

UNCLASSIFIED

MANHATTAN DISTRICT HISTORY

BOOK IV - PILE PROJECT

X-10

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VOLUME 3 - DESIGN

APPENDIX - A, B, C, D, ■ 4A

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UNCLASSIFIED

THIS DOCUMENT CONSISTS OF <sup>99</sup>~~121~~ PAGES  
NO. 4 OF 4 COPIES. SERIES A

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JOHN E. HARTSOCK  
REVIEWED BY *JWH* DATE *9/15/79*  
*Ernie Hedges, D.D., 50-10.23. 10/24/85*

**APPENDIX A**  
**MAPS AND DIAGRAMS**

~~RESTRICTED DATA~~  
This document contains restricted data as  
defined in the Atomic Energy Act of 1946.

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MANHATTAN DISTRICT HISTORY

BOOK IV - PILE PROJECT

VOLUME 3 - DESIGN

APPENDIX A

MAPS AND DIAGRAMS

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✓ 4	Map - Site Map
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12	Diagram - Sectional View of Pile from Control Rod Side
13	Diagram - Sectional View of Pile from Discharge End
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29	Diagram - Schematic Arrangement Hydraulic Shim Rod Drive
30	Diagram - No. 2 Safety Circuit
31	Diagram - Schematic Arrangement electric Regulating Rod Drive
32	Diagram - Driving Mechanism for Regulating and Shim Rods

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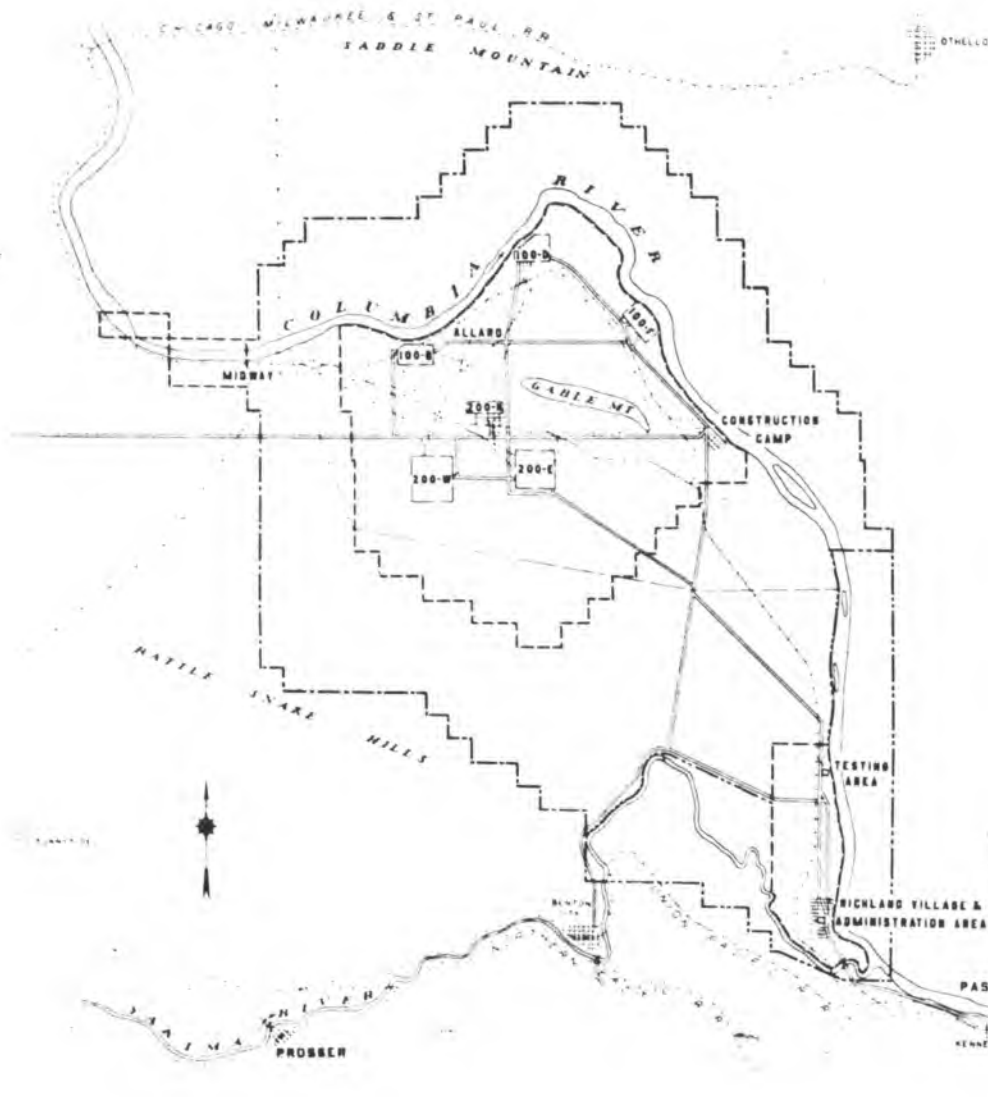
<u>No.</u>	<u>Description</u>
33	Diagram - Control Rod for Shim and Fine Control
34	Diagram - Sections Showing Regulating or Shim Rods and the Special Fittings of the Pile Shield through which These Rods Pass
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<u>No.</u>	<u>Description</u>
72	Diagram - Process Waste Storage Tanks
73	Diagram - Dissolver
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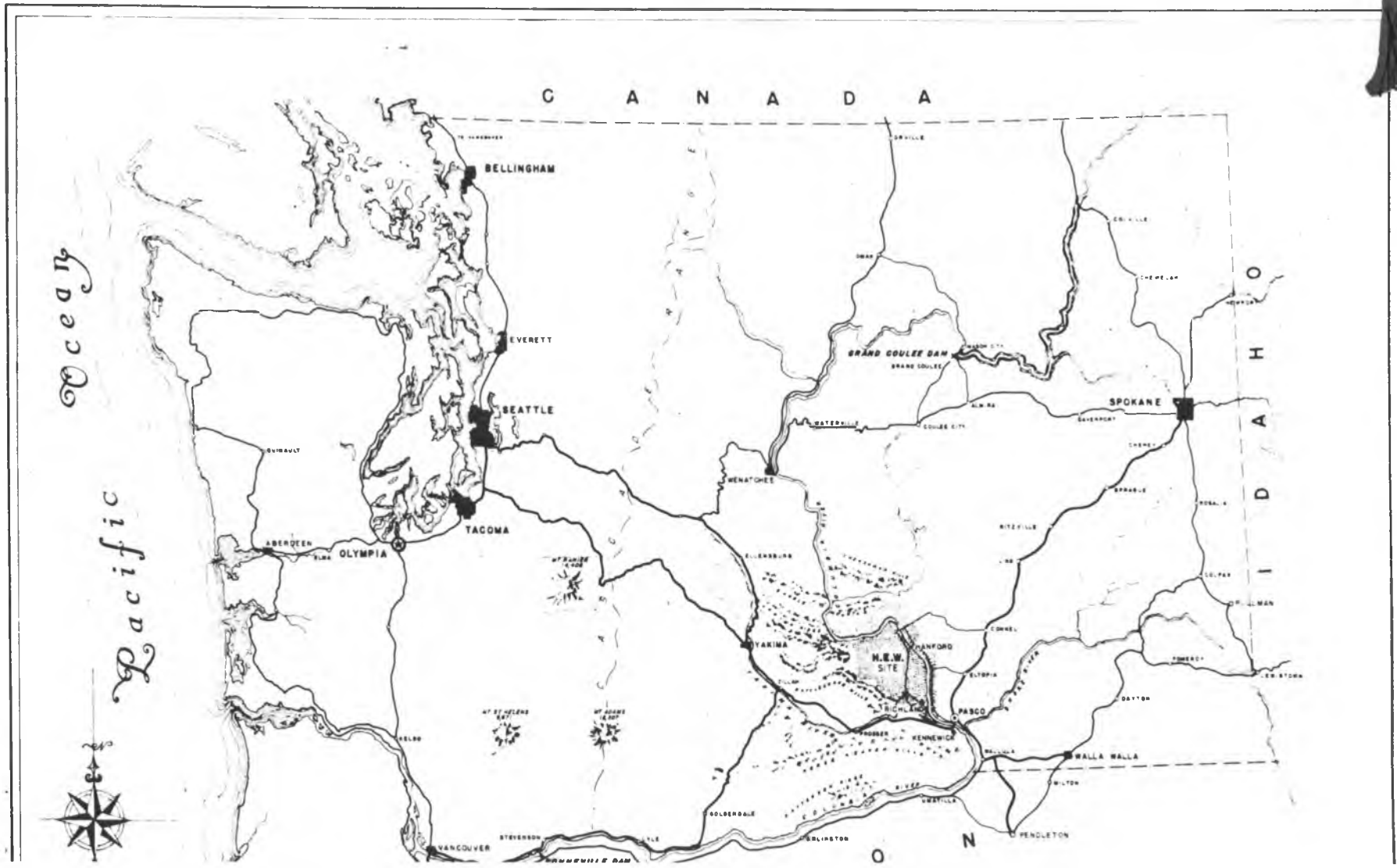
**LEGEND**

- 100-B PILE AREA
- 100-D " "
- 100-F " "
- 200-N PROCESS METAL STORAGE AREA
- 200-E SEPARATION AREA
- 200-W " "

- AREA ACQUIRED IN FEE
- - - AREA LEASED-OCCUPANTS REMOVED
- AREA LEASED-OCCUPANTS REMAIN
- == ROADS
- RAILROADS
- - - FENCE
- POWER LINES
- WATER LINES

**HANFORD ENGINEER WORKS**





C A N A D A

Ocean  
Pacific

I D A H O



BELLINGHAM

EVERETT

SEATTLE

TACOMA

OLYMPIA

ABERDEEN

VANCOUVER

WENATCHEE

YAKIMA

GRAND COULEE DAM

GRAND COULEE

SPOKANE

H.E.W. SITE

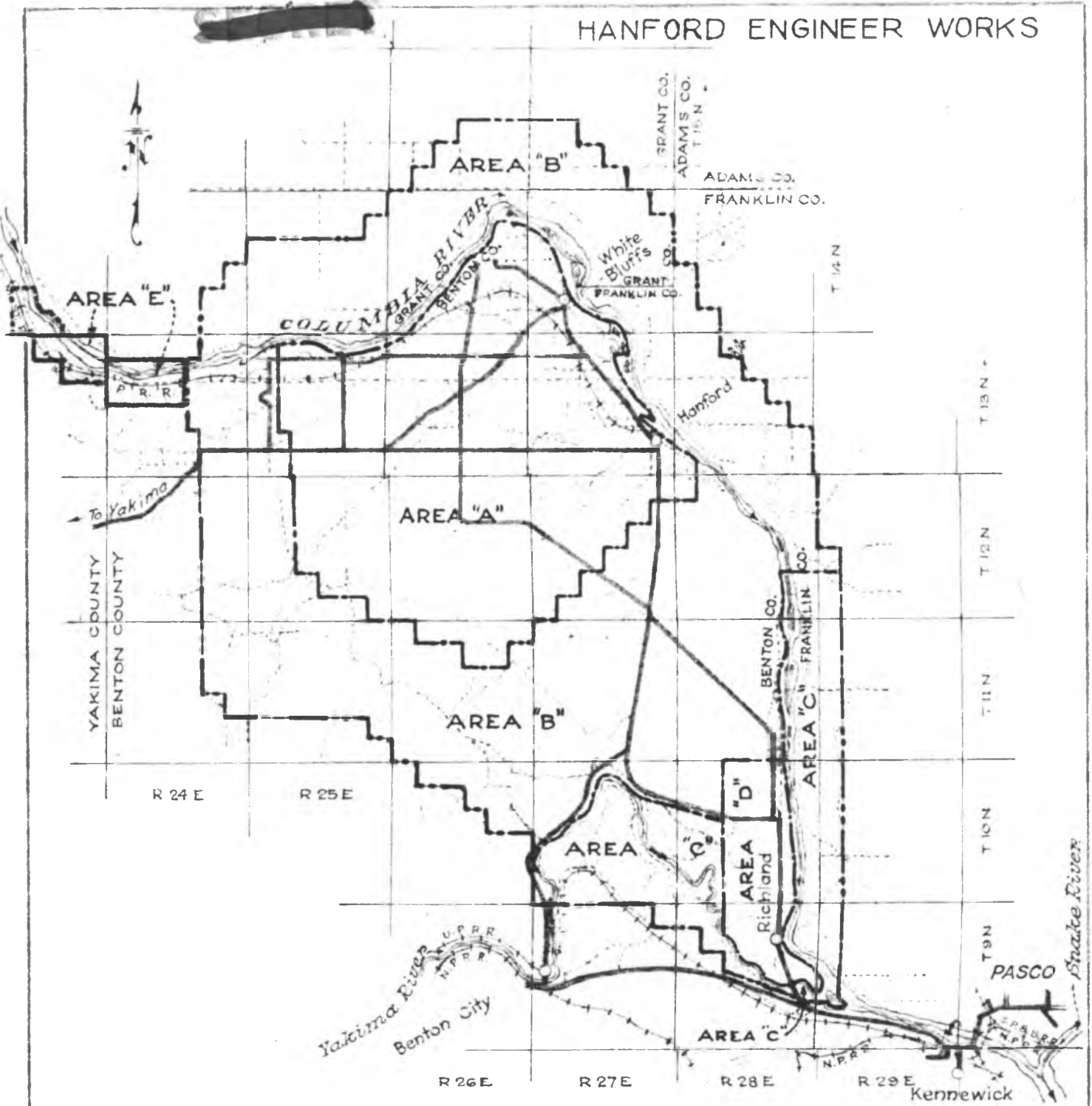
PASCO

WALLA WALLA

PENDLETON

O R E G O N

# HANFORD ENGINEER WORKS



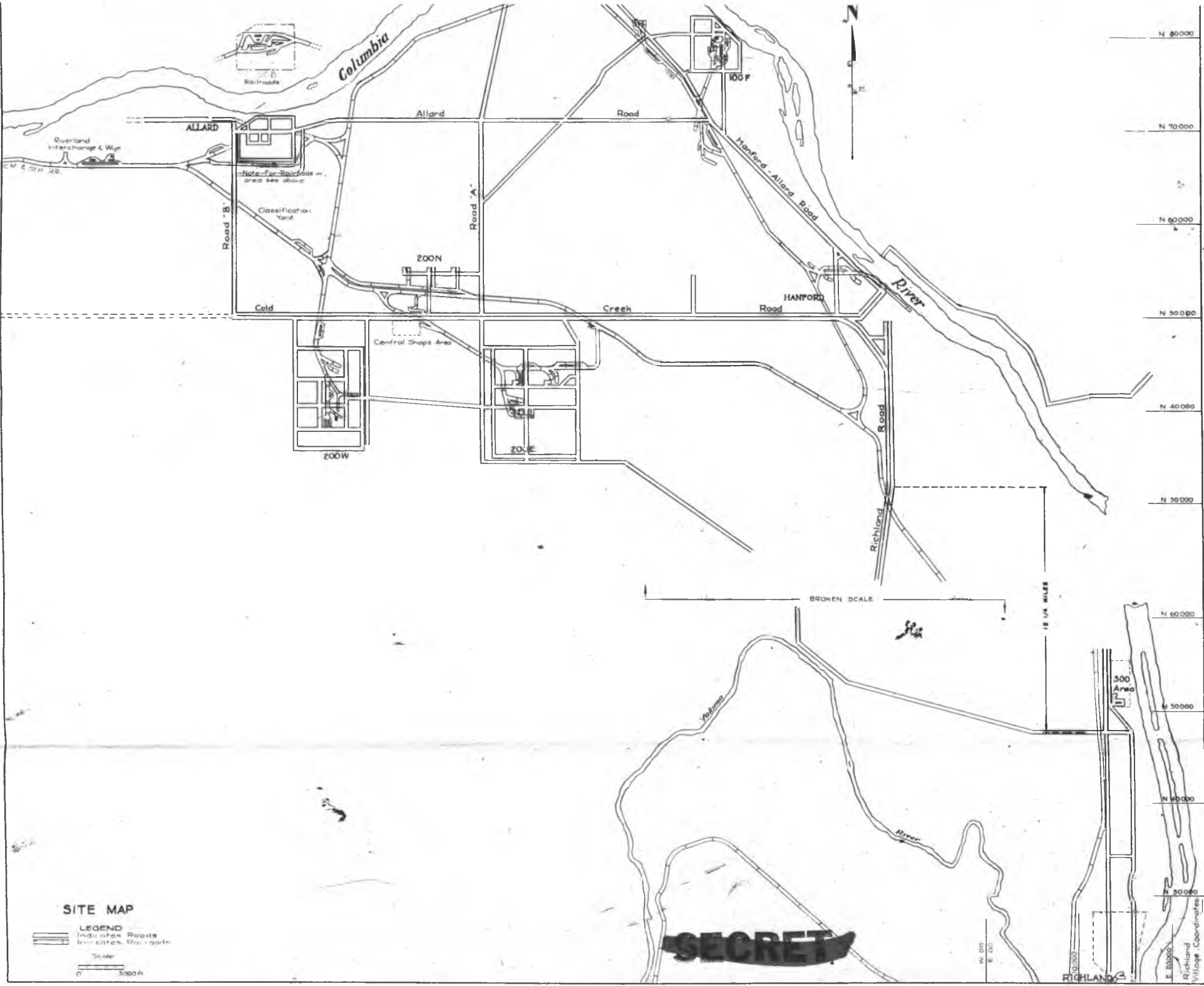
AREA "A" & "D" - Acquired in fee	- *	140,081	Acres
AREA "B" - Acquired by lease	- **	239,014	Acres
AREA "C" - Restrictive Agreement	-	43,227	Acres
AREA "E" - Acquired by lease	-	6,649	Acres

\* Includes 23,800 Acres of Public Domain  
 \*\* Includes 45,353 " " " "

**CLASSIFICATION CANCELLED**  
 OR CHANGED TO Unclassified  
 BY AUTHORITY OF HW-37965-L Kally  
 BY AWA/ada DATE 2-13-29

209 213 6-27-29





N 80000  
 N 70000  
 N 60000  
 N 50000  
 N 40000  
 N 30000

BROKEN SCALE

1.8 1/4 MILES

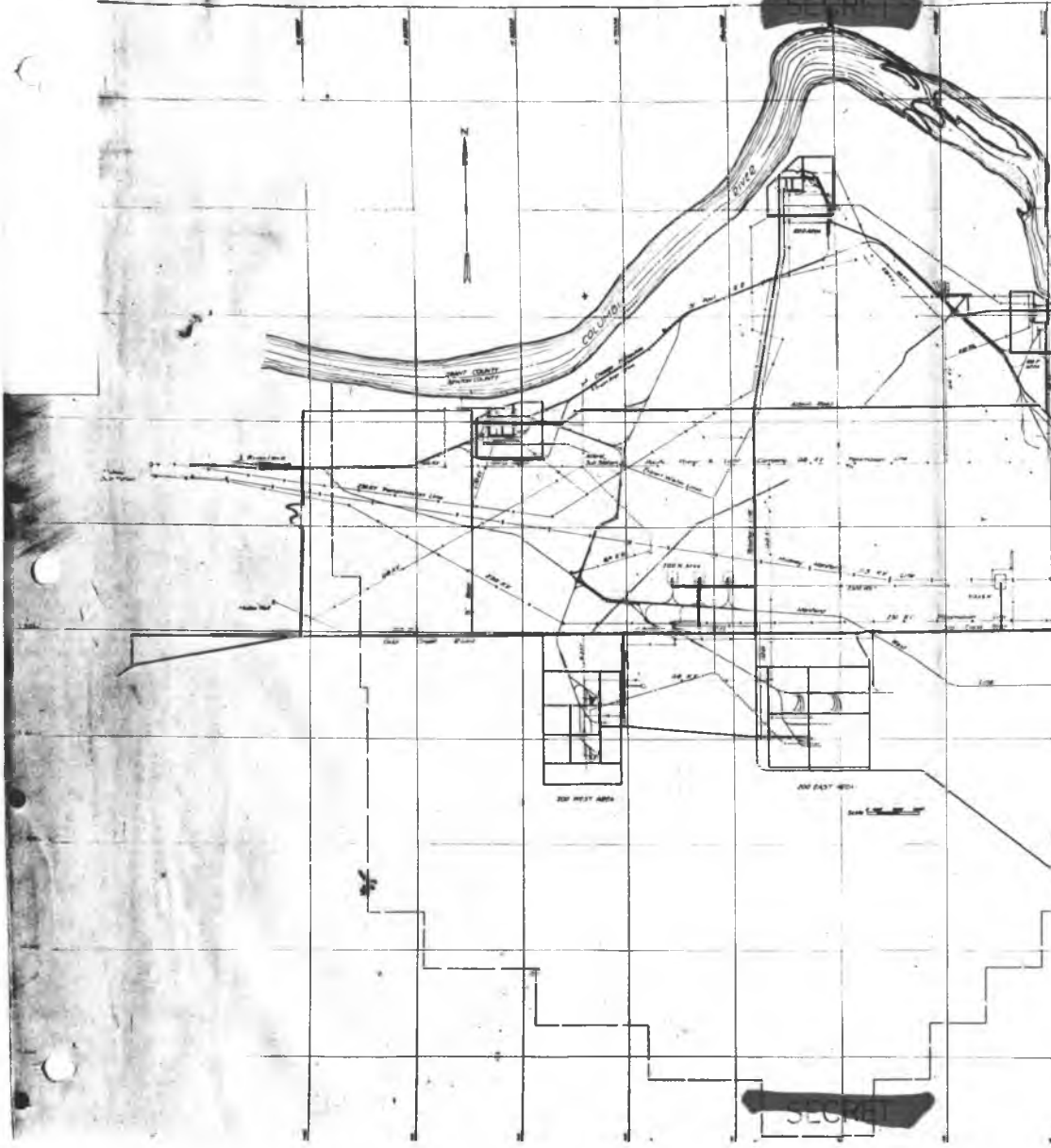
N 60000  
 N 50000  
 N 40000  
 N 30000  
 E 20000  
 RICHLAND  
 Richland  
 Village Coordinates

**SITE MAP**

**LEGEND**  
 ———— Roads  
 - - - - - Railroads  
 --- --- Canals

Scale  
 0 5000 FT

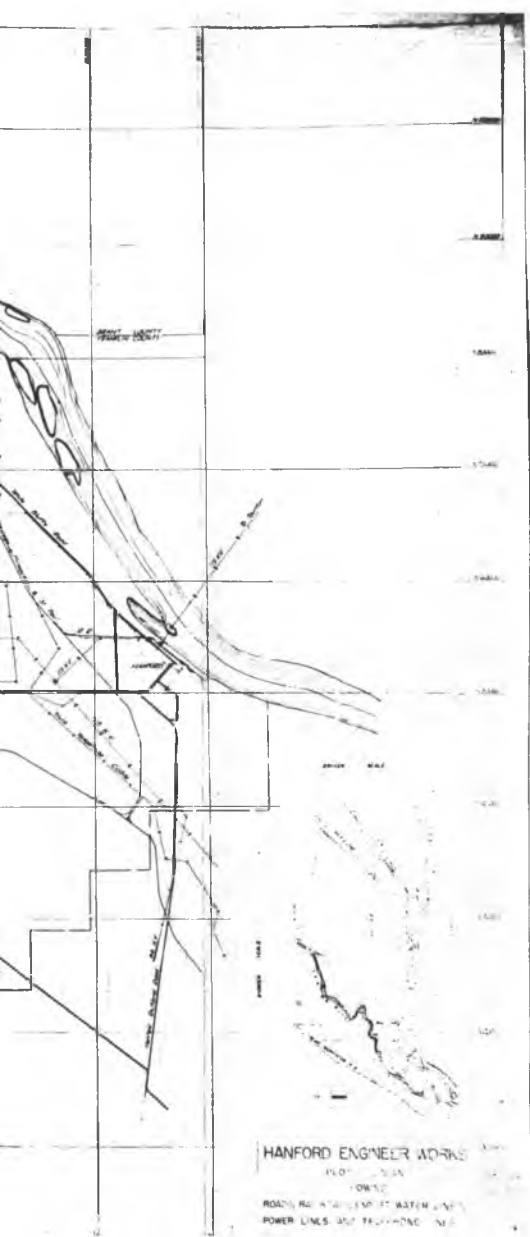
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NEW WEST AREA

NEW EAST AREA

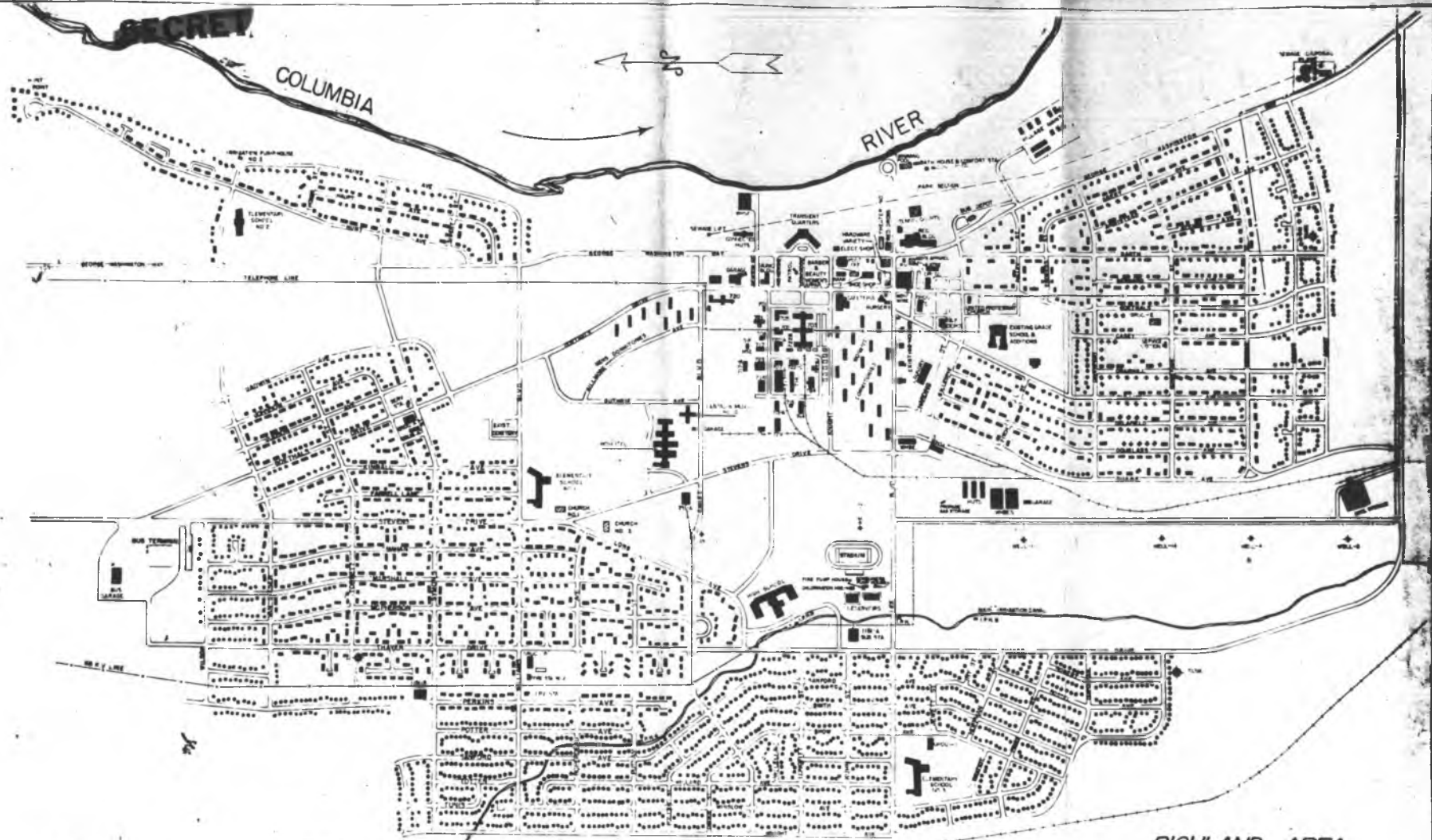
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COLUMBIA

RIVER



RICHLAND AREA



**SECRET**

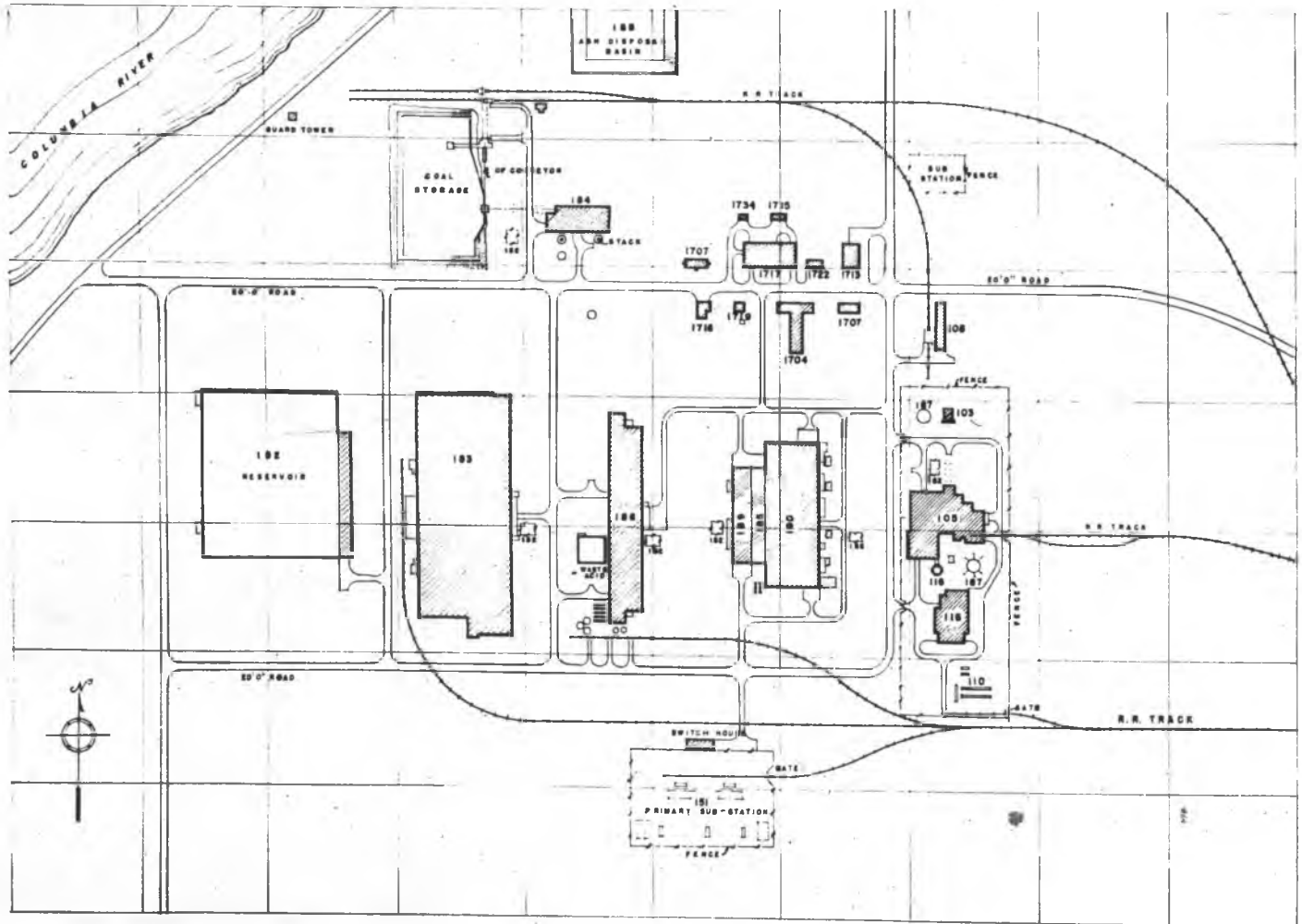
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FORM 5000 10-58

TRIP

• LEGEND •

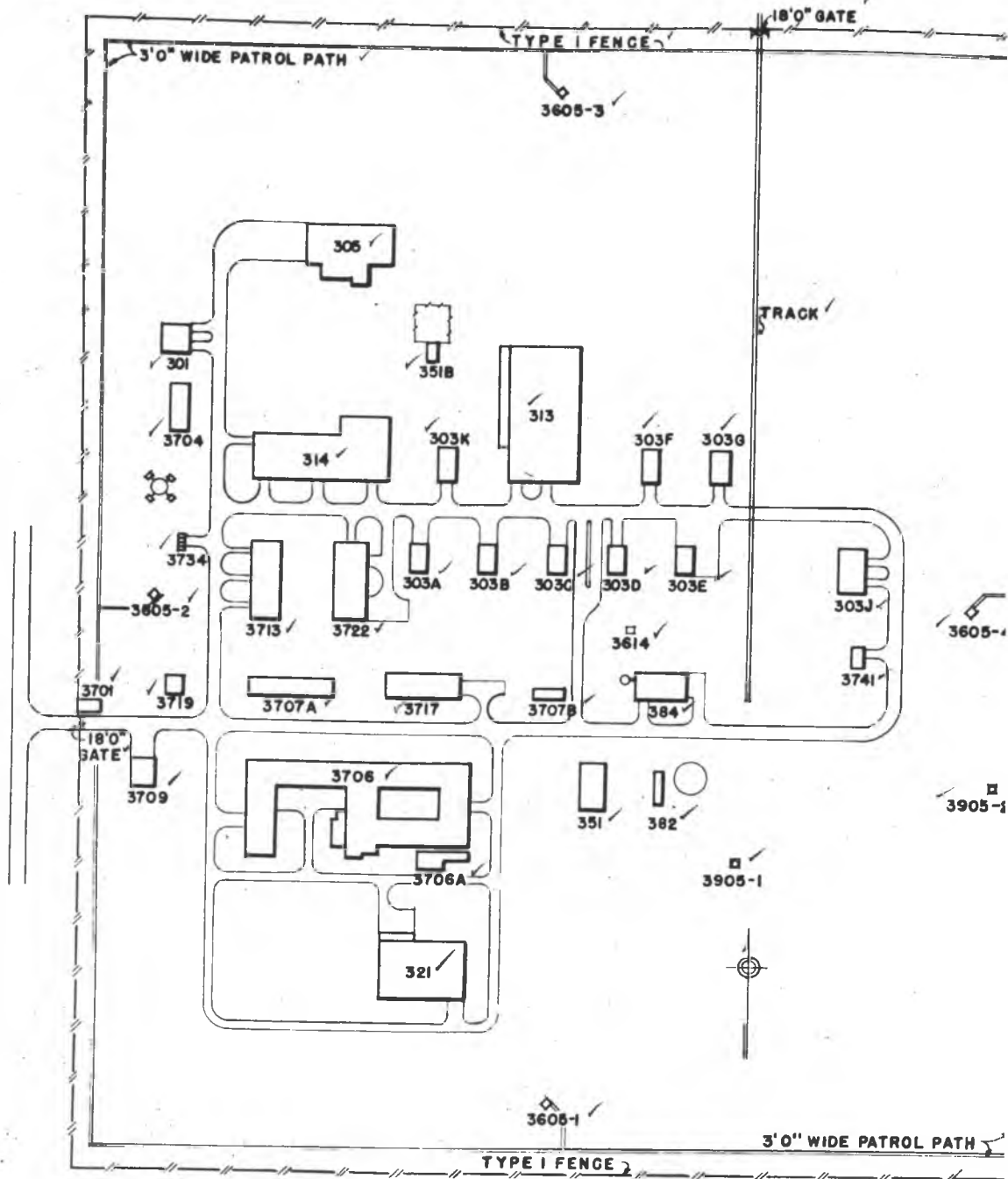
- 108 METAL STORAGE
- 109 PILE BUILDING
- 107 RETENTION BASIN
- 108 CHEMICAL BUILDING
- 110 HELIUM STORAGE
- 118 HELIUM CIRCULATION & PURIFICATION
- 116 STACK
- 19 PRIMARY SUB-STATION
- 192 SECONDARY SUB-STATION
- 181 RIVER PUMP HOUSE
- 182 RESERVOIR & PUMP HOUSE
- 183 FILTER PLANT & PUMPS
- 188 POWER HOUSE
- 188 DEAERATING PLANT
- 186 DEMINERALIZATION PLANT
- 187 ELEVATED TANKS
- 188 ASH DISPOSAL BASIN
- 189 REFRIGERATION BLDG.
- 190 MAIN PUMP HOUSE
- 1701 GATE HOUSE & CLOCK ALLEY
- 1704 SUPERVISOR'S OFFICE & LAB.
- 1707 CHANGE HOUSE
- 1708 FIRE HEADQUARTERS
- 1718 STOREROOM
- 1718 OIL & PAINT STORAGE
- 1716 AUTOMOTIVE REPAIR SHOP
- 1717 COMBINED SHOPS
- 1719 FIRST AID
- 1720 PATROL HEADQUARTERS
- 1722 AREA SHOP
- 1734 CYLINDER STORAGE



1-11

SECRET

# METAL FABRICATION AND TESTING 300 AREA LAYOUT



## • LIST OF BUILDINGS •

- ✓ 301 STORAGE - GRAPHITE
- ✓ 303 - A,B,C,D,E,F,G,J,K. METAL STORAGE BLDGS.
- ✓ 305 TEST PILE
- ✓ 313 SLUG MACHINING AND CANNING
- ✓ 314 ROD EXTRUSION
- ✓ 321 SEPARATION LABORATORY
- ✓ 351 - 351-B SUB STATION
- ✓ 382 PUMP HOUSE
- ✓ 384 BOILER HOUSE
- ✓ 3605 - 1,2,3 & 4 GUARD TOWERS
- ✓ 3614 MONITOR STATION
- ✓ 3701 GATE HOUSE
- ✓ 3704 SUPERVISOR'S OFFICE
- ✓ 3706 LABORATORY
- ✓ 3706 - A AIR CONDITIONING
- ✓ 3707 - A CHANGE HOUSE
- ✓ 3707 - B CHANGE HOUSE
- ✓ 3709 FIRE HEADQUARTERS
- ✓ 3713 STORE ROOM - SUPPLIES
- ✓ 3717 INSTRUMENT SHOP
- ✓ 3719 FIRST AID
- ✓ 3722 AREA MAINTENANCE SHOP
- ✓ 3734 CYLINDER STORAGE
- ✓ 3741 BOX STORAGE
- ✓ 3905 - 1,2 WELLS

