$\sigma_1 = 16.92$ KSI

$\sigma_2 = 11.11$ KSI

$\sigma_3 = -.119$ KSI

$S_{12} = 16.92 - 11.11 = 5.81$ KSI

$S_{23} = 11.11 - (.12) = 11.23$ KSI

$S_{31} = -.12 - 16.92 = -17.04$ KSI

$P_b = |-17.04| = 17.04$ KSI

$P_b \leq 1.5\, S_m$

$17.04 \leq 1.5(20) = 30$ KSI

Stiftner Bar

Max stress Joint 54 (Not shown on plots)

$P = 119$ psi

$\sigma_1 = 0.07$ KSI

$\sigma_2 = -25.87$ KSI

$\sigma_3 = 0$ KSI

$S_{12} = 0.07 - (-25.87) = +25.94$ KSI

$S_{23} = -25.87 - 0 = -25.87$ KSI

$S_{31} = 0 - 0.07 = -.07$ KSI

$P_b = |+25.94| = 25.94$ KSI

$P_b \leq 1.5\ S_m$

$25.94 < 1.5(20) = 30$ KSI O.K.

For relative displacement between the sealing surfaces of the door and plenum opening for internal P= 119 psi see Fig of Finite Element Analyses of Access Door Reinforcement (Plenum).

For relative displacement between sealing surfaces of the door and plenum opening for vacuum along with dog loads under under vacuum, see Fig. of Finite Element Analysis of Access Reinforcement (Plenum).

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Buckling of 9'X12' Door Stiffner

use simple supported beam Analyses

for 18" section of door

$$M = \frac{wl^2}{8} = \frac{(119\ \frac{lb}{in^2})(18\ in)(108)^2\ in^2}{8} = 3.123 \times 10^6\ in\text{-}lb$$

From Roark Case 15 p 344 Sect. XV.

with ends held vertical + not fixed in Horz. plane

$$M' = \frac{\pi b^3 d \sqrt{EG\left(1 - 0.63\left(\frac{b}{d}\right)\right)}}{6l}$$

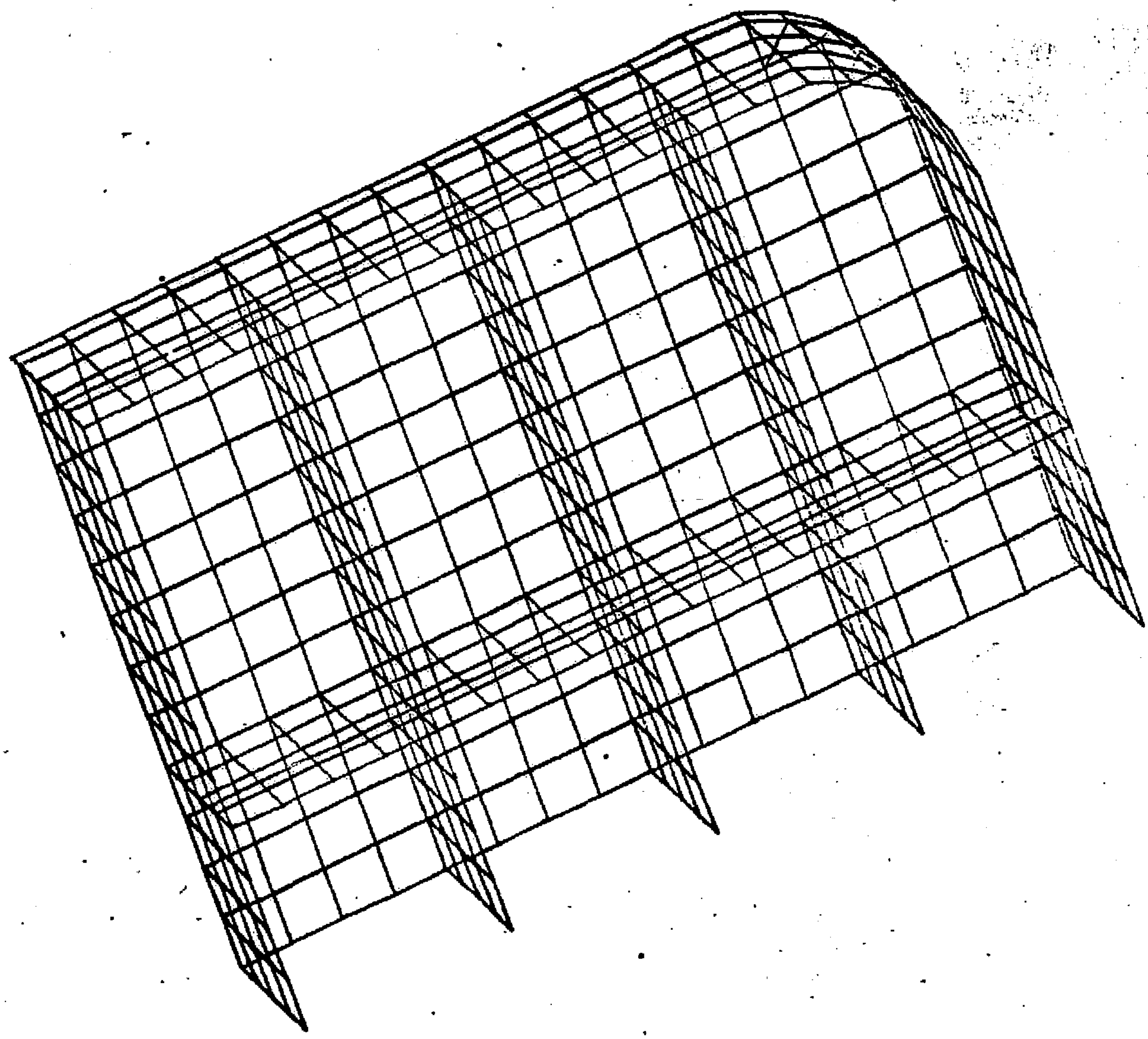
$$M' = \frac{\pi(2.18)^3(15)\sqrt{(28 \times 10^6)(11.15 \times 10^6)\left(1 - 0.63\left(\frac{2.18}{15}\right)\right)}}{6(38.5)}$$

.908

$M' = 3.56 \times 10^7$ in-lbs

The applied moment is much less than the critical moment. Analysis is conservative because restraint of plat not considered.

