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Operation
UPSHOT-KNOTHOLE
NEVADA PROVING GROUNDS

March - June 1953

Project 6.13

EFFECTIVENESS OF FAST SCAN RADAR FOR FIREBALL STUDIES AND WEAPONS TRACKING

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OPERATION UPSHOT-KNOTHOLE

Project 6.13

EFFECTIVENESS OF FAST SCAN RADAR FOR FIREBALL STUDIES AND WEAPONS TRACKING

REPORT TO THE TEST DIRECTOR

June 1955

U. S. Naval Electronics Laboratory
San Diego 52, California

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ABSTRACT

The U. S. Navy Electronics Laboratory Fast Scan Radar was used in Operation UPSHOT-KNOTHOLE to establish the degree of usefulness of the high information rate provided (20 scans per second) in determining relevant burst phenomena. Fast scan data on Shots 7, 8, and 9 were recorded on film by the radar test personnel for familiarization, training, and for the purpose of choosing the optimum radar site for Shot 10.

The burst phenomenon of the 280-mm shell was readily discernible on the radar indicators but, due to the large amounts of ground clutter in the vicinity of the projectile track and the somewhat excessive range to the projectile, the shell was not seen in flight.

The fast scan radar provides a practical means by which high-speed radar information incident to the bomb-burst can be observed and recorded for later analysis in determining bomb yield.

It is recommended that if rapid scan radar is needed in yield determination, a fast scan radar tailored specifically for the detection of the burst phenomenon be constructed and tested with future nuclear devices.

FOREWORD

This report is one of the reports presenting the results of the 78 projects participating in the Military Effects Tests Program of Operation UPSHOT-KNOTHOLE, which included 11 test detonations. For readers interested in other pertinent test information, reference is made to WT-782, Summary Report of the Technical Director, Military Effects Program. This summary report includes the following information of possible general interest.

a. An over-all description of each detonation, including yield, height of burst, ground zero location, time of detonation, ambient atmospheric conditions at detonation, etc., for the 11 shots.

b. Compilation and correlation of all project results on the basic measurements of blast and shock, thermal radiation, and nuclear radiation.

c. Compilation and correlation of the various project results on weapons effects.

d. A summary of each project, including objectives and results.

e. A complete listing of all reports covering the Military Effects Tests Program.

CONTENTS

ILLUSTRATIONS

PPI photographs of Shot 7 - Figures 3.2 through 3.6 are a time sequence showing formation of crescent shaped echo of the burst

TABLES

[redacted]

CHAPTER 1

INTRODUCTION

1.1 OBJECTIVE

The main objective was to obtain the maximum amount of pertinent radar data on the 280-mm projectile track, location of the burst, and other burst phenomena from one location. Since no other available military radar equipment provided a sufficiently high information rate, the U. S. Navy Electronics Laboratory (NEL) Fast Scan Radar was chosen. This radar provides 20 complete scans per second which was believed to be rapid enough to permit the recording of all pertinent radar data attendant to the firing of the 280-mm projectile. In addition, it was expected that this radar would give better radar return phenomena than the slower scan equipment currently in use.

1.1.1 Secondary Objectives

To demonstrate the usefulness of rapid recordings of radar data on burst phenomena in general.

To determine the character of radar echoes from the impact area, i.e., whether return was caused by ionized particles in the fireball, from shock wave, or from dust and/or debris picked up after impact.

To evaluate the fast scan radar technique for the purpose of determining yield.

To record electromagnetic refraction through the fireball for Project 6.2.[1]

The foregoing objectives were considered desirable in the light of previous experience by Wright Air Development Center in using standard radar for Indirect Bomb Damage Assessment. Insufficient data were obtained due to the normal slow scan rate and the extremely short burst phenomena.

---

[1] James, Frank E., IBDA Phenomena and Techniques, WT-751.

[redacted]

1.2 BACKGROUND AND THEORY

Radar tracking of projectiles provides useful tactical data on the source of enemy fire and the effectiveness of friendly fire. Radar tracking of projectiles falls into two categories as follows:

(1) Azimuth, range and elevation tracking by means of an automatic tracking-type radar such as is used for mortar tracking.

(2) Azimuth and range tracking on a surveillance or search-type radar by means of target movement on the PPI indicator.

The first category is used for high-angle fire such as mortars or high-angle howitzers. The second category is used for high-velocity flat-trajectory missiles where automatic track radar cannot be used because of the low elevation angle and ground clutter problems.

The second category requires a radar with a high antenna scan rate in order to get a significant number of looks at the projectile during flight so that a continuous track is left on the indicator. Standard surveillance radars obtain only three or four looks at the projectile because of its high velocity. It is practically impossible to establish a track from such scanty data. A radar of a considerably higher scan rate is needed for this purpose. The NEL Fast Scan Radar is capable of performance in the second category and has been successfully tested against 105-mm howitzer projectiles fired with a flat trajectory. Continuous trajectory tracks were obtained and recorded on film. These data have not been included in a published report but the 35-mm film data are available at NEL.

The firing of the atomic cannon at the Nevada Proving Ground afforded an opportunity to evaluate this equipment both for tracking of flat trajectory projectiles and its effectiveness in the study of burst phenomena.

