Chapter 10
TEST of SERVICE EQUIPMENT and MATERIALS

10.1 OBJECTIVES

This phase of Operation Hardtack included three projects whose objectives were to determine the ionospheric effects of nuclear detonations, and to determine the effects of nuclear radiation on certain selected energized electronic-fuze components, and on an energized Corporal fuze system.

10.2 BACKGROUND

The United States Army has a high-priority requirement for an electronic system usable on a nuclear battlefield to determine nuclear-burst data from friendly, as well as from enemy detonations. The ionospheric experiments were designed to increase available knowledge in three areas: (1) technical information for use in approximating, by electronic means, the location of the burst point of a nuclear device; (2) information to aid in refining the analysis of electromagnetic-pulse wave form pertaining to its possible correlation to nuclear-burst data of military value (height of burst, range, yield and type of device); and (3) experimental data which would be of assistance in the determination of extent and amount of disruption to radio communication from a nuclear detonation.

The Army considered essential the evaluation of the vulnerability of ordnance electronic-fuze items in stockpile to nuclear detonations, particularly from nuclear-radiation effects. Also, it was necessary to determine the effect of nuclear radiation upon the functioning characteristics of a typical captive guided-missile fuze system. Accordingly, an experiment was designed and conducted in an effort to obtain this information considered essential in the research and development program on fuzes for bombs, rockets, mortar projectiles, mines and missiles.

10.3 WAVE FORM OF ELECTROMAGNETIC PULSE FROM NUCLEAR DETONATIONS

The objective was to obtain and analyze the wave form of the electromagnetic (EM) pulse resulting from nuclear detonations. In particular, broad-band measurements were made from 0 to 10 Mc at ranges up to 460 miles.

Previous measurements of the EM pulse were made during Operations Crossroads, Sandstone, Greenhouse, Buster-Jangle, Tumbler-Snapper, Ivy, Upshot-Knothole, Castle, Teapot, and Redwing. The equipment used for these measurements ranged from narrow-band tuned receivers to broad-band untuned receivers. The antennas used with these receivers varied from simple probes to specially designed discones. Equipment similar to that used by Operation Hardtack Project 6.4 had been used during Operation Castle. In general, the EM-pulse energy was found to be predominantly in the low frequencies (approximately 10 to 20 kc), with measurable components at frequencies as high as 300 Mc. The duration of the EM pulse was found to be approximately 50 μsec, with an initial rise time as short as 10 μsec.

Experiments during Operations Teapot and Plumbbob demonstrated the feasibility of locating the point of detonation of a nuclear device. Also, analysis of available wave-form data has in-

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dicated a possible correlation between wave-form parameters and nuclear-burst information, such as height of burst, range, yield, and type of nuclear device. Based upon this possible correlation and other pertinent information, the Army has formulated a tactical requirement for a system (known as Pin Point) to determine various burst parameters that pertain to both friendly and enemy nuclear detonations.

The data pulses were recorded with Dumont Type 298 and Type 321 cameras at five different time bases, 0.2, 0.25, 1, 2, and 10 μsec/cm. There were two scopes per sweep range to provide a safety factor. The total number of scopes used was six. Tektronix Types 517 and 545 were used for the two fastest time bases: namely, 0.2 and 0.25 μsec/cm. The other four scopes were Hewlett-Packard Type 150. Two laboratory-built cathode-follower receivers were used to match the two probe antennas (12 inches, and 1 meter long, respectively) to the 50-ohm cable.

Two stations were used: Kusaie, 460 miles from Bikini and 420 miles from Eniwetok; and Wotho, 100 miles from Bikini and 240 miles from Eniwetok. At Kusaie, the site was located just off the beach on the north shore of the island. The site at Wotho, located on the northwestern shore of the island, was similar to the one at Kusaie. The sites consisted of three S44G demountable shelters. The equipment was housed in one of the shelters; the other two were used for office and darkroom space. Each antenna used had its own ground plane, made of galvanized chicken wire. The ground planes were installed on or near the ground, just above the water line. The remote antenna and ground plane were located behind the shelters at a distance of about 500 feet from the local ground plane.

The data required was the exact wave form of the EM pulse out to 100 μsec, with an expanded view of the initial rise. Since the main objective of this experiment was to obtain the overall wave form, rather than to examine the wave form for kilomegacycle components, equipment commensurate with the objective was chosen. The best scope available within the range of interest was the Tektronix 517. Since the band width of the cathode follower was better than that of the 517, the latter was the limiting piece of equipment. Accordingly, frequency components above 60 Mc were not detected.

