[redacted]

OPERATION REDWING

A PRELIMINARY REPORT

[redacted] (ERIT)

Submitted by Task Group 7.1

[redacted]

Rf Sym: 3466-139130

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CENTRAL M & R
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21 JULY 1956

COL No.	
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CONTENTS

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[redacted] (ERIE)

INTRODUCTION

This is a preliminary report, and therefore, does not give either complete or final results of the work of the various projects. No information on the construction of the device is included in order that the classification may be kept to Secret Restricted Data.

The [redacted] was detonated as the Erie shot on a 300 foot tower near the center of Runit Island, Eniwetok Atoll, at 0615:29.3, May 31, 1956.

DELETED

[redacted]

[redacted]

PART I

GENERAL INFORMATION

[redacted]

[redacted]

[redacted] (ERIE)

ENIWETOK OBSERVED WEATHER FOR 31 MAY 1956
ERIE. DETONATION TIME 0615M

Sea Level Pressure	1009.1 mb
Free Air Surface Temperature	80.5°F
Dew Point Temperature	73.5°F (Wet Bulb 75.4°F)
Relative Humidity	80.2%
Surface Wind	100° at 12 kts; gusts to 15 kts
Visibility	Over 10 miles

CLOUDS

1/10 cumulus; bases estimated 1500 feet (no tops reported - estimated to be at 3500-4000 feet approximately 10 miles east of station).

2/10 altocumulus; bases estimated 19,000 feet; thin but opaque (possibly 1000 feet thick).

10/10 cirrostratus; bases estimated 30,000 feet; no tops reported (9/10 transparent).

WEATHER

No showers reported in local area. In general appeared clear and exceptionally good visibility. No haze apparent.

STATE OF SEA

Ocean Side: Wave heights 4.5 feet, period 5 seconds, direction 090°.

Lagoon Side: Wave heights less than 1 foot.

ENIWETOK SOUNDING (301700Z)

Pressure (Millibars)	Height (Feet)	Temperature (°C)	Dew Point (°C)
1000	280	26.5	21.6
850	4,920	17.3	09.7

6

Pressure (Millibars)	Height (Feet)	Temperature (°C)	Dew Point (°C)
796	6,791	16.8	02.5
700	10,310	10.8	-07.4
693	10,630	10.3	-07.8
600	14,440	-00.9	-16.2
500	19,130	-09.2	-23.5
423	23,327	-15.3	-29.2
417	23,688	-14.1	-28.2
400	24,720	-16.4	-30.3
300	31,590	-33.2	-45.6
296	31,824	-34.1	-46.4
200	40,480	-56.3	M
150	46,300	-68.2	M
100	54,070	-78.7	M
98	54,462	-78.7	M
83	57,611	-76.0	M
76	59,383	-68.8	M
73	60,072	-71.5	M
64	62,664	-71.1	M
55	65,617	-62.7	M
50	67,580	-61.6	M
25	81,896	-54.0	M
14	94,449	-44.1	M

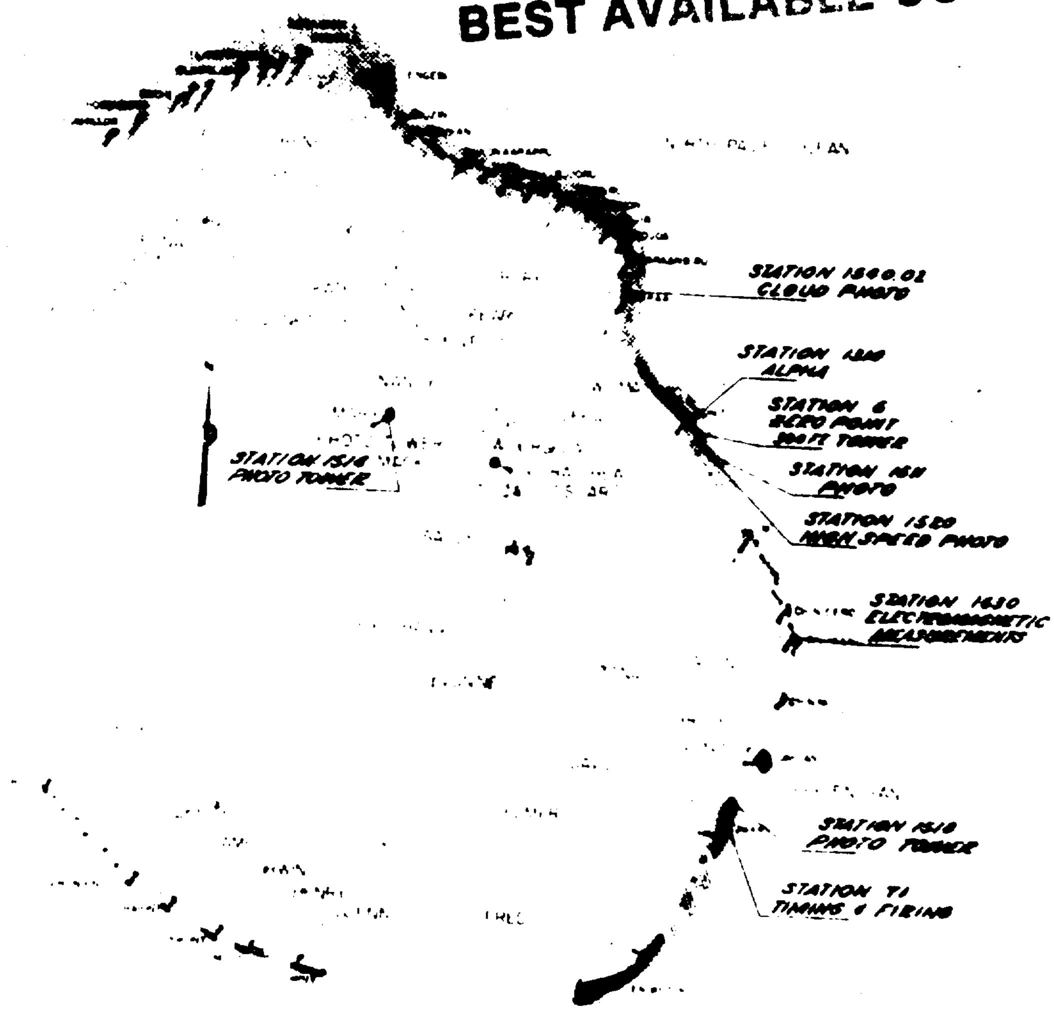
WINDS ALOFT (301700Z)

Height (Feet)	Direction (Degrees)	Speed (Knots)	Height (Feet)	Direction (Degrees)	Speed (Knots)
1,000	100	24	32,000	260	23
2,000	100	24	34,000	250	34
3,000	100	20	35,000	240	38
4,000	100	18	36,000	260	36
5,000	090	17	38,000	270	32
6,000	090	14	40,000	280	32
7,000	080	09	42,500	280	32
8,000	100	07	45,000	280	31
9,000	100	05	47,500	280	28
10,000	080	04	50,000	260	33
12,000	100	05	52,500	280	31
14,000	090	08	55,000	320	16
16,000	080	09	57,500	020	08
18,000	070	12	60,000	080	10
20,000	360	06	65,000	090	23
22,000	050	03	70,000	100	29
24,000	060	11	75,000	100	35
25,000	260	13	80,000	100	63
26,000	260	15	85,000	090	69
28,000	250	17	90,000	090	64
30,000	250	19	94,000	090	67

7

[redacted]

[redacted]



[redacted]

Fig. 0-1 Eniwetok Atoll, Scientific Stations and Zero Point

[redacted]

[redacted]

