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HEAVY LIFT HELICOPTER - CARGO HANDLING ATC PROGRAM. VOLUME II. FABRICATION OF TEST HARDWARE AND FIXTURES (INTEGRATED TEST RIG)

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Boeing Vertol Company

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report formally documents the efforts and results of the cargo handling system segment of the Heavy Lift Helicopter (HLH) Advanced Technology Component (ATC) development program.

The purpose of the HLH/ATC was to minimize technical, cost and schedule risks associated with future HLH system research.

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20. Abstract (continued)

development, test and evaluation (RDTE) and production programs. This was achieved by design, fabrication, and testing of specific ATC hardware in three critical air vehicle subsystems:

a. Rotor/Drive System
b. Flight Control System
c. Cargo Handling System

This report covers only the cargo handling system and consists of three volumes:

Volume I - Detail Design, Structural and Weights Analysis, and Static and Dynamic Load Analysis

Volume II - Fabrication of Test Hardware and Fixtures (Integrated Test Rig)

Volume III - Results of Tests, Inspections and Evaluations

Volume II contains the design criteria, physical description, stress analysis, fabrication and supporting data for the Integrated Test Rig which was used to conduct system testing of the full-scale cargo-handling ATC hardware.

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INTRODUCTION

Final design ATC hardware was based on subsystem design development testing. Verification of the cargo handling system ATC design goals, accomplished in advance of an aircraft installation, required a test fixture with which system performance could be demonstrated.

Since no suitable evaluation fixture existed, the ATC program included preparation of such a fixture. This fixture, the integrated test rig (ITR), was designed to permit: operation of the ATC developed hardware through all its functions; verification of performance and reliability characteristics, failure modes and effects, and maintenance characteristics; demonstration of 1800 hoisting cycles using both suspension modes at design load and speed and demonstration of maximum static load.

Although the ITR was erected on Boeing Vertol property, its design provided for dismantlement and reerection at another site. To support use at another location, appendixes to this document include foundation loads, descriptive drawings, air supply operating instructions, and an instrumentation calibration procedure.

GENERAL DESCRIPTION OF INTEGRATED TEST RIG (ITR)

MAJOR ELEMENTS OF TEST FIXTURE

The integrated test rig is shown in Figure 1. It consists of two steel I-beam towers, 14x14 feet square, supporting a pair of horizontal internally braced 30-inch-deep wide-flange I-beams with a 40-foot span and a 70-foot vertical clearance. Lateral outriggers buttress the towers.

The major elements of the ITR are:

1. Main structure consisting of towers and overhead section.

2. Footings and foundation with provisions for three ground tiedown points ("dead men").

3. Pneumatic power generation (hoist drive air supply) including fuel supply.

4. Utility power and communication.

5. Control room and enclosure.

6. Instrumentation and data recording system.

7. Stairway to control room and work platform.

8. Provisions for utility hoist.

9. Site improvements including access roads.

FULL-SCALE STATIC SIMULATION - HLH INSTALLATION

The test rig simulates a full-scale installation of the cargo handling system (CHS) in the Heavy Lift Helicopter (HLH), Figures 2 and 3, in the following respects:

1. Two steel frames simulate the a/c mounting structure for the hoists and signal conductor reels. These are removable to permit complete ground buildup of individual hoists and associated assemblies including the wiring to form a "hoist module". The assembled "modules" are raised with the overhead utility hoist and installed between the main overhead and auxiliary horizontal I-beams. Each hoist module also mounts the span positioning equipment and has space provisions for hoist separations of 16, 22 and 26 feet.

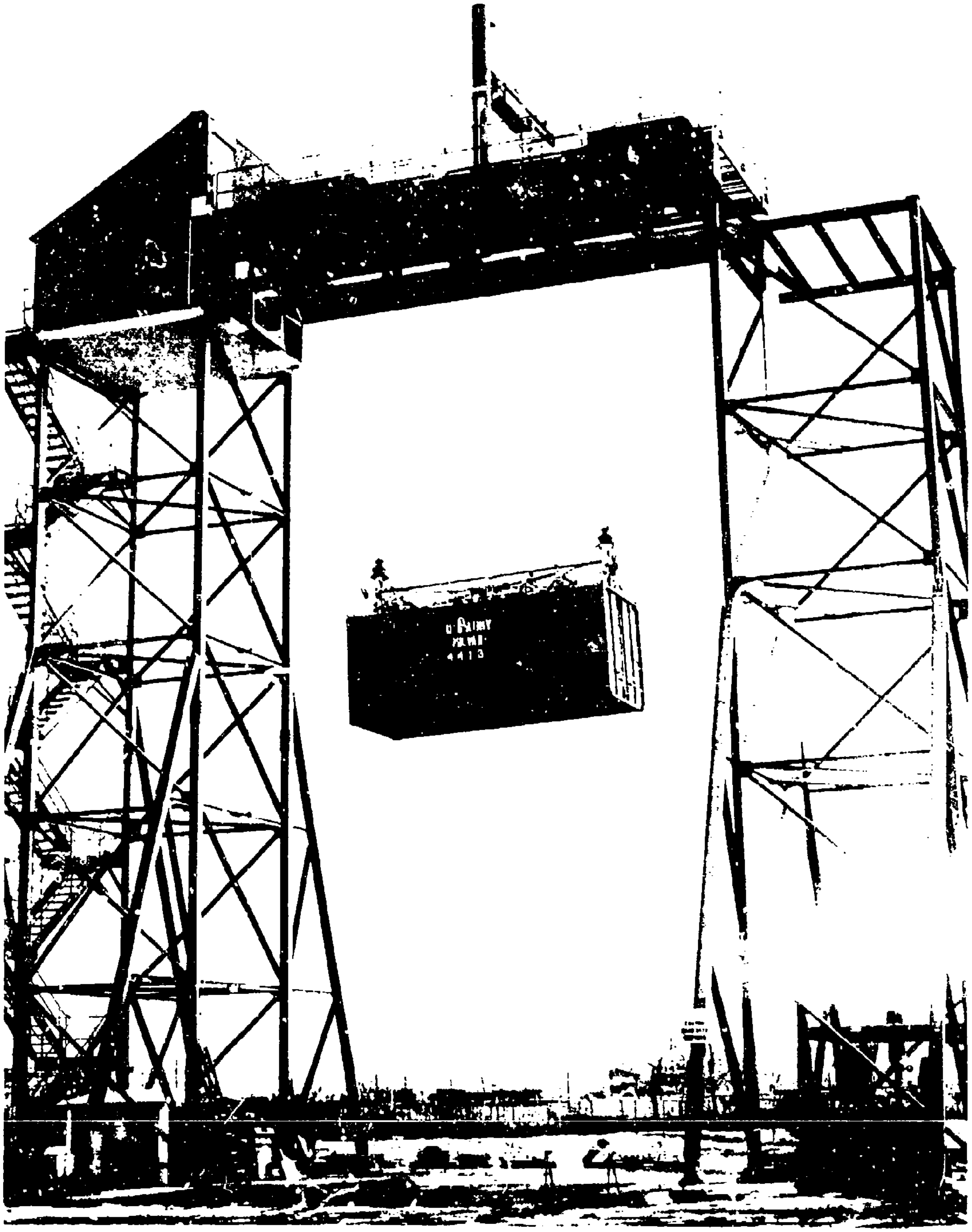


Figure 1. HLH Cargo Handling System Integrated Test Rig Hoisting - 29-Ton Load.

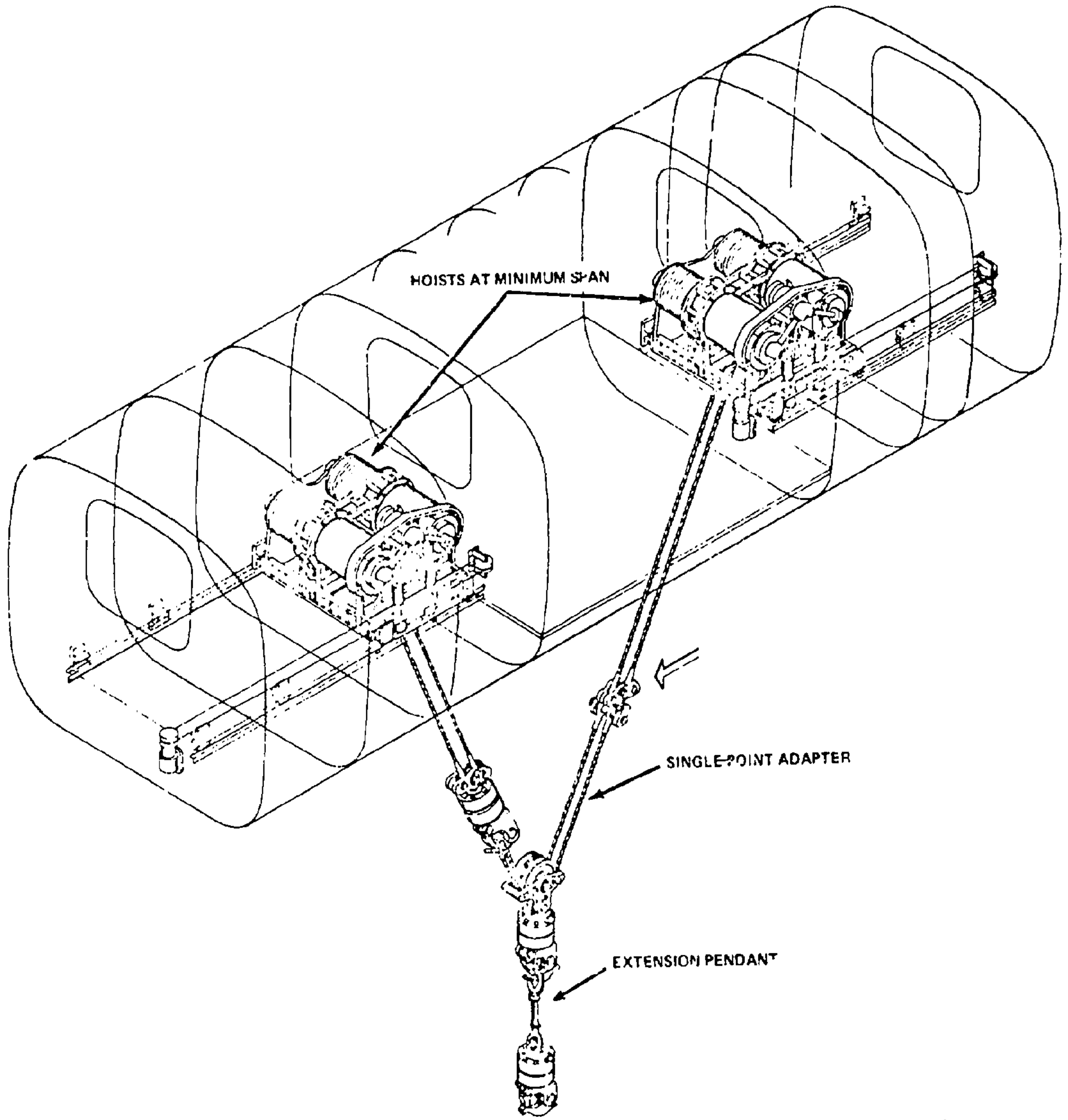


Figure 2. Single-Point Mode - Hoist Installation in HLH.

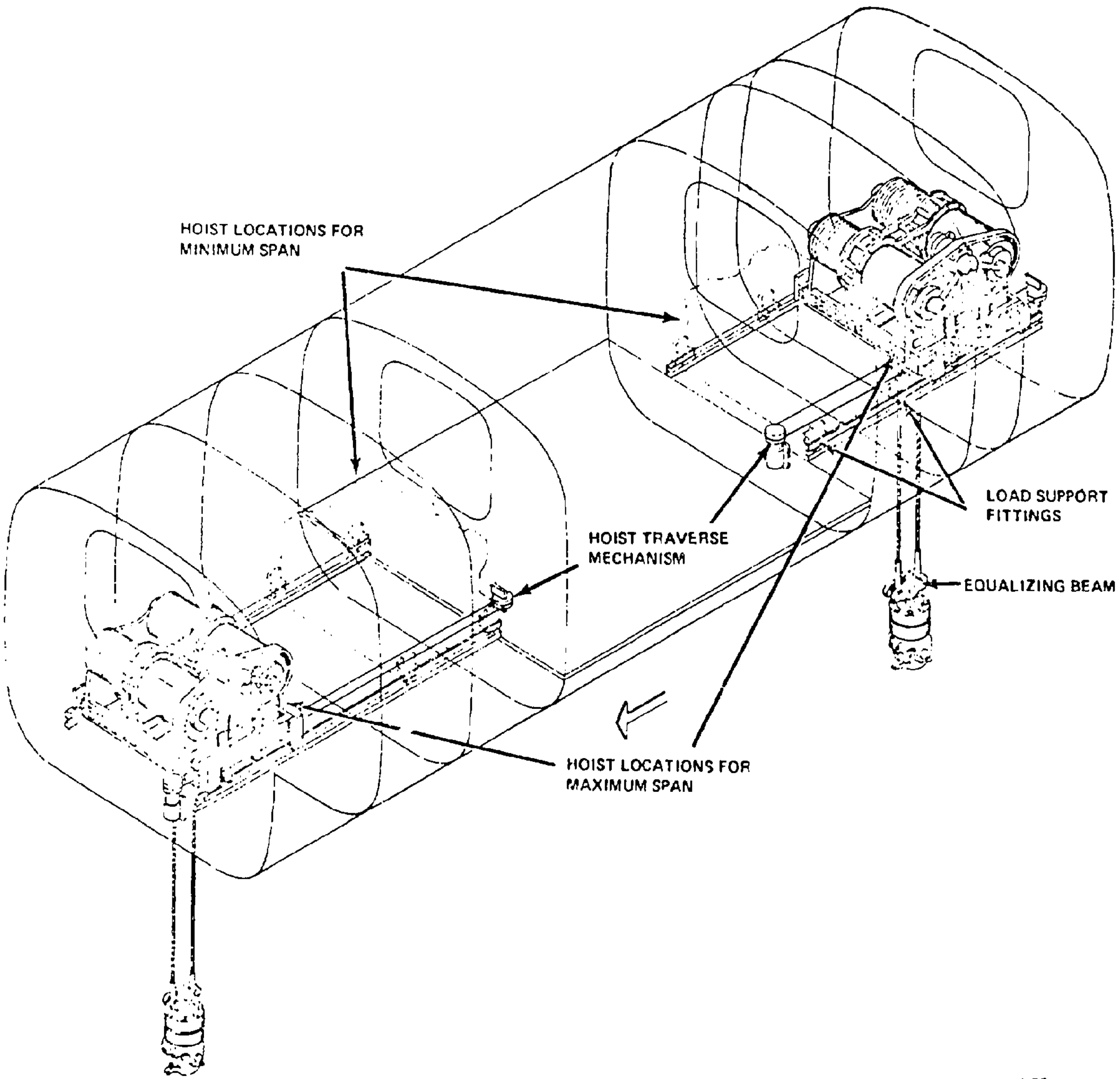


Figure 3. Dual-Point Mode - Hoist Installation in HLH.

2. Power, control, geometry and physical spacing of hoist assemblies.

3. Fuselage level attitude.

4. Relative location, type of hoist controls and displays, and layout of the rear-facing, load-controlling-crewman (LCC) station.

5. A 50-foot cable deployment with full-scale, rigged loads.

RIG LOCATION

The ITR is located at the Boeing Vertol Company facility, Ridley Park, Pennsylvania.

DESIGN REQUIREMENTS AND CRITERIA

HARDWARE COMPATIBILITY

The test rig design shall be compatible with the following full-scale cargo handling system hardware to be installed and operated in the test rig:

Hoist and tension member assembly
Hoist drive unit
Load isolators
Span positioning system
Signal conductor reels
Controls and displays systems
Coupling
Single-point adapters
Cable cutters
Pneumatic distribution system

and the following GFE (non-CHS) auxiliary equipment:

8' x 8' x 20' MILVAN
Container handling device

SUSPENSION AND HOIST SPAN ARRANGEMENT

Both single-point and two-point suspension arrangements shall be provided. Hoist span positioning space and functional provisions shall be incorporated for both 16- and 26-foot suspension spans.

DESIGN LOADS

Steady Vertical Loads

The individual hoists must support vertical loads and accommodate a 60/40 load split based on the two-point suspension. The loads to be supported are:

System design operating load	= 28.0 tons
Hoist design operating load (28x0.6)	= 16.8 tons
System maximum static load (28x2.5g)	= 70.0 tons
Hoist maximum static load (28x2.5gx0.6)	= 42.0 tons
Failure case (single hoist, any span position)	= 70.0 tons

Transient Vertical Loads

Some transient vertical loads may be encountered under differential hoisting (load levelling). The normal load tilt (multipoint mode) will not exceed ±15°. Load release transients are insignificant (loads above 1,000 lb cannot be released).

Side, Overturning, and End Loads

The hoists are "single-point payout"; therefore, tension member loads shall always act through the longitudinal (fore-aft) centerline of the test rig. No side, end, or overturning loads are anticipated due to testing except as may be encountered from load swinging (±5°, est.) or wind. Load motion shall not result in the loads striking the rig structure.

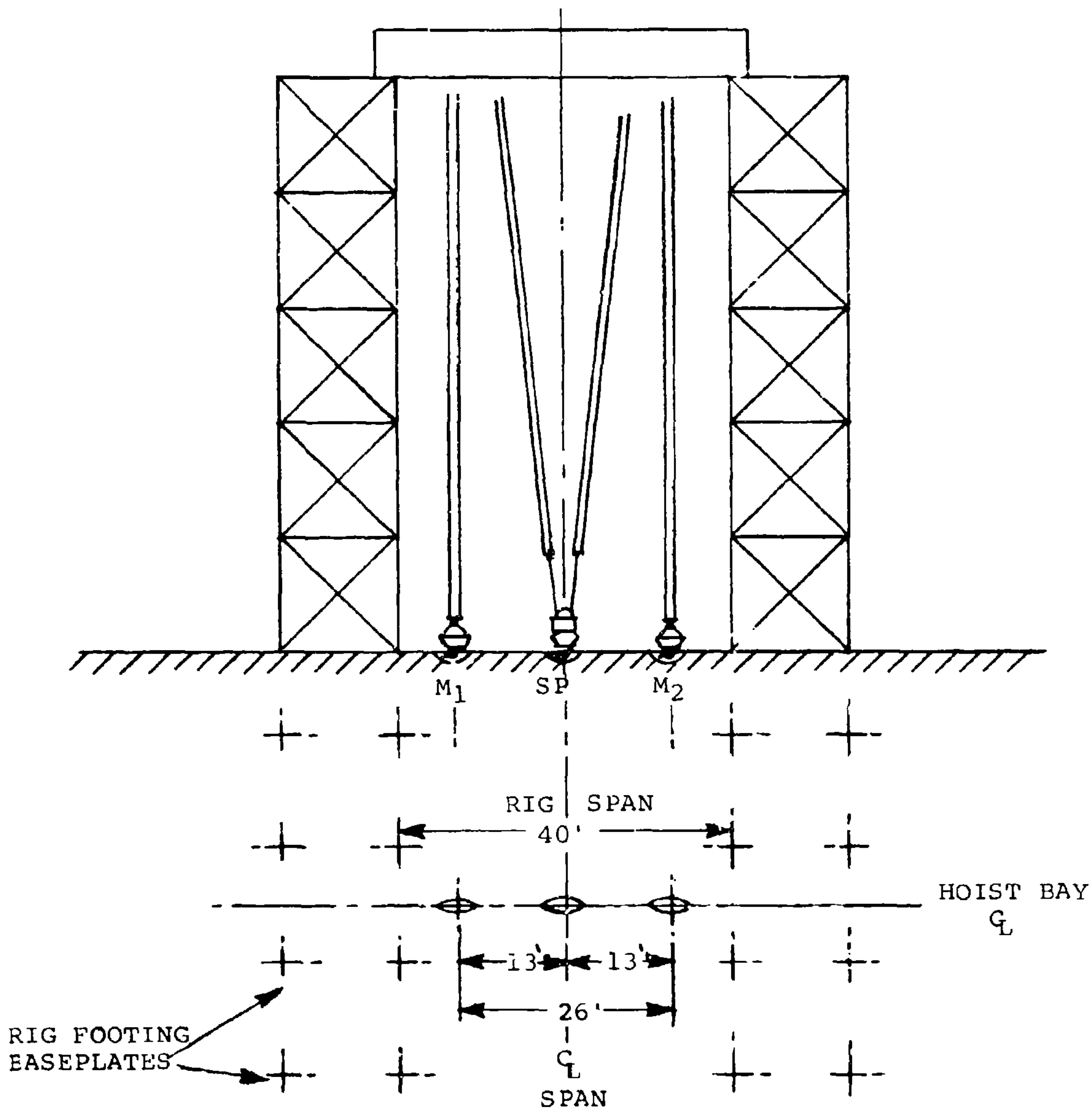
Maximum Static Load Provisions

Tiedown provisions in the ITR foundation are required for application of the maximum design static load to either individual or both hoists as shown in Figure 4.

The loading member, ring or bar, with a maximum 2-1/2 inch diameter, is to be compatible with CHS coupling. Space must be provided for coupling attachment/release.

FAILURE CRITERIA

Failure simulation involving severe load transients or high load release tests was not a requirement of the ATC program.



LOAD CAPACITIES: M_1, M_2 = 42 Tons

SP = 70 Tons

Figure 4. Multi-Point and Single-Point Static Loading Schematic.

Rig survival - no collapse - was provided in the design in the event of a sling or other failure under maximum static load. The vertical columns are the main support for the control room and are independent of the column struts in case of strut removal by impact of the test load (due to a suspension failure).

LOAD SIZE AND ACCESS

The standard test load size is an 8' x 8' x 20' container. A 40-foot clear span between overhead supports is required to provide vehicular clearance around the load for load placement and removal. Direct access is required along the fore-aft centerline and between the supports and superstructure of one tower to accommodate a MILVAN on a flatbed trailer.

LOAD LIFT

The test rig is to have a clear height of 70 feet.

HOISTING SPEED

Design hoisting and lowering speed (with load) is 60 fpm. Design payout speed (without load) is 120 fpm.

UTILITIES AND COMMUNICATION

The following provisions shall be made for utilities:

1. Equipment hoist - 6,000 lb capacity
2. Intercom - LCC station to ground and test areas
3. Storage area
4. Cooling water for PPG heat exchanger
5. Work platforms around hoists
6. Lightning protection
7. Aircraft warning signals
8. Weather protection for cargo system and PPG
9. Electrical requirements for the cargo system, pneumatic power generator, related instrumentation, general utility and equipment hoist, and the cargo handling device shall be as follows:

28V DC	Direct current
5V AC	Single-phase, 400 Hz
26V AC	Single-phase, 400 Hz
115V AC	Single-phase, 60 Hz, regulated
120/208V AC	Three-phase, 60 Hz
120/280V AC	Three-phase, 400 Hz

Compliance with MIL-STD-704 is required.

CONTROL ROOM

The control room shall house the LCC station, with a full view of the cargo in the ground and hoisted positions, the controls for the PPG and all related instrumentation. The floor loading criteria of 125-150 psf (light industrial) shall be used.

SAFETY CONSIDERATIONS

In addition to ITR failure criteria, the structure and location of operating equipment and utilities shall meet OSHA* requirements. The personnel stairway shall be remote from the test load.

*Williams - Stieger Industrial Safety, Oct. 1970.

TRANSPORTABILITY CONSIDERATIONS

The rig design shall incorporate provisions for dismantlement and reerection at another site.

PNEUMATIC POWER GENERATOR

A pneumatic power generator (PPG), located at ground level, and air distribution system shall be used to supply air to the hoists at a pressure ratio of 4.3 and a temperature of 450°F. Operating controls, pressure regulation and safety devices are required.

DATA REQUIREMENTS

Recordings are to be made of the following parameters (as delineated in Table I):

Ambient conditions - temperature and pressure
Supply air - temperature and pressure
Air turbine operation - temperature, pressure and speed
Control inputs and functions
Tension member - load, angle, payout length
Cargo system noise

DETAIL DESIGN

DESIGN CONSIDERATIONS

Selection of the ITR configuration was based on the following design considerations:

1. Control room requirement

   Access to hoist test location
   Simulation of HLH LCC station
   Drinking water, but no lavatory or toilet facilities

TABLE I. ITR - TEST DATA AND INSTRUMENTATION REQUIREMENTS.

Data Requested	Unit	Max. Range	Reqd. Accuracy	No. of Trans-ducers	Oscil	Visual Monitor	Memo Scope	W.B. FM.
PNEUMATIC POWER GENERATOR								
Supply Air Temp.	°F	0-500	±1%	1	X			
Supply Air Pressure	PSIA	0-60	±1%	1	X			
HOIST DRIVE								
Turbine Inlet Pressure	PSIG	0-50	±1%	4	X			
Turbine Inlet Temp.	°F	32-500	±1%	4	X			
Turbine Exhaust Temp.	°F	32-500	±1%	2	X			
Turbine Motor RPM	±VDC	5	±2%	1	X			
HOIST CABLE DATA								
Cable Tension	lb	0-30000	.1%	4		X		
Cable Angle-Longitudinal	DEG	30°Fwd/40°Aft	.1%	2		X		
Cable Angle-Lateral	DEG	30	.1%	2		X		
Cable Payout	FT	100	±2%	2		X		
Hoist RPM (Load Velocity)	RPM	25	±2%	2		X		
CABLE LENGTH INDICATOR								
Hoist Position (Fwd)	FWD/MID/AFT	N/A		0		X		
Hoist Position (Aft)	FWD/MID/AFT	N/A		0		X		
HOIST CONTROL								
Command Velocity	±VDC	5	±2%	2	X			
CARGO COUPLING								
Mech. Release Signal	±VDC	28	±2%	2			X	
NEAR-& FAR-FIELD NOISE	db	140		1				X
WIND VELOCITY	MPH	60		1		X		
AMBIENT AIR TEMPERATURE	°C	-10+40		1		X		

2. Span/overhead structure

Vehicle clearance for manipulating load
Variable cargo hoist span
Center mount for davit

3. Safety

OSHA standards
Stairway remote from test load - single egress location

4. Outriggers

Wind loading requirement
Access to test load through base of tower

5. Transportability

Possible use of ITR at another site required inclusion of splices and bolted joints at significant locations

6. Footings and foundation

Detail design based on known local rock formations determined by site borings.

CONFIGURATION DESCRIPTION

Because of height requirements of the towers and the relative low design loads, a trussed frame configuration was selected. Requirements for a control room made the selections of a 14-foot-square tower desirable. Easy installation of stairways on this type of tower was also a factor in the selection. Outriggers were used on each leg of the tower in the inboard-outboard plane for two reasons:

1. Wind loading, and
2. Need to remove secondary bracing in lower portions of tower to permit a loaded truck to drive through the tower.

Outriggers in the fore-aft plane were not required because the criteria used were not factors in this plane. Also, horizontal components of test loads are reacted by four frames in the fore-aft plane, while in the inboard-outboard direction only the two inner frames will react the horizontal component of loading.

Highlights of the ITR design including layouts of the test fixture and equipment are discussed in the following text.

MATERIAL DESIGN CRITERIA

Structure

Structural steel - Commercial A36 (AISC Specification)

Allowable	22,000 psi
Yield	36,000 psi
Ultimate	60,000 psi

Welding practice - AISC
Bolts - ASTM A325
Design loads - per requirement section.

Environmental factors - Wind - 30 psf (loaded)
50 psf (unloaded)
Snow - NE local standard

Safety factor - 1.5 (on maximum/failure load using material allowable.)

Footings and Foundation

Concrete - 3,000 psi compressive strength at 28 days - reinforced, continuous pour

Reinforcing steel - per ASTM A61

Anchor bolts - ASTM Spec A325

Footings - 3,000 psi concrete on bedrock

Anchor beams - to mate with Crosby-Laughlin round pin shackles

TRADE-OFFS/COST REDUCTION

An alternative A-frame configuration for the structure was considered. It was rejected in favor of the selected design since higher column stiffness requirements would have resulted in a heavier design. Also, bolted and riveted construction was eliminated as more costly than the welded design used. Use of a 60-foot span to accommodate a 40-foot load length was also considered. This option was not implemented due to an estimated cost increase of approximately 20%.

MEMBER SIZING

	Size	Type	Lb/Ft
Main beams	30x14	WF	172
Main vertical supports (towers)	8x8	WF	40
Tower bracing	(2) 4x3-1/2	Angles	9.1

TOWER STRUCTURES

Transportability

To facilitate disassembly and reerection, each of the tower columns included splices which consisted of a combination of welding and bolting at the joints, bolted connections at each of the four diagonal struts in the adjacent bay, and bolted joints at the outrigger struts.

Using this construction configuration, each tower could be dismantled into two discrete sections and the supporting outriggers could be disassembled for shipping without the necessity for welding cuts.

Stairways

Stairways were enclosed by 42-inch guardrails on both sides with a 32-inch handrail being incorporated on the inside guardrail. The handrail was located 3 inches into the 30-inch stairway.

The stairway was located entirely outside the outboard tower columns for safety considerations. This removed it as far as possible from the test load in the event of any failure in the suspension system.

Utility Connection to Tower Column

An outboard column was used as the terminating point for the utility connection from an adjacent building. The connection was made between the 28-foot and 42-foot levels with an attachment force of approximately 1,000 lb.

Warning Beacons

Beacon type lights normally required atop the structure for the protection of low-flying aircraft were not required for the site selected because of higher structures in the adjacent area.

OVERHEAD STRUCTURE

Overhead Beam Location Holes

The tower/beam assembly was predrilled to simplify assembly. The tower/beam holes are close fitting. The hoist module attachment was also predrilled.

Slots were not provided for temperature changes as estimated changes were small.

Camber was not specified in the overhead beams, since only 0.7 inch beam deflection was anticipated at the 70-ton static load.

Work Platform

Grip strut, an expanded-metal, nonslip surface, was used for the open work platforms around the hoists. A uniform floor loading of 235 psf was used.

Davit Assembly

The davit assembly or jib crane reach was 12 feet. It had a 6,000-lb hoisting capability. This satisfied the need for lifting the hoist modules and other equipment from the ground, over the side, or through the hoist location to the overhead structure.

The hoist cable reach was 89 feet. Maximum hoisting rate was 40 fpm. Guardrails surrounding the hoist module locations had sections which were removable for hoist installation and removal by the over-the-side method.

HOIST ASSEMBLY MODULES

The hoist module consisted of a simple welded framework and lift points including the hoist main support fittings and hoist positioning tracks. The function of the module was to facilitate preinstallation and checkout of each hoist assembly on the ground (similar to engine quick prep-packages). The module weight was minimized to keep the davit and utility hoist size down. Web material was 1-inch and flanges were .75-inch plate.

Each hoist was removable from its module. Both modules were identical and provided a hoist span positioning travel of 60 inches.

Hoist Shelters

A portable shelter (tarpaulin) was provided for each hoist test location. Each section was removable during hoist testing.

CONTROL-ROOM OPERATOR'S STATION

The control-room operator's station eye level duplicated the HLH LCC position as shown on Figure 5.

The control room floor area was approximately 130 sq ft. A solid, precast-concrete, nonslip floor was used with a design

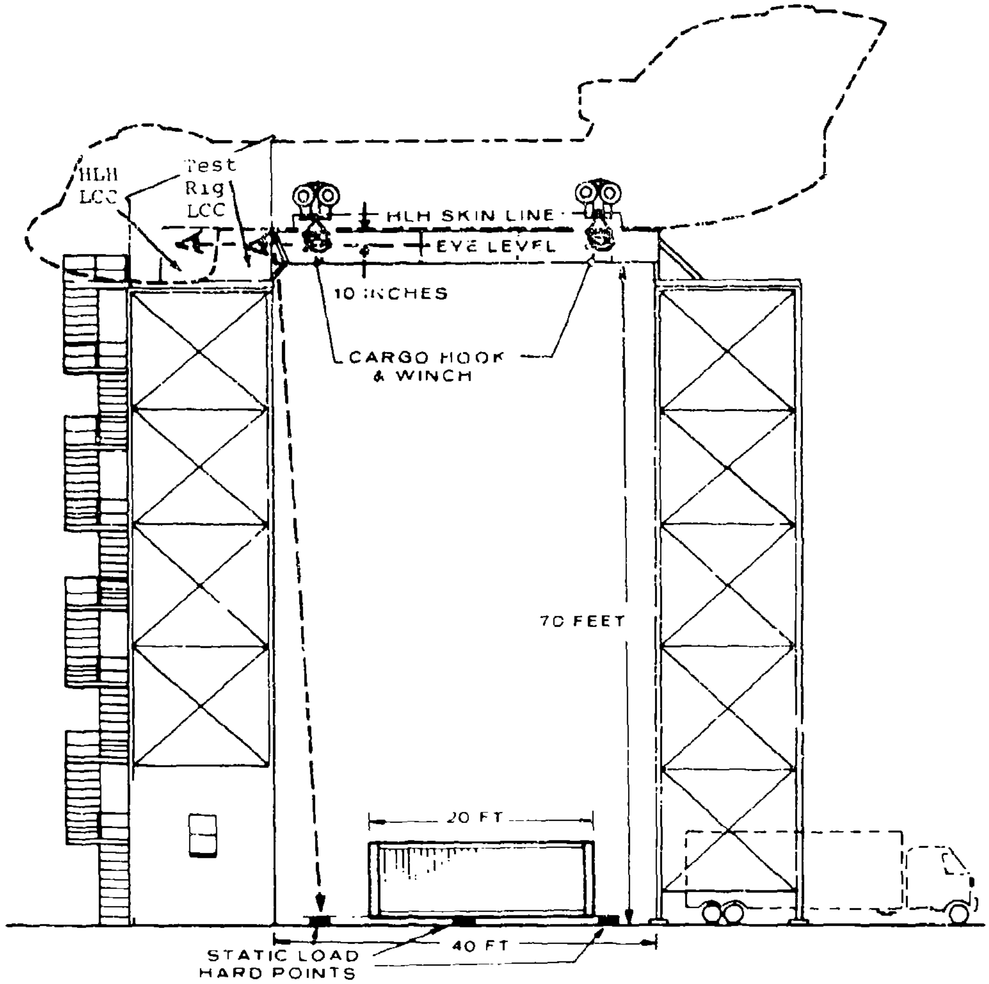


Figure 5. Test Rig, Showing Load-Controlling Crewman's View of Cargo.

floor loading of 172 psf.

LCC load viewing windows, looking aft and downward, were constructed of high-impact-strength polycarbonate (Lexan). A removable protective bar was installed across the main window. Side observation windows were of thermopane.

Except for doors and windows, the enclosure was fully insulated. Heat was furnished by a 3-kw thermostatically controlled space unit. A 5,000-Btu window-mounting airconditioner was provided for summer operation.

SITE LOCATION AND FOUNDATION

The test rig site location was selected to make maximum use of local rock foundations. To minimize service roads, the test rig was oriented adjacent to existing roadways.

The service road included a "Y" with one branch through the base of one tower and the other parallel to the overhead structure for truck pickup or deposit of a load within the reach of the jib crane.

The service road also provided for servicing of the fuel tank located 100 feet from the PPG unit.

Underground static load points in the concrete surface between the towers, along the hoist centerline, provided a 70-ton loading capability at the center point and 42 tons at each of the multi-point loading points. Slots were provided for entry of the cargo hooks, and covers were used to allow the surface traffic over these points.

The working surface around the test rig was asphalt covered, for vehicular traffic and surface drainage.

STRESS ANALYSIS

A stress analysis was performed to substantiate the design strength of the towers and overhead structure, using a Boeing Watfor "plain frame" computer program. An analysis of the hoist module frames and foundation reaction loads was also made. Analysis details are provided as Appendix I.

UTILITIES AND COMMUNICATION

Primary electrical service to the ITR was 277/480 volts AC 3Ø 60 Hz supplied from an adjacent building bus via a utility pole. Four distribution panels were provided in the control room: 480-volt, lighting, regulated-power, and 28-VDC.

Raceways and conduit were provided between the control room, the work platform and the PPG location.

Specific power requirements were serviced from the following sources:

115-Volt Regulator - Stabiline EMT 4115

15 KVA
Input: 95-135V
Output: 115V 50/60 cy. 1Ø
110-120V adjustable
Long-range amps: 130.0

400-Hz Electronic Inverter - Sorensen FCD 3P1000

1000 VA - 3 Ø
Input: 208/230V 48 to 65 cy 3 Ø
Output volts: ±10% 115/200V
3 Ø 4 wire
115V L-L 3 Ø 3 wire
Output volt reg: ±1%
Output freq.: 360-440 cy ±1%
Load range: 0-1000 VA
Distortion unity PF load: (360-400 CPS) 3%

28VDC - Instrumentation

Solid-state power supply - Sorensen MA28-125

Output:

Volts (DC)	Current (AMPS)	Reg.	Metered
18-36	0-125	.2%	Yes

28VDC - PPG Starting System

4-12VDC heavy duty truck batteries

Communication provisions included:

1. Telephone linking the control room, plant switchboard and base of tower.

2. Powered intercom system including four headsets, two keyed and two noise-cancelling microphones, and five interconnect boxes.

PNEUMATIC POWER GENERATOR (PPG)

Four possible PPG locations were considered: two on the overhead structure and two on the ground level. The two locations at the top of the structure were eliminated due to the additional structure required. In comparing the ground locations - the bay below the control room and the ground bay of the opposite tower - the latter was selected for the following reasons:

1. Elimination of:
   a. fire hazard in vicinity of stairway for operating personnel.
   b. the need for a fireproof structure around the air supply unit and special ducting, and
   c. the need for an alternate stairway or secondary means of egress.

2. Simplification of PPG fuel system.

3. Ease of servicing and isolation from personnel.

4. Provision of direct view of PPG from upper-level control room during operation.

The pneumatic power generator unit (air supply) was self-contained and consisted of the following components described in the system schematic, Figure 6:

1. 250-C20 Allison engine rated @ 294 HP at sea level 95°F, serving as a power unit. Additional components include a starter/generator, voltage regulator, 24VDC battery pack, fuel boost pump, oil reservoir, and oil/water heat exchanger.

2. A T-63 compressor with a modified T-63 gearbox.

3. An interface gearbox (step-up) and power transfer shaft as shown in the overall gearing arrangement, Figure 7.

4. A surge control valve designed to prevent compressor surge under all operating ambients from zero to maximum capacity of the compressor. The valve was controlled by a vacuum switch located in the compressor inlet bell mouth.

5. A pressure controller compatible with the cargo system pneumatic power distribution system. This valve was controlled by pressure sensed in the header upstream of the hoists.

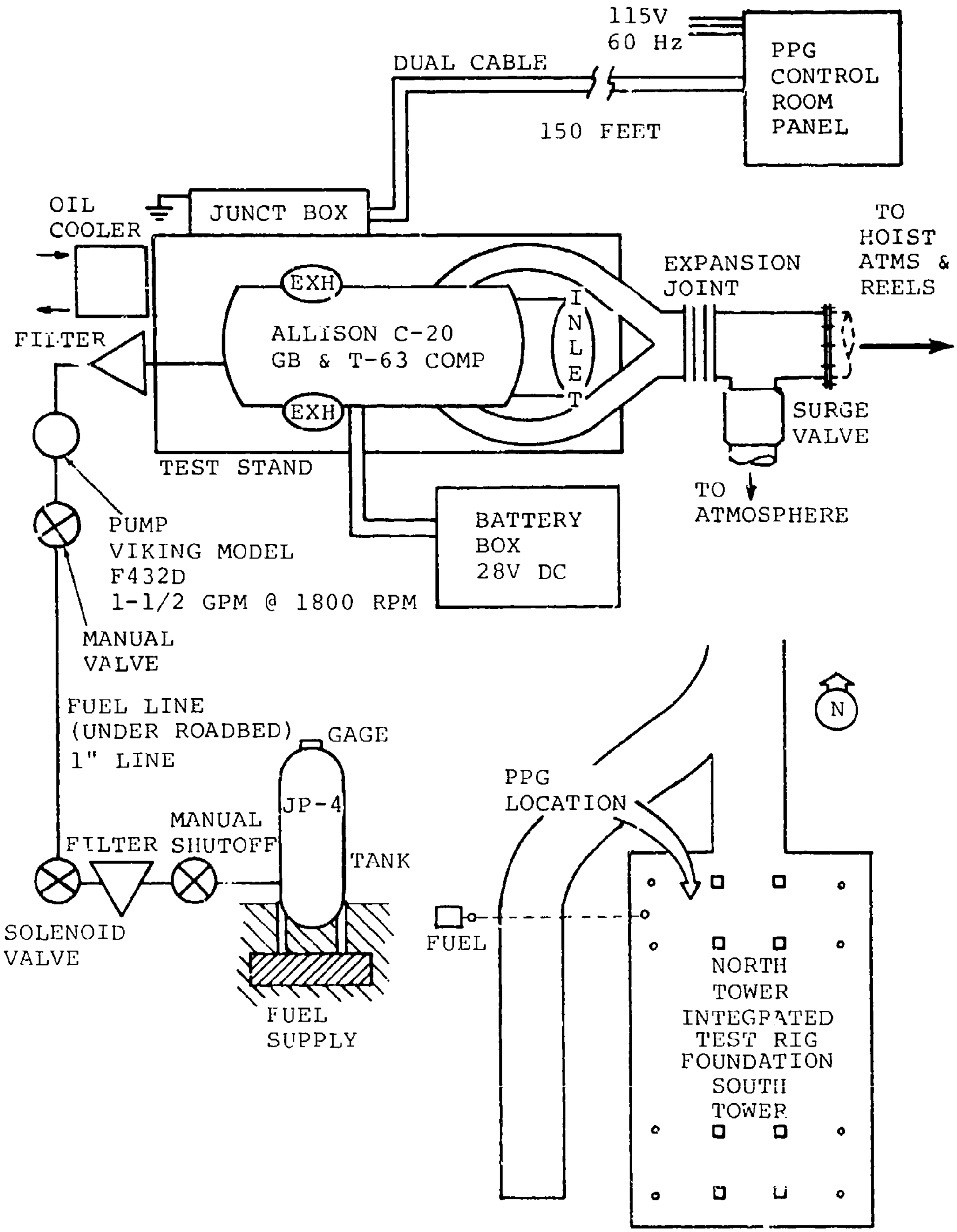


Figure 6. Schematic - HLH/ATC Pneumatic Power Generator (PPG) and Generator Location.

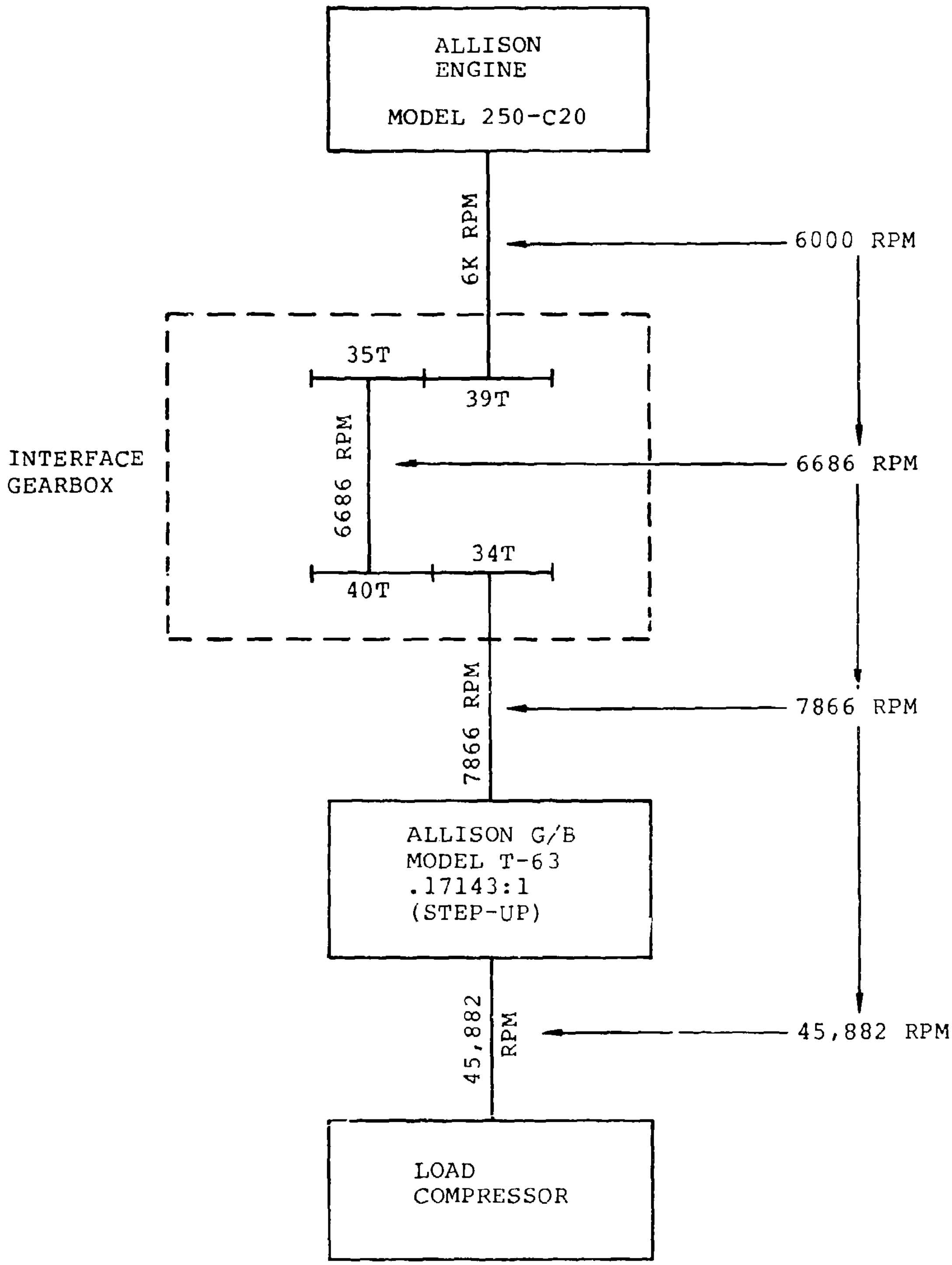


Figure 7. PPG Gearing Arrangement.

6. PPG control panel located adjacent to the LCC station, which included engine/compressor gearbox speeds, temperature and pressure instrumentation, fuel and battery charger controls, and emergency shutdown devices.

7. A 275-gallon fuel tank with manual and emergency valving with spark-arresting provision.

8. Approximate pressure gages and gearbox chip warning sensors and 150-foot control cable.

<u>Air Distribution System</u>

The air distribution system, constructed of Schedule 5 304 stainless steel, was rated for 60 psi at 543°F. The system consisted of:

1.	Main riser	6-inch I D
2.	Main header	6-inch, upstream of both hoists 3-inch, feeder between hoists
3.	Supply risers	2-1/2-inch flexible ducts
4.	Insulation	3-1/2-inch, with weatherproofed aluminum jacket
5.	Dump valve	2-1/2 globe, manually operated (for start and warmup control)
6.	Drain valve	for removal of line condensation.

A total pressure pickup and a thermocouple (I/C junction) were included in the 6-inch header to measure air supply conditions.

INSTRUMENTATION

The ITR instrumentation system was specifically designed to record and display the parameters necessary to evaluate the function and performance of the HLH cargo handling system. The parameters recorded and displayed were in addition to the load-controlling crewman station monitoring equipment.

An instrumentation console located in the ITR control room contained the equipment necessary to monitor and record the temperatures, pressures, isolator loads, cable angles and other auxiliary signals.

A listing of the instrumentation equipment used is shown in Table II. For wiring and other detail, refer to the Instrumentation Family Tree ST30861 listed under Design Layouts and shown in Appendix II.

TABLE II. COMPONENT LISTING, INSTRUMENTATION SYSTEM - HLH CARGO HANDLING SYSTEM.

Equipment	Model	Characteristics	Function	Warning	Comments
Temp.Indicator, Love Controls(7ea)	100-818	Range 0-600 Deg T/C Type "J" (I/C) Accuracy ±1% of scale Recorder output 0-1V	Indicates exhaust temp;supply air temp & hoisting & rev.valve temp.	No	Auxiliary output used to drive recording galvo.
Temp.Indicator Love Controls(1ea)	Same	Same	Indicates ATM temp.for operator monitoring	No	Operates thru selector switch for ATM temp.
Temp.Selector Switch Thermo-Electric(1ea)	33112	No.channels-12	Switches ATM T/C inputs	-	—
Temp.Probe; Thermo-Elec.(1ea)	5J212OL	Accuracy ±0.5% Probe Length 6" Type Iron-Constantan	Temp transducer for temp indicators	-	—
Pressure Ind. Dynisco (5ea)	ER466A2	Range 0-100 PSI Accuracy ±1% full scale Response time 1.5 sec Aux. output 0-1 Volt	Indicates supply air, hoisting & rev. air pressures	Yes	Auxiliary output used to drive recording galvo, conditions & amplifies pressure transducer signal.
Pressure Transducer(5ea)	103	Range 0-75 PSI, 112.5 PSIA Max.	Press. transducer for press. indicators	-	—
Load Isolator Panel	ST30869	Range 0-100KIP Accuracy ±0.1% of input	Indicates compression load in each of four load isolators	No	Receives load signal & ref.from cable tension & angle interface electronics

TABLE II. CONTINUED.

Equipment	Model	Characteristics	Function	Warning	Comments
Cable Angle Ref. Panel	ST30873	Range 0-100 Deg. Accuracy ±0.1%	Indicates angle of four-hook cables	No	Same as above
Closed-Circuit TV System Hitachi Ltd.	ST30852	Range-50 yards Field of view 3ft x 3ft	Used to observe moving parts on cargo handling modules & container position	No	—
Intercom System	ST30859	No.of stations-4 Type-Headset with mike	Used for communication between the operator & crewmen	-	—
Oscillograph Recorder CEC(3ea)	5-124	No.channels-18 Speeds 0.25,1,4, 16,64 IPS	Used as graphic recording devices	No	—
Pressure Probe United Sensor	PTC12	Adjustable immersion length Max.operating temp-1600°F	Static pressure transmitter	No	—
	PTC8	Same as above	Total pressure transmitter	No	
Galvo CEC(21ea)	7-315	Frequency response 0-60 Hz (±2%) Sensitivity 12.2 UA/IN Impedance 26 Ohms	(Used as transducers for graphic recording oscillograph)	No	See dwg.ST30854A for recorder parameter info.
Galvo CEC(2ea)	7-319	Frequency response 0-350 Hz (±2%) Sensitivity 426 UA/IN Impedance 26 Ohms	Same as above	-	Same as above

TABLE II. CONCLUDED.

Equipment	Model	Characteristics	Function	Warning	Comments
Galvo CEC (7ea)	7-351	Frequency response 0-12 Hz (±2%) Sensitivity 2.66 UA/IN Impedance 33 Ohms	Same as above	-	Used to record outputs of temp. indicators-see ST30854A.
Oscillator H-P (1ea)	200CDR	Range 0-600 kHz Output 0-40 Volts	Used as time event marker source	-	—
Amplifier Burr-Brown (6ea)	2088/16	Frequency range 0-10 kHz Gain ADJ 1-1000 CMR ADJ 40-140 DB	Used as buffer amplifier-see ST30860	No	—
D.C. Null Meter H-P	413A/R	Range ImV-1000 V Accuracy ±0.1% of input	Used as an auxiliary monitor	No	—
Power Supply Kepco	ABC 10.C.75M	Range 0-10V 0-0.75A	Used as a calibration voltage source	No	—
Load Cell Bud (2ea)	T3P2B	Range 0-50K lb Sens 3mV/V	Used to measure hook load	No	—
Meter Panel Simpson	—	Range 0-50mA Accuracy ±1%	Used to indicate cable speed	No	Receives cable length signals from hoist interface electronics.
Anemometer-Taylor Instrument Co. Rochester, N.Y.	—	Dual range-zero adjust 0-25 mph 0-100 mph	Used to indicate wind velocity & direction	No	—

The instrumentation system was configured, as shown on Figure 8, in a two-bay console designated rack "A" and rack "B". Rack "A" included the equipment to monitor and record hoisting and reversing air turbine motor (ATM) temperatures, exhaust temperatures, main supply air temperature, hoisting and reversing air pressures, supply pressure, isolator loads, and cable angles. The recording oscillograph, closed-circuit television (CCTV) system switch panel, ±15 volt power supply, event oscillator, and intercom station were also located in rack "A". The CCTV monitor, DC null voltmeter, hoist control unit, hoist interface electronics, cable tension and length interface electronics, recording oscillograph and buffer amplifiers were located in rack "B". The data recording format is shown in Table III. Additional equipment added to the system included a recording oscillograph "C" used for recording cable tensions, two null panel meters for observing cable payout speed, an oscillograph control box with event button, a brake release counter, eight chip detectors, and a 12-channel temperature panel with selector switch. During initial checkout, supply pressure and antisurge valve characteristics were investigated. An x-y plotter, B&F conditioner with amplifier, and a dekabox were used to plot supply pressure.

Temperature Instrumentation

Temperature probes were inserted into the air ducts of each hoist drive unit to measure the turbine inlet, exhaust and supply air temperatures. They acted as transducers for the seven temperature indicators in the instrumentation system.

Evaluation of the hoist duty cycle required monitoring of the surface temperatures of the hoist main bevel gear casing, the secondary forward and aft bevel gear casings, the hoist brake casing, the ATM oil pressure line, and the ATM oil return line of each hoisting module. Silver-soldered T/C junctions were attached to each of the six surfaces with Caulk grip cement (dental cement) and routed to a 12-channel T/C selector switch via a six-lead thermocouple cable. The selected channel temperature was displayed on a separate indicator. The selector switch and temperature indicator were located on a panel which was positioned in front of the hoist operator.

Pressure Instrumentation

Pressure probes were inserted into the air duct at the same location as the temperature thermocouples in the ATM inlet and were connected by flexible tubing to the pressure transducers.

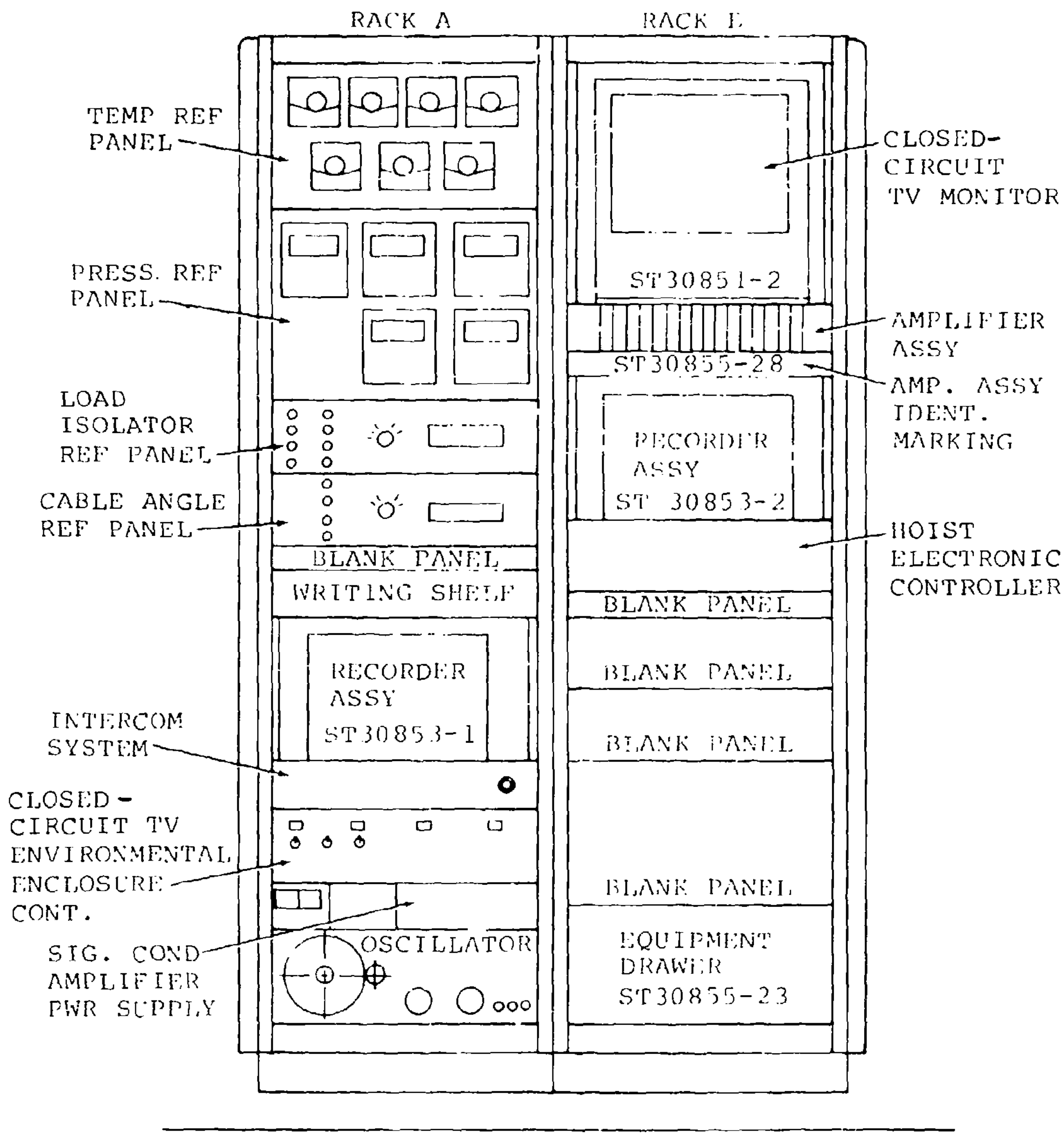


Figure 8. Instrumentation Rack Console ST30855-1.

TABLE III. ITR INSTRUMENTATION SYSTEM - RECORDED DATA FORMAT.

Recorder A		Recorder B		Recorder C	
Chnl.	Measurement Parameter	Chnl.	Measurement Parameter	Chnl.	
1	T1-Fwd,hoisting,°F	1	P2-Fwd,hoisting,psig		<u>Load Isolators</u>
2	Time/event	2	P4-Aft,hoisting,psig		
3	T2-Fwd,reverse,°F	3	A1-Fwd,turbine speed	1	Fwd hoist, fwd
4	T3-Aft,hoisting,°F	4	-- Blank	2	Fwd hoist, aft
5	T4-Aft,reverse,°F	5	A2-Fwd,cable payout	3	Aft hoist, fwd
6	T5-Fwd,exhaust,°F	6	A5-Aft,turbine speed	4	Aft hoist, aft
7	-- Blank	7	-- Blank	5	Load cell
8	T6-Supply air,°F	8	A6-Aft,cable payout	6	Time/event
9	T7-Aft, exhaust,°F	9	-- Blank		
10	P1-Supply air,psia	10	Fwd,speed command		
11	P5-Aft,reverse,psig	11	A7-Aft,H,Mod.Valv.amps		
12	Aft,torque sw.	12	Aft,speed command		
13	Aft,brake sw.	13	-- Blank		
14	P3-Fwd,reverse,psig	14	A3-Fwd,H,Mod.Valv.amps		
15	-- Blank	15	-- Blank		
16	Fwd,torque sw.	16	-- Blank		
17	Fwd,brake sw.	17	Sync.Signal		
18	-- Blank	18	Time/event		

Load Isolator Instrumentation (Cable Tension)

A load cell for axial load sensing was an integral part of each load isolator. The output from the 350-ohm strain gage bridge on the cell was amplified and conditioned by the hoist cable tension and cable length interface electronics.

Cable Tension and Load Instrumentation

The load isolator reference panel located in rack "A" had a five-position rotary selector switch, four calibration adjustment potentiometers and a three-place digital panel meter which displayed the selected axial load.

An auxiliary method of measuring cable tension was employed using two load cells in series with each coupling and a BLH universal percentage indicator.

Cable Angle Instrumentation

The cable angle sensing mechanism employed two linear transformers (see Figure 9) which produced electrical signals proportional to the longitudinal and/or lateral angles that the cable made with the vertical centerline of the hoist.

The cable angle reference panel had a five-position selector switch, four angle adjustment potentiometer, and a digital panel meter for readout.

Cable Payout Instrumentation

The cable length sensing mechanism (see Figure 10) employed a linear transformer whose electrical output signal was a function of the number of turns of the cable drum from the cable up (stow) position.

Two cable length signals, one for each hoist assembly, were recorded. By relating the cable payout trace deflection to oscillograph paper speed, a cable payout rate or load velocity could be determined.

Hoist Input Command Instrumentation

The hoist operator's control grip thumb switch supplied a command signal to the hoist controller logic. The command signal, conditioned to a 0-5VDC output for 0-100% command and interfaced with other controller network logic, determined the hoisting or lowering rate. In the single hoist mode, each command signal was recorded on rack "B" oscillograph.

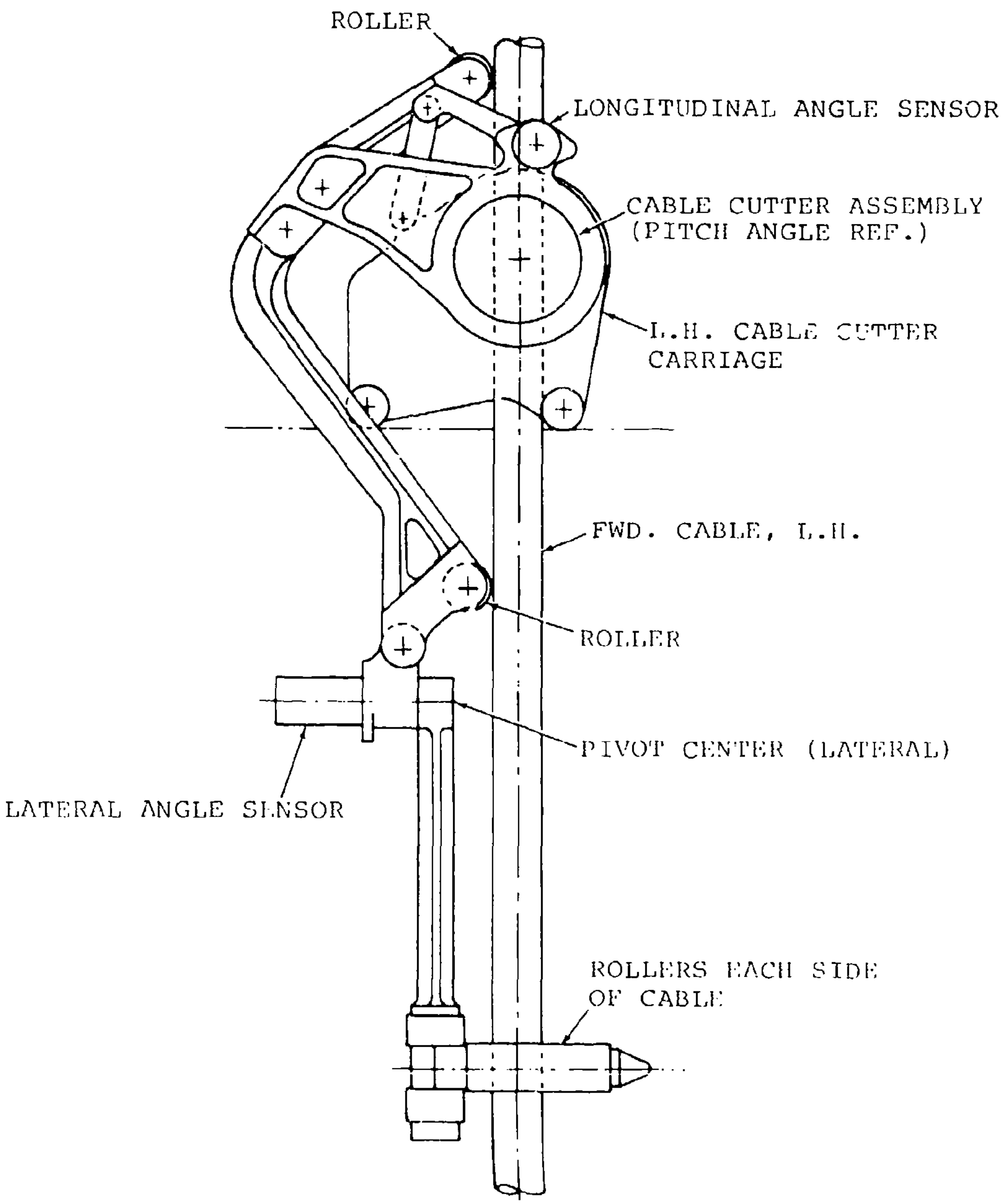


Figure 9. Cable Angle Sensor Mechanism.

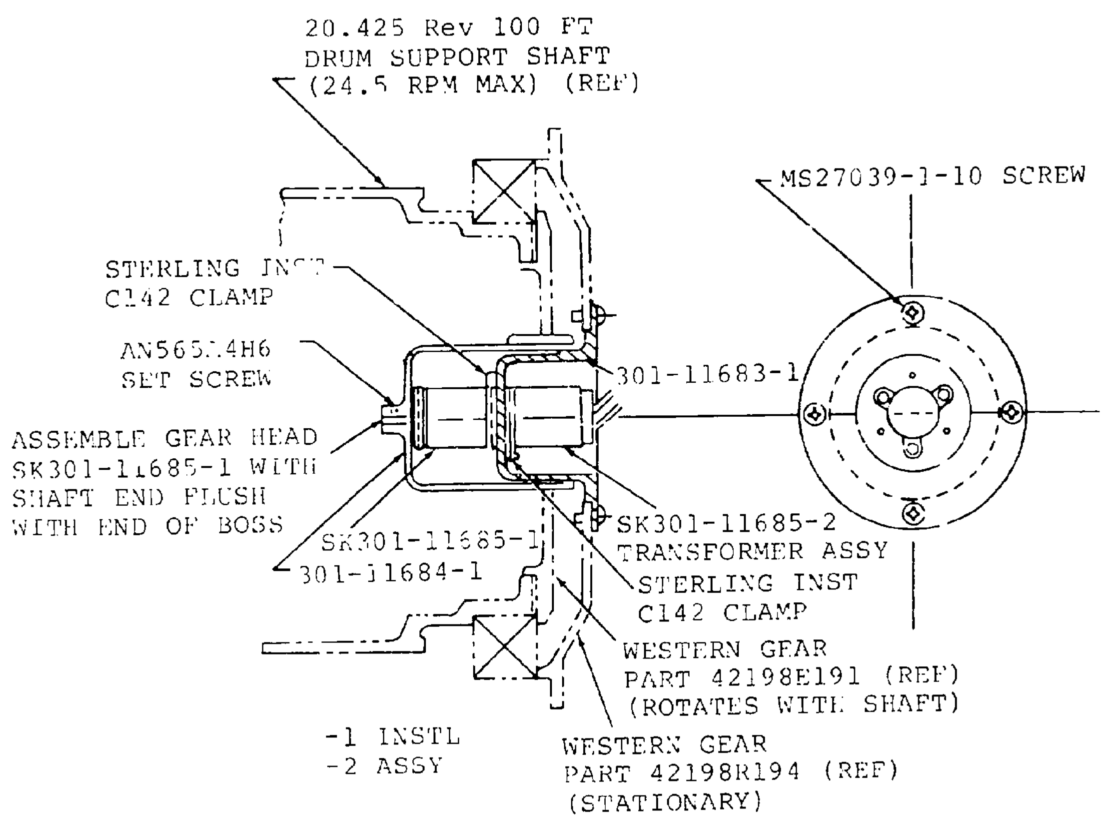


Figure 10. Cable Payout Sensor •

In the sync mode, only the forward hoist command signal was recorded since the aft hoist unit was commanded from the forward grip thumb switch.

Cargo Coupling Instrumentation (Mechanical Release Signal)

The hoist operator's cargo system control panel mechanical release switch was used for recording the command signal to the coupling solenoids and was recorded on rack "B" oscillograph.

Cable Payout Speed Instrumentation

The cable payout was derived from a sensing mechanism employing two magnetic pickups (MPU) which sensed ATM shaft speed. The ATM shaft speed was directly related to cable payout speed by the system gearing as represented in Table IV.

The MPU analog signal was conditioned and recorded on the rack "B" oscillograph.

Cable Speed Instrumentation

The payout speed signal was also fed to two zero center panel meters directly in front of the hoist operator. This provided the operator with a visual indication of cable payout speed and rate change or load velocity.

Power Requirements

The instrumentation system required 115 VAC 50-60 Hz and 28 VDC power supplies.

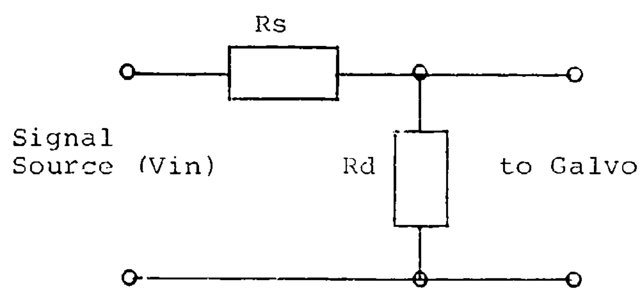
Recording Instrumentation

The recording instrumentation consisted of the galvanometer input network, the galvanometer, and the recording oscillograph which housed the galvos. The galvo input networks were as shown in Figure 11. The networks were installed on the terminal boards on the junction panel located in rack "A". All the recorded signals from each source were terminated in the same manner with the matching networks located on the rack "A" junction panel.

The recording galvanometers selected for pressure, rpm and modulating valve measurements had a minimum upper frequency response limit of 200 Hz to permit observation of oscillatory, fluctuating or step input signals.

TABLE IV. ATM SHAFT SPEED RELATED TO CABLE PAYOUT SPEED BY SYSTEM GEARING.

Cable Speed (fpm)	Shaft Speed (rpm)	MPU Frequency (Hz)	Speed Signal (VDC)
120	8,000	5,250	5.00
60	4,000	2,625	2.50
30	2,000	1,313	1.25
15	1,000	656	0.625
7.5	500	328	0.312
3.75	250	164	0.156



Resistor values were derived from the following formula:

$$Rs = \frac{Vin}{D\ Ig} \quad \text{where}$$

Rs = calculated source resistance
Vin = input voltage
D = desired deflection in inches; usually 2.0
Ig = galvo undamped D-C sensitivity in UA or MA/IN. (see manufacturer's specs)
Rd = required damping resistance, from manufacturer's spec sheet

Figure 11. Galvo Input Networks.

Galvanometers with a lower frequency response limit were used for the temperature, cable payout and command signal instrumentation.

Six Burr-Brown amplifiers located in rack "B" were used as buffer amplifiers to isolate those signal sources which did not have sufficient current magnitude to drive the recording galvanometers directly.

A 5-Hz signal was fed to one recording channel on each oscillograph to provide an accurate time/data correlation. The signal was in series with an event switch which served to correlate the start time on each of the three recording oscillographs. The event switch was located at the LCC station, with two recorder "on" lights and two recorder start switches.

Closed-Circuit TV System (CCTV)

A CCTV system was installed to monitor the moving parts on the hoist assembly during system testing. The system consisted of a monitor, a switch panel, and a camera enclosed in an environmental housing. The switch panel was located in rack "A", while the monitor was at the top of rack "B". The camera zoom lens is manually adjustable for the desired field of view.

Intercom System

A four-station intercom system was provided to enable the LCC station to have constant communications with three other stations. They were:

1. Ground crewman station
2. Rack "B" instrumentation monitor
3. Hoist assembly station

Each station was fitted with a dynamic mike and headset combination.

Calibration Procedures

Each system was calibrated daily, prior to PPG startup and post-calibrated when the day's testing has been accomplished, as described in Appendix IV. Periodic calibrations were in compliance with MIL-C-45662. All instrumentation calibrations were traceable to the National Bureau of Standards.

Container Weighing Instrumentation

The weighing instrumentation for the loaded MILVAN container consisted of two 50,000-lb Baldwin-Lima-Hamilton load cells and a Baldwin-Lima-Hamilton universal percentage indicator. The cargo handling system was in the two-point suspension configuration with one load cell in series with each hook. The SR4 universal percentage indicator was used to measure the individual loads. Connections to the load cells were made using two 70-foot eight-conductor cables from the load cells up to the test rig control room. The measured load using the load cells was within 0.7% of the calculated load.

Maximum Load Test Instrumentation

Three of the load isolator transducers from the hoist units were used for the maximum static load demonstration test. The calibrated transducers were used as the main load-sensing elements during the test.

The isolator load signals which represented the hook load were conditioned and recorded on the CEC recording oscillograph,"C". The conditioned load signal was also displayed for the LCC on a digital voltmeter which indicated the load directly in pounds. The equipment is shown schematically in Figure 12.

DESIGN LAYOUTS

The integrated test rig is described by the engineering drawings given in Appendix II. Besides the basic ITR structural design, additional subsystems were required for the assembly, installation, functional operation and test of the cargo system. Each of the required design items is identified on the following drawings:

System Test Drawing Tree - SK301-11676
(See Figure 65 in Appendix II)

- Hoist installation, including
  - Hoist module
  - Span positioning
- Control system wiring
- Assembly/handling fixtures
- LCC station platform
- Miscellaneous test fixtures and wiring

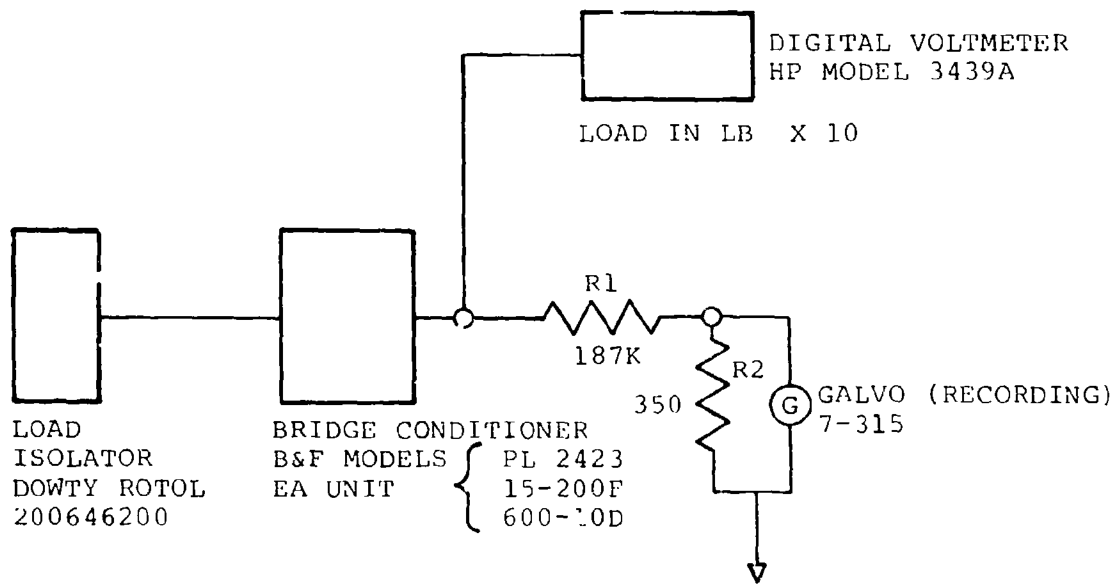


Figure 12. Maximum Load Test Network.

System Wiring - SK301-11694
(See Figure 68 in Appendix II)

A schematic showing the electrical integration of the cargo handling system is shown in Figure 67.

FABRICATION

STRUCTURE PREFABRICATION

The following items were prefabricated and yard assembled prior to delivery to the test site:

1. Fore-aft frames
2. Control room enclosure
3. Hoist modules
4. Overhead beams
5. Overhead lateral beams and davit supports
6. Control room floor
7. Stairway sections
8. Outriggers and frame bracing
9. Footing pads

FOUNDATION

Excavations· exact site location, and footing designs were adjusted to utilize available rock strata. Figures 13 and 14 show the excavation, location of bedrock, and foundation preparation. Figure 15 shows the ground tiedowns provided in the foundation.

