A’ Brief. History of the Tower Shielding Facility and Programs

- Tower Shielding Facility
- Hoisting Equipment and Handling Pool
- Tower Shielding Reactor
- TSR-II Assembly and Outer Reflector
- Reactor Suspension System
- TSF-SNAP Reactor
- Big Beam Shield
- Experimental Programs
- Cask Drop Tests
- Conduct of Experiments
- Equipment and Material Used for Experiments
- Waste Generation and Disposal
- Future

TOWER SHIELDING FACILITY

- *Built I954*
- *Purpose to enable studies of asymmetric shield configuration for the Aircraft Nuclear Propulsion Project*
- *Requirements: Research in region free from ground and structure scattering of radiation from reactor.*
- *Guyed steel structure 315 feet high*
- *Conform to AISC specifications for steel buildings (1953)*
- *Towers form a 100- by 200-ft rectangle*
- *Unit weight of towers less than 400 lb/ft - gives minimal safety factor for maximum load (1.7)*
- *Maximum load 105 mph wind or 55 ton reactor shield raised 200 ft with 80 mph wind*
- *Two-inch plow steel guys (16) stressed to 75,000 lbs each to minimize tower movement as loads are raised*
- *Towers and guys electrically shielded by means of wire grounding net*
- *Underground Control Building*

HOISTING EQUIPMENT AND HANDLING POOL

- 2 hoist control stations

- 6 hoists:

  2 for reactor could raise 55 tons to 200 ft

  4 to move crew compartment to same elevation with different separation distance

- Hoists in building away from towers

- Pool for storing reactor in its 12-ft-diam tank is 20 ft x 20 ft x 25 ft

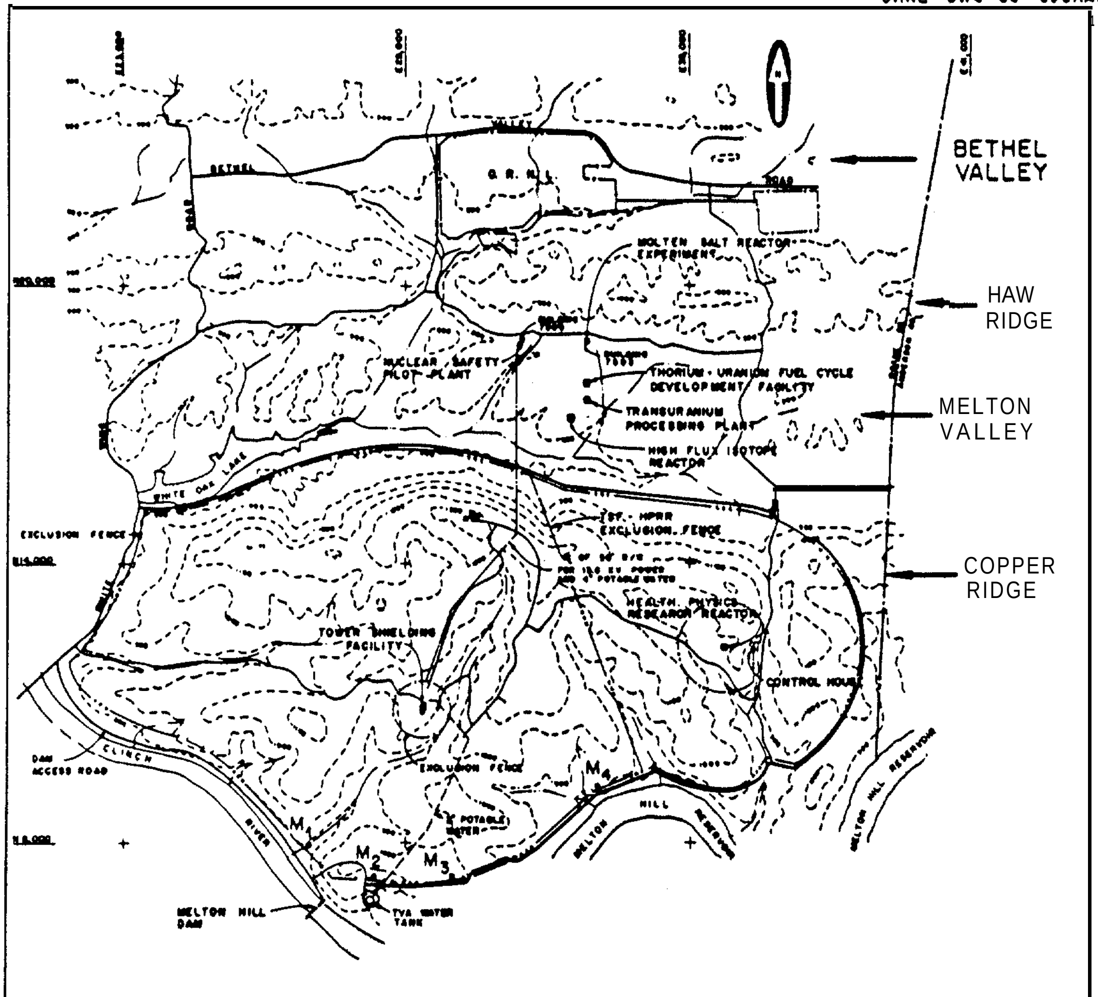
- KTAM (Architech Engineer) defied operating limits of hoisting equipment

- ORNL Quality Department developed testing methods and procedures

- Two of the tower hoists were subsequently used in a Cask Drop Test Program for testing irradiated fuel shipping casks

  Test pad Armour plate impact surface
  71 tons ribar steel
  600 tons concrete

ORNL-DWG 66-695RAR



SCALE IN FEET

AREA TOPOGRAPHY
TOWER SHIELDING FACILITY
OAK RIDGE NATIONAL LABORATORY
DRAWING 6

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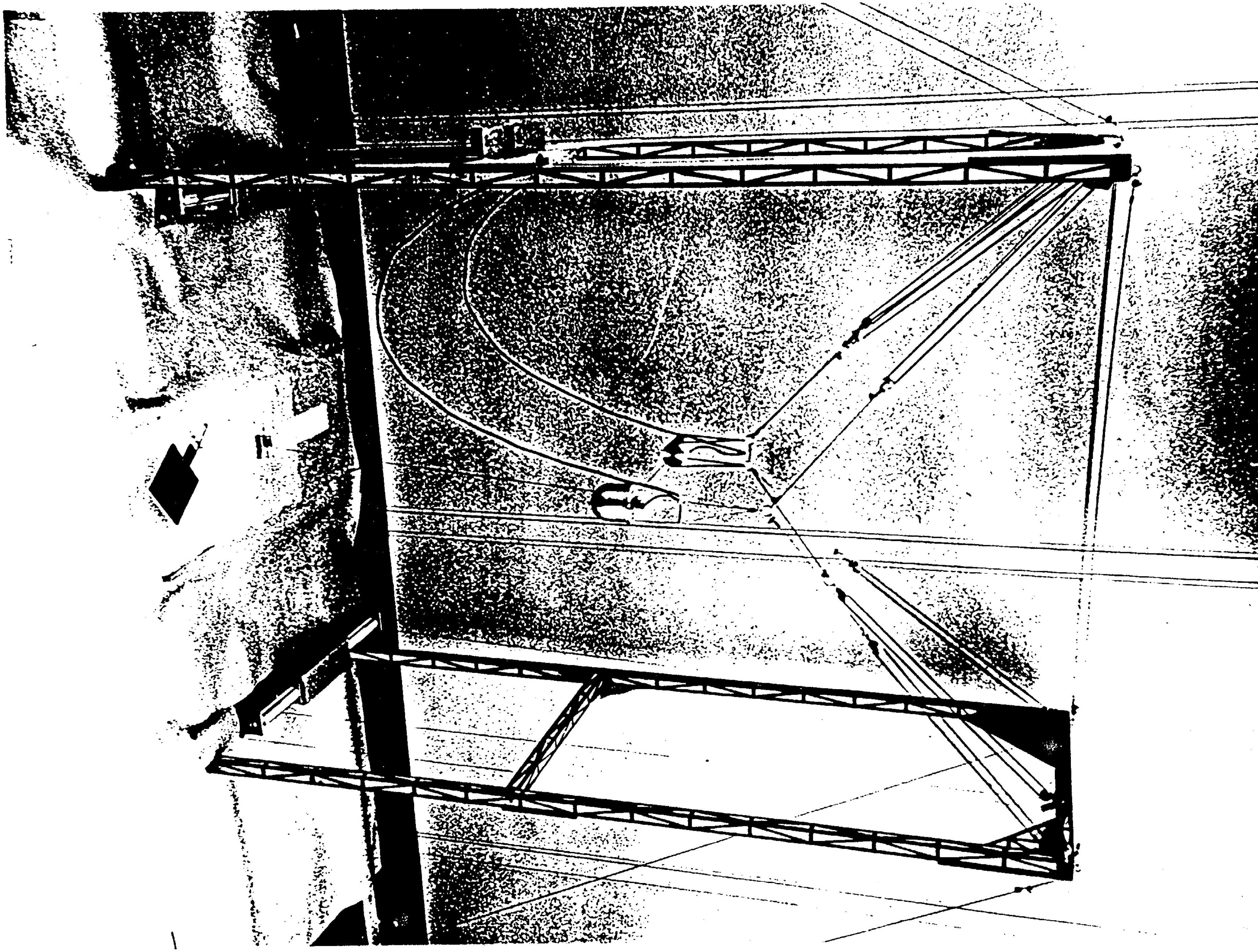

