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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In The Matter of	)	
	)	
COMMONWEALTH EDISON COMPANY	)	Docket Nos. 50-454-OL
	)	50-455-OL
(Byron Nuclear Power Station,	)	
Units 1 & 2)	)	

SUMMARY OF THE TESTIMONY OF
KENNETH T. KOSTAL
ON CONTENTION 1

I. Kenneth T. Kostal is the assistant manager of the Structural Department of Sargent & Lundy.

II. Mr. Kostal is familiar with the work performed by Systems Control Corporation for Byron. Systems Control supplied, per S&L design specifications, main control boards (including DC fuse panels), local instrument panels, cable trays, and cable tray hangers. Mr. Kostal's testimony discusses the capacity of various Systems Control-supplied components to carry design loads.

III. The first component discussed in Mr. Kostal's testimony is cable tray hangers. The most significant engineering evaluation of cable tray hangers at Byron was performed pursuant to Edison Byron NCRs 850 and 885. A random sample of 80 hangers, encompassing 358 connections, was inspected, and all discrepancies were evaluated. None of the discrepant welds had design significance. Additional engineering evaluations were performed on specific weld connections as well, and each of these determined that the particular discrepancy at issue did not have design significance. Mr. Kostal concludes that the Systems Control cable tray hangers are capable of carrying design loads, and therefore their quality is adequate.

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IV. Mr. Kostal's testimony then discusses Systems Control cable trays, including cable tray fittings, ladder cable trays, and ladder fittings. Cable tray stiffener welding was evaluated by S&L, and the discrepancies discovered in the sample of 227 stiffeners were found to be not design significant. In addition, further analysis demonstrated that the stiffeners are not required for the functioning of the cable trays. Cable tray fittings also were evaluated, and it was determined that because of redundant load paths the fitting welds are not required for the fittings to meet structural load-carrying requirements. A recent inspection of cable ladder trays and ladder fittings determined that all identified discrepancies are not design significant, and therefore these components are capable of carrying design loads. Mr. Kostal concludes that the Systems Control cable trays, including solid-bottom trays and fittings and ladder trays and fittings, are capable of carrying design loads, and therefore their quality is adequate.

V. Mr. Kostal's testimony then discusses Systems Control local instrument panels. Mr. Kostal describes the seismic qualification of the panels, and explains the recent weld inspection program implemented for the panels due to the weld discrepancies discovered by Torrey Pines Technology during its third party review of Systems Control. This inspection program was evaluated and the conclusion was reached that the entire population of local instrument panels is seismically qualified. Mr. Kostal concludes that the Systems Control local instrument panels are capable of carrying design loads, and therefore their quality is adequate.

VI. The final components discussed by Mr. Kostal are the DC fuse panels supplied by Systems Control. Mr. Kostal describes the seismic qualification of the DC panels, and then discusses the engineering evaluation of the weld discrepancies identified on the panels which was performed to determine whether the non-tested panels could be deemed to be equivalent to the seismically-tested panel for the purposes of seismic qualification. Mr. Kostal concludes that the Systems Control DC fuse panels are capable of carrying design loads, and therefore their quality is adequate.

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TESTIMONY OF
KENNETH T. KOSTAL

Q.1. Please state your name.

A.1. Kenneth Thomas Kostal.

Q.2. Who is your employer?

A.2. Sargent & Lundy.

Q.3. Please describe Sargent & Lundy.

A.3. Sargent & Lundy is a consulting engineering firm providing services to the utility industry. The firm has been in existence since 1891 and has exclusively performed engineering and consulting work on energy related areas of the utility industry since its founding.

Q.4. What are Sargent & Lundy's responsibilities in connection with the Byron Station?

A.4. It is the architect/engineer responsible for the design of the plant.

Q.5. What types of engineering work does Sargent & Lundy perform at Byron?

A.5. Sargent & Lundy performs engineering work related to all aspects of design: mechanical, architectural, civil/structural, and electrical.

Q.6. What is your position at Sargent & Lundy?

A.6. I am a partner and assistant manager of the Structural Department.

Q.7. Please describe your job responsibilities.

A.7. I assist the manager of the Structural Department in coordinating all structural, architectural, and civil engineering design for Sargent & Lundy. I assist the manager in all matters of supervision, administration, personnel and technical policies. I have direct responsibility for the Specifications, Geotechnical, and Water Resources & Site Development Divisions.

Q.8. What is your educational and employment background?

A.8. I graduated from the University of Illinois in 1965 with a BA in Architectural Engineering and in 1967 with a MS in Architectural Engineering. I have 19 years of experience in the field of civil engineering which includes civil/structural/architectural engineering and design work for fossil and nuclear power

plants. My assignments have included 14 units with a total capacity in excess of 10,000 megawatts. I have also been involved in numerous studies.

Prior to joining Sargent & Lundy in 1967 I was engaged by the University of Illinois as an instructor in structural design and as an engineer responsible for structural design and construction drawings for light office buildings.

I am a registered professional engineer in 25 states and I also have a separate structural engineering license in the State of Illinois and am licensed in Alberta, Canada. Presently I am a member of the following organizations:

American Concrete Institute
American Institute of Steel Construction
American Nuclear Society
American Society of Civil Engineers
Structural Engineers Association of Illinois
Western Society of Engineers

Q.9. How many years have your worked with nuclear power facilities?

A.9. Seventeen years.

Q.10. What nuclear power facilities have you been involved with?

A.10. Ft. St. Vrain (Public Service Colorado), Donald C. Cook (American Electric Power), Byron/Braidwood, Zion, LaSalle County (Commonwealth Edison) Marble Hill (Public Service Indiana), and Clinton (Illinois Power).

Q.11. What types of work have you performed in connection with your work on nuclear power facilities?

A.11. Throughout my career at Sargent & Lundy I have been involved in the structural, architectural, and civil engineering aspects of numerous nuclear power plants. I began my career at Sargent & Lundy as a designer on the Ft. St. Vrain nuclear power plant. I was specifically involved in concrete foundation design and steel superstructure. As I progressed through a series of supervisory positions on various nuclear plants, I was responsible for coordinating civil/structural, architectural, and drafting activities. While assigned to these projects I was intimately involved with the licensing activities for each and have on numerous occasions made technical presentations to the NRC relating to structural issues. I have also provided testimony on technical issues to various ASLBs relating to civil and structural issues.

Q.12. Are you familiar with Systems Control Corporation?

A.12. Yes. Systems Control Corporation ("SCC") is a vendor that supplied components to Byron. The components supplied to Byron by Systems Control fall into four broad categories: main control boards (including DC fuse panels), local instrument panels, cable trays, and cable tray hangers. The components supplied by Systems Control were designed to meet specifications established by Sargent & Lundy. These design specifications are F/L 2788 (main control boards), F/L 2805 (local instrument panels), and F/L 2815 (cable trays and hangers).

Main control boards provide the mountings for various types of instrumentation in the main control room at Byron. DC fuse panels also were provided under the Sargent & Lundy specification for main control boards. The DC fuse panels provide the mountings for various fuses and relays which protect the direct current system, and are located in the battery rooms adjacent to the main control room at the plant. Local instrument panels are the mountings for various instrumentation located throughout the plant. Cable trays support the plant's cables. Cable trays supplied by Systems Control were in two configurations. The first type, which comprises about 97% of the safety-related cable trays at the plant, is a steel

trough way composed of sheet metal steel, 12", 18", 24", or 30" wide by 4" to 6" in height. The second tray configuration is known as a "ladder" or "open bottom" tray. It resembles a steel ladder, with pipe rungs at approximately 12" intervals. This type of tray is used where cables must be permitted to drop below the tray (through the rungs) for routing to electrical equipment. Both types of cable trays are connected to the plant's main structure by cable tray hangers.

Q.13. What is the scope of your testimony?

A.13. My testimony discusses the capacity of various Systems Control-supplied components to carry design loads. In particular, my testimony will encompass cable trays, cable tray hangers, local instrument panels, and DC fuse panels. The testimony of Bradley Maurer, of Westinghouse, addresses the main control boards supplied to Byron by Systems Control. My testimony will include discussion of the engineering evaluations performed by S&L on the Systems Control components, and after reviewing the condition of each component I will testify to my professional opinion of the component's adequacy.

Q.14. Are you familiar with the engineering evaluations performed by Sargent & Lundy on the Systems Control-supplied components?

A.14. Yes, I am. Each of the evaluations to which I refer in my testimony falls within my area of professional expertise, and I have reviewed each of them. The evaluations of the Systems Control cable trays and cable tray hangers were performed by structural engineers who work under my indirect supervision. The evaluations involving the DC fuse panels and local instrument panels were performed by mechanical engineers, who do not work under my supervision. The evaluations of the DC panels and local instrument panels at issue, however, involve structural issues, even though these components fall within the overall scope of work performed by our mechanical engineers.

Q.15. What is the purpose of the engineering evaluations that have been performed by Sargent & Lundy on components supplied to Byron by Systems Control?

A.15. The purpose of these evaluations is to determine the design significance, if any, of the discrepancies identified in the Systems Control equipment supplied to the site.

Q.16. Over what period of time have these evaluations been performed?

A.16. They have been performed since 1977, first as a means of dispositioning specific nonconformance reports and, more recently, in preparation for this hearing after it was learned that source inspections of SCC-supplied components by Pittsburgh Testing Laborabory after February 1980, had not been fully implemented.

Q.17. Please define the term "design significance."

A.17. "Design significance," as used in my testimony, relates to the ability of structural components to perform their intended function, which is to carry all design loads within code-established allowable stresses. Code-established allowable stresses are incorporated into the design criteria for all equipment supplied to Byron. These code established allowable stresses have been developed to assure additional margins of safety against failure. Code writers typically attempt to attain a margin of approximately two. This means that a structure designed to a code could carry approximately twice the design load and not fail. Anything which affects the ability of a structural component to perform a function within the code-allowable stresses has design significance. As is discussed in detail in the following testimony,

Sargent & Lundy's engineering evaluations demonstrated that the stresses on Systems Control components installed at Byron are within the code-allowable stresses, and consequently no item was found to have design significance.

Q.18. What are the elements that comprise the design loads that Systems Control equipment must be able to carry?

A.18. Systems Control equipment is designed to carry both dead loads and seismic loads. Dead loads derive from the weight of the equipment itself along with additional dead loads imposed by cable, instruments or other equipment. The equipment also is designed to withstand the effects of seismic loads, which are a function of the building seismic response at the location of the equipment.

Q.19. Please define the term "design margin."

A.19. The concept of margin is one that is inherent in the engineering discipline. Engineers design a structure such that it is sufficiently strong to withstand the expected forces and stresses with spare or extra strength to account for uncertainties and contingencies. This extra strength is called margin.

"Design margin" is the difference between code-allowable stress and actual stress. Engineers maintain the presence of design margins by ensuring that actual stress is less than code-allowable stress. For example, connections are designed in groups rather than individually. The most highly stressed connection is designed to be within code-allowable stresses; therefore, all other connections within the group, which are not highly stressed, have even greater design margins. Thus, the actual stresses for most connections in the example will be less than those allowed by the applicable code.

There is a second margin in the structural design of connections. This is the margin that code writers put into the design process in the form of the difference between code-allowable stresses and the failure of a component. Code writers typically attempt to obtain a margin of approximately two when they write a code. This means that a structure designed to a code could carry approximately twice the design load and not fail.

Q.20. Please describe the Systems Control cable tray hangers at Byron.

A.20. Systems Control provided cable tray hanger assemblies at Byron. Figure 1, attached to my testimony, depicts a typical cable tray support system: a cable tray

hanger is comprised of both horizontal and vertical members, which can be tube or channel strut members. These members are fabricated in the shop with end connections which are welded to the connecting vertical or horizontal members. Figures 2 and 3 are details of the connection of a horizontal to vertical member. They illustrate the location of the Systems Control shop weld and the Hatfield Electric Company field weld (Hatfield installed the components supplied to the site by SCC). The hanger assembly, when field installed, supports the cable tray.

