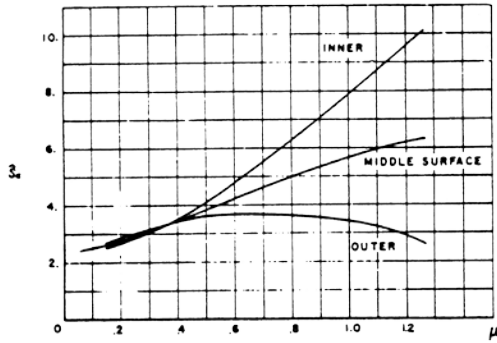
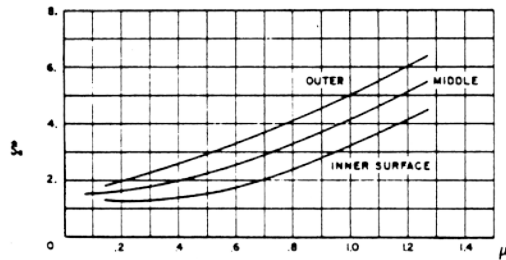


Figure 1

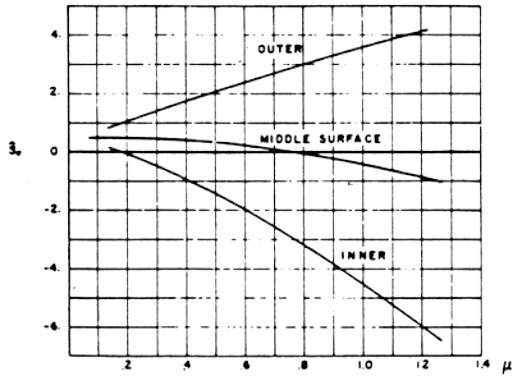


A— \hat{S}_r for $\phi = 0$ vs. $\beta\rho_0$ (capped cylinder), $\nu = 0.3$

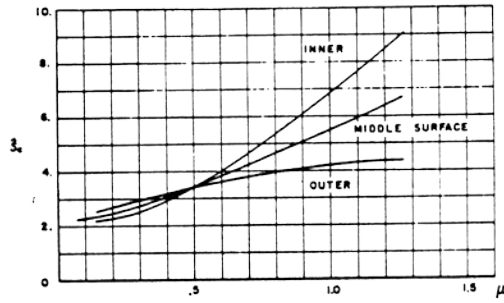


C— \hat{S}_r for $\phi = \pi/4$ vs. $\beta\rho_0$ (capped cylinder), $\nu = 0.3$

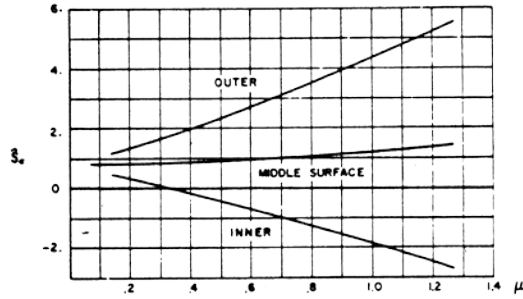
NOTE
 REFERENCE: "STATE OF STRESS IN A CIRCULAR CYLINDRICAL SHELL WITH A CIRCULAR HOLE," WELDING RESEARCH COUNCIL BULLETIN 102, 1965.



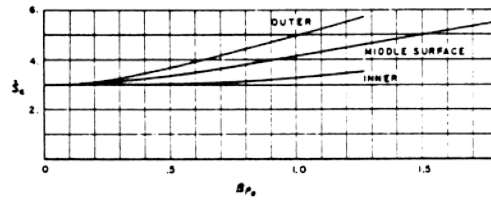
E— \hat{S}_r for $\phi = \pi/2$ vs. $\beta\rho_0$ (capped cylinder), $\nu = 0.3$



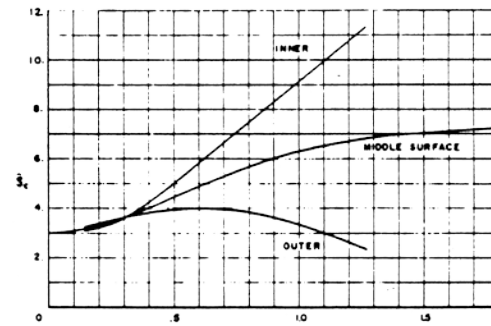
B— \hat{S}_r for $\phi = \pi/8$ vs. $\beta\rho_0$ (capped cylinder), $\nu = 0.3$



D— \hat{S}_r for $\phi = 3\pi/8$ vs. $\beta\rho_0$ (capped cylinder), $\nu = 0.3$



F— \hat{S}_r at $\phi = \pi/2$ for Case II (extension case) vs. $\beta\rho_0$, $\nu = 0.3$



G— \hat{S}_r at $\phi = 0$ for Case III (internal pressure), $\nu = 0.3$

GILBERT ASSOCIATES, INC.

FIGURE 1

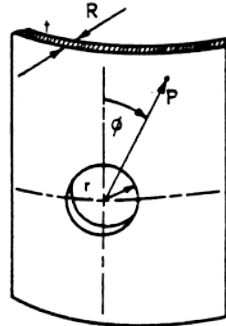
Figure 2

Table 3—Stress Concentration Factor Variations for Different β_{Po} at Various Angles—Capped Cylinder

β_{Po}	$r = 0.30$		
	$(\hat{S}_c)_{upper}$	S_c	$(\hat{S}_c)_{lower}$
$\phi = 0$			
0.14142	2.75054	2.64709	2.54365
0.21213	2.94174	2.81900	2.69625
0.28284	3.13290	3.03670	2.94050
0.35355	3.30842	3.28570	3.26297
0.42426	3.45933	3.55467	3.65001
0.49497	3.58032	3.83486	4.08940
0.56568	3.66795	4.11911	4.57027
0.63639	3.72044	4.40201	5.08357
0.70710	3.73656	4.67874	5.62091
0.84852	3.66013	5.20121	6.74228
0.98994	3.44158	5.66483	7.88789
1.13137	3.09080	6.06690	9.02300
1.27279	2.61996	6.37120	10.12243
$\phi = \pi/8$			
0.14142	2.46986	2.33179	2.19372
0.21213	2.66925	2.47978	2.29030
0.28284	2.87265	2.67011	2.46758
0.35355	3.06813	2.89212	2.71611
0.42426	3.25013	3.13783	3.02553
0.49497	3.41823	3.40126	3.38629
0.56568	3.56589	3.67806	3.79024
0.63639	3.69959	3.96509	4.23059
0.70710	3.81810	4.25958	4.70107
0.84852	4.01561	4.86482	5.71403
0.98994	4.16952	5.48212	6.79472
1.13137	4.29120	6.10374	7.91627
1.27279	4.39120	6.72431	9.05741
$\phi = \pi/4$			
0.14142	1.79394	1.56884	1.34374
0.21213	2.01190	1.65385	1.29580
0.28284	2.23906	1.76710	1.29514
0.35355	2.46909	1.90438	1.33966
0.42426	2.70142	2.06304	1.42466
0.49497	2.93776	2.24160	1.54544
0.56568	3.18071	2.43944	1.69816
0.63639	3.43312	2.65648	1.87983
0.70710	3.69754	2.89277	2.08800
0.84852	4.27107	3.42439	2.57771
0.98994	4.91382	4.03512	3.15642
1.13137	5.63074	4.72359	3.81643
1.27279	6.42060	5.48575	4.55090
$\phi = 3\pi/8$			
0.14142	1.12040	0.80340	0.48640
0.21213	1.35527	0.81807	0.28087
0.28284	1.59750	0.83819	0.07888
0.35355	1.84227	0.86252	-0.11723
0.42426	2.08946	0.88996	-0.30954
0.49497	2.34032	0.91983	-0.50065
0.56568	2.59629	0.95182	-0.69263
0.63639	2.85862	0.98593	-0.88675
0.70710	3.12823	1.02243	-1.08337
0.84852	3.69078	1.10414	-1.48249
0.98994	4.28578	1.20142	-1.88293
1.13137	4.91210	1.31959	-2.27291
1.27279	5.56731	1.46418	-2.63894
$\phi = \pi/2$			
0.21213	1.08342	0.46892	-0.14557
0.28284	1.32929	0.44570	-0.43787
0.35355	1.57420	0.41483	-0.74454
0.42426	1.81691	0.37473	-1.06744
0.49497	2.05720	0.32403	-1.40912
0.56568	2.29480	0.26158	-1.77164
0.63639	2.52926	0.18654	-2.15617
0.70710	2.75997	0.09861	-2.56273
0.84852	3.20626	-0.11635	-3.43897
0.98994	3.62829	-0.38079	-4.38988
1.13137	4.02201	-0.68968	-5.40137
1.27279	4.38777	-1.03524	-6.45827

Table 3-Continued

β_{Po}	\hat{S}_c (Middle Surface only)					
	$\phi = 0$	$\pi/10$	$\pi/5$	$3\pi/10$	$2\pi/5$	$\pi/2$
1.4142	6.6163	7.1556	7.2307	4.7269	0.6424	-1.4030
1.5909	6.7936	7.7349	8.3542	5.6384	0.6623	-1.8994
1.7677	6.9059	8.4207	9.5285	6.6467	0.7164	-2.4293



$$\mu = \frac{1}{2} \sqrt[4]{3(1-\nu^2)} \frac{r}{\sqrt{Rt}}$$

The membrane stress concentration factor S_c and the total stress concentration factor \hat{S}_c are, respectively, defined by

$$S_c = \frac{\text{largest of } (N_1, N_2)}{\text{largest of } (N_1^0, N_2^0)} = \hat{S}_c \quad (\text{middle surface})$$

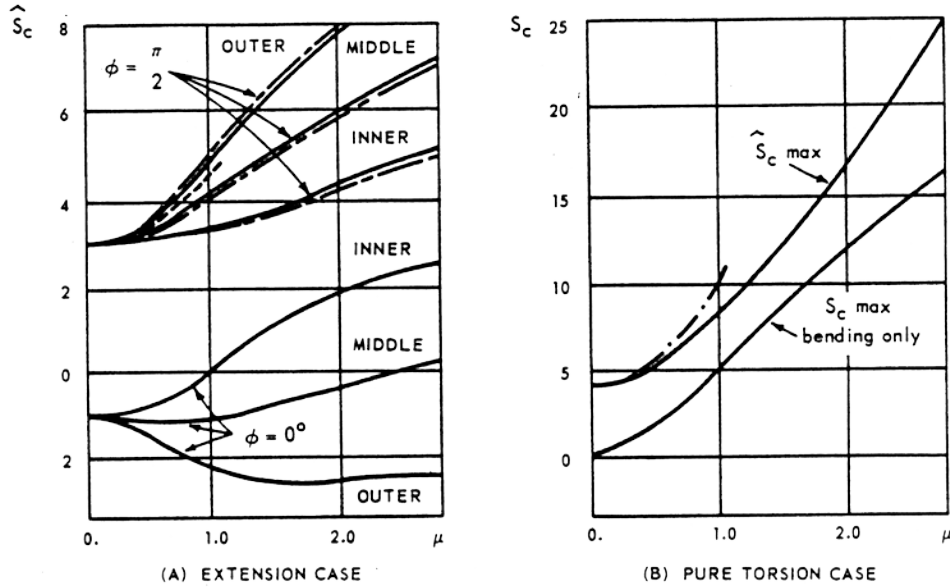
$$\hat{S}_c = \frac{\text{largest of } (\sigma_1, \sigma_2)}{\text{largest of } (\sigma_1^0, \sigma_2^0)} \quad (\text{for fixed } r, \phi)$$

where N_1^0, N_2^0 are the nominal principal stress resultants and σ_1^0, σ_2^0 are the nominal flexural stresses for the shell under the same loading but without the hole. N_1 and N_2 denote the principal stress resultants, σ_1 and σ_2 the principal stresses respectively. The stress concentration factor is calculated as a function of ϕ .

