LA-2569



LOS ALAMOS SCIENTIFIC LABORATORY
OF THE UNIVERSITY OF CALIFORNIA o LOS ALAMOS NEW MEXICO

# NEUTRON TISSUE DOSE RATE SURVEY FOR THE GODIVA II CRITICAL ASSEMBLY

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# NEUTRON TISSUE DOSE RATE SURVEY FOR THE GODIVA II CRITICAL ASSEMBLY

by

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## ABSTRACT

A neutron tissue dose rate survey was made for the Godiva II critical assembly using the Hurst neutron proportional counter. Measurements were made at 10 points from 40 to 350 meters. The data indicated values of approximately 25 mrad/hr per 100 watts operating power at 40 meters to 0.25 mrad/hr per 100 watts operating power at 350 meters. The results are consistent with the mean free path of 250 meters. The data are estimated to be uncertain by no more than 30 per cent.



## ACKNOWLEDGMENTS

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## INTRODUCTION

Critical assemblies are gaining widespread use as laboratory tools for scientific investigations of fission processes. The health physicist is confronted with the problem of dealing with the biological hazards encountered by the investigator utilizing such an assembly.

The task is complicated by the lack of knowledge of the neutron spectrum in the evaluation of the neutron tissue dose as required by typical field survey meters. The purpose of this investigation was to provide an estimate of the neutron tissue dose rate as a function of distance from the Godiva II critical assembly through use of the Hurst proportional counter.

## MATERIALS AND METHODS

### Description of the Field Geometry and the Godiva II Critical Assembly

The Godiva critical assembly is located in a building called a Kiva.*[1] The Kiva is located on a canyon floor (Fig. 1) and is 1/4 mile from the control room. Measurements were made along the road leading from the Kiva to the control room. The active material in the Godiva II

*Kiva, the Indian name for a ceremonial house, is used for the building which houses the critical assemblies.

assembly is made up of a bare mass of approximately 60 kg of enriched $U^{235}$. The critical mass is a right circular cylinder 7 inches in diameter with a hemispherical dome, mounted on a triangular stand (Fig. 2). The critical mass is surrounded by a wire screen cage 9 inches in diameter. The horizontal midplane of the critical mass is approximately 78-1/2 inches from the Kiva floor.* The electronic control circuitry occupies a position on the stand.

There are numerous mechanisms and interlocks which provide a maximum degree of safety. No shielding is around the assembly itself, but the concrete Kiva (20-inch walls, 8-inch ceiling), the block house (Fig. 1), and the canyon walls create conditions that complicate "free air" measurements.

## Description of the Hurst Proportional Counter and Associated Electronics

The Hurst proportional counter (HPC) was a commercial type manufactured by Reuter-Stokes Electronic Components, Inc. The construction of the counter has been described in detail by Wagner and Hurst.[2] This counter was connected to a voltage divider which placed 0.285 of the collecting voltage on the field tubes. The voltage applied to the central wire was +1400 volts. The output of the counter was connected first to a Model 130N line driving preamplifier, then to a 101A linear amplifier with delay line clipping, and finally to a multichannel

*The specific height above the floor is dependent upon whether the assembly mount is placed on casters.

analyzer (Fig. 3). Alpha calibrations were taken before and after each change in location. Background readings were subtracted from each neutron run. The portable unit consisted of the HPC, high voltage power supply, voltage divider, preamplifier power supply, and the Model 130N line driving preamplifier, all of which were mounted in the back of the pickup truck (Fig. 4). Power and signal cables of 750-foot lengths were positioned on reels in the back of the pickup and used as a particular position required. The power cable was No. 12 rubber-covered three-wire cable for carrying 110 volt power, while the signal cable was RG-71/U. When distances were less than 750 feet, measurements were made utilizing the patch panel at the Kiva. For distances greater than 750 feet, the signal and power cables were taken directly to the control room.

The method of tissue dose evaluation is given in detail in reference 2. The parameters of the counter used in this survey were 50-cm pressure of cyclopropane gas at 22°C (mass equal to approximately 0.070 grams). Integral bias curves with the Hurst proportional counter are shown in Figure 5.