The rig was erected with prefabricated fore-aft frames joined at the splices and supported by outriggers. Inboard and outboard frames were assembled between the main columns on alignment pins and welded in place.

The main overhead beams were drilled and bolted on assembly. The lateral beam components and davit supports were then welded in place. Figures 16 through 26 illustrate the assembly method and main features of the structure. The control room enclosure assembly, Figure 27, was hoisted in place and joined to the main column pads. Figure 28 shows the ITR after complete erection, including the air distribution duct. For reassembly at another site, the towers (split into four units at the splice joints), the overhead structure disassembled to its basic components, the davit, outriggers, and control room shelter can be shipped as individual items. Table V delineates weight breakdown of the ITR structural assemblies.

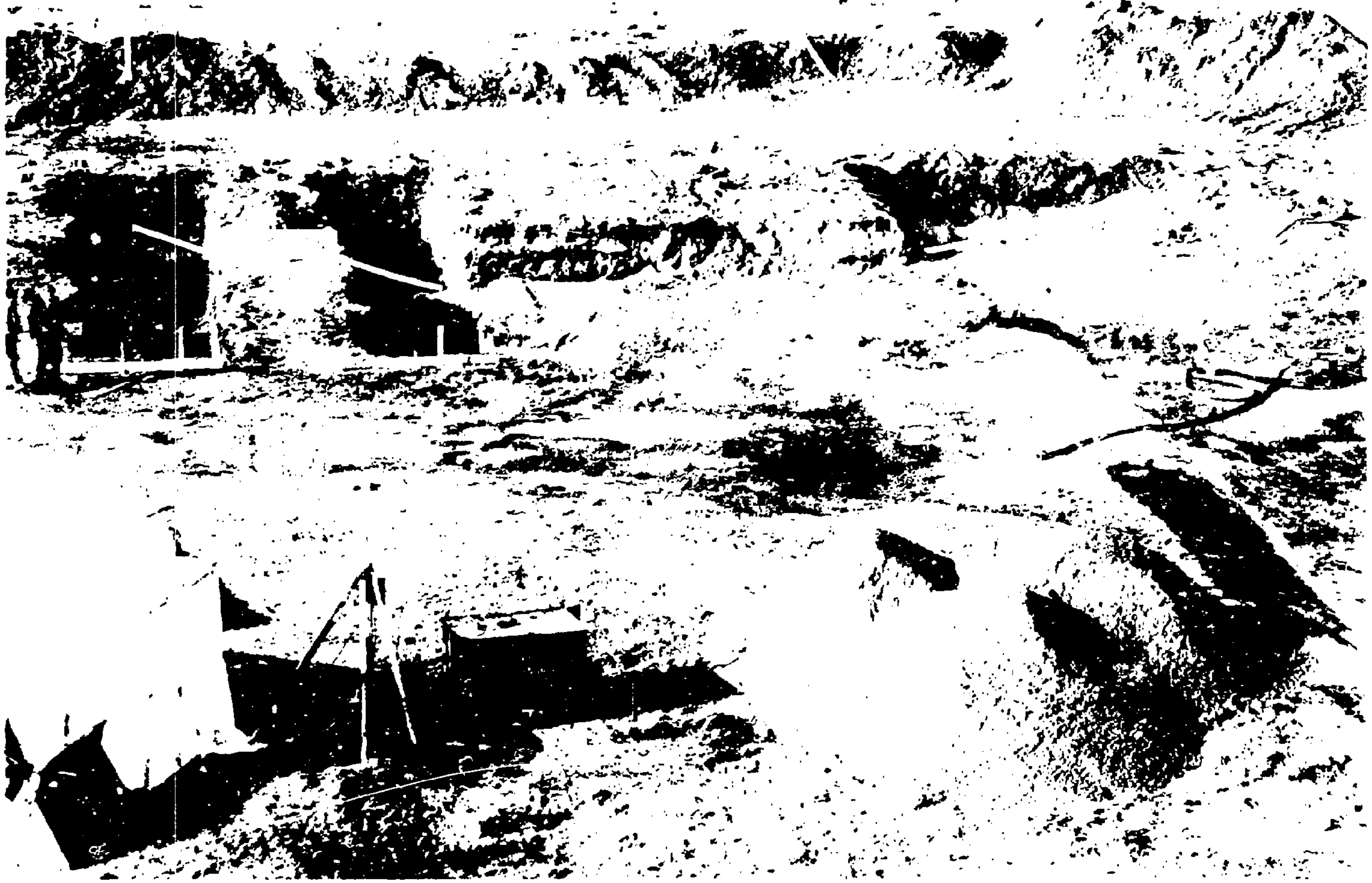


Figure 13. Excavation for ITR Foundation.

Figure 14. Preparation of Footings and Foundation.

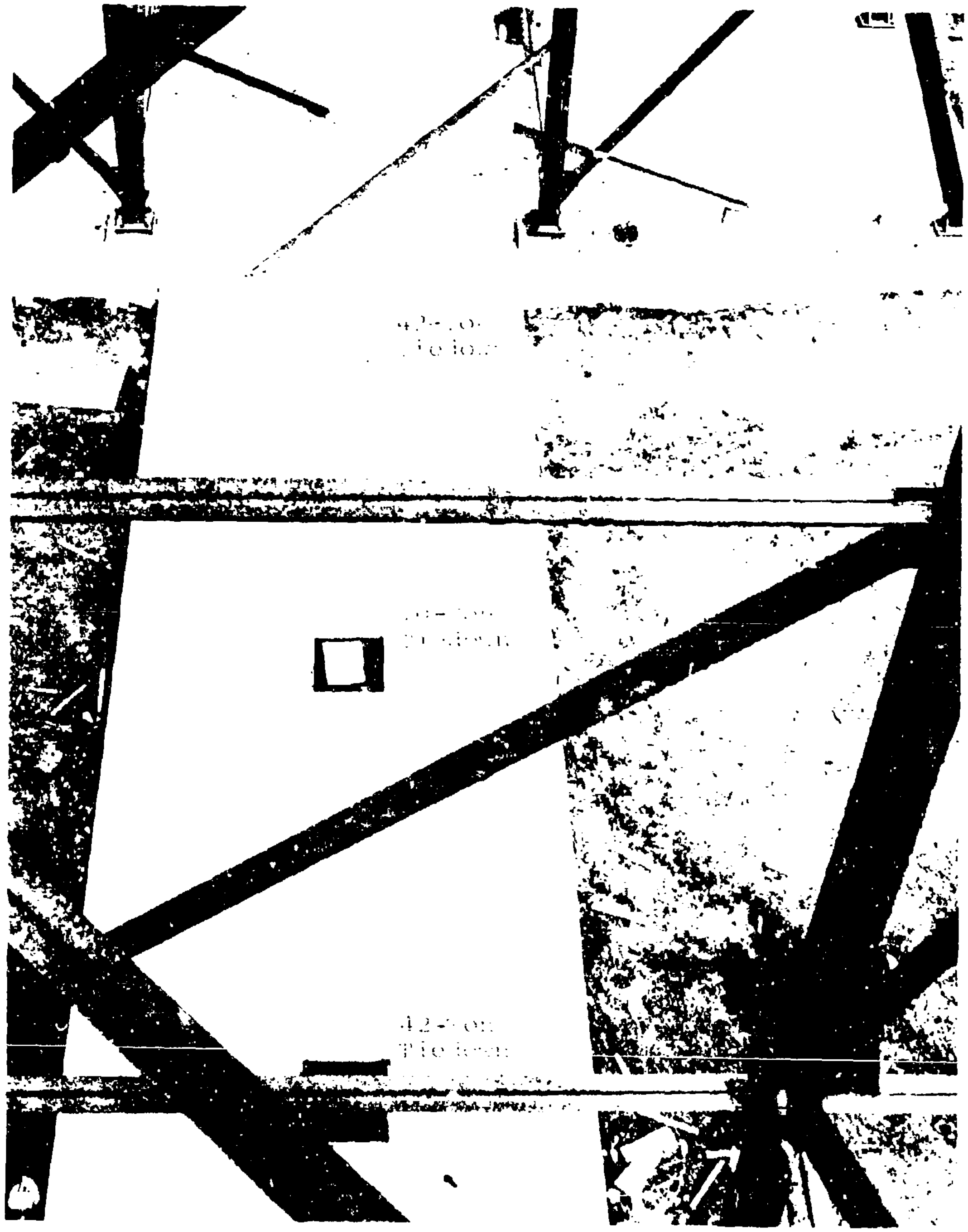


Figure 15. Three Ground Tiedown Points in Foundation.

Number	Component	Number	Component
1.	Lower Inboard-Outboard Frames	7.	Rails
2.	Upper Inboard-Outboard Frames	8.	Frame Struts
3.	Overhead Beams	9.	Modules
4.	Work Platforms	10.	Davit Mast
5.	Outrigger Members	11.	Davit Platform
6.	Stairways and Landings		

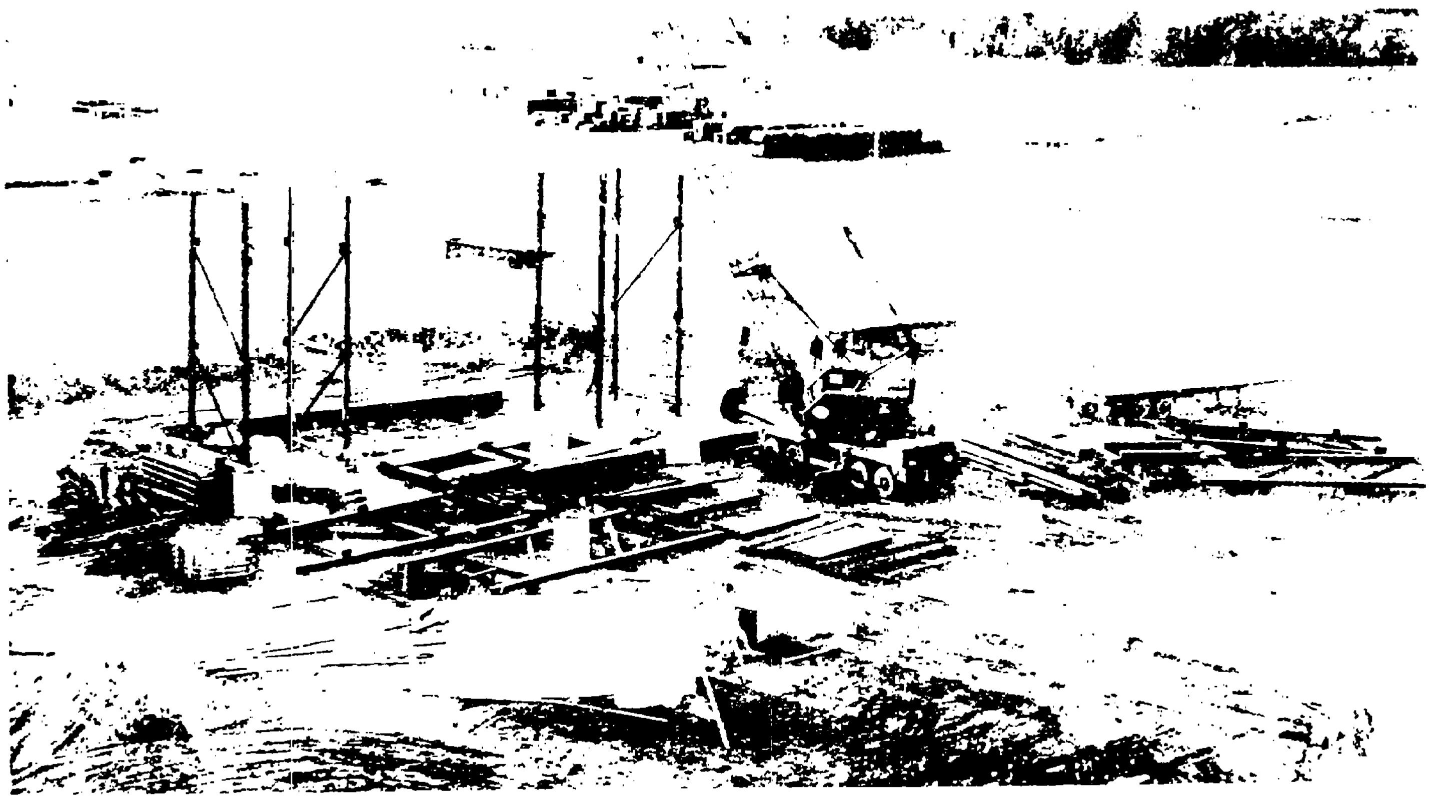


Figure 16. Rig Components and Raising of Lower Main Frames.

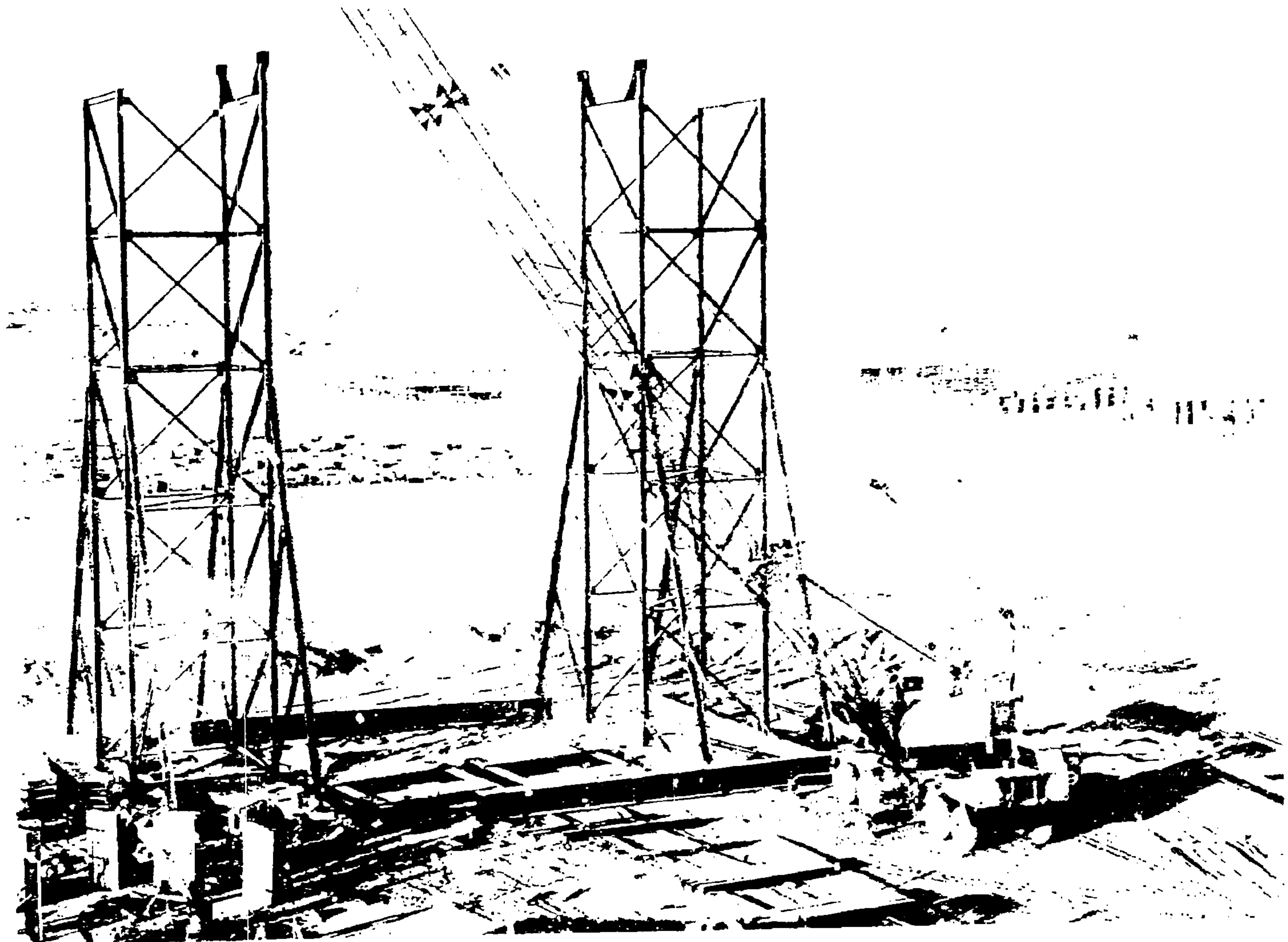


Figure 17. Complete Tower Frames Erection.

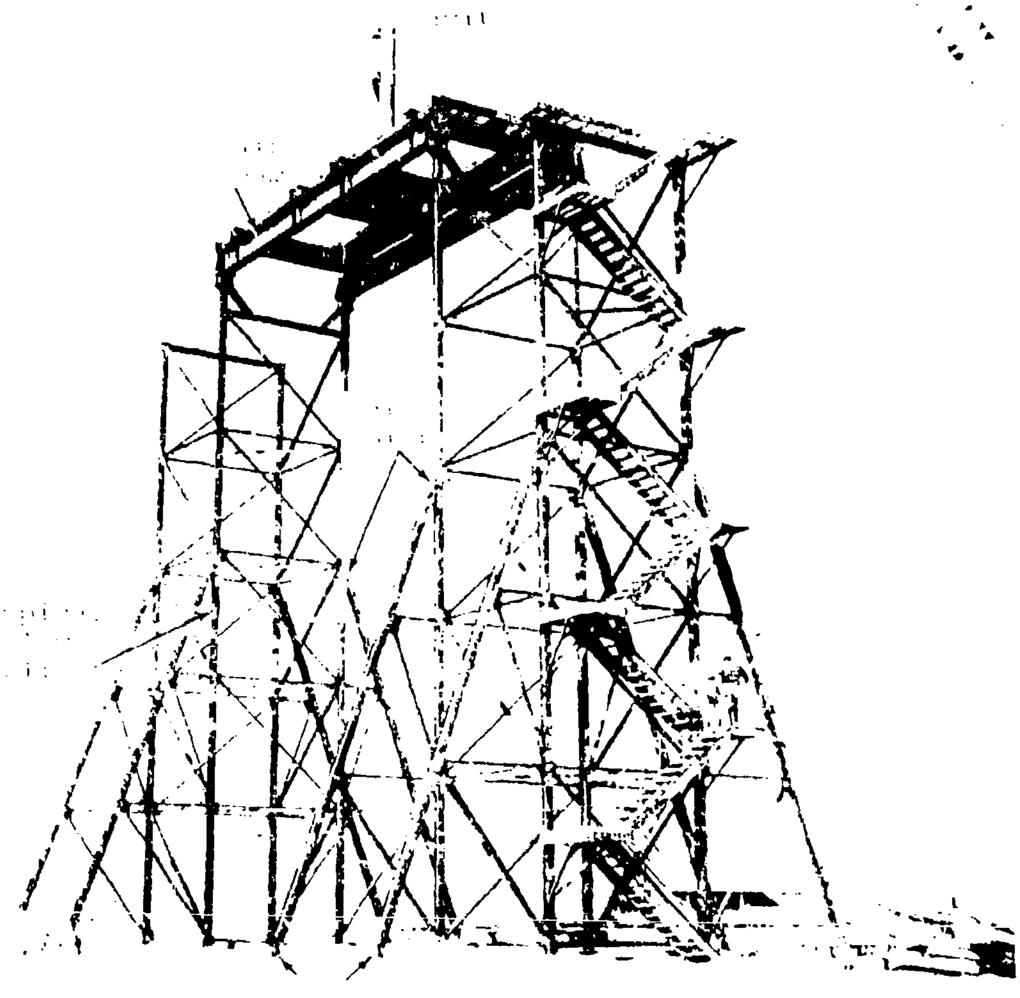


Figure 18. Overhead and Stairway Installation.

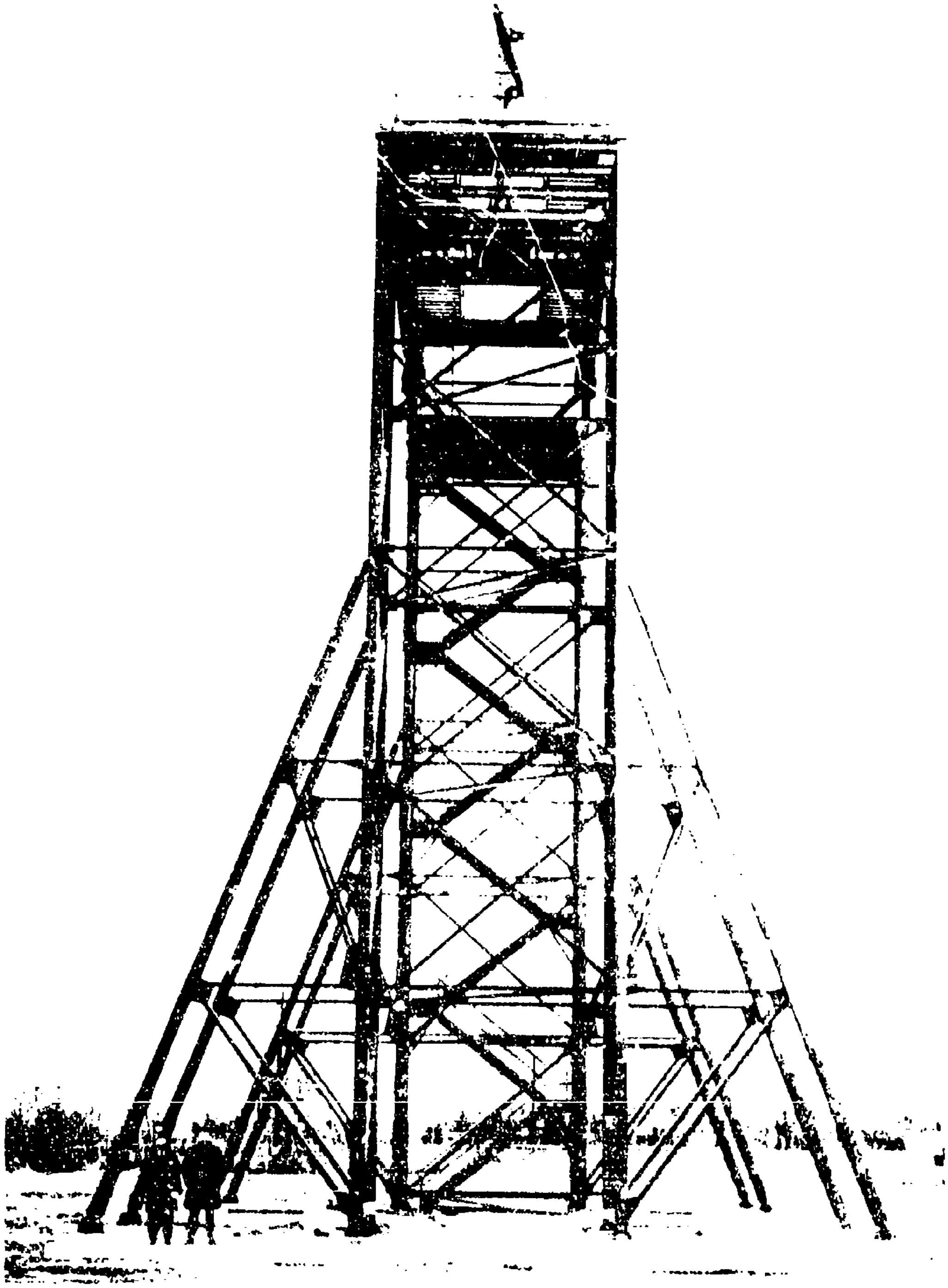


Figure 19. End [illegible]

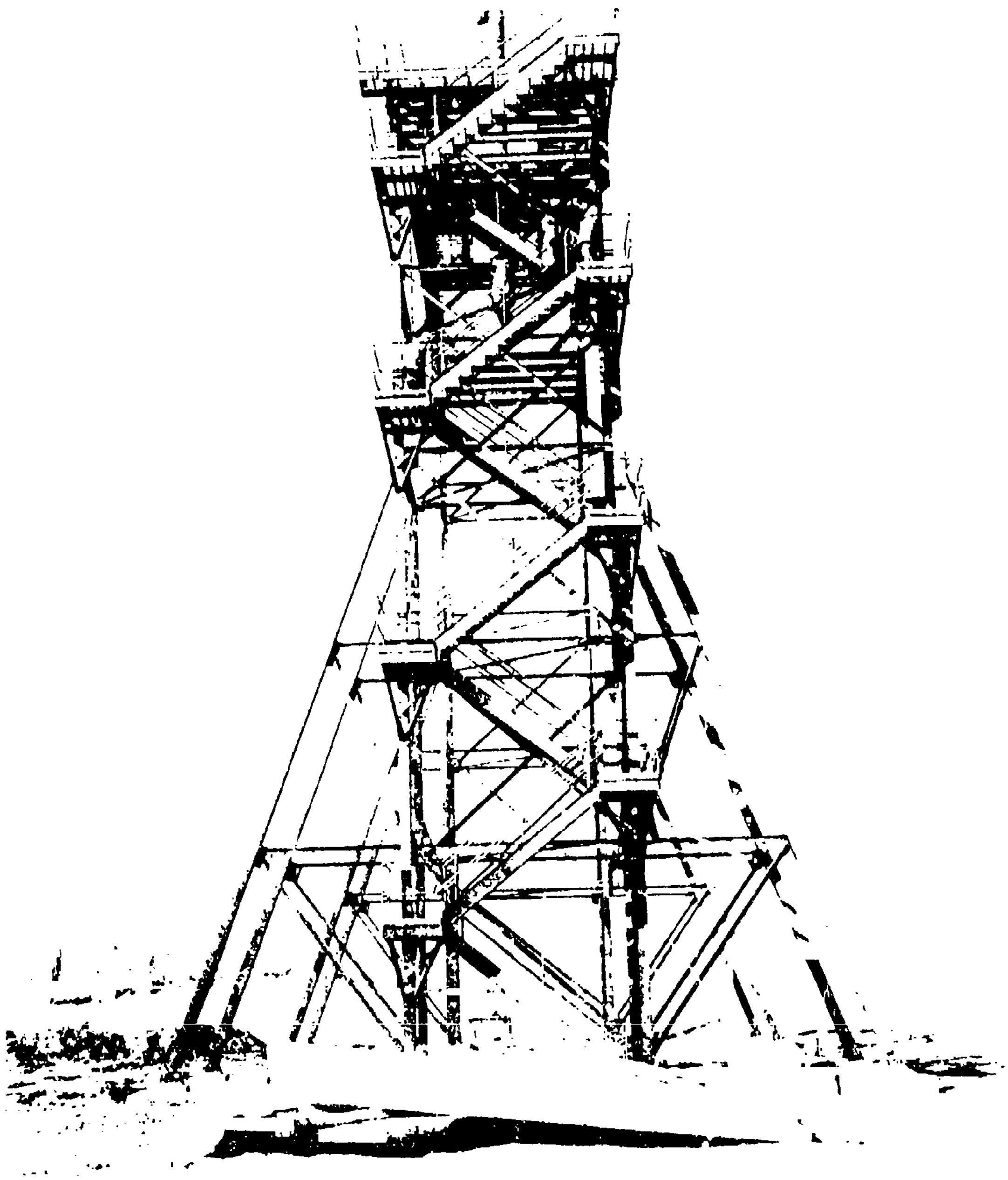


Figure 20. End View of Forward Tower.

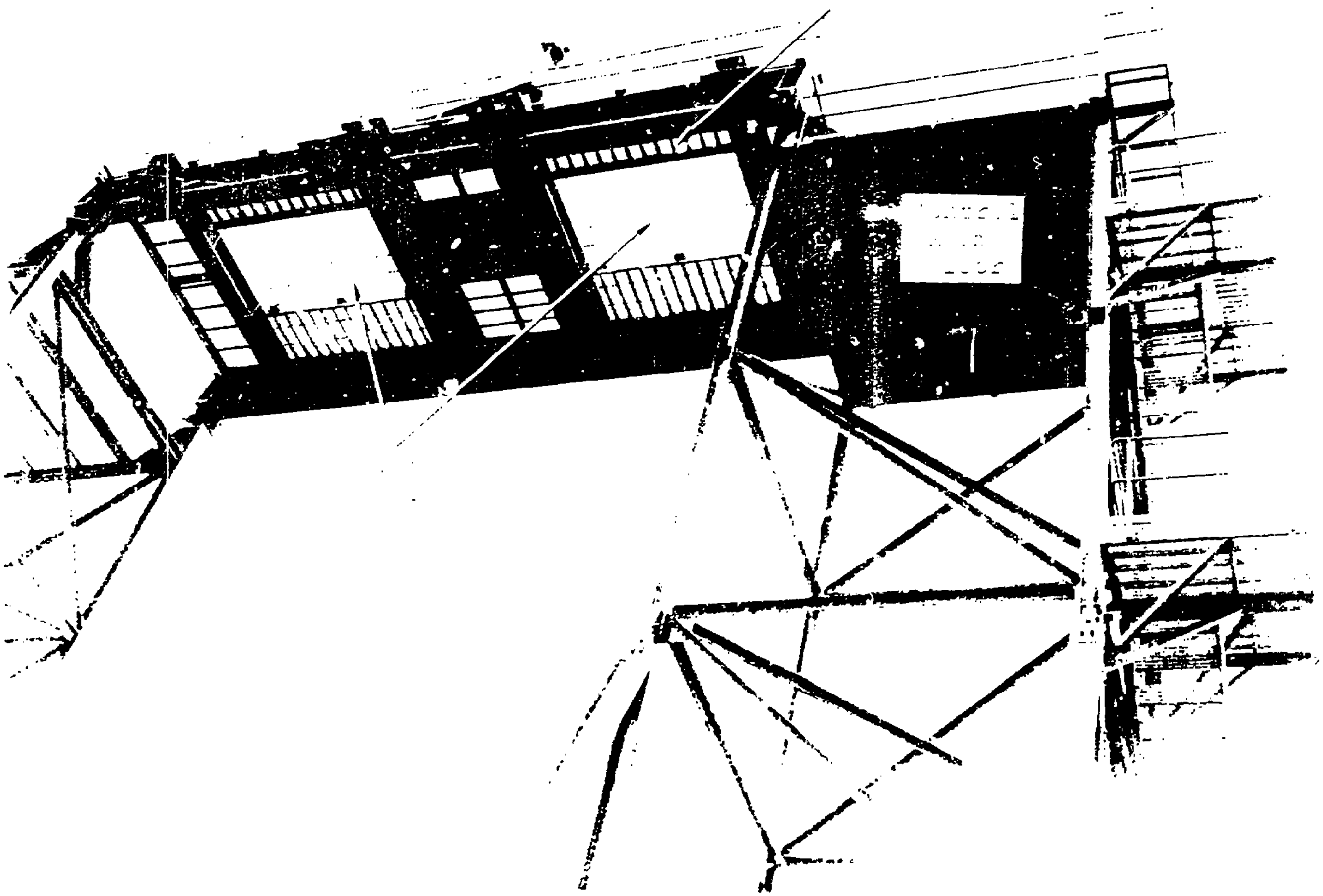


Figure 21. Under View of Overhead Structure and Hoist Module Location.

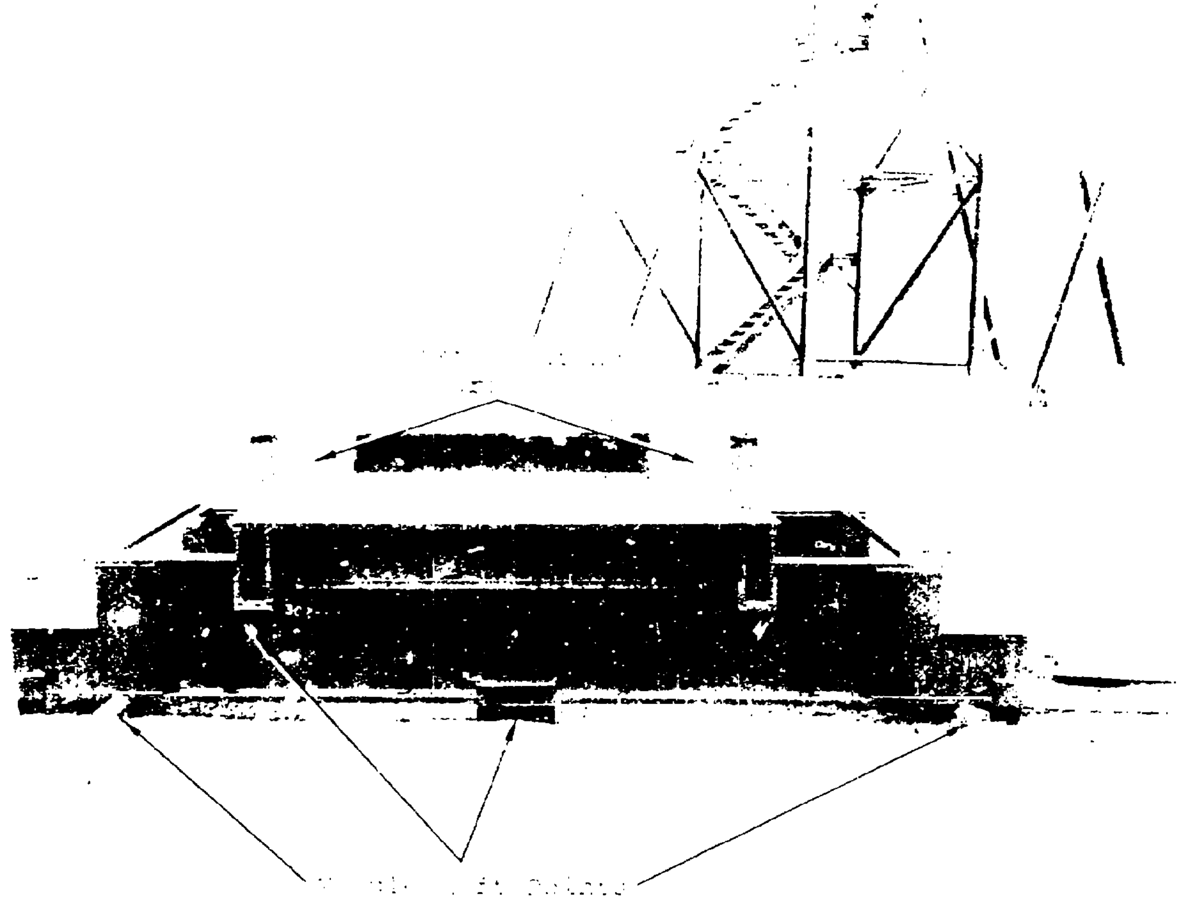


Figure 22. Hoist Modules (Inverted).

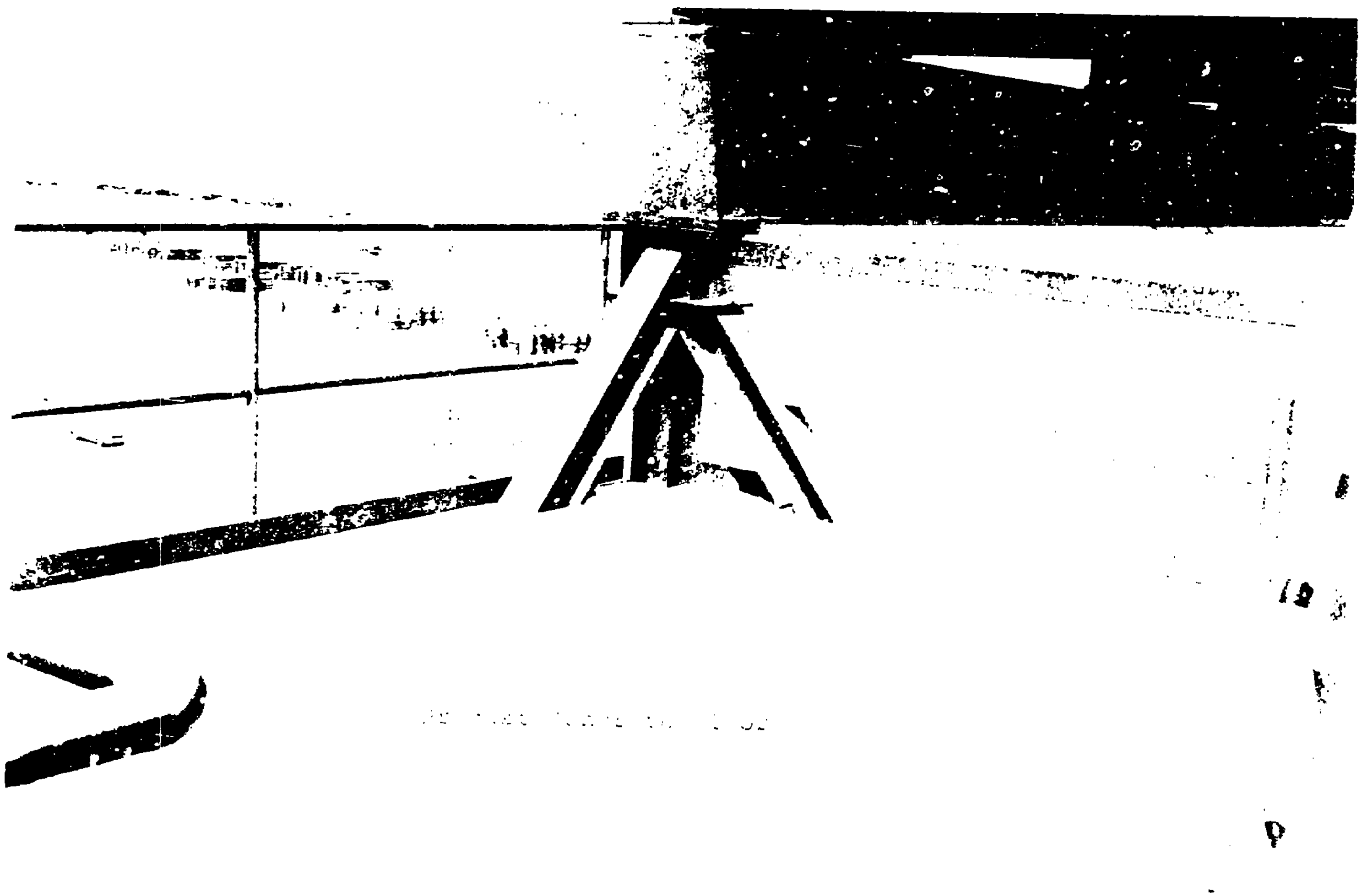


Figure 23. Control Room Area - Top of Forwara Tower.

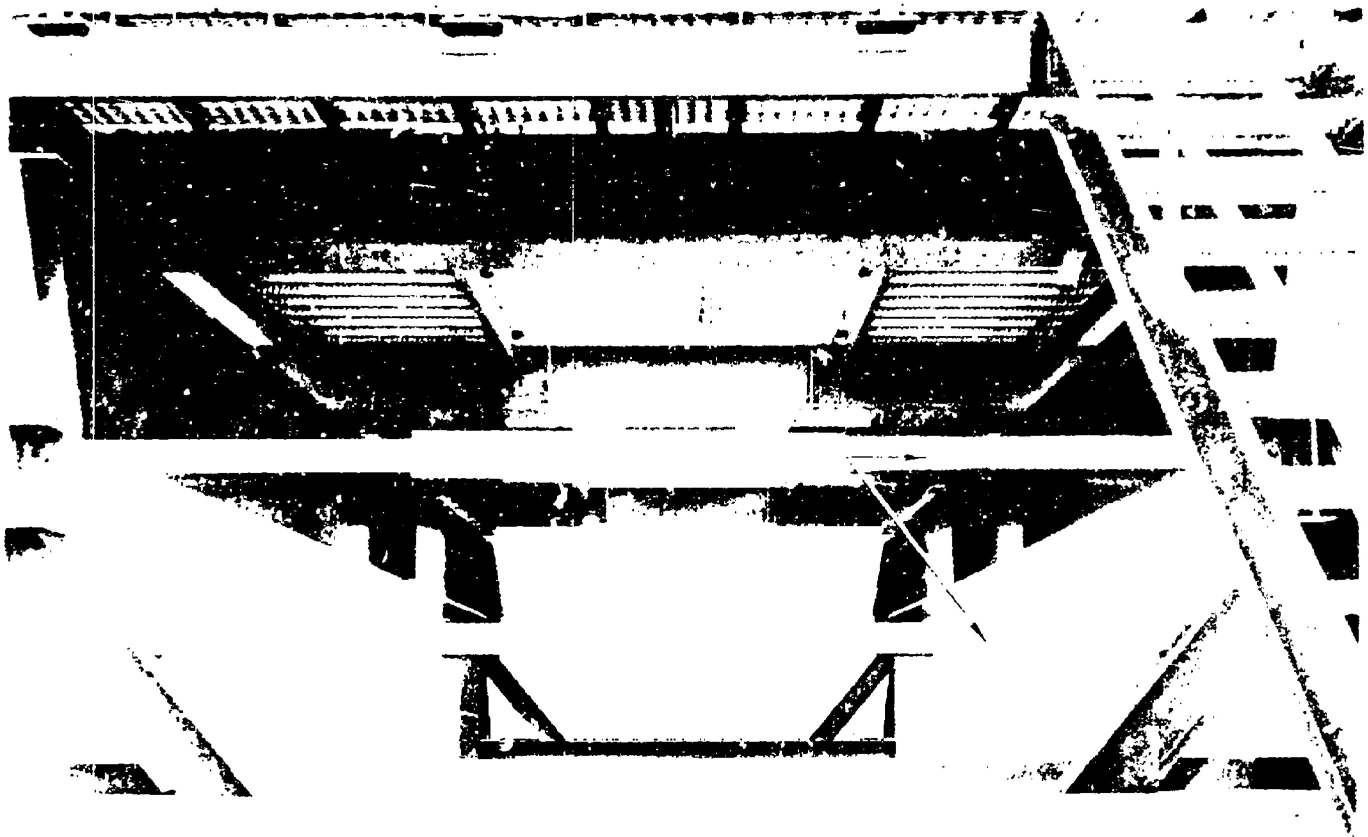


Figure 24. View of Overhead Section From LCC Position; Forward Tower.

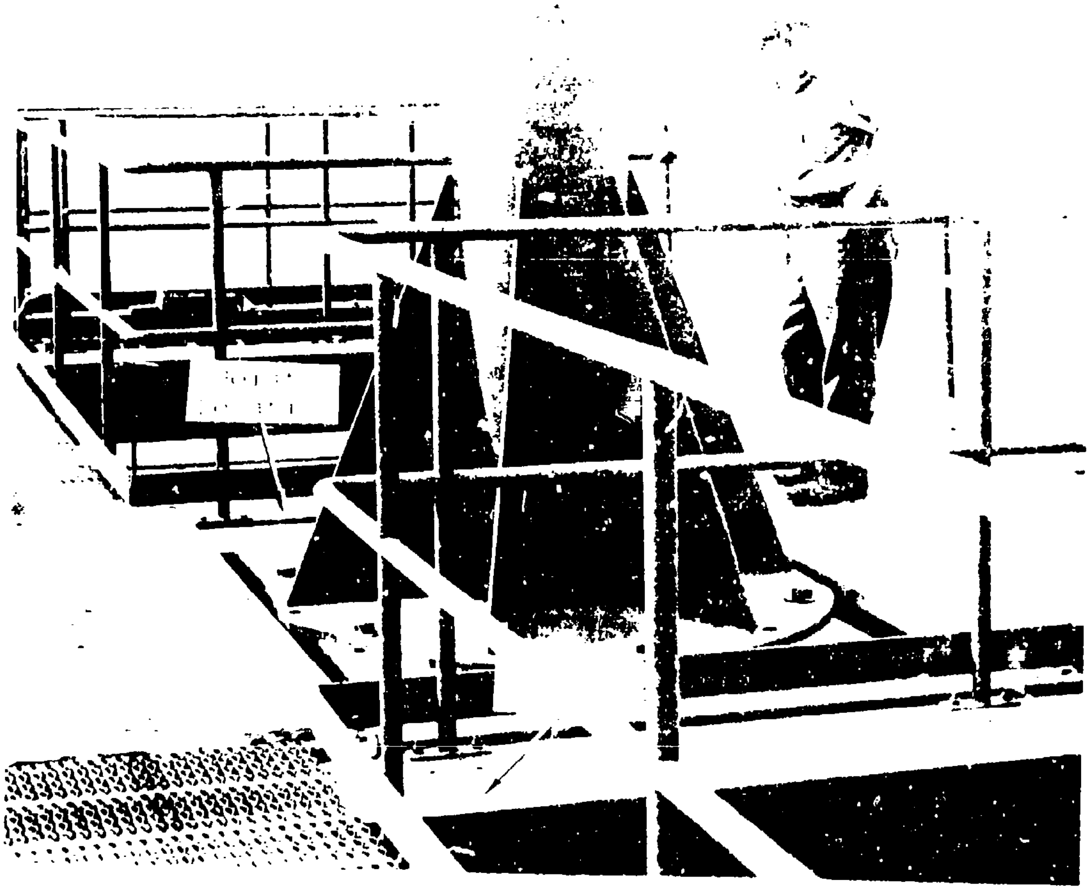


Figure 25. Work Platform and [illegible] Control Room Location.

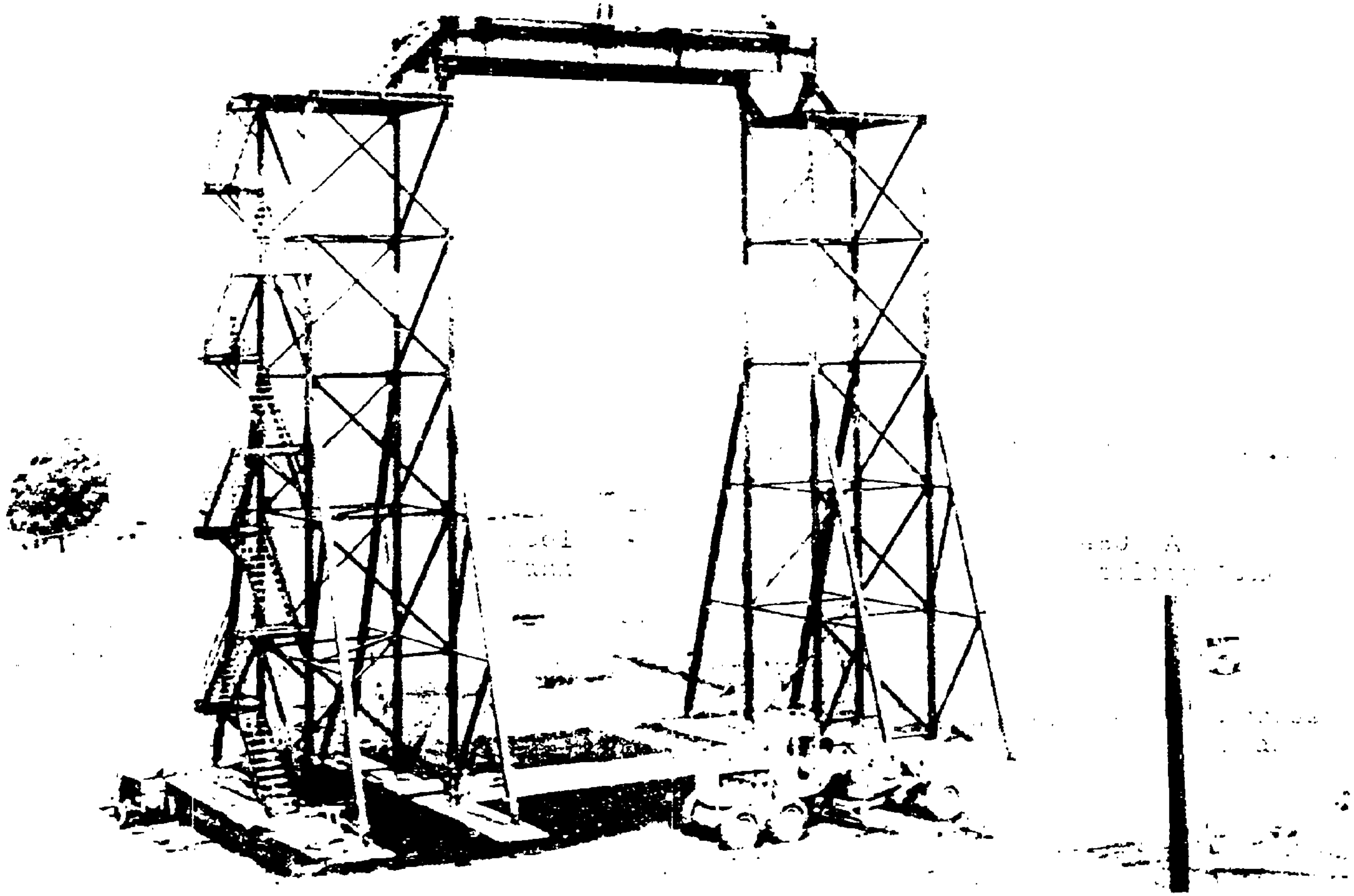


Figure 26. Completed ITR Framework on Foundation.

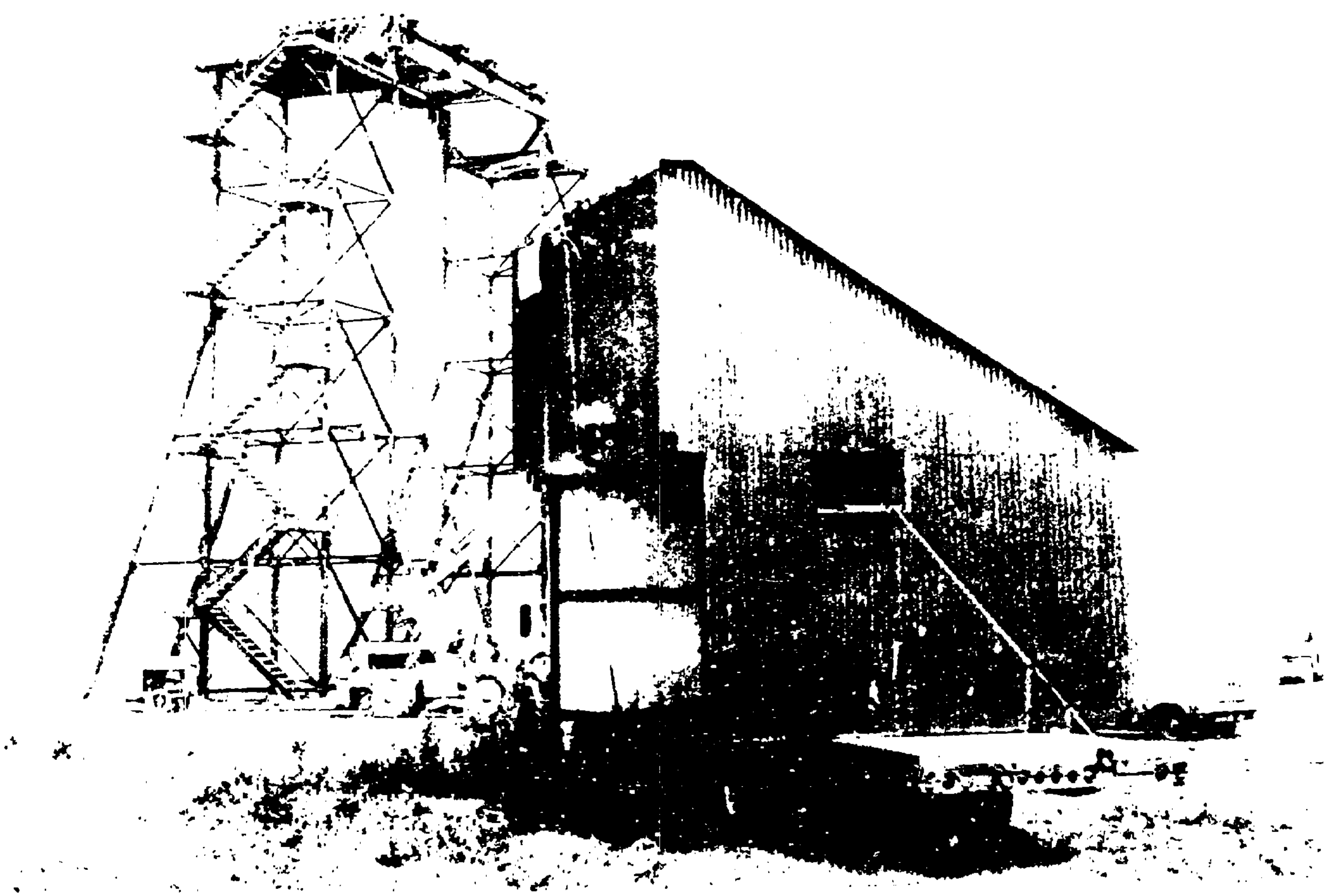


Figure 27. Control Room Enclosure Assembly.

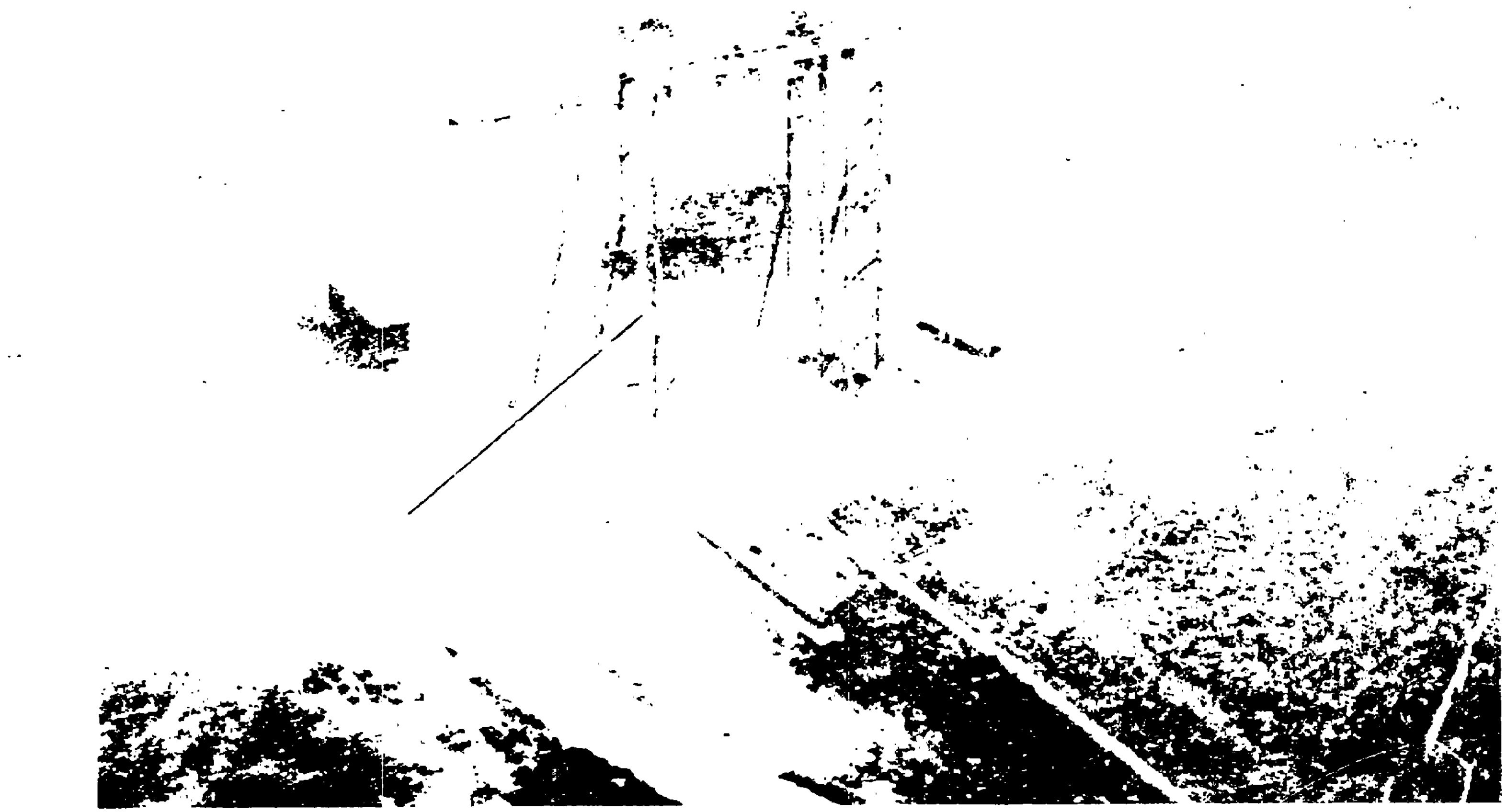


Figure [illegible]. Aerial View Of Complete Structure and Hot Air Distribution Duct.

TABLE V. ITR WEIGHT BREAKDOWN.

Drawing No.	Nomenclature	Qty.	Wt/Assy (lb)	Total Wt. (lb)
SK301-11304-1	Tower Assy.	1	38,723	38,723
SK301-11304-2	Tower Assy.	1	42,750	42,750
SK301-11302-1	Hoist Module	2	2,470	4,940
SK301-11302-2	Davit Mount	1	6,207	6,207
SK301-11302-3	Module Support	2	6,274	12,548
SK301-11302-4	Platform Assy.	1	831	831
SK301-11302-6	Platform Assy.	1	831	831
SK301-11302-5	Beam Assy.	2	8,081	16,162
Aux.Hoist - 6,000-Lb Load Lifter		1	3,365	3,365
Mast (Jib Crane)		1	3,965	3,965
X73-003-AS-Y03	Control Room Enclosure	1	15,000	15,000
			TOTAL	145,322

HOIST MODULE INSTALLATION

Each module was hoisted over the side of the ITR work platform from a truckbed using the overhead davit and a short-reach, adjustable-cg sling, ST40972. The side and module handrails were removed at each module location. Hoisting clearance between the jib crane hook and the work platform kick plates was 9 feet 4 inches. (Note: Safety harnesses were worn by personnel on the ITR platform; hard hats below.) Figure 29 shows both modules enplacements. Each module was secured with four bolts, each torqued in place to AISC requirements. The hoist enclosure handrails were used to support a tarpaulin for protection against the weather.

"Open loop" operation of each hoist was required to accomplish installation of the cargo coupling and attachment of the signal conductor cable. Test instrumentation and lash-up of control room equipment followed.

The following cargo system components were removable from the ITR overhead work platform without requiring operation of the system:

1. Hoist drive
2. Pneumatic valves and ducting
3. Signal conductor reel
4. Hoist
5. Span actuator
6. Rails (with hoist removed)

The following components were removable, but they required operation of the PPG and control system:

1. Hoist cables
2. Cable cutter assemblies
3. Signal conductor disconnect

PPG AND AIR SUPPLY INSTALLATION

The air supply installation consisted of the pneumatic power generator (power unit, load compressor and controls) prepared as a separate package and the air distribution system. The PPG location and air distribution insulated piping are shown in Figures 30 through 35.

INSTRUMENTATION INSTALLATIONS

The LCC station and test rig instrumentation installations are shown in Figures 36 through 41.

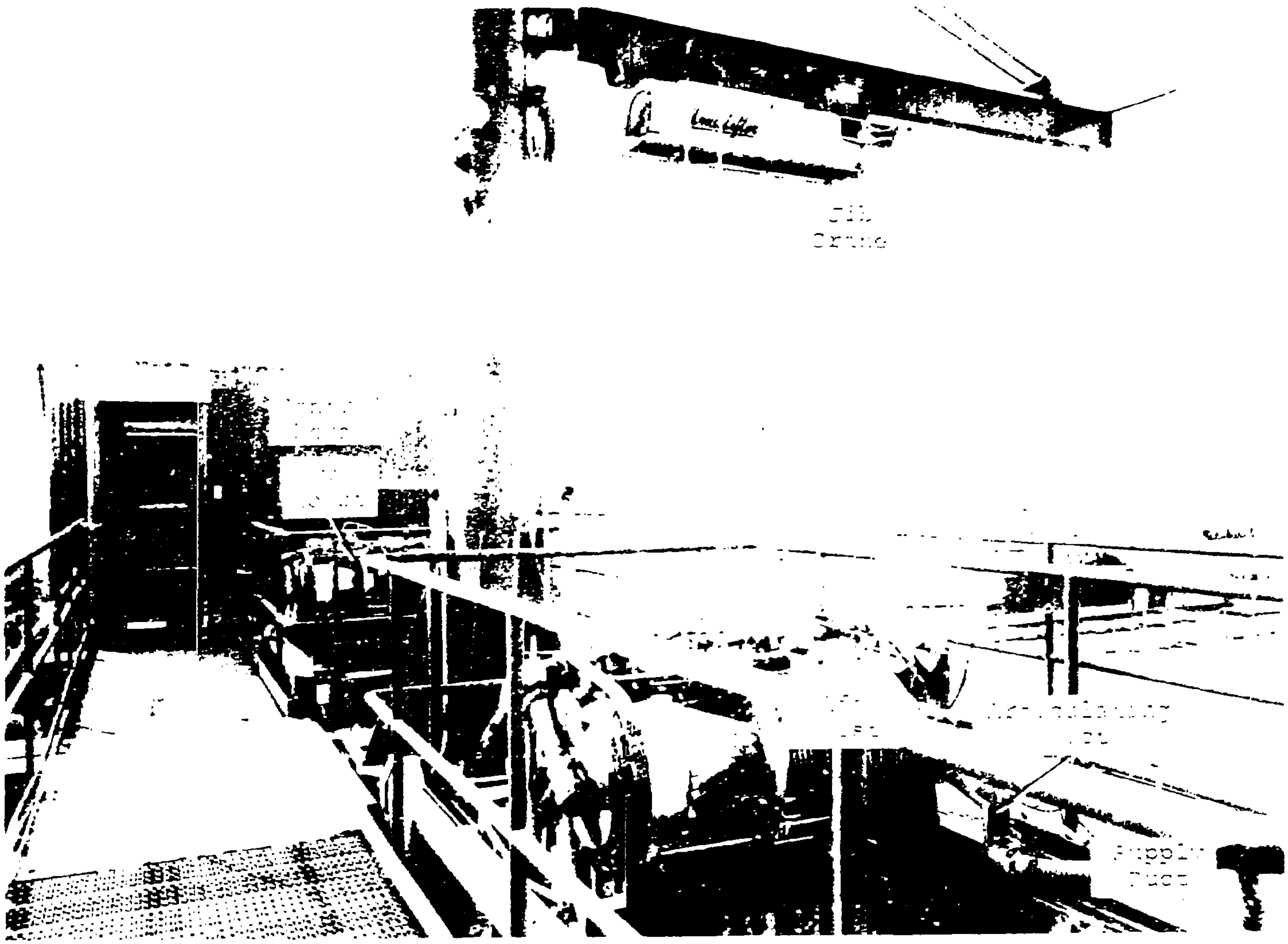


Figure 29. Hoist System Installed in ITR.

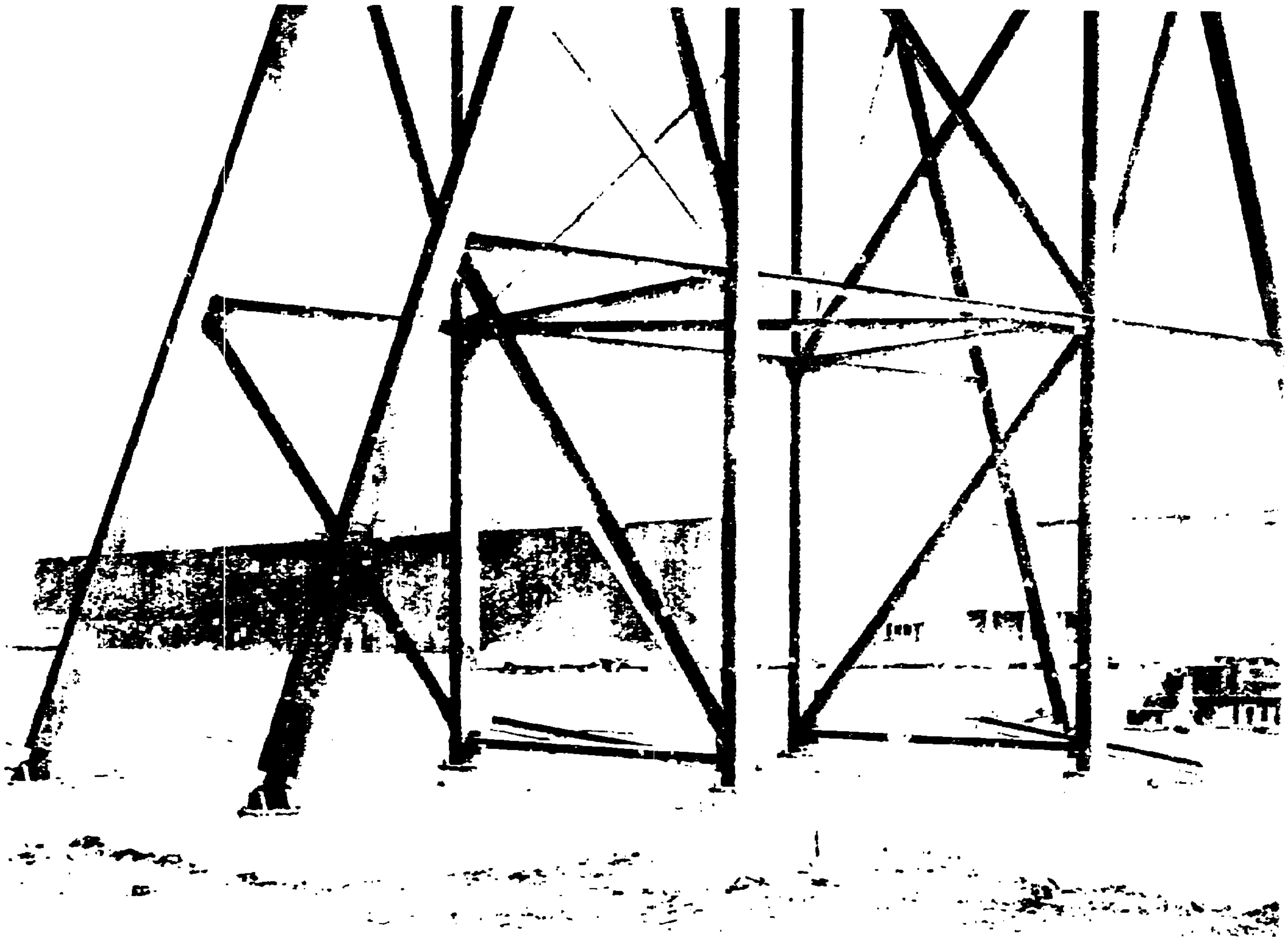


Figure 30. PPG Pad at Aft Tower.

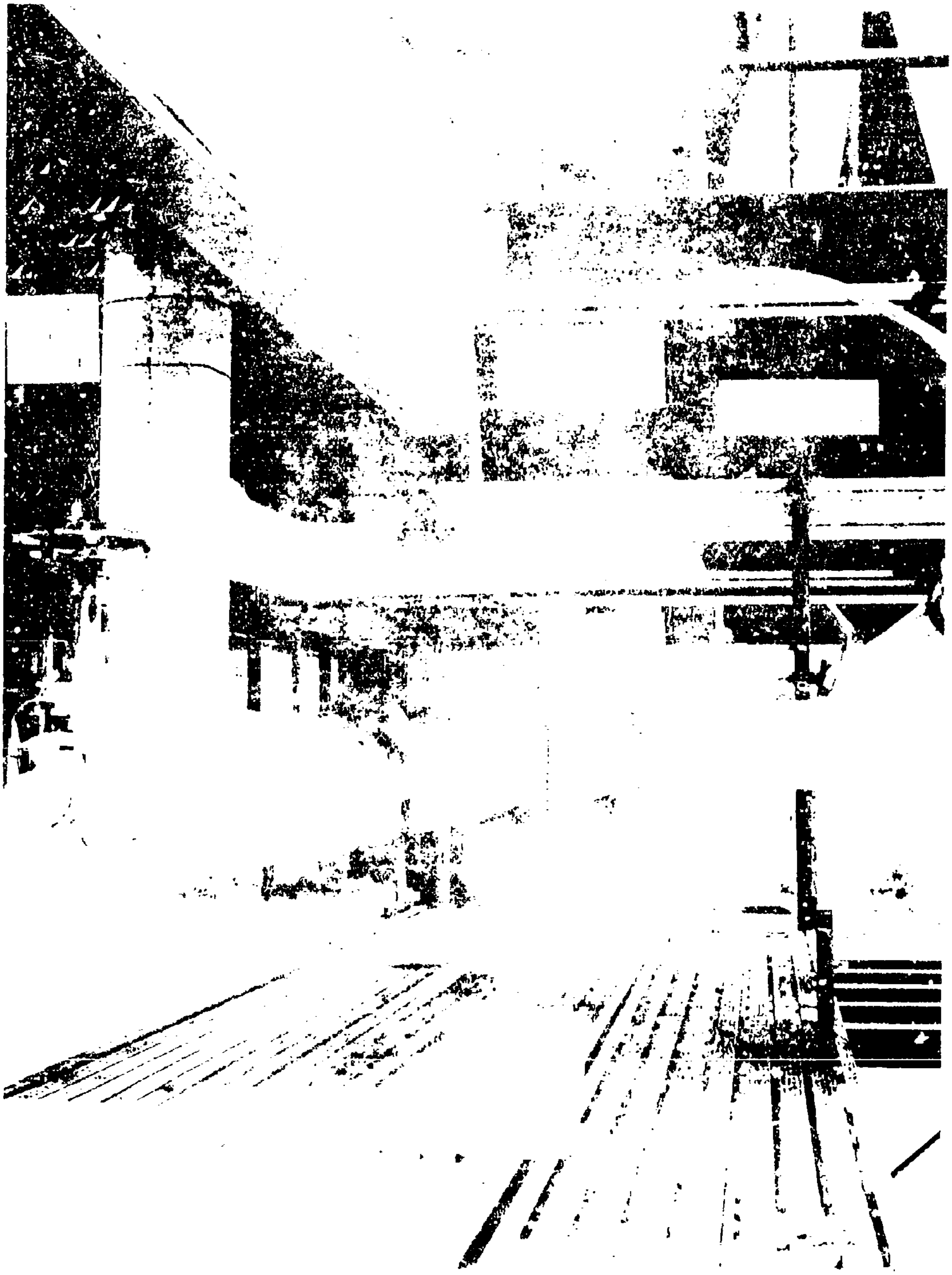


Figure 2[illegible] ... [illegible] air supply.

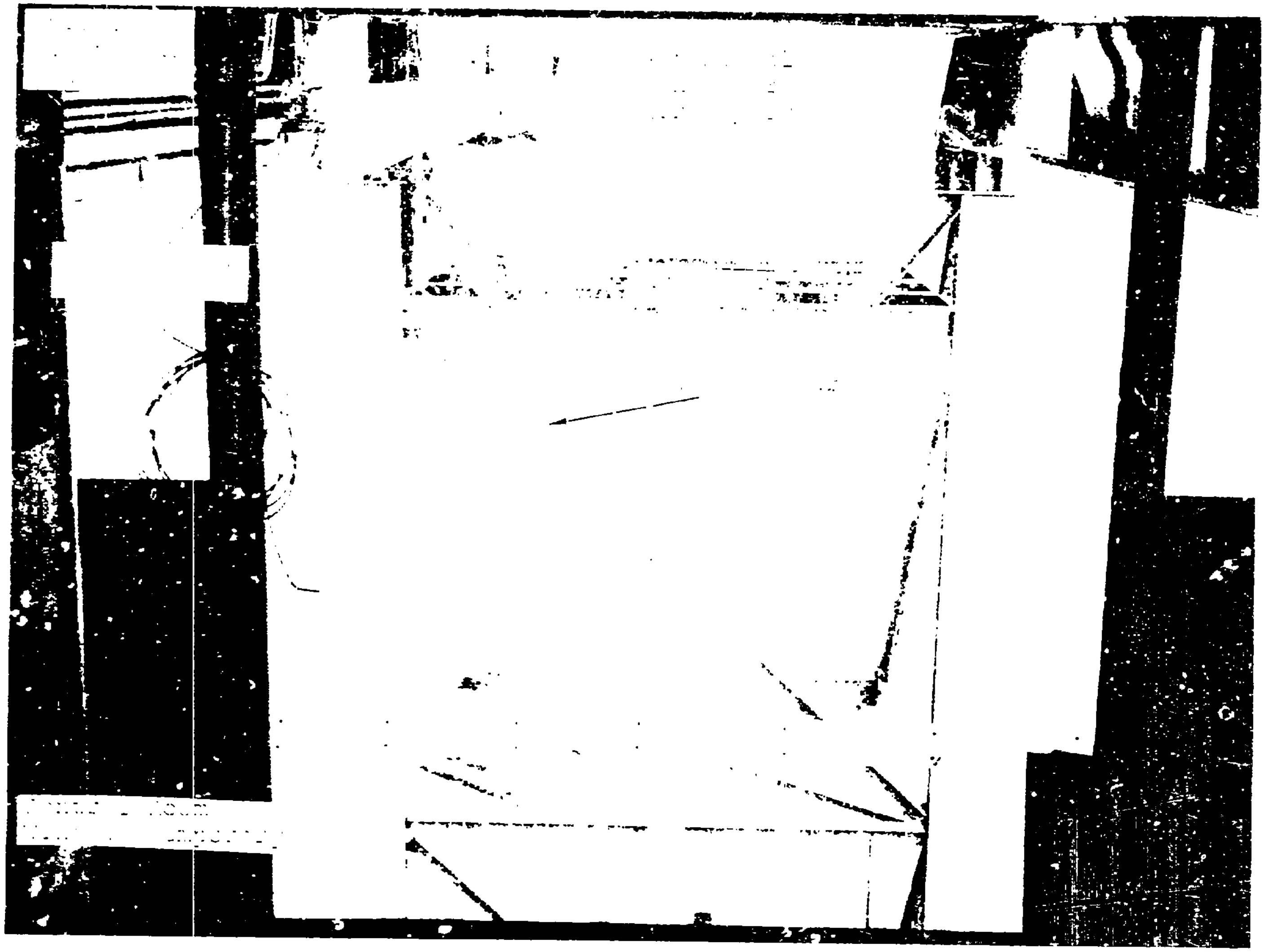


Figure 32. Insulated Air Header and Riser.