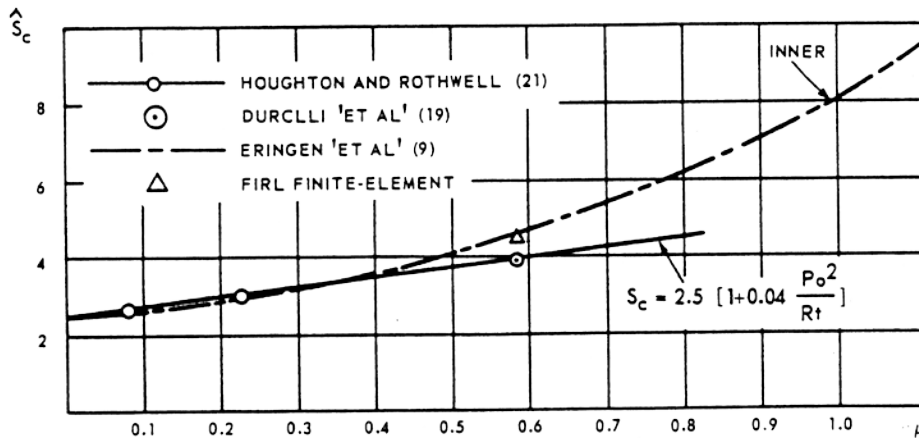
NOTE
REFERENCE: "STATE OF STRESS IN A CIRCULAR CYLINDRICAL SHELL WITH A CIRCULAR HOLE." WELDING RESEARCH COUNCIL BULLETIN 102, 1965.

Figure 3

STRESS DISTRIBUTION AROUND OPENINGS IN CYLINDRICAL SHELLS



- LIKERKKEKER (11)
- ERINGEN, NAGHDI AND THIEL (9)
- LUR'E (1)
- · - · - SHEVLIAKOV AND ZIEGEL (11)

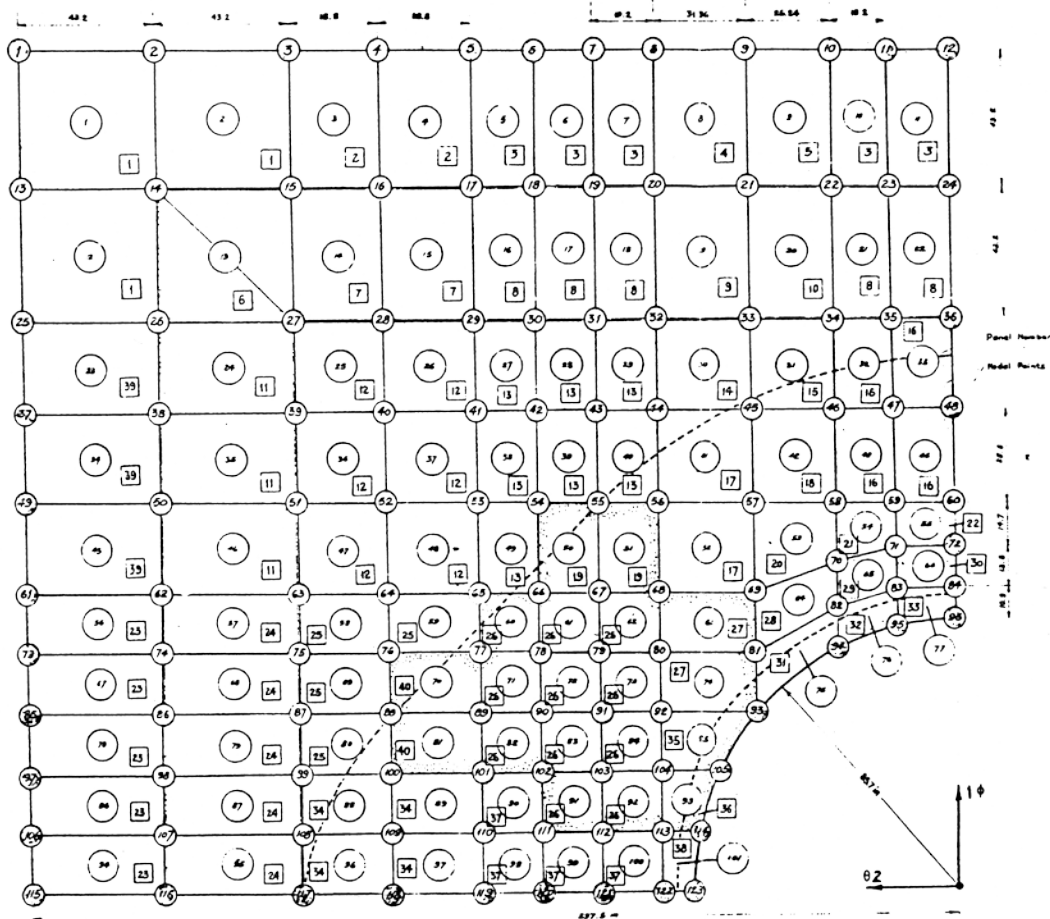


GILBERT ASSOCIATES, INC.

FIGURE 3

Figure 4

GRID FOR FINITE ELEMENT ANALYSIS
 OF THE STRESSES AROUND OPENINGS



- Node Point Number
- Panel Number
- Panel type number.

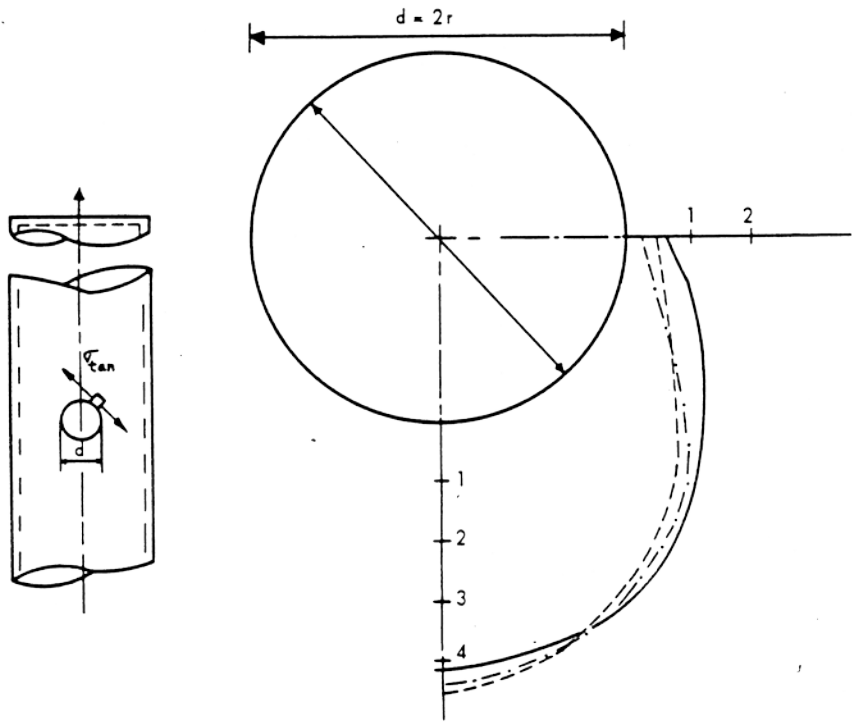
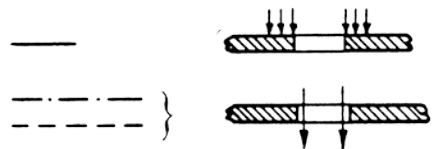
GILBERT ASSOCIATES, INC.

FIGURE 4

Figure 5

MEMBRANE STRESS AROUND OPENING EDGE
(VESSEL SUBJECT TO INTERNAL PRESSURE)

EXPERIMENTAL (REF. 19)
THEORETICAL
VAN DICKE, ERINGEN 'ET AL'
FINITE ELEMENT SOLUTION

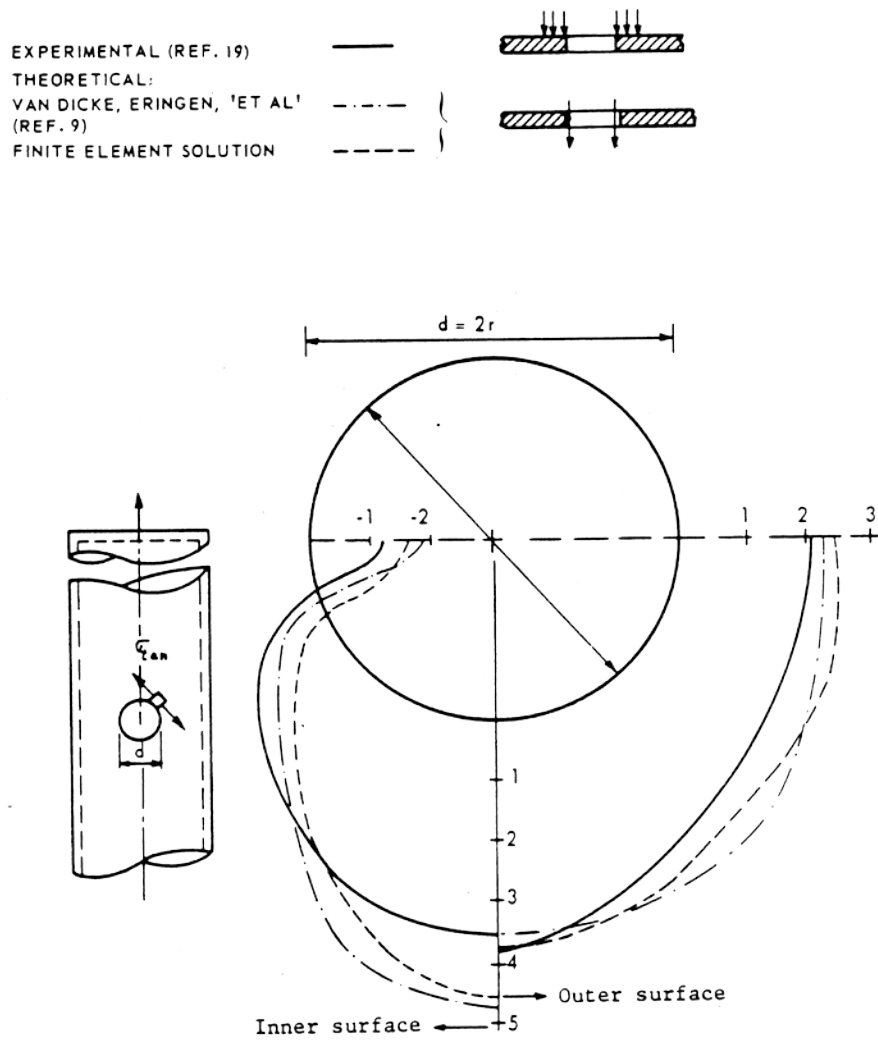


GILBERT ASSOCIATES, INC.