## RESULTS AND DISCUSSION

The measured dose rate versus distance relation is shown in Figure 6, using the data given in Table I. The data are estimated to be uncertain by no more than 30 per cent and normalized to an

arbitrary power level of 100 watts.* An $RD^2$ versus D relation is shown in Figure 7. These data indicate a mean free path of approximately 250 meters which appears to be consistent with field measurements.[3] The data from 40 to 100 meters appear to be low. These low values can be explained by the shielding afforded by the blockhouse as shown in Figure 1.

Comparison of these data with those taken at the Little Eva critical assembly indicates consistent results.[4] For any given distance within the range of measurements, the observed dose rate with Godiva II is approximately 0.1 to 0.2 of that observed with Little Eva. This is the result of two major factors: (a) the large amount of shielding around Godiva II which tends to decrease the dose rate; (b) the canyon walls near the Kiva which contribute more scatter than that present with Little Eva.

*Under well-controlled laboratory conditions an error of less than 10 per cent can be obtained. However, for these experiments which involved long cables and amplifiers in the field, the larger estimated errors appear to be more realistic.

TABLE I

Neutron Tissue Dose Rate Vs Distance Values

for the Godiva II Critical Assembly

| Distance from Center of Godiva II (meters) | Neutron Tissue Dose Rate (mrad/hr for 100 watts operating power) |
|---|---|
| 40 | 23.0 |
| 60 | 14.2 |
| 80 | 8.19 |
| 100 | 4.19 |
| 140 | 2.40 |
| 180 | 1.33 |
| 220 | 0.66 |
| 280 | 0.23 |
| 320 | 0.25 |
| 350 | 0.20 |

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1. Wimett, T. F., and Orndoff, J. D., "Applications of Godiva II Neutron Pulses," Proc. Sec. Intern. Conf. Peaceful Uses Atomic Energy, Geneva, Vol. 10, p. 499, United Nations (1958).

2. Wagner, E. B., and Hurst, G. S., "Advances in the Standard Proportional Counter Method of Fast Neutron Dosimetry," Rev. Sci. Instr., 29, 153 (1958).

3. Glasstone, S., ed., "Effects of Nuclear Weapons," p. 388, U. S. Gov't Printing Office (1957).

4. Engelke, M. J., Reibe, B. B., Sayeg, J. A., "Neutron Tissue Dose Survey for the Little Eva Critical Assembly," p. 4, Report LA-2425 (April 1960).

