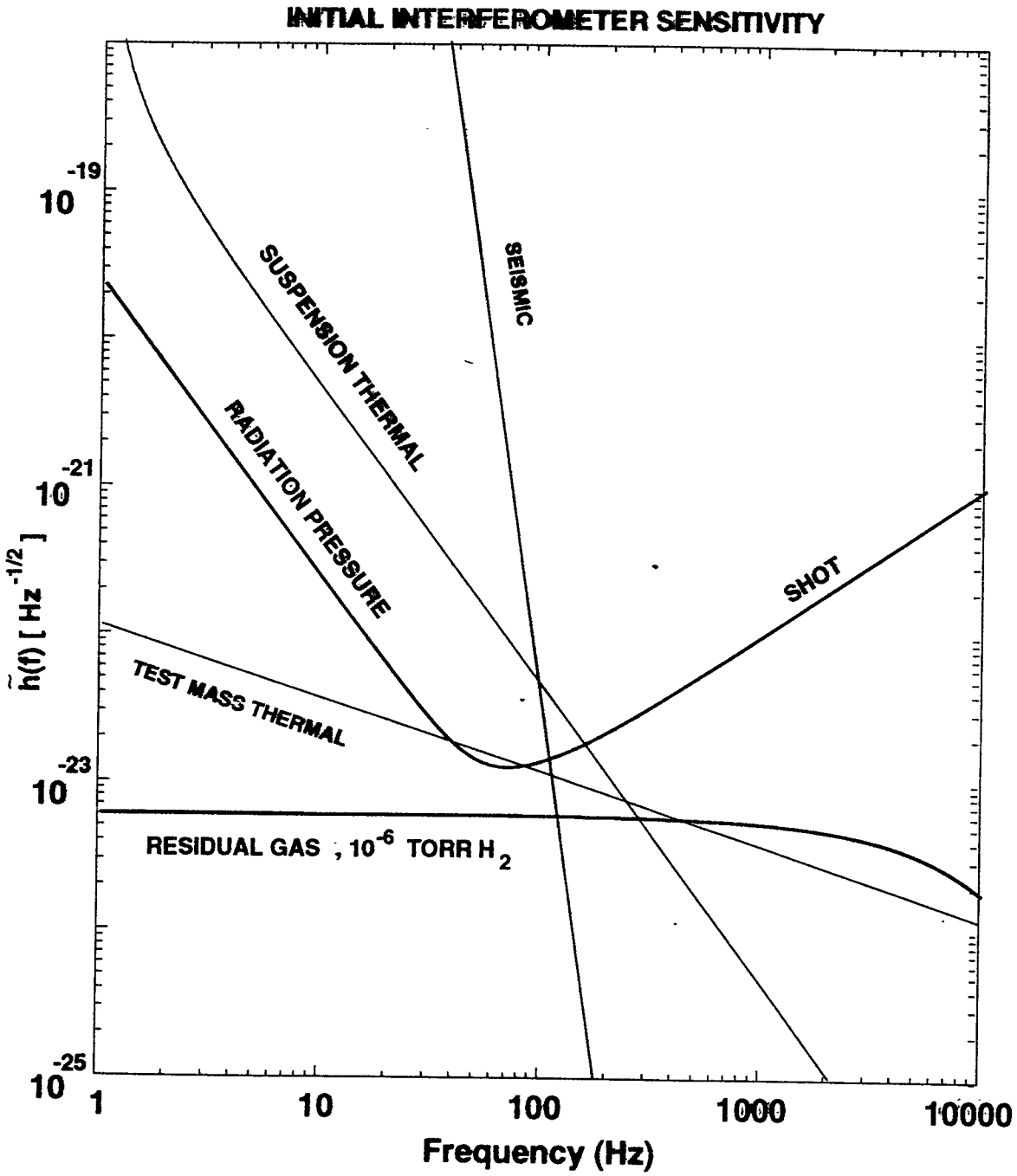
Facilities and Vacuum Equipment

Mark Coles

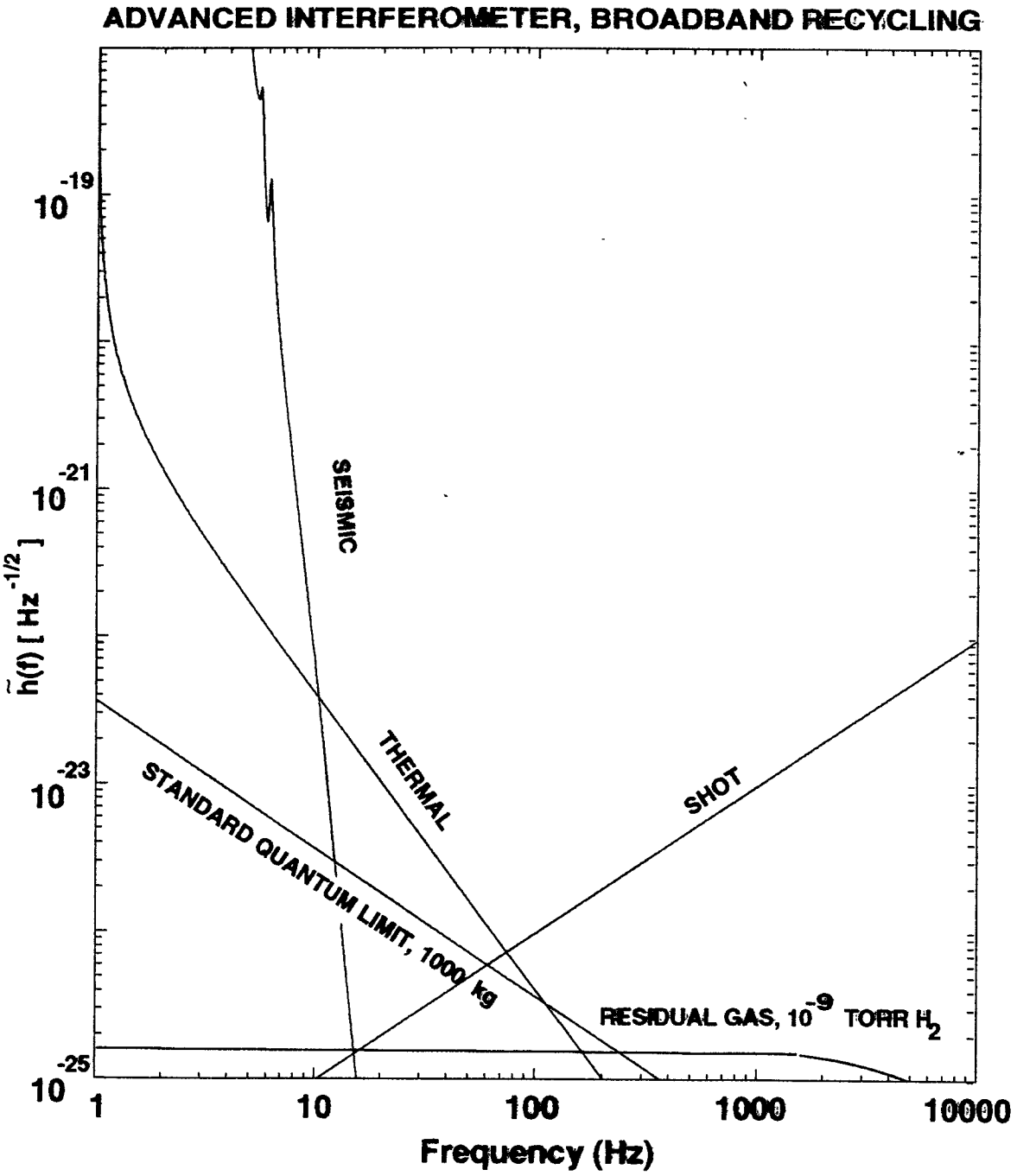
Presentation Objectives

- Technical Requirements
  - » vacuum system
  - » civil construction
- Implementation Status
- Future Plans

INITIAL DESIGN PERFORMANCE GOAL

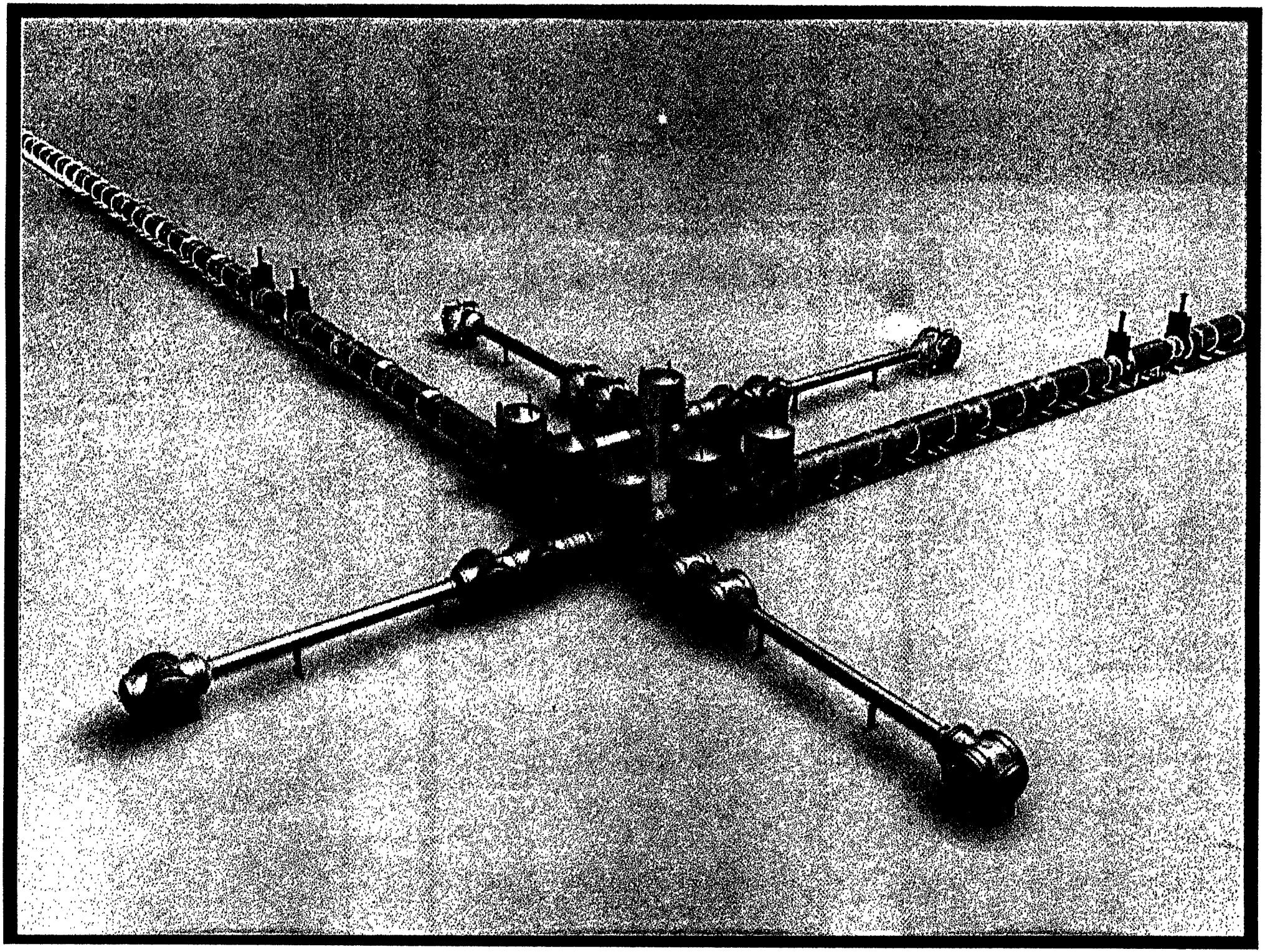


ADVANCED DESIGN PERFORMANCE GOAL



VACUUM EQUIPMENT (SCOPE)

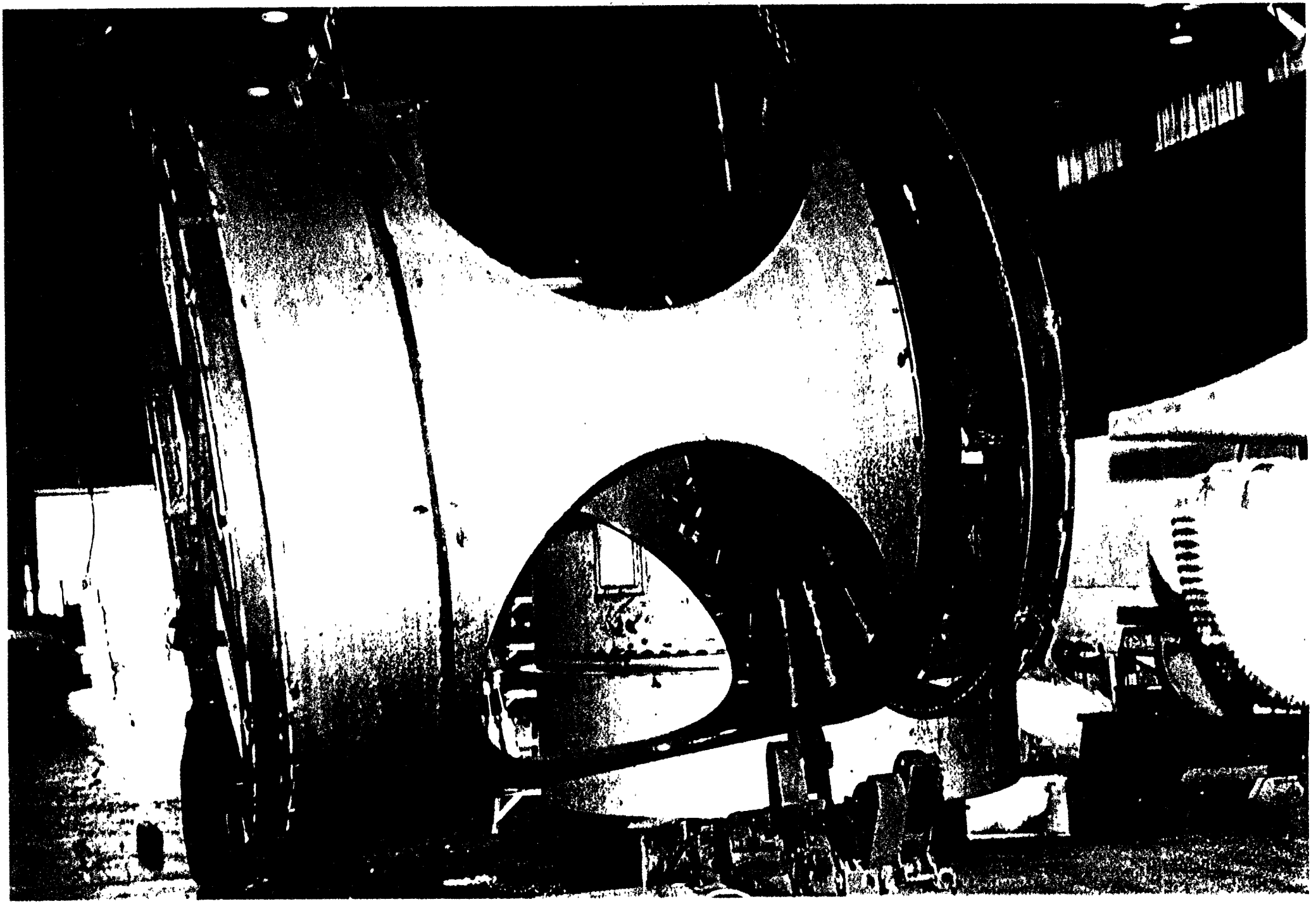
- Corner, Mid, and End stations include:
  - Vacuum envelope (all stainless steel)- 34 large chambers, ~1000 feet of 72 inch, 48 inch, 30 inch vacuum pipe, ~100 large diameter bellows and >200 large flange connections, ~1000 smaller flanged connections.
  - Pumping subsystem - 10 Roots pumping carts, 20 turbomolecular pump carts, 100 ion pumps, 12 large cryogenic pumps.
  - Valve subsystem - 4x60 inch, 32x48 inch, ~100 x 10 inch gate valves, plus hundreds of small valves.
  - Monitor and control subsystem - ~100 sets of gauges, ~200 valve controllers, 12 cryogenic pump controllers, 100 ion pump controllers.
  - Vent and purge subsystem - High purity air distribution system with 10 dry air compressors, 20 soft wall clean rooms (class 100).
  - Bakeout subsystem - 10,000 square feet of heating and insulating blanket with ~100 temperature controllers.

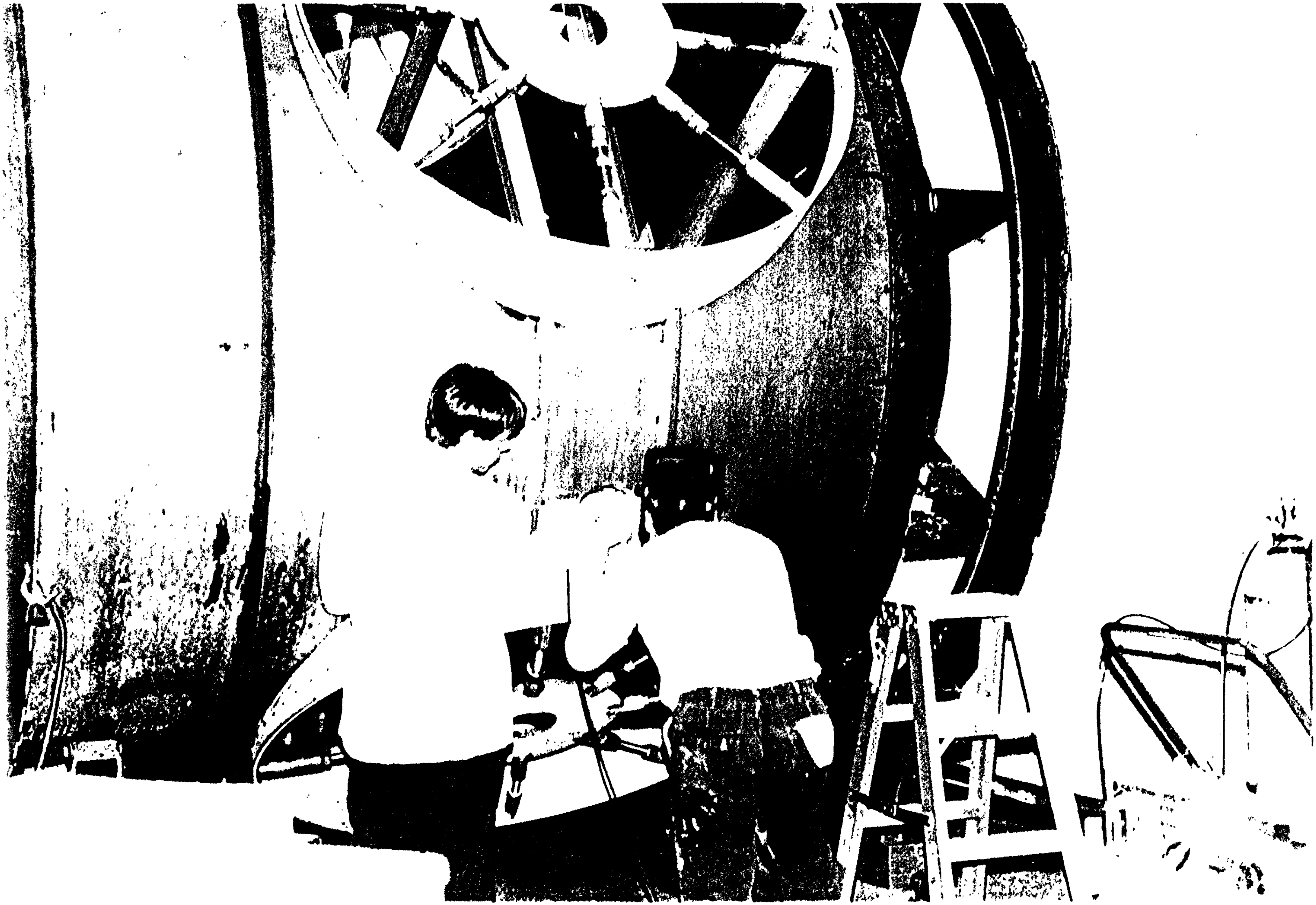


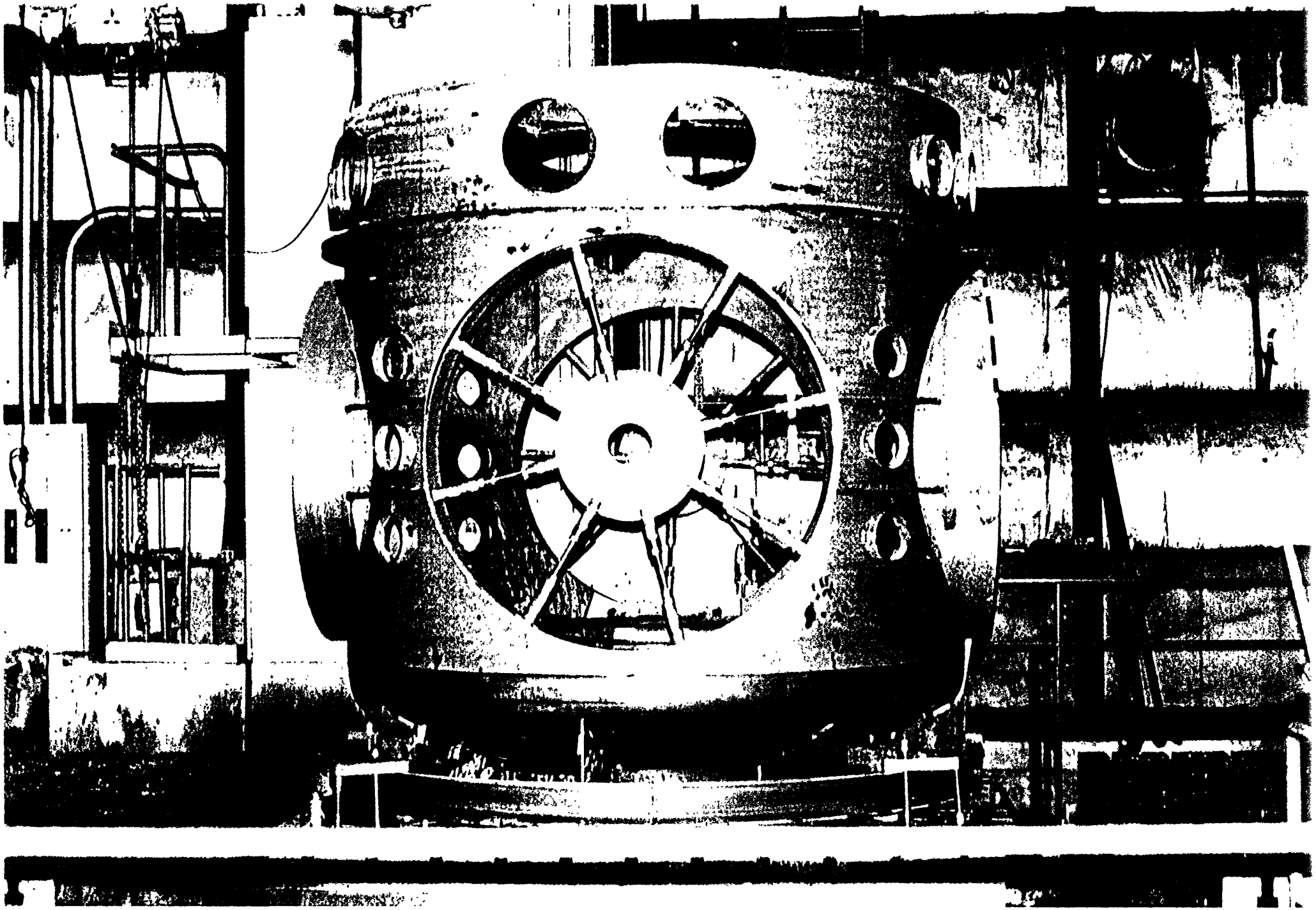
Vacuum Equipment Status

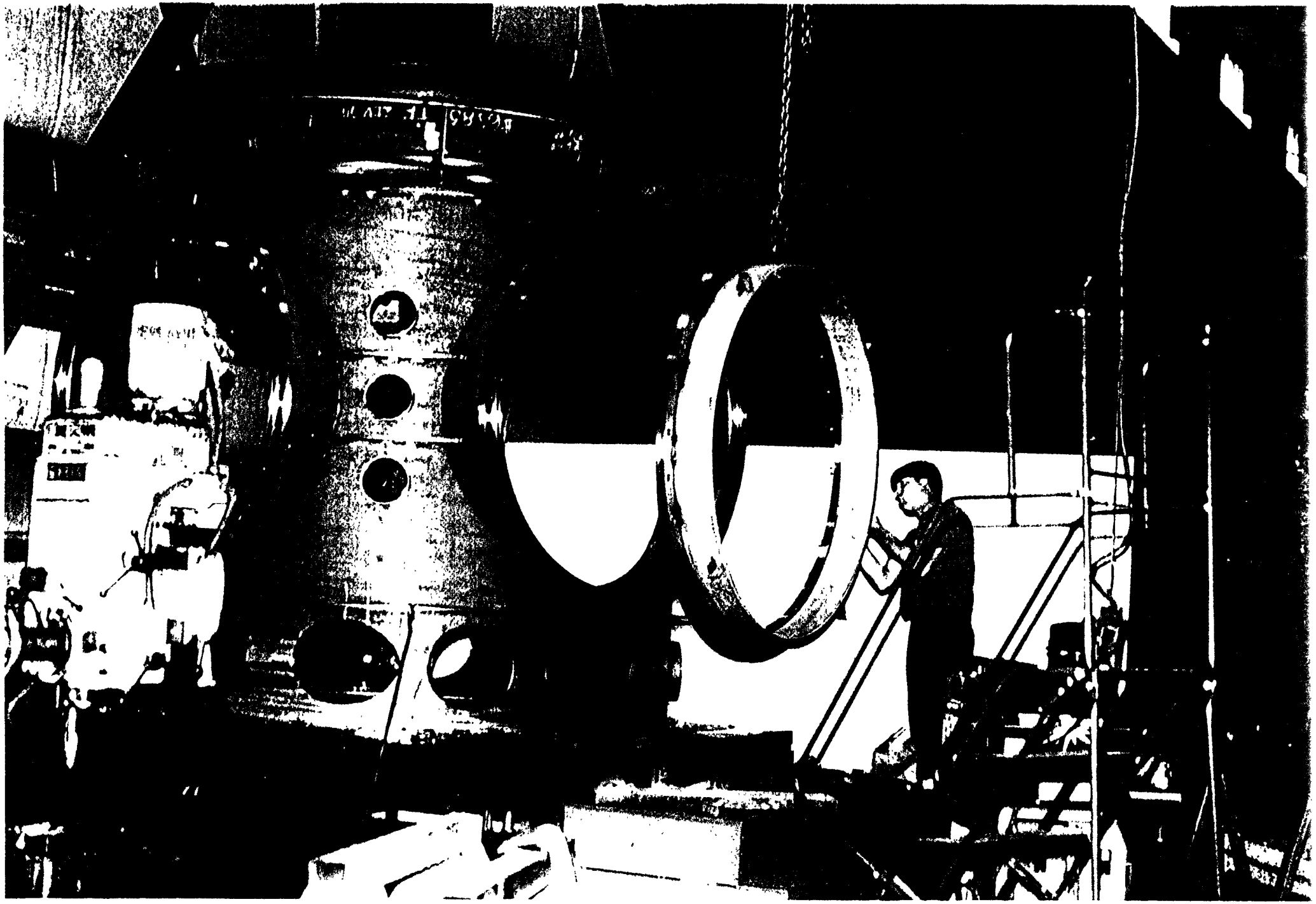
John Worden, Allen Sibley

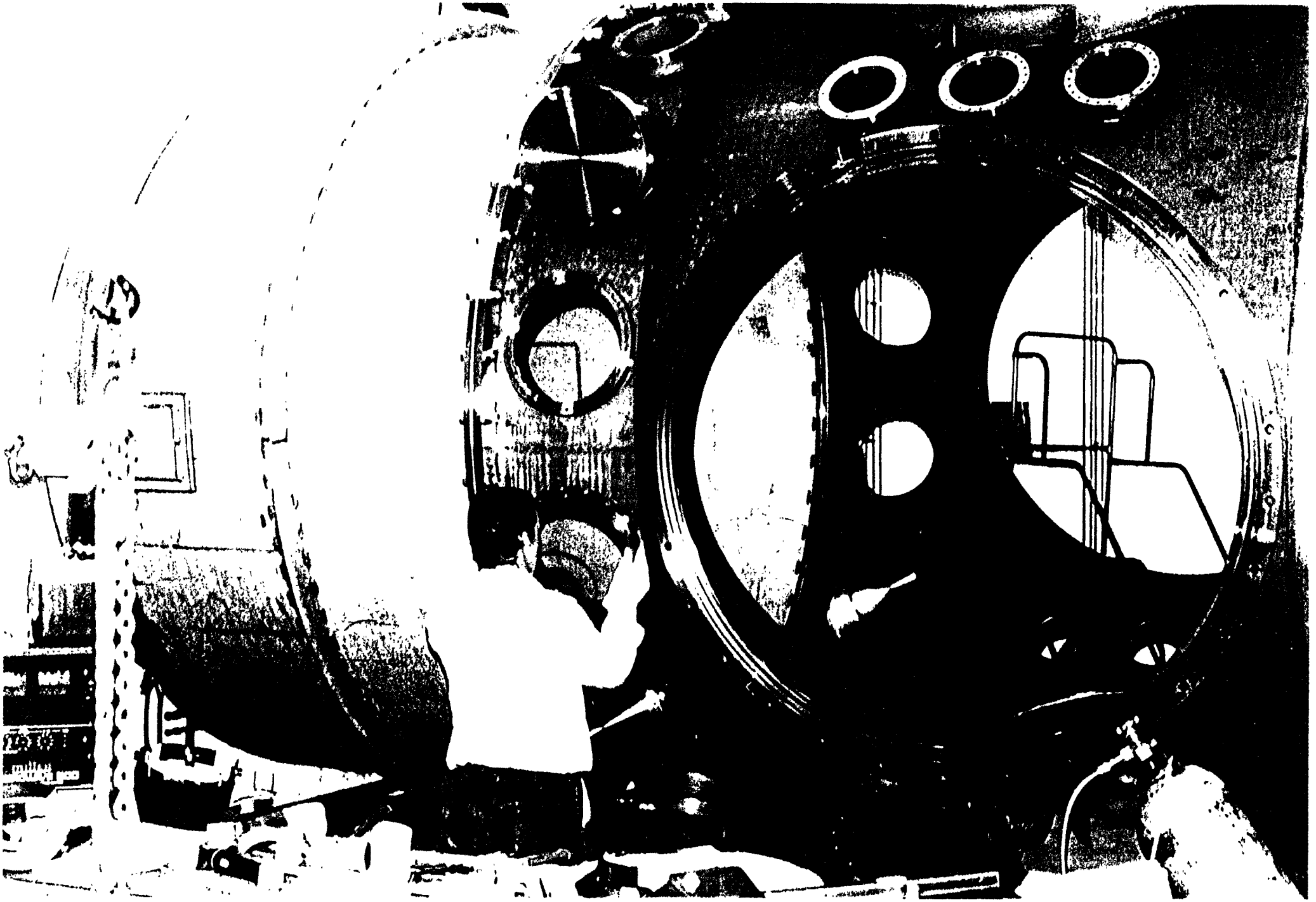
- **Chamber fabrication:**
  - BSC prototype fabrication, cleaning, and test complete
  - Prototype bakeout heater blanket/controller delivery/test complete
  - HAM chambers in fabrication
  - First 6 BSC chambers in fabrication
- **Purchased equipment:**
  - Delivery of 4 main turbopump carts, 2 auxiliary turbo carts
  - Delivery of 2 main roughing pump carts
  - Delivery of 4 - 48" gate valves
  - Delivery of prototype large ion pump