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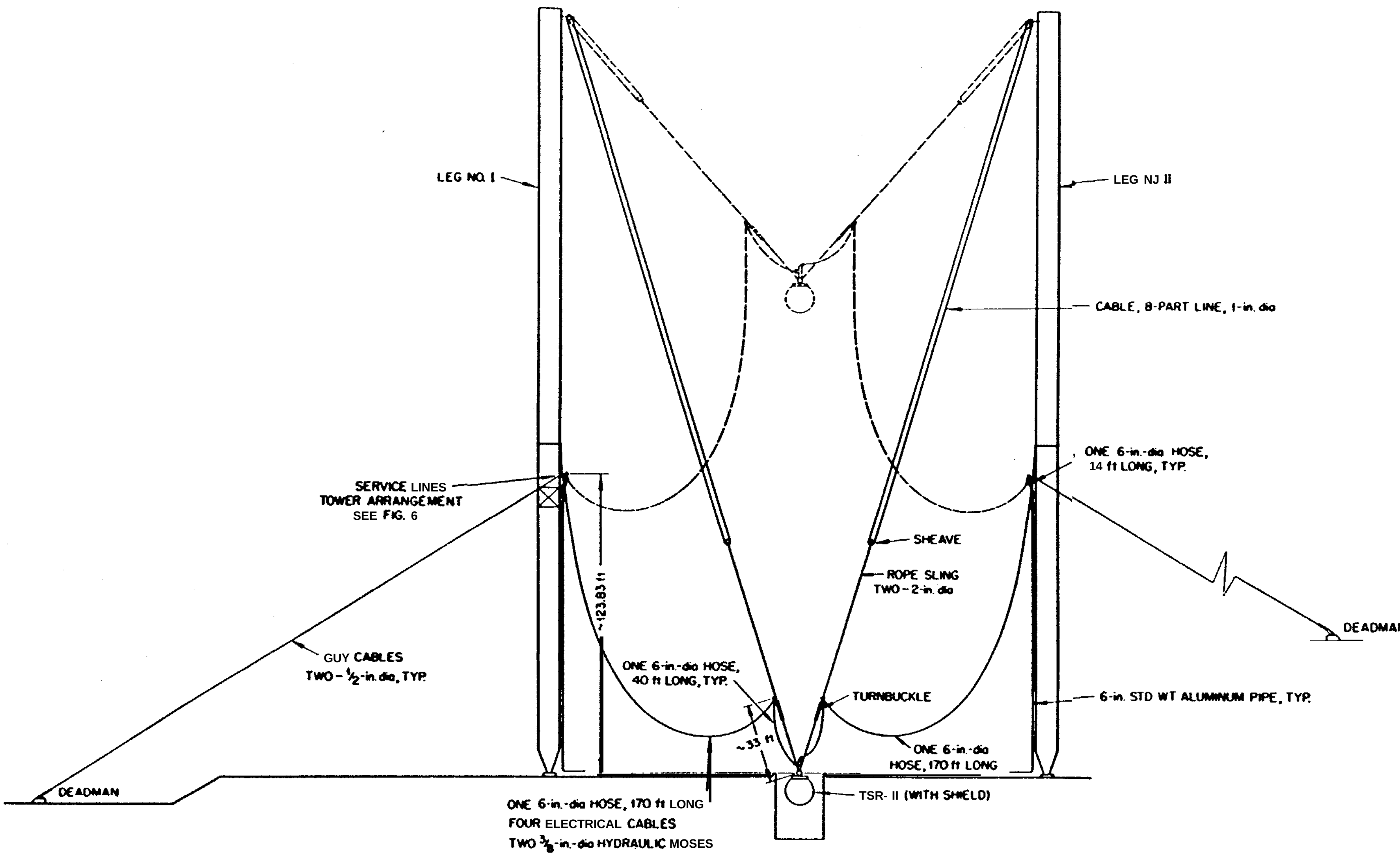
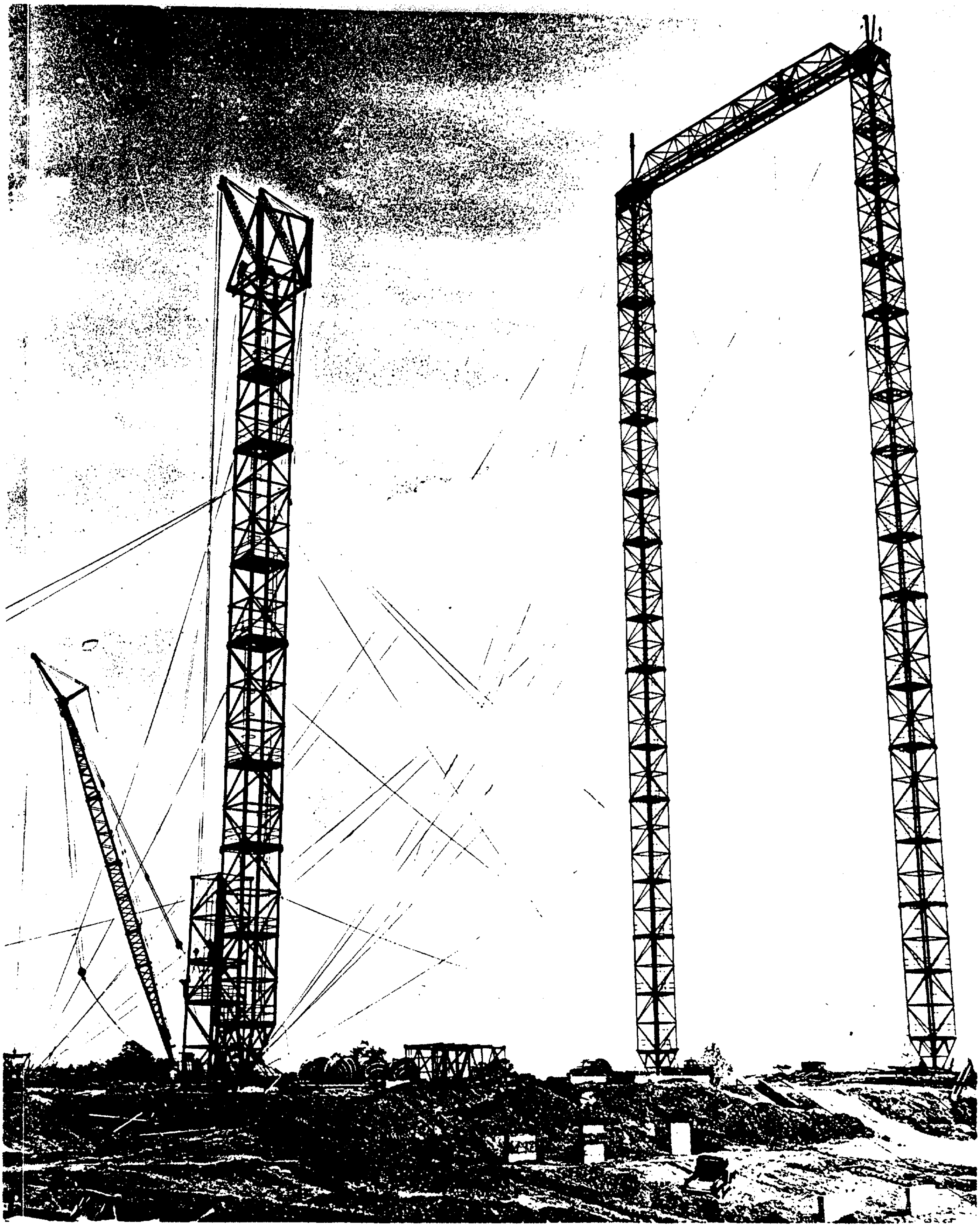
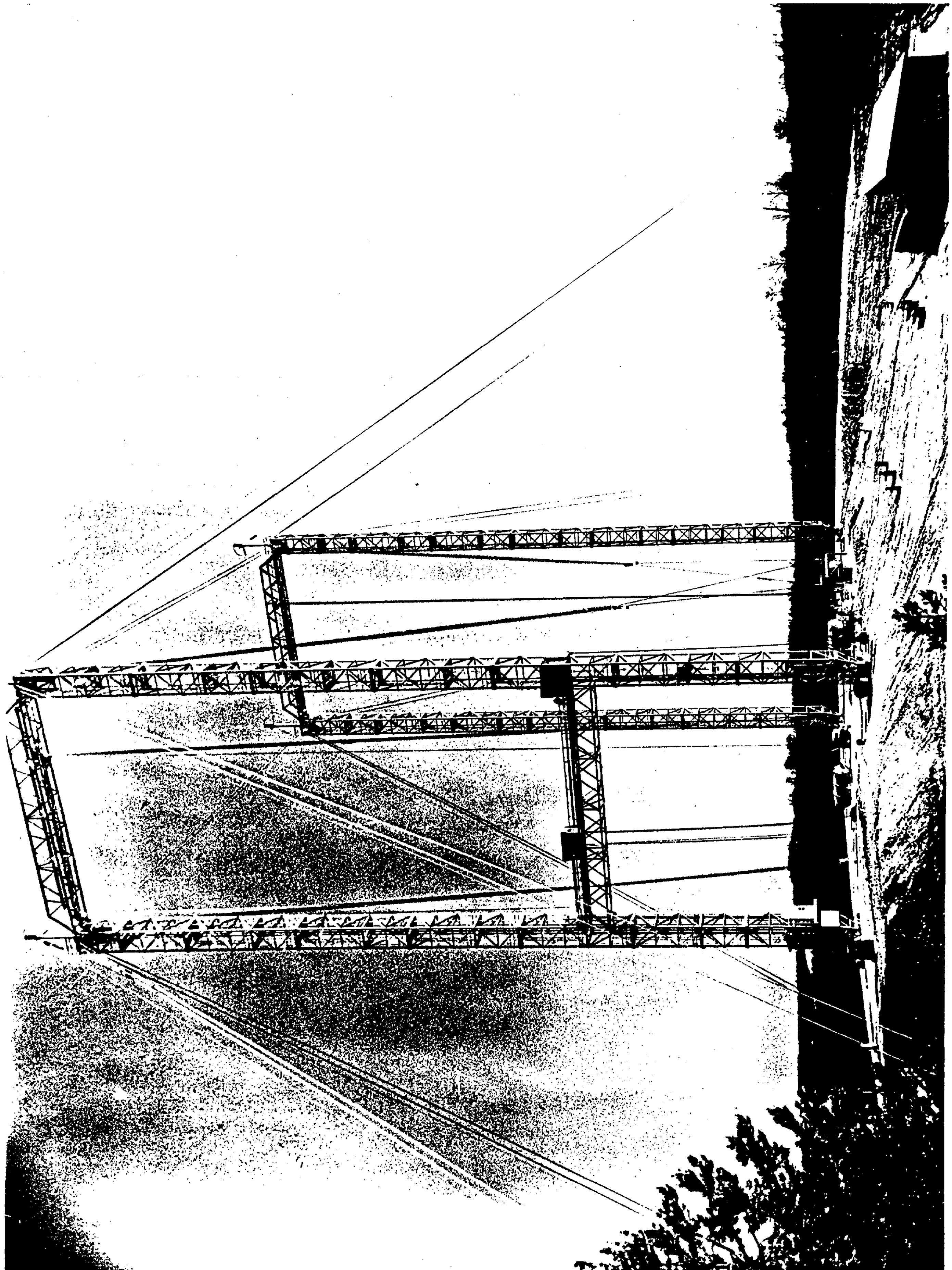
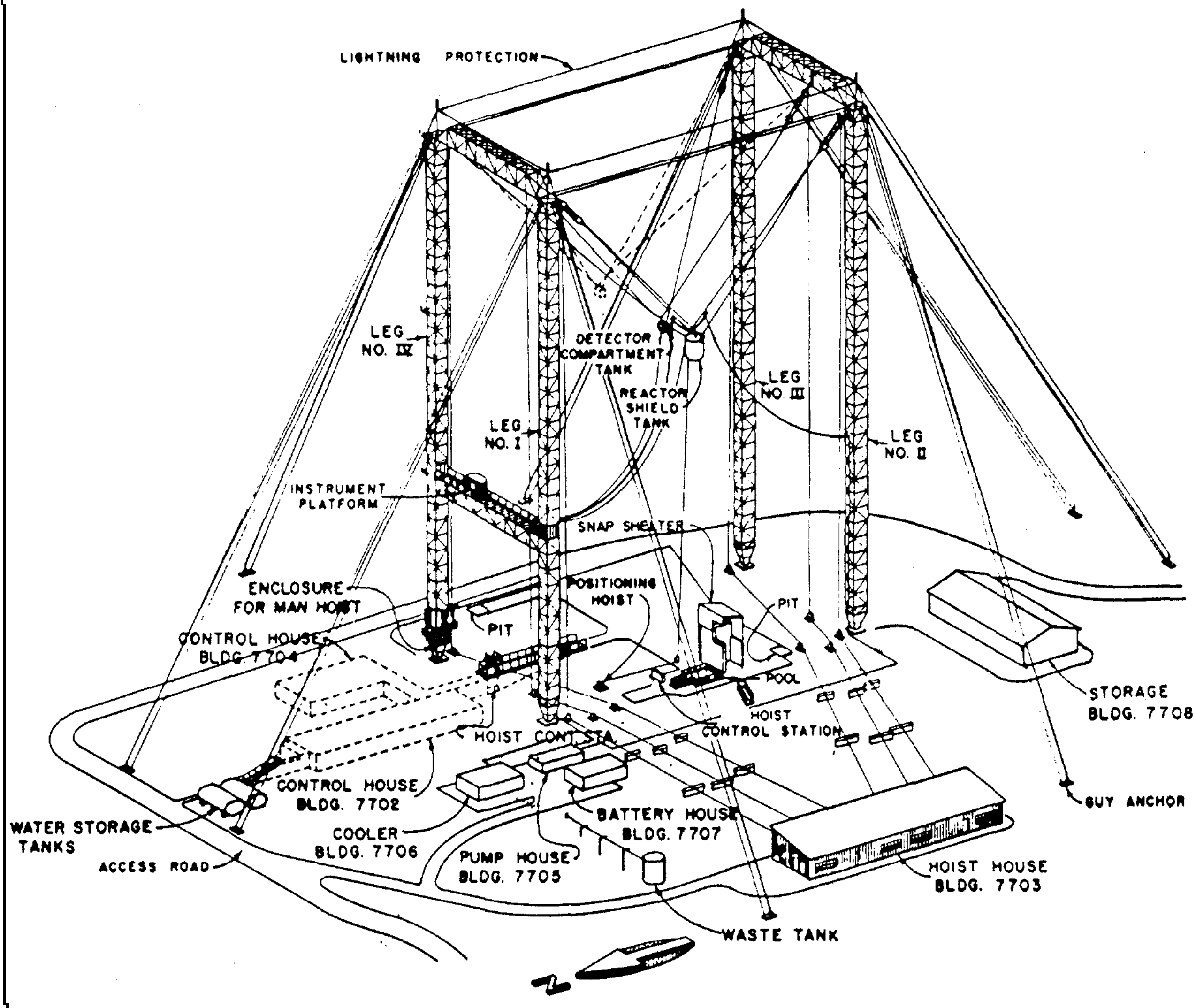


LEG NO. I
LEG NJ II
CABLE, 8-PART LINE, 1-in. dia
, ONE 6-in.-dia HOSE,
14 ft LONG, TYP.
SERVICE LINES
TOWER ARRANGEMENT
SEE FIG. 6
SHEAVE
ROPE SLING
TWO - 2-in. dia
~123.83 ft
DEADMAN
GUY CABLES
TWO - 1/2-in. dia, TYP.
ONE 6-in.-dia HOSE,
40 ft LONG, TYP.
TURNBUCKLE
6-in. STD WT ALUMINUM PIPE, TYP.
~33 ft
ONE 6-in.-dia
HOSE, 170 ft LONG
DEADMAN
TSR- II (WITH SHIELD)
ONE 6-in.-dia HOSE, 170 ft LONG
FOUR ELECTRICAL CABLES
TWO 3/8-in.-dia HYDRAULIC MOSES





ORNL-DWG 66-698R



TRIMETRIC

TOWER SHIELDING FACILITY

OAK RIDGE NATIONAL LABORATORY

DRAWING 0

C-11085 R-2

OFFICIAL USE ONLY

TOWER SHIELDING REACTOR

0 BSR in tank of water, power 100 kW

0 Position variable in tank

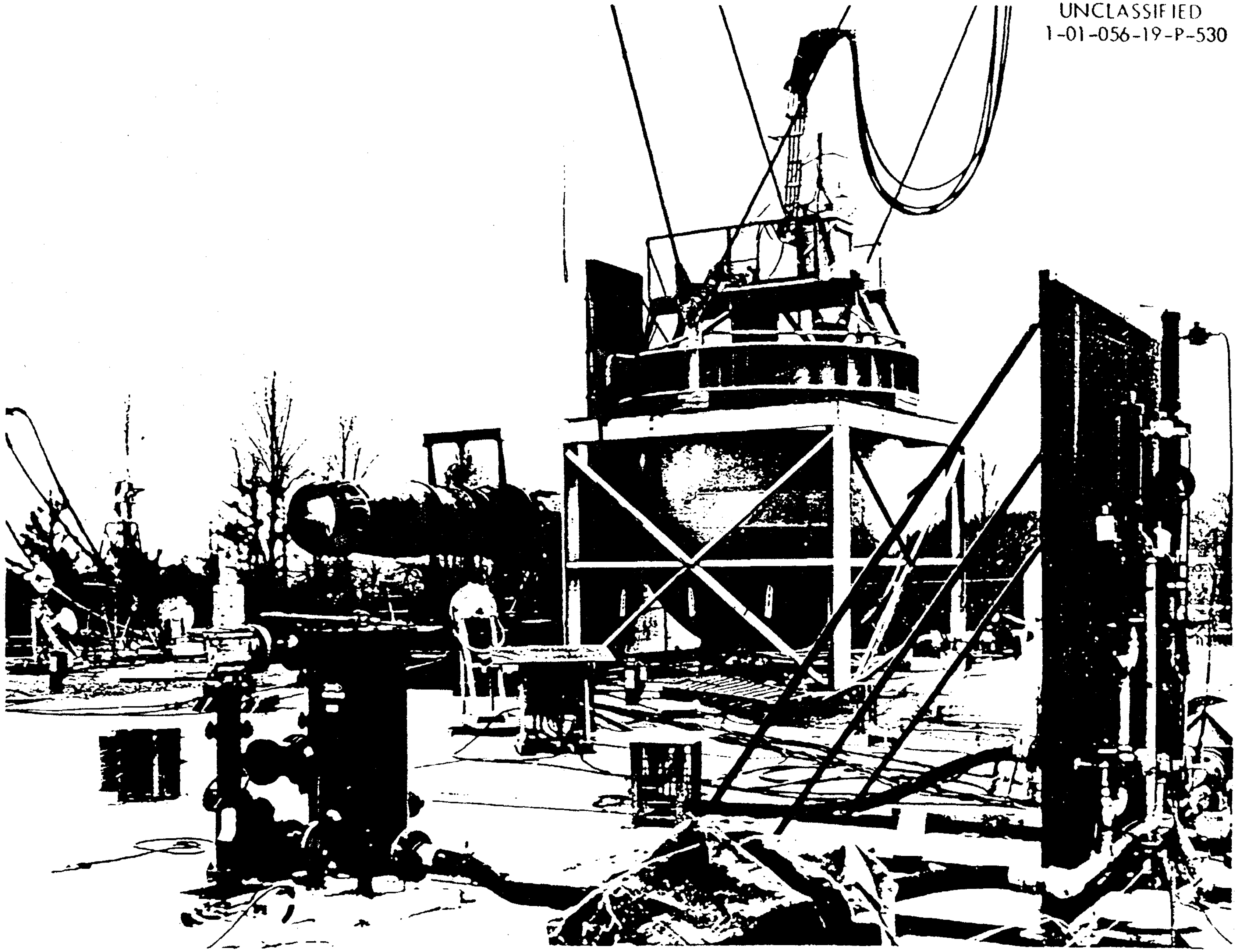
0 Capable of being operated suspended

0 Used for many experiments in a variety of shields

0 Raised power to 500 kW, pumped water from pool to cool reactor

0 Needed higher reactor power and a radiation source that was closer to that from proposed Aircraft Nuclear Propulsion designs

0 Convair ASTR was brought to TSF and operated at elevated positions in 1958 to obtain radiation scattering data close to ground



TSF REACTOR AND J-57 JET ENGINE IN OPERATING POSITION.

TSR-II ASSEMBLY FABRICATED BY ORNL

0 Three region core (internal reflector, fuel annulus, and outer reflector)

0 Located in lower section of cylindrical aluminum tank with hemispherical bottom

0 Core supported by a central cylinder

0 Two pass cooling in core

0 Tank 8 ft long, 37 inch diameter, 3/4-inch-thick wall

0 Tank designed to ASME Boiler and, Pressure Vessel, I956 edition, Section VII, "Unfired Pressure Vessels"

OUTER REFLECTOR

0 Region surrounding fuel annulus but inside reactor tank

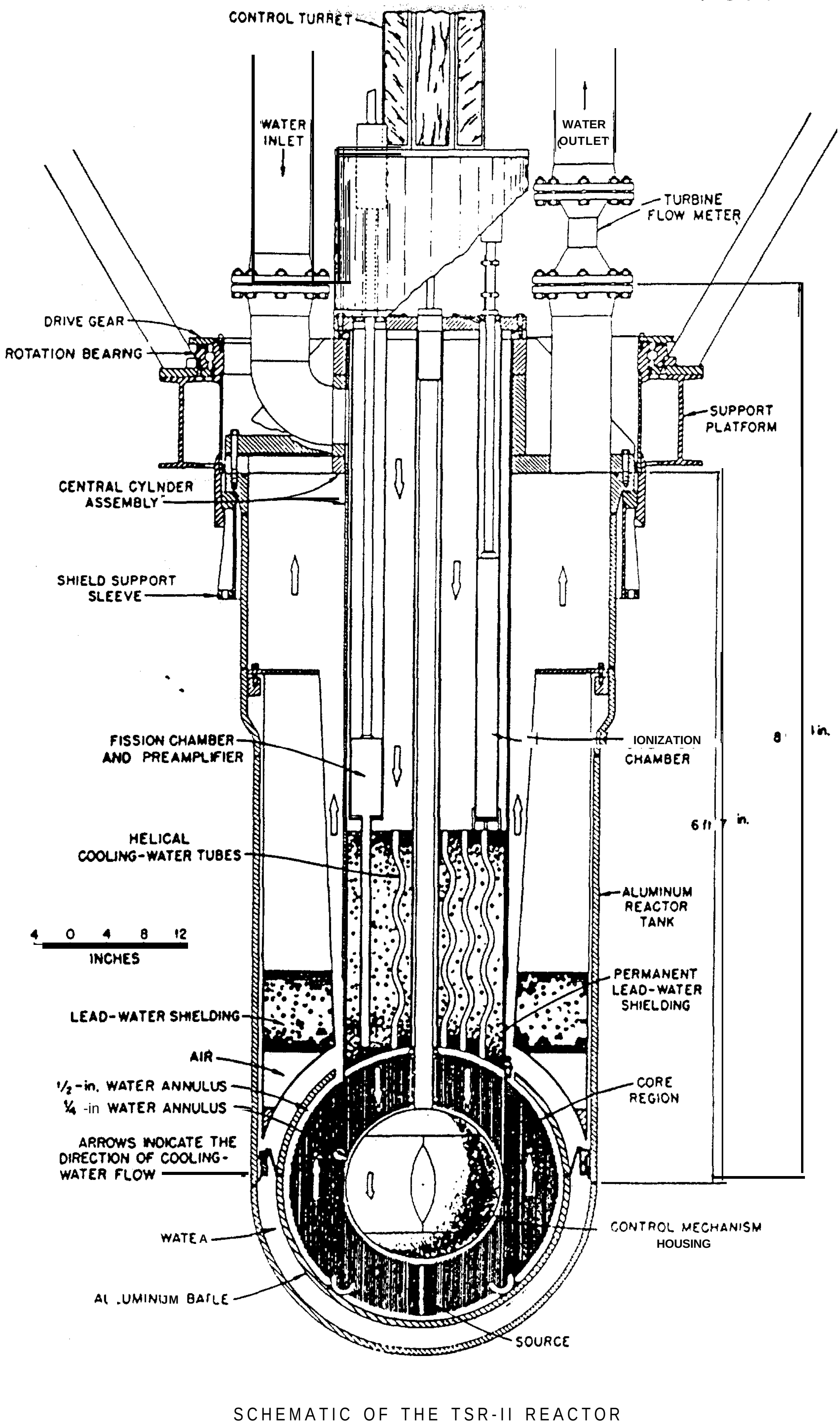
0 Presently consists of 3/4-in-thick aluminum shell 1/2 inch outside fuel elements followed by water

