Turbine Building
Yankee Nuclear Power Station
Structural Analysis Report

For: Yankee Atomic Electric Company
By: Cygna Energy Services

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Turbine Building and Turbine Pedestal

Yankee Nuclear Power Station

Rowe, Massachusetts

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I. EXECUTIVE SUMMARY

1.1 Purpose

The purpose of this report is to summarize the results of the structural analyses performed by Cygna Energy Services* (Cygna) for Yankee Atomic Electric Company (YAEC). The results described in this report pertain to the Turbine Building and Turbine Pedestal at the Yankee Nuclear Power Station (YNPS), Rowe, Massachusetts.

1.2 Scope

As requested by YAEC, Cygna has performed detailed structural analyses of the two structures. The analyses described in this report were based on the following input data for YNPS:

1. Study of the existing structural drawings of the two structures (see Appendix A).

2. Design Criteria (see Section III).

3. Seismic ground motion specified by the Yankee Composite Spectrum (YCS) and the NRC Spectrum.

1.3 Conclusions

- The Turbine Building does not comply with the established criteria and minimum strengthening of the structure will be necessary for the Yankee Composite Spectrum.

- The Turbine Pedestal does comply with the criteria for both the YCS and NRC Spectrum. No modification of the existing structure is required.

*Cygna Energy Services is the new name for EES, Inc. Ownership, philosophy and staffing of the firm remains the same.

II. BUILDING DESCRIPTIONS

2.1 Turbine Building

The Turbine Building is rectangular in plan and measures 115.5 ft. in the north-south direction and 159.0 ft. in the east-west direction. It serves various functions, and it is comprised of the Turbine Room at the north end, the Heating and Boiler Room at the south-east corner, the Control Room, Switchgear Room, and Boiler Feed Pump area at the south end of the building (Figures A.1-A.8).

The Turbine Room is a five-story steel frame structure located at the north end of the building. Its plan dimensions are 77 ft. in the north-south direction and 159 ft. in the east-west direction, and it is 81 ft. in height. Lateral load resistance is provided by four diagonally braced perimeter frames, in which normally only 1 bay in each frame is braced at a given story level (Figures A.13 and A.14). Diagonal braces are typically two steel channels of section C 10 x 20 laced together to form an open box section. Only one built-up brace is provided in a braced bay. The working points of braces are typically at beam flange to column face intersections. Interior columns support a light metal grating floor at the second floor and a 5 to 7 inch concrete slab on steel framing at the third floor (Figures A.9 and A.10). The third and fourth stories above are completely open, which allows for the removal and installation of turbine machinery. The roof is supported by north-south trusses at 22 to 27 ft. spacing. Lateral bracing of the main trusses are provided by two sway braces in the east-west direction. The roof diaphragm is stiffened by horizontal cross-bracing composed of steel double-angle sections (Figure A.12).

Fascia on the north, east, and west sides are provided by non-load bearing concrete masonry walls at the ground level, and insulated metal paneling above (Figures A.5 - A.8).

At the fifth floor, a movable crane is supported by heavy girders in the east-west direction, which are in turn independently supported by columns offset from the east-west perimeter frames.

The Turbine Room exterior columns are supported by spread footings. Grade beams connecting footing pedestals exist along the west frame line and along a portion of the north and east frame lines (Figure A.15).

The portion of the building housing the Heating and Boiler Room is 38.5 ft. (north-south) by 44 ft. (east-west). It is a two-story steel frame structure 31 ft. high. Its east perimeter frame is an extension of the east frame at the Turbine Room, and it shares three common columns with the Turbine Room south perimeter frame. The roof is constructed of light steel decking. At the second floor, a 5 inch concrete slab floor exists on the west half of the room; the east half is completely open up to the roof. Masonry walls separate this room from adjacent areas. Lateral support is provided by its attachment to the turbine room.

The structure housing the Control Room, Switch Gear Room, and Boiler Feed Pump area is three stories high, and its dimensions are 38.5 ft. (north-south) by 115 ft. (east-west) by 49.5 ft. tall. An 8.5 ft. high masonry wall penthouse 67 ft. by 14 ft. in plan containing cable trays is supported on the roof.

The vertical load carrying system of this part of the building is composed of bearing walls and columns. Floor loads are carried by simply-supported north-south steel girders at 22 to 27 ft. spacing (Figure A.11). These girders frame into common columns shared with the turbine room at the north side, and are supported at the south by grouted beam pockets in the 3 to 4 ft. thick reinforced concrete shield wall. At the roof level precast inverted T-beams with 9 inches of cast-in-place concrete cover span from the shield wall to the common columns (Figure A.16).

There are 3 ft. thick concrete shield walls at the east and west ends of the control room between the third floor and the roof (Figures A.17-A.19). However, these walls do not continue below the third floor. They are end-supported at the third floor by the south shield wall and 3 ft. square concrete columns. 12 inch thick masonry walls serve as partition or exterior walls below that level.

In general, nonstructural masonry walls can be found at all levels of this part of the building, serving as exterior curtain walls and interior partition walls.

A strip footing supports the south shield wall, but otherwise spread footings have been used. At the west end of the building, a grade beam ties the individual spread footing pedestals on grid line 13 to the shield wall strip footing (Figure A.15).

The footings at grid lines C and G support twin columns carrying loads from the Control Room to the South and the Turbine Room to the North. In addition, at the third floor a continuous concrete floor slab will act as a rigid horizontal diaphragm connecting the building together in its response to seismic loads. In end result the building acts as a coupled shear wall and braced frame system.

Review of design details show that concrete floor slabs are supported by bearing only, and that no positive connections exist for the transfer of seismic lateral loads from the floor diaphragms into vertical structural elements. Such connections will have to be provided in order to tie the building together and allow for the full participation of all lateral load resisting elements.

2.2 Turbine Pedestal

The Turbine Pedestal is located approximately in the middle of the Turbine Room. This structure is a reinforced concrete moment-resisting frame 34.5 ft. high. It is supported by eight rectangular columns whose cross-sectional dimensions range from 5.5 ft. to 11.5 ft. The frame has 1 bay in the transverse north-south direction, with centerline to centerline spans ranging from 21 to 27 ft. In the east-west direction, there are three bays ranging from 21 to 36 ft. for a total centerline length of 92 ft. Girder depths are roughly 8 to 10 ft (See Figures A.20-A.27).

The top of the Pedestal is level with the third floor of the Turbine Room. However, the Pedestal is structurally separated from the Turbine Building because a 1 inch joint isolates the pedestal from the surrounding concrete slab at this level.

The turbine is continuously anchored to the top of the Pedestal by bolts, and this effectively acts as a rigid diaphragm which ties the frame together horizontally.

An intermediate level concrete slab on beams framing into the four west end columns supports the generator.

The Pedestal is supported by a 4.5 ft. thick reinforced concrete mat foundation.

III. PERFORMANCE CRITERIA

3.1 Materials

3.1.1 Reinforced Concrete Walls

The concrete for shield walls was specified to have a 28-day compressive strength of 2500 psi. As shown in Figures A.17 - A.19, the reinforced concrete walls have very small height to depth ratios. Accordingly, their ultimate strength is primarily controlled by shear strength. The ultimate shear strength as per ACI 318-77 is:

$$v_u = 2\sqrt{f'c} = 2\sqrt{2500} = 100 \text{ psi.}$$

3.1.2 Reinforced Concrete Frame Members

With the exception of footings, cast-in-place concrete for frame members and floor slabs was specified to have a 28-day strength of 3000 psi. The ultimate strength of axial and flexural members was determined as per Chapter 10 of ACI 318-77.

3.1.3 Steel Frame Members

The structural steel for the Turbine Building was specified to conform to ASTM A7, which has a yield strength of 33 ksi. Stresses up to code allowables as given in Part 1 of the AISC Specifications are allowed

3.1.4 Unreinforced Concrete Masonry Walls

The allowable ultimate strength of unreinforced concrete masonry walls is given in Section 7.0 of the Seismic Reevaluation and Retrofit Criteria [1]. The compressive strength of masonry, f'm, has been determined to be

1000 psi and 600 psi on net section for ASTM C-90 and C-129 block units, respectively.

3.1.5 Allowable Soil Pressures

The bearing capacity for the soil underneath all footings is 8 ksf if earthquake loads are not considered and 10.6 ksf if they are included.

3.2 Loadings

3.2.1 Dead Loads

Design dead loads and their related member forces were considered in the evaluation. For the Turbine Building, no internal beam moments were generated at beam-column joints because all beam-column connections are of the simple shear type.

3.2.2 Live Loads

For the Turbine Building, live loads and their related member forces were also included in the evaluation. There was no consideration of live load for the Turbine Pedestal.

3.2.3 Earthquake Loads

The earthquake loads were specified by the YCS and NRC Spectrum (Figure C.1). Equivalent viscous damping of 7% was assumed in accordance with Table D-3 of the Criteria [1].

3.2.4 Load Combinations

The load combinations considered in this evaluation are as follows:

(1) $D + L + T_o + R_o + P_o + (E \text{ or } W \text{ or } M)$

(2) $D - E$

where:

D = Dead loads

L = Live loads

E = Earthquake loads

T_o = Thermal loads

R_o = Pipe reactions

P_o = Pressure equivalent static loads

W = Wind loads

M = Missile Loads

and in equation (2), earthquake induced member forces are assumed to act opposite to dead loads.

IV. ANALYSIS PROCEDURES

4.1 General

Both the Turbine Building and Turbine Pedestal were analyzed based on linear elastic theory. Dynamic properties of the structures were evaluated in terms of characteristic mode and frequency information.

For the stress evaluation of the structures, the response spectrum method of dynamic analysis was used. The combination of individual modal displacements, member forces, and stresses was carried out by the square root of the sum of squares (SRSS) procedure. In order to account for the multi-directional nature of seismic input, results from the three orthogonal directions were combined by the SRSS method.

For the Turbine Building, as-built details of ten selected steel brace connections to beam-column joints were obtained from field investigations. The stresses in these joints and their connectors due to YCS and NRC Spectrum loads were evaluated. Based on the performance of these representative joints, general conclusions were drawn regarding the behavior of all joints.

For the generation of floor level acceleration time histories, individual modal displacements were superposed for each time step of the total response (See Sect. VI).

4.2 Computer Programs

Three computer programs were utilized in the analyses. The program BATS [5] was used to perform the modal extraction and response spectrum analyses. MOST [6] and INSPEC [7] were employed to generate floor acceleration time histories and the corresponding floor-amplified response spectra (ARS), respectively.

4.3 Assumptions

The computer program BATS assumes that each floor level of a structure can be modeled as a set of horizontal diaphragms rigid in plane. Each diaphragm is attached to one or more substructures which provide vertical and lateral support. A diaphragm has two horizontal and one torsional degrees of freedom which thus define the lateral displacements of all of its attached substructures. A consequent result of the rigid diaphragm modeling is the further assumption that beam elements do not deform axially nor bend in the plane of the diaphragm. However, horizontal flexible links can be used to connect individual diaphragms and elastically couple their degrees of freedom. Thus, a structure is modeled as a three-dimensional system of vertical frame or wall substructures supporting horizontal rigid diaphragms. Inertia properties of the structure are lumped at the floor diaphragms. The computer program BATS further reduces this system to an equivalent lumped mass and stick model prior to frequency and mode shape analysis.

4.4 Horizontal Models

4.4.1 Turbine Building

The Turbine Building is characterized by several open floors in the Turbine Room area. Accordingly, in order to adequately model the relative motion of structural frames, the Turbine Building was discreticized into several diaphragms and substructures (Figure B.1, B.2, and B.9).

The Control and Switchgear Room area have concrete slabs at all floor and roof levels, and therefore it was modeled as a single substructure and diaphragm bounded by grid lines 7, 13, J and G. Lateral resistance is provided by the 3 to 4 foot thick concrete shield walls along grid lines 8, 13, and J, and by the braced frame on grid line G.

The north, east, and west braced perimeter frames of the Turbine Room area were each modeled as individual substructures. At the top level all the frames, including the frame on line G, were connected to a single diaphragm representing the cross-brace stiffened roof system (Figure B.7). At elevation 1052'-8", the concrete slab is significantly perforated. Therefore, two diaphragms were used in the turbine area connected to each other and to the Control Room diaphragm by flexible links (Figure B.4). The stiffness properties of these links were derived from the actual area of continuous steel reinforcement and beams. At all other elevations, the individual planar braced frames were separated and free to move relative to each other (Figures B.3, B.5, and B.6).

At elevation 1037'-8", the Turbine Building provides partial lateral support for the Service Building in the north-south direction, and the Office Building in both directions. These attached buildings were modeled as equivalent mass-spring systems (Figure B.8). The springs in these models represented the stiffnesses of vertical X-bracing and flexible roof diaphragms.

Bracing was assumed in grid line A to achieve stability for the Office Building in the E-W direction. It was also assumed to be self-stabilized in the N-S direction in the mass-spring model generated.

The calculated seismic weight of the Turbine Building included structural deadweight, architectural elements and facades, partition and shield walls, the deadweight of the movable crane at elevation 1082'-8", and the possible laydown weight of turbine machinery at elevation 1052'-8". For the Service and Office Buildings, the design roof deadweight of 20 psf was used increased by an additional 5 psf to account for steel frames, architectural finishes and attachments, and mechanical attachments.

4.4.2 Turbine Pedestal

The Turbine Pedestal was modeled as a one-story moment-resisting space frame with a single rigid diaphragm at the top level, elevation 1052'-8" (Figure B.10). All member properties were based on uncracked concrete sections, neglecting the contribution of steel reinforcement. Beam-column joints were assumed to act as rigid-bodies.

The seismic weight of the Turbine Pedestal included structural deadweight and the weights of the supported turbine and generator.

4.5 Vertical Models

4.5.1 Turbine Building

In general, substructures are not coupled in the vertical direction. Floor diaphragms are flexible in the out-of-plane direction, and since beam connections are of the shear type, no bending moments are induced in beams by relative vertical displacements.

Accordingly, three separate models were developed to reflect the different vertical load carrying systems of the building. Equivalent lumped mass and spring mechanical models were utilized. The effective floor masses were represented by concentrated masses, and the combined stiffnesses of supporting walls, columns, and braces were represented by elastic springs. In addition, the truss-supported turbine area roof and the 4-foot thick Control Room roof are much stiffer than the floor diaphragms. In the vertical models, these elements were assumed to act as rigid-body masses.

The Control and Switch Gear Rooms constituted the first model (Figure B.11). Masses were supported by springs representing the shield wall on the south side of the building and the steel braced frame on grid line G. Five masses connected by six springs were used. The purpose of this model was to generate ARS for piping supported by the south concrete shield wall.

The second vertical model represented the turbine area (Figure B.12). The equivalent mechanical system was composed of two parallel systems of four masses linked at the top to a common rigid body mass representing the turbine area roof. One series of masses and springs incorporated the mass tributary to grid line C and the supporting colums and braces, and the remaining mass and stiffness were lumped into the parallel system. The results of the analysis of this model was used to determine the column and brace forces caused in the turbine area by vertical ground acceleration.

The third vertical model represented a typical column in grid line G (Figure B.13). These columns are characterized by the fact that they support vertical loads from the control room roof and floor slabs as well as the turbine room. The equivalent mechanical system for one of these columns was a series of five masses and springs. This model was used to generate ARS and determine column forces in grid line G caused by vertical ground acceleration.

4.5.2 Turbine Pedestal

The Turbine Pedestal was modeled in two dimensions in the vertical direction. The axial stiffnesses of columns in the north-south bays were added, and the flexural properties of east-west beams were added. Mass was lumped at the four beam-column joints of the two-dimensional east-west frame and the ARS location point. Thus, a total of five degrees of freedom were defined in the vertical direction. This resulted in a model of the Pedestal in the east-west direction analogous to a beam supported by multiple elastic springs, i.e., the columns (Figure B.14).

This approach correctly considered the stiffness-coupling effect of the Turbine Pedestal beams. Since the Pedestal is symmetric about its east-west centerline axis, no generality was lost by two-dimensional modeling. The analyses of this system resulted in ARS for supported piping and the Turbine Pedestal column loads caused by vertical acceleration.

V. ANALYSIS RESULTS

5.1 Structural Characteristics

5.1.1 Turbine Building

The first 31 modes of the Turbine Building were included in the calculation of dynamic response to horizontal ground motion. Table D.1 summarizes the frequencies, periods and modal masses of each of these modes. The sum of these modal masses in the north-south and east-west directions was greater than 90% of the total mass. The selection of the first 31 modes was therefore adequate to determine the dynamic response of the structure.

In the north-south direction, dynamic response was predominantly governed by the third mode, which had a frequency of 2.24 cps. This mode defined the response of 69% of the mass of the Turbine Building.

In the east-west direction, the majority of the mass of the Turbine Building was governed by three modes. The fourth mode, which had a frequency of 2.34 cps, characterized 18% of the total mass of the Turbine Building. It was associated with the east-west vibration of the Turbine Room steel frames. The 25th mode, which had a frequency of 12.34 cps, characterized 32% of the total mass of the Turbine Building. It was associated with the east-west vibration of the Office Building. The 26th mode, which had a frequency of 12.64 cps, charactrized 24% of the total mass. It was associated with the east-west vibration of the Turbine Room steel frame at Line C. All other modes individually contributed less than 12% of the total combined mass of the Turbine Building, Service Building, and Office Building.

The characteristic frequencies of the Turbine Building in the vertical direction were different among the three models developed for this purpose. Because of the limited number of degrees of freedom in these models, all modes were taken into consideration.

The first model, representing the Control and Switchgear Rooms, was relatively stiff due to the concrete shield walls. The predominant frequency of this model was 26.4 cps, and the corresponding mode included 92% of the total mass of the model.

The second model, representing the turbine room, had a predominant frequency of 18.6 cps. The mode associated with this frequency contained 87% of the total mass.

The third model, representing a typical column on line G, had a predominant frequency of 10.3 cps. The mode associated with this frequency contained 96% of the total mass.

5.1.2 Turbine Pedestal

In the horizontal direction, the Turbine Pedestal was modeled as a one-story three-dimensional space frame with a single rigid diaphragm. Accordingly, the response of this structure was governed by three modes (Table D.2). All three were considered in calculating dynamic response.

The first mode was associated with the translation of the structure in the east-west direction. It had a frequency of 7.42 cps and included 100% of the total mass in the east-west direction.

The second mode was associated with the translation of the structure in the north-south direction. It had a frequency of 8.64 cps, and it included 94.5% of the total mass in the north-south direction.

The third mode was primarily torsional, and to a certain extent translational in the north-south direction. It had a frequency of 10.2 cps, and it included 5.5% of the total mass in the north-south direction.

All five modes of the Turbine Pedestal were used to determine its response in the vertical direction. As expected, the Pedestal was found to be very stiff. The predominant mode, the first, had a frequency of 29.5 cps. It included 50.8% of the total mass. The second mode had a frequency of 30.9 cps. It included 25.9% of the total mass. The third mode had a frequency of 41.1 cps. It included 19.3% of the total mass. The fourth mode had a frequency of 47.6 cps, and it included 4.0% of the total mass. The fifth mode was not significant.

5.2 Analytical Results

As stated in Section 4.4.1, modal contributions to structural response were combined by the square root of the sum of squares (SRSS) procedure. The individual results from earthquake loading applied in the three orthogonal directions were combined by the SRSS method.

5.2.1 Turbine Building

5.2.1.1 YCS Loads

The loads, displacements, and member forces produced in the building by the YCS ground motion are summarized in Tables E.1 to E.4.

Table E.1 presents an overall summary of the seismic base shears and resulting maximum displacements at elevation 1052'-8". In the north-south direction, the shear produced in the attached Turbine Building, Service Building, and Office Building was

1548 kips, or 14.6% of their total combined weight. In the east-west direction, the shear produced in these three buildings was 923 kips, or 8.7% of their weight. The maximum displacements at elevation 1052'-8" were 0.26 inches and 0.04 inches in the north-south and east-west directions, respectively.

Table E.2 summarizes the axial loads and stresses produced in diagonal braces of the two north-south steel frames. No significant overstress occurred for YCS loading.

The results of the stress analysis of ten representative brace to beam-column joints are given in Table E.3. No overstress occurred.

Maximum and minimum loads produced in individual footings are shown in Table E.4. Neither overstress nor uplifting occurred in any footings.

The steel frame columns themselves were adequate for the maximum vertical loads produced by dead, live, and seismic loads.

Overstress and hence cracking occurred in concrete shield wall on Grid Line J. The extreme fiber stress was 630 psi which exceeds concrete's modulus of rupture of 410 psi. Since this wall is under-reinforced, its ultimate moment capacity is less than its crack moment. Development of the flexural cracks in the wall may significantly reduce its moment capacity.

Floor slab connections as given by the contract drawings of the Turbine Building were examined. No connections were provided for the transfer of seismic inertia loads from floor slabs into structural frames and walls. Such connection must be provided in order to engage these structural systems.

5.2.1.2 NRC Spectrum Loads

The loads, displacements and member forces in the building are summarized in Tables E.5 to E.8.

Table E.5 presents an overall summary of the seismic base shears and resulting maximum displacements at Elev. 1052'-8". In the N-S direction, the shear produced in the three attached buildings was 2863 kips, or 27.0% of their total weight. In the E-W direction, the shear produced was 1520 kips, or 14.3% of the total weight. The maximum displacements at El. 1052'-8" were 0.51 and 0.08 inches in the N-S and E-W directions, respectively.

Table E.6 summarizes the axial force developed in the diagonal braces of the two N-S and two E-W steel frames. The compression forces developed in three braces located in Frame Line 5, two braces in Frame Line G and four braces in Frame Line C exceeded the corresponding allowable buckling forces. Since the diagonal braces are the only lateral force resistance mechanism of the steel frames, buckling of these braces will significantly reduce the lateral load resistance capacity of the frames.

The results of the stress analysis of the brace to beam-column connections are given in Table E.7. Overstresses occurred in five connections. The maximum overload ratio was 1.5.

The maximum and minimum loads produced in individual footings are shown in Table E.8. Seismic load in conjunction with dead and live loads produce excessive soil bearing pressures at Footings G-8, G-5, C-11 and C-8. The maximum overstress was 17%, which occurred at Footing G-8. Seismic load acting opposite to dead load also produced net uplift forces at eight footings. The maximum uplift force was 226 kips at Footing G-8. Since a large part of the footing shear resistance comes from the friction force developed between the footing and soil, presence of the uplift force will eliminate the friction force and consequently reduce the shear resistance capacity of the footing.

The steel columns were adequate.

Overstress and cracking occur in the concrete shield wall on Grid Line J. The extreme fiber tensile stress for out-of-plane bending was 1310 psi, which exceeded the modulus of rupture of concrete, 410 psi.

5.2.2 Turbine Pedestal

5.2.2.1 YCS Loads

The loads, displacements, and member forces produced in the Turbine Pedestal by the dead load and YCS loads are summarized in Tables E.9 to E.11.

The beam and column stress resultants produced by vertical acceleration were only about 2% or less of the stress resultants due to horizontal acceleration. Thus, they were negligible in the SRSS combination of the results of the three orthogonal directions.

Table E.9 presents an overall summary of the seismic base shears and resulting maximum displacements at elevation 1052'-8". In the north-south direction, the base shear was 893 kips, or 17.2% of the total weight. In the east-west direction, the shear produced was 979 kips, or 18.9% of the total weight. The maximum displacements at elevation 1052'-8" were .02 inches and .03 inches in the north-south and east-west directions, respectively.

Table E.10 summarizes the column forces produced by the YCS loads. These structural elements were subjected to axial loads and biaxial moments. Interaction effects on capacity were evaluated by the load contour method. All results of the load contour interaction equation were less than 1.0, indicating that the columns were acceptable for the YCS. In addition, service dead loads in the columns were never exceeded by the upward loads produced by the YCS loads.

Table E.11 shows the beam bending moments and shear forces. The applied forces and moments were less than 0.41 of the corresponding ultimate strengths of these members.

The maximum soil pressure of the Turbine Support Mat Foundation under dead load plus YCS applied in two horizontal directions and the vertical direction is 4.06 KSF, which is smaller than the allowable pressure, 10.6 KSF.

The absolute sum of the maximum displacement of the Turbine Building and Turbine Pedestal at elevation 1052'-8" was 0.28 inches. This was less than the gap of 1.0 inch separating the two structures.

5.2.2.2 NRC Spectrum Loads

The loads, displacements and member forces produced in the Turbine Pedestal by the dead load and NRC spectrum loads are shown in Tables E.12 to E.14. The negligible beam and column forces due to the vertical NRC spectrum were also excluded in the

SRSS combination of the results of the three orthogonal directions.

Table E.12 shows an overall summary of the seismic base shears and resulting maximum displacements at Elev. 1052'-8". In the N-S direction, the base shear was 1645 kips, or 31.8% of the total weight. In the E-W direction, te base shear was 1427 kips, or 27.5% of the total weight. The maximum displacements at Elev. 1052'-8" were 0.04 inches and 0.06 inches in the N-S and E-W directions, respectively.

Table E.13 summarizes the column forces produced by the YCS loads. As shown in this table, all results of the load contour interaction equation were less than 1.0, indicating that the columns were acceptable for the NRC Spectrum loads. In addition, service dead loads in the columns were never exceeded by the upward loads produced the NRC Spectrum loads.

Table E.14 shows the beam bending moments and shear forces. The applied forces and moments were less than 0.66 of the corresponding ultimate strengths of these members.

The maximum soil pressure of the Turbine Support Mat Foundation under dead load plus NRC Spectrum applied in two horizontal directions and the vertical direction is 5.00 KSF, which is smaller than the allowable pressure, 10.6 KSF.

The absolute sum of the maximum displacement of the Turbine Building and Turbine Pedestal at Elev. 1052'-8" was 0.55 inches. This was less than the gap of 1.0 inch seperating the two structures.

VI. GENERATION OF THE ARS

The amplified response spectra (ARS) were generated for the analyses of piping systems supported by the Turbine Building and the Turbine Pedestal. There are three support points for which ARS were determined. Two of these are located on the Turbine Building at elevation 1037'-8" and 1052'-8". The ARS for these points were labeled ARS PT. 1 and ARS PT. 2. These points are shown in Figure F.1. The remaining point, ARS PT. 106, was located on the Turbine Pedestal at elevation 1052'-8". This point is shown in Figure F.14.

The generation of each ARS proceeded along the following methodology:

For each of the three orthogonal directions, a statistically independent synthetic ground acceleration time history was developed using the program NRCQUAKE [8]. These time histories were verified to match the YCS or NRC Spectrum according to the criteria specified in the USNRC Standard Review Plan Section 3.7.1. For the vertical acceleration time history, a scale factor of two-thirds was applied. The dynamic characteristics of the structure were obtained as described in Sect. V.1. The mode shape ordinates, given at the center of mass of each floor diaphragm, were transformed via rigid-body constraint equations to the ARS support point. The acceleration time histories of the ARS support point could then be calculated by the superposition of the acceleration time-histories of individual modes, when subjected to the input ground motions. This superposition was computed by the program MOST [6], using the assumed structural damping of 7% of critical damping.

The response of the structures into vertical ground acceleration was independent of the response to horizontal ground acceleration. Thus, the vertical acceleration time history of the ARS support point was computed separately.

These support point acceleration time histories were then input to the response spectrum calculation program, INSPEC [7]. These were calculated for the two horizontal directions and the one vertical direction. The peaks in their spectra were broadened by 15%. The resultant spectra give the maximum accelerations experienced by supported subsystems.

For the ARS located in the Turbine Building, two critical damping ratios, 2% and 3% were used. The ARS corresponding to the YCS loads and NRC Spectrum loads are shown in Figs. F.2 to F.7 and Figs. F.8 to F.13, respectively. All these ARS are identified by the location point and direction.

For the ARS located in the Turbine Pedestal, only 3% cirtical damping ratio was used. The ARS coresponding to the YCS loads and NRC spectrum loads are shown in Figs. F.15 to F.17 and Figs. F.18 to F.20, respectively.

VII. SUMMARY OF REVIEW

7.1 Turbine Building

1. The steel columns have adequate capacity to resist the axial force produced by a combination of dead load, live load plus either YCS loads or NRC Spectrum loads.

2. The diagonal braces have adequate capacity to resist YCS loads except for one diagonal brace located in Grid Line 5. Under NRC Spectrum loads, however, three braces located in Grid Line 5, two braces located in Grid Line G and four braces located in Grid Line C are overstressed in compression. Consequent buckling of these braces will result in a reduction of the lateral load resistance capacity in the three frames.

3. The brace to beam-column connections have adequate capacity to transfer YCS loads. Under NRC spectrum loads, however, five connections are overstressed.

4. Due to a combination of dead load and YCS loads, the soil has adequate bearing capacity and all footings will not be subjected to uplift force. If YCS loads were replaced by NRC Spectrum loads, the soil under four footings are overstressed in bearing by less than 17%. Eight of the footings are also subjected to the uplift force which could reduce the shear resistance of the footings.

5. Due to dead load plus either YCS loads or NRC Spectrum loads, the flexural tensile stress developed in the 3'-0" thick shield wall located in Grid Line J will exceed the modulus of rupture of the concrete. Since the shield wall is under-reinforced, development of the flexural cracks in the wall may significantly reduce its flexural capacity.

6. Connections for the transfer of seismic shear forces from concrete floor slab to structural frames and walls are lacking.

7. The absolute sum of the maximum displacements of the Turbine Building and Turbine Pedestal at Elev. 1052'-8" are 0.28 inches and 0.55 inches under YCS loads and NRC Spectrum loads, respectively. These displacements are less than the 1.0 inch gap separating the two structures.

7.2 Turbine Pedestal

1. Reinforced concrete columns are adequate to resist combined axial loads and biaxial bending moments resulting from dead load and YCS loads or NRC Spectrum loads. Also, service dead loads in columns are not exceeded by upward loads imposed by YCS loads or NRC Spectrum loads.

2. Reinforced concrete beams are adequate to resist shear forces and bending moments imposed by dead load and YCS loads or NRC Spectrum loads.

3. The bearing strength of soil underlying the mat foundation of the Turbine Pedestal is not exceeded under dead load and YCS loads or NRC Spectrum loads.

7.3 Attached Office Building

The Office Building does not have sufficient lateral load resistance capacity to take either YCS loads or NRC Spectrum loads.

VIII. RECOMMENDED MODIFICATIONS

1. Modifications are necessary for the Turbine Building against YCS loads or NRC Spectrum loads, as follows:

   a) Additional braces and shear walls should be installed in order to redistribute seismic lateral forces. This would relieve the stresses in existing braces, connections and shield wall at Grid Line J.

   b) Installation of additional braces and shear walls will also lessen the effects of seismic overturning moments. In general, the number of braced bays in lower stories should be increased. This modification will decrease the seismic uplift on the end columns of these bays.

   c) Positive connections must be provided for shear transfer from concrete floor slabs to the lateral load resisting system.

2. No modifications are necessary for the Turbine Pedestal.

APPENDIX A

CONTRACT DRAWINGS

APPENDIX A

CONTRACT DRAWINGS

I. TURBINE BUILDING

FIG.	STONE & WEBSTER DWG. 9699-
A.1 - A.4	FA-1A to 1D
A.5 - A.8	FA-2A to 2D
A.9 - A.11	FS-3A, 3B, & 4A
A.12	FS-5A
A.13 - A.14	FS-6B & 6C
A.15	FC-1A
A.16	FC-15A
A.17 - A.19	FC-17A to 17C

II. TURBINE PEDESTAL

FIG.	STONE & WEBSTER DWG. 9699-
A.20 - A.23	FC-19A to 19D
A.24 - A.27	FC-20A to 20D

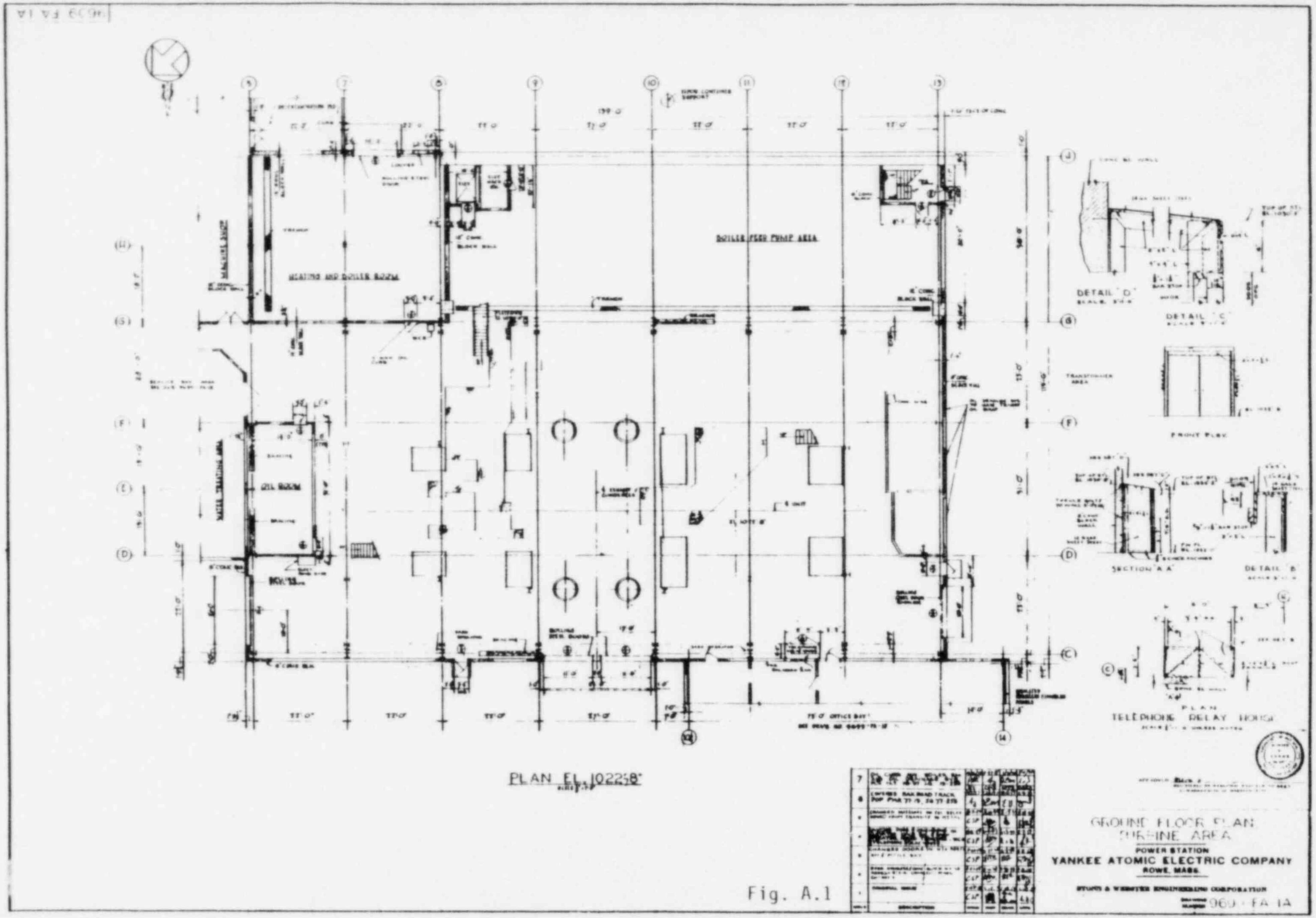


Fig. A.1

Yankee Atomic Electric Company
Turbine Building and Turbine Pedestal
80023; Report No. EY-YR-80023-9; Rev. 1

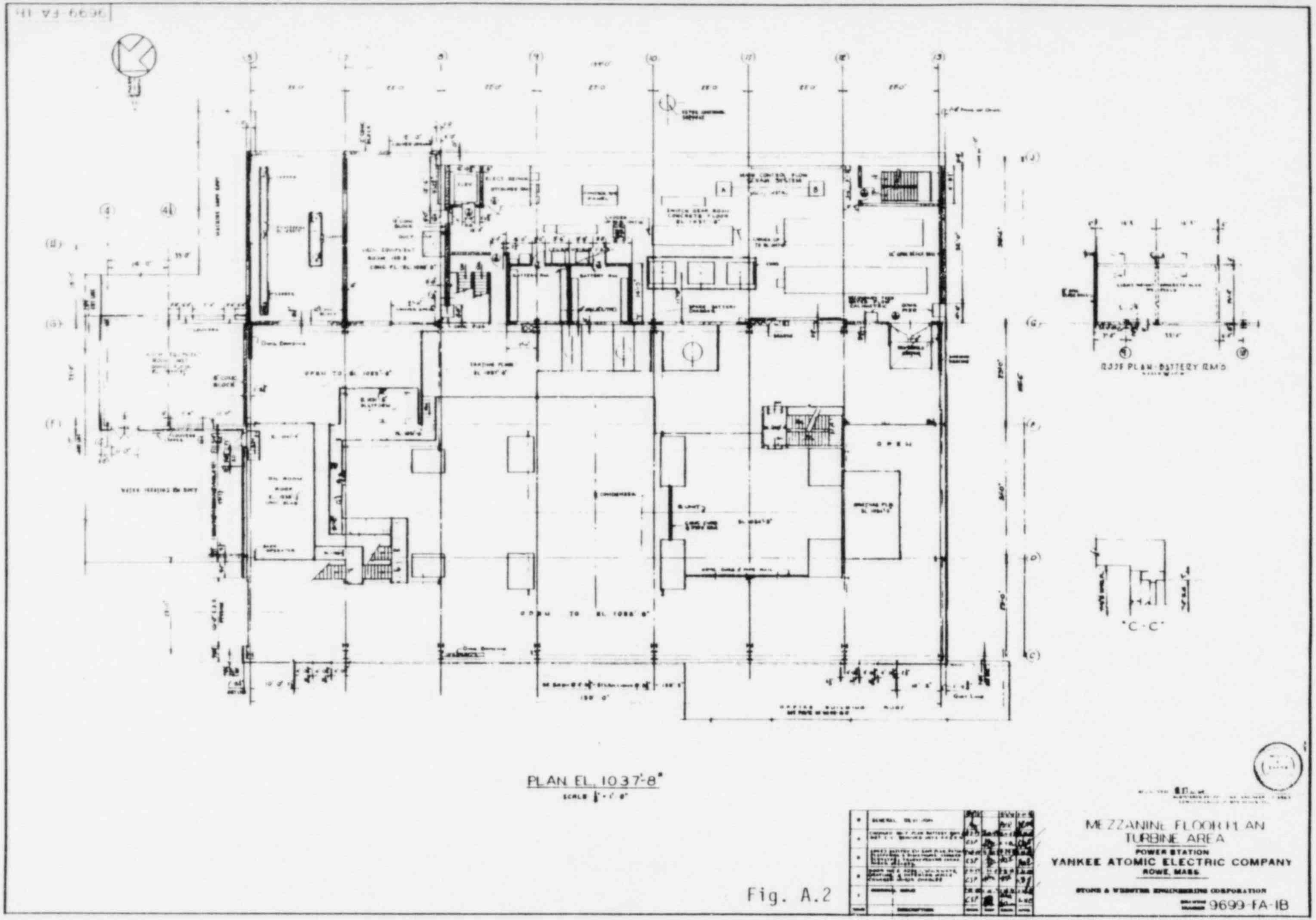

PLAN EL. 1037'-8"
ROOF PLAN-BATTERY RM'S
"C-C"
MEZZANINE FLOOR PLAN
TURBINE AREA
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699-FA-1B

