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HISTORICAL REPORT

ATOMIC BOMB TESTS ABLE AND BAKER

(OPERATION CROSSROADS)

By Authority of JOINT CHIEFS OF STAFF ... 1949

By John H. ...

AD-A995 213

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Director of Ship Material, Joint Task Force One

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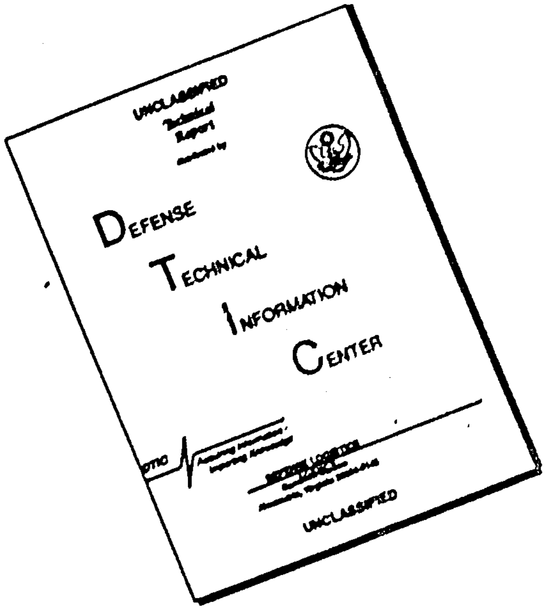

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HISTORY OF DIRECTOR OF SHIP MATERIAL

OPERATION CROSSROADS

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CHAPTER 6

ARMY GROUND GROUP

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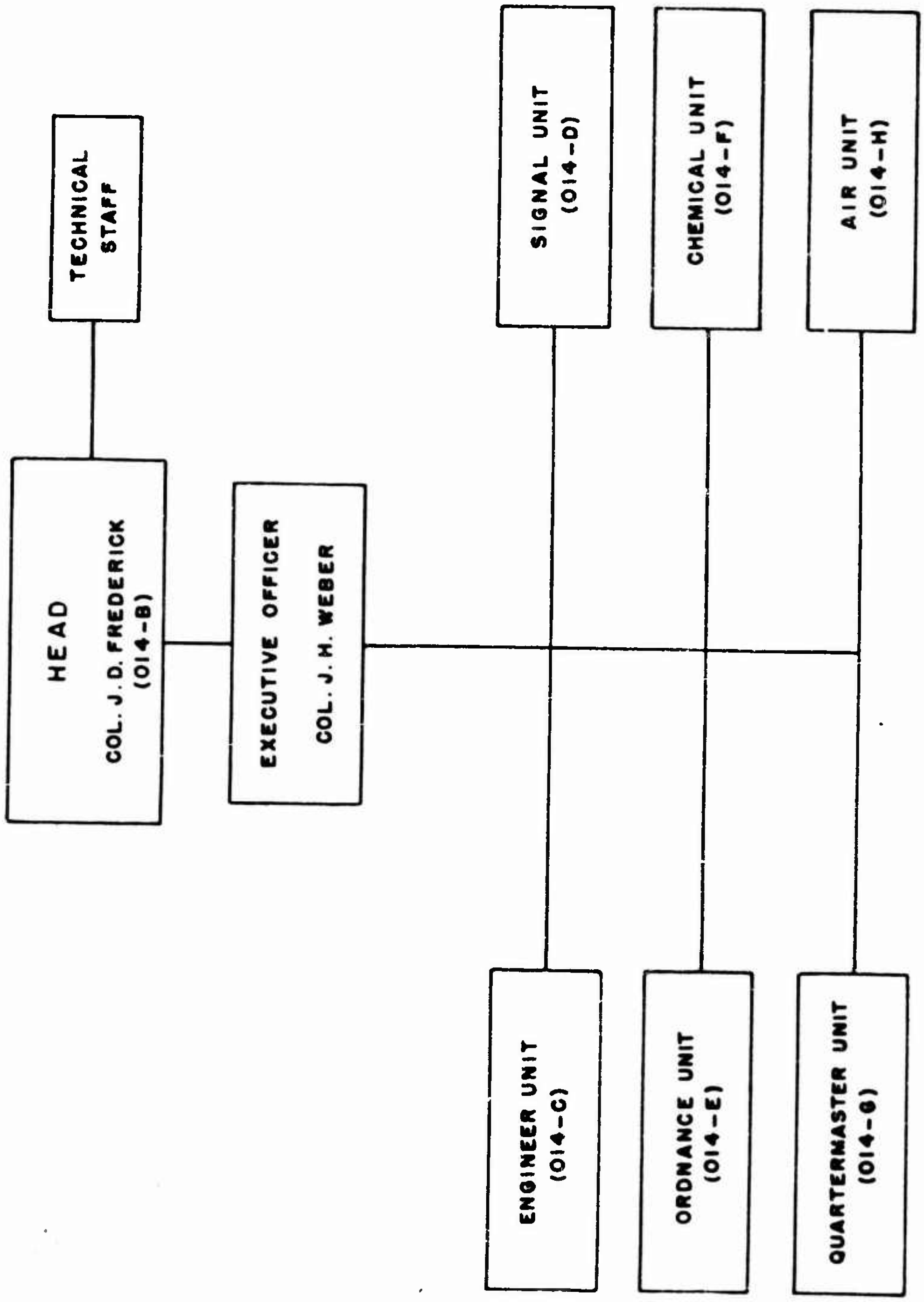
ARMY GROUND GROUP (014-B-H)



ARMY GROUND GROUP

Exploratory Discussions

On 2 January 1946, Vice Admiral Blandy discussed with Brig. Gen. William A. Borden and Col. Gervais W. Trichel of the New Developments Division, War Department Special Staff, the general subject of Army participation in the atomic bomb test, which had been proposed but not yet approved by the Joint Chiefs of Staff. General Borden suggested the desirability of having a senior Army Ground Forces officer as a staff adviser, and Maj. Gen. A. C. McAuliffe subsequently received this assignment. The Army decided that the New Developments Division was to coordinate Army participation in the tests, keeping interested agencies informed of the status of the project.

Colonel Trichel met with Admiral Parsons on 21 January to discuss representation of the Army technical services in the tests, and it was agreed at this time that the Army technical services should have representatives on the staff of the Director of Ship Material, who was charged with preparation of the target ships. These representatives were to form a group with the same relative position as groups from the various Navy bureaus. The following day Colonel Trichel made arrangements with the Army Service Forces for selection of representatives from the technical services.

On 23 January, Colonel Trichel arranged with Brigadier General Hewett for the Army Ground Forces to propose a list of equipment for test, and the next day he began work on the organization of an Army technical group. After a conference on 25 January with representatives of the technical services, Colonel Trichel organized a group of staff representatives as a planning unit to serve under the Director of Ship Material, who in a conference the same day briefed them on the target planning aspects of the tests. Later this group became the nucleus of the Army Ground Group. Also the same day, the group attended a conference called by the Deputy Commander for Technical Direction at which Dr. von Neumann presented data on the range of effects to be expected from the explosion of the atomic bombs. This technical staff group, responsible for selection of test items, coordination with interested agencies, arrangement for target ship space, and personnel requirements, comprised the following:

Col. H. H. Pohl	Corps of Engineers
Col. J. H. Weber	Ordnance Department
Lt. Col. S. B. Lucy	Quartermaster Corps
Lt. Col. W. E. Plummer	Signal Corps
Maj. O. O. Kenworthy	Chemical Warfare Service

Lt. Col. F. W. Browning was designated as liaison officer for the Transportation Corps with the Task Force. Colonel Pohl, as senior officer, directed the activities of the group.

Formation of Group

The Army organization under the Director of Ship Material began to take final shape on 25 January when Col. John D. Frederick, Inf., assumed his duties as commanding officer, Army Ground Group, though the planning unit was not absorbed until 4 February. Towards the end of February, Admiral Blandy requested a rough draft of the plan for Army Ground Group participation. The head of the Group immediately prepared and submitted the plan, which received Admiral Blandy's approval early in March. The final draft was published on 18 March as Annex N to the Operation Plan.

The Army Ground Group consisted of a headquarters section and six operating units, one for each of the technical services participating in the tests. By 22 March the headquarters section was organized into command, technical, and administrative units. The command unit included the Commanding Officer of the Group, the Executive officer, an Operations officer and their clerical assistants. The technical unit comprised representatives of the technical services involved:

Col. L. P. Jordan	Quartermaster Corps
Lt. Col. S. F. Musselman	Ordnance Department
Lt. Col. S. B. Smith	Corps of Engineers
Major E. K. Walters	Army Air Forces
Capt. H. C. Adams	Chemical Warfare Service
Capt. C. H Wollenberg	Signal Corps

Members of the technical unit were heads of the six operating units of the Army Ground Group. The operating units were composed of groups of inspection teams, each of which was assigned to and embarked in a target ship. The administrative units consisted of an administrative officer, a senior non-commissioned officer, and a staff of enlisted personnel to handle office routine, and other duties as required. The headquarters section of the Army Ground Group was embarked in WHARTON along with other groups under the Director of Ship Material.

Responsibility

The responsibility of the Army Ground Group was to determine the effect of an atomic bomb upon selected items of Army equipment at graduated distances from the burst.[1] The responsibility of the various technical units was to support the Army Ground Group Plan by subjecting equipment to radiological, heat, pressure, and blast effects not contemplated in the original service and engineering specifications, and to inspect and analyze the results. It was considered that exposure of Army equipment on the weather decks of target ships would approximate the exposure in field operations closely enough to have definite value. The Army Ground Group did not itself employ any special instrumentation with the exception of specialized Signal Corps equipment used in conjunction with the Electronics Group.[2] Pertinent data regarding blast, pressure, and

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[1]See Annex N: Army Ground Group Plan.

[2]See Chapter 8: ELECTROMAGNETIC PROPAGATION.

other phenomena would be made available from other agencies participating in the tests. The inspection teams of each operating unit were assigned to target ships carrying equipment under the cognizance of that particular unit. The duty of the commander of each inspection team was to insure the loading, care, exposure, and inspection before and after the test of all items under his charge, and to make a report of the results. The duty of the unit officer representing each of the technical services was to coordinate the activities of all the inspection teams representing his service and to prepare an overall technical report of the results based upon reports of the inspection teams and his own observations.

SUPPORT OF ARMY GROUND GROUP PLAN

Quartermaster Unit

The Quartermaster Corps formally entered Operation Crossroads at the conference of 25 January, called by the New Developments Division, War Department Special Staff, when Lt. Col. Sam G. Lucy was designated as technical unit representative for the corps on the staff of the Director of Ship Material. The primary concern of the Quartermaster Corps was to determine what items of its equipment and supply should be tested and to coordinate planning within the Army and Navy groups. The Quartermaster Corps representative requested that the Operations Section, Military Planning Division, office of Quartermaster General, submit lists of such items for test as were desired by the Sections for Research and Development, Fuels and Lubricants, and Subsistence. With these lists it was possible to work out a program which avoided duplication of effort.

Organizational details were worked out with all interested sections of the Quartermaster Corps. Col. L. P. Jordan was assigned as head of the Quartermaster Unit, which comprised a technical staff and inspection teams.[1]

In the early planning stages, nineteen target vessels at various positions in the target array were tentatively selected for exposure of material. Material was requisitioned from various depots and ordered sent to collecting points near naval shipyards where ships were to be prepared. Layout plans were devised for each of the target ships. Prior to completion of plans, the Director of Ship Material ordered the number of exposure locations reduced from nineteen to eleven, with consequent reduction in personnel and material requirements. By 27 February, all test planning had been completed and personnel were given a final briefing before proceeding to various shipyards to load and secure equipment prior to departure for the

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[1] See Annex N, App. II: Quartermaster Section

target area.

Test lots of over one hundred and fifty standard articles of food and clothing were to be exposed on the weather decks of the following ships:[1]

NEW YORK	CARTERET (APA-70)
ARKANSAS	CORTLAND (APA-75)
NEVADA	FALLON (APA-81)
PENNSYLVANIA	BLADEN (APA-63)
SARATOGA	NIAGARA (APA-87)
PENSACOLA	

The program of the Quartermaster Unit for exposure of fuel and lubricants was of special interest to the Air Unit, the Bureau of Aeronautics Group, and the Bureau of Ships Group. The program was worked out in liaison with these agencies with the Quartermaster Unit responsible for its execution. A specialist in fuel and lubricants was assigned to the Quartermaster Unit to supervise this phase of its work.

In the early planning stages it was desired to test three barrels of various types of gasoline and diesel fuel at each of five graduated locations in the target array, but the Task Force Commander looked with disapproval upon proposals for exposure of even limited quantities of these inflammables because of the fire hazard to target vessels and embarked equipment.

As a result of conferences with the Bureau of Aeronautics Group and the Air Unit, the exposure program was revised, and on 21 March, the Task Force approved the revised program. This final program called for exposure of five lots of fuel and lubricants, one lot each to be placed on the concrete drydock (ARDC-13) and on four LCT's located downwind in the target array at such distances from the drydock as to minimize the possibility that fire could envelop other targets.[2] The effects of radiation were to be investigated by means of racks at each

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[1] See Annex N, App. II, Table 2: Subsistence, Clothing, and Equipment Test Items.

[2] See Annex N, App. II, Table 3: Fuels and Lubricants Test Items.

exposure station with various grades of fuel in test tubes or similar containers protected by different kinds of shielding, such as lead and wax.

Engineer Unit

At the meeting of representatives of the technical services on 25 January, 1946, Colonel H. H. Pohl was designated as technical unit representative for the Corps of Engineers, and he reported on the same day to the Director of Ship Material. Colonel Pohl carried out the early planning of engineer activities until relieved on 2 March by Lt. Col. Sherwood B. Smith, who, as the technical unit representative from the Corps of Engineers, became head of the Engineer Unit.

The Engineer Unit comprised a technical staff, six inspection teams, and an engineer detachment. The technical staff included specialists in the various types of Engineer equipment: mechanical, electrical, bridging, water supply, fire fighting, and surveying.[1]

The urgent requirement of this unit, after reporting to the Director of Ship Material on 25 January, was the selection of the equipment to be included in the tests and coordination of planning with Navy groups. Colonel Trichel had already furnished a list of equipment desired by the Army Ground Forces. Engineer items were discussed with the Engineer Board, the Corps of Engineers' research agency, which made some additions for technical reasons before the original list of forty-eight items was established. In order to avoid duplication, coordination was effected with other technical staff representatives and with the Bureau of Yards and Docks and the Bureau of Ships. It was agreed that the Ordnance Unit would handle all demolition packs and firing devices along with other explosive items. It was similarly agreed that the Quartermaster Unit would handle

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[1] See Annex N, App III: Engineer Section.

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the 3,000-gallon tank, glass fabric, equipment coated with synthetic rubber, and supplies of fuel and lubricants. Tests on fire hose and some fire extinguishers were omitted when it was learned that the Navy planned to expose similar equipment. Plans for exposing a bridge were developed after the Bureau of Yards and Docks stated that it did not plan to expose any construction equipment. One item, generator hydrogen M2, was dropped from the list because it was already known to be insufficiently rugged to stand up under blast. The final list contained nineteen items of Engineer equipment, each one representative of a particular type of an important variation of a type such as a standard diesel tractor, a mine detector set, a floating bridge, a metascope, an odograph, and so on.[1]

When the final list had been agreed upon, the Engineer Unit made arrangements with the Bureau of Ships Group for exposure of the material. It was agreed that items of equipment, both packed and in operating condition, would be exposed on three auxiliaries, GILLIAM (APA-57), DAWSON (APA-79), and BANNER (APA-60). The Engineer item requiring the greatest effort in handling was the M4A2 Bridge, which was to be exposed in two rafts of three bays each, floating in the water. When the target array had been approved, the Director of Ship Material decided that one raft should be tied to the stern mooring buoy of ARKANSAS and the other astern of LST-661. Choppy conditions in the Lagoon influenced the decision that all bridging equipment would be moved to Bikini in an LST, discharged, assembled on a protected beach, and towed to the designated locations.

One officer was sent to Pearl Harbor, arriving there on 3 March, to coordinate movement of equipment to designated ships. The technical staff left San Francisco by air for Pearl Harbor on 15 March. The head of the unit remained with the headquarters section in Washington.

Upon request, the Second Engineer Special Brigade, Camp San Luis Obispo, furnished two officers and forty enlisted men for the engineer detachment, plus ten enlisted specialists for inspection duties. This group, with two officer specialists ob-

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[1]See Annex N, App. III, Table 2: Test Items for Engineer Section

tained from Fort Belvoir, embarked on 23 March from San Francisco for Pearl Harbor aboard USAT FRED AINSWORTH.

Ordnance Unit

Following conferences with the Director of Ship Material on 25 January, the Ordnance representatives organized their requirements for the target exposure into two headings, material and ammunition. Test materials were under cognizance of five staff specialists in tank and automotive equipment, small arms and aircraft armament, ammunition, artillery, and fire control.[1] When Colonel Weber, who had acted for the Ordnance Department in early conferences, was designated executive officer of the Army Ground Group on 11 February, Lt. Col. S. F. Musselman was appointed head of the Ordnance Unit.

Consultation with other Army units and with the Bureau of Ordnance Group and the Bureau of Ships Group resulted in a reduction of the number of items initially planned for exposure, consideration being given both to avoidance of duplication and limitation of space on target ships. The forty-five material items included small arms, light and heavy artillery, fire control directors, range finders, rocket launchers, tanks, and armored cars;[2] and the ninety-nine ammunition items included cartridges, shell, fuses, rockets, flares, bombs, dynamite, grenades, mines, and Bangalore torpedoes.[3] One of each of the material items was assigned to NEVADA, ARKANSAS, PENNSYLVANIA, and SARATOGA, and sets of the ammunition items to LST-52, LST-661, LST-220, LST-545, and YOG-83.[4]

Late February and early March were spent in assembling

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[1] See Annex N, App. IV: Ordnance Section.

[2] See Annex N, App. IV: Table 2: Material Test Items.

[3] See Annex N, App. IV: Table 3: Ammunition Test Items.

[4] See Annex W, App. II: Condition of Ships as to Regular and Special Ammunition Explosives.

personnel, arranging inspection procedure, ordering shipment of test items to various naval shipyards, coordinating shipboard lay-out, and other planning.

The operations officer of the Ordnance Unit proceeded to the West Coast on 25 February to make detailed plans with production officers of the naval shipyards at Bremerton, Hunter's Point, and Terminal Island for loading and securing test items aboard target ships. The material inspection teams arrived at assigned ships during the first week in March. The ammunition and bomb disposal officers arrived at Benicia Arsenal early in March to assist in loading ammunition test items aboard U. S. S. ARTEMIS (AKA-21) at Port Chicago for shipment to Pearl Harbor. The bomb disposal officer and three enlisted men sailed aboard this ship. On 18 March, the ammunition officer proceeded by plane to Pearl Harbor to make detailed transfer loading plans of ammunition and equipment from ARTEMIS to target ships. During the first week in March, the head of the Ordnance Unit and three staff specialists had proceeded by air to the West Coast to supervise and assist in loading of material on target ships.

Supplemental ammunition personnel were transferred from Aberdeen Proving Ground to Pearl Harbor to fill vacancies in the table of organization which could not be filled by the Army's Hawaiian Department.

On 25 March, the head of the Ordnance Unit reported from Terminal Island that loading and securing of all material test items assigned to NEVADA, ARKANSAS, PENNSYLVANIA, and SARATOGA had been completed except for miscellaneous small items and accessories to be taken care of either enroute to or at the target area. After the announcement of test postponement, the chief of the Ordnance Unit returned to Washington early in April to report on overall status of ships on the West Coast.

Signal Unit

The initial Signal Corps contact with Operation Crossroads was made by Lt. Col. N. C. Miller and Lt. Col. W. E. Plummer, Plans and Operations Division, Office of the Chief Signal Officer, on 25 January 1946. After attending conferences and consulting with Task Force personnel, they determined that the Signal Corps had a major interest in the project. The Signal Corps Engineering Laboratories, under the Office of the Chief Signal Officer, were requested to take control of Signal Corps planning and participation.

Col. J. D. O'Connell and Capt. G. K. Green, of SCEL, attended Admiral Solberg's conference on 4 February, and immediately initiated their program. After Captain Green returned to Washington on 6 February as Signal Corps Technical Operations Officer, the selection of target material and electronics projects was begun. Col. W. L. Martin was assigned as SCEL project officer to coordinate procurement of personnel and material and to act as staff officer to the head of the Army Ground Group.

Signal Corps projects in Operation Crossroads fell into two categories, those concerning exposure of target material to the explosion and those concerning the physics of the explosion. The latter projects, carried out under the Electronics Group, included monitoring, radar photography of the target array, radiation studies, telemetering of radiation, and after-effect radio-activity.[1] Captain Green was attached to the Electronics Group, upon request of that group, for scientific work in connection with explosion phenomena, while remaining responsible to the Signal Unit for exposure of target material. Numerous items of communications and electronics equipment for use by the Task Force were supplied by the Signal staff member of the Army Ground Group through the Signal depots and field installations.

The second week in February, nine civilian engineers were assigned from SCEL to serve as consultants and scientific assistants. Shortly thereafter, six Signal Corps officers and eight enlisted specialists from SCEL were assigned to the target vessels and the electronics ship, AVERY ISLAND.

Capt. C. H. Wollenberg became head of the Signal Unit, which comprised a technical staff, an electronics operating group of enlisted men attached to the technical staff, and six

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[1]See Chapter 8: ELECTROMAGNETIC PROPAGATION.

inspection teams.[1] The technical staff, numbering an executive officer and nine civilian engineers, was assigned to the electronics ships AVERY ISLAND, which was to carry the Electronics Group. From this point the activities of the six inspection teams assigned to target ships could be coordinated, while carrying on the technical work in the ship's laboratories.

The Signal Unit planned to expose representative items of field and communication equipment, including telephones, teletypewriters, sound-locating sets, and radio and radio gear, aboard six target ships: PRINZ EUGEN, SARATOGA, NEVADA, INDEPENDENCE, ARKANSAS, and GASCONADE (APA-85), as well as on Bikini Island.[2] Exposure of this material, which involved its installation, testing, and inspection, was to be carried out by personnel of the Signal Unit under the direction of the Electronics Group.

Chemical Unit

The first phases of participation of the Chemical Unit, after the exploratory conferences on 25 January, were carried out by Major O. O. Kenworthy, Chemical Warfare Service, who organized the Chemical Unit and served as its head until relieved on 1 March by Capt. Henry C. Adams. The unit was organized into a technical staff and six inspection teams.[3]

In connection with the operation, the Chemical Warfare Service desired to obtain data, in the form of laboratory analyses, on items of their equipment after exposure to an atomic bomb explosion. It was desired particularly to determine the effect of heat and radiation on the sensitive organic dyes in colored smoke munitions and on toxic agents. Early planning was directed towards selecting types of equipment for exposure, ob-

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[1] See Annex N, App. V: Signal Section.

[2] See Annex N, App. V, Table 2: Test Items.

[3] See Annex N, App. VI: Chemical Section.

taining space on target ships, and organizing personnel for loading and inspection.

In early February, the Chemical Warfare Service, during a conference at the Naval Medical Research Institute, Bethesda, Maryland, offered its services to the Naval Medical Research Section, The head of the group accepted the offer. A veterinary officer and two chemical officers were attached to the Naval Medical Research Section to assist in the testing of the effects of the atomic bomb blast on goats and other animals, and a civilian specialist and a chemical officer from Camp Detrick, Maryland, were also assigned to investigate the effects on simulated bacterial agents. These personnel, while maintaining liaison with the Chemical Warfare Service, were embarked with the Naval Medical Research Section aboard BURLESON.

Towards the end of March, Edgewood Arsenal, in Maryland, and Dugway Proving Ground, Tooele, Utah, furnished personnel to re-staff the laboratory of the 43rd Chemical Company in Hawaii, which was the chemical company providing inspection teams. A representative of the Chemical Warfare Service had already arrived in Hawaii to indoctrinate the inspection teams and assist in loading of target ships there.

The list of Chemical Warfare Service test items had not been completed until 6 March because of differences of opinion over the advisability of exposing chemical agents during the test. On that date, the Director of Ship Material approved the exposure of chemical agents, including distilled mustard gas, nitrogen mustard gas, phosgene, cyanogen chloride, and German agent, provided that they were contained in 105 mm shell bodies. These were then added to the twenty-nine items which had been approved late in February along with allocation of space in six target vessels. The gas shells were sent by air courier to Hawaii in mid-March for loading on the target ships with the other Chemical Warfare Service test items.

The final list of thirty-four items, including protective clothing, colored smoke grenades, gas casualty aid kits, gas masks, incendiary bomb clusters, smoke shells, gas detection equipment, and chemical shells, was chosen to exemplify standard types of equipment and ammunition fillings.[1] The items

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[1] See Annex N, App. VI, Table 2: Test Items.

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were to be exposed on YOG-83, LCT-818, LCT-874, LST-52, LST-661, and [illegible]. In addition, a hundred pound bomb and two four-pound bombs with simulated filling were assigned to NEVADA and INDEPENDENCE. Fifteen sets of air purification equipment were provided for exposure under cognizance of the Naval Medical Research [illegible].[1]

[illegible]

On 18 January, the Army [illegible] submitted a list of test requirements to the Task Force and from this list a program for exposure of material was developed. The Air Technical Service Command, at Wright Field, was assigned to the tasks of collecting test items and inspecting results after the tests. At a staff conference, it was decided to place this program under the Army Ground Group, with Major E. K. Walters, Air Corps, as head of the Air Unit. The head of the Air Unit was also responsible for maintaining liaison with the Deputy Commander for Air of the Task Force, concerned primarily with operational phases of the Operation Crossroads, and with Navy groups and Wright Field.

The Air Unit comprised a technical staff and three inspection teams.[2] The exposure plan called for display of representative items covering a wide range of equipment and material, including wing panels, [illegible] sections, gasoline tanks, gyro instruments, [illegible], [illegible], P-47 fuselages, and crash trucks.[3] The program for [illegible] aviation fuel and lubricants was worked out with the [illegible] Aeronautics Group and assigned to the [illegible]. Further liaison with the Bureau of Aeronautics [illegible] an agreement by which the Air Unit [illegible] conception of a "com-

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[1] See [illegible]: Instrumentation.

[2] See Annex N, [illegible].

[3] See Annex [illegible].

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plete" aircraft, so that duplication might be avoided. The Air Unit agreed that the Bureau of Aeronautics Group's display of target aircraft of naval types would satisfy its own requirements, and that it would display representative aircraft equipment and accessories acceptable to that Group. The Army Air Forces desired to determine the distortion and heat effects of the blast in three zones upon its test items. In addition, information on related equipment was expected from other groups.

The Director of Ship Material, upon request by the Air Unit on 5 February, made deck space available on NEVADA, NEW YORK, and INDEPENDENCE for display of the test items. Inspection teams were assigned to each of these ships.

TEST OPERATIONS

Preliminary Inspections

Personnel and activities of the Army Ground Group were transferred progressively from Washington to the West Coast and thence to Hawaii during April. All officers of the technical staff with the exception of the heads of the Ordnance, Air, and Signal Corps Units reported at Pearl Harbor and began the work of inspecting test items on the target ships and of coordinating the activities of the inspection teams. Colonel Jordan, head of the Quartermaster Unit, was in overall command of Army personnel there. The Commanding Officer of the Army Ground Group, Colonel Frederick, inspected test items on target ships at Terminal Island and Mare Island during the first week in April, after which he returned to headquarters in Washington to participate in further planning. The Administrative Unit moved the office files and equipment and set up headquarters on WHARTON on 20 April. In the week prior to departure of WHARTON for Pearl Harbor, the heads of the three units mentioned above visited Terminal Island to inspect test items under their cognizance on the ships there. With the arrival of Colonel Frederick and Colonel Weber and the return of the three Unit heads on 2 May, the headquarters section was reestablished in full on WHARTON.

Final Preparations

While at Pearl Harbor, officers of the technical staff revisited the target ships to check the condition of all equipment and to brief the ship inspection teams on their activities during the pre-test period at Bikini. Although preparations for the tests were well advanced, a survey of the equipment, after arrival at Bikini, indicated that better results would probably be obtained if some items were exposed in locations other than had been assigned on the weather decks of certain target ships.

Arrangements were made for new allocations of space on four auxiliaries, and brackets and pad-eyes for securing the test items were installed on these ships in mid-June. In addition to the final pre-test inspections and the work of photographing its test items, each Unit had special tasks to perform. The Quartermaster Unit, apart from shifting items to the newly assigned spaces, installed four special test racks of pure hydrocarbons and arranged for color photographs of these racks and for a specially fitted lead cube for measuring the radioactivity at the rack installed on ARDC-13. The Engineer Unit unloaded the engineer bridging equipment for two rafts from LST-661, assembled it on the beach, and moved the rafts to their assigned positions in the array. The Signal Corps Unit set up several radio installations and a radio tower on Bikini Island as well as checking and testing special installations in SARATOGA and INDEPENDENCE. After arrival on 15 June of BURLESON, which brought the specialists for handling biological warfare agents, the Chemical Unit arranged the displays of special BW bombs on four target ships in addition to those included in the six chemical warfare test lots. The Ordnance Unit completed the exposure of all pallets of ammunition items and collected and returned to ARTEMIS all ammunition in excess of that required for display to be used later for control purposes in the laboratory tests of exposed ammunition. The necessity of protecting certain test lots from possible damage by the fragmentation bomb to be dropped on Queen Day was met either by putting protective covering over the lots or by temporarily stowing them below decks. When this task was performed the Army Ground Group reported to Major General McAuliffe that it was ready for the Queen Day rehearsal.