It should be noted that each weld, both the shop weld by Systems Control and the field weld by Hatfield, is required to support the total design loads for the hanger. Depending on the connection detail, one of the two welds will govern the capability of the connection to accept design loads in that it will be the most highly stressed weld in that connection. Regardless of which weld is governing, both welds are designed to accept code-allowable stresses; therefore, the noncontrolling weld is less highly stressed and has a greater design margin which allows the weld to accomodate discrepancies. This represents an additional conservatism in the design of the plant's cable tray hanger system.

Q.21. Please describe the engineering evaluations performed by Sargent & Lundy on cable tray hangers provided by Systems Control.

A.21. The most significant engineering evaluation performed by Sargent & Lundy for Systems Control cable tray hangers at Byron occurred in 1984, pursuant to Commonwealth Edison's Byron NCRs 850 and 885. NCR 850 was issued to document and track the problem of general weld quality discrepancies found on Systems Control hangers by Hatfield Electric Company quality control personnel at Byron.

NCR 850 was issued in September 1983, and subsequently Hatfield was asked to provide more detailed information on the weld discrepancies it had identified. NCR 885 was issued in February 1984 to track disposition of the detailed weld discrepancies provided by Hatfield. Thus NCRs 850 and 885 encompass the same issue.

In order to address the general concern for weld quality covered in NCRs 850 and 885, a random sample of 80 hangers from the population of 5,717 Systems Control hangers at Byron was identified by Sargent & Lundy for weld inspection. The sample was selected from the population of hangers using a list of random numbers. This selection process ensured that the sample was

unbiased and representative of all hangers in the plant. The sample captured all commonly used connection types, including 44 connections that, based on the original design, were deemed to be highly stressed.

The inspections of the selected hangers were performed by Hatfield with verification through field inspections by CECo's third party inspectors (Sargent & Lundy Level III inspectors on loan to Commonwealth Edison). The 80 hangers included 358 Systems Control shop-welded connections. Of the 358 connections inspected from the sample of 80 hangers, 252 connections had no discrepancies, and 106 were found to have some form of discrepancies such as underlength, undersize, overlap, undercut, craters, and two connections with missing portions of welds. None of the welds had cracks.

The engineering evaluation of the discrepant welds was performed in the same manner as in the Byron QC Inspector Reinspection Program. That portion of a weld with a discrepancy was conservatively deleted from the total weld length, and new connection capacities were calculated. These new connection capacities were evaluated against the design capacities. Based on the results of the evaluations, none of the discrepant welds had design significance This fact was

later confirmed by the results of a structural computer analysis of the three hanger assemblies which include the three most discrepant welds identified during the inspection program.

Q.22. Please explain the nature of the analysis performed with respect to the most discrepant welds.

A.22. In order to determine whether the hangers which incorporated the most discrepant welds identified in the inspection program remained capable of carrying design loads notwithstanding the discrepant weld, detailed computer models were developed for the three hanger assemblies. These hangers were those which contained the three welds found during the evaluation of the 358 connections to have the greatest reductions in load capacity. Each connection in these hanger assemblies was mapped, encompassing both Systems Control and Hatfield welds associated with these connections, and all identified weld discrepancies, including the most discrepant welds, were incorporated into the the computer model.

Each model was then analyzed for design loading conditions for the entire hanger assembly. This analysis redistributed the loads among the hanger connections to reflect the presence of the weld discrepancies.

The analysis showed that even though an individual connection had reduction in weld capacity, none of the connections or structural members exceeded the code-allowable stress, even when loaded to twice the design load.

This demonstrates that inherent margins do exist in the hangers in the cable tray hanger system in the form of load-bearing redundanies. These analyses thus further demonstrate that the weld discrepancies identified in the inspections of System Control hangers are not significant in relation to hanger load-carrying capacity.

Q.23. Has Sargent & Lundy performed other engineering evaluations at Byron which indicate the adequacy of Systems Control cable tray hangers?

A.23. Yes. Sargent & Lundy has performed various other evaluations on specific hanger connections. In each case these evaluations showed that the weld discrepancies did not compromise the design.

Byron NCR 813, issued in April 1983, identified the fact that welds were undersized for DV-2 connections (Figure 4) which use strut members (P5501). For the connection detail specified, only a 1/16" fillet weld could be installed, in lieu of the 1/8" weld specified.

Drawings called for the use of the DV-2 connection with P5501 strut members on 593 hangers. 64 of these connections were randomly selected for engineering evaluation to determine if the use of a 1/16" weld was acceptable. Due to the extremely low stress in this connection type as originally designed, all of the sampled connections were found to have adequate load carrying capacity.

In evaluating the DV-2 connection no credit was taken for weld penetration into the radius of the strut member. Figure 4 illustrates the curvature of the strut members. Weld is deposited between the plate and the curved section of the strut. This portion of the weld is not considered in the design to carry loads, although the weld penetration provides additional weld capacity.

In addition, the macro-etching of a DV-2 connection showed that the actual effective weld size was twice that of the 1/16" weld size used in the initial disposition of NCR 813. A macroetch is made by cutting through the weld joint transverse to the weld length, polishing the surface and applying an etching acid to reveal the exact amount of weld penetration. The connection selected for macroetching was the DV-2 connection with a P5501 strut with the smallest weld size

from among the 13 DV-2 connections with discrepancies identified in the random sample of 80 cable tray hangers reviewed in response to NCRs 850 and 885. The results of the eight macroetches performed on the connection indicated that the actual effective throat on the macroetched sides ranged from 0.09 to 0.15 inches. The assumed effective throat used in the evaluation of NCR 813 was 0.044 inches (the effective throat of 1/16" weld), which is approximately one-half of the minimum value found on the macroetched samples.

Because NCR 813 did not identify weld quality as a problem, its disposition addressed the issue of weld size only. Subsequently, in order to consider the effect of possible weld quality discrepancies in the DV-2 connections, the results of the weld quality inspections of DV-2 connections in the sample of the 80 hangers associated with NCRs 850 and 885 were used to establish the weld with the greatest reduction in load-bearing capacity. This weld capacity level was applied to all DV-2 connections. Since large design margins exist in the DV-2 connection it was found that the connection can accomodate the lowest weld capacity level and still remain within code-allowable stress.

Sargent & Lundy's evaluations in connection with Byron NCR 893 are also pertinent to the issue of overall

hanger weld quality. This NCR, issued in March 1984, documented an allegation that welds in the DV-162 connections (Figure 5) were undersized by 1/8". The DV-162 connection is used in two types of hanger assemblies, those in longitudinally-braced hangers and those in unbraced hangers. For longitudinally-braced hangers it was shown that the Hatfield field welds associated with this connection govern the design capacity of the connection. Therefore, our engineering evaluation determined that a shop weld undersized by 1/8" was acceptable.

For unbraced hangers, which constitute approximately 50% of the total DV-162 connections, the SCC weld generally governs the design; therefore, an inspection biased toward a group of highly stressed unbraced hanger connections was performed. A sample of 100 connections out of a total population of 2,563 DV-162 connections was inspected for weld size, length, and quality. 41 connections contained no discrepancies. 59 connections contained discrepancies, although nine contained only weld quality discrepancies, and not discrepancies of weld size. All of the 59 connections with discrepancies were determined to be capable of carrying design loads. Moreover, the inspection revealed that there was no general tendency toward

welds being undersized by as much as 1/8", as originally stated in NCR 893; in fact, a portion of the weld was undersized by 1/8" or more in only 6% of the connections sampled, and 50% of the connections had full size or larger welds.

The disposition of Byron NCR 772 represents a comparable situation. This NCR was issued in January 1983, and documented the fact that the horizontal weld to the inside of the gusset plate in DV-1 and DV-4 connections was omitted in some cases. Upon review of the connection, Sargent & Lundy concluded that the weld could be omitted without having an impact upon the required design capacity. Engineering evaluation demonstrated that the two vertical welds in the connection were, in themselves, sufficient to carry the design loads.

Q.24. Are there other CECo Byron NCRs related to cable tray hangers supplied by Systems Control?

A.24. Yes. CECo's Byron NCR 105 encompassed the welder qualifications and procedures utilized by Systems Control in the fabrication of cable tray hangers. One hundred percent of the hangers on site at that time (1977) were inspected and all weld discrepancies were corrected.

CECo's Byron NCR 407 also involved Systems Control hangers. This NCR, issued in August 1979, documented the fact that two hangers were fabricated with DV-1 connections rather than the specified DV-5 connections. These types of connections are similar, however, and Sargent & Lundy concluded that the substitution of one for the other was acceptable on the subject hangers.

Q.25. Do you have an opinion concerning the quality of the cable tray hangers supplied by Byron by Systems Control?

A.25. Yes, I have concluded that because the cable tray hangers are capable of carrying design loads, the quality of these hangers is adequate.

Q.26. What is the basis for your opinion?

A.26. My opinion is based on engineering judgment that relies on the following significant elements, each of which reflects the margins which characterize the cable tray hanger system: first, the absence of design significant discrepancies identified in any of the evaluations performed with respect to Systems Control hanger work; second, the load-bearing redundancies which exist in the cable tray hanger system; and third, the conservative design and analytical criteria utilized by Sargent & Lundy at the Byron Station.

With regard to the first point, the 358 connections on the 80 randomly sampled hangers that were inspected in conjunction with NCRs 850 and 885 did not have any design significant discrepancies. Moreover, the connections inspected and evaluated in connection with resolution of the Byron NCRs involving specific hanger connections also did not demonstrate design significant discrepancies. Specifically, the evaluations of the DV-2 and DV-162 connections determined that they were adequate in their as-built condition to sustain design loads. In sum, no discrepancies with design significance were identified in any of the engineering evaluations of Systems Control cable tray hangers performed over the years by Sargent & Lundy.

With regard to the second point, the analysis of the three hanger assemblies with the most discrepant welds showed that the hangers, through the distribution of loading, are capable of carrying design loads. The computer analysis demonstrated that none of the connections or members exceeded the allowable stress even when loaded to twice the design load. The large design margins in these hangers confirms my professional judgment that large design margins exist in Systems Control hangers throughout the plant, and that the SCC hangers are able to absorb weld discrepancies

through their load-bearing redundancies and still carry design loads.

With regard to the third point, there exist conservatisms in the design and analytical criteria utilized by S&L. Conservatism is applied in the design of cable tray hangers through an enveloped seismic response spectra, which is typically used in the industry. Further design conservatism derives from the use of a time history analysis to determine a more exact seismic response for Byron hangers.

Sargent & Lundy's conservative analytical criteria in evaluating weld capacity furthe: confirms my judgment concerning Systems Control hangers. This further conservatism derives fro the deletion in our engineering evaluations, for the purposes of recalculating weld capacity, of that portion of a weld which has discrepancies. The discrepant portions of the welds still have a significant amount of structural strength in most cases; e.g., in cases of porosity the weld may have no reduction in strength at all.

Because of the absence of design significant discrepancies, the load-bearing redundancies present in the cable tray hangers system, plus the conservatisms of overall Byron design and the Sargent & Lundy analyses

of the hangers, it is my professional judgment that the Systems Control cable tray hangers at Byron Station are capable of carrying design loads.

Q.27. Are any additional inspections of Systems Control cable tray hangers being performed?

A.27. Yes. During the inspection of the 358 connections, two instances of missing portions of welds were observed. These welds were associated with a DV-8 connection (Figure 3) and a DV-120 (Figure 6) connection. Even though these missing portions of welds were evaluated and found to have no design significance, they caused the largest amount of capacity reduction in the discrepant connections. Consequently, in order to assure that missing portions of welds do not compromise the adequacy of other connections, an additional inspection program for missing portions of welds is being performed. 100% of all connections which cannot accomodate the largest amount of capacity reduction as determined in the evaluation of the missing portions of welds and still remain within code-allowables will be inspected for missing portions of welds. Any weld missing a portion of weld will be evaluated and the portion will be restored if current design requirements require such a disposition.

Q.28. Please describe the Systems Control cable trays at Byron.

A.28. The cable tray system is shown in Figure 7. This figure depicts cable trays, a cable tray fitting, associated stiffeners attached to the cable tray, and fitting and adjoining attachments. The figure also depicts the cable tray hangers which support the cable trays to the main building structure. The cable trays are steel trough-ways comprised of sheet metal which support the plant cables. The trays are formed by bending flat pieces of steel into trough configurations that can be 12", 18", 24" or 30" in width, with side channels 4" to 6" in height. Sheet metal V-shaped stiffeners are stitch welded across the bottom of trays to provide support (Figure 8). These stiffeners are placed at 5' intervals. The fabricated sections of tray are bolted together in the field and the sections are supported by cable tray hangers.