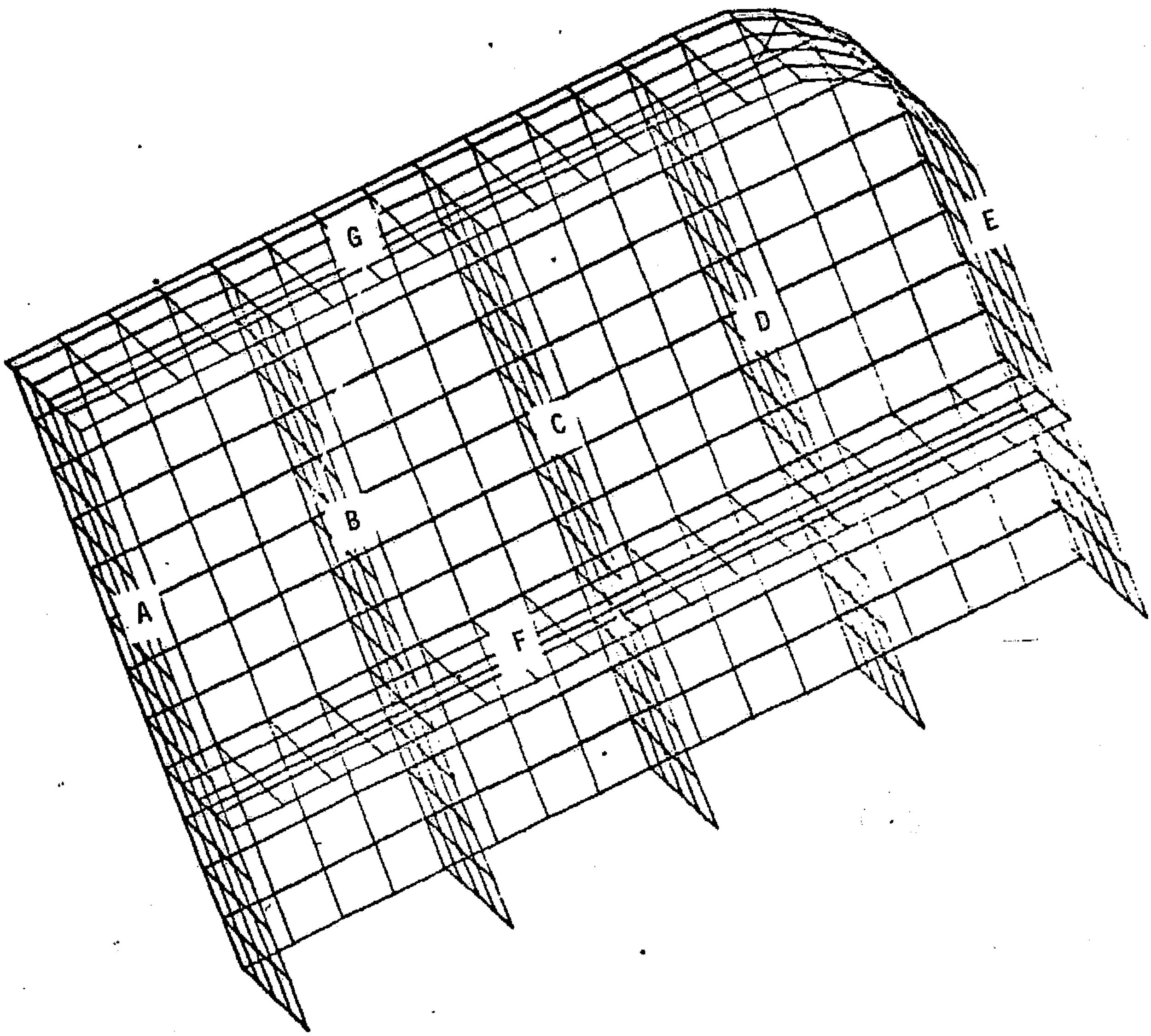
∴ Lateral Buckling is no problem



SPEC 1.1 NTF 9 X 12 DOORS

0 SCALE

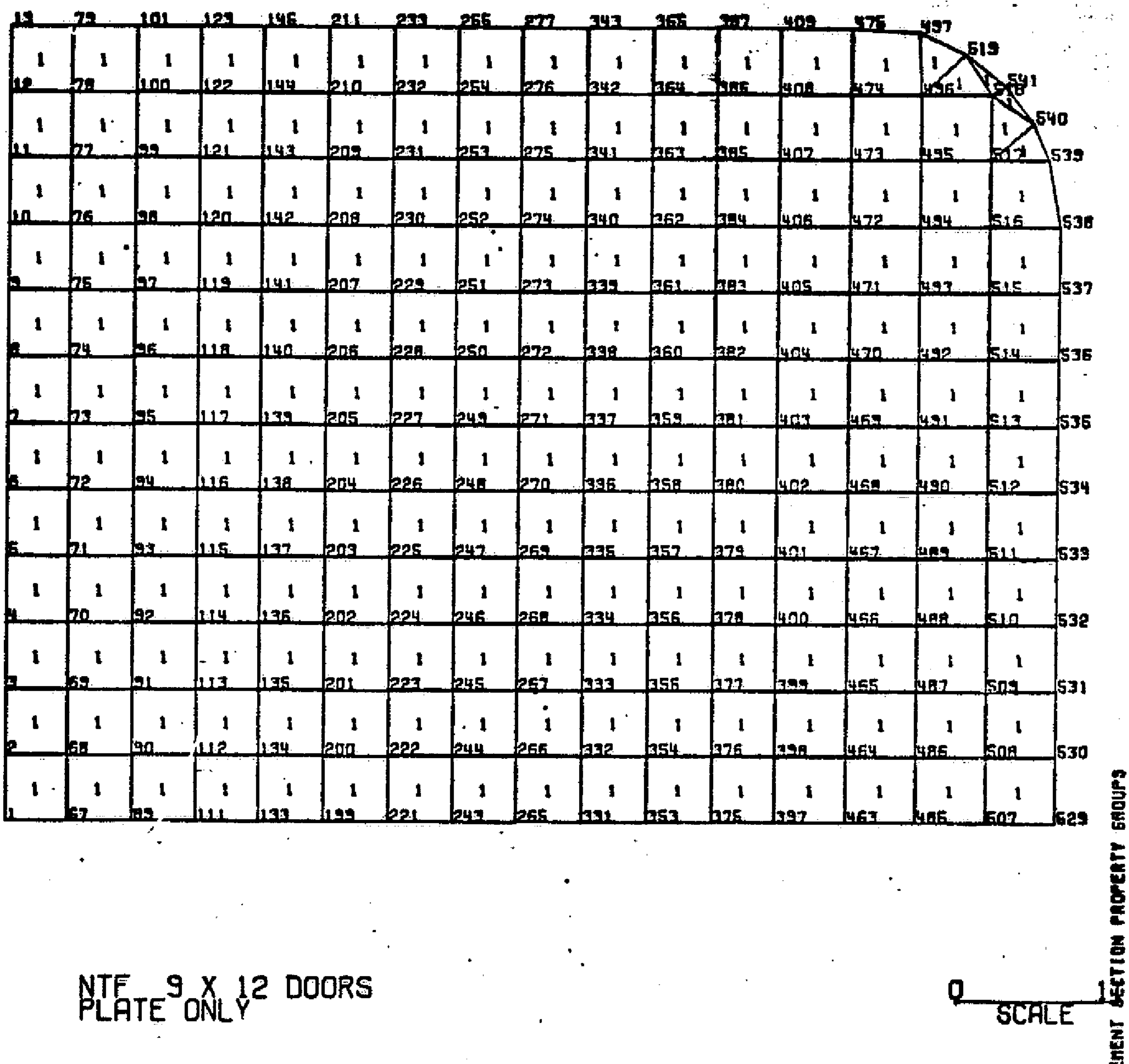
Figure 1A



SPEC 1.1 NTF 9 X 12 DOORS

0 13
SCALE

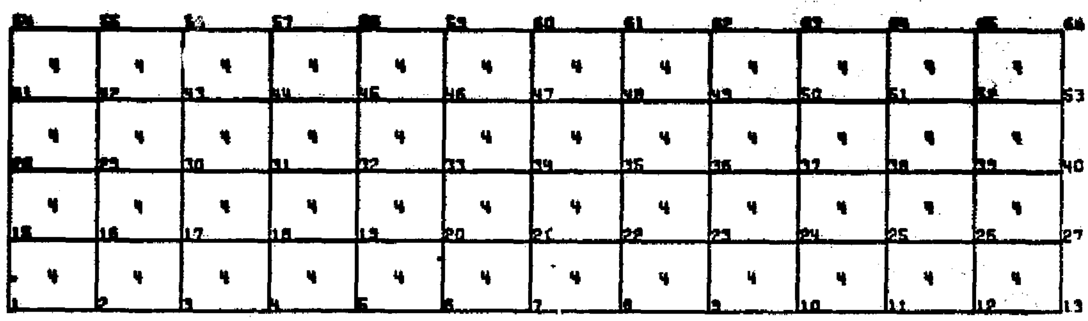
Figure 1B



SPEC 2-1

NTF 9 X 12 DOORS
PLATE ONLY

Figure 2

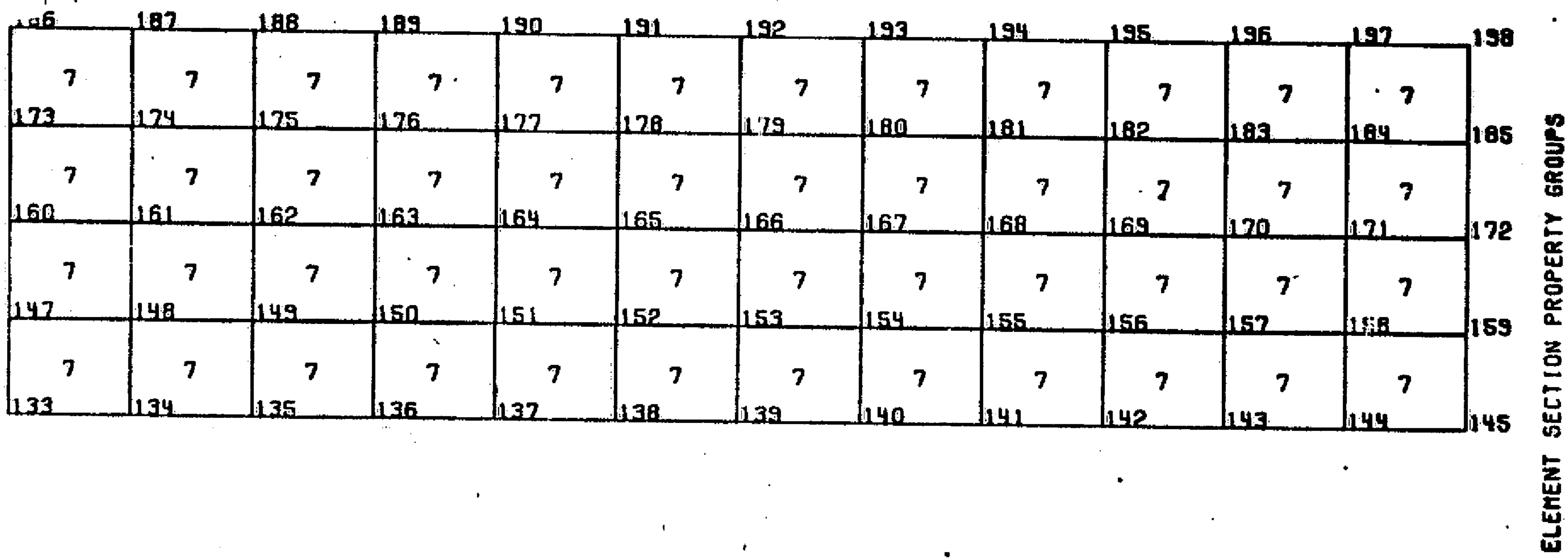


SPEC 3.1 NTF 9 X 12 DOORS
STIFFENER BAR A

0 SCALE 8

ELEMENT SECTION PROPERTY GROUPS

Figure 3

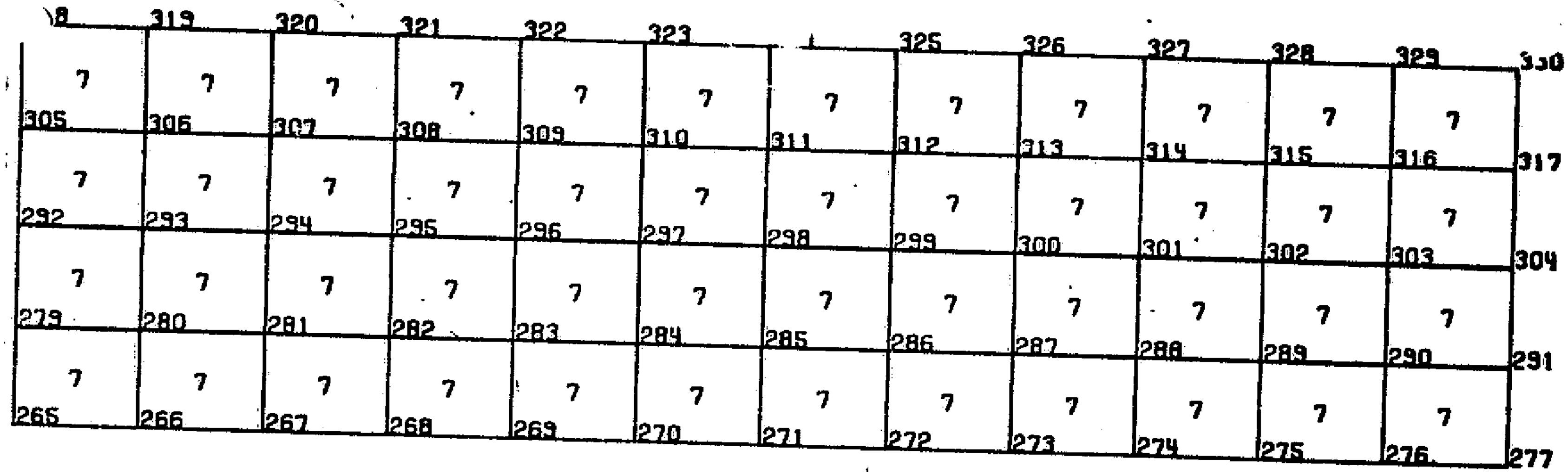


SPEC
4.1

NTF 9 X 12 DOORS
STIFFENER BAR B

0 8
SCALE

Figure 4



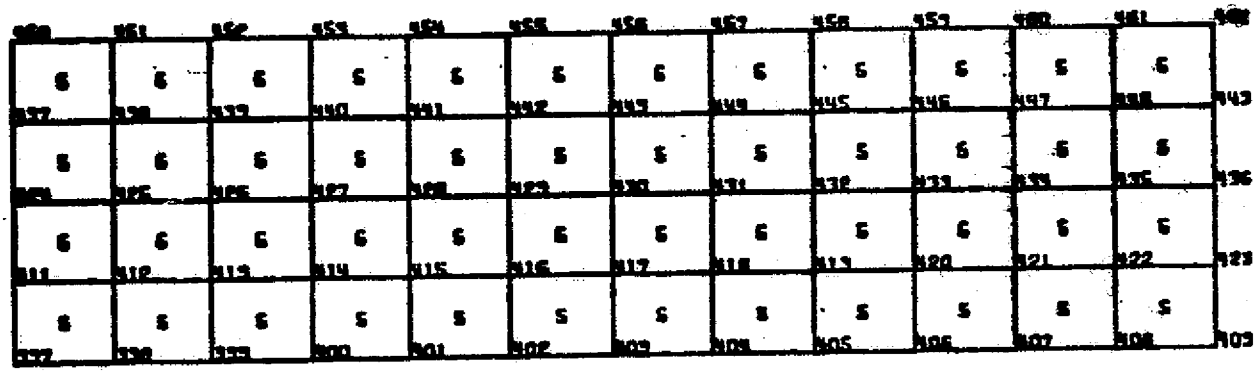
SPEC
5.1

NTF 9 X 12 DOORS
STIFFENER BAR C

0
SCALE

ELEMENT SECTION PROPERTY GROUPS

Figure 5

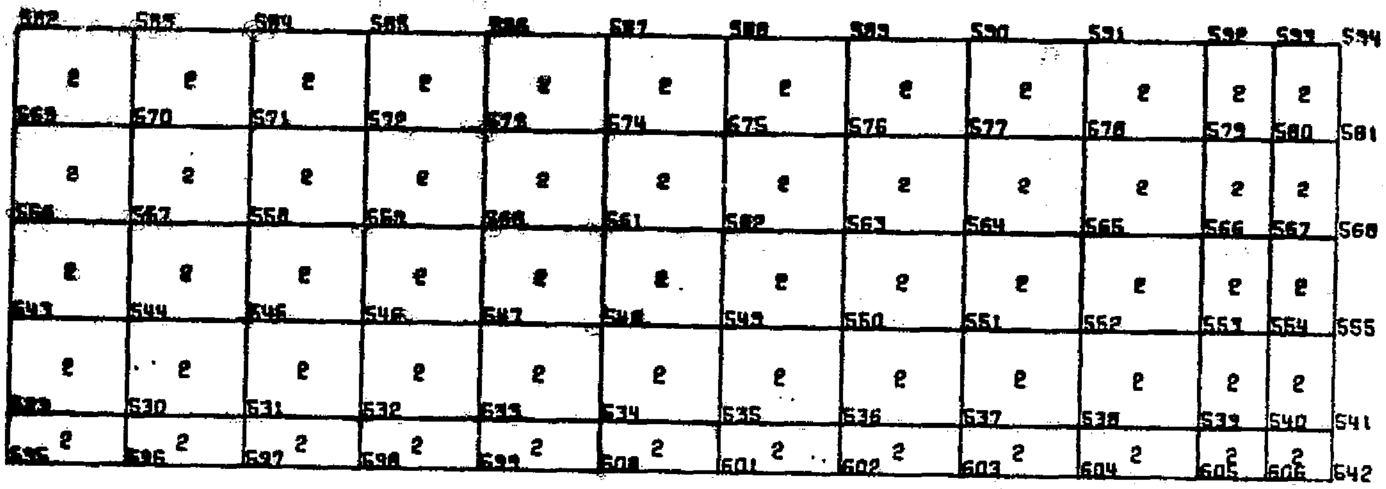


SPEC 6.1 NTF 9 X 12 DOORS
STIFFENER BAR D

0 SCALE 8

Figure 6

ELEMENT SECTION PROPERTY GROUPS

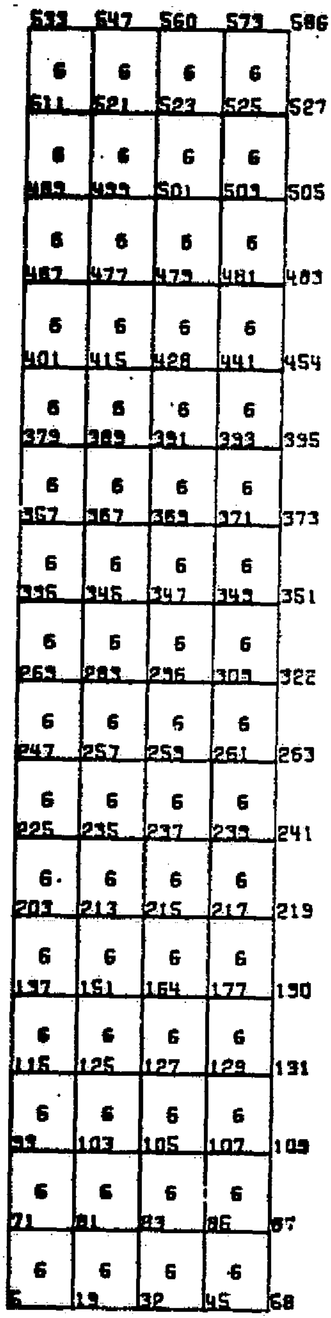


SPEC 7.1 NTF 9 X 12 DOORS