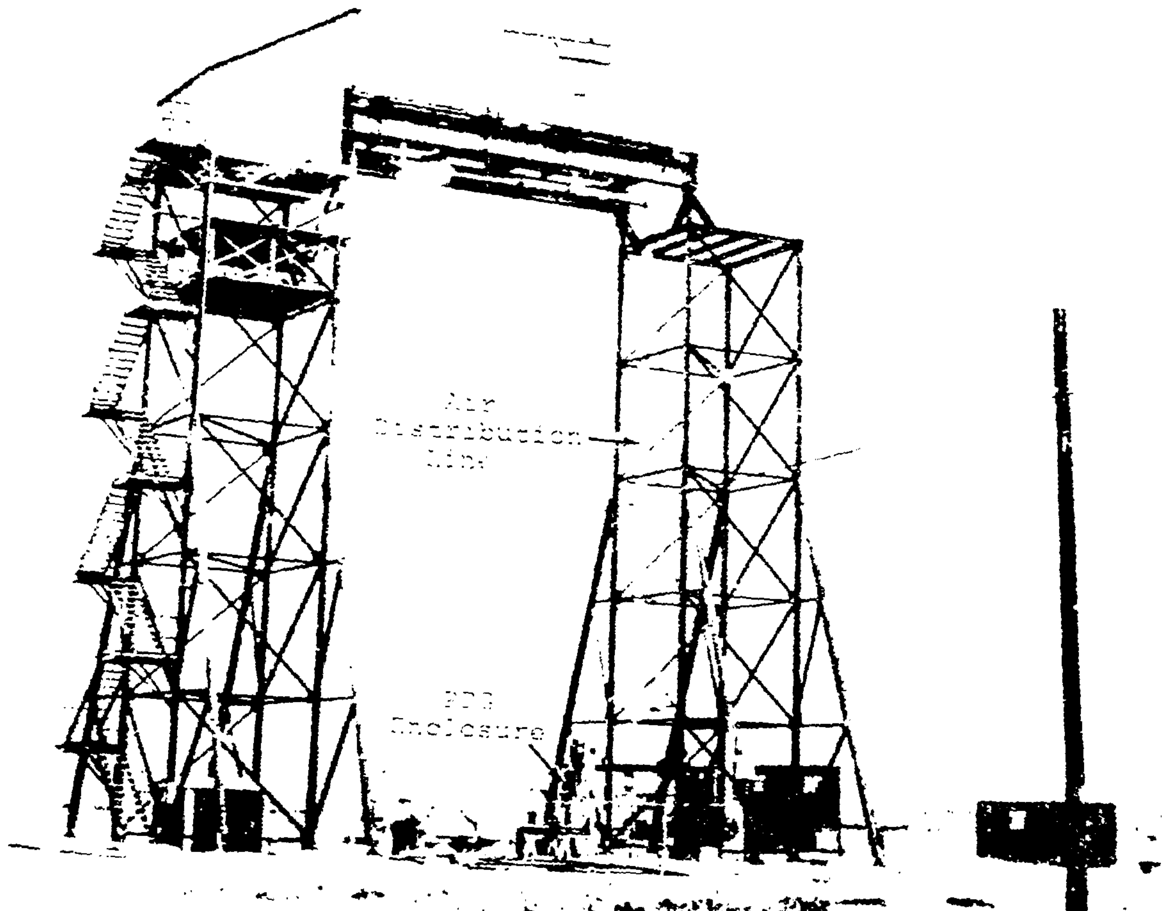


Figure 33. Complete PPG Enclosure and Air Distribution Line.

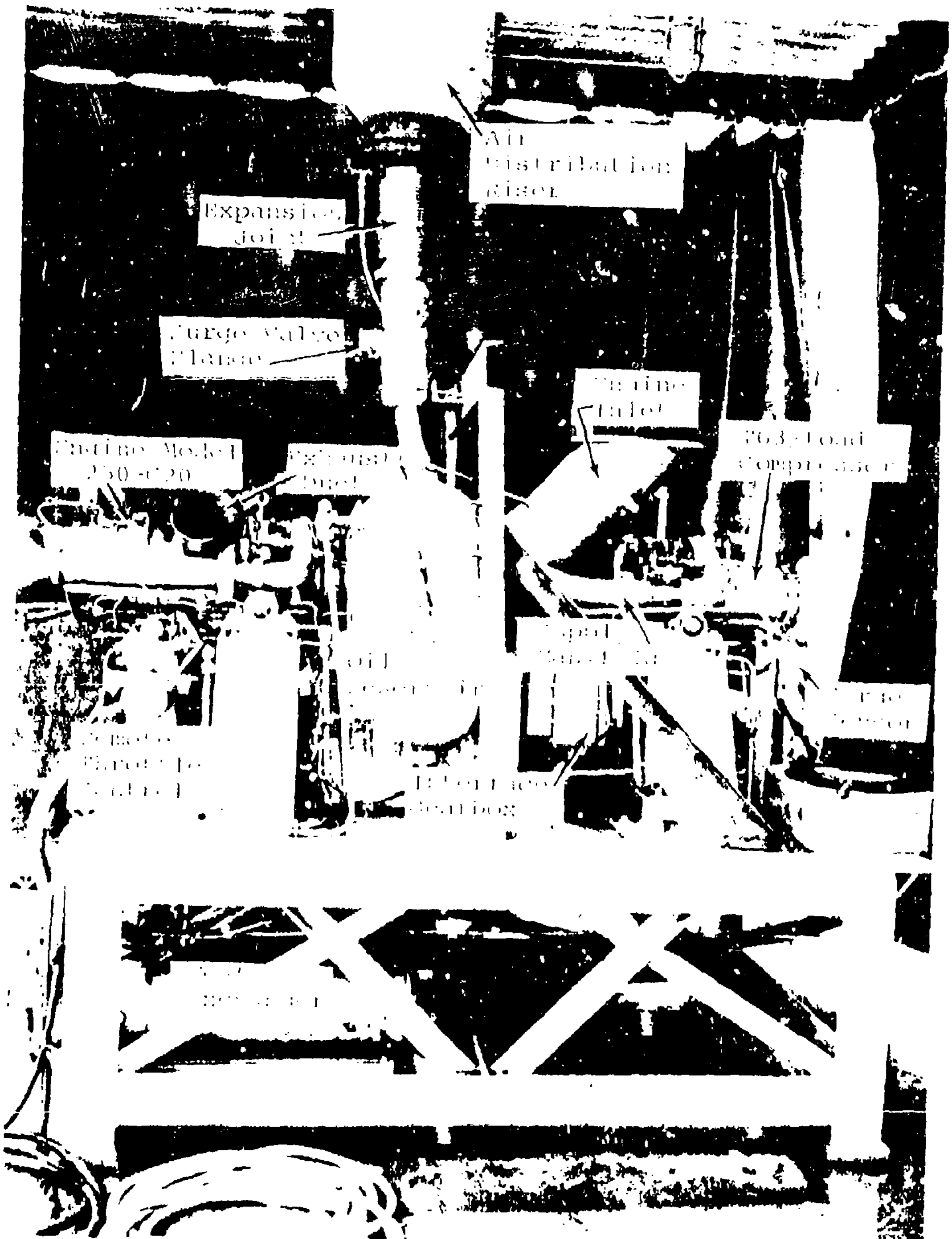


Figure 34. Side View of PPG.

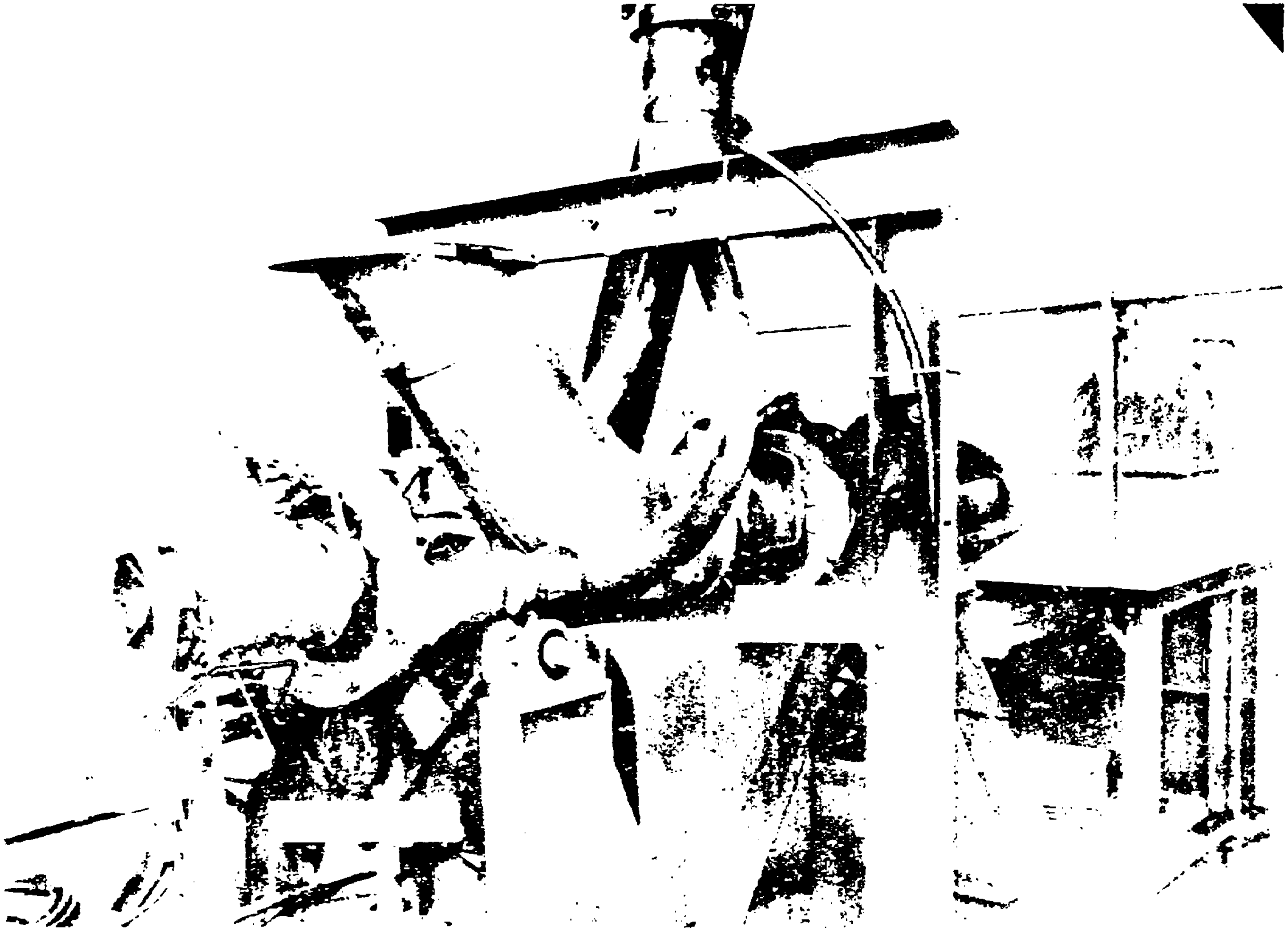
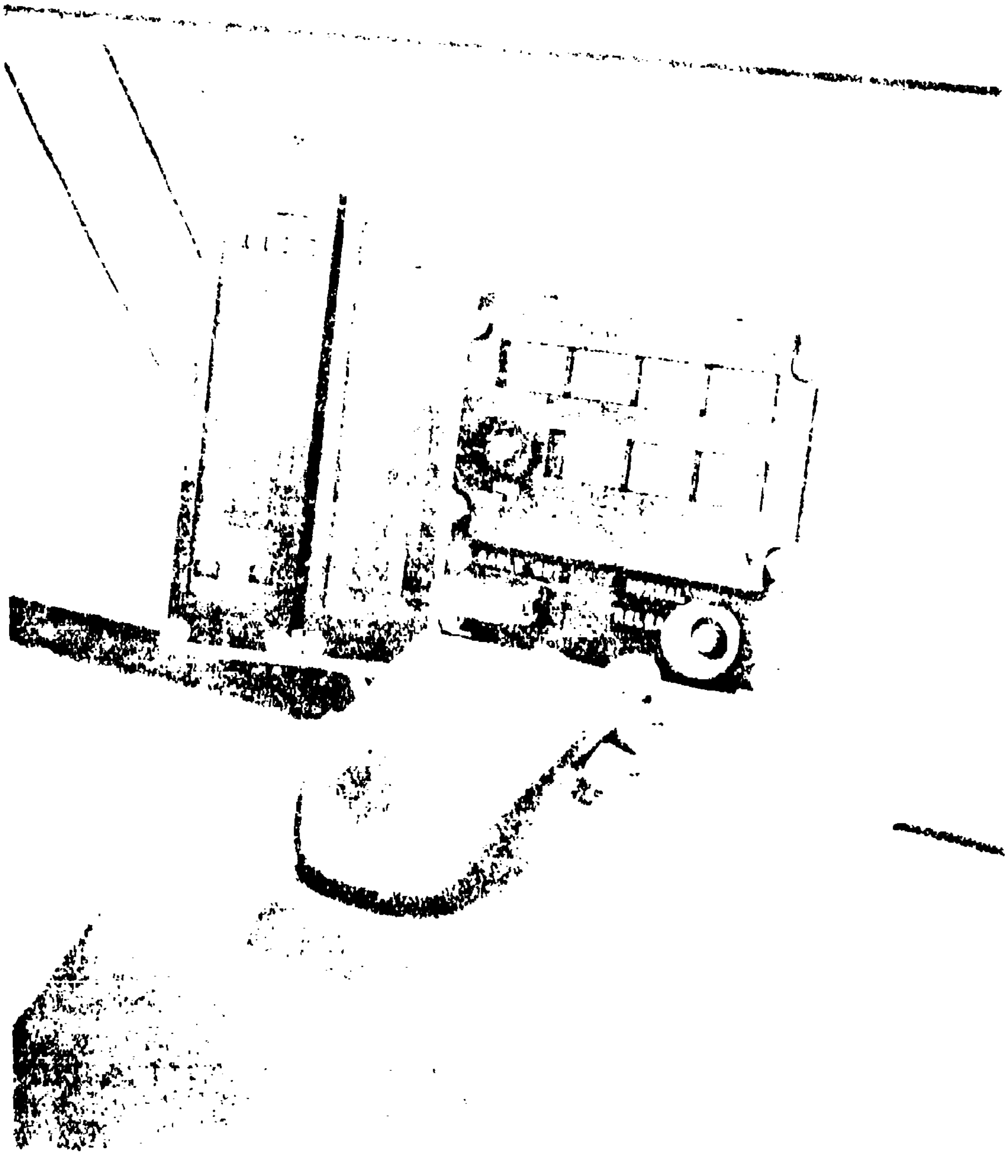


Figure [illegible]. Three-Quarter View of Load Compressor and Engine Inlet.



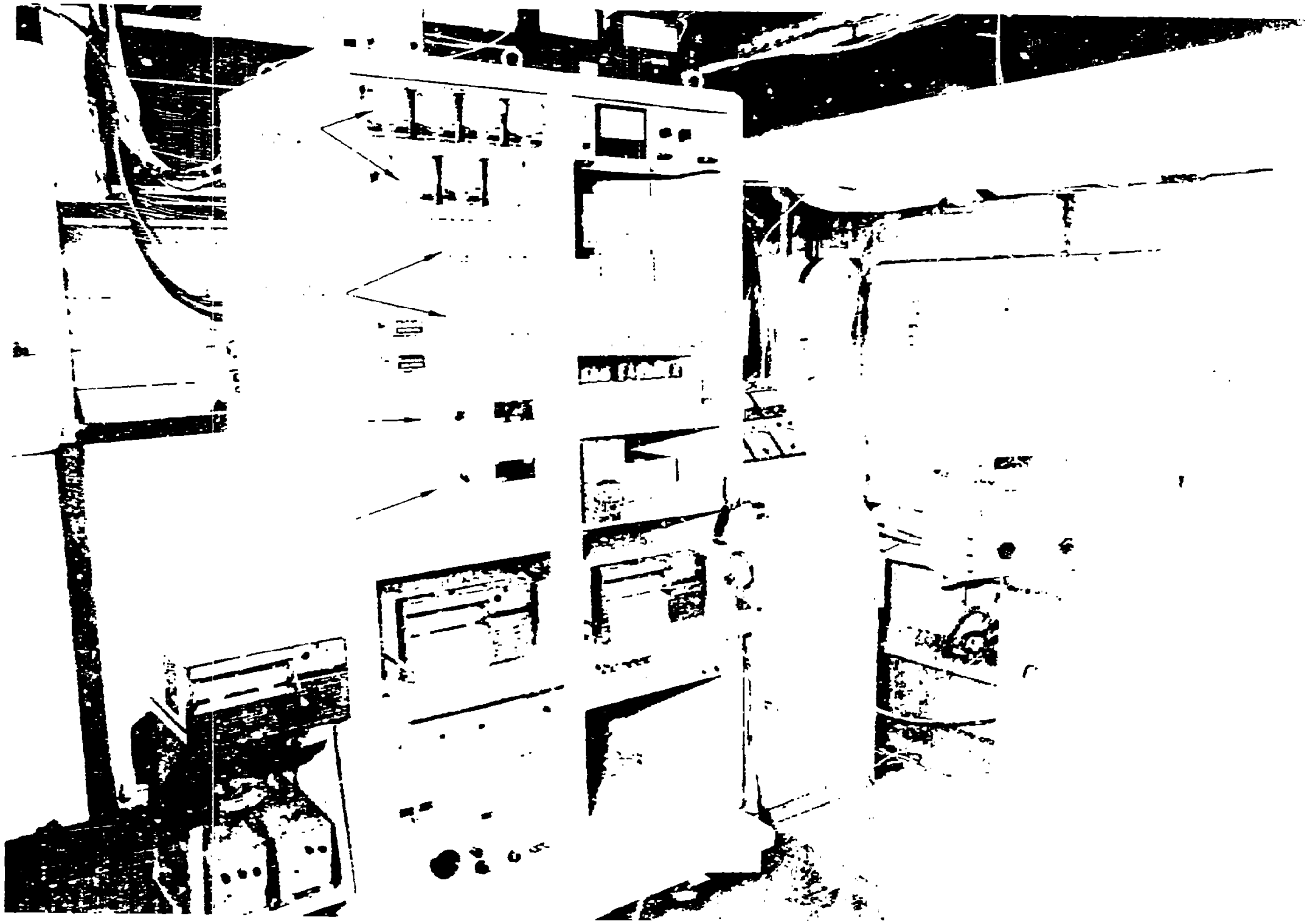


Figure 37. Instrumentation, PPG and ICC Station.

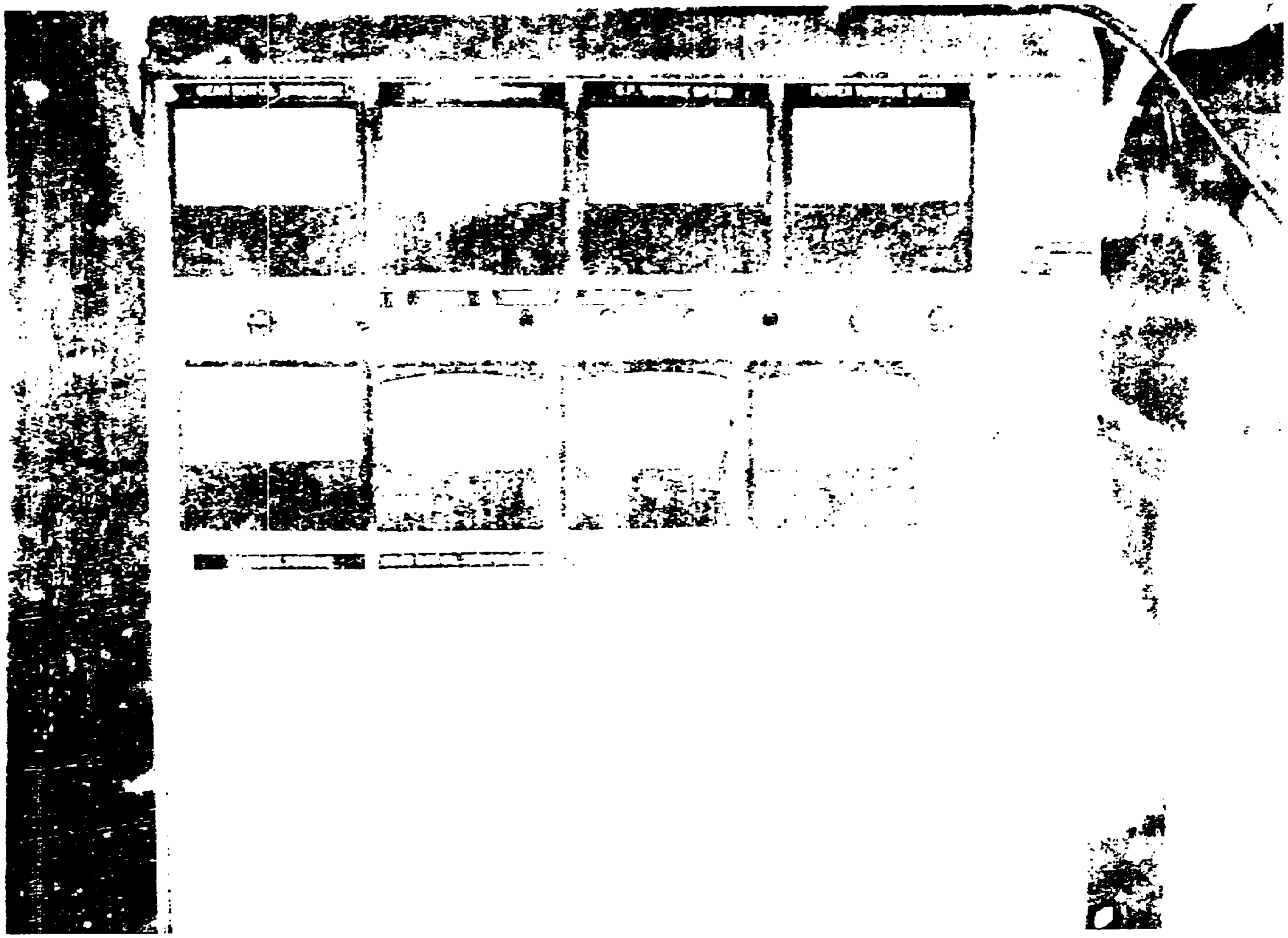
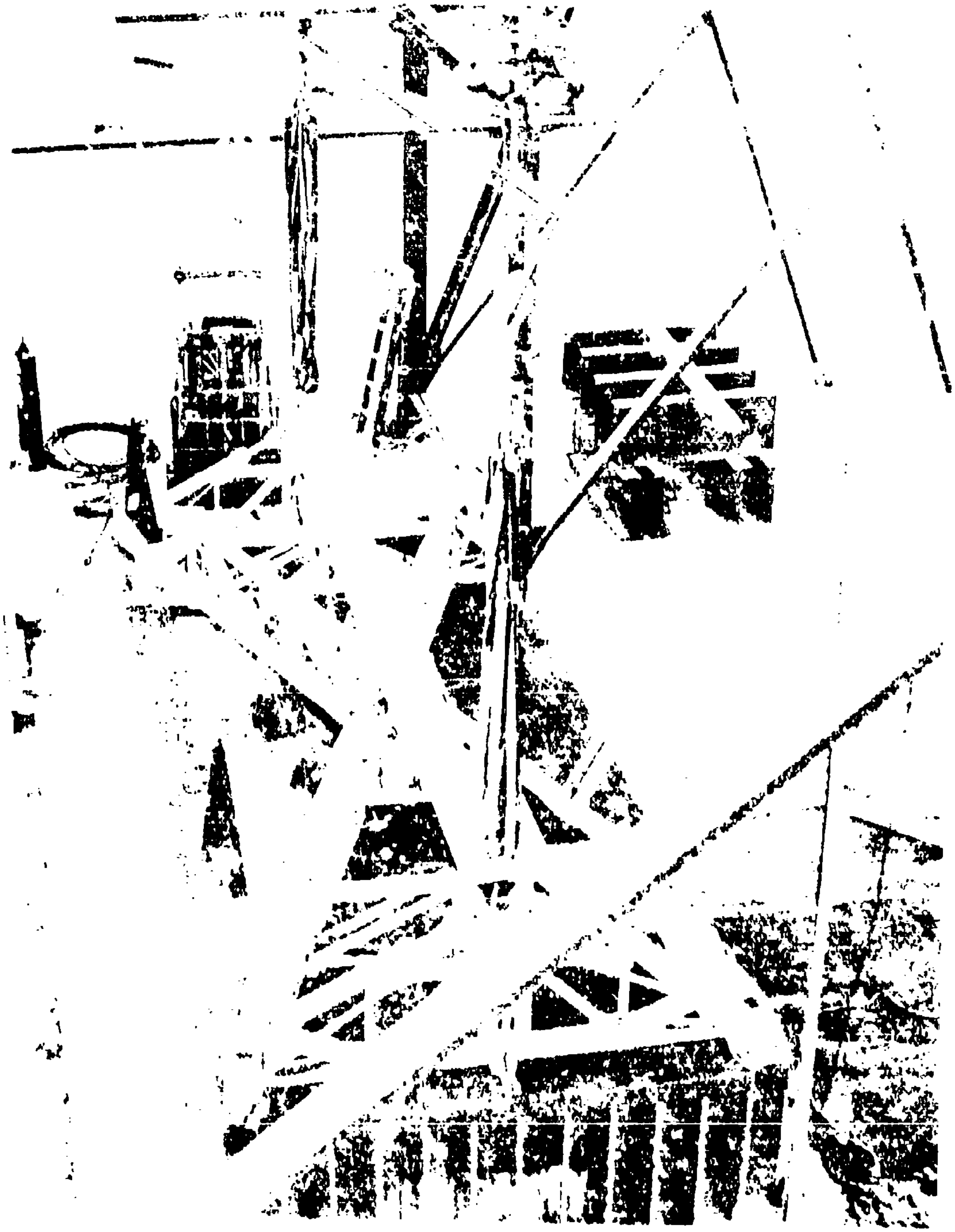


Figure 31. TPB Control Console.



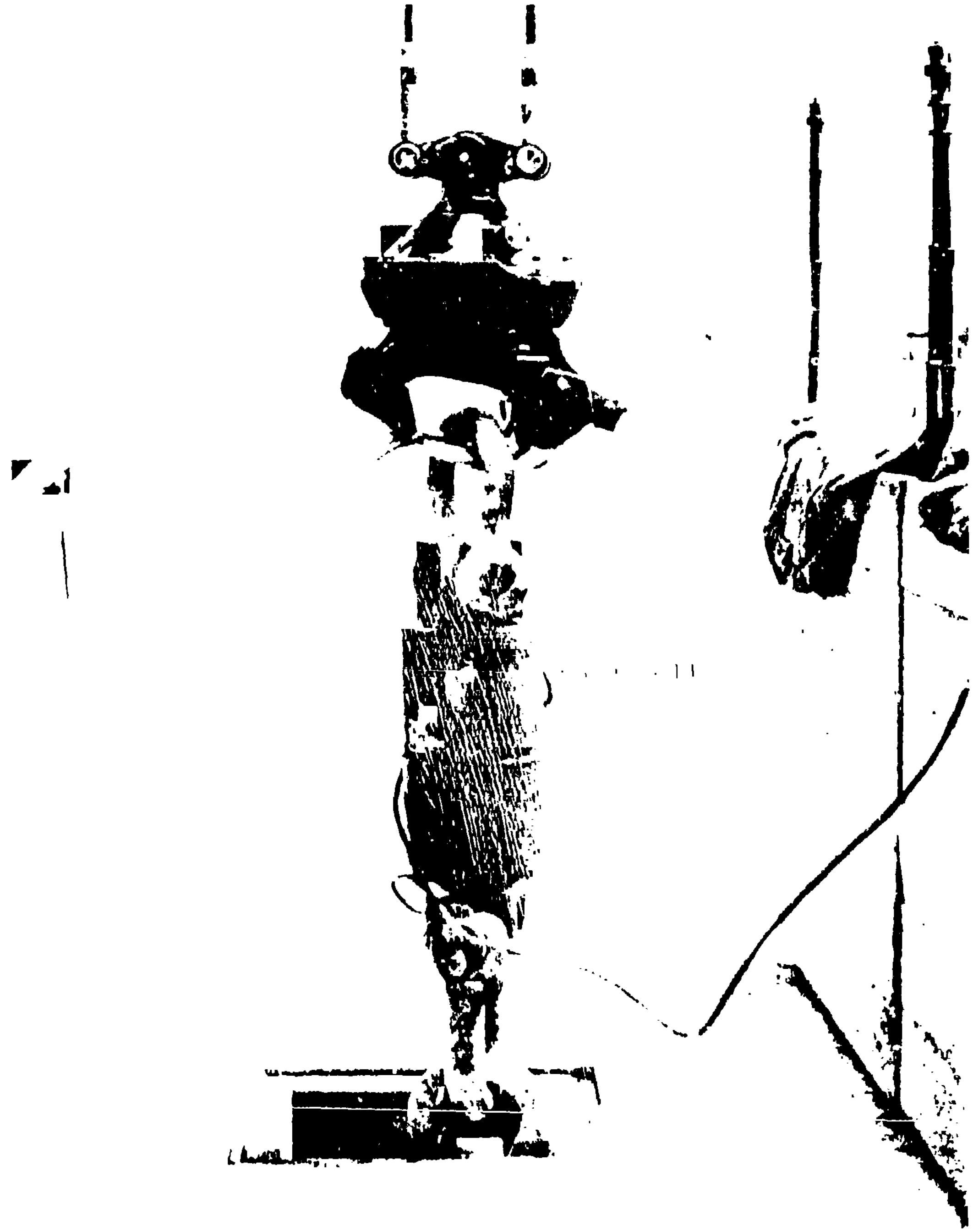


Figure 41. Static Load Test Instrumentation.

PROOF LOADING

Handling fixtures and the utility hoist were proof-loaded in accordance with the following schedule:

Fixture	Rated Load, lb	Proof Load, lb
Hoist sling ST-51273	2,000	4,000
Hoist and module sling ST-40972	6,000	12,000
Utility hoist-load lifter Series 700 and jib crane (davit) model no.990740	6,000	9,000

SPECIMEN INSTALLATION AND REMOVAL

The cargo system demonstration hardware was initially installed in the individual hoist modules at ground level. Only small hand tools and a sling were required. The modules were elevated on 4-foot workstands to provide access below the assembly. The module buildup started with the span positioning track and drive. The installation of the hoists (with cable) followed, with addition of the equalizer bar, angle and payout sensors, load isolators, hoist drives, pneumatic ducting, and system wiring. Figure 42 shows the hoist/module assembly before emplacement in the ITR.

USE OF INTEGRATED TEST RIG

The integrated test rig was used to perform the following general categories of cargo handling system tests:

1. Functional check of components
2. Control system studies (open and closed loop)
3. System performance
   a. No load - speed
   b. Constant load - speed
   c. Stall torque (live loads)
4. Static loads to maximum (ground tiedown)
5. Individual hoist operation
6. Endurance
7. Asymmetric load
8. PPC regulator valve development
9. General operating indoctrination
10. Dynamic analysis (high-speed photography)
11. Load acquisition demonstrations using a container handling device

The PPC starting and operating procedures used are outlined in Appendix III. The instrumentation calibration procedure used is given in Appendix IV.

Figure 41. Hoist System Test Installation.

Test operations were performed under the prevailing weather conditions for the Philadelphia area during the months of October through April, which included rain, freezing temperatures, snow, hail, and winds up to 35 miles per hour with higher gusts.

Typical events in the ITR program are illustrated in the following figures.

Figure 43 shows a view of the control room during a typical operation. One man is monitoring the instrumentation, one is monitoring the PPG control panel, and the third is operating the hoists from the simulated LCC station.

Figure 44 shows a view of the cargo couplings from the LCC station. The forward coupling, which is nearest the viewer, is in the stowed position. The aft coupling is in the full-up position.

Figure 45 shows a view over the LCC operator's left shoulder during synchronous hoisting of two separate kirksite block loads.

Figure 46 shows a U.S. Army MILVAN container being hoisted using the GFE helicopter-transported container handling device.

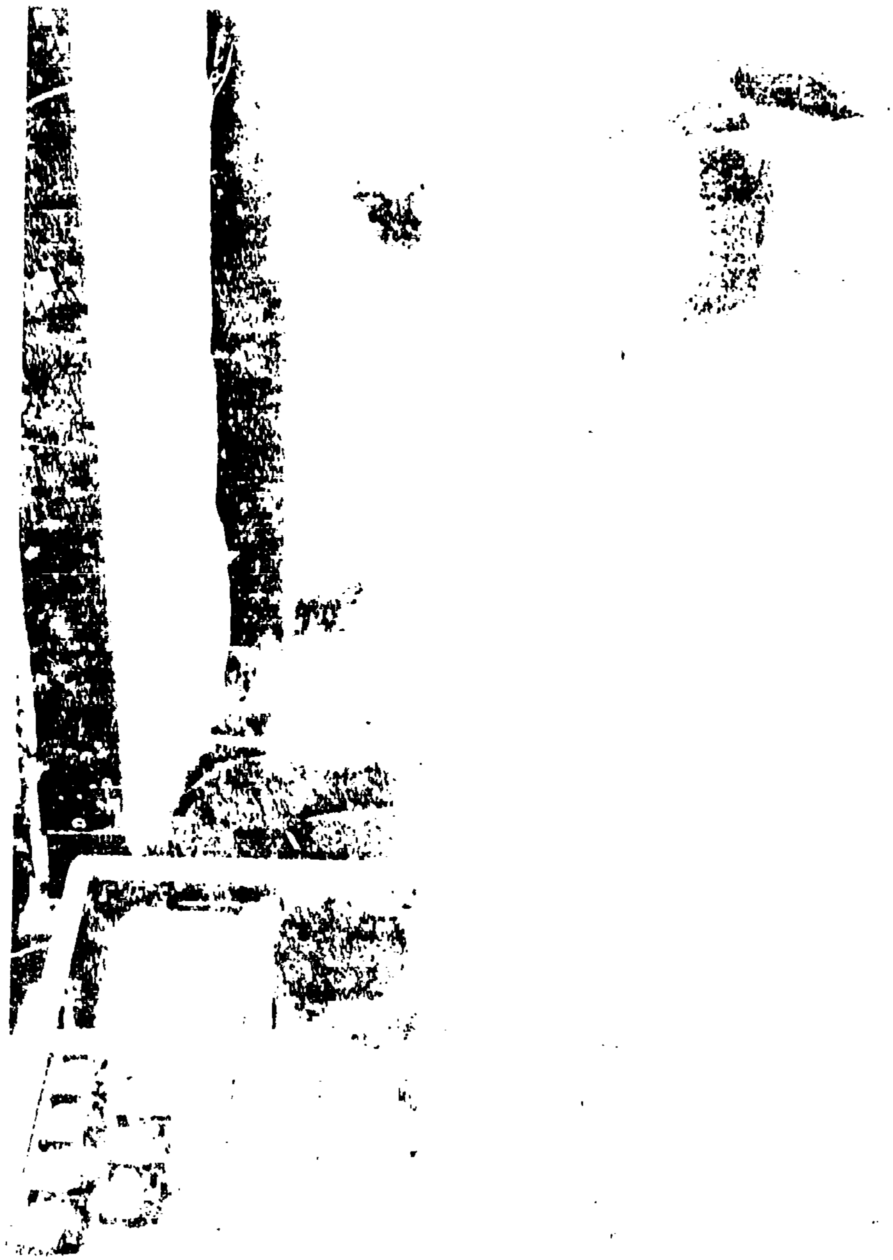
Figure 47 shows a kirksite block load being hoisted using the single-point adapter and sheave system, which is designed to large-load vertical lifts of up to 35 tons.

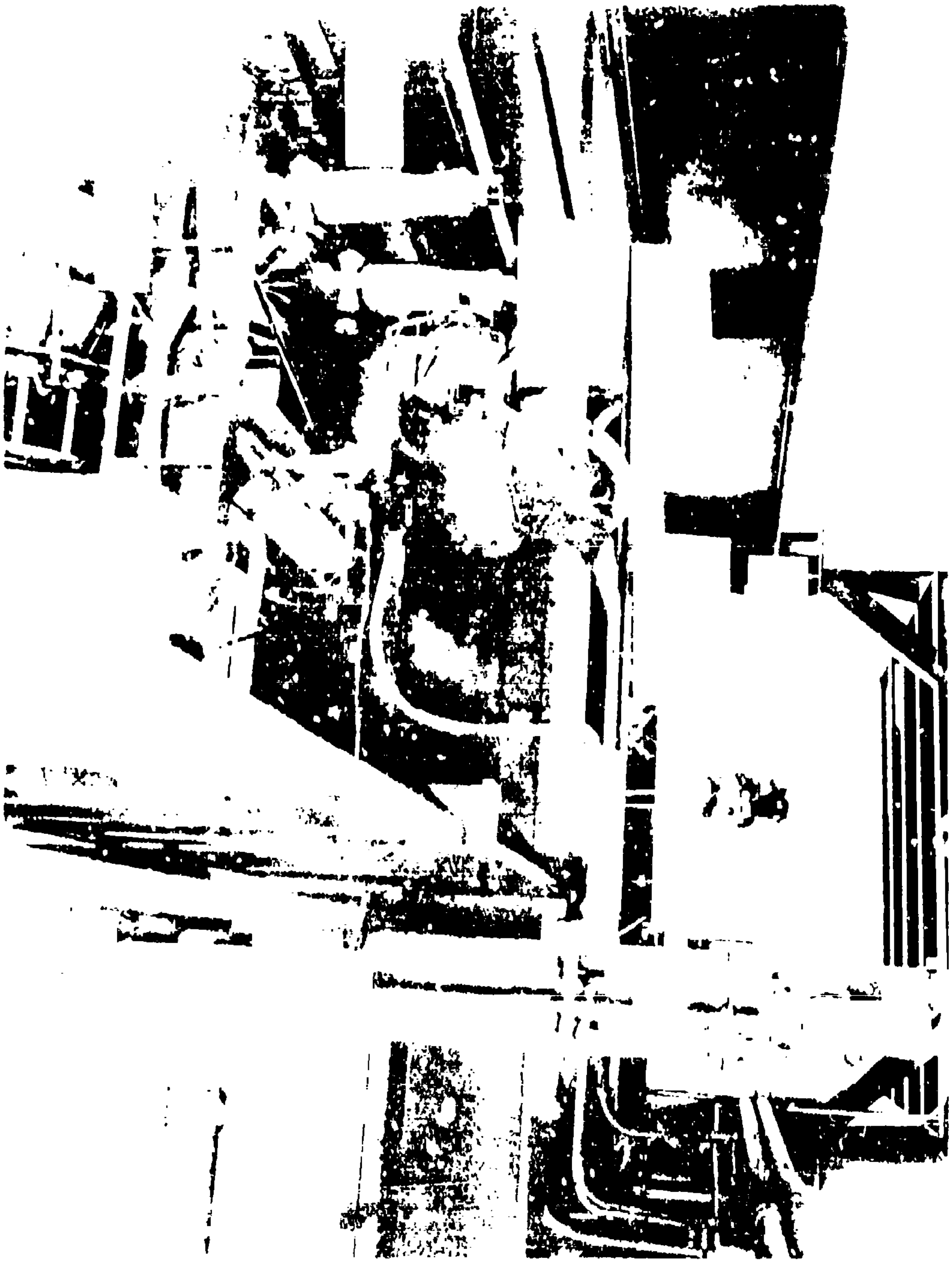
Figure 48 shows the drive-through capability of the aft test rig tower. A MILVAN container on a standard high-bay flatbed trailer is being positioned for hoisting.

CONCLUSIONS AND RECOMMENDATIONS

The integrated test rig was a viable fixture for the cargo handling ATC program from the viewpoints of compliance with contractual design objectives, design simplicity, fabrication, erection, system installation, and instrumentation.

Uses of the integrated test rig could be expanded to include maintenance training if work platforms were added beneath the overhead structure to provide access to the hoist assemblies similar to what will exist in the actual helicopter. Improvements are needed in the PPG system; to increase its air supply capacity and equipment reliability.





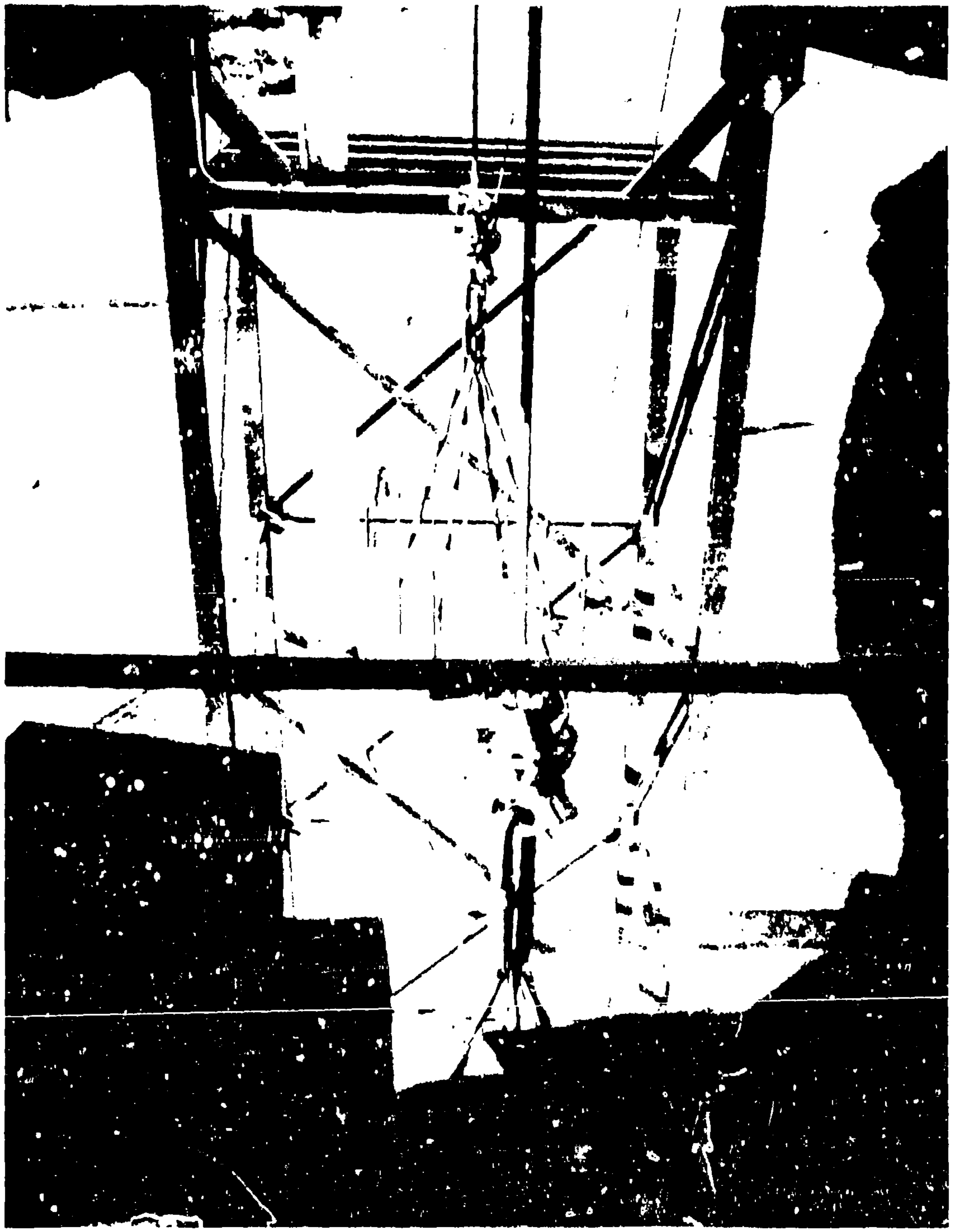


Figure 45. [illegible] View of Two [illegible] [illegible] Near Top of Lift Cycle.

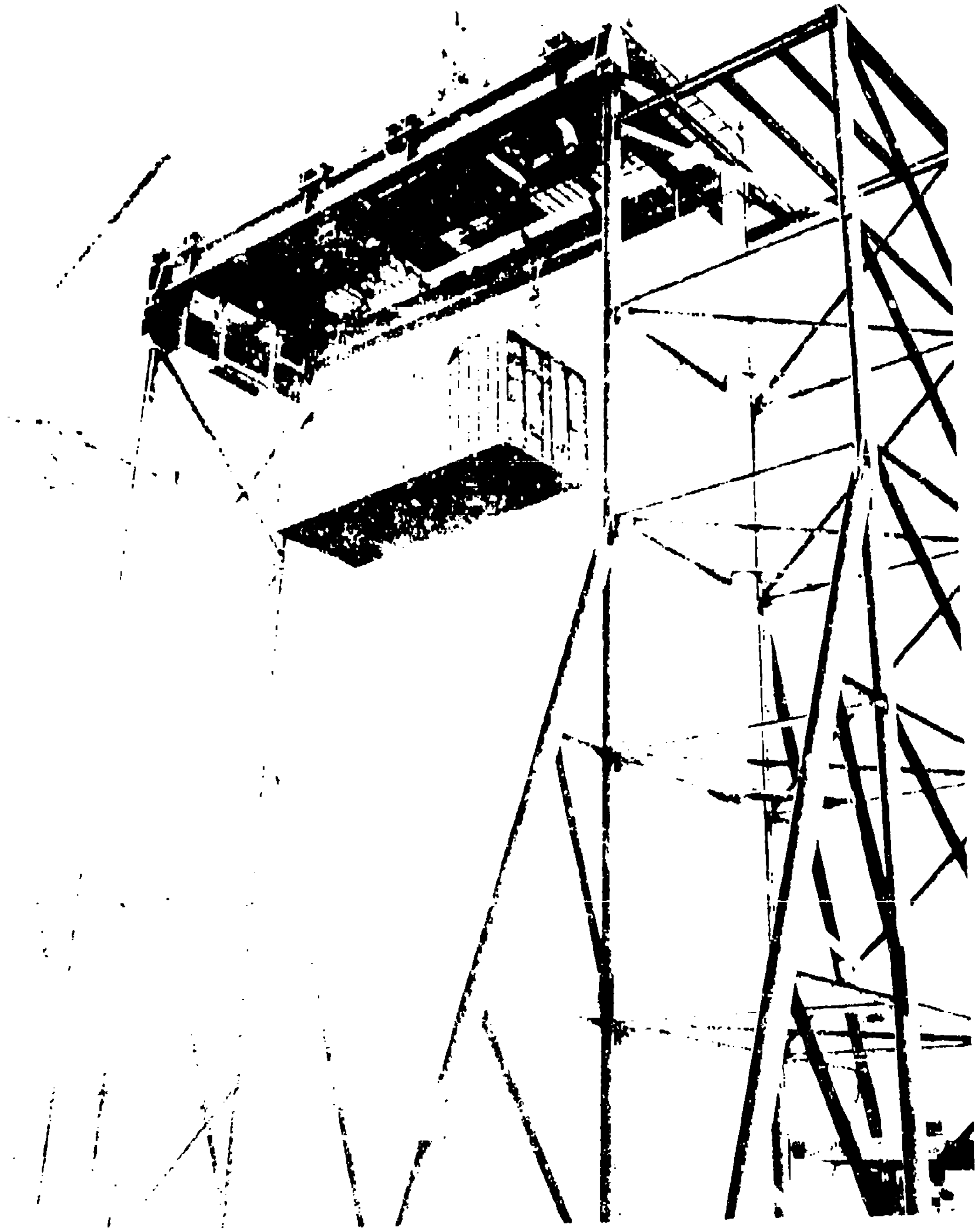


Figure 16. [illegible] MILVAN With Container [illegible]

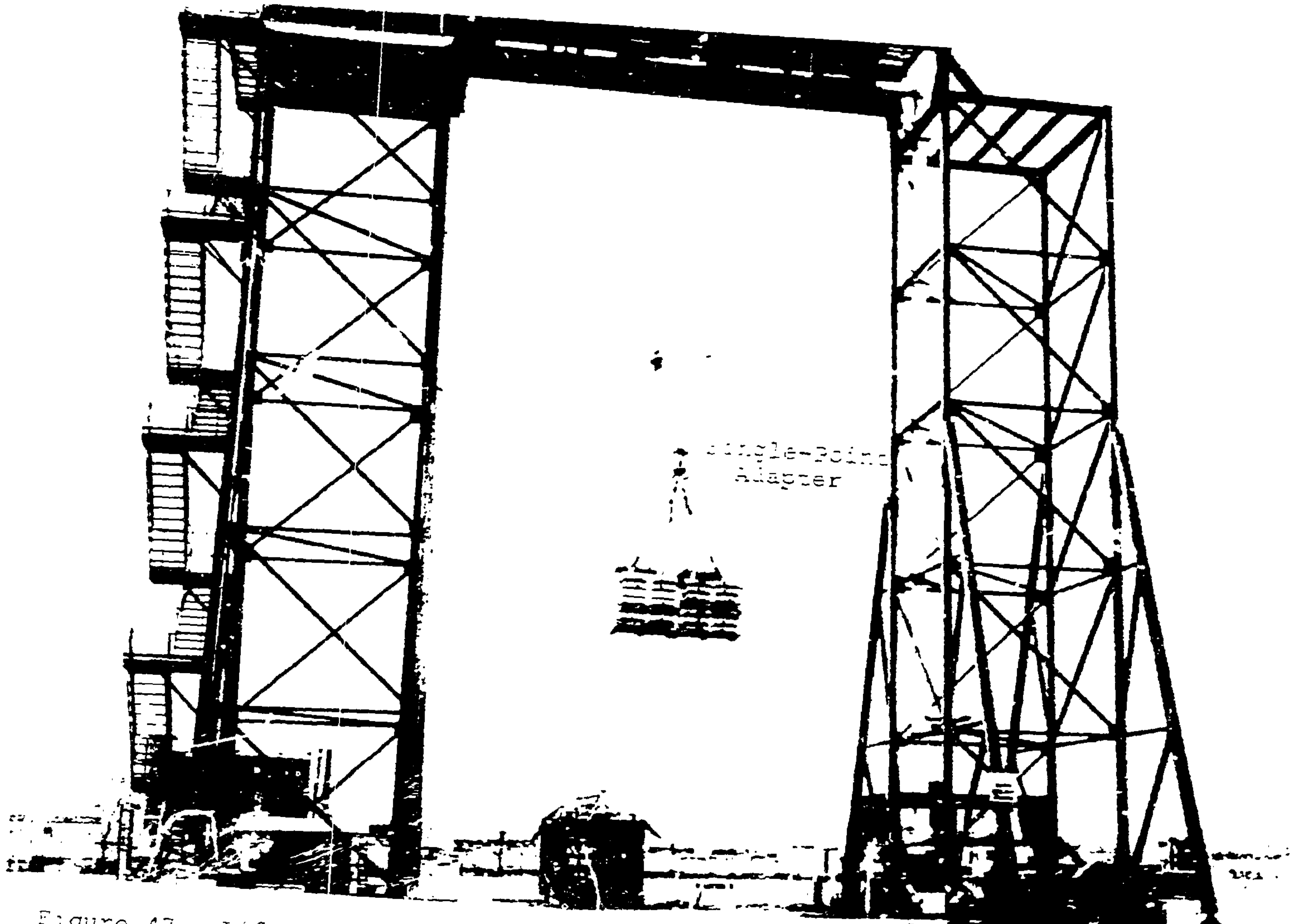


Figure 47. Lifting a 29-Ton Load With Single-Point Adapter - Hoist Span Was 16 Feet.

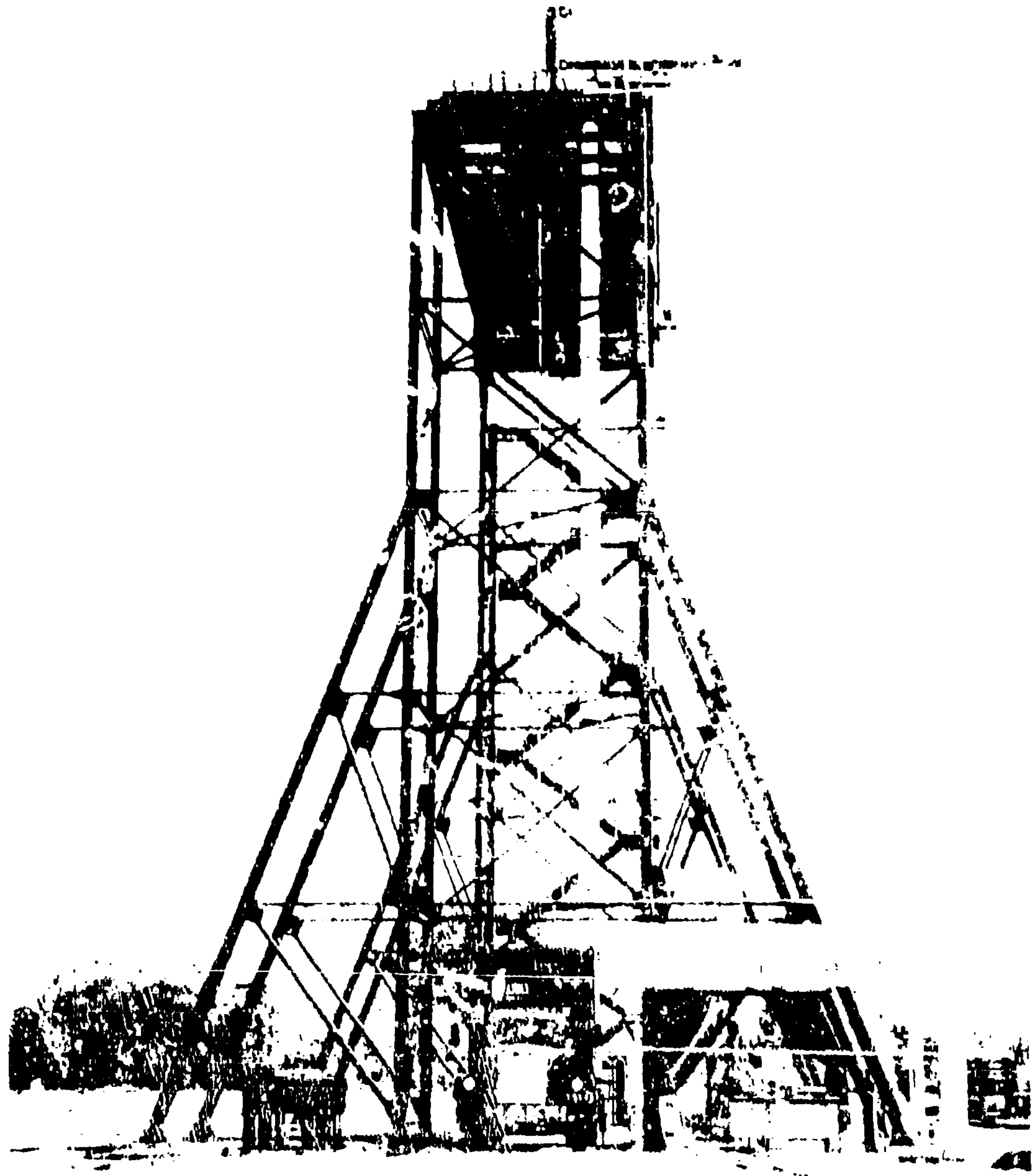


Figure 4[illegible]. Unloading [illegible] Through Base of Aft Tower.

APPENDIX 1
INTEGRATED TEST RIG STRESS ANALYSIS

TABLE OF CONTENTS

LIST OF SYMBOLS

A	Cross Section Area - In.^{2}
c	Distance from Neutral Axis to Extreme Fiber of Beam
d	Depth of Beam or Girder - Inches
E	Modulus of Elasticity of Steel - KSI
e	Load Eccentricity - Inches
FA	Allowable Stress for Compression Members - KSI
fa	Computed Axial Stress - KSI
fb	Computed Bending Stress - KSI
FCR	Failure Stress - KSI
fv	Computed Shear Stress - KSI
I	Moment of Inertia of Section - In.^{4}
J	Polar Moment of Inertia - In.^{4}
L	Span Length - Inches
l	Actual Unbraced Length - In.
M	Moment - In. KIPS
M.S.	Margin of Safety
P	Applied Load - KIPS
q	Shear Flow - Lb./In.
R	Reaction - KIPS
r	Governing Radius of Gyration - In.
Ss	Section Modulus - In.^{3}
T	Torsional Moment - In. K
V	Static Shear on Beam - KIPS
Δ	Deflection - Inches
τ	Torsional Shear Stress - KSI

APPENDIX I
INTEGRATED TEST RIG STRESS ANALYSIS

SUMMARY

This appendix is presented to substantiate the strength of towers and overhead steel structure designed for use during testing of cargo hoists of the heavy lift helicopter. It is intended that the data contained herein be used as a basis for establishing the structural integrity of the structure for load changes during HLH testing and/or for tests other than the HLH tests.

A-36 type steel was used throughout since it is common for the steel industry and affords an economical design. American Institute of Steel Construction, Inc., Allowable Stresses and Design Practices, as printed in the sixth edition of their manual, were used. ASTM A325 bolts were used for all connections.

Strength requirements were based upon cargo system loads: 28-ton, design; 70-ton, limit. Rig survival - no collapse - is one of the provisions in the design in the event of a sling or other failure during testing. The towers were designed using 1.5 factors of maximum test load, or failure loads, with a horizontal load resulting from a 5° component in both cases. All horizontal load components were considered reversible. Stairways, walkways, and work platforms were designed to meet the requirements of the Occupational Safety and Health Standards (Code of Federal Regulations, Title 29, Chapter XVII, Part 1910).

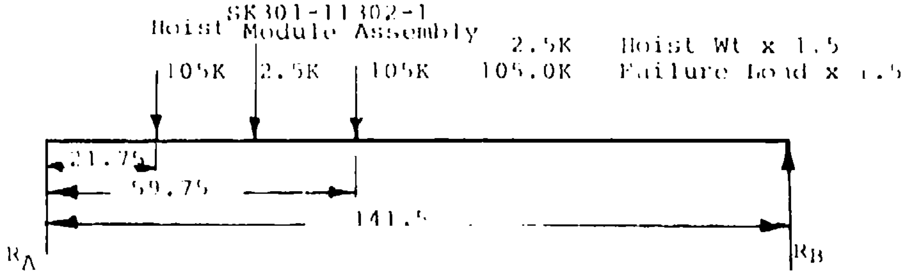
Because of height requirements of the towers and the relative low design loads, a trussed frame configuration was selected. Requirements for a control room in a location near the hoists so that the hoist operator could be located in the same relative position as he would be in the helicopter made the selection of a 14-foot-square tower desirable. Easy installation of stairways on this type of tower was also a factor in the selection of this configuration. Outriggers were used on each leg of the tower in the inboard-outboard plane for two reasons:

1. The possibility of an enclosure being erected over the top of the towers which would result in considerable wind loading.

2. The requirement that the secondary bracing be removed in the lower portions of the tower to permit a loaded truck to drive through the tower.

Outriggers in the fore-aft plane were not required because the two conditions stated above are not factors in this plane. Also, horizontal components of test loads are reacted by four frames in the fore-aft plane, while in the inboard-outboard direction only the two inner frames will react the horizontal component of loading.

The tower assemblies as delivered by the fabricator were not of the configuration as intended in the original design. This optional construction was analyzed and found to have adequate strength for the requirements of the hoist test tower loads. The reaction loads on the foundation are not as evenly distributed in the optional construction as in the original design; however, since the foundations are resting on bedrock, the optional configuration is sufficient for all test requirements. The configuration as delivered is referred to in the stress analysis as the optional construction configuration.



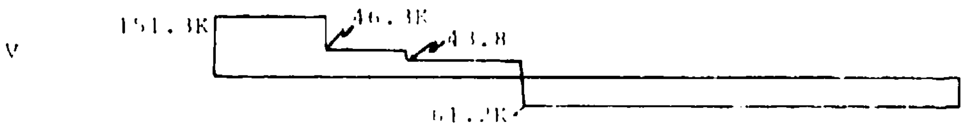
Failure Condition
70 tons on (1) hoist

$\Sigma M_{R_A} = 105(21.75) + 105(59.75) + 2.5(40.75) = R_B(141.5)$

$2280 + 6280 + 10[illegible] = 141.5\ R_B$

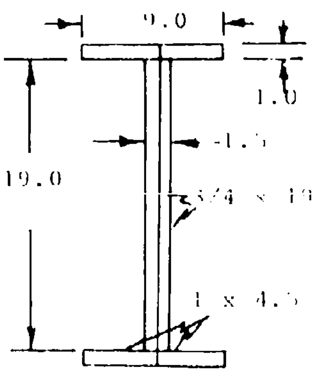
$R_B = \dfrac{8661}{141.5} = 61.2K$

$R_A = 61.2 - 105 - 105 - 2.5 = 151.3K$



$M_{MAX} = 81.75(61.2) = 5000$ In-K

S Req'd $= \dfrac{5000 \text{ In-K}}{20 \text{ KSI}} = 250 \text{ In}^3$



(2) 3/4 x 19 I = 428.7(2) = 857.4 In^4

(4) 1 x 4.5 I = 200 x 9 = 1800.0 In^4

2657.4 In^4

$S = \dfrac{I}{c} = \dfrac{2657.4}{10} = 265.4 \text{ In}^3$

$f_b = \dfrac{5000 \text{ In-K}}{265.4 \text{ In}^3} = 18.85$ KSI Bending Stress

Max Test Load = 1/2 Failure Condition

$f_b = 9.[illegible]$ KSI Bending Stress

Cross-Sectional Area at Point of Max Shear

$$A = (2)11(.75) = 16.50 \text{ In.}^2$$

$$f_s = \frac{P}{A} = \frac{151.3}{16.5} = 9.17 \text{ KSI Shear Stress}$$

$$M.S. = \frac{14.5}{9.17} - 1 = .58$$

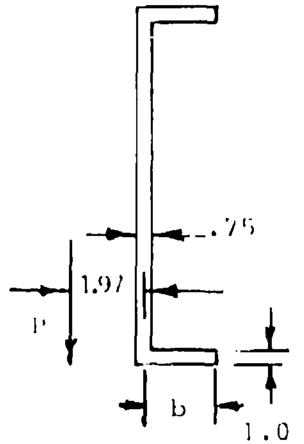
Long. Shear $f_s = \frac{VQ}{Ib}$ at weld (4) 3/8 welds

$$Q = 9(10) = 90 \text{ In.}^4$$

$$f = \frac{151.3(90)}{2657(1.5)} = 3.42 \text{ KSI Long. Shear}$$

Torsional Shear

Element	b	t	bt^3
Flange	4.125	1.0	4.125
Flange	4.125	1.0	4.125
Web	20.0	.75	8.43
		Σbt^3 =	16.680



$$J = \frac{2bt^3}{3} = \frac{16.68}{3} = 5.56$$

Torsion = (1.97-e)52.5K = 1.35(52.5) = 70.8 in K
e = .622

Torsional Shear Stress

$$\tau = \frac{Tt}{J} = \frac{70.8(.75)}{5.56} = 9.55 \text{ KSI}$$

$$P = \frac{70T(1.5)}{4} = 52.5K$$
(1.5 = F.S.)

M.S. - Margin of safety based on allowable design stress (22 KSI tension, 14.5 KSI shear)

Bending

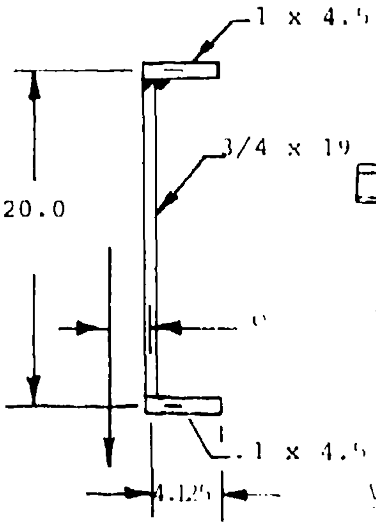
$$M.S. = \frac{Fa}{fa} - 1 = \frac{22}{18.85/1.5} - 1 = .75$$
(1.5 = F.S.)

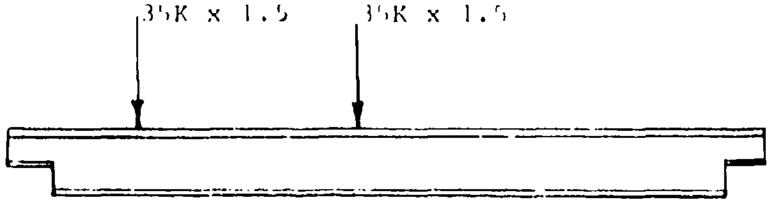
Shear

$$\frac{14.5}{9.55/1.5} - 1 = 1.28$$

SK301-11302-1

Shear Center





$I = 2[4.125 \times 1.0 \times 10^2] + \frac{.75 \times 20^3}{12}$

$= 825 + 500 = 1325 \text{ in}^4$

$\frac{Vy}{I} = \frac{70000 \times 10}{1325} = 528 \text{ psi}$

Flange $q = 528(1.0\,x)$ when $x = 0$, $q = 0$

$x = 4.12$, $q = 2175$ lb/in at corner

Web $q = 2175 + 528(10)\frac{.75}{2} - .667y\left(\frac{.75y}{2}\right)$

$= 2175 + 1982 - 250y^2$

$= 4157 - 250y^2$

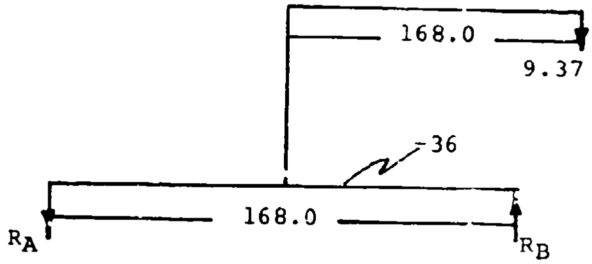
$2175(20) + 1982(20).667 = 70{,}000$

$70{,}000\,e = 4.12(528)20 = 43500$

$e = \frac{43500}{70000} = .622$

SK301-11302-2 Assembly
Auxiliary Hoist Mount

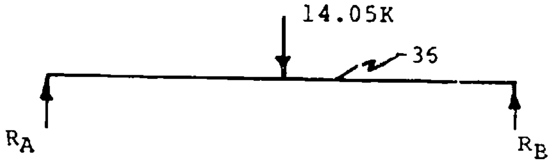
D.O Wt Hoist 3.37
Max.Load 6.00
9.37K



9.37 x 1.5 = 14.05K

$$-R_A = R_B = \frac{14.05(168)}{168} = 14.08K \text{ (2 beams)}$$

7.04K/beam



$$R_A = R_B = \frac{P}{2} = \frac{14.05}{2} = 7.02K$$

Total Moment = 14.05 (168) + 7.02 (84) - 2 beams

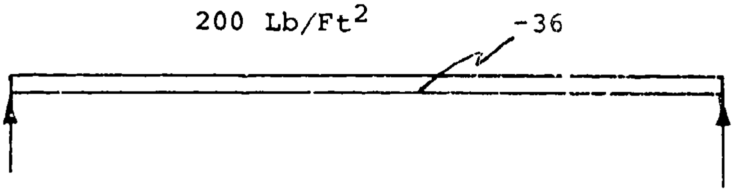
= 2360 + 592

= 2952 In K - 2 beams

1476 In K/beam

$$f_b = \frac{M}{S_x} = \frac{1476}{121.1} = 12.2 \text{ KSI} - 14 \text{ WF } 78$$

SK301-11302-2



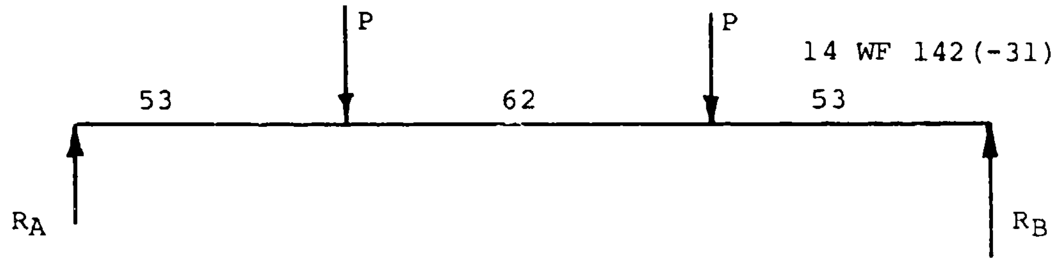
$$M = \frac{wl^2}{8} = \frac{.05(168)^2}{8} = 176 \text{ In}\cdot\text{K}$$

$$f_b = \frac{M}{Sx} = \frac{176}{121.1} = 1.45 \text{ KSI}$$

Total Stress - Uniform Load + Hoist Load

$$f_b = 12.2 + 1.45 = 13.65 \text{ KSI}$$

SK301-11302-3
Hoist Module Support Assembly

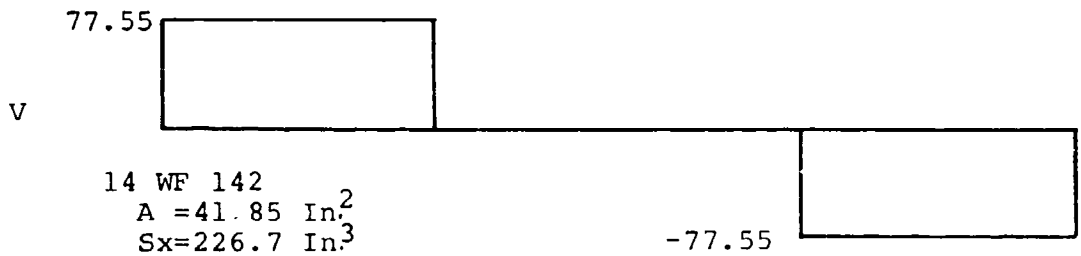


Failure Condition

$$P = \frac{151.3}{2} + \frac{DD\ Wt}{2} =$$

$$= 75.65 + \frac{2.5(100.75)}{141.5} = 75.65 + 1.9 = 77.55$$

$$R_A = R_B = 77.55$$



14 WF 142
$A = 41.85\ In.^2$
$Sx = 226.7\ In.^3$

$$f_s = \frac{P}{A} = \frac{77.55}{41.85} = \quad 86\ \text{KSI Shear Stress}$$

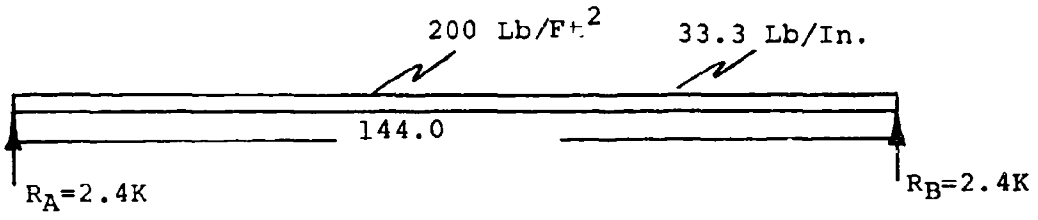
$$M_{MAX} = 77.55(53) = 4120\ \text{In-K}$$

$$f_b = \frac{M}{Sx} = \frac{4120}{226.7} = 18.15\ \text{KSI}$$

Max. Test Load = 1/2 Failure Condition

$$f_b = 9.1\ \text{KSI}$$

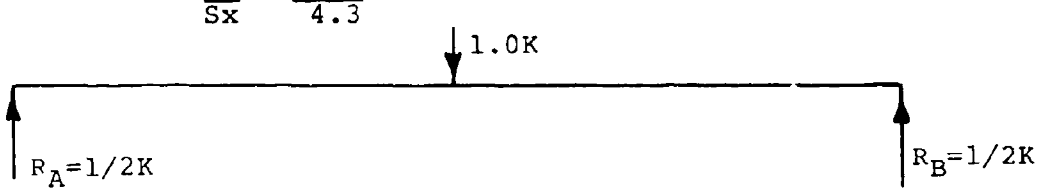
SK301-11302-3



-32 6[8.2 Lb $S_x = 4.3 \text{ In.}^3$

$$M_{MAX} = \frac{wl^2}{8} = \frac{33.3(144)^2}{8} = 86.3 \text{ In. K}$$

$$f_b = \frac{M}{S_x} = \frac{86.3}{4.3} = 20.07 \text{ KSI}$$



$$M_{MAX} = \frac{P7}{4} = \frac{1.000(144)}{4} = 36 \text{ In}\cdot\text{K}$$

$$f_b = \frac{M}{S_x} = \frac{36}{4.3} = 8.38 \text{ KSI}$$

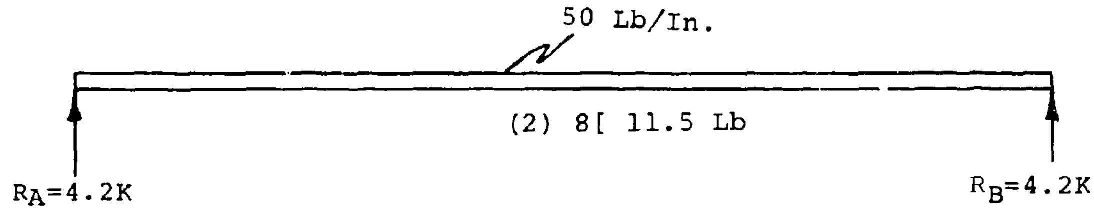
Grip Strut Flooring Capacity (members tack welded together)

Concentrated load	1100 Lb.
Uniformly dist. load	353 Lb/Ft^2

SK301-11302-4

Work Platform Assembly

Design load 200 Lb/Ft.



$$M_{MAX} = \frac{wl^2}{8} = \frac{.05(168)^2}{8} = 176.2 \text{ In. K}$$

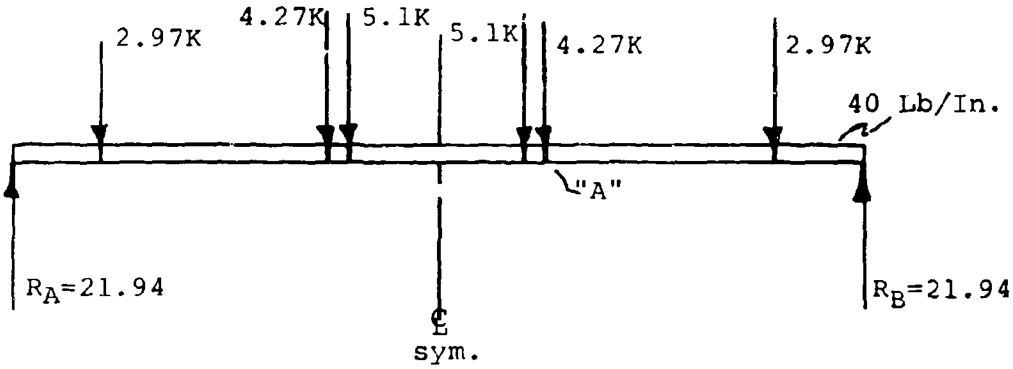
$$f_b = \frac{M}{Sx} = \frac{176.2}{16.2} = 10.88 \text{ KSI}$$

Grip strut on this assembly has a capability of 235 Lb/Ft^2 of uniformly distributed load and a concentrated load of 633 Lb at the midpoint.

