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ATTENUATION OF RADIATION FROM DISTRIBUTED GAMMA SOURCES AS A FUNCTION OF WALL THICKNESS OF A CONCRETE BLOCKHOUSE

by

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The experiment described in this paper constitutes part of the shielding program conducted by Army Nuclear Defense Laboratory and was designed to experimentally verify theoretical calculations used to predict the amount of radiation protection afforded by above-ground structures in a fallout radiation field. This prediction method was developed by Dr. Spencer and associates of the National Bureau of Standards and is presented in the NBS Monograph 42.

This method requires the knowledge of some physical parameters of a structure such as mass thickness of the walls and the geometric orientation of the detectors within the structure. From this information, a reduction factor for any given structure may be calculated.

This Laboratory's experimental program was initially begun by measuring the attenuation of a simple structure with no complicating internal or external geometries and will proceed to more complex structures with basements, interior partitions, and upper floors.

EXPERIMENTAL PLAN.

The experimental plan called for the simulation of uniform contamination around a building and the measurement of the dose rate at various positions inside the structure.

ABSTRACTED IN NSA

ORNL-LABRY WITHDRAWN AVENUE

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The reduction in dose rate due to the wall was then compared to that calculated by Dr. Spencer's method.

The experimental structure was a simple, square, windowless, concrete blockhouse shown in the first slide.

Slide #1 - Photo of Blockhouse

The inside dimensions were 12 ft x 12 ft x 8 ft. The basic wall of the blockhouse was reinforced concrete; mass thickness 48 pounds per square foot or psf. Two thicknesses of concrete were added to the basic wall in increments of 45.7 psf, this resulted in wall thicknesses of 93.7 psf and 139 psf, respectively. The thickness of the roof was 50 psf of steel for the first two wall thicknesses and 92 psf for the 139 psf wall thickness.

A simulated fallout radiation field was produced around the blockhouse by moving point sources successively to positions in a grid pattern; however, because of symmetry of the structure, only one-eighth of the field required simulation.

The next slide shows the grid pattern of source positions around the blockhouse.

SLIDE #2 - Grid Pattern Around Blockhouse

The simulated area was divided into a series of squares which increased in size as the distance from the building increased. Dose rate measurements were made with the source placed at the center of each square and the results were utilized in calculating the dose rate from a uniformly

contaminated area surrounding the blockhouse. The experiment was conducted using point sources of cobalt 60, and cesium 137.

The next slide will show the method used for exposing the sources.

SLIDE #3 - Tilter in Upright Position

The shield, housing the source, was mounted on a tilting mechanism. A source lifting assembly was placed into the shield and the shield was tilted remotely. Next slide.

SLIDE #4 - TILTER IN EXPOSURE POSITION

After the shield was tilted, the compressor pump was activated remotely and the source was blown to the end of the aluminum riser tube. This exposure method was later refined by installing a reverse air-flow system, thus making it possible to return the source to the shield by simply reversing the flow of the air.

This system made it possible to expose the source with the shield in tilt position and return the source to the shield before tilting the shield upright, thus eliminating a tilting correction in the dose reading and making it possible to remotely expose the source as close as 1 inch above the ground.

Radiation detectors used in this experiment were Victoreen ionization chamber dosimeters; in ranges of 0-1 mr and 0-10 mr. The reading accuracy and the reproducibility of these detectors was found to be within $\pm$1% of a full scale reading.

The detector positions within the blockhouse are shown in the next slide.

SLIDE #5 - DETECTOR POSITIONS WITHIN BLOCKHOUSE

Detectors were placed at the center of the blockhouse 3 feet, and 6 feet above the floor. Other detectors were located in the corners, between the center of the blockhouse and the corner detectors, and on the centerline of the building. In addition, for each of the off-center detectors, there was an "image" position in each quadrant of the building. The dose rate at a given detector position for an area completely surrounding the building was obtained by summing the dose rates from the detectors at the "image" positions.

The distance from the center of the blockhouse to the boundary of the grid pattern using cobalt 60 point sources was 400 feet for the 48 psf and the 139 psf walls and 430 feet for the 93.7 psf wall. Areas contaminated at these distances yielded dose rate readings which are approximately 92% of the infinite field dose rate. This was determined from free field experiments reported in NDL-TR-2, entitled, Scattered Radiation and Free Field Dose Rates from Distributed Sources af cobalt 60 and cesium 137.

Using the cesium 137 point source, the field grid pattern extended to a distance of 340 feet from the center of the blockhouse with the 48 psf wall thickness, to 200 feet for the 93.7 psf wall thickness, and to 100 feet for the 139 psf wall thickness. These distances represent 92%, 85%, and 75%

of the infinite field dose rate respectively.

From the dose readings at the various source positions, the dose rate was determined in milliroentgens per hour for a uniform source density of one curie per square foot of the area completely surrounding the blockhouse. Dose rates for each row were summed and plotted as cumulative dose rates versus distance from the center of the building to the boundary of the grid as shown on the next slide. These dose rates were then extrapolated to obtain the infinite field dose rate by comparing the wall attenuation plot with a similar plot for free field dose rates.

