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PROJECT DANNY BOY

POR-1810

(WT-1810)

PROJECT 1.1b

CLOSE-IN AIR BLAST FROM A NUCLEAR DETONATION IN BASALT

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Sandia Corporation  
Albuquerque, New Mexico

June 1962

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ABSTRACT

Close-in air blast from the Danny Boy event resulted almost entirely from the ground-shock-induced air blast. Little pressure resulted from venting gases. Consequently, measured pressures were only one-third to one-fourth of those predicted. Ground-shock-induced pressures from the nuclear charge were found to attenuate less rapidly than those from chemical explosives.

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#### ACKNOWLEDGEMENTS

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CHAPTER 1

INTRODUCTION

1.1 OBJECTIVE

The objective of the air blast measurement program was to determine the overpressure-time-distance relationship at ground level along one blast line for the purpose of determining the extent of close-in blast suppression. This experiment extends blast observations from charges buried in basalt to 430 tons, a yield larger by a factor of 20 than yields of Project Buckboard. The new data permit some indication of the extent to which differences in close-in blast can be attributed to differences in the type of explosive used (nuclear or chemical explosive).

1.2 BACKGROUND

Close-in air blast along the ground surface has been measured on underground detonations from high explosives in Nevada Test Site desert alluvium using high-explosive charges of 256 (References 1, 2, and 3), 2,560 (Reference 1), 40,000 (References 1 and 4), and 1,000,000 (Reference 5) pounds. It has also been observed on a surface nuclear detonation (References 6 and 7) and on two relatively shallow nuclear detonations (References 6, 7, and 8) in the same medium. On Project Buckboard (Reference 9) blast overpressures were measured along the ground from three 40,000-pound detonations at three different burst depths in basalt. The Buckboard experiments led to the conclusion that no difference in the suppression of peak overpressure is attributable to the harder medium; that is, with high explosives, suppression of peak overpressure is essentially the same in alluvium and basalt.

A typical overpressure waveform from an underground high-explosive detonation shows a ground-shock-induced pressure pulse (often referred to as the "front porch") followed by the main portion of the blast wave

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generated by the venting of the explosion gases (Figure 1.1a). The waveforms from Project Danny Boy (Figure 1.1b) are explained later.

### 1.3 INSTRUMENTATION

#### 1.3.1 Gage Locations

Gages were located along an approximately SE radius at radial distances along the ground at 200, 265, 350, 470, 630, 840, 1120, 3100, and 8500 feet. Typical gage installations are shown in Figure 1.2. Figure 1.3 shows the completed gage installation with the cleared area immediately around the gage. This photograph was taken looking toward surface zero.

#### 1.3.2 Gage Types

Measurements were made using Ballistic Research Laboratories self-recording pressure gages (Figure 1.4). In these gages, a battery-operated motor drives a turntable carrying either an aluminized glass disc or a stainless steel disc. A pressure sensitive diaphragm, connected directly to a scribe, permits the pressure record to be inscribed on the disc as the turntable rotates. The gage motor is started by a timing signal at -1 second. Standard pressure-time gages (PT's) were used at Stations 1 through 7, and very low pressure gages (VLP's) were used at Stations 6 through 9). Both types of gages were installed at Stations 6 and 7.

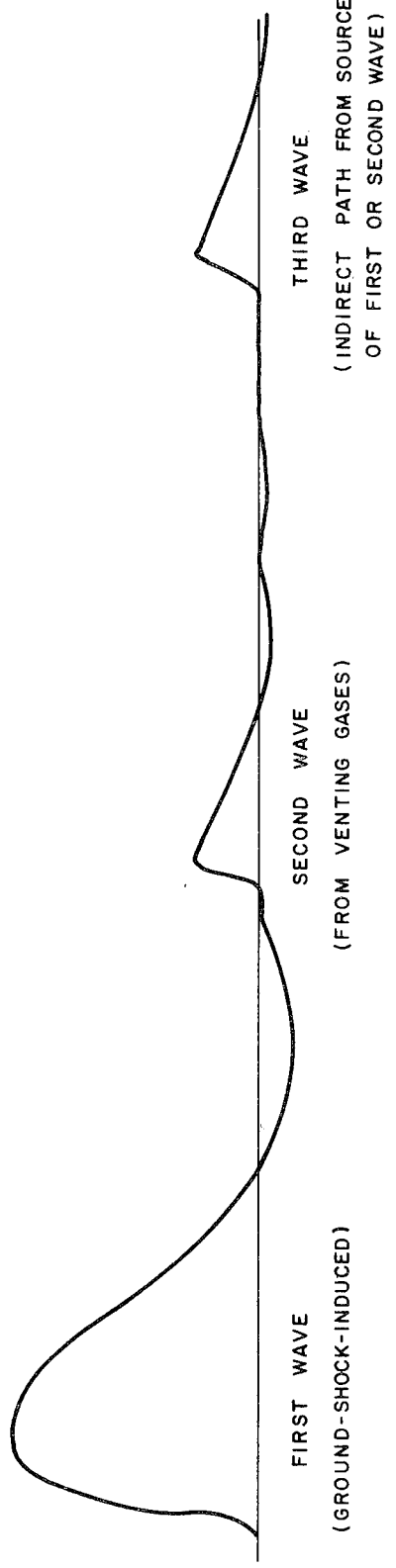
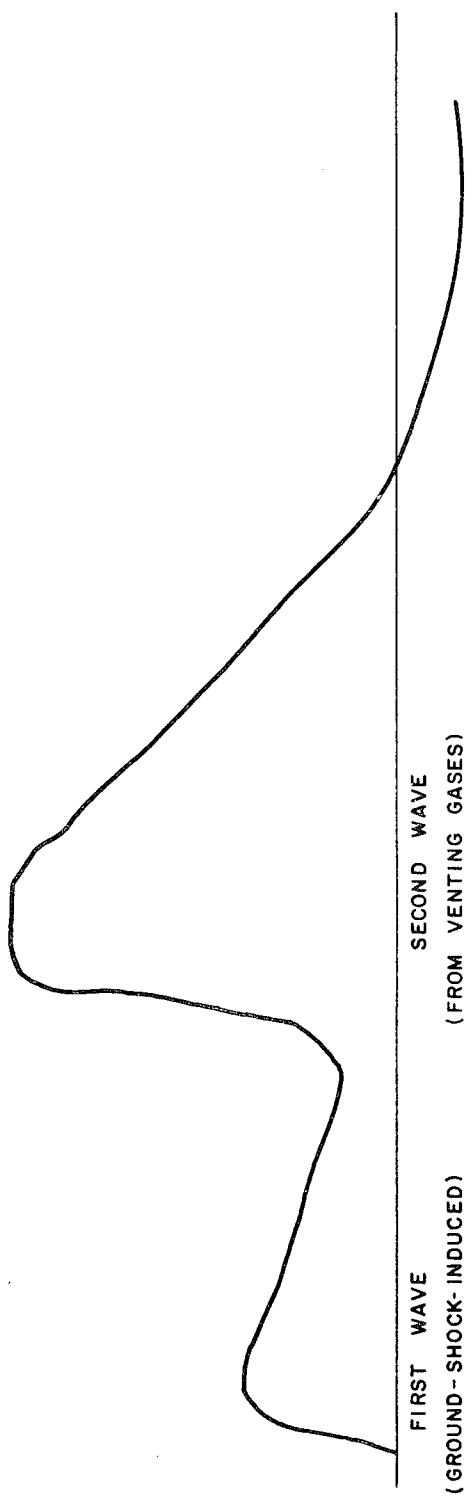


