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Project Officer's Report—Project 6.9

Correlation of Present and Previous Electric Field Measurements

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19 ABSTRACT (Continue on reverse if necessary and identify by block number)

On most previous nuclear detonations, signatures and quantitative measurements of the electric field signals associated with the detonations have been obtained at distances such that normal radiation field characteristics apply. On Small Boy, measurements were made by other projects from stations located much closer in, such as to be inside, on the boundary of and just outside the limits of the ionized sphere created by the nuclear burst. The electric field characteristics in these regions were unknown. In the hope of providing continuity from the region of the unknown into the reasonably well understood region of the radiation field, this project was requested to make the typical radiation field type of measurement which has been made on previous detonations.

This report covers the signature characteristics and quantitative measurements of the electric field signal from Small Boy as seen from outside the immediate region of the theoretical generating mechanism.

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OPERATION SUN BEAM

SHOT SMALL BOY

PROJECT OFFICERS REPORT – PROJECT 6.9

CORRELATION OF PRESENT AND PREVIOUS ELECTRIC FIELD MEASUREMENTS

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FOREWORD

Classified material has been removed in order to make the information available on an unclassified, open publication basis, to any interested parties. The effort to declassify this report has been accomplished specifically to support the Department of Defense Nuclear Test Personnel Review (NTPR) Program. The objective is to facilitate studies of the low levels of radiation received by some individuals during the atmospheric nuclear test program by making as much information as possible available to all interested parties.

The material which has been deleted is either currently classified as Restricted Data or Formerly Restricted Data under the provisions of the Atomic Energy Act of 1954 (as amended), or is National Security Information, or has been determined to be critical military information which could reveal system or equipment vulnerabilities and is, therefore, not appropriate for open publication.

The Defense Nuclear Agency (DNA) believes that though all classified material has been deleted, the report accurately portrays the contents of the original. DNA also believes that the deleted material is of little or no significance to studies into the amounts, or types, of radiation received by any individuals during the atmospheric nuclear test program.

ABSTRACT

On most previous nuclear detonations, signatures and quantitative measurements of the electric field signals associated with the detonations have been obtained at distances such that normal radiation field characteristics apply. On Small Boy, measurements were made by other projects from stations located much closer in, such as to be inside, on the boundary of, and just outside the limits of the ionized sphere created by the nuclear burst. The electric field characteristics in these regions were unknown. In the hope of providing continuity from the region of the unknown into the reasonably well understood region of the radiation field, this project was requested to make the typical radiation field type of measurement which has been made on previous detonations.

This report covers the signature characteristics and quantitative measurements of the electric field signal from Small Boy as seen from outside the immediate region of the theoretical generating mechanism.

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CORRELATION OF PRESENT AND PREVIOUS ELECTRIC FIELD MEASUREMENTS

Introduction

The Small Boy experiment of Operation Sunbeam, conducted at the Nevada Test Site on July 14, 1962,

The Denver Research Institute (DRI) participated in this experiment with the objective of measuring the vertical component of the radiated electromagnetic pulse for correlation with data obtained from previous nuclear test operations.

Background

Measurements of the EM signals from nuclear detonations have been carried out during most of the past nuclear test operations. Recordings were obtained for several of the shots at distances of 10 to 20 kilometers by photographing a triggered oscilloscope trace of the transient signal produced by the detonation. The same basic technique was used to record the Small Boy waveform.

Description of the Experiment

The DRI recording system was housed in a trailer located 12.3 kilometers NW of ground zero, well removed from power lines and other potential sources of radio noise. Primary power was supplied by diesel generators.

The radiated EM signal was received with a short vertical antenna and the antenna voltage applied through a cathode follower and delay line to the vertical amplifiers of oscilloscopes. The oscilloscope sweeps were triggered externally prior to the arrival of the waveform, to insure that the leading edge and early time detail would be accurately displayed. The oscilloscope traces were photographed with continuously moving 35-millimeter film. Figure 1 is a block diagram of one channel of the recording system which employed two independent channels. A total of seven oscilloscopes were used with staggered sensitivities and sweep rates to provide a large dynamic recording range.