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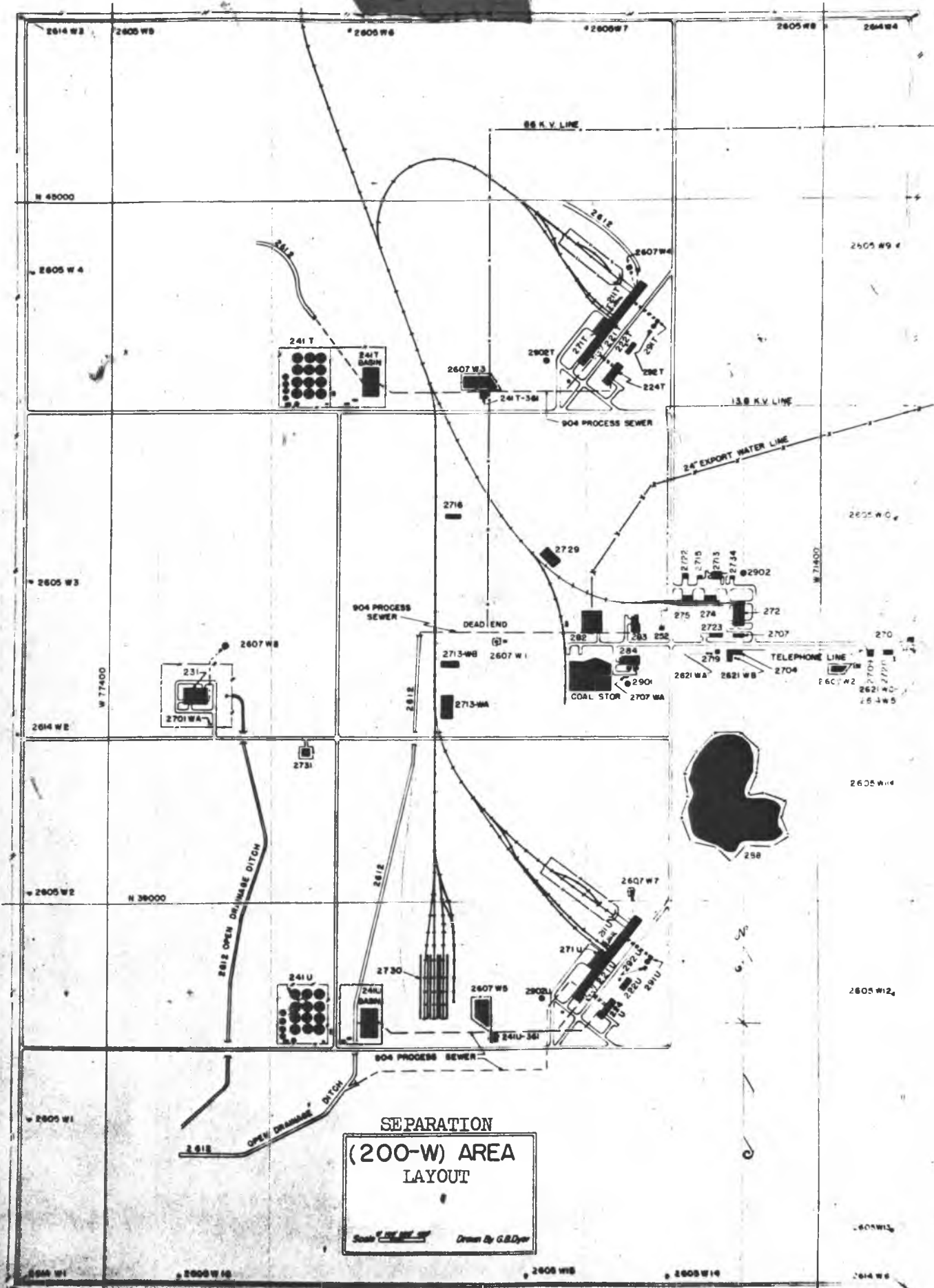
APPENDIX A 9

SEPARATION AREA LAYOUT

Legend

- 211 - Tank Farm
- 221 - Separation Building
- 222 - Sample Preparation Building
- 224 - Concentration Building
- 231 - Isolation Building
- 241 - Waste Disposal
- 252 - Secondary Substation
- 271 - Service Building
- 272 - Shops
- 274 - Machinery Store-House
- 275 - Chemical Store-House
- 282 - Reservoirs and Pump House
- 285 - Filter Plant
- 284 - Power House
- 291 - Ventilation Building
- 2901 - Water Storage
- 2902 - Water Storage
- 2704 - Supervisors' Office
- 2707 - Change House
- 2715 - Store Rooms
- 2715 - Oil and Paint Storage
- 2719 - First Aid
- 2722 - Paint and Riggers Shop
- 2723 - Laundry
- 2734 - Cylinder Storage

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SEPARATION  
 (200-W) AREA  
 LAYOUT

Scale 1" = 100' Drawn By G.B.Dyer

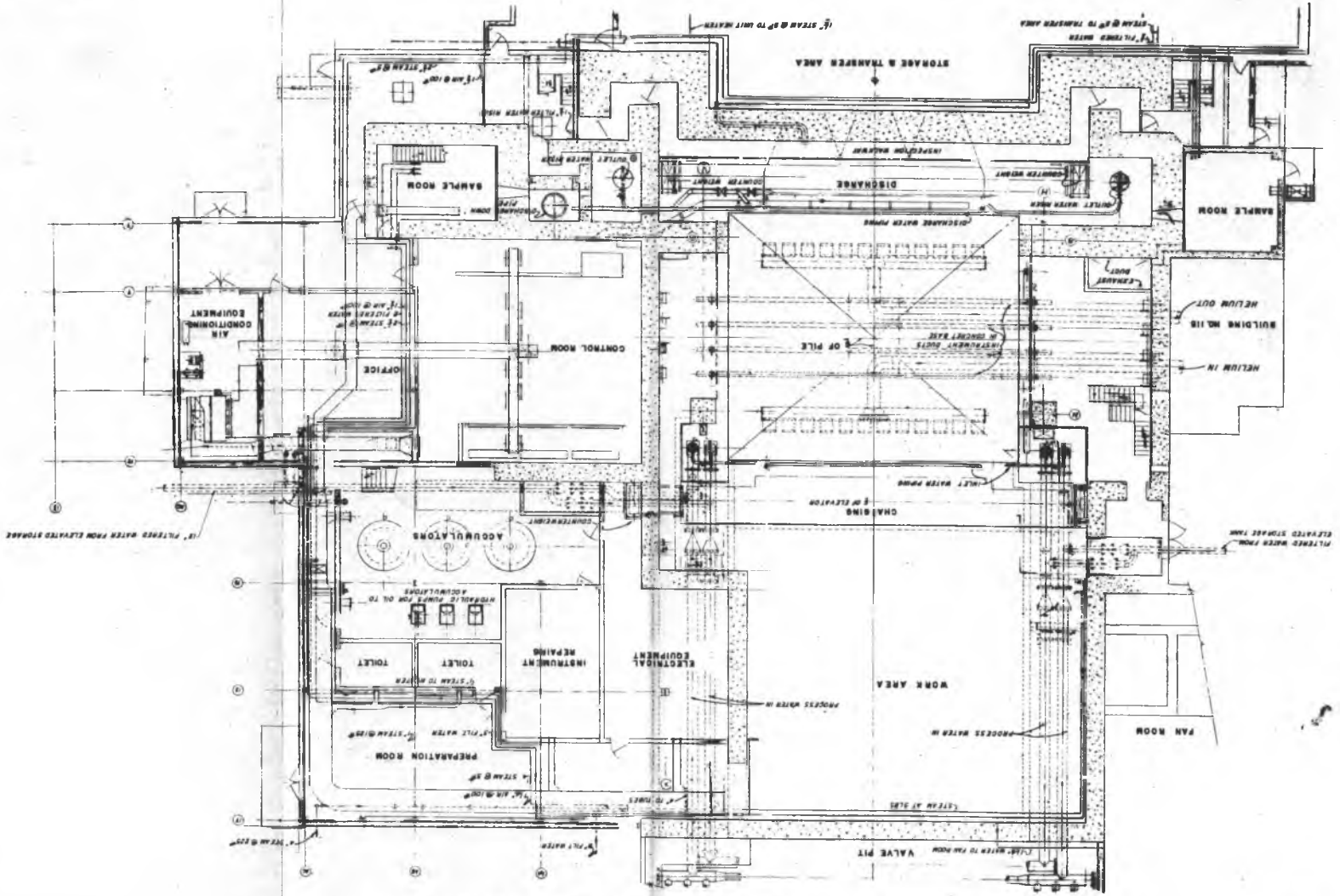
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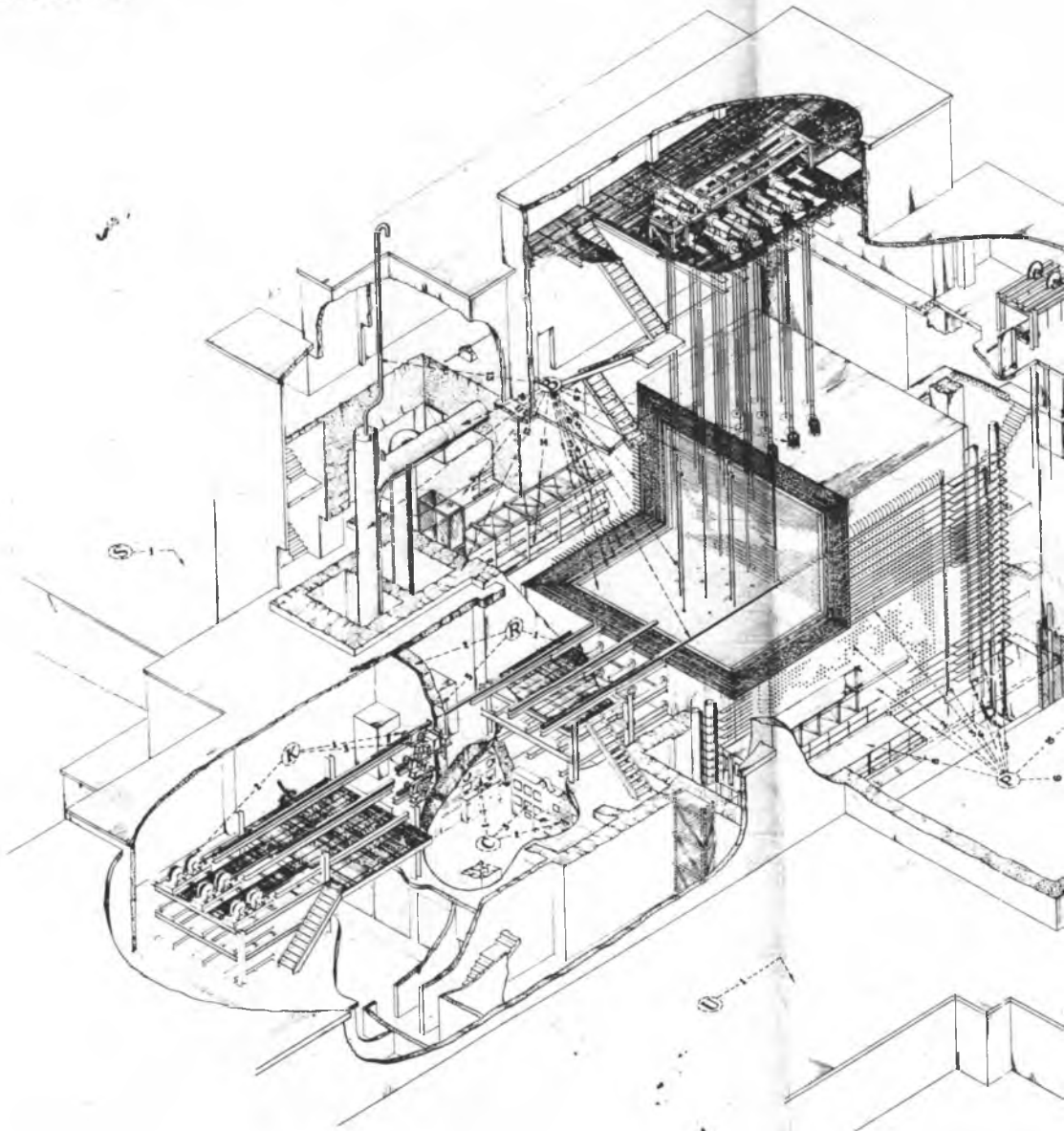
A10

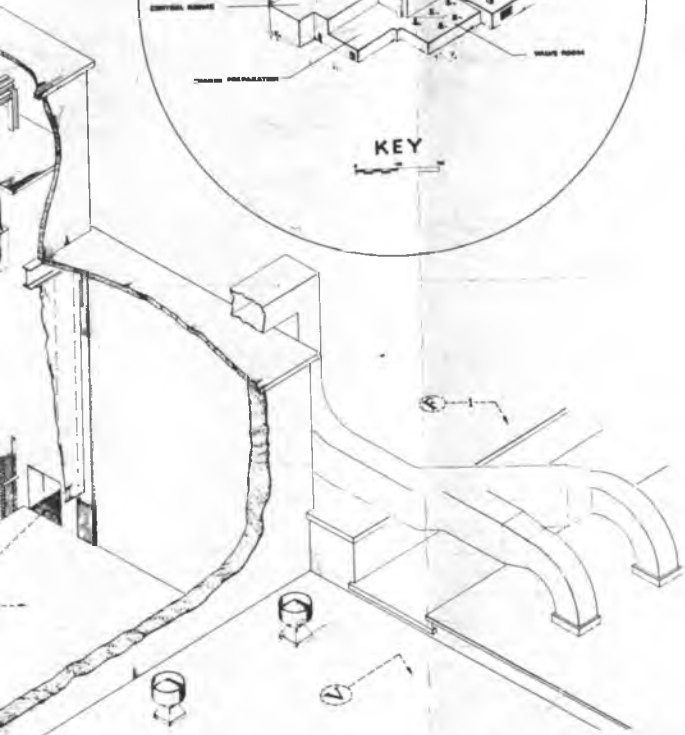
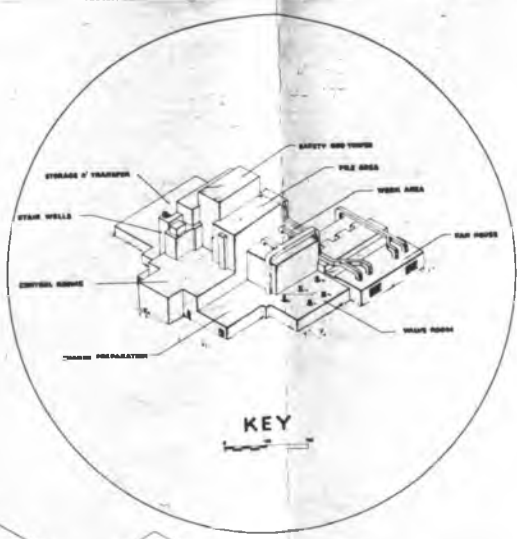


GROUND FLOOR PLAN OF BUILDING NO. 105

10001

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# HANFORD ENGINEER WORKS PILE BUILDING

## CHARGING FACE

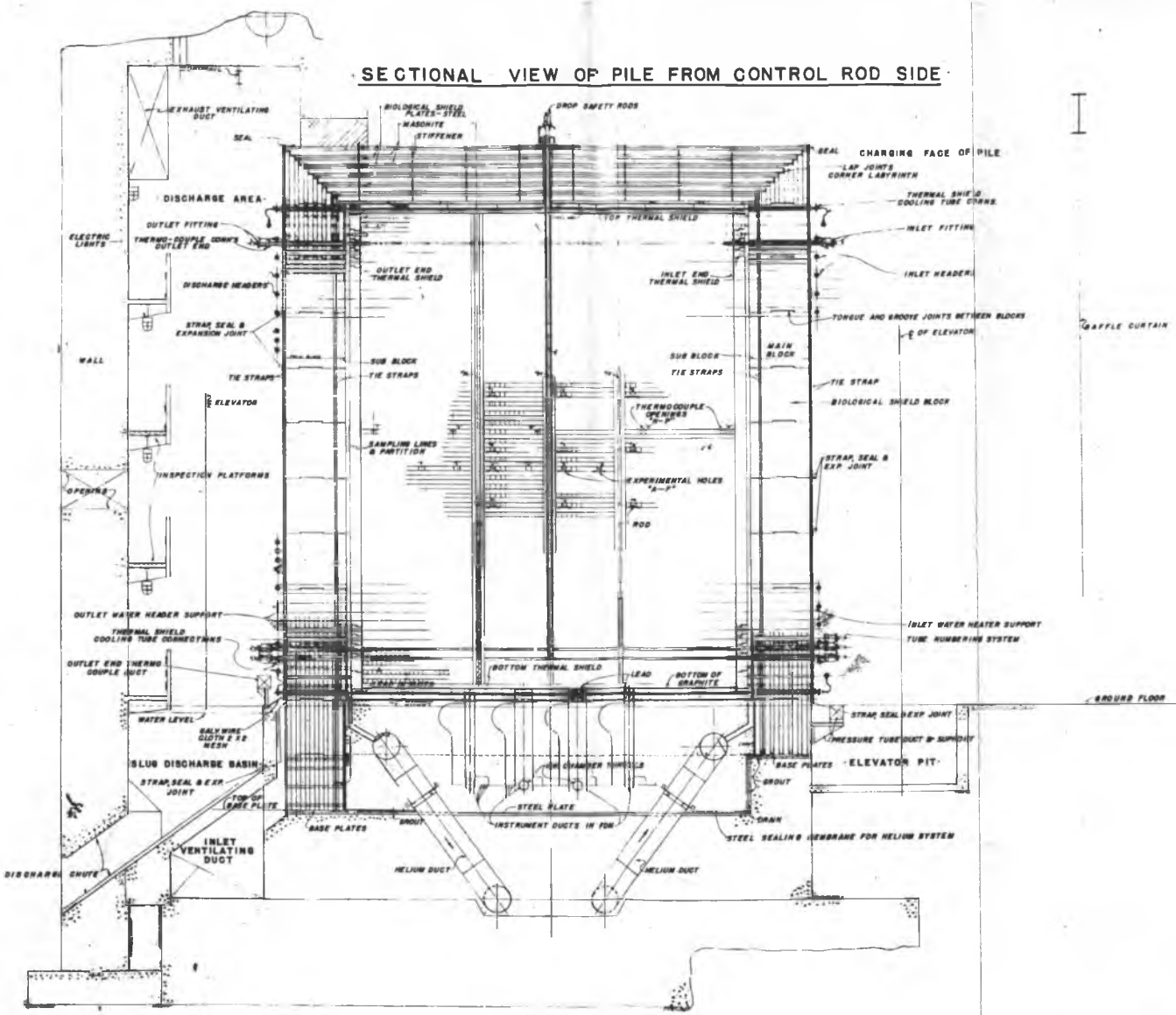
- CHARGE F
- U-1 ARMORING
- FACE OF J
- M-1 SHELF C
- M-2 SHELF D
- M-3 SHELF E
- M-4 SHELF F
- M-5 SHELF G
- M-6 SHELF H
- M-7 SHELF I
- M-8 SHELF J
- M-9 SHELF K
- M-10 SHELF L
- M-11 SHELF M
- M-12 SHELF N
- M-13 SHELF O
- M-14 SHELF P
- M-15 SHELF Q
- M-16 SHELF R
- M-17 SHELF S
- M-18 SHELF T
- M-19 SHELF U
- M-20 SHELF V
- M-21 SHELF W
- M-22 SHELF X
- M-23 SHELF Y
- M-24 SHELF Z
- M-25 SHELF AA
- M-26 SHELF AB
- M-27 SHELF AC
- M-28 SHELF AD
- M-29 SHELF AE
- M-30 SHELF AF
- M-31 SHELF AG
- M-32 SHELF AH
- M-33 SHELF AI
- M-34 SHELF AJ
- M-35 SHELF AK
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- M-50 SHELF AZ
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- M-397 SHELF OI
- M-398 SHELF OJ
- M-399 SHELF OK
- M-400 SHELF OL
- M-401 SHELF OM
- M-402 SHELF ON
- M-403 SHELF OO
- M-404 SHELF OP
- M-405 SHELF OQ
- M-406 SHELF OR
- M-407 SHELF OS
- M-408 SHELF OT
- M-409 SHELF OU
- M-410 SHELF OV
- M-411 SHELF OW
- M-412 SHELF OX
- M-413 SHELF OY
- M-414 SHELF OZ
- M-415 SHELF PA
- M-416 SHELF PB
- M-417 SHELF PC
- M-418 SHELF PD
- M-419 SHELF PE
- M-420 SHELF PF
- M-421 SHELF PG
- M-422 SHELF PH
- M-423 SHELF PI
- M-424 SHELF PJ
- M-425 SHELF PK
- M-426 SHELF PL
- M-427 SHELF PM
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- M-429 SHELF PO
- M-430 SHELF PP
- M-431 SHELF PQ
- M-432 SHELF PR
- M-433 SHELF PS
- M-434 SHELF PT
- M-435 SHELF PU
- M-436 SHELF PV
- M-437 SHELF PW
- M-438 SHELF PX
- M-439 SHELF PY
- M-440 SHELF PZ
- M-441 SHELF QA
- M-442 SHELF QB
- M-443 SHELF QC
- M-444 SHELF QD
- M-445 SHELF QE
- M-446 SHELF QF
- M-447 SHELF QG
- M-448 SHELF QH
- M-449 SHELF QI
- M-450 SHELF QJ
- M-451 SHELF QK
- M-452 SHELF QL
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- M-454 SHELF QN
- M-455 SHELF QO
- M-456 SHELF QP
- M-457 SHELF QQ
- M-458 SHELF QR
- M-459 SHELF QS
- M-460 SHELF QT
- M-461 SHELF QU
- M-462 SHELF QV
- M-463 SHELF QW
- M-464 SHELF QX
- M-465 SHELF QY
- M-466 SHELF QZ
- M-467 SHELF RA
- M-468 SHELF RB
- M-469 SHELF RC
- M-470 SHELF RD
- M-471 SHELF RE
- M-472 SHELF RF
- M-473 SHELF RG
- M-474 SHELF RH
- M-475 SHELF RI
- M-476 SHELF RJ
- M-477 SHELF RK
- M-478 SHELF RL
- M-479 SHELF RM
- M-480 SHELF RN
- M-481 SHELF RO
- M-482 SHELF RP
- M-483 SHELF RQ
- M-484 SHELF RR
- M-485 SHELF RS
- M-486 SHELF RT
- M-487 SHELF RU
- M-488 SHELF RV
- M-489 SHELF RW
- M-490 SHELF RX
- M-491 SHELF RY
- M-492 SHELF RZ
- M-493 SHELF SA
- M-494 SHELF SB
- M-495 SHELF SC
- M-496 SHELF SD
- M-497 SHELF SE
- M-498 SHELF SF
- M-499 SHELF SG
- M-500 SHELF SH
- M-501 SHELF SI
- M-502 SHELF SJ
- M-503 SHELF SK
- M-504 SHELF SL
- M-505 SHELF SM
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- M-507 SHELF SO
- M-508 SHELF SP
- M-509 SHELF SQ
- M-510 SHELF SR
- M-511 SHELF SS
- M-512 SHELF ST
- M-513 SHELF SU
- M-514 SHELF SV
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- M-521 SHELF TC
- M-522 SHELF TD
- M-523 SHELF TE
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- M-538 SHELF TT
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- M-544 SHELF TZ
- M-545 SHELF UA
- M-546 SHELF UB
- M-547 SHELF UC
- M-548 SHELF UD
- M-549 SHELF UE
- M-550 SHELF UF
- M-551 SHELF UG
- M-552 SHELF UH
- M-553 SHELF UI
- M-554 SHELF UJ
- M-555 SHELF UK
- M-556 SHELF UL
- M-557 SHELF UM
- M-558 SHELF UN
- M-559 SHELF UO
- M-560 SHELF UP
- M-561 SHELF UQ
- M-562 SHELF UR
- M-563 SHELF US
- M-564 SHELF UT
- M-565 SHELF UY
- M-566 SHELF UZ
- M-567 SHELF VA
- M-568 SHELF VB
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- M-570 SHELF VD
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- M-594 SHELF WB
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- M-597 SHELF WE
- M-598 SHELF WF
- M-599 SHELF WG
- M-600 SHELF WH
- M-601 SHELF WI
- M-602 SHELF WJ
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- M-605 SHELF WM
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- M-609 SHELF WQ
- M-610 SHELF WR
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- M-612 SHELF WT
- M-613 SHELF WU
- M-614 SHELF WV
- M-615 SHELF WW
- M-616 SHELF WX
- M-617 SHELF WY
- M-618 SHELF WZ
- M-619 SHELF XA
- M-620 SHELF XB
- M-621 SHELF XC
- M-622 SHELF XD
- M-623 SHELF XE
- M-624 SHELF XF
- M-625 SHELF XG
- M-626 SHELF XH
- M-627 SHELF XI
- M-628 SHELF XJ
- M-629 SHELF XK
- M-630 SHELF XL
- M-631 SHELF XM
- M-632 SHELF XN
- M-633 SHELF XO
- M-634 SHELF XP
- M-635 SHELF XQ
- M-636 SHELF XR
- M-637 SHELF XS
- M-638 SHELF XT
- M-639 SHELF XU
- M-640 SHELF XV
- M-641 SHELF XW
- M-642 SHELF XX
- M-643 SHELF XY
- M-644 SHELF XZ
- M-645 SHELF YA
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- M-647 SHELF YC
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- M-649 SHELF YE
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- M-677 SHELF ZG
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- M-684 SHELF ZN
- M-685 SHELF ZO
- M-686 SHELF ZP
- M-687 SHELF ZQ
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- M-689 SHELF ZS
- M-690 SHELF ZT
- M-691 SHELF ZU
- M-692 SHELF ZV
- M-693 SHELF ZW
- M-694 SHELF ZX
- M-695 SHELF ZY
- M-696 SHELF ZZ



- GENERAL INFORMATION**
1. GENERAL INFORMATION OF NEER WORKS BUILDING 6 FACE
- FACE OF PILE**
- 1.1 BUILDING COMPOSED OF LAMINATIONS OF STEEL AND CONCRETE.
- 1.2 MAIN TOWER PROJECT THROUGH SHAFT AND PILE HEADS.
- 1.3 MAIN TOWER LIFTED INTO TOWER. PLAN CONTROLLED BY TOWER FEED HEADS. THIS HEADS MADE IT POSSIBLE TO FEED INTO TOWER WITH DIFFERENTIAL SPEEDS. LESS ACTIVE TOWER WITH NUMBER OF HEADS, MORE TRANSPARENT, OTHER HEADS FEED.
- 1.4 VALUE IN EACH HEAD.
- 1.5 TOWER FOR CONCRETE OF BUILDING PILE.
- 1.6 AUXILIARY PUMP SYSTEM MAKES POSSIBLE BRINGING OF ANY SELECTED HEADS AT TIME OF LOADING PILE.
- 1.7 ELEVATOR PLATFORM FOR USE IN LOADING TOWER AND FOR ANY WORK ON PILE FACE. CAN BE WITHDRAWN AND ELEVATOR NOT BELIEF.
- 1.8 MAIN AREA. LENGTH DETERMINED BY POSSIBILITY OF MOVING TO REVERSE ALUMINUM TUBE FROM PILE. DUCT LEADS IN AIR FOR VENTILATION AND REMOVAL OF RADIOACTIVE EMANATIONS.
- 1.9 CAPABLE CONTROL FORCES VENTILATION TO SWEEP OVER WHOLE FACE OF PILE.
- TOWER HOUSE**
- 2.1 EQUIPMENT FOR CIRCULATING AIR THROUGH PILE BUILDING TO REMOVE RADIOACTIVE GASES.
- WATER ROOM**
- 3.1 WATER FOR CONTROL OF FLOW OF WATER IN INLET PIPES FROM REACTOR.
- 3.2 THERMAL BARRIER IN PILE LIFT UP IN CRACKS CLOSE TO PILE.
- 3.3 THERMAL BARRIER CONSTRUCTED OF RUBBER TO REMOVE MAJOR PART OF HEAT OF IMMEDIATE HEATING AND HEATING UNIT.
- 3.4 GAP FOR ENTRANCE OF HELIUM INTO PILE, REPLACES HYDROGEN, HELIUM ABSORBING COMPONENT OF AIR. LAMINATED SHOULD TO AVOID RISK OF RADIATION TO LIFE. SAFE FOR PERSONNEL.
- 3.5 SAFETY ROOM CONSTRUCTED IN TOWER. HELIUM IN TOWER. HELIUM SHOULD BE KEPT IN CASE OF EMERGENCY TO AVOID REACTION WITH HELIUM. HELIUM SHOULD BE KEPT IN CASE OF EMERGENCY TO AVOID REACTION WITH HELIUM. HELIUM SHOULD BE KEPT IN CASE OF EMERGENCY TO AVOID REACTION WITH HELIUM.
- 3.6 SAFETY ROOM CONSTRUCTED IN TOWER. HELIUM IN TOWER. HELIUM SHOULD BE KEPT IN CASE OF EMERGENCY TO AVOID REACTION WITH HELIUM. HELIUM SHOULD BE KEPT IN CASE OF EMERGENCY TO AVOID REACTION WITH HELIUM.
- 3.7 SAFETY ROOM CONSTRUCTED IN TOWER. HELIUM IN TOWER. HELIUM SHOULD BE KEPT IN CASE OF EMERGENCY TO AVOID REACTION WITH HELIUM. HELIUM SHOULD BE KEPT IN CASE OF EMERGENCY TO AVOID REACTION WITH HELIUM.
- 3.8 SAFETY ROOM CONSTRUCTED IN TOWER. HELIUM IN TOWER. HELIUM SHOULD BE KEPT IN CASE OF EMERGENCY TO AVOID REACTION WITH HELIUM. HELIUM SHOULD BE KEPT IN CASE OF EMERGENCY TO AVOID REACTION WITH HELIUM.
- 3.9 SAFETY ROOM CONSTRUCTED IN TOWER. HELIUM IN TOWER. HELIUM SHOULD BE KEPT IN CASE OF EMERGENCY TO AVOID REACTION WITH HELIUM. HELIUM SHOULD BE KEPT IN CASE OF EMERGENCY TO AVOID REACTION WITH HELIUM.
- 3.10 SAFETY ROOM CONSTRUCTED IN TOWER. HELIUM IN TOWER. HELIUM SHOULD BE KEPT IN CASE OF EMERGENCY TO AVOID REACTION WITH HELIUM. HELIUM SHOULD BE KEPT IN CASE OF EMERGENCY TO AVOID REACTION WITH HELIUM.
- ROD ROOM**
- 4.1 MAIN AREA OF WHICH NEVER MAY BE USED FOR COMPENSATION OR BALANCE PART OF UNKIND MARCH OF MULTIPLICATION FACTOR AND TWO FOR THE SAFETY TO SAFETY CONTROL OF THE CONSTRAINT OF THE POWER OUTPUT.
- 4.2 LEAD-CONCRETE WALL PROTECTS OPERATORS DURING SAFETY ACTIVITY IN CONTROL ROOMS WHILE THEY ARE IN PILE.
- 4.3 SAFETY ROOMS ESCAPE IN SAFETY FROM ROOMS BUT MAJORS POSSIBLE ENTRANCE TO ROOM AFTER DELAY OF ACTIVITY.
- BACK ROOM**
- 5.1 BACK AND FRONT DRIVE CONTROL ROOM.
- 5.2 FLEXIBLE HOUSE OPERATING ROOM HELIUM COOLING WATER TO ROOM AND LEAD HEATED WATER FROM ROOM.
- 5.3 HELIUM WATER TRANSMITS TO CONTROL ROOM INDICATION BY POSITION OF CONTROL ROD.
- CONTROL ROOM**
- 6.1 LIGHTS ON CONTROL PANEL GIVE INDICATION OF TEMPERATURE OF KEY POINTS IN ANY TUBE EXCESSIVE TEMPERATURES WILL BE SHOWN PANEL FACING THIS ON OPPOSITE SIDE OF ROOM GIVES INDICATION IF PRESSURE IS ONLY OF ANY TUBE EXCESSIVE OR HELIUM BEING PRESENTLY RANGE.
- 6.2 CONTROL PANEL PROVIDES INDICATION OF POSITION OF RODS AND OF OTHER OPERATING CONDITIONS. OPERATOR ADJUSTS POWER LEVEL BY ALTERING POSITION OF RODS BY REMOTE CONTROL.
- 6.3 POWER OUTPUT INDICATED ON PANEL. WATER HEATED ON BACK OF REACTOR OF WATER FLOW AND HEAT AND OUTLET TEMPERATURES.
- STORAGE AND TRANSFER**
- 7.1 BENCH FOR TEMPORARY UNDERWATER STORAGE OF BRISTLED UNDERWATER BLOBS. EQUIPMENT FOR TRANSPORT OF BLOBS TO CARDS WHICH CARRY THEM TO STORAGE AREA.
- 7.2 FURTHER DETAILS SHOWN ON ISOMETRIC VIEW OF PILE BUILDING FROM DECOMMISSION FACILITY.

SECRET

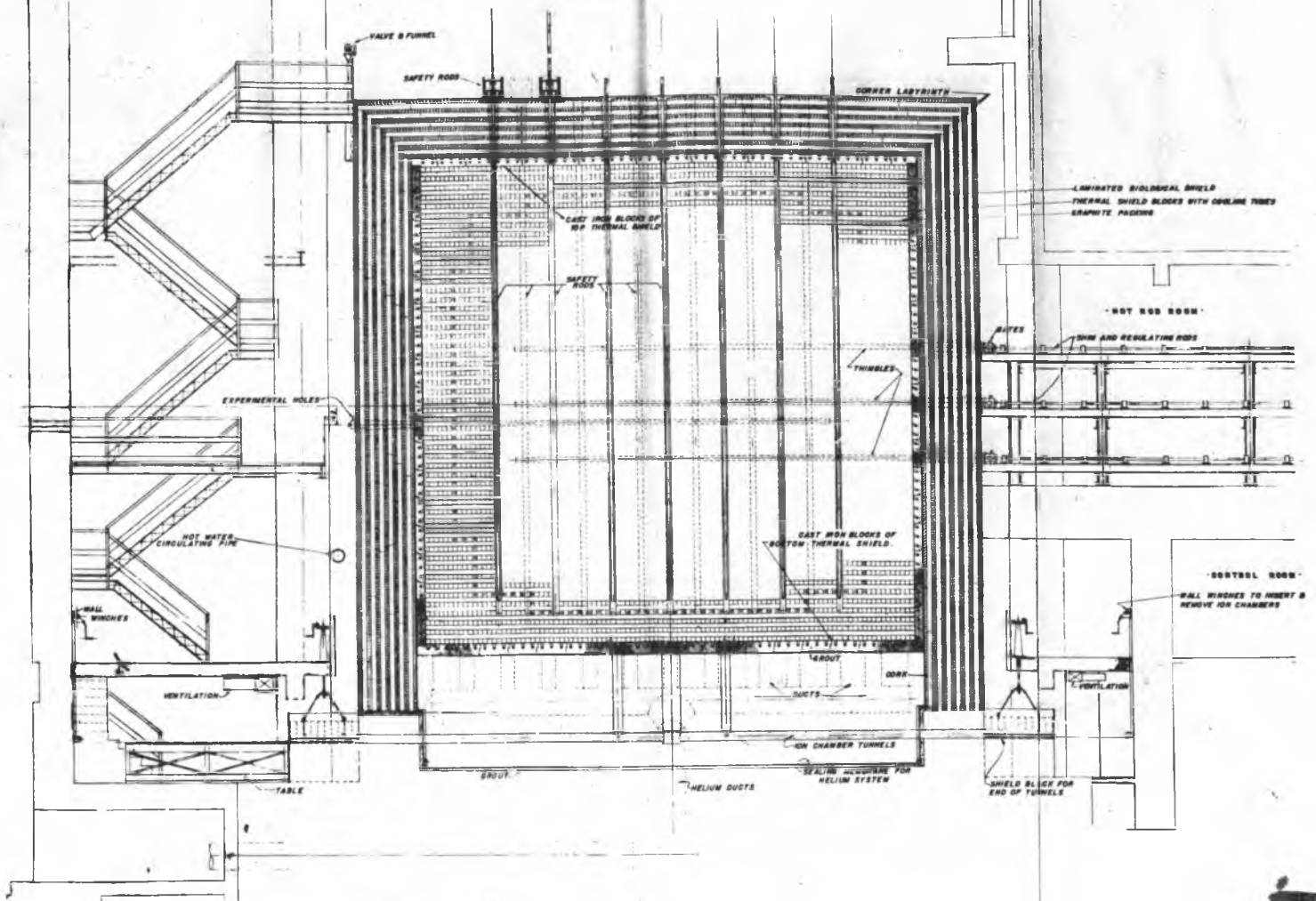
SECTIONAL VIEW OF PILE FROM CONTROL ROD SIDE



