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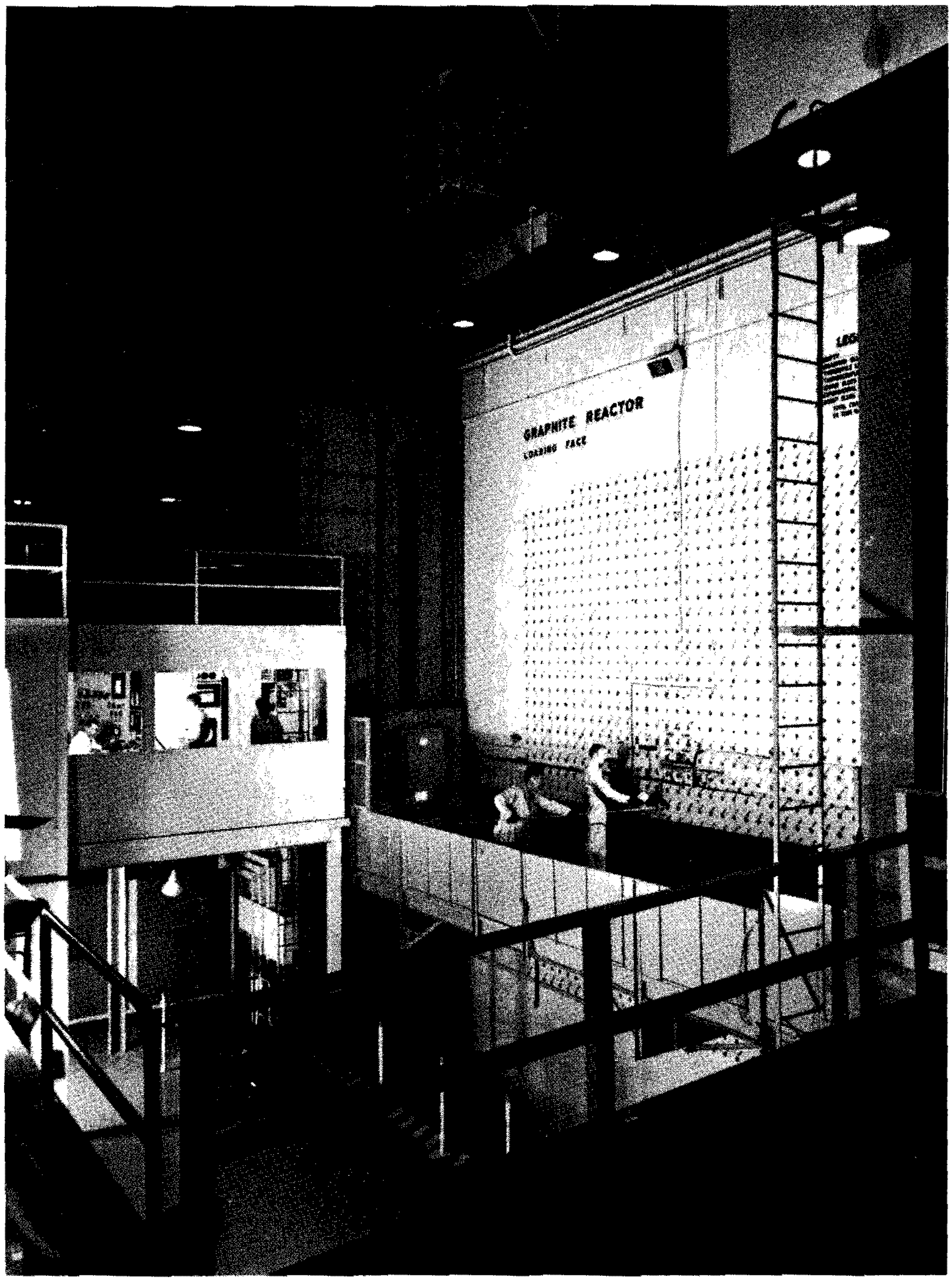
EXPERIMENT FACILITIES OF THE OAK RIDGE GRAPHITE REACTOR

S. D. Sheppard



EXPERIMENT FACILITIES

OF THE

OAK RIDGE GRAPHITE REACTOR

OAK RIDGE NATIONAL LABORATORY

OAK RIDGE, TENNESSEE

ORNL-TM-266

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OAK RIDGE NATIONAL LABORATORY
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Introduction

This publication contains up-to-date descriptive material and dimensional sketches of the ORNL Graphite Reactor and its experiment facilities. Information of this type should be useful to experimenters in selecting appropriate facilities in designing equipment and in understanding the relationship of their experiments to others in the reactor and to the parts of the reactor itself.

Table 1. Research Openings into Graphite Reactor

Kind of Facility	Number of Facilities	Maximum Thermal Neutron Flux	In-Cd Ratio	Gamma (R/hr)	Approximate Temperature
4-in.-sq horizontal	42	3.6×10^{11} to 1×10^{12}	20	3×10^{5} to 8×10^{5}	35°C to 160°C
4-in.-sq vertical	3	8×10^{11}	20	6.7×10^{5}	135°C to 140°C
4-in.-dia.	1	8.9×10^{11}			50°C
1.38-in.-diameter horizontal	4	1×10^{12}	20	9×10^{5}	35°C
2 3/4 in. x 3/8-in. foil slot	1	1.1×10^{12}	20	9×10^{5}	160°C
Unused fuel channels in core region	5	5.5×10^{11} to 1×10^{12}	20	4.5×10^{5} to 9×10^{5}	35°C
Unused fuel channels in reflector region	418	10^{10} to 3×10^{11}		10^{4} to 3×10^{5}	30°C to 50°C
14-in.-sq biological tunnel lead-lined	1	1.3×10^{9}	~70 Cd Ratio (Mn)	200	25°C to 35°C
14-in.-sq biological tunnel, bare	1	5×10^{8}	73 Cd Ratio (Mn)	3.4×10^{3}	25°C to 35°C
7-in. x 3-in. x 3-in. inclined biological tunnel	1	1×10^{9}	10^{5}	360	Room Temperature
5-ft-sq vertical thermal column	1	1.5×10^{7}	$\sim 10^{6}$	135 at top of column	Room Temperature
2 1/2-ft-sq horizontal thermal column	1	5×10^{9}	130	1.2×10^{4}	Room Temperature
Unused 9-in.-sq ionization chamber holes	2	10^{7} to 10^{9}	~70 Cd Ratio (Mn)	$\sim 5 \times 10^{3}$	35°C

1. The Graphite Matrix

The graphite is built up as a 24-ft-square section 24-ft - 4-in. high, Figure 1.1. There are 73 courses of 4-in.-square graphite blocks of dimensions from 8-in. to 50-in., Figure 1.2. A one-inch space was left on the north and south sides, between the graphite and concrete, and was packed with asbestos rope for thermal insulation.

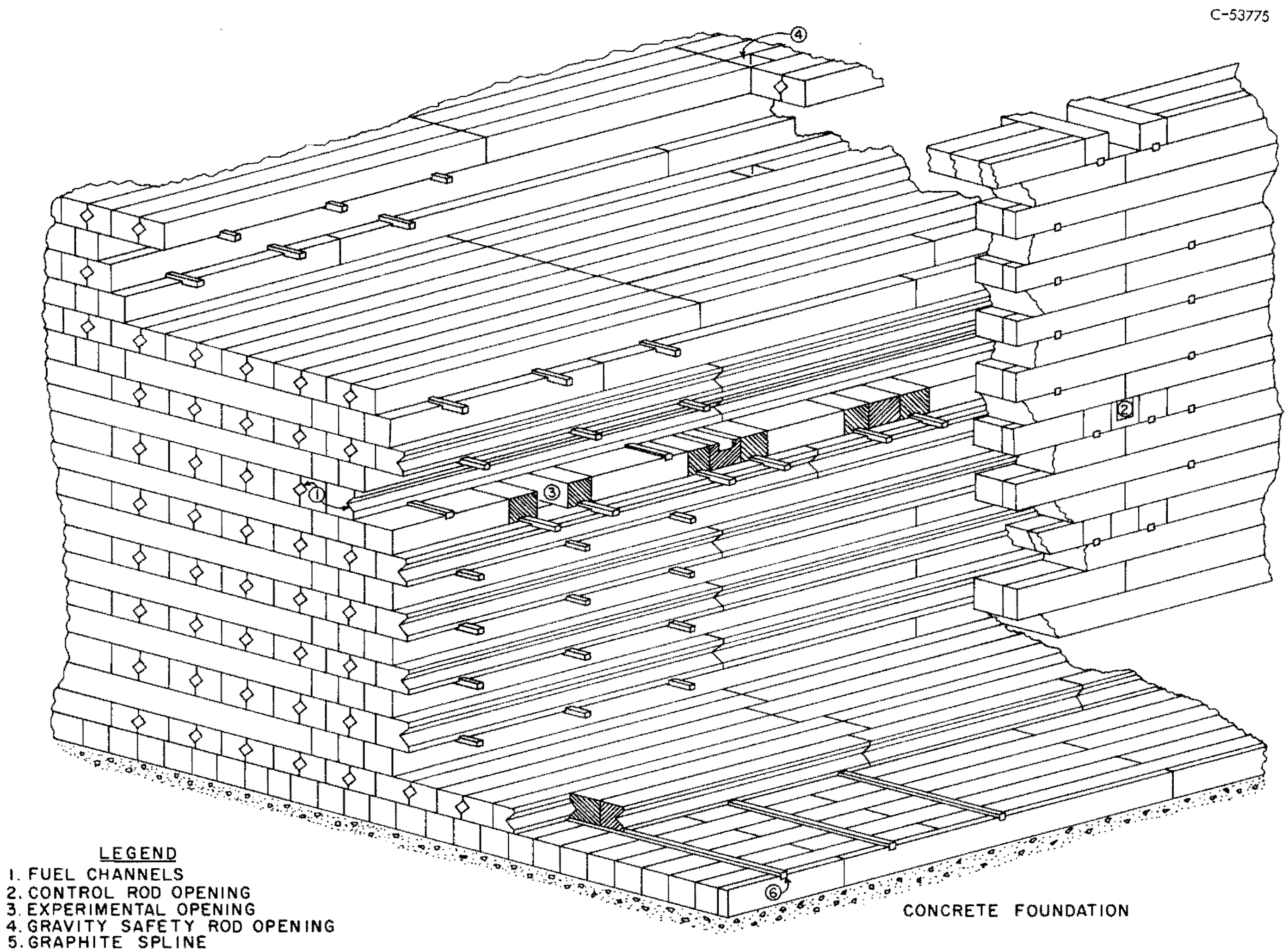

Fig. 1.1 DETAILS OF GRAPHITE MATRIX ASSEMBLY

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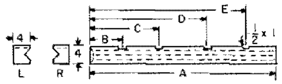
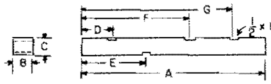
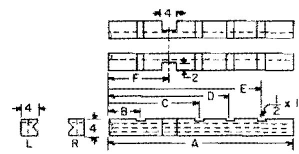


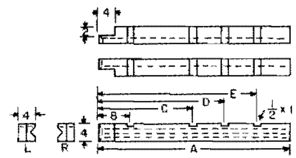
BLK. No.	A	B	C	D	E	No OF KWY
36	48	22	30			2
37	48	18	26			2
38	48	46				1
39	48	42				1
40	48	6				1
41	48	2				1
46	50	4	44			2
48	46	42				1
51	50	48				1
54	50	2				1
56	46	4				1
103	50	22	30	46		3
105	50	18	26			2
106	50	4	20	28		3
109	50	24	32			2
112	48	2	22	30		3
113	48	18	26	46		3
116	46	30	38			2
119	50	16	24	48		3
120	50	4	12	20	44	4
121	50	2	26	34		3
123	50	6	30	38	46	4
124	46	4	8	16		3
125	46	8	16			2
127	46	26	34			2
130	50	12	20	44		3
131	50	6	30	38		3
134	46	12	20			2
135	48	14	22	46		3
136	48	10	18	42		3
137	48	2	26	34		3
138	46	6	30	38		3
139	48	30	38			2
140	48	26	34			2
141	48	10	18			2
142	48	14	22			2
169	48	44				1
170	48	20	28			2
171	48	4				1
175	50	6	46			2
177	46	4	16	24		3
178	46	16	24			2
180	46	22	30	42		3
181	46	22	30			2
182	46	30	38	42		3
185	50	4				1
186	50	46				1
187	50	20	28			2
188	50	22	30			2
189	50	6				1
190	50	44				1
192	46	18	26			2
193	46	20	28			2



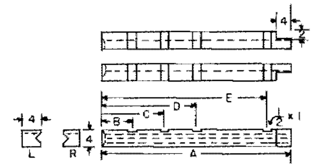
BLK No	A	B	C	D	E	F	G	No.OF KWY.
2	48	4	4	8				1
3	48	4	4	24				1
4	32	4	4	8				1
5	16	4	4	8				1
9	48	2	4	24				1
11	16	2	4	8				1
17	50	4	4	8	24	40		3
20	46	4	4	8	24	40		3
21	16	4	4	8				1
22	18	4	4	2				1
23	14	4	4	6				1
25	8	4	4	2				1
26	8	2	4	2				1
28	14	2	4	8				1
29	16	2	4	2				1
30	18	2	4	8				1
32	48	4	4	8	24			2
33	48	4	4	18		26		2
34	48	4	4	6				1
35	48	4	4	2				1
60	34	4	4	8				1
61	50	4	4	8	24			2
72	50	4	4	8				1
74	50	4	4	22	34			2
75	10	4	4	4				1
77	22	4	4	2				1
78	32	4	4	2				1
84	50	4	4	14		26		2
85	18	4	4	4				1
86	12	4	4	2				1
88	20	4	4	2				1
89	36	4	4	10		18		2
90	18	4	4	2				1
91	10	4	4	2				1
92	32	4	4	4				1
93	48	4	4	16		24		2
94	12	4	4	4				1
95	48	4	4	12		24		2
115	48	4	4	8		16		2
143	48	4	4	10		18		2
144	48	4	4	26		34		2
145	48	4	4	10		18	42	3
146	48	4	4	2		26	34	3
157	16	4	4	4		8		2
158	18	4	4	8		12		2
160	48	4	4		24	28	40	3
161	48	4	4	4	8			2
162	42	4	4	8				1
174	6	4	4	2				1
183	20	4	4	2	14			2
191	14	4	4	2	6			2



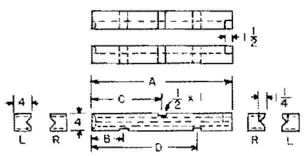
BLK No	A	B	C	D	E	F	No OF KWY
43L	48	38				42	1
52 R/L	48		10			6	1
69							
79							
99L	48	38	46			42	2
100L	48	2	10			6	2
107L	48	2	10	22	30	6	4
111L	48	18	26	38	46	42	4
129L	48	10	18	38		42	3
133L	48	10	30	38		6	3