Cable tray fittings are used when a change in direction of the cable tray run is required, to form the intersection of two or more trays, or to make a transition from one size tray to another (Figure 9). Cable tray fittings are fabricated in a similar manner to straight sections of cable tray. Additional welds are provided in tray fittings to splice together ver-

tical side channels located where the fittings change direction in order to form a continuous side channel. Stiffeners are also attached to the bottom of tray fittings.

In addition to the solid bottom cable trays and fittings just described, ladder trays (Figure 10) are also used. Ladder trays are constructed utilizing two sheet metal side channels which are connected together with pipe rungs at approximately 12" intervals. These pipe rungs are welded to the side channels. The resulting open bottom of this type of tray allows cables to drop out of the bottom of the tray to equipment located beneath the tray. T-type ladder tray fittings are used where two ladder trays intersect and these fittings are constructed in a similar manner to straight ladder trays.

Q.29. Please describe the engineering evaluations performed by Sargent & Lundy on cable trays provided to Byron by Systems Control.

A.29. Engineering evaluations have been performed on all the types of Systems Control cable trays and fittings described in Question 28. These evaluations have been based on the inspection results obtained at various times during fabrication and erection.

First, the welding of cable tray stiffeners has been evaluated. Discrepant welds on cable tray stiffeners were identified in July 1980, and Commonwealth Edison's Byron NCR 529 was issued to document and track this concern. Specifically, weld length and spacing on tray stiffeners did not conform to design specifications. As I stated above, cable tray stiffeners are steel sheet metal members stitch welded to the underside of cable trays to provide additional structural rigidity to the trays. Continuous welds attaching the stiffener to the tray bottom are provided at the ends of the stiffener.

A random sample of cable tray stiffeners was inspected to address this issue. The sampling plan was established to ensure that representative types of cable trays and cable tray fittings were selected. Cable trays and fittings at all building floor elevations were included in the sample and consequently no specific floor was favored by inspection of a majority of samples from that elevation. Both straight sections of cable tray and various types of cable tray fittings were included in the sample.

Inspections were performed by Pittsburgh Testing Laboratory and verified by Commonwealth Edison's Byron site quality assurance personnel. 123 cable tray and

cable tray fitting sections encompassing 227 individual stiffeners were inspected. All of the stiffeners had weld in excess of the minimum amount required by design.

After completion of the inspection of stiffener weld length and spacing, in early 1981, the NRC Staff requested a review of the quality of the stiffener welds, in addition to the length and spacing of the welds. Review of stiffener weld quality subsequently was documented in Edison Byron NCR 707. Reinspection of the same 123 cable trays and fittings examined for weld length and spacing was performed for weld quality. Weld discrepancies were found in each stiffener, and included lack of fusion, undersize, cracks, craters, undercut, and porosity. In addition, small linear crack indications approximately 1/4" in length were observed. These indications were evaluated to be non-propagating due to their material characteristics and small size. Engineering evaluation of the discrepant welds was performed. That portion of a weld with a discrepancy was conservatively deleted from the total weld length, and new weld capacities were calculated. These new capacities were evaluated against the actual required capacities. It was determined that all welds were adequate to transfer design loads.

Sargent & Lundy performed an additional evaluation of cable tray stiffeners in preparation for these hearings which focused on the ramifications of the presence of cracks in the end welds of stiffeners. As noted above, small cracks had been identified in the weld inspections performed in connection with the evaluation of stiffener weld quality. In the Byron QC Inspector Reinspection Program, when a crack was observed in a weld the entire weld conservatively was considered to carry no load. To follow the same methodology with regard to Systems Control welds, Sargent & Lundy performed an engineering evaluation which, to reflect the existence of cracks in the end welds of a stiffener, conservatively assumed the complete absence of a stiffener from a cable tray. This analysis thus conservatively assumed the absence of both the stiffener's end welds and the stitch welding to the bottom of the cable tray. The analysis demonstrated that the membrane capacity of the sheet metal cable tray bottom is adequate to support the cable load for the tray span between hangers. The analysis showed that the bottom of the cable tray transfers the cable load either directly to the adjacent hangers or to the side walls of the tray and from the side walls to the adjacent hangers. Consequently, the evaluation indicated that the absence of tray stiffeners is not

significant to the design, and cable trays will carry design loads even without stiffeners.

The results of the above-described evaluations of stiffeners have led me to conclude as a matter of engineering judgment that the stiffeners supplied by Systems Control to Byron are adequate to carry design loads.

Q.30. Please describe the engineering evaluation performed by Sargent & Lundy with regard to Systems Control cable tray fittings.

A.30. Inspections of cable tray fittings were performed in 1977 pursuant to Commonwealth Edison's Byron NCR 105. NCR 105 was issued in response to the fact that Systems Control did not have approved welder qualifications and procedures. As part of the overall response to the nonconformance 99 fittings, out of approximately 1,200 which were at the Byron site at that time, were inspected by Industrial Contract Services for the purpose of determining SCC weld quality. Both stiffener welds and side channel welds were inspected. No discrepancies were found in the stiffener welds. Four fittings were found to have side channel weld discrepancies. These discrepancies included lack of fusion, porosity, and a missing weld attaching a corner bent

plate to the cable tray side channel. None of these discrepancies had design significance.

An engineering assessment was performed to review discrepant side channel welds. This assessment considered all load carrying elements in the fitting. Since alternate load paths are available to transfer loads through the fitting around the discrepant fitting weld the engineering assessment, at that time, concluded that these discrepancies had no design significance and would not be detrimental to the performance of the cable tray fittings. Although fitting welds do provide an added element of structural rigidity, the close proximity of hangers and the presence of stiffeners provide the needed structural integrity to assure the proper performance of the cable tray system.

In June 1984, Sargent & Lundy performed an additional engineering evaluation in order to confirm that the fitting welds are not required to meet structural load-carrying requirements for any fitting because of the presence of alternate load paths to carry the cable loading through the tray fittings. The evaluation confirmed that the fitting welds are not required to enable fittings to meet load requirements due to the existence of redundant load paths.

However, the evaluation determined that in one configuration, involving the outside fitting weld of a 90 degree fitting, only one load-bearing redundancy exists, the fitting stiffener. The fitting weld therefore is required if the stiffener weld in that corner of the fitting is missing. The condition of a missing stiffener weld at the outside corner of a 90 degree fitting has not been found in any inspection. In order to assure that this condition does not exist, however, all 90 degree fittings will be inspected to ensure that the outside fitting weld is there and uncracked. If a fitting side channel weld is either missing or cracked, the stiffener weld at that corner will be inspected. If the fitting weld is missing or cracked and the stiffener weld is also discrepant, the fitting will be repaired.

Q.31. Please describe the engineering evaluation performed by Sargent & Lundy on Systems Control ladder cable trays and ladder fittings.

A.31. Ladder-type trays (Figure 10) and ladder-type fittings make-up less than 3% of the entire length of cable trays found on the Byron project. A review of ladder trays and fittings was recently conducted in response to a question from the NRC Staff concerning the welding on these components. This review found that one

of the two welds called for in the design specifications to connect the tray rungs to the side channels generally was not present in the trays. The specifications called for the rungs to be connected to the side channels by both a horizontal weld along the bottom of the rung and a circumferential weld at the point where the rung meets the side channel. It is the horizontal weld that is not present (Figure 10, weld B).

Subsequent to this review, S&L determined that in 1976 it had informed Systems Control that the horizontal weld did not have to be installed. This decision was documented in meeting notes. The drawings for the ladder trays issued shortly thereafter did not reflect the deletion of the horizontal weld. Systems Control apparently acted in accordance with the decision made at the meeting. We learned of this problem at the time of the recent review of the ladder trays.

To confirm that the present condition of the ladder trays is adequate to carry design loads, an inspection program was implemented. Sargent & Lundy Level III inspectors on loan to Commonwealth Edison inspected a random sample of 17 straight sections of ladder tray, encompassing 300 weld connections. Discrepancies identified in this inspection included lack of fusion,

craters, underlength, and overlap. No cracks were observed nor were there any circumferential welds missing.

An engineering evaluation was performed to determine whether the inspected ladder trays can adequately support design loads while incorporating the identified weld discrepancies in the circumferential welds and the absence of the horizontal weld. Further engineering evaluation was performed to determine whether the entire population of ladder trays can adequately support design loads while incorporating the greatest reduction in circumferential weld capacity determined to exist based on the ladder tray weld inspection.

In addition, ten randomly selected ladder tray fittings, approximately 20% of the total fittings, were inspected to verify that the welded connections on the fittings are similar to those found in the straight sections of ladder trays. The connections on the ladder fittings were determined to be similar to those on the straight ladder tray sections, and the ladder tray fittings then were evaluated incorporating the greatest reduction in circumferential weld capacity associated with the weld discrepancies observed on the inspected straight ladder tray sections.

No design significant weld discrepancies were identified in the 300 ladder tray connections inspected. Moreover, application of the greatest reduction in weld capacity for the circumferential welds determined in the sample inspection of straight ladder tray connections to the entire population of ladder trays, including ladder tray fittings, did not reveal any instances in which a component could not carry design loads, even in the absence of the horizontal weld. Consequently, my pro- fessional judgment is that the ladder trays and ladder tray fittings supplied to Byron by Systems Control are adequate to carry design loads.

Q.32. Do you have an opinion concerning the quality of the cable trays supplied to Byron by Systems Control?

A.32. Yes, I have concluded that because the cable trays are capable of carrying design loads, the quality of these trays, including solid-bottom trays and fittings and ladder trays and fittings, is adequate.

Q.33. What is the basis for this opinion?

A.33. My opinion is based on engineering judgment that relies on the following significant elements, each of which reflects the margins which characterize the cable tray system: first, the absence of design sig-

nificant discrepancies identified with respect to Systems Control cable tray work, including solid bottom trays, ladder trays, and associated fittings; second, the load-bearing redundancies which exist in the cable tray system; and third, the conservative design and analytical criteria utilized by Sargent & Lundy at the Byron Station.

With regard to the first point, the inspections of Systems Control cable tray stiffeners, cable tray fittings, and cable ladder trays and ladder fittings, resulted in the identification of no discrepancies with design significance.

The second point relied upon for my engineering judgment is illustrated by the engineering evaluations of cable trays, which demonstrate the load-bearing redundancies that exist in the cable tray system. For instance, the strength of the cable tray sheet metal bottom to transfer loads to the vertical sections of the trays is not taken into account in the stiffener design and required stiffener welding. In our evaluation of stiffener welds all loads were assumed to act on the stiffener, which transfers the loads to the side sections of the cable tray and through the side sections to the cable tray hangers. In actuality, a major portion of the load is trans-

ferred through the cable tray bottom into the vertical side sections of the tray or directly to a hanger. This was demonstrated in Sargent & Lundy's recent analysis of the cable tray without stiffeners, which showed that cable trays will function within code-allowables even in the absence of stiffeners.

In addition, S&L's evaluation of fitting welds confirmed the presence of load-bearing redundancies in cable tray fittings. Because of alternate load paths, fitting welds are not required to maintain the structural adequacy of the component.

With regard to the third point, as in the case of cable tray hangers conservatism is applied in the design of cable trays through an enveloped seismic response spectra, which is typically used in the industry. As with the hangers, further conservatism derives from the use of a time history analysis to determine a more exact seismic response for cable trays at Byron.

In addition, the methodology of the engineering evaluations performed by S&L for cable trays provides further conservatism in the analysis of this Systems Control component. This conservatism derives from the deletion, for the purposes of recalculating weld

capacity, of that portion of a weld which is deemed discrepant. The discrepant portions of the welds still have a significant amount of structural strength in most cases, and this load-bearing capacity is disregarded for the purposes of analysis.

In view of these design and evaluation conservatisms and the fact that no significant design discrepancies were identified for the Systems Control cable trays, my professional judgment is that the Systems Control cable tray system, encompassing solid bottom trays and fittings, and ladder trays and fittings, is capable of carrying design loads.