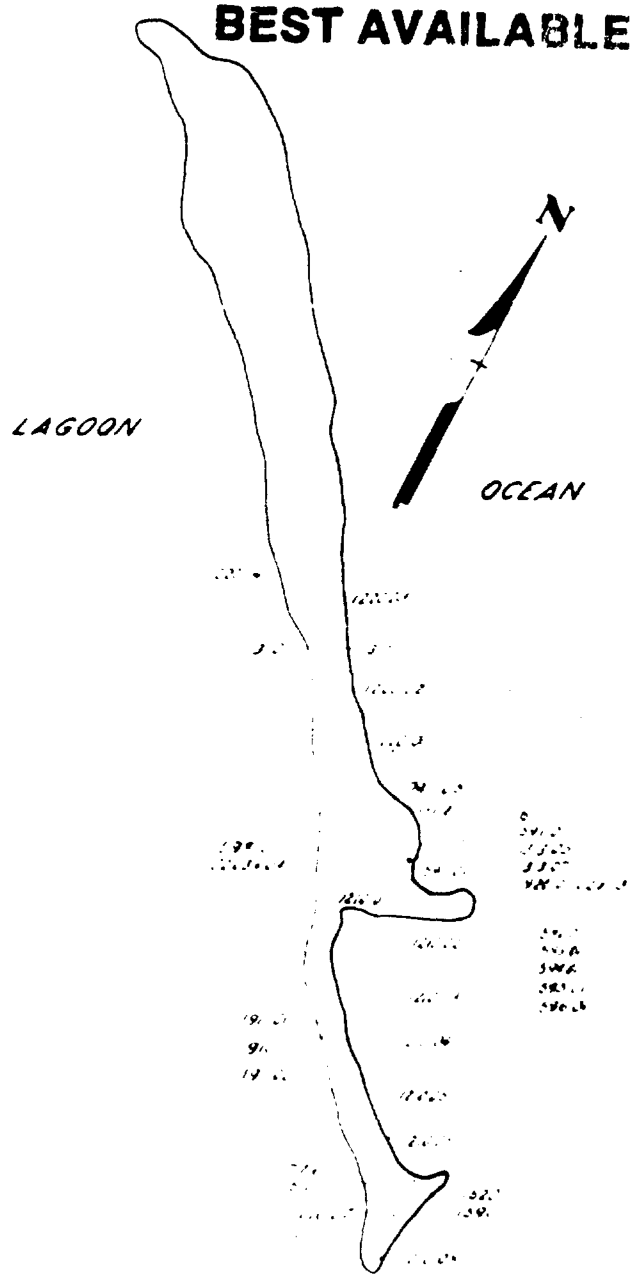
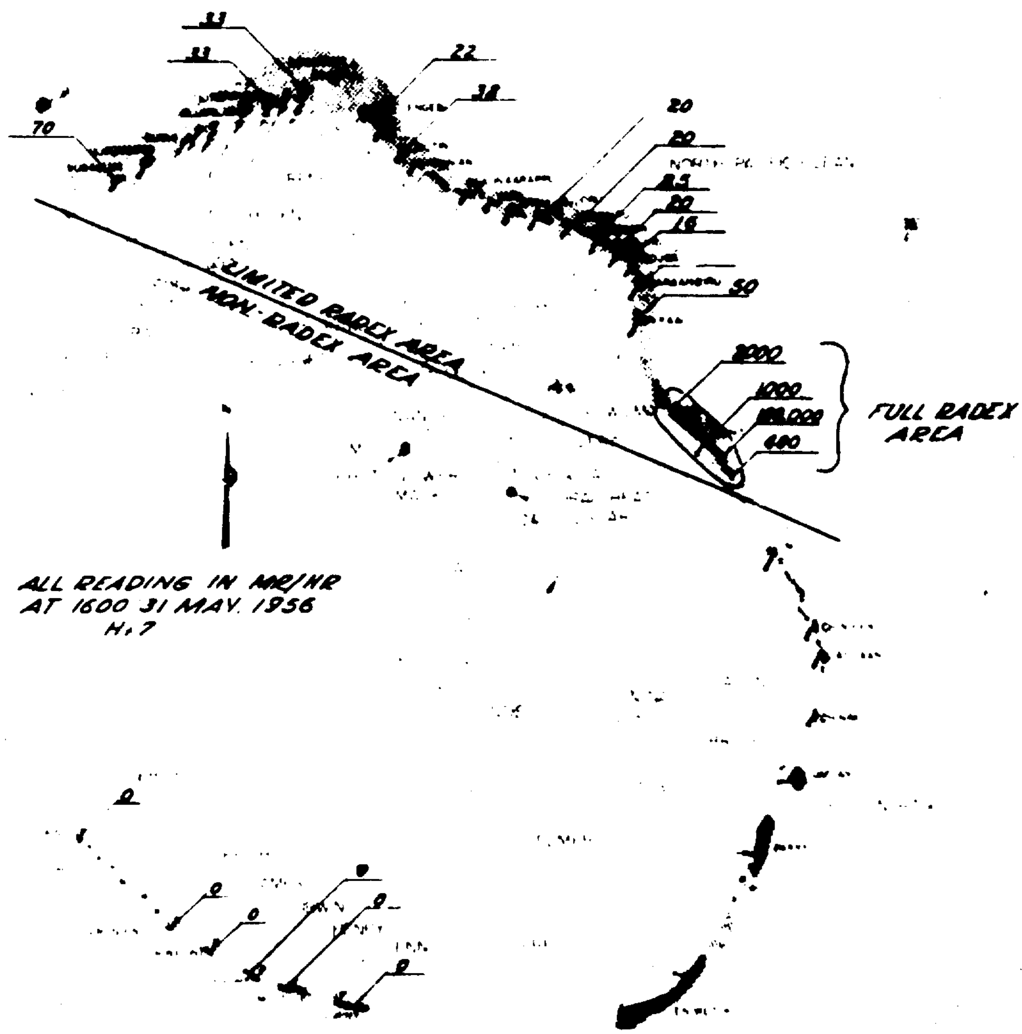


Fig. O-2 Runit Island - Scientific Stations

[redacted]

[redacted]

[redacted]



[redacted]

Fig. 0-3 RadSafe Survey H + 7

[redacted]

[redacted]

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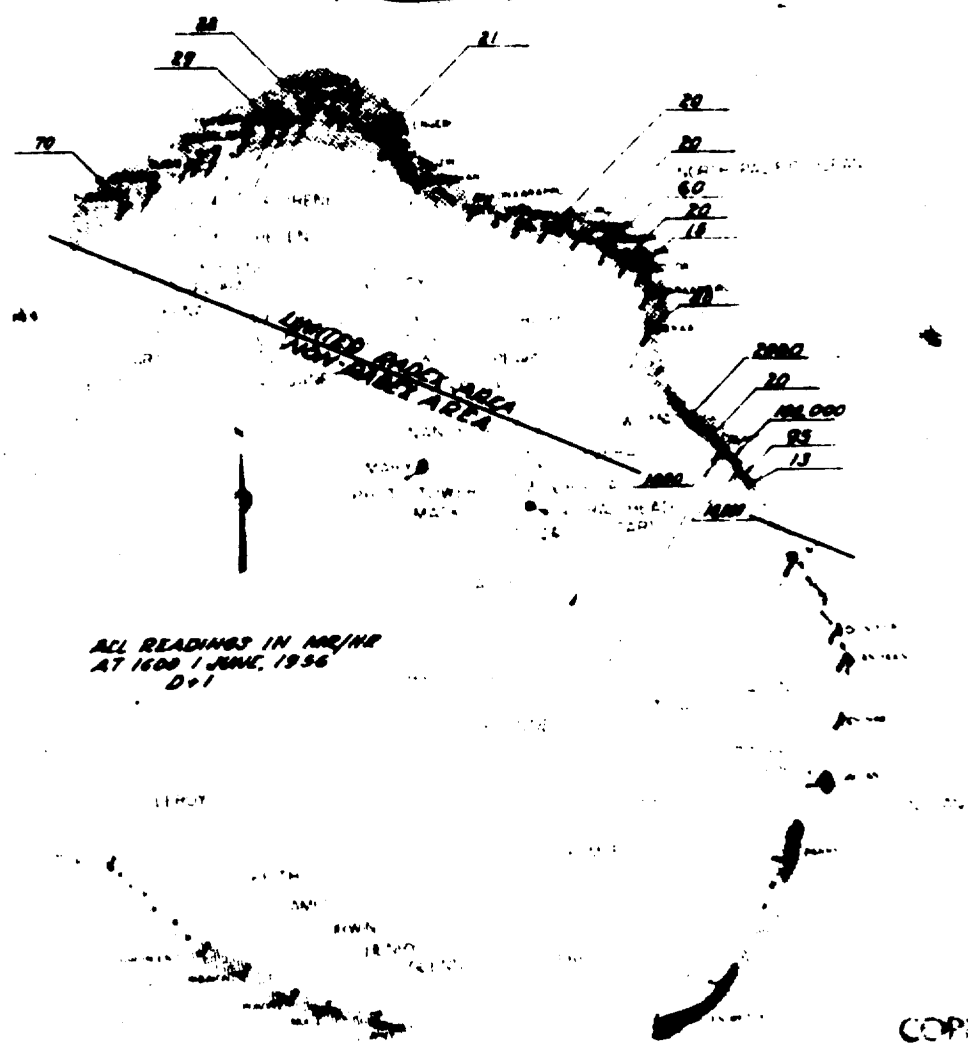


