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OPERATION REDWING

A PRELIMINARY REPORT

OF

[redacted] (KICKAPOO)

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Submitted by Task Group 7.1

RG 326 US ATOMIC ENERGY COMMISSION

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[redacted] (KICKAPOO)

INTRODUCTION

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PART I

GENERAL INFORMATION

Observed Weather at Shot Time

Fig. O-1 - Eniwetok Atoll Map

Fig. O-2 - Scientific Stations and Zero Point

Fig. O-3 - RadSafe Survey, D-Day

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KICKAPOO
ENIWETOK OBSERVED WEATHER FOR 14 JUNE 1956
AT DETONATION TIME 1126M

Sea Level Pressure	1009.8 mbs
Free Air Surface Temperature	85.6°F
Wet Bulb Temperature	78.1°F
Dew Point Temperature	75.3°F
Relative Humidity	71.0%
Surface Wind	090° - 6 knots
Tropopause	55,570 ft., -78°C
Visibility	10 Miles

CLOUDS:

2/10 cumulus; estimated bases at 1500 ft. with radar reports indicating tops at 18,000 to 21,000 feet.
1/10 stratocumulus; bases at 2500 feet.
6/10 altocumulus; estimated at 12,000 feet. (thick) (all opaque)
4/10 cirrus; estimated at 30,000 feet. (mostly transparent)

AREA WEATHER SUMMARY FROM AIRCRAFT: (located approx. 1[illegible] miles NE of GZ)

Broken cumulus clouds (4-6/8) with tops at 10,000 to 11,000 ft. (no showers or cumulus over GZ) Widely scattered cumulus tops over 15,000 ft. in area. One cumulus buildup to 15,000 ft. located west of GZ.

RADAR OBSERVATIONS:

Heavy cumulus buildups evident by echoes to northeast and north of GZ area. Dissipating cumulus touching southern end of GZ island at shot time. Rain showers to the NE thru E (est. 7 miles away).

STATE OF SEA:

Ocean Side: Wave heights 4 feet, period 7 seconds, direction 090°.
Lagoon Side: Less than one foot swells.

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ENIWETOK UPPER AIR SOUNDING (release time 1115M)

Pressure (Millibars)	Height (Feet)	Temperature (°C)	Dew Point (°C)
1000	310	26.7	21.5
996		25.7	20.4
892		18.3	15.1
850	4,930	16.3	13.5
755	8,301	12.3	09.5
700	10,310	10.0	05.8
688		09.5	04.8
658	12,008	07.1	-06.8
638		05.8	-02.5
609		03.1	-01.6
600	14,460	02.6	-02.0
552	16,699	-00.2	-05.5
543	17,093	-01.0	-14.1
506	18,898	-04.4	-20.9
500	19,290	-04.9	-20.9
472		-07.0	-21.6
400	24,880	-17.0	-31.9
386	25,787	-17.2	M
300	31,780	-31.6	M
260		-39.3	M
209		-55.5	M
200	40,720	-57.3	M
150	46,530	-69.0	M
137		-72.0	M
105		-78.2	M
100	54,270	-77.0	M
88	58,464	-73.7	M
76		-72.7	M
50	67,810	-62.6	M
39		-57.5	M
32		-51.6	M
27		-52.6	M
25	72,320	-49.5	M
24		-48.0	M
08	107,448	-41.7	M
07	110,348	-35.7	M

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WINDS ALOFT (release time 1115M)

Height (Feet)	Direction (Degrees)	Speed (Knots)	Height (Feet)	Direction (Degrees)	Speed (Knots)
1,000	090	10	34,000	350	10
2,000	090	12	35,000	350	10
3,000	090	15	36,000	360	11
4,000	090	14	38,000	360	15
5,000	100	12	40,000	360	17
6,000	120	10	42,500	020	19
7,000	100	6	45,000	350	19
8,000	080	4	47,500	320	21
9,000	060	8	50,000	340	21
10,000	030	9	52,500	030	22
12,000	030	11	55,000	060	23
14,000	030	9	57,500	070	21
16,000	020	5	60,000	080	21
18,000	020	10	65,000	100	27
20,000	070	10	70,000	090	40
22,000	040	10	75,000	090	67
24,000	030	11	80,000	100	64
25,000	020	9	85,000	100	62
26,000	030	8	90,000	090	72
28,000	010	8	95,000	100	78
30,000	360	8	98,000	100	78
32,000	350	10			