Fig. A.2

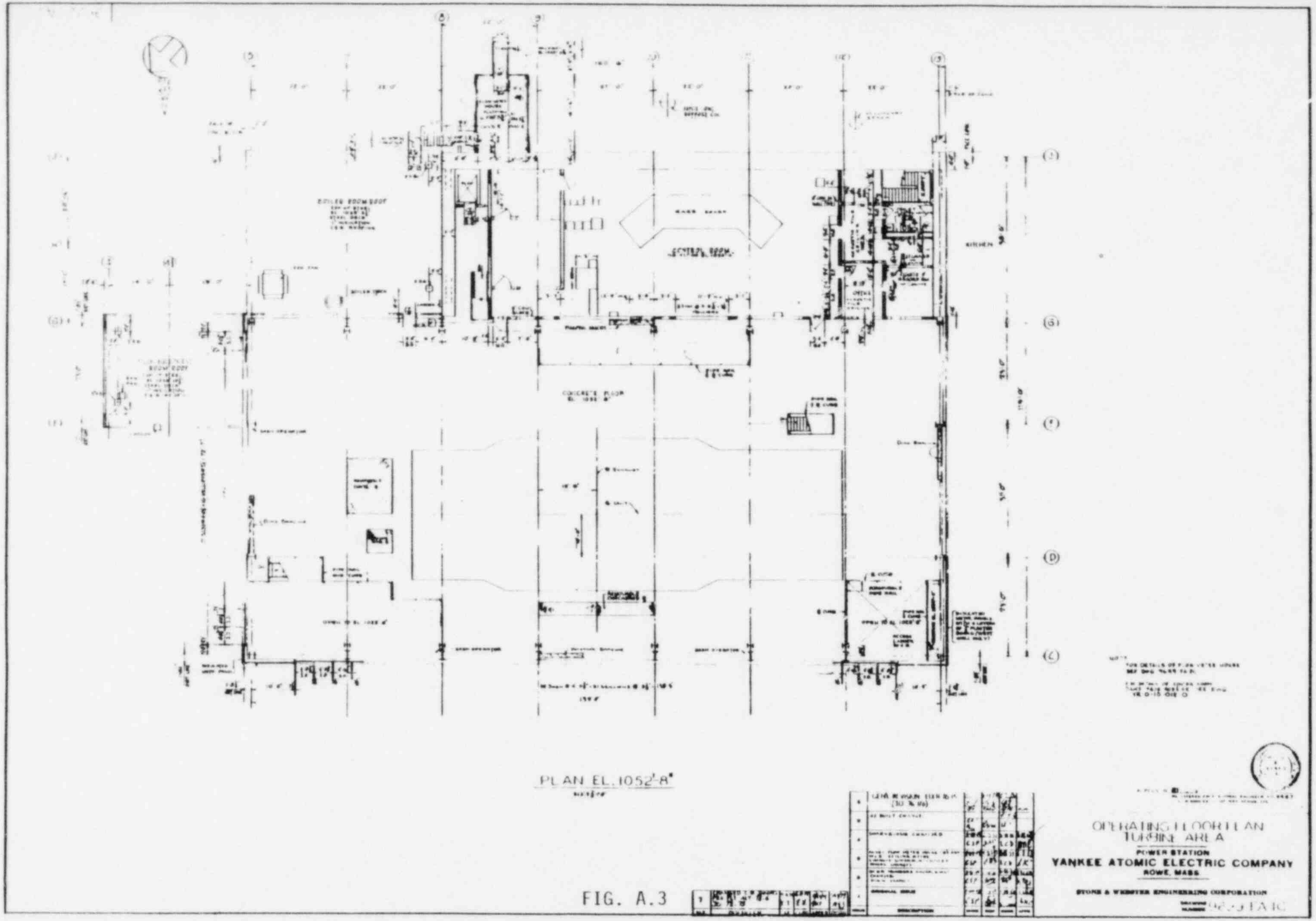

PLAN EL. 1052'-8"
KITCHEN
CONCRETE FLOOR
CONTROL ROOM
OPERATING FLOOR PLAN
TURBINE AREA
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION

FIG. A.3

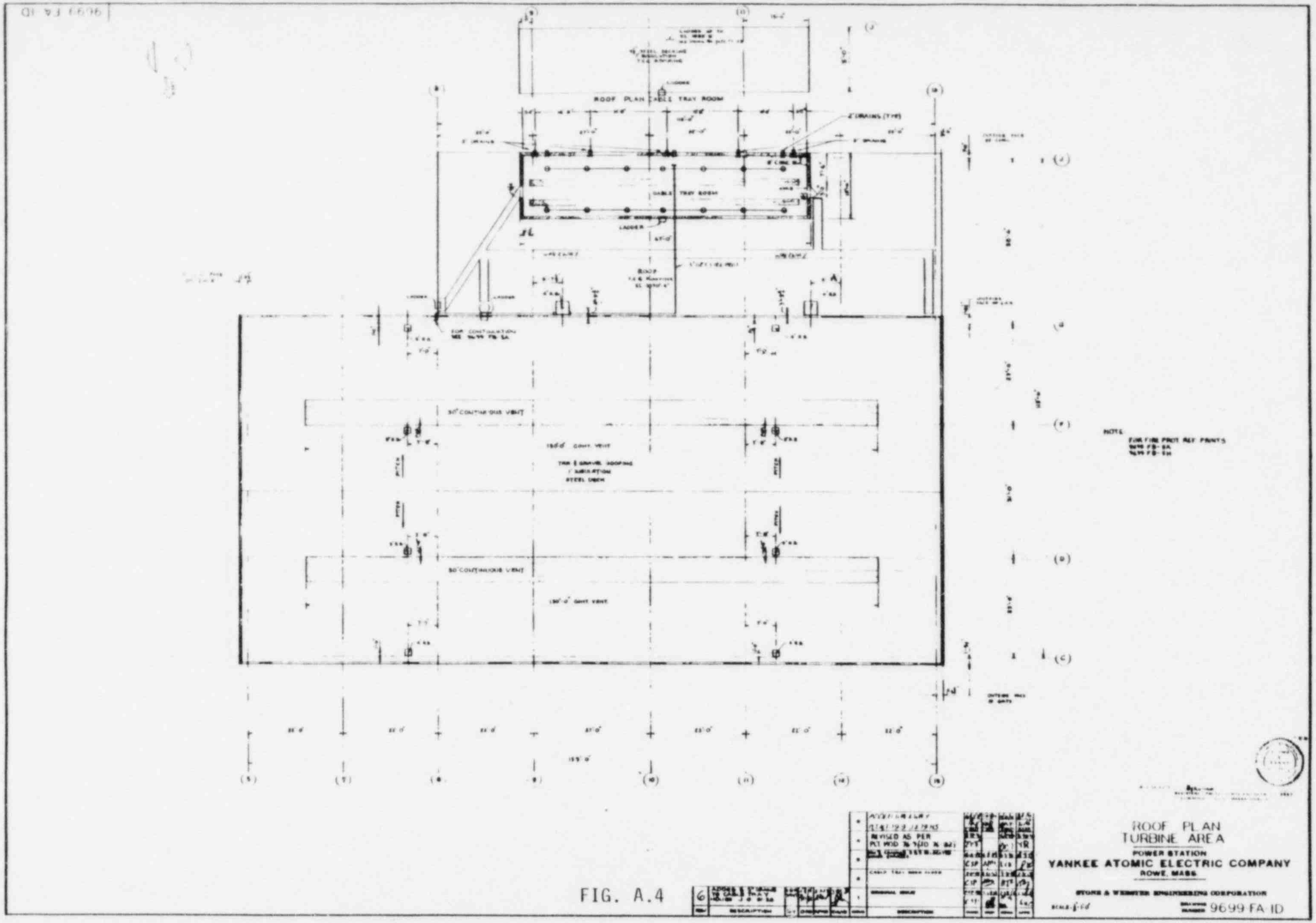


FIG. A.4

Yankee Atomic Electric Company
Turbine Building and Turbine Pedestal
80023; Report No. EY-YR-80023-9; Rev. 1

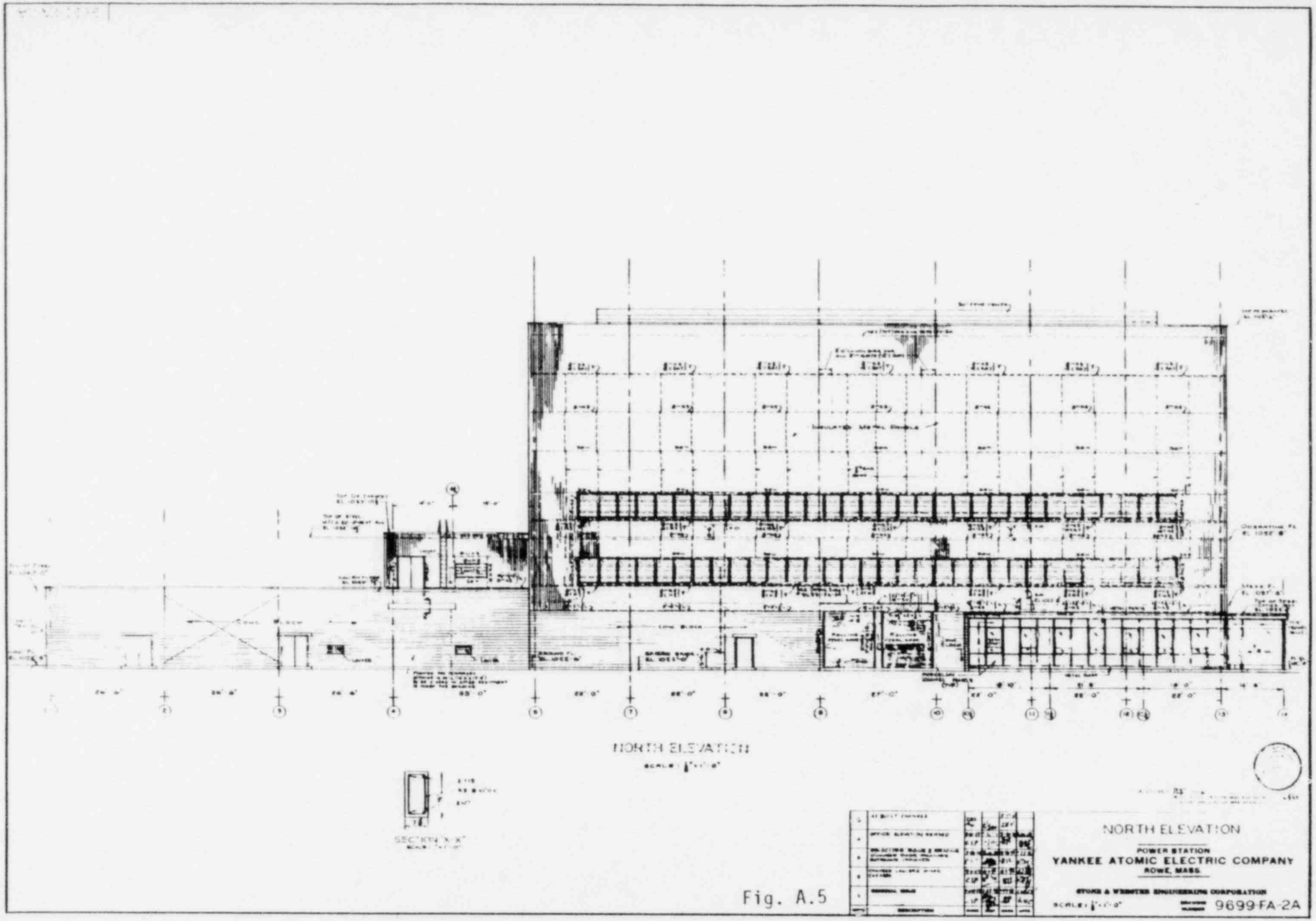

NORTH ELEVATION
SECTION "X-X"
NORTH ELEVATION
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699-FA-2A

Fig. A.5

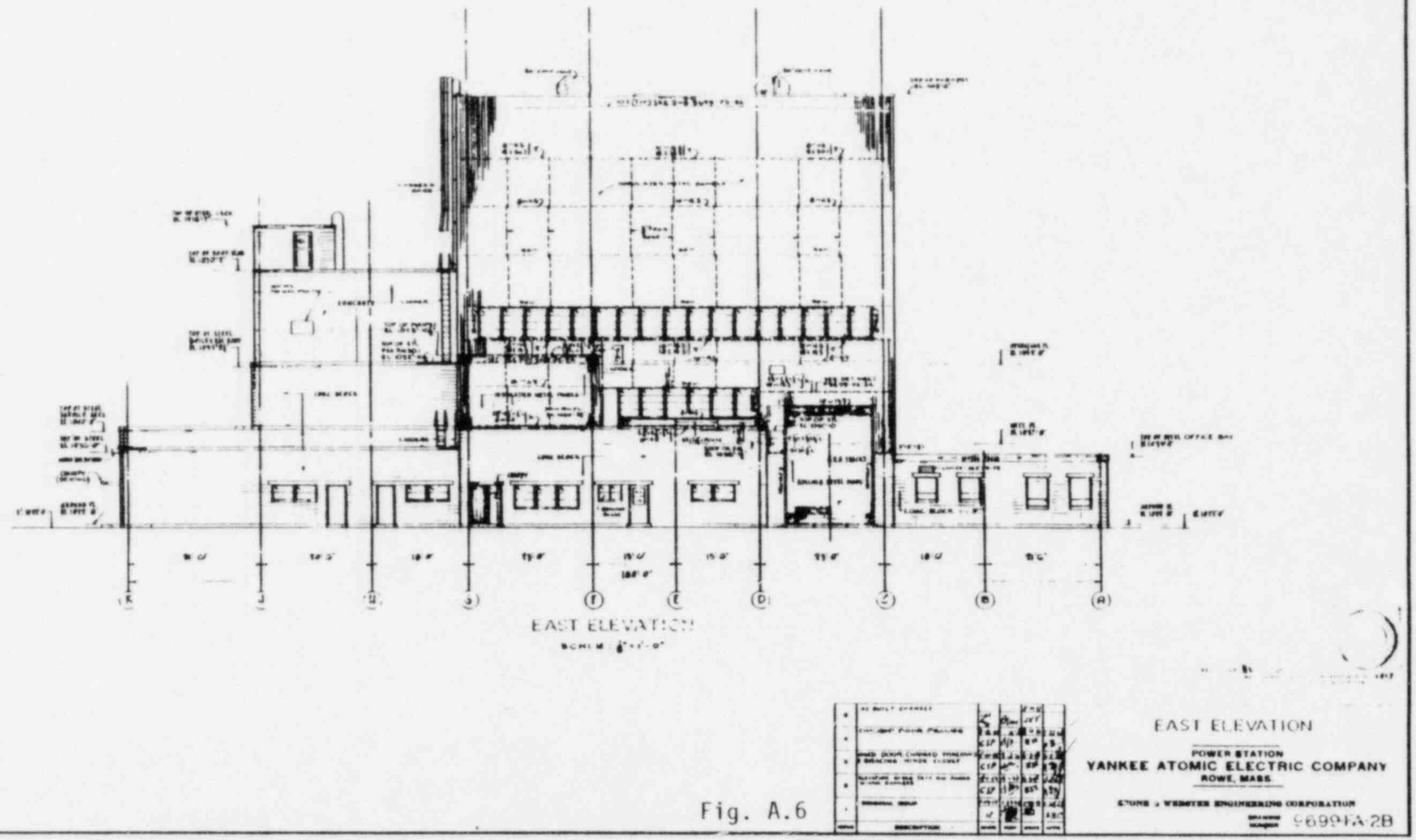

EAST ELEVATION
EAST ELEVATION
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699FA-2B

Fig. A.6

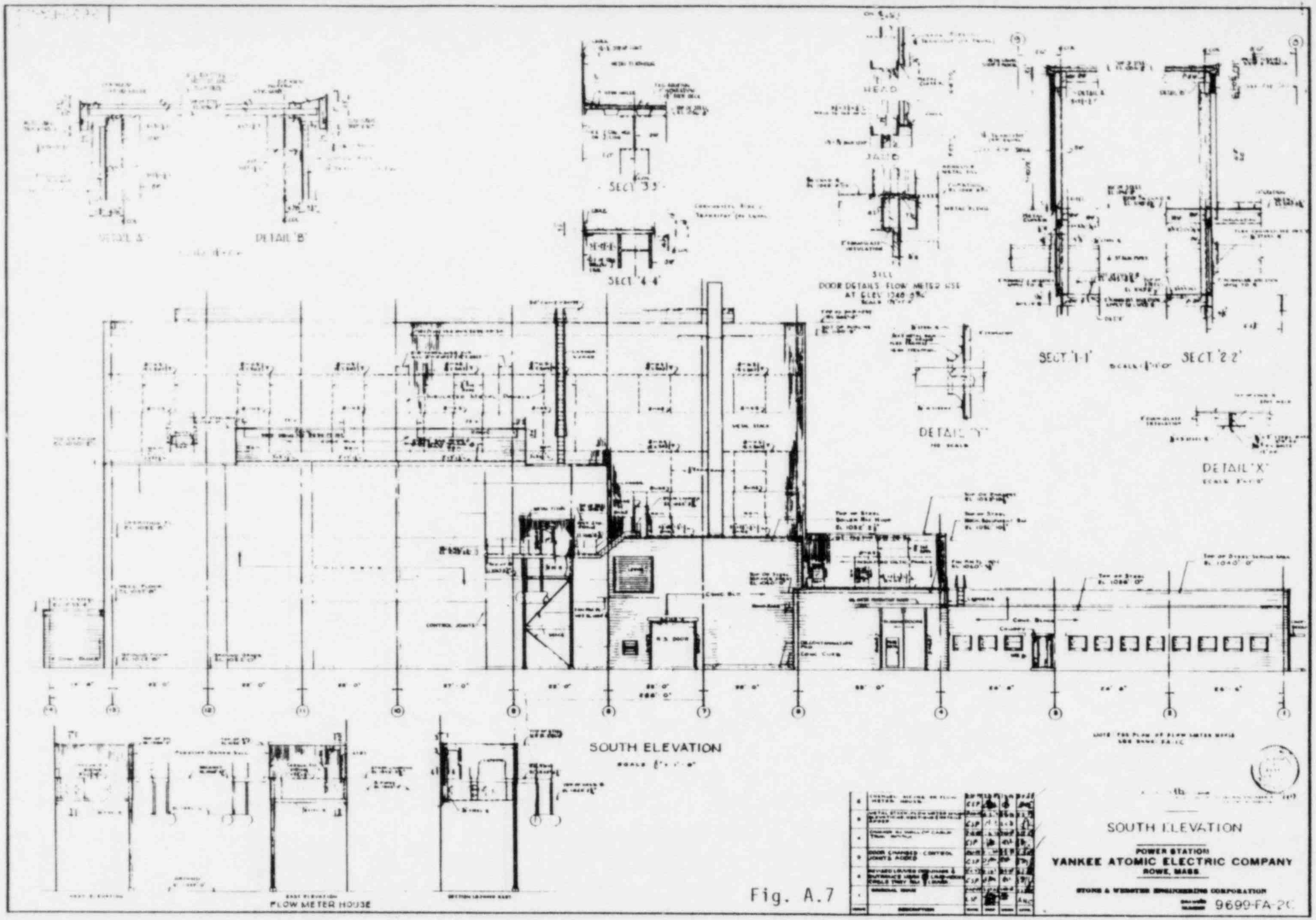


Fig. A.7

Yankee Atomic Electric Company
Turbine Building and Turbine Pedestal
80023; Report No. EY-YR-80023-9; Rev. 1

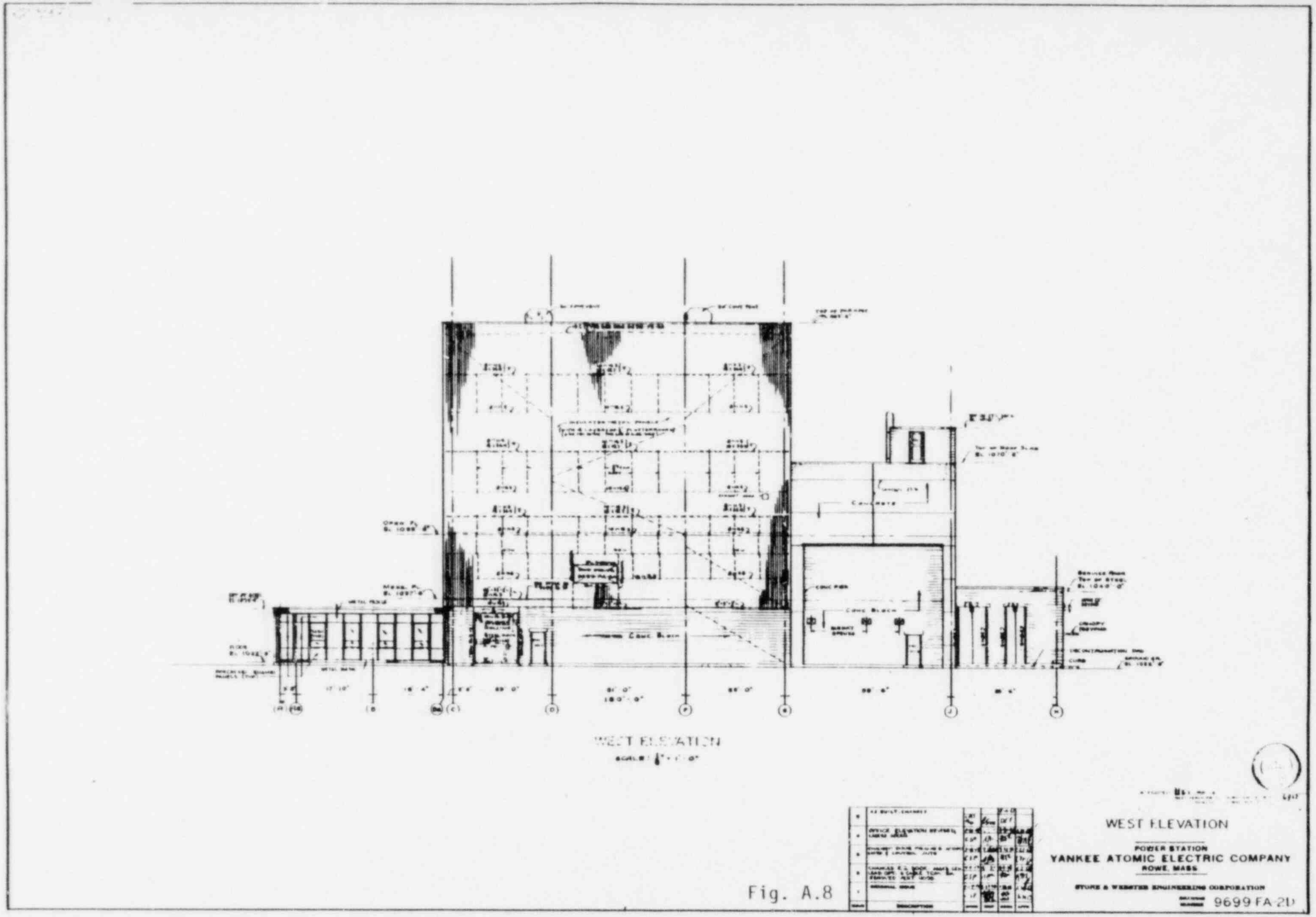

WEST ELEVATION
WEST ELEVATION
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699-FA-2D

Fig. A.8

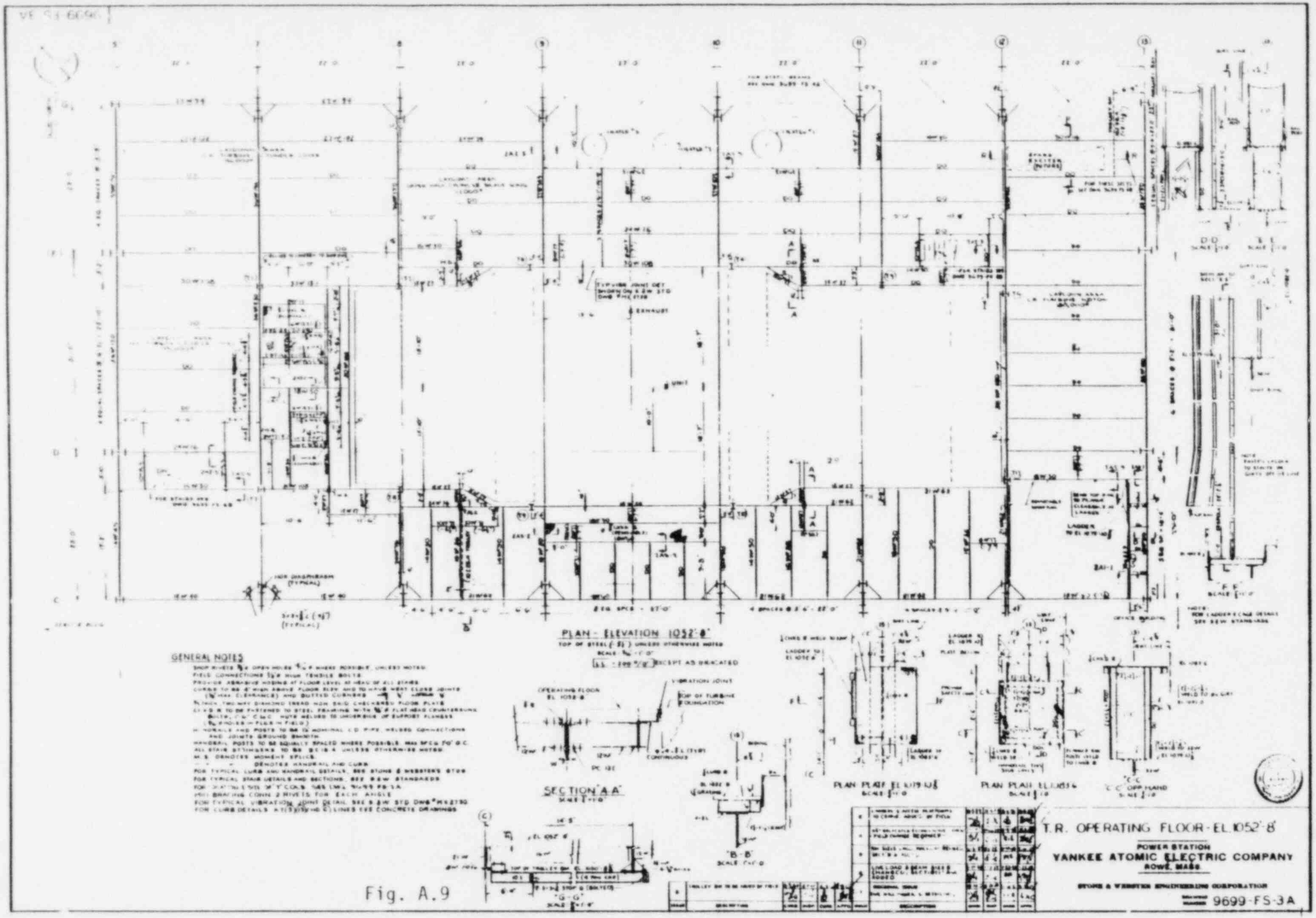

PLAN - ELEVATION 1052'-8"
GENERAL NOTES
SECTION "A-A"
"B-B"
"G-G"
PLAN PLAT EL.1079'-12
PLAN PLAT EL.1083'6
"C-C" OPP. HAND
T.R. OPERATING FLOOR - EL.1052'-8"
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699-FS-3A

Fig. A.9

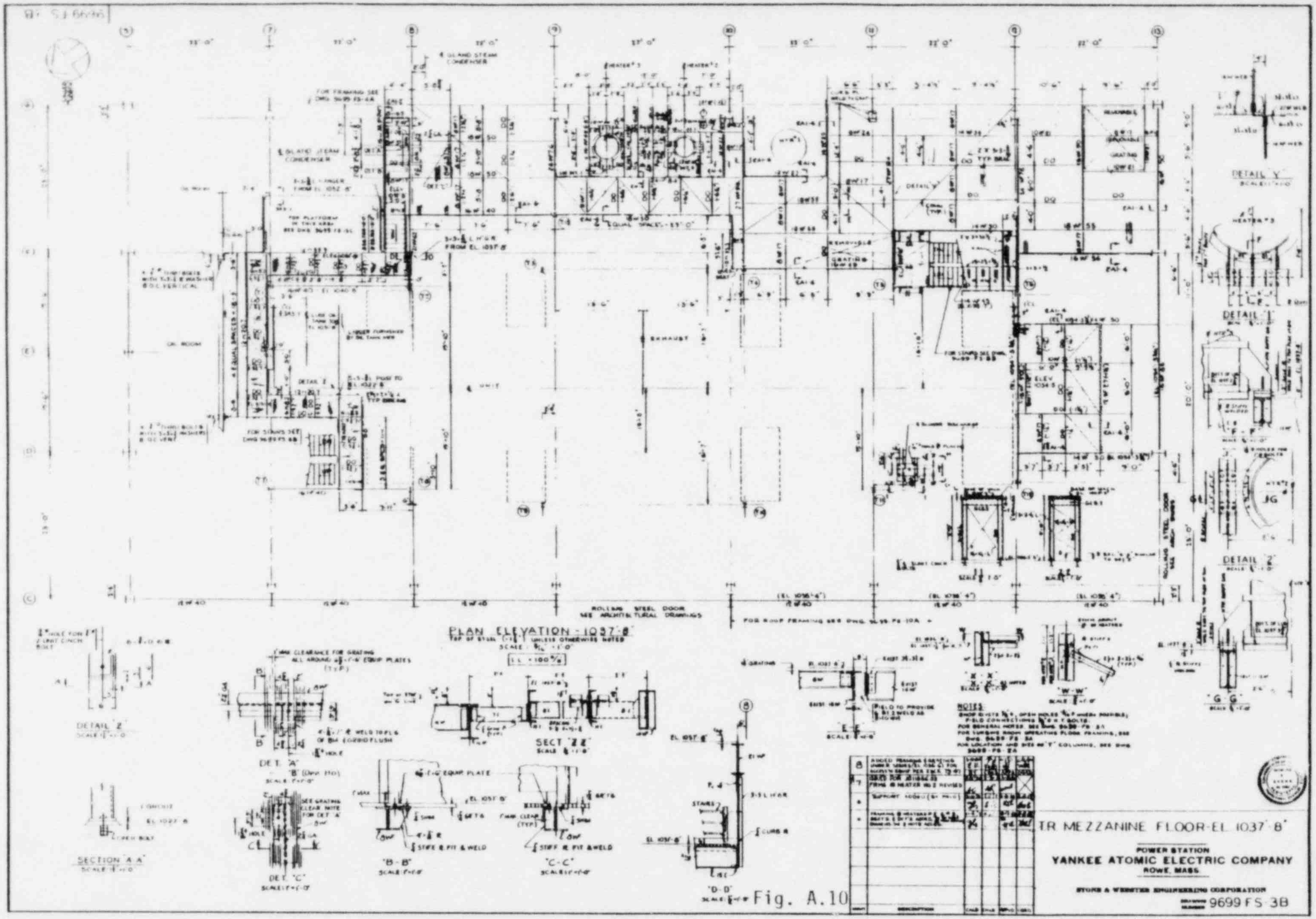


Fig. A.10

Yankee Atomic Electric Company
Turbine Building and Turbine Pedestal
80023; Report No. EY-YR-80023-9; Rev. 1

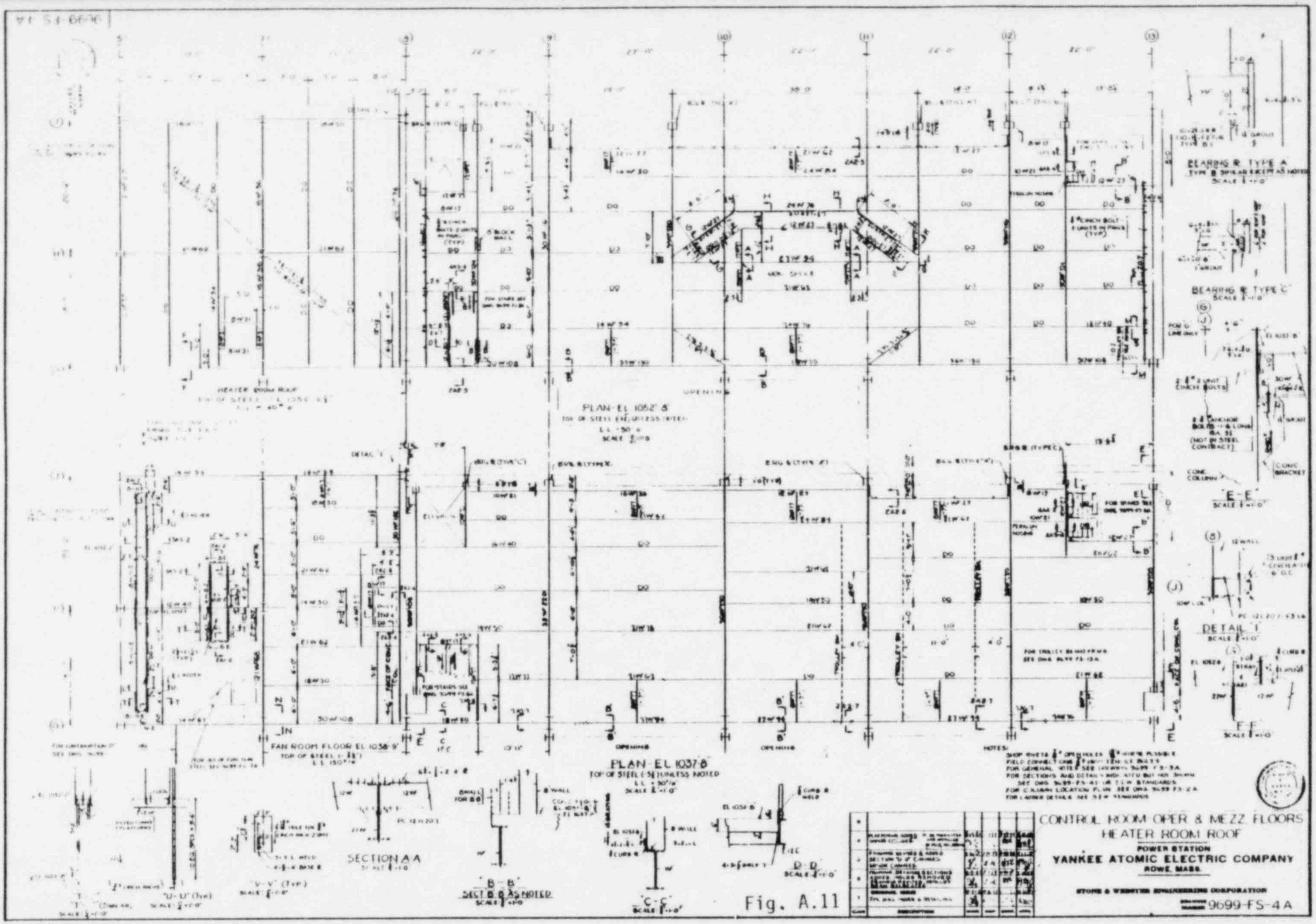


Fig. A.11

CYGNA

Yankee Atomic Electric Company
Turbine Building and Turbine Pedestal
80023; Report No. EY-YR-80023-9; Rev. 1