A12

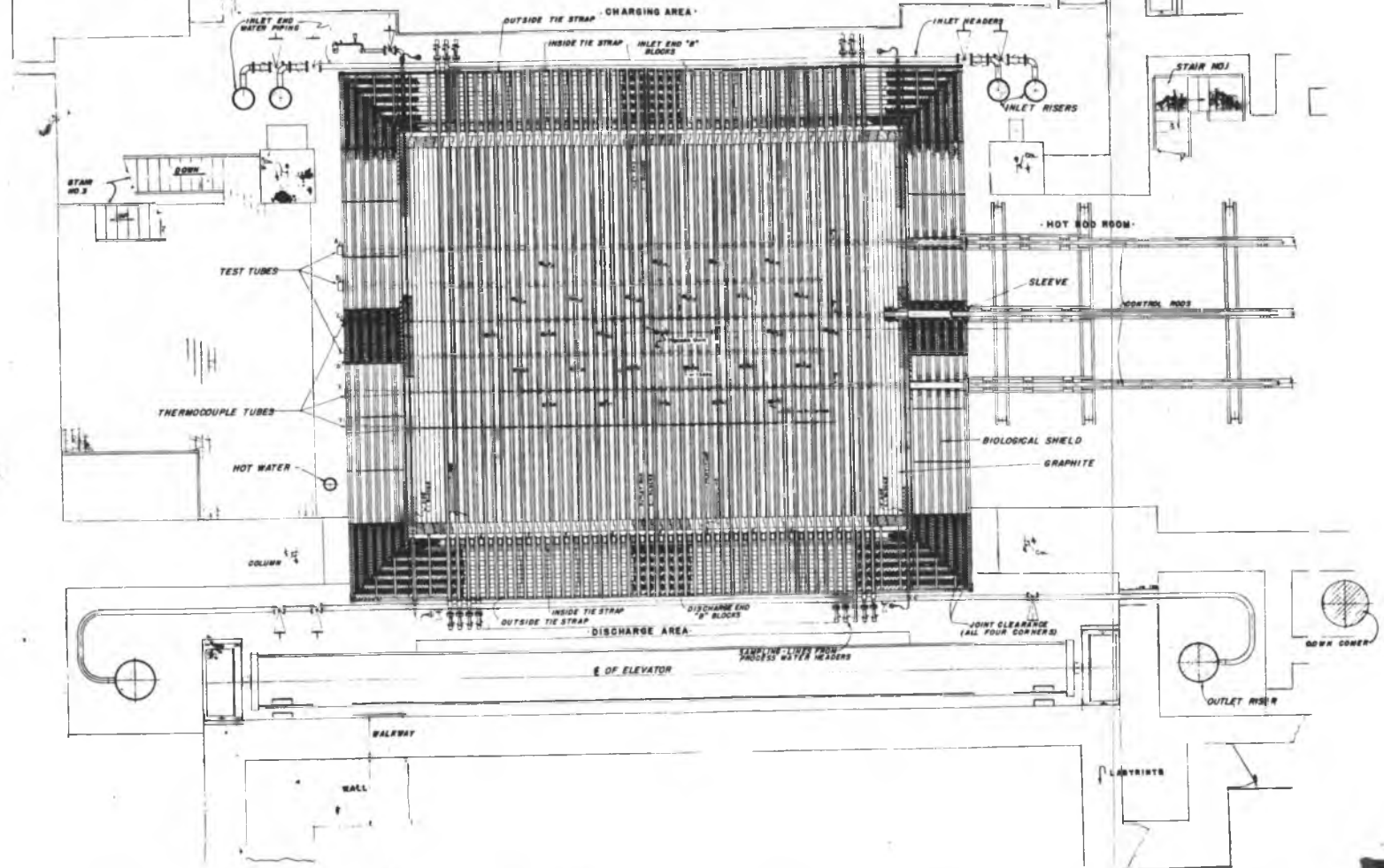
SECRET  
H.M.D-422-4

SECTIONAL VIEW OF PILE FROM DISCHARGE END



A13  
H-M-B-423-4

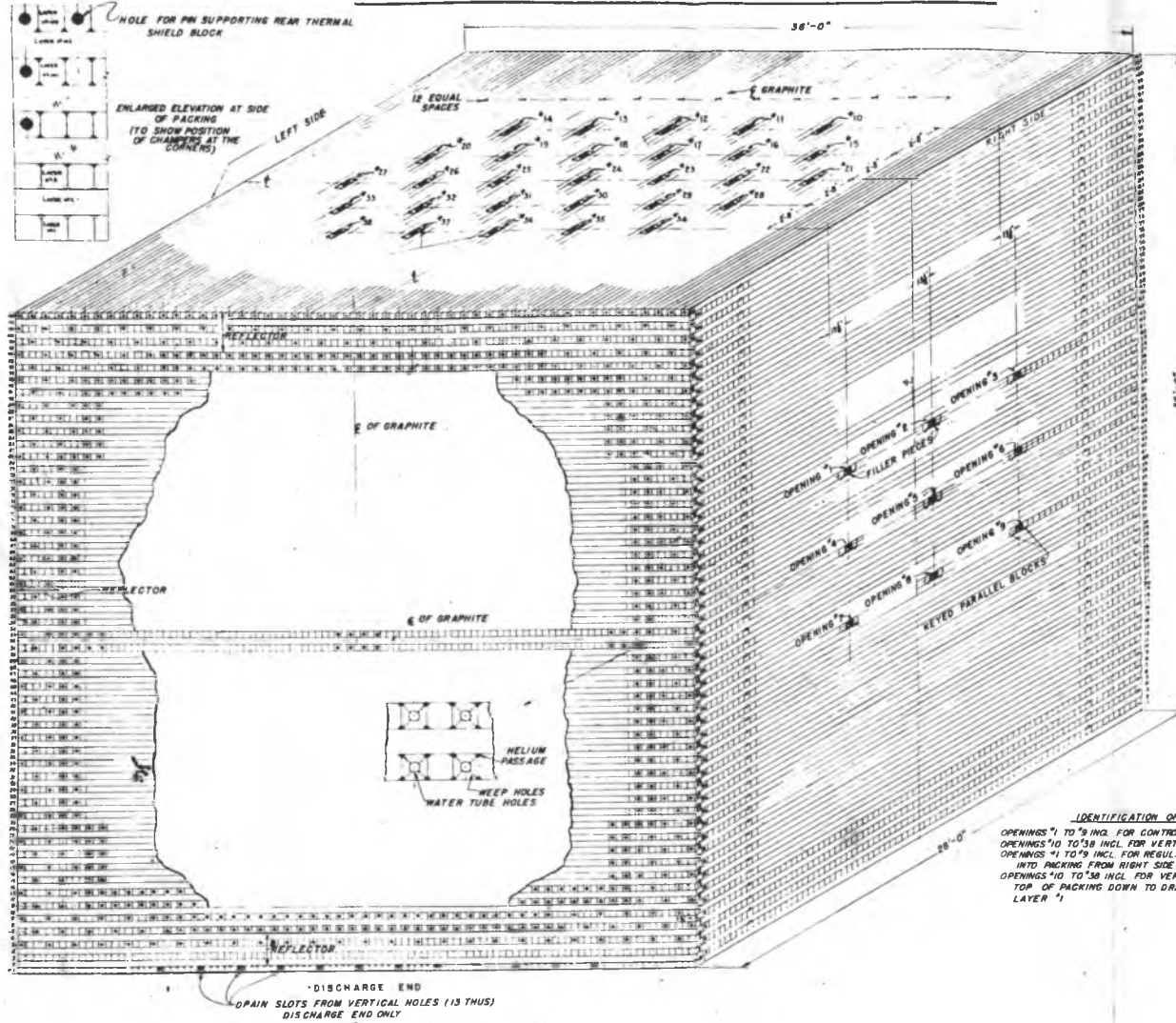
SECTIONAL VIEW OF PILE FROM TOP



A14

H-M-B-421-4

# EXTERNAL ISOMETRIC VIEW OF GRAPHITE ASSEMBLY



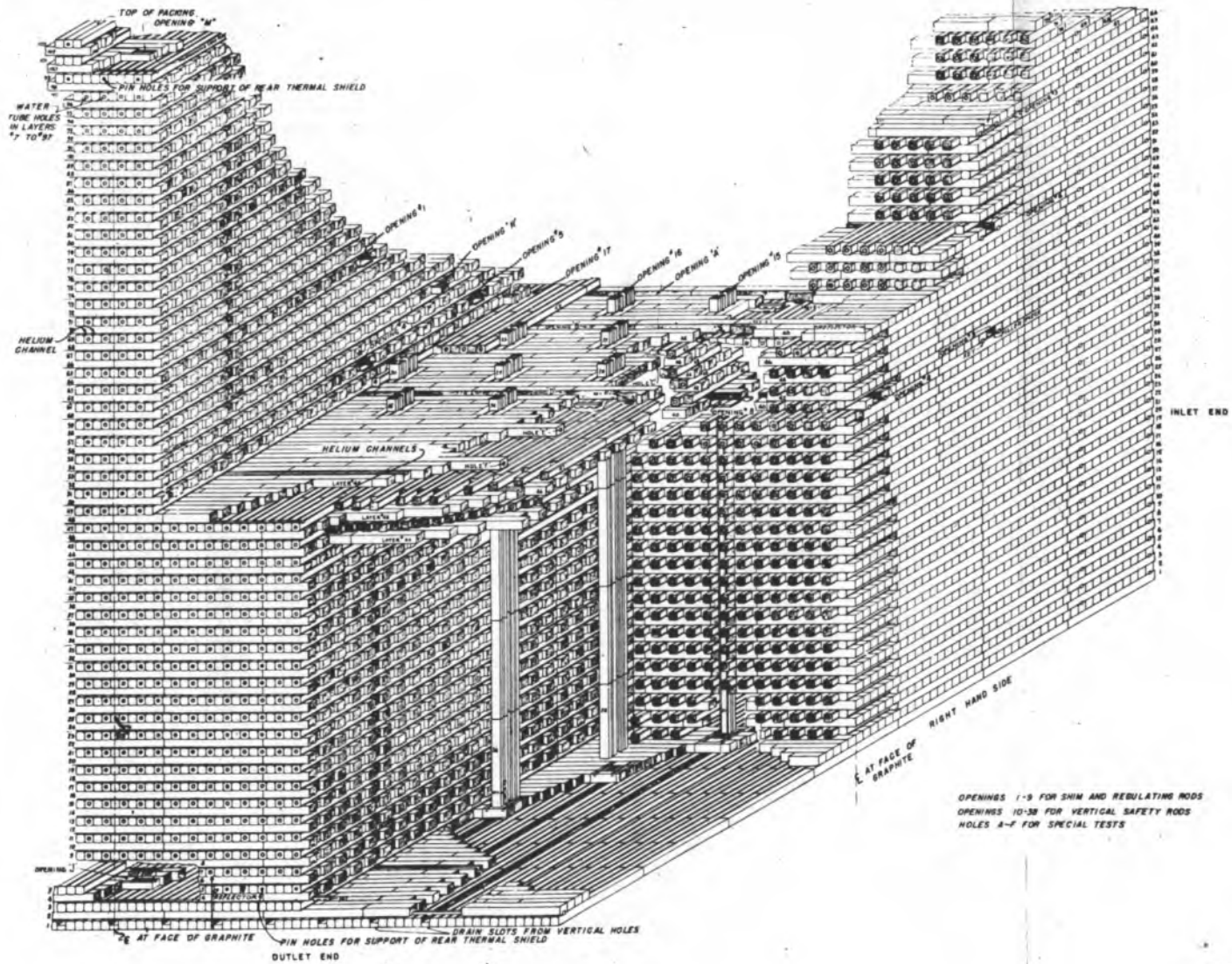
IDENTIFICATION OF CONTROL OPENINGS  
 OPENINGS 1 TO 9 INCL. FOR CONTROL RODS (7 SHM - 2 REG)  
 OPENINGS 10 TO 13 INCL. FOR VERTICAL SAFETY RODS  
 OPENINGS 1 TO 9 INCL. FOR REGULATING AND SHM RODS EXTEND 29" ±  
 INTO PACKING FROM RIGHT SIDE. RODS ENTER FROM RIGHT SIDE  
 OPENINGS 10 TO 13 INCL. FOR VERTICAL SAFETY RODS EXTEND FROM  
 TOP OF PACKING DOWN TO DRAIN SLOTS AT TOP OF PACKING  
 LAYER 1

A15

~~SECRET~~  
 H-M-B-405-4



CUTAWAY ISOMETRIC VIEW OF GRAPHITE ASSEMBLY



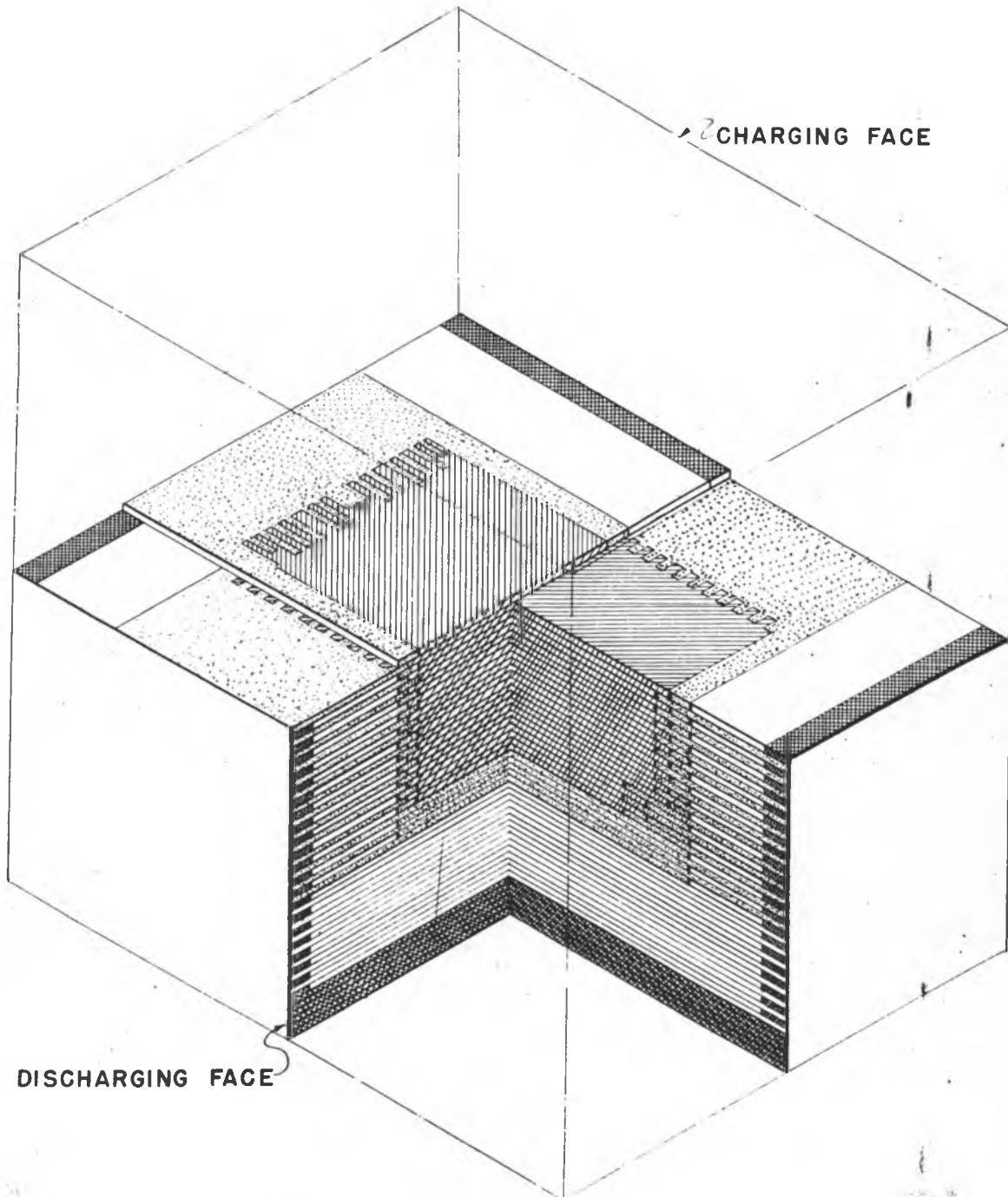
OPENINGS 1-9 FOR SHIM AND REGULATING RODS  
 OPENINGS 10-38 FOR VERTICAL SAFETY RODS  
 HOLES 4-7 FOR SPECIAL TESTS

A16





H-M-β-406-4

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SCHEMATIC ARRANGEMENT OF DIFFERENT GRADES OF GRAPHITE IN THE PILE



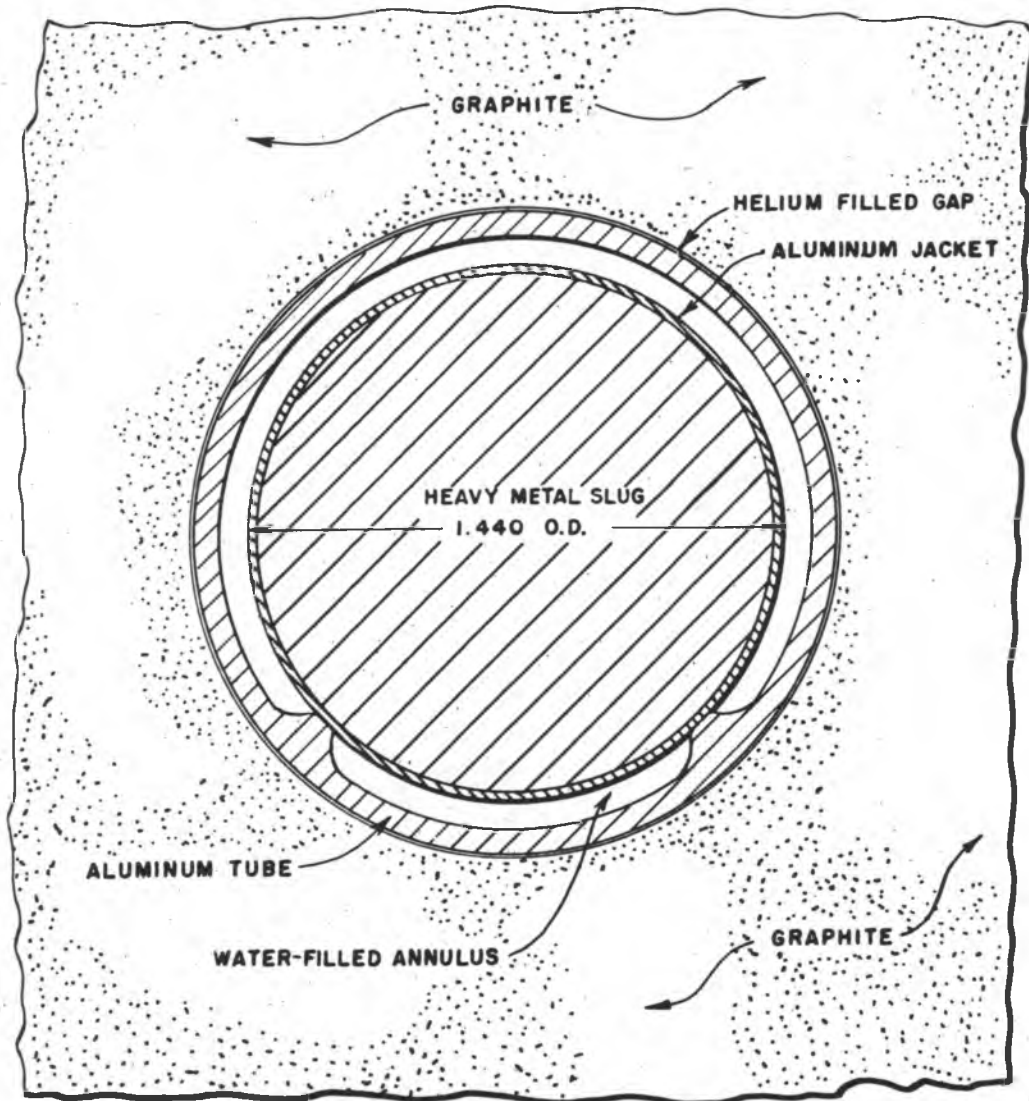
LEGEND

-  GREEN (KENDALL - CHICAGO)
-  WHITE (KENDALL - STANDARD)
-  BLUE (CLEVES - STANDARD)
-  RED (MIXTURE OF POORER GRADES)

A17  
~~SECRET~~  
H-M-B-407-1

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CROSS SECTION THROUGH A CHARGED TUBE IN THE PILE



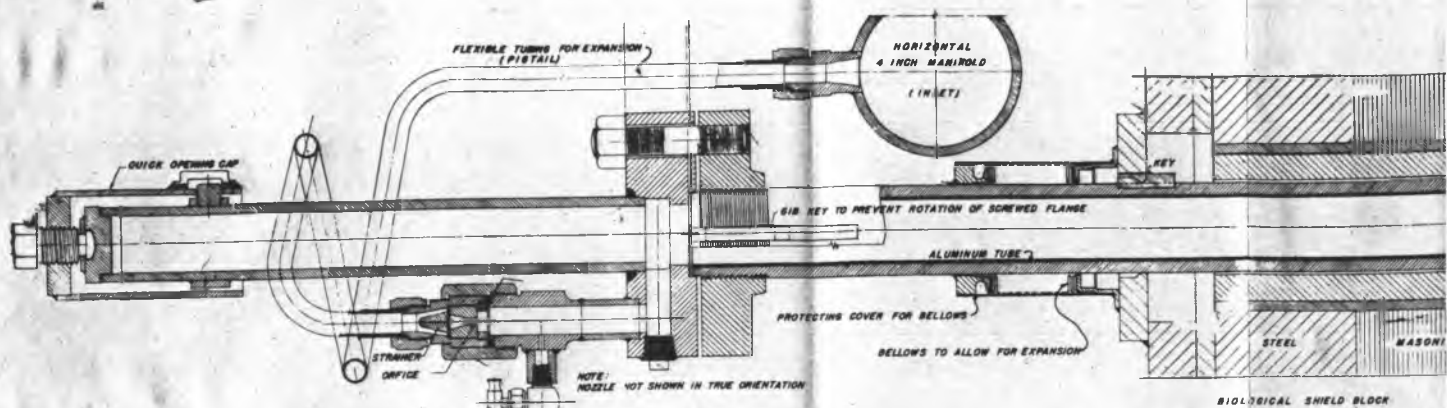
(APPROX: DOUBLE SIZE)

A18

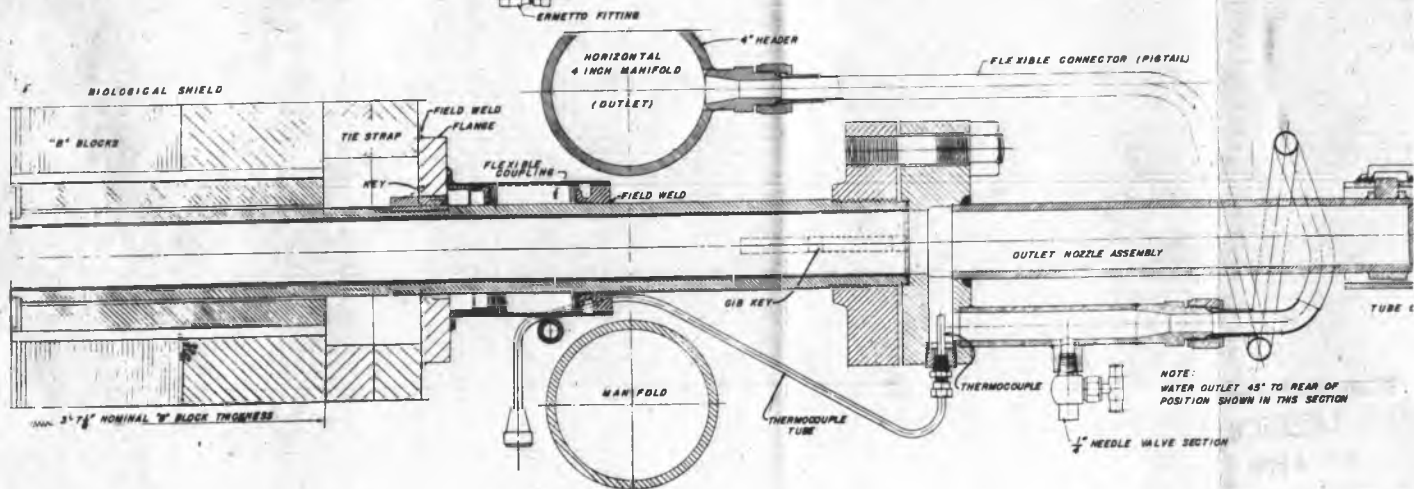
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H-M-B-510-4

**WATER CONNECTIONS AT FACES OF PILE**

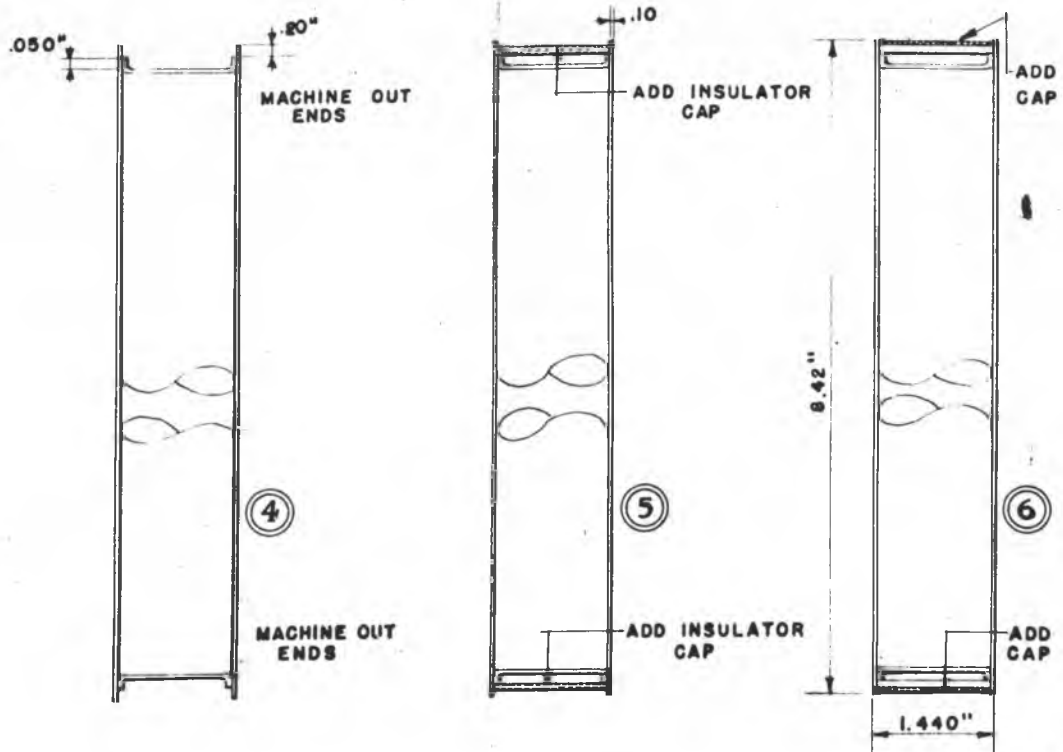
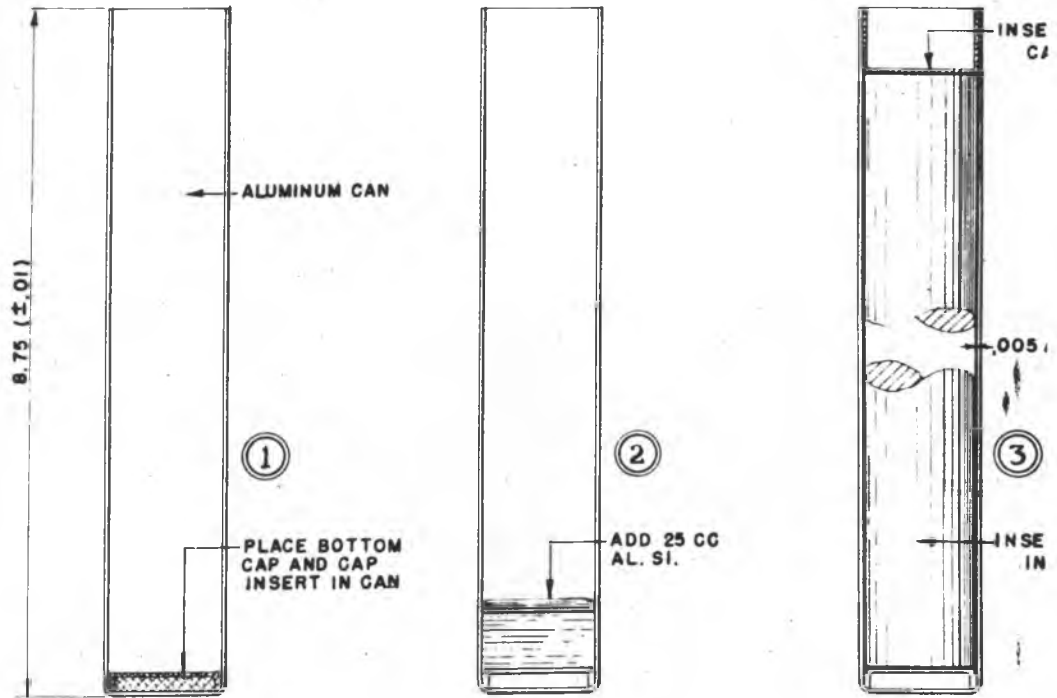


**INLET TUBE SECTION**



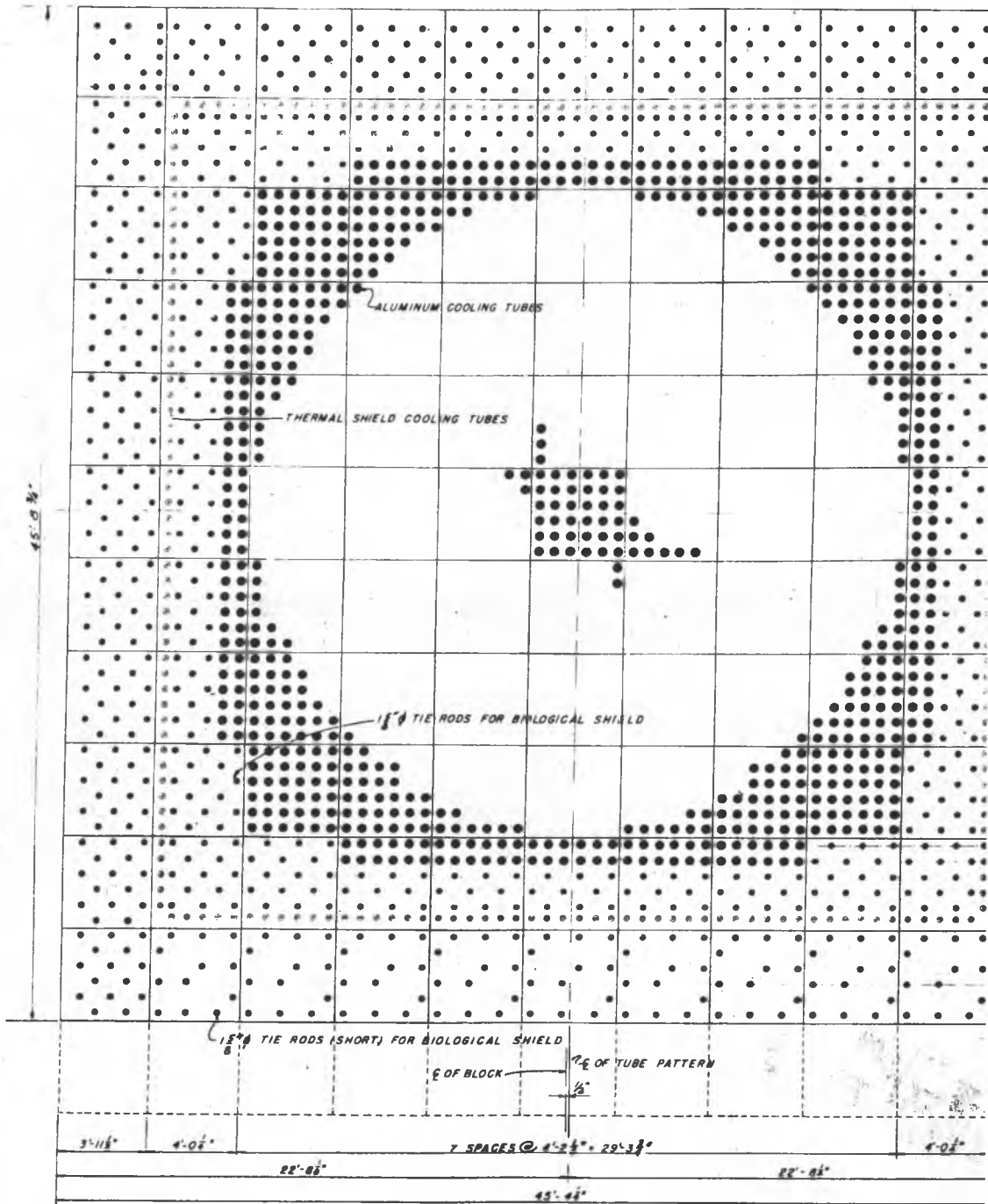
**OUTLET TUBE SECTION**

# CANNING PROCESS

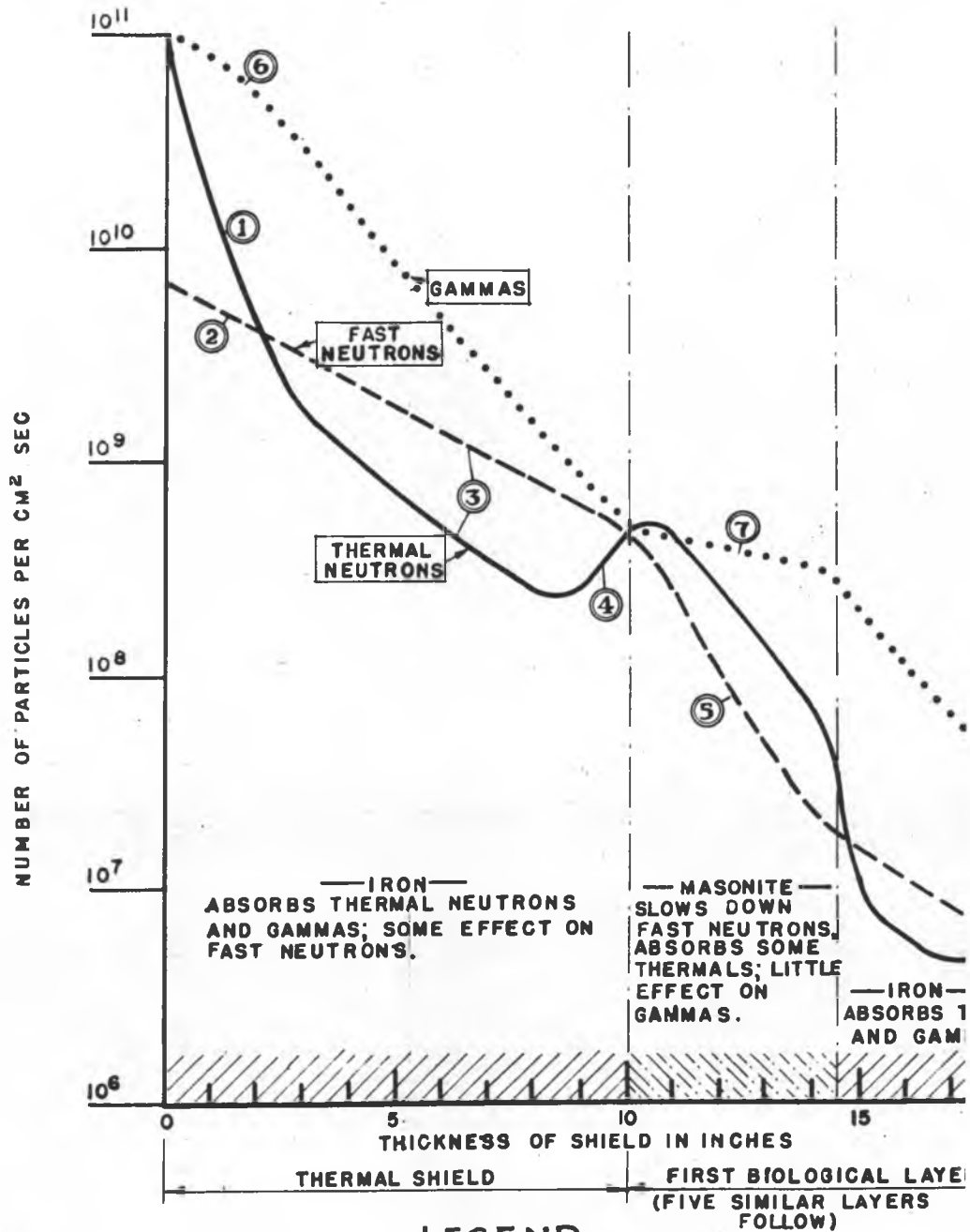


# ARRANGEMENT OF TUBES & BIOLOGICAL SHIELD BLOCKS AT CHARGING FACE

BIOLOGICAL SHIELD BLOCKS—



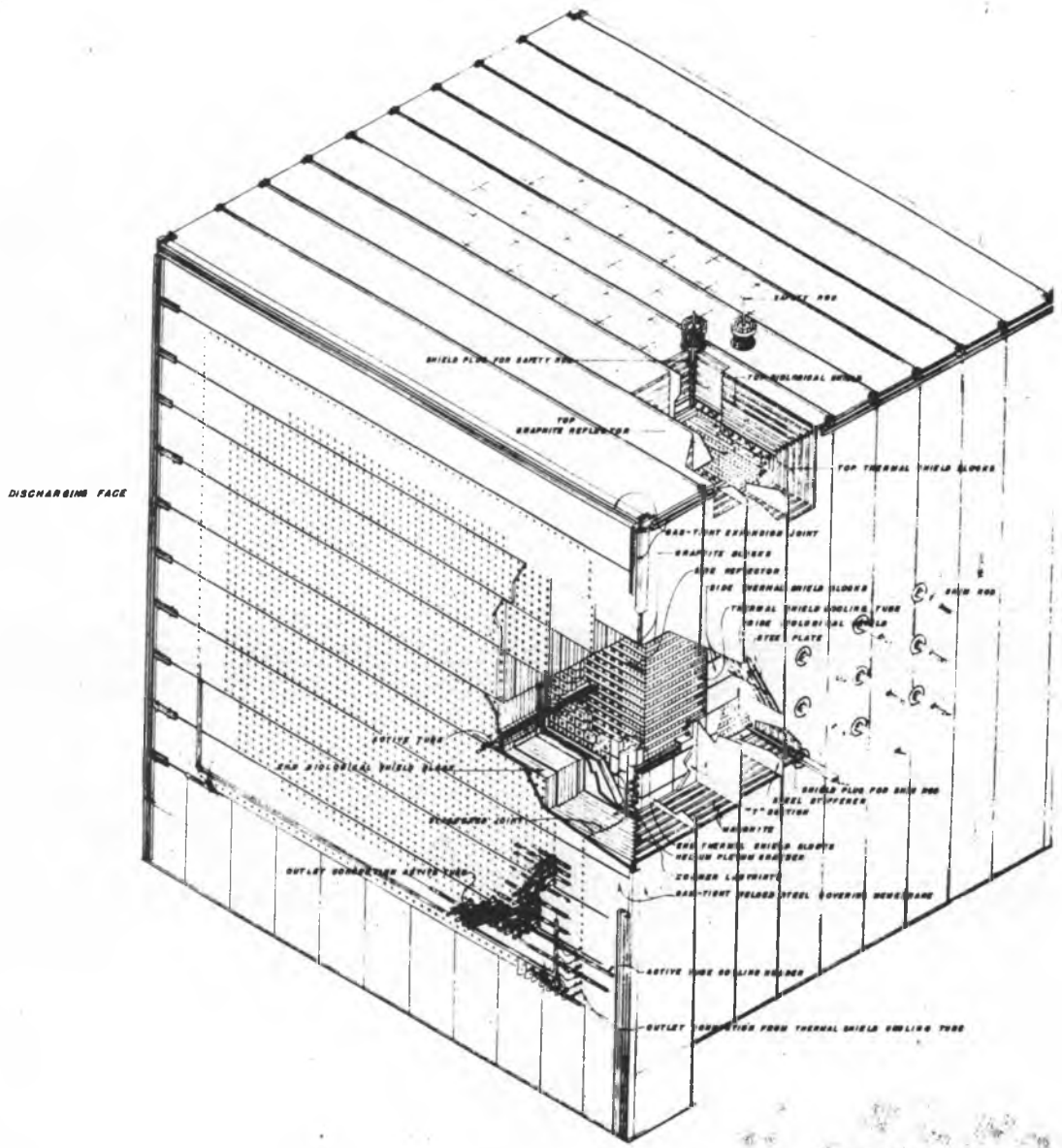
# ACTION OF COMPOSITE SHIELD



## LEGEND

- ① THERMAL NEUTRONS RAPIDLY ABSORBED
- ② FAST NEUTRONS GRADUALLY SLOWED
- ③ MIXTURE OF FAST AND THERMAL NEUTRONS APPROACHES EQUILIBRIUM
- ④ THERMAL NEUTRONS DIFFUSE BACK FROM MASONITE LAYER
- ⑤ FAST NEUTRONS RAPIDLY SLOWED DOWN IN MASONITE
- ⑥ GAMMA DECREASE AT LESS THAN EXPONENTIAL RATE BECAUSE OF GAMMA PRODUCTION BY THERMAL NEUTRONS CAPTURED IN THIS REGION
- ⑦ GAMMAS GRADUALLY ABSORBED BY MASONITE

PILE SHIELDING

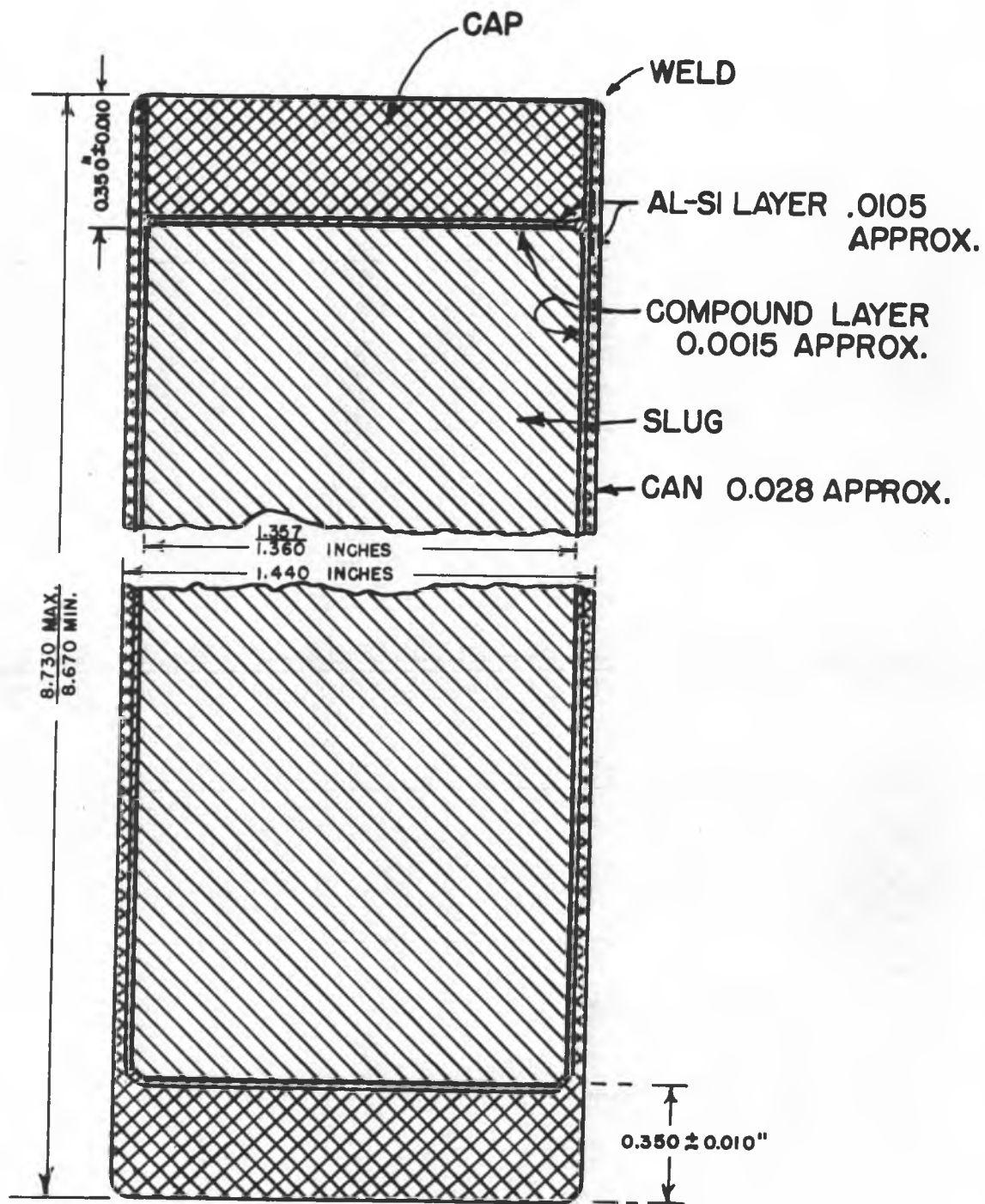






**SECRET**

# ASSEMBLED SLUG



ASSEMBLY MUST PASS THROUGH A FULL LENGTH TUBE GAUGE 1.455" DIAMETER

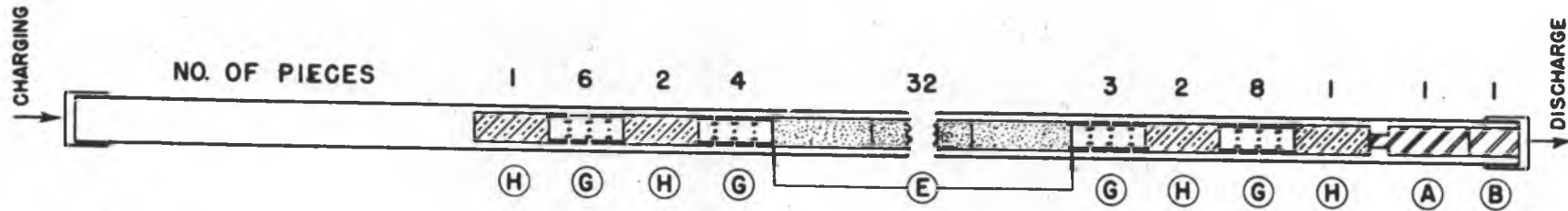
A26

**SECRET**

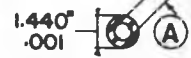
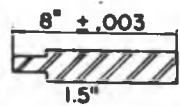
H-M-F-115-1

Rev.