0 Gamma-ray shielding above upper central fuel elements is a permanent 2-ft layer of lead shot and water penetrated by 133 helical tubes - for reactor cooling water flow

0 Shield plugs above annular elements made to match shield outside vessel

O Shield and reflector descriptions and reactivity worths addended

ORNL-DWG 87-11650



SCHEMATIC OF THE TSR-II REACTOR

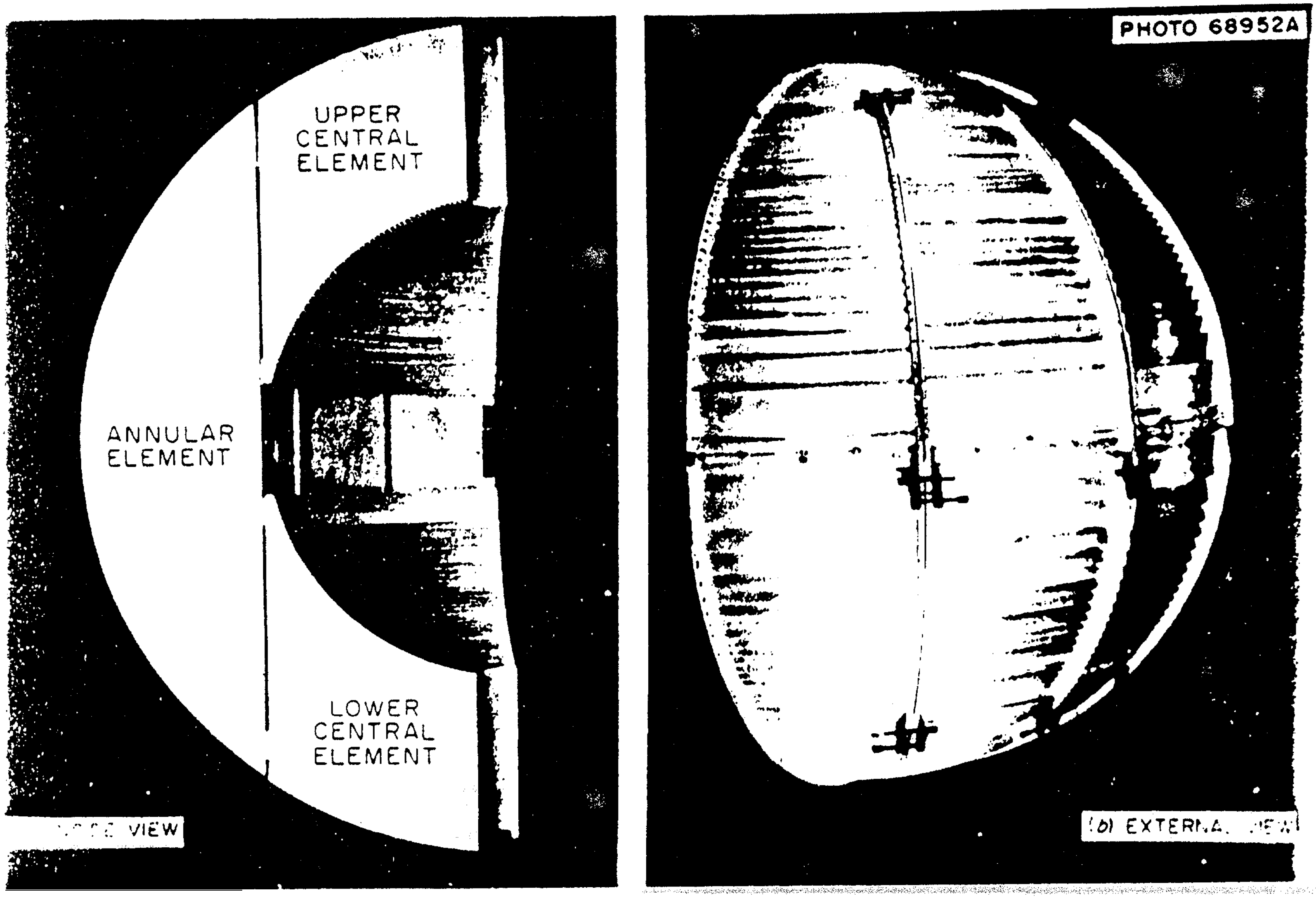


Fig. 4.2. TSR-II elements assembled in a quarter sphere [a, inside view; b, external view).

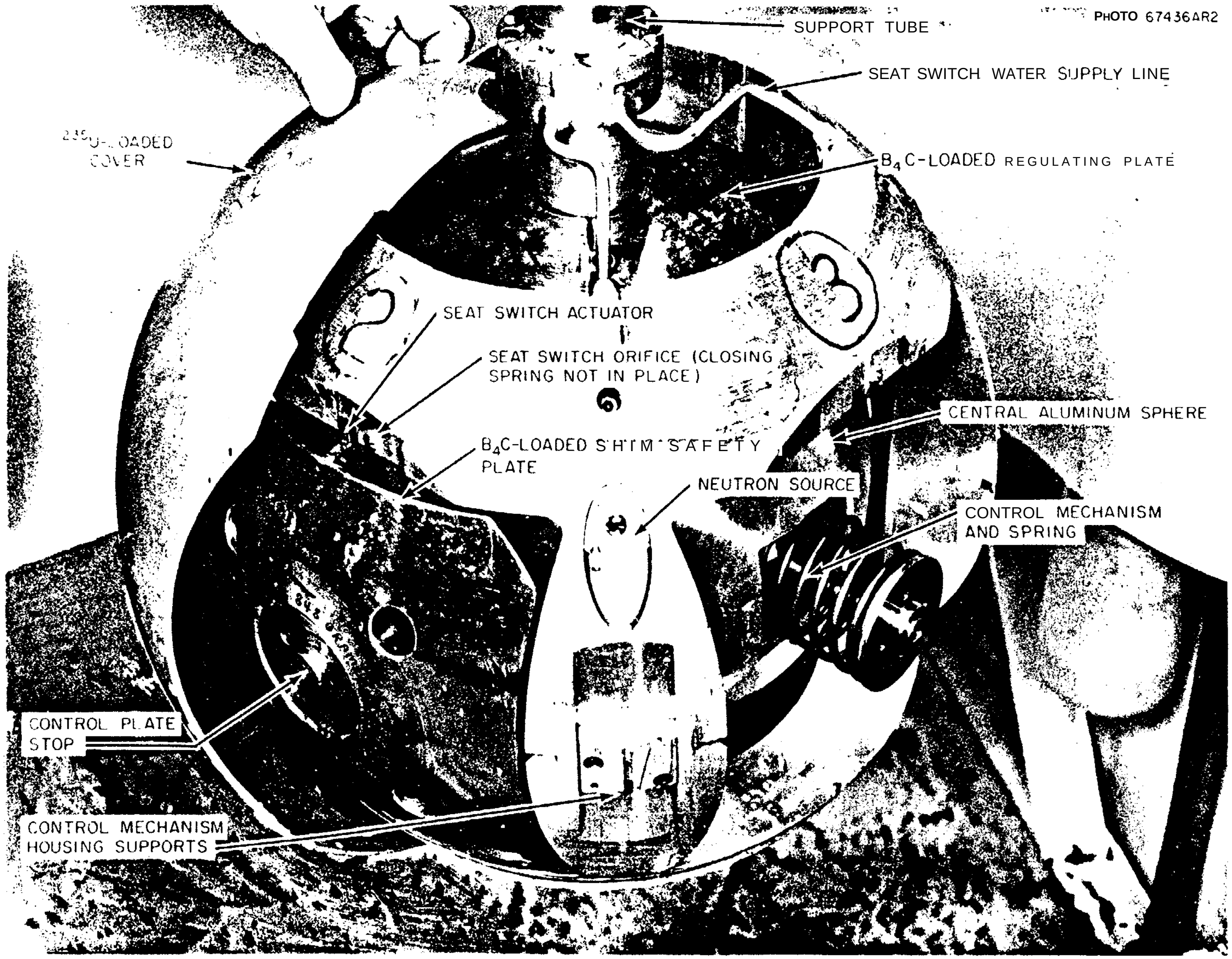
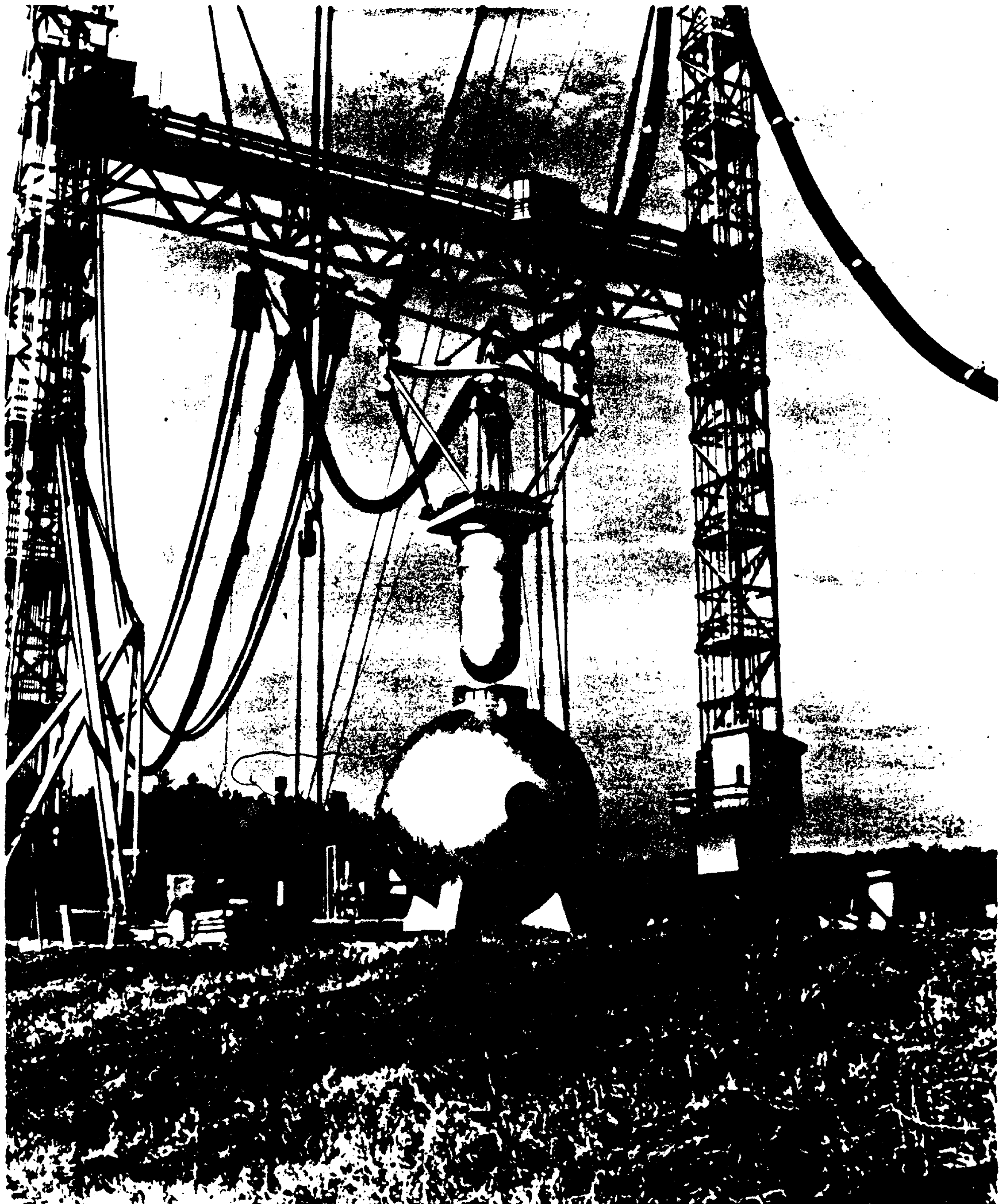


Figure 4.3. Control Mechanism Housing

REACTOR SUSPENSION SYSTEM

- *Reactor support frame with rotating collar fitted with bayonnet connections*
- *Platform, hoses, and cables suspended from tower hoists I and II*
- *Collar can be rotated to pick up bare reactor tank or reactor tank and shield, and in one case, two nested shields (COOL I and COOL II)*
- *Various shields provided different reactor spectrum*
- *Shields inside pressure vessel also could be changed*
- *Used during 1960 with a spherical beam shield, Pratt and Whitney Asymmetric Shield, the COOL Shields, and the bare reactor tank*
- *TSF SNAP Reactor also operated from 1964-1968*