SK301-11302-5
Main Fore & Aft Beam Assembly

Dead Wt Only
16' position

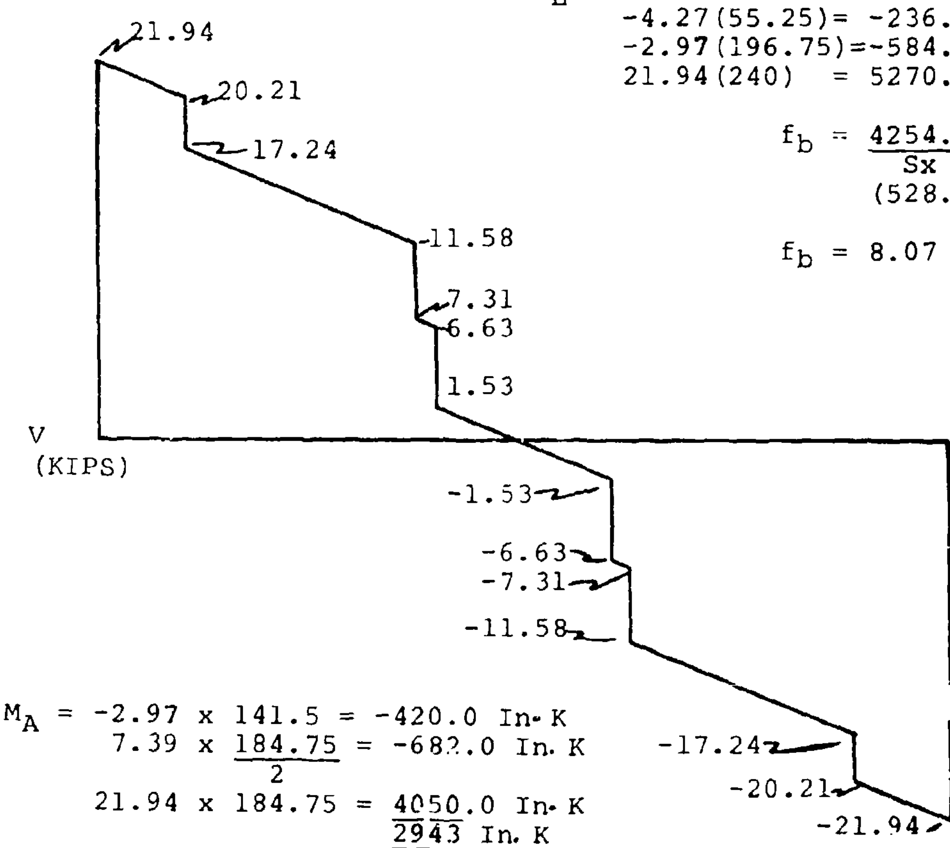
30WF172
A =50.72 In^2
Sx=528.2 In^3



$M_{℄}$ = -5.1(38.25) = -195.2
-4.27(55.25)= -236.0
-2.97(196.75)=-584.0
21.94(240) = 5270.0

$f_b = \frac{4254.8}{Sx}$ In· K
(528.2)

f_b = 8.07 KSI

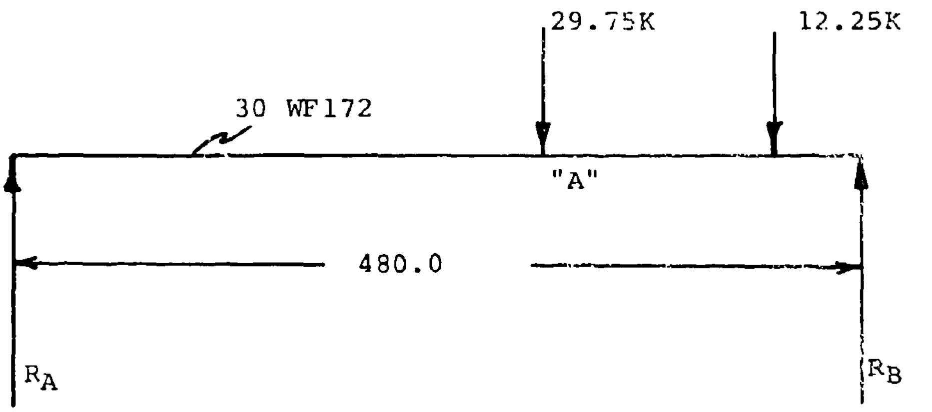


M_A = -2.97 x 141.5 = -420.0 In· K
7.39 x $\frac{184.75}{2}$ = -68[illegible].0 In. K
21.94 x 184.75 = 4050.0 In· K
2943 In. K
$\frac{}{Sx}$ = 5.58 KSI
(528.2)

SK301-11302-5

30 WF172

Test load -
Failure condition
16' hoist position
28-ton load @ 1.5 F.S.



$$\Sigma M_{R_A} = 29.75(295.25) + 12.25(436.75) - 30\ R_B$$

$$R_B = \frac{8780 + 53.50}{480} = \frac{141.30}{480} = 29.5K$$

$$R_A = 12.5$$

$$M_A = -141.5(12.25) + 184.75(29.5)$$
$$-1732 + 5450 = 3718 \text{ In. K}$$

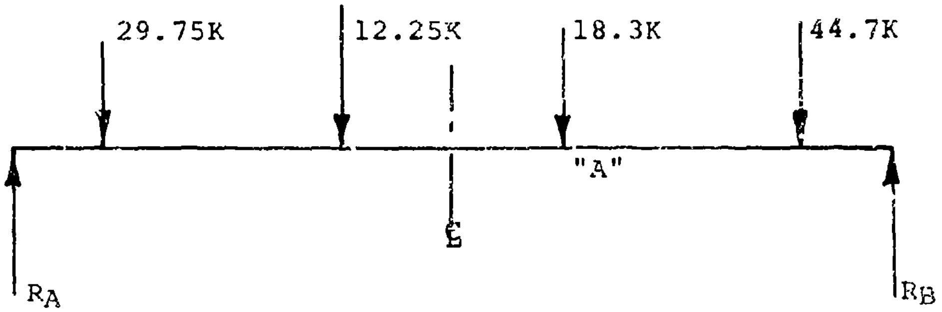
$$f = \frac{M_A}{S_x} = \frac{3718}{528.2} = 7.04 \text{ KSI Failure load}$$
$$5.58 \text{ KSI DD Wt}$$
$$12.62 \text{ KSI}$$

SK301-11302-5

30 WF172

Proof load
26' hoist position
70-ton load @ 1.5 F.S.
.60-.40 load split

40% proof load   60% proof load

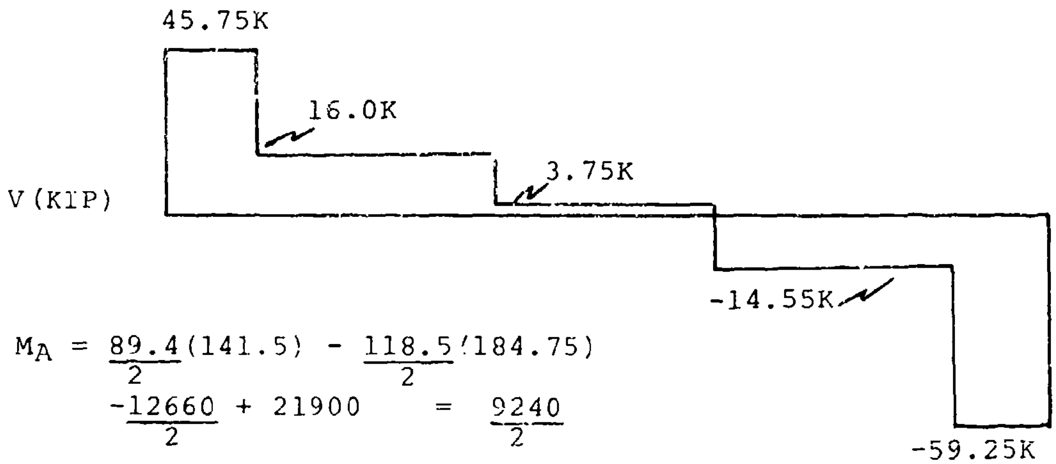


$$\Sigma M_{R_A} = 29.75(43.25) + 12.25(184.75) + 18.3(295.25) + 44.7(436.75)$$

$$\frac{2575}{2} + \frac{4530}{2} + \frac{10800}{2} + \frac{39000}{2} \qquad -480R_B$$

$$R_B = \frac{2845.2}{480} = 59.25K$$

$$R_A = 45.75K$$



$$M_A = \frac{89.4}{2}(141.5) - \frac{118.5}{2}(184.75)$$

$$-\frac{12660}{2} + 21900 = \frac{9240}{2}$$

$$f_b = \frac{4620}{528.8} = 8.75 \text{ KSI Load}$$

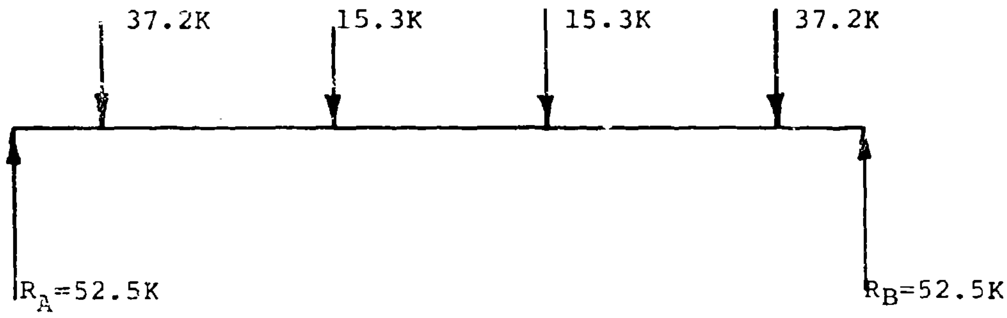
$$\underline{5.58} \text{ KSI DD Wt}$$

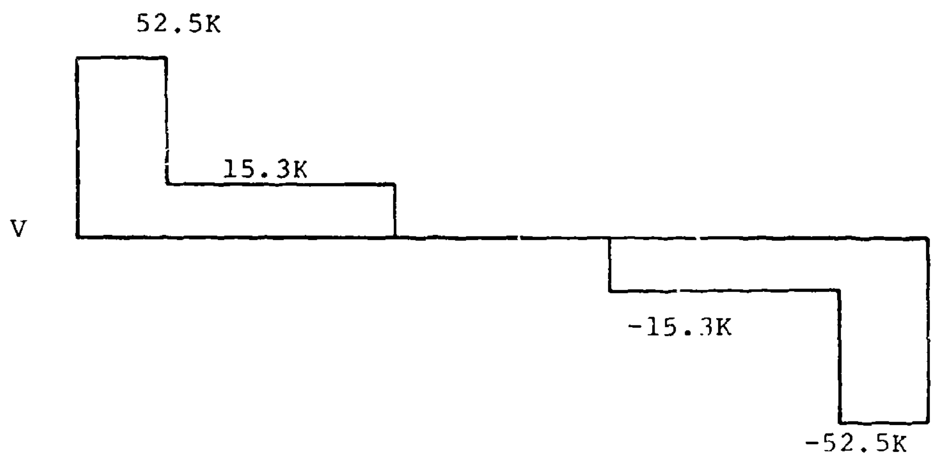
$$14.33 \text{ KSI}$$

<u>SK301-11302-5</u>

30 WF172

Proof load
26' hoist position
70-ton load @ 1.5 F.S.
.50-.50 load split





$$M_{MAX} = -52.5(184.75) + 37.2(141.5)$$

$$= 9700 + 52.70 = 4430 \text{ In.K}$$

$$f_b = \frac{M_{MAX}}{S_x} = \frac{4430 \text{ In.K}}{528.2 \text{ In.}^3} = 8.75 \text{ KSI load}$$

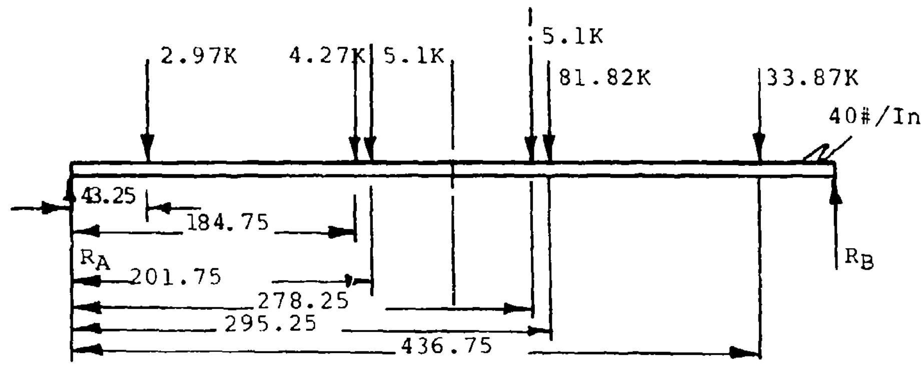
$$\underline{8.07} \text{ KSI DD Wt}$$

$$16.82 \text{ KSI}$$

30 WF172
A =50.72
Sx=528.2 In^3

SK301-11302-5

Failure Condition
at 16' position
70-ton proof load
(DD Wt included)



$$\Sigma M_{R_A} = 19.20(240)+2.97(43.25)+4.27(184.75)+5.1(201.75)+5.1(278.25)$$

$$+81.82(295.25) + 33.87(436.75)-480R_B$$

$$= 4608 + 128.45 + 788.88 + 1028.93 + 1419.08 + 24157.36 + 14792.72$$

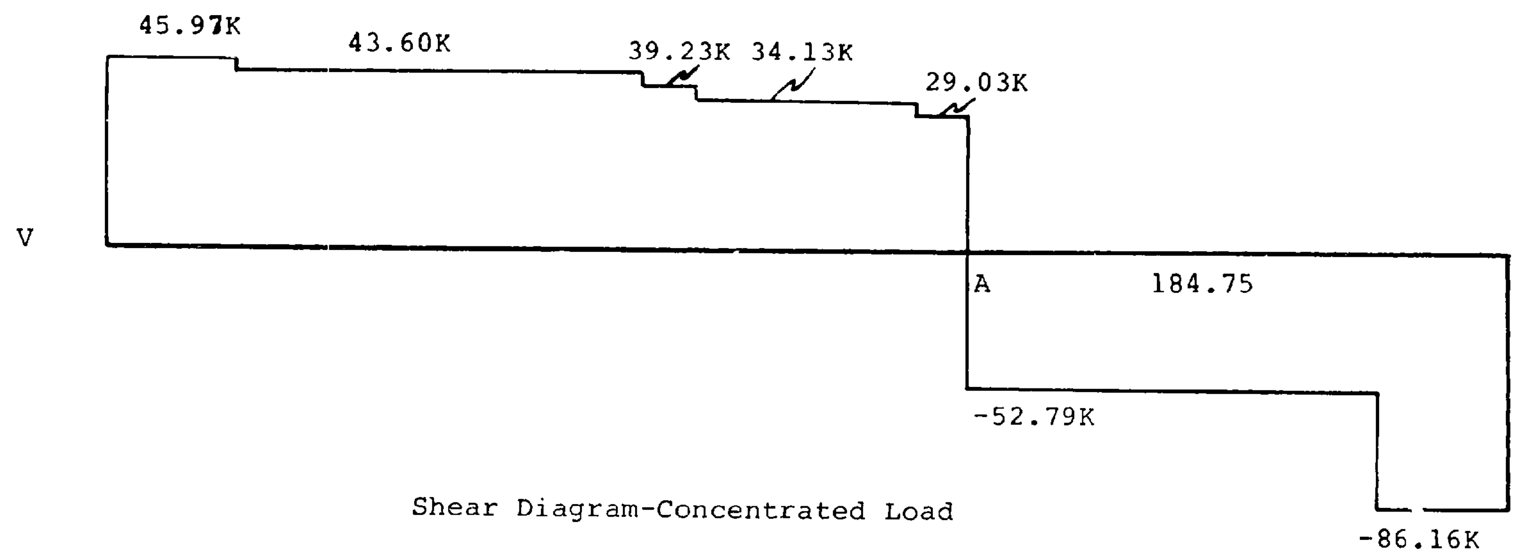
$$R_B = \frac{46923.42}{480} = 97.76K$$

$$\Sigma Fu = +19.20 + 2.97 + 4.27 + 5.1 + 5.1 + 81.82 + 33.87 -97.76-R_A$$

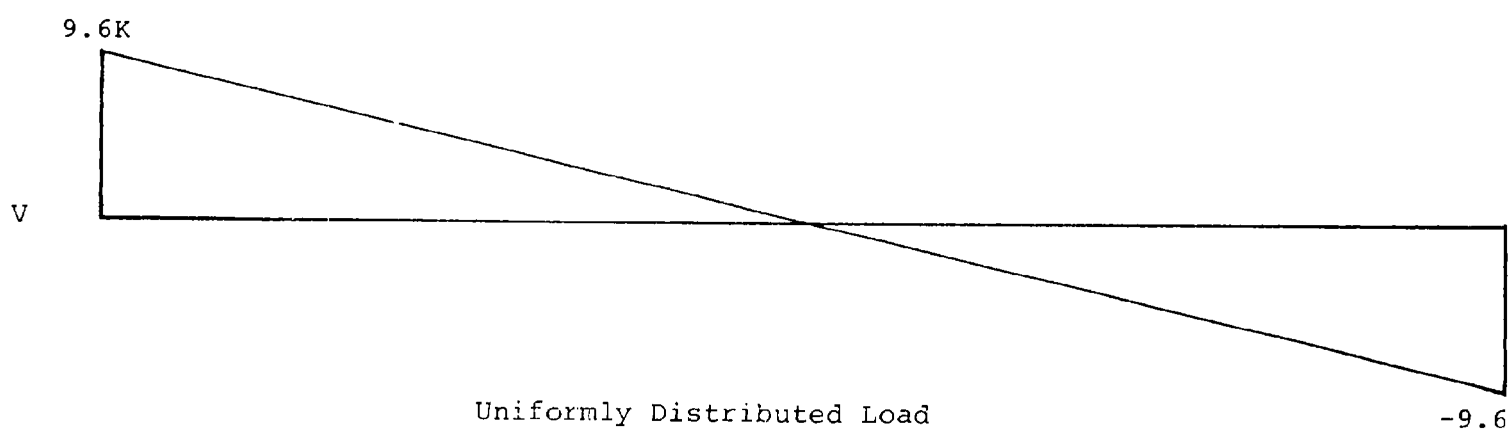
$$R_A = 54.57$$

SK301-11302-5

Failure condition
at 16' span
70-ton proof load



Shear Diagram-Concentrated Load



Uniformly Distributed Load

30 WF172 — SK301-11302-5 — Failure condition at 16' span 70-ton proof load

Moment is Max. at PT. "A"

Solving for Max. Mom.

$$M_A = -86.16(184.75)-9.6(184.75) + 33.87(141.5)-400.45$$

$$= 12498.6 \text{ In.K}$$

$$f_b = \frac{12498.6}{528.2} = 23.7 \text{ KSI}$$

30 WF172
$A = 50.72 \text{ In}^2$
$S_x = 528.2 \text{ In}^3$

<u>SK301-11302-5</u> Failure condition at 26' position 70-ton proof load (DD Wt included)

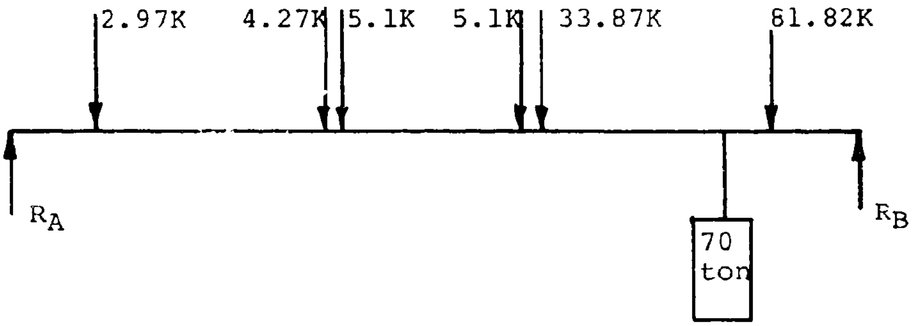


Figure A

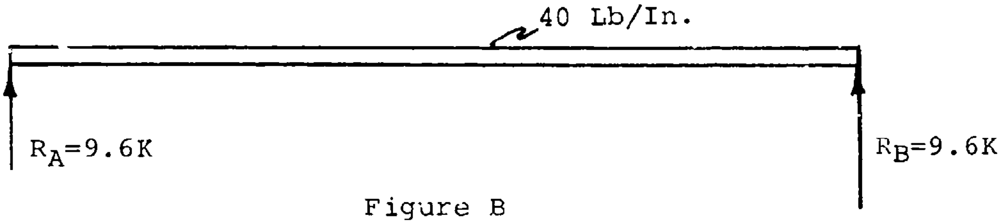


Figure B

Figure A

$$\Sigma M_{RA} = 128.45 + 788.88 + 1028.93 + 1419.08 + \underset{(10000.12)}{33.87(295.25)}$$

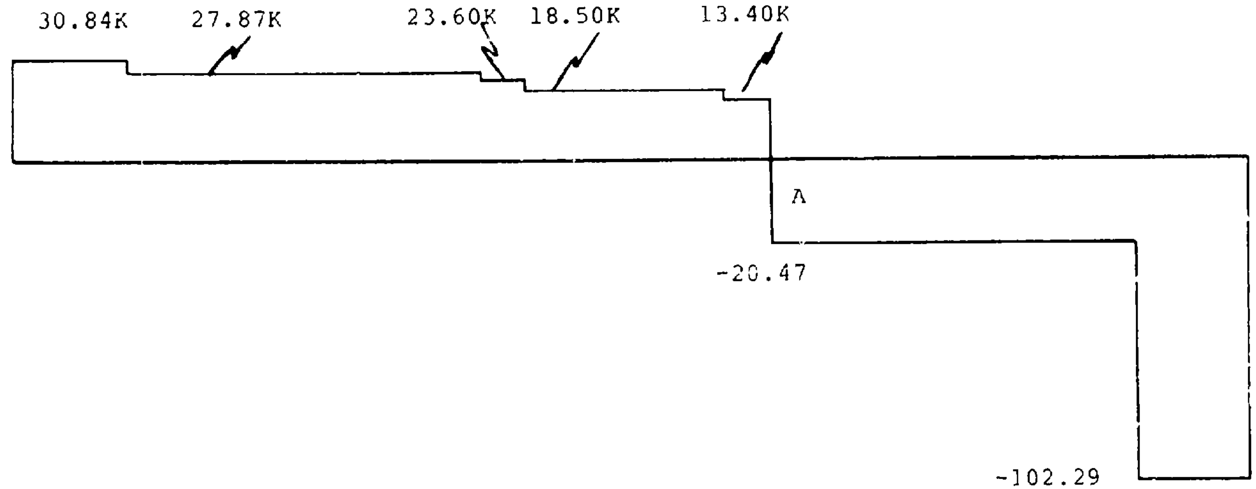
$$+ \underset{(35734.89)}{81.82(436.75)} - 480R_B$$

$$R_B = \frac{49,100.34}{480} = 102.29K$$

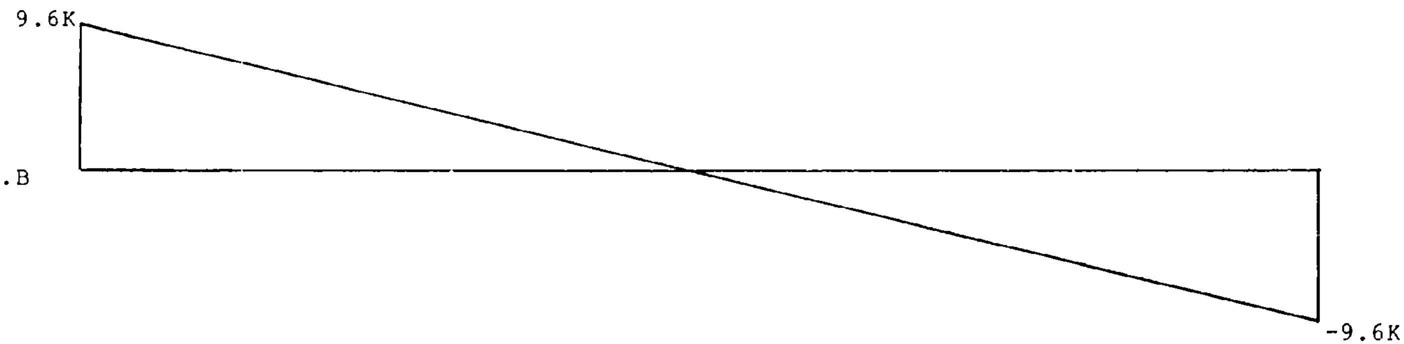
$$R_A = 30.84K$$

Shear and Moment Diagram on Page 100.

SK301-11302-5 at 26' location
70-ton proof load



V
Fig.A



V
Fig.B

SK301-11302-5 Failure condition
at 26' position
70-ton proof load

Moment is Max. at PT. "A"

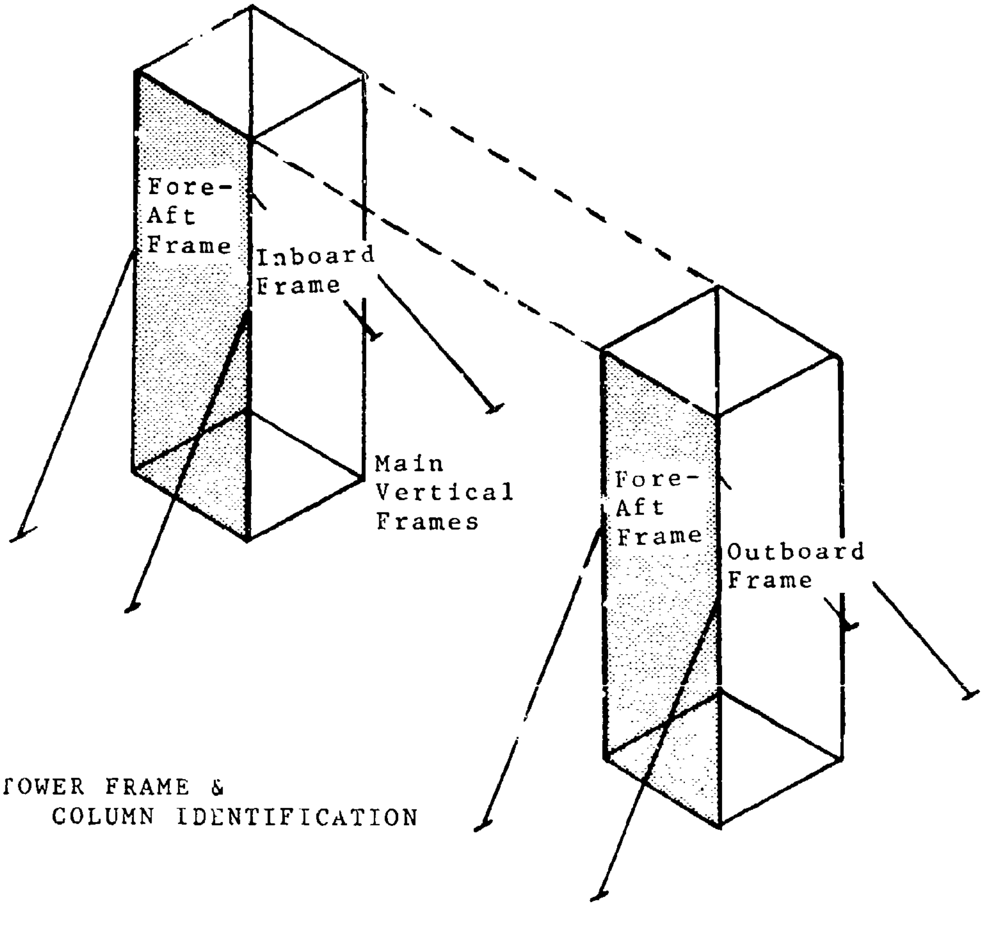
$$M_{MAX} = -102.29(184.75)-9.6(184.75)+81.82(141.5)\div 400.45$$

$$= \frac{8693.72}{528.2} = 16.45 \text{ KSI}$$

SK301-11304-1
Tower Assembly

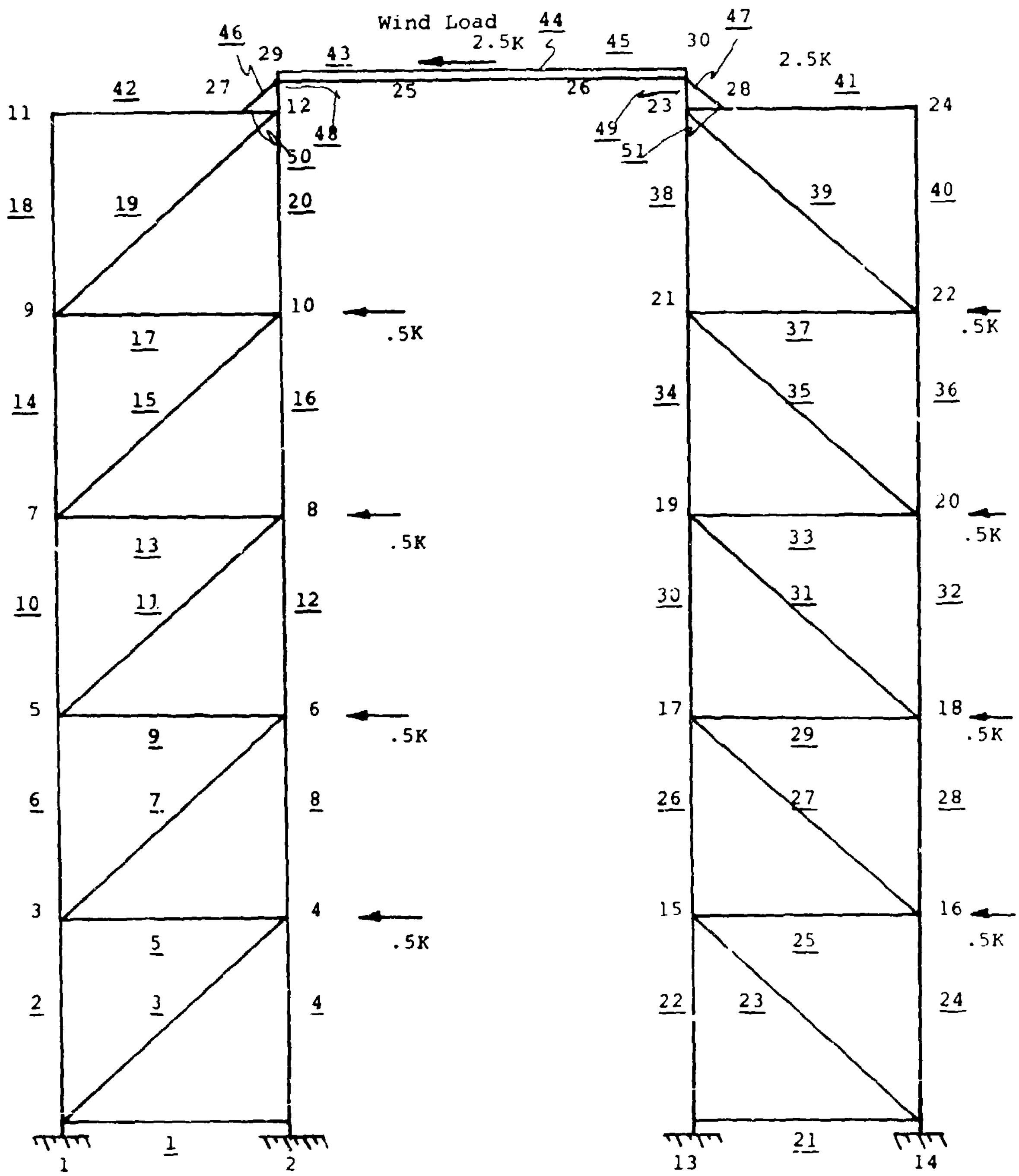
The tower assembly is analyzed using the plain frame computer program.* The fore-aft frame is analyzed using three separate loads: wind loads, test loads, and deadweight. The total load from the three combined loads and stress is computed for each member. The inboard-outboard frame is analyzed in the same way. To obtain the maximum stress in the main vertical columns it is necessary to add the stress found in the inboard-outboard frame to the stress of the fore-aft frame found as a result of the horizontal test loads only. The tower component identification is shown below.

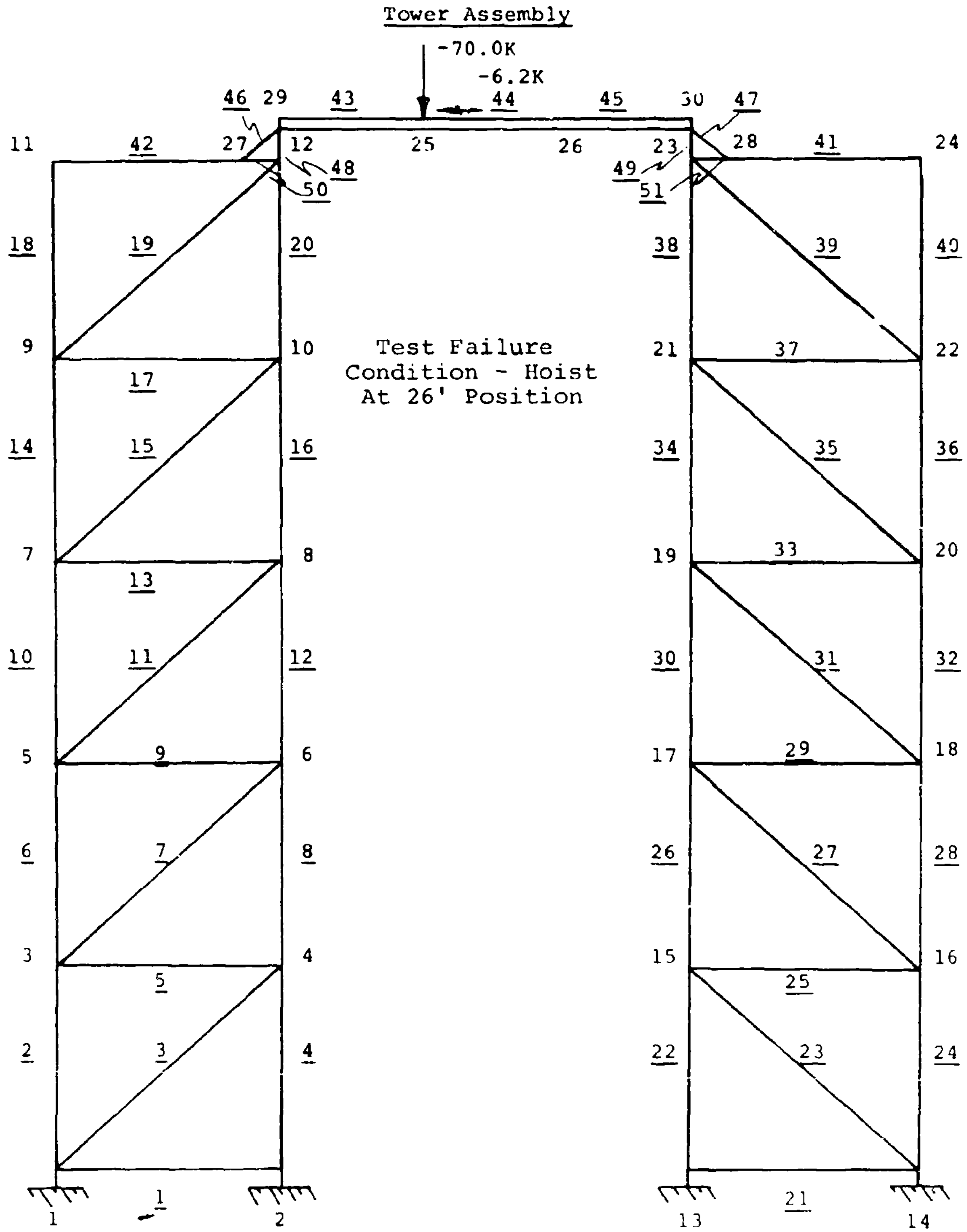
(*Boeing-Wichita Watfor computer program.)



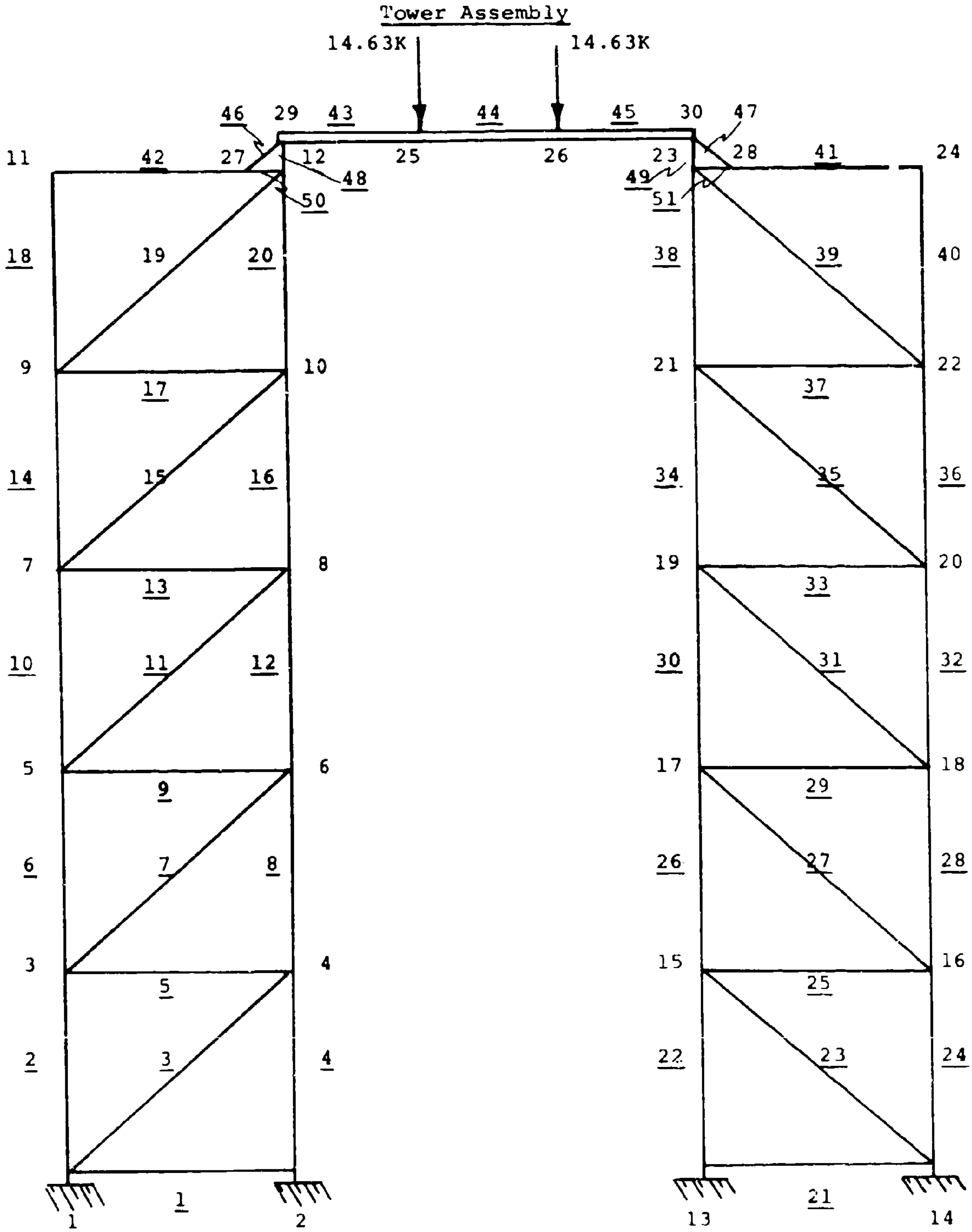
TOWER FRAME &
COLUMN IDENTIFICATION

Tower Assembly - Fore-Aft Frame





Tower Assembly
-70.0K
-6.2K
Test Failure
Condition - Hoist
At 26' Position


Tower Assembly
14.63K
14.63K
46
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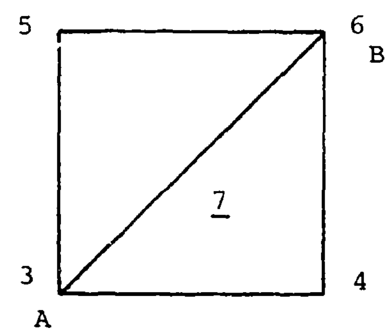
14

GLOSSARY - COMPUTER ANALYSIS

Coordinates of Joints - Location of joints of frame using X and Y coordinate axes, the X axis being the line formed by base of towers and the Y axis the left-hand column centerline.

Member End Action - Nodes 1 and 2 define coordinate axis system of each member (see example). Node 1 represents "A" end of member; Node 2 represents "B" end of member. The line 3-6 is the Y axis of the member. The X axis is 90° to the Y axis. Negative "X" action at the "A" end, and positive "X" action at the "B" end would indicate tension (KIPS) in member. "Y" action indicates shear (KIPS) in member. MZ action indicates moment (In.K.) about X axis of member.



Member Information:

Area - Cross-sectional area ($In.^2$) of member.

Inertia - Moment of inertia ($In.^4$) of member.

Modulus - Modulus of elasticity of member.

Length - Length in inches.

Actions applied at joints - load applied at joints.
Support Reactions - foundation loads.

X Reaction - Shear

Y Reaction - Positive (down load)
- Negative (up load)

TABLE VI. TOWER ASSEMBLY - FORE-AFT FRAME LOADS (KIPS).

Member	Size	Area	Moment	Wind Load	Test Load	Dead-weight	Horiz. Test Only	Total Load
1	(7Γ) 4x3-1/2x3/8	5.34	.00	.00	.00	.00	.00	.00
2	8 WF 31	9.12	18.73	12.27	25.99	5.92		44.18
3	7Γ 4x3-1/2x3/8	5.34	.49	5.92	9.13	2.08		17.13
4	8 WF 40	11.76	13.47	-16.24	25.63	7.28	14.56	16.67
5	7Γ 4x3-1/2x3/8	5.34	1.94	-3.93	-6.74	-1.54		-12.21
6	8 WF 31	9.12	1.82	8.63	19.82	4.52		33.07
7	7Γ 4x3-1/2x3/8	5.34	1.41	5.41	9.18	2.09		16.68
8	8 WF 40	11.76	6.29	-12.26	31.77	8.68	11.7[illegible]	28.19
9	7Γ 4x3-1/2x3/8	5.34	1.58	-3.53	-6.87	-1.57		-11.97
10	8 WF 31	9.12	6.50	5.45	13.61	3.10		22.16
11	7Γ 4x3-1/2x3/8	5.34	1.48	4.73	9.23	2.10		16.06
12	8 WF 40	11.76	4.35	-8.62	37.94	10.08	8.97	39.40
13	7Γ 4x3-1/2x3/8	5.34	1.95	-2.93	-6.64	-1.51		-11.08
14	8 WF 31	9.12	6.43	2.76	7.53	1.72		12.01
15	7Γ 4x3-1/2x3/8	5.34	.44	4.00	9.05	2.06		15.11
16	8 WF 40	11.76	35.35	-5.44	44.15	11.50	6.16	50.21
17	7Γ 4x3-1/2x3/8	5.34	1.42	-2.75	-7.51	-1.71		-11.97
18	8 WF 31	9.12	36.70	.36	.98	.22		1.56
19	7Γ 4x3-1/2x3/8	5.34	6.71	3.55	9.72	2.22		15.49
20	8 WF 40	11.76	115.96	-2.75	50.22	12.88	3.39	60.35
21	7Γ 4x3-1/2x3/8	5.34	.00	.00	.00	.00		.00

TABLE VI. Continued.

Member	Size	Area	Moment	Wind Load	Test Load	Dead-weight	Horiz. Test Only	Total Load
22	8 WF 40	11.76	-10.75	16.08	9.21	7.28		32.57
23	⅂Γ 4x3-1/2x3/8	5.34	-.28	-5.87	.88	2.08		-2.91
24	8 WF 31	9.12	-12.05	-12.15	2.45	5.92		-3.78
25	⅂Γ 4x3-1/2x3/8	5.34	1.05	4.39	-.64	-1.54		-2.21
26	8 WF 40	11.76	-2.48	12.13	9.80	8.68		30.61
27	⅂Γ 4x3-1/2x3/8	5.34	.49	-5.36	.86	-2.09		-2.41
28	8 WF 31	9.12	1.60	-8.53	1.87	4.52		-6.66
29	⅂Γ 4x3-1/2x3/8	5.34	.75	3.99	-.65	-1.57		1.77
30	8 WF 40	11.76	1.62	8.52	10.38	10.08		28.98
31	⅂Γ 4x3-1/2x3/8	5.34	.45	-4.68	.87	2.10		-1.71
32	8 WF 31	9.12	-2.31	-5.38	1.29	3.10		-.99
33	⅂Γ 4x3-1/2x3/8	5.34	.77	3.40	-.63	-1.51		1.26
34	8 WF 40	11.76	-7.14	5.37	10.96	11.50		27.83
35	⅂Γ 4x3-1/2x3/8	5.34	.23	-3.96	.85	2.06		-1.05
36	8 WF 31	9.12	2.39	-2.72	.72	1.72		-.28
37	⅂Γ 4x3-1/2x3/8	5.34	.73	3.21	-.71	-1.71		.79
38	8 WF 40	11.76	-14.64	2.71	11.53	12.88		27.12
39	⅂Γ 4x3-1/2x3/8	5.34	1.83	-3.50	.93	2.22		-.35
40	8 WF 31	9.12	13.57	-.36	.09	.22		
41	8 WF 31	9.12	34.21	-.11	.02	.06		
42	8 WF 31	9.12	149.98	.12	.29	.06		.47

TABLE VI. Concluded

Member	Size	Area	Moment	Wind Load	Test Load	Dead-weight	Horiz. Test Only	Total Load
43	30 WF 172	50.65	See Page 99					
44	30 WF 172	50.65	See Page 99					
45	30 WF 172	50.65	See Page 99					
46	8 WF 31	9.12	-27.86	2.36	7.91	1.84		12.11
47	8 WF 31	9.12	-16.40	-2.33	.92	1.84		
48	8 WF 40	11.76	-34.44	-1.33	52.70	13.41		64.78
49	8 WF 40	11.76	-17.11	1.31	11.60	13.41		26.32
50	8 WF 31	9.12	116.95	-1.85	-5.81	-1.34		-9.00
51	8 WF 31	9.12	50.44	1.83	-.64	-1.34		

SK301-11304-1
Tower Assembly - Fore-Aft Frame

The following calculations are for stress in the members of the frame (see page 103 for member numbers).

General Equation:

$$f = \frac{\text{Moment x 1.5}}{\text{Section Modulus}} + \frac{\text{Total Axial Load x 1.5}}{\text{Area}}$$

Member 19

$$f = \frac{6.71 \times 1.5}{3.0} + \frac{15.49 \times 1.5}{5.34} = 3.36 + 4.36 = 7.72\text{KSI}$$

$$\frac{L}{r} = \frac{226.5}{1.25} = 181 \quad Fa = 6.56$$

Member 20

$$f = \frac{115.96 \times 1.5}{35.5} + \frac{60.35 \times 1.5}{11.76} = 4.92 + 7.70 = 12.62\text{KSI}$$

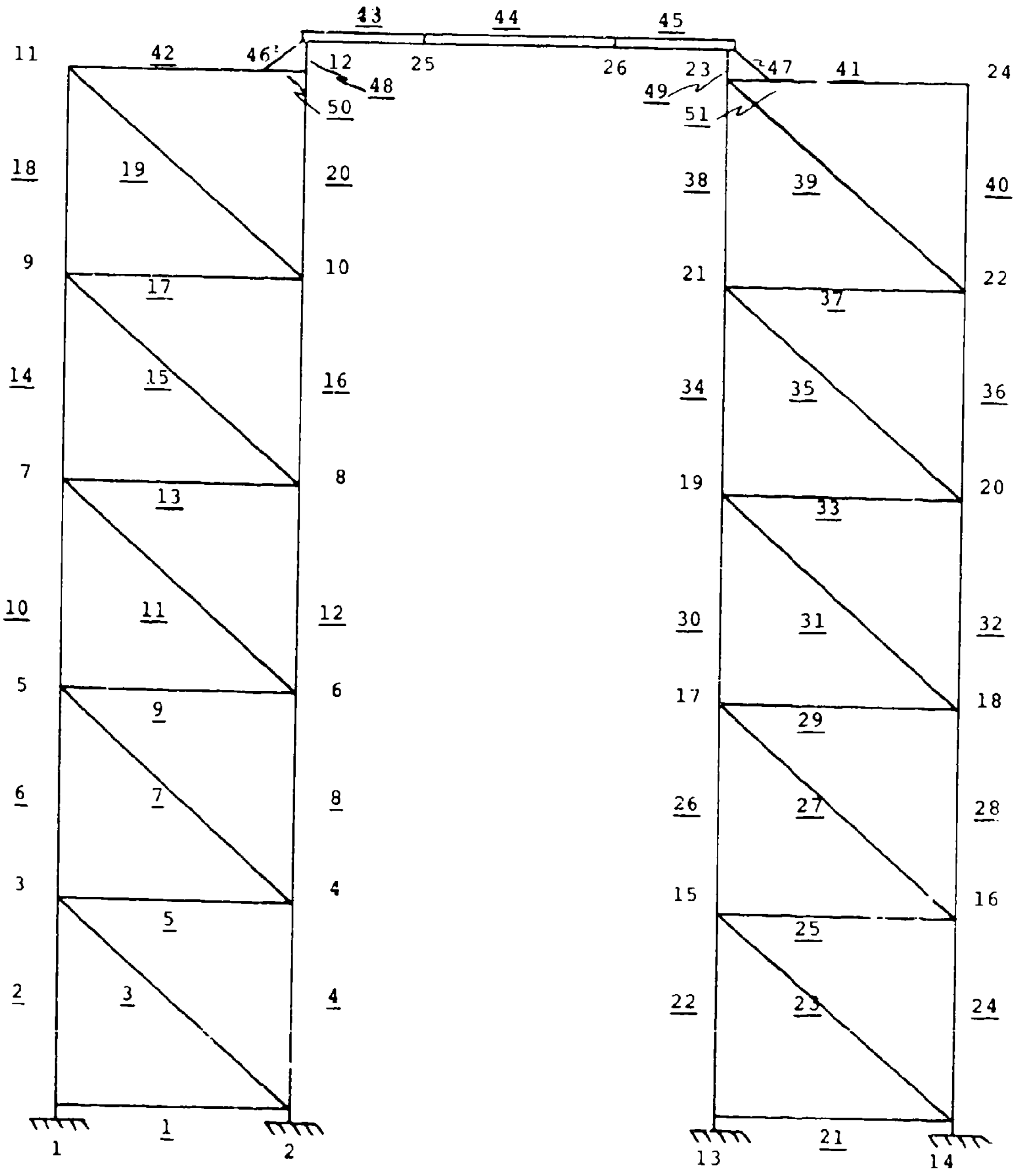
$$\frac{L}{r} = \frac{152}{2.04} = 74.5 \quad Fa = 14.89 \text{ KSI}$$

Member 42

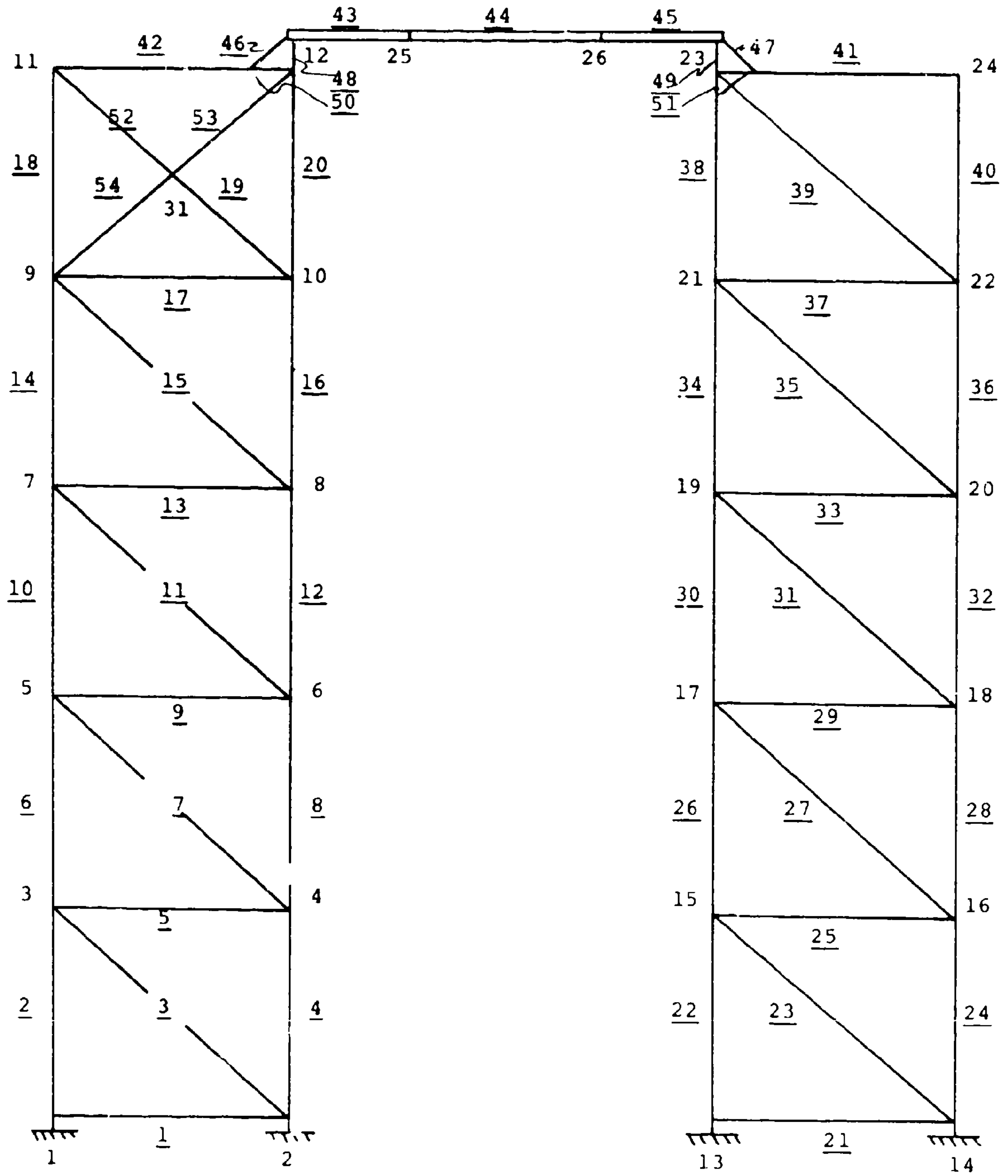
$$f = \frac{149.98 \times 1.5}{27.4} + \frac{.47 \times 1.5}{9.12} = 8.23 + .08 = 8.31\text{KSI}$$

$$\frac{L}{r} = \frac{168}{2.01} = 83.5 \quad Fa = 14.03 \text{ KSI}$$

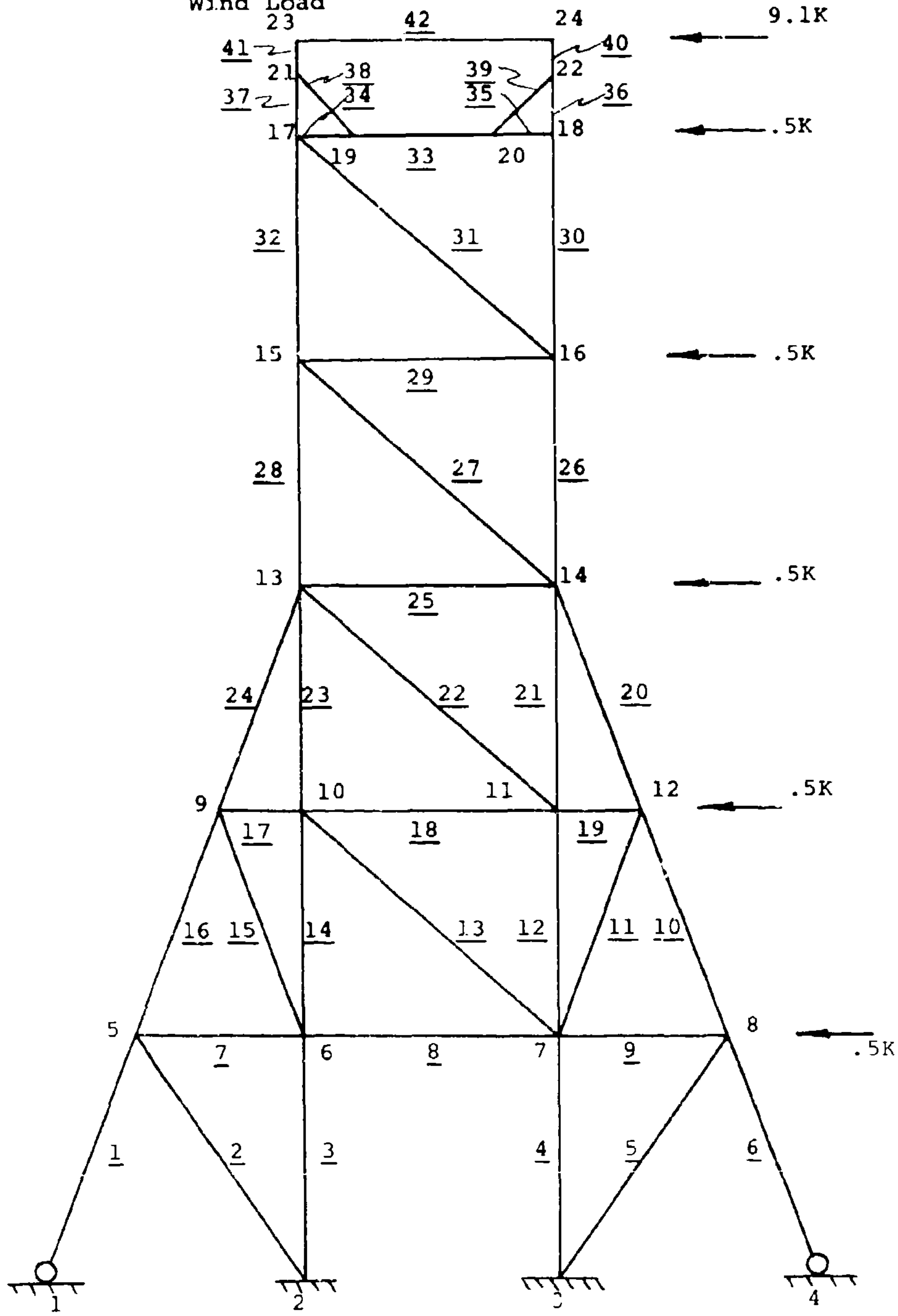
Tower Assembly
(Optional Construction)



Tower Assembly
(Optional Construction)

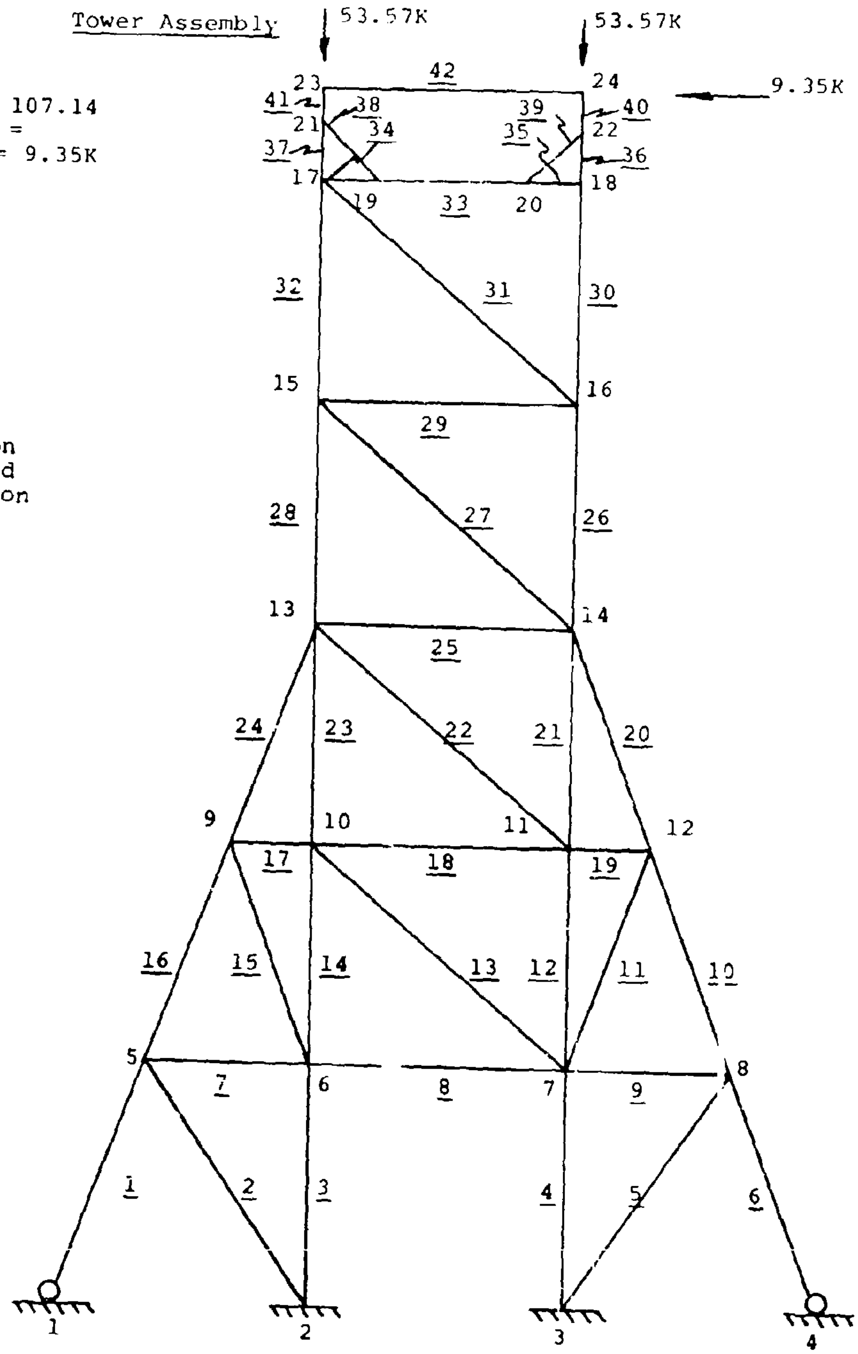


Tower Assembly - Inboard-Outboard Frame
Wind Load



Tower Assembly

53.57 + 53.57 = 107.14
SIN 5° (107.14) =
.0871 (107.14) = 9.35K



Failure Condition
70—ton proof load
26' hoist position

Tower Assembly

Deadweight Load

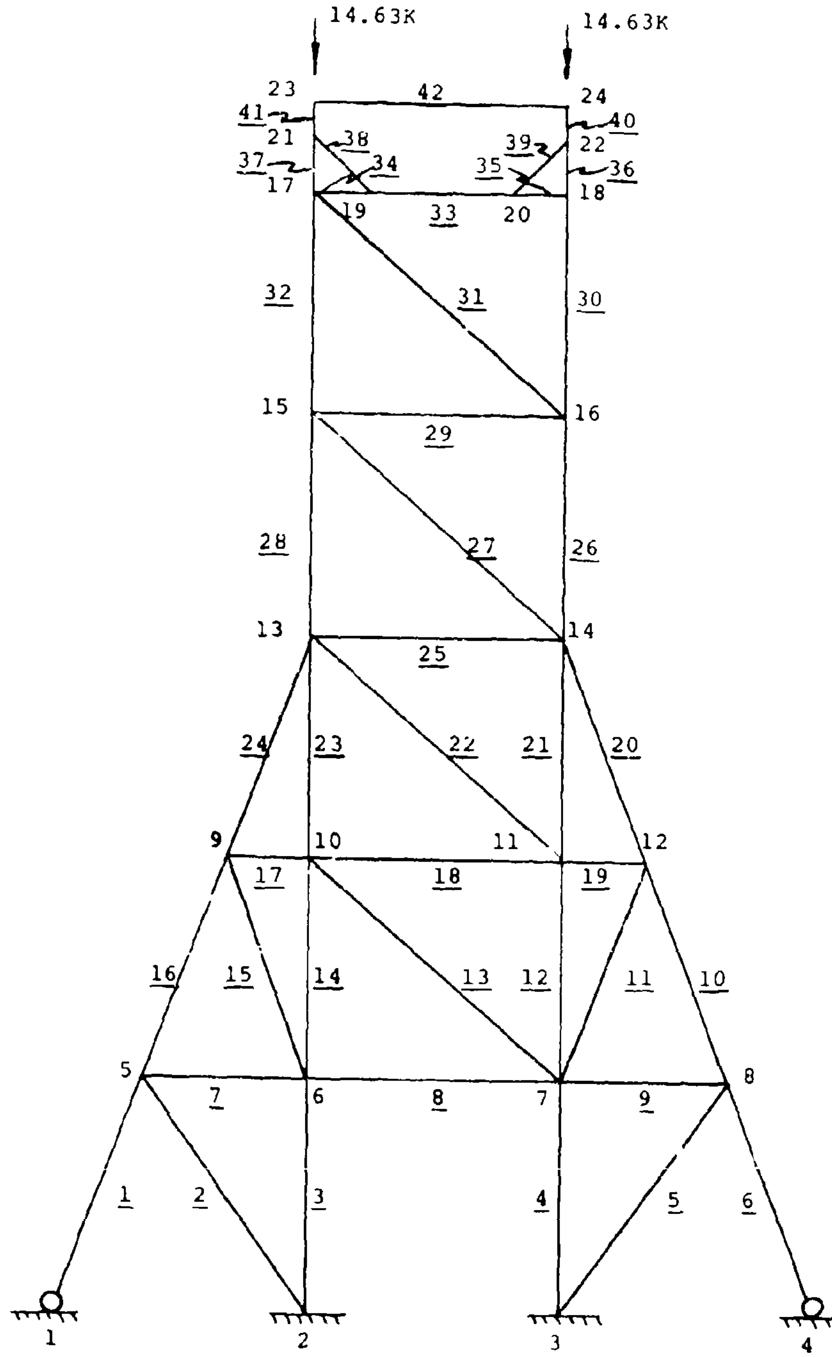


TABLE VII. TOWER ASSEMBLY - INBOARD/OUTBOARD FRAME.

Member	Size	Area	Sect.Mod.	Moment	Wind Ld	Test Ld	Dead-weight	Total
1	10 WF 33	9.71	9.2	Very small	+14.94	31.03	4.89	50.86
2	7Γ 4x3-1/2x3/8	5.34	3.0		-.68	4.38	1.24	4.94
3	8 WF 40	11.76	12.1		+8.72	40.27	8.65	57.64
4	8 WF 40	11.76	12.1		-8.35	28.28	9.92	29.85
5	7Γ 4x3-1/2x3/8	5.34	3.0		1.02	3.92	1.02	5.96
6	10 WF 33	9.71	9.2		-15.63	3.04	4.50	-8.09
7	7Γ 4x3-1/2x3/8	5.34	3.0		.60	-3.90	-1.10	-4.40
8	7Γ 4x3-1/2x3/8	5.34	3.0		.65	-2.01	-.62	-1.98
9	7Γ 4x3-1/2x3/8	5.34	3.0		-.90	-3.48	-.90	-4.78
10	10 WF 33	9.71	9.2		-14.75	6.40	5.37	-2.98
11	7Γ 4x3-1/2x3/8	5.34	3.0		-.19	4.70	1.46	5.97
12	8 WF 40	11.76	12.1		-7.16	23.75	8.36	24.95
13	7Γ 4x3-1/2x3/8	5.34	3.0		-1.52	.19	.03	-1.30
14	8 WF 40	11.76	12.1		8.61	35.08	7.34	51.03
15	7Γ 4x3-1/2x3/8	5.34	3.0		.13	5.55	1.41	7.09
16	10 WF 33	9.71	9.2		14.35	34.77	5.95	55.07
17	7Γ 4x3-1/2x3/8	5.34	3.0		-.07	-3.79	-.97	-4.83
18	7Γ 4x3-1/2x3/8	5.34	3.0		1.09	-3.86	-1.17	-3.94
19	7Γ 4x3-1/2x3/8	5.34	3.0		.62	-3.23	-1.00	-3.61
20	10 WF 33	9.71	9.2		-14.90	11.08	6.81	2.99
21	8 WF 40	11.76	12.1		-6.74	23.21	6.21	24.68

TABLE VII. Concluded.

Member	Size	Area	Sect.Mod.	Moment	Wind Ld	Test Ld	Dead-weight	Total
22	T4x3-1/2x3/8	5.34	3.0	1.11	-.68	.84	.25	.41
23	8 WF 40	11.76	12.1	9.37	7.64	35.29	7.55	50.48
24	10 WF 33	9.71	9.2	1.29	14.44	40.23	7.34	62.01
25	T4x3-1/2x3/8	5.34	3.0	3.71	5.42	13.16	2.34	20.92
26	8 WF 40	11.76	12.1	12.29	-11.67	42.01	14.60	44.94
27	T6x3-1/2x3/8	6.84	6.5	3.50	-13.47	-12.49	.01	-25.96
28	8 WF 40	11.76	12.1	9.06	20.71	73.58	14.60	108.89
29	T4x3-1/2x3/8	5.34	3.0	2.87	10.10	9.36	-.01	19.45
30	8 WF 40	11.76	12.1	22.95	-2.77	50.68	14.58	63.49
31	T6x3-1/2x3/8	6.84	6.5	8.17	-13.20	-12.86	.02	-26.04
32	8 WF 40	11.76	12.1	12.05	11.66	65.16	14.60	91.42
33	8 WF 31	9.12	27.4	246.90	5.15	4.98	.05	10.18
34	8 WF 31	9.12	27.4	5.01	11.80	11.30	-.11	21.99
35	8 WF 31	9.12	27.4	205.44	-1.84	-2.96	-.15	4.95
36	8 WF 40	11.76	12.1	112.70	-6.03	46.58	14.38	54.93
37	8 WF 40	11.76	12.1	97.71	5.91	58.95	14.40	79.81
38	8 WF 31	9.12	27.4	24.51	-8.58	-7.96	.25	-16.29
39	8 WF 31	9.12	27.4	35.46	8.92	10.27	.29	29.48
40	8 WF 40	11.76	12.1	143.68	-.49	53.09	14.60	67.20
41	8 WF 40	11.76	12.1	133.90	.49	54.11	14.60	69.20
42	8 WF 31	9.12	27.4	83.72	4.55	4.52	-.05	9.02

Tower Assembly - Inboard/Outboard Frame

$$f = \frac{M \times 1.5}{S} + \frac{P \times 1.5}{A}$$

Member 1 $f = \frac{50.86 \times 1.5}{9.71} = 7.86$ KSI

$\frac{L}{r} = \frac{162.0}{1.94} = 83.5 \quad F_A = 14.03$ KSI

Member 2 $f = \frac{.90 \times 1.5}{3.0} + \frac{4.94 \times 1.5}{5.34} = .45 + 1.39 = 1.84$ KSI

$\frac{L}{r} = \frac{189}{1.25} = 151 \quad F_A = 7.69$

Member 3 $f = \frac{3.28 \times 1.5}{12.1} + \frac{57.64 \times 1.5}{11.76} = .41 + 7.36 = 7.77$ KSI

$\frac{L}{r} = \frac{152}{2.04} = 74.5 \quad F_A = 14.89$

Member 15 $f = \frac{1.03 \times 1.5}{3} + \frac{7.09 \times 1.5}{5.34} = .52 + 1.99 = 2.51$ KSI

$\frac{L}{r} = \frac{162}{1.25} = 129.6 \quad F_A = 9.30$ KSI

Member 23 $f = \frac{9.37 \times 1.5}{12.1} + \frac{50.98 \times 1.5}{11.76} = 1.16 + 6.44 = 7.60$ KSI

$\frac{L}{r} = 74.5 \quad F_A = 14.89$ KSI

Member 24 $f = \frac{1.29 \times 1.5}{9.2} + \frac{62.01 \times 1.5}{9.71} = .21 + 9.58 = 9.79$

$\frac{L}{r} = 83.5 \quad F_A = 14.03$

Member 25 $f = \frac{3.71 \times 1.5}{3.0} + \frac{20.92 \times 1.5}{5.34} = 1.85 + 5.88 = 7.73\text{KSI}$

$\frac{L}{r} = \frac{168}{1.25} = 134 \quad F_A = 8.94$

Member 28 $f = \frac{9.06 \times 1.5}{12.1} + \frac{108.89 \times 1.5}{11.76} = 1.12 + 13.90 = 15.02\text{KSI}$

$\frac{L}{r} = \frac{152}{2.04} = 74.5 \quad F_A = 15.90$ KSI (A-36 steel)

Member 31 $f = \frac{8.17 \times 1.5}{6.5} + \frac{26.04 \times 1.5}{6.84} = 1.88 + 5.50 = 7.38\text{KSI}$

<u>Over</u>

$\frac{L}{r} = \frac{227}{1.39} = 163 \quad F_A = 7.16$ KSI

Member 32 $f = \frac{12.05 \times 1.5}{12.1} + \frac{91.42 \times 1.5}{11.76} = 1.49 + 11.65 - 13.14\text{KSI}$

$\frac{L}{r} = 74.5 \quad F_A = 15.90$ KSI

Member 35 $f = \frac{205.4 \times 1.5}{27.4} + \frac{4.95 \times 1.5}{9.12} = 11.24 + .81 = 12.05\text{KSI}$

$\frac{L}{r} = \frac{38.0}{1.61} = 23.6 \quad F_A = 20.35$ KSI

Maximum Stress in Main Vertical Columns

f = f(Inbd-Outbd Frame)+ f(Fwd-Aft Frame Horiz.Test Only)

Member 28 $f = 15.02 + \frac{6.16 \times 1.5}{11.76} = 15.80$ KSI

$\frac{L}{r} = \frac{152.0}{2.01} = 75.62 \quad F_A = 15.90$ KSI

SK301-11304-1
Tower Assembly - Column Splice - Friction

Design splice load = 70.98 x 1.5 = 106.4K
(Max.load) 70.98 = 8.97 + 62.01

16 Ea. 3/4 Dia. Bolts/Splice

Friction Load/Bolt = 19.2K(.35) = 6.73K

16 x 6.73K = 107.6K

(2) 3/4 x 9.0 Plate A = 13.5 $In.^2$

$$f = \frac{P}{A} = \frac{106.4}{13.5} = 7.88 \text{ KSI}$$

32 In. of 3/8 Fillet Weld (3.6 K/In.) = 115K

Diagonal Strut Splice - Friction

Design Splice Load = 16.06 x 1.5 = 24.1K
(Max.load)

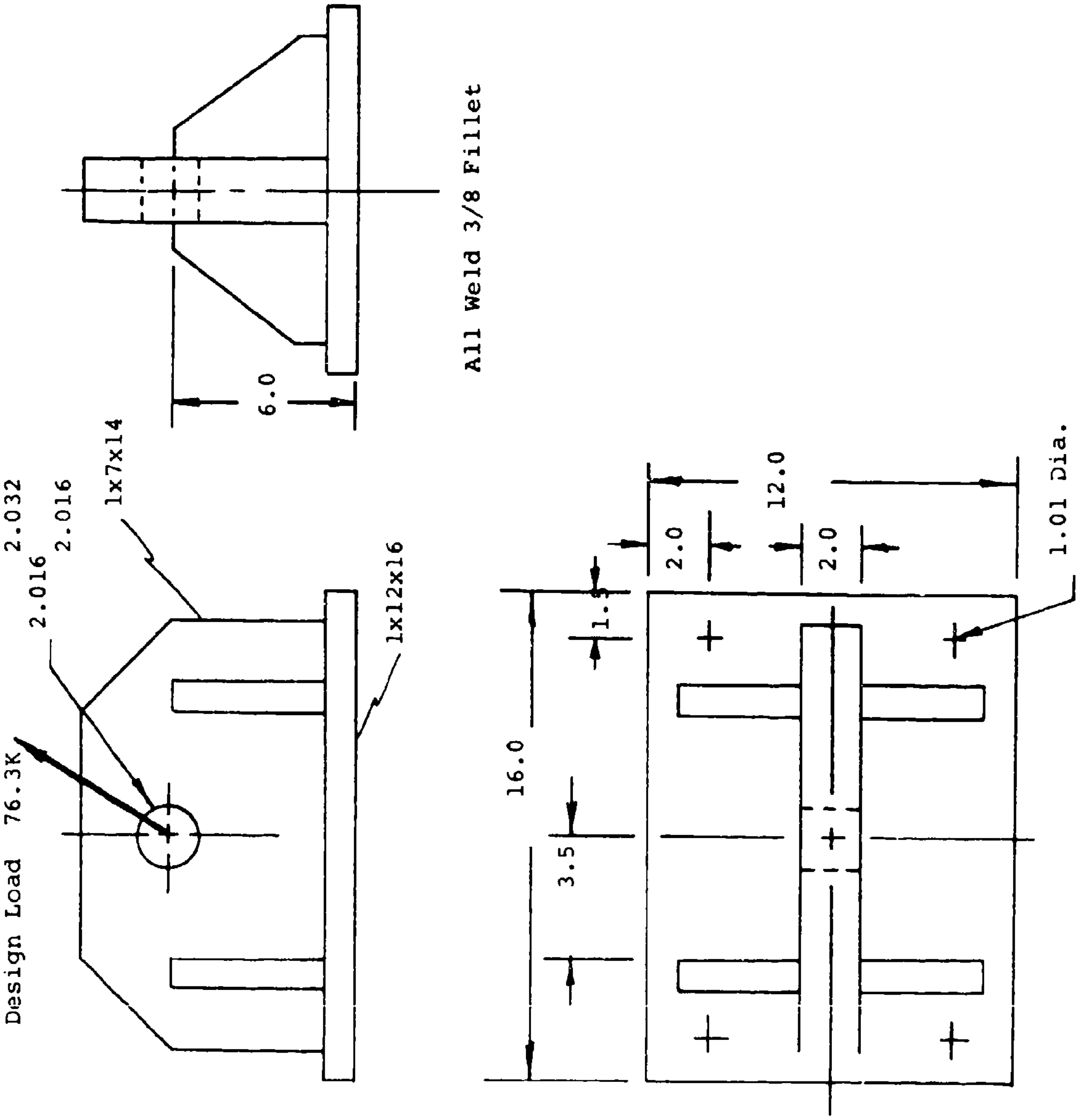
(2) Ea. 3/4 Dia. Bolts/Splice - Double Friction

Friction Load/Bolt = 2 x 6.73 = 13.46K

2 Bolts = 26.92K

SK301-11304-10

Outrigger Base Plate Assembly



SK301-11304-10 Assembly
-82 Assembly
Outrigger Tiedown Assembly

-1C Assembly Shear Out

Shear Area - 1.5 x 2 x 2 = 6.0 $In.^2$

Shear Stress = $\frac{P}{A} \quad \frac{76.3}{6} = 12.7$ KSI

Tension at 2.0 Diameter Hole -82 Assembly

Area = 2 x 3 = 6.0 $In.^2$

$$f_f = \frac{P}{A} = \frac{76.3}{6.0} = 12.7 \text{ KSI}$$

Double Shear Pin 2.0 Diameter A307

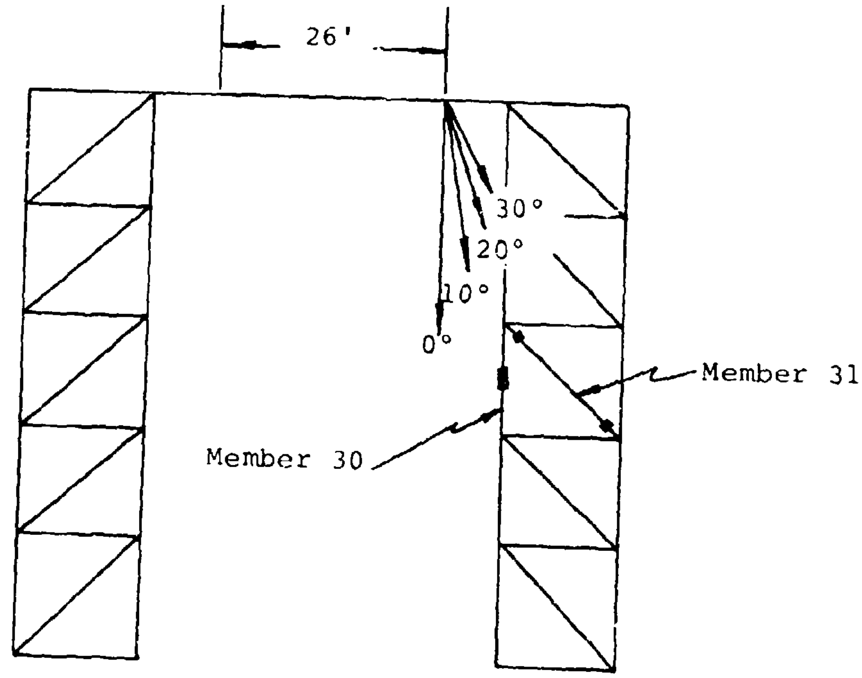
$A = 2 \quad r^2 = 6.28$ $In.^2$

$$S = \frac{P}{A} = \frac{76.3}{6.28} = 12.14 \text{ KSI}$$

Inches of 3/8 Inch weld required.

$$\frac{76.3}{3.6} = 21.2 \text{ In.}$$

Failure Loads @ 0°, 10°, 20° & 30°
Single-Point - 26-Ft Hoist Position



	Location of Failure
Failure Load 0° -- 537.0K	Member 30 Friction splice in main vertical column (8 WF 40)
Failure Load 10° -- 297.0K	Member 31 Friction splice in diagonal brace
Failure Load 20° -- 180.0K	Member 31 Friction splice in diagonal brace
Failure Load 30° -- 135.0K	Member 31 Friction splice in diagonal brace

Towers would not collapse from these failure conditions.