Figure 1.1 Typical Waveforms from Buried HE and Nuclear Detonation

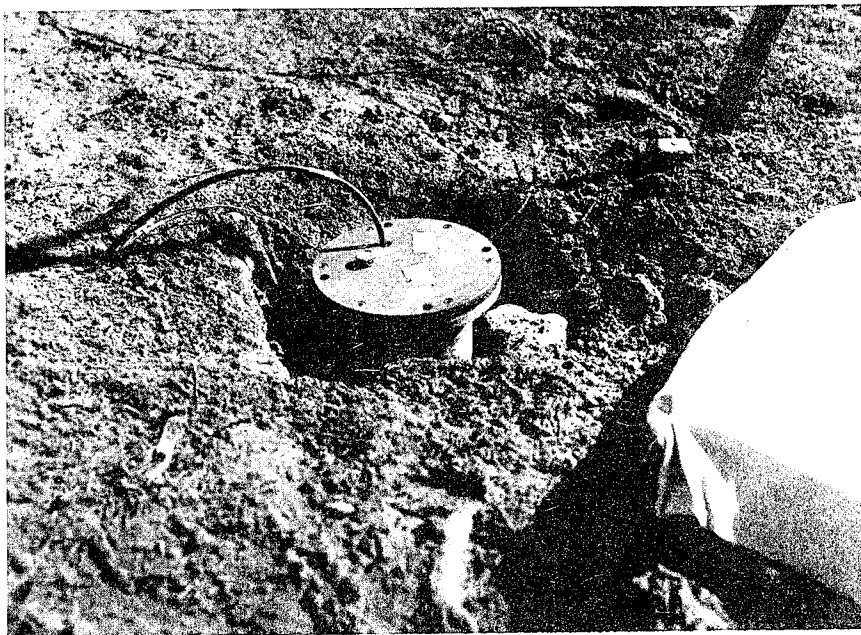


Figure 1.2 Typical Gage Installation



Figure 1.3 Cleared Area Around Gage Installation

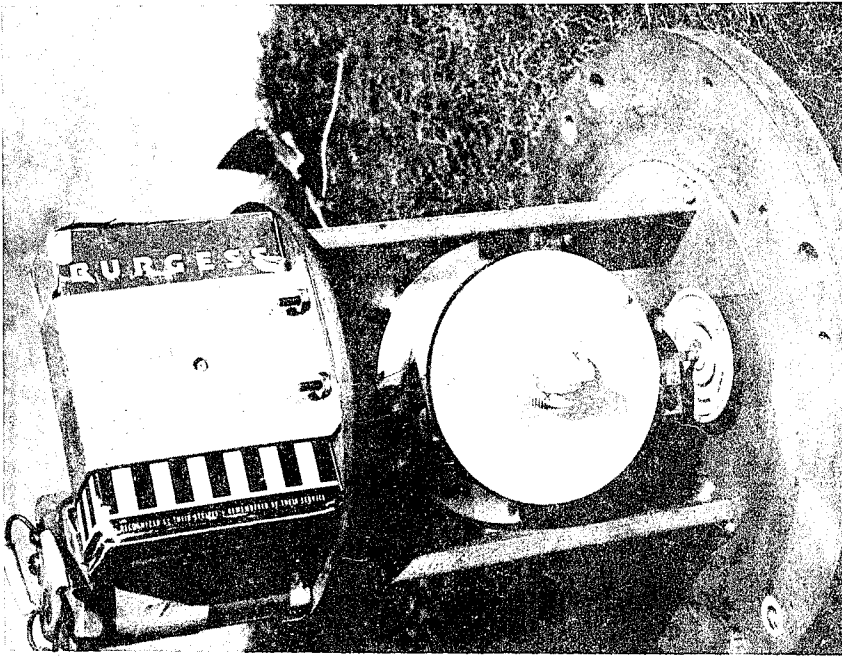
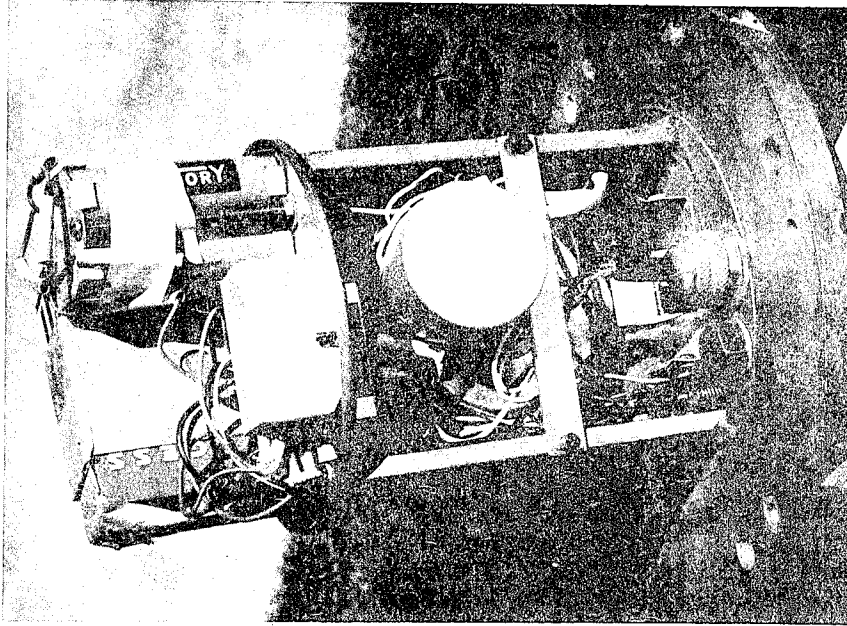


Figure 1.4 Self-Recording Pressure-Time Gage

CHAPTER 2  
TEST RESULTS

2.1 SUMMARY OF RESULTS

Table 2.1 summarizes the results of the pressure measurements. Because peak pressures only were obtained at Stations 5, 6B, 7B, and 8, records of pressure-time are not reproduced. Pressure records from the remaining seven gages are shown in Figures 2.1 through 2.4. Time in the figures is time from the arrival of the signal shown. The pressure wave illustrated is the first wave in all cases except at the 3100-foot station (Station 8), where the wave shown, as explained later, is from another source.

2.2 PEAK OVERPRESSURE

Figure 2.5 shows peak overpressures as a function of ground range. Also shown is the curve predicted before the shot for a slightly larger yield and a comparatively deeper burst depth; set ranges of the gages were based upon this curve. As indicated by the figure, all pressure records obtained were one-third to one-half of the set range.

2.3 POSITIVE PHASE

The positive-phase impulse of the pressure records is shown in Figure 2.6. The duration of the positive phase as a function of ground range is given in Figure 2.7. As is usual in pressure measurements, the scatter in positive-phase duration data is considerably greater than that in either peak overpressure or positive-phase impulse.

2.4 ARRIVAL TIMES

Arrival times are plotted in Figure 2.8.

TABLE 2.1 SUMMARY OF RESULTS

<u>Station</u>	<u>Ground range (feet)</u>	<u>Type of gage</u>	<u>Capsule range (psi)</u>	<u>Peak pressure (psi)</u>	<u>Arrival time (sec)</u>	<u>Positive- phase duration (sec)</u>	<u>Positive- phase impulse (psi-msec)</u>
1	200	PT	1/2	.255	-	.276	48.3
2	265	PT	1/2	.16	.510	.250	23.08
				.04	1.48	.685	
3	350	PT	1/2	.11	.815	.365	21.36
				.02	1.83	.410	
4	470	PT	1/2	.12	1.075	.505	19.86
				.04	1.485	.08	
				.03	2.38	.70	
5	630	PT	1/2	.075	PEAK	ONLY	
6A	840	PT	1/2	.045	1.070	.145	3.52
6B	840	VLP	1/4	.080	PEAK	ONLY	
7A	1120	PT	1/2	.055	1.385	.345	10.47
7B	1120	VLP	1/4	.070	PEAK	ONLY	
8	3100	VLP	1/4	.027	3.64		
				.065	11.25	.125	2.72
9	8500	VLP	1/4	.060	PEAK	ONLY	

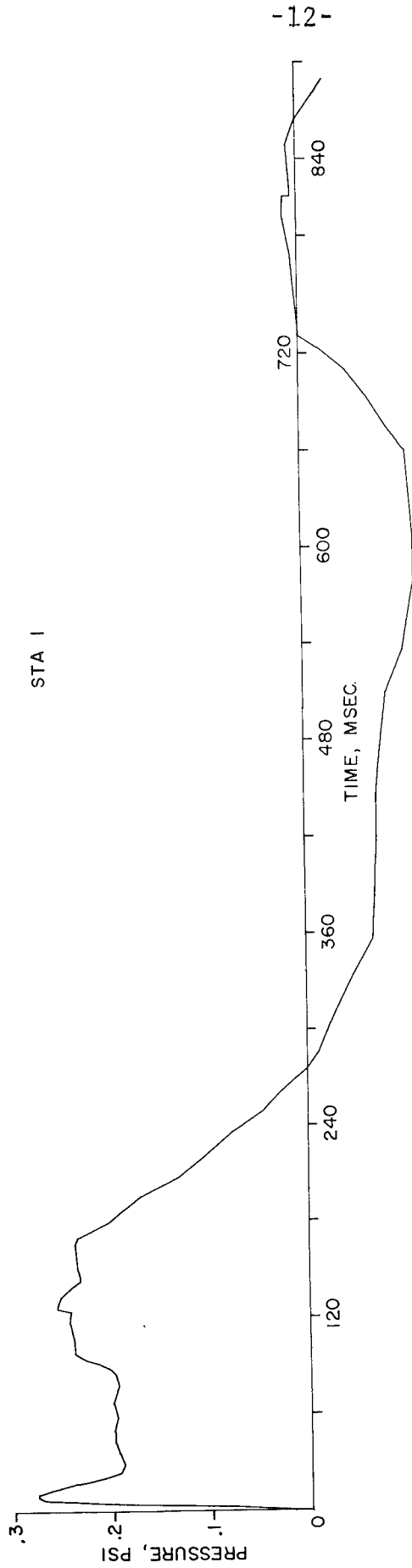


Figure 2.1 Pressure Records

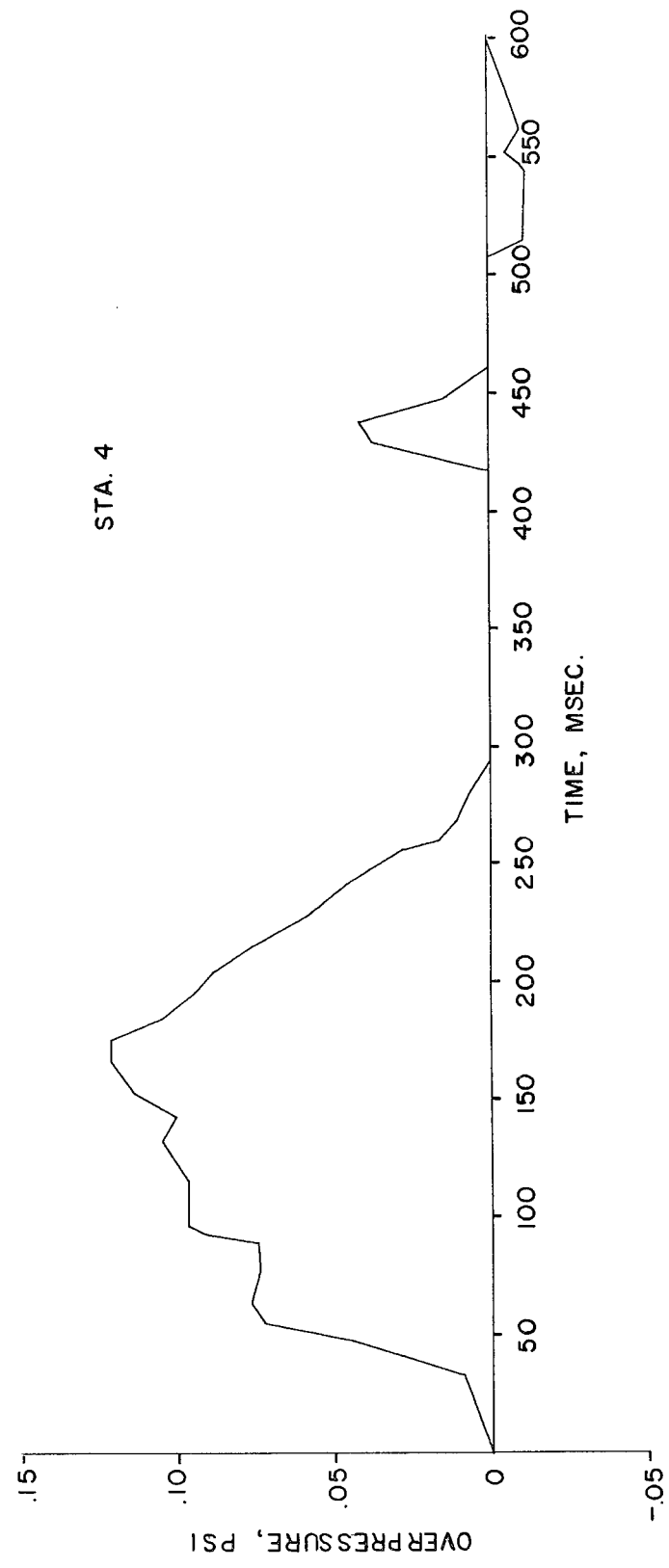
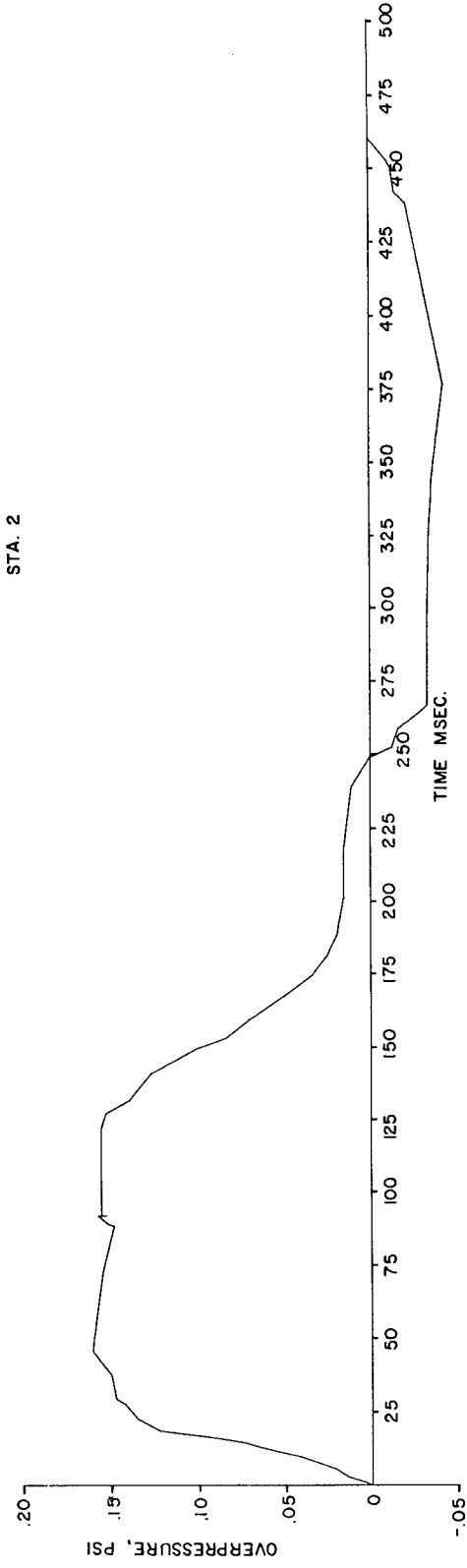