STIFFENER BAR E

0 SCALE 8

ELEMENT SECTION PROPERTY GROUPS

Figure 7



SPEC
8.1

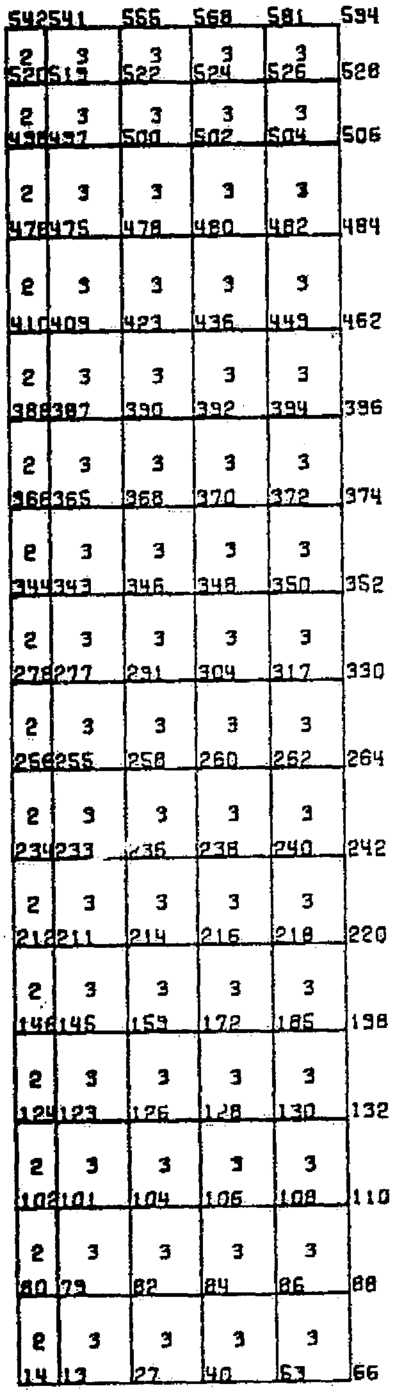
NTF 9 X 12 DOORS
STIFFENER BAR F

ELEMENT SECTION PROPERTY GROUPS

0 1
SCALE

Figure 8

ELEMENT SECTION PROPERTY GROUPS

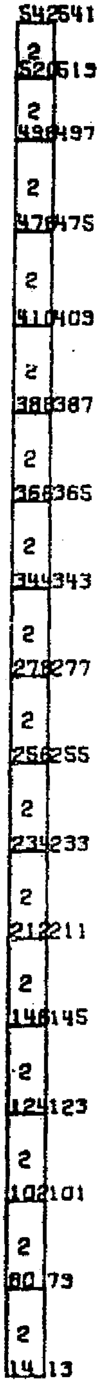


SPEC 9.1

NTF 9 X 12 DOORS
STIFFENER BAR G

0 11
SCALE

Figure 9



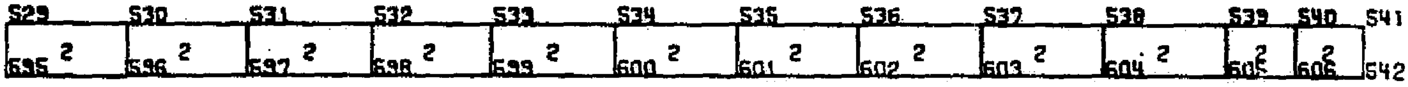
ELEMENT SECTION PROPERTY GROUPS

SPEC
In.1

NTF 9 X 12 DOORS
SEAL FLANGE - TOP

0 11
SCALE

Figure 10



SPEC
11.1

NIF 9 X 12 DOORS
SEAL FLANGE - SIDE

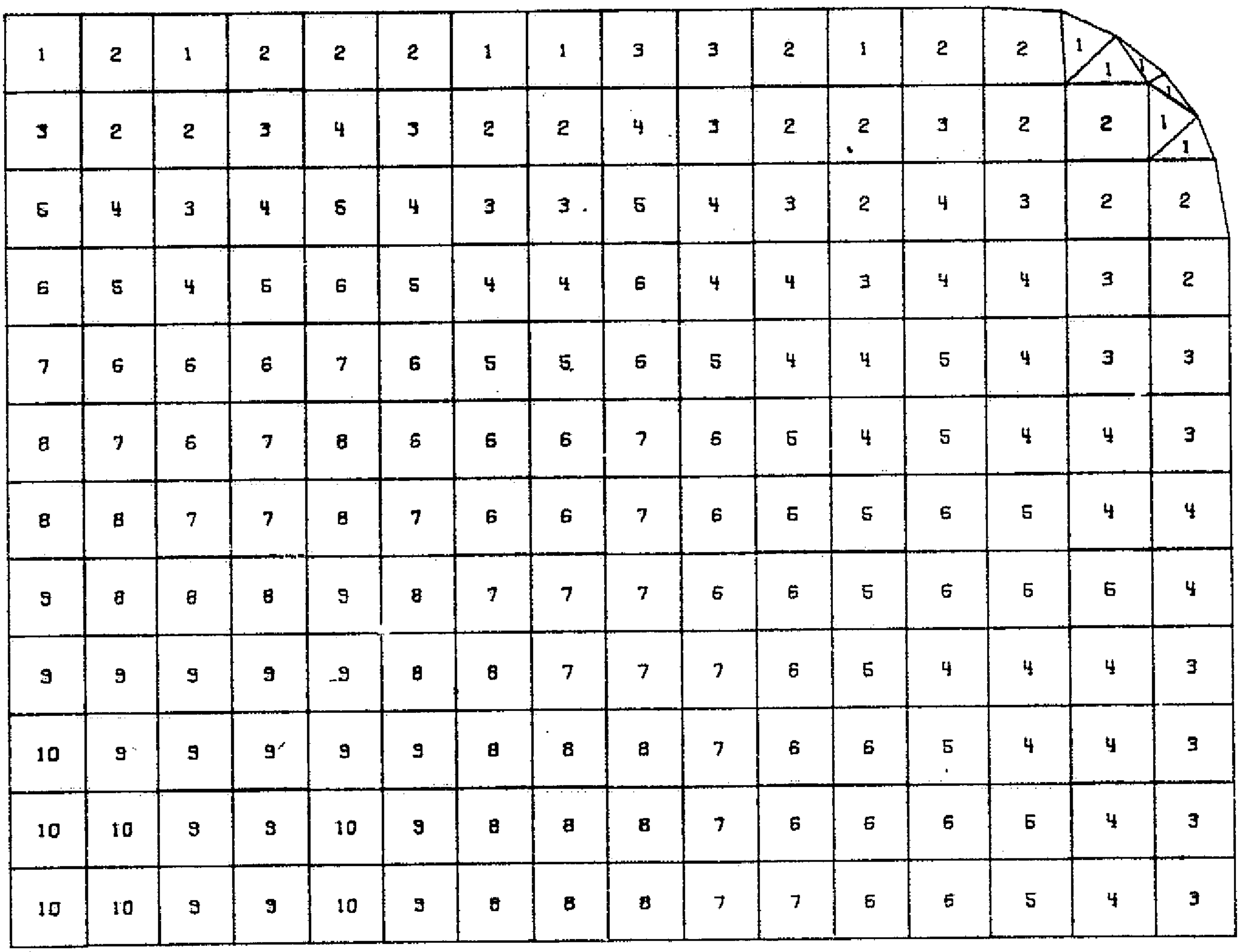
0 SCALE

ELEMENT SECTION PROPERTY GROUPS

Figure 11

10/1/1

DISPLAY= PS1 /1000 . NODE= 1 . SURFACE= 0



SPEC 2.1

NTF 9 X 12 DOORS
PLATE ONLY

0 SCALE 11

Figure 12

DISPLAY= PS1 /1000 , NODE= 1, SURFACE= 1 10/1/1

2	1	0	2	2	1	0	2	3	1	0	1	3	0	1 / 0 / 6	
9	-1	-1	1	9	-1	-1	1	9	0	-1	0	8	-1	-1	7 / 3 / 1