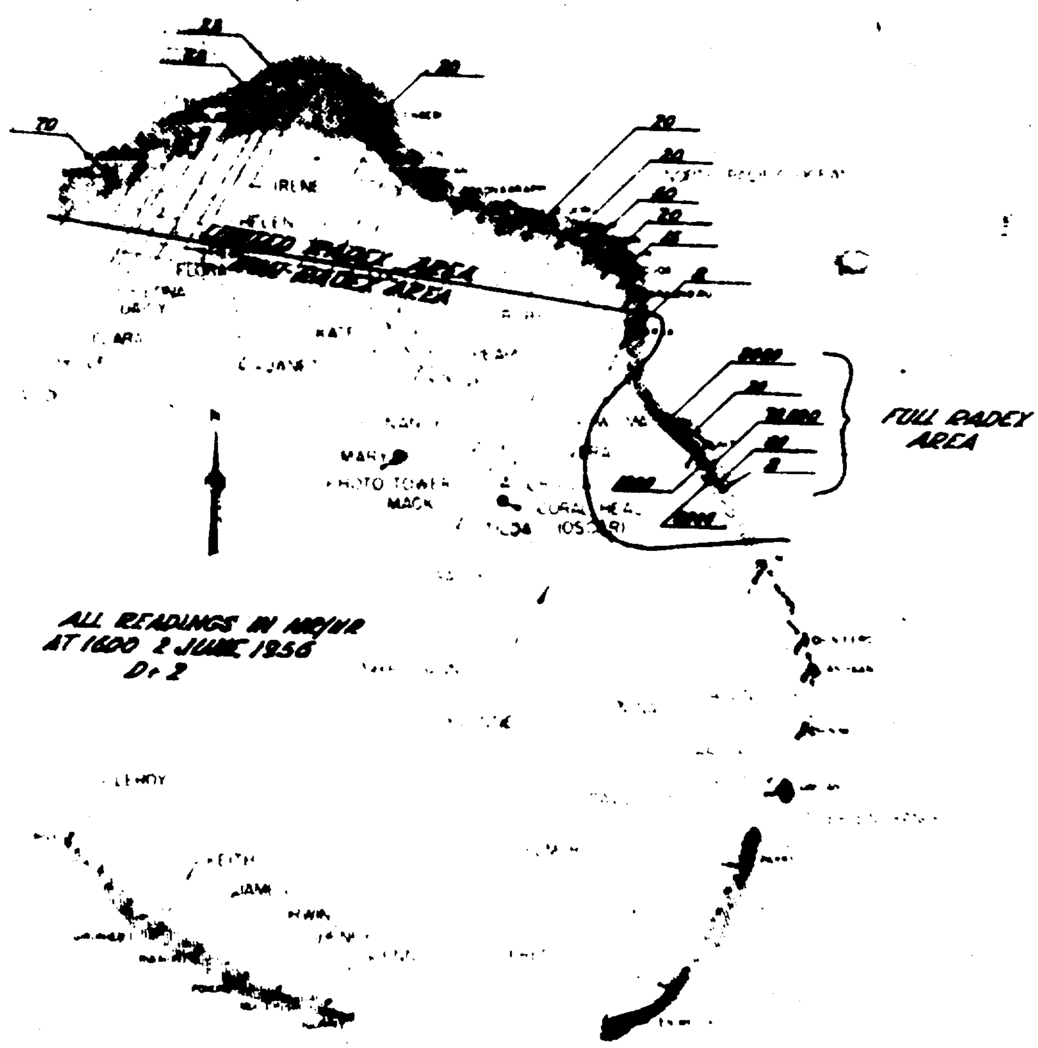
[redacted]

FIG. 0-b -
RadSafe Survey, D + 1

[redacted]

[redacted]

[redacted]



[redacted]

Fig. 0-5 RadSafe Survey, D + 2

[redacted]

PART II

TASK UNIT 3

DOD PROGRAMS

K. D. Coleman
Col. K. D. Coleman
CTU-3

Program 4 - Biomedical Effects	Lt Col C. W. Bankes
Program 5 - Aircraft Structures	CDR M. R. Dahl
Program 6 - Test of Service Equipment and Materials	Lt Col C. W. Bankes
Program 8 - Thermal Radiation and Effects	CDR A. H. Higgs Maj. W. C. Linton

[redacted]

[redacted]

[redacted] (FRIP)

Project 4.1 - Flash Blindness - Colonel R. S. Fixott

OBJECTIVES

To gain information regarding the behavior of lid reflexes under the high illumination produced by atomic devices; to further evaluate the blink reflexes as a protective mechanism against chorioretinal burns.

To gain information on shutter and filter mechanisms for eye protection against chorioretinal burns caused by atomic weapons of various types and yields.

INSTRUMENTATION

The basic instrumentation for this shot was identical with that used for [redacted] (Lacrosse), [redacted] (Cherokee) and [redacted] (Zuni). Because of failure to produce lesions at previously calculated distances in the earlier events, permission was obtained to use four additional exposure sites; TOM, URIAH, VAN and CHINIETRO (ALVIN); which are nearer to ground sero than the original exposure facility at JAPTAN (DAVID). While this change did not entirely succeed in bracketing the threshold of burn production, it did, however, produce a spectrum of burn severity which otherwise would not have been obtainable on any single shot. Electronic instrumentation and timing signals were employed only at the station on JAPTAN (DAVID). Temporary racks, holding ten rabbits each, were used for each of the four forward sites. Animals placed in these racks were used for blink reflex and filter studies only.

RESULTS

General

Chorioretinal burns were produced in 42 of 113 rabbits and 6 of 8 monkeys exposed to the flash of this shot. Lesions resulted at all stations. Calculated caloric yields at the exposure sites ranged from [redacted] inversely corresponding to distances of 2.7 to 8.1 statue miles.

Blink Reflex Studies

Blink reflex exposures produced chorioretinal damage in 21 of 38 rabbits and 6 of 8 monkeys. Evaluation of blink reflex time (in this case, the time and duration of eye exposure) awaits appraisal of the high speed photography of the animal eyes during the explosion.

Laboratory studies using increasingly powerful photoflash bulbs reveals a relatively constant blink reflex time of approximately 320 ms for rabbits and monkeys and about 160 ms for man. Using similar blink reflex times and recognising the twofold greater relative opening of the rabbit pupil, earlier investigations estimated that the rabbit is susceptible to retinal burns at distances about 25 percent greater than those equally harmful to man. By analogy therefore, the production of burns at 8.1 statue miles extrapolates to 6.5 miles for man.

As evidenced by the data it was noted that smaller (and apparently less severe) lesions were encountered at increasing distances from the fireball. Details of burn pathology must await laboratory study which cannot be accomplished at the Pacific Proving Grounds. It is of interest to observe that retinal hemorrhaging in this exposure series was associated with what appears to be lesions of intermediate severity. This is in contrast to the findings of previous investigators who noted hemorrhaging in connection with the most severe burns. It may be that additional information on the incidence of this reaction and/or other phenomena may be significant in the development of a comprehensive subjective grading system analogous to that used in the evaluation of the cutaneous flash burns.

Staggered Shutter Studies

Retinal burns were sustained by 10 of 32 rabbits exposed behind staggered shutters at JANTAN (DAVID). According to preselected shutter timing, two burns were produced during the initial 7-to-10 ms of the weapon flash. Both burns were located centrally in the rabbit eye and appeared almost pin-point in size. These lesions, while definitely minimal, were nevertheless discernible on a 24 hour re-check when they were documented by fundus photography.