Figure 2.2 Pressure Records

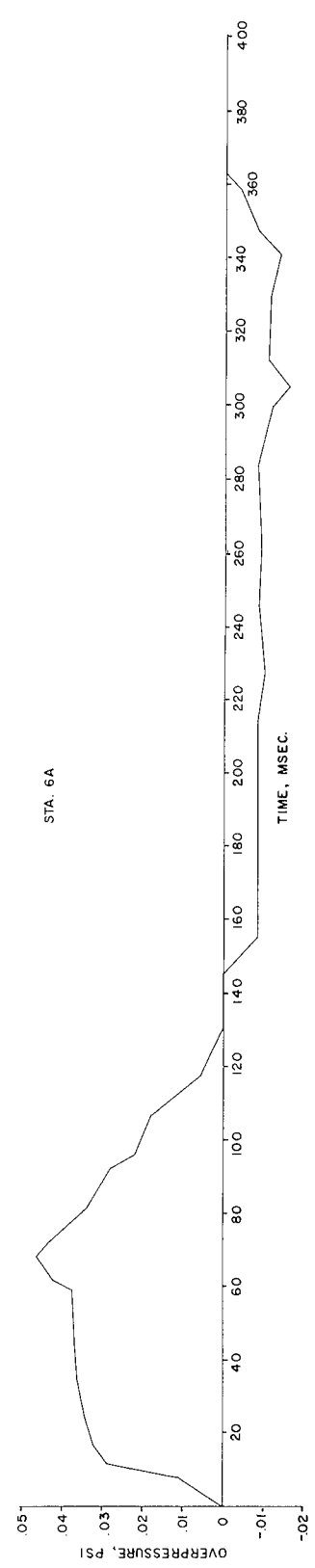
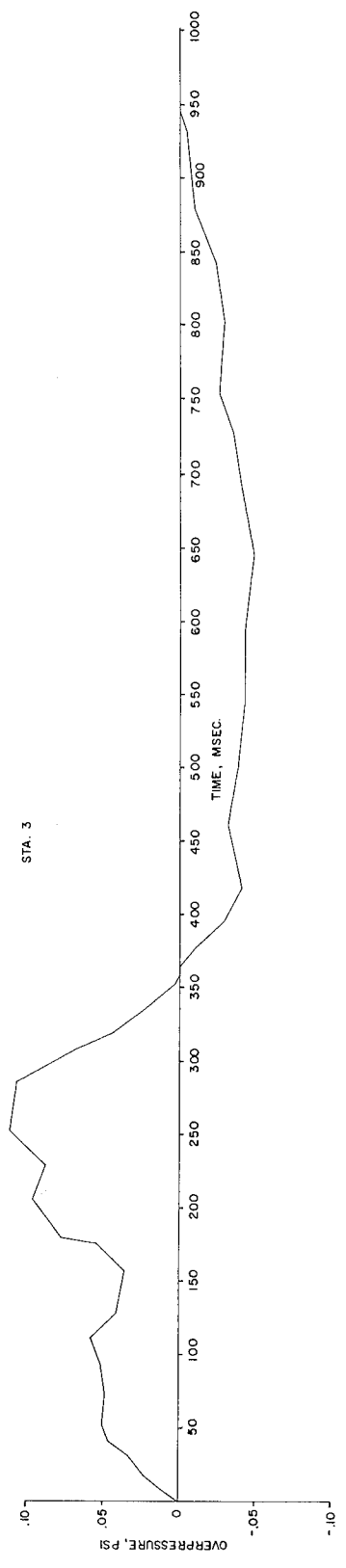


Figure 2.3 Pressure Records

STA. 7A

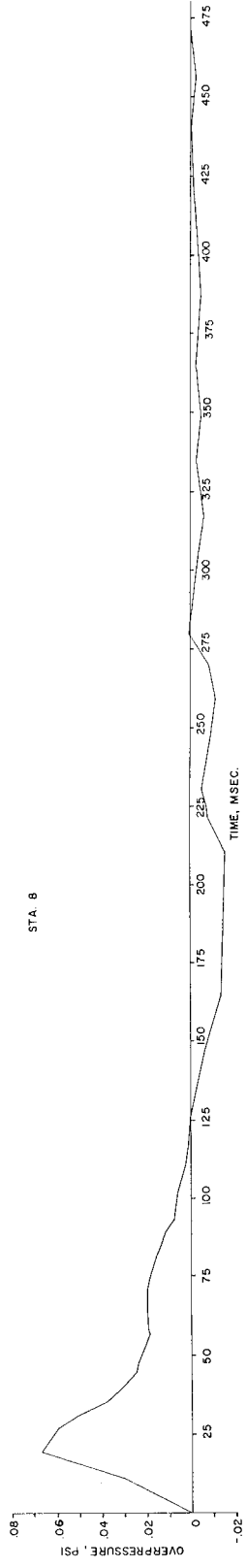
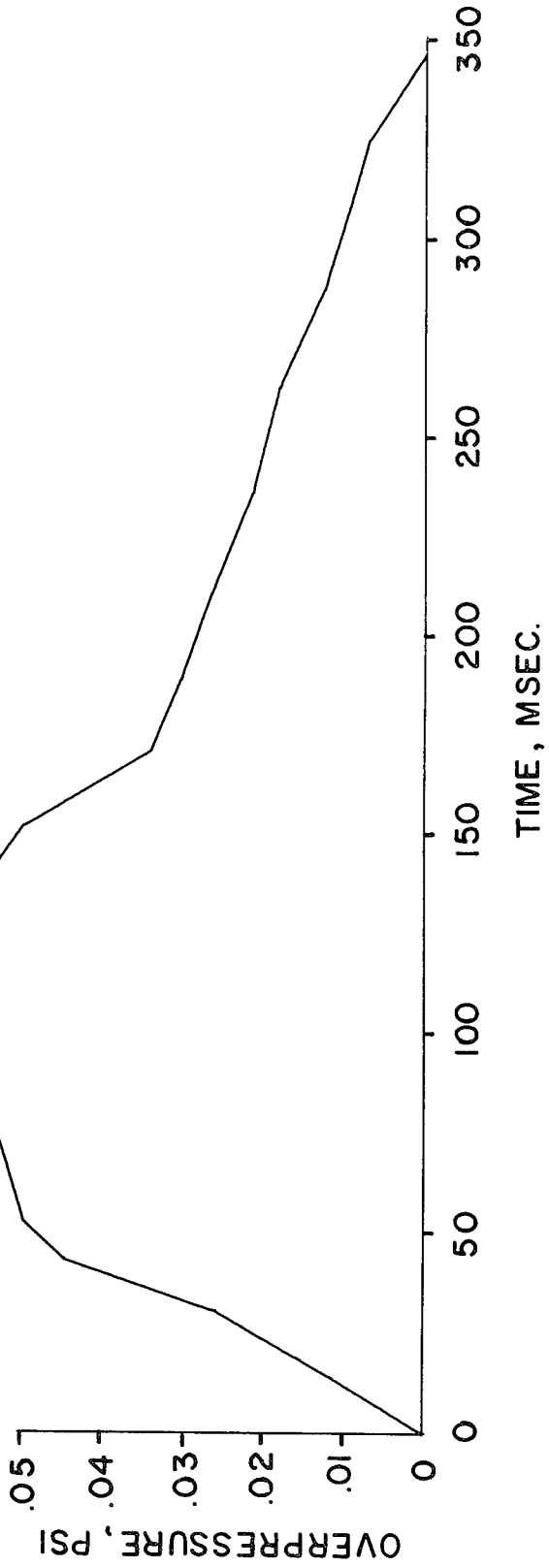