FIGURE 5

Figure 6

SURFACE STRESSES AROUND-OPENING EDGE
 (VESSEL SUBJECT TO INTERNAL PRESSURE)

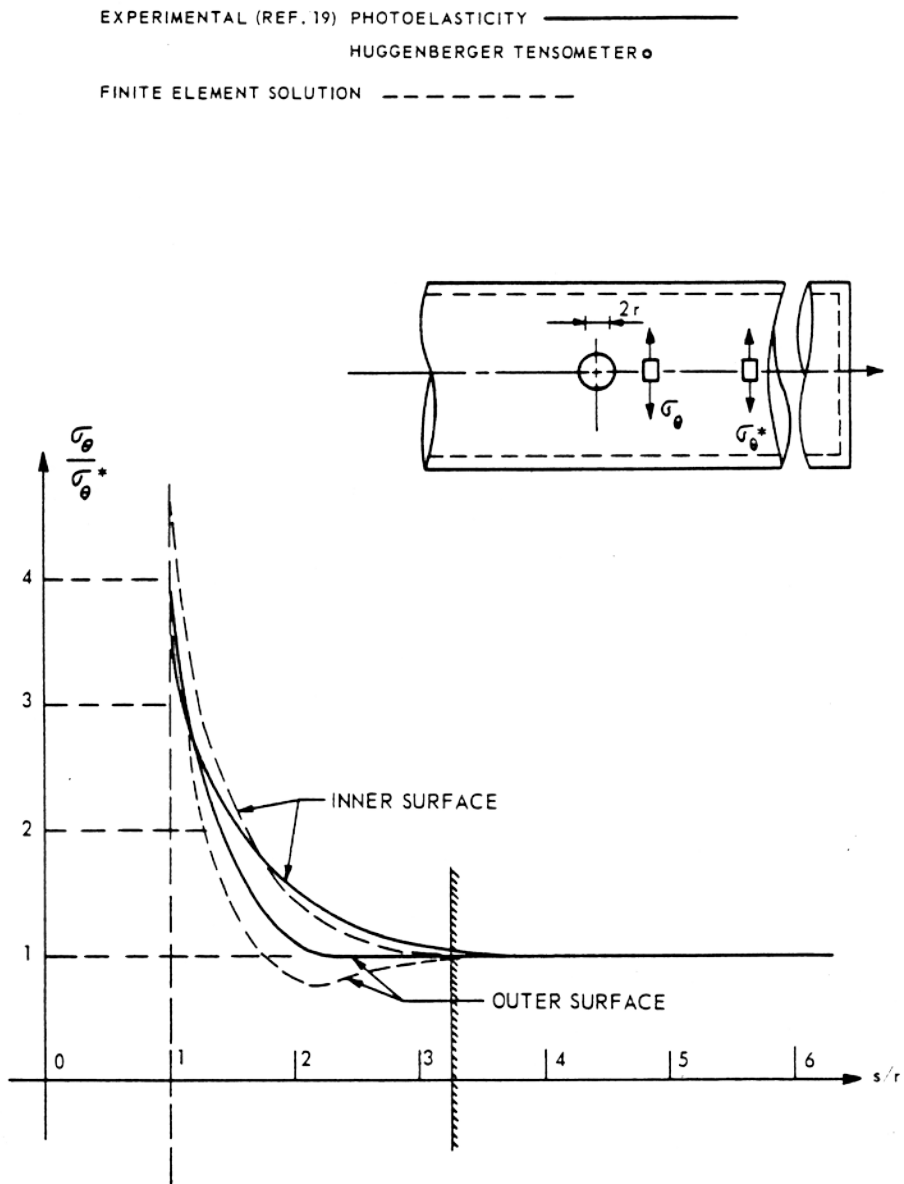


GILBERT ASSOCIATES, INC.

FIGURE 6

Figure 7

HOOP STRESSES ALONG LONGITUDINAL AXIS
(VESSEL SUBJECT TO INTERNAL PRESSURE)

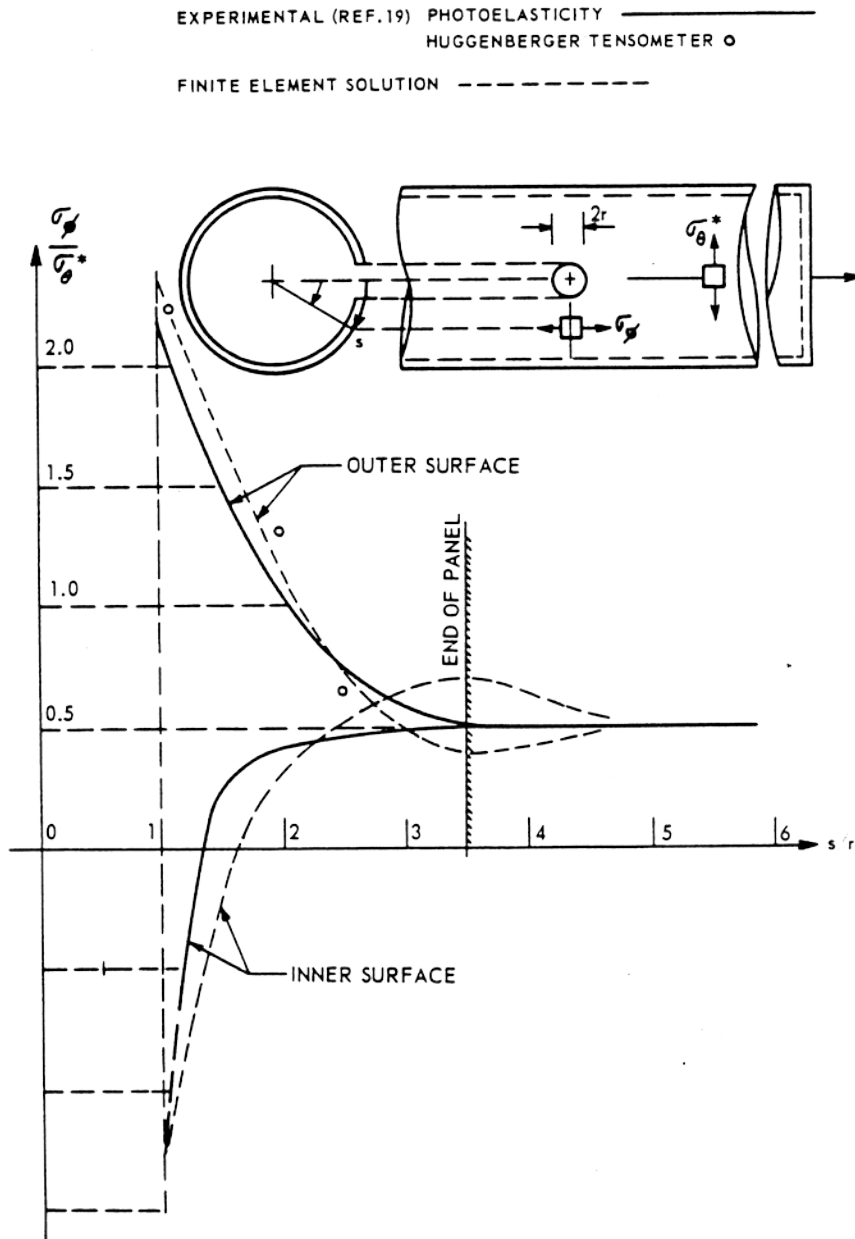


GILBERT ASSOCIATES, INC.

FIGURE 7

Figure 8

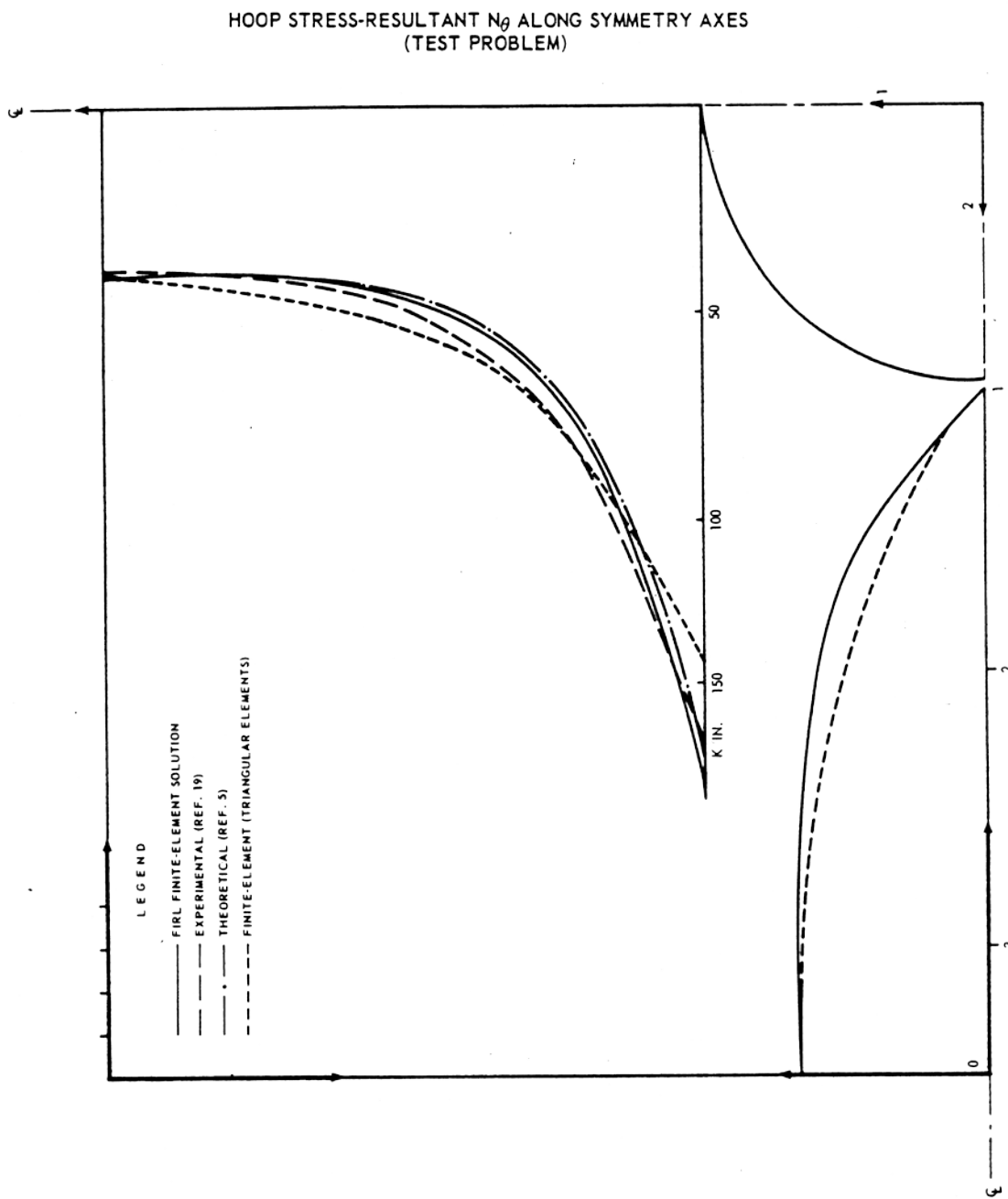
AXIAL STRESSES ALONG TRANSVERSE AXIS
(VESSEL SUBJECT TO INTERNAL PRESSURE)



GILBERT ASSOCIATES, INC.

FIGURE 8

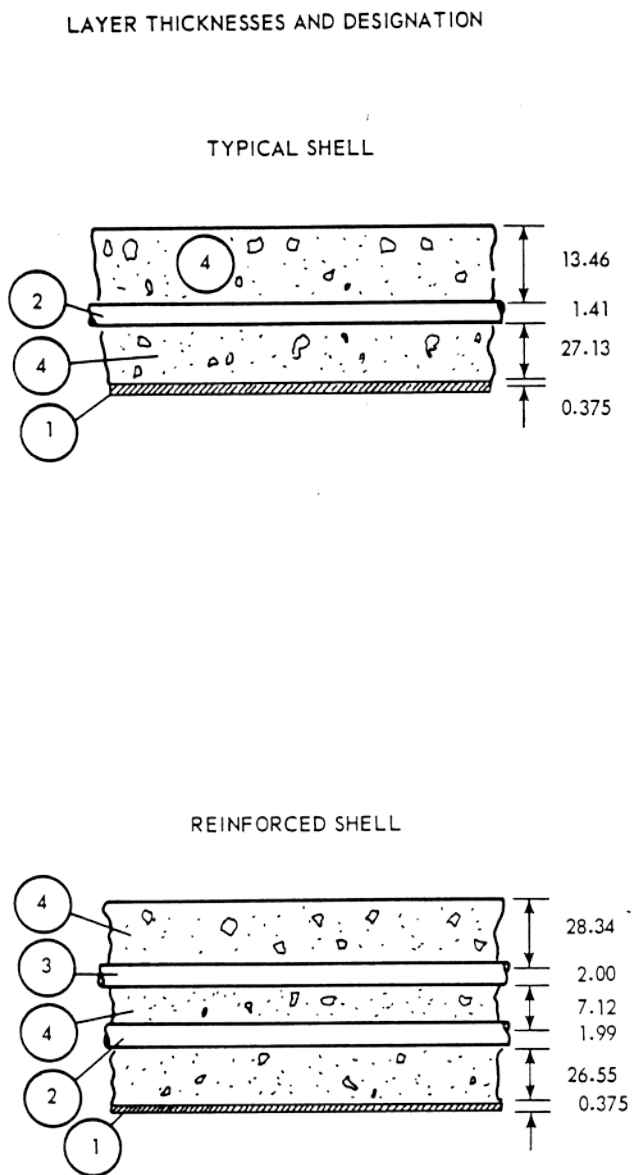
Figure 9



GILBERT ASSOCIATES, INC.