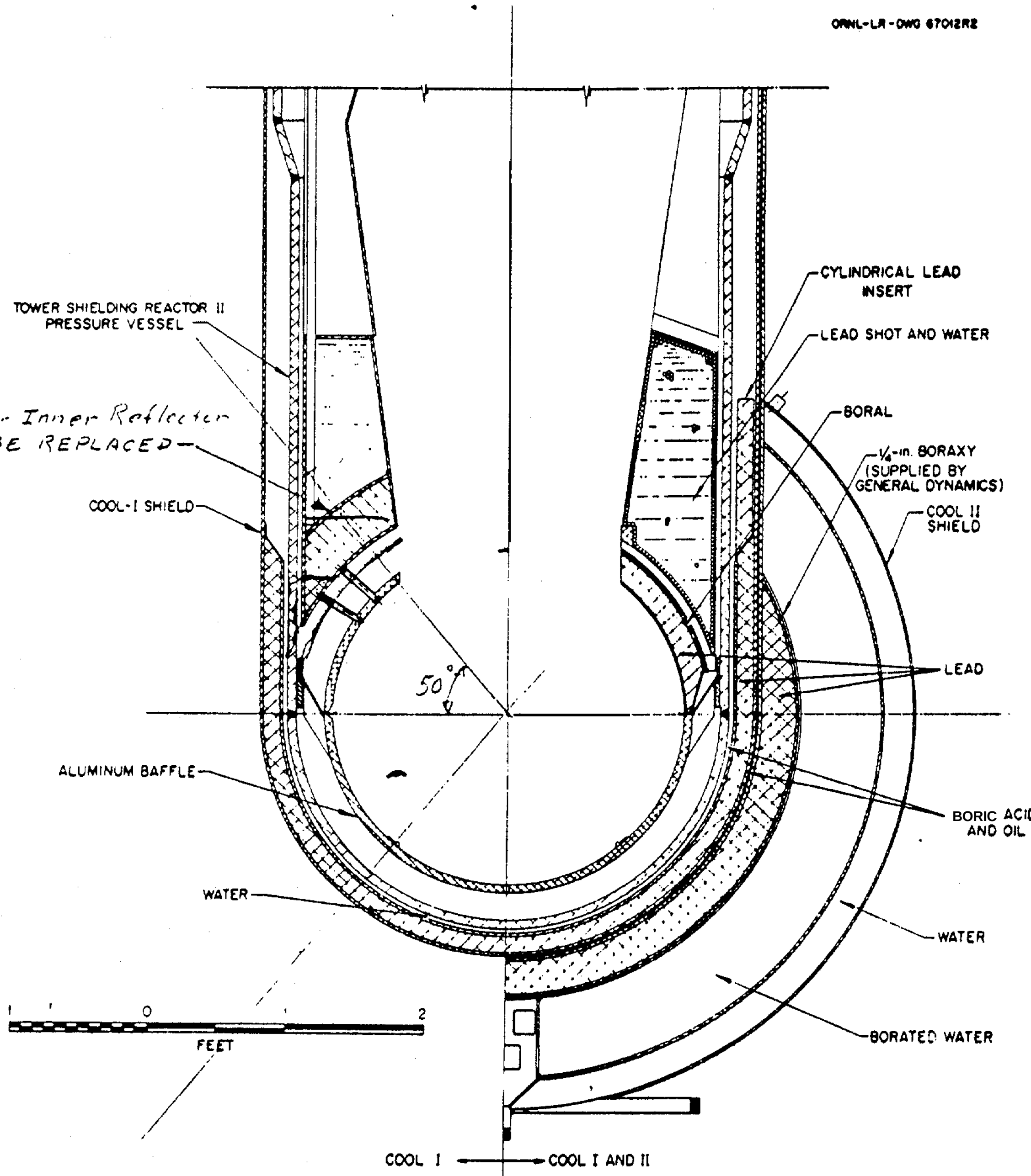
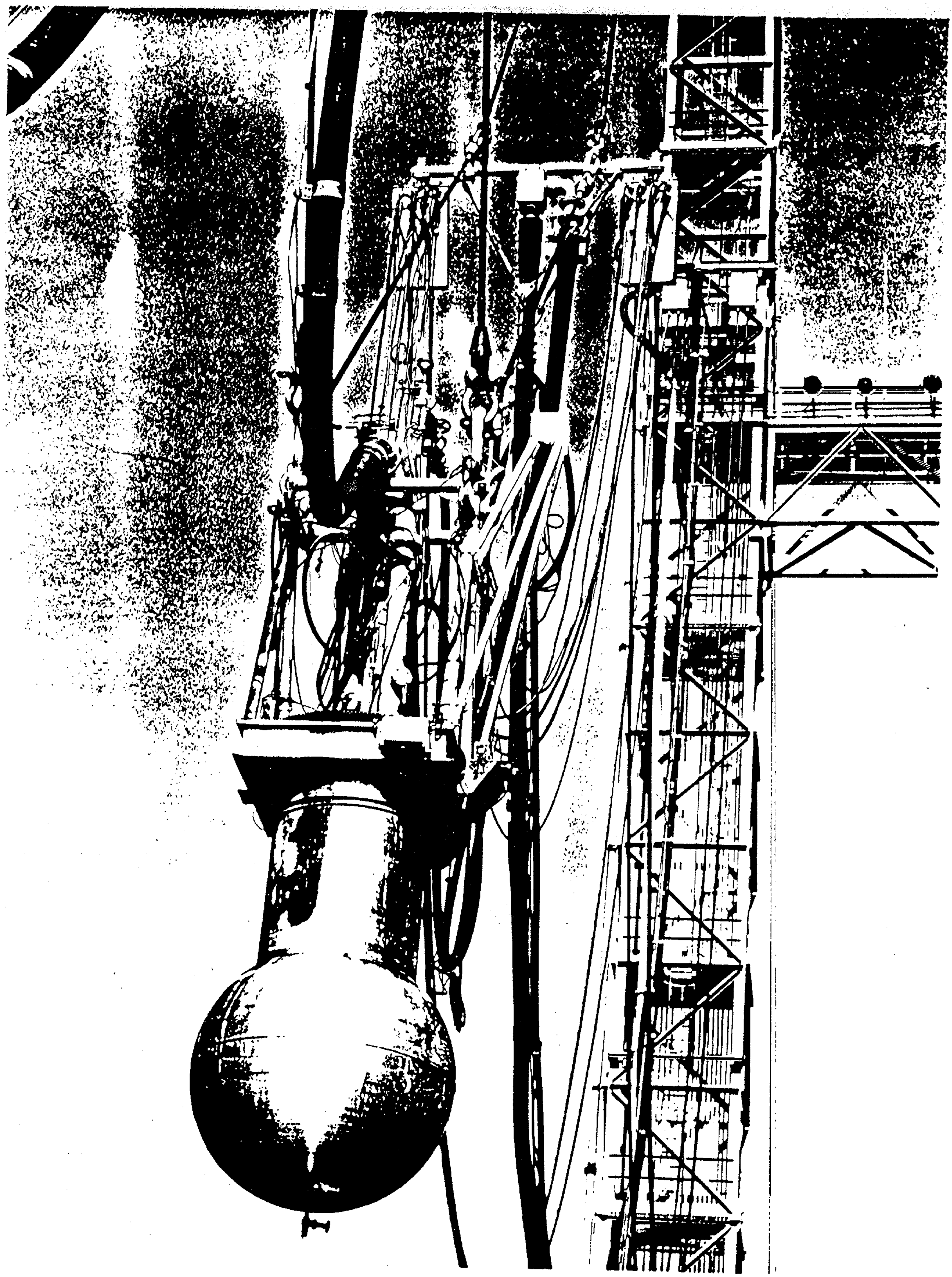


Fig. 3.5. Shield configuration.



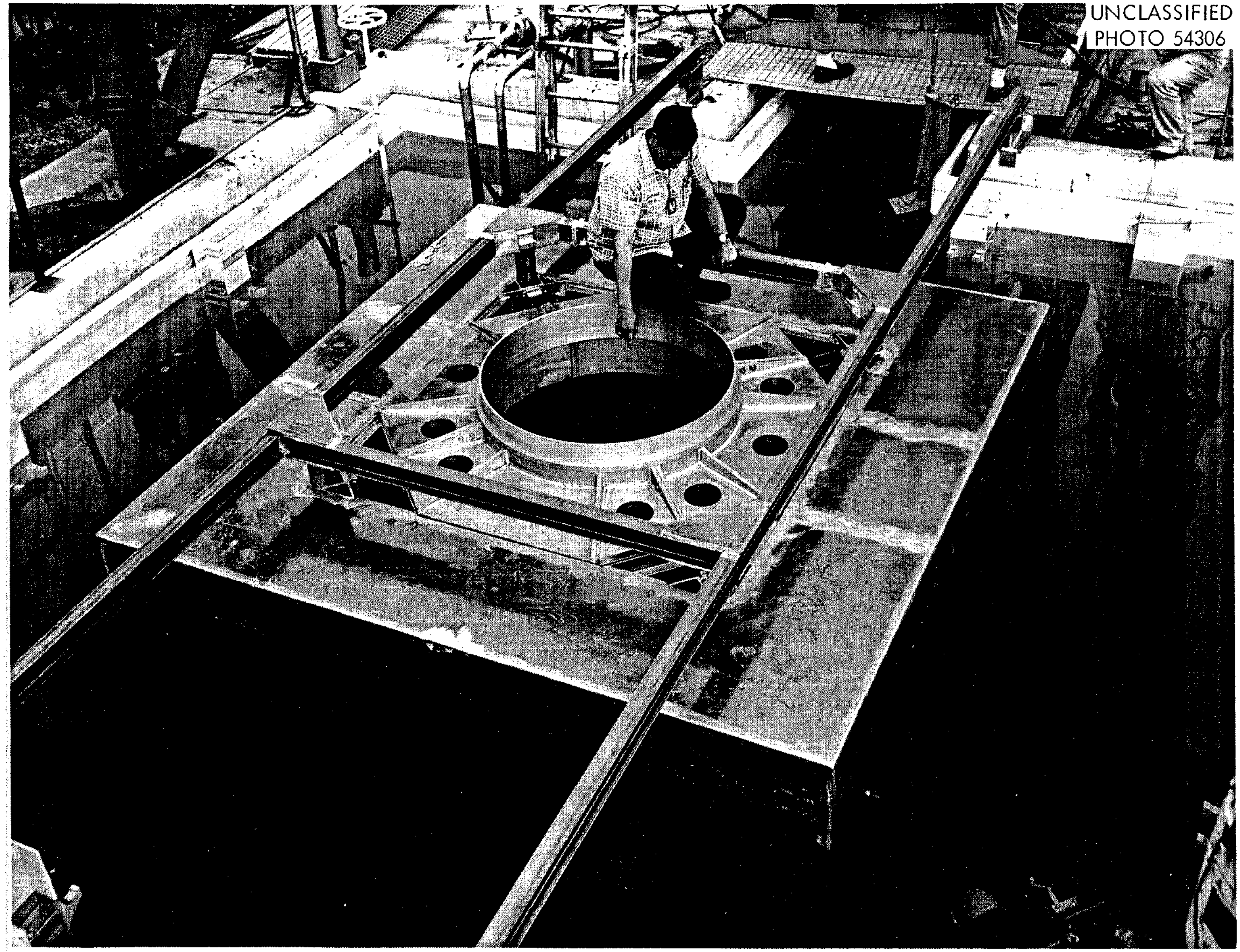
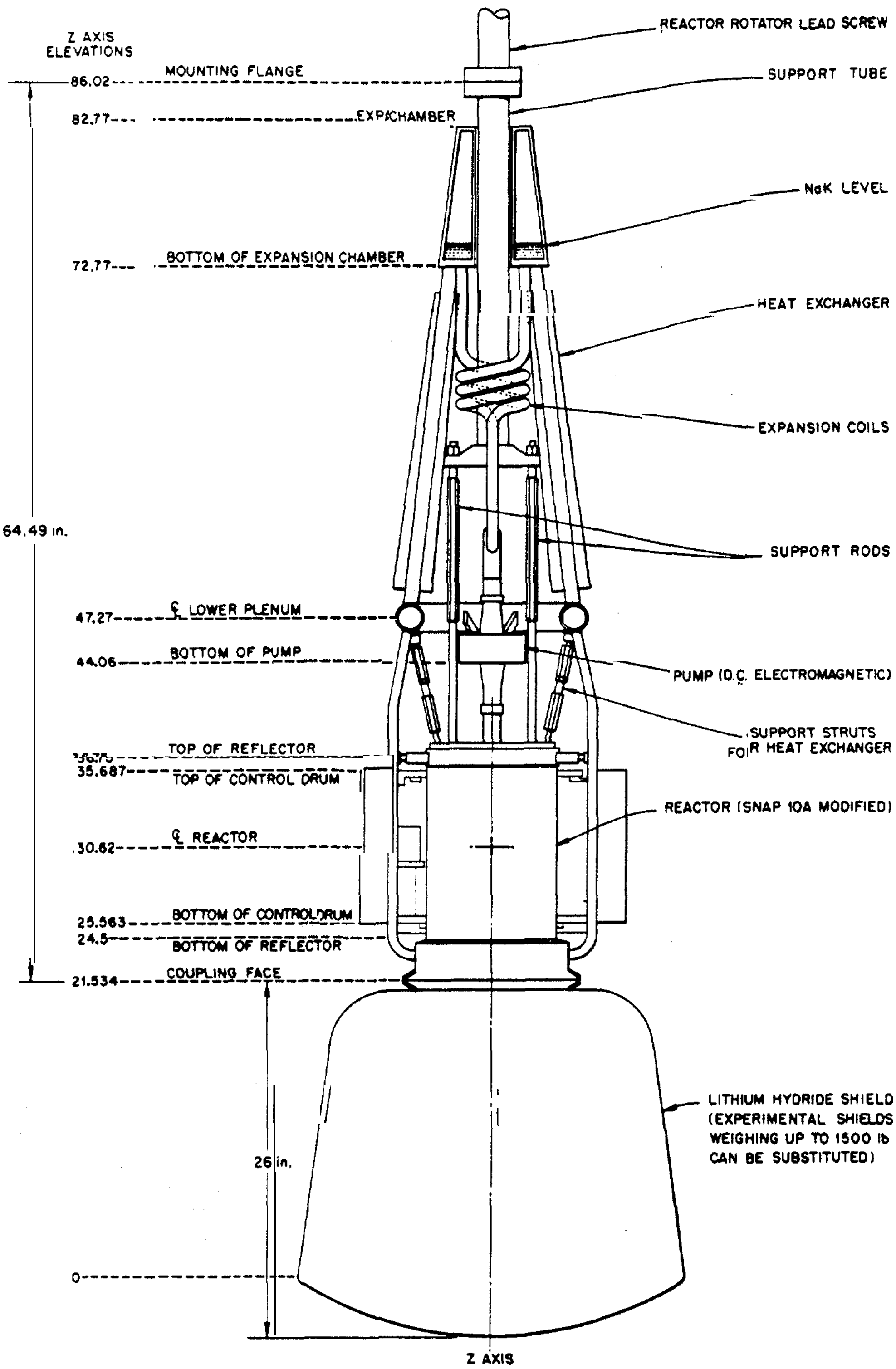