Figure 2.4 Pressure Records

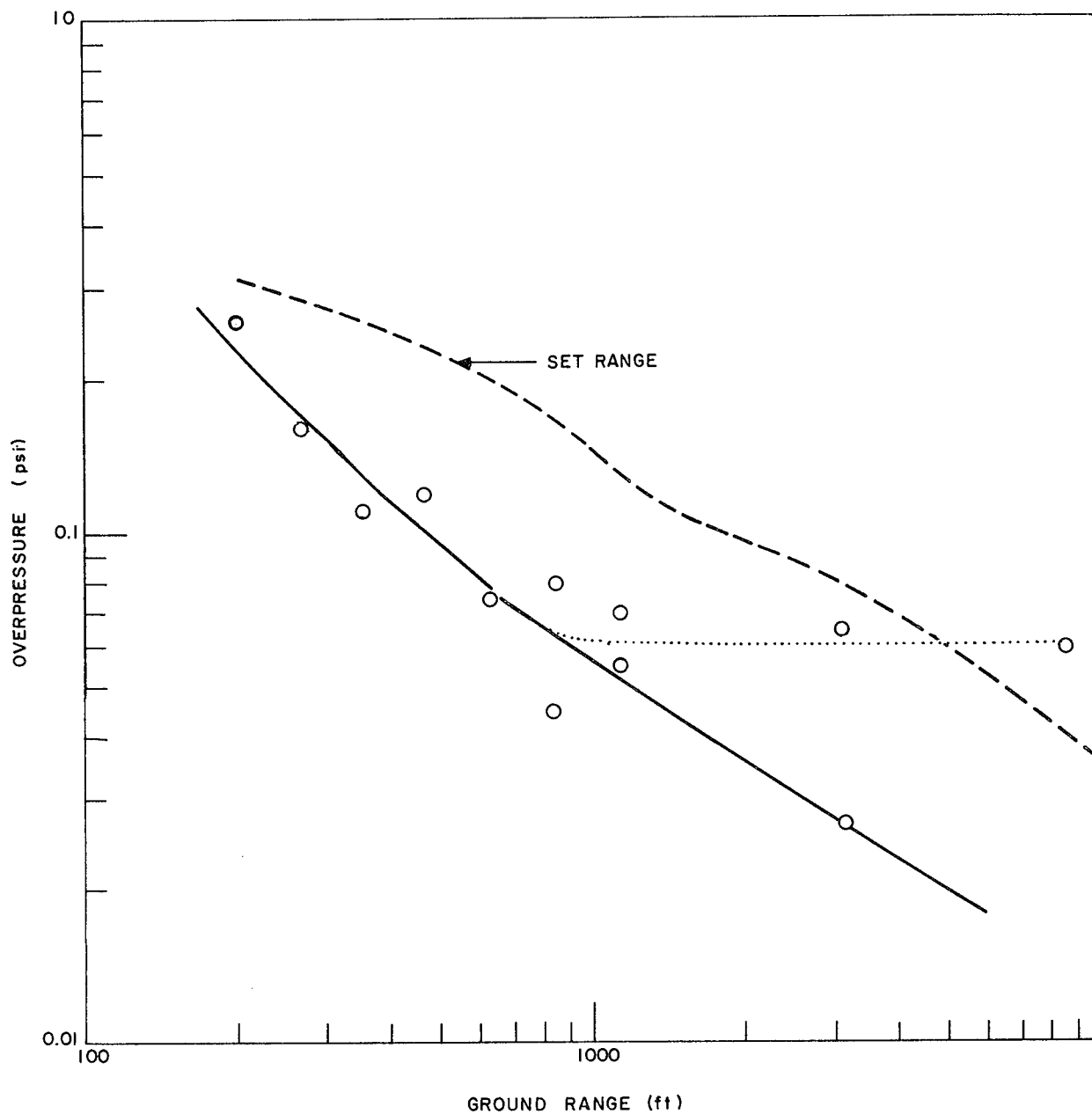


Figure 2.5 Maximum Overpressure versus Ground Range

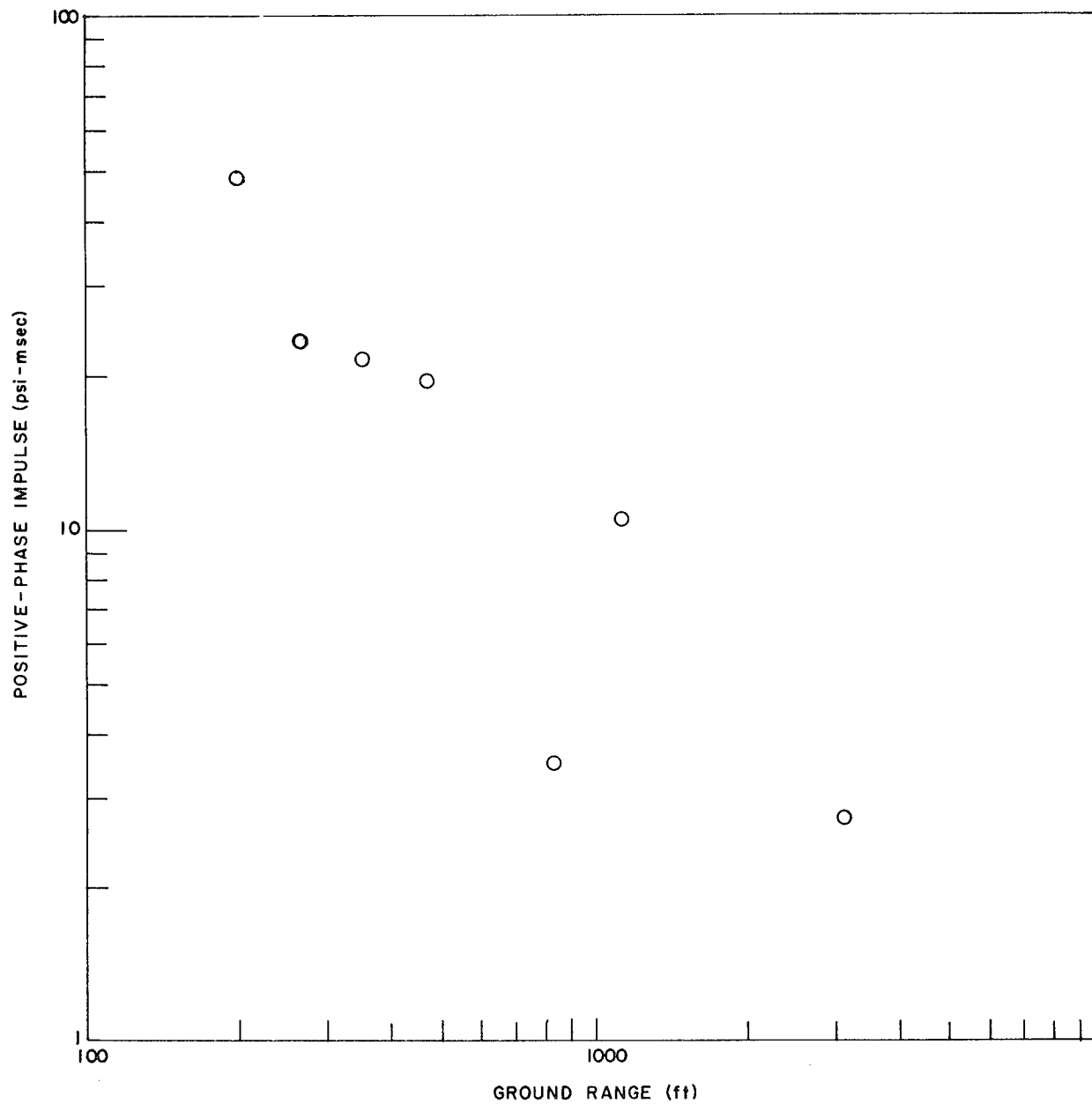


Figure 2.6 Positive Impulse versus Ground Range

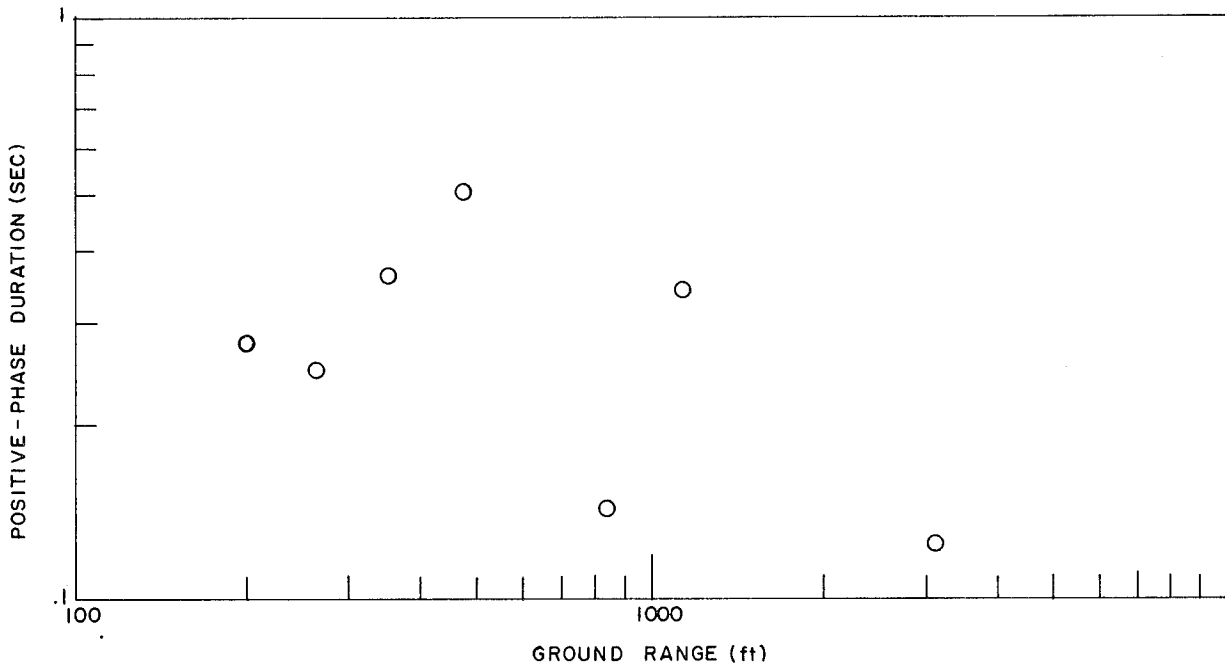
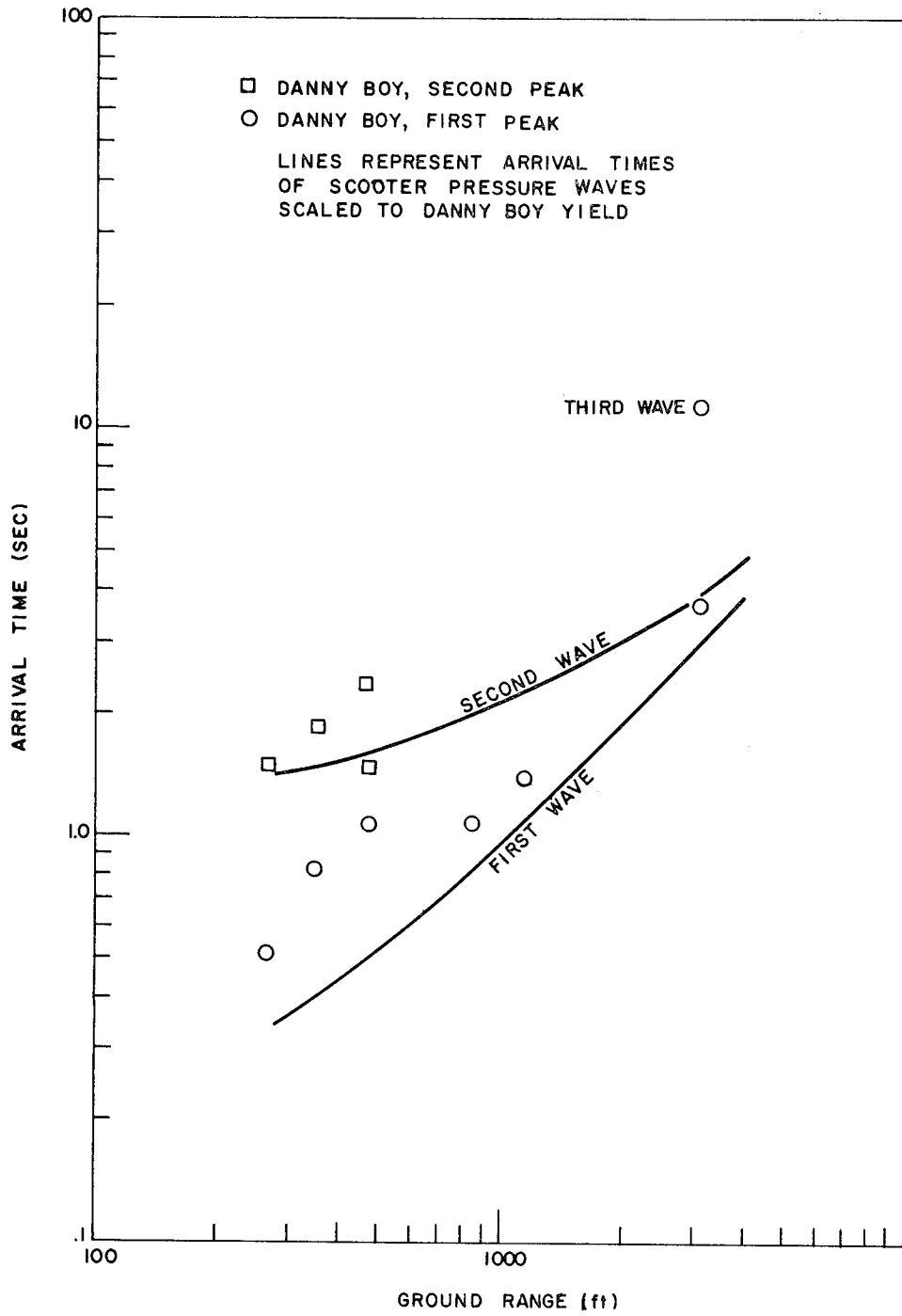


Figure 2.7 Positive Phase Duration versus Ground Range



## CHAPTER 3

### DISCUSSION

#### 3.1 WAVE SHAPE

The most unusual thing about the waveforms from the Danny Boy detonation is that upon first examination they showed only a single pressure pulse, that shown in Figures 2.1 to 2.4. This is in contrast to waveforms from high-explosive detonations in basalt and desert alluvium (Buckboard Shot 12 and Scooter) at an only slightly greater burst depth; these have shown two distinct pulses, the second one dominant.

Initial plotting of the arrival times of these waves (Figure 2.8) only added to the confusion, since they fell between those of the first and second waves of Scooter scaled to the Danny Boy yield. In addition, the arrival time at 3100 feet (Station 8) was far too late to be directly associated with the waves whose arrivals were noted from the closer stations.

Careful scrutiny revealed barely discernable signals following the main signals at the four closest stations (Stations 1, 2, 3, and 4). Plots show (Figure 2.8) that these waves follow the preceding ones by about the same interval that the Scooter waves followed the first. This suggested that the main signals were ground-shock-induced waves, and that the very weak secondary waves were caused by venting gases. These latter waves were too much attenuated to be observed at Stations 6, 7, and 8.

Similarly, close examination of the record from Station 8 shows a very weak earlier wave whose amplitude was only 0.027 psi. Its arrival time was in agreement with arrivals of the dominant (first) wave at the other stations. This fact, together with the observation that the second wave had disappeared at even closer stations, leads to the conclusion that the weaker wave was the first or ground-shock-induced wave, that the second wave had disappeared, and that the third and dominant signal at Station 8 must have had a different origin. Since amplitudes at Stations 8 and 9 are nearly the same, the wave must have attenuated very slowly. The arrival of the third wave at Station 8

at 11.25 seconds and its amplitude justify its being attributed to a 2400-pound microbarograph calibration charge detonated 11,800 feet away at zero time. Obviously, the values from this wave cannot be considered further in relation to Project Danny Boy.

### 3.2 PEAK OVERPRESSURE

Peak overpressures of the main (first) wave as a function of ground range scaled to a 1-pound charge are shown in Figure 3.1. The relatively constant overpressure beyond  $12 \text{ ft/lb}^{1/3}$  represents the third wave, attributed to the microbarograph calibration shot. Also shown in Figure 3.1 is a curve representing expected pressures from the second or gas-venting pulse based on high-explosive data at the same scaled burst depth. For this pulse, there was essentially no difference in peak overpressure from high explosives detonated in alluvium and basalt, and it was upon the combined data that the estimates of expected overpressures had been based. Since the arrival times (Figure 2.8) were bracketed by the arrival times of first and second pulses of Project Scooter scaled to Danny Boy yield, they could not be used without the later arrivals at the three closest stations to indicate conclusively whether the single pulse shown on the Danny Boy records represented a ground-shock-induced air shock or a gas-venting pulse.