Since the time of the first minimum is calculated as occuring at about [redacted] it would seem that the burns were produced by the energy of the first pulse alone. If true, this finding becomes of interest in considering the time of closing for protective shutters. The low incidence (12.5 percent) of burns during the first 50 ms of the explosion somewhat minimizes the possibility of significant injury produced by the first pulse.

Staggered shutter exposures to the initial 60-to-250 ms of the detonation caused burns in about 50 percent of animals exposed during these intervals. The time to the second maximum is calculated at [redacted] it is apparent that this group of animals were subjected, not only to the energy of the first flash but also the greater portion of the second pulse. Resolution of actual shutter speed in all cases is contingent upon appraisal of the high speed photography accomplished at the time of the explosion.

[redacted]

DELAYED SHUTTER STUDIES

In the delayed shutter exposures, 6 of 16 rabbits sustained retinal burns. The lesions were produced mostly in cases where the exposure included the maximum or near maximum flux of the second pulse. Increments of the flash beyond 0.6 seconds did not produce burns in this event.

FILTER STUDIES

Burns produced behind filters at URIAH and VAN at 3.0 and 3.8 miles, respectively, were similar in size and appearance to blink reflex lesions sustained on CAPTAN (DAVID) at [redacted] distance from ground zero. From this it is inferred that the filters reduced the calorie dose and dose rate at URIAH and VAN to a level below that which could produce burns.

PROTECTIVE ELECTRONIC SHUTTERS

These shutters were inoperative at H hour due to a fire in the wiring circuit at H -4 minutes. With the grid mechanism fully open, the shutter still reduces the incident visible light by about 60 percent. As a first approximation it is estimated that the energy reaching the rabbit eye was effectively reduced from [redacted] to about [redacted] It is of interest that no lesions were produced in the animals behind the protective shutters. Within the limits imposed by the yield of the weapon and the blink reflex time, it would appear that the threshold of burn production for this event lies between [redacted]

CONCLUSIONS

The blink reflex time for animals and man is not sufficiently rapid to protect against the flash from an atomic detonation of [redacted]

[redacted]

yield. An air burst of this size at dawn of a clear day (93 percent atmospheric transmission) is sufficient to produce chorioretinal burns at [redacted] for monkeys and rabbits and [redacted] for man. At this yield and these distances the energy of the first 50 ms of the detonation, and particularly that of the first pulse alone [redacted] is of little significance in the production of burns. The highest incidence of burning occurred in those animals whose eye exposure included the period from 60 through 200 ms.

There is limited evidence that burns could be produced at somewhat greater distances under identical conditions of exposure at the Pacific Proving Grounds. It is believed, however, that chorioretinal burning assumes its greatest significance for the pilot and air crews at high altitudes where specific absorption effects by salt water spray and excessive humidity are not factors of atmospheric attenuation. Additional information is needed on the spectrum of the atomic flash in order to predict the distances at which burning is significant.

The rate of delivery of thermal energy is of prime importance in the production of chorioretinal burns.

At near-threshold distances, filters of the colors and densities tested will prevent chorioretinal burns; at intermediate distances these filters will reduce the incidence and severity of the lesions.

[redacted]

[redacted] (FRIF)

Project 5.3 - In-Flight participation of a B-66 - R. W. Bachman

OBJECTIVE

The primary objective of this test was to measure the gust effect of a low yield nuclear weapon on a B-66B aircraft in flight.

INSTRUMENTATION

Instrumentation of the B-66 for this shot consisted of 60 thermocouples and 73 strain gages at 7 stations on the left wing, 9 thermocouples and 10 strain gages at 2 stations on the right wing, 34 thermocouples and 13 strain gages at 7 stations on the left stabilizer, and 9 thermocouples and 12 strain gages at 3 stations on the right stabilizer, plus 63 channels of correlating information.

RESULTS

The B-66 aborted their participation on FRIF. Pilot could not get one engine started just prior to take-off time. The B-66 was back in commission for the next event, [redacted] (FLATHEAD).

[redacted]

[redacted]

[redacted] (ERIE)

Project 5.4 - In-Flight Participation of a B-57B -

1st Lt Harold M. Wells, Jr.

OBJECTIVE

The objective of this test was to measure the effects of a low yield nuclear detonation of an in-flight B-57B aircraft weapons system.

INSTRUMENTATION

Out of 220 channels being recorded, 10 data channels were lost for various reasons. They have been repaired, or replaced by spares.

AIRCRAFT POSITION IN SPACE

The JB-57B was flying at an absolute altitude of 10,140 feet, heading 052° T in a tail-on position at t_o. Horizontal range to ground zero at t_o was 3829 feet (aircraft travelling at 710 ft/sec). Aircraft position at time of shock arrival (H + 12.56 seconds) has been determined to be 14,006 feet beyond ground zero. Heading same as t_o, altitude 10,540 feet.

RESULTS

Thermal: Total thermal energy measured was [redacted] of allowable limit).

Gust: Total gust load at time of shock arrival was 60% of allowable limit for the B-57B.

Overpressure: Peak overpressure was [redacted] at H + 12.6 sec.

[redacted]

PYTHON (ERIE)

Project 5.5 - In-Flight Participation of an F-84-F - 1st Lt R. F. Mitchell

OBJECTIVE

Sideloads F-84F - The objective of this participation was to study the dynamic response of fighter structure to anti-symmetric blast loads.

INSTRUMENTATION

Waiter - Instrumentation of primary concern consisted of 37 thermocouples located in the right flap, right aileron, right wing, right stabilizer and the engine inlet and outlet. Correlative instrumentation consisted of time zero fiducial signal, radiometer, and calorimeters located at Sta. 90, bottomside of the fuselage.

Barley - The instrumentation consisted of strain gage bridges located at Sta. 90 and 150 on left and right wing; Sta. 365 on the fuselage; Flt. Sta. 12 and 35.5 on the left and right stabilizer and W.L. 20 and 53 on the fin. The forementioned strain gage bridges yielded bending moment information. Structural responses were related to energy inputs with overpressure transducers located on a nose boom and in the sides of the fuselage. A total of 100 channels of information were capable of being recorded.

AIRCRAFT POSITION IN SPACE

The aircraft was flying at an absolute altitude of 6,060 feet on an inbound heading of 050° 30' T at t_o. The horizontal range and offset were - 8,083 feet and 12,024 feet respectively. The shock arrival position (at H ≠ 10.3 seconds) was 6,060 feet altitude; 12,256 feet offset; and ≠ 830 feet horizontal range. These positions were very close to the intended positions.

[redacted]

RESULTS

Thermal - Maximum irradiance measured was [redacted]

Total thermal energy measured was [redacted]

Gust - 70% design limit in side fuselage bending.

Overpressure - [redacted] at H + 10.3 seconds.

Out of the 100 channels recorded, there were 3 channels that failed. In addition, the two fireball cameras were turned on too early, consequently the film ran out before time zero.

Participation of Waiter (Capabilities F-94F) was not planned for the [redacted] shot (FRT).

[redacted]

[redacted] (ERIF)

Project 5.6 - In-Flight participation of an F-101A - Capt M.H. Levin

OBJECTIVE

The objective of Project 5.6 is to determine the responses of an in-flight F-101A aircraft to the thermal, blast and gust effects of a nuclear detonation.

INSTRUMENTATION

The aircraft was instrumented with radiometers, calorimeters and pressure transducers to measure the thermal and blast inputs and with strain gages, thermocouples and various other instruments to measure the aircraft responses to the inputs. For this shot, the aircraft was positioned to theoretically receive 80% design limit distributed up load on the stabilator based on the positioning yield.

AIRCRAFT POSITION IN SPACE

The aircraft was to fly at 12,000 feet absolute on an inbound heading of 050°T at a TAS of 800 fps. It was planned that the aircraft would be 7,000 feet short of ground zero at T_o with shock arrival occurring 8.75 seconds later with the aircraft over ground zero. Actual shot day position showed the aircraft to be 7,540 feet short of ground zero at T_o with shock arriving 8.833 seconds later with the aircraft being 390 feet short of ground zero.

RESULTS

Damage: There was no apparent damage to the aircraft.