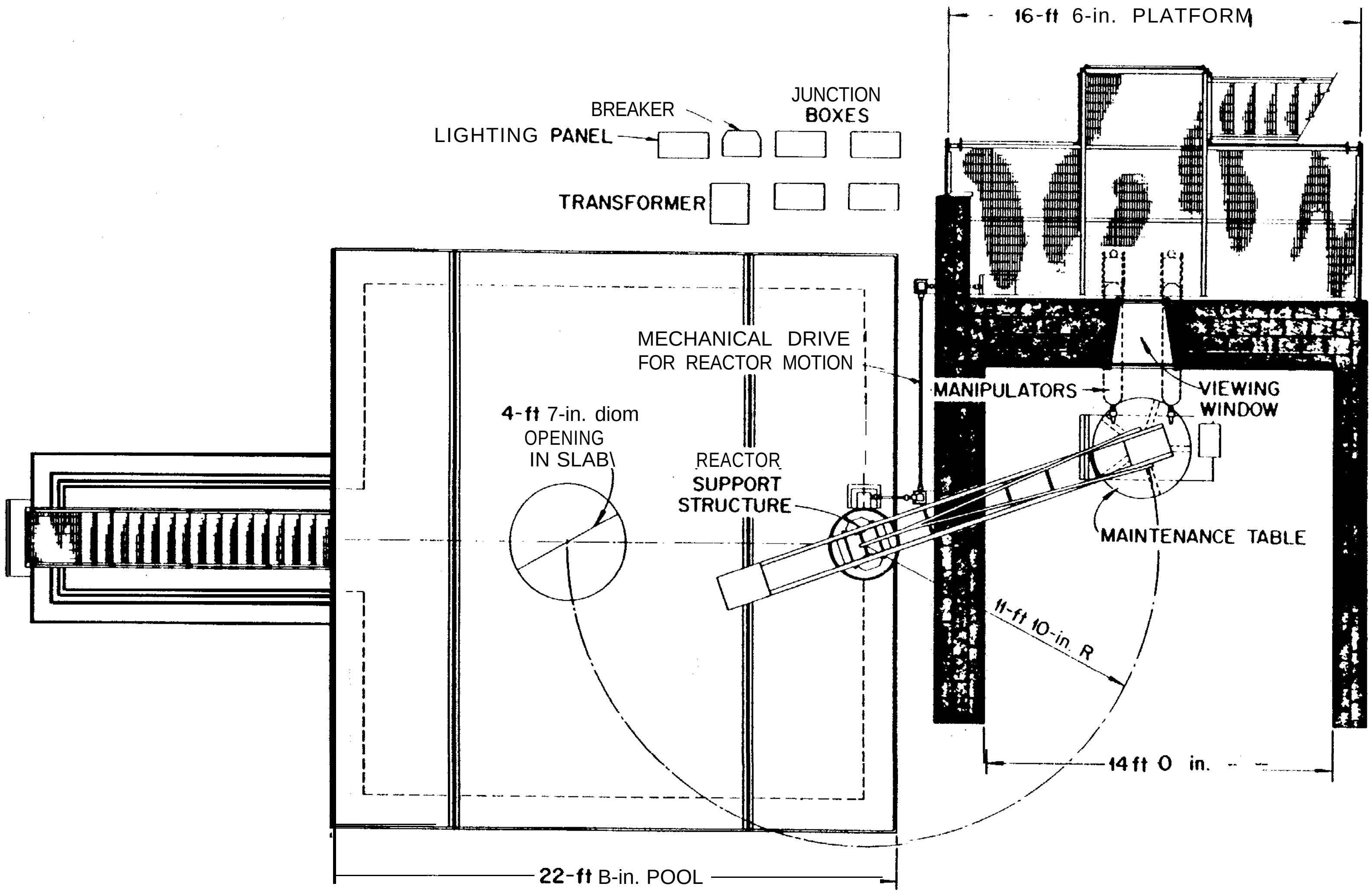
Figure 11. Shield Handling Float

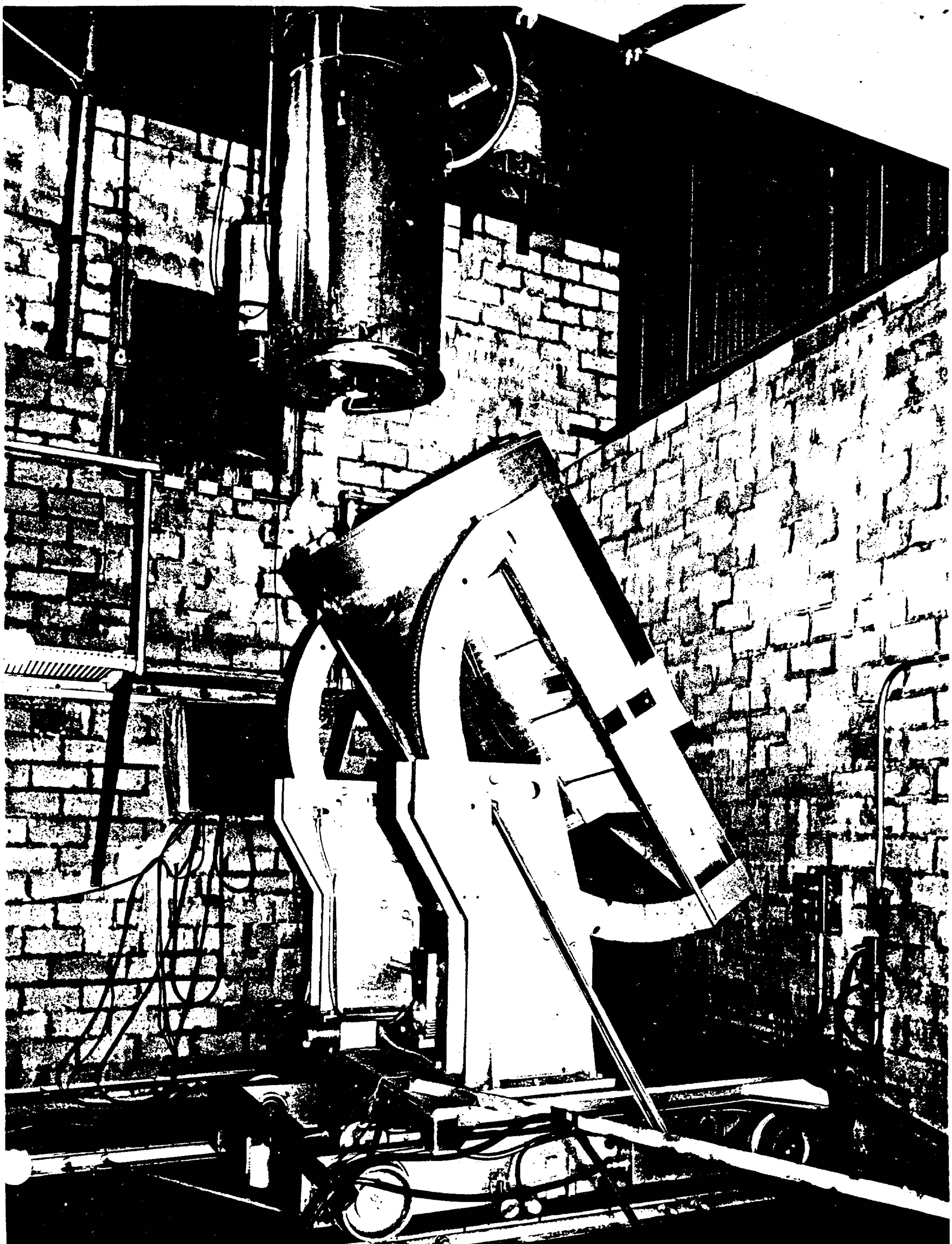
TSF Snap Reactor

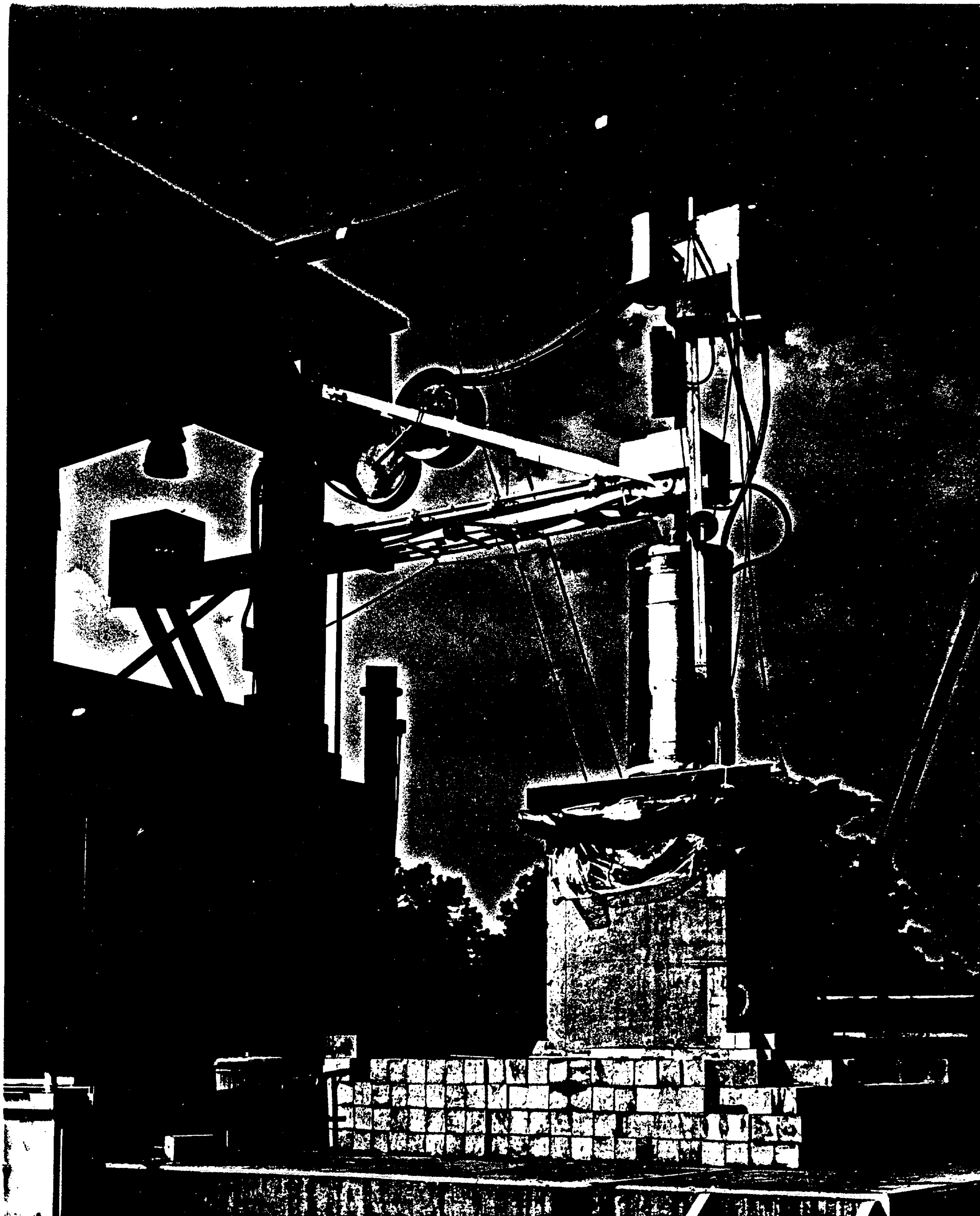
- Designed by Atomics International (AI)
- Highly-enriched (approximately 93%) ^{235}U fuel
- ZrH moderator - alloyed with fuel
- Beryllium-reflected and controlled
- NaK-cooled
- Nominal power 10 kW (th)
- Fast leakage flux (>0.1 MeV) 1×10^{15} n/cm^2 $\times$ 5 sec
- LiH SNAP-2 shield
- Critical experiment by TSF staff
- Assembly by ORNL
- NaK loading by TSF staff with AI adviser
- Operated alternately with TSR-II by TSF staff
- Reactor intact with NaK is at Y-12 with Be reflector and controls at the TSF

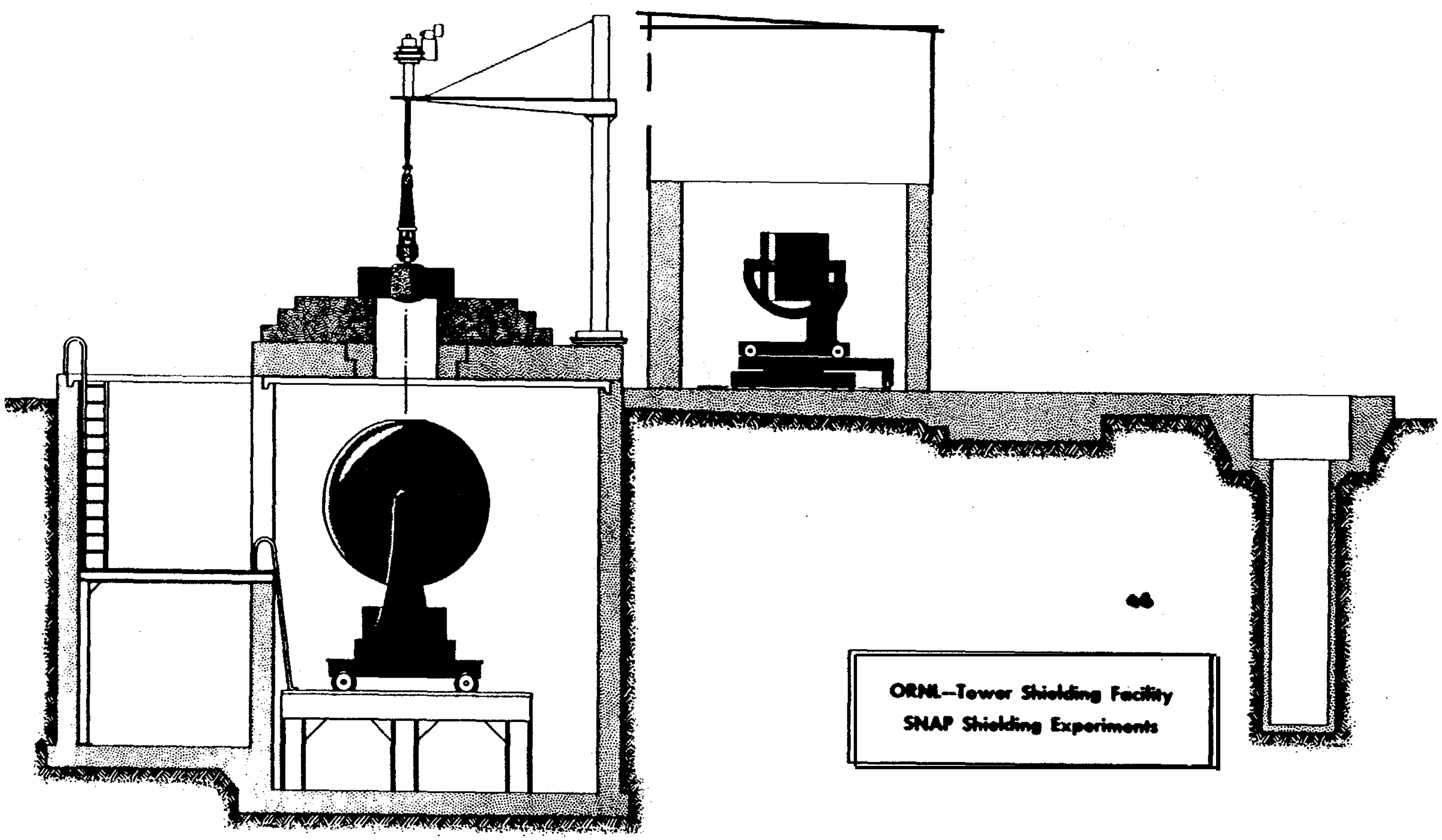


TSF –SNAP Reactor for Shielding Research.


16-ft 6-in. PLATFORM
BREAKER
JUNCTION BOXES
LIGHTING PANEL
TRANSFORMER
MECHANICAL DRIVE FOR REACTOR MOTION
MANIPULATORS
VIEWING WINDOW
4-ft 7-in. diom OPENING IN SLAB
REACTOR SUPPORT STRUCTURE
MAINTENANCE TABLE
11-ft 10-in. R
14 ft 0 in.
22-ft B-in. POOL







Facilities Arrangement

BIG BEAM SHIELD

- *Completed in 1973*
- *Shield is concrete 14 ft wide and 13 ft high, with an inner stainless steel tank filled with water and stainless steel slabs*
- *Truncated shield leaves one side open for experimental purpose*
- *Track mounted lead shutter can be placed in front of reactor or moved to place a concrete slab with 30-in diam collimator opening in front of reactor*
- *Shield has penetrations for control chambers*
- *Aerial hoses disconnected and replaced with fixed ground mounted pipes and hoses*
- *Sheet metal shed has been added to cover top of shield and reactor*
- *Leakage flux outside collimator at 1 MW is* $2 \times 10^{11}\ n/cm^2/s$

ORNL-DWG 75-15295A

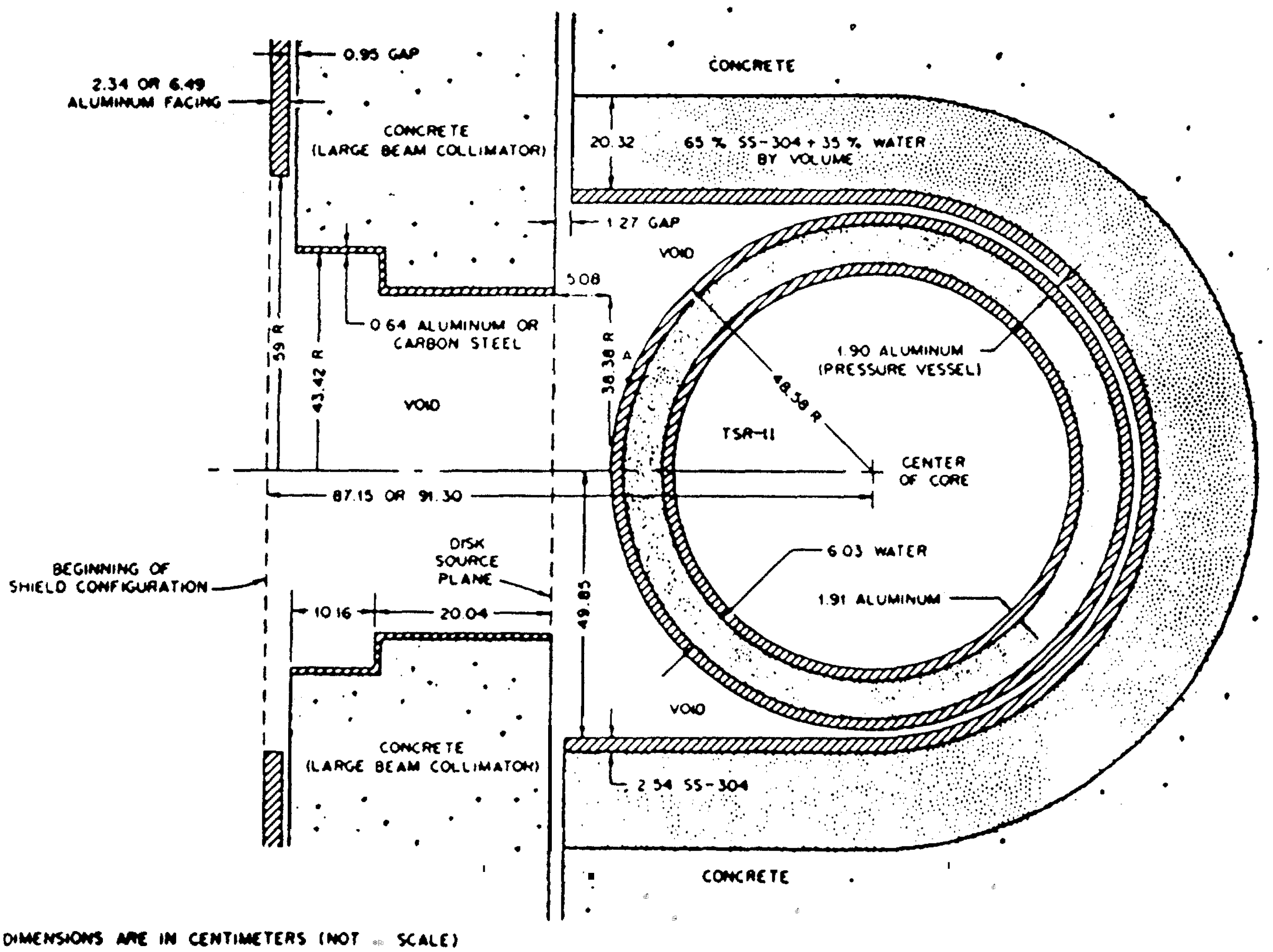
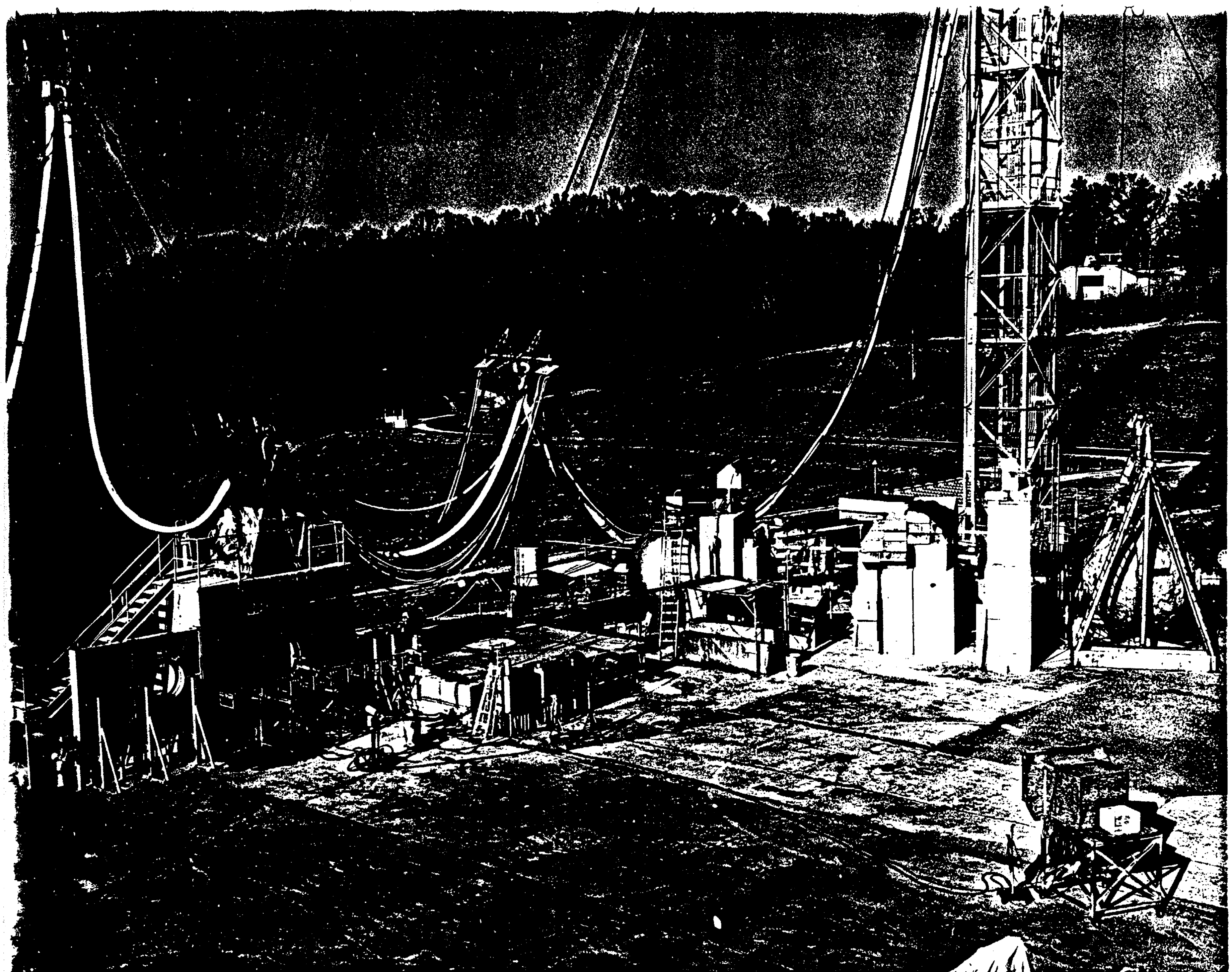