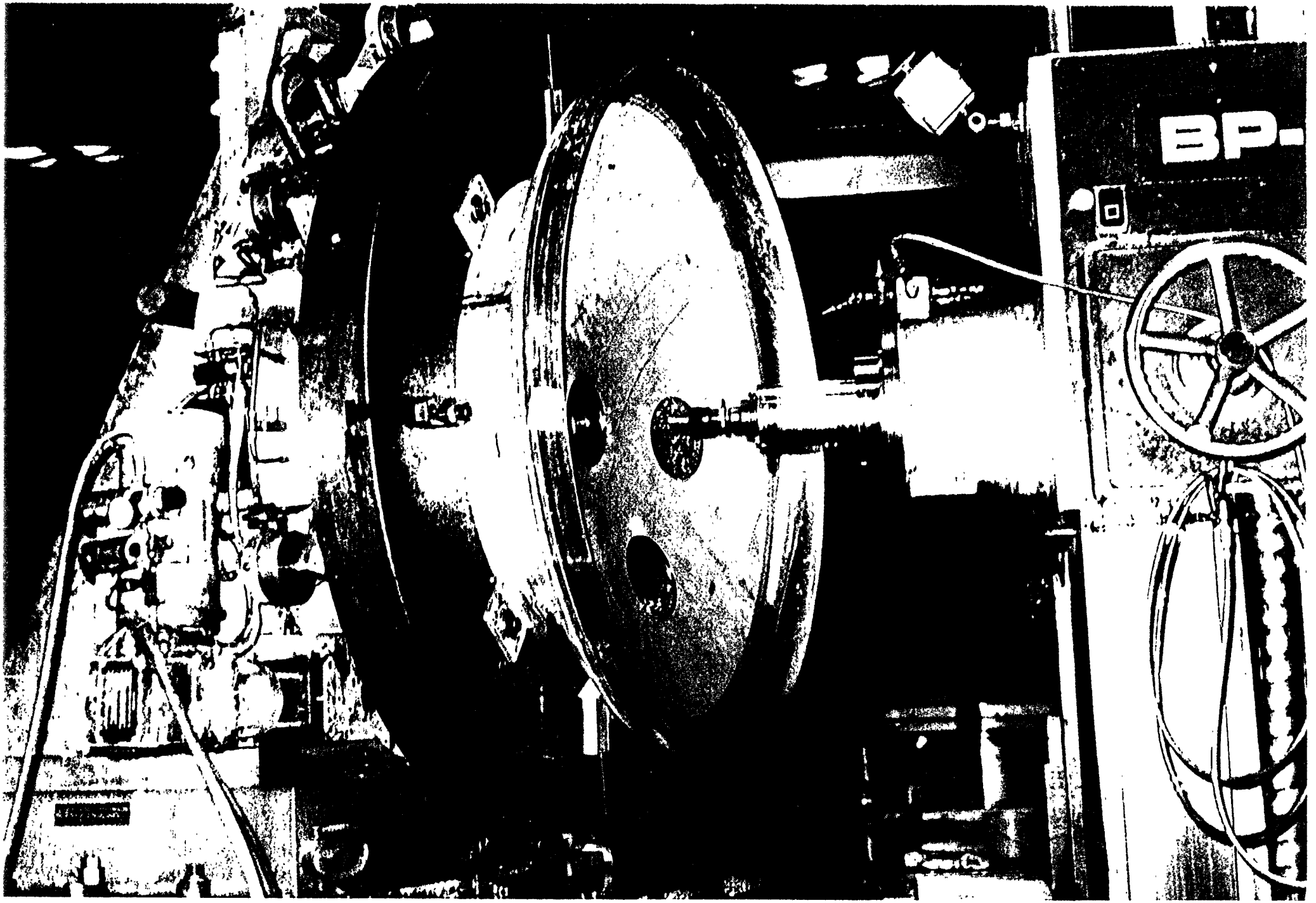


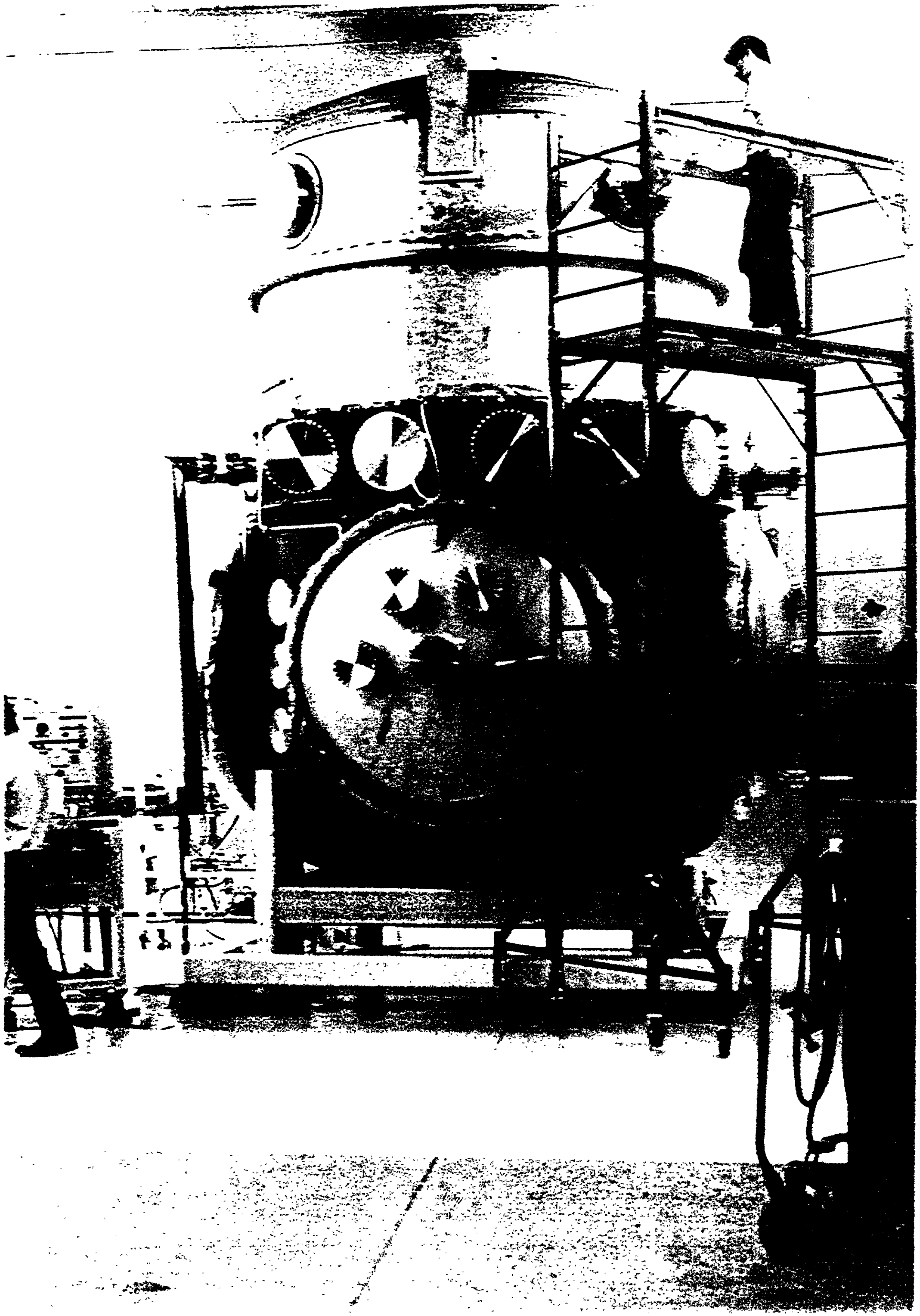









BP-



100 hour pumpdown test results

- The cleaning and baking procedures were very effective.
- There was little evidence of hydrocarbon contamination after the bakeout. Partial pressures of hydrocarbons were 3 to 4 orders of magnitude below hydrogen.
- Principal gas loads after the nitrogen soak are hydrogen, water, nitrogen.
- 100 hr gas load for nitrogen exceeds LIGO goals. Additional analysis being done to see if we can live with this.

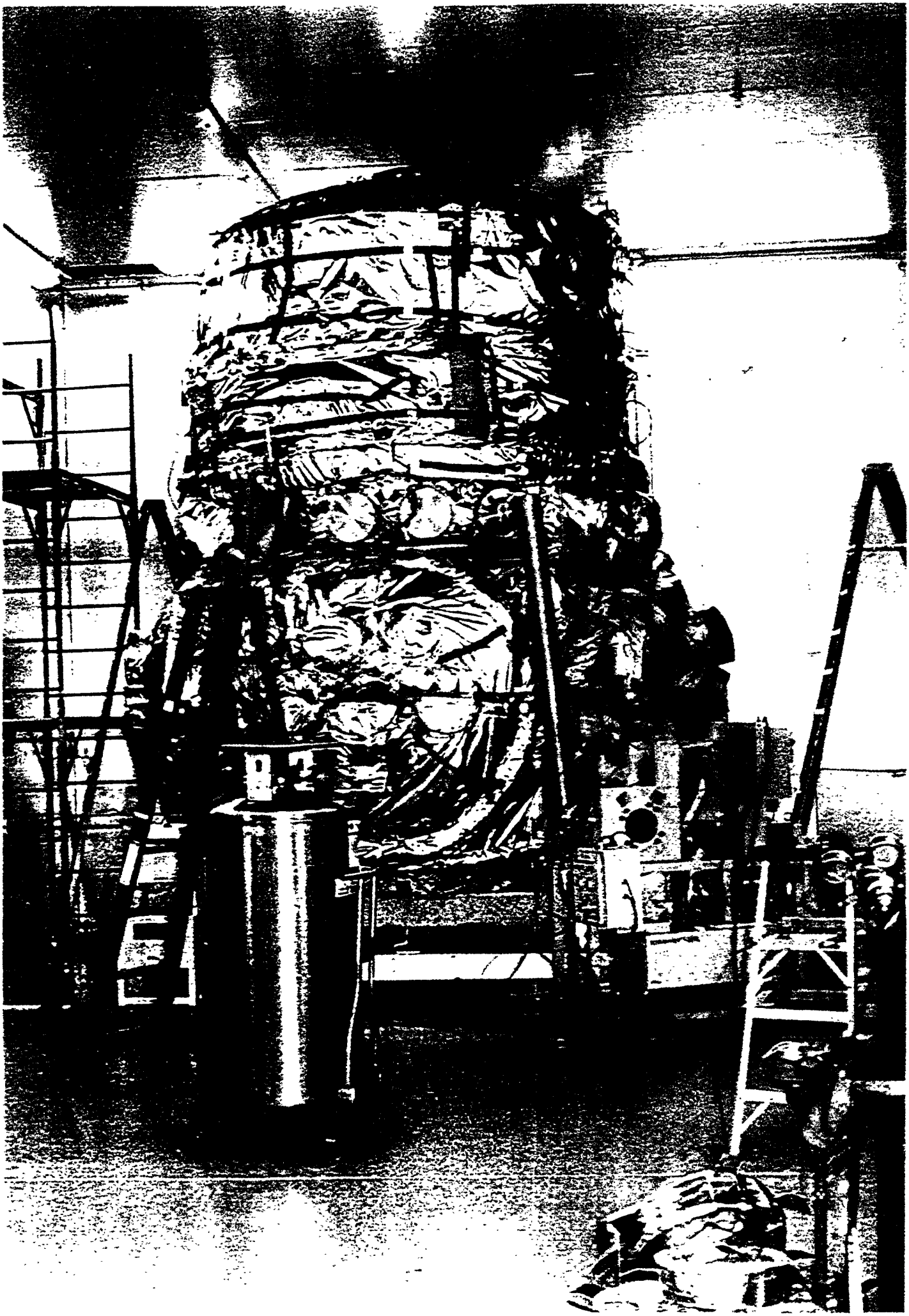
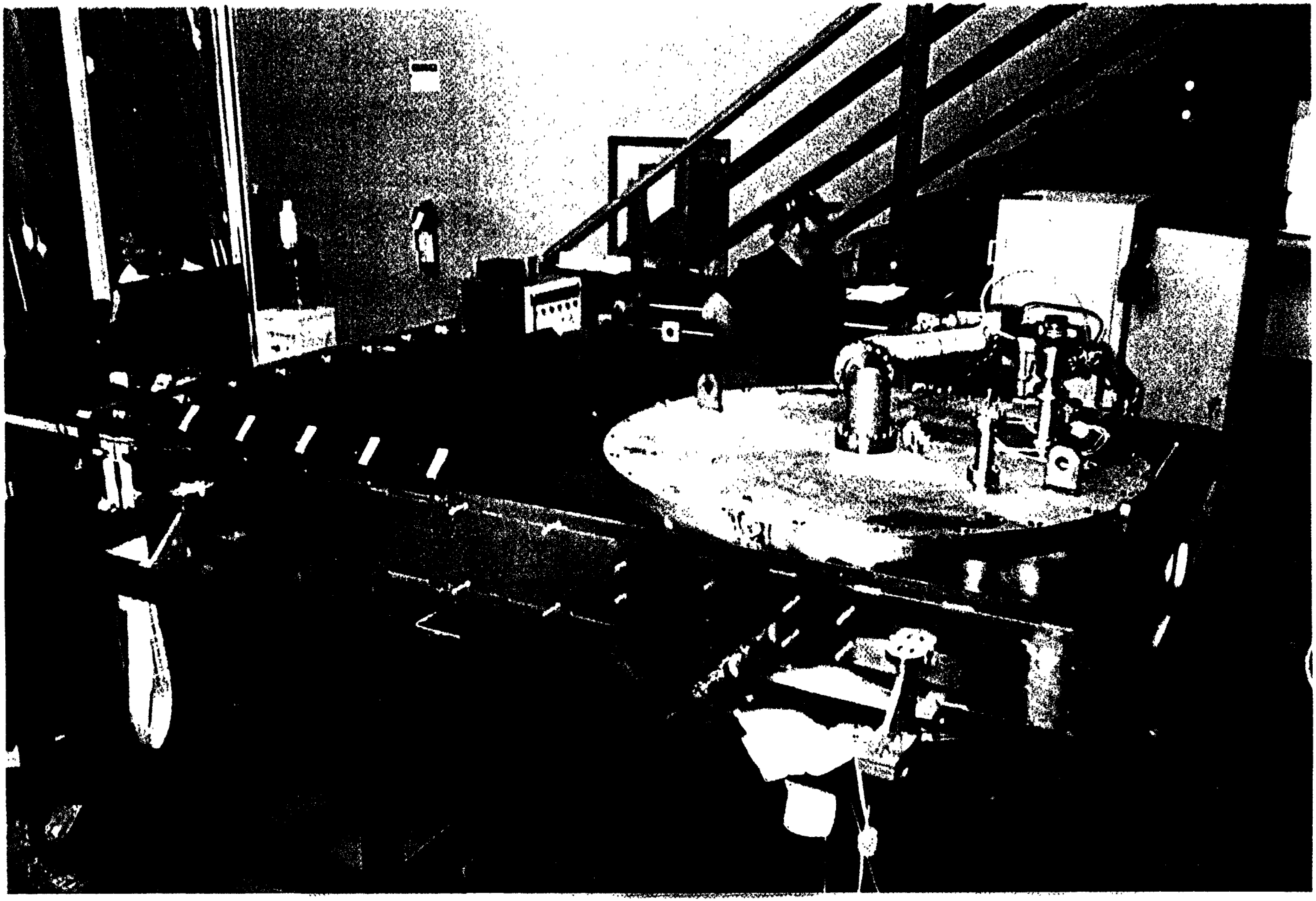


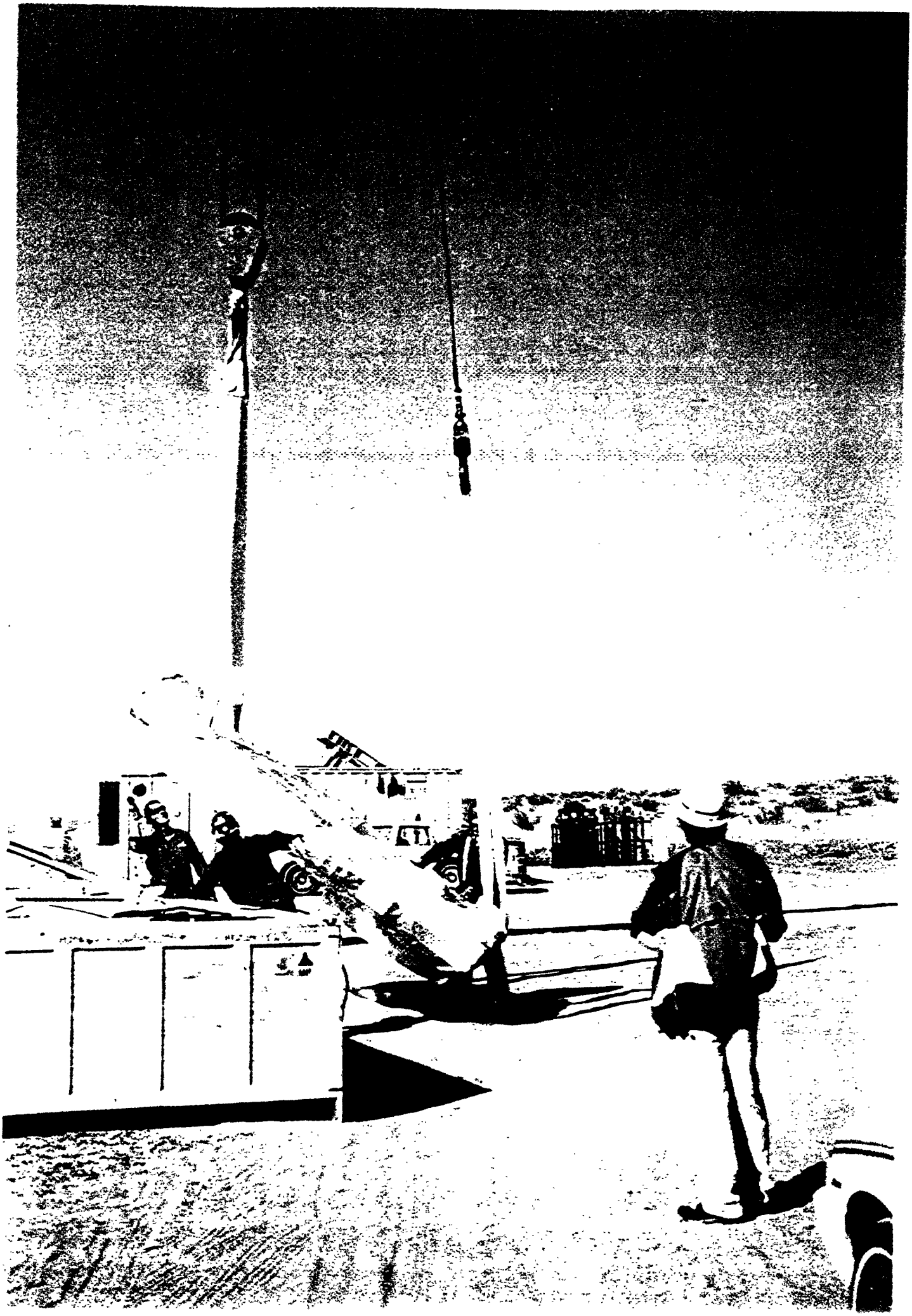
TABLE 1.7
BSC 100 HR TEST
VERTEX + BEAMMANIFOLD PREDICTED

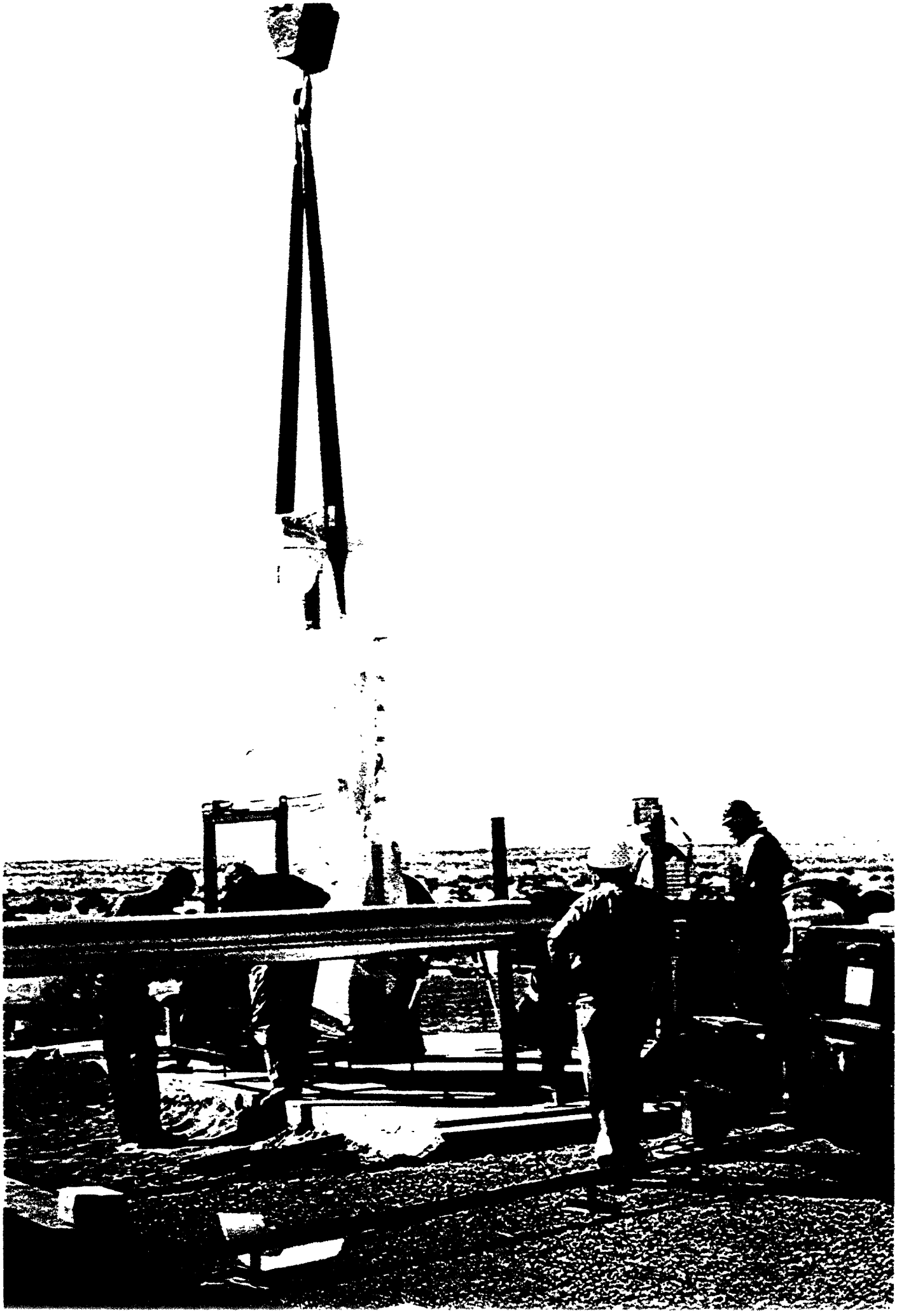
	BSC				VERTEX + MANIFOLD			
LINEAL LENGTH VITON (CM)	2650				37639			
AREA (M^2)	55				478			
VITON/SS_AREA	48.18				78.74			
	GAS LOAD Torr-L/s	SPECIFIC RATE Torr-L/s-cm^2	SPEED approx. L/S	Pressure Torr	RATE Torr-L/s-cm^2	SPEED L/S	Pressure Torr	Pressure GOALS Torr
H2	5.5E-06	1.0E-11	535	1.03E-08	1.00E-11	12000	3.983E-09	5.0E-09
H2O	5.5E-06	1.0E-11	290	1.90E-08	1.00E-11	20000	2.39E-09	5.0E-09
N2	5.5E-06	1.0E-11	237	2.32E-08	1.00E-11	8000	5.975E-09	5.0E-10
CO	2.8E-06	5.0E-12	237	1.16E-08	5.00E-12	8000	2.988E-09	5.0E-10
CO2	2.8E-07	5.0E-13	190	1.45E-09	5.00E-13	8000	2.988E-10	2.0E-10
CH4	8.3E-07	1.5E-12	290	2.84E-09	1.50E-12	8000	8.963E-10	2.0E-10
OTHER	6.1E-07	1.1E-12	190	3.18E-09	1.10E-12	8000	6.573E-10	5.0E-10
SUM				7.15E-08			1.719E-08	1.19E-08



48" gate valve status

- 4 of 8 gate valves delivered (needed to begin beam tube installation)
- Design problems encountered due to LIGO's unique requirements:
  - no lubricants
  - vacuum load either side
  - low shock and vibration req't





Beam Tube

Larry Jones, Rai Weiss, Cecil Franklin, Rich Riesen

- Long LIGO partnership with Chicago Bridge and Iron to develop a cost effective method of producing large quantities of clean, low hydrogen outgassing stainless steel tube

QT Outgassing Data

PREBAKE OUTGASSING RATES

H_2O	$\frac{1.2\times10^{-8}}{t(\text{hours})}$ torr liters/sec cm^2
H_2	$2.9\pm0.2\times10^{-14}$
CO	$< 2\times10^{-13}$
CO_2	$< 3\times10^{-13}$
CH_4	$< 1\times10^{-13}$