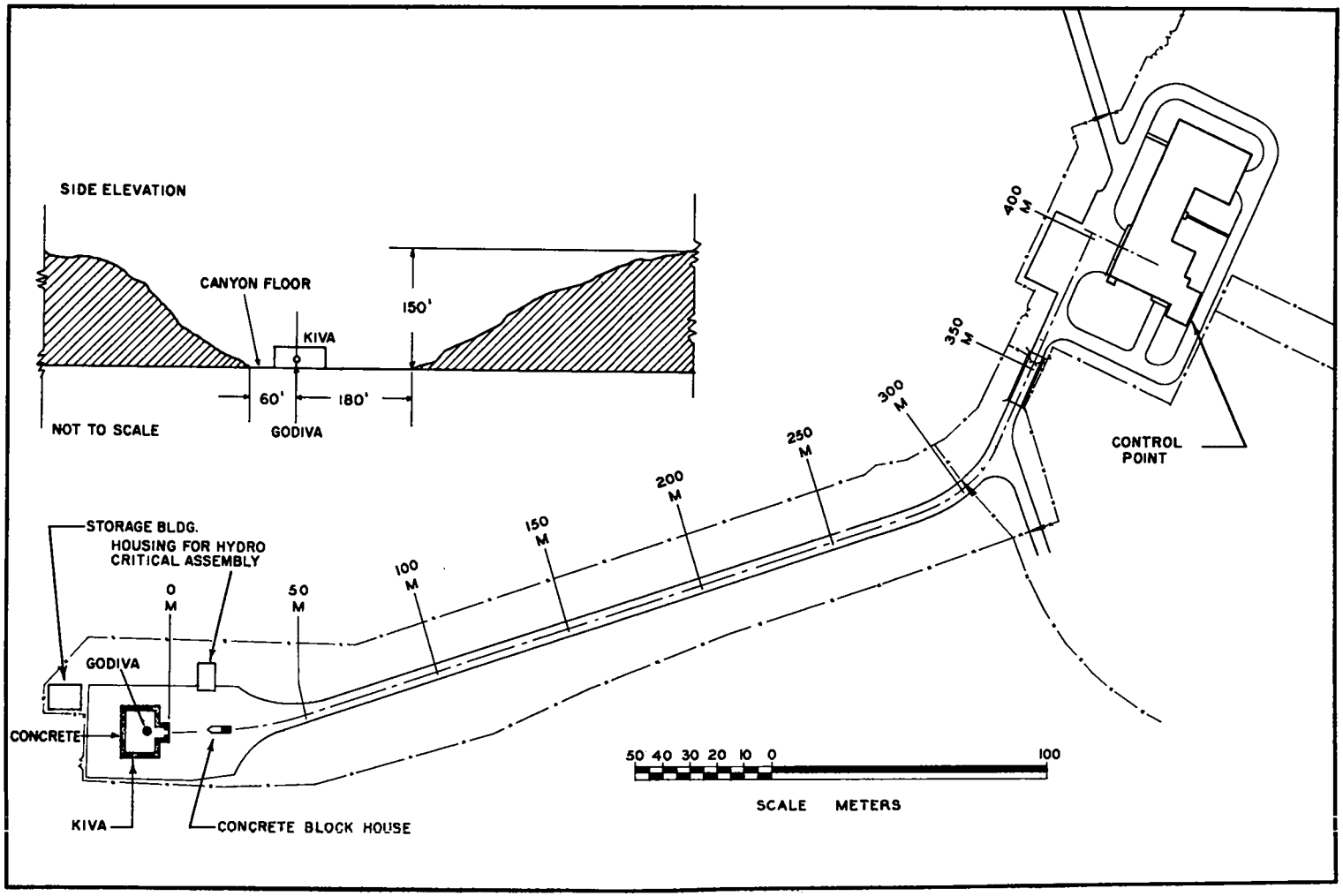


Fig. 1 Location of Godiva II assembly with respect to surrounding terrain (distance from the 0 reference point to the Godiva II assembly is 8.5 meters).