On Shot 10 the echo from the projectile as it progressed from the gun position to ground zero was expected. The echo characteristics of the burst expected on all shots were circle or horseshoe-shaped echoes in the vicinity of ground zero, a shadowing effect behind the echo, and an attenuation of targets covered by or enclosed in the crescent-shaped echo. At the instant of burst on Shot 7, it was anticipated that the corner reflector echoes in line with and behind the fireball would shift in bearing approximately one degree because of refraction of the radar energy.[1]

[redacted]

CHAPTER 2

INSTRUMENTATION AND OPERATIONS

2.1 INSTRUMENTATION

The NEL Fast Scan Radar is a pulse-type radar with a very high antenna scan rate and pulse repetition rate. It was developed primarily for the shipboard detection of small targets such as periscopes and snorkels in heavy sea clutter. A basic feature comparison of the NEL radar and typical airborne and shipborne surface-search radar is shown in Table 2.1.

The high information rate available from the NEL radar coupled with the fast decay time on the indicator screens, makes it an ideal instrument for the study of rapidly changing target phenomena either in position or amplitude. Its use in the study of burst phenomena provides 50 to 200 separate "looks" in contrast to the single look possible using a conventional type radar on 360-degree scan. Therefore, the fast scan radar provided a much better potential means of yield determination than the conventional radars which were used prior to these tests.

The van mounted radar was instrumented with two 35-mm Mitchell movie cameras, one on the PPI Indicator and one on the B Indicator. Both cameras were synchronized with the antenna rotation on a scan-by-scan basis so that a frame of film was exposed during each scan of the antenna. In this manner the film data were obtained at a rate of 20 frames per second. By viewing the film data on a conventional projector at 24 frames per second, a realistic playback of the radar data is obtained even though it is speeded up by 20 per cent. Conversely, frame-by-frame examination gives detailed data at 1/20 second intervals.

Each shot required different equipment location, antenna beam tilt and range and bearing adjustment on the two indicators. A summary of significant parameters and data are listed in Table 2.2 for all shots covered in this report.

Corner reflectors were placed on the hillside 7 miles beyond and in line with the top of the main tower for Shot 7 only. The B-scope sector was centered on these targets in order to obtain electromagnetic refraction data for Project 6.2.

[redacted]

TABLE 2.1 - Comparison of NEL Radar and Airborne and Shipborne Surface Search Radars

Parameters	NEL Fast Scan	Airborne AN/APS-33	Shipborne AN/SPS-4
Transmitter			
Frequency (MC)	9375	9375	5400
Peak Power (KW)	125	70	200
Pulse Length (micro sec)	0.25	0.5, 5.0	0.37, 1.37
Pulse recurrence frequency (pps)	6200 to 2000 (Continuously Variable)	800, 200	650
Antenna			
Scan rate (rpm)	1200	5 to 24	5 to 15
Beam size (degrees)	5 x 5 (conical)	3 horiz. by cosec. vert.	2.0 horiz. by 12 vert.
Type scan	Linear-horiz. plane for 360°	Linear-horiz. plane 360° or sector 60°	Linear-horiz. for 360°
Receiver			
Noise figure (db)	18	18	14
IF center freq. (MC)	30	60	60
IF bandwidth (MC)	8	5 or 1.0	5.0
Indicators			
Type presentation	PPI and B	PPI	PPI
Tube size	10" 5"	5"	10"
Screen type	P-4 P-4	P-7	P-7
Range scales (miles)	2-20 var. 2-20 var.	0 to 5 0 to 60 variable 120, 200 fixed	2, 4, 10, 20, 80 fixed
Bearing Sector width (degrees)	90 to 350 variable		
Range Sector length (miles)	1 to 20 variable		
Range Sector position(miles)	0 to 20 variable		

[redacted]

TABLE 2.2 - Equipment Positioning Information on Shots 7, 8, 9, and 10

	Shot 7 (25 Apr)	Shot 8 (19 May)	Shot 9 (8 May)	Shot 10 (25 May)
Radar position coordinates (AMS V796)	840;892	840;892	917;622	845;715
Range to burst (yd)	13,200	11,000	12,000	11,700
Antenna tilt (degrees)	-1°	+2°	+3°	+3°
Maximum range on PPI (yd)	28,800	12,400	13,200	13,000
B-scan indicator range-MIN (yd)	25,600	9,000	9,800	10,000
B-scan indicator range-MAX (yd)	28,200	12,000	12,400	12,600
B-scan indicator bearing width (degrees)	90	90	90	90
B-scan indicator bearing center (degrees)	GZ	GZ	GZ	GZ + 20°

2.2 OPERATIONS

For each shot the radar site was chosen as a function of expected blast yield, character of terrain, radar clutter conditions, and radar range capabilities. In all except Shot 10 (the 280-mm projectile test) optimum location of the radar was used. For Shot 10, it was not operationally feasible, within the imposed safety limitations, to locate the radar in any place where it would not receive considerable background clutter. Time was insufficient to cut an access road to the originally chosen site. Consequently, total loss of projectile track resulted and serious degradation of radar performance during and immediately after the burst was encountered. The site which was made available was situated sufficiently further back from the gun and ground zero and sufficiently higher than the original site so that a condition of extremely high level ground clutter masked the entire area in the path of the projectile. These difficulties became evident during pretest attempts by radar test personnel to optimize radar receiver sensitivity versus background clutter in the area of the projectile path. In view of the relatively small number of pretest projectiles and the

