Attachment 3

Prairie Island Nuclear Generating Plant Earthquake Analysis: Reactor-Auxiliary-Turbine Building

John A. Blume & Associates Report JAB-PS-02

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PIONEER SERV CE & ENGINEERING CO.

PRAIRIE ISLAND NUCLEAR GENERATING PLANT

Earthquake Analysis of the Reactor-Auxiliary-Turbine Building

Revised January 22, 1971

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PRAIRIE ISLAND NUCLEAR GENERATING PLANT
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INTRODUCTION

The purpose of this report is to summarize the procedures used and the results obtained from the earthquake analysis of the Reactor-Auxiliary-Turbine Building for the Prairie Island Nuclear Generating Plant. Based on the design criteria stated below, maximum translational accelerations, displacements, shears, and moments and maximum torsional accelerations, moments, and rotations, all versus height, for the various structural units of the combined Reactor-Auxiliary-Turbine Building have been developed.

DESIGN CRITERIA

The earthquake analysis has been based on the response spectra of Reference 1*. The results of the analyses presented in this report are for the Design Earthquake (0.06g). Values for the Maximum Credible Earthquake (0.12g) can be obtained by doubling the presented results.

DESCRIPTION OF BUILDINGS

The Prairie Island Plant consists of two Reactor Buildings, an Auxiliary Building and a Turbine Building all as one interconnected structure. Floor plans are shown in Figures 1** through 6 and sections are shown in Figures 7, 8, and 9. The structure has a mat foundation which is nominally 4 ft thick and the top of the mat foundation slab is at Elevation 693 ft. The plan dimensions of entire structure are 440 ft by 345 ft. Each Reactor Building consists of a Shield Structure and a Containment Vessel. The Shield Structure is a cylindrical concrete shell approximately 120 ft in diameter and 201 ft

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* References are listed in Appendix A.
** Tables and Figures are presented at the end of the text.

high. The Containment Vessel, which is a steel cylindrical shell approximately 105 ft in diameter and 186 ft high, is enclosed by the Shield Building. The Containment Vessel houses the reactor and appurtenant equipment.

The term Auxiliary Building as used by Pioneer Service & Engineering Co., generally refers to the entire structure between the Reactor Buildings and the Turbine Building. However, in this report, this entire structure has been divided into two separate structures. The area which is generally south of line L is termed the Fuel Tank Area and the remaining structure which is generally north of line L and south of line G is termed the Auxiliary Building. The Auxiliary Building and the Fuel Tank Area are connected at all floor levels and the foundation level. The Auxiliary Building and the Fuel Tank Area are reinforced concrete structures with a steel roof over the fuel handling area. This roof is termed the Auxiliary Building Roof. The Auxiliary Building and the Fuel Tank Area are connected to the Reactor Buildings at the foundation level only.

The Turbine Building below the operating floor is basically a steel structure, except for the area between column rows "8" and "10" which is primarily a concrete structure. Above the operating floor the Turbine Building is a steel structure. The Turbine Building is connected to the Auxiliary Building at the foundation, mezzanine floor, operating floor, and roof levels.

MATHEMATICAL MODEL OF BUILDING

General Description

The mathematical model of the combined Reactor-Auxiliary-Turbine structure is shown in Figures 10, 11, and 12. Figures 10 and 11 are southwest and southeast isometric views showing the general arrangement of the various elements of the model. Figure 12 shows a more detailed presentation of the model with mass point numbers and their elevations. The model is a discrete mass system with masses lumped at each floor and roof level, at points of intersection of diagonal bracing in the steel structures and at intermediate points in the shield and containment structures. The structure has been idealized as a three-dimensional model with 109 degrees of freedom that include north-south and east-west

translation for symmetrical elements and both translation and torsional rotation for unsymmetrical and irregular elements. Each mass point represents the mass of the concrete and steel structural elements and equipment at a particular level plus the tributary mass of the equipment and walls between adjacent levels. A snow load of 50 psf on the roof of each structure was included in the analysis. The vertical column on the model labeled Reactor Support Structure represents the concrete structure within the Containment Vessel that supports the reactor, steam generators, and other equipment.

Soil-Structure Interaction

The structure is founded on a densified granular soil and the soil-structure interaction under seismic conditions is represented by the translational and rotational springs in the model as shown in Figure 12 and Table 2. The stiffnesses of these springs were determined by using equations developed for the case of a rigid plate on a semi-infinite elastic half-space.[2,3,4] Soils properties used in the computation of the springs are summarized in Table 1. The numerical values of the resulting soils springs are listed in Table 2.

Physical Properties

In general, the moments of inertia and effective shear areas of the vertical elements between the mass points were determined for the concrete structures by cutting a horizontal section through the building between mass points and computing the moments of inertia and shear areas of the walls thus intersected. The stiffnesses of the braced steel structures were computed by considering the axial deformation of the bracing members. The moduli of elasticity of concrete and steel were taken as 3,200,000 and 29,000,000 pounds per square inch, respectively. The properties of the individual elements of the model are summarized in Table 3 and explained in more detail in the following discussion. Walls used for the computation of section properties are shown in Figures 1 through 6. The actual individual wall stiffnesses used are not presented but can be readily calculated.

For the Shield Building, Containment Vessel, and the Fuel Tank Area, the computed stiffnesses were based on shear areas and moments of inertia determined as explained above. Both shear areas and moments of inertia are therefore tabulated for these two structures. The stiffnesses of the concrete portion of the Auxiliary Building were computed in a similar manner, except that shear deformations only were considered. Therefore, Table 3 includes only shear areas for this structure. In the Auxiliary Building, along line G between Elevations 775 ft and 790.5 ft, the stiffness in the north-south direction was based on the deformation of the bracing struts at lines 3, 5, 7, 9, 11, and 15. The area listed in Table 3 is the axial area of the struts. The stiffness in the east-west direction was based on the axial deformation of the bracing members between Elevations 775 ft and 790.5 ft. The axial area of these members is given in Table 3.

The stiffnesses of the steel Auxiliary Building Roof were based on the axial deformation of the bracing members and the areas summarized in Table 3 are the axial areas of the diagonal bracing members. It has been assumed that the bracing along lines 7 and 11 between P and Q is connected to the concrete walls forming the enclosure over the fuel pool.

The stiffnesses of the Turbine Building in the east-west and north-south directions were computed as follows. For the east-west direction, between Elevations 790.5 ft and 715 ft, the stiffnesses were based on the axial deformation of the bracing members along column line A. Areas summarized in Table 3 are the axial areas of the diagonal bracing members. Between Elevations 695 ft and 715 ft, the stiffness was based on the axial deformation of the steel bracing and the shear deformation of the concrete wall along line A. The axial area of the bracing and the shear area of the wall are summarized in Table 3. For the Turbine Building in the north-south direction, the stiffnesses between Elevations 790.5 ft and 715 ft were based on the flexural deformation of the 36 WF 194 columns with cover plates along line A on column lines 1 through 17. The moment of inertia of these columns is listed in Table 3. Between Elevations 715 ft and 695 ft,

the stiffness was based on the shear deformation of the concrete walls along lines B and 10 between line A and D. The shear area of these walls are given in Table 3.

The stiffnesses of the Turbine Supports and the Reactor Support Structures were based on the shearing and flexural deformation of the concrete structural elements. The section properties of these items are summarized in Table 3.

Centers of mass and rigidity were calculated by conventional methods of structural analysis and the locations of these centers of mass and rigidity are summarized in Table 4.

Connecting Links

As shown on the mathematical model in Figures 10, 11, and 12, the Turbine and Auxiliary Buildings are connected at the foundation, mezzanine, operating, and roof levels. The connection at the foundation level has been idealized as a link that is capable of transmitting moments about a vertical axis and horizontal forces in the north-south and east-west directions. This connecting link is not capable of transmitting moments about the horizontal axis because the major lateral force-resisting elements of the Turbine Building are in the region near line A and the foundation slab is not sufficiently rigid to transmit these moments from the Auxiliary Building to line A. The connecting links at the mezzanine, operating, and roof levels are capable of transmitting moments about a vertical axis and horizontal forces in the north-south and east-west directions.

The Auxiliary Building and the Fuel Tank Area are connected by links at Elevations 715 ft, 735 ft, 755 ft, and 775 ft. The first three of these links are capable of transmitting moments about a vertical axis and horizontal forces in the north-south and east-west directions. The link at Elevation 775 ft is capable of transmitting moments about a vertical axis and horizontal forces in the north-south direction only.

As shown on the mathematical model in Figure 12, the Reactor Buildings are structurally separate from the Auxiliary Building and the Fuel Tank Area at all levels except the foundation. At the foundation, the effect of the continuous slab between the Reactor Building and adjacent buildings has been accounted for by the spring connecting these buildings as shown in the model.

SUMMARY OF ANALYTICAL PROCEDURES

The spectral method was used for the dynamic analysis of the Reactor-Auxiliary-Turbine Building. In this method, the maximum response for each mass point for each mode is computed and then the modal responses are combined to determine the total response. The total response was determined by computing the square root of the sum of the squares of the maximum response of each mode. The structure was analyzed for earthquake motion in both the north-south and east-west directions acting non-concurrently. A more detailed presentation of the analytical procedure is given in Appendix B.

RESULTS OF THE ANALYSIS

Periods

As previously mentioned, the mathematical model of the combined Reactor-Auxiliary-Turbine Building has 109 degrees of freedom and the same number of possible modes of vibration. In the analysis, the periods of all 109 modes were determined and it was observed that the fifty-first and higher modes have periods of vibration approaching that of a rigid system and have a negligible participation in the overall response. For this reason the influence of the fifty-first and higher modes was neglected in the analysis. The relatively large number of modes considered in the analysis reflects the fact that the structure is actually a combination of seven buildings and that in some cases several modes are due primarily to the response of only one building of the combined structure.

Modes of vibration were identified as being due primarily to the deformation of specific structural elements (or a combination of such elements) and were assigned appropriate damping values based on the following table.

Item	Percent of Critical Damping
Containment Vessel	1.0
Shield Building	2.0
Steel Structures	2.0
Reinforced Concrete Construction	2.0
Foundation	5.0

The first fifty modes of vibration and the damping values assigned to each of these modes are summarized in Table 5.

Response

Curves showing the maximum translational accelerations, displacements, shears, and moments and torsional accelerations, moments, and rotation have been prepared for the Shield Buildings, Containment Vessels, Auxiliary Building, Fuel Tank Area, and Turbine Building and are presented in Figures 13 through 62. Results for the other structural elements shown on the mathematical model (Figure 12), are summarized in Table 6. The results shown in the Figures are in directions both parallel and perpendicular to the direction of the applied earthquake. The results presented in Table 6 are in a direction parallel to the applied earthquake. The corresponding results in a direction perpendicular to the applied earthquake are 25 percent of the results in the parallel direction.

The accelerations and displacements of the various mass points of the structures presented herein are those of the respective centers of mass. The shears and torques are with respect to the center of rigidity of the applicable structure. All curves and tabulated values are shown with a plus sign.

For design purposes, they are equally applicable in both positive and negative directions. For example, for a north-south earthquake, translational values act in both the north and south directions. Rotational values should be assumed to act in both the clockwise and counterclockwise directions.

For the symmetrical buildings of the Prairie Island Plant, such as the Shield Building and Containment Vessel, in which the centers of mass and rigidity coincide, values of translational accelerations, shears, moments, and displacements only are presented. For the unsymmetrical portion of the Auxiliary and Turbine Buildings, in which the centers of mass and rigidity do not coincide, values of translational accelerations, shears, moments, and displacements, and values of torsional accelerations, moments, and rotations are presented. The acceleration at any point within these buildings is the vector sum of the translational acceleration and the acceleration due to rotation. The acceleration at any given point in the structure due to rotation is obtained by multiplying the rotational acceleration at the center of mass by the distance from the center of mass to the given point. Displacements at any point within this building are calculated in a similar manner.

The maximum forces in the connecting links between the various structures are shown in Table 7.

RECOMMENDATIONS

It is recommended that the subject structure be designed to resist the seismic shears and moments presented herein. A vertical acceleration of 0.04g acting simultaneously with the horizontal accelerations is recommended for design. No increase in allowable stresses for short-term loads should be used for design of Class I structures or equipment.

The structure should also be reviewed to ensure that it can resist twice the seismic shears and moments described above without hindering the ability of the plant to safely shut down. A vertical acceleration of 0.08g acting simultaneously with twice the horizontal accelerations used for design is recommended as criteria for safe shutdown of the plant.

TABLE 1

SOILS PROPERTIES[1)]

Elastic Modulus	7,000 Kip/ft^2
Shearing Modulus	2,500 Kip/ft^2
Poisson's Ratio	0.40

1) This soils data has been obtained from Reference 1.

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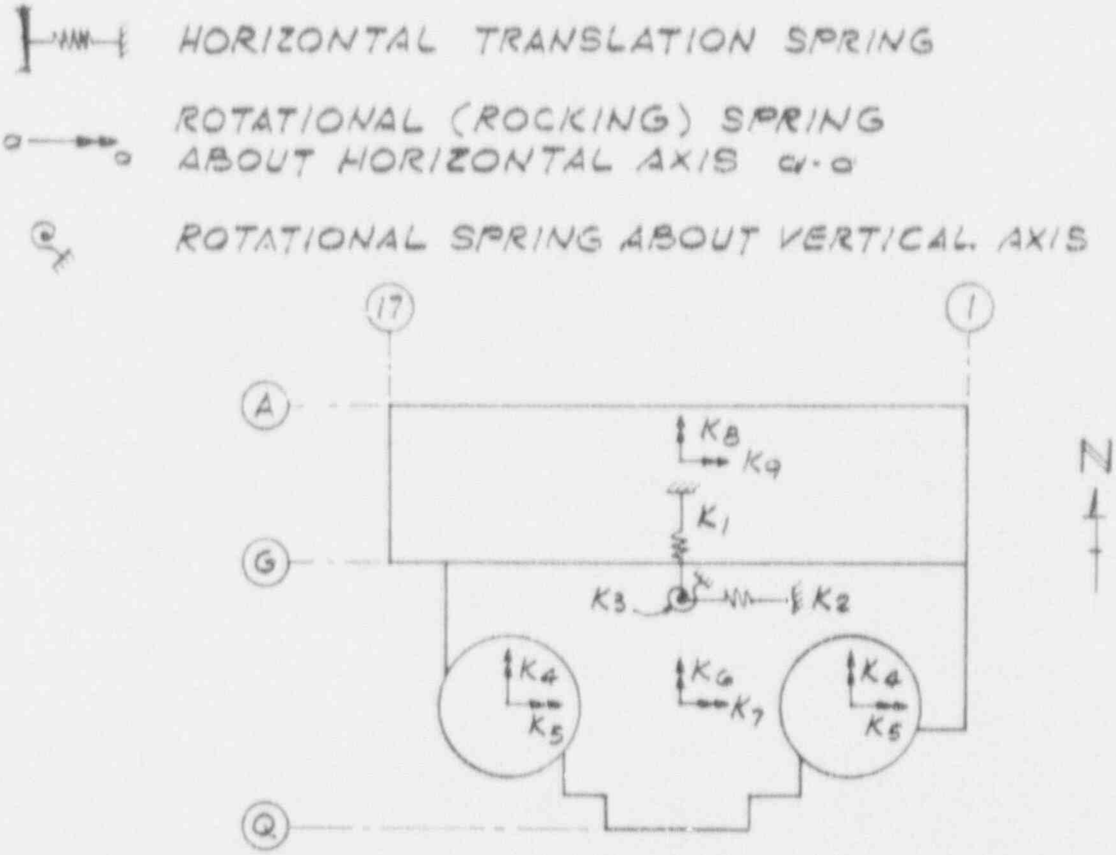
PRAIRIE ISLAND NUCLEAR GENERATING PLANT

TABLE 2

FOUNDATION SPRING CONSTANTS

LEGEND:



PLAN
NO SCALE

ITEM	AREA	DESCRIPTION	VALUE	UNITS
K1	ENTIRE STRUCTURE	TRANSL. IN N-S DIREC.	2.46×10^6	KIP/FT.
K2	ENTIRE STRUCTURE	TRANSL. IN E-W DIREC.	2.34×10^6	KIP/FT.
K3	ENTIRE STRUCTURE	ROTATION ABOUT VERT.	9.56×10^{10}	KIP-FT/RAD
K4	SHIELD BUILDING	ROCKING ABOUT N-S AXIS	3.34×10^9	KIP-FT/RAD
K5	SHIELD BUILDING	ROCKING ABOUT E-W AXIS	3.34×10^9	KIP-FT/RAD
K6	AUXILIARY BLDG.	ROCKING ABOUT N-S AXIS	28.44×10^9	KIP-FT/RAD
K7	AUXILIARY BLDG.	ROCKING ABOUT E-W AXIS	12.27×10^9	KIP-FT/RAD
K8	TURBINE BLDG.	ROCKING ABOUT N-S AXIS	1.95×10^9	KIP-FT/RAD
K9	TURBINE BLDG.	ROCKING ABOUT E-W AXIS	2.85×10^9	KIP-FT/RAD

TABLE 3

SUMMARY OF WEIGHTS AND SECTION PROPERTIES[1)]

Item	Mass Point	Weight, K	Area, ft² N-S Dir.	Area, ft² E-W Dir.	Moment of Inertia, 1000 ft⁴ N-S Dir.	Moment of Inertia, 1000 ft⁴ E-W Dir.
Shield Building,[2)] Units 1 & 2	1,1A	2011				
			509	509	930	930
	2,2A	4003				
			461	461	1593	1593
	3,3A	3450				
			461	461	1593	1593
	4,4A	4049				
			461	461	1593	1593
	5,5A	4648				
			445	445	1477	1477
	6,6A	3793				
			445	445	1477	1477
	7,7A	2940				
			434	434	1403	1403
	8,8A	2819				
			4045	4045	9320	9320
Containment Vessel,[2)] Units 1 & 2	9,9A	189				
			10.25	10.25	12.4	12.4
	10,10A	268				
			10.35	10.35	26.8	26.8
	11,11A	300				
			20.64	20.64	57.0	57.0
	12,12A	1096				
			20.64	20.64	57.0	57.0
	13,13A	696				
			19.80	19.80	52.4	52.4
	14,14A	569				
			19.80	19.80	52.4	52.4
	15,15A	452				
			19.27	19.27	49.4	49.4
	16,16A	315				
			20.64	20.64	57.0	57.0
Reactor Support[2)] Structure, Units 1 & 2	17, 17A	3863				
			873.	873.	530	530
	18,18A	5194				
			1332.	1332.	579	579
	19,19A	6856				
			909.	909.	470	470

TABLE 3

SUMMARY OF WEIGHTS AND SECTION PROPERTIES[1)]

(Continued)

Item	Mass Point	Weight K	Area, ft² N-S Dir.	Area, ft² E-W Dir.	Moment of Inertia, 1000 ft⁴ N-S Dir.	Moment of Inertia, 1000 ft⁴ E-W Dir.
Reactor Building[2)] Foundation, Units 1 & 2	20,20A	29406	---	---	---	---
Auxiliary Bldg Roof, South Part	21	600	0.114	0.464	---	---
Fuel Tank Area	22	1615				
			168.	229.	68.9	105.7
	23	5781				
			1101.	1599.	80.9	904.8
	24	9864				
			1151.	1830.	52.1	1429.8
	25	12895				
			764.	901.	106.7	813.5
Auxiliary Bldg. Roof, North Part	26	600	0.114	0.132	---	---
Auxiliary Bldg.	27	2240				
			0.75	0.43	---	---
	28	12383				
			985.	820.5	---	---
	29	15274				
			1245.	1301.	---	---
	30	21903				
			846.	1118.5	---	---
	31	19554				
			2013.	1088.5	---	---
Auxiliary Bldg.- Fuel Tank Area Foundation	32	65329	---	---	---	---
Turbine Support[2)] Units 1 & 2	33,33A	8201				
			855	855	169.7	3.64
	34,34A	3444				
			807	807	163.2	3.44
	35,35A	3029				
			1495	1451	358.8	20,48

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TABLE 3

SUMMARY OF WEIGHTS AND SECTION PROPERTIES[1]

(Continued)

Item	Mass Point	Weight K	Area, ft²		Moment of Inertia, 1000 ft⁴	
			N-S Dir.	E-W Dir.	N-S Dir.	E-W Dir.
Turbine Support[2] Foundation, Units 1 & 2	36,36A	7074	---	---	---	---
Turbine Bldg.	37	2440				
			--	0.326	0.00203	---
	38	670				
			---	0.310	0.0273	---
	39	660				
			---	0.340	0.0273	---
	40	5687				
			---	0.325	0.0273	---
	41	3887				
			3) ---	0.691	---	---
			154	69	---	---
Turbine Bldg. Foundation	42	3734				

Notes:

1) See text for explanation of values in this table.
2) Unlettered numbers refer to Unit No. 1 (e.g. mass point 1)
   Lettered numbers refer to Unit No. 2 (e.g. mass point 1A)
3) Bracing
   Shear Walls

TABLE 4

SUMMARY OF LOCATIONS OF CENTERS OF MASS AND RIGIDITY

Structure	Mass Point	Center of Mass[1)]		Center of Rigidity[1)]	
		X	Y	X	Y
Shield Building, Unit 1	1-8	335.5	250.0	335.5	250.0
Shield Building, Unit 2	1A-8A	104.5	250.0	104.5	250.0
Containment Vessel, Unit 1	9-16	335.5	250.0	335.5	250.0
Containment Vessel, Unit 2	9A-16A	104.5	250.0	104.5	250.0
Reactor Support Structure, Unit 1	17-19	335.5	250.0	335.5	250.0
Reactor Support Structure, Unit 2	17A-19A	104.5	250.0	104.5	250.0
Reactor Building Foundation, Unit 1	20	335.5	250.0	---	---
Reactor Building Foundation, Unit 2	20A	104.5	250.0	---	---
Auxiliary Building Roof, South Part	21	220.0	303.2	220.0	345.0
Fuel Tank Area	22	220.0	288.0	220.0	288.0
	23	220.0	288.0	220.0	288.0
	24	220.0	285.0	220.0	285.0
	25	220.0	285.0	220.0	285.0
Auxiliary Building Roof, North Part	26	220.0	219.8	220.0	178.0

Note: Table continued on next page.

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TABLE 4

SUMMARY OF LOCATIONS OF CENTERS OF MASS AND RIGIDITY

(Continued)

Structure	Mass Point	Center of Mass[1]		Center of Rigidity[1]	
		X	Y	X	Y
Auxiliary Building	27	220.0	93.8	221.9	126.0
	28	220.0	167.8	220.0	144.9
	29	227.9	174.4	221.9	157.9
	30	228.7	163.0	251.7	168.4
	31	238.8	169.5	239.8	139.5
Auxiliary Building - Fuel Tank Area Foundation	32	231.3	148.8	---	---
Turbine Support, Unit 1	33-35	330.5	61.5	330.5	61.5
Turbine Support, Unit 2	33A-35A	109.5	61.5	109.5	61.5
Turbine Support Foundation, Unit 1	36	330.5	61.5	---	---
Turbine Support Foundation, Unit 2	36A	109.5	61.5	---	---
Turbine Building	37	220.0	28.0	220.0	0.0
	38	220.0	0.0	220.0	0.0
	39	220.0	0.0	220.0	0.0
	40	220.0	15.9	220.0	0.0
	41	220.0	15.7	220.0	0.0
Turbine Building Foundation	42	220.0	10.0	---	---
Entire Structure, base rotation about a vertical axis	--	223.8	190.4	---	---

1) Measured in feet from the intersection of column lines A and 17. The plus-x direction is east of column line 17 and the plus-y direction is south of column line A.

September 27, 1968

TABLE NO. 5

PERIODS OF VIBRATION

Mode	Period, Seconds	Damping Value % of Critical
1	0.545	4
2	0.538	4
3	0.500	3
4	0.489	3
5	0.444	2
6	0.422	2
7	0.414	3
8	0.365	3
9	0.335	2
10	0.323	2
11	0.304	2
12	0.296	2
13	0.270	3
14	0.256	3
15	0.254	3
16	0.211	2
17	0.174	3
18	0.153	1
19	0.153	1
20	0.153	1
21	0.153	1
22	0.120	2
23	0.113	2
24	0.105	3
25	0.090	2

Mode	Period, Seconds	Damping Value % of Critical
26	0.086	2
27	0.082	2
28	0.082	2
29	0.082	2
30	0.082	2
31	0.077	2
32	0.075	2
33	0.068	2
34	0.067	2
35	0.066	2
36	0.066	2
37	0.061	2
38	0.058	2
39	0.054	2
40	0.051	2
41	0.050	2
42	0.045	2
43	0.042	1
44	0.042	1
45	0.042	1
46	0.042	1
47	0.039	2
48	0.038	2
49	0.038	2
50	0.038	2

TABLE 6

DESIGN VALUES FOR MISCELLANEOUS ELEMENTS*

Structure	Mass Point	Earthquake Direction	Acceleration, g	Shear, K	Moment, kip-ft	Displacement, ft
Turbine	33,33A	N-S	0.11	900	0	0.015
Support	34,34A		0.08	1180	18,000	0.011
Structure	35,35A		0.06	1360	34,000	0.009
	36,36A		0.06		53,000	0.008
Turbine	33,33A	E-W	0.12	980	0	0.012
Support	34,34A		0.08	1260	19,600	0.010
Structure	35,35A		0.06	1440	47,200	0.008
	36,36A		0.06		67,300	0.007
Reactor	17,17A	N-S or	0.15	570	0	0.012
Support	18,18A	E-W	0.10	1100	12,000	0.011
Structure	19,19A		0.07	1500	36,500	0.010
	20,20A		0.06		60,200	0.009
Auxiliary	21	N-S	0.20	120	1,620	0.022
Building						
Steel Roof	26	N-S	0.20	120	1,620	0.022
Auxiliary	21	E-W	0.37	220	11,090	0.057
Building	21a			290		
Steel Roof	21b		-	300	-	-
	21c			370		
	21d		-	430	-	-
	23-21b			210		
	26	E-W	0.45	270	6,500	0.035

* Increase all values by 10 percent (see Appendix C).

January 22, 1971

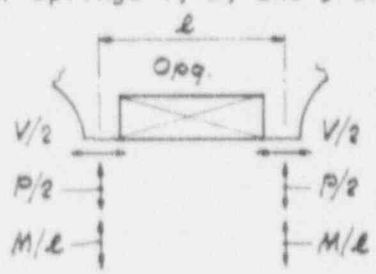
TABLE 7

DESIGN VALUES FOR CONNECTING SPRINGS

No.	Elev. Ft.	Buildings Connected	Earthquake Direction	Axial Force, P Kips	Shear Force, V Kips	Moment, M Ft-Kips
1	775	Auxiliary Bldg.-Fuel Tank Area	X (E-W)	51	--	6021
			Y (N-S)	299	--	1674
2	755	Auxiliary Bldg - Fuel Tank Area	X	48	90	3950
			Y	200	58	849
3	715	Auxiliary Bldg - Fuel Tank Area	X	133	349	1246
			Y	166	190	481
4	715	Auxiliary Bldg-Turbine Bldg.	X	46	139	295
			Y	194	70	599

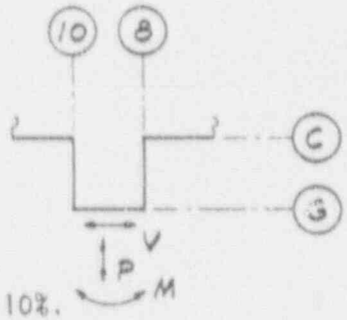
NOTES:

1) Design Values for Springs 1, 2, and 3 are to be applied thus:

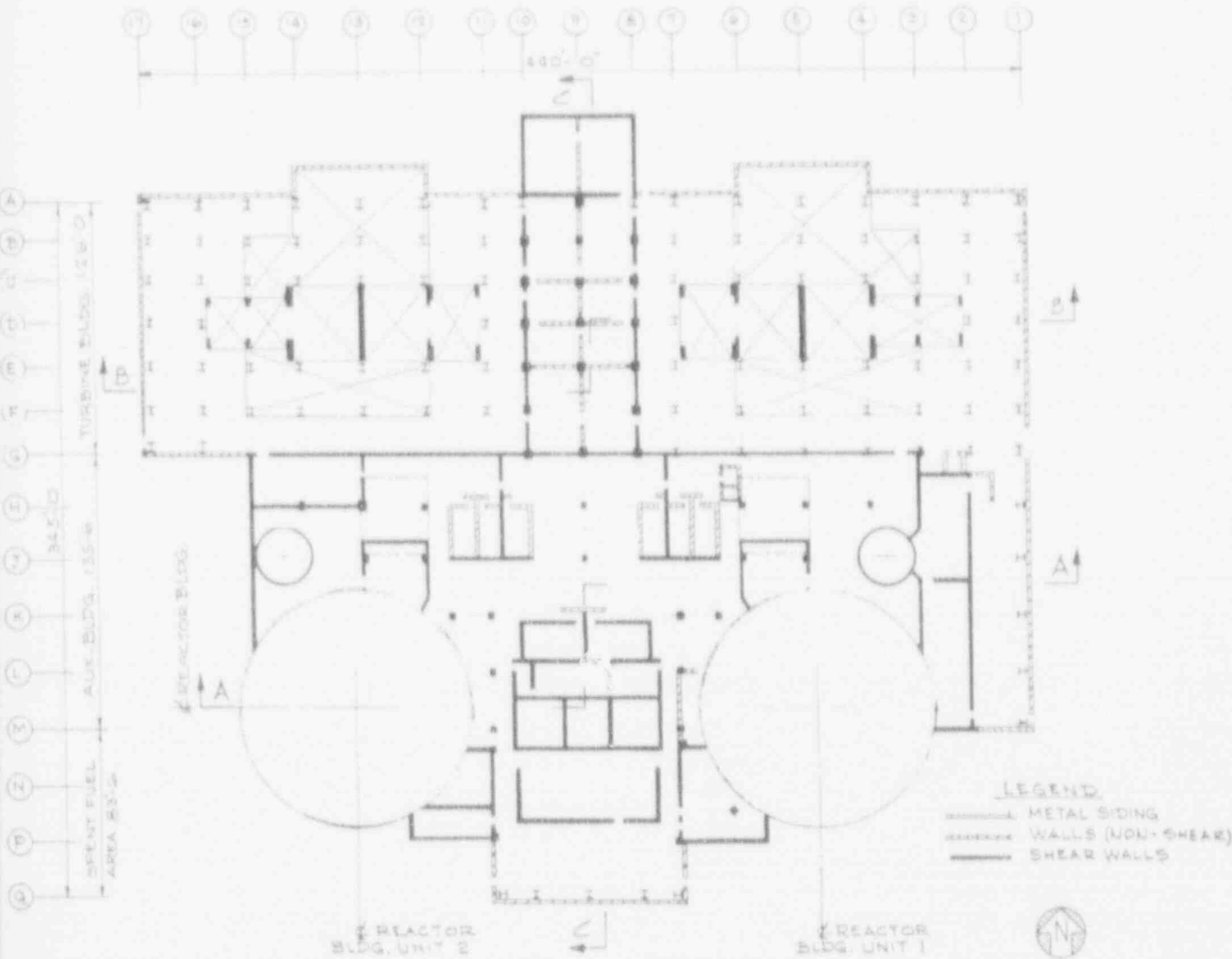


Double-headed arrows indicate that forces are to be applied in either direction.

2) Design Values for Spring 4 are to be applied thus:



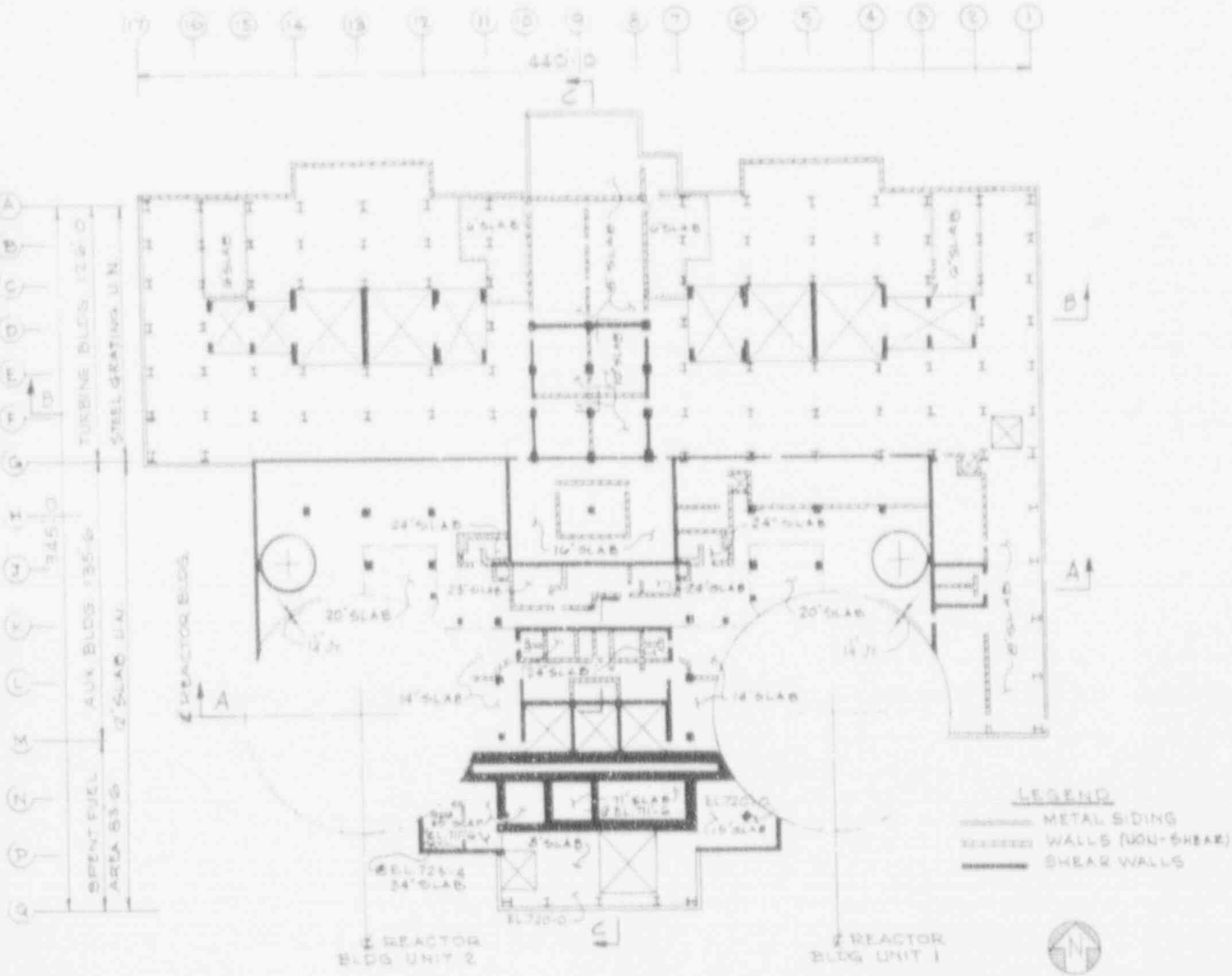
3) Increase all values by 10%. (See Appendix C).



