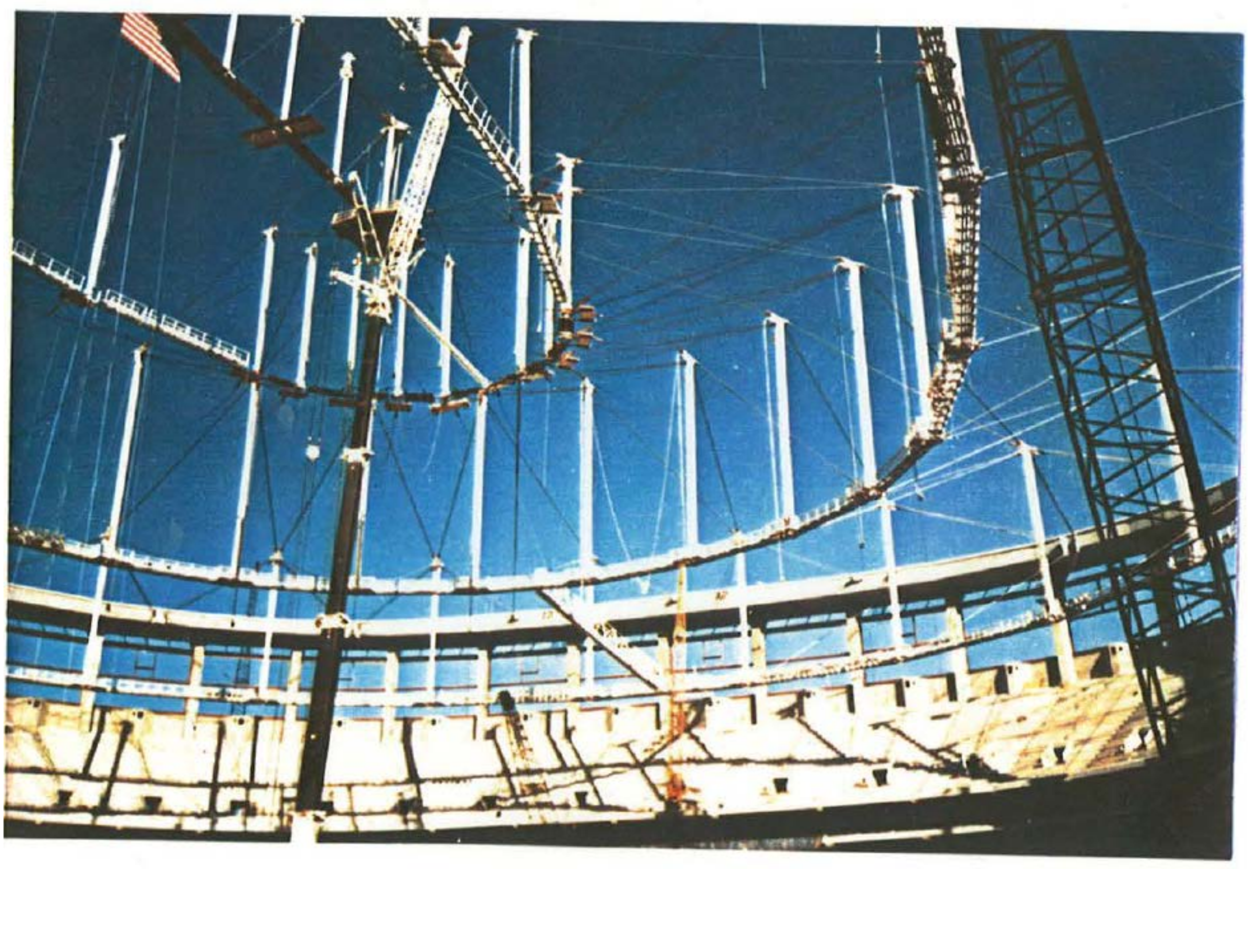
INVESTIGATION OF OCTOBER 17, 1991 ROOF CABLE STRUCTURE ACCIDENT AT GEORGIA DOME CONSTRUCTION SITE, ATLANTA, GEORGIA

U.S. DEPARTMENT OF LABOR
OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

March 1992



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Office of Construction and Engineering

March 1992

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EXECUTIVE SUMMARY

A construction worker was killed and two workers were injured on October 17, 1991, at 2:40 p.m. when their work platform was struck by a collapsing steel post, 47 feet long, after a cable attachment plate fractured. The collision of the steel post with the work platform, 230 feet above ground, resulted in a worker falling to the ground and being killed. At the time of the accident, the workers were in the process of hoisting the center truss of the roof cable system during the construction of the Georgia Dome project in Atlanta, Georgia. There were six construction workers, employed by the roof erection contractor, on the work platform or on the bottom chord of the center truss when the accident occurred. The workers were using hydraulic pumps to apply loads to the temporary jacking strands in order to make the permanent diagonal cable connection to the center truss.

Representatives from the Occupational Safety and Health Administration's (OSHA) Atlanta West Area Office arrived at the scene of the accident site within four hours of the accident. The Office of Construction and Engineering, OSHA National Office, Washington, D.C., was requested to provided assistance in determining the cause of the accident. Personnel from the Office of Construction and Engineering visited the construction site to gather relevant information and documents for the investigation.

Based on eyewitness accounts, laboratory test results, observation of the fractured attachment plate and engineering calculations based on the estimated forces provided by the roof erection company in the cables immediately prior to the accident, the Occupational Safety and Health Administration concludes that:

1. The accident occurred due to the collapse of a steel post following the fracture of an attachment plate located at the top of a hoop "A" post. The attachment plate was loaded in excess of its capacity. The overloading was the result of the bending moment created by the eccentrically applied tensioning force of the temporary jacking strands to the attachment plate.

2. The fractured attachment plate was not adequately proportioned for the tensioning force applied during the roof erection immediately prior to the accident.

3. Engineering calculations were not done, by the roof erection company, to determine and verify the structural adequacy of the attachment plate assemblies for the erection loads to which these plate assemblies were subjected during the erection of the roof cable system, as per contract document requirements.

4. Workers, who were on the platform and involved in the specific construction activity preceding the accident, were not clearly instructed regarding the jacking sequence and the amount of tensioning force to be applied to the temporary jacking strands to make the final connection of the diagonal cables and the roof center truss. Written instruction or the erection drawings indicating the magnitude of tensioning force to be applied to the temporary jacking strands were not available to the erection crew.

1.0 INTRODUCTION

An accident occurred on October 17, 1991, at approximately 2:40 p.m. during the erection of the roof cable structure at the construction site of Georgia Dome in Atlanta, GA., resulting in one death and injuries to two construction workers. At the time of the accident the workers were located on top of a work platform, about 230 feet above ground. They were in the process of hoisting the center truss in position to make the final connection of a diagonal cable to the bottom joint of the center truss. While the temporary jacking strands were tensioned and the center truss was raised to about 12 inches within its final location, an attachment plate at the top a hoop "A" post fractured. Following the plate fracture, the post rotated and struck the work platform suspended below the bottom of the center truss, resulting in a worker falling to the ground and being killed. Two other workers on the platform sustained injuries to varying degrees.

A compliance officer from the OSHA Atlanta West Area Office arrived at the scene of the accident on 10-17-1991 at about 6.00 p.m. to gather information relating to the activities preceding the accident. The compliance officer took photographs and collected evidence and documents relating to the accident. The Office of Construction and Engineering, OSHA National Office in Washington, D.C., was requested by the Area Office to provide assistance in the investigation to determine the cause of the accident.

The OSHA investigation included the eyewitness accounts, interviews of the parties involved in construction, observations of fractured attachment plate assemblies, review of the cable roof erection procedure, construction documents and laboratory test report and engineering calculations. The engineering calculations were based upon the estimated magnitude of forces in cables connected to the failed attachment plate, immediately prior to the accident. The estimated cable forces were furnished by the roof erection contractor.

Throughout the course of this investigation, the Office of Construction and Engineering worked together with personnel of the OSHA Regional Office and OSHA Atlanta West Area Office.

2.0 DESCRIPTION OF THE ERECTION PROCEDURE AND ACCIDENT

The roof of the 70,500 seat Georgia Dome Stadium in Atlanta, Georgia is a cable supported structure of oval configuration, approximately 770 x 610 feet. The dome, in plan, consists of three elliptical configurations of decreasing dimensions at varying elevations, supported by a network of ridges cables, hoop cables, posts and diagonal cables. See Figures 2.01 and 2.02 for roof plans showing lay-out of ridge cable, hoop, and diagonal cable. Figure 2.03 indicates the cross-section of the roof structure along minor and major axes. The entire roof cable structure is supported at equally spaced connections by a concrete compression ring beam on the perimeter of the Dome. At the center of the Dome, a center truss, 35 feet deep and 184 feet long, spanning in the east-west direction, connects the centers of the two circular segments.

The ridge cables consist of wire ropes of diameters varying from 3 inches to 1 inch. The diagonals consist of structural strands also of varying sizes of 3-5/8 inch to 1-3/8 inch in diameter. The vertical posts, are steel pipes of different heights spanning between ridge cables and the elliptically placed cables. A steel gusset plate at the top of the post is connected to an attachment plate which connects the ridge cables and diagonal cable. At bottom of the post is also a steel gusset plate which is connected to an attachment plate connecting the diagonal cables and the elliptically placed cables, called hoops. Figures 2.04 and 2.05 indicate typical vertical post details showing the gusset plates at both ends of the post. At some locations, as many as four ridge cables and two diagonals cables are connected to the attachment plate. The intersecting points of all the cables and steel post are named as "node" in the engineering drawings.

There are three cable hoops of elliptical configuration , identified as hoops "A", "B" and "C", consisting of two 3-1/8 inch diameter, four 4 inch diameter and four 3-5/8 inch diameter structural strands respectively. Each hoop is connected to the bottom of the steel posts and the lower end of the diagonal cables at 26 node points. The posts at the hoop "A" (identified as PA) are steel pipes of 16 inch diameter x 0.5 inch in thickness. The posts at the hoop "B" and "C" (PB and PC respectively) are 24 inch diameter x 0.562 inch thick. The top and bottom chords and the diagonals of the center truss are tension members consisting of structural strands. The vertical members of the center truss are compression members consisting of steel pipes. Ten ridge cables are spaced at equal angles and connected to the attachment plates of the end post members of the center truss. At the bottom of the end post of the center truss, 10 diagonals are connected to the plate with a similar detail. See figure 2.06 and 2.07 for center truss end post attachment plate details.

The accident occurred during the process of connecting the diagonal cable at node 1308 to the bottom of the east end vertical post of the center truss.

The construction of the Georgia Dome is administered by a team of four companies, hereafter called the construction managers. The fabrication and erection of the cable roof structure and the roof fabric are performed by a construction company, hereafter referred to as the erection company. The erection company was provided with a set of contract design drawings by the structural engineer of record to develop the erection procedure and prepare detail and erection drawings of the cable roof structure (shop drawings). According to the statement of the project engineer of the erection company, the structural engineer of record also provided a computer model of the roof structure to the erection company. The computer model indicated the final forces in all members of the roof cable structure under the application of dead load at the completion of roof cable assembly.

The method and sequence of erection of the cable system for the roof structure was not specified by the structural engineer of record. It was left to the steel erection company to select the system best suited for the job based upon the available resources of the erection company to deliver the finished assembled structure. The erection company prepared shop drawings for review and approval of the structural engineer of record through the construction managers. The submittal included a set of erection drawings and erection procedures. The erection drawings included details of the attachment plates, temporary weldment brackets, jacking cable layouts etc. The erection drawing also indicated the forces of all ridge cables and diagonals and the elevation of nodes of the roof structure at various stages of erection. No computations were submitted to the structural engineer of record for review and approval.

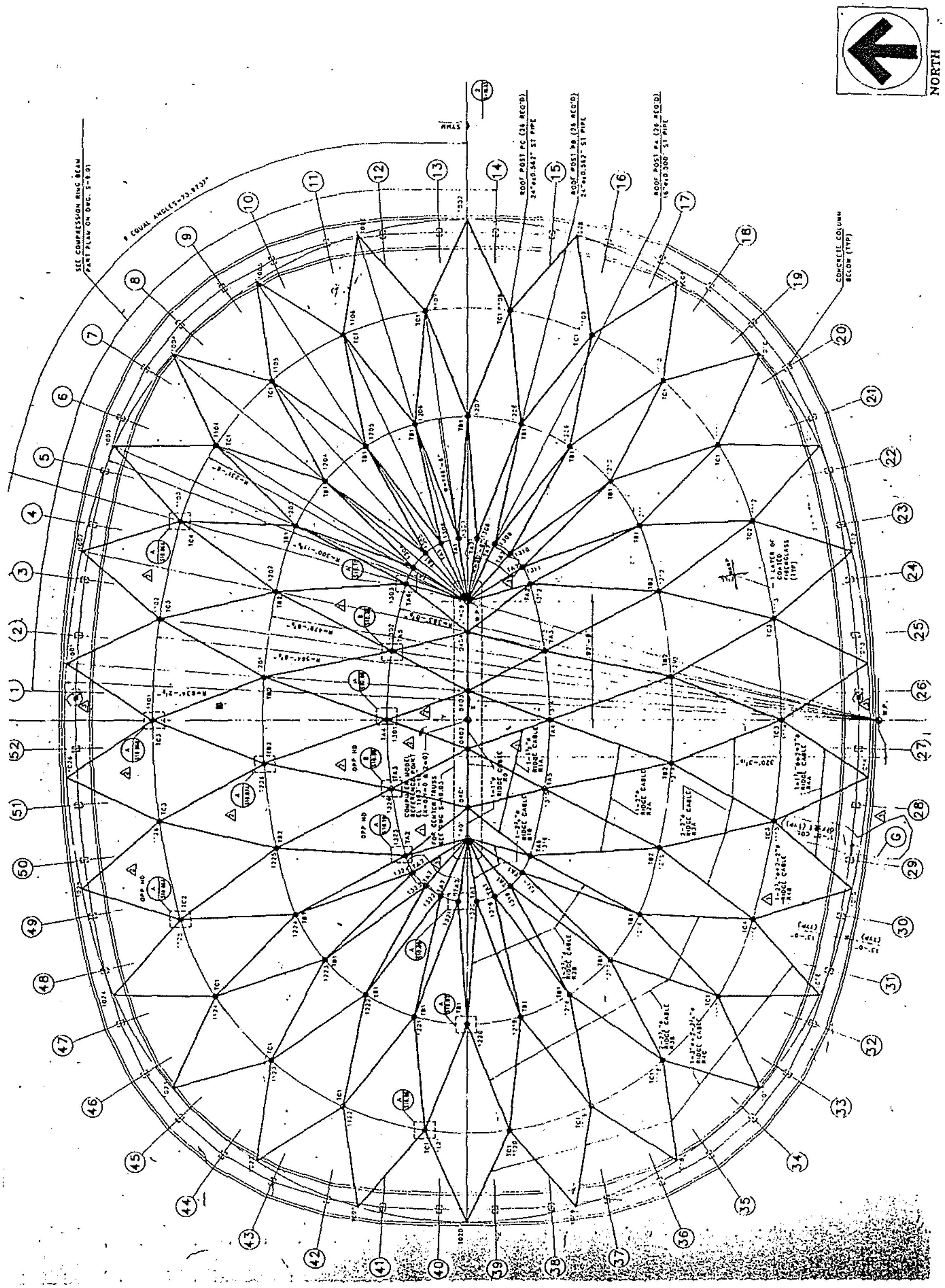
The erection procedure adopted and approved for use at the construction site consisted of assembling the entire cable ridge net on the ground and then lifting it in stages to the desired elevation. The approved erection procedure furnished by the erection company is attached in Appendix A. First of all, the entire ridge cable is laid out on the ground and with the help of a crane, the top attachment plates for the ridge cables were connected to the ridge cables at the appropriate locations. At this time, the ridge cables between the attachment plates were in a slack position. The center truss, temporarily supported by guys, was also assembled on the ground directly below its final location and placed vertically. Ridge cables were then connected to the center truss top chord joints. The lifting of the ridge net was then undertaken.

Lifting cables were placed from the top attachment plate of hoop C to the compression rings and to the center truss. Fig. 2.08 is the layout of the ridge net lifting cable arrangement. Ridge net was then hydraulically lifted by jacking at selected locations. Ridge net was raised and the connections to the ring beam at the perimeter of the dome was completed. At this time, the center truss was also off the ground but distance away from its final position. Following the connection of the ridge net to the compression ring, hoop C cables were laid out in the elliptical configuration on the ground and jacked to position after which diagonal cables from the compression ring were connected to the "C" hoop. The PC posts consisting of steel pipes were raised by a crane and connections made with the attachment plates of the ridge cables at the top and with the hoop cables at the bottom. Thereafter, the "B" hoop cables were laid out on the ground and jacked to approximate location of the bottom of "B" posts suspended from the ridge net and the PB posts were lifted and attached to the ridge cables and hoop "B". Following this, diagonals were connected. The same steps were repeated for the "A" hoop. At the completion of hoop "A" installation, the PA posts were jacked up, the top and bottom connections were made in a similar manner. The installation of the diagonal cables to the top of PB posts were then completed. The final step was to raise the center truss to its final elevation and complete all the connections of the diagonal cable to the bottom chord of the center truss. At the time of the accident, the workers were in the process of applying tension force to the diagonal jacking strands in order to make the connection of the diagonal cable between the bottom of the east end post of the center truss and top of the PA post at node 1308.

As discussed earlier and shown in Figures 2.06 and 2.07, at each of the two end posts of the center truss, 10 ridge cables were to be connected at the top attachment plates of the end post and 10 diagonal cables were to be connected to the bottom attachment plates of the end posts. The 10 ridge cables had been connected to the top of each end posts prior to the accident. The truss was being raised to make the final connection of the diagonal cables to the bottom of the truss end post. Eight temporary jacking strands were connected to the top of the gusset plates of posts PA at nodal points 1303 through 1312 at the east end, and at nodal points 1316 through 1325 at the west end of the center truss, see Fig. 2.01. The other end of these eight temporary jacking strands from the nodal points mentioned above were connected to the bottom attachment plate of the center end posts. Two work platforms were suspended from the center truss, one on the east end and the other on the west end. The construction workers and the hydraulic pumps used to jack the temporary jacking strands were on the work platform. As per the erection company, only four of the eight temporary strands were supposed to be jacked, and the other four strands were provided as a means of "safety ", which were to be used only in the final stage of the center truss hoisting. When the erection would approach near the final stage, all the 8 strands were to be tensioned for a force of 22.5 kips each, i.e., a total of 180 kips.

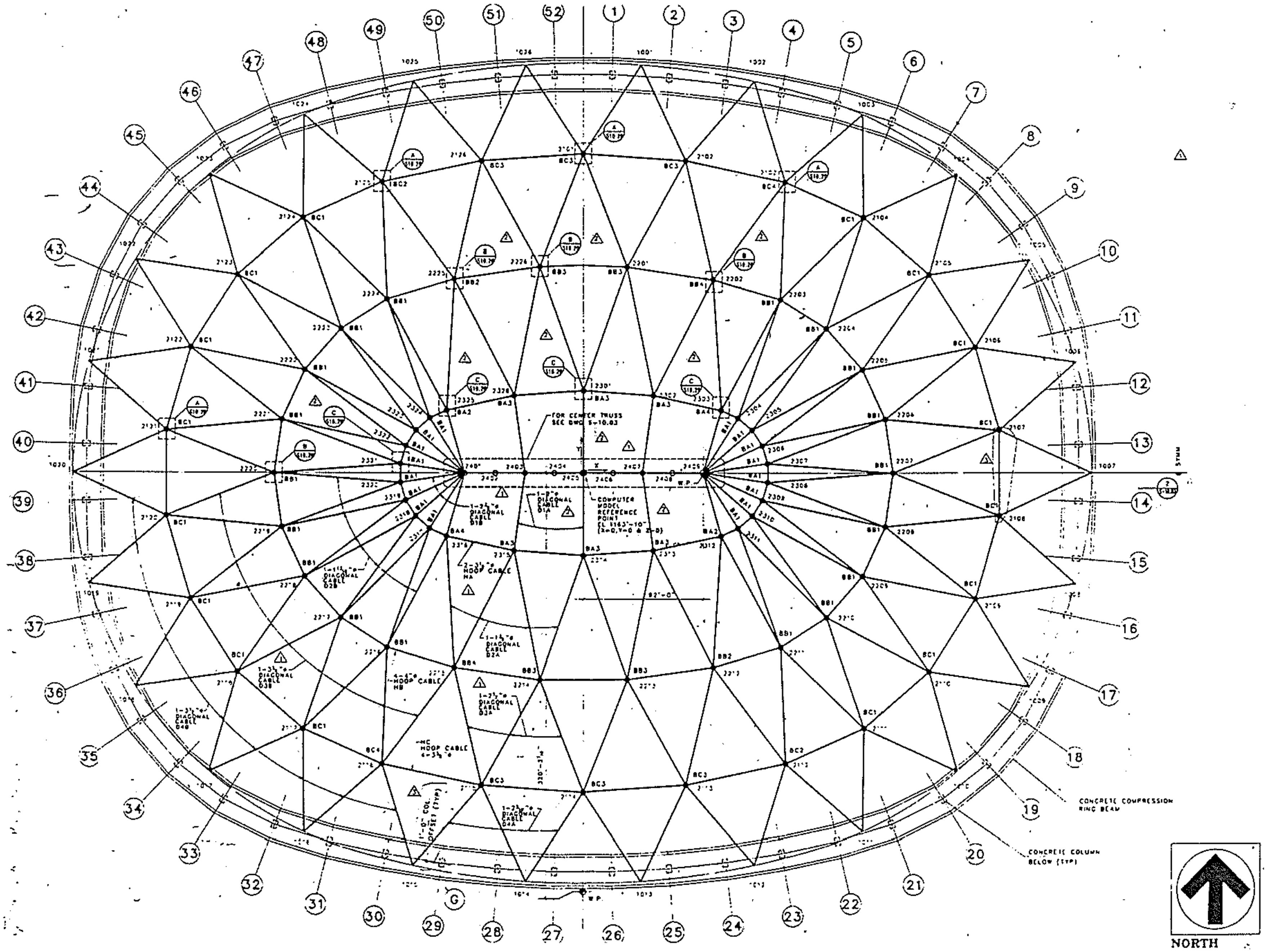
The intent of the erection procedure as described by the steel erection company, in the interview after the accident, called for a force of 4 x 35 = 140 kips to be initially applied to a set of four strands at the diagonal cables at nodal joints mentioned above. A final tension force of 22.5 kips at each of the 8 strands, total of 180 kips (8 x 22.5 = 180 kips) was to be applied to the complete set of eight strands to bring the truss at the proper elevation, following which the diagonal cables would be permanently connected. This procedure, as explained above, was intended to be followed. However, on the day of the accident, all eight strands were jacked by the crew to a force of 30 to 35 kips each at the nodal point 1308. A force of 240 to 280 kips was therefore applied to the temporary jacking strands at nodal point 1308 resulting in fracture of the attachment plate at the top of "PA" post. Figure 2.11 shows the mating of the fractured sections of the attachment plate (Photo was taken by the private testing laboratory, discussed in Section 5). The higher force in the jacking cables caused the fracture of the top attachment of "PA" post at node 1308 location. Subsequent to the fracture of the plate, the post rotated towards the work platform and struck the platform.

The top attachment plate which fractured is identified as TA-7 plate on the shop drawing. It is located at nodal point 1308 on the drawing prepared by the structural engineer of record. Figure 2.10 shows the elevation and plan of the plate assembly. The plate assembly is composed of four 1-1/4 inch thick steel plates identified as Pa, Pb, Pc and Pd. Plate Pd connects one ridge cable to the top and one diagonal cable to the bottom of the center truss end member. Plates Pc and Pd are the plates which connect the two cables from the top of post to the top of PB post of hoop "B" at nodes 1207 and 1208. The three plates Pd, Pc, and Pb are groove welded to a horizontal plate Pa, as shown in Figure 2.10. The assembly of all the four plates is then connected to the post top gusset plate with a 4 inch diameter bolt through a hole in the plate Pd, see Figs. 2.09 and 2.10. Fig. 2.09 also shows the temporary jacking strands connected to the top gusset plate of the post PA at the bracket with a 2" diameter high strength bolt. Plate Pa fractured along a horizontal plane adjacent to the end of plates Pb and Pc, plate Pd also fractured along a vertical plane at the end of plates Pb and Pc, and along a horizontal plane near the bottom side of the plate Pa, see Fig. 2.18 for fractured locations of the plate. Figures 2.12, 2.13, 2.14 and 2.15 are the east portion of the fractured plate TA-7. The west portion of the fractured plate was still attached to the top of the post in the rotated position, see. Figs. 2.16 and 2.17. Both portions of the fractured plate assembly were retrieved for examination by an independent testing laboratory by the construction managers.