Fig. 4.18. Top view of Tower Shielding Facility Reactor and large beam collimator geometry.



Experimental Programs

- Tower Shielding Reactor
  - Basic ANP design data, for divided shield with detector in tank of water 5 ft. cube and reactor radiation as a function of azimuthal beam.
  - Two pi shield studies - reactor & crew compartment.
  - GE-reactor shields - test designed shield.
  - Compartmentalized shield.
  - SNAP mockup studies.

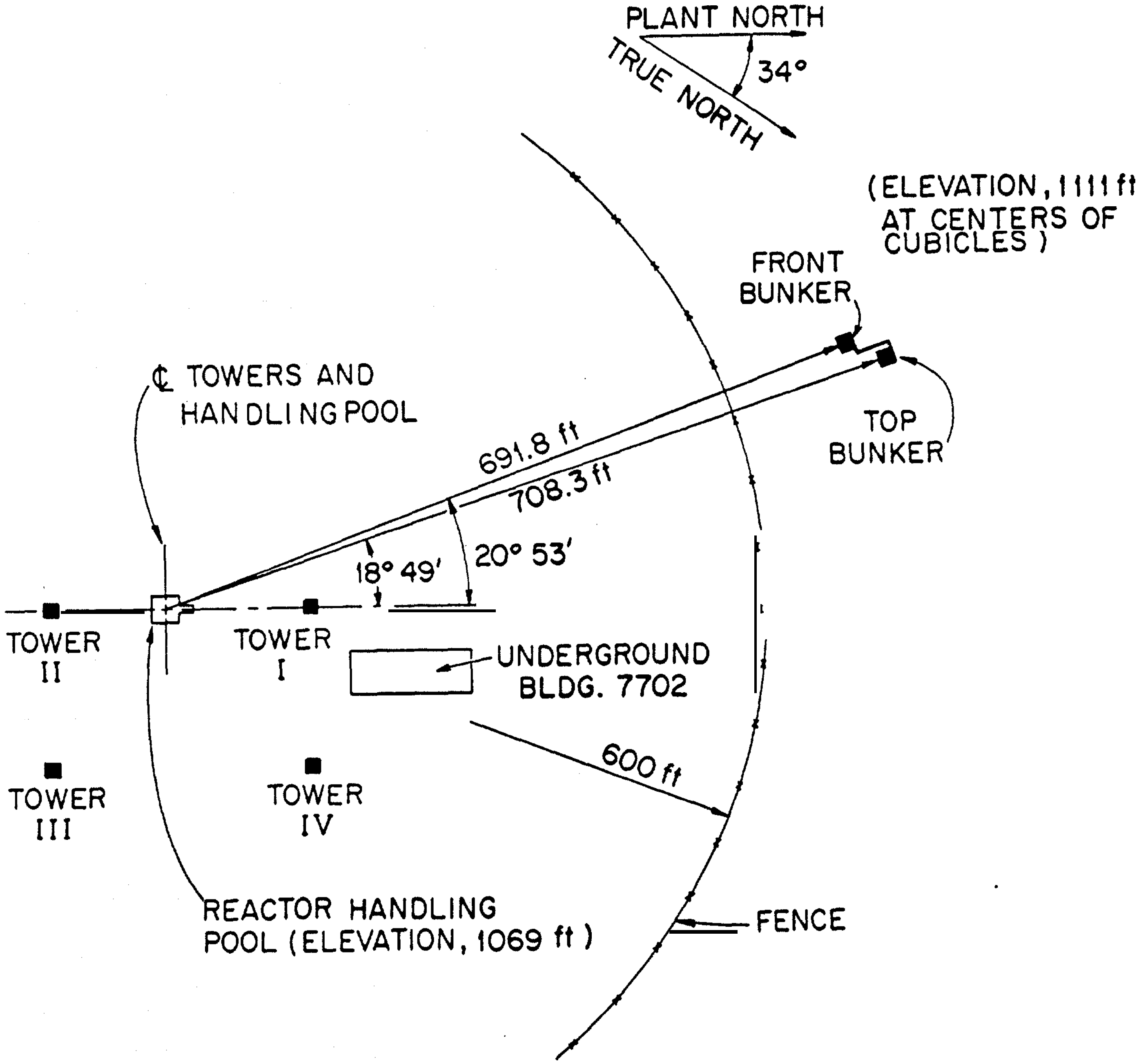
- Convair ASTR
  - Determine effectiveness of reactor and crew compartment shield from ground level to 200 ft.

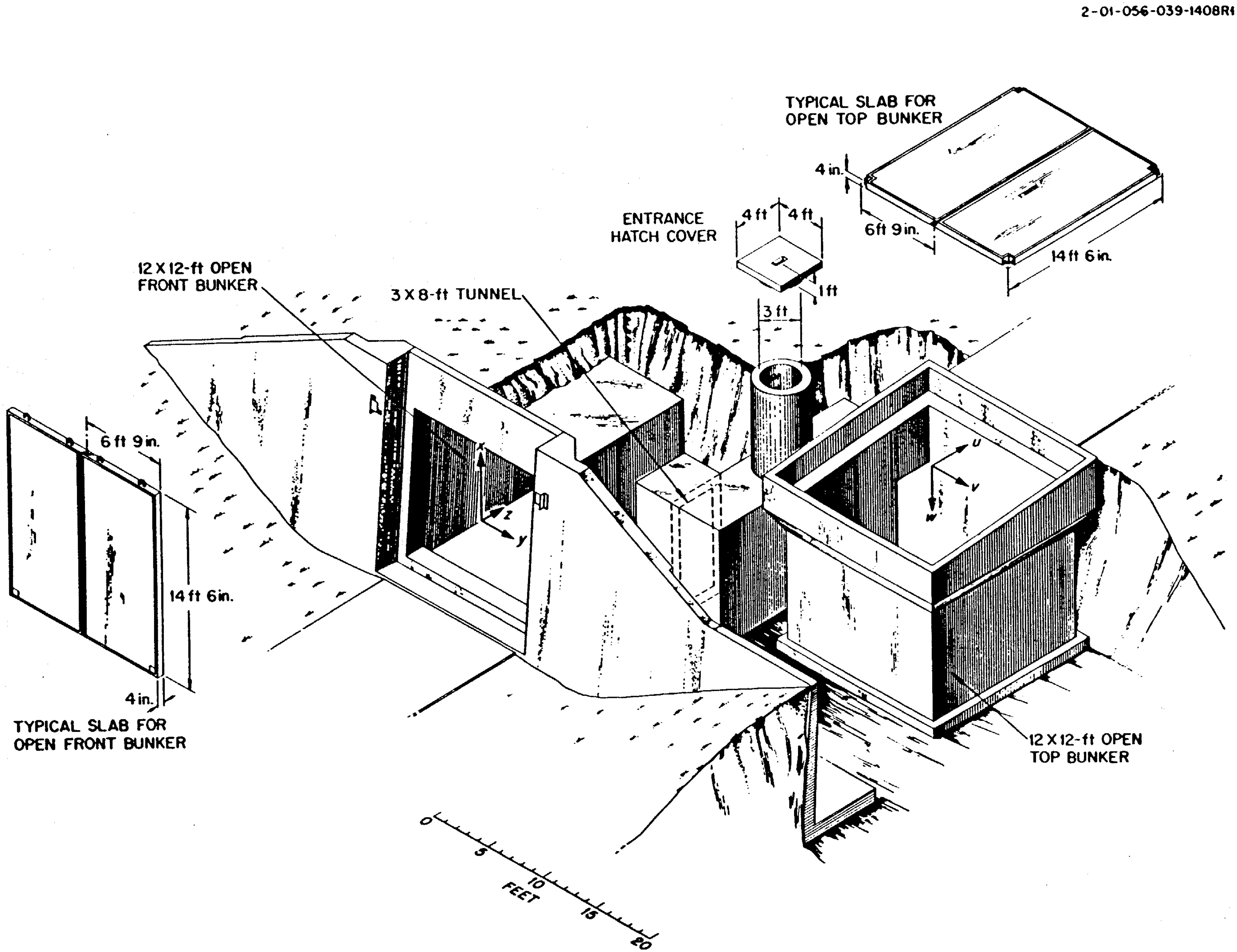
Experimental Programs - Continued

- TSF SNAP
  - Measure leakage radiation.
  - Eliminate scattered radiation and determine effectiveness of LiH shield.
- TSR-II
  - Check design of P&W reactor crew shield and Boeing Crew Shield.
  - Basic shield design studies of scattering and reflection.
  - Determine effectiveness of Civil Defense Shelters.
  - Determine effectiveness of NASA Silo Shields.
  - Do parameter studies of Battle Vehicles for U.S. Army Ordnance Corp - COOL.

Experimental Programs - Continued

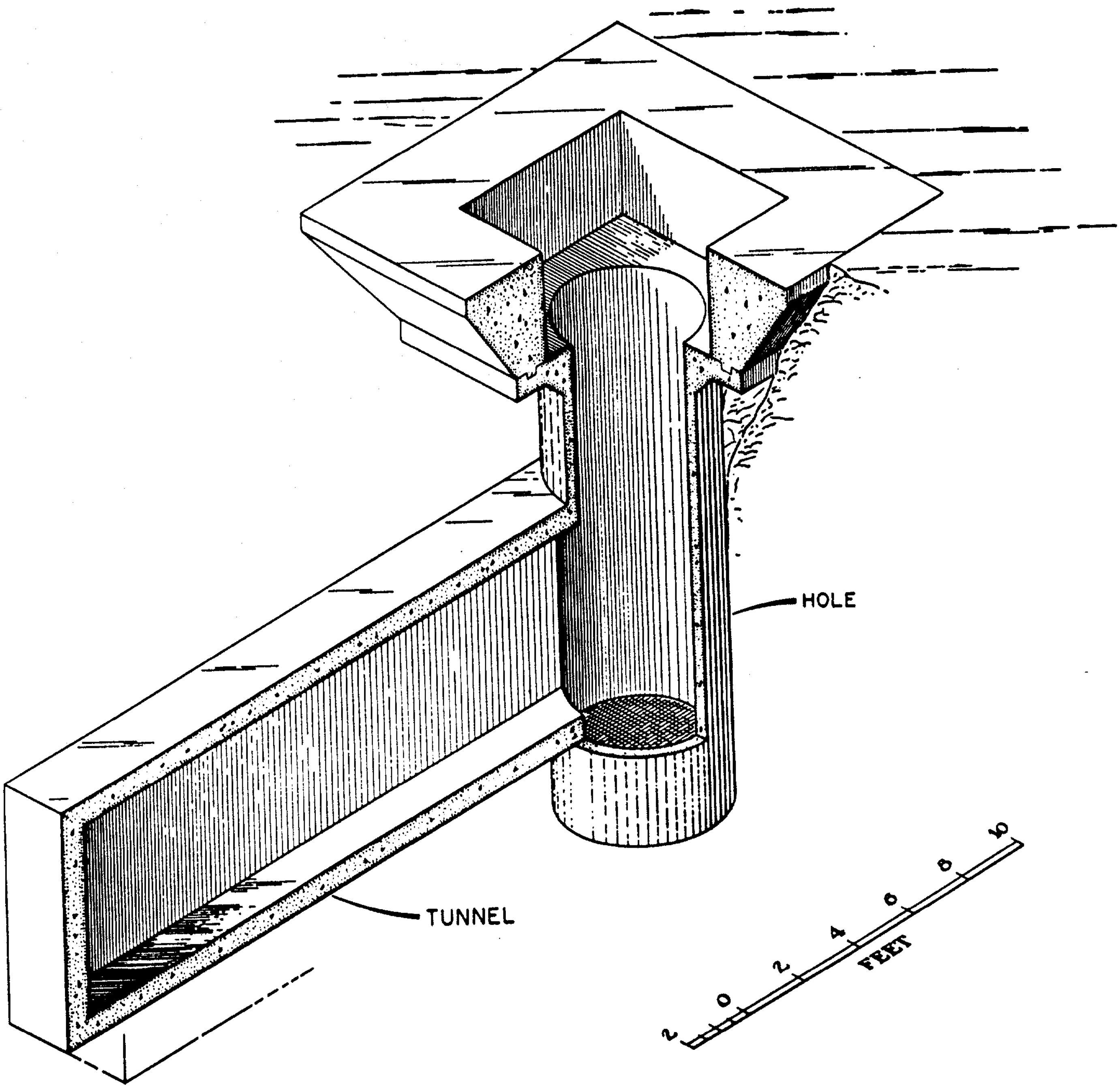
- Parameter studies for Gas Cooled Reactors.
- Parameter studies for Liquid metal Reactor latest being JASPER Program.
- Parameter studies for Naval vessels.