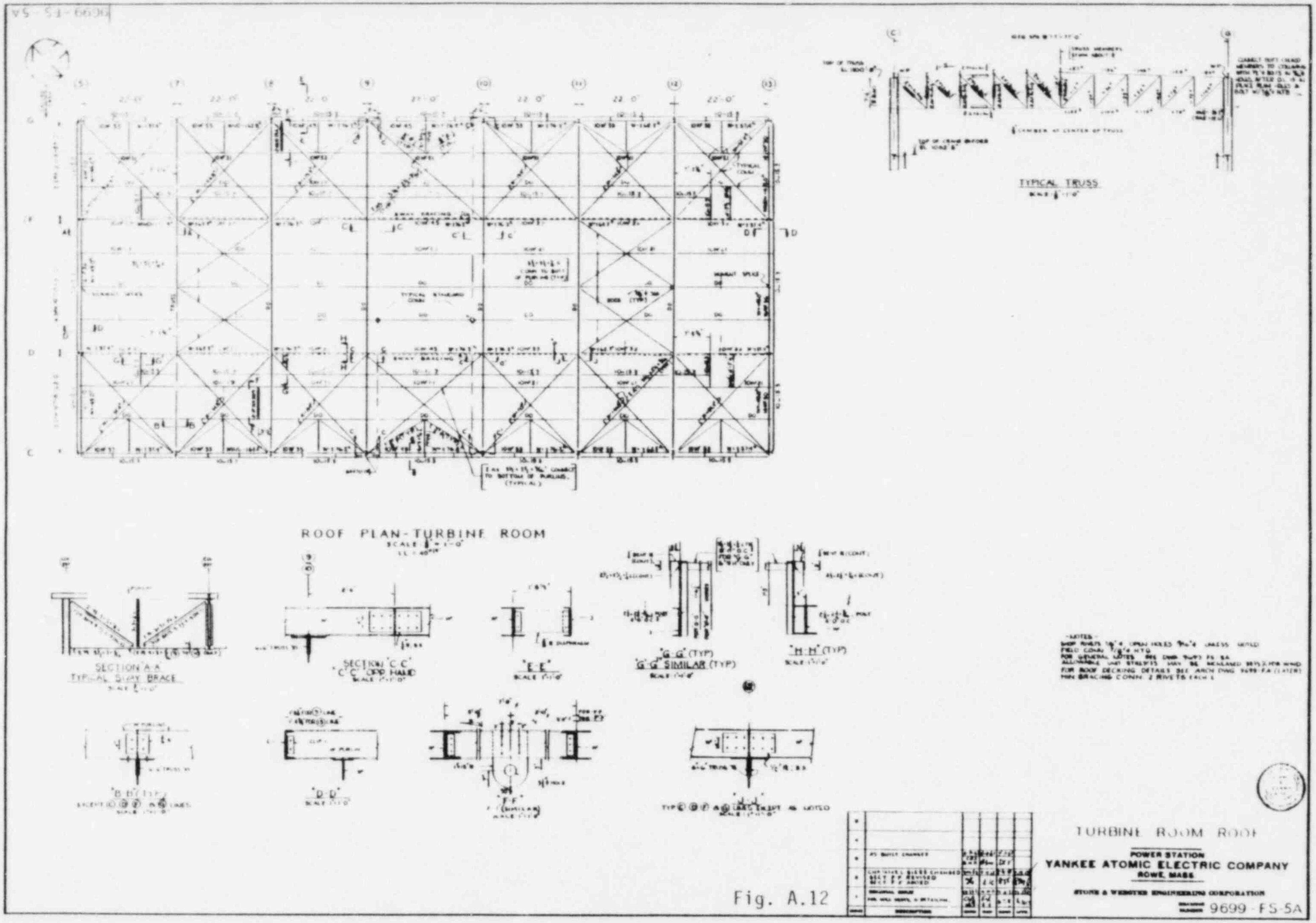

9699-FS-5A
TYPICAL TRUSS
ROOF PLAN-TURBINE ROOM
SECTION "A-A"
TYPICAL SWAY BRACE
SECTION "C-C"
"C'-C'" OPP HAND
"E-E"
"G-G" (TYP)
"G'-G'" SIMILAR (TYP)
"H-H" (TYP)
"B-B" (TYP)
"D-D"
"F-F"
TURBINE ROOM ROOF
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699-FS-5A

Fig. A.12

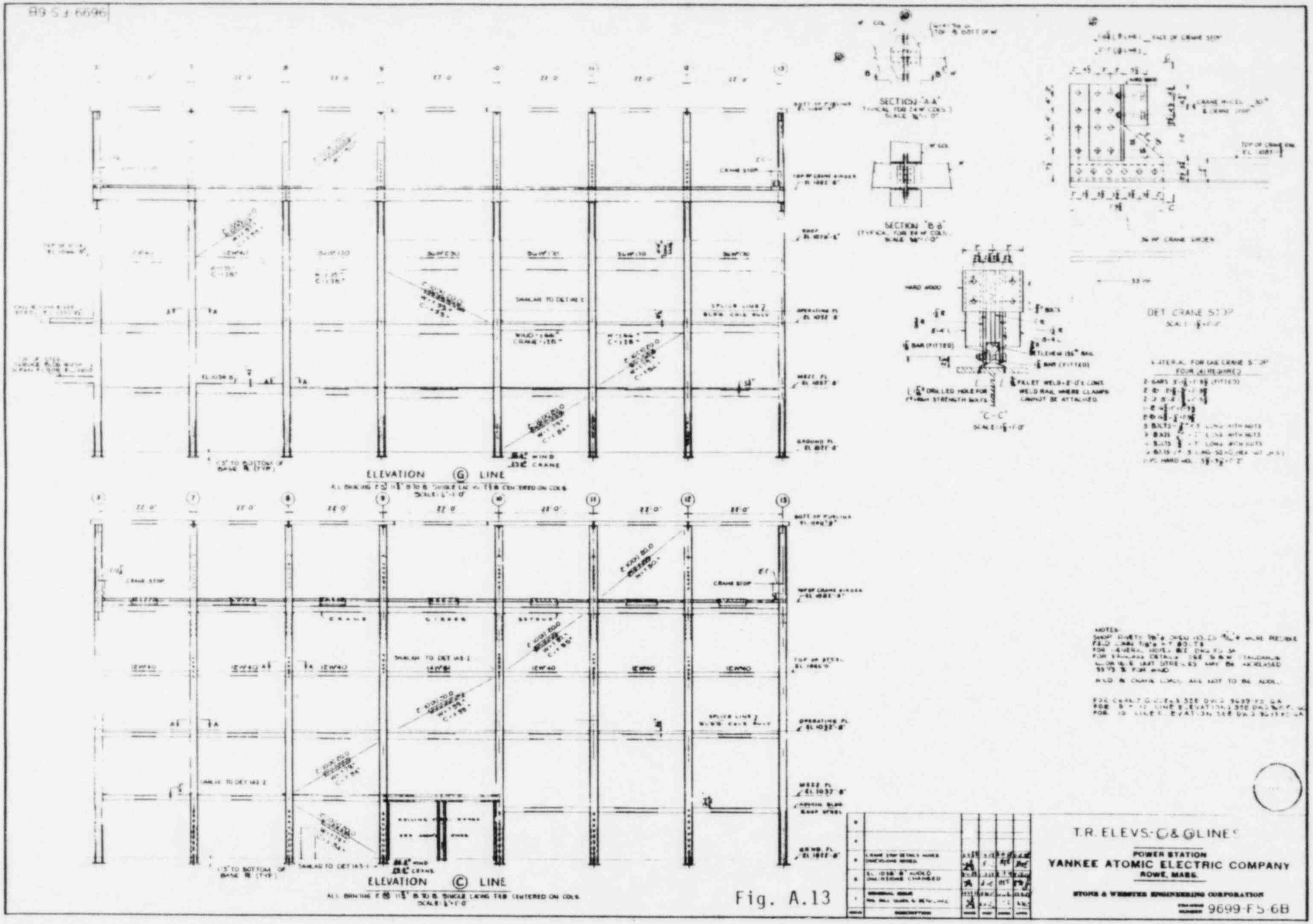

ELEVATION G LINE
ELEVATION C LINE
SECTION "A-A"
SECTION "B-B"
"C-C"
DET. CRANE STOP
CRANE STOP
T.R. ELEVS. C & G LINES
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699-FS-6B

Fig. A.13

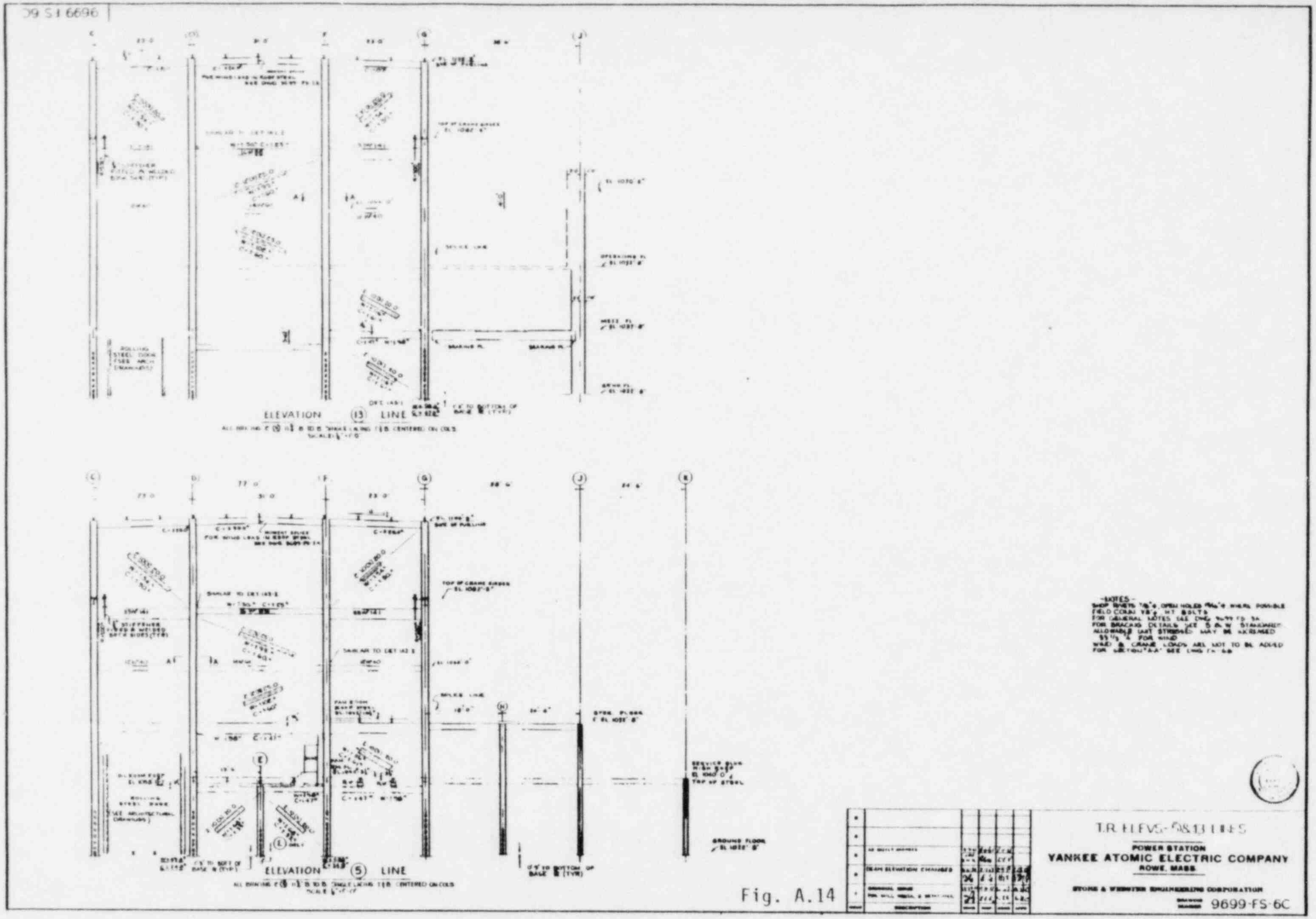
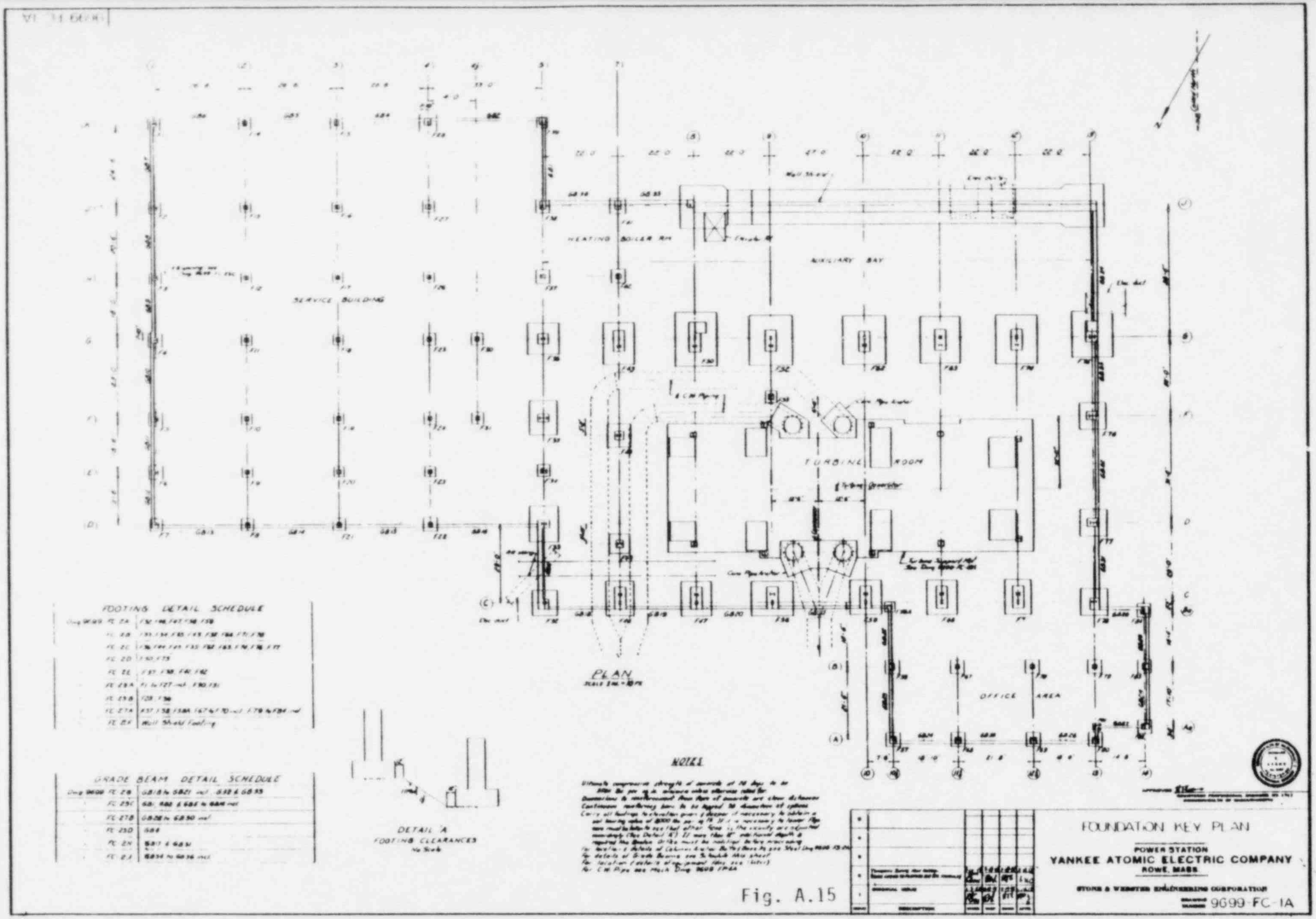
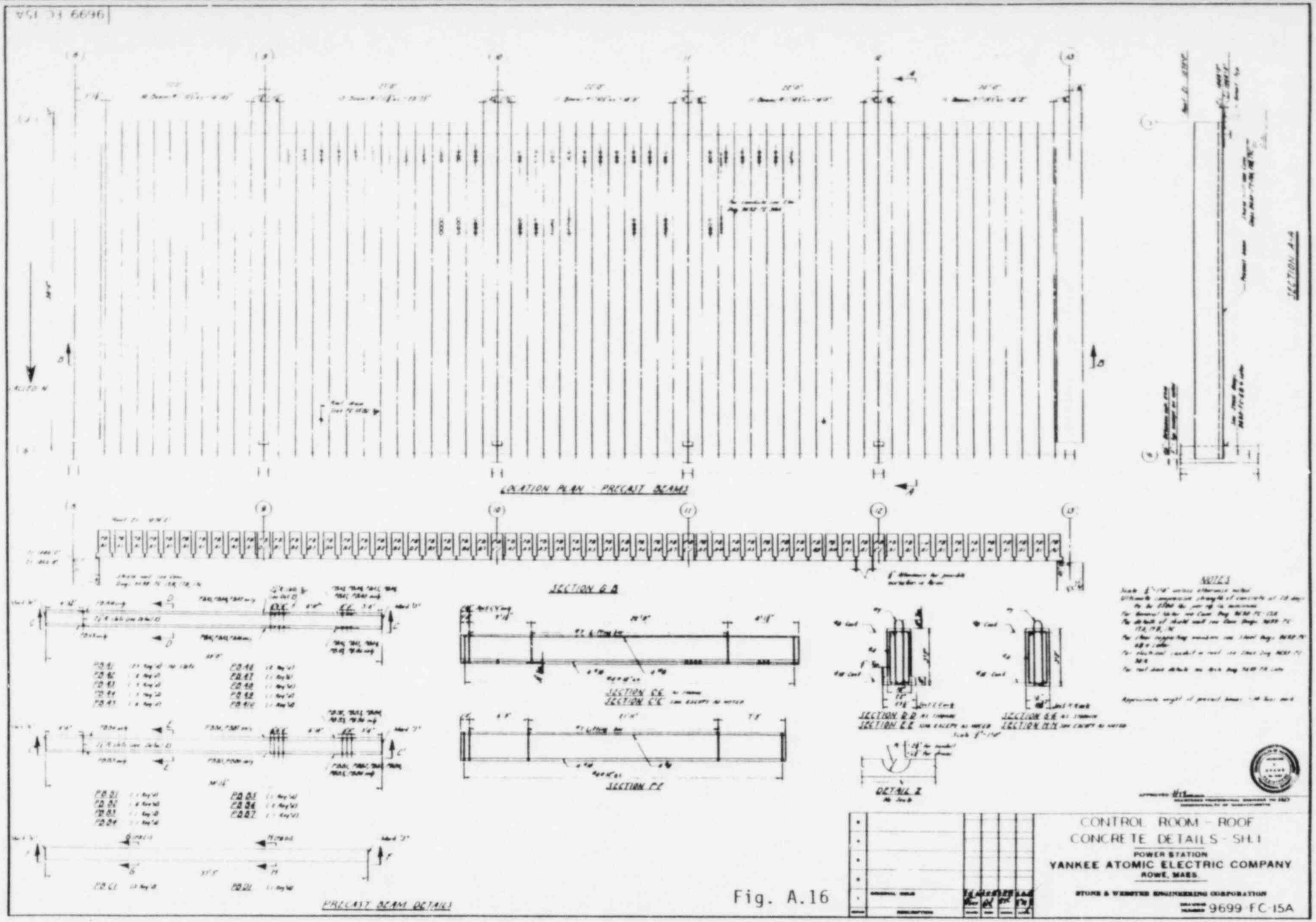

ELEVATION (13) LINE
ELEVATION (5) LINE
T.B. ELEVS-(5)&(13) LINES
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699-FS-6C

Fig. A.14



FOOTING DETAIL SCHEDULE
GRADE BEAM DETAIL SCHEDULE
SERVICE BUILDING
HEATING BOILER RM
AUXILIARY BAY
TURBINE ROOM
OFFICE AREA
PLAN
DETAIL A
FOOTING CLEARANCES
NOTES
FOUNDATION KEY PLAN
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699-FC-1A

Fig. A.15



9699 FC 15A
LOCATION PLAN - PRECAST BEAMS
SECTION G-G
SECTION A-A
NOTES
SECTION C-C
SECTION F-F
SECTION D-D
SECTION E-E
DETAIL Z
PRECAST BEAM DETAILS
CONTROL ROOM - ROOF
CONCRETE DETAILS - SH.1
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699-FC-15A

Fig. A.16

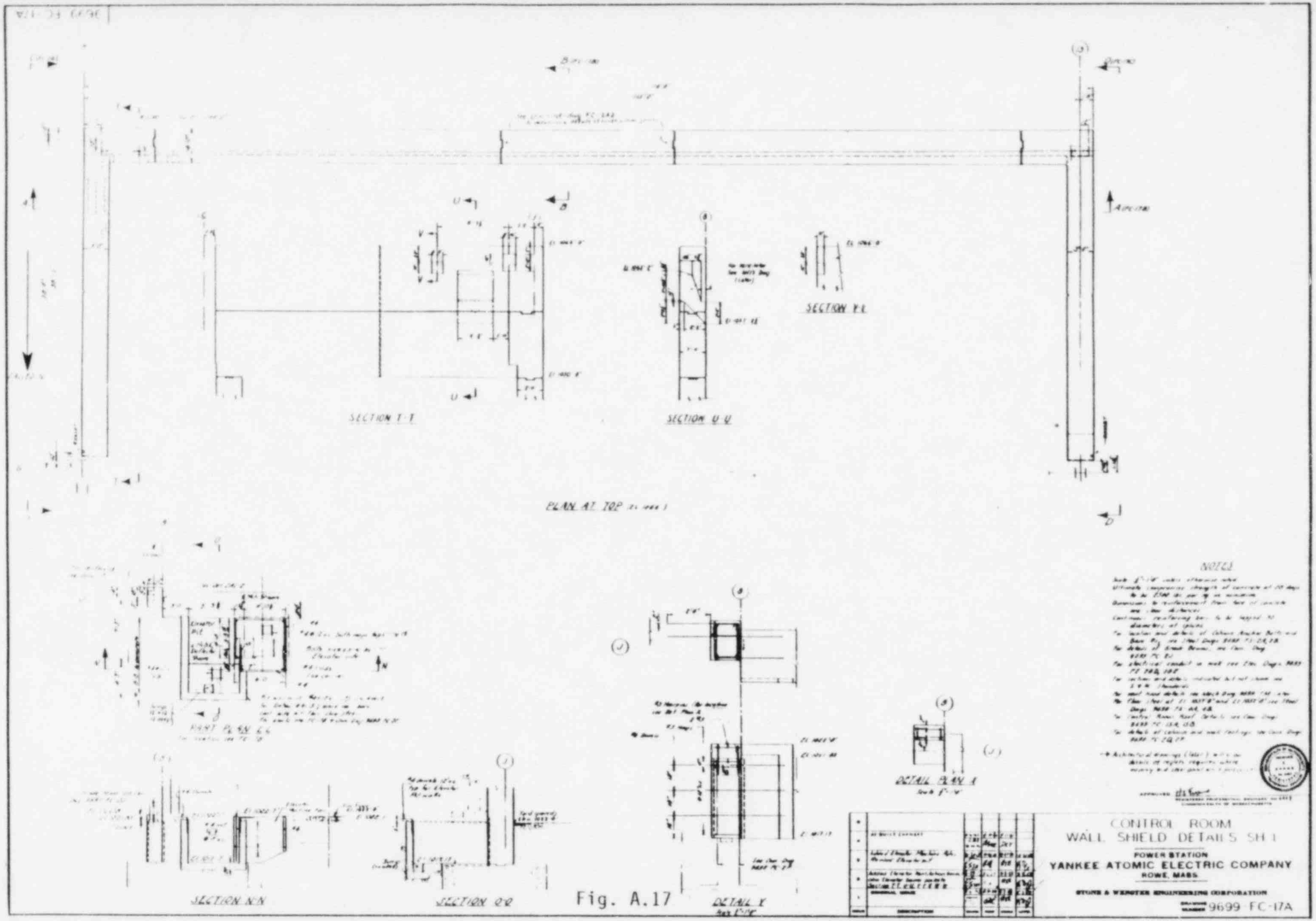

SECTION T-T
SECTION U-U
SECTION V-V
PLAN AT TOP
NOTES
PART PLAN C-C
SECTION N-N
SECTION O-O
DETAIL Y
DETAIL PLAN A
CONTROL ROOM
WALL SHIELD DETAILS SH 1
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699-FC-17A

Fig. A.17

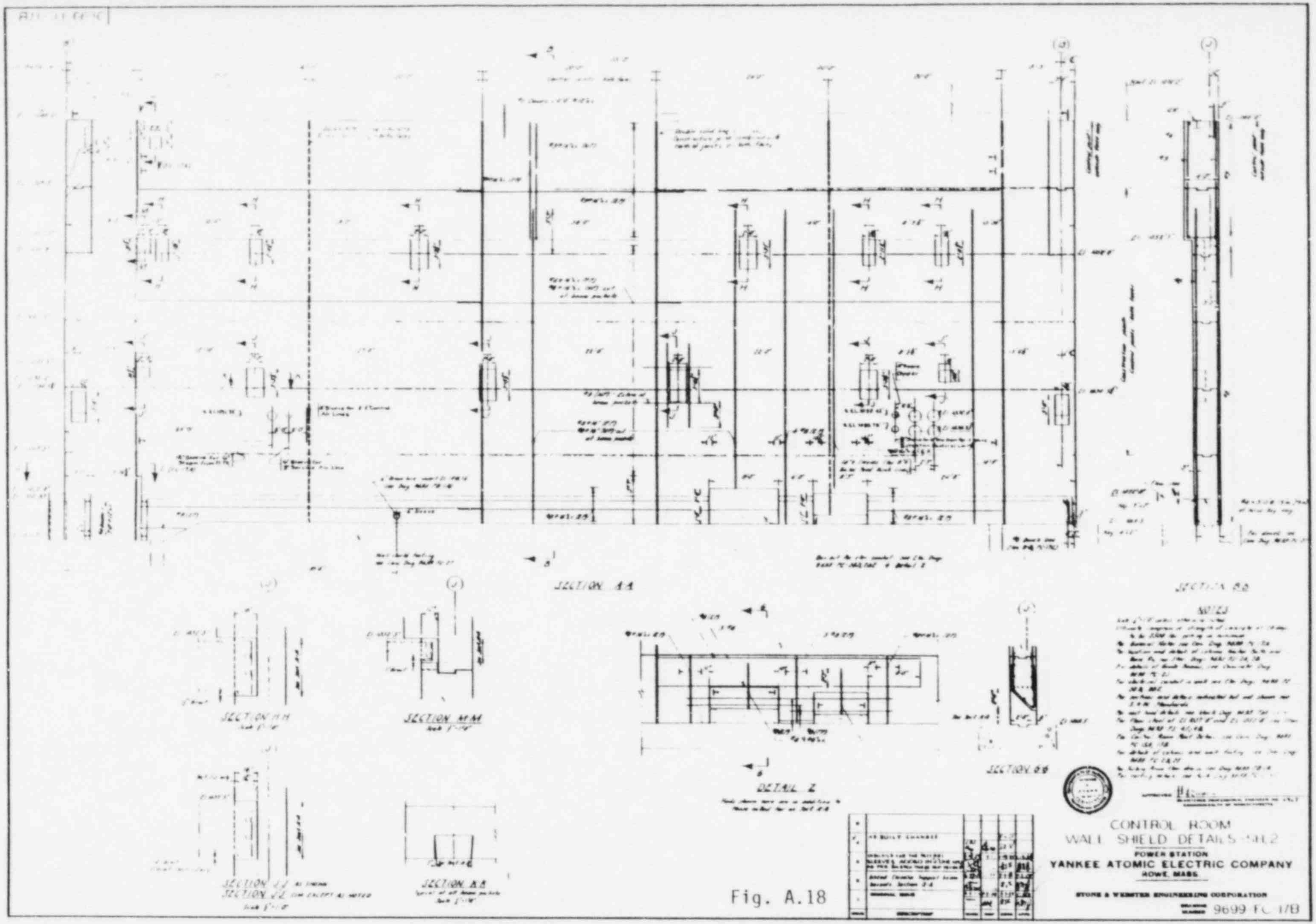
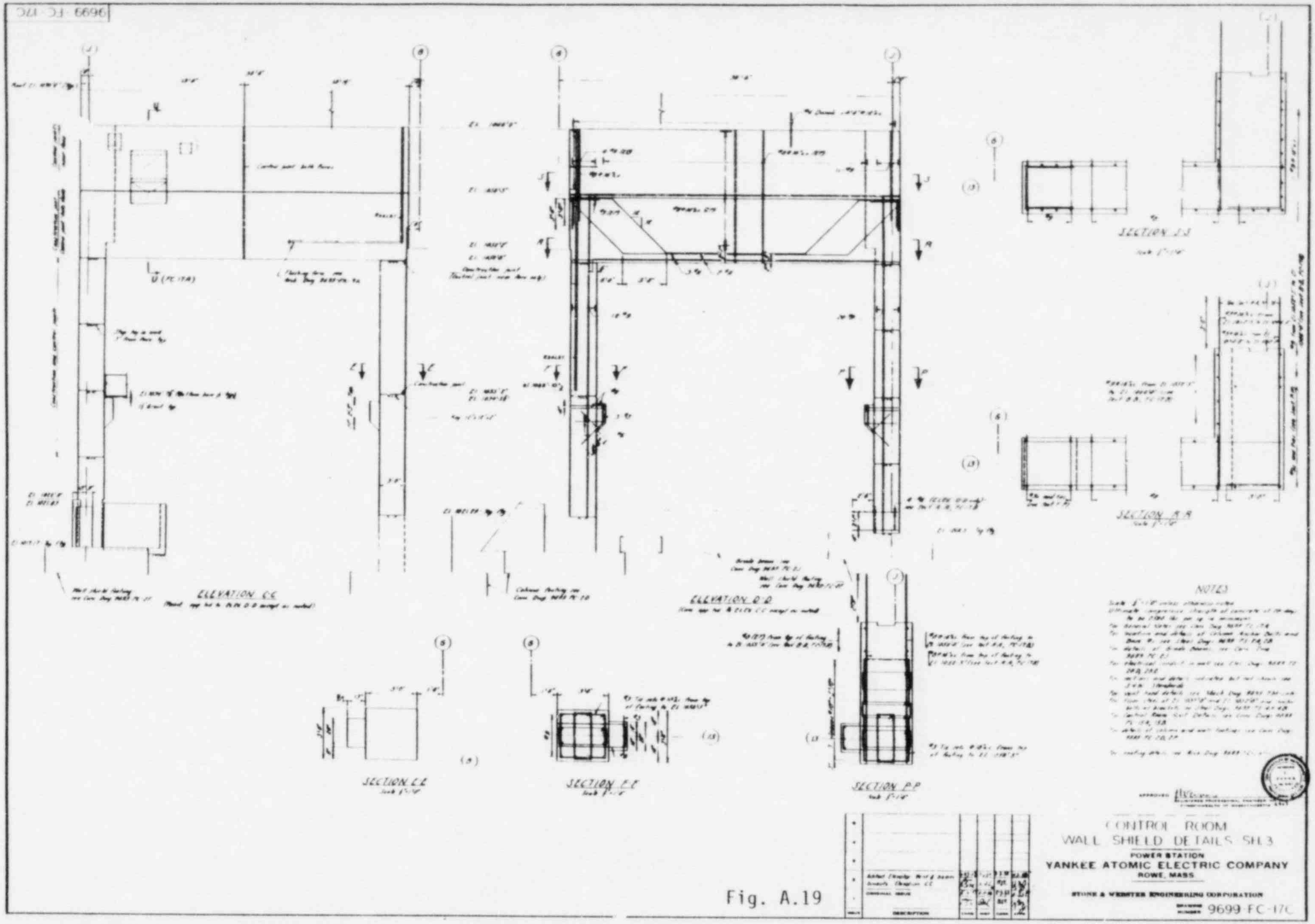

SECTION A-A
SECTION B-B
NOTES
SECTION H-H
SECTION M-M
DETAIL Z
SECTION G-G
SECTION J-J
SECTION K-K
CONTROL ROOM
WALL SHIELD DETAILS SH.2
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699 FC 17B

Fig. A.18



ELEVATION C-C
ELEVATION D-D
SECTION J-J
SECTION R-R
SECTION C-C
SECTION F-F
SECTION P-P
NOTES
CONTROL ROOM
WALL SHIELD DETAILS SH.3
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699-FC-17C

Fig. A.19

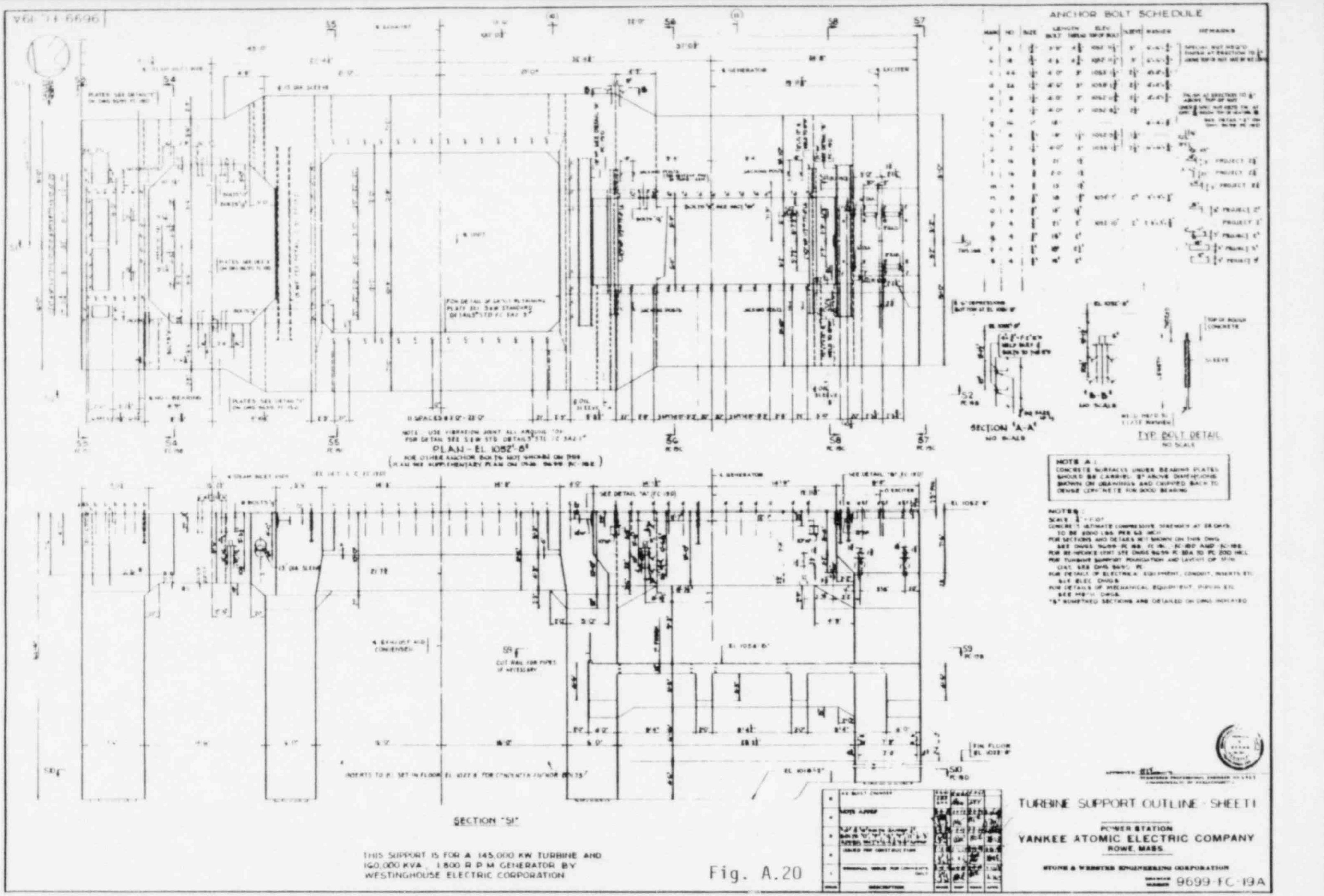


Fig. A.20

Yankee Atomic Electric Company
Turbine Building and Turbine Pedestal
80023; Report No. EY-YR-80023-9; Rev. 1

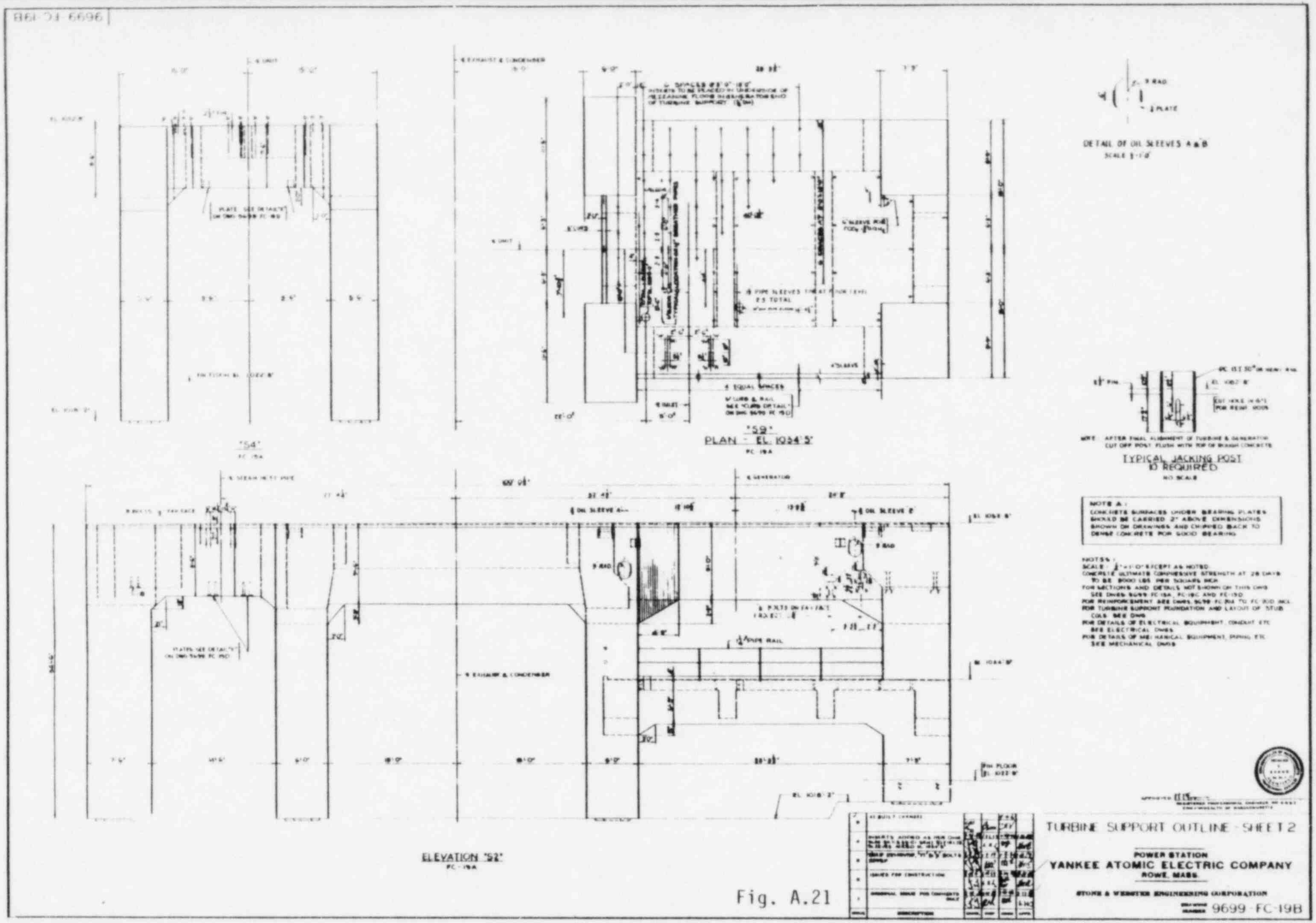

"54"
FC-19A
"59"
PLAN - EL. 1034'-5"
FC-19A
DETAIL OF OIL SLEEVES A & B
TYPICAL JACKING POST
10 REQUIRED
NO SCALE
ELEVATION "52"
FC-19A
TURBINE SUPPORT OUTLINE - SHEET 2
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699-FC-19B