FIGURE 9

Figure 10

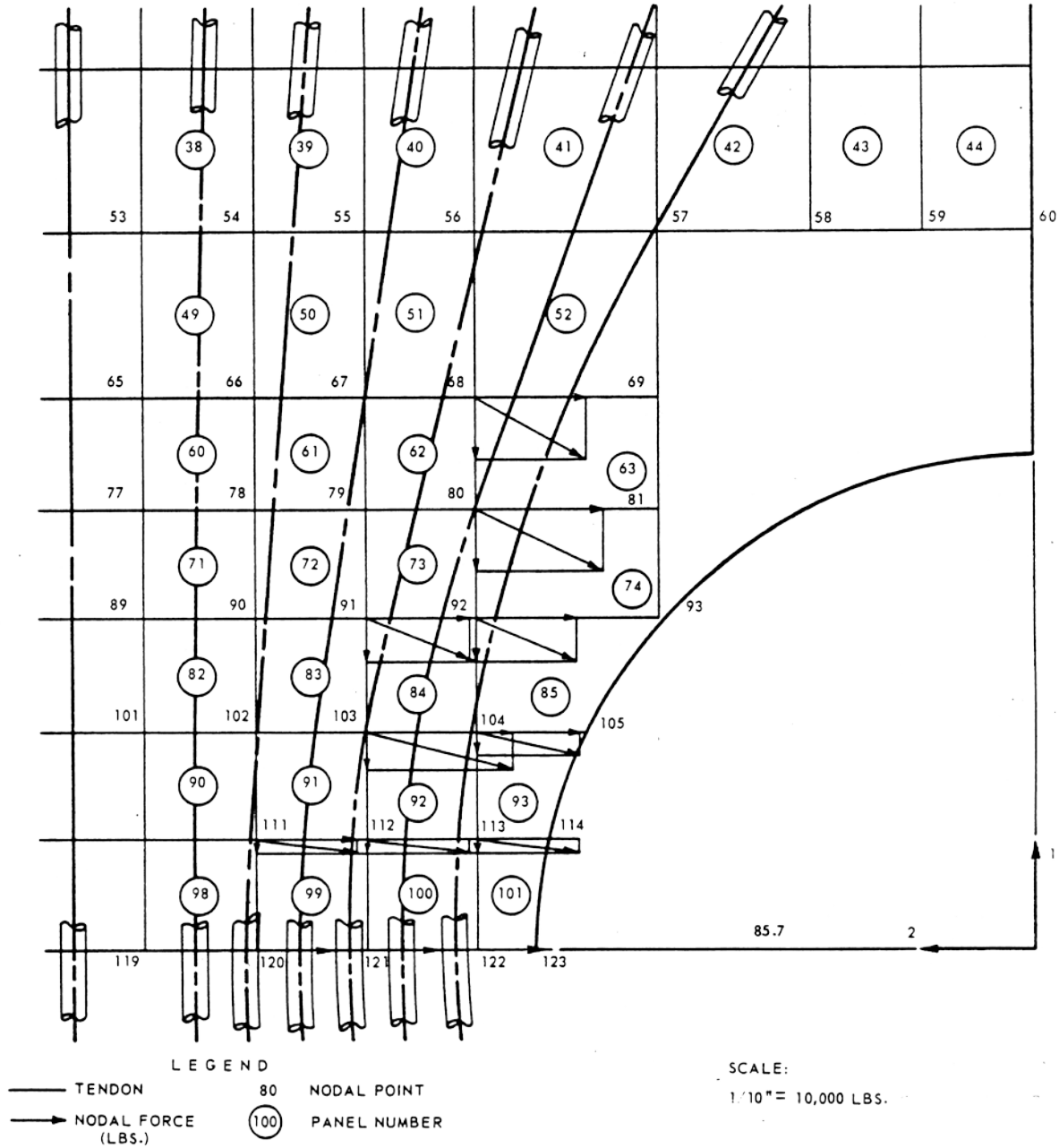


GILBERT ASSOCIATES, INC.

FIGURE 10

Figure 11

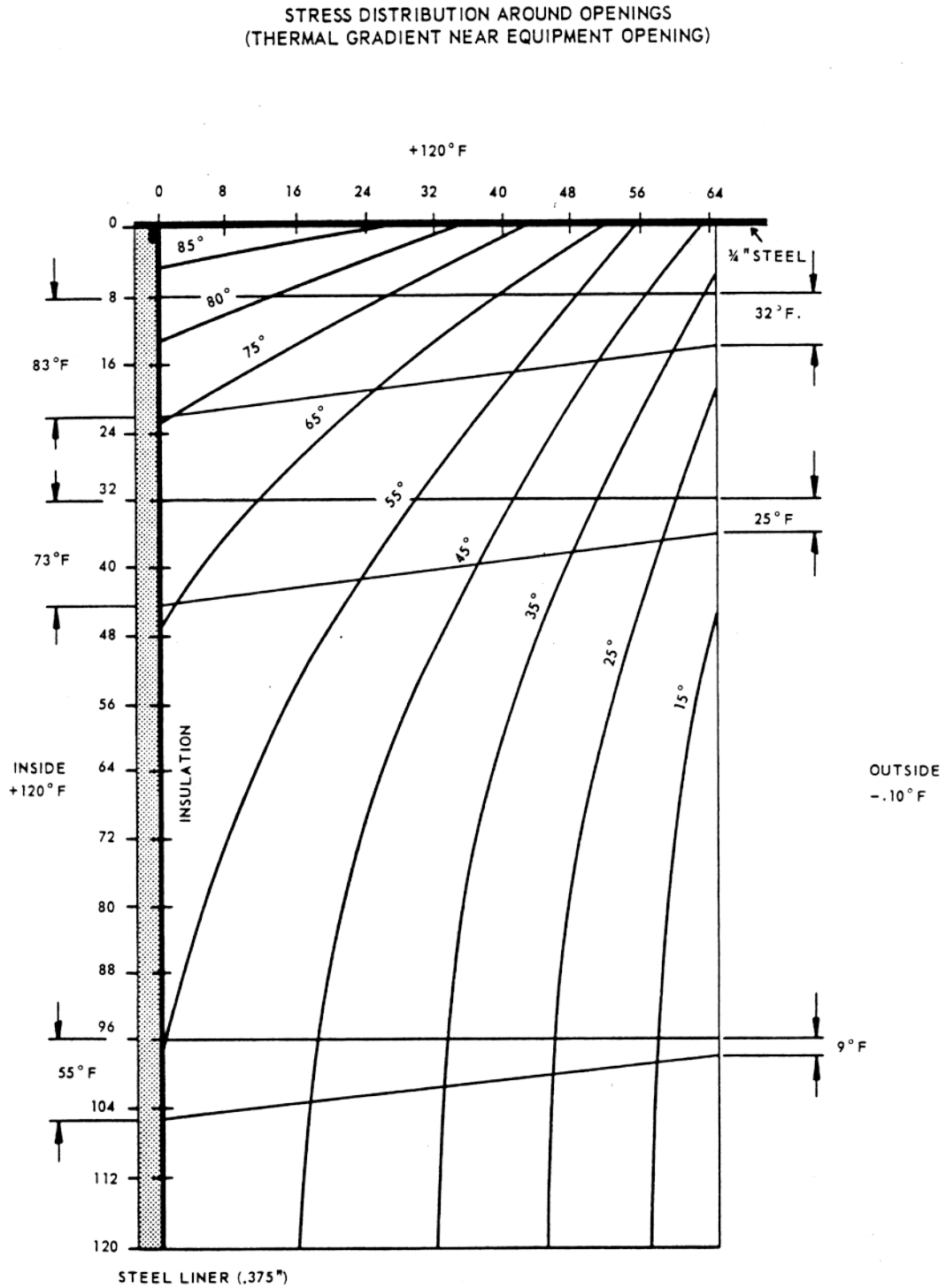
NODAL FORCES DUE TO CURVATURE OF TENDONS IN NEIGHBORHOOD OF OPENING



GILBERT ASSOCIATES, INC.

FIGURE 11

Figure 12

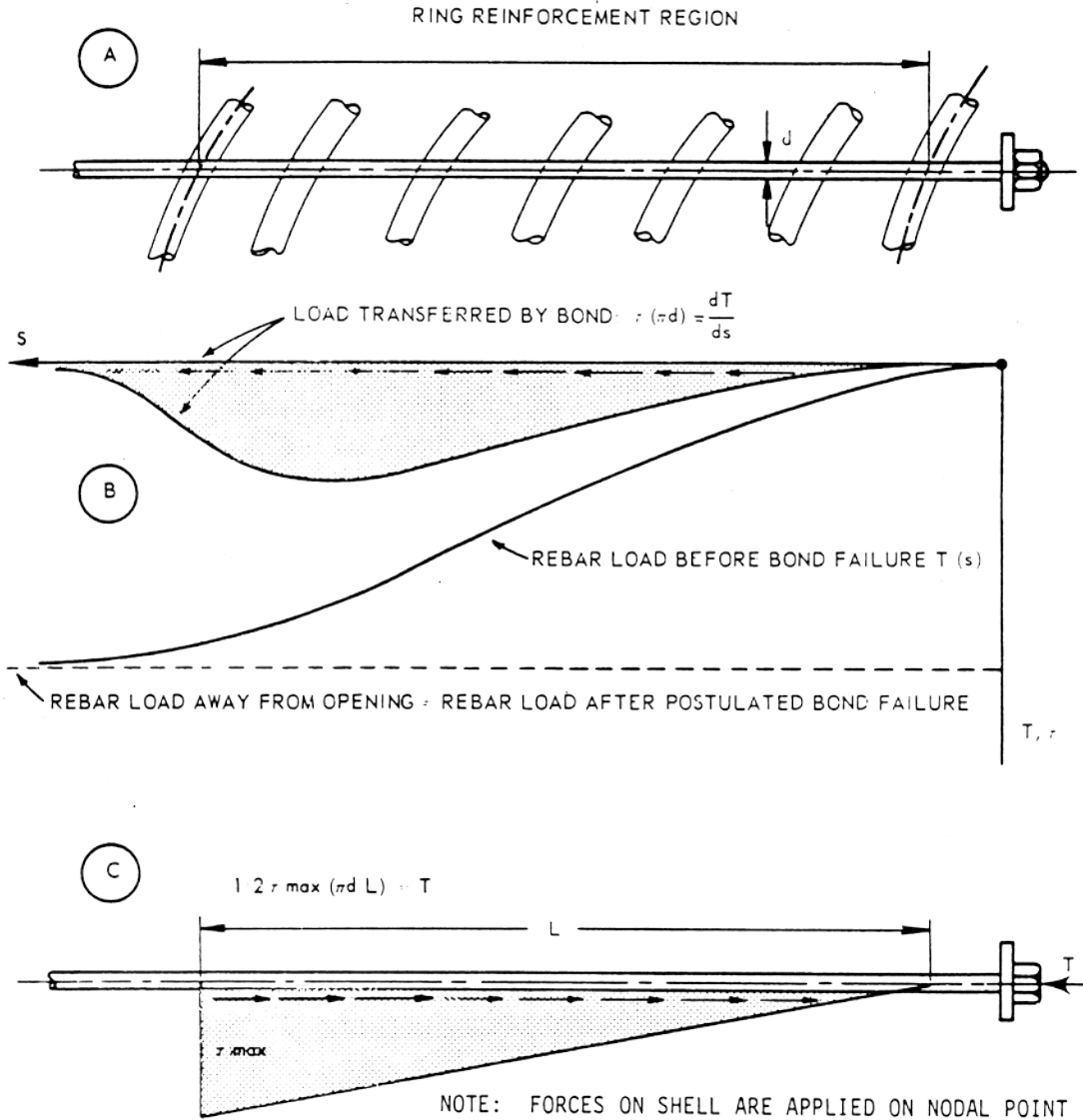


GILBERT ASSOCIATES, INC.