The next slide shows plot of the cumulative dose rates versus distance from the center of the blockhouse for cobalt 60 with the detector at the three foot height.

SLIDE #6 - DOSE RATE VERSUS DISTANCE CURVE

The uppermost curve shows the free field dose rates. The next curves represent dose rates for the 48, 93.7, and 139 psf wall thicknesses, respectively. These curves are very nearly parallel to the free field curve and show a nearly constant ratio beginning at approximately 100 feet from the building. From this data it was assumed that the ratio between the free field dose rate and the dose rate through various wall thickness was constant to an infinite distance. The dose rates shown on the right are the extrapolated infinite field dose rates.

Infinite field dose rates for cesium 137 were determined similarly.

Data will be presented here only for the center detectors at the 3 foot and 6 foot heights. Data for the off center detector positions within the blockhouse are still being analyzed.

Experimental reduction factors were determined for the detectors at the 3 foot and 6 foot heights at the center of the blockhouse.

SLIDE #7 - EXPERIMENTAL AND THEORETICAL REDUCTION FACTORS 3 FEET

This slide shows the experimental reduction factors and the theoretical reduction factors calculated using Dr. Spencer's method plotted versus the mass thickness of the wall. The detector is at a 3-foot height. The pair of curves on top are for cobalt 60 and the pair at the bottom are for cesium 137.

The curves for both cobalt 60 and cesium 137 show very close agreement between the experimental and theoretical reduction factors for wall thickness up to 139 psf. The maximum difference for cobalt 60 is 8% and for cesium 137 is 5%.

The next slide shows similar results for the detector at the 6 foot height.

SLIDE #8 - EXPERIMENTAL AND THEORETICAL REDUCTION FACTOR - 6 FEET

Although slightly larger differences between experimental and theoretical reduction factors were noted for the 6

foot height. However, the maximum differences was 15% for cobalt 60 and 20% for cesium 137.

The complete report on this experiment will be published as NDL-TR-43 and should be released within the next two months.

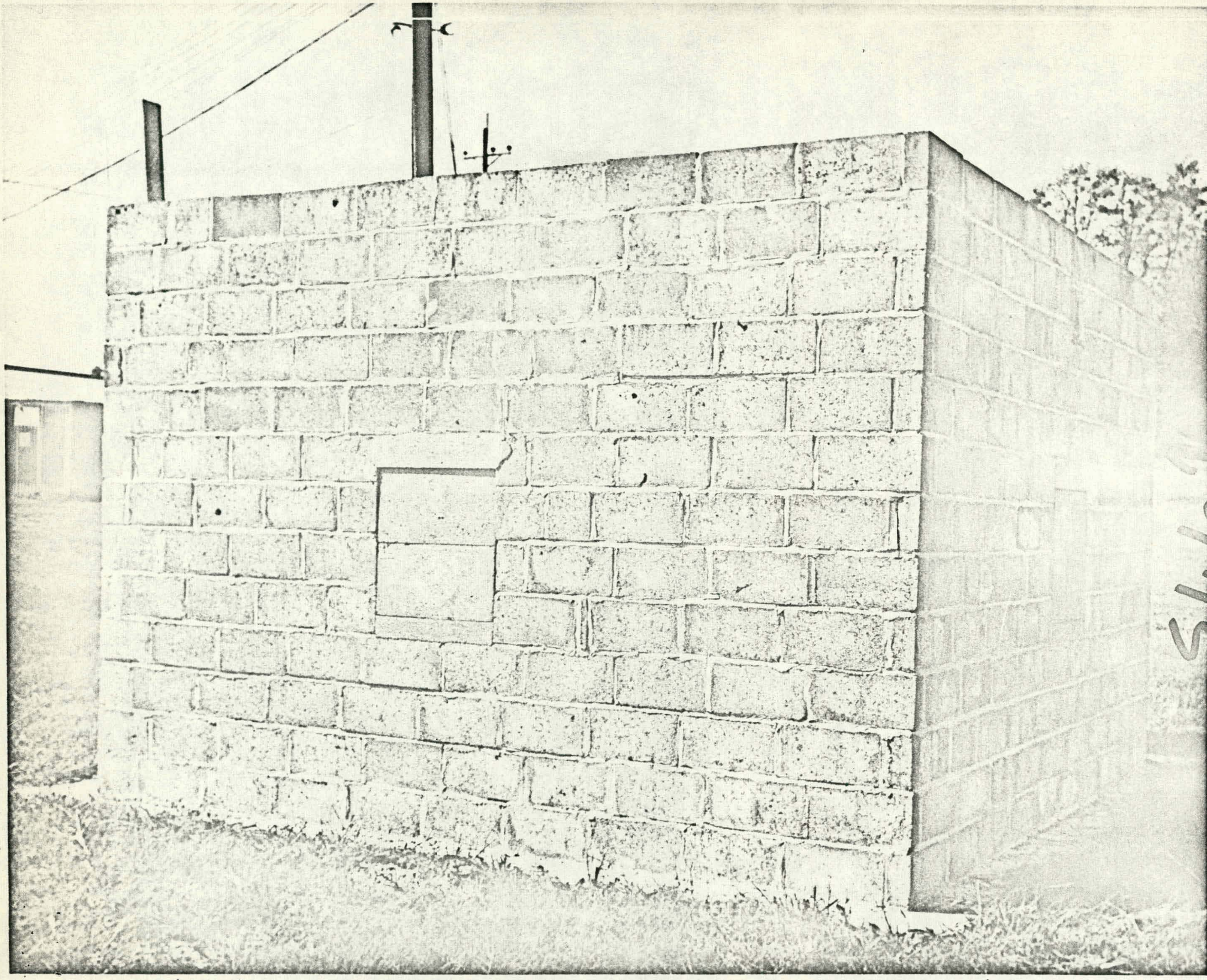
Similar experiments were conducted with contamination on the roof of the blockhouse. This data has been previously reported in NDL-TR-6. Similarly close agreement was shown between experimental and theoretical reduction factors with varying roof thicknesses up to 50 psf.