11	1	0	2	12	1	0	2	11	1	-1	1	11	0	-2	0
12	3	1	3	12	3	1	2	12	2	0	2	12	1	-2	0
12	4	2	3	12	3	1	3	12	3	1	2	12	1	-1	1
11	4	2	4	11	4	1	3	11	4	1	2	11	2	-1	1
9	6	4	4	9	6	3	3	8	5	2	2	7	4	1	2
6	9	13	8	6	9	12	8	4	9	11	7	3	10	12	6
10	6	6	6	10	6	4	6	8	3	3	4	5	1	1	3
11	5	6	6	11	4	4	5	9	3	2	4	8	0	0	2
12	6	6	7	11	6	4	6	10	4	3	4	10	1	0	1
12	7	5	7	11	6	4	6	10	5	3	4	11	2	0	1

SPEC 2.1 NTF 9 X 12 DOORS
PLATE ONLY

0 11
SCALE

Figure 13

DISPLAY= PS1 /1000 , NODE= 1 , SURFACE= 2 10/1/1

1	3	4	2	2	4	4	1	2	4	4	1	2	4	2 / 2	
0	6	6	4	0	6	6	3	1	6	6	3	0	6	5	3 / 2
2	6	7	6	2	7	7	6	1	6	8	4	0	6	8	4
3	7	8	7	3	7	8	6	2	7	8	5	1	6	9	4
4	8	9	8	4	8	9	7	3	7	9	6	1	7	9	5
6	9	11	10	6	9	10	9	6	8	9	7	3	7	9	6
8	9	11	11	8	8	10	9	7	7	9	8	5	6	7	6
13	7	3	8	12	6	2	6	11	6	1	3	8	2	-1	3
9	12	12	11	8	12	11	10	7	10	9	7	4	7	6	3
8	14	14	12	8	13	12	10	6	11	10	8	3	9	8	4
9	13	14	12	8	12	13	10	7	10	10	8	4	8	9	4
9	13	14	12	8	12	13	11	7	10	10	8	4	7	9	4