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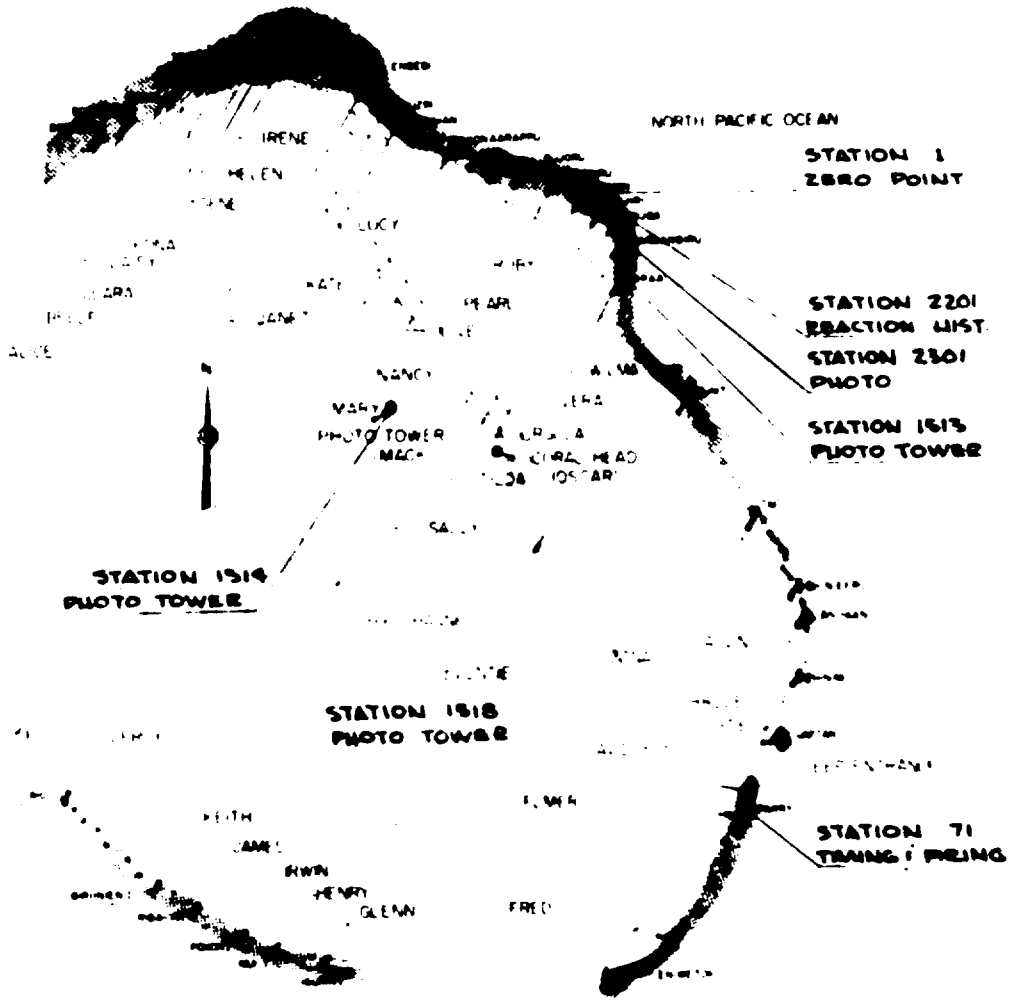