PLANT NORTH
TRUE NORTH
34°
(ELEVATION, 1111 ft AT CENTERS OF CUBICLES)
FRONT BUNKER
TOP BUNKER
℄ TOWERS AND HANDLING POOL
691.8 ft
708.3 ft
18° 49′
20° 53′
TOWER II
TOWER I
UNDERGROUND BLDG. 7702
TOWER III
TOWER IV
600 ft
REACTOR HANDLING POOL (ELEVATION, 1069 ft)
FENCE

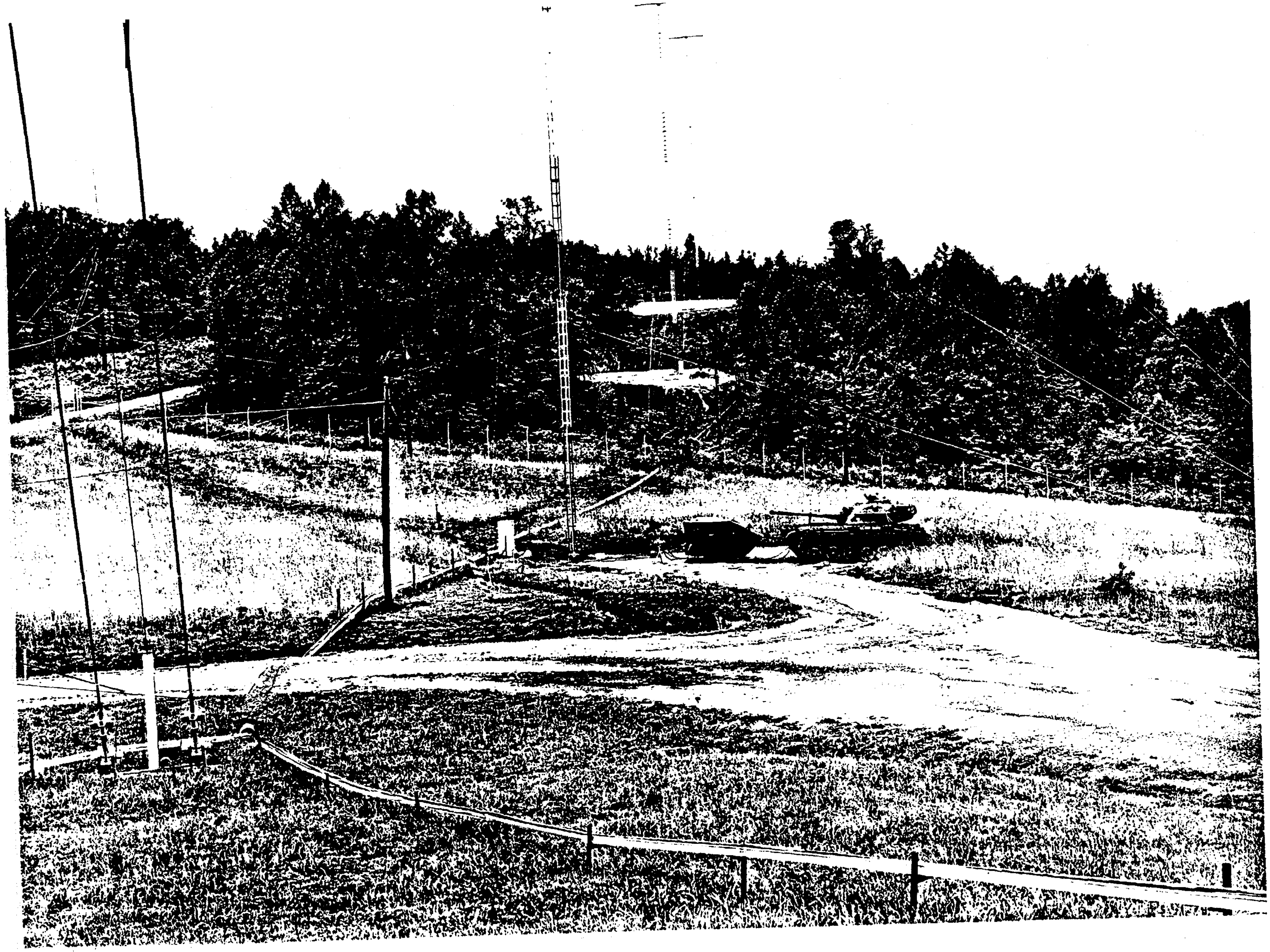


2-01-056-039-1408R1
TYPICAL SLAB FOR
OPEN TOP BUNKER
4 in.
6ft 9in.
14 ft 6 in.
ENTRANCE
HATCH COVER
4 ft
4 ft
1 ft
3 ft
12 X 12-ft OPEN
FRONT BUNKER
3 X 8-ft TUNNEL
6 ft 9 in.
14 ft 6in.
4 in.
TYPICAL SLAB FOR
OPEN FRONT BUNKER
x
y
z
u
v
w
12 X 12-ft OPEN
TOP BUNKER
0
5
10
15
20
FEET

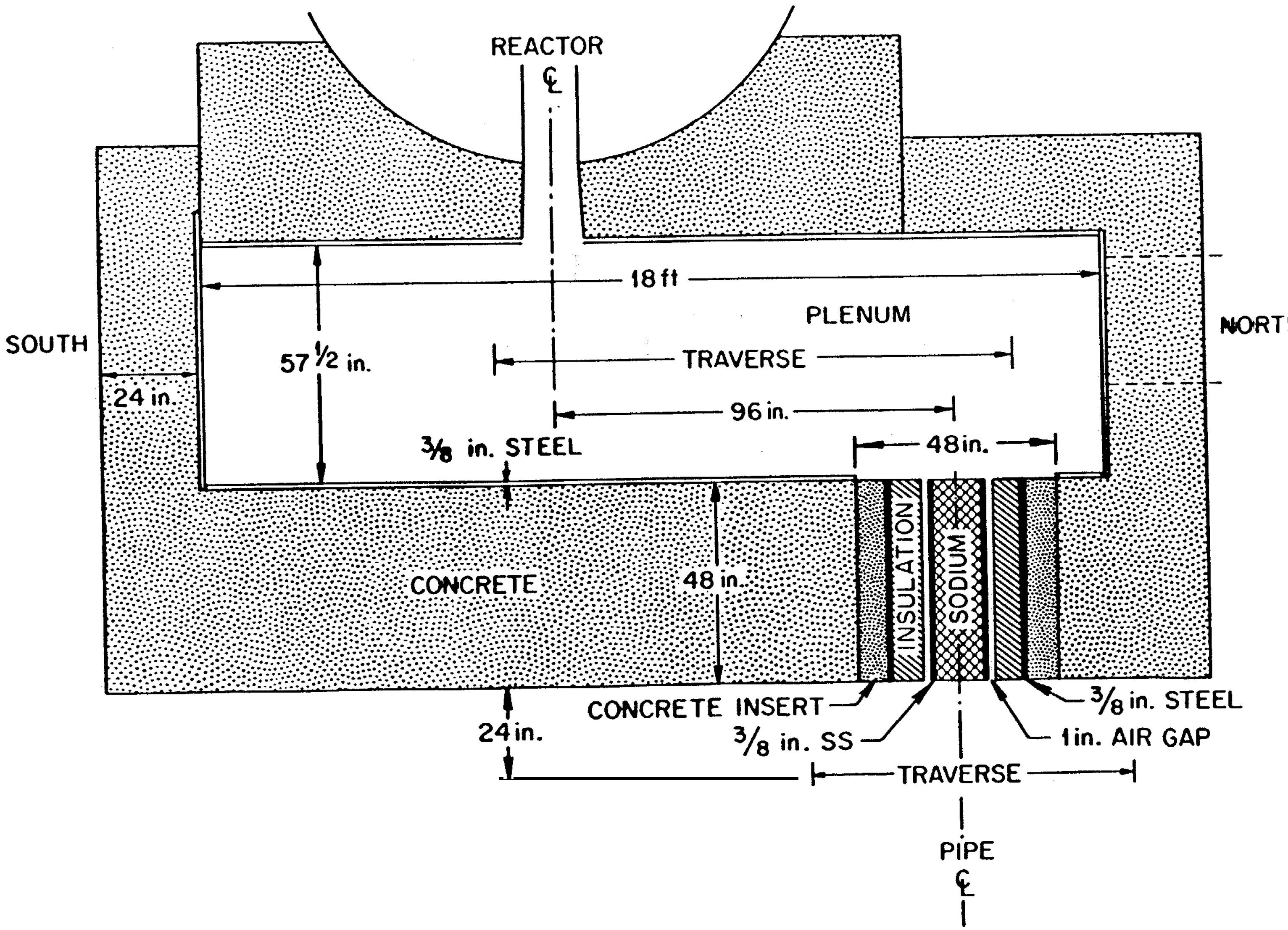
2-01-056-33D-1218

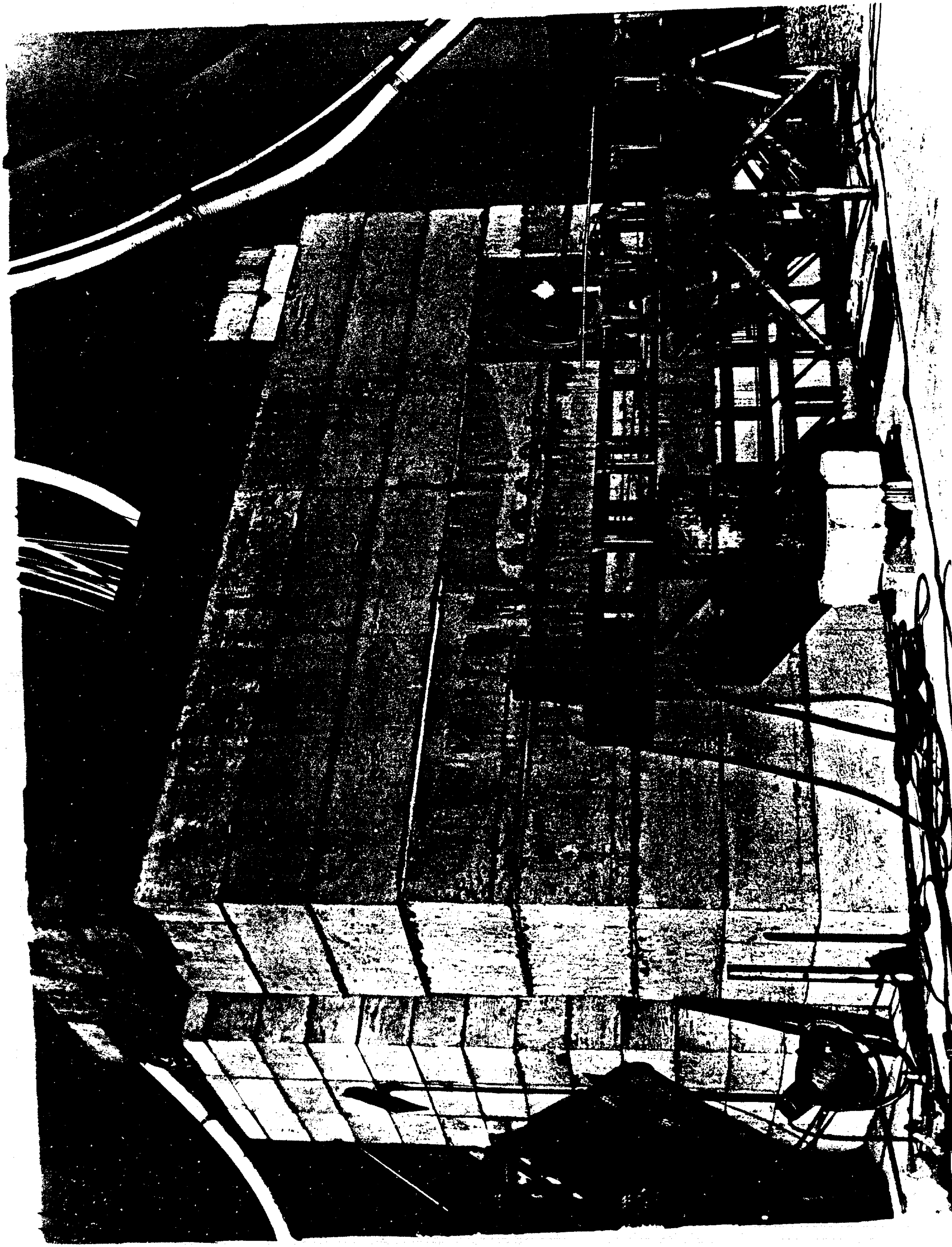


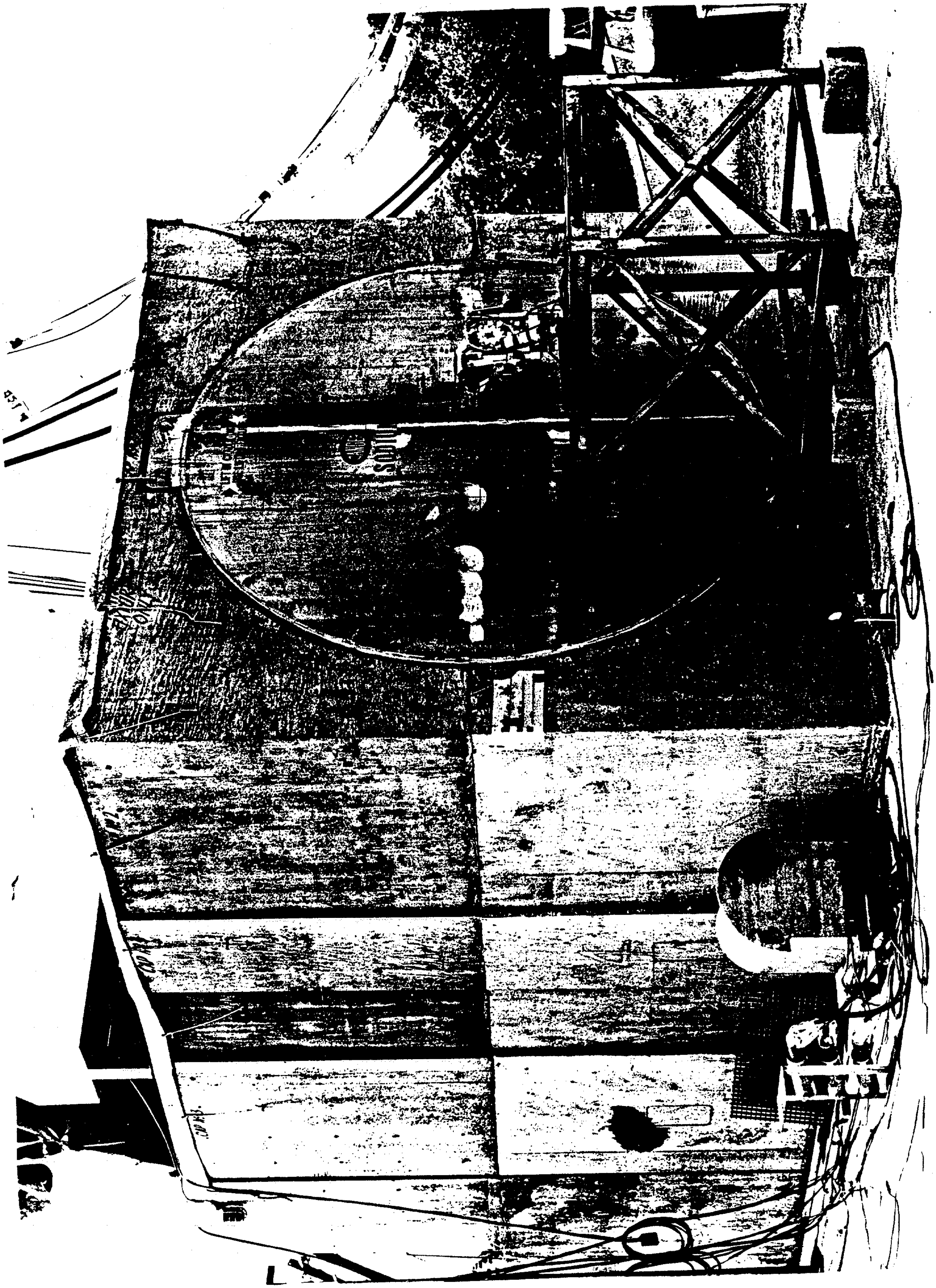
Cutaway View of Hole-Tunnel Configuration.