Test Able Operations

Evacuation and return of Army personnel during the rehearsal was carried out according to schedule and without incident. The subsequent inspections of test displays revealed that only minor damage was inflicted by the fragmentation bomb and that this would not interfere with the operation of any equip-

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ment or reduce the value of the test on Able Day. The only member of the Army Ground Group participating with Initial Boarding Teams in the Able Day operations was assigned as Bomb Disposal Officer to the Team reboarding target ships exhibiting Army ammunition. The Headquarters Section remained in WHARTON and the Army inspection teams in the quarters transports with the crews of the target ships during the operation. These teams re-entered the Lagoon and returned to their respective ships on 2 July with reboarding teams (A) and (B)[1] of the ships' crews. After completing the first visual inspection of test items to garner information for the Gross Damage Report, the officers of the technical staff concentrated upon obtaining photographs and preparing selected specimens of equipment for shipment to laboratories for analysis. Among the items included for shipment were approximately one-half of the aircraft instruments exposed by the Bureau of Aeronautics Group which were to go to Wright Field for study by technicians of the Army Air Force. Lack of lifting facilities necessitated that three heavy items of Ordnance equipment remain on NEVADA until return of that ship to a shipyard. The Group completed its technical inspections on 13 July and immediately began preparation of the Interim Report on the results.

Participation in Second Test

Just prior to Test Able, the various technical units had submitted to the Chiefs of the Technical Services recommendations as to Army participation in Test Baker. When the decision of the Joint Chiefs of Staff, to whom this had been referred, was received in favor of such participation, the Group adopted a plan of operations and, following the technical inspections after Test Able, made preparations for the second test. It was decided that the conditions of an amphibious landing would be simulated with test items exposed on Bikini Island, on beached

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[1]See Annex X: Reboarding and Inspection Plan.

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landing craft, and on landing craft anchored at the edge of the target array. Carrying out the adopted plan, the Quartermaster Unit established a fuels and lubricants dump and supply point and a general quartermaster stores dump and supply point at selected sites on Bikini Island. Three general quartermaster test lots were put aboard LST-125 and three fuels and lubricants lots, together with two test lots of invasion pipe and two lots of coal, were displayed in the supply points on the Island. A collapsible 1000-gallon tank was removed from CORTLAND and landed on the island as part of the fuel dump. The Engineer Unit loaded several items of heavy equipment for display on LST-545 and assembled another raft of bridging which was tied, astern of ARDC-13 after William Day. The Ordnance Unit, displaying its items in a manner to simulate support of a landing operation, placed numerous vehicles and artillery pieces in locations on LCT-812 and LST-125 and items of other types, including ammunition, on LST-545 and LCT-1113. A complete landing communication network installation was set up by the Signal Corps Unit. Since the Air and Chemical Units were not to participate in Test Baker, personnel of these Units, except the two Unit heads who remained as technical advisers, were released from the Group for return to their permanent stations. Inspection teams of the four Units engaged in Test Baker were not attached to individual target ships as for the first test, and certain personnel of these teams were also released and others combined into new teams.

Test Baker Operations

Preparations for the second test were about ninety percent complete by William Day and the Army Group participated in full in the rehearsal. Movements from target ships and encampments on Bikini Island and return proceeded according to schedule. Preparation of display of Army test items on Bikini Island and in beached landing craft were completed and photographed on 23 July when Major General McAuliffe inspected the entire exposure. No Army personnel were assigned to Initial Boarding Teams for the underwater test, and as in Test Able, the Group was dispersed in WHARTON and various quarters transports. Because of the persistent radioactivity in the areas in which Army test items were displayed, no inspections were possible until 30 July when Colonel Weber accompanied by four staff officers made a preliminary reconnaissance of the installations on Bikini Island. Detailed inspections of the Quartermaster and Engineer displays and Signal Corps installations began the following day and were completed by 3 August. The inspections of Ordnance equipment in beached landing craft were delayed slightly but were progressed rapidly after inspection teams were encamped on Bikini Island. These inspections supplied the data submitted in the Gross Damage Report on 5 August. Examination of Army items on all target ships except NEVADA was complete and items of equipment selected for return to laboratories from the island displays and landing craft were ready for shipment by 10 August. It had been planned to haul the bridging raft onto the beach at Enyu Island for disassembly and shipment, However, the radiological monitors expressed the opinion that data to be derived from study of the bridging did not justify the radiological hazards involved, and the rafts were towed to sea and sunk. Personnel of the Army Ground Group were released for return to Hawaii and the United States on available transportation as inspections were completed. Colonel Frederick departed from Bikini by air on 9 August with Colonel Jordan who remained in Hawaii for one week to supervise and coordinate the analysis of Quartermaster test items shipped to Hawaiian depots. Headquarters of the Group on WHARTON was closed on 11 August when Colonel Weber left Bikini by air and the remainder of the Headquarters staff sailed from Bikini aboard KENNETH WHITING on 14 August. That same day, the Headquarters office was re-opened by Colonel Weber in the Bureau of Ships where the Group was to prepare its final reports.

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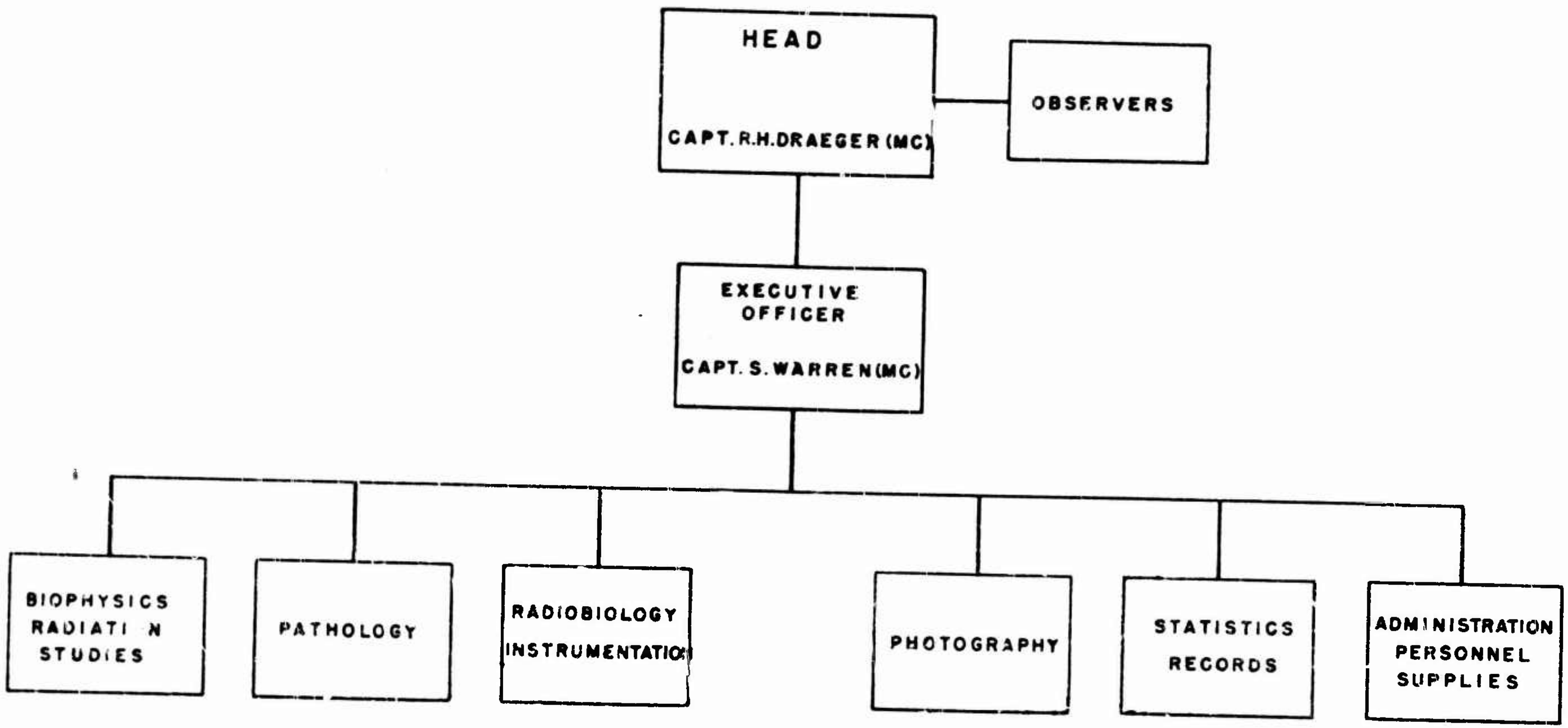
CHAPTER 7

NAVAL MEDICAL RESEARCH SECTION

NAVAL MEDICAL RESEARCH SECTION (OI4-M2)



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NAVAL MEDICAL RESEARCH SECTION

Exploratory Discussions

The Medical Section of the U. S. Naval Technical Mission to Japan spent the last three months of 1945 there, along with representatives of the Manhattan District and the Army Medical Corps, investigating the atomic bomb explosions at Nagasaki and Hiroshima. Personnel of this section were drawn upon when, in early January, the Naval Medical Research Institute began discussions of its participation in Operation Crossroads. Since many victims of the atomic bombs in Japan were not recognized as victims until late in the course of disease, it became apparent that means of early and accurate diagnosis must be developed and made familiar to medical officers. Operation Crossroads offered controlled conditions such as were not available in Japan, where scientific investigations were made a considerable time after the explosions, and without an accurate knowledge of the conditions existing at the time.

In the early stages of planning it was obvious that the Bureau of Medicine and Surgery representative to the Task Force, Capt. G. M. Lyon (MC), must be responsible not only for the safety of personnel engaged in the operation, but also for a program of scientific investigation of the biologic effects of the atomic bomb. It was as a result of this dual responsibility that first the Naval Medical Research Section and later the Damage Control Safety Section, both with quite dissimilar responsibilities and tasks, developed under the Safety Adviser of the Task Force, who also functioned as head of the Medical Group.

Formation of Section

The Naval Medical Research Section grew out of a confer-

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ence called in early January by the medical officer-in-command of the Naval Medical Research Institute, Bethesda, Md. Capt. R. H. Draeger (MC), became head of the Section, which was to function under the Director of Ship Material as part of the Medical Group, with Capt. S. Warren (MC), as executive officer. As plans developed, the Section called in personnel from Army and civilian sources to assist in its work, which soon embraced not only pathology, but special projects with the National Institute of Health, the Department of Agriculture, the National Cancer Institute, the U. S. Geological Survey, the U. S. Public Health Service, and university medical and scientific groups. Army personnel included representatives from the Chemical Warfare Service, Medical Corps, and Veterinary Corps. The Section was embarked on BURLESON, which had been fitted out as an animal transport.[1]

Responsibility

Even following studies in Japan and other scientific investigations, the status of knowledge concerning the effects of an atomic bomb explosion upon animate material was not such as to allow prediction of these effects from physical measurements alone. The responsibility of this Section was to determine the probable effects of an atomic bomb explosion upon naval personnel and medical equipment under various conditions. The reason for the position of this Section under the Director of Ship Material is obvious when one considers that serious injury to a ship's crew might make ship damage irrelevant.

It was planned to expose living animals and a wide variety of biologic material to the bomb effects aboard target vessels at various distances from the burst, and to correlate the biologic effects with the physical findings supplied by instrumentation. Studies of the results were to be continued at the Naval

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[1]See Chapter 2: PREPARATION OF NON-TARGET SHIPS: Instrumentation Ships.

Medical Research Institute after the experiment.

The Section was responsible for support of the Reboarding and Inspection Plan of the operation by detailed planning of its own activities.[1]

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[1] See Annex X, App. III: Bureau of Medicine and Surgery Inspection.

PLAN OF MATERIAL EXPOSURE

General Considerations

The Naval Medical Research Section planned to expose its test material at representative stations, ranging from weather decks to engine room, on twenty-two target vessels in various parts of the target array, so that practically every type of exposure and protection might be studied. The test material comprised animals, sera, hormones, vitamins, bacteria, seeds, insects, medical and dental supplies, and special displays. The Bureau of Ships Group converted BURLESON for use of the Section as an animal and laboratory ship, providing animal pens, feed bins, autopsy rooms, personnel accommodations, and space for the pathology, hematology, radiobiology, and biochemistry laboratories. This ship, as headquarters of the Section, retained a certain percentage of the test material for comparison with what was exposed to the burst.

Instrumentation

An important aspect of the work of the Naval Medical Research Section was to make an accurate correlation of experimental biological findings with physical data. This aspect of its work involved a detailed study of the injuries produced by the transmission of energy through air, water, and solid material, as well as by radiation, which remains a topic of prime importance. The liberation of ionizing radiation by the bomb burst is peculiar to the atomic bomb; its thermal radiations are far more intense than those of an ordinary bomb. The fact that the ionizing energy of an atomic bomb includes gamma rays and neutrons required study of the various biologic effects of radiation. The ionizing radiation may produce profound alteration in cells and organisms with regard only to their immediate characteristics, so that it becomes necessary to make a detailed determination of these effects in practically every type of living organism.

The correlation of experimental findings with physical data required the use of instrumentation in connection with exposure of test material. At every station where animals and other test material were exposed, a wide variety of measuring devices were installed to record time and intensity factors of heat, air pressure, wind velocity, surface acceleration, and intensity of ultra-violet, neutrons and gamma rays, so that an interpretation of the factors producing injury could be made. The instrumentation included Sonne cameras, R. meters, air pressure gauges, Geiger counters, photographic gamma-ray detectors, ultra-violet recorders, and thermal measuring instruments.

Representatives of the Army Chemical Warfare Services planned to test fifteen of their air purification equipments, collective protectors designed to filter out harmful substances from the air, by exposing rats to filtered and unfiltered air. The success of the work of the Section was dependent to a large degree upon a complete pattern of physical measurements at each biologic test station.

Animals

The Naval Medical Research Section planned to use 200 pigs, 200 goats, and 4,000 rats in its exposure program. Human beings, of course, would have been more satisfactory than animals, and as a matter of fact ninety-odd persons volunteered by letter before the first shot, including a "lifer" at San Quentin Penitentiary, with a wife and two children on the outside, and another man who insisted that his name not be used lest the public think him crazy. The purpose in using animals, despite numerous protests from anti-vivisectionists, was to provide a satisfactory substitute for personnel, with the expectation that the use of these animals would reveal information applicable to the protection and treatment of human beings who may be exposed to the various effects of atomic bombs.

Goats, pigs and rats were selected as experimental animals for the atomic bomb tests for both scientific and practical reasons. These species vary in their physiologic response to ionizing radiations and provide therefore a wide range of pathologic changes. In addition they are hardy animals able to withstand tropical conditions and survive unattended on target ships which could not be reboarded for hours or perhaps days. Since these species have been studied in scientific experiments in many laboratories, a large body of data is available for comparison. Results obtained on them with regard to changes in white blood cells and other constituents, as well as effects on internal organs, may be transferred with the aid of known factors to indicate the probable effects on human beings.

It has long been known that radiation of various kinds produces profound effects upon cancer. The National Cancer Institute provided 120 mice of high and low predilection to cancer for exposure in the tests. It was planned to follow these strains of mice, some of which nearly always develop cancer, others rarely, to see to what extent the development of cancer in them was affected by exposure to atomic bombs. Cornell University provided special neurotic goats.

Insects, Bacteria, and Other Test Material

The plan to expose grain insects developed from the knowledge of their genetic character permitting large numbers of generations to be obtained for studies in heredity. These were provided by the Department of Agriculture. A geneticist of the University of Rochester arranged for a special type of fruit fly, drosophila, with a well-documented genetic history of many years, to be flown to Bikini, exposed to the burst, and flown back, as this fly will not survive in the tropics. These flies did not arrive.

The Army Biological Warfare Division provided biological warfare agent simulants, living bacteria sealed in eighty aluminum cases, to determine what mutations might occur due to radiation exposure. It was thought possible that the intensity and character of radiation from atomic bombs might produce alterations in bacteria that would render harmful bacteria harmless and would make the dangerous properties more pronounced in others.

The Department of Agriculture, which is interested in bacteria as a component in providing nitrogen to soils, planned to follow changes produced in nitrofying bacteria, with studies of soil samples taken from Bikini Island before and after th bursts. Because of conflicting information on the effects of an atomic bomb on soil fertility, the Department of Agriculture also furnished samples of three types of soil for exposure, Caribou loam from Maine, Decatur clay loam from Georgia, and Houston black clay from Texas, from which test seeds were to be grown after return of the samples following the tests. The Department provided a large number of seeds and insects for exposure, as well as various vaccines and sera; with a special representative to supervise their tests.

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OPERATIONAL PROCEDURE

Embarkation and Departure

All animals and other test samples were placed aboard BURLESON in San Francisco during the month of May. Accommodations for the animals, their loading, and installation of laboratory equipment on the ships was under the immediate supervision of Lt. S. H. Seal, (MC). Navy men with previous experience in animal husbandry had been screened from available personnel and assigned to BURLESON to assist in caring for the animals. Humane treatment to insure healthy specimens of animals for the tests was stressed. The animals, obtained from all parts of the United States were dipped, vaccinated, and treated for parasites prior to being hoisted aboard in special loading cages. Once on board, the pigs and goats were placed in wooden pens and the rats were housed in cages placed on racks. Especially prepared foods had been procured and more than eighty tons of hay and grain were stored on board for the goats and pigs. During the last week in May, members of the Research Staff, who had been stationed in various parts of the country for several months while making arrangements for the experiments, joined Captain Draeger on BURLESON. The entire Group departed on 1 June and arrived at Bikini on 12 June making a direct run to reduce the sea-time for the test animals.

Test Able Operations

Upon arrival at Bikini, the Medical Research Staff readied the animals for the tests and arranged for their placement on board the target ships. It was desired to maintain the animals in their normal living conditions on BURLESON until just before the test when Service Division 11 would assist in rapid distribution of the animals to their assigned locations. During the interval prior to placement of the test specimens, the Group numbered and took a blood count on each animal to be exposed to the air burst. The numbers, assigned each animal for its medical history, were placed on the animal by tagging the goats and pigs and notching the ears of the rats and guinea pigs. The blood counts were a part of the comparative studies of each animal before and after the tests which would give the best indication of radiation effects.

Animals placed aboard twenty-two of the target ships for the first test included 176 goats, 147 pigs, 3030 rats, 58 guinea pigs, and 109 mice. The animal locations were chosen to provide information as to the effects of distance from the center of the explosion, the dispersal of radioactive material by the wind, and the protection afforded in various parts of the ships. All locations were those normally occupied by personnel, in both below and above deck stations, and in both open and sheltered spots. Specific experiments were performed with certain animals to test the protection of various types anti-flash creams against flash burns. Other test specimens including medical and dental supplies, bacteria, insects, seed, cloth swatches, and chemical packets were exposed in selected locations where instrumentation was available.

Members of the Naval Medical Research Section did not engage in initial reboarding and clearance operations but remained on BURLESON during the test and prepared for rapid recovery of the test specimens after re-entry. As soon as authorized after the Test Able burst, teams of the section commenced collection of the animals and samples. No difficulties were encountered in this task and the Section reported recovery of all animals and samples complete on 4 July. Approximately 90% of the test animals were recovered alive. Of the remaining 10%, the Section established that some had been killed by secondary blast injuries and others by ship sinkings. The recovered animals and test samples were placed immediately in the laboratories on BURLESON for continuous study and analysis. The rapid collection of the animals permitted the Section to outline the resultant effects of radiation in the Gross Damage Report submitted 5 July which was supplemented by confirming data in the Interim Report[1] of 28 July.

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[1]See Enclosure (E) DSM ltr. Serial 00441 of 4 August 1946: Interim Report for Test Able.

Test Baker Operations

Since members of the Research Section did not participate in technical inspections of the target ships, their principal tasks between tests were studying the recovered animals and test objects and readying animals for the second test. In order to determine the probable effects of a shallow underwater bomb explosion upon personnel aboard ships, the Section decided to place animals on four target ships for Test Baker. The choice of target ships was limited by the number of animals available, by considerations of animal recovery, and by the type of injuries anticipated. The animals placed aboard four auxiliaries included 20 pigs and 200 rats, exposed so as to provide information regarding injury from solid blast and radiation from radioactive contamination of the ships. Instruments and other test specimens were placed on five additional auxiliaries, two battleships, and one carrier. When the animals were stationed on the target ships on Baker Day minus one, the Section photographed each target location and installed an adequate supply of food and water at each station to provide for the animals during the anticipated period of delay in reboarding.

Difficulties encountered in clearance of ships following the Test Baker blast prevented early recovery of the animals and test specimens. Part of the animals were recovered on 28 July and the remainder were collected by 30 July. Slightly over 60% of the animals were recovered alive although a number, including all pigs, died within the first two weeks after recovery. After all test specimens had been collected and a preliminary report submitted to the Director of Ship Material, the Naval Medical Research Section departed in BURLESON for the United States on 5 August. BURLESON was routed via San Pedro to Washington, D. C., where on 23 September approximately 2500 of the original 5000 animals and the other test samples used in the experiments were delivered to the Naval Medical Research Institute at Bethesda, Maryland, for further laboratory study.

CHAPTER 8

ELECTRONICS GROUP

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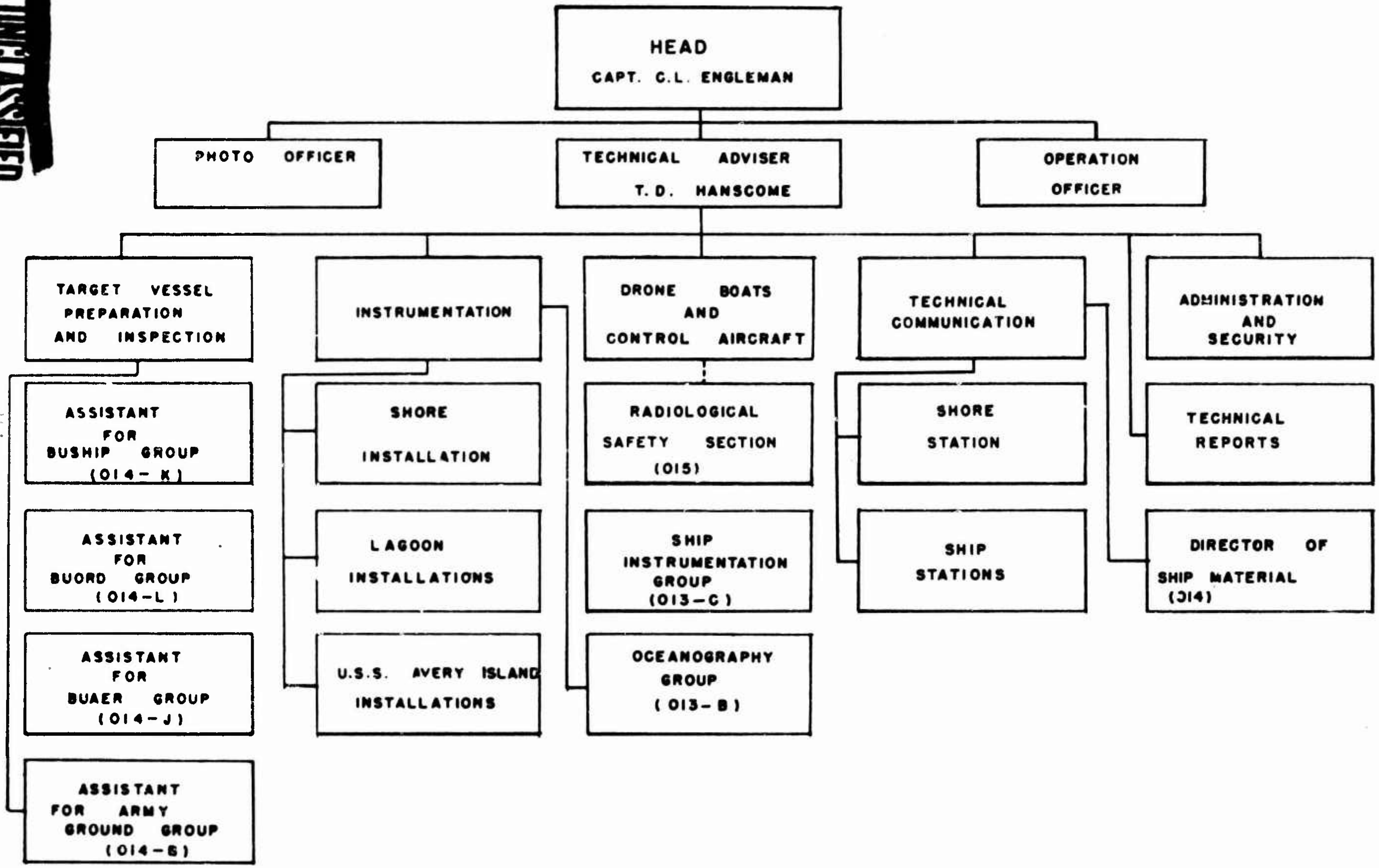
ELECTRONICS GROUP (013-D)



ELECTRONICS GROUP

Formation of Group

The Electronics Group originated on 21 January when Capt. C.L. Engleman reported for duty as the Electronics Coordinating Officer on the Technical Staff of the Task Force. Personnel for the Group were drawn initially from sections of the Bureau of Ships concerned with electronics, and from field activities of the Bureau, such as the Electronics Field Service Group of the Naval Research Laboratory. Later, the Group drew upon its commercial field engineers. As the plans for exposing materials on target ships grew in scope, the Bureau of Aeronautics and the Army Ground Groups furnished personnel for coordinating their work in ship preparation and inspection with regard, respectively, to airborne and Signal Corps equipment. The Bureau of Ordnance attached officers to the Electronics Group in connection with plans for fire-control radar equipment. The undertaking of additional instrumentation projects made it necessary for the Group to draw personnel from many commercial, academic, and military agencies. One officer of the Group, Comdr. F.X Foster, was assigned as Special Assistant in Communications for the Director of Ship Material early in February, when it became apparent that special problems in communications would present themselves. The Director of Ship Material had AVERY ISLAND prepared with the necessary laboratories and facilities for use as an electronics ship, and the Group was embarked in this ship. After arrival at Bikini, COASTERS HARBOR was designated as electronics repair ship for the target and instrumentation sections.[1]

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[1] See Chapter 2: PREPARATION OF NON-TARGET SHIPS: Instrumentation Ships.

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Responsibility

The initial responsibility of the Electronics Group, while in its formative stages, was to effect plans for the preparation and inspection of shipborne electronics material, under the normal cognizance of the Bureau of Ships and Bureau of Ordnance, to be exposed aboard the target ships. This responsibility was soon expanded to include electronics equipment of the Bureau of Aeronautics and the Signal Corps, with the Electronics Group taking in personnel from the Bureau of Aeronautics Group and the Army Ground Group. The functions of the Group were further increased in late February as a result of a conference of the Technical Staff on electronics attended by the Director of Ship Material and the Electronics Coordinating Officer. At this meeting, representatives of the instrumentation Groups and the Los Alamos Group, while agreeing to the necessity of electronics equipment as an essential part of the instrumentation, expressed doubt as to the feasibility and available equipment within their organizations. The Director of Ship Material, supported by the head of the Electronics Group, volunteered to take over full responsibility for execution of the electronics instrumentation projects, as well as for providing services for other instrumentation projects which would be required in the tests. Accordingly, the Electronics Group became responsible for the electronics projects in the Instrumentation Plan[1] and the Communication and Electronic Plan.[2] It was largely responsible for carrying out the studies of electromagnetic propagation projected in the Instrumentation Plan, and it provided services in connection with measurements of wave motion, blast pressure, shock and of other phenomena. It offered support to the Safety Plan[3] in connection with its work

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[1] See Annex G: Instrumentation Plan. (Conf./Secret)

[2] See Annex C: Communication and Electronic Plan.

[3] See Annex E: Safety Plan.

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on drone boats and on telemetering data from Geiger Counters located on target ships. Contingent with the assumption of responsibility for practically all electronics instrumentation projects except those retained by the Los Alamos Group for the timing signals and bomb detonation, the Electronics Group became one of the instrumentation groups accountable to the Technical Director. The Group continued to maintain close relationship with and certain responsibilities to the Director of Ship Material, particularly with regard to exposure of target materials.

SHIP PREPARATION AND INSPECTION

Preliminary

The major task of the Electronics Group was execution of the program for preparation of electronics equipment for exposure on target ships and inspection of damage. In general, the exposure program involved all the normal complement of electronics equipment aboard the combatant target ships, with the equipment in operative condition. The Group coordinated the exposure of all types of electronics equipment, shipborne, airborne, and Signal Corps, but was directly responsible only for shipborne equipment under the normal cognizance of the Bureau of Ships and the Bureau of Ordnance. Preparation of the airborne equipment on target ships was made by the Bureau of Aeronautics Group, and the Army Ground Group effected the work of exposing Signal Corps equipment. The overall inspection requirements were outlined at a conference with the Bureau of Ships Group on 25 January, when the policy was adopted that inspection of electronics equipment aboard the target vessels would be made primarily by the ships' crews, with personnel from the staff of the Electronics Group to make special inspections, as necessary, to develop special information. The Electronics Group undertook to formulate general and detailed inspection plans for training ships' crews as well as members of the Group.

Personnel

The preparation of general inspection instructions and forms for use by ships' crews was completed in tentative form on 1 February and was in final form and approved by 14 February. The instructions and forms were incorporated in the Director of Ship Material's "Blue Book".[1] One officer,

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[1]See "Instructions to Target Vessels for Tests and Observations by Ships' Force". (BuShips)

Comdr. W. W. Hawes, after reporting for duty on 23 January, was placed in charge of ship preparation and inspection. On 1 February, the Electronics Group requested the Electronics Field Service Group of the Naval Research Laboratory to assist in the ship preparation and inspection project by the assignment of qualified personnel to the Group. By 1 March, twenty-two officers of this agency had reported for duty, and ten were assigned to specific target ships to coordinate ship preparation, while the others remained on the staff to assist in inspection plans.

Equipment in Operation During Tests

The program of the Electronics Group required that electronics equipment in certain target ships be in operation during the tests, not only for study of the effects of the explosions on the equipment themselves, but also as a means of carrying out some of the scientific investigations projected in the Instrumentation Plan. It had been decided, with reference to the types of equipment installed, that PENNSYLVANIA, PENSACOLA, WAINWRIGHT, RALPH TALBOT and PARCHE were to have operating equipment. By early February, when the Group had determined which equipments were to be in actual operation on these target ships, a power survey was undertaken to permit immediate rectification of any deficiency in power available to operate the specified equipments. The target ships were notified by dispatch of the power requirements, and Commander Hawes made personal visits to survey the condition of the equipment to be put into operation and the state of available power supply. This work was completed by 1 March.