PRAIRIE ISLAND NUCLEAR PLANT
GROUND FLOOR PLAN AT
ELEV. 695'

JAN. 22, 1971

FIG. NO. 1



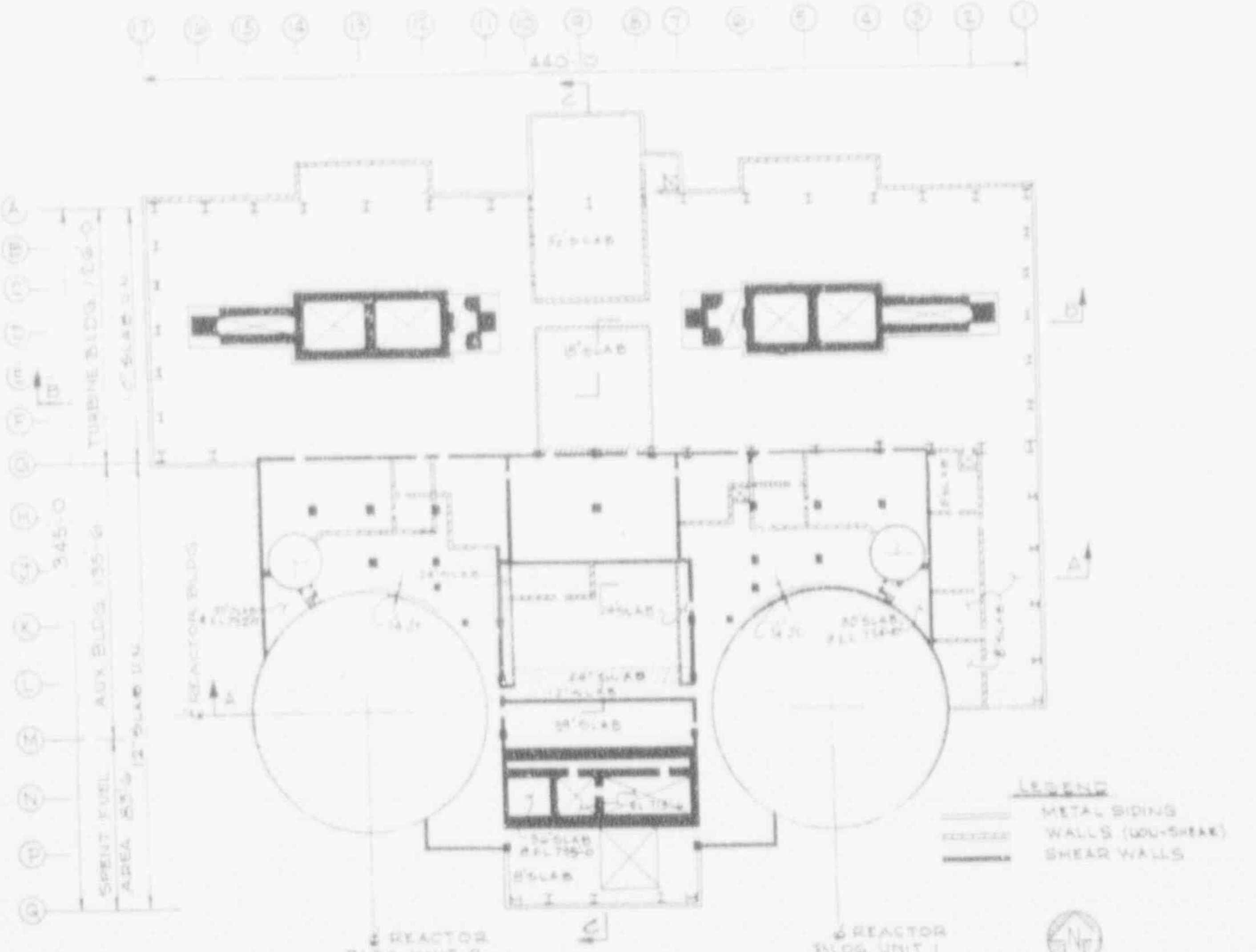
PRAIRIE ISLAND NUCLEAR PLANT

FLOOR PLAN AT

ELEV. 715'

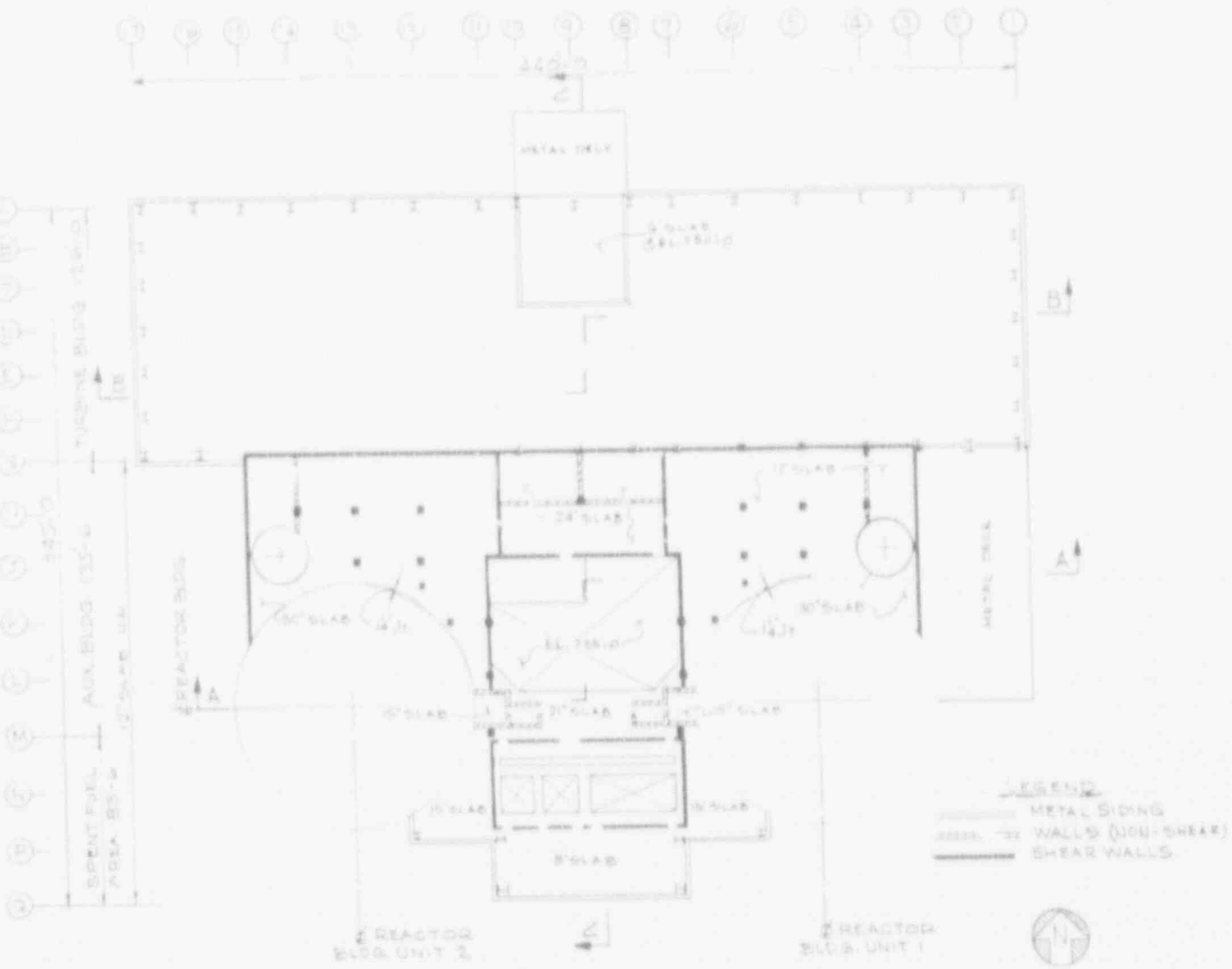
FIG. NO. 2

22, 1971



PRAIRIE ISLAND NUCLEAR PLANT
FLOOR PLAN AT
ELEV. 735'
FIG. NO. 8

JAN. 22, 1971



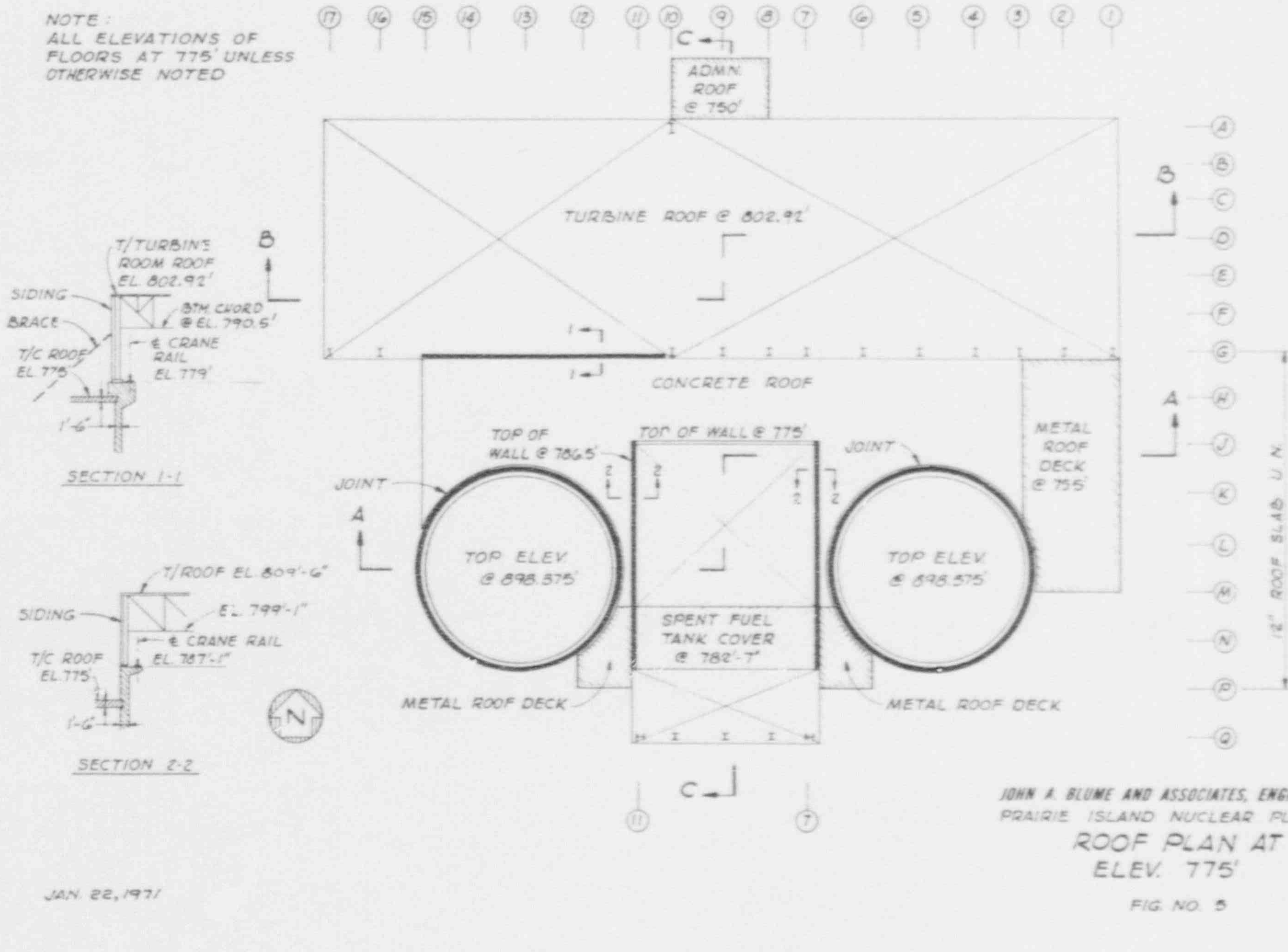
PRAIRIE ISLAND NUCLEAR PLANT

FLOOR PLAN AT ELEV. 755'

FIG. NO. 4

JAN. 22, 1971

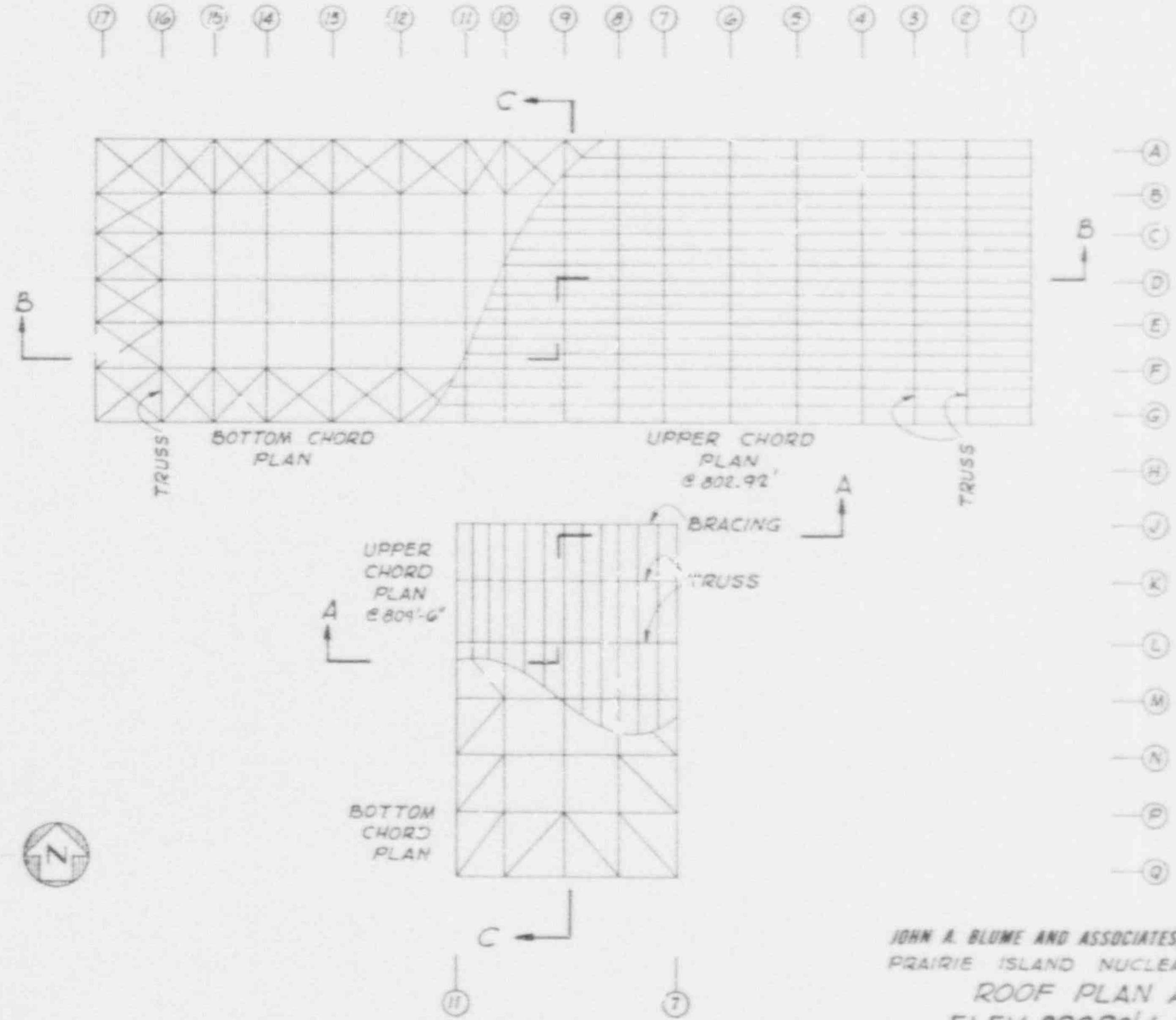
NOTE:
ALL ELEVATIONS OF FLOORS AT 775' UNLESS OTHERWISE NOTED



JOHN A. BLUME AND ASSOCIATES, ENGINEERS
PRAIRIE ISLAND NUCLEAR PLANT
ROOF PLAN AT
ELEV. 775'

FIG. NO. 5

JAN. 22, 1971

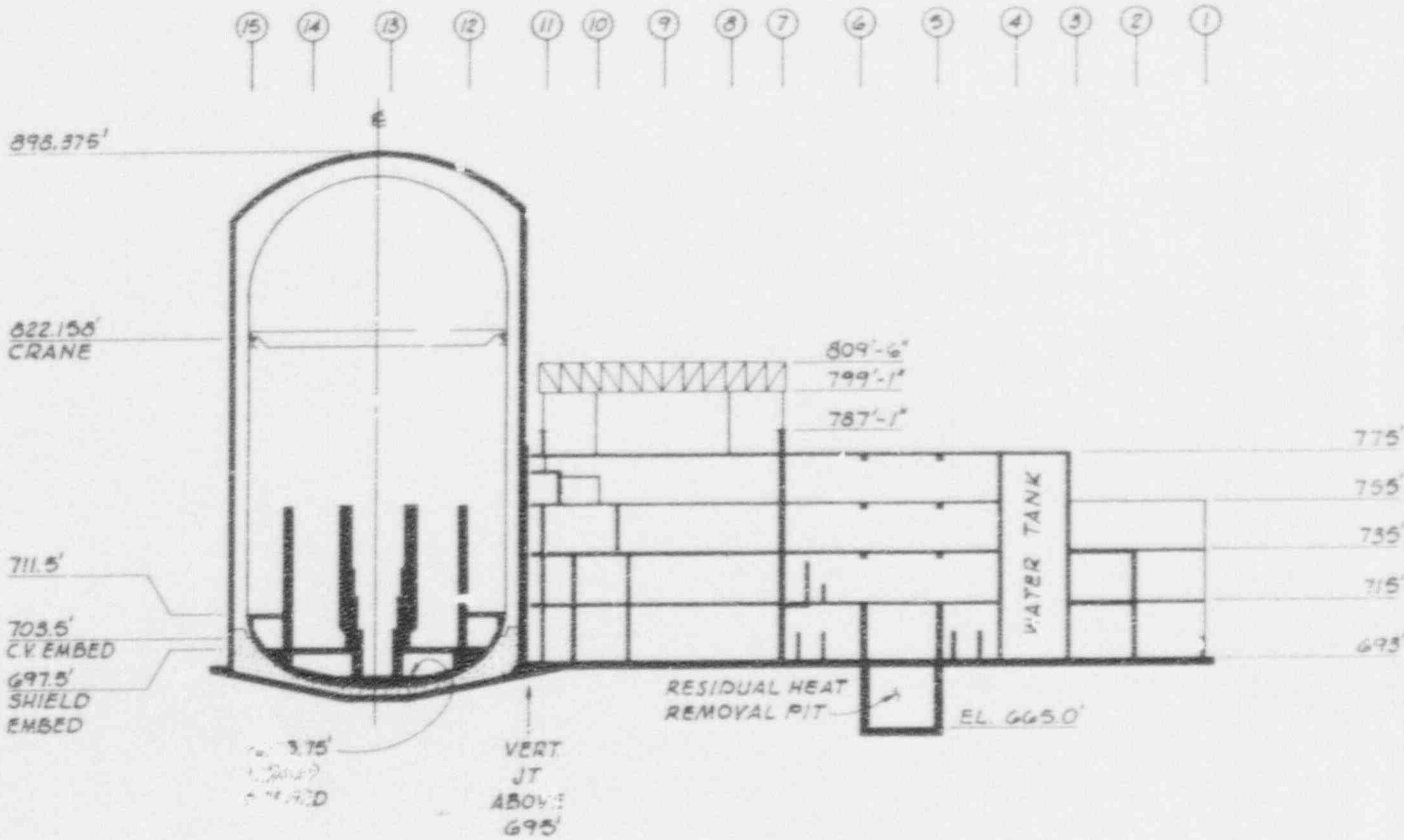


JAN. 22, 1971

JOHN A. BLUME AND ASSOCIATES, ENGINEERS
PRAIRIE ISLAND NUCLEAR PLANT

ROOF PLAN AT
ELEV. 802.92' & 811'

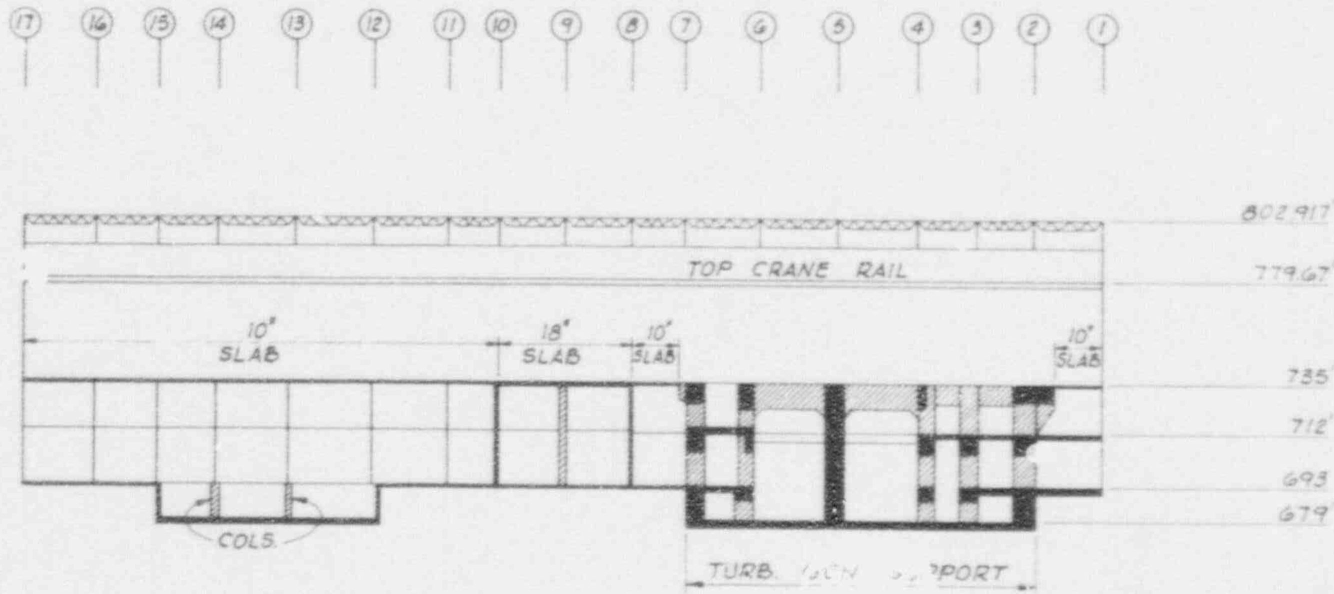
FIG. NO. 6



JOHN A. BLUME AND ASSOCIATES, ENGINEERS
PRAIRIE ISLAND NUCLEAR PLANT
SECTION A-A

JAN. 22, 1971

FIG. NO. 7



JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR PLANT

SECTION B-B

FIG. NO. 8

JAN. 22, 1971

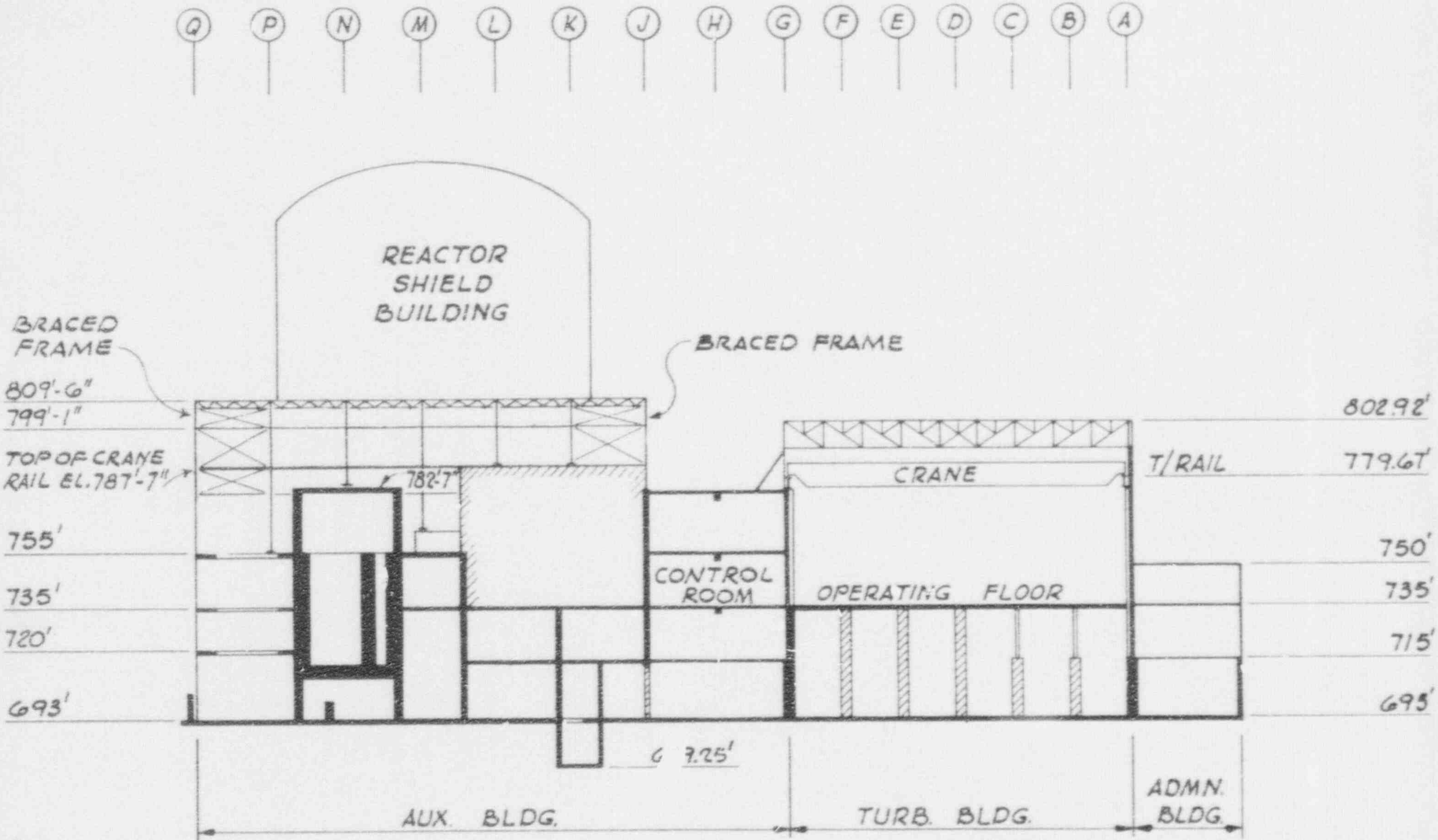


FIGURE NO. 9

JAN. 22, 1971

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR PLANT

SECTION C - C

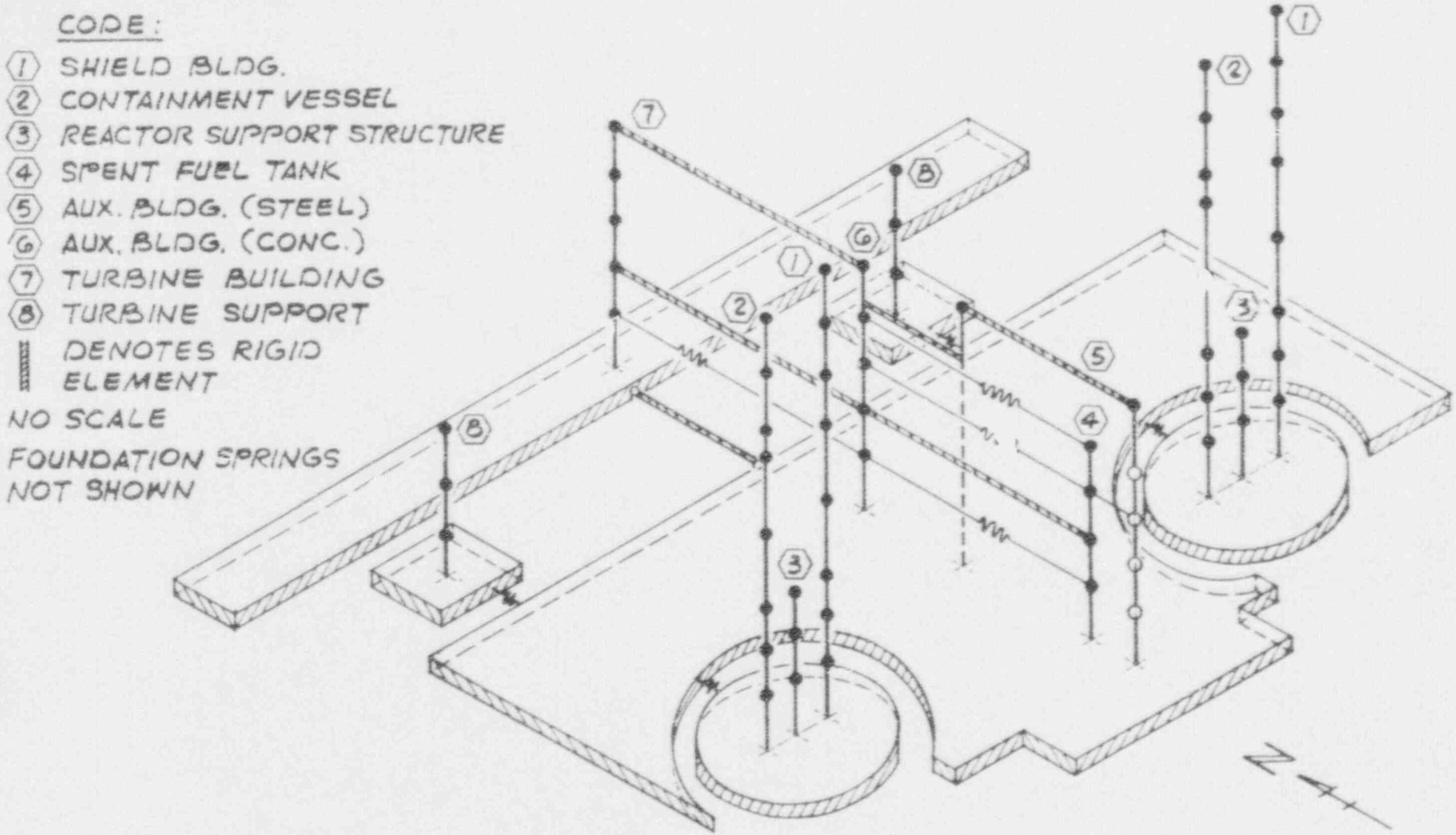


FIGURE NO. 10

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR PLANT

MATHEMATICAL MODEL

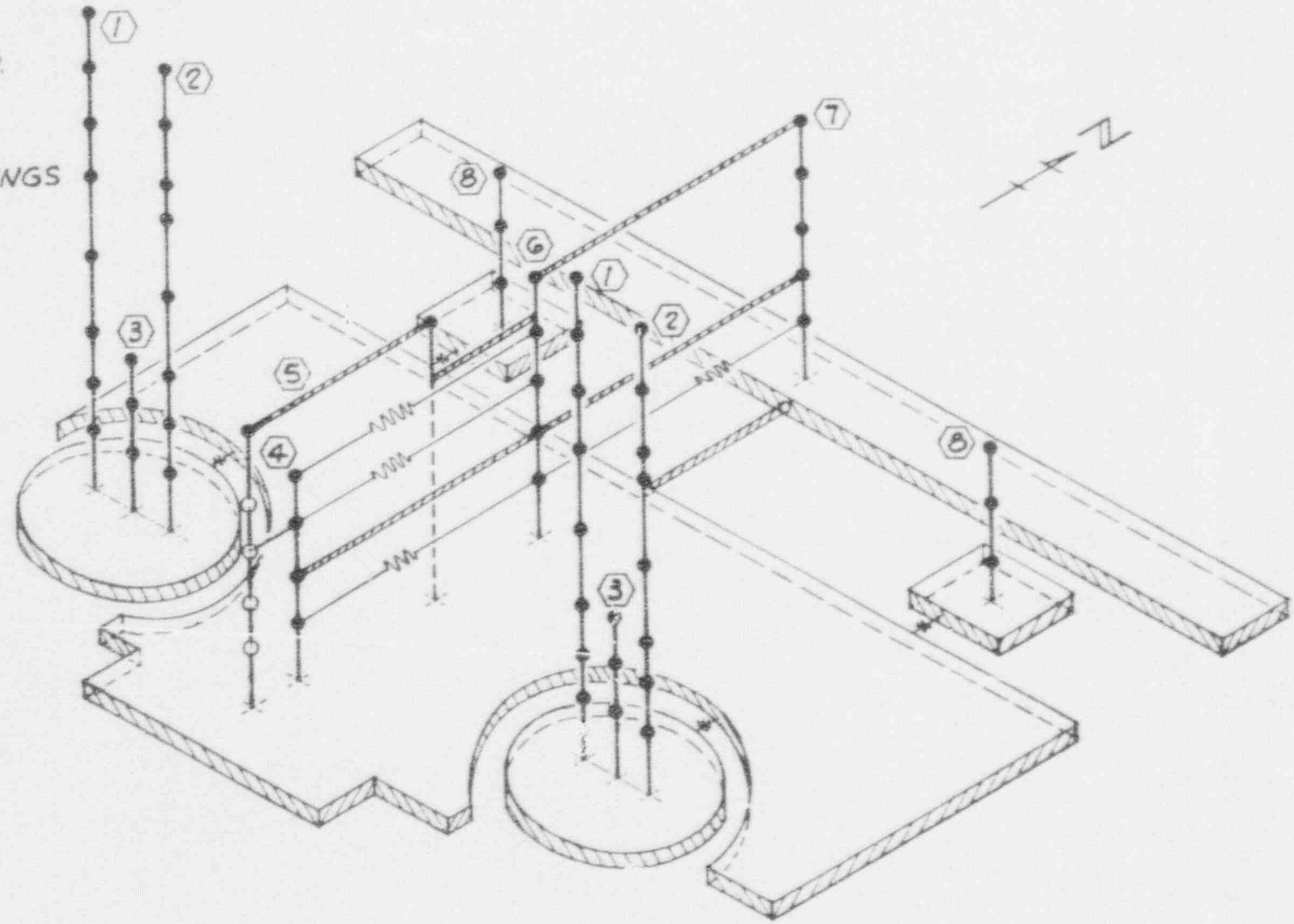
SOUTHWEST VIEW

NOTES:

⬡ - SEE FIGURE NO. FOR CODE

NO SCALE

FOUNDATION SPRINGS NOT SHOWN



JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR PLANT

MATHEMATICAL MODEL

SOUTHEAST VIEW

FIGURE NO. 11

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND NUCLEAR PLANT
MATHEMATICAL MODEL
WEST ELEVATION

⬡ - SEE FIGURE NO. 1 FOR CODE

NO SCALE

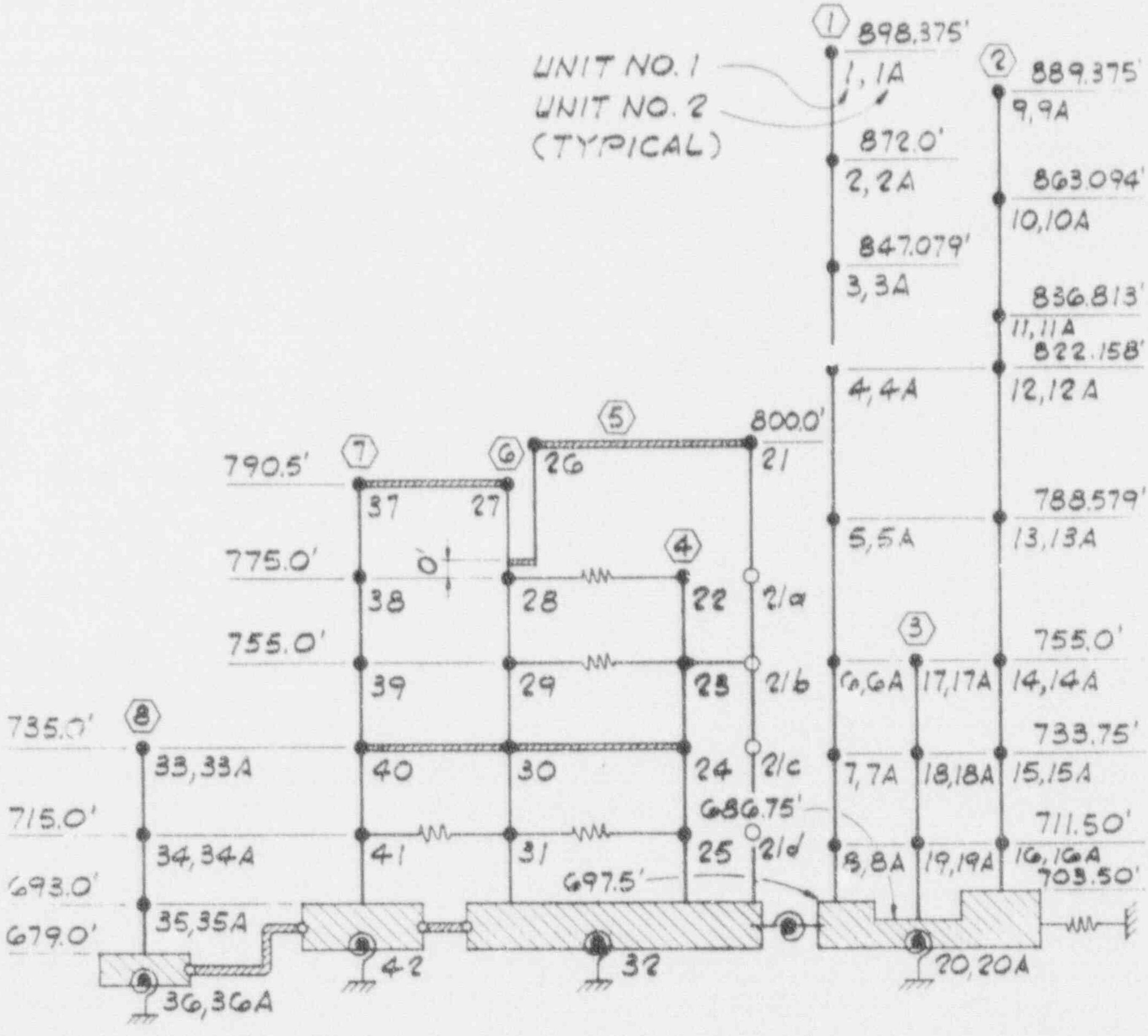


FIGURE NO. 12

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND SHIELD BUILDING
EARTHQUAKE IN N-S OR E-W DIRECTION
MAXIMUM ACCEL. DIAGRAM (TRANSLATION)

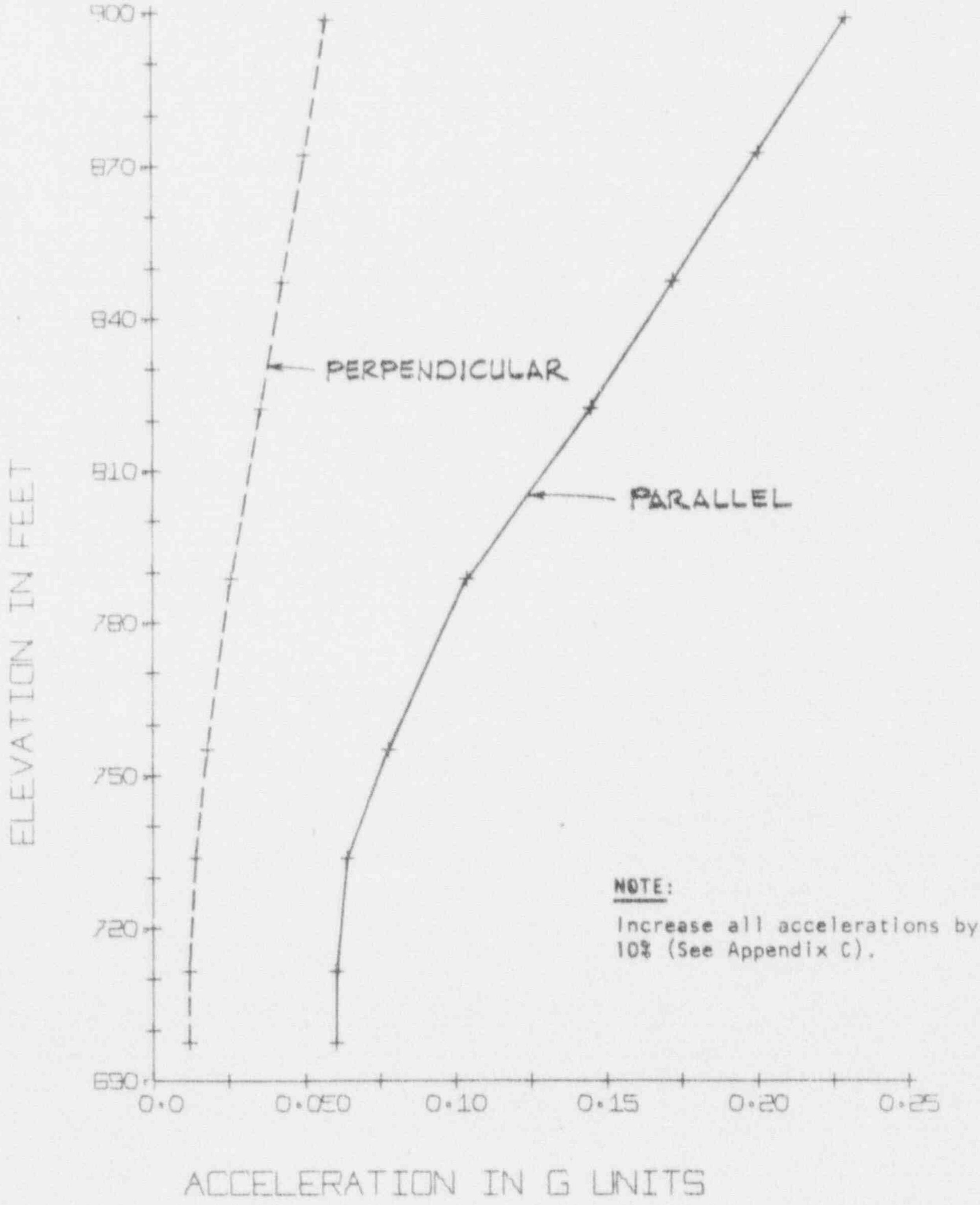


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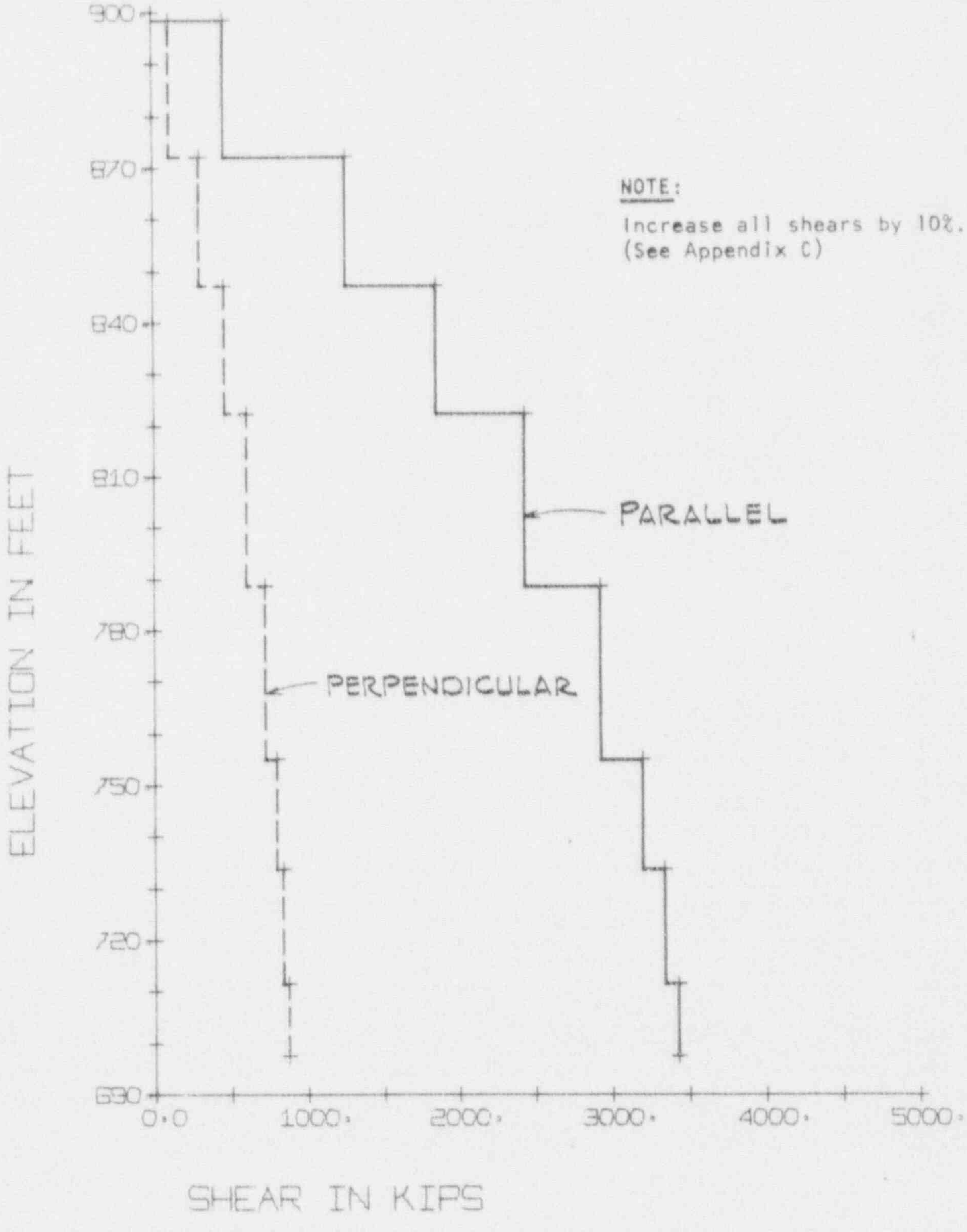
FIGURE NO. 13

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND SHIELD BUILDING
EARTHQUAKE IN N-S OR E-W DIRECTION
MAXIMUM SHEAR DIAGRAM

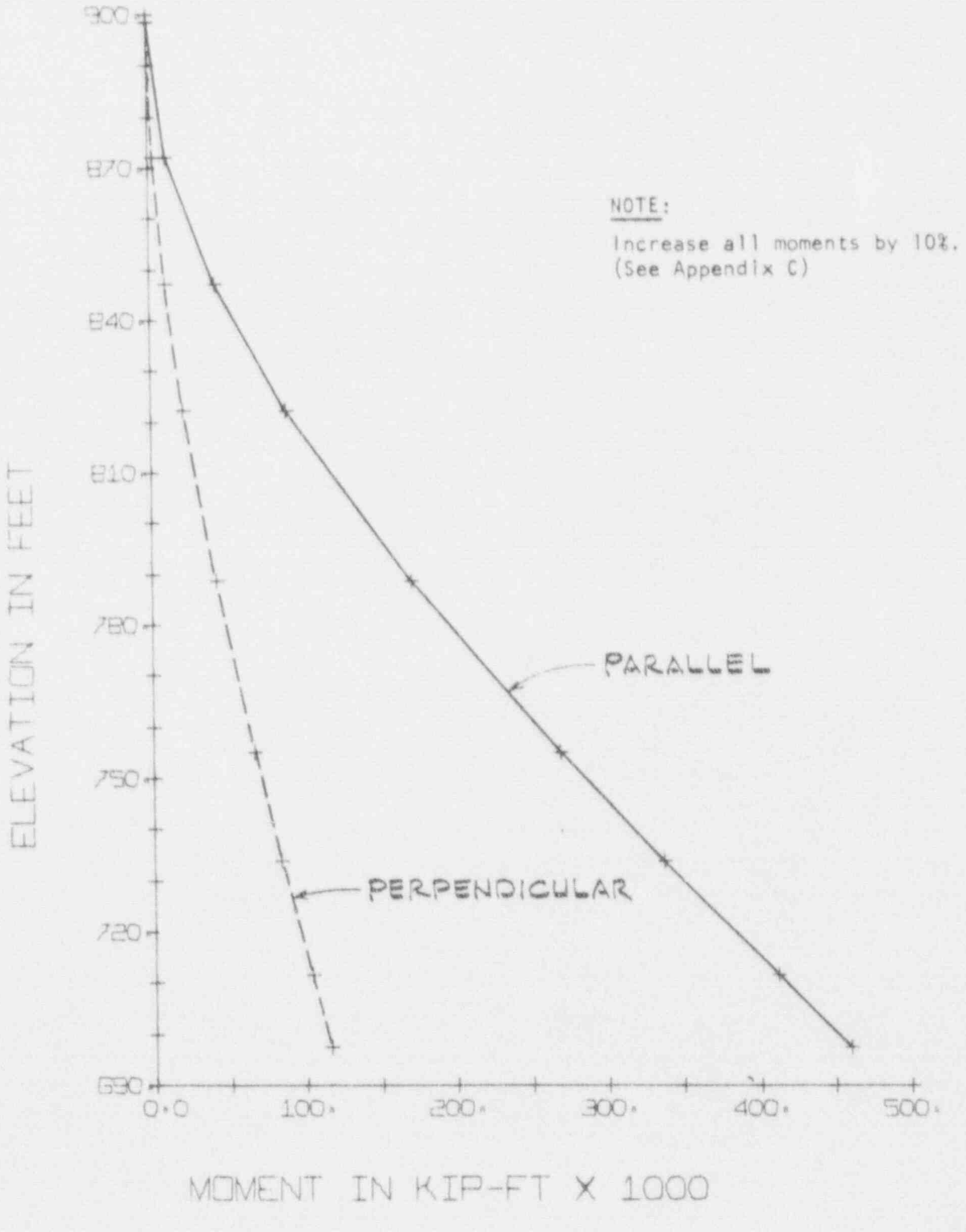


SEP 27 1968

FIGURE NO. 14

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND SHIELD BUILDING
EARTHQUAKE IN N-S OR E-W DIRECTION
MAXIMUM MOMENT DIAGRAM



JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND SHIELD BUILDING
EARTHQUAKE IN N-S OR E-W DIRECTION
MAXIMUM DISPLACEMENT DIAGRAM

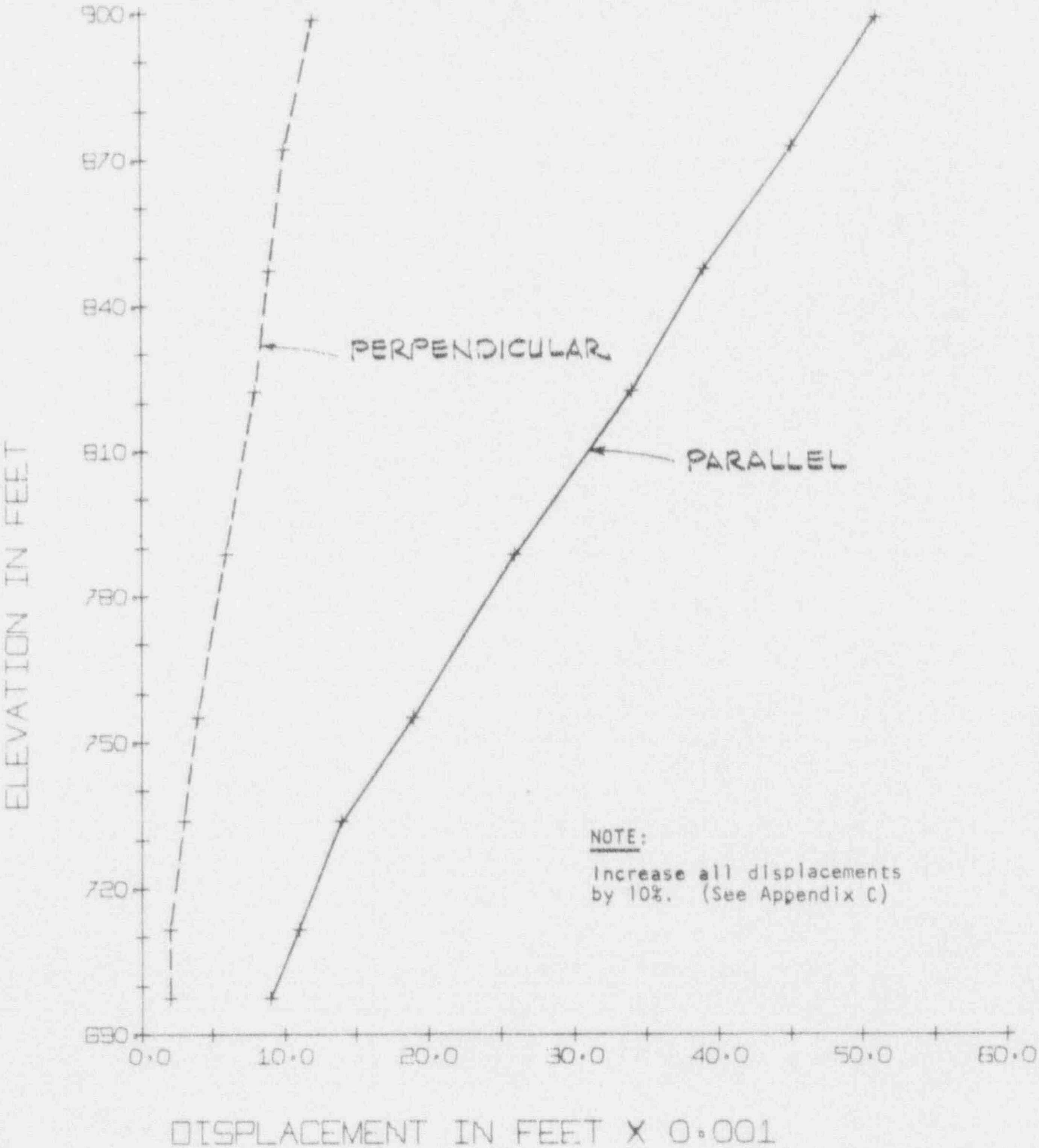


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FIGURE NO. 16

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND CONTAINMENT VESSEL EARTHQUAKE IN N-S OR E-W DIRECTION MAXIMUM ACCEL. DIAGRAM (TRANSLATION)

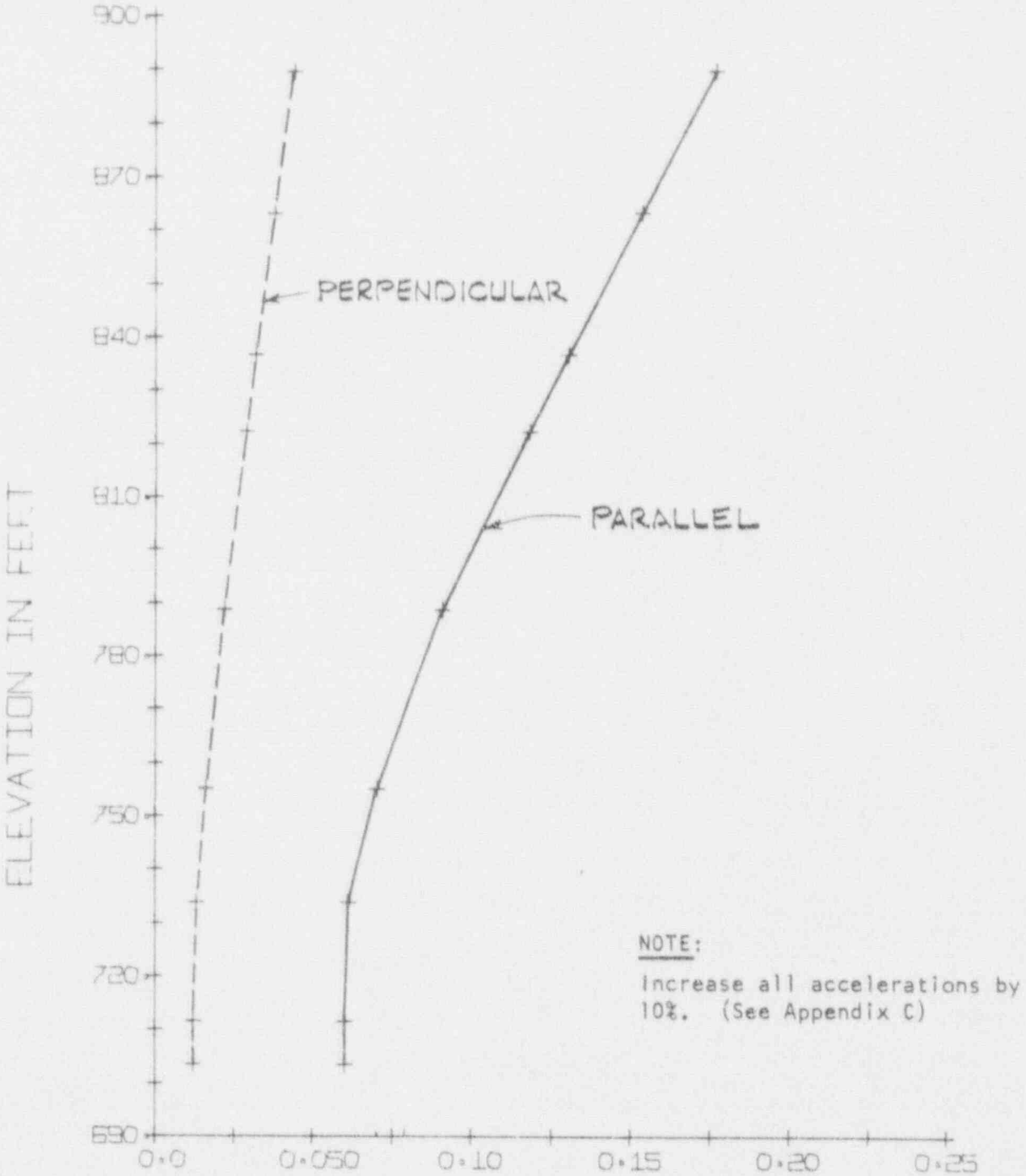

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FIGURE NO. 17

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND CONTAINMENT VESSEL
EARTHQUAKE IN N-S OR E-W DIRECTION
MAXIMUM SHEAR DIAGRAM

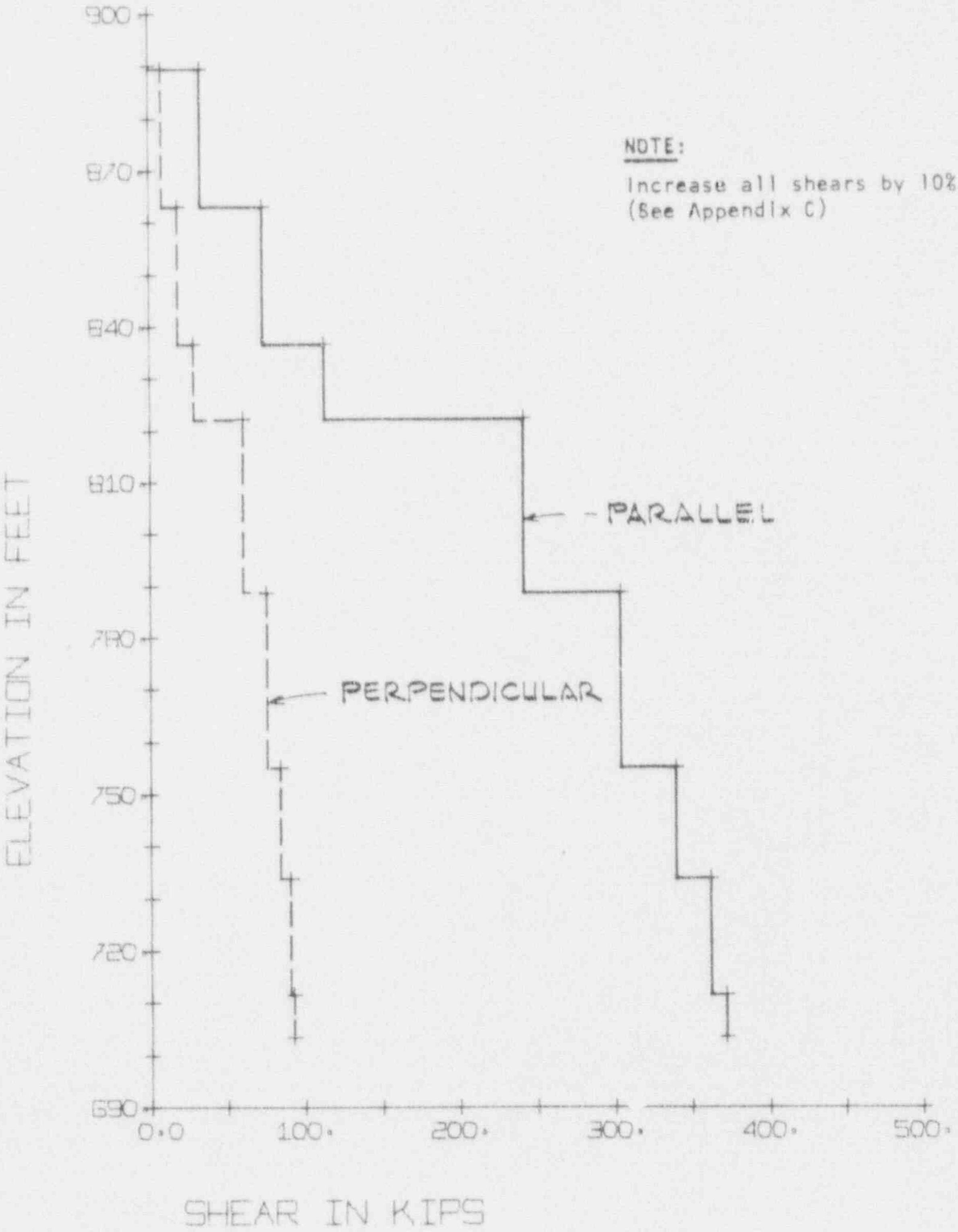

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FIGURE NO. 18

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND CONTAINMENT VESSEL EARTHQUAKE IN N-S OR E-W DIRECTION MAXIMUM MOMENT DIAGRAM

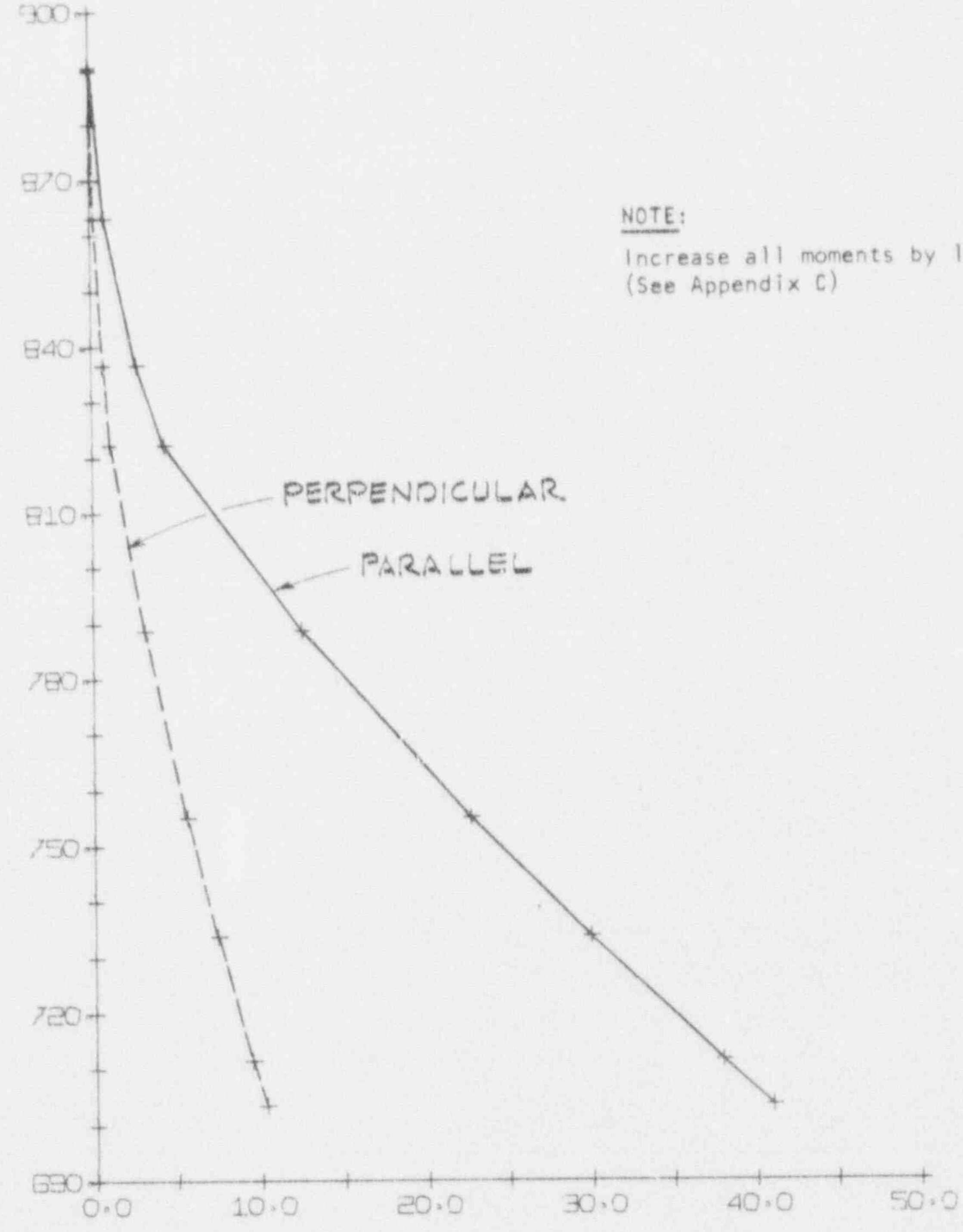

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FIGURE NO. 19

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND CONTAINMENT VESSEL
EARTHQUAKE IN N-S OR E-W DIRECTION
MAXIMUM DISPLACEMENT DIAGRAM