[redacted]

fact that an access road had not been cut to the original site for Shot 10, moving the radar at the last minute was precluded; therefore, receiver gain was optimized by reducing it to the point where the projectile path area was not completely saturated. Even so, in an earnest attempt to retain maximum receiver sensitivity, the gain setting was optimized at a level considerably above that which would have been practical with conventional radar (see Fig. 2.1). This was made possible because of the inherent "moving target discrimination" capabilities of this radar. At the time this test was made, it had been determined in operational tests of the fast scan radar that moving targets whose signal strength was from one-half to equal that of fixed background clutter could easily be detected if their rate of travel was 30 knots and above.

Figure 2.2 is a PPI photograph of the Yucca Flat area and Fig. 2.3 is a map of the same area (Shots 7 and 9). Figures 2.4 and 2.5 show the same data for Frenchman Flat (Shots 8 and 10). On these figures point "A" is the Radar Location for Shots 7 and 9. Point "B" is the Radar Location for Shot 8 and point "C" is the Radar Location for Shot 10. Point "D" shows the original optimum radar site for Shot 10.

Shot 10 Results - The anticipated horseshoe echo did not appear because receiver gain setting had been optimized for projectile path area. Shock wave phenomena were evident in that the U. S. Signal Corps' tower echoes were blanked out two times in close succession.

[redacted]