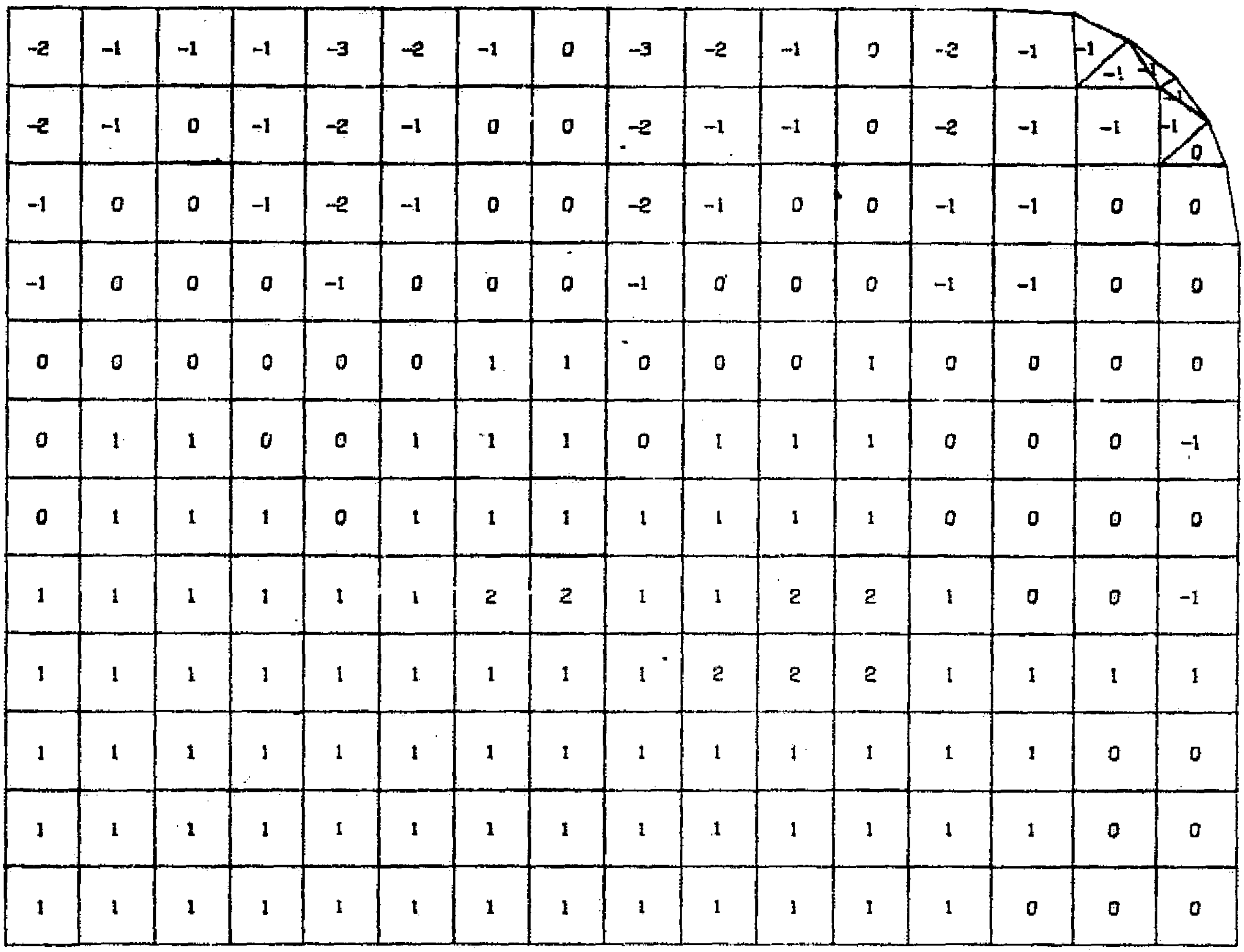
SPEC
2.1

NTF 9 X 12 DOORS
PLATE ONLY

0 SCALE 1

Figure 14

DISPLAY= PS2 /1000 . NODE= 1 . SURFACE= 0



SPEC 2.1 NTF 9 X 12 DOORS
PLATE ONLY

0 SCALE

Figure 15

DISPLAY= PS2 /1000 , NODE= 1 , SURFACE= 1

10/1/1

-2	-2	-2	-1	-3	-3	-2	0	-3	-3	-3	0	-2	-4	0 / -2	
3	-3	-5	-3	3	-4	-5	-2	2	-5	-5	-2	2	-5	-5	0 / 0
6	-3	-6	-3	5	-3	-6	-2	4	-4	-7	-2	4	-6	-7	-1
7	-3	-7	-3	6	-3	-7	-2	5	-3	-7	-2	5	-4	-8	-2
7	-2	-7	-3	7	-3	-6	-2	6	-3	-6	-2	6	-4	-8	-3
8	-2	-6	-3	7	-2	-6	-2	6	-2	-6	-2	6	-3	-7	-3
6	-1	-3	-3	6	0	-3	-2	4	0	-3	-2	2	-1	-4	-3
-1	0	3	1	-1	0	3	2	-1	1	4	2	-2	1	4	-1
6	-1	-2	-1	4	-1	-2	0	4	-1	-1	0	2	-2	-2	0
9	-2	-5	-2	9	-2	-5	-2	8	-2	-5	-1	7	-4	-6	-3
11	-2	-6	-2	11	-2	-6	-2	9	-3	-6	-2	8	-4	-8	-3
11	-2	-6	-2	11	-2	-6	-2	10	-3	-6	-2	8	-4	-9	-3

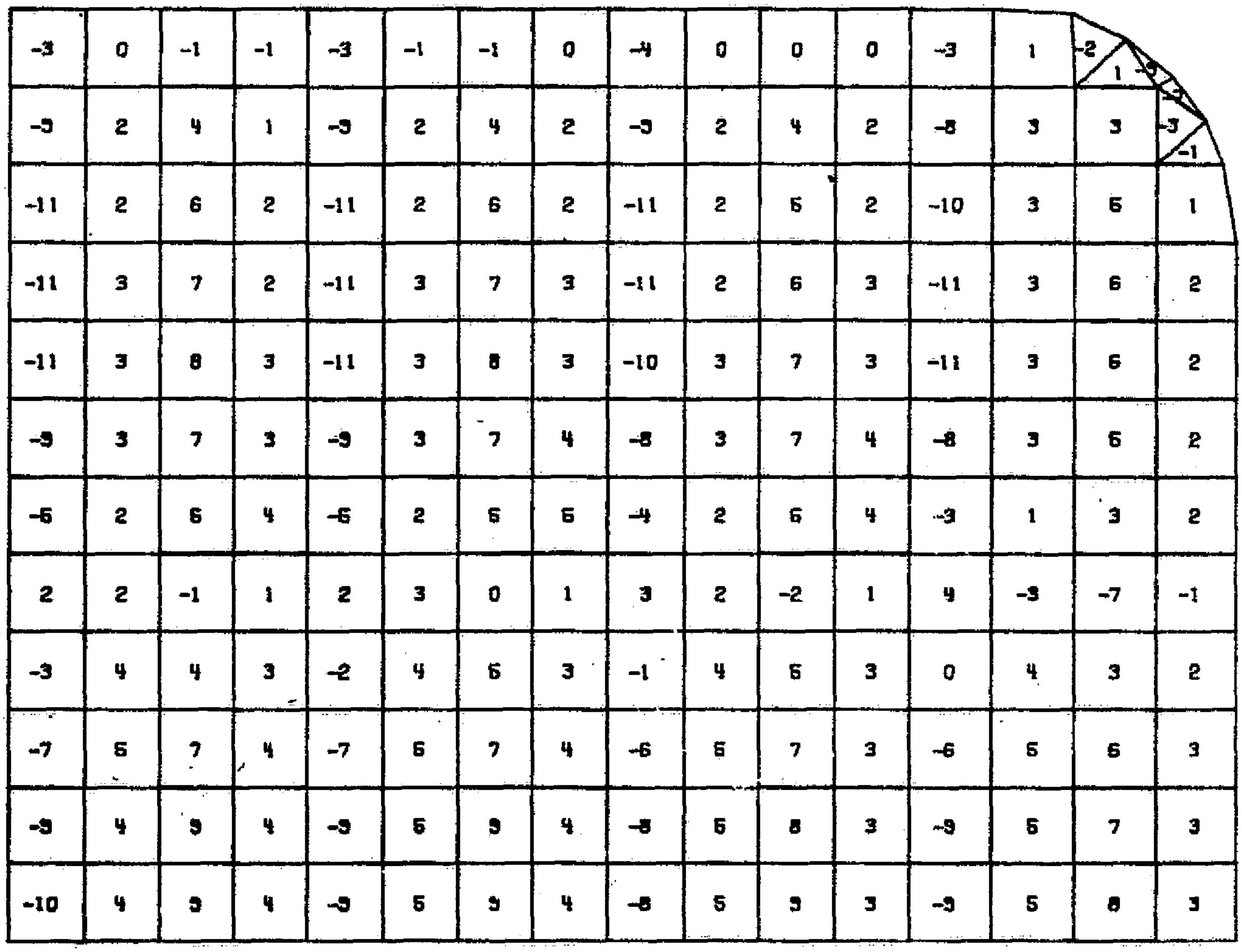
SPEC 2.1

NTF 9 X 12 DOORS
PLATE ONLY

0 SCALE 11

Figure 16

DISPLAY= PS2 /1000 . NODE= 1. SURFACE= 2



SPEC 2.1 NTF 9 X 12 DOORS PLATE ONLY

0 SCALE

Figure 17

10/1/1

DISPLAY= PS1 /1000 . NODE= 1 . SURFACE= 0

0	0	0	0	-2	1	0	0	1	1	1	2
0	0	0	0	0	1	1	1	2	2	3	3
1	2	2	2	3	3	3	4	4	4	5	4
10	10	10	9	9	9	8	8	7	6	6	4