- BAKE AT 140 - 150 C for 670 hours

POST BAKE OUTGASSING RATES

H_2O	$< 8\times10^{-18}$
H_2	$8.6\pm0.2\times10^{-14}$ (increase from welds)
CO	$2.5\pm0.1\times10^{-16}$

QT Outgassing Data (cont)

CO_2	$1.6\pm0.3\times10^{-16}$	torr liters/sec cm^2
CH_4	$3.0\pm0.3\times10^{-16}$	
Sum amu > 45	$< 4\times10^{-18}$	

POST BAKE OUTGASSING TEMPERATURE DEPENDENCE

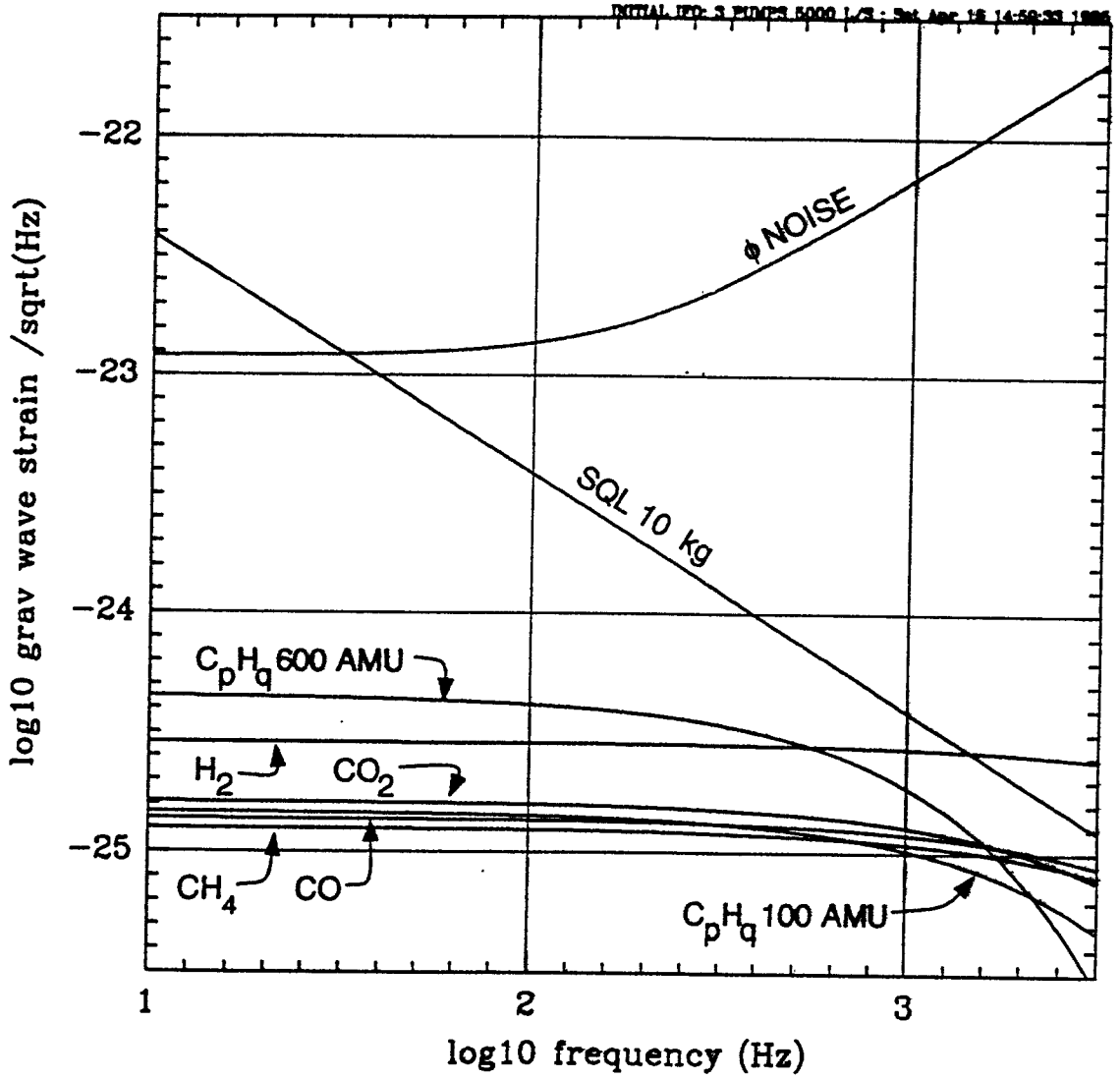
- Temperature increase to double outgassing at 300K

H_2 :	From room temperature fluctuations	4.9 K
	From outgassing ratio 413K/300K	8.9
H_2O		4.8
CO_2		6.5

Beam Tube Hydrogen Outgassing Data

- spec 1.e-13 torr lit/sec/cm^2
- QT result 2.9e-14
- lot 1 1.3e-14
- lot 2 8.4e-15
- lot 3 7.1e-15
- lot 4 3.e-15
- lot 5 1.e-14

Initial Interferometer Noise Budget

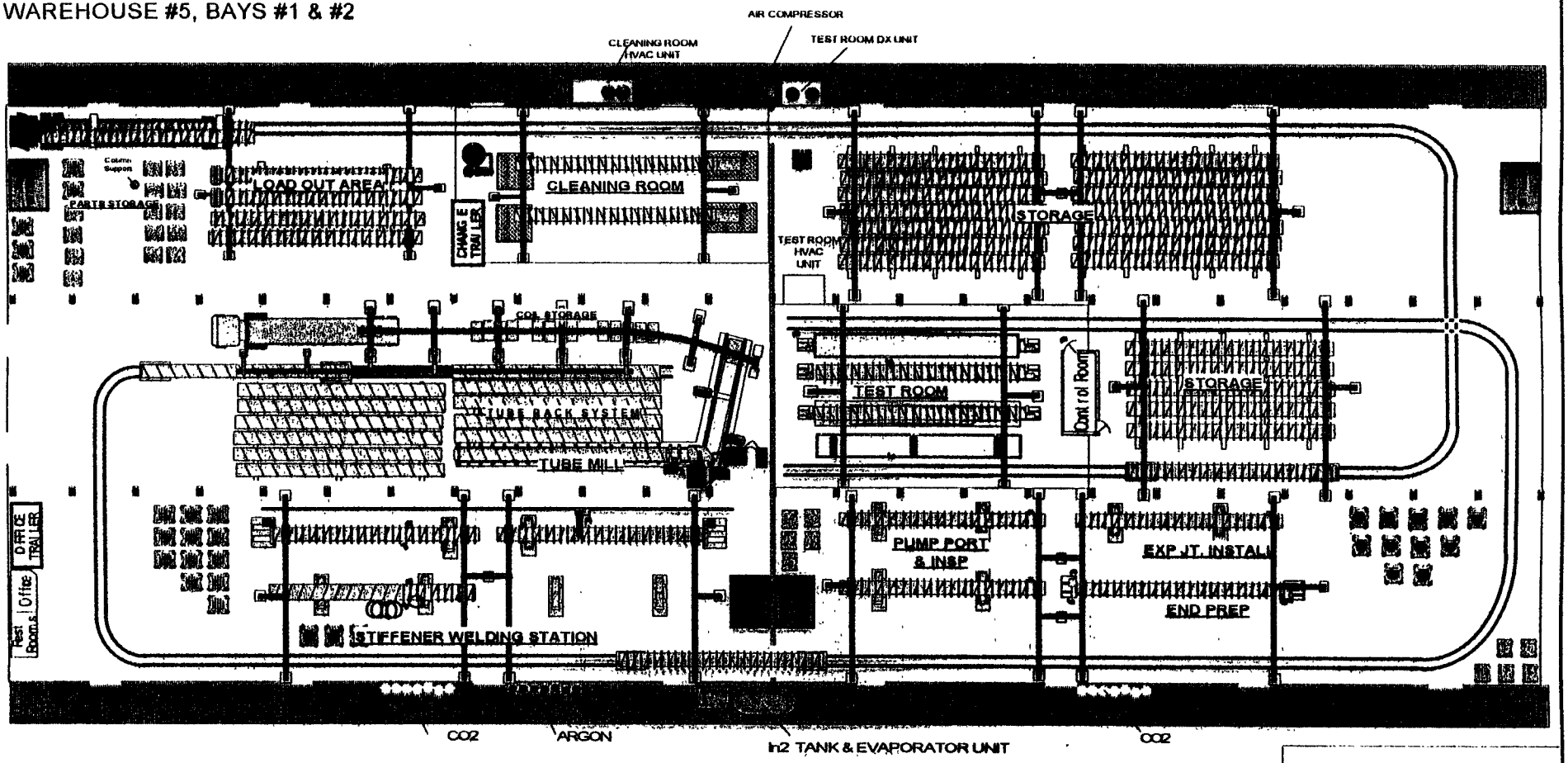


Beam Tube

- Beam tube factory built, commissioned, and operating in Pasco, WA:
  - » Delivered spiral tube mill and qualified performance
  - » Qualified other fabrication eqpt and fixtures
    - 160 tubes fabricated
    - 133 passed leak test (no failures!) - *8.2 miles of weld!*
    - 50 cleaned