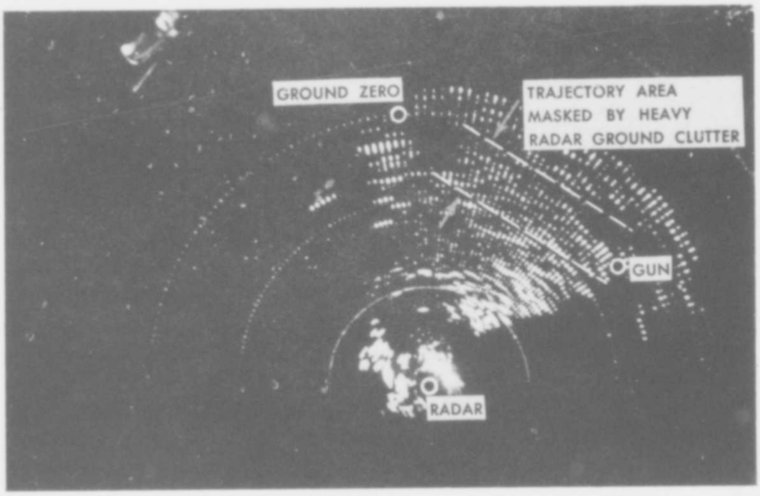


Figure 2.1 - PPI photograph showing heavy clutter in the trajectory area

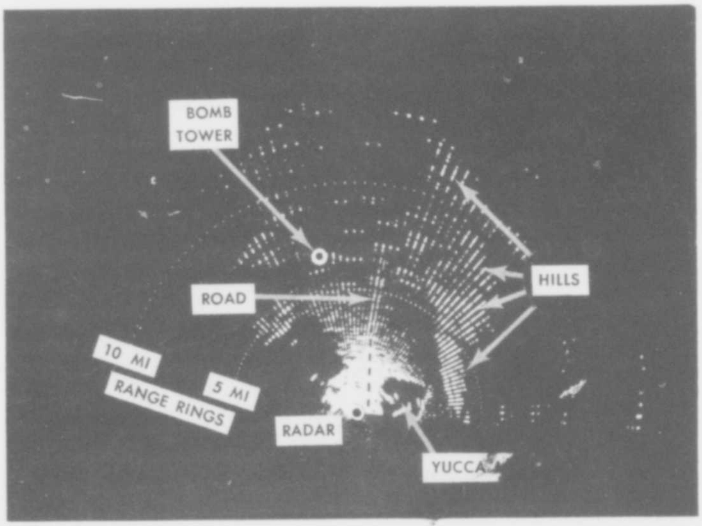


Figure 2.2 - PPI photograph of Yucca Flat area

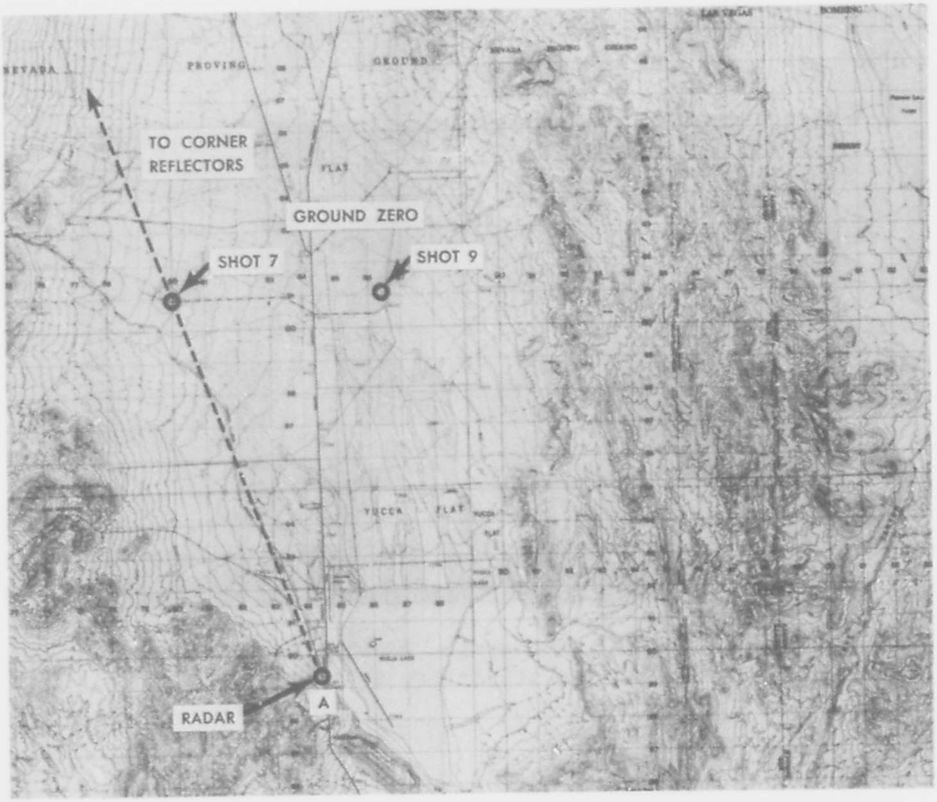


Figure 2.3 - Map of Yucca Flat area

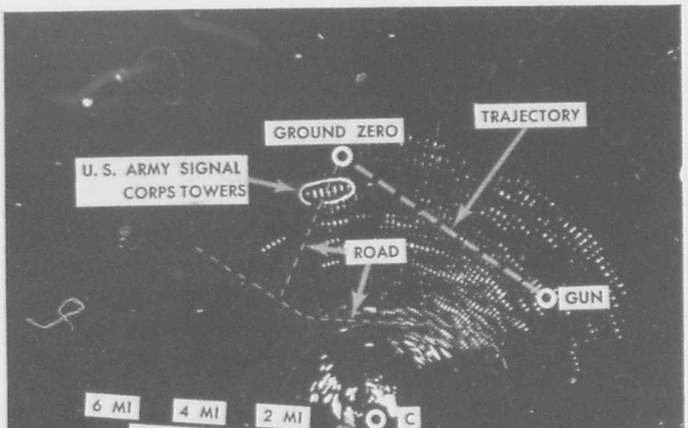


Figure 2.4 - PPI photograph of Frenchman Flat area

[redacted]