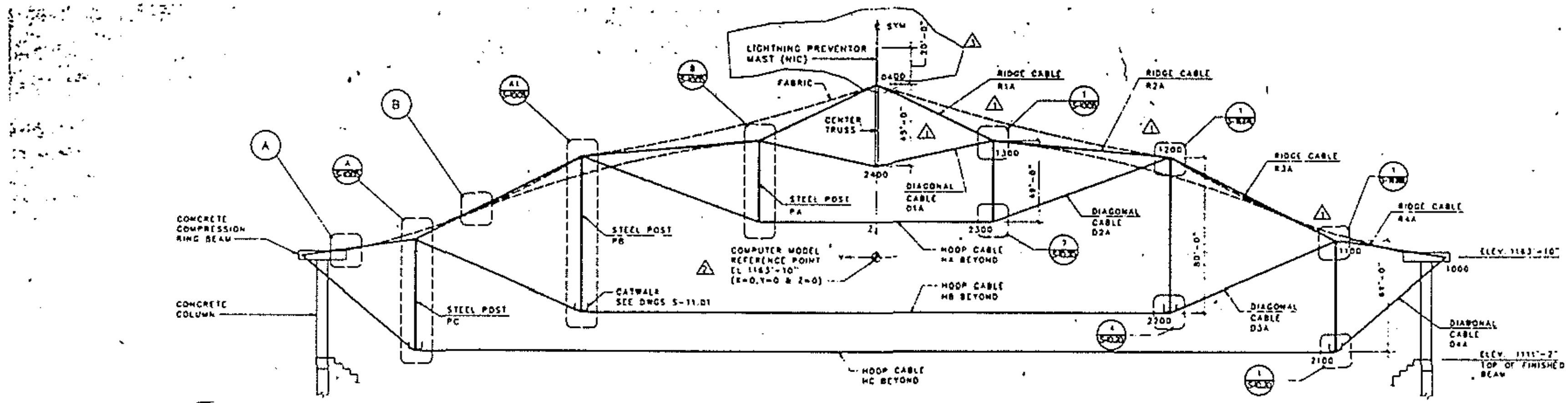
RIDGE CABLE LAYOUT PLAN

FIG. 2.01



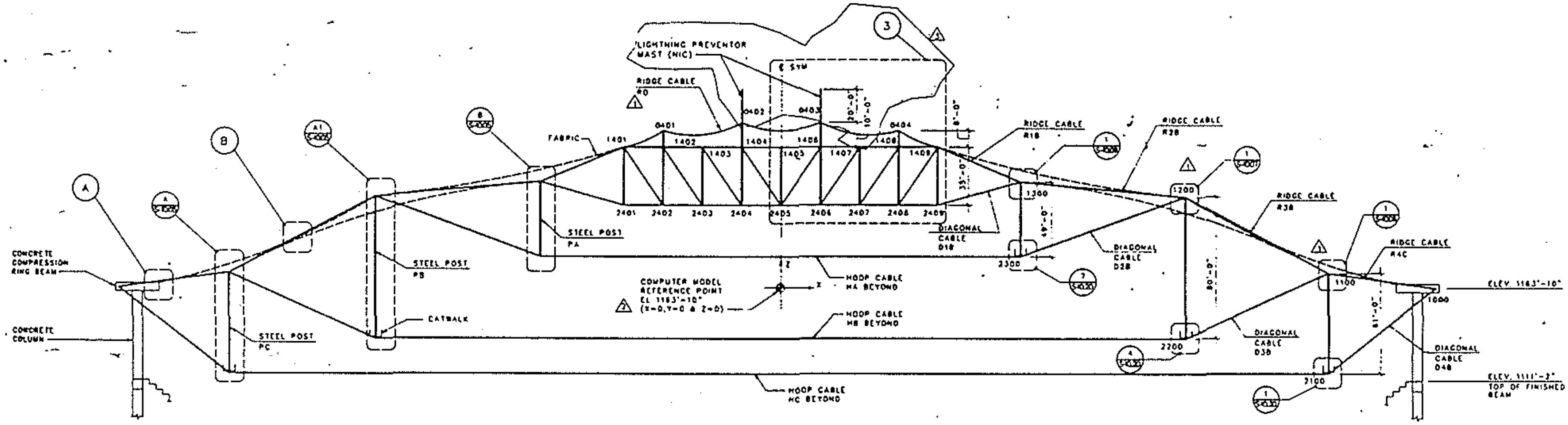
HOOP AND DIAGONAL CABLE LAYOUT

FIG.2.02



SECTION ALONG MINOR AXIS (1)

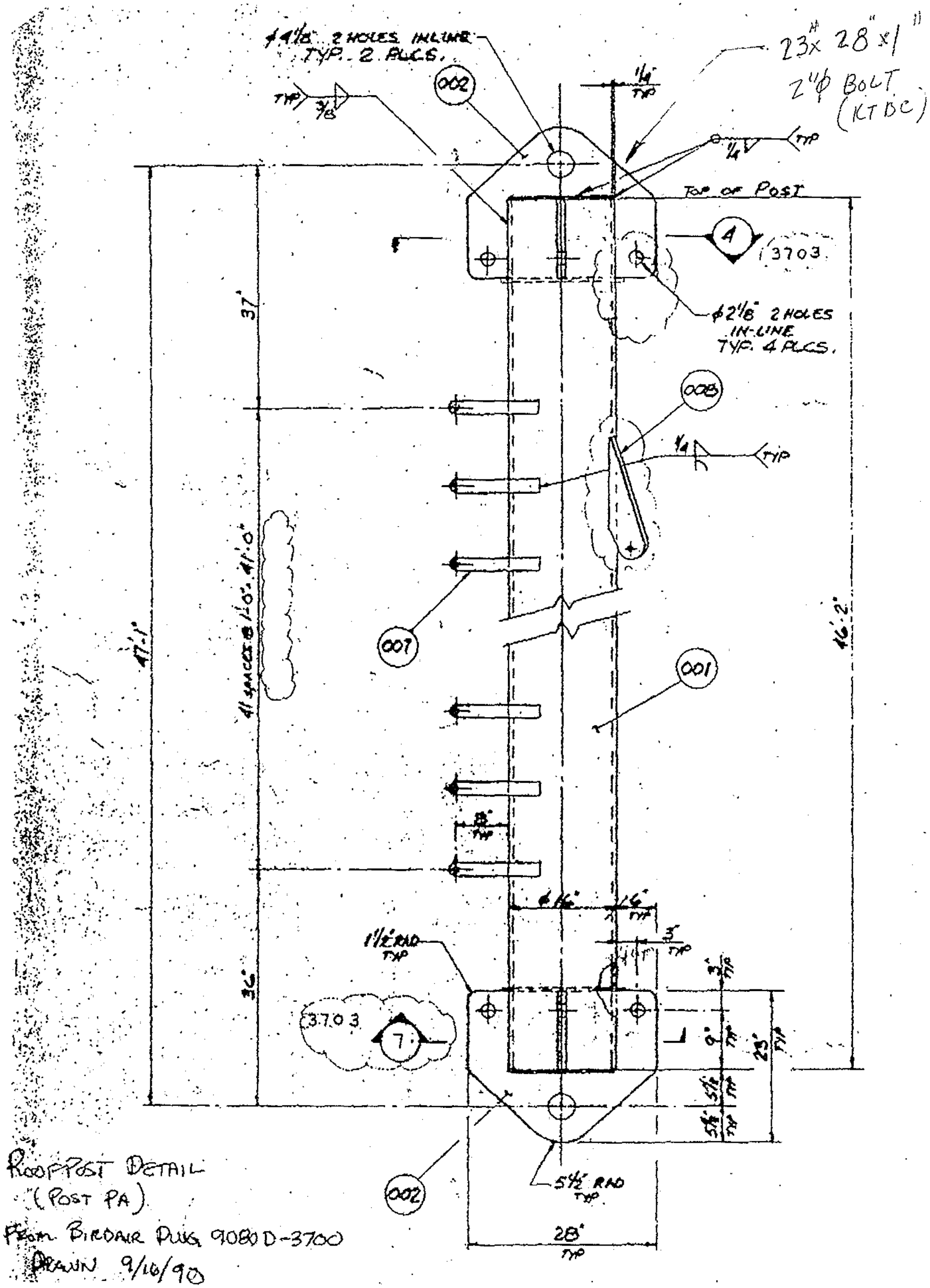
NOTE:
FOR NOTES SEE DRAWING S-10.01



SECTION ALONG MAJOR AXIS (2)

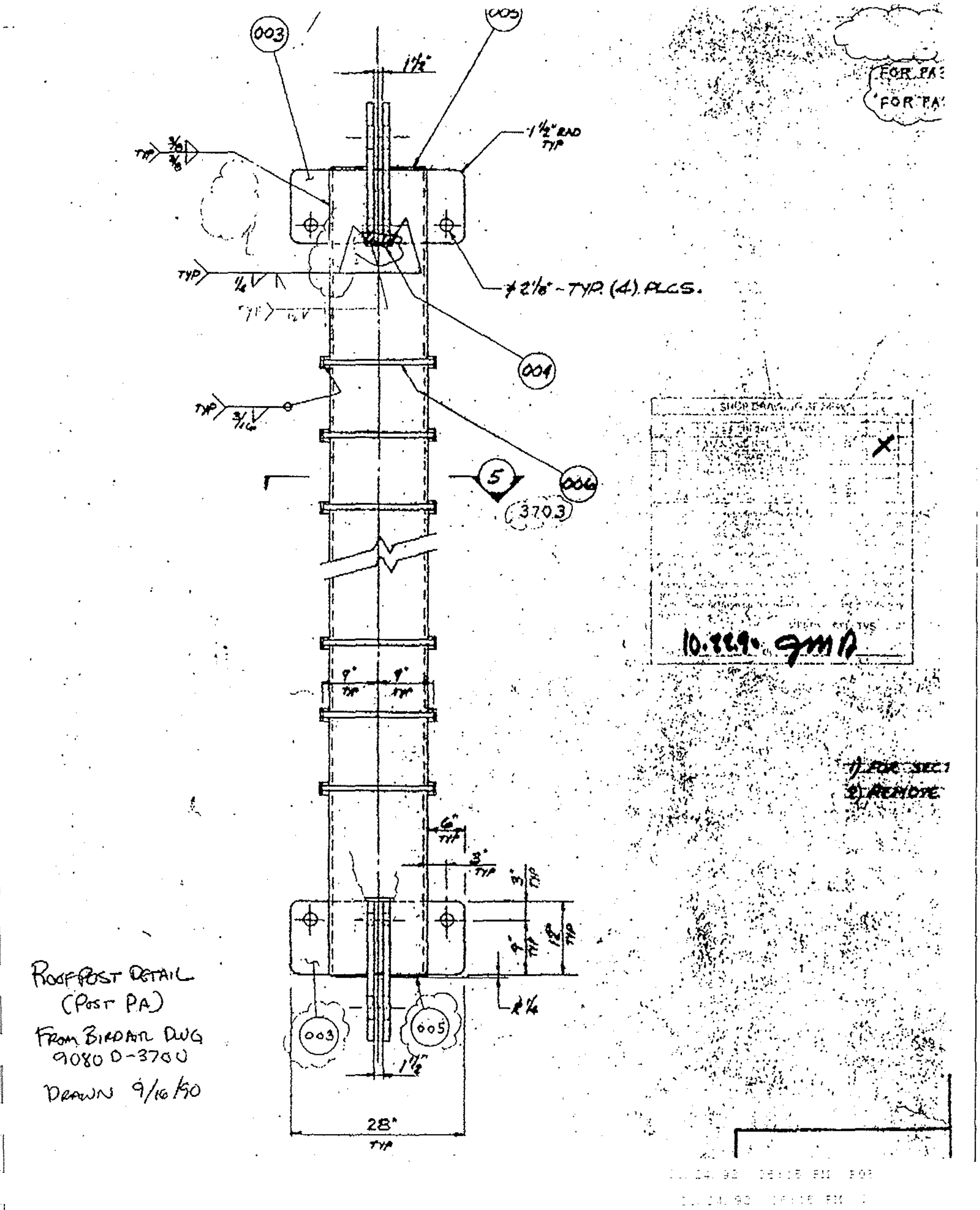
ROOF SECTIONS

FIG.2.03



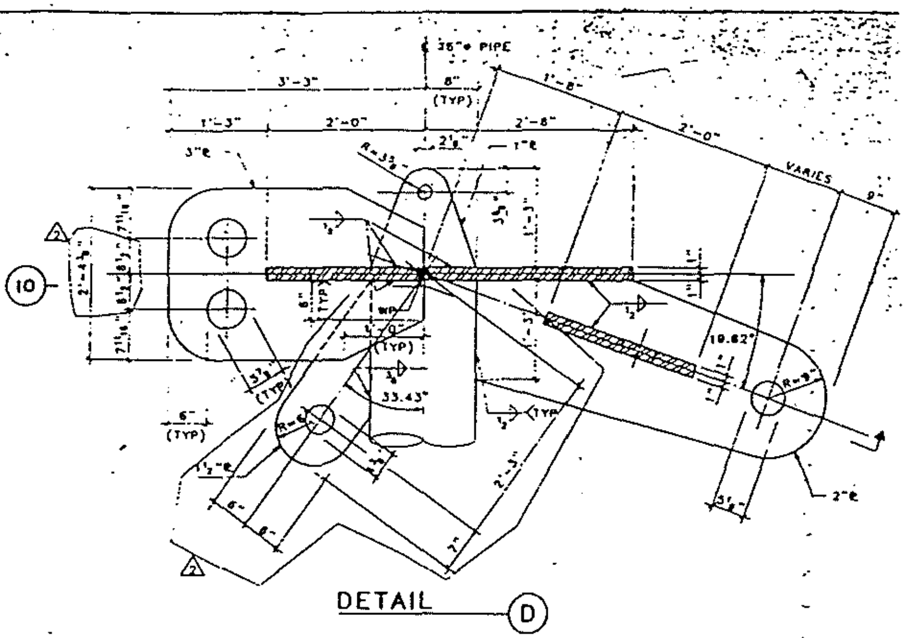
STEEL POST (PA) DETAILS

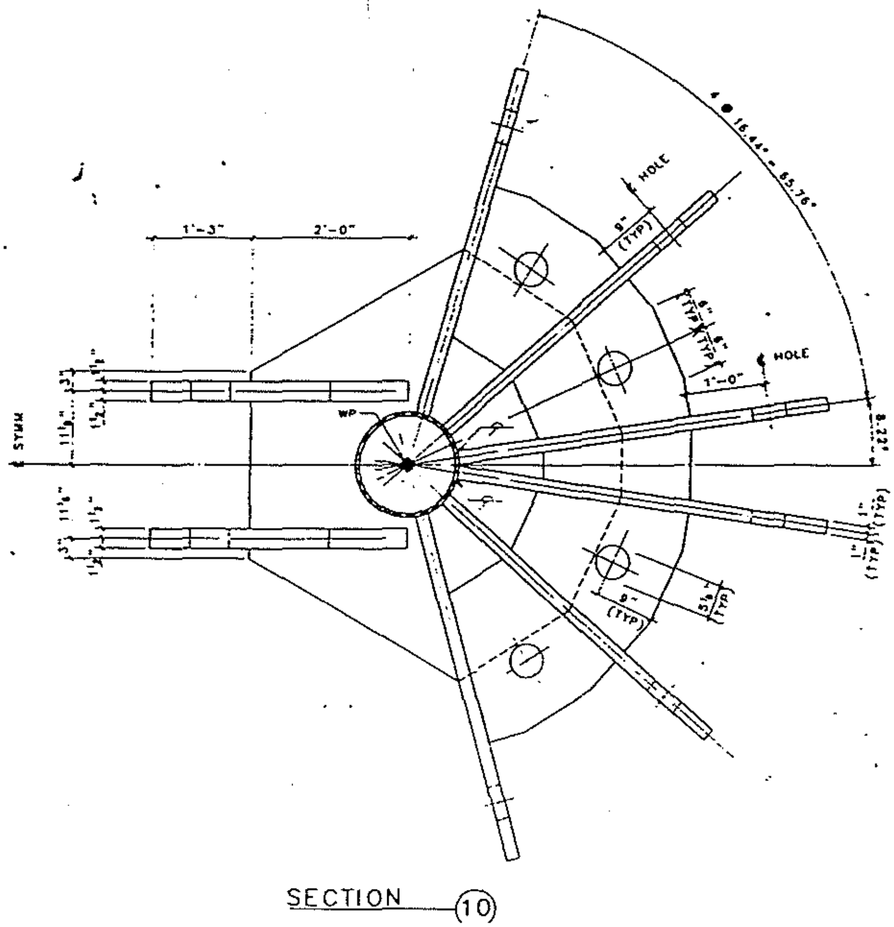
FIG 2.04



STEEL POST (PA) DETAILS

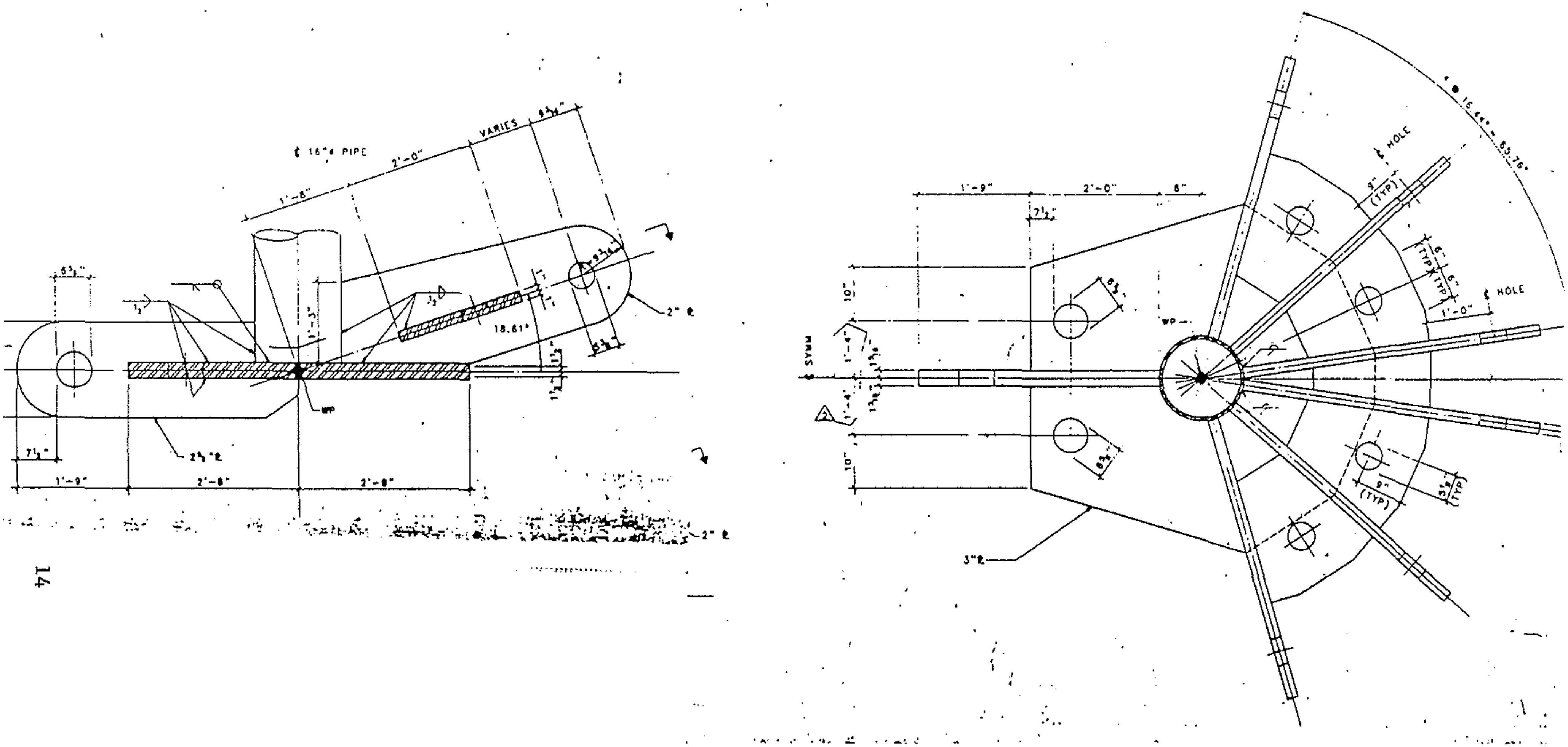
FIG. 2.05





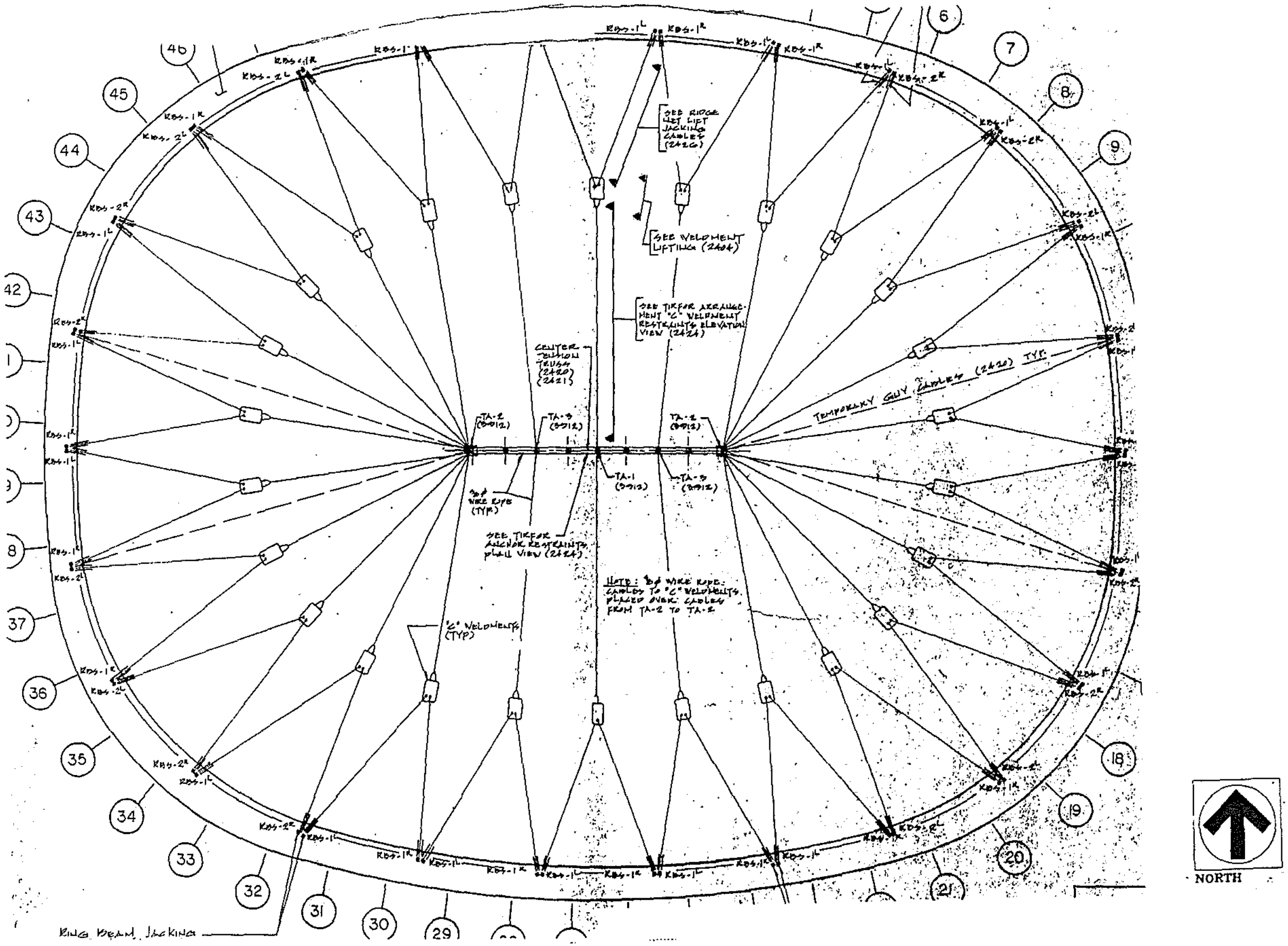
CENTER TRUSS END POST ATTACHMENT PLATE DETAIL– TOP OF THE POST