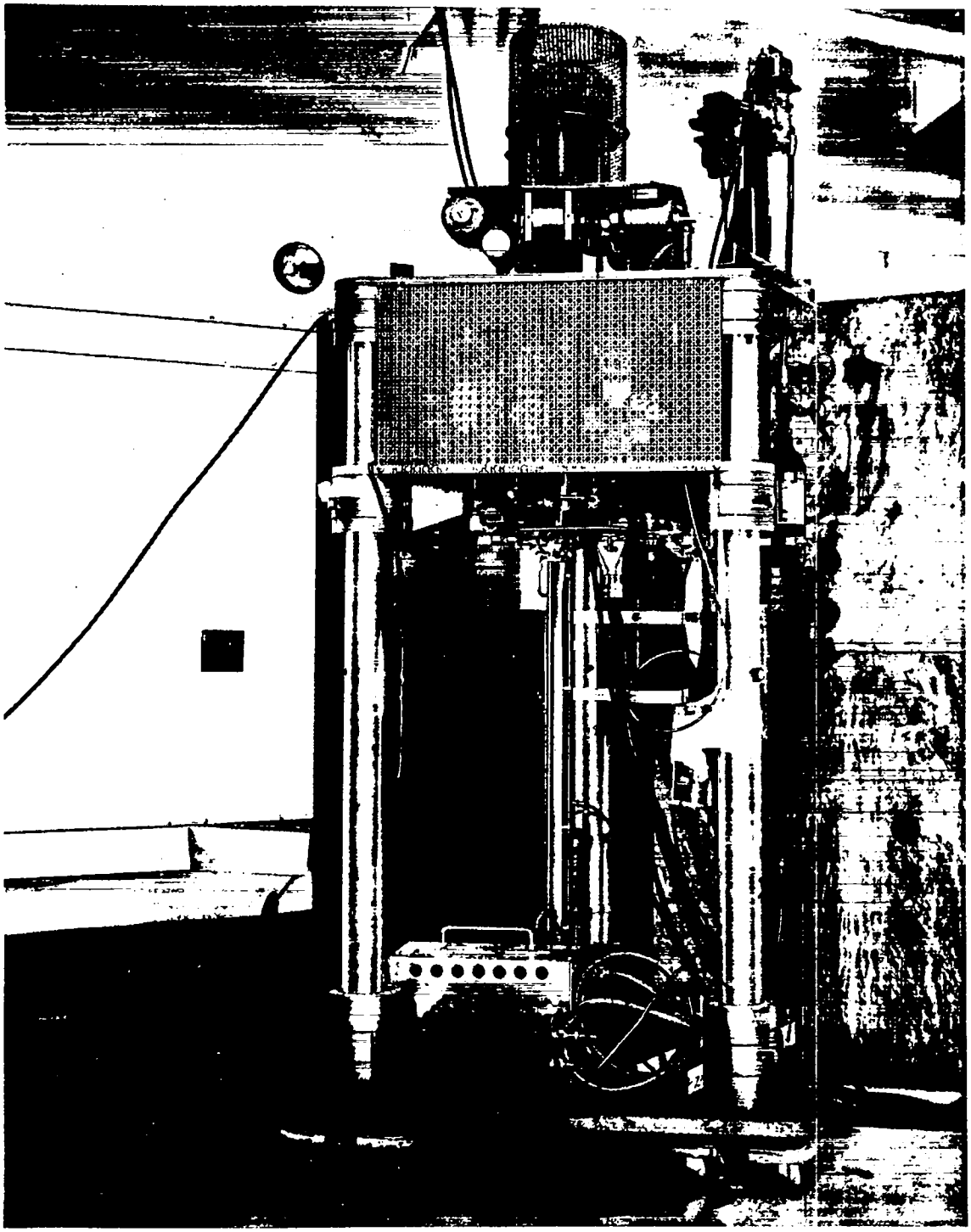

Fig. 2 Godiva II critical assembly mounted on stand.