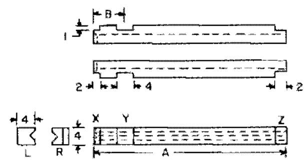
BLK No.	A	B	C	D	E		No OF KWY.
49	50	8	48				2
57	46	8					1
101	48	6					1
102	50	8					1
108	50	8	24	32			3
114	48	6	18	26			3
118	50	8	16	24	48		4
126	46	8	12	20			3
132	48	6	26	34			3
176	46	8	20	28			3



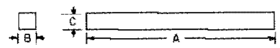
BLK No	A	B	C	D	E		No.OF KWY
55	50	2	42				2
97	50	42					1
98	48	42					1
104	50	18	26	42			3
110	48	22	30	42			3
45	46	38					1
117	46	26	34	38			3
122	50	2	26	34	42		4
128	48	14	22	42			3
179	46	18	26	38			3



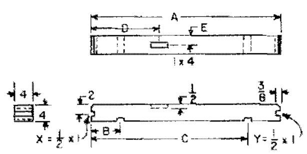
BLK No	A	B	C	D		No OF KWY
16R	50	10	26	42		3
16L	50	10	26	42		3
19R	46	6	22	38		3
19L	46	6	22	38		3
167	28		4	20		2



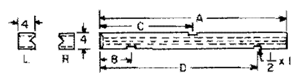
BLK No	A	B		KEYWAYS
164	28	8		Y & Z
165	44			X & Z
166	48			X & Z



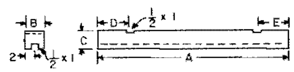
BLK. No	A	B	C	
1	48	4	4	
7	16	4	4	
8	48	2	4	
13	16	2	4	
24	8	4	4	
27	8	2	4	
31	32	4	4	
58	46	4	4	
59	14	4	4	
62	10	4	4	
63	50	4	4	
70	20	2	4	
71	20	4	4	
73	24	4	4	
76	22	4	4	
80	12	4	4	
81	12	2	4	
82	18	4	4	
83	18	2	4	
87	36	4	4	



BLK. No	A	B	C	D	E	END KEYWAYS
147	16		12	8	1.5	Y ONLY
148	16		12	8	2.5	Y ONLY
149	16		12			Y ONLY
150	48	8	20	12	1.5	X & Y
151	48	8	20	12	2.5	X & Y
152	48	8	20			X & Y
153	48					X & Y
154	48			8	1.5	X & Y
155	48			8	2.5	X & Y
156	16			8	1.5	X & Y
159	16					X & Y

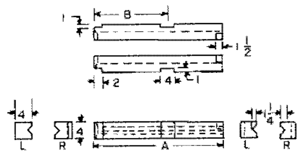


BLK No	A	B	C	D		No.OF KWY.
14	48					0
15	50	8	24	40		3
18	46	8	24	40		3
47	46					0
96	50					0
168	44	4	32			2
172	44	12	40			2
173	28	8	24			2

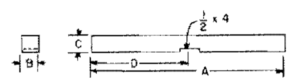


BLK. No.	A	B	C	
64	32	4	4	
65	48	4	4	
66	20	4	4	
67	44	4	4	
68	46	4	4	

ALL DIMENSIONS ARE GIVEN IN INCHES
R - DESIGNATES RIGHT HAND
L - DESIGNATES LEFT HAND



BLK. No.	A	B	
163	28	20	



BLK No.	A	B	C	D	
6	48	4	4	16	
10	48	2	4	16	
12	32	4	4	16	

FIG. 1.2 DETAILS OF GRAPHITE BLOCK DIMENSIONS

2. Charging Holes

The metal channels through the blocks, Figures 1.1 and 2.1, are arranged on 8-inch centers at the face of the reactor in 36 horizontal rows of 35 holes each, Figure 2.2. The openings are 1 3/4-in. square in cross section set on edge and are made by two 45° cuts in the sides of two adjacent blocks. The ends of the cuts are chamfered 1/8-in. x 3/8-in. to a 30° angle so as to prevent any shoulder that might cause blocking of the metal as it is pushed through the channels in case the graphite should shift slightly during operation of the reactor. The charging tubes, Figure 2.3, extend two inches into the channels at the front face. The stepped plugs for the charging tubes are shown in Figure 2.4. At the back ends of the channels, the graphite is cut back in a rectangular opening 2 1/2-in. x 3 1/2-in. long to prevent any possible hanging up of metal slugs at the top of the channel when they are discharged.

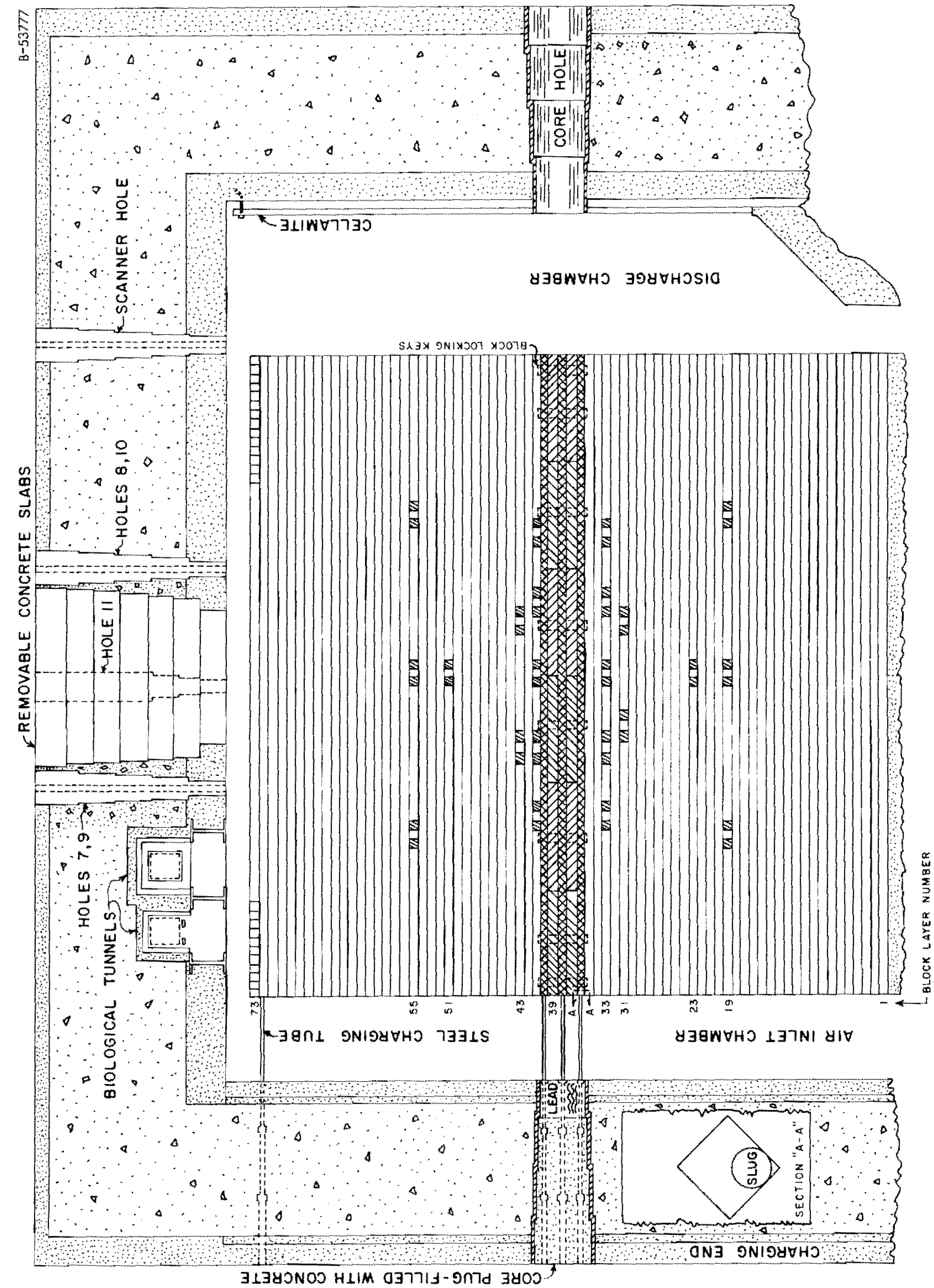


FIG. 2.1 VERTICAL SECTION THROUGH REACTOR

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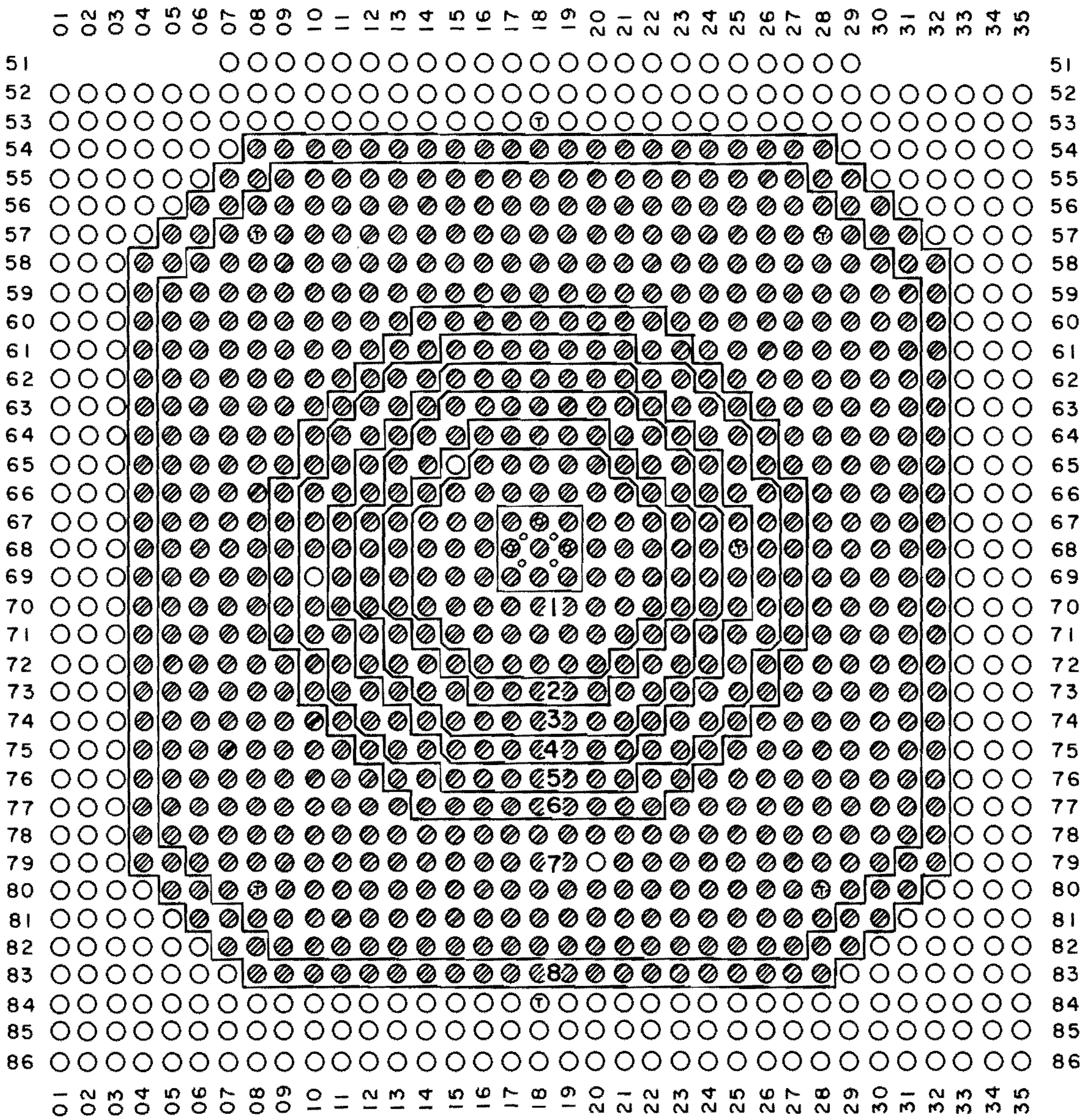