Preparing Electronics Equipment

With respect to other target vessels, the Group sent dispatches before the middle of February outlining the requirements for preparing electronics equipment. In general, this involved bringing the ships' electronics equipment to as near full complement as possible and placing all such equipment in full operating condition. On 7 March, a list of test equipment to be used by inspection parties and staff personnel was drawn up, comprising several hundred items, and procurement was initiated to obtain this equipment for loading on AVERY ISLAND.

Airborne Electronics

The program for exposure of airborne electronics equipment and inspection of damage was carried out under the Electronics Group by liaison personnel from the Bureau of Aeronautics Group. On 1 February, Lt. E. V. Sizer was designated as Bureau of Aeronautics liaison officer for airborne electronics equipment, and he undertook the organization and execution of the airborne program, drawing upon personnel of the Airborne Coordinating Group of the Naval Research Laboratory. By the end of March, plans for this program had been completed with procurement of test equipment, auxiliary power sources, and spare parts. The program called for exposure of various types of airborne electronics equipment in the aircraft which the Bureau of Aeronautics Group had mounted on various target vessels.[1] These were standard installations normal to operating aircraft, such as radio transmitters and receivers, homing equipment, direction finders, range receivers, interphones, altimeters, frequency meters, and various kinds of radar equipment, all numbering about four hundred items. The MHF radio equipment included the ARC/ART and GF/RU types. The VHF radios were of the ARC type. The radar equipment was the airborne search radar APS-4 and the night fighter radar APS-6.

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[1]See Chapter 5: SHIP PREPARATION PLAN: Target Aircraft.

Inspection Plans

Early in March, sections were organized for inspection of Bureau of Ships and Bureau of Ordnance equipment. By the middle of April, an overall inspection plan defining the functions of the different activities involved was incorporated into the Inspection and Reboarding Plan.[1] Following postponement of the tests, the Group realized that additional trained personnel would be required for special inspection duties in order to fulfill the assigned tasks, and accordingly, negotiated a contract with the Raytheon Corporation, late in April, to supply eight field engineers for inspection duties and staff planning. These personnel reported prior to the sailing of AVERY ISLAND on 6 May.

After AVERY ISLAND arrived at Pearl Harbor on 14 May, a series of intensive inspection was begun on the target ships available in that port to determine the general state of preparedness of the electronics equipment. These vessels, numbering over forty, included the major combatant types as well as many destroyers, transports and submarines. After arrival at Bikini, personnel from AVERY ISLAND contined to make preliminary inspections on the target ships which had not been available at Pearl Harbor. Inspection and surveillance of equipment continued up until the time of evacuation for Test Able. Comdr. J. E. Rice arrived at Bikini on 14 June to assume duties as Electronics Inspection officer. During the pre-test period, equipments were maintained and kept in operable condition by the various ships' forces with the assistance for minor repairs from personnel of COASTERS HARBOR.

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[1]See Annex X, App. IX: Electronics Inspection Plan.

TECHNICAL COMMUNICATIONS

Preliminary

The Electronics Group provided the technical communications facilities required in the Communication and Electronic Plan.[1] The three phases of this elaborate installation, which in magnitude was comparable to that required in the wartime amphibious assault forces, involved communications for the Commander of the Task Force, the Director of Ship Material, and special projects. These tasks were carried out by Comdr. F. X. Foster, who, while a member of the Electronics Group, was Special Assistant for Communication to the Director of Ship Material. The principal objective was to supplement the normal communications facilities of ships in the Task Force with the many additional facilities required because of the nature of Operation Crossroads. During February, key groups of the staff determined their communication requirements and shipments of special equipment began. The major features of the communication project are outlined briefly below.

Task Force Flagship

The flagship of the Task Force, MOUNT MCKINLEY, which carried Vice Admiral Blandy, was the control center for all the activities in Operation Crossroads, especially communications. The ship was initially equipped with radioteletype equipment (RA TT), but two additional frequency-shift keyers were added, with elaborate secrecy equipment, to carry the heavy communications traffic. A complete soundproof broadcasting booth was installed, with high-quality connection lines from the flying bridge to radio central, and two

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[1]See Annex C: Communication and Electronic Plan.

TBM transmitters were modified for use of a complete set of radio-photo equipment. One television transmitter and two television receivers were installed.

Director of Ship Material Ship

A completely new radio room was provided on WHARTON, which carried the Director of Ship Material and his groups. Five TCS transmitters, two SCR-608 equipments, two 50-UFS transmitter-receivers, and one MQ-1 were installed, the latter two types being frequency-modulated transceivers which provide short-range communications with a high degree of radio security. New communication and coding rooms were built, and ten receivers, comprising eight RAO, one RBS, and one RCH, were installed. A TBK transmitter was modified for frequency-shift keying and installed with radio-teletype equipment, as well as one Type 15 and one Type 19 teletype with secrecy equipment. A TCK transmitter for the high-frequency conference circuit, duplex operation, was provided. Two television receivers with four remote viewers were installed.

Instrumentation Ships

The Technical Director, embarked in KENNETH WHITING, was provided with a conference network for his instrumentation groups by means of high-speed radio-teletype installations on KENNETH WHITING, ALBEMARLE, CUMBERLAND SOUND, and SHANGRI-LA, which carried the drone aircraft. The TBK transmitters on these vessels were modified for frequency-shift keying, and the associated RATT converters were installed with secrecy equipment. In addition, KENNETH WHITING received an installation of 50-UFS equipment. A completely new radio room was installed on AVERY ISLAND, which carried the Electronics Group. Five transmitters, one TCK and one TCS type, two SCR-608 equipments, and one 50-UFS, were installed, as well as five RAO receivers. Television installations comprised one transmitter and two receivers with six remote viewers.

Press and Observer Ships

The press ship, APPALACHIAN, was provided with the most modern types of broadcasting equipment. An elaborate central, and remote-control lines were piped in from the flying bridge to radio central for use by commentators on the bridge. Ten type ART-13 portable transmitters were procured for use in boats and at shore installations to provide live programs from remote locations. Two TCC transmitters were obtained from de-activated air fields in California and installed on the ship for high-quality broadcasts, and fifty crystals of various frequencies were ground for operation of these transmitters. Five transmitters of the TBK and TBA types were modified for frequency-shift keying in connection with radio-teletype to provide for the high-speed transmission of news stories to the mainland. A TBK transmitter was modified for frequency-shift keying to provide for radio-photo transmission. Two Navy television receivers, of a type developed during the war for use on drone aircraft, six remote viewers, and one monitoring television transmitter were installed for use of the press. For the observers and additional press representatives embarked on PANAMINT and BLUE RIDGE, one television transmitter and two receivers were installed on each of the ships, and arrangements were made for high-quality broadcasting.

Communications for Director of Ship Material

The Bureau and Army Groups carrying out the work of the Director of Ship Material required a network of communications among the target ships, both before and after the tests, to facilitate the work of ship preparation and inspection, which was controlled by the Director of Ship Material from WHAR-

TON. Installations of either SCR-608 or SCR-610 were made on all target ships, providing a communication network, with WHARTON as the control point. Since target ships would be without power during the tests and the period of reboarding, it was necessary to install gasoline-driven motor-generator sets and battery stocks for emergency use. Sixty additional motor-generator sets were held in reserve for issuance to target ships losing power as a result of the blast. The small fuel tanks of the motor-generator sets were replaced by fifty-gallon gasoline drums. Two hundred storage batteries and accompanying charging circuits were carried on AVERY ISLAND. SCR-608 equipments were also installed on Bikini, Aomoen, and Enyu Islands. WHARTON and AVERY ISLAND carried emergency communication equipment comprising fifty Pogo Sticks, fifty Walkie-Talkies, and 100 Handie-Talkies, transceiver types SCR-511, SCR-300, and SCR-536, respectively.

Special Communication Projects

Twenty-five Walkie-Talkies were delivered to KENNETH WHITING for use of the wave measuring parties of the Oceanography Group. Technical personnel and radio-photo equipment were supplied MOUNT MCKINLEY and APPALACHIAN for press work. One special project was devised for receiving the bombardier's talk on his bombing run for the information of test parties aboard KENNETH WHITING. Other projects called for providing communication facilities to special groups, such as radio equipment on the twenty-five LCPL's used for radiological safety reconnaissance. Another special project of interest called for the operation of the TBL transmitters, voice modulated, on the target ships PENNSYLVANIA, RHIND, PENSACOLA, and ANDERSON, with microphones mounted on deck to furnish pick-up facilities for broadcasting the sound of the bomb explosion.

ELECTROMAGNETIC PROPAGATION

Preliminary

The numerous studies of electromagnetic propagation which comprised an important part of the Instrumentation Plan,[1] were coordinated by the Electronics Group. These studies involved the use of many types of Army and Navy electronics equipment, as well as numerous related devices located in the target array, aboard observation ships, in the Marshall Islands, in Hawaii, in the United States, and in other widely distributed areas. In addition to standard airborne and shipborne electronics equipment of the Navy and Signal Corps, special equipments were developed to satisfy the technical requirements of Operation Crossroads.

Propagation in Target Area

Following one of the early conferences on 7January, representatives of the Naval Research Laboratory proposed measurements, over a wide range of frequencies, of both the possible changes in propagation of electromagnetic waves near the atomic explosion and the reflectivity of the explosion area by means of radar. This program of measurements was integrated with the basic plan of the Electronic Group for the exposure of electronics equipment of target ships. It was agreed

[1] See Annex G: Instrumentation Plan. (Conf./Secret)

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that operating equipment should be monitored at some distance from the explosion for a study of the effect of the explosion on operating efficiency during the shot and for a period thereafter, and that transmission studies should be a secondary objective of this monitoring project. In addition, plans called for obtaining a radar plot of the positions of target ships during and after the bursts, with the radar installation providing information, which would permit reflectivity studies as a secondary objective. The Naval Research Laboratory undertook responsibility for execution of two projects, one to comprise the monitoring of electronics equipment on target ships, the other comprising the radar plot, with transmission and reflectivity studies as secondary objectives.

Monitoring the Equipment on Target Vessels

The original plans specified that one of each of the standard naval fire-control and search radars would be in operation aboard a target ship and monitored with intercept receivers aboard AVERY ISLAND. Various other groups and activities, when apprised of this project, required additonal monitoring channels to furnish information from a variety of devices in the target area, and at one time more than fifty additional channels had been requested of the Electronics Group. Shortages of personnel and equipment resulted in a drastic reduction in satisfying these requirements. The Electronics Group finally provided for monitoring of fifteen separate radio and radar equipments in operation on five target ships, PENNSYLVANIA, PENSACOLA, WAINWRIGHT, RALPH TALBOT, and PARCHE, ranging from battleship to submarine. The equipments included four communications transmitters, set at various frequencies, two types of fire-control radar, a fighter-director radar, four surface-search radars, three air-search radars, one periscope search radar, and three IFF sets, with the radar equipments representing the X, S, and P bands. Standard equipment was used for monitoring, with recording by means of motion pictures and Esterline-Angus chart recorders. Personnel from the Naval Research Laboratory commenced installation of the

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monitoring equipment on AVERY ISLAND in late February. As of her sailing date from San Francisco, 6 May, all monitoring channels were installed and substantially complete from antennas to recording instruments. During the pre-test electronic rehearsals at Bikini, difficulties were experienced from weak signals from the transmitter equipment aboard target ships and interference from other radar and IFF equipment in the Task Force. Changes were effected several days before Able Day which overcame these difficulties.

Radar Plotting of Target Array

The original plan for obtaining a radar plot of the target array, with studies of reflectivity from the explosion area, called for installation of airborne radar equipment in a PBM-5 seaplane. The Technical Staff rejected this plan because of overcrowding of airway channels. It was decided then to install radar equipments on Aomoen Island for unattended operation during the explosions, with automatic photographing of the screens by motion-picture cameras. Four types of radar sets were specified:

One MPG-1 (X-band) Coastal Gunfire Control
Two APQ-7 (X-band) High Definition Airborne Bombing
One APS-2F (S-band) Airborne Search
One APS-34 (K-band) Airborne Search

The signals from the equipments installed on Aomoen Island were directed toward the explosion area, giving a photographic record of the radar plot of the target area. The transmission characteristics of the explosion area were studied by monitoring the signals passing through the blast with the intercept receivers on AVERY ISLAND. These modified radar receivers were fitted with Esterline-Angus chart recorders to show the flucuations in signal level and continuous-film cameras to show deflections. Advance parties left Washington in March and April to install the APS-2F and APS-34 equipments at Bikini Atoll. The installation of the MPG-1 and APQ-7 radars was under cognizance of the Signal Corps and was installed on Aomoen late in May. Installation of radar receiving equipment on AVERY ISLAND was carried on concurrently with that of the monitoring equipment. Monitoring receivers, timing equipment, and recording cameras operated satisfactorily during the electronic rehearsal held 18 June but heavy interference ruined recordings on S-band transmitters during the Queen Day rehearsal. This trouble was mitigated in advance of Able Day.

Reflectivity Measurements

Signal Corps representatives in the Electronics Group were in charge of three projects to observe radar reflections from the column of ionized gas at near and great distances. The first two involved distances of tens and hundreds of miles. On 15 March, the representatives from the Signal Corps Engineering Laboratories proposed that the light, height-finding radar, type AN/TPS-10, called "L'l Abner", be installed on on of the target ships near the blast, where, pointed toward the burst, it could sweep in elevation. When limitations of time and equipment proved this scheme impractical, it was decided to employ the standard Navy radars, surface search (SG) and fighter director (SP), aboard the observer ship PANAMINT. Later, when it was found that these radars could not be made available, the ship's SK radar was used for measuring the specific reflectivity of the ionized gases at S-band frequencies. A 35-mm camera was installed for photographing the A-type indicator of this radar trained on the explosion.

Supplementing this project, another project called for the measurement of the radar reflections at a distance of several hundred miles. Preliminary investigation showed a frequency of about 100 megacycles to be most suitable at such a distance, and it was accordingly planned to use an air-search radar, SCR-270 or SCR-271; but this plan was abandoned when it was learned that neither of these sets was available at Kwajalein and Eniwetok. However, a long-range early-warning radar, AN-TPS-1B, was available at both places, and plans were made to use this set, which operates in the L band, at Kwaja-

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lein. Modifications of the set were made to permit reception at two hundred miles, and arrangements were made for photographing the A-type indicators.

Remote Monitoring of Radio Transmissions

The Electronics Group was able to use normal Navy radio facilities at various places for monitoring transmissions from target ships, so that long-range emissions might be observed to supplement observations at the scene. Instructions were dispatched to Radio Honolulu, San Francisco, Balboa, Guam, Manila, and Adak for monitoring signals from the TBL transmitters operating on PENNSYLVANIA, PENSACOLA, and PARCHE during the explosion. The transmitters were keyed with the letters "a", "b", and "c", followed by a long dash, until twenty-four hours before the first test, when all keys and relays were tied down to obtain a continuous tone. Special arrangements were made for notifying the stations of the approximate time of the tests.

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Infra-Red Measurements

In the middle of April, the Evans Signal Laboratory also proposed that infra-red measurements would be of value. It was suggested that a study of the infra-red emissions from the blast should yield interesting data on the energy level of the blast. The installations of the infra-red equipment comprised a high-speed photo-thermal detector, with filters to pass energy between near and far infra-red, and still cameras to record the indications on the oscilloscope. The detector, filter, and optical attenuator were calibrated against the sun as a standard source. The equipment was set up on the forward gun platform of AVERY ISLAND.

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BLAST, PRESSURE, AND SHOCK MEASUREMENTS

Preliminary

The Electronics Group undertook two tasks in connection with measurements of blast, pressure, and shock, which comprised an important section of the Instrumentation Plan. The first of these, involving a record of pressure waves in air and water, was carried out by means of sonobuoys in a program that presented no unusual technical problems. But the second task, requiring telemetering of pressure data from target ships not likely to survive, called for the rapid development of an elaborate instrumentation program in a relatively new field, an experimental program which could not guarantee positive results. This program enlisted the services of many technical and commerical agencies to deal with numerous problems, and it is described at some length.

Sonobuoys

The sonobuoy project was undertaken in February after members of the Electronics Group had conferred with Dr. E. Klein and other scientists at the Naval Research Laboratory who were interested in this means of providing a record of the pressure waves in air and water. The Naval Research Laboratory provided technical personnel to carry out the project. Twenty type JM-3 sonobuoys, of the type used for harbor protection, were anchored in the Lagoon in pairs, ten pairs being strung out in a line radially from the center of the target array. Beginning at 900 feet from center, the pairs were located at 300-foot intervals to a maximum distance of 3,600 feet. One buoy of each pair was installed in the normal manner, with the hydrophone, a pressure-sensitive element, used to record sonic pressures produced under the surface. The other buoy used the same type hydrophone mounted in air to record pressures above the surface.

Sonobuoy Recorders

The buoys contained the usual frequency-modulated transmitter, and the twenty receivers, one for each buoy, were located on Aomoen Island at a distance of about eight miles from the center of the target array. The receivers were connected individually to twenty recording elements in a thirty-element recording oscillograph, so that a record would be provided of the time the pressure wave reached each sonobuoy as well as the approximate value of the pressure intensity at each hydrophone. From this record, the progress of the pressure wave as a function of time, distance, and intensity could be reconstructed. The two recorders were of a type designed and built by the Gulf Refining Company for seismological studies, with two timing standards, a synchronous motor and a 1C -cycle tuning fork. The recorders were started optionally by either a Black Box[1] or a photoelectric device operated by the flash of the explosion. Installation of receiving and recording equipment was completed on Aomoen Island on 10 June. Because of the heat and humidity which caused the paper tape in the recorders to swell, and air conditioner for the receiving hut was included in the installation. Moorings for the buoys were laid on 12 June and all buoys were planted within the following week. Several frequency checks were made on all buoy transmitters and the island receivers prior to the Queen Day rehearsal, at which time satisfactory recordings from all twenty sonobuoys were taken.

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[1]The "Black Box" was a secret starting device developed by the Los Alamos group. A number of the devices were used throughout the target array for remote-controlled starting of various instruments. Because of the highly secret nature of the device, each was installed and maintained by members of the Los Alamos Group.

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Telemetering

The fact that some of the target vessels favorably located for collecting scientific data were unlikely to survive indicated the need for a means of recording this valuable data at a safe distance. Collection and recording of data from such locations could be accomplished by telemetering which in general is an electronic system providing transmission of data from a measuring station to a remote receiving and recording station. More elaborately, a telemetering system consists of an input device whose function is to convert the phenomena to be measured into an electrical signal, an electronic amplifier to raise the input signal to a level high enough to modulate a frequency-modulated signal, and a distant receiver with suitable recording equipment.

The Ships Instrumentation Group was confronted with the particular problem of measuring the pressure-time relation of the air blast in Test Able at eighteen points on two auxiliaries at different positions in the target array, and the pressure-time relation of the underwater shock wave in Test Baker. In January, this group recognized the need for telemetering in working out a solution to this problem, and it soon became evident that the project should come under the Electronics Group. On 15 February, the Electronics Group took active charge of a project for telemetering the data from the pressure gauges and recording it at a remote point.

Contacting Research Agencies

During the week of 18 February, the Electronics Group contacted several research agencies, commercial, military, and academic, which were known to have engineers working on telemetering systems. Several of these, including Princeton University, Cornell Aeronautical Laboratories, Westinghouse Research Laboratories, and the Naval Ordnance Test Station at Inyokern, California, were able to supply technical liaison and personnel. Westinghouse representatives, after discussion of the problem in the Bureau of Ships, decided that the required instrumentation could be assembled and installed within the time available. These representatives accompanied Dr. Hanscome of the Electronics Group on a visit to the Navy Air Experimental Station, Philadelphia, to inspect telemetering equipment then under consideration; and it was decided that an air pressure gauge of the Stratham type should be furnished the Station so that the functioning of its telemetering system with this gauge could be determined, even though the system was not adaptable to water shock measurements.

On 22 February, representatives of the various research agencies conferred in Washington with the Electronics Group and the Ships Instrumentation Group. A number of decisions were reached. The existing telemetering systems of the Navy Air Experimental Station, the National Defense Research Council (Princeton), and the Cornell Aeronautical Laboratory apparently could be adapted for the air blast measurements of Test Able, but a new system must be developed for Test Baker, as no existing system was suitable for measurement of the water shock wave. Telemetering equipment and technical personnel should be transferred from various agencies to the Westinghouse Laboratories in Pittsburgh, where the new system would be devised. Detailed plans were deferred until a later meeting in Pittsburgh.

Telemetering Plans

On 26 February, at a conference in Pittsburgh, the various technical representatives brought their preliminary plans to bear upon the specific problems of Tests Able and Baker. Decisions were made relative to frequencies, radiation power, antenna design, and other general matters. For Test Able, it was decided, after a canvas of the three available telemetering systems, to install one NDRC eighteen-channel system on each of the two APA's, using two frequency channels, with two NDRC receivers and recording systems on AVERY ISLAND. For Test Baker, six independent transmitting and receiving systems would be used, each operating on one of the six frequency channels. Westinghouse agreed to supply the transmitters and power amplifiers, and Cornell undertook to modify NAES receivers for use. Westinghouse was to develop the input system for the piezo-electric crystals supplied by the Ships Instrumentation Group for its gauges. Because of the limited time available, it was decided that both Westinghouse and Cornell should work on recorders for Test Baker to insure that a suitable recorder would be on hand.

Telemetering Installations

By the middle of May, all preparations for installation of the transmitting equipment aboard APA-57, APA-64, APA-65, and APA-87 were completed and the antennas were installed. Towards the last of April, it was decided to install one channel of Test Baker equipment aboard APA-65, as there were two spares, so that this equipment could be tested in the first explosion under actual conditions of operation. The telemetering system required thirty-six independent frequency channels for Test Able and six for Test Baker. Installations were made in two APA's for Test Able. One NDRC system, Type I Model B, using eighteen channels, was installed in the nearer target vessel, where it was expected to be lost or damaged beyond repair. One NDRC system, using eighteen channels, was installed in the farther target vessel, and was expected to survive. For Test Baker, six NAES systems, modified to handle one broad-band channel each, were installed, two channels for the nearer target vessel and four for the farther one, used in connection with the piezo-electric hydrophones for measurement of underwater shock wave.

Television

Early in February, after the Oceanography Group had requested the use of television for measuring wave heights, the Electronics Group organized a television project. The initial project was intended for remote observation of wave formations only, with receiving equipment installed in an aircraft and the image recorded by motion pictures.[1] When this project was well underway, it became evident that the television cameras also would provide a means of observing at other remote stations the general area of the explosion. Accordingly another project was set up to provide receivers for observation on MOUNT MCKINLEY, WHARTON, APPALACHIAN, AVERY ISLAND, BLUE RIDGE, and PANAMINT.

Television Installations

For wave measurement, two television cameras and transmitters were installed on Bikini Island on towers seventy-five feet high. The two transmitters, separated by about four miles, were fitted with nineteen inch and twenty-four inch telephoto lenses to cover a field of view about five miles wide at the center of the target array, under the explosion in Test Able. Wave height was indicated on two calibrated poles set in the water in the field of the television cameras. The television equipment was of standard Navy design: two frequency channels were assigned to the transmitters.

Successful wave measurement by means of television required a direct line-of-sight between the transmitters on Bikini Island and receivers. This condition was obtained by

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[1]See Chapter 11: WAVE MEASUREMENT: Photogrammetry Installations.

installing the television receivers in two PBM-5 seaplanes, which also carried automatic recording 35-mm cameras. In this way it was possible to obtain a photographic record of the wave heights on the calibrated poles pictured in the field of the television cameras.

Each of the observing ships previously mentioned was fitted with two receivers, one for each of the two channels, and four monitor repeaters for each receiver, providing ten viewing positions in all. AVERY ISLAND was also fitted with an additional transmitter and receiver on the bridge for testing the installations on the other ships. Under the direction of Lt. O. K. Bell, who was assigned as project officer, the television equipment was procured, shipped to Bikini, and installed on the island by 1 June. After the initial tests of the equipment at Bikini, modification was made to relay the transmissions received in the two PBM planes to the observer ships to increase signal strength. As a means for protecting the iconoscopes of the television transmitters on Bikini from the intense light of the initial flash of the explosion, another modification provided a device on each camera, which placed a neutral density filter in front of the camera lens a few seconds before and removed it a few seconds after the blast through the operation of timing signals. A Hobart automatic processing camera was installed on AVERY ISLAND to record the still pictures of the television receivers at one-second intervals and to project these pictures continuously thirty seconds after exposure.

Sonobuoys and Fathometers

Two sonobuoys, operating on suitable frequencies, were installed in Bikini Lagoon for the use of the Oceanography Group in its wave measurements. Twenty-five portable fathometers were provided in the same program, some of them being mounted in the Lagoon on buoys, the others on target ships. Provisions were made for auxiliary power for the fathometers normally carried on target vessels, so that these could also be used by the Oceanography Group.

Timing Signals

Several projects were set up to assist the Los Alamos Group in providing the timing signals required for the tests. Approximately 600 crystals and installation kits were obtained for modifying RBB receivers to crystal control. Remote control timing devices were procured and installed on CUMBERLAND SOUND. Six TBM-10 transmitters were installed on the same ship as a source for the radio timing signals of the Los Alamos Group. The Electronics Group furnished technical personnel as well as material in carrying out these projects.

Navigational Radar Beacons

Three projects were undertaken for homing the B-29 plane carrying the atomic bomb. One X-band racon, type AN/CPN-6, was installed on Erik Island to provide radar beacon facilities for practice runs of the B-29 before the actual drop. One of the same type beacons, with auxiliary power facilities, was installed on NEVADA, the target ship, to home the plane on its bombing run in Test Able. Additional navigational aids were provided by the installation of two YR non-directional racons, one on Enyu Island, the other on Erik Island. These installations were completed in April and the beacons were operated daily for two two-hour periods from 10 May through Able Day.

Telemetering for Geiger Counters

On 15 April, upon request from the Radiological Safety Section, a project was initiated to provide telemetering of the indications from the Geiger counters installed on target ships in significant parts of the target array. The purpose of these measurements was to determine the time at which the radioactivity dropped to a level low enough to permit reboarding of target ships. The radio transmitter for the telemetering had to be capable of unattended operation for from nine to twelve hours. Investigation revealed that the Signal Corps had a transmitter available, SCR-694, which met these requirements. Accordingly, the Signal Corps representative of the Electronics Group carried out the project. Six of these transmitters, with two units held in reserve, were installed on target vessels, APA-57, APA-64, APA-79, APA-85, APA-86, and LCT 1078, where battery operation could continue for a period of as much as twenty hours. These transmitters were used in connection with ion chamber radiation measuring devices provided by the Los Alamos Group, which were substituted for Geiger counters at inner target positions because of the low saturation level of the latter.

In Test Baker, this program was expanded to include fourteen transmitting positions, using both Geiger counters and ion chambers, with telemetering equipment borrowed from the Sonobuoy Project.

Drone Boat Program

At a conference held early in April, the Technical Director and the Radiological Safety Adviser of the Task Force explained the need for collection of samples of highly radioactive waters in the Lagoon without human aid. It was desired to test samples of water taken within two hours after detonation at a spot within 1500 yards of the center of the contaminated area. Securing of such samples in Test Able was desirable, while in Test Baker it was of vital importance. Since it was considered possible that no personnel would be able to enter the array area for several days after the test, the only means of ascertaining the extent of the radiological hazard was by utilizing some controlled device fitted with Geiger counters and transmitters. At this conference, it was decided to employ drone boats for this purpose,[1] as the Bureau of Ships had developed such boats in the wartime "Stinger" project.

The head of the Electronics Group was requested to supply, install, and maintain electronics equipment in the drone boats; and accordingly, the Group set up a project, on 5 April, to meet these requirements, which involved support of the Drone Boat Plan, drawn up in tentative form on 12 April.[2] The eight LCVP boats must contain radio receiving equipment to feed the signals to the remote control apparatus for slipping the anchor cable, starting and stopping the engine, steering, changing speed, starting and stopping the pump for collection of water samples, and starting the radar beacon. As plans developed, control of the drones was shifted from the TBM aircraft of SHANGRI-LA to the control ship BEGOR (APD-127), which operated auxiliary transmitters, acted as project headquarters, and launched two of the drone boats, while using the TBM aircraft for observation purposes. Four additional drones were launched by EPPING FOREST (LSD-4), with the two remaining drones held in reserve at Kwajalein. The drones carried radio transmitters for telemetering the counting rate of Geiger counters when the boats were guided through the Lagoon to investigate the intensity of the radioactivity in various sectors prior to re-entry.

Installations on Drone Boats

The Electronics Group obtained the services of Comdr. C. C. Busenkell, an officer experienced in drone operations, and assigned him as electronics project officer of the Task Unit (1.1.3), which, under Comdr. R. R. Bradley with headquarters on BEGOR, was to operate the drones. Two civilian engineers were engaged from the Bell Telephone Company to assist Com-

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[1]See Chapter 5: DRONE PROGRAM: Collection of Water Samples

[2]See Annex CC: Drone Boat Plan

mander Busenkell. Installation and testing of the drone equipment got underway towards the end of April at the Naval Shipyard, Terminal Island. On 1 May, the Deputy Task Force Commander for Technical Direction visited Terminal Island and conferred with the head of the Electronics Group, the Task Unit Commander, Task Unit Electronics Adviser, and other interested parties. It was at this conference that, following suggestions from the Electronics Group, the decision was made to shift the control of equipment from TBM aircraft to BEGOR, with conning officers remaining in the aircraft. The Electronics Group supervised tests at Terminal Island to insure that the reduction in the height of the transmitting antennas from the aircraft altitude to the masts of BEGOR, with consequent radio shadows from intervening target ships, would not interfere with operations. The Drone Boats arrived at Bikini the first week in June and their calibration was completed prior to the Queen Day rehearsal. For that rehearsal, two of the boats were released from moorings off Enyu Island and under remote control from BEGOR satisfactorily scanned the Lagoon and collected ten water samples each.