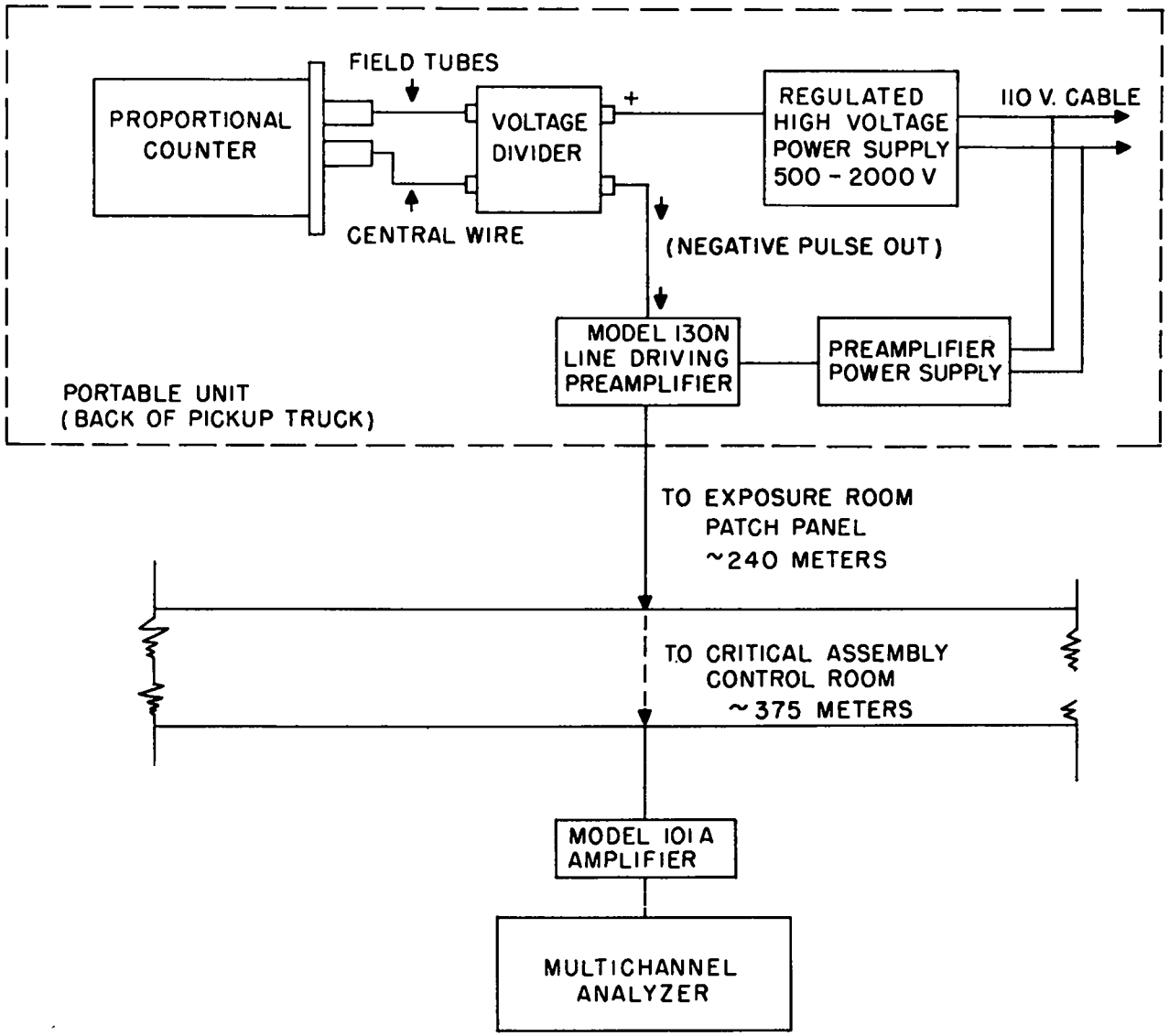


Fig. 3 Schematic diagram of electronic components used in the Godiva dose rate survey.