Failure Loads

$$F_{cr} = \frac{C\pi^2 E}{\left(\frac{L}{r}\right)^2} = \text{Critical stress}$$

Use a value for c of 1.5 which corresponds to an effective length of .815L in the x-x axis.

K = 1.0 in the y-y axis

x-x Axis

$$F_{cr} = \frac{286 \times 10^6}{\left[\frac{.815(226)}{1.25}\right]^2} = 13 \text{ KSI}$$

y-y Axis

$$Fcr = \frac{286 \times 10^6}{\left[\frac{226}{1.56}\right]^2} = 13.6 \text{ KSI}$$

x-x Axis is critical Fcr = 13.0 KSI for double angle struts

30° Load Angle

Moment in diagonal member - 9.10 In. K
Axial load in diagonal member - 20.92K
Above values are member loads as a result of a 50K load applied on fwd-aft frame.

$$fa = \frac{P}{A} = \frac{20.92}{5.34} = 3.92 \text{ KSI}$$

$$fb = \frac{M}{S} = \frac{9.10}{3.0} \frac{\text{In K}}{\text{In}^3} = 3.03 \text{ KSI}$$

$$(3.03 + 3.92)\,x = 13.0 \text{ KSI}$$

$$x = \frac{13.0}{6.95} = 1.87$$

50K(1.87) = 93.40K/Frame
93.40K(2) = 186.80K total failure load

20° Load Angle

Member loads as a result of a 50K load applied on fore-aft frame:

$M = 6.82$ In. K
$P = 15.65$ K

$$f_b = \frac{M}{S} = \frac{6.82}{3.0} = 2.27 \text{ KSI}$$

$$fa = \frac{P}{A} = \frac{15.65}{5.34} = 2.94 \text{ KSI}$$

$$(2.27 + 2.94)x = 13.0 \text{ KSI}$$

$$x = \frac{13.0}{5.21} = 2.49$$

50K(2.49) = 125K/Frame

250K total failure load

10° Load Angle

Member loads as a result of a 50K load applied on fore-aft frame:

$M = 4.12$ In. K
$P = 9.5$ In. K

$$f_b = \frac{M}{S} = \frac{4.12}{3.0} = 1.37 \text{ KSI}$$

$$fa = \frac{P}{A} = \frac{9.5}{5.34} = 1.78 \text{ KSI}$$

$$(1.37 + 1.78)x = 13.0 \text{ KSI}$$

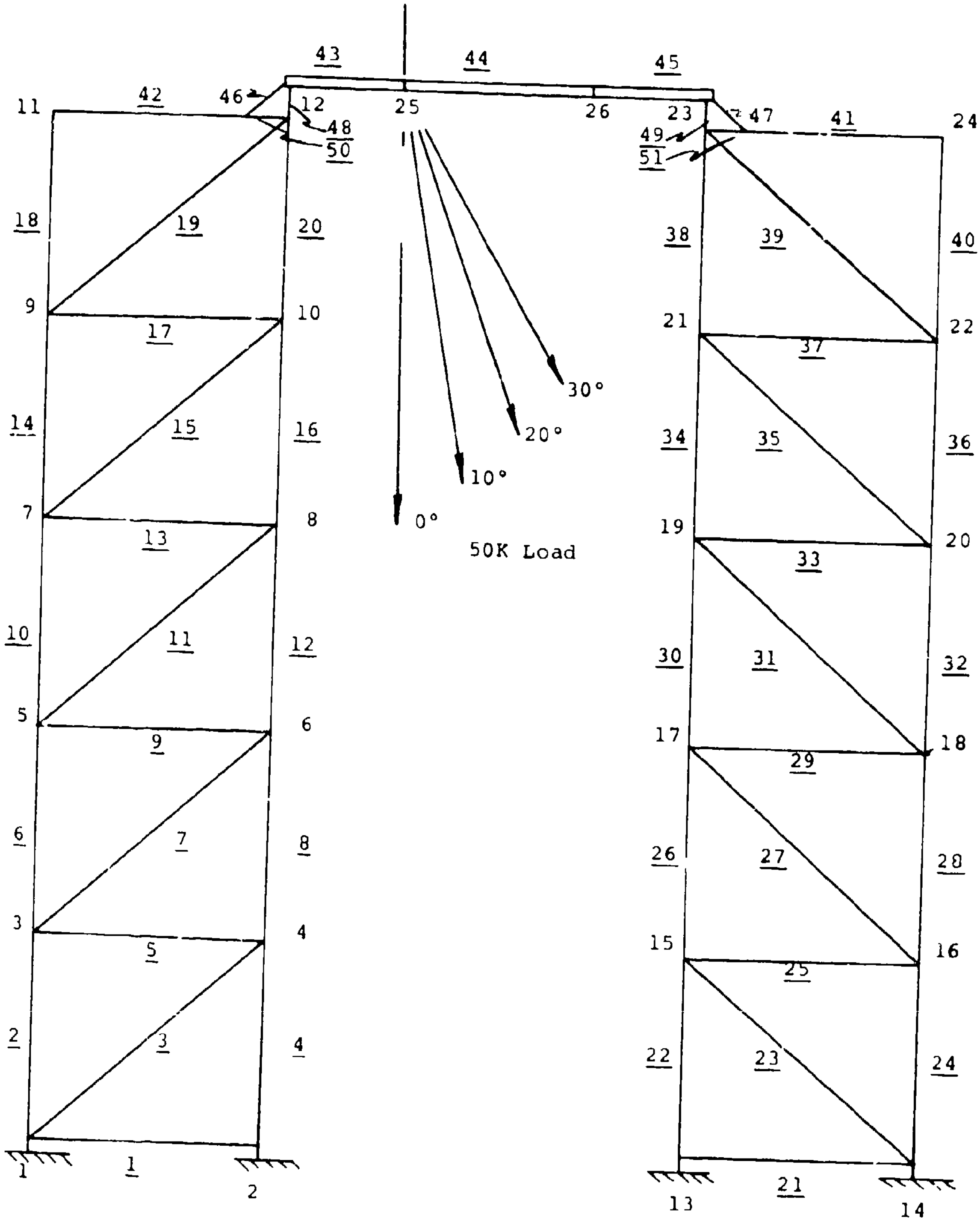
$$x = \frac{13.0}{3.15} = 4.12$$

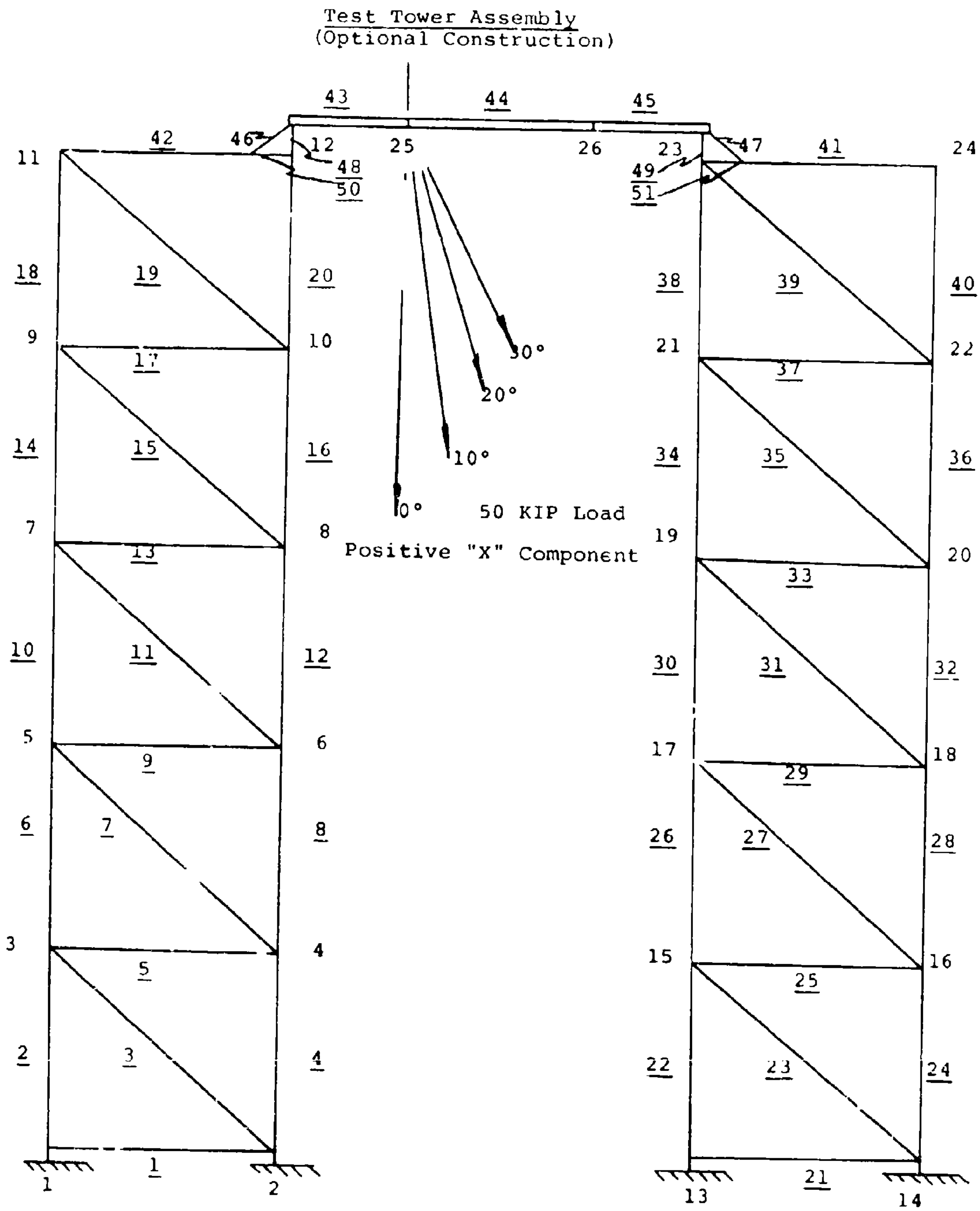
50K x 4.12 = 206 K/Frame
412K Total failure load

0° Load Angle

412K total failure load

Test Tower Assembly




Test Tower Assembly
(Optional Construction)
50 KIP Load
Positive "X" Component
0°
10°
20°
30°

Foundation Requirements

The following pages show foundation requirements in KIPS. In the load column, five separate load requirements are listed:

1. Foundation requirements as a result of side wind loads.

2. Foundation requirements as a result of test failure loads.

3. Foundation requirements as a result of positive or negative horizontal component of test load in the fore-aft direction.

4. Foundation requirements as a result of deadweight of overhead structure.

5. Foundation requirements as a result of deadweight of tower.

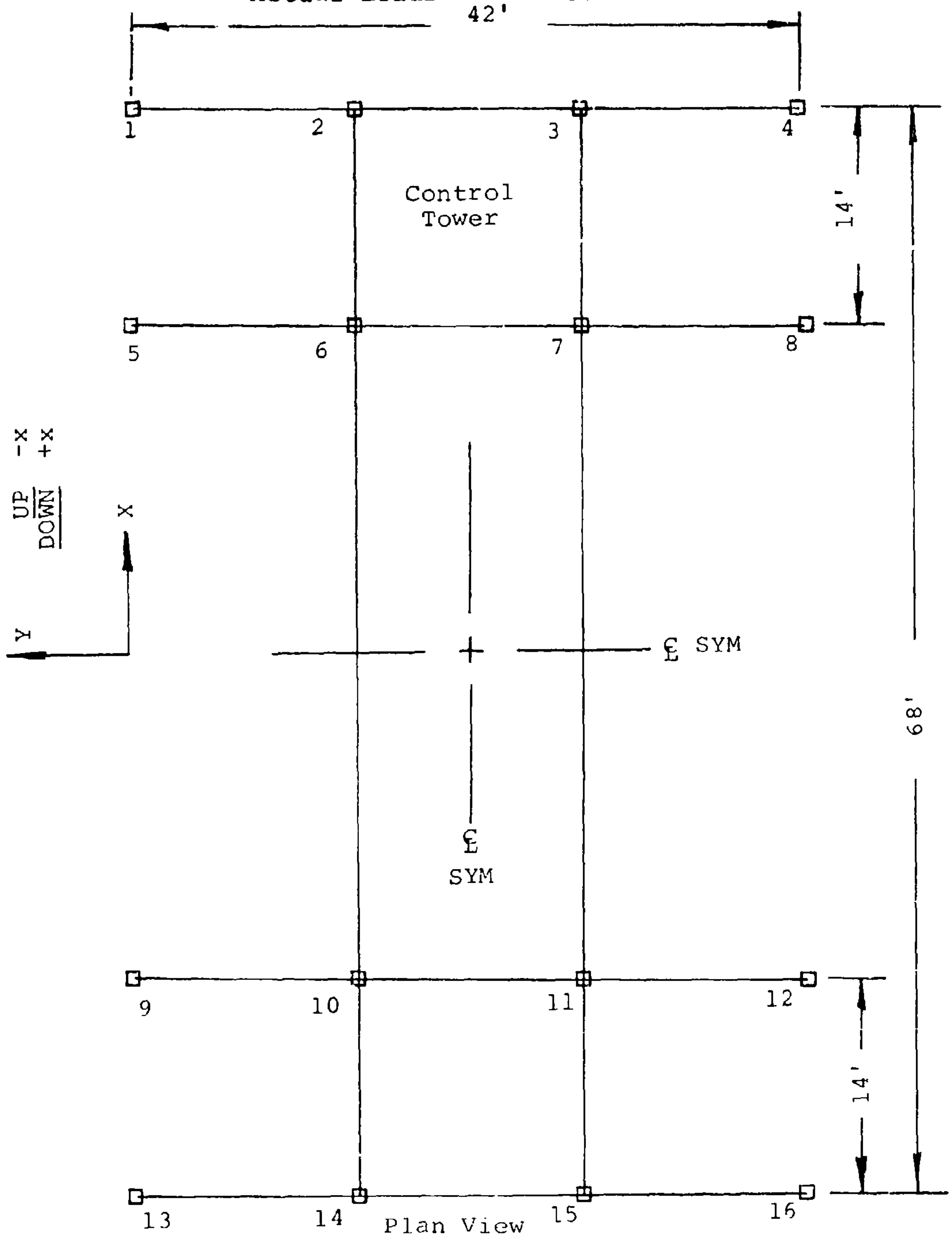
All horizontal loads are considered to be reversible, and therefore maximum foundation requirements are symmetrical about ℄ in both X and Y planes.

Load Table VIII is the same as load Table IX except that the horizontal component of test load is reversed.

Table X shows foundation requirements as a result of the empty load container swinging into the tower at maximum possible height of 58 feet. This condition results in maximum uplift requirement.

Foundation Loads

Actual Loads - No Factors



Plan View

TABLE VIII. REACTION LOADS - 70-TON FAILURE CONDITION.

	Column No. ○ (KIPS)							
	①		②		③		④	
	X	Z	X	Z	X	Z	X	Z
(1) Wind Load	2.57	6.99	.19	3.88	.24	-3.30	2.79	-7.57
(2) Test Load		4.47		14.01		10.05		3.22
(3) + Horiz.Comp.Test			-3.09	-14.56	-3.09	-14.56		
(4) Deadwt. Overhead				4.28		4.48		
(5) Deadwt. Tower				10.70		10.70		
TOTAL	2.57	11.46	-2.90	18.31	-2.85	7.37	2.79	-4.35
	⑤		⑥		⑦		⑧	
(1)	5.17	14.02	.42	8.18	.62	-7.53	5.40	-14.67
(2)	10.73	29.12	-2.59	29.80	2.33	21.40	-1.05	2.85
(3)			.01	14.56	-.01	14.56		
(4)		2.85		7.12		7.48		2.99
(5)				10.70		10.70		
TOTAL	15.90	45.99	-1.96	70.36	2.94	46.61	4.35	-8.83

TABLE IX. REACTION LOADS - 70-TON FAILURE CONDITION.

	①		②		③		④	
(1) Wind Load	2.57	6.99	.19	3.88	.24	-3.30	2.79	-7.57
(2) Test Load		4.47		14.01		10.05		3.22
(3) -Horiz.Comp.Test			3.09	14.56	3.09	14.56		
(4) Deadwt. Overhead				4.28		4.48		
(5) Deadwt. Tower				10.70		10.70		
TOTAL	2.57	11.46	3.28	47.43	3.33	36.49	2.79	4.35
	⑤		⑥		⑦		⑧	
(1)	5.17	14.02	.42	8.18	.62	-7.53	5.40	-14.67
(2)	10.73	29.12	-2.59	29.80	2.33	21.40	-1.05	2.85
(3)			.01	-14.56	-.01	-14.56		
(4)		2.85		7.12		7.48		2.99
(5)				10.70		10.70		
TOTAL	15.90	45.99	-2.16	41.24	2.94	17.49	3.35	-8.83

TABLE X. REACTION LOADS - IMPACT OF LOAD CONTAINER ON TOWER.

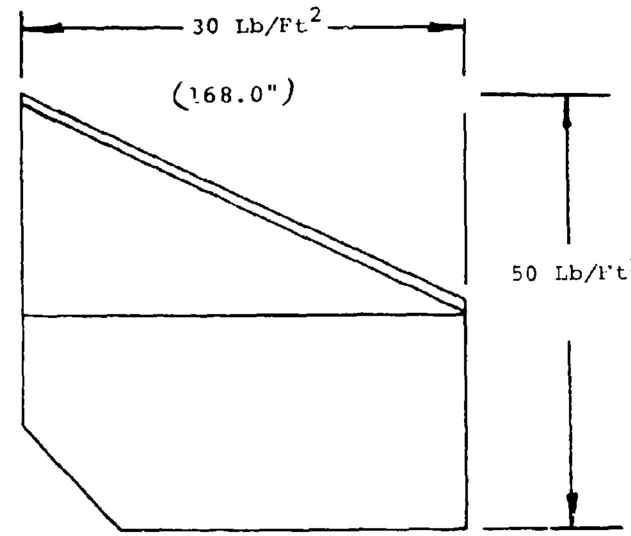
	Column No. ◯ KIPS							
	①		②		③		④	
	X	Z	X	Z	X	Z	X	Z
(1) Impact Load		22.6		52.7		52.7		22.6
(2) Deadweight		15.5		11.0		11.0		5.5
TOTAL		28.1		63.7		63.7		28.1
	⑤		⑥		⑦		⑧	
(1)		-22.6		-52.7		-52.7		-22.6
(2)		5.5		11.0		11.0		5.5
TOTAL		-17.1		-41.7		-41.7		-17.1
	⑨		⑩		⑪		⑫	
(1)		22.6		52.7		52.7		22.6
(2)		5.5		11.0		11.0		5.5
TOTAL		28.1		63.7		63.7		28.1
	⑬		⑭		⑮		⑯	
(1)		-22.6		-57.7		-52.7		-22.6
(2)		5.5		11.0		11.0		5.5
TOTAL		-17.1		-41.7		-41.7		-17.1

(1) 8.0K weight moving horizontally strikes tower at a velocity of 20.6 Ft/Sec. Resulting reaction at base of tower is shown in KIPS.

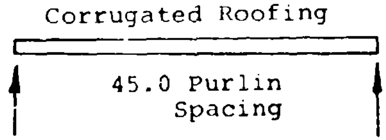
(2) Deadweight of overhead steel and deadweight of tower acting at base of tower in KIPS.

TABLE XI DEADWEIGHTS.				
Dwg. No.	Nomenclature	Qty.	Dead Wt/Assy.	Total Dead Wt.
SK301-11304-1	Tower Assy.	1	38723	38723
SK301-11304-2	Tower Assy.	1	42750	42750
SK301-11302-1	Hoist Module	2	2470	4940
-2	Davit Mount	1	6207	6207
-3	Module Support	2	6274	12548
-4	Platform Assy.	1	831	831
-6	Platform Assy.	1	831	831
SK301-11302-5	Beam Assy.	2	8081	16162
—	—	—	—	—
Test Hoist		2	1700	3400
Aux. Hoist		1	3365	3365
Mast		1	3965	3965
—	—	—	—	—
TOTAL				133,722#

Control Room Shelter



Control room shelter designed for a 50-Lb/Ft^2 wind load on projected frontal area. Roof is designed for 30-Lb/Ft^2 snow load on vertical projected area.



Standard 2-2/3 x 1/2
Galvanized Corr. Sheet

$$M = \frac{Wl^2}{8} = \frac{2.5\ \text{Lb/In.}\,(45)^2}{8}$$

$$M = .634\ \text{In. K}$$

$$f = \frac{M}{S} = \frac{.634}{.0532} = 11.9\ \text{KSI}$$

$$S = .0532\ \text{In.}^3 \text{ per ft of width}$$

Control Room Shelter

5.0 Lb	Snow
.6	
5.6 Lb	

Roof Load/Running In. of Rafter

180" 3[4.1 Lb/Ft

$$M = \frac{Wl^2}{8} = \frac{5.6(180)^2}{8} = 22.7 \text{ In-Lb}$$

$$f = \frac{M}{S} = \frac{22.7}{1.1} \text{ In. K} = 20.6 \text{ KSI}$$

Wind Load/Stud

100 Lb/Ft 8.32 Lb/In.

84" 3[4.1 Lb

$$M = \frac{Wl^2}{8} = \frac{8.32(96)^2}{8} = 9.6 \text{ In. K}$$

$$f = \frac{M}{S} = \frac{9.6}{1.1} = 8.73 \text{ KSI}$$

Sill Wind Load

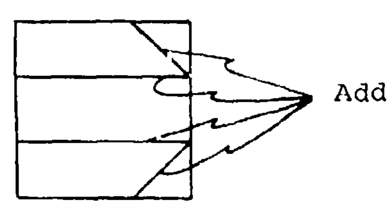
250 Lb/Ft. 20.8 Lb/Ft

168.0 3x3x3/16 Sq Tube

$$M = \frac{Wl^2}{8} = \frac{20.8(168)^2}{8} = 73.3 \text{ In. K}$$

$$f = \frac{M}{S} = \frac{73.3}{1.732} = 42.3 \text{ KSI}$$

Add Horizontal Braces @ 8-Ft Level



APPENDIX II
DRAWINGS - DESIGN LAYOUTS

The integrated test rig is described by the following drawings which are provided as the listed figures.

Figure	Drawing No.	Title
49	SK301-11277	Structures Installation - HLH Hoist Test
50	SK301-11304	HLH Hoist Tower Assembly
51	SK301-11302	HLH Overhead Assembly
52	X72-002-AS-YD3/1	Site Plan - Paving and Utilities, Plan and Sections
53	X72-002-AS-YD3/2	Foundations - Plans, Sections and Details
54	X73-003-AS-YD3/2	Pneumatic Power Generator Shelter HLH/ATC Cargo Handling System
55	X73-003-AS-YD3/3	Control Room Plans, Elevations and Section
56	X73-003-AS-YD3/4	Control Room Section and Details
57	V73-003-AS-YD3	Removable Handrail Details
58	X73-003-M-YD3/1	Piping Arrangement, Test Tower Top Section
59	X73-003-M-YD3/2	Piping Arrangement, Test Tower Base
60	X73-003-M-YD3/3	Fuel Piping Arrangement - PPG Unit
61	V73-001-E-YD3	Electrical Single Line Diagram
62	X73-003-E-YD3/1	Electrical HLH/ATC Cargo Handling Test Rig
63	X73-003-E-YD3/2	Control Room Electrical Layout
64	SK301-11564	Load Controlling Crewman Platform - Integrated Test Rig

Figure	Drawing No.	Title
65	SK301-11676	System Test - Drawing Tree
66	ST40972	Lifting Sling, Hoist/Module
67	ST51273-1	Hoist Lifting Fixture
68	SK301-11694	Integrated Test Rig - System Wiring
69	ST30861	Instrumentation Drawing Tree

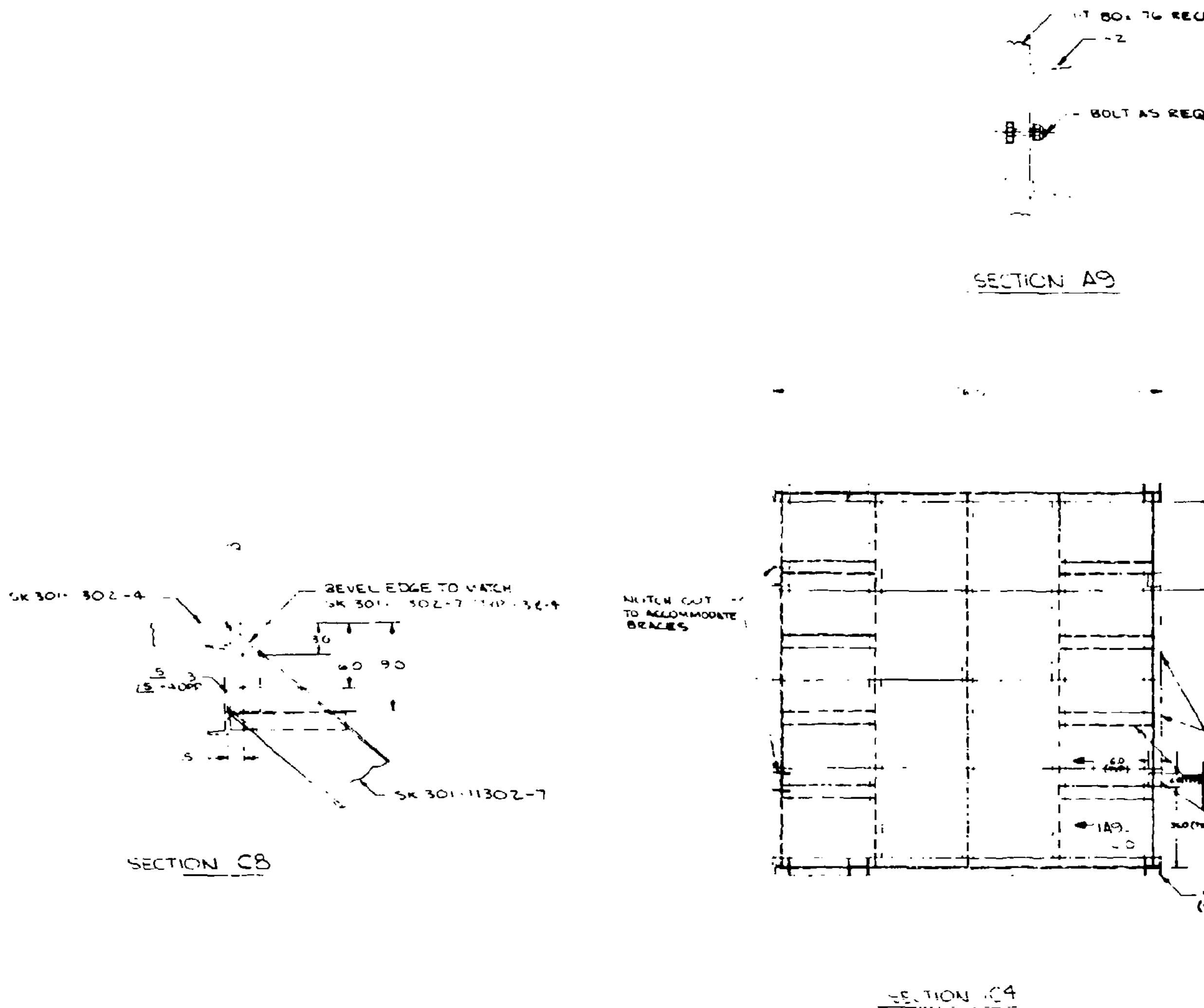
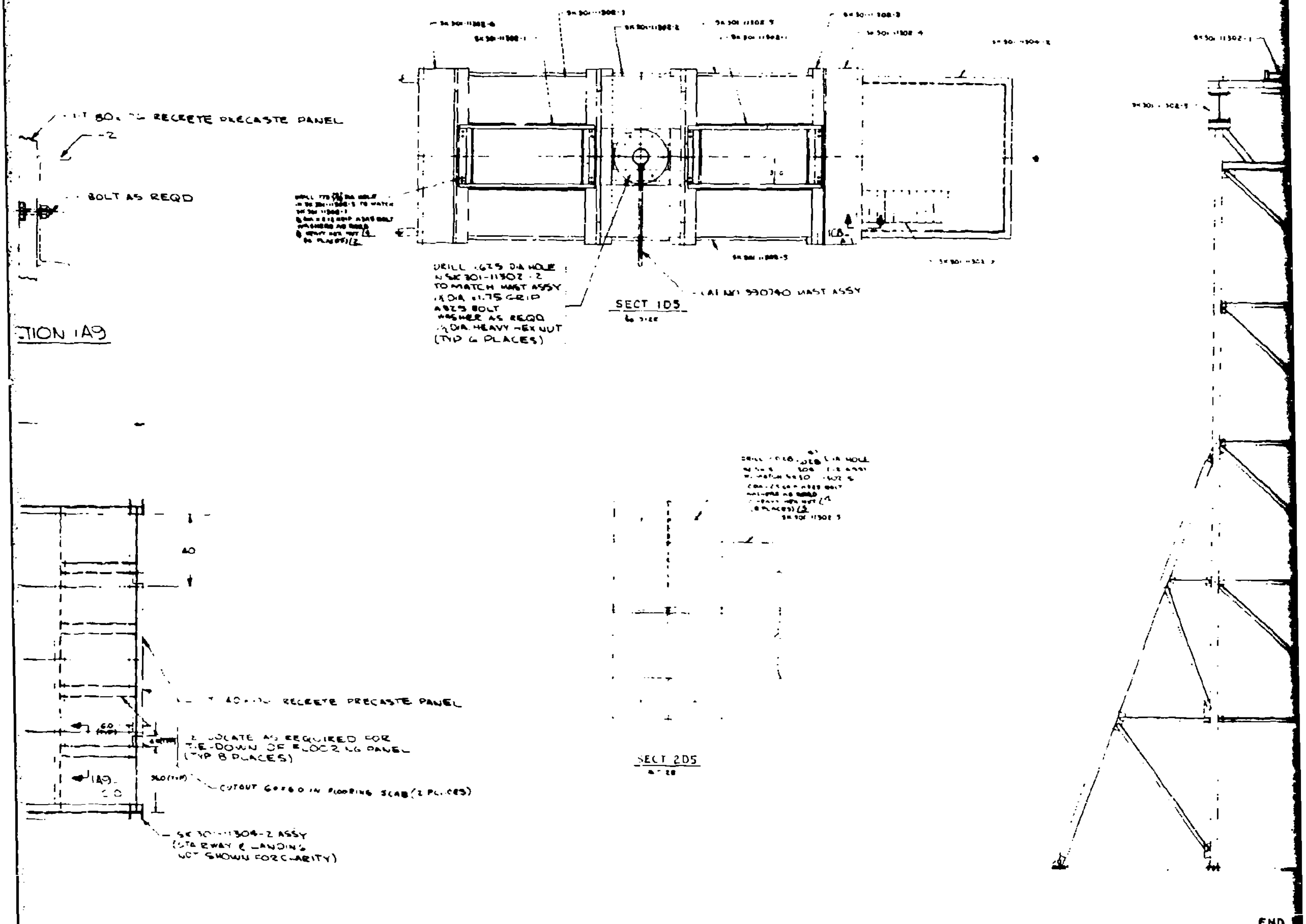
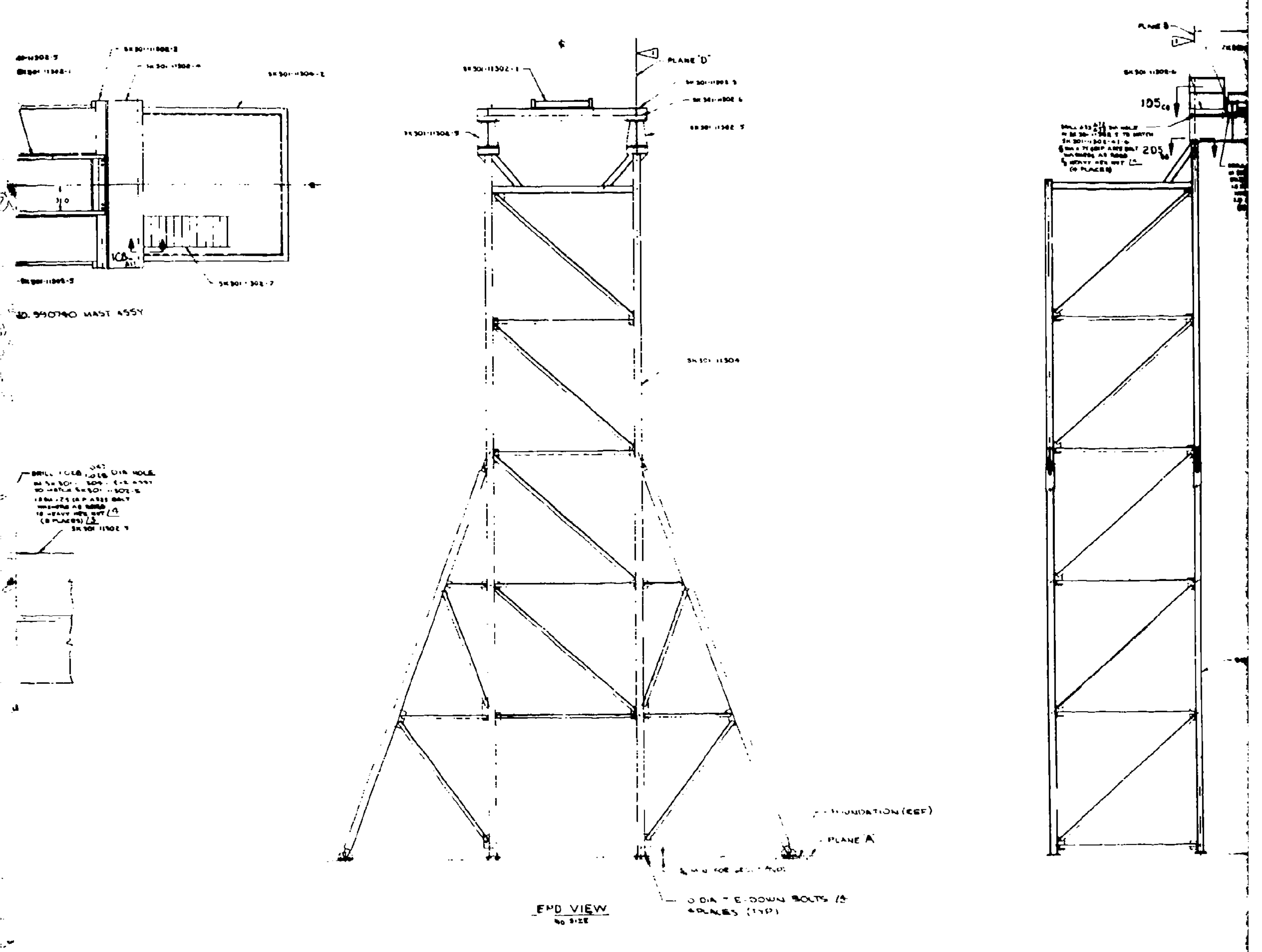


Figure 49. Structures Installation - HLH Hoist Test.

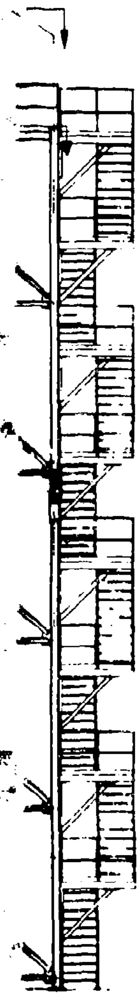


SK301-11277 | 1

B


PLANE 'D'
SK301-11304
FOUNDATION (REF)
PLANE 'A'
END VIEW
NO SIZE
MAST ASSY
CAT.

SK301-112



GENERAL NOTES:

1. ALL FABRICATION & ERECTION PER AISC SPECIFICATIONS.
2. SEE VERTOL WORK STATEMENT FOR FINISH PAINT COLOR REQUIREMENTS

⚠ PLANE 'B', PLANE 'C' & PLANE 'D' TO BE PERPENDICULAR TO PLANE 'A' WITHIN ±1.0 IN 81.0

⚠ SHIM AS REQD TO PROVIDE PROPER ALIGNMENT OF SK 301-11302-1 HOIST MODULE

⚠ SHIM (F) AS REQD TO INSURE PROPER ALIGNMENT OF SK 301-11302-5

⚠ TORQUE PER AISC SPECIFICATIONS.

⚠ WELD TO SK 301-11302-4 AND BOLT TO SK 301-11302-7 WITH ⅝ DIA. BOLTS.

1	-4	-1302-3		
4	1 40 x [illegible]	[illegible]		[illegible] STEEL PRODUCTS COMPANY
1	CAT NO 990740	JIB CRANE		[illegible] CRANE, HOIST & TOWER DIVISION
[illegible]	1⅛	NUT		HEAVY HEX
40	1	NUT		HEAVY HEX
6	¾	NUT		HEAVY HEX
8	⅝	NUT		HEAVY HEX
16	[illegible] DIA x [illegible] GRIP	BOLT		A325 HEX HD
16	[illegible] DIA x [illegible] GRIP	BOLT		A325 HEX HD
8	1 DIA x [illegible] GRIP	BOLT		A325 HEX HD
16	¾ DIA x [illegible] GRIP	BOLT		A325 HEX HD
8	⅝ DIA x .75 GRIP	BOLT		A325 HEX HD
6	1⅛ DIA x 1.75 GRIP	BOLT		A325 HEX HD
1	-4	ANGLE		3 x 3 x ¼ [illegible] x 3 [illegible]
8	-2	CHANNEL		6 C 8.2 #/FT x 40.0
1	SK301-11302-7	STAIRWAY ASSY	04	
1	SK301-11302-6	PLATFORM ASSY	05	
2	SK301-11302-5	BEAM ASSY	04	
1	SK301-11302-4	PLATFORM ASSY	04	
2	SK301-11302-3	WORK PLATFORM ASSY	04	
1	SK301-11302-2	DAVIT MOUNTING ASSY	04	
2	SK301-11302-1	HOIST MODULE ASSY	09	
[illegible]	SK301-11304-2	TOWER ASSY	04	
1	SK301-11304-1	TOWER ASSY	05	
—	-1	STRUCTURES INSTL		

PARTS LIST

L. WEBER

STRUCTURES INSTL - HLH HOIST TEST

J 77272 SK301-11277

2

1

APPLICATION

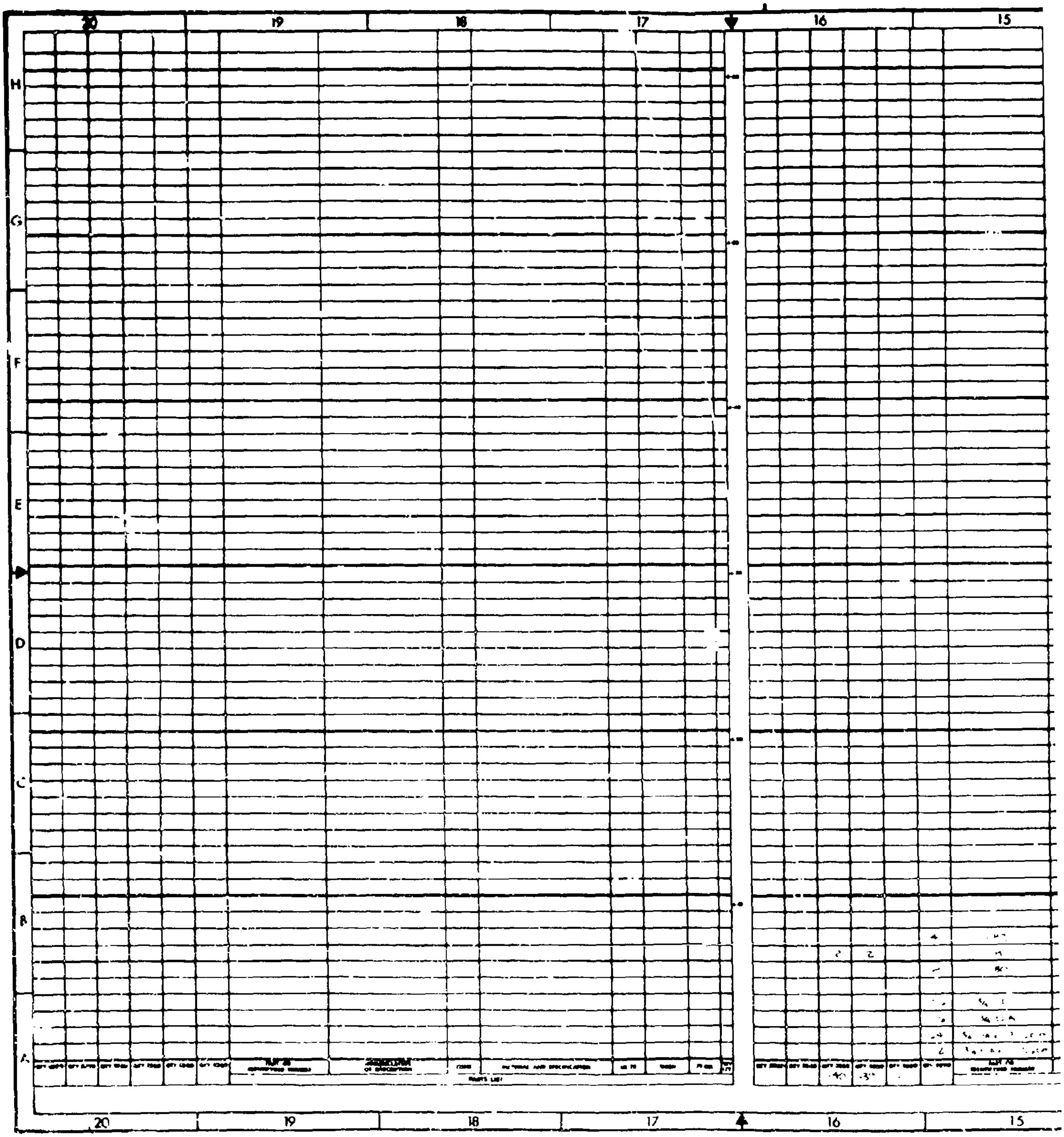


Figure 50. HLH Hoist Tower Assembly (Sheet 1)

A

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15	14	13

Part or Identifying Number	Nomenclature or Description	Zone	Material and Specification
-82	OUTRIGGER STRUT ASSY		
-81	ANGLE		3 x 3 x ... x 5.0 A36 STEEL
-80	GUSSET		.375 x ... A36 STEEL
1/4 - [illegible]	LAT WASHER		
3/4 DIA	HEAVY HEX NUT		
DIA x [illegible]	A 307 STEEL [illegible]		
DIA x [illegible]	[illegible]		

PARTS LIST

Qty Reqd -44	Qty Reqd -39	Qty Reqd -38	Qty Reqd [illegible]	Qty Reqd [illegible]	Qty Reqd	Part or Identifying Number	Nomenclature or Description	Material and Specification
					6	3/16 DIA x 3.0	COTTER PIN	
					8	-78	PIN (OR EQUIV)	2.0 DIA x 7.0 ASTM A307 STEEL
						4 DIA x 75 FT	STANDARD PIPE	
						[illegible] FT	STANDARD PIPE	
				[illegible]		[illegible] FT	FIR / PINE	CONSTRUCTION GRADE
					4	[illegible]	LUG	.375 x [illegible] A36 STEEL
					8	-76	SPLICE PLATE	.75 x 9.0 x 20.0 A36 STEEL
		3				[illegible]	SPACER	[illegible] STD PIPE [illegible] A36 STEEL
2	2					4.0 [illegible] x 70.0 LONG	GRIP STRUT SAFETY GRATING	A M CASTLE & CO
1						5 2 01L x 30.0 LONG	GRIP STRUT SAFETY GRATING	A M CASTLE & CO
8						8 2 01L x 30.0 LONG	GRIP STRUT SAFETY GRATING	A M CASTLE & CO.
3	3					3 2 01L x 70.0 LONG	GRIP STRUT SAFETY GRATING	A M CASTLE & CO.
					6	2.0 D.	WASHER	ASTM A 307 OR EQUIV
						[illegible]	RAILING	[illegible] A36 STEEL
					4	[illegible]	SUPPORT	5.0 x 8.0 x 8.0 A36 STEEL
					12	[illegible]	GUSSET	[illegible] A36 STEEL
					12	[illegible]	[illegible]	[illegible] A36 STEEL
						[illegible]	[illegible]	[illegible] A36 STEEL
						[illegible]	FRAME	[illegible]
						[illegible]	FRAME	[illegible]
					2	[illegible]	BRACE	[illegible]
						[illegible]	TIE PLATE	.375 x [illegible]
					4	[illegible]	STRUT	[illegible]
					10	[illegible]	STRUT	[illegible]
						-58	BRACE	[illegible] SQUARE TUBE
					2	[illegible]	PLATE	[illegible]
				3		-56	BEAM	[illegible]
1						[illegible]	PLATE	[illegible]
						[illegible]	WALKWAY ASSY	
		4				[illegible]	RAIL	1.0 DIA STD PIPE x 73.0 [illegible]
		2				[illegible]	RAIL	1.0 DIA STD PIPE x 42.0
		2				[illegible]	RAIL	1.0 DIA STD PIPE x 22.5 0
		[illegible]				-50	[illegible]	
		1				[illegible]	[illegible]	[illegible] x 52.0
						[illegible]	RAIL [illegible]	[illegible]
[illegible]						[illegible]	FRAME	[illegible]
						[illegible]	FRAME	[illegible] x 40.0
2	2					[illegible]	FRAME	[illegible] x 40.0
3	3					-44	PLATE	.375 x 5.0 x 5.0
						[illegible]	BRACE	[illegible] SQUARE TUBE
						[illegible]	BRACE	[illegible] SQUARE TUBE
						[illegible]	BRACE	[illegible] SQUARE TUBE A36 STEEL
				4		[illegible]	[illegible] ASSY	
				4		[illegible]	LANDING ASSY	
				[illegible]		-38	STAIRWAY ASSY	
						[illegible]	GUSSET	[illegible] A36 STEEL
					[illegible]	[illegible]	GUSSET	[illegible]
					4	[illegible]	[illegible]	[illegible]
					4	[illegible]	PLATE	[illegible]
			4			[illegible]	BRACKET	[illegible]
			4			[illegible]	PLATE	[illegible]
					4	[illegible]	[illegible]	[illegible]
					4	[illegible]	[illegible]	[illegible]
					4	[illegible]	[illegible]	[illegible]
					[illegible]	[illegible]	[illegible]	[illegible]
					[illegible]	[illegible]	[illegible]	[illegible]
						[illegible]	[illegible]	.375 x [illegible]
			[illegible]			[illegible]	STRUT	[illegible]
					[illegible]	[illegible]	[illegible] PLATE	[illegible]
					[illegible]	[illegible]	[illegible]	[illegible]
					[illegible]	[illegible]	[illegible]	[illegible]
					[illegible]	[illegible]	[illegible]	[illegible]

PARTS LIST

12	11	10	9

[illegible]K 301-11304 | 1

8	7	6	5	4	3	2

GENE AL NOTES

1. SEE P/L FOR DIMENSIONS NOT SHOWN
2. BREAK ALL SHARP CORNERS
3. ALL WELDS TO BE MADE IN ACCORDANCE WITH AISC AND AWS STANDARDS.
4. ALL STEEL WILL BE A36 OR AN APPROVED EQUIVALENT
5. MAXIMUM STRAIGHTNESS DEVIATION = 1/1000 OF THE OVERALL LENGTH
6. FLAME CUTTING IS PERMISSIBLE ON ALL PARTS EXCEPT THAT THE HOLES ARE NOT TO BE FLAME CUT
7. PAINT PER AISC SPECIFICATION (FIELD PAINT). SEE VERTOL WORK STATEMENT FOR PAINT REQUIREMENTS
8. [illegible] MAY BE USED IN THE FABRICATION OF TOWERS
9. STRUCTURAL TOLERANCES TO BE PER AISC STANDARD UNLESS OTHERWISE NOTED ON DWG
10. ALL WELD & FILLET WELD UNLESS OTHERWISE NOTED

[illegible] TOWER IS [illegible] TEST [illegible] ONLY

[illegible] WE [illegible] EDGES OF [illegible] (45 × .25) [illegible] NEST AGAINST WEB

[illegible] OPTIONAL TO CHAMFER INSIDE EDGES (45 × .25) [illegible] CLEAR RADIUS

[illegible] AS REQD

[illegible] FOR [illegible] AS REQD

[illegible] MAKE SECONDARY STRUTS & BRACES BOLTED CONNECTIONS BOLTED AT APPROPRIATE PLACES FOR [illegible] OF TOWER

[illegible] SEE DETAIL 387 [illegible] SHT 2

[illegible] PER AISC SPECIFICATIONS

TACK WELD GRIP STRUT TO CHANNEL ALSO TACK WELD GRIP STRUT BETWEEN PANELS EVERY 12-14 INCHES

[illegible] OPTIONAL TO BOLT WITH 5/8 [illegible] STAIRS THAT MUST BE REMOVED FOR [illegible] OF TOWER

QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION		
					8	[illegible]	STRUT		4
					5	[illegible]			
					5				
					20				
					[illegible]				4
					4	[illegible]	STRUT		6
					4	[illegible]	SPACER		375
			4				GUSSET		O
							[illegible]		2 O
			1				BASE PLATE		C
					4		BRACKET ASSY		
					2		SPACER		
					[illegible]		BRACE		8W
					[illegible]		STUB BEAM		12
					2		BEAM		8W
					[illegible]		BEAM		8W
					2		COLUMN		8W
					2		COLUMN		8W
							TOWER ASSY		
							TOWER ASSY		
			10	[illegible]	[illegible]				

TEST ENGR

SK-301-304

8	7	6	5	4	3	2

					8	[illegible]	STRUT		[illegible] 4 1 0
					9				
					[illegible]				
					20				
									[illegible]
					4		STRUT		[illegible]
					4		SPACER		[illegible]
		4					GUSSET		[illegible] x 4 x 50
							[illegible]		[illegible]
							BASE PLATE		[illegible]
					4		BRACKET ASSY		
							SPACER		[illegible]
							BRACE		[illegible]
							STUB BEAM		[illegible]
							BEAM		8W 31#/FT [illegible]
							BEAM		8W 31#/FT [illegible]
							COLUMN		[illegible]
							COLUMN		[illegible]
							[illegible]		
							TOWER ASSY		
QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	QTY REQD	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION
			10	2					

PARTS LIST

...ITH AISC AND AWS STANDARDS.
...D EQUIVALENT
...000 OF THE OVERALL LENGTH
...ARTS EXCEPT THAT THE HOLES ARE NOT TO BE FLAME CUT
...AINT). SEE VERTOL WORK STATEMENT FOR [illegible] REQUIREMENTS
...CATION OF TOWERS
...OADED UNLESS OTHERWISE NOTED ON DWG
...EWISE NOTED.

...TED CONNECTIONS [illegible] AT [illegible] PLATE

...IFICATIONS

...O TACK WELD [illegible] STRUT BETWEEN

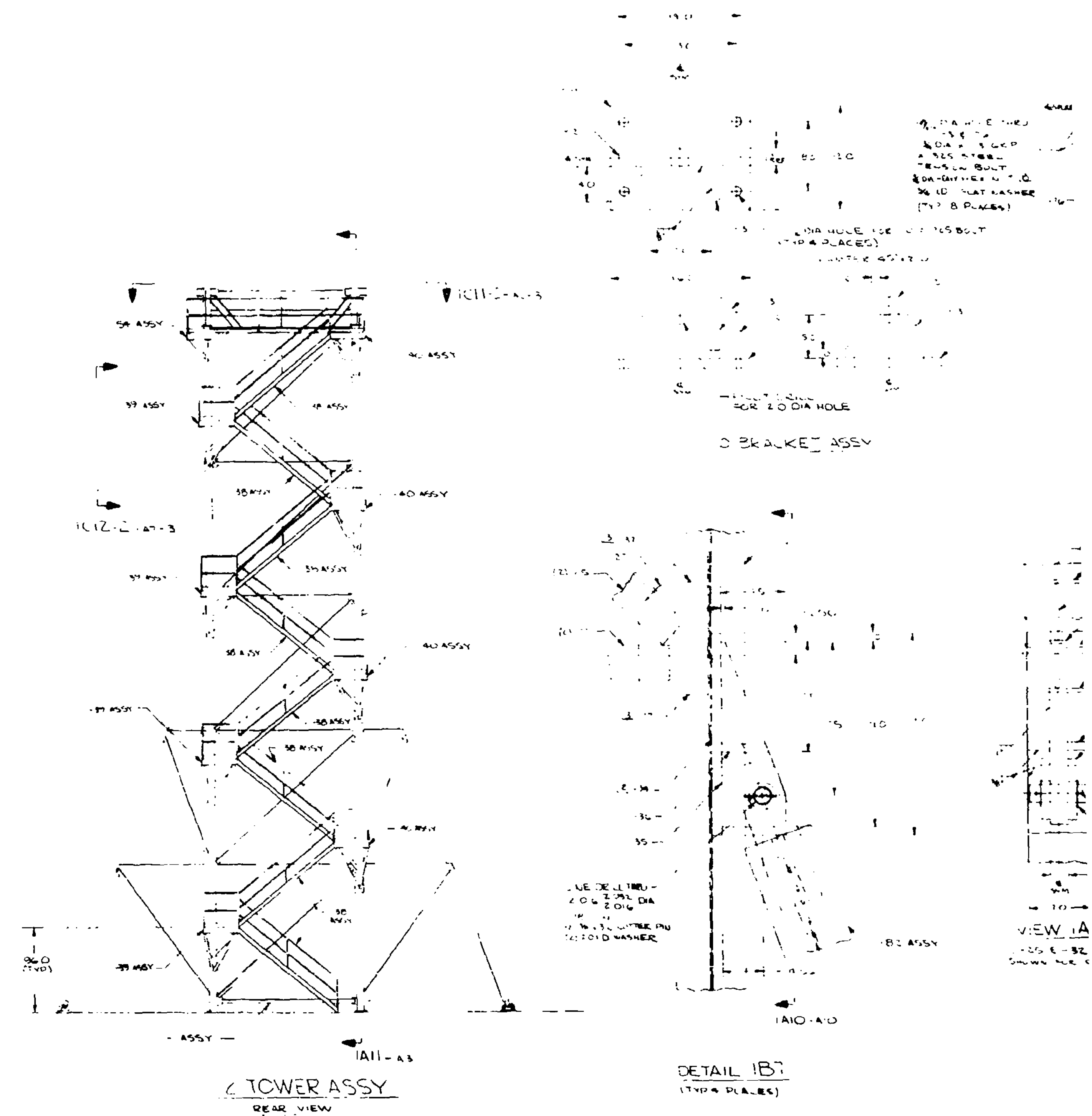
[redacted]

THE BOEING COMPANY
COMMERCIAL AIRPLANE DIVISION

HEAVY LIFT HEL CENTER
[illegible] TOWER ASSY

SK-301-1304

SK-301-304



A

B

Figure 50. HLH Hoist Tower Assembly (Sheet 2).

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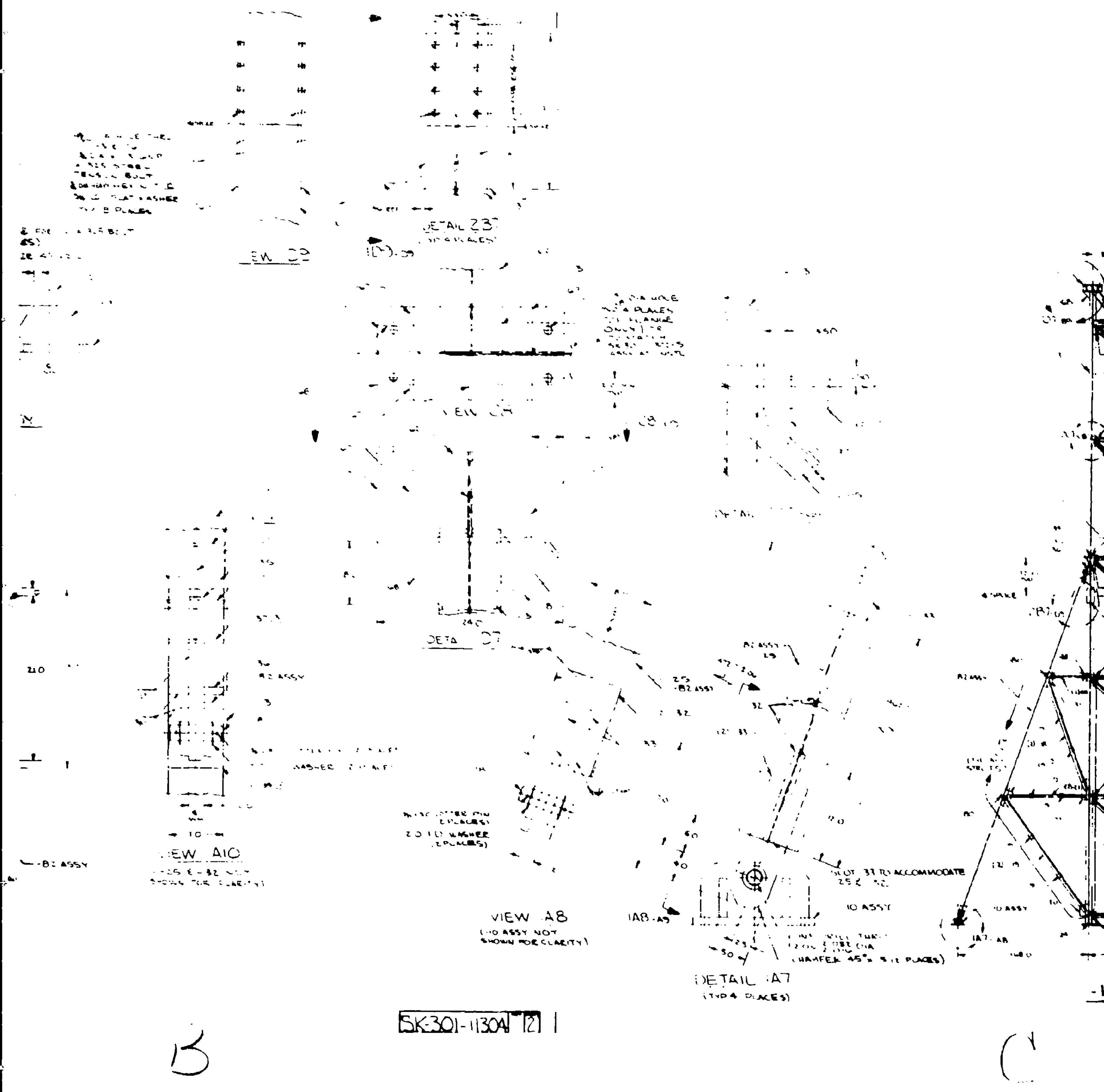
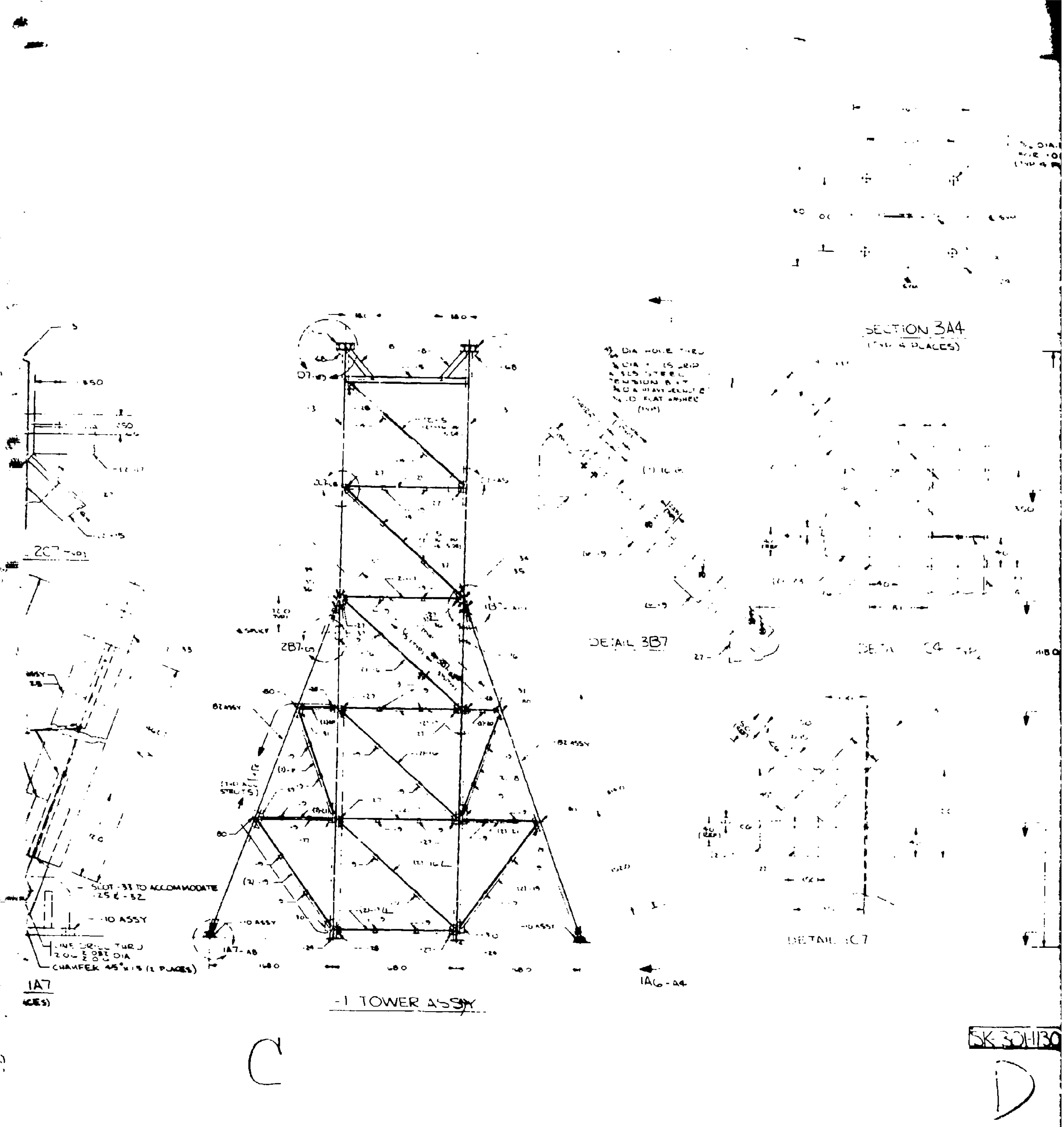
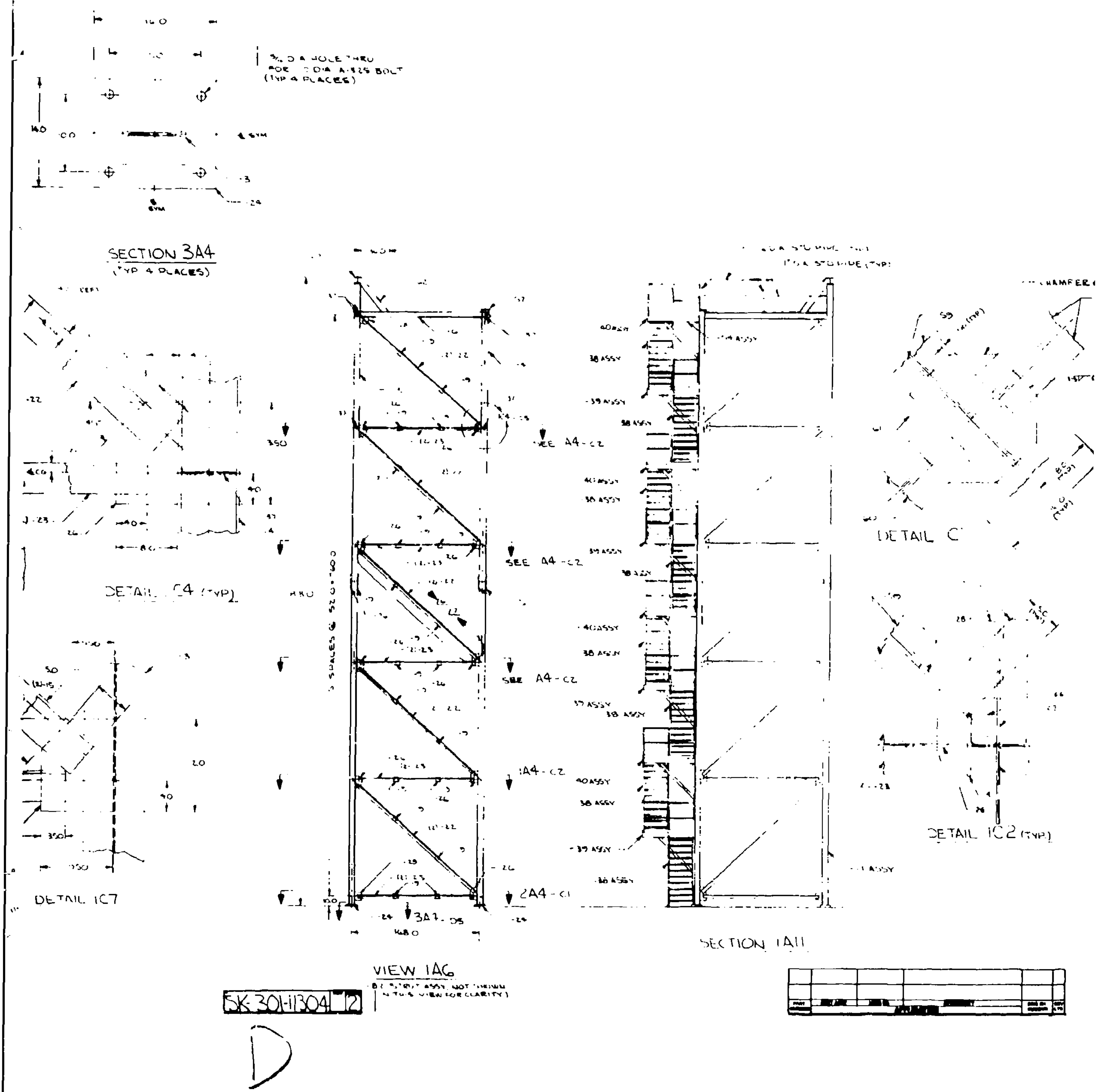
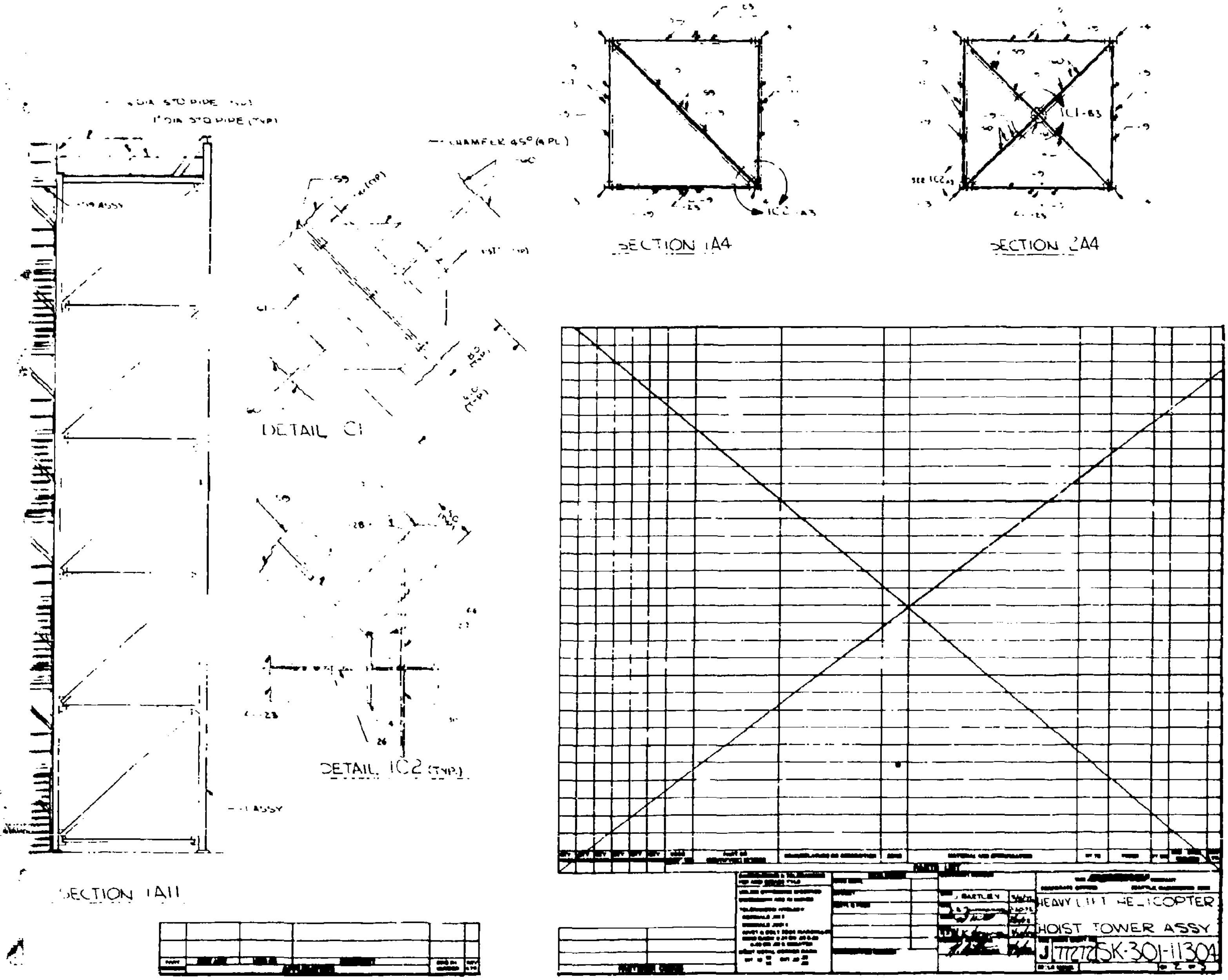

DETAIL 23
VIEW D9
VIEW CH
DETAIL D7
VIEW A10
-B2 ASSY
VIEW A8
(10 ASSY NOT SHOWN FOR CLARITY)
DETAIL A7
(TYP 4 PLACES)
10 ASSY
SK-301-1130A 2
B


SECTION 3A4
(TYP 4 PLACES)
DETAIL 3B7
DETAIL 3C7
-1 TOWER ASSY
SLOT .33 TO ACCOMMODATE
-10 ASSY
1A7
2C7
1A6-A4
C
D


SECTION 3A4
(TYP 4 PLACES)
DETAIL 1C4 (TYP)
DETAIL 1C7
SEE A4-C2
SEE A4-C2
SEE A4-C2
1A4-C2
2A4-C1
3A1-D5
VIEW 1A6
SECTION 1A11
DETAIL 1C2 (TYP)
40 ASSY
38 ASSY
39 ASSY
SK-301-11304 12
D


1" DIA STD PIPE (TYP)
CHAMFER 45° (4 PL)
SECTION 1A11
DETAIL C1
DETAIL 1C2 (TYP)
SECTION 1A4
SECTION 2A4
PARTS LIST
HEAVY LIFT HELICOPTER
HOIST TOWER ASSY
J 77272 SK-301-11304

E

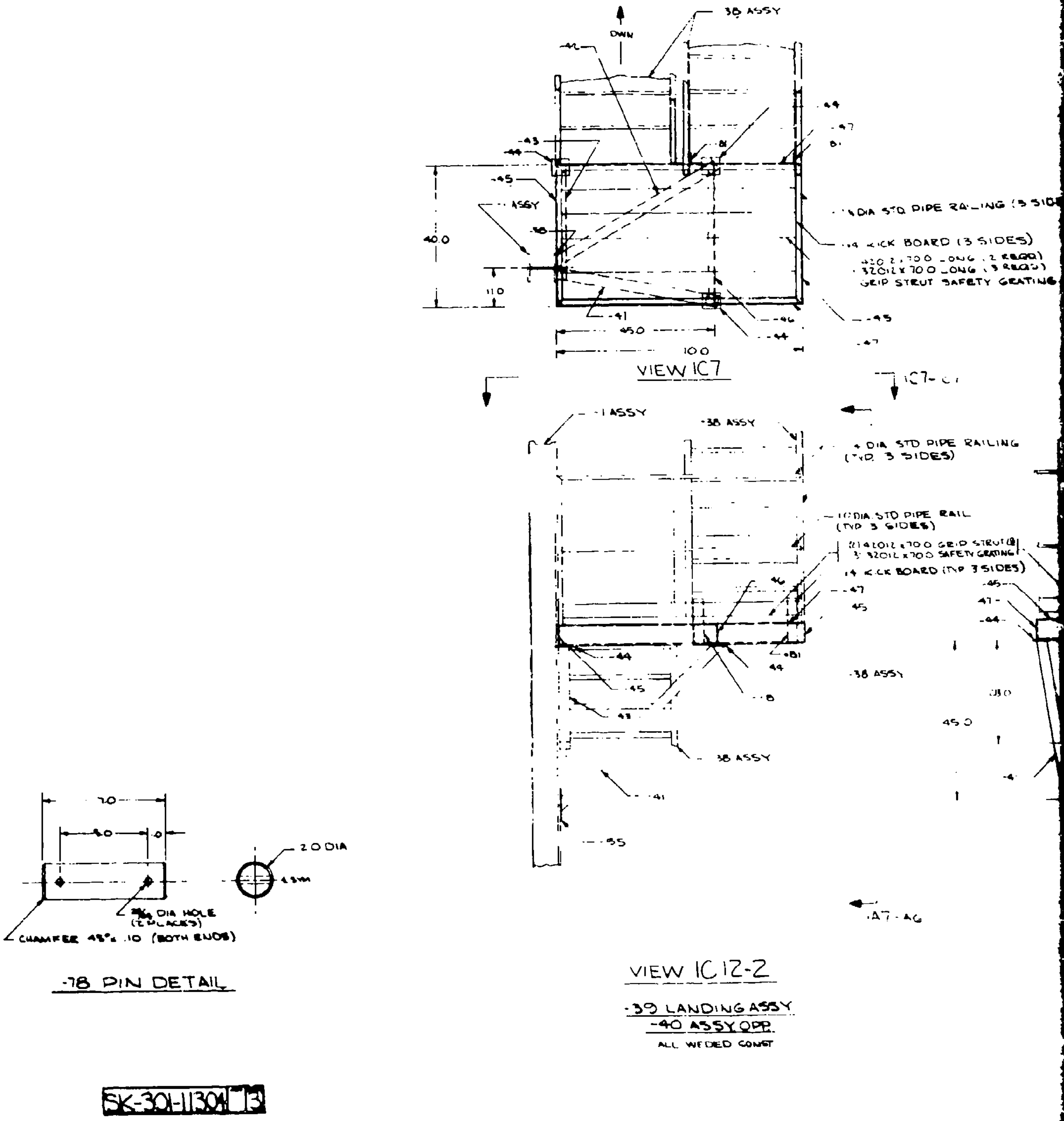


Figure 50. HLH Hoist Tower Assembly (Sheet 3).