FIG. 2.06



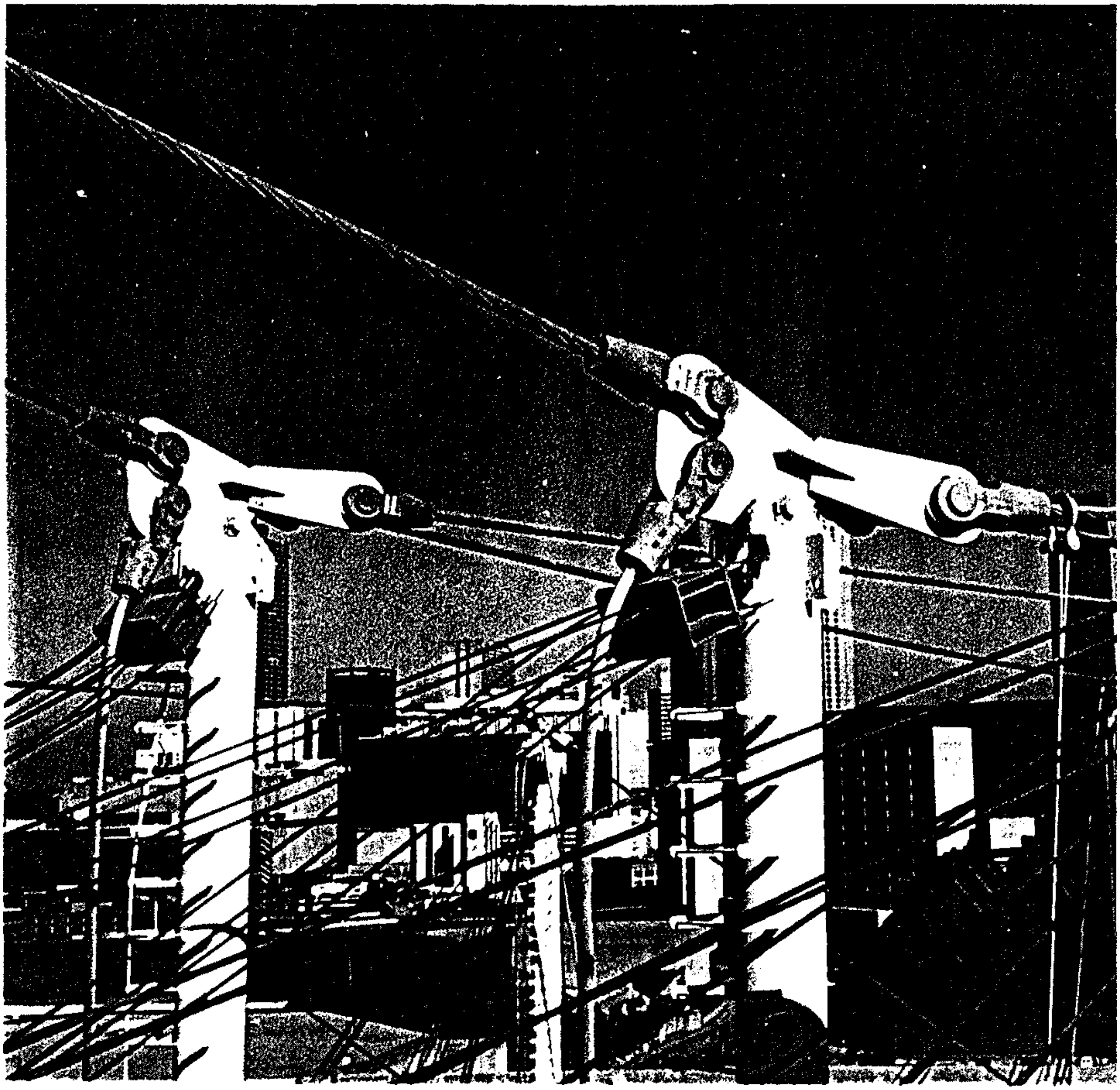
CENTER TRUSS END POST ATTACHMENT PLATE DETAIL -BOTTOM OF THE POST

FIG.2.07



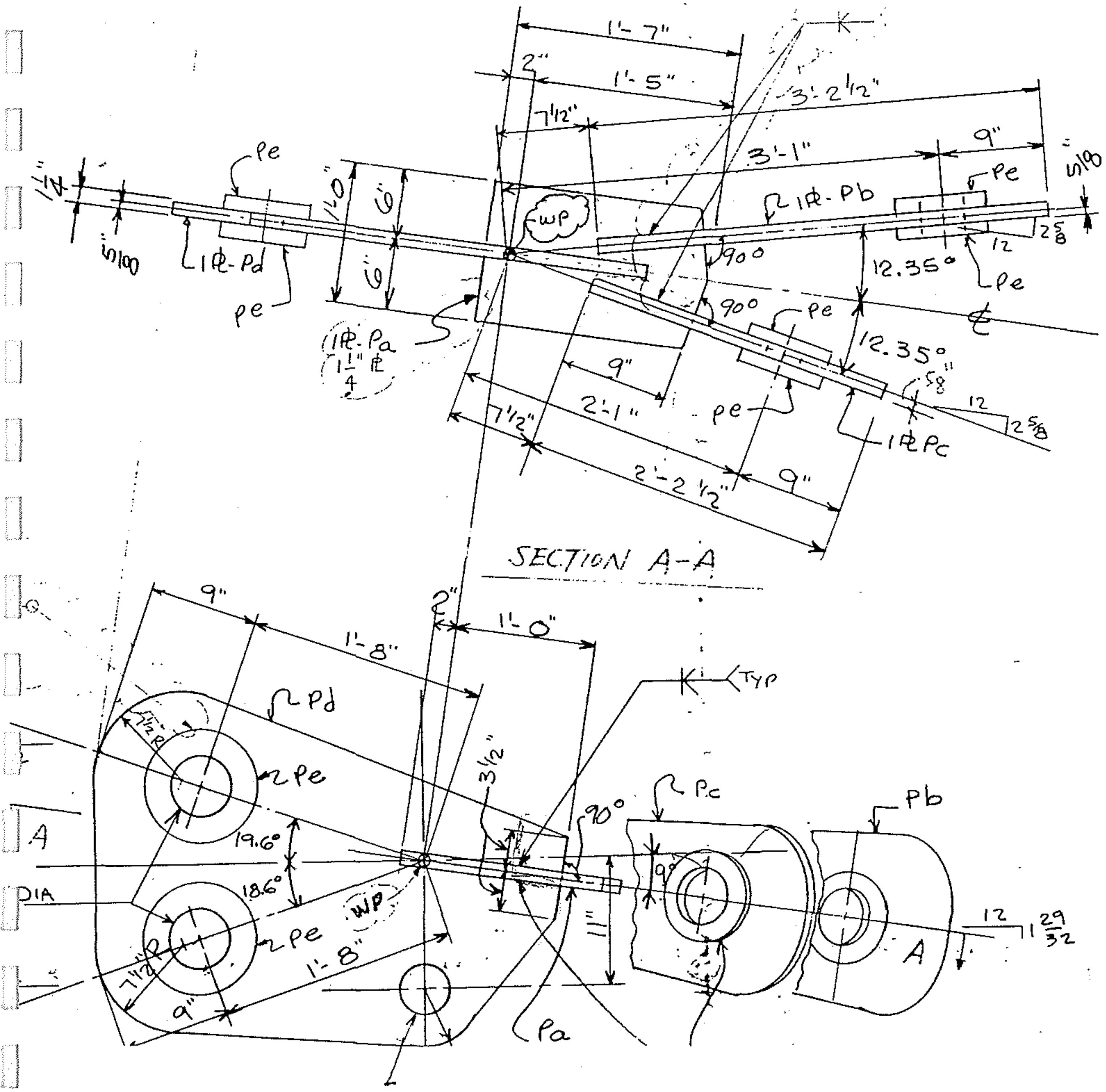
RIDGE NET LIFTINF CABLE ARRANGEMENT

FIG.2.08



PA POST TOP ATTACHMENT PLATE AND BRACKET OF THE JACKING STRANDS.

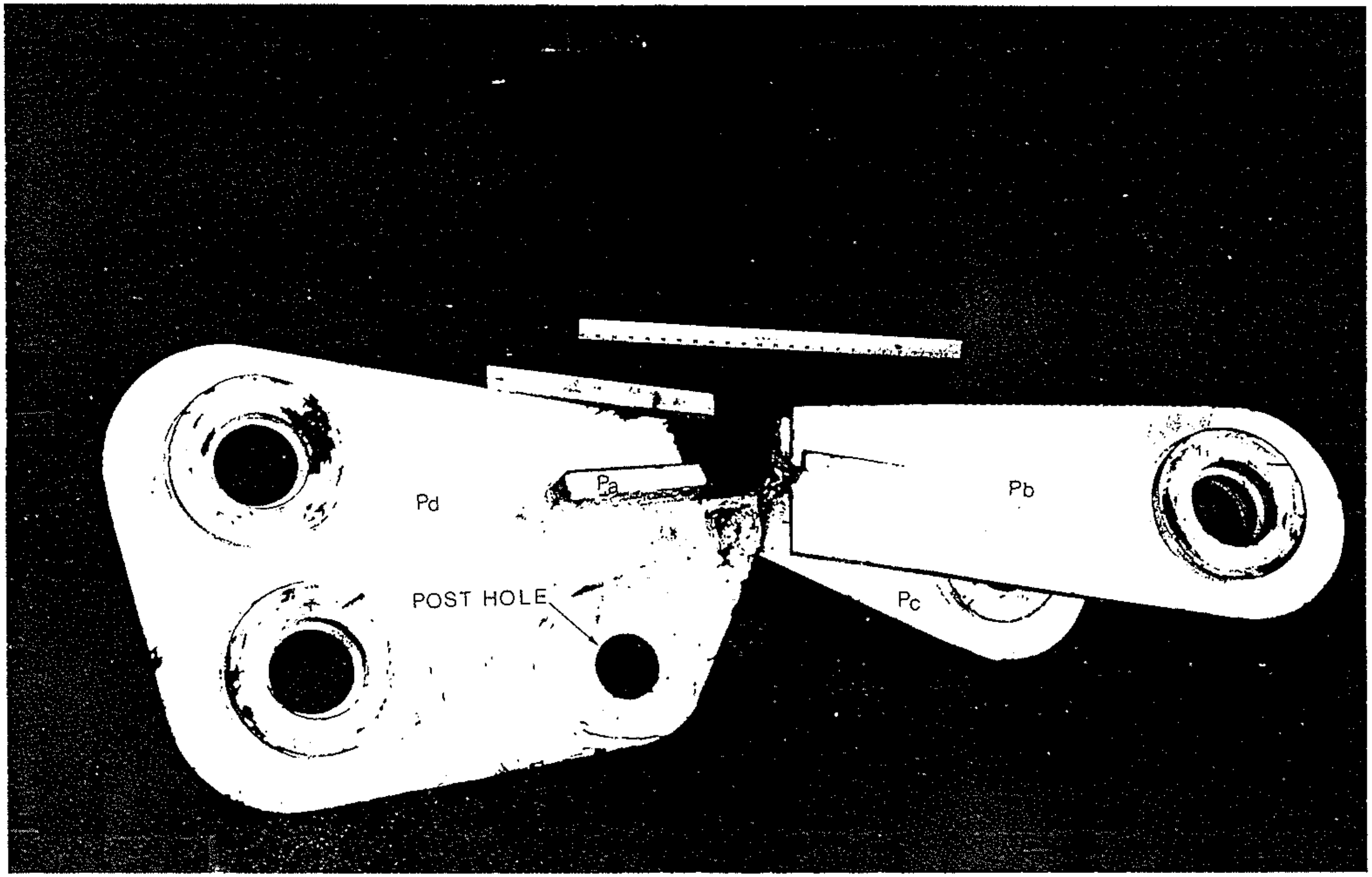
FIG.2.09



ELEVATION

ELEVATION AND SECTION OF THE PA POST ATTACHMENT PLATE

FIG. 2.10

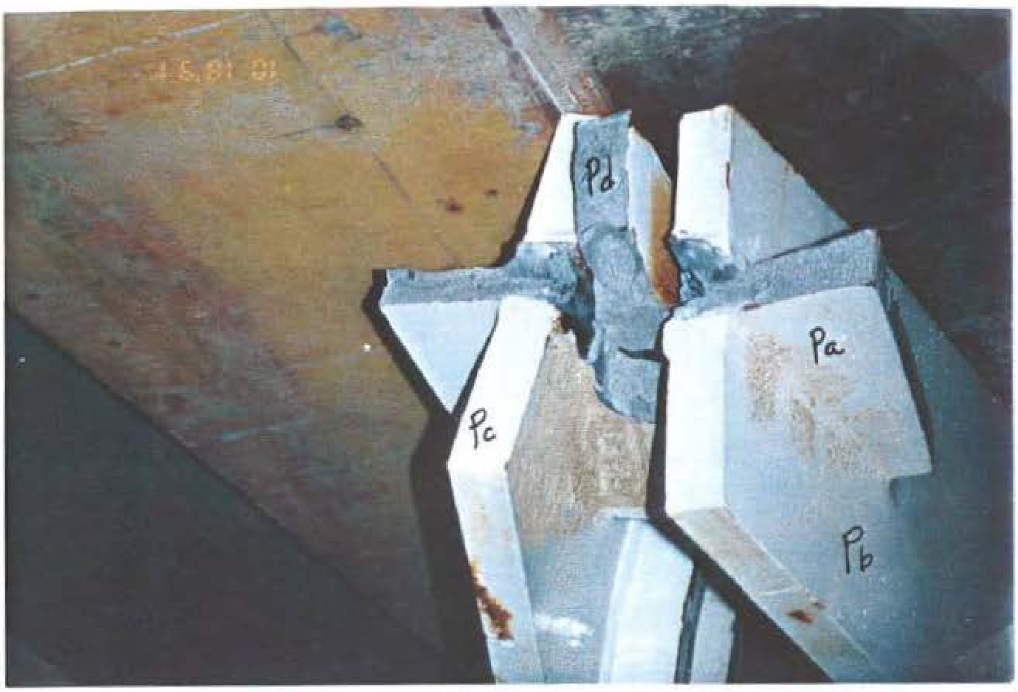


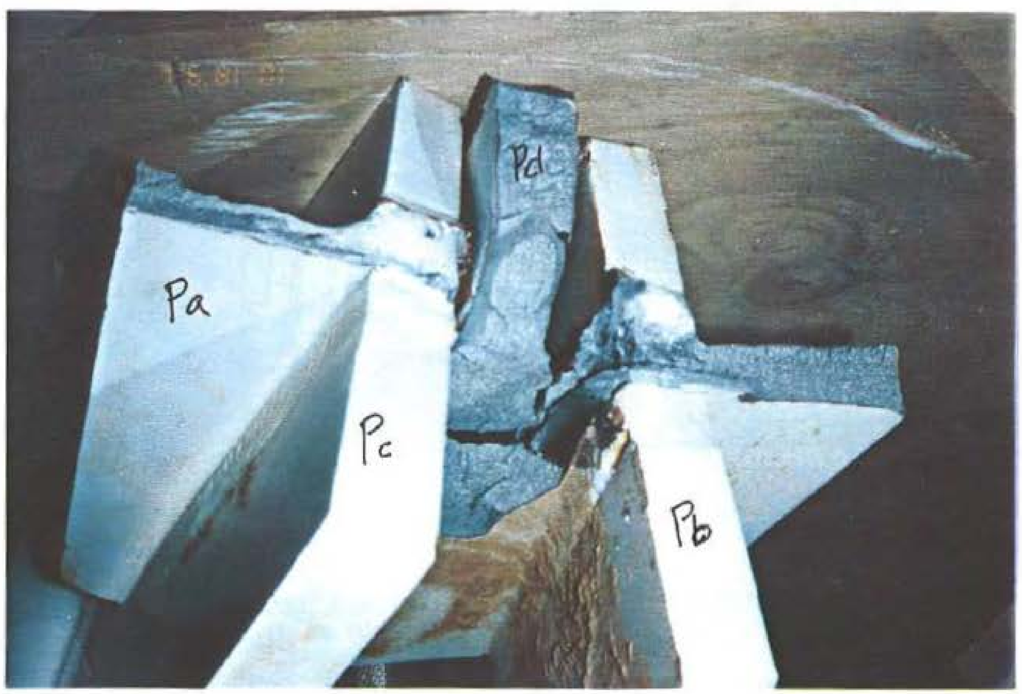
PA ATTACHMENT PLATE AFTER THE ACCIDENT
SHOWING THE MATING SECTIONS

FIG. 2.11

EAST PORTION OF THE FRACTURED ATTACHMENT PA-7 PLATE

FIG. 2.12

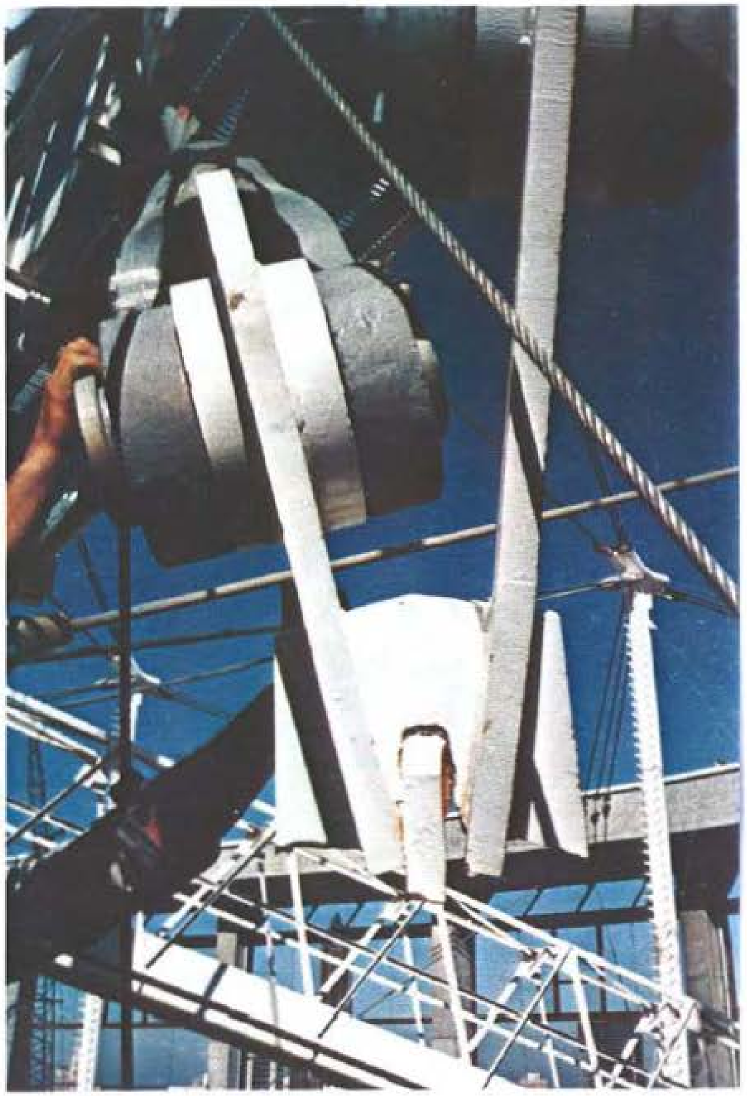




EAST PORTION OF THE FRACTURED PLATE (ANOTEER VIEW) FIG. 2.13

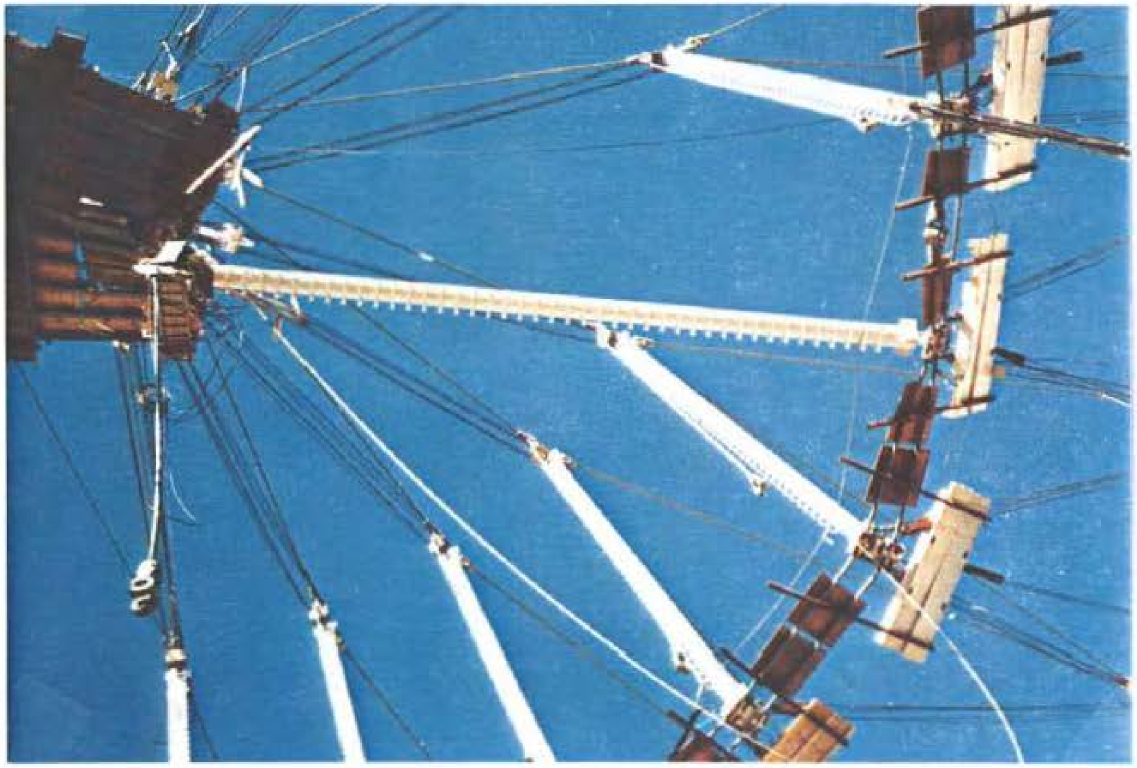
EAST PORTION OF THE PLATE AFTER THE FRACTURE
IN AN UPSIDE DOWN POSITION.

FIG.2.14



EAST PORTION OF THE FRACTURED PLATE

FIG.2.15



POST PA IN THE ROTATED POSITION AFTER THE PLATE FRACTURE
POST HIT THE WORK PLATEFORM AT THE LEFT SIDE

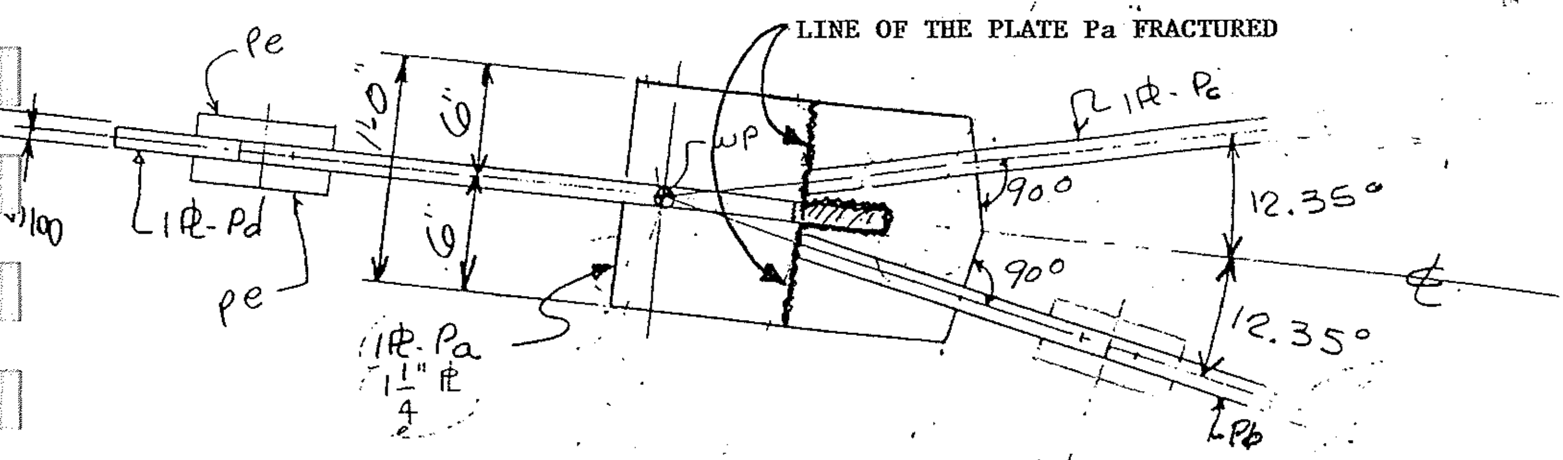
FIG. 2.16

WORK PLATEFORM AT THE
EAST END OF THE CENTER TRUSS

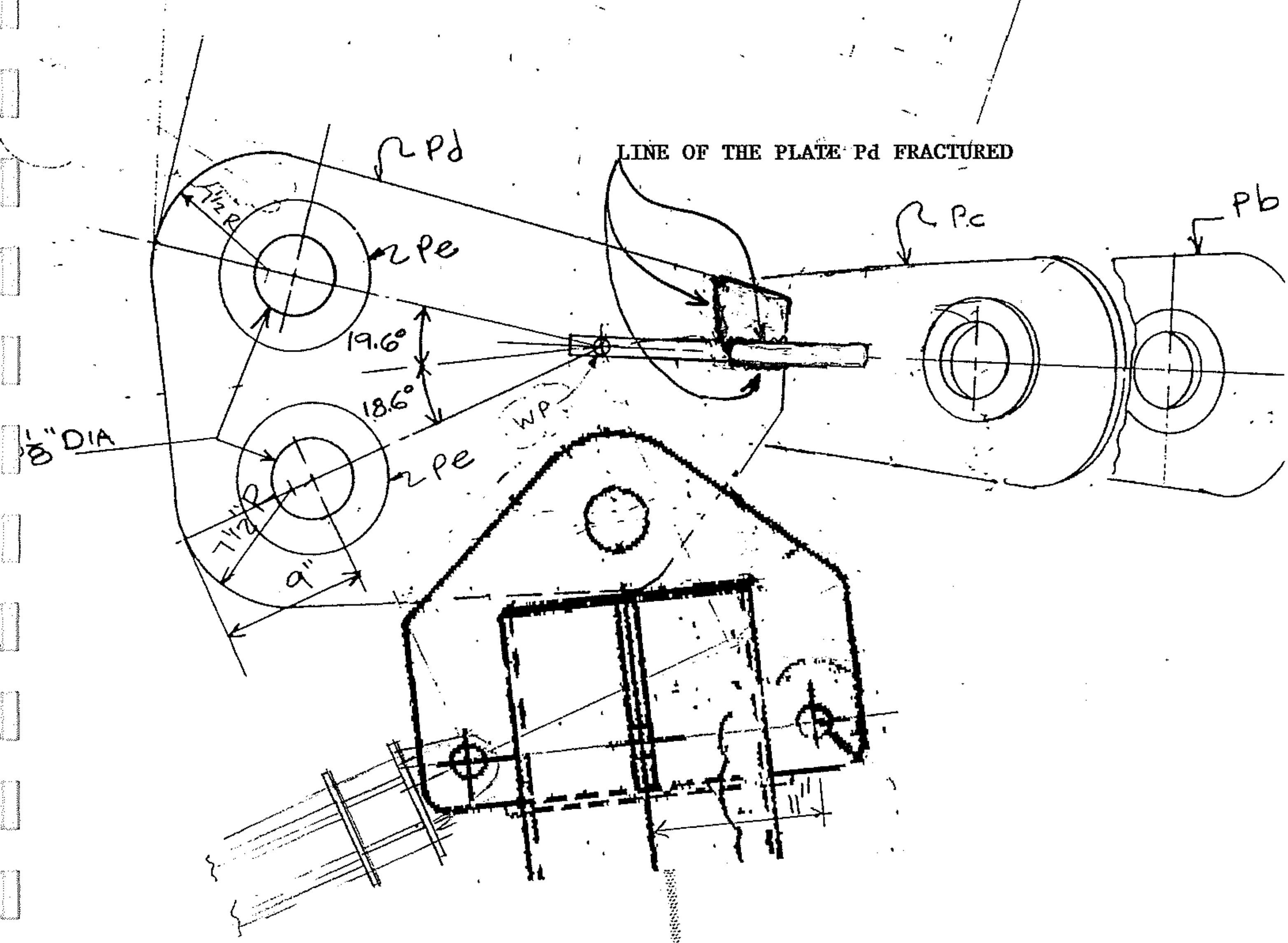
POST PA

POST PA AND THE WEST PORTION OF THE FRACTURED PLATE ROTATED AFTER THE ACCIDENT

FIG. 2.17



PLAN OF THE ATTACHMENT PLATE



ELEVATION VIEW OF THE ATTACHMENT PLATE AND POST TOP PLATE

ATTACHMENT PLATE TA-7 FRACTURED LOCATIONS

FIG.2.18

3.0 CONDUCT OF INVESTIGATION

The following construction documents were made available to the OSHA investigation team through the project manager of the Dome construction management group:

1. Cablenet Erection Procedure prepared by the roof erection contractor, reviewed and approved by the structural engineer of record. (Appendix A)

2. Structural Drawings relating to the structural notes, roof geometry, compression ring beam, ring beam cable anchor details, roof cable layout, center truss, cable connection detail etc. These drawings were prepared by the structural engineer of the record.

3. Project Specifications, prepared by the structural engineer of record consisting of Section 700-Fabric Roofing System and Section 710-Fabric Roof Structural Steel. These specifications were furnished to the roof erection company for fabrication and erection of the fabric roof structure. (Appendix B-portion of the Specifications)

4. Shop Drawings related to the roof erection sequences, attachment plates fabrication details, weldment lifting assembly, forces in the roof cables at various stages of roof erection etc. These drawings were prepared by the roof erection contractor and subsequently reviewed and approved by the project architect, structural engineer of the record and the construction management team of the project.

5. Sketches of the revised top attachment plate assembly for the posts PA after the accident. The plates were redesigned by the structural engineer of record. However there were no structural calculations available associated with the redesign. (Appendix C)

6. Outlines of "A Weldment Repair Procedure" proposed by the roof erection contractor to secure the stability of the roof cable after the accident. (Appendix D).

