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HISTORY
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OPERATION IVY

JOINT TASK FORCE 132

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HISTORY
of
OPERATION IVY

1951–1952

CONDUCTED BY JOINT TASK FORCE 132
under the Command of
Major General P. W. Clarkson, United States Army

Written by
MAJOR FRANK E. MOORE JR., USA
and
LIEUTENANT H. GORDON BECHANAN, USNR

S[redacted]

Contents

Chapter XVI

RADIOLOGICAL SAFETY

Radiological Safety is a general term used to denote the methods by which the damage and radiation effects of an atomic explosion, or of radiological material spread by some other means, is confined and controlled, thereby preventing or avoiding hazards to the health of personnel. Plans for IVY RadSafe evolved around the principle that two distinct time periods exist when dangerous nuclear radiation is emitted following an atomic detonation. Protection against the primary radiological effects occurring at the time of detonation, the first time period of danger, was provided by removing personnel to safe distances from ground zero points. Secondary radiation, occurring during the second time period of danger and caused by radiological activation of soil and water around ground zeros and by the process of fall-out, was a matter of great concern for CJTF 132 during the planning of radiological safety for Operation IVY. Consequently, the evaluation of meteorological conditions and tendencies, particularly that of winds at varying levels and their potential influence on radioactive fall-out, was the subject of much study throughout both the IVY planning and operational periods. Detonation of the shots under unfavorable weather conditions could have subjected units of the Task Force and neighboring inhabited islands to harmful radioactive contamination. Measures for protection against these secondary hazards, by far the largest area of IVY RadSafe planning, were accomplished through the use of instruments designed to indicate directly both the presence and intensity of radioacitvity at given places; by area reconnaissance; through maintenance of contamination situation maps; by the posting of hazardous areas; through minimizing the spread of contaminated material into uncontaminated areas; and by the development and utilization of decontamination procedures.

The anticipated yields of both the experimental MIKE device and the KING bomb scheduled to be tested during IVY were such that precautions to an extent never before taken became necessary to insure proper safety of Task Force personnel and of the population centers bordering the Eniwetok Danger Area. The scope of test operations was such that, in carrying out maximum safety measures, an evacuation of Eniwetok Atoll was necessary for MIKE Shot. Early plans for evacuation of the Atoll during KING Shot were ultimately revised to provide for an immediate evacuation following KING Shot should that necessity arise. Although the early plans envisaged that the Firing Party for MIKE Shot would remain ashore in a specially constructed bunker, the final plans called for the complete evacuation of all personnel. The bunker plan was cancelled due to the potential radiation danger and due to the excessive cost involved for its construction.

The chief RadSafe Officer for the Task Force, Captain R. H. Maynard, USN, was assigned to the Task Force Headquarters Staff and was responsible for advising the CJTF on the measures necessary to insure the radiological safety of all personnel who would be connected with the actual tests. The major technical RadSafe element of the Task Force was Task Unit 7 of the Scientific Task Group. This unit had Task Force-wide responsibilities while the other three Task Groups possessed essentially self-contained RadSafe units. During the period when the Task Force was afloat, the radiological safety of personnel became the function of the individual ship's RadSafe facilities, subject, of course, to the instructions of the CJTF as promulgated through CTG 132.3. All RadSafe operations for IVY were treated as routine and complied with the established permissible radiological exposures for routine work, except for those activities which specifically were designated as special operations by CJTF 132.

In order to better control and record these routine exposures, criteria governing radiological physical examinations for Task Force personnel were promulgated by the Task Force Headquarters early in 1952. It was stipulated that:

1. Radiological physical examinations would be required for all civilian personnel of the Task Force whose duties would require that they handle radioactive material, or who would be in the Forward Area during or after Shot times. In addition to the military radiological monitors, all military personnel who would work in areas containing radioactivity; on shot islands after detonations; on contaminated aircraft; and with radioactive products would be required to have radiological physical examinations. Eniwetok Island and other administrative and housing islands were not to be considered as contaminated areas, however.

2. Examinations were to be accomplished within three months prior to movement to the Forward Area, except in the case of civilian personnel employed at LASL for whom special arrangements had previously been made. One copy of the radiological physical examination—including analysis of chest X-ray, complete blood count and urinalysis—was to be forwarded to CJTF 132, and one copy retained by the Task Group concerned. Finally, personnel who would be required to have the examination would not be allowed to leave the continental United States prior to compliance with these criteria.

With the exceptions of one RadSafe officer procured for Task Group 132.2 and of the military personnel procured for Task Unit 7 by the Task Force Headquarters, the responsibility for providing RadSafe personnel was a function of the respective Task Group Commanders. The personnel procurement problem facing CTG 132.1 was much greater than that of the other Task Groups. In addition to his duties as the Task Force RadSafe Officer, Captain Maynard was designated as the Commander, Task Unit 7. Following his designation, the initial action to meet Task Unit 7 personnel requirements was taken when letters from CJTF 132 were sent in early March 1952, to the following headquarters with requests as indicated:

1. Commandant, USMC, through CNO, for five radiological monitors, including one officer and four enlisted men.

2. Director of Military Personn[redacted]d-quarters, USAF, for nine radiological mon[redacted]s (seven officers and two enlisted men), four photographic assistants for photodosimetry, one stenographer, and one clerk typist.

3. Chief of Naval Personnel, through CNO, for five radiological monitor officers, one electronics officer, three radiological instrument repairmen, and one yeoman typist.

4. AC of S, G-1, Department of the Army, for seven radiological monitors, one laboratory director (Signal Corps), four laboratory technicians (Chemical Corps), two supply clerks, and one stenographer.

Since the assignment of military personnel to the RadSafe Task Unit was to be of such short duration, it was recommended that they be assigned on a temporary duty basis for a period of approximately four months at Eniwetok beginning on or about 15 August 1952. The majority of these requested personnel were RadSafe engineers, graduates of the three-year military courses in RadSafe engineering. The utilization of such highly trained personnel was based on the excellent opportunity which IVY would provide for field training. Also, there was a need for a certain number of personnel who would be able to make "on-the-spot" evaluations qualified by background training and knowledge. In May, following, CTU 7 submitted a request to CTG 132.1 for the civilian personnel needed to complete the RadSafe organizational requirements of the Task Unit. Personnel from Los Alamos, from Oak Ridge, and from the Evans Signal Laboratory were chosen.

At the time Operation IVY preliminary planning got underway, the planning problems associated with RadSafe fell roughly into two categories—preoperational considerations and postoperational measures. In general, the preoperational problems were negligible. Initially, there had been a problem in connection with the residual radiation of previous tests and from the shipment of radioactively contaminated cargo originally located on islands which had served earlier as shot sites. This residual radiation soon dissipated itself, however. Through the acquisition of new equipment and through the medium of training and general familiarization of personnel of the various Task Groups with the techniques of radiological operations, the remaining preoperational problems were easily enough resolved.

In September 1951, CJTF 132 had sent a letter to CTG 132.2 requesting information on the status of RadSafe facilities at Eniwetok Island. He was informed that no Radiac equipment was available for use by Task Group 132.2; no personnel trained in the use of Radiac equipment were available in the Task Group; and the AEC Resident Engineer had no technical facilities with which to advise CTG 132.2 or to establish RadSafe criteria when granting access to the previously contaminated islands of Runit, Eberiru, Engebi, and Muzin. By late September, a request had been made of the Army to furnish a limited amount of standard Radiac equipment to CTG 132.2 in order that he would be provided with the means for fulfilling radiological safety requirements during the build-up period. By December, CTG 132.2 was informed that the following Radiac equipment was being procured and would be shipped as it became available:

1. High Range Portable Survey Meter	6 ea.
2. Low Range Portable Survey Meter	6 ea.
3. Low Range Dosimeter, with suitable charging and indicating instrumentation.	20 ea.
4. High Range Dosimeter, with suitable indicating instrumentation.	20 ea.
5. Portable Alpha Meter	2 ea.
6. Radium Source, 25 mg	1 ea.

The first shipment, consisting of the first three items listed above, was made in late December, while the balance went forward in subsequent shipments.

Procurement of equipment necessary to meet the needs of the technical RadSafe Unit (Task Unit 7 of Task Group 132.1) was initiated in March 1952. A set of memoranda was prepared at that time by Major J. D. Servis, USA, then in the Technical Branch of the J–3 Division of the Task Force Headquarters. These memoranda listed available equipment, then in storage, which could be shipped to the Forward Area without renovation as well as that equipment, also in storage, which could be shipped to the Forward Area after inspection, tests, and renovation. At the same time, a total listing of equipment required by Task Unit 7 had been prepared by the J–4 Division of Task Group 132.1. This listing gave descriptions, possible sources of supply, and action agencies for each item. Following a study of the list, it was evident that the majority of the equipment items could be procured from AEC stock or from the military Services. At about that same time, Major Servis inspected and selected certain types of Radiac instruments then undergoing renovation in the instrument repair section at LASL. Generally speaking, these instruments were acceptable though a number of beta-gamma survey meters were lacking in Geiger-Müller tubes. Information, nevertheless, indicated that the tubes could be procured from LASL prior to shipment. Procurement of film badges and calibration standards was initiated as soon as Task Unit 7 appropriation numbers were obtained from JTF 132. Simultaneously, the LASL shipping department agreed to activate a project for the phasing and tropicalization of the selected Radiac equipment.

The acquisition of additional items of RadSafe equipment continued. A conference with personnel of the AFSWP Test Command in New Mexico concerning the possible use of Test Command radiological detection instruments during IVY indicated that AFSWP would concur in the loan of fifty-five AN/PDR-T1B and twenty-six MX–5 survey instruments to Task Unit 7. An inspection made of a mobile radiochemical laboratory at Kirtland AFB resulted in the conclusion that it was unsatisfactory—consequently, efforts to obtain a new model from OCSigO were continued. The initial request had been for two such laboratories, one to be placed on Parry Island and the other aboard the RENDOVA as part of the RadSafe Center afloat. The problem of evacuating the unit from Parry without damaging it, however, was the basis for the downward revision of the initial request from two laboratories to one. It was later ascertained that the delivery of a new radiochemical laboratory van was not possible prior to 15 September 1952. Delivery at such a late date would preclude its use in Operation IVY since it would not be available for loading aboard the RENDOVA prior to her scheduled departure from the West Coast. This problem was resolved when the Army agreed to fabricate and instrument some required special equipment in a van which was available at that time. In addition, since certain items of water-bath temperature regularity equipment needed for installation of a Photo Laboratory in the RENDOVA could not be procured commercially in time for installation, the Evans

Signal Laboratory generously agreed to provide a portable field-type Photo Laboratory van to Task Group 132.1 for joint use by the Task Force. Inasmuch as neither of these items of RadSafe equipment was standard, the cooperation of the Army and Evans Signal Laboratory resulted in substantial savings to the Task Force.

One of the RadSafe equipment problems peculiar to Operation IVY was the necessity for procuring gamma intensity reading meters to be used under water. This requirement was brought forward in April 1952, by Dr. Ogle, Deputy Commander of the Scientific Task Group. He was of the opinion that after the detonation of MIKE there would exist in the MIKE area, for a reasonable length of time, a fairly large flux of both slow and fast neutrons. The shallow parts of the reef, toward both Bogallua and Engebi, would be exposed by the blast wave, thus permitting the reef to become activated by slow neutrons. In a matter of three or four days, the water in this area would become decontaminated by the normal flow of currents to the ocean, but the reef, itself, could remain fairly radioactive. If it became necessary for recovery parties to work in this area, standing in the water, the normal beta or gamma intensity reading meters would indicate little reef contamination due to the shield of water. Hence, it was believed prudent that these special meters be procured.

Concurrent with RadSafe training in Task Group 132.3 was the procurement of certain items of operational RadSafe equipment. Packaged weather-deck spray units, together with installation plans, were developed by BuShips and distributed to ships of the Task Force. This equipment was designed to be used in combating the hazard of contamination from radioactive fall-out. Items of special clothing supplied to Task Group 132.3 were standard stock items and the ships' allowances had been established by the Bureau of Supplies and Accounts (BuSandA). Units of the Task Group were individually responsible for procuring their own Radiac equipment in accordance with Op-Nav Instruction 9670.2, Ship Type Electronic Plan, and were responsible for the maintenance of the equipment. For repairs beyond the capacity of individual ships, a repair shop and reserve instrument pool were established aboard the RENDOVA to be used in conjunction with Task Group 132.1 repair facilities.

CTG 132.4 began his initial planning [redacted] Rad-Safe in February 1952, and in March, a list of supplies and equipment required for use in the Task Group Radiological Section at Kwajalein was submitted to the Air Force Director of Materiel. On 7 April, a supply directive was received indicating that procurement action on the requested material was being taken. Early in March, the Task Group 132.4 RadSafe Section had been assigned an aircraft decontamination area at Kwajalein; the area proved to be unsuitable, however, since it was located on the parking ramp and in such close proximity to the engine run-up area that the possibility of spreading contamination over wide areas was introduced. In addition, the pavement was of asphalt which easily collects contamination. It was also of insufficient slope to permit drainage of contaminated washing solutions. An isolated area on the downwind end of the Island was obtained and plans were made to construct a decontamination ramp, 120′ x 200′, of trowel-finished concrete. The ramp wash area was sloped one inch per ten feet for easy flushing and positive drainage into the open seas. This area was so located on the Island that it could be roped off if contamination persisted without hindering operations in more congested areas. Approval of the CTG 132.4 request for construction of the decontamination ramp was given by CJTF 132 toward the end of April.

During the same period of planning for aircraft decontamination, two buildings on Kwajalein were obtained for use as a Personnel Decontamination Center, one building (formerly a latrine), 12′ x 24′, and one shower house, 20′ x 40′. The smaller building was used as an office and the shower room was converted into the actual space where personnel decontamination would occur. Additional facilities were constructed in the Center for the storage and issue of clothing and for the repair and calibration of Radiac instruments.

Beginning with the early planning phase, considerable thought was given to the RadSafe measures which would be required for the sampling aircraft. In contrast to GREENHOUSE, during which sampling was accomplished by drone aircraft, the sampling aircraft to be utilized in IVY were manned. It was planned that equipment for pilot protection would include filters in the pressurization system to filter radioactive particles from the air taken into the aircraft; a rate-meter to determine intensities; and a dosimeter to determine the total exposures of the pilots.

With the choice of the F-84G as the sampling aircraft, the problem of pilot safety became more complex. A preliminary inspection of an F-84G aircraft at Kirtland revealed that insufficient space existed in the cockpit for installation of filters at the terminals of the pressurization system. Subsequent studies indicated that a filter could be placed in the pressurization line forward of the intercooler-regulator "Y" connection, and, by modifying this line, the filter could be placed in the defroster line which was an independent system located under the windshield of the cockpit. Such a trial installation was made on those F-84G's scheduled for IVY, but being used in Nevada for TUMBLER-SNAPPER. Final decision, of course, remained with WADC. Later, a request was made by the Commander-designate of the Test Aircraft Unit that a filtering unit be installed on the aircraft oxygen system. The proposal met with objections inasmuch as it was [illegible]sumed that pilots would be on one hundred per[illegible]t oxygen during the actual sampling operations. Even if this were not the case, data from previous tests had indicated that inhaled large particles were of no more danger than external radiation. At about the same time, difficulties were experienced with the paper being used in the filters installed in the cabin pressurization system. The ultimate decision on the whole problem of F-84G filtering was resolved when improved and thinner paper was chosen and the filters were installed in the pressurization system. This insured, all circumstances considered, the maximum possible protection against contamination of air in the cockpit and the air that would be inhaled by the pilots.

As modification plans progressed, two instruments were considered for installation for determining pilot exposures. They were the Proteximeter, developed by Victoreen; and an integrated dosimeter, the Integron, developed by Dr. Bob E. Watt of LASL. Due to the limited time for procurement of the instruments and due to the considerable modification requirements for the Proteximeter, it was decided in March that the LASL Integron would be used. It was redesigned t[illegible]et space requirements and the prototype was received by Task Group 132.4 on 14 April. The instrument was then blueprinted and, on 16 April, the blueprints were forwarded to WADC for the manufacture of a total of twenty. Five of these instruments had been placed in training aircraft at Indian Springs, Nevada, 21 April, and tests had proved them to be very satisfactory during Operation TUMBLER-SNAPPER.

An additional safety measure coming under study was protective clothing for the pilots. A conference was held in Washington early in July 1952, for the purpose of determining the possible necessity and the feasibility of providing protective clothing for the sampling aircraft pilots during MIKE sampling. Dr. Harold Plank of Task Group 132.1 presented details of certain computations which indicated that the magnitude of the flux of soft radiation expected to occur during the sampling operations for MIKE would be approximately 100 Kev average with a half-thickness value of approximately .2 mm of lead. Lt. Colonel R. A. House, USAF, of the Technical Branch of the Headquarters' J-3 Division presented data which had been obtained from earlier tests made on various aircraft components and commercial protective materials using an 85 Kev gamma source. He then continued to recommend a choice of the following solutions:

1. Flying suit of several plies of leaded glass fabric or a suit of vinyl (.5 mm Pb equivalent) sandwiched between ordinary or leaded glass cloth.