Q.34. Please describe the local instrument panels supplied to Byron by Systems Control.

A.34. 76 local instrument panels were supplied to Byron by Systems Control. These panels are located throughout the plant and support instrumentation which monitor and control functions and equipment located in proximity to the panels.

The panels (Figures 11 and 12) are either 4' wide or 8' wide. They consist of vertical channel sections, horizontal structural tubes and angles and diagonal angle members. The entire instrument panel is welded

together and anchored to the main building structure by bolting. The instrument panel is braced with angle knee braces and diagonal cross braces. These members provide additional structural support in the lateral direction. The instruments are mounted on the horizontal tube steel members.

Q.35. Were any weld discrepancies discovered on the local instrument panels supplied by Systems Control during their installation at the Byron plant?

A.35. Yes, discrepant welds were found in 1980 on local instrument panels supplied by Systems Control. A 100% reinspection was performed on the instrument panels by Pittsburgh Testing Laboratory. Weld discrepancies were repaired.

Q.36. Why were these discrepant welds repaired?

A.36. They were repaired in order to preserve the validity of the seismic qualification test performed on these panels.

Q.37. When was the seismic qualification test performed?

A.37. It was performed in 1980 by Wyle Laboratories.

Q.38. What was the nature of the testing?

A.38. Prior to conducting seismic qualification testing, the natural frequency of the equipment first must be determined. This determination is made by conducting resonance search tests. In the case of local instrument panels supplied by Systems Control, resonance search tests were conducted on one 4' wide and one 8' wide panel.

These tests determined that the natural frequency of both the 4' and 8' panels is greater than 33 hertz (cycles per second). Panels with natural frequencies greater than 33 hertz will not experience dynamic amplification on the floor seismic input and are therefore considered rigid for seismic qualification purposes. Since the construction of the 4' local instrument panels is similar to the construction of the 8' panels, and since both panels were determined to be rigid and therefore would not experience amplification of the seismic input motion, Systems Control selected the 8' wide panel for the required seismic qualification test.

The 8' wide local instrument panel was then tested for seismic qualification by being subjected to a "shake table" test. This test subjects the panel to an input

motion that bounds the highest floor response spectra calculated at the location of all the local instrument panels in the plant. The test is deemed to be successful if the panel and the associated instrumentation mounted on the panel remain functional after the test has been completed. The 8' wide panel supplied by Systems Control passed the "shake table" test. As provided in the applicable IEE 344-1975 standard, it was concluded that all 4' and 8' wide local instrument panels fabricated by Systems Control were seismically qualified as long as their fabrication was accomplished in conformance with the same fabrication drawings and specifications as that used for the fabrication of the tested panel.

The test results of the resonance search test on the 4' and 8' panels and the shake table test on the 8' panel were reviewed by Sargent & Lundy. It was concluded that the tests were properly conducted by Wyle Laboratories, and that the results met the requirements of the specification (F/L-2809) developed by Sargent & Lundy.

Q.39. Were any discrepant welds discovered on Systems Control-supplied local instrument panels subsequent to 1980?

A.39. Yes. In June 1984, Torrey Pines Technology, while reviewing local instrument panels as a part of its third party review of the Systems Control work at Byron, inspected approximately 10% of the welds on seven different local instrument panels, 207 welds in total. Torrey Pines found no discrepancies on three of the seven panels. The other four panels were found to have 17 total discrepancies, eight on one, five on another, three on another, and one on the other. The weld discrepancies found by Torrey Pines resulted in minimal reduction in weld capacity.

Nevertheless, because of the Torrey Pines inspection findings, a weld inspection program was implemented to confirm that the local instrument panels installed at Byron were sufficiently equivalent to the panel qualified by Wyle to warrant applying the Wyle test results to the entire Byron local instrument panel population.

Q.40. What was the nature of this weld inspection program?

A.40. Sargent & Lundy Level III weld inspectors on loan to Commonwealth Edison inspected 17 local instrument panels, one of which had also been inspected by Torrey Pines. On four of these panels, two 4' and two 8' panels, all accessible welds were inspected. One of

these four panels was the Wyle-tested 8' panel, panel 1PL54J, which had been partially inspected by Torrey Pines. In addition, one of the four panels, panel 1PL78JA, was the 4' panel that had been resonance search tested by Wyle. These panels were completely inspected in order that a direct comparison could be made for equivalency purposes between the Wyle-tested 4' and 8' panels and two randomly selected 4' and 8' panels. On the other 13 inspected panels, ten weld connections were inspected for length, size, and quality. The ten connections were chosen as follows: two highly stressed connections in each panel, two connections similar to those found discrepant by Torrey Pines, and six connections selected randomly. A total of 389 weld connections were inspected, totalling 1,457 welds (including the 207 welds inspected by Torrey Pines).

Inspection of the local instrument panels by Sargent & Lundy identified similar weld discrepancies to those found by Torrey Pines. 271 discrepancies were found; they included overlap, craters, undercut, arc strikes, and underlength. No cracked or missing welds were found.

Q.41. How were these discrepancies dispositioned?

A.41. These discrepant welds were dispositioned by determining the effective quantity of weld on the inspected panels and by comparing that quantity with the same welds on the panels tested by Wyle Laboratory. In calculating the effective weld we conservatively deleted from the total weld that portion of the weld which was deemed to be discrepant. Our review of the inspections found that the total effective weld on the completely inspected two randomly selected 4' and 8' panels was greater than the total effective weld on the 4' and 8' tested panels. In the other 13 inspected panels the total effective weld on each of the panels was greater than the total effective weld on the similar welds of the tested 4' and 8' panels.

Comparison of the as-built condition of the two fully-inspected local instrument panels and the 13 partially-inspected panels with the Wyle-tested 4' and 8' panels thus demonstrated that the untested panels were equivalent to the tested panels for the purposes of seismic qualification. Based on these results we concluded that the entire Byron local instrument panel population is in sufficiently equivalent condition to the tested 4' and 8' panels to justify applying the

seismic qualification test results from the tested 8' panel to the non-tested panels.

Q.42. Did Sargent & Lundy use any other means to determine whether or not the non-tested panels were equivalent to the tested panels for purposes of the seismic qualification performed by Wyle Laboratories?

A.42. Yes, in addition to using the results of the weld discrepancy evaluations to confirm the equivalency of the local instrument panels, Sargent & Lundy developed a detailed computer model of an 8' local instrument panel utilizing finite elements. A dynamic analysis was performed on this model to determine forces and stresses at each connection on the panel. The results of the analysis confirmed that the computer model was similar in dynamic characteristics to the Wyle-tested 8' panel. The analysis also showed that the most highly stressed connection was stressed to only 10% of the code-allowable stress. Consequently, by applying the greatest reduction in weld capacity identified in the inspections of local instrument panels to the most highly stressed connection the connection is stressed only to 12% of its code-allowable stress. In other words, the greatest reduction in weld capacity identified in the inspections when applied to the most high-

ly stressed connection of a local instrument panel still results in a design margin of eight. Because this is the design margin at the most highly stressed connection, the margin at other connections will be greater than eight.

Q.43. Do you have an opinion concerning the quality of the local instrument panels supplied to Byron by Systems Control?

A.43. Yes, I have concluded that because the local instrument panels are capable of carrying design loads, the quality of these panels is adequate.

Q.44. Please describe the DC fuse panels supplied to Byron by Systems Control.

A.44. Four DC fuse panels were supplied to Byron by Systems Control. Two panels are located in the Unit 1 Auxiliary Building Battery Room, and two are located in the Unit 2 Auxiliary Building Battery Room.

Each panel is 72" wide by 90" high by 18" deep. The panels each have a right half and a left half, with an outward opening door on each half. Each panel is constructed utilizing structural angles for horizontal, vertical and diagonal members. These members are

welded together to form an integral frame. Light-gauge sheet metal is attached by welding to the structural angle frame. Fuses and relays which protect the DC system are mounted to the internal structural steel members.

Q.45. Were any weld discrepancies discovered in the DC fuse panels supplied to Byron by Systems Control?

A.45. Yes. Discrepant welds were found in 1981 on the DC fuse panels supplied by Systems Control during an inspection of the panels by Sargent & Lundy Level III inspectors on loan to CECo.

Q.46. Were these discrepant welds repaired?

A.46. No. It was always intended to perform an equivalency analysis to demonstrate the panels' seismic qualification. Until recently Sargent & Lundy believed that Westinghouse's analysis of the Byron main control boards encompassed a review of the DC fuse panels. We recently learned, however, that Westinghouse had not evaluated the DC panels, and Commonwealth Edison requested Sargent & Lundy to perform the appropriate analysis for the panels.

Q.47. Were the DC fuse panels seismically qualified?

A.47. Yes, they were seismically qualified in 1980 by Wyle Laboratories.

Q.48. What was the nature of the seismic qualification?

A.48. As in the case of local instrument panels, the adequacy of a DC fuse panel to carry dead and seismic loads is determined through seismic qualification testing. One of the four DC fuse panels (panel 1DC10J) was seismically qualified by testing at Wyle Laboratories. Both a resonance search test and a "shake table" test was performed on the tested panel.

Q.49. How were the discrepant welds identified on the DC fuse panels dispositioned?

A.49. Our analysis utilized the results of the inspection of the accessible welds on the four DC panels performed in 1981 by Sargent & Lundy Level III inspectors on loan to CECo. 2,170 welds were inspected, and 986 discrepancies were identified. The types of discrepancies identified included lack of fusion, craters, undercut, porosity, underrun, and underlength. In addition to these discrepancies, missing welds were found on one portion of one of the non-tested panels.

Sargent & Lundy performed a comparison of the effective weld of the tested panel to the effective weld of the other three panels in order to determine the equivalency of the panels for the purposes of seismic qualification. The effective weld was determined conservatively by deleting from the total weld that portion of a weld which was deemed to be discrepant. Panels 1DC11J and 2DC11J were found to have weld present throughout the panels and total effective weld greater than that of the tested DC fuse panel (panel 1DC10J). Therefore these panels were determined to be seismically qualified through their equivalency to the Wyle-tested panel. The results of the weld inspection of the panels did not enable a finding of equivalency to be made for panel 2DC10J. The 1981 inspection of panel 2DC10J found that weld is present and in equivalent quantity to that of the tested panel in all but one location of the panel. Missing stitch welds were identified along the length of the cross-braced diagonal angle members located in the center of the panel (Figure 13). Welds are present at the ends of these members.

In order to determine whether panel 2DC10J is in fact equivalent to the Wyle-tested panel for the purposes

of seismic qualification Sargent & Lundy developed a finite element model of panel 2DC10J. This model encompassed the as-built condition of the panel, including the missing welds. A computer analysis utilizing this model determined the dynamic characteris cs of the panel, and these characteristics were found to be similar to the dynamic characteristics found in the Wyle resonance search test of panel 1DC10J. We also determined that the dynamic characteristics at various instrument attachment locations were similar to the dynamic characteristics at similar locations in the tested panel. From these results I have concluded that panel 2DC10J is equivalent to the Wyle-tested DC fuse panel in terms of seismic qualification.

Because of the missing welds in panel 2DC10J the finite element analysis was also utilized to ensure that the diagonal cross-braced members were not over-stressed and that the welded end connections of the cross-braced members were adequate to transfer design loads. The analysis provided the stresses present at the connections of the panel so that these stresses could be compared to the code-allowable stresses. The analysis showed that the most highly stressed connection was stressed to only 38% of its

allowable capacity and thus confirmed that the members and connections could carry design loads within code-allowables.

Q.50. Do you have an opinion concerning the quality of the DC fuse panels supplied to Byron by Systems Control?

A.50. Yes, I have concluded that because the DC fuse panels are capable of carrying design loads, the quality of these panels is adequate.

Q.51. Is work presently being performed on DC fuse panel 2DC10J?

A.51. Yes. The missing stitch welds on this panel are being installed. The decision by Commonwealth Edison to install the missing stitch welds was made prior to Sargent & Lundy's evaluation of the panel.