Ship Inspections

The crew of some 100 civilian and military electronics repair and inspection men arrived at Bikini aboard AVERY ISLAND on 1 June. During that month, these men worked in cooperation with target ship crews in inspecting and repairing items of ship electronics gear and in assisting technicians already there with special projects on the islands. Nearly 4,000 major items of electronics equipment were placed in full operating condition on the target ships and were itemized and classified in the ship inspection forms. Members of the Electronics Group did not participate with Initial Boarding Teams in the re-entry after the bombing but formed electronic inspection teams which began visual inspections of equipment after general reboarding had been authorized. A preliminary visual inspection of the numerous electronics items was completed within three days following the first boarding and the information based on this inspection was placed in the hands of the Director of Ship Material five days after the explosion. When this was done, the inspection teams began more thorough and detailed examinations of the equipment, using power to operate and test items where practicable. Part of the Group concentrated on the repair and re-installation of equipment to return as much as possible to operable readiness for the second test.

Performance of Special Projects

Teams working on the special projects also examined equipment on the several islands as soon as possible after reentry. For the most part, the program of special projects in Test Able was conducted as planned, although certain unpredictable events decreased the value of the records.

The television transmitters on Bikini operated well for sixteen hours after starting, establishing a record for continuous unattended television camera operation. Television reception on all observer ships was good and the Hobart camera on AVERY ISLAND produced a complete pictorial record for over two hours commencing shortly before the explosion. A last-minute change in the position of AVERY ISLAND ordered by the Radiological Safety Section made it impossible to monitor radar waves directly through the blast, thus reducing the significance of the transmission studies. Eleven of the fifteen transmitters on target ships produced signal level records which could be monitored on AVERY ISLAND without difficulty. Two Drone Boats patrolled the Lagoon throughout Able Day and collected water samples in various areas.

Special Projects for Test Baker

All items of electronic equipment were prepared and itemized on forms for Test Baker as for the first test. There was a major change, however, in that no electronic equipment was to be in operation on target ships during the underwater test because of possible interference to signals controlling the atomic bomb. This caused cancellation of the projects for monitoring the radar signals from within the target array. The navigational radar beacons on Erik and Enyu Islands were no longer needed and were dismantled, but the beacon on NEVADA was shifted to SARATOGA, and with another low-frequency beacon set up on CRITTENDEN, was used for directional aid for photographic aircraft.

Nearly all other special projects, with some modifications and improvements, were prepared again for the second test. Two sonobuoys with hydrophones were placed on each of four ships, with recording equipment on Aomoen Island, to measure the time of arrival of the blast in air. The two television cameras on towers on Bikini Island were again prepared to provide a general view of the explosion area and to furnish information on wave heights. The same receivers were to be operated on observer ships and in the two photographic aircraft provided with 35-mm cameras. It was decided to again track the target ships' movements with radar during the second test with secondary objectives of measuring the propagation through and the reflection from any ionized cloud formed in the blast. For this project, the seven radars on Aomoen Island were readied with cameras for the indicators and five intercept receivers were prepared on AVERY ISLAND. Water pressure telemetering channels originating at pressure gauges, two on BRACKEN and four on BRISCOE, were prepared for operation. A slightly more elaborate system of telemetering for Geiger counters was set up throughout the array. Two Geiger counters, each modulating a sonobuoy transmitter, were placed on each of three ships, one on the deck and one suspended at 100-foot depth. Similar installations of ion chambers were placed on three other ships. Two Geiger counters with sonobuoys were moored in the array, one at 100-foot depth, 5,000 yards east of the explosion center, the other five miles west of the explosion center. Receivers and recording equipment were on both AVERY ISLAND and HAVEN. Eight Drone Boats were readied for the second test to obtain radioactive water samples for analysis in estimating the efficiency of the bomb. Modifications were made on these boats to prevent recurrence of the failure in engine starting and anchor cable slipping that had occurred in the first test.

Inspections after Test Baker

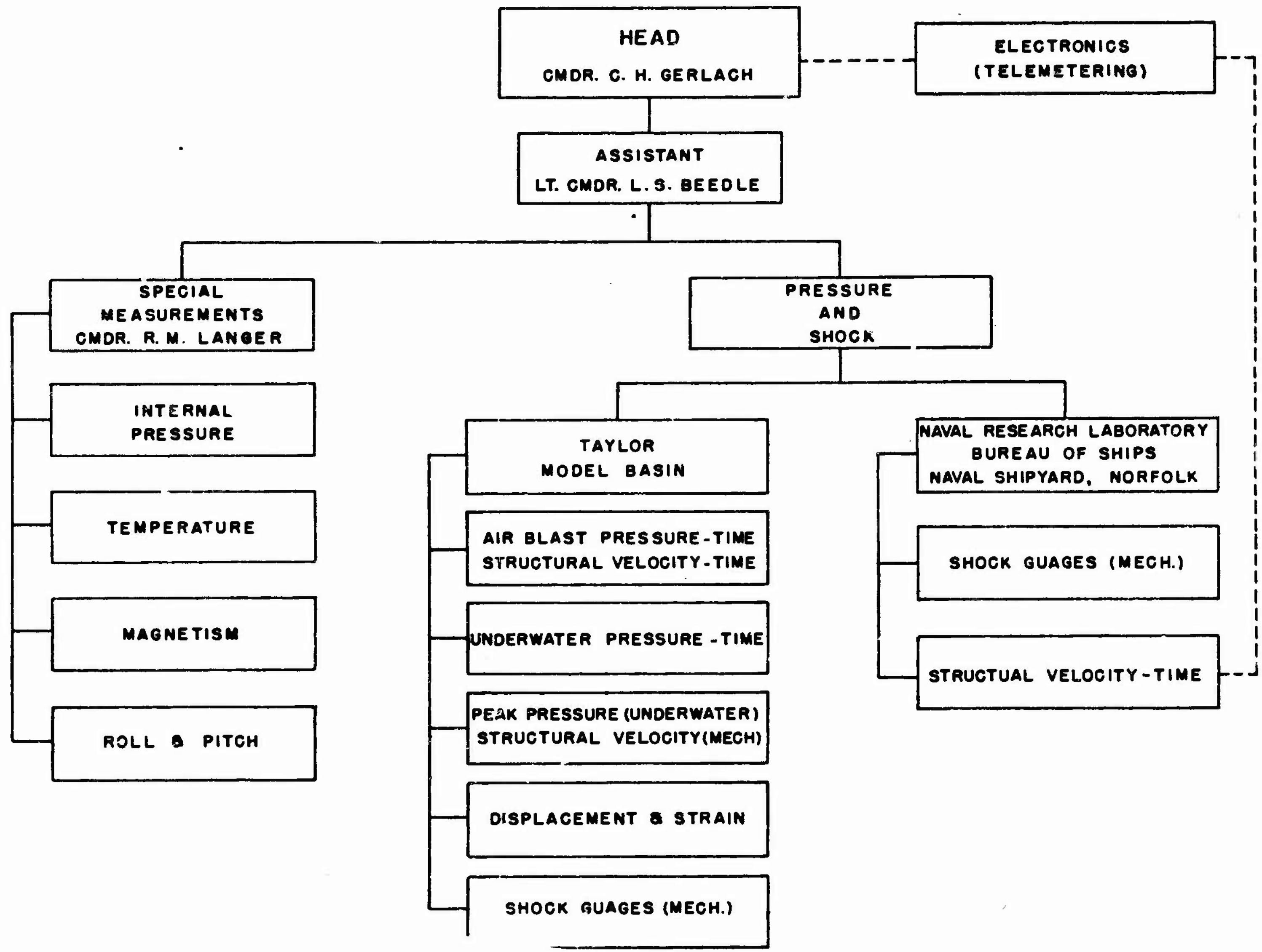
The delay caused by radiological hazards following th underwater burst hampered the speedy recovery of instrument and inspections of equipment. Camera film and tape recor were obtained from the instruments on Aomoen Island oi Baker Day by personnel who landed on the island in helicopter: General inspections on target ships were held up until decontamination processes rendered the ships safe for reboarding. So much of the equipment was radiologically contaminated that the Group decided to concentrate inspections on a few target ships located in advantageous spots which would provide a good overall estimate of results.

As inspections of electronic equipment and special projects were completed, members of the Group were released for return to the United States. Many members of the Group had left following Test Able. When it became apparent that the inspection of target ships was to be prolonged, it was decided to move the target inspection section of the Electronics Group to FULTON and permit return of AVERY ISLAND. This shift was made on 7 August and on the same day AVERY ISLAND departed with a large portion of the electronics technical staff. The head of the Electronics Group departed by air shortly thereafter to re-establish headquarters in the Bureau of Ships. Members remaining at Bikini were embarked in WHARTON under Comdr. J. E. Rice, who, in addition to supervising the completion of the target ship inspections, set up a repair shop for repair and maintenance of the instruments used by the radiological monitors. Inspections of the Electronics Group were finished on 15 August and the section departed on that date. The instrument repair unit with Comdr. W. W. Hawes in charge was transferred to HAVEN which was to remain in Kwajalein while further examination and studies of the contamination problem were conducted.

CHAPTER 9

SHIPS INSTRUMENTATION GROUP

SHIPS INSTRUMENTATION GROUP (013-C)



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SHIPS INSTRUMENTATION GROUP

Exploratory Discussions

Prior to formation of the Ships Instrumentation Group, the Underwater Explosion Research Group of the Bureau of Ships took part in the early discussions of the proposed atomic bomb tests since this Group was normally concerned with the nature of underwater explosions and their effects upon ships. During the exploratory period, the Group was mainly interested in shaping an experimental program which would reveal new information or information not yet satisfactorily proved.

Information on damage to ships involved two phenomena: first, the cut-off of the direct shock wave by an opposite shock wave (rarefaction) which might arrive at the target after reflection from the surface; and second, the cavitations resulting from the initial motions of the target under action of the shock front.

On 7 January, this group conferred with various Navy agencies, as well as with Los Alamos representatives, at a conference sponsered by the Bureau of Ordnance.[1] Vice Admiral Blandy explained that all instrumentation efforts would be correlated under the Technical Director, who was responsible to the Deputy Task Force Commander for Technical Direction. It soon became obvious, as planning developed in later conferences, that work in ships instrumentation would be a joint concern of both the Technical Director and the Director of Ship Material.

At this meeting it was decided that the time schedule would not allow the development and use of new instruments. The primary interest of the Bureau of Ships was in structural response of target vessels and shock phenomena aboard those

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[1] See Chapter 10: ORDNANCE INSTRUMENTATION GROUP: Exploratory Discussions.

vessels as well as a collateral interest in loadings. The Bureau of Ships had support for its interests from the David Taylor Model Basin and the Naval Research Laboratory, both of which were represented at the meeting, and from special experimental agencies of the Norfolk Naval Shipyard and the Bureau itself.

Formation of Group

The Ships Instrumentation Group was organized on 7 January, under direction of the Underwater Explosion Research Group of the Bureau of Ships, with Comdr. C. H. Gerlach as head. The formal organization developed as discussions continued on the specific problems of what measurements to make and how to make them. Two special sections were organized, one concerned with pressure and shock, the other with radiation, internal pressure, magnetism, and roll and pitch. Personnel for the first section were drawn from the Design Branch of the Bureau of Ships. The Physics Section of the Research Branch of the Bureau supplied personnel for the other section, which was under Comdr. R. M. Langer, who was also head of the Ships Technical Photography Section.[1] The necessity of telemetering data during test explosions to a receiving station at a safe distance from the explosions required liaison with the Electronics Group,[2] and an assistant in electronics was appointed early in March. The delay in filling this billet influenced a decision to turn over one group of pressure measurements to the Electronics Group. The Ships Instrumentation Group, less the section under Commander Langer, was embarked in KENNETH WHITING.

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[1]See Chapter 12: SHIPS TECHNICAL PHOTOGRAPHY SECTION: Formation of Section.

[2]See Chapter 8: BLAST, PRESSURE AND SHOCK MEASUREMENT: Telemetering.

Responsibility

The Ships Instrumentation Group was directly involved in support of the Instrumentation Plan,[1] under the Technical Director. The execution of its part in the plan involving installations on target vessels as well as other work in connection with preparation of target vessels, measurements of damage, and damage studies, made this Group responsible also to the Director of Ship Material.

The primary responsibility of the Ships Instrumentation Group was to measure ships response under the shock wave loading to which each was subjected by the explosions. Emphasis was placed on the structural mechanics of loading and response, so that correlation between the two might be investigated. Operation Crossroads involved other problems of interest, such as effects of temperature and radiation, internal pressure, and shock wave velocity, which were also to be investigated. It was not intended to make the instrumentation of the tests a formal study in loading and response, as may be better done in less complicated tests, but to obtain data for a correlation between explosion phenomena and damage, and to establish a basis for correlation between these tests and conventional experimentation with explosives.

Following the conferences in early January and later conferences with Los Alamos representatives, the Ships Instrumentation Group decided against use of photographic recording methods, which were subject to damage, except for the installation of one string oscillograph. This instrument would determine what happened to photosensitive paper and could be checked against alternative means if a readable record were obtained on the paper. It was also decided that no attempt would be made at stress or strain analysis. The conditions of the operations were such that principal reliance had to be placed on mechanical gauges with measurements made on a time basis.

Since structural response is of the same nature in both

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[1] See Annex G: Instrumentation Plan. (Conf./Secret)

air and water explosions, the instrumentation for structural response was to be essentially the same for both tests. But shock wave loadings from air blast and underwater shock wave are of a different nature, so that the loading pattern for the two tests must be different and unrelated; in each case the particular quantities were measured as a function of distance.

In general, measurements of the properties of loading in free field were a responsibility of the Ordnance Instrumentation Group. The Ships Instrumentation Group was interested in measurement of loading in the immediate vicinity of structure and the time properties of the loading.

Measurement Problems

For the air blast in Test Able, it was possible to accomplish loading measurements by concentrating not upon the rise of the pressure to its peak, but rather upon the remainder of the pressure-time curve, as the mechanical gauges of the Ordnance Instrumentation Group were expected to measure the peaks anyway. Mechanical recorders of the pen-and-ink type would provide the necessary frequency response for such measurements. The only gauges available were eight diaphragm blast gauges, handmade and difficult to fabricate, the sensitive element of which consists of a strain wire pick-up. These gauges were divided between two target vessels.

Two solutions were proposed for what seemed a deficiency in pressure-time measurements of the air blast, a deficiency which was a consequence of recording difficulties, especially those stemming from radiation effects.

One solution was the use of submerged tanks. Using water as a protection against radiation effects, measurement could be made close to a point below the explosion by means of gauges and recording equipment in submerged tanks resting on the bottom of the Lagoon. From the measurement of pressure in water it would be possible to calculate the pressure that existed in air. Four such tanks, each employing two gauges, were submerged in the Lagoon.

The other solution, by which the pressure-time curve in the immediate vicinity of the target vessels could be measured, involved telemetering the intelligence to a receiving station on a vessel outside the range of radiation interference.

Telemetering--Air Pressure

The technical problems of installation and operation of the telemetering system were placed under the Electronics Group[1] while the Ships Instrumentation Group remained responsible for the location of the gauges and the records obtained.

After considerable searching, a reasonably satisfactory gauge of commercial manufacture was found which had been used by a section of the National Defense Research Council at Princeton. This gauge is of the diaphragm type with a strain wire sensitive element, though entirely different from the diaphragm blast gauge previously referred to. The telemetering system allowed use of thirty-six of these gauges, equally divided between two target vessels. They were arranged to cover structure of various orientations from the direction of the explosion, with a few of the gauges placed inside the target vessels.

Telemetering was considered especially important for pressure-time measurements of underwater shock in Test Baker because of the more stringent frequency response requirements of gauge and recording equipment, even though no effort would be made to track the rise of pressure to its peak. It was decided that great effort should be made to obtain a frequency response not less than 30-40 kilocycles. Much higher response was desirable, but tests showed the impracticality of trying to operate complicated recording equipment in target vessels by remote control, especially when the equipment would hardly remain stable if left unattended for half a day, as the operation required. Telemetering remained the only practical solution. The records obtainable by telemetering would fall short of the desired requirements, but they would nonetheless provide valuable measurements with creditable resolution.

Pressure Gauges

The gauge used in these underwater measurements is a tourmaline crystal operating by piezo-electric effect. With the

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1 See Chapter 8: BLAST, PRESSURE AND SHOCK MEASUREMENT: Telemetering.

apparatus available, it was possible to install only six gauges, all of them mounted against the sides of target vessels. Four were located on one vessel, two covering different depths on the side facing the explosion, one on the opposite side at one of the two depths, and the fourth located against the bottom. The two gauges installed on a second target vessel were at one of the two depths used in the first ship, one on the side facing the explosion, the other on the opposite side. For Test Baker, it was planned to substitute tourmaline crystals for the strain sensitive diaphragm type in those submerged tanks surviving the first test, and to use magnetic wire recorders instead of pen-and-ink oscillographs. These gauges, employed in free field, would be positioned with reference to the same type gauges mounted on the target vessels. It was considered that the frequency response of this recording would be less than four kilocycles.

The only other pressure gauge for a time record of loading was of piston type, with a frequency response of about fifteen cycles. This guage, the engine indicator type, recorded by means of a stylus on wax paper carried by a motor-driven drum. Two of these gauges were used.

Underwater Shock Wave Measurement

The only remaining gauges used for loading measurement were peak-reading mechanical gauges, entirely concerned with underwater loading. The foil gauges of the Ordnance Instrumentation Group measured the air shock loading. The Ships Instrumentation Group considered that no formal effort could be made in measuring free air shock wave and reflected shock wave properties with gauges mounted on target vessels or on an practical support based upon the vessels. Considering the long wave lengths in air and the complicated orientations of structure possible, the Group felt that such gauges could hardly be mounted outside the influence of reflections, which confuse analysis.

Measurement of underwater shock is less complicated because wave lengths are shorter than in air and reflecting surfaces are more controlled. It was decided to make a limited effort, parallel to the installation of time-recording underwater pressure gauges, with peak-recording mechanical gauges, which have a well-documented history in free field. Accordingly, a number of ball-crusher gauges, identical with those installed in free field by the Ordnance Instrumentation Group, were held against the side of certain target vessels having a side shell of single skin, though this whole installation was considered to be on a somewhat uncertain footing as far as positive results were concerned. These ball-crusher gauges were installed on target vessels over a large range at three depths of submergence, and on near and far side with reference to the explosion. All of them were backed up by gauges similarly placed but slightly removed from the vessels to allow for transit time of the shock wave and response time of the gauge.

Finally, forty Modugno gauges, which have had extensive use, were installed in a manner similar to that of ball-crusher gauges in free field. This is a diaphragm type again in which the depression of the diaphragm correlates with peak pressure.

Summary

The loading instrumentation efforts were largely concentrated on measurements in the vicinity of structure. The use of peak-reading gauges in such measurements was rather severely circumscribed. In Test Able the foil gauges of the Ordnance Instrumentation Group would cover the field as effectively as possible, since it was impractical to separate the direct and reflected shock waves. But in Test Baker, with its underwater shock waves, the physical size of the gauge introduced a serious complication. For gauges and apparatus giving time records, either the radiation or the required high-frequency response presented difficult technical problems; and in this respect the installations were conditioned by limitations of apparatus and technique.

RESPONSE INSTRUMENTATION

Measurement Problems

The Group spent its principal efforts in response instrumentation upon measuring two aspects of the response of target vessels to blast and shock waves; the motion of elements of ship structure and the motion of ship components such as equipment and machinery. The motion of the ship as a body, though adequately covered in the instrumentation, was considered least important from the standpoint of significant damage.

Time measurements of structural response were probably even more important than similar measurements of structural loading. This follows from two outstanding considerations. First, there is not enough information on the behavior of structure under impulsive loading to permit any action to be characterized by a single parameter, except perhaps in the case of simplest structures, more or less idealized. One must look further at the complete picture of loading and response. Second, a somewhat extensive series of tests concerned with non-contact explosions has built up a substantial background of measurements on a time basis, affording the best means for correlating the atomic bomb tests with documented experience with conventional explosives.

Nevertheless, it was decided that mechanical gauges should play a large part. Their use was not beset with the complications surrounding the use of ball-crusher gauges against the skin of the target vessels, and their use was further recommended in view of the hazards involved in the recording apparatus necessary for other types.

Instantaneous Velocity Meters

Instantaneous velocity was the only successful candidate in the selection of measurements to be made on a time basis. There appeared to be no other quantity which could be measured so satisfactorily under the conditions of the tests. In connection with previous underwater explosion work, several types of accelerometers have been used, all with indifferent success. The problem of their use was not considered insoluable, but members of the Group had not had experience with any technique reliable enough to warrant an intensive effort, and it was not entirely clear what to do with an acceleration measurement in attempting to analyze a situation involving complicated structures. The Group was likewise unfamiliar with any of the displacement gauges which could be used. The choice of velocity measurements stemmed in part from the fact that a velocity meter was available which had been successfully used in similar work, as well as from the belief, shared by members of the Group, that velocity would be the most easily treated property of single plates subjected to the underwater shock.

Means of Recording

Since photographic or photo-sensitive recording processes had been ruled out, there arose the problem of what means of recording to use. The pen-and-ink type of oscillograph was obviously unuseable because of its slow frequency response. Attention focused early on the magnetic wire recorder developed during the war for sound recording, but it soon became obvious to the Group, during investigation of this equipment, that it lacked the necessary fidelity and discrimination. Modifications of the magnetic wire recorder with the intention of compensating for the variable permeability of the wire, as well as the low fidelity of the amplifier, were abandoned as impractical.

As this point two alternative recording methods were turned to, and they both offered prospects good enough to warrant their development as the recording systems used. The velocity meters were about equally divided between the two.

One scheme retained the magnetic wire recorder with a frequency modulation system which compensated for the lack of uniform permeability of the wire and which obviated the use of the low-fidelity amplifier. The other scheme involved the use of the "recordograph", an acetate recorder which is also a sound recording device. In this recorder a finely designed stylus system, magnetically operated, embosses a piece of film. An auxiliary carrier, amplitude modulated, was added to this system to enable measurements in the low frequencies.

Location of Velocity Meters

The velocity meters divide themselves into two groups with respect to location. Those of one group were mounted on the hull structure directly subjected to the loading--decks, side shell, and superstructure. The others were located on foundations of vital machinery and control equipment. The installation was arranged to provide substantially duplicate instrumentation on two pairs of vessels at different ranges. Sixty two velocity meters were installed. Those located on the hull structure divided themselves into three transverse belts, one well forward, one about amidships, and one aft; and in each belt, gauges were located at the keel, on the side shell, on the deck, and in some cases on the superstructure. The gauges that were installed on machinery and control equipment do not fall into this sort of grouping. These measurements were supported and extended by a peak-reading mechanical gauge, specially developed for these tests, called the impulsive velocity gauge.

Miscellaneous Shock Gauges

A number of other shock gauges were installed in accordance with the principles governing the installation of velocity meters, and in most cases alongside them. Two types, the multi-frequency reed gauge and three variants of peak accelerometers, were used in quantity. The reed gauge recommended itself, despite the limited history of its use, because it constitutes a system practically equivalent to shock-mounted equipment. The three types of accelerometers--mass plug accelerometers, "putty" gauges, and NDRC accelerometers--have been extensively used, and their history is well known. Pallographs, shock displacement gauges, seismic displacement gauges, and Jacklin accelerometers were installed principally for comparative purposes, though the pallographs and shock displacement gauges were expected to add information on the bodily motion of the target vessels. Groups of strain gauges, distributed in the three belts with the velocity meters, were expected to add information on the integral vibration, or whipping, of target vessels.

A technique was developed for determining the maximum displacement suffered by equipment, especially shock-mounted equipment. Lead strips, abutting on nearby fixed structure were fastened to pieces of equipment in more than a thousand installations, so that measurements of displacement could be made both at particular points and in any plane of the ship.

Summary

Efforts on response instrumentation were related to the problem of response as regards force, time, and distance. This divided itself into two categories, the motion of the ship and its structural components, and the shock damage to machinery and equipment. Measurements on a time basis were made of the velocity acquired by structure and equipment. This group made use of all mechanical gauges of familiar history, and reed gauges and peak accelerometers were used in appreciable numbers.

TEMPERATURE, PRESSURE, AND OTHER INSTRUMENTATION

Preliminary

During the conference in early January, Los Alamos representatives, while explaining major effects of the proposed atomic bomb explosions, gave no information on such matters as temperatures at various stations, pressures and winds in ship compartments, roll and pitch, and possible magnetic effects. It soon became apparent that these were matters of primary concern to the Ships Instrumentation Group. Study of them would assist in analysis of all kinds of damage, such as fires, accidents below decks, hull displacements and so on. The Group decided that additional physical parameters of the target ships should be investigated insofar as conditions permitted. The Physics Section of the Research and Standards Branch of the Bureau of Ships undertook the task as part of the Ships Instrumentation Group.

The program was restricted to measures of severe simplicity, without recourse to scientific and industrial methods, which though satisfactory in ideal conditions, would not meet the realistic conditions of the tests. The time schedule hardly allowed for development of special devices, and it was agreed that such devices were to be avoided in order to complete procurement, construction, and testing within two months.

Temperature

The Group decided that temperatures should be taken of many inert materials by passive methods, requiring no starting or stopping, with emphasis upon broad coverage of the target array rather than high accuracy. The method of meeting these conditions was to expose a great variety of selected materials to direct radiation from the blast, and then to look for significant physical and chemical changes related to temperature, these changes to be analyzed in terms of the radiation load as a function of time, distance from the blast, wave length distribution of the light, and composition of the atmosphere. Late in January, the Group delegated construction of temperature specimens to the Naval Engineering Experiment Station, at Annapolis, Maryland. This agency had already developed special techniques, like temperature-indicating paints, in working on the gas turbine project for the Navy. The program called for installation of test panels, comprising temperature-measuring devices and temperature specimens, on weather decks and in compartments of ten target vessels in each of three areas; namely, within 1,000 yards, 1,000 to 2,000 yards, and over 2,000 yards. A set of test panels was retained for calibration an analysis.

Among the temperature specimens were a variety of glasses (common, plate, pyrex, and quartz) and four color filters for evaluation of thermal and optical transmission. Thermal insulation panels, comprising the four most common insulating materials and lagging, were included for direct exposure to the blast A selection of cotton and wool uniform cloths was expected to provide information in addition to what is already known concerning the effects of heat blast on clothing worn by naval personnel during battle conditions. Panels embracing a variety of polished metals, plated metals, and metal foils were exhibited for evaluation of surface absorption characteristics. Five panels were devoted to paints of different color, consistency, and gloss for light absorption studies.

Temperature-measuring devices had to accompany the temperature specimens. Metal fusion panels of a variety of metals in different wire or rod sizes, for the range from about 700 to 7,000 degrees F., were expected to yield significant data, both on magnitude and duration of temperature. To augment this information, low-temperature vitreous glazes of known fusion temperatures were included for correlation of temperature-duration data. A temper-color panel was made, consisting of thirteen homogeneous polished steel balls ranging from one-eighth to two inches in diameter, mounted on sheet transite. The temperature-indicating panel, consisting of thermidex temperature-indicating paints, fusible pellets, and fusible ceramic cones, was provided for measurements in the range of 311 to 1,472 degrees F. This same panel includes Tempil pellets in the range from 125 to 1,600 degrees F. Seger and Orton cones, also installed on the temperature-indicating panel for the range from 2,200 to 3,600 degrees F., are ceramic materials which fuse completely at rated temperature. The test section also included facilities for studying the change in residual magnetism of metal rods, magnetized to different densities, after exposure to temperature effects of the blast.

In addition to the topside installations, temperature-indicating paints were extensively striped on pre-selected surfaces amidships, in engine rooms, on magazines, in plot rooms, and on miscellaneous instruments. This program, carried out at the request of the Bureau of Ordnance Group, involved hundreds of surfaces on over fifty of the target vessels. About twenty maximum-reading fast-response 200-1,000 degrees F. dial-type thermometers and five thermographs were installed in protective casings and located on certain vessels.

On 15 March, the crated temperature specimens for thirty target vessels were shipped to West Coast shipyards. Meanwhile, the shipyards had constructed racks on target vessels for exposure of the temperature specimens. Stout bulkheads were chosen for outside exposures. Plan had attempted to avoid shadows from obstructions and other equipment, but it was nonetheless expected that a substantial fraction of the test specimens would prove unproductive because of changes in headings of target vessels, violent effects of blast and spray, and unforeseen accidents. However, every surviving specimen would be instructive, especially those in the interior array at distances less than 1,000 yards.

The Group also planned studies of all interesting thermal phenomena on the target vessels themselves. It was planned to remove specimens of thermal effects to laboratories for analysis. There, correlations could be made with photographic and optical observations of change in luminosity of the blast as a function of time, and of spectral distribution of light as shown on the various spectrographs located on nearby islands and distant ships.[1]

Late in March reports from Los Alamos representatives on thermal conditions to be expected became available. These reports would have been of considerable value at an earlier date, both in saving time and in making possible the measurement of other interesting data which had to be set aside for later tests.

Interior Pressures and Winds

The pressure wave described by Los Alamos representatives in conferences of January and February was expected to last a few tenths of a second, with air pressures up to ten pounds per square inch. Such pressures would certainly blow open doors, windows, and hatches on many target vessels, allowing dangerous pressures and winds in passageways and interior compartments, hangar decks and turrets. The Ordnance Instrumentation Group undertook the measurement of free field air pressure which would damage ships' hull and superstructure. Interior pressures were a problem for the Ships Instrumentation Group.

The Group believed that a pressure-time curve in interior compartments would give data not only on the pressures, but also on the winds in passageways to such compartments, and that these winds could be used to estimate air flow through passages. The fact that it is possible to estimate air flow under known pressure differentials indicated that a peak-pressure reading would suffice to give adequate information on all pressure and wind effects in interior compartments. As other measurements would reveal the exterior pressure, it was planned to take only a few pressure-time records, and to round out the information from these by measurements of peak pressure in many interior compartments.

The Group initiated manufacture of the necessary pressure-time recording elements which were calibrated and tested at

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[1] See Chapter 12: PHOTOGRAPHIC ACTIVITIES OF VARIOUS GROUPS: Moving-film Spectrographs.

the David Taylor Model Basin. The pressure-sensitivity element of this device is a modified bellows from an aneroid barometer, with the bellows connected to a stylus which writes on a blackened disc rotated by a clock spring, giving both positive and negative pressure records. Movement was started by the pressure blast itself.

About forty such pressure-time recording elements were assigned to twenty target vessels at various distances from the blast, some for wardrooms or hangar decks, others deep in machinery spaces and in intermediate positions. A few of the target vessels received three or four of the elements.