FIG. 2.2 OGR FUEL LOADING PATTERN

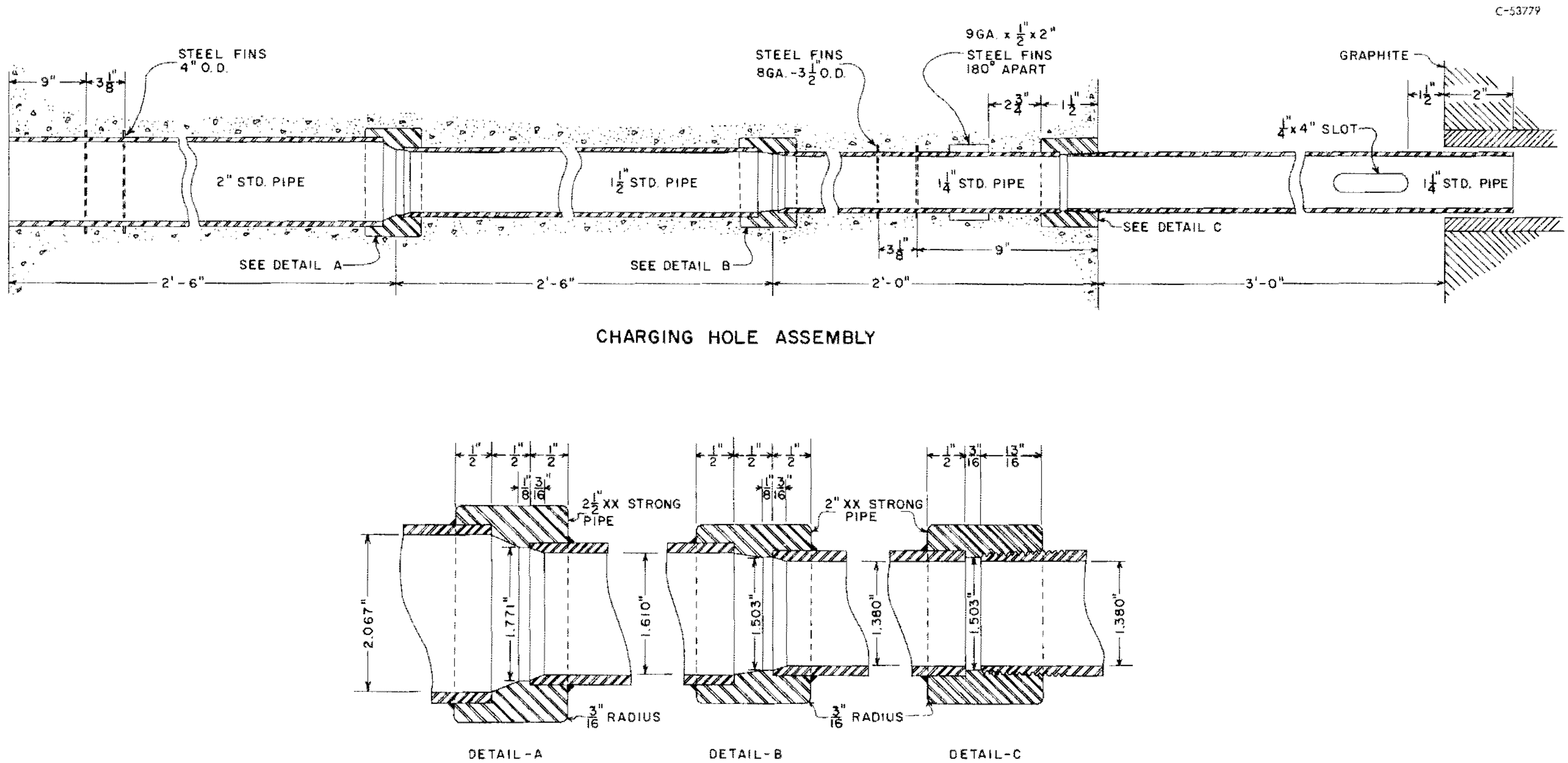

Fig. 2.3 CHARGING HOLE

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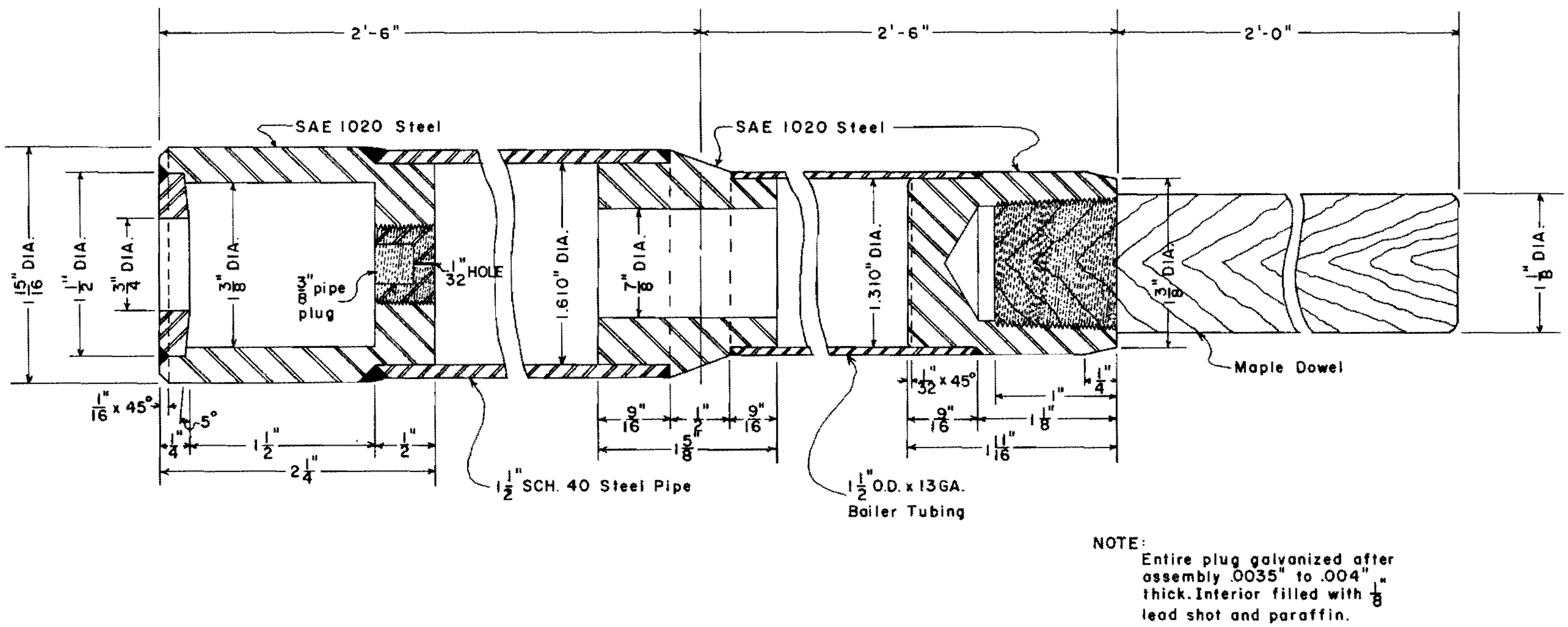

Fig. 2.4 CHARGING HOLE PLUG

3. Core Holes

Holes through the shield are located on both the front and rear faces, Figures 2.1 and 3.1. Charging tubes through the front face plug, with the exception of the one for the foil slot, are the same as those for the rest of the reactor. The charging hole for the foil slot is rectangular in cross section and is closed by a four-step solid steel plug.

The plug in the back face contains a 2-S aluminum tank which can be filled with water to act as a radiation shutter. A concrete-shielded water tank just outside the hole normally acts as the biological shield when the shutter tank is empty. Shielding configurations are built up in the outer tank and checked for attenuation efficiency.

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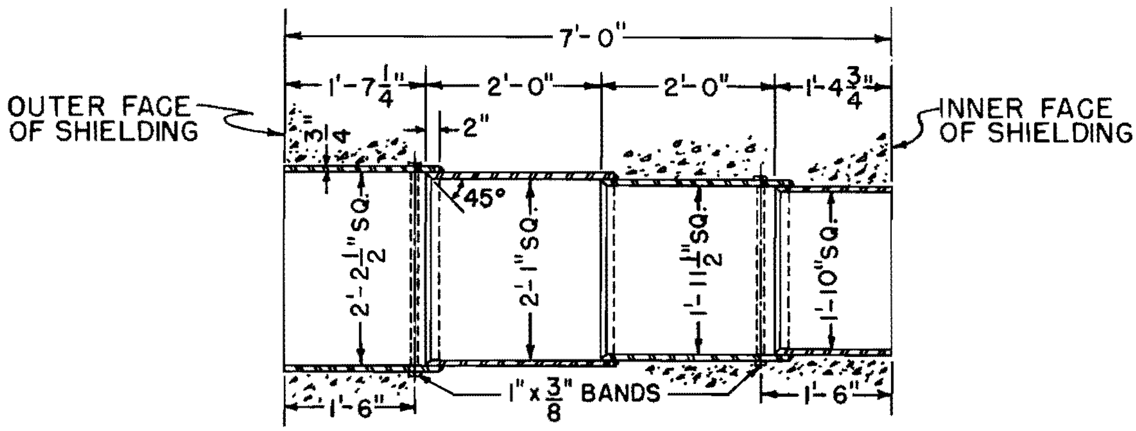

CORE HOLE— CHARGING END

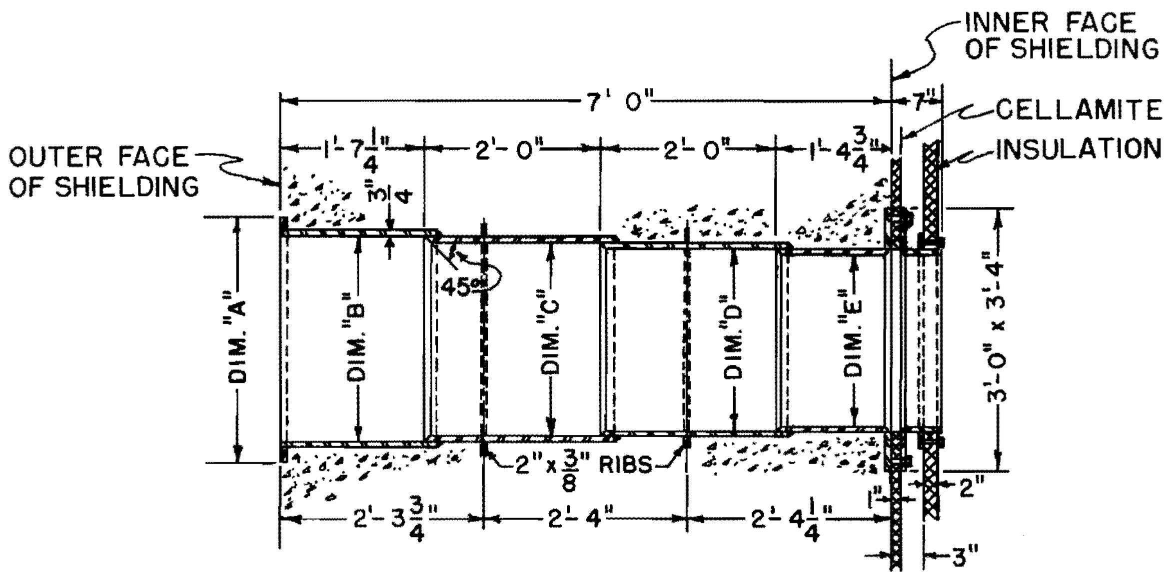

FIG. 3.1 CORE HOLE— DISCHARGING END

DIM. "A" $2'\text{-}9\frac{1}{2}'' \times 3'\text{-}1\frac{1}{2}''$
DIM. "B" $2'\text{-}4\frac{9}{32}'' \times 2'\text{-}8\frac{3}{16}''$
DIM. "C" $2'\text{-}2\frac{25}{32}'' \times 2'\text{-}6\frac{5}{8}''$
DIM. "D" $2'\text{-}1\frac{5}{16}'' \times 2'\text{-}5\frac{7}{64}''$
DIM. "E" $1'\text{-}11\frac{19}{32}'' \times 2'\text{-}3\frac{41}{64}''$

4. Experiment Holes

4.1. Four-Inch-Square Holes

Most experiments are placed in the four-inch-square holes in the north and south faces of the reactor, Figures 4.1 - 4.3. The hole openings are closed with 4-in. by 4-in. by 6-ft long graphite stringers with holes drilled in them to accommodate experiments, instruments, etc., as needed. The outer one-ft section is plugged with a 4 5/8-in. by 4 5/8-in. by 1-ft laminated steel and masonite shield. If an experiment is such that this internal shielding cannot be used, additional outside protection is necessary.

4.2. "Stringer" Hole

Hole 14 is used specifically for the irradiation of either experiment or radioisotope targets. It is opened for inspection or removal of specimens only during the weekly reactor shutdowns.

4.3. Pneumatic Tubes

Hole 22 contains both a large and a small pneumatic-tube facility. The large tube will accommodate "rabbits" (special capsules in which specimens are placed) 1.280-in. in diameter and 3.516-in. long; the small tube accommodates "rabbits" 0.75-in. in diameter and 2.5-in. long. The large tube will transport specimens weighing up to 59 grams net.

These tubes make it possible to irradiate both experiment and radioisotope specimens for short periods without requiring a reactor shutdown for insertion and removal.

4.4. Hole 71

Hole 71, Figure 4.13 is a 4-in.-diameter vertical hole that has been fitted with a 3-in. liner so that it may be cooled by air circulation. Specimens are placed in an aluminum container and are lowered to the desired level; or, in special cases, they are suspended at the desired level with waxed linen string. Entrance to the hole is through a six-place rotating shielded magazine. Irradiated samples may be stored in the magazine until they decay enough to be handled safely. The facility

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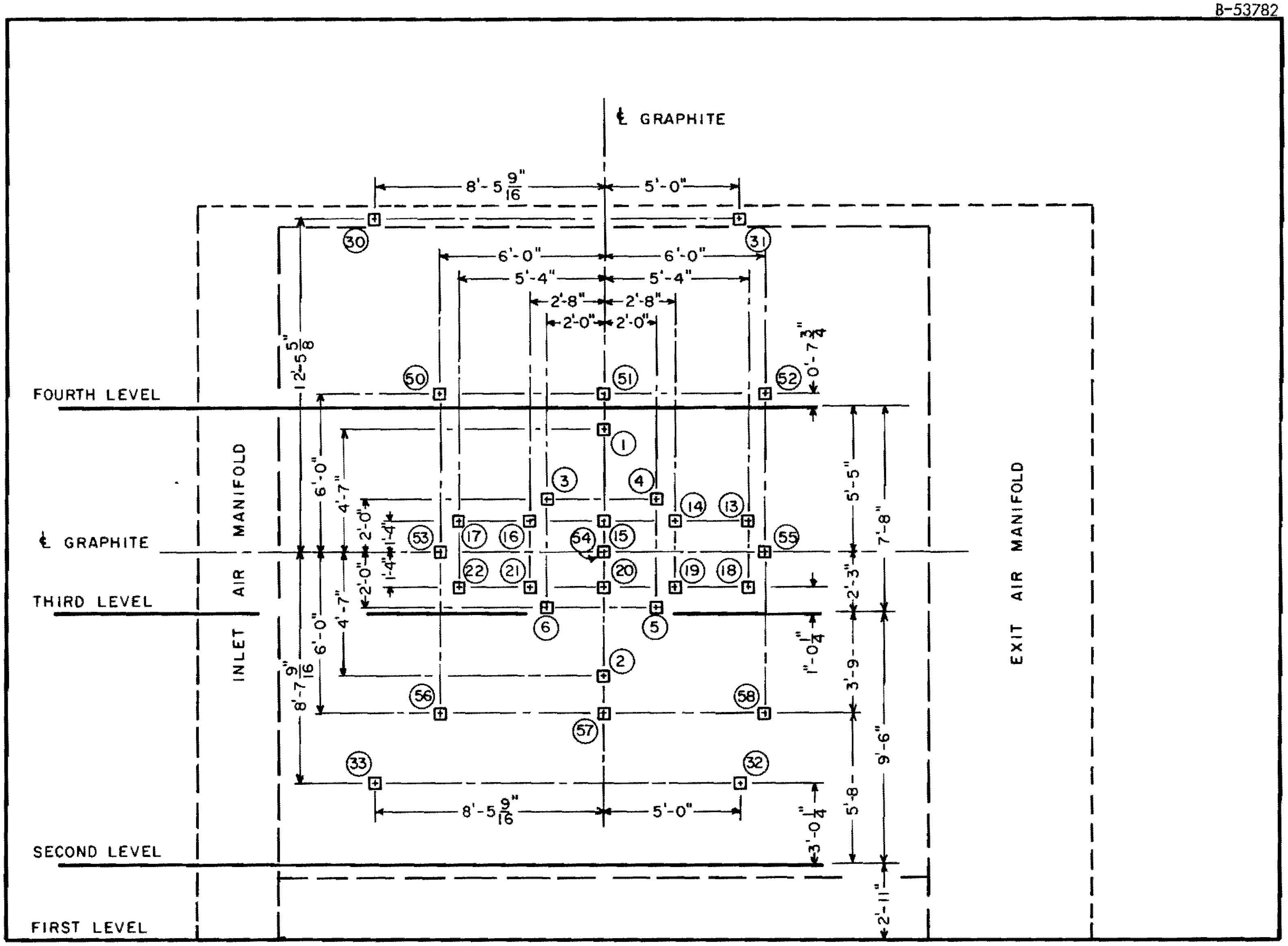