2. Wrap-around insert to parachute using lead impregnated vinyl or rubber or leaded glass fabric.

3. Loose shroud or wrap-around apron of above materials to be worn over the normal flying clothing.

4. Lead sheet, or above materials, placed in pockets over vital parts of the body.

Following an open discussion, it was concluded that .5 mm of lead protection would screen out sufficient soft gamma radiation to permit a two-fold increase in the size of the cloud sample collected; that operations would be conducted on the basis of 5r (measured gamma) planned dose with the anticipation that accidents resulting from unforeseen circumstances would not result in doses in excess of 20r; that, from a biological viewpoint, no eye hazard was anticipated but from a psychological

...point, protection in the form of a lead-glass ... would be desirable; and that the body ex-tremities presented no primary radiation concern. It was interesting to note that all members of the conference agreed that, if the protective suit were ... discarded because of operational difficulties, no real health hazard to the pilots would exist ... the proposed cloud sampling plans. Never-theless it appeared that the psychological benefits ... be advantageous.

Following this conference, a meeting was ar-ranged with a representative of the Bar-Ray Products, Inc., of Brooklyn, N. Y., at which the ... merits of the recommended materials were discussed. It was concluded that a loose ... of the lead-glass fabric, eight plies in ...ness, would meet the requirement for .5 mm ... protection. This could be made to fit ... the head, drape part way down the back, ... extend over the sides and front of the body ... a point just below the knees. Quick release ...aps could be provided so as to retain the safety ... of quick removal in the event of bail-out. The Test Aircraft Unit Commander-designate ... to fabricate a sample shroud prototype and ... the design to Bar-Ray Products, Inc., ...oduction of fifteen additional eight-ply, ...ad-glass fabric shrouds. He further agreed to ... field tests to the final product during Oper-ation TEXAN, the Task Group 132.4 IVY ...rsal.

In the meantime, plans were also made to test ... rubber shrouds in TEXAN. The rubber ... proved, however, to be extremely un-...table and impracticable. They were cum-... and stiff, hence lacking in the desired ...ity: they did not permit sufficient passage ... to the body; and it was doubtful that they could be discarded safely by the pilots in the event of emergency bail-outs. At the same time, the leaded glass fabric shroud proved to be very satis-factory, having been subjected to a four-hour test. Based on the TEXAN tests, it was firmly decided to procure shrouds made of the leaded glass fabric with positive release snaps attached and Bar-Ray Products was awarded a contract. After the es-tablishment of the Task Force Headquarters in the Forward Area, information was received that the protective clothing had been completed and shipped on 7 October, thus resolving the problem.

While the problem of procuring RadSafe equip-ment was being dealt with throughout the Task Force, the matter of RadSafe training responsibil-ities was receiving attention in the Task Groups. RadSafe training for Task Group 132.2 was car-ried out on three levels. The first level, basic training, required that every officer and enlisted man receive at least six hours of training for the purpose of becoming familiar with the problems involved so as to insure intelligent cooperation with decontamination crews. During the month of May 1952, approximately 450 personnel at-tended a six-hour course given by an officer in-structor from USARPAC. The second, the inter-mediate course, consisted of the training of team leaders; monitoring team leaders; supervisors; instructors and assistant instructors. In addi-tion, two personnel were sent each week to the Fleet Training Center at Pearl Harbor for a forty-hour course. The third level of training consisted of sending ten key NCO's to the USARPAC Chemical Unit at Schofield Barracks for a 120-hour course. Graduates of this course were integrated into the Task Group RadSafe program as instructors and monitors.

The first steps in preparing for radiological safety within Task Group 132.3 was to develop the operational efficiency necessary to carry out all phases of RadSafe and was accomplished through the medium of training. The com-manding officers of surface and air units of the Task Group were directed to utilize every op-portunity to train key officer and enlisted per-sonnel of the unit RadSafe organizations utilizing the facilities available at regular training centers such as the Damage Control School, Treasure Island, San Francisco, and other Fleet Training Centers at San Diego and Pearl Harbor. On-the-job training was emphasized and consisted principally of lectures and drills.

For Task Group 132.4, SAC provided four RadSafe officers who arrived at Kirtland during the first week of July. Together with the Task Group Staff RadSafe Officer, they arranged train-ing and indoctrination of personnel of that Task Group. Toward the middle of July, all Task Group 132.4 personnel at Kirtland received an orientation course under the direction of the Test Support Unit and similar training was begun at Kwajalein early in August. All Task Group 132.4 personnel at Kwajalein were provided with RadSafe manuals. In addition, the Navy gave a quota to Task Group 132.4 for eight personnel to attend the five-day RadSafe course at the Fleet Underway School in Pearl Harbor.

As studies and plans advanced and as details of the cloud sampling requirements became known, the problems of insuring pilot safety in the F-84G's continued to be a matter of concern. Plans relative to permissible dosages for personnel participating in IVY had been based on the standard of 3r, measured gamma only, over a three-month operational period. This limitation posed a serious problem in planning a reasonable flexibility for the cloud sampling operations inasmuch as it was difficult to predict the dosages which might occur for the F-84G pilots, even with the protective measures being adopted. At an informal meeting in the Division of Biology & Medicine, AEC, on 21 May 1952, Dr. Shields Warren disclosed that he had had several discussions with Dr. Graves relative to the IVY problems involved with manned aircraft sampling and the difficulties associated with trying to remain within the prescribed permissible exposure levels. Although Dr. Warren had, in the past, steadfastly refused to officially allow a dosage of more than 3r for a three-month operational period (based on a .3r/week routine lifetime exposure), he did at that time state that AEC, through his offices, would be receptive to a proposal from CJTF 132 that a special emergency exposure of 20r, subject to several restrictions, be established for Operation IVY.

In view of the fact a one-time 20r exposure would bar pilots from future tests, Dr. Warren recommended that concurrence first be obtained from the Surgeon General, Headquarters, USAF. Therefore, on 29 May 1952, CJTF 132 requested the Air Force Surgeon General to submit his comments on the proposal and on 31 July 1952, in an indorsement to the basic communication, the Surgeon General indicated agreement with the opinion of Dr. Warren that no permanent physiological damage to individuals would result from a one-time exposure of 20r. That office was of the opinion that the decision to allow the 20r dosage could be accomplished by a command decision and that a nominal modification of existing standards was unnecessary.

In the meantime and in anticipation of the concurrence of the Air Force Surgeon General, a letter was sent by the CJTF to the Director, Division of Biology & Medicine, AEC, proposing that a special, safe emergency exposure be permitted under the RadSafe regulations governing Operation IVY so as to allow for a 20r integrated dosage, measured gamma only, subject to the following conditions:

1. Personnel in special category of allowed twenty (20.0) roentgens dosage will be the crew of actual sampling aircraft (i. e., pilots of F-84 aircraft).
2. Personnel in special category will be allowed total dosage of 20.0r for the entire Operation IVY.
3. Personnel who receive the maximum allowed twenty (20.0) roentgens will not be asked to receive a similar "one short exposure dose" of this extent for at least two (2) years. This does not preclude additional exposures on a lifetime basis of .3r/week as presently prescribed.
4. Suitable records will be maintained to insure that medical records of such individuals in their parent agencies reflect the exposures so that compliance with restrictions above can be realistically carried out.
5. Personnel expecting to be in the category as outlined above will be given the special RadSafe physical examination before exposure and at least once per year for 2 years after the exposure period.
6. Reports of results of medical examinations will be made by the respective Department of Defense services, or sponsoring agency, if nonmilitary, to AEC with suitable identifying data. This step is in the overall interest of maintaining one central repository for exposure records of all personnel involved in atomic tests of the AEC

Although the early verbal approval of AEC was made known, it was not until 29 August that CJTF 132 received the AEC formal approval to permit the 20r exposure. This letter further modified the proposals in the CJTF's letter to permit an upper limit of 25r and further recommended that pilots receiving the total allowable dosage not be used in subsequent operations where more than normal permissible dosages of radiation would be received unless their services were needed to avert an imminent threat to national security.

In the meantime, more detailed special radiological safety regulations than had previously

... established were drawn up in the Task Force Headquarters and published in order to provide ... overall RadSafe precautions during and immediately following detonations. These regulations appeared in the RadSafe annex to Op-Plan [illegible]52 and provided that:

1. Individuals or groups working in contaminated areas or with contaminated equipment would be accompanied by RadSafe monitors who would inform persons in charge of groups of the radiological hazards involved and when maximum permissible exposure had been reached.

2. Names of all individuals who were expected to enter radioactive areas would be submitted to CTG 132.1 in the form of an eligibility list two weeks prior to the tests.

3. All islands in the Atoll were to be considered contaminated after each Shot until reported clear by CJTF 132.

4. No aircraft in the air at H-Hours should be closer than twenty miles (slant range) from the detonation points; and, after detonations, no aircraft should operate inside the air RADEX or closer than ten miles from the rising column or visible cloud unless specifically directed otherwise. If a tactical situation arose, necessitating entry into the air RADEX, tactical dosage allowance standards would apply.

5. All persons in aircraft at Shot times, or at subsequent times when engaged in operations in or near the cloud or RADEX track, would wear film badges.

6. Pilots and co-pilots of aircraft in the air at Shot times would use modified all-purpose .1 density filter goggles and copilots would, as an extra precaution, cover their eyes at H-Hours.

7. All Task Force multiengine aircraft in the air at H-Hours within 100 miles of detonation points would carry a person designated as a RadSafe monitor and equipped with suitable Radiac equipment as well as a RADEX plot. This monitor was to be capable of calculating allowable exposures under both tactical and operational conditions.

8. Transportation of radioactive materials to and from the Forward Area would be in accordance with AEC regulations for escorted shipment of such material. Monitoring of radioactive test materials en route would be the responsibility of escorting scientific personnel as directed by CTG 132.1.

9. No radioactive material was to be removed from the test site except as authorized in the experimental Programs.

10. No ships with personnel were to be permitted inside the Lagoon or closer than twenty-five nautical miles from Shot islands at the times of detonation. Bearings of danger from immediate radioactive fall-out for ship operations would be established by CJTF 132 on the basis of forecast wind directions at the intended time of detonation and this danger section would be designated as surface RADEX. All ships of the Task Force would remain outside the RADEX danger bearings, radial limitations and time restrictions. However, if ships were directed tactically into the RADEX, movement of ships would be governed by tactical dosage guides.

11. Individuals on board ships of the Task Force would be protected collectively from hazards of blast, heat, and radiation by movement of the ships.

12. Boats operating in waters near Shot islands after Shot times were subject to contamination and monitors would be required for all such craft operating north of Parry Island after Shot times until such time as radiological restrictions were lifted.

13. Film badges were to be forwarded regularly to the Photodosimetry Laboratory of CTG 132.1 where all processing and recording would be accomplished. Copies of exposure records would be furnished to Task Group Commanders.

In the consideration of possible tactical situations developing immediately after detonations, deviation in allowable exposures had to be anticipated and responsible commanders were directed to base their decisions on the current DOD criteria covering exposure to gamma radiation in tactical situations which stated that:

1. Uniform acute (immediate) dosages of 50r to a group of personnel would not appreciably affect its efficiency as a fighting unit.

2. Uniform acute dosage of 100r would produce nausea and vomiting in occasional cases but not to an extent which would render personnel ineffective as a fighting unit. A period

of rest and individual evaluation should be given as soon as possible to personnel receiving an acute dosage of 100r or more. Dosages of approximately 150r, or greater, could be expected to render personnel ineffective as troops within a few hours, although the mortality produced by 150r would be very low with eventual recovery of physical fitness to be expected. Commanders should, therefore, assume that if a substantial number of their men should receive acute radiation doses well above 100r, there would be a grave risk that their commands would rapidly become ineffective as fighting units. Cumulative radiation doses over the entire body of about 200r could substantially reduce the life expectancy of the irritated individual.

Another factor for which provisions had to be made in RadSafe planning for IVY was that of non-Task Force civil populations. During an informal meeting with Dr. Warren at the Nevada Test Site in the latter part of April 1952, Captain Maynard was apprised of the AEC views concerning protection of civil populations during atomic tests. Though AEC was at that time primarily concerned with the civil population inhabiting areas bordering the Nevada Test Site, it was equally interested in the measures to be used at the Pacific Proving Ground. Although definite plans had not been made at that time to provide solutions for this problem, a conference on the matter was scheduled to be held at CINCPAC Headquarters in July. Further discussions with Dr. Warren and his deputy, Dr. John C. Bugher, were deemed advisable with the desired end of a clear understanding by AEC of the Task Force treatment of the problem of protecting the populations bordering the PPG.

On 10 July 1952, AEC and JTF 132 representatives briefed CINCPAC personnel on the possible special hazards of IVY and on the necessary precautions required to insure the safety of the inhabitants of Pacific Islands as well as surface or air units other than those of the Task Force. It was concluded that the existence of hazards at Ujelang was a definite possibility, though the existence of hazards at Bikini was remote. Hazards to other islands in the vicinity were considered negligible, but the air routes through Wake d be affected for short periods of time. Since the only persons to be at Bikini were Task Force personnel, CJTF 132 would provide, from forces allocated to the Task Force, a capability for their temporary removal in the event of necessity. It was recommended at that time that CINCPAC provide a capability at Ujelang and be prepared to temporarily evacuate approximately 160 native inhabitants. At the same time the CJTF agreed to place a Task Force RadSafe engineer aboard the evacuation vessel to assist in on-the-spot monitoring and evaluations.

The Commanding Officer of the LST 827 was alerted on 29 September to be prepared to evacuate Ujelang Atoll for a period of approximately three days. On 21 October, plans were definitely established for the LST 827 to evacuate Ujelang completely of all personnel by one day before MIKE Shot for a period of approximately four days and the promised RadSafe engineer of JTF 132 was provided to conduct shipboard observations and ground surveys of Ujelang prior to disembarkation of the natives.

Plans were also made for a CINCPACFLT representative to be attached to the Task Force Headquarters Staff during the Shot periods for the purpose of representing CINCPACFLT on matters relating to possible off-site radiological hazards incident to the detonations. Captain H. H. Haight, MC, USN, was designated and was authorized access by CJTF 132 to the appropriate Task Force Staff Divisions and areas under Task Force cognizance as were necessary in the performance of his duties. Captain Haight joined the Task Force Staff in October and was allocated space aboard the ESTES for his activities.

In late July 1952, a conference was held at the Headquarters of the 9th Weather Group, Andrews AFB, for the purpose of discussing matters concerning post-shot cloud tracking and reporting. In order to insure prompt and timely dissemination of data on radioactive fall-out and its subsequent effect on areas along the route of the atomic cloud, a number of decisions were made which included some doubling up and assignment of dual missions. It was planned that the sampling aircraft, utilizing their special equipment, would supply information during the period from H-Hour to H+6 hours. From H+6 hours [redacted]

And for the period from H+12 hours to H+48 hours weather reconnaissance aircraft would be ... d for special tracking flights by designation ... true bearings and maximal and minimal ... from zero for demarkation of area boundaries. ... Task Group 132.4 WB-29 aircraft were designated to accomplish this mission subsequent to both MIKE and KING Shots. When contact was made with the radioactive fall-out areas, the aircraft -under the direction of the B/199 equipment operator—tracked the edges of the radioactive area to determine its extent. Particular emphasis was placed on establishing the leading (westernmost) edge of a particular fall-out area and its rate of movement. At fifteen-minute intervals, coded messages were dispatched from the aircraft to the ESTES. This code was one developed by Task Group 132.4 and was utilized [redacted]

It was in August that Headquarters, JTF 132, received information from the Division of Biology and Medicine, AEC, that the AEC's New York Operations Office (NYOO) had proposed for Operation IVY a program known as the World Wide Fall-out Monitoring Program. This program was designed to collect data on any or all fall-out as well as to assure the public that the radiation and fall-out of the various atomic tests were being monitored and charted by competent authority and responsible agencies. A central liaison section was established at Kwajalein, consisting of one officer from JTF 132—representing both CINCPAC and JTF 132—and Dr. Merrill Eisenbud of NYOO. CINCPAC agreed to provide eighteen enlisted men, six each to be stationed for the duration of the operation at Kwajalein, Guam, and Hawaii respectively. With each group of six enlisted men was one NYOO representative, and, to accomplish the mission, one each long-range aircraft was provided by CINCPAC at the Guam and Hawaii locations. For Kwajalein, a Task Force aircraft (Task Group 132.3) was furnished. Upon request, at the appropriate times, flights over each of the assigned areas were conducted. The instruments aboard the aircraft were able to determine if fall-out had contaminated the areas below; and, when positive readings were received, landings were made, if possible, to obtain samples. Since much of the area around Kwajalein and Guam precluded landing on the islands, amphibious aircraft were provided at these two locations.