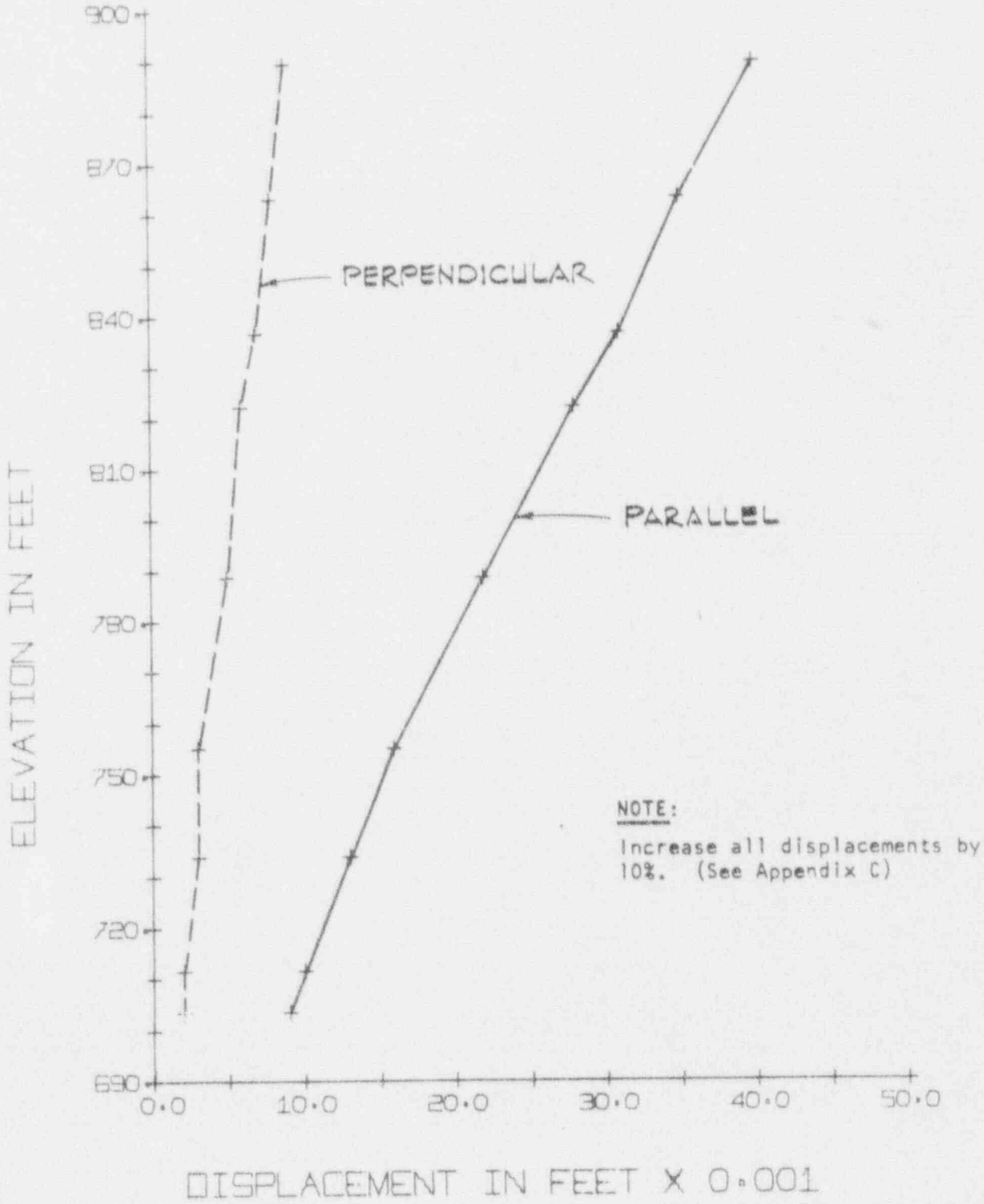

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FIGURE NO. 20

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND AUX CONC BLDG

EARTHQUAKE IN N-S DIRECTION

MAXIMUM ACCEL. DIAGRAM (TRANSLATION)

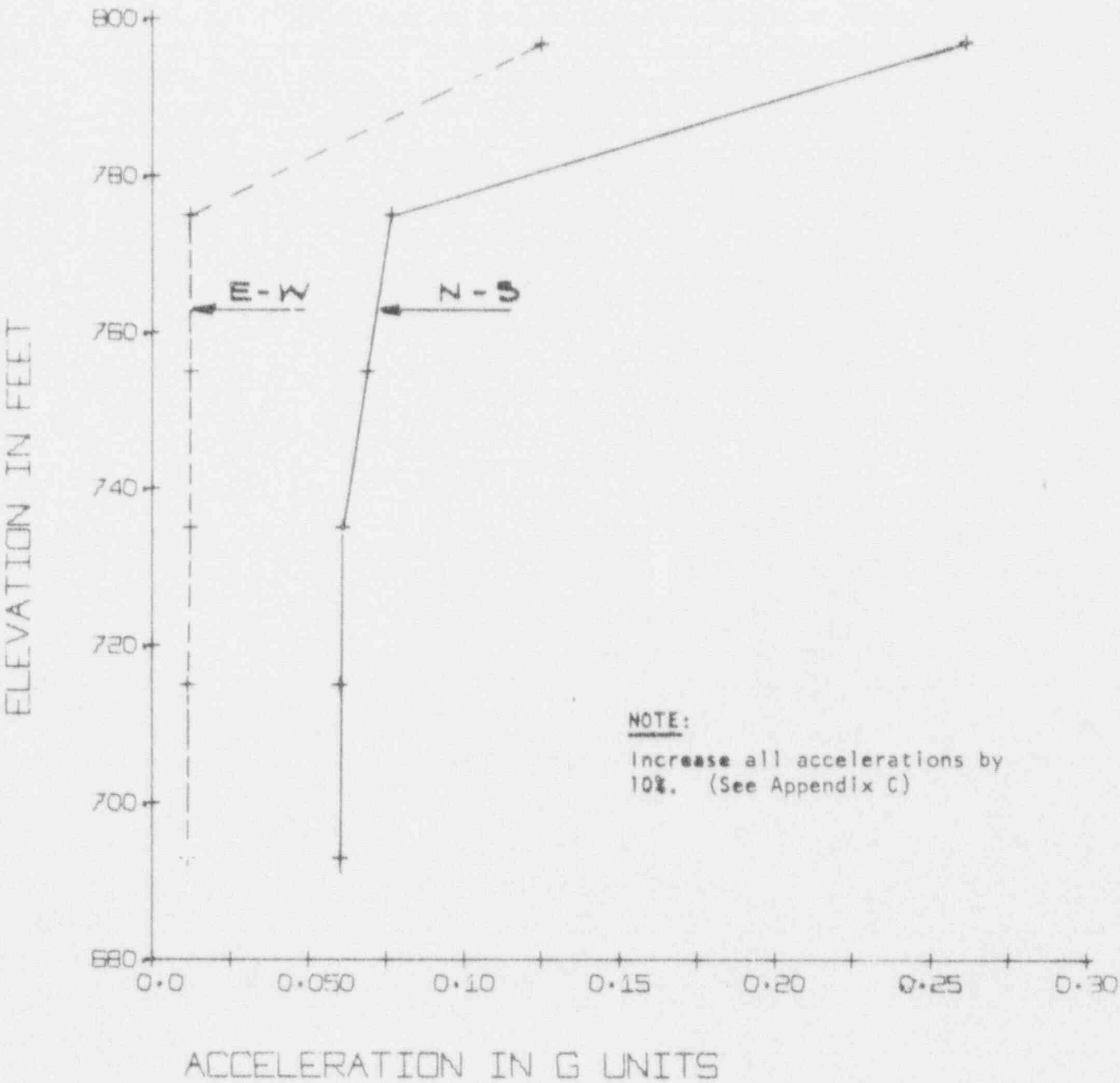

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FIGURE NO. 21

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND AUX CONC BLDG
EARTHQUAKE IN N-S DIRECTION
MAX ACCEL DIAGRAM (ROTATION)

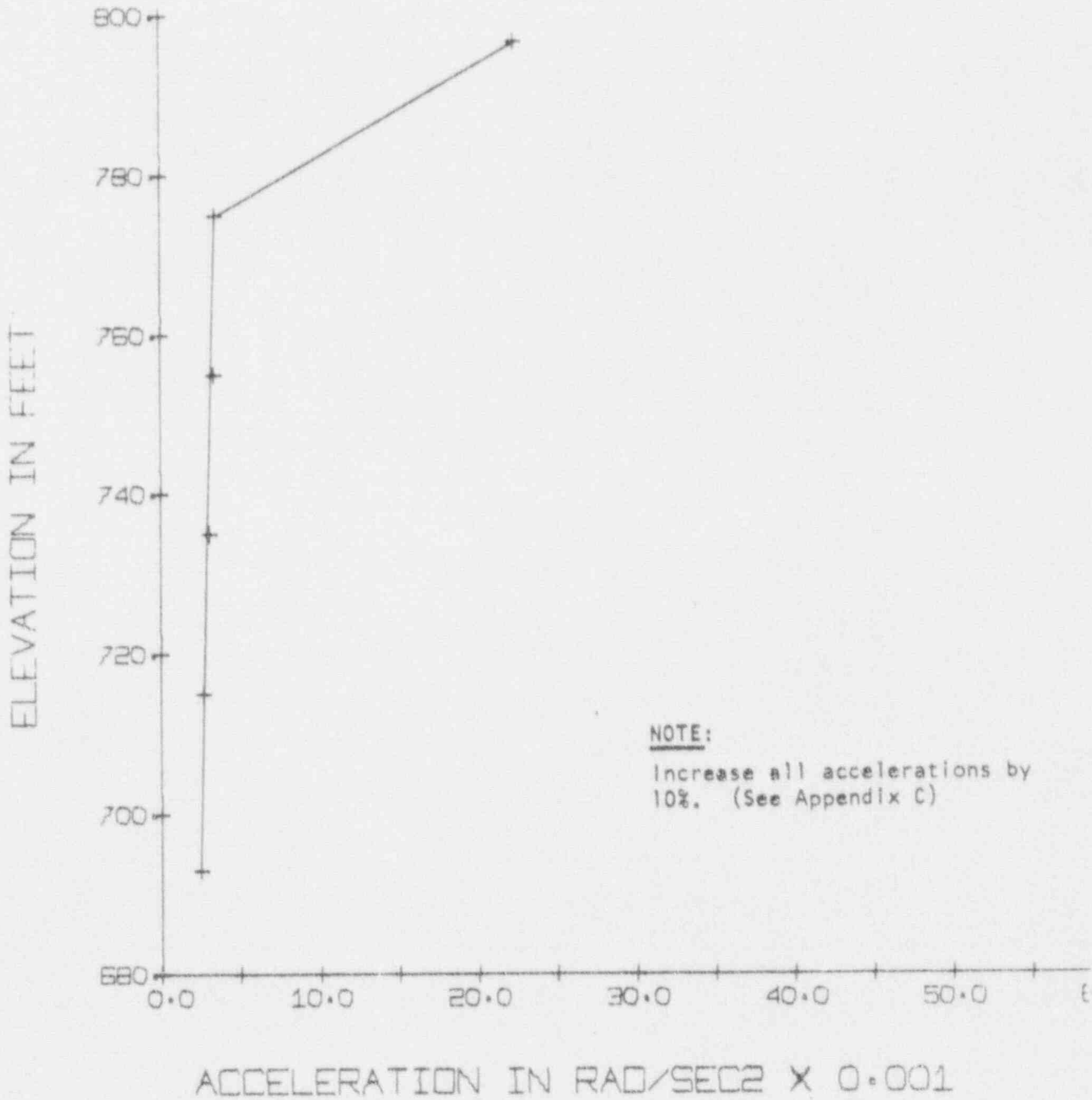

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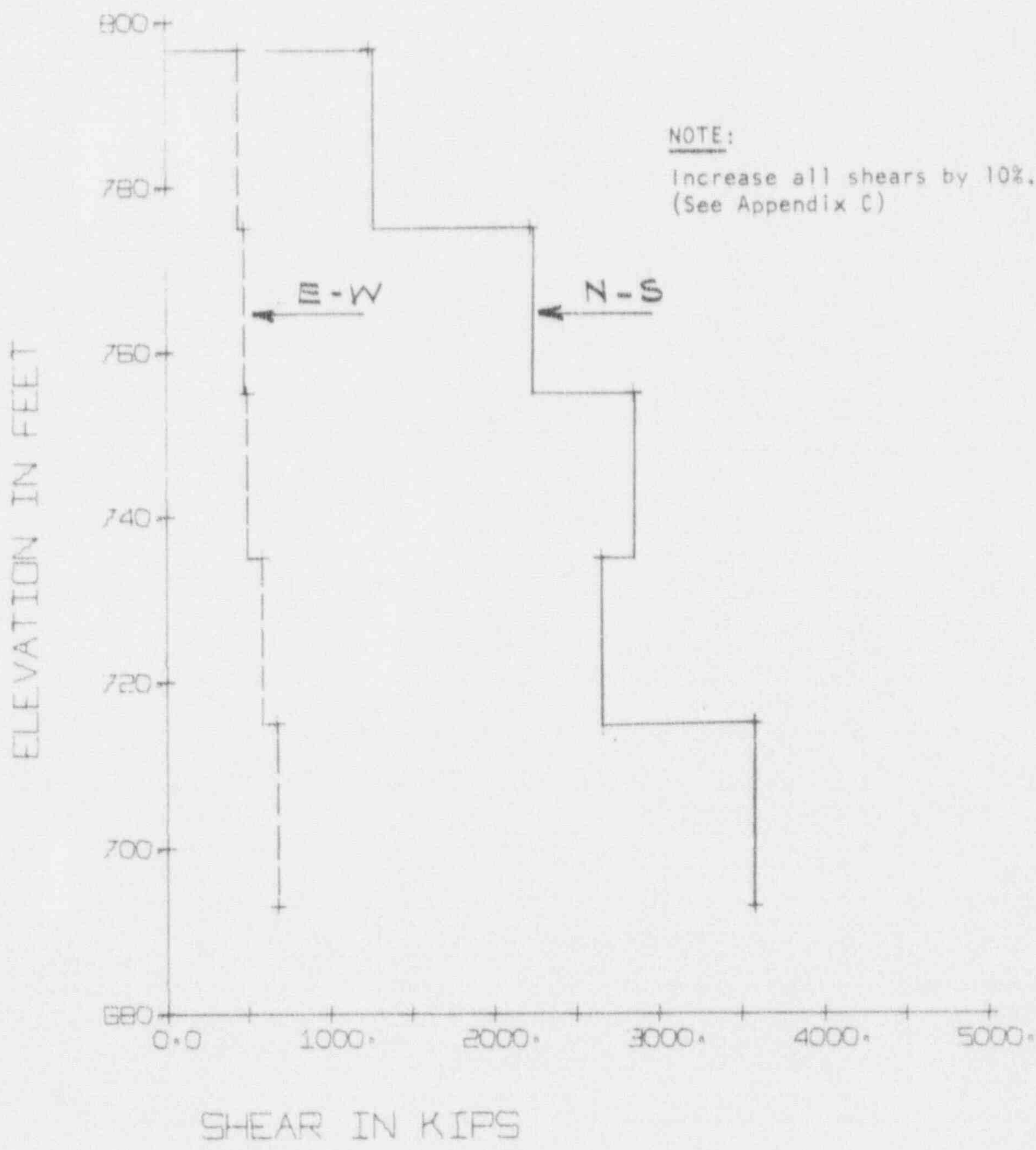
FIGURE NO. 22

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND AUX CONC BLDG
EARTHQUAKE IN N-S DIRECTION
MAXIMUM SHEAR DIAGRAM



NOTE:
Increase all shears by 10%.
(See Appendix C)

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FIGURE NO. 23

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND AUX CONC BLDG
EARTHQUAKE IN N-S DIRECTION
MAXIMUM MOMENT DIAGRAM

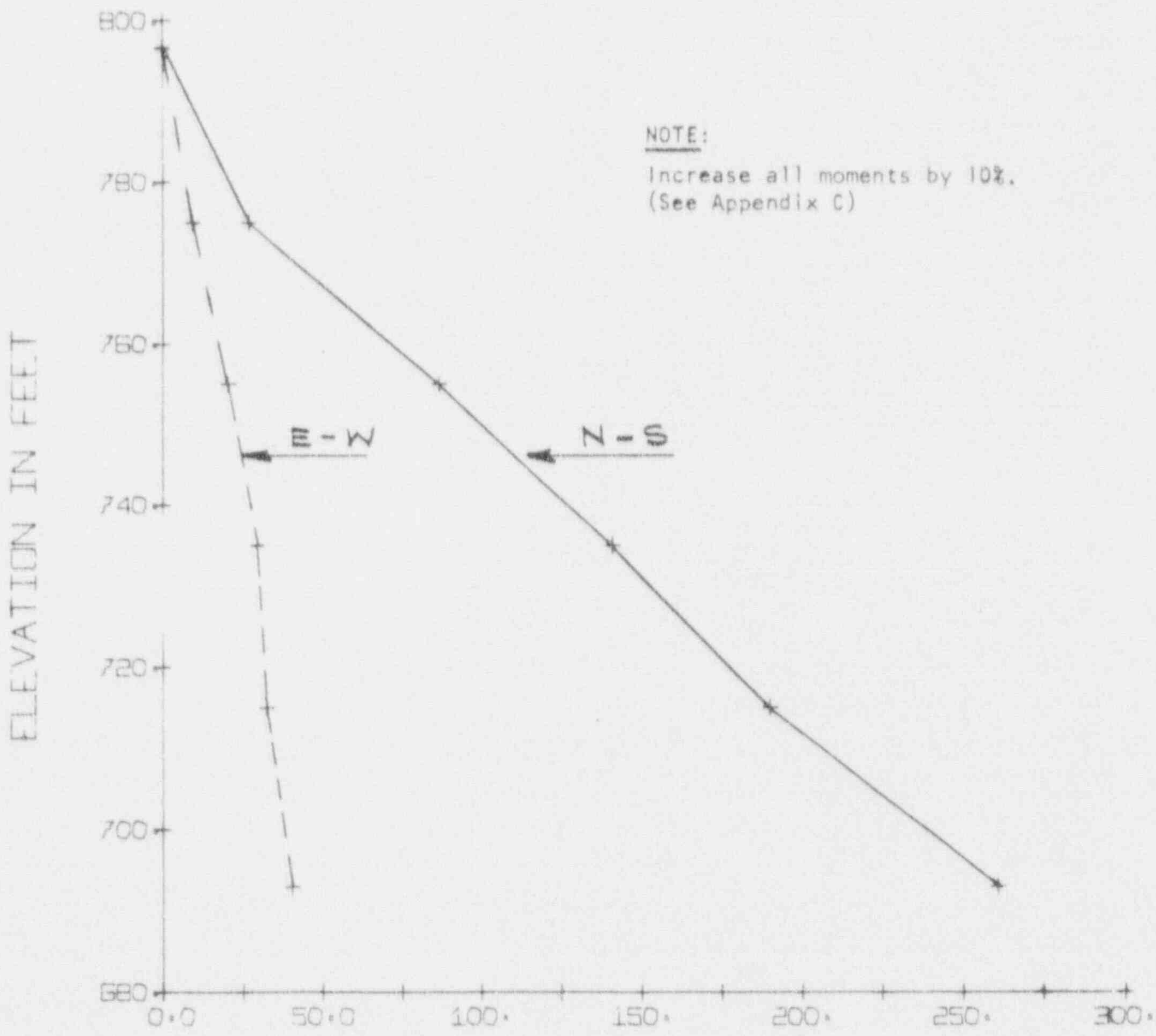

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FIGURE NO. 24

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND AUX CONC BLDG

EARTHQUAKE IN N-S DIRECTION

MAXIMUM TORQUE DIAGRAM

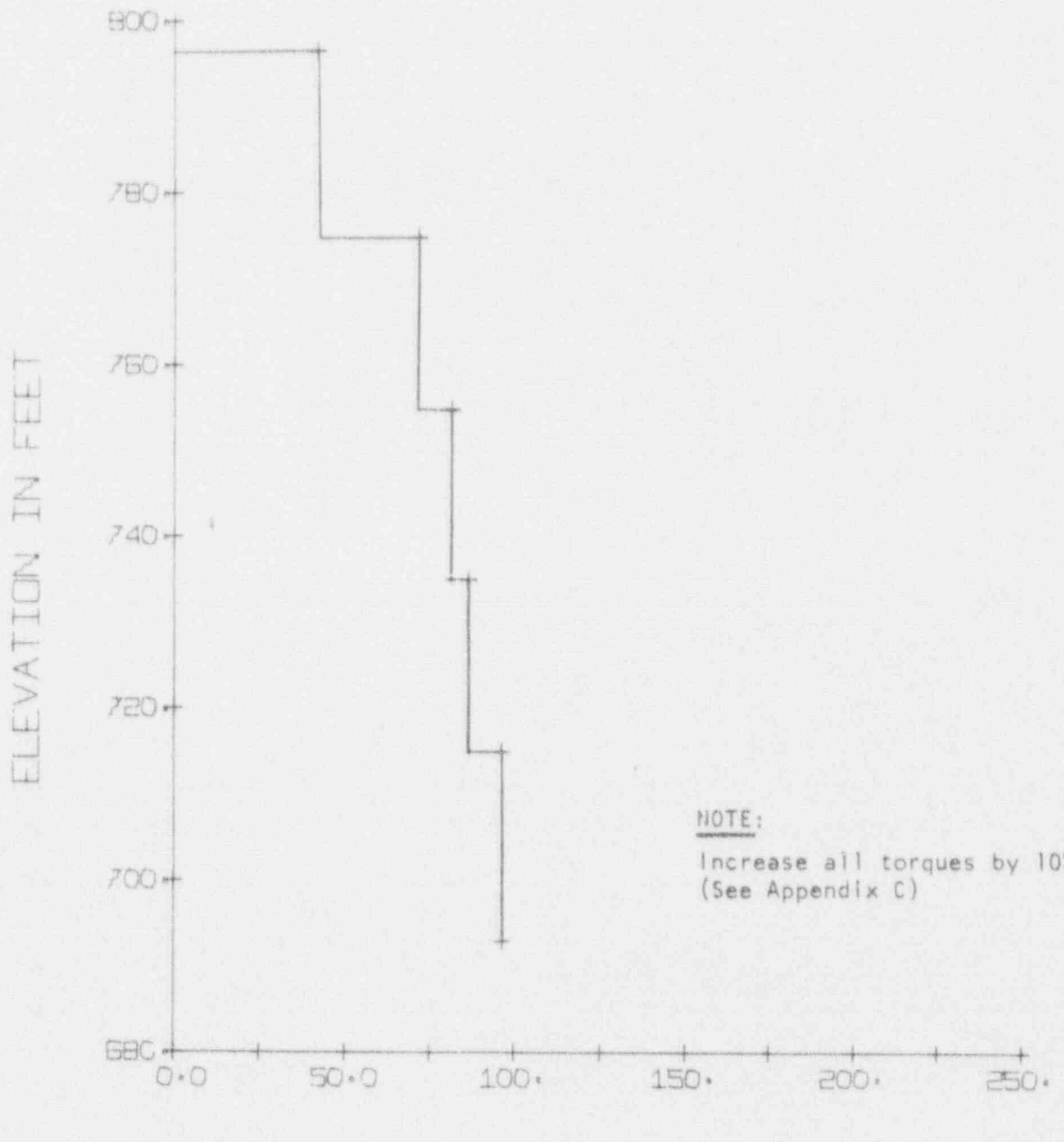

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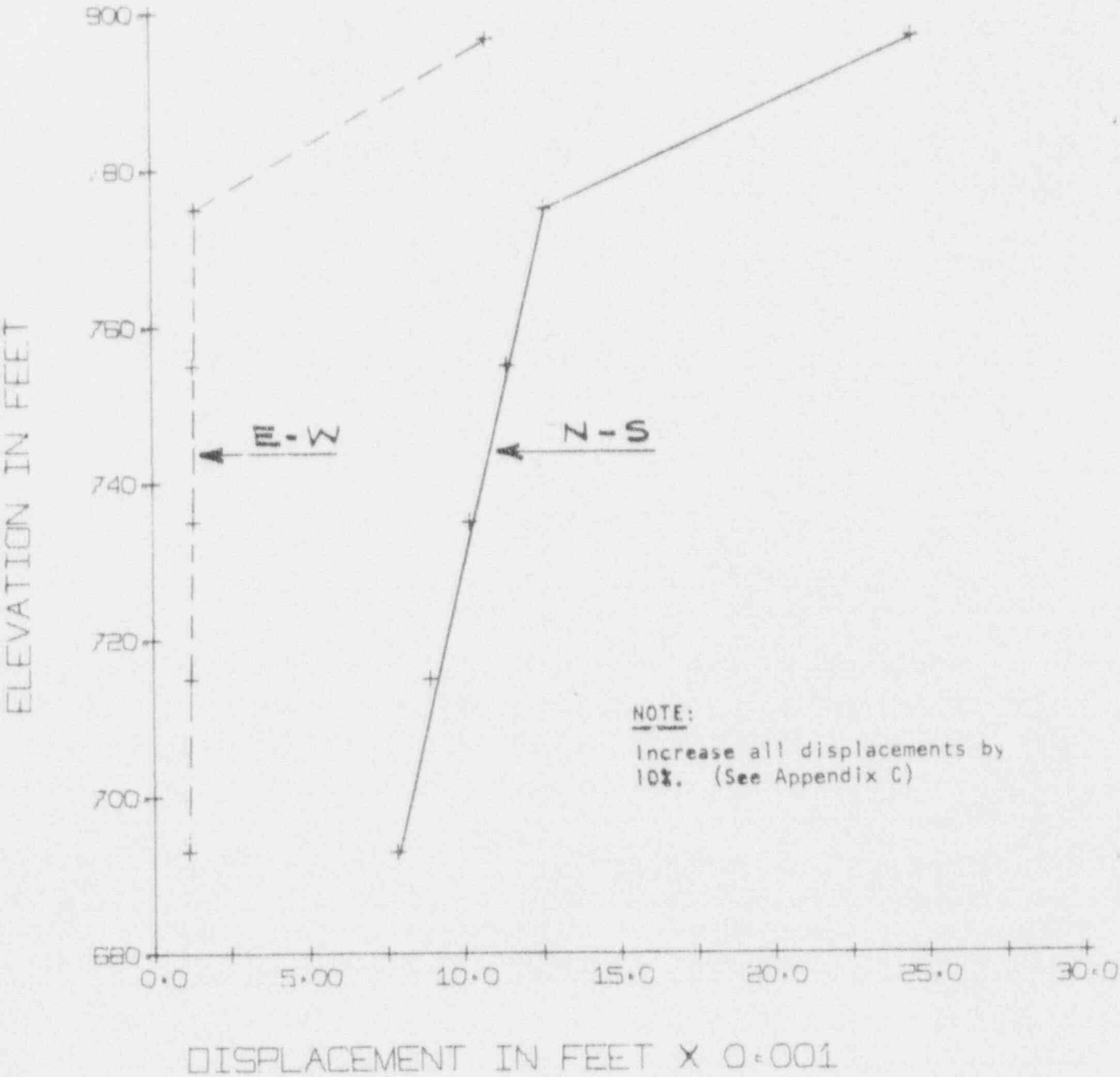
FIGURE NO. 25

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND AUX CONC BLDG

EARTHQUAKE IN N-S DIRECTION

MAXIMUM DISPLACEMENT DIAGRAM



NOTE:

Increase all displacements by 10%. (See Appendix C)

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FIGURE NO. 26

JOHN A. BLUME AND ASSOCIATES, ENGINEERS
PRAIRIE ISLAND AUX CONC BLDG
EARTHQUAKE IN N-S DIRECTION
MAXIMUM ROTATION DIAGRAM

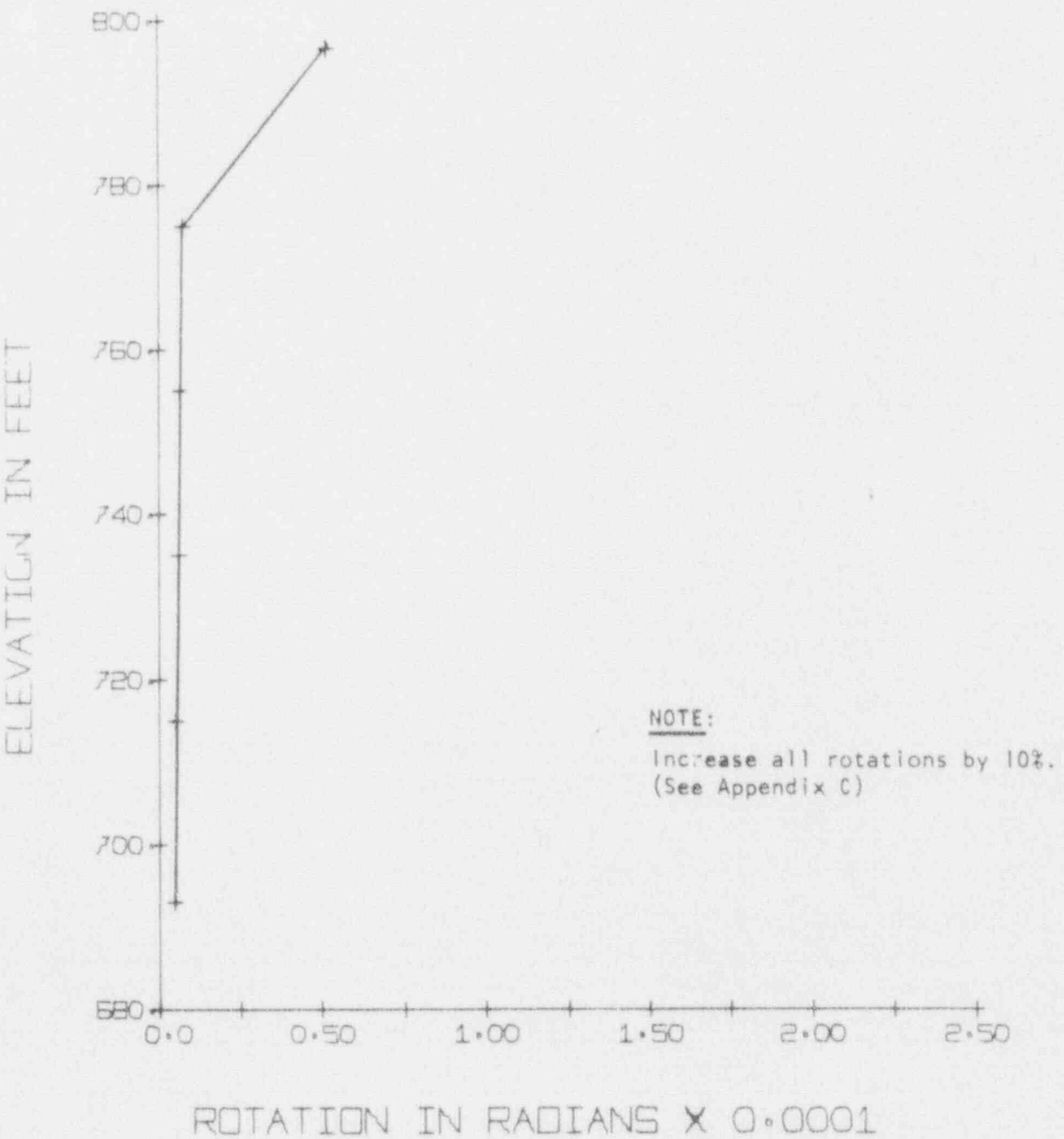

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FIGURE NO. 27

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND AUX CONC BLDG

EARTHQUAKE IN E-W DIRECTION

MAXIMUM ACCEL. DIAGRAM (TRANSLATION)

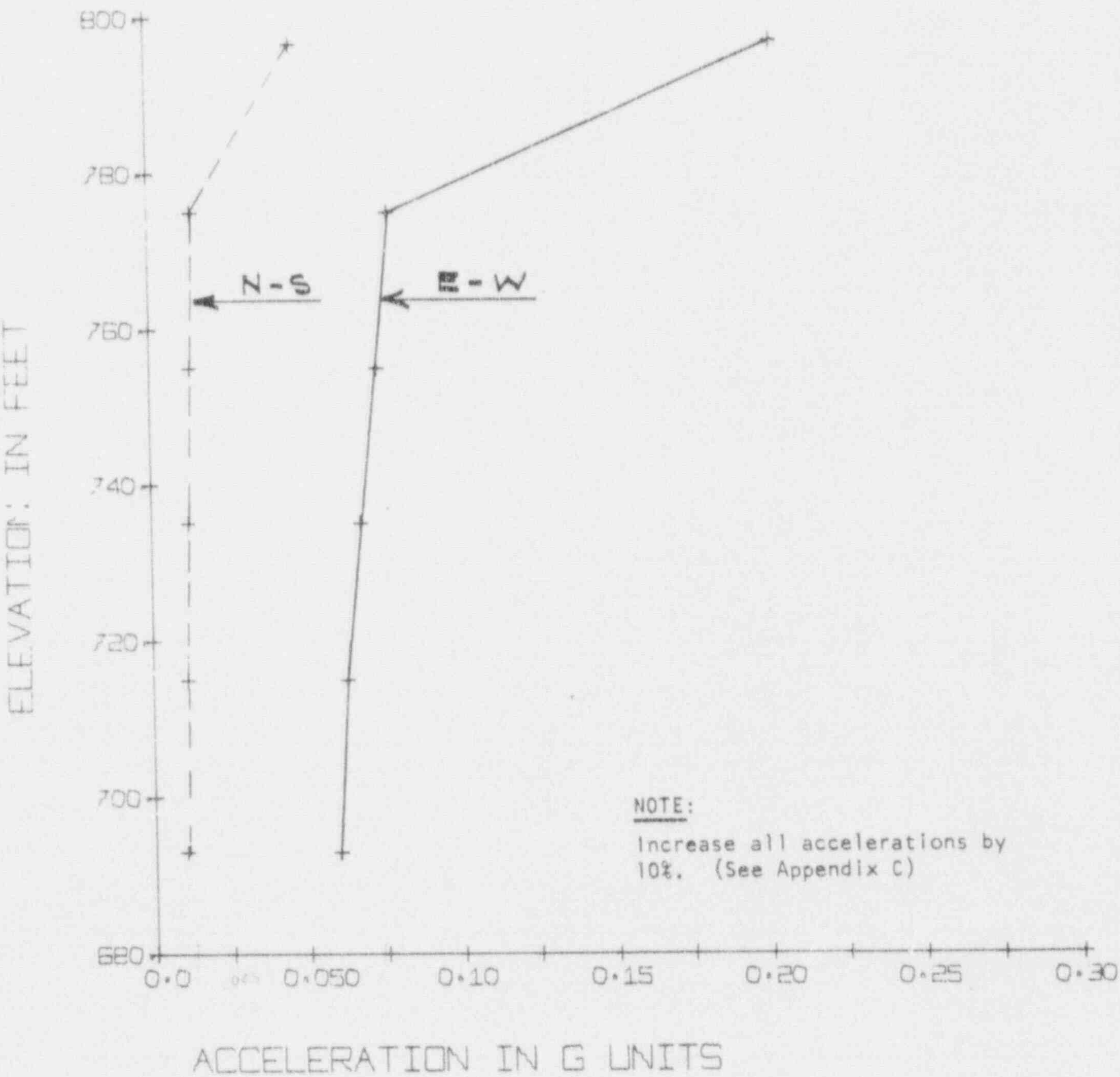

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FIGURE NO. 28

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND AUX CONC BLDG

EARTHQUAKE IN E-W DIRECTION

MAX ACCEL DIAGRAM (ROTATION)