Instrumentation: There was no apparent damage to the instrumentation. Of the 50 oscillograph recorded parameters, only three positively did not produce data. One radiometer was burned out prior

[redacted]

[redacted]

to flight time; one accelerometer was unreadable due to defocusing of its galvanometer and one calorimeter, although functioning properly, was not considered reliable due to its large range and small deflection. Three or four thermocouples may have been malfunctioning but, due to the small temperature rises existing, it was impossible to definitely determine. Excessive vibration of the photo panel again occurred at shock arrival, rendering two frames (.125 sec) unreadable. All 26 gages functioned properly and no data was lost.

Gust Data: The aircraft experienced a multiple shock arrival indicating that it was above the triple point path. Overpressure measured was about [redacted] on the first shock, about half that on the second shock 1.6 seconds later, and half again on a third shock .25 seconds later. Gust response was about 75% for torque and 40% for shear and bending, confirming the load distribution encountered on [redacted] (LACROSSE). Future positions will be revised to account for the new load distribution.

Thermal Data: Thermal response was again considerably less than expected. A T of about $30^{\circ}F$ was experienced on the honeycomb surfaces.

Nuclear Radiation: A reading of [redacted] taken from the pilots film badge. [redacted] was predicted based on positioning yield.

General: The participation was again successful from this project's standpoint. Gust responses were generally higher than previously experienced and the data collected has thus far correlated excellently with previous data and predictions.

[redacted]

[redacted]

[redacted]TED

[redacted] (FRIF)

Project 5.7 - Thermal Flux and Albedo Measurements from Aircraft -

Lt. P. F. Harward

OBJECTIVE

The objective of this shot was to obtain thermal flux and albedo information of a nuclear detonation with airborne calorimeters, radiometers, and sixteen millimeter motion picture cameras.

INSTRUMENTATION

Instrumentation within the purview of Project 5.7 which was installed in the B-57 included nineteen NRDL calorimeters and two NRDL radiometers for measuring the direct and surface reflected thermal radiation. These instruments possessed various fields of view and were suitably filtered to obtain qualitative spectral distribution information. Six USAF N-9 cameras were utilized to obtain photographic coverage of the fireball, the earth's surface, and of clouds beneath the aircraft. Two of the cameras oriented towards ground zero were equipped with spectroscopic attachments to obtain continuous spectra in the visible region. Of the other two tail position cameras, one camera had a blue filter and the other had a red filter for the purpose of obtaining pictures at both extremes of the visible region of the spectrum. The remaining two cameras were oriented vertically for the purpose of obtaining photographic coverage of the earth's surface and of clouds beneath the aircraft.

Instrumentation installed in the B-66 consisted of the basic twenty-one thermal instruments, and twelve cameras.

AIRCRAFT POSITION IN SPACE

Information of the position in space of each aircraft is contained

[redacted]

in the postshot reports of the following projects: Project 5.3, B-66 aircraft; and Project 5.4, B-57 aircraft.

<u>RESULTS</u>

Thermal: The preliminary value of total thermal input to the aircraft obtained on Project 5.7 instrumentation is included in the postshot report of the appropriate project indicated above.

Photographic data: of the twenty cameras under the purview of Project 5.7, twelve were not run at all because of the abort of the B-66. Of the six cameras in the B-57, the blue filtered tail camera suffered film breakage and obtained no pictures. This film was destroyed. Apparently reasonably good results were obtained with the remaining five cameras. The two cameras equipped with the spectroscopic attachment which were located in the EG&G Parry photo tower also apparently obtained good results.

Film Summary:

Number of Magazines Loaded	Number of Magazines Run	Number of Magazines for Analysis	Number of Magazines Destroyed
20	8	7	13

[redacted]

[redacted] (ERIE)

Project 5.9 - Weapon Effects on Missile Structures and Materials -

Lt C. J. Cosenza

OBJECTIVE

The ultimate objective of this test is to determine the vulnerability of certain ballistic missile structures and materials to a nuclear fireball. The immediate objective is a determination of the amount of material vaporized from the surface of an object exposed within a fireball and the variation of this material loss with shape, orientation, range, and the type of material involved. Further, an attempt is being made to measure various phenomona occuring within a fireball by various methods of instrumentation.

INSTRUMENTATION

Six specimens were equipped with minature tape recorders. Each instrument recorded six data channels as well as two timing channels. The data being measured consisted of specimen temperature and accelerations, and the rate of vaporization of the surface material. In addition, many specimens contained mechanical devices for obtaining measurements of peak overpressure within the fireball and time histories of the specimen accelerations.

RESULTS

No results are available at this time. The radiation level of the recovery area is so high that no specimens have been retrieved. Aerial photographs have been taken to preserve any evidence of the penetration of the specimens into the ground. The photographs will be used later to aid the recovery effort.

[redacted]

[redacted]

DELETED

[redacted] (FRIF)

Project 6.1 - Accurate Location of an Electromagnetic Pulse Source -

F. A. Lewis

OBJECTIVE

To utilize the electromagnetic signal originating from nuclear weapon detonation to determine ground zero of detonation. Secondarily to obtain the yield data that is available in the bomb pulse.

PROCEDURE

Location of ground zero is made by use of an inverse Loran principle. The exact time the bomb pulse is received at various stations is recorded. The exact time difference in receipt of the electromagnetic pulse between two stations will be used to determine a hyperbolic curve which runs through ground zero. The point of intersection of two or more curves determines ground zero.

There are two systems. One of the systems is known as the long base line system and the other, the short base line system. Each system has two sets of stations. The long base line has one set of stations located in the Hawaiian Islands (Midway, Palmyra, and Maui) with synchronizing antenna station at Haiku, Maui, and the other set of stations in the States (Harlingen, Texas; Blytheville, Arkansas; Kinross, Michigan and Rome, New York) with synchronizing antenna station at Cape Fear, North Carolina. The short base lines have one set of stations located in the Hawaiian area (Kona, Hawaii; Papa, Hawaii; and Red Hill, Maui) the other set in California (Pittsburg, Woodland, and Maryville).

RESULTS

Short base line.

[redacted]

Hawaii. Kona net all stations received and recorded electromagnetic pulse emanating from bomb detonation.

California. Woodland net all stations received and recorded electromagnetic pulse emanating from bomb detonation.

Long base line.

Hawaii. Lahaina net all stations received and recorded electromagnetic pulse emanating from bomb detonation.

Stateside. Harlingen AFB Texas net all stations received and recorded electromagnetic pulse emanating from detonation.

Griffiss AFB New York reports equipment failure.

CONCLUSIONS

No conclusions can be made until further information is received from data reduction and interpretation.

[redacted]

[redacted] (ERIE)

Project 6.3 - Effects of Atomic Explosion on the Ionosphere -

M. Hawn

OBJECTIVE

The objective of Project 6.3 is to obtain data on the effects of high yield nuclear explosions on the Ionosphere. Principally, to investigate the area of absorption, probably due to the high altitude radioactive particles, and to study the effect of orientation relative to the earth's magnetic field on F2 layer effects.

INSTRUMENTATION

The system comprises:

Two Ionosphere recorders, type C-2, operating on pulse transmission, installed in 6 ton trailer vans, one located at Rongerik Atoll and one located at Kusaie in the Caroline Islands.

One Ionosphere recorder, type C-3, operating on pulse transmission, installed in a C-97 plane based at Eniwetok Island.

Detailed Description:

Ionosphere recorder site (Rongerik Atoll)

site (Kusaie)

AN/CPQ-7, type C-2 Ionosphere recorder with a power output of 10 KW peak pulse alternately transmitting and receiving automatically over the range of frequencies from 1 to 25 megacycles. This equipment measures and records at vertical incidence the virtual height and critical frequencies of ionized regions of the upper atmosphere.

A 600 ohm multiple wire antenna designed and erected, so that the direction of maximum intensity of radiation will be at the desired vertical angle over all of the operating frequency range from 1 to 23

[redacted]

megacycles. The transmitting and receiving antennas and the ground plane were in mutual perpendicular planes with the plane of the transmitting antenna oriented 53 degrees to the East of Magnetic North.

Ionosphere recorder site (C-97 airplane)

Same as for Rongerik and Kusaie, except that a C-3 Ionosphere recorder was used. This recorder is the same as the C-2, except for a few modifications and improvements.

The transmitting antenna in the C-97 was a single wire delta fastened to the lateral extremities of the tail assembly.