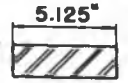
## TYPICAL ARRANGEMENT OF SLUGS IN ACTIVE TUBES



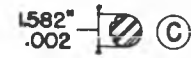
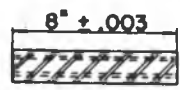
### TYPES OF SLUGS



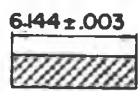
STAINLESS STEEL  
12-14 CHROME



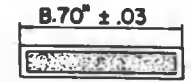
STAINLESS STEEL  
12-14 CHROME



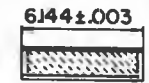
GROVED  
STAINLESS STEEL



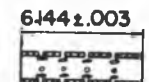
ALUMINUM



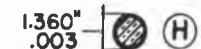
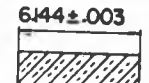
ACTIVE METAL SLUG  
ALUMINUM COVERED.



10% CADMIUM 90% LEAD  
SLUG - ALUMINUM  
COVERED.



PERFORATED TUBULAR  
SLUG - ALUMINUM  
TUBING.



LEAD SLUG  
ALUMINUM COVERED

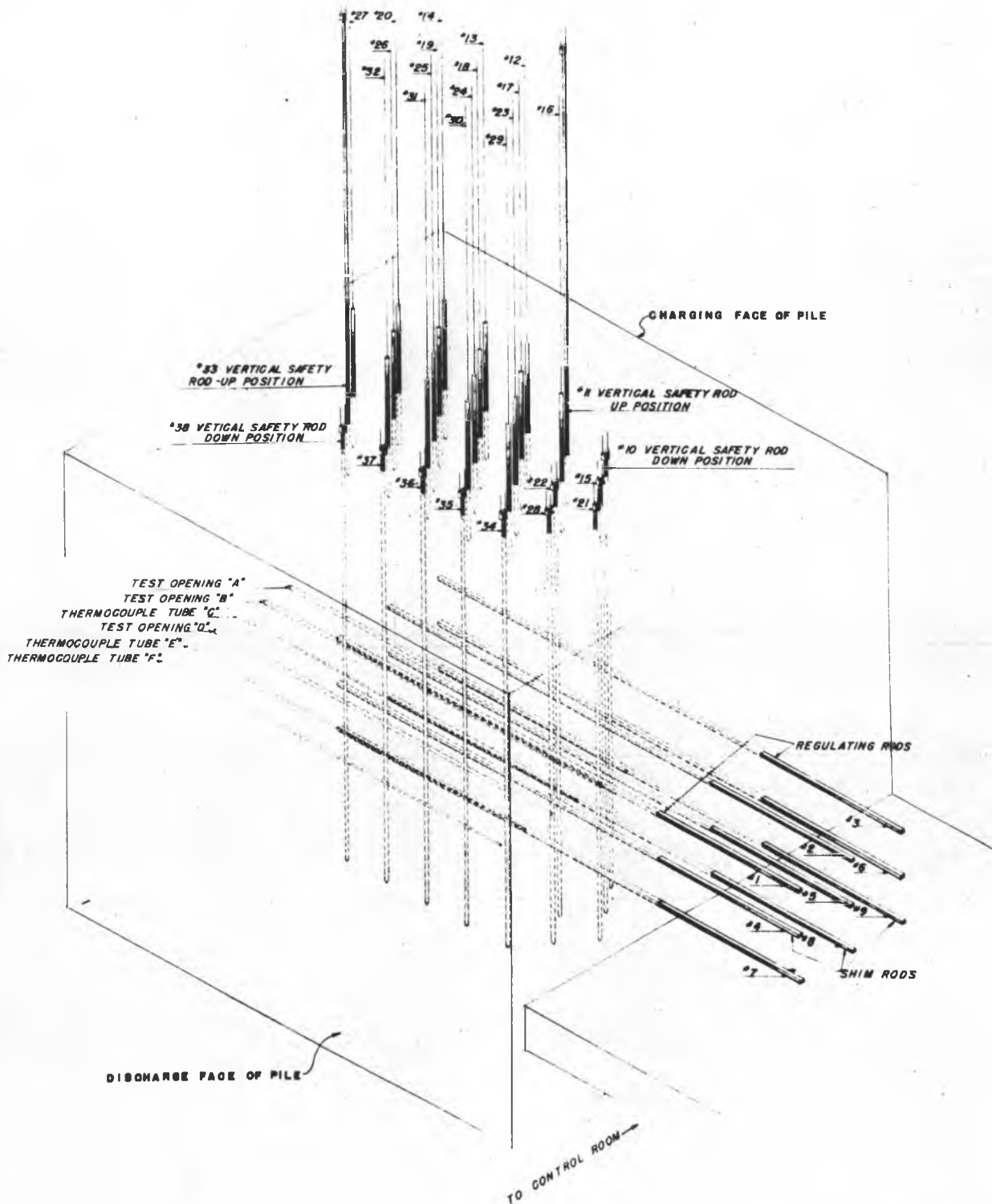
NOTE: COMBINED LENGTH OF (A) AND (B) =  $13\frac{1}{8}''$ ; LENGTHS OF INDIVIDUAL PIECES ARE SUBJECT TO VARIATION.

SECRET  
H-M-B-511-4

A27

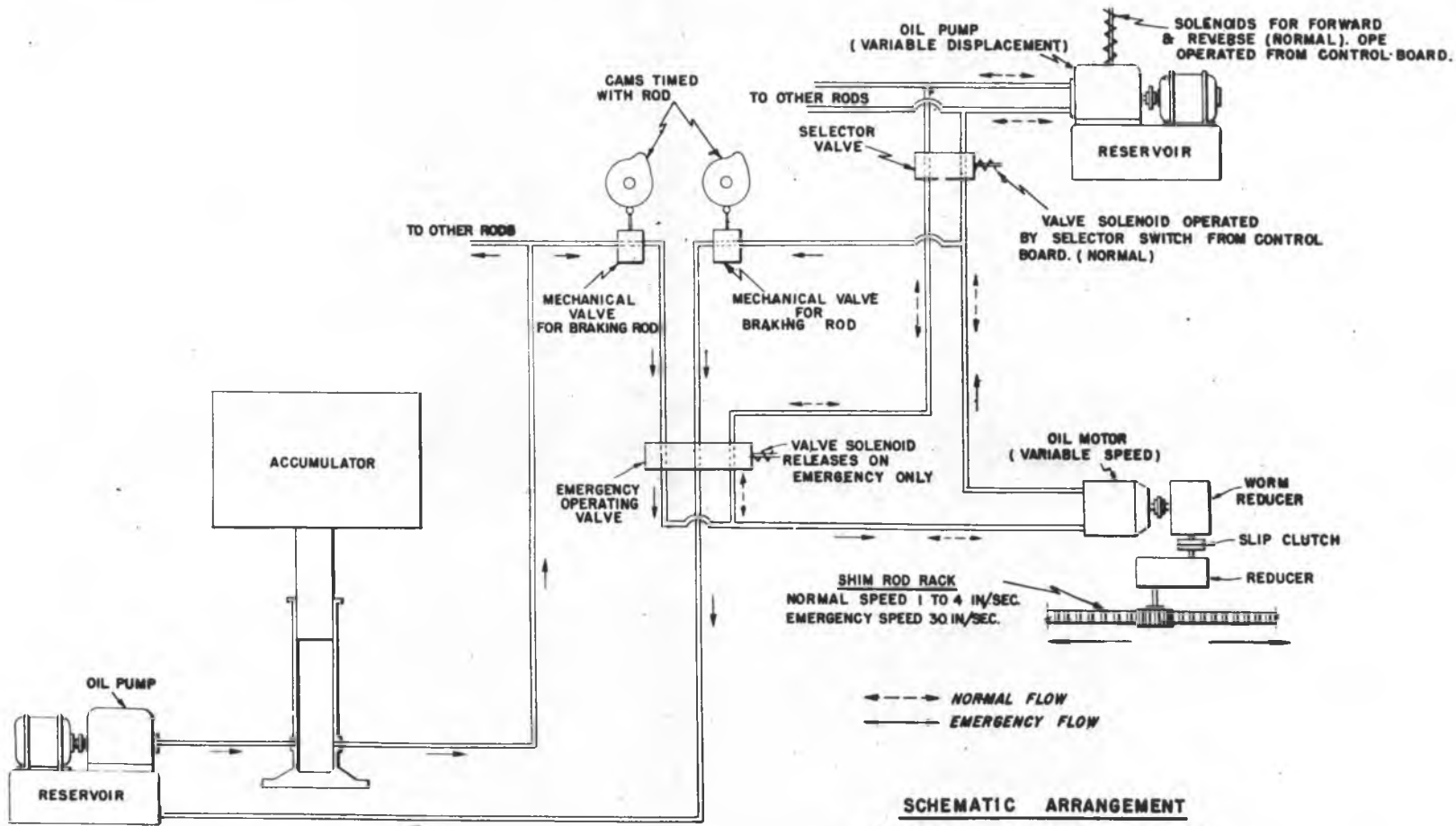
~~SECRET~~

ISOMETRIC DIAGRAM SHOWING ROD PATTERN FOR  
VERTICAL DROP SAFETY RODS AND SHIM AND  
REGULATING RODS (HORIZONTAL)



A28

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H-M-B-608-1

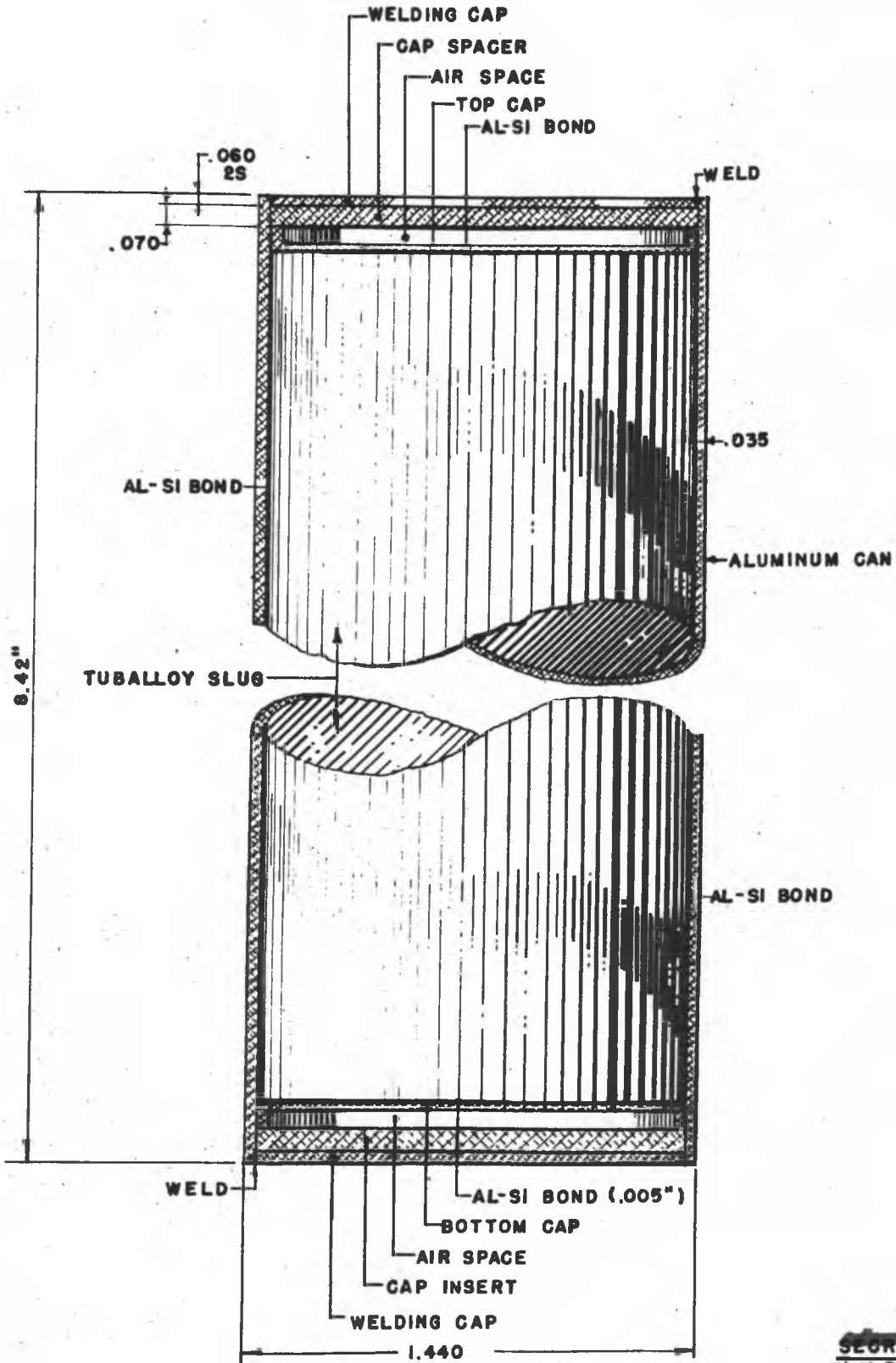


**SCHEMATIC ARRANGEMENT**  
**HYDRAULIC SHIM ROD DRIVE**

H-M-B-615-4  
A29

~~SECRET~~

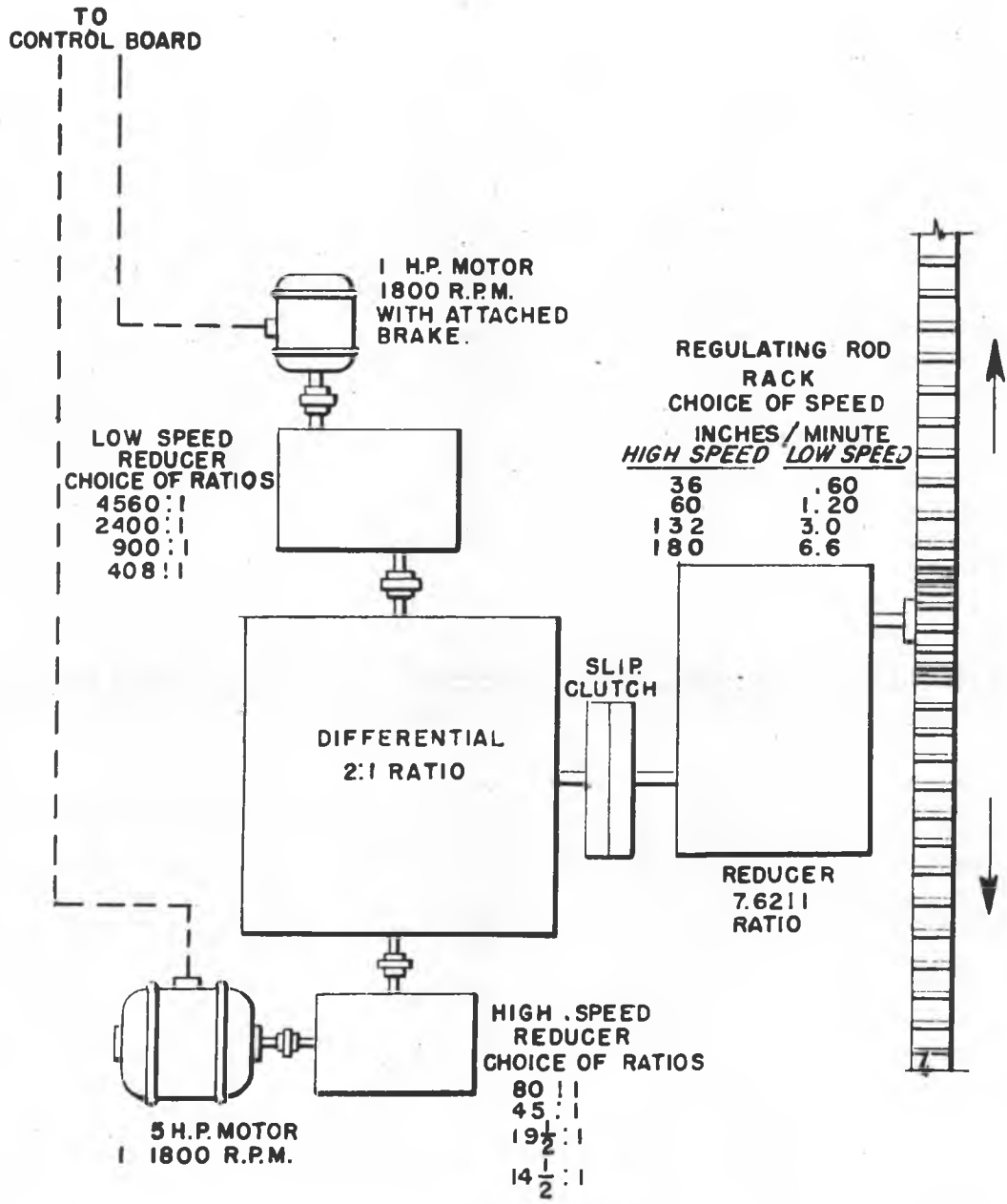
# ASSEMBLED SLUG



A25

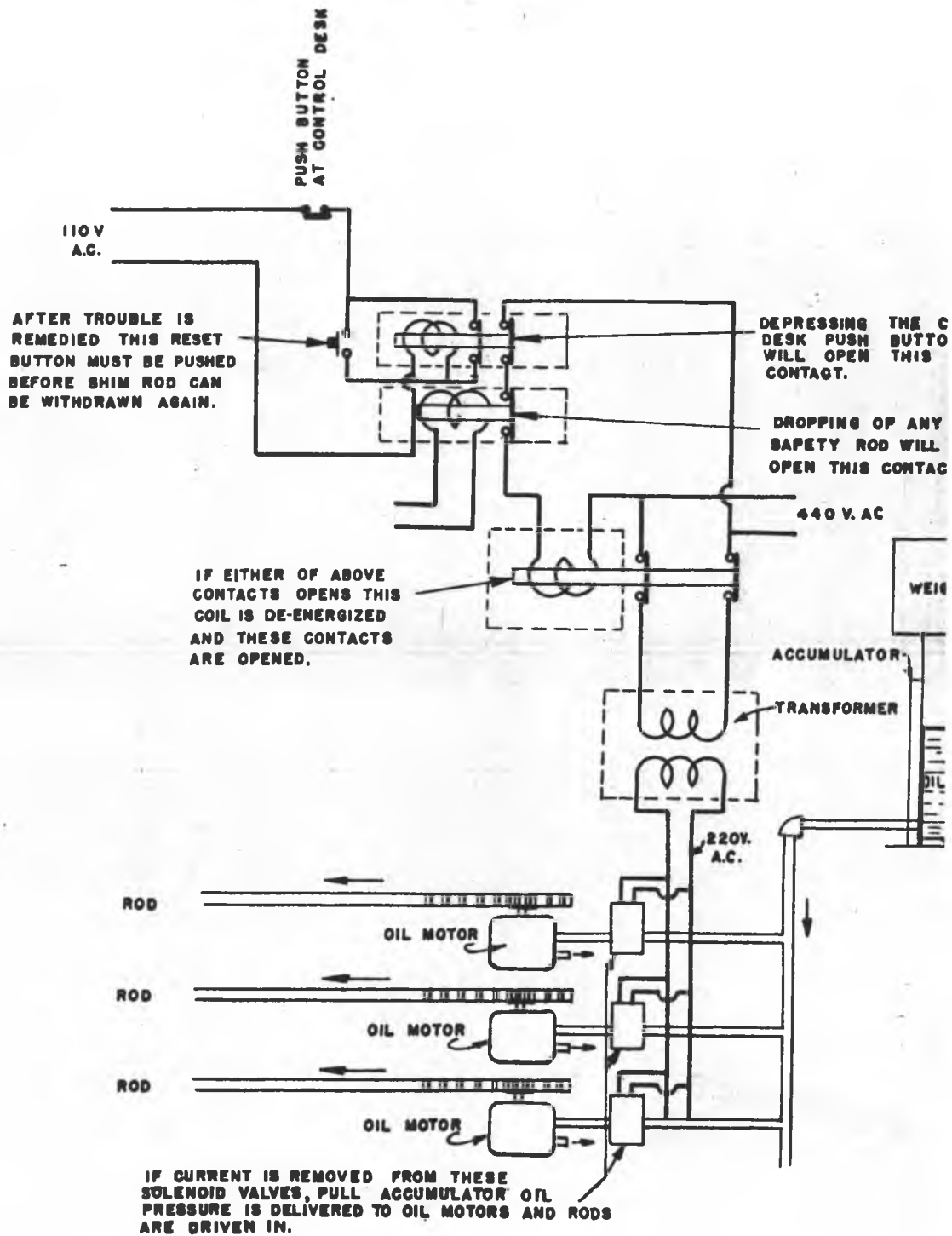
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HM-121-1

**SECRET**



**SCHEMATIC ARRANGEMENT**  
**ELECTRIC REGULATING ROD DRIVE**

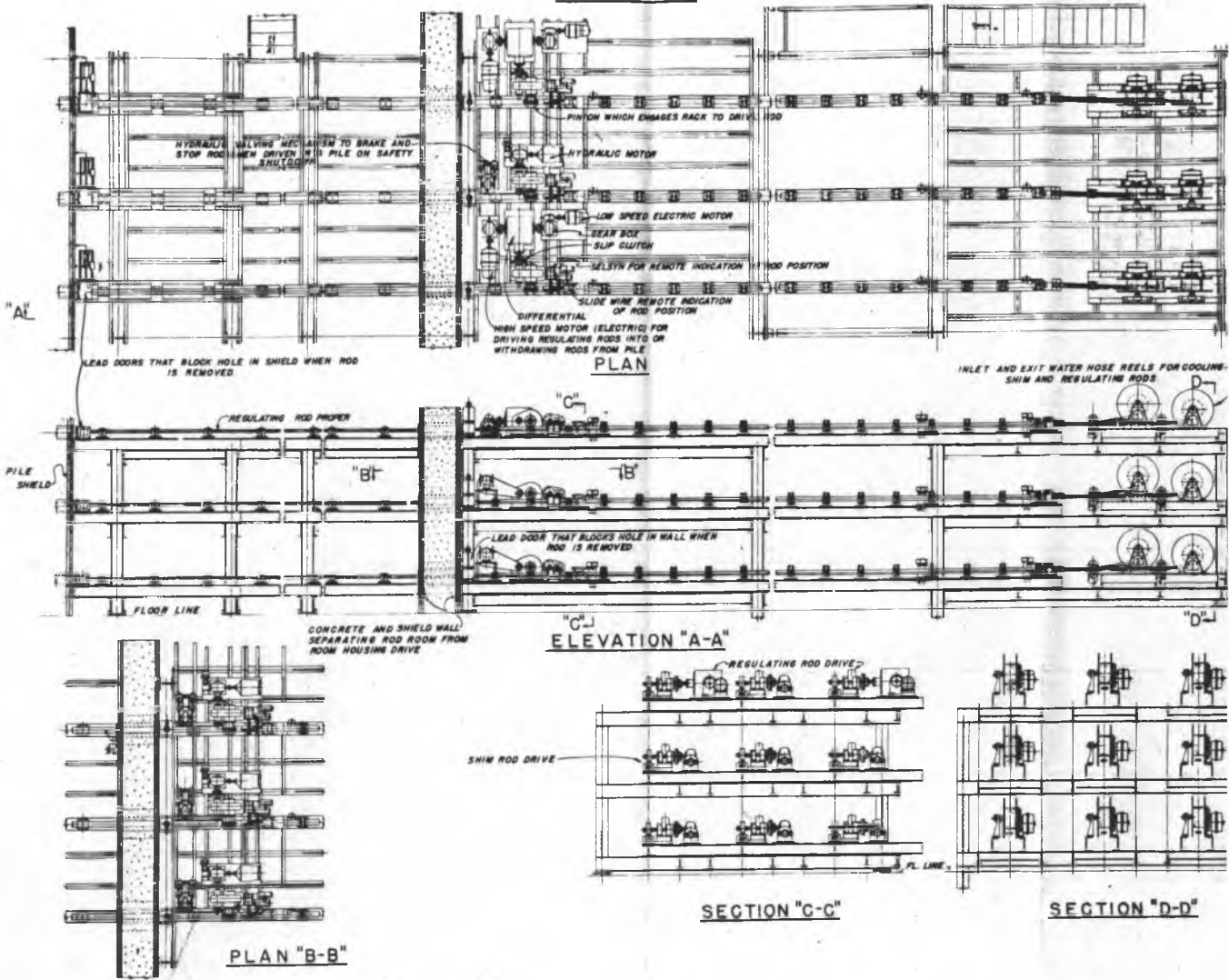
# NO.2 SAFETY CIRCUIT





SECRET

# DRIVING MECHANISMS FOR REGULATING AND SHIM RODS

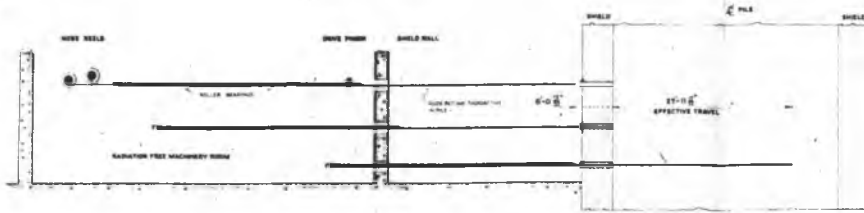


PLAN "B-B"

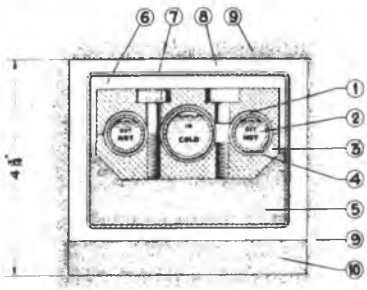
SECTION "C-C"

SECTION "D-D"

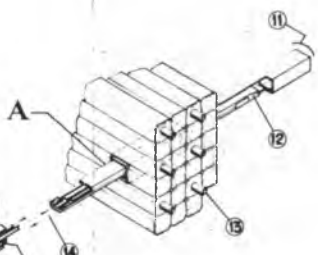
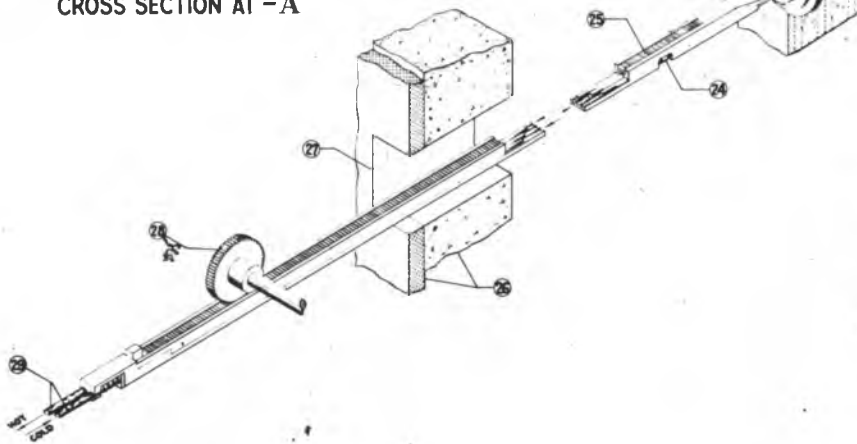
**SECRET**



**CONTROL ROD MOVEMENT  
SCHEMATIC**



**CROSS SECTION AT -A**



**LEGEND**

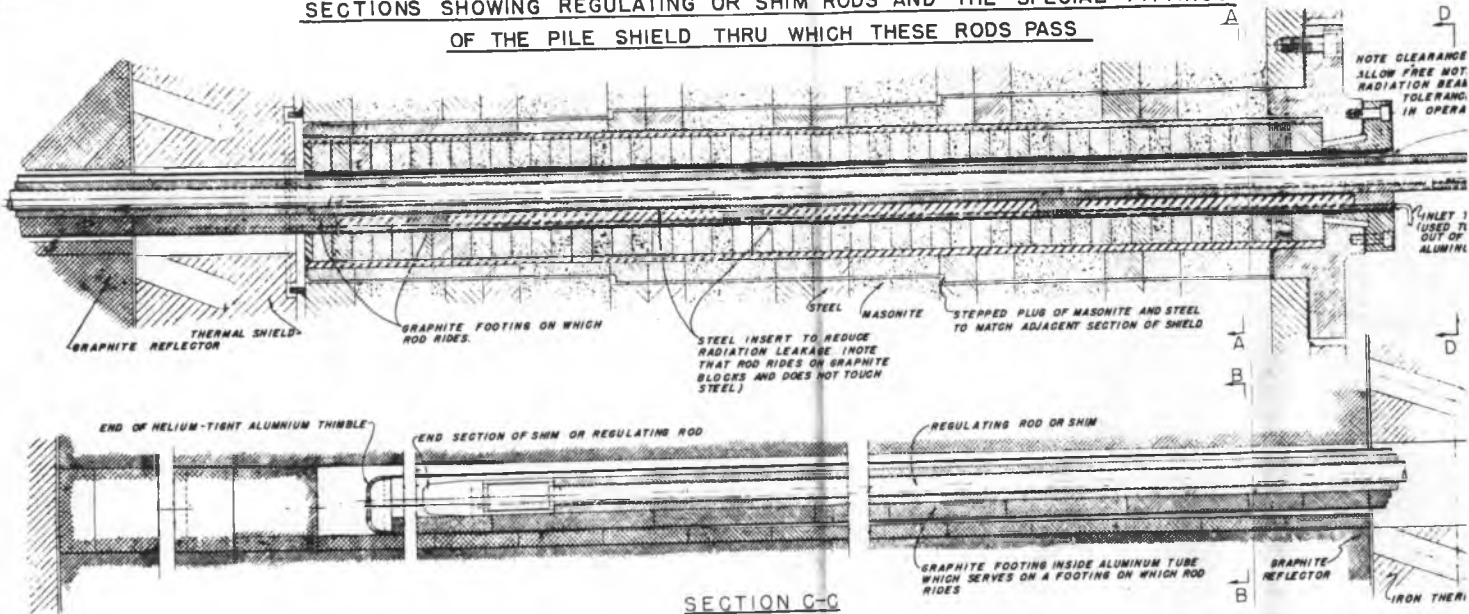
	ALUMINUM		CAST IRON
	LEAD		STEEL
	BORON		GRAPHITE
	WATER		CONCRETE
	MASONITE		

- 1 METALLIC ROD SPRAYED ON ALUMINUM TUBES - ABSORBS THERMAL NEUTRONS - DELIVERS UP HEAT OF CONDENSATION TO COOLING TUBES - RE-RADIATES NEGLIGIBLE FRACTION OF ENERGY AS GAMMA RADIATION (IN CONTRAST TO CADMIUM) - DEVELOPS NO RESIDUAL RADIOACTIVITY.
- 2 WATER REMOVES HEAT OF CONDENSATION FROM PILE.
- 3 ALUMINUM - STRUCTURAL MATERIAL - ABSORBS FEW NEUTRONS DEVELOPS RELATIVELY SMALL RADIOACTIVITY - THIS QUICKLY DECAYS - THIS SIMPLIFIES REMOVAL.
- 4 ALUMINUM COILING TUBES SYMMETRICALLY ARRANGED - MINIMIZE WARPING DUE TO THERMAL EXPANSION.
- 5 GRAPHITE LUBRICATES MOTION OF ROD.
- 6 CLEARANCE FOR MOTION OF ROD.
- 7 ALUMINUM TUMBLES - LOW NEUTRON ABSORPTION - PREVENTS ESCAPE OF RADIOACTIVE GASES FROM PILE - NORMALLY FLUSHED OUT CONTINUALLY WITH CO<sub>2</sub> TO MINIMIZE ACTIVATION OF AIRBORNE COMPONENT OF ATMOSPHERE.
- 8 CLEARANCE - ALLOWS WITHDRAWAL OF TUMBLES FOR REPAIRS.
- 9 GRAPHITE - MINORATING MEDIUM OF PILE - LEAD UP IN BLOCKS 4 1/2" THICK.
- 10 GRAPHITE FILLER - UNDERMINES LEAKAGE OF NEUTRONS.
- 11 ALUMINUM CAP - CLOSURE END OF TUMBLES.
- 12 TAPERED TIP - MINIMIZES CHANCE OF ROD TO CATCH AND STICK.
- 13 ACTIVE ZONE OF PILE - ALUMINUM TUBES CARRY GRAPHITE SLICES - DIRECTION OF FLOW OF WATER.
- 14 GRAPHITE BED - CARRIES ROD WITH MINIMUM FRICTION.
- 15 GRAPHITE REFLECTOR OF NEUTRONS - CONTAINS NO URANIUM PORTION OF ROD IN THIS ZONE HAS LITTLE INFLUENCE ON REACTION.
- 16 THERMAL SHIELD WITH COOLING TUBES CONVERTED IN BY LEAD.
- 17 BIOLOGICAL SHIELD.
- 18 SHIELD PLUG - CARRIES TUMBLES AND ROD THROUGH BUILT UP SHIELD - MINIMIZES LEAKAGE OF RADIATIONS ABOUT THE PERIMETER FOR REPAIRS BY CUTTING WELD AT OUTER FACE / SHIELD.
- 19 GRAPHITE BLOCKS - LOCATED BETWEEN BOTTOM OF ROD AND I OF TUMBLES - CARRY ROD WITH MINIMUM FRICTION.
- 20 HIGH GAMMA RAY ABSORBERS - OCCUPY SPACE BETWEEN GRAPHITE BLOCKS - DEPRESS SLIGHTLY TO AVOID SCRAPPING.
- 21 TON TONES - ALTERNATELY STEEL AND MASONITE - HAVE A CHARACTERISTIC SIMILAR TO THOSE OF BIOLOGICAL SHIELD.
- 22 STEEL PIPE FORMING FRAMEWORK FOR CONSTRUCTION OF I PLUG.
- 23 JOINT IN WATER PIPES.
- 24 BACK FOR DRIVING ROD.
- 25 CONCRETE WALL AND POSSIBLE LEAD COVERING - PROTECTS IN MAINTENANCE ROOM AGAINST RADIATIONS FROM ACTIVATED HYDROGEN - TO BE SEALED BY 1/4" CASING AROUND ROD - C LITTING THROUGH WALL - HOLD THROUGH CASING MAY BE BY DOOR OPERATED REMOTELY BY COMPRESSED AIR.
- 26 PNEUMATIC DRIVES ROD.
- 27 FLEXIBLE HOSE - CARRY COLD WATER IN AND HOT WATER OUT.