No comparisons have been made between the experimental and theoretical results for detector locations other than those reported. However, all data has been accumulated and the analysis is in progress for other detector positions, and the individual source to detector readings for the various wall thicknesses. The work is being done jointly with Penn State University.

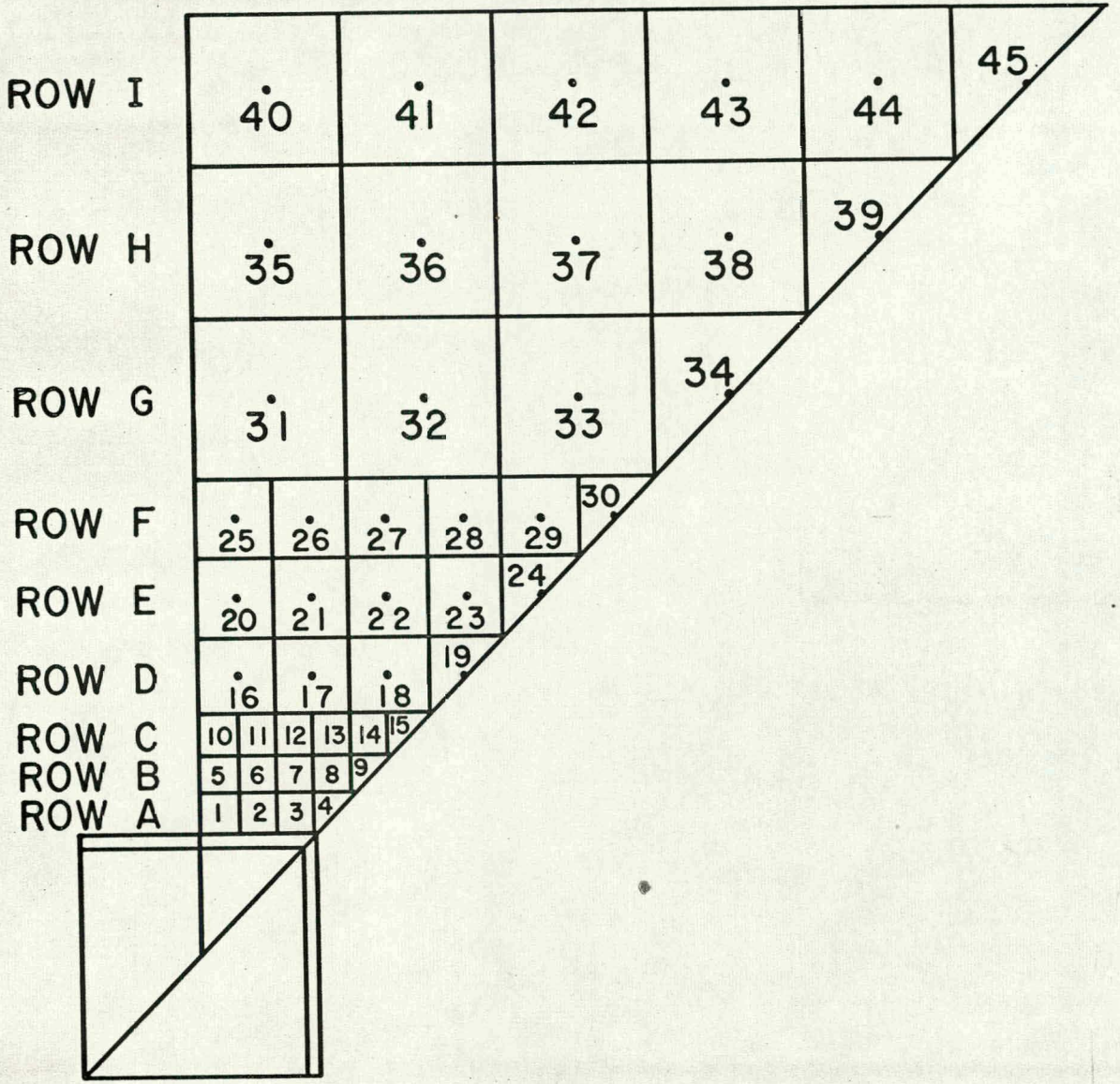
Data analyzed up to this point, however, shows satisfactory agreement between experimental and theoretical reduction factors.