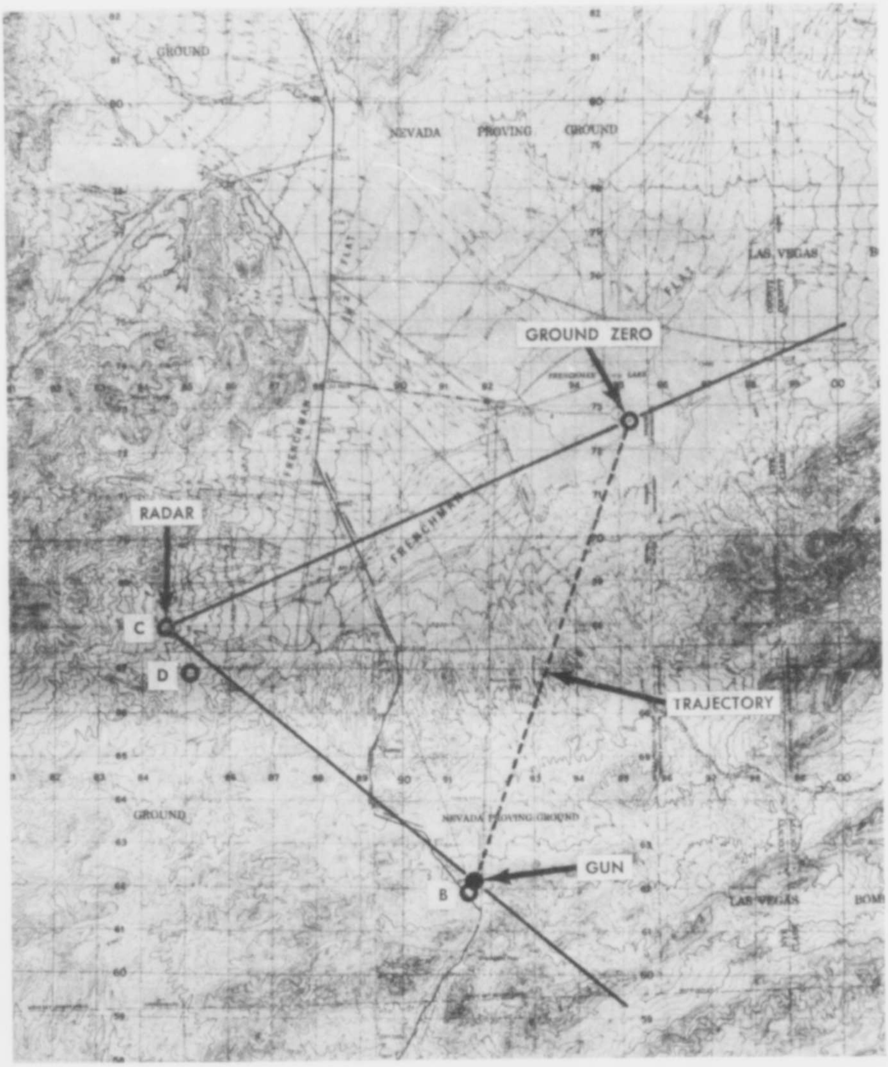


Figure 2.5 - Map of Frenchman Flat area

CHAPTER 3

RESULTS, OBSERVATIONS, AND DISCUSSION

3.1 RESULTS

3.1.1 Shot 7

Detailed study of the film data obtained on Shot 7 for the refraction experiment under Project 6.2 did not indicate the anticipated refraction phenomenon. It was noted, however, that the echoes from the corner reflectors, and the terrain at closer ranges between the tower and reflectors were highly attenuated and completely disappeared for 14 seconds after time of burst. Targets as close as 10 degrees on either side were not affected (both the PPI and B-scan photographs show this). Figure 3.1 shows two PPI photographs, one just before the burst and the other 1/20 second after the burst. The area of attenuation is marked. Film data from both indicators was supplied Project 6.2 personnel for this use.

The main bomb tower is plainly visible in the PPI photograph (Fig. 3.1) at a range of 13,200 yd. The three smaller towers to the east of the main tower were also plainly visible on the indicator. At the instant of burst (called T_0 hereafter), the main tower echo disappeared completely from the indicator. A crescent-shaped echo formed immediately and progressed to 1500 yd range from ground zero and reached a size of approximately 3000 yd in diameter in 2.2 sec. It then gradually diminished in size until it vanished 14.3 sec later. It was noted that the expanding echo caused all other echoes in its interior to disappear. The PPI photographs in Figs. 3.2 through 3.6 show the sequence of events. The B-scope sector was centered on the corner reflectors 7 miles beyond the main tower to obtain refraction data for Project 6.2 so no information on the burst echo was obtained on this indicator.

3.1.2 Shot 8

The antenna tilt was adjusted for 2 degrees above the horizon as indicated in Table 2.2 above so that foreground targets in the vicinity of ground zero were just visible on the indicators. At T_o the tower echo disappeared in the same manner as in Shot 7. The crescent-shaped echo anticipated was observed.

3.1.3 Shot 9

The antenna beam was tilted upward 3 degrees on Shot 9 to be sure that the beam intersected the burst point. In so doing, many of the ground clutter targets in the vicinity of ground zero were not visible on the indicators except for the four Signal Corps towers positioned 3000, 4000, 5000, and 6000 ft to the northwest of ground zero. No echo was observed from the fireball or shock wave at T_o. The echoes of the towers were blanked out two times in close succession, for a period of 0.15 sec the first time and 0.10 sec the second time with a 0.10 sec interval. No echo was observed from the fireball.

3.1.4 Shot 10

Severe ground clutter was present over most of the trajectory of the 280-mm projectile on the radar indicators. Consequently, none of the track was observed at the time of the gun test. Echoes from the burst and debris were observed on the indicator but were of short duration (see Sec. 1.2).

3.2 DISCUSSION

3.2.1 Shot 7

Shot 7 provided a good radar echo on the PPI indicator; however, the range scale was set for observation of the corner reflectors at 15 miles distance and accurate measurements of the burst echo are not possible because of its small size on the PPI. It could not be determined whether the initial echo was caused by the fireball. The later echo which was very large was caused by dust and debris. Those targets inside the crescent-shaped echo which were not destroyed by the blast were obscured by propagation attenuation through the fireball and cloud.

The high scan rate of the radar provided approximately 286 "looks" at the burst as the echo size grew.

3.2.2 Shot 8

The data provided by Shot 8 show some step-by-step crescent-shaped echo development; however, tilting of the antenna obscured other phenomena associated with the burst.

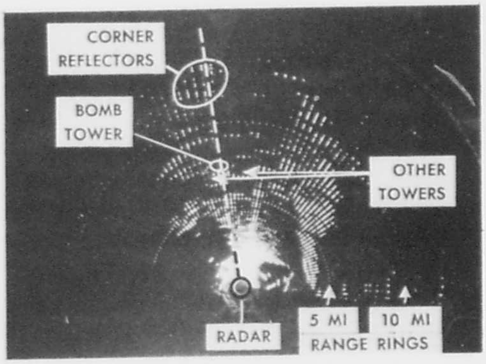
3.2.3 Shot 9

The first disappearance of the tower targets can probably be attributed to high radar attenuation by the shock wave as it covered the towers. The targets reappeared as soon as the direct wave passed over.