An examination of Project Buckboard data shows that the first ("front porch") wave from Buckboard Shot 11 at a scaled burst depth of  $0.75 \text{ ft/lb}^{1/3}$  is given by  $p = 1.2 r^{-.97}$ , where  $r$  is the scaled ground range. For Buckboard Shot 12 at a scaled burst depth of  $1.25 \text{ ft/lb}^{1/3}$ , the relationship was  $p = 0.9 r^{-1.1*}$ . Interpolation between these relationships gives a predicted "front porch" wave for Danny Boy of about  $p = 0.95 r^{-1.1}$ . This relationship is shown in Figure 3.1. The close agreement of the measured data to this prediction is taken as final evidence that the dominant pulse measured is, in fact, the ground-shock-induced air shock. A best-fit pressure-distance relationship for the measured pressures is about  $p = 0.32 r^{-.70}$ . Even with this spread between measured and predicted pressures, it is clear (1) that peak pressures from the nuclear shot are less than were predicted from high-explosive data and (2) that the pressure attenuates less rapidly from the nuclear detonation than it did from high-explosive detonations in the same medium and at comparable burst depth.

---

\*Pressures in the first wave in alluvium are less; the corresponding relationship for Scooter being  $p = 0.52 r^{-1.1}$ .

Peak overpressure values for the gas-venting pulse at the three closest stations are also shown in Figure 3.1. These signals are so small a part of set range that great precision cannot be obtained. They do show that the gas-venting pulse is only about one-third as large as the ground-shock-induced pulse. This is in contrast to high-explosive experience where the ground-shock-induced pulse at nearly the same scaled burst depth is about one-third of the gas-venting pulse.

All values from the gage at Station 6A are low, but a careful re-evaluation revealed no reason for modifying the numbers shown.

### 3.3 POSITIVE-PHASE IMPULSE

Although it is possible to define the peak overpressure associated with each portion of the blast wave, it is not worthwhile to define their positive-phase impulses. This is because the amplitudes of all but the dominant wave of Danny Boy are so low (only a few mils on the original record) and such a small portion of set range that scatter in data is especially large. Also, comparisons with high-explosive data are difficult, because there the "front porch" typically runs into the dominant wave, making it impossible to define them separately. Therefore, it was to be expected that the values measured on Project Danny Boy, consisting only of impulse from the ground-shock-induced wave, would fall below the impulses predicted from high-explosive waves, which are made up of contributions from both the ground-shock-induced and gas-venting waves (Figure 3.2).

### 3.4 POSITIVE-PHASE DURATION

As in the case of the positive-phase impulse, only the positive-phase duration of the dominant wave of Danny Boy can be compared with the total positive-phase duration from high explosives, which includes both first and second waves. Danny Boy results and a comparison with total positive-phase duration from high-explosive tests scaled to 1 lb are shown in Figure 3.3.

### 3.5 EXPLOSIVE IMPLICATIONS

Close-in air blast from above-ground detonations is known with sufficient accuracy that estimates of explosive yield can be made from pressure-distance observations. Only slightly less accurate estimates can be made for

high-explosive detonations underground where the gas-venting pulse is dominant. For nuclear charges in basalt at deeper depths below ground, as evidenced by Danny Boy where the dominant pulse is ground-shock-induced, such estimates appear to have little meaning. Because the dominant wave from the nuclear detonation appears to attenuate less rapidly than the first wave from high-explosive detonations, estimates of Danny Boy yield vary with the ground distance of the peak pressure observations from 75 tons near the closest station to 325 tons at 1120 feet.

The very small gas-pressure pulse from the Danny Boy event may be attributed to the almost total lack of moisture in the basalt. More significant, second pulses may be expected from detonations in media with greater water content or in media (such as limestone) where chemical reactions can be expected to produce higher gas pressures. These measurements are useful in determining the relative importance of gas pressure as a mechanism of crater formation and, hence, should be continued on nuclear cratering events.