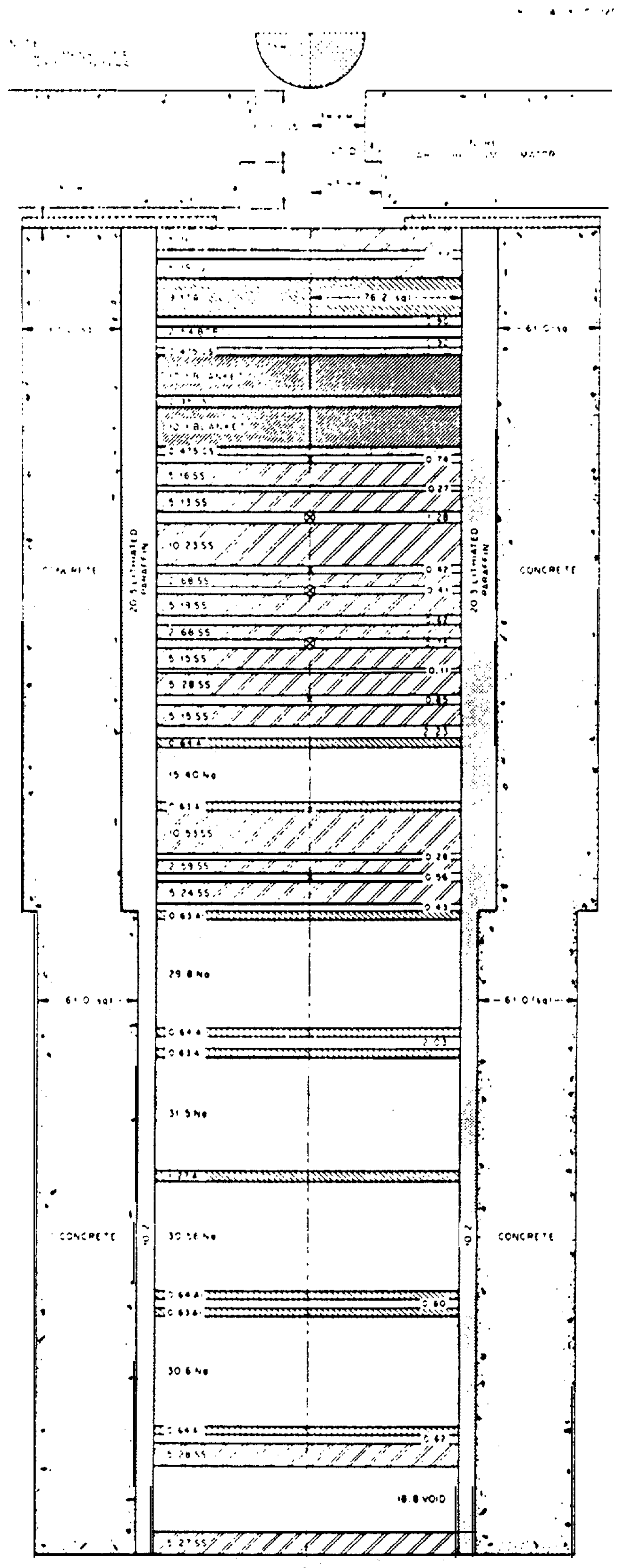


ORNL-DWG 72-8684R1









76.2 sq
61.0 sq
20.3 LITHIATED PARAFFIN
CONCRETE
0.74
0.27
10.23 SS
0.41
5.19 SS
2.66 SS
5.15 SS
5.28 SS
15.40 Na
10.55 SS
2.59 SS
0.56
5.24 SS
29.8 Na
61.0 sq
31.5 Na
30.56 Na
10.2
30.6 Na
0.60
5.28 SS
18.8 VOID

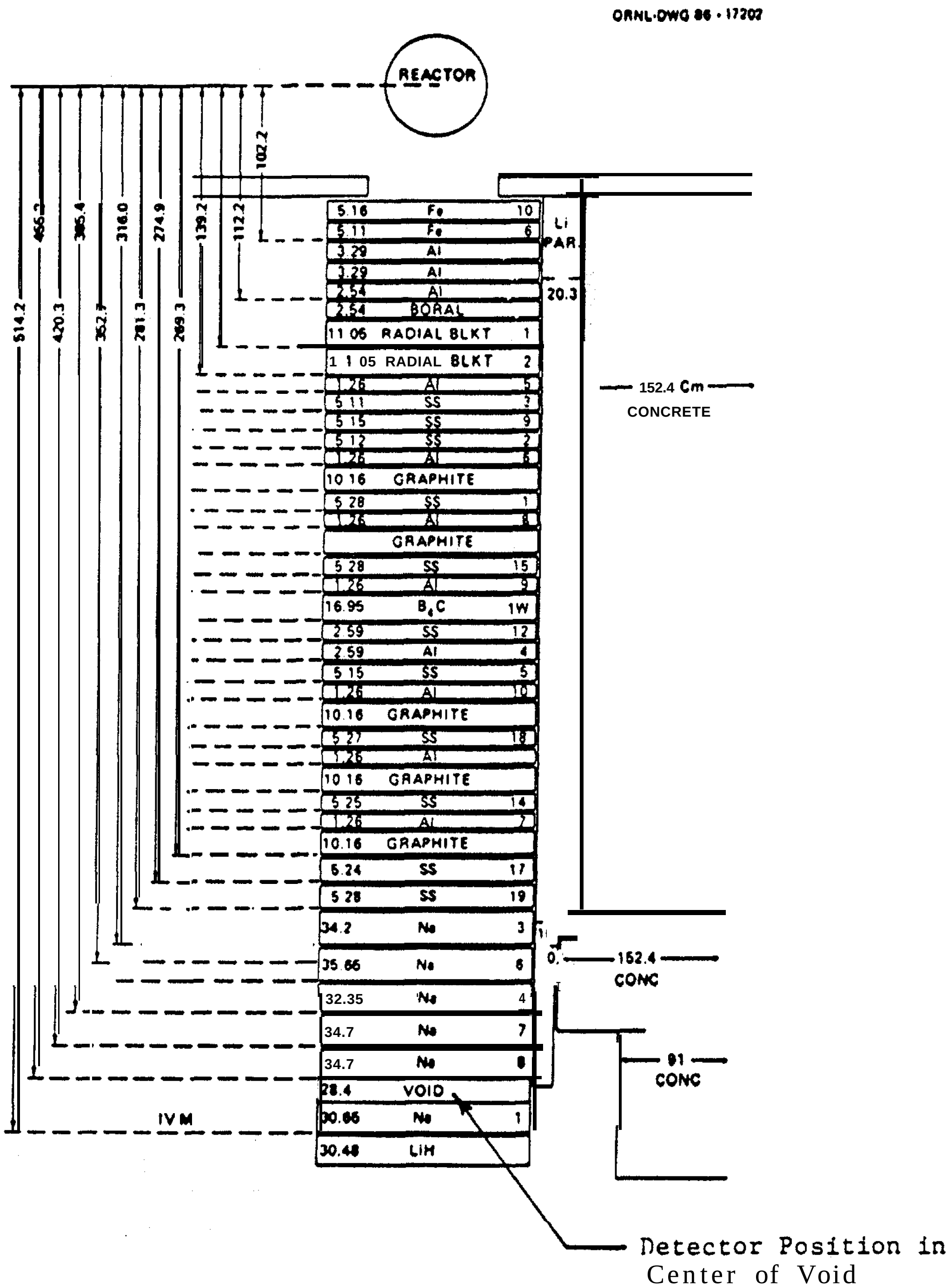


Figure 12. Schematic of SM1 plus shield configuration for Item IVM. Note: Lithiated paraffin covers lateral sides of configuration.

Cask Drop Tests

- Part of test facilities for Radioactive Material Transport Packages.
- Impact Pad (2nd)
  - 70 tons Rebar Steel
  - 600 tons concrete
  - Armour plate surface 8 ft x 20 ft.
- Punch Tests
  - 5 in. diam., steel punch welded to pad
- Lifting Capability
  - 35 ton (have dropped 23 tons - 30 ft.) Could be doubled with modifications.
- Restricted to New Clean Casks.

Cask Drop Tests - Continued

- Have made 41 tests at TSF.
- DOE stopped testing in 1988 because of concern about shock damage to reactor.
- Testing may again be allowed since the reactor operation has been stopped.

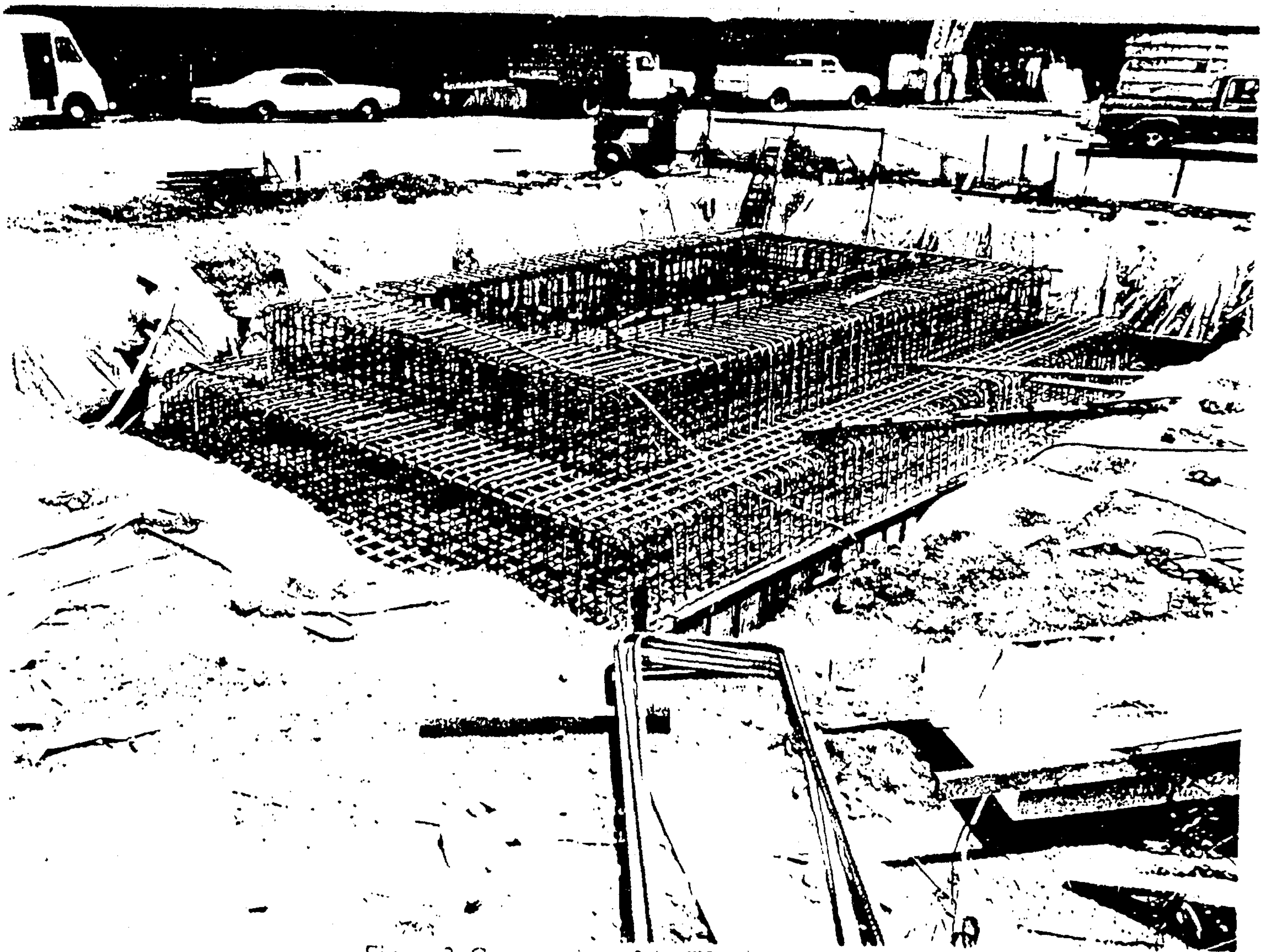
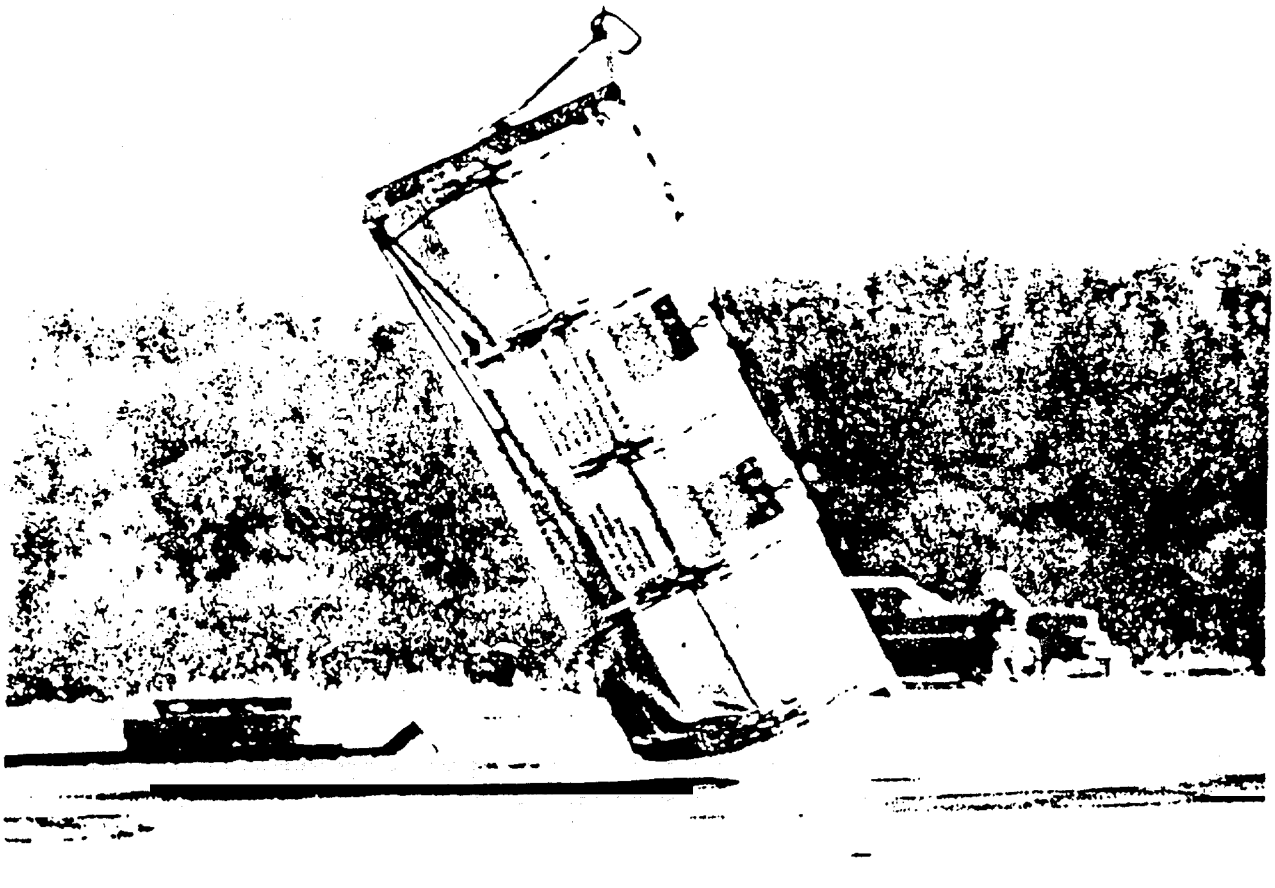


Figure 2. Construction of the TSF drop pad.

OKNL PHOTO 5821-77

Fig. 3.3. Impact pad of the ORNL Drop Test Facility.



Impact of a 23 ton UF_6 package during a 9-m drop test. Results will serve as a basis for the Safety Analysis Report for Packaging (SARP).

Conduct of Experiments

- Experiments always conducted at the lowest power and in the shortest time possible to obtain data.

- Limitation were placed on the integrated dose reaching the perimeter fence:

  - Shall be minimum practical.

  - Shall be within DOE Radiation Protection Guidelines 5480.11.

  - Shall not exceed 100 mrem in any consecutive days.

- Even with no shielding around the elevated TSR-II tank, the above limits were not restrictive.

- Since 1973, operation of the TSR-II has been in the Big Beam Shield.

- Improved data taking equipment has greatly reduced operating power and time requirements.

Conduct of Experiments - Continued

- With reactor at maximum power of 1 MW and with beam fully open the dose rate at the west gate in the 600 ft. fence is only 20 mrem/hr.

- With a shielding experiment in place and the reactor operated at the power necessary to obtain data, the neutron dose rate at the edge of the configuration for a Bonner Ball measurement ran 230 mrem/hr, and for a Hornyak Button detector, 43.6 rem/hr.

Equipment and Material Used for Experiments and Maintenance

- Radioactive Calibration Sources

- Fuel elements (enriched U)
  - in reactor,
  - in experimental configurations,
  - in storage.

- Uranium
  - Depleted for experiments.
  - Normal for experiments.

- Iron and Stainless Steel
  - Induced activity in shielding material.

- Mixed Material
  - Control mechanisms.

Equipment and Material Used for Experiments and Maintenance - Continued

- Hazardous Material
  - Sodium - Reuse 5' x 5' x I', 1 I'D x 5', 1 I'D x 2%
  - Lithium Hydride - Reuse
  - Nak - Y-12
  - Gasoline - Truck Use
- RCRA Materials
  - Lead
  - Cadmium

Waste Generation and Disposal

- Liquid
  - Demineralizer-regenerates
    - Drained to storage tank.
    - Trucked to laboratory for treatment.
    - Now use commercial vendor to supply resin and do not regenerate.

- Solid Materials
  - Metal
    - (Al-W) ~ 5’ x 5’ slabs are used over and over again.
    - Special shields - partially radioactive - storage for eventual disposal (aluminum, iron, lead, stainless steel).
  - Concrete
    - Many configuration - stored for reuse.

Waste Generation and Disposal

- Miscellaneous
  - Hoses
  - Paraffin

- Disposal
  - Minor disposal of material before 1985.
  - Between 1987 and 1991, 50 truckloads removed. Program now must fund disposal of items used.

- Fuel Elements
  - TSR elements returned for reprocessing.
  - Convair ASTR - returned to Convair.
  - TSF SNAP - stored at Y-12.
  - TSR-II - Being maintained in reactor and in silo. Will be sent for reprocessing or to storage facility.

- Experimental Fuel
  - Return to suppliers in past what is on hand will be returned for disposal.

Future

- DOE ordered facility shut down in October 1992. Change of future operation low.
- Develop a Shutdown Plan by June 1993.
- When plans are formalized and funds available, remove fuel from facility.
- Characterize maintenance requirements and turn facility over to DOE for decommissioning.
- Comply with all regulations:

  - Federal
  - State
  - MMES
  - ORNL
  - Research Reactors Division