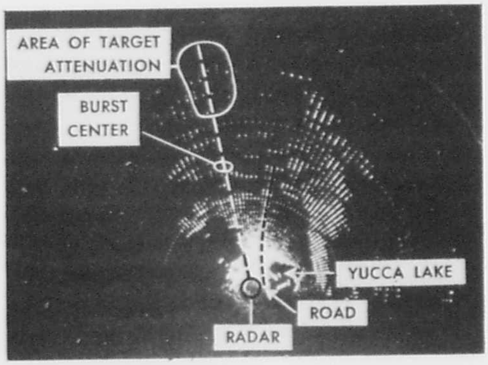
[redacted]

3.2.4 Shot 10

Tracking of the 280-mm projectile on the indicator during Shot 10 was not possible due to intense ground clutter throughout the track. It is believed that the radar was stationed too far from track to obtain a detectable target. Fast scan radar effectiveness in tracking projectiles of this type was not demonstrated during this test. Determination of the point of burst and its approximate size by the echo characteristics would have been possible had receiver gain setting been optimized for this purpose. Howitzer projectiles (105-mm) have been tracked at shorter ranges (3500 yd) with this radar in previous tests. It is firmly believed that the 280-mm projectile could have been tracked satisfactorily if the proper radar receiver gain and radar siting had been possible.



BEFORE BURST



AFTER BURST 1/20 SECOND AFTER ABOVE PHOTO

Fig. 3.1 - PPI photographs showing attenuation of radar energy through burst center

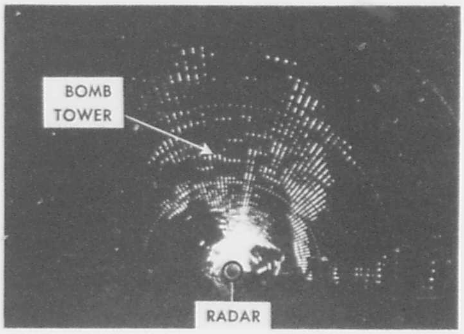


Figure 3.2 - 1/20 second before burst

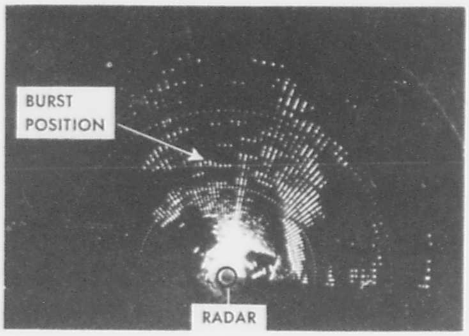


Figure 3.3 - T_o time of burst

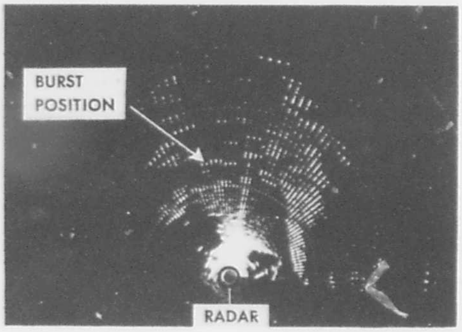


Figure 3.4 - T_o +1 second

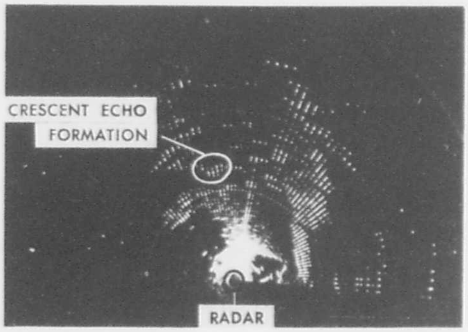


Figure 3.5 - T_o +2.2 seconds

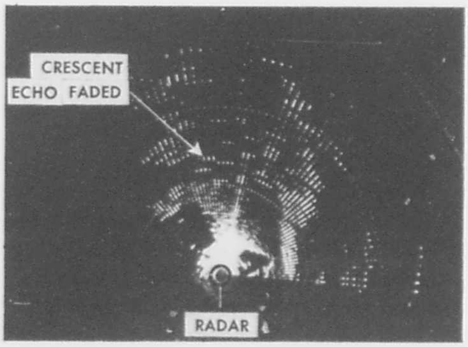


Figure 3.6 - T_o +14.3 seconds

PPI photographs of Shot 7 - Figures 3.2 through 3.6 are a time sequence showing formation of crescent shaped echo of the burst

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

The burst phenomena of the 280-mm shell on Shot 10 were readily discernible on the indicators as was the case in previous shots. Due to the large amounts of ground clutter in vicinity of the track and the somewhat excessive range to the projectile, the shell was not seen in flight.

From initial evaluation of film data it appears that radar energy is highly attenuated by the fireball and the most intense portion of the shock wave. This results in a characteristic reduction or obscuration of echoes by the initial phase phenomena for targets in the immediate vicinity of the burst. Some 286 pictures of a single shot were made of effects attendant to a single burst.

No absolute conclusions can be made at this time about utilizing the fast scan radar data for determining yield. Information concerning this factor could be much more conclusive if specific tests for this purpose were made and closely correlated with other yield measuring devices.

The refraction data desired by Project 6.2 were recorded on film and furnished to them. Although no refraction phenomenon is apparent after examination of the film, a more detailed study by Project 6.2 personnel may have brought out pertinent data. Any findings will be reported under that project number.