Fig. A.21

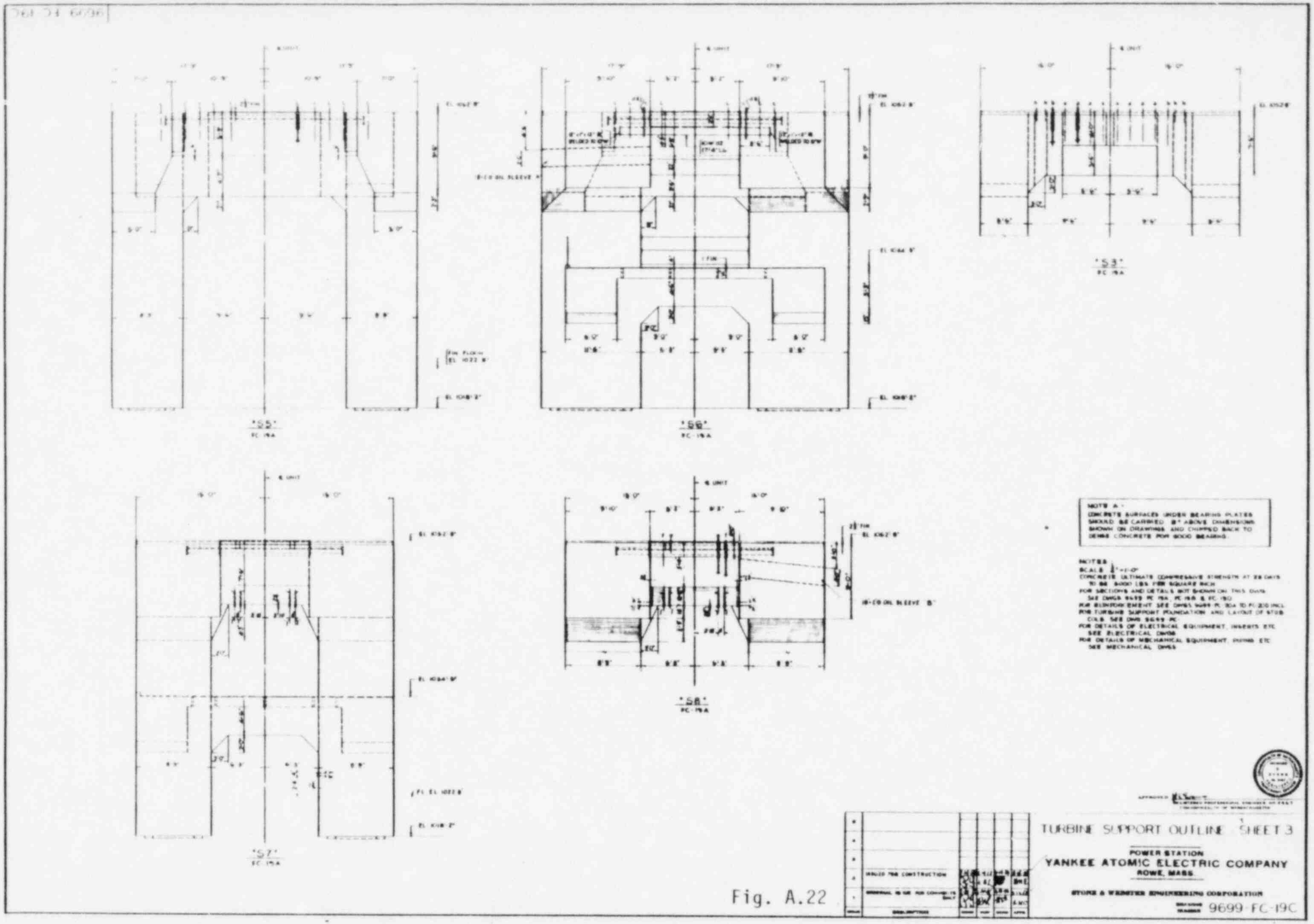
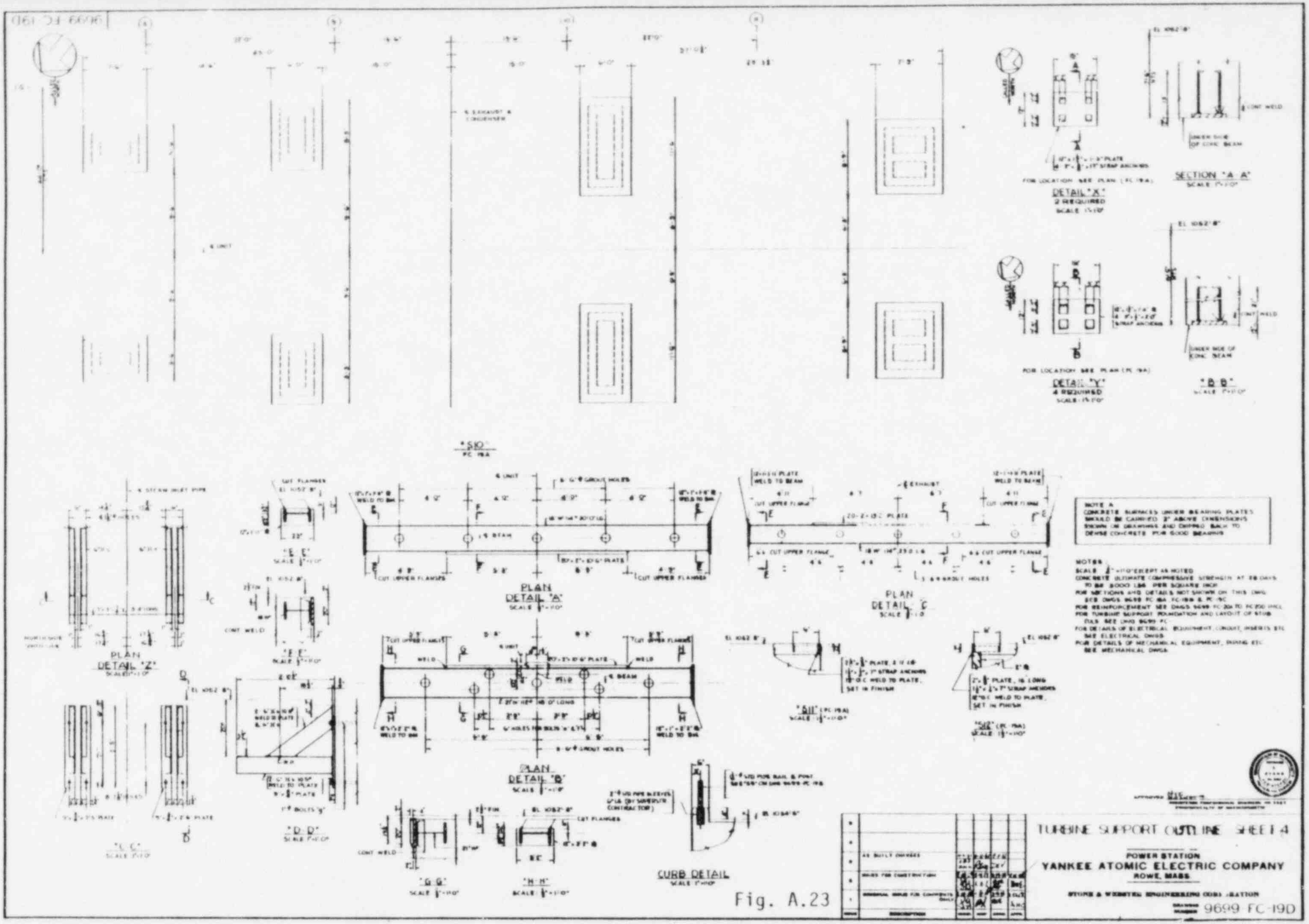
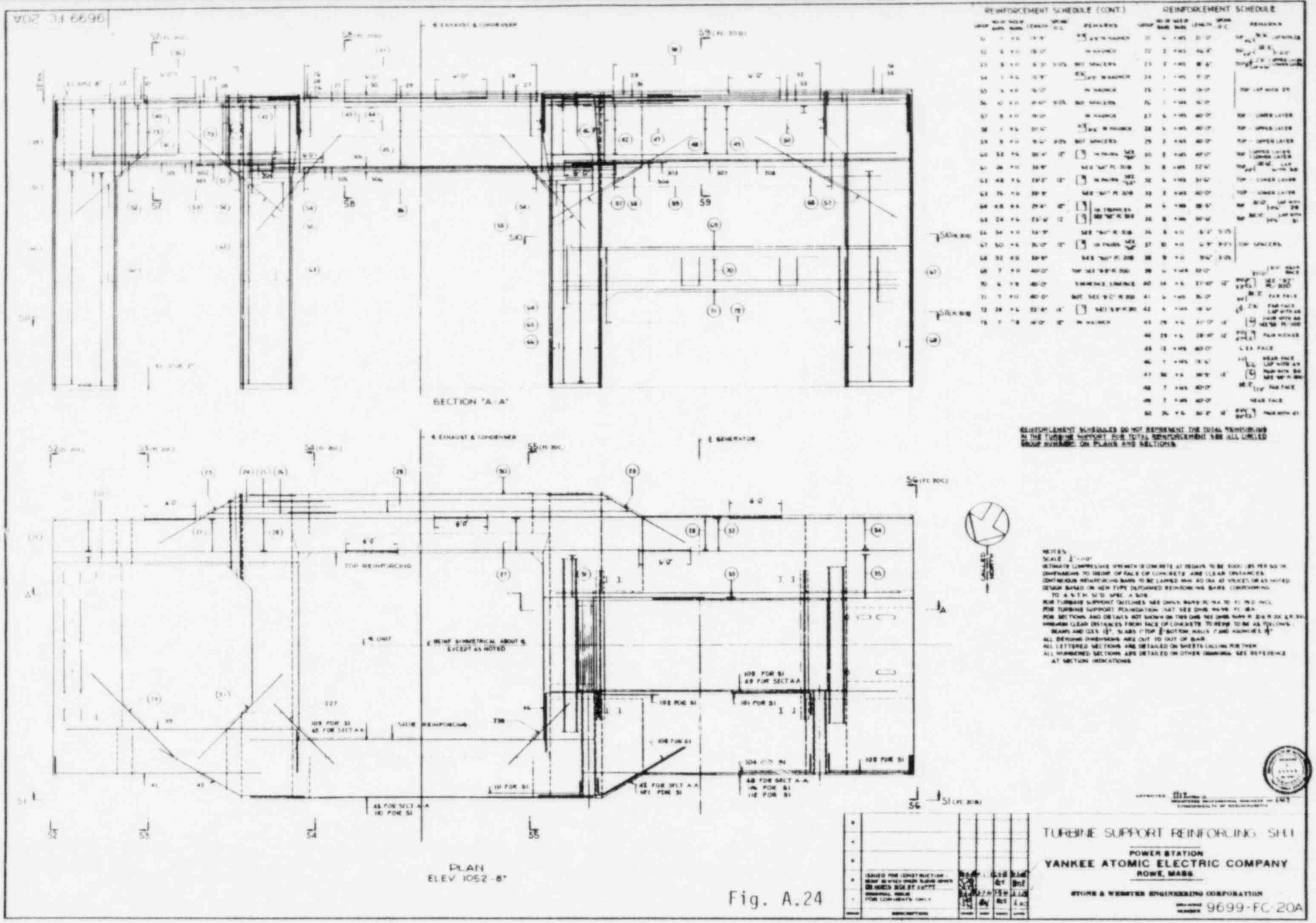

"S5"
"S6"
"S3"
"S7"
"S8"
TURBINE SUPPORT OUTLINE SHEET 3
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699-FC-19C

Fig. A.22



TURBINE SUPPORT OUTLINE SHEET 4
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
9699 FC-19D
PLAN DETAIL "A"
PLAN DETAIL "B"
PLAN DETAIL "C"
PLAN DETAIL "Z"
DETAIL "X"
DETAIL "Y"
SECTION "A-A"
CURB DETAIL

Fig. A.23



REINFORCEMENT SCHEDULE (CONT.)
REINFORCEMENT SCHEDULE
SECTION "A-A"
PLAN
ELEV 1052-8"
REINFORCEMENT SCHEDULES DO NOT REPRESENT THE TOTAL REINFORCING IN THE TURBINE SUPPORT. FOR TOTAL REINFORCEMENT SEE ALL CIRCLED GROUP NUMBERS ON PLANS AND SECTIONS.
TURBINE SUPPORT REINFORCING SH 1
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699-FC-20A

Fig. A.24

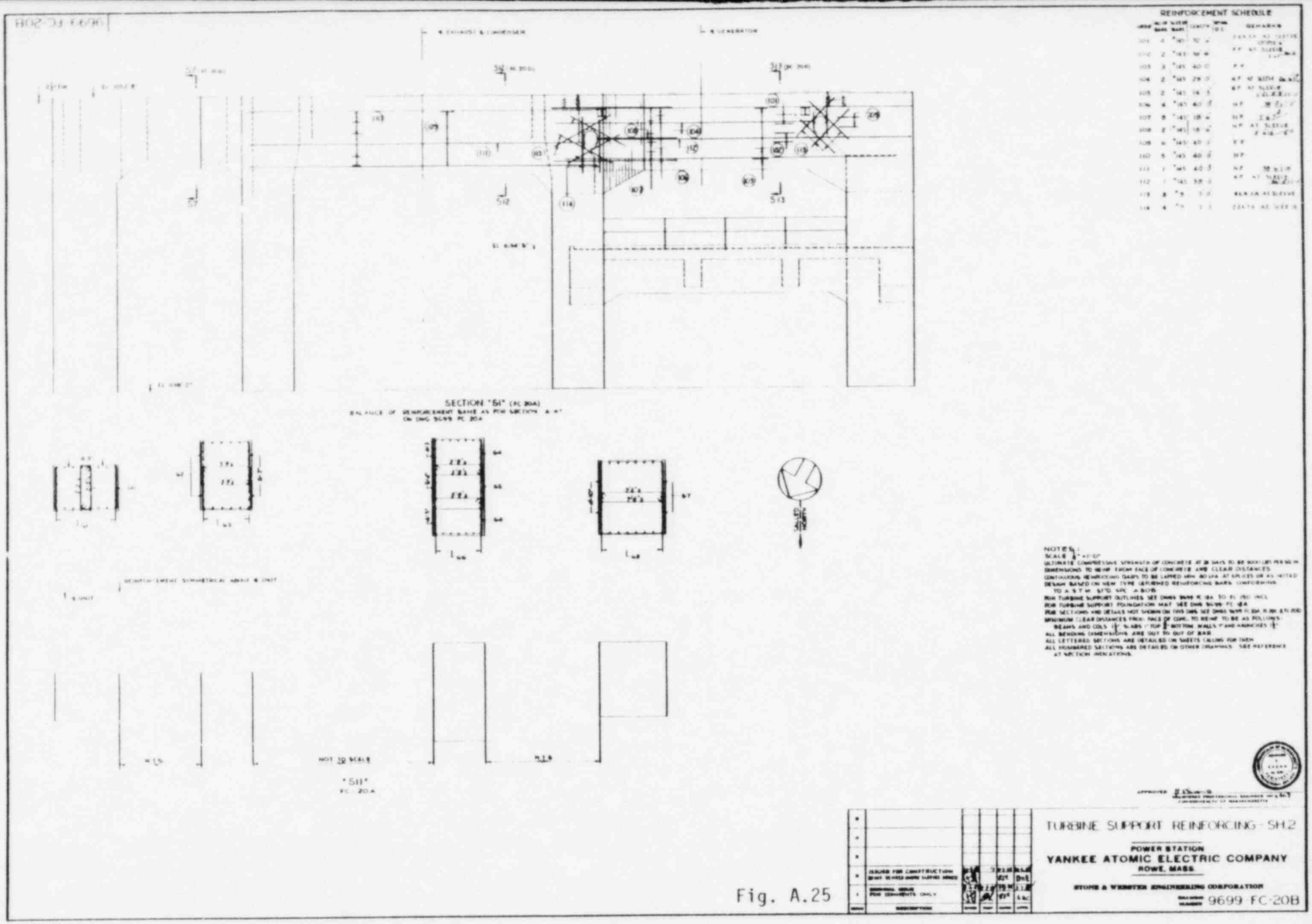

9699-FC-20B
REINFORCEMENT SCHEDULE
SECTION "S11" (FC 20A)
NOTES:
NOT TO SCALE
"S11"
FC-20A
TURBINE SUPPORT REINFORCING - SH.2
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699-FC-20B

Fig. A.25

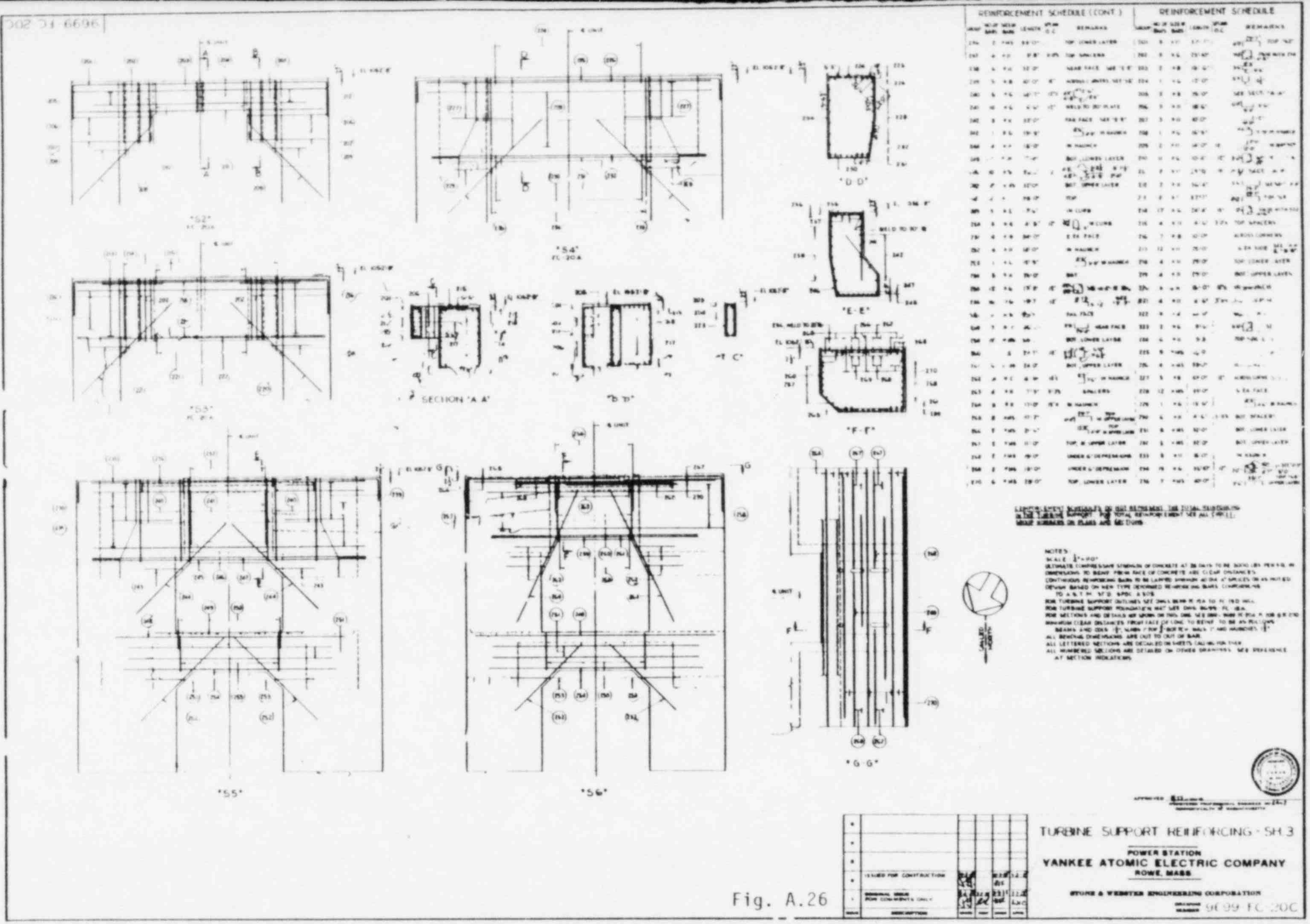
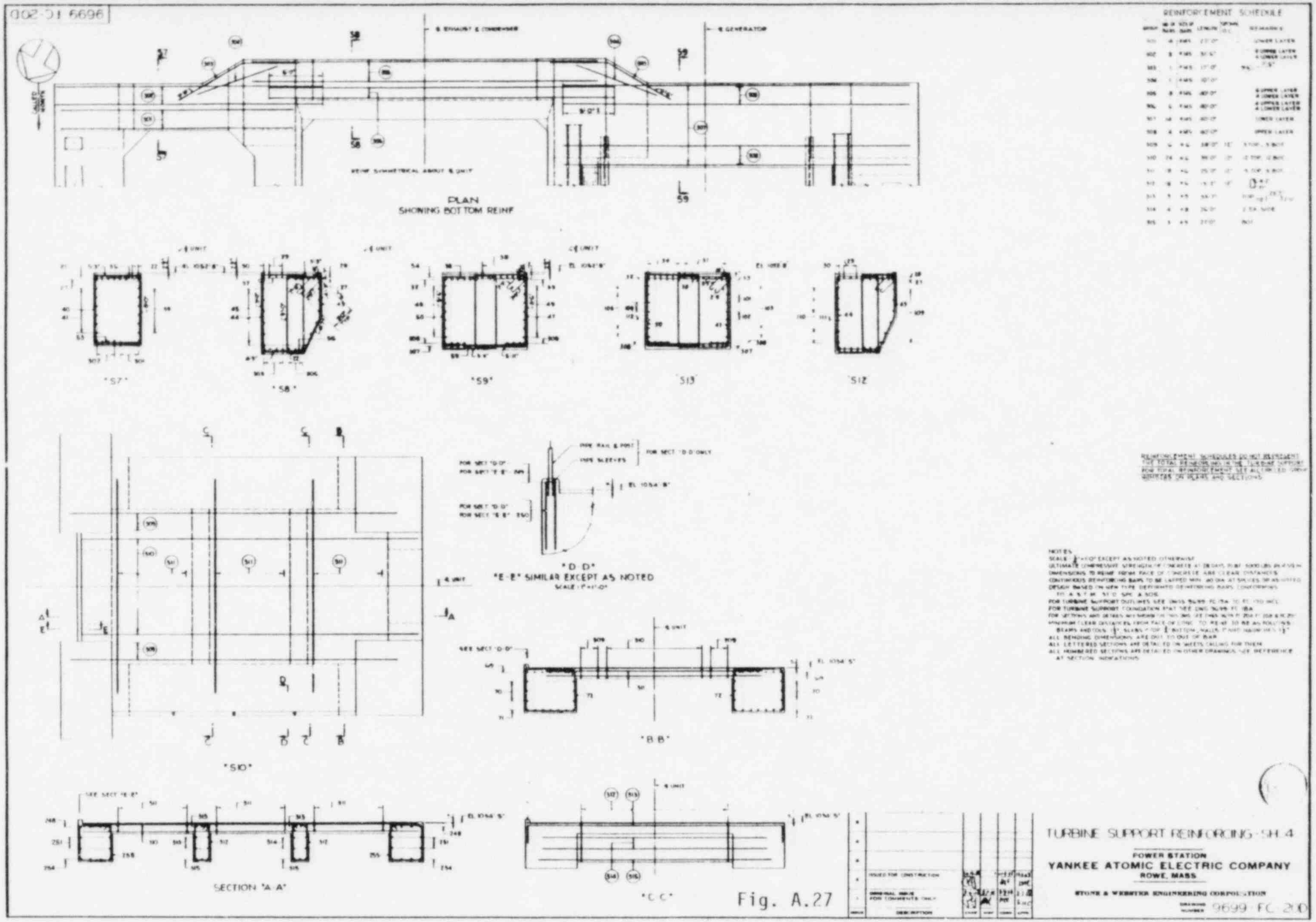

9699-FC-20C
REINFORCEMENT SCHEDULE (CONT.)
REINFORCEMENT SCHEDULE
"S2"
"S3"
"S4"
FC-20A
SECTION "A-A"
"B-B"
"C-C"
"D-D"
"E-E"
"F-F"
"G-G"
"S5"
"S6"
NOTES:
TURBINE SUPPORT REINFORCING - SH 3
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
ISSUED FOR CONSTRUCTION
9699-FC-20C

Fig. A.26


9699-FC-20D
REINFORCEMENT SCHEDULE
PLAN
SHOWING BOTTOM REINF
"S7"
"S8"
"S9"
"S13"
"S12"
"D-D"
"E-E" SIMILAR EXCEPT AS NOTED
"B-B"
"S10"
SECTION "A-A"
"C-C"
TURBINE SUPPORT REINFORCING-SH.4
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
9699-FC-20D
Fig. A.27

APPENDIX B

COMPUTER MODELS

APPENDIX B

LIST OF FIGURES

I. HORIZONTAL MODELS

I.1 Turbine Building

I.2 Turbine Pedestal

II. VERTICAL MODELS

II.1 Turbine Building

II.2 Turbine Pedestal

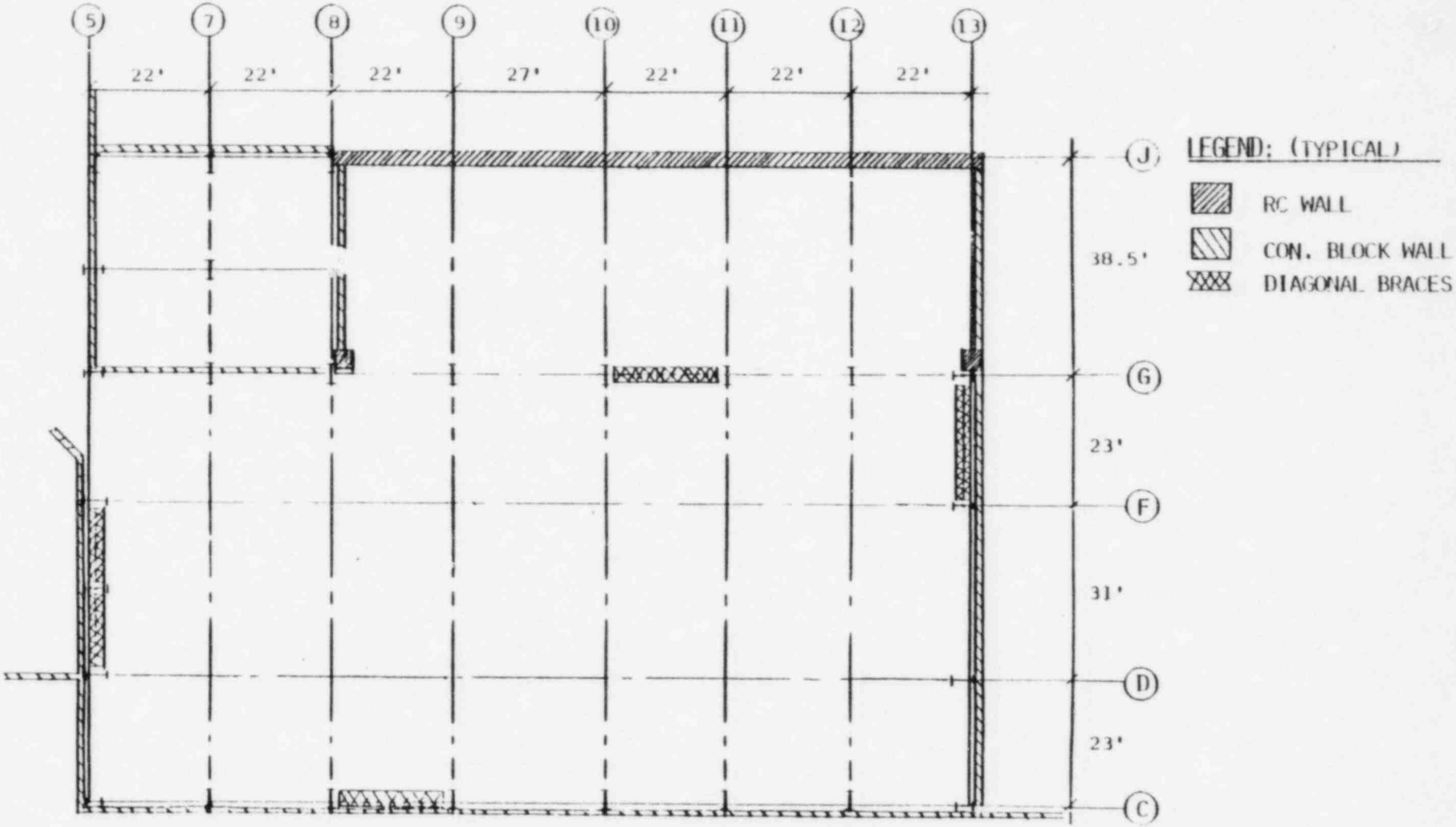
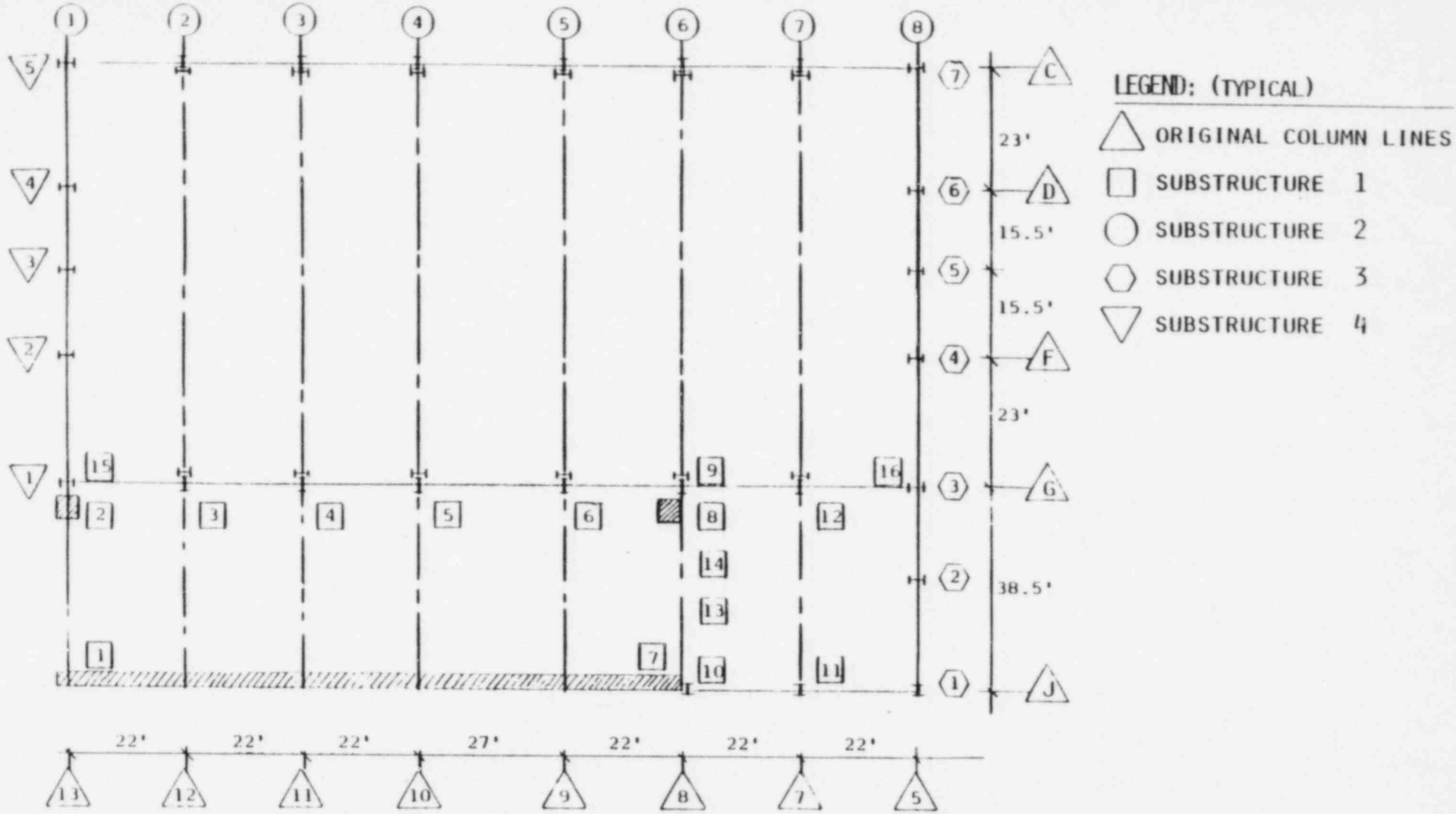


FIG. B.1 GENERAL LAYOUT PLAN
TURBINE BUILDING



PLAN VIEW

FIG. B.2 SUBSTRUCTURE MODELING
TURBINE BUILDING

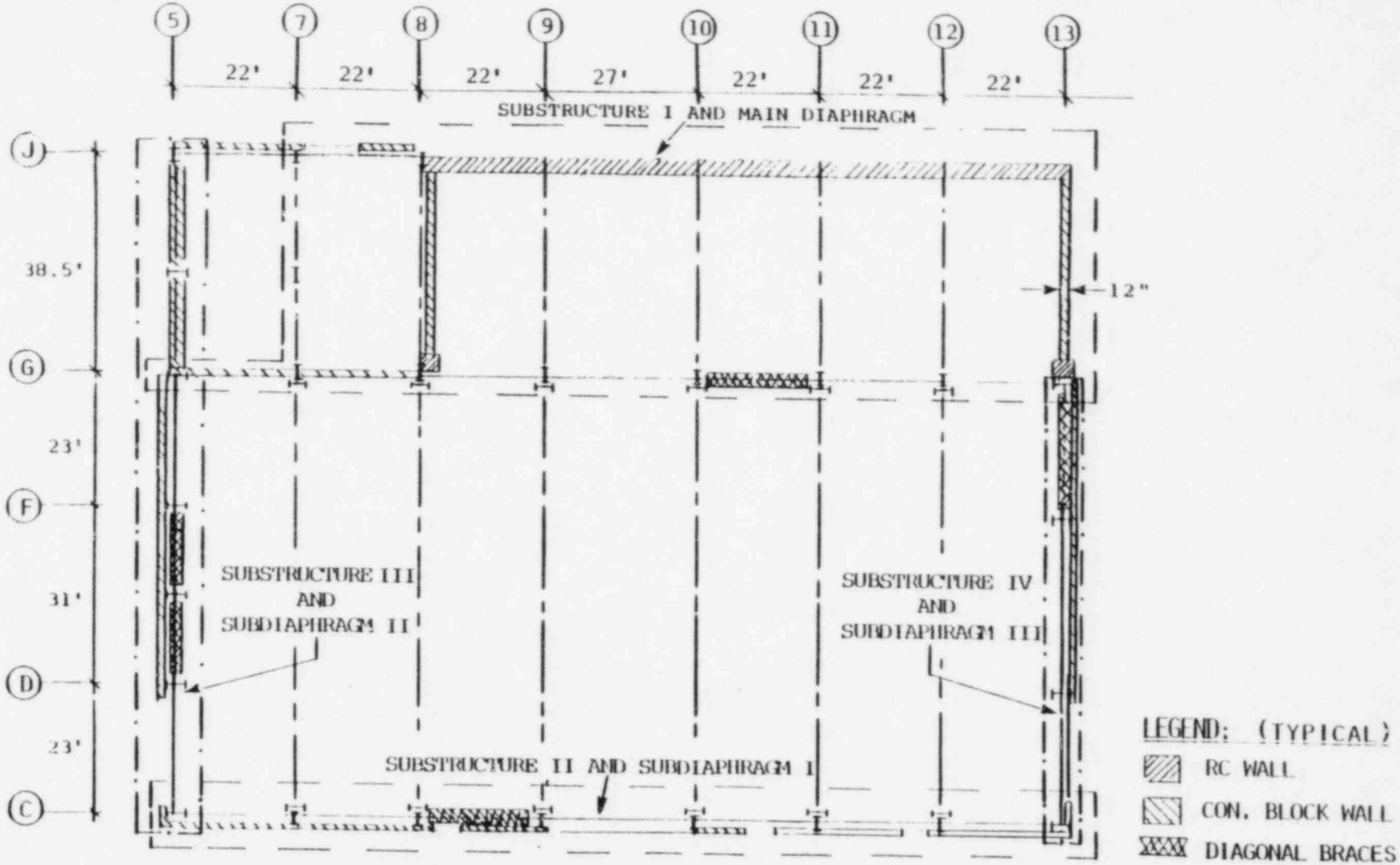


FIG. B.3 SUBSTRUCTURES AT ELEVATION 1037'-8"
TURBINE BUILDING

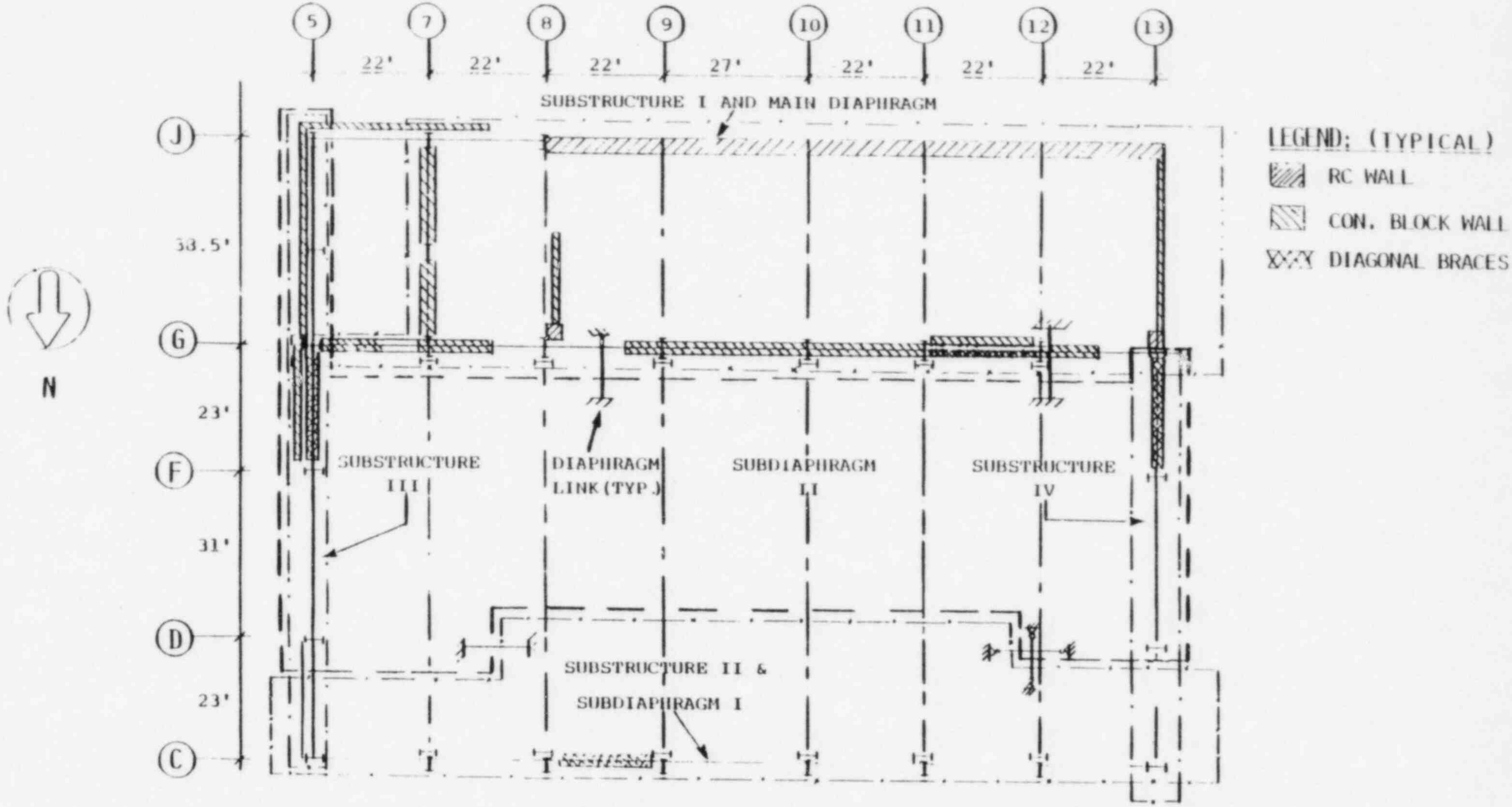


FIG. B.4 INTERCONNECTED FLOOR DIAPHRAGMS AT ELEVATION 1052'-8"