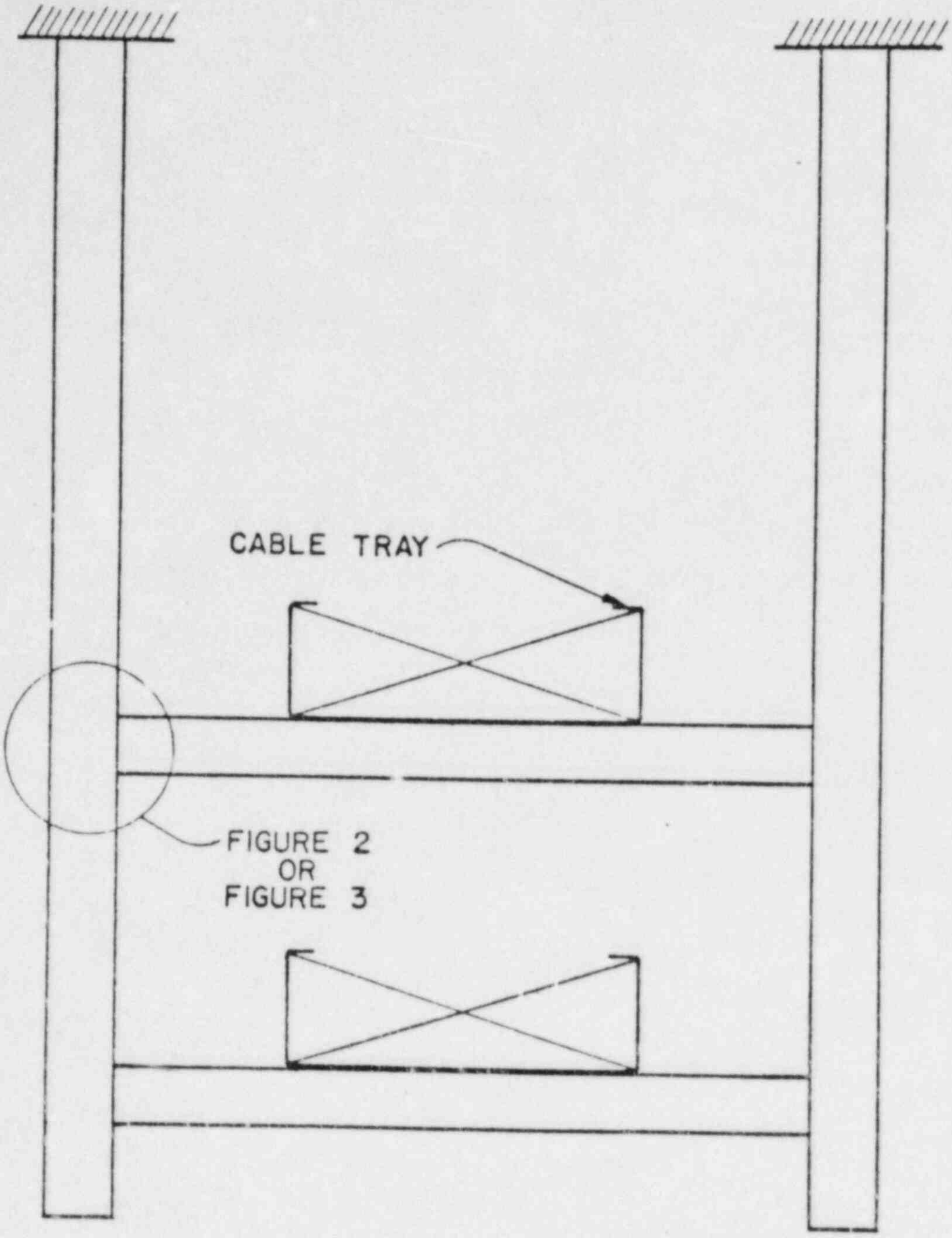


FIGURE 1

SYSTEM CONTROL
CABLE TRAY HANGER

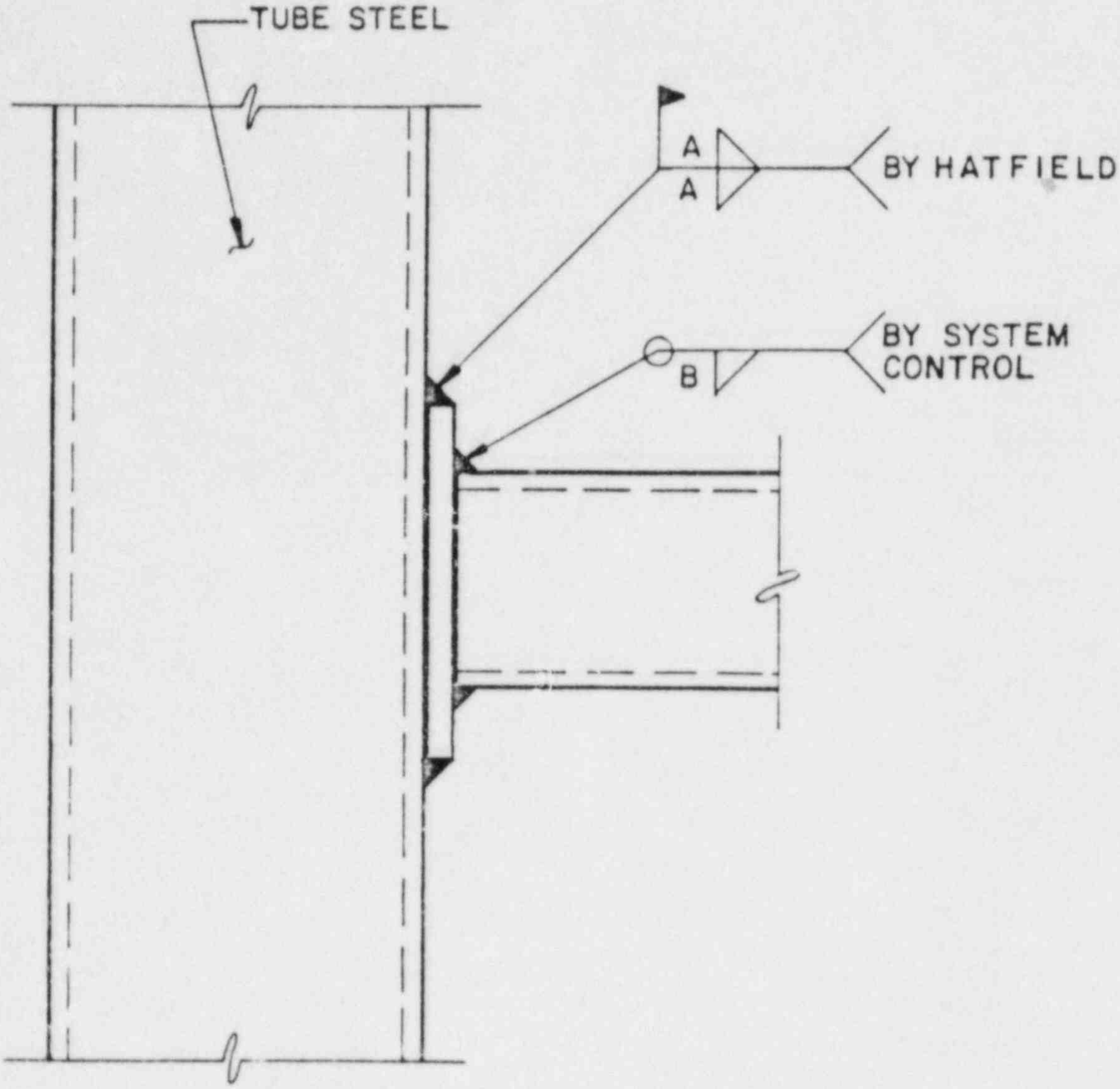


FIGURE 2

SYSTEM CONTROL
TYPICAL CABLE TRAY
HANGER WELDED CONNECTION

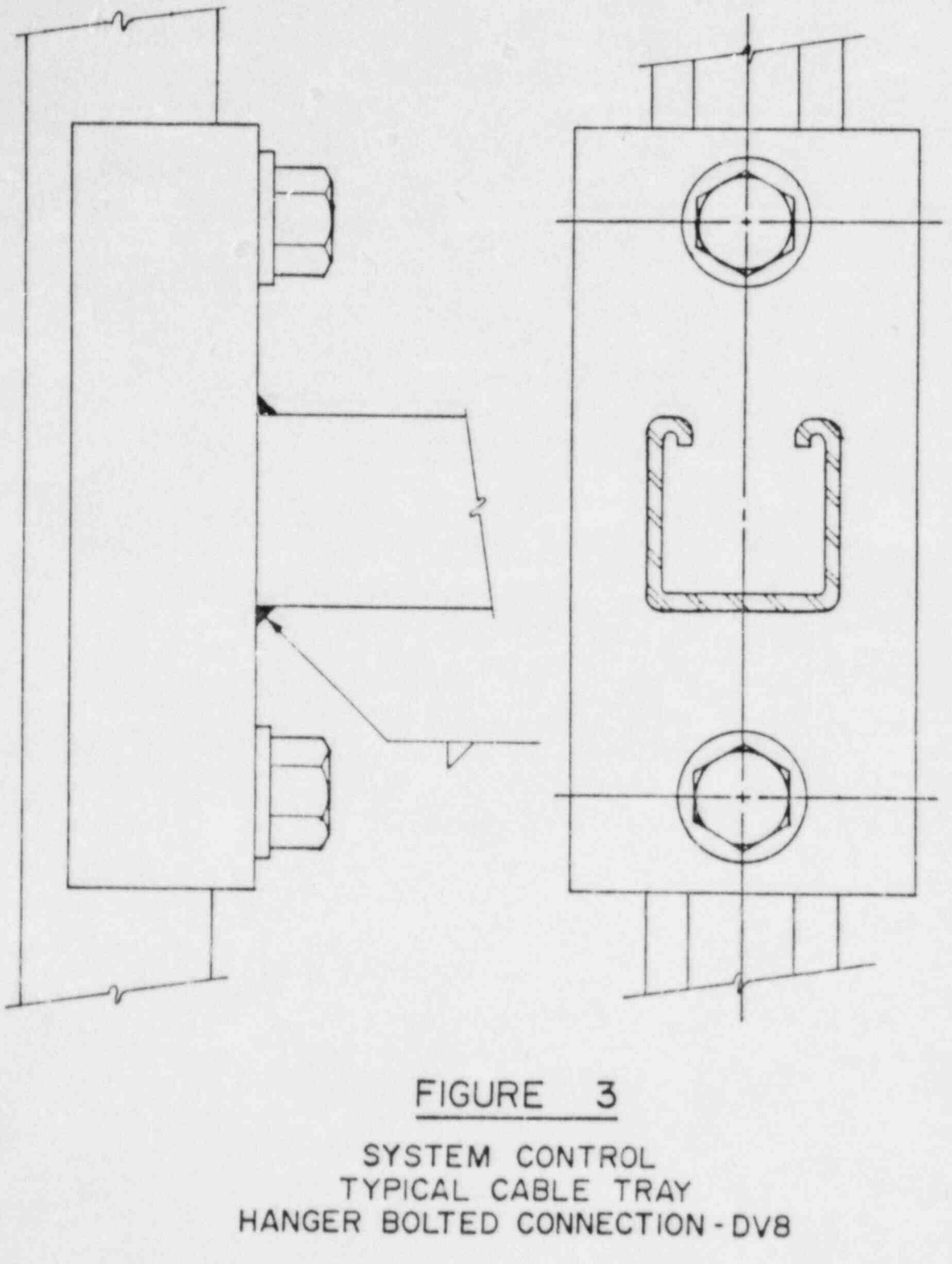