After conferences in the Bureau of Ships and the Bureau of Standards, the Group designed a new gauge for peak pressure measurements. This gauge, designed for both positive and negative response, consists of a volume of air, in pyrex glass, sealed from the outside by an orifice immersed under a water surface. Tests by the Taylor Model Basin confirmed the calculated sensitivity of these pyrex glass gauges and the expected response time of a few milliseconds.

Three hundred of these gauges were assigned to about twenty-five target vessels for installation in interior compartments of special interest. The final shipment was sent on 23 March, slightly over a month after the contract for their manufacture was let. They required no adjustment beyond resetting between Test Able and Test Baker.

The heat and pressure of the atomic blast in Test Able was expected to leave a great volume, something under 1,000 yards in diameter, as a vacuum which, collapsing in about one second, would produce striking wind effects, with possible some oscillation of pressure. Immediately thereafter the rising ball of fire would cause surface winds of such magnitude and duration as to produce important wave and spray effects.

Attempts were made to obtain a special propeller-type recording anemometer for the measurement of these windage effects, and it was expected that about five of these equipments, modified from a development carried on for the Bureau of Aeronautics, would be completed in time for the first test. This device, which has been tested up to 200 miles per hour, has a response time of less than one second and registers wind magnitude and direction. A special housing was designed to protect it from the shattering effects of the initial shock and winds.

Roll and Pitch

The Group decided to carry on stability investigations for the various types of target vessels. It seemed important to measure listings in the surface winds created in both tests, and this data, when correlated with accurate measurements of waves, would be invaluable in theoretical discussions of the motion of ships, and would be useful also as a check on various kinds of stabilization equipment used in the Navy.

Early in February, plans were made with the Design Branch of the Bureau of Ships for these tests. Gyro equipment and inclinometers were fitted with scribes to record on coated discs driven by clocks. Early in March, the New York Naval Shipyard, which had undertaken the manufacturing program, delivered the completed equipments to designated target ships on the West Coast and at Pearl Harbor, where the equipments, all self-contained and self-activated, were installed on the center-line of target ships near the forward gyro compartment.

All these internal measurements of roll and pitch were to be correlated with external photographic measurements. Long-focus cameras had been mounted ashore to record ship motions, and some of the outlying ships carried motion-picture cameras on their superstructures.[1] It was expected that the whole program would provide the most complete set of data ever obtained on various phases of violent ship motion.

Other Physical Observations

The Ships Instrumentation Group made other measurements

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[1] See Chapter 12: PHOTOGRAPHIC ACTIVITIES OF VARIOUS GROUPS: Ships Instrumentation.

involving ship magnetism, aerology, and shock velocity.

The program for measuring the effect of underwater shock on the permanent magnetism of ships originated in the Research and Standard Branch of the Bureau of Ships, where it was planned in liaison with the Bureau of Ordnance. There were two general objectives. First, determination should be made of the near-miss effect of the atomic bomb on a ship's permanent magnetism. Second, this change in magnetism, if any, should be correlated with changes from other known underwater shocks, so that a rough evaluation of the shock might be made. The Bureau of Ordnance provided portable magnetometers necessary for taking readings, before and after each shot, on nine target ships in various parts of the target array. It was agreed that these readings could be correlated with changes in permanent longitudinal magnetism from previous knowledge of characteristic magnetic signatures.

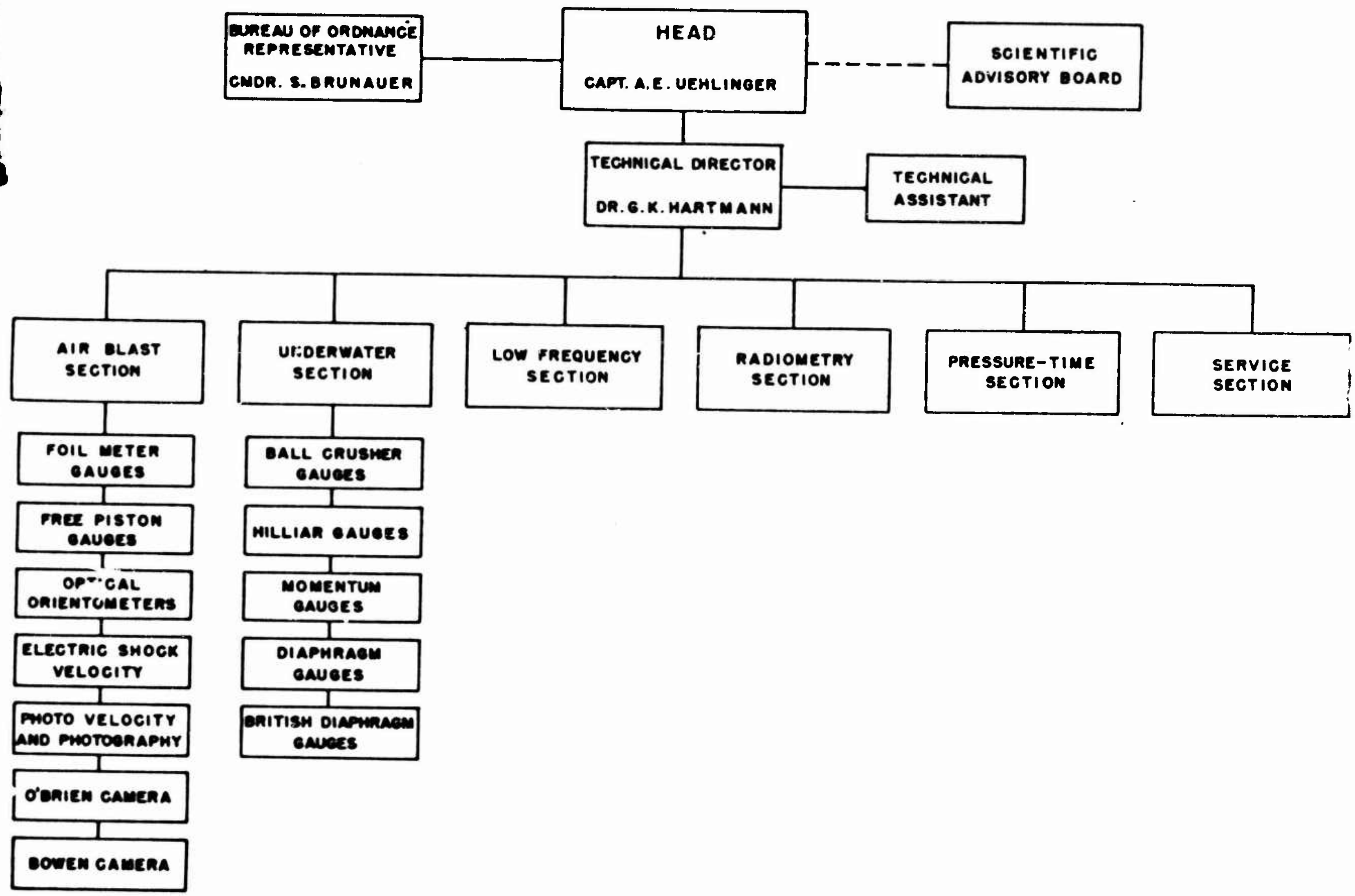
The Research and Standards Branch also proposed that aerological observations at sea level would be of interest in evaluating results of other measurements such as pressure, temperature, and spectrography. The Aerology Section of the Bureau of Aeronautics supplied the necessary number of instruments for this program. Hygrothermographs, barographs, psychrometers, maximum and minimum thermometers, and shelters for recording instruments were located among installations on Bikini, Aomoen, Airukiiji, and Ourakaen Islands, as well as on target ships.

To the numerous photographic measurements of shock velocity, the Ships Instrumentation Group decided late in March to add another device. This consisted of a mirror arranged in the form of a dihedral angle, which would be mounted topside on about fifteen target ships near the blast. This device embodies the well-known optical principle of using a dihedral mirror to produce a definite deflection of a light beam almost independent of the orientation of the dihedral in azimuth. When the light beams from the mirrors to the cameras are intercepted by the shock waves, the lights will flicker, giving the time of arrival of the shock wave at this line of sight; and when the shock wave strikes the mirror itself, the light will go out, and another reading of the time of arrival at the position of the target ship will be obtained. Though this method can give extremely important results with great economy, it is necessary to predict the heading of the ships at the time of the blast within about 30°, and it is also necessary to be lucky with respect to the accuracy of the bomb drop.

CHAPTER 10

ORDNANCE INSTRUMENTATION GROUP

ORDNANCE INSTRUMENTATION GROUP (013-G)



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ORDNANCE INSTRUMENTATION GROUP

Exploratory Discussions

During the fall of 1945, the Bureau of Ordnance explored the possibilities of arranging surface and underwater tests of surplus explosives in large quantities, measured in hundreds of tons, against surplus naval vessels. These plans advanced in conferences until they included details on general considerations such as the probable effects of various explosions, both surface and underwater, and the available instruments for measuring these effects. Comdr. Stephen Brunauer and Dr. G. K. Hartmann, of the Research and Development Division of the Bureau of Ordnance, took leading parts in this early planning.

The Deputy Chief of Naval Operations for Special Weapons who meanwhile had been authorized to start planning the atomic bomb tests, held a conference on 21 December 1945, in which the general plan of the atomic bomb tests was explained. In this conference, Los Alamos representatives helped clarify the duties of the Bureau of Ordnance, and early in January, Commander Brunauer was designated officer-in-charge for the bureau's participation in Operation Crossroads. He appointed various committees for the numerous special tasks anticipated.

The first meeting of the Bureau of Ordnance committees, planned for 7 January, developed into an all-day conference of representatives of various Navy bureaus, Army groups, Los Alamos, Manhattan District, National Defense Research Council, and other agencies. At this meeting, Vice Admiral Blandy, who had just been designated Commander of Joint Task Force One, explained the general plan for the tests. Commander Brunauer presented the general plans of the Bureau of Ordnance and Dr. Hartmann explained its technical tasks.

Formation of Group

The Ordnance Instrumentation Group, with Comdr. Stephen

Brunauer as head, evolved from these exploratory discussions in which the Bureau of Ordnance participated. Towards the last of January, the group assembled most of its personnel, and committees were established for air blast measurements, underwater measurements, low frequency investigations, radiometry and ordnance equipment. At an early stage in the preparations, the ordnance equipment committee was separated from the Instrumentation Group to form the nucleus of the Ordnance Material Group[1] which was placed under the Director of Ship Material with Capt. E. B. Mott in charge.

An overall planning and coordinating committee, with Dr. Hartmann as chairman, supervised the work of the committees of the Instrumentation Group. A scientific advisory board was appointed to advise the committees on scientific problems connected with the tests. Personnel for the Group were drawn from twenty organizations; namely, the Bureau of Ordnance, the Naval Ordnance Laboratory, the Naval Proving Ground, Dahlgren, the Naval Ordnance Test Station, the Naval Powder Factory, the Naval Mine Warfare Test Station, the David Taylor Model Basin, the Naval Research Laboratory, the Aberdeen Proving Ground, the Woods Hole Underwater Explosives Research Laboratory, the University of Washington, the University of Rochester, Princeton University, the Institute for Advanced Study, Duke University, Harvard University, George Washington University, the University of Chicago, Cornell University, and New York University.

The work of the Bureau of Ordnance Instrumentation Group may be divided into three stages: (1) planning, organization and preparation, prior to Bikini operations, (2) field operations at Bikini, and (3) preparations of reports and disposal of equipment after return to Washington. Comdr. Brunauer was head of the group in the first and third stages; Captain A. E. Uehlinger took over during the field operations, with Dr. Hartmann providing technical direction in the field.

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[1] See Chapter 4: BUREAU OF ORDNANCE GROUP.

Responsibility

The Ordnance Instrumentation Group was directly involved in support of the Instrumentation Plan,[1] under the Technical Director, to whom the group was responsible. Originating in the Bureau of Ordnance, it was closely connected with all phases of the Ordnance program, but the exposure of ordnance material was a responsibility of the Bureau of Ordnance Group under the Director of Ship Material. Naturally there was to be a correlation of material damage and instrumentation. The general relationship of this Group with the Ships Instrumentation Group may be illustrated by a logical division of responsibilities, this Group measuring loading free field, the latter Group making measurements of loading only in the immediate vicinity of structure. In a broad sense the two measurements are closely related.

The primary technical responsibility of this Group was to make measurements of the air blast wave and the underwater shock wave. A good deal of this responsibility had been undertaken earlier by the Los Alamos Group, but it gradually shifted responsibility for carrying out the program to the Ordnance Instrumentation Group, which also undertook a program of low-frequency measurements and radiometry.

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[1] See Annex G: Instrumentation Plan. Conf./Secret)

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AIR BLAST INSTRUMENTATION

Measurement Problems

At the first meeting of the Air Blast Committee on 30 January, the chairman, Dr. G.W. Lampson, who had just returned from Los Alamos, discussed the instrumentation experience gained in the Trinity test, with a brief explanation of the use of instruments and the reasons for their failure. The Ordnance Instrumentation Group planned to use many of the same type gauges, both mechanical and electrical, in Operation Crossroads, so that it was necessary to investigate the problems concerned with their correct installation.

The general problem in instrumentation of the air blast in Test Able was to measure the peak pressure as a function of distance and time, both on the surface and in the water. The group planned the use of four types of pressure gauges distributed at appropriate distances to measure the air blast wave as a function of distance. These gauges comprised aluminum foil meters, ball-crusher gauges, scratch recorders, and free piston recording gauges.

Aluminum Foil Meters

The Trinity test had revealed foil meters to be the most reliable gauge used. An aluminum foil meter was designed at Princeton especially for Operation Crossroads. It was planned to use 1,000 of these meters, under the supervision of personnel from Princeton, for measuring maximum pressure at various points in the target array both in free field and inside target ships. These foil meters are sensitive to the direction from which the blast wave comes. For that reason planning called for the mounting of five blast pots at each point of mea-

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surement, one facing the blast, two facing up and down, and two facing right and left. At certain points the meters were placed inside enclosed spaces such as gun turrets and compartments for measurement of interior pressure. Ten of these meters were installed on each of the battleships, carriers, cruisers, and most of the destroyers, as well as on many auxiliaries.

Ball-Crusher Gauges

Of the 1,500 ball-crusher gauges needed for the tests, only 250 were immediately available, and it was decided to arrange for manufacture of the whole lot at the Naval Gun Factory. Certain modifications of the gauge had to be made, and this design work was carried out at Woods Hole, which also undertook to train personnel in the handling of the gauge. The ball-crusher gauges were to be used for measurement of the high maximum pressures in Test Able on NEVADA, ARKANSAS, INDEPENDENCE, NAGATO, and some of the light vessels near the center of the target array. Some of the groups were to be mounted on wooden floats attached to anchor buoys of the close-in target vessels, and others were mounted on special buoys individually anchored and connected by cables resting on the bottom.

Free Piston Recording Gauges

For measurement of blast impulse and pressure-time curve, the Group planned to use thirty-five free piston recording gauges in Tests Able and Baker. This type of gauge, which was originated at Woods Hole, had been previously used to measure blast impulses from charges fired in the open, but certain design changes were necessary for its use in Operation Crossroads. The specifications for the performance of the gauge were made on the basis of estimates by the Los Alamos group, and the problem was handed over to the Pilot Company, Cambridge, Massachusetts, for design of the instrument and manufacture of the required number. These gauges were assigned to ARKANSAS, NEW YORK, SALT LAKE CITY, and various other vessels throughout the target array. In this gauge, a stylus attached to the piston writes on a rotating drum which is set in motion by an exterior signal. Fourteen Black Boxes,[1] required to start the gauges at the proper time, were supplied and installed by the Los Alamos Group.

Linear and Logarithmic Axis Recorders

Dr. J. E. Henderson, of the University of Washington, proposed measuring the pressure-time curve of the air blast by the use of a special recording technique modified from one developed at the University in connection with previous ordnance work. Arrangements were made for the participation of Dr. Henderson and special assistants. This project involved the use of linear and logarithmic axis recorders. Sixteen of these time-axis pressure recorders, half of them linear and the other half logarithmic, were installed on seven of the target vessels, including NEVADA and others close to the center of the target array. The logarithmic recorders were self-starting, but the linear recorders required a time signal to start the recording disc.

Other Peak-Pressure Gauges

Only two other peak-pressure gauges, the diaphragm and indentation types, were used, both for measuring the peak air blast pressure. Four of the indentation type were mounted on NEVADA, because of the higher range of this type. Sixteen of the diaphragm type were divided among seven of the close-in target vessels, including NEVADA, where they were suspended in air above the decks to free them from effects of structure.

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[1]See Chapter 8: footnote, page 212.

Pyramidal Orientometers

Knowledge of the relative bearing of the ship with reference to the burst was an essential part of the measurement by foil meters. Pin-hole cameras, called pyramidal orientometers, were specially designed to provide this knowledge, and to indicate the height of the burst. This instrument consists of a hexagonal pyramid of about one-foot altitude with sides of steel plate each containing two small holes. The initial flash of the bomb, penetrating the pinholes on the side most directly exposed makes a pair of flash burns on the piece of one-inch white pine plank forming the base of the pyramid. From the position of the burns with relation to the pinholes, the height and direction of the burst may be calculated. The pyramids were installed on the sides of target vessels carrying foil meters by welded angle irons. Precautions were taken for recovery of the recording plank even though the pyramid might be blown off.

Shock Wave Velocity Measurements

Apart from the measurements of air blast, four methods were used to determine the rate of propagation of the air shock wave, so that the peak pressure relatively close to the burst could be computed from the velocity. Pressure gauge measurements close to the burst were considered impractical. The first of these, involving use of sonobuoys, was carried out by the Electronics Group.[1] Twenty sonobuoys were placed in pairs at 100-yard intervals on a radial line beginning at a point close to the target center, with radio-link recording facilities on Aomoen Island.

Fifteen pairs of blast switches were installed on target vessels along a radial line, at the same stations as the free piston recording gauges, with recording made on magnetic tape and

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[1] See Chapter 8: BLAST, PRESSURE, AND SHOCK MEASUREMENT: Sonobuoys and Sonobuoy Recorders.

Aberdeen chronograph recorders. It was planned to run the tapes at such speeds as to give time resolution of less than one millisecond. Comparison of the records with exact measurements of the distances between switches before the burst allows computation of blast velocity.

Photographic Methods

Parelleling the sonobuoy measurements, ten argon flash units were mounted on target vessels in a radial line beginning close to the center of the array, so that the flashes from these units would be within the field of a 35-mm General Radio continuous motion camera installed on Tower C on Aomoen Island. The argon flashes are caused by a powerful condenser discharge which, triggered by passage of the blast wave, explodes a charge surrounded by argon gas. As the wave passes outward, the successive flashes are recorded as spots of light on a continuous film. It was arranged to record an accurate timing trace on the same film by means of a flashing neon light driven by a tuning fork within the camera.

Three Eastman Type III high speed cameras, with a wide field at the range of the burst, were installed on Tower C on Aomoen Island for photographing the propagation of the shock wave out to around 3,000 feet. These cameras, which run 1,500 frames per second on 16-mm film, had timing superimposed on the same film, and were started by a timing signal.

UNDERWATER INSTRUMENTATION

Measurement Problems

In the underwater instrumentation in Test Able, eight linear and eight axis pressure recorders were used for measuring the underwater pressure-time curve caused by reflection of the air blast. They were installed on the same target vessels as those used for measuring air blast, except that they were suspended from cables, one at twenty-foot depth and one at a hundred feet. Ten indentation peak-pressure gauges were suspended from NEVADA, and at another station a few hundred yards away, at depths of 10, 20, 50, 80, and 100 feet. Fifteen diaphragm peak-pressure gauges were suspended on the same cables with the time axis pressure recorders. Forty orientation gauges were installed, one in the container with each pressure-time recorder, to determine the orientation of the recorder with respect to the burst. These gauges are small lead cylinders containing film arranged so that maximum exposure of film to radiation will be on the side towards the burst.

The general problem in instrumentation of the underwater shock wave in Test Baker, when the greater proportion of energy would go into water pressure, was to make more extensive measurements of peak pressure and duration, impulse and duration, pressure-time curve of underwater shock, underwater shock impulse, and damage effects. These measurements were all closely related to those in the instrumentation of air blast and underwater shock wave in Test Able, when greater stress was laid on air blast. The instrumentation of underwater shock wave in Test Able was used again in Test Baker with the addition of more extensive outlay of underwater instruments.

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Ball-Crusher and Diaphragm Gauges

The Ordnance Instrumentation Group undertook to measure the peak pressure and duration of the underwater shock wave by means of an elaborate underwater installation of ball-crusher gauges. One thousand of these gauges were located at ten stations on a radial line from close to the center of the target array to a point over one mile away. Each station had four gauges at each five-foot depth interval, suspended on vertical cables from special buoys. A sector free of traffic and coral heads was chosen for the Test Baker installation. This installation was supplemented by 100 diaphragm gauges, of a type developed by the Underwater Explosives Research Laboratory at Woods Hole, for measuring impulse and duration. These gauges were installed at six of the stations in eight blocks of two gauges each at twenty-foot depth intervals at each station.

Other Gauges

Two piston-type gauges were integrated into the installation of ball-crusher and diaphragm gauges. Twenty-two Hilliar gauges, used for measuring the pressure-time curve of the underwater shock wave, were installed in pairs at thirty-foot depth at each of the eleven closest stations. Forty Hartmann momentum gauges for measurement of underwater shock impulse were installed in pairs at fifty-foot depth at eight stations, and groups of three at eight other stations. Ten British pot gauges were installed at diaphgragm gauge stations at about thirty-foot depth to measure the damage effects of the underwater shock wave.

Low-Frequency Sound Measurements

The fact that the Bureau of Ordnance has normal cognizance of acoustic and pressure mines made low-frequency sound measurements a matter of special interest. The committee responsible for these measurements planned to measure both the acoustic fields set up in the 0-200 cycle region and the underwater pressures due to surface waves, these two types of measurement relating, respectively, to acoustic and pressure mines. This plan was to be carried out for both Tests Able and Baker. Hydrophones were the instruments used.

Hydrophones

Five Mark 1 Model 4 hydrophones, specially designed to meet the rugged conditions of Operation Crossroads, were installed on the bottom of the Lagoon at ranges from 500 to 6500 yards along a straight line. The units were connected by a submarine cable to recording facilities in a hut on Enyu Island. This type hydrophone functions by means of a diaphragm which changes the inductance in one arm of an alternating current bridge. The remainder of this bridge was at the end of the cable several miles away on Enyu Island. The pressure changes due to surface waves, these changes being very low in frequency were recorded by means of an Esterline Angus pen-and-ink recorder, and a magnetic tape was used for the higher frequencies of acoustic fields. Two Black Boxes were required for starting the equipment.

RADIOMETERY INSTRUMENTATION

Measurement Problems

The general instrumentation problems of the radiometry committee, which included members from the Naval Research Laboratory, the Naval Ordnance Laboratory, and Los Alamos, involved measurements of radiation phenomena of the explosions. In general, these measurements pertained to the total energy distribution of the flashes, and the thermal effects of the fire ball. The instruments used, all of standard design, included thermocouples, camerasm oscilloscopes, photocells, and spectrographs. The measurements undertaken by the Ordnance Instrumentation Group were part of the comprehensive radiometery program contained in the Instrumentation Plan.

Unfocused Bolometers

Unfocused bolometers of the thermocouple type were used to obtain measurement of the total radiation energy of the flash in Test Able. This installation, comprising two sets of three unfocused bolometers, was provided with suitable amplifiers and recording devices, and the thermocouples contained radiation filters making them spectrally selective. In Test Able, one set of the unfocused bolometers was carried in a PBM-5 seaplane, and the second set was on a ship at a different range from the center of the target array, allowing for measurement of atmospheric absorption. Timing signals were required. In Test Baker, the set on the seaplane was used for aerial observation alone. The data from the bolometers was recorded on an automatic strip type recorder.

Focused Bolometers

Focused bolometers, mounted on the topside of KENNETH WHITING, were used in Test Able for obtaining thermal radiation data on the rising fire ball immediately after the flash and continuing until no further radiation was received. The readings of radiation intensity were recorded on a strip-type recorder equipped with a base of one-second indicator marks, while bore-sighted cameras kept a photographic record of the ascending fire ball. A similar installation of three gang-mounted focused bolometers was used in Test Baker. Both installations required timing signals.

Spectrography

Three controllable slit spectrographs of prism type, one medium and two small, were used in Test Able for obtaining the spectral distribution of the flash. The data obtained from the spectrographs could be correlated with that of the bolometers for finding an absolute spectral radiation curve from which the temperature of the explosion might be computed. All three spectrographs were mounted topside on KENNETH WHITING, and the spectral distribution was recorded photographically.

Photoelectric Units

It was planned to obtain data on the intensity of the flash as a function of time by means of photoelectric units. Two complete units were used. Each unit included a photoelectric cell with filters, an amplifier, and a pulse analyzer comprising two oscilloscopes, each operating at widely different time sweeps, with cameras for recording the oscilloscope trace. The sets were adjusted to respond to different ranges of Angstrom units. In Test Able, both sets were located topside on KENNETH WHITING, but in Test Baker they were carried in a PBM-5 seaplane for aerial observation free from the attenuation caused by water vapor near sea level.

Photographic Measurement of Fire Ball

Special high-speed cameras were used for measuring the rate of growth of the fire ball. Two drum-streak (O'Brien) cameras, supplied and operated by the University of Rochester, covered the time range of 0-5 milliseconds, with a time resolution of 10^{-7} and a space resolution of about three feet at seven miles. One of these was installed in Tower C, Station 4, on Aomoen Island. The other was mounted on the stabilized gun director of a destroyer, which took station on a bearing east-northeast of Bikini Island at a range of about ten miles. The installation was made so that the shutters of the cameras would close five milliseconds after the burst, leaving a streak record on photographic film. One Bowen camera was installed on the beach at Aomoen Island to record the rate of growth of the fire ball during the first 220 microseconds. This camera records on seventy-six individual frames with an interval between frames of about three microseconds. Black Boxes were required for starting all the cameras.

CHAPTER 11

OCEANOGRAPHY GROUP

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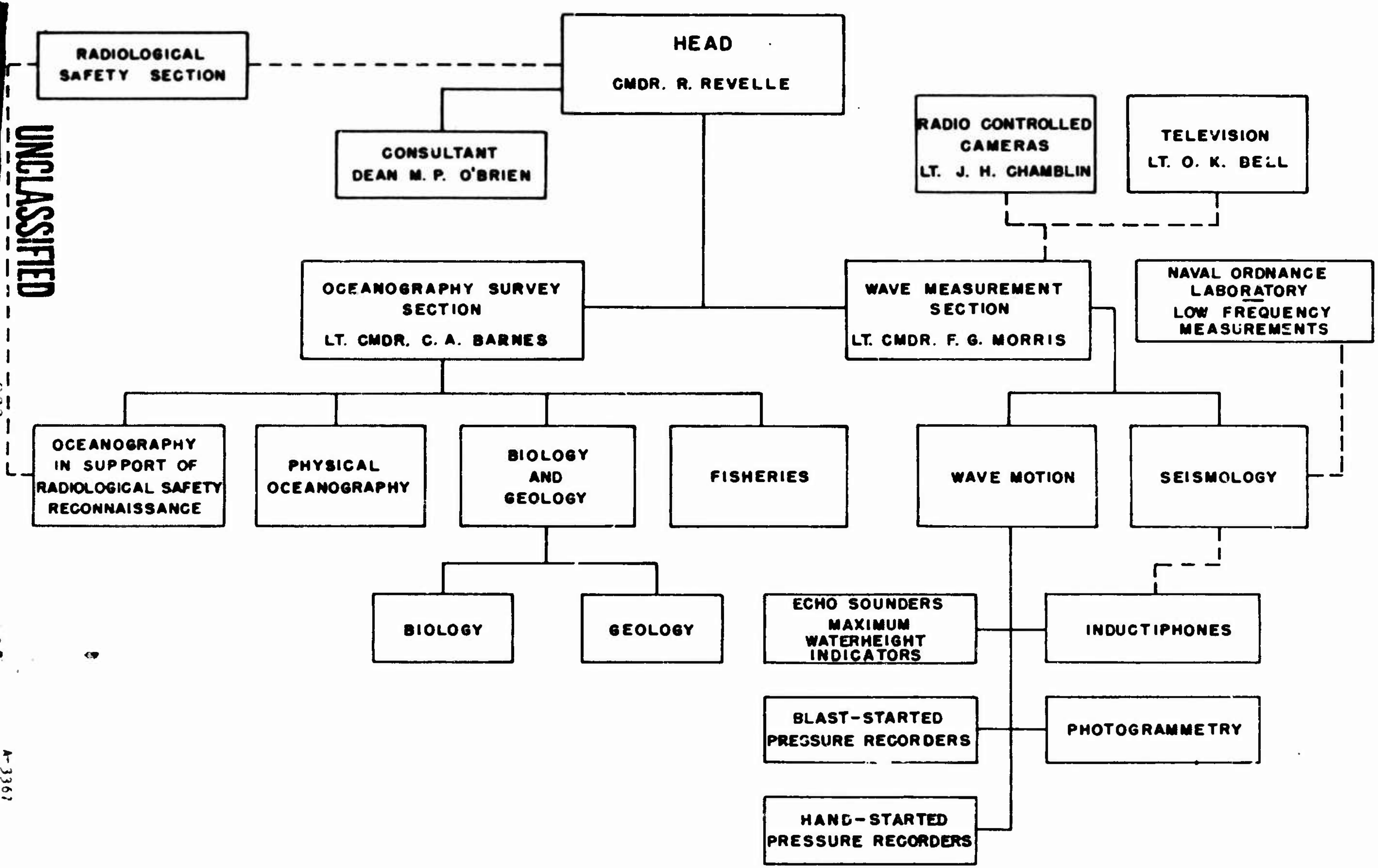
OCEANOGRAPHY GROUP (013-B)



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OCEANOGRAPHY GROUP

Exploratory Discussions

In October of 945, shortly after the first public suggestion of possible tests of atomic bombs against naval vessels, Mr. N. J. Holter, a physicist in the Bureau of Ships, suggested that surface water waves generated by the explosions be measured by means of equipment developed by the Bureau during the war, and by other equipment specially designed for the purpose. On 13 December, the Deputy Chief of Naval Operations for Special Weapons conferred with representatives of the Manhattan District, the Hydrographic Office, and the Bureau of Ships, relative to this and other proposals concerning wave measurement. In this conference the oceanographic facilities of the Bureau of Ships and the Hydrographic Office was described for representatives of the Manhattan District. The group discussed ocean currents as they affected the choice of a safe test site, and Bureau of Ships personnel outlined their program of wave studies and instrumentation. Col. S. L. Warren of the Manhattan District pointed out that radiological safety during the tests, for both near and distant observers, was basically a problem in meterology and oceanography.