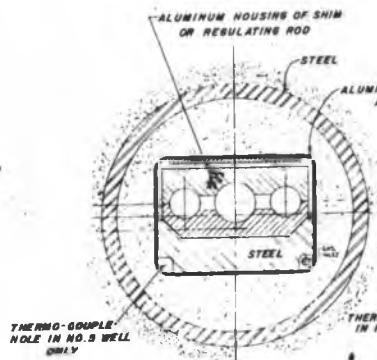
**CONTROL ROD  
FOR SHIM AND FINE CONTROL**

SECRET

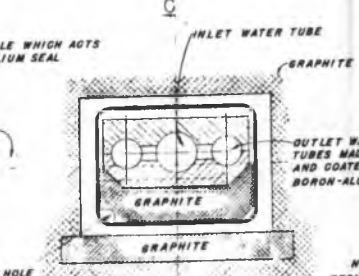
SECTIONS SHOWING REGULATING OR SHIM RODS AND THE SPECIAL FITTINGS  
OF THE PILE SHIELD THRU WHICH THESE RODS PASS



SECTION C-C

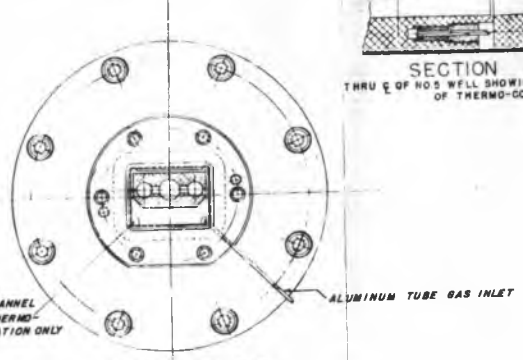


SECTION A-A



SECTION B-B

SECTION THRU SHIM ROD AND GRAPHITE OF PILE SHIELD  
SECTION TAKEN A FEW INCHES INSIDE THE THERMAL SHIELD

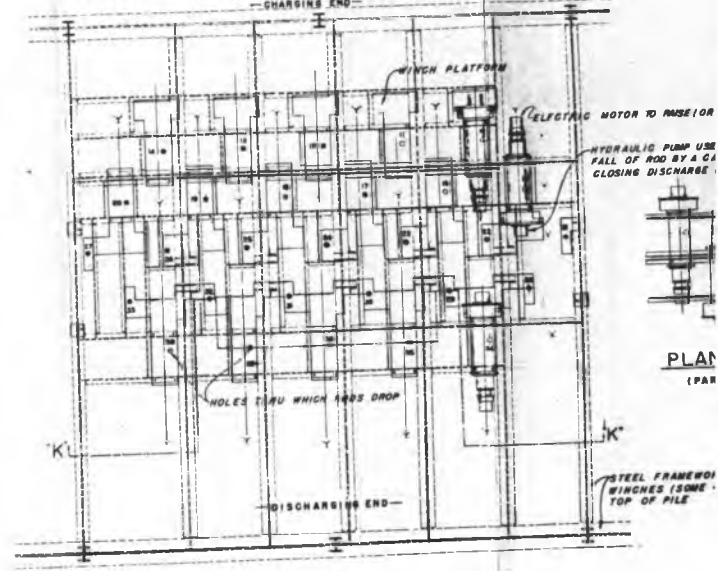
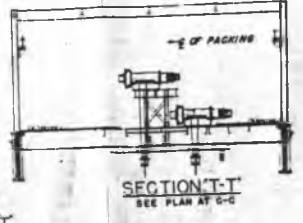
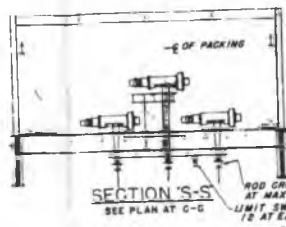
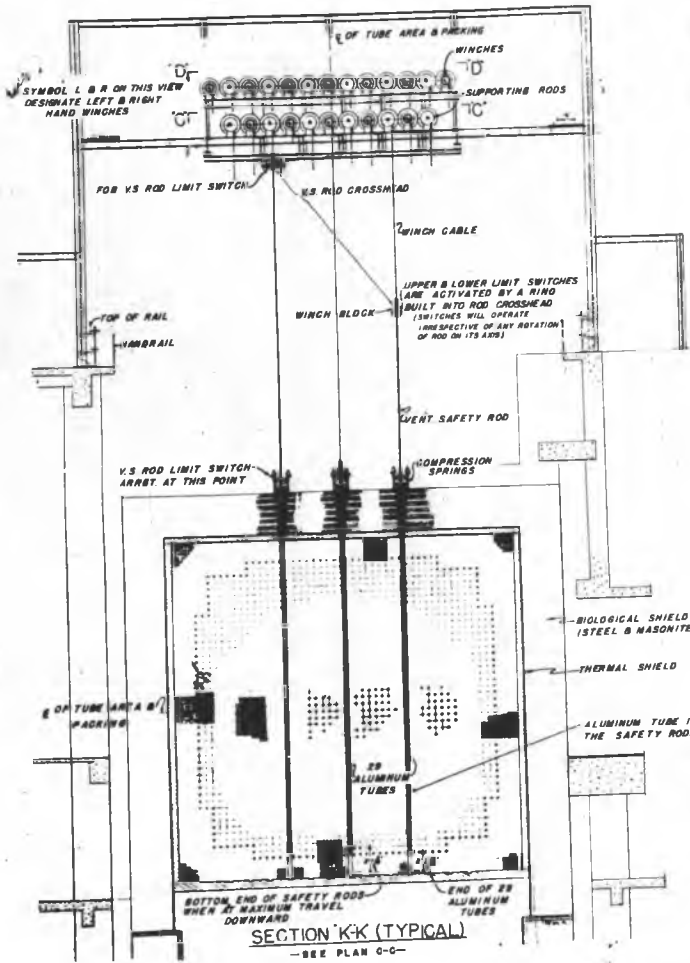


ELEVATION D-D

NOTE: THIS CHANNEL REQUIRED FOR THERMO-COUPLE INSTALLATION ONLY

SECRET

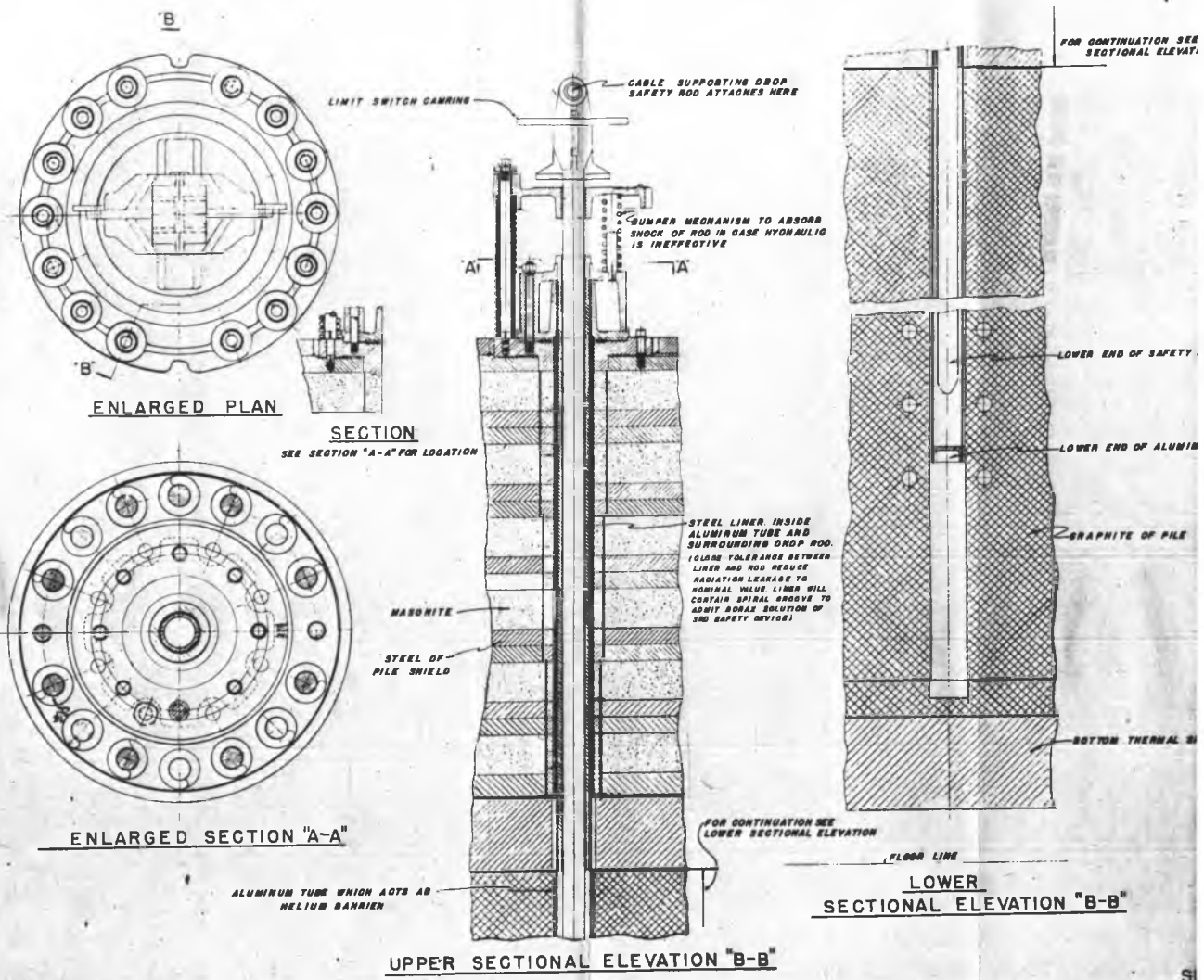
# PLAN AND ELEVATION OF VERTICAL SAFETY RODS



PLAN AT 0-C

SECRET

# SECTION THRU DROP SAFETY ROD AND SPECIAL FITTINGS OF THE PILE SHIELD THRU WHICH THE ROD PASSES

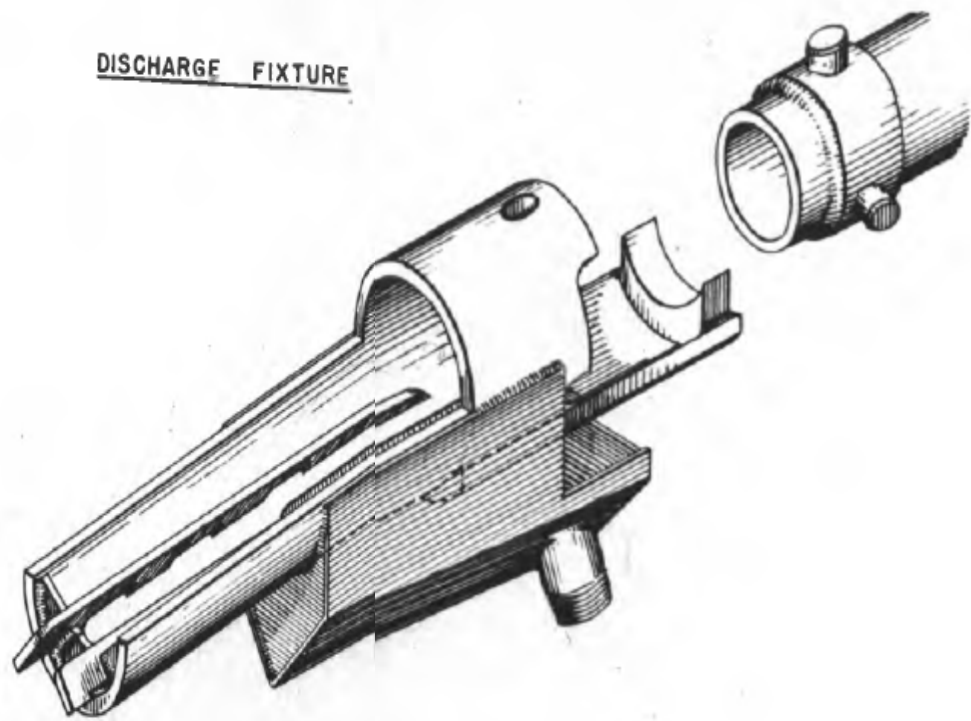


FOR CONTINUATION SEE SECTIONAL ELEVATION

FOR CONTINUATION SEE LOWER SECTIONAL ELEVATION

SH

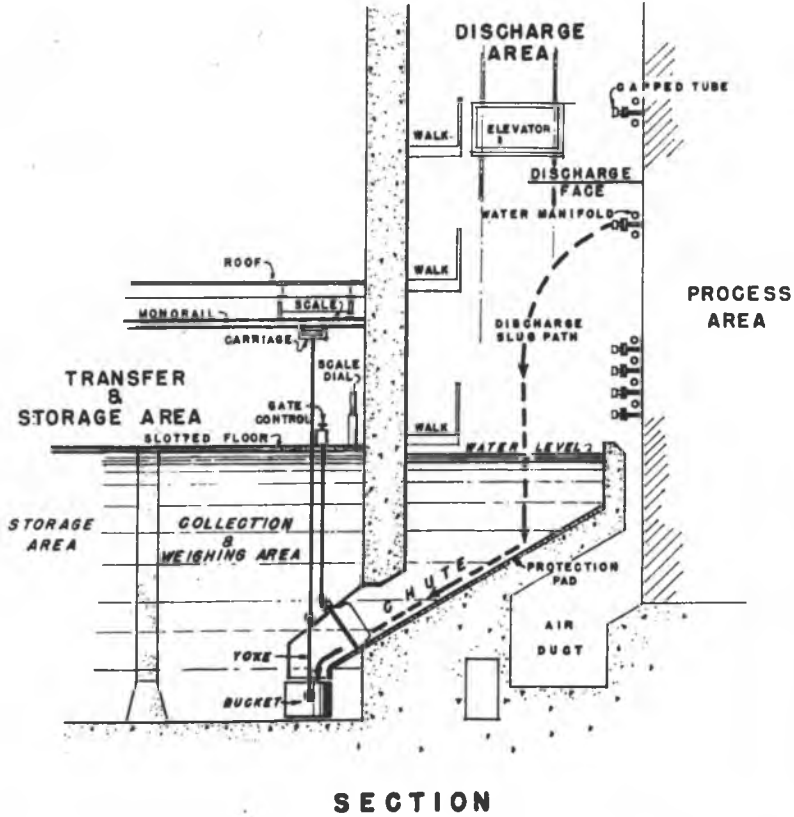
DISCHARGE FIXTURE



A40  
H-M-B-9100-1  
R 6/95

~~SECRET~~

SLUG HANDLING AFTER PILE  
DISCHARGE

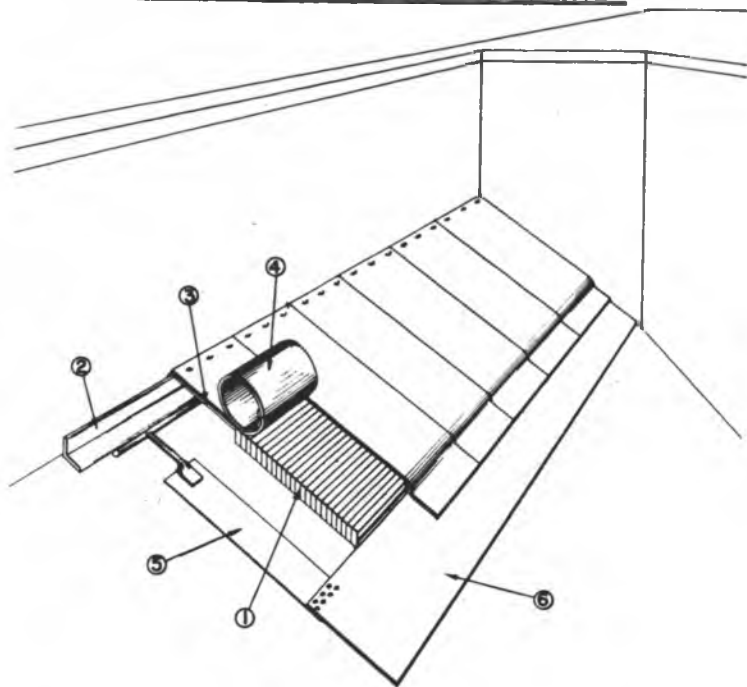


A41

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H-M-B-914-1  
R 6/45

~~SECRET~~

ARRANGEMENT OF MATTRESS PLATES

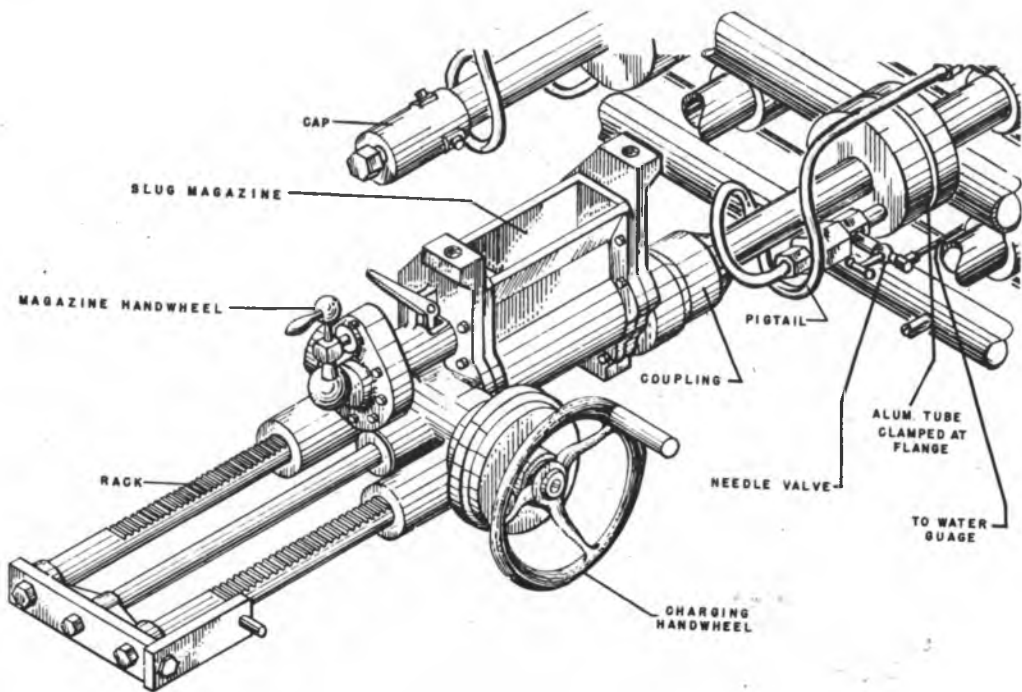


- 1 LAMINATED MATTRESS PLATE
- 2 MATTRESS PLATE ANCHOR ANGLE
- 3 MATTRESS PLATE EXTENSION
- 4 MATTRESS PLATE COVER
- 5 AUXILIARY MATTRESS PLATE HANGER
- 6 AUXILIARY MATTRESS PLATE

A42

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H-M-B-912-4  
R 6/48





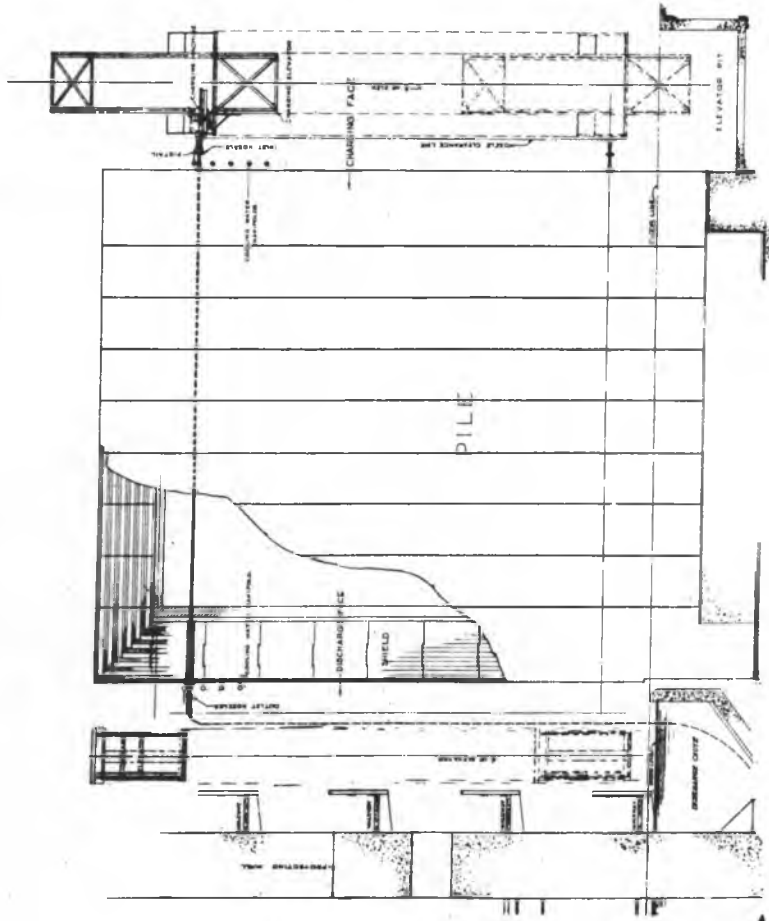
H-M-411-1

A39

CHARGING MACHINE  
&  
INLET WATER FITTINGS

~~SECRET~~

# ELEVATION OF CHARGING MACHINE

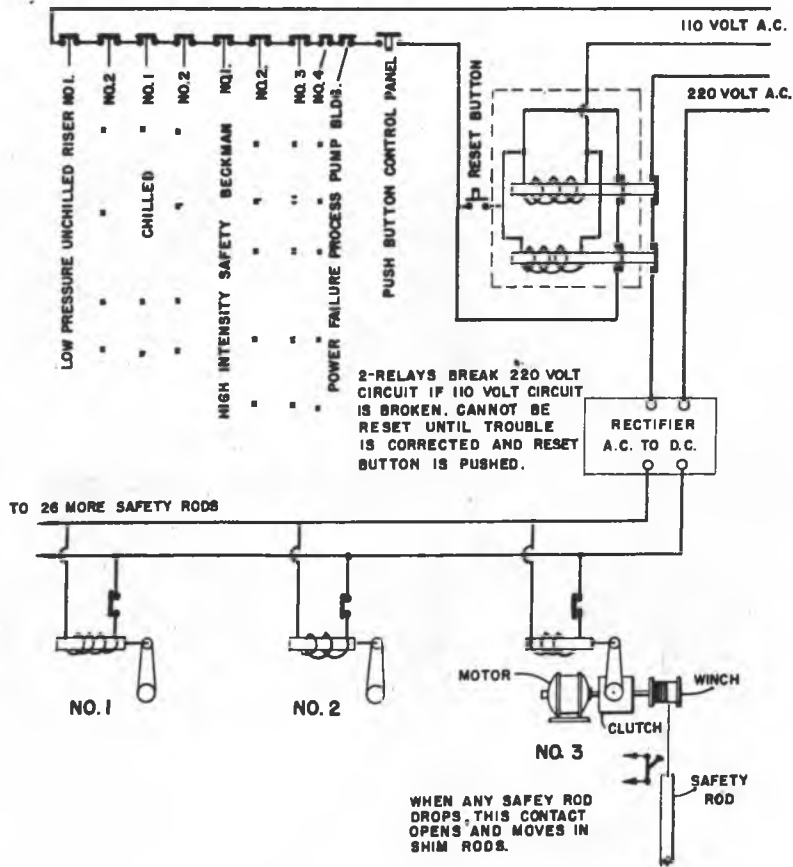


A38

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H-M-B-907-4  
R 6/45

~~SECRET~~

### NO I. SAFETY CIRCUIT

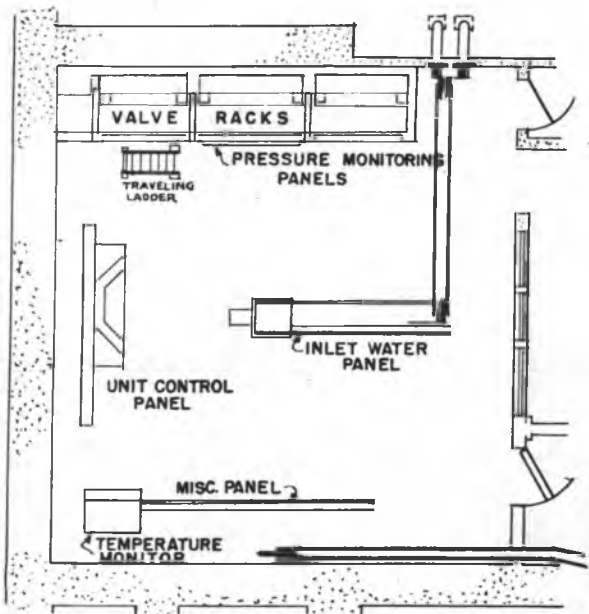


A37

~~SECRET~~  
H-M-B-729-1  
R 5/48

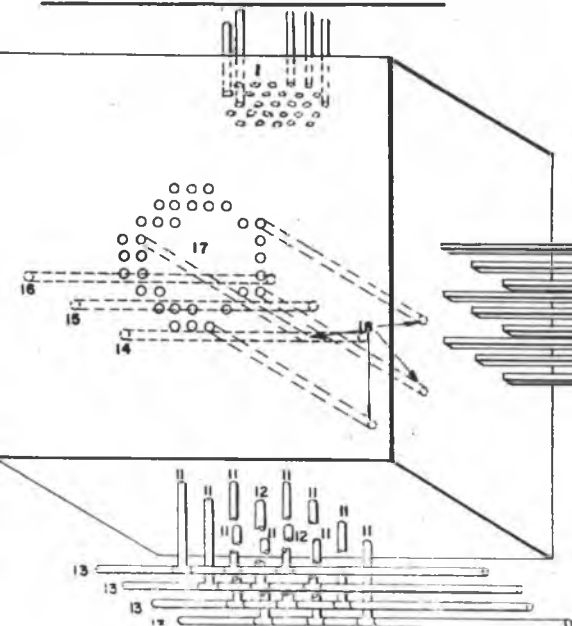
~~SECRET~~

# MAIN CONTROL ROOM



~~SECRET~~  
H-M-1

PILE SHOWING PRINCIPLE POINTS  
OF INSTRUMENTATION & CONTROL



1- SAFETY RODS (29) DROP INTO PILE WHEN SAFETY CIRCUIT IS BROKEN.

2, & 4, REGULATING RODS ELEC. OPERATION.

3, 5, 6, 7, 8, 9, & 10 - SHIM RODS HYDRAULIC OPERATION.

11- EIGHT INCH RISERS (10) THROUGH BOTTOM SHIELDING FOR ION CHAMBERS.

12. SIXTEEN INCH RISERS (2) THROUGH BOTTOM SHIELDING FOR ION CHAMBERS.

13. EIGHT INCH PIPES (4) CONTAINING ION CHAMBERS.

14. EXPERIMENTAL HOLE "A" FOR NEUTRON CHAMBER.

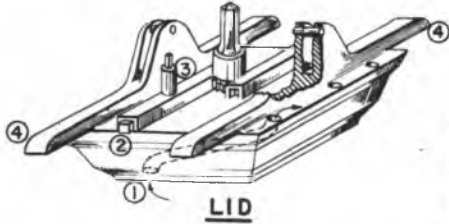
15. EXPERIMENTAL HOLE "D" FOR GAMMA CHAMBER TO BE USED DIFFERENTIALLY WITH "A" HOLE UNIT.

16. EXPERIMENTAL HOLE "F" FOR NEUTRON THERMOPILE.

17. DISCHARGE END OF 2004 TUBES THERMOCOUPLE IN EACH TUBE.

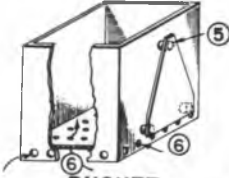
18. CHARGING END OF 2004 TUBES - PRESSURE GAUGE CONNECTION FOR EACH TUBE.

# CASK ASSEMBLY

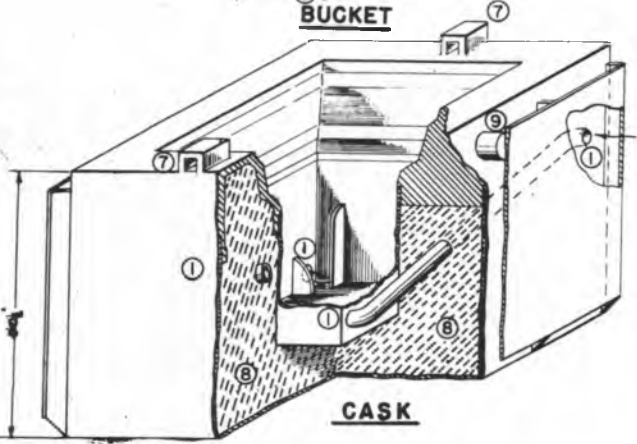


LID

- ① WATER CIRCULATING TUBE
- ② LOCKING BAR
- ③ BALL LOCK
- ④ LID ARMS
- ⑤ LUG FOR LIFTING BUCKET
- ⑥ HOLES FOR WATER CIRCUI THROUGH BUCKET
- ⑦ CATCHES FOR LOCKING BA
- ⑧ LEAD FILLED CASK WALL
- ⑨ LUG FOR LIFTING CASK



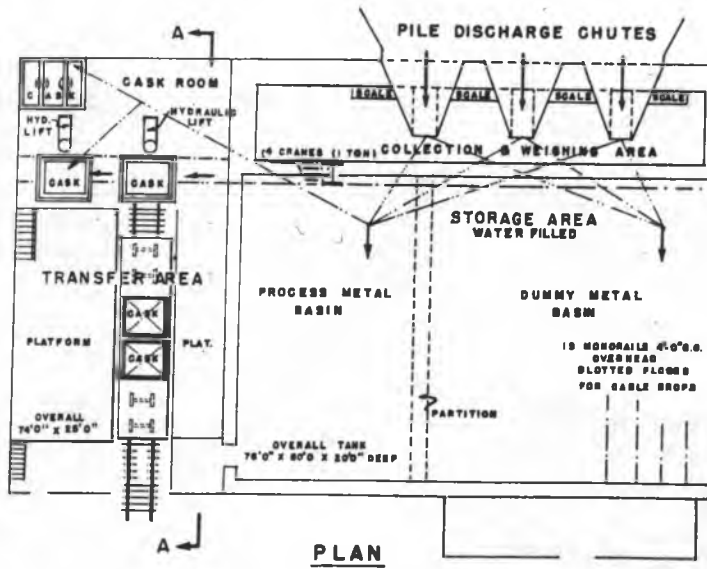
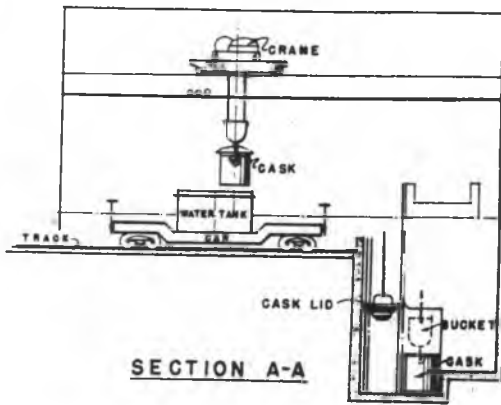
BUCKET



CASK

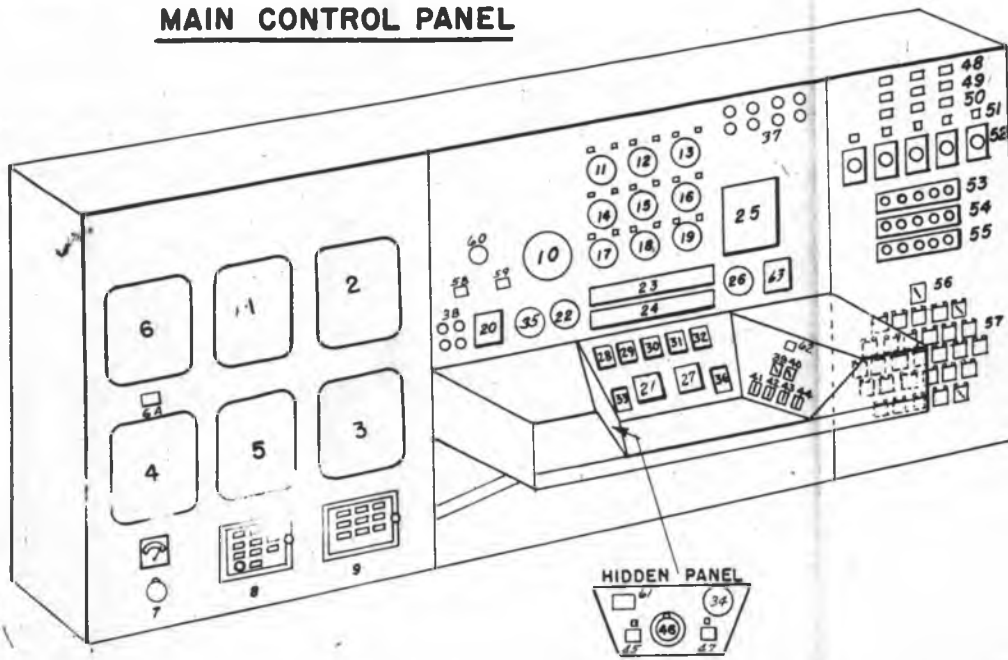
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# TRANSFER STATION & STORAGE BASIN



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## MAIN CONTROL PANEL



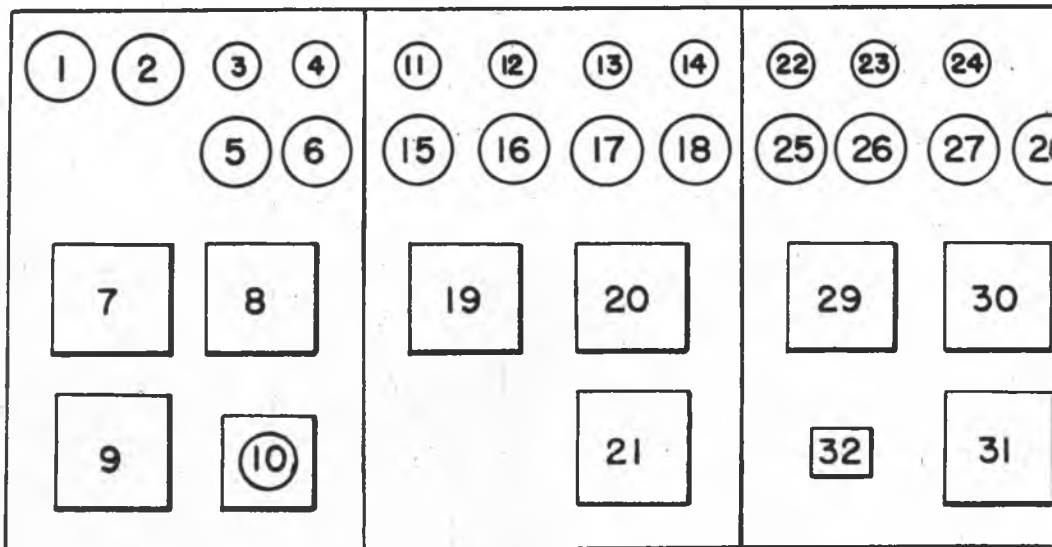
- 1) L&N recorder operated by Beckman micro-microammeter and neutron chamber under the pile, Beckman #2
- 2) L&N recorder operated by Beckman micro-microammeter and chamber monitoring water activity in the downcomer, Beckman #1
- 3) Multi-point L&N recorder operated by Beckman micro-microammeter and neutron chambers under the pile, Beckmans 3 and 4
- 4-5) Blank panels
- 6) Continuous single-point recorder recording position of regulating rod in use
- 6A) Toggle switch for selecting regulating rod to be recorded at 6
- 7) Voltmeter and switch for measuring battery voltage in galvanometer system
- 8) Switches to by-pass first "out" limit switches on shim rods
- 9) Nine switches for cutting the 9 Selsyns in and out of service

- 10) L&N circular chart recorder for differential power level indicator
- 11-19) Nine Selsyns indicating the position of 7 shim and 2 reg. rods. Reg. rods are 11 and 13. Green light over each Selsyn shows when rod is all in, red light shows when rod is all out
- 20) Range switch for differential power level indicator
- 21) Shunt for level galvanometer
- 22) Duplicate Selsyn for #1 regulating rod
- 23) Ground glass scale for level galvanometer
- 24) Ground glass scale for deviation galvanometer
- 25) Twenty-eight drop annunciator
- 26) Duplicate Selsyn for #2 regulating rod
- 27) Shunt for deviation galvanometer
- 28) Indicating meter for Beckman #1
- 29) Indicating meter for Beckman #2
- 30) Indicating meter for differential power level indicator
- 31) Indicating meter for Beckman #3

- 32) Indicating meter for Beckman #4
- 33) Push button to drive in the 7 shim rod high speed. Can be locked down with key
- 34) Electric interval time
- 35) Electric clock with sweep second hand
- 36) Push button operating #1 safety circuit to be locked down with key
- 37) Alarm lights for discharge water monitor
- 38) Indicating lights for doors into disc area at 0', 10', 20', and 30' levels
- 39) Switch to select regulating rod to be operated
- 40) Duplicate of 39 for other control rod locked so only 1 rod at a time can be operated
- 41) Switch for high speed, low speed selection of one regulating rod
- 42) Switch for direction selection of one regulating rod
- 43) Switch for high speed, low speed selection of other regulating rod
- 44) Switch for direction selection of other regulating rod
- 45) Switch to move a shim rod in either direction. Green light above switch indicates if controlled by this switch is in operation
- 46) Ten-point selector switch for selection of the 7 shim rods to be moved
- 47) Duplicate of 45 for second hydraulic accumulator
- 48) Green lights show when accumulator is above normal operating height
- 49) Amber lights show when the accumulator is just below normal operating height
- 50) Red lights show when levels have dropped point where the "low" annunciator flashes
- 51) Five indicator lights show green when rod power, shim rod power, #1 reg. rod power, #2 reg. rod power, and instrument power are on
- 52) Keys for locking power off, on the systems
- 53, 54, 55) Fifteen key by-pass switches for passing various safety circuits as needed during repairs and maintenance
- 56) Control for withdrawing or lowering rods individually or in groups, dependent upon setting of individual rod controls
- 57) Controls for tripping 29 safety rods usually. Green light above each control indicates when rod is in, and red light when rod is out
- 58, 59) Switches to turn on shim rod oil pumps
- 60) Selector switch to put "A" hole neutron chamber on either #2 Beckman or the galvanometer
- 61) Switch to operate both shim rod pumps to drive rods at twice normal speed
- 62) Reset button for alarm lights (37)

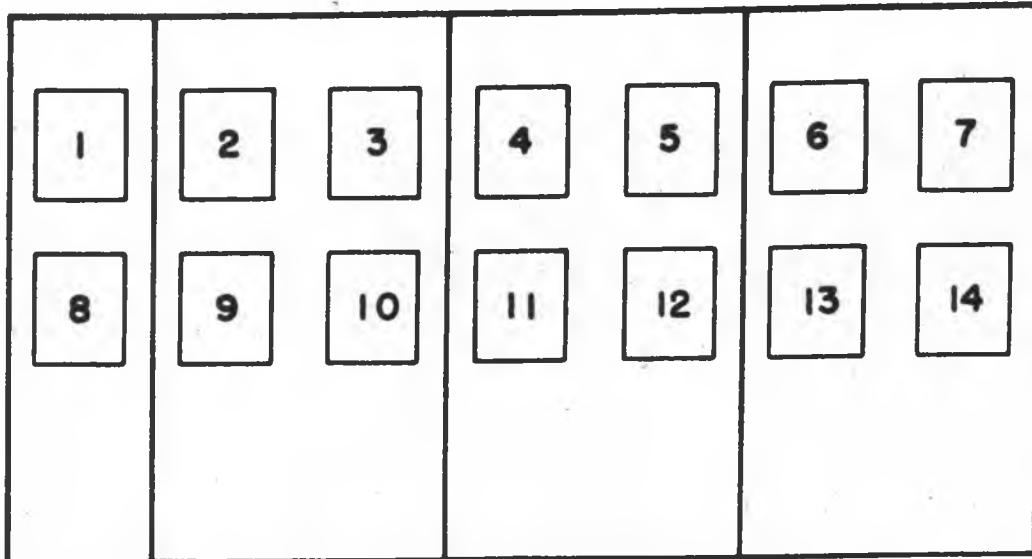


MISCELLANEOUS CONTROL PANEL



- 1) Helium exit pressure
- 2) Helium inlet pressure
- 3) #1 regulating rod exit water pressure
- 4) #2 regulating rod exit water pressure
- 5) #1 regulating rod exit water temp.
- 6) #2 regulating rod exit water temp.
- 7) Four-point recorder for:
  - a) % air in helium 0-100%
  - b) % air in helium 0-2%
  - c) % H<sub>2</sub>O in helium at pile exit
  - d) % H<sub>2</sub>O in helium at sample point 0-1%
- 8) Two-point recorder for:
  - a) helium temperature into pile
  - b) helium temperature out of pile
- 9) Two-point recorder, helium inlet and exit activity
- 10) Recording flowmeter, helium circulation rate into pile
- 11) #3 shim rod exit water pressure
- 12) #4 shim rod exit water pressure
- 13) #5 shim rod exit water pressure
- 14) #6 shim rod exit water pressure
- 15) #3 shim rod exit water t
- 16) #4 shim rod exit water t
- 17) #5 shim rod exit water t
- 18) #6 shim rod exit water t
- 19) Four-point recorder, exit temp. of rods #1, #2, and
- 20) Four-point recorder, exit temp. of rods #4, #5, and
- 21) Four-point recorder, miscellaneous exit water
- 22) #7 shim rod exit water p
- 23) #8 shim rod exit water p
- 24) #9 shim rod exit water p
- 25) #7 shim rod exit water t
- 26) #8 shim rod exit water t
- 27) #9 shim rod exit water t
- 28) Pile exit water pressure
- 29) Four-point recorder, exit temp. of rods #7, #8, and
- 30) Indicating temp. potentiometer and 32 DPDT toggle switch
- 31) Four-point temperature recorder controlled from 30
- 32) Selector switch for "B" thermocouples

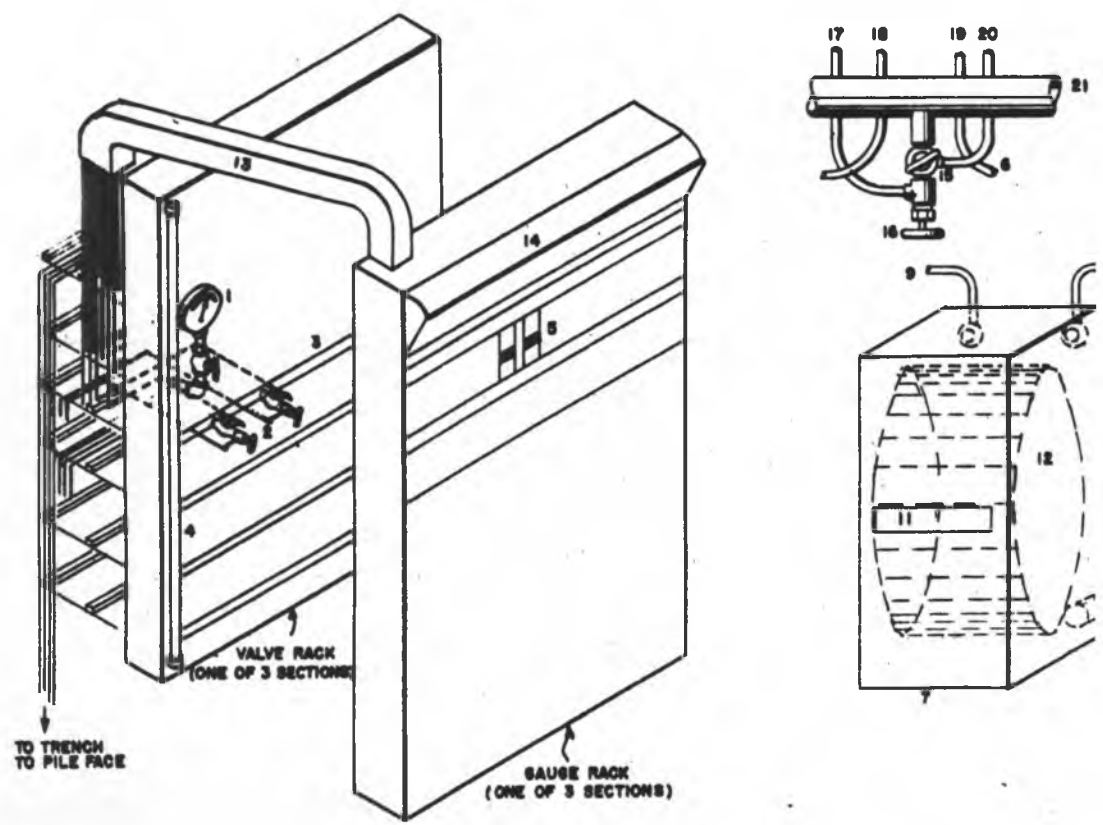
**INSTRUMENT**  
**MONITORING ROOM PANEL**