FIGURE 3

SYSTEM CONTROL
TYPICAL CABLE TRAY
HANGER BOLTED CONNECTION - DV8

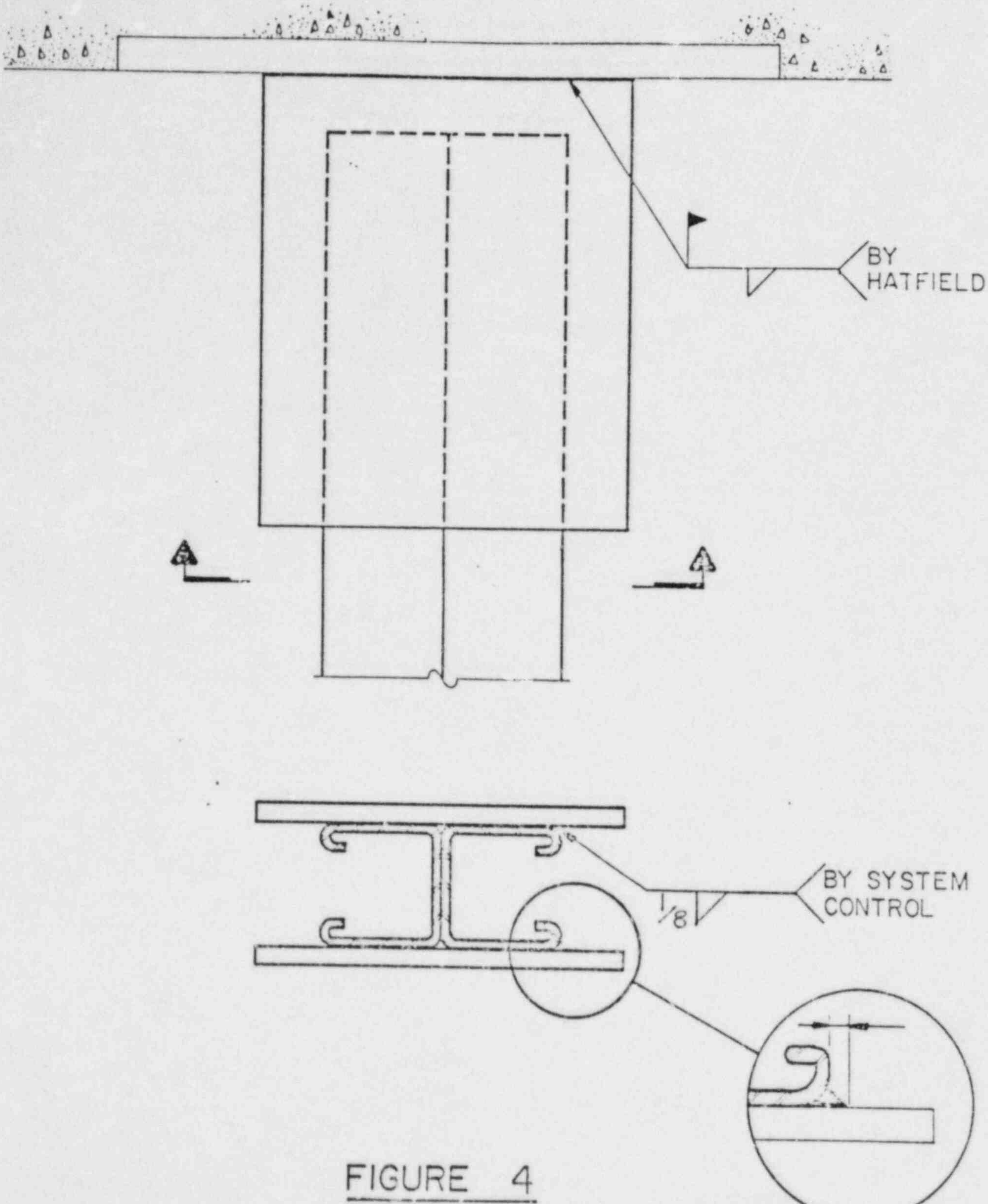


FIGURE 4
SYSTEM CONTROL
HANGER CONNECTION DV2

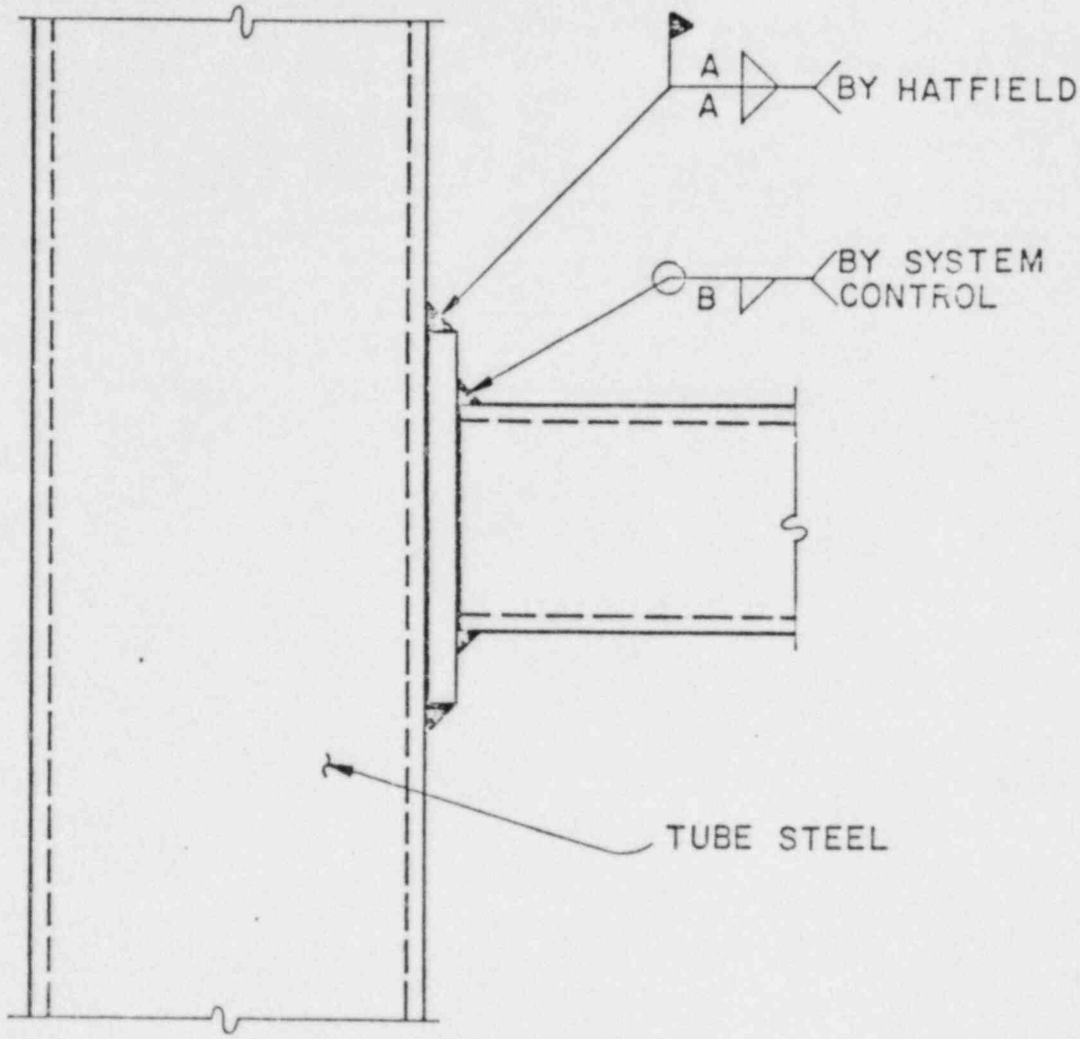
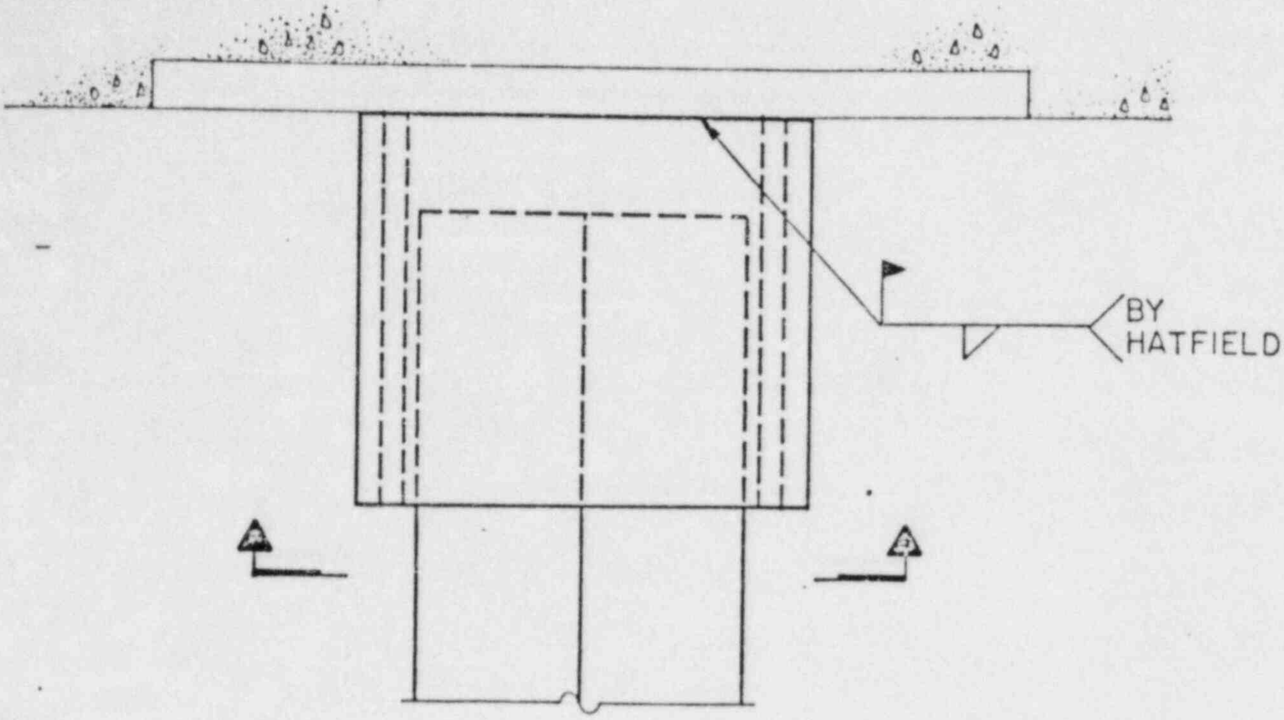