FIGURE 12

Figure 14

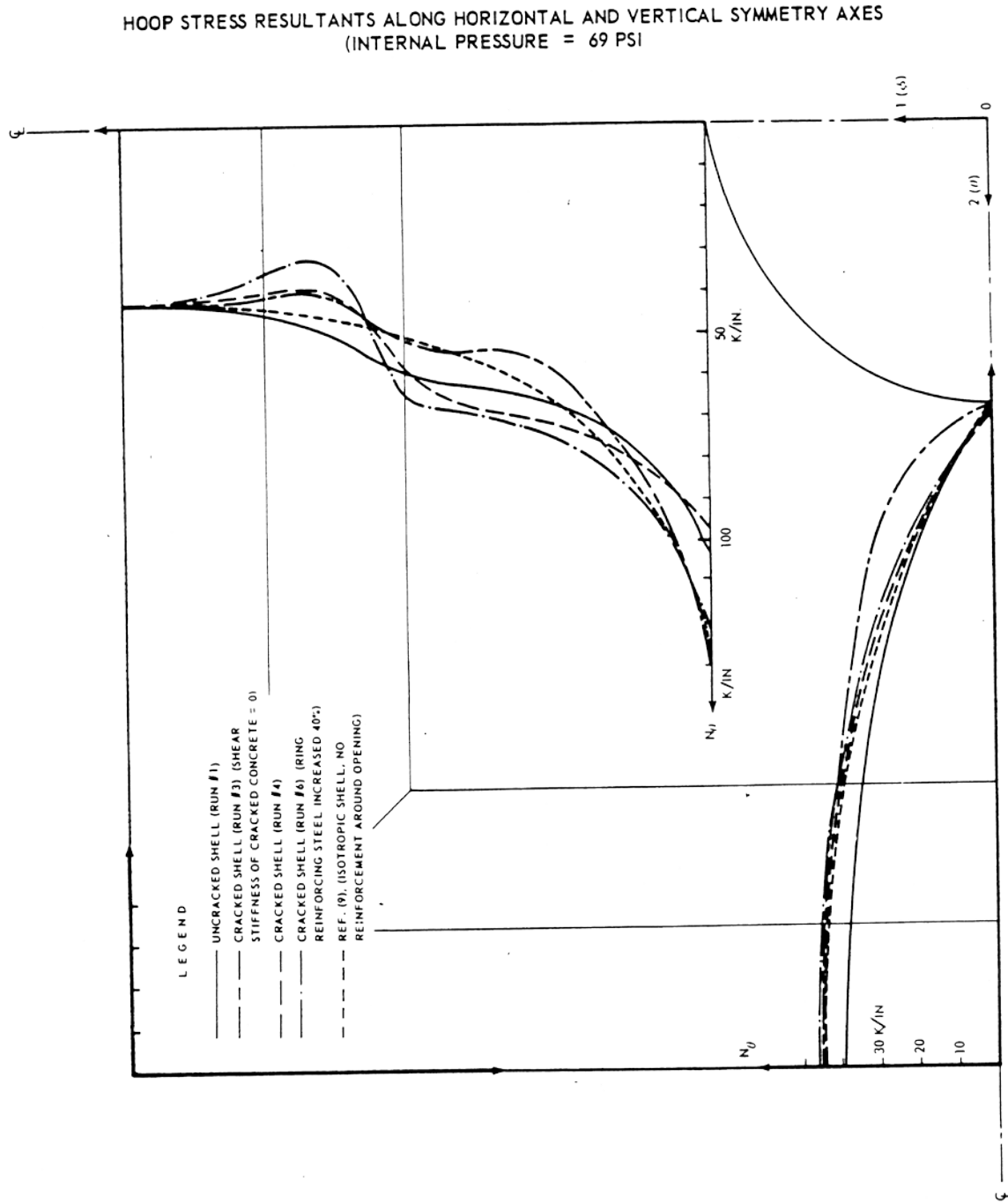
STRESS DISTRIBUTION AROUND OPENINGS
 (EFFECT OF BOND FAILURE ALONG TERMINATED REBARS)



NOTE: FORCES ON SHELL ARE APPLIED ON NODAL POINT NUMBERS 100-104, 109-113, and 118-122.

LOADS APPLIED IN FINITE ELEMENT ANALYSIS

Figure 15

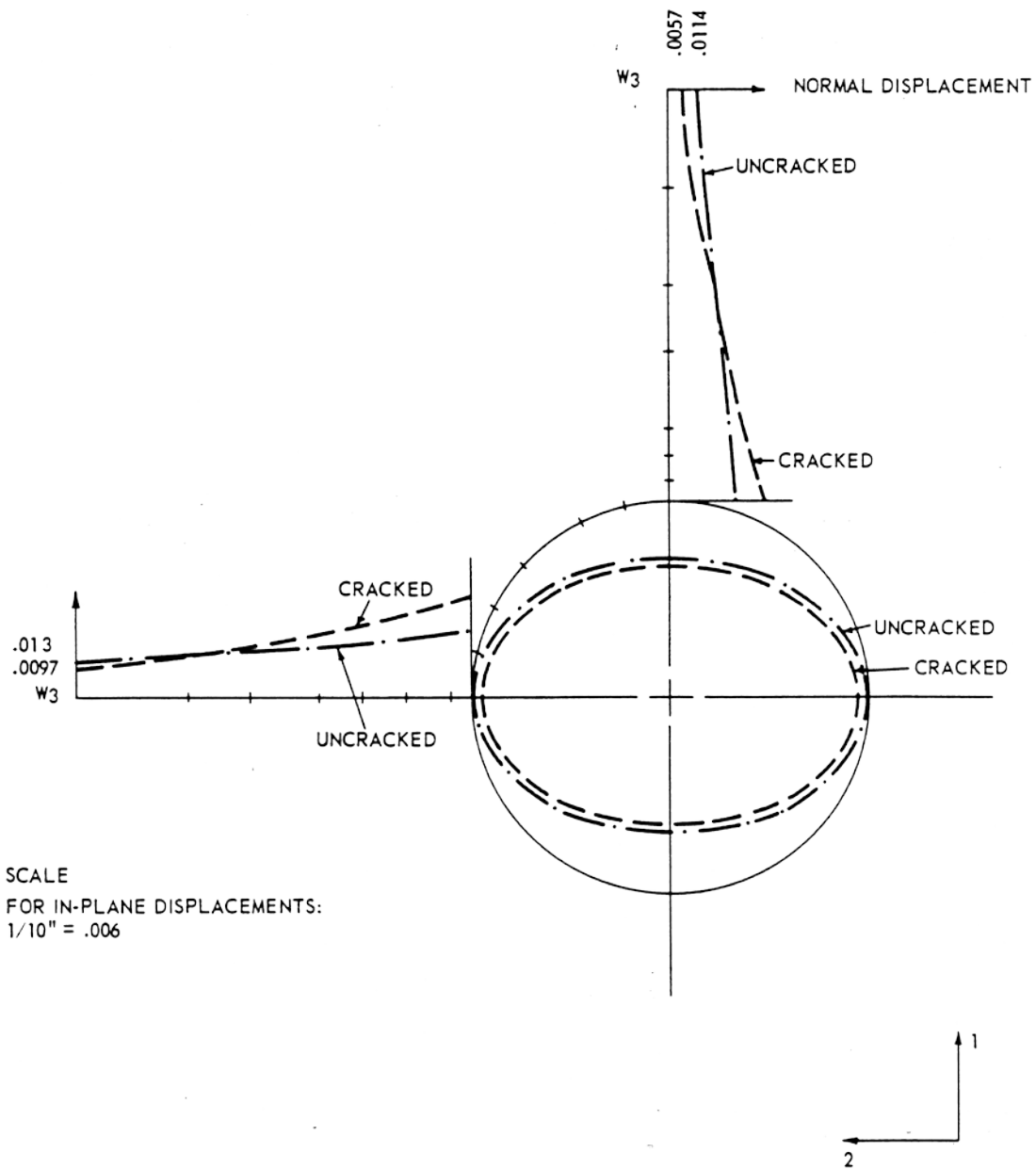


GILBERT ASSOCIATES, INC.

FIGURE 15

Figure 16

SHELL DISPLACEMENTS
(FINAL VERTICAL PRESTRESS)

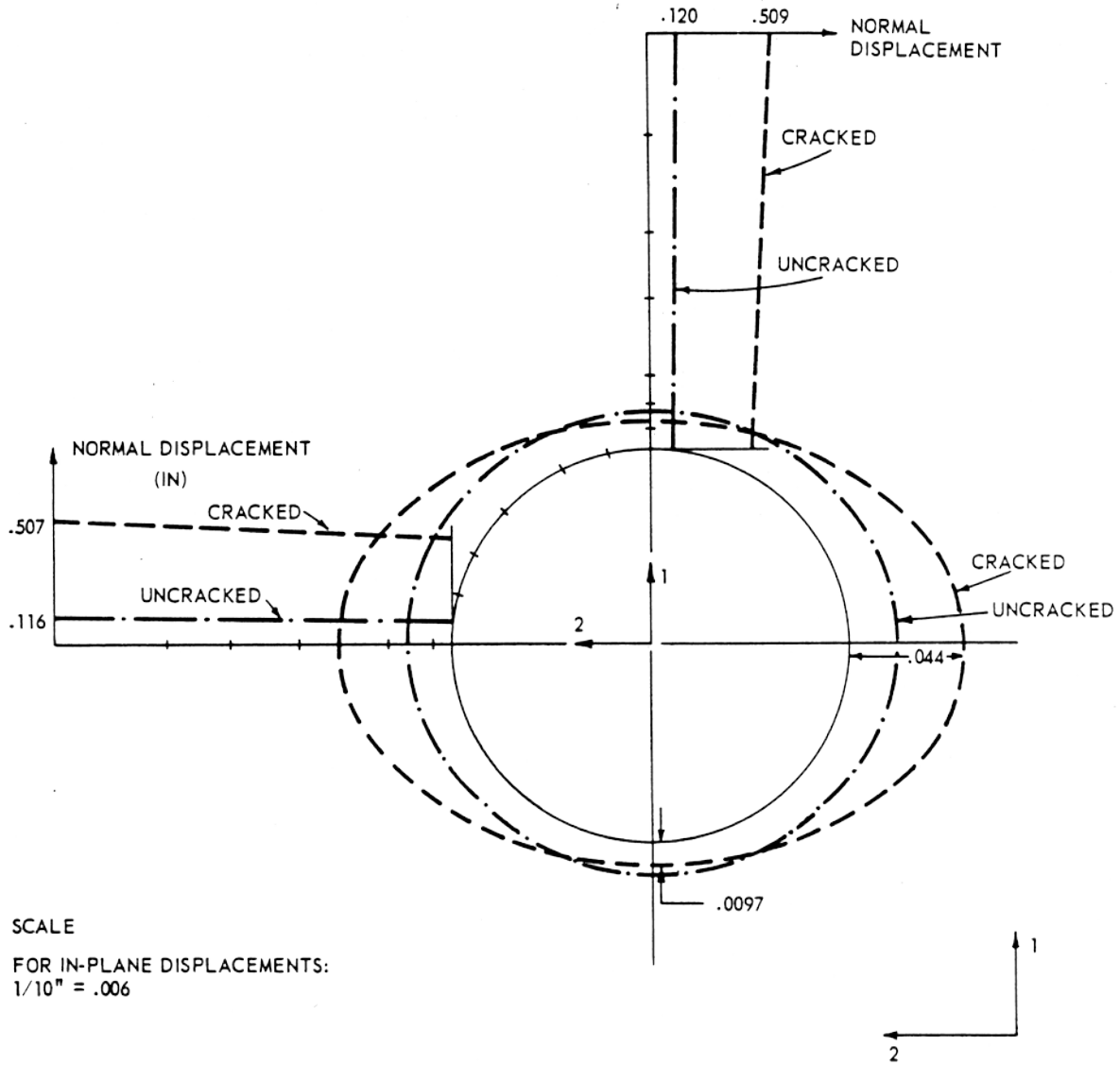


GILBERT ASSOCIATES, INC.