Fig. 0-1 - Eniwetok Atoll Map

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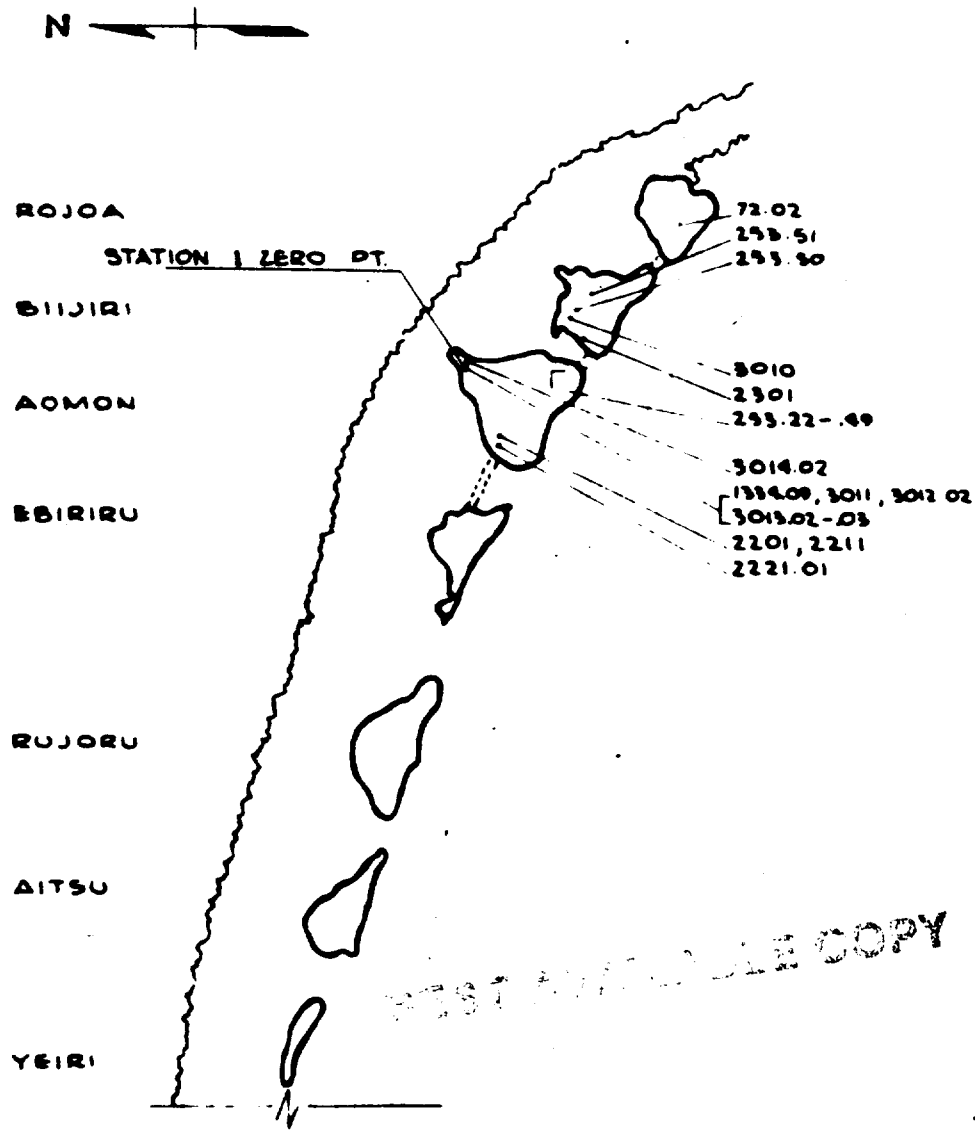