- 1) Recorder For pH Of Waste Water Entering River
- 2) Recorder For Intermediate Retention Basin Monitor
- 3) Recorder For Inlet Retention Basin Monitor
- 4) Recorder Of Radiation Intensity 20' Far Side Discharge Area
- 5) Recorder For Stack Air Monitor
- 6) Recorder Integron Dosage Measurement
- 7) Recorder Integron Dosage Measurement
- 8) Recorder Of Radiation Intensity Top Of Pile And Transfer Area
- 9) Recorder Of Gamma Activity Of Retention Basin Exit Water
- 10) Recorder Of Beta Activity Of Retention Basin Exit Water
- 11) Recorder Of Radiation Intensity 0', 10', 20', 30' Near Side Discharge Area
- 12) Recorder For Exhaust Air Monitor
- 13) Recorder For Integron Dosage Measurement
- 14) Recorder For Integron Dosage Measurement

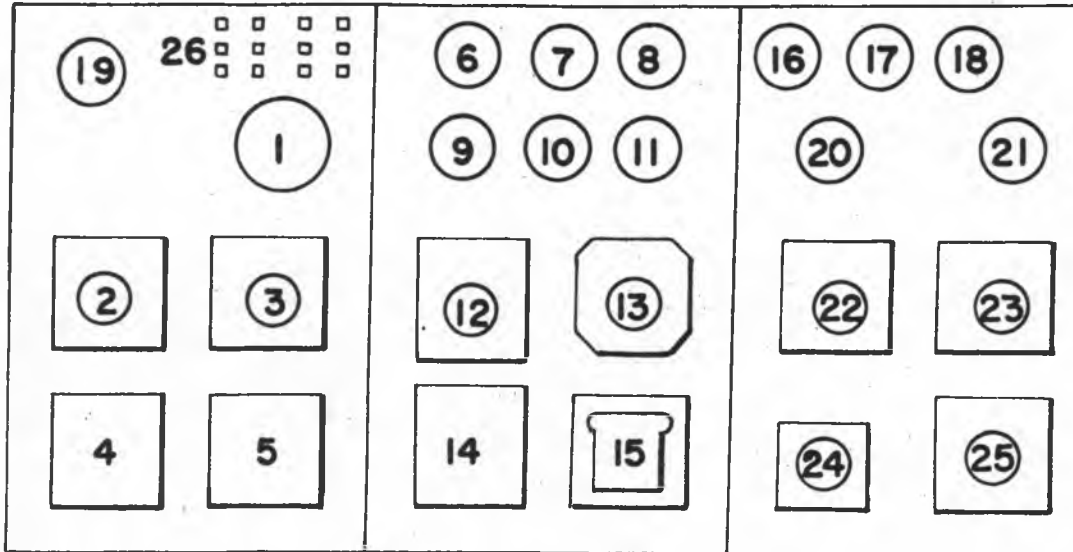
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### VALVE RACK AND GAUGE BOARD

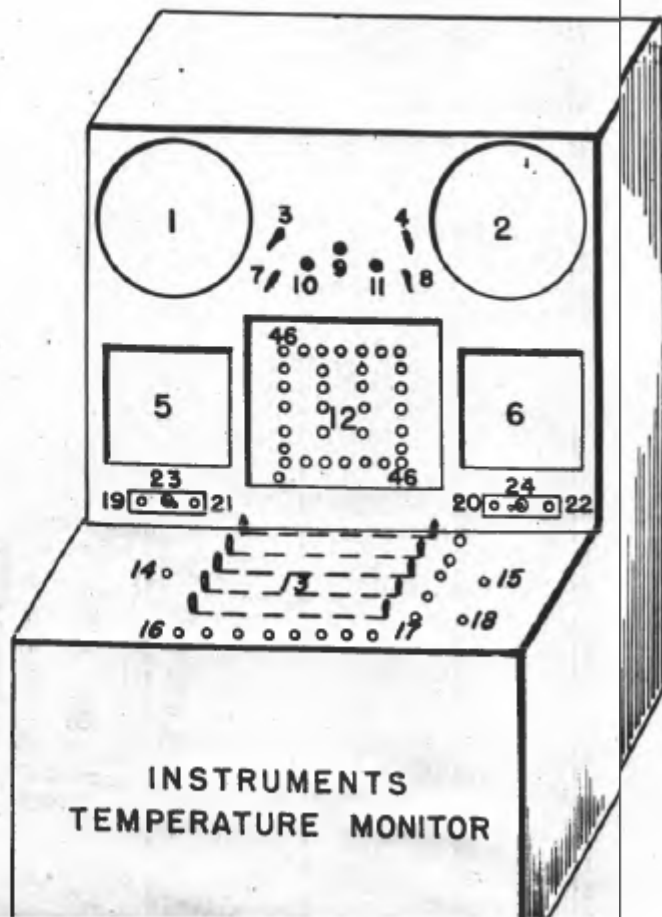


- 1) Master gauge
- 2) Valve assembly, one for each tube and individual Panellit gauge
- 3) Horizontal gauge header
- 4) Master gauge riser connecting all horizontal gauge headers
- 5) Individual Panellit gauge, one for each tube
- 6) Detail of valve assembly
- 7) Detail of Panellit gauge
- 8&9) Series relay connections
- 10) Pressure connection
- 11) Transparent slot
- 12) Rotating pressure indicating element. Shows white at normal pressure, red on low pressure, and green on high pressure
- 13) Conduit for 3/16 outside diameter copper tubes to pressure gauge
- 14) Indicating lights
- 15) Two-way valve, connects Panellit gauge to either master gauge, or to tube pressure connection
- 16) Needle valve to shut off individual Panellit gauge as necessary
- 17) Line to Panellit gauge
- 18) Line from next valve on left to its corresponding tube
- 19) Line from next valve on right to its corresponding Panellit gauge
- 20) Line from tube at pile face
- 21) Header to master gauge

## INSTRUMENTS INLET WATER PANEL



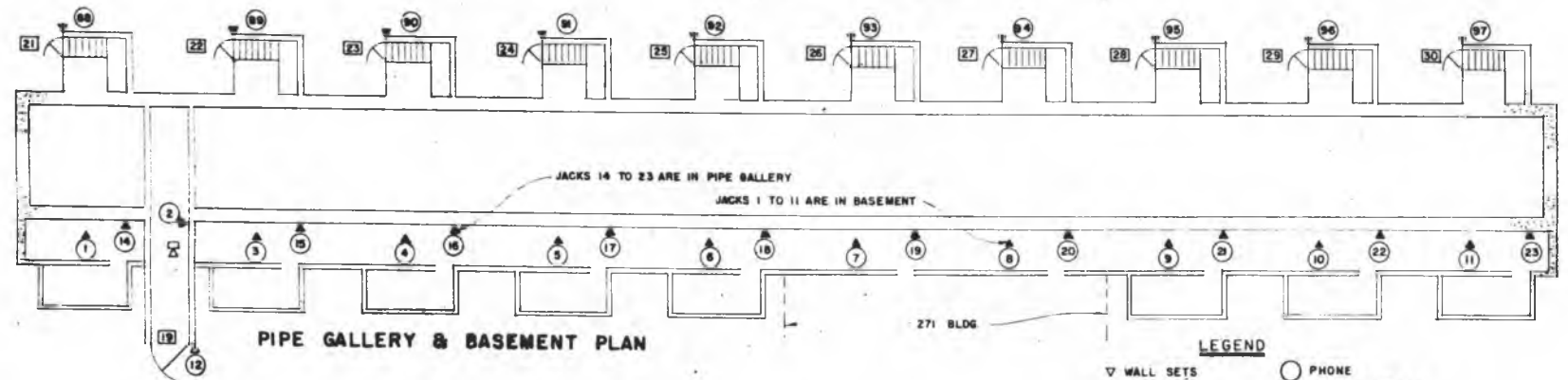
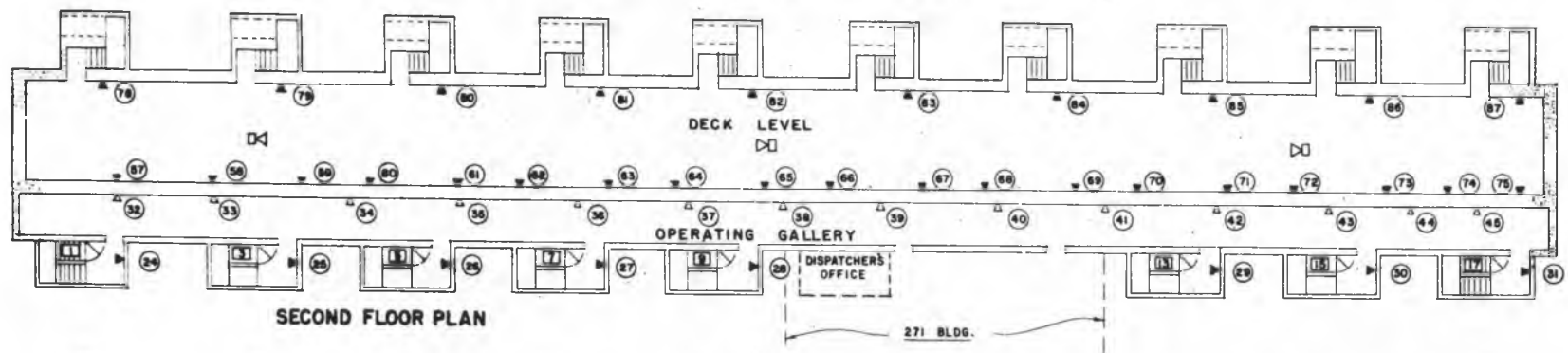
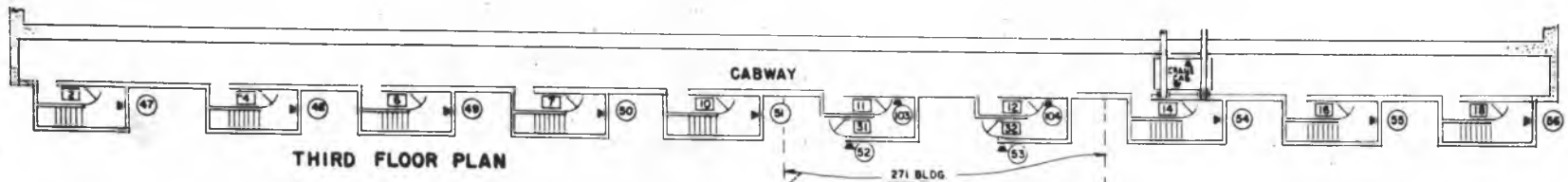
- |  |   |
|--|---|
| <ol style="list-style-type: none"><li>1) Water pressure, left-hand unchilled 20" riser</li><li>2) Total flow, rate of heat transfer (kw.), and temperature difference, recorder</li><li>3) Flow and temperature recorder, left-hand unchilled 20" riser</li><li>4) Kilowatt calculator (blank door)</li><li>5) Flow converter (blank door)</li><li>6) Main steam pressure</li><li>7) Stand-by filtered water pressure</li><li>8) Stand-by raw water pressure, valve pit</li><li>9) Water pressure, left-hand chilled 20" riser</li><li>10) Water pressure, chilled header, at valve pit</li><li>11) Water pressure, unchilled header at valve pit</li><li>12) Flow and temperature recorder, left-hand chilled 20" riser</li><li>13) Two-pen pressure recorder, chilled and unchilled headers at valve pit</li><li>14) Temperature differential converter (blank door)</li></ol> | <ol style="list-style-type: none"><li>15) Two-point temperature recorder temperature each side of valve in by-pass between chilled and unchilled headers</li><li>16) Water pressure, left-hand tank</li><li>17) Water pressure, right-hand tank</li><li>18) Inlet water pressure, therm shield</li><li>19) Instrument air pressure</li><li>20) Water pressure, right-hand chilled 20" riser</li><li>21) Water pressure, right-hand unchilled 20" riser</li><li>22) Flow and temperature recorder right-hand chilled 20" riser</li><li>23) Flow and temperature recorder right-hand unchilled 20" riser</li><li>24) Two-point recorder, high tank levels</li><li>25) Flow recorder, water to therm shield</li><li>26) Storage tank level indicating lights</li></ol> |
|--|---|



- 1&2) I&N single-point recorders
- 3&4) Retractable plugs for I&N recorders, 1 and 2 respectively
- 5&6) Brown high speed recorders
- 7&8) Retractable plugs for Brown recorders, 5 and 6 respectively
- 9) Jack for monitoring 2004 tubes
- 10) Jack for monitoring 1002 tubes
- 11) Jack for monitoring other 1002 tubes
- 12) Jack board containing a jack for each individual tube
- 13) Five rows of 40 plugs each for plugging into 200 or less jacks on 12
- 14&15) Jacks for plugging recorder into 200 tube system
- 16) Forty indicator lights
- 17) Row skip switches
- 18) 200-point repeat switch
- 19&20) Monitor starting switches
- 21) Row selector switch -- rows 01-23
- 22) Row selector switch -- rows 24-46

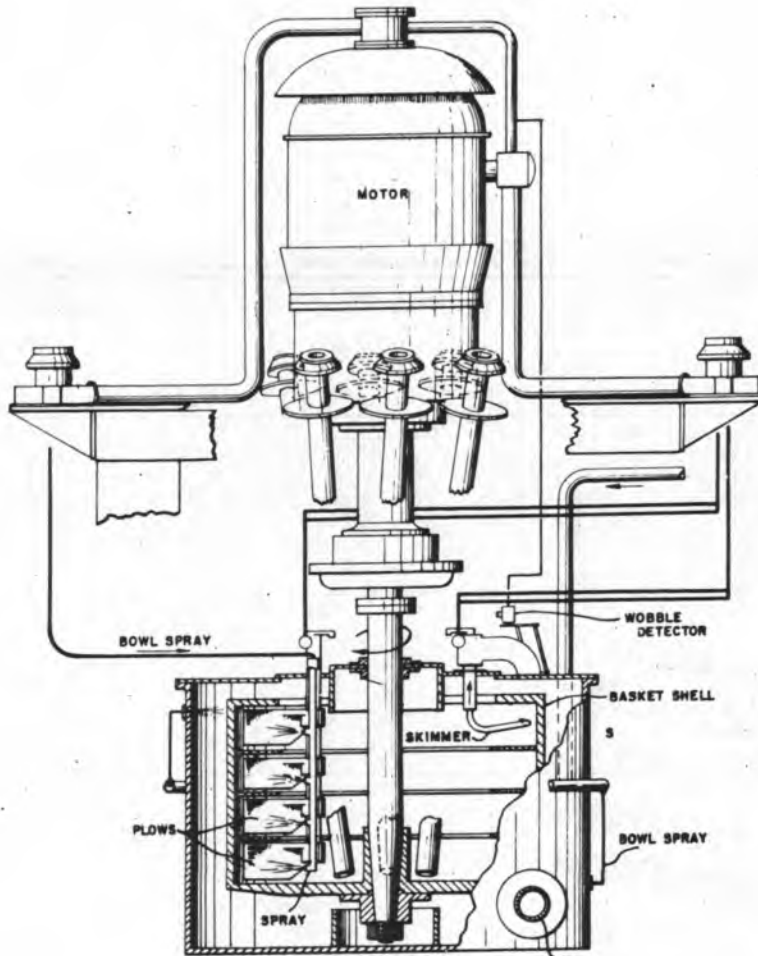
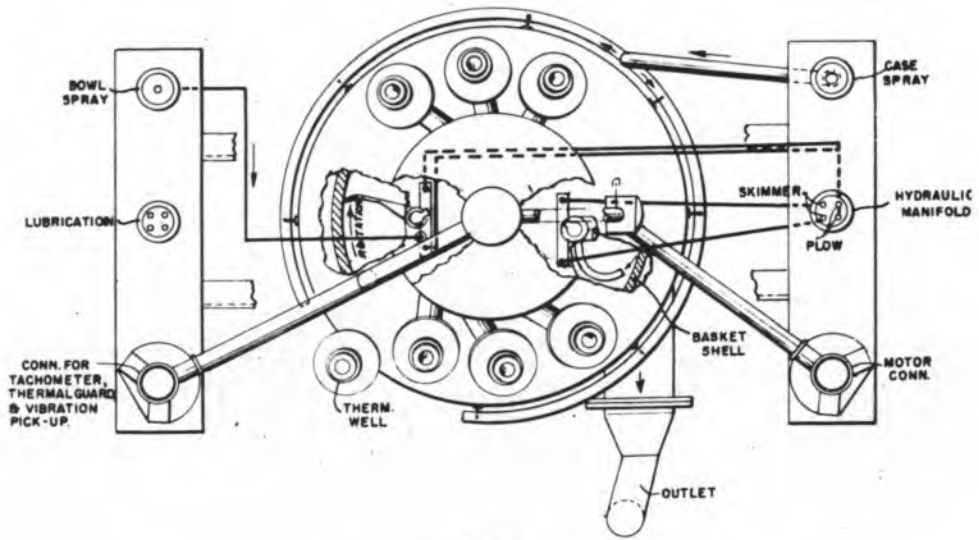
SECRET

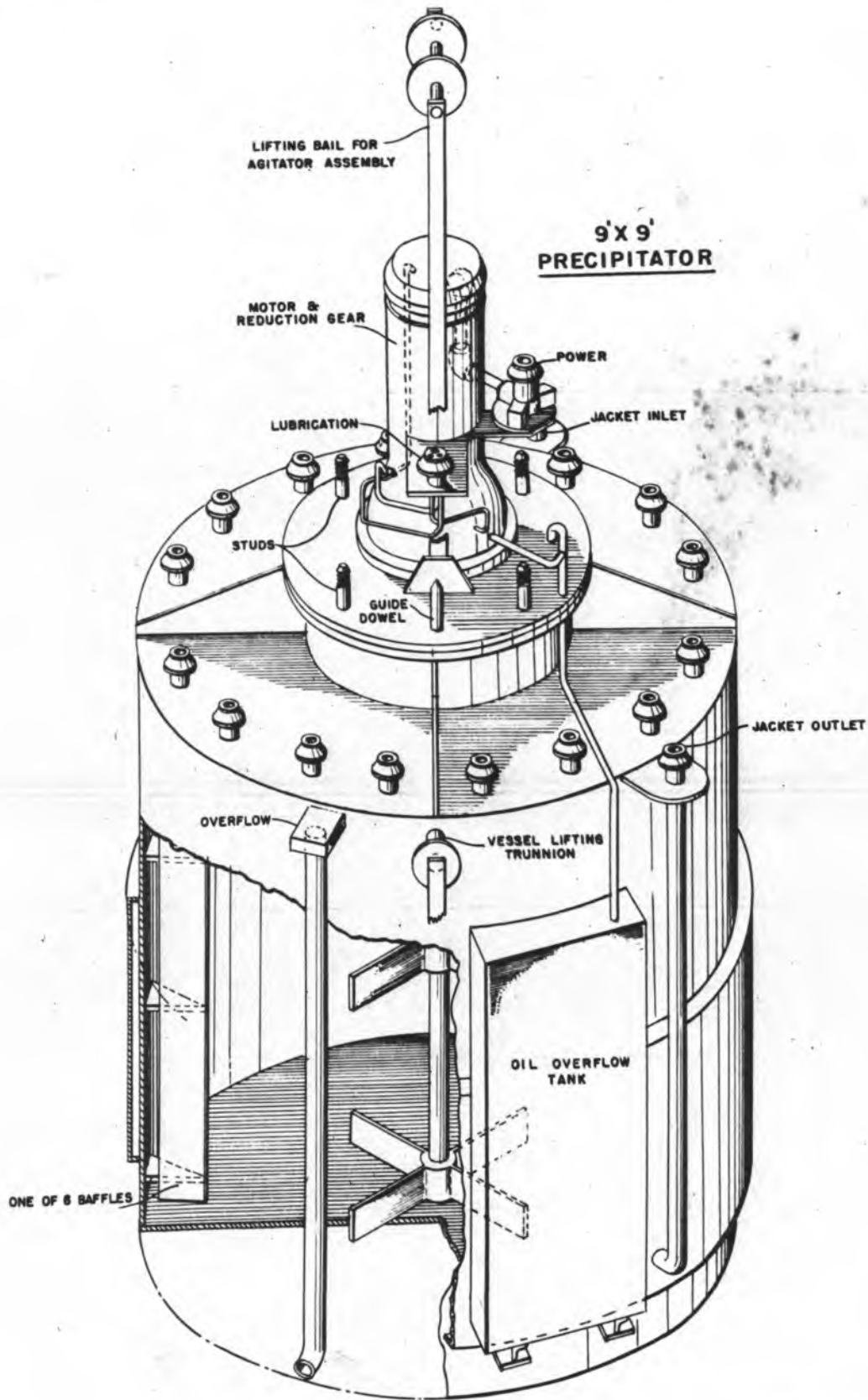
SECRET



- LEGEND**
- ▽ WALL SETS
  - ▽ PHONE JACKS
  - ◇ ALARMS
  - PHONE
  - ELEC LOCKED DOOR

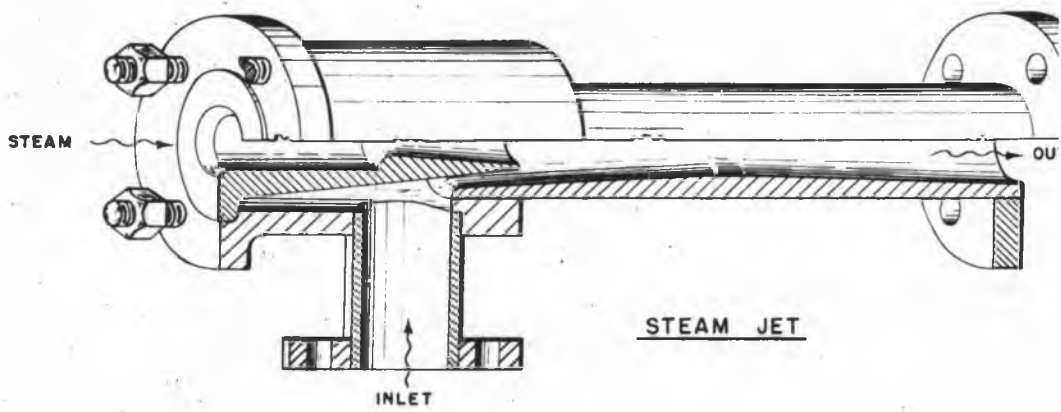
**CENTRIFUGE**





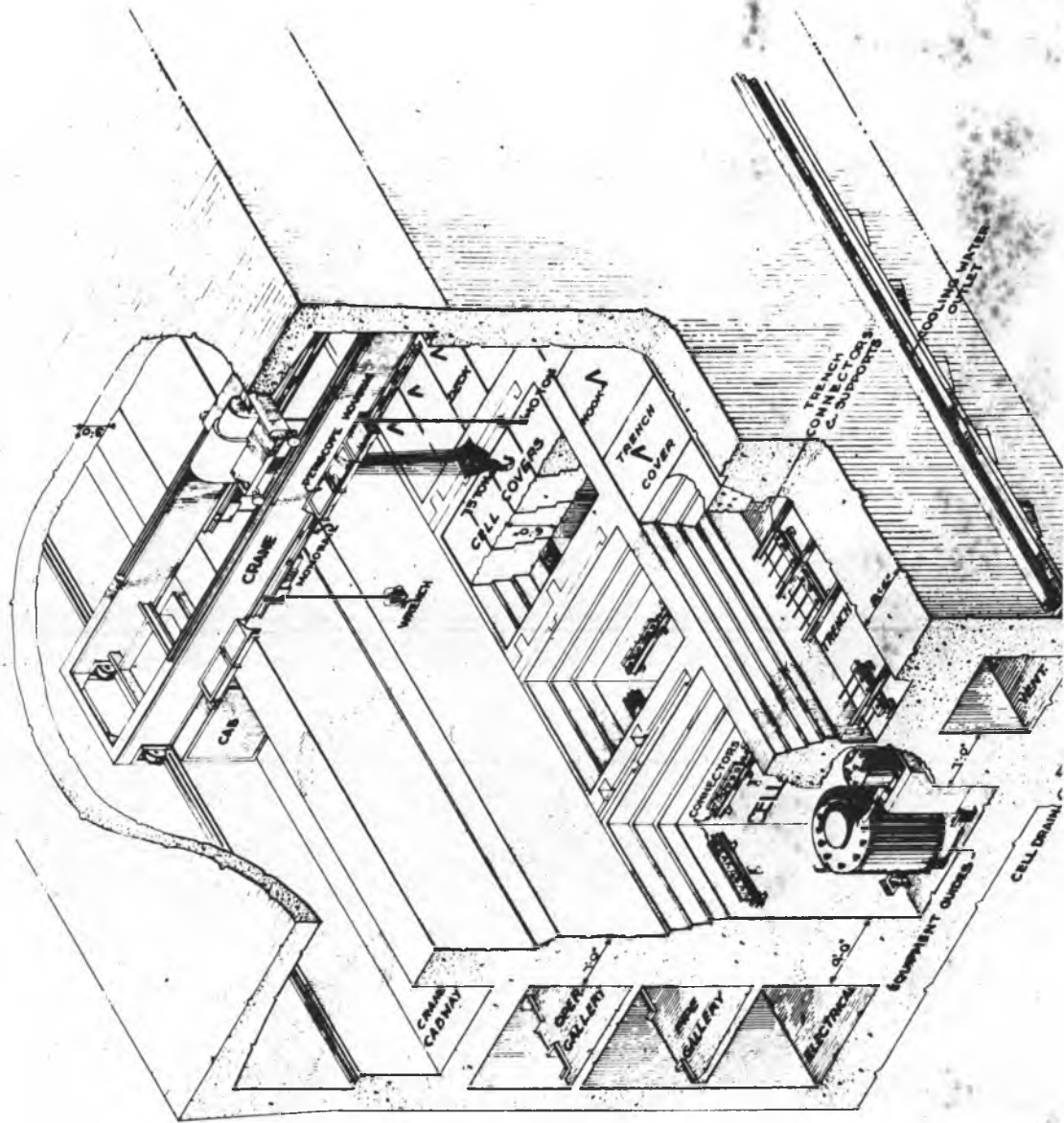


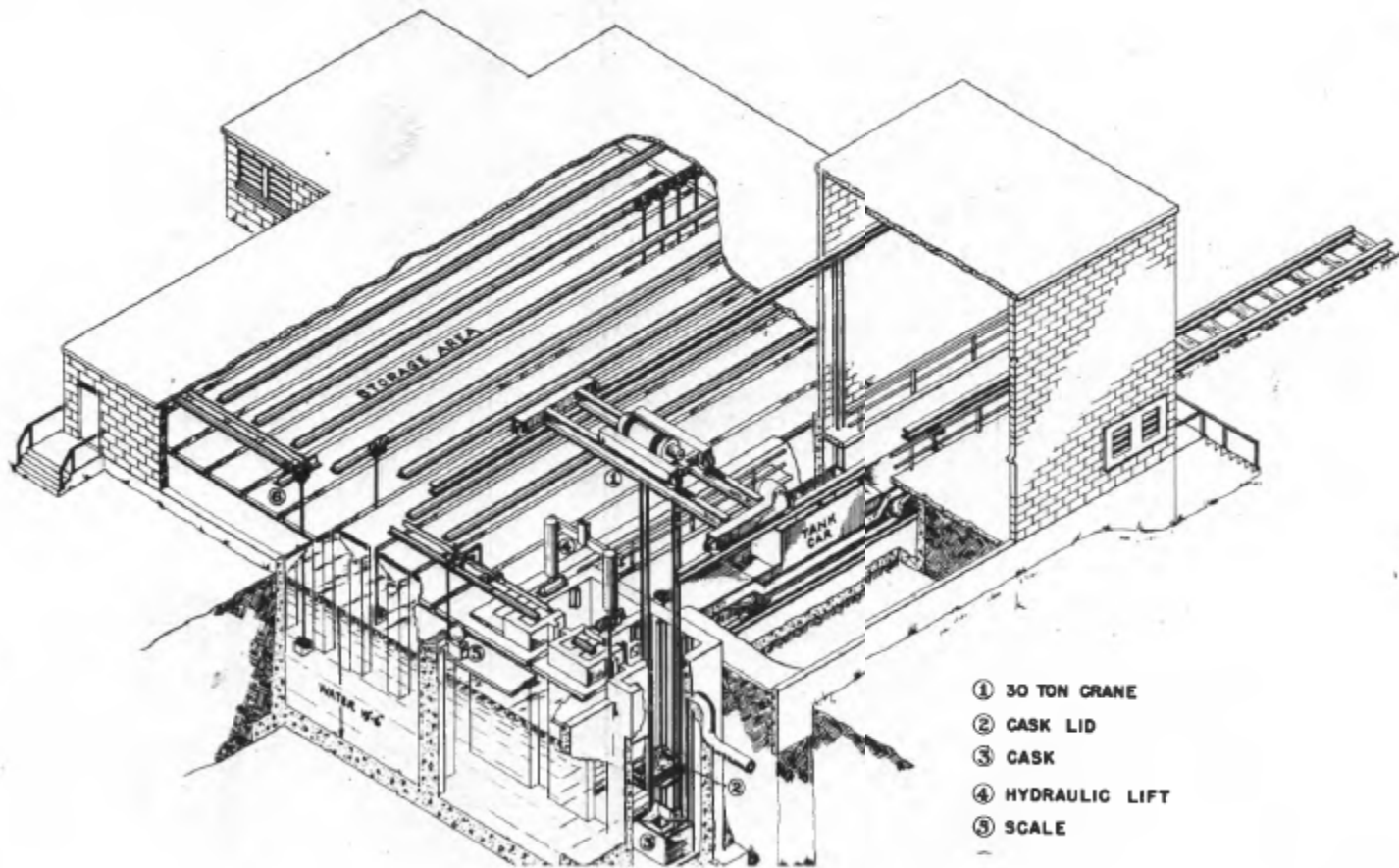
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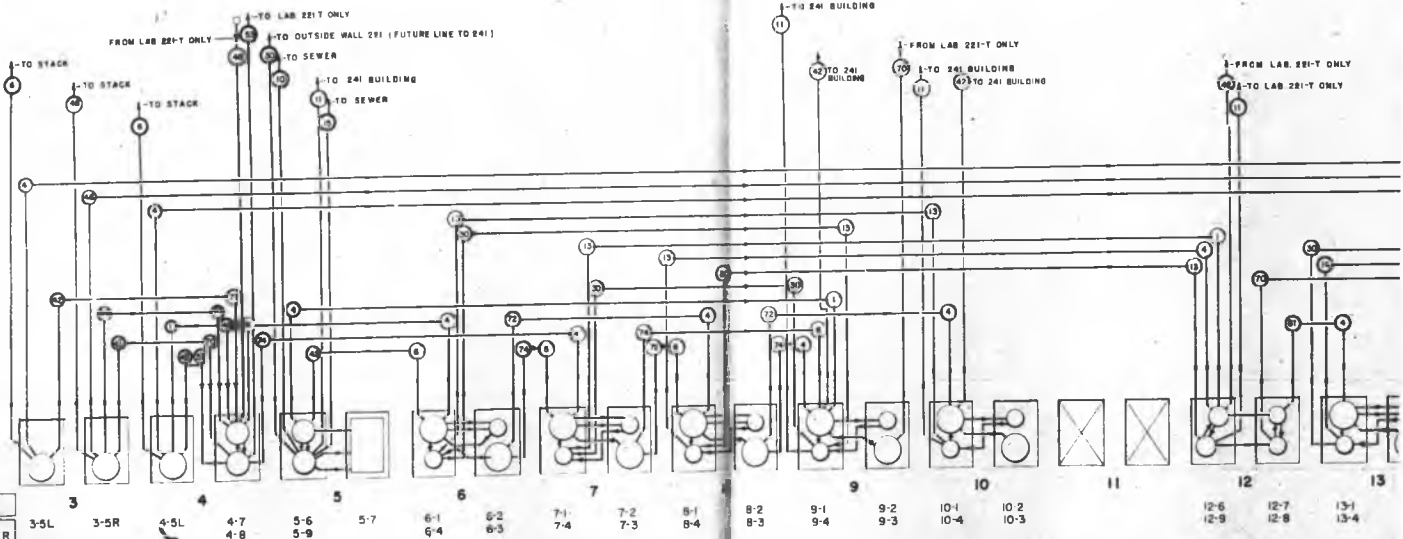
STEAM JET