As the operational phase of IVY got underway, it became apparent that provisions should be made for backup RadSafe monitors in the event that unexpected or unusually adverse radiological conditions should hinder the normal operations of monitor personnel. To provide for such an eventuality, CJTF 132 dispatched a letter to each of the Task Group Commanders on 29 September 1952 directing that volunteer commissioned or scientific personnel be selected and trained as backup monitors. The training was to consist primarily of familiarization with simple field-type Radiac instruments and their operation and utility; background information; information on nuclear radiations; and field problems. The anticipated employment of these monitors was to be on a limited basis commensurate with their training but, nonetheless, contributing an additional factor of complete mission accomplishment with the limited dosages allowed for Task Force personnel. For planning purposes, the following number of back-up monitors was suggested:

Headquarters, JTF 132	10 monitors.
Task Group 132.1	20 monitors.
Task Group 132.2	Participation of previously trained "Q" cleared personnel.
Task Group 132.3	5 monitors.

Task Group 132.1 established the planned RadSafe Center on the RENDOVA prior to Shot time to serve as operations headquarters for all Task Force RadSafe activities as well as those of Task Group 132.1 during the afloat period. From that time onward, RadSafe data was collected and assimilated at that point before being forwarded to the Command Center aboard the ESTES. With receipt of this information in the ESTES, based after detonations on ground survey information as augmented with the cloud tracking reports, radiological situation maps of all neighboring atolls and all islands of Eniwetok Atoll were maintained. The information thus compiled formed the basis for the periodic briefings, situation reports and maps prepared for the CJTF and his Task Group Commanders. In coordination with CTG 132.4, who developed the air RADEX plot, the RadSafe Center assembled data on the overall RADEX situation. Other functions of the RadSafe Center were to provide information for unit planning of RadSafe operations; to determine the disposition of all working parties

. . n the contaminated areas; to establish R . . safe check points; and to maintain an opera- . . . table to provide details for all groups who . . . . d to enter contaminated areas each day. . . special clothing was provided to previously . . . gnated recovery personnel while, at the same . . . supervision was maintained over working . . . dules of the Task Group 132.1 radiochemical l . . atory, photodosimetry developing facilities, a . . Radiac repair equipment. Personnel de- . . tamination facilities were coordinated with t . . existing ship facilities in the sense that all . . uipment was placed in operational readiness p . . r to evacuation from the RadSafe Center on Parry Island.

Shot phase RadSafe procedures required unit commanders to insure that records of exposed personnel be maintained, using dosimeters and film badges. Primarily, these personnel were aircraft crews, boat crews and ships' damage control parties. When work in a contaminated area had been completed, film badges were forwarded to the Task Group 132.1 laboratory where all processing and recording was accomplished.

Special instructions to apply in the event ships were subjected to fall-out contamination were published. Prior to Shot times, low-range survey meters were provided at several points on the ships and were read at frequent intervals for one week after Shot time. When indications of fall-out were noted, the ship's spray system was broken out and continued in operation until instruments indicated that fall-out was completed or the vessel was clear of the fall-out area. If ships of the Task Force indicated contamination by fall-out or by contaminated personnel coming aboard, every effort was made to localize the contamination. In order to prevent contamination of vessels from radioactive material in Lagoon waters, periodic samples were collected from the Lagoon; analysis made in the laboratory van aboard the RENDOVA; and, in the event contamination was indicated, notification made immediately to CTG 132.3.

Provisions also were made for the post-shot release of Naval vessels either under a final RadSafe clearance or an operational clearance. Final clearance implied that the area or object concerned had been monitored and found to have at no point a reading exceeding 0.015r/24-hour beta plus gamma and no detectable alpha-emitting isotopes. In the event a vessel had some area or material, at the conclusion of Operation IVY, which had not yielded to decontamination, the vessel could be released to its type commander under an operational clearance. However, for this type of release, an integrated dose of beta plus gamma of below 3r, and no detectable alpha radiation, applied in general. Resurvey of the contaminated area would be conducted within the next three months and referred to the type commander for final clearance.

When it was ascertained that aircraft decontamination was necessary, land-based aircraft on Kwajalein were towed to the decontamination area where working parties decontaminated them as quickly as possible. Limited decontamination of carrier-based aircraft was accomplished aboard the RENDOVA; however, it was planned that major decontamination of Task Group 132.3 aircraft (except for helicopters which would be treated at Eniwetok) would be accomplished, if such became necessary, by utilizing Task Group 132.4 facilities. Aircraft decontamination operations aboard the RENDOVA necessitated observance of minute precautions due to the crowded conditions aboard. The area used was well isolated from personnel living spaces and from ventilator intakes while a clear water shed to the sea was provided in order to prevent spread of contamination to other parts of the vessel. Provisions were made to dispose of contaminated items within the decontamination area and any material leaving that area was carefully monitored. Special consideration was given to the helicopters since they were in constant use and it was necessary to keep them decontaminated at all times.

At the completion of a decontamination operation, the personnel involved were monitored on the spot, first with clothing on, then again when all clothing had been removed. It it were found necessary, they were sent to a personnel decontamination center where the individual was advised of his degree of contamination with special attention directed to hands, hair and soles of shoes. After showering, personnel were then subjected to a second monitoring. and, if skin counts were less than twice background count, were released. Washing was continued as necessary to assure the required degrees of decontamination.

Although various uncertainties existed in predetermining the trajectory of the atomic cloud with resultant radioactive fall-out, MIKE Shot was considered to be the detonation with significant health hazards to surrounding areas. All possible measures were taken to minimize these hazards. The proper use of weather was, of course, the major safety measure. The order to detonate MIKE Shot was given only at a time when wind conditions presented minimal health hazards to inhabited islands as well as air and surface traffic routes in the Pacific. At the same time, CJTF 132 was prepared to advise CINCPAC of any unforeseen hazards which might develop as well as to make recommendations on appropriate precautions. This was accomplished in the following manner:

1. At or about H-9 hours, CJTF 132 dispatched to CINCPAC a summary of the latest information develcped during his critical operational briefing before MIKE. The general trajectory of the upper portion of the atomic cloud during a seventy-hour period was prognosticated and a message was dispatched containing this general trajectory prognosis including best estimates of possible interference with air and surface traffic routes, the RadSafe outlook for Ujelang Atoll and recommended precautionary measures as appropriate.

2. During the period from H-Hour to M+8 days, any significant information de[redacted] which was relative to Ujelang and the sea and air routes of the Pacific was dispatched to CINCPAC as appropriate. A daily message was dispatched at 2000 local time giving a summary of RadSafe data pertaining to areas other than those used by JTF 132 and based on information obtained from cloud monitoring and tracking out to 1,000 miles air radius in the significant quadrant; on the monitoring of water samples from significant inhabited atolls up to a radius of approximately 600 miles; and on continuing weather prognosis.

Thus it was that radiological safety for the Task Force was planned. The field of radiological safety, relatively a new one insofar as techniques and applications are concerned, has been one about which there have been popular and widespread misconceptions. Though the subject of these misconceptions cannot be treated here, it should be pointed out that the great success of the IVY RadSafe program went far to allay the misgivings of IVY participants new to atomic tests. Devised, as it was, for coping with unusually large explosions, the success of the program should serve as an example of what concentrated efforts, though oftentimes tedious and painstaking, can and will achieve in the future.

R[redacted]ICTED DATA
ATOMIC [redacted] ACT 1946

[redacted]

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Chapter XX

MIKE SHOT AND REENTRY TO ENIWETOK ATOLL

From the earliest days of IVY planning, MIKE Shot was looked to as the high point of that Operation. H-Hour for MIKE had been set for 0715, local, on 1 November 1952. The last hours of waiting at Eniwetok were tense. Hard work and technical ingenuity had combined to overcome the tremendous scientific and operational obstacles to the entry into a new field of atomic development. With the completion of the retirement from the Eniwetok Lagoon of the evacuation fleet during the early morning hours, the train of events gradually began to pass from human control into the realms of natural law and history. The final preparations for the MIKE event, intricate and detailed though they were, had progressed very much as scheduled; but not, however, without those threatening incidents of happenstance which seem to characterize the climaxing hours of long anticipated and carefully planned events. Since the weather, the key consideration in the final decision to detonate, seemed to be holding favorable, these incidents may have assumed greater magnitude than they should. Nevertheless, the anxiety was great on behalf of preventing any circumstance—human or mechanical—which might cause a postponement.

During the last few days prior to MIKE, both surface and air patrolling had been intensified. On the afternoon of M–1 day, three contacts, all surface vessels, were made by the P–2V patrol in the patrol sector bearing 285° from ground zero. Two of these vessels were effectively warned and diverted to courses leading away from the Danger Area while the third, the British merchantman HARTISMERE, was not successfully diverted from a course carrying it in the general direction of Eniwetok. A second P–2V was dispatched to warn the HARTISMERE; but, before it could make contact, engine trouble developed at about 1630 and the aircraft had to turn back in an effort to reach the evacuated airstrip on Eniwetok. The CARPENTER was vectored out to assist in the event ditching should become necessary; another P–2V was directed to intercept, rendezvous, and accompany the disabled plane to Eniwetok; and the SAR Coordination Center was notified at Kwajalein from which point an SA–16 was dispatched, only to arrive at Eniwetok at about the same time as the P–2V in distress. At the same time, a crash crew was ferried by helicopter from the RENDOVA to stand by the strip. Though the departure of the RENDOVA from the Lagoon was correspondingly delayed, the aircraft had safely landed at Eniwetok by 2030 with one engine feathered and the other running rough. The plane was immediately secured against blast effects and the crew and crash party evacuated to the RENDOVA around 2130.

While success was met in the all-out effort to avoid a possible Shot postponement on the account of a downed crew in an area subject to radioactive fall-out, the task of diverting the HARTISMERE remained to be accomplished. And in the meantime, word was received in the ESTES that six men, scheduled for evacuation with the last group departing from Parry Island, could not be located as scheduled by the master muster list. Since an incomplete muster would also have resulted in Shot postponement, hurried effort was made to locate these personnel. Although it was reported that they had been seen departing the personnel pier on Parry, it could not be determined that they had reported aboard their scheduled vessel. At approximately 2230, their presence on the COLLINS rather than on the ship they had originally been scheduled to board was verified, dispelling the anxiety on their behalf.

With the safe landing of the P–2V and the locating of the unaccounted for six men, the major elements remaining which might possibly necessi-

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TECHNICAL INFORMATION DEPARTMENT
INFORMATION PRODUCTS SECTION

POSITION VACANCY

POSITION - Senior Technical Writer for Environmental Information Center Writing/Editing Support.

QUALIFICATIONS - This position requires a Bachelors Degree or equivalent experience in technical writing, technical journalism, technical communications, English, business administration, engineering, or physical, nuclear or earth science plus four years of experience in the preparation of technical information products. Should have knowledge and familiarity in scientific jargon, mathematical notation and chemical symbology. Must have the ability and skill to write, edit, and prepare clear, concise and acceptable reports and documents on environment, safety, and health related information including health physics, industrial hygiene, radiological waste, environment, etc. Must be able to communicate well with scientists and managers. Desirable necessary skills include ability to operate personal computers, and office equipment such as lettering machines, microfilm reader/printers, etc. Must qualify for a "Q" clearance and possess a valid drivers license.

INTEREST - Inform B. F. Eubank no later than close of business (1700 hrs) Wednesday, August 7, 1991 of interest in position. All candidates are to provide a one page write-up addressing the following:

1. Their qualifications for the position.

2. Why they want the position.

All write-ups are due to B. F. Eubank no later than close of business (1700 hrs) Thursday, August 8, 1991.

tate a Shot delay appeared to be narrowed to unfavorable weather developments; failure to divert the HARTISMERE, if her speed had increased; or technical failure of some mechanism connected with the MIKE Device. By early morning on M-Day, the air search patrols were discontinued and all P–2V's, except for one which continued the effort to contact and divert the HARTISMERE, were ordered back to Kwajalein. Contact was effected and proper warning given to the HARTISMERE prior to H-Hour at which time she was a little over 300 miles from Eniwetok.

While the operational and control problems induced by these last-minute incidents were being resolved, there was continuing elsewhere in the Task Force the detailed and minute study of all weather data. To repeat again, conditions were required which would be favorable not only for scientific measurements but for fall-out over air and surface routes as well as populated islands throughout the Central Pacific and for the Task Force evacuation fleet. The weather briefing held at 2130 on M–2 days had presented an extremely favorable picture. By 2130 on M–1 day, however, there was a less favorable outlook. The CJTF decided to review the weather situation again at 0300, approximately four hours prior to H-Hour. At midnight, the wind pattern, which had been adjudged marginally favorable for a radioactive fall-out pattern, changed abruptly and providentially to a most favorable pattern—one placing all fall-out north of ground zero. By 0300, the entire weather picture was most favorable and the Shot schedule was finally and firmly laid on. In the meantime, the Firing Party had completed preparations at the Shot site; had boarded an AVR at 0030; and had reached the ESTES in the southern end of the Lagoon by 0200. The ESTES then departed the Lagoon at 0315. By 0400, the CJTF was notified that all personnel were accounted for aboard their respectively assigned evacuation vessels and that with the departure of the CURTISS from the Lagoon at 0410, all Task Force personnel would be at sea.

As the Task Force ships had steamed out of the Lagoon, they had proceeded to their respectively assigned stations as follows:

1. The LEO, the COLLINS, and the SHANKS proceeded to an area south-southeast of the Atoll and maneuvered under the tactical command of the LEO at distances of thirty- to fifty miles from ground zero.

2. The AGAWAM, the ARIKARA (w barges in tow), the ELDER, the LIPAN (w the AFDL in tow) and the YUMA (escort five LCU's), proceeded to an area east-southe of the Atoll and maneuvered under the tacti command of the AGAWAM at distances fr thirty to fifty miles from ground zero.

3. The OAK HILL proceeded on vari courses at varying speeds through prescri positions in support of certain scientific me urements. Shot-time position of this ves was 30.4 miles, 135° true from ground zero.

4. Escorted by the FLETCHER and RA FORD, the CURTISS proceeded to a Shot-ti position thirty-five miles from ground zero on true bearing of 090°.

5. The RENDOVA, with the CARPENTE as plane guard, proceeded to a Shot-time po tion bearing due south at a distance of thir miles from ground zero. Prior to taking th station, tne RENDOVA operated in an ar south-southeast of the Shot island at distan between twenty and thirty miles.

6. The ESTES proceeded to an operating ar southeast of the Atoll where she cruised distances of twenty-eight to fifty miles from t Shot island. At Snot time, she was in a po tion thirty miles from ground zero on a beari of 155° true.

7. The O'BANNON assumed station at 30′ north and 165° east (intermediate refueli area between Kwajalein and Eniwetok) to pr vide a reference point for those refueling oper tions occurring at that point; to assist the le KB–29 Tanker in rendezvousing fighters wh required; and to augment SAR facilities in t area.

8. The HORIZON had proceeded to and w maneuvering seventy-two miles north of grou zero in the vicinity of a Project 6.4b seamou

With evacuation completed and with all shi maneuvering in the prescribed patterns, the maj activity afloat was centered in the ESTES, t nerve center of Shot time operations. In t Control Room, the television screens show panels at the MIKE location were under consta surveillance by General Clarkson, Dr. Grav and Mr. Burriss to ascertain that the intric systems of the MIKE Device were operating planned. [redacted]rom this room on the ESTES, the detonation of MIKE could be postponed at any time. The Joint Operations Center had taken on an atmosphere of watchful waiting and the Air Operations Center in the CIC Room was ready to direct MIKE Shot air participation.

Almost two hours before the CURTISS departed the Lagoon the first Task Group 132.4 aircraft had departed from Kwajalein. Concurrent with the maneuvering of the naval units at sea, the airstrip on Kwajalein had become the center of intense Air Task Group activity. The Shot time activity of Task Group 132.4 aircraft fell into three general categories according to times of mission. The pre-Shot missions called for two B-29 Canister Drop aircraft and one WB-29. The two B-29's were the first to arrive over the target area—at 0410; and their mission was to drop parachute-suspended, calibrated canisters so as to position them in space over the target area at a designated time just a few minutes prior to the detonation. The other pre-Shot mission was to be performed by one WB-29 which was assigned the task of reporting on any rain-shower activity in the target area, as well as any significant weather upwind from groun[redacted]ero. The area to be covered was from a point midway between Parry and Elugelab Islands directly upwind for sixty miles including a zone ten miles to each side of its flight track.