Fig. 0-2 - Scientific Stations and Zero Point

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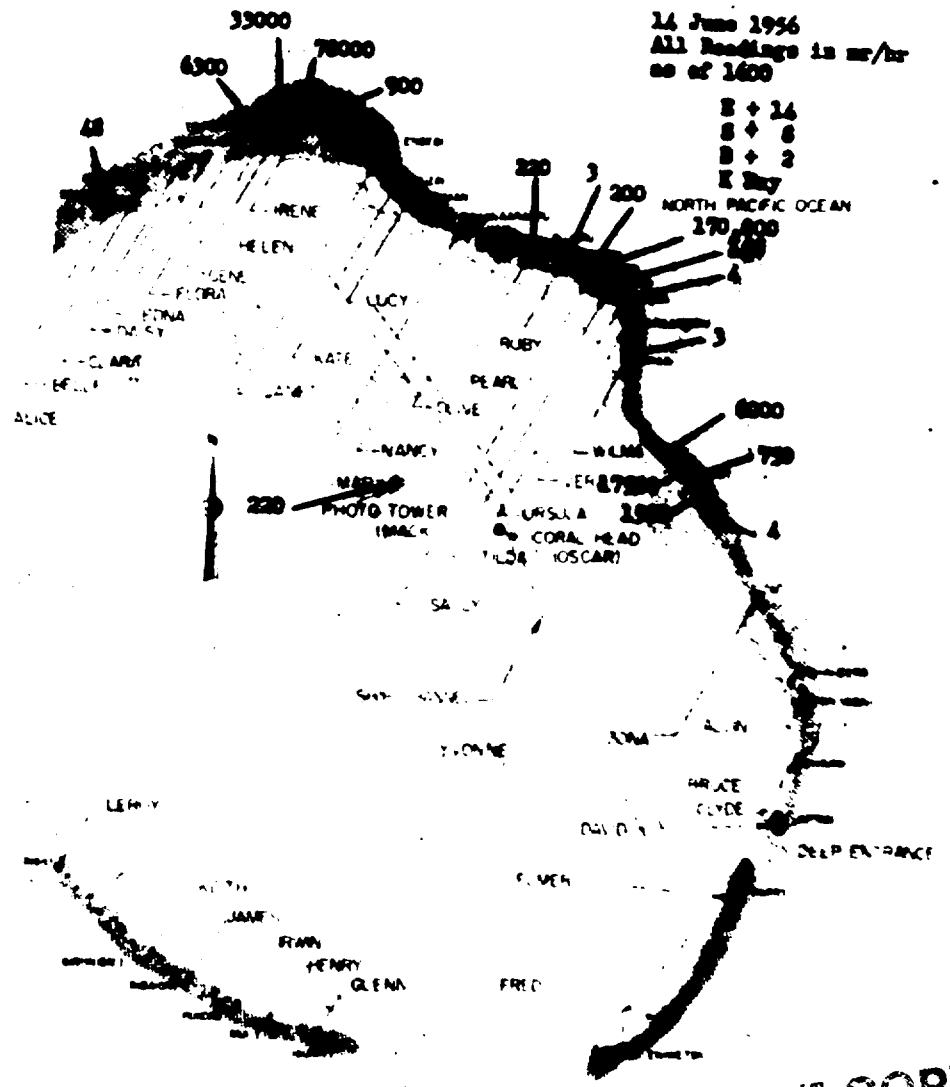

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Fig. [illegible] - Radiofo Survey, B-Bay

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PART II

TASK UNIT 3

DOD PROGRAMS

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

Program 2 - Nuclear Radiation and Effects	CDR D. C. Campbell
Program 5 - Aircraft Structures	CDR M. R. Dahl
Program 6 - Tests of Service Equipment and Materials	Lt Col C. W. Bankes

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[redacted] (KICKAPOO)

Project 2.51 - Neutron Flux Measurements and Shielding Studies - C.W. Lake

OBJECTIVES

To measure the neutron flux and energy spectrum as a function of distance from the point of detonation of [redacted] device. Also, to evaluate the [redacted] device.

To compare the foil detector method of determining dose in rep with the chemical and semi-conductor methods.

INSTRUMENTATION

In order to evaluate the [redacted] for shot [redacted] (Kickapoo), three instrument lines were required. The lines were laid as follows: One line extending along the projection on the ground of the long axis of the device; one line at 45° to this projection; and one line at 64° to this projection. It was desired that the third line be placed at 90° to the long axis of the device, however, a permanent structure along the 90° line required the use of the 64° angle.

Each instrument line consisted of a 1 inch steel cable laid along the ground. At each 100 yard interval the following detectors were placed. Am, 1 cm. or 2 cm. B^{10} shielded Pu^{239}, U^{238}, S, Chemical Dosimeters, Germanium Dosimeter, and Navy DT60 Glass Dosimeters. Only two samples of Np^{237} were available for this shot. One sample was placed at the 200 yard station on the 0° line and one at the 100 yard station on the 64° line.

RESULTS

As of this date no results are available. All data will be compiled for submission at a later date.