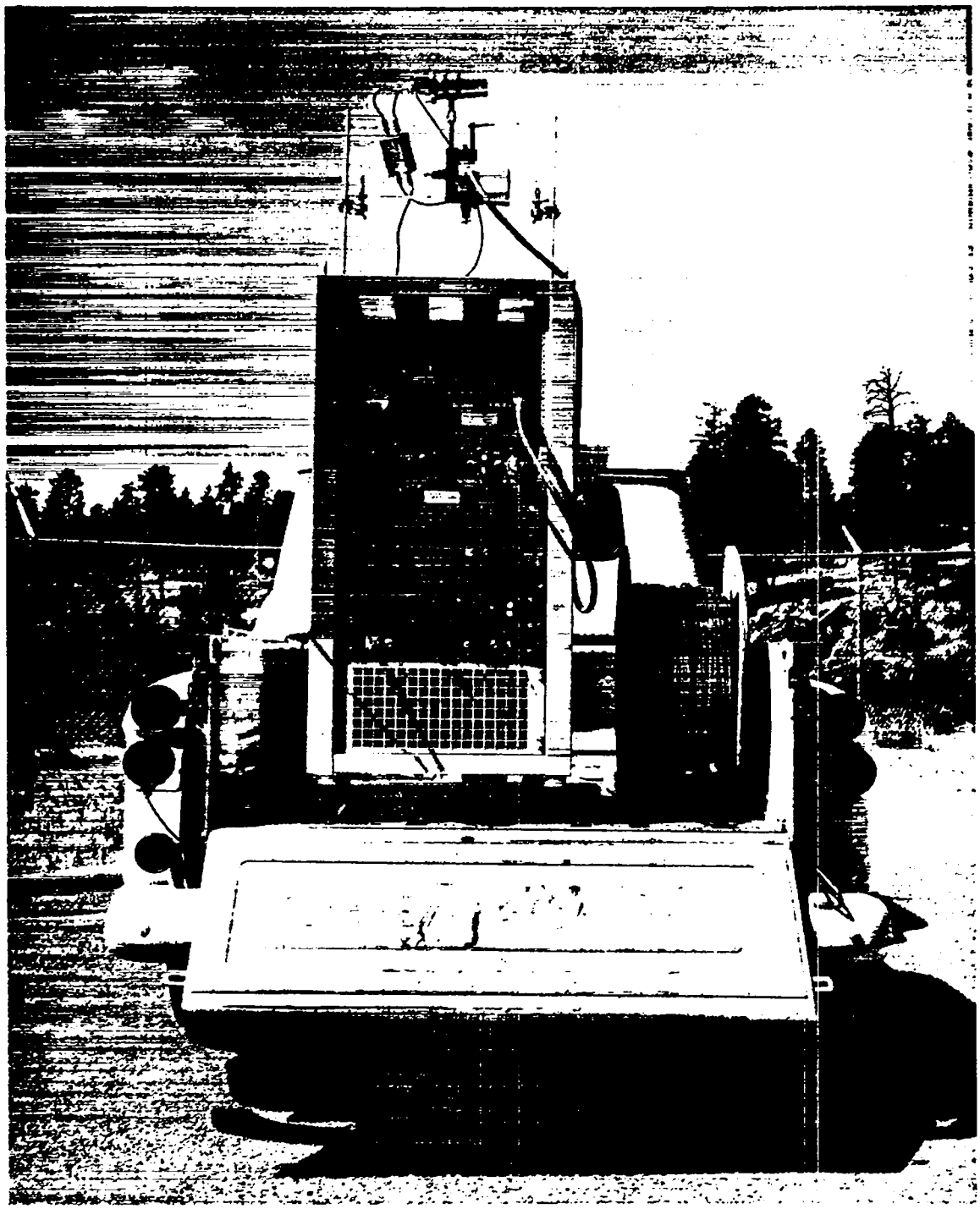

Fig. 4 The Hurst proportional setup in trailer.

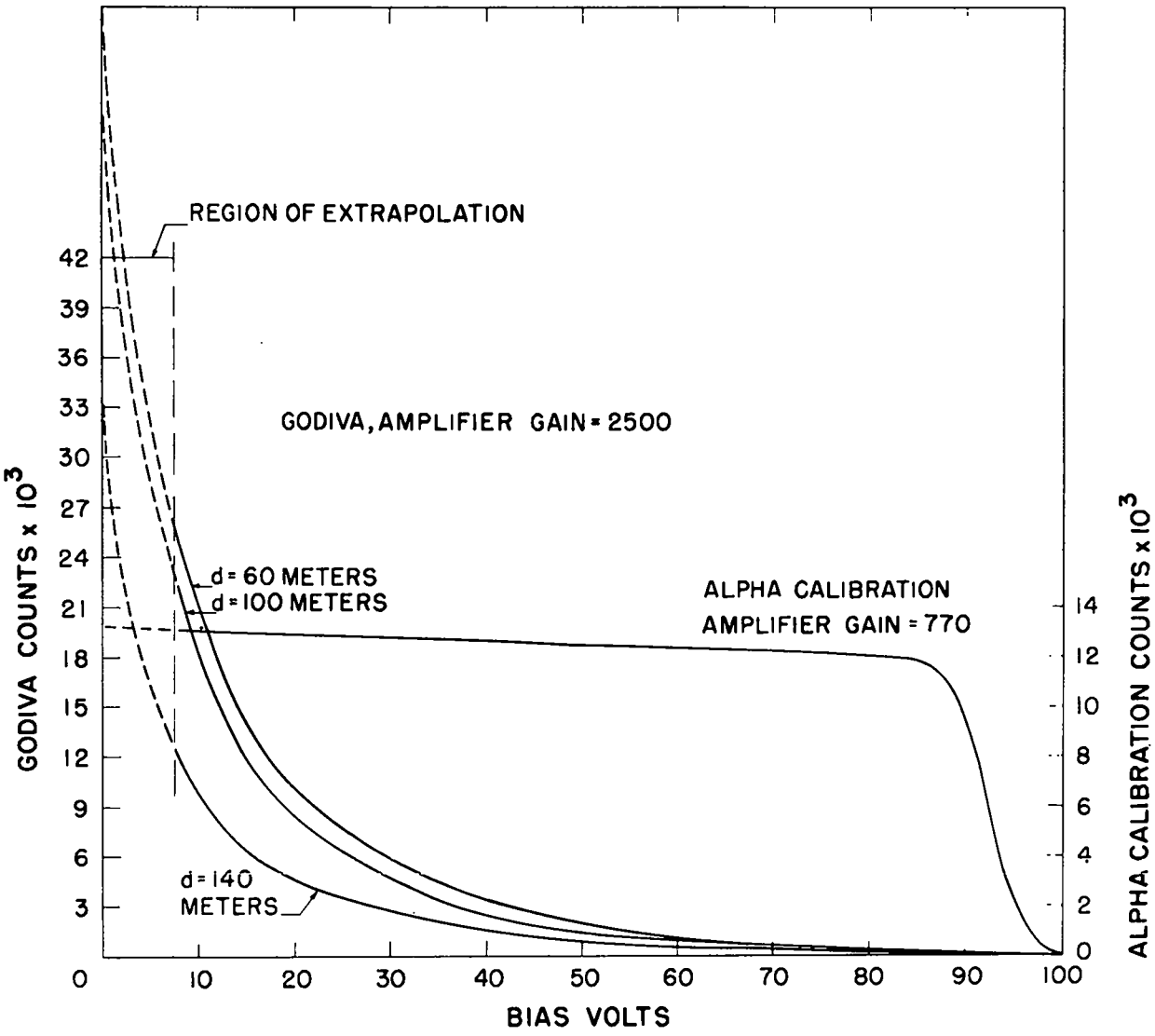


Fig. 5 Integral bias curves with the Hurst proportional counter.