BIG PASCO

WAREHOUSE #5, BAYS #1 & #2



CB&I

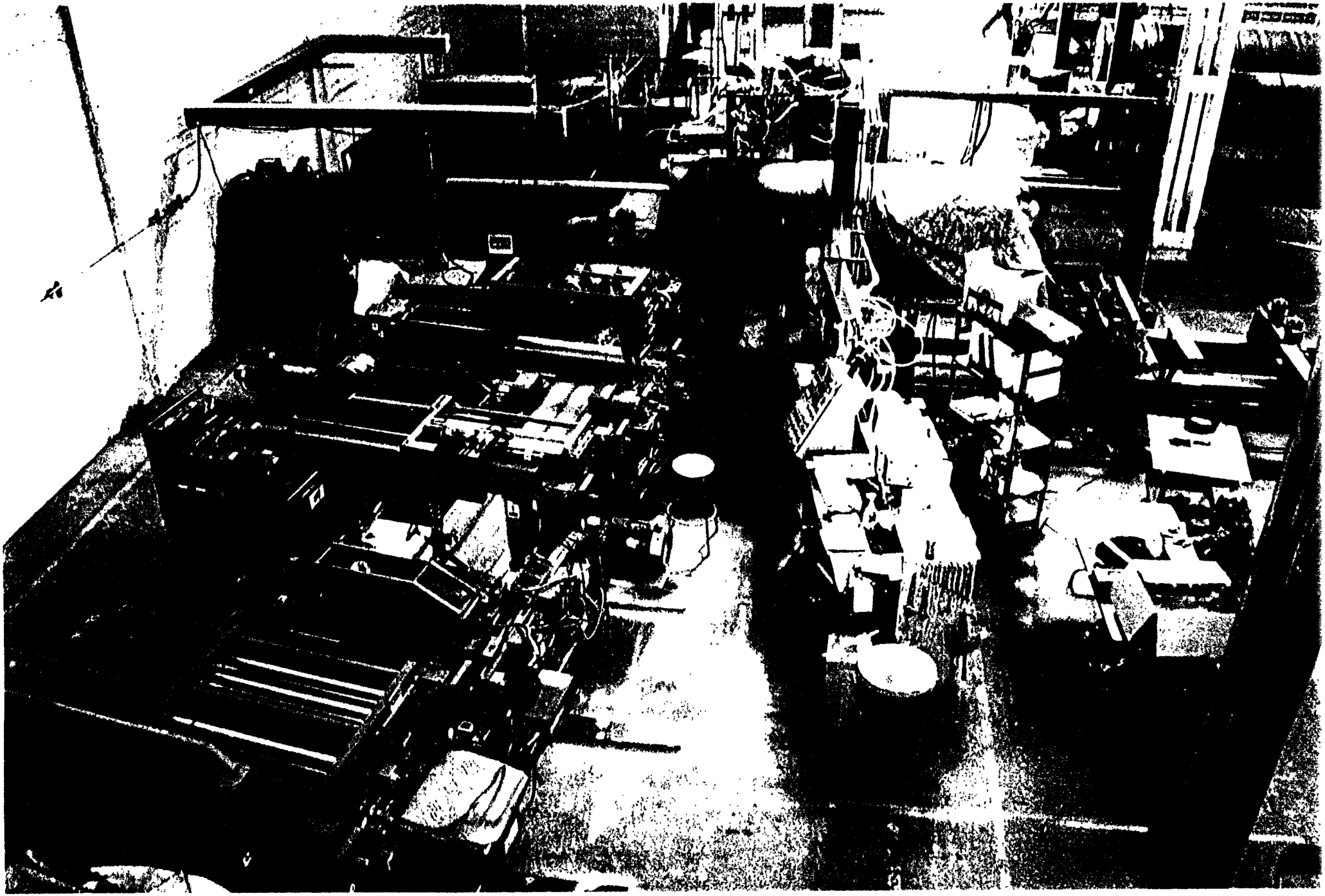
HANFORD LOCATION

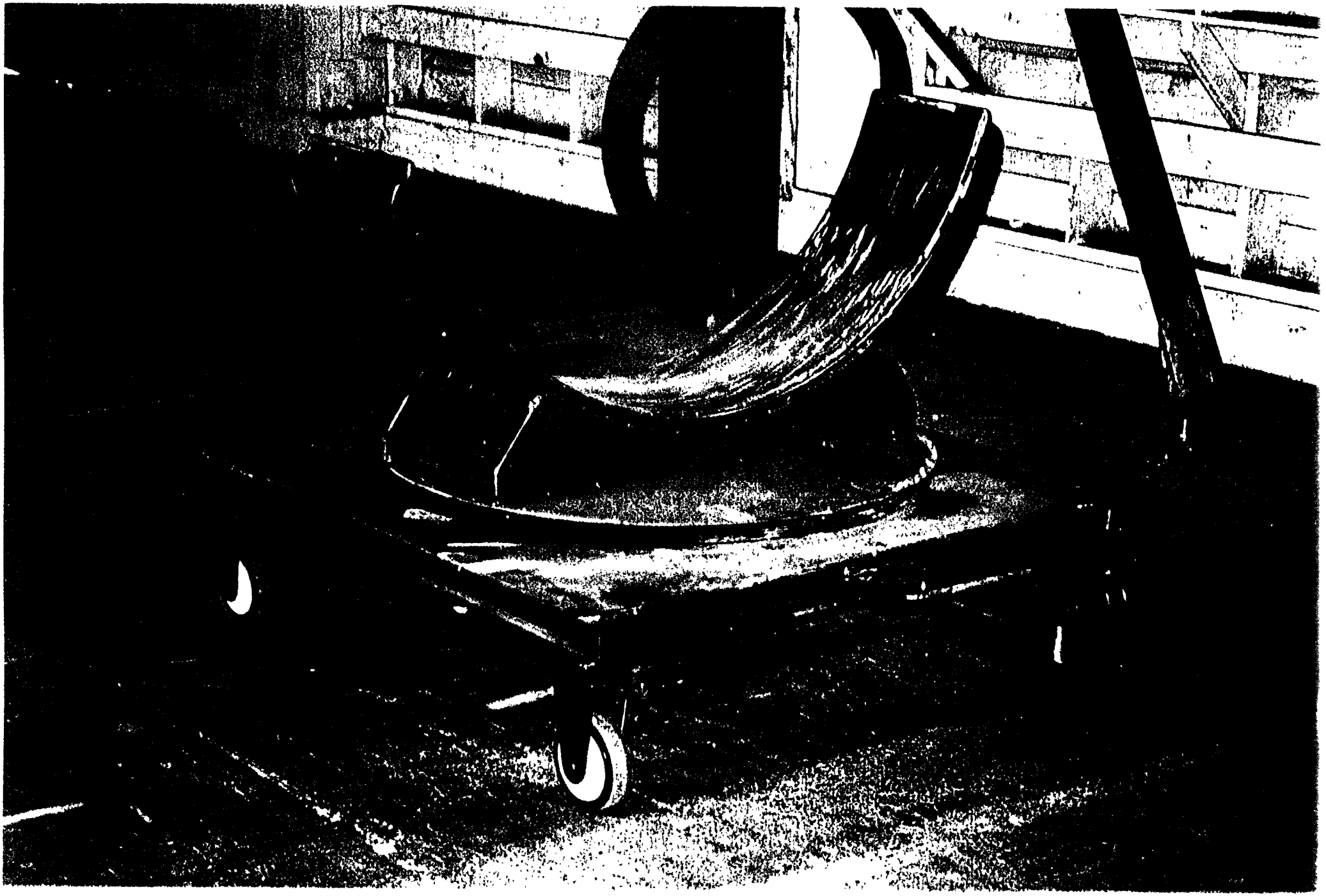
FABRICATION FACILITY

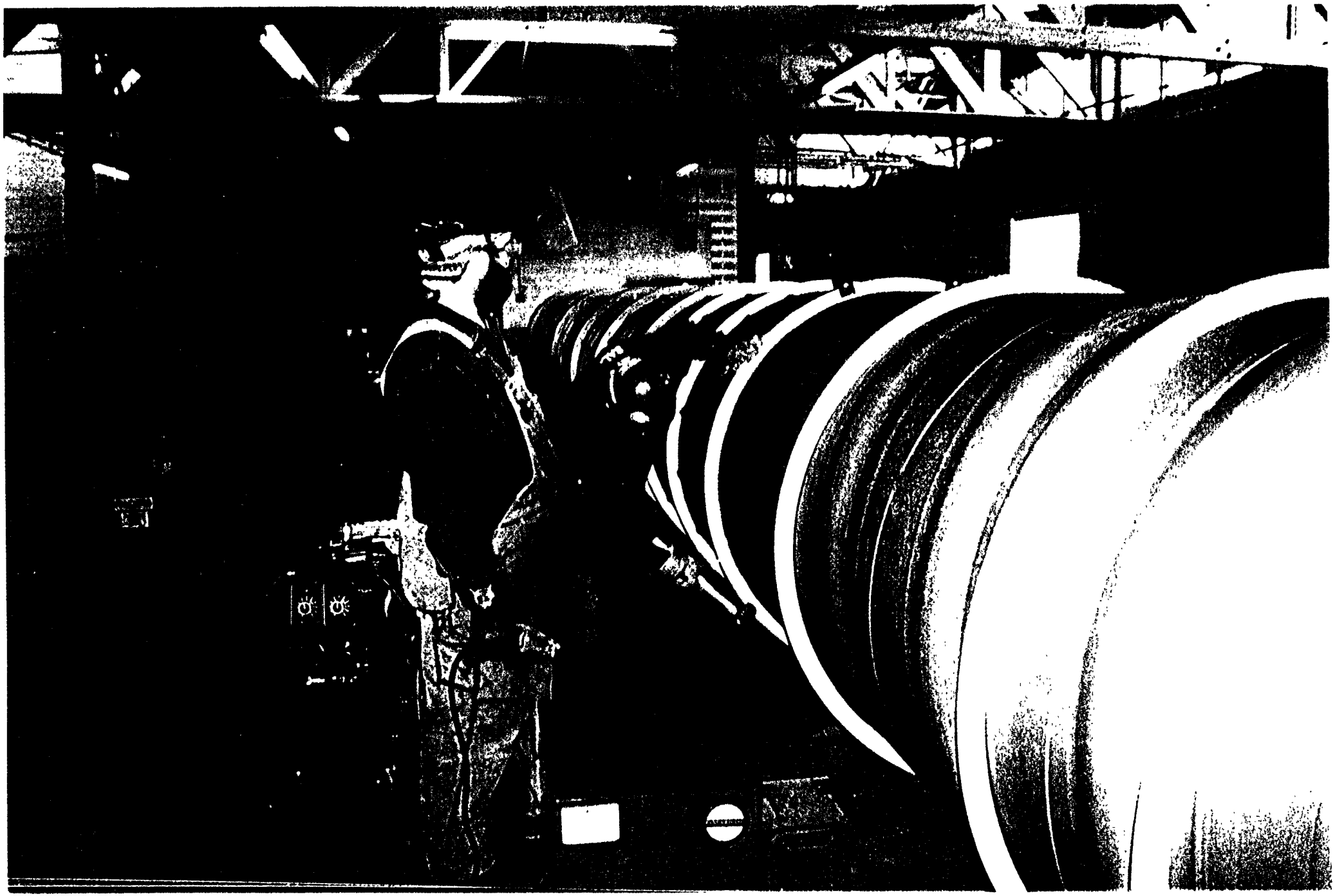
BIG PASCO WHSE #5, BAYS 1 & 2

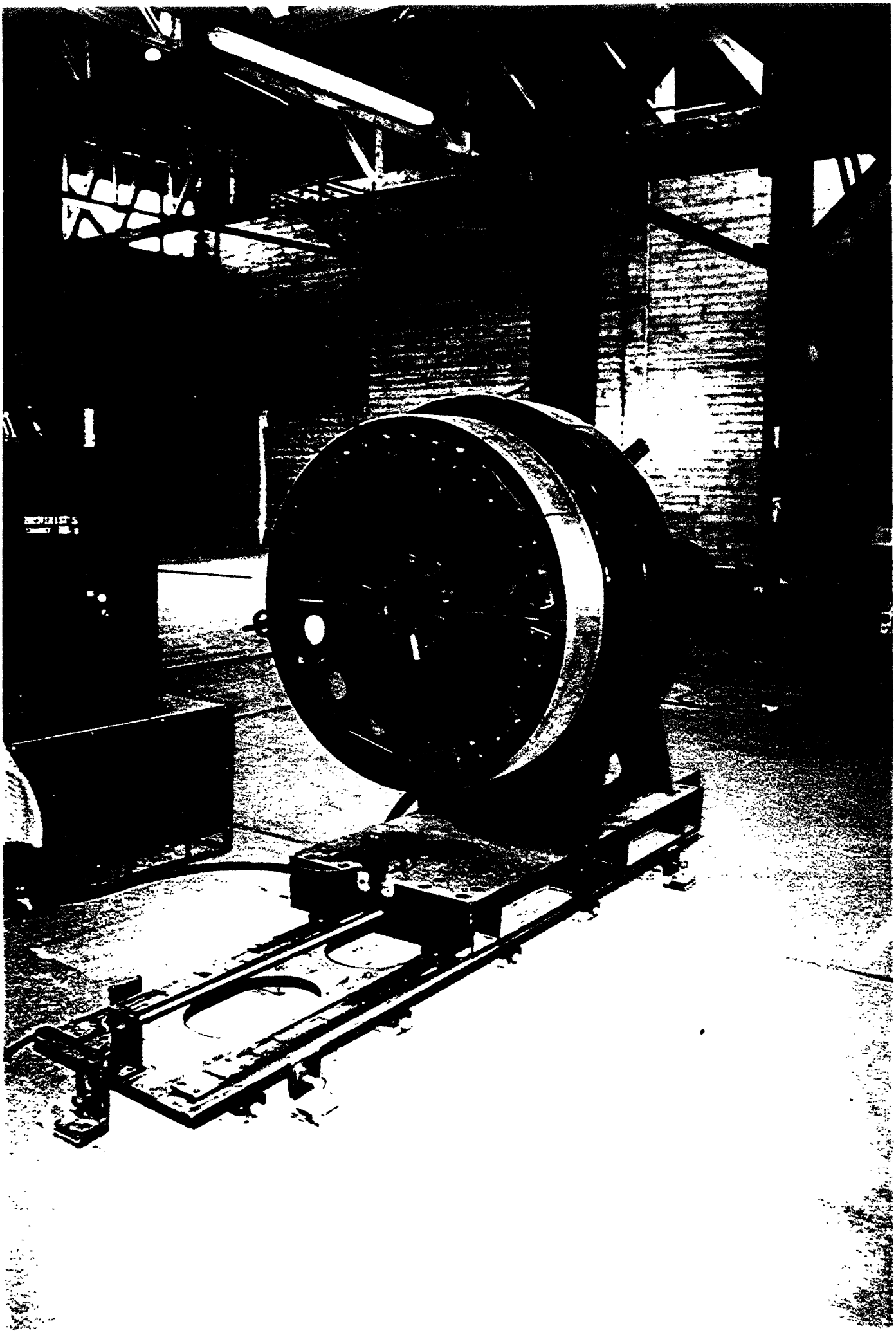
PCTBTS20

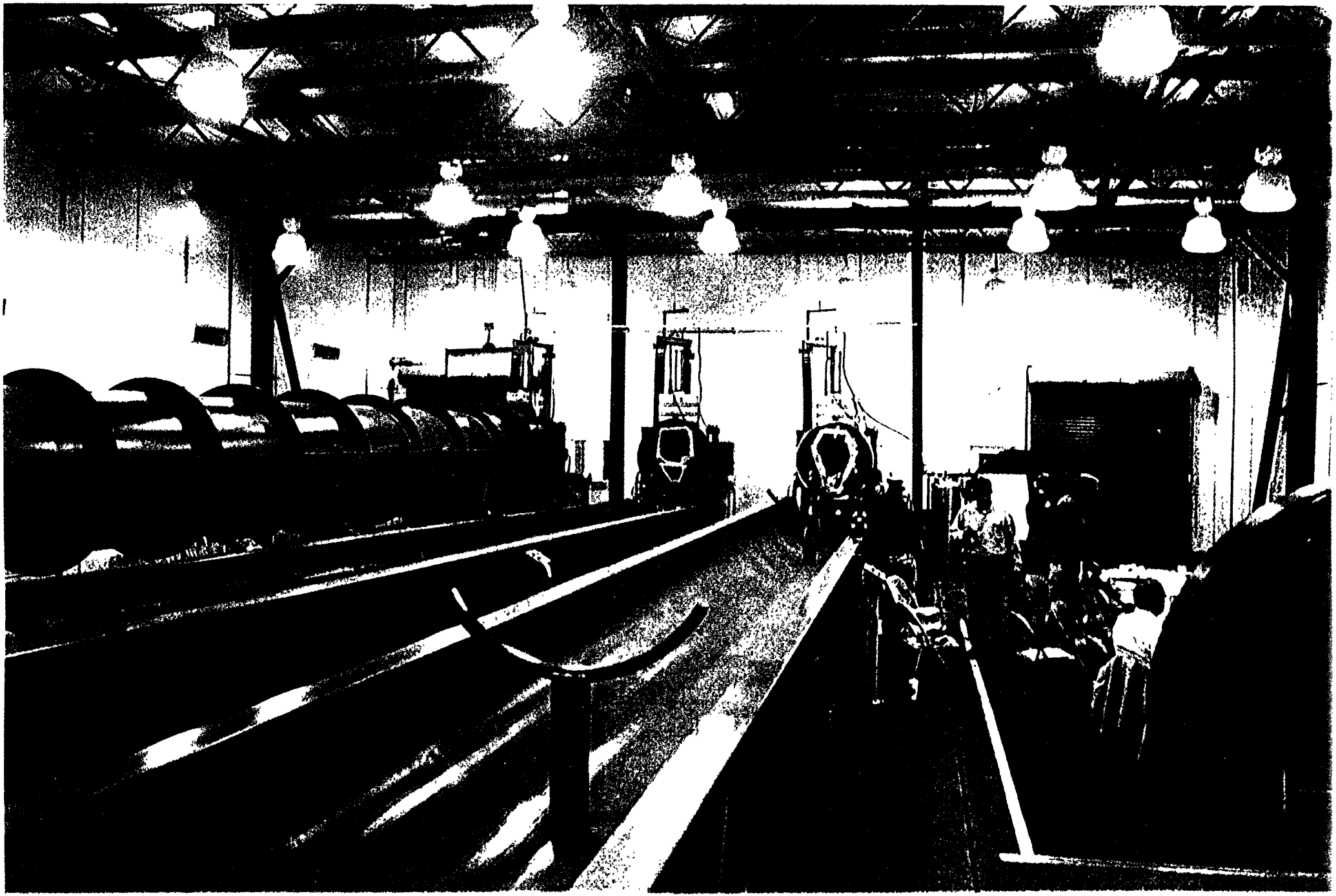
BIGPASO1.CVS



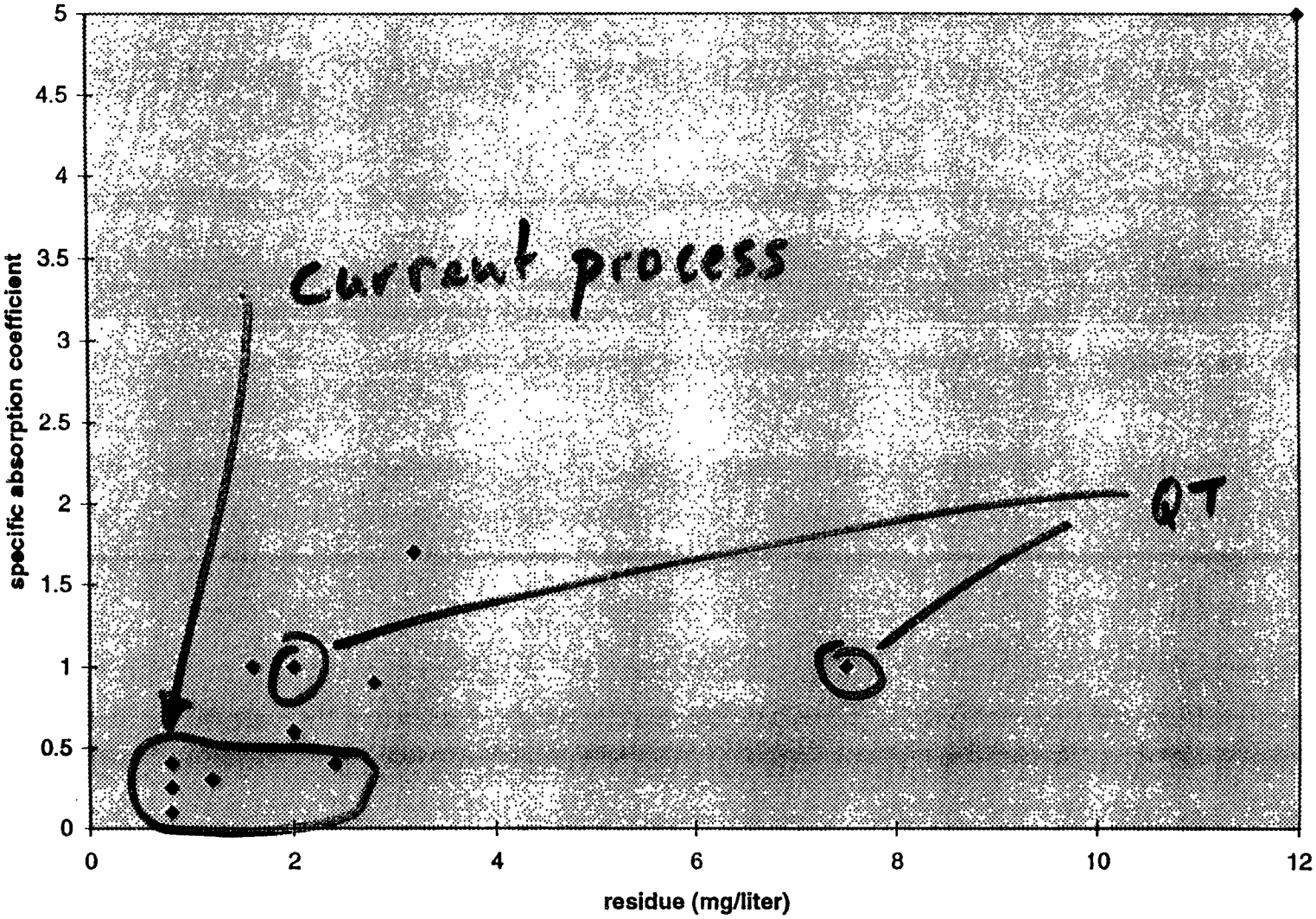






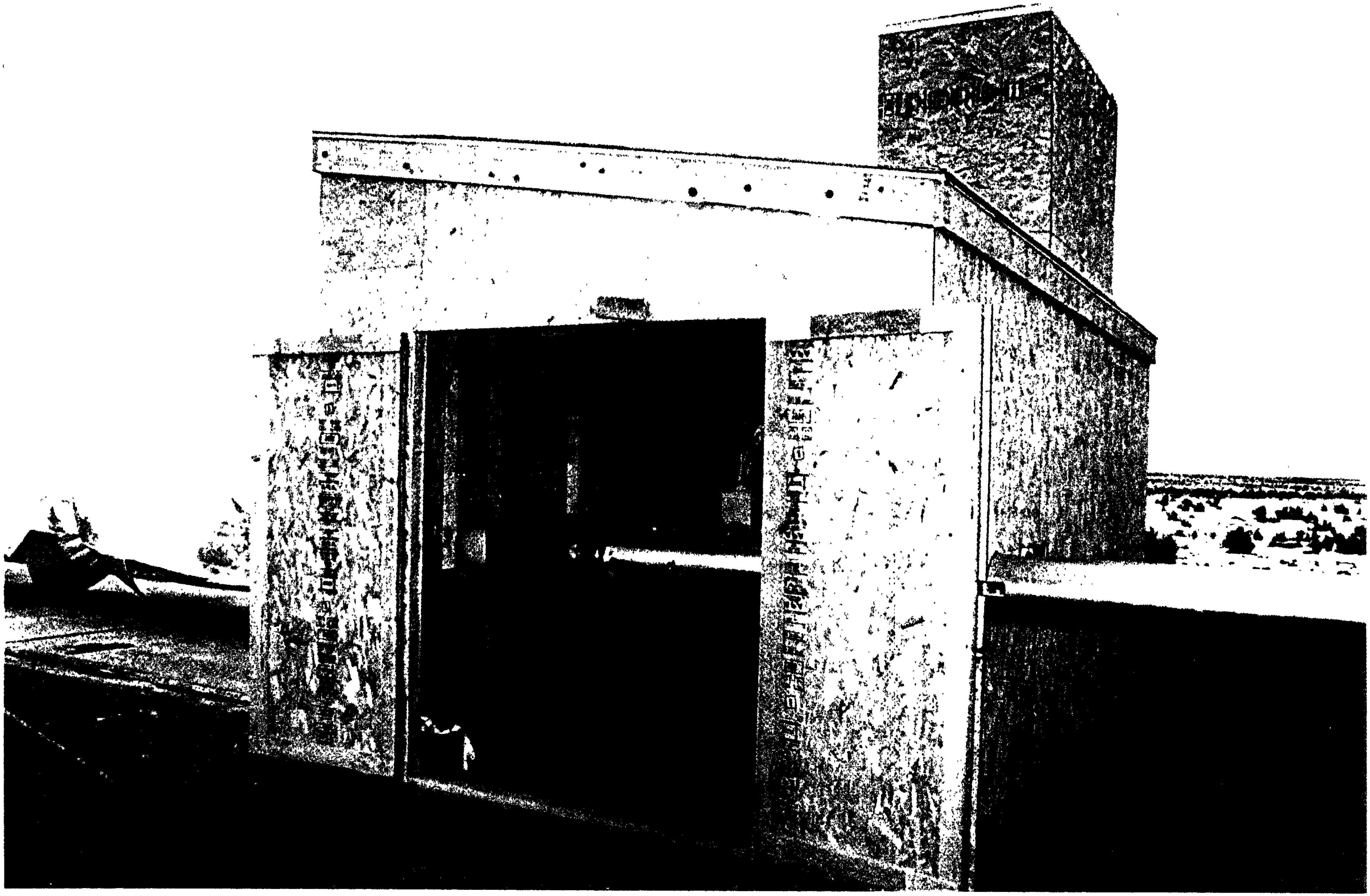


absorption coefficient vs residue

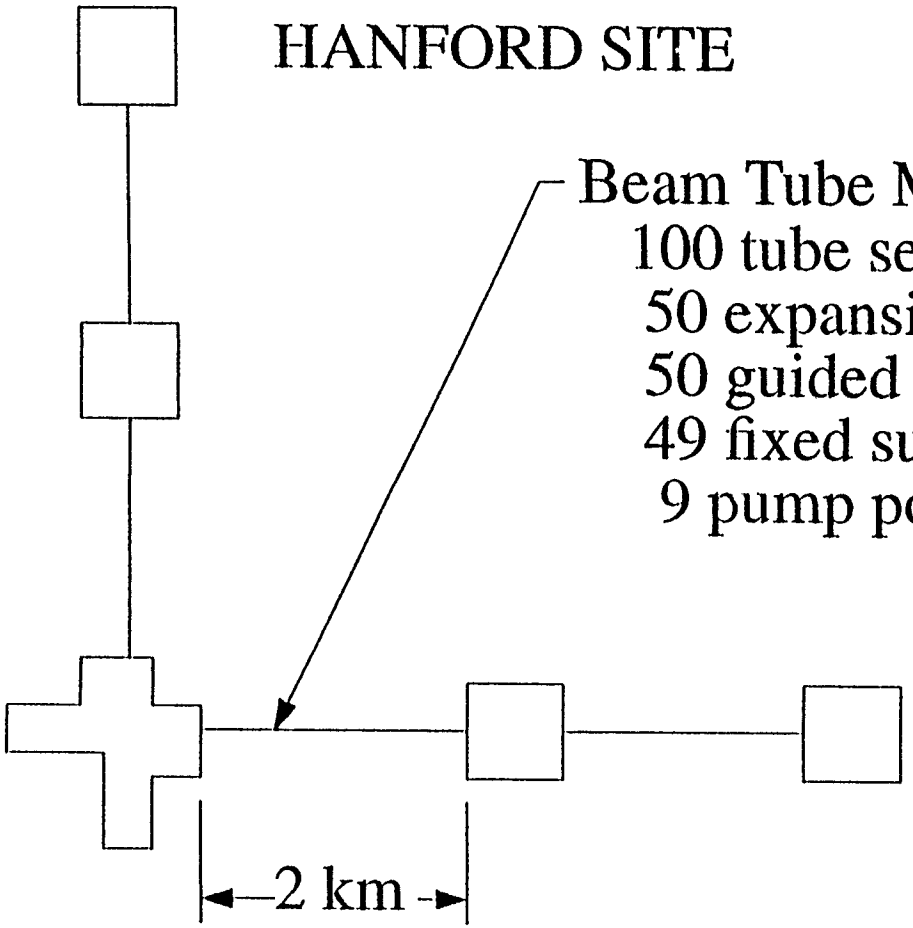


BT installation

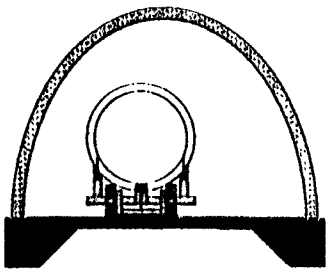
- Installation:
  - » weld enclosures, air filtration system delivered to site
  - » terminating gate valves at mid-station installed
  - » high precision site survey completed to provide reference locations for BT installation
  - » 29 beam tubes installed on site
  - » 27 girth weld leak tested - no failures