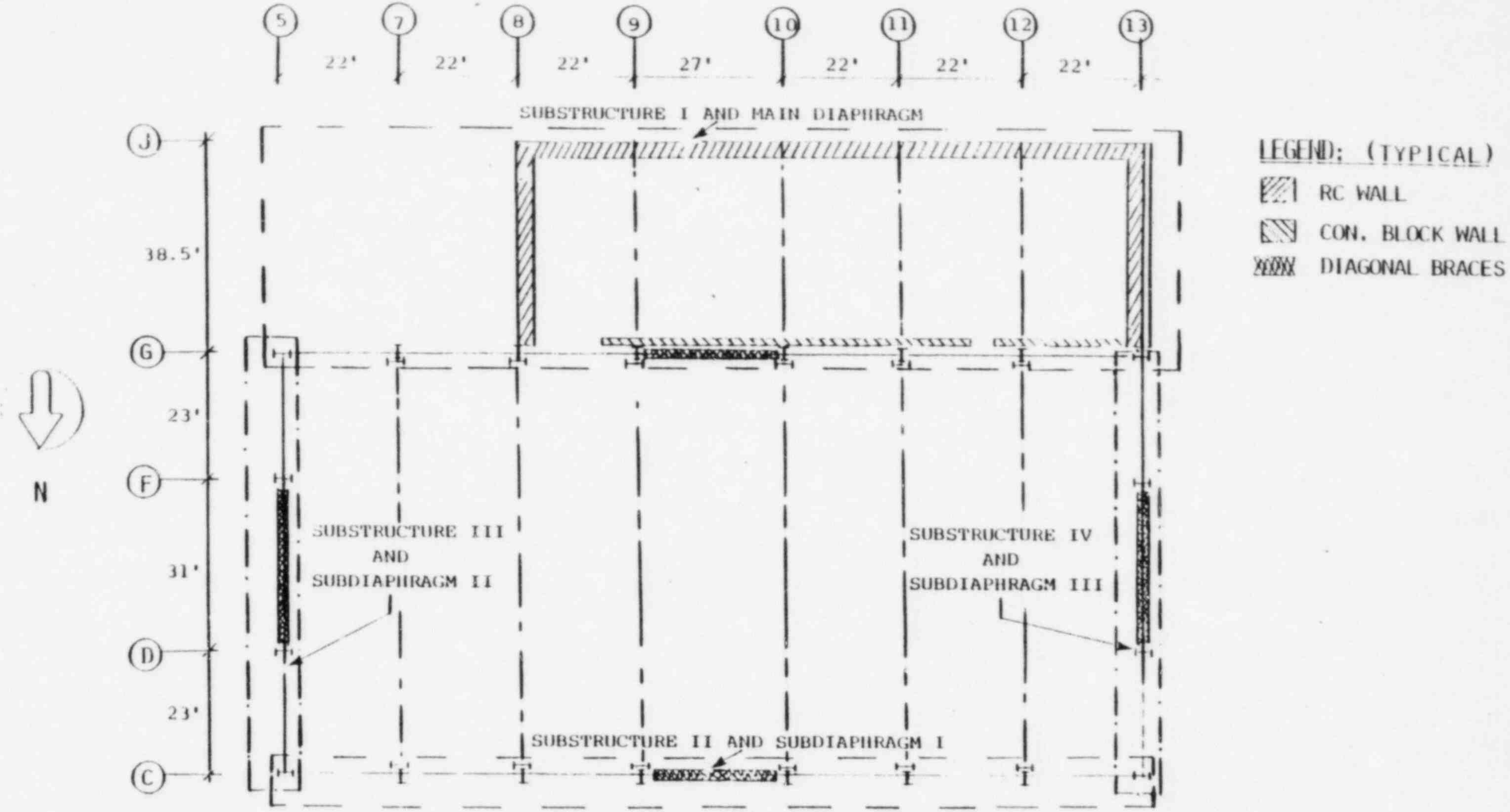


FIG. B.5 SUBSTRUCTURES AT ELEVATION 1066'-0"
TURBINE BUILDING

LEGEND: (TYPICAL)

XXXX DIAGONAL BRACES

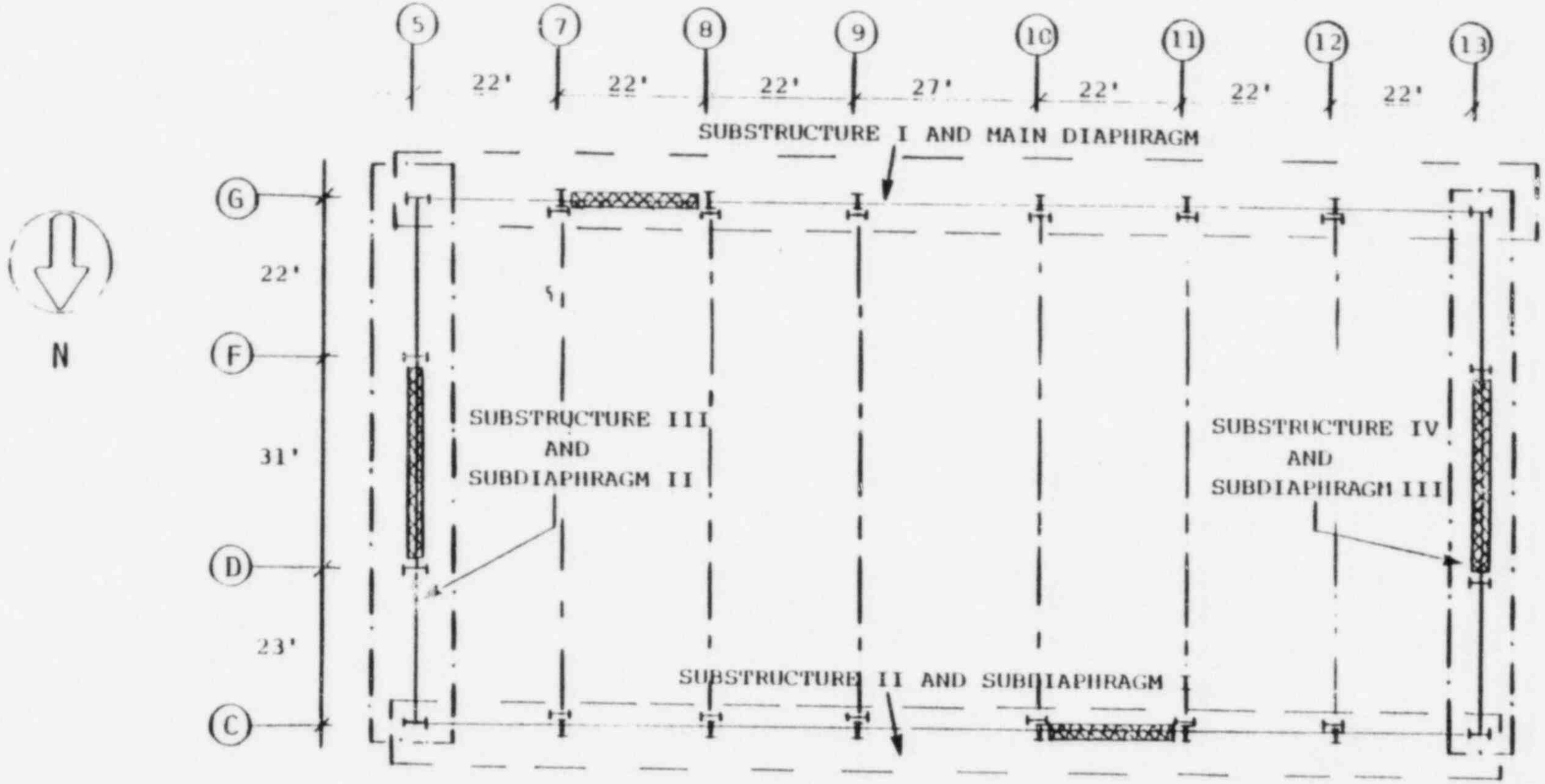


FIG. B.6 SUBSTRUCTURES AT ELEVATION 1082'-8"
TURBINE BUILDING

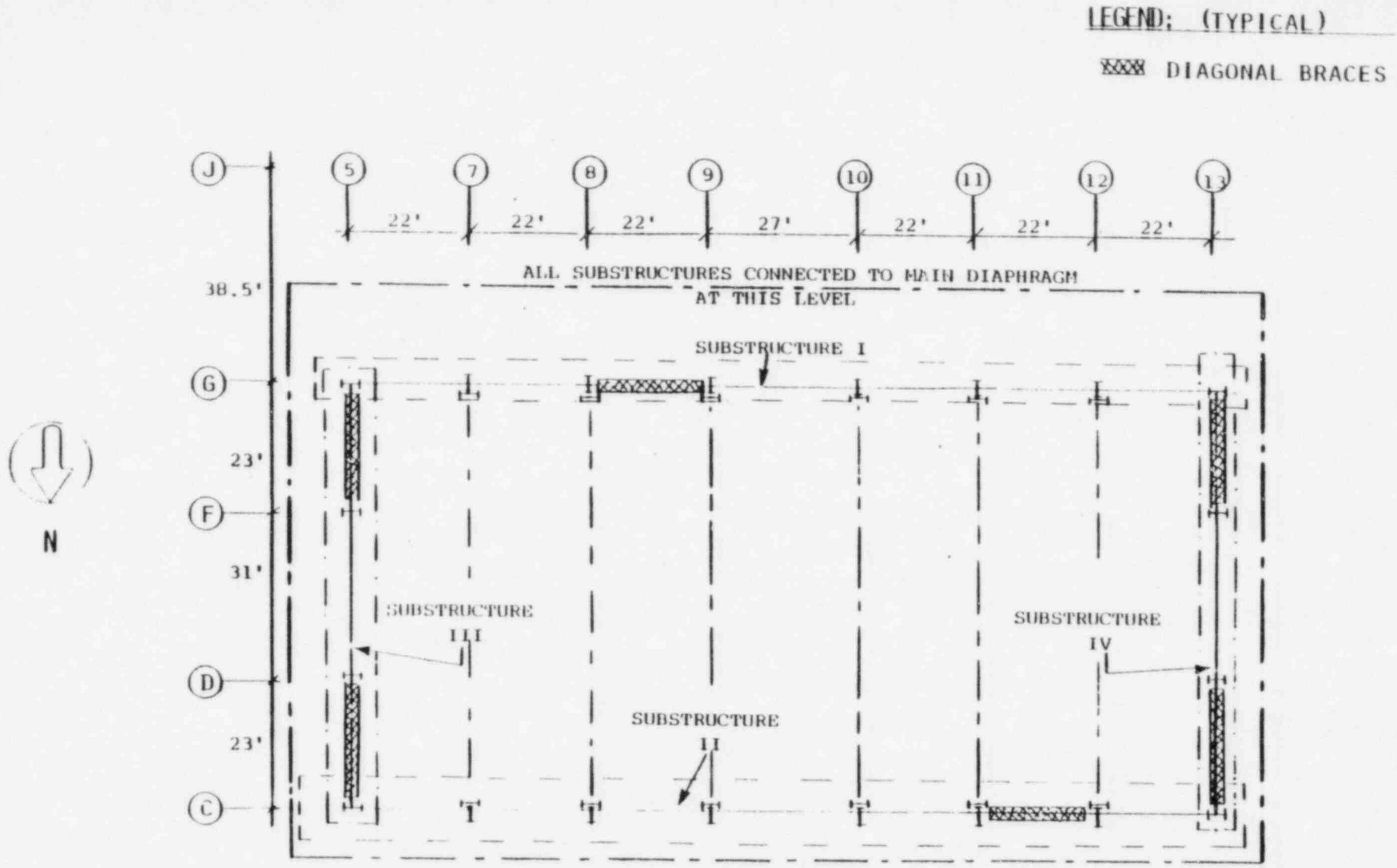
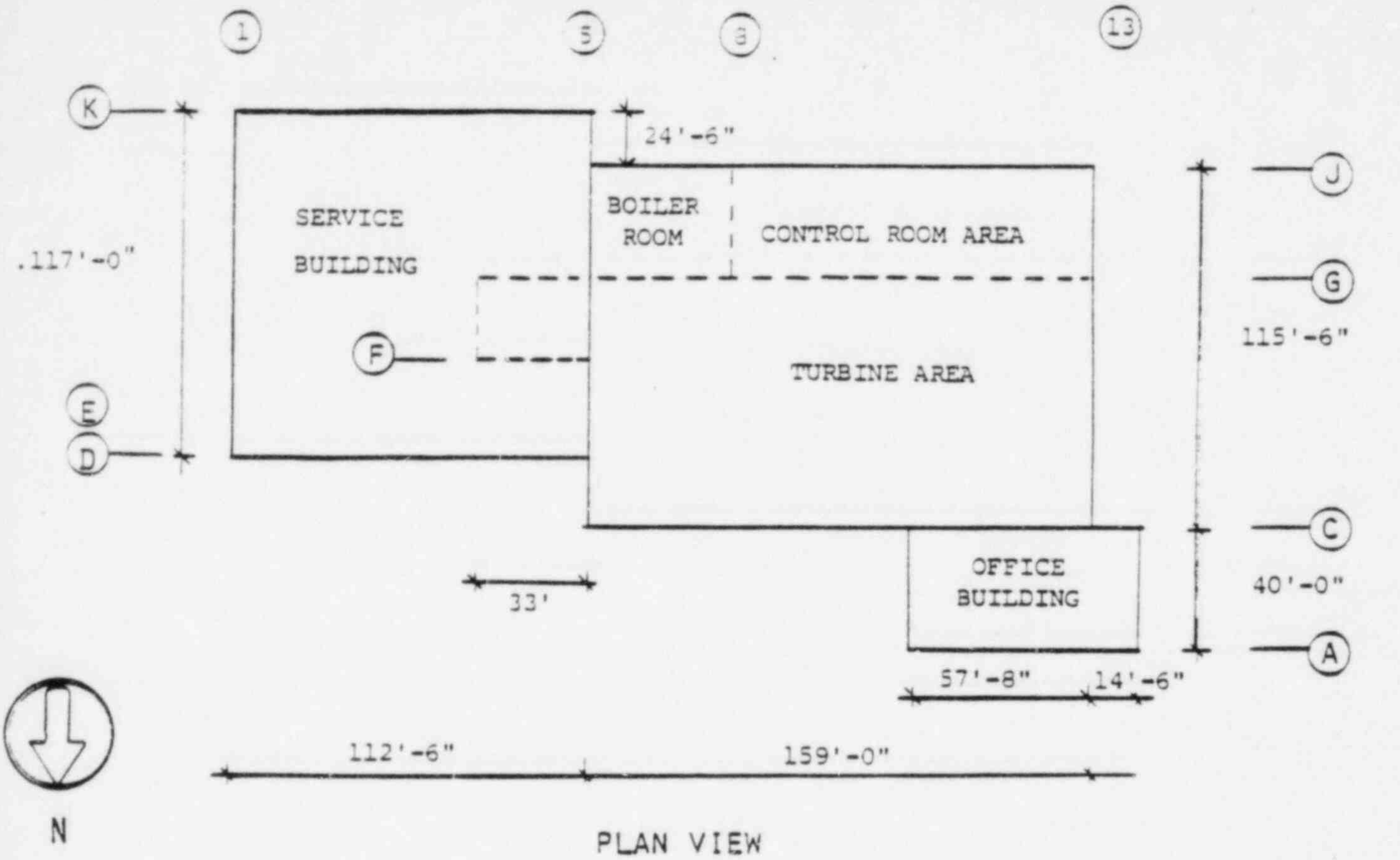
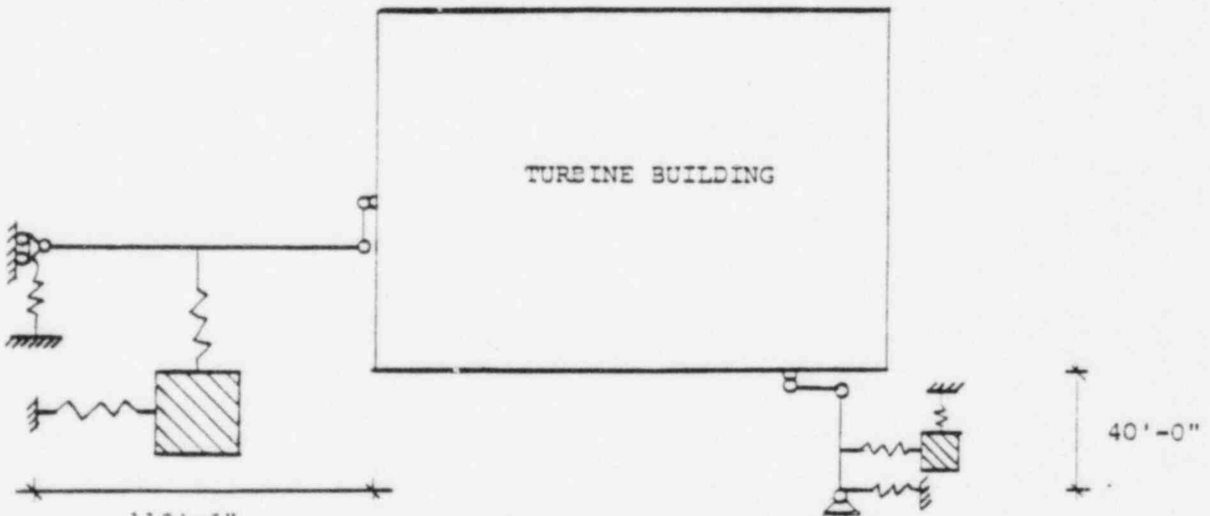


FIG. B.7 SUBSTRUCTURES AT ELEVATION 1096'
TURBINE BUILDING



PLAN VIEW

ARRANGEMENT OF ATTACHED BUILDINGS



PLAN VIEW

EQUIVALENT MODELING

FIG. B.8 MODELING OF ATTACHED BUILDINGS

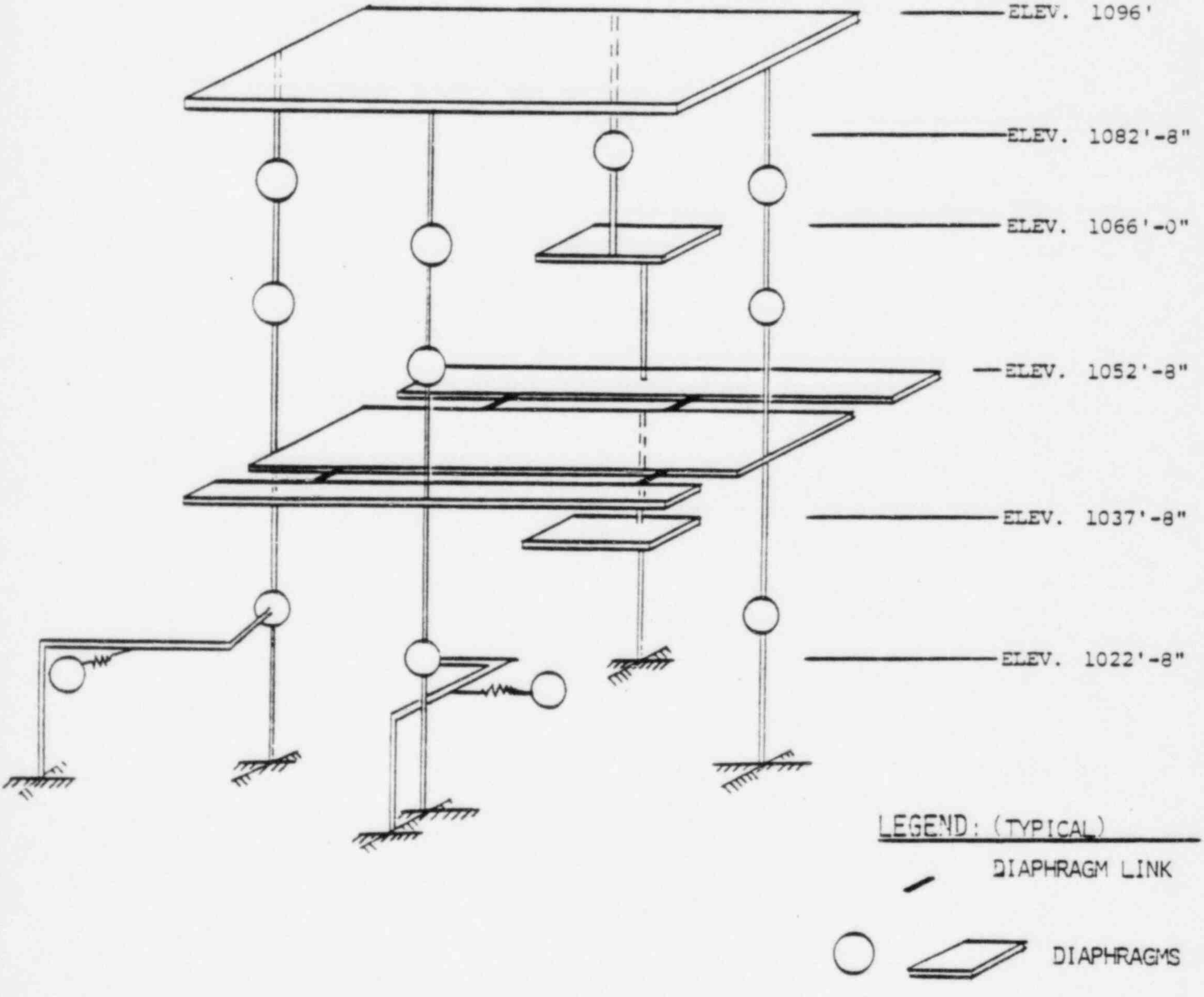
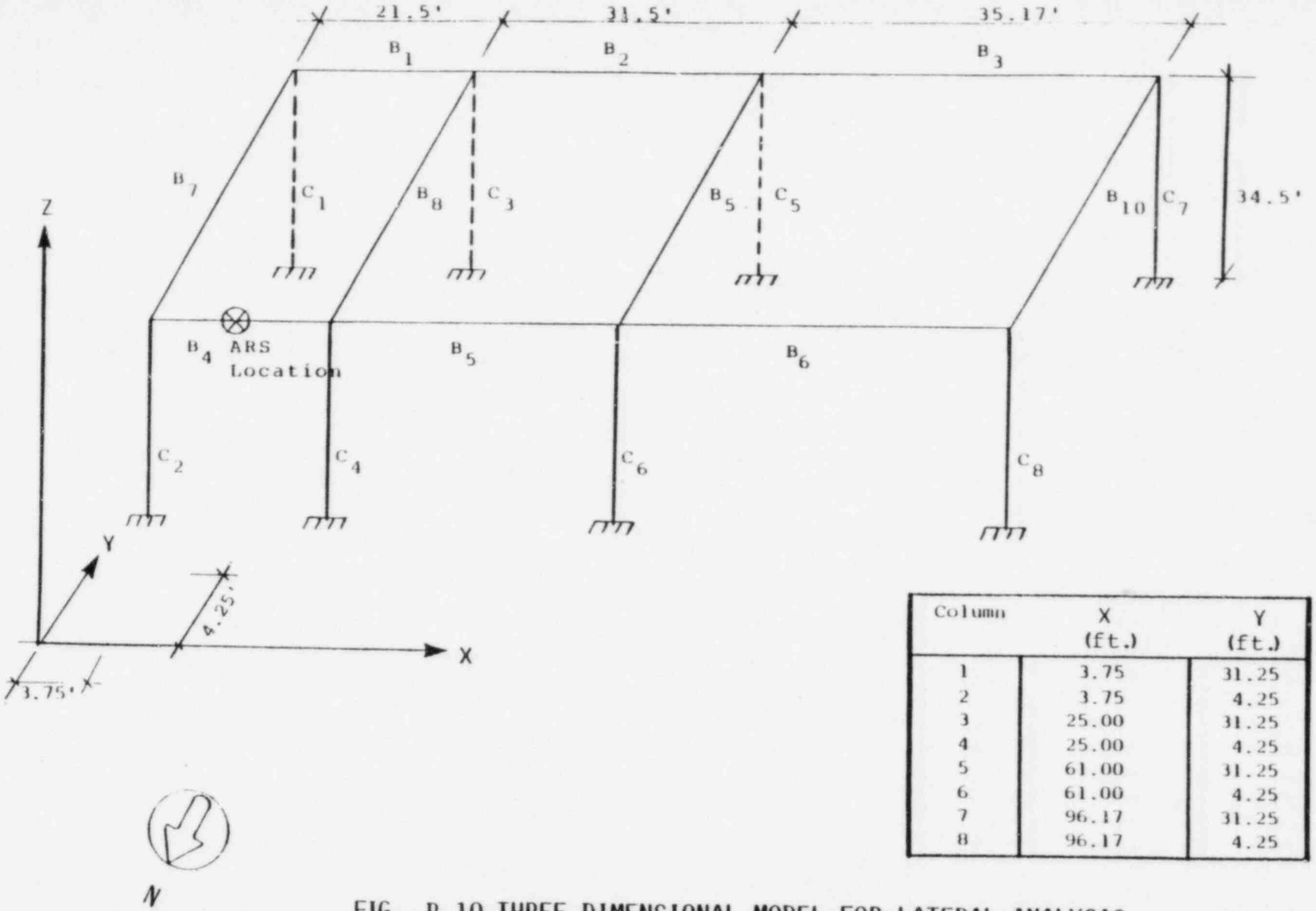
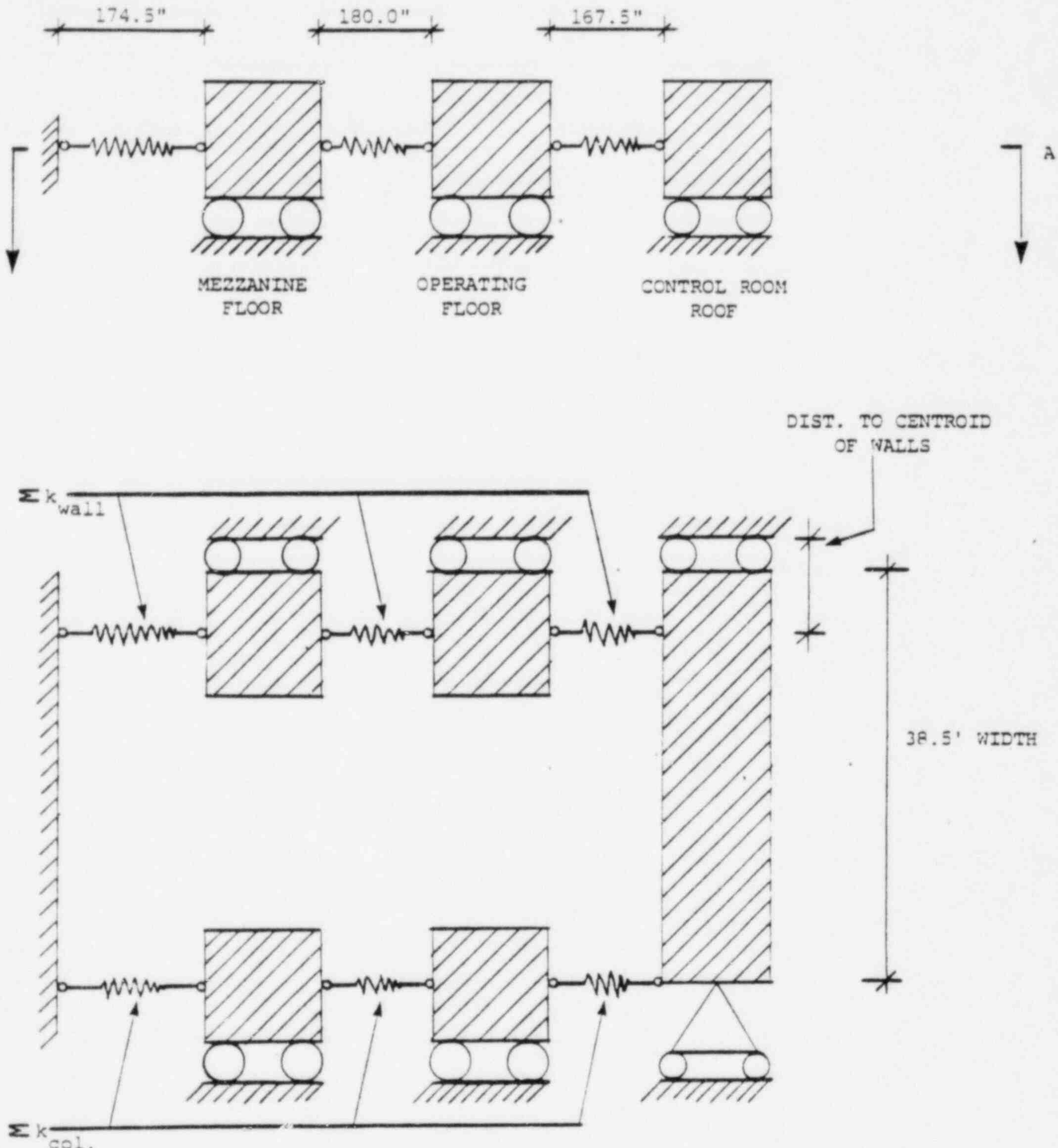


FIG. B.9 SCHEMATIC REPRESENTATION
TURBINE BUILDING STICK MODEL



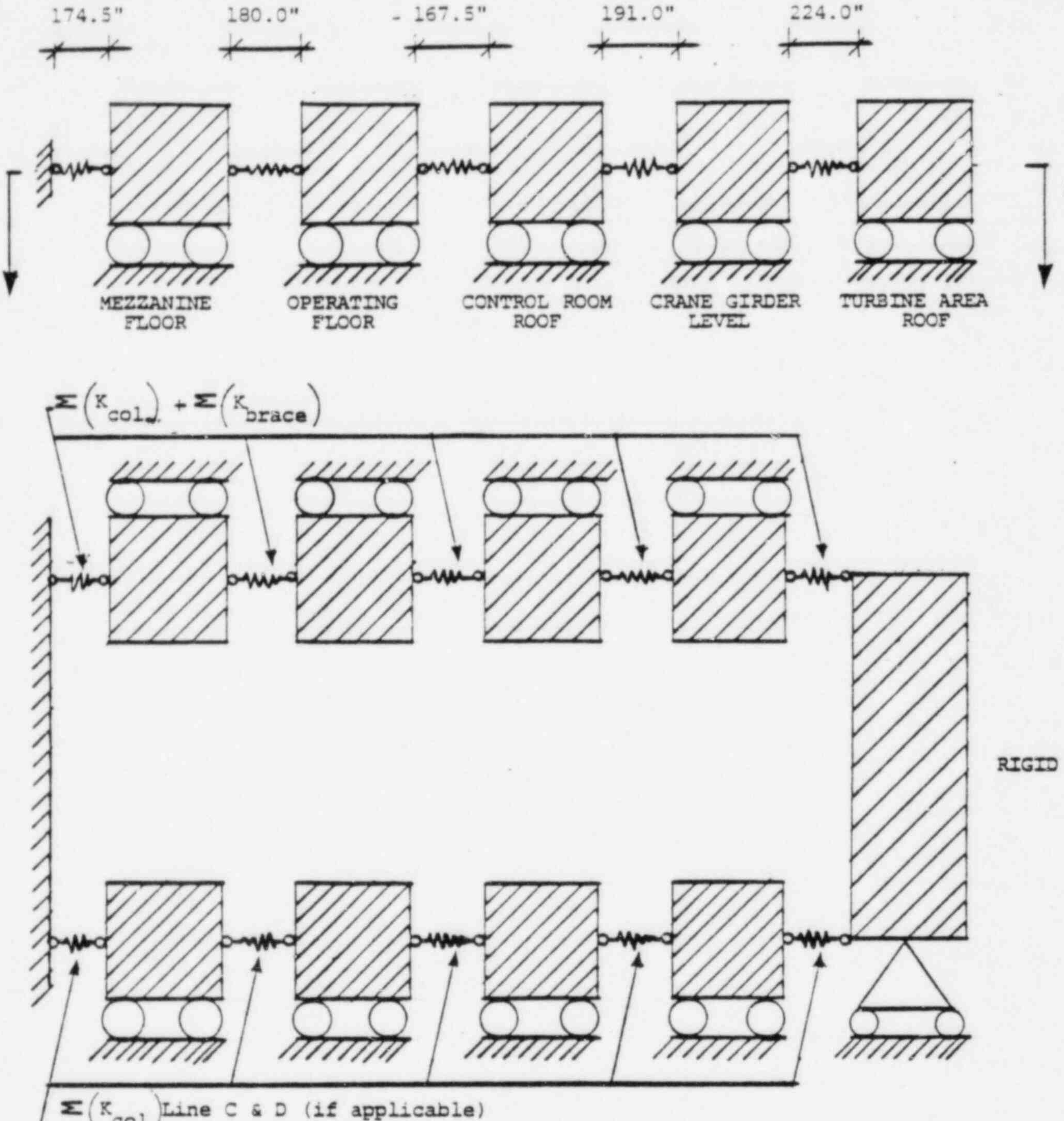
Column	X (ft.)	Y (ft.)
1	3.75	31.25
2	3.75	4.25
3	25.00	31.25
4	25.00	4.25
5	61.00	31.25
6	61.00	4.25
7	96.17	31.25
8	96.17	4.25