4.2 RECOMMENDATIONS

It is recommended that if rapid scan radar is needed in yield determination, a fast scan radar tailored for the detection of the burst phenomenon be built and tested with future nuclear devices. The AN/APS-49 radar now under construction would probably be very satisfactory for this purpose. This anti-submarine radar is now under construction by the Hazeltine Corporation, Long Island, New York for the U. S. Navy Bureau of Aeronautics. It is patterned after the U. S. Navy Electronics Laboratory's Fast Scan Radar but has greater bearing resolution and maximum range capabilities.

It is further recommended that any fast scan radar equipment developed or used for future work in the study of the burst phenomena have higher bearing resolution with a total of approximately 45 degree azimuth coverage and an effective rate of 50 frames per second. This increased information rate and resolution would provide a greater quantity of more accurate data for analysis of the burst phenomena than could be obtained using the NEL Fast Scan Radar.

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63 Director, Technical Documents Center, Evans Signal Laboratory, Belmar, N.J.
64 Director, Operations Research Office, Johns Hopkins University, 7100 Connecticut Ave., Chevy Chase, Md., Washington 15, D.C.
65- 71 Technical Information Service, Oak Ridge, Tenn. (Surplus)

NAVY ACTIVITIES

72- 73 Chief of Naval Operations, D/N, Washington 25, D.C. ATTN: OP-36
74 Chief of Naval Operations, D/N, Washington 25, D.C. ATTN: OP-03EG
75 Director of Naval Intelligence, D/N, Washington 25, D.C. ATTN: OP-922V
76 Chief, Bureau of Medicine and Surgery, D/N, Washington 25, D.C. ATTN: Special Weapons Defense Div.
77 Chief, Bureau of Ordnance, D/N, Washington 25, D.C.
78 Chief of Naval Personnel, D/N, Washington 25, D.C.
79 Chief, Bureau of Ships, D/N, Washington 25, D.C. ATTN: Code 348
80 Chief, Bureau of Supplies and Accounts, D/N, Washington 25, D.C.
81- 82 Chief, Bureau of Aeronautics, D/N, Washington 25, D.C.
83 Chief of Naval Research, Department of the Navy Washington 25, D.C. ATTN: Code 811
84 Commander-in-Chief, U.S. Pacific Fleet, Fleet Post Office, San Francisco, Calif.
85 Commander-in-Chief, U.S. Atlantic Fleet, U.S. Naval Base, Norfolk 11, Va.
86 Commandant, U.S. Marine Corps, Washington 25, D.C. ATTN: Code AO3H
87 Superintendent, U.S. Naval Postgraduate School, Monterey, Calif.
88 Commanding Officer, U.S. Naval Schools Command, U.S. Naval Station, Treasure Island, San Francisco, Calif.
89 Commanding Officer, U.S. Fleet Training Center, Naval Base, Norfolk 11, Va. ATTN: Special Weapons School
90 Commanding Officer, U.S. Fleet Training Center, Naval Station, San Diego 36, Calif. ATTN: (SPWP School)

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91 Commanding Officer, U.S. Naval Damage Control Training Center, Naval Base, Philadelphia 12, Pa. ATTN: ABC Defense Course
92 Commanding Officer, U.S. Naval Unit, Chemical Corps School, Army Chemical Training Center, Ft. McClellan, Ala.
93 Commander, U.S. Naval Ordnance Laboratory, Silver Spring 19, Md. ATTN: EH
94 Commander, U.S. Naval Ordnance Laboratory, Silver Spring 19, Md. ATTN: R
95 Commander, U.S. Naval Ordnance Test Station, Inyokern, China Lake, Calif.
96 Officer-in-Charge, U.S. Naval Civil Engineering Res. and Evaluation Lab., U.S. Naval Construction Battalion Center, Port Hueneme, Calif. ATTN: Code 753
97 Commanding Officer, U.S. Naval Medical Research Inst., National Naval Medical Center, Bethesda 14, Md.
98 Director, U.S. Naval Research Laboratory, Washington 25, D.C. ATTN: Code 2029
99 Director, The Material Laboratory, New York Naval Shipyard, Brooklyn, N.Y.
100 Commanding Officer and Director, U.S. Navy Electronics Laboratory, San Diego 52, Calif. ATTN: Code 4223
101-102 Commanding Officer, U.S. Naval Radiological Defense Laboratory, San Francisco 24, Calif. ATTN: Technical Information Division
103 Officer-in-Charge, Special Weapons Supply Depot, U.S. Naval Supply Center, Norfolk 11, Va.
104 Commanding Officer and Director, David W. Taylor Model Basin, Washington 7, D.C. ATTN: Library
105-106 Commanding Officer, U.S. Naval Photographic Center, Anacostia, D.C.
107 Commander, U.S. Naval Air Development Center, Johnsville, Pa.
108 Director, Office of Naval Research Branch Office, 1000 Geary St., San Francisco, Calif.
109-115 Technical Information Service, Oak Ridge, Tenn. (Surplus)