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[redacted] (KICKAPOO)

Project 5.6 - In-Flight Participation of an F-101A Aircraft - Capt M.H. Lewin

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. A correlation of the responses, combined with known characteristics of any weapon, will be used to define the maximum safe delivery capability of the aircraft.

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 [redacted] (Kickapoo) shot, the aircraft was positioned to receive maximum gust inputs consistant with minimum nuclear radiation. By positioning to theoretically receive 3.454 REM, the maximum expected gust response was about 50%.

AIRCRAFT POSITION IN SPACE

The aircraft was to fly at 7,000 feet absolute on an inbound heading of 040° at a ground speed of 800 feet per second. It was planned that the aircraft would be 1700 feet short of ground zero at zero time with shock arrival occuring 5.6 seconds later at a horizontal range of 2800 feet. Actual shot position was 200 feet beyond and 260 feet to the left of the planned zero time position with shock arriving 6.85 seconds later at a horizontal range of 4000 feet.

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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, 47 produced usable data. Two thermocouples gave unreliable readings. One shear gage was disconnected and no trace was recorded. One of the blast camera pictures was unintelligible due to muddy water splashed on the lens during takeoff. The photopanel camera, recording 26 parameters, functioned properly and produced good data. It vibrated at shock arrival but no data was lost.

Gust Data: The aircraft experienced a double shock arrival indicating that it was above the triple point path. Overpressure measured about [redacted] on the first shock, and about 1/3 that on the second shock 0.84 seconds later. Gust response was about 15% for shear and bending and about 25% for torque on the first shock. Gust response was negligible on the second shock.

Thermal Data: Although not of primary importance, thermal response was again considerably less than predicted. A ΔT of about 6° F on the unpainted and about 12° F on the black painted honeycomb was recorded.

Nuclear Radiation: A reading of 1.6 REM was recorded on the pilot's film badge. Based on positioning yield, 3.454 REM was predicted.

General: The participation was again successful from this project's standpoint. It produced data in the lower yield range not heretofore measured.

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[redacted]

[redacted] (KICKAPOO)

Project 6.1 - Accurate Location of an Electromagnetic Pulse Source -

E. A. Lewis

OBJECTIVE

To utilize the electromagnetic signal originating from nuclear weapon detonations 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.

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There are [redacted] systems being tested. The system known as the short base line or Marol System operates a net in the Hawaiian Islands and another net in California. Each net consists of one master station with slave stations connected with microwave link 30 to 60 miles on either side. The slave stations receive and automatically transmit the bomb pulse to the master station where pulse shape and time differences are analyzed. The California net has the master station located at Woodland and slave stations near Pittsburg and Marysville. The Hawaiian net has the master station located at Kona, Hawaii and the slave stations at Red Hill, Maui; and Papa, Hawaii. Each net will attempt to determine one hyperbolic line or a line of position and will not attempt an exact fix or exact location of ground zero.

The second system known as the long base line system has one net of stations in the Hawaiian area and another in the Continental U.S. Each long base line net requires a synchronizing transmitter and receiving station located not more than 1500 miles from the transmitter. For the Hawaiian net

[redacted]

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the transmitter is located at Haiku, Oahu and receiver sites at Midway Island, Lahaina, Maui and Palmyra Island. For the Stateside net the transmitter is located at Carolina Beach, North Carolina and receiver sites at Harlingen AFB, Texas, Kinross AFB, Michigan, Blytheville AFB, Arkansas, and Forestport, New York. Each receiver station will determine exact time of receipt of bomb pulse. From this information lines of position will be drawn and definite fixes or exact location of ground zero will be determined for each net.

RESULTS

Late schedule change prevented this project from being notified of exact shot time.

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Project 6.3 - Effects of Atomic Explosions on the Ionosphere - M. Haun

OBJECTIVE

The objective of Project 6.3 is to obtain data on the effects of high yield nuclear explosions on the Ionosphere. Primicipally, 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 ionised 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 megacycles.

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The transmitting and receiving antennas and the ground plane were in mutual perpendicular planes with the plane of the transmitting antenna oriented 53° 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.

RESULTS

Stations at Rongerik and Kusaie operated successfully during this test. The C-97 did not participate. There were no noticeable effects on the Ionosphere from this test.