FIG. B.10 THREE DIMENSIONAL MODEL FOR LATERAL ANALYSIS OF TURBINE PEDESTAL



SECTION "A" - PLAN

FIG. B.11 MECHANICAL MODEL 1 FOR VERTICAL ANALYSIS OF TURBINE BUILDING



SECTION B - PLAN

FIG. B.12 MECHANICAL MODEL 2 FOR VERTICAL ANALYSIS OF TURBINE BUILDING

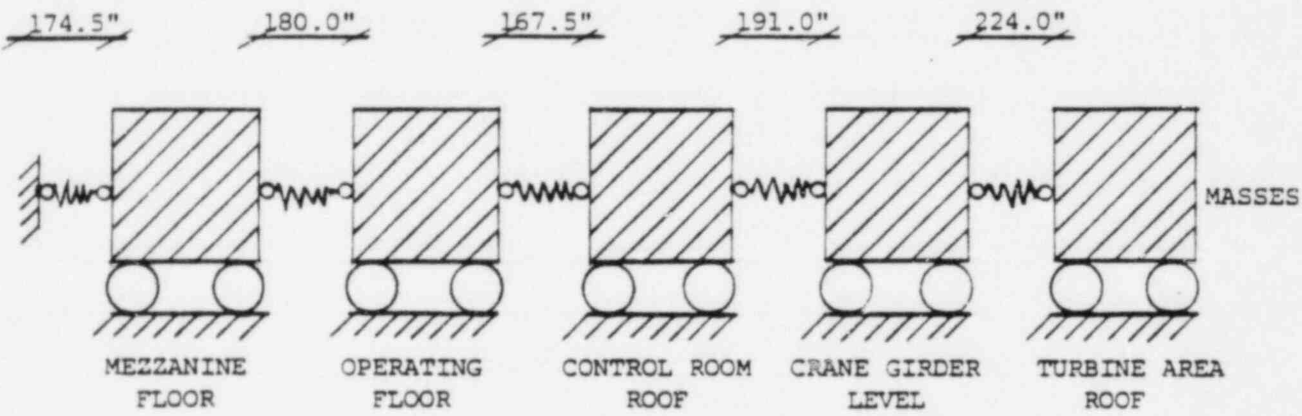


FIG. B.13 MECHANICAL MODEL 3 FOR VERTICAL ANALYSIS OF TURBINE BUILDING

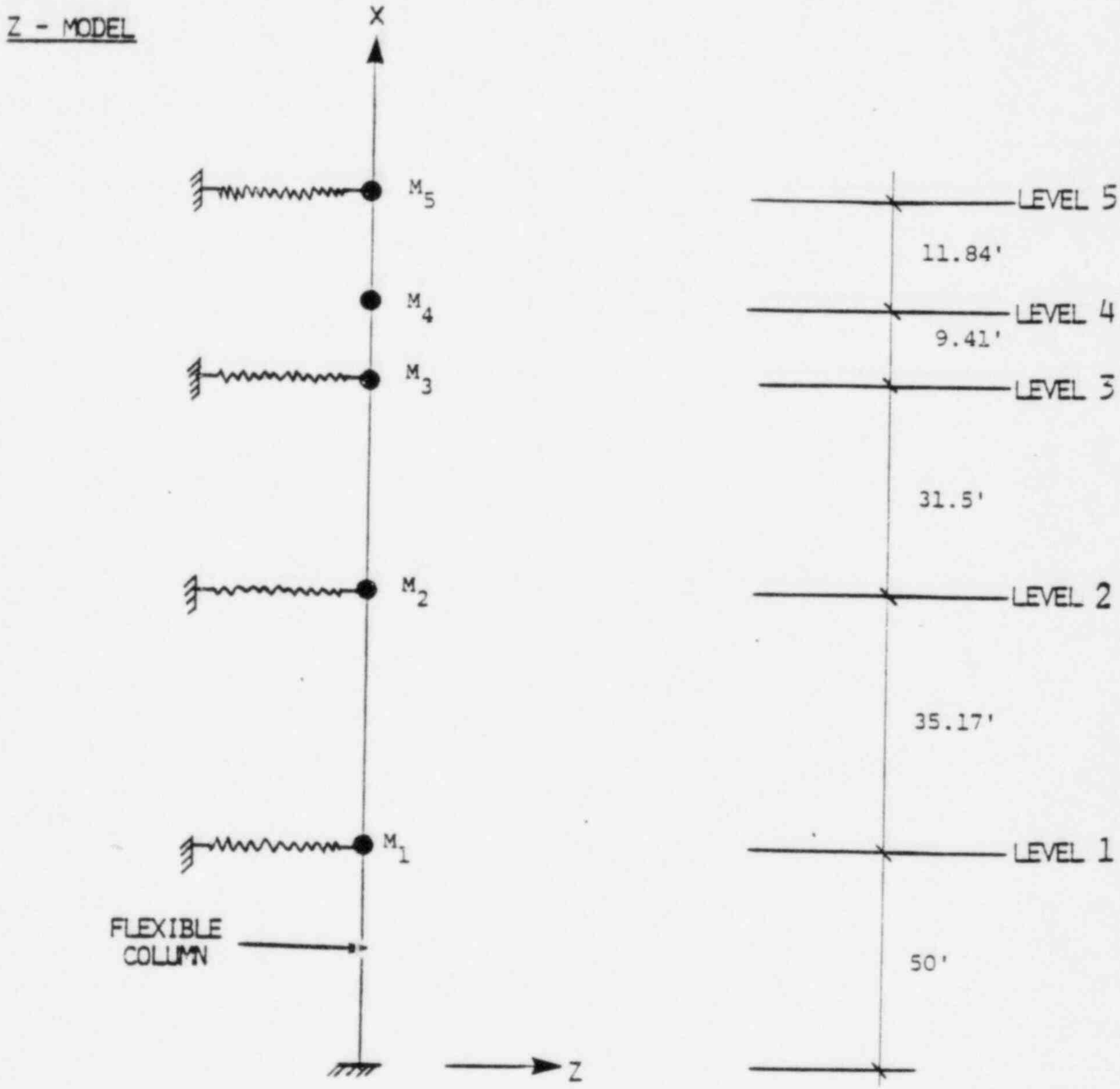


FIG. B.14 STICK MODEL FOR VERTICAL ANALYSIS OF TURBINE PEDESTAL

APPENDIX C

EARTHQUAKE RESPONSE SPECTRA

APPENDIX C

LIST OF FIGURES

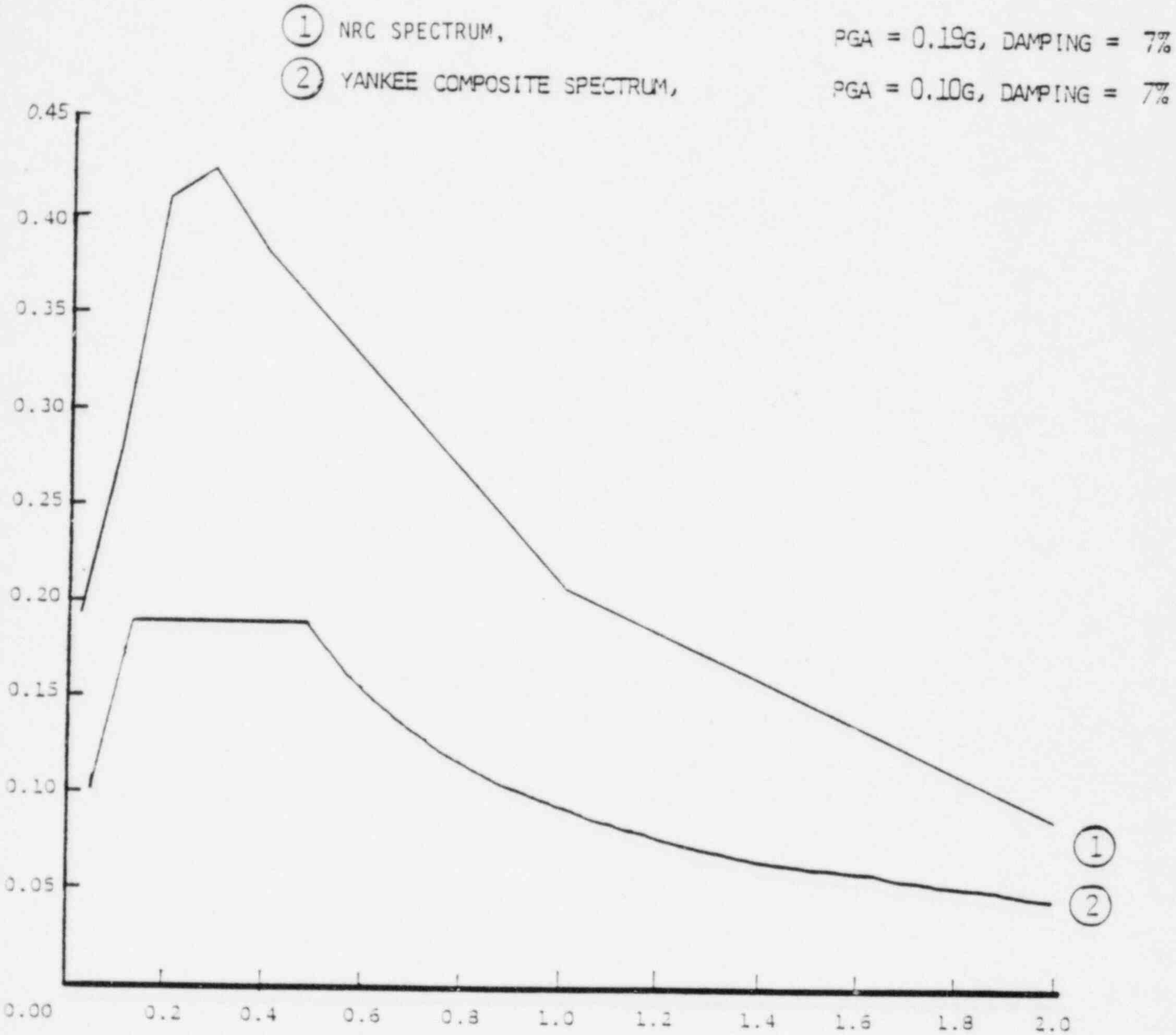


FIG. C.1 EARTHQUAKE SPECTRA

APPENDIX D

TABLE OF DYNAMIC CHARACTERISTICS

APPENDIX D

LIST OF TABLES

TABLE D.1

DYNAMIC CHARACTERISTICS - TURBINE BUILDING

Mode	F (Hz)	T (sec's)	Modal Mass $k\text{-}s^2/ft$ X (EW)	Y (NS)	Remarks
1	1.56	0.641	0.0	1.1	Office Building, NS
2	1.77	0.564	0.9	0.0	Office Building, EW
3	2.24	0.447	0.8	18.9	Frame on Line 5, NS
4	2.34	0.427	4.9	3.5	Steel Frame Line C, EW
5	3.35	0.298	0.0	2.0	Turbine Building, NS
6	3.59	0.278	0.4	0.2	
7	4.25	0.235	0.1	0.0	
8	4.48	0.223	0.0	0.2	
9	4.72	0.212	0.5	0.0	Frame on Line 13, EW
10	4.80	0.209	0.0	0.0	
11	4.93	0.203	0.9	0.0	Frame on Line 13, EW
12	5.26	0.190	0.1	0.0	
13	5.49	0.182	0.0	0.0	
14	6.43	0.156	0.0	0.0	
15	6.66	0.150	0.0	0.0	
16	7.26	0.138	0.1	0.0	
17	7.33	0.136	0.0	0.0	
18	7.88	0.127	0.0	0.0	
19	7.96	0.126	0.0	0.0	
20	8.46	0.118	0.0	0.0	
21	8.92	0.112	0.0	0.0	
22	9.21	0.109	0.0	0.0	
23	9.94	0.101	0.1	0.0	Frame on Line 13, EW
24	10.23	0.098	0.0	0.0	
25	12.34	0.081	8.8	0.0	Office Building, EW
26	12.64	0.079	6.6	0.0	Steel Frame Line C, EW
27	14.02	0.071	0.4	0.0	
28	14.82	0.068	0.1	0.1	
29	15.30	0.065	0.3	1.1	Turbine Building, NS
30	15.64	0.064	0.0	0.0	
31	16.57	0.060	0.6	0.0	Steel Frame Line C, EW

TABLE D.2

DYNAMIC CHARACTERISTICS - TURBINE PEDESTAL

Natural Frequencies

Mode	F (Hz)	T (sec's)	Modal Mass $k\text{-}s^2/ft$ X (EW)	Modal Mass $k\text{-}s^2/ft$ Y (NS)	Remarks
1	7.42	.135	100.	0.	E-W Mode
2	8.64	.116	0.	94.5	N-S Mode
3	10.2	.098	0.	5.5	Torsional Mode

APPENDIX E

RESULTS OF ANALYSIS

APPENDIX E

LIST OF TABLES

TABLE E.1

SUMMARY INFORMATION - TURBINE BUILDING

EVALUATION FOR YANKEE COMPOSITE SPECTRUM 7% DAMPING

Structure	Turbine Building	
Model	Building without fixes, no block walls	
Structural Materials	Reinforced Concrete Walls	f'_c = 2500 psi
	Steel Braces	Fy = 33 ksi (existing)
		= 36 ksi (new)
	Unreinforced Concrete	f'_m = 1000 psi (ASTM C-90)
	Masonry Walls, not grouted	f'_m = 440 psi (ASTM C-129)
		Type N Mortar
Clearance	1.0 in X and Y directions around Turbine Pedestal at Elevation 1052'-8".	
Maximum Displacement (YCS) (Approximate)	X (EW): 0.04 Y (NS): 0.26	$\frac{\text{CL.}}{\text{Max. Displ.}}$ = X: 25.0 Y: 3.83
Dynamic Properties	Total Mass	330.0 K-S /FT
	Total Weight	10626 K
	Seismic Base Shears (YCS SPECTRUM)	X (EW): 923 K = 8.7%W Y (NS): 1548 K = 14.6%W
	Predominant Natural Periods:	X (EW): 0.081 sec. Y (NS): 0.447 sec.

TABLE E.2

EVALUATION OF DIAGONAL BRACES - TURBINE BUILDING

(YCS SPECTRUM 7% DAMPING)

Story	Frame	Column	P Seismic (kips)	f_a (ksi)	F_A per AISC Part I (ksi)	$\frac{f_a}{F_A}$
1096'	5	C-D	75.	6.4	17.1	.37
1096'	5	G-F	56.	4.8	17.1	.28
1082'-8"	5	D-F	143.4	9.8	18.6	.53
1066'-0"	5	D-F	161.	11.0	18.6	.59
1052'-8"	5	F-G	220.	18.7	18.2	1.03
1037'-8"	5	D-E	131.	11.1	22.6	.49
1037'-8"	5	E-F	131.	11.1	22.6	.49
1096'-0"	G	9-8	127.	11.8	18.9	0.57
1082'-8"	G	8-7	146.	12.4	19.4	0.64
1052'-8"	G	12-11	38.	3.2	19.4	0.17
1037'-8"	G	11-10	24.	2.0	19.4	0.11
1096'	13	C-D	57.1	4.9	17.1	.29
1096'	13	F-G	52.	4.4	17.1	.27
1082'-8"	13	D-F	124.	8.4	18.6	.45
1066'-0"	13	D-F	132.	9.0	18.6	.48
1052'-8"	13	F-G	106.	9.0	18.2	.49
1037'-8"	13	F-G	108.3	9.2	18.0	.51
1096'-0"	C	12-11	83.	7.1	17.3	0.41
1082'-8"	C	11-10	158.	13.4	18.0	0.75
1066'-0"	C	10-9	154.	13.1	18.0	0.73
1052'-8"	C	9-8	118.	10.0	18.4	0.55
1037'-8"	C	8-9	127.	10.8	18.4	0.59

TABLE E.3

EVALUATION OF BRACE TO BEAM-COLUMN JOINT CONNECTIONS
TURBINE BUILDING

LOADS IN BRACE TO BEAM-COLUMN JOINT CONNECTION
LOADING: YANKEE COMPOSITE SPECTRUM 7% DAMPING

Connection Level Above	Frame Line	Column ID At Top	Braced Load $P_{seismic}$	Connection Capacity As Per AISC Sect. 1.5.2	Remarks
1096'	13	C	75.	201	OK - original design for wind controls
1096'	G	9	127.	167	OK
1082'-8"	13	F	124.	436	OK - original design for wind controls
1082'-8"	G	8	146.	235	OK
1066'-0"	5	F	161.	235	OK
1066'-0"	C	10	155.	302	OK
1052'-8"	13	F	106.	302	OK
1037'-8"	5	E	131.	176	OK
1037'-8"	5	E	131.	176	OK
1037'-8"	13	F	108.3	302	OK

TABLE E.4

FOUNDATION LOAD SUMMARY - TURBINE BUILDING
EVALUATION FOR YCS SPECTRUM 7% DAMPING

Ftg. Id.	Dead Load 1 Col.	Ftg.	Overlying Soil	Live Load, 2	Seismic Load, 3	Combination 1+2+3	1-3	Ftg. Capacity
C-13	39	31	41	277	36	424	75	678
D-13	81	25	26	247	75	454	57	623
F-13	81	22	19	247	66	435	56	623
G-13/RC	268+264	88	79	355	211	1265	488	1781
G-12	561	76	53	638	61	1389	629	1830
G-11	566	63	46	625	9	1309	666	1621
G-10	566	76	53	625	13	1333	682	1830
G-9	566	86	104	625	82	1463	674	1921
G-8/RC	278+264	111	107	630	508	1898	252	2035
G-7	126	45	34	550	85	840	120	1145
G-5	101	21	29	379	151	681	0	797
J-8/RC	28+2313	252	262	82+221	497	3655	2358	6455
J-7	28	8	6	82	0	124	42	215
J-5	29	6	5	56	0	96	40	170
F-5	108	30	25	301	140	604	23	848
E-5	7	4	4	22	0	37	15	130
D-5	108	41	43	301	176	669	16	954
C-5	32	25	23	250	47	377	33	596
C-12	87	38	35	419	54	633	106	742
C-11	87	36	33	419	40	615	116	795
C-10	87	60	62	419	22	650	187	848
C-9	87	78	100	419	45	729	220	1272
C-8	87	54	56	419	130	746	67	919
C-7	87	62	61	419	0	629	210	795
J-13	2313	229	262	221	386	3411	2418	6074

NOTES:
1. Col. dead and live loads are from S&W Dwg. #FS-2B.
2 Ftg. wt. includes concrete pedestal and grade beam, if any.
3. Overlying soil wt = 0.1 ksf x (A_{ftg} - $A_{pedestal\ +\ grade\ beam}$) x (1022'-8" - T.O. Ftg Elev.)

TABLE E.5

SUMMARY INFORMATION - TURBINE BUILDING
EVALUATION FOR NRC SPECTRUM 7% DAMPING

Structure	Turbine Building			
Model	Building without fixes, no block walls			
Structural Materials	Reinforced Concrete Walls	f'_c	=	2500 psi
	Steel Braces	Fy	=	33 ksi (existing)
			=	36 ksi (new)
	Unreinforced Concrete	f'_m	=	1000 psi (ASTM C-90)
	Masonry Walls, not grouted	f'_m	=	440 psi (ASTM C-129)
		Type N Mortar		
Clearance	1.0 in X and Y directions around Turbine Pedestal at Elevation 1052'-8".			
Maximum Displacement (Approximate)	X (EW): 0.08"	$\frac{\text{CL.}}{\text{Max. Displ.}}$	=	X: 12.5
	Y (NS): 0.51"			Y: 2.0
Dynamic Properties	Total Mass			330.0 K-S^2/FT
	Total Weight			10626 K
	Seismic Base Shears			X (EW): 1520 K = 14.3%W
				Y (NS): 2863 K = 27.0%W
	Predominant Natural Periods:			X (EW): 0.081 sec.
				Y (NS): 0.447 sec.

TABLE E.6

EVALUATION OF DIAGONAL BRACES - TURBINE BUILDING
STRESSES IN DIAGONAL BRACES
LOADING: NRC SPECTRUM 7% DAMPING

Story	Frame	Column	P Seismic (kips)	f_a (ksi)	F_A per AISC Part I (ksi)	$\frac{f_a}{F_A}$
1096'	5	C-D	147.	12.5	17.1	.73
1096'	5	G-F	112.	9.6	17.1	.56
1082'-8"	5	D-F	285.	19.4	18.6	1.04
1066'-0"	5	D-F	318.	21.6	18.6	1.16
1052'-8"	5	F-G	427.	36.3	18.2	1.99
1037'-8"	5	D-E	254.	21.6	22.6	.96
1037'-8"	5	E-F	254.	21.6	22.6	.96
1096'-0"	G	9-8	252.	21.4	18.9	1.13
1082'-8"	G	8-7	290.	24.7	19.4	1.27
1052'-8"	G	12-11	74.	6.3	19.4	0.32
1037'-8"	G	11-10	75.	6.4	19.4	0.33
1096'	13	C-D	114.	9.7	17.1	.57
1096'	13	G-F	105.	9.0	17.1	.53
1082'-8"	13	F-D	249.	16.9	18.6	.91
1066'-0"	13	D-F	263.	17.9	18.6	.96
1052'-8"	13	F-G	207.	17.6	18.2	.97
1037'-8"	13	F-G	212.	18.1	18.2	1.00
1096'-0"	C	12-11	165.	14.0	17.3	0.81
1082'-8"	C	11-10	311.	26.4	18.0	1.47
1066'-0"	C	10-9	304.	25.8	18.0	1.44
1052'-8"	C	9-8	229.	19.5	18.4	1.06
1037'-8"	C	8-9	246.	20.9	18.4	1.14

TABLE E.7

EVALUATION OF BRACE TO BEAM-COLUMN JOINT CONNECTIONS
TURBINE BUILDING
LOADS IN BRACE TO BEAM-COLUMN JOINT CONNECTION
LOADING: NRC SPECTRUM 7% DAMPING

Connection Level Above	Frame Line	Column ID At Top	Braced Load (kips) $P_{seismic}$	Connection Capacity As Per AISC Sect. 1.5.2	Remarks
1096'	13	C	114.	201	OK - original design for wind controls
1096'	G	9	252.	167	Overstressed
1082'-8"	13	F	248.	436	OK - original design for wind controls
1082'-8"	G	8	290.	235	Overstressed
1066'-0"	5	F	318.	235	Overstressed
1066'-0"	C	10	305.	302	OK
1052'-8"	13	F	207.	302	OK
1037'-8"	5	E	254.	176	Overstressed
1037'-8"	5	E	254.	176	Overstressed
1037'-8"	13	F	212.	302	OK

TABLE E.8

FOUNDATION LOAD SUMMARY - TURBINE BUILDING
EVALUATION FOR NRC SPECTRUM 7% DAMPING

Ftg. Id.	Dead Load 1			Live Load, 2	Seismic Load, 3	Combination		Ftg. Capacity
	Col.	Ftg.	Overlying Soil			1+2+3	1-3	
C-13	39	31	41	277	72	460	39	678
D-13	81	25	26	247	150	529	-18	623
F-13	81	22	19	247	137	506	-15	623
G-13/RC	268+264	88	79	355	475	1529	224	1781
G-12	561	76	53	638	120	1448	570	1830
G-11	566	63	46	625	17	1317	658	1621
G-10	566	76	53	625	25	1345	670	1830
G-9	566	86	104	625	163	1544	593	1921
G-8/RC	278+264	111	107	630	986	2376	-226	2035
G-7	126	45	34	550	170	925	35	1145
G-5	101	21	29	379	293	823	-142	797
J-8/RC	28+2313	252	262	82+221	964	4122	1891	6455
J-7	28	8	6	82	0	124	42	215
J-5	29	6	5	56	0	96	40	170
F-5	108	30	25	301	280	744	-117	848
E-5	7	4	4	22	0	37	15	130
D-5	108	41	43	301	345	838	-153	954
C-5	32	25	23	250	93	423	-13	596
C-12	87	38	35	419	107	686	53	742
C-11	87	36	33	419	80	811	76	795
C-10	87	60	62	419	43	671	166	848
C-9	87	78	100	419	87	771	178	1272
C-8	87	54	56	419	255	1068	-58	919
C-7	87	62	61	419	0	629	210	795
J-13	2313	229	262	221	757	3782	2047	6074

NOTES:
1. Col. dead and live loads are from S&W Dwg. #FS-2B.
2 Ftg. wt. includes concrete pedestal and grade beam, if any.
3. Overlying soil wt = 0.1 ksf x (A_{ftg} - $A_{pedestal + grade beam}$) x (1022'-8" - T.O. Ftg Elev.)

TABLE E.9

SUMMARY INFORMATION - TURBINE PEDESTAL
EVALUATION FOR YANKEE COMPOSITE SPECTRUM 7% DAMPING)

Structure	Turbine Pedestal		
Model	Three-Dimensional Space Frame		
Structural Materials	Concrete Steel Reinforcement	f'_c F_y	= 3000 psi = 40 ksi (existing)
Clearance	1.0 in X and Y directions at Elevation 1052'-8".		
Maximum Displacement (Approximate)	X (EW): 0.03" Y (NS): 0.02"	$\frac{\text{CL.}}{\text{Max. Displ.}}$ =	X: 33 Y: 50
Dynamic Properties	Total Mass Total Weight Seismic Base Shears		160.9 $K\text{-}S^2/FT$ 5182 K X (EW): 979 K = 18.9%W Y (NS): 893 K = 17.2%W
	Predominant Natural Periods:		X (EW): 0.135 sec. Y (NS): 0.116 sec.

TABLE E.10

EVALUATION OF COLUMNS - TURBINE PEDESTAL
STRESS RESULTANTS IN COLUMNS
SEISMIC LOADING: YANKEE COMPOSITE SPECTRUM
7% DAMPING

Column Id.	Member Loads Combined Dead and Seismic P (kips)	Mns (ft-kips)	Mew (ft-kips)	Ultimate Strengths Under Axial Load P Mns (ft-kips)	Mew (ft-kips)	Result of* Biaxial Moment Interaction Eq. < 1.0
C1, C2	423	1390	420	6000	4390	.03
C3, C4	878	1540	1090	6220	8480	.06
C5, C6	745	3020	1940	7200	13800	.07
C7, C8	244	2420	2680	7420	8360	.12

*Biaxial Moment Interaction Equation:

$$\left(\frac{M_x}{M_{ox}}\right)^n + \left(\frac{M_y}{M_{oy}}\right)^n \leq 1.0$$

where:

n = 2.4 for Columns C1, C2, C5, and C6
n = 2.2 for Columns C3 and C4
n = 2.5 for Columns C7 and C8

TABLE E.11

EVALUATION OF BEAMS - TURBINE PEDESTAL
STRESS RESULTANTS IN BEAMS
SEISMIC LOADING: YANKEE COMPOSITE SPECTRUM 7% DAMPING

Beam	SHEAR (KIPS)					MOMENT (KT-KIPS)				
	Dead Load V_D	Seismic (SRSS) V_E	Sum $V_D + V_E$	Concrete Ultimate Strength Ø V_C	Load Ultimate Strength	Dead Load Md	Seismic (SRSS) Me	Sum Me + Md	Ultimate Strength Ø Mu	Load Ultimate Strength
B1	33	134	167	583	.29	529	736	1265	7450	.17
B2	103	166	169	779	.22	1291	999	2290	11900	.19
B3	138	136	274	1060	.26	1438	1622	3060	13900	.22
B4	33	134	167	583	.29	529	736	1265	7450	.17
B5	103	66	169	779	.22	1291	999	2290	11900	.19
B6	138	136	274	1060	.26	1438	1622	3060	13900	.22
B7	27	35	62	414	.15	156	331	487	4530	.11
B8	2	99	101	670	.15	248	936	1184	9610	.12
B9	0	258	258	628	.41	114	1612	1726	8160	.22
B10	0	264	264	919	.29	68	1652	1584	9730	.16

TABLE E.12

SUMMARY INFORMATION - TURBINE PEDESTAL
EVALUATION FOR NRC SPECTRUM 7% DAMPING

Structure	Turbine Pedestal		
Model	Three-Dimensional Space Frame		
Structural Materials	Concrete Steel Reinforcement	f'_c F_y	= 3000 psi = 40 ksi
Clearance	1.0 in X and Y directions around Turbine Pedestal at Elevation 1052'-8".		
Maximum Displacement (Approximate)	X (EW): 0.06" Y (NS): 0.04"	$\frac{\text{CL.}}{\text{Max. Displ.}}$ =	X: 17 Y: 25
Dynamic Properties	Total Mass Total Weight Seismic Base Shears		160.9 $K\text{-}S^2/FT$ 5182 K X (EW): 1645 K = 31.7%W Y (NS): 1427 K = 27.5%W
	Predominant Natural Periods:		X (EW): 0.135 sec. Y (NS): 0.116 sec.

TABLE E.13

EVALUATION OF COLUMNS - TURBINE PEDESTAL
STRESS RESULTANTS IN COLUMNS
SEISMIC LOADING: NRC SPECTRUM 7% DAMPING

Column Id.	Member Loads. Combined Dead and Seismic P (kips)	Mns (ft-kips)	Mew (ft-kips)	Ultimate Strengths Under Axial Load P Mns (ft-kips)	Mew (ft-kips)	Result of* Biaxial Moment Interaction Eq. ≤ 1.0
C1, C2	517	2300	620	6300	4600	0.11
C3, C4	950	2510	1670	6400	8600	0.15
C5, C6	583	3460	4590	6790	13160	0.25
C7, C8	67	3950	4260	6810	7700	0.44

*Biaxial Moment Interaction Equation:

$$\left(\frac{M_x}{M_{ox}}\right)^n + \left(\frac{M_y}{M_{oy}}\right)^n \leq 1.0$$

where:

n = 2.4 for Columns C1 through C4
n = 2.5 for Columns C5 and C6
n = 2.65 for Columns C7 and C8

TABLE E.14

EVALUATION OF BEAMS - TURBINE PEDESTAL
STRESS RESULTANTS IN BEAMS
SEISMIC LOADING: NRC SPECTRUM 7% DAMPING

	SHEAR (KIPS)					MOMENT (KT-KIPS)				
Beam	Dead Load V_D	Seismic (SRSS) V_E	Sum $V_D + V_E$	Concrete Ultimate Strength ϕV_C	Load Ultimate Strength	Dead Load Md	Seismic (SRSS) Me	Sum Me + Md	Ultimte Strength ϕ Mu	Load Ultimate Strength
B1	33	223	256	583	0.44	529	1230	1759	7450	0.24
B2	103	110	213	779	0.27	1291	1663	2954	11900	0.25
B3	138	227	365	1060	0.34	1438	2715	4153	13900	0.30
B4	33	223	256	583	0.44	529	1230	1759	7450	0.24
B5	103	110	213	779	0.27	1291	1663	2954	11900	0.25
B6	138	227	365	1060	0.34	1438	2715	4153	13900	0.30
B7	27	56	83	414	0.2	156	527	683	4530	0.15
B8	2	157	159	670	0.24	248	1494	1742	9610	0.18
B9	0	412	412	628	0.66	114	2576	2690	8160	0.33
B10	0	422	422	919	0.46	68	2639	2707	9730	0.28

APPENDIX F

AMPLIFIED RESPONSE SPECTRA

APPENDIX F

LIST OF FIGURES

I. TURBINE BUILDING

II. TURBINE PEDESTAL

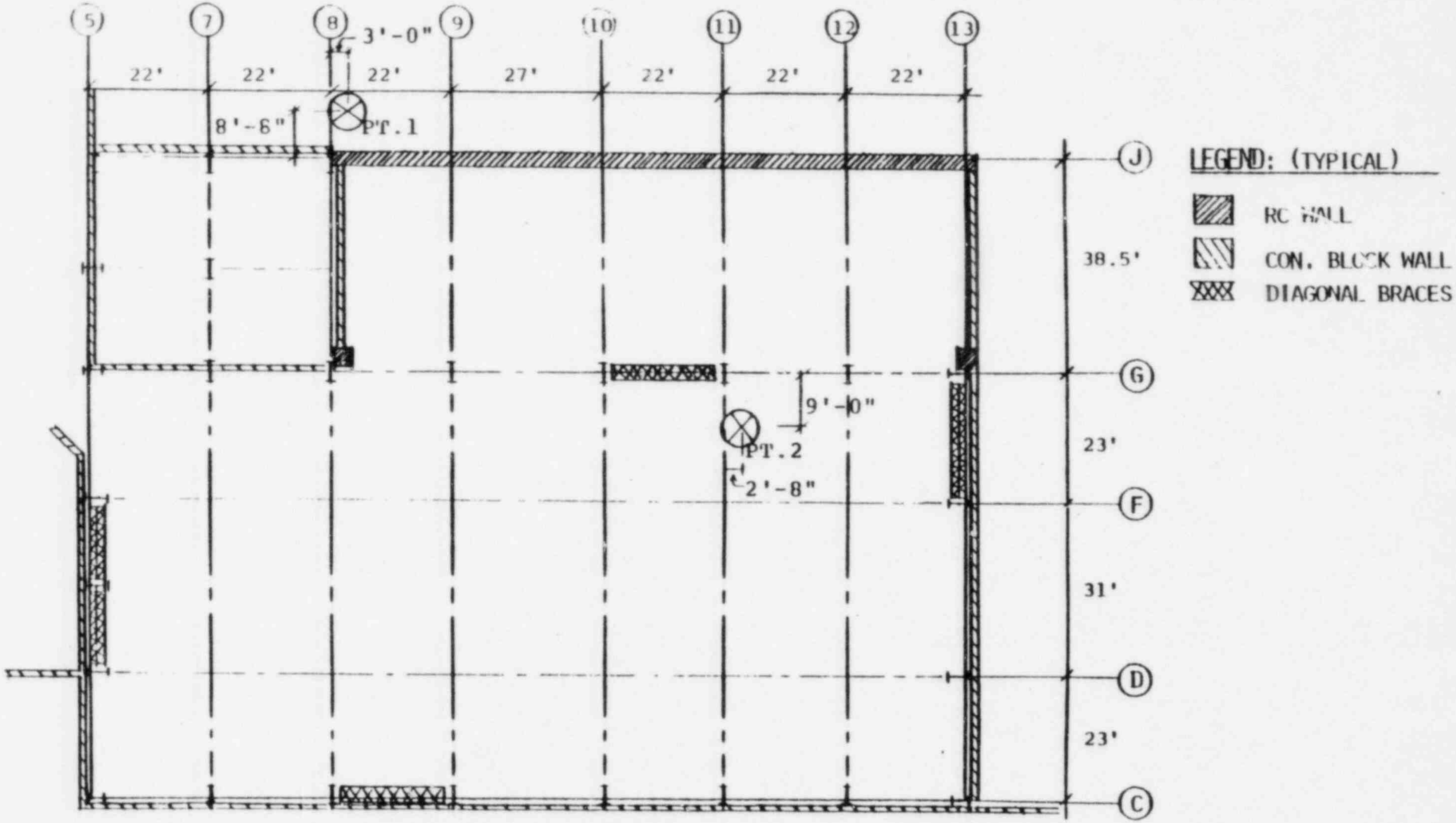


FIG. F.1 ARS LOCATION KEY PLAN
TURBINE BUILDING

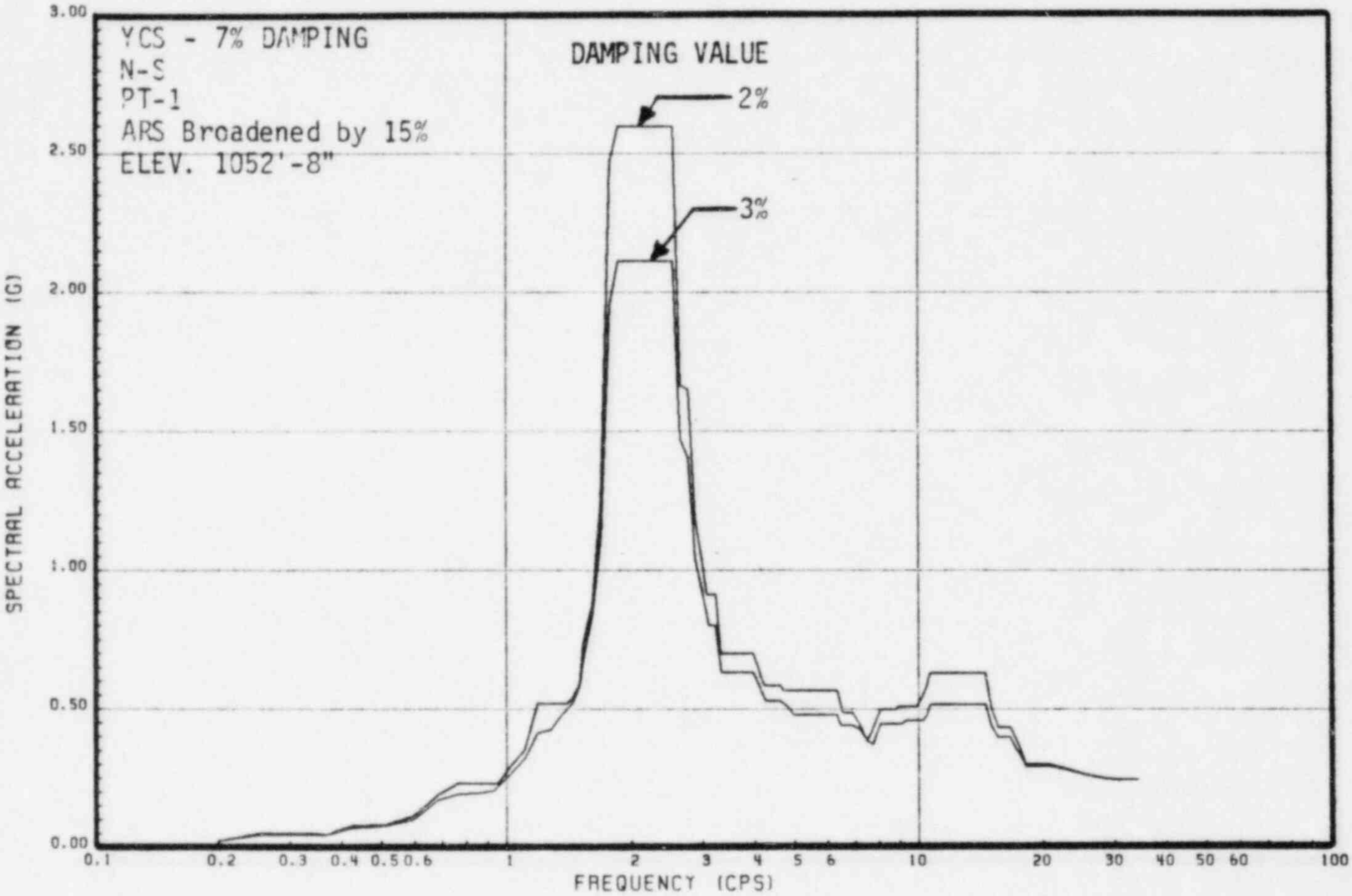

YCS - 7% DAMPING
N-S
PT-1
ARS Broadened by 15%
ELEV. 1052'-8"
DAMPING VALUE
2%
3%
SPECTRAL ACCELERATION (G)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.1
0.2
0.3
0.4
0.5
0.6
1
2
3
4
5
6
10
20
30
40
50
60
100
FREQUENCY (CPS)