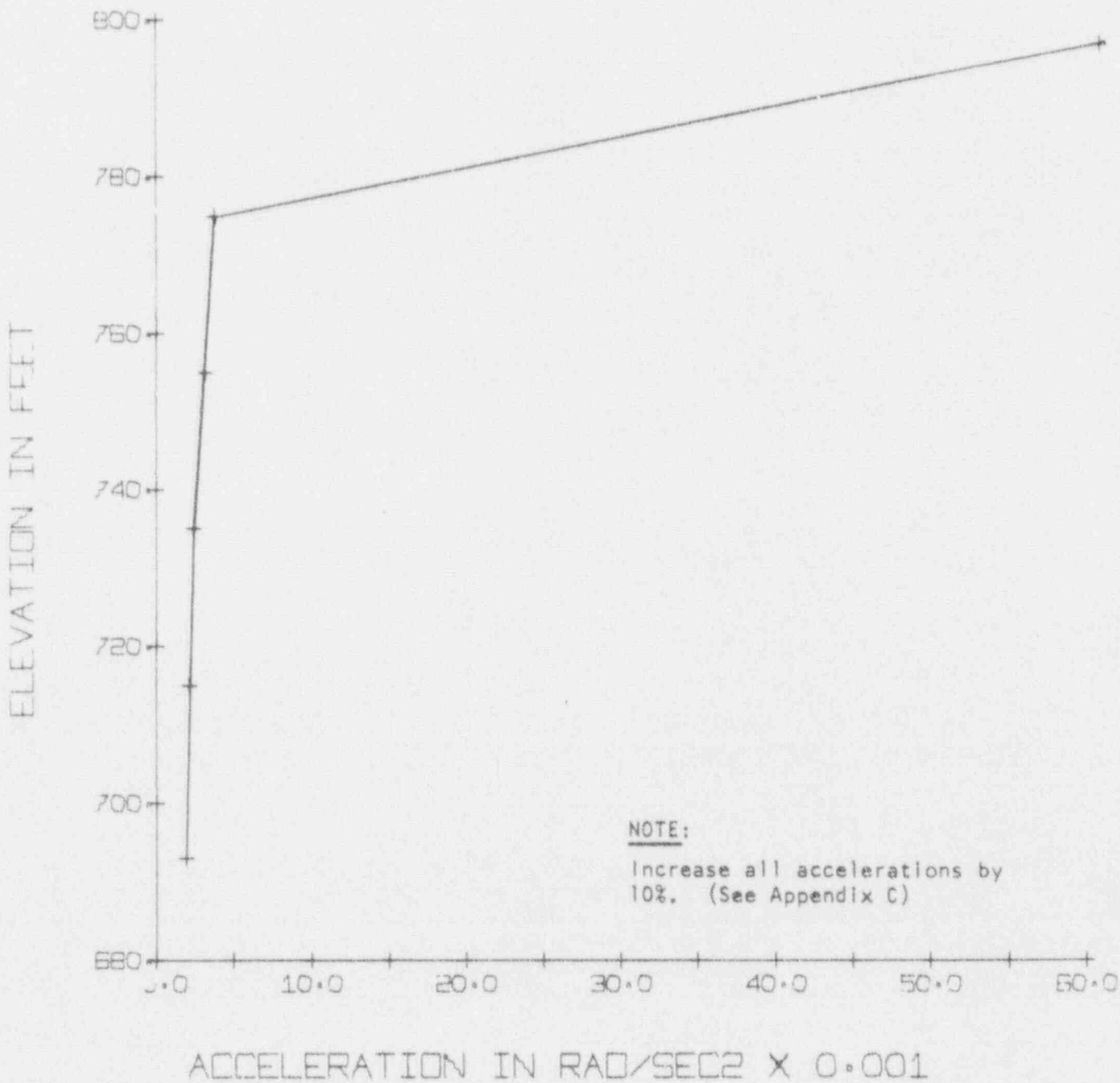

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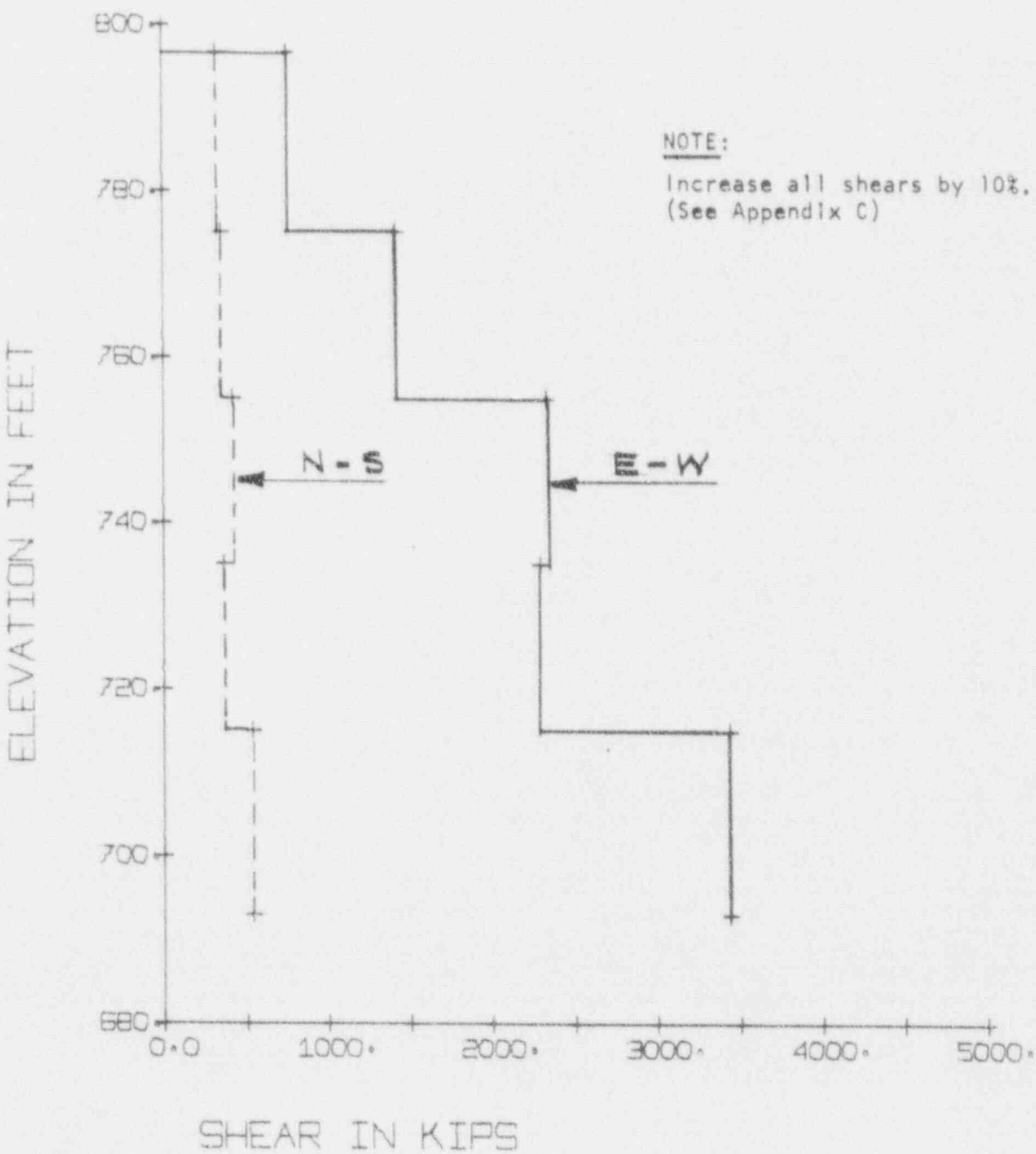
FIGURE NO. 29

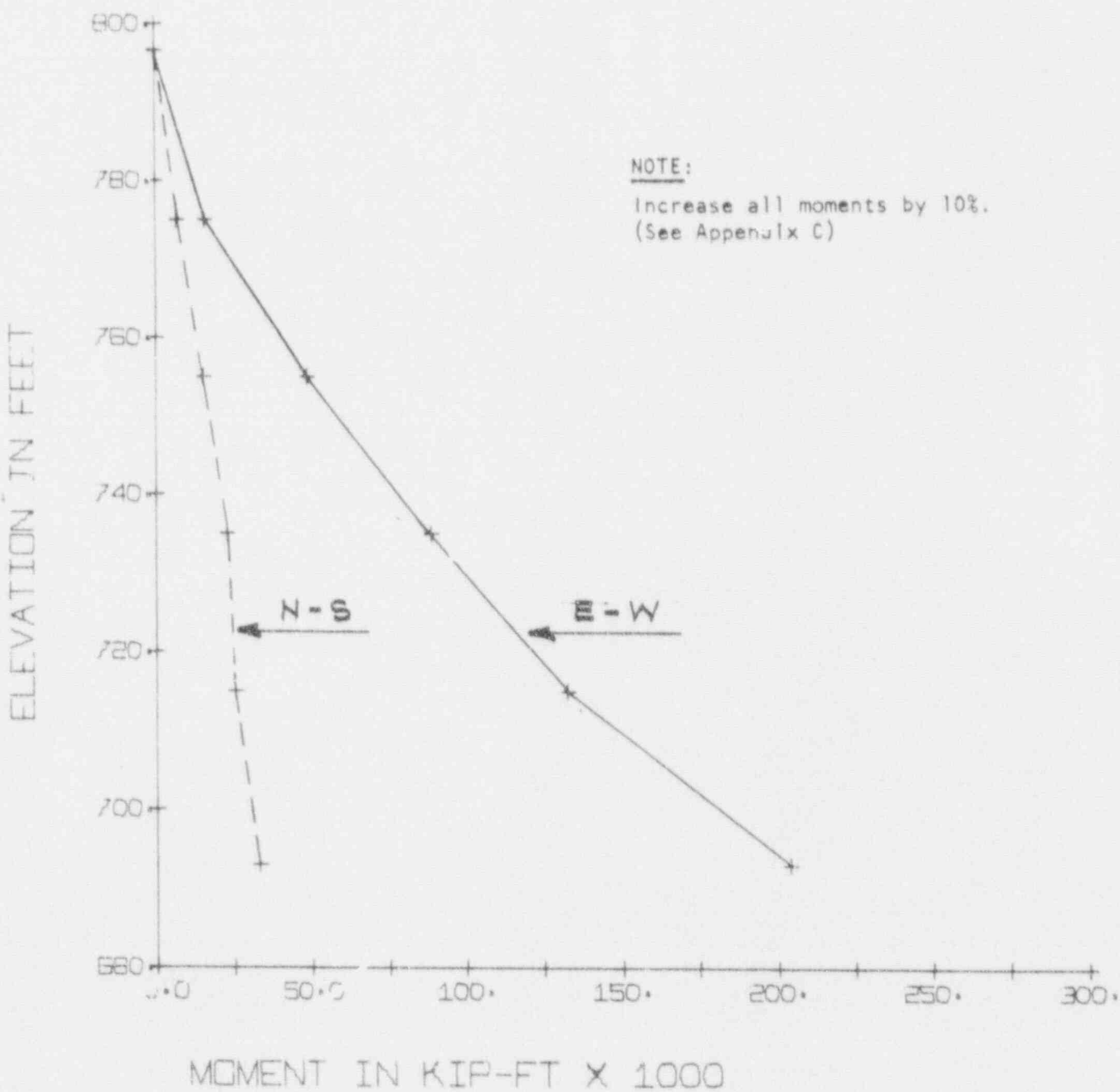
JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND AUX CONC BLDG
EARTHQUAKE IN E-W DIRECTION
MAXIMUM SHEAR DIAGRAM



JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND AUX CONC BLDG
EARTHQUAKE IN E-W DIRECTION
MAXIMUM MOMENT DIAGRAM



SEP 27 1968

FIGURE NO. 31

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND AUX CONC BLDG
EARTHUQAKE IN E-W DIRECTION
MAXIMUM TORQUE DIAGRAM

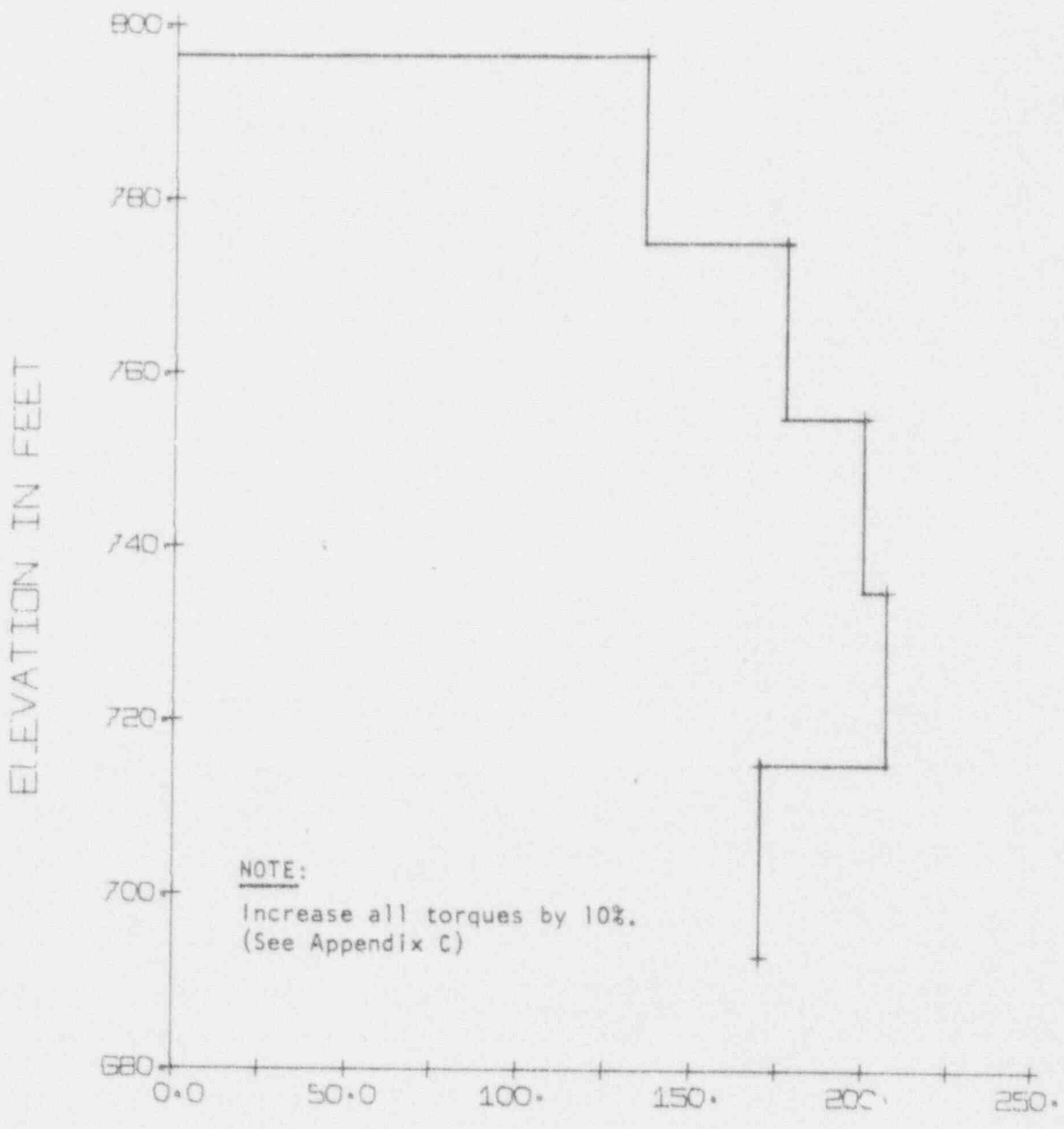


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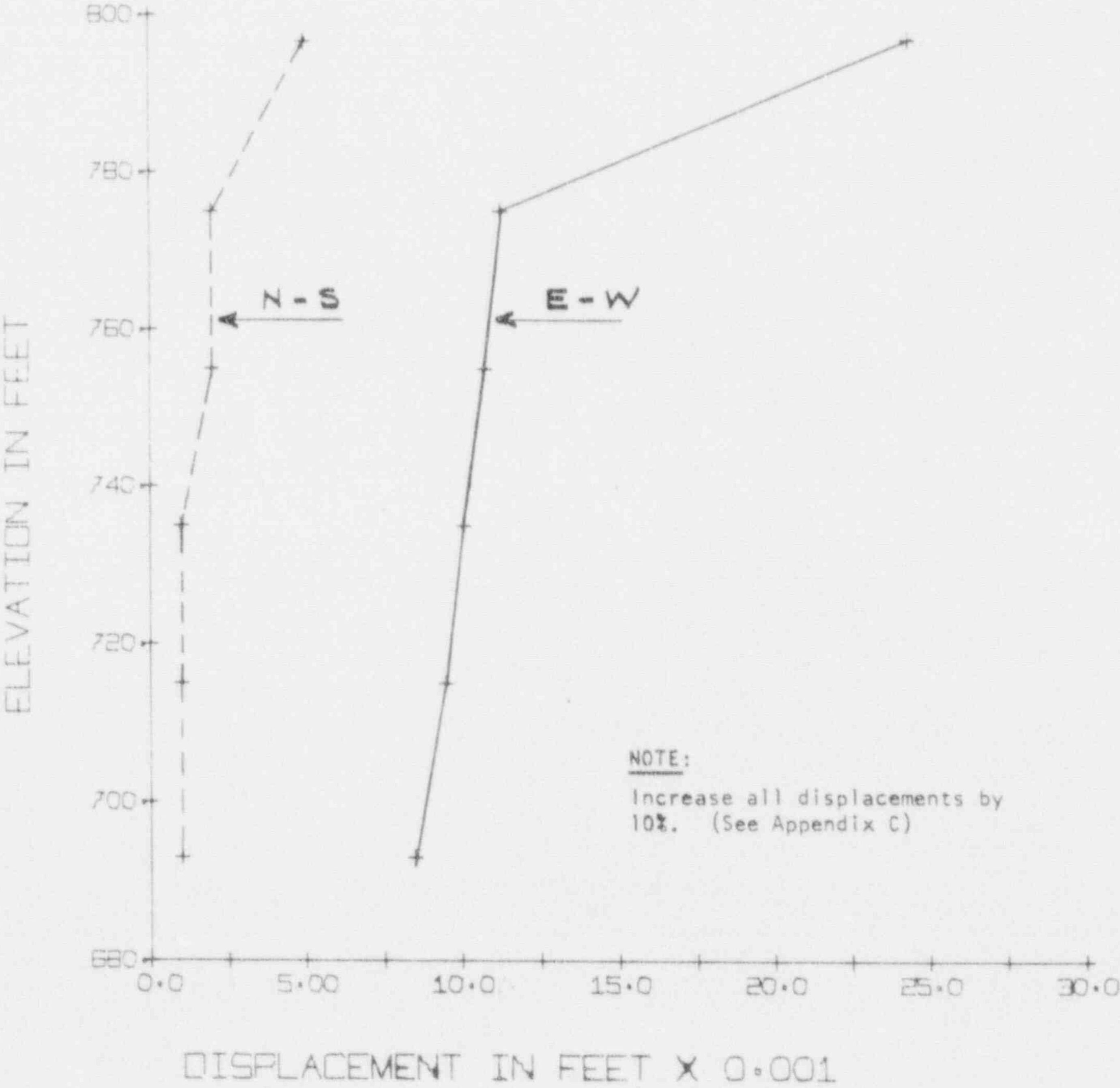
FIGURE NO. 32

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND AUX CONC BLDG

EARTHQUAKE IN E-W DIRECTION

MAXIMUM DISPLACEMENT DIAGRAM



NOTE:

Increase all displacements by 10%. (See Appendix C)

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FIGURE NO. 33

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND AUX CONC BLDG

EARTHQUAKE IN E-W DIRECTION

MAXIMUM ROTATION DIAGRAM

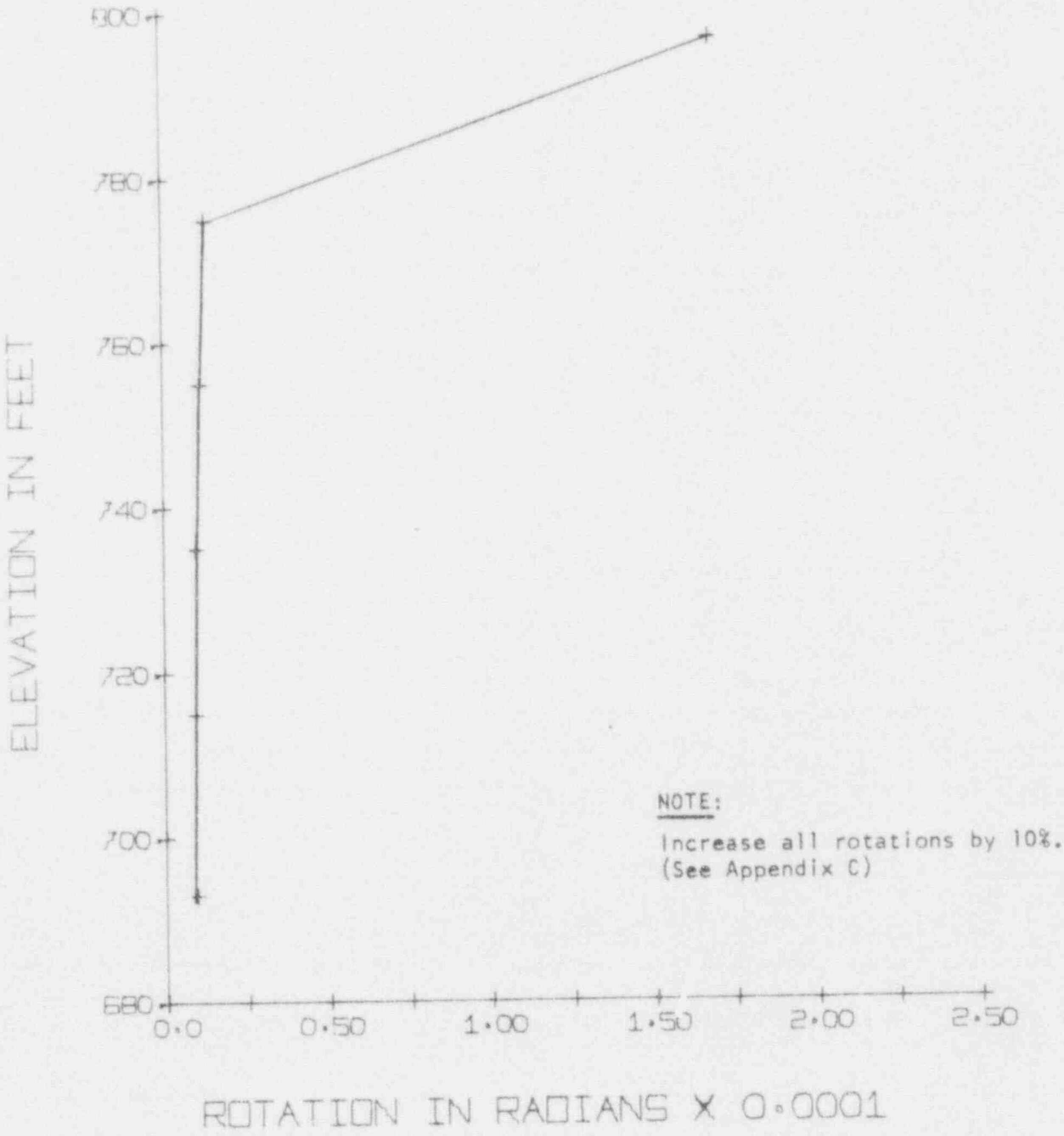

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FIGURE NO. 34

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND FUEL TANK AREA

EARTHQUAKE IN N-S DIRECTION

MAXIMUM ACCEL. DIAGRAM (TRANSLATION)

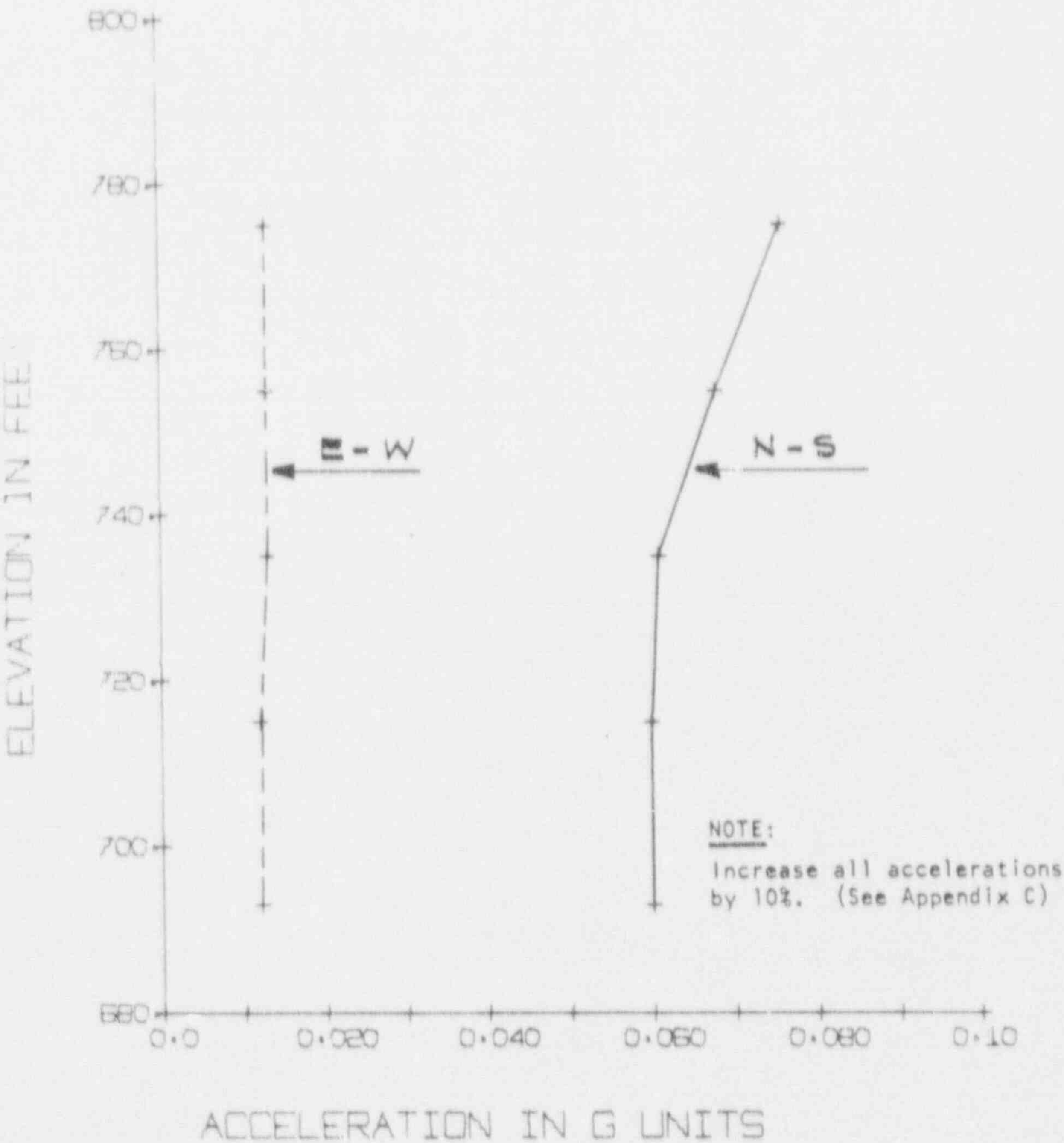

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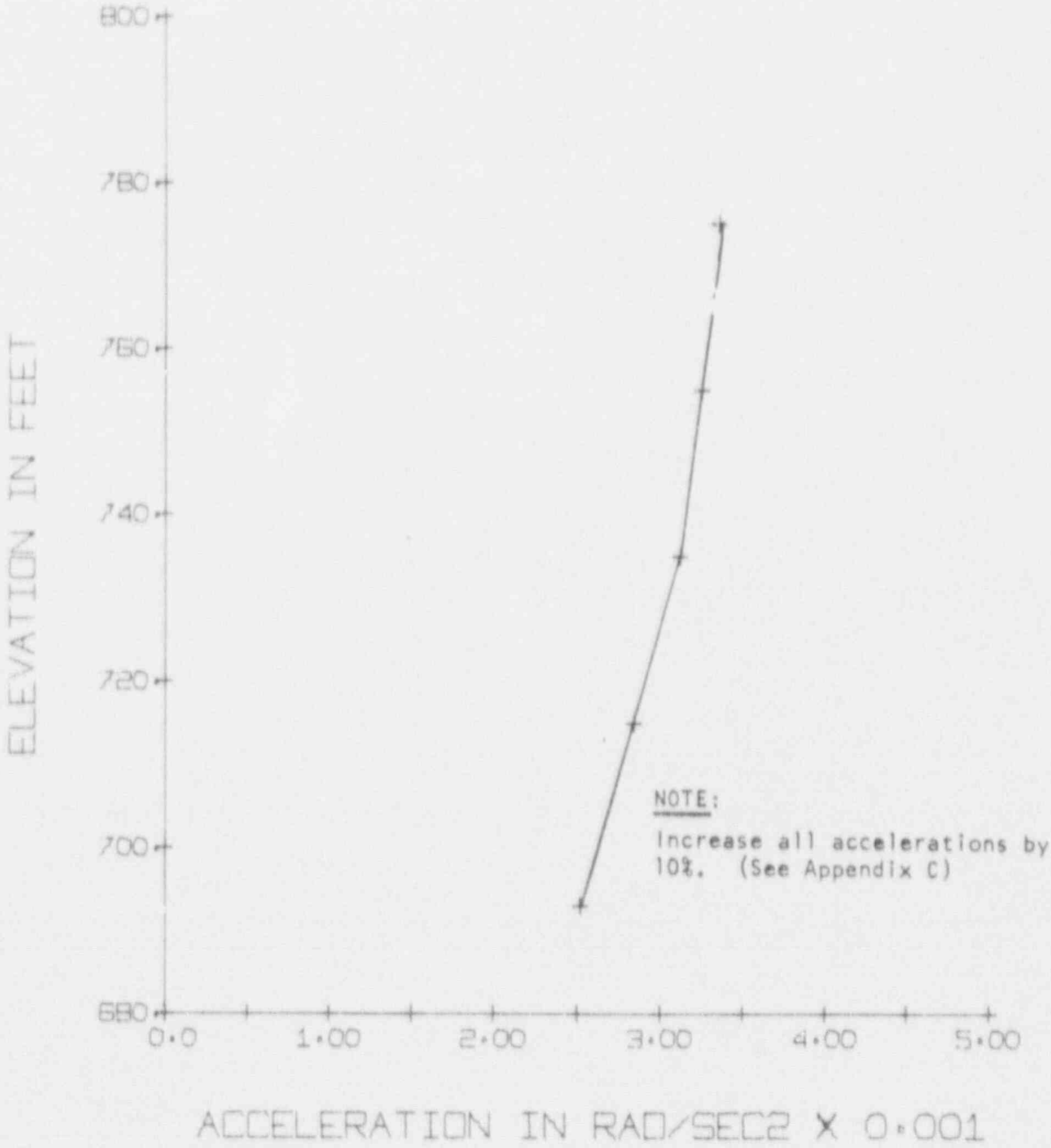
FIGURE NO. 35

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND FUEL TANK AREA

EARTHQUAKE IN N-S DIRECTION

MAX ACCEL DIAGRAM (ROTATION)