OPERATIONAL

Ground stations at Rongerik and Kusaie, using 15 second sweep operated on normal 24 hour schedule, 5 sweeps per hour.

Airborne Station C-97: Did not participate in this test. Airplane was at Hickam AFB for 200 hour maintenance check.

RESULTS

Stations at both Rongerik and Kusaie operated successfully during this test. C-97 airborne station did not participate.

There were no noticeable effects on the Ionosphere from this test.

[redacted]

[redacted] (FRIT)

Project 6.5 - Analysis of Electromagnetic Pulse Produced by Nuclear Explosions - C. J. Ong

OBJECTIVE

The objective of Project 6.5 is to obtain waveforms of the electromagnetic radiation for all the detonations during Operation REDWING. This data is to be used in connection with a continuing study relating the waveform parameters to the height and yield of the detonation.

INSTRUMENTATION

Two identical stations are used to record data, one at Eniwetok and one at Kwajalein.

The instrumentation consists of a wide-band receiver with separate outputs connected to each of the three oscilloscopes. Mounted on each oscilloscope is a Polaroid Land Camera for recording the transient display.

RESULTS

Station A: Eniwetok

Data was recorded on all oscilloscopes. The predicted field strength was [redacted] and the measured field strength was [redacted] The waveforms are good and should provide data when analyzed.

Station B: Kwajalein

Data was recorded on all oscilloscopes. The predicted field strength was [redacted] and the measured field strength was [redacted] The recorded wave forms were of good quality and should provide data.

[redacted]

[redacted]

CONCLUSIONS

Examination of the predicted field strengths and the measured field strengths show that the field strength is evidently attenuated exponentially and is not a linear relationship.

All data has been forwarded to Evans Signal Laboratory for final analysis.

[redacted]

[redacted]

[redacted] (ERIF)

Project 8.5 - Airborne High Resolution Spectral Analysis - R. Zirkind

OBJECTIVE

To determine the spectral characteristics of the radiant power of an airburst fireball prior to its being shocked by the reflected wave.

INSTRUMENTATION

The spectral distribution of the radiant power is obtained from a medium quartz Hilger spectrometer. The spectrum is sampled in narrow bands by photocells in the visible region and PbS cells in the infra-red. The electrical signal is then recorded on an Ampex 814 tape recorder, with a resolution time of 150 μ sec. The transmission measurement is accomplished by beaming a pulsed light signal of known output and spectral distribution from a fixed point on the ground towards the aircraft. The attenuated beam is received by a detector in the aircraft and recorded on a Heiland recorder. The detector consists of two filtered photomultiplier tubes sampling two spectral regions, (1) .3-.55 microns and (2) .6-1.05 microns. In addition, a quartz filtered calorimeter, 22 degrees field of view, is utilized to measure the approximate radiant exposure received at the spectrometer.

RESULTS

The aircraft was located at the desired position, namely 22,000 feet absolute, directly over ground zero at T_0, during the entire length of the thermal pulse.

The spectrometer operated normally and to date good data has been obtained on 10 channels

The transmission measurements were carried out successfully to H -6.5 seconds. The latter corresponds to the last available light pulse as the light source was extinguished on the H-5 second signal.

DISCUSSION

The thermal data appears to be very interesting, in particular, in the infra-red region; that is, the duration of the thermal pulse was about 5 seconds as compared to the blue region which had a duration of about 2.5-3 seconds. This difference has not appeared on broad band calorimeters as their sensitivity is considerably lower than that of the spectrometer system employed here. Further, this lends credence to the theory that the hot shocked gases within the fireball at later times are still capable of emitting significant amounts of radiation in infra-red regions of 1-3 microns.

PART III

TASK UNIT 1

LASL PROGRAMS

Keith Boyer
Advisory Group

Program 10 -	Thermal Radiation and Hydrodynamics	H. Hoerlin
Program 11 -	Radiochemistry	G. Cowan
Program 12 -	External Neutron Measurement and High Energy Gamma Measurement	R. L. Aamodt
Program 13 -	Fission Reaction Measurements	J. S. Malik
Program 15 -	Photo-Physics	G. L. Felt
Program 16 -	Physics & Electronics & Reaction History	B. E. Watt
Program 19 -	Nuclear Vulnerability	Lew Allen

[redacted]

[redacted] (ERIE)

Project 10.1 - Fireball Hydrodynamics - J. F. Mullaney

L. N. Blumberg

The yield of the [redacted] (Erie), computed on the basis of diameter - time data from nine Fastman films, is recommended to be [redacted]

The three methods of computation employed are based on Equation 17 (Chapter 5, LA 1021) as discussed in ROP-12. The integral form of Equation 17 is consistent with pre-Teapot radiochemistry; the differential form is based on the yield of King shot as 540 KT; and the Mach number scaling method utilizes IBM problem M and Castle data normalized to 1 KT by D. Seacord and T. Snyder. The Bethe-Fuchs mass treatment was employed in all methods with a total weight of [redacted] pounds included.

Results obtained from photo stations at Parry, Piiraai, and Mack are presented in Table 10.1-1. A yield of [redacted] was also obtained by the integral method from two heavily fogged Runit films. Inclusion of this result will not significantly effect the quoted yield.

The effect on the yield of including various amounts of mass is shown in Table 10.1-2. All items within the noted distance of the center of the bomb were listed, and their mass and position entered into the mass treatment.

[redacted]

TABLE 10.1-1

Yield (in KT)

Photo Station	Integral Method	Differential Method	Mach Scaling
Parry (3 films)	DELETED	DELETED	DELETED
Mack (3 films)			
Piiraai (3 films)			

TABLE 10.1-2

Radius of Sphere Assumed Vaporized	Weight Included in Sphere	Yield
Meters	Pounds	Kilotons
DELETED	DELETED	DELETED

It appears from the rate of change of yield with weight that the effect of mass beyond 7 meters from the center of the bomb is not significantly large.

Project 10.2 - Time-of-Arrival - J. F. Mullaney

The time-of-arrival method was employed to estimate the yield of the [redacted] (ERIE) through use of hand-held stop watches at Station 1518, Parry Island. The shock wave was heard clearly, and there was almost exact agreement in time interval as measured by several observers. The time of arrival at the microbarograph station of Project 31.1 at Eniwetok Island was also noted by Carter Broyles (Sandia). The times of arrival and ranges of these stations are given in Table 10.2-1.

The weather conditions of interest, as observed at Eniwetok at shot time are:

Pressure:	1,009.1 mb
Temperature:	80.3°F, relative humidity 80.2%
Wind:	12 knots from 100°, with gusts to 15.

The sound velocity calculated using the expression 1.4 pressure/density is 1145 feet per second. A wind of 12 knots from 100° adds 57 feet to the air path between Ground Zero and the Eniwetok station, and 228 feet to the path to Station 1518. The shock wave speed (still slightly above sound speed) in the last third of the path to Eniwetok is then:

$$\frac{(72,727 + 57) - (48,593 + 228)}{61.3 - 40.4} = 1147 \text{ fps}$$

The sound speed 1145 fps is in good agreement with this figure, and is used in getting the yield estimates in Table 10.2-1.

As was indicated in the report on LACROSSE, an empirical reflection factor of 1.6 seems appropriate for a land-based surface shot. The [redacted] (ERIE) was not a surface shot but was fired on a 300-ft. tower. D. F. Seacord, Jr., and Carter Broyles point out that in the case of a tower shot, the reflection factor should not be applied in calculating the traverse time for the first few hundred feet (about 500 feet in this case), and then for several hundred feet, the increase in shock velocity accompanying Mach stem formation must be considered; for the remainder of the path, the reflection factor is used. When the path length is great, there is no advantage in using this involved procedure, owing to the uncertainty about the reflection factor. Yields obtained using reflection factors of 2 and of 1.6 over the entire path length are given in Table 10.2-1.