SPEC 3.1

NTF 9 X 12 DOORS
STIFFENER BAR A

0 — 8
SCALE

Figure 18

DISPLAY= PS1 /1000 , NODE= 1 , SURFACE= 1

0	0	0	0	-2	1	0	0	1	1	1	2
0	0	0	0	0	1	1	1	2	2	3	3
1	2	2	2	3	3	3	4	4	4	5	4
10	10	10	9	9	9	8	8	7	6	6	4

SPEC 3.1

NTF 9 X 12 DOORS
STIFFENER BAR A

0 SCAL

Figure 19

DISPLAY= PS1 /1000 , NODE= 1 , SURFACE= 2 10/1/1

0	0	0	0	-2	1	0	0	1	1	1	2
0	0	0	0	0	1	1	1	2	2	3	3
1	2	2	2	3	3	3	4	4	4	5	4
10	10	10	9	9	9	8	8	7	6	6	4

SPEC
3.1 NTF 9 X 12 DOORS
STIFFENER BAR A

0 SCALE 8

Figure 20

DISPLAY= PS2 /1000 . NODE= 1 . SURFACE= 0 10/1/1

-17	-16	-16	-15	-14	-13	-12	-10	-8	-6	-4	-2
-8	-6	-7	-7	-7	-7	-6	-6	-5	-5	-4	-4
0	0	0	-1	-1	-2	-2	-2	-3	-3	-4	-4
1	1	1	0	1	0	0	-1	-1	-2	-3	-4

SPEC 3.1

NTF 9 X 12 DOORS
STIFFENER BAR A

0 ____ 8
SCALE

Figure 21

DISPLAY= PS2 /1000 . NODE= 1. SURFACE= 1

-17	-16	-16	-15	-14	-13	-12	-10	-8	-6	-4	-2
-8	-8	-7	-7	-7	-7	-6	-6	-5	-5	-4	-4
0	0	0	-1	-1	-2	-2	-2	-3	-3	-4	-4
1	1	1	0	1	0	0	-1	-1	-2	-3	-4

SPEC 3.1

NTF 9 X 12 DOORS
STIFFENER BAR A

0 8
SCALE

Figure 22

DISPLAY= PS2 /1000 . NODE= 1 . SURFACE= 2

-17	-16	-16	-15	-14	-13	-12	-10	-8	-6	-4	-2
-8	-8	-7	-7	-7	-7	-6	-6	-5	-5	-4	-4
0	0	0	-1	-1	-2	-2	-2	-3	-3	-4	-4
1	1	1	0	1	0	0	-1	-1	-2	-3	-4

SPEC
3.1

NTF 9 X 12 DOORS
STIFFENER BAR A

0 SCALE

Figure 23

DISPLAY= PS1 /1000 , NODE= 1 , SURFACE= 0

10/1/1

0	0	0	0	-2	1	0	0	1	1	1	1
0	0	0	0	0	1	1	1	2	2	3	3
1	1	2	2	2	3	3	4	4	4	4	4
10	10	9	9	9	8	8	7	7	6	5	4

SPEC
4.1

NTF 9 X 12 DOORS
STIFFENER BAR B

0 8
SCALE

Figure 24

DISPLAY= PS1 /1000 . NODE= 1 . SURFACE= 1

10/1/1

0	0	0	0	-1	1	0	1	1	1	1	1
0	0	0	0	0	1	1	1	2	2	3	3
1	2	2	2	2	3	3	4	4	4	4	4
10	10	9	9	8	8	8	7	7	6	5	4

SPEC 4.1

NTF 9 X 12 DOORS
STIFFENER BAR B

0 SCALE 8

Figure 25

10/1/1

DISPLAY= PS1 /1000 , NODE= 1 , SURFACE= 2

0	0	0	0	-2	0	0	0	1	1	1	2
0	0	0	0	0	0	1	1	2	2	3	3
1	1	2	2	2	3	3	4	4	4	4	4
10	9	9	9	9	8	8	7	7	6	5	4

SPEC
4.1

NTF 9 X 12 DOORS
STIFFENER BAR B

0 — 8
SCALE

Figure 26

DISPLAY= PS2 /1000 . NODE= 1 . SURFACE= 0 10/1/1

-16	-16	-15	-14	-14	-13	-11	-10	-8	-6	-4	-2
-7	-7	-7	-7	-7	-6	-6	-5	-5	-6	-4	-4
0	0	0	-1	-1	-2	-2	-2	-3	-3	-4	-4
1	1	1	0	1	0	0	0	-1	-1	-2	-4

SPEC
4.1

NTF 9 X 12 DOORS
STIFFENER BAR B

0 SCALE

Figure 27

10/1/1

DISPLAY= PS2 /1000 . NODE= 1 . SURFACE= 1

-16	-16	-15	-15	-12	-12	-11	-10	-8	-6	-4	-3
-7	-7	-7	-7	-6	-6	-6	-5	-5	-5	-4	-4
1	0	0	-1	-1	-1	-2	-2	-3	-3	-4	-4
1	1	1	0	0	0	0	0	-1	-1	-2	-4

SPEC
4.1

NTF 9 X 12 DOORS
STIFFENER BAR B

0 8
SCALE

Figure 28

DISPLAY= PS2 /1000 . NODE= 1 . SURFACE= 2

-16	-16	-15	-14	-1[illegible]	-13	-12	-10	-8	-6	-4	-2
-7	-7	-7	-7	-7	-7	-6	-5	-5	-5	-4	-3
0	0	0	-1	-1	-2	-2	-2	-3	-3	-4	-4
1	1	0	0	1	0	0	0	-1	-2	-3	-4

SPEC 4.1

NTF 9 X 12 DOORS
STIFFENER BAR B

0 8
SCALE

Figure 29

DISPLAY= PS1 /1000 . NODE= 1 . SURFACE= 0

0	0	0	0	-1	0	0	0	0	1	1	1
0	0	0	0	0	0	1	1	1	2	2	3
1	1	2	2	2	2	3	3	3	4	4	4
8	8	8	7	7	7	7	6	6	5	5	3

SPEC
5.1

NTF 9 X 12 DOORS
STIFFENER BAR C

0 SCALE 8

Figure 30

10/1/1

DISPLAY= PS1 /1000 , NODE= 1 , SURFACE= 1

0	0	0	0	0	1	0	0	1	1	1	1
0	0	0	0	0	1	1	1	2	2	2	2
1	2	2	2	2	3	3	3	3	4	4	3
8	8	8	7	5	7	7	6	6	5	5	3

SPEC 5.1

NTF 9 X 12 DOORS
STIFFENER BAR C

0 SCALE 8

Figure 31

10/1/1

DISPLAY= PS1 /1000 , NODE= 1 , SURFACE= 2

0	0	0	1	-2	0	0	0	0	1	1	2
0	0	0	0	0	0	1	1	1	2	3	3
1	1	1	2	2	2	2	3	3	4	4	4
8	8	7	7	8	6	6	6	6	5	4	3

SPEC 5.1

NTF 9 X 12 DOORS
STIFFENER BAR C

0 — 8
SCALE

Figure 32

10/1/1

DISPLAY= PS2 /1000 , NODE= 1 , SURFACE= 0

-13	-13	-13	-12	-11	-11	-9	-8	-7	-5	-3	-2
-6	-6	-6	-6	-5	-5	-5	-4	-4	-4	-4	-3
0	0	0	-1	-1	-1	-1	-2	-2	-3	-3	-4
1	1	1	0	0	0	0	0	-1	-1	-2	-3

SPEC 5.1

NTF 9 X 12 DOORS
STIFFENER BAR C

0 SCALE 8

Figure 33

DISPLAY= PS2 /1000 . NODE= 1. SURFACE= 1

-13	-13	-13	-12	-8	-9	-9	-8	-7	-5	-4	-4
-6	-6	-6	-6	-4	-4	-4	-4	-4	-4	-4	-4
1	0	0	-1	-1	-1	-1	-2	-2	-3	-3	-4
1	1	1	0	0	0	0	0	0	-1	-2	-4

SPEC
5.1

NTF 9 X 12 DOORS
STIFFENER BAR C

0 8
SCALE

Figure 34

10/1/1

DISPLAY= PS2 /1000 . NODE= 1. SURFACE= 2

-13	-13	-13	-12	-14	-12	-10	-9	-7	-5	-3	-1
-6	-6	-6	-6	-7	-6	-5	-5	-4	-4	-3	-2
0	0	-1	-1	0	-2	-2	-2	-2	-3	-3	-3
0	0	0	0	1	0	0	0	-1	-1	-2	-1

SPEC
5.1

NTF 9 X 12 DOORS
STIFFENER BAR C

0 SCALE

Figure 35

DISPLAY= PS1 /1000 . NODE= 1 . SURFACE= 0

10/1/1

0	0	0	0	0	0	0	0	0	0	1	1
0	0	0	0	0	0	0	1	1	1	2	2
1	1	2	2	1	1	1	2	2	3	3	3
6	6	5	4	4	4	5	4	4	4	3	2

SPEC
5.1

NTF 9 X 12 DOORS
STIFFENER BAR D

0 8
SCALE

Figure 36

10 / 1 / 1

DISPLAY= PS1 /1000 . NODE= 1 . SURFACE= 1

0	0	0	0	0	1	0	0	0	0	0	0
1	1	0	0	0	1	1	1	1	1	2	1
2	2	2	2	0	2	2	2	3	3	3	2
6	6	6	5	1	5	5	5	4	4	4	2