JOHN A. BLUME AND ASSOCIATES, ENGINEERS
PRAIRIE ISLAND FUEL TANK AREA
EARTHQUAKE IN N-S DIRECTION
MAXIMUM SHEAR DIAGRAM

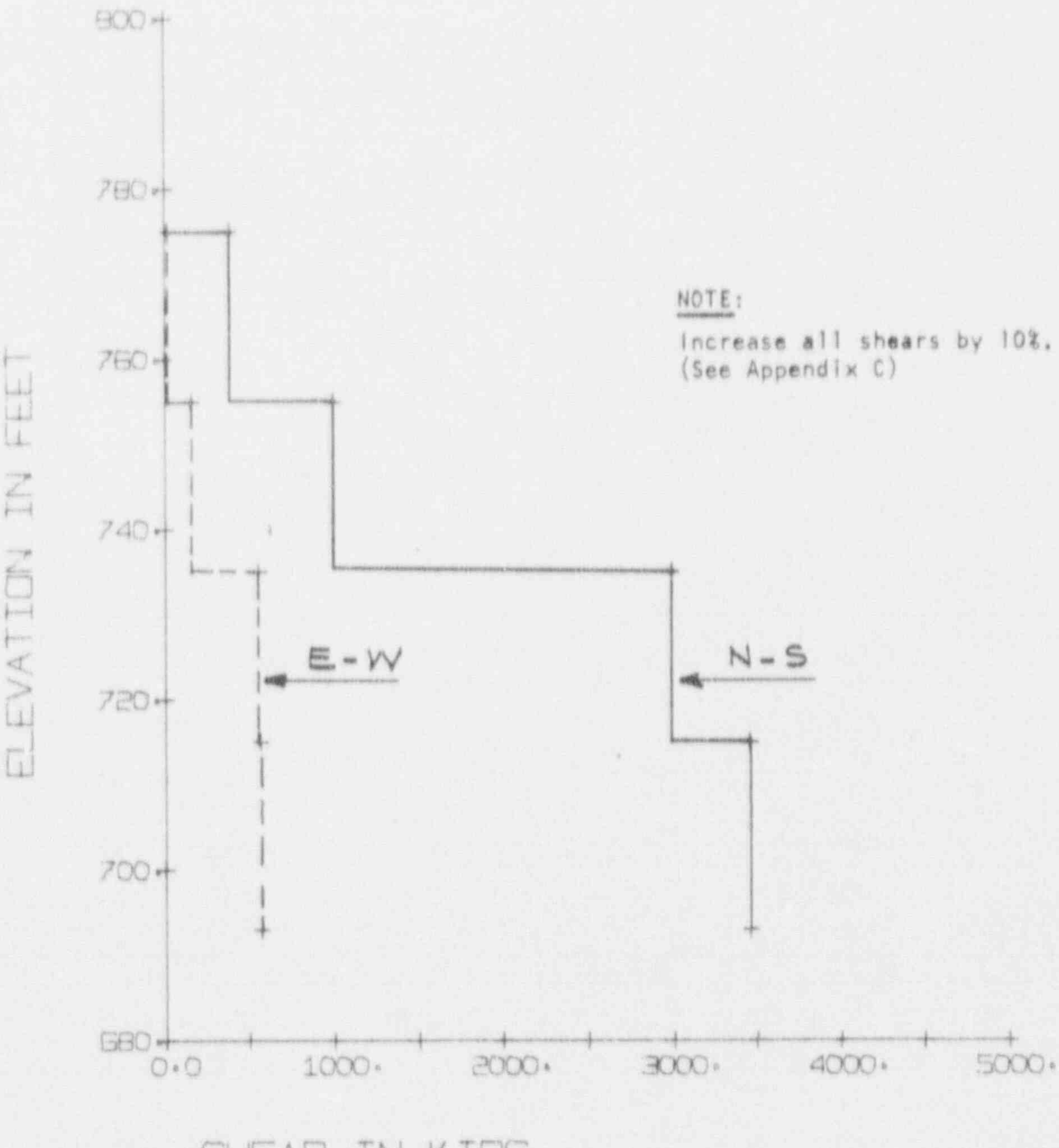


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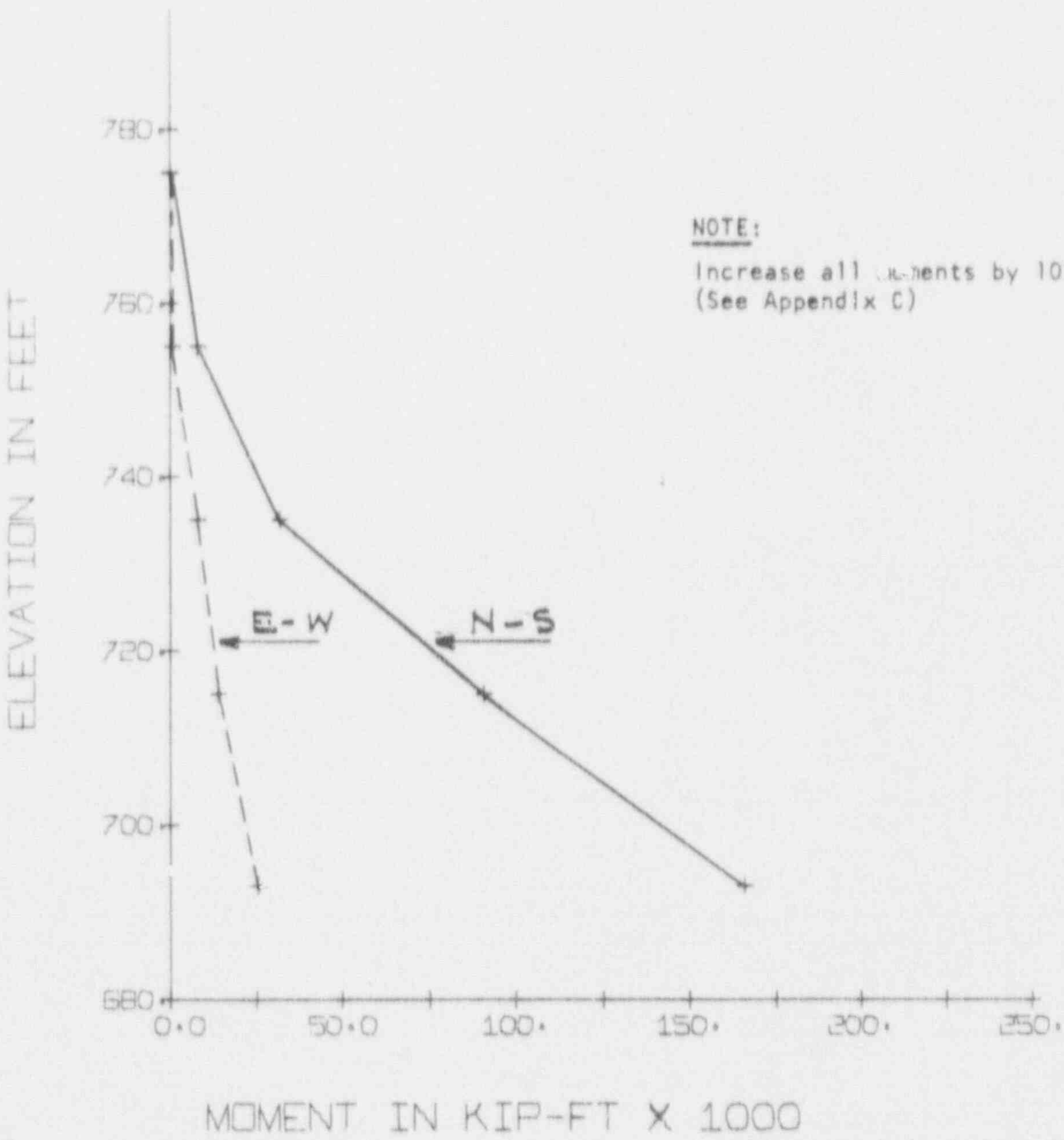
FIGURE NO. 37

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND FUEL TANK AREA
EARTHQUAKE IN N-S DIRECTION
MAXIMUM MOMENT DIAGRAM



NOTE:

Increase all moments by 10%. (See Appendix C)

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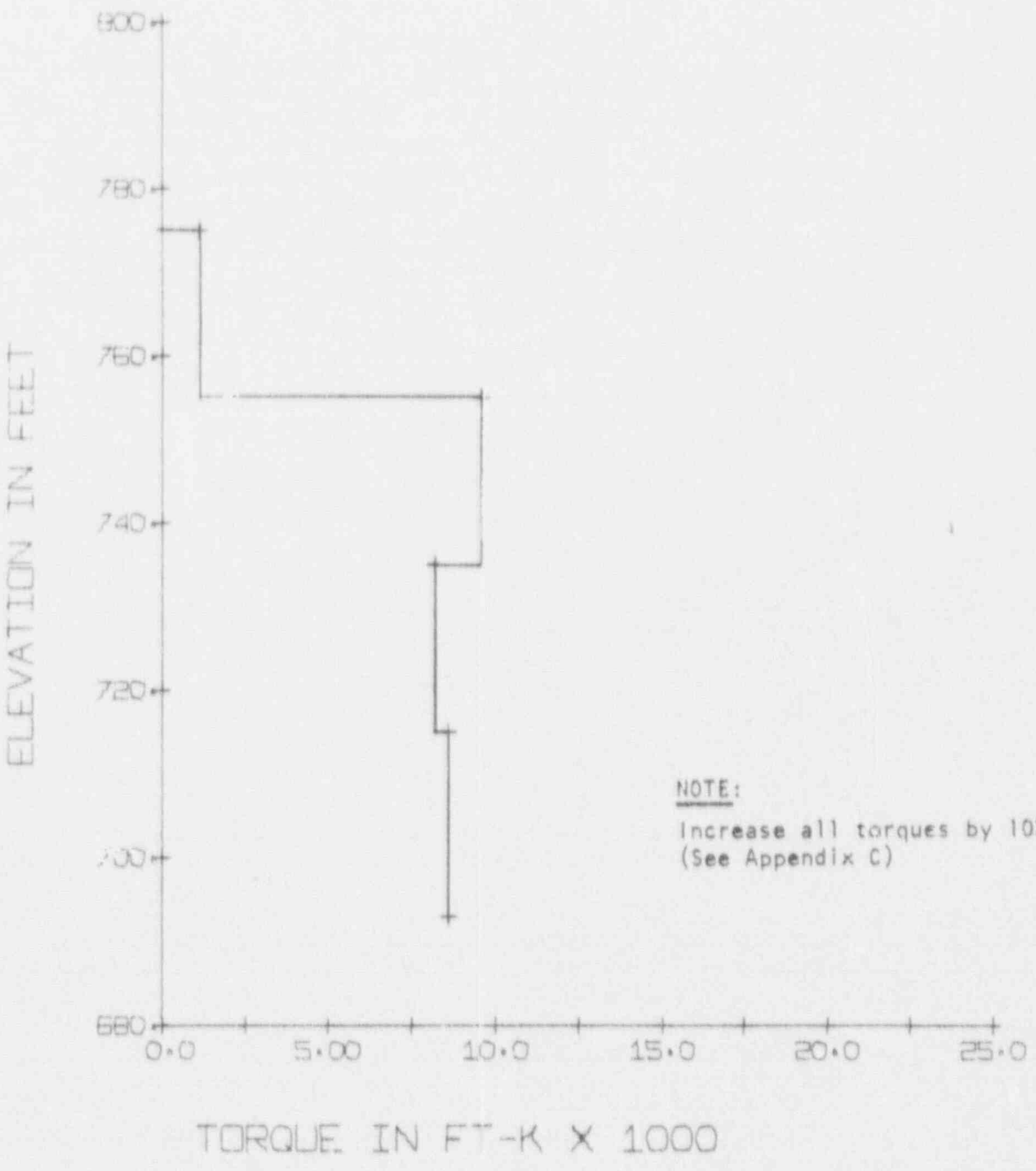
FIGURE NO. 38

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND FUEL TANK AREA

EARTHQUAKE IN N-S DIRECTION

MAXIMUM TORQUE DIAGRAM



NOTE:

Increase all torques by 10%.
(See Appendix C)

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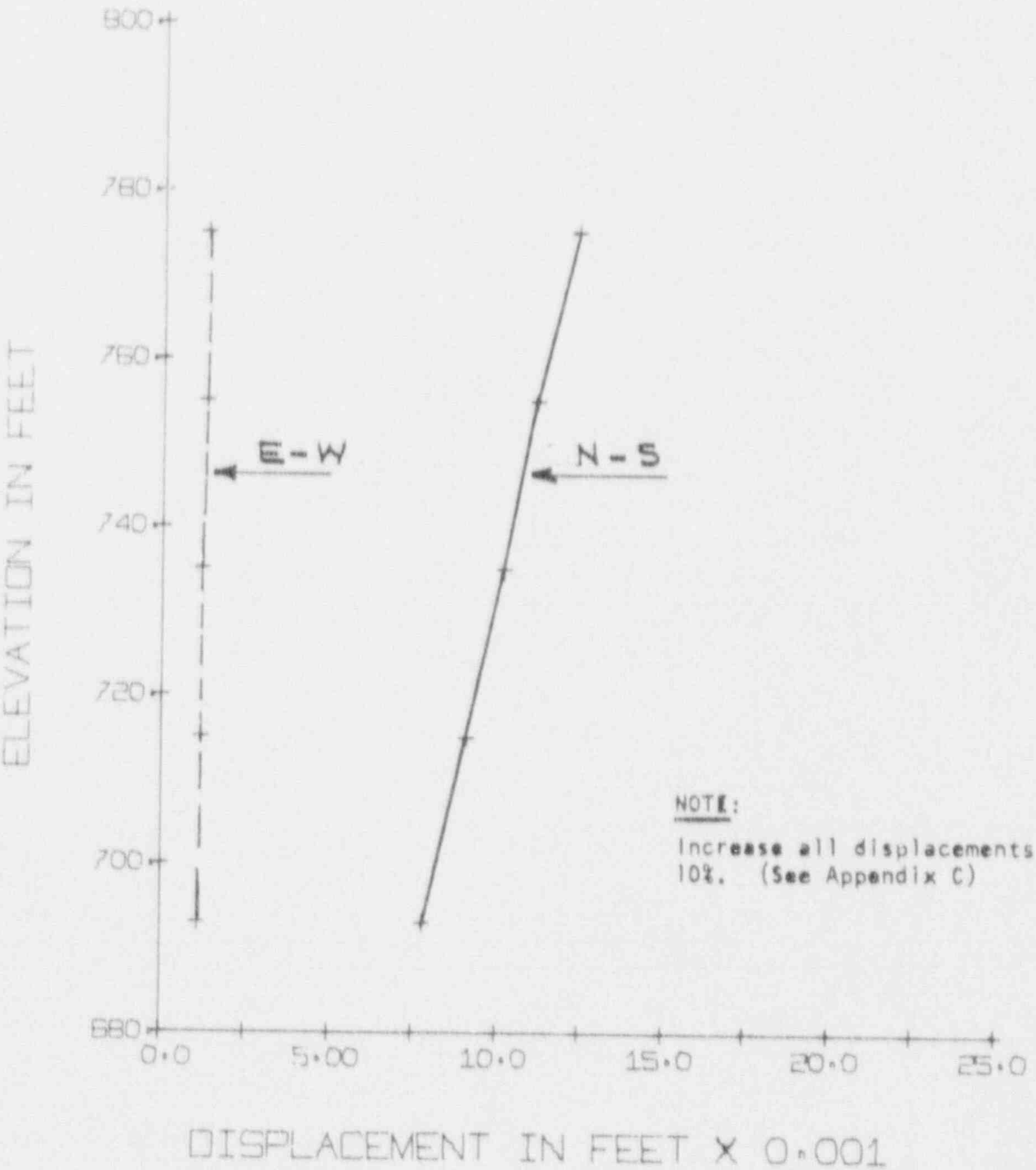
FIGURE NO. 33

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND FUEL TANK AREA
EARTHQUAKE IN N-S DIRECTION
MAXIMUM DISPLACEMENT DIAGRAM



NOTE:

Increase all displacements by 10%. (See Appendix C)

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FIGURE NO. 40

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND FUEL TANK AREA
EARTHQUAKE IN N-S DIRECTION
MAXIMUM ROTATION DIAGRAM

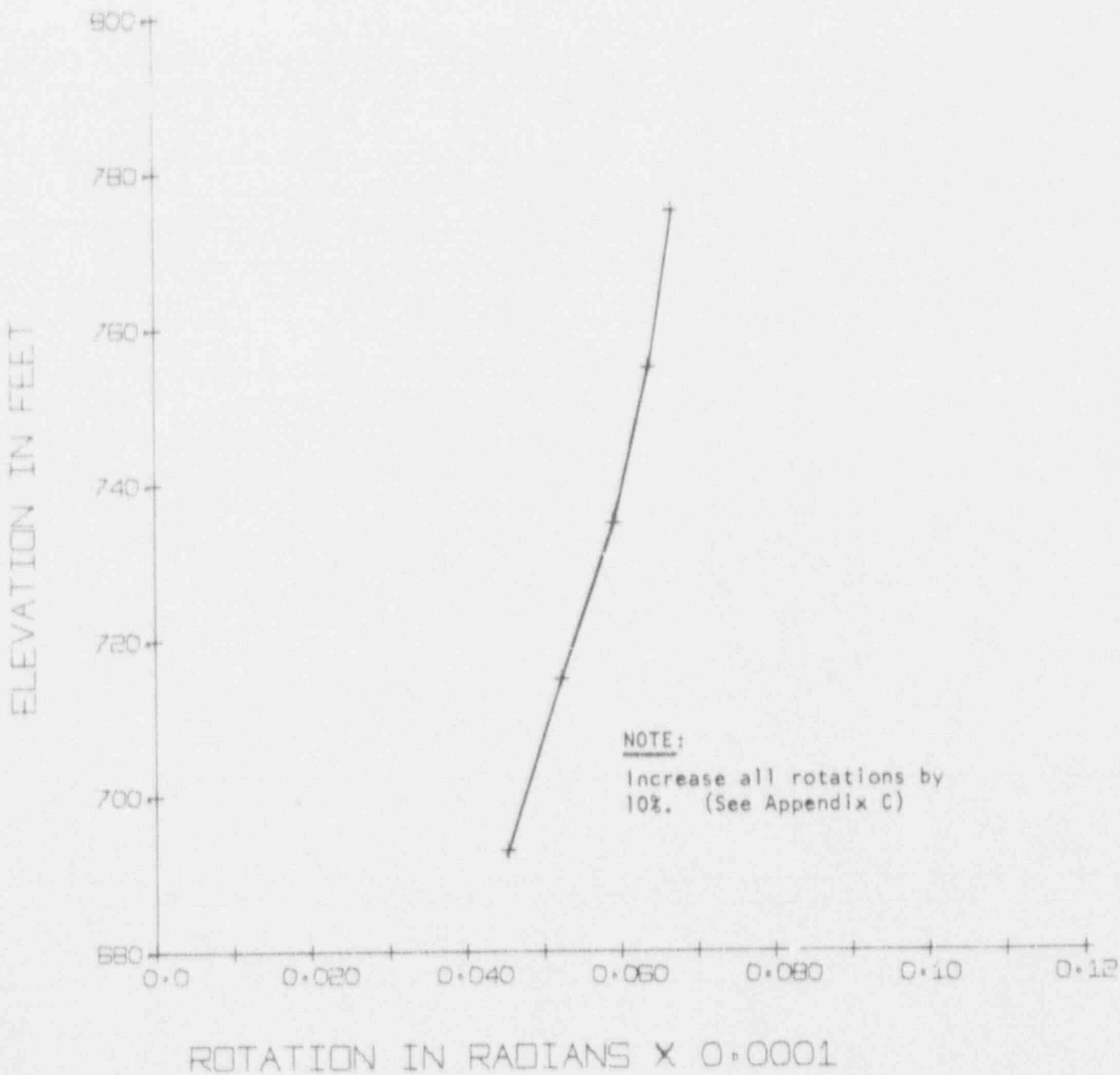

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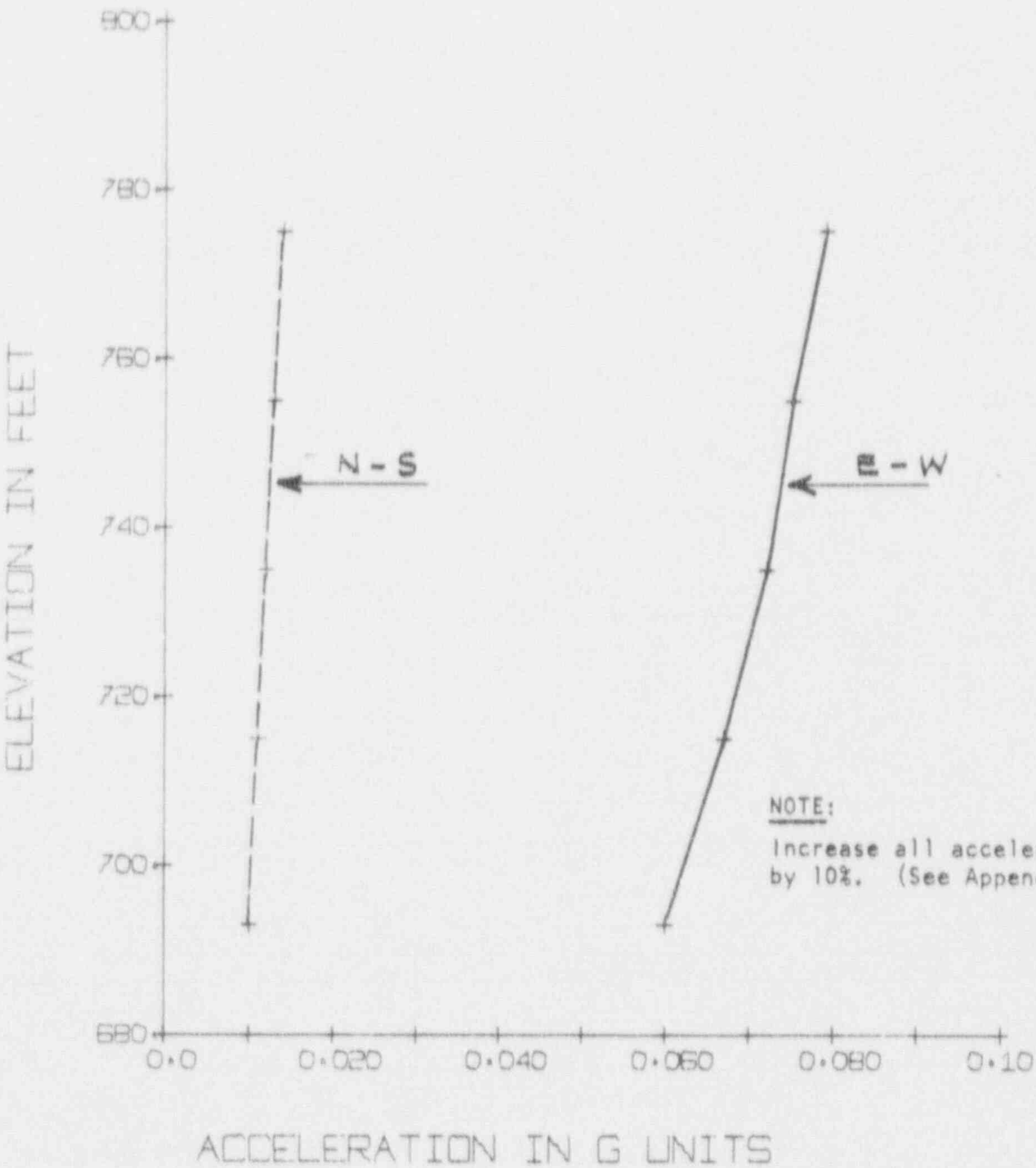
FIGURE NO. 41

JOHN A. BLUME AND ASSOCIATES, ENGINEERS
PRAIRIE ISLAND FUEL TANK AREA
EARTHQUAKE IN E-W DIRECTION
MAXIMUM ACCEL. DIAGR (TRANS)



NOTE:
Increase all accelerations by 10%. (See Appendix C)

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FIGURE NO. 42

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND FUEL TANK AREA

EARTHQUAKE IN E-W DIRECTION

MAX ACCEL DIAGRAM (ROTATION)

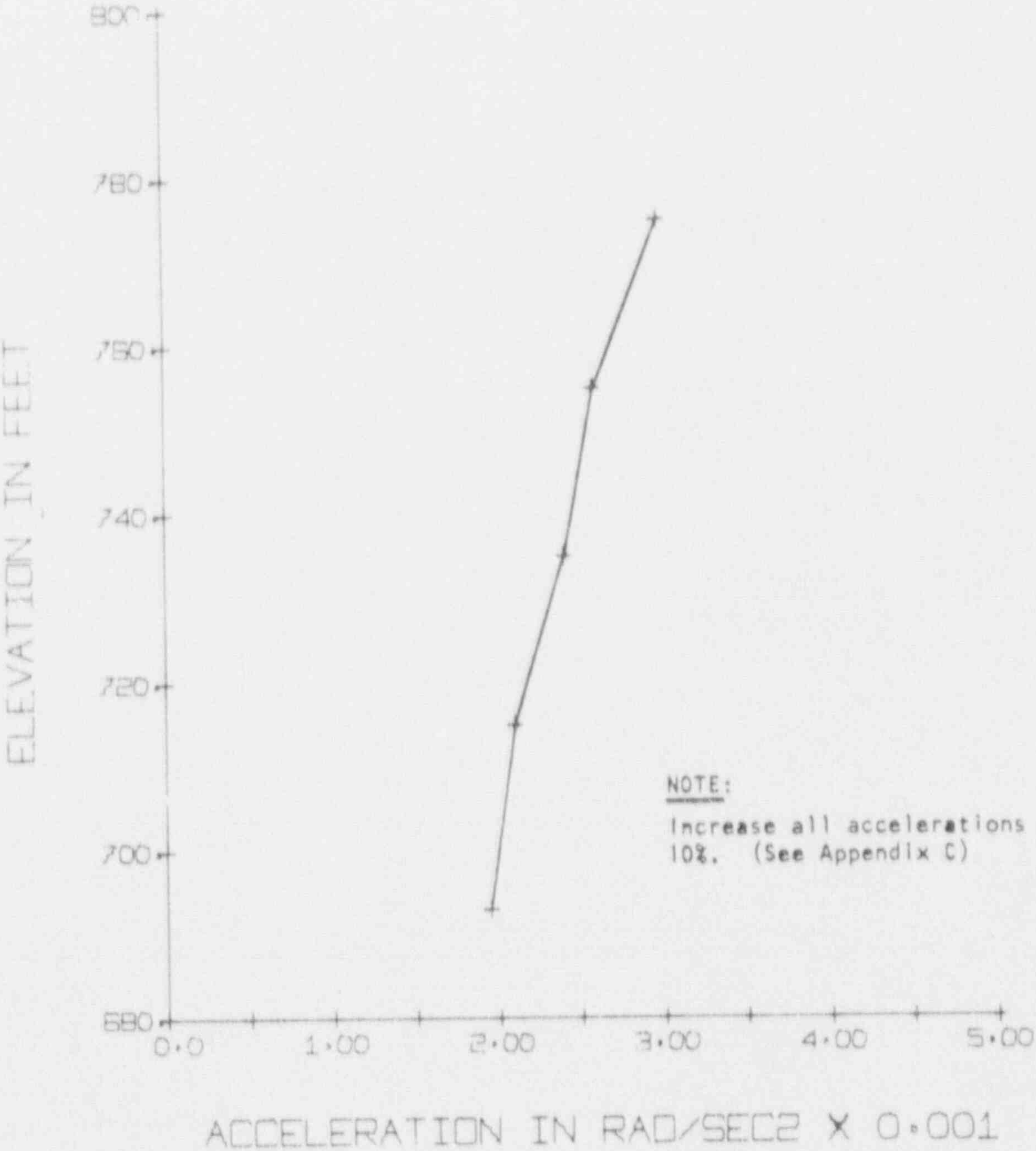

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FIGURE NO. 43

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND FUEL TANK AREA
EARTHQUAKE IN E-W DIRECTION
MAXIMUM SHEAR DIAGRAM

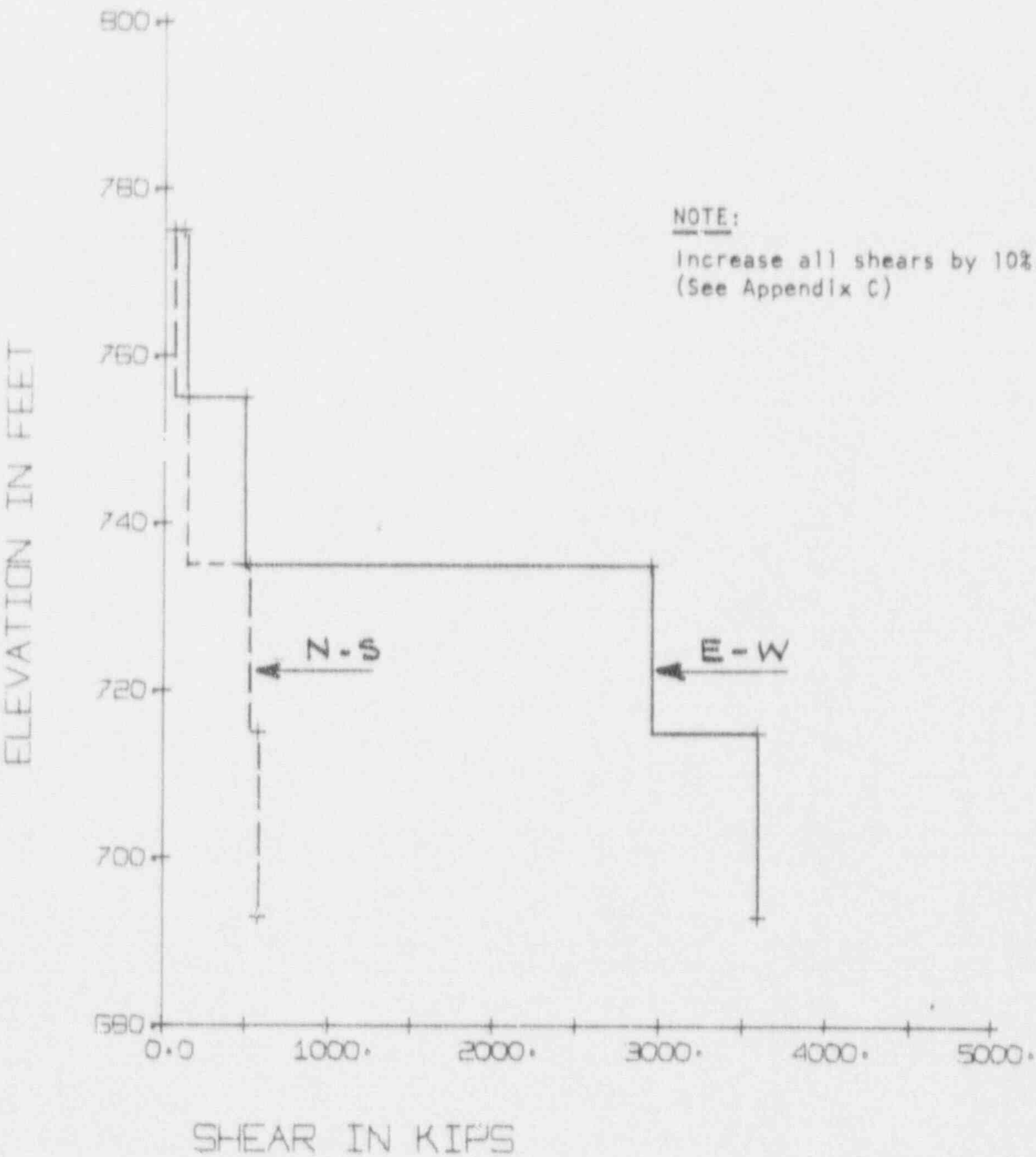

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FIGURE NO. 44

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND FUEL TANK AREA
EARTHQUAKE IN E-W DIRECTION
MAXIMUM MOMENT DIAGRAM

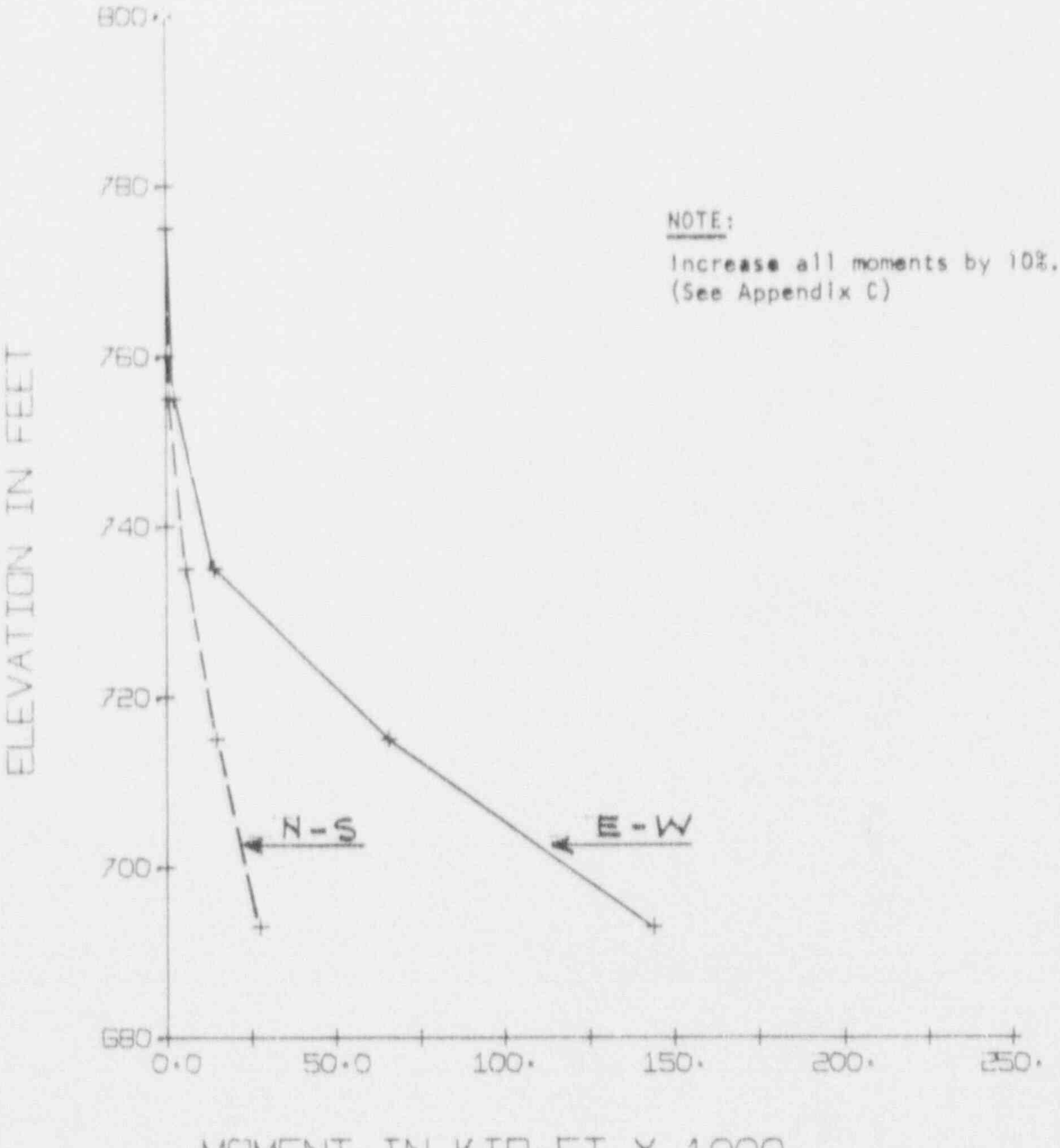

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FIGURE NO. 45

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND FUEL TANK AREA
EARTHQUAKE IN E-W DIRECTION
MAXIMUM TORQUE DIAGRAM