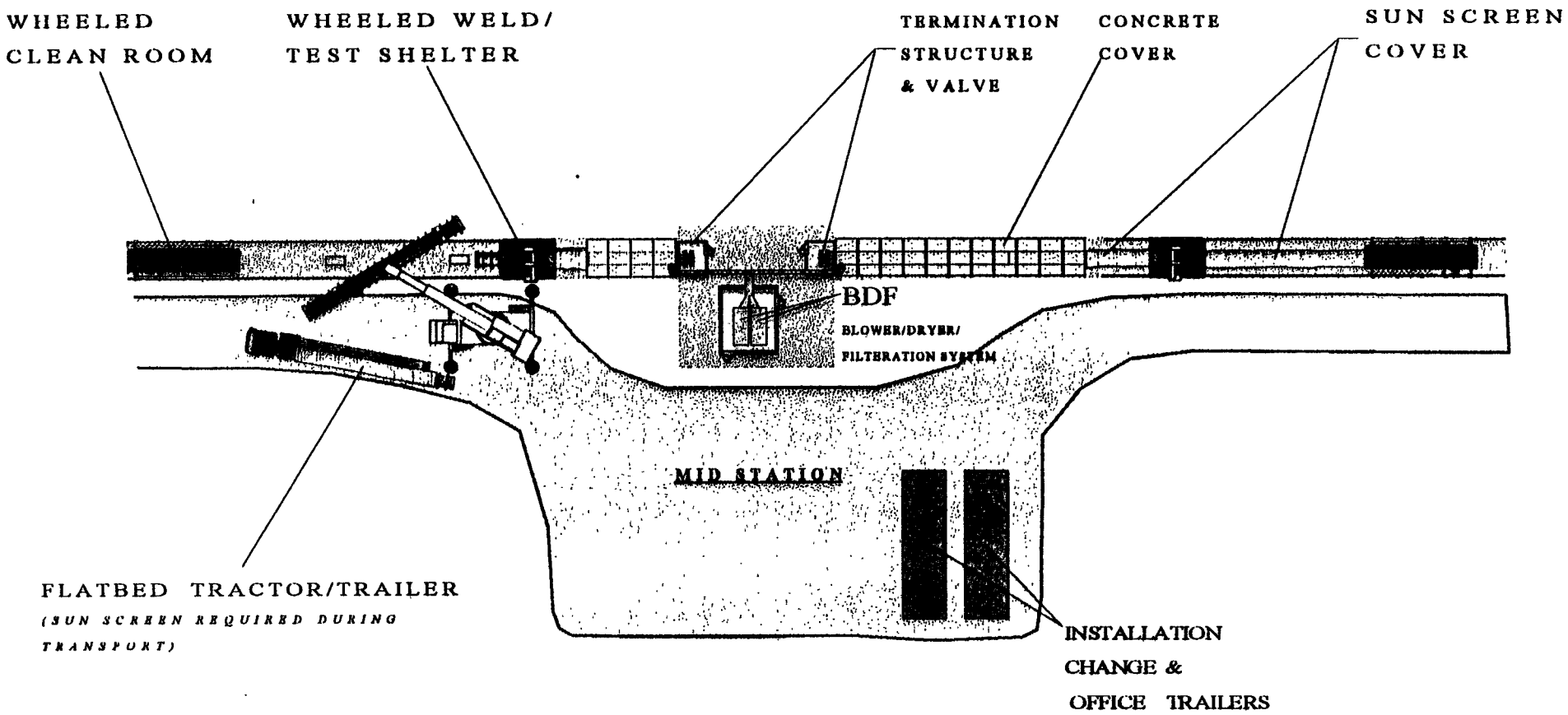


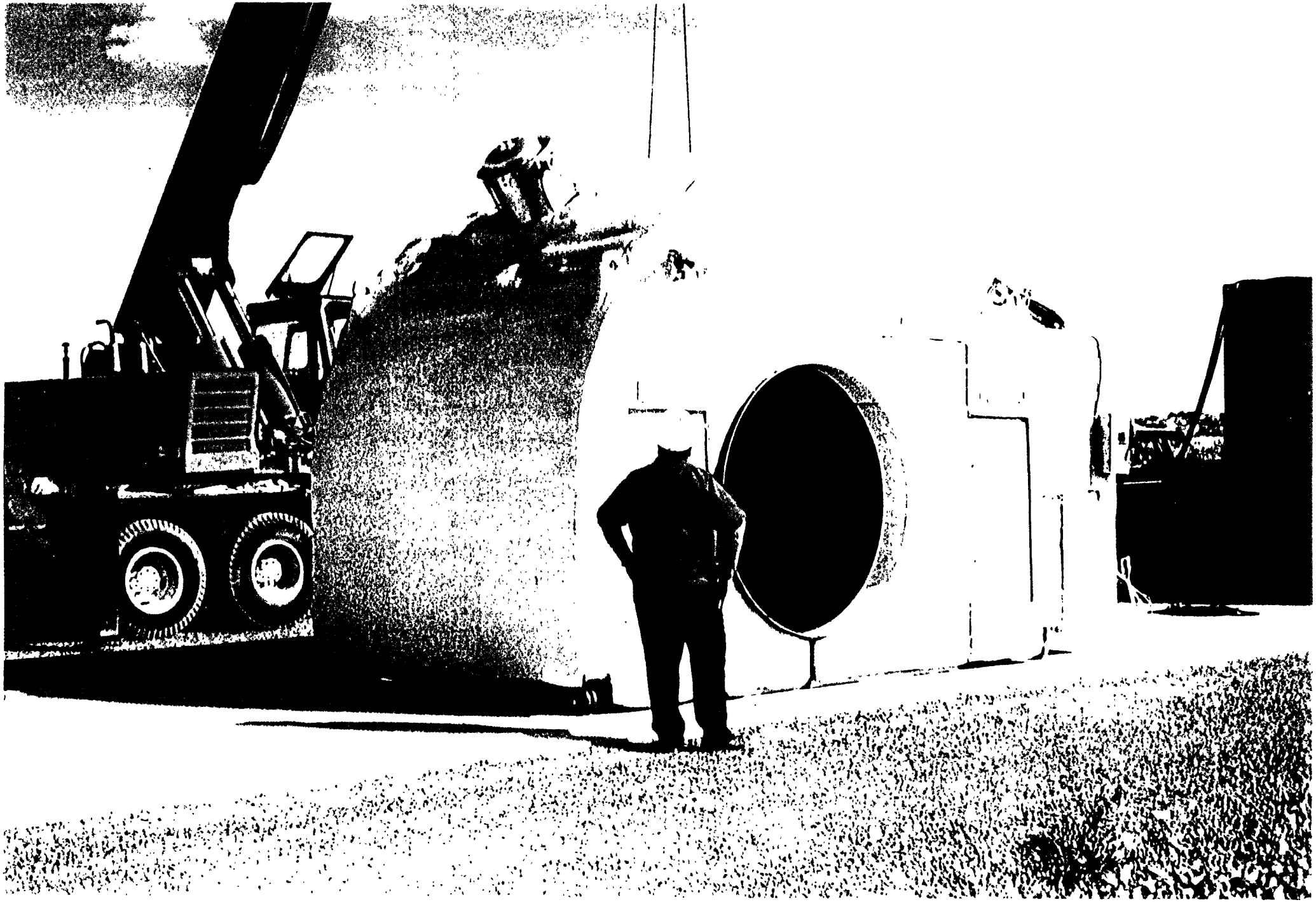
BEAM TUBE MODULES

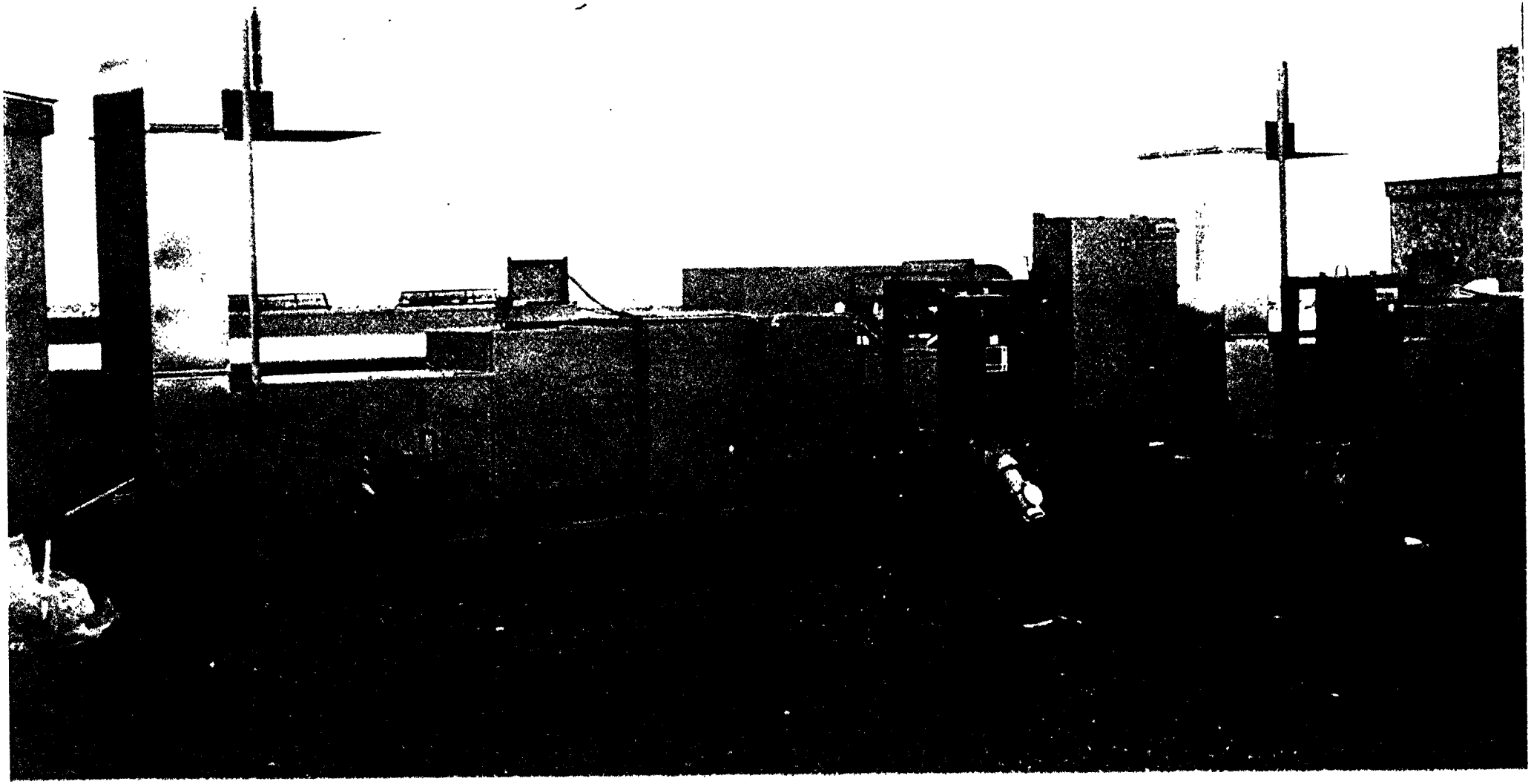


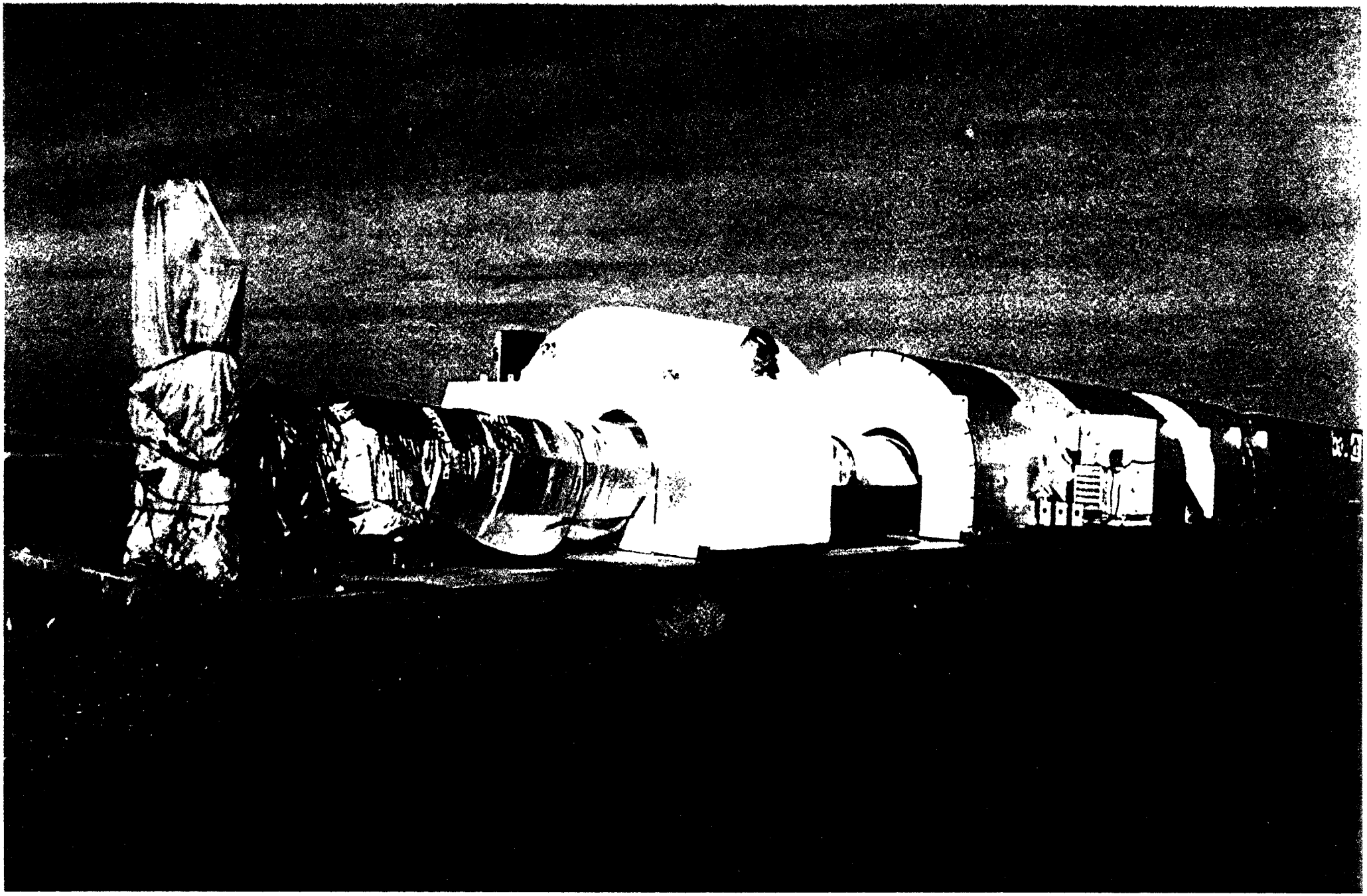
LIGO INSTALLATION PLAN

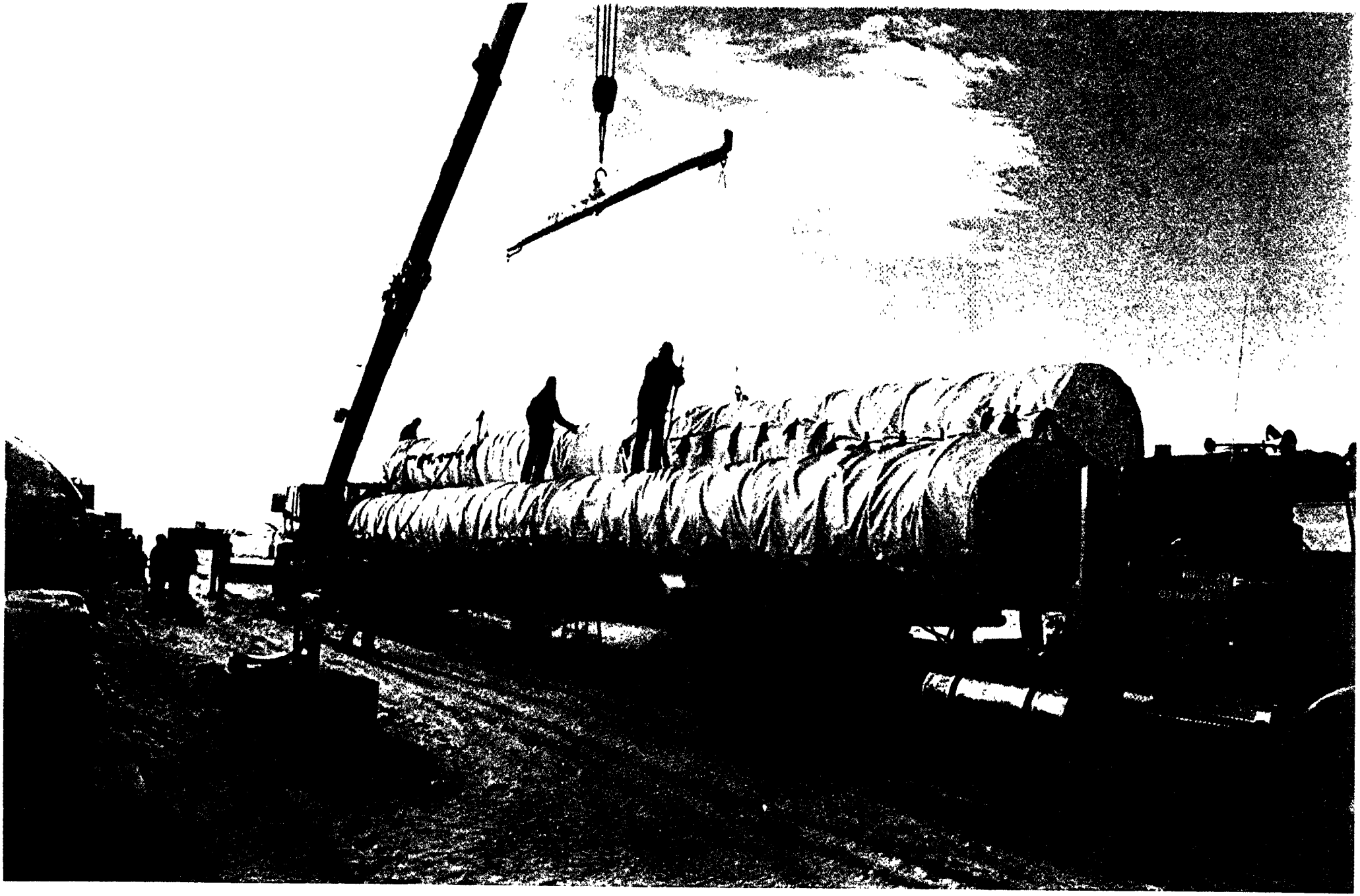


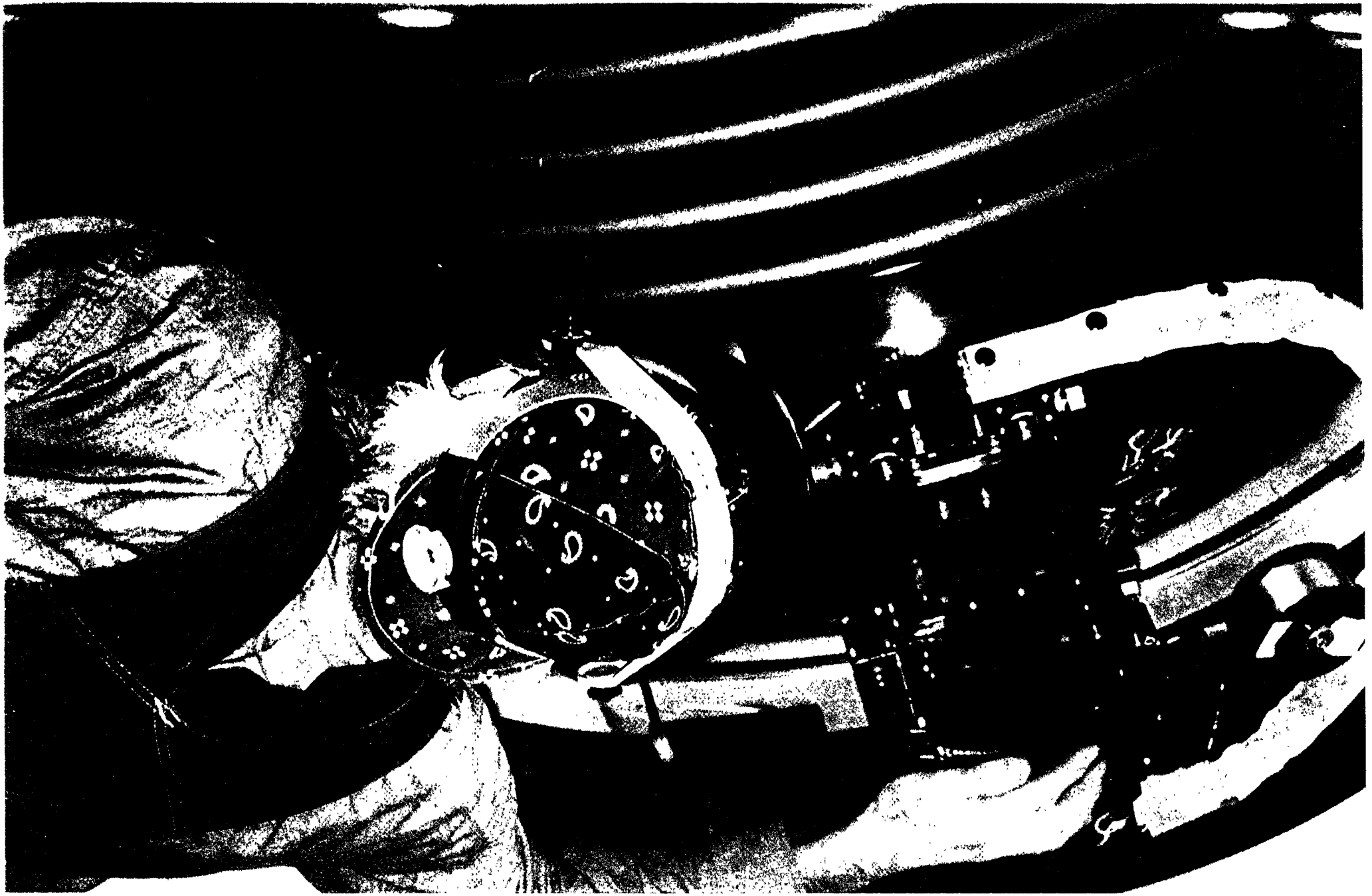


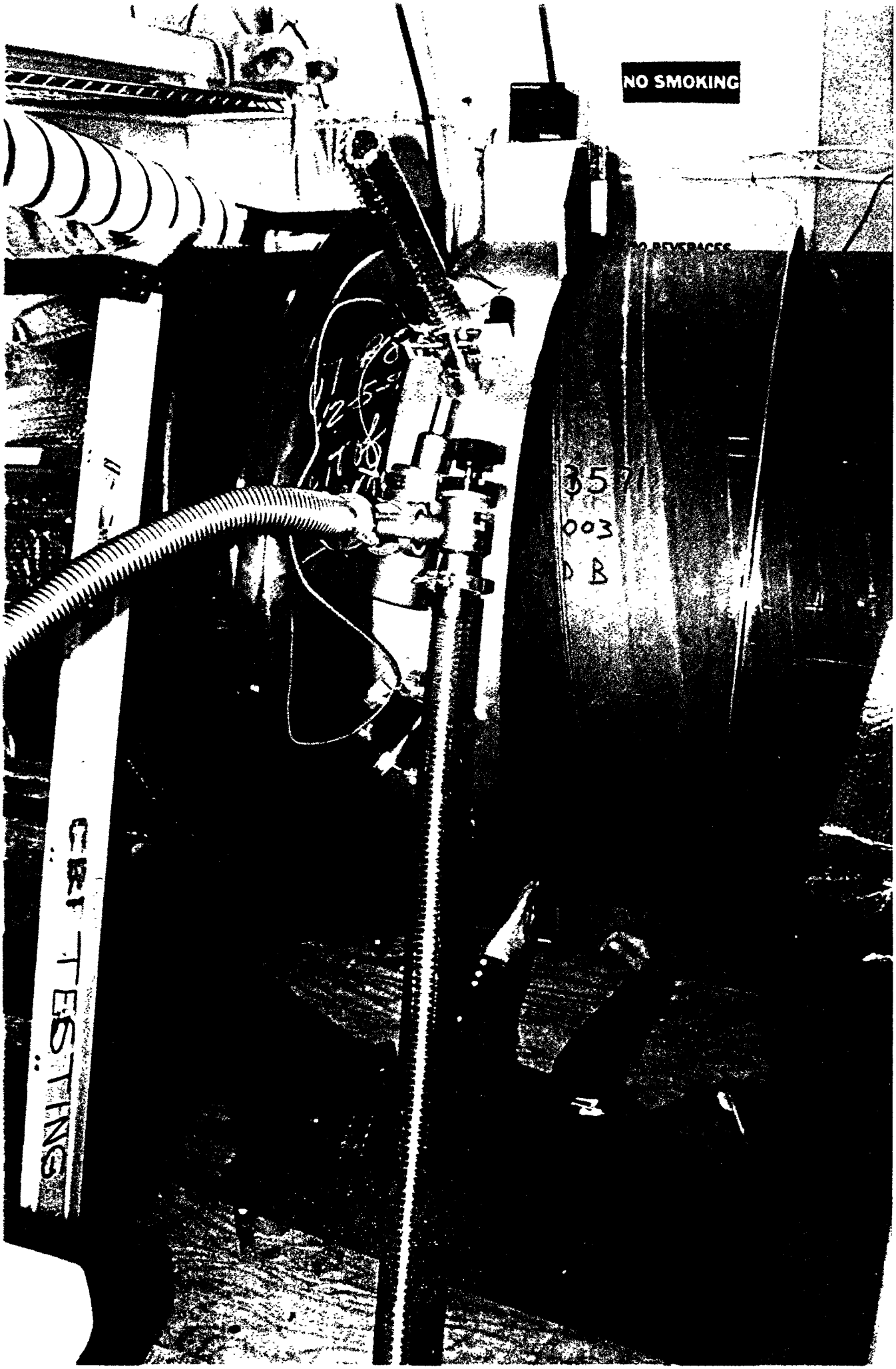




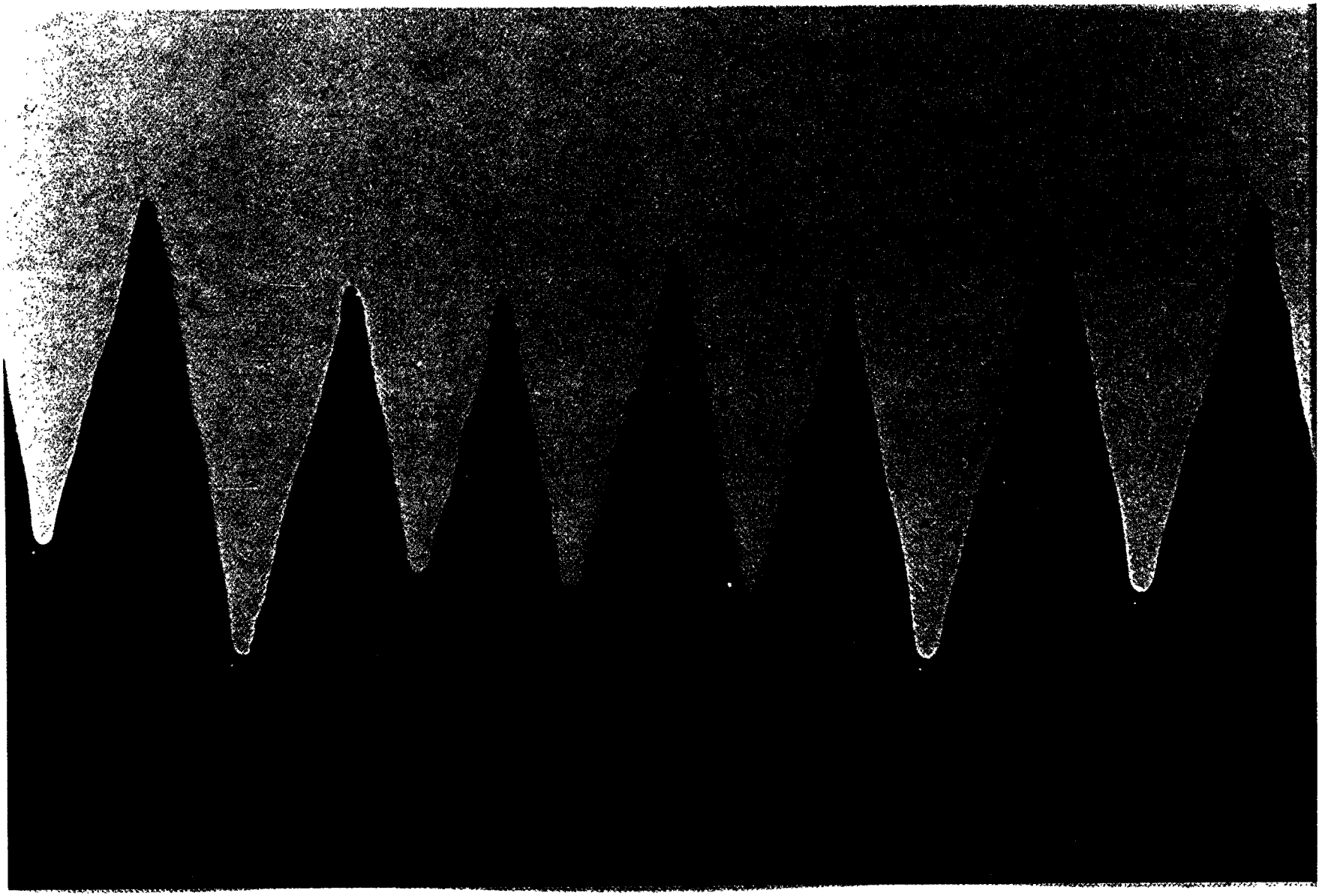







NO SMOKING
TESTING

JPL-



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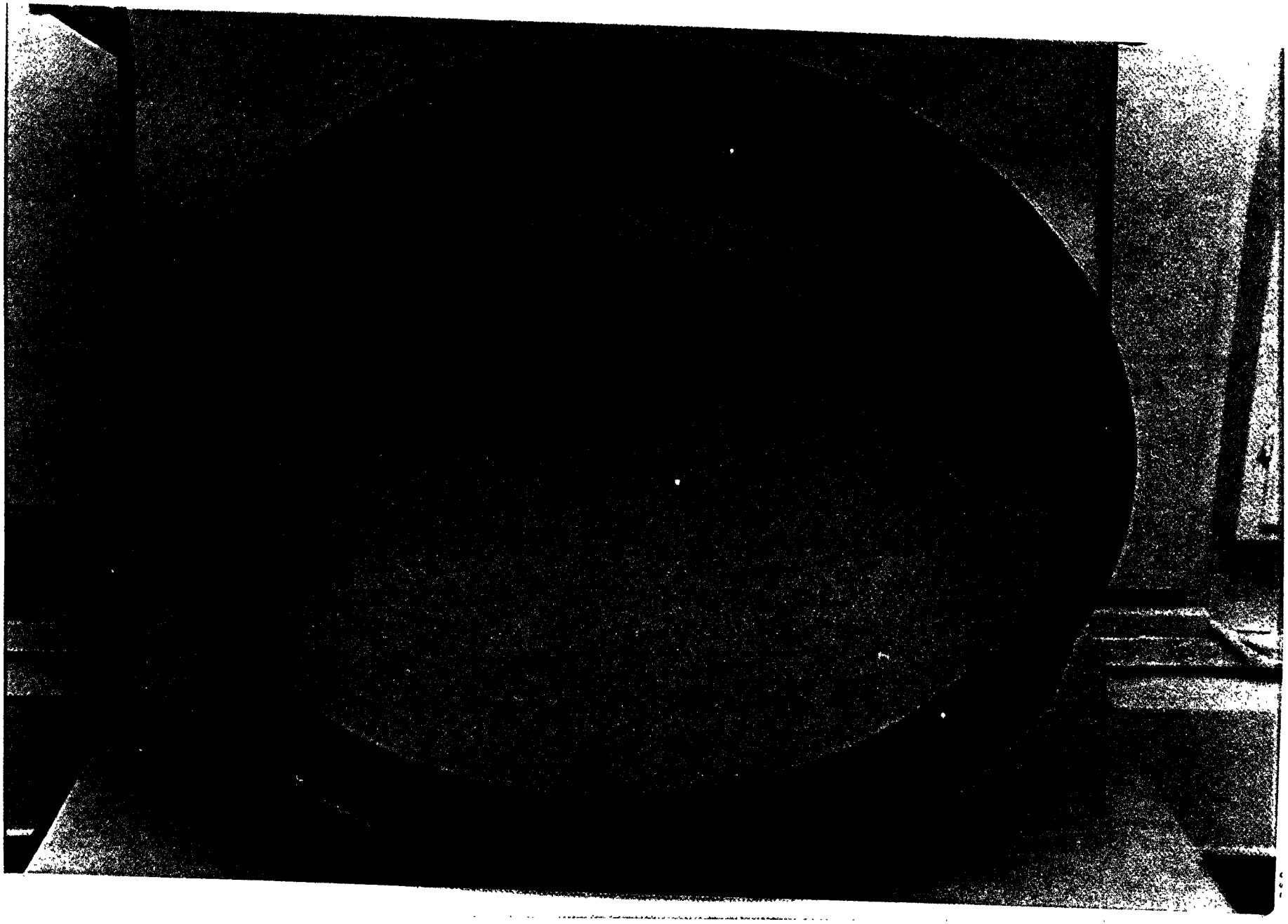
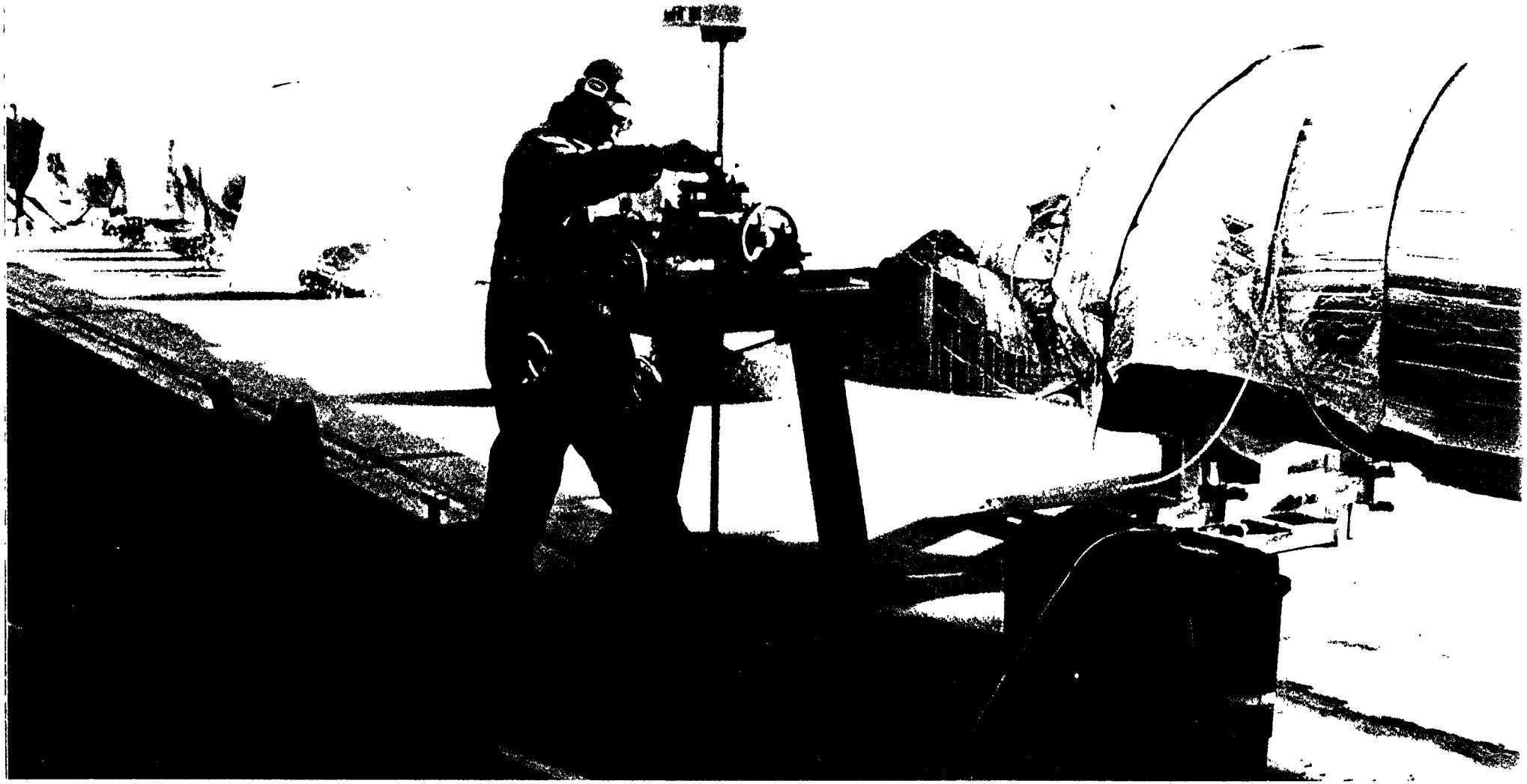
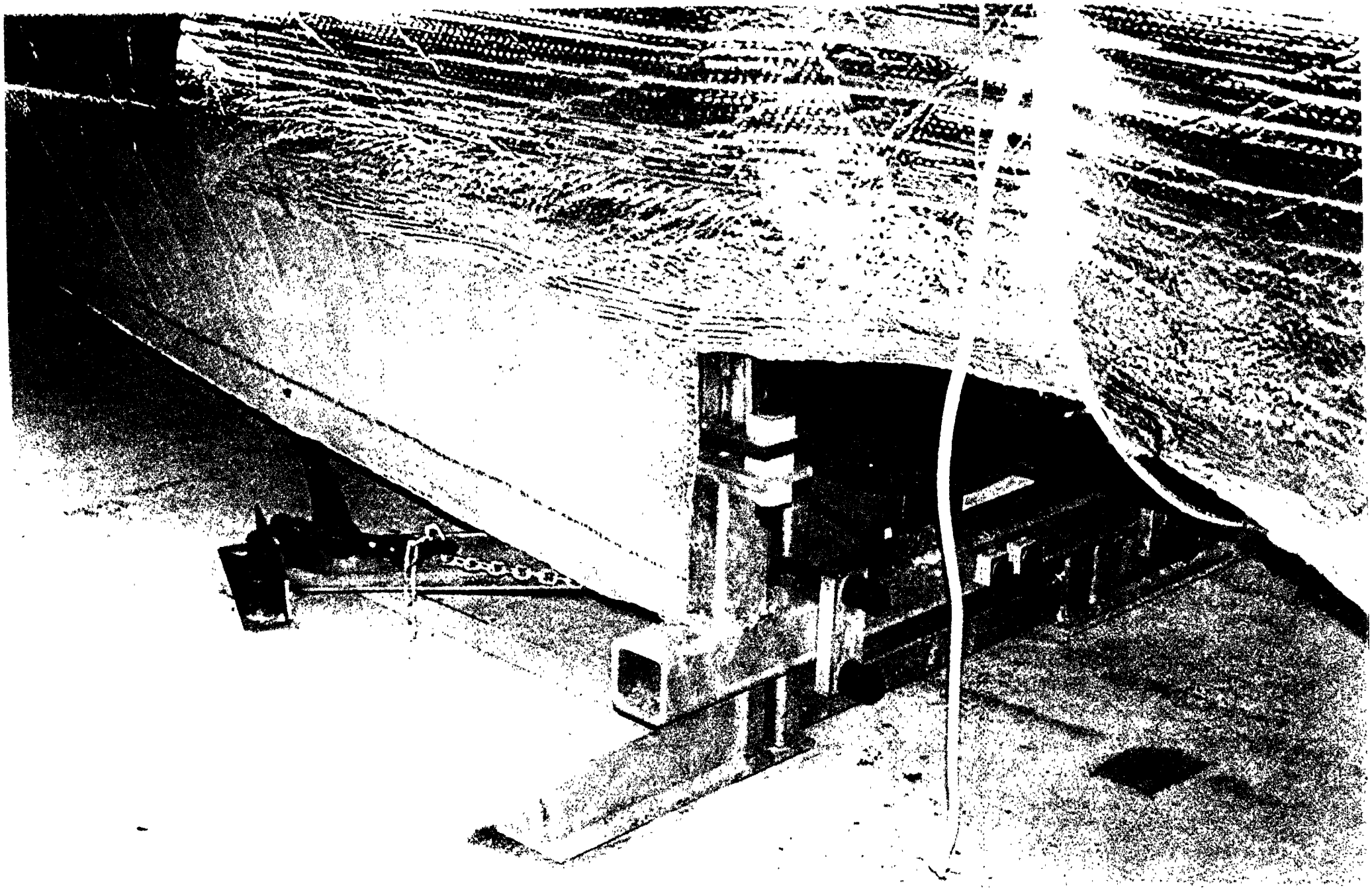