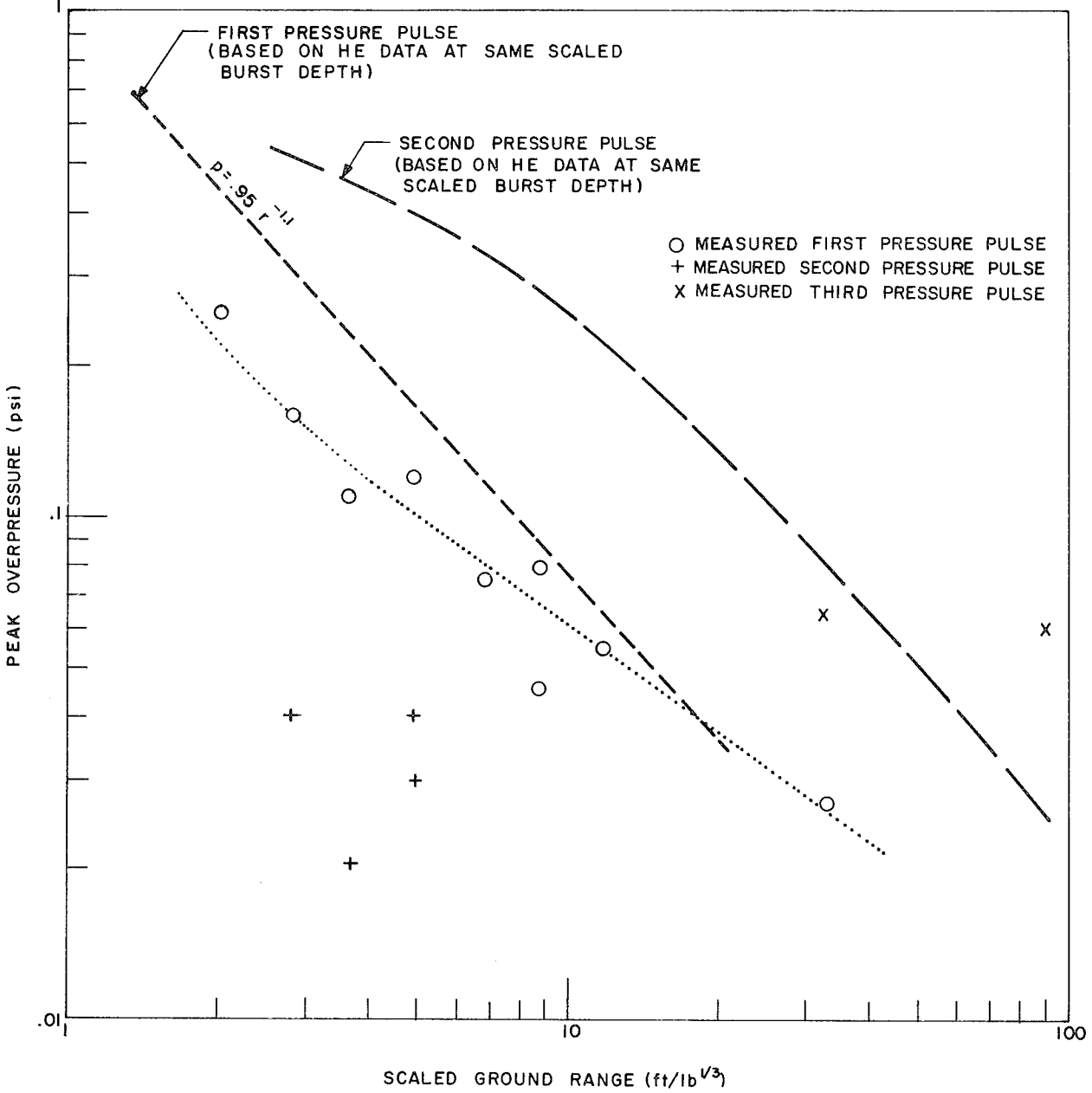


Figure 3.1 Maximum Overpressure versus Scaled Ground Range

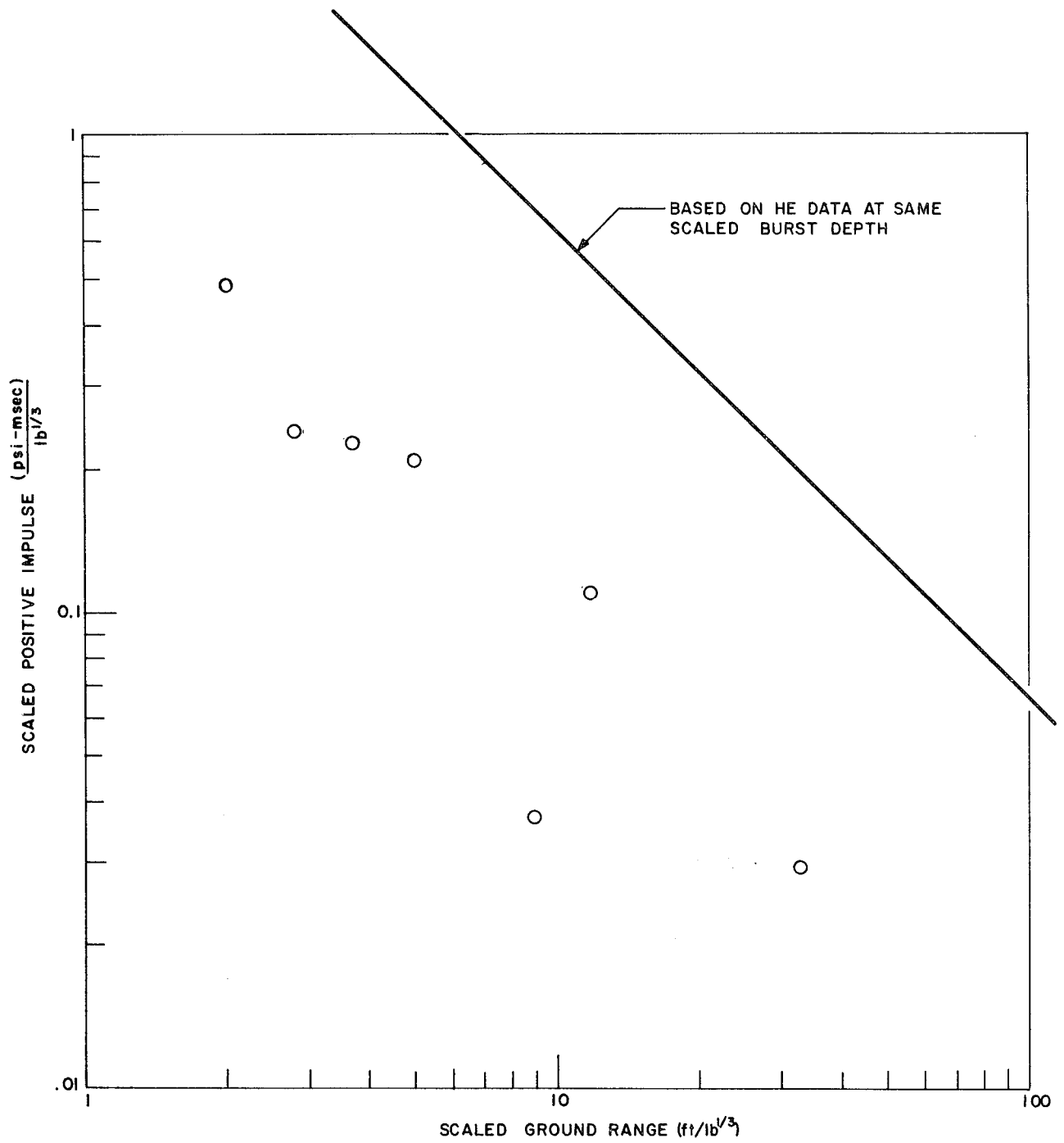


Figure 3.2 Scaled Positive Impulse versus Scaled Ground Range

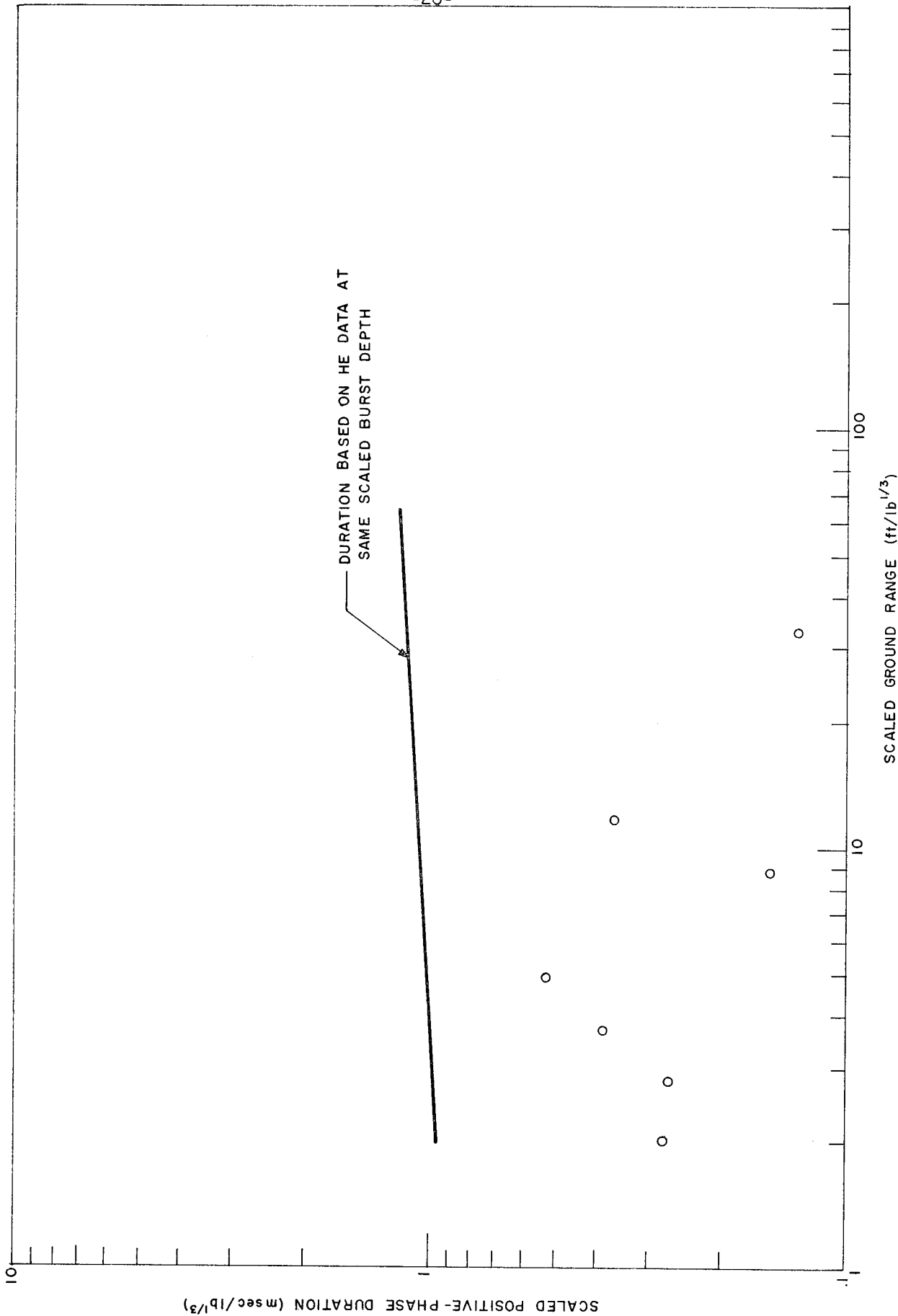


Figure 3.3 Scaled Positive Phase Duration versus Scaled Ground Range

CHAPTER 4

CONCLUSIONS

The dominant pressure pulse from the Danny Boy event is shown to have been the ground-shock-induced air blast. Only a very small pressure pulse resulting from the venting of explosive gases was recorded at the three closest stations. Since a significant pulse results from the venting gases of high-explosive detonations at the same scaled burst depths, this is the most pronounced difference between close-in air blast from nuclear and high-explosive detonations underground. Peak overpressures from venting gases were only about one-third those of the ground-shock-induced pulse, while with high explosives at the same scaled burst depths they were about three times the ground-shock-induced pressure. This drastic reduction in venting-gas pressures accounts almost entirely for the fact that the close-in blast from nuclear charges is suppressed more by charge burial than that from high-explosive charges.

The peak ground-shock-induced air pressure is shown to attenuate less rapidly for a nuclear charge in basalt than for high-explosive charges in the same medium.

The TNT equivalent of the blast from Project Danny Boy can be deduced only from the peak overpressures of the ground-shock-induced wave. Since the waves are attenuating at different rates, the apparent blast yield ranges from 75 tons at the closer stations to about 325 tons near the station at 1120 feet.

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BOEING	The Boeing Company, Aero-Space Division, Seattle Attn: R. H. Carlson
EG&G	Edgerton, Germeshausen, and Grier, Inc. , Boston, Las Vegas, and Santa Barbara
ERDL	U. S. Army Engineer Research & Development Laboratory, Fort Belvoir
LRL	Lawrence Radiation Laboratory, Livermore
NDL	U. S. Army Chemical Corps., Nuclear Defense Laboratory, Maryland
REECo	Reynolds Electrical and Engineering Co. , Las Vegas
SC	Sandia Corporation, Albuquerque
SRI	Stanford Research Institute, Menlo Park
UCLA	University of California, Los Angeles
USC&GS	Coast and Geodetic Survey, Washington, D. C. and Las Vegas
USPHS	U. S. Public Health Service, Las Vegas
USWB	U. S. Weather Bureau, Las Vegas
WES	USA C of E Waterways Experiment Station, Vicksburg

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- 9- 11 Commanding General, U.S. Continental Army Command, Ft. Monroe, Va.
- 12 Director of Special Weapons Development Office, Headquarters CONARC, Ft. Bliss, Tex. ATTN: Capt. Chester I. Peterson
- 13 President, U.S. Army Artillery Board, Ft. Sill, Okla.
- 14 President, U.S. Army Air Defense Board, Ft. Bliss, Tex.
- 15 Commandant, U.S. Army Command & General Staff College, Ft. Leavenworth, Kansas. ATTN: ARCHIVES
- 16 Commandant, U.S. Army Armored School, Ft. Knox, Ky.
- 17 Commandant, U.S. Army Artillery and Missile School, Ft. Sill, Okla. ATTN: Combat Development Department
- 18 Commandant, U.S. Army Aviation School, Ft. Rucker, Ala.
- 19 Commandant, U.S. Army Infantry School, Ft. Benning, Ga. ATTN: C.D.S.
- 20 Commandant, U.S. Army Ordnance and Guided Missile School, Redstone Arsenal, Ala.
- 21 Commanding General, Chemical Corps Training Comd., Ft. McClellan, Ala.
- 22 Commanding General, The Engineer Center, Ft. Belvoir, Va. ATTN: Asst. Cndt, Engr. School
- 23 Director, Armed Forces Institute of Pathology, Walter Reed Army Med. Center, 625 16th St., NW, Washington 25, D.C.
- 24 Commanding Officer, Army Medical Research Lab., Ft. Knox, Ky.
- 25 Commandant, Walter Reed Army Inst. of Res., Walter Reed Army Medical Center, Washington 25, D.C.