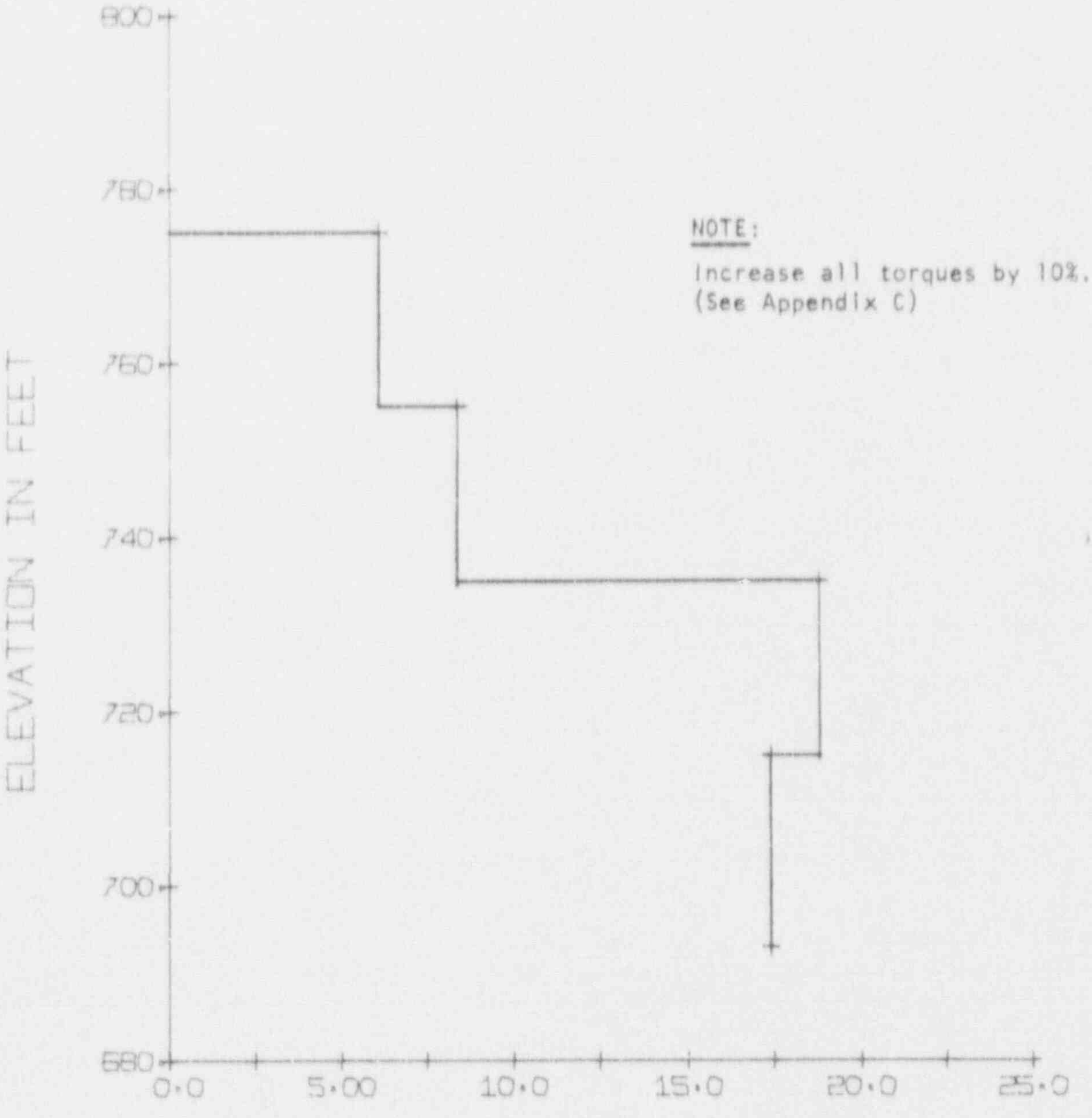

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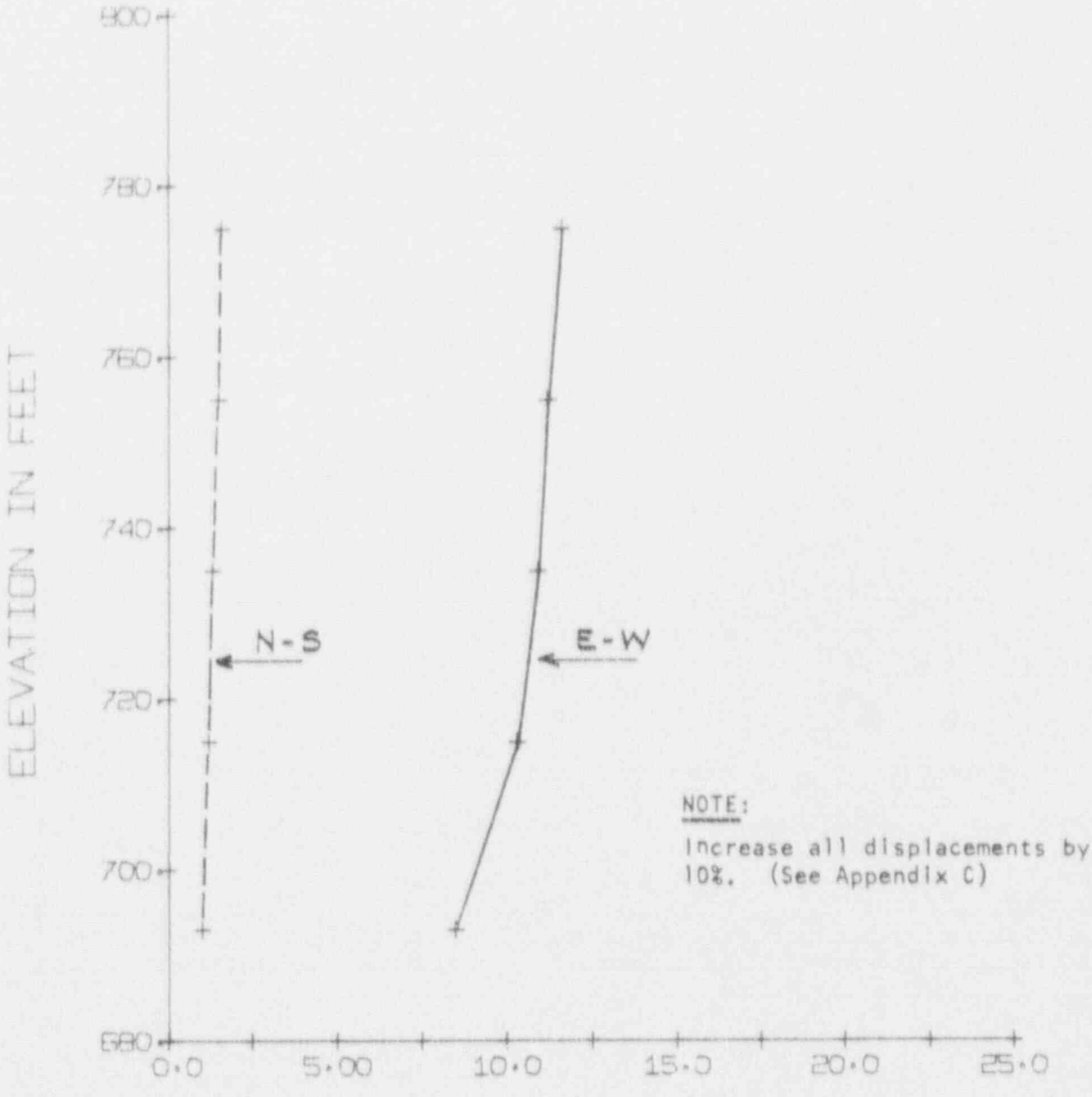
FIGURE NO. 46

JOHN A. BLUME AND ASSOCIATES, ENGINEERS
PRAIRIE ISLAND FUEL TANK AREA
EARTHQUAKE IN E-W DIRECTION
MAXIMUM DISPLACEMENT DIAGRAM



JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND FUEL TANK AREA

EARTHQUAKE IN E-W DIRECTION

MAXIMUM ROTATION DIAGRAM

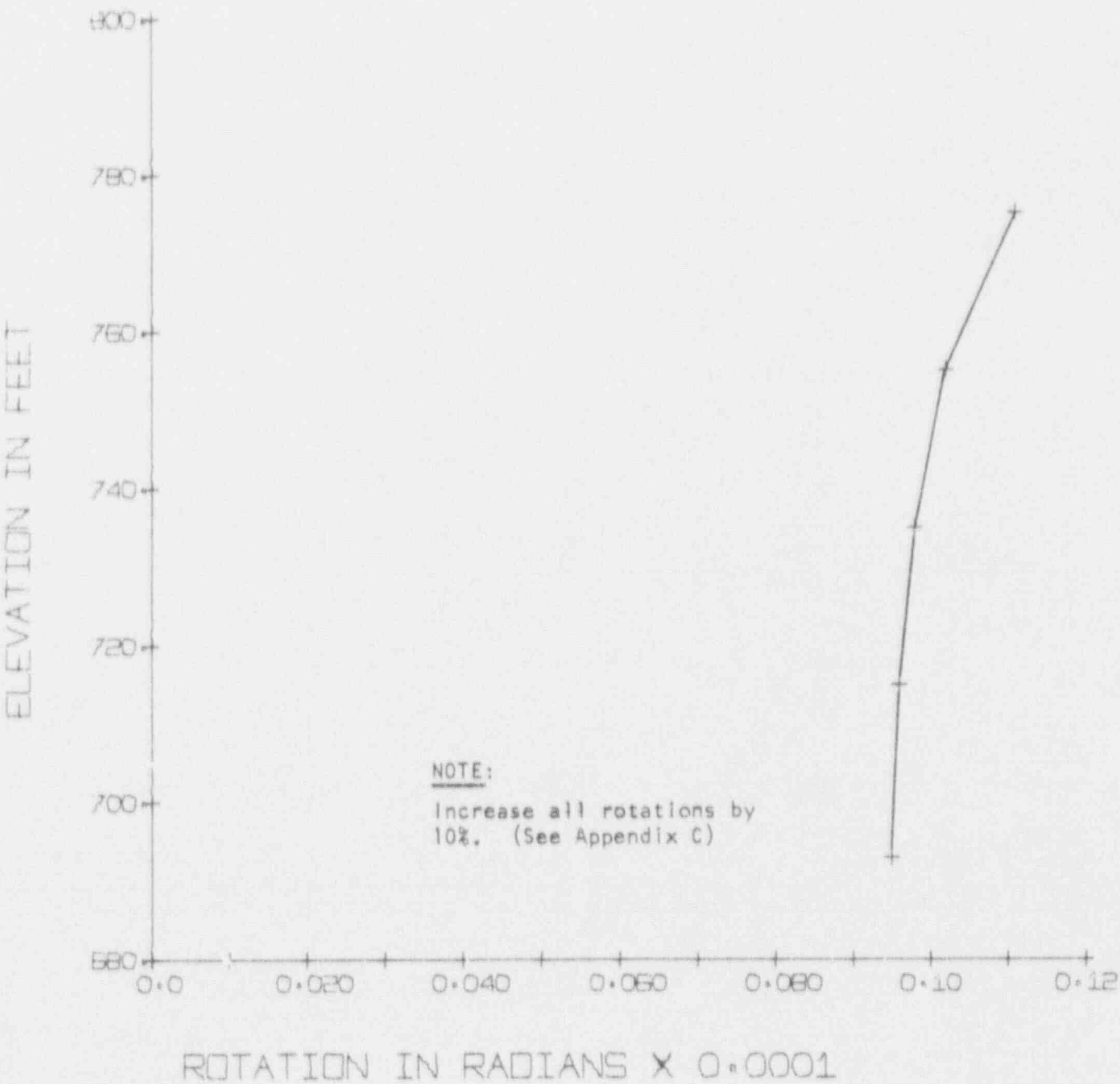


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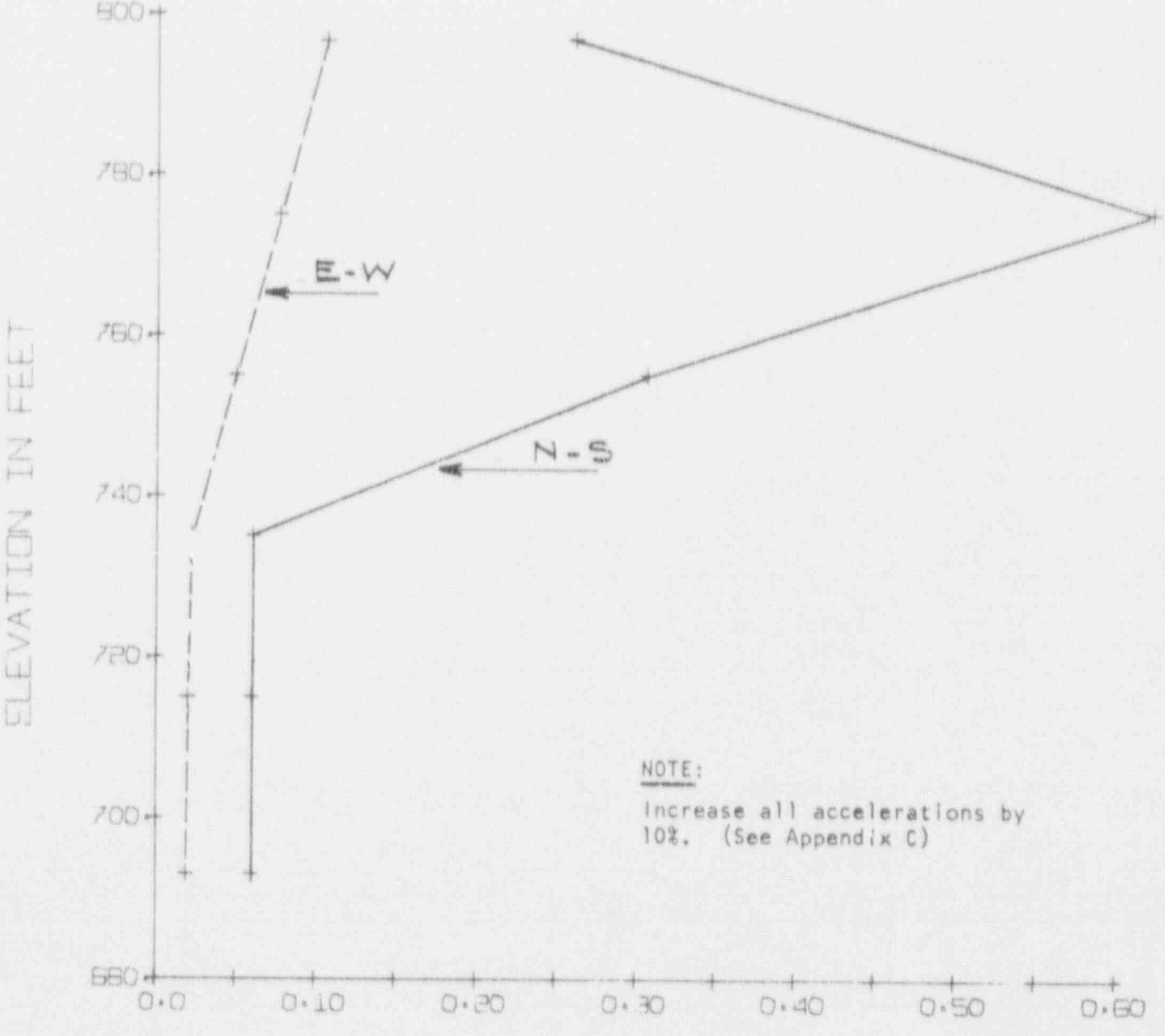
FIGURE NO. 48

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND TURBINE BUILDING
EARTHQUAKE IN N-S DIRECTION
MAX ACCEL DIAGRAM (TRANSLATION)



NOTE:

Increase all accelerations by 10%. (See Appendix C)

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FIGURE NO. 49

JOHN A. BLUME AND ASSOCIATES, ENGINEERS
PRAIRIE ISLAND TURBINE BUILDING
EARTHQUAKE IN N-S DIRECTION
MAX ACCEL DIAGRAM (ROTATION)

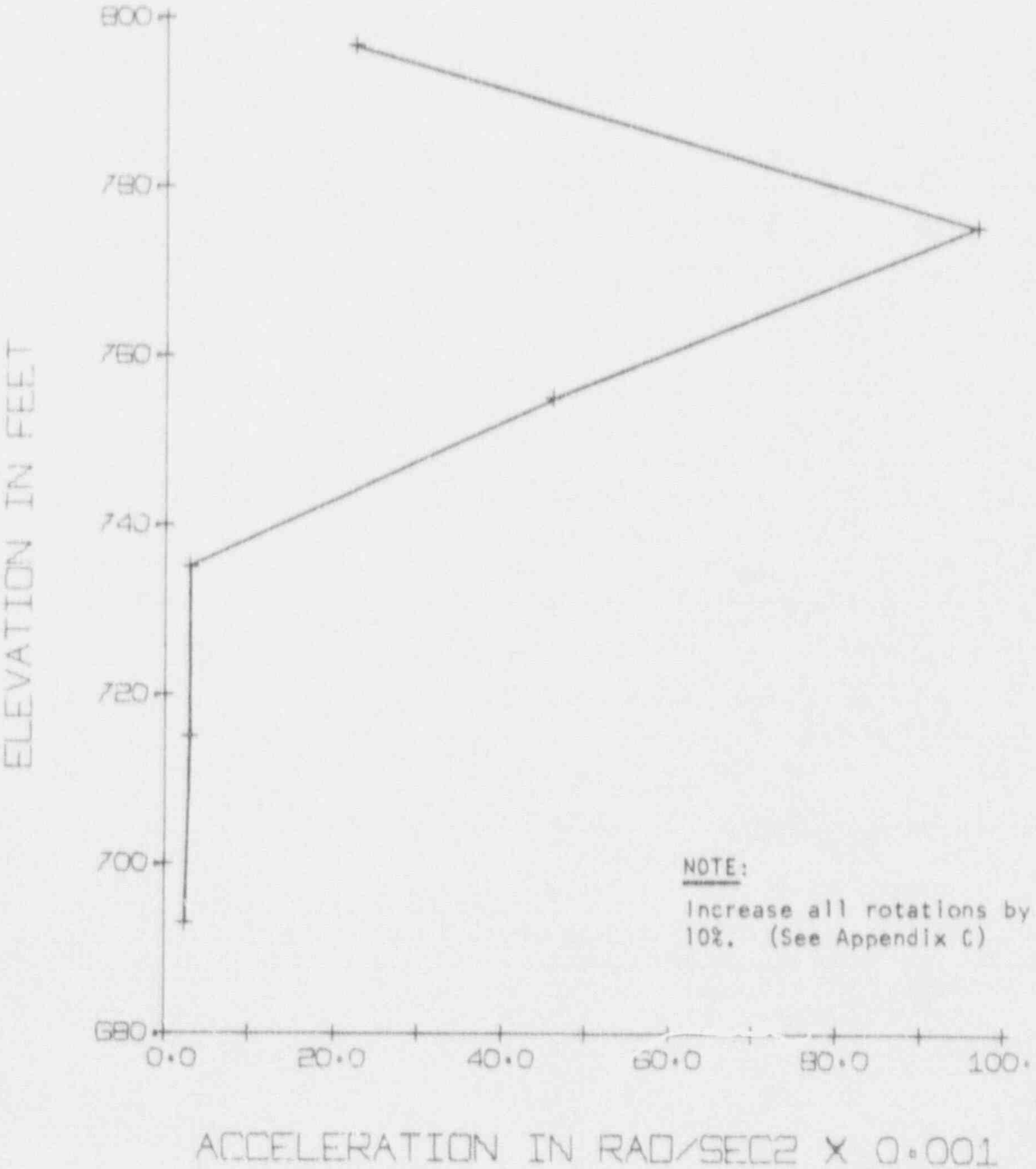

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FIGURE NO. 50

JOHN A. BLUME AND ASSOCIATES, ENGINEERS
PRAIRIE ISLAND TURBINE BUILDING
EARTHQUAKE IN N-S DIRECTION
MAXIMUM SHEAR DIAGRAM

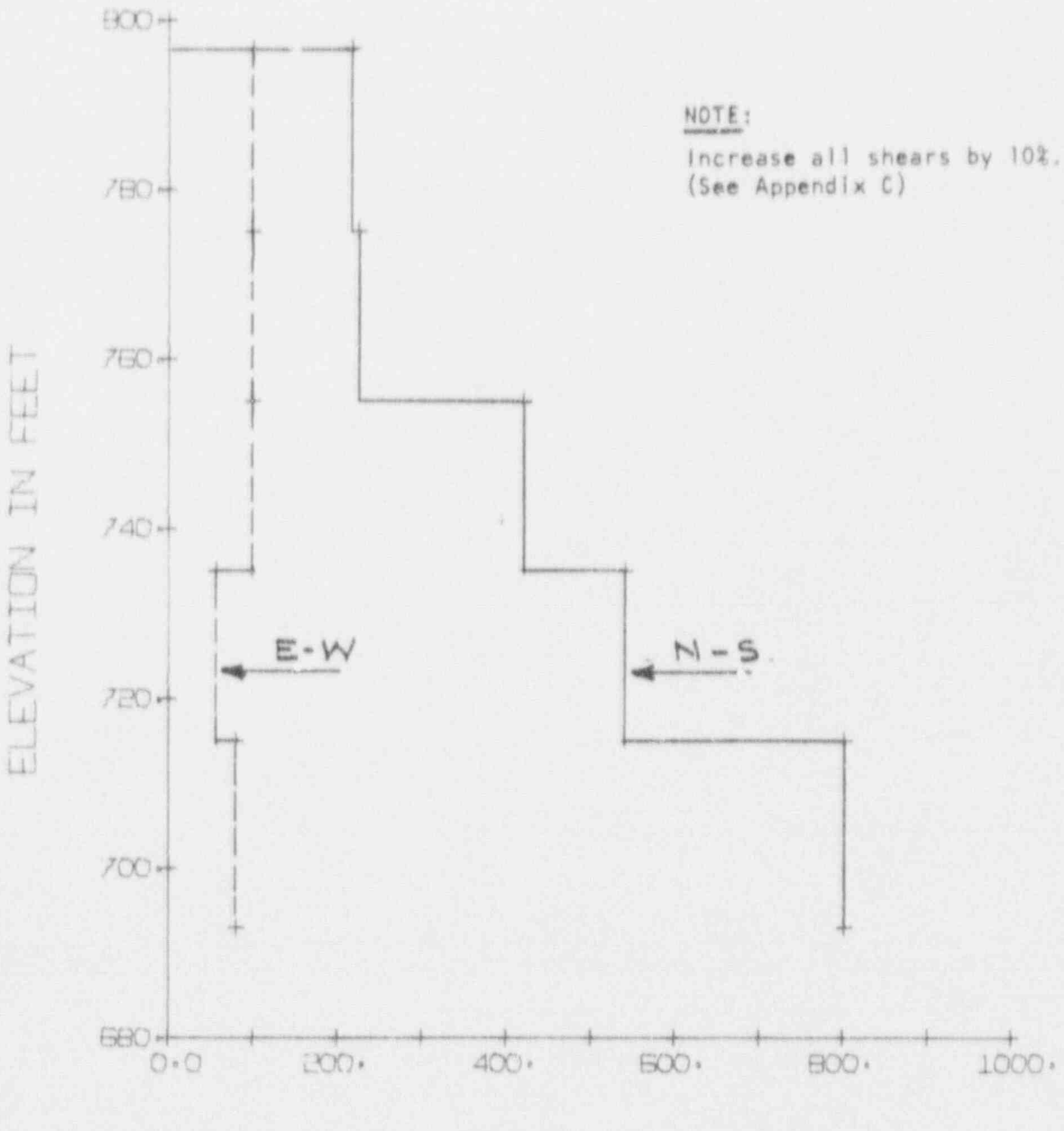

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FIGURE NO. 51

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND TURBINE BUILDING
EARTHQUAKE IN N-S DIRECTION
MAXIMUM MOMENT DIAGRAM

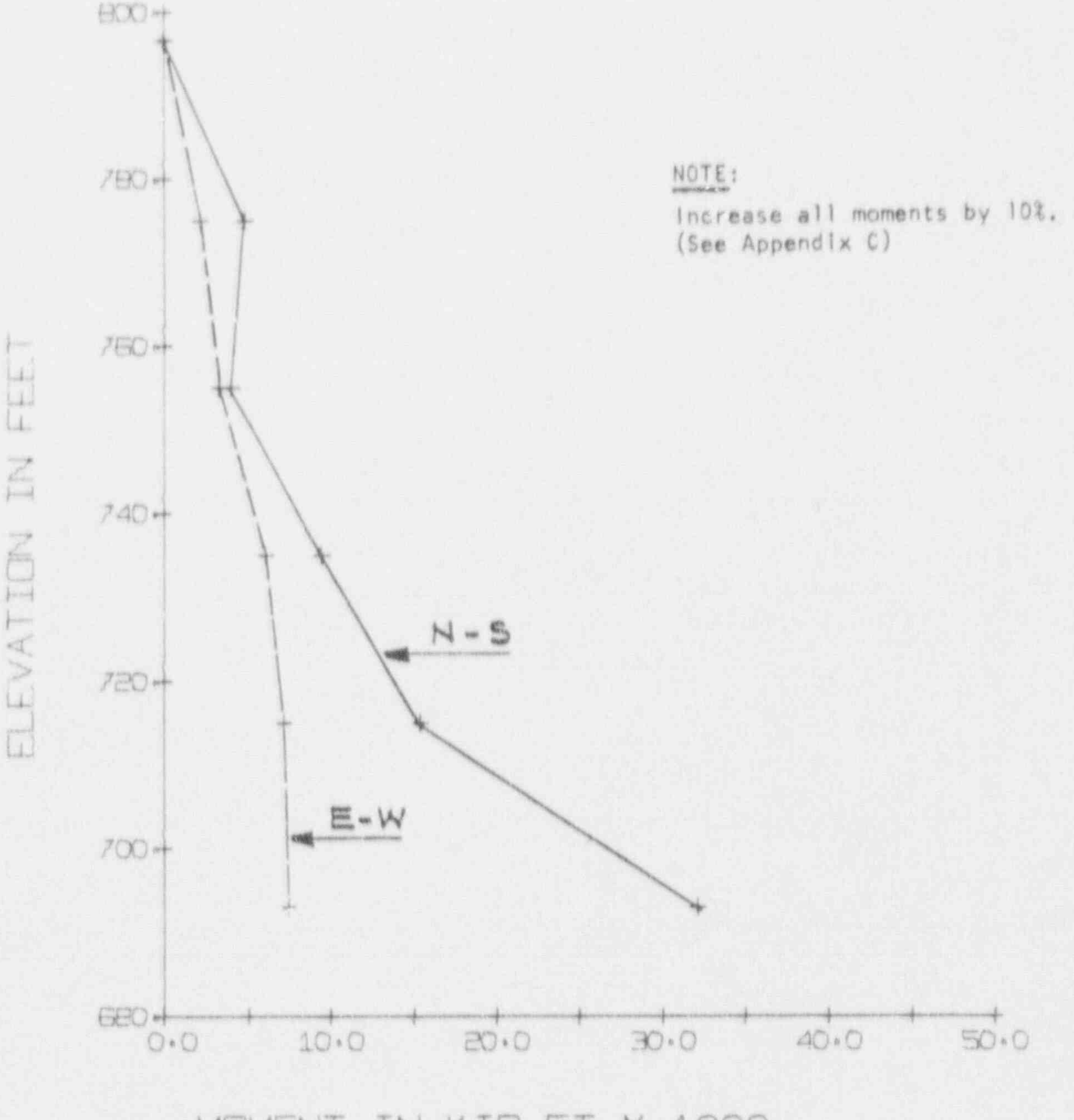

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FIGURE NO. 52

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND TURBINE BUILDING
EARTHQUAKE IN N-S DIRECTION
MAXIMUM TORQUE DIAGRAM

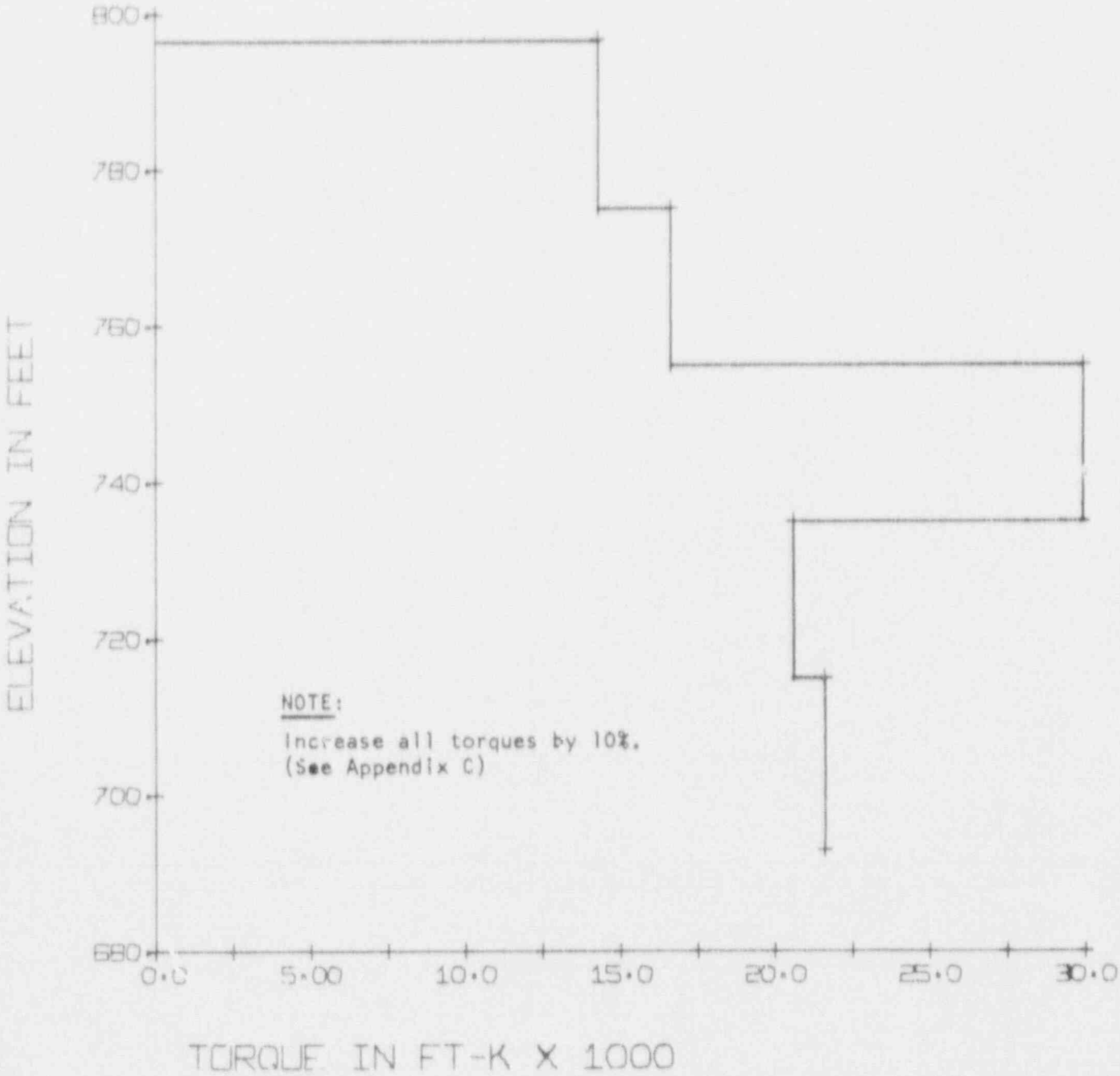

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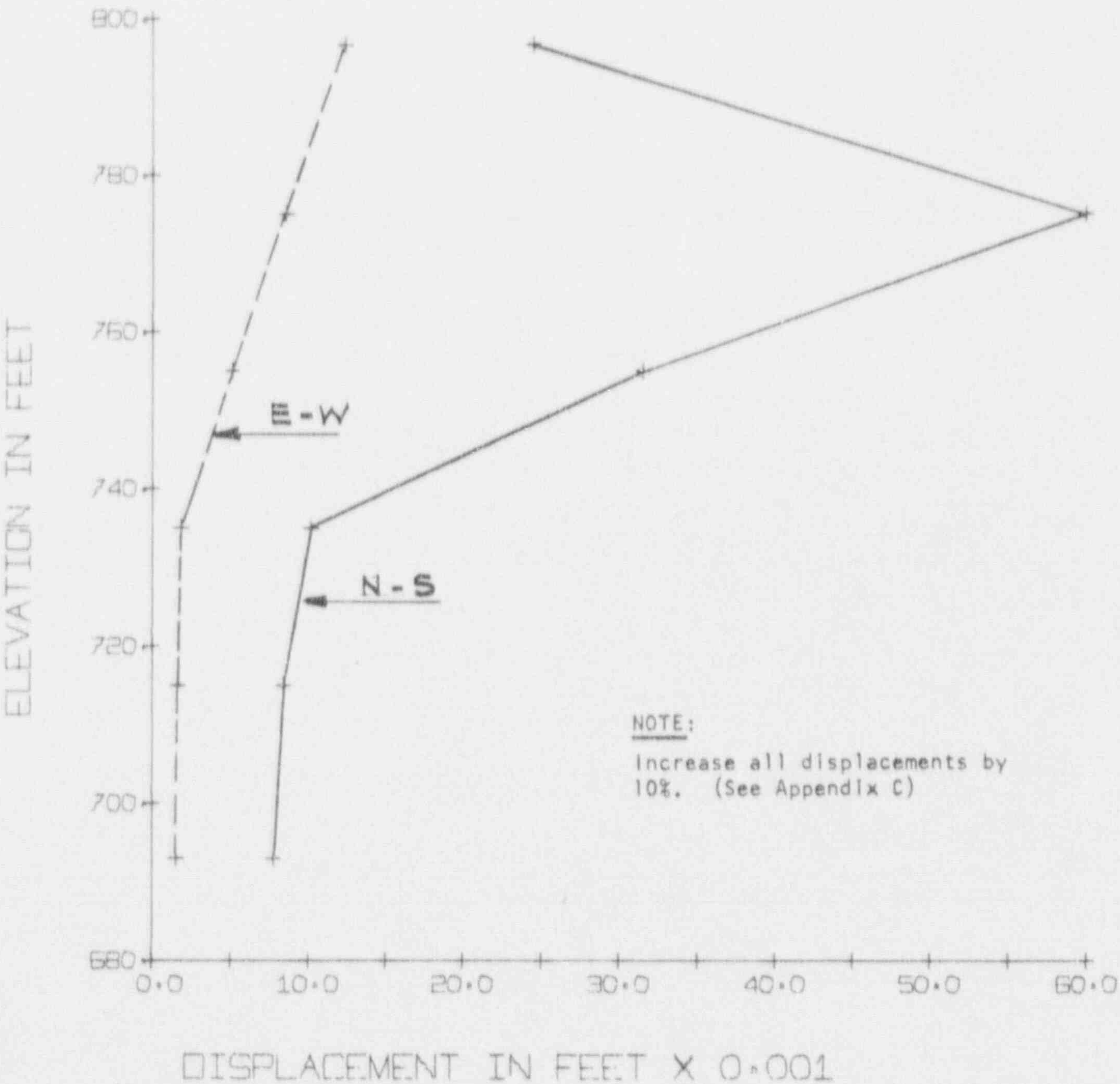
FIGURE NO. 53