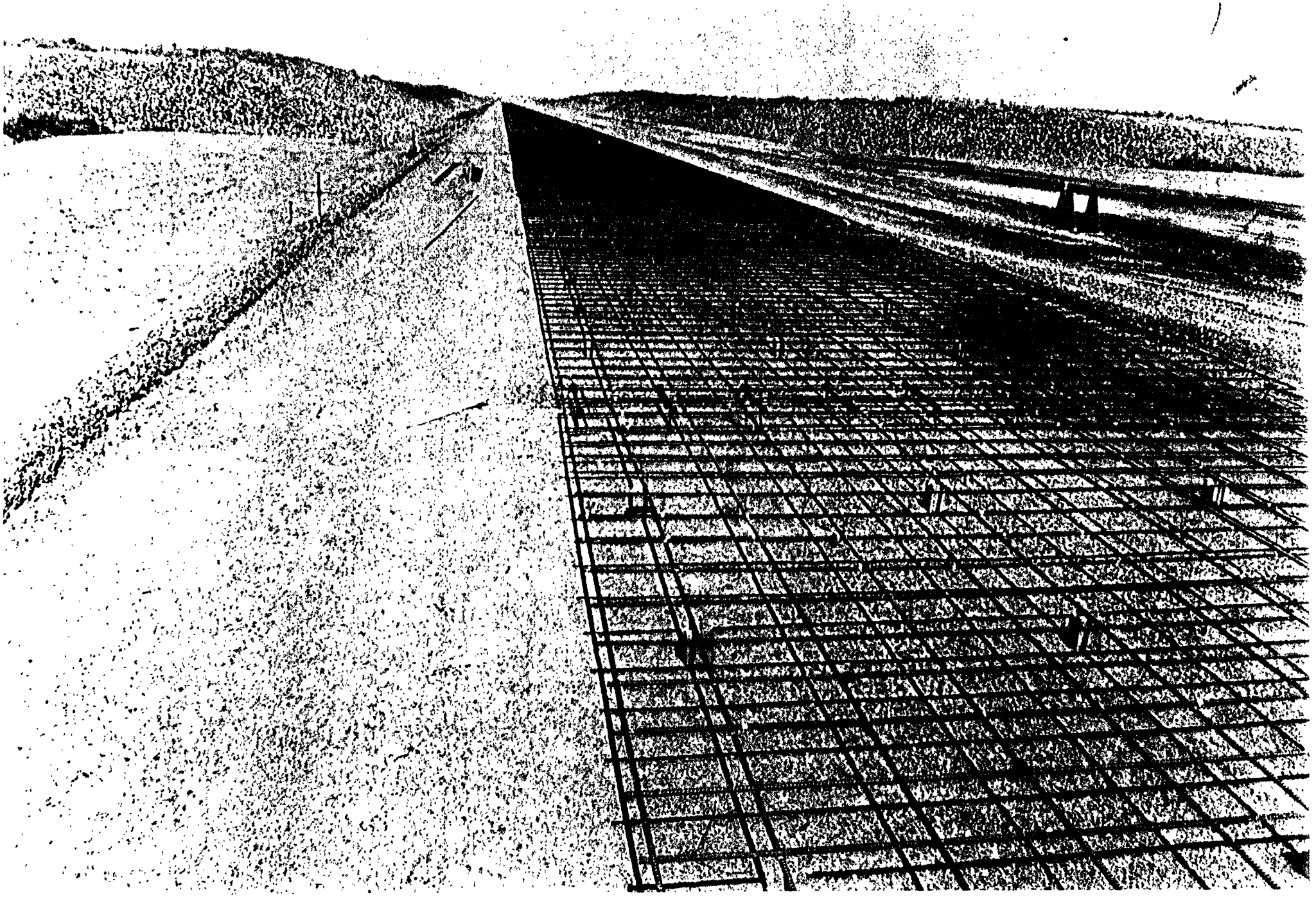
BT Alignment

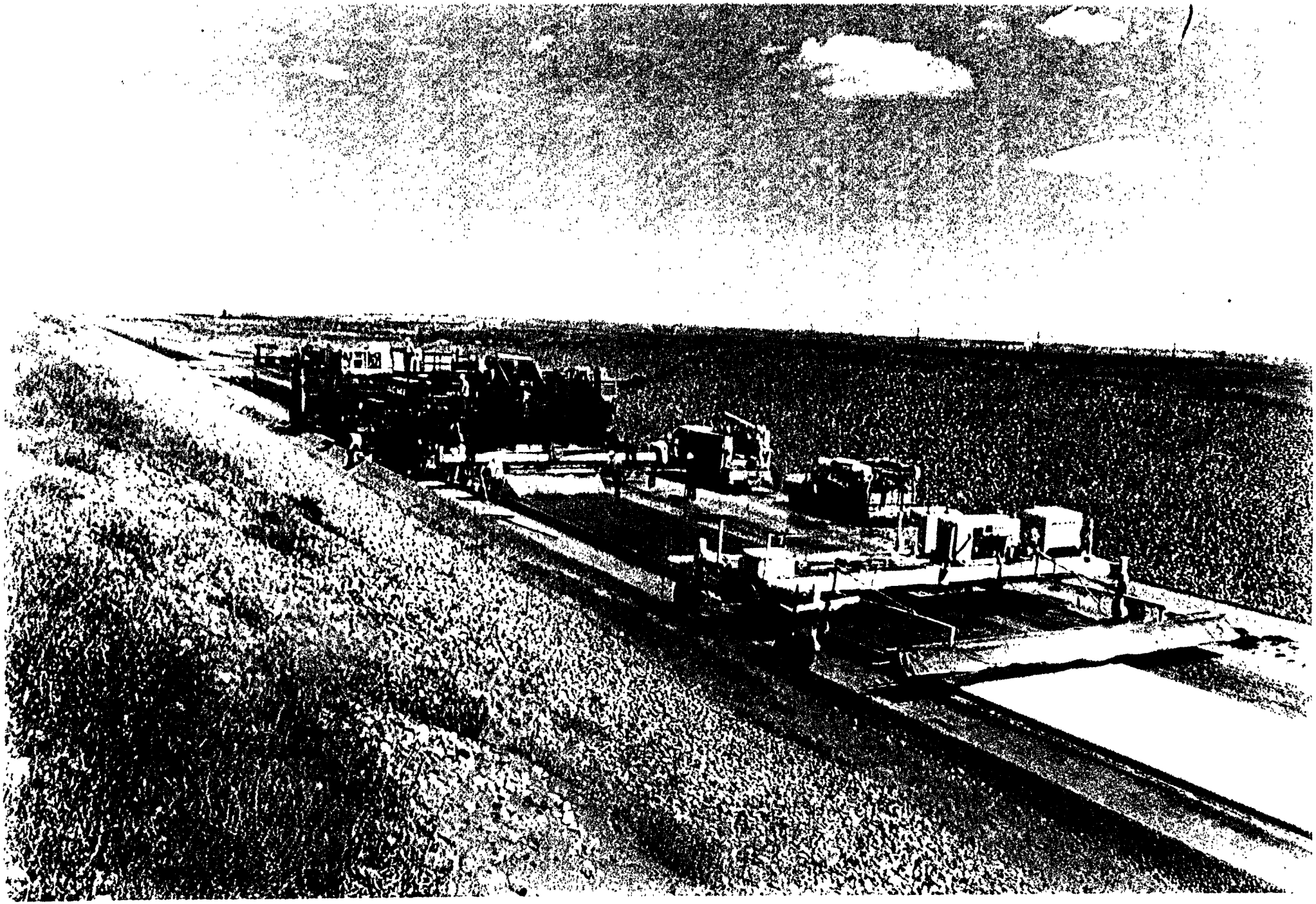
Allen Sibley

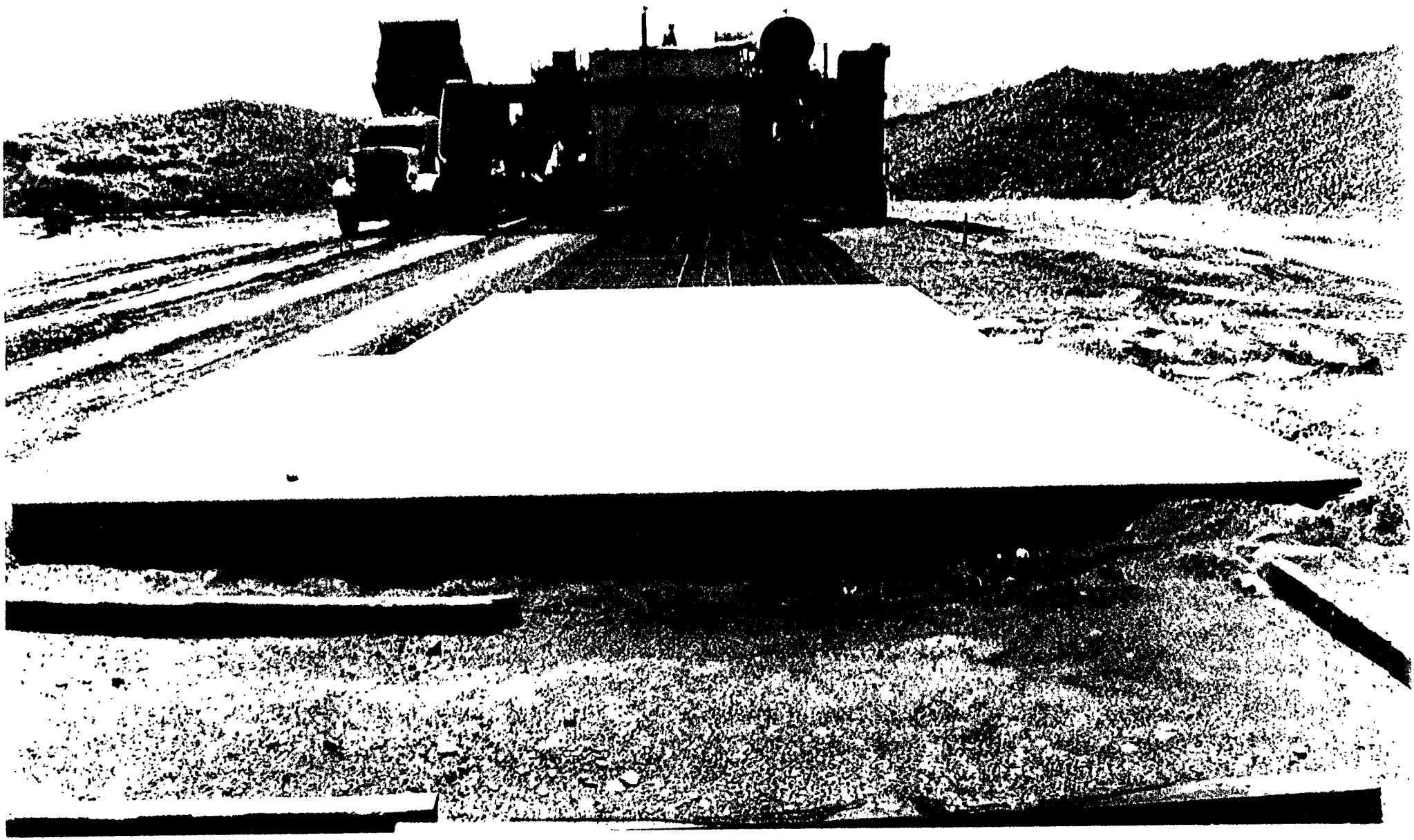
- QA contract with Rodgers to spot check early CBI measurements
- CBI uses differential GPS
- Max alignment range of BT support is 3 inches. Want to center BT within this range.

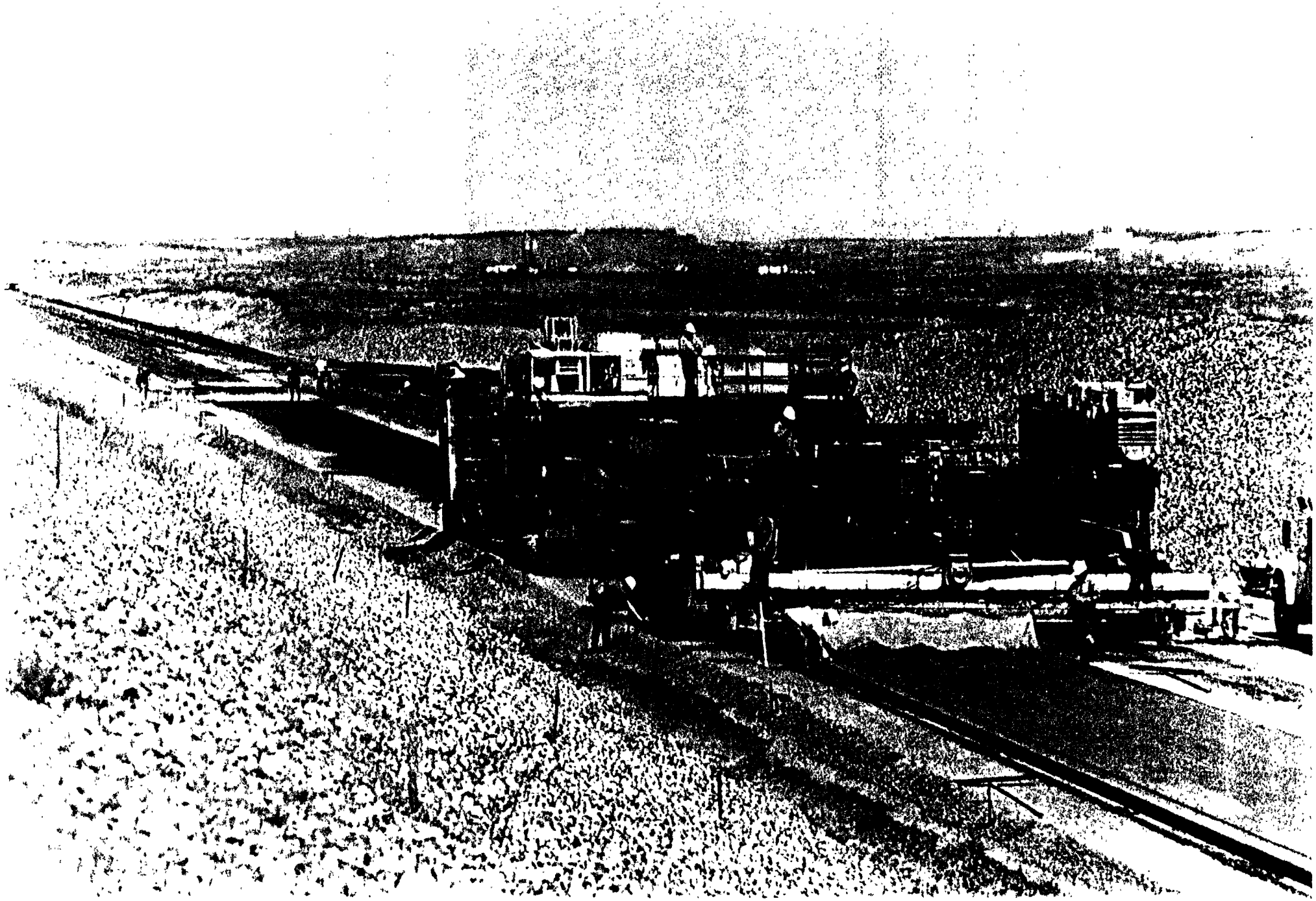


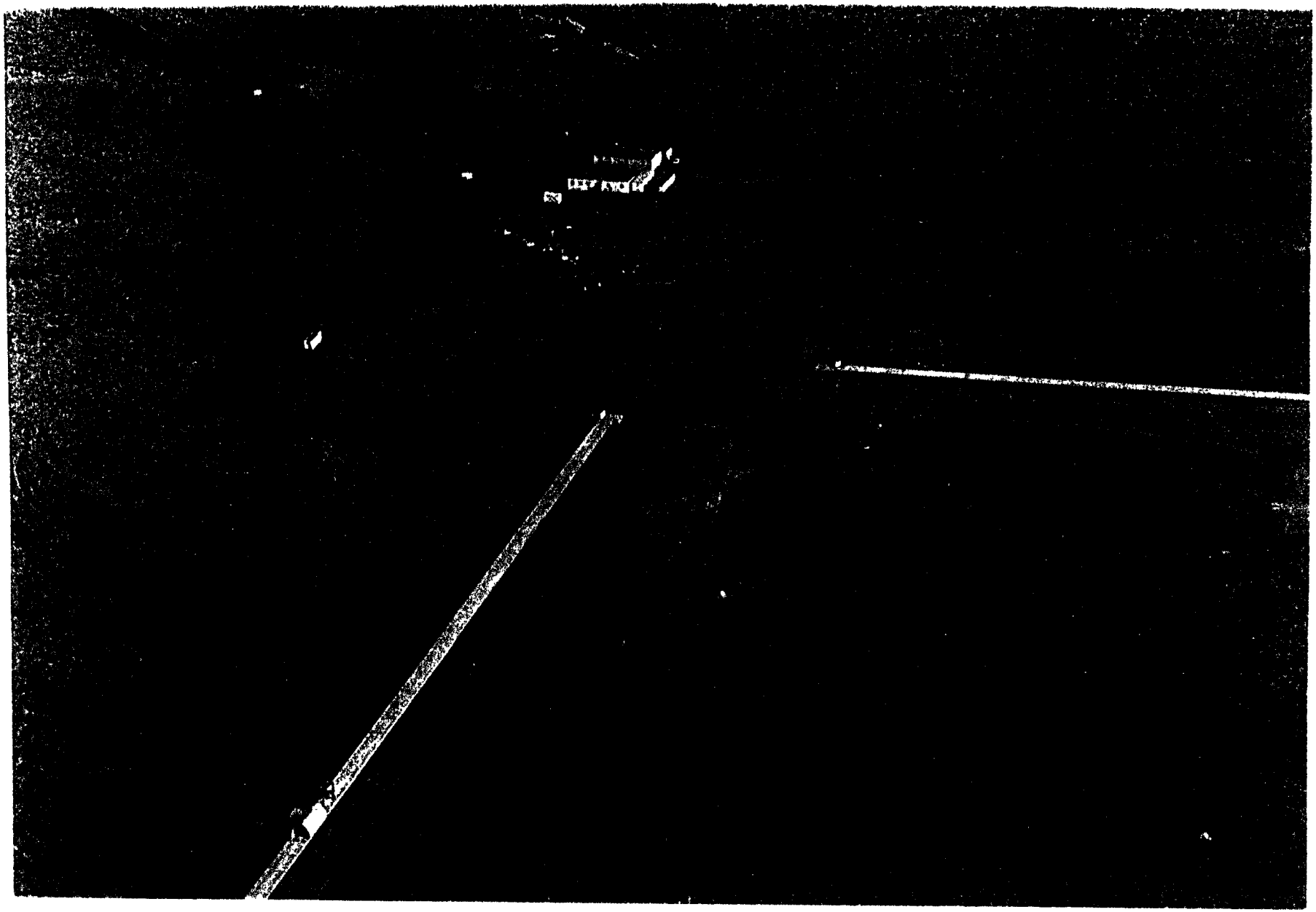










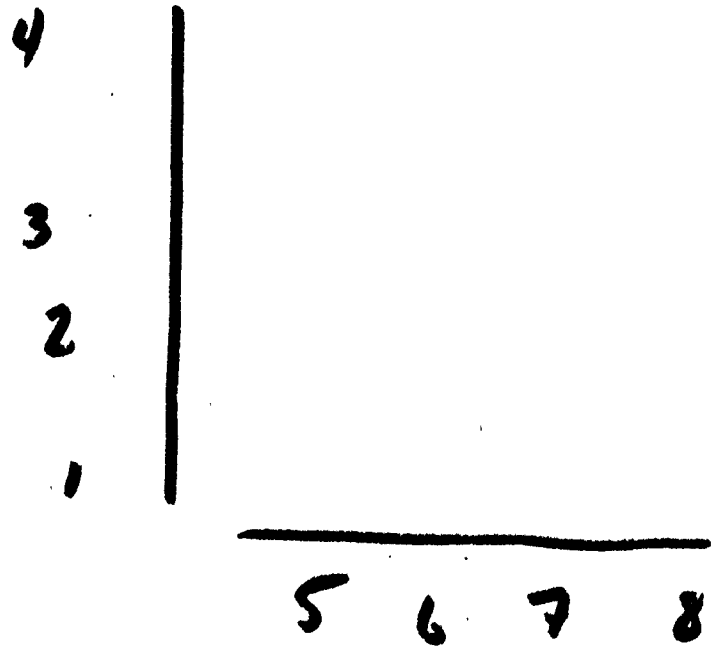


Precision Survey

Allen Sibley

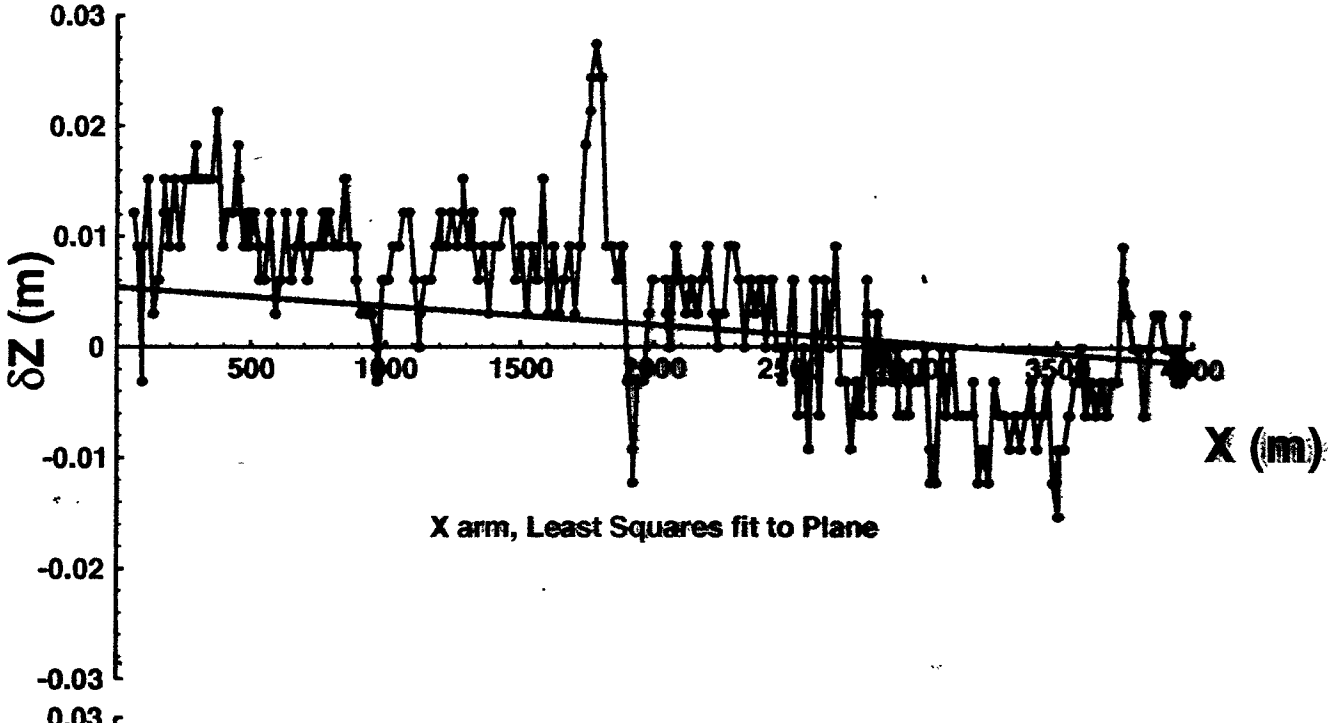
- Site fiducialization by Rogers (local) and IMTEC (Kansas City)
- Combination of differential GPS and optical methods
- Rogers - elevations and ranges - dGPS
- IMTEC - elevations and lateral - optical

Point	Rogers survey relative to RMP model (mm)	IMTEC survey relative to RMP model (mm)	Delta (Rogers - IMTEC)	IMTEC best fit plane
1	0	0	0	0
2	-6	-4	-2	0
3	-6	7	-13	-5
4	6	-5	11	0
5	-3	0	-3	-1
6	3	5	-2	4
7	3	2	1	4
8	3	0	3	0
		IMTEC statistical uncertainty +/- 1 mm		

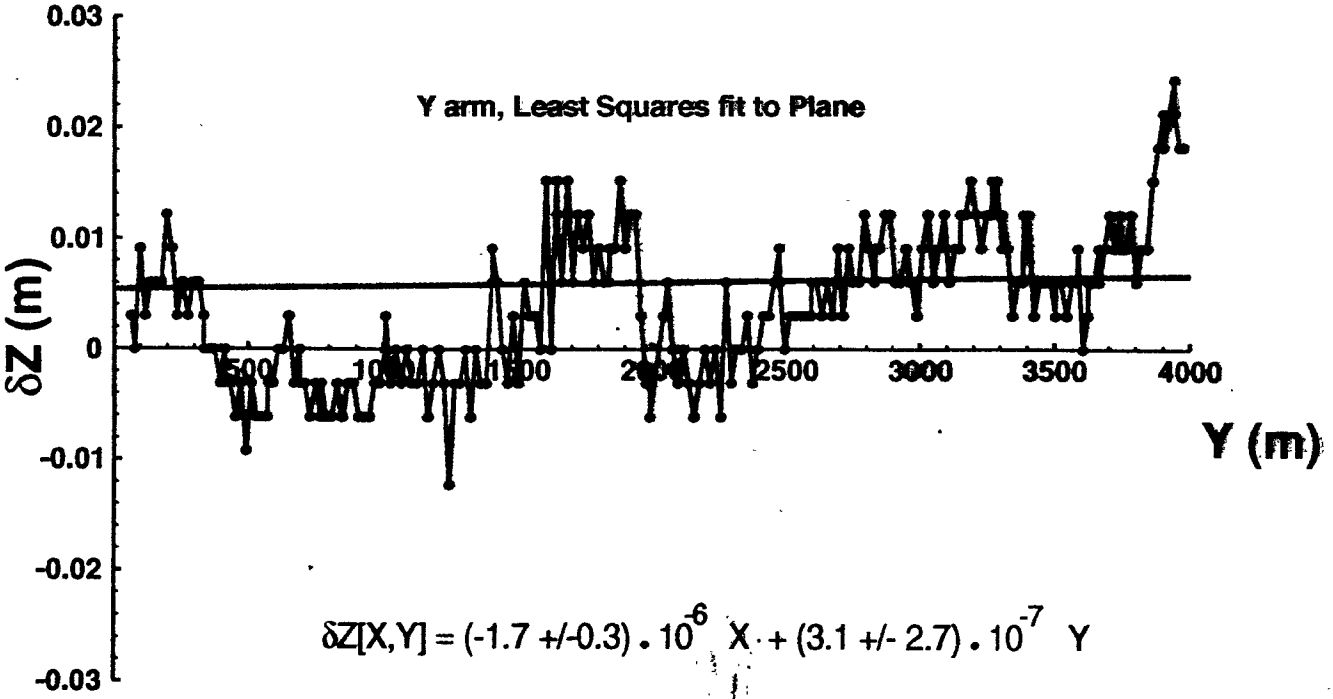


#67
66+50
249

WA BT Slab Survey Results



X arm, Least Squares fit to Plane



Y arm, Least Squares fit to Plane

$$\delta Z[X,Y] = (-1.7 +/- 0.3) \cdot 10^{-6}\ X + (3.1 +/- 2.7) \cdot 10^{-7}\ Y$$

$$\sigma_Z = 0.0068\ \text{m} \quad ; \text{P-V} = 0.043\ \text{m}$$

LIGO

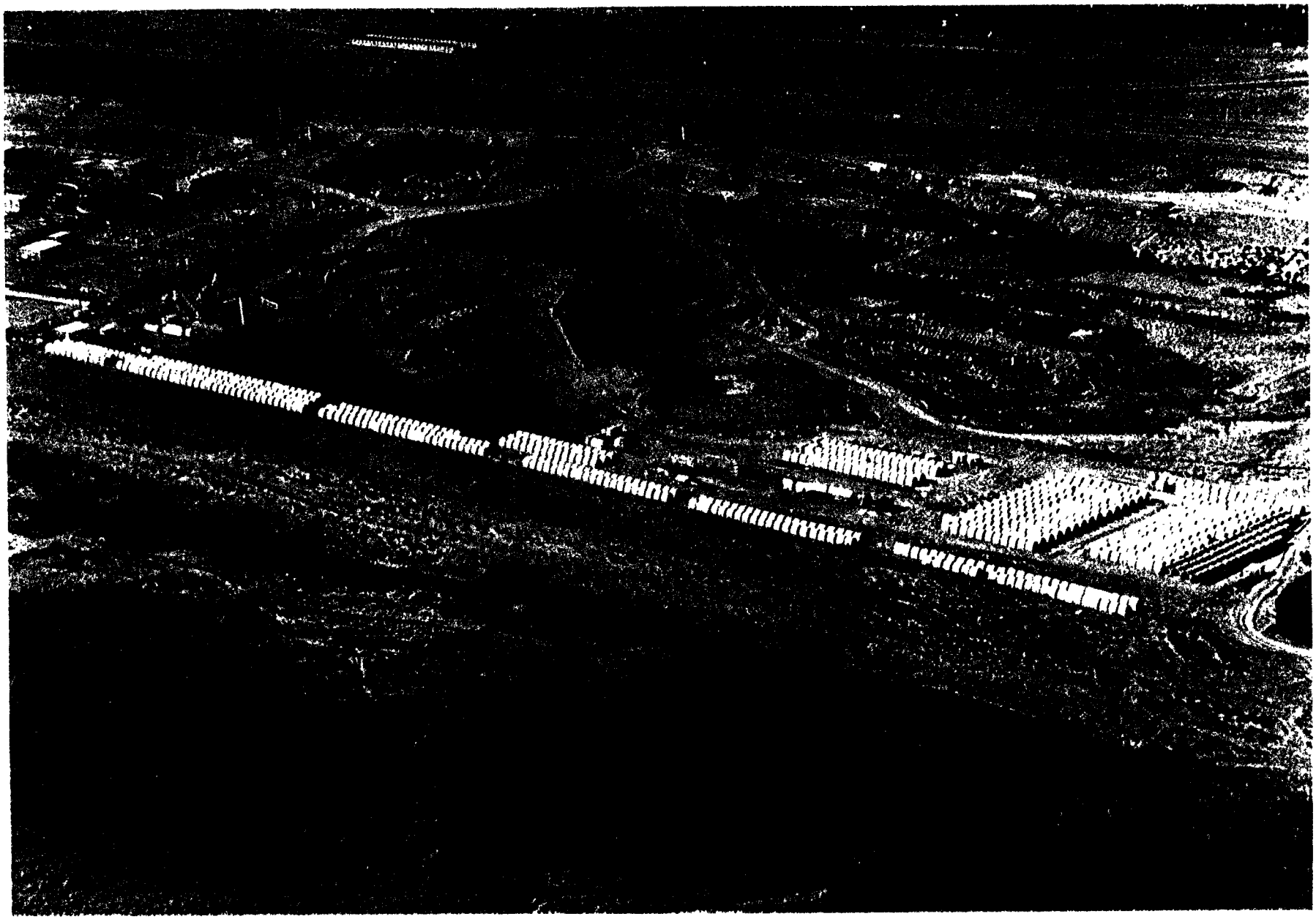
LIGO-G960211-00-E

/home/lazz/Presentations/NSF_Reviews/NSF_96_10/Salb_Fit_VG.fm5

Beam Tube Enclosure

Fred Asiri, Otto Matherny

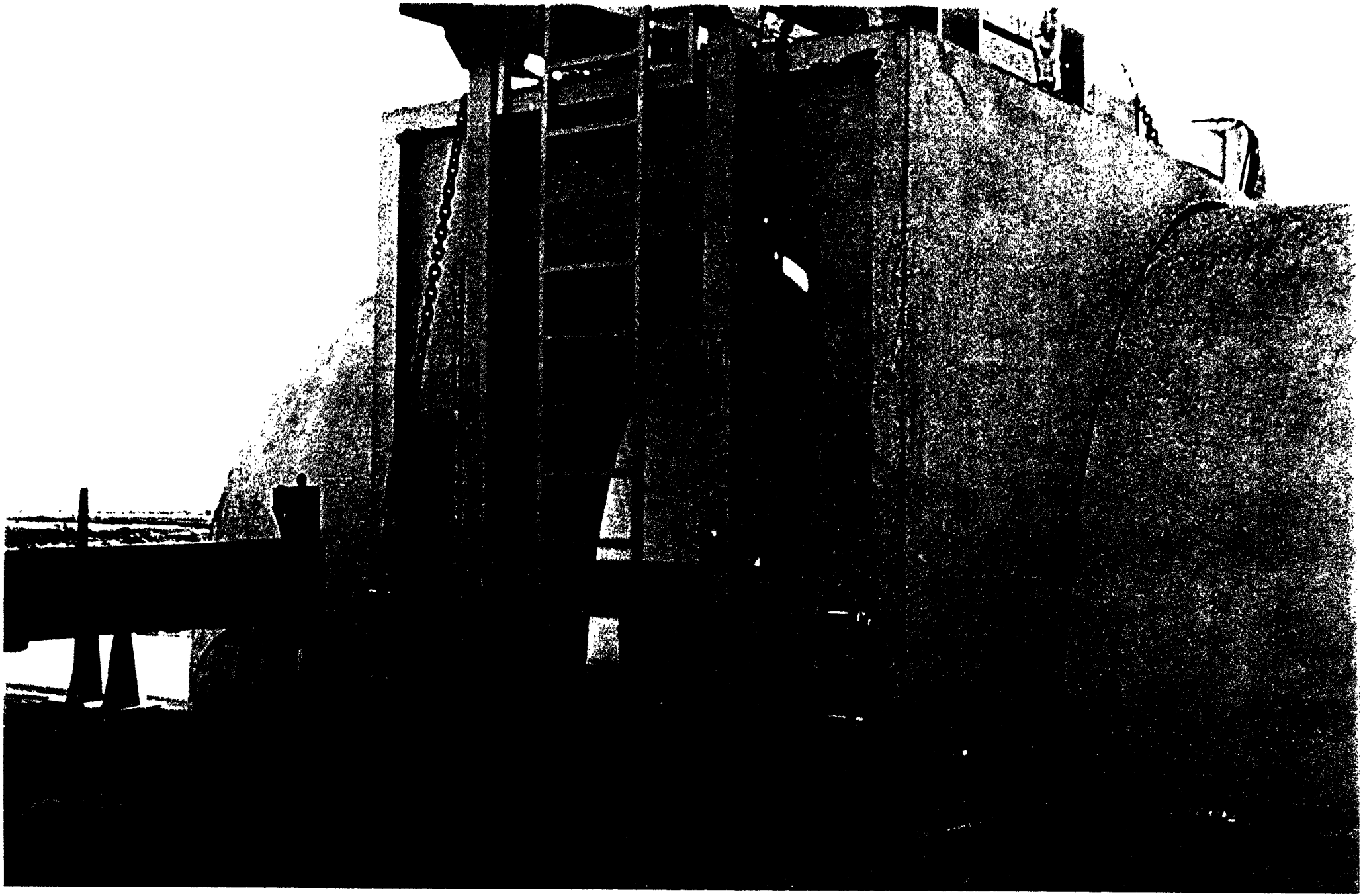
- Status:
  - approx 2000 pre-cast BTE's fabricated
  - approx 150 BTE's installed
  - Installation contractor works approx 3-5 sections behind CBI on-site to avoid interference