7. Tabulations showing - "Jacking loads on temporary jacking stands - between "A" hoop and center truss" prior to De-jacking for the attachment plate reinforcements and the "Maximum Loads to Final Jack" after the accident. (Appendix E)

8. Computer print out showing "Approximately nodal coordinates and cable force at the time of accident" from the erection company. (Appendix F)

Both portions of the fractured attachment plate TA-7 assembly were retrieved by the construction managers of the project and forwarded to an independent laboratory for testing. The tests was conducted to verify the mechanical and compositional properties of the fractured steel plate. The metallurgical examination was also conducted.

Interviews of construction workers and engineers were conducted to obtain accounts of the collapse, to determine the construction activities preceding the collapse and the design and erection procedures of the roof cable systems.

The structural calculations were made to compute the approximate steel plate stresses at its critical locations due to the jacking loads immediate preceding the collapse, based on the estimated forces provided by the roof erection company.

The conclusion regarding the cause of the failure was based on all the above information.

4.0 INTERVIEW STATEMENTS

Five construction workers were interviewed by personnel of the OSHA Atlanta West Area Office immediately following the accident. Among those interviewed were four workers who were located on the temporary work platform, 230 feet above stadium floor level and suspended under the bottom of the center truss. Another worker interviewed was at the concourse level at the time of the accident. The OSHA investigating team also interviewed the construction managers, the project engineer of the roof erection company and the structural engineer of record. The following are the summary of the highlights of their interview statements.

HIGHLIGHTS OF INTERVIEW STATEMENTS

WITNESS NUMBER (JOB TITLE)	HIGHLIGHTS OF INTERVIEW
1 Superintendent Erection Co.	o Were jacking the center truss. o Heard a pop very loud, then the mast broke loose. o An ironworker directly hit by the falling mast.
2 Ironworker Erection Co.	o Helping jacking crew. o The crew had pulled up with two pumps. One pump had come up to 35k and other was coming up about 30k. o Heard a sound like a loud bang. Nothing unusual noticed. o Went back pumping when heard another loud bang followed by the accident.
3 Rigger Erection Co.	o Was running pump at time of the accident. Had 35k on pump. o Has started reacting pump. o Heard loud noise followed by accident.
4 Superintendent Structural Conc. Frame	o Was on the main concourse level; at 33 A line. o Heard a loud noise. Saw a man going over the edge of the platform to the ground. o Saw another man hanging on the east side of the platform.
5 Rigger Erection Co.	o On the work platform at the time of the accident. o Were working on hydraulic pumps which pulled up the cables to raise the structure. o Heard a cracking sound on "A" hoop. o Wondered what was wrong, then started retracting my pump. "I was facing away from everybody. Accident occurred. Something hit me."

6 Project Engineer Erection Co.	o Eight temporary cables were jacked, four with a tensile force of 35k each, four with a force of 30k each at the connection plate which fractured, immediately prior to the accident. The total force imposed on the fractured plate, prior to the accident, was in the order of 260 to 280 kips. o Erection procedure and details were reviewed and approved by the structural engineer of record. No calculations were made to verify the integrity of the connection plates for the construction loads. Since the erection forces in the cables were lower than the ultimate strength of the cables therefore, it was concluded there was no need to check the adequacy of the plate. o The workers were in error in applying this magnitude of force. They were instructed to apply a tensile force of only 35k in each of the four temporary jacks (total force = 140k) till the final lift in which case a force of 22.5k was to be applied in eight cables (total force = 180k). o The erection drawings indicated a force of 117k to be applied to the diagonal jacking cables at this connection plate. A decision was made at the site to increase the load of 117k to 140k. o Since the accident, it has been determined that a force of 180k, as estimated earlier, would not have been sufficient to make the final connection with the center truss. Instead, a force of 228k was needed to complete the erection. o The erection company provided a set of erection loads along with the estimated eccentricity to the structural engineer of record to redesign the connection plates after the accident. o The bolt used for the connection of the temporary jacking cable was 2" dia ASTM A354. o The center truss was approximately 12" to 16" away from final position prior to the accident. o The ultimate capacity of the jacking cable was 58 kips.

5.0 LABORATORY TESTING

The fractured portion of the top attachment plate at node point 1308 containing the plates marked Pb, Pc and a part of Pa and Pd was secured and delivered to a private testing laboratory by the construction management team for conducting metallurgical examination to determine the nature and origin of fracture. Tests were also conducted to verify mechanical and compositional properties of the steel plates. The following is a summary of the test results of the private testing laboratory based on a report dated, January 29, 1992, obtained from the construction managers.

1. The plates Pa and Pd conformed to the compositional and tensile strength requirements of ASTM A572 Grade 50.

2. The plates Pa and Pd satisfied the minimum toughness requirement of 15 ft-lbs at 70°F.

3. The groove welds between plates Pa and Pd were satisfactory and no evidence of defects like porosity, entrapped slag or cracks were found.

4. There were three origins of the fracture which were all located at the underside of plate Pa near the intersection of plates Pb, Pc and Pd. The examination of the fracture origins indicated that the failure was the result of overload tearing in a tough material. Inelastic (permanent) deformations had occurred at the surface of plate Pa adjacent to the fracture origins, and on the outboard surfaces of plates Pb and Pc adjacent to the end of plate Pa. The occurrence of inelastic deformation indicates that the connection had been subjected to loads, prior to fracture, which generated localized stresses in excess of the plate material's yield strength. Overload (overstress) condition precipitated the connection fracture.

6.0 DISCUSSION, EVALUATION AND CONCLUSION

Erection of Roof Cable System

The erection of the dome roof system consisted of the "design, supply, fabrication, shipment and erection of these principal items - Fabric, acoustic liner, clamping system, cables, structural steels and all their fittings" as specified in the project specifications (Appendix B). The specifications were prepared by the structural engineer of record and furnished to the erection company as part of the contract documents.

In specification Section 700, paragraph 1.4 General Requirement, it is stated that:

> "B. General Requirements
>
> 1. Continuously monitor the installation and the erection of the structural steel, steel cables, wire rope and the fabric membrane to insure that the structure is constructed in accordance with the engineering design and to insure that no construction loading either damages or over-stresses any part of the roof."

The specification Section 710, paragraph 1.4.A.8 also stated:

> "8. The Roof Contractor shall be solely responsible for the determination of the erection sequencing and procedures. The Roof Contractor shall analyze the cable and steel structure at various stages in his erection sequence to ensure stability of the structure as well as to ensure that none of the temporary nor permanent components of the structure are overstressed."

Interview statements of the construction managers and project engineer of the erection company had revealed that there were no engineering design calculations made, by the roof erection company, to verify the adequacy of the steel attachment plate assemblies for the application of the temporary jacking load during the entire erection process. As per the project engineer of the erection company, "a comparison of the temporary jacking loads to the ultimate capacity of the cables were made to ensure that during no stage of the jacking operation, the jacking load would exceed the ultimate strength of the cables. Based on this premise, it was assumed that the attachment plate assemblies would be satisfactory to resist the temporary jacking loads during various stage of cablenet lifting, as long as the cables were not stressed in excess of their ultimate capacity."

The above specifications Section 710 paragraph 1.4.A also required:

> "9. The above analysis results as well as pertinent calculations shall be submitted for review by the Engineer with the complete erection procedures

and drawings. The Engineer's review shall in no way or means diminish the Roof Contractor's obligations and responsibilities to erect the structure in a safe and proper fashion." and

"10. The Roof Contractor's erection analysis, procedures and drawings shall be prepared under the supervision of a Professional Engineer registered in the Georgia and signed and sealed by him."

Shop drawings related to the roof erection sequences, details of attachments plates etc. (Item #4 in Section 3 of this report), were not signed and sealed by a Professional Engineering registrated in State of Georgia.

Construction Activities at the time of the accident

The lifting of ridge net assembly was underway and was close to the final stage at the time of the accident, as per the project engineer of roof erection company. The workers had completed all the permanent cables and posts connections with the exception of D1 cables. D1 cables are the diagonal cables connecting the bottom chords of center truss to the top attachment plates at PA posts. See Figures 6.01, 6.02 and 6.03. The D1 cables were in slack position and all the temporary jacking strands of the diagonal cables were tensioned to some initial loads to maintain the center truss in a position which was only a short distance away from its final elevation. The Jacking Sequence "D1 Cable Installation" as outlined in the "Cablenet Erection Procedure" (Appendix A) was in progress.

As per the erection company, immediately preceding the accident, the workers on the east work platform were using two hydraulic pumps and applying load to each of the 8 jacking strands, that were attached to the top of the post PA at node 1308. The east bottom joint of the center truss was only few inches (12 to 16") away from its final connection locations. According to the workers on the east work platform, while the strands were being jacked, they heard a loud bang sound at which time they stopped the pumps, but did not notice anything unusual. Soon thereafter they resumed pumping, then they heard another loud noise, following which they saw the PA post collapse. The jacking loads were approximately 30 kips in one pump and 35 kip in the other pump. A total of 240 kips to 280 kips force were applied to the jacking strands, when the accident occurred.

The intent of the erection procedure as described by the steel erection company, in the interview after the accident, called for a force of 4 X 35 = 140 kips to be initially applied to a set of four strands at the diagonal cables. A final tension force of 22.5 kips at each of the 8 strands, total of 180 kips (8 X 22.5 = 180 kips) was to be applied to the complete set of eight stands to bring the truss at the proper elevation, following which the diagonal cables would be permanently connected. This procedure was intended to be followed. However, on the day of the accident immediately prior to the accident, all eight stands were erroneously jacked by the crew to a force of 30 to 35 kips each at the nodal point 1308. A force of 240 to 280 kips was therefore applied to the temporary jacking strands at nodal point 1308. This force was higher than the intended force of 180 kips, as per the roof erection company.

Loads in The Jacking Strands of PA Posts:

Appendix E of this report contains the tabulations showing "Jacking Loads on Temporary Jacking Strands Between A Hoop and the Center Truss". Column 1 of the tabulations are loads that existed in all the 26 nodal joints of hoop A. These jacking loads were recorded by the roof erection company prior to the "De-jacking" of the strands for the repair and/or reinforcement of the PA plates. With the exception of "zero" force in node point 8 (which is node 1308 of the fractured plate) , the range of jacking loads that existed immediately prior to the accident was 20,000# to 132,000#. These loads were the initial jacking forces in the temporary strands between the A hoop and the center truss. Column 2 of the tabulation are the "Maximum Load to Final Jack". These are the forces actually applied to the D1 diagonal jacking strands to make the final cable connections after the repair/replacement of attachment plates were completed. These forces were also recorded by the roof erection company. The range of loads was 80,000# to 228,000#. The jacking load applied at node 1308 to make the final permanent connection with the redesigned attachment plate was 228 kips which was approximately 27% higher than the original intended loads of 180 kips.

The Attachment Plate TA-7 of Node 1308

The attachment plate TA-7 of node 1308 consists of four 1-1/4 inch thick steel plates identified as Pa, Pb, Pc and Pd in the shop fabrication drawings, prepared by the roof erection company. Plate Pb, Pc and Pd were groove welded to the horizonal plate Pa as shown in Fig. 2.10. Plate Pb and Pc each has one 5-1/8 inch diameter hole where the ridge cable connects to the top posts of hoop B. Plate Pd has two 5-1/8 inch diameter and one 4-1/8 inch diameter holes, the 5-1/8 " holes were for the ridge cable to center truss top joint and the diagonal cable to the center truss bottom joint connections, the 4-1/8" hole was for the post PA top plate connection.

As per the structural engineer of record, at the completion of the roof structure, the forces in all four cables (3 ridge and 1 diagonal) and the steel post will be acting toward the

W.P. (Working Point) concentrically. The W.P. is located 2 inches from the left side of the plate Pa center line as indicated in the detail of Fig. 2.10.

The method of the roof cable erection adapted by the contractor as described earlier, called for the center truss to be raised to its final location by jacking of the temporary diagonal strands between top of hoop A post and the bottom of the center truss. The diagonal jacking strands were attached to a welded bracket at the post PA top steel gusset plate and the welded bracket was connected to the post gusset plate by a 2 inch diameter high strength bolt, see Figures 6.04 and 6.05. During the jacking process, the jacking load applied to the strands was transmitted to the attachment plate through this 2" diameter bolt. Due to the offset position of the bolt hole with respect to the attachment plate assembly, the application of the jacking loads would not be concentric with the other cable forces during cablenet lifting operation. Hence, a bending moment was introduced to the attachment plate assembly by the eccentricity of the jacking loads.

Following the accident, the roof erection company proceeded securing all the PA posts by lashing all the attachment plates together and then visually inspected all the plates. All the DI temporary strands were then de-jacked and the PA top attachment plate assemblies were reinforced. Appendix C and Appendix D indicate revised plate assembly details and an outline of the repair procedure. The redesign was performed by the structural engineer of record and was based on the maximum eccentric force to be applied to the jacking strands, during the final erection after the accident.

Location and Forces of Node 1308 at The Time of The Accident

Appendix-F of this report contains the computer print-out, which identifies the coordinates of all the nodal joints and the forces which existed in all the cablenet members at the time of the accident. This information was provided by the roof erection company to the OSHA investigation team after the accident. From the above computer print-out and the contractor's shop drawings (drawing # 9080D1010 & 9080D1011), it was determined that the location of node 1308 was approximately 11"-10" lower than its final elevation at the time of the accident. Nodal joints 1207 and 1208, at top of Hoop B, were about one foot lower than node 1308 and were approximately 1'-5" higher than their final location. The center truss east top joint was about 18 feet higher than node 1308, and was approximately 12 feet lower than its final elevation. See Fig. 6.06 for positions of the cables at the time of the accident and their final positions at the completion of the roof erection.

Forces in the two ridge cables between node 1308 to the nodes 1207 and 1208, at the top of hoop B post, were approximately 99 and 100 kips. Force in ridge cable between node 1308 and the center truss was approximately 89 kip and force in PA post was approximately 19 kips, as per the same computer print-out. The diagonal D1 cable was not connected to the bottom of the center truss, and therefore had no force.

Based on the eccentric forces of 240 to 280 kips in the diagonal jacking cables and the relative position of the nodal joints discussed above, the tensile stress at the groove weldea joint of the plates Pa/Pd adjacent to the end of plate Pd plate was determined to be 62 to 72 ksi, and the flexural tensile stress at the bottom of plate Pa adjacent to the left end of the plates Pb and Pc determined to be 76 to 88 ksi. These stresses were higher than the yield strength of the plate material. As per the lab test results, the average yield strength of the plate Pa and Pd was 59 ksi and 55.5 ksi respectively and the average ultimate tensile strength of the plate material was 85.5 ksi, see Fig. 6.07. (test results taken from the lab report). At the time of the accident, the stresses in the critical locations of the attachment plate assembly due to the eccentrically applied jacking forces were determined to be either approaching or exceeding the ultimate tensile strength of the material. The high stresses caused the plate to fracture.

The above stresses were calculated based on the theoretical locations of the nodal joints 1308, 1207, 1208 and the center truss, and were also based on the forces in the ridge cables and the PA post, furnished by the roof erection contractor in their computer print-out. Though it must be recognized that the position of the nodal joints and the magnitude of other member forces could be slightly different from the computer print-out values due to the application of higher than intended loads to the temporary diagonal jacking strands. Due to the structural complexity of the entire roof cable system and the ever changing position of the joints during the erection process, the exact locations of nodal joints and magnitude of the forces at node 1308 could not be ascertained with a high degree of accuracy at the precise moment of the accident. However, it was determined that regardless of the slight variations in the nodal position and the member forces, the tensile stresses in the critical locations of the plate assembly would remain higher than the yield strength of the material due to the eccentrically applied jacking loads in the diagonal strands.

Conclusions

Based on the above discussion and evaluation, the following conclusions are drawn.

1. The accident occurred due to the collapse of a steel post following the fracture of an attachment plate located at the top of a hoop "A" post. The attachment plate was loaded in excess of its capacity. The overloading was the result of the bending moment created by the eccentrically applied tensioning force of the temporary jacking strands to the attachment plate.

2. The fractured attachment plate was not adequately proportioned for the tensioning force applied during the roof erection immediately prior to the accident.

3. Engineering calculations were not done, by the roof erection company, to determine and verify the structural adequacy of the attachment plate assemblies for the erection loads to which these plate assemblies were subjected during the erection of the roof cable system, as per contract document requirements.

4. Workers, who were on the platform and involved in the specific construction activity preceding the accident, were not clearly instructed regarding the jacking sequence and the amount of tensioning force to be applied to the temporary jacking strands to make the final connection of the diagonal cables and the roof center truss. Written instruction or the erection drawings indicating the magnitude of tensioning force to be applied to the temporary jacking strands were not available to the erection crew.

THE COMPLETED ROOF CABLE STRUCTURE AT THE TIME OF THE ACCIDENT. THREE HOOP CABLES, THE POSTS, AND RIDGE CABLES

FIG. 6.01

TOP OF THE PA POSTS SHOWING THREE RIDGE CABLES, STEEL POST, TEMPORARY JACKING STRANDS. THE DIAGONAL CABLES WERE IN A SLACK POSITION.

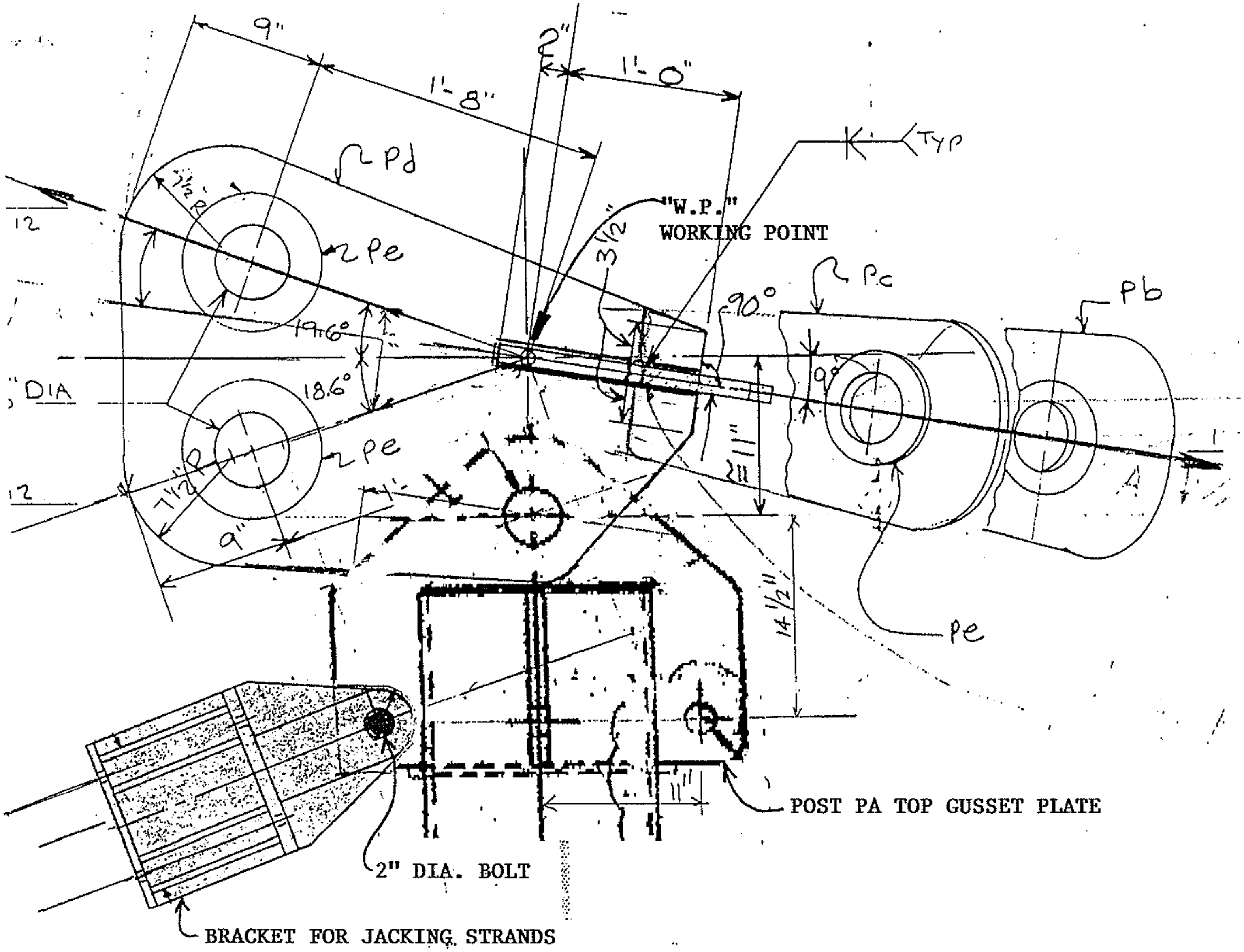
FIG. 6.02

CLOSE UP OF THE TOP OF PA POST.

FIG. 6.03

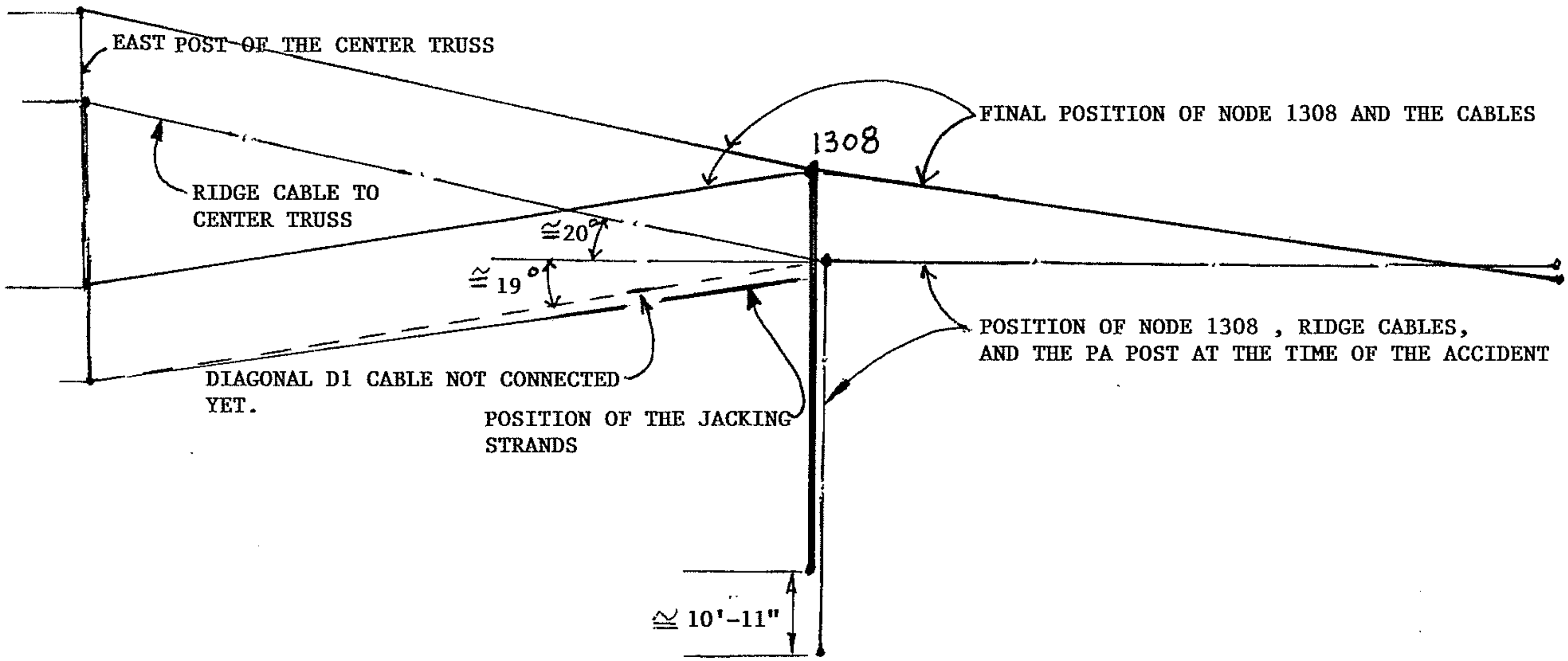
ATTACHMENT PLATE AT TOP OF PA POST
AND THE TEMPORARY JACKING CABLE CONNECTION DETAILS

FIG. 6.04



PA PLATE ASSEMBLY WITH JACKING STRAND BRACKET

FIG.6.05



LOCATION OF ALL CABLES AND POST AT THE TIME
OF THE ACCIDENT-AS PER COMPUTER PRINT OUT (APPENDIX-F)

FIG. 6.06

Results of the tensile tests are given in Table 3, as follows:

TABLE 3

CONNECTION PLATE TENSILE TEST RESULTS

	Plate - Pa No. 1	Plate - Pa No. 2	Plate - Pd No. 1	Plate - Pd No. 2	Specified per ASTM:A572 Grade 50
Yield Strength, ksi (0.2% offset)	60.0	58.5	56.0	55.0	50.0
Ultimate Tensile Strength, ksi	85.5	86.0	85.0	85.5	65.0
Elongation, % (2-in. gage)	29.5	29.5	26.5	27.0	21.0
Reduction in Area, %	57.0	58.0	65.0	64.0	--

FIG. 6.07

APPENDIX - A

CABLENET ERECTION PROCEDURE

BEERS - GEO[illegible]GIA DOME

BEERS · RUSSELL · HOLDER · BARTON-MALOW

SUBMITTAL FORM

Submitted By: Birdair Inc

Specification Title: 07-700 Fabric Roofing System

Specification Section No: 07-700 L4.0.3

Cablenet Erection Procedures

Submittal No. 425
(Assigned By PM)

SHOP DRAWING REVIEW

A	NO EXCEPTIONS TAKEN	
B	MAKE CORRECTIONS NOTED	X
C	AMEND & RESUBMIT	
D	REJECTED - SEE REMARKS	
E	REVIEWED ONLY FOR LOADS IMPOSED ON THE STRUCTURE	

Corrections or comments made on the shop drawings during this review do not relieve contractor from compliance with requirements of the drawings and specifications. This check is only for review of general conformance with the design concept of the project and general compliance with the information given in the contract documents. The contractor is responsible for: confirming and correlating all quantities and dimensions; selecting fabrication processes and techniques of construction; coordinating his work with that of all other trades; and performing his work in a safe and satisfactory manner.