FIGURE 16

Figure 17

SHELL DISPLACEMENTS (69 PSI INTERNAL PRESSURE)

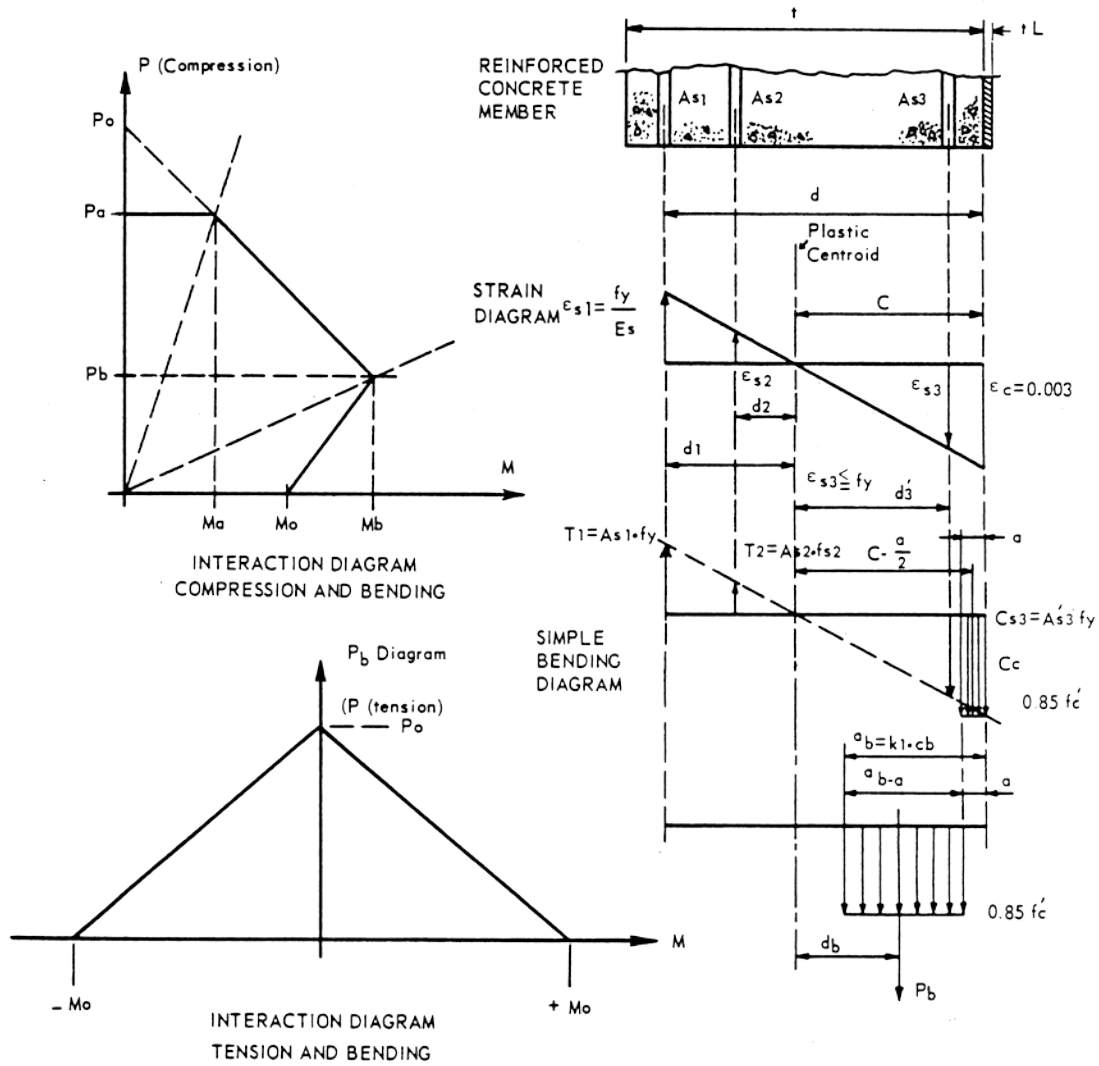


GILBERT ASSOCIATES, INC.

FIGURE 17

Figure 18

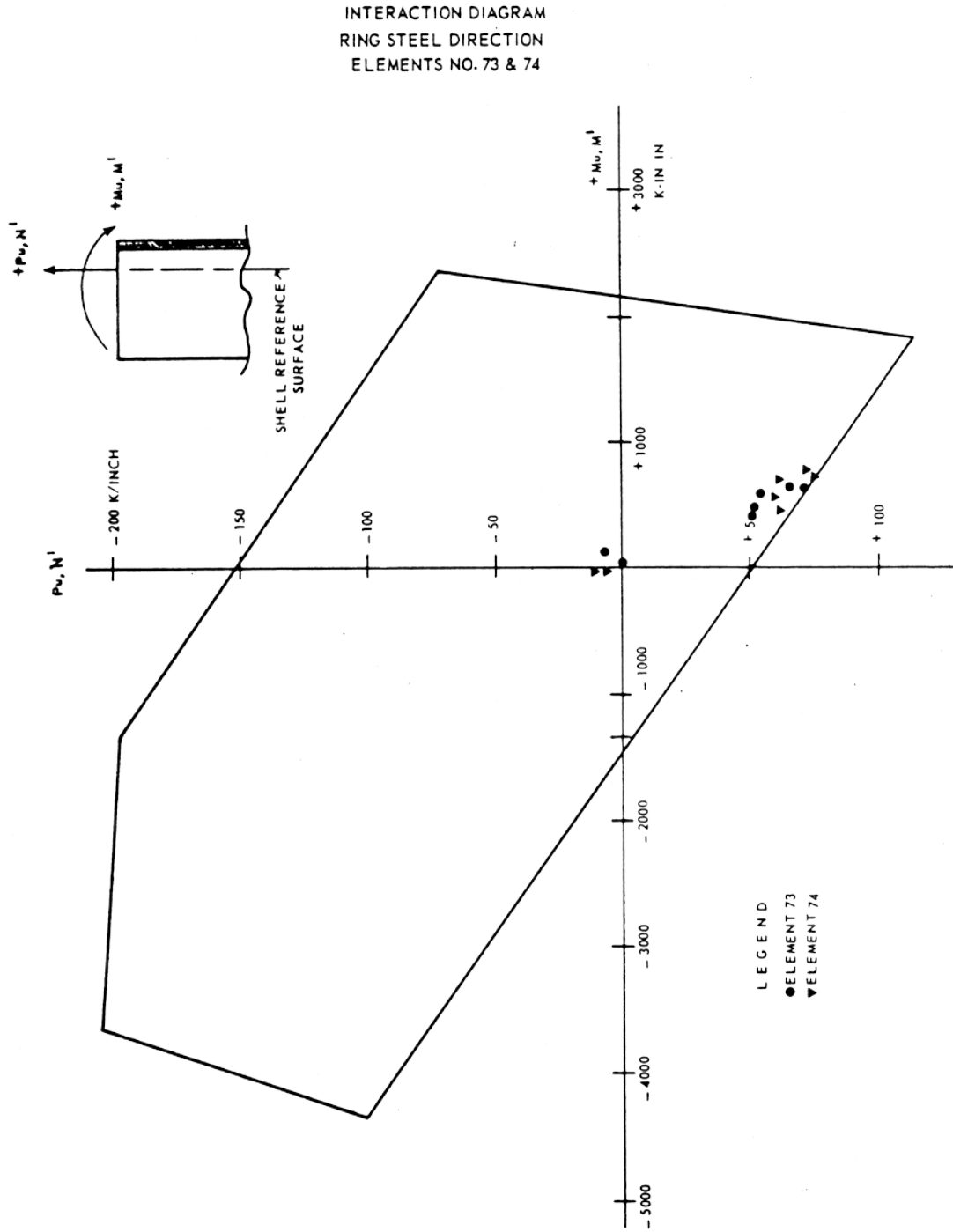
INTERACTION DIAGRAM FOR AXIAL
 COMPRESSION/TENSION AND BENDING



GILBERT ASSOCIATES, INC.

FIGURE 18

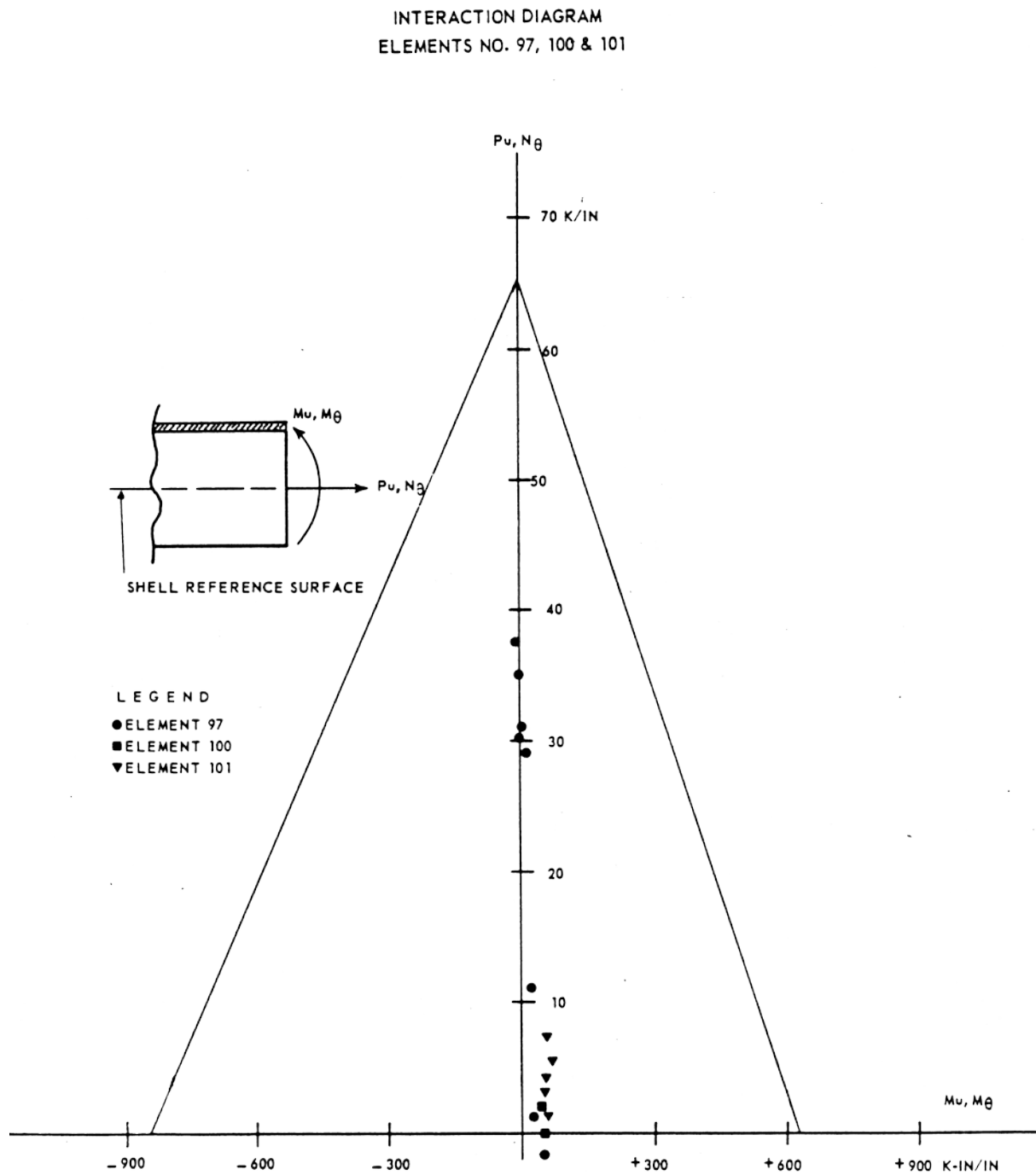
Figure 19



GILBERT ASSOCIATES, INC.