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[redacted]

[redacted] (KICKAPOO)

Project 6.4 - Determination of Characteristics of Airborne Flush Mounted Antennas and Photo Tubes for Yield Determination at Extended Ground-to-Air Ranges - A. J. Waters

OBJECTIVES

To determine the effectiveness of flush mounted airborne antennas and phototubes at various ground-to-air ranges in detecting characteristic low frequency electromagnetic radiation and visible radiation, respectively.

To determine the temporal and amplitude characteristics of the low frequency electromagnetic radiation at various ground-to-air ranges.

To determine the temporal and intensity characteristics of visible radiation at various ground-to-air ranges.

To determine the effects of ambient conditions upon the satisfactory measurement of the parameters specified in the first two items.

INSTRUMENTATION

2 fiducial antennas	1 scope camera
1 synchronizer	1 DuMont Scope (dual beam)

TECHNIQUE

Signal is received by antenna fed through an amplifier and then to the scope. The signal is then photographed. Distance was approximately 16 miles.

RESULTS

Equipment was set up on Parry Island. Signal was received by both antennas. Picture was taken and recorded. Because of difference in channel settings on the scope, one trace is visible, the other is off scale.

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Project 6.5 - Analysis of Electromagnetic Pulse Produced by Nuclear Explosion - 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.

The wide-band receiver consists of one primary and four secondary cathode follower amplifiers. An antenna, frequency insensitive in the range of interest is fed directly into the primary cathode follower. The primary cathode follower is then connected to four individual cathode followers by a 50-ohm coaxial cable. Only three secondary cathode followers are utilized, the fourth serving as a spare.

The number one and two cathode followers feed oscilloscopes with sweep speeds of approximately 30 microseconds per centimeter and 10 microseconds/centimeter respectively. The number three cathode follower is connected to the third oscilloscope through a 2 microsecond delay line. The third oscilloscope has a sweep speed of 1.0 microseconds/centimeter. All oscilloscopes were triggered simultaneously by the DC trigger device

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located in the primary cathode follower and connected directly to the receiving antenna. The 2 microsecond delay line was added to permit the leading edge of the waveform to be recorded.

In order to establish a definite time relationship between the reception of the signal and the triggering of a given device such as a counter or transmitter, a time marker pip, generated by the delay trigger from one of the oscilloscopes, is fed through the 2 microsecond delay line and superimposed on the initial portion of the received waveform.

PROCEDURE

All oscilloscopes are calibrated against a known frequency standard for sweep linearity.

The cathode follower triggering system is set to trigger approximately 6db. above the noise level. The vertical deflectors of the oscilloscopes are set to receive the predicted field strength.

RESULTS

Station A - Parry Island

Positive results obtained on fast and slow sweep speed oscilloscope. The signals obtained were of good quality. Camera shutter on the medium sweep speed oscilloscope failed to open and no data was recorded.

The predicted field strength was [redacted] and the measured field strength was [redacted]

Station B - Kwajalein

The shot time was changed and it was impossible to notify this station in time.

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PART III

TASK UNIT 1

LASL PROGRAMS

Keith Boyer
Keith Boyer
Advisory Group

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Program 16 - Physics & Electronics & Reaction History

B. E. Watt

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[redacted]

[redacted] (KICKAPOO)

Project 16.3 - Electromagnetic Investigations - R. Partridge

Project 16.3 measures the time interval between the primary and secondary reactions in multi-stage devices by direct oscilloscopic recording of the electromagnetic radiation in the radio frequency range. In addition, methods of obtaining other diagnostic information from this radiation are investigated.

Equipment was operated to attempt to measure alpha, the rate of rise of the nuclear reaction. Satisfactory radio silence was obtained, but the signal radiated does not appear to follow alpha.

The time interval equipment was operated, using this device for a dry run. All channels operated correctly.

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PART IV

TASK UNIT II

UCRL PROGRAMS

W. D. Gibbins
Dep for UCRL

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Program 21 - Radiochemistry	R. H. Goeckermann
Program 22 - History of the Reaction	L. F. Wouters
Program 23 - Scientific Photography	H. B. Keller

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[redacted] (KICKAPOO)

Project 21.1 - Radiochemical Analysis - R. Goeckermann

Fission yield

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[redacted]

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[redacted]

[redacted] (KICKAPOO)

Project 21.2 - Sample Collection - R. Batzel

The Air Force Special Weapons Center supplied six F-84G sample planes and one B-57 as control aircraft.