FIG. F.2

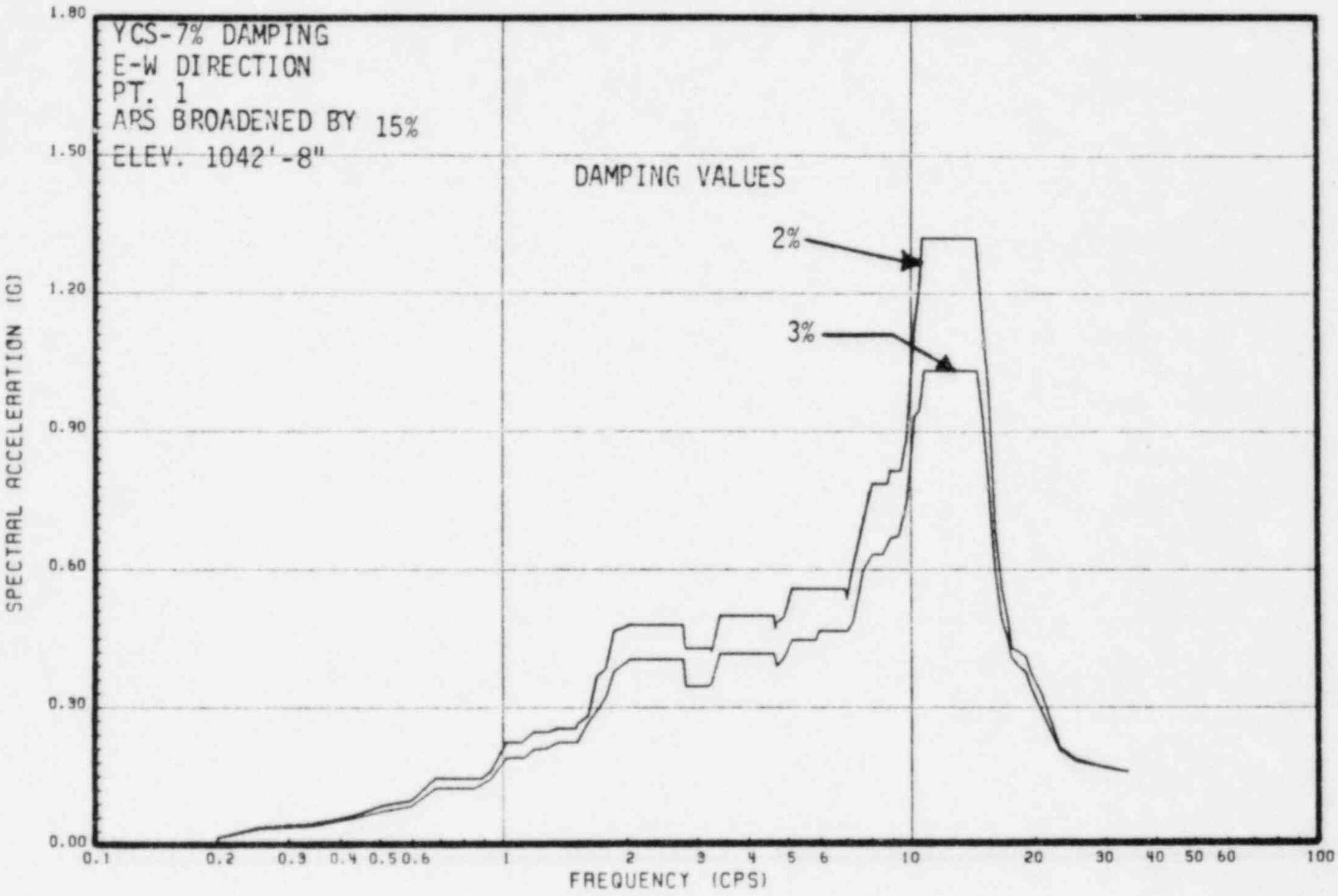

YCS-7% DAMPING
E-W DIRECTION
PT. 1
ARS BROADENED BY 15%
ELEV. 1042'-8"
DAMPING VALUES
2%
3%
1.80
1.50
1.20
0.90
0.60
0.30
0.00
SPECTRAL ACCELERATION (G)
0.1
0.2
0.3
0.4
0.5
0.6
1
2
3
4
5
6
10
20
30
40
50
60
100
FREQUENCY (CPS)

FIG. F.3

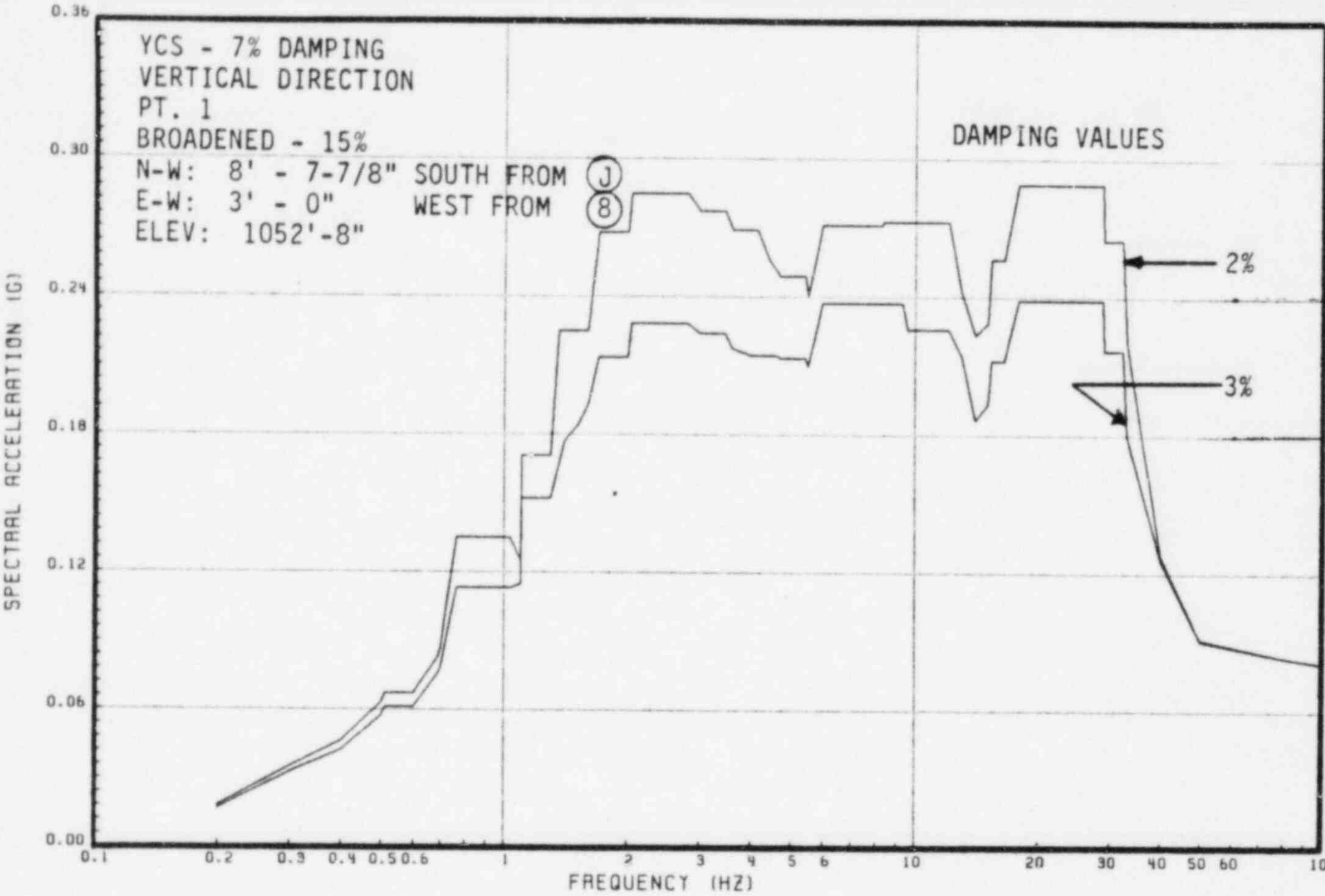
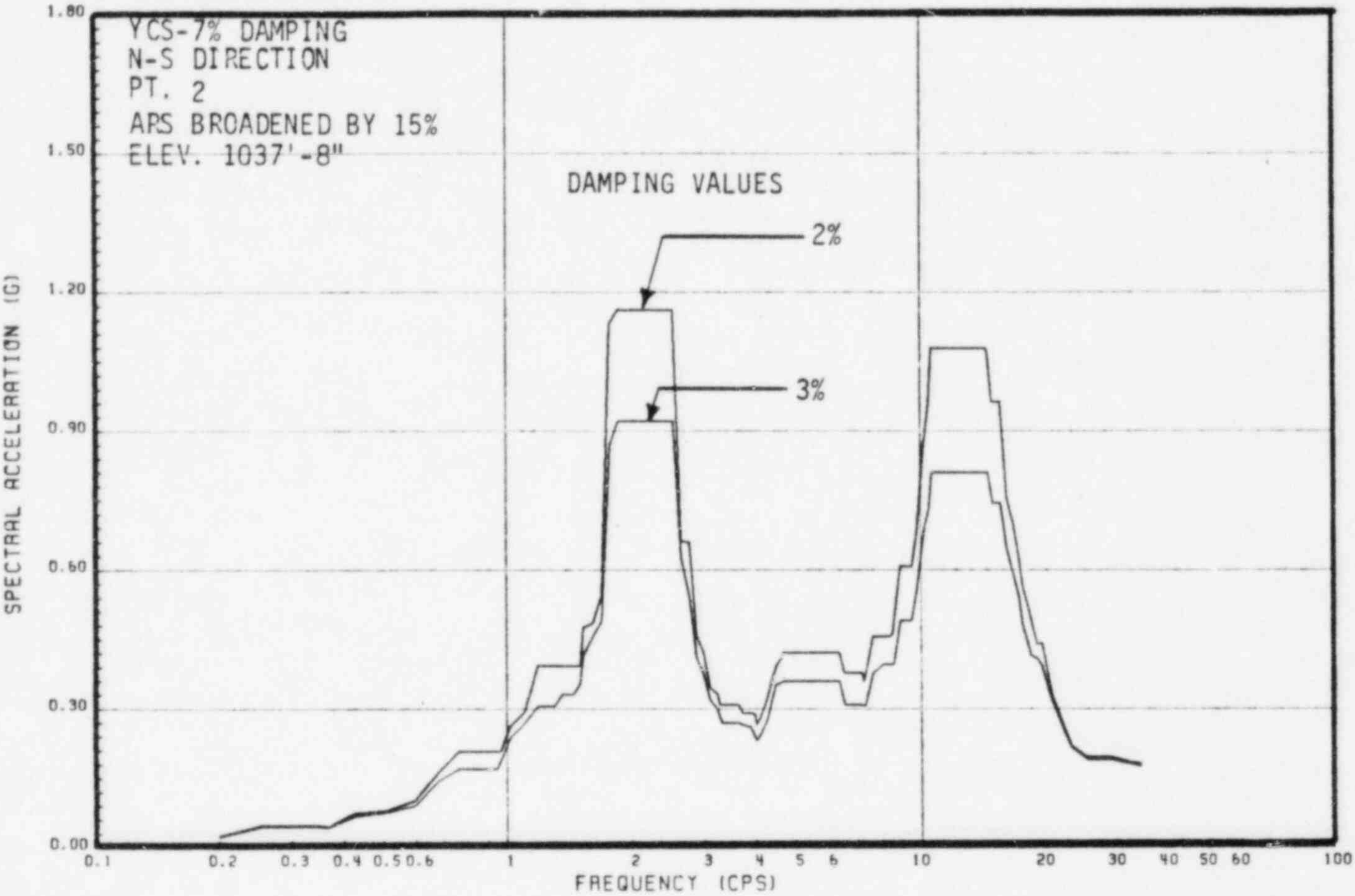
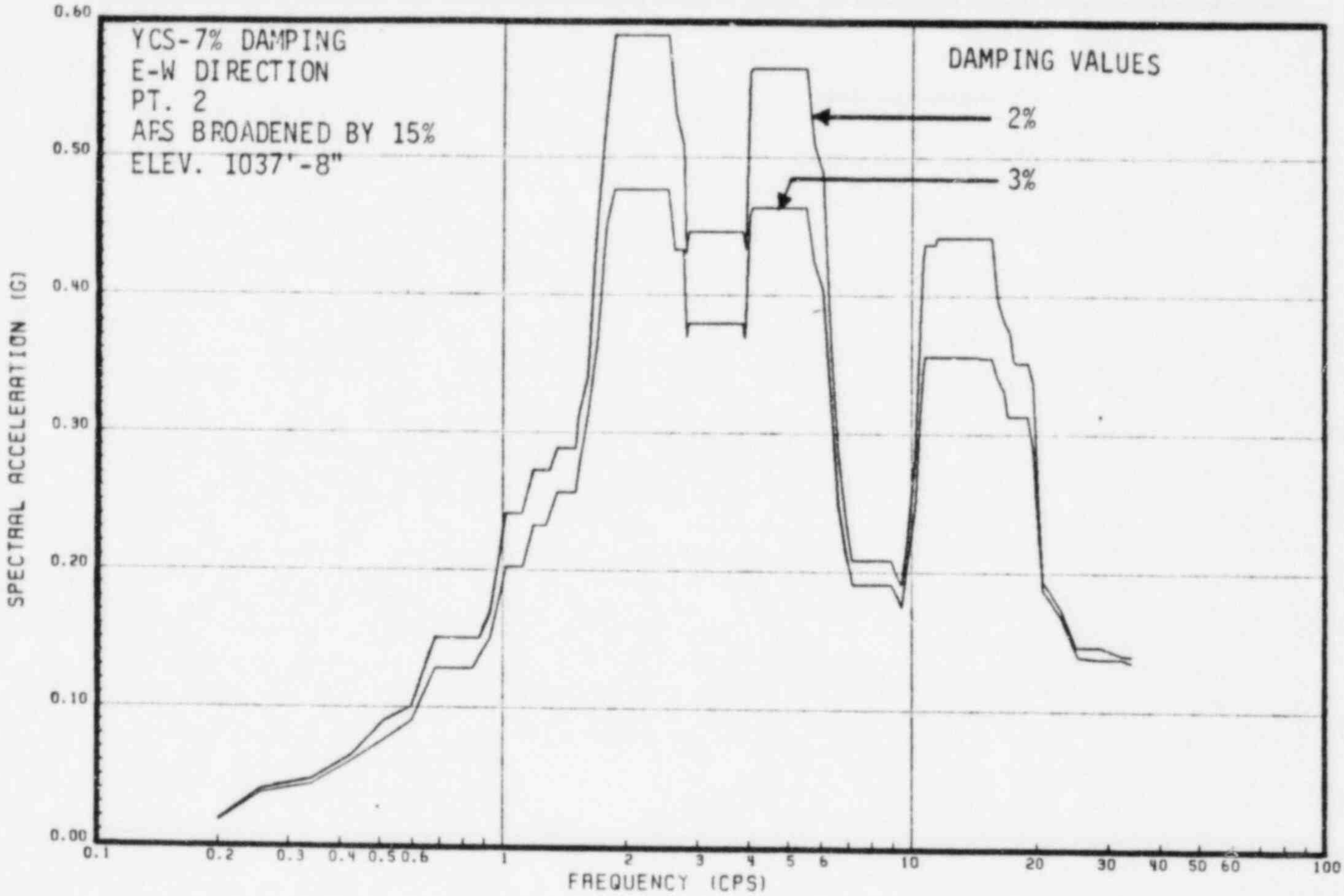

YCS - 7% DAMPING
VERTICAL DIRECTION
PT. 1
BROADENED - 15%
N-W: 8' - 7-7/8" SOUTH FROM J
E-W: 3' - 0" WEST FROM 8
ELEV: 1052'-8"
DAMPING VALUES
2%
3%
SPECTRAL ACCELERATION (G)
FREQUENCY (HZ)
0.36
0.30
0.24
0.18
0.12
0.06
0.00
0.1
0.2
0.3
0.4
0.5
0.6
1
2
3
4
5
6
10
20
30
40
50
60
100

FIG. F.4



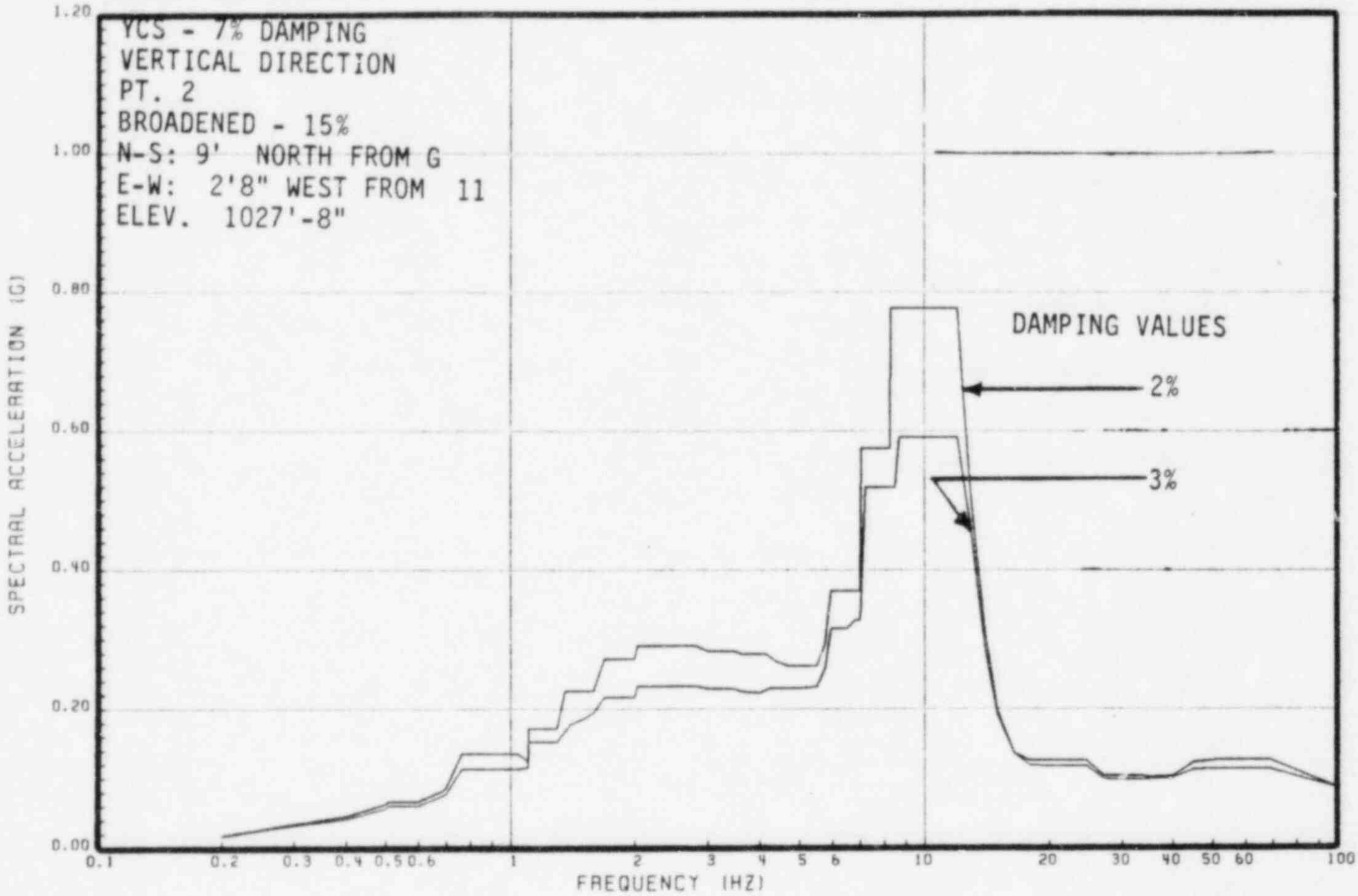
YCS-7% DAMPING
N-S DIRECTION
PT. 2
APS BROADENED BY 15%
ELEV. 1037'-8"
DAMPING VALUES
2%
3%
SPECTRAL ACCELERATION (G)
FREQUENCY (CPS)
1.80
1.50
1.20
0.90
0.60
0.30
0.00
0.1
0.2
0.3
0.4 0.5 0.6
1
2
3
4
5
6
10
20
30
40
50
60
100

FIG. F.5



YCS-7% DAMPING
E-W DIRECTION
PT. 2
AFS BROADENED BY 15%
ELEV. 1037'-8"
DAMPING VALUES
2%
3%
SPECTRAL ACCELERATION (G)
FREQUENCY (CPS)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.1
0.2
0.3
0.4
0.5
0.6
1
2
3
4
5
6
10
20
30
40
50
60
100

FIG. F.6



YCS - 7% DAMPING
VERTICAL DIRECTION
PT. 2
BROADENED - 15%
N-S: 9' NORTH FROM G
E-W: 2'8" WEST FROM 11
ELEV. 1027'-8"
DAMPING VALUES
2%
3%
SPECTRAL ACCELERATION (G)
FREQUENCY (HZ)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.1
0.2
0.3
0.4
0.5
0.6
1
2
3
4
5
6
10
20
30
40
50
60
100

FIG. F.7

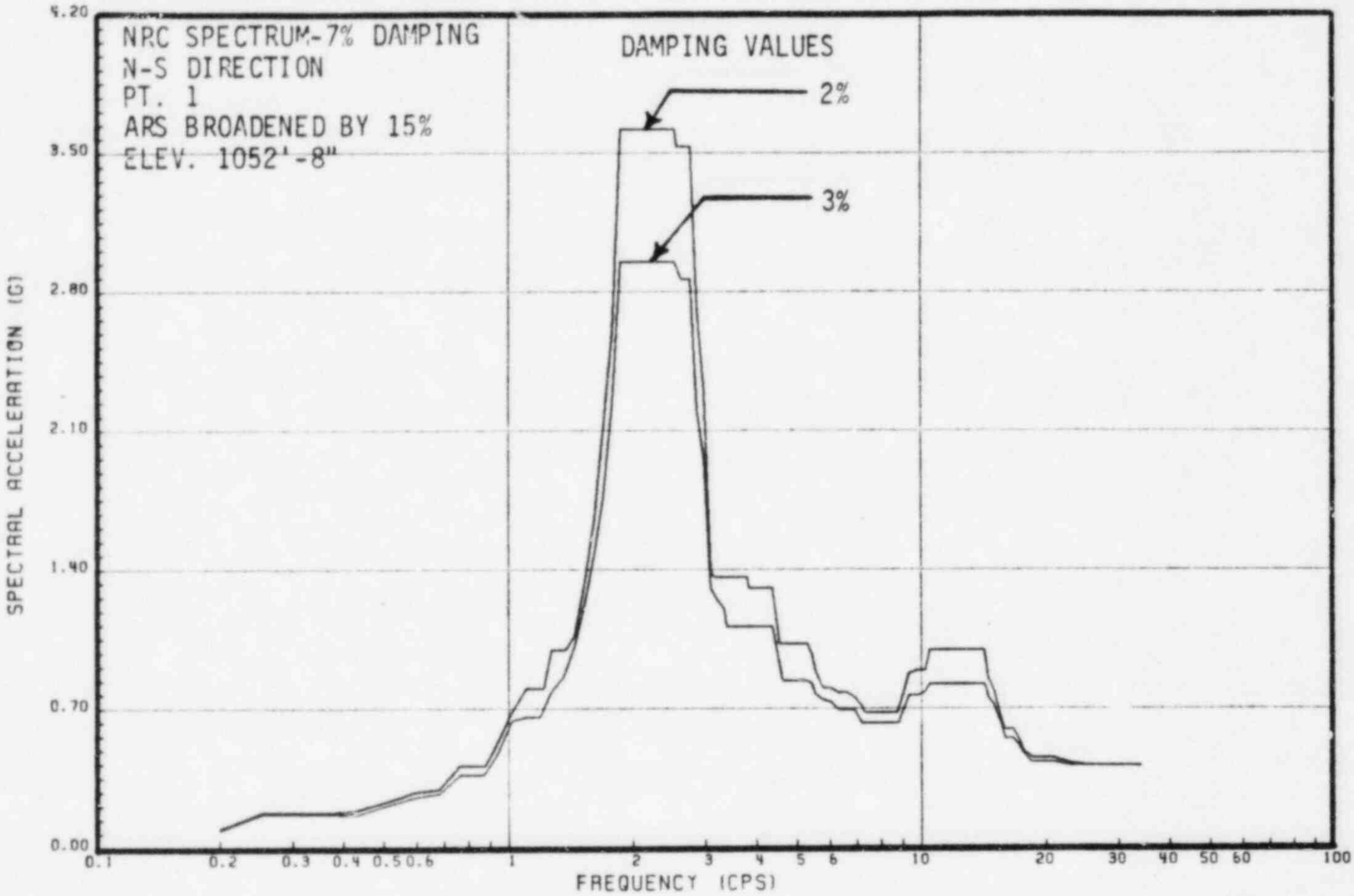
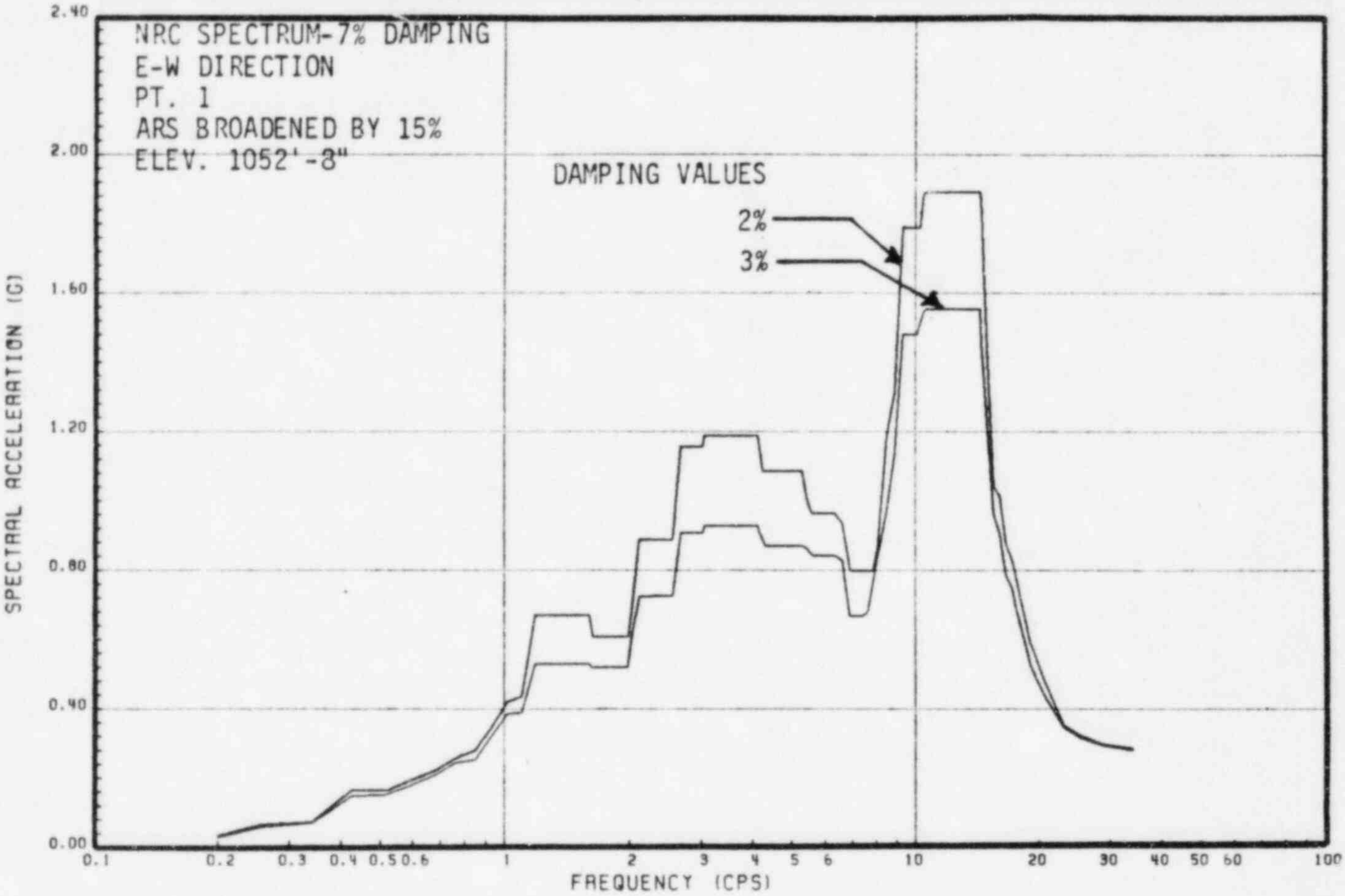

NRC SPECTRUM-7% DAMPING
N-S DIRECTION
PT. 1
ARS BROADENED BY 15%
ELEV. 1052'-8"
DAMPING VALUES
2%
3%
SPECTRAL ACCELERATION (G)
4.20
3.50
2.80
2.10
1.40
0.70
0.00
0.1
0.2
0.3
0.4
0.5
0.6
1
2
3
4
5
6
10
20
30
40
50
60
100
FREQUENCY (CPS)

FIG. F.8



NRC SPECTRUM-7% DAMPING
E-W DIRECTION
PT. 1
ARS BROADENED BY 15%
ELEV. 1052'-8"
DAMPING VALUES
2%
3%
SPECTRAL ACCELERATION (G)
2.40
2.00
1.60
1.20
0.80
0.40
0.00
0.1
0.2
0.3
0.4 0.5 0.6
1
2
3
4
5
6
10
20
30
40
50
60
100
FREQUENCY (CPS)

FIG. F.9

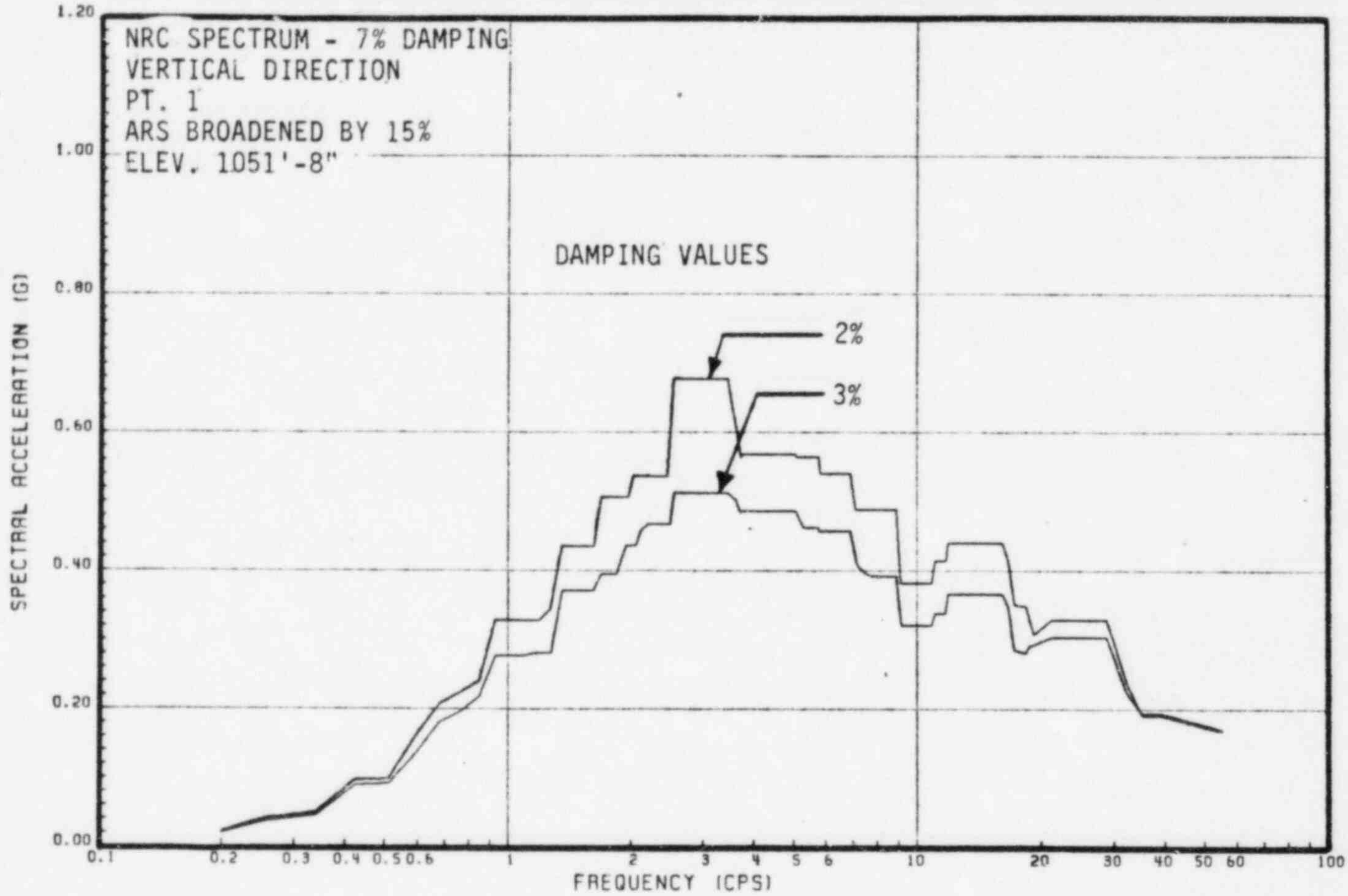

NRC SPECTRUM - 7% DAMPING
VERTICAL DIRECTION
PT. 1
ARS BROADENED BY 15%
ELEV. 1051'-8"
DAMPING VALUES
2%
3%
SPECTRAL ACCELERATION (G)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.1
0.2
0.3
0.4 0.5 0.6
1
2
3
4
5
6
10
20
30
40
50 60
100
FREQUENCY (CPS)

FIG. F.10

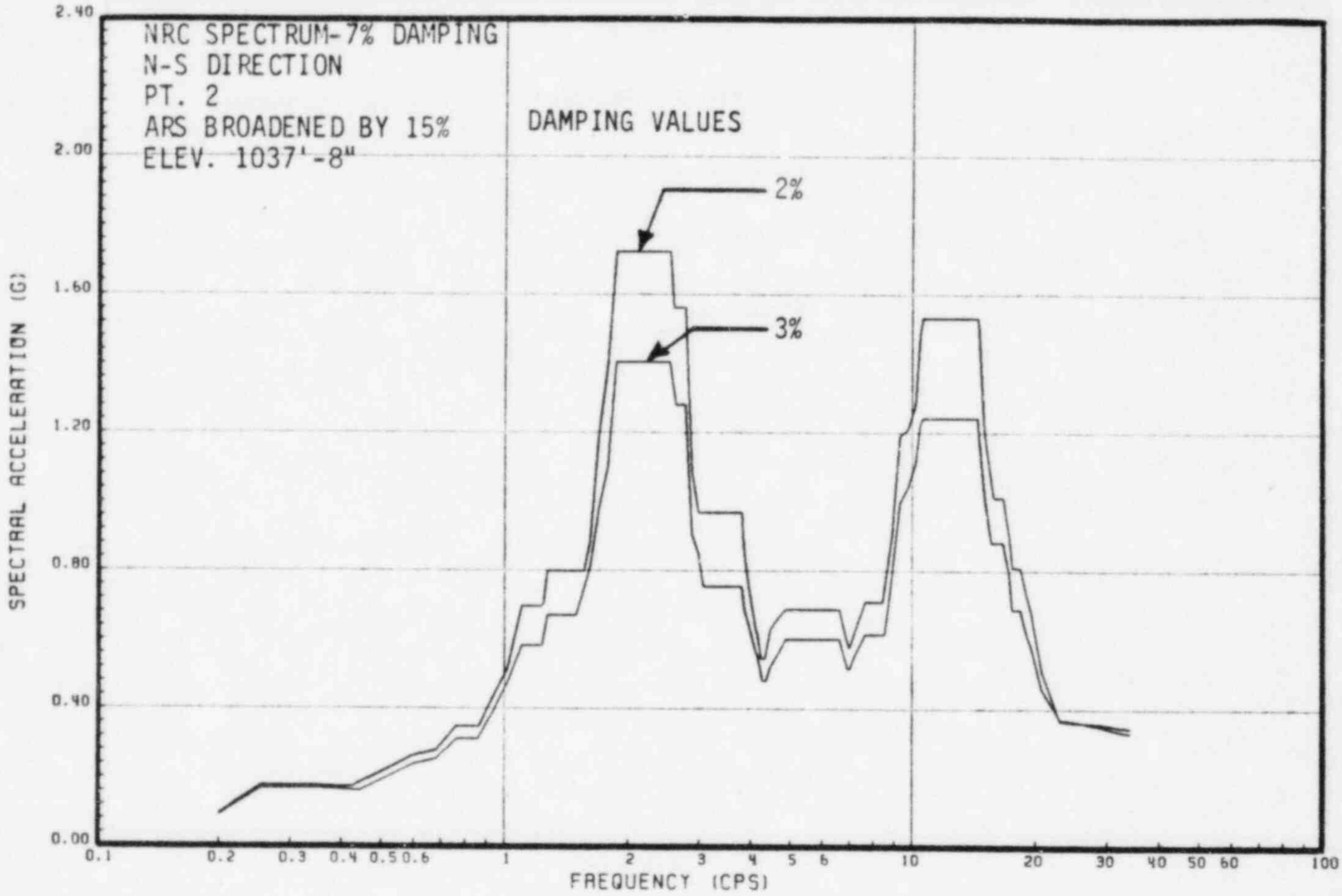
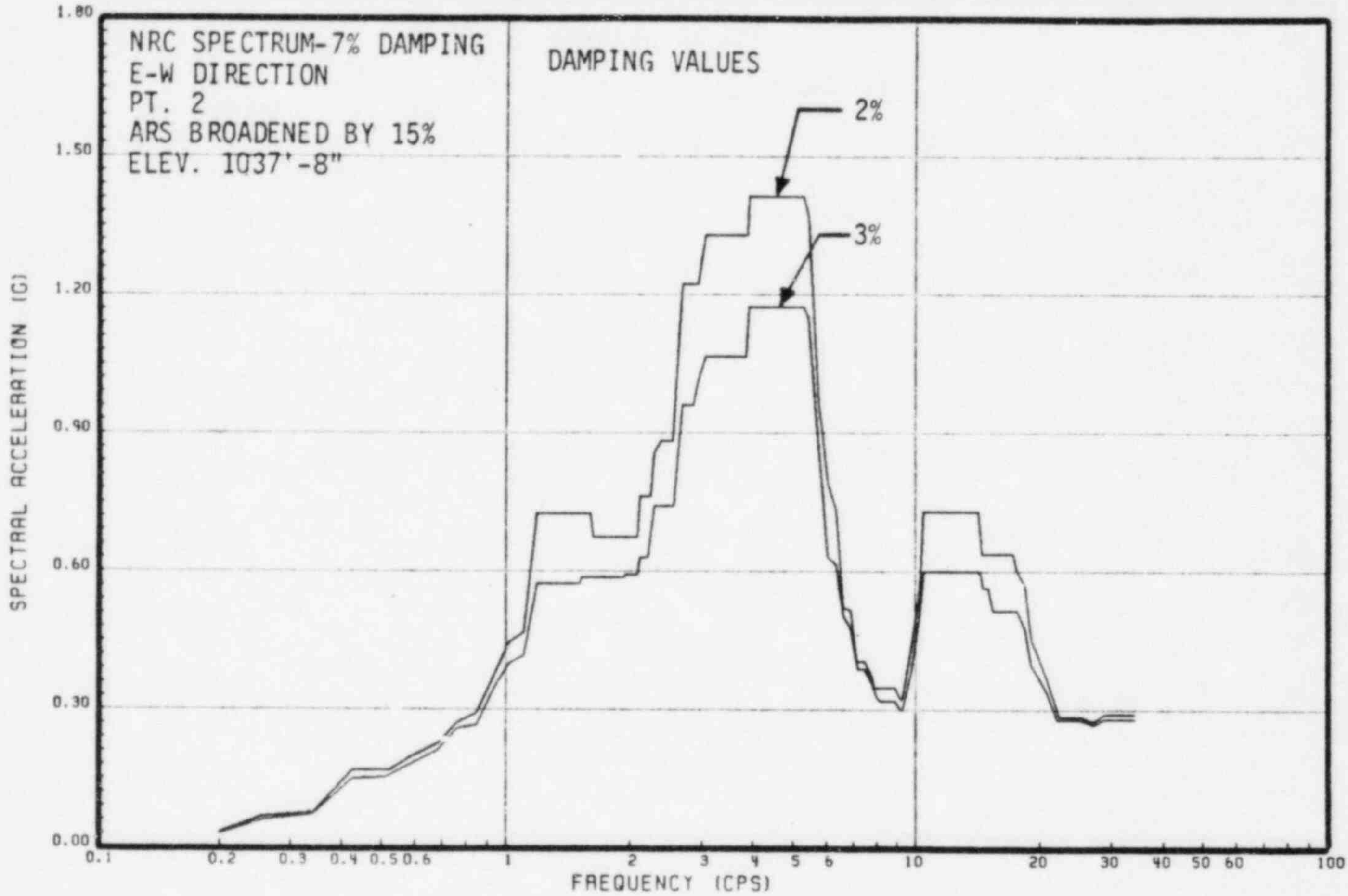