Between 0410 and 0713, the remaining nineteen aircraft scheduled to be airborne in the Eniwetok vicinity by Shot time arrived in their designated orbiting areas and began final preparations to carry out their Shot time and post-Shot time missions. Of these aircraft, only six were assigned critical positions in space for the moment of the detonation. The flight patterns assumed by the Effects B-36D and B-47B were such as to position them south of, and in a tail aspect to, ground zero at the moment of detonation. The B-36D was to be at an altitude of 40,000 feet, 13.5 nautical miles, horizontal range, from ground zero, whereas the B-47B was to be at 35,000 feet and 11 nautical miles, horizontal range, from ground zero. The three Photo C-54's, call signs PETER-2, -3 and -4, assumed individual race track patterns in order to be positioned at the moment of detonation as follows:

Aircraft	*Azimuth from ground zero*	*Distance from ground zero*	*Altitude*
PETER-2	45° true	40 nautical miles	10,000 feet.
PETER-3	225° true	40 nautical miles	14,000 feet.
PETER-4	180° true	40 nautical miles	12,000 feet.

The last of the six aircraft assigned critical Shot time positions was the Instrumentation B-50 with the mission of measuring air attenuation just prior to MIKE Shot and obtaining IBDA data following the detonation. This aircraft was scheduled to be at 25,000 feet at a distance of forty-two nautical miles southeast of ground zero at Shot time.

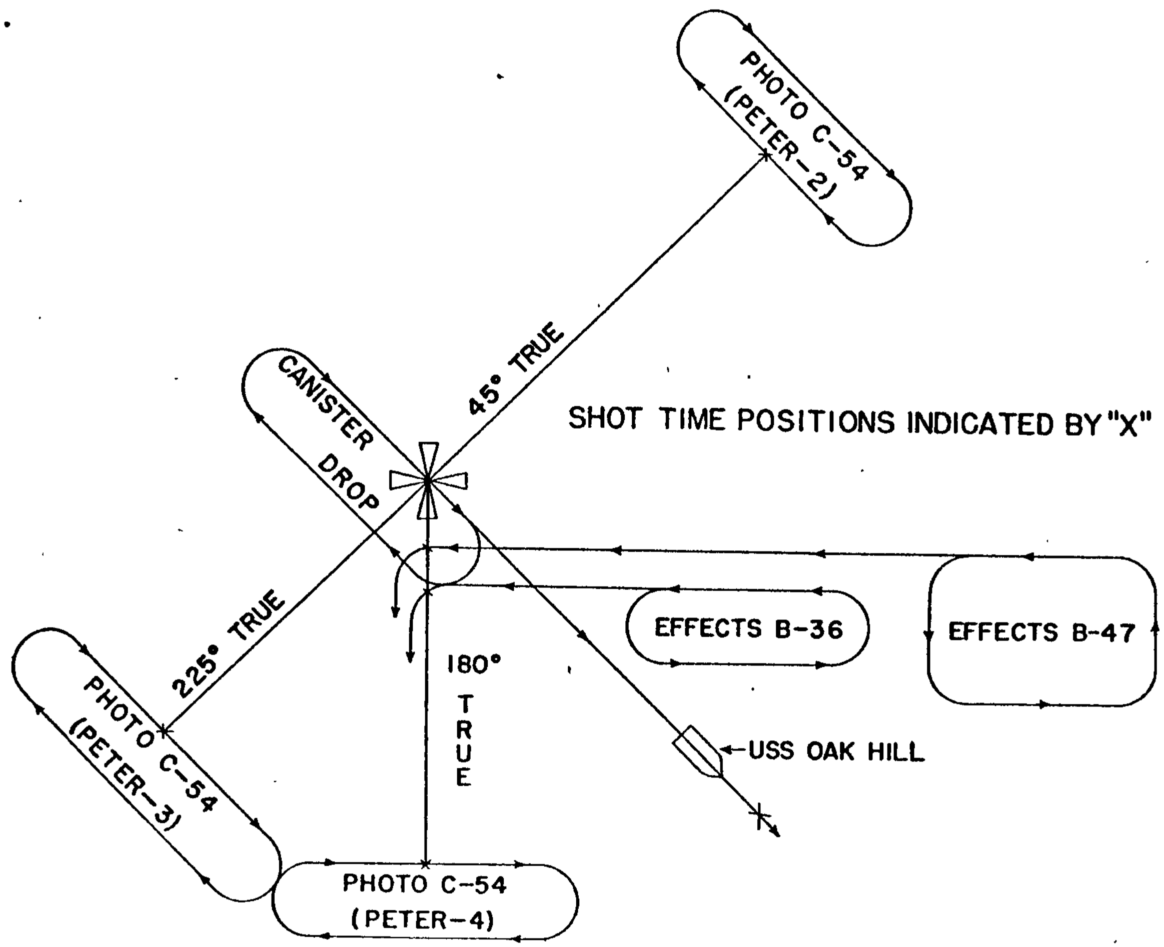
Orbiting in an area fifty nautical miles southeast of ground zero were those aircraft which were also airborne at the time of detonation because of their immediate post-Shot missions in connection with the initiation of sampling operations. The B-36H Control aircraft was at 40,000 feet and, with the arrival of the two Sniffer F-84G's at the same altitude just two minutes prior to H-Hour, the remaining aircraft continued to orbit as follows:

Aircraft	*Time of arrival*	*Altitude*	*Function*
B-29	0615M	20,000 feet	Primary control.
B-29	0615M	17,000 feet	Secondary control.
KB-29	0633M	15,500 feet	Refueling.
KB-29	0633M	15,000 feet	Refueling.
SA-16	0645M	10,000 feet	Search and rescue.
SB-29	0705M	10,000 feet	Search and rescue.

With the exception of the B-36H which was under direct control of the ESTES Air Controller for sampling operations, all aircraft in this area were controlled by the Primary Control B-29 which was in turn controlled by the ESTES Air Controller.

By H-30 minutes two WB-29's, one at 13,000 feet and the other at 21,000 feet, were orbiting

MIKE SHOT



CANISTER DROP

TWO B-29'S 41 MILES FROM GZ AT 30,000 FT. ALTITUDE

PHOTO C-54

THREE C-54'S EACH 40 N MILES FR GZ ALTITUDES
P-2 10,000 FT.
P-3 14,000 FT.
P-4 12,000 FT.

EFFECTS B-47

11 N MILES FROM GZ AT 35,000 FT. ALTITUDE

EFFECTS B-36

13.6 N MILES FR GZ AT 40,000 FT. ALTITUDE

[redacted]

fifty nautical miles north of ground zero. The mission of these two aircraft was to obtain air samples in support of the AFOAT–1 sampling program. At the same time, two additional Photo C–47's were orbiting at 10,000 feet, one positioned at eighty-five nautical miles south of ground zero and the other at eighty-five nautical miles east of ground zero. Following the detonation, these two C–47's were to obtain photographic documentation of the size, shape and rate of rise of the atomic cloud.

At H–30 minutes, the final report on rain-shower activity was received from the WB–29 which had made its run over and upwind from the target area. No showers or significant weather developments in the vicinity which could affect the Shot schedule were observed. With this report and with no discrepancies noted in the positioning of aircraft, the stage was set.

The time-count, voice broadcast was made from the ESTES to the other vessels by radio. As an additional safety precaution in the event radio transmission should fail, instructions and copies of the time broadcast script had been provided each ship. Instructions to either put on high-density goggles or face away from ground zero at H–1 minute were repeated at intervals. The broadcast was begun at H–3 hours, and prior to the announcement that the time was H–30 minutes, most personnel, who were free to do so, had assumed vantage points from which to observe the first known thermonuclear explosion. As subsequent time counts were announced, tension and expectancy increased. Many imaginations were running free as they speculated upon the sight they were to shortly witness.

The final count-down was made and MIKE was detonated at 0714:59.4±0.2. The error of approximately 0.6 seconds was due to a power failure aboard the ESTES a few minutes prior to H-Hour. The Shot, as witnessed aboard the various vessels at sea, is not easily described. Accompanied by a brilliant light, the heat wave was felt immediately at distances of thirty to thirty-five miles. The tremendous fireball, appearing on the horizon like the sun when half-risen, quickly expanded after a momentary hover time and appeared to be approximately a mile in diameter before the cloud-chamber effect and scud clouds partially obscured it from view. A very large cloud-chamber effect was visible shortly after the detonation and a tremen conventional mushroom-shaped cloud soo peared, seemingly balanced on a wide, dirty Apparently, the dirty stem was due to the particles, debris, and water which were s high into the air. Around the base of the s there appeared to be a curtain of water v soon dropped back around the area where island of Elugelab had been.

The shock wave and sound arrived at the va ships approximately two and one-half mi after the detonation, accompanied by a shar port followed by an extended, broken, rum sound. The pressure pulse and the reduced sure period as received by ear were exceptio long.

Although the upper cloud first appeared un ally white, a reddish-brown color could soon be within the shadows of its boiling mass as it cended to greater height and spread out over Atoll area. At approximately H+30 minutes upper cloud was roughly sixty miles in diam with a stem, or lower cloud, approximately tw miles in diameter. The juncture of the stem v the upper cloud was at an altitude of about 45 feet. Numerous projecting fingers could be served in the neighborhood of the juncture of stem with the upper cloud. Though later evid questioned the accuracy of the readings and i cated lower heights, the preliminary cloud-rise prepared shortly after the detonation indicated following for the top of the mushroom at var time intervals:

Time in minutes	*Height*
H+1.5	57,
H+2.6	108
H+3.4	110.
H+5.7	118.

The cloud had ascended very rapidly and soon peared, in the words of one observer, to ha "splashed" against the tropopause. After appr imately fifty-six minutes, the entire cloud appea to have become stabilized at an altitude of ov 120,000 feet, though this figure was later qu tioned also. By this time, deforming effects winds were becoming apparent though as late sunset on M-Day distant and high portions of cloud could still be observed.

The two Canister Drop B–29's had begun dro ping their canisters at H–9 minutes and w safely out of the area by the time of detonatio

[redacted]

By 0911, both aircraft had returned to Kwajalein. The Effects B-36D and B-47B sustained no serious or adverse effects as a result of the detonation and both returned to Kwajalein. The quality of data obtained in the successful accomplishment of missions by these four aircraft is narrated in the subsequent chapter on Programs.

The three Photo C-54's succeeded in accomplishing 16mm and 35mm movie coverage and obliques of the cloud. By 1039, two of these aircraft had returned to Kwajalein. The third one remained in the target area to obtain low oblique crater photography beginning at H+1½ hours. This latter aircraft encountered considerable radiation and both the crew and the aircraft were found to be contaminated upon returning to Kwajalein at 1120. As a result of the contamination, the low oblique photographs were heavily fogged.

By H—15 minutes, the Instrumentation B-50 had accomplished the required air attenuation readings at which time it proceeded to its Shot-time position. Following the detonation, scope photography was accomplished to determine IBDA from a great distance. By 0849, the B-50 had completed its mission and returned to Kwajalein.

The two Photo C-47's at the eighty-five nautical mile positions began recording their positions to an accuracy of five miles at H-15 minutes. Following the detonation, photographs were made of the atomic cloud at one-minute intervals until H+1 hour. The recording of positions simultaneous with exposures provided a means for identifying the photographs with reference to the distance from ground zero.

At H+30 minutes, the two WB-29's, used for taking AFOAT-1 samples, maneuvered so as to remain north of the visible cloud and outside the radioactive area. When the cloud had dissipated to the extent that the AFOAT-1 sampling could commence without danger of over contamination, the AFOAT-1 director aboard one of the aircraft initiated operations. By 1346, these two aircraft had completed their missions and were on the ground at Kwajalein.

Following the detonation, the Control B-36H left its orbit area and assumed a flight pattern downwind from the cloud at 40,000 feet. Once this had been accomplished, the two Sniffer F-84G's were vectored by the Primary Control B-29 to the B-36H. The Sniffers, under the direction of a scientific observer aboard the B-36H, accomplished their missions of determining the height and intensity of specified portions of the cloud, obtained samples, and were directed to return to the Control B-29. Subsequent to the completion of inflight refueling, the two Sniffers returned to Kwajalein, landing there at 0955.

Simultaneous with the Sniffer operations, the two Control B-29's, the two Tanker KB-29's and the SAR aircraft moved to a new orbiting area approximately twenty miles south of the cloud track. With the arrival direct from Kwajalein of three additional KB-29 Tankers at approximately H+2 hours, all was in readiness for those refueling operations necessary in the sampling area proper.

The regular cloud sampling by the F-84G's began at approximately H+1½ hours and was completed at approximately H+5½ hours. Sampling operations occurred in three flights—RED, WHITE, and BLUE in that order. RED Flight departed Kwajalein so as to arrive in the sampling area at H+1½ hours at an altitude of 40,000 feet for rendezvous with the Control B-29 aircraft. Refueling was accomplished at the intermediate refueling area (165° E and 10°30′ N) over the control destroyer, after which courses were set for the sampling area where the F-84G's were vectored to the Control B-36H for the actual sampling. The F-84G uses approximately 1,200 pounds of fuel per hour at altitudes over 40,000 feet and fuel loads had to be watched closely. Pilots were instructed that when fuel was down to 1,500 pounds, they would descend to rendezvous with the Tanker aircraft. In the event the fuel load were reduced to 1,000 pounds before the Tanker could be located, the pilot was to set a course for and land at the Eniwetok strip, where an emergency party would have already commenced operating the airstrip facilities.

The story of one of the pilots who flew into the MIKE cloud probably best describes the actual mission of the Sampler pilot. Lieutenant Colonel Virgil K. Meroney, USAF, Sampler Element Commander, led the RED Flight of four Samplers and was the first to enter a portion of the towering MIKE cloud. The bottom of the flat part of the mushroom-shaped cloud had been estimated at about 55,000 feet by the Sniffers; therefore, RED Flight could only enter a portion of the stem of the mushroom. The first penetration was made at near maximum altitude of 42,000 feet. At approximately H+1¾ hours, Colonel Meroney was vectored from directly over the B–36 Control aircraft to a small segment extending from the stem of the cloud. He and his wing man turned and flew in the direction of the segment for fifteen minutes before making contact with it. Apparently, the cloud was so massive that, although the Control aircraft seemed to be quite close in, the segment was approximately 100 miles away. Upon entering the cloud, a pilot was well occupied. First, he had to fly his aircraft on instruments; there were three radiation instruments to observe and he was required to record critical information so that he could report it to the scientists in the Control aircraft; and, in addition, the pilot was required to use a stop watch in order to time his stay in radiation of over one roentgen intensity.

Immediately upon entering the cloud, RED LEADER was struck with its intense color. It cast a red glow over the cockpit and his radiological instruments indicated maximum readings. There was no way of knowing how much more radioactive the area actually was than the maximum readings of his instruments were indicating. The hand on the Integron, which showed the rate at which radioactivity was being accumulated, "went around like the sweep second hand on a watch . . . And I had thought it would barely move!" The combination of most instruments indicating maximum readings and the red glow like the inside of a red-hot furnace was "staggering" and Colonel Meroney quickly made a ninety degree turn to leave the cloud. When he came out, his stop watch showed that he had spent five minutes in radiation over 1r. He reported to the Control B–36 and collected his wing man by which time it was time for RED–3 and –4 to enter the cloud. RED LEADER cautioned them not to go in too far and they disappeared into the cloud. For reasons unknown, RED–4 spun out shortly after entering, but managed to regain control at 20,000 feet. Shortly, both aircraft were directed to get together and return for refueling. RED–3 and RED–4 each attempted to find the Control B–29 and the Tankers but they were both unsuccessful. The APX–6 IFF radar equipment in RED–4 was not functioning properly; thus, the observers in the Control B–29 could not positively identify him as signals were weak and intermittent. At the same time, RED–4 was unable to pick up a radio beacon signal from either the automatic or null positions on his radio compass. By the time he did establish contact with the Control B–29, his fuel load had been reduced to 1,000 pounds. After several attempts to rendezvous with the B–29, he was instructed to go down to 20,000 feet where he was given further instructions to orbit with the Tanker aircraft. He was then approximately ninety-five miles north of Eniwetok. Shortly afterwards, he advised the Control B–29 that his radio compass was again operating and that he had picked up the Eniwetok beacon, whereupon he was instructed by the Control aircraft to depart for the Eniwetok strip. It was believed that he had between 400 and 500 pounds of fuel remaining at that time. The weather at Eniwetok was 0.7 overcast with rain squalls throughout the area. He was at 19,000 feet, in and out of the clouds, when he received his first steer of 116° from Eniwetok. Control of the situation was being exercised by CTG 132.4 from the ESTES and DF steers were being provided RED–4 by the emergency party at the Eniwetok Tower. However, CTG 132.3, who was monitoring the circuits in the CIC aboard the RENDOVA, was soon aware of the emergency and, consequently, was able to provide three helicopters early enough that one was in position in the Lagoon to observe RED–4 as he made his attempt to reach the strip.