TABLE 10.2-1

Station	Range (feet)	Bearing	Arrival Time (Seconds)	YIELD, KILOTONS Reflection Factor 1.6	YIELD, KILOTONS Reflection Factor 2.0
Parry 1518	48,593	173° 49'	DELETED	DELETED	DELETED
Eniwetok	72,727	187° 23'			
			Average		

[redacted]

[redacted] (FRIP)

Project 11.1 - Radiochemical Analysis - G. Cowan

The [redacted] fission yields are as follows:

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The suggested best value is

[redacted]

Add about [redacted] Detector data are not yet available. Capture to fission ratio is [redacted]

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[redacted]

[redacted]

[redacted] (RHIR)

Project 11.2 - Sampling - H. F. Plank
(P. F. Moore)

EQUIPMENT

Four F-84 and two B-57 type aircraft equipped for cloud sampling as described in the [redacted] Report were used on this mission. The F-84 aircraft were designated by the code name Tiger, the B-57 aircraft that were used for sampling was given the code name of Hotshot and the other B-57, which was used as the control aircraft, was Cassidy.

WEATHER

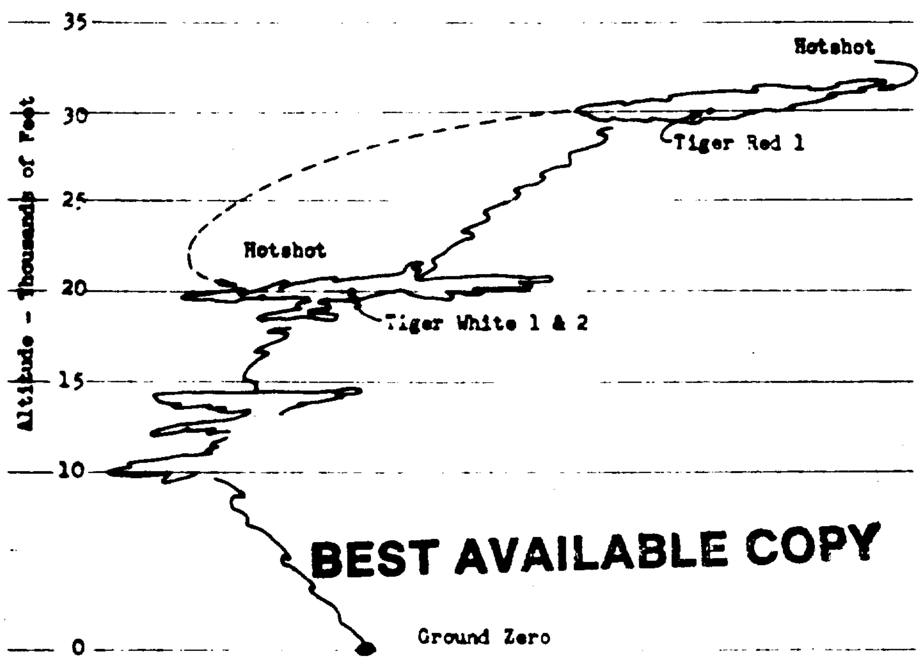
Predicted and observed wind shears were very high, on the order of 200 to 300 degrees and 8 to 10 knots in velocity difference per 5,000 feet change in altitude. Cloud cover consisted of about 3/8 scattered alto-stratus from 18,000 to 20,000 feet, but this did not intrude on the bomb cloud or interfere with visual penetration of the sampling targets.

CLOUD DESCRIPTION

The cloud rose in a straight column reaching a top altitude of 32,000 feet in less than 10 minutes. The cloud began to break up rapidly under the influence of the strong directional wind shears although velocities were low enough so that the cloud did not break into separate pieces for a considerable time, but instead stretched out into a long, very thin spiral shape, until about 1½ hours after burst time, when the arms of the spiral started to break apart and spread out into small thin strata. The cloud was of a very pronounced red color at all times, which was of great aid in locating the long, thin strings of the cloud in which sampling penetrations were made.

[redacted]

after they were removed from the aircraft. This discrepancy was not large enough to be serious and was compensated in any event by slightly larger dosages taken by most of the sampling aircraft. The ratios of in-cloud dosage to final dosage and integron to film badge readings were entirely consistent with those encountered on past operations.



View of Erie cloud during sampling operations looking north [redacted] (ERIE)

Project 12.1 - Threshold Detectors - W. Biggers

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[redacted]

Project 12.2 - Phonex - D. Phillips

The phonex experiment as described in GREENHOUSE Report WT-68 was performed at two nuclear explosions during Operation REDWING. At [redacted] (ERIE) shot there were two stations (300 yds. and 600 yds. from ground zero) looking through holes in the J-13 shield. Two stations (450 yds and 750 yds.) were eliminated a few days before shot time. The reason for this was the danger of lip scattering by hydrogen in the concrete and paraffin shield as pointed out by Louis Rosen.

To alleviate this situation, the aperture through the shield was reduced using heavy material. In the case of the 300 yd. station, the line of sight passed along a 3" I.D. transite pipe through the shield. This pipe was lined with steel tubing 21" long, 2" I.D., and ½" wall thickness. The lines of sight to the other stations all passed through an opening of rectangular cross section about 8" x 10". Two steel tubes approximately 30" long, 2½" I.D., ½" wall were cut and hard soldered together in such a way that one could be placed along the line of sight to the 600 yd. station and the other along the J-13 line. The rest of the space through the rectangular aperture was filled by packing it with about 130 lbs of lead wool. This eliminated the lines of sight to the 450 yd. and 750 yd. stations. However, it should have materially reduced the number of neutrons scattered through small angles by hydrogen and then passing along the line to the 300 yd. and 600 yd. stations.

Both stations were heavily sand bagged, particularly the near station. At this station, extra shielding in the form of lead wool was placed on top of the collimator and in front of the forward blast plate.

[redacted]

[redacted]

The total thickness of lead on top of the collimator was probably less than 1". The lines of sight through the blast plate were protected by 1¼" I.D. pipe about 8" long welded to the front of the plate. Around these pipes lead wool was packed to a thickness of about 4". The front, top, and sides of the collimator were protected by several layers of sand bags.

The 300 yd station contained three phonex cameras having polyethylene radiators 0.001", 0.0025", and 0.003" thick. Ilford nuclear emulsion plates were used at the rear small angle positions only. The four plates in each camera were as follows: 300μC2, 200μC2, 300μE1, and 200μE1.

The cameras at the 600 yd. station were similar except for one. Instead of a 0.003" polyethylene radiator at the front of the camera, a deuteroparaffin radiator was used at the rear. This camera was used by Louis Rosen to look for the angular distribution of protons from the photodisintegration of the deuteron.

Cameras were recovered from the 600 yd. station about mid-afternoon of E-day. Development of the plates from Rosen's camera and from the 0.0025" radiator camera was started immediately. The C2 emulsions gave good readable plates reasonably free of background. The E1 emulsions, although showing less background, do not show at all well the beginnings of proton tracks whose energies are greater than about 10 or 12 mev.

Two hundred and eighty-one tracks were measured on one of the C2 plates by Louis Rosen. The results of this analysis are shown in Table 122-1 and the neutron energy spectrum extrapolated back to the outside of the bomb is shown in Fig. 12.2-1.

The cameras from the 300 yd. station were recovered three days later.

[redacted]

[redacted]

Development was started immediately on the plates from two of these cameras plus the plates from the third camera from the 600 yd. station.

The C2 emulsions were too dark to be read and the E1 plates, though probably readable, are practically useless for the high energy end of the spectrum.

It should be emphasized that these data are preliminary. Attention is called to the number of tracks recorded for each half mev energy interval as shown in the table.

We wish to thank J. Hill, R. Newman and R. Blossom for their assistance in making last minute changes. Also we would like to state our appreciation of the cooperation which we have received from Buddy Schuts and the other machinists.

[redacted]

[redacted]

[redacted] (ERIE)

TABLE 12.2-1

PLATE #B14E

NEUTRON ENERGY INTERVAL	NUMBER OF TRACKS	(FOLDING* DISTANCE IN AIR (YDS)	Q (E) NEUTS/½ MEV

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[redacted]

[redacted]

[redacted]ED
(ERIB)

Project 13.1 - Measurement of Alpha and Boost - H. Grier

J. Malik

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The records obtained were poor - a large amount of hash, attributed to inductive blocking condensers used in the detectors made over half of the traces unreadable. Those records which were usable had a rather small dynamic range and resulted in rather wide scatter in the data points and did not permit an accurate time-tie. Enough data were obtained to make a time-tied splice of the data over essentially the full dynamic range encompassed.