FIGURE 5

DV162



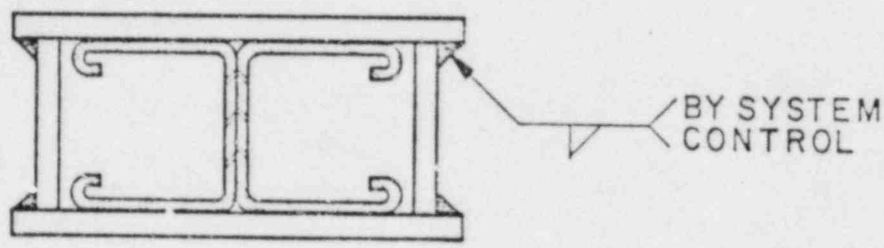


FIGURE 6
SYSTEM CONTROL
HANGER CONNECTION DV120

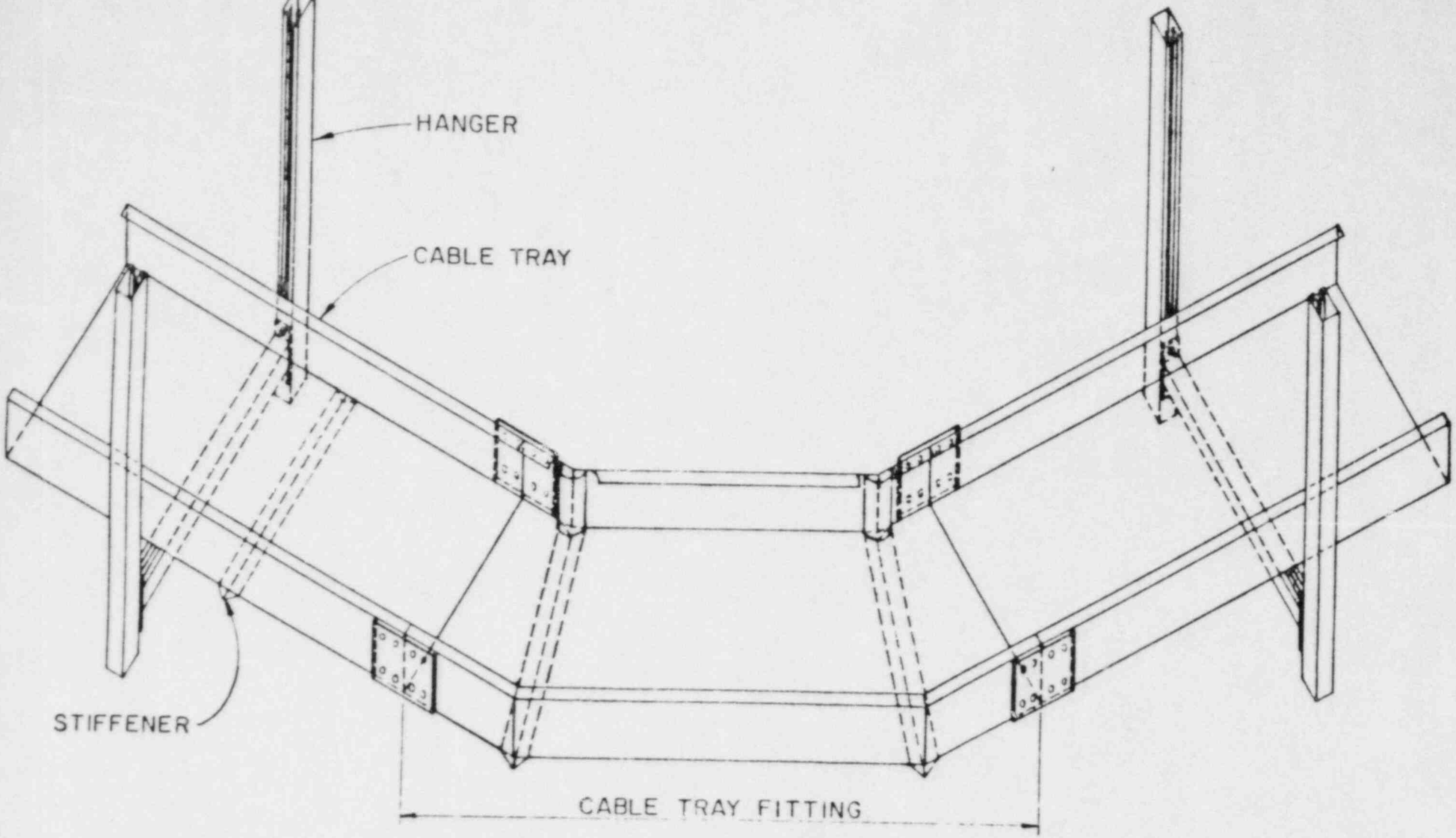
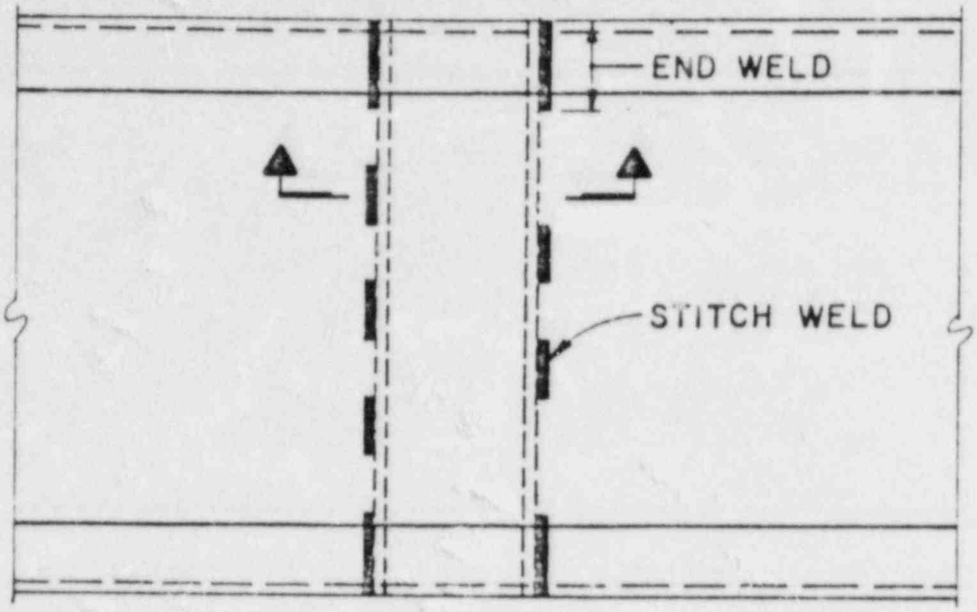
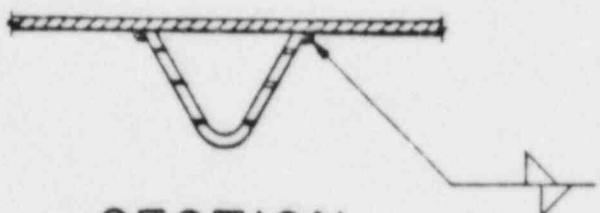