FIG. 4.1 NORTH FACE OF REACTOR

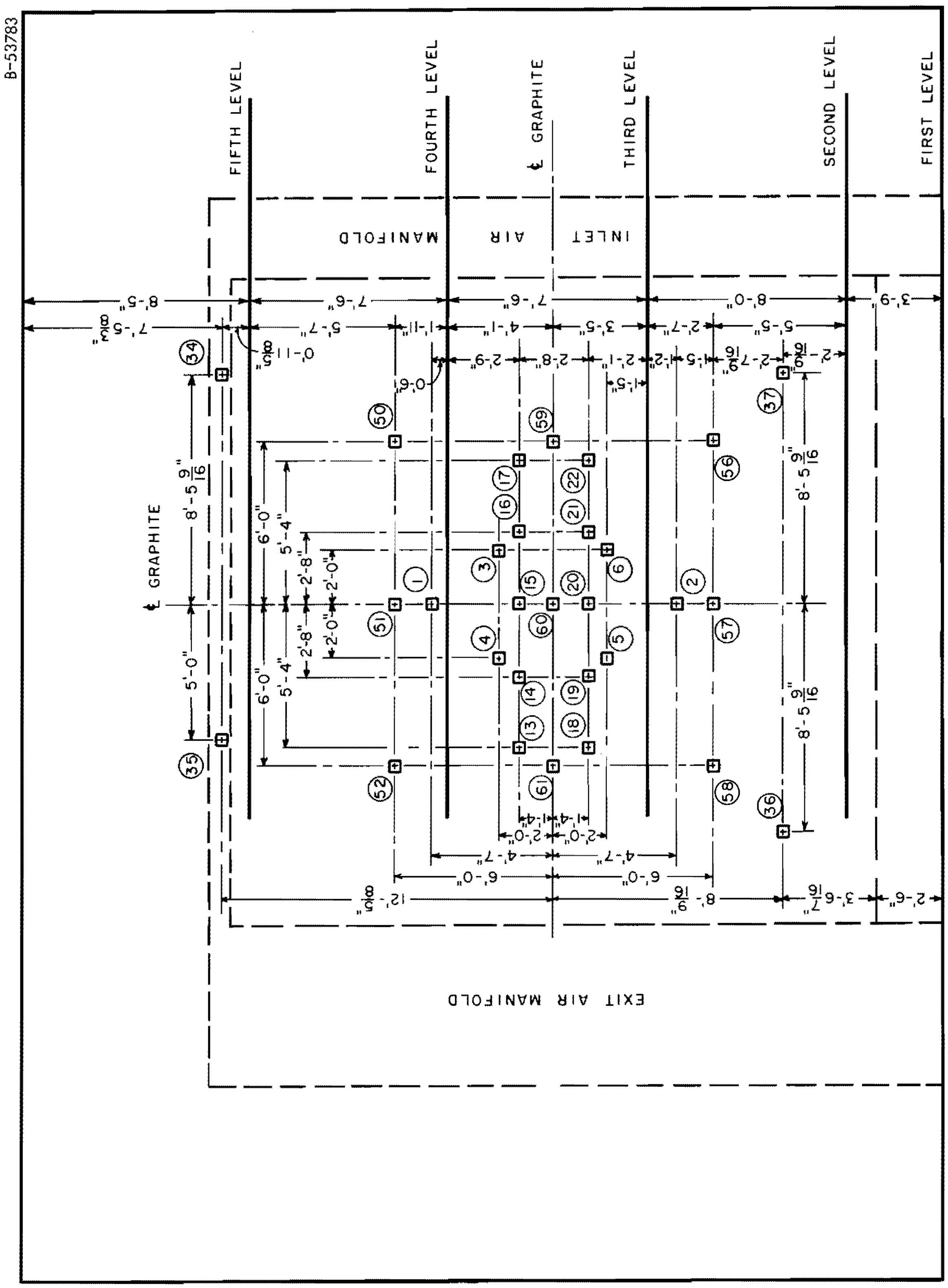

FIG. 4.2 SOUTH FACE OF REACTOR

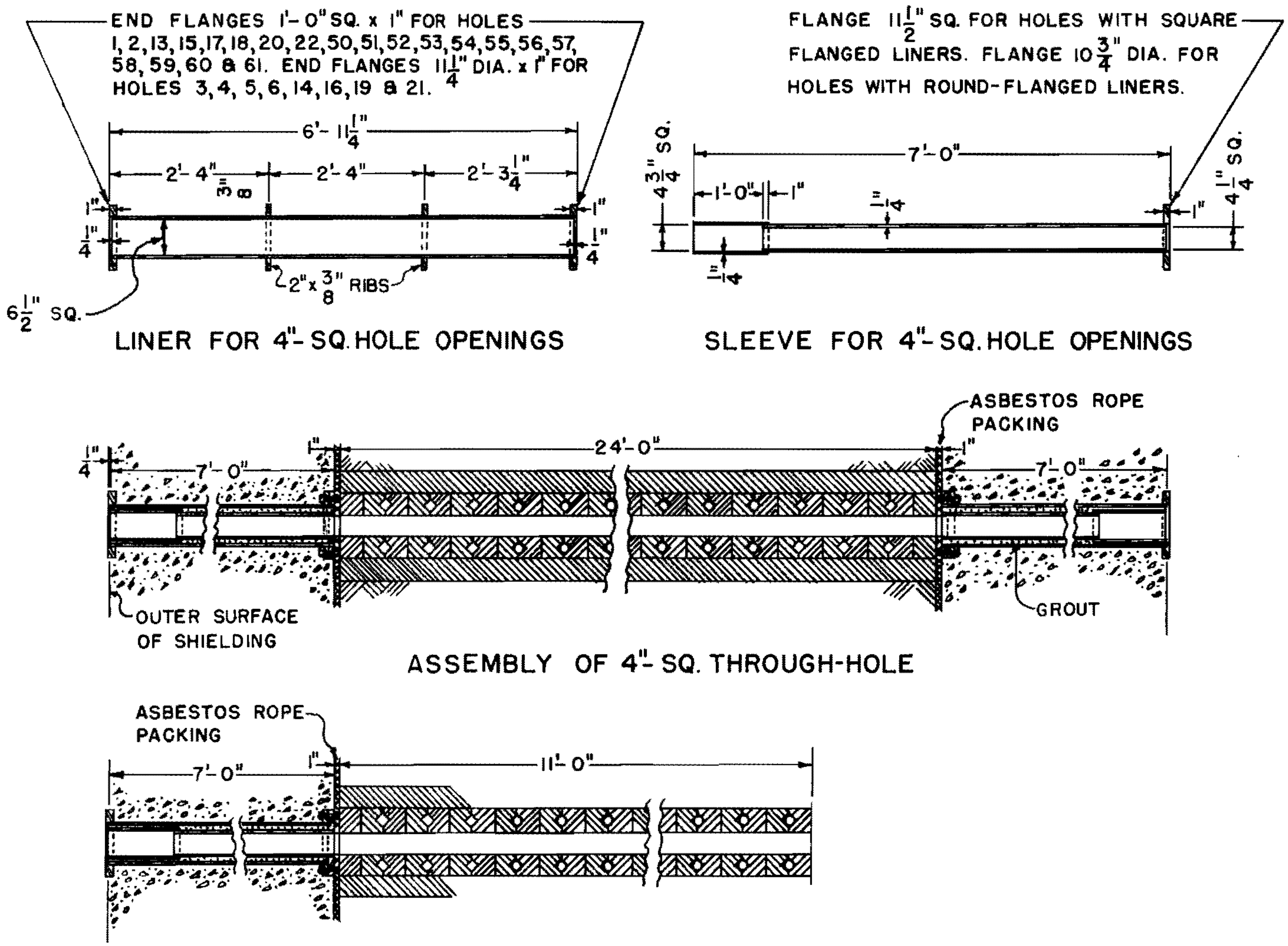

FIG. 4.3 ASSEMBLY OF 4"- SQ. HALF-HOLE

allows short-term irradiations at near room temperature at a maximum neutron flux density of 8.9 x 10^{11} n/cm^2/sec.

4.5. Biological Tunnels

Two biological tunnels are located in the top shielding on the south side of the reactor, Figure 4.4. Figure 4.5 shows the irradiation chamber of the tunnel to the east and the third of three gates through which the specimen container must pass in order to reach the chamber. The west tunnel is identical in size but is lined with 4-in. of lead as shown in Figure 4.6.

The gates operate vertically in channels open to the top of the reactor shield. Shielding of the gate channels is accomplished by the use of stepped concrete plugs with small holes to accommodate the lifting cables.

4.6. Thermal Column and Inclined Biological Tunnel

The thermal column, Figure 4.7, is a stack of graphite blocks in a 5-ft square hole through the roof of the reactor shield and centered over the reactor core. The top is shielded by a 5-ft square aluminum tank of water with lead and cadmium shielding around the sides. Materials to be irradiated or radiation shield configurations to be tested are lowered through the water to the bottom of the tank.

The inclined biological tunnel, Figure 4.8, is built into the thermal column. The irradiation chamber is encased in a 4-in. thick layer of bismuth metal and is covered with a 4-in. bismuth plug backed by a 4-ft graphite plug in the insertion hole. Specimens, maximum size 7-in. x 3-in. x 3-in., are placed in a graphite box affixed to the lower end of the bismuth plug and are lowered into the irradiation chamber by means of a motor-driven hoist.

4.7. Periscope or Utility Holes

Holes 40 - 45, Figures 4.9, 4.10, and 4.11, are 6-in. holes that were designed for either general utility or to accommodate periscopes for observation of the discharge face of the reactor matrix. When not in use, the holes are closed with stepped shield plugs, Figure 4.12. At present, Hole 40 contains an ionization chamber used in reactor control.

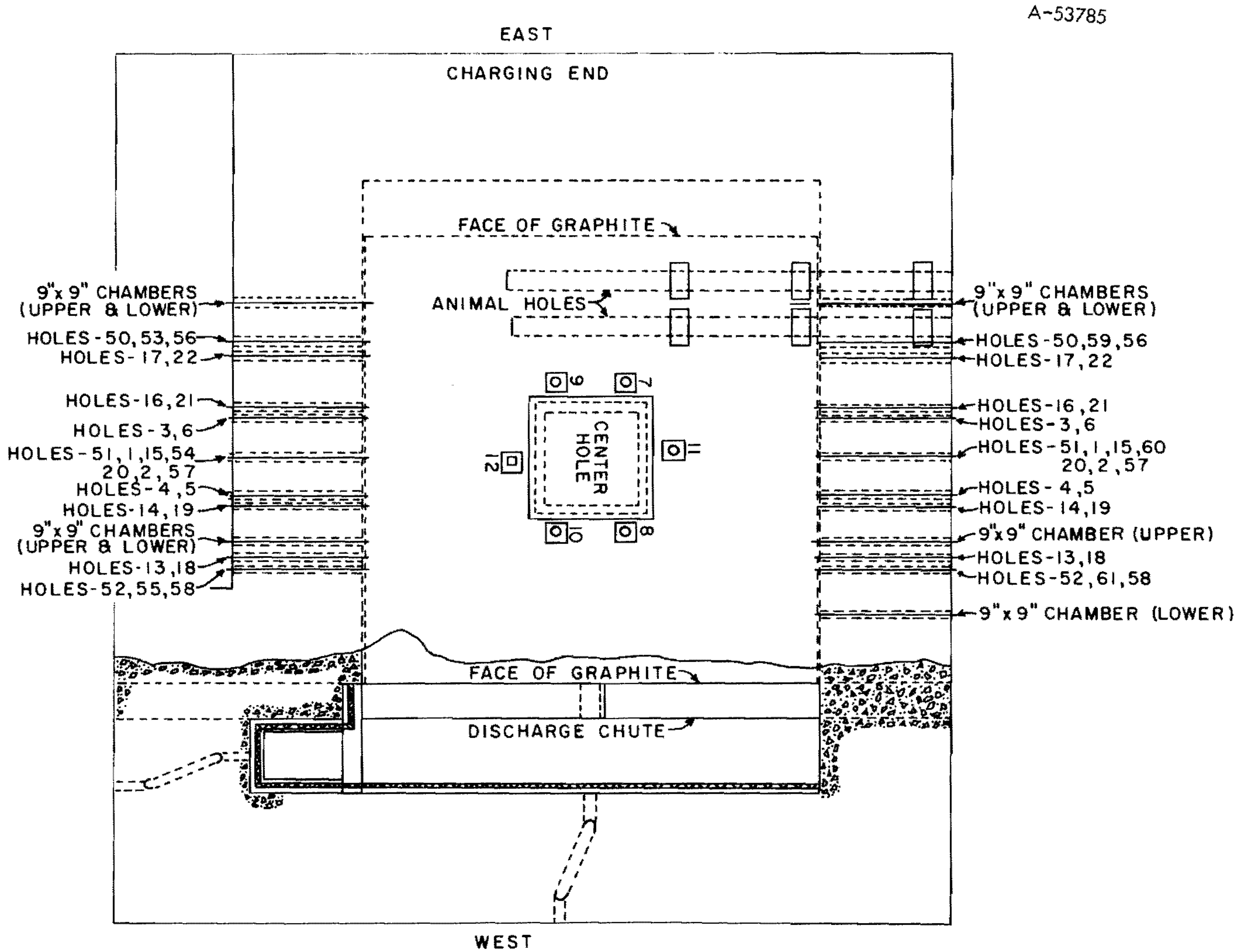

FIG. 4.4 PLAN VIEW OF REACTOR

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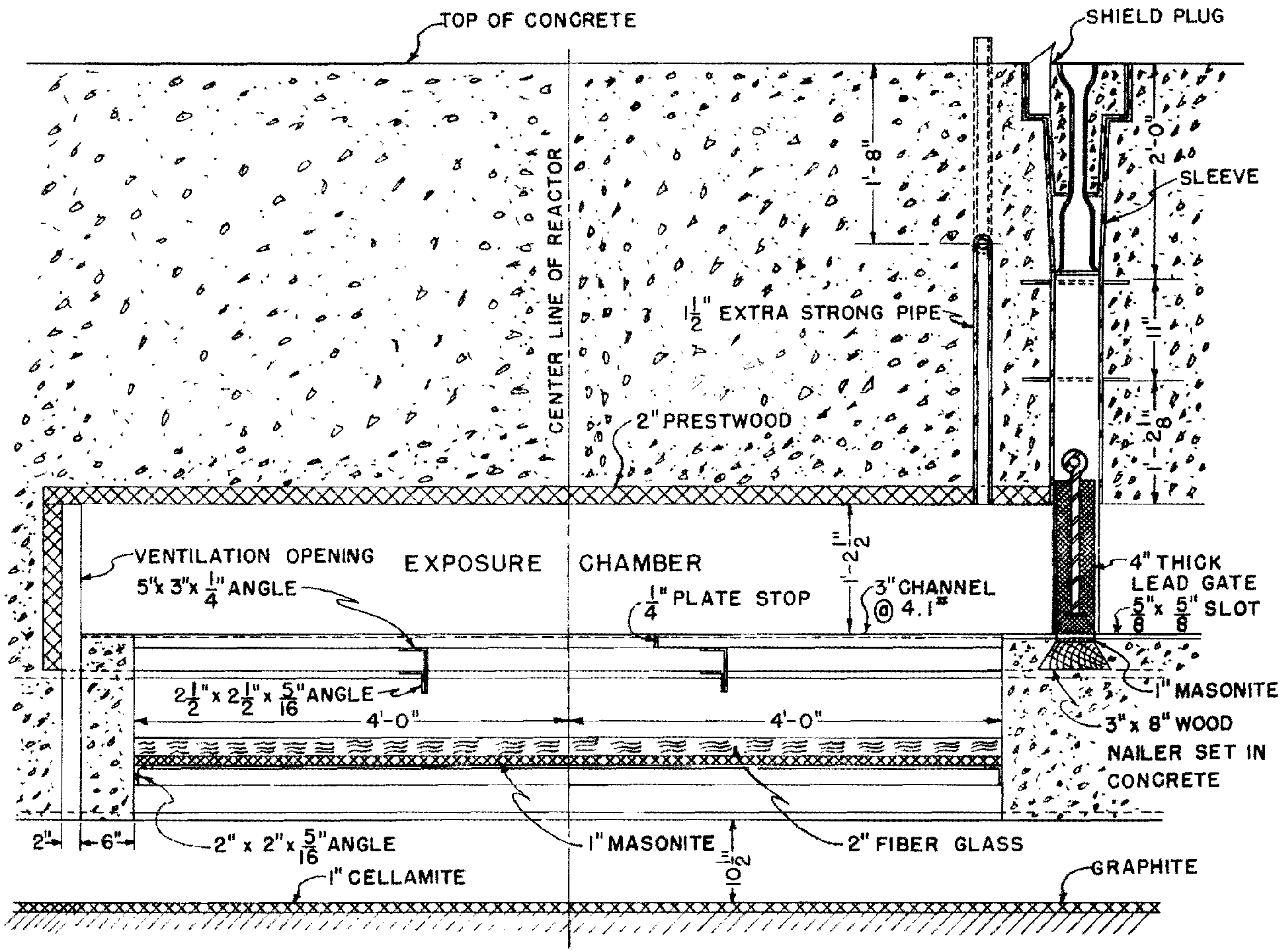