In the meantime, RED–3, on instructions from the Control aircraft, had already proceeded to Eniwetok, landing safely with zero fuel remaining. On his second DF steer, RED–4 gave his altitude as 19,000 feet with gauges showing empty but engine still running. The next transmission from RED–4 was to the Eniwetok Tower saying that his engine had just flamed out and he was at 13,000 feet. At 10,000 feet, he reported that he thought he could make it and that he had the Atoll in sight. Another DF steer was given at 8,000 feet. At 5,000 feet he called the Tower saying he didn't think he could make it and that he planned to bail out at 2,000 feet. At 3,000 feet, he gave his last transmission—"I have the helicopter in sight and am bailing out."

The pilot of the initial helicopter sent from the RENDOVA first spotted RED–4 at approximately 800 to 500 feet altitude about one-half mile north of the Island of Igurin in the southwest portion of the Atoll. Since they were on collision courses, the helicopter altered course to follow him. The helicopter pilot estimated RED–4's airspeed as 150 knots in a level glide. Shortly after this, the pilot of the helicopter observed that the tip tanks were released and possibly the canopy also. He was directly behind the F–84 on a heading of 090°. The aircraft continued in the same manner, hitting the water in a tail low attitude with a slightly low right wing. The aircraft hit the water without having dive breaks, flaps, or wheels down. The plane seemed to be under positive control all the way to the water. Upon contact, it skipped 100 to 300 yards before striking the water again. As it struck, the nose dug in and the plane flipped over on its back. The helicopter arrived over the aircraft approximately one minute after initial contact. The aft section of the plane was still visible but sinking. The helicopter continued patrolling the area, noting the position and calling for three more helicopters to join in the search. An SA–16 was also searching in the immediate area. The position of the aircraft as it sank was approximately 3.4 miles from the approach end of the Eniwetok Island runway. An oil slick, one glove, and several maps were sighted floating at the scene of the crash. Extensive attempts to locate the pilot were of no avail.

As the subsequent sampling missions were completed, the F–84G's were given vectors by the B–36H to the Tankers in the sampling area. After refueling they proceeded to the intermediate refueling area, made visual contact, refueled again if necessary and then returned to Kwajalein.

Samples obtained by RED Flight as well as one sample from the second flight, WHITE Flight, were each approximately the size predicted and were satisfactory for yield computations. Sample quality is governed by the capability of penetrating the main body of the cloud and successful sampling also requires that the duration of the sampling mission be limited not by the capabilities of the aircraft but by the maximum allowable radiation exposure of the sampling crew. Unforeseen operational limitations in flight times arose because the IFF blips from the sampling aircraft were obscured on the radar equipment in the Control B–29 by cloudy weather which existed at the time of sampling. As a result, the sample Control B–36 was directed to fly farther from the main cloud mass than it should have been. Eventually, the details of the cloud were lost to those in the Control B–36; hence, the sampling aircraft were required to fly excessively long distances to reach the cloud. They then had to conduct a cloud search as well as a sampling mission, although the former was to have been the function of the Control B–36. After sampling, the aircraft then incurred the risk of running very low on fuel by having to return over a great distance to the refueling area. Because of these operational limitations, the Sampler aircraft in the WHITE and BLUE Flights did not meet the requirement capability of spending two hours in the sampling area.

Twelve samples for radiochemical analysis were obtained, however, by the Sampler F–84G's. Upon return to Kwajalein, these test samples taken from the MIKE cloud were immediately removed from the aircraft and prepared for return to various laboratories within the United States. Special MATS flights numbered 1E and 2E were scheduled to transport the MIKE samples to the ZI as soon as possible after return to Kwajalein of the sampling aircraft. These MATS flights departed as scheduled and the samples were delivered at various laboratories in the ZI within a period of approximately thirty hours.

The aircraft of RED Flight only approached the limit of the planned operational radiation exposure to pilots. The lower sample sizes collected by WHITE and BLUE Flights reflected the absence of the maximum planned exposure to pilots. The first flight exposures were in the 3 to 4r level, the second flight in the 0.5 to 1r level and the third flight was in the 0.2 to 0.4r level. Because the aircraft had been carefully hand-polished, the cockpit background was very much lower than expected and the total radiation exposures were approximately forty percent less than had been anticipated. In view of the fact that these aircraft were exposed to radiation intensities in excess of 500 r/hr, the low exposures incurred by RED Flight should be considered a testimony to the skill of the pilots.

Use of shielded flight clothing by RED Flight apparently provided about a four- to five-fold reduction in radiation exposures. This effect did not appear to be significant for the WHITE Flight, although, for the BLUE Flight there again appeared to be significant protection. The projection afforded the first flight apparently corresponds to evidence that a considerable fraction of the radiation flux in the cloud during this flight's penetration was due to the decay of U^{239} which gives a 73 kev gamma ray. This evidence was gained from an analysis of the decay rate of reported peak radiation intensities of the cloud.

The maximum radiation received by any one individual was 17.8r, incurred by a member of the SA–16 crew in the search for the downed F–84G. At the time that the SA–16 was notified to join in the search for the downed aircraft, it was flying on the opposite side of the Shot area. Since speed was of essence, the pilot assumed a straight-line course to the scene of the crash which carried him through the radiation field. Although the time at which he passed through the area was approximately three hours after the detonation, his aircraft accumulated between 20 and 25r's. The maximum radiation registered by an aircraft—the Photo C–54 which had been subjected to fall-out while making photographic coverage of the crater—was 29r.

Meanwhile, the preliminary phase of the reentry and sample recovery operations following MIKE Shot had begun at H+10 minutes when the first RadSafe survey helicopter had been launched from the RENDOVA. At an altitude of twenty-five feet and at a ground speed of 10 mph, this initial survey covered both Eniwetok and Parry Islands before its mission was interrupted by a rain squall which somewhat contaminated the helicopter. At H+15 minutes, two helicopters were dispatched to Parry to recover data from the photo tower and from within the administrative compound. By H+40 to H+45 minutes, two more helicopter flights had been launched—one flight to carry the Task Group 132.4 emergency reentry party to the Eniwetok strip to operate facilities and the other to carry an H&N utilities party to Parry for surveying damage and checking reefers, powerhouses and the water plant.

Commencing at about H+2 hours, a group of scientific personnel, headed by Dr. W. E. Ogle, which had been transferred by helicopter from the ESTES to the RENDOVA, proceeded to make an early overall damage survey as well as a complete RadSafe survey. The RadSafe survey team, operating via helicopter, got as far north as Runit Island where excessive, active fall-out was encountered. This helicopter flight then returned to the RENDOVA. By this time, the MIKE cloud—having billowed out at the tropopause level—formed a huge canopy over the Atoll and its surrounding waters. Heavy rain showers were in progress and were concentrated mainly within and around the lower cloud stem; and, earlier, heavy mud fall-out had occurred and had been encountered by the initial RadSafe survey team. Simultaneous with these activities, all utilities on Parry and Eniwetok were reported in operating condition and the crash crew was ready, if an emergency arose, to receive aircraft at the Eniwetok strip by H+2 hours.

During the morning hours, the winds being received from Bikini continued to indicate that the very favorable pattern of air flow aloft was holding; that is, cloud was moving all to the northwest of ground zero up to about 70,000 feet. By H+5 hours, the early, overall survey of the Atoll—accomplished at altitudes varying between 800 to 1,500 feet to avoid excessive ground radiation—had been completed by scientific and monitor personnel.

Later in the day, reports from the Navy Task Group, responsible for the radiological safety of the Task Force while afloat, indicated that no ships had encountered fall-out as of 1600, M-Day; however, the HORIZON—which had been seventy-two miles north-northeast of ground zero at Shot time and which had then steamed in a northeast direction for four hours—reported that she was just beyond the fall-out area and that radiation levels on board were 14 mr/hr average, 50 mr/hr maximum. Her topside water spray system had proved successful, however, in reducing this contamination.

Earlier, at H+7 hours, a Lagoon water survey had commenced in accordance with a plan which had been initiated by CTG 132.3. This involved a pass across the Lagoon on an east-west control line between Runit and Rigili Islands, taking samples of water at the surface and at thirty-five foot depths. An additional north-south line, running in the direction of the Shot site from Coral Head at the center of the Lagoon, was used for taking samples as radiation levels permitted. Additional water samples were taken at the Deep Entrance, in the anchorage areas and at the Wide Passage. These early samples revealed no contamination in the waters of the southern half of the Lagoon.

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At about this time, a message was sent to CTG 132.4 prescribing tracks for the first WB–29 cloud tracking mission, WILLIAM–5, takeoff time H+12 hours. Early cloud tracking showed the cloud to be moving very generally in four segments—one segment from above 80,000 feet moving westerly; one segment between 40,000 and 80,000 feet moving northwesterly; another segment between 20,000 and 40,000 feet moving northeasterly; and the segment from the surface to 20,000 feet moving west-northwesterly, all at about sixteen knots. At 1700, another message was sent to Kwajalein prescribing the tracks for the second WB–29 cloud tracking mission, WILLIAM–6, scheduled to take off at H+24 hours.

As of 0715 local on M+1 day, all ships had reported negative fall-out and early morning water samplings of the Lagoon again revealed no contamination of its southern half. On the basis of this water sampling, as well as other evaluations, the time for reentry (R-Hour) was announced and the Navy Task Group entered the Lagoon at 0900 with assurances that Eniwetok and Parry were officially cleared by RadSafe authorities and significant fall-out was no longer expected. The RadSafe control point for all traffic north of Japtan Island was established in Building 57 on Parry Island. All Lagoon traffic south ot Japtan was unrestricted though swimming was permitted only at the authorized beaches.

After reentry, an early damage survey was accomplished by the Director of the Blast Measurements Program. On Eniwetok Island, some damage was sustained by the B–29 hangar, an extremely large structure approximately 200 feet long in which the main doors had been left open. The building was racked slightly and the center line of the roof span sagged downward about six inches, front and rear. Of interest are the facts that five L–13's and the disabled P–2V aircraft were parked in the open without damage; that a movie screen which had been left up was undamaged; and that water tanks were intact.

On Parry Island, several pyramidal tent flies were torn at the seams on the sides facing in the direction of the blast. Some corrugated sheet iron had been blown loose from some of the warehouses and some superficial damage was suffered by the large buildings in the CMR area.

In the Biijiri, Aomon, and Eberiru groups of islands, the brush-type vegetation was bent away from the blast center and there was slight charring of the leaves. Damage was beyond the moderate level. The first indication of washing occurred at Kirinian. On Engebi Island, the guns of Project 6.2 were intact; the grass was green at the base, but the upper part was scorched; and the Island did not appear to have been washed over by water though there was evidence of blast and scorching. The islands of Bogon, Bogarikk, and Teiteiripucchi as well as the others in the chain down to Bogallua were swept clean. There was a fine deposit of coral sediment over the reef rock and nothing was left of the Krause-Ogle Box, suggesting that it had burned or exploded and that violent wave action had swept away the debris. In place of Elugelab, the Shot island, there was a huge crater, approximately one mile in diameter, extending from the western end of Teiteiripucchi almost to San Ildefonso. The depth was difficult to judge because of the turbidity of the water.

On M+1 day, a detailed ground and air survey of the Atoll was made. Also, P–2V Flight CHARLIE from Kwajalein in connection with the World-Wide Fall-Out Survey (Flights ABLE and BAKER had been delayed because of the slow movement of the cloud) made a sweep of the southwestern Marshalls, including Ujelang, reporting negative results. This was the signal for the relanding of the natives of Ujelang, an operation which was completed on the afternoon of M+1 day.

At 1400, M+1 day, a message was sent to Kwajalein directing the final WB–29, WILLIAM–7, to proceed to a point 14° North, 165° East and, from this point, to search an area clockwise from 315° true to 010° true out to an approximate distance of 450 miles at altitudes between 10,000 and 15,000 feet. On this flight, which was well out in the northwest quadrant, readings were higher than on the flights of the previous day. All flights up to this time had indicated negligible fall-out in the northwest quadrant and none in the southeast and southwest quadrants. Radiation levels at flight altitudes were, in general, 5 to 10 mr/hr outside of the aircraft with an allowance for a factor of 10 higher for rain showers concentrating fall-out particles at lower altitudes. This was considered insignificant as a health hazard; and, by 2000 on the same day, a RadSafe advisory message was sent to CINCPACFLT stating that no health hazard problems existed on air or surface routes as a result of the MIKE detonation.

Early recoveries continued on M+1 day and it appeared that early reentry to Runit Island, the site for KING Shot, by M+2 days was feasible. This would include reestablishing a labor camp with a control monitor on Runit so that KING instrumentation could be initiated.

At earliest daylight on M+2 days, World Wide Fall-Out Flights ABLE and BAKER from Kwajalein were initiated, covering those areas of the Marshall group not covered by Flight CHARLIE of the previous day. No significant activity was reported. As of M+2 days, no Task Group 132.3 vessel had encountered fall-out other than minute amounts during evening showers of approximately 5 mr/hr on topside decks which reduced to background by morning.

On M+2 days, complete recovery was made from the Bogallua bunker. Recovery programs were reviewed each evening between Task Group 132.1 scientific personnel and the RadSafe control group. On this basis, sites, allowable periods of work and boat and plane schedules—along with plans for the work necessary for KING Shot instrumentation—were established for the following day.

On the night of M+2 days, the final RadSafe advisory was sent to CINCPACFLT indicating that no health hazard to surface or air routes existed anywhere in the Pacific Ocean Area as a result of MIKE Shot. At the same time, the outlying weather stations at Ponape, Kusaie, Majuro and Bikini indicated no delayed fall-out as of 1800 local, M+2 days. With this message to CINCPAC/CINCPACFLT, the MIKE event was officially secured as a possible hazard to areas outside of JTF 132 responsibility; though message from Guam indicated, subsequently, that airborne contamination had reached a maximum of approximately 5 mr/hr but with no fall-out on the ground as of M+4 days. And so it was that only a little over fifty hours after the MIKE detonation the operational aspects of the Shot were drawing to a close. Even before this period was closed Task Force personnel were already well occupied with the preparations for KING Shot.

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Chapter XXI

KING SHOT

In contrast to the experimental nature of the MIKE device leading toward the devel[redacted] a usable weapon in the [redacted]

Preparing and delivering the KING weapon to the strike aircraft was a function of Task Unit 5, Task Group 132.1. The various components were procured through the Sandia Corporation Production Department, Albuquerque, New Mexico, and, by 20 October 1952, all of the components had been completed. At that time, the weapon was assembled in a ready condition with its detonators, fuses and all other components—less the capsule—ready for firing. On 4 November, two C-124 aircraft departed Kirtland AFB for Kwajalein with the KING bomb, less the capsule, aboard one aircraft and the capsule aboard the other. Both units arrived at Kwajalein on 7 November, where the bomb and components were moved aboard the CURTISS, which had proceeded to Kwajalein shortly after MIKE Shot.

Meanwhile, on 3 November, CJTF 132 had set the tentative date for KING Shot as 13 November with H-Hour planned as 1130 local. The Task Force Command Post had remained afloat until M+4 days at which time it was transferred back to Parry Island according to schedule. Immediately upon return to Parry, work was begun to install necessary communications facilities for the Joint Operations Center (JOC) ashore. The overall requirements were essentially the same as those aboard the ESTES during MIKE Shot. Direct telephone circuits were installed from the JOC to the Control Room on Parry, to CTG 132.2 on Eniwetok Island, to CTG 132.3 in the RENDOVA, and to CTG 132.4 who would be in the ESTES during the time of the actual shot. Other special circuits were required for RadSafe monitoring, weather, voice-time broadcast and VIP briefing. The Control Center aboard the ESTES, the Kwajalein Air Operations Center (AOC) and the Airborne Control Center operated in essentially the same manner as during MIKE Shot.

The Control Station for KING Shot was located in Building 311 on Parry and was subdivided into a Timing Room and a Control Room. The former contained the EG&G timer which, when activated by the release of KING from the Drop B-36, furnished time signals in relation to the time of detonation to ground scientific stations from H-30 seconds to H-Hour. Communications facilities in the Timing Room consisted of a ten-watt Motorola radio netted with the Control Room and the ESTES CIC; VHF remote control and backup on a net with the Drop aircraft and the ESTES CIC; and two headset telephone circuits to the Control Room.

The Control Room was operated as the Command Post for CJTF 132 and his Scientific

De. . Through the following means of communication, the CJTF was able to direct and control KING-Day operations:

1. VHF control and backup on the same net as the Drop B–36 and the ESTES CIC.
2. A ten-watt Motorola radio netted with the Timing Station and the ESTES CIC.
3. Two headset telephone circuits to the Timing Station.
4. Voice intercom system with the Scientific Director and Headquarters, JTF 132.
5. Hot-line telephone circuits to the ESTES CIC and Headquarters, JTF 132.