SLIDES TO BE USED IN PRESENTATION

NO.	TITLE
1	PHOTOGRAPH OF BLOCKHOUSE
2	GRID PATTERN AROUND BLOCKHOUSE
3	TILTER UPRIGHT
4	TILTER TILTED
5	DETECTOR POSITIONS IN BLOCKHOUSE



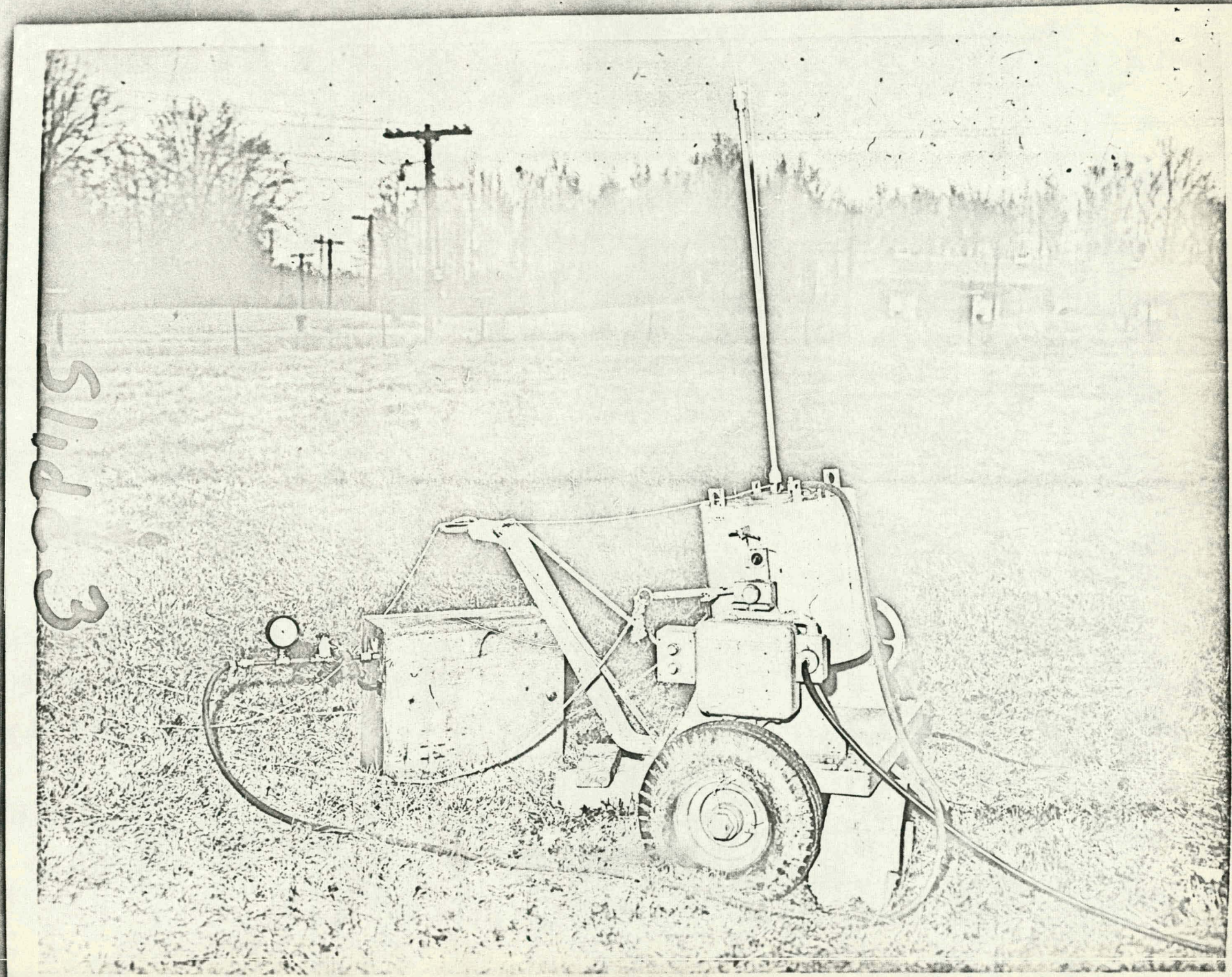
Slide 1