A

B

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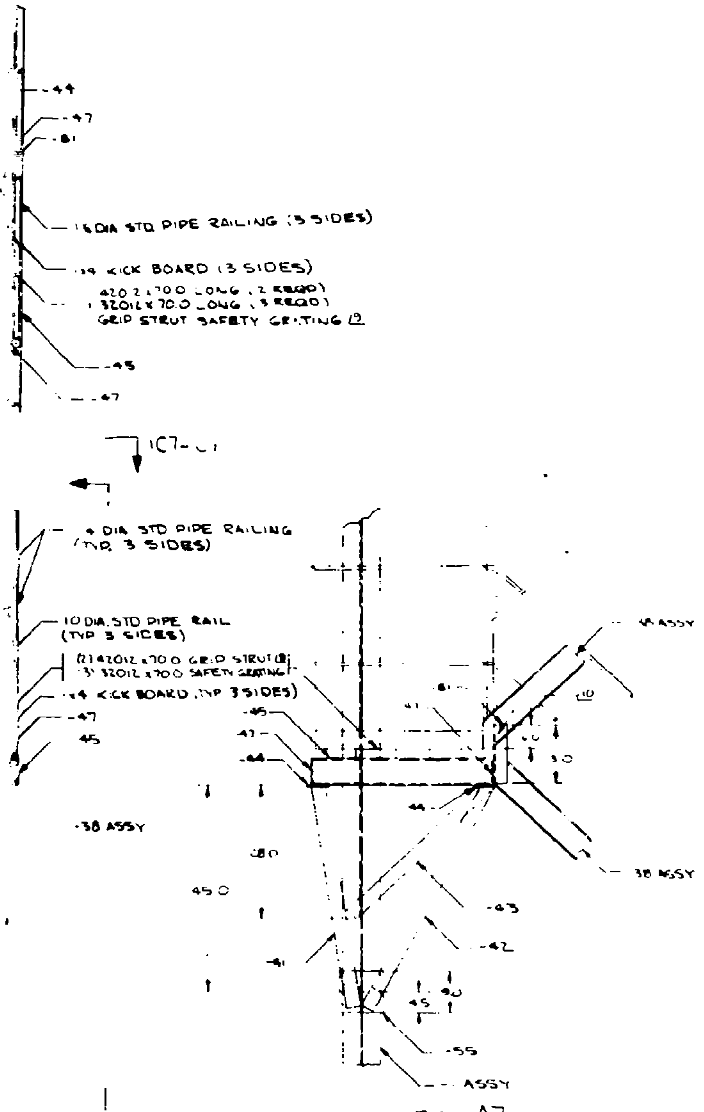
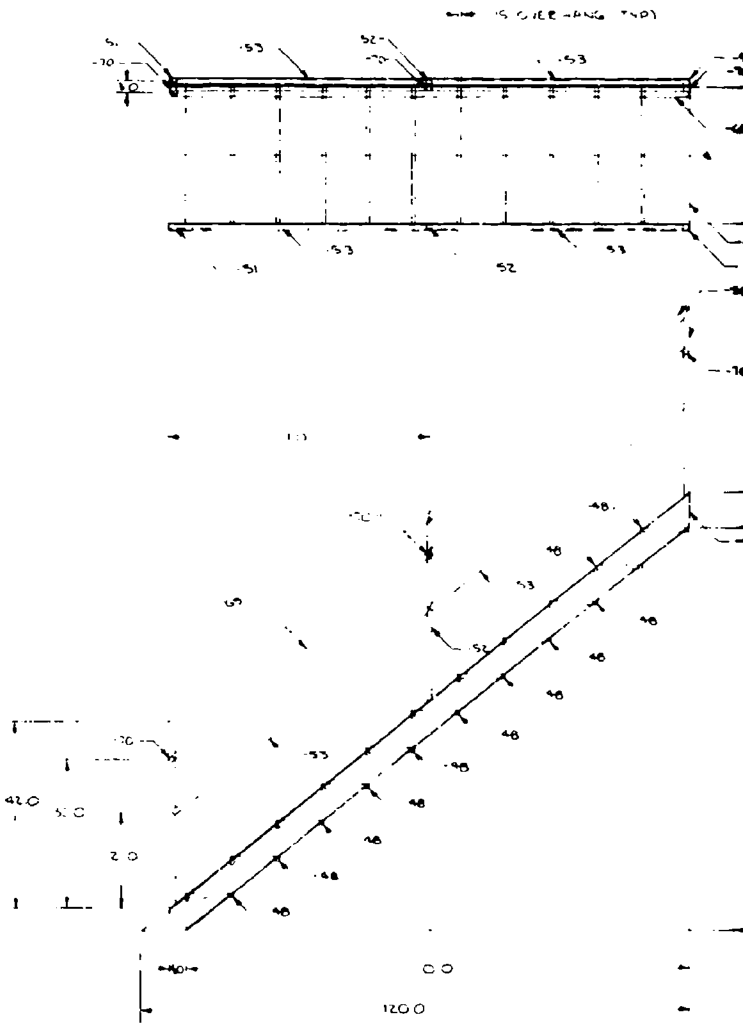


VIEW 1A7



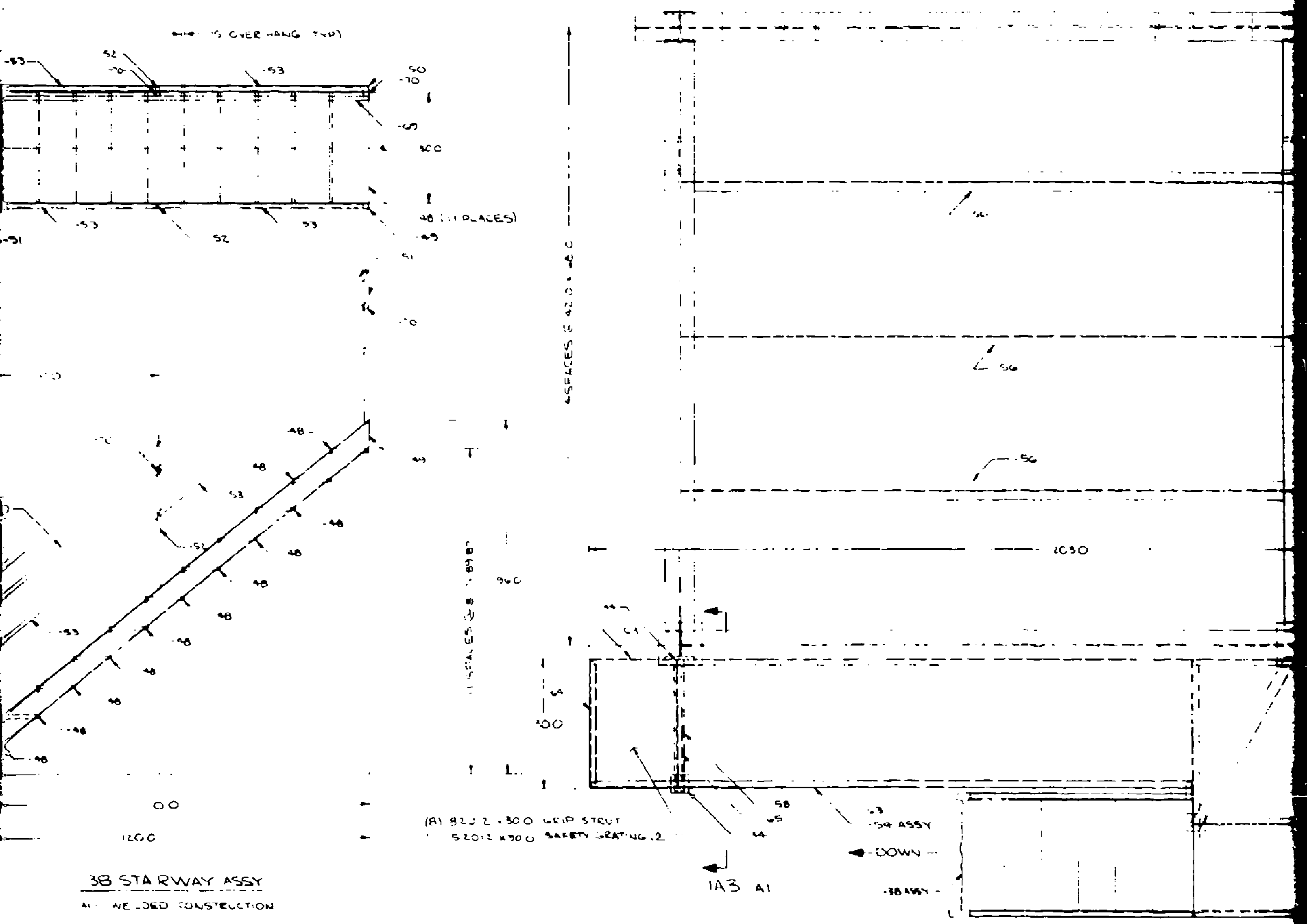
38 STAIRWAY ASSY

ALL WELDED CONSTRUCTION

SK-301-11304 3

B

C

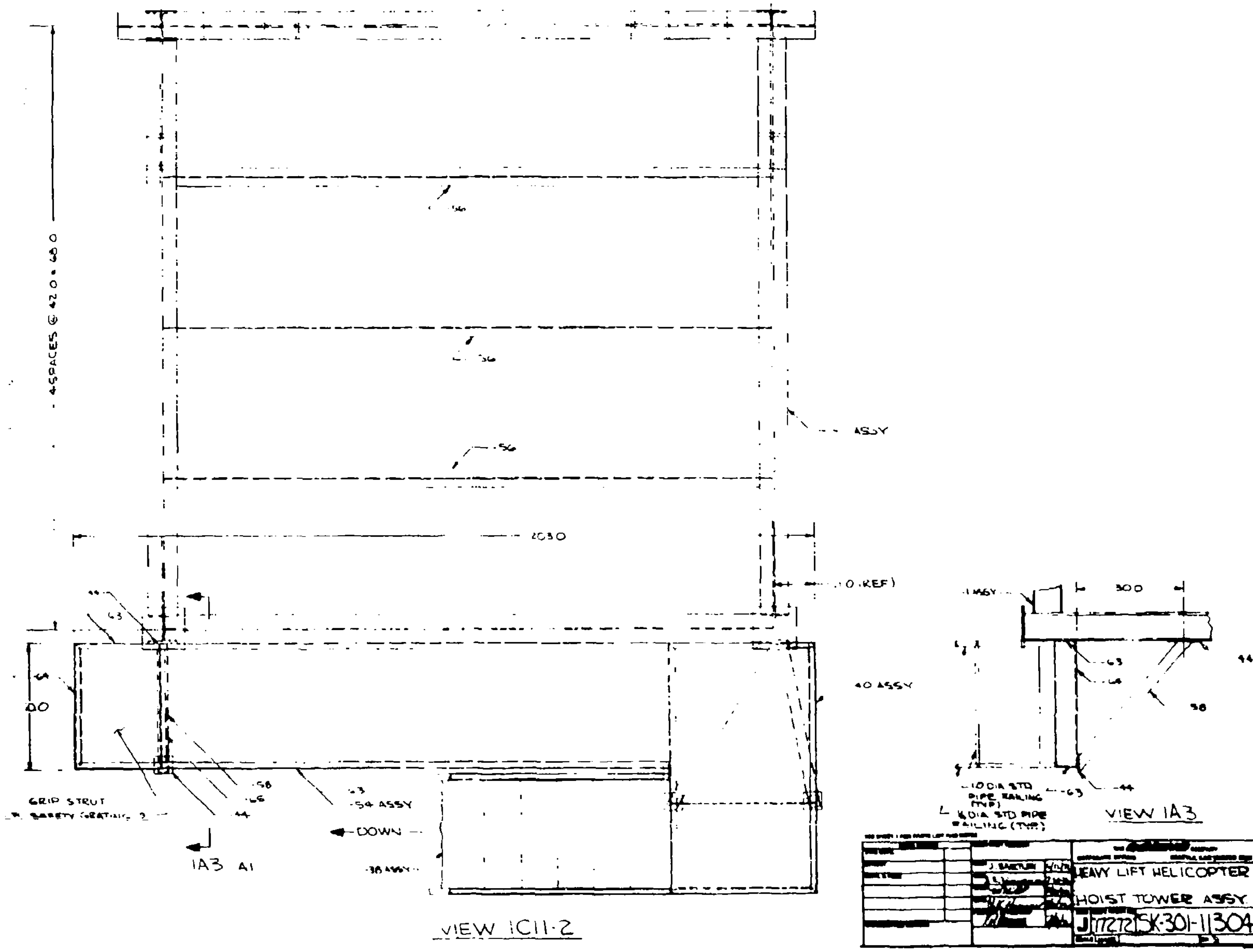


38 STAIRWAY ASSY

ALL WELDED CONSTRUCTION

VIEW C11-2

SK-301-11304 3



4 SPACES @ 42.0 = 168.0
ASSY
203.0
.0 (REF)
40 ASSY
GRIP STRUT
SAFETY GRATING
-58
-66
-44
-63
-54 ASSY
DOWN
-38 ASSY
1A3
A1
VIEW 1C11-2
30.0
-63
-66
44
58
-44
1.0 DIA STD PIPE RAILING (TYP)
1.5 DIA STD PIPE RAILING (TYP)
VIEW 1A3
HEAVY LIFT HELICOPTER
HOIST TOWER ASSY
J
77272
SK-301-11304

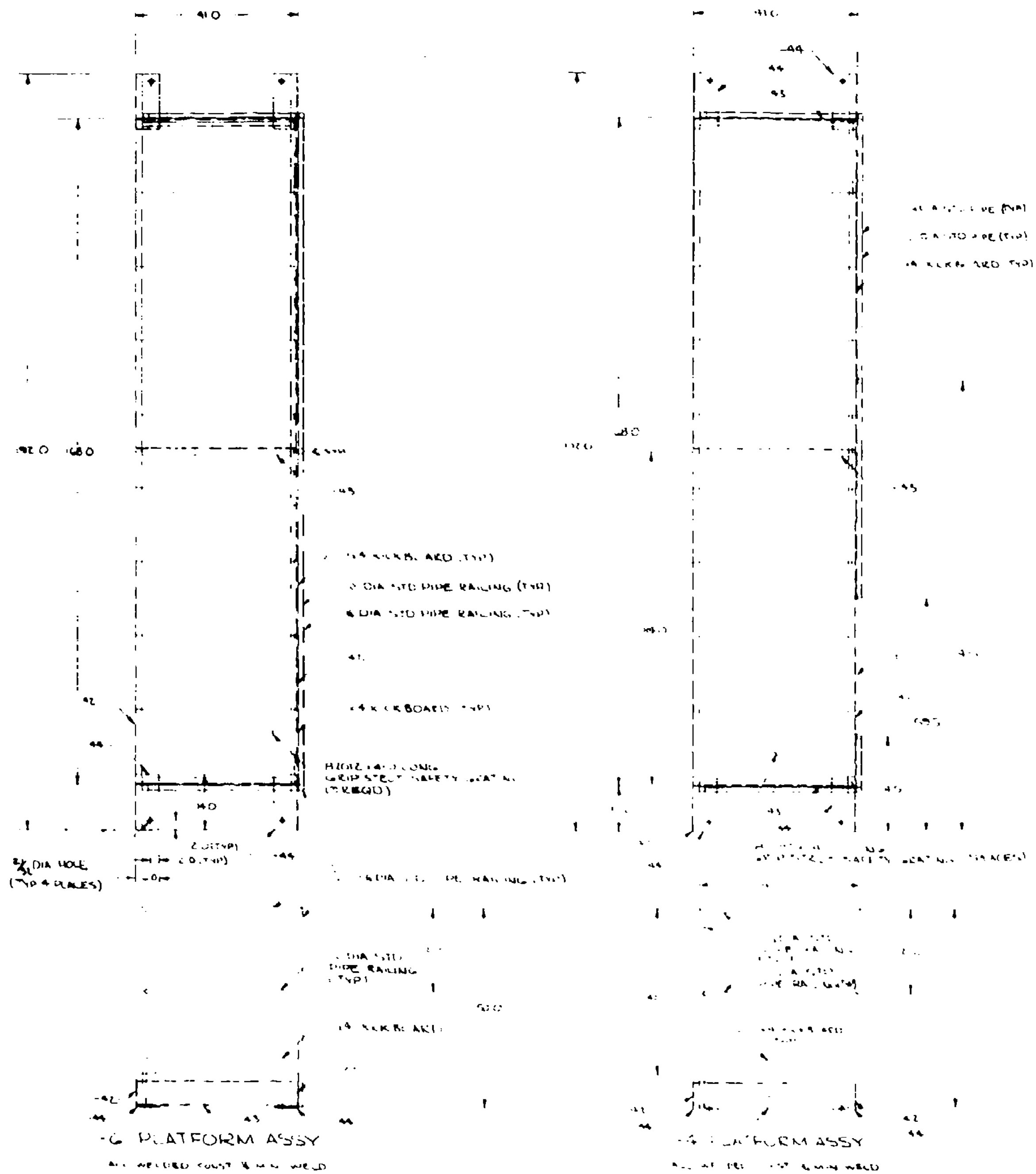
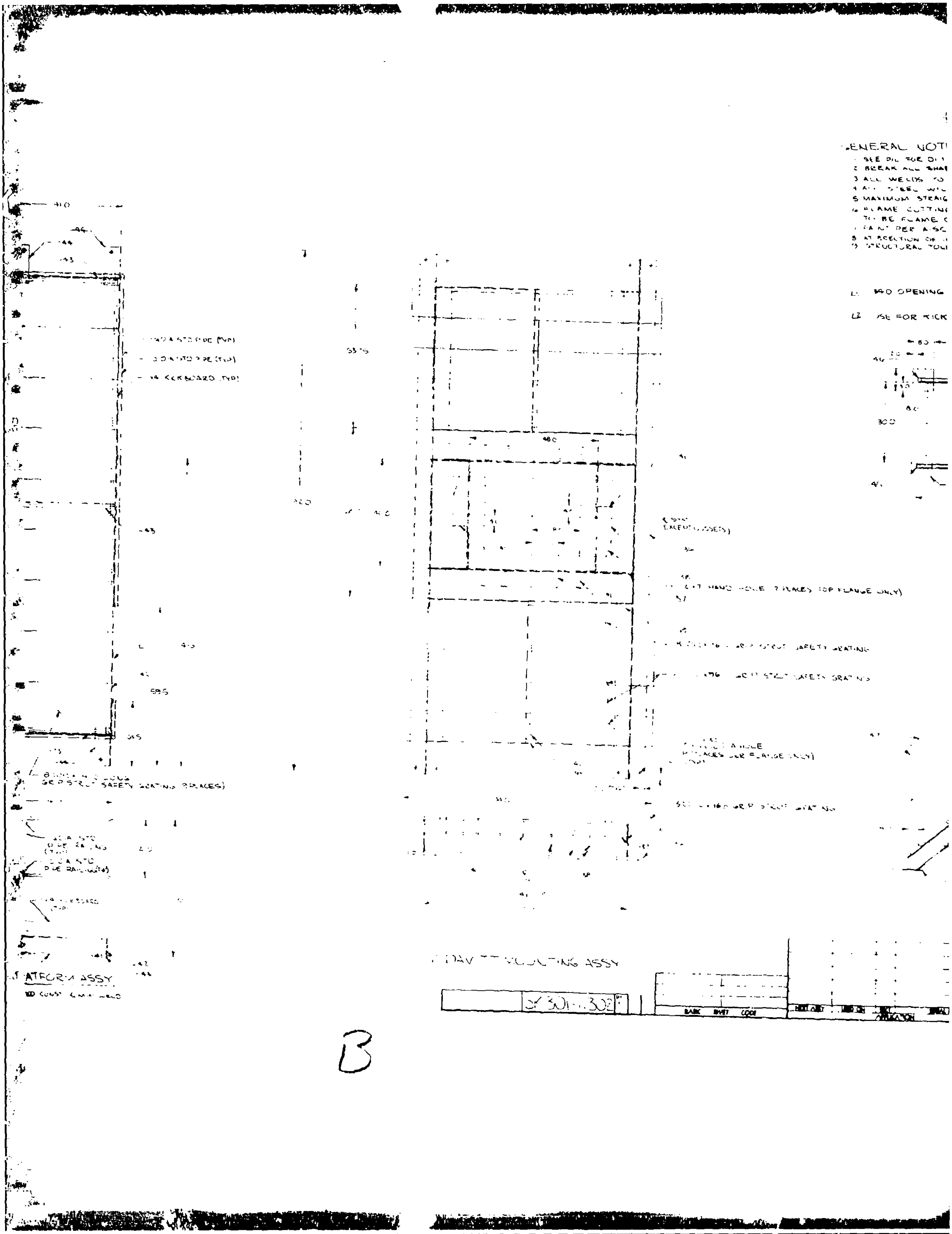


Figure 51. HLH Overhead Assembly.

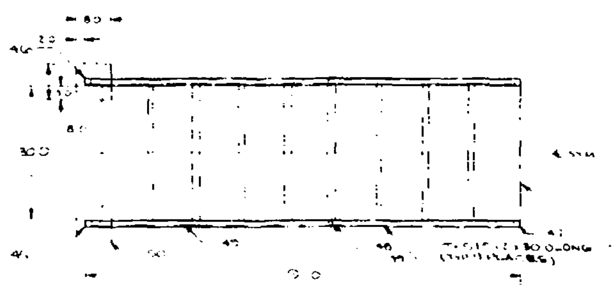


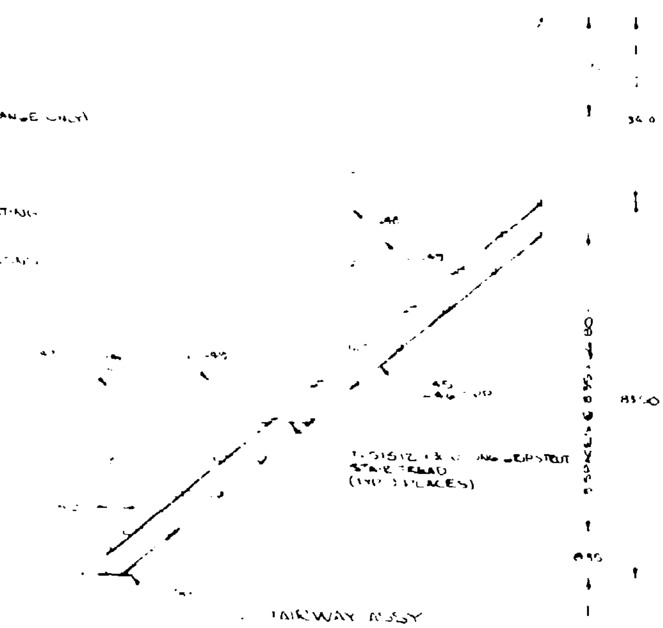
GENERAL NOT
ATFORM ASSY
DAVIT MOUNTING ASSY
BASIC
RIVET
CODE
NEXT ASSY
APPLICATION
B

GENERAL NOTES.
1. SEE P/L FOR DIM NOT SHOWN
2. BREAK ALL SHARP CORNERS.
3. ALL WELDS TO BE MADE IN ACCORDANCE WITH AISC AND AWS STANDARDS
4. ALL STEEL WILL BE A36 OR APPROVED EQUIVALENT
5. MAXIMUM STRAIGHTNESS DEVIATION = 1/1000 OF THE OVERALL LENGTH
6. FLAME CUTTING IS PERMISSIBLE ON ALL PARTS, EXCEPT THAT THE HOLES ARE NOT TO BE FLAME CUT
7. PAINT PER AISC SPECIFICATION (FIELD PAINT) SEE VERTOL WORK STATEMENT FOR PAINT REQUIREMENTS
8. AT ERECTION OF -5 BEAM ASSY, ANY EXISTING CAMBER TO BE UPWARD
9. STRUCTURAL TOLERANCES TO BE PER AISC STANDARD UNLESS OTHERWISE NOTED ON DWG.

11. 34.0 OPENING IN RAILING TO ACCOMMODATE STAIRWAY.

12. USE FOR KICKBOARDS, AS REQD.





STAIRWAY ASSY

QTY	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION
6	5201Z x 96.0	GRIP STRUT SAFETY GRATING
32	4201Z x 48.0	
2	8201Z x 96.0	
9	8201Z x 41.0	GRIP STRUT SAFETY GRATING
9	T-5151Z x 30.0	GRIP STRUT STAIR TREAD
2	1 x 4 x 14 FT. (12)	FIR / PINE
1	1.5 DIA x 90 FT.	STD PIPE
1	1.0 DIA x 24 FT	STD PIPE
2	-50	PLATE
4	-49	RAILING
2	-48	RAILING
2	-47	RAILING
1	-46	OPP. -45
1	-45	CHANNEL
4	-44	MOUNTING
3	-43	CHANNEL
2	-42	CHANNEL
10	-41	GUSSET
2	-40	CHANNEL
4	-39	CHANNEL
2	-38	BEAM
2	-37	BEAM
2	-36	BEAM
2	-35	RAILING
2	-34	RAILING
16	-33	GUSSET
4	-32	CHANNEL
2	-31	BEAM
2	-30	PLATE
4	-29	PLATE
2	-28	PLATE
8	-27	GUSSET
8	-26	GUSSET
	-25	BEAM
4	-24	PLATE
2	-19	WEB
4	-18	WEB
12	-17	GUSSET
8	-16	GUSSET
4	-15	GUSSET
	-14	PAD
2	-13	LWR FLANGE
2	-12	UPR FLANGE
2		BEAM
	-7	STAIRWAY
	-6	PLATFORM
2	-5	OVERHEAD
	-4	PLATFORM
2	-3	WORK PLATFORM ASSY
1	-2	DAVIT MOUNT ASSY
2	-1	HOIST MOUNT

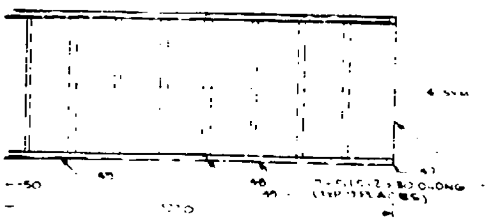
TEST ENGRG
7590

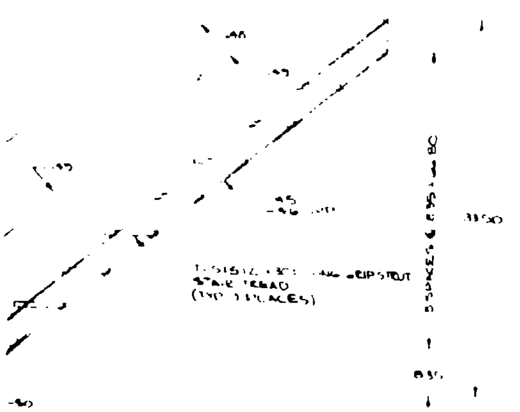
ES.

1. NOT SHOWN
... CORNERS.
... BE MADE IN ACCORDANCE WITH AISC AND AWS STANDARDS.
... BE A36 OR APPROVED EQUIVALENT
... NESS DEVIATION = /000 OF THE OVERALL LENGTH.
... IS PERMISSIBLE ON ALL PARTS EXCEPT THAT THE HOLES ARE NOT CUT
... SPECIFICATION (FIELD PAINT). SEE VERTOL WORK STATEMENT FOR PAINT REQUIREMENTS
... BEAM ASSY, ANY EXISTING CAMBER TO BE UPWARD
... RANCES TO BE PER AISC STANDARD UNLESS OTHERWISE NOTED ON DWG.

... IN RAILING TO ACCOMMODATE STAIRWAY

... BOARDS, AS REQ'D





STAIRWAY ASSY
... WELDED CONSTRUCTION
... AS REQ'D

QTY	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL / SPECIFICATION
6	52012 x 96.0	GRIP STRUT SAFETY GRATING	
32	42012 x 48.0		
2	82012 x 96.0		
7	82012 x 41.0	GRIP STRUT SAFETY GRATING	
9	T-51512 x 30.0	GRIP STRUT STAIR TREAD	
2	1 x 4 x 14 FT. 12	FIR/PINE	CONSTRUCTION GRADE
1	1.5 DIA x 50 FT	STD PIPE	
1	1.0 DIA x 25 FT	STD PIPE	
2	-50	PLATE	.25 x 8.0 x 8.0
4	-49	RAILING	1.0 DIA STD PIPE x 71.0
2	-48	RAILING	1.0 DIA STD PIPE x 74.0
2	-47	RAILING	1.5 DIA STD PIPE x 220.0
1	-46	OPP. -45	
1	-45	CHANNEL	6 C 8.2 #/FT x 181.0
4	-44	MOUNTING PLATE	.25 x 6.0 x 14.0
3	-43	CHANNEL	8 C 11.5 #/FT x 41.0
2	-42	CHANNEL	8 C 11.5 #/FT x 192.0
10	-41	GUSSET	.50 x 5.79 x 12.62
2	-40	CHANNEL	6 C 8.2 #/FT x 53.75
4	-39	CHANNEL	6 C 8.2 #/FT x 76.5
2	-38	BEAM	14 WF 78 #/FT x 40.0
2	-37	BEAM	14 WF 78 #/FT x 76.5
2	-36	BEAM	14 WF 78 #/FT x 172.0
2	-35	RAILING	1.0 DIA STD PIPE x 74.0
2	-34	RAILING	1.5 DIA STD PIPE x 180.0
16	-33	GUSSET	.375 x 7.81 x 12.62
4	-32	CHANNEL	6 C 8.2 #/FT x 141.0
2	-31	BEAM	14 WF 142 #/FT x 192.0
2	-30	PLATE	.50 x 6.0 x 24.0
4	-29	PLATE	.50 x 24.0 x 50.0
2	-28	PLATE	.75 x 12.0 x 24.0
8	-27	GUSSET	.75 x 11.67 x 28.81
8	-26	GUSSET	.75 x 7.16 x 27.75
	-25	BEAM	30 WF 172 #/FT x 492.0
4	-24	PLATE	1.0 x 4.25 x 12.0
2	-19	WEB	.75 x 11.0 x 150.0
4	-18	WEB	.75 x 19.0 x 22.5
12	-17	GUSSET	.75 x 3.75 x 19.0
8	-16	GUSSET	.75 x 3.25 x 19.0
4	-15	GUSSET	.75 x 3.25 x 9.0
2	-14	PAD	1.0 x 12.5 x 72.0
2	-13	LWR FLANGE	1.0 x 4.5 x 125.0
2	-12	UPR FLANGE	1.0 x 4.5 x 150.0
2	-11	BEAM	8 WF 24 #/FT x 62.0
	-7	STAIRWAY ASSY	
	-6	PLATFORM ASSY	
2	-5	OVERHEAD BEAM ASSY	
	-4	PLATFORM ASSY	
2	-3	WORK PLATFORM ASSY	
1	-2	DAVIT MOUNTING ASSY	
2	-1	HOIST MOUNTING ASSY	

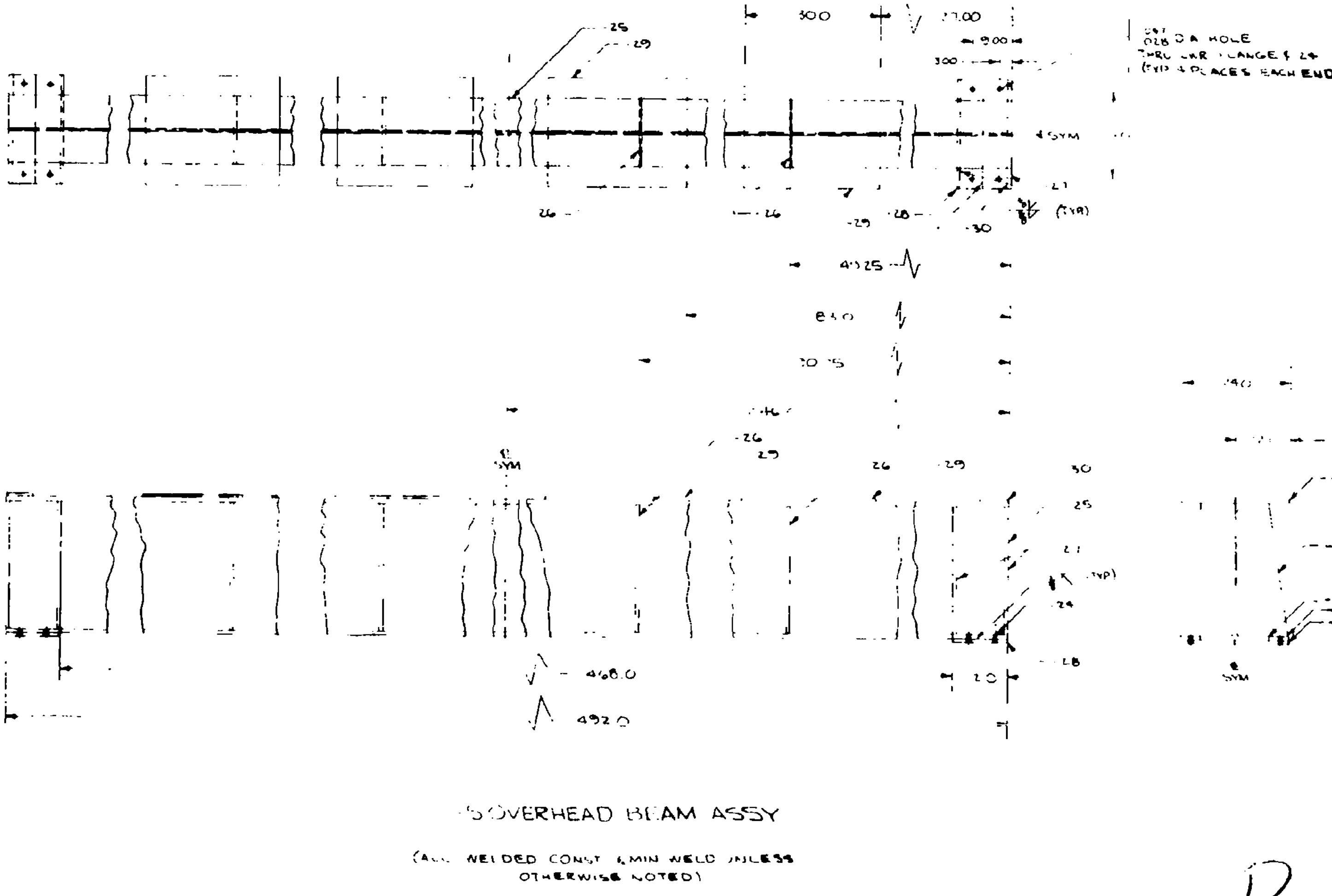
THE BOEING COMPANY
VERTOL DIVISION

HEAVY LIFT HELICOPTER

OVERHEAD ASSY.

SK-301-11302

TEST ENG'G 79540



A

B

Figure 51. HLH Overhead Assembly (Sheet 2).

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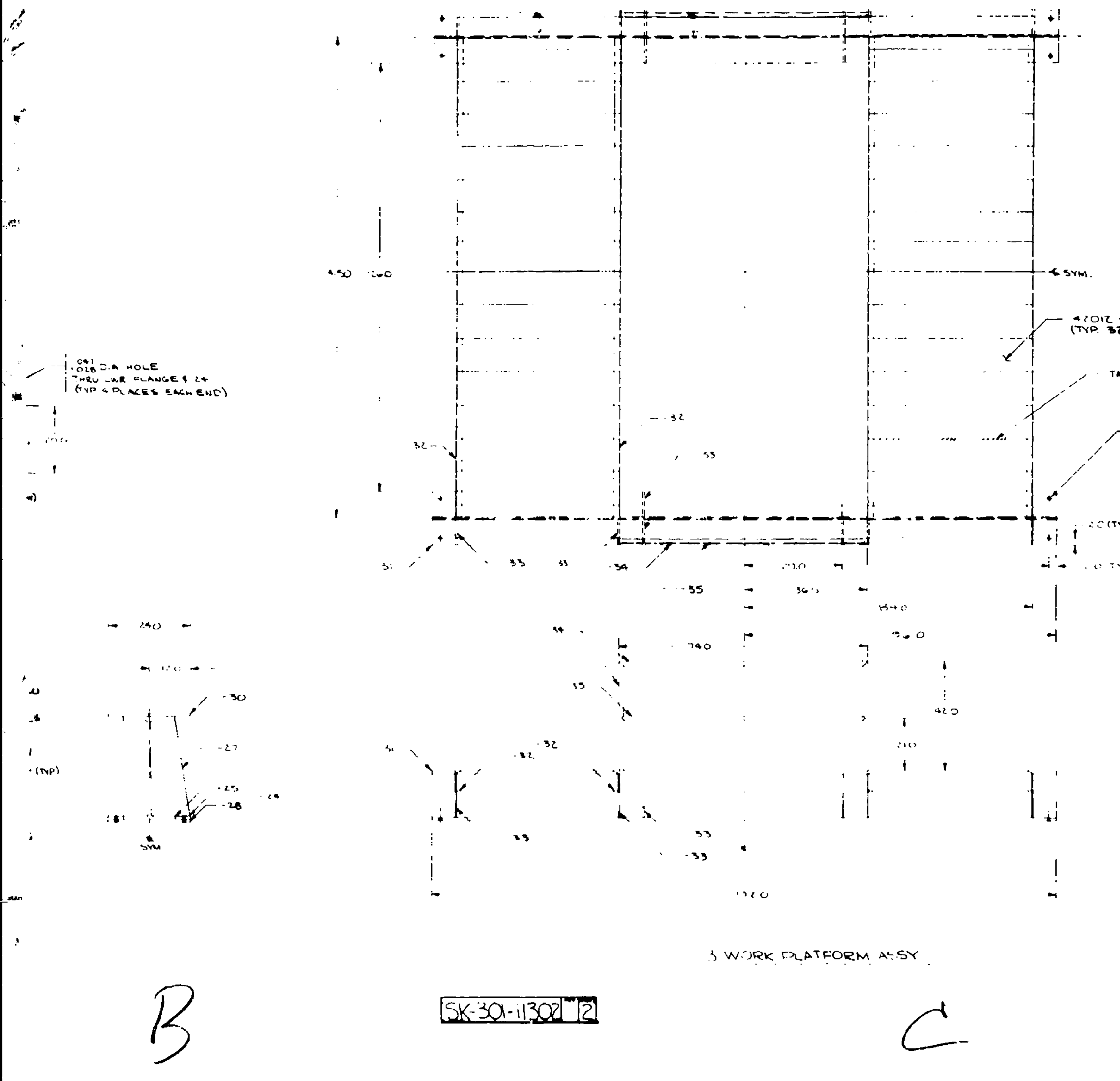
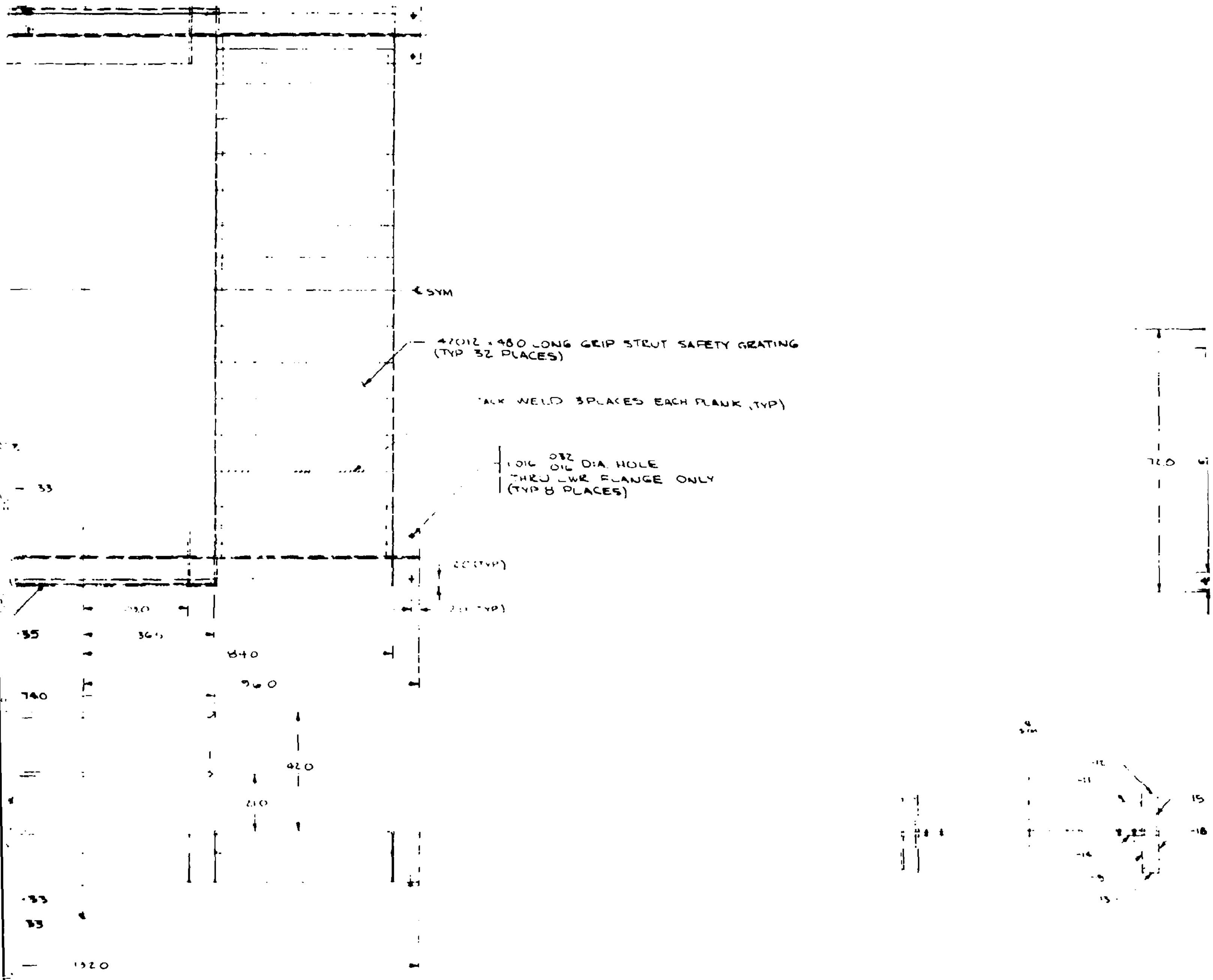


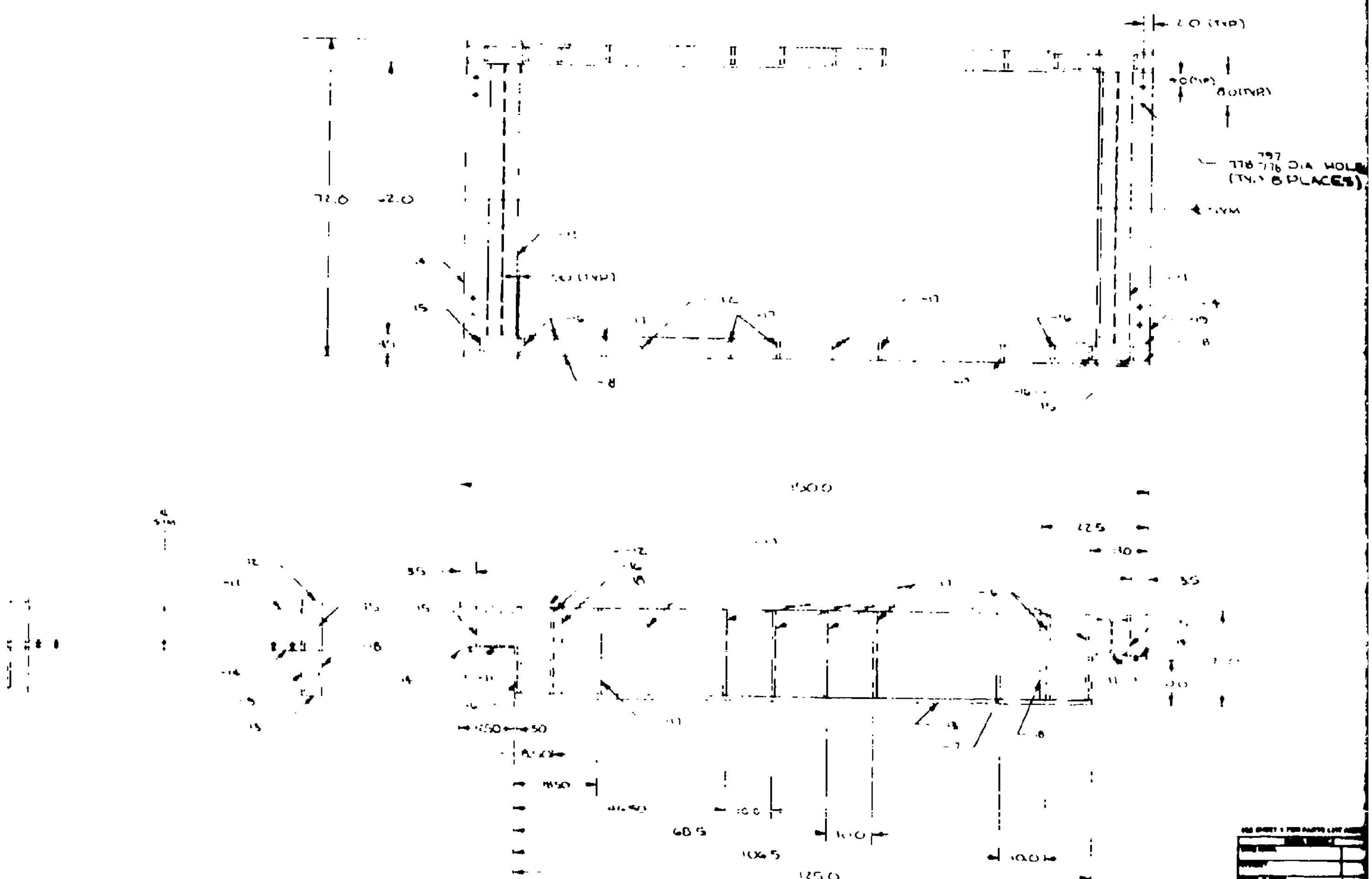
3 WORK PLATFORM ASSY



– 3 WORK PLATFORM ASSY

C

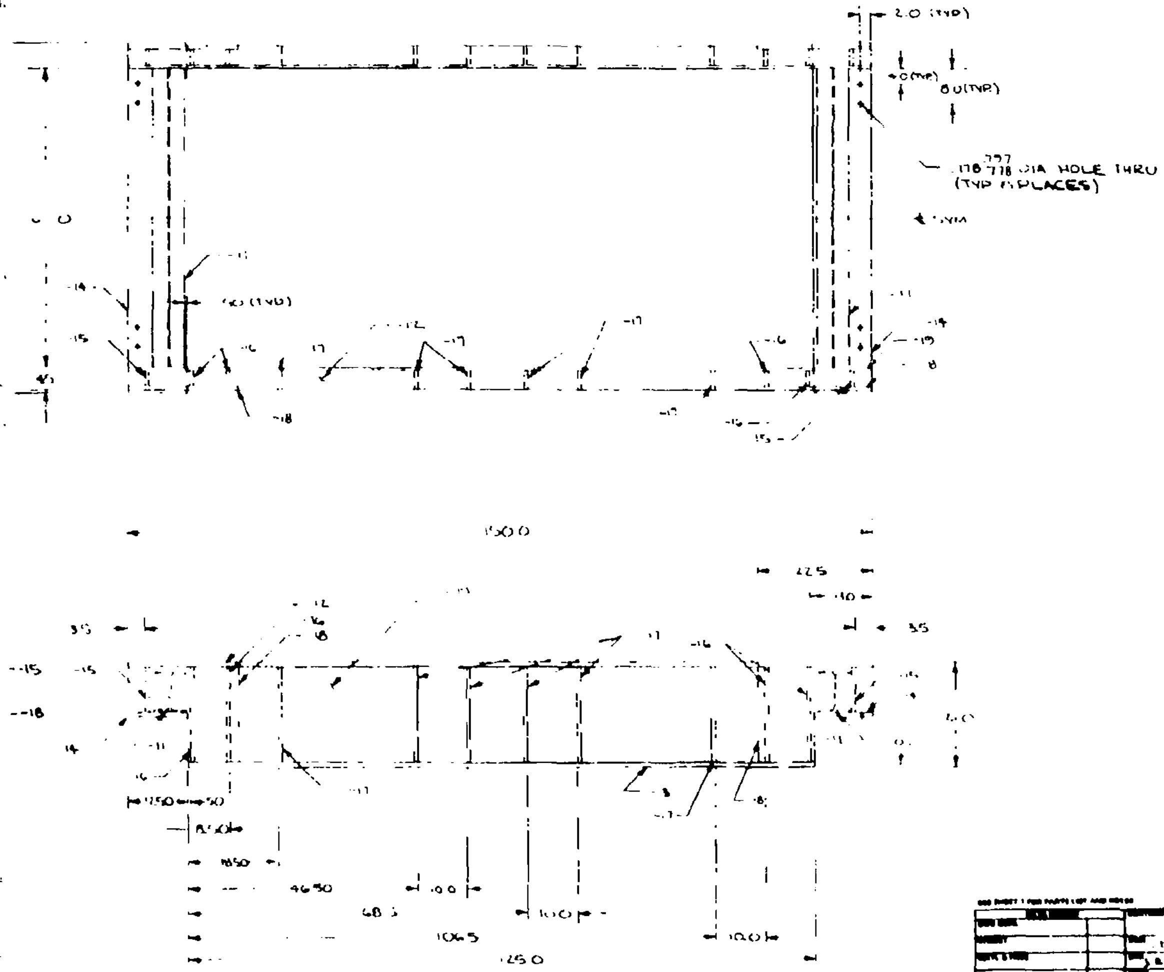
D



-1 FWD HOIST MOUNTING ASSY

ALL WELDED CONST - 3/16 MIN WELD

D



-1 FWD HOIST MOUNTING ASSY

ALL WELDED CONST

HEAVY LIFT HELICOPTER

OVERHEAD ASSY

J 77272 SK-301-11302

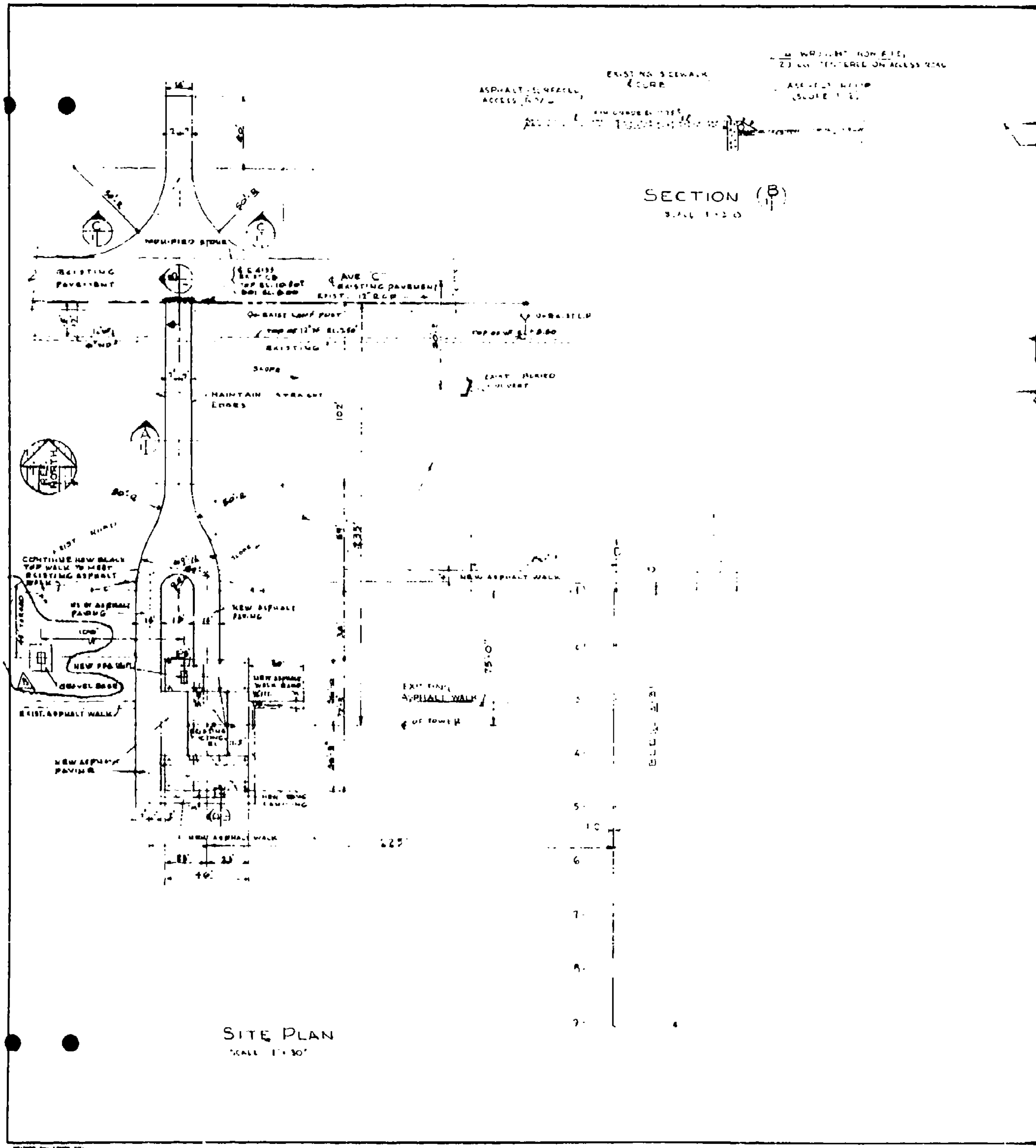


Figure 52. Site Plan - Paving and Utilities, Plan and Sections

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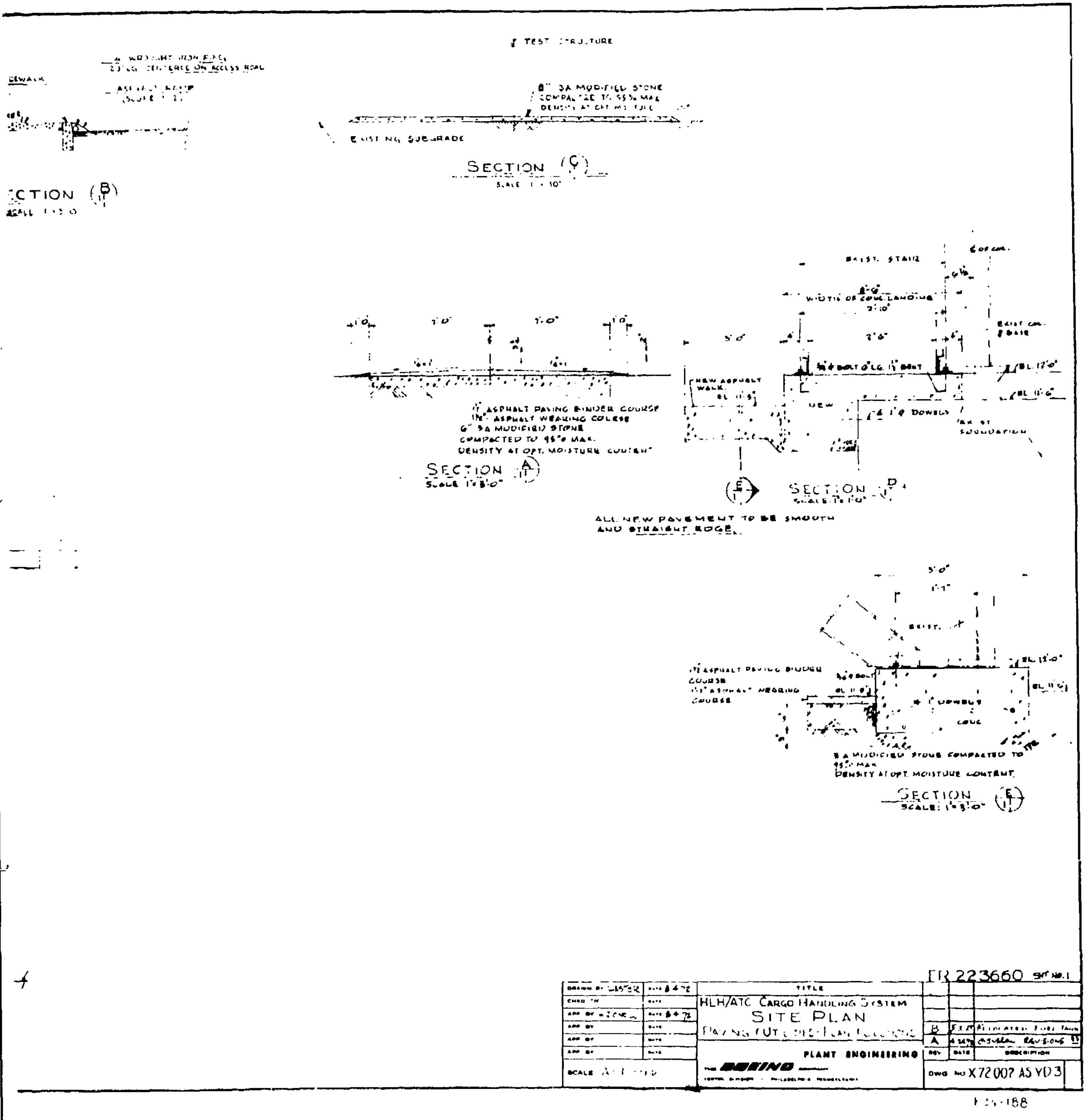

Plan and Sections

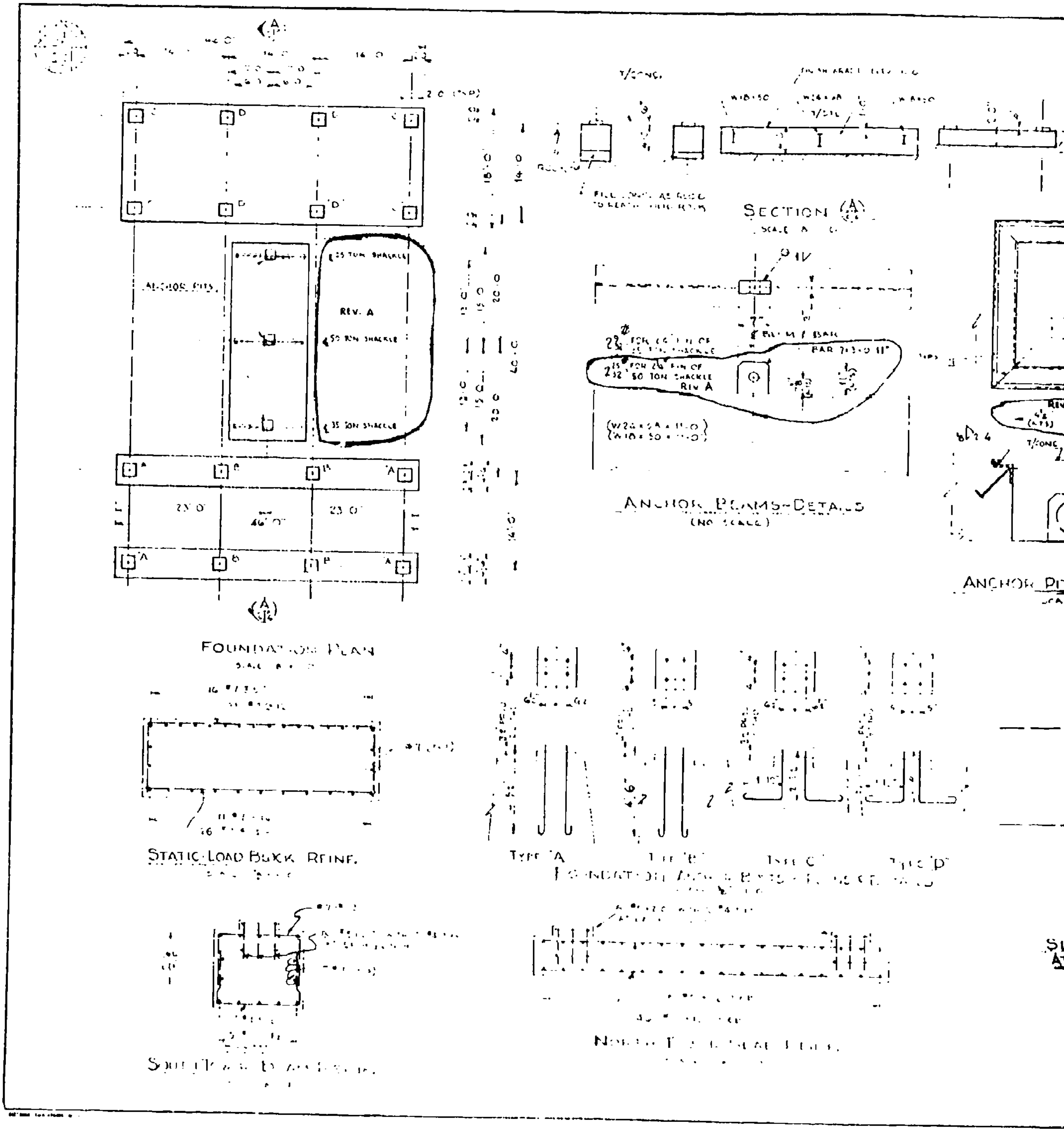

Figure 53. Foundations - Plans, Sections and Details.

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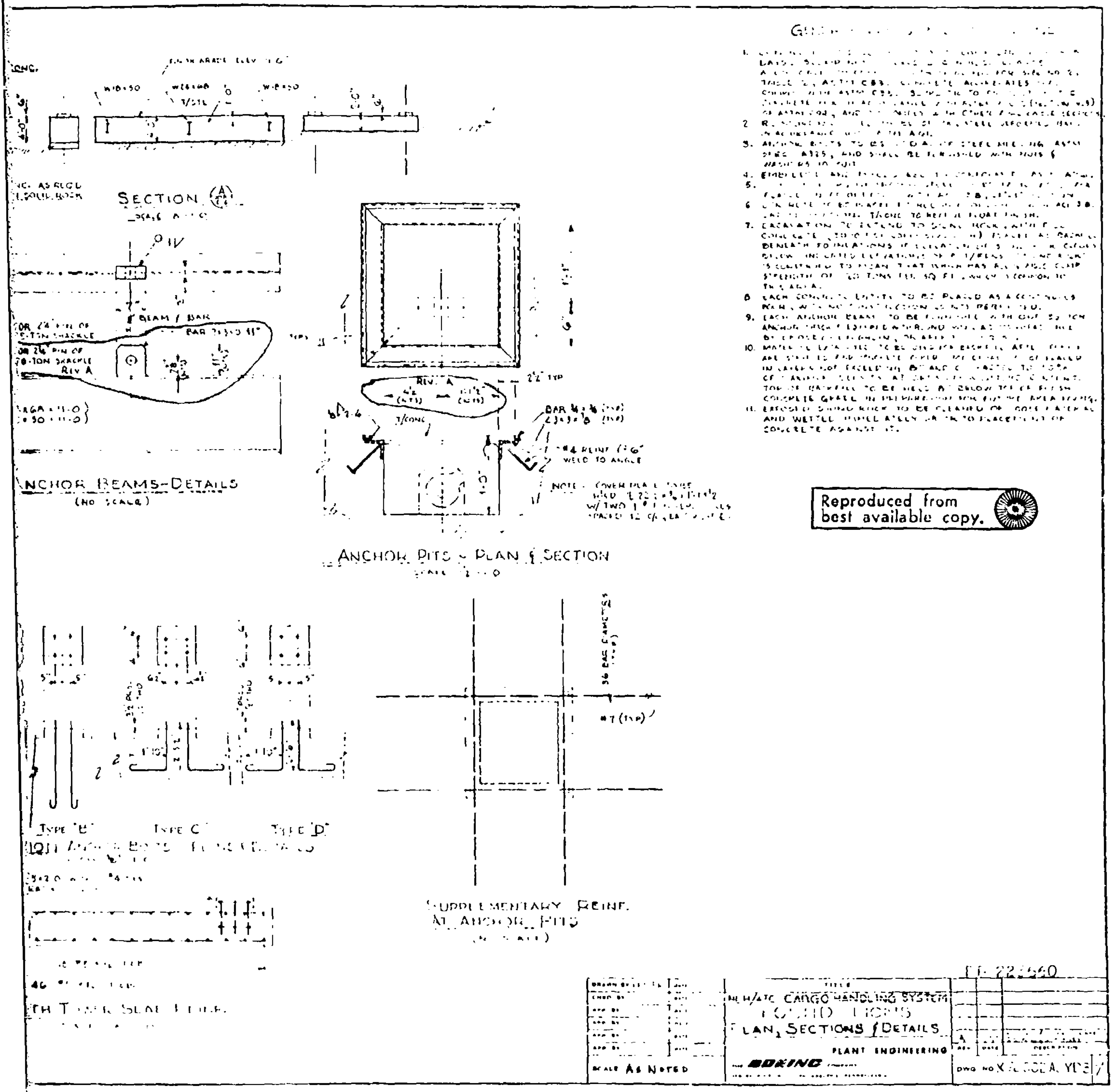
A



SECTION
ANCHOR BEAMS-DETAILS
(NO SCALE)
ANCHOR PITS - PLAN & SECTION
SUPPLEMENTARY REINF. AT ANCHOR PITS
TYPE "B"
TYPE C
TYPE "D"
CARGO HANDLING SYSTEM
PLAN, SECTIONS & DETAILS
PLANT ENGINEERING
BOEING
SCALE AS NOTED

etails.

B

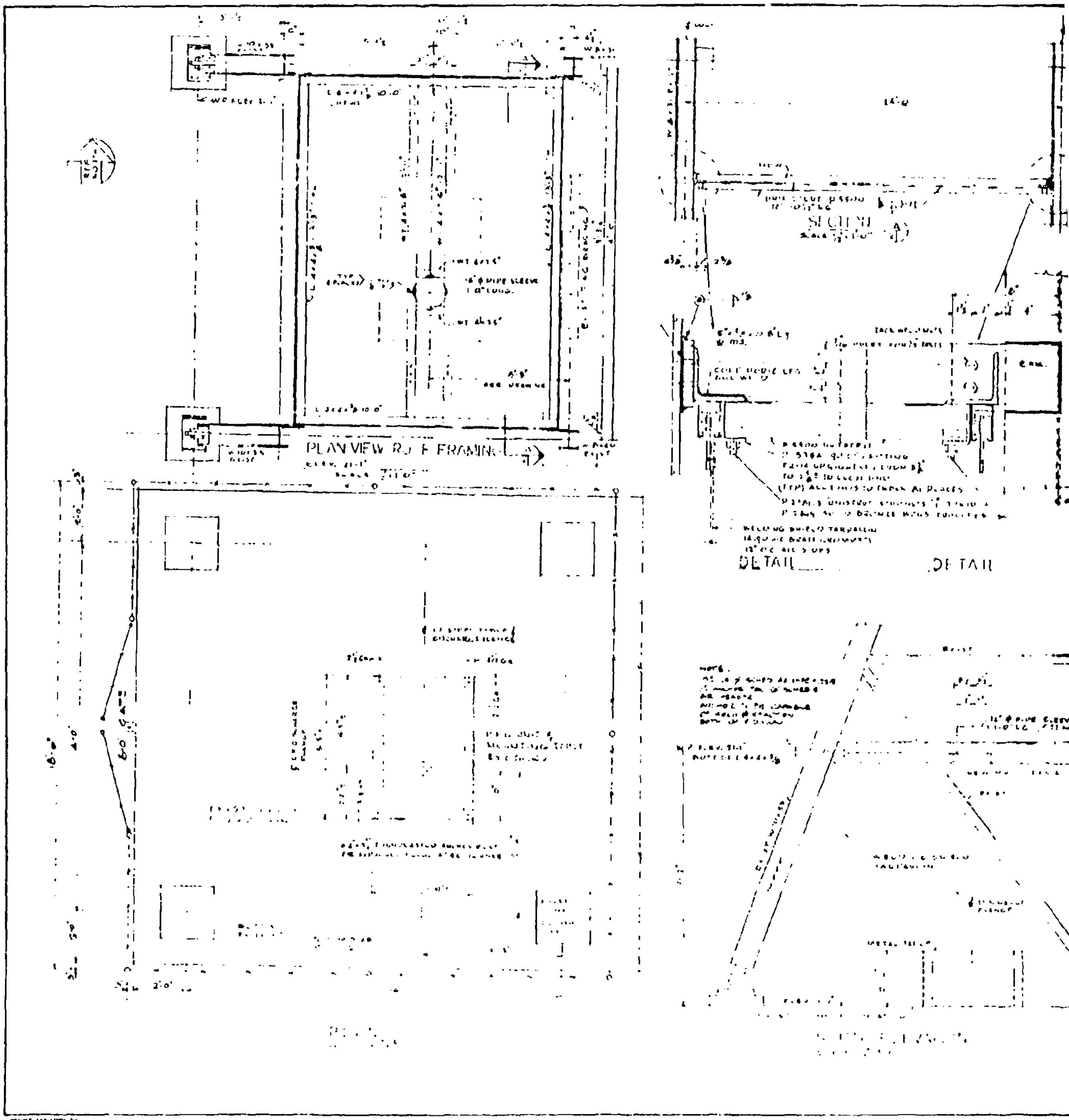


Figure 54. Pneumatic Power Generator Shelter, HLH/ATC Cargo Handling System.