HEERY / RFI / TVS

Date 4-9-91 By ________

SUBMITTED FOR
MAR 22 1991
APPROVAL
WRT

SHOP DRAWING REVIEW

A	NO EXCEPTIONS TAKEN	
B	MAKE CORRECTIONS NOTED	X
C	AMEND & RESUBMIT	
D	REJECTED-SEE REMARKS	
E	REVIEWED ONLY FOR LOADS IMPOSED ON THE STRUCTURE	

Corrections or comments made on the shop drawings during this review do not relieve contractor from compliance with requirements of the drawings and specifications. This check is only for review of general conformance with the design concept of the project and general compliance with the information given in the contract documents. The contractor is responsible for confirming and correlating all quantities and dimensions; selecting fabrication processes and techniques of construction; coordinating his work with that of all other trades and performing his work in a safe and satisfactory manner.

WEIDLINGER ASSOCIATES
Consulting Engineers

Date 4-8-91 By ________

A. APPROVED AS NOTED FOR ARCHITECT'S REVIEW ✓
B. REVISE AND RESUBMIT
C. REJECTED

This review is for [illegible] conformance with [illegible] and specification [illegible] [illegible] [illegible] [illegible] [illegible] contract [illegible]

BEER[illegible]

3-25-91

By ________

SHOP DRAWING SUBMITTAL NO.

A-1

GEORGIA DOME

ROOF CABLE NET INSTALLATION

RIDGE CABLE LAYOUT

1. 4' X 4' X 1' concrete pads are laid out on the playing field in accordance with drawing 2400. Roof top weldments attach to the concrete pads. Pads are laid out in a compressed condition in such a way that the ridge cables will be in a slack condition from roof weldment to roof weldment.

2. Temporary weldment brackets are attached to the concrete pads per drawing 2403, and roof top weldments are attached to the brackets.

3. Ridge cables are laid out on the infield with the use of a crane in the appropriate position, shown on drawing 2415 (North West Quadrant). 4000

4. Paint marks on ridge cables are properly located in saddle grooves of roof weldments. Aluminum filler bars are inserted in grooves, and top cover plates are installed snug tight to secure cable location.

5. Temporary lifting brackets and saddle plates are attached to the ends of roof weldments, per drawing 2404, which are used for ridge net lifting.

6. Prior to ridge net lift, final check of ridge cable lay out is made and all cover plate bolts are fully tensioned by means of load indicator washers.

TENSION TRUSS ASSEMBLY

1. Concrete pads are laid out on the centerline of the playing field at the proper location for the bottom of the tension truss posts.

2. Temporary brackets are attached to the pads, tension truss posts are attached to the brackets, and posts are laid on the ground to the north.

3. Top cord, bottom cord, and diagonal cables are laid out and attached to the tension truss. Paint marks on cables are properly located in clamping grooves, aluminum filler bars are inserted, and cover plates are installed to 50% pre-load to secure cable locations.

4. Tension truss is stood up vertically by the use of cranes, plumbed and temporarily guyed by the use of ground anchors, per drawing 2421.

5. Final check of cable lay out is made and all cover plate bolts are fully tensioned by means of load indicator washers.

RIDGE NET LIFT

1. All ridge cables are attached to the tension truss, and overhead temporary guys are attached from the top ends of the tension truss to the ring beam, per drawing 2420.

2. Ridge net lift rigging is installed per drawing 2425. Temporary tirfor restraints are attached from "C" weldments to the bottom of tension truss to allow "C" weldments to clear the stadium seating during the lift. Lifting cables are run from the "C" weldments to the ring beam, over a temporary ring beam saddle to the ring beam jacking bracket, per drawing 2426.

3. Ridge net is hydraulically lifted using lift rigging uniformly by jacking simultaneously at 52 jacking locations around the ring beam. Drawings 2900 and 2901 show the ridge net just lifted off the playing field. Note, tirfor restraints will be let out as lift continues to minimize load, but allow clearance of ridge net from stadium seating.

4. Ridge net will continue to be lifted, per drawings 2902 and 2903, at which point tirfor cables will be removed.

5. Ridge net will continue to be lifted, per drawings 2904 and 2905, until approximately 25 Kips of load per jacking cable. Note, tension truss will have been lifted off the ground at this point in time.

6. The tension truss will be lifted at the two ends by the use of cranes, per drawings 2906 and 2907, to allow final jacking and attachment of ridge net with a single jacking strand. Two backup cables will be used as safety cables at all times during ridge net lift.

7. Ridge net raised and connected to ring beam, per drawings 2908 and 2909.

HOOP C LIFT

1. Hoop C cables are laid out on the playing field per drawing 2440.

2. Paint marks on cables are properly located in cable grooves of roof bottom weldments. Aluminum filler bars are inserted and cover plates are installed snug tight to secure cable locations.

3. Final check of cable lay out is made, and all cover plate bolts are fully tensioned by means of load indicator washers.

4. Hoop C is jacked to final position similar to ridge net lift per drawings 2910 and 2911. D4 cables are attached from the ring beam to roof bottom weldments.

POST C INSTALLATION

1. C Post installation will start at column line 1 and 26 simultaneously and proceed from both locations in a clockwise direction.

2. C Post will be lifted off the ground by use of a crane and attached to the roof top weldment first.

3. After connection of top weldment, post will continue to be lifted along with ridge net, per drawing 2912.

4. Bottom connection of roof post will be made per drawing 2913 and 2914.

5. Post will continue to be installed per drawing 2915 and 2916.

6. All C posts will be installed per drawing 2917 and 2918.

HOOP B LIFT

1. Hoop B cables are laid out on the playing field per drawing 2440.

2. Paint marks on cables are properly located in cable grooves of bottom weldments. Aluminum filler bars are inserted and cover plates are installed snug tight to secure cable locations.

3. Final check of cable lay out is made and all cover plate bolts are fully tensioned by means of load indicator washers.

4. Hoop B is jacked to approximate position of the bottom of B Post suspended from the ridge net.

POST B & D3 CABLE INSTALLATION

1. With B Hoop in its approximate position, the B Post is lifted off the ground by use of a crane, and attached to the roof top weldment first.

2. The B Post is connected to the bottom weldment and hoop cables, and the D3 cables are tensioned by the use of temporary jacking cables to approximately 20 to 40 kips. All B Posts are installed per drawings 2919 and 2920.

3. D3 cables are then uniformly jacked to their final position and connected, using temporary jacking cables, by jacking at 52 locations, per drawings 2921 and 2922.

HOOP A LIFT

1.. Hoop A cables are laid out on the playing field, per drawing 2440.

2. Paint marks on cables are properly located in cable grooves of bottom weldments,. Aluminum filler bars are inserted and cover plates are installed snug tight to secure cable locations.

3. Final check of cable lay out is made, and all cover plate bolts are fully tensioned by means of load indicator washers.

4. Hoop A is jacked to approximate position of the bottom of A Post suspended from the ridge net.

POST A & D2 CABLE INSTALLATION

1. With A Hoop in its approximate position, the A Post is lifted off the ground by use of a crane and attached to the roof top weldment first.

2. The A Post is connected to the bottom weldment and hoop cables, and the D2 cables are tensioned by the use of temporary jacking cables to approximately 20 to 40 kips. All A posts are installed per drawings 2923 and 2924.

3. No further jacking of the D2 cables occurs at this time, until the D1 cables are installed. D1 cables are installed next, to reduce jacking load on D1 cables.

D1 CABLE INSTALLATION

1. D1 cables are uniformly jacked to their final position and connected using temporary jacking cables, per drawings 2925 and 2926.

D2 CABLE INSTALLATION - FINAL JACKING

1. D2 cables are uniformly jacked to their final position and connected using temporary jacking cables, per drawings 2927 and 2928.

APPENDIX – B

PROJECT SPECIFICATIONS FOR

FABRIC ROOFING SYSTEM AND

FABRIC ROOF STRUCTURAL STEEL

4/2/90

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. The conditions of the Contract (General, Supplementing and other Conditions) and the General Requirements sections of Division 1 are part of this section.

B. The work covered in this section consists of furnishing all labor, materials and equipment, necessary for the fabrication and erection of the fabric roof structure, complete as shown on the drawings, or inferable therefrom and/or specified in accordance with the requirements of the tender documents. Work is to include, but not necessarily be limited to, the design, supply, fabrication shipment and erection of the following principal items.

1. Fabric roof membrane including closures.
2. Acoustic liner, including all associated supporting cables and clamps.
3. Clamping systems including all molded and extruded rubber elements and gaskets.
4. Cables and associated end fittings.
5. Structural steel for the roof system including, but not limited to, posts, cable anchorages, center ridge, catwalks and bridges, prime and finish painting and erection of steel components, all as shown on the structural drawings.
6. Warranty and Service and Maintenance Agreement for the Roof Structure. Base warranty for one year.

C. Related Requirements
Section 07710: Structural steel shall be supplied per section 07710 and erected per this section.

1.2 ROOF CONTRACTOR REQUIREMENTS

A. Qualification of Contractor: Supply, fabrication an erection of the Fabric Roof structure is limited to firms with proven experience as coater, fabricator and erector of teflon coated fiberglass fabric structures:
Acceptable Roof Fabricators:

O.C. Birdair
Amherst, New York

B. Fabrication: The entire fabrication of the fabric system shall be done by a single contractor who will have undivided responsibility for the specified performance of all component parts.

C. Roof Installation: Installation shall be performed under the direction of the firm which manufactures the fabric, fabricates the roof and under the observation of technical personnel from the Engineer/Owner experienced in the installation and handling coated fiberglass fabric tension structures. These personnel should be at the site at all times during roof installation.

EXHIBIT "A"

1.3 QUALITY ASSURANCE

A. Except as otherwise shown or noted, all work shall comply with the requirements of the latest editions of the following standards. In case of conflict between the referenced standards and the project specifications, the more stringent shall govern:
1. American Society for Testing and Materials (ASTM) as referenced herein.
2. Aluminum Association "Specifications for Aluminum Structures", all sections.
3. American Institute of Steel Construction (1985 Edition).
   a. "Code of Standard Practice for Steel Buildings and Bridges", and Supplements No. 1, 2, 3, and 5.
4. American Welding Society - "Structural Welding Code AWS 01.1-90.
5. Research Council on Riveted and Bolted Structural Joints - "Specifications for Structural Joints Using ASTM A-325 or A-490.
6. Steel Structure Painting Council - Painting Manual, Vols. 1 and 2.
7. Standard Building Code of the Southern Code Congress.

1.4 SUBMITTALS AND OTHER REQUIREMENTS

A. At time of contract signing submit one (1) copy each to the Owner of the following Information:
1. Construction Schedule: Submit a bar schedule for all phases of the fabric roof installation.
2. Fabric Roof Warranty, Inspection and Maintenance: Submit a warranty agreement as shown in Appendix A.
3. Submit and Inspection and Maintenance Program as outlined in Appendix B to this section.

B. Before Fabrication
1. Fabric Membrane: Samples. Submit a one square yard fabric sample for each of the fabrics (outer, and acoustic liner), identical with each type of fabric to be used to the Engineer and Architect. Submit also one sample each of the synthetic rubber moldings, identified as to intent, location and installation.
2. Shop Drawings: Shop drawings shall be prepared for all the fabric roof work and be submitted to the Engineer for review.
3. Submit three prints and one sepia to the Engineer for review. All the shop drawings shall be prepared in a timely manner.
4. No fabrication work shall be done without approved shop drawings.
5. Shop drawings for the fabric roof, shall be submitted in accordance with the general conditions, showing all detailing, sized and lengths of cables and end fittings, all edge, connections, and splice details and all fabric attachment hardware and any and all items not shown on the Contract Drawings but as required to complete the work specified herein. Shop drawings shall be prepared by or under the supervision of a registered engineer in the State of Georgia.
6. Shop drawings shall be carefully checked before being submitted for review, and shall be submitted in the order in which they are needed for the execution of the work, well in advance, and not all at one time. Submitted drawings shall show all material required for the work, whether or not indicated on the Contract drawings. Engineer's review of shop drawings will be for general conformance only.

7. Immediately make all corrections to drawings as required and a keep a satisfactory history of all changes by separately numbered and dated modification on a convenient portion of each drawing affected.
8. Any materials delivered at the shop or site not meeting the requirements shall not be used without the Engineer's review. The Contractor shall be entirely responsible for the completeness of the work and provide all necessary required pieces, connections or the like, whether or not shown on the drawings.
9. Submit shop drawings of all components and parts thereof, which form part of this roof system.
10. Fabric Panels: Shop drawings shall include all information necessary for fabrication of the roof covering fabric including relationship to fabric clamps, aluminum plates and rubber gaskets. They shall indicate size and shape of envelope including drawings showing the cut fabric shapes and location of shop and field connections, size type and extent of all welded seams and seaming sequence when required. The location of the warp and fill shall be clearly shown.
11. Provide to the Engineer the representative stress/strain data of the material used for each panel.
12. The method of support for packaged fabric in transit shall be detailed and submitted. When material is to be crated, the fabricator shall submit drawings showing the folding sequence, location of folding lines and methods of securing padding and type of crating to be used. Fabric shall not be folded except when adequately padded to prevent creasing.
13. Fabric Clamps: Submit fabrication drawings showing in detail the fabric clamps including all rubber gaskets with their components fully dimensioned. In addition, non-standard items of this clamp shall be shown individually in detail and fully dimensioned. Identify all pieces and materials and their control markings. Drawing shall also clearly identify the position of the piece in the structure.
14. Cables, Cable Clamps and Cable Sockets: Submit shop drawings of cables, cable clamps and end fittings showing all materials, gauges, finishes, lengths, diameters and fittings types, locations and orientations with dimensions adjusted for shop conditions.
15. Proposed Erection Procedure: Submit for the Engineer's review. The Contractor shall detail the methods and sequence of erection. Engineer's review is for general conformance to the structural intent only. The Contractor shall remain responsible for all means and methods of construction, equipment and safety for workers and the structure.
16. Roof Erection Control and Verification: Submit a construction monitoring procedure demonstrating compliance with the requirements herein for measurement and control of fabric stresses.

B. General Requirements
1. Continuously monitor the installation and the erection of the structural steel, steel cables, wire rope and the fabric membrane to insure that the structure is constructed in accordance with the engineering design and to insure that no construction loading either damages or over-stresses any part of the roof.
2. Allowable stresses during erection are defined as follows:
   a. Fabric - 0.2 times strip tensile strength
   b. Wire Rope - 0.5 times breaking strength

3. Implement Controls and procedures, including stress measurements of the fabric, to assure that the following monitoring is completed.
   a. All roof system installation activity must occur in accordance with a pre-established erection plan which indicates a detailed sequence of work.
   b. A reaction plan is in place which assures that should cable or fabric membrane over-stresses occur as installation takes place, an immediate response is made to reduce the stresses to within acceptable limits.
   c. Provisions must be made so that in case of high winds during the period when the fabric membrane is not substantially tensioned that the fabric will not be damaged by the action of such winds. Should damage occur, the Roof Contractor shall be responsible for repair or replacement of the same.
   d. In its final configuration the roof system develops the specified uniform fabric membrane prestress at the specified geometry.
   e. Representative cable force, work point geometry and fabric stress measurements at sufficient locations shall be recorded and shall be available to the Engineer throughout the installation phase. A record of these measurements shall be submitted to the Architect at the end of the work.
4. Equipment Calibration: Supply the Engineer with proof of calibration of the testing equipment before commencing with the monitoring and installation process.
5. Notification: If at any time during the stressing process the monitoring indicates that loads or stress levels exceed the design loads or stress levels, the Contractor shall immediately stop that portion of the work in question and notify the Engineer. The Engineer and/or his representative along with the Roof Contractor will determine the procedure, revisions or action required to alleviate the overloading conditions. If, in the investigation, it is determined that the overloading is due to mishandling, workmanship or engineering by the Roof Contractor, this delay shall be the sole responsibility of the Roof Contractor and no costs shall be added to the contract sum for any actions taken or recommended by the Engineer.

C. Other Submittals
1. A schedule of shop drawings with submission dates.
2. A schedule of samples and technical data with their submission dates.
3. A complete list of all Subcontractors and suppliers to the Roof Contractor, including the steel Subcontractor(s).

D. Fabric Repair Manual and Kit
1. Upon completion of the Work, submit four (4) copies of an operation and repair manual for the fabric roof structure do the Engineer as specified herein. The manual shall include a schedule for routine inspection, an inspection checklist, instructions for emergency repair and use of emergency repair materials, and guarantee as specified elsewhere. Provide a repair kit at the site for emergency repair, packaged and turned over to the Owners.

   Teflon Coated Roof Material:

   1 dozen 12" diameter patch W/F.E.P. sheets.
   3 dozen 5" diameter patch W/F.E.P. sheets.
   3 dozen 4" x 8" rectangular patch W/F.E.P. sheets.

4/2/90

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. The conditions of the Contract (General, Supplementing and other Conditions) and the General Requirements sections of Division 1 are part of this section.

B. Structural steel required for Roof structure as indicated on the Drawings and includes, but is not necessarily limited to:
1. Steel Posts.
2. Cable Anchorages and Connectors, except cable anchorages at the perimeter compression ring.
3. Prime and finish painting and field touch up painting.
4. Catwalks and connecting bridges attached to roof structure.
5. Miscellaneous steel shapes, plates, bolts, etc., required to complete the work.
6. Erection of Steel Components.

C. Responsibilities of Contractors
1. The Roof Contractor shall supply, fabricate and erect all the structural steel, including shipping to the site.
2. The Roof Contractor shall provide for the preparation and painting of the steel, including field touch up.

D. Related Work Described Elsewhere

Fabric Roof - Section 07-700

1.2 CODES AND STANDARDS: Comply with provisions of following, except as otherwise indicated.

A. Southern Standard Building Code.

B. AISC "Code of Standard Practice for Steel Buildings and Bridges."
1. Paragraph 4.2.1 of the above code is hereby modified by deletion of the following sentence: This approval constitutes the Owner's acceptance of all responsibility for the design adequacy of any connections designed by the fabricator as a part of his preparation of these shop drawings."

C. AISC "Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings," including "Commentary" of Supplements thereto as issued.

D. AISC "Specifications for Structural Joints using ASTM A 325 or A 490 Bolts" approved by the Research Council or Riveted and Bolted Structural Joints of the Engineering Foundation.

E. AWS D1.1 "Structural Welding Code."

EXHIBIT "A"

F. ASTM A6 "General Requirements for Deliver of Rolled Steel Plates, Shapes, Sheet Piling and Bars for Structural Use."

G. In the event of conflict between pertinent codes and regulations and the requirements of the referenced standards or these Specifications, the Provisions of the more stringent shall govern.

1.3 QUALIFICATIONS OF SUPPLIERS AND PERSONNEL

A. The steel fabricator shall have not less than five years continuous experience in the fabrication and erection of structural steel.

B. The cable dome erector shall have not less than three years continuous experience in the erection of the cable and steel structures of similar complexity.

C. Qualifications for Welding Work: Qualify welding processed and welding operators in accordance with AWS "Standard Qualification Procedure."
1. Provide certification that welders to be employed in work have satisfactorily passed AWS qualification tests.
2. If recertification of welders is required, retesting will be Contractor's responsibility.

D. Testing and inspection of the structural steel, will be done by a Testing Laboratory, retained and paid for by the Owner. The Contractor shall furnish the Testing Laboratory, at no cost, the following:
1. A complete set of approved erection drawings and shop drawings.
2. Cutting lists, order sheets, material bills and shipping bills and schedules.
3. A complete set of all welding procedures and current certificates of all Welders.
4. Information as to time and place of all rolling and shipment of material to shops.
5. Representative sample pieces requested for testing.
6. Full and ample means and assistance for testing all material and proper facilities and access, including scaffolding, temporary work platforms, etc. for inspection of the work in the shop and in the field.

E. The Engineer and the Testing Laboratory inspector shall have the right to inspect the work in the shop of field anytime during the period of fabrication or erection.

F. The inspector shall check for "first class" workmanship of steel, both in the shop and field, and check general compliance with the Contract Documents and steel shop drawings. He shall test welded and bolted connections as outlined below. The inspector shall record types and locations of all defects found in the work and measures required and performed to correct such defects.

G. The Contractor shall make all repairs to defective work to the satisfaction of the Engineer and inspector and at no additional cost to the Owner.

H. The independent inspector shall record and submit reports of his inspection and test findings together with subsequent repair operations to the Owner, Engineer and Roof Contractor.

I. The work of the independent inspector shall in no way relieve the Contractor of his responsibility to comply with all requirements of the Contract Documents.

J.
   a. The edges of material to be welded will be ultrasonically examined for evidence of laminations, inclusions or other discontinuities. The extent to which such defects will be permitted and the extent of repair permitted shall be determined by the Inspector and made in accordance with ASTM A6, Par. 9. Repairs made by welding shall be done in compliance with the requirements of the "Structural Welding Code" and the accepted welding procedures.
   b. The root layer of all multiple pass welds and the backside of groove welds make from both sides, after back gouging or chipping, will be examined by magnetic particle inspection (or dye penetration if magnetic particle inspection is not feasible.)

K. Welded connections shall be tested by non-destructive testing as follows: The following welds shall be tested 100%:
   a. All welding on the steel posts.
   b. All full penetration and/or groove welds.
   c. All welds in the center ridge truss assemblies.

L. Non-destructive test methods shall include the following:
   a. Radiographic or ultrasonic procedures for full penetration and/or groove welds.
   b. Ultrasonic methods for tee or corner welds.
   c. Magnetic particle testing for fillet welds.

M. All other welds shall be visually inspected.

1.4 SUBMITTALS

A. Shop Drawings
   1. The Roof Contractor shall submit Shop Drawings to the Engineer for approval in accordance with the General Conditions of these Specifications.
   2. The drawings shall show all shop and erection details including cuts, copes, connection holes, threaded fasteners, bolts, studs and spacing, etc.
   3. The drawings shall show all welds, both shop and field, by the currently recommended symbols of the American Welding Society.
   4. Erection plans and drawings shall be drawn to a scale of at least 1/16" to the foot with section and detail sketches to a larger scale. Erection drawings shall include details of all connections to other parts of the structure, contractor designed or supplied erection fittings, sequence of erection, shores, towers and other pertinent information.
   5. The Contractor shall not fabricate any material until after the approval of framing plans and detail sketches nor proceed with any work for which such drawings are required until they have been approved. Erection drawings shall be submitted for approval first, and

no detail shop drawings shall be submitted until the erection plans have been approved.

6. Shop drawings shall be carefully checked before being submitted to the Engineer for approval, and shall be submitted in the order in which they are needed to the execution of the work, well in advance and not all at one time. Submitted drawings shall show all structural steel required for the work, whether or not indicated on the Drawings.
7. The Roof Contractor shall immediately make all corrections to his drawings as required by changes ordered or authorized by the Engineer and shall keep a satisfactory history of all changes by separately numbered and dated modifications on a convenient portion of each drawing affected.
8. The Roof Contractor shall be solely responsible for the determination of the erection sequencing and procedures. The Roof Contractor shall analyze the cable and steel structure at various stages in his erection sequence to ensure stability of the structure as well as to ensure that none of the temporary nor permanent components of the structure are overstressed.
9. The above analysis results as well as pertinent calculations shall be submitted for review by the Engineer with the complete erection procedures and drawings. The Engineer's review shall in no way or means diminish the Roof Contractor's obligations and responsibilities to erect the structure in a safe and proper fashion.
10. The Roof Contractor's erection analysis, procedures and drawings shall be prepared under the supervision of a Professional Engineer registered in the State of Georgia and signed and sealed by him.

B. Proofs of Compliance

1. The Contractor shall furnish an affidavit from the producer of the steel certifying that the steel meets the minimum requirements as specified. If no mill tests are furnished contractor shall pay for any tests required to show compliance.

C. Proofs of Qualification

1. Submit to the Engineer evidence satisfactory to him that the steel fabricator and steel erector are qualified for the work in accordance with the requirements of the Section of these Specifications.

D. Manufacturers Literature

1. Provide copies of manufacturers specifications and installation instructions for the following products:
   a. High Strength Bolts.
   b. All Paints.

1.5 PRODUCT HANDLING

A. Protection: Use all means necessary to protect structural steel before, during and after installation and to protect the installed work and materials of all other trades.

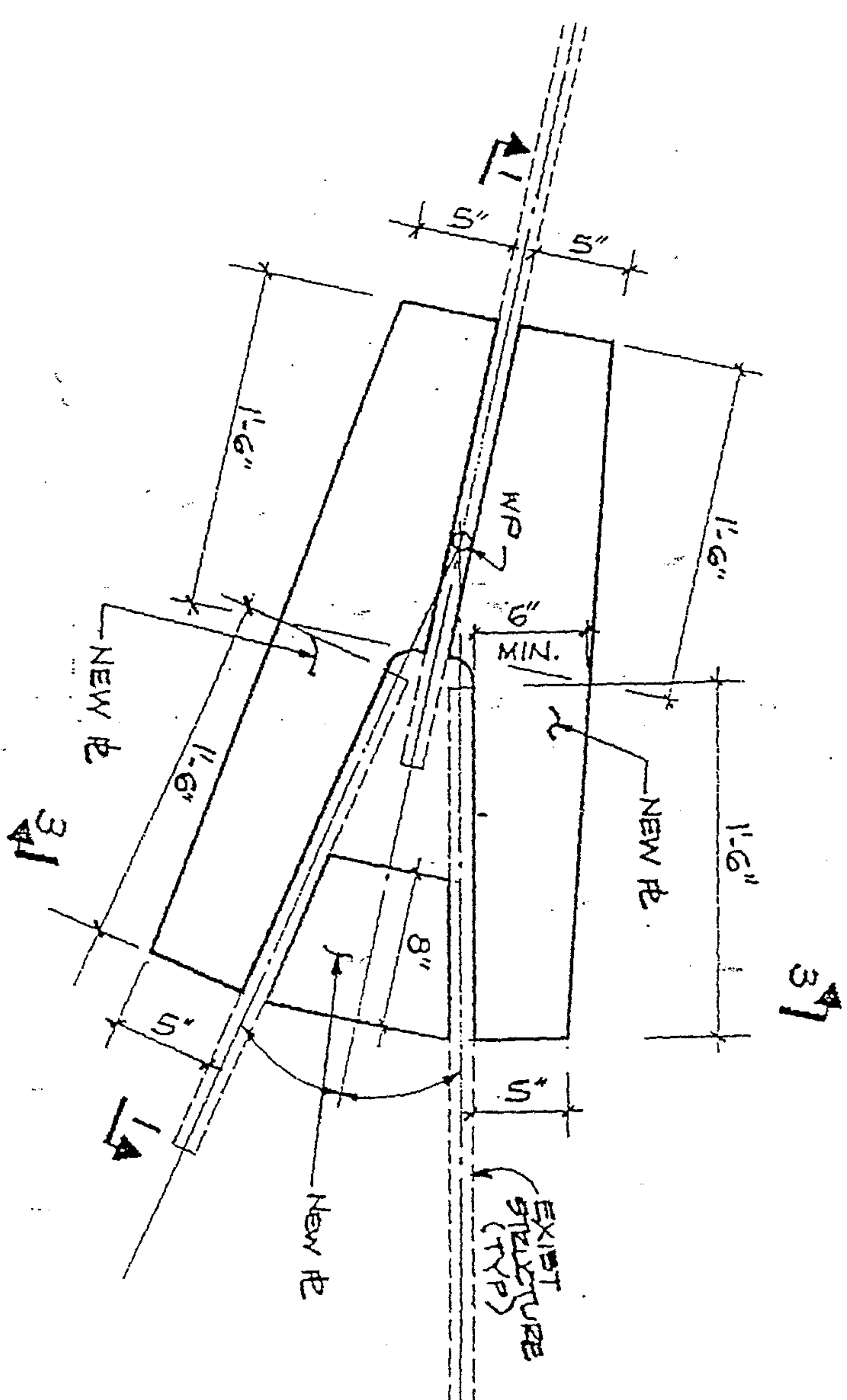
1.6 REJECTION AND REPLACEMENT

A. In the event of damage to the steel, immediately make all repairs and replacements necessary to the approval of the Engineer and at no additional cost to the Owner.