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R

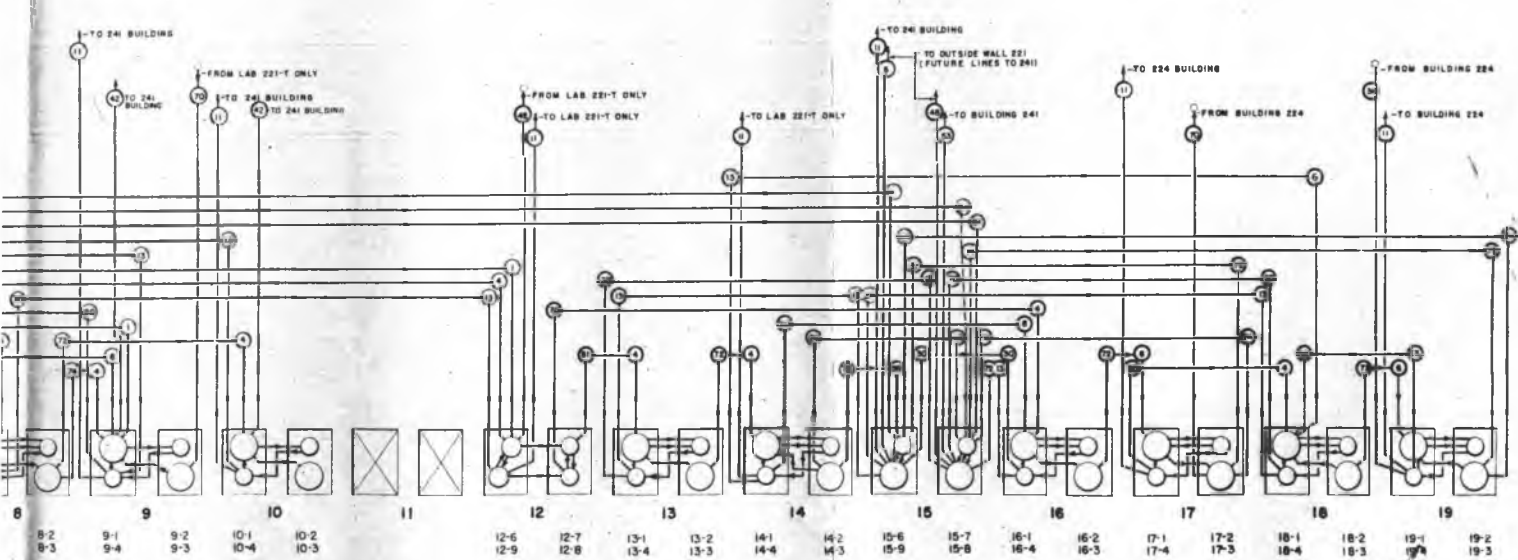




SECTION  
EQUIPMENT  
PIECE NUMBER

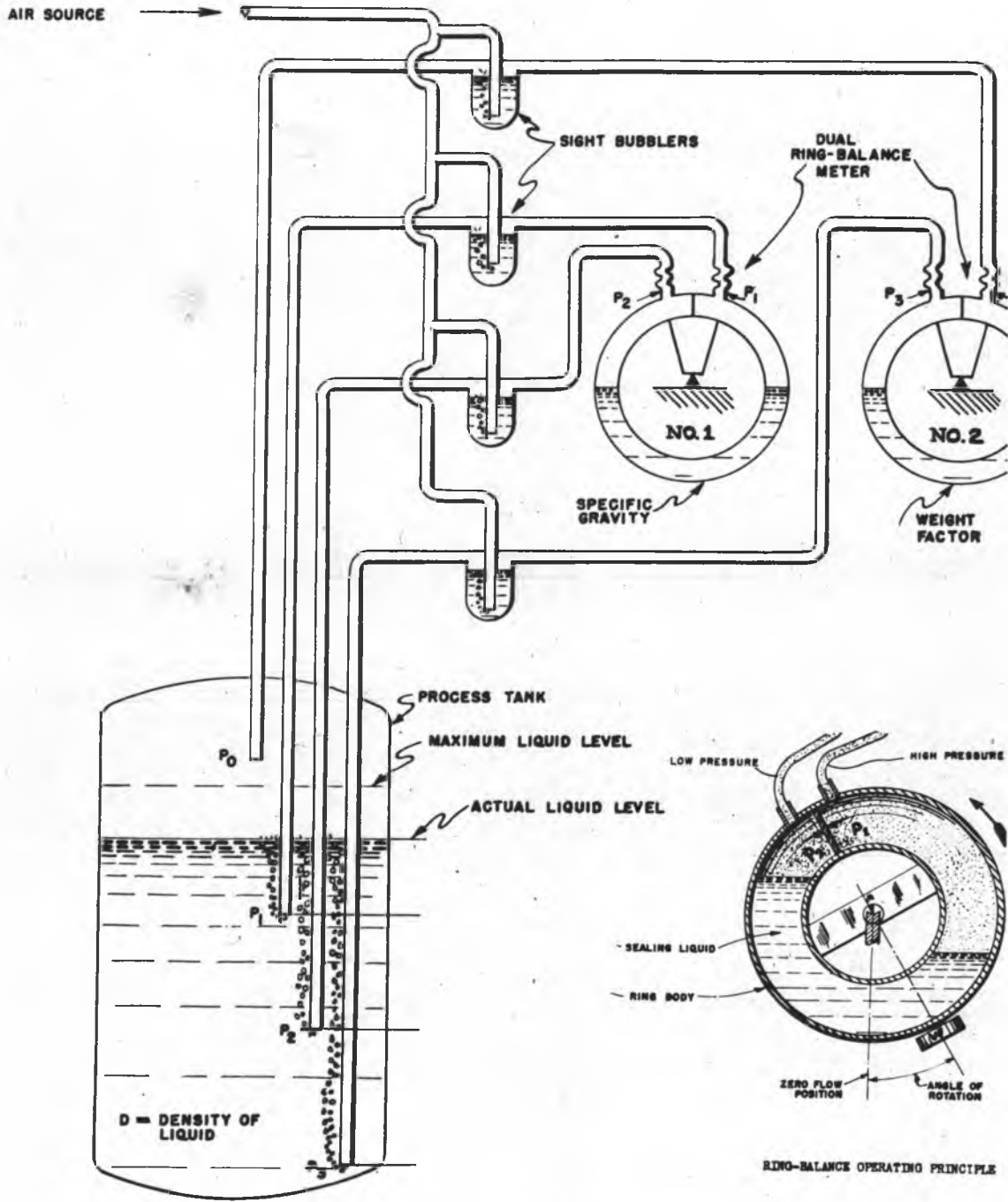


221 BLDG. PROCESS PIPING DIAGRAM

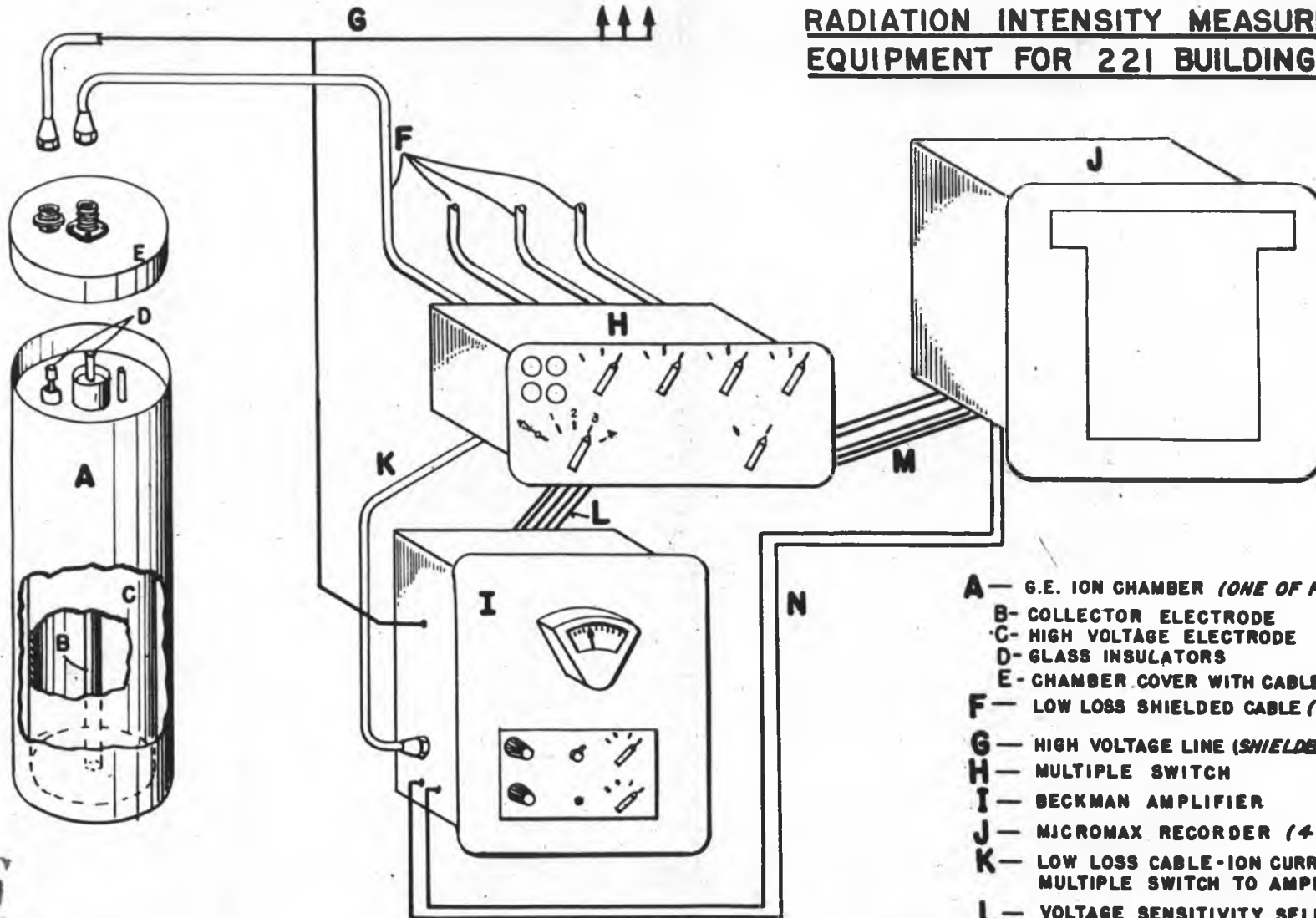


221 BLDG. PROCESS PIPING DIAGRAM

### LIQUID LEVEL MEASUREMENT WITH SPECIFIC GRAVITY AND WEIGHT FACTOR

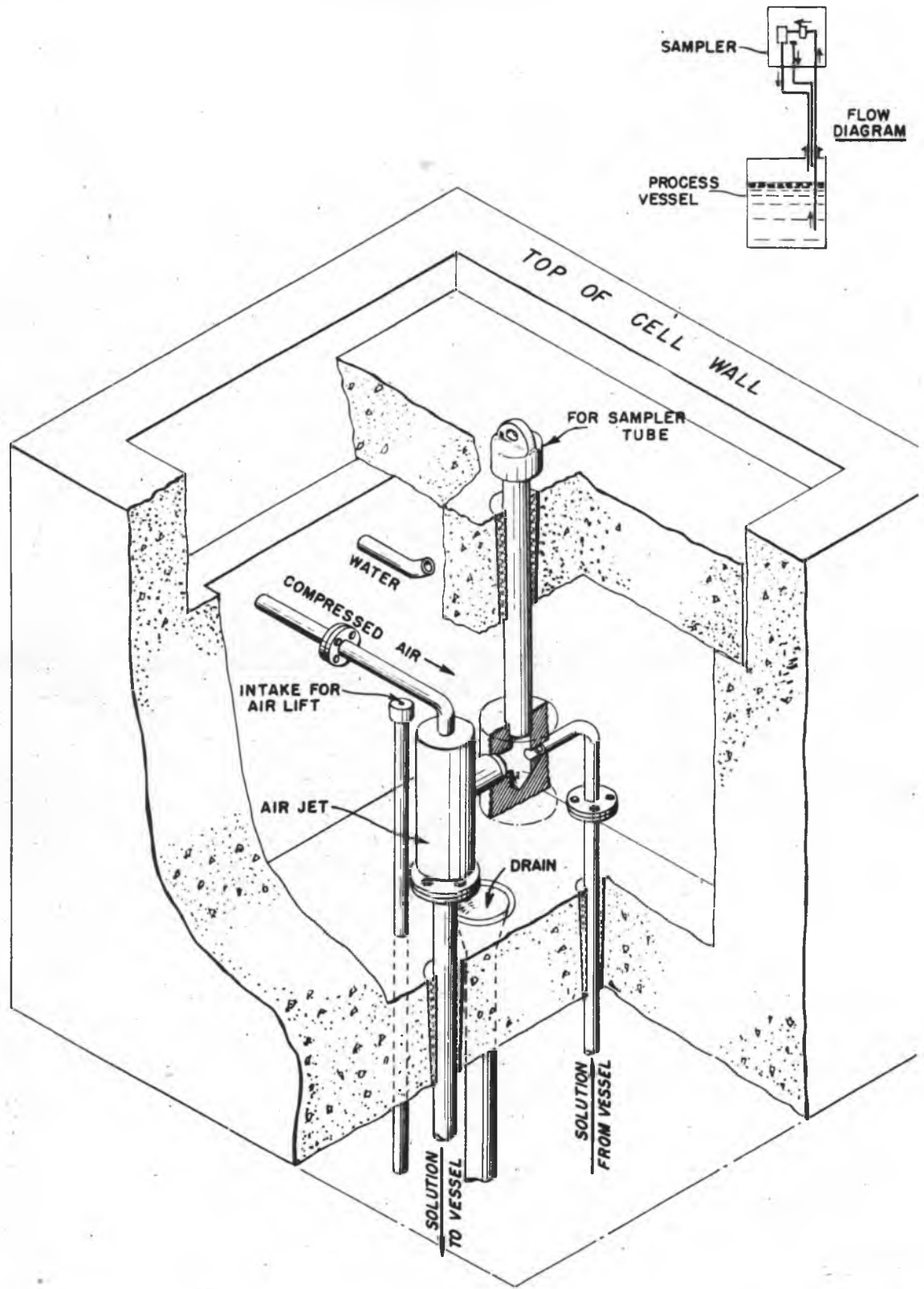


**RADIATION INTENSITY MEASUREMENT  
EQUIPMENT FOR 221 BUILDING CELLS**



- A** — G.E. ION CHAMBER (ONE OF FOUR)
- B** — COLLECTOR ELECTRODE
- C** — HIGH VOLTAGE ELECTRODE
- D** — GLASS INSULATORS
- E** — CHAMBER COVER WITH CABLE CONNECTORS
- F** — LOW LOSS SHIELDED CABLE (FOR 4 CHAMBERS)
- G** — HIGH VOLTAGE LINE (SHIELDED) TO 4 CHAMBERS
- H** — MULTIPLE SWITCH
- I** — BECKMAN AMPLIFIER
- J** — MICROMAX RECORDER (4 POINT)
- K** — LOW LOSS CABLE-ION CURRENT FROM MULTIPLE SWITCH TO AMPLIFIER.
- L** — VOLTAGE SENSITIVITY SELECTION LINES FOR EACH CHAMBER

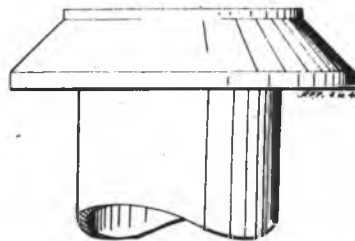
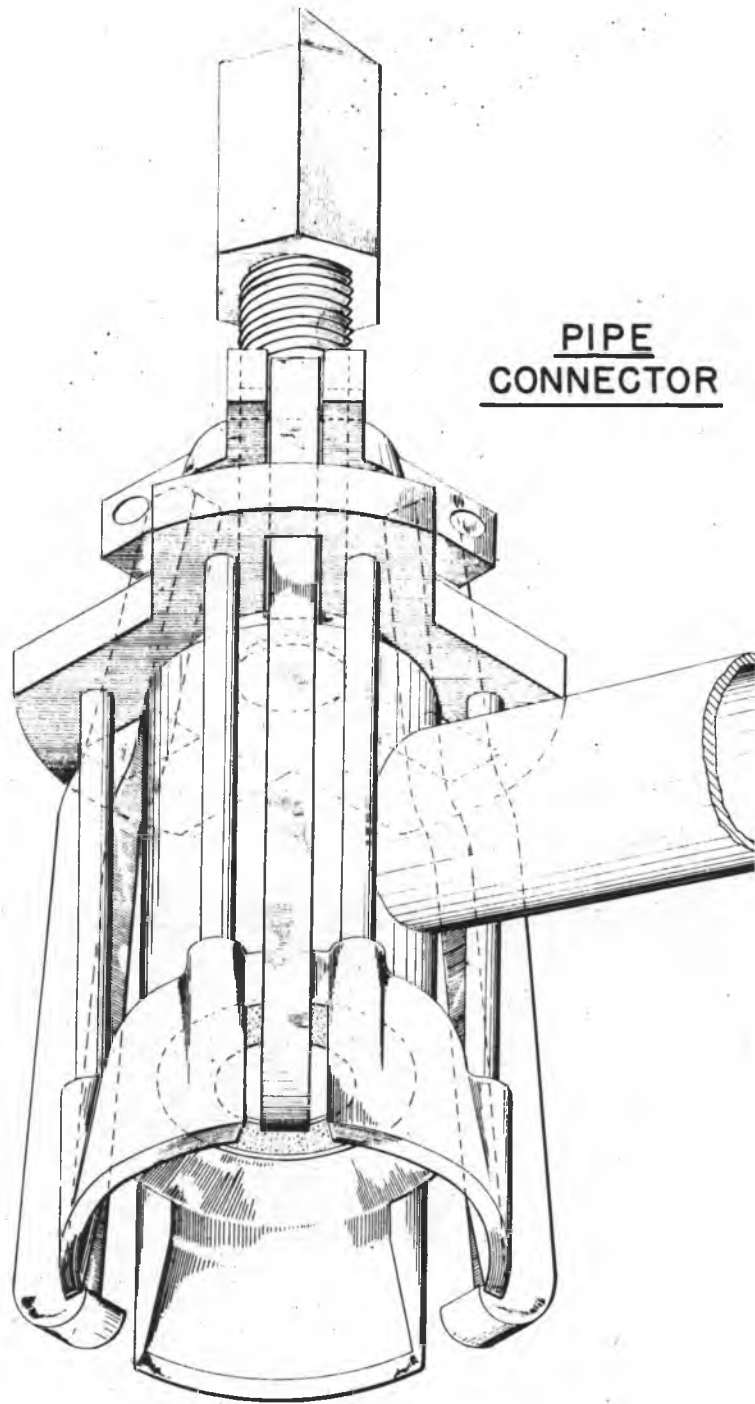
**SAMPLER**



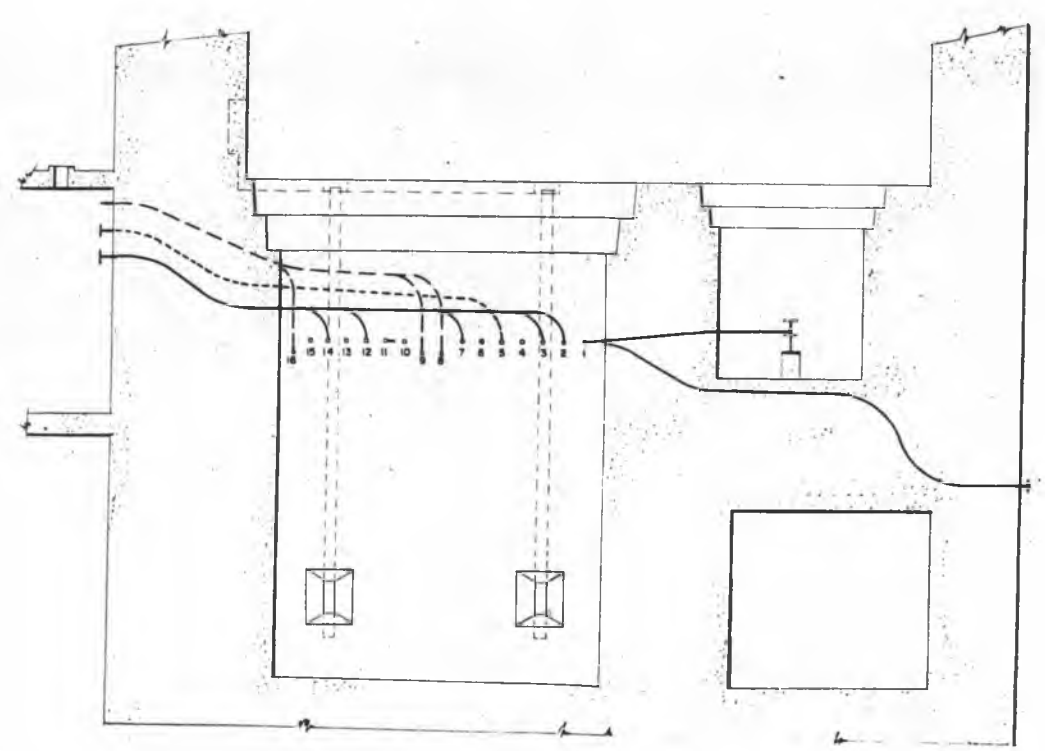
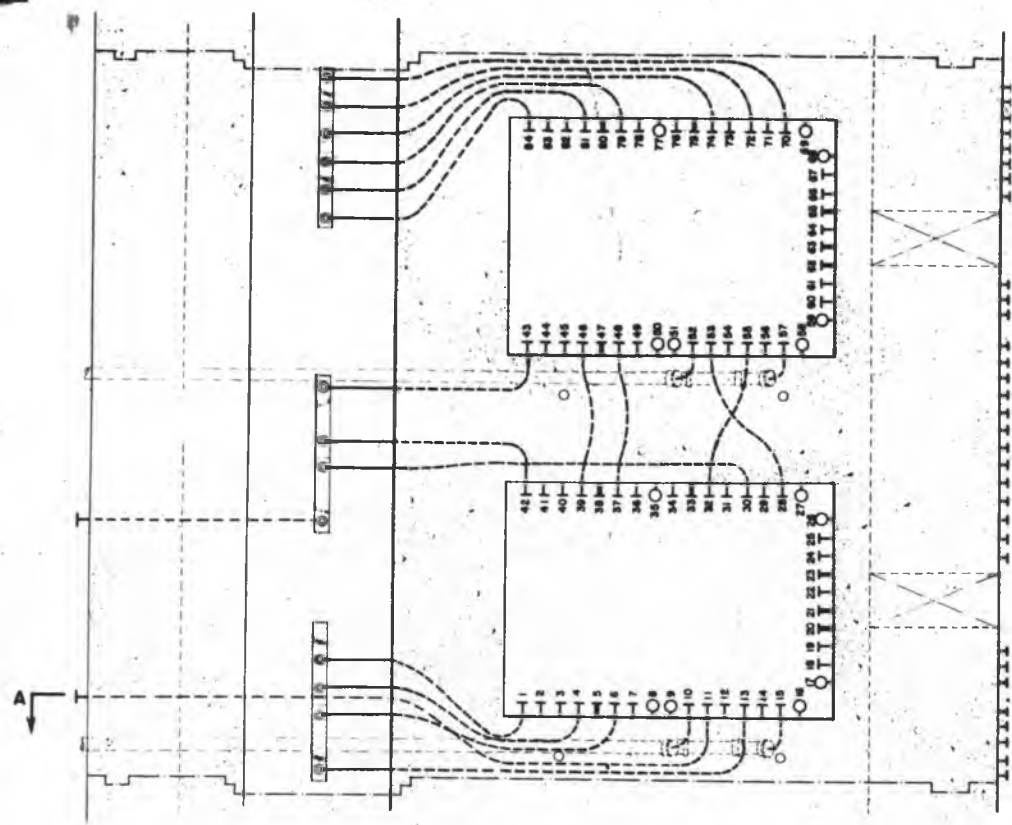


SECRET

PIPE  
CONNECTOR



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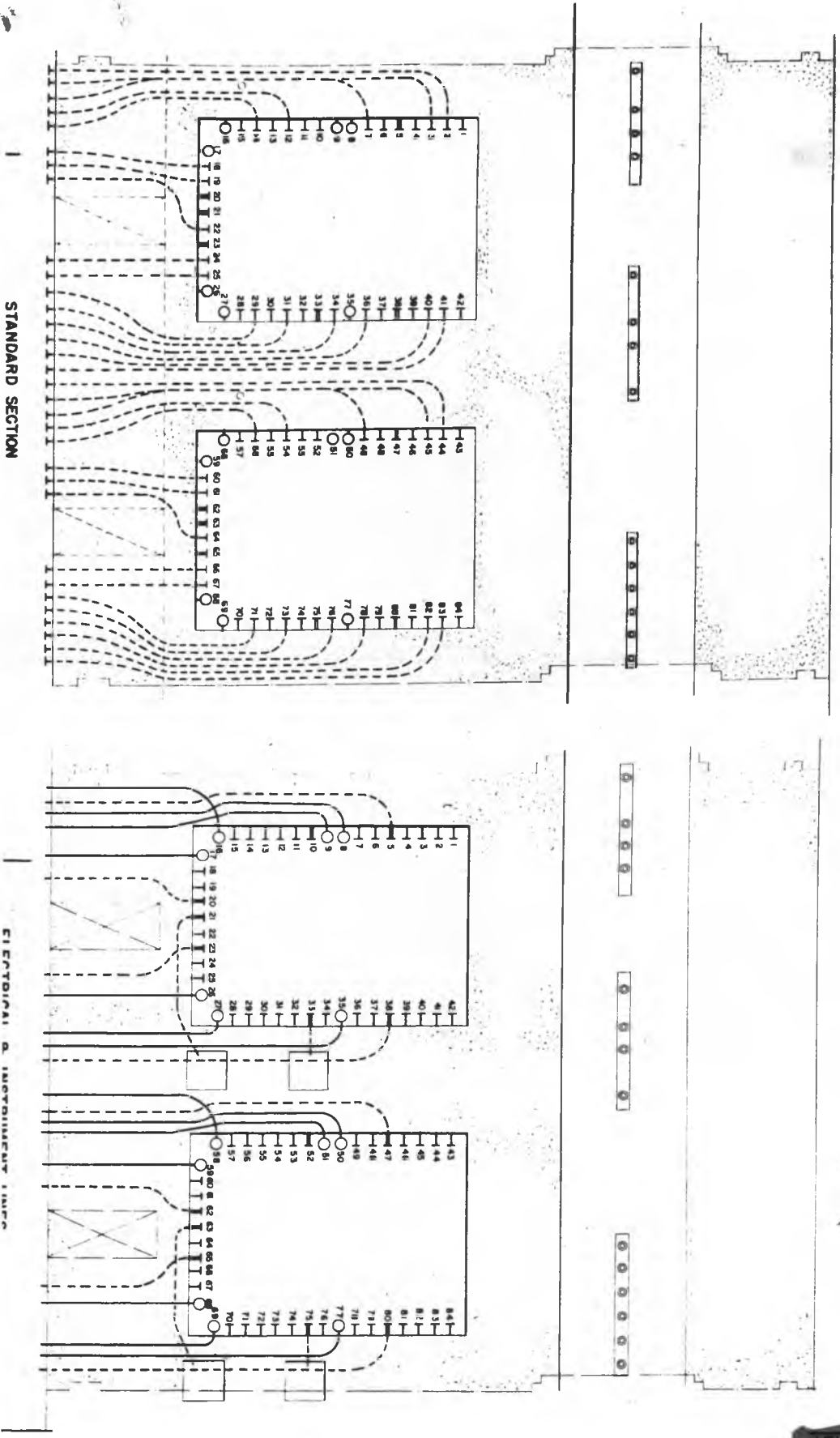


**SECTION A-A**  
ELECTRICAL ————  
INSTRUMENTS - - - - -  
STEAM, CHEMICAL ————

h

PAGE 314

PAGE 314



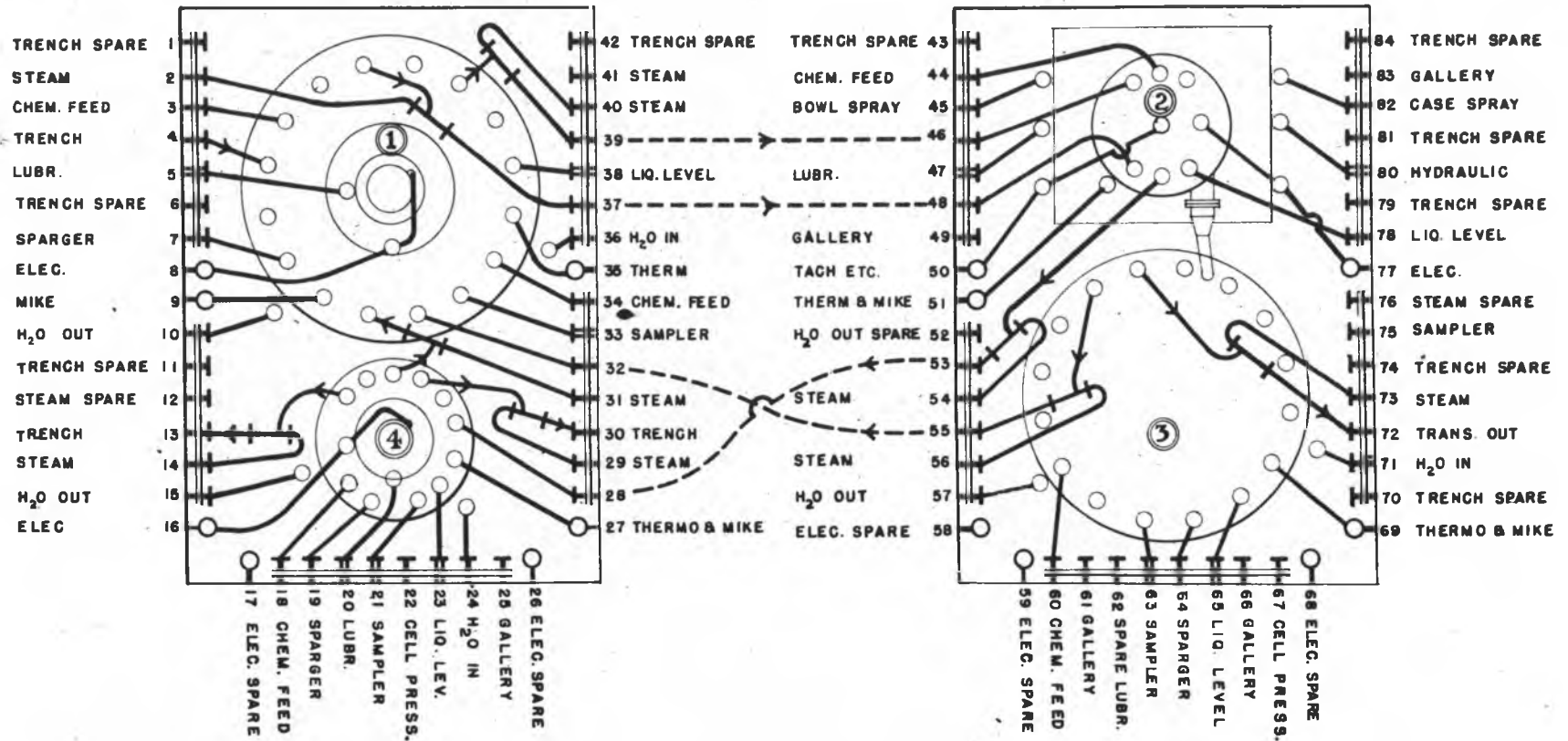
STANDARD SECTION

ELECTRICAL EQUIPMENT RACK

SECRET

CELL NO. 25

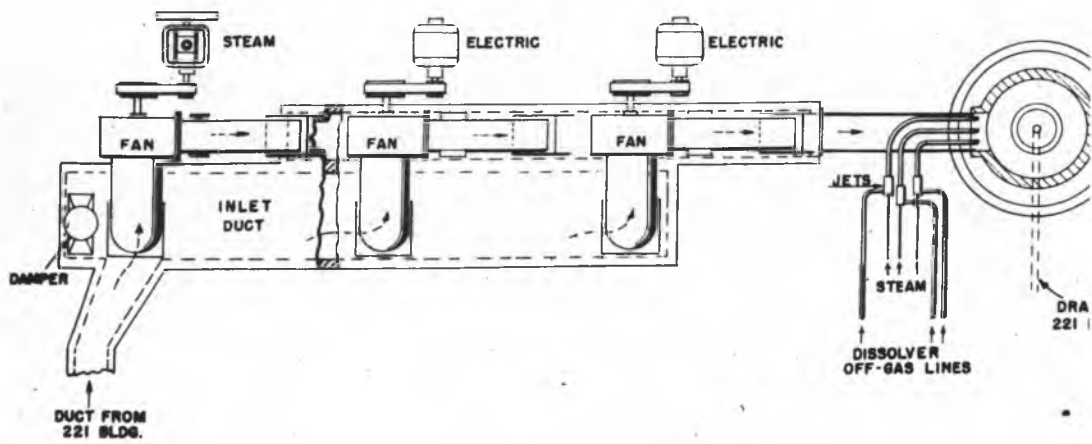
CELL NO. 26



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<u>Section</u>	<u>Cell</u>	<u>Function</u>
1	1 & 2	Storage of contaminated discarded equipment
2	3	Railroad tunnel for bringing in metal
2	4	Storage of slugs with fractured coating. This cell is kept filled with water (see 212 Building)
3	5 & 6	Coating removal, metal dissolving and reduc
4	7	Coating removal, metal dissolving and reduc
4	8	Metal solution storage
5	9	Sewage disposal, holding tanks
5	10	Sewage disposal, sewer cell
6	11 & 12	Spare. May be used for a by-product precipi tation before extraction
7	13 & 14	Extraction
8	15 & 16	Extraction (spare)
9	17 & 18	Treatment of waste metal solution
10	19 & 20	Treatment of waste metal solution (spare)
11	21 & 22	Spare, unequipped
12	23 & 24	Storage and oxidation of metal solution
13	25 & 26	First decontamination cycle, by-product precipitation
14	27 & 28	First decontamination cycle, product precipitation
15	29 & 30	Treatment of decontamination wastes
16	31 & 32	Second decontamination cycle
17	33 & 34	Second decontamination cycle
18 & 19	35, 36, 37 & 38	Third decontamination cycle (spare)
20	39 & 40	Spare, unequipped

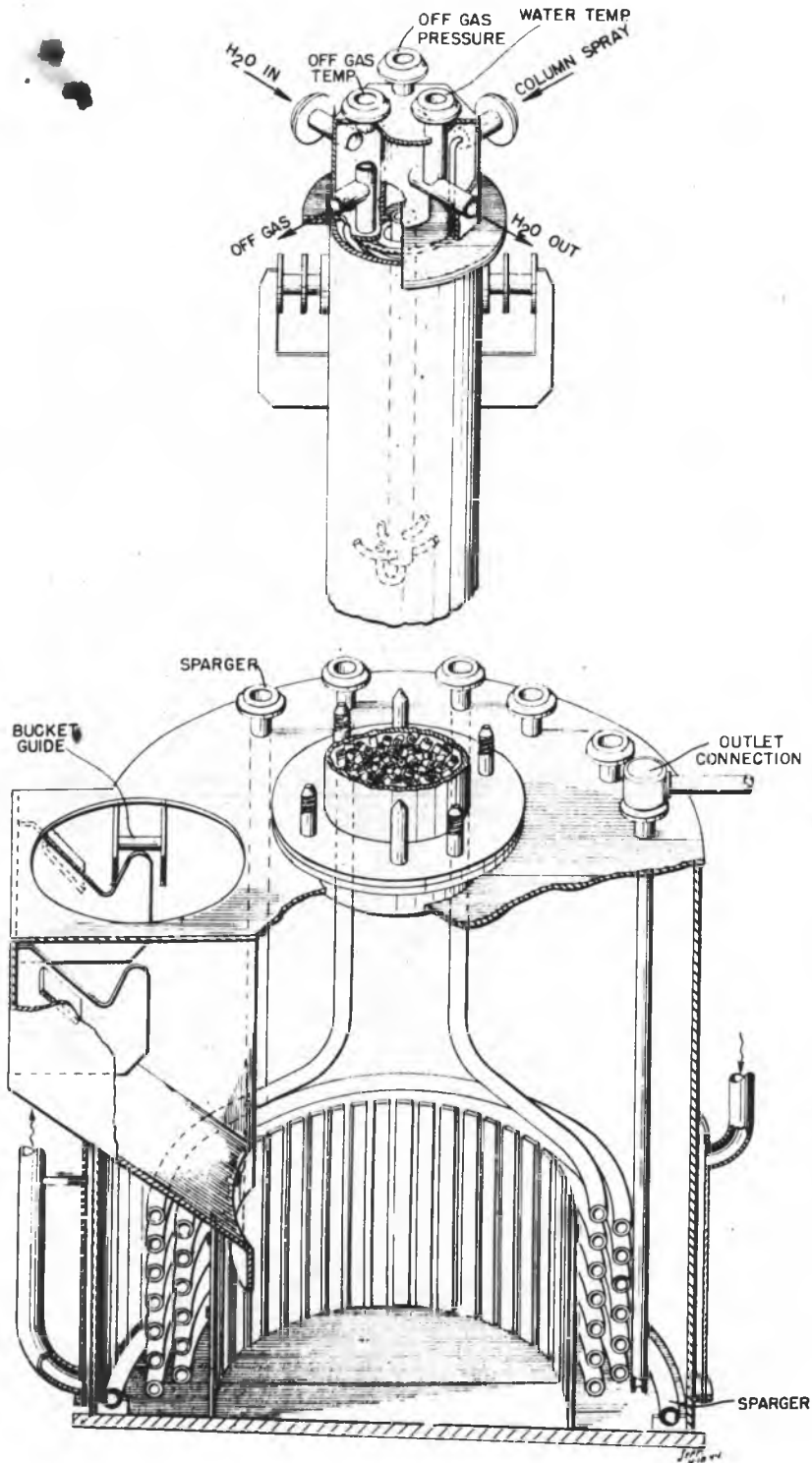
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VENTILATION BUILDING LAYOUT

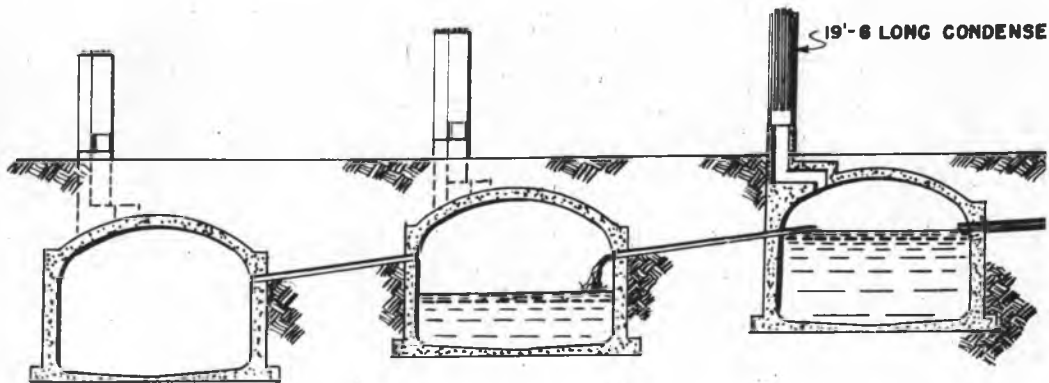
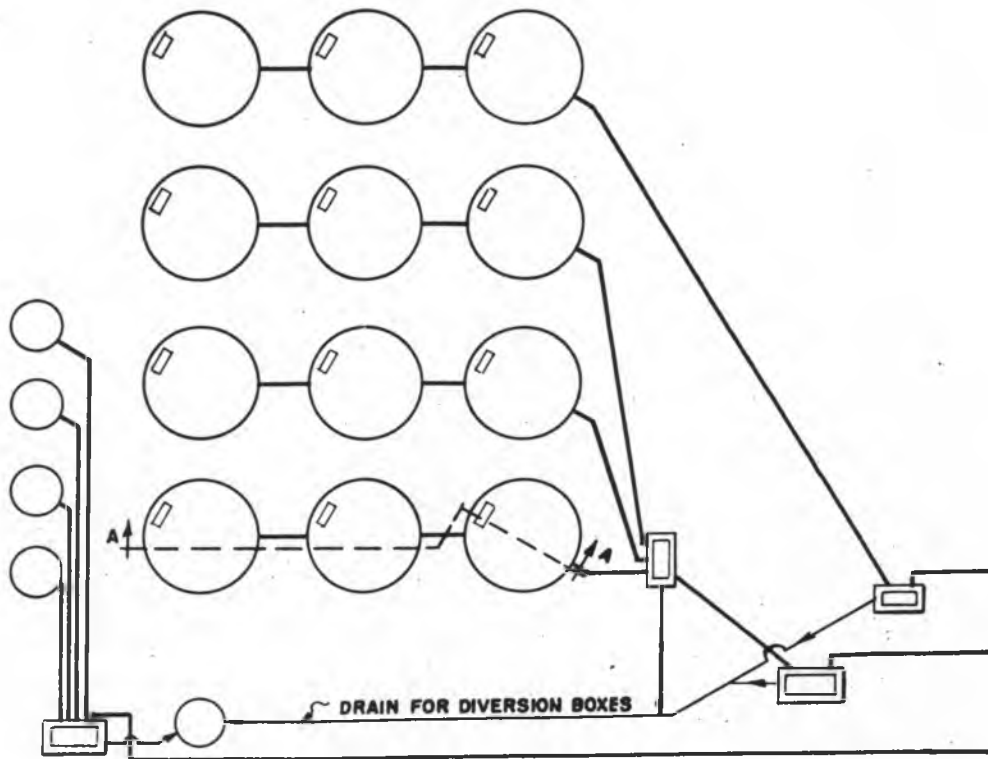
3  
A