The reliability of the recorded pulse was such that the time axis was accurate to within 0.05 percent, while the voltage axis was accurate to within 3 percent.

The data was recorded on Kodak Tri-X film which was developed in Ilford Microphen fine-grain developer for about 12 minutes at 72 F. These films were then enlarged to 8-by-10-inch size and printed on glossy paper.

Correlation of the data was performed by arranging the various wave form and shot parameters in tabular form.

Selected photographs of the actual pulse wave forms are shown in Figures 10.1 through 10.9. The shot name, yield, range, and calibration data are included on the photographs. Table 10.1 summarizes the wave form and shot parameters. Discussion of the data obtained on several shots follows.

Shot Yucca (see Figures 10.1 and 10.2). No data was recorded at Wotho for this shot because of technical photographic problems. Several camera shutters did not open. Trace intensity was, in general, too low for proper recording. Also, field strength at Kusaie indicated that deflection at Wotho would have been some five times the scope limits.

All scopes at Kusaie triggered, and the signal was recorded. The wave form was radically different from that expected. The initial pulse was positive, instead of the usual negative. The signal consisted mostly of high frequencies of the order of 4 Mc, instead of the primary lower-frequency component normally received (Figures 10.1 and 10.2). The fact that Shot Yucca was a very-high-altitude shot may have provided a more favorable propagation path for the higher frequencies that were recorded.

Shot Cactus (see Figures 10.3, 10.4 and 10.5). The signal from this shot was received and recorded at Wotho. A secondary positive spike appeared in the signal, even though a single-

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stage nuclear device was used (Figure 10.4). The wide band width and large dynamic range of the system permitted recording of the high-frequency initial spike at the 240-mile range.

Shot Cactus did not trigger the Kusaie scopes, which were set for a trigger level of 0.5 volts/meter.

Shot Fir (see Figures 10.6 and 10.7). This shot triggered all scopes at Wotho. [redacted] Note also the small positive signal occurring immediately before the main negative spike.

No scopes were triggered at Kusaie. Field strength was not up to the predicted value. Prominence of the higher frequencies in the initial pulse may have been responsible for the lack of trigger, since the higher-frequency components tend to be greatly attenuated at the 450-mile range.

Shot Nutmeg (see Figures 10.8 and 10.9). At Wotho, all scopes triggered and wave forms were recorded (Figure 10.8). [redacted] A small positive spike was noted on the Shot Nutmeg wave form, as on Shot Fir. The range was 100 miles for each of these shots. Peak negative-field strength was greater than predicted at both Kusaie and Wotho. Local shielding, consisting of two walls of lead-loaded paraffin, perpendicular to each other, could have produced a corner-reflector effect. This could have produced greater field strength, especially at the higher frequencies.

At Kusaie, all scopes were triggered by interference at minus one half second. Consequently, no data was recorded other than on the Tektronix 517, which did not require resetting of the trigger.

Data presented in Table 10.1 indicate the following correlations and conclusions: (1) The presence of a second stage in a thermonuclear weapon can be detected within certain range and system-band-width limitations. (2) Correlations of first and second crossover points with total yield, noted in previously recorded wave forms, are supported by these measurements. (3) The correlation of negative-field strength with yield is also supported by these measurements. [redacted] (4) In order to obtain wave forms with good correlations on all of the above items, system band-width should be at least 15 Mc. (5) The different wave form recorded from Shot Yucca indicates that high-altitude bursts can be differentiated from surface bursts. (6) The prediction method used (based on Operation Redwing final report data), is valid at ranges up to 250 miles, provided both shielding and [redacted] are taken into consideration.

10.4 EFFECTS OF NUCLEAR DETONATIONS ON THE IONOSPHERE

This project originally had as its prime objective the determination of the effects of high-altitude large-yield nuclear detonations on the ionosphere, and on signals propagated via the ionosphere. After Shots Teak and Orange were rescheduled, no suitable station locations could be found for relocation of the project equipment, so this project objective was changed. The new objective was to increase the recorded knowledge about ionospheric effects of large-yield surface detonations.

This project was divided into two elements: Wake Island, the northern station, and Kusaie,

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