APPENDIX-C

SKETCHES OF THE REVISED ATTACHMENT PLATES

PLAN VIEW



NOTE:
PROPOSED REINFORCING
DETAIL FOR TOP WELDMENT
TA1 & TA7.

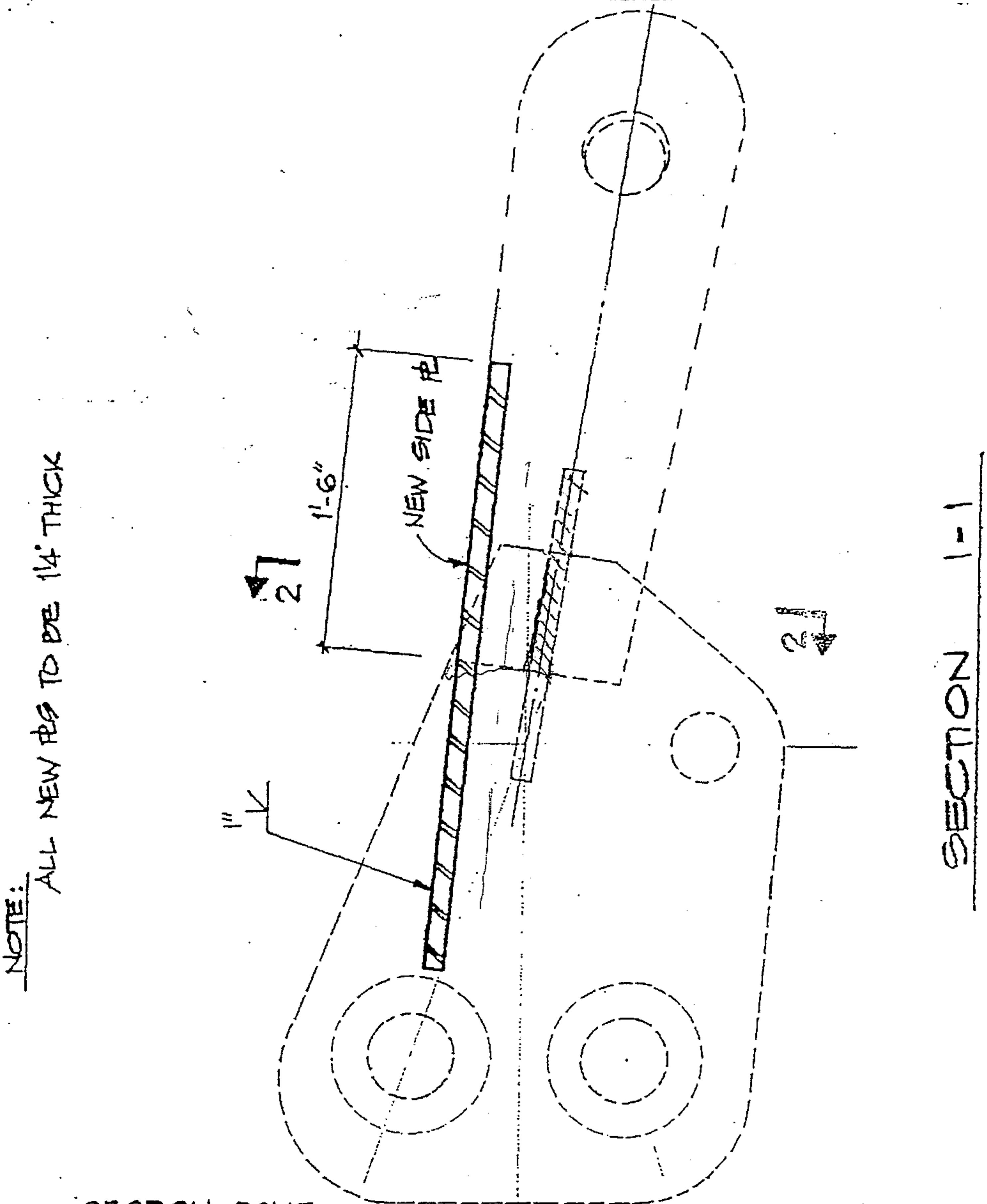
Project: GEORGIA DOME

WEIDLINGER ASSOCIATES
Consulting Engineers

RECEIVED
OCT 23 1991
BIRDAIR, INC.

Date: 10-23-91
Scale: 1½" = 1'-0"
Drawing no.: SK-344

C-1



Project: GEORGIA DOME

Date: 10-23-91

WEIDLINGER ASSOCIATES

Consulting Engineers

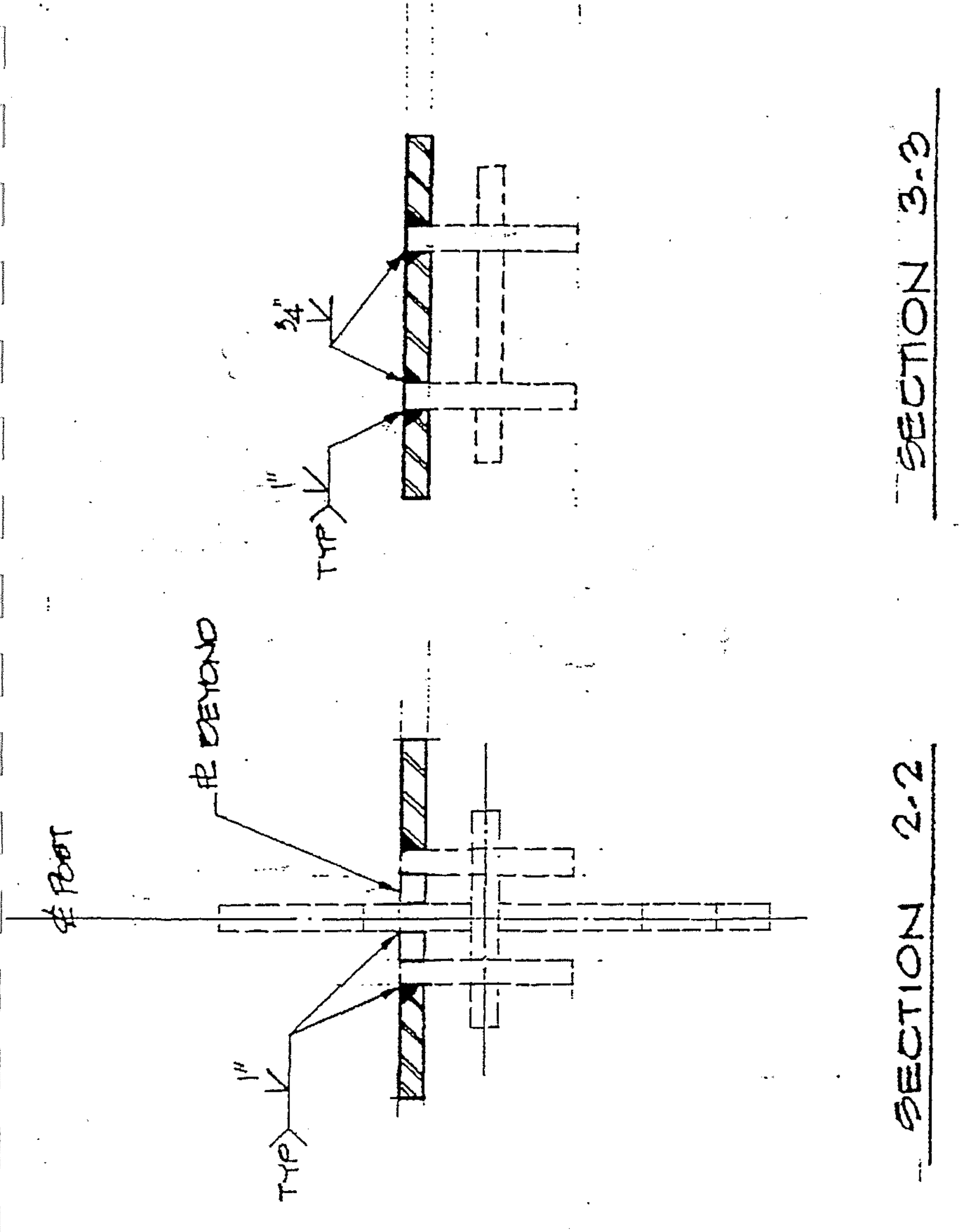
RECEIVED

OCT 23 1991

Scale: 1½" = 1'-0"

Drawing no.: SK-345

C-2



Project: GEORGIA DOME

Date: 10-23-91

WEIDLINGER ASSOCIATES

Consulting Engineers

Scale: 1½" = 1'-0"

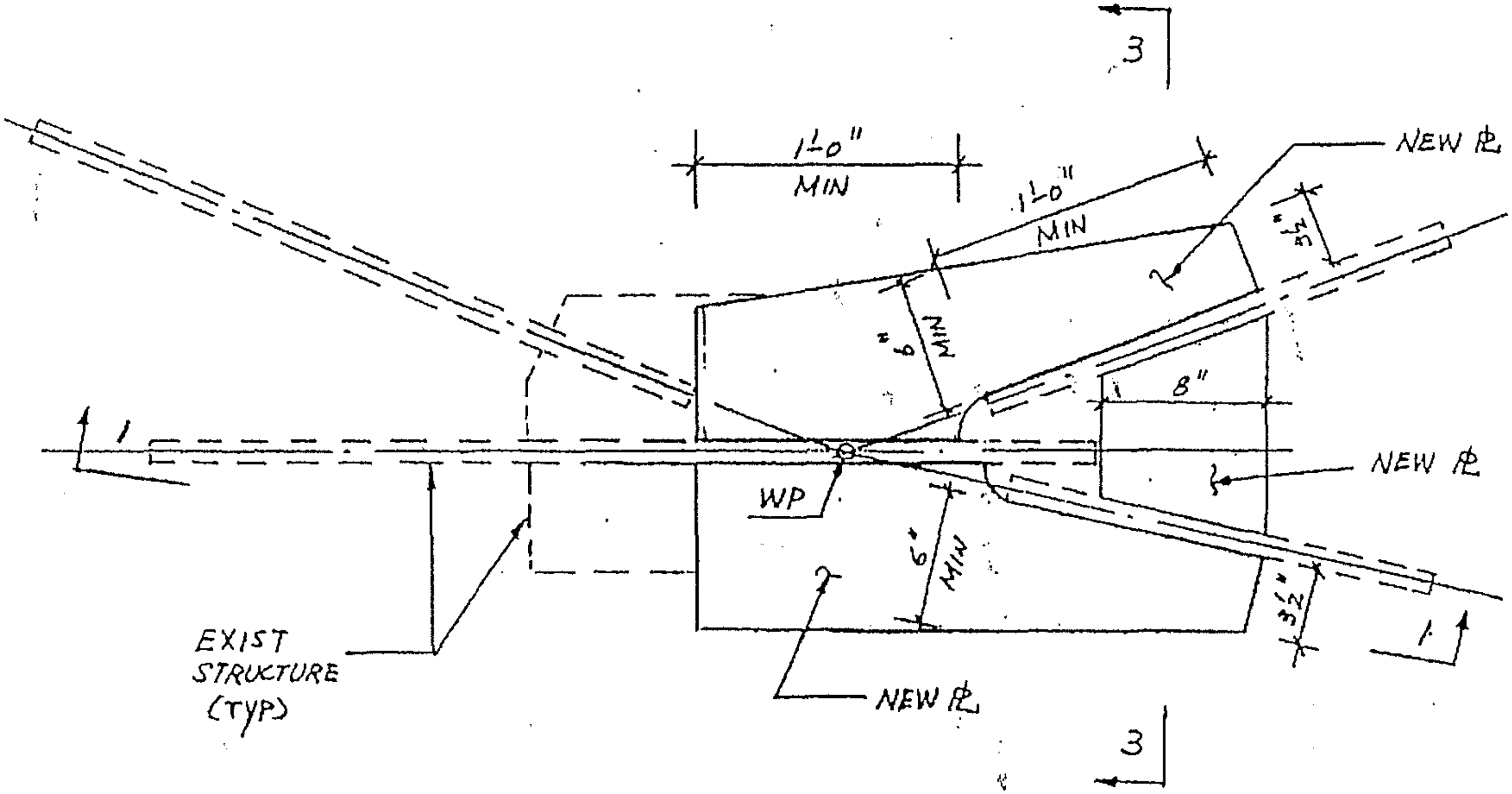
Drawing no.: SK-346

RECEIVED

C-3

Project: GEORGIA DOME

WEIDLINGER ASSOCIATES
Consulting Engineers



PLAN VIEW

DESIGN FORCES PROVIDED BY BIRDAIR ARE AS FOLLOWS,

a) AXIAL RIDGE CABLE FORCES:
$R_1 = 101^K$ AND $R_2 = 211^K$

b) MOMENT FORCE OF 45^{1-K}

c) JACKING FORCE = 100^K (CONCENTRIC WITH D1) + 40^K (ECCENTRIC)

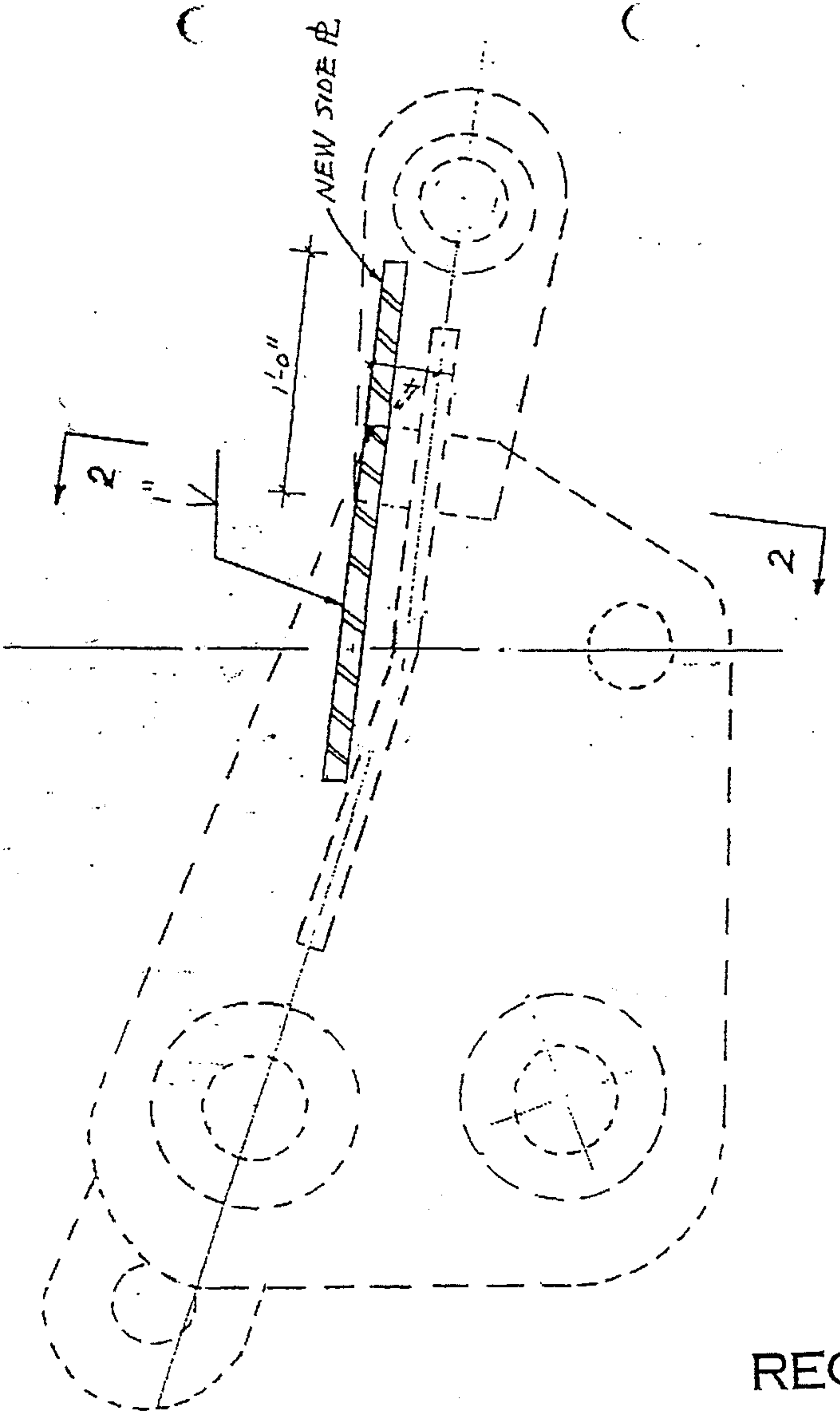
NOTE:
PROPOSED REINFORCING DETAIL FOR TOP WELDMENT TA2 & TA6.

RECEIVED
OCT 28 1991
BIRDAIR, INC.

Date: 10-25-91
Scale: 1 1/2" = 1'-0"
Drawing no.: SK-347

C-4

NOTE: ALL NEW PLs TO BE 1¼" THICK.



SECTION 1-1

RECEIVED

OCT 28 1991

BIRDAIR, INC.

Project: GEORGIA DOME

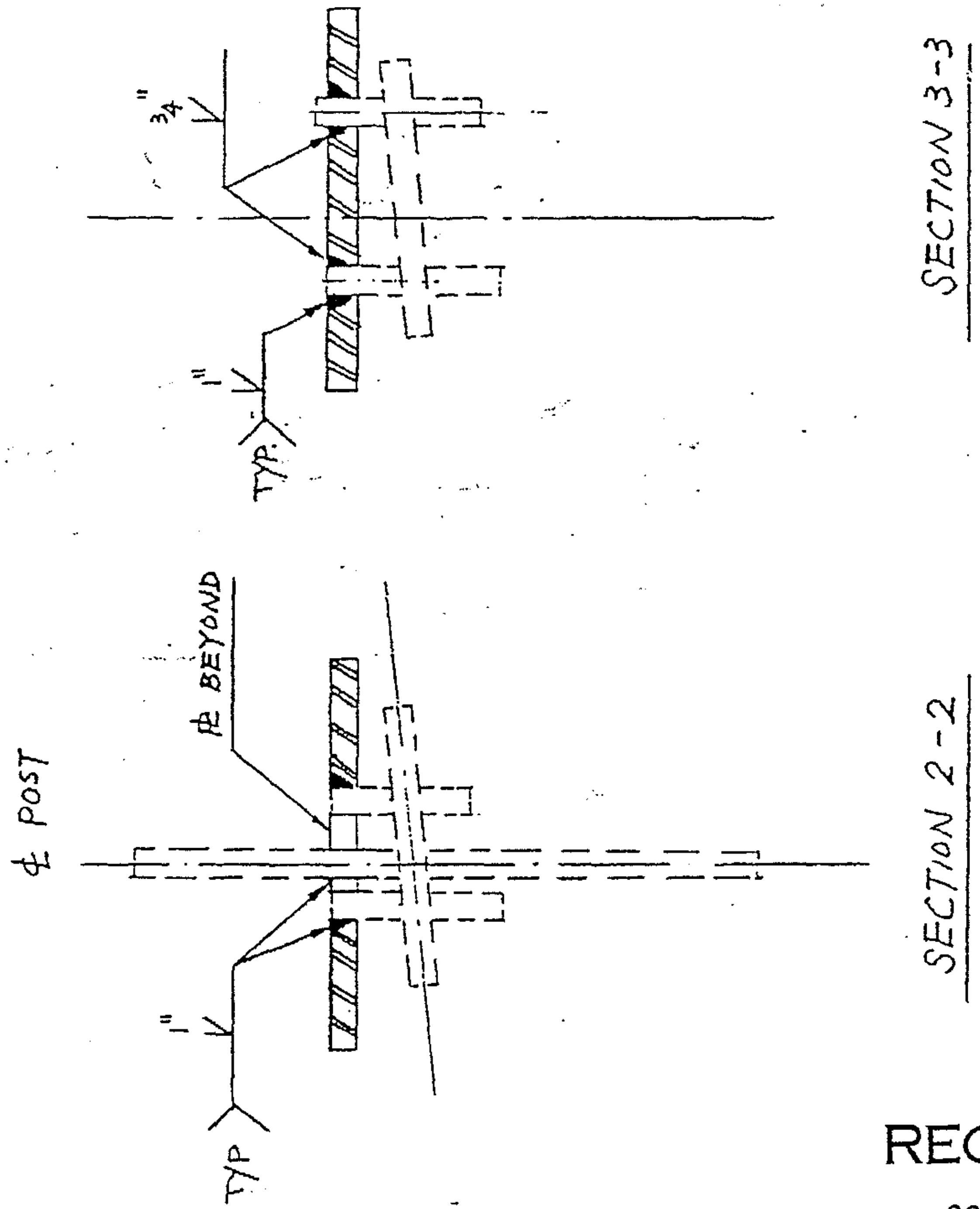
Date: 10-25-91

WEIDLINGER ASSOCIATES

Consulting Engineers

Scale: 1½" = 1'-0"

Drawing no.: SK-348



RECEIVED
OCT 28 1991
BIRDAIR, INC.

Project: GEORGIA DOME

Date: 10-25-91

WEIDLINGER ASSOCIATES

Consulting Engineers

Scale: 1½" = 1'-0"

Drawing no.: SK-349

APPENDIX – D

OUTLINE OF THE REPAIR PROCEDURE OF THE PLATES

BIRDAIR, INC.
65 Lawrence Bell Drive
Amherst, New York 14221-7094 U.S.A.
716-633-9500 800-622-2246
Fax: 716-633-9850

DMB 11-F

TRANSMITTAL LETTER

TO: Beers - Georgia Dome

DATE: 10-29-91
REFERENCE: Georgia Dome

If enclosures are not as noted, please inform us immediately.

ATTENTION: Rick Blue

ENCLOSED:

	COPIES MANUALS		LITERATURE
	COPIES PRINTS		SPECIFICATIONS
	COPIES SEPIAS		SAMPLES
6	COPIES XEROXS		OTHER

FOR: Approval

AS FOLLOWS: "A" Weldment Repair Proceedure

REMARKS:

COPY: Matt Levy ~~T.F. Jing~~ (Weidlinger)
: Jim Ford

SIGNED

Name Title

Form No. 22

D-1

BIRDAIR

A WELDMENT REPAIR PROCEDURE

INDEX

1. A Weldment Repair Procedure.
2. Weidlinger letter dated October 23, 1991, with attached sketches.

   SK-344
   SK-345
   SK-346
   SK-347
   SK-348
   SK-349

3. Welding Procedure.
4. AWS - Partial Penetration Groove Welds

   BTC-P4 Prequalified Welded Joint
   Matching Filler Metal Requirements
   Minimum Preheat and Interpass Temperature

SCHEDULE

1. 10/29/91 Submittal of Repair Procedure
2. 10/30/91 Welders Certification at job site
   (copy of Certification to follow)
3. 10/31/91 Commence repair procedures on site.

BIRDAIR

A WELDMENT REPAIR PROCEDURE

Note: All repairs per Weidlinger's letter dated October 23, 1991 and attached sketches from Weidlinger, SK-344, SK-345, SK-346, SK-347, SK-348 and SK-349.

1. Attached sketch shows A weldment locations numbered 1 thru 26. Attached chart shows current jacking loads at all points.

2. At the East end, the weldments at points 8 (first) and 7 will be replaced and jacked with new weldments, with additional reinforcement added prior to commencing welding repairs at other East end locations.

3. At the West end, two (2) points will be repaired simultaneously.

4. The procedure will be to de-tension the two (2) points to zero jacking load. This will reduce the ridge cable forces from B to A to approximately 40 kips per cable (from 100 to 200 kips per cable in the present condition).

5. The two (2) points will be selected in a sequence to maintain several jacked points between the two (2) points being de-tensioned, to minimize increased jacking loads on adjacent points.

6. The first two (2) points to be de-tensioned will be 18 and 23, since presently they have low jacking loads (20 kips and 24 kips respectively) and have four (4) jacked points in between them.

7. Work cages will be hung from the top of A posts to perform the welding. After the welding is complete, the welds will be inspected by the Owner's testing agency as determined by the Engineer, and approved prior to re-jacking the points.

8. Upon completion of the welding of the two (2) points, the two (2) points will be jacked to 100 kips each prior to de-tensioning the next points.

9. The corner points (16 and 25) will be completed as the last points on the West end, since the plates may not be available initially.

BIRDAIR

A WELDMENT REPAIR PROCEDURE (CON'T.)