Aircraft	Time after shot - Hours	Alt. Collected - Thousand feet	Fission - One Wing	Pilot Radiation
053	0.45 - 1.00	15.5	0.99×10^{15}	
038	1.00 - 1.15	14.2	1.40×10^{15}	
049	1.15 - 1.30	15 - 15.5	2.74×10^{15}	
046	1.30 - 1.45	11.7 - 14	2.32×10^{15}	
054	1.40 - 1.50	15 - 16.5	4.09×10^{15}	
032	1.45 - 2.00	14.7 - 15	3.07×10^{15}	

The cloud on [redacted] (Kickapoo) topped at 17,000 feet and the base was at 12,000 feet.

The samples collected were large enough for all measurements necessary. The success of the sampling was due to the cooperation and interest shown by the Air Force personnel.

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[redacted]

[redacted] (KICKAPOO)

Project 21.3 - Short Half-life Activities - F. Meuyer

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Another phase of Project 21.3 was engaged in finding total tritium in the cloud. This was done in the following manner: Carrier amounts of heavy water, krypton and xenon were added to the collection bottles prior to the program. The collection system consisted of filters for particulate

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matter and collection bottles mounted on the sampling planes. Gas samples were collected at various altitudes and times following the detonation and returned to Parry for separation. Krypton, xenon, water and carbon dioxide were separated from the gas sample and molybdenum was separated from the filter sample. Krypton, xenon and molybdenum were collected to determine fissions per collection bottle. The remaining activities, C^{14} and H^{3} were returned to the laboratory, as barium carbonate and water for the determination of total tritium and possibly C^{14} yield.

The fission bottle data are shown in Table 21.3-1.

TABLE 21.3-1

FISSION BOTTLE DATA TIME - 11.26 6/14/56

Bottle	RM-Ki - FP-92	RM-Ki - FP-94	RM-Ki - FP-98	RM-Ki - FP-100
Flt.	Tiger Red 1	Tiger Red 2	Tiger White 2	Tiger Blue 1
Alt.	14,500	13,500	12,000	14,500
Coll. Time*	+50 - 58	+63 - 67	+88 - 105	+98 - 100
Net Sample Wt.	6 cm.	5½ cm.	17 cm.	13½ cm.
PSI**	<100	175	600	500

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* Time of collection after shot time (minutes).

** Final pressure of gas collected (PSI).

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[redacted] (KICKAPOO)

Project 22.1 - Measurement of Alpha - L. F. Wouters

EXPERIMENTAL TECHNIQUE

The gamma rays produced by the nuclear reaction were detected by fluor-photocell detectors located in a lead lined "doghouse" 1864 feet from the zero point. A 27 foot lead pipe served to collimate the gamma rays onto an array of four fluors. The four fluors were positioned in tandem along the gamma path and were observed by a total of three photodiodes and four photomultiplier units. Combinations of gamma attenuators between fluors and optical attenuators between different detector units on the same fluor enabled the attainment of complete coverage from the 30th generation level to well above the peak expected gamma signal. The detector outputs were transmitted by cable to recording oscillographs located in the blockhouse where cameras provided a permanent film record of the signals.

RESULTS

The reaction history experiment was successful in measuring the high explosive transit time and the reaction rate of the [redacted] (Kickapoo) device.

H.E. Transit Time - The high explosive transit time was measured to be [redacted] from the x-unit pulse to the time of 50th generation level of the fission reaction.

Alpha - Preliminary reaction history results are indicated in Fig. 22.1-1 and 22.1-2. Fig. 22.1-1 is a plot of the equivalent gamma Mev per second point source strength versus time as obtained from a slope-amplitude fit of the individual pieces of data. Fig. 22.1-2 is an alpha versus time curve derived from Fig. 22.1-1.