- 26 Commanding General, Qm R&E Comd., QM R&E Cntr., Natick, Mass. ATTN: Tech. Library
- 27- 28 Commanding Officer, Chemical Warfare Lab., Army Chemical Center, Md. ATTN: Tech. Library
- 29 Commanding General, Engineer Research and Dev. Lab., Ft. Belvoir, Va. ATTN: Chief, Tech. Support Branch
- 30 Director, Waterways Experiment Station, P.O. Box 631, Vicksburg, Miss. ATTN: Library
- 31 Commanding Officer, Picatinny Arsenal, Dover, N.J. ATTN: ORDBB-TK
- 32 Commanding Officer, Diamond Ord. Fuze Labs., Washington 25, D.C. ATTN: Chief, Nuclear Vulnerability Br. (230)
- 33- 34 Commanding General, Aberdeen Proving Grounds, Md. ATTN: Director, Ballistics Research Laboratory
- 35 Commanding General, Frankford Arsenal, Bridge and Tacony St., Philadelphia, Pa.
- 36 Commanding Officer, Watervliet Arsenal, Watervliet, New York. ATTN: ORDBF-RR
- 37 Commander, Army Rocket and Guided Missile Agency, Redstone Arsenal, Ala. ATTN: Tech Library
- 38 Commanding General, White Sands Missile Range, N. Mex. ATTN: ORDBS-OM
- 39 Commander, Army Ballistic Missile Agency, Redstone Arsenal, Ala. ATTN: ORDAB-HT

- 40 Commanding General, Ordnance Tank Automotive Command, Detroit Arsenal, Centerline, Mich. ATTN: ORDMC-RO
- 41 Commanding General, Ordnance Weapons Command, Rock Island, Ill.
- 42 Commanding General, U.S. Army Electronic Proving Ground, Ft. Huachuca, Ariz. ATTN: Tech. Library
- 43 Commanding General, USA Combat Surveillance Agency, 1124 N. Highland St., Arlington, Va.
- 44 The Research Analysis Corp., 6955 Arlington Rd., Bethesda 14, Md.
- 45 Commanding General, U. S. ORD Special Weapons-Ammunition Command, Dover, N.J.

#### NAVY ACTIVITIES

- 46- 47 Chief of Naval Operations, D/N, Washington 25, D.C. ATTN: OP-03EG
- 48 Chief of Naval Operations, D/N, Washington 25, D.C. ATTN: OP-75
- 49- 50 Chief of Naval Research, D/N, Washington 25, D.C. ATTN: Code 811
- 51- 53 Chief, Bureau of Naval Weapons, D/N, Washington 25, D.C. ATTN: DLI-3
- 54- 58 Chief, Bureau of Naval Weapons, D/N, Washington 25, D.C. ATTN: RAAD-25
- 59 Chief, Bureau of Ordnance, D/N, Washington 25, D.C.
- 60 Chief, Bureau of Ships, D/N, Washington 25, D.C. ATTN: Code 423
- 61 Chief, Bureau of Yards and Docks, D/N, Washington 25, D.C. ATTN: D-440
- 62 Director, U.S. Naval Research Laboratory, Washington 25, D.C. ATTN: Mrs. Katherine H. Cass
- 63- 64 Commander, U.S. Naval Ordnance Laboratory, White Oak, Silver Spring 19, Md.
- 65 Director, Material Lab. (Code 900), New York Naval Shipyard, Brooklyn 1, N.Y.
- 66 Commanding Officer and Director, Navy Electronics Laboratory, San Diego 52, Calif.
- 67 Commanding Officer, U.S. Naval Mine Defense Lab., Panama City, Fla.
- 68- 69 Commanding Officer, U.S. Naval Radiological Defense Laboratory, San Francisco, Calif. ATTN: Tech. Info. Div.
- 70- 71 Commanding Officer and Director, U.S. Naval Civil Engineering Laboratory, Port Hueneme, Calif. ATTN: Code L31
- 72 Commanding Officer, U.S. Naval Schools Command, U.S. Naval Station, Treasure Island, San Francisco, Calif.
- 73 Superintendent, U.S. Naval Postgraduate School, Monterey, Calif.
- 74 Commanding Officer, U.S. Fleet Sonar School, U.S. Naval Base, Key West, Fla.
- 75 Commanding Officer, U.S. Fleet Sonar School, San Diego 47, Calif.
- 76 Officer-in-Charge, U.S. Naval School, CEC Officers, U.S. Naval Construction Bn. Center, Port Hueneme, Calif.
- 77 Commanding Officer, Nuclear Weapons Training Center, Atlantic, U.S. Naval Base, Norfolk 11, Va. ATTN: Nuclear Warfare Dept.
- 78 Commanding Officer, Nuclear Weapons Training Center, Pacific, Naval Station, San Diego, Calif.
- 79 Commanding Officer, U.S. Naval Damage Control Tng. Center, Naval Base, Philadelphia 12, Pa. ATTN: ABC Defense Course
- 80 Commanding Officer, Air Development Squadron 5, VX-5, China Lake, Calif.