NRC SPECTRUM-7% DAMPING
N-S DIRECTION
PT. 2
ARS BROADENED BY 15%
ELEV. 1037'-8"
DAMPING VALUES
2%
3%
SPECTRAL ACCELERATION (G)
FREQUENCY (CPS)
2.40
2.00
1.60
1.20
0.80
0.40
0.00
0.1
0.2
0.3
0.4 0.5 0.6
1
2
3
4
5
6
10
20
30
40
50
60
100

FIG. F.11



NRC SPECTRUM-7% DAMPING
E-W DIRECTION
PT. 2
ARS BROADENED BY 15%
ELEV. 1037'-8"
DAMPING VALUES
2%
3%
SPECTRAL ACCELERATION (G)
1.80
1.50
1.20
0.90
0.60
0.30
0.00
0.1
0.2
0.3
0.4
0.5
0.6
1
2
3
4
5
6
10
20
30
40
50
60
100
FREQUENCY (CPS)

FIG. F.12

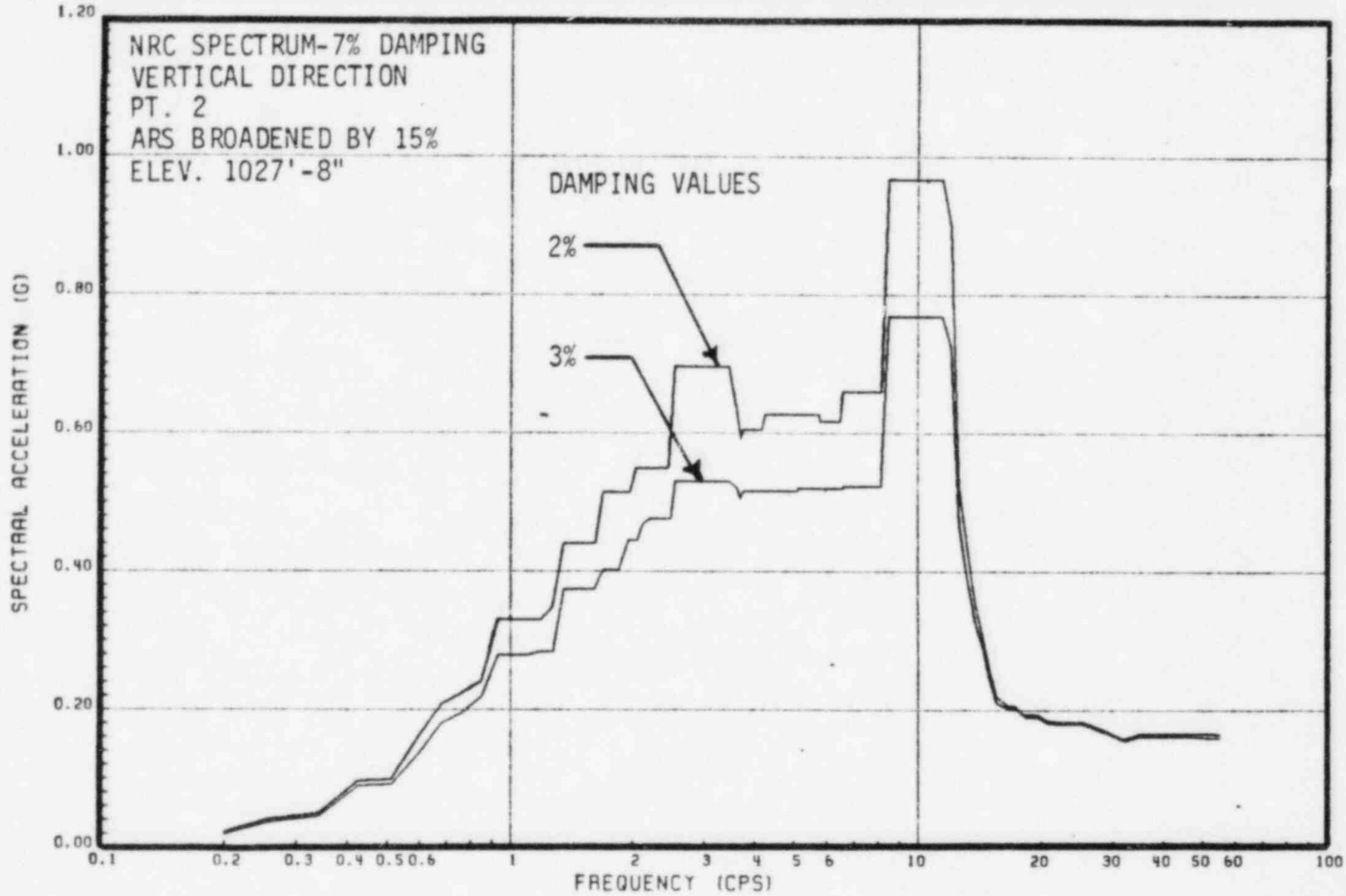

NRC SPECTRUM-7% DAMPING
VERTICAL DIRECTION
PT. 2
ARS BROADENED BY 15%
ELEV. 1027'-8"
DAMPING VALUES
2%
3%
SPECTRAL ACCELERATION (G)
FREQUENCY (CPS)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.1
0.2
0.3
0.4
0.5
0.6
1
2
3
4
5
6
10
20
30
40
50
60
100

FIG. F.13

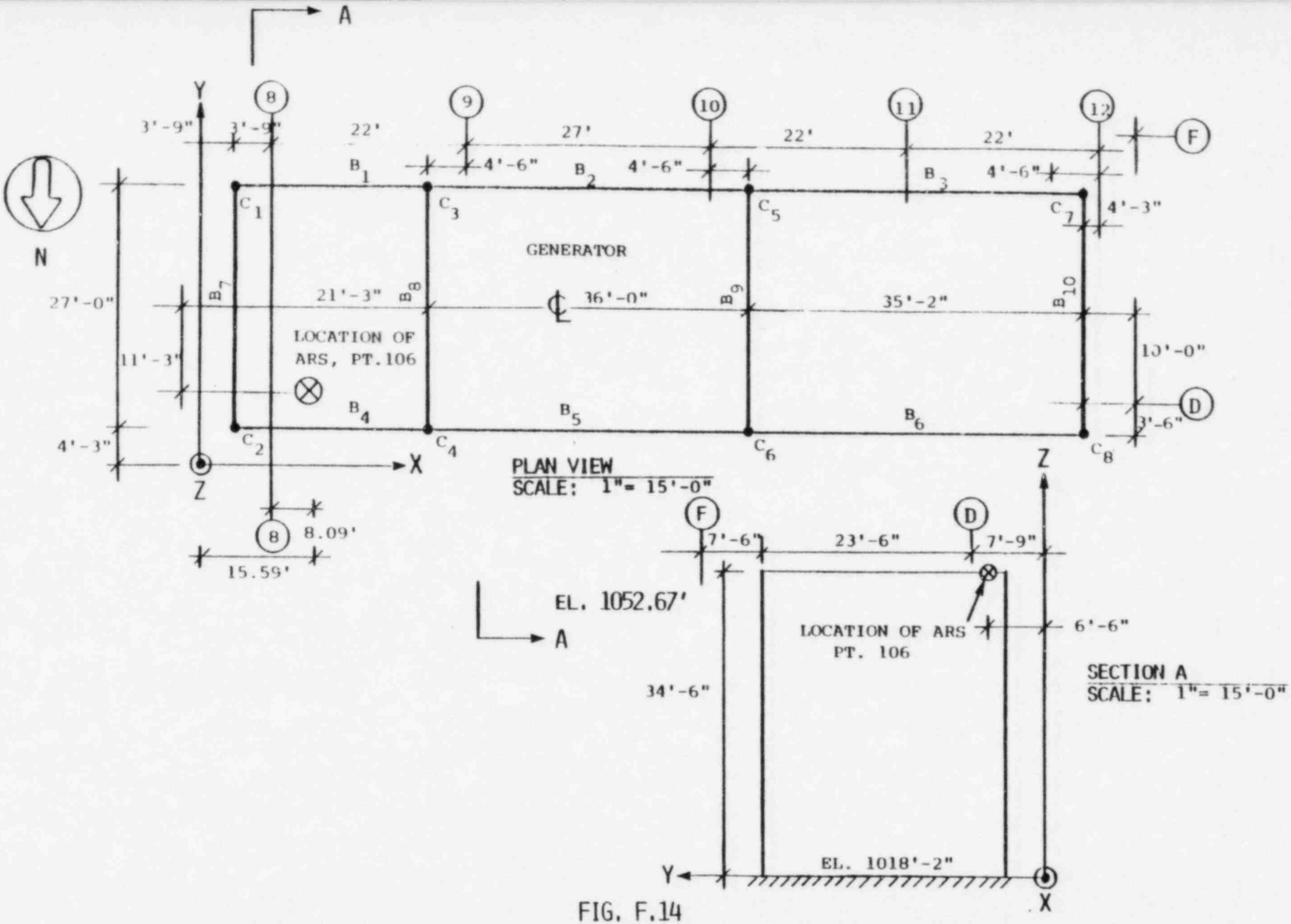

A
Y
8
9
10
11
12
F
3'-9"
3'-9"
22'
27'
22'
22'
4'-6"
4'-6"
4'-6"
4'-3"
N
B_1
B_2
B_3
C_1
C_3
C_5
C_7
GENERATOR
27'-0"
B_7
21'-3"
B_8
36'-0"
B_9
35'-2"
B_{10}
11'-3"
LOCATION OF
ARS, PT.106
10'-0"
B_4
B_5
B_6
D
3'-6"
4'-3"
C_2
C_4
C_6
C_8
X
Z
PLAN VIEW
SCALE: 1"= 15'-0"
8
8.09'
15.59'
Z
F
D
7'-6"
23'-6"
7'-9"
EL. 1052.67'
A
6'-6"
LOCATION OF ARS
PT. 106
34'-6"
SECTION A
SCALE: 1"= 15'-0"
Y
EL. 1018'-2"
X

FIG. F.14

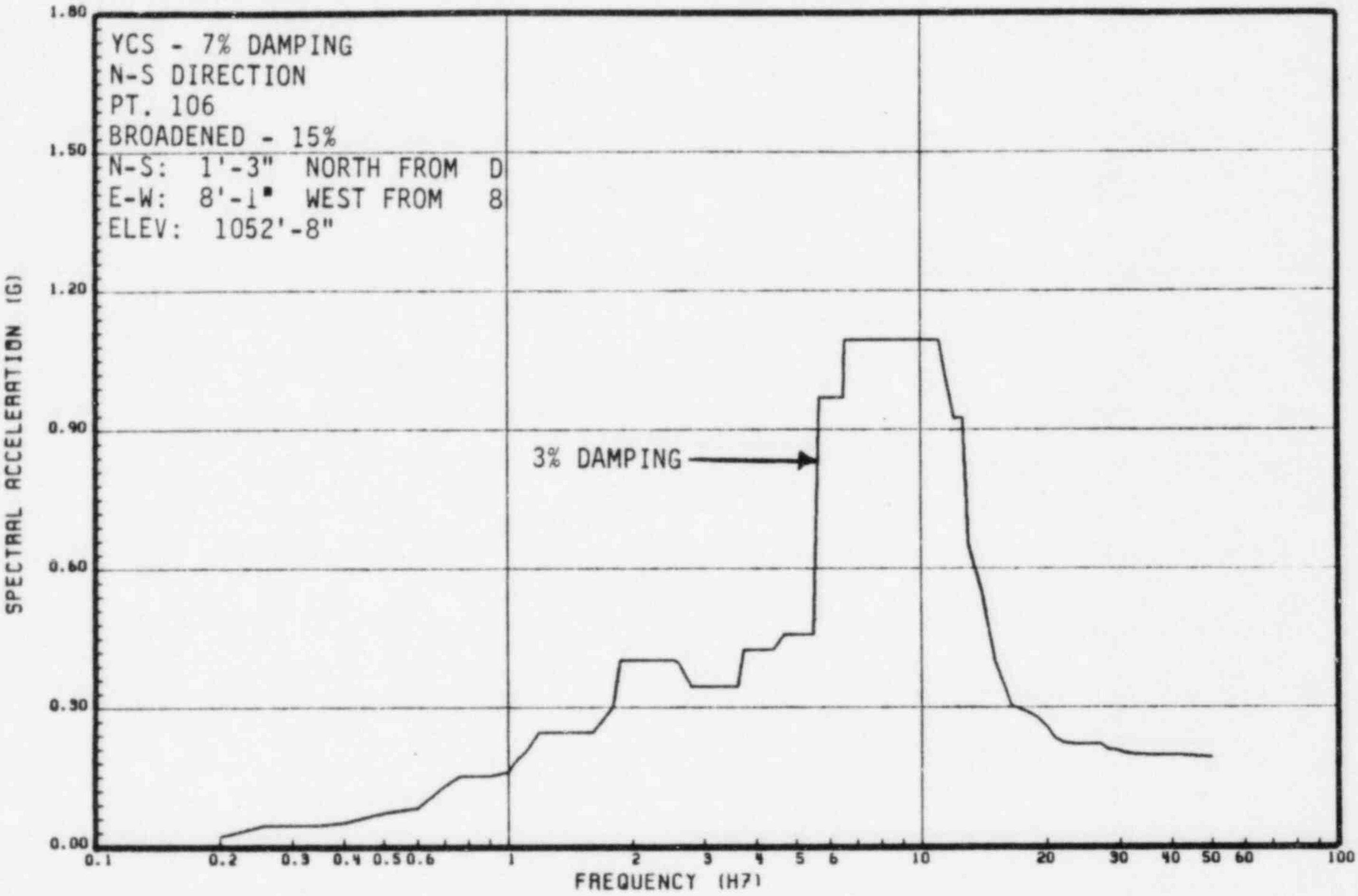

YCS - 7% DAMPING
N-S DIRECTION
PT. 106
BROADENED - 15%
N-S: 1'-3" NORTH FROM D
E-W: 8'-1" WEST FROM 8
ELEV: 1052'-8"
3% DAMPING
SPECTRAL ACCELERATION (G)
FREQUENCY (HZ)
1.80
1.50
1.20
0.90
0.60
0.30
0.00
0.1
0.2
0.3
0.4
0.5
0.6
1
2
3
4
5
6
10
20
30
40
50
60
100

FIG. F.15

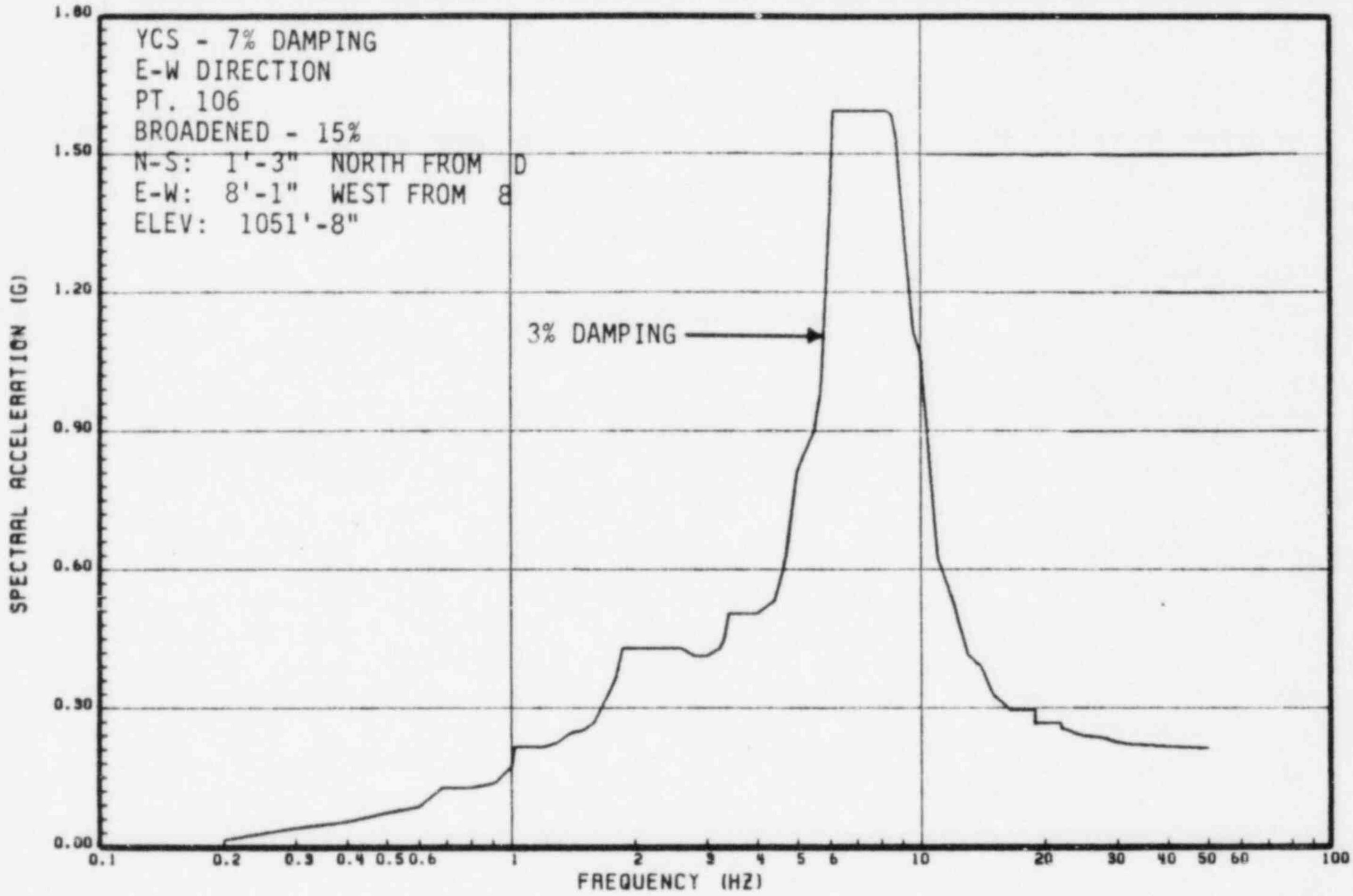

YCS - 7% DAMPING
E-W DIRECTION
PT. 106
BROADENED - 15%
N-S: 1'-3" NORTH FROM D
E-W: 8'-1" WEST FROM 8
ELEV: 1051'-8"
3% DAMPING
SPECTRAL ACCELERATION (G)
FREQUENCY (HZ)
1.80
1.50
1.20
0.90
0.60
0.30
0.00
0.1
0.2
0.3
0.4
0.5
0.6
1
2
3
4
5
6
10
20
30
40
50
60
100

FIG. F.16

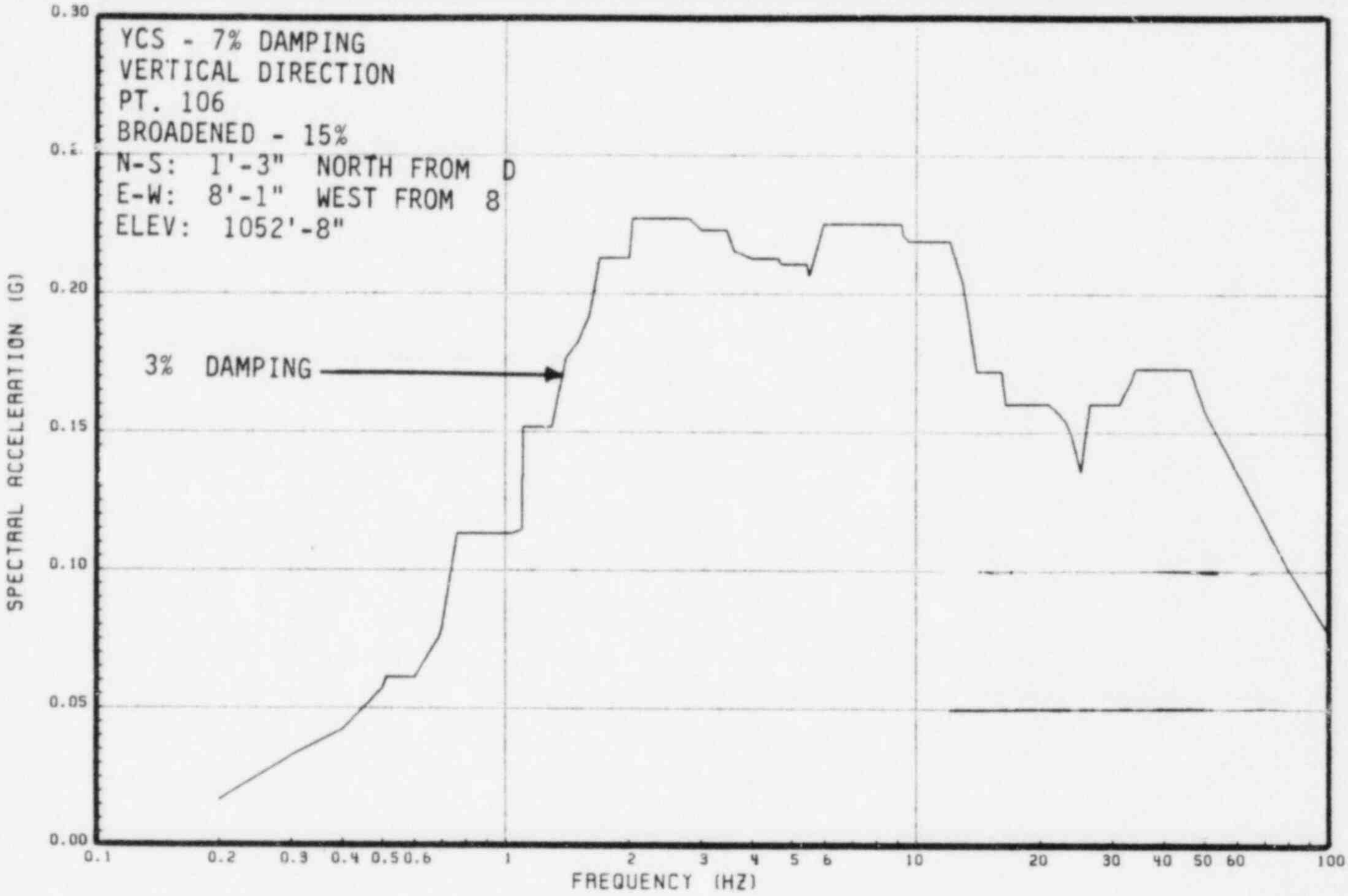

YCS - 7% DAMPING
VERTICAL DIRECTION
PT. 106
BROADENED - 15%
N-S: 1'-3" NORTH FROM D
E-W: 8'-1" WEST FROM 8
ELEV: 1052'-8"
3% DAMPING
SPECTRAL ACCELERATION (G)
FREQUENCY (HZ)
0.30
0.20
0.15
0.10
0.05
0.00
0.1
0.2
0.3
0.4
0.5
0.6
1
2
3
4
5
6
10
20
30
40
50
60
100

FIG. F.17

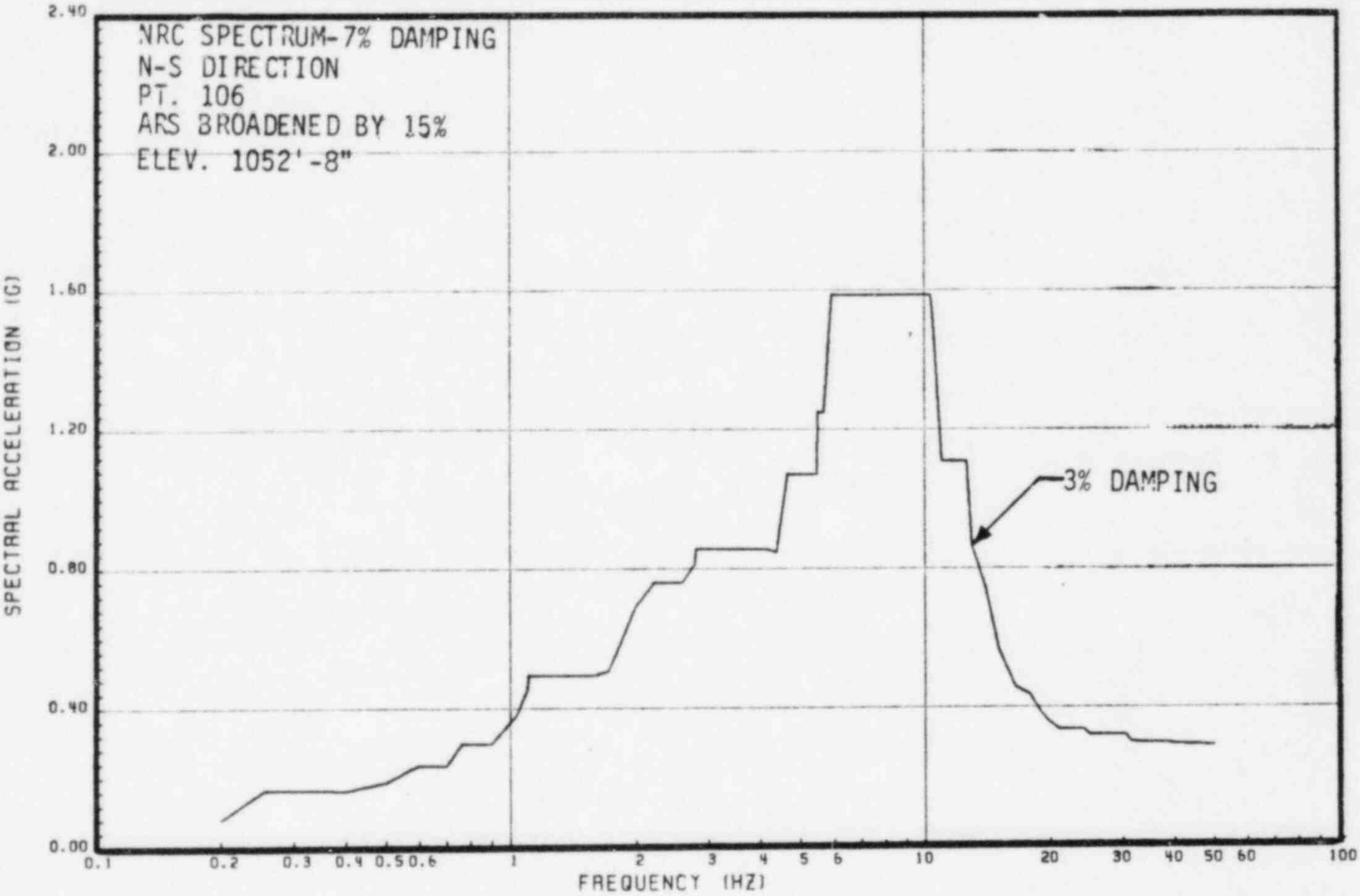

NRC SPECTRUM-7% DAMPING
N-S DIRECTION
PT. 106
ARS BROADENED BY 15%
ELEV. 1052'-8"
3% DAMPING
2.40
2.00
1.60
1.20
0.80
0.40
0.00
SPECTRAL ACCELERATION (G)
0.1
0.2
0.3
0.4
0.5
0.6
1
2
3
4
5
6
10
20
30
40
50
60
100
FREQUENCY (HZ)

FIG. F.18

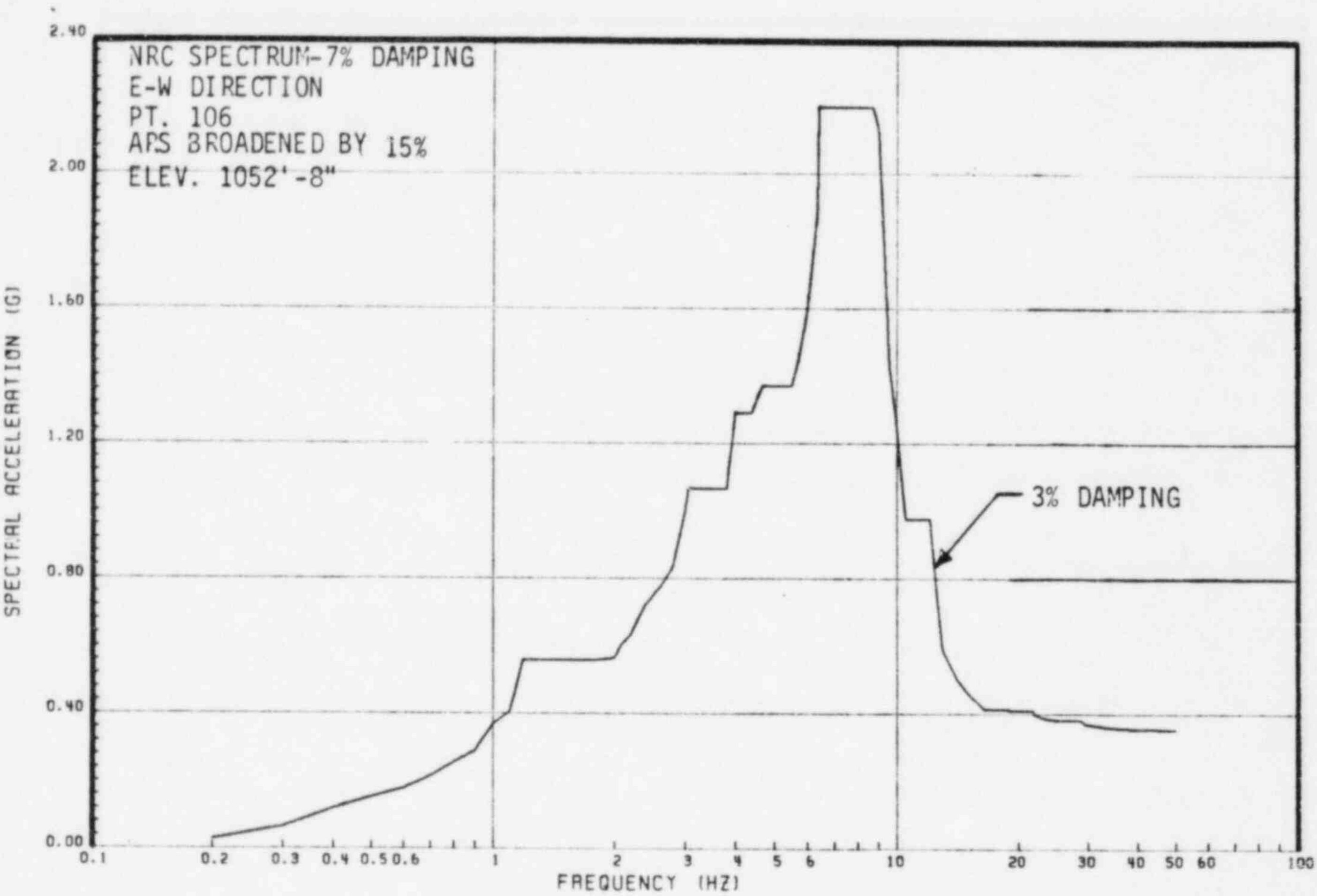

NRC SPECTRUM-7% DAMPING
E-W DIRECTION
PT. 106
ARS BROADENED BY 15%
ELEV. 1052'-8"
3% DAMPING
SPECTRAL ACCELERATION (G)
FREQUENCY (HZ)
2.40
2.00
1.60
1.20
0.80
0.40
0.00
0.1
0.2
0.3
0.4 0.5 0.6
1
2
3
4
5
6
10
20
30
40
50 60
100

FIG. F.19

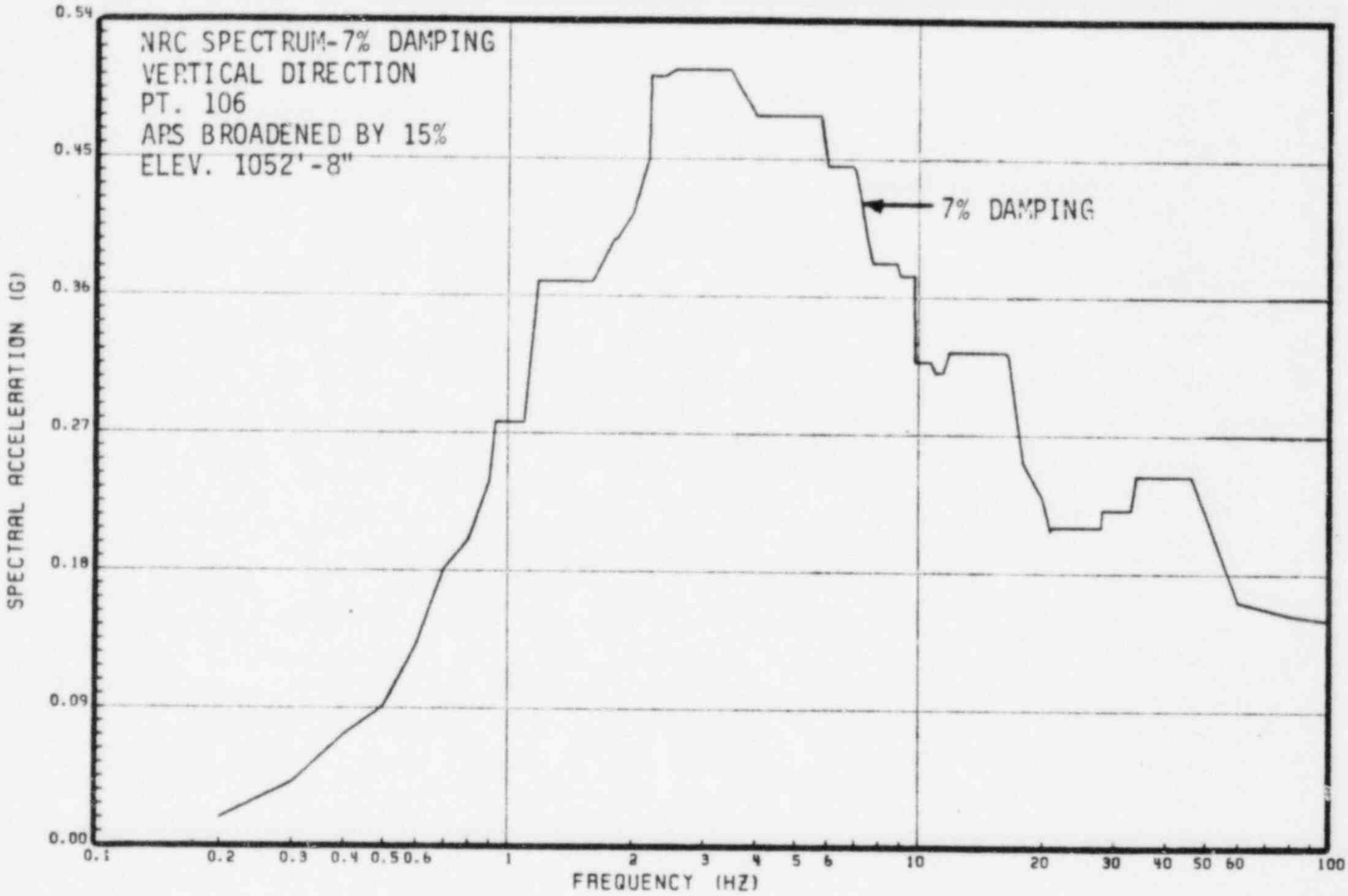

NRC SPECTRUM-7% DAMPING
VERTICAL DIRECTION
PT. 106
APS BROADENED BY 15%
ELEV. 1052'-8"
7% DAMPING
SPECTRAL ACCELERATION (G)
0.54
0.45
0.36
0.27
0.18
0.09
0.00
0.1
0.2
0.3
0.4
0.5
0.6
1
2
3
4
5
6
10
20
30
40
50
60
100
FREQUENCY (HZ)

FIG. F.20

APPENDIX G

REFERENCES

APPENDIX G

REFERENCES

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