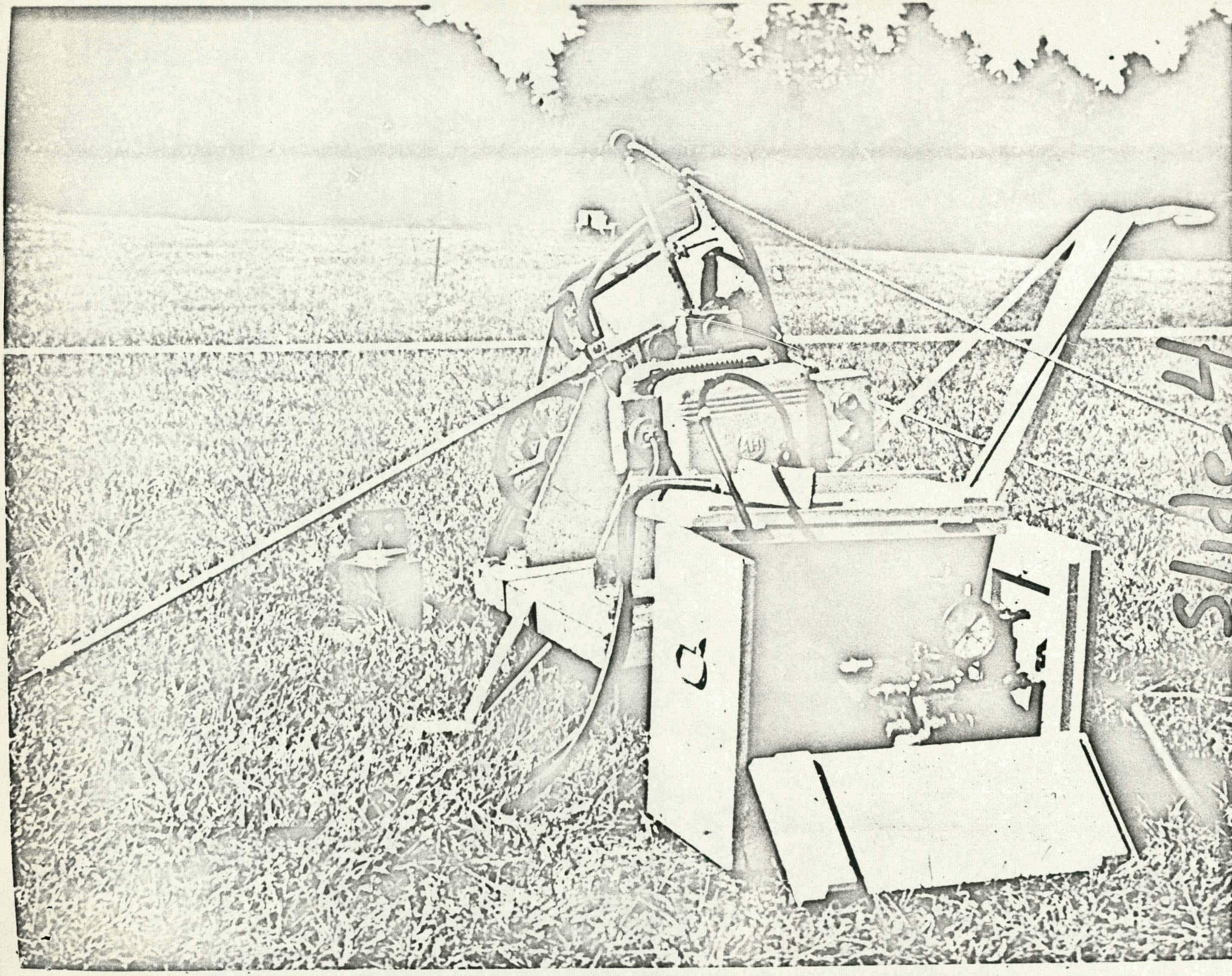


GRID PATTERN

ROWS A-I

POINT SOURCE POSITIONS 1-45

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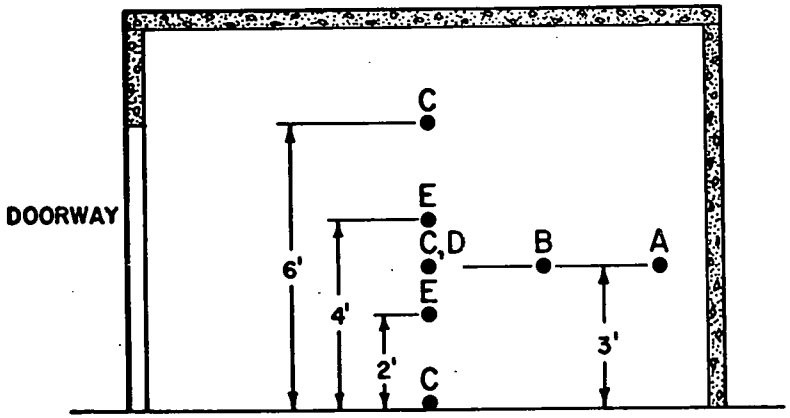
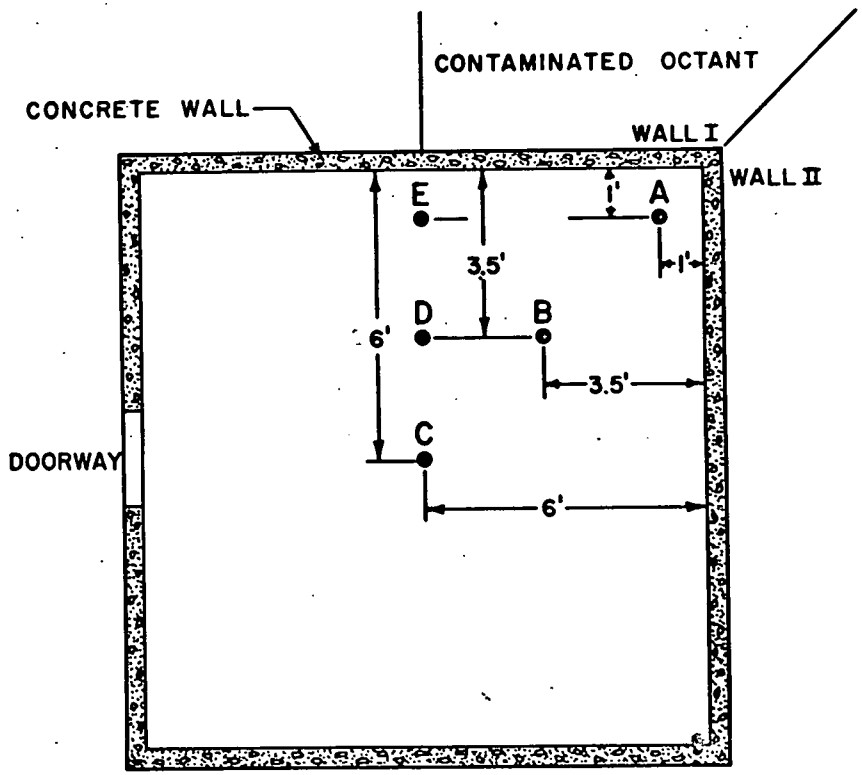