A total of ten detectors were used - two of Neher's photomultiplier detectors to cover the early part of the curve and eight of EG&G's photocell detectors. The detectors used to measure the boost region were

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[redacted]

51

[redacted]

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Table 13.1-1 is a summary of the data obtained in the region prior to boost. The indicator numbering convention lists the detector number in the tens position and the scope number in the units position (1 is EG&G - 3343, 2 is K-1421, 3 is K-1409). The conversion from roentgens to neutrons DELETED through use of Watt's Program 5 code (LA-1984) considering all neutrons equivalent and taking DELETED (This is the same procedure used by Watt). First-order least square fits to the data were made by Goodwin (J-13) and Harper (T-1) and are listed together with values obtained by EG&G's graphical base-line and difference methods.

The data obtained are shown in Figs 13.1-1 thru 13.1-6. The data shown in Fig. 13.1-6 are probably not relevent and are shown only to indicate dynamic range and was not the only limiting factor to explain the loss of boost data.

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[redacted]

52

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[redacted] (FRIE)

TABLE 13.1-1

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[redacted]

[redacted] (ERIE)

TABLE 13.1-1 (Contd)

INDICATOR	DISTANCE (METERS)	NEUTRONS/ ROENTGEN	$\dot{Q}$ MIN NEUT/SEC	$\dot{Q}$ MAX NEUT/SEC	ALPHA (SH^{-1})			COMMON TIMING	
					α B.L.	α DIFF	α L.S.	t (sh)	$\dot{Q}$

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- 54 -

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CONTD. FOR SANDIA

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54 55

[redacted]

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[redacted]

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[redacted]

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[redacted]

DE[redacted]ERIE)

Project 13.3 - ENS Monitoring - D. Henry

J. Malik

Monitoring of the S-units used to detonate the device was performed by Sandia (D. Henry) using their microwave telemetering system. Results of their measurements are:

DELETED

[redacted]

[redacted]

[redacted] ([illegible])

Project 15.1 - EG&G PHOTOGRAPHY - H. Grier

D. F. Seacord

FIREBALL YIELDS

A total of eleven Eastman films from four stations (Parry, Runit, Mack, and Piirani) give an average yield of [redacted] The three films from Runit were exposed to greater than 10,000 R, but images were obtained through selective processing.

Although a relatively large scatter exists in the film data from a given station, there is no systematic error attributable to mass effect. The average yields per station are comparable for the close-in stations, but the Parry average is higher, being influenced by two films which give yields greater than [redacted]

Taking into consideration the random scatter, it is recommended that the [redacted] ([illegible]) fireball yield be quoted as: [redacted]

RHANGMETERS

Four Rhangmeters operated successfully at the central point giving readings of [redacted] respectively. One obtains an average yield of [redacted] from these readings using the formula $W = 0.1t_m^2$.

[redacted]

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[redacted]

[redacted] (XXIX)

Project 15.2 - HIGH SPEED PHOTOGRAPHY

EARLY FIREBALL GROWTH

Project 15.2 operated Station 1520 on Runit for the [redacted] shot to obtain information on the growth of the very early fireball. One of the purposes for such a study was to gain knowledge about reproducibility of gas boosted fission bombs. The exact geometry of bomb and case will be fired again in the [redacted] shot, and the degree of difference of the two early fireball expansions should give data on the relative yields of the two bombs. Unfortunately the [redacted] will probably be changed to a lower yield for the [redacted] shot contrary to earlier expectations. Thus the information to be obtained by comparison of the [redacted] and the [redacted] shots will be a scaling law and not reproducibility data. Even the scaling law will not be too good because the yield of the [redacted] for that shot will not be known very well.

Cameras were operated in Station 1520 also to study the fireball growth in color and in frame pictures. The experimental setup was identical to that described in the Project 15.2 Pre-operational Report.

Station 1590, the wooden mirror shed in front of station 1520, was rebuilt after the [redacted] shot to allow viewing of the 300 foot tower. The arrangement of the turning mirrors in the photobunker and the perspective introduced by the orientation of the tower made the tower appear tilted in the pictures. The slits within the streak cameras were set at an angle of about 11½ degrees from the horizontal to line up on the horizontal direction of the cab. Mirror distortion corrections were made in the focus position to give very good dynamic focus. For full speed, 4,000 rps, the slit is moved forward 3/4 inch. The half speed correction is ½ inch, and the quarter speed correction is 1/8 inch.

The thin Panatomic X film worked quite well in the radiation field of the bunker. The film shows about 3 or 4 roentgens total dose. Unfortunately, the color film had no color calibration on it and therefore the degree of coloring of the fireball will not be known. Development of the Panatomic X film was 20 minutes in the Berry developer BD7B and the color film was processed 5 minutes in D-76.

All the cameras operated to give excellent results. DELETED

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[redacted]

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[illegible]

[redacted]

71

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[redacted]

[redacted]

DELETED

[redacted]

74

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[redacted]

DELETED

Figure 15.2-7
Framing Camera
Record

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DELETED

[redacted]

Project 16.3 - Electromagnetic Measurements - R. E. Partridge

For [redacted] the electromagnetic recording system was directed primarily at measuring alpha. Sufficient coverage was provided to record seven generations on two Rossi scopes, each backed up by a linear scope. Sufficient gain was provided to deflect the most sensitive scopes one-half scale with a field strength of one millivolt per meter. A relatively narrow-band antenna was used, centered at 75 M.C.

A high radio noise background required reducing the gain by a factor of four just before the shot to prevent continuous triggering. The exponential form of the signal was masked by severe interference, predominantly near 50 M.C. This probably was the Lookout Mountain voice countdown transmitter on 49.5 M.C.

The time interval system was operated as a dry run for two-stage devices. All scopes functioned correctly.

[redacted]

[redacted]ERIE)

Project 19.1 - Nuclear Vulnerability - Lew Allen, Jr.

The purpose of this experiment was to investigate the damaging effects of neutron heating incurred when an atomic weapon is exposed to the neutron flux from an atomic explosion. The experimental lay-out was as follows: DELETED

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Neutron fluxes were measured at each of the two locations with the assistance of Proj. 2.51. Preliminary study of these measurements indicate that the flux of high energy neutrons (greater than 1 Mev) was less than was anticipated.

The reasons for the discrepancies between the predictions and the observed results have not yet been determined and must await a detailed analysis of the experimental information.

[redacted]

[redacted]

Project 19.2 - BATS - Lew Allen, Jr.

The purpose of the experiment was to investigate certain feature of the proposal knowns as BATS which had been described in Los Alamos T-Division Report, T-793. Nine spheres were hung from booms at the 250 ft. level of the [redacted] tower. These spheres consisted of a graphite layer, 2 ft. in outer diameter which enclosed a steel ball, 8 inches in outer diameter, at the center of which was a sphere consisting of a sample of the blanket material 2 inches in diameter. The sample consisted of graphite containing Li^6 in amount equivalent to about LiC_{500}. In addition U^{235} was added in concentration which varied from sample to sample such that the most concentrated sample contained U^{235} in amount equivalent to about UC_{200}.

It was expected that the steel spheres could be recovered after the shot whereupon an analysis of the sample it contained would reveal valuable information regarding the production of tritium under the conditions of high neutron flux, low tritium concentration, and the high temperature caused by energy released from the U^{235} in the sample. An initial recovery attempt was made one month after the shot. Due to the high radiation levels still present only one sphere was recovered, this one was returned to Los Alamos for disassembly and analysis. It is anticipated that the remaining spheres can be recovered on about plus two months.

[redacted]

[redacted]

PART IV

TASK UNIT 4

SC PROGRAMS

E. L. Jenkins
CTU-4

Program 31 - Microbarography R. Heppelwhite

[redacted]

[redacted]RIE)

Project 31.1 - Microbarograph - W. A. Gustafson

The purpose of this project was to measure winds in ozone layer of the atmosphere. This was accomplished by measuring at several sites the arrival times of the shock wave reflected from the ozone layer. Five sites were operated: Ujelang, Wotho, Rongerik, Bikini, and Eniwetok. At each site two stations were operated about one mile apart. The difference in arrival times gives the angle of incidence of the shock and information from several stations may be combined to give the winds.

On [redacted](ERIE) good shot records were obtained from all stations but no temperature and wind vectors are yet available.

[redacted]

[redacted]

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