FIG. 4.5 EXPOSURE CHAMBER OF EAST BIOLOGICAL TUNNEL

A-53787

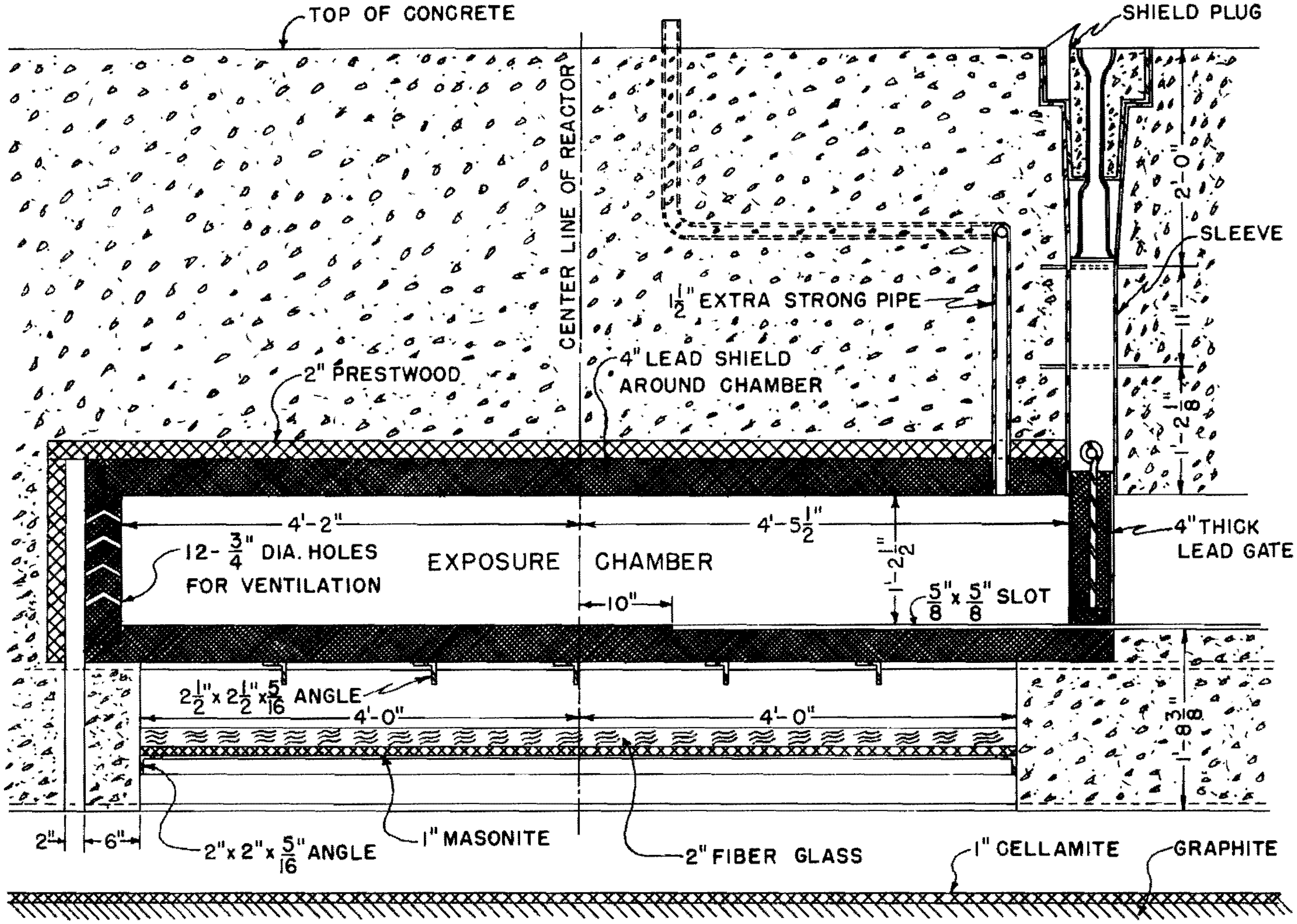

FIG. 4.6 EXPOSURE CHAMBER OF WEST BIOLOGICAL TUNNEL

A-53788

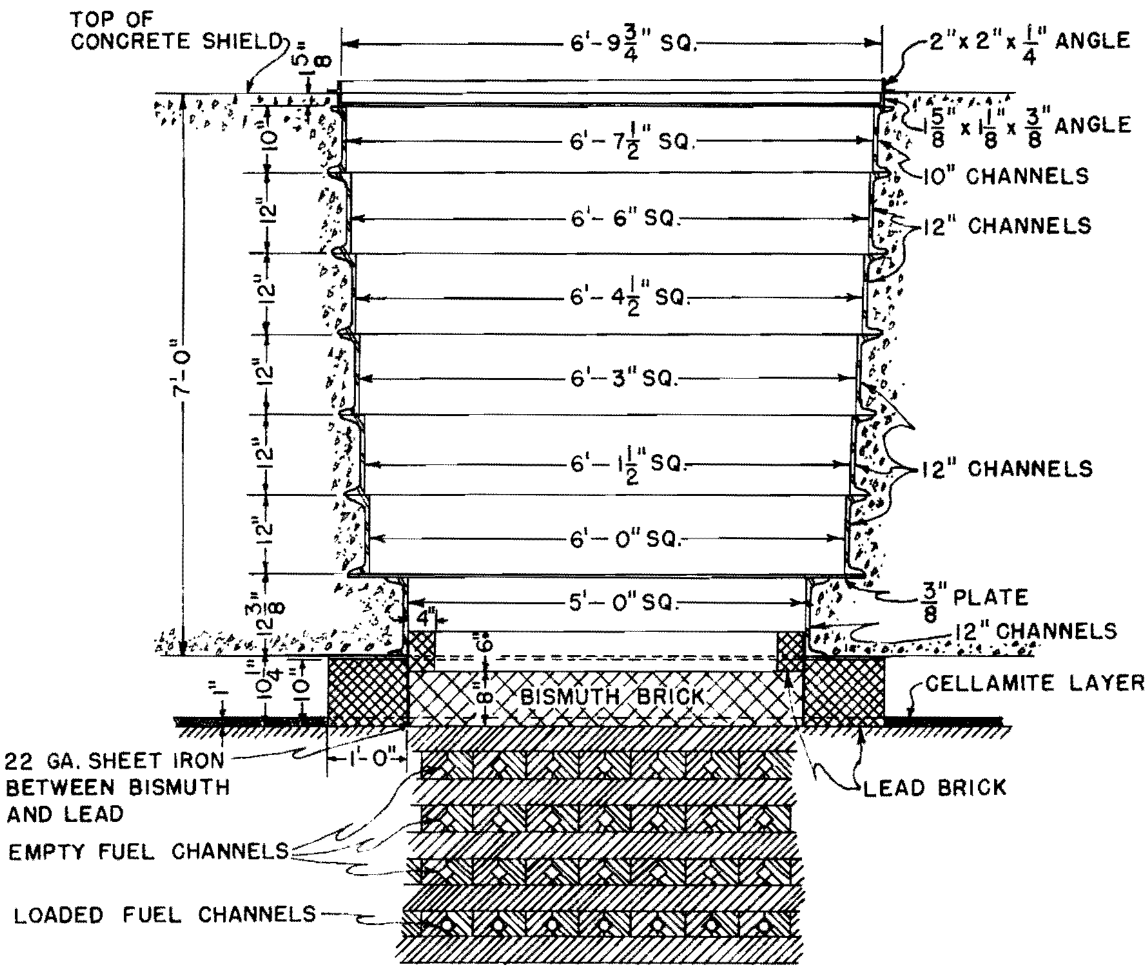

FIG. 4.7 THERMAL COLUMN HOLE

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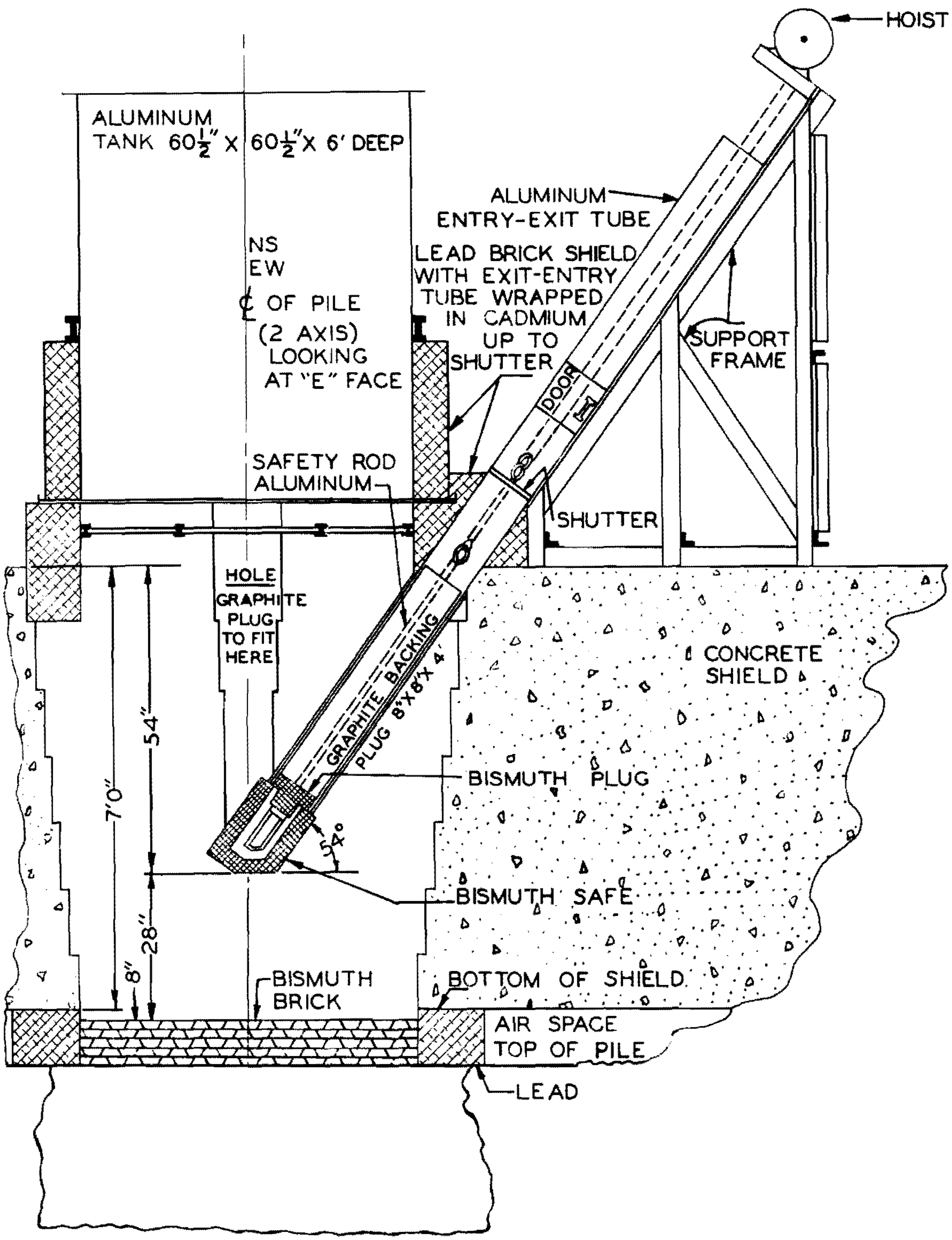