Shortly after this conference, Comdr. Roger Revelle, who was in charge of special oceanographic programs in the Bureau of Ships, described in memoranda to the Manhattan District the scientific and contractual relations of the Bureau and the Hydrographic Office with the major oceanographic laboratories, including the Scripps Institution of Oceanography, the Woods Hole Oceanographic Institution, and the University of California Engineering Department and Division of War Research. He also outlined special facilities and personnel available for wave work in the Bureau itself, principally in the oceanography subsection of the Sonar Design Section. The Hydrographer similarly discussed the diffusion problem in the open sea and suggested the choice of a western tropical Pacific area as a test site, at the same time proposing a biological survey.

Formation of Group

The Oceanography Group as a formal participant in Operation Crossroads grew out of these preliminary discussions. As duties were assigned to the oceanographic personnel in the Bureau of Ships, starting with wave measurements, adding oceanographic surveys, and finally including support of radiological safety reconnaissance, the need for this group as a designated staff section became apparent. Late in January, Comdr. Roger Revelle and his assistants were assigned to the Crossroads Section of the Bureau of Ships as the nucleus of the Group, and on 5 February, he was designated officer-in-charge of oceanographic measurements on the Technical Staff of the Task Force.

The Oceanographic Group, with Commander Revelle as head, was organized into two main sections dealing with oceanographic surveys and wave measurement. The first of these included four subsections for radiological safety reconnaissance, physical oceanography, biology and geology, and fisheries. The wave measurement section included two subsections dealing with wave motion and seismology. Special liaison was maintained with other instrumentation groups. Civilian personnel were drawn from many public and private scientific agencies to assist in planning and carrying out the technical work of the Group.

The oceanographic survey personnel were embarked in the survey ship BOWDITCH, which surveyed the target area in March, as well as in six small craft used in this work. The wave motion and seismic personnel were embarked in FULTON Personnel concerned with radiological safety were aboard HAVEN with other members of the safety group, and the nine destroyers and six PGM's used for safety reconnaissance. The head of the Group remained in KENNETH WHITING in contact with the Technical Director.

Responsibility

The Oceanography Group, as one of the instrumentation groups in Operation Crossroads, was directly responsible to the Technical Director. Throughout the preparatory stages it functioned as part of the organization of the Director of Ship Material, to which it was closely related, not only because of the personnel included in the Group, but because of the technical assistance and facilities this organization was able to provide.

The general responsibility of the Oceanography Group, under the Technical Director, was at first somewhat generally defined as all matters relating to oceanographic measurements. The Group became primarily responsible for preparing and carrying out the Oceanographic Survey Plan.[1] Its duties in this connection logically developed into a major responsibility for radiological safety reconnaissance in support of the Safety Plan.[2] The nature of its scientific work was such that it inevitably became involved in this manner in operational phases of Operation Crossroads.

The elaborate instrumentation required for carrying out the many different scientific and operational tasks of the Group revolved it in support of the Instrumentation Plan.[3] This instrumentation relied, in part, upon special means such as television and photography, so that it was necessary to maintain close liaison with other instrumentation groups, particularly those for photography and electronics.

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[1]See Annex R: Oceanographic Survey.

[2]See Annex E: Safety Plan.

[3]See Annex G: Instrumentation Plan. (Conf./Secret)

WAVE MEASUREMENT

Preliminary

In the latter part of December, wave measurements were among the topics of discussion in a conference called by the Bureau of Ordnance, which was attended by Rear Admiral (then Commodore) Parsons, Rear Admiral Solberg, and representatives of the Bureau of Ships, the Manhattan District, and the Los Alamos Laboratories. The Alamos representatives particularly emphasized the importance of wave measurements and called upon Comdr. Revelle to describe the proposed methods of measurement, which included portable echo sounders and bottom-mounted echo sounders.

As the Group elaborated upon its plans, suggestions for wave measurement were received from the Woods Hole Oceanographic Institution, the Admiralty Research Laboratory in England, the University of California Division of War Research, and the U. S. Navy Electronics Laboratory. Suggestions from Mr. M. P. O'Brien, Dean of the University of California Department of Engineering, for model studies of wave generation, preliminary to the full-scale atomic bomb studies, were subsequently carried out by his personnel and others.

Photogrammetry and Television

At a later meeting, which dealt with photographic requirements, the head of the Oceanography Group, recommended photogrammetry for wave measurements by means of simultaneous aerial and ground photography, controlled by radio links, with an installation of camera towers on the atoll islands. The Technical Photography Group agreed to obtain the services of a specialist who had developed methods for simultaneous aerial and ground wave photography, using radio control, in cooperation with scientists of the University of California. Mr. Holter arranged a meeting in Washington of experts in photogrammetry in which he explained the technical needs for personnel and equipment. At this meeting the conferees also witnessed a television demonstration to consider whether image quality was sufficient to justify the use of television for viewing breakers arriving at Bikini Island following the explosions. It was agreed that television observations were a useful addition to the photographic plan because of the desirability of obtaining estimates of wave height immediately after the tests and the impracticability of measuring breaking waves by means of pressure recorders.

Several further meetings enabled the Group, with assistance from Dean O'Brien, to outline a specific wave photography plan for incorporation into the Photographic Plan,[1] which was being developed by Captain Quackenbush, with a special section of technical photography for activities related to the Bureau of Ships.[2] Television personnel were drawn from the Naval Research Laboratory, the Radio Corporation of America, and the Bureau of Aeronautics. A special section of the Group was organized for installing and operating two television transmitters on Bikini Island, and two television receivers with motion picture cameras in two of the photographic aircraft.[3] After basic plans were completed, this section was assigned to the Electronics Group.[4]

Model Basin Studies

Dean O'Brien maintained in early planning stages that previous model studies and theory concerning waves generated by explosions were not adequate to allow useful predictions of wave phenomena following either the air or sub-surface test.

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[1]See Annex L, App. II: Wave Measurement Flight Plan.

[2]See Chapter 12: PHOTOGRAPHIC ACTIVITIES OF VARIOUS GROUPS: Oceanography.

[3]See Chapter 5: OPERATIONAL PLANS: Photographic Aircraft.

[4]See Chapter 8: WAVE MEASUREMENT: Television and television Installations.

This conclusion was confirmed by scientists of the Los Alamos Group, whose independent theoretical computations in developing a scaling law had encountered, first, the uncertainty whether the linear dimensions scale as the fourth or the third root of the energy, and second, the unknown effect of relatively shallow water on the height-distance relationship for explosive waves. Accordingly, the Group arranged that a series of model tests be undertaken under the direction of Prof. J. W. Johnson of Dean O'Brien's staff. The investigations were instituted at the Woods Hole laboratories, but were transferred to the David Taylor Model Basin and finally to the Naval Warfare Mine Test Station, Solomons, Maryland, as the size of the charges used increased from 0.1 pound to 1,000 pounds.

Instrumentation Studies

Studies in wave instrumentation began intensively during the latter part of January when the Oceanography Group held numerous conferences with special representatives of Woods Hole, the University of California, and the Navy Electronics Laboratory. A bottom-mounted pressure recorder, capable of withstanding intense blast pressures and yet sensitive to small pressure changes due to wave motion, was hastily designed at Woods Hole. One of the group returned to the University of California to design a mechanism for starting the recorder clocks by the blast pressure. The problems of starting and accurately timing the echo-sounding recorders were solved, but it was found that available portable echo sounders were not capable of soundings to 180 feet, so that modifications had to be worked out. The Bureau of Ships assigned the construction and procurement of necessary equipment for the various types of instruments to the University of California, the Woods Hole Institute, and the Navy Electronics Laboratory, and commercial contracts for production of the instruments were let with five different companies. Maximum water-level recorders, simple but rugged in design, proposed by Mr. Holter, and radio reporting wave buoys, suggested by Dr. Focke of the Electronics Laboratory, were added to the instrumentation plan, with arrangements for their construction by the Electronics Laboratory.

Fathometers

The instrumentation plans for wave measurement completed early in February were followed in substantial detail. Fathometers were used on both target vessels and special buoys. Fifteen portable-type fathometers were mounted on the outside of the hulls of fifteen target vessels, with cables running inside the vessels to recorders, which were started, timed, and stopped by clocks. Ten fathometers were installed on buoys designed for minimum roll under wave action, and cables connected them with recording facilities located on target ships. The Group realized that many target ships in advantageous positions had their own fathometers and arrangements were made with the Bureau of Ships Group for an auxiliary power supply in these ships so that these fathometers might also be used.

Photogrammetry Installations

Two television cameras and video transmitters were mounted on towers on Bikini Island. Motion picture cameras on board two PBM-5 seaplanes photographed the received images. A pole marker had been placed in the camera field of view to aid in subsequent calculations of wave or breaker heights. Stereoscopic still cameras, synchronously operated at about one-second intervals by radio timing signals, took photographs from four seventy-five foot towers, two on Bikini Island, one on Enyu and one on Aomoen, as part of the plan which included three photographic aircraft. These three PBM-5 seaplanes, one at 5,000 feet and two at 12,000 feet, arrived at favorable positions over the array when the largest waves rolled up Bikini beach, so that they were able to provide photographs, timed by the radio link, which showed the whole disturbed area from the burst center to subsidence point of the large waves.

Bottom Pressure Recorders and Wave Buoys

About twenty mechanical pressure recorders, heavy 200-pound units capable of withstanding blast shock, were laid 500 yards apart on the Lagoon bottom on a line radially away from the point of burst for measuring wave height as a function of time by recording hydrostatic pressure on the bottom. They were buoyed and interconnected for recovery purposes. Half of these were hand started and half by blast pressure. This instrument contained its own recorder, comprising a pen and rotating drum. Two special wave buoys, modified from the radio sonobuoys developed during the war, were also used to measure wave height against time. These two buoys were planted at about 4,000 and 8,000 yards from the point of burst to send data on wave heights by frequency-modulated radio to one of the PBM-5 seaplanes, where the oscillograph record was photographically recorded.

Water Height and Level Indicators

Ten maximum water height indicators, were mounted near the water's edge at Bikini Island. These indicators included an electrical circuit so arranged that certain fuses would burn out as the water rose in height. Other indicators were used also which recorded water height on water-sensitive colored paper. One recording water level meter was mounted on a pile off Bokororyuru Island, and another was similarly mounted at Rukoji Island, to maintain continuous records from which the increase of wave length with travel distance might be determined.

Swell Recorders

While the Group was planning its instrumentation, the Minesweeping Section of the Bureau of Ships proposed that the waves resulting from the bomb might be high and long enough at sufficiently great distances to sweep pressure-type mines. This section expressed the desire to take measurements with portable swell recorders, using the Mark 1 Model 4 acoustic system, at distances between 10 and 200 miles from the explosion, as these equipments, which operate on a variable reluctance principle, can detect changes of water pressure of less than an inch. It was agreed that these sensitive instruments would be valuable for measuring small wave disturbances resulting either directly from the bomb or from a submarine landslide set off by seismic vibrations from the burst. With the assistance of mine technical personnel, installations were made on the bottom at from five to fifteen fathoms, two near Kwajalein and one near Eniwetok, two at Wotho and two at Rongelap, manually operated, for the long-distance installations, and two each near Yurochi and Namu, operated by timing signals and recorded ashore, for the Bikini installations.

Seismology Problems

The seismological work of the wave measurement section in the Oceanography Group involved the equipment and personnel of four separate organizations. Plans for this work underwent many changes before final stabilization. In a conference in early January with the U.S. Geological Survey, it was agreed that seismic measurements were desirable, not only to determine the amplitude and character of the earth motion resulting from the bombs, but also to gain information on the subsurface structure of the atoll. By the well-known refraction and reflection measurements used in geo-physical prospecting, definitive data might be obtained on the controversial Darwain-Dana-Davis theory, which holds that coral atolls are built up from gradually submerging volcanoes. The Geological Survey assumed responsibility for making arrangements with a geophysical prospecting firm to make the seismic measurements, the costs being shared between the Bureau of Ships and the War Department Corps of Engineers, working through the Military Geology Unit of the Survey.

Initial Seismology Plans

More detailed seismic plans were worked out at a meeting with representatives of the Geological Survey and the Geotechnical Corporation of Cambridge, Massachusetts. The Corporation was to supply men and material under contract to the Geological Survey. The construction of five seismic huts on Aomoen, Yurochi, Namu, Chieerere, and Enyu Islands was approved by the Task Force Commander. Shortly afterwards, the Geological Survey learned that the installations planned by the Naval Ordnance Laboratory were such that seismic profiles of the atoll could be obtained more staisfactorily before the tests by a series of small charges dropped along cross sections of the atoll, with use of the Mark 1, Model 4 acoustic system to pick up and record the explosions. Such data were needed by the Laboratory for preliminary calibration work on their low-frequency receivers, as part of the low-frequency sound investigations carried out under the Ordnance Instrumentation Group.[1] The Survey then cancelled its plans because of the apparent duplication of effort.

Coordination of Plans

At about this time it was learned that the U. S. Coast and Geodetic Survey, through the Office of Research and Inventions, was planning tide and seismic investigations at points distant from Bikini Atoll. A general meeting was called to clarify the plans of all groups to avoid duplications. It was decided in this and later meetings that the atomic bomb tests could best serve, not as an energy source, for making seismic refraction or reflection measurements to determine subsurface geological structure, but as an opportunity to study, as planned earlier, the amplitude and character of seismic vibrations in coral rock resulting from a known source.

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[1]See Chapter 10: UNDERWATER INSTRUMENTATION: Low-frequency Sound Measurements.

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With the agreement of other agencies, the Oceanography Group decided to support the Naval Ordnance Laboratory proposal to determine seismic profiles from refraction measurements using depth charges. Plans were made to include the Bureau of Ships Mark 1, Mod. 4 acoustic installations on Yurochi and Namu as part of this network, and to place sensitive equipment on Chieerete, if possible, to furnish two cross sections at approximately right angles with instruments at each end. For accomplishing the second objective of the seismic program, comprising a study of earth motion from the bomb or subsequent landslides, the Group decided to obtain personnel and equipment from the Coast and Geodetic Survey and the Geotechnical Corporation under a contract with the Bureau of Ships.

Seismic Sea Wave at Hawaii

The bulk of the wave measurement section sailed for Bikini on 20 March, but after postponement of the tests on 23 March, the Task Force diverted their ships to Pearl Harbor, where the section reported to Commander Naval Task Group for duty. The postponement allowed for a check of all the sixty-five tons of equipment awaiting shipment to Bikini. While the section was at Pearl Harbor, the Hawaiian Islands were struck by a devastating seismic sea wave originating just south of the Aleutian Islands. Unfortunately there was no advance information, and the scientific opportunity of a lifetime could not be put into effect. It was considered unlikely that further waves would develop, but the section unpacked some of the equipment and kept it operating for several days on a northern Oahu beach. The scientific personnel were able to give some assistance to the Commander-in-Chief, Pacific Fleet, during the night of 1 April, when numerous ships asked for information on precautionary measures, by advising that a ship in the open sea would not notice a seismic sea wave at all, unless very close to the epicenter. During the next few days as much time as possible was spent studying the beaches affected by the sea wave.

Measurement of Water Crater

The postponement allowed time for study by the Group of means for measuring the size of the "crater" produced in the water by the subsurface burst in Test Baker. Conferences at the University of California resulted in a simple design of instruments to be planted on the bottom near the explosion point. As finally developed, this apparatus consisted of a series of small, rugged steel cylinders enclosing film of various sensitivities to radiation from the fire ball of the bomb. These cylinders were secured at 100-feet intervals to 1,000 feet of chain laid along a radial line starting outward 200 feet from the explosion point, with the inner end anchored, the outer end attached to a buoy. It was expected that this installation would remain approximately in place as the water swept outward, so that some of the cylinders would be uncovered and thus exposed to the radiation from the cavity filled with radioactive material, while the water would shield from gamma rays the cylinders which remained covered.

OCEANOGRAPHIC SURVEY

Preliminary

Following the exploratory discussions, the Oceanography Group began active work not only in the technical problems of wave measurement, but also in the field of physical oceanography, biology, geology, and fisheries. Every effort was made to insure that all cognizant government and civilian agencies were represented and that no proper interests were neglected. Basic to the investigations in all four fields was the decision to have BOWDITCH make a survey of the physical oceanography of Bikini Atoll, for BOWDITCH eventually became the home for a large number of scientists engaged in a full-fledged scientific expedition, which was an essential preliminary to the tests themselves. The planning of the Bowditch Expedition was a major task involving many different civilian scientific agencies.

Physical Oceanography

Early in the planning for Operation Crossroads, the Hydrographic Office informed the Deputy Chief of Naval Operations for Special Weapons, in answer to his request of 7 January, that available data on ocean currents in and around Bikini Atoll were not sufficiently complete for purposes of the operation, and recommended use of BOWDITCH for a survey. The Hydrographic Office discussed the proposed survey in a number of conferences, and on 18 January, Vice Admiral Blandy requested the Office to undertake an oceanographic survey of Bikini Atoll and surrounding waters along the general lines it had proposed, with the Bureau of Ships arranging for collaboration of other agencies. The Hydrographer designated Commander Revelle as his representative in planning and implementing the work. The first step was to make BOWDITCH available for the first part of the survey beginning in early March, and for her later assignment to the Task Force. The Oceanography Group requested Woods Hole to undertake technical responsibility for physical oceanographic work and to supply personnel and equipment.

The general objective of the physical oceanographic survey was to establish the current regime and related oceanographic conditions in Bikini Atoll and surrounding waters which would influence the scattering and diffusion of radioactive substances resulting from the bursts. Field measurements were planned to include current surveys using current meters, current poles, drift bottles, and dye markers in the Lagoon, its entrances and exits, and the surrounding waters, so that current depths, patterns, profiles, and the net water exchange between Lagoon and open sea might be determined. Other work involved collection of water samples at surface and subsurface levels, measurement of temperature, analysis of chemical characteristics of the water, and bathythermograph lowerings, as means of gaining additional information about the circulation and the depth of the mixed layer and to aid in estimating diffusion. Observations of waves, wind, tides, and weather, supplementary to information from other sources, were to be made to complete the picture of prevailing conditions.

Fisheries

Commercial fishing interests in the Pacific were disturbed, when the proposed tests first appeared in the newspapers, over the possibility of far-reaching harmful effects upon the commercial fish supply. Accordingly, on 21 November 1945, the Secretary of the Interior pointed out these dangers to the Secretary of the Navy, and offered the technical advice of the Fish and Wildlife Service in the selection of a site where these dangers would be least. The Chief of the Division of Fishery Biology, who became an adviser in these matters, concurred in the selection of Bikini Atoll as a locality where minimum damage to fisheries would occur. Vice Admiral Blandy planned further cooperation by the Fish and Wildlife Service in the experiments and observations to determine the effects of the bomb bursts, above and at the surface, of the reef and Lagoon fishes of Bikini Atoll, and on the pelagic or migratory fishes, particularly tunas, in the surrounding ocean waters. The Oceanography Group, through conferences with representatives of the Fish and Wildlife Service and the U. S. National Museum, arranged for a fisheries investigation in the Bowditch Expedition.

The government agencies, which supplied personnel and equipment, pointed out the opportunity in Operation Crossroads to acquire fundamental scientific knowledge in many fields, including the effects of concussion, wave action, and radiant effects of heat, light, and radioactivity upon aquatic organisms. They planned to measure the immediate and long-range effects of the bursts upon the fish population of Bikini Atoll, and the rate of repopulation, through reproduction and immigration, of the fish populations destroyed. To accomplish these objectives, observations were necessary to identify the species of fishes and their relative numbers both before and after the explosions. For comparative purposes Eniwetok and Rongerik Atolls were to be studied in the same way, so that seasonal effects would be minimized. It was planned that specimens not only were to be identified and enumerated, but samples were to be prepared for examination as to pathological condition of tissues and morphometric characteristics.

Biology

It was agreed in early planning that the ecological phase of the field study of Bikini Atoll and surrounding waters was an important one. Suggestions as to the type of work to be done were obtained by Colonel Warren in a conference at San Francisco with representatives of the Scripps Institution of Oceanography, the Fish and Wildlife Service, the California Academy of Sciences, the California State Division of Fish and Game, the University of Washington School of Fisheries, and other agencies. The Oceanography Group, after receiving these suggestions, carried on talks with public and private scientific agencies in Washington, and it was decided that the primary responsibility for the biological survey would be undertaken by the U. S. National Museum. Late in January, the Secretary of the Smithsonian Institution presented the plans of the U. S. National Museum, which Vice Admiral Blanoy approved towards the end of February.

The plans for the biological survey called for a quantitative inventory of flora and fauna at Bikini, at Eniwetok, which would likely feel only moderate effects, and at Rongerik, not likely to be affected at all. These inventories were to be made prior to the bursts, as soon afterwards as possible, and at varying intervals for a considerable period to estimate long-period effects and the rate of repopulation. The field work would include collecting and estimating populations of littoral and land animals, algae, seed plants, and plankton of the Lagoon and open sea.

Geology

Members of the Oceanography Group discussed geological problems with representatives of the U. S. Geological Survey, which agreed to furnish three geologists for the Bowditch Expedition. Expenses were to be borne by the War Department as part of the work of its Corps of Engineers in the military geology of the Pacific area. On 8 March, Vice Admiral Blandy approved these arrangements. The personnel from the Geological Survey were specifically selected to study bottom sediments, using both bottom sampling and photographic methods, and to investigate the physiography and geology of the islands of Bikini Atoll, the shore and beach processes, and the ecology of coral reefs.

The purpose of the geological investigations was to study possible effects of the explosion, like erosion of the inner face of Bikini Island by waves and currents, changes in bottom topography by transportation of sediment near the explosion, and radioactive effects on the bottom sediments and the reef coral. The geological work was carried on in collaboration with the seismic investigations.

The Bowditch Expedition

The Bowditch Expedition was to go to Bikini in March, long before other Task Force activities, and the Oceanography Group spent the greater part of January and February preparing the expedition. The commanding officer of BOWDITCH came to Washington late in January to study plans, and it was decided to procure two small AGS's, three YMS's, one YP, three DUKW's, and six LCVP's to assist the larger vessel. BOWDITCH sailed from the West Coast on 17 February for Pearl Harbor, and three days after arrival at Pearl, she departed for Bikini. Scientific work was begun in Bikini Lagoon on 11 March, with the work made difficult, until the late arrival of the two AGS's, by the choppy sea.

Biological Collecting

The botanical work at Bikini was completed around the middle of April. All the islands were visited, and a survey was made of the existing flora. Herbarium samples were collected and prepared for return to the United States. Soil samples were collected for pollen analyses. the benthic, littoral, and pelagial algal flora of the Lagoon were investigated as thoroughly as conditions would permit. Members of the group conducted qualitative and quantitative zooplankton tows in and outside the Lagoon, and an attempt was made to correlate the results with current data as an aid to the study of the mixing phenomena present. Ecological work supplemented the plankton collecting program. One member of the group made a complete bird collection except for two or three types which the natives mentioned but which could not be found. Littoral mollusks, crustaceans, and insects were also collected and preserved. The biologists made a relatively complete census of the flora and fauna of the atoll.

Geological Investigations

The geological work was carried on in two parts. Two specialists conducted studies of the reef and island geology and physiography, while another investigated the bottom sediments and configuration both in the target area and in the shallow water between the target area and Bikini Island. Several hundred bottom sediment samples were collected. The bottom corals and sediments were photographed in situ, some in color. A bathymetric and sedimentary survey of the outer slope of the atoll was undertaken.

Fisheries Work

In the pre-bomb survey of the reef fish at Bikini, several thousand specimens were collected by means of poison, nets, and spearing. The poison technique, using rotenone, accounted for the major quantity. All the fish were preserved and returned to the United States for classification. The pelagic and Lagoon fish, collected by hand lines, nets, and spearing, were subjected to quantitative analysis. The three YMS's and one YP were used as fishing vessels near the reefs, in the passes, and in the open Lagoon and ocean. The main catches came from the area in and near Enyu Channel and the southwestern passes. After the fishing vessels had completed their work at Bikini, they departed for Rongerik to conduct part of the control work for the fisheries survey, collecting fish and freezing them on the YP for return to the United States for histological studies.

Oceanographic Measurements

The oceanographic survey obtained essential data by variious methods used in oceanographic and hydrographic field work. Current measurements were made with the Von Arx current meter, current poles, and dye markers. The current meter is an instrument which operates from shipboard by means of a vane much like an anemometer. The poles, sixteen feet long, were equipped with yellow pennants, radar reflectors, and lights, so that visual and radar bearings could be taken on them both day and night as they drifted in the current. The dye markers were dropped from a PBM-5 seaplane for determining the direction and speed of currents over the reef and through the small channels, and aerial photographs revealed current data from measurements made on the prints. As the waters of the Lagoon are very clear, with the bottom visible at 150 feet, it was possible to gather data on both the surface and bottom currents over the reef and in the smaller channels. Measurements of salinity, oxygen, and temperature, both in the Lagoon and outside waters, were related to the current studies.

Results of Oceanographic Survey

The survey provided essential information on currents within and outside the Lagoon, tides and swells, and diffusion. Analysis of the survey resulted in a division of the Lagoon into two segments. In the northern segment, bounded along the southern edge by a line running from a point midway between Enyu and Bikini to north of Bokororyuru, the surface currents flow from slightly north of east to south of west, with a variation in velocity from 0.3 to 0.6 knots. The flow over the reef from Namu eastward to Enyu is always into the Lagoon, irrespective of the tidal cycle. From Namu west and south to Eniirikku, the currents at all depths over the reef and through the channels change with the tide, out on ebb and in on flood, and are usually weak, from 0.1 to 0.3 knots. The currents through the southwestern channels vary from an average of 1.5 knots during flood to 2.5 during ebb. The currents through the western edge of Enyu Channel are always out of the Lagoon, varying from 0.3 knots at flood to 0.6 at ebb. The tides and swells were found to conform to standard data supplied by the Coast and Geodetic Survey. Diffusion studies, an important safety consideration, revealed an intensive vertical mixing and slow circulation inside the Lagoon, with very sluggish communication with the outside.

RADIOLOGICAL SAFETY RECONNAISSANCE

Preliminary

The Oceanography Group was directly involved in support of the Safety Plan.[1] During January and early February, the Group made a preliminary study of the possible effects of diffusion and other oceanographic factors on safety problems, and on 15 February, certain proposals concerning safety problems were made to members of the Radiological Safety Section of the Task Force. It was agreed at this time that the Oceanography Group besides furnishing personnel and equipment, would be responsible for installing water systems for radioactivity measurements in nine destroyers and six PGM's for sampling and measurements to 1,000 feet. Gear for making deep water radiological measurements would also be installed and operated on all these vessels by oceanographic personnel. The head of the Oceanography Group was made a member of the Radiological Safety Advisory Board, and an officer in the Oceanography Group was designated project officer for radiological safety reconnaissance.

Preparations

The PGM's were fitted with their special oceanographic equipment at the naval shipyard, Pearl Harbor, and the destroyers at the naval repair base, San Diego. Specialized hoisting equipment was necessary for the vessels. A large amount of the required scientific equipment was obtained from the Hydrographic Officer, the Bingham Oceanographic Foundation of Yale University, the Bermuda Biological Station of the Royal Society, the Coast Guard, the Scripps Institution, the

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[1]See Annex R, App. I: Oceanography in Connection with Safety Reconnaissance.

University of Washington, the Fish and Wildlife Service, and commercial concerns. Twenty-two oceanographic observers went through a quick training program set up at Woods'Hole. The Army Air Forces, Woods Hole, and the Scripps Institution furnished professional oceanographers.

After arrival at Bikini, the project officer and his technicians assisted in the installation of bottom-mounted radioactivity measuring equipment in the passages of Bikini Atoll and at other locations around its periphery. The shore recorders for these instruments were installed in the seismic huts on Enyu, Chieerete, Namu, and Aomoen Islands, and a similar installation was made at Eniwetok. Other oceanographic personnel boarded the destroyers and PGM's to which they were assigned in order to instruct ships' crews in the operation of winches, handling of sampling bottles, and chemical analysis of water samples. During and after the rehearsals before each test, the destroyers equipped with deep sampling equipment took synoptic observations of temperature, salinity, and oxygen content of the water down to a thousand meters, as a basis for analysis of the large-scale currents prevailing just prior to the tests in the critical areas around Bikini.

Operations

At the time of the safety reconnaissance, two oceanographers were stationed on each destroyer equipped with a thousand-meter sampling gear, and one or two observers were stationed on the other destroyers and the PGM's. The group furnished a liaison officer to the Radiological Safety Section embarked in MOUNT MCKINLEY to assist in predicting and tracking the diffusion and down-current movment of the contaminated water. The destroyers and PGM's collected water samples at intervals, and returned them to HAVEN, headquarters of the Radiological Safety Section, for chemical and radiological analysis. After the safety of the critical areas had been established, some of the destroyers with deep sampling equipment were detailed to follow the down-current diffusion as far as practical west of Bikini to provide information as to the contamination to be expected from large concentrations released at sea.