The frequency response of one of the two identical recording channels is shown in Figure 2. The high frequency cut-off near 5 megacycles is due to the delay network which was used to produce a time delay

This relatively long time delay generated a reference base line at zero potential at the beginning of each trace from which signal amplitudes and half-cycle lengths could be accurately measured. Figures 3 a, b, are photographs showing the transient response of the equipment to a square wave with a fast rise time. From Figure 3 b the rise time of the output pulse is about 0. 1 microsecond , consistent with a high-frequency cut-off near 5 megacycles.

The dynamic recording range was determined by reference to data from previous detonations at near ground level of devices of about the same yield as that predicted for Small Boy. Calculations based on these data indicated a peak field strength of 150 volts/meter. The oscilloscope sensitivities were therefore adjusted to produce full scale deflections at field strengths of from 50 to 250 volts/meter.

Equipment Description:

Antenna.

The antenna system for each channel consisted of a vertical aluminum rod 1/4 inch in diameter and 2 meters in length with a plexiglass base support. The base support formed the cover of a box which housed a cathode follower to match the high antenna impedance to the low-impedance co-axial signal cable. The cathode follower housing was sealed to keep out dust and moisture. The antenna effective height was taken to be 1/2 its physical height for the range of frequencies involved. The two antennas were located approximately 50 feet apart in a cleared level area 200 feet in front of the recording trailer. Power was supplied to the cathode followers through shielded cable.

Distortion of the waveform due to clipping in the cathode follower circuit was prevented by attenuating the signal with capacitive voltage dividers at the base of each antenna. The signal strengths were reduced by 50:1 and 16:1, respectively, for channels 1 and 2.

Delay network and trigger pulse generator.

The transient signal from each antenna was used to derive a trigger pulse which initiated the oscilloscope sweeps prior to the arrival of the waveform at the oscilloscope deflection plates. The trigger generator had a variable threshold trigger level and was capable of generating an output pulse for input signals of either polarity. A dead time of approximately 1 millisecond prevented successive triggers from occurring while the waveform was being recorded.

Delay of the waveform with respect to the trigger pulse was accomplished with a lumped constant delay network which had a delay time of 2.5 microseconds and a characteristic impedance of 100 ohms.

Oscilloscopes and Cameras.

Tektronix type 513 oscilloscopes were used to display the transient waveform which was then photographed with continuously moving 35-mm film. The film motion was transverse to the direction of the oscilloscope sweep and was advancing at the rate of 1 cm per second during the recording period.

Calibration.

Calibration of the recording system was performed both prior to and after the detonation. A sine wave of known amplitude and frequency was applied at the cathode follower input through a dummy antenna capacitor, and the calibrate signals displayed by each oscilloscope were recorded on film. The antenna capacitance was measured with an impedance bridge prior to the shot and checked again when the post-shot calibration was carried out. The measured value was a nominal 20 pf. A power amplifier was used to increase the amplitude of the calibrate signals to a level which would drive the large attenuators at the base of each antenna. Calibration of the oscilloscope sweep rates was accomplished at the same time by accurately measuring the frequency of the calibrate signals.

Fast transient pulses from a transient generator were also used during the calibration period prior to the shot. This aided the operator in adjusting the oscilloscope controls for maximum resolution with a waveform similar in character to that expected from the detonation. It also provided a quick check of the equipment response.

Data Reduction and Analysis

The Small Boy waveforms presented in this report are accurate tracings of the original film data. The tracings were made by enlarging the waveform and calibration signals with a 35-mm projector. The images were focused onto a horizontal glass plate from below and traced onto centimeter grid graph paper. Calculation of the Fourier spectra was accomplished with an electronic computer.

Data

Figures 4 through 6 show the transient waveform obtained from the Small Boy event recorded at three different sensitivities and sweep rates. Figure 7 is a plot of the Small Boy event frequency spectrum obtained from the waveform shown in Figure 5.

Results and Conclusions

Figures 8 through 11 are reproductions of some typical waveforms and their associated frequency spectra which were obtained by the National Bureau of Standards Central Radio Propagation Laboratory during previous test operations.[1] They are included here for comparison with the Small Boy data.

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1 A. G. Jean, "Quarterly Report on Project T/620/E/NBS", NBS 3C121(1955) W. L. Taylor, "Redwing Waveforms and Spectra", NBS 3CB102 (1957)

Table 1 lists some basic characteristics of the Small Boy waveform for comparison with several other waveforms recorded by the NBS during previous shots in the 1-10 kiloton range and at distances of less than 25 kilometers.

The high-frequency spike which occurred at the beginning of the Small Boy signal was not recorded during previous experiments.