Concurrent with the aforementioned activities on Parry Island, working parties had been preparing the Shot site for the KING detonation. Since no camp facilities had been reestablished on Runit Island following MIKE Shot, all work in preparation for KING was accomplished by working parties dispatched from Parry Island. Construction of scientific stations and installation of instruments progressed smoothly although some projects north of Runit were somewhat rushed in order to meet the scheduled Shot date. This was due to the fact that relatively high radioactivity lev in those areas limited the time a working party could operate.

By 9 November, all indications pointed toward the successful testing of KING on schedule and an operational message was dispatched to the Department of the Army and AEC giving the scheduled date and hour of KING Shot as 1130 local on 13 November. By the following day, it was apparent that the weather trend was becoming more unfavorable. The requirement for minimum cloud cover conditions was a critical one in that it called for less than 0.3 overall cloud cover and no clouds below 2,000 feet—preferably none below 3,000 feet. The overall requirement was for conditions amenable to a visual bomb-drop from 45,000 feet; whereas, the requirement for no clouds below 2,000 feet was to permit maximum efficiency in the measurements of thermal radiation.

Despite the unfavorable weather trend observed on the 10th, hopes for a detonation on schedule were still optimistic when at a Command Conference on 11 November the execute order was confirmed. By 1000 local on the following day, the last timing signal run had been completed and, with the exception of two powerhouse personnel on Runit Island, all had been evacuated from the northern islands by 1830. A second Command Conference was held at 2130 and the execute order was again confirmed. The final confirmation of weather was made at 0200 on 13 November and, although it had become marginal, satisfactory conditions were anticipated by Shot time. Kwajalein and Eniwetok were closed to all transient traffic at 0400. The final security sweep of northern islands was made by helicopter, beginning at 0700 and by 0800 the helicopter had returned to Runit and evacuated the two H&N powerhouse personnel. All Task Group 132.3 ships, except the ESTES and HORIZON which were to remain in the Lagoon, had proceeded to open sea by 0830. The timing station checkout began at 0830 and by 0930, voice-time signals were begun from the B–36 Drop aircraft.

By 1100, all Task Force aircraft and ships were orbiting in assigned patterns and Eniwetok and Parry personnel not on assigned jobs had moved to advantageous positions to observe the Shot. Even to the untrained observer, it was apparent as H-Hour approached that cloud cover was steadily increasing and the orbiting aircraft could be seen only for short intervals between breaks in the clouds. By H-Hour, the weather had gone completely "sour" and the announced indefinite postponement did not come as a surprise. Aircraft were directed to return to base and ships to the Lagoon. Later in the afternoon of 13 November, a new K-Day was announced as 15 November. Although a successful drop had not been accomplished, the activities on 13 November served as an excellent rehearsal with full Task Force participation.

The general weather picture presented a favorable outlook at the Command Conference on the night of 14 November. The four-hour fall-out pattern was forecast to lie in a narrow cone of thirty-five degrees from 240° true to 275° true, all within a radius of eighty miles. Due to the deep trade pattern aloft, wind directions were invariant and the surface RADEX from ground level to the top of the sounding, 70,000 feet, was in a cone of ninety degrees measured from 200° to 290° true. Twenty-four, forty-eight, and seventy-hour trajectories indicated that cloud levels at all heights were moving westward. Overall conclusions indicated a most favorable pattern and recommendations were made to detonate KING in accordance with the new schedule. However, due to cloud conditions and unexpected bad weather affecting aircraft operations in the Kwajalein terminal area, a last-minute command decision was made to again postpone the Shot until 1130 on the following day, 16 November.

As of the Command Conference on 15 November, the fall-out pattern continued to be very favorable. Good, strong easterly winds in the levels below 35,000 feet, where the "hot" dirt cloud was expected to extend after Shot time, were predicted. Although upper-level winds just below the tropopause were to be toward the southeast quadrant after the detonation, the dirt cloud was not expected to reach these levels and the fall-out pattern was considered very favorable. The forecast indicated that surface RADEX would extend from 210° to 290° true from H-hour to H+3 hours with a radial distance of ninety miles while the air RADEX would be concentrated in the west, southwest sector. Overall conclusions from a weather and RadSafe standpoint were again for most favorable conditions and recommendations were made that KING be detonated at 1130 on 16 November.

Ships of Task Group 132.3 departed the Eniwetok Lagoon in the following order preparatory to KING Shot:

1800, K–1 Day:	The O'BANNON departed for control destroyer position at Lat. 10°–30′ N., Long. 165°–00′ E.
0500, K-Day:	The OAK HILL departed for station bearing 050° true, distance seventeen miles from ground zero.
0800, K-Day:	The COLLINS departed via the Wide Passage, for station five miles south of the entrance buoy to the Wide Passage.
0810, K-Day:	The AGAWAM stood out via the Wide Passage and formed 1,500 yards astern of the COLLINS.
0815, K-Day:	The LIPAN stood out via the Wide Passage and formed 1,500 yards astern of the AGAWAM.
0820, K-Day:	The RENDOVA stoo the Deep Entrance operated within AN communication ra of the ESTES.
0845, K-Day:	The CARPENTER FLETCHER joined with the AGAW COLLINS, and LIP COMCORTDESD ELEVEN assumed tical command of element.

The CURTISS and the LEO remained Kwajalein during KING Shot and the LST which had proceeded to Bikini prior to the November H-Hour, remained at Bikini in or to provide for emergency evacuation should necessity arise due to fall-out. The ELDE ARIKARA, and YUMA had been released fr CTG 132.3 control prior to K-Day. When first postponement of KING Shot was announ all Task Group 132.3 security patrols had reve to their K–2 days status with three DDE's two P–2V's on station. However, with the sec postponement of K-Day, the air patrol was duced to one aircraft and the surface patrol reduced from three DDE's to two DDE's the general movement to sea on 16 Novem At H-Hour, two P–2V's were airborne in sup of Scientific Project 9.2.

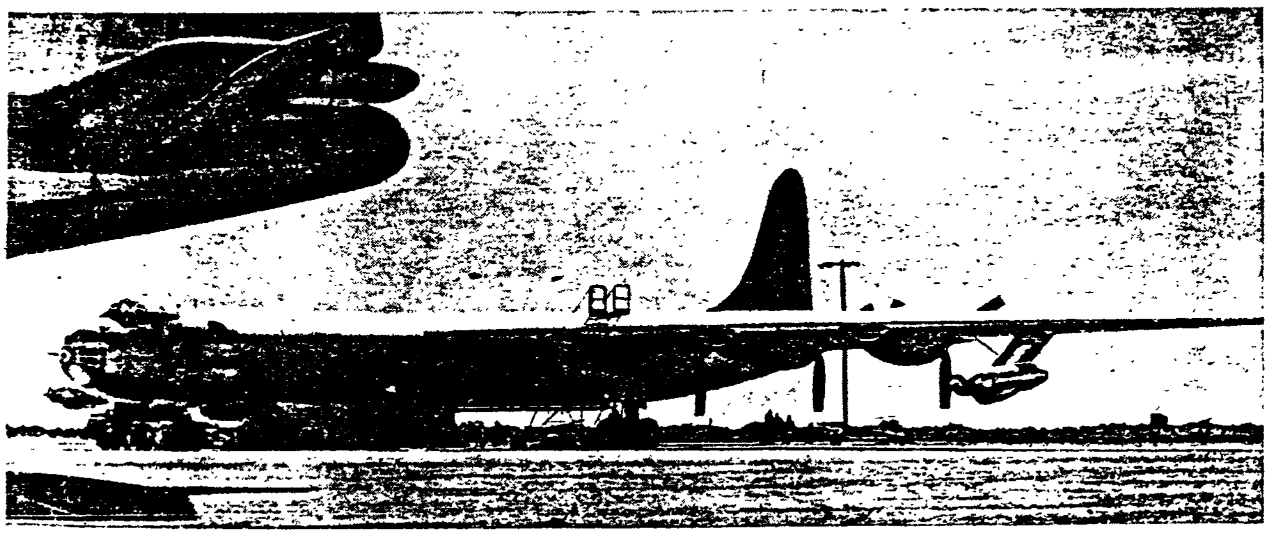
Since Task Group 132.2 remained on Eniwe Island during the KING event, its mission relatively simple. Necessary measures were ta to protect Task Group material and equipm against any blast and thermal effects of detonation. The signal communications sys was manned and personnel were instructed a protective measures in the event of radioac fallout. Personnel had also been instructed as procedures to be followed in the event of an em gency evacuation. By 1115, the various T Group 132.2 units were in position, either to p form missions or to observe the Shot. The offi observer party was assembled at the Offic Beach Club on Eniwetok Island and all person were able to follow the sequence of events o loudspeakers.

Concurrent with the final KING preparation Eniwetok Atoll, the Air Task Group had beg dispatching aircraft from Kawjalein in order properly position them prior to H-Hour. The preshot aircraft activity can be roughly considered in relation to aircraft deployment in four areas of activity—the target area; the orbiting area, fifty nautical miles southeast of ground zero; the intermediate refueling area at Lat. 10° 30′ N., Long. 165° E.; and the Kwajalein area. In the target area at Shot time were the Drop B–36H, Effects B–36D and B–47B, two Instrumentation B–50's, two Canister Drop B–29's and three Photo C–54's. All of these aircraft were assigned prescribed flight patterns in order to permit their precise positioning at H-Hour. Those aircraft which were scheduled to accomplish missions in the vicinity of the KING cloud immediately following the detonation were in the orbiting area. Included in this increment were the Control B–36H, two Control B–29's, two Tanker KB–29's, two F–84G's, and one SAR SA–16. At the intermediate refueling area, orbiting over the O'BANNON, were two Tanker KB–29's and one SAR SA–16. With the exception of one WB–29 Shower Activity Reporting aircraft en route back to Kwajalein, one Photo RB–50 thirty nautical miles southeast and one Photo C–47 approximately fifty nautical miles south of ground zero, the remaining aircraft were in the Kwajalein area, either awaiting take off or in an airborne status en route to designated rendezvous points.

By 0630 on K-Day, the KING weapon had been prepared for dropping, loaded aboard the B–36H Drop aircraft and was en route to Eniwetok. Inflight insertion of the capsule was performed by the bombardier, adhering to normal procedures. By H–3 hours, the Drop aircraft had begun orbiting over the target area, conducting practice runs in order to reduce, with each run, the timing accuracy to a point well within the allowable plus ten or minus twenty seconds. The orbit pattern of the Drop B–36 was a left-hand one, six miles wide, terminating in a bomb run passing over Rigili Island on a heading of 070° at an altitude of 40,000 feet. The ESTES Air Controller had full operational control over the Drop aircraft and monitored its course on the radar scope, transmitting information as required. As trial runs were being made, wind conditions at various levels were transmitted to the B–36 which, in turn, was able to make required adjustments prior to H-Hour.

The target consisted of an array of brightly painted oil drums, mounted on pilings in the form of a cross at ground zero with small radar reflectors set on the center drums. An offset aiming point, consisting of a large radar reflector, was located on the northern end of Runit Island, 1,900 feet due south of ground zero. Though small, the target was visible optically from a distance of twenty-five miles and the large, offset reflector was visible by radar for a range of sixty miles. Actual release was visual.

A voice-time script was used to announce time hacks from the Drop B–36. Based on a detonation time of 1130, times were announced at H–2, -1½, and –1 hours, H–30, –15, and –5 minutes. At two minutes before drop time, a count-down



Loading KING into the Drop B–36 at Kwajalein was initiated from the Drop B–36, terminating in "Bomb Away." The time count until detonation was then broadcast from the Parry Island Control Station. KING dropped for approximately fifty-six seconds and detonated at an altitude of 1,480 (plus or minus twenty) feet. The detonation was approximately one second early with a circular error of about 570 feet.

KING Shot was perhaps more spectacular in many respects than MIKE Shot—due, primarily, to the relatively close distance (approximately eleven miles) of observers to ground zero. The heat wave was immediately felt by observers and the growth of the fireball, the development of the cloud-chamber effect, and the formation of the conventional mushroom-shaped cloud were all clearly visible. In approximately forty-five seconds after detonation, the shock wave hit Parry Island and the sound was very similar to that experienced when in close proximity to the firing of a 90mm gun. The cloud rose rapidly to a great height, spread out over Parry Island and seemed to remain suspended there until it began to disperse. An early report estimated the cloud height to be approximately 67,000 feet with the base of the mushroom at 40,000 feet.

K-Day had begun as an almost cloudless day with a few low, fair-weather cumulus clouds; by midday, however, and as the KING cloud began to spread out radially in long streaks to the west, to the southeast, and to the southwest near and above the tropopause, the atmosphere had changed to a high, thin overcast. Small convective showers were early evident for a period of about two hours until once again trade conditions reestablished themselves. These showers were probably caused by the temporary slight distortion of the general area circulation.

The two Canister Drop B–29's were in position on schedule though one of them developed bomb release difficulties and had to release its six canisters by salvo operation. Of the twelve canisters dropped, only eight functioned properly; two had incurred free fall due to parachute malfunction, resulting in impact prior to detonation; and two incurred electronic failure. Approximately seventy-five percent of the required data was obtained from the eight canisters. Both of the Canister Drop B–29's had returned to Kwajalein by 1334. The two Instrumentation B–50 aircraft were in position at Shot time and remained on course until H+20 seconds in order to obtain IBDA data. At H+20 seconds, one executed a sharp turn to the left and the other to the right in order to be in a straight and level tail aspect to ground zero at the time the shock wave was received. No substantial damage was incurred by either of these aircraft and they returned to Kwajalein.

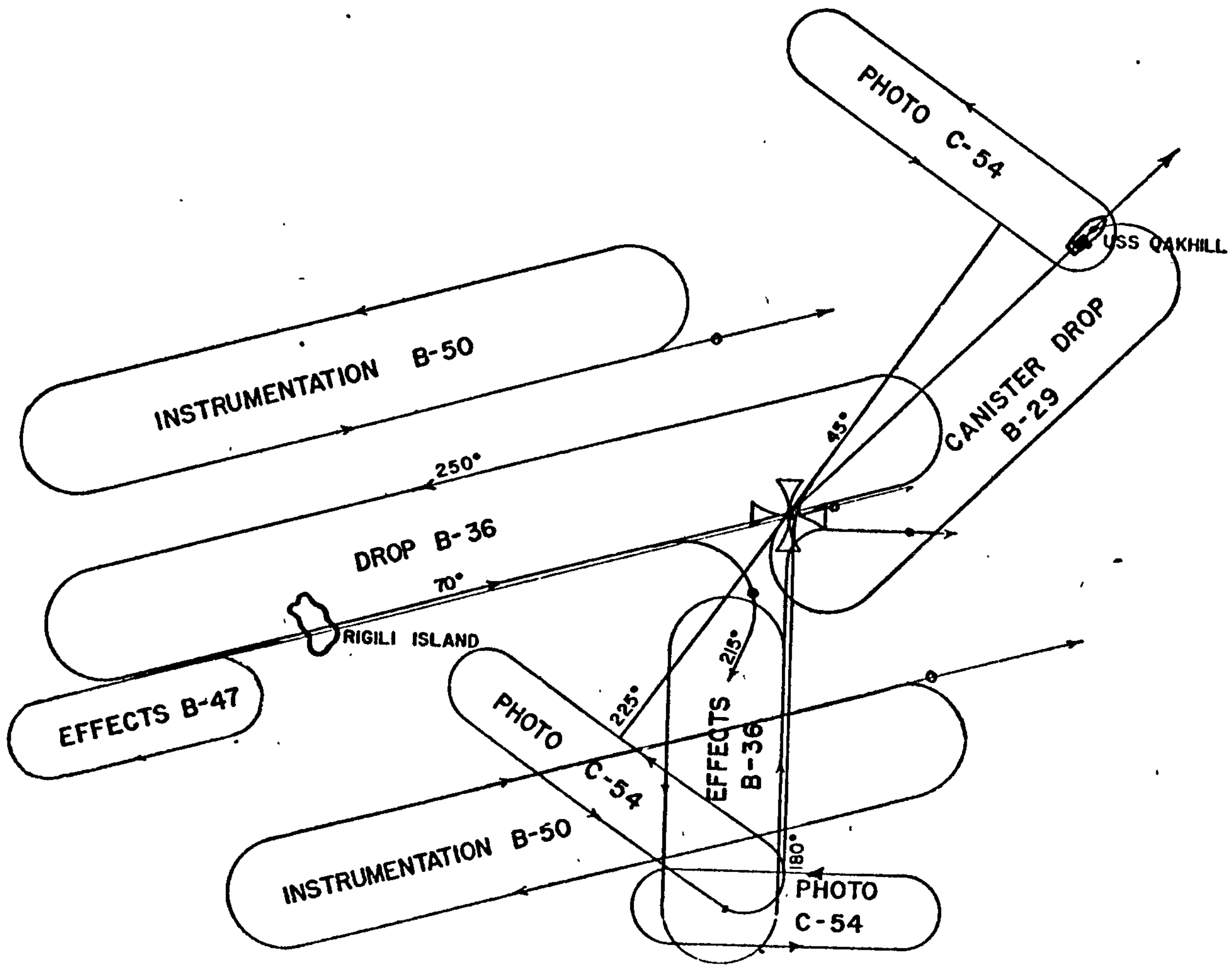
By positioning the B–36D and B–47B Effects aircraft (both equipped with installed thermocouples, strain gauges, and accelerometers of various types with recording meters and oscilloscopes) at the very threshold of damage, the actual structural distortion and skin temperature rise under realistic conditions were determined. Both aircraft were properly positioned at Shot time; no serious damage was incurred by either; and they were released for return to Kwajalein.