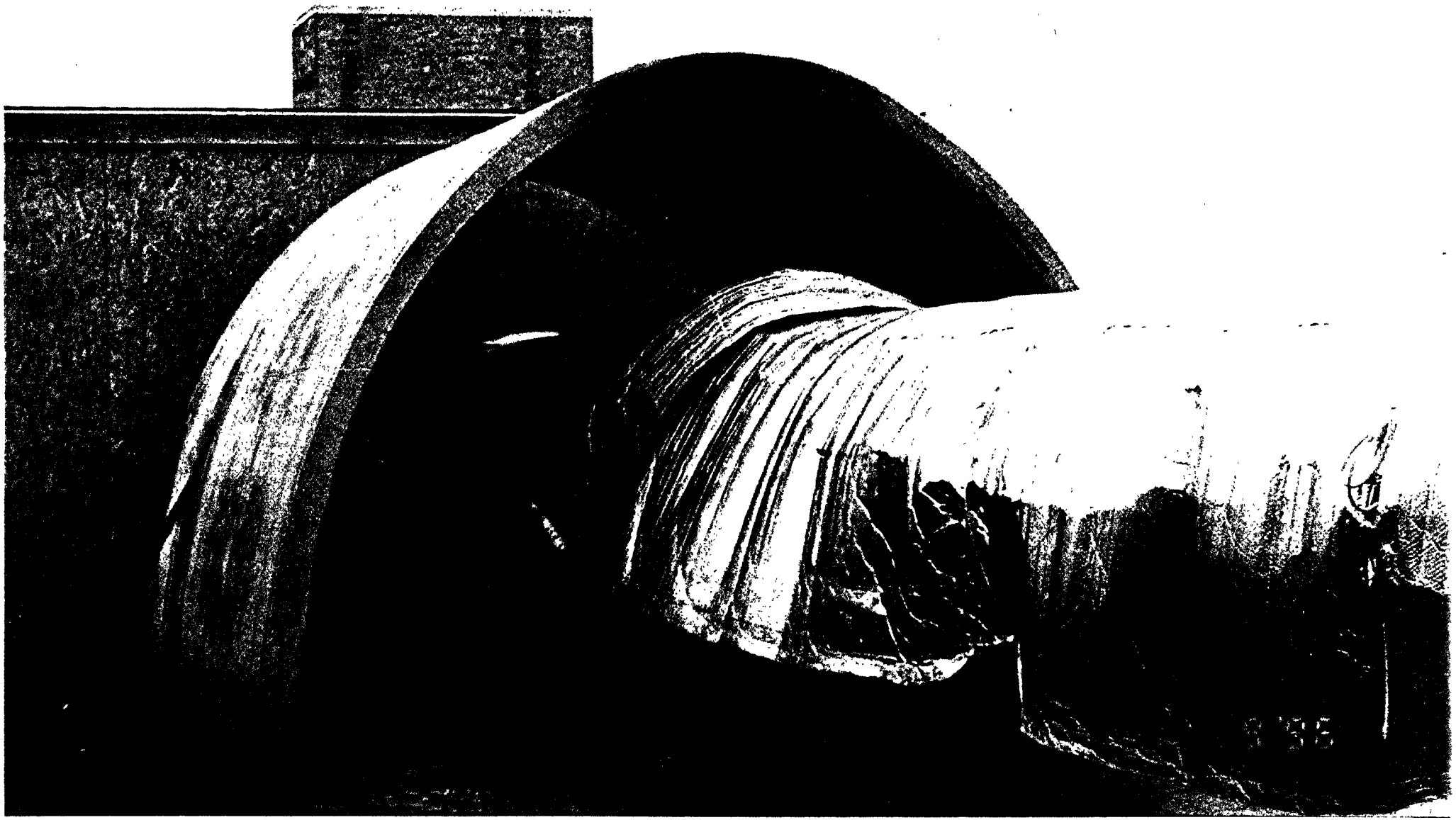


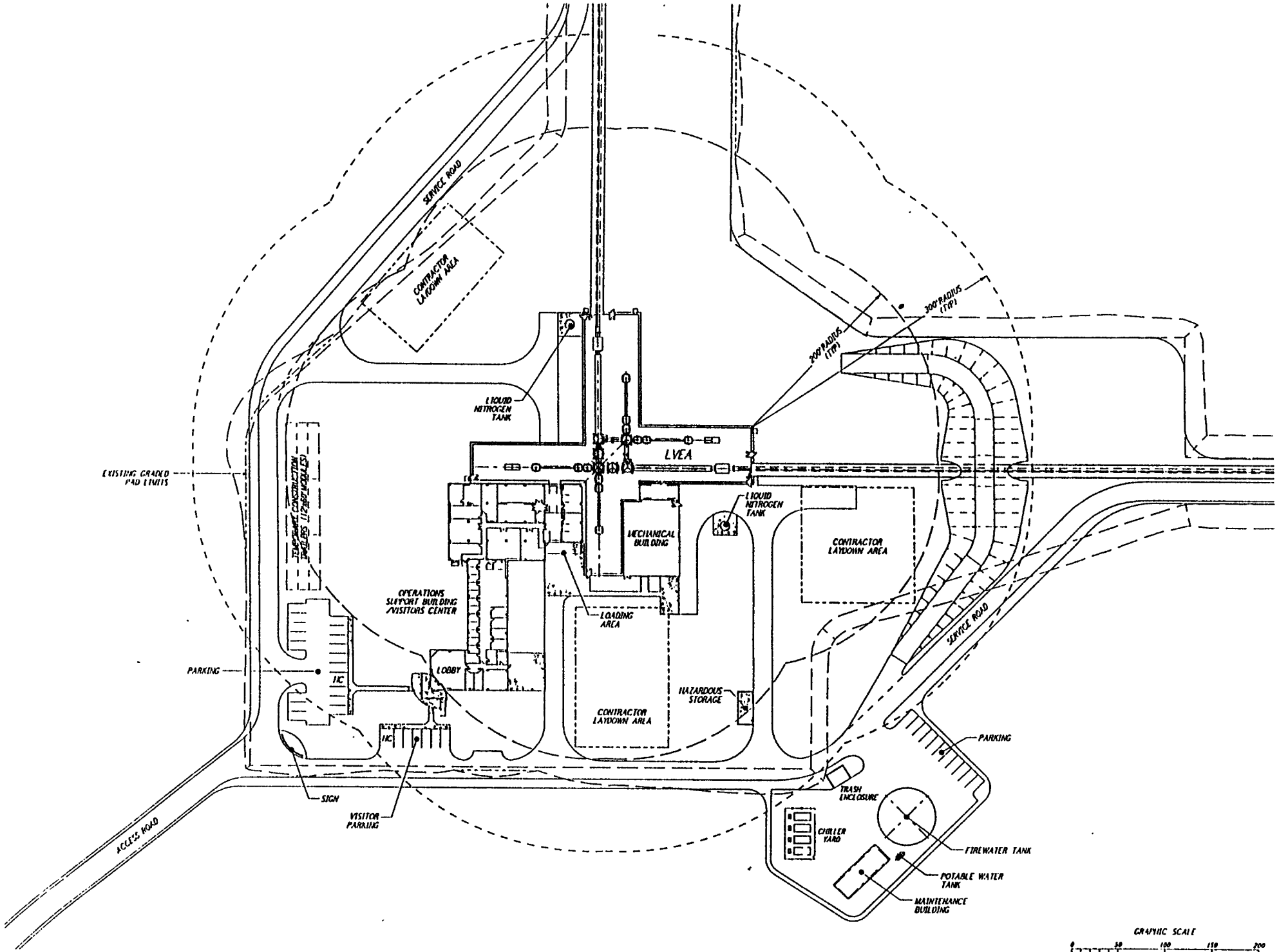
BTE Fab QA

- BTE's inspected by RMP in ACME yard.
- Rejection rate is approx 1%
- No stress cracking found. Normal shrinkage cracks only

G960194-76 -O-Pr





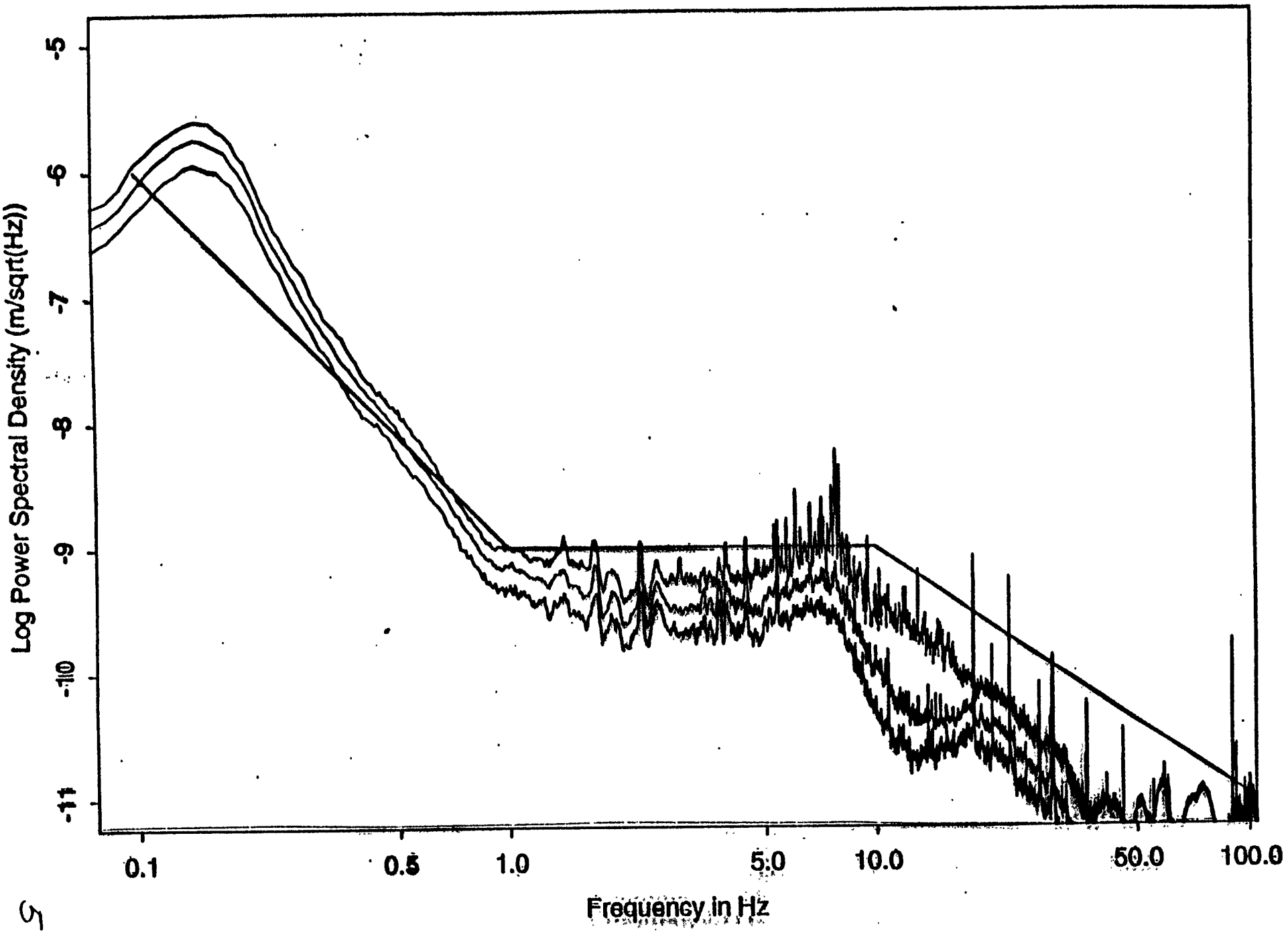

SERVICE ROAD
CONTRACTOR LAYDOWN AREA
300' RADIUS (TYP)
200' RADIUS (TYP)
LIQUID NITROGEN TANK
LVEA
EXISTING GRADED PAD LIMITS
TEMPORARY CONSTRUCTION TROLLERS (12 REQ'D MODULES)
LIQUID NITROGEN TANK
MECHANICAL BUILDING
CONTRACTOR LAYDOWN AREA
OPERATIONS SUPPORT BUILDING /VISITORS CENTER
LOADING AREA
SERVICE ROAD
PARKING
LOBBY
HAZARDOUS STORAGE
CONTRACTOR LAYDOWN AREA
PARKING
TRASH ENCLOSURE
CHILLER YARD
FIREWATER TANK
POTABLE WATER TANK
MAINTENANCE BUILDING
SIGN
VISITOR PARKING
ACCESS ROAD
GRAPHIC SCALE
0 50 100 150 200
SCALE: 1" = 50'
10/6/95

Civil Construction

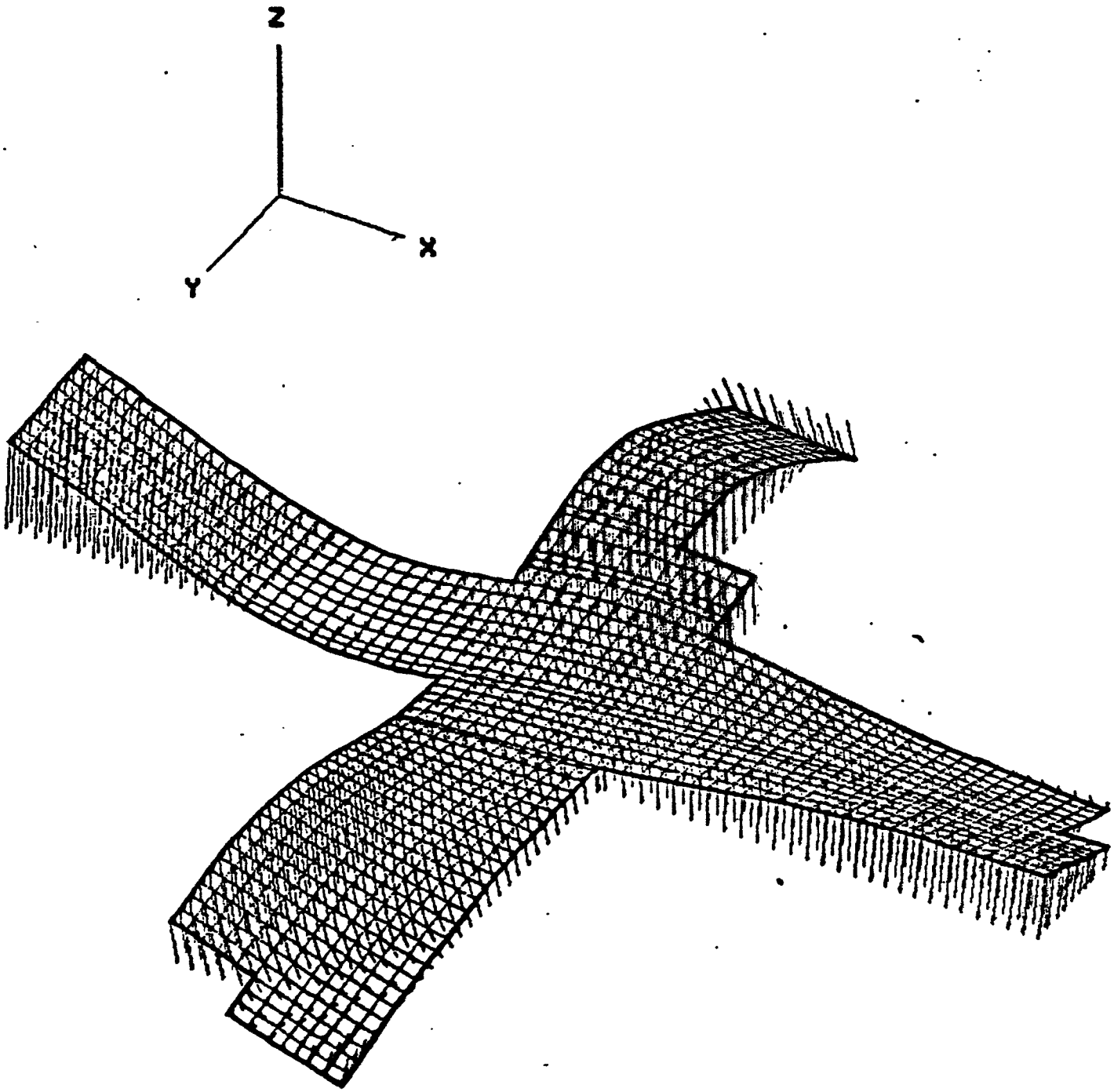
Otto Matherny

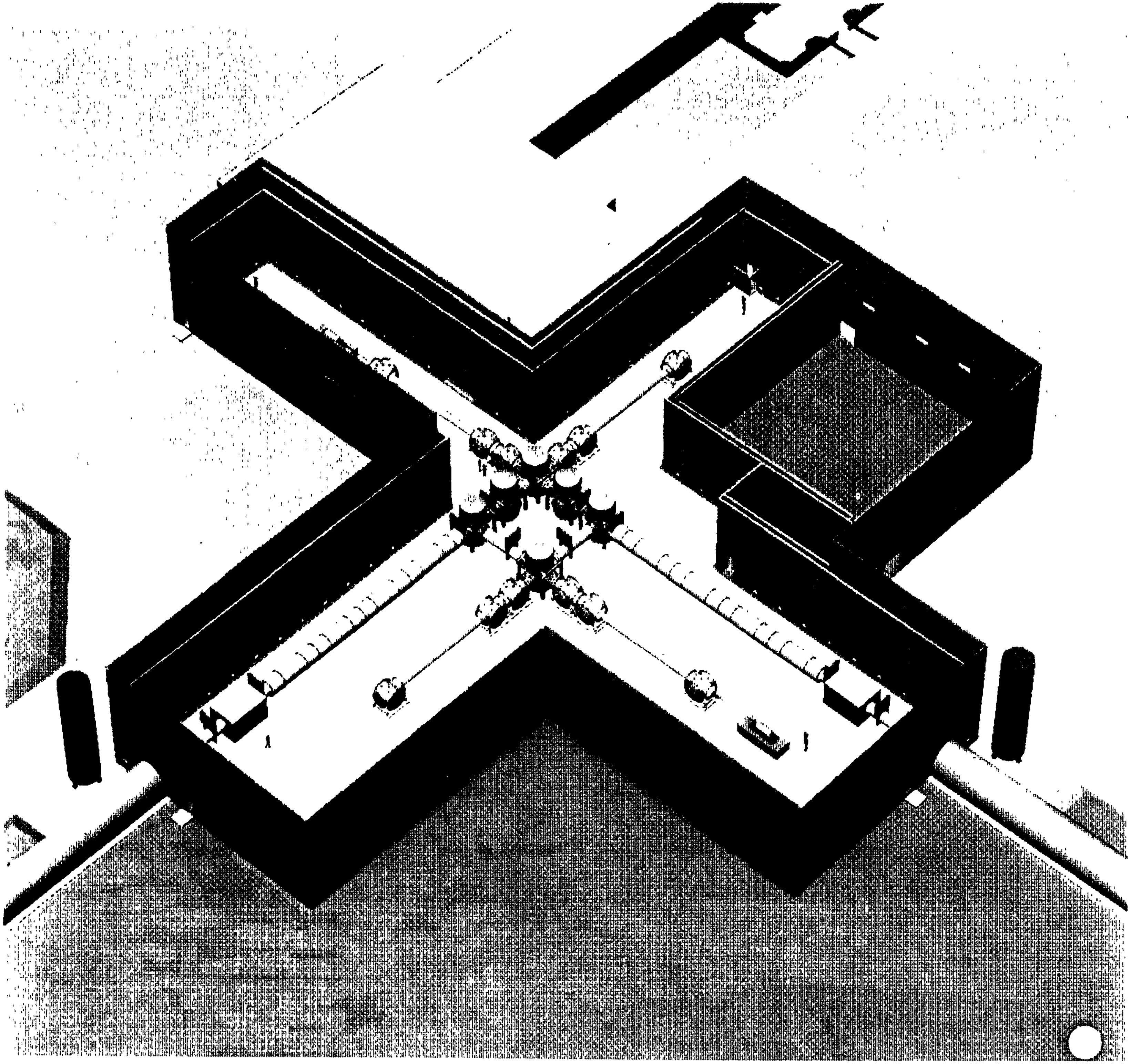
- WA site
  - completed finish grade and slip form of slab
  - completed service road and distributed electric power along arms
  - initiated construction of WA bldgs:
    - » foundations
    - » steel erection

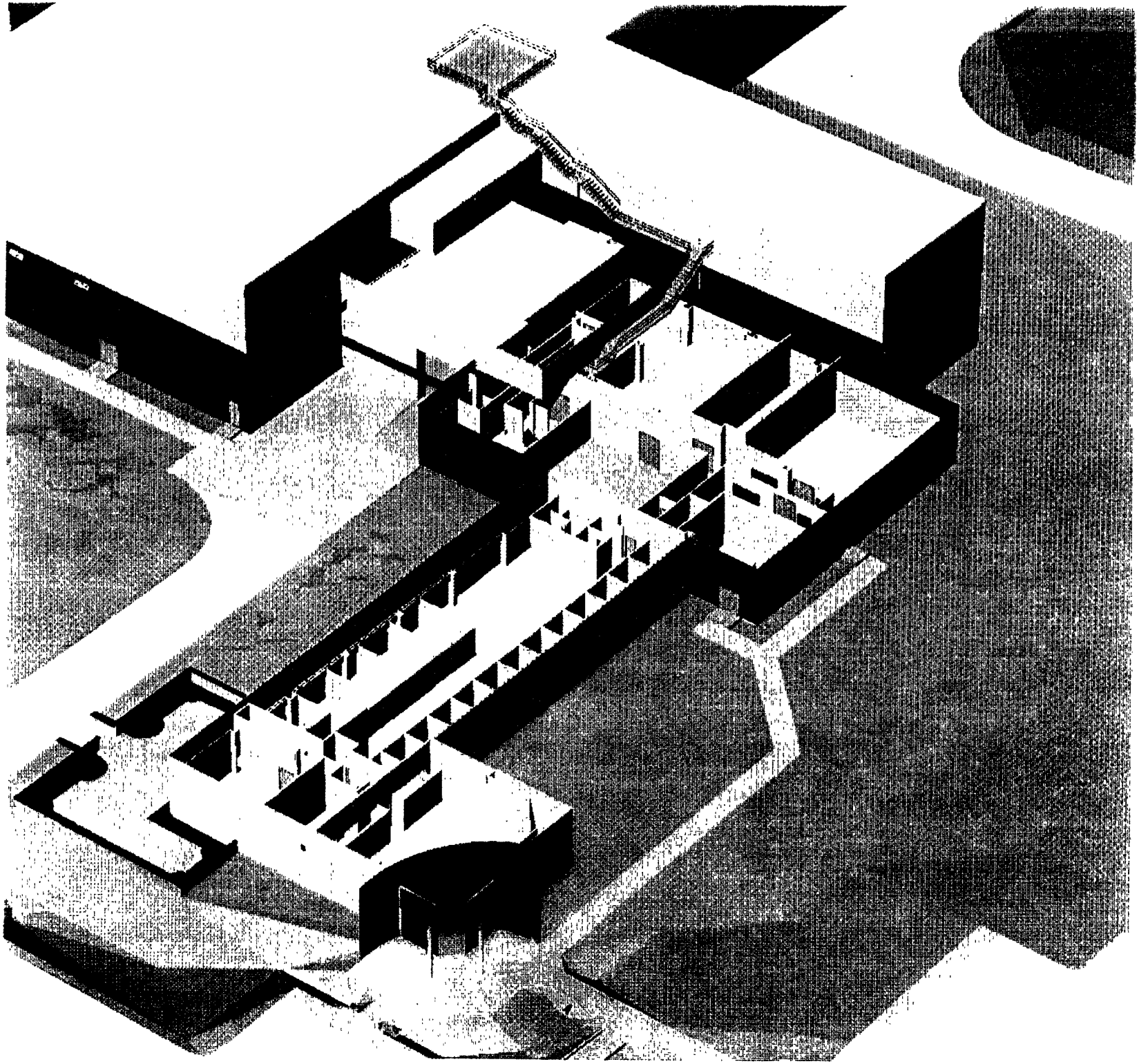
Corner Station Vertical, Late Night December 12