FIGURE 19

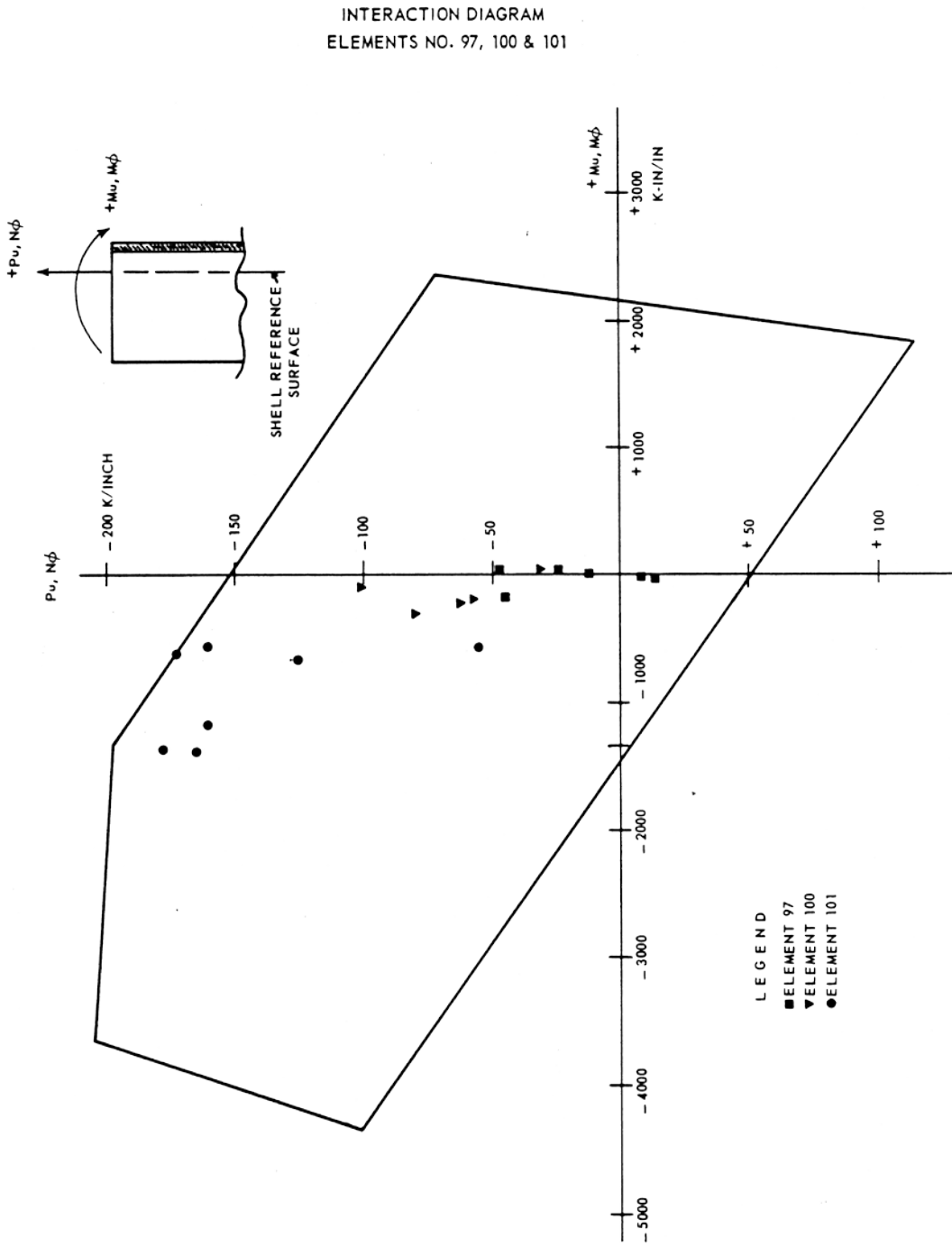
Figure 20



GILBERT ASSOCIATES, INC.

FIGURE 20

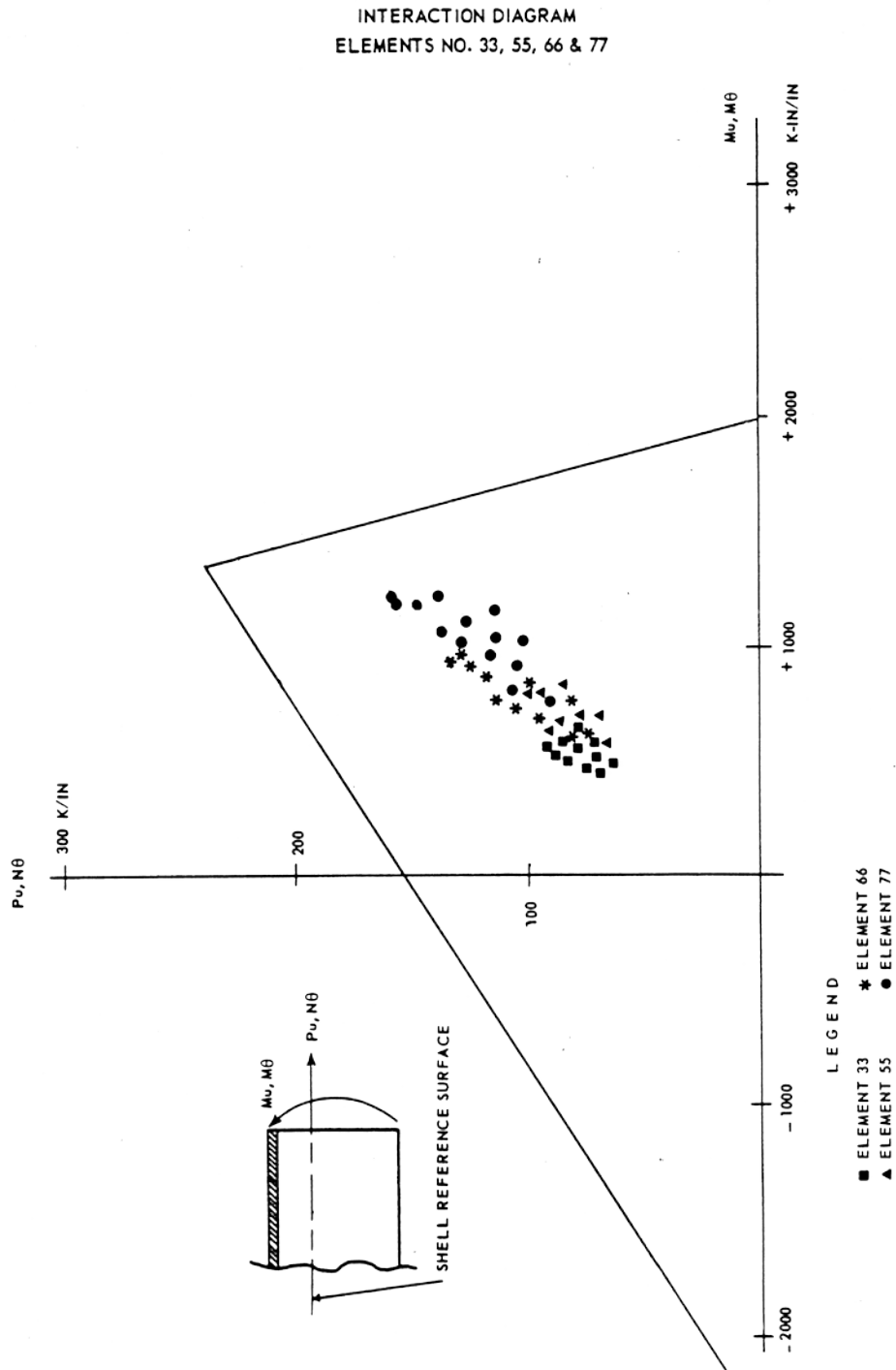
Figure 21



GILBERT ASSOCIATES, INC.

FIGURE 21

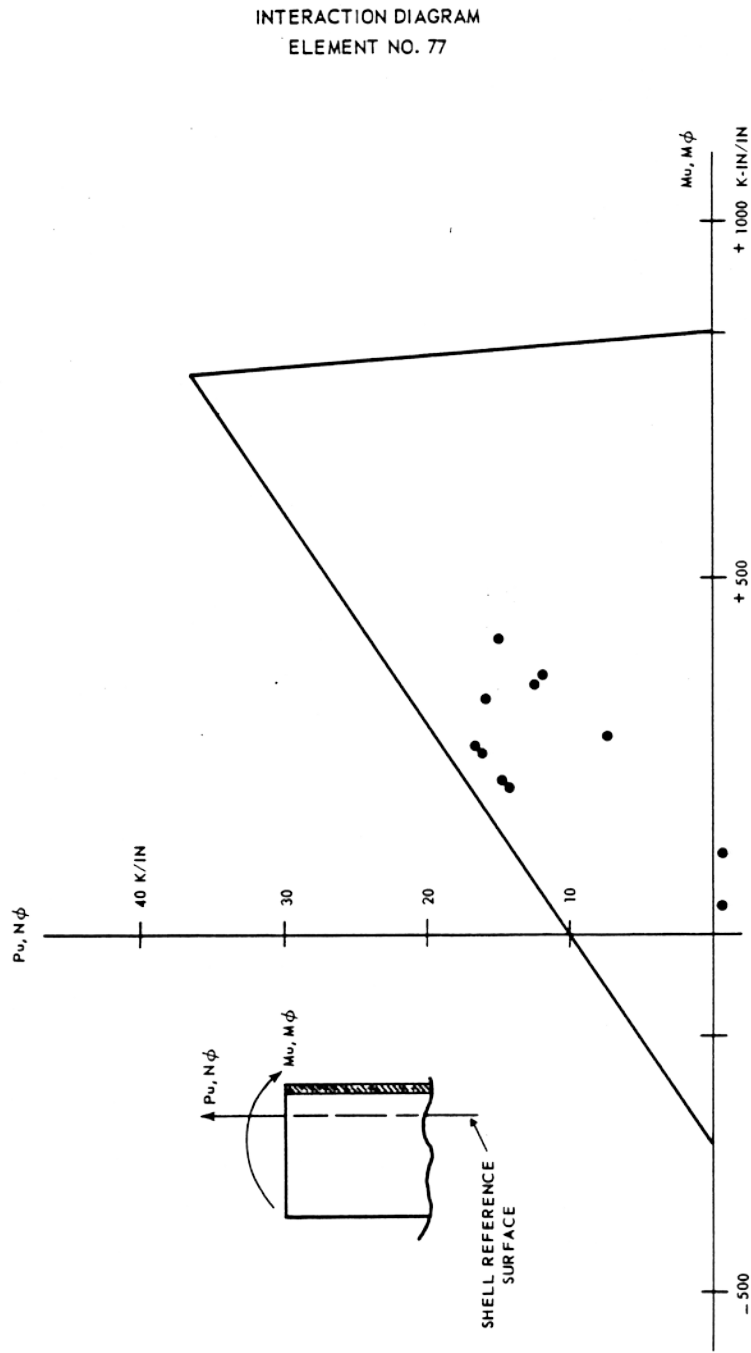
Figure 22



OILBERT ASSOCIATES, INC.