Instrumentation to record the World time of the detonation was not included in the broad band system used at the Nevada Test Site; however, the time of 1830:00.034 was recorded for the Small Boy event in Denver. This time, corrected for the difference in the propagation paths between WWV and the NTS, was derived from a digital clock synchronized with WWV and is not in agreement with the published time of 1830:00.123.

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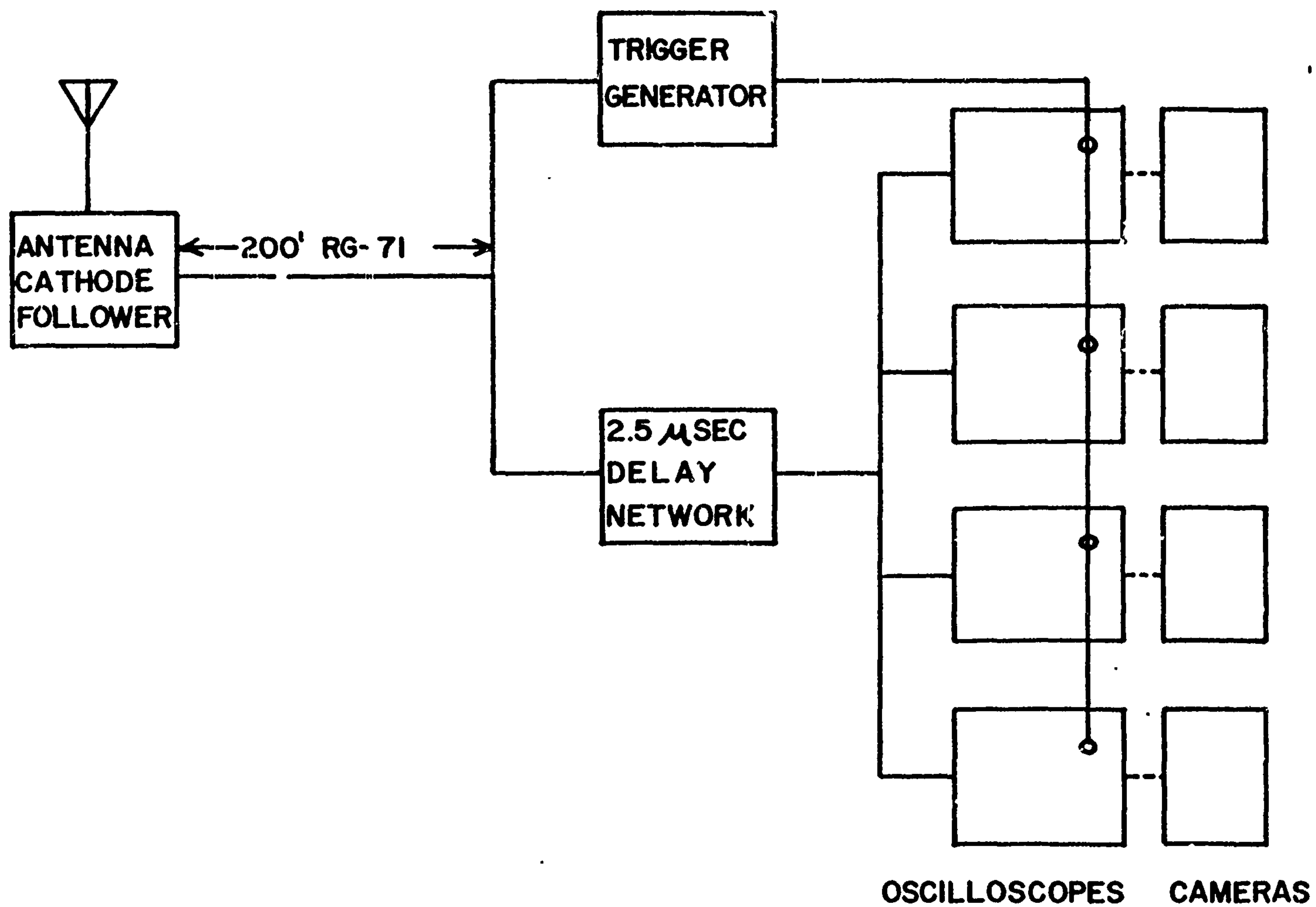

Figure 1 Block diagram, one channel of broadband recording system.

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