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND TURBINE BUILDING
EARTHQUAKE IN N-S DIRECTION
MAXIMUM DISPLACEMENT DIAGRAM



NOTE:
Increase all displacements by 10%. (See Appendix C)

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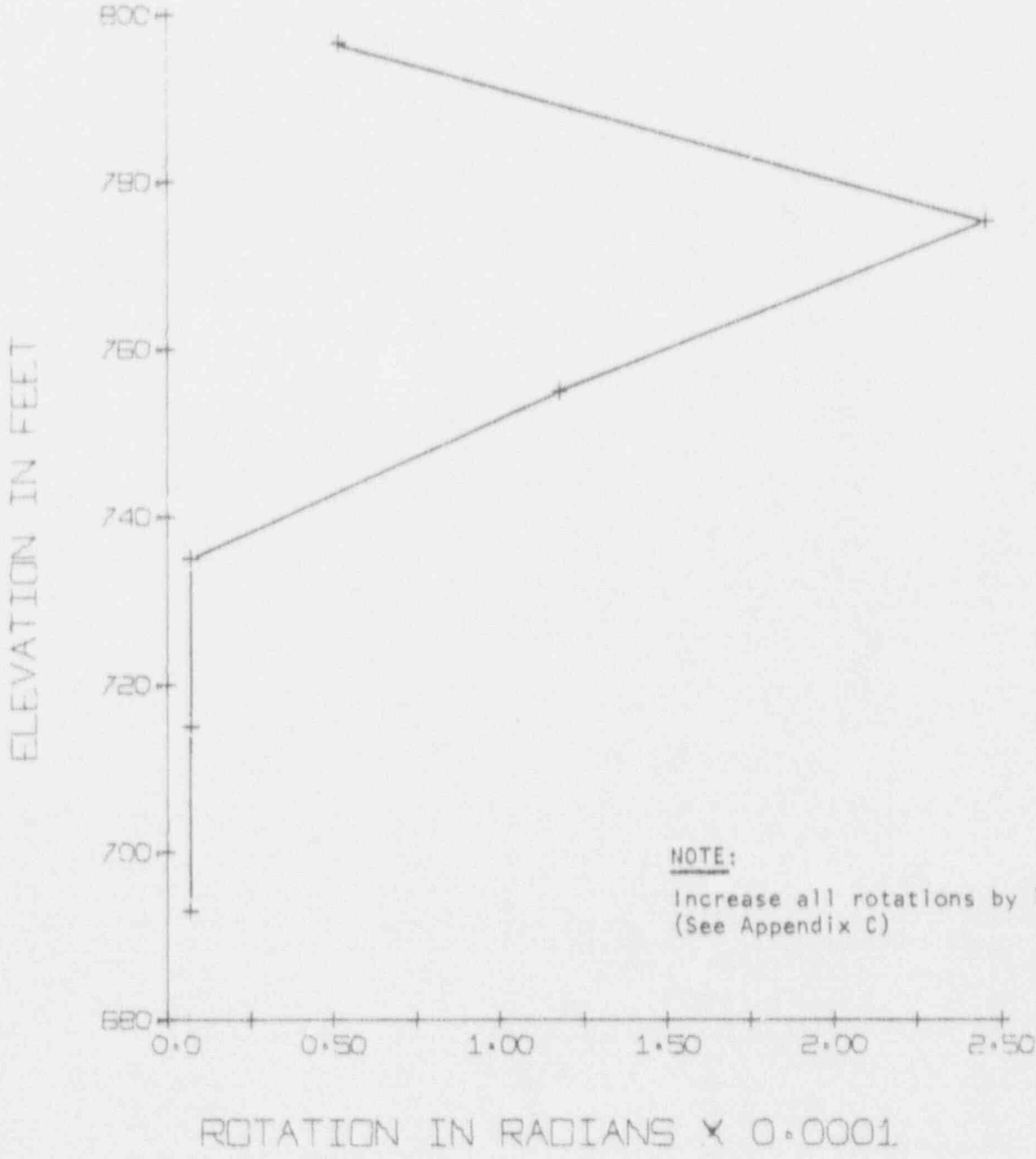
FIGURE NO. 54

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND TURBINE BUILDING EARTHQUAKE IN N-S DIRECTION MAXIMUM ROTATION DIAGRAM



NOTE:

Increase all rotations by 10%.
(See Appendix C)

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FIGURE NO. 55

JOHN A. BLUME AND ASSOCIATES, ENGINEERS
PRAIRIE ISLAND TURBINE BU[illegible]NG
EARTHQUAKE IN E-W DIRECT[illegible]
MAX ACCEL DIAGRAM (TRANS[illegible]ON)

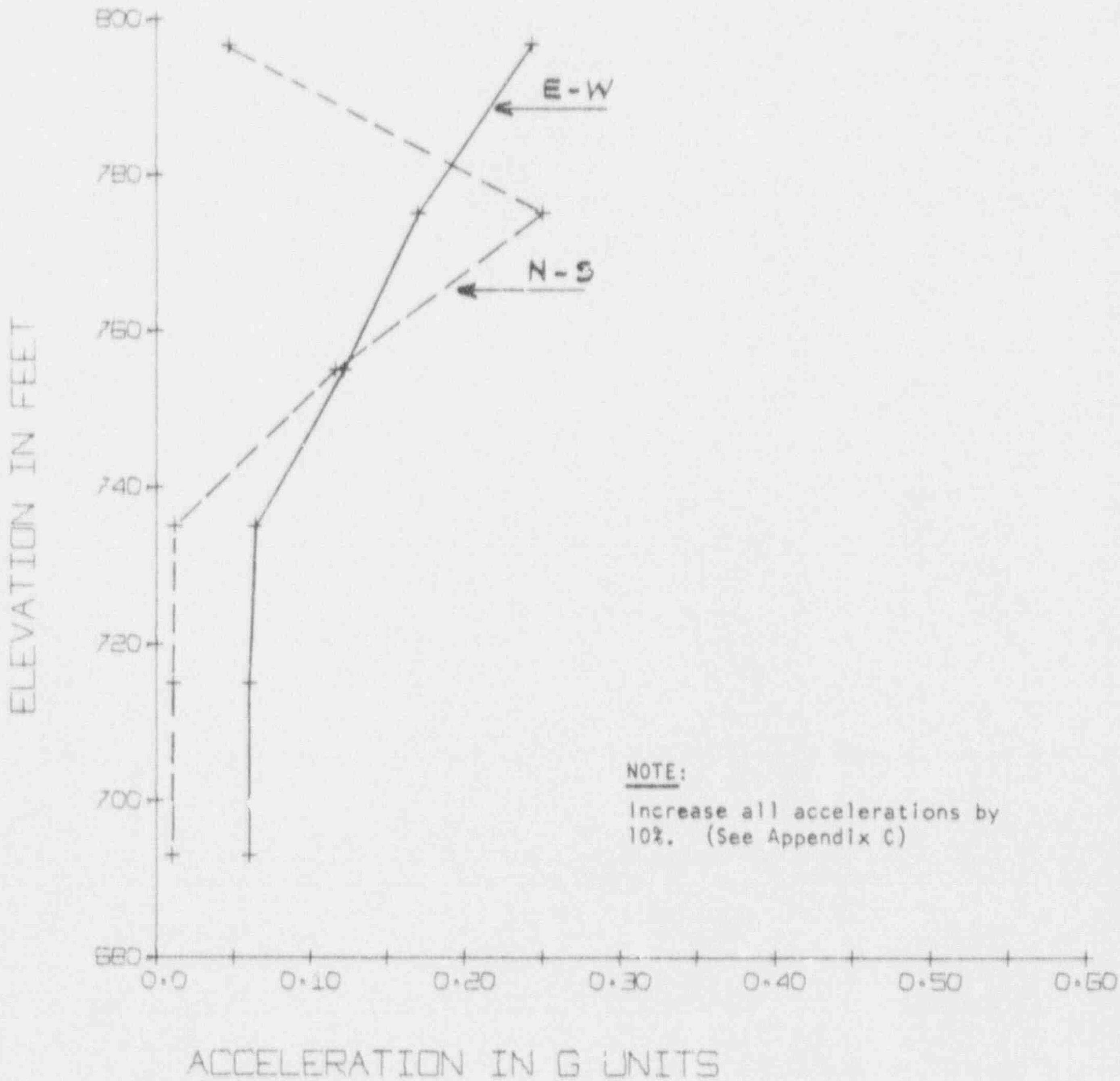

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FIGURE NO. 56

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND TURBINE BUILDING
EARTHQUAKE IN E-W DIRECTION
MAX ACCEL DIAGRAM (ROTATION)

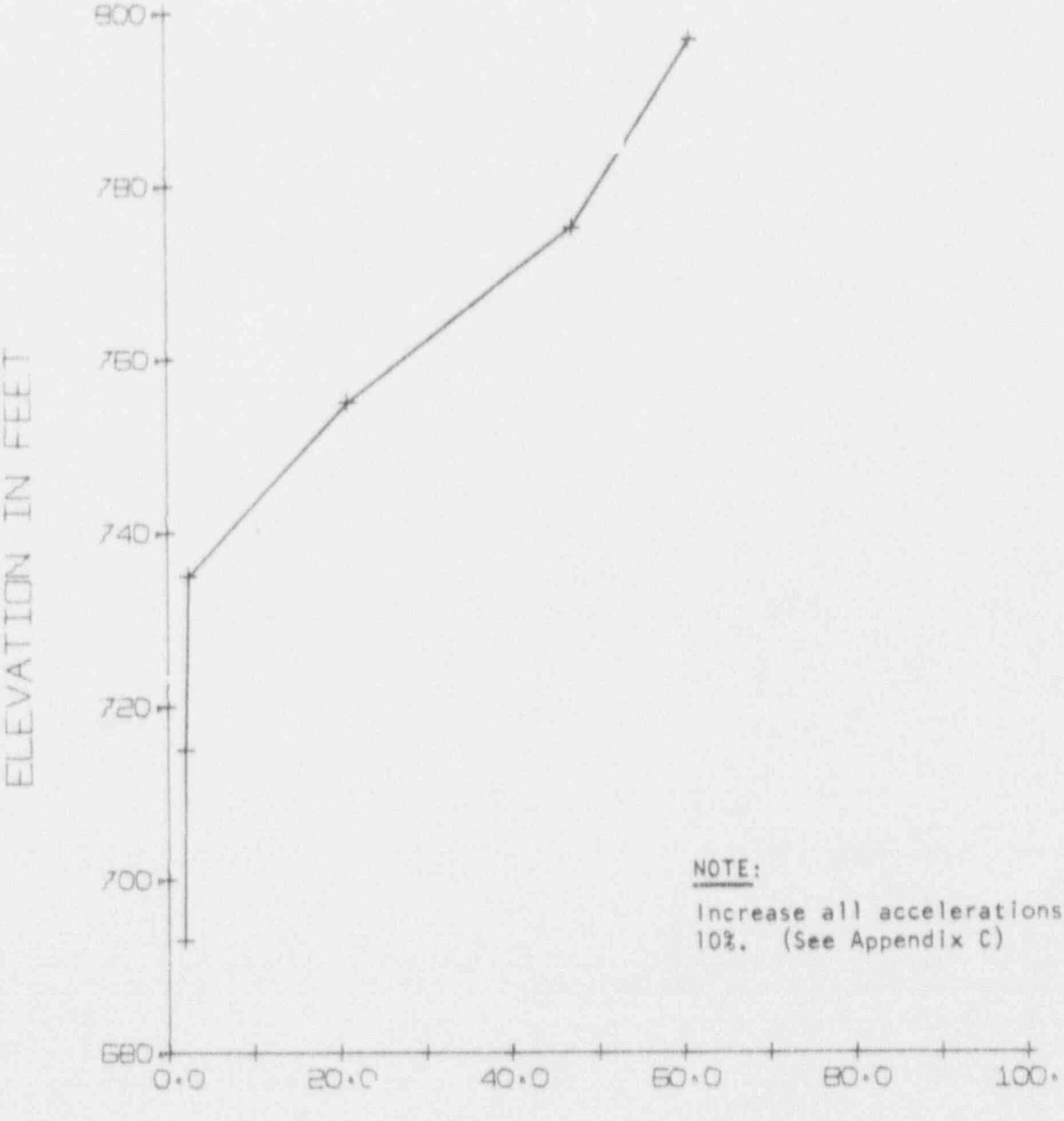

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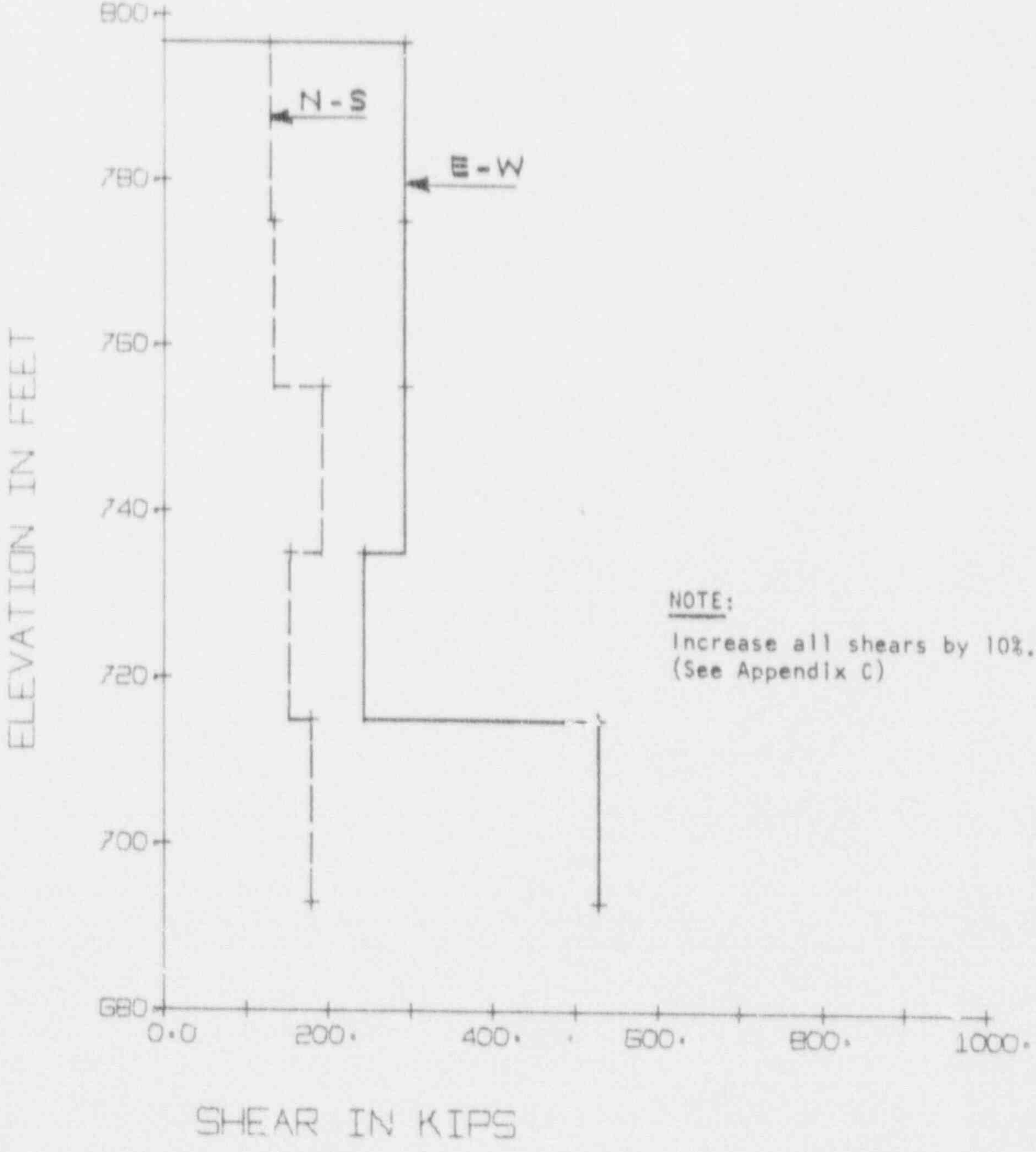
FIGURE NO. 57

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND TURBINE BUILDING
EARTHQUAKE IN E-W DIRECTION
MAXIMUM SHEAR DIAGRAM



NOTE:
Increase all shears by 10%.
(See Appendix C)

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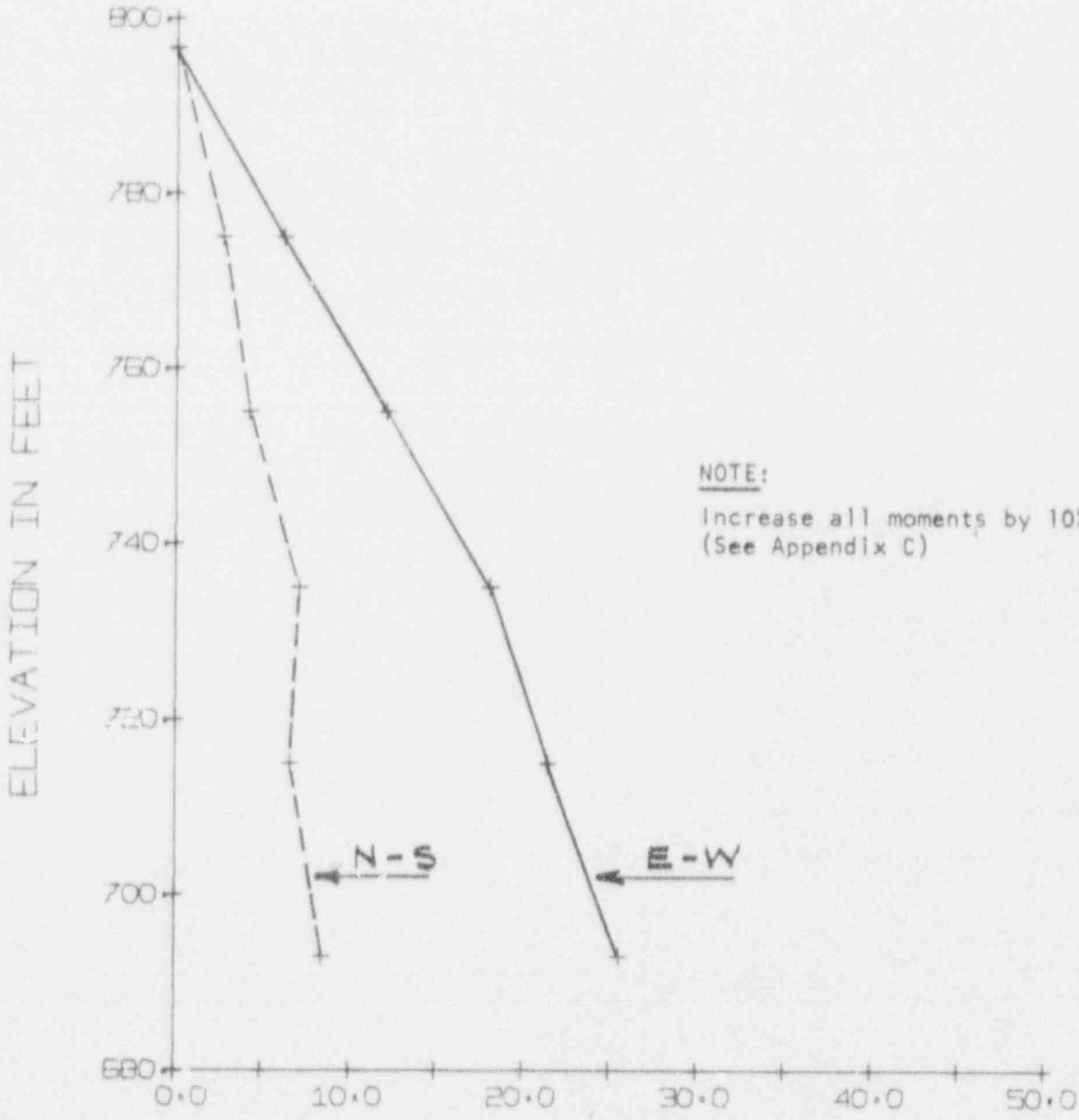
FIGURE NO. 58

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND TURBINE BUILDING
EARTHQUAKE IN E-W DIRECTION
MAXIMUM MOMENT DIAGRAM



NOTE:

Increase all moments by 10%.
(See Appendix C)

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FIGURE NO. 59

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND TURBINE BUILDING EARTHQUAKE IN E-W DIRECTION MAXIMUM TORQUE DIAGRAM

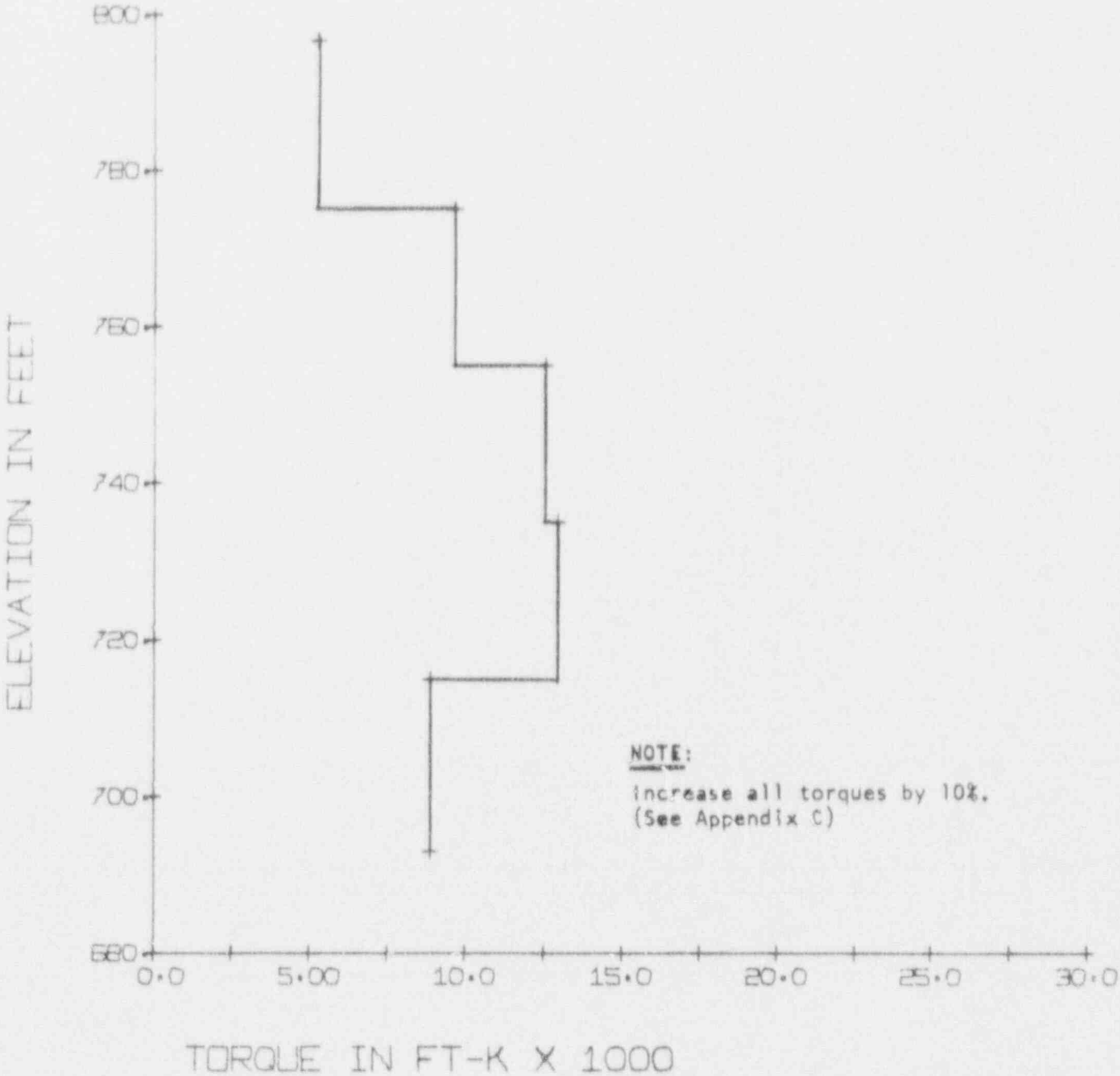

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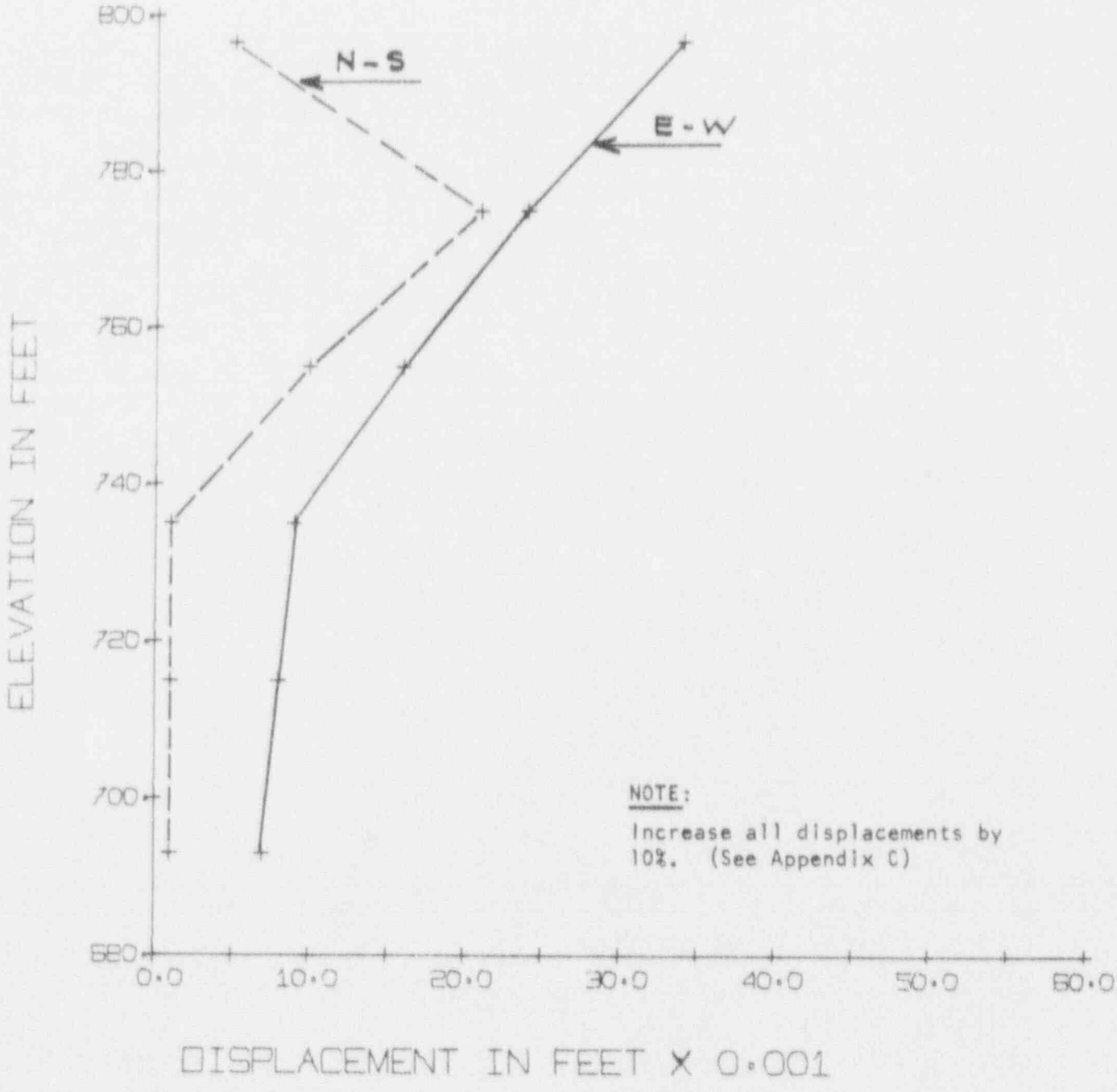
FIGURE NO. 60

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND TURBINE BUILDING
EARTHQUAKE IN E-W DIRECTION
MAXIMUM DISPLACEMENT DIAGRAM



NOTE:

Increase all displacements by 10%. (See Appendix C)

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FIGURE NO. 61

JOHN A. BLUME AND ASSOCIATES, ENGINEERS

PRAIRIE ISLAND TURBINE BUILDING

EARTHQUAKE IN E-W DIRECTION

MAXIMUM ROTATION DIAGRAM

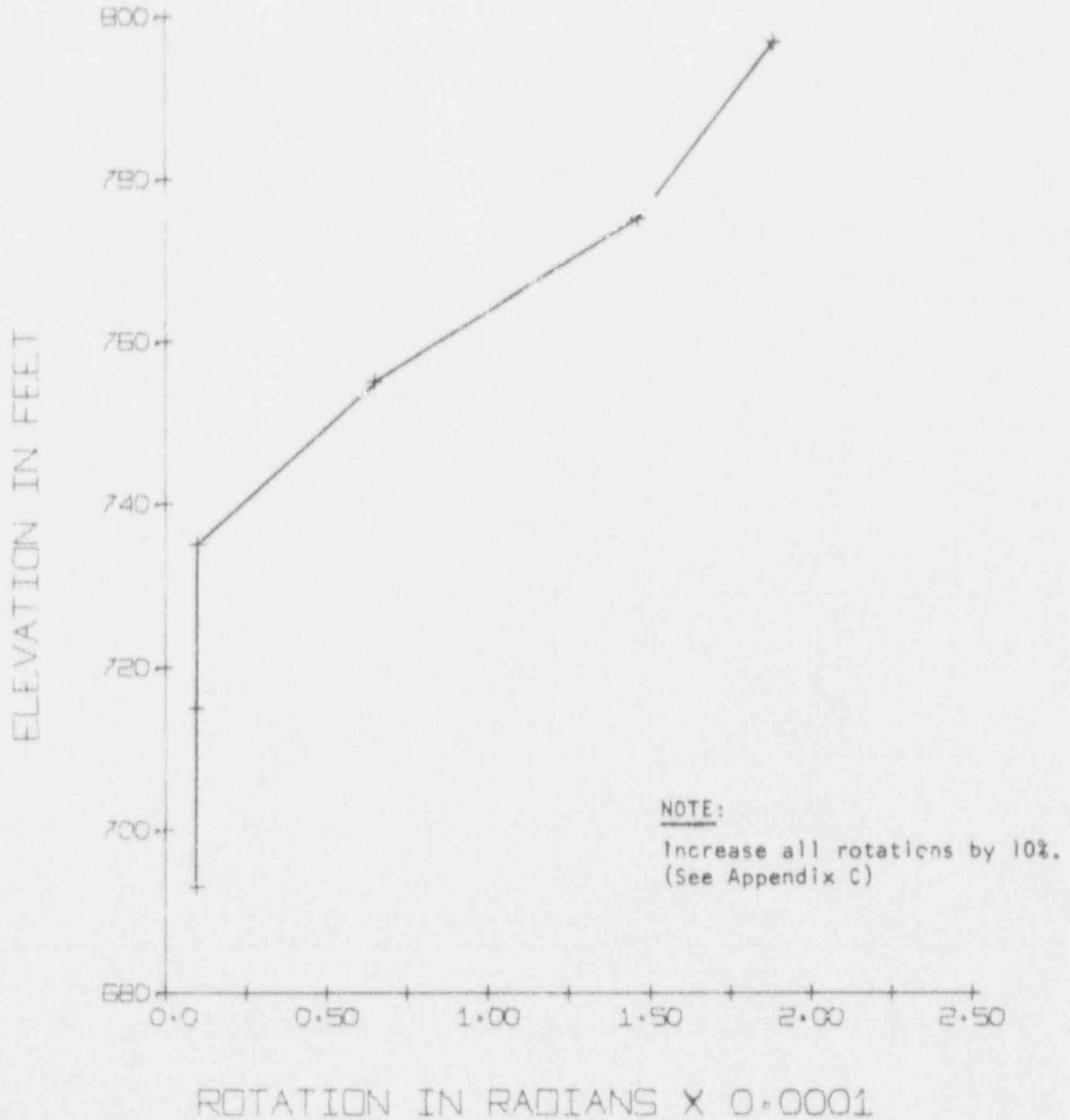

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FIGURE NO. 62