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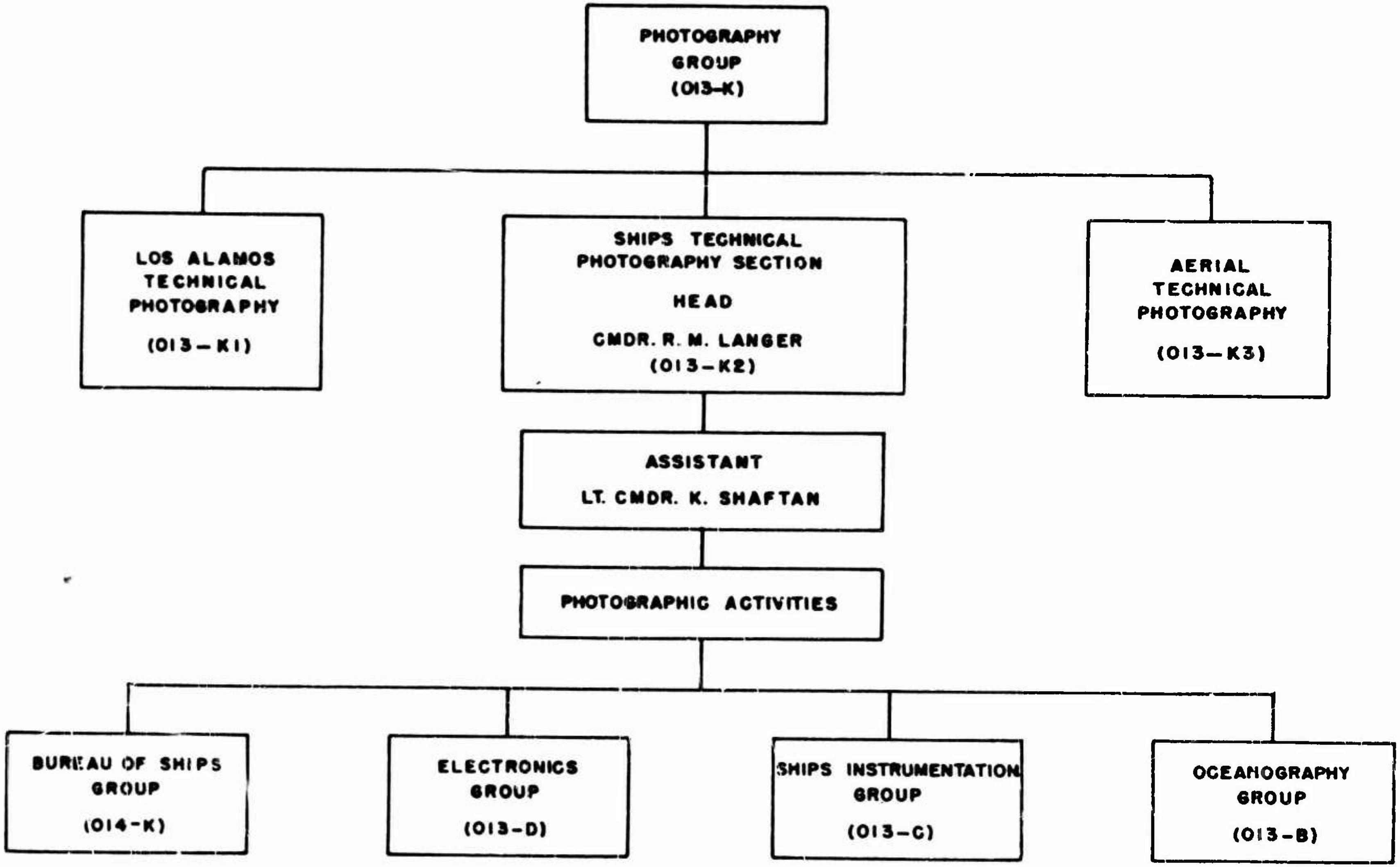
CHAPTER 12

SHIPS TECHNICAL PHOTOGRAPHY SECTION

SHIPS TECHNICAL PHOTOGRAPHY SECTION (013-K2) OF PHOTOGRAPHY GROUP (013-K)



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SHIPS TECHNICAL PHOTOGRAPHY SECTION

Exploratory Discussions

During the early Technical Staff meeting in January, representatives of the Bureau of Ships and the Bureau of Ordnance, especially instrumentation personnel, discussed photography as an auxiliary method of instrumentation. Los Alamos representatives brought out that photography aboard target ships was impractical because of the great amounts of lead shielding which would be required for protection against radioactivity. The question of this [illegible] of photography was temporarily set aside. Later in January, the technical need for photography again appeared, even if it were impractical on target ships near the center of the target array. Moreover, it was clear that the photography required for technical purposes was quite different from the kind carried on by the general photographer and that a separate group would have to be formed specifically for the problems of technical photography. A number of aerial photography problems were presented by representatives of the Bureau of Aeronautics. The chief requirement of the Los Alamos Group was for high-speed motion-picture cameras for observing the rate of growth of the ball of fire. The Bureau of Ships Group, as well as instrumentation groups closely related to it, like those for Electronics, Ship Instrumentation, and Oceanography, also had special requirements.

Formation of Section

The general requirements for all photography in Operation Crossroads resulted in the formation of the Photography Group, which came under Capt. R. S. Quackenbush. It soon became apparent that the major part of the work of this Group would be non-technical; and for that reason three special sections were formed within the Group to handle technical photography for the Los Alamos, Bureau of Ships, and Aerial Groups, with their work coordinated in the Photographic Plan.[1]

The Bureau of Ships Technical Photography Section was included upon request, with Comdr. R. M. Langer as head, when the several Groups associated with that Bureau each submitted special photographic requirements. The Section was embarked in WHARTON in order that close liaison could be maintained with the various Groups under the Director of Ship Material.

Responsibility

The Ships Technical Photography Section was responsible for coordinating the photographic requirements of all groups under the Director of Ship Material and instrumentation groups closely associated with his work. The needs of all groups had to be formulated in terms of equipment available in the Navy or readily available outside, but technical groups, in general, procured equipment or material of special character for their own purposes. Arrangements were made for processing exposed film and distributing prints. The Section was responsible to the head of the Photography Group for coordinating these technical requirements into the Photographic Plan, while being responsible to the technical groups themselves for liaison and assistance. The Section also assumed direct responsibility, under the Technical Director, for carrying out certain photographic projects, such as those involving icaroscopes, the moving-film spectrograph, and cameras on target ships,[2] and the training of technical personnel in the use of the special equipment.

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[1]See Annex L: Photographic Plan.

[2]See Annex G: Instrumentation Plan

PHOTOGRAPHIC ACTIVITIES OF VARIOUS GROUPS

Ship Preparation and Inspection

The major effort of the Section was in support of the inspection activities under the Bureau of Ships Group,[1] which controlled the inspections by all groups under the Director of Ship Material. The main object of photography was to obtain detailed records of the influence of the bomb burst on the great variety of animals and equipment exposed aboard the target ships, as well as on the target ships themselves. When the Groups from the Bureau of Ships, Bureau of Ordnance, Bureau of Aeronautics, Bureau of Medicine and Surgery, and Army Ground Forces had submitted their requirements for the inspections, it was estimated that 50,000-60,000 still exposures would be needed for all the before-and-after photographs. The photographic record was to include photographs, in advance of Test Able, of all special deck loadings of equipment as well as locations on board the ships where damage might well be expected. Beside the close-up still photography for recording damage, pictures were taken from Aomoen and Enyu Islands using long focus cameras to pick up striking movements of the ships and any exceptional events.

The head of the Photography Group assigned forty photographer's mates for use on inspection teams. Each photographer's mate remained with the same team throughout the inspections in order to become familiar with the technical point of view of the inspectors with whom he worked. The section designed slates on which each photographer could record essential data such as serial number of the picture, type and number of ship, distance, camera position, description of the equipment pictured, and comments. These slates, properly marked, were a part of each photograph.

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[1] See Chapter 2: REBOARDING AND INSPECTION: Preliminary Inspections.

Oceanography

The main photographic interest of the Oceanographic Group was in the measurement of waves, especially in Test Baker, from both aircraft and ground stations. There were a number of serious problems. Aerial photography suffered from the restrictions of distance and altitude from the blast. Ground photography was in danger of fogging because of the quantities of radioactive material mixed with the waters of the Lagoon that might be sprayed or rained upon installations. Cameras must remain unattended for considerable periods in the heat and high humidity of a tropical climate. But the requirements were important enough to justify these risks, even to contemplate building lead-lined housing to protect film from gamma radiation. Reports from Los Alamos subsequently became more encouraging with regard to the prospects of fogging. Estimates on the thickness of lead shielding decreased until it was decided that on Aomoen, Bikini, and Enyu Islands, no shielding would be necessary, though an inch or more was provided in most cases. The Oceanographic program, which largely involved photogrammetry in connection with wave measurements, was completed in the latter part of January,[1] and was included in the Photographic Plan.

Electronics

The photographic requirements of the Electronics Group were crystallized during February to comprise ordinary motion picture cameras with high aperture lenses for photographing oscilloscopes or radar screens.[2] These cameras, supplied by

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[1]See Chapter 11: WAVE MEASUREMENT: Photogrammetry and Television; Photogrammetry Installations.

[2]See Chapter 8: ELECTROMAGNETIC PROPAGATION

the Naval Research Laboratory, were operated by electronics personnel on AVERY ISLAND in making photographic records of the burst as it appeared on radar equipment at a distance of about twenty miles. The ship carried photographic facilities which made it practically independent with respect to photography. Similar photographic installations, started by timing signals, were made on Aomoen Island for photographing the screens of radar equipment operating there. The Electronics Group also required several thousand still photographs of its material exposed on target ships.

Ships Instrumentation

The Ships Instrumentation Group had planned to use photographic methods for recording data of its instruments aboard target ships until Los Alamos representatives expressed doubt of success. Accordingly, the Group abandoned these methods in favor of other methods of recording. The Group chose, however, to use three types of photography, all under the direction of the head of the Ships Technical Photography Section, who was also a member of the Ships Instrumentation Group. First, still photographs were made of all gauges and other devices used in the instrumentation to show construction and location. Temperature racks were photographed in color. Secondly, photographic observations of target ships by means of motion-picture cameras were to supplement physical measurements of roll and pitch and shock wave velocity. The Photography Section planned the installation of Jerome and gun cameras in weather-tight boxes on the superstructures of fourteen outlying target ships, upwind from the burst, chosen for their advantageous position for viewing important target ships near the center of the array. These cameras, some of them in duplicate installations, were directed so that they would record the roll and pitch not only of target ships within their field but also of the ships upon which they were mounted. They ran for six minutes after being started by timing signals. High speed motion-picture cameras, mounted on towers on the islands, were designed to obtain the shock wave velocity in the first one and one-half seconds of its life.[1] These cameras were arranged to view the blast itself and also receive light reflected from mirrors on some twenty ships within a radius of fifteen hundred yards. The third type of photography used by the Group involved spectrography.

Moving-Film Spectrographs

The Spectrography requirements of the Ships Instrumentation Group were part of the general program of spectrographic measurements in the Instrumentation Plan for studying the flash from the explosion.[2] The Group was specially interested in supplementing its temperature measurements on target vessels. The assembly of cameras into spectrographs was a highly specialized undertaking directed by personnel from the Naval Ordnance Test Station, Inyokern, California, who had been astronomers. Design and construction began the first of March, and five instruments were delivered early in May. Two moving-film spectrographs were installed on a tower on Enyu Island, arranged to start by means of remote timing signals. Measuring the color distribution of the flash for the first few seconds was essential for study of the temperature of the light, its total brilliance, and the absorption by the atmosphere between the bomb and camera. These factors are important not only for a study of temperatures, but also for knowledge of the mechanism of the shock wave and of the bomb itself.

Underwater Photography

Because of the availability of certain specialists within its

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[1]See Chapter 9: TEMPERATURE, PRESSURE, AND OTHER INSTRUMENTATION: Other Physical Observations.

[2]See Chapter 10: RADIOMETRY INSTRUMENTATION: Spectrography.

parent organization, the Bureau of Ordnance Group was able to cast an underwater photography team of experienced personnel, which was available for any group in the field that needed its services.[1] Some underwater photography of deep-lying equipment had already been planned as part of the Oceanographic Group. In connection with this work, the techniques used were similar to those which had been developed at Woods Hole. It was expected that underwater photography would be valuable in recording damage to sunken target vessels for purposes of inspection and salvage.

Icaroscope Observations

Toward the end of the war, the Navy had developed a device called the Icaroscope to enable lookouts to search for air attacks coming from the direction of the sun. The Technical Staff recognized the application of this device for observing the bomb blast, as the flash of light from an atomic bomb is so brilliant that ordinary methods of observation, whether visual or photographic, become insensitive to variations in contrast. The Photography Section carried out the program for use of the Icaroscope both singly by observers and in conjunction with cameras. At the beginning of March, there were only twenty-five of these devices in existence, but twenty-five more were immediately ordered and by the end of April were ready for use. The Icaroscopes were placed on nine observer ships so that special observers could report striking features of the burst, such as unsymmetrical shape, opaque regions, or halos. Four mounts for motion-picture cameras were designed, built, and tested, for installation with Icaroscopes on KENNETH WHITING and other observing ships.[2]

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[1]See Chapter 4: UNDERWATER ORDNANCE UNIT: Underwater Photography Section.

[2]See Annex G: Instrumentation Plan.

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Aerial Photography

The long-focus cameras installed on Aomoen and Enyu Islands were twenty and forty inch aerial cameras set to commence at the time of the blast and to take pictures at intervals of about three seconds for several minutes. In addition to the aerial cameras, a hand-triggered long-focus camera was assigned to the technical observer of the Director of Ship Material to photograph any outstanding events, such as fires, sinkings, collisions, and explosions during his observational flights over the array after the blasts Army planes were similarly equipped.

Stereoscopic Photography

A few days before the test, the Director of Ship Material and the head of the Bureau of Ships Group agreed that there was a need for stereoscopic photography of topside damage to target ships. This photography would provide a permanent record of significant damage from which unusual deflection measurements could be made. It would be particularly good for recording damage to the sides of target ships where actual deflection measurements are difficult to make. A lay-out for two stereoscopic camera systems was made and assembled quickly aboard a tug made available by the head of the Salvage Unit. Due to lack of time, it was necessary to resort to make-shift devices to overcome the equipment shortages. K-25 cameras, activated by portable batteries, were mounted about 80 feet apart on board each of tug AN-87 and PGM-23. A special wooden base, mounted on two tripods, carried a pair of speedgraphic cameras separated at a distance of five feet. Both systems were operated by photographer's mates attached to the Initial Boarding Teams under supervision of Lt. E. W. Peterkin. All stereoscopic photographs were taken during reboarding operations. The wide separation of the K-25 cameras made it possible to triangulate many portions of structural damage and give quantitative measures of the distortions found in cases where normal surveying methods would have been long and arduous.

CHAPTER 13

SUMMARY

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SUMMARY

Organization for Technical Reports

During the return trip of WHARTON from Kwajalein to San Francisco, the Director of Ship Material and remaining Group leaders established the personnel organization for preparation of the final reports which were to be submitted to the Deputy Commander for Technical Direction after the damage data had been analyzed. There were many factors to consider in determining the personnel to be retained for this organization. Many of the officers who had volunteered for the operation were due for release; others, whose services were essential for the activities and inspections at Bikini, would not be needed for preparation of the reports. The various branches of the Navy desired the services of still other officers, as well as some of the civilian technicians, for duties elsewhere. The personnel selected for retention were thoroughly familiar with the overall aspects of the tests, particularly with regard to those reflected in their specialities. The Deputy Commander had agreed that each of the Groups should prepare the reports in the headquarters of its parent organization in order that it would have ready access to such information as might be necessary for comparative studies of the data. This would also allow members of the parent organization to assist in the study and analysis and at the same time to consider the data in the light of immediate effects on design programs. The Rear Echelon, which, in addition to maintaining liaison with the Groups in the field had started preparations for Test Charlie, arranged for space and facilities in each of the Bureaus for the returning groups. The Army Ground Group, having completed its inspections at Bikini early in August, established its headquarters in the Bureau of Ships on 3 September. The Director of Ship Material returned to the Bureau shortly thereafter and commenced work on some special problems while awaiting return of the other Groups which were scheduled to reconvene the last week in September.

Decontamination Problems

Even before the return of the Technical Staff from Bikini, top Naval leaders recognized the seriousness of the radiological contamination problem and the lack of trained radiological monitors within the Navy. The Chief of Naval Operations, in a letter on 27 August, directed that a Radiological Safety Program be established in the Navy, the program to be organized by Task Force One and operated by the Bureau of Personnel. The first step, under this program, was a school for radiological monitors set up in the Task Force by Comdr. E. J. Kaufman, who had been at Bikini and was familiar with the radiological hazards imposed by contamination. Contamination difficulties were brought out more strongly when Commander Western Sea Frontier reported that radioactivity readings on non-target ships returning to West Coast ports were higher than allowable tolerance. This meant that these ships which had not even been close to the downpour of water in Test Baker had become contaminated, especially on their underwater hulls, by operation within the Lagoon after the test. These ships so contaminated had to be isolated until decontamination processes cleared them. The problem of clearance was posed to the Bureau of Ships which had cognizance of the hulls and machinery of the vessels as well as responsibility for their docking, and to the Bureau of Medicine and Surgery which was interested in the protection of shipyard workers and ships' crews working on these vessels. When the Director of Ship Material returned to Washington on 9 September, these Bureaus were endeavoring to draw up instructions for guidance of the shipyards in clearing contaminated ships. The Director of Ship Material, who had gained considerable experience with decontamination processes at Bikini, formulated the first set of instructions issued to the shipyards, and upon request of the Commander Western Sea Frontier and the Radiological Safety Officer of the 12th Naval District, returned to San Francisco to personally develop and supervise decontamination procedures. Later in September, when the Director of Ship Material was again in Washington, he established a section within his organization to progress all work on decontamination. This section, under Capt. W. S. Maxwell, was to later become an integral part of the Bureau of Ships.

Conclusion

All Groups reassembled in their headquarters in the various bureaus during the last week in September. The President of the United States announced the postponement of Test Charlie on 12 September, at which time the Groups discontinued all staff work on this project. The preparation of all reports were progressed rapidly, and by the end of October, the final reports of the Army Ground Group and the Bureau of Aeronautics Group had been submitted to the Director of Ship Material. On 31 October, Task Force One was dissolved. Members of the staff who were to continue work on the reports were ordered to be attached to the Joint Crossroads Committee. This committee, of which Rear Admiral W. S. Parsons was chairman and of which the Director of Ship Material was a member, was made responsible for submission to the Joint Chiefs of Staff of the final reports on the effect of atomic bomb explosions on Naval vessels. As 1946 drew to a close, it was anticipated that the major portion of all reports would be ready in March 1947.

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    III. Target Area Flight Lines for Vertical Photography
    IV. Target Area Flight Lines for Trimetregon Photography (Appendix Number Duplicated)
    IV. Titling and Handling Instructions (Still Photographs)
    V. Titling Instructions (Aerial Photographs)
    VI. Titling Instructions - Motion Picture - Jerome - Fastax Film
    VII. Handling Instructions - Motion Picture
    VIII. Handling Instructions - Aerial
    IX. Classification of Exposed Sensitized Material

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I. Oceanography in connection with safety Reconnaissance (Tab)

S. HARBOR INFORMATION

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I. Berth Assignments

II. Tide Tables

III. Sunrise and Sunset Tables

T. AEROLOGICAL PLAN

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I. Climatology

U. BOAT POOL PLAN

V. TYPHOON PLAN

W. SHIP PREPARATION PLAN

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I. Condition of Target Ships as to Liquid Loading

II. Condition of Target Ships as to Loading of Allowance and Special Ammunitions and Explosives

III. Conditions of Target Ships as to Aircraft Loading

IV. Condition of Target Ships as to Equipment in Operation

V. Condition of Target Ships as to Watertight Closures

VI. Conditions of Target Ships as to Aircraft Loading for Test "B"

X. REBOARDING AND INSPECTION PLAN

Appendix

I. Organization for General Control of Inspections

II. BuShips Target Ship Inspections

III. BuMed Research Section Inspections

IV. BuOrd Target Ship Inspections

V. BuAer Target Ship Inspections

VI. Army Inspections
VII. Safety Instructions for Target Ship Crew and Target Ship Inspections.
VIII. Ship Material Inspection Communication Plan
IX. Electronics Inspection Plan
X. Initial Boarding Teams
2 Tabs Instructions to Target Vessels for Tests and Observations by Ship's Force (BuOrd and BuShips)

Y. AIR-SEA RESCUE PLAN
Appendix
1. 1 Copy to CinCPOA SOP-34 (Distributed only to Units Not Normally Operating under CinCPac

Z. NON-PARTICIPATING OBSERVERS PLAN

AA. RONGERIK EVACUATION PLAN

BB. REPORTS

CC. DRONE BOAT PLAN

2.
SMYTH, H. D., ATOMIC ENERGY FOR MILITARY PURPOSES, pp. 224-5 (Princeton, 1945)

3.
GROSS DAMAGE REPORT FOR TEST ABLE: Director of Ship Material Serial 00174 of 6 July 1946, with enclosures (A) thru (H). (Secret)

4.
INTERIM REPORT FOR TEST ABLE: Director of Ship Material Serial 00441 of 4 August 1946, with enclosures (A) thru (H). (Secret)

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5\. GROSS DAMAGE REPORT OF TEST BAKER: Director of Ship Material Serial 00443 of 5 August 1946, with enclosures (A) thru (G). (Secret)

6\. INTERIM REPORT FOR TEST ABLE: Director of Ship Material Serial 00447 of 27 August, with enclosures (A) thru (F). (Secret)

Appendix II

LIST OF TARGET VESSELS

LIST OF TARGET VESSELS

ARKANSAS	(BB-33)
NEW YORK	(BB-34)
NEVADA	(BB-36)
PENNSYLVANIA	(BB-38)
PENSACOLA	(CA-24)
SALT LAKE CITY	(CA-25)
NAGATO	
SAKAWA	
PRINZ EUGEN	
SARATOGA	(CV -3)
INDEPENDENCE	(CVL-22)
LAMSON	(DD-367)
CONYNGHAM	(DD-371)
MUGFORD	(DD-389)
RALPH TALBOT	(DD-390)
MAYRANT	(DD-402)
RHIND	(DD-404)
STACK	(DD-406)
WILSON	(DD-408)
HUGHES	(DD-410)
ANDERSON	(DD-411)
MUSTIN	(DD-413)
WAINWRIGHT	(DD-419)
SKIPJACK	(SS-184)
SEARAVEN	(SS-196)
TUNA	(SS-203)
SKATE	(SS-305)
APOGON	(SS-308)
DENTUDA	(SS-335)
PARCHE	(SS-384)
PILOTFISH	(SS-386)

GILLIAM	(APA-57)
BANNER	(APA-60)
BARROW	(APA-61)
BLADEN	(APA-63)
BRACKEN	(APA-64)
BRISCOE	(APA-65)
BRULE	(APA-66)
BUTTE	(APA-68)
CARLISLE	(APA-69)
CARTERET	(APA-70)
CATRON	(APA-71)
CORTLAND	(APA-75)
CRITTENDEN	(APA-77)
DAWSON	(APA-79)
FALLON	(APA-81)
FILLMORE	(APA-83)
GASCONADE	(APA-85)
GENEVA	(APA-86)
NIAGARA	(APA-87)
LST 52	
LST 133	
LST 220	
LST 545	
LST 661	
LCI 327	
LCI 329	
LCI 332	
LCI 549	
LCI 615	
LCI 620	
LCT 412	
LCT 414	
LCT 705	

LCT 812
LCT 816
LCT 818
LCT 874
LCT 1013
LCT 1078
LCT 1112
LCT 1113
LCT 1175
LCT 1237

YO - 160

YOG - 83

ARDC - 13

6 LCM 1 - 6

6 LCVP 7 - 12

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Appendix III

OPERATIONAL DESIGNATIONS OF GROUPS AND UNITS

OPERATIONAL DESIGNATIONS OF GROUPS AND UNITS

JOINT TASK FORCE ONE

AGC-7 - - MOUNT MCKINLEY -------- (FF)

Task Group 1.1 - (Technical Group).

Task Unit 1.1.1 - (Laboratory Unit).

AV-5	ALBEMARLE (F)
LCT(6)	1359
LSM	60

Task Unit 1.1.2 - (Instrumentation).

APH-112	HAVEN
AP-7	WHARTON
APA-67	BURLESON
AV-14	KENNETH WHITING
AG-76	AVERY ISLAND
AV-17	CUMBERLAND SOUND

Task Unit 1.1.3 - (Drone Boat Unit).

APD-127	BEGOR

Task Group 1.2 - (Target Vessel Group).

CA-131	FALLRIVER (F)

Task Unit 1.2.1 - (Battleship and Cruiser Unit).

<u>BatDiv-7</u>

BB-33	ARKANSAS (F)	*
BB-34	NEW YORK	*
Ex-Jap BB	NAGATO	*

<u>BatDiv-9</u>

BB-38	PENNSYLVANIA (F)	*

BB-36	NEVADA *

CruDiv-23

CA-25	SALT LAKE CITY (F) *
CA-24	PENSACOLA *
Ex-Jap CL	SAKAWA *
Ex-German CA	PRINZ EUGEN *

Task Unit 1.2.2 - (Aircraft Carrier Unit).

CarDiv-31

CV-3	SARATOGA *
CVL-22	INDEPENDENCE (F) *

Task Unit 1.2.3 - (Destroyer Unit).

DesDiv-1

DD-410	HUGHES (F) *
DD-367	LAMSON *
DD-390	RALPH TALBOT *
DD-404	RHIND *
DD-411	ANDERSON *

DesDiv-2

DD-406	STACK *
DD-408	WILSON *
DD-419	WAINWRIGHT (F) *

DesDiv-3

DD-389	MUGFORD *
DD-368	FLUSSER
DD-371	CONYNGHAM *
DD-413	MUSTIN *

DesDiv-4

DD-402	MAYRANT	*
DD-403	TRIPPE	

Task Unit 1.2.4 (Submarine Unit).

SubDiv-111

SS-184	SKIPJACK	*
SS-196	SEARAVEN	*
SS-203	TUNA	*
SS-305	SKATE	*

SubDiv-112

SS-335	DENTUDA	*
SS-308	APOGON	*
SS-384	PARCHE	*
SS-386	PILOTFISH	*

Task Unit 1.2.5 (Landing Craft Unit).

LST Group - 9

LST - 133	*	LST - 545	*
LST - 52	*	LST - 661	*
LST - 220	*	LST - 125	

LCI Group - 7

LCI - 329	*	LCI - 549	*
LCI - 327	*	LCI - 615	*
LCI - 332		LCI - 620	*

LCT Group - 15

LCT - 1130		LCT - 1113	*
LCT - 816	*	LCT - 1114	
LCT - 818	*	LCT - 1115	

LCT - 874	*	LCT - 1116
LCT - 1078	*	LCT - 1132
LCT - 1112	*	LCT - 1155

<u>LCT Group - 21</u>

LCT - 1237	*	LCT - 1175
LCT - 412	*	LCT - 1187
LCT - 414	*	LCT - 1268
LCT - 812	*	LCT - 1341
LCT - 705	*	LCT - 1377
LCT - 1013	*	LCT - 1415

<u>Miscellaneous Group</u>

ARDC - 13	*
YOG - 83	*
YO - 160	*

Task Unit 1.2.6 (Merchant Type Unit)

<u>TransDiv - 91</u>

APA-57	GILLIAM	*	APA-70	CARTERET	*
APA-60	BANNER	*	APA-81	FALLON	*
APA-66	BRULE	*			
APA-69	CARLISLE	*			

<u>TransDiv - 92</u>

APA-77	CRITTENDEN	*	APA- 75	CORTLAND	*
APA-61	BARROW	*	APA-79	DAWSON	*
APA -68	BUTTE	*			

<u>TransDiv - 93</u>

APA-87	NIAGARA	*	APA-71	CATRON	*
APA-63	BLADEN	*	APA-83	FILLMORE	*
APA-64	BRACKEN	*	APA-86	GENEVA	*
APA-65	BRISCOE	*			

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TransDiv - 94

APA	- 58	APPLING
APA	- 85	GASCONADE *
APA	- 21	ARTEMIS

Task Unit 1.2.7 (Salvage Unit)

ARST	- 3	PALMYRA	ATA	- 180	
ARS	- 8	PRESERVER	ATA	- 185	
ARS	- 22	CURRENT	ATA	- 192	
ARS	- 23	DELIVER	ATF	- 83	CHICKASAW
ARS	- 33	CLAMP	ATF	- 148	ACHOMAWI
ARS	- 39	CONSERVER	ATR	- 40	
ARS	- 42	RECLAIMER	ATR	- 87	
ASR	- 1	WIDGEON	ARSD	- 1	GYPSY
ASR	- 8	COUGAL	ARSD	- 2	MENDER
LCT	- 581		AN	- 79	ETLAH
LCT	- 746		AN	- 80	SUNCOCK
LCT	- 1184		AN	- 85	ONEOTA
LCT	- 1420		AN	- 88	SHAKAMAXON

Task Group 1.3 (Transport Group)

Task Unit 1.3.1 (Transport Unit)

TransDiv - 31

APA	- 27	GEORGE CLYMER	APA	- 235	BOTTINEAU
APA	- 228	ROCKBRIDGE	APA	- 227	BEXAR
APA	- 229	ROCKINGHAM	AKA	- 99	ROLETTE
APA	- 230	ROCKWALL	AKA	- 101	OTTAWA
APA	- 231	SAINT CROIX	LST	- 817	
APA	- 33	BAYFIELD	LST	- 881	
APA	- 45	HENRICO			

Task Unit 1.3.2 (Press Unit)

AGC	- 1	APPALACHIAN

Task Unit 1.3.3 (Observers Unit).