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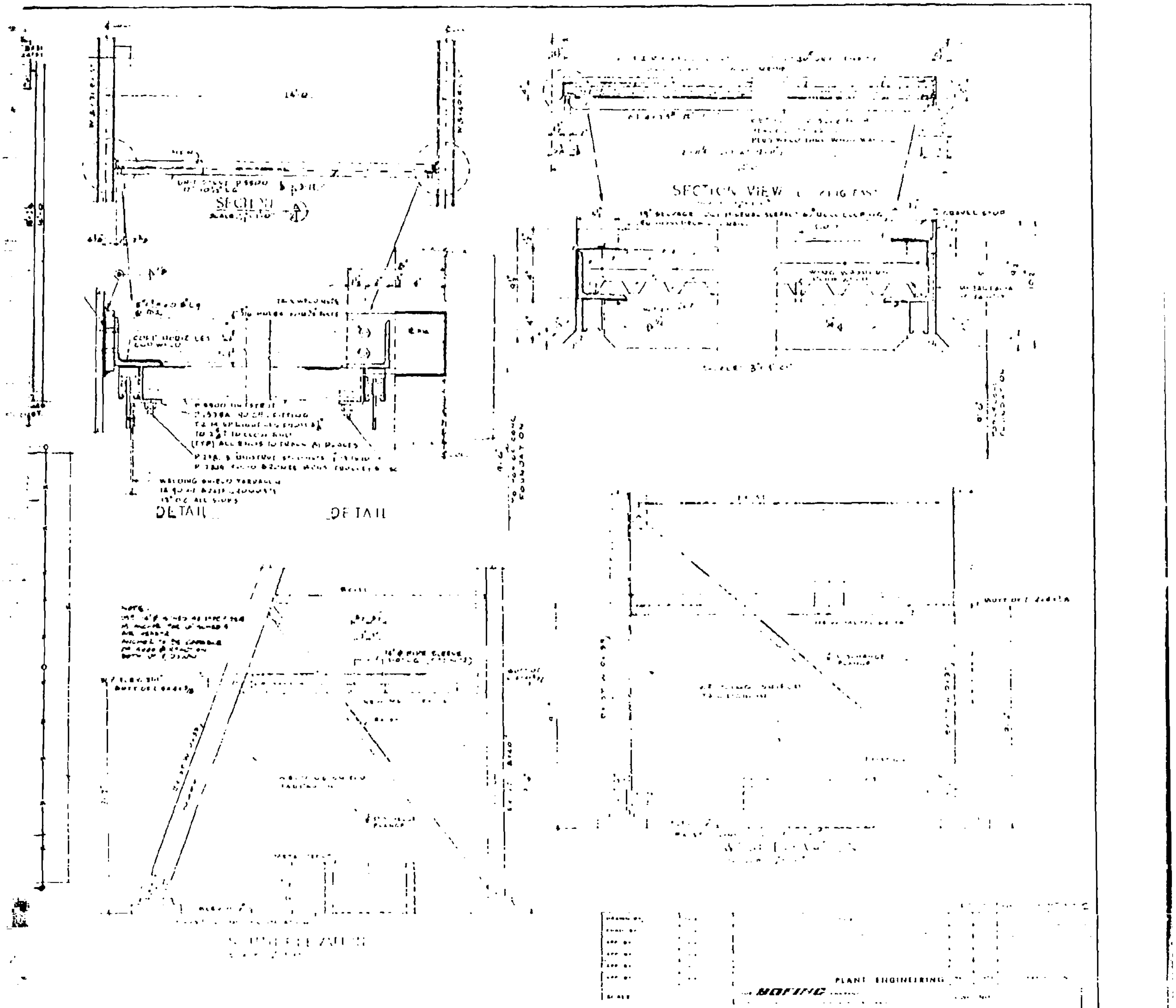

B

ter, HLH/ATC

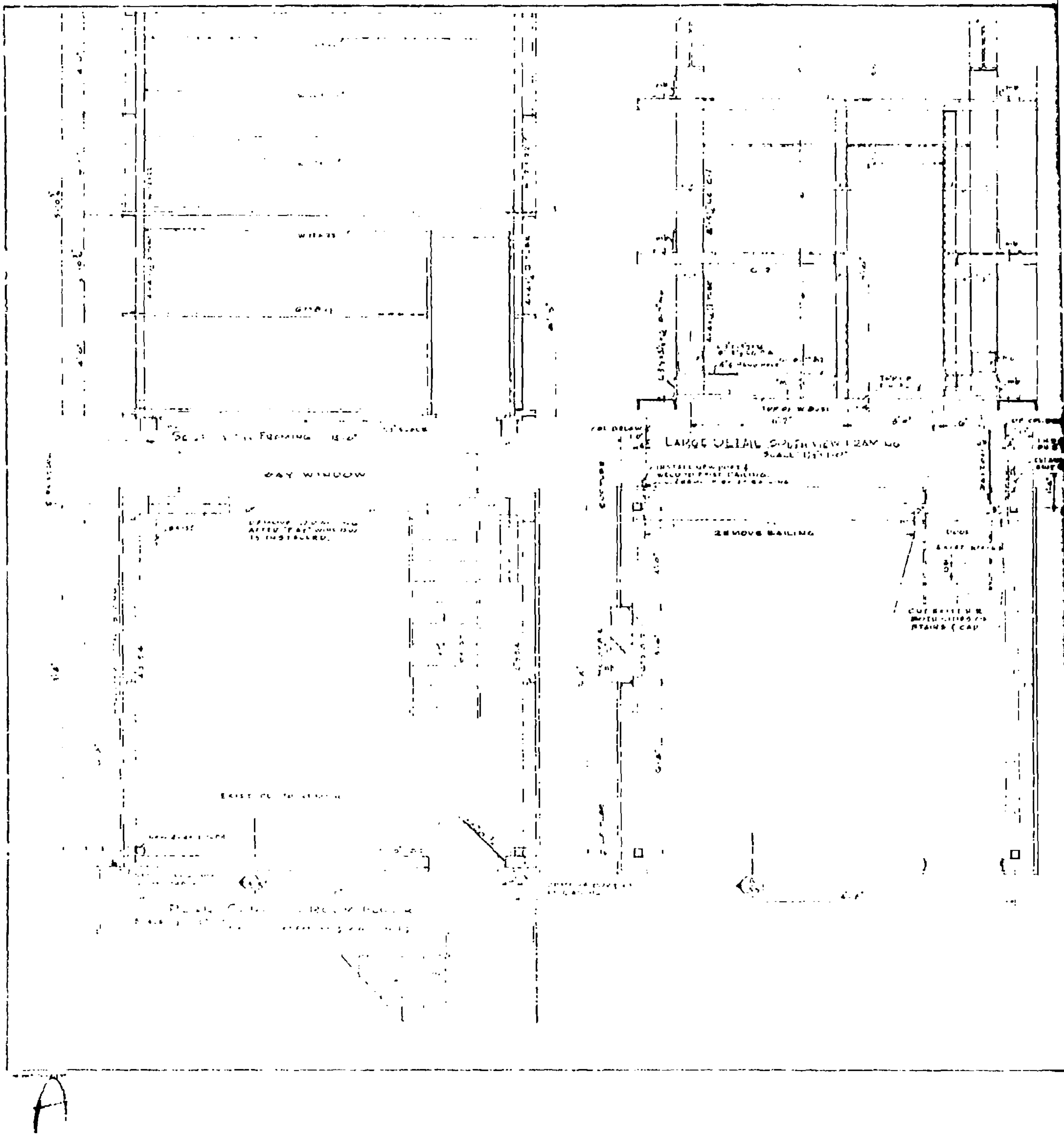

Figure 55. Control Room Plans, Elevations and Section.

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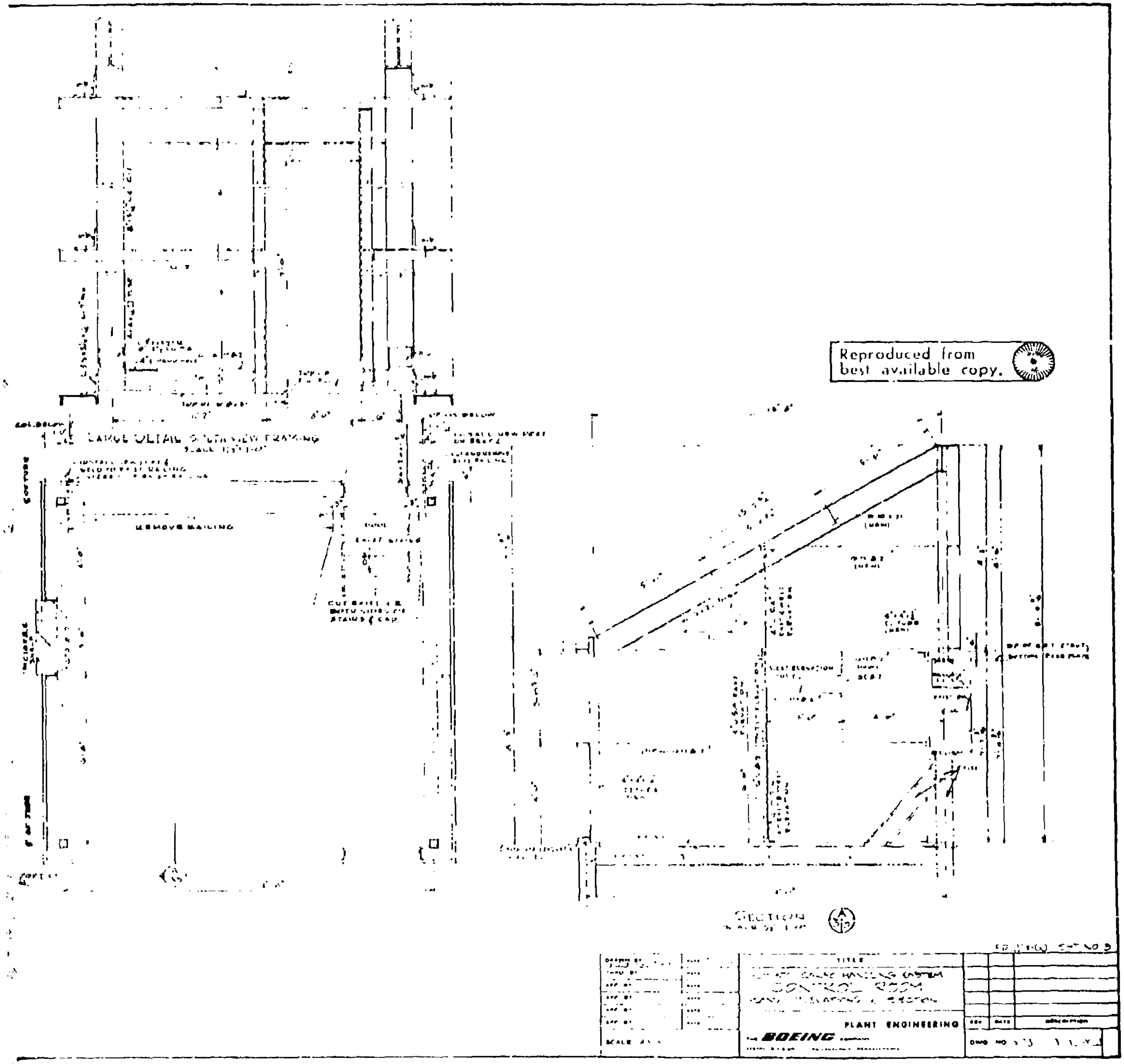

REMOVE RAILING
SECTION
CONTROL ROOM
PLANT ENGINEERING
BOEING

Section.

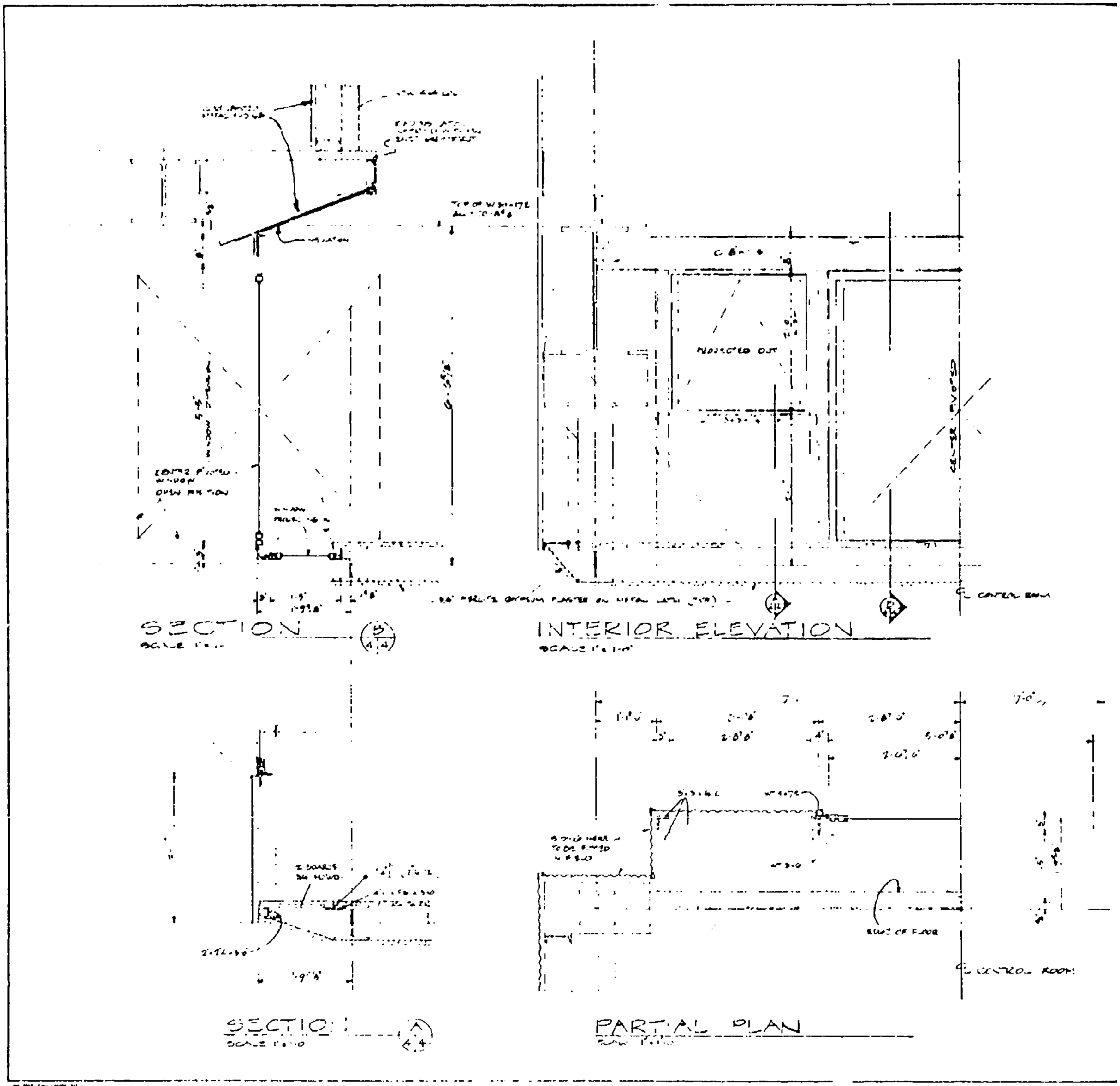
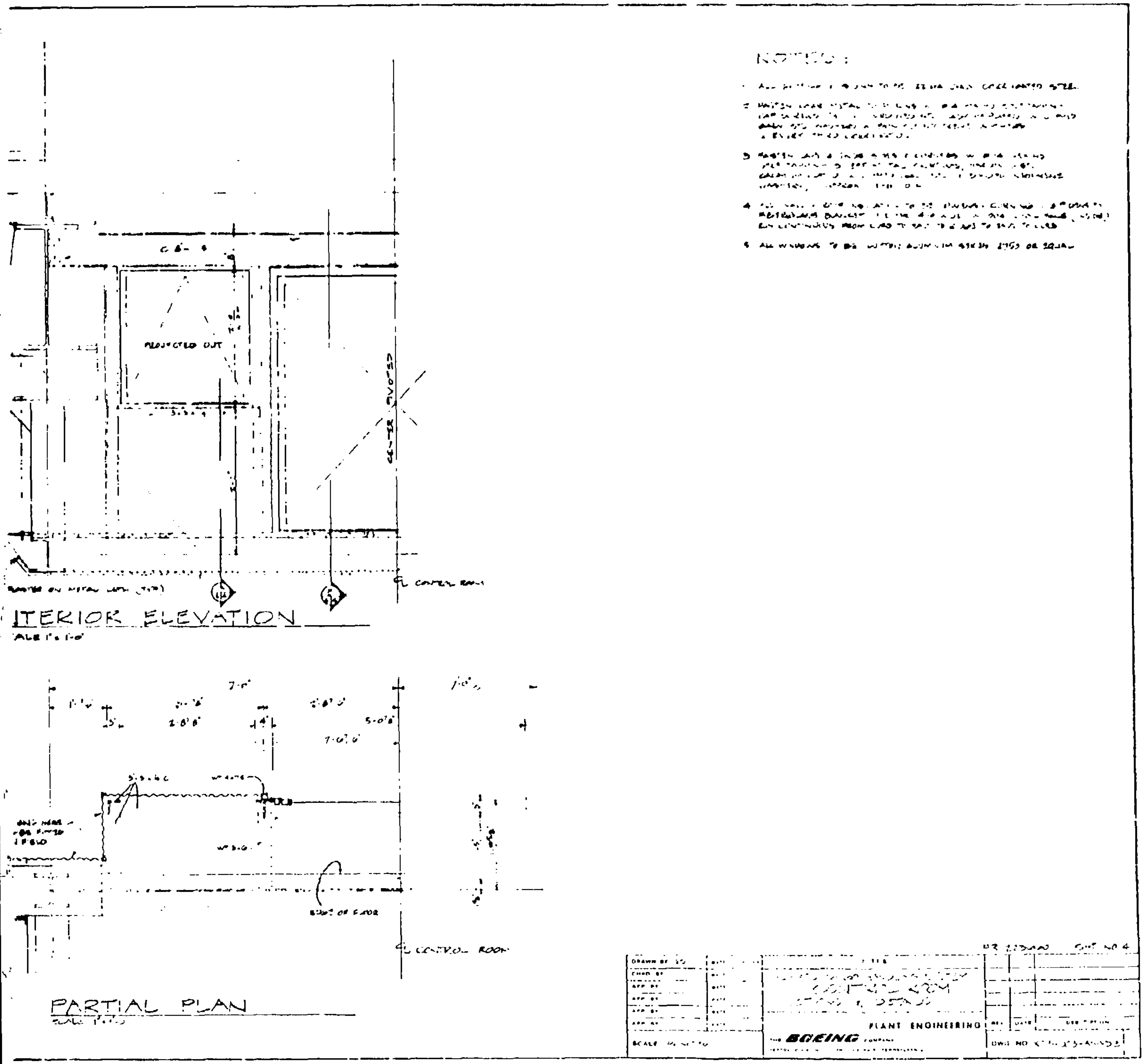


Figure 56. Control Room Section and Details.


NOTES:
PROJECTED OUT
ITERIOR ELEVATION
PARTIAL PLAN
CONTROL ROOM
PLANT ENGINEERING
BOEING

tails.

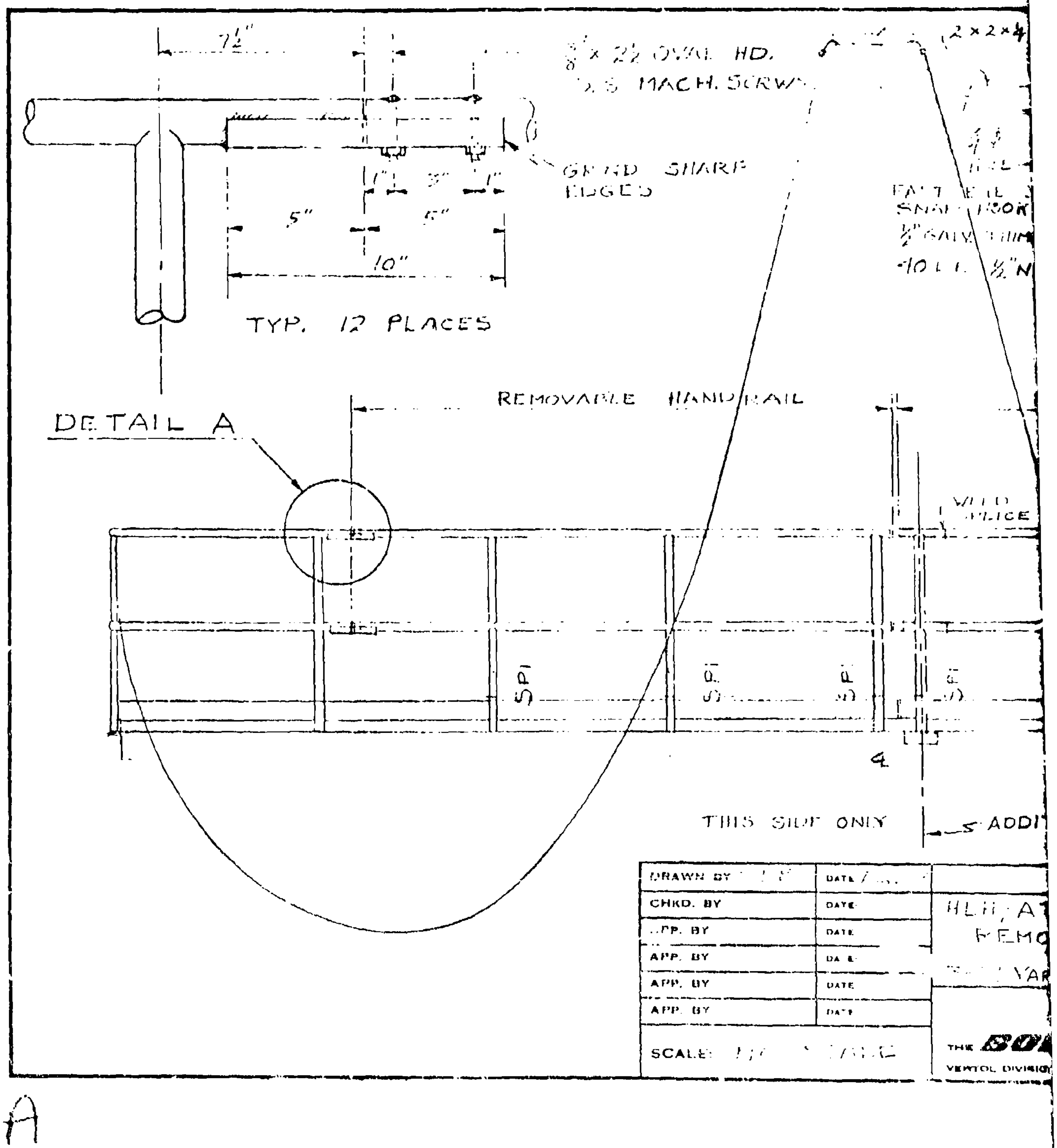
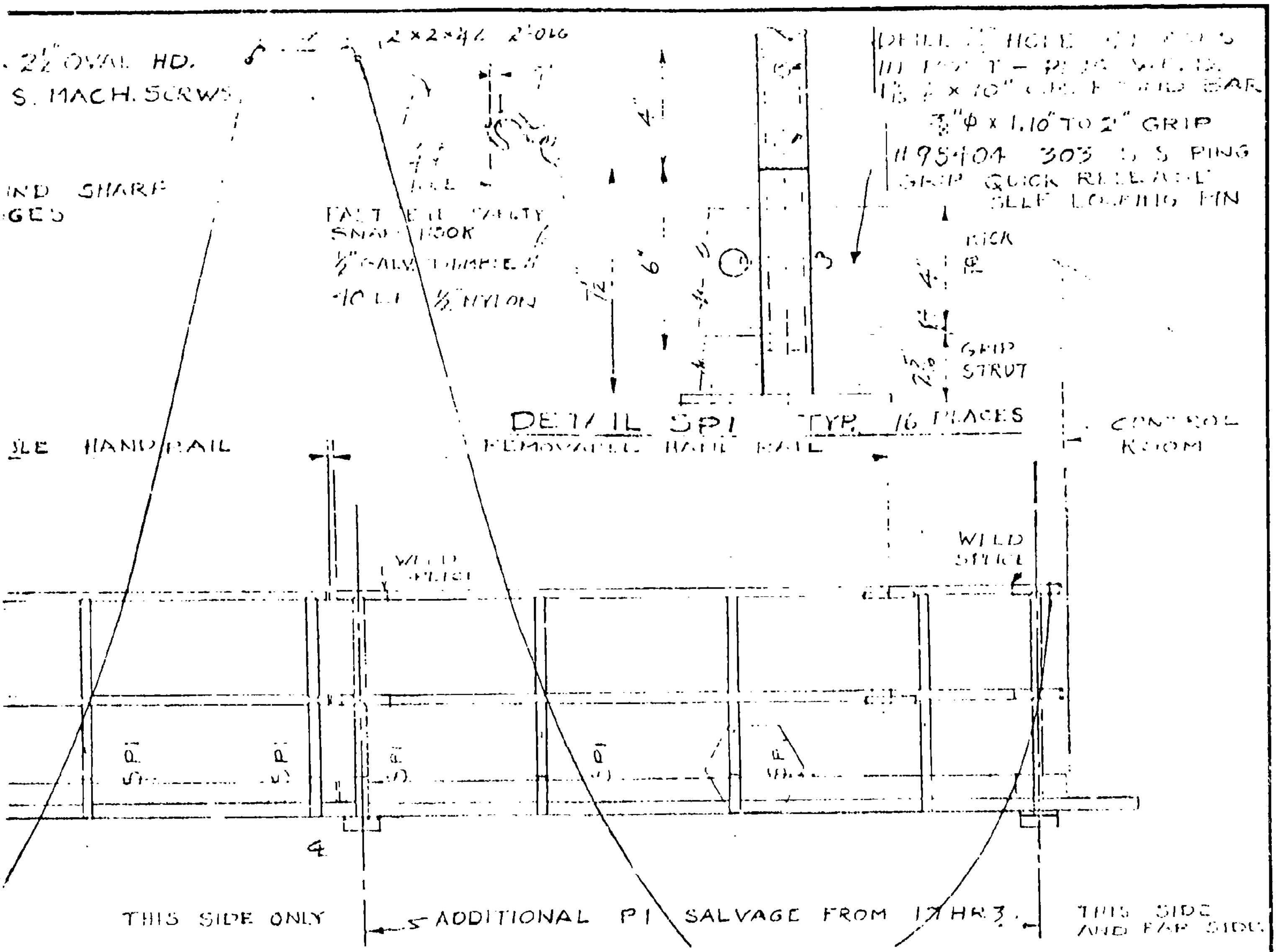


Figure 57. Removable Handrail Details.



DRAWN BY	DATE	TITLE			
CHKD. BY	DATE	HLH/ATC CARGO HANDLING SYS			
APP. BY	DATE	REMOVABLE HANDRAIL			
APP. BY	DATE	DETAILS CTR 7			
APP. BY	DATE				
APP. BY	DATE	PLANT ENGINEERING	REV	DATE	DESCRIPTION
SCALE:		THE BOEING COMPANY VERTOL DIVISION	DWG. NO.		

B

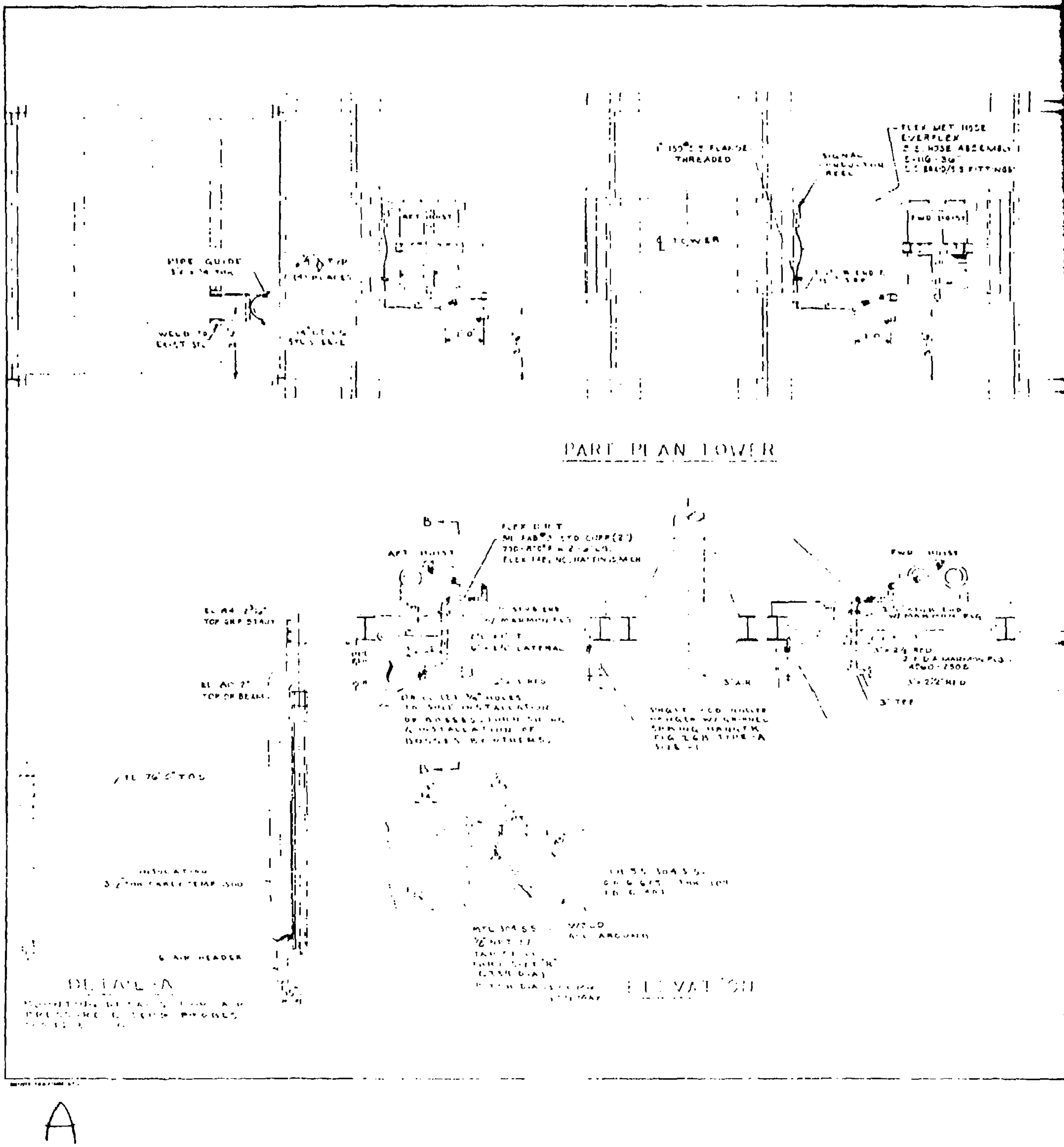


Figure 58. Piping Arrangement, Test Tower Top Section.

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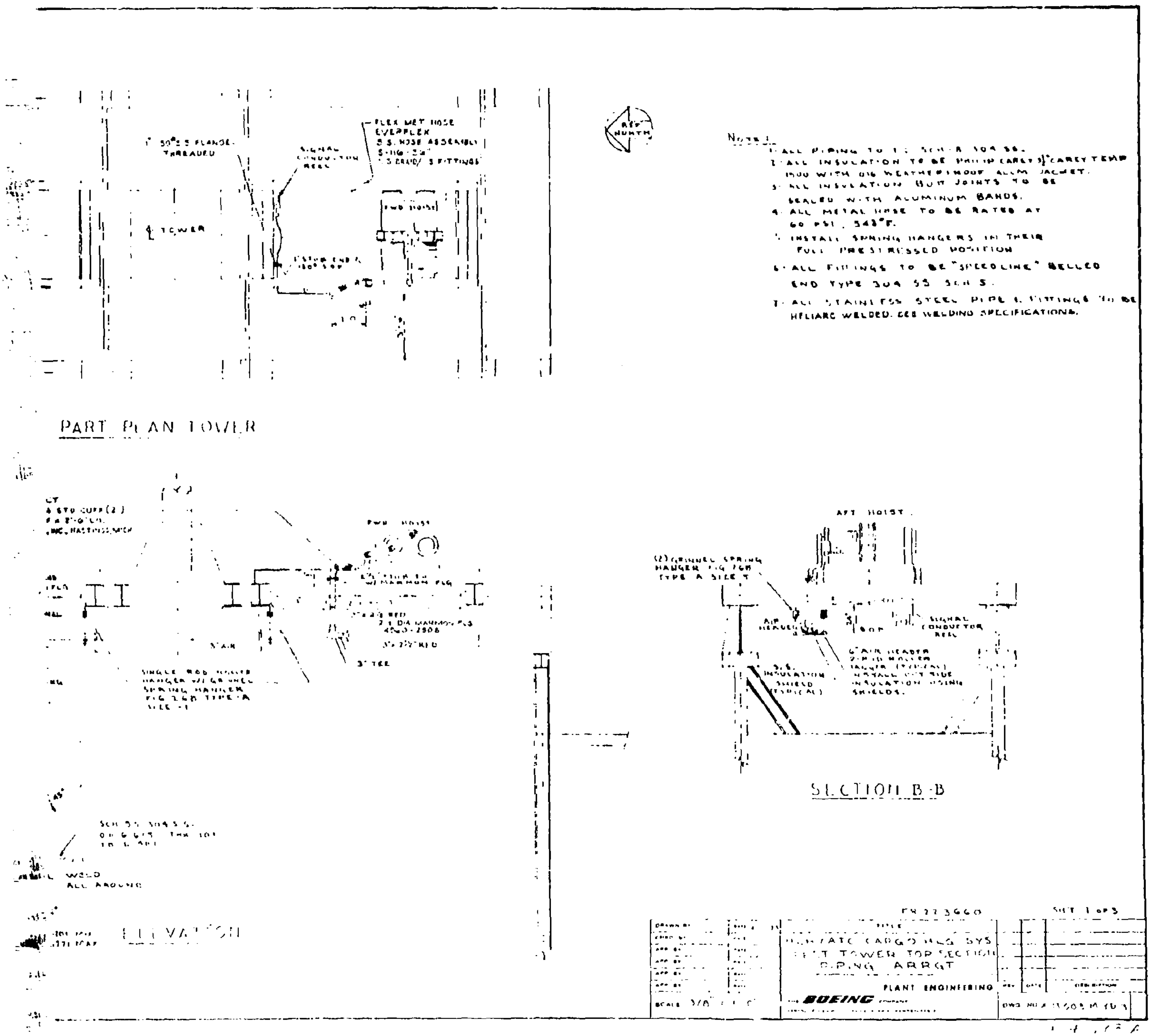
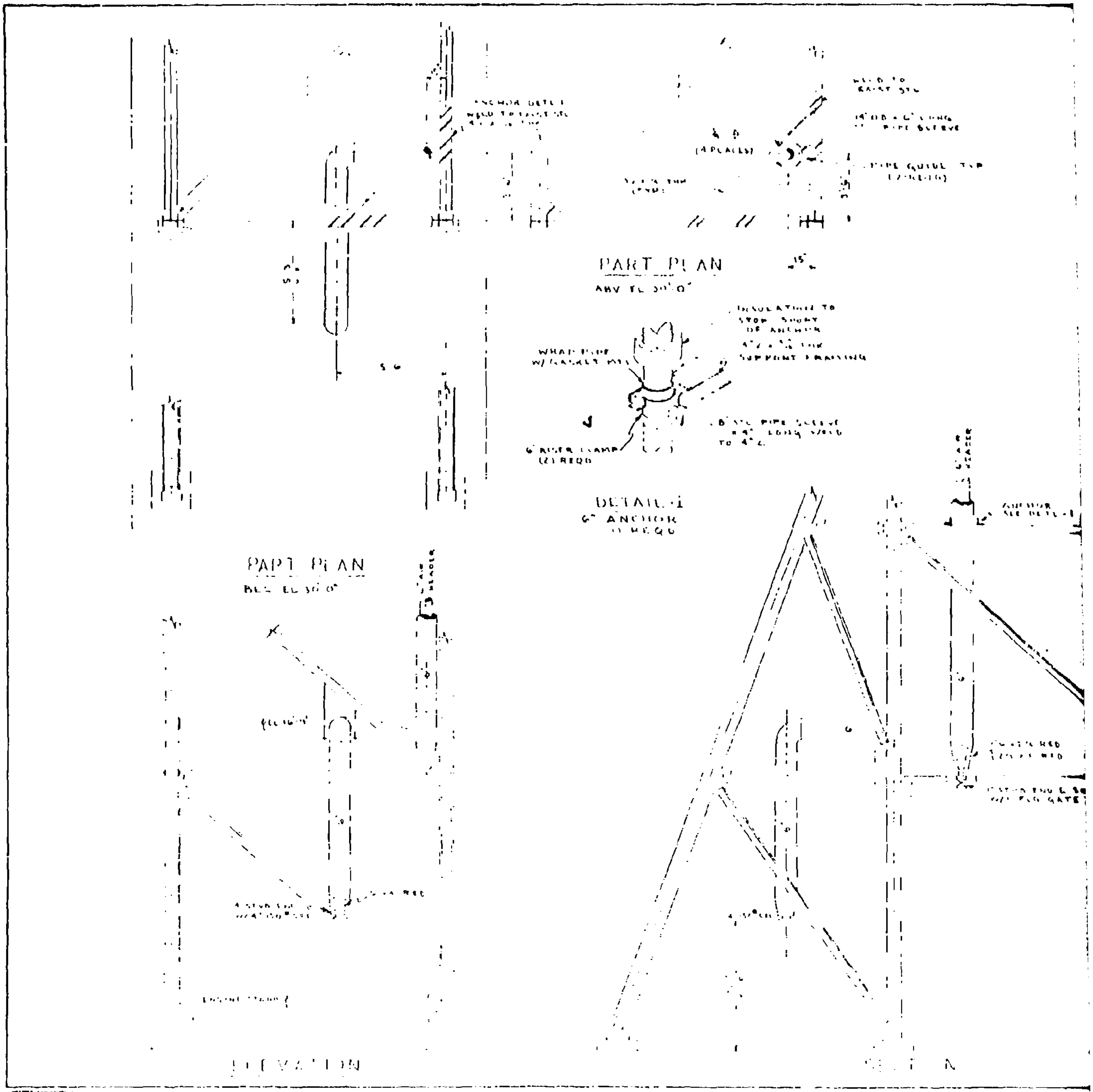
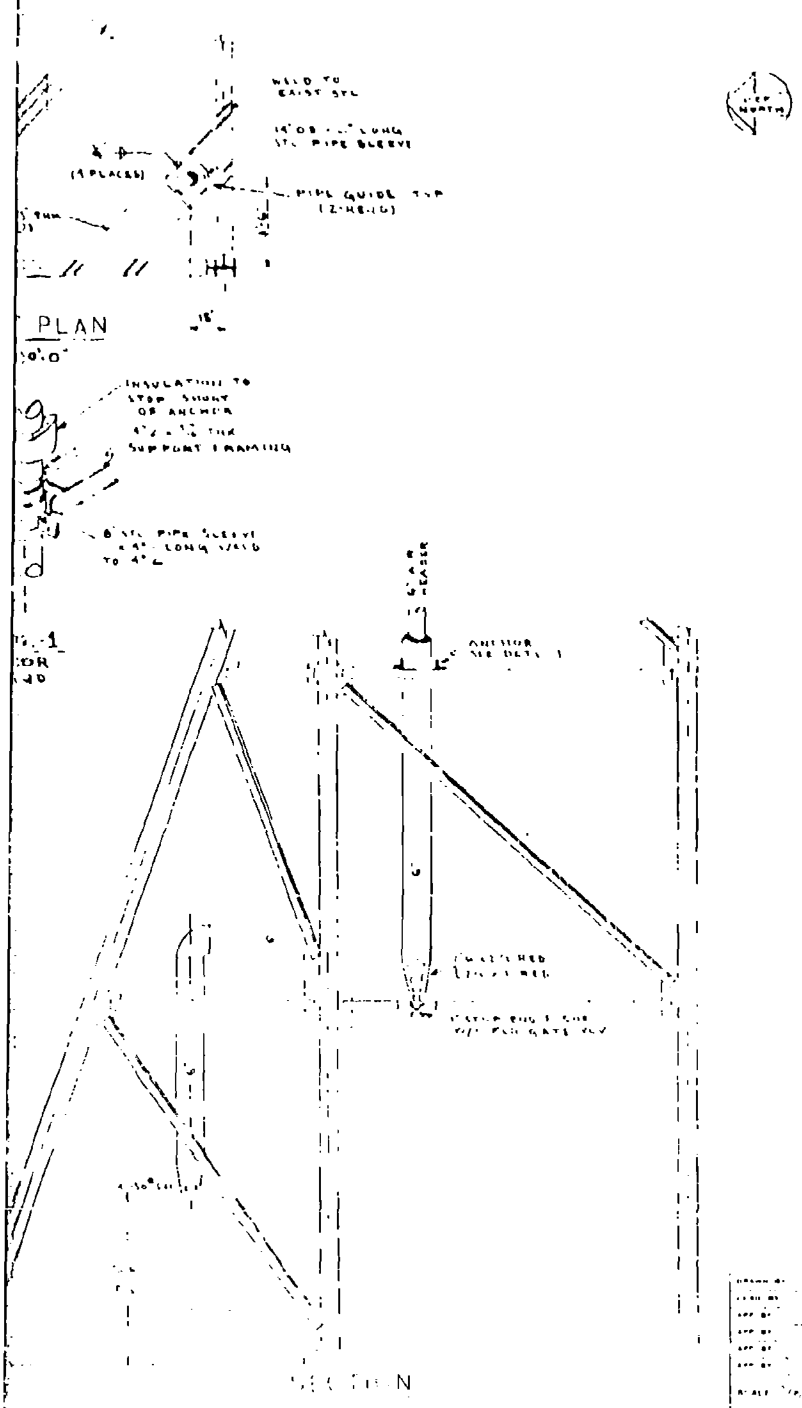

PART PLAN TOWER
FLEX MET HOSE
EVERFLEX
TOWER
FWD HOIST
SIGNAL CONDUCTOR REEL
NOTES:
ALL INSULATION BUTT JOINTS TO BE SEALED WITH ALUMINUM BANDS.
ALL METAL HOSE TO BE RATED AT 60 PSI, 343°F.
INSTALL SPRING HANGERS IN THEIR FULL PRESTRESSED POSITION
ALL FITTINGS TO BE "SPEEDLINE" BELLED END TYPE 304 SS SCH 5.
ALL STAINLESS STEEL PIPE & FITTINGS TO BE HELIARC WELDED. SEE WELDING SPECIFICATIONS.
AFT HOIST
SECTION B-B
ELEVATION
WELD ALL AROUND
PIPING ARRGT
PLANT ENGINEERING
BOEING

p Section.



A

Figure 59. Piping Arrangement, Test Tower Base.



NOTES:

1. SEE [illegible]
2. ALL INSULATION TO BE [illegible] 1½" [illegible] WITH [illegible] WEATHERPROOF [illegible] JACKET.
3. ALL FITTINGS TO BE [illegible] WELDED END TYPE 304L S.S. SCH 5.
4. ALL GASKETS TO BE 1/16 COMPRESSED ASBESTOS [illegible]
5. ALL STAINLESS STEEL PIPE & FITTINGS TO BE HELIARC WELDED. SEE WELDING SPECIFICATIONS.
6. ALL INSULATION [illegible] TO BE SEALED WITH ALUMINUM BANDS.

PLANT ENGINEERING

BOEING

B

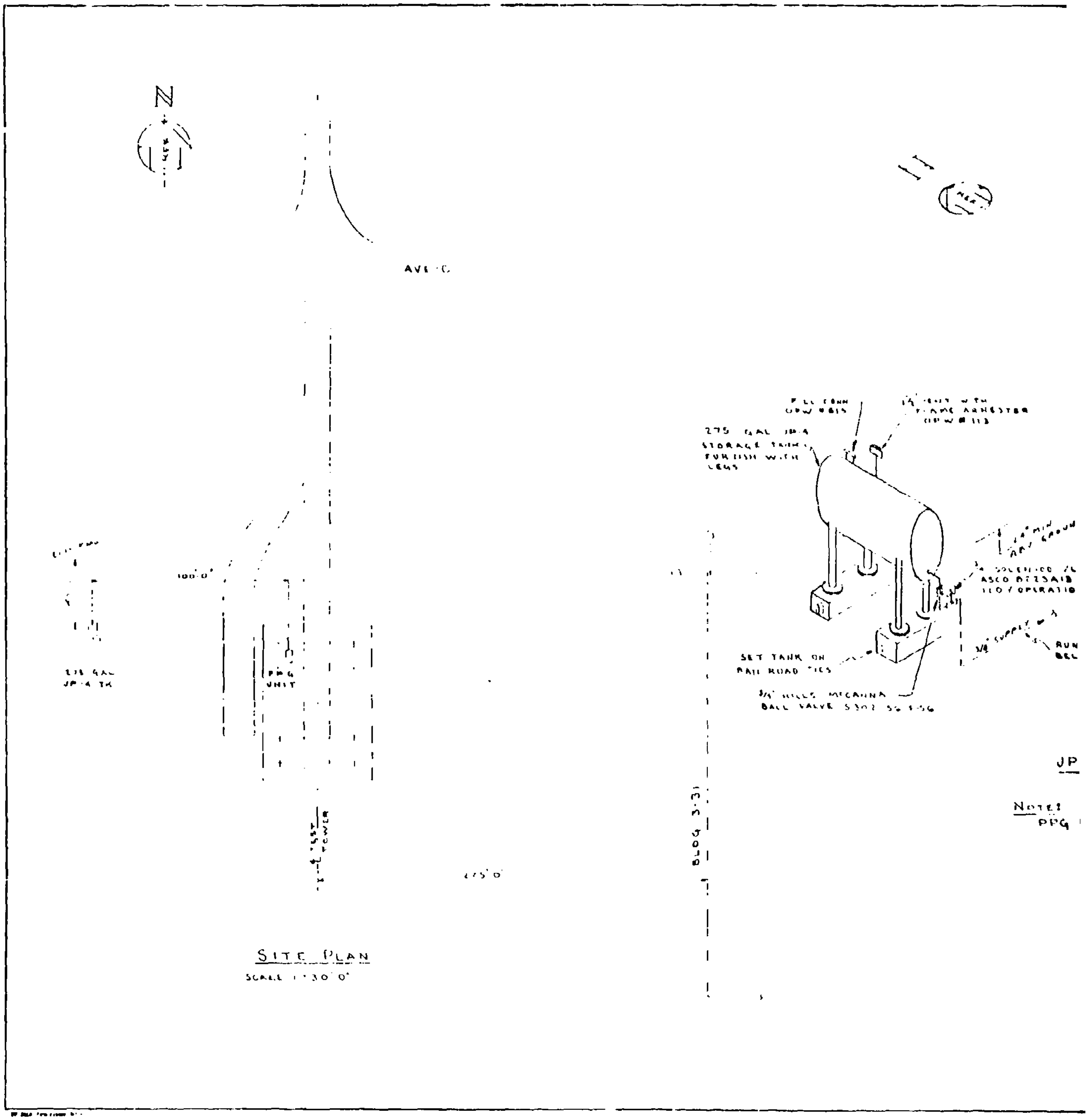
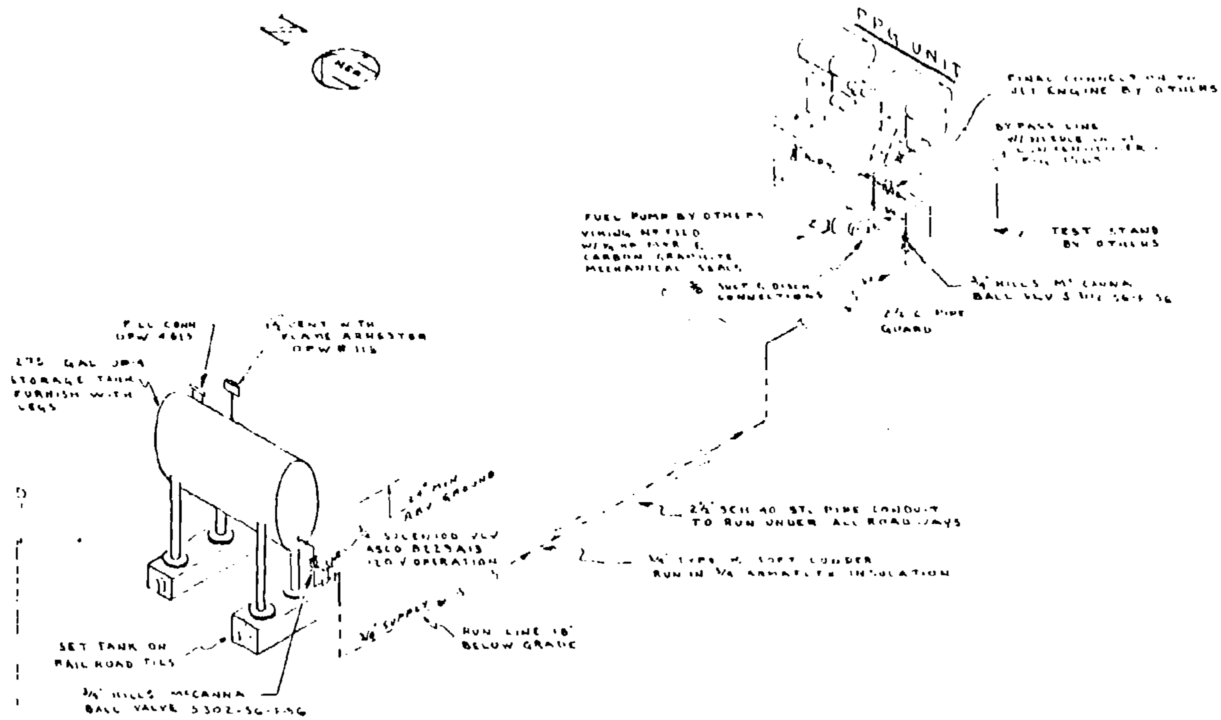


Figure 60. Fuel Piping Arrangement - PPG Unit.



JP-4 SUPPLY PIPING DETAILS

(NO SCALE)

Note:
PPG UNIT & FUEL PUMP BY OTHERS.

BLDG 3-31

DRAWN BY	DATE	TITLE	
CHKD BY	DATE	TEST POWER PPG UNIT	
APP BY	DATE	PIPING ARRGT	
APP BY	DATE	PLANT ENGINEERING	REV / DATE / DESCRIPTION
SCALE NOTED		THE BOEING COMPANY	DWG NO X 3003

SHT 3 of 3

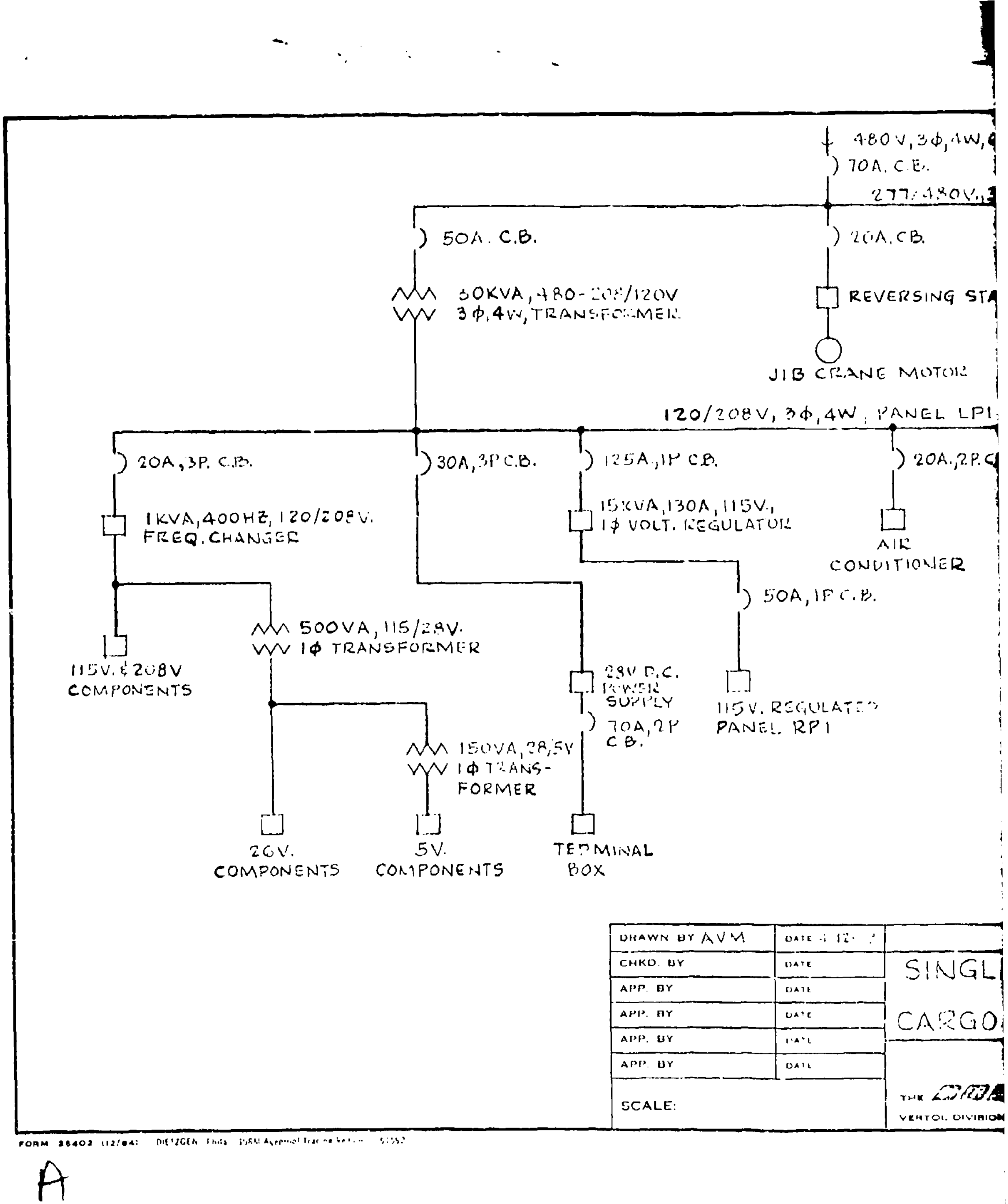


Figure 61. Electrical Single Line Diagram.

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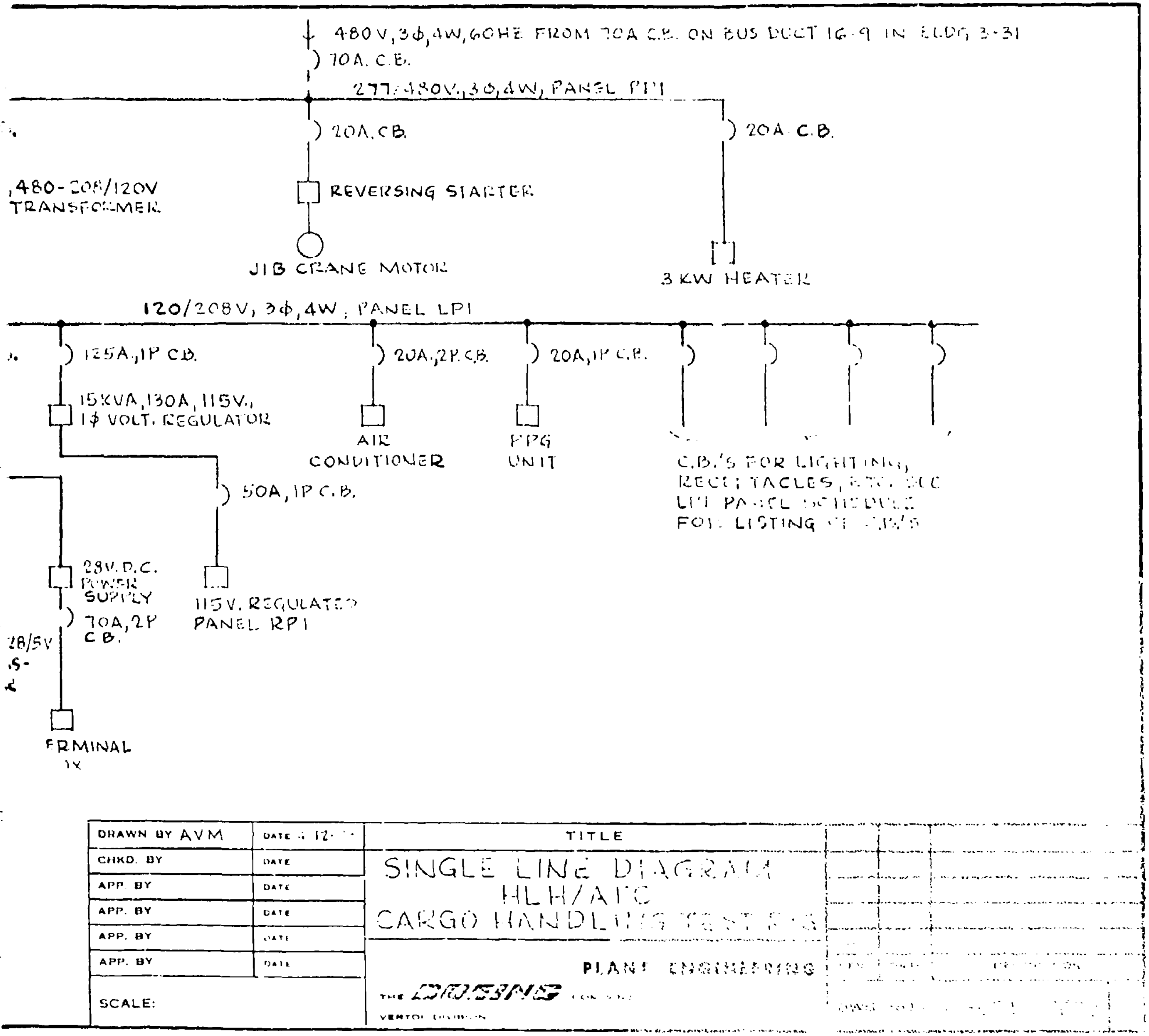
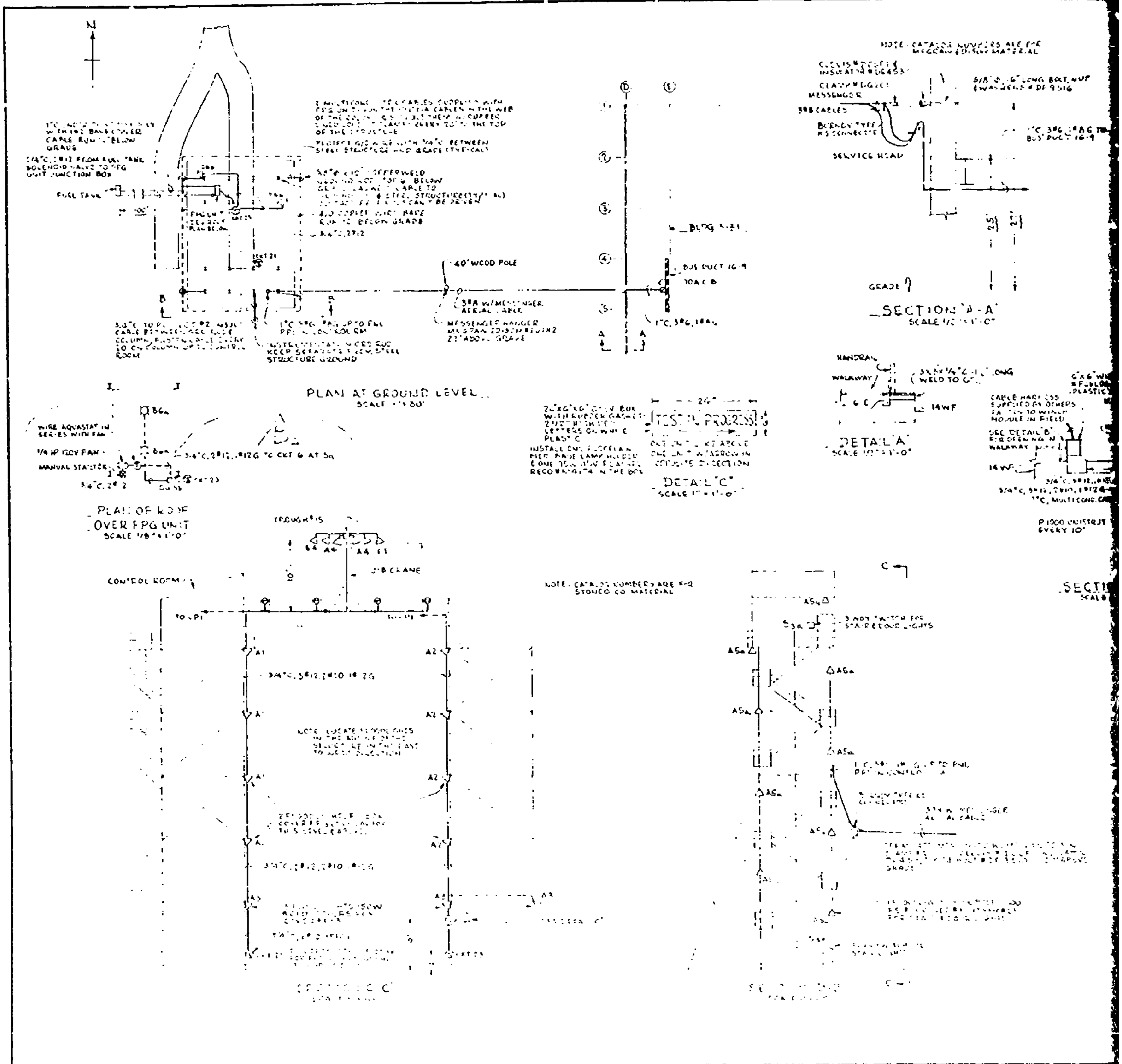

480V, 3φ, 4W, 60HZ FROM 70A C.B. ON BUS DUCT 16-9 IN BLDG 3-31
70A. C.B.
277/480V, 3φ, 4W, PANEL PP1
20A. C.B.
20A. C.B.
REVERSING STARTER
JIB CRANE MOTOR
3 KW HEATER
480-208/120V TRANSFORMER
120/208V, 3φ, 4W, PANEL LP1
125A., 1P C.B.
20A., 2P C.B.
20A., 1P C.B.
15KVA, 130A, 115V., 1φ VOLT. REGULATOR
AIR CONDITIONER
FPG UNIT
C.B.'S FOR LIGHTING, RECEPTACLES, ETC. SEE LP1 PANEL SCHEDULE FOR LISTING OF C.B.'S
50A, 1P C.B.
28V. D.C. POWER SUPPLY
70A, 2P C.B.
115V. REGULATED PANEL RP1
28/5V
ERMINAL
DRAWN BY AVM
CHKD. BY
APP. BY
APP. BY
APP. BY
APP. BY
DATE
SCALE:
TITLE
SINGLE LINE DIAGRAM
HLH/ATC
CARGO HANDLING TEST RIG
PLANT ENGINEERING
THE BOEING COMPANY
VERTOL DIVISION

gram.



A

Figure 62. Electrical HLH/ATC Cargo Handling Test Rig.

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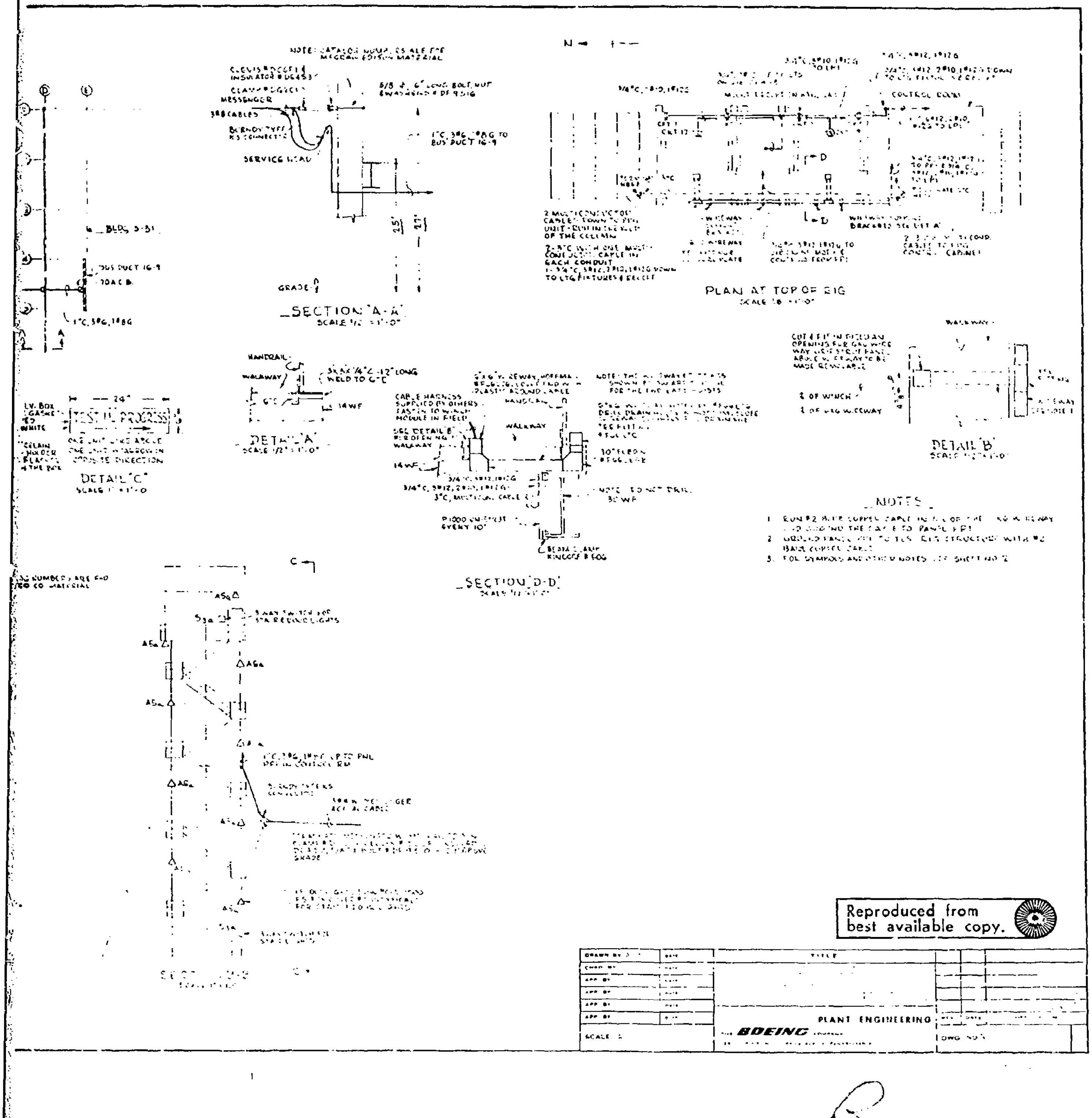
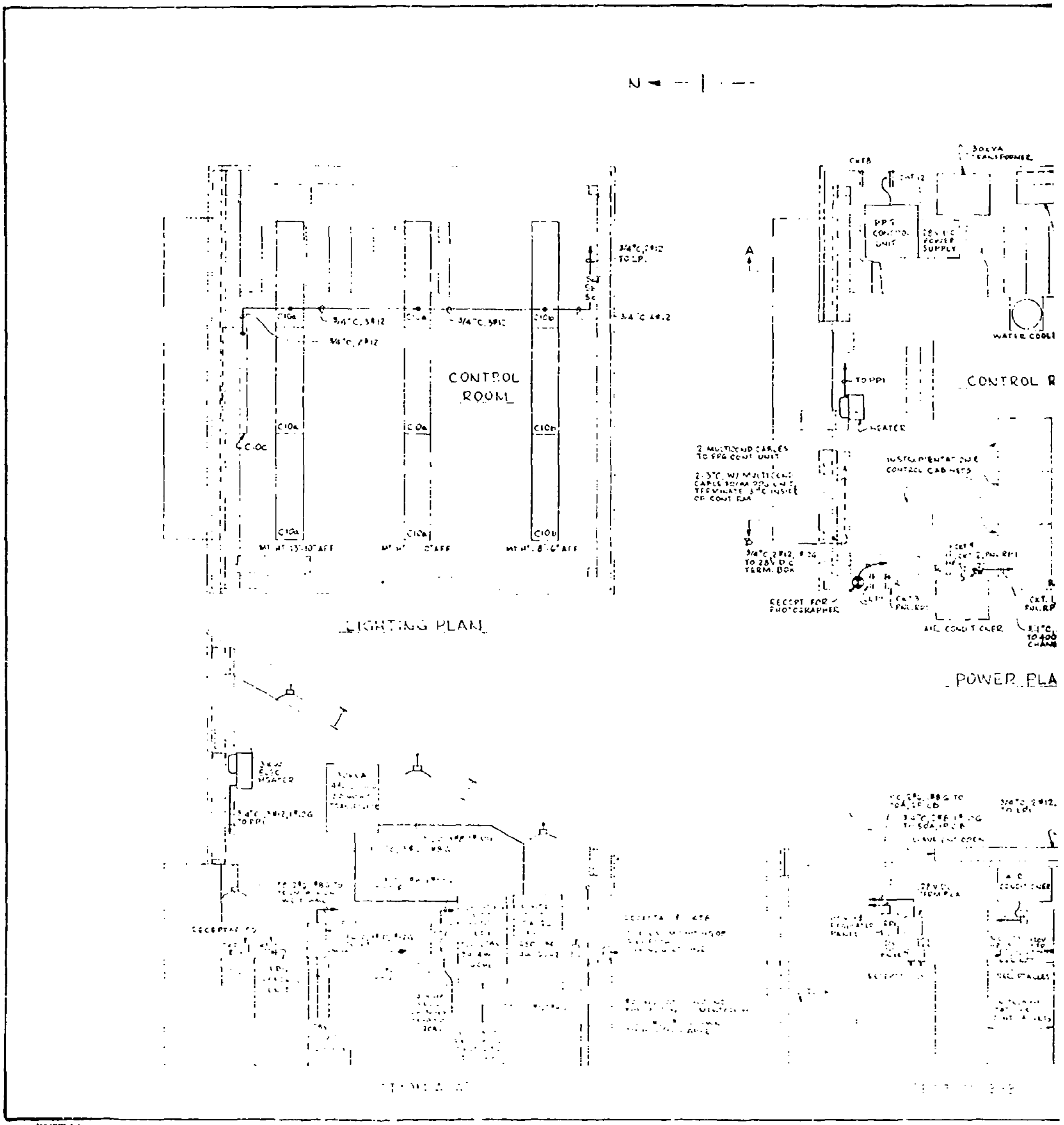

SECTION "A-A"
PLAN AT TOP OF RIG
DETAIL "A"
SECTION "D-D"
DETAIL "B"
DETAIL "C"
NOTES
Reproduced from best available copy.
PLANT ENGINEERING
BOEING

Test Rig.



A

Figure 63. Control Room Electrical Layout.

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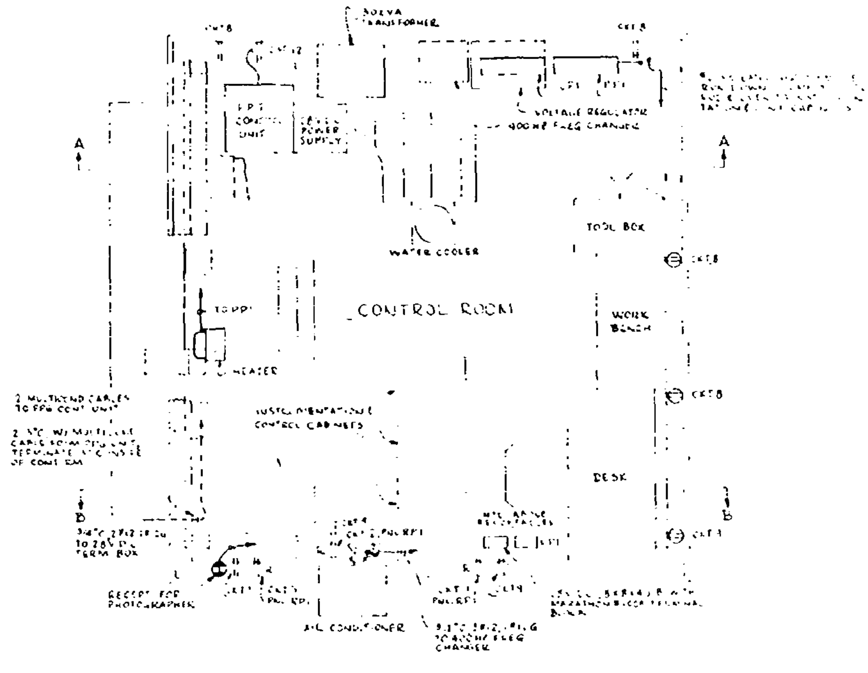

POWER PLAN

SYMBOLS

NOTES

BOEING PLANT ENGINEERING

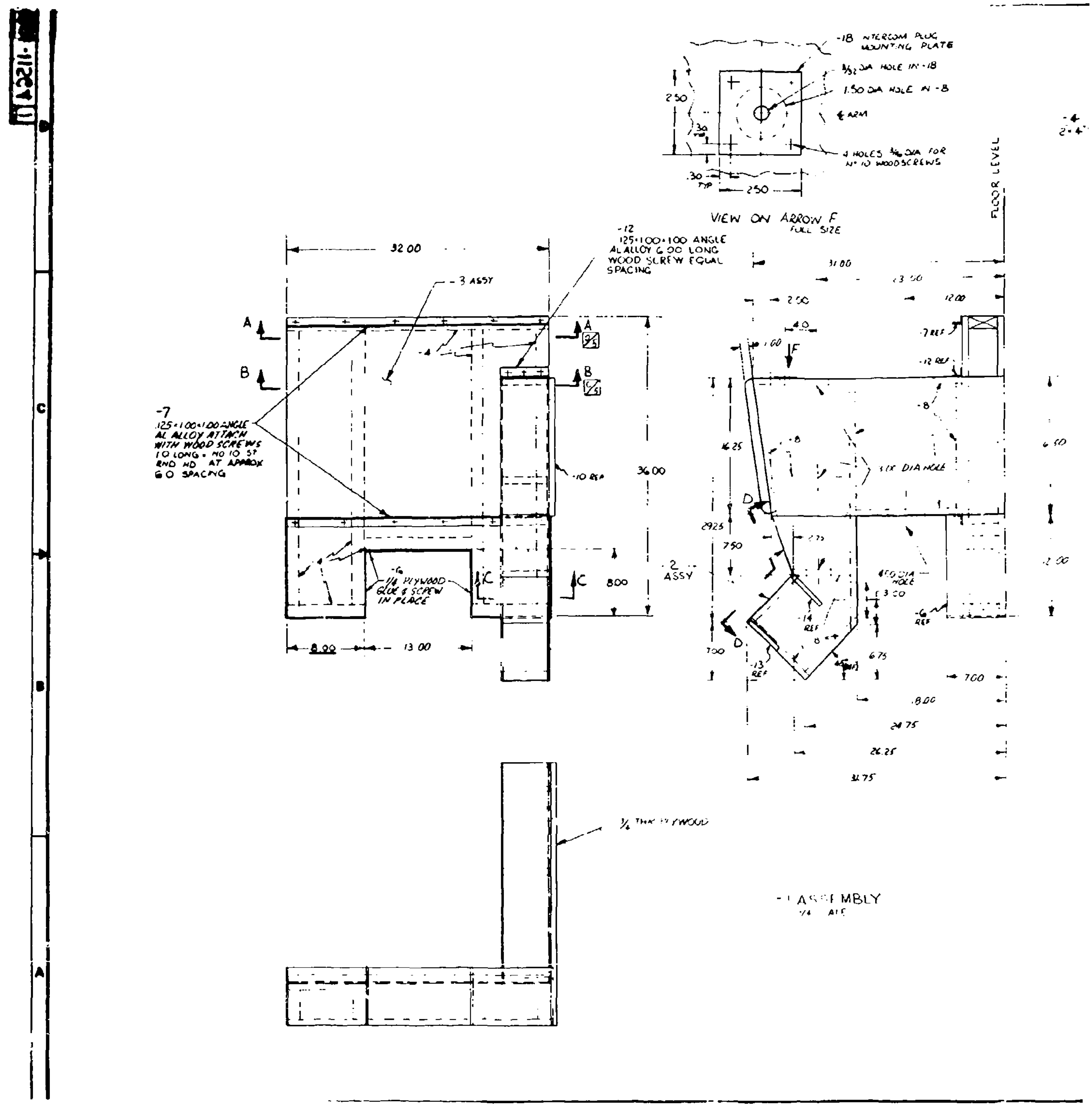

Figure 64. Load Controlling Crewman Platform - Integrated Test Rig.