SPEC 6.1

NTF 9 X 12 DOORS
STIFFENER BAR D

0 SCALE 8

Figure 37

DISPLAY= PS1 /1000 . NODE= 1. SURFACE= 2 10/1/1

0	0	0	1	-1	-1	0	0	0	1	1	2
0	0	0	1	0	0	0	0	1	1	2	3
1	1	1	2	2	0	1	2	2	2	3	3
5	5	5	4	7	4	4	4	4	4	3	2

SPEC 6.1 NTF 9 X 12 DOORS STIFFENER BAR D

0 SCALE 8

Figure 38

10/1/1

DISPLAY= PS2 /1000 . NODE= 1. SURFACE= 0

-8	-8	-8	-7	-7	-7	-6	-6	-5	-4	-2	-2
-4	-4	-4	-4	-3	-3	-3	-3	-3	-3	-3	-2
1	0	0	-1	0	0	0	-1	-1	-2	-2	-2
1	1	1	0	0	0	1	0	0	0	-1	-2

SPEC 6.1 NTF 9 X 12 DOORS
STIFFENER BAR D

0 8
SCALE

Figure 39

10 / 1 / 1

DISPLAY= PS2 /1000 . NODE= 1 . SURFACE= 1

-6	-8	-6	-8	-3	-4	-6	-5	-5	-4	-4	-4
-3	-3	-3	-4	-2	-1	-2	-2	-2	-3	-3	-4
1	1	0	-1	-1	0	0	0	-1	-1	-2	-3
2	2	2	1	0	1	1	0	0	0	0	-2

SPEC
6.1

NTF 9 X 12 DOORS
STIFFENER BAR D

0 ———— 8
SCALE

Figure 40

DISPLAY= PS2 /1000 . NODE= 1 . SURFACE= 2 10/1/1

-9	-9	-8	-7	-11	-9	-7	-6	-6	-3	-1	0
-4	-4	-4	-3	-5	-6	-4	-3	-3	-2	-2	-1
0	0	-1	-1	1	-1	-1	-1	-1	-2	-2	-2
0	0	0	-1	0	0	1	0	0	-1	-2	-2

SPEC 6.1 NTF 9 X 12 DOORS
STIFFENER BAR D

0 8
SCALE

Figure 41

10/1/1

DISPLAY= PS1 /1000 . NODE= 1. SURFACE= 0

0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	0	1	0	0	0
1	1	1	2	2	2	2	1	1	1	1	1
1	1	1	3	3	2	3	3	3	2	2	2
1	2	3	4	2	4	1	6	6	3	4	3

SPEC 7.1

NTF 9 X 12 DOORS
STIFFENER BAR E

0 — 8
SCALE

Figure 42

DISPLAY= PS1 /1000 . NODE= 1 . SURFACE= 1

2	2	1	0	3	2	1	0	0	-1	-1	-2
2	2	2	1	1	2	2	2	2	1	0	0
2	2	3	2	0	3	3	3	4	3	2	2
4	4	3	4	-1	3	6	6	7	5	4	4
1	2	2	4	6	4	1	6	6	2	3	2

SPEC 7.1 NTF 9 X 12 DOORS
STIFFENER BAR E

0 SCALE

Figure 43

DISPLAY= PS1 /1000 . NODE= 1 . SURFACE= 2 10/1/1

0	0	0	1	0	-1	-1	0	0	2	3	4
-1	-1	0	2	0	-1	-1	-1	0	1	2	3
-1	-1	0	2	3	0	0	0	-1	0	1	1
-1	0	-1	1	6	1	2	1	1	1	0	0
1	2	3	4	-2	4	1	6	6	4	5	5

SPEC 7.1 NTF 9 X 12 DOORS
STIFFENER BAR E

0 SCALE 8

Figure 44

DISPLAY= PS2 /1000 . NODE= 1 . SURFACE= 0 10/1/1

0	0	0	-1	0	-1	-1	-2	-2	-2	-1	-1
0	0	0	-1	0	-1	-1	-1	-1	-1	-1	-1
0	0	0	-1	-1	-1	-1	0	0	0	-1	-1
0	0	-1	0	-4	-1	-2	0	2	0	0	0
-2	0	-4	0	-11	2	-4	0	3	-1	0	1

SPEC 7.1 NTF 9 X 12 DOORS STIFFENER BAR E

0 — 8 SCALE

Figure 45

10/1/1

DISPLAY= PS2 /1000 . NODE= 1 . SURFACE= 1

0	0	0	-1	0	1	0	-1	-2	-5	-6	-6
1	1	0	-1	-1	0	0	0	-1	-3	-4	-4
2	2	1	-1	-2	0	1	1	1	0	-1	-2
3	3	2	2	-6	1	1	3	4	4	3	2
-2	0	-4	0	-11	2	-4	0	3	-1	0	1

SPEC 7.1

NTF 9 X 12 DOORS
STIFFENER BAR E

0 8
SCALE

Figure 46

DISPLAY= PS2 /1000 . NODE= 1. SURFACE= 2

10/1/1

-1	-1	-1	0	-4	-3	-3	-2	-1	1	1	2
-1	-1	-1	-1	0	-2	-2	-2	-1	0	0	0
-2	-2	-2	-1	-1	-2	-3	-2	-1	-2	-2	-2
-4	-3	-6	-3	-3	-3	-5	-4	-1	-4	-4	-3
-2	0	-4	1	-11	2	-4	0	3	-1	0	1

SPEC 7.1

NTF 9 X 12 DOORS
STIFFENER BAR E

0 SCALE

Figure 47

10/1/1

DISPLAY= PS1 /1000 . NODE= 1. SURFACE= 0

3	2	2	1
3	3	2	1
3	2	1	0
2	1	1	1
2	1	0	0
2	1	0	0
1	0	0	0
0	0	1	1
1	0	0	0
1	1	0	0
1	0	0	0
-1	0	1	2
1	0	0	0
1	1	0	0
1	0	0	0
-1	0	1	2

SPEC 8.1 NTF 9 X 12 DOORS STIFFENER BAR F

0 11 SCALE

Figure 48

DISPLAY= PS1 /1000 , NODE= 1 , SURFACE= 1

3	2	1	0
4	3	2	1
3	2	2	1
1	1	1	1
2	1	0	-1
2	1	0	0
2	1	0	0
-1	-1	0	1
1	0	0	-1
2	1	0	0
2	1	0	0
-1	-1	0	1
1	0	0	-1
2	1	0	0
2	0	0	0
0	-1	1	2

SPEC 8.1 NTF 9 X 12 DOORS
STIFFENER BAR F

0 11
SCALE

Figure 49

10/1/1

DISPLAY= PS1 /1000 . NODE= 1 . SURFACE= 2

3	2	2	2
3	2	2	1
2	1	0	0
3	2	1	0
2	1	1	1
1	1	0	0
0	0	0	0
2	1	1	1
0	0	1	0
0	0	0	0
0	0	0	0
1	6	1	2
0	0	1	0
0	1	0	0
0	0	1	0
0	0	1	3

SPEC 8.1

NTF 9 X 12 DOORS
STIFFENER BAR F

0 11
SCALE

Figure 50

DISPLAY= PS2 /1000 , NODE= 1 , SURFACE= 0

10/1/1

-3	-3	-2	-1
-1	-3	-3	-2
-1	-2	-3	-4
-2	-2	-3	-5
-1	-2	-3	-5
0	-2	-3	-6
0	-2	-4	-6
-1	-2	-4	-6
-1	-2	-4	-6
0	-2	-4	-6
-1	-3	-4	-6
-2	-2	-4	-6
-2	-2	-4	-6
-1	-3	-4	-5
-1	-3	-4	-5
-2	-3	-4	-6

SPEC 8.1

NTF 9 X 12 DOORS
STIFFENER BAR F

0 SCALE 1

Figure 51

DISPLAY= PS2 /1000 , NODE= 1 , SURFACE= 1

-3	-3	-3	-3
-1	-3	-3	-3
-1	-2	-2	-2
-2	-2	-2	-1
0	-2	-4	-6
0	-1	-3	-5
1	-1	-3	-5
-2	-2	-3	-4
0	-2	-4	-6
0	-2	-4	-6
0	-2	-4	-5
-3	-3	-4	-6
-1	-2	-4	-6
-1	-3	-4	-5
0	-3	-4	-5
-4	-4	-5	-6

SPEC
8.1

NTF 9 X 12 DOORS
STIFFENER BAR F

0 SCALE 11

Figure 52

DISPLAY= PS2 /1000 , NODE= 1 , SURFACE= 2

-3	-3	-1	0
-2	-3	-3	-2
-2	-3	-4	-5
-1	-2	-5	-8
-1	-1	-3	-4
0	-2	-4	-6
-1	-2	-4	-7
-1	-1	-4	-8
-1	-2	-4	-5
-1	-3	-4	-6
-1	-3	-5	-6
-2	-1	-4	-7
-2	-3	-4	-6
-2	-3	-4	-5
-2	-3	-4	-6
-2	-2	-4	-5