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- 81 Commanding Officer, Naval Air Material Center, Philadelphia 12, Pa. ATTN: Technical Data Br.
- 82 Commanding Officer U.S. Naval Air Development Center, Johnsville, Pa. ATTN: NAS, Librarian
- 85 Commanding Officer, U.S. Naval Medical Research Institute, National Naval Medical Center, Bethesda, Md.
- 84- 85 Commanding Officer and Director, David W. Taylor Model Basin, Washington 7, D.C. ATTN: Library
- 86 Commanding Officer and Director, U.S. Naval Engineering Experiment Station, Annapolis, Md.
- 87 Commander, Norfolk Naval Shipyard, Portsmouth, Va. ATTN: Underwater Explosions Research Division
- 88 Commandant, U.S. Marine Corps, Washington 25, D.C. ATTN: Code AO3H
- 89 Director, Marine Corps Landing Force, Development Center, MCS, Quantico, Va.
- 90- 98 Chief, Bureau of Naval Weapons, Navy Department, Washington 25, D.C. ATTN: RRL2
- 99 Commander-in-Chief, U.S. Pacific Fleet, Fleet Post Office, San Francisco, Calif.
- 100 Commanding General, Fleet Marine Force, Pacific, Fleet Post Office, San Francisco, Calif.

AIR FORCE ACTIVITIES

- 101 Air Force Technical Application Center, HQ. USAF, Washington 25, D. C.
- 102 Hq. USAF, ATTN: Operations Analysis Office, Office, Vice Chief of Staff, Washington 25, D. C.
- 103 Director of Civil Engineering, HQ. USAF, Washington 25, D.C. ATTN: AFCEE-ES
- 104-108 HQ. USAF, Washington 25, D.C. ATTN: AFCIN-3D1
- 109 Director of Research and Development, DCS/D, HQ. USAF, Washington 25, D.C. ATTN: Guidance and Weapons Div.
- 110 The Surgeon General, HQ. USAF, Washington 25, D.C. ATTN: Bio.-Def. Pre. Med. Division
- 111 Commander, Tactical Air Command, Langley AFB, Va. ATTN: Doc. Security Branch
- 112 Commander, Air Defense Command, Ent AFB, Colorado. ATTN: Operations Analysis Section, ADCOA
- 113 Commander, Hq. Air Research and Development Command, Andrews AFB, Washington 25, D.C. ATTN: RDRWA
- 114 Commander, Air Force Ballistic Missile Div. HQ. ARDC, Air Force Unit Post Office, Los Angeles 45, Calif. ATTN: WDSOT
- 115 Commander, Second Air Force, Barksdale AFB, La. ATTN: Operations Analysis Office
- 116-117 Commander, AF Cambridge Research Center, L. G. Hanscom Field, Bedford, Mass. ATTN: CR&ST-2
- 118-122 Commander, Air Force Special Weapons Center, Kirtland AFB, Albuquerque, N. Mex. ATTN: Tech. Info. & Intel. Div.
- 123-124 Director, Air University Library, Maxwell AFB, Ala.
- 125 Commander, Lowry Technical Training Center (TW), Lowry AFB, Denver, Colorado.
- 126 Commandant, School of Aviation Medicine, USAF Aerospace Medical Center (ATC), Brooks AFB, Tex. ATTN: Col. G. L. Hekhuis
- 127-129 Commander, Wright Air Development Center, Wright-Patterson AFB, Dayton, Ohio. ATTN: WCACT (For WCOSI)
- 130-131 Director, USAF Project RAND, VIA: USAF Liaison Office, The RAND Corp., 1700 Main St., Santa Monica, Calif.
- 132 Commander, Rome Air Development Center, ARDC, Griffiss AFB, N.Y. ATTN: Documenta Library, RCSSL-1
- 133 Commander, Air Technical Intelligence Center, USAF, Wright-Patterson AFB, Ohio. ATTN: AFCIN-4Bla, Library
- 134 Assistant Chief of Staff, Intelligence, HQ. USAFE, APO 633, New York, N. Y. ATTN: Directorate of Air Targets
- 135 Commander-in-Chief, Pacific Air Forces, APO 953, San Francisco, Calif. ATTN: PFCIE-MB, Base Recovery

OTHER DEPARTMENT OF DEFENSE ACTIVITIES

- 136 Director of Defense Research and Engineering, Washington 25, D.C. ATTN: Tech. Library
- 137 Chairman, Armed Services Explosives Safety Board, DOD, Building T-7, Gravelly Point, Washington 25, D.C.
- 138 Director, Weapons Systems Evaluation Group, Room 1E880, The Pentagon, Washington 25, D.C.
- 139-142 Chief, Defense Atomic Support Agency, Washington 25, D.C. ATTN: Document Library

- 143 Commander, Field Command, DASA, Sandia Base, Albuquerque, N. Mex.
- 144 Commander, Field Command, DASA, Sandia Base, Albuquerque, N. Mex. ATTN: FCTG
- 145-146 Commander, Field Command, DASA, Sandia Base, Albuquerque, N. Mex. ATTN: FCWT
- 147 Administrator, National Aeronautics and Space Administration, 1520 "H" St., N.W., Washington 25, D.C. ATTN: Mr. R. V. Rhode
- 148 Commander-in-Chief, Strategic Air Command, Offutt AFB, Neb. ATTN: OAWS
- 149 U.S. Documents Officer, Office of the United States National Military Representative - SHAPE, APO 55, New York, N.Y.

ATOMIC ENERGY COMMISSION ACTIVITIES

- 150-152 U.S. Atomic Energy Commission, Technical Library, Washington 25, D.C. ATTN: For DMA
- 153-154 Los Alamos Scientific Laboratory, Report Library, P.O. Box 1663, Los Alamos, N. Mex. ATTN: Helen Redman
- 155-159 Sandia Corporation, Classified Document Division, Sandia Base, Albuquerque, N. Mex. ATTN: H. J. Smyth, Jr.

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- 173-178 Chief, Air Force Technical Applications Center, Washington 25, D.C.
- 179-193 Commander, Field Command, Defense Atomic Support Agency, Sandia Base, Albuquerque, N. Mex. ATTN: FCWT
- 194-198 Headquarters, DOD Test Organization, Field Command, DASA, P. O. Box 207, Mercury, Nev.
- 199 Commander, Air Force Cambridge Research Lab., Laurence G. Hanscom Field, Bedford, Mass.
- 200-201 Holmes & Narver, Inc., 849 South Broadway, Los Angeles 14, Calif. ATTN: Project Officer, Proj. 3.1
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- 206-207 United ElectroDynamics, Inc., 200 Allendale Road, Pasadena, Calif.
- 208-209 Director, Waterways Experiment Station, Jackson, Miss. ATTN: Project Officer, Proj. 9.1
- 210-211 Los Alamos Scientific Laboratory, P. O. Box 1663, Los Alamos, N. Mex.
- 212-213 U. S. Atomic Energy Commission, Albuquerque Operations Office, P. O. Box 5400, Albuquerque, N. Mex. ATTN: K. F. Hertford
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- 234 Battelle Memorial Institute, 505 King Avenue, Columbus 1, Ohio. ATTN: Dr. H. W. Russell
- 235 Director, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.
- 236-237 University of California, Lawrence Radiation Laboratory, Technical Information Division, Berkeley 4, Calif. ATTN: Dr. R. K. Wakerling
- 238-272 University of California, Lawrence Radiation Laboratory, Technical Information Division, P. O. Box 808, Livermore, Calif. ATTN: C. G. Craig
- 273-276 Union Carbide Nuclear Company, X-10 Laboratory Records Department, P. O. Box X, Oak Ridge, Tenn.
- 277 Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Ill. ATTN: Dr. Hoylande D. Young
- 278 University of California, Lawrence Radiation Laboratory, Technical Information Div., P. O. Box 808, Livermore, Calif. ATTN: Clovis Craig (For Test Group Div., Mercury, Nev.)

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- 287 U. S. Atomic Energy Commission, San Francisco Operations Office, 2111 Bancroft Way, Berkeley 4, Calif. ATTN: Tech. Serv. Div.
- 288 U. S. Geological Survey, Washington 25, D. C. ATTN: Dr. Thomas B. Nolan
- 289 U. S. Geological Survey, Tepeco Building 25, Federal Center, Denver 25, Colo. ATTN: F. W. Stead
- 290 U. S. Public Health Service, Division of Radiological Health, Rm. 5094 South Building, 4th and C Streets, S.W., Washington 25, D. C. ATTN: James G. Terrill, Jr.
- 291 Brookhaven National Laboratory, Technical Information Division, Upton, Long Island, N. Y. ATTN: Classified Doc. Group
- 292-293 U. S. Army Chemical Corps, Nuclear Defense Laboratory, U. S. Army Proving Ground, Md.
- 294-295 University of Michigan, Central Document Control Station, Rm. 2202, Administrative Office, Ann Arbor, Mich. ATTN: VESLAC
- 296-299 Sandia Corp., Sandia Base, P. O. Box 5800, Albuquerque, N. Mex. ATTN: Records Management and Services Dept.
- 300 Sandia Corp., Livermore Branch, Livermore, Calif. ATTN: Document Control Section
- 301 U. S. Bureau of Mines, Washington 25, D. C. ATTN: John E. Crawford, Chief Nuclear Engineer
- 302-304 Laboratory of Nuclear Medicine and Radiation Biology, School of Medicine, Univ. of California, Los Angeles, 900 Veteran Ave., Los Angeles 24, Calif. ATTN: Harland B. Thompson
- 305-306 Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill. ATTN: Document Library
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- 312-316 U. S. Atomic Energy Commission, Technical Library, Washington 25, D. C.
- 317 U. S. Army Engineer Research and Development Laboratory, Ft. Belvoir, Va. ATTN: S. E. Dwornik
- 318 U. S. Coast and Geodetic Survey, Seismological Field Survey, 133 Herman St., San Francisco, Calif. ATTN: William K. Cloud
- 319-321 Director, U. S. Coast and Geodetic Survey, U. S. Dept. of Commerce, Washington 25, D. C. ATTN: Dr. Dean Carder
- 322 U. S. Atomic Energy Commission, Nevada Operations Office, P. O. Box 1676, Las Vegas, Nev. ATTN: Thomas Pierce, U. S. Coast and Geodetic Survey
- 323 U. S. Atomic Energy Commission, Division of Technical Information Extension, Oak Ridge, Tenn. (Master)
- 324-405 U. S. Atomic Energy Commission, Division of Technical Information Extension, Oak Ridge, Tenn. (Surplus)

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