The three Photo C–54 aircraft were in position at H–Hour with zero error and each aircraft accomplished its mission of cloud photography under the guidance of the chief photographer aboard. The Photo C–47 which was to be twenty miles south of Eniwetok Island at an altitude of 10,000 feet was one and one-half nautical miles out of position but well within the permissible plus or minus five nautical mile error. Following the detonation, this C–47 obtained photographs of the atomic cloud at one-minute intervals until H+1 hour, at which time it was released for return to Kwajalein. Although the operating altitude of the Photo RB–50 was to be 22,000 feet, it developed turbo trouble and could get no higher than 13,000 feet. Fortunately, cloud cover was such that it was able to accomplish its mission of atomic cloud photography from that altitude. Its return flight to Kwajalein was made via Bikini with photographic coverage of that Atoll made prior to landing at Kwajalein.

At H-Hour, the aircraft which had been orbiting thirty miles southeast of Eniwetok Island left that area to accomplish their respective missions. The B–36H Control Aircraft established a pattern at an altitude of 40,000 feet in a direction downwind from the atomic cloud. This pattern was maintained throughout the sampling operations with special emphasis being placed on keeping the pattern between the cloud and Eniwetok Island. The Primary Control B–29, at 20,000 feet with the Secondary Control B–29 and two Tanker KB–29's following in [redacted]ked-down

[redacted]

KING SHOT



CANISTER DROP

TWO B-29'S
16.9 N. MILES FROM GZ AT 30,000 FT. ALTITUDE.

INSTRUMENTATION

60,000 FT. SLANT RANGE FROM GZ, 20,000 FT. ALTITUDE, 2 MILES AHEAD OF DROP AIRCRAFT.

EFFECTS B-47

9800 FT. HORIZONTAL RANGE FROM GZ, HEADING 70°, ALTITUDE 35,000 FT. NO CHANGE IN HEADING FOR DETONATION.

DROP B-36

ALTITUDE 40,000 FT. TURNS TO 215° IMMEDIATELY AFTER BOMB RELEASE.

EFFECTS B-36

35,000' HORIZONTAL RANGE FROM GZ 32,000 FT. ALTITUDE.

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[redacted]

trail formation, proceeded to establish a flight pattern twenty miles south of the cloud track similar to that adopted by the Control B-36. Radar contact with the Control B-36 was maintained at all times. The two Sniffer F-84G's, at 40,000 feet, and the SAR SA-16, at 10,000 feet, were in radar contact with the Primary Control B-29. Precautionary plans were made so that, had the Control B-36 aborted, the Primary Control B-29 would have climbed to 30,000 feet and assumed the duties of the B-36H. The Secondary Control B-29 would then have become the Primary Control aircraft.

The two Sniffer aircraft were vectored by the Control B-29 to the Control B-36 for the "sniffing" operation, remaining on the primary control frequency until visual contact had been made with the B-36. Once under control of the B-36, they were directed to carry out their missions by the scientific observer aboard that aircraft. Upon completion of their missions, the two Sniffers reformed as a two-ship flight and requested the Primary Control B-29 to direct them to the Tankers. When inflight refueling had been accomplished, the Sniffers again reformed and were directed by the Control B-29 to return to Kwajalein.

The primary refueling point for the F-84G's was in the sampling area with a secondary point over Eniwetok Island and an emergency point located at Lat. 10° 31′ N., Long. 165° E. The refueling area over Eniwetok was utilized when conditions in the sampling area prevented or made rendezvous with Tankers doubtful. The emergency refueling point was utilized in the event of excessive fuel loss due either to failure of tip tanks and pylon to feed or to syphoning of fuel overboard. When rendezvous and refueling could not be accomplished in the sampling area, the Sniffers or Samplers were directed by the Primary Control B-29 to the Tankers over Eniwetok. Pilots of the F-84G's were instructed to land at Eniwetok Island when rendezvous could not be made with these Tankers. In all cases, the F-84G's were released by the Control B-36H with sufficient fuel, not less than 2,000 pounds, to effect rendezvous with the Control B-29, attempt inflight refueling and, if unsuccessful, proceed to the Eniwetok strip with 500 pounds reserve fuel.

Ten KB-29 Tanker aircraft were utilized to accomplish the required inflight refueling of the Sniffers and Samplers. Of these ten aircraft, six were in the sampling area, two over Eniwetok Island, and two in the emergency refueling area. Inflight refueling was a complete success during KING operations and a minimum of problems were encountered. Contributing materially to the success of the refueling mission was the employment of F-84G Samplers in two-ship flights rather than four. During MIKE Shot, four-ship flights had reported into the sampling area but only two were employed at a time and the other two were required to orbit for approximately thirty to forty-five minutes prior to being utilized. This resulted not only in some confusion but also in an excessive expenditure of fuel. A total of fifteen wet hook-ups were made during KING Shot inflight refueling operations with a total of 10,200 pounds JP-4 fuel being transferred.

To fulfill the cloud sampling requirements, twelve F-84G aircraft had been scheduled to depart from Kwajalein in three flights of four aircraft each. These flights were further subdivided into elements of two aircraft each. The following is the schedule which was established for the F-84G sampling mission.

Aircraft	Call sign	Take off	Departing altitude	Target time	Return altitude
2/F-84G's	PEBBLE RED 1 and 2	1210	40,000 ft	1300	30,000 ft.
2/F-84G's	PEBBLE RED 3 and 4	1240	40,000 ft	1340	30,000 ft.
2/F-84G's	PEBBLE WHITE 1 and 2	1300	40,000 ft	1400	30,000 ft.
2/F-84G's	PEBBLE WHITE 3 and 4	1345	40,000 ft	1445	30,000 ft.
2/F-84G's	PEBBLE BLUE 1 and 2	1410	40,000 ft	1510	30,000 ft.
2/F-84G's	PEBBLE BLUE 3 and 4	1430	40,000 ft	1530	30,000 ft.

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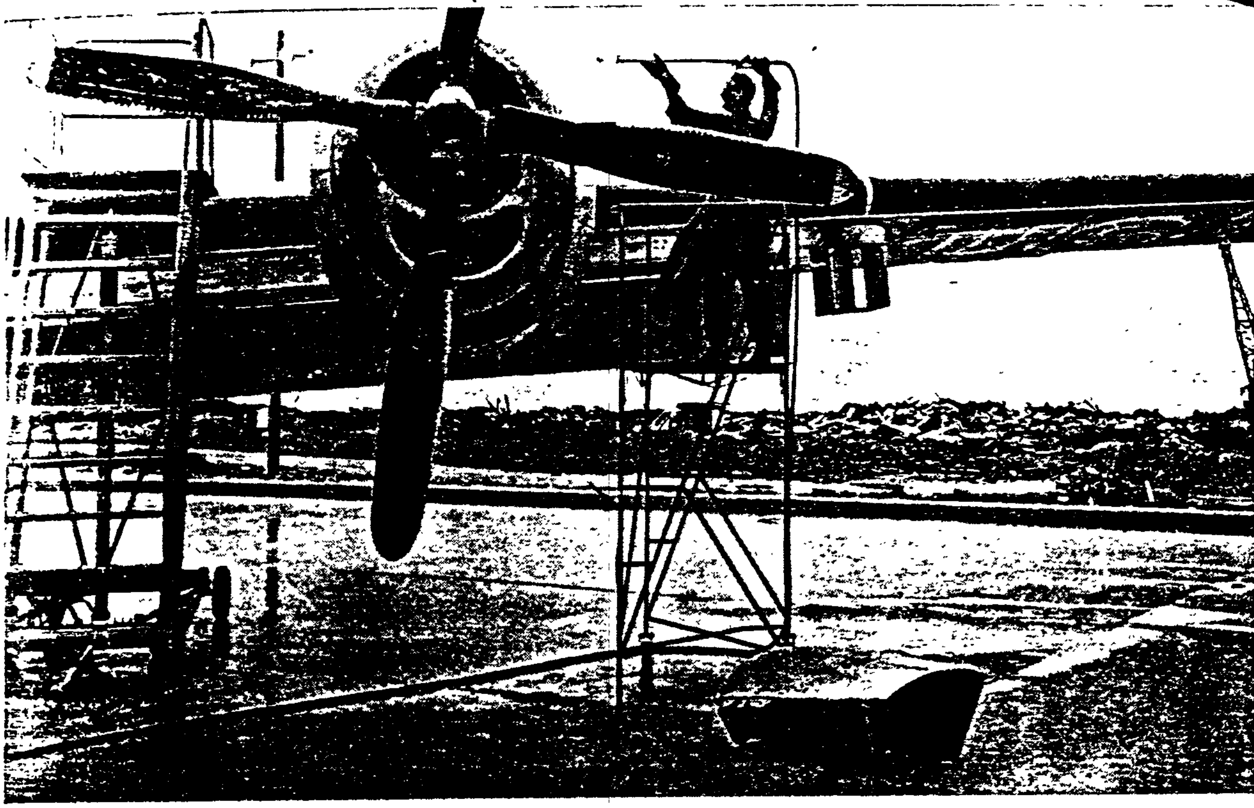
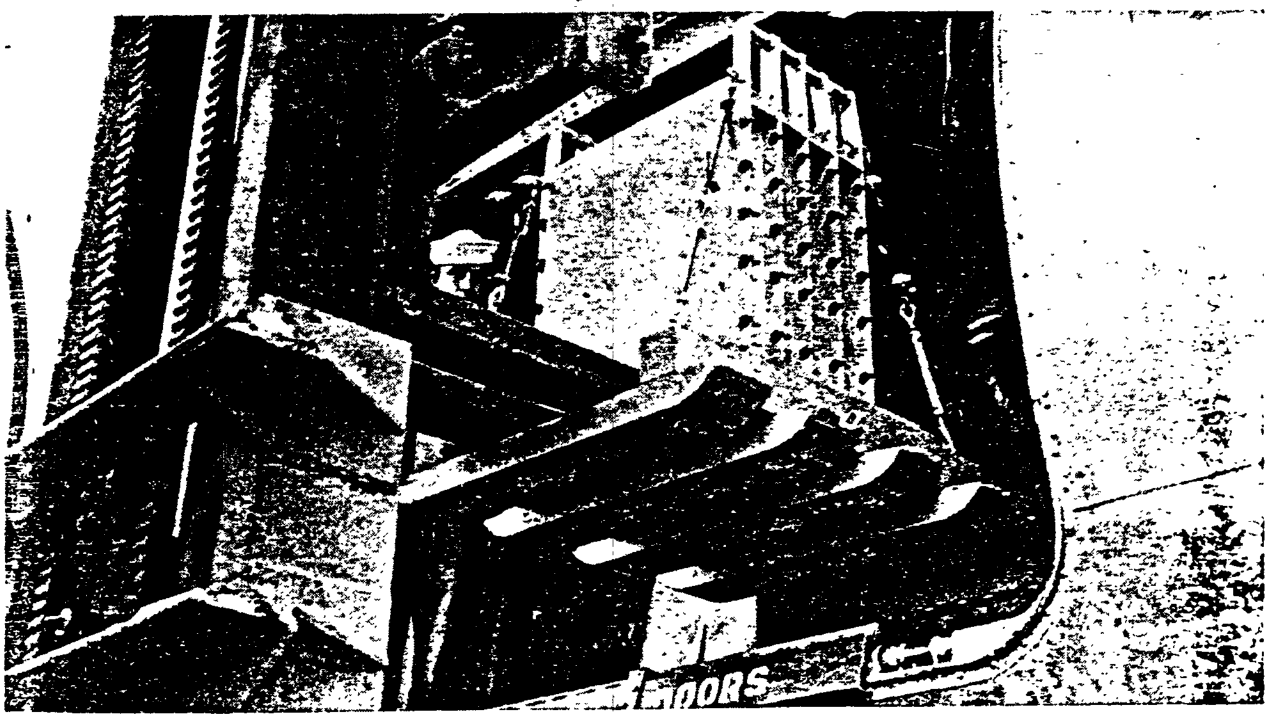


Aircraft Decontamination on Kwajalein



Transferring Cloud Samples at Kwajalein For Delivery to the ZI

[redacted]

PEBBLE WHITE 3 aborted on takeoff when its landing gear failed to retract and it had to return to Kwajalein. A substitute was dispatched but it also was forced to return due to engine malfunction. PEBBLE WHITE 4 aborted one hour after takeoff due to fuel malfunction, and, with its return, this element of PEBBLE WHITE was cancelled. With the exception of a few minutes difference in target times, the mission of the remaining F-84G's was a complete success.

The cloud structure was initially good for big samples but it dispersed rapidly at almost all levels due to strong wind shear. An attempt, however, was made to obtain at least three samples above 42,000 feet. The following is a short resume of KING sampling results and radiation intensity as a measure of sample strength is given in mr/hr for one panel at one meter at H+6 hours. Samples obtained by PEBBLE RED 1 and 2 were taken at 42,000 and measured 260 and 235, respectively. PEBBLE RED 3 and 4 obtained approximately one-third of their samples at 42,000 feet and the remainder at 31,000 feet, measuring 215 and 115, respectively. The third element, PEBBLE WHITE 1 and 2, was unable to reach the upper cloud and the samples obtained above 45,000 feet gave readings of 40 and 60, respectively. Samples obtained by PEBBLE BLUE 1 and 2 at 31,000 feet, measured 800 each, and those taken by PEBBLE BLUE 3 and 4, at 27,000 feet, gave readings of 600 and 325, respectively. The two Sniffer aircraft had obtained samples at 30,000 feet, which read 510 each. Although the above samples were somewhat smaller than those taken during MIKE Shot, they were considered entirely adequate for the radiochemical determinations to be performed.

As the sampling aircraft returned to Kwajalein, their samples were removed, prepared for shipment and loaded aboard two MATS R6D aircraft. The first R6D departed at 1650 and the second at 1850. Both aircraft had delivered their cargo to Kirtland AFB within twenty-eight hours after the loading at Kwajalein.

In the meantime, early reentry to the Runit Area had begun at H+10 minutes and by H+18 minutes, the helicopters being sent from the RENDOVA had landed on Parry Island and the initial aerial survey soon got underway. Information received from this survey group at H+50 minutes indicated that little contamination was evident on Runit and the remaining K-Day recovery parties departed on schedule for Runit and adjacent islands. At H+75 minutes, a fairly comprehensive preliminary report of the damage and contamination on Runit was received. Tent frames were demolished and charred; there was evidence of a washover of the northern end of the island; the radar target had been dished out; NRL revetments were eroded; and although the blockhouse remained, its sand revetment was gone. Water in the target vicinity indicated no contamination but a reading of 300 mr was registered 500 feet above the target. Ground contamination at the Runit powerhouse was 3 mr. However, it should be noted that due to the fireball size, the lower dirt cloud—with induced activity from soil and water—was estimated to be a consideration from the standpoint of maximum permissible exposures. This was true since an additional total dosage, even as small as 900 mr, for some of the recovery personnel would have resulted in cases of total dosages in excess of the permissible 3.9 r for Operation IVY.

At H+3 hours, another helicopter had completed a Lagoon water survey and by H+5 hours, the Navy Task Group had returned to the Lagoon. This action, of course, had been anticipatory and predicated on advice from Headquarters, JTF 132, relative to fall-out predictions. By K+1 day, the KING recovery program had essentially been completed and Operation IVY was rapidly drawing to a close.