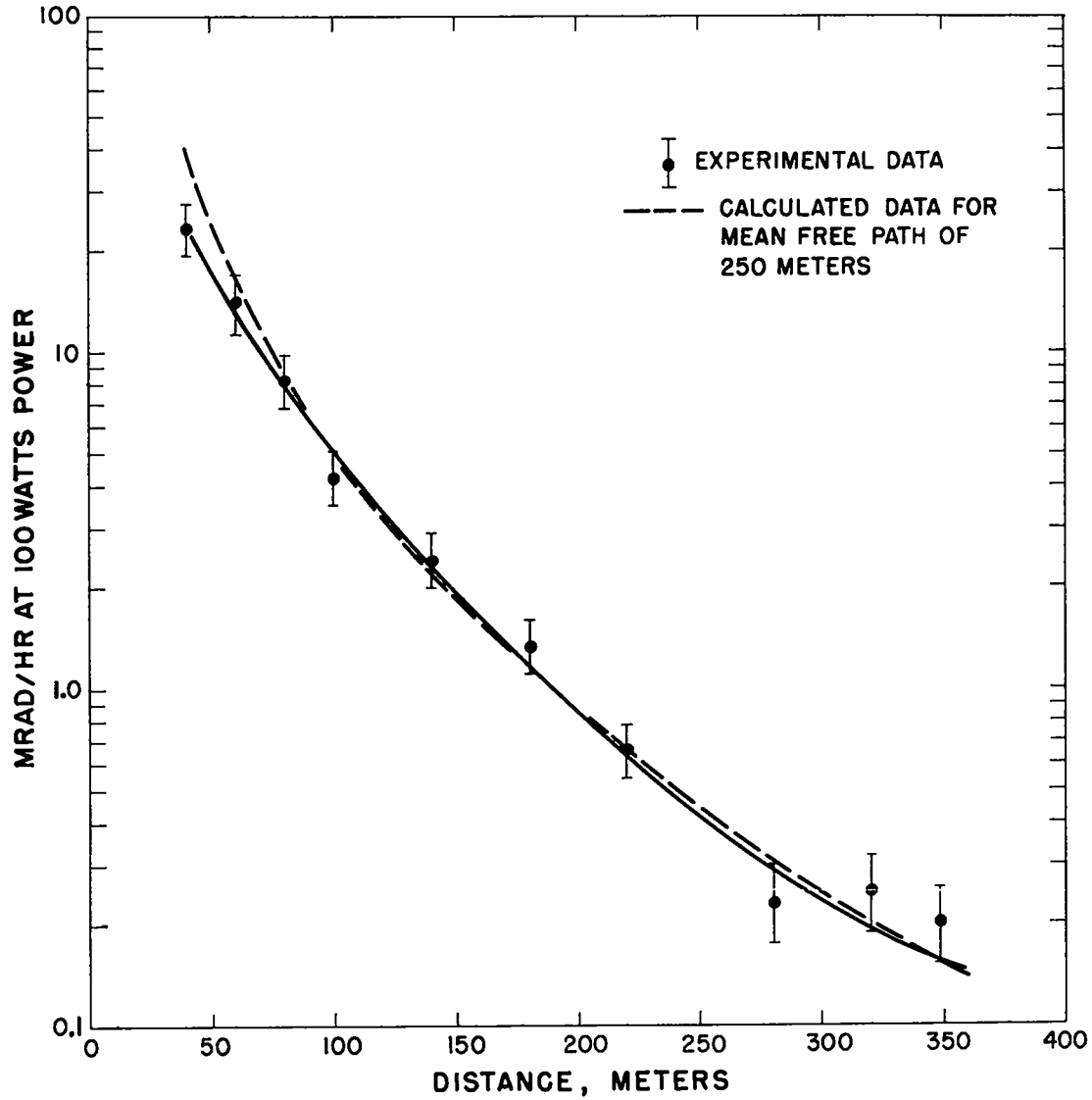


Fig. 6 Neutron tissue dose rate versus distance for Godiva II critical assembly.