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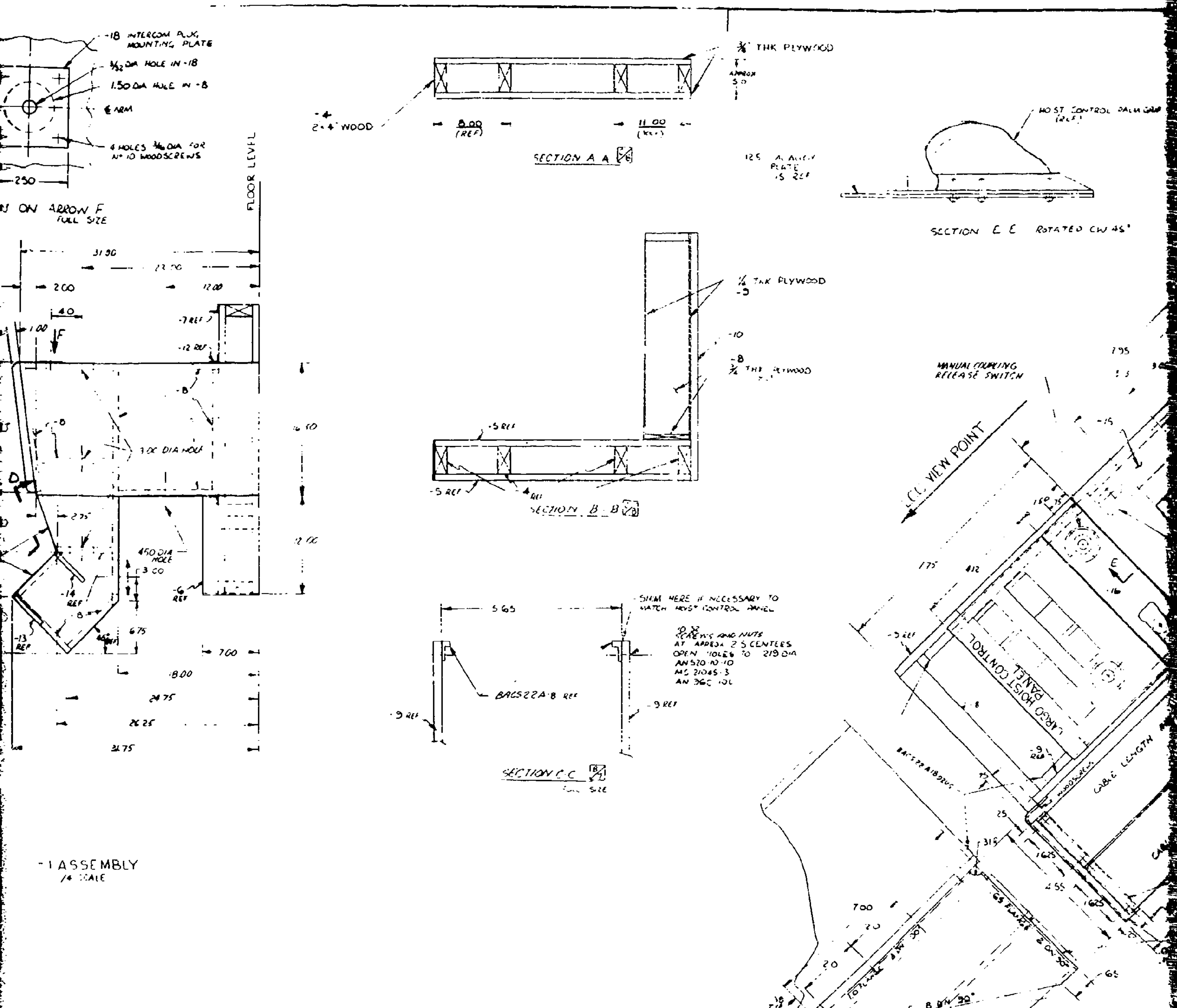
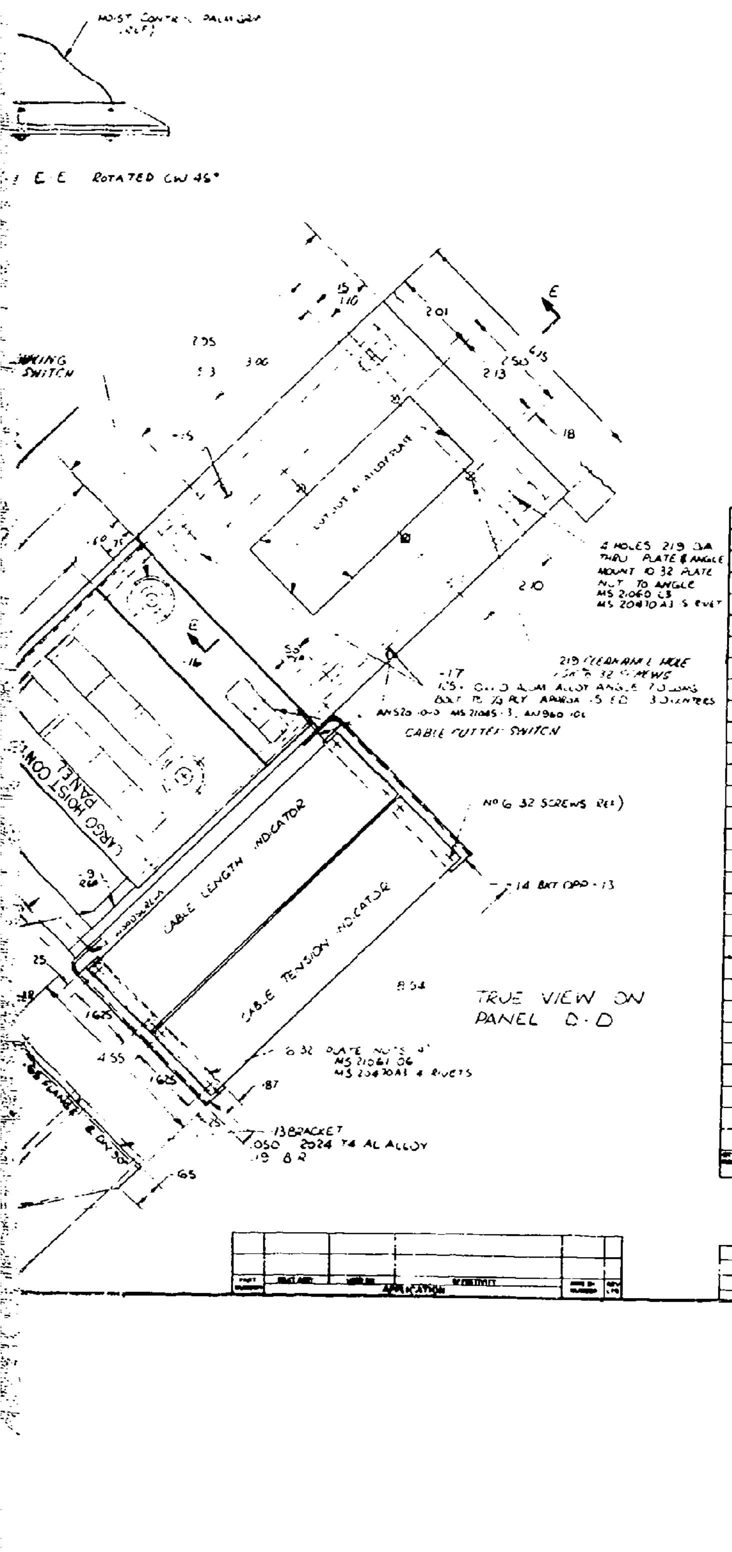
A


-18 INTERCOM PLUG MOUNTING PLATE
3/32 DIA HOLE IN -18
1.50 DIA HOLE IN -8
℄ ARM
4 HOLES 3/16 DIA FOR Nº 10 WOODSCREWS
ON ARROW F
FULL SIZE
FLOOR LEVEL
3/8" THK PLYWOOD
-4
2×4" WOOD
8.00 (REF)
11.00
SECTION A-A
.125 AL ALLOY PLATE
HOIST CONTROL PALM GRIP (REF)
SECTION E-E ROTATED CW 45°
1/4 THK PLYWOOD
-5
-10
-8
3/4 THK PLYWOOD
-5 REF
SECTION B-B
3.00 DIA HOLE
4.50 DIA HOLE
SHIM HERE IF NECESSARY TO MATCH HOIST CONTROL PANEL
5.65
BACS22A-8 REF
-9 REF
SECTION C-C
FULL SIZE
MANUAL COUPLING RELEASE SWITCH
VIEW POINT
CARGO HOIST CONTROL PANEL
CABLE LENGTH
-1 ASSEMBLY
4 HOLES .219 DIA
SK301-11564

B



NOTES

1. MATERIALS & HARDWARE MAY BE SUBSTITUTED TO SUIT AVAILABILITY
2. GLUE & SCREW -2 ASSY AS NECESSARY
3. GLUE & SCREW -3 ASSY AS NECESSARY
4. -1 TO BE ASSEMBLED IN ITR CONTROL ROOMS
5. INDICATORS, SWITCHES CONTROLLER & PANEL SHOWN FOR REF ONLY
6. PAINT 'COCKPIT GREY'

QTY	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION
2	BAC S22 A18	DZUS RAIL	
8	MS 21061-06	PLATE NUT	
4	MS 21060-L3	PLATE NUT	
16	MS 20470A3-4	RIVET	
8	MS 20470A3-5	RIVET	
AR AR AR	Nº 10 × 1.0 RND HD WOODSCREW		COMML
8	AN 520-10-10	SCREW	
8	MS 21045-3	NUT	
18	AN 960-10	WASHER	
1	-18	MTG PLATE	.125 × 2.5 × 2.5 2024 T4 AL ALY
2	-17	ANGLE	1/8 × 1.0 × 1.0 AL ALY ANGLE × 7.0
	-16	SWITCH PANEL	EXISTING
1	-15	MTG PLATE	.125 × 6.2 × 8.0 2024 T4 AL ALY
1	-14	OPP -13	
1	-13	BRACKET	.050 × 6 × 8 2024 T4 AL ALY
	-12	CLIP	1/8 × 1.0 × 1.0 AL ALY ANGLE × 6.0
	-11	ARM REST	2 × 6 × 16 SPONGE RUBBER
1	-10	REINFORCING	17 × 31 × 3/4 COMML PLY
2	-9	SIDE PLATE	26 × 37 × 3/4 COMML PLY
	-8	FRAME	37.0 × 56.5 × 3/4 COMML PLY
2	-7	ANGLE	1/8 × 1.0 × 1.0 AL ALY ANGLE × 32.0
	-6	BACK PLATE	60.5 × 7 × 3/4 COMML PLY
2	-5	COVER	32 × 36 × 3/4 COMML PLY
1	-4	FRAME	2 × 4 LUMBER COMML × 7.6 LG
	-3	PLATFORM ASSY	
	-2	ARM ASSY	
	-1	ASSEMBLY	

PARTS LIST

DAAJ01 71-C-0840(P6)

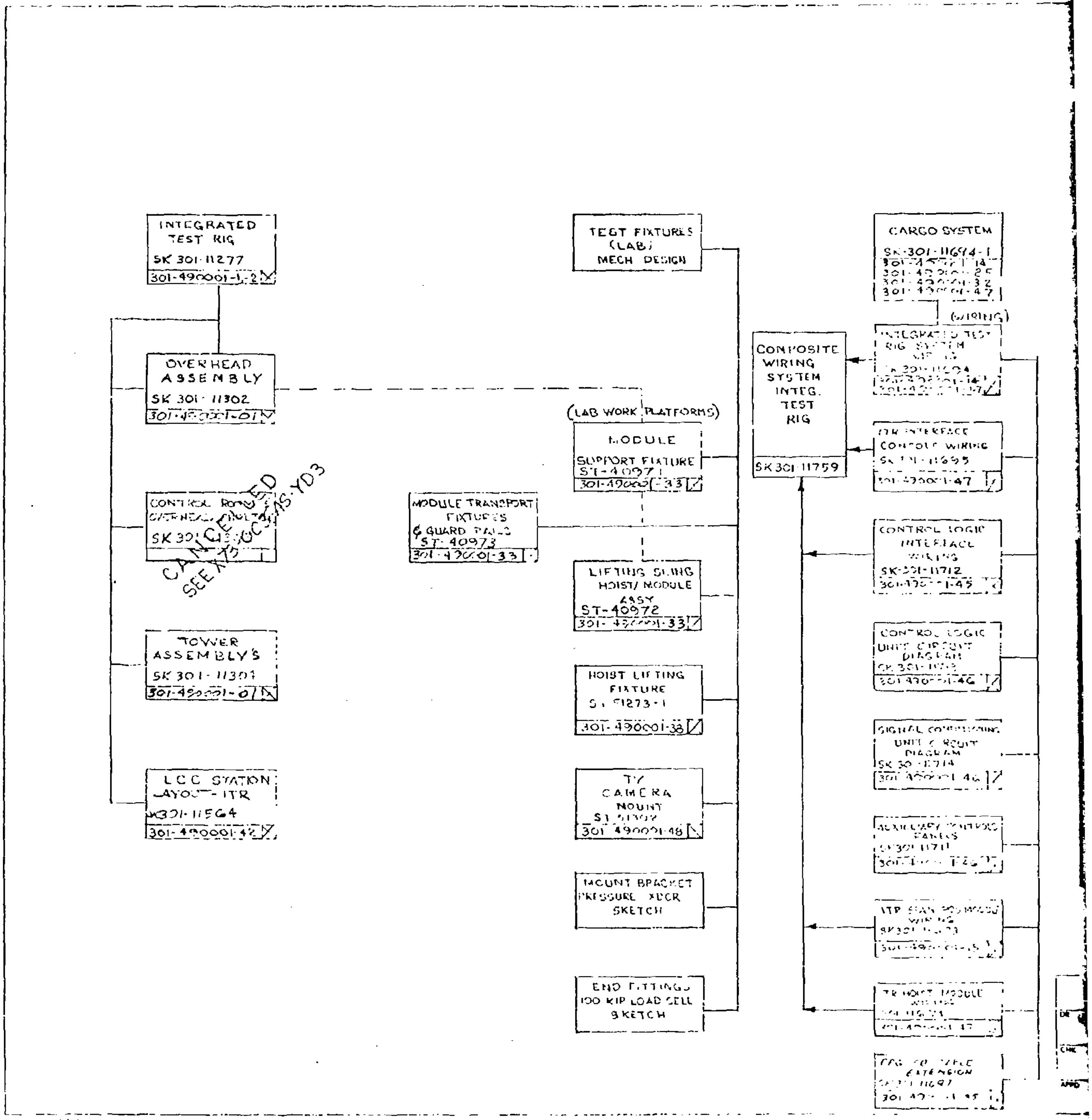
LOAD CONTROLLING CREWMAN PLATFORM INTEGRATED TEST RIG

J 77272 SK301-11564

SCALE 4

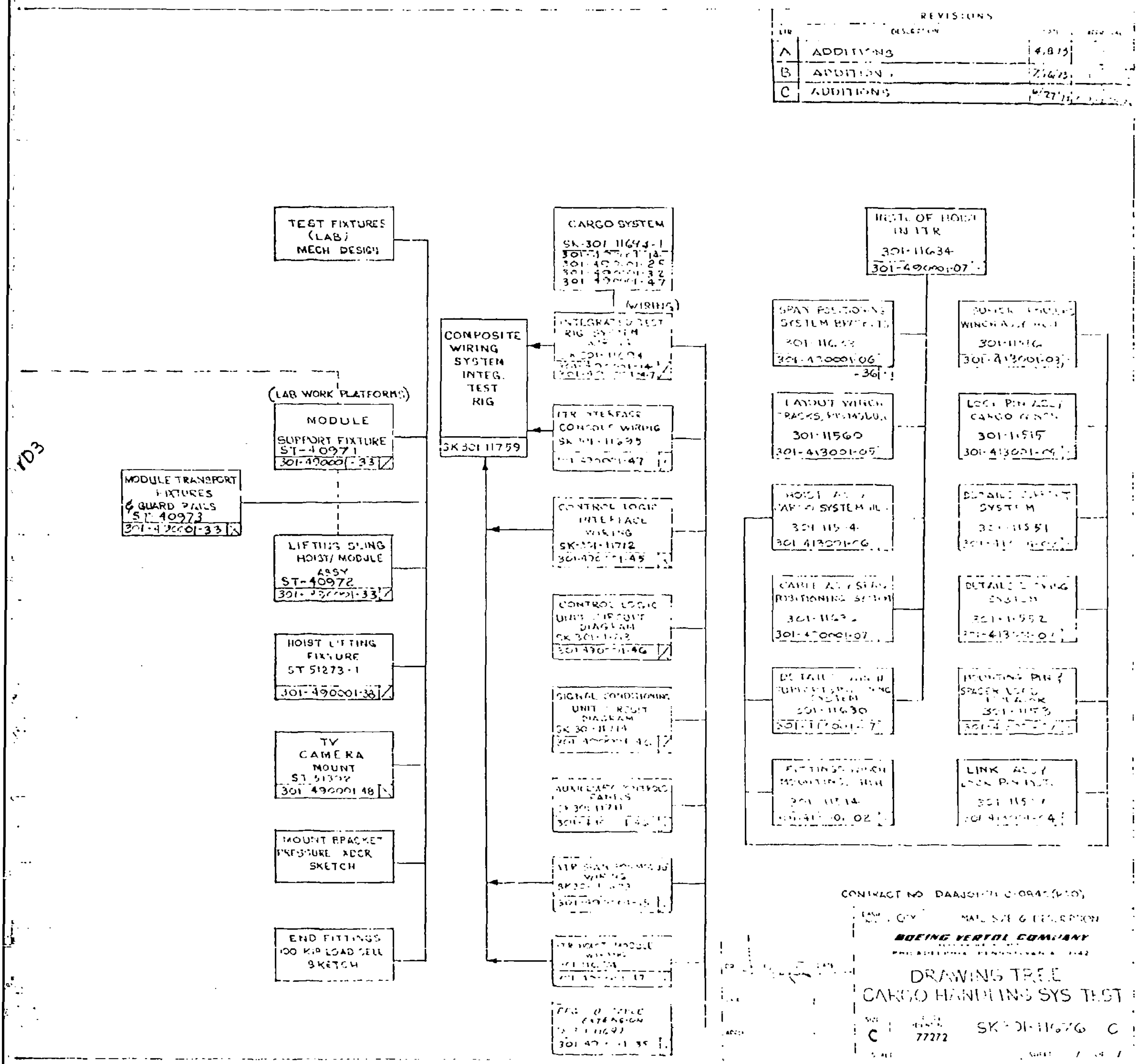
APPLICATION

FASTENER CODES

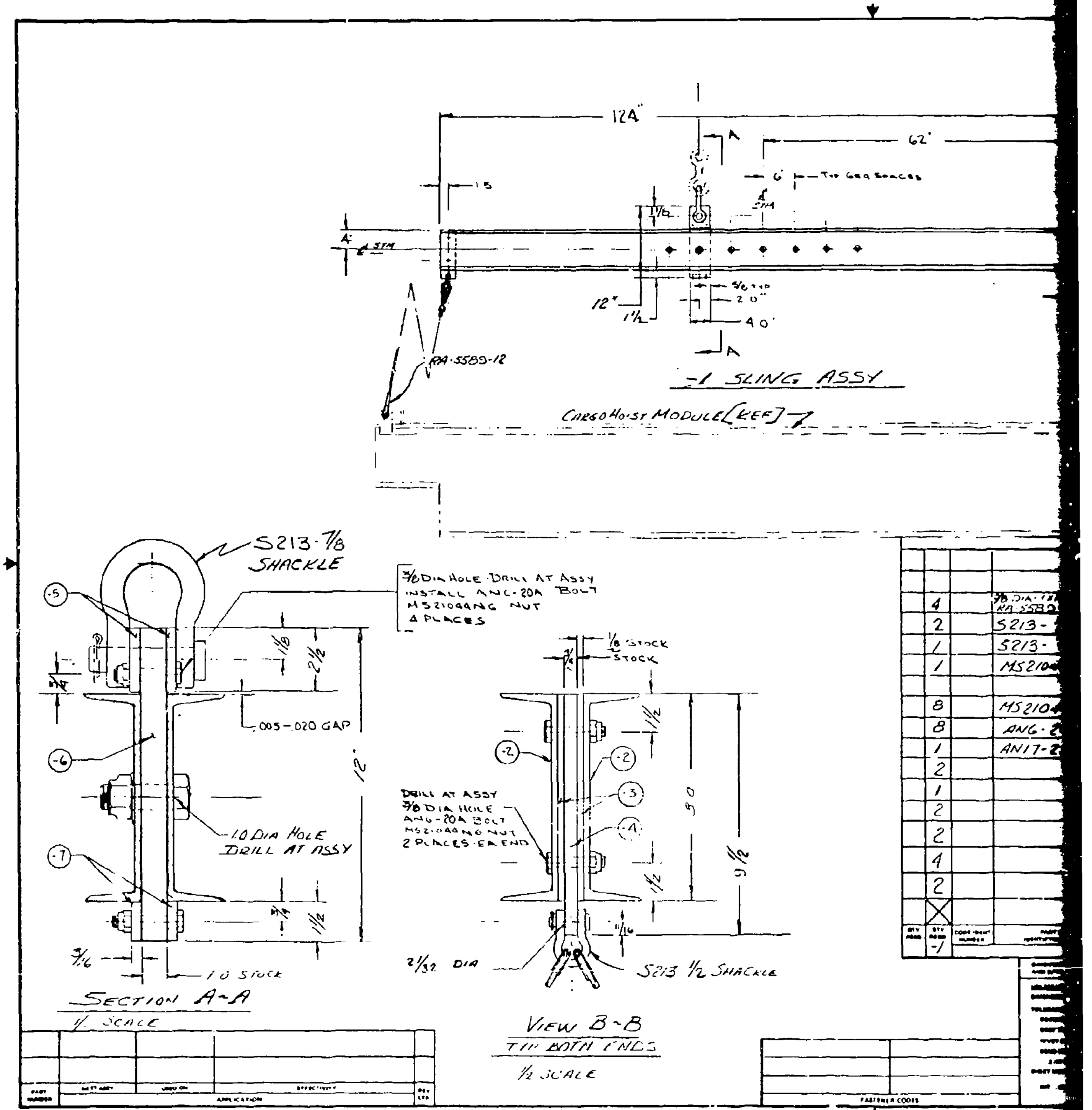


A

Figure 65. System Test - Drawing Tree.



/stem Test - Drawing Tree.



A

Figure 66. Lifting Sling, Hoist/Module

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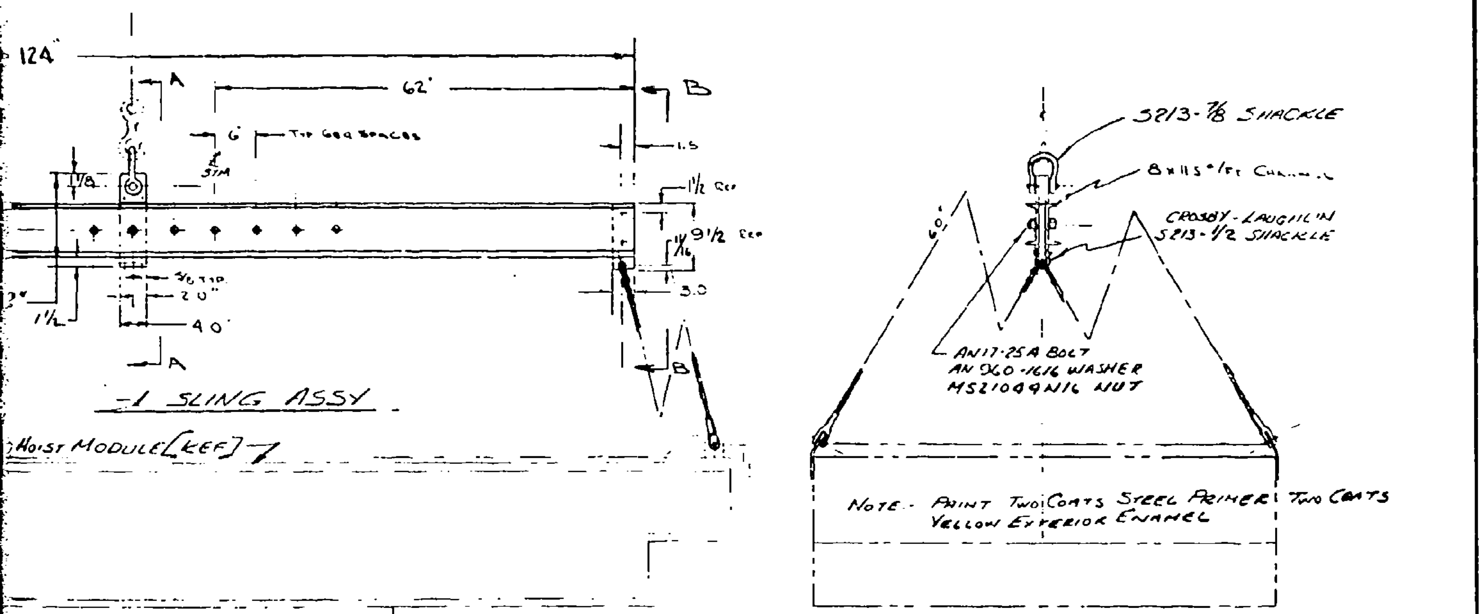

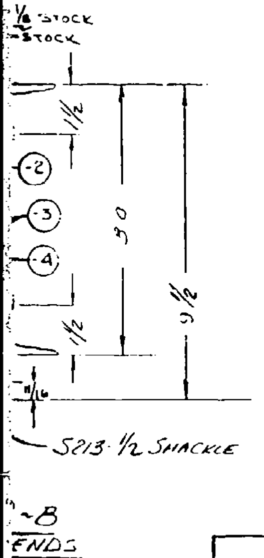

QTY REQD	QTY REQD -1	CODE IDENT NUMBER	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION		FINISH	ITEM	SERIALIZATION BASE NUMBER	REV LTR
	4		7/8 DIA-1313 STAINLESS STEEL WIRE ROPE - 60" LENGTH KR 5555-12 ONE END - THIMBLE PLAIN LOOP OTHER END		ACCO WIRE ROPE DIV AMERICAN CHAIN CABLE 211 S. PENNSYLVANIA AVE. WILKES BARRE PA					
	2		5213-1/2	SHACKLE	CROSBY-LAUGHLIN	CHESTER HARDWARE				
	1		5213-7/8	SHACKLE	CROSBY-LAUGHLIN					
	1		MS21044N16	NUT						
	8		MS21044N6	NUT						
	8		AN6-20A	BOLT						
	1		AN17-25A	BOLT						
	2		-7	SPACER	3/16 x 1 1/2 x 4 - STEEL PLATE - COMM'L				1020	
	1		-6	CENTER PLATE	1 x 4 x 12 - STEEL PLATE COMM'L				1020	
	2		-5	SPACER	3/16 x 1 1/2 x 4 STEEL PLATE - COMM'L				1020	
	2		-4	LIFT PLATE	3/4 x 3 x 9 1/2 - STEEL PLATE - COMM'L				1020	
	4		-3	SPACER	1/8 x 3 x 8 STEEL PLATE COMM'L				1020	
	2		-2	CHANNEL	8 x 11.5#/FT - 124" LENGTH STEEL CHANN				A-36	
	X		-1	SLING ASSY						

PARTS LIST

THE **BOEING** COMPANY
CORPORATE OFFICES SEATTLE WASHINGTON 98124

SLING ASSEMBLY
HOIST MODULE

D | 77272 | ST-10972

FASTENER CODES

B

Hoist/Module .

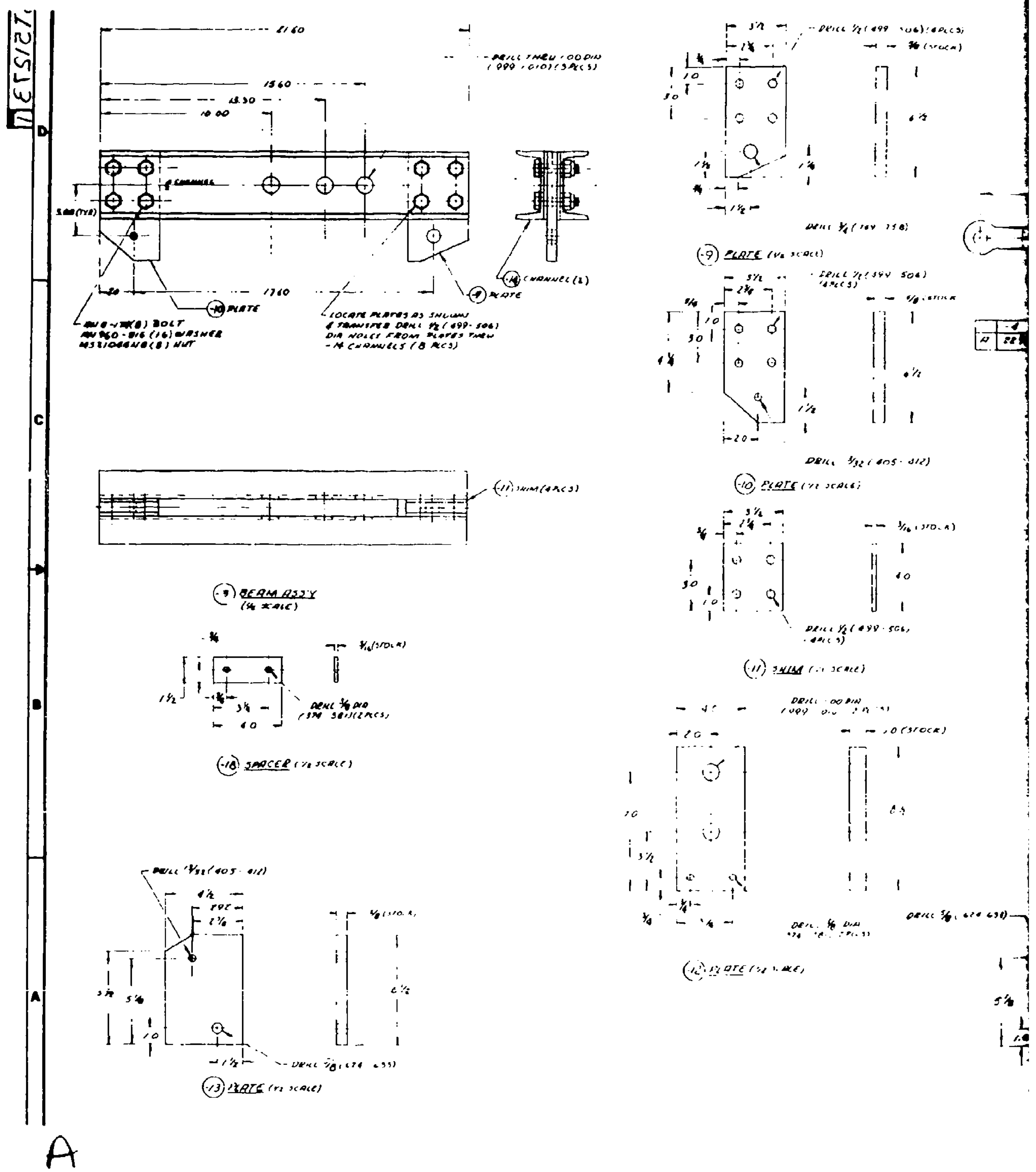

Figure 67. Hoist Lifting Fixture (Sheet 1).

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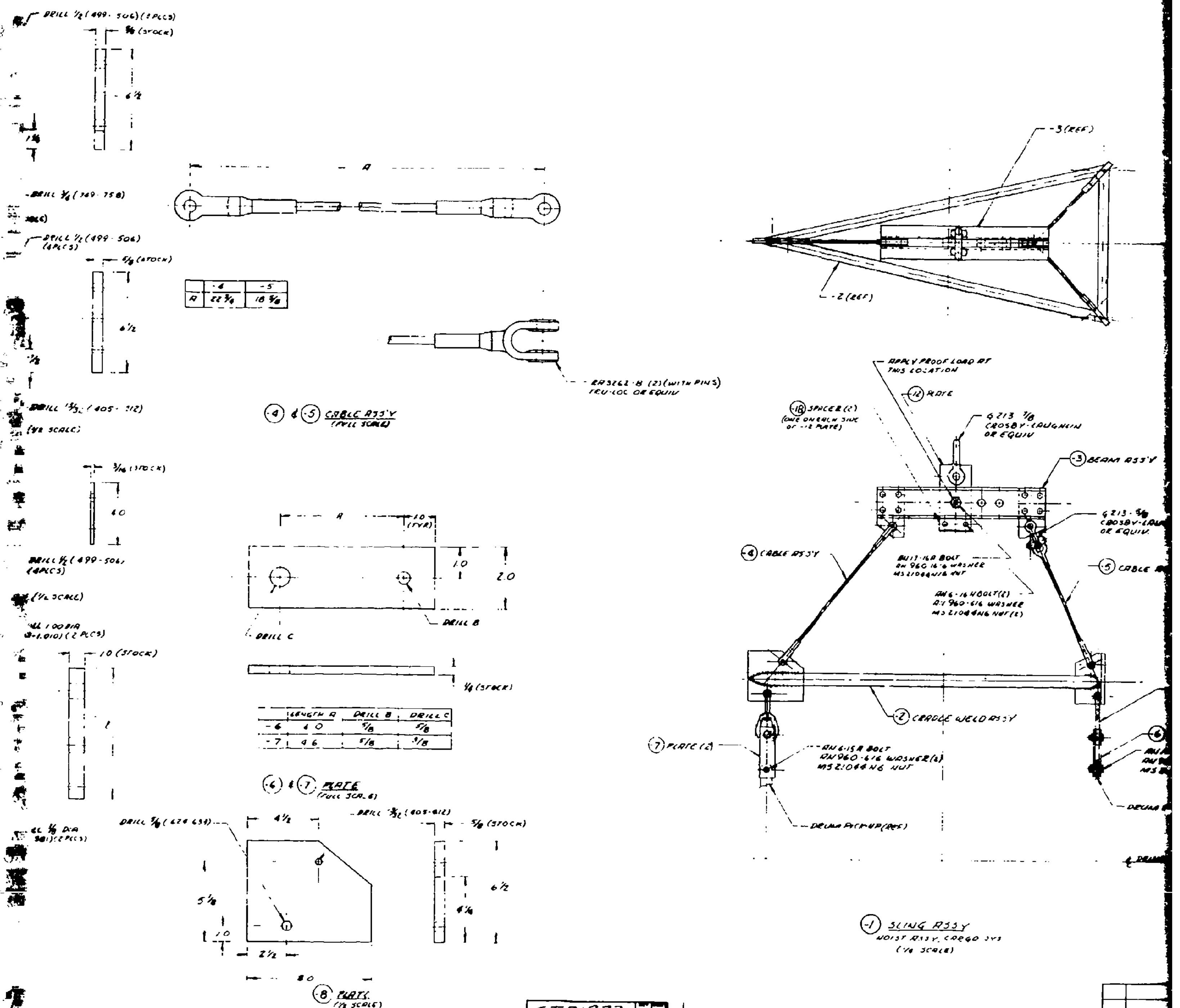


	-4	-5
A	22¾	18⅝

	LENGTH A	DRILL B	DRILL C
-6	4.0	⅝	⅝
-7	4.6	⅝	⅜

ST51273 | 7

B

C

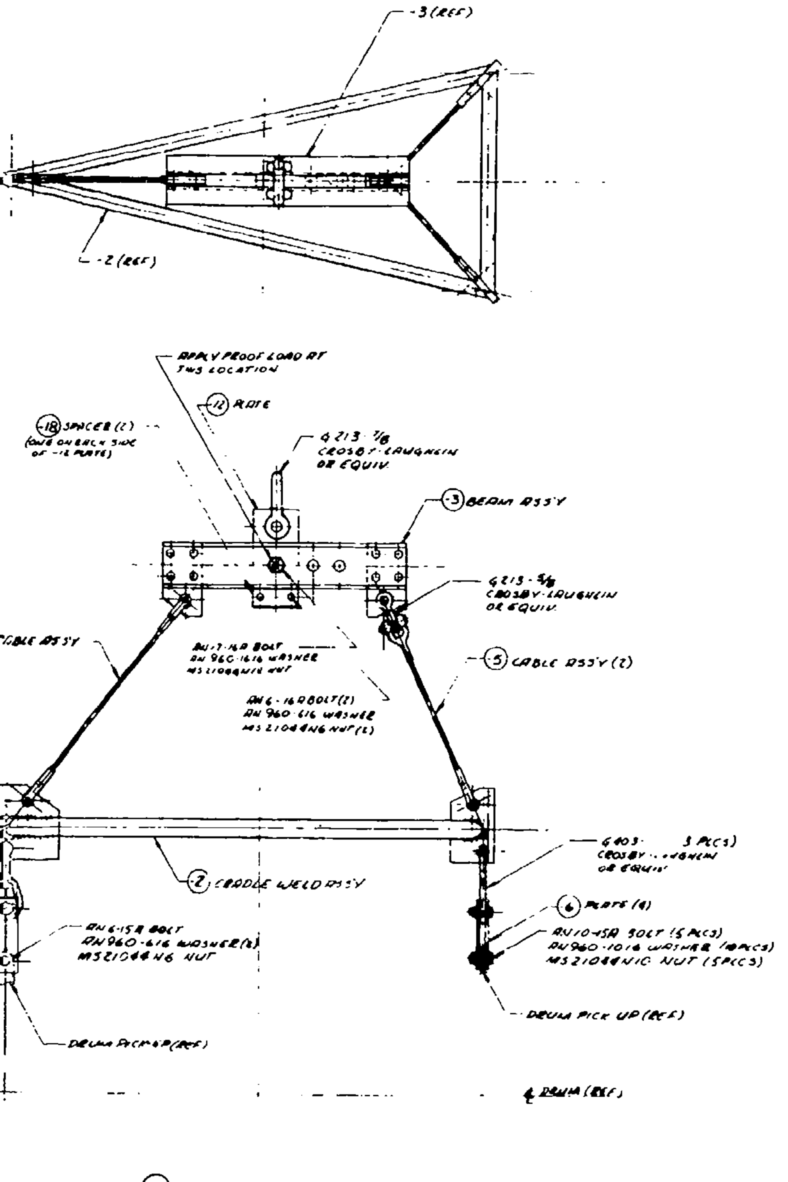
NOTES (UNLESS OTHERWISE SPECIFIED)

1. [illegible]

2. PAINT - APPLY TWO COATS STEEL PRIMER & TWO COATS OF YELLOW EXTERIOR ENAMEL.

3. RATED LOAD 2000 #
PROOF LOAD 4000 #
APPLY PROOF LOAD AT LOCATION INDICATED BY ✱.

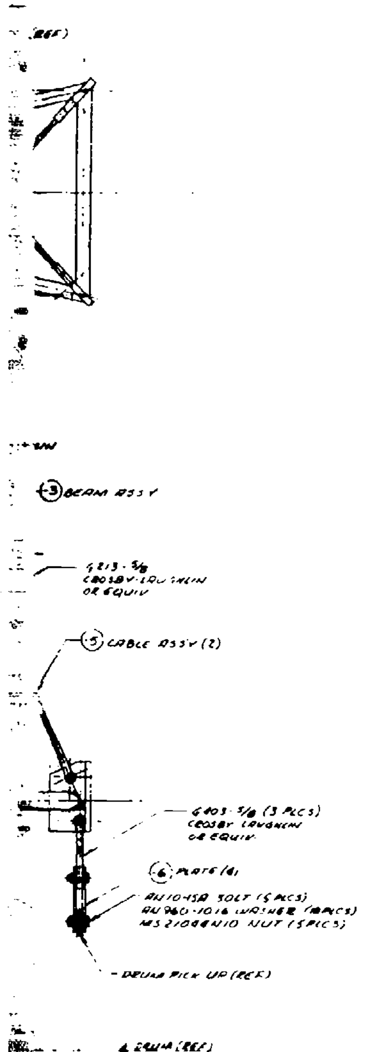
⚠ MANUFACTURER MUST GUARANTEE THE CABLE ASSY TO BE ABLE TO SUSTAIN 6150 LBS WITHOUT RUPTURE



-1 SLING ASS'Y
HOIST ASS'Y, CARGO SYS
(1/4 SCALE)

-3	-2	-1		PART NO.	NOMENCLATURE	ZONE	MATERIAL
		1		MS21044N16	NUT	B-4	
		1/2		AN960-1616	WASHER	B-4	
		5		MS21044N10	NUT	B-3	
8				MS21044N6	NUT	C-8	
		3		MS21044N6	NUT	A-4	
		1/2		AN960-1016	WASHER	B-3	
1/2				AN960-816	WASHER	C-8	
		1/2		AN960-616	WASHER	A-4	
		5		AN10-15A	BOLT	B-3	
8				AN8-17A	BOLT	C-8	
		1		AN6-15A	BOLT	A-4	
		2		AN6-16A	BOLT	B-4	
		1		AN17-16A	BOLT	B-4	
		2		-18	SPACER	B-4	4 × 1 1/2 × 3/16 CRS PLATE
		3		G403 - 5/8	SWIVEL	B-3	CROSBY-LAUGHLIN [illegible]
		1		G213 - 7/8	SHACKLE	C-4	CROSBY-LAUGHLIN OR [illegible]
		1		G213 - 5/8	SHACKLE	B-3	CROSBY-LAUGHLIN OR [illegible]
	1			-17	TUBE	B-2	1 1/2 × .134 × 22 LNG [illegible]
	1			-16	TUBE	B-4	1 1/2 × .134 × 50 LNG [illegible]
	1			-15	TUBE	C-5	1 1/2 × .134 × 50 LNG [illegible]
2				-14	CHANNEL	D-7	4 × 1 5/8 @ 5.4 #/FT × 22 [illegible]
	2			-13	PLATE	B-8	7 × 5 × 5/8 CRS PLATE
		1		-12	PLATE	A-7	10 × 7 1/2 × 1.0 CRS PL[illegible]
4				-11	SHIM	B-7	3 1/2 × 4 × 1/16 CRS PL[illegible]
1				-10	PLATE	C-7	7 × 4 × 5/8 CRS PL[illegible]
1				-9	PLATE	D-7	7 × 4 × 5/8 CRS PL[illegible]
	1			-8	PLATE	A-6	7 × 8 1/8 × 5/8 CRS P[illegible]
		2		-7	PLATE	A-6	7 × 2 × 1/4 CRS PLA[illegible]
		4		-6	PLATE	A-6	6 × 2 × 1/4 CRS PLATE
		2		-5	CABLE ASS'Y	C-4	[illegible]
		1		-4	CABLE ASS'Y	C-6	[illegible]
X		1		-3	BEAM ASS'Y	B-8	
	X	1		-2	CRADLE WELD ASS'Y	A-4	
		X		-1	SLING ASS'Y	A-4	

C



NOTES (UNLESS OTHERWISE SPECIFIED)

1. [illegible]

2. PAINT - APPLY TWO COATS STEEL PRIMER & TWO COATS OF YELLOW EXTERIOR ENAMEL

3. RATED LOAD 2000 #
PROOF LOAD 4000 #
APPLY PROOF LOAD AT LOCATION INDICATED BY ✱.

4 (in triangle). MANUFACTURER MUST GUARANTEE THE CABLE ASSY TO BE ABLE TO SUSTAIN 6150 LBS WITHOUT RUPTURE

QTY -3	QTY -2	QTY -1	PART NO.	NOMENCLATURE	ZONE	MATERIAL AND SPECIFICATION
		1	MS21044N16	NUT	A 4	
		1/2	AN960-1616	WASHER	B 4	
		5	MS21044N10	NUT	B 3	
8			MS21044N8	NUT	C 8	
		3	MS21044N6	NUT	B 4	
		1/2	AN960-1016	WASHER	B 4	
1/2			AN960-816	WASHER	C 8	
		1/2	AN960-616	WASHER	B 4	
		5	AN10-15A	BOLT	B 3	
8			AN8-17A	BOLT	C 8	
		1	AN6-15A	BOLT	B 4	
		2	AN6-16A	BOLT	B 4	
		1	AN17-16A	BOLT	B 4	
		2	-18	SPACER	B 4	4 × 1½ × 5/16 CRS PLATE - COMM'L 1020
		3	6403 - 5/8	SWIVEL	B 3	CROSBY-LAUGHLIN OR EQUIV
		1	6213 - 7/8	SHACKLE	C 4	CROSBY-LAUGHLIN OR EQUIV
		1	6213 - 5/8	SHACKLE	B 3	CROSBY-LAUGHLIN OR EQUIV
	1		-17	TUBE	B 2	1½ × .134 × 22 LNG SEAMLESS STEEL - COMM'L 1025
	1		-16	TUBE	B 4	1½ × .134 × 50 LNG SEAMLESS STEEL - COMM'L 1025
	1		-15	TUBE	C 5	1½ × .134 × 50 LNG SEAMLESS STEEL - COMM'L 1025
2			-14	CHANNEL	D 7	4 × 1⅝ @ 5.4 #/FT × 22 LNG - STEEL CHAN. A-36
	2		-13	PLATE	B 8	7 × 5 × 5/8 CRS PLATE - COMM'L 1020
		1	-12	PLATE	B 7	10 × 7½ × 1.0 CRS PLATE - COMM'L 1020
4			-11	SHIM	B 7	3½ × 4 × 5/16 CRS PLATE - COMM'L 1020
1			-10	PLATE	C 7	7 × 4 × 5/8 CRS PLATE - COMM'L 1020
1			-9	PLATE	B 7	7 × 4 × 5/8 CRS PLATE - COMM'L 1020
	1		-8	PLATE	B 6	7 × 8¼ × 5/8 CRS PLATE - COMM'L 1020
		2	-7	PLATE	B 6	7 × 2 × ¼ CRS PLATE COMM'L 1020
		4	-6	PLATE	B 6	6 × 2 × ¼ CRS PLATE - COMM'L 1020
		2	-5	CABLE ASS'Y	C 6	[illegible]
		1	-4	CABLE ASS'Y	C 6	[illegible]
X		1	-3	BEAM ASS'Y	B 8	
	X	1	-2	CRADLE WELD ASS'Y	B 4	
		X	-1	SLING ASS'Y	B 4	

SLING ASS'Y-
HOIST ASS'Y, CARGO SYS.
HLH

77272 5T51273

SHEET 1 OF 2

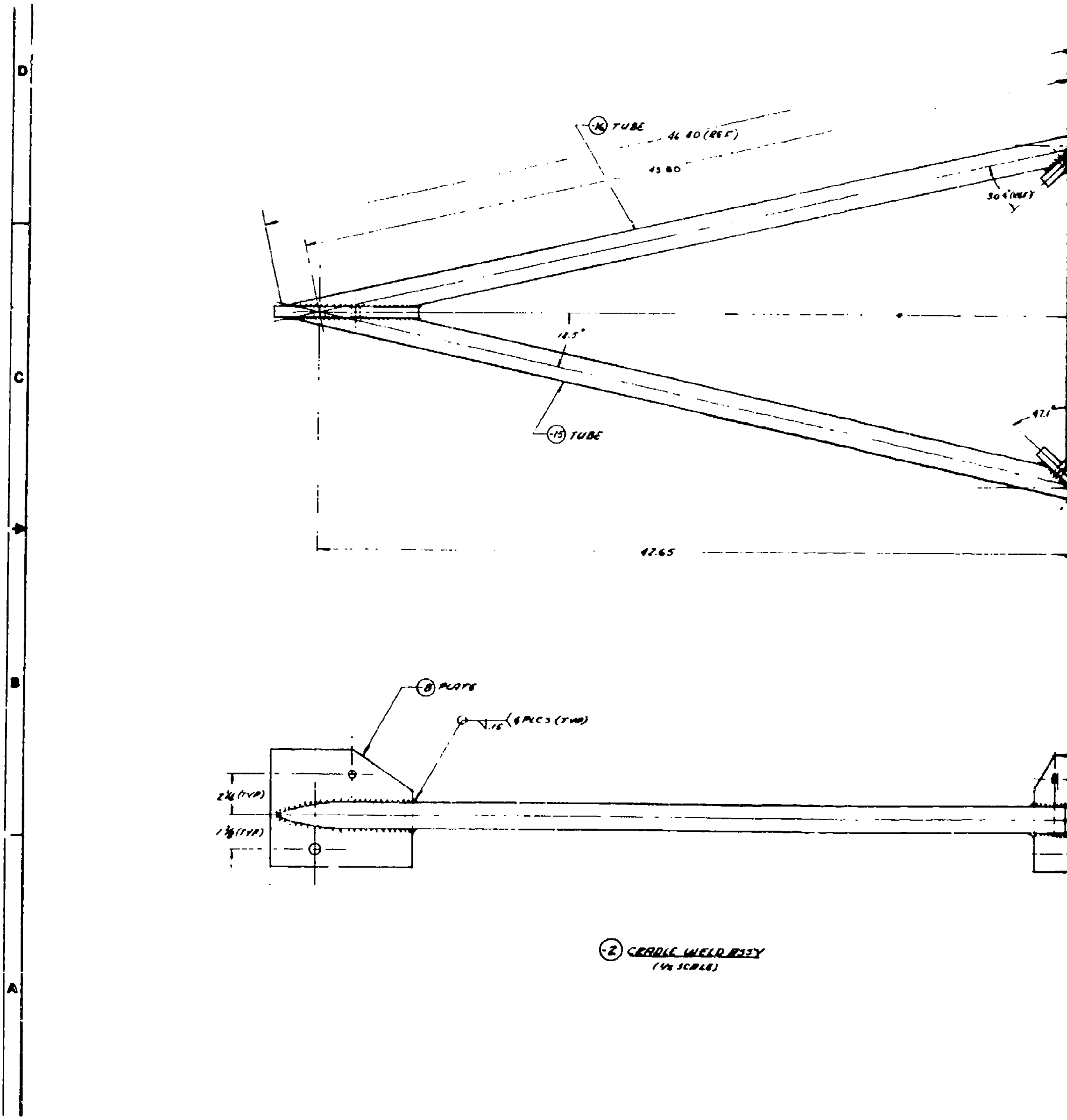
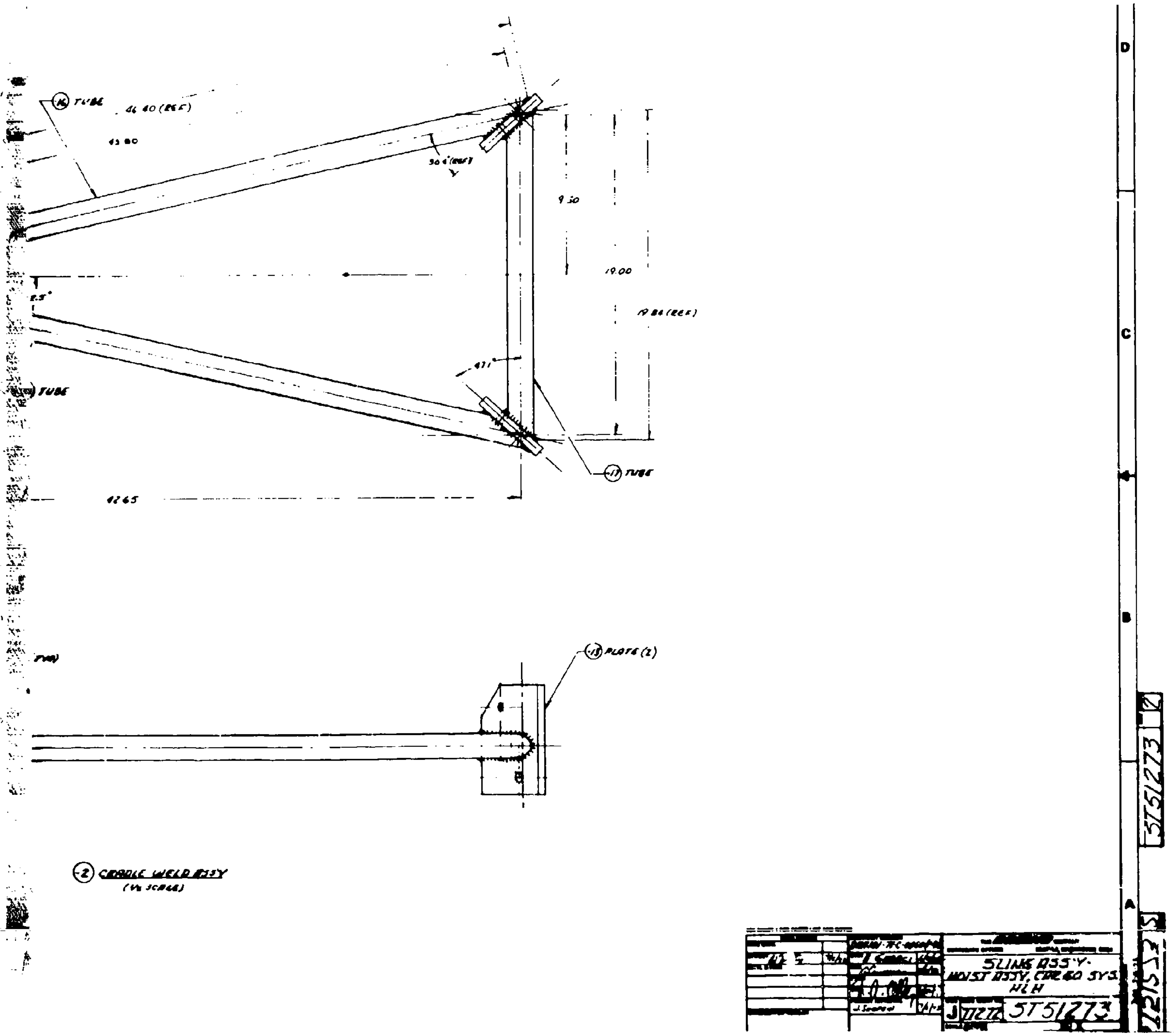


Figure 67. Hoist Lifting Fixture (Sheet 2).


TUBE
46.40 (REF)
9.50
19.00
19.84 (REF)
TUBE
-17 TUBE
42.65
-18 PLATE (2)
-2 CRADLE WELD ASSY
(½ SCALE)
SLING ASS'Y - HOIST ASSY, CARGO SYS. HLH
J
5T51273
D
C
B
A
5T51273

heet 2).

B

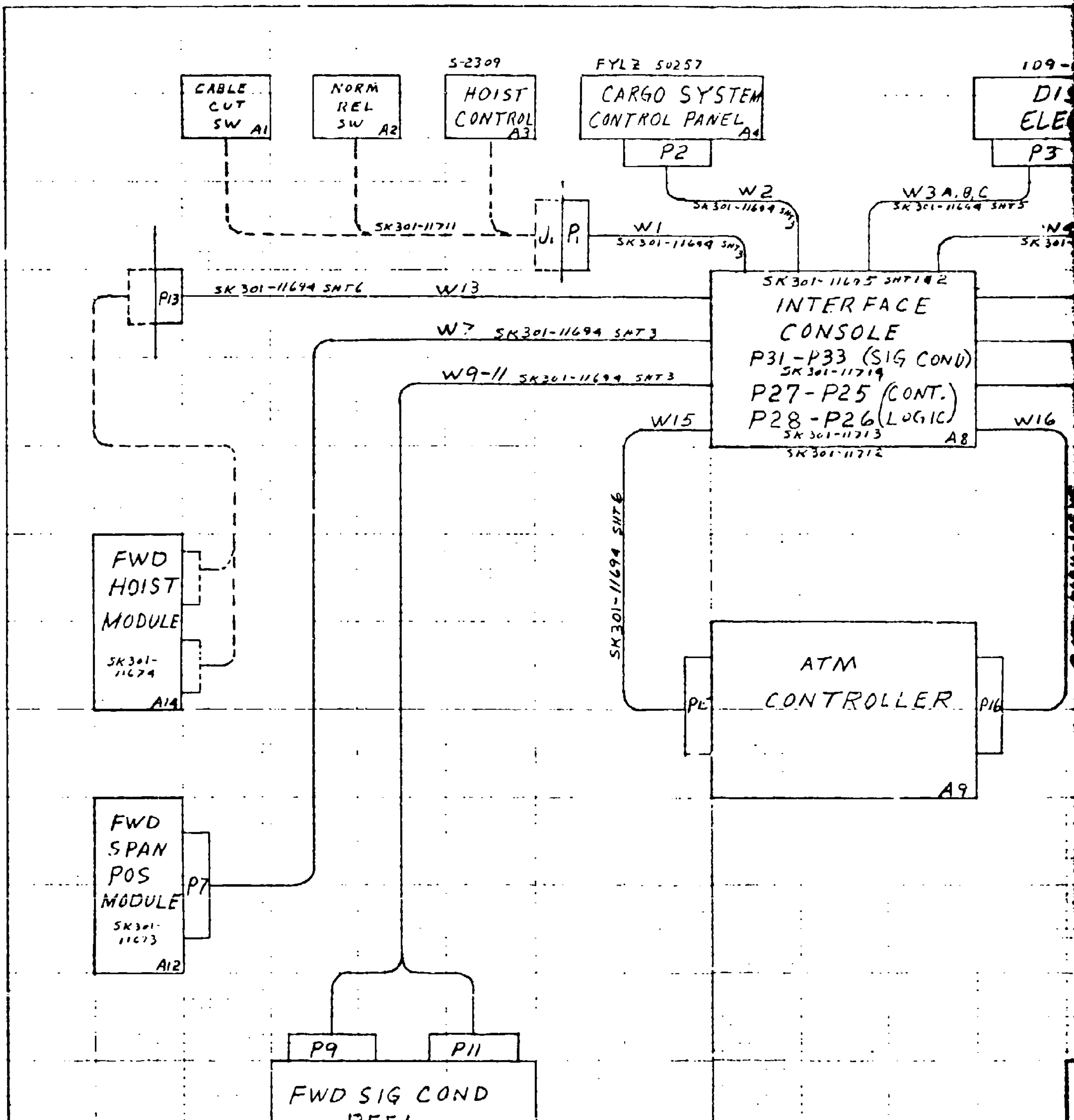


Figure 68. Integrated Test Rig - System Wiring.

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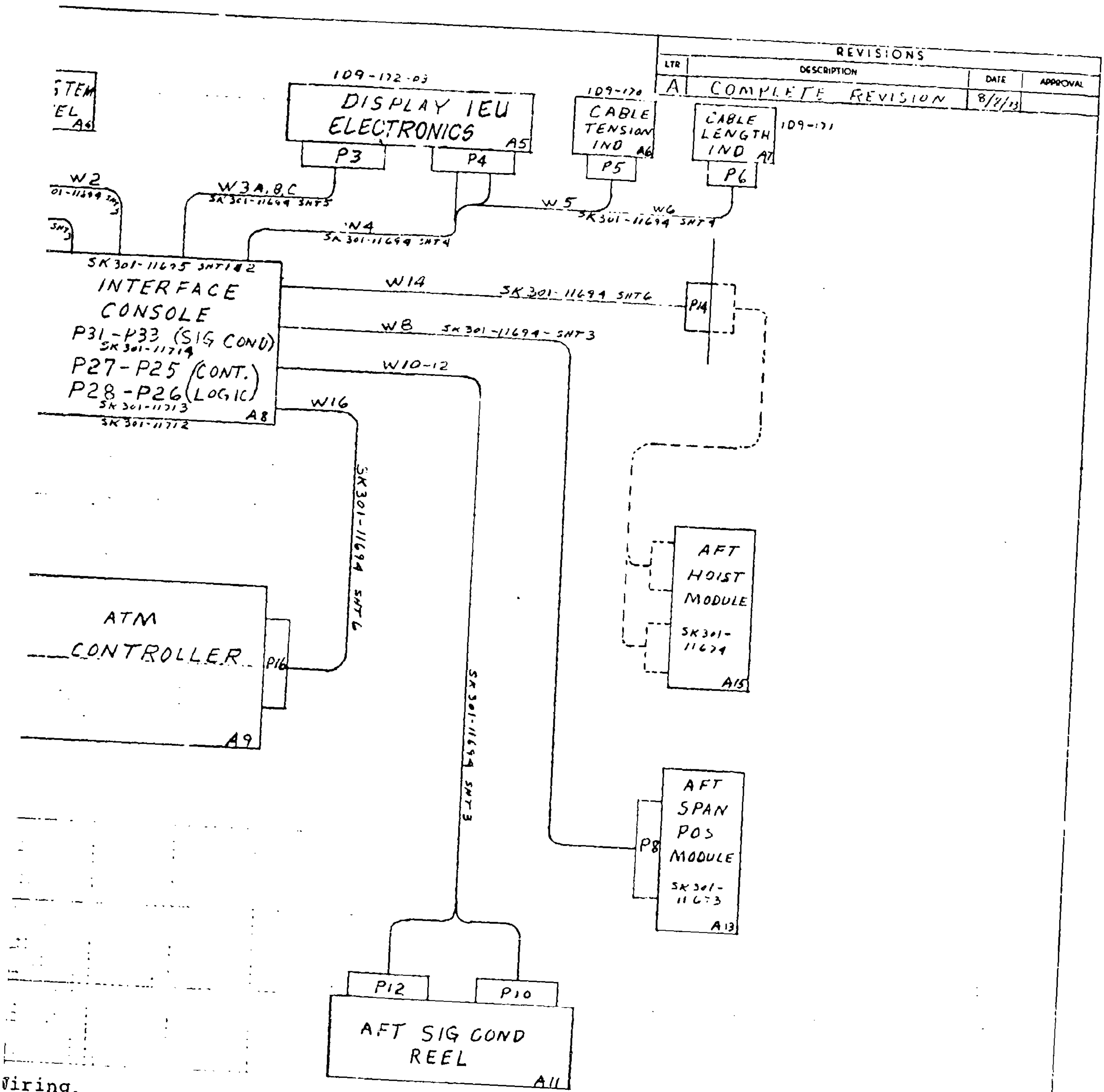
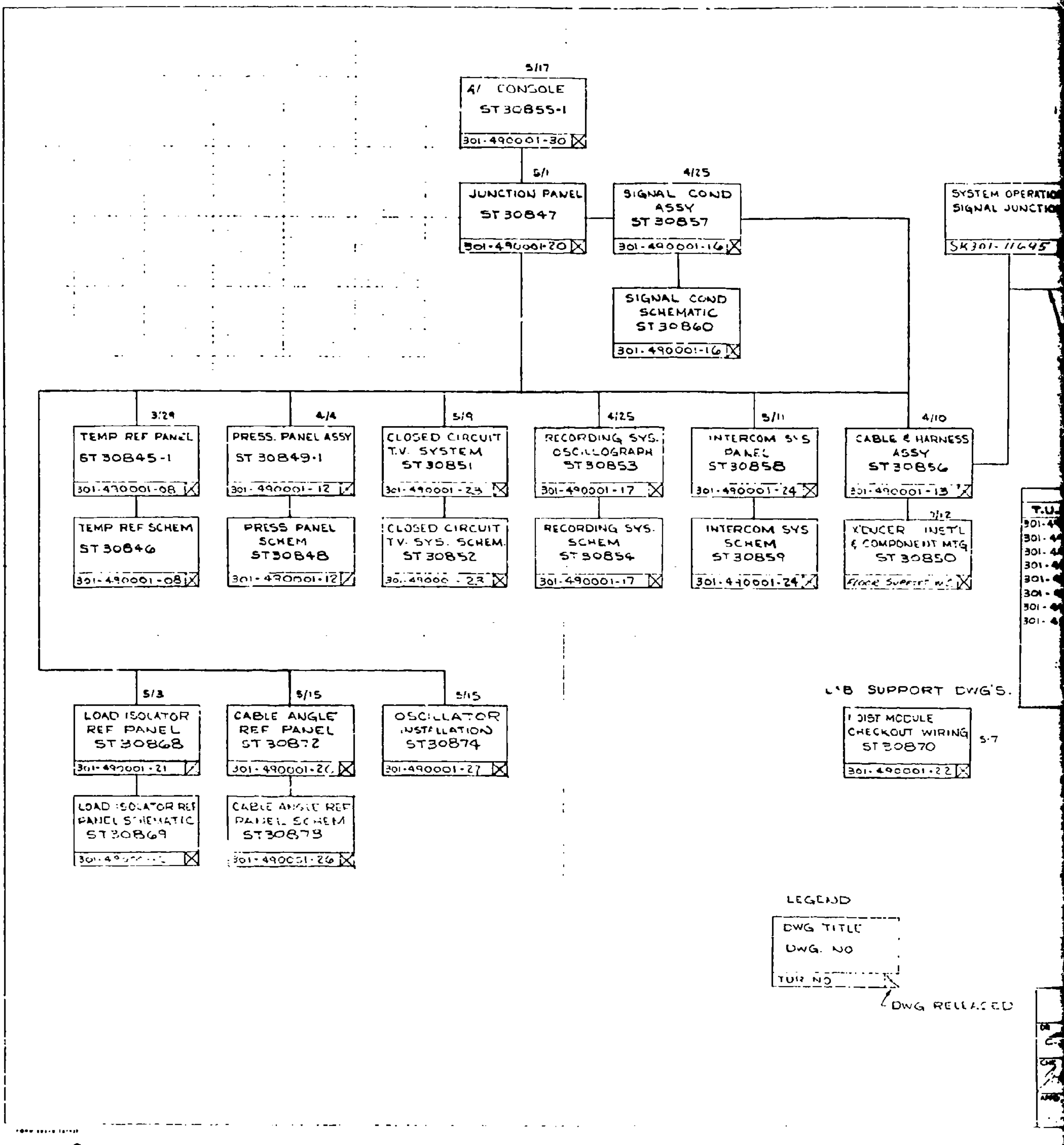
A



REVISIONS
LTR
DESCRIPTION
DATE
APPROVAL
A
COMPLETE REVISION
DISPLAY IEU ELECTRONICS
A5
P3
P4
109-172-03
CABLE TENSION IND
A6
P5
109-170
CABLE LENGTH IND
A7
P6
109-171
W2
W3A,B,C
SK 301-11694 SHT 5
W4
SK 301-11694 SHT 4
W5
W6
SK 301-11694 SHT 4
SK 301-11695 SHT 1&2
INTERFACE CONSOLE
P31-P33 (SIG COND)
SK 301-11714
P27-P25 (CONT.)
P28-P26 (LOGIC)
SK 301-11713
SK 301-11712
A8
W14
SK 301-11694 SHT 6
P14
W8
SK 301-11694 - SHT 3
W10-12
W16
SK 301-11694 SHT 6
ATM CONTROLLER
P16
A9
SK 301-11694 SHT 3
AFT HOIST MODULE
SK 301-11694
A15
AFT SPAN POS MODULE
P8
A13
P12
P10
AFT SIG COND REEL
A11

Wiring.

B



A

Figure 69. Instrumentation Drawing Tree.

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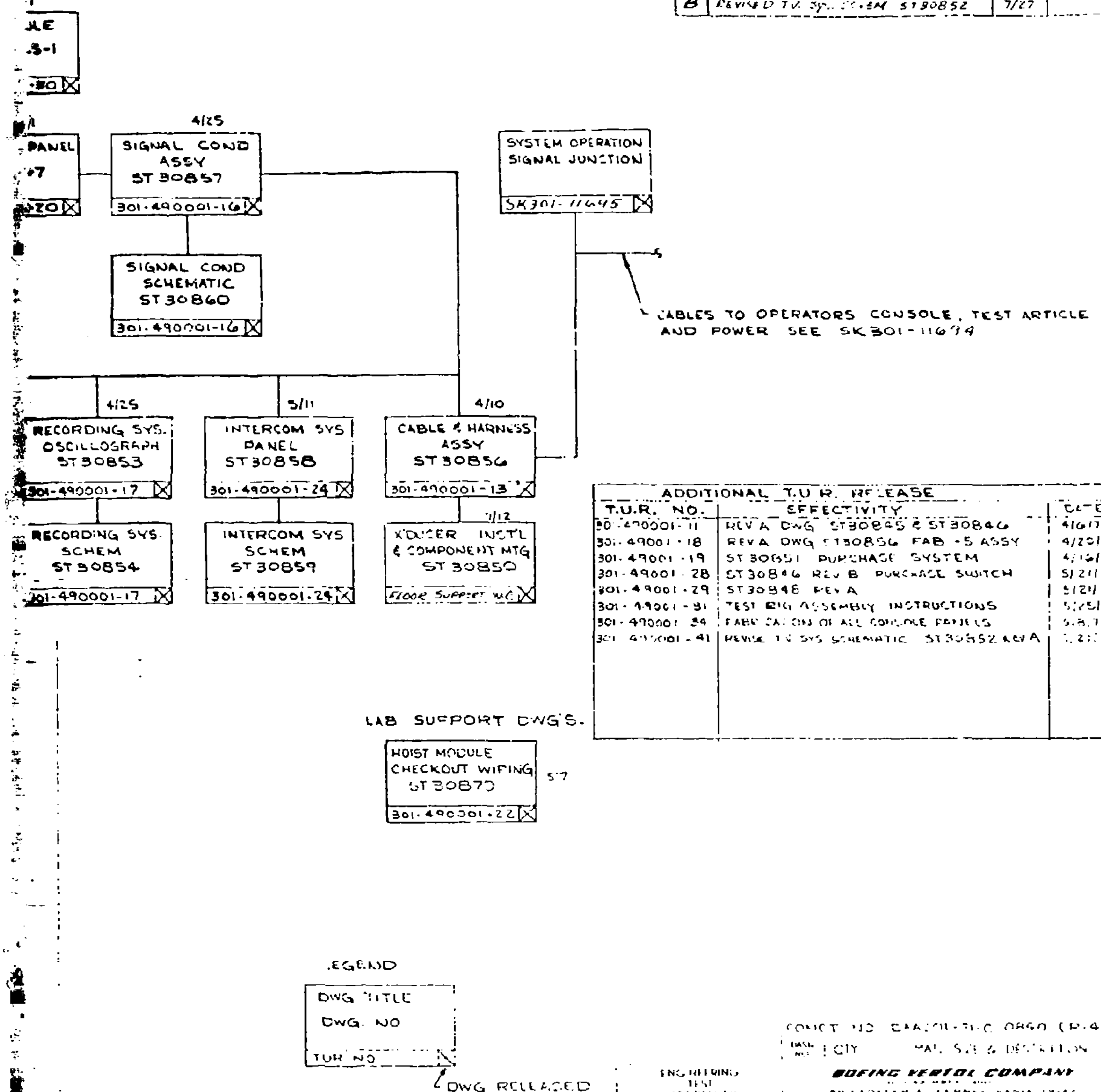
REVISIONS			
LTR	DESCRIPTION	DATE	APPROVAL
A	RELEASED XDUCER INSTL ST30850	7/26	
B	REVISED T.V. SYS SCHEM ST30852	7/27	



ADDITIONAL T.U.R. RELEASE		
T.U.R. NO.	EFFECTIVITY	DATE
301-490001-11	REV A DWG ST30845 & ST30846	4/6/73
301-49001-18	REV A DWG ST30856 FAB -5 ASSY	4/20/73
301-49001-19	ST30851 PURCHASE SYSTEM	4/16/73
301-49001-28	ST30846 REV B PURCHASE SWITCH	5/21/73
301-49001-29	ST30848 REV A	5/21/73
301-49001-31	TEST RIG ASSEMBLY INSTRUCTIONS	5/25/73
301-490001-34	FABRICATION OF ALL CONSOLE PANELS	6.8.73
301-490001-41	REVISE TV SYS SCHEMATIC ST30852 REV A	[illegible]

CONTRACT NO. DAAJ01-71-C-0860 (P-40)

DASH NO. | QTY | MATL, SIZE & DESCRIPTION

ENGINEERING TEST LABORATORY

DR [illegible] DATE 4/[illegible]

CHK

APPD

BOEING VERTOL COMPANY

PHILADELPHIA, PENNSYLVANIA 19142

INSTRUMENTATION DRAWING TREE, CARGO HANDLING SYSTEM TEST

SIZE C 77272 ST30861

B

APPENDIX III
PNEUMATIC POWER GENERATOR - STARTING AND OPERATING PROCEDURE

PRERUN CHECKOUT

1. Remove all covers from unit:

   a. Unit covers
   b. Exhaust cover
   c. Bleed valve wooden plug

2. Turn on water for oil cooler.

3. Turn on hand shutoff valve in fuel line at 275-gal. tank.

4. Check all switches on control panel for "OFF" position.

5. Attach all electrical connectors:

   a. 2 control lines at engine
   b. 3 thermo couple leads at engine
   c. 2 control lines at console
   d. 3 thermo couple leads at console
   e. 110-VAC line at console
   f. 14-VDC connector from batteries to APU
   g. 28-VDC connectors from batteries to APU

STARTING PROCEDURE - CONTROL CONSOLE

1. Turn power "ON".

2. Turn fuel valve "ON".

3. Turn fuel pump "ON" (requires 10 seconds to pressurize line).

4. Turn starter and ignition "ON".

5. When gas producer speed reaches 13-15%, increase throttle control with momentary jog. Observe engine starting limits.

6. When gas producer speed reaches 52-58%, turn "OFF" starter and ignition. Allow engine to warm up at idle for 1 minute.

7. Increase throttle control to "full speed" with momentary jog. Observe engine continuous run limits.

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STOP PROCEDURE

1. Decrease throttle control to idle position with momentary jog. Run for 2 minutes at "idle" position.

2. Decrease throttle control to "stop" position.

3. When gas producer speed is less than 15%, turn "OFF" fuel pump and fuel valve.

4. Turn "OFF" power.

POST-RUN SHUTDOWN

1. Turn "OFF" water to oil cooler.

2. Turn "OFF" hand fuel valve at 275-gal. tank.

3. Disconnect electrical connectors:

   a. 110-VAC at console
   b. 14-VDC from batteries to APU
   c. 28-VDC from batteries to APU

4. Install covers after unit has cooled:

   a. Exhaust covers
   b Bleed valve wooden plug
   c. Unit cover

TABLE XII. NORMAL PPG OPERATING LIMITS.

Parameter	Run Condition	Range or Limit*
T_{T5}	GI	700°-900°F
T_{T5}	Max Continuous	1430°F
N1	Start	12%-15%
N1	GI	59%-65%
N1	Max Continuous	104%
N2	GI	74.8%-104.7%
N2	Max Continuous	103.8%
P Turb.GB	GI	50-130 psi
P Turb.GB	Max Continuous	115-130 psi
T Turb.GB	GI-Max Continuous	130-225°F
P Compressor GB	GI	90 psi
P Compressor GB	Max Continuous	110 psi
T Compressor GB	Max Continuous	225°F

*Values are for S.L. Standard operation. For information on transient limitations, consult the GMC Allison Div. 250-C20 Engine Operation and Maintenance Manual.

APPENDIX IV
INSTRUMENTATION CALIBRATION PROCEDURE

The following represents the basic calibration steps carried out before and after daily hoist system operation.

TEMPERATURES

Operating Mode	Power Source	Osc A	Chanl. Selection
Cal.	R.C.	.25 ips	1 thru 7; then zero
Normal	On	.25 ips	Zero

PRESSURES

Operating Mode	Input	Osc A	Cal. Pushbutton
Cal.	Depress Cal.	.25 ips	1-5 depress each
Normal	--	--	--

LOAD ISOLATORS

Operating Mode	Input	Indication	Adjust
Cal.	Depress sense	30.0	Adjust each pot

CABLE ANGLE

Operating Mode	Input		Read Voltage At	Adjust
Normal	.25V/DEC	Fwd/Pitch	CTB4 Pins 1&2	Adj.each pot for panel reading in accordance with CTB4 voltage reading
		Fwd/Roll	CTB4 Pins 4&5	
		Aft/Pitch	CTB4 Pins 7&8	
		Aft/Roll	CTB4 Pins 10&11	

CABLE PAYOUT SPEED

Operating Mode	Input	Apply To	Adjust
Normal	5.0VDC=120 FPM	CTB3 Pins 1&2	Adj.A1 gain for 2.0" trace deflection
		CTB3 Pins 4&5	Adj.A2 gain for 2.0" trace deflection

CABLE PAYOUT LENGTH

Operating Mode	Input	Apply To	Adjust
Normal	5.0VDC=100 Ft	CTB4 Pins 14&15	Adj.A5 gain for 2.0" deflection
		CTB4 Pins 18&19	Adj.A6 gain for 2.0" deflection

SPEED COMMAND CAL.

Operating Mode	Input	Indication	Adjust
Normal	6.0V=100%	2.0" trace deflec.	Press fwd then aft control grip thumb switches.

MOD. VALVE CURRENT CAL.

Operating Mode	Input	Apply At	Adjust
Normal	1.5VDC-100%	CTB3 Pins 24&25	A3 gain for deflection
		CTB3 Pins 9&10	A7 gain for deflection