10. The complete sequence for the West end is as follows:

Points

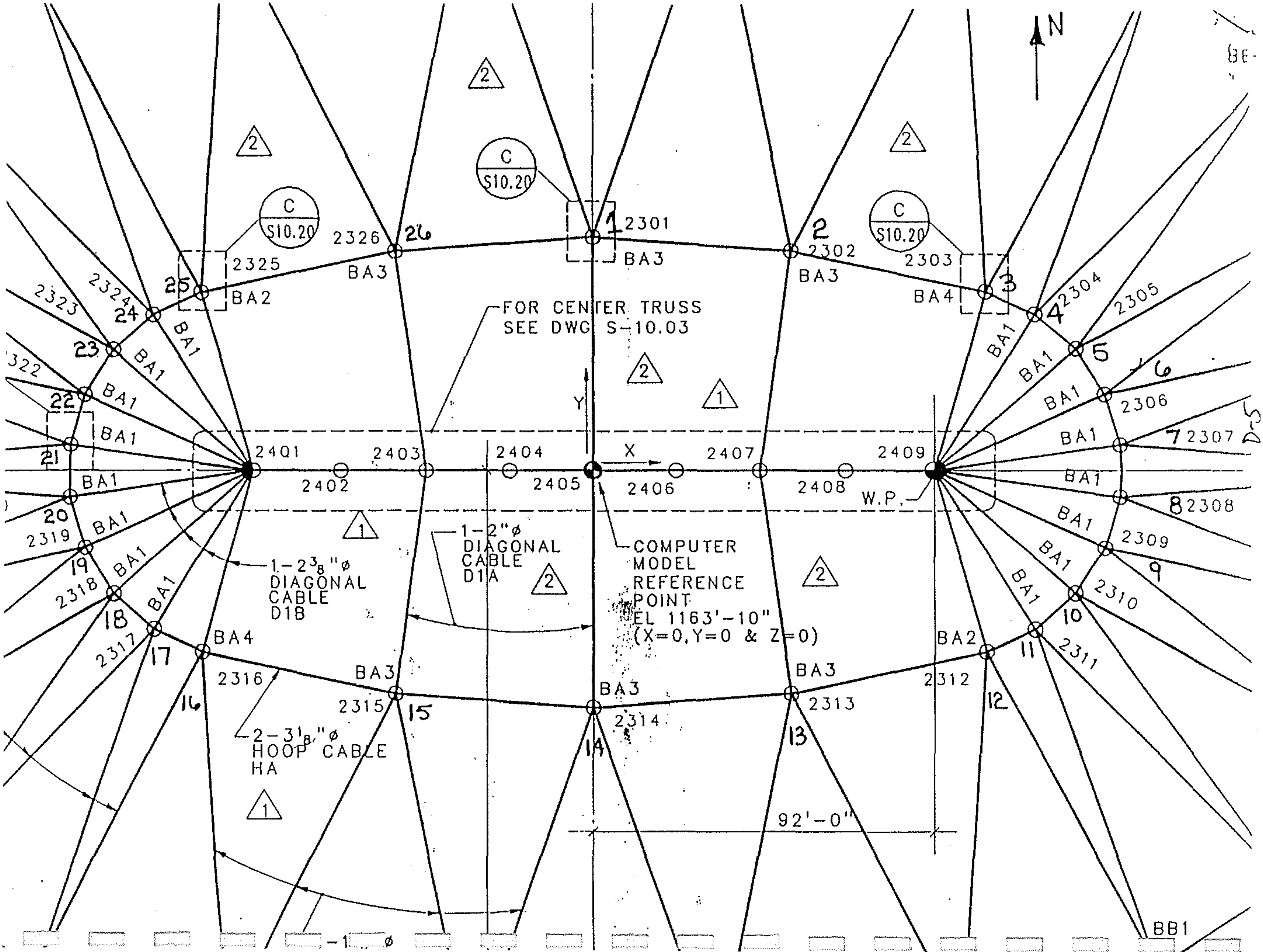
1. 18,23
2. 17,21
3. 20,24
4. 19,22
5. 16,25

11. The sequence for the East end is as follows: (The West end procedures apply)

Points

1. 8,7 replace with new weldments
2. 4,9
3. 5,10
4. 6,11
5. 3,12

12. **Note:** The side points 1,2,13,14,15,26 do not require rework due to different weldment design and lower jacking and ridge cable loads.


N
FOR CENTER TRUSS
SEE DWG S-10.03
C
S10.20
2301
2302
2303
2304
2305
2306
2307
2308
2309
2310
2311
2312
2313
2314
2315
2316
2317
2318
2319
2322
2323
2324
2325
2326
2401
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2403
2404
2405
2406
2407
2408
2409
BA1
BA2
BA3
BA4
BB1
W.P.
X
Y
1-2 3/8"ø
DIAGONAL
CABLE
D1B
1-2"ø
DIAGONAL
CABLE
D1A
COMPUTER
MODEL
REFERENCE
POINT
EL 1163'-10"
(X=0, Y=0 & Z=0)
2-3 1/8"ø
HOOP CABLE
HA
92'-0"
D-5

BIRDAIR

JACKING LOADS (CURRENT)

POINT	
1	44,500 lbs.
2	44,500 lbs.
3	88,000 lbs.
4	88,000 lbs.
5	64,000 lbs.
6	88,000 lbs.
7	102,000 lbs.
8	0 lbs.
9	92,000 lbs.
10	132,000 lbs.
11	88,000 lbs.
12	56,000 lbs.
13	50,000 lbs.
14	44,500 lbs.
15	50,000 lbs.
16	72,000 lbs.
17	136,000 lbs.
18	20,000 lbs.
19	100,000 lbs.
20	132,000 lbs.
21	132,000 lbs.
22	88,000 lbs.
23	24,000 lbs.
24	124,000 lbs.
25	60,000 lbs.
26	50,000 lbs.

APPENDIX – E

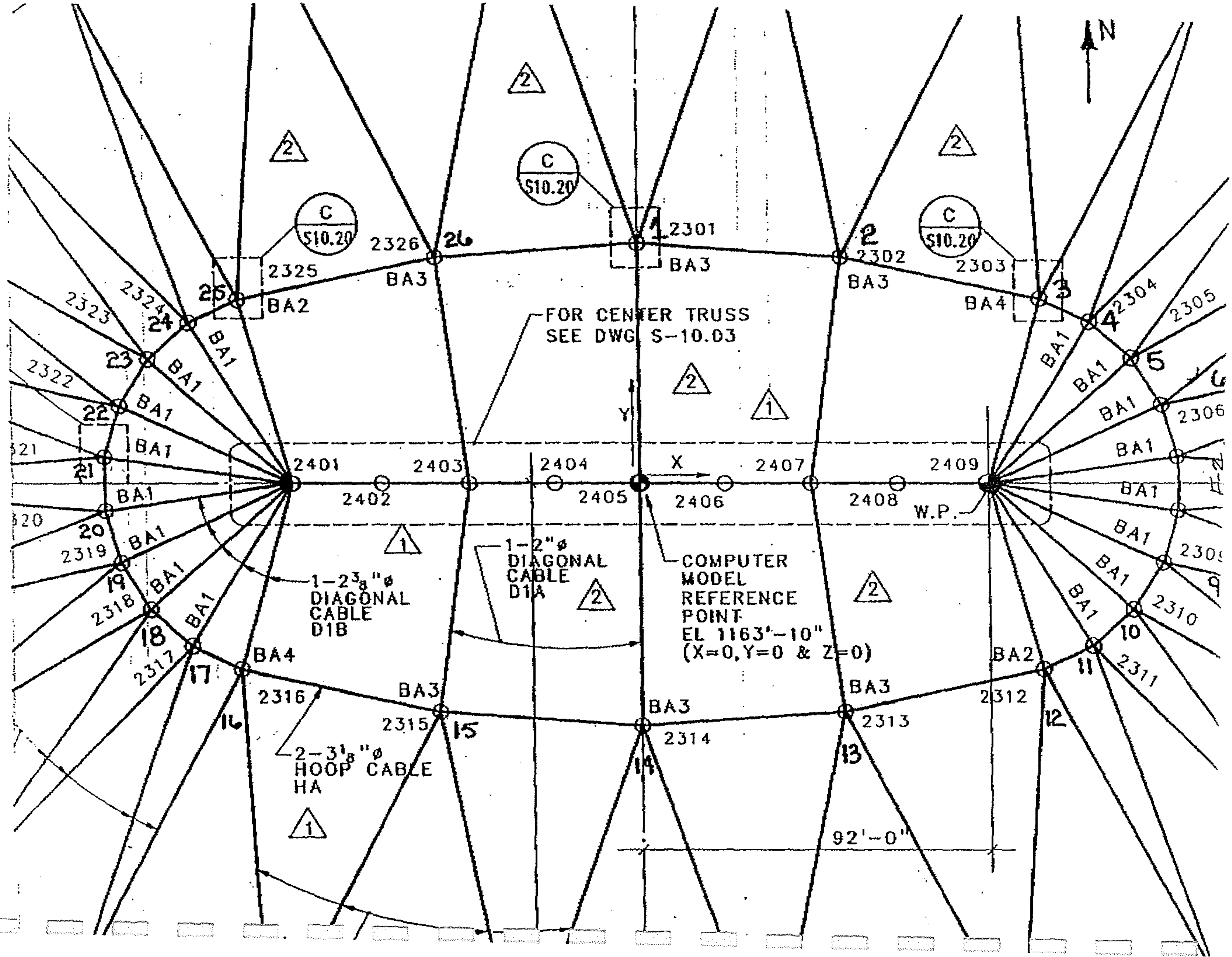
JACKING LOADS ON TEMPORARY STRANDS

BEERS GEORGIA DOME TEAM

Jacking Loads On Ridge Cables
Between "A" Hoop and Centertruss

Node Point	COLUMN 1 Prior To De-jacking	COLUMN 2 Max. Loads to Final Jack
1.	44,500 lbs.	92,000 lbs.
2.	44,500 "	80,000 "
3.	88,000 "	172,000 "
4.	88,000 "	228,000 "
5.	64,000 "	228,000 "
6.	88,000 "	228,000 "
7.	102,000 "	228,000 "
8.	0 "	228,000 "
9.	92,000 "	228,000 "
10.	132,000 "	228,000 "
11.	88,000 "	228,000 "
12.	56,000 "	188,000 "
13.	50,000 "	88,000 "
14.	44,500 "	92,000 "
15.	50,000 "	88,000 "
16.	72,000 "	172,000 "
17.	136,000 "	228,000 "
18.	20,000 "	228,000 "
19.	100,000 "	228,000 "
20.	132,000 "	228,000 "
21.	132,000 "	228,000 "
22.	88,000 "	228,000 "
23.	24,000 "	228,000 "
24.	124,000 "	228,000 "
25.	60,000 "	188,000 "
26.	50,000 "	88,000 "

1-9-92


N
2
C
S10.20
FOR CENTER TRUSS
SEE DWG S-10.03
2301
2302
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2312
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2314
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2316
2317
2318
2319
2320
2321
2322
2323
2324
2325
2326
BA1
BA2
BA3
BA4
2401
2402
2403
2404
2405
2406
2407
2408
2409
X
Y
W.P.
1
1-2^3/$_8$"ø
DIAGONAL
CABLE
D1B
1-2"ø
DIAGONAL
CABLE
D1A
COMPUTER
MODEL
REFERENCE
POINT
EL 1163'-10"
(X=0,Y=0 & Z=0)
2-3^1/$_8$"ø
HOOP CABLE
HA
92'-0"

APPENDIX F

COMPUTER PRINT OUT–

APPROXIMATE NODAL COORDINATES AND CABLE FORCES AT THE TIME OF THE ACCIDENT

IRDAIR, INC.
5 LAWRENCE BELL DRIVE
AMHERST, NY 14221
716-633-9500 800-622-2246
AX: 716-633-9850

TRANSMITTAL LETTER

O: U. S. DEPARTMENT OF LABOR - OSHA
2400 HERODIAN WAY, SUITE 250
SMYRNA, GA 30080

DATE: FEBRUARY 11, 1992
REFERENCE: GEORGIA DOME
BIRDAIR PROJECT NOS. 9080/5313

IF ENCLOSURES ARE NOT AS NOTED, PLEASE INFORM US IMMEDIATELY.

ATTENTION: MR. THOMAS HARVEY

NCLOSED:

	COPIES MANUALS		LITERATURE
ONE EACH	COPIES PRINTS		SPECIFICATIONS
	COPIES SEPIAS		SAMPLES
	COPIES XEROXS	ONE	OTHER

FOR: INFORMATION

FOLLOWS:

DRAWINGS: 9080D3929 - CCP-7 (TEMPORARY CONNECTOR TOP OF A POST.

9080D1000
9080D1001 FINAL COMPUTER MODEL - FABRIC
9080D1010 INSTALLED, DEAD WEIGHT, NO APPLIED
9080D1011 LOADS (WIND OR SNOW).
9080D1012 WE DO NOT HAVE KNOWLEDGE OF APPLIED
9080D1013 LOADS (WIND OR SNOW).
9089D1014

COMPUTER FILE: GG1 20KD2 D1.BLF - APPROXIMATE NODAL COORDINATES AND CABLE FORCES AT TIME OF ACCIDENT.

EMARKS:

TOM:

PER YOUR REQUEST, THE ABOVE INFORMATION. I WOULD LIKE TO STRESS AGAIN THAT AT THE TIME OF THE ACCIDENT SINCE WE WERE WITHIN THE SAFE ALLOWABLE LOAD ON ALL CABLES, WE ASSUMED WE WERE WITHIN SAFE ALLOWABLE STRESSES ON THE CABLE CONNECTORS.

cc: RICK FISHER

SIGNED [signature]

WESLEY R. TERRY	PROJECT MANAGER
NAME	TITLE

F-1

X (ft) Y (ft) Z (ft)

GEORGIA DOME :: WEID MODEL 6-12-90 :: PRESTRESS + BIRDAIR FULL DEAD LOAD

193	3 269	0 1	0 2	4 0									
1	000000	44.2993	311.9718	0.0323	0.000E+00	0.000E+00	0.000E+00	-4.515E+1	-6.230E+2	1.003E+2	0.000E+0	0.000E+0	0.000E+0
2	000000	132.0518	299.7401	0.0207	0.000E+00	0.000E+00	0.000E+00	-9.265E+1	-8.830E+2	1.420E+2	0.000E+0	0.000E+0	0.000E+0
3	000000	215.6112	274.3352	-0.0119	0.000E+00	0.000E+00	0.000E+00	-4.701E+2	-1.276E+3	2.146E+2	0.000E+0	0.000E+0	0.000E+0
4	000000	288.2585	228.2679	-0.0583	0.000E+00	0.000E+00	0.000E+00	-1.079E+3	-1.221E+3	2.588E+2	0.000E+0	0.000E+0	0.000E+0
5	000000	344.7569	163.4169	-0.0506	0.000E+00	0.000E+00	0.000E+00	-1.344E+3	-8.444E+2	2.552E+2	0.000E+0	0.000E+0	0.000E+0
6	000000	380.4774	85.1513	0.0083	0.000E+00	0.000E+00	0.000E+00	-1.466E+3	-4.047E+2	2.490E+2	0.000E+0	0.000E+0	0.000E+0
7	000000	392.6399	0.0000	0.0446	0.000E+00	0.000E+00	0.000E+00	-7.343E+2	3.398E+2	1.215E+2	0.000E+0	0.000E+0	0.000E+0
8	011000	0.0000	244.2062	-49.2144	0.000E+00	0.000E+00	0.000E+00	1.396E+3	1.409E-9	1.745E-8	0.000E+0	0.000E+0	0.000E+0
9	111000	78.7342	238.7324	-49.1887	0.000E+00	0.000E+00	0.000E+00	1.995E-9	1.947E-9	2.530E-8	0.000E+0	0.000E+0	0.000E+0
10	111000	155.9557	222.4464	-49.1809	0.000E+00	0.000E+00	0.000E+00	2.765E-9	1.116E-9	1.138E-8	0.000E+0	0.000E+0	0.000E+0
11	111000	216.4141	195.5173	-49.3666	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	2.393E-9	0.000E+0	0.000E+0	0.000E+0
12	111000	266.6219	152.4044	-49.3638	0.000E+00	0.000E+00	0.000E+00	-1.204E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
13	111000	302.3013	96.6710	-49.0661	0.000E+00	0.000E+00	0.000E+00	0.000E+0	2.440E-9	6.156E-9	0.000E+0	0.000E+0	0.000E+0
14	111000	320.6674	33.0918	-48.7071	0.000E+00	0.000E+00	0.000E+00	2.195E-9	1.130E-9	1.217E-8	0.000E+0	0.000E+0	0.000E+0
15	101000	320.6674	0.0000	-48.7520	0.000E+00	0.000E+00	0.000E+00	0.000E+0	1.365E+3	0.000E+0	0.000E+0	0.000E+0	0.000E+0
16	011000	0.0000	157.7029	-27.1711	0.000E+00	0.000E+00	0.000E+00	1.781E+3	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
17	111000	33.4810	157.7029	-27.1282	0.000E+00	0.000E+00	0.000E+00	7.208E-7	4.902E-8	1.298E-6	0.000E+0	0.000E+0	0.000E+0
18	111000	99.8033	148.4896	-27.1631	0.000E+00	0.000E+00	0.000E+00	-4.581E-7	6.180E-8	1.504E-7	0.000E+0	0.000E+0	0.000E+0
19	111000	152.0288	133.2784	-27.2445	0.000E+00	0.000E+00	0.000E+00	-6.469E-8	-3.446E-8	1.021E-8	0.000E+0	0.000E+0	0.000E+0
20	111000	187.3767	110.9091	-27.4010	0.000E+00	0.000E+00	0.000E+00	-1.099E-7	4.172E-8	5.544E-9	0.000E+0	0.000E+0	0.000E+0
21	111000	214.9339	79.4394	-27.4557	0.000E+00	0.000E+00	0.000E+00	-3.152E-8	2.972E-8	3.980E-8	0.000E+0	0.000E+0	0.000E+0
22	111000	232.3428	41.4042	-27.1912	0.000E+00	0.000E+00	0.000E+00	0.000E+0	4.438E-8	8.500E-8	0.000E+0	0.000E+0	0.000E+0
23	101000	238.3080	0.0000	-27.0667	0.000E+00	0.000E+00	0.000E+00	1.219E-8	1.608E+3	5.590E-8	0.000E+0	0.000E+0	0.000E+0
24	011000	0.0000	64.6001	4.1520	0.000E+00	0.000E+00	0.000E+00	1.829E+2	-1.926E-2	-1.463E-2	0.000E+0	0.000E+0	0.000E+0
25	111000	53.3413	60.6114	4.7311	0.000E+00	0.000E+00	0.000E+00	-2.939E-3	-2.996E-2	-2.895E-2	0.000E+0	0.000E+0	0.000E+0
26	111000	105.5215	48.8329	4.9229	0.000E+00	0.000E+00	0.000E+00	-3.616E-3	-1.599E-2	-3.963E-2	0.000E+0	0.000E+0	0.000E+0
27	111000	118.5671	42.7268	4.8772	0.000E+00	0.000E+00	0.000E+00	-2.820E-3	-6.401E-3	-4.763E-2	0.000E+0	0.000E+0	0.000E+0
28	111000	129.3602	33.1870	4.9258	0.000E+00	0.000E+00	0.000E+00	6.555E-3	5.268E-3	-4.096E-2	0.000E+0	0.000E+0	0.000E+0
29	111000	137.0827	21.0270	4.9293	0.000E+00	0.000E+00	0.000E+00	1.869E-2	8.821E-3	-3.540E-2	0.000E+0	0.000E+0	0.000E+0
30	111000	141.1308	7.2025	4.9285	0.000E+00	0.000E+00	0.000E+00	2.716E-2	4.120E-3	-3.264E-2	0.000E+0	0.000E+0	0.000E+0
31	101000	141.1308	0.0000	4.9227	0.000E+00	0.000E+00	0.000E+00	0.000E+0	1.847E+2	0.000E+0	0.000E+0	0.000E+0	0.000E+0
32	001000	0.0000	0.0000	36.9994	0.000E+00	0.000E+00	0.000E+00	5.069E+2	5.265E+1	-2.179E-2	0.000E+0	0.000E+0	0.000E+0
33	101000	22.3872	0.0000	36.7139	0.000E+00	0.000E+00	0.000E+00	2.088E-8	0.000E+0	-7.350E-9	0.000E+0	0.000E+0	0.000E+0
34	101000	44.9972	0.0000	36.7431	0.000E+00	0.000E+00	0.000E+00	1.041E-8	3.528E+1	2.718E-8	0.000E+0	0.000E+0	0.000E+0
35	101000	68.0568	0.0000	36.7384	0.000E+00	0.000E+00	0.000E+00	-9.455E-9	0.000E+0	-1.160E-7	0.000E+0	0.000E+0	0.000E+0
36	101000	91.8132	0.0000	36.8366	0.000E+00	0.000E+00	0.000E+00	-1.438E-8	4.022E+2	6.045E-8	0.000E+0	0.000E+0	0.000E+0
37	011000	0.0000	244.2215	11.7871	0.000E+00	0.000E+00	0.000E+00	1.475E+2	-1.269E-7	-1.711E-8	0.000E+0	0.000E+0	0.000E+0
38	111000	78.7750	238.7512	11.8128	0.000E+00	0.000E+00	0.000E+00	-6.066E-8	-1.357E-7	-2.557E-8	0.000E+0	0.000E+0	0.000E+0
39	111000	156.0122	222.4403	11.8214	0.000E+00	0.000E+00	0.000E+00	-2.658E-8	-3.570E-8	-9.468E-9	0.000E+0	0.000E+0	0.000E+0
40	111000	216.4526	195.3325	11.6355	0.000E+00	0.000E+00	0.000E+00	-3.340E-9	-4.305E-9	-5.048E-9	0.000E+0	0.000E+0	0.000E+0
41	111000	266.5402	152.3199	11.6387	0.000E+00	0.000E+00	0.000E+00	-7.340E-9	-9.341E-9	-1.646E-9	0.000E+0	0.000E+0	0.000E+0
42	111000	302.3734	96.8142	11.9368	0.000E+00	0.000E+00	0.000E+00	-2.424E-8	-1.469E-8	-5.151E-9	0.000E+0	0.000E+0	0.000E+0
43	111000	321.0604	33.2292	12.2950	0.000E+00	0.000E+00	0.000E+00	-4.207E-8	-8.319E-9	-8.936E-9	0.000E+0	0.000E+0	0.000E+0
44	111000	33.5762	158.8673	52.8702	0.000E+00	0.000E+00	0.000E+00	3.448E-3	3.575E-2	-2.269E-3	0.000E+0	0.000E+0	0.000E+0
45	111000	100.2218	149.5332	52.8364	0.000E+00	0.000E+00	0.000E+00	6.455E-3	2.055E-2	-1.623E-2	0.000E+0	0.000E+0	0.000E+0
46	111000	152.8456	134.1261	52.7595	0.000E+00	0.000E+00	0.000E+00	6.325E-3	1.300E-2	-3.213E-2	0.000E+0	0.000E+0	0.000E+0
47	111000	188.0926	111.6389	52.6050	0.000E+00	0.000E+00	0.000E+00	-6.496E-4	-1.211E-3	-4.654E-2	0.000E+0	0.000E+0	0.000E+0
48	111000	215.4140	80.2164	52.5510	0.000E+00	0.000E+00	0.000E+00	-1.301E-2	-8.692E-3	-5.469E-2	0.000E+0	0.000E+0	0.000E+0
49	111000	232.9573	42.0992	52.8165	0.000E+00	0.000E+00	0.000E+00	-2.433E-2	-7.393E-3	-6.092E-2	0.000E+0	0.000E+0	0.000E+0
50	101000	239.0503	0.0000	52.9431	0.000E+00	0.000E+00	0.000E+00	-1.446E-2	6.253E+1	-3.169E-2	0.000E+0	0.000E+0	0.000E+0
51	011000	0.0000	63.0766	53.1304	0.000E+00	0.000E+00	0.000E+00	3.372E+1	5.012E-4	-2.688E-2	0.000E+0	0.000E+0	0.000E+0
52	111000	53.5183	59.5066	53.7207	0.000E+00	0.000E+00	0.000E+00	-2.076E-5	1.410E-4	-7.030E-3	0.000E+0	0.000E+0	0.000E+0
53	111000	106.2455	48.2626	53.9180	0.000E+00	0.000E+00	0.000E+00	-2.474E-5	1.960E-5	-1.676E-3	0.000E+0	0.000E+0	0.000E+0
54	111000	119.0935	42.3666	53.8775	0.000E+00	0.000E+00	0.000E+00	-1.021E-5	7.054E-6	-9.509E-4	0.000E+0	0.000E+0	0.000E+0
55	111000	129.6812	33.2336	53.9292	0.000E+00	0.000E+00	0.000E+00	-7.031E-6	-9.547E-7	-1.056E-3	0.000E+0	0.000E+0	0.000E+0
56	111000	137.4792	21.2314	53.9319	0.000E+00	0.000E+00	0.000E+00	-1.579E-5	-7.915E-6	-1.901E-3	0.000E+0	0.000E+0	0.000E+0
57	111000	141.6122	7.3967	53.9303	0.000E+00	0.000E+00	0.000E+00	-2.710E-5	-1.065E-5	-2.689E-3	0.000E+0	0.000E+0	0.000E+0
58	001000	0.0000	0.0000	71.9980	0.000E+00	0.000E+00	0.000E+00	3.358E+2	0.000E+0	7.359E-9	0.000E+0	0.000E+0	0.000E+0
59	101000	22.3719	0.0000	71.7139	0.000E+00	0.000E+00	0.000E+00	8.242E-8	0.000E+0	-5.563E-8	0.000E+0	1.773E-2	0.000E+0