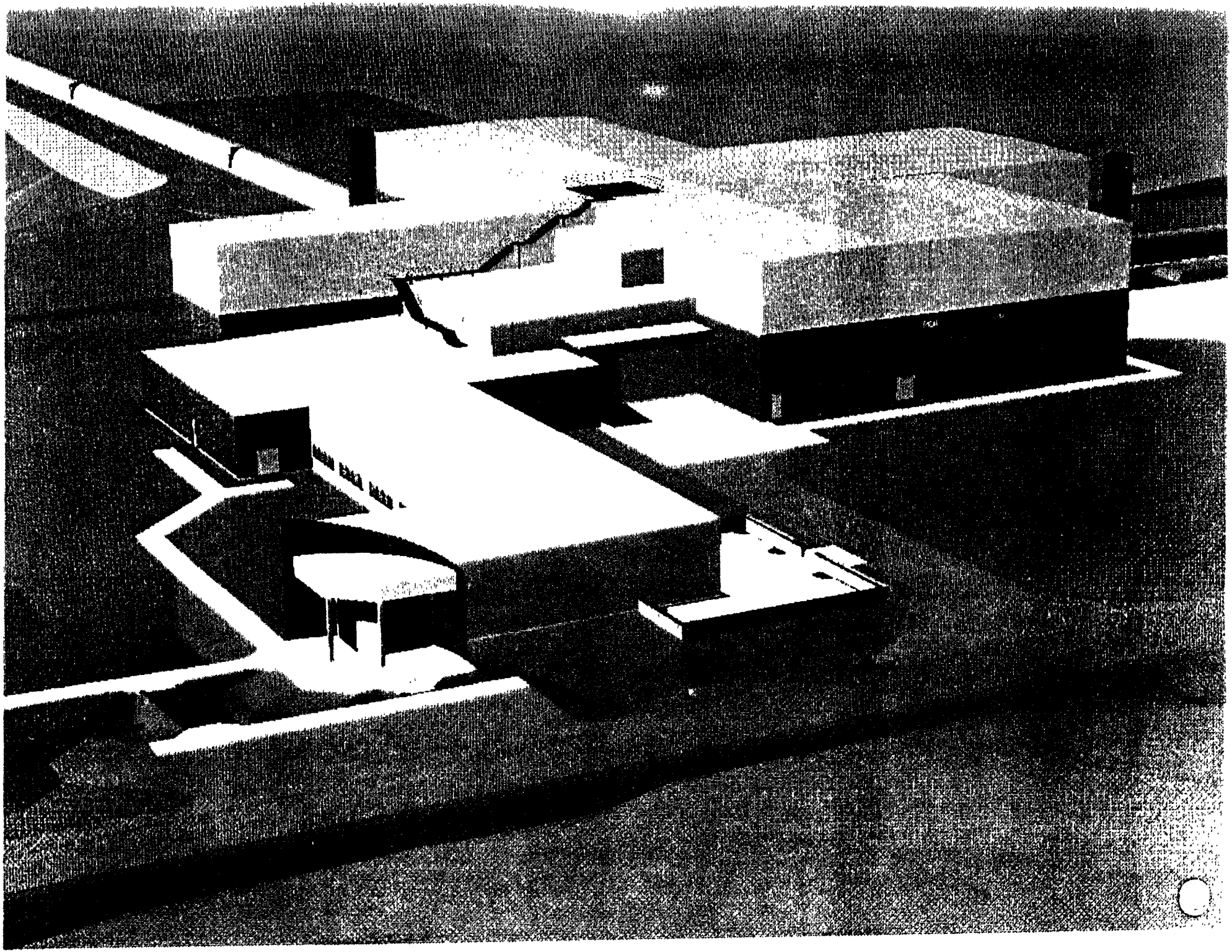


Eigenvector for Mode 14, Freq = 8.2818 Hz

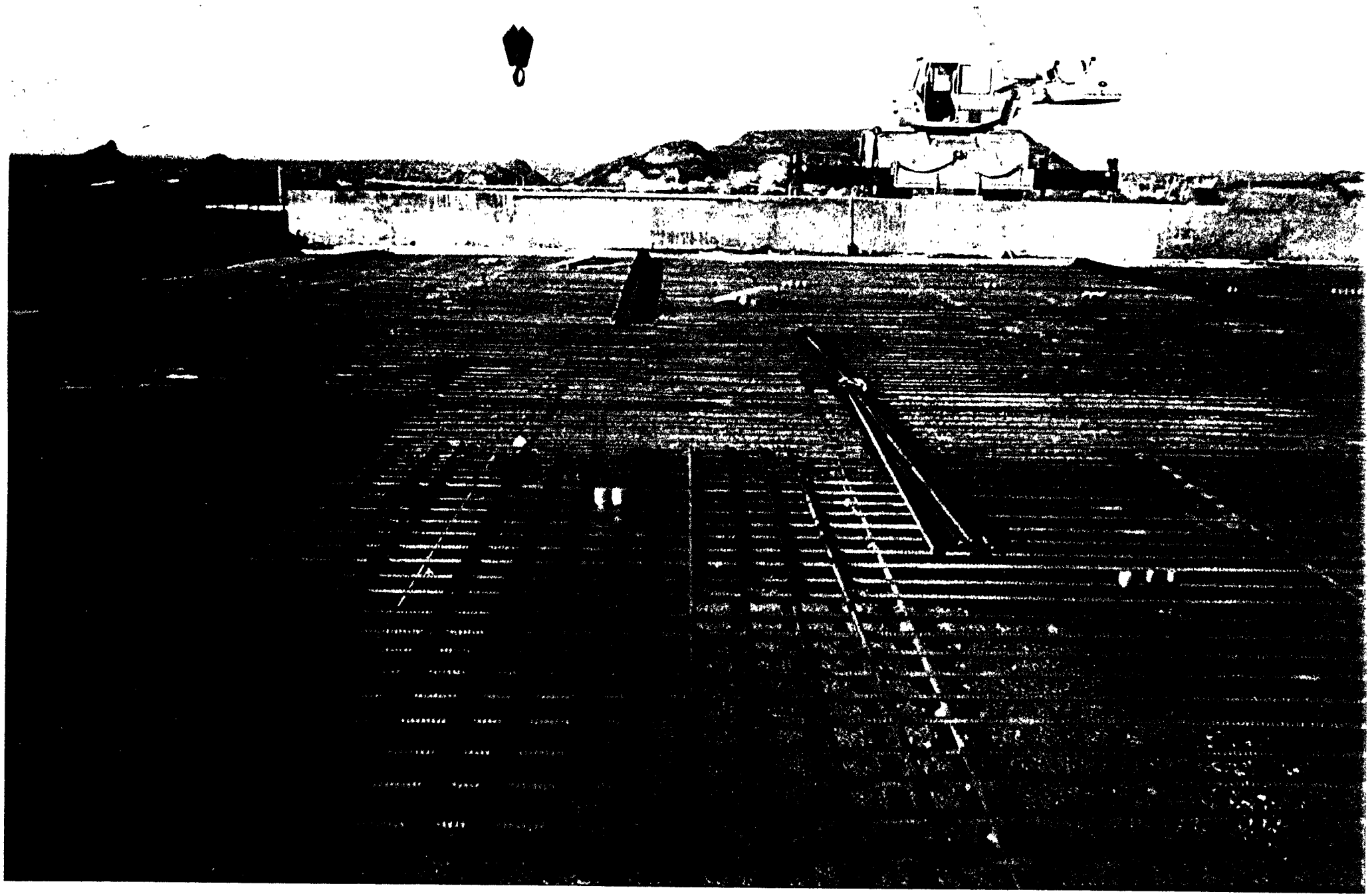


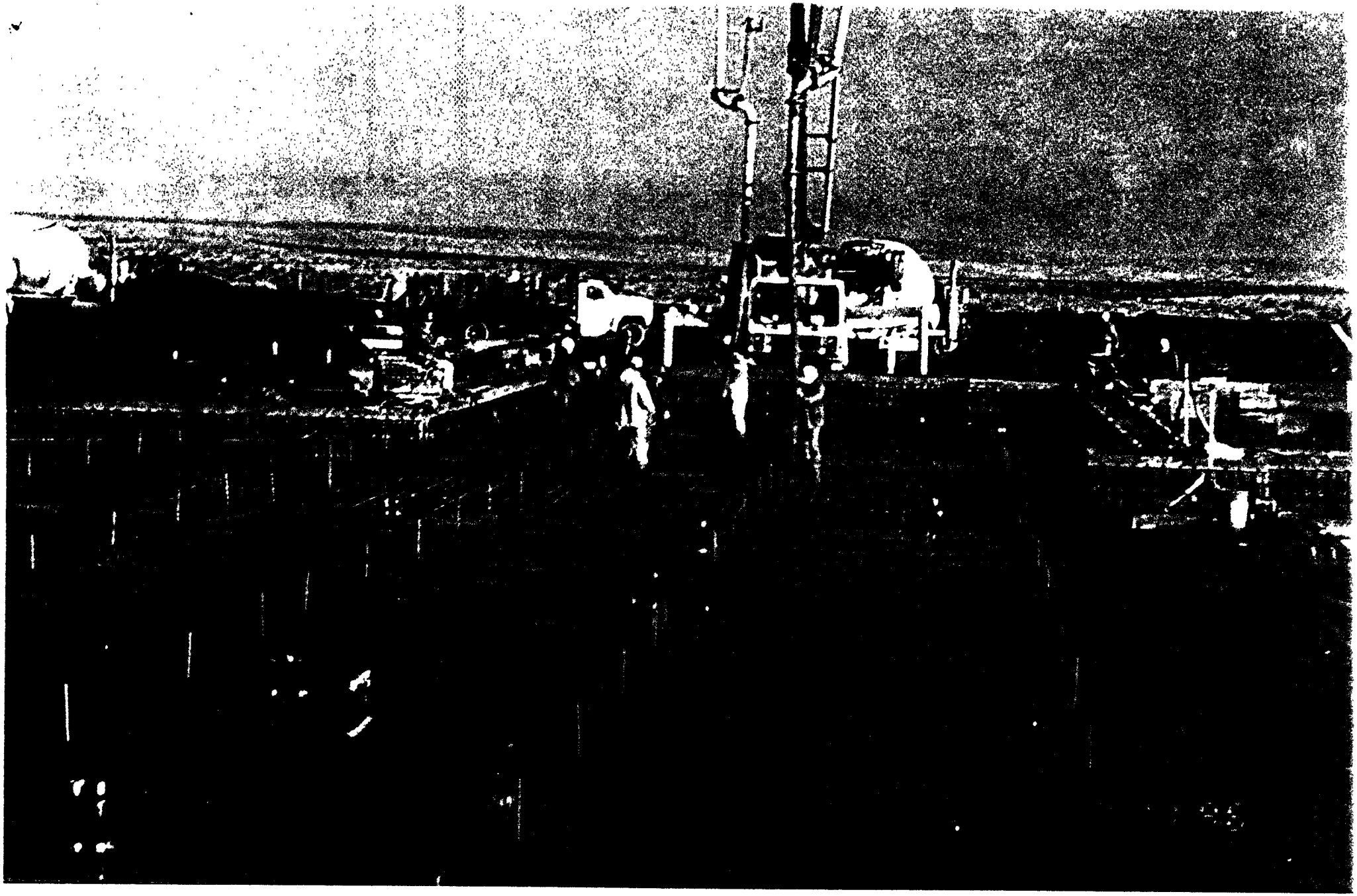


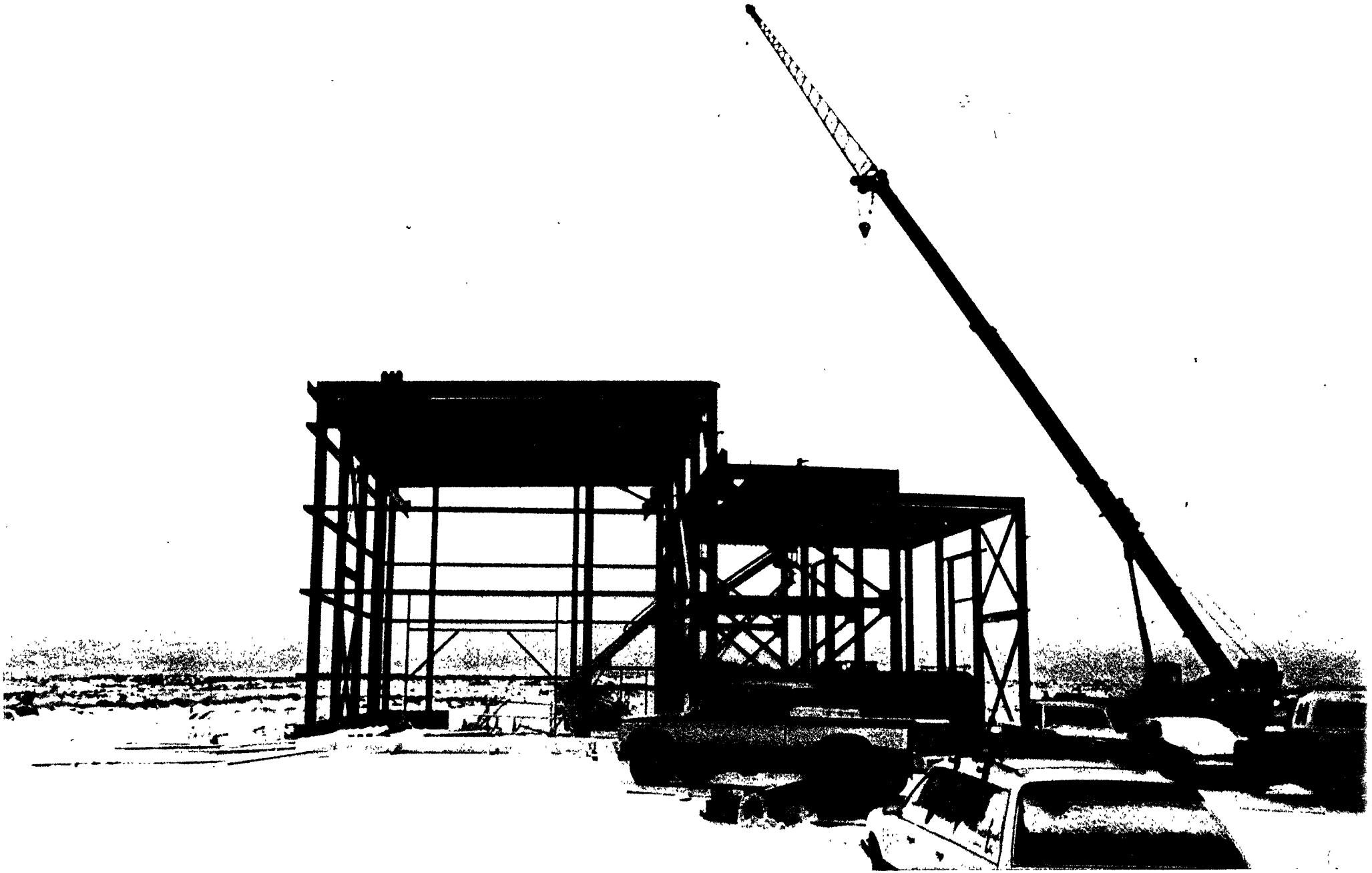




G960194-10 -O-Pv







LA Bldg Design

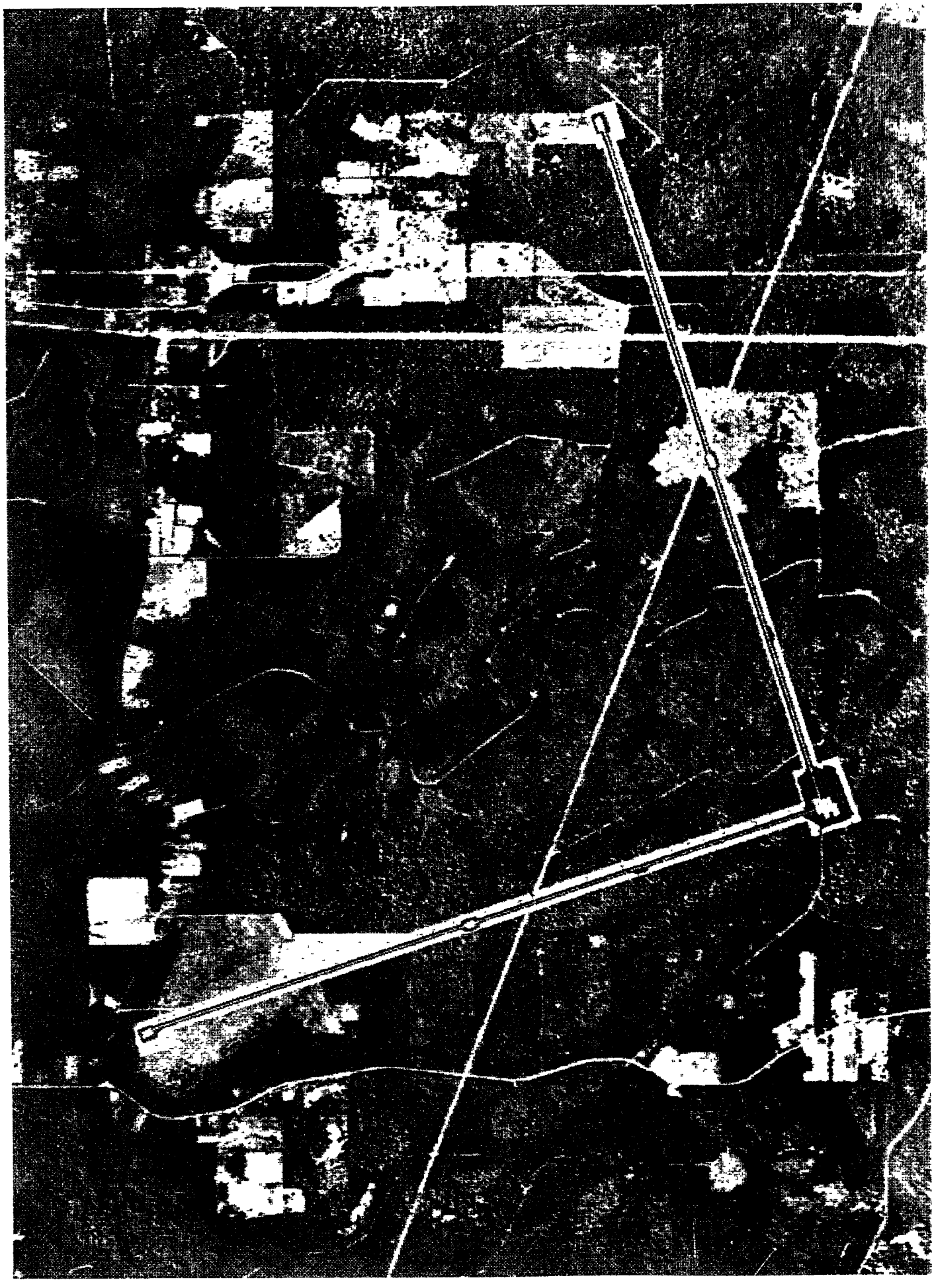
Fred Asiri

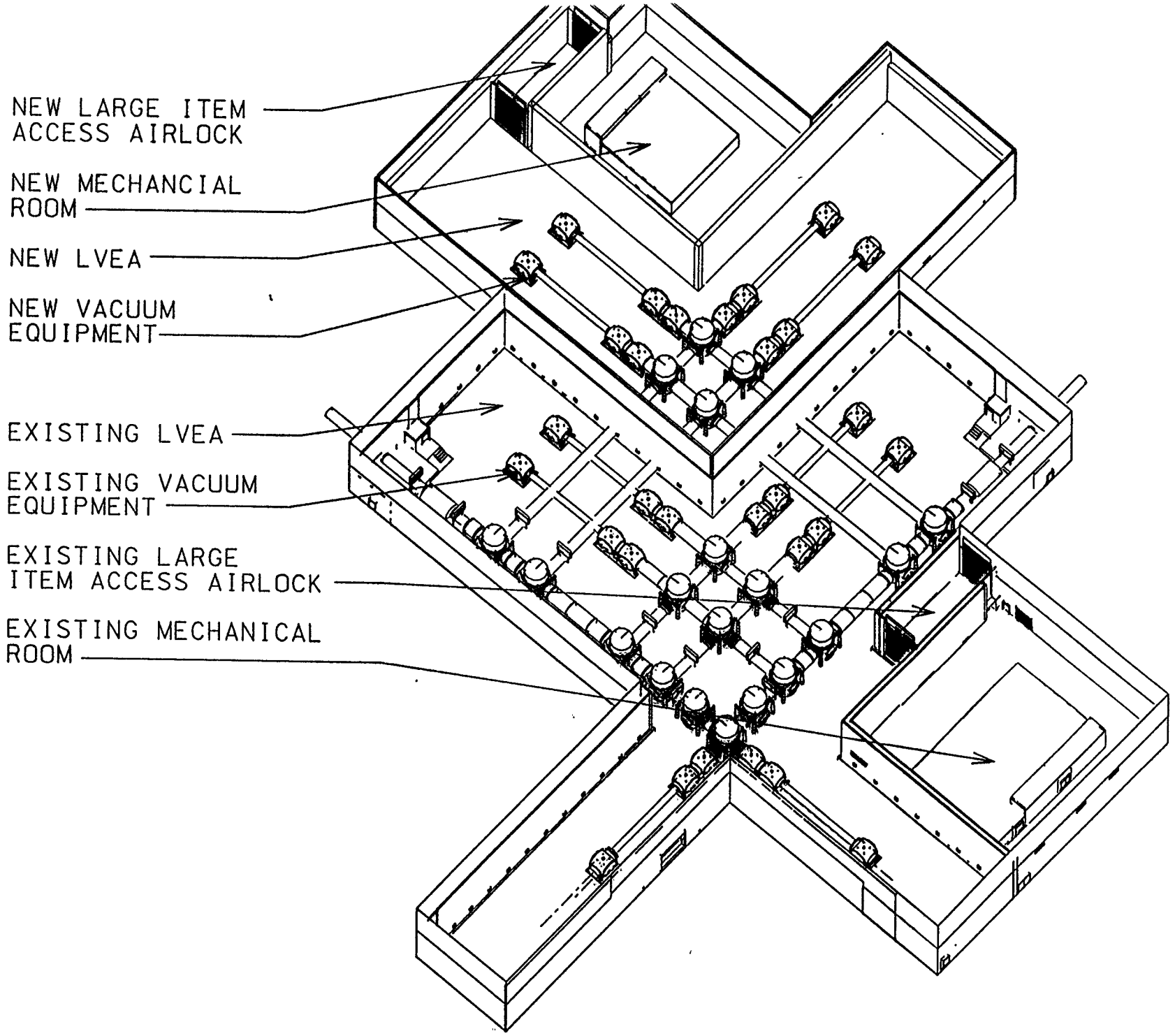
- Final design completed May 96
  - 2 IFO design
- Reviewed by Baton Rouge architectural firm for standard practices and materials
- Recommendations incorporated into final design
- Architectural approval obtained from LSU per site agreement

LA site civil construction

Gerry Stapfer, Fred Asiri, Otto Matherny

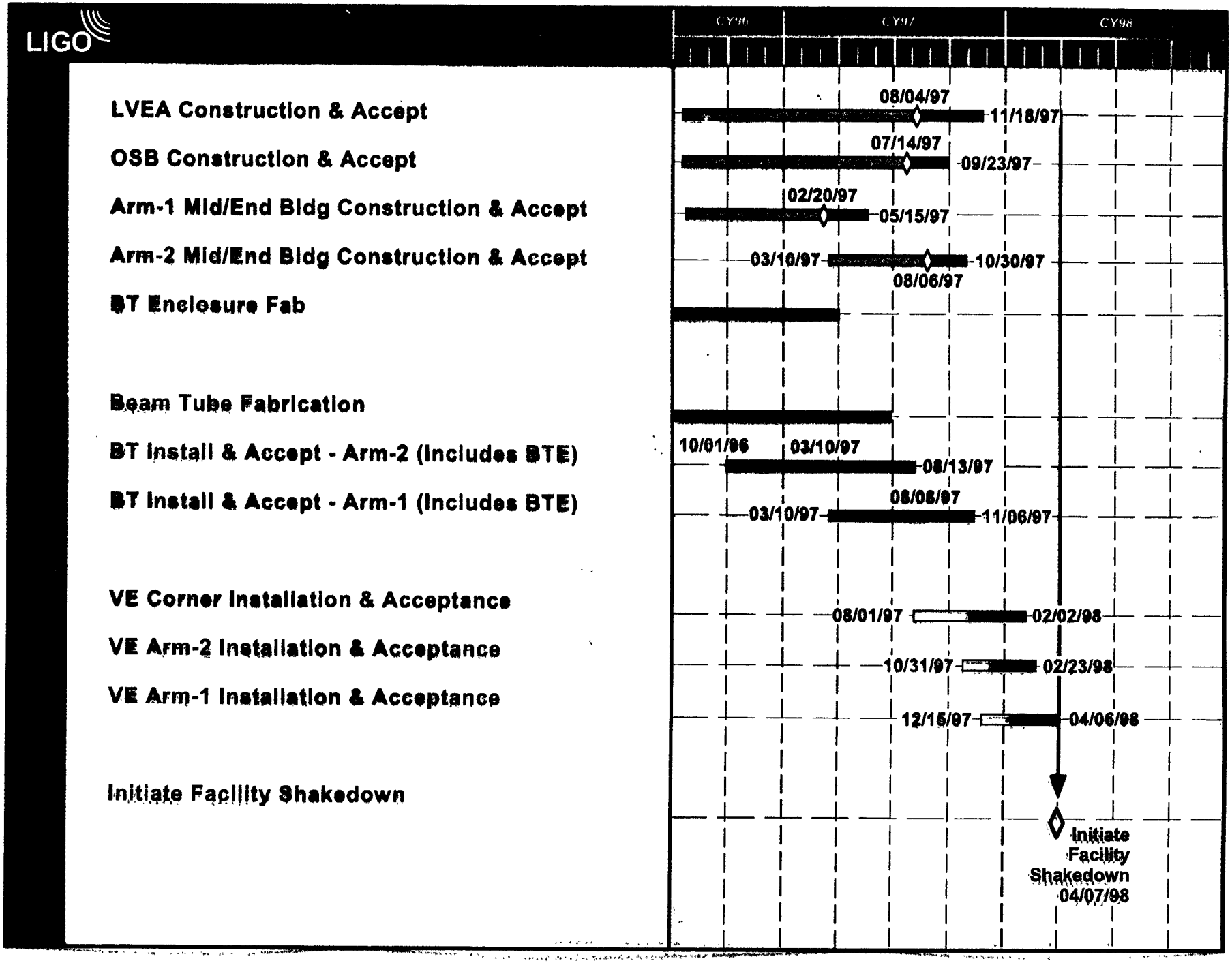
- completed rough grade work
- bid and award of buildings, road, slab
- road work begins this week
- site complications:
  - rain
  - pipeline crossings
  - power lines raised over site




NEW LARGE ITEM ACCESS AIRLOCK
NEW MECHANCIAL ROOM
NEW LVEA
NEW VACUUM EQUIPMENT
EXISTING LVEA
EXISTING VACUUM EQUIPMENT
EXISTING LARGE ITEM ACCESS AIRLOCK
EXISTING MECHANICAL ROOM

FACILITIES CONSTRUCTION & EQUIPMENT INSTALLATION SUMMARY SCHEDULE - HANFORD SITE

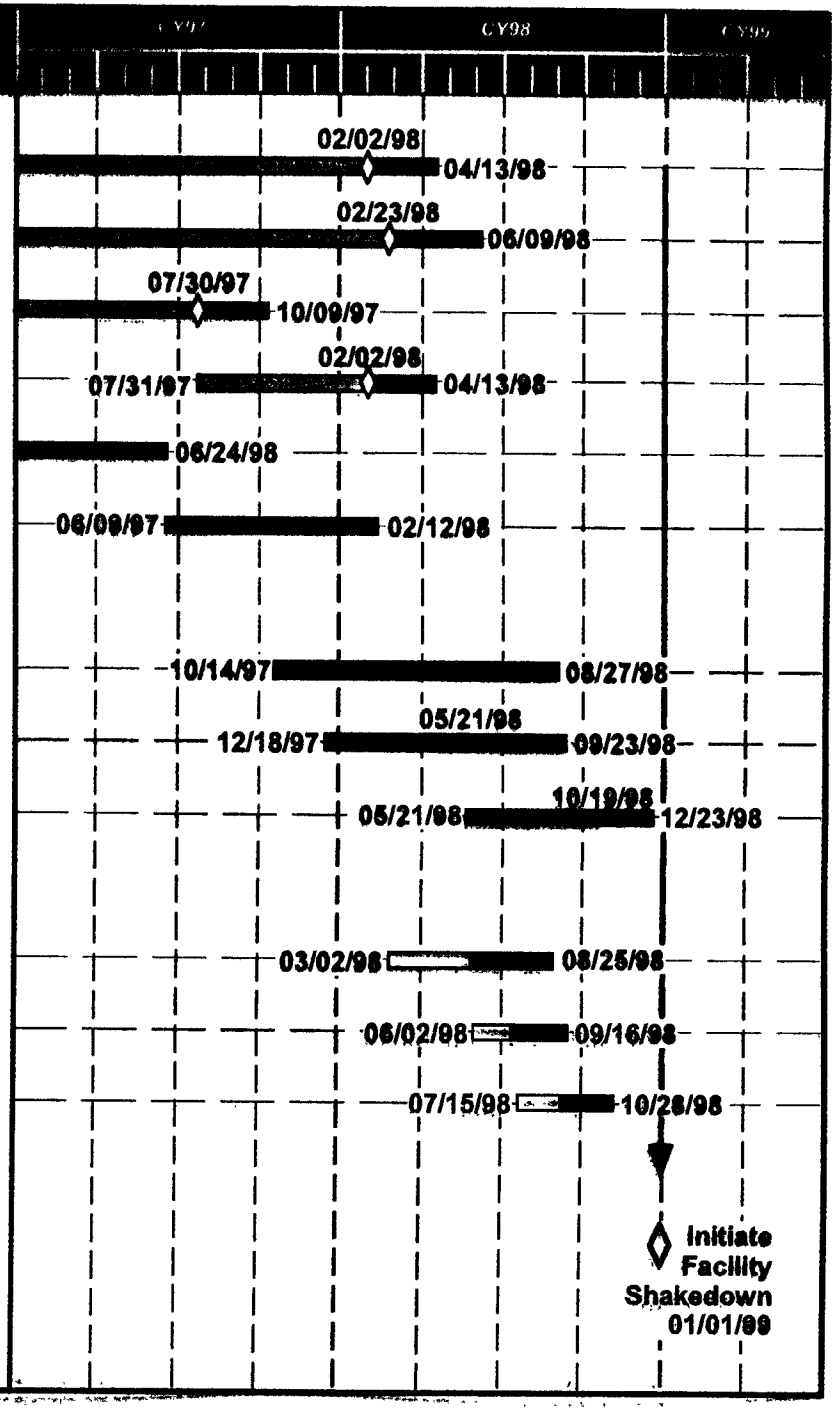
LIGO



FBF
11/14/96

FACILITIES CONSTRUCTION & EQUIPMENT INSTALLATION SUMMARY SCHEDULE - LIVINGSTON SITE

LIGO



FBF
12/10/96

Summary

- All major facility contracts obligated
- We have entered a very busy phase of activity - civil construction, fabrication, and installation activities underway at both observatory sites and at vendors
- We are executing QA oversite plans to maintain requirements and schedule.
- No indications of significant cost growth
- No show stoppers so far