A-53789

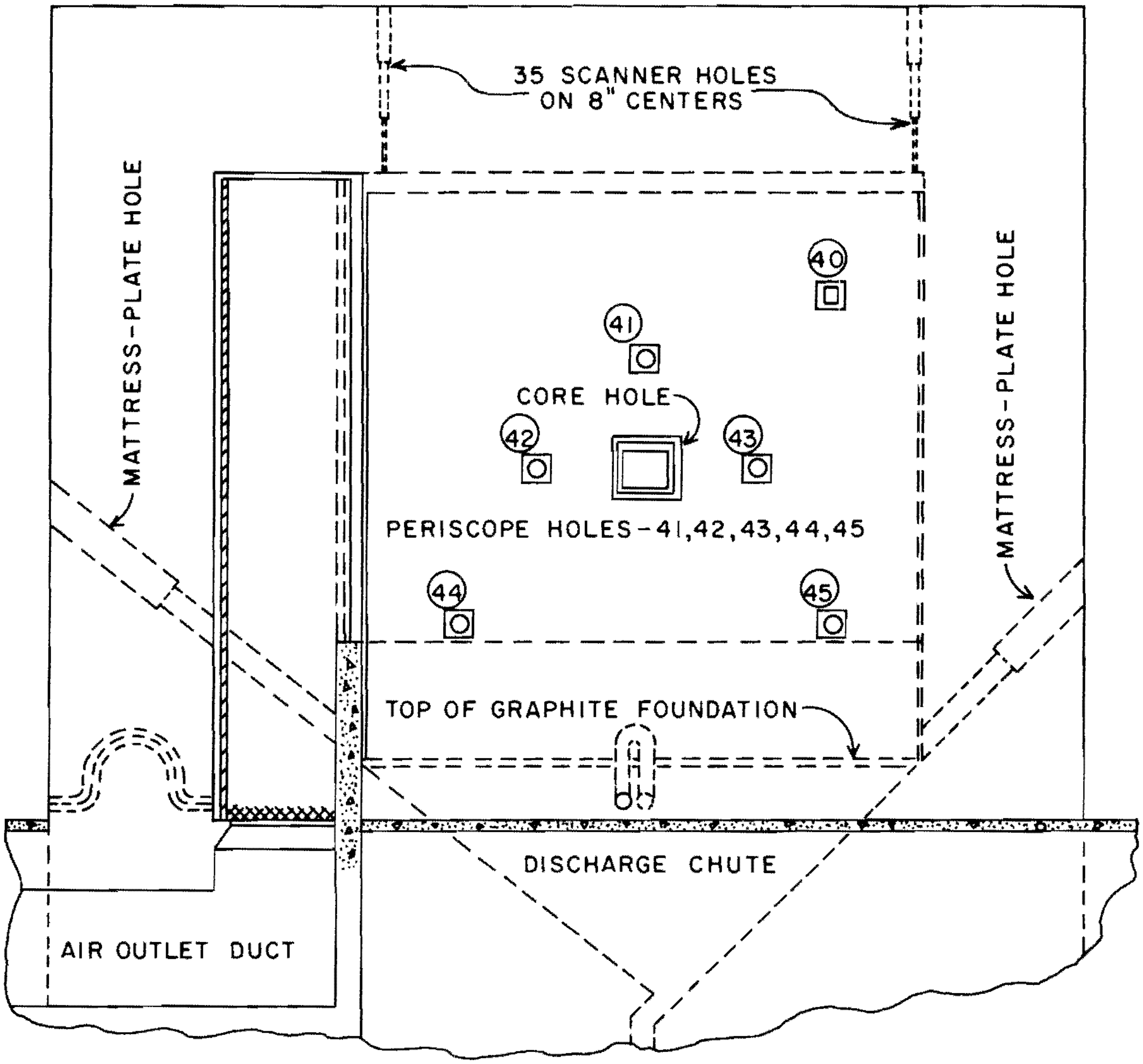


FIG. 4.9 ELEVATION OF DISCHARGE END WALL

A-53790

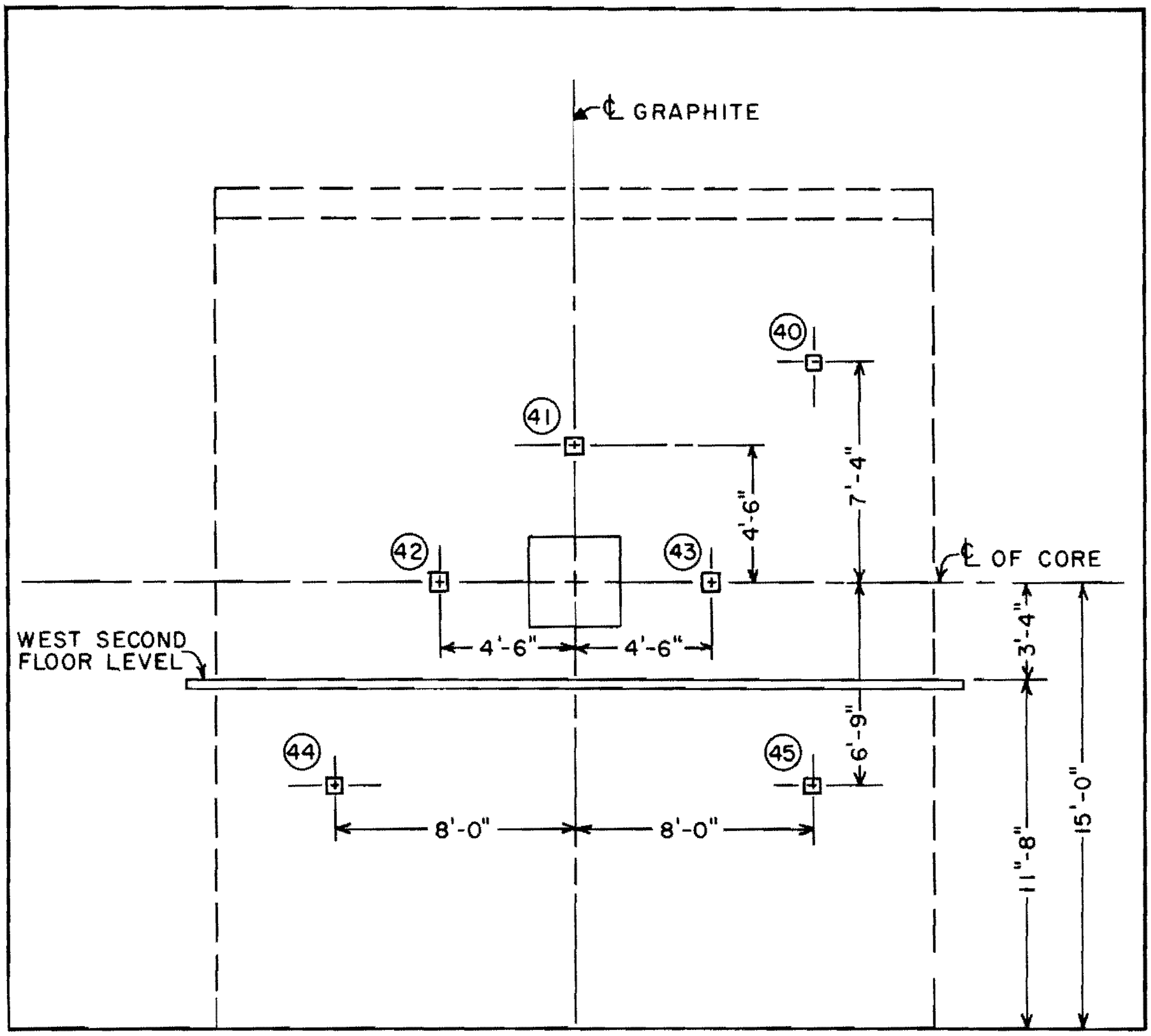


FIG. 4.10 WEST FACE OF REACTOR

A-53791

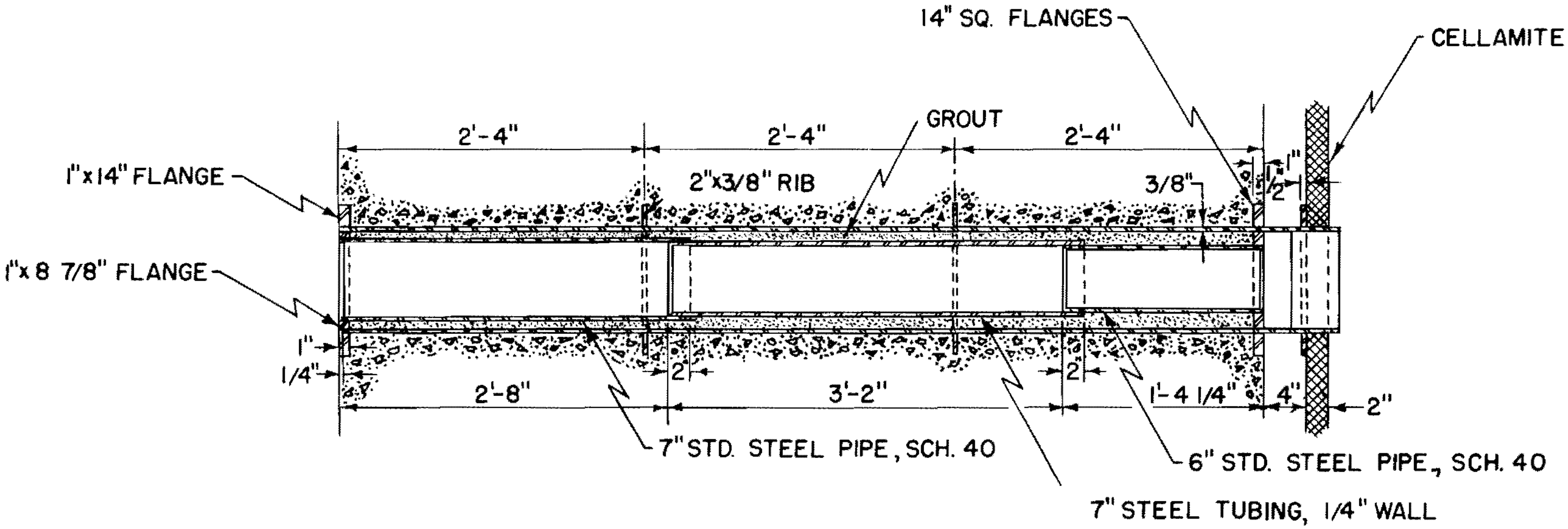


FIG. 4.11 HOLES 40* 41, 42, 43, 44, AND 45

*HOLE 40 DOES NOT CONTAIN AN INNER SLEEVE SO IT HAS THE DIMENSIONS OF THE SQUARE OUTER SLEEVE.

A-53792

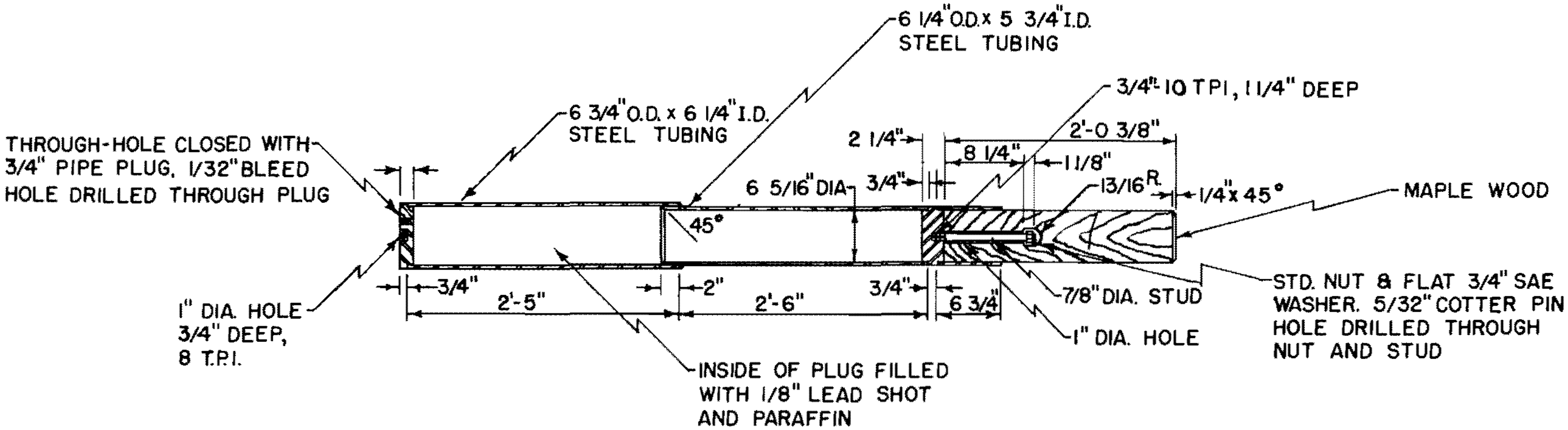


FIG. 4.12 PLUG FOR HOLES 41-47

Holes 46 and 47 through the top shield, Figures 4.13 and 4.14, are similar in construction to Holes 40 - 45 and were designed to allow periscopic observation of the exit-air manifold from the reactor top.

4.8. Nine-Inch Holes

Holes 30 - 37, Figures 4.1, 4.2, and 4.15, are 9-in. square holes designed for either ionization chambers or for large experiments. At present, Holes 32, 33, and 36 contain uncompensated ionization chambers which initiate signals for three independent safety channels. Compensated ionization chambers in Holes 34 and 37 initiate signals that are used for a micro micro ammeter and a power-level recorder, respectively. Holes 31 and 35 have been permanently closed. A steel "H" beam extends from Hole 31 to Hole 35 across the top of the graphite.