[redacted] DATA
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Chapter XXII

THE TEST PROGRAMS AND EARLY EVALUATIONS

At the very core of the tests which were given the name of Operation IVY were, of course, the eleven Scientific Programs. The Programs were of the essence of the tests and provided the means whereby the effectiveness, the efficiency, the design theories, and the phenomena of the two detonations were measured. Though the assessment of the scientific findings and conclusions drawn from the data assembled by the Programs is not properly the responsibility of this History, a short account of the Programs, of their less technical aspects and of some of the early evaluations of the data procured from them is appropriate for presentation here. Only the more basic and the more preliminary results can be presented and it should be stressed that conclusions based on the information here given may very well be inaccurate or misleading inasmuch as data reduction is still being carried on at many laboratories and can quite likely lead to different conclusions. The detailed findings and conclusions which will be based on the data gained from the IVY Scientific Programs will appear in the future as separate and specialized reports which will carry interest in most cases for the scientific specialist only. The attempt here, then, is to present for the general reader and nonspecialist a brief and simple statement relative to the intent and earlier assessment of the Programs.

PROGRAM 1—Radiochemistry

The objective of this Program was the collection and radiochemical analysis of atomic debris samples, the primary purpose of the analysis being the determination of yields. For MIKE Shot, an attempt was made to obtain pertinent diagnostic information which would indicate whether or not, and to what extent, the desired thermonuclear reaction took place and propagated. This was accomplished by means of analysis designed to detect activity in selected "tracer" materials such as germanium oxide, scandium, tungsten, sodium fluoride, nickel, lead, and others. Quantities of these materials were built into or placed in the vicinity of the device.

The quantity of gaseous and particulate atomic debris samples collected from the detonation-induced clouds of both Shots, utilizing collectors mounted on manned F-84G aircraft, was adequate. Shielded flight clothing to reduce radiation exposures was effectively used by the F-84G pilots during MIKE Shot sampling operations. Instrumentation of the clothing indicated that low energy gamma radiation was present in the MIKE cloud during some of the penetrations, though the radiation exposures received by these pilots were in all cases well within the prescribed limits. The early analysis of these samples indicated the yield of the MIKE device to have been [redacted]f the KING weapon to ha[redacted] There is a discrepancy between this yield for MIKE and that given by ball-of-fire photography (see the discussion of Program 3 herein), and it appears that the ball-of-fire result is the more reliable one.

PROGRAM 2—Progress of the Nuclear Reaction

This Program was designed to analyze the performance of the device and the weapon, utilizing various diagnostic measurements. New and untested experimental techniques were devised for MIKE Shot and a large and gratifying amount of data was obtained. For MIKE Shot, measurements were made of alpha (loga[redacted] of rise of the nuclear reaction) [redacted]rigger" bomb; the time from the [redacted]eaction to the beginning of the thermonuclear reaction; the time characteristics of the thermonuclear "burning" in the central portion of the device; the rate of propagation of the thermonuclear reaction; and the energy spectrum of the neutron flux. The

[redacted]

for these measurements was recorded 9,000 feet from the device in a concrete bunker which was connected to the device cab by a helium-filled tunnel, the Krause-Ogle Box, through which gamma ray and neutr[redacted] pass with little attenuation. Th[redacted] All other MIKE Shot measurements were highly successful.

For KING Shot, alpha and transit time (time from firing signal to first nuclear reaction) were measured, the latter by a remote me[redacted]t technique capable of tactical utilizatio[redacted]

PROGRAM 3—Scientific Photography

This Program had many objectives, each of which involved photographic documentation of some aspect of the detonations. Ball-of-fire growth, cloud development, and illumination versus time were measured for both Shots. For MIKE Shot, an indirect measurement of the internal temperature distribution was made by observing light signals from selected spots on the outer surface of the steel case of the MIKE device. Th very early disintegration of the device case was observed by high speed photography and the MIKE crater structure was documented by both preshot and postshot aerial photography. For KING Shot, the precise position of the burst was measured. In addition, Bhangmeters (devices designed to obtain a remote and quick yield result from light signal observation) were utilized for both Shots.

Generally speaking, three main types of cameras were used to accomplish the above—one type producing a record composed of a number of discrete photographs or frames; another producing a continuous "streak" record; and a third producing a single picture at a known time after a detonation. Depending upon the phenomenon being photographed, film speeds from sixteen frames per second to 3,500,000 frames per second were utilized.

A great amount of data was obtained despite some equipment failures. Some of the film records have yet to be completely analyzed; however, preliminary analysis of the films of ball-of-fire growth indicated the following yield [redacted]ues:

MIKE Shot------------------ [redacted]
KING Shot------------------ [redacted]

The KING Shot burst position, designated as a position 1500 feet high, was determined to have had a circular error of 570±35 feet and a height of burst of 1480±20 feet.

PROGRAM 4—Neutron Measurements

Program 4 was primarily devoted to the measurement of total numbers of neutrons (in various known energy ranges) arriving at fixed distances along the ground. Such neutron "counting" is accomplished by laboratory analysis of the neutron-induced radioactivity in selected "threshold detector" materials such as gold, tantalum, indium, iodine, zirconium, and others. For each Shot, many detector stations were established in a line extending outward from ground zero. In addition, an attempt was made to measure as a function of time, utilizing a device known as the "Fission-Catcher Camera", the total number of neutrons arriving at a few selected points. The basic difference between the two types of measurements here outlined should be noted. The first allows only a counting of neutrons and furnishes no information as to when a particular neutron arrived, whereas the second does allow for such a time separation.

Since the detector station positions for MIKE Shot were purposely chosen on a basis of the possibility of a relatively low yield, many of the samples were lost. Nevertheless, thirty-five samples were recovered—some from within the MIKE crater—and are undergoing analysis at LASL. Thirty-eight samples from KING Shot were recovered and are also undergoing analysis. All of the "Fission-Catcher Cameras" were destroyed by the blast.

It should be pointed out that the relatively large amount of measurement station destruction and the resulting potential data loss suffered by this Program is not indicative of a poorly designed experiment. The high attenuation of a neutron signal passing through air dictated that the stations be relatively near ground zeros and the value of such close-in data was considered to be well worth the risk of losing a few inexpensive stations. One of the greater potential values of these neutron measurements is to explain why a device failed or detonated with a yield much lower than predicted. Had the detonations been less successful, these stations would have gained proportionately in importance.

PROGRAM 5—Gamma Ray Measurements

This Program was devoted to the study of gamma radiation. Measurements were made of gamma ray intensity as a function of both time and distance for both prompt and delayed gamma radiation. The closeup instrumentation was also designed for diagnostic studies and studies of shock wave effects upon gamma radiation. The more distant instrumentation was concerned largely with fall-out and included utilization of several newly developed collection and recording devices.

Total doses were measured with film badges for both Shots, many badge stations having been established on the lines extending from ground zeros as already noted. For the first few seconds, gamma-ray intensity versus time (one ten-millionth of a second time resolution) was measured with phosphor photocelloscilloscope-camera combinations. More distant intensity versus time measurements (few seconds time resolution) were made with ionization chamber-recorder combinations. Fall-out samples were collected over both land and water at selected points ranging from a few to several hundred miles from ground zeros.

On MIKE Shot, most of the film badge stations were destroyed. Some meager data was extracted, nevertheless, from those which were located more than 4,500 yards from ground zero. High resolution intensity records were obtained in sufficient quantity to indicate the pronounced effect of the shock wave and to measure the time between the two fission phases of the device. Lower time resolution intensity records were obtained on seven islands of Eniwetok Atoll while recordings of fall-out on Kusaie Island and Ujelang Atoll were also obtained. Usable fall-out samples—some of them as a function of time—were collected on the islands of Eniwetok Atoll, on rafts in the lagoon, on buoy-type sea stations and at other atolls. It is expected that analysis of these samples and the ionization chamber-recorder data will definitely augment understanding of the problems of overall fall-out hazards, particularly because of the time dependence of portions of the data.

For KING Shot, the film badge stations out to 1,200 yards were destroyed—apparently by a large block of concrete which rolled down the line wrecking both film badge and neutron detector stations. The remainder of the badges were recovered and are presently undergoing analysis. Usable intensity versus time data was obtained with both slow and fast time resolutions. No significant fall-out was recorded on any island of the Atoll other than Runit. The KING fall-out samples which were obtained from twenty-four fall-out collector stations on islands of the Atoll exhibited extremely low activity, thus indicating that very slight to no fall-out had occurred.

PROGRAM 6—Blast Measurements

This Program was designed to study the characteristics of the MIKE and KING blast waves; their propagation through air, water, and earth; and their transient effects upon these media. In particular, data was sought to document pressure versus time as a function of distance from ground zeros at the surface; material velocity behind the shock front at known positions in space; shock wind, afterwind and sound velocity before, during and after blast wave passage; water surface motions in both deep and shallow water; subsurface earth accelerations; subsurface pressures in both deep and shallow water, including acoustic pressure waves at great distances; air density versus time before, during and after shock wave passage; and air pressure versus time at known positions in space. The tremendous energy release associated with MIKE Shot and the quasi-operational nature of the KING Shot drop assured that great interest would be shown in this Program by both the AEC and DOD.

The experimental techniques utilized to accomplish the above measurements were too many and too varied to allow description in an account of this type. For example, they included techniques ranging from tiny self-recording "indenter" gauges to completely instrumented bomber-type aircraft (the B-36D and the B-47B). A large amount of usable data was obtained, every Project reporting at least partial success in its cursory report in spite of many unforeseen difficulties due to inclement weather effects on some stations. Some tentative conclusions which can be drawn are:

1. The basic blast pattern from nuclear explosions now appears to be established on quite firm theoretical and empirical grounds in a self-consistent theory beginning with the growth of the ball-of-fire and extending to pressures less than one pound per square inch.

2. Atmospheric inhomogeneities markedly affect the blast variables at great distances for large yield detonations. In particular, under normal temperature lapse rate conditions, peak pressures at great distances are markedly reduced.

3. Blast hydrodynamics offer considerable immediate promise as a diagnostic tool on future tests of atomic weapons.

The following facts of interest have resulted from preliminary review of the data gained:

1. Water surface displacement was two to four feet at Runit Island and one to three feet at Parry Island for MIKE Shot. The waves produced by this Shot were, generally, much smaller than predicted, being approximately one-tenth of that expected within the Lagoon and nonexistent in the open sea.

2. A newly devised light and inexpensive deep sea mooring, utilizing the top of undersea mountains rising to within 5,000 feet under the surface, was proven highly successful. This ability to establish semirigid reference points in midocean may well offer a valuable technique to [redacted]dies in general.

[redacted] on Parry Island for both MIKE and KING Shots were identical—0.36 pounds per square inch. This anomaly appears to be due to a refraction effect.

PROGRAM 7—Long Range Detection

Program 7 was designed to aid in the development of, and to obtain calibration data for, specialized equipment and techniques for the detection (and analysis, to whatever degree is feasible) of a nuclear explosion at great distances. The techniques utilized were extremely diverse in nature, covering the fields of electromagnetic radiation transport; airborne low frequency sound; seismic wave propagation; the detection of ball-of-fire light; and the tracking, collection, and analysis of airborne debris samples.

The quantity and general characteristics of the data and samples collected by this Program indicated success, though practically no information on reduction and analysis of this data is available at this writing. Existing cloud cover and smoke obscuration make the Bhangmeter results appear questionable. Communication difficulties lessened the effectiveness of KING Shot air sampling operations, but the samples obtained were adequate for at least partial analysis. MIKE Shot air sampling was more successful. Most remote stations reported reception of excellent signals in conjunction with MIKE Shot.

PROGRAM 8—Thermal Radiation Measurements

This Program was designed to investigate the thermal radiation emitted by an atomic detonation. Near the earth's surface, attempts were made to measure the total thermal energy received as a function of distance from ground zero; the time variation of thermal intensity received; and the energy spectrum exhibited by this radiation. In conjunction with these measurements, and to aid in the interpretation of results, the atmospheric attenuation (transmission property) along light paths of interest was studied. Instrumented bomber-type aircraft (the B-36D and the B-47B) were employed to study, in free air and at altitudes significant to delivery aircraft, the thermal intensity versus time and the associated radiation-induced aircraft-skin temperatures. The latter information is essential to studies of safe aircraft delivery techniques. The instrumentation utilized to accomplish the above included thermocouples, bolometers, photocell-recorder combinations, high speed spectrographs and skin patches.

Results were most gratifying, the only serious loss of data occurring in the "total thermal" project for KING Shot. A great amount of data, the quality of which appeared to be excellent, was obtained from both Shots. Cursory analysis points out the following facts:

1. The appa[redacted]al energy of MIKE Shot was at leas[redacted] This value is uncorrected for clouds an[redacted]t and hence is somewhat low.

2. On MIKE Shot, the left wing access door of the B-36D experienced a temperature rise of 93° F. The thickness of the aluminum was 0.025 inches and the aircraft was approximately

fifteen nautical miles slant range from zero at an altitude of 40,000 feet. This aircraft re- ceived a relatively high thermal flux of 46.9 BTU per square foot. The predicted value based on [redacted] yield wa[redacted] per square foot.

3. The apparent thermal energy of KING Shot was at leas[redacted]

PROGRAM 9—Electromagnetic Phenomena

This Program was concerned with the detection and measurement of various electromagnetic phenomena associated with nuclear detonations. One Project studied the correlation between nuclear explosion-induced ionospheric disturb- ances and the interruption of radio communica- tions. Another made a feasibility study of radar scope photography as an IBDA technique. In addition, two Projects concerned themselves with documentation of the broad band electromagnetic signal given off by a detonation—one being par- ticularly interested in selected "standard" radio frequency (20 KC and 4.214 MC) bands; and the other devoted to testing the feasibility of this technique for making remote diagnostic measure- ments, and hence being particularly interested in the early, first-few-millionths-of-a-second, signal characteristics.

The techniques used to obtain data for the above included airborne radar scope photography; the reception and recording of selected radio transmissions; and the documentation of iono- spheric height and continuity. Quantitative measurements of the explosion-induced electro- magnetic signal were made possible by displaying reception of that signal on the faces of cathode ray tubes and recording photographically for evaluation.

The results of this effort were excellent and all Projects obtained usable data from both Shots. For MIKE Shot, the early electromagnetic signal was displayed in sufficient detail to allow a rough measurement of the time delay between primary and secondary fission reactions. A Navy P2V aircraft flying 200 miles west of Eniwetok and transmitting a continuous wave signal to Bikini was able to contact Bikini approximately two hours after MIKE Shot, indicating no long time disruption in the ionosphere. Also for this Shot, the radar scope photographs show both ball-of-fire growth and shock progress.

PROGRAM 10—Timing and Firing

The timing and firing Program was prima one of support rather than experimentation. its name implies, it was devoted to furnishing various experimental Projects with the timing nals required for starting equipment on both Sh and with supplying the arming and firing signal the MIKE device. In addition, vital informa was telemetered from the vicinity of the MI device to the control room aboard the ESTES

With the exception of a number of "Blue Bo which failed to operate properly on both Sh this Program can be considered highly succes A complete photographic record of the televi monitoring of the MIKE device aboard the ES was obtained. For KING Shot, there were reports of equipment failing to receive sig except in the case of some of the "Blue Boxes

PROGRAM 11—Preliminary Geophy and Marine Survey of Test Area

This Program was designed to obtain de information as to the configuration and stru of Eniwetok Atoll in order that the effects its structure of MIKE Shot and other high shots presently planned for future tests mig more readily and reliably interpreted. In tion, it included a study of the biological co nation effects resulting from an atomic near water.

Prior to MIKE Shot, both acoustic sou and seismic refraction surveys were conduc and around the Eniwetok reef. Ground tests were accomplished in conjunction wit explosive detonations and two deep-drill were sunk to unaltered basement rock. I tion, samples of marine life were collecte before and after the Shot in order that the cal effects of radiation contamination m subsequently analyzed in the laboratory c ing this portion of the Program. The only priate preliminary statement of results Program in that usable data was recovere being reduced and studied.

For the first time, a boring was sunk a ples obtained at great depth on a Pacif settling a question which has been a m conjecture for many years and providing tion for the scientific interpretation of

Preparing For a TNT Charge in Program 11

al seismic data obtained during the tests. Sam-
es of Olivine Basalt rock were obtained at a depth
4,222 feet on Parry Island of Eniwetok Atoll.
A condensed and superficial account of the IVY
ientific Programs as has been given here cannot
ssibly convey a true representation of the wide-
pread efforts that went into the making of the
Program schedules. Long hours of research; a
reat volume of coordination between civilian and
ilitary agencies; and a large spirit of cooperation
s well as extensive construction and hard work at
Eniwetok were all necessary for the planning, mounting, and execution of the eleven Programs. The completion of these Programs and the acquisition of the data they have provided was absolutely essential to an efficient and successful conclusion to Operation IVY. The high degree of success achieved is a tribute to the concerted efforts of those personnel connected, either directly or indirectly, with Joint Task Force 132. Finally, this success can only be considered as more than an adequate reward and justification for the time, energy and the human and material resources invested in IVY.