AGC - 13	PANAMINT
AGC - 2	BLUE RIDGE

Task Group 1.4 (Army Ground Group)

Task Unit 1.4.1 (Engineer Unit)
Task Unit 1.4.2 (Signal Unit)
Task Unit 1.4.3 (Ordnance Unit)
Task Unit 1.4.4 (Chemical Unit)
Task Unit 1.4.5 (Quartermaster Unit)
Task Unit 1.4.6 (Air Unit)

Task Group 1.5 (Army Air Group)

Task Unit 1.5.1 (Tactical Operations Unit)
Task Unit 1.5.2 (Photographic Army Air Unit)
Task Unit 1.5.3 (Instrumentation and Test Requirements Unit)
Task Unit 1.5.4 (Air Transport Unit)
Task Unit 1.5.5 (Air Service Unit)
Task Unit 1.5.6 (Army Drone Unit)

Task Group 1.6 (Navy Air Group)

CV-38	SHANGRI-LA
CVE-117	SAIDOR
AVP-49	ORCA

<u>ComDesRon - 5</u>

<u>DesDiv-51</u>

DD - 834	TURNER	DD - 883	N. K. PERRY
DD - 835	C. P. CECIL	DD - 787	KYESS
DD - 882	FURSE		

Task Group 1.7 (Surface Patrol)

DesRon - 7

DesDiv - 71

DD - 722	BARTON	DD - 725	O'BRIEN
DD - 723	WALKE	DD - 770	LOWRY
DD - 724	LAFFEY		

DesDiv - 72

DD - 692	A. M. SUMMER	DD - 694	INGRAHAM
DD - 693	MOALE	DD - 781	R.K.HUNTINGTON

Task Group 1.8 (Service Group)

Task Unit 1.8.1 (Repair and Service Unit)

AD	- 14	DIXIE	AR	- 6	
AG	- 74	COASTERS HARBOR	ARB	- 3	PHAON
AO	- 54	CHICKASKIA	ARB	- 8	TELEMAN
AO(W)	- 11	TOMBIGBEE	ARD	- 29	
AO(W)	- 61	SEVERN	ARG	- 6	CEBU
AO	- 69	ENOREE	ARL	- 11	CREON
AKS	- 4	POLLUX	ARL	- 24	SPHINX
AKS	- 13	HESPERIA	AS	- 11	FULTON
ATA	- 124		AW	- 2	WILDCAT
ATA	- 187		IX	- 150	QUARTZ
ATF	- 75	SIOUX	IX	- 158	LIMESTONE
ATF	- 100	CHOWANOC	LST	- 388	Rec. Ship
ATF	- 107	MUNSEE	LST	- 861	P. O.
ATF	- 118	WENATCHEE	YC	-1009	
YF	- 733		YF	- 991	
YF	- 754		YF	- 992	
YF	- 990		YF	- 734	
YF	- 735		YF	-735	
YF	- 385		YF	- 752	
YF	- 753		YOG	- 63	
YO	- 199		YOG	- 70	
YO	- 132		YW	- 92	

Task Unit 1.8.3 (Despatch Boat and Boat Pool)

LSD - 25	SAN MARCUS	APB - 44	PRESQUE ISLE
LSD - 5	GUNSTON HALL	PGM - 23	
LCT - 1361		PGM - 24	
LCT - 1461		PGM - 25	
LCI - 977		PGM - 29	
LCI - 1091		PGM - 31	
LCI - 1062		PGM - 32	
LCI - 1067			

Task Unit 1.8.4 (Medical Unit)

AH - 13	BENEVOLENCE
AH - 9	BOUNTIFUL

Task Unit 1.8.5 (Survey Unit)

AGS - 4	BOWDITCH	AGS - 10	JOHN BLISH
YP - 636		AGS - 13	JAMES M. GILLIS
YMS - 354			
YMS - 358			
YMS - 413			

Task Unit 1.8.6 (Construction Unit)

53rd Construction Battalion

Task Unit 1.8.7 (Rongerik Evacuation Unit)

LST -871
LST -989

* Target Vessels

Appendix IV

LIST OF PERSONNEL

DIRECTOR OF SHIP MATERIAL

SOLBERG, T. A., R. Adm.

KNISKERN, L.A., Capt.
SLAVEN, F. W., Capt.

EDSON, N. D., Comdr.
FOSTER, F; X., Comdr.
LAMOREAUX, R., Comdr. (CEC)

ANDERSON, R. G., Lt.Comdr.
COIL, J. A., Lt.Comdr.
FRASER, O. W., Lt. Comdr.
JACKSON, H. A., Lt.Comdr.
RODDIS, L. H., Lt. Comdr.

DIBERTO, E. J., Lt.(jg)
MC CROSKY, D. H., Lt.(jg)
SNOW, E., Lt.(jg)

BLABER, O. J., Ens.
MCKEON, W. J., Ens.

PULA, T., Ens.
STELZER, R. B., Ens.
SWANSON, D. R., Ens.
TARDY, H. E., Ens.
WATKINS, V. B., Ens.

ELLIS, R. E., CY
MAYER, J. J., CY
O'LEARY, A. J., CY
SWEET, C. L., CY

RICHARD, M., Y1c
WARD, L. F., Y1c

JOHNSON, R. K., Y2c

DIXON, C. E., S1c
FRANK, L. J., S1c
OLINE, R. A., S1c

BUREAU OF SHIPS GROUP

FOREST, F. X., Capt.
BELL, R. C., Capt.
CREASOR, P. S., Capt.
MAXWELL, W. S., Capt.
LAMONS, E. W., Capt.
HONSINGER, L. V., Capt.

ARNOLD, H. A., Comdr.
BATCHELLER, E. H., Comdr.
BETHEA, J. S., Comdr.
BREZ, H. M., Comdr.
CUNDIFF, C. R., Comdr.
FEE, J. J., Comdr.
GAASTERLAND, C. L., Comdr.
HOFFMAN, E. J., Comdr.
KEHL, G., Comdr.
KELLER, W. W., Comdr.
ROE, J. W., Comdr.
SHIRLEY, J. V., Comdr.
SNYDER, J. C., Comdr.
WATERS, J. M., Comdr.

ERICKSON, J. A., Lt. Comdr.
GLOSTEN, L. R., Lt. Comdr.
GROSSWENDT, H. L., Lt.Comdr.
HORRELL, J. C. Lt. Comdr.
MAC KAY, P., Lt. Comdr.
RITCH, J. B., Jr., Lt.Comdr.
TOWNE, S. R., Lt.Comdr.
TUCKER, H. C., Lt. Comdr.
ZEIGLER, G. E., Lt. Comdr.

BOYCE, E., Lieut.
DULING, H., Lieut.
HATHAWAY, K. G., Lieut.
KATZENSTEIN, E. S., Lieut.
POHL, H. A., Lieut.

DISTEFANO, J. F., Lt.(jg)
MARTIN, J. J., Lt.(jg)
MC ALEER, R. W., Lt.(jg)

REED, J. W., Elect.
WATTS, A. L., Elect.

MAXWELL, W. S., jr., CM
DEMILLE, G. P., CY
GOULDEN, H. E., CY
HOLLANDER, C. H., CY
ANDERSON, E. E., Y2c
ARMSTRONG, R., Y2c
BRASSEY, E. B., Y2c
KINNISON, W. J., Y2c
NEWLAN, W. L., Y2c
TURPIN, G. W., Y2c
GRAHAM, C. A., Y2c
GARDNER, J. E., Y3c
MESSMORE, C. D., Y3c
PORTER, R. A., Y3c
DIPAOLA, A., GM1c
OSTERGOOD, K., GM1c
SMITH, P. R., TC1c
GILLIAM, W. F., CM2c
SKINNER, F. V., F1c
BRYSON, V. G., jr., S1c
BUTLER, J. B., S1c
CREST, T. H., S1c
DAPPER, E. F., S1c
HAMPTON, A., S1c
MALLORY, C. W., S1c
OSBORNE, C. E., S1c
REED, R. F., S1c
SADDLESON, G. J., S1c
SEGALL, M., S1c
SHAW, D. B., S1c

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SHERMAN, R. E., S1c
WOOLET, W. E., S1c
WREN, W. W., S1c
CARPENTER; J. L., S2c
FOERG, R. P. S2c
KULICK, H., S2c

MITCHELL, M. L., S2c
PRADO, N., S2c
SEADALE, S. A., S2c
SHADDI, W. E., S2c
SLATER, G. A., S2c
YATES, H. D., S2c

CIVILIAN PERSONNEL

AMICK, W. K.
ARMSTRONG, W. J.
BLAND, C. F.
BOWMAN, N. L.
BOEHLY, N. W.
BUTT, W. G.
COCHRANE, H. P.
CULPEPPER, E. G.
DECKER, C. A.
ELLIOTT, S. B.
EPPES, C. E.
FLETCHER, A. E.
FROMUTH, R. L.
GRABLE, G. B.
GRIGG, J. C.
JUCCIARONE, N. T.

KEARNS, J. J.
KUNDE, C. O.
LAPHAM, E. G.
LOVELL, K. R.
MADISON, J. C.
MEYER, R. M.
MC KEAN, W. B.
MILLER, R. D.
OLDSON, N. P.
PANOFF, R.
SMITH, H. F.
STECHER, E. B.
STROPE, W. E.
THIELMAN, A. C.
VASTA, J.
WISE, W. P.

DAMAGE CONTROL SAFETY SECTION

SCHNEIDER, O., Capt.

COHEN, M., Comdr.

BANKHEAD, A. J., Lieut.Comdr.
EMMETT, J. E., Lieut.Comdr.
MC COY, J. J., jr., Lieut.Comdr.
MUSSER, H. O., Lieut. Comdr.
ROBBINS, J. J., Lieut. Comdr.

COMBS, H. W., jr., Lieut.
GOLAS, S., Lieut.
MORRISON, G. W., jr., Lieut.
TIDWELL, H. B., Lieut.
WILLIS, R. E., Lieut.

HARDIN, L. V., Lt.(jg)
SARSFIELD, J. J., Lt.(jg)
SYKES, F. W., Lt.(jg)

ROGERS, A. L., Ens.
VONRADESKY, H., Ens.

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BUREAU OF ORDNANCE GROUP

MOTT, E. B., Capt.
PIGGOT, C. S., Capt.

FREEDMAN, A. S., jr., Comdr.
DUDLEY, H. C., Comdr.
O'NEIL, E., Comdr.
MC KNIGHT, J. T., Comdr.
RUSSE; F. W., jr., Comdr.

CAVENDER, J. L., Lt. Comdr.
COCO, A. J., Lt. Comdr.
FOX, E. S., Lt. Comdr.
JAQUISS, G. J., Lt. Comdr.
JOHNSON, T. W., Lt. Comdr.
RAGSDALE, M. M., Lt. Comdr.
SIMPSON, J. P., jr., Lt. Comdr.
TATUM, H. M., Lt. Comdr.
TAYLOR, H. B., Lt. Comdr.
VANCE, C. F., Lt. Comdr.

ANTHONY, E. R., Lieut.
DICHTEL, W..J., Lieut.
DICKERSON, C. D., Lieut.
GANNARELLI, A., Lieut.
KILLORIN, F. H., Lieut.
POPKO, S., Lieut.
RAMSDELL, C. A., Lieut.
SICARD, E. A., Lieut.
SIMPSON, W. A., Lieut.
SUTTON, F. M., Lieut.
TROUTT, R., Lieut.

BILLING, W. M., jr., Lt.(jg)
CYNAR, W. P., Lt. (jg)
DENTON, H. H., Lt. (jg)
MOORE, H. S., Lt.(jg)
WEGSTEIN, J. H., Lt.(jg)

CARTER, T. L., Ens.
CONNALLY; H. E., Ens.
GROVE, H. L., Ens.
MORRISON, T. D., Ens.

COALE, V. B., ChGun.
DAHL, A. A., Mach.

CIVILIANS

DYER, A. C.
GREEN, C. A.
HUNTER, W. A.
KATELL, A.
LAPHAM, E. G.
LESSIG, O. I.
SARANIERO, E. J.
SCOTT, J.
STOCKARD, J. M.

MCDONOUGH, E. T., CY
SORMRUD, S. R., CY
SLACK, D. L., Y1c
WHITEHEAD, M. H., Y1c
SAMBORSKI, E. T., Y2c
ANNACONE, E. T., Y3c
HUDAK, J. C., Y3c
KEPNER, D. M., Y3c
DESENA, P. J., S1c (Y)
JARZYWA, W. G., S1c(Y)
SLOAN, W. B., S1c(Y)

GOODMAN, G. jr., ACFC
NOLTE, C. A., ACOM
WILLIAMS, B. G., AOM2c

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EVANS, P. J., CSAO
FOSTER, T. D., CSAO
MICHA, P., CSAO
SINGLETON, W. R., CSAO

GORMAN, R. T., CFC
HAMMILL, K. H., CFC
JONES, R. A., CFC
KAMERY, D. V., CFC
ROMIG, C. V., CFC
SMITH, W. L., CFC
WEST, V., CFC
JOHANSON, R. C., FC1c

DICKISON, J. M., CMN
WOMACK, J, P., CMN
LEVY, M. L., MN1c

BARRY, E. A., PhoM2c
GAERKE, C. E., PhoM3c

HILL, R. C., ETM3c
SANDO, J. R., ETM3c

HEATH, H. P., CTC
WILLS, T. T., CTC
BRUENE, A., CTC
MCENTIRE, D. E., TC1c

B ERRY, A. R., CGM
HICKOX, C. R., CGM

MYER, L. B. CGM
PRICE, C. M., CGM

MC GIBBON, R. C., GM1c
STANGIL, T. T., GM1c
FINCHER, W. M., GM3c

BLANTON, J. R., CTM
EDDLAM, K. W., CTM
FENTON, R. J., CTM
FITZSIMMONS, K. J., CTM
LEWIS, F. R., CTM
MILLER, J. A., CTM
MILLER, R. R., CTM
MILLER, W. L. CTM
MONKS, J. R., CTM(E)
CASTRO, G. R., TM1c
DOOLITTLE, R. G., TM1c
HARMON, T. L., TM1c
LARGE, W. G., TM1c
LESLIE, D. C., TM1c
SAWYER, C. D., TM1c
BOUCHEY, G., TM2c
CASPERS, H., TM2c
CORRIGAN, J. F., TM2c
GOLDEN, J., TM2c
HALL, J. M., TM2c
HAYWARD, J. T., TM2c
ROSLING, E., TM2c
THEABOLD, E., TM2c
WINICK, M., TM2c

BUREAU OF AERONAUTICS GROUP

LONNQUEST, T. C., Capt.
DODSON, J. E., Capt.

LEYDON, J. K., Comdr.
REEDY, J. R., Comdr.

HOKINS, W. A., Lieut.Comdr.
TAYLOR, H. B., Lieut.Comdr.
TORREY, J. A., Lieut.Comdr.

MORRISON, J., Maj., USMC

ARNOLD, J. T., Lieut.

DAY, J. J., ACOM
MCINTIRE, G. R., ACM
MOORE, J. W., CY
NORRIS, E. E., ACM
RUOTALA, A. W., ACMM
WALDRON, J. W., CY

ARMY GROUND GROUP

FREDERICK, J. D., Col.
JORDAN, L. P., Col.
WEBER, J. H., Col.

BROWNING, F. W., Lt.Col.
DAUBERT, H. H., Lt. Col.
DAVIDSON, J. W., Lt. Col.
GOLDMAN, M. S., Lt.Col.
MUSSELMAN, S. F., Lt.Col.
SMITH, S. B., Lt. Col.

BREDIN, R. A., Maj.
CHERRY, E..K. , Maj.
CLARK, L. E., jr.,Maj.
DAVIES, R. J., Maj.
GRANT, G. P., Maj.
JANOWSKI, T. R., Maj.
WALTERS, E. K., Maj.
ULRICH, J. A., Maj.

ADAMS, H. C., Capt.
BELL, G. L., Capt.
BORSELLINO, J., Capt.
BUCHANAN, E. E., Capt.
DAY, J. S., Capt.
ELKO, J. J. Capt.
FINKLEMAN, N., Capt.
GRIMES, D. L., Capt.
HALEY, A. G., Capt.
HUSE, R. N., Capt.
MATTHEWS, V. C., Capt.
MIELKE, R. A., Capt.
NOVAK, W. G., Capt.
QUICK, G. H., Capt.
ROWAN, R. S., Capt.
SAMUSSON, L. F., Capt.
SMITH, W. G., Capt.

TAIPALE, T. A., Capt.
THORNBRUE, C. N., Capt.
WOLLENBERG, C., Capt.

ALEXANDER, J. F., 1st Lt.
BIPPUS, E. S., 1st Lt.
BUNKER, E. R., jr., 1st Lt.
DONOHUE, E. J., 1st Lt.
DYBER, J. A., 1st Lt.
GRAHAM, J. J., 1st Lt.
KING, W. B., jr., 1st Lt.
LEGERSKI, J. B., 1st Lt.
LOVE, U., 1st Lt.
MAURY, E. S., 1st Lt.
MORT, T. A., 1st Lt.
POWERS, D. U., 1st Lt.
TAYLOR, R. R., 1st Lt.
WINDBLAD, C. F., 1st Lt.

ANDREWS, E. R., 2nd Lt.
ANDERSON, L. E., 2nd Lt.
BROOKS, J. M., 2nd Lt.
GERTH, J. H., 2nd Lt.
LINEBERRY, F. L., 2nd Lt.
MARTIN, N. R., 2nd Lt.
MC SORLEY, F. N., 2nd Lt.
MENGIS, C. L., 2nd Lt.
MEREDITH, J. A., 2nd Lt.
PUGACZ, A. O., 2nd Lt.
WOTIZ, J. H., 2nd Lt.

CONSTABLE, E. R., 1st/Sgt
SCULL, J. D., 1st/Sgt
ADAMS, H. H., M/Sgt
ASMAN, A., M/Sgt
BIEMER, P. I., M/Sgt
EVANS, R. A., M/Sgt

KUESTER, F. E., M/Sgt
LEFEVRE, J. R., M/Sgt
PARKER, W. L., M/Sgt
PHILLIPS, J. C., M/Sgt
RHODES, T. C., M/Sgt
SHEETS, W. L., M/Sgt
STECH, E. J., M/Sgt
TUCKER, T. G., M/Sgt
WARNKE, A..H., M/Sgt
ARRIGONA, J. S., T/Sgt
BROWN, W. A., T/Sgt
CAIN, B. F., T/Sgt
HALE, C., T/Sgt
JENTES, C. L., T/Sgt
MESSERALL, F. T., T/Sgt
MORDAN, J. F., T/Sgt
O'BRIEN, W. J., T/Sgt
PAYE, R. W., T/Sgt
PERKINS, W. D., T/Sgt
REED, A. R., T/Sgt
WALKER, G. T., T/Sgt
WALL, F. V., T/Sgt
WHITE, L. D., T/Sgt
ALLAN, G., jr.,S/Sgt
ARMSTRONG, J. B., S/Sgt
CLEGG, E. T., S/Sgt
COOPER, J. H., S/Sgt
FOWLE, J. S., S/Sgt
GNADT, J. F., S/Sgt
HARRISON, A. B., S/Sgt
HERMSMEIER, A. A., S/Sgt
HUNTER, J. S., S/Sgt
MCCARTHY, W. F., S/Sgt
REN, L. E., S/Sgt
SANCHEZ, A., S/Sgt
SEUSS, R. J., S/Sgt
THORSON, M. T., S/Sgt
WIANT, A. N., S/Sgt
WILLIAMS, R. S., S/Sgt

COLLINS, R. D., T/3
GRABLE, C. F., T/3
HIATT, W. R., T/3
MAY, R. T., T/3

BARNES, E. W., Sgt
BOWERS, R. L., Sgt
BRAUN, K. L., Sgt
CASSITY, E. A., Sgt
DIPPEL, L. E., Sgt
HILLMAN, E. S., Sgt
JESIOLOWSKI, E., Sgt
MARL, D. S., Sgt
PATRICK, W. L., Sgt
SHOEMAKE, R. W., Sgt
SPENCER, J. E., Sgt
STRAND, O. J., Sgt
STUERMER, H. A., Sgt
WICKE, R. L., Sgt

AHLSTRAND, M. C., T/4
ASHLEY, V. G., T/4
BRADSHAW, E. C., T/4
BROOKS, W. D., T/4
BUTLER, D. W., T/4
CARP, G., T/4
COOK, J. R., T/4
DRUM, E. W., T/4
FORESTER, A. G., T/4
JULIE, L., T/4
KNIBLOE, W. E., T/4
LANGSTON, W. W., T/4
MATUZESKI, R. R., T/4
MCCLELLAND, J. P., T/4
MENDEL, R., T/4
NUCCI, E. J., T/4
PATTEN, M. C., T/4
RUBENSTEIN, M. L., T/4
SEELLY, M. A., T/4

STAUVERMAN, R. J., T/4
WEISS, A. A., T/4
WIRTH, D. P., T/4

BARBER, H. E., Cpl
BASEY, H. E., Cpl
KESSLER, H. M., Cpl
O'NEAL, R. C., Cpl
VICORY, A. H., Cpl
BEAUCHAMP, T. E., T/5
BONNETT, G. L., T/5
BROWN, A. C., T/5
CECIL, T. A., T/5
COLE, D. B., T/5
CRAWFORD, J. A., T/5
CRNICH, A. F., T/5
DURAND, J. B., T/5
DURKEE, W. C., T/5
FIELDS, D. C., T/5
HARPER, F. A., T/5
HENNAN, J. J., T/5
KIRKPATRICK, E., T/5
KLEIN, H. R., T/5
LERUD, R. H., T/5
LUDDEN, E. R., T/5
MOXLEY, N. H., T/5
MURRAY, D. E., T/5
RAPP, G. C., T/5
SALASSI, W. L., T/5
SEGEL, K. D., T/5
SHRANK, A. V., T/5
SNELTJES, W. L., T/5
STANKIEWICZ, S., T/5
TRIMM, J. T., T/5
WIETRICK, W. J., T/5
ABBOTT, F M., pfc
BAIR, K. D., Pfc
BENDLAGE, M. W., Pfc
BOOSA, F. D., Pfc
CAMPBELL, K. W., Pfc

CHANEY, J. E., Pfc
CHING, C. Y. L., Pfc.
CHONG, H. W. K., Pfc
COLE, E. S., Pfc
COLLINS, R. A., Pfc
COX, F. jr., Pfc
DUMYHAN, G. F., Pfc
ETTER, B. G., Pfc
FAIR, J. L., Pfc
FESLER, J. J., Pfc
FISHER, D. M., Pfc
FRANCO, P. J., Pfc
GAILEY, R. K., Pfc
GRANT, A. G., Pfc
GRANTHAN, C. H., Pfc
HALLEY, G. E., Pfc
HALPERN, S. E., Pfc
HANNAN, J. A., Pfc
HARRISON, J. H., Pfc
HAVENS, L. J., Pfc
HAYES, R. R., Pfc
HEDGES, E. J., Pfc
HOLTZCLAW, J. L., Pfc
HOWARD, E. jr., Pfc
HURST, R. S., Pfc
IRRER, C. E., Prc
IRWIN, H. J., Pfc
KNIGHTON, G. W., Pfc
LAKNER, J. F., Pfc
LATTA, C. B., Pfc
LEWIS, J. D., Pfc
MASTIN, J. J., Pfc
MCGEHEE, G. H., Pfc
MILHORN, M. H., Pfc
MORGAN, J. H., Pfc
MULKEY, R. A., Pfc
NIELSON, A. W., Pfc
NORRIS, W., Pfc
PARSONS, F. J., Pfc
PENDERGRASS, C., Pfc.

PIERCE, L., Pfc
POWER, F. J., Pfc
RILEY, H. J., Pfc
ROBERTS, C. A., Pfc
ROBINSON, D. W., Pfc
ROSEN, D. E., Pfc
SANDALL, W. jr., Pfc
SATTLETIGHT, L. W., Pfc
SEAKE, J. T., Pfc
SHAW, R. J., Pfc
SPRAGUE, P., Pfc
THORNTON, E. W., Pfc
TRAILER, P. R., Pfc
WALTERS, F. A., Pfc
WALTER, H., Pfc
WEIDE, W. jr., Pfc
WHITNEY, J. R., Pfc
WILLIAMSON, F. jr., Pfc
WOLFE, R. W., Pfc
ACKER, W. W., Pvt
BARRY, R. H., Pvt
BATEMAN, R. B., Pvt
BELLOT' ', A. E., Pvt
CANDOLORE, W., Pvt
CHASE, G. D., Pvt
CREDO, R. F., Pvt
CROSS, S. T., Pvt
CURTIS, M. L., Pvt
DAVIDSON, G. C., Pvt
DEPARASIS, O. A., Pvt
DIETZ, B. T., Pvt
DOOLEY, J. M., Pvt
DOYLE, M. J., Pvt
DUERR, C. A., Pvt
DUNCAN, R. E., Pvt
DYLEWSKI, S. W., Pvt
ENGELMYER, E. R. Pvt.
FERGUSON, J. E., Pvt
FISHER, W. S., Pvt
GILLESPIE, G. B., Pvt

HALLAM, R. C., Pvt
HANING, H. G., Pvt
HARSCH, G. F., Pvt
HAYES, R. D., Pvt
HECKMAN, L. T., Pvt
HENRY, B. jr., Pvt
HILL, R. C., jr., Pvt
HITE, R. C., Pvt
HOFFA, F. J., Pvt
JAMES, E. C., Pvt
JAROSINSKI, R. S., Pvt
JAY, H. P., Pvt
JONES, L. G., Pvt
JONES, R. L., Pvt
KEENE, E. G., Pvt
KIEFFER, R. J., Pvt
KOVARIK, F. A., Pvt
KRIEGSHAUSER, W., Pvt
LAUDENBERG, J. L., Pvt
LEONE, J. J., Pvt
LISSAUER, E. R., Pvt
LONG, C. T., Pvt
LONTOS, A. L., Pvt
LORCH, R. E., Pvt
MCGREW, J. D., Pvt
MCGUIRE, R. A., Pvt
MC HUGH, F. P., Pvt
MEROLA, J. D., Pvt
MIEMCZEWSKI, J., Pvt
MONTANELLI, D. C., Pvt
MURAKAMI, M., Pvt.
NELSON, J. H., Pvt
NORTON, L. E., Pvt
ORR, D. L., Pvt
PHILLIPS, R. A., Pvt
PRICE, J. W., Pvt
RAK, H. F., Pvt
REYNOLDS, E. F., Pvt
RICHARDS, J. D., Pvt
ROWLEY, K. G., Pvt

RUPERT, E. J., Pvt
RUSSELL, W. L., Pvt
RYMER, W. W., jr., Pvt
SCHUBER, A. F., Pvt
SHEPHERD, B. T., Pvt
SIMMONS, G. F., Pvt
SPERA, J. P., Pvt
STEVENS, B. A., Pvt
STRAUSSFOGEL, E., Pvt
TURSI, R. R., Pvt
TUTTLE, P. R., Pvt
UPTON, E. T., Pvt
WARREN, H. E., Pvt
WESOLOWSKI, M., Pvt
WILSON, J. R., Pvt.
WINN, R; A., Pvt.
WISE, M. E., Pvt.
WITSCHEY, J. F., Pvt
YERMAN, G. L., Pvt

UNCLASSIFIED

DRAEGER, R. H., Capt. (MC)
LANG, F. R., Capt. (MC)
WARREN, S., Capt. (MC)

LEE, R. H., Comdr. H(S)
TULLIS, J. L., Comdr. (MC)

CRONKITE, E. P., Lt.Comdr.(MC)
SMITH, R. E., Lt.Comdr. H(S)

EICHER, M., Lieut. H(S)
MADDEN, R. J., Lieut.H(S)

HARRIS, C. A., Lt.(jg) (MC)
PARK, J. T., Lt.(jg) (D)L

ARMY PERSONNEL

DECORSEY, E., Col.
CAHOON, D. H., Maj.
WAGERS, R. P., Capt.
BOYERS, C.L., Jr.,1st Lt.
HOFFMAN, E. D., 1st Lt.
BEVERIDGE, G. W., 1st Lt.

CIVILIANS

Dr. W. H. BATCHELOR
R. F. COWING
J. C. FRANKENFELD
R. L. EVANS
F. C. MACINTOSH
Dr. E. E. POCHIN

RUEGSEGGER, A., CMMA
SHAW, J. M., jr., CMMS
WISE, J. J., jr., MMS2c

PATTERSON, W. R., CM1c
SHOW, L. J., CM1c

FERGUSON, E. E., CRM

FILTEAU, T.W., CPhoM
COPE, H. F., PhoM3c

GROVES, C. O., jr., CY
LANDRY, E., CY
PODESTA, J. J. CY
WILSON, J. E., CY
BIRD, J. A., Y2c
DEVORE, B., Y2c
RIDENOUR, G. E., Y2c
SAWYER, F. H., Y2c
MILLER, H. H., Y2c
CORRALL, A., Y3c

WAGNER, C. E., CPhm
KELLY, F. J., PhM1c
WARREN, L., PhM1c
ESCOBAR, E., PhM2c
GORDON, L. H., PhM2c
HAVRANEK, R. E., PhM2c
SCHACHER, C. J., PhM2c
BARLOW, G., PhM3c
BINION, W. W., PhM3c
CARSON, B. E., PhM3c
DEMORROW, D. L., PhM3c
DEXTER, R. L., PhM3c
LEWIS, L. B., PhM3c
OLSON, A. L., PhM3c
RAYMAN, D. R., PhM3c
WILSON, J. M., PhM3c

MILLER, J. G., SK3c

ROBERTSON, R., Cox.

ERICKSON, M. N., S1c(Y)
HARSHBARGER, E., S1c(Y)
NILSON, E. H., S1c
PEDERSON, H., S1c
STOCKSTILL, T., S1c
TRAVIS, J. L., jr., S1c
ALLEN, R. L., S2c
AUDAS, G. E., S2c
BARROW, W. E., S2c
BOUGHTER, R. S., S2c
BROCK, R., S2c
CALLIHAN, R. F., S2c
CARHART, K. S., S2c
CARY, J. R., S2c
CLEARY, D. F., jr., S2c
COOK, O. L., jr., S2c
CRIM, J. R., S2c
DEBOLT, R. M., S2c
DOSECK, H. R., S2c
DYER, E. L., S2c
EARNHARDT, J. R., S2c
FEHLING, R. J., S2c
FELIX, J. T., S2c
GILL, J. V., S2c
GOMETZ, N. G., S2c
GORMAN, W. P., S2c
GREENLEE, E. J., S2c
GRIDER, L. J., S2c
HEILMAN, A. H., S2c
HENSON, R., S2c
HITTLE, W. S., jr., S2c
HOVEL, E. E., S2c
KENT, E. D., S2c
LIPPS, D., S2c
MAGRUM, N., jr., S2c
MASSEY, F. L., S2c
MASTROSTIFANO, A., S2c
MC CLOSKEY, L. V., S2c
MC GRORY, F. V., S2c
MIRACLE, J. E., S2c
MOBLEY, C. E., S2c
MURPHY, T., S2c
NELSON, J. F., S2c
PHILHOWER, E. R., S2c
POTTER, A. T., S2