AIR FORCE ACTIVITIES

116 Asst. for Atomic Energy, Headquarters, USAF, Washington 25, D.C. ATTN: DCS/O
117 Director of Operations, Headquarters, USAF, Washington 25, D.C. ATTN: Operations Analysis
118 Director of Plans, Headquarters, USAF, Washington 25, D.C. ATTN: War Plans Div.
119 Director of Research and Development, Headquarters, USAF, Washington 25, D.C. ATTN: Combat Components Div.
120-121 Director of Intelligence, Headquarters, USAF, Washington 25, D.C. ATTN: AFOIN-IB2
122 The Surgeon General, Headquarters, USAF, Washington 25, D.C. ATTN: Bio. Def. Br., Pre. Med. Div.
123 Deputy Chief of Staff, Intelligence, Headquarters, U.S. Air Forces Europe, APO 633, c/o PM, New York, N.Y. ATTN: Directorate of Air Targets
124 Commander, 497th Reconnaissance Technical Squadron (Augmented), APO 633, c/o PM, New York, N.Y.
125 Commander, Far East Air Forces, APO 925, c/o PM, San Francisco, Calif.
126 Commander-in-Chief, Strategic Air Command, Offutt Air Force Base, Omaha, Nebraska. ATTN: Special Weapons Branch, Inspector Div., Inspector General
127 Commander, Tactical Air Command, Langley AFB, Va. ATTN: Documents Security Branch
128 Commander, Air Defense Command, Ent AFB, Colo.
129 Commander, Air Training Command, Scott AFB, Belleville, Ill. ATTN: DCS/O GTP
130 Commander, Air Research and Development Command, PO Box 1395, Baltimore, Md. ATTN: RDDN
131 Commander, Air Proving Ground Command, Eglin AFB, Fla. ATTN: AG/TRB
132-133 Director, Air University Library, Maxwell AFB, Ala.
134-141 Commander, Flying Training Air Force, Waco, Tex. ATTN: Director of Observer Training
142 Commander, Crew Training Air Force, Randolph Field, Tex. ATTN: 2GTS, DCS/O
143 Commander, Headquarters, Technical Training Air Force, Gulfport, Miss. ATTN: TA&D
144-145 Commandant, Air Force School of Aviation Medicine, Randolph AFB, Tex.
146-147 Commander, Wright Air Development Center, Wright-Patterson AFB, Dayton, O. ATTN: WCOSI
148-149 Commander, Air Force Cambridge Research Center, LG Hanscom Field, Bedford, Mass.
150-152 Commander, Air Force Special Weapons Center, Kirtland AFB, N. Mex. ATTN: Library
153 Commandant, USAF Institute of Technology, Wright-Patterson AFB, Dayton, O. ATTN: Resident College
154 Commander, Lowry AFB, Denver, Colo. ATTN: Department of Armament Training
155 Commander, 1009th Special Weapons Squadron, Headquarters, USAF, Washington 25, D.C.
156-157 The RAND Corporation, 1700 Main Street, Santa Monica, Calif. ATTN: Nuclear Energy Division
158 Commander, Second Air Force, Barksdale AFB, Louisiana. ATTN: Operations Anal. Office
159 Commander, Eighth Air Force, Westover AFB, Mass. ATTN: Operations Anal. Office
160 Commander, Fifteenth Air Force, March AFB, Calif. ATTN: Operations Anal. Office
161-167 Technical Information Service, Oak Ridge, Tenn. (Surplus)

OTHER DEPARTMENT OF DEFENSE ACTIVITIES

168 Asst. Secretary of Defense, Research and Development, D/D, Washington 25, D.C. ATTN: Tech. Library
169 U.S. Documents Officer, Office of the U.S. National Military Representative-SHAPE, APO 55, New York, N.Y.
170 Director, Weapons Systems Evaluation Group, OSD, Rm 2E1006, Pentagon, Washington 25, D.C.
171 Commandant, Armed Forces Staff College, Norfolk 11, Va. ATTN: Secretary
172-177 Commanding General, Field Command, Armed Forces Special Weapons Project, PO Box 5100, Albuquerque, N. Mex.
178-179 Commanding General, Field Command, Armed Forces, Special Weapons Project, PO Box 5100, Albuquerque, N. Mex. ATTN: Technical Training Group
180-188 Chief, Armed Forces Special Weapons Project, Washington 25, D.C. ATTN: Document Library Branch
189 Office of the Technical Director, Directorate of Effects Tests, Field Command, AFSWP, PO Box 577, Menlo Park, Calif. ATTN: Dr. E. B. Doll
190 Commanding General, Military District of Washington, Room 1543, Building T-7, Gravelly Point, Va.
191-197 Technical Information Service, Oak Ridge, Tenn. (Surplus)

ATOMIC ENERGY COMMISSION ACTIVITIES

198-200 U.S. Atomic Energy Commission, Classified Technical Library, 1901 Constitution Ave., Washington 25, D.C. ATTN: Mrs. J. M. O'Leary (For DMA)
201-202 Los Alamos Scientific Laboratory, Report Library, PO Box 1663, Los Alamos, N. Mex. ATTN: Helen Redman
203-207 Sandia Corporation, Classified Document Division, Sandia Base, Albuquerque, N. Mex. ATTN: Martin Lucero
208-210 University of California Radiation Laboratory, PO Box 808, Livermore, Calif. ATTN: Margaret Edlund
211 Weapon Data Section, Technical Information Service, Oak Ridge, Tenn.
212-225 Technical Information Service, Oak Ridge, Tenn. (Surplus)

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AEC, Oak Ridge, Tenn.

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