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Fig. 22.1-1 - Kickapoo Reaction History

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Fig. 22.1-2 - Alpha vs Time (Kickapoo)

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[redacted]

[redacted] (KICKAPOO)

Project 22.3 - S-Unit Monitoring - C. E. Ingersoll

E. C. Woodward

The technique used for monitoring the S-unit consisted of telemetering signals from signal sources in the immediate neighborhood of the [redacted] (Kickapoo) device by high frequency radiofrequency methods to a receiving and recording station located on Parry. The signals were then recorded on oscillographs.

The signal sources were the load ring pulse of the I-unit and the output of a fluor - photomultiplier detector near the S-unit which measured both the S-unit output and the gamma rays from the nuclear reaction.

The oscillograph displays consisted of a raster scope display containing all signals and a linear sweep display on a 517 oscillograph which showed greater detail of the load ring pulse signal and the S-unit signal.

The results of the measurement are as follows:

Time from beginning of I-unit load ring pulse to beginning of S-unit pulse :

Yield of S-unit =

DELETED

Probable times from beginning of x-unit load ring pulse to gamma pulse signal and equipment cutoff of [redacted] respectively lead to value of Z = [redacted]

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[redacted]

32

[redacted] (KICKAPOO)

Project 23.1 - Fireball and Bhangmeter - H. Grier

D. J. Barnes

FIREBALL

Fireball yields have been computed for three films, one each from Parry, Mack and Piirsai, with the following results:

Parry ϕ =

Mack ϕ =

Piirsai ϕ =

DELETED

The fireball yield is determinined to be

DELETED

BHANGMETER

Four Bhangmeters at the control point gave the same value of time to minimum,

DELETED

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[redacted]

DELETED

Fig. 23.1-1

COMMODORE
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DELETED

Fig. 23.1-2

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[redacted]

PART IV

TASK UNIT 4

SC PROGRAMS

E. L. Jenkins
CTU-4

Program 30 - Vulnerability — J. H. Scott

Program 31 - Microbarography — R. Heppelwhite

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[redacted]

[redacted] (KICKAPOO)

Project 30.1 - Fireball Effects - F. E. Thompson

The primary objective of Project 30.1 was to determine the rate of removal of metal from aluminum, copper and steel samples inside a fireball.

Two techniques were employed to attain these objectives. In the first method, a 12-inch diameter, 290 foot steel column was erected to within 10 feet of the weapon cab. Samples of three metals, 24 ST aluminum, 1020 cold-rolled steel and 99.9 percent pure copper were positioned in pipe couplings at eight stations located along the steel column. Each sample had four shorting-and-opening probes which were embedded at varying depths. They actuated when the material had been vaporized to the probe depth. Signal leads were run from the samples through a 1-1/4 inch conduit inside the column to a recording shelter at the foot of the tower.

In the second method, four recoilless rifles were mounted on the tower cab. These rifles positioned projectiles containing test metals in the fireball. It was hoped to capture two of the projectiles in catchers limiting their exposure. High speed motion picture cameras were used to obtain projectile positioning.

Based on an examination of samples from the first method of investigation, the test data indicates that of 48 instrumentation probes in the upper four stations of the column, 18 appear to have actuated. Of these 18, five were recorded on magnetic tape. Continuing examinations of other samples may yield additional information. Instrumentation at lower stations within the column failed to indicate any temperature change.

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[redacted]

[redacted]

Indications are that the basic recording system operated properly and that principal failure occurred in gauges and/or wiring. Counts were obtained from neutron detectors at two stations in the lower portion of the column, but these data may not be wholly reliable. Data from ball crusher gauges installed to obtain peak air pressures, have not yet been reduced.

In the second method of investigating the metallic samples, the data are somewhat sketchy. Although the sample projectiles reached their predicted positions at the time they were engulfed by the fireball, only two badly mutilated copper segments have been recovered. Not much information can be obtained from these. However, two steel projectile cases were found on the ground after the shot and these may yield some useful data.

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[redacted]

[redacted]

[redacted] (KICKAPOO)

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. Four sites were operated: Ujelang, Wotho, Rongerik, 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] (KICKAPOO) good records were obtained at all stations operated except Rongerik. However, only Wotho and Ujelang were distant enough to get ozonosphere signals and three directions are necessary to extract temperature and wind data from the recordings.

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[redacted]

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