A-53793

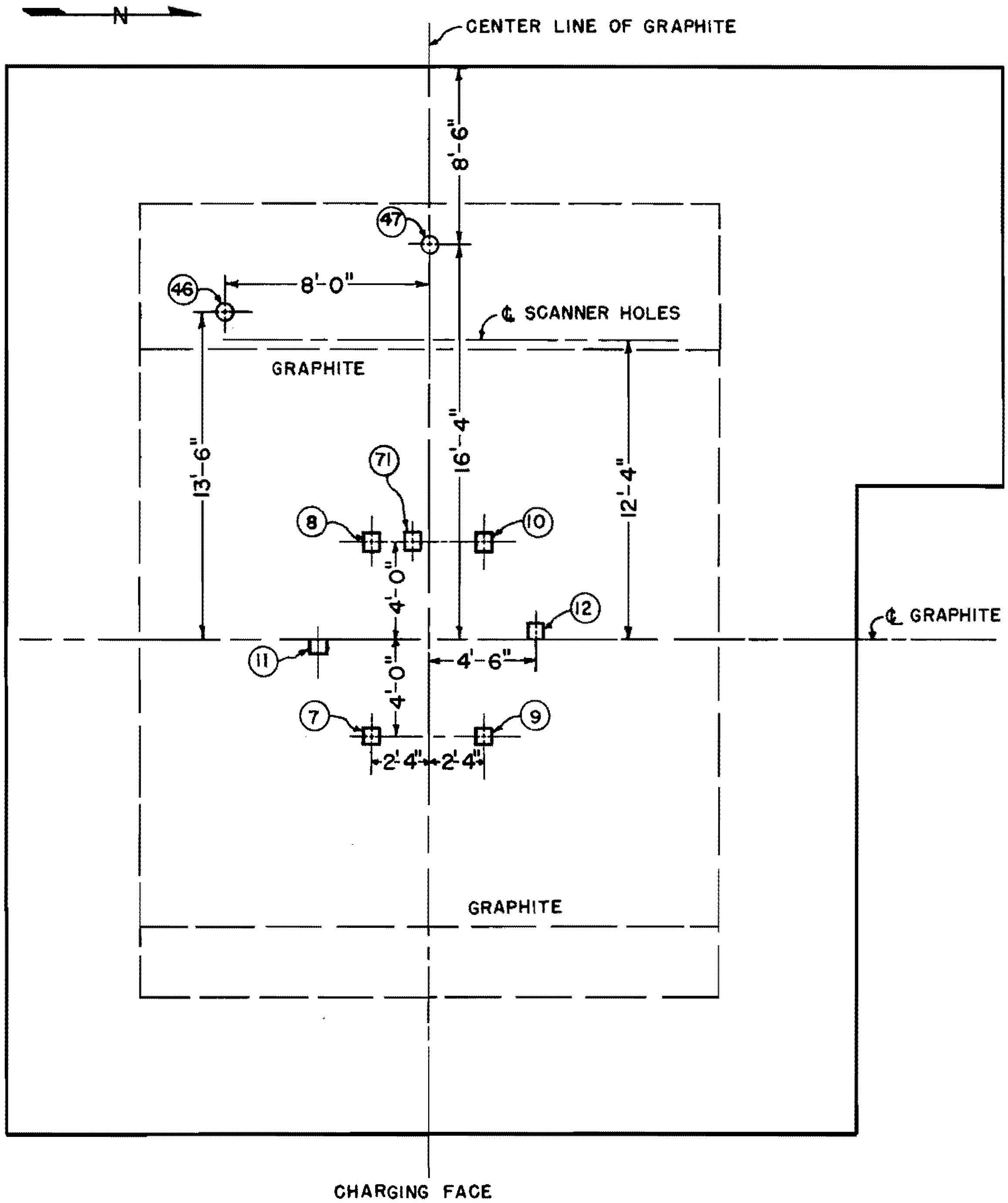


FIG. 4.13 TOP VIEW OF REACTOR

A-53794

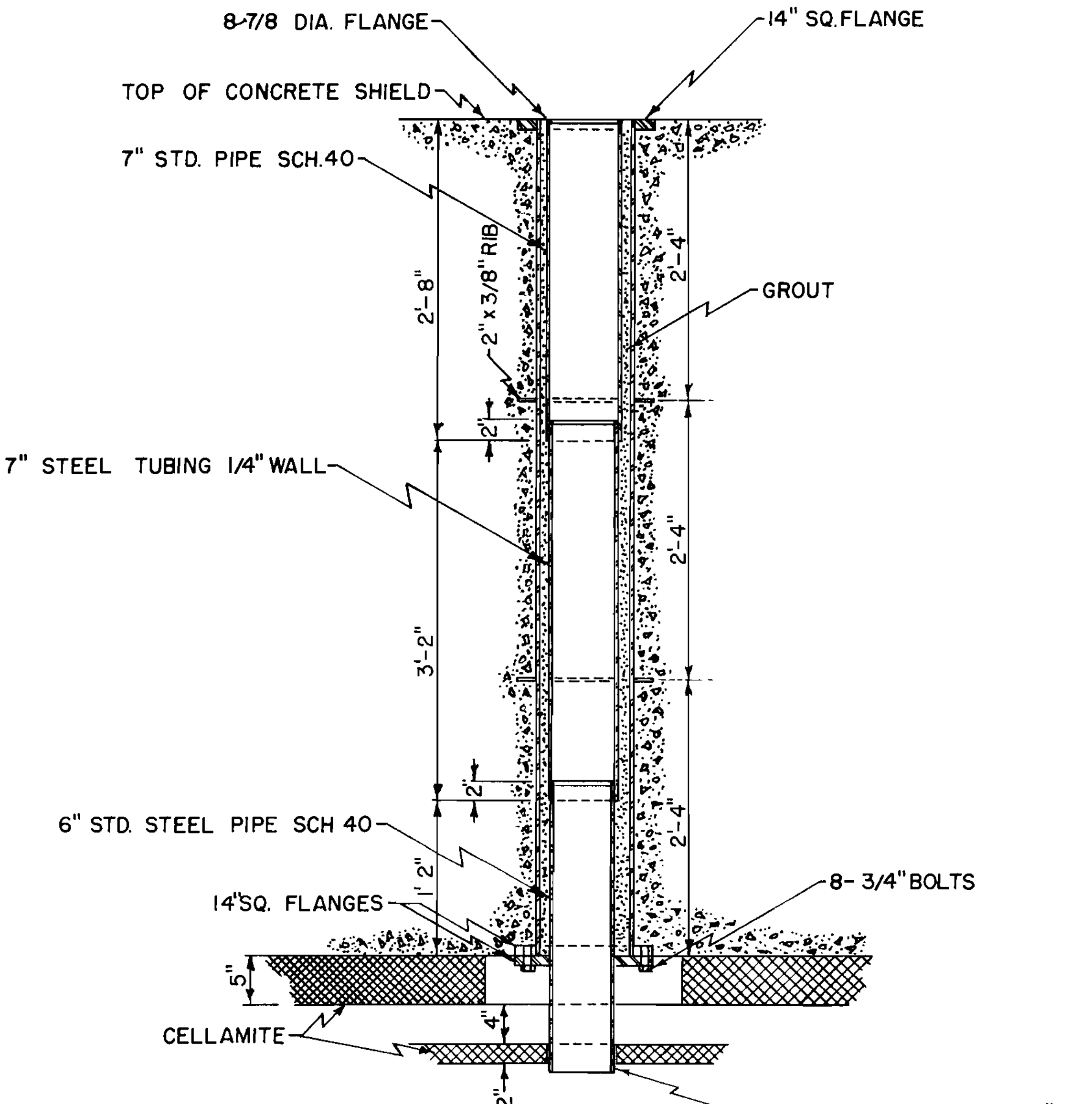
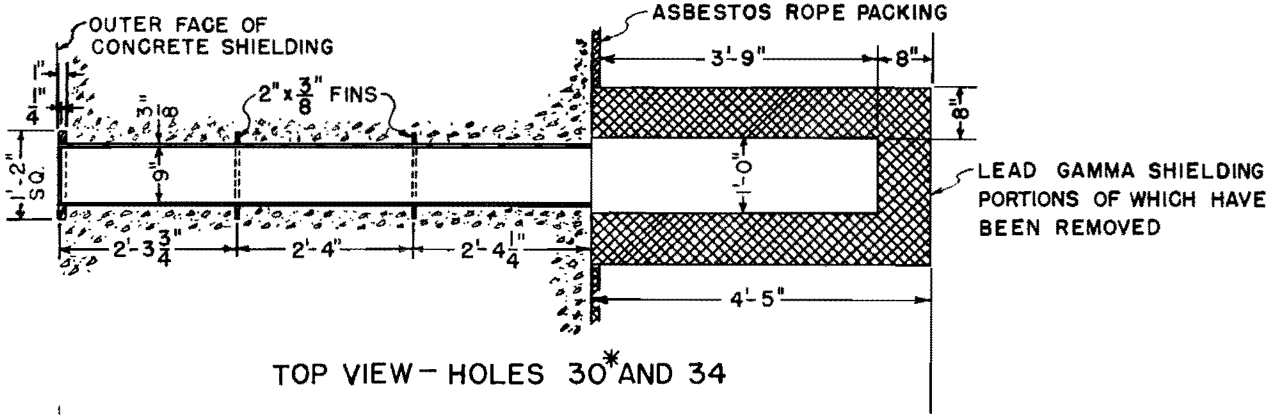


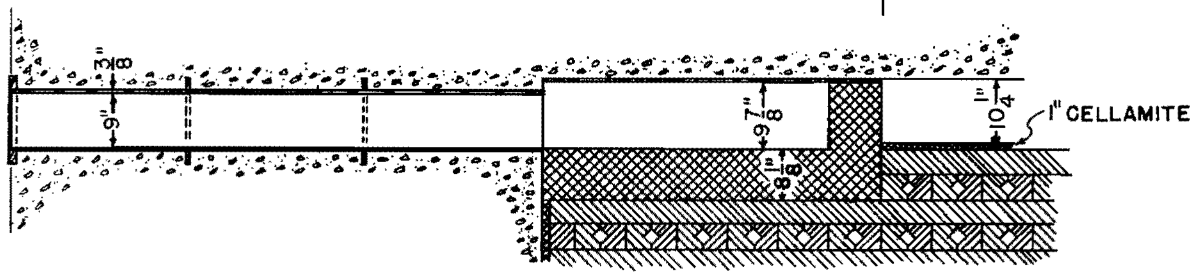
FIG. 4.14 HOLES 46 AND 47

A-53795

* PART OF LEAD HAS BEEN REMOVED FROM THESE HOLES



TOP VIEW - HOLES 30* AND 34



SIDE VIEW - HOLES 30* AND 34

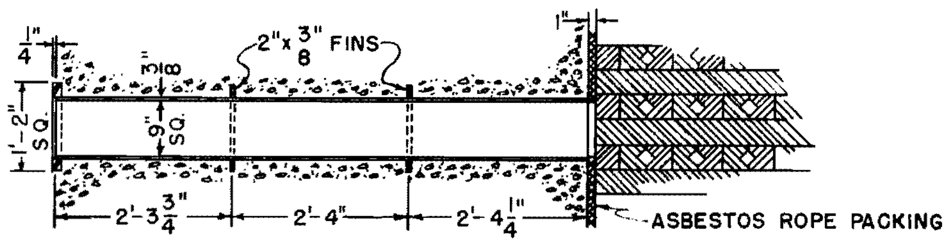


FIG. 4.15 SIDE VIEW - HOLES 32, 33, 36 AND 37

5. Control and Maintenance

The following holes were not designed as experimental facilities. However, modifications of the safety and control systems have released some of them to be converted to experiment facilities.

5.1. Safety Rods

Holes 7, 8, 9, and 10, Figures 4.13, 5.1, and 5.2, were designed to let safety rods No. 7, 8, 9, and 10 drop into the reactor through the top shielding. Holes 7, 8, and 9 were modified to accommodate new safety rods, 3 1/2-in. square by 9-ft long, containing 1/16-in. thick cadmium sheet in their walls. The increased reactivity worth of these rods made it possible to remove No. 10 from the reactor and Hole 10 was converted to an experiment facility.

Holes 11 and 12, Figure 5.3, were also changed from safety holes to experiment facilities when it was found that they were not needed for their original purpose, boron-steel shot tubes.

5.2. Shim Rods and Regulating Rods

Both shim rods and regulating rods enter the reactor from the north side. Shim rods No. 3, 4, 5, and 6 operated in Holes 3, 4, 5, and 6, Figure 5.4. Rods No. 3 and 4 were found to be unnecessary for reactor control, so they were removed and the corresponding holes were converted to experiment facilities.

Rods No. 1 and 2, the regulating rods, are used for operating the reactor while in the "manual" mode because their drives are designed to insert or withdraw small increments of reactivity for smooth control in this mode.

In the "automatic" mode, shim rod No. 6 is fully withdrawn and is used as a safety rod. No. 5 shim rod is operated by the servo-control system and becomes the regulating rod. Regulating rods 1 and 2 become shim rods and are inserted or withdrawn only to keep the No. 5 rod operating in a limited reactivity range.

A-53796

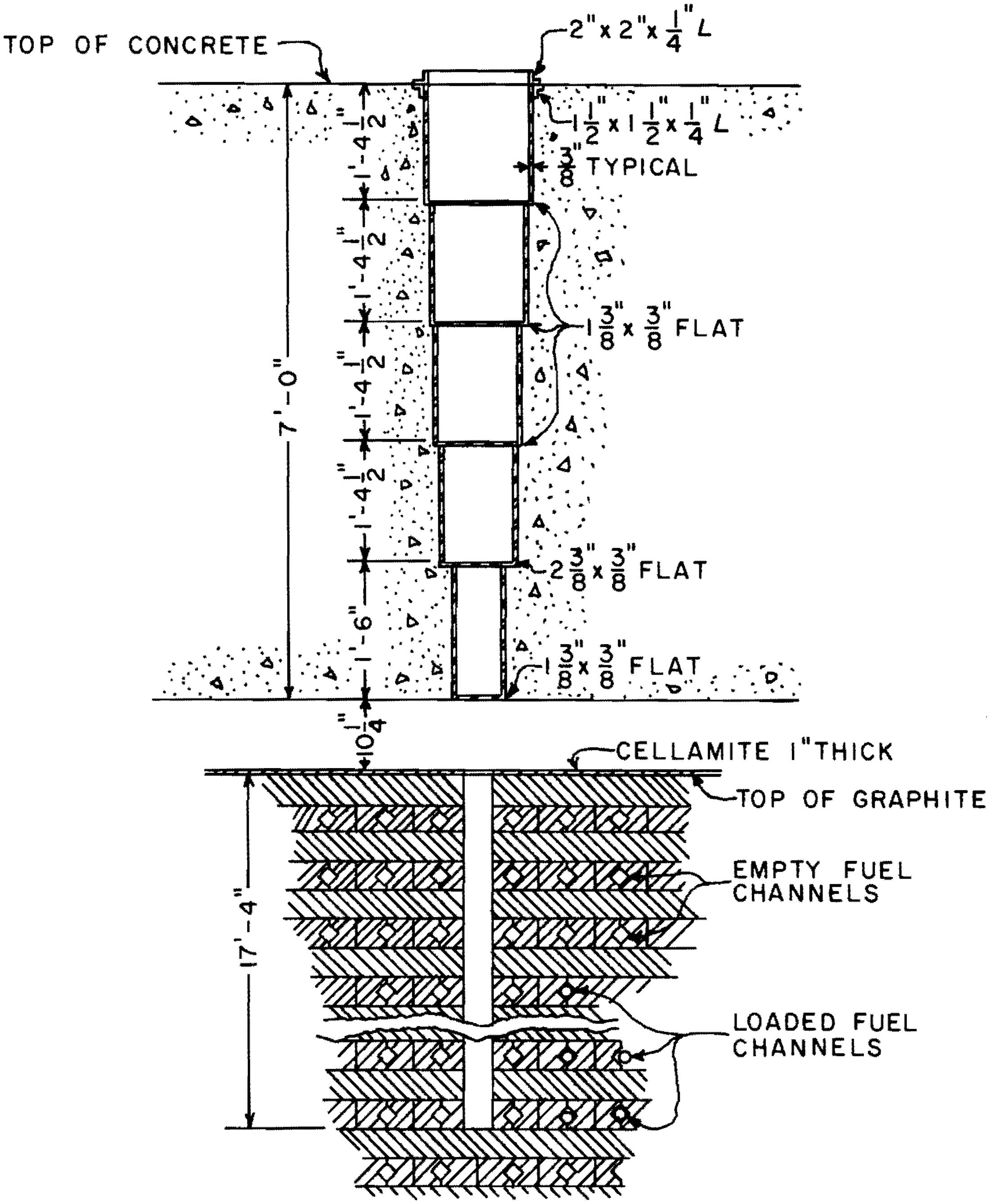
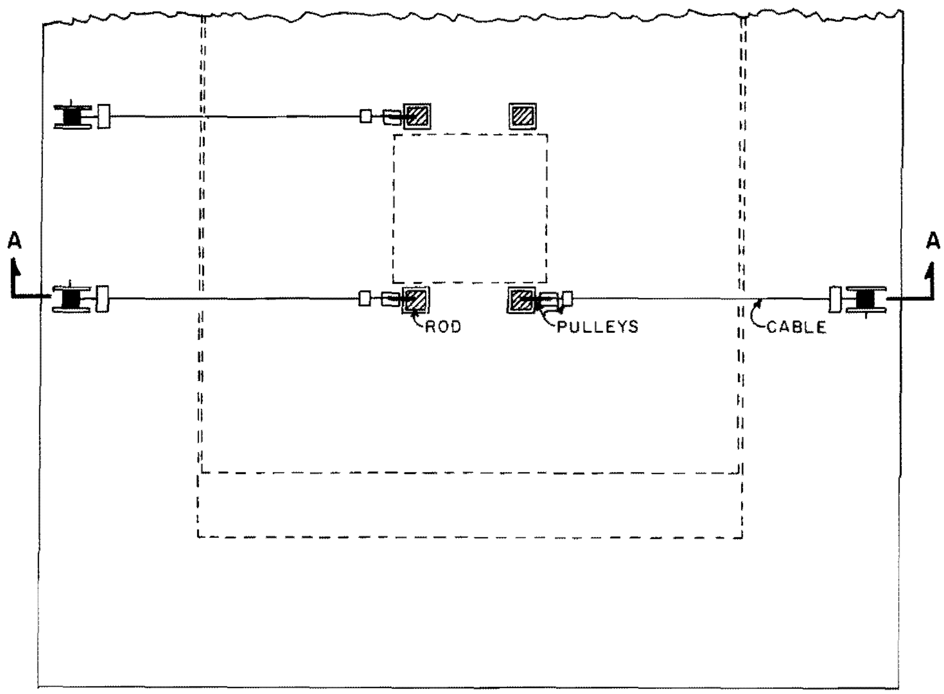
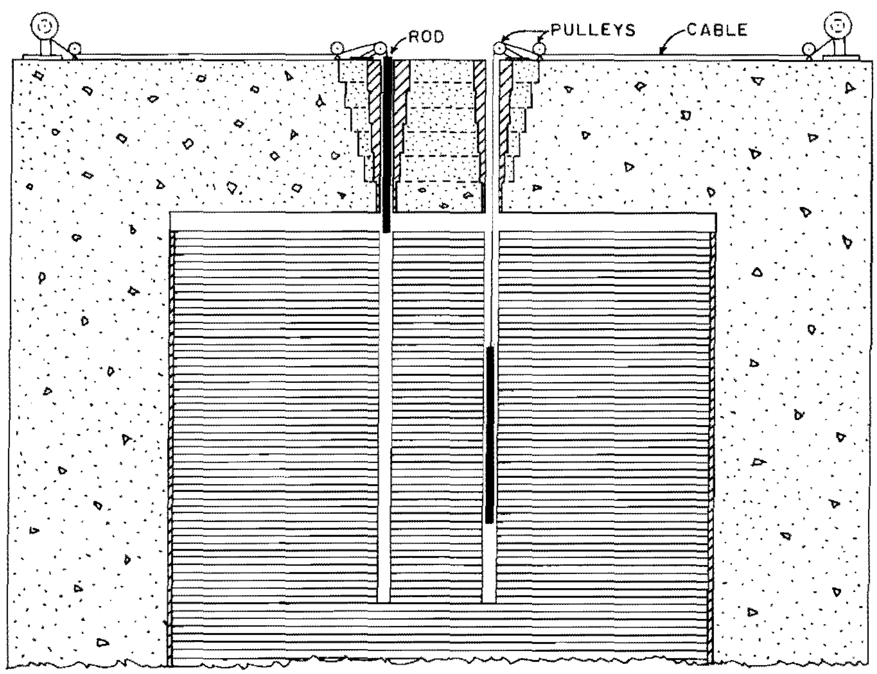