SPEC 8.1 NTF 9 X 12 DOORS STIFFENER BAR F

0 11 SCALE

Figure 53

DISPLAY= PS1 /1000 . NODE= 1. SURFACE= 0

3	1	1	0	0
0	1	1	0	0
1	1	0	0	0
2	1	0	0	1
4	2	2	2	2
-5	0	2	2	2
3	0	1	2	3
3	1	1	2	3
5	2	2	3	4
-8	-1	2	3	5
4	1	2	3	5
3	1	2	3	5
5	2	2	3	5
-8	-1	2	4	6
4	1	2	4	6
3	2	2	4	5

SP[illegible]
9.1

NTF 9 X 12 DOORS
STIFFENER BAR G

0 11
SCALE

Figure 54

10/1/1

DISPLAY= PS1 /1000 , NODE= 1. SURFACE= 1

3	3	1	0	0
0	2	2	1	0
2	2	1	2	2
1	-1	-1	1	4
4	4	2	2	1
-5	3	3	3	5
3	2	2	3	4
0	0	0	1	5
5	4	2	3	4
-7	2	4	4	5
4	3	2	4	6
0	0	1	2	5
5	4	2	3	5
-7	2	3	4	6
4	3	3	4	5
0	1	1	2	5

SPEC 9.1

NTF 9 X 12 DOORS
STIFFENER BAR G

0 1
SCALE

Figure 55

10/1/1

DISPLAY= PS1 /1000 . NODE= 1. SURFACE= 2

3	1	0	1	1
1	0	0	0	0
1	-1	0	0	0
4	3	1	1	0
4	1	2	3	2
-5	-2	1	2	2
3	-1	0	1	2
5	3	2	2	2
6	0	2	3	4
-8	-3	1	3	4
4	-1	1	2	4
6	3	3	4	5
5	0	1	3	5
-8	-4	1	3	5
4	0	1	3	6
6	4	4	5	6

SPEC 9.1

NTF 9 X 12 DOORS
STIFFENER BAR G

0 11
SCALE

Figure 56

DISPLAY= PS2 /1000 , NODE= 1 , SURFACE= 0

10/1/1

1	-1	-1	-1	-1
-4	-2	-1	-1	0
-1	0	0	0	0
-1	0	0	0	0
3	-3	-4	-2	-1
-15	-6	-4	-2	-1
-7	-2	-1	-1	0
-2	-1	-1	0	0
3	-4	-4	-2	-1
-20	-11	-5	-2	0
-10	-4	-2	-1	0
-2	-2	-2	0	1
3	-3	-4	-2	-1
-20	-10	-4	-2	0
-10	-4	-2	-1	0
-2	-3	-2	0	1

SPEC 9.1

NTF 9 X 12 DOORS
STIFFENER BAR G

0 11
SCALE

Figure 57

10/1/1

DISPLAY= PS2 /1000 . NODE= 1 . SURFACE= 1

1	0	-1	-2	-2
-4	0	0	0	0
0	1	0	0	0
-1	-2	-1	-1	0
3	-2	-4	-3	-2
-15	-6	-3	-2	-1
-6	-1	0	-1	0
-2	-4	-3	-1	0
4	-2	-4	-3	-2
-20	-7	-4	-2	-1
-10	-2	-1	-1	0
-2	-6	-4	-1	0
4	-1	-3	-2	-1
-20	-6	-3	-2	-1
-3	-2	-1	-1	-1
-2	-6	-4	-1	0

SPEC 9.1 NTF 9 X 12 DOORS STIFFENER BAR G

0 11 SCALE

Figure 58

10/1/1

DISPLAY= PS2 /1000 . NODE= 1 . SURFACE= 2

1	-3	-2	-1	0
-4	-5	-2	-1	-1
-1	-1	-1	-1	-1
-1	1	1	-1	-2
2	-6	-4	-2	0
-15	-12	-5	-2	0
-8	-3	-2	-1	-1
-2	1	1	1	1
2	-6	-4	-2	0
-21	-15	-5	-2	0
-11	-6	-2	-1	0
-3	0	0	1	1
2	-6	-4	-1	0
-20	-15	-5	-1	0
-11	-6	-2	-1	0
-3	-1	-1	1	2

SPEC 9.1

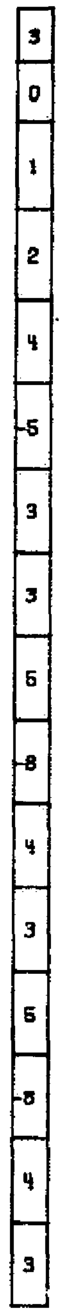
NTF 9 X 12 DOORS
STIFFENER BAR G

0 SCALE 11

Figure 59

10/1/1

DISPLAY= PS1 /1000 . NODE= 1 . SURFACE= 0



SPEC
10.1

NTF 9 X 12 DOORS
SEAL FLANGE - TOP

0 11
SCALE

Figure 60

10/1/1

DISPLAY= PS1 /1000 . NODE= 1. SURFACE= 1

SPEC 10.1

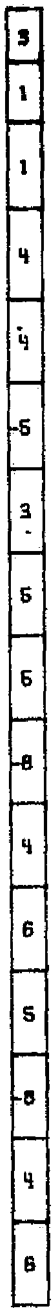
NTF 9 X 12 DOORS
SEAL FLANGE - TOP

0 11
SCALE

Figure 61

10 / 1 / 1

DISPLAY= PS1 / 1000 . NODE= 1 . SURFACE= 2



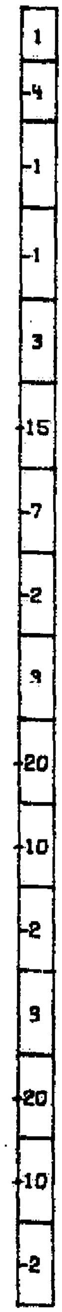
SPEC 10.1

NTF 9 X 12 DOORS
SEAL FLANGE - TOP

0 SCALE 11

Figure 62

DISPLAY= PS2 /1000 . NODE= 1 . SURFACE= 0



SPEC
10-1

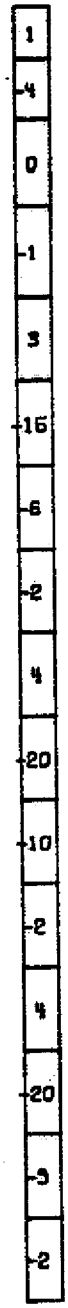
NTF 9 X 12 DOORS
SEAL FLANGE - TOP

0 SCALE 11

Figure 63

10/1/1

DISPLAY= PS2 /1000 , NODE= 1 , SURFACE= 1



SPEC
10.1

NTF 9 X 12 DOORS
SEAL FLANGE - TOP

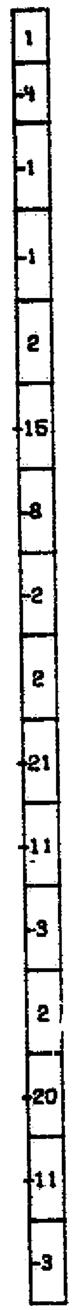
0 11
SCALE

Figure 64

23

DISPLAY= PS2 /1000 . NODE= 1 , SURFACE= 2

10/1/1



SPEC 10.1

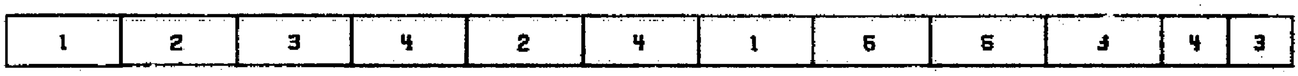
NTF 9 X 12 DOORS
SEAL FLANGE - TOP

0 SCALE 11

Figure 65

10/1/1

DISPLAY= PS1 /1000 , NODE= 1 , SURFACE= 0



SPEC
11.1

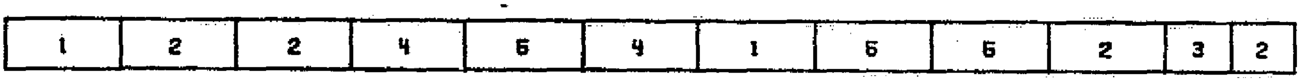
NTF 9 X 12 DOORS
SEAL FLANGE - SIDE

0 8
SCALE

Figure 66

DISPLAY= PS1 /1000 , NODE= 1 , SURFACE= 1

10/1/1



SPEC
11.1

NTF 9 X 12 DOORS
SEAL FLANGE - SIDE

0 8
SCALE

Figure 67

10/1/1

ISPLAY= PS1 /1000 , NODE= 1 , SURFACE= 2

SPEC
11.1

NIF 9 X 12 DOORS
SEAL FLANGE - SIDE

0 SCALE 8

Figure 68

10/1/1

DISPLAY= PS2 /1000 . NODE= 1 . SURFACE= 0

-2	0	-4	0	-11	2	-4	0	3	-1	0	1

SPEC 11.1

NTF 9 X 12 DOORS
SEAL FLANGE - SIDE

0 SCALE

Figure 69

DISPLAY= PS2 /1000 , NODE= 1. SURFACE= 1 10/1/1

-2	0	-4	0	-11	2	-4	0	3	-1	0	1

SPEC 11.1 NTF 9 X 12 DOORS
SEAL FLANGE - SIDE

0 8 SCALE

Figure 70

DISPLAY= PS2 /1000 . NODE= 1. SURFACE= 2 . 10/1/1

-2	0	-4	1	-11	2	-4	0	3	-1	0	1

SPEC
11.1

NTF 9 X 12 DOORS
SEAL FLANGE - SIDE

0 SCALE 8

Figure 71