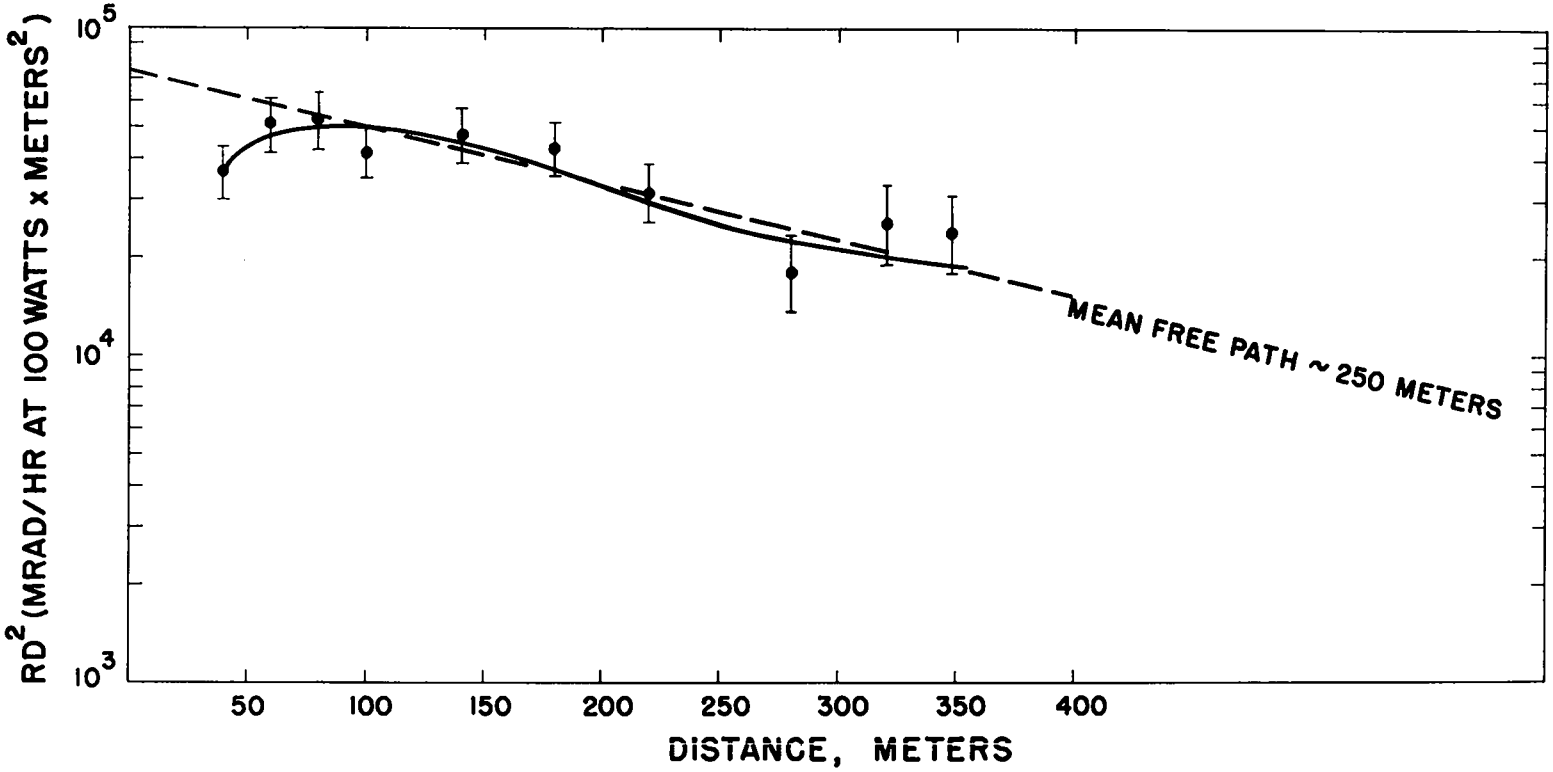


Fig. 7 Plot of dose rate times distance squared vs distance for the Godiva II critical assembly.