FIGURE 7

TYPICAL CABLE TRAY AND CABLE TRAY FITTING



PLAN



SECTION

FIGURE 8

CABLE TRAY
STIFFENER DETAILS

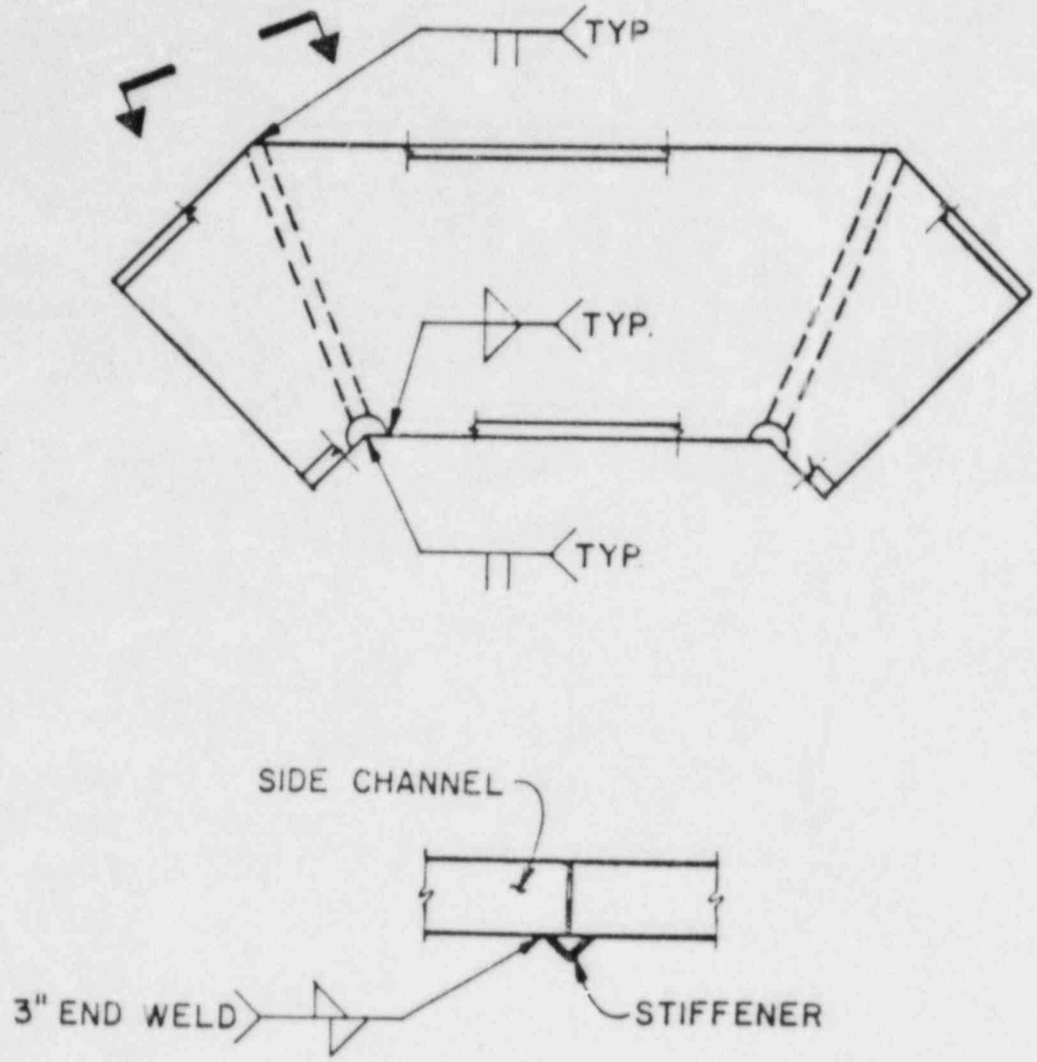


FIGURE 9

TYPICAL CABLE TRAY FITTING
90° BEND

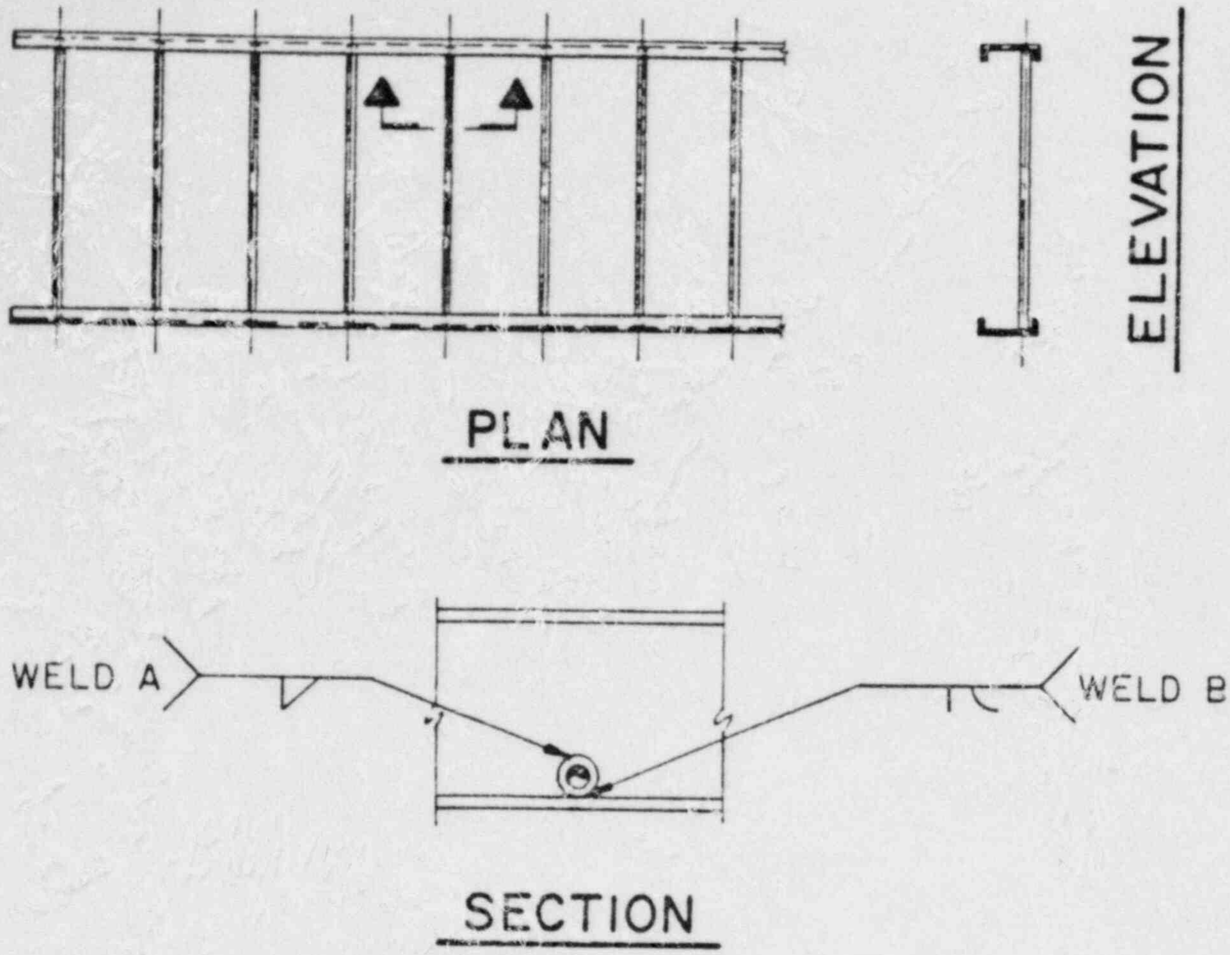


FIGURE 10

LADDER TYPE
CABLE TRAY

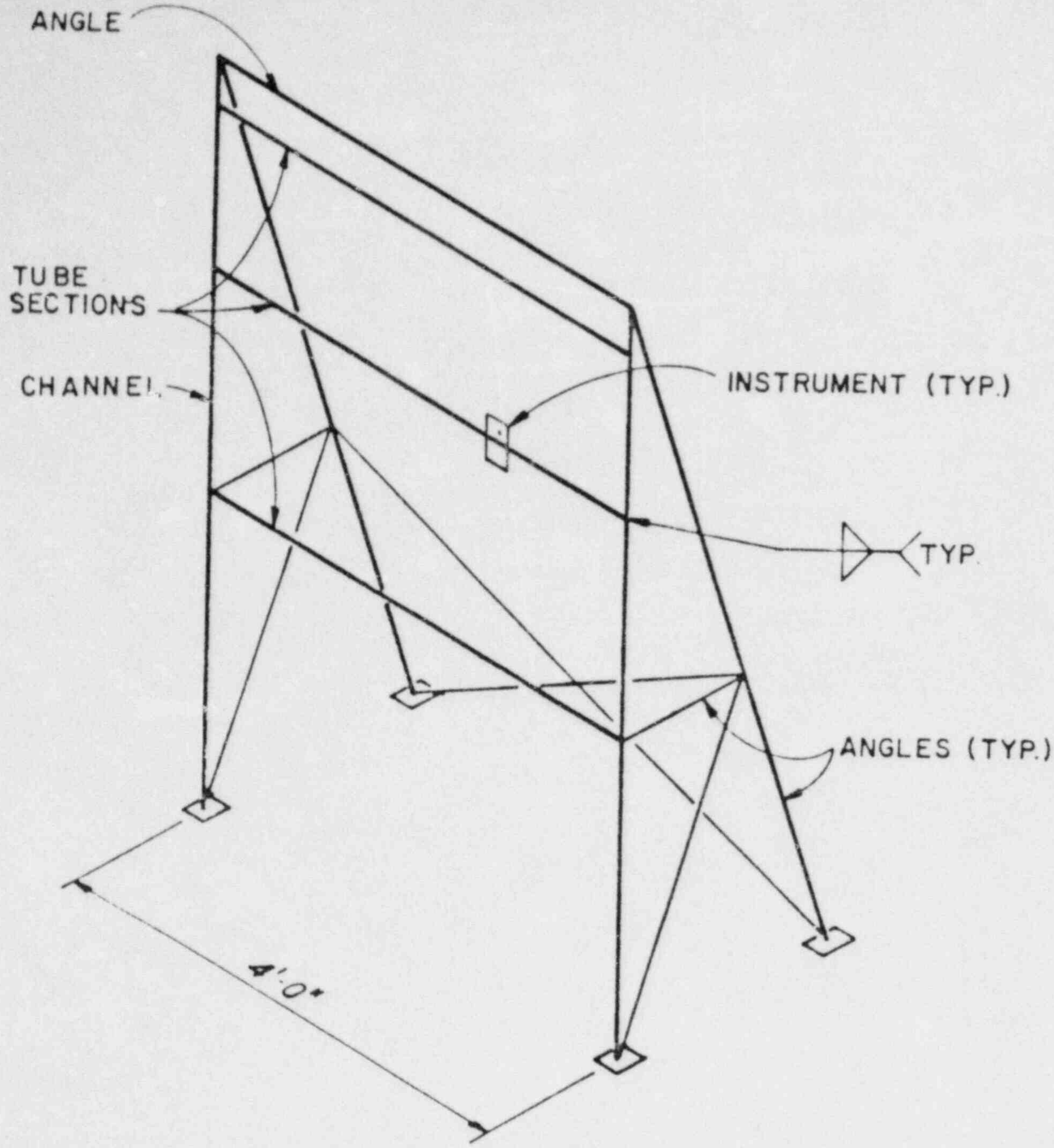


FIGURE 11

LOCAL 4'-INSTRUMENT PANEL

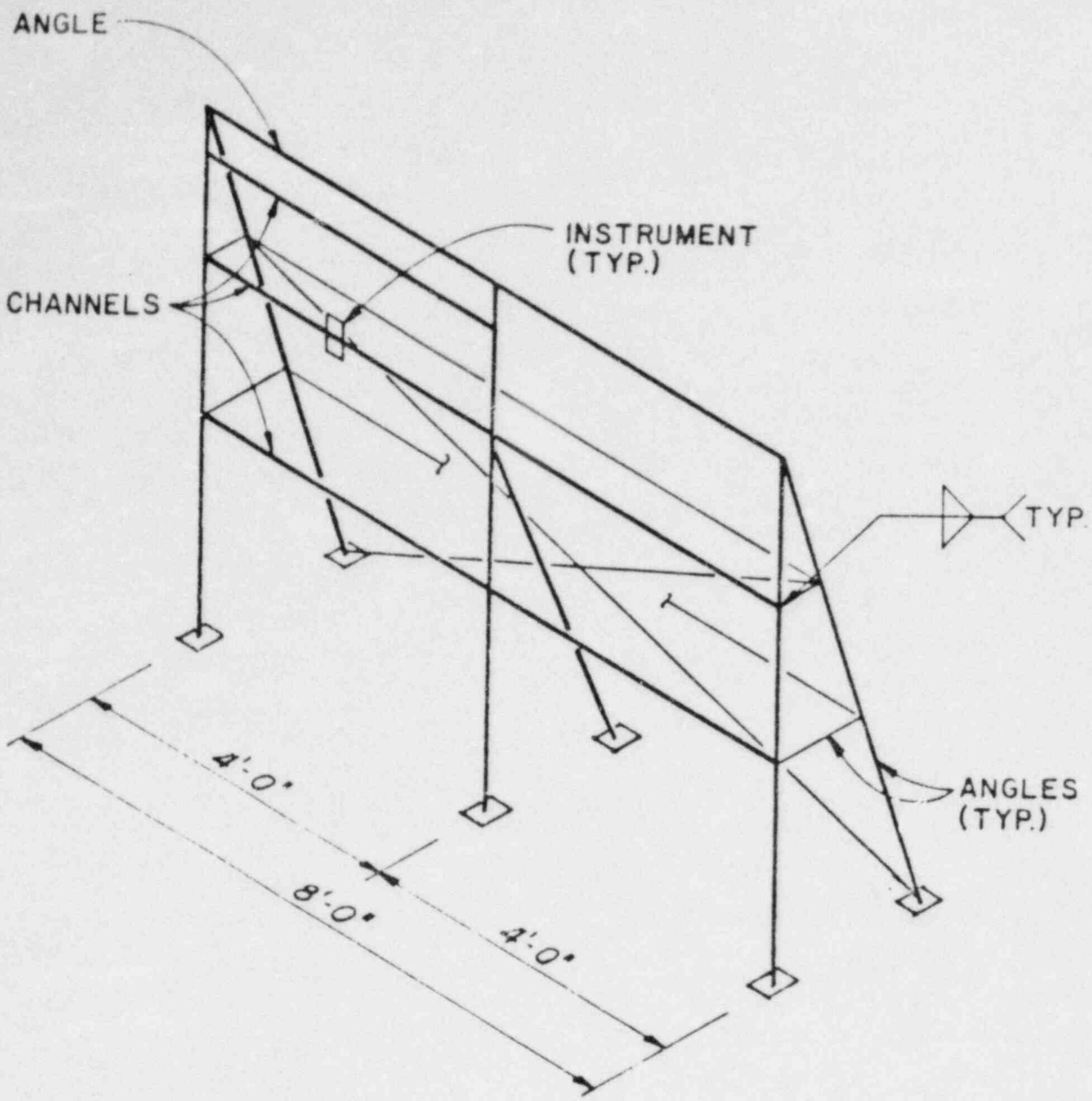


FIGURE 12
LOCAL 8'-INSTRUMENT PANEL

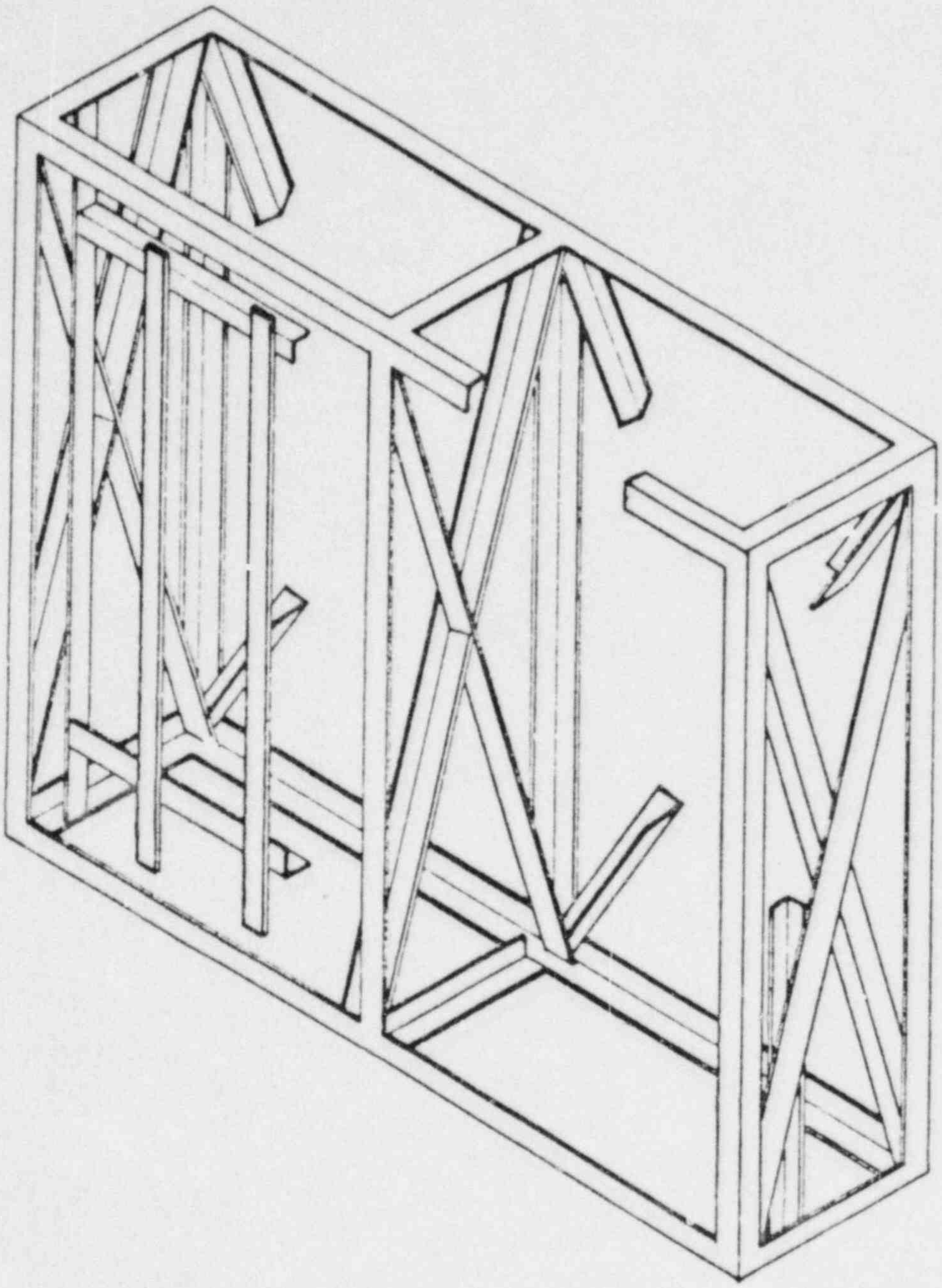


FIGURE 13

DC FUSE PANEL