FIGURE 22

Figure 23

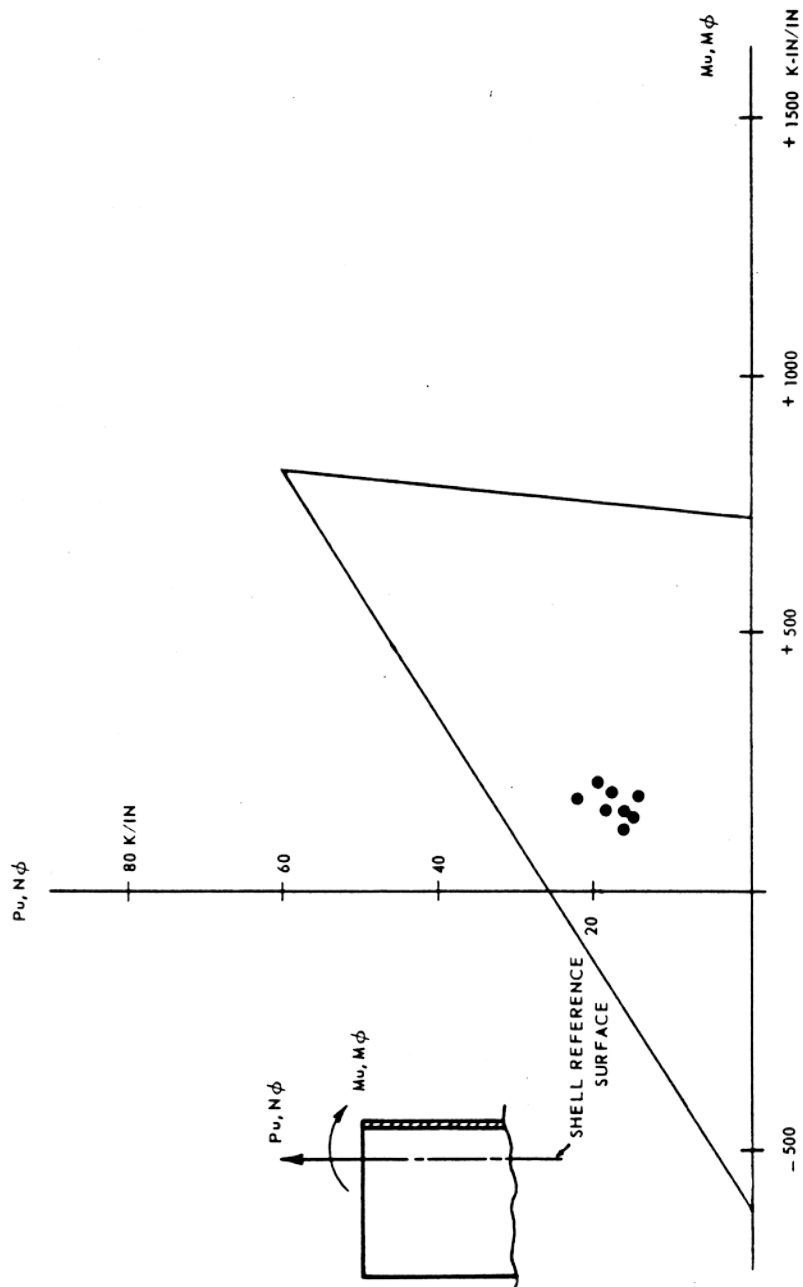


GILBERT ASSOCIATES, INC.

FIGURE 23

Figure 24

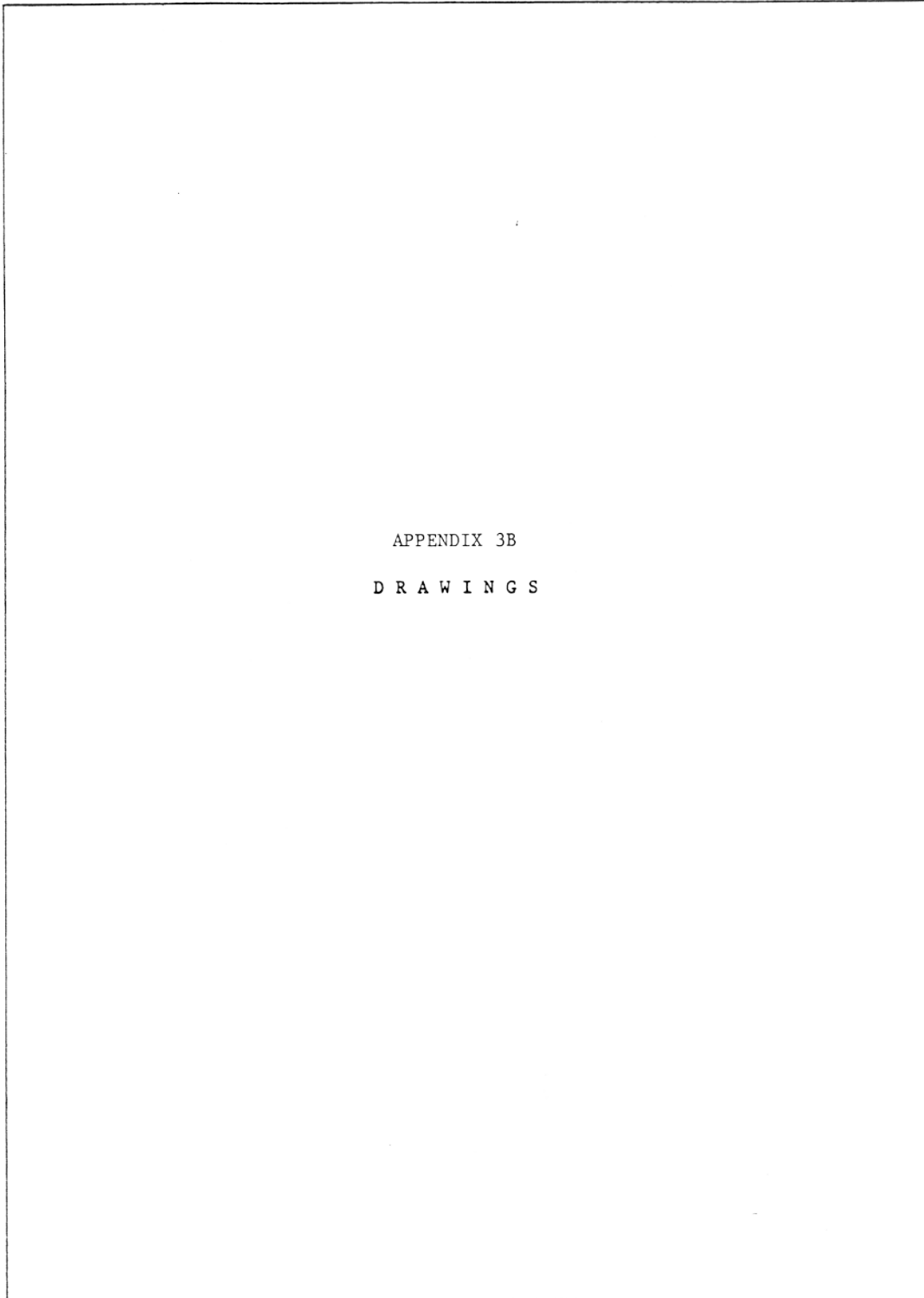
INTERACTION DIAGRAM
ELEMENT NO. 55



GILBERT ASSOCIATES, INC.

FIGURE 24

Drawings



APPENDIX 3B
D R A W I N G S

GILBERT ASSOCIATES, INC.

3B-69

*Figure Drawing 1 Reactor Containment Vessel - Equipment/Personnel Access Reinforcement -
Enlarged Sections*

Figure Deleted

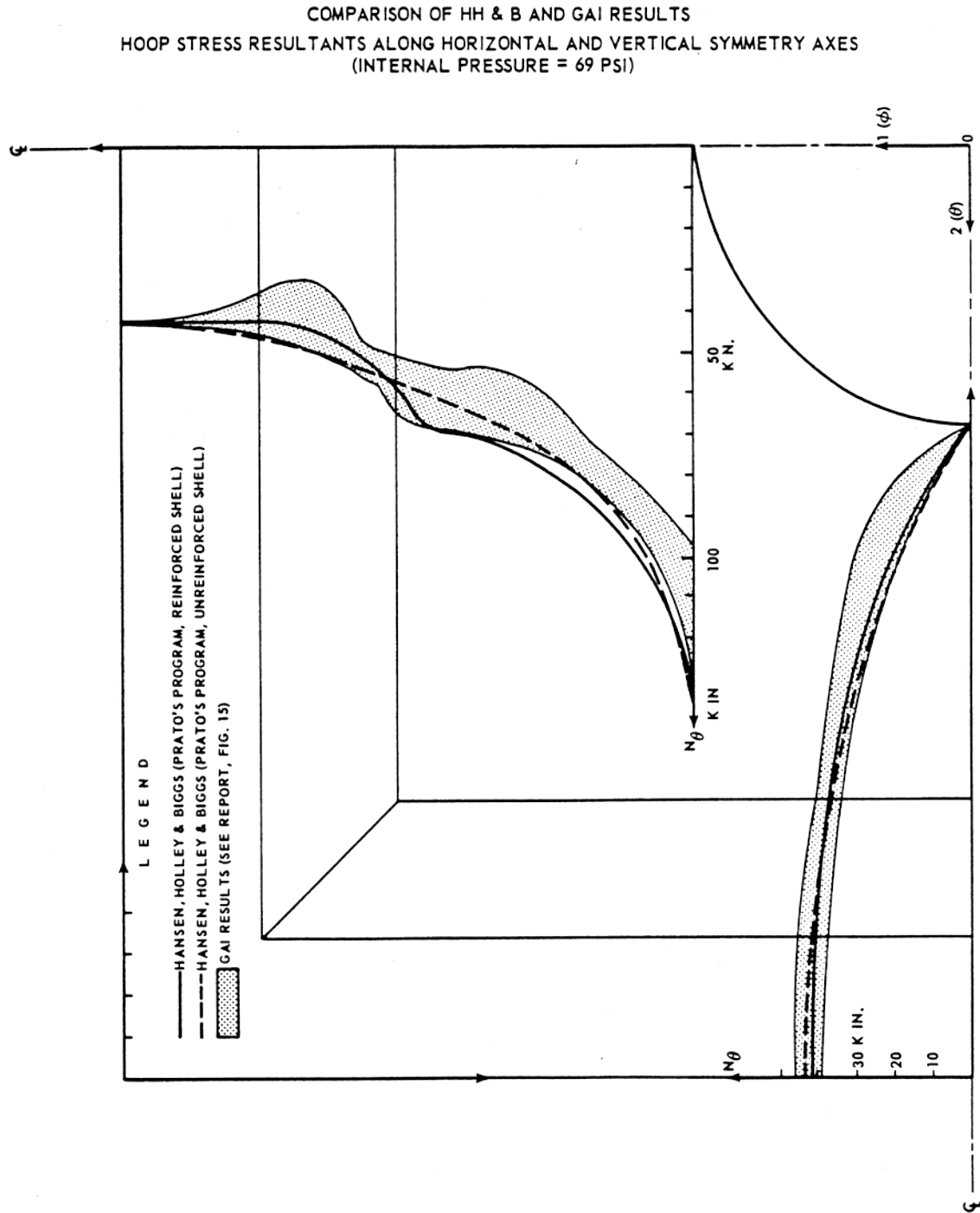
Refer to Drawing
D421-0024 Rev. 006

*Figure Drawing 2 Reactor Containment Vessel - Equipment Access Opening Reinforcement -
Stretch-out & Sections*

Figure Deleted

Refer to Drawing
D421-0022 Rev. 007

Figure I Comparison of H.H. & GAI Results Hoop Stress Resultants Along Horizontal and Vertical Symmetry Axes (Internal Pressure = 69 PSI)



GILBERT ASSOCIATES, INC.

FIGURE I

*Figure Drawing 1 Reactor Containment Vessel - Equipment/Personnel Access Reinforcement -
Enlarged Sections*

Figure Deleted

Refer to Drawing
D421-0024 Rev. 006

*Figure Drawing 2 Reactor Containment Vessel - Equipment Access Opening Reinforcement -
Stretch-out & Sections*

Figure Deleted

Refer to Drawing
D421-0022 Rev. 007

Figure Drawing 3 Large Openings - Pour Schedule