60	101000	44.9683	0.0000	71.7436	0.000E+00	0.000E+00	0.000E+00	3.517E-9	0.000E+0	-6.874E-9	0.000E+0	0.000E+0	0.000E+0
61	101000	68.0143	0.0000	71.7379	0.000E+00	0.000E+00	0.000E+00	1.647E-8	0.000E+0	7.376E-7	0.000E+0	1.053E+2	0.000E+0
62	101000	91.7590	0.0000	71.8463	0.000E+00	0.000E+00	0.000E+00	-1.285E-7	2.836E+2	-2.938E-8	0.000E+0	0.000E+0	0.000E+0
63	101000	22.3697	0.0000	81.7144	0.000E+00	0.000E+00	0.000E+00	-5.960E-8	3.735E+1	3.743E-8	0.000E+0	0.000E+0	0.000E+0
64	101000	68.0135	0.0000	77.7381	0.000E+00	0.000E+00	0.000E+00	-4.132E-6	2.920E+1	-8.193E-6	0.000E+0	0.000E+0	0.000E+0
65	111111	29.8315	289.0605	6.0884	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
66	111111	14.9526	267.0600	7.7222	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
67	111111	55.4852	287.5636	6.0984	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
68	111111	67.1365	263.4367	7.7382	0.000E+00	0.000E+00	0.000E+00	-1.041E-9	2.208E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0
69	111111	114.7220	279.7261	5.8148	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
70	111111	96.7457	259.3024	7.7536	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
71	111111	139.9252	274.4264	5.9309	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
72	111111	147.9305	248.4814	7.7576	0.000E+00	0.000E+00	0.000E+00	0.000E+0	1.041E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0
73	111111	196.2914	257.5339	5.3214	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
74	111111	176.1215	239.9352	7.7421	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
75	111111	215.9646	248.6863	5.4577	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
76	111111	216.1601	221.9741	7.6421	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
77	111111	264.9779	217.6908	5.6751	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
78	111111	240.6683	206.4373	7.6386	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
79	111111	281.3359	203.7098	5.7130	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
80	111111	273.8596	177.9239	7.6367	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
81	111111	319.4970	160.0087	5.6801	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
82	111111	292.9365	156.0617	7.6386	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
83	111111	331.1523	141.9051	5.6576	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
84	111111	316.6633	119.2740	7.8331	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
85	111111	355.2011	89.0813	5.5696	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
86	111111	328.7612	92.8610	7.8384	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
87	111111	361.2034	68.3981	5.3580	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
88	111111	341.1172	50.7701	8.0645	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
89	111111	367.8079	10.8430	6.2524	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
90	111111	345.2750	21.9677	8.0554	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
91	111111	11.1590	215.8541	25.1600	0.000E+00	0.000E+00	0.000E+00	-2.294E-9	5.830E-9	-2.204E-9	0.000E+0	0.000E+0	0.000E+0
92	111111	22.3712	187.3514	38.8782	0.000E+00	0.000E+00	0.000E+00	-2.161E-9	5.494E-9	-2.151E-9	0.000E+0	0.000E+0	0.000E+0
93	111111	63.7671	212.2265	25.2818	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
94	111111	48.6772	185.5567	38.9884	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
95	111111	85.8998	209.1126	25.2593	0.000E+00	0.000E+00	0.000E+00	-1.582E-9	6.580E-9	-3.571E-9	0.000E+0	0.000E+0	0.000E+0
96	111111	93.0630	179.3136	38.9607	0.000E+00	0.000E+00	0.000E+00	-1.014E-9	4.215E-9	-2.549E-9	0.000E+0	0.000E+0	0.000E+0
97	111111	137.4648	198.2024	25.2234	0.000E+00	0.000E+00	0.000E+00	8.898E-9	1.163E-8	-7.537E-9	0.000E+0	0.000E+0	0.000E+0
98	111111	118.8400	173.8635	38.9149	0.000E+00	0.000E+00	0.000E+00	4.350E-9	5.684E-9	-4.359E-9	0.000E+0	0.000E+0	0.000E+0
99	111111	154.9595	193.0808	25.2817	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
100	111111	153.9027	163.6078	38.9436	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
101	111111	195.3062	174.9842	25.1677	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
102	111111	174.0798	154.5589	38.8908	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
103	111111	207.0252	167.5111	25.1163	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
104	111111	197.5609	139.5810	38.7882	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
105	111111	240.4615	138.7961	25.1137	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
106	111111	214.2811	125.2196	38.7850	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
107	111111	249.5406	128.3453	25.1063	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
108	111111	232.4802	104.2848	38.7582	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
109	111111	273.4931	91.3019	25.2920	0.000E+00	0.000E+00	0.000E+00	1.356E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
110	111111	244.4714	85.7625	38.8460	0.000E+00	0.000E+00	0.000E+00	1.086E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
111	111111	279.2978	78.6256	25.3632	0.000E+00	0.000E+00	0.000E+00	1.801E-9	1.420E-9	-1.078E-9	0.000E+0	0.000E+0	0.000E+0
112	111111	256.1342	60.3676	39.0039	0.000E+00	0.000E+00	0.000E+00	1.538E-9	1.212E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0
113	111111	291.8409	36.1710	25.5698	0.000E+00	0.000E+00	0.000E+00	3.709E-9	0.000E+0	-1.883E-9	0.000E+0	0.000E+0	0.000E+0
114	111111	262.4388	39.1311	39.0919	0.000E+00	0.000E+00	0.000E+00	2.931E-9	0.000E+0	-1.562E-9	0.000E+0	0.000E+0	0.000E+0
115	111111	293.8376	22.1990	25.6095	0.000E+00	0.000E+00	0.000E+00	4.128E-9	1.673E-9	-2.156E-9	0.000E+0	0.000E+0	0.000E+0
116	111111	266.4729	11.1112	39.1720	0.000E+00	0.000E+00	0.000E+00	3.318E-9	1.345E-9	-1.803E-9	0.000E+0	0.000E+0	0.000E+0
117	111111	22.3843	126.9377	52.8582	0.000E+00	0.000E+00	0.000E+00	-3.429E-9	-9.782E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0
118	111111	11.1946	95.0142	52.9449	0.000E+00	0.000E+00	0.000E+00	-3.685E-9	-1.051E-8	0.000E+0	0.000E+0	0.000E+0	0.000E+0
119	111111	40.2232	125.7488	52.7823	0.000E+00	0.000E+00	0.000E+00	2.999E-8	-1.494E-7	-3.212E-9	0.000E+0	0.000E+0	0.000E+0
120	111111	46.8718	92.6225	53.0659	0.000E+00	0.000E+00	0.000E+00	5.040E-8	-2.511E-7	2.158E-9	0.000E+0	0.000E+0	0.000E+0

121	111111	84.6709	119.5569	52.9196	0.000E+00	0.000E+00	0.000E+00	-3.760E-8	-7.249E-8	-6.465E-9	0.000E+0	0.000E+0	0.000E+0
122	111111	69.1088	89.5592	53.2140	0.000E+00	0.000E+00	0.000E+00	-6.006E-8	-1.158E-7	-4.719E-9	0.000E+0	0.000E+0	0.000E+0
123	111111	102.2297	115.7772	53.0633	0.000E+00	0.000E+00	0.000E+00	0.000E+0	-1.015E-8	0.000E+0	0.000E+0	0.000E+0	0.000E+0
124	111111	104.2382	82.0096	53.4239	0.000E+00	0.000E+00	0.000E+00	0.000E+0	-1.157E-8	0.000E+0	0.000E+0	0.000E+0	0.000E+0
125	111111	137.3214	105.5218	53.0608	0.000E+00	0.000E+00	0.000E+00	-2.903E-9	-5.349E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0
126	111111	121.7982	76.9194	53.4467	0.000E+00	0.000E+00	0.000E+00	-3.105E-9	-5.721E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0
127	111111	141.6015	103.5573	53.0074	0.000E+00	0.000E+00	0.000E+00	0.000E+0	1.747E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0
128	111111	130.3568	72.9873	53.3797	0.000E+00	0.000E+00	0.000E+00	0.000E+0	1.707E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0
129	111111	165.1104	88.5657	52.9080	0.000E+00	0.000E+00	0.000E+00	-3.497E-9	-3.511E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0
130	111111	142.1217	65.4860	53.3318	0.000E+00	0.000E+00	0.000E+00	-3.963E-9	-3.979E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0
131	111111	168.6356	85.5219	52.9605	0.000E+00	0.000E+00	0.000E+00	1.642E-9	2.204E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0
132	111111	149.1747	59.3996	53.4016	0.000E+00	0.000E+00	0.000E+00	1.512E-9	2.030E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0
133	111111	186.8674	64.5724	52.9209	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
134	111111	158.3050	48.9198	53.3799	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
135	111111	189.4578	60.5714	52.9095	0.000E+00	0.000E+00	0.000E+00	2.959E-9	2.239E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0
136	111111	163.4919	40.9191	53.3694	0.000E+00	0.000E+00	0.000E+00	2.169E-9	1.641E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0
137	111111	201.1907	35.1563	53.0794	0.000E+00	0.000E+00	0.000E+00	1.302E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
138	111111	169.3819	28.2041	53.4508	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
139	111111	202.5517	30.5479	53.0507	0.000E+00	0.000E+00	0.000E+00	4.962E-9	1.885E-9	-1.365E-9	0.000E+0	0.000E+0	0.000E+0
140	111111	172.1184	18.9861	53.4216	0.000E+00	0.000E+00	0.000E+00	1.144E-9	0.000E+0	-1.348E-9	0.000E+0	0.000E+0	0.000E+0
141	111111	206.6348	2.4607	53.1371	0.000E+00	0.000E+00	0.000E+00	3.012E-9	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
142	111111	174.1723	4.9250	53.4656	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
143	111111	7.3197	42.4370	62.3939	0.000E+00	0.000E+00	0.000E+00	4.117E-9	-1.160E-8	0.000E+0	0.000E+0	0.000E+0	0.000E+0
144	111111	14.7045	21.6137	71.8282	0.000E+00	0.000E+00	0.000E+00	8.007E-9	-2.257E-8	5.800E-9	0.000E+0	0.000E+0	0.000E+0
145	111111	43.3213	40.0262	62.7697	0.000E+00	0.000E+00	0.000E+00	1.889E-8	3.612E-8	-2.664E-8	0.000E+0	0.000E+0	0.000E+0
146	111111	33.0337	20.3727	72.0126	0.000E+00	0.000E+00	0.000E+00	0.000E+0	-1.138E-9	-9.526E-9	0.000E+0	0.000E+0	0.000E+0
147	111111	58.4676	39.1885	61.0558	0.000E+00	0.000E+00	0.000E+00	-4.686E-6	1.924E-5	-7.063E-6	0.000E+0	0.000E+0	0.000E+0
148	111111	63.3749	19.0425	69.2108	0.000E+00	0.000E+00	0.000E+00	4.169E-6	-1.712E-5	7.552E-6	0.000E+0	0.000E+0	0.000E+0
149	111111	93.2726	31.8861	61.9506	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
150	111111	80.3353	15.5545	70.0124	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
151	111111	101.4341	32.2330	59.8124	0.000E+00	0.000E+00	0.000E+00	1.475E-9	4.919E-9	-5.245E-9	0.000E+0	0.000E+0	0.000E+0
152	111111	96.6187	16.1902	65.7715	0.000E+00	0.000E+00	0.000E+00	-1.526E-9	-5.079E-9	-1.544E-9	0.000E+0	0.000E+0	0.000E+0
153	111111	110.0340	28.3250	59.7893	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
154	111111	100.9442	14.2363	65.7643	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
155	111111	117.1217	22.2269	59.8352	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
156	111111	104.5116	11.1759	65.7928	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
157	111111	122.3463	14.2041	59.8281	0.000E+00	0.000E+00	0.000E+00	3.428E-9	1.591E-9	-2.434E-9	0.000E+0	0.000E+0	0.000E+0
158	111111	107.1412	7.1432	65.7856	0.000E+00	0.000E+00	0.000E+00	2.503E-9	1.161E-9	-2.093E-9	0.000E+0	0.000E+0	0.000E+0
159	111111	125.1131	4.9487	59.8144	0.000E+00	0.000E+00	0.000E+00	1.280E-8	1.898E-9	-8.374E-9	0.000E+0	0.000E+0	0.000E+0
160	111111	108.5332	2.4888	65.7725	0.000E+00	0.000E+00	0.000E+00	6.262E-9	0.000E+0	-6.105E-9	0.000E+0	0.000E+0	0.000E+0
161	101111	7.2872	0.0000	77.0815	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
162	101111	15.1638	0.0000	78.8965	0.000E+00	0.000E+00	0.000E+00	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
163	101111	37.9562	0.0000	77.7005	0.000E+00	0.000E+00	0.000E+00	-3.117E-9	0.000E+0	1.105E-9	0.000E+0	0.000E+0	0.000E+0
164	101111	53.2504	0.0000	76.4519	0.000E+00	0.000E+00	0.000E+00	2.171E-8	0.000E+0	2.181E-9	0.000E+0	0.000E+0	0.000E+0
165	101111	75.7547	0.0000	74.9823	0.000E+00	0.000E+00	0.000E+00	-3.927E-8	0.000E+0	1.411E-8	0.000E+0	0.000E+0	0.000E+0
166	101111	83.7495	0.0000	72.9911	0.000E+00	0.000E+00	0.000E+00	9.092E-8	0.000E+0	-1.287E-8	0.000E+0	0.000E+0	0.000E+0
167	001000	0.0000	0.0000	76.5409	0.000E+00	0.000E+00	0.000E+00	8.321E-2	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
168	000000	29.0460	288.5860	3.9710	0.000E+00	0.000E+00	0.000E+00	1.038E+2	1.597E+2	-2.660E+1	0.000E+0	0.000E+0	0.000E+0
169	000000	55.9630	287.1360	3.9040	0.000E+00	0.000E+00	0.000E+00	-7.487E+1	1.601E+2	-2.453E+1	0.000E+0	0.000E+0	0.000E+0
170	000000	115.7800	281.0700	3.5170	0.000E+00	0.000E+00	0.000E+00	1.010E+2	1.165E+2	-2.093E+1	0.000E+0	0.000E+0	0.000E+0
171	000000	138.9980	277.2640	3.3420	0.000E+00	0.000E+00	0.000E+00	-8.745E+1	2.842E+2	-4.107E+1	0.000E+0	0.000E+0	0.000E+0
172	000000	203.2100	263.5020	2.3760	0.000E+00	0.000E+00	0.000E+00	2.087E+2	1.833E+2	-3.976E+1	0.000E+0	0.000E+0	0.000E+0
173	000000	215.7500	259.3290	2.1460	0.000E+00	0.000E+00	0.000E+00	-2.732E+0	3.840E+2	-5.471E+1	0.000E+0	0.000E+0	0.000E+0
174	000000	283.8990	226.2620	0.6340	0.000E+00	0.000E+00	0.000E+00	3.372E+2	1.559E+2	-5.300E+1	0.000E+0	0.000E+0	0.000E+0
175	000000	286.9330	223.6560	0.6370	0.000E+00	0.000E+00	0.000E+00	1.061E+2	3.668E+2	-5.529E+1	0.000E+0	0.000E+0	0.000E+0
176	000000	338.2920	162.4910	0.8950	0.000E+00	0.000E+00	0.000E+00	3.679E+2	5.345E+1	-5.363E+1	0.000E+0	0.000E+0	0.000E+0
177	000000	341.2470	157.9130	0.9160	0.000E+00	0.000E+00	0.000E+00	2.023E+2	3.164E+2	-5.527E+1	0.000E+0	0.000E+0	0.000E+0
178	000000	361.2680	87.9910	2.8700	0.000E+00	0.000E+00	0.000E+00	3.630E+2	-5.269E+1	-5.324E+1	0.000E+0	0.000E+0	0.000E+0
179	000000	364.0680	70.8420	3.3050	0.000E+00	0.000E+00	0.000E+00	-2.791E+2	2.425E+2	-5.501E+1	0.000E+0	0.000E+0	0.000E+0
180	000000	366.9010	11.9100	4.3260	0.000E+00	0.000E+00	0.000E+00	3.407E+2	-1.567E+2	-5.534E+1	0.000E+0	0.000E+0	0.000E+0
181	000000	40.9870	306.9180	-3.6730	0.000E+00	0.000E+00	0.000E+00	-6.069E+1	-9.286E+1	-6.798E+1	0.000E+0	0.000E+0	0.000E+0

182	000000	46.8780	306.5080	-3.6750	0.000E+00	0.000E+00	0.000E+00	3.866E+1	-8.224E+1	-5.577E+1	0.000E+0	0.000E+0	0.000E+0
183	000000	128.0690	295.1940	-3.6830	0.000E+00	0.000E+00	0.000E+00	-8.468E+1	-9.691E+1	-7.865E+1	0.000E+0	0.000E+0	0.000E+0
184	000000	133.8470	293.9710	-3.6870	0.000E+00	0.000E+00	0.000E+00	3.662E+1	-1.185E+2	-7.660E+1	0.000E+0	0.000E+0	0.000E+0
185	000000	211.0770	270.4010	-3.7810	0.000E+00	0.000E+00	0.000E+00	-1.523E+2	-1.325E+2	-1.266E+2	0.000E+0	0.000E+0	0.000E+0
186	000000	215.6790	268.3390	-3.7920	0.000E+00	0.000E+00	0.000E+00	1.363E+0	-1.351E+2	-8.574E+1	0.000E+0	0.000E+0	0.000E+0
187	000000	284.0160	226.3380	-2.9890	0.000E+00	0.000E+00	0.000E+00	-2.668E+2	-1.216E+2	-1.842E+2	0.000E+0	0.000E+0	0.000E+0
188	000000	286.9840	223.7850	-2.9880	0.000E+00	0.000E+00	0.000E+00	-5.902E+1	-2.069E+2	-1.356E+2	0.000E+0	0.000E+0	0.000E+0
189	000000	338.8840	162.5930	-3.7790	0.000E+00	0.000E+00	0.000E+00	-1.992E+2	-2.809E+1	-1.269E+2	0.000E+0	0.000E+0	0.000E+0
190	000000	341.5720	158.3980	-3.7580	0.000E+00	0.000E+00	0.000E+00	-1.593E+2	-2.504E+2	-1.850E+2	0.000E+0	0.000E+0	0.000E+0
191	000000	374.5320	86.0320	-3.7500	0.000E+00	0.000E+00	0.000E+00	-1.312E+2	1.933E+1	-8.355E+1	0.000E+0	0.000E+0	0.000E+0
192	000000	375.9370	81.1890	-3.7240	0.000E+00	0.000E+00	0.000E+00	-2.144E+2	-1.866E+2	-1.757E+2	0.000E+0	0.000E+0	0.000E+0
193	000000	387.1700	2.5220	-3.6930	0.000E+00	0.000E+00	0.000E+00	-1.472E+2	6.764E+1	-1.008E+2	0.000E+0	0.000E+0	0.000E+0

1	8	181	0.02230	3.456E+06	0.512	129.829	150
2	182	9				106.342	
3	183	9				150.547	
4	184	10	0.05100	3.312E+06		145.113	
5	10	185				237.646	
6	186	11				159.332	
7	11	187				345.650	
8	188	12				253.712	
9	12	189				237.221	
10	190	13				349.074	
11	13	191				156.127	
12	192	14				333.499	
13	14	193				190.130	
14	37	17	0.02604	3.456E+06		110.580	
15	17	38				182.909	
16	38	18				65.540	
17	18	39	0.05472			235.151	
18	39	19				153.912	
19	19	40				390.107	
20	40	20				194.981	
21	20	41				339.601	
22	41	21				231.892	
23	21	42				295.240	
24	42	22				261.864	
25	22	43				255.214	
26	43	23				258.884	
27	24	44	0.00780			15.500	50
28	44	25				15.400	
29	25	45					
30	45	26				22.600	
31	26	46	0.01370				
32	46	27				29.800	
33	27	47					
34	47	28				29.400	
35	28	48					
36	48	29				29.500	
37	29	49					
38	49	30				30.000	
39	30	50					
40	32	51	0.00830			54.345	
41	34	52	0.01660			37.030	150
42	36	53	0.02347			121.541	
43	36	54				135.187	
44	36	55				176.143	
45	36	56				145.043	
46	36	57				117.009	
47	8	9	0.21889	3.312E+06		1338.778	
48	9	10				1317.967	
49	10	11				1285.[illegible]	

cable force (Kips)
+ tension
− compression

50	11	12				1197.898	
51	12	13				1206.049	
52	13	14				1297.199	
53	14	15				1364.615	
54	16	17	0.26670			1781.110	
55	17	18				1752.392	
56	18	19				1685.939	
57	19	20				1605.468	
58	20	21				1555.048	
59	21	22				1533.061	
60	22	23				1535.511	
61	24	25	0.08140			178.776	
62	25	26				178.940	
63	26	27				183.199	
64	27	28				183.796	
65	28	29				184.261	
66	29	30				184.593	
67	30	31				184.679	
68	58	59	0.06310			335.867	
69	59	60				334.954	
70	60	61				345.200	
71	61	62				331.679	
72	32	59	0.00830	3.456E+06		-60.658	
73	33	60				18.884	
74	34	61				14.828	
75	35	62				39.362	
76	32	33	0.07115	3.312E+06		506.900	
77	33	34				496.817	
78	34	35				483.601	
79	35	36				462.151	
80	8	37	0.14350	4.176E+06	0.490	-53.705	100
81	9	38	0.28700			-104.566	
82	10	39				-168.809	
83	11	40				-244.469	
84	12	41				-238.737	
85	13	42				-241.009	
86	14	43				-240.341	
87	17	44				-83.634	
88	18	45				-86.715	
89	19	46				-188.265	
90	20	47				-194.213	
91	21	48				-200.201	
92	22	49				-179.524	
93	23	50	0.14350			-88.036	
94	24	51	0.08450			-5.883	
95	25	52	0.16900			-6.316	
96	26	53				-10.149	
97	27	54				-19.742	
98	28	55				-17.452	
99	29	56				-18.049	
100	30	57				-18.618	
101	32	58	0.04225			-5.508	
102	34	60	0.08450			-18.876	
103	36	62	0.19650			-213.489	
104	1	168	0.03840	2.880E+06	0.512	362.951	150
105	168	66				170.701	
106	66	37				170.778	
107	1	169				359.190	
108	169	68				180.875	
109	68	38				180.953	
110	2	170				414.802	

111	170	70		259.254
112	70	38		259.335
113	2	171	0.05153	606.121
114	171	72		306.074
115	72	39		306.185
116	3	172	0.07924	641.365
117	172	74		360.972
118	74	39		361.164
119	3	173		866.924
120	173	76		479.185
121	76	40		479.377
122	4	174		933.610
123	174	78		558.486
124	78	40		558.710
125	4	175		877.656
126	175	80		492.010
127	80	41		492.234
128	5	176		904.686
129	176	82		529.201
130	82	41		529.419
131	5	177		860.191
132	177	84		480.781
133	84	42		481.005
134	6	178		874.995
135	178	86		504.492
136	86	42		504.676
137	6	179		817.645
138	179	88		443.969
139	88	43		444.152
140	7	180		818.323
141	180	90		439.397
142	90	43		439.558
143	37	91	0.02670	54.254
144	91	92		54.439
145	92	44		54.628
146	38	93		93.219
147	93	94		93.404
148	94	44		93.593
149	38	95		83.998
150	95	96		84.184
151	96	45		84.372
152	39	97		65.434
153	97	98		65.619
154	98	45		65.808
155	39	99	0.04970	178.838
156	99	100		179.183
157	100	46		179.532
158	40	101		191.039
159	101	102		191.385
160	102	46		191.736
161	40	103		193.103
162	103	104		193.448
163	104	47		193.798
164	41	105		185.867
165	105	106		186.212
166	106	47		186.561
167	41	107		196.592
168	107	108		196.937
169	108	48		197.285
170	42	109		200.074
171	109	110		200.416

	110	48		200.762
73	42	111		163.648
	111	112		163.992
	112	49		164.340
.76	43	113		162.294
	113	114		162.635
	114	49		162.981
79	43	115		149.398
.80	115	116		149.740
	116	50		150.087
	44	117	0.01330	78.821
83	117	118		78.821
	118	51		78.822
	44	119		20.912
.86	119	120		20.913
	120	52		20.916
	45	121		36.793
	121	122		36.794
.90	122	52		36.797
	45	123		58.187
	123	124		58.189
.93	124	53		58.192
	46	125	0.02490	159.456
	125	126		159.460
	126	53		159.466
.97	46	127		108.491
	127	128		108.495
	128	54		108.501
200	47	129		111.823
	129	130		111.828
	130	54		111.834
203	47	131		157.785
	131	132		157.790
	132	55		157.796
	48	133		151.697
207	133	134		151.702
	134	55		151.709
	48	135		133.090
210	135	136		133.095
	136	56		133.102
2	49	137		124.779
213	137	138		124.783
	138	56		124.789
5	49	139		98.891
	139	140		98.895
217	140	57		98.901
8	50	141		100.356
9	141	142		100.359
220	142	57		100.364
1	51	143	0.00747	24.826
2	143	144		24.862
	144	63		24.899
224	52	145		19.289
5	145	146		19.324
6	146	63		19.360
227	52	147		2.117
8	147	148		2.146
9	148	64		2.178
230	53	149		37.262
1	149	150		37.293
2	150	64		37.323

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233   53  151  0.02490                   67.041
234  151  152                             67.116
235  152   62                             67.193
236   54  153                             92.435
237  153  154                             92.511
238  154   62                             92.588
239   55  155                            143.892
240  155  156                            143.968
241  156   62                            144.044
242   56  157                            121.168
243  157  158                            121.243
244  158   62                            121.319
245   57  159                             89.080
246  159  160                             89.156
247  160   62                             89.232
248  167  161  0.00330                     0.083
249  161  162                              0.085
250  162   63                              0.089
251   63  163                              0.156
252  163  164                              0.152
253  164   64
254   64  165                              0.138
255  165  166                              0.134
256  166   62                              0.131
257  181    1  0.02230 3.456E+06           0.000
258  182    1
259  183    2
260  184    2  0.05100 3.312E+06
261  185    3
262  186    3
263  187    4
264  188    4
265  189    5
266  190    5
267  191    6
268  192    6
269  193    7
  1
  1 4.176E+06    0.300     0.490
  1
  1    0.27900 5.582E-02 5.582E-02 1.116E-01
  2
  1    011000
  2    000011
  1   33   59   60  1 1   1  -18.748     0.198     0.000     0.000     0.000     0.000     0.000    6.917-0.0003 0.0000 1.0000
  2   59   63   60  1 1   2  -18.583    -0.693     0.000     0.000     0.000    -6.934     0.000    0.000-0.0003 0.0000 1.0000
  3   35   61   62  1 1   1  -30.725     0.608     0.000     0.000     0.000     0.000     0.000   21.277-0.0007 0.0000 1.0000
  4   61   64   62  1 1   2  -15.313   -21.100     0.000     0.000     0.000  -126.608     0.000    0.000-0.0007 0.0000 1.0000
 61     0.000     0.000    -1.000
  1       0.00      0.00      0.00      0.00      0.00      0.00
  2       0.00      0.00      0.00      0.00      0.00      0.00
  3       0.00      0.00      0.00      0.00      0.00      0.00
  4       0.00      0.00      0.00      0.00      0.00      0.00
  5       0.00      0.00      0.00      0.00      0.00      0.00
  6       0.00      0.00      0.00      0.00      0.00      0.00
  7       0.00      0.00      0.00      0.00      0.00      0.00
  8       0.00      0.00     -7.11      0.00      0.00      0.00
  9       0.00      0.00    -14.35      0.00      0.00      0.00
 10       0.00      0.00    -13.57      0.00      0.00      0.00
 11       0.00      0.00    -12.79      0.00      0.00      0.00
 12       0.00      0.00    -12.79      0.00      0.00      0.00
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