FIG. 5.1 HOLES 7, 8, 9, AND 10

B-53797



PARTIAL PLAN OF REACTOR



SECTION "A-A"

FIG. 5.2 GRAVITY SAFETY RODS

A-53798

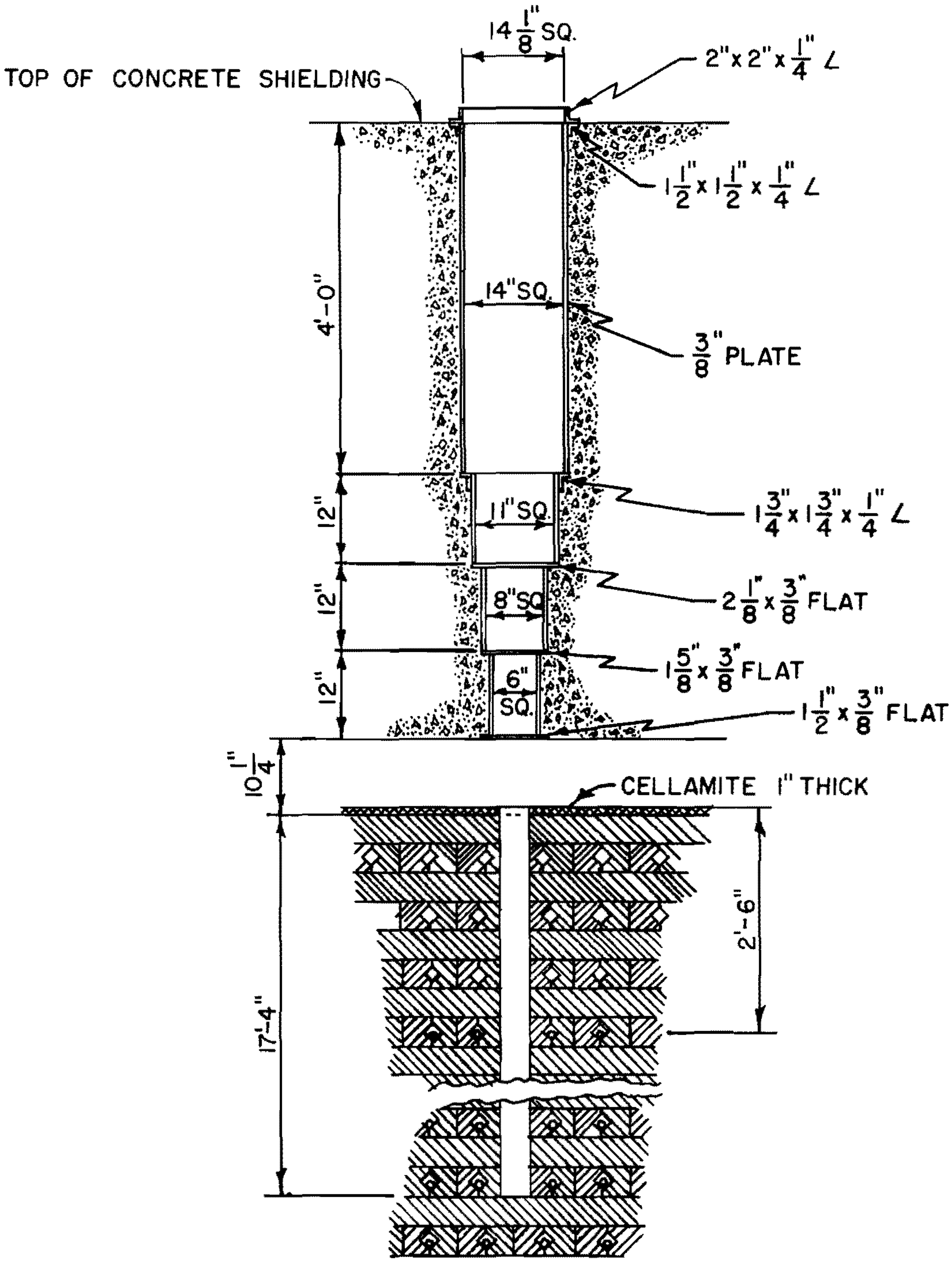
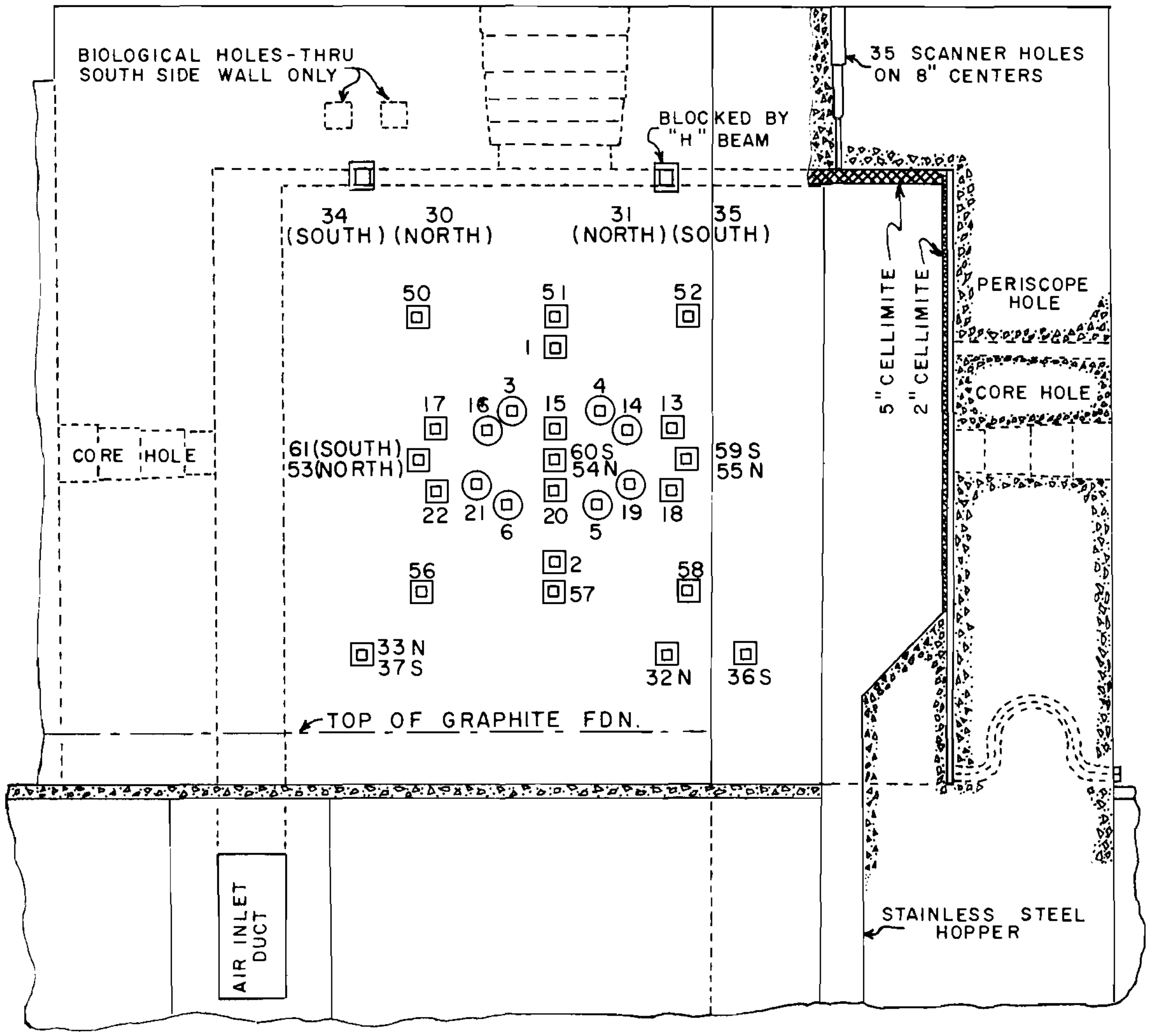


FIG. 5.3 HOLES 11 AND 12

A-53799



EXP'T HOLE-50,51,52,53,54,55,56,57,58,3,4
13,14,15,16,17,18,19,20,21,22

REGULATING ROD HOLE - 1,2

SHIM ROD HOLE - 5,6

IONIZATION CHAMBER HOLE - 30,31,32,33 NORTH,34,35,36,37 SOUTH

WATER-COOLED TUBE - 19

FIG. 5.4 ELEVATION OF NORTH & SOUTH SIDE WALLS

5.3. Scanner Holes

These thirty-five 4-in. diameter holes extend through the top shield above the exit-air maniford. They are located on 8-in. centers above the fuel channels and are used as observation and maintenance ports. When the reactor is operating, the scanner holes are closed with the stepped shield plugs shown in Figure 5.5.

A-53800

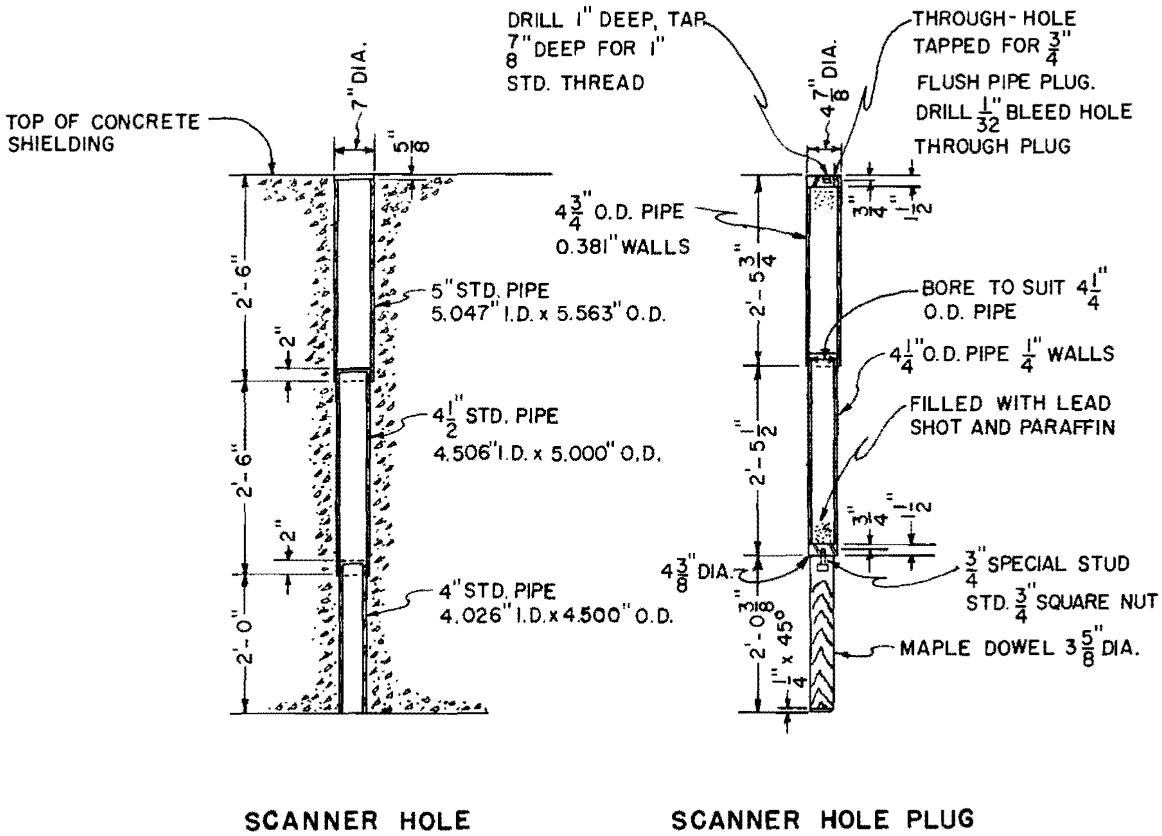


FIG. 5.5

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