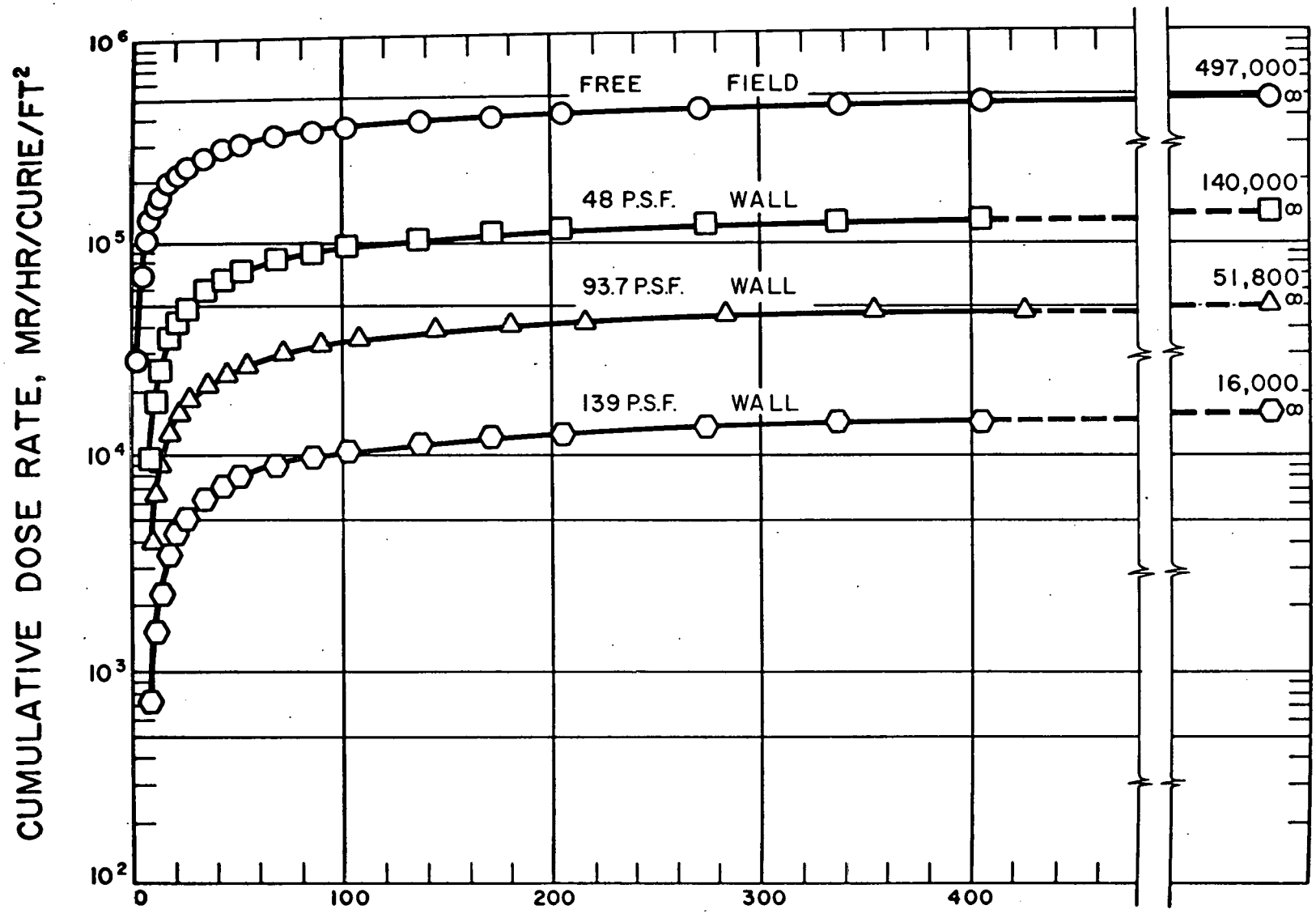
SECTION



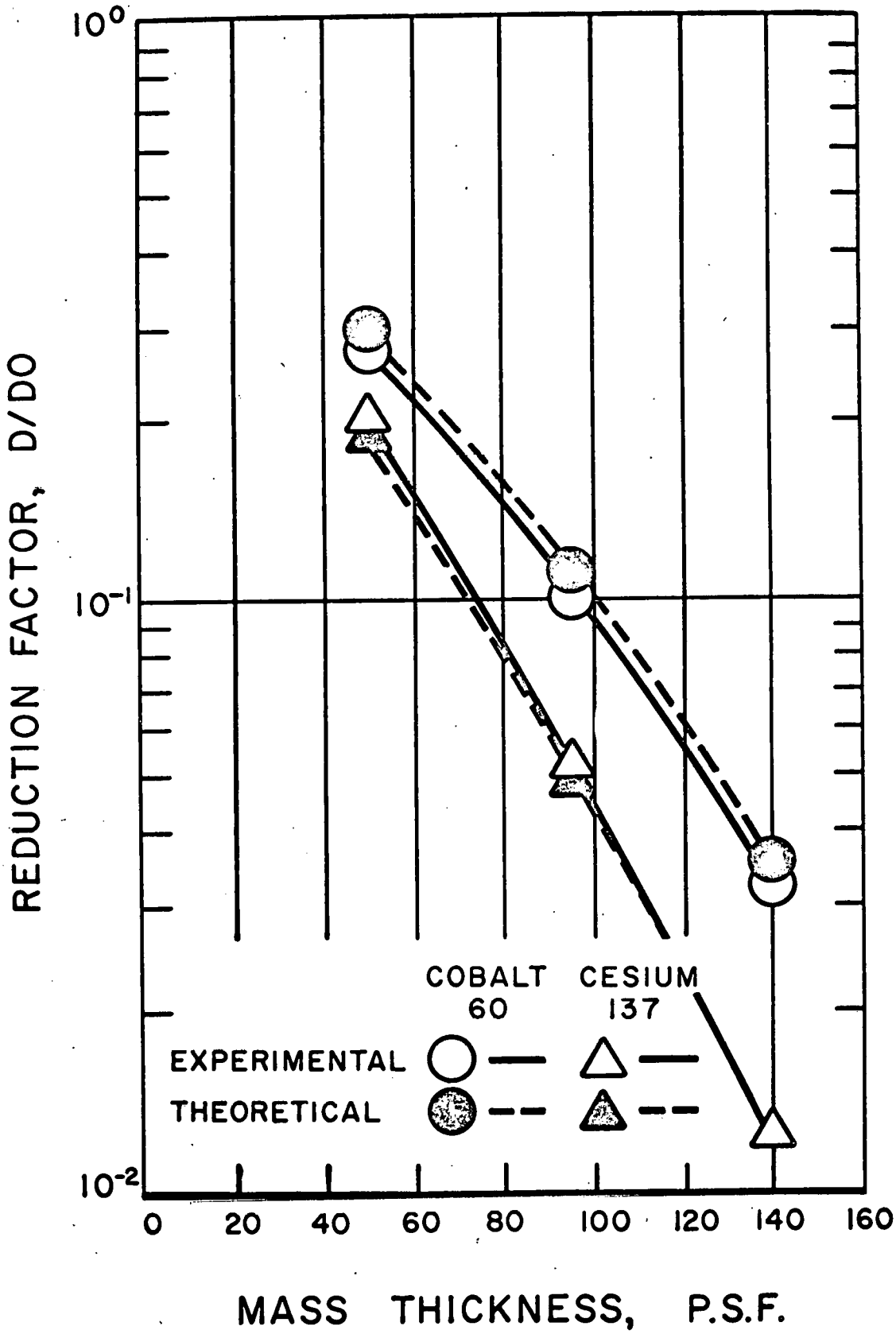
PLAN

BLOCKHOUSE

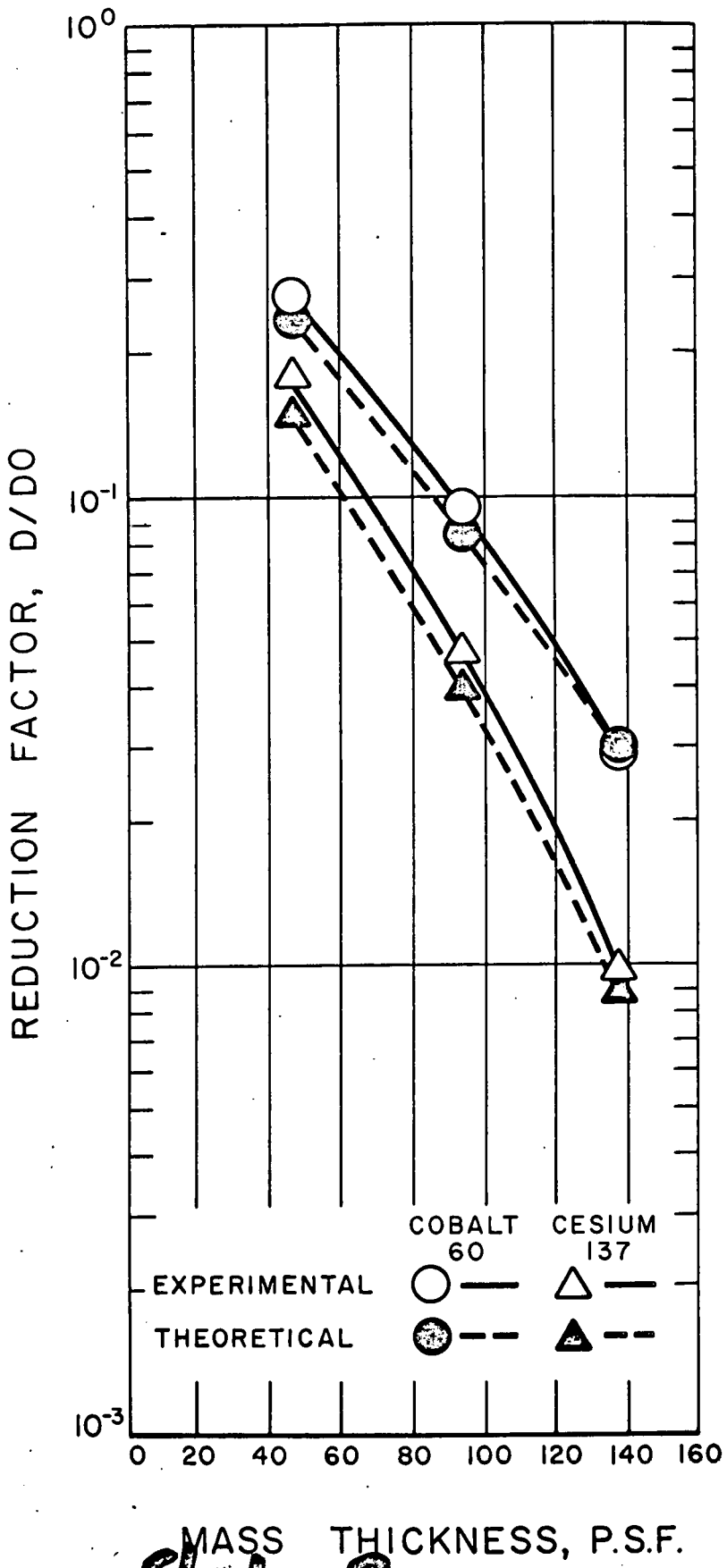
Slide 5


CUMULATIVE DOSE RATE, MR/HR/CURIE/FT²
10⁶
10⁵
10⁴
10³
10²
0
100
200
300
400
FREE FIELD
48 P.S.F. WALL
93.7 P.S.F. WALL
139 P.S.F. WALL
497,000
140,000
51,800
16,000
DISTANCE, FEET

Slide 6


REDUCTION FACTOR, D/DO
10^0
10^{-1}
10^{-2}
0
20
40
60
80
100
120
140
160
COBALT 60
CESIUM 137
EXPERIMENTAL
THEORETICAL
MASS THICKNESS, P.S.F.

Slide 7


REDUCTION FACTOR, D/DO
10^0
10^{-1}
10^{-2}
10^{-3}
0 20 40 60 80 100 120 140 160
MASS THICKNESS, P.S.F.
COBALT 60
CESIUM 137
EXPERIMENTAL
THEORETICAL

Slide 8