SECRET



DISSOLVER

~~SECRET~~

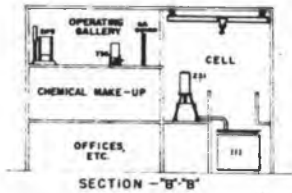


SECTION ON A-A OF 78'-0" DIA. STORAGE TANKS

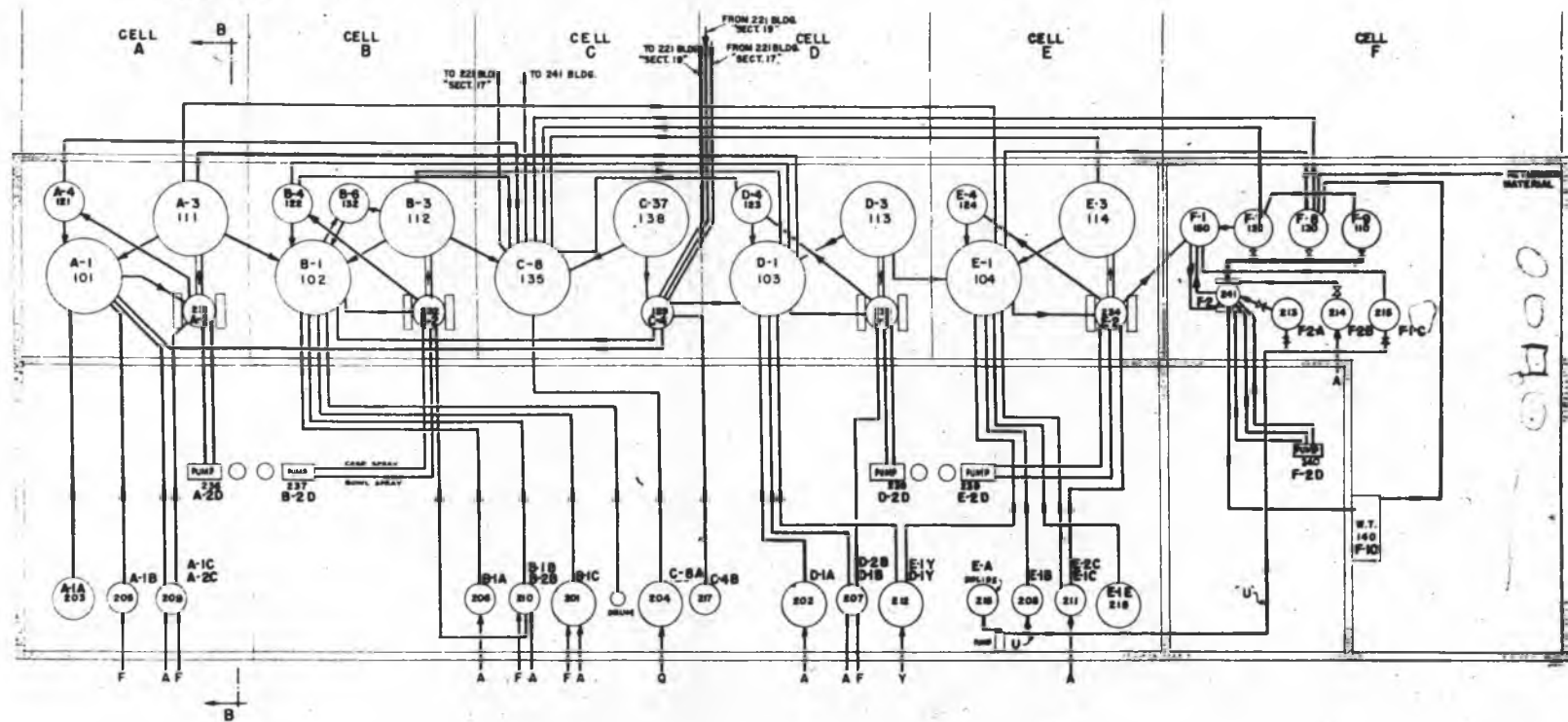
241 BUILDING

~~SECRET~~  
H-77-C-32

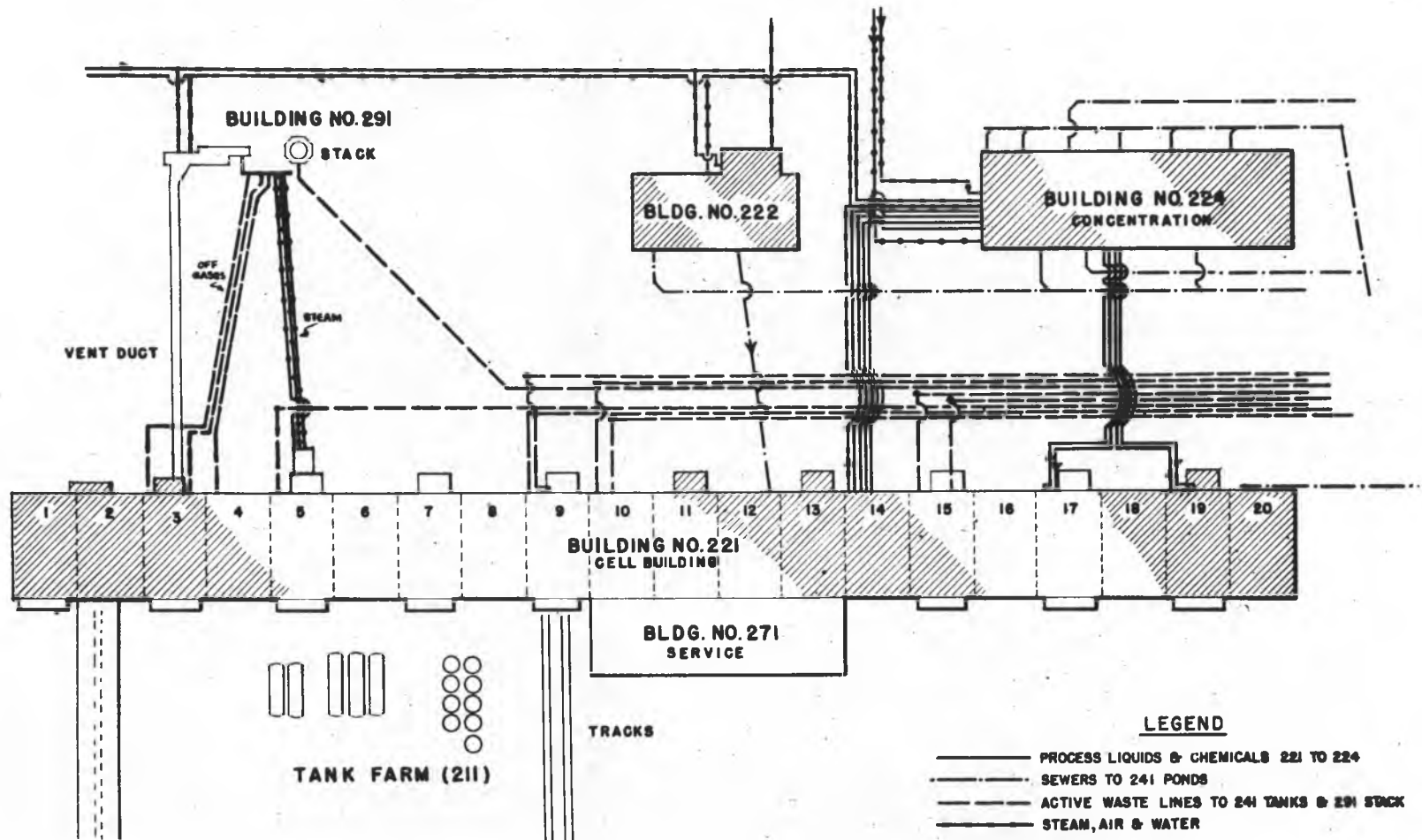


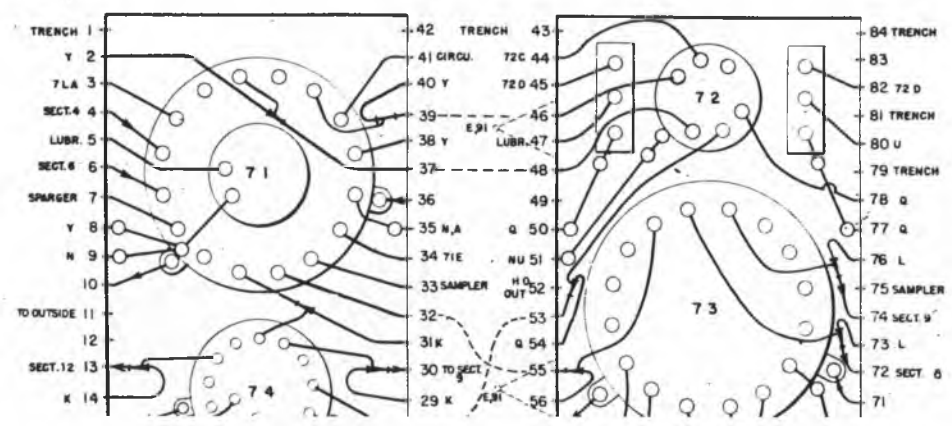
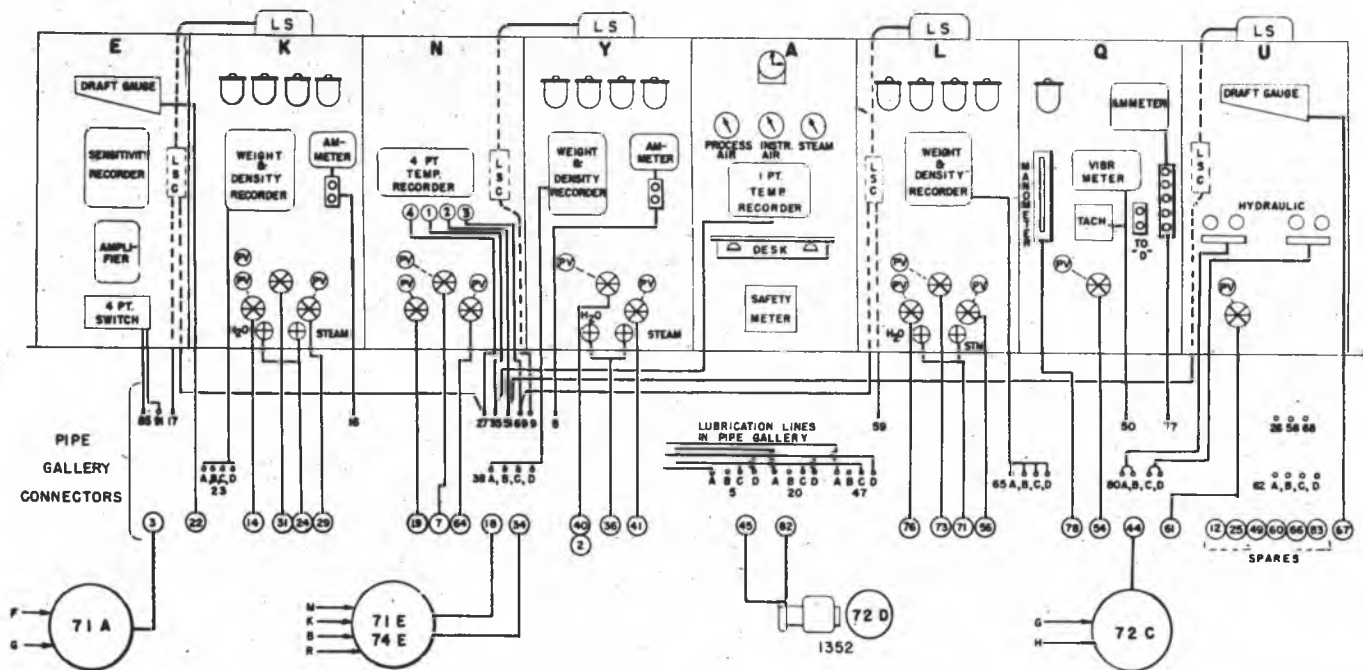


**224 BUILDING**  
**CHEMICAL & PROCESS PIPING**



**OUTSIDE PIPING DIAGRAM & MAP OF IMMEDIATE AREA**  
**BUILDING NO. 221**

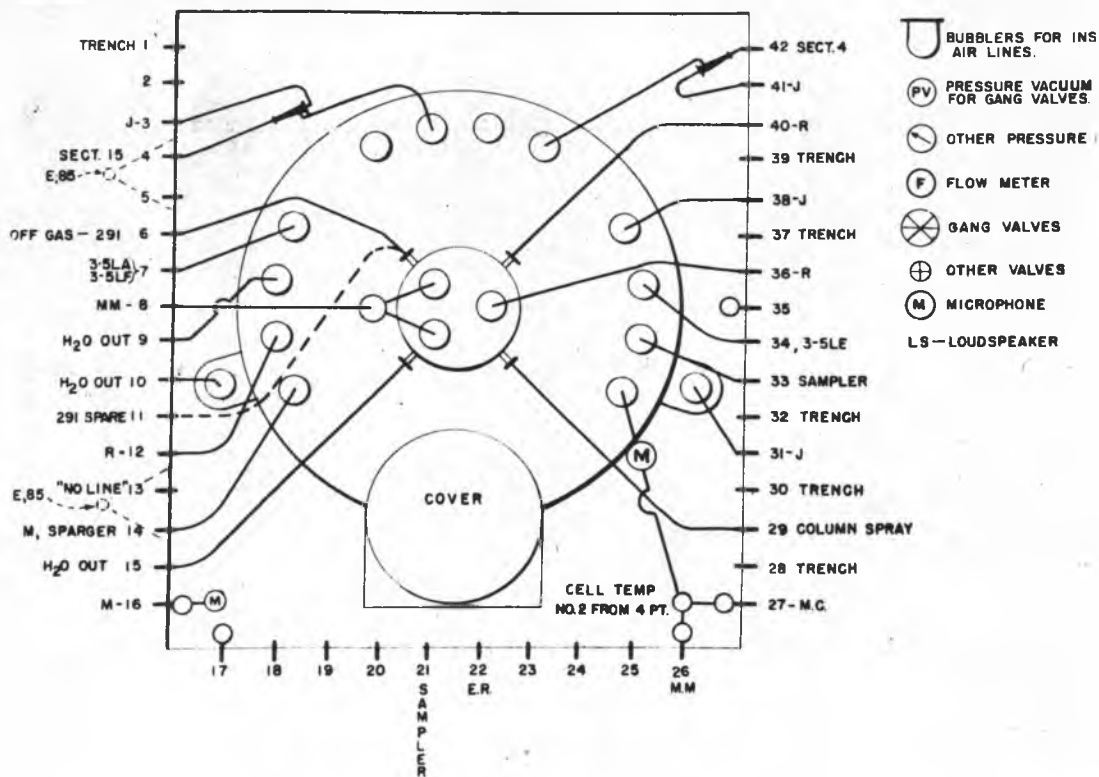
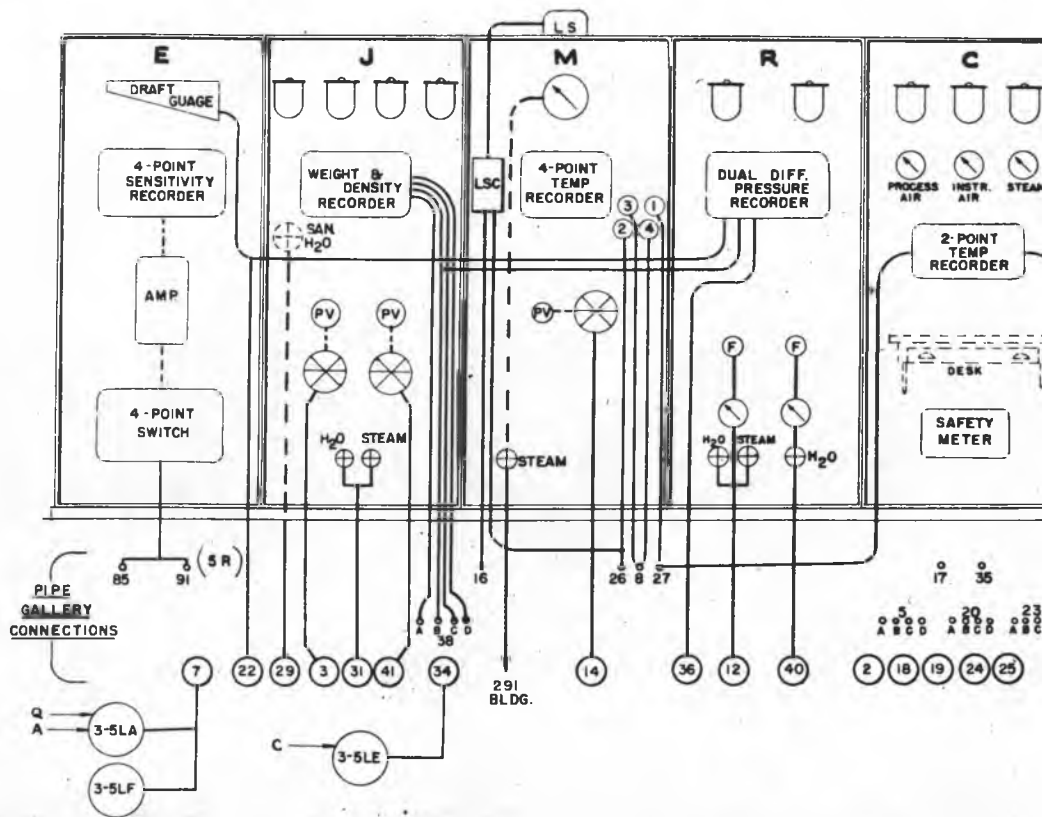


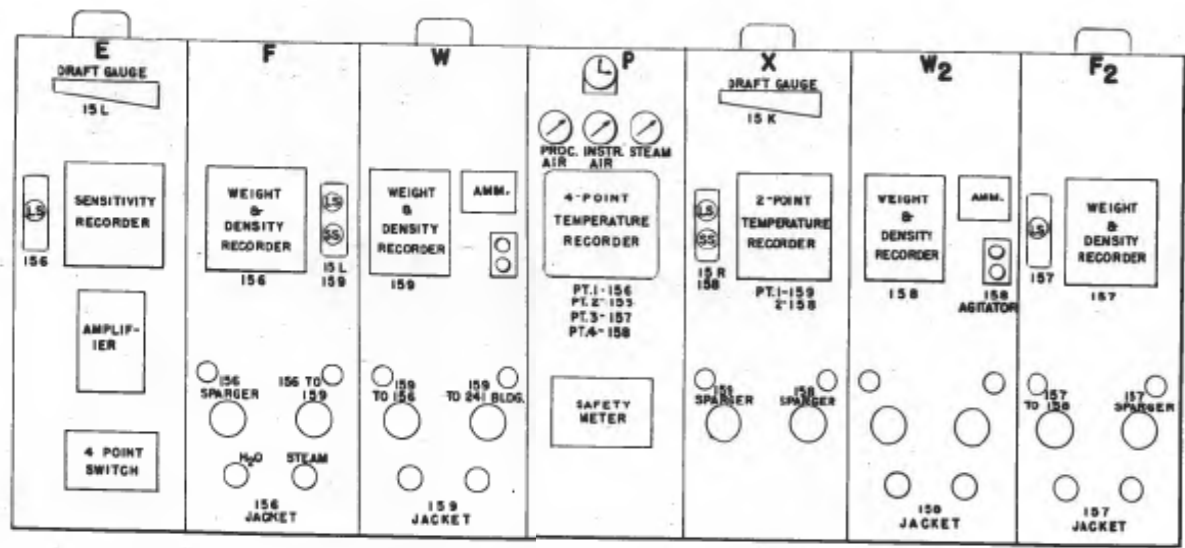


- LEGEND**
- BUBBLERS FOR INSTRUMENT AIR LINES.
  - PRESSURE VACUUM GAUGES FOR GANG VALVES
  - OTHER PRESSURE GAUGES
  - GANG VALVES
  - OTHER VALVES
  - MICROPHONES
  - LS - LOUDSPEAKER
  - LSC - LOUDSPEAKER CONTROL

SECRET

## CONTROL PANEL ARRANGEMENT SECTION 3-L





SECTION 15 - GAUGE BOARD

H-7-C-306

**SECRET**

**APPENDIX B**

**CHARTS AND TABULATIONS**

**SECRET**

MANHATTAN DISTRICT HISTORY

BOOK IV - PILE PROJECT

VOLUME 3 - DESIGN

APPENDIX B

CHARTS AND TABULATIONS

<u>No.</u>	<u>Description</u>
1	Principal Dimensions of Pile
2	Tabulation of Permanent Plant Road Mileage
3	Tabulation of Richland Commercial Establishments
4	Tabulation of Religious Groups Represented in United Protestant Church
5	Tabulation of Design Costs
6	Wilmington Area Engineer's Organization Chart
7	du Pont Design Division Organization Chart

PRINCIPAL DIMENSIONS OF PILE

The following dimensions were to be the principal ones of the Pile as submitted in the Metallurgical Laboratory design suggestion:

Axial length of active cylinder	23 feet ✓
Radius of active cylinder	16 feet ✓
Thickness of reflector	16 $\frac{1}{2}$ inches ✓
Total weight of metal	200 metric tons ✓
Weight of graphite in Pile	850 metric tons ✓
Weight of graphite in reflector	315 metric tons ✓
Radius of metal rods	0.67 inch
Number of rods in Pile	1695
Weight of aluminum in Pile	8.7 metric tons





TABULATION OF PERMANENT PLANT ROAD MILEAGE

<u>CLASSIFICATIONS AND TYPE OF SURFACES</u>	<u>MILES</u>
New Construction Inter and Intra-Area Roads (Road Mix and Plant Mix)	198.01 miles
New Construction Richland Village (Road Mix, Penetration and Gravel Surfaced)	55.20 miles
Existing Roads Improved (Gravel Surfaced and Road Mix)	16.00 miles
Existing Roads Maintained (Gravel Surfaced and Road Mix)	27.75 miles
Patrol Trails Improved and Maintained (Packed Sand and Gravel)	49.90 miles
Total	<hr/> 344.86 miles



~~SECRET~~

TABULATION OF RICHLAND COMMERCIAL ESTABLISHMENTS

<u>ESTABLISHMENTS</u>	<u>NUMBER</u>
Food Stores	5
Drug Stores	3
General Merchandise Store	1
Variety Store	1
Shoe Repair Shop	1
Barber & Beauty Shop	1
Women's & Children's Apparel Shop	1
Men's Clothing & Shoe Store	1
Hardware Store	1
Optical Shop	1
Electrical Shop	1
Garage & Service Station	1
Service Stations	3
Western Union Office	1
Railway Express Agency	1
Laundry	1
Milk Depot	1
Post Office	1
Bank	1

~~SECRET~~

TABULATION OF RELIGIOUS GROUPS REPRESENTED

IN UNITED PROTESTANT CHURCH

1. Methodist
2. Baptist
3. Presbyterian
4. Nazarene
5. Episcopalian
6. Christian
7. Congregational
8. Evangelical
9. Church of Christ
10. United Brethren
11. Salvation Army
12. Lutheran
13. Pentecostal
14. Assembly of God
15. Adventist
16. Miscellaneous Protestant Groups

~~SECRET~~

TABULATION OF DESIGN COSTS

<u>AREA</u>	<u>ENGINEERING DESIGN</u>
100	\$27,925.64
1700	18,773.06
200	533,691.33
2700	8,045.60
300	53,637.32
3700	16,091.20
500	34,864.26
600	195,776.22
700	40,227.99
800	16,091.20
900	107,274.64
1100	348,642.58
TC	211,867.41
(HC	158,230.09
CC (GC	5,363.73
(YC	5,363.73
TOTAL	\$2,681,866.00

**AREA ENGINEER**  
 William L. Sapper Major  
 Supervises and directs the projects assigned to his office. Directs and supervises the work of contractors on projects. Responsible to the District Engineer for satisfactory completion of projects.  
 1 Clerk-Stenographer CAP-4

1 Assistant  
 D. C. Van Dine Captain

1 Technical Assistant  
 O. B. Campbell Captain  
 1 Jr. Clerk Typist CAP-2

**Executive Officer**  
 D. M. Stowers Major  
 \* 1 Jr. Clerk Steno. CAP-2

**PROTECTIVE SECURITY SECTION**  
 Chief of Section J.F. Clancy, 1st Lt.  
 Coordinating Protective Security measures of units under the Wilmington Area Offices.  
 1 Jr. Clerk Typist, CAP-2

**AUDIT SECTION 4600**  
 Chief of Section .....W.C. Rothwell CAP-12  
 Supervises and coordinates the activities of all Audit functions in connection with construction and operational facilities on CPFF Contracts.  
 Asst. Chief of Section...E.T. Diving CAP-11

**CONTROL SECTION 3500**  
 Chief of Section.....E. B. Tremml P-4  
 Supervises all Control functions including Priorities, C.M.P. allotments and reports, Field Progress reports, engineering and material requirements and expediting of critical orders.

**ADMINISTRATIVE SECTION**  
 Chief of Section.....J. R. Olson CAP-8  
 Supervises all Administrative functions including Personnel, Payrolls, Purchasing, Travel Orders, Mail and Records and Office Service Activities.

**ENGINEERING SECTION**  
 Chief of Section.....[Name]  
 Supervises the checking on all plans and specifications.

- 001 Chief Proj. Auditor (Field) CAP-10
- 001 Super. Auditor (Transm.) CAP-8
- 1 Assoc. Admin. Assistant CAP-8
- 001 Associate Auditor CAP-8
- 1 Jr. Const. Cost Auditor CAP-7
- 001 Super. Auditor (Time) CAP-7
- 1 Clerk-Stenographer CAP-4
- 002 Clerks CAP-4
- 2 Asst. Clerk Steno. CAP-3
- 001 Asst. Clerk Typist CAP-3
- 001 Checker (Materials) CAP-3
- 001 Assistant Clerk CAP-3
- 7 Jr. Clerk Typists CAP-2
- 005 of which assigned to Engr. in Charge, Field
- 3 Jr. Clerk Steno. CAP-2
- 001 of which assigned to Engr. in Charge, Field
- 2 Calc. Machine Operators CAP-2
- 001 of which assigned to Engr. in Charge, Field
- 1 Junior Clerk CAP-3

01 Inspector (Gen. Const.) SP-7  
 1 Assistant Clerk Steno. CAP-3

1 Asst. Clerk Steno. CAP-3  
 3 Jr. Clerk Typists CAP-2  
 1 Chauffeur CPC-3

1 Jr. Clerk Steno  
 1 Jr. Clerk Typist

**OPERATIONS SECTION**  
 Chief of Section....C. W. Swartout, 1st Lt.  
 Supervises and coordinates performance of work under operation contracts. Acts as liaison officer between Area Engineer and operators.  
 Asst. Chief of Section...O. P. Bergelin, 1st Lt.

**PROPERTY & SAFETY SECTION**  
 Chief of Section...R.T. Swofford, Jr. Captain  
 Supervises receiving and transfer of all property, assumes accountability for all property. Supervises all safety functions.

1 Auditor CAP-9  
 2 Clerks CAP-4  
 1 Asst. Clerk Steno. CAP-3

001 Jr. Administrative Asst. CAP-7  
 002 Inspectors (Materials) SP-6  
 001 Clerk CAP-4  
 1 Junior Clerk CAP-2  
 001 Jr. Clerk Typist CAP-2

\* Denotes dual capacity  
 00 Assigned to Engineer in Charge (Field)

**AREA ENGINEER**  
 William L. Sapper Major  
 Supervises and directs the projects assigned to his office. Directs and supervises the work of contractors on projects. Responsible to the District Engineer for satisfactory completion of projects.  
 1 Clerk-Stenographer CAF-4

8 Officers  
 65 Civilians

1 Technical Assistant  
 J. B. Campbell Captain  
 1 Jr. Clerk Typist CAF-2

**Executive Officer**  
 D. M. Stowers Major  
 1 Jr. Clerk Steno. CAF-2

**PROTECTIVE SECURITY SECTION**  
 Chief of Section J.F. Clancy, 1st Lt.  
 Coordinating Protective Security measures of units under the Wilmington Area Offices.  
 1 Jr. Clerk Typist, CAF-2

**LABOR RELATIONS SECTION**  
 Chief of Section  
 G. H. Enollmeyer CAF-10  
 Coordinates and acts as liaison agent for the Area Engineer on all labor matters.

**SECTION 3600**  
 E. B. Tremml P-4  
 functions including statements and reports, engineering and expediting of

**ADMINISTRATIVE SECTION**  
 Chief of Section.....J. R. Olson CAF-8  
 Supervises all Administrative functions including Personnel, Payrolls, Purchasing, Travel Orders, Mail and Records and Office Service Activities.

**ENGINEERING SECTION 4600**  
 Chief of Section.....Bert Bowells P-5  
 Supervises the checking for approval on all plans and specifications.

**ENGINEER IN CHARGE (FIELD) 5600**  
 Chief of Section.....A. T. Cochran P-6  
 Supervises the work of contractors on projects. Acts as liaison agent between Area Engineer and contractors on matters effecting projects.

1 Steno. SP-7  
 1 Steno. CAF-3

1 Asst. Clerk Steno. CAF-3  
 3 Jr. Clerk Typists CAF-2  
 1 Chauffeur CPC-3

1 Jr. Clerk Steno. CAF-2  
 1 Jr. Clerk Typist CAF-2

1 Assoc. Engin. (Mech.) P-3  
 1 Asst. Engin. (Civil) P-2  
 1 Principal Insp. (Elect.) SP-6  
 1 Principal Inspector SP-6  
 2 Inspectors (Gen. Const.) SP-6  
 1 Clerk-Stenographer CAF-4  
 1 Jr. Clerk Stenographer CAF-2

**OPERATIONS SECTION**  
 Chief of Section.....C. W. Swartout, 1st Lt.  
 Supervises and coordinates performance of work under operation contracts. Acts as liaison officer between Area Engineer and operators.  
 Asst. Chief of Section...O. P. Bergelin, 1st Lt.

**PROPERTY & SAFETY SECTION**  
 Chief of Section...R.T. Swofford, Jr. Captain  
 Supervises receiving and transfer of all property, assumes accountability for all property. Supervises all safety functions.

1 Auditor CAF-9  
 2 Clerks CAF-4  
 1 Asst. Clerk Steno. CAF-3

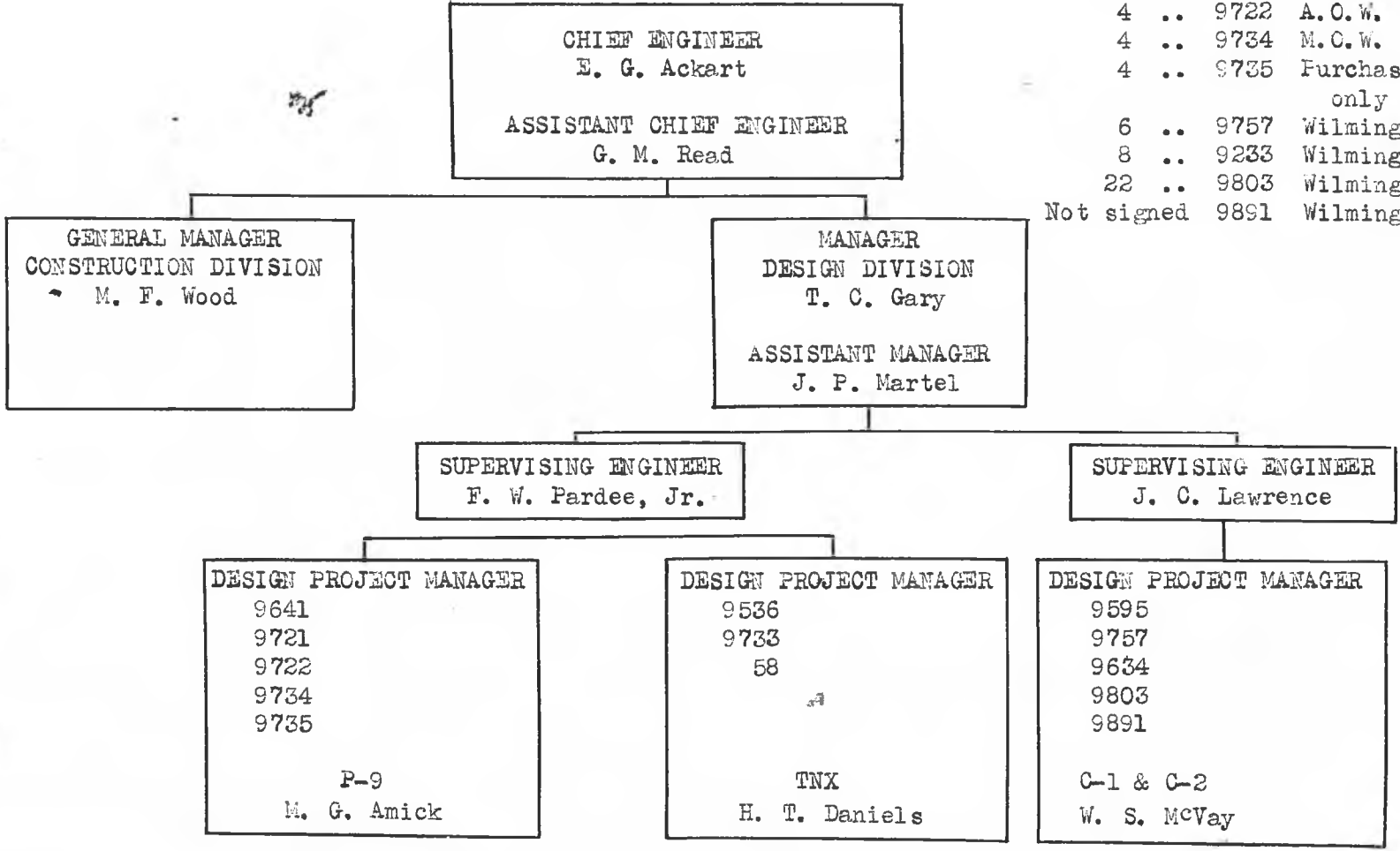
1 Jr. Administrative Asst. CAF-7  
 2 Inspectors (Materials) SP-6  
 1 Clerk CAF-4  
 1 Junior Clerk CAF-2  
 1 Jr. Clerk Typist CAF-2

**SECRET**  
 FUNCTIONAL AND POSITION CHART  
 Wilmington Area  
 Section, Division, or Area  
 Wilmington, Delaware  
 Station  
 1 November 1943

E. I. DU PONT DE NEMOURS & CO. (INC.)  
 ENGINEERING DEPARTMENT  
 Design and Construction Divisions  
 Manhattan District - Organization Chart.

KEY

CONTRACT	PROJECT	LOCATION
1	.. 9536	Hanford
23	.. 9733	Clinton
1	.. 58	Clinton
2	.. 9595	Wilmington
3	.. 9634	Wilmington
4	.. 9641	Unknown
4	.. 9721	W. R. O. W.
4	.. 9722	A. O. W.
4	.. 9734	M. O. W.
4	.. 9735	Purchasing only
6	.. 9757	Wilmington
8	.. 9233	Wilmington
22	.. 9803	Wilmington
Not signed	9891	Wilmington



APPENDIX C

REFERENCES



~~SECRET~~

MANHATTAN DISTRICT HISTORY

BOOK IV - PILE PROJECT

VOLUME 3 - DESIGN

APPENDIX C

REFERENCES

<u>No.</u>	<u>Description</u>	<u>Location</u>
1. ✓	Site Investigations and Travel Schedule of Col. Matthias	Area Engineer H.E.W. Classified Files Case "OOO"
2. ✓	Preliminary Site Report	Area Engineer H.E.W. Classified Files Case "CCC" "NNN" "PPP"
3. ✓	Ichthyology Reports	District Office Files Area Engineer H.E.W. Classified Files
4. ✓	Feasibility Report of 26 November 1942	District Office Files Metallurgical Information Office, Chicago, Illinois
5. ✓	Design of Helium-Cooled Plant Report #CE - 277	District Office Files Metallurgical Information Office, Chicago, Illinois
6. ✓	Design of Helium-Cooled Plant Report #CE - 324	District Office Files Metallurgical Information Office, Chicago, Illinois
7. ✓	Design of Liquid-Cooled Plant Report #CE - 407	District Office Files Metallurgical Information Office, Chicago, Illinois
8.	Ichthyological Studies	District Office Files Area Engineer H.E.W. Classified Files

~~SECRET~~

<u>No.</u>	<u>Description</u>	<u>Location</u>
9.	Specifications for Process Water-Pumps	Wilmington Engineering Dept. Wilmington, Del. Spec. 2002
10.	Survey of Separation Processes Report #CN 1017	District Office Files Metallurgical Information Office, Chicago, Illinois
11.	Survey of Separation Processes Report #CN 1603	District Office Files Metallurgical Information Office, Chicago, Illinois
12.	Survey of Separation Processes Report #CN 2519	District Office Files Metallurgical Information Office, Chicago, Illinois
13. ✓	Bismuth Phosphate Process	Area Engineer, H.E.W. Tech. Manual Sec. C
14. ✓	Report on Richland Village Design by G. A. Pehrson, 8 June 1943	Area Engineer H.E.W. Office Engineer

APPENDIX D

GLOSSARY

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MANHATTAN DISTRICT HISTORY

BOOK IV - X-10 PROJECT

VOLUME 3 - DESIGN

APPENDIX D

GLOSSARY

Activated Carbon. - Activated carbon is charcoal produced by the destructive distillation of vegetable matter such as wood, with or without the addition of chemicals.

Aluminum. - Aluminum is the chemical element of atomic number 13. The metallic aluminum was chosen for the Pile cooling tubes and slug jackets because of its low neutron absorption cross section ( $0.124 \times 10^{-24}$  square centimeters) and its resistance to corrosion by water at the temperatures encountered in the Pile reaction.

Aluminum-Silicon Alloy. - This is the eutectic alloy of the aluminum-silicon system. It consists of 88 per cent aluminum and 12 per cent silicon. The alloy is used as a bonding medium in the canned slug since it has a lower melting point than aluminum and virtually the same corrosion resistance.

Billets. - A billet is a bar of metal. In this volume, it refers specifically to the form in which metallic uranium is received at the Hanford Engineer Works.

Boron. - Boron is the chemical element of atomic number 5. It is used, in the form of a coating, in the safety and control rods of the Hanford Piles because of its high slow neutron absorption cross section ( $700 \times 10^{-24}$  square centimeters).

Cadmium. - Cadmium is the chemical element of atomic number 48. It is a white ductile metal belonging to the zinc family. Cadmium was suggested as a possible control means, since it has a high neutron-capture cross section approximately  $3000 \times 10^{-24}$  square centimeters.

Carbon. - Carbon is the chemical element of atomic number 6. It is a non-metallic element, one of which forms is graphite which is used in the Pile as the moderator. Carbon has a low neutron-capture cross section of  $0.0045 \times 10^{-24}$  square centimeters, thus making it possible to use it without too high a neutron loss.

Columbium. - Columbium is the chemical element of atomic number 41. Columbium is one of the fission products encountered in the separation of plutonium from the fission products and uranium by use of the fractional volatilization process.

Cross Section. - See Neutron-Capture Cross Section.

Deaeration. - Deaeration is the term used to refer to the process by which dissolved gases are removed from water. In this process, the carbon dioxide content is reduced from about 70 parts per million to about 2 parts per million, and the oxygen content from about 14 to about 0.05 parts per million. Deaeration is obtained by passing the water in a finely dispersed state through towers in which a vacuum is maintained by means of steam jets.

Decay Period. - The decay period for any substance is the time required for the radioactivity of that particular substance to decrease to a safe level, as determined by health and safety

requirements. The activity of the slugs arises from the fission products and other elements formed with the production of plutonium. Some of this activity is transferred to the effluent water and circulating helium.

Demineralization. - Demineralization is the term used to refer to the process by which dissolved salts and acids are removed from water. Demineralization is obtained by passing the water through two exchangers, the first removing the dissolved salts of calcium, magnesium and sodium, and the second removing the acids formed in the first exchanger, except for the carbonic acid which is formed in the second exchanger.

Deuterium. - Deuterium is that isotope of hydrogen of atomic number 2. Its symbol is  $H^2$  or D and it is the principal component of heavy water. Deuterium has a neutron-capture cross section of only  $0.0009 \times 10^{-24}$  square centimeters.

Dissolving. - Dissolving is that step in the separation process for the recovery of plutonium in which the aluminum jackets are removed from the metallic uranium pieces and the uranium, containing plutonium and many other elements, is placed in solution in preparation for the subsequent process steps.

Electrochemical Series. - An arrangement of the metals in the order of the amount of electromotive force set up between the metal and solution when the metal is placed in a normal solution of any of its salts.

Elutriation. - Elutriation is one of the final steps in the separation and isolation of plutonium. This step consists of purification

by washing the precipitate and decanting the wash liquor.

Extraction. - Extraction is that step in the separation process in which the plutonium is separated from the uranium and from the large majority of the many other elements present.

Flash Vaporization. - Flash vaporization refers to that type of vaporization which is instantaneous. In the original Pile design for a water-cooled unit employing water recirculation, this type of vaporization would have been used in removing dissolved gases from the water through a sudden reduction of pressure from about 20 pounds per square inch to near atmospheric with the temperature of the water at the boiling point of the water.

Heavy Hydrogen. - See Deuterium.

Hydrogen. - Hydrogen is the simplest chemical element known, of atomic number 1. Its neutron-capture cross section is  $0.325 \times 10^{-24}$  square centimeters.

Hydrogen Peroxide. - Hydrogen peroxide is a clear, colorless liquid found in the Pile exit water. Before water could be recirculated through the Pile structure, it would be necessary to remove a portion of the oxygen to prevent erosion of equipment.

Imhoff Tank. - An Imhoff tank is a tank for sewage clarification, consisting of a sedimentation chamber with sloping floor leading to slots through which the solids settle to the sludge-digestion chamber.

Impact Wrench. - The impact wrench used in the Separation Building for maintenance of equipment and replacement of parts consists of an electrically driven wrench which can be lowered from the

operating crane and placed on the actuating nut of the piping which has to be loosened or tightened. The impact feature of the wrench enables a stubbornly turning fitting to be pounded loose in much the same way a sledge hammer would act.

Ion Chamber. - An ionization chamber measures the total number of ions directly produced in it. These ions are charged particles of matter due to the removal from or addition to the particles of one or more electrons. The chamber usually consists of two plane electrodes between which there is a strong enough electric field to draw all the ions to the electrodes before they recombine but not strong enough to produce secondary ions.

Isolation. - Isolation is the final step in the separation process for plutonium, in which the element is separated from the last of its associated elements and prepared for shipment.

Labyrinth. - A labyrinth as used in reference to the Pile Area consists of the entrance to the Pile discharge face protected by concrete. This entrance is so designed that radiation present in the discharge area must bounce at least twice before it can escape, thus reducing the energy of the radiations to a safe level.

Neutron Absorber. - A neutron absorber is one which possesses the ability to absorb neutrons well, i.e., it has a large neutron-capture cross section.

Nitrogen. - Nitrogen is the chemical element of atomic number 7. It is a gaseous element occurring in the atmosphere and has a high neutron-capture cross section of  $1.75 \times 10^{-24}$  square centimeters, which prohibits the use of circulation of air through the Pile



structure to remove impurities.

Outgassing. - Outgassing is the process of driving hidden gases out of substances by means of heating or evacuating.

Polymerization. - Polymerization is a reaction in which two or more molecules of the same substance combine to form a compound, from which the original substance may or may not be regenerated, the new molecular weight being a multiple of that of the original compound.

Primary Radiation. - The primary radiation of radioactive materials consists of the original alpha, beta or gamma emitted by these materials.

Proportional Counter. - A proportional counter is an ionization chamber in which one of the electrodes is so designed that there is, besides the primary ions, a large number of secondary ions formed, thus increasing the total pulse of current. It is possible to design and operate such counters in such a way that the total number of ions formed is proportional to the number of primary ions formed.

Reactor. - The term reactor is used synonymously with reacting unit, the unit in which the chain reaction is sustained.

Secondary Radiation. - Secondary radiation is the result of ionization of other particles due to the primary radiation, and the scattering and reflection of the primary rays by particles.

Silica Gel. - Silica gel is a form of colloidal silica (silicon dioxide) like coarse sand in appearance but possessing many fine pores and therefore extremely absorbent.

Syphon (Steam-Jet). - A steam-jet syphon is a device used in the Separation Building for transferring solutions in which a jet of steam is used to create vacuum for suction. These syphons are used so that necessary maintenance work on pumps can be eliminated.

Thimbles. - The aluminum wells into which the vertical safety rods drop are known as thimbles.

Uranium Hexafluoride. - Uranium hexafluoride had been developed industrially and in large enough quantities to suggest its use as a coolant for an enriched-uranium plant. Fluorides are good coolants.

Xenon. - Xenon is the chemical element of atomic number 54.

Xenon-135 is a member of the tellurium-iodine-xenon-caesium-barium decay chain which is encountered in the Pile reaction. It is radioactive with a half life of 9.4 hours. It led to a poisoning of the Pile because of its high neutron absorption cross section (approximately  $5,000,000 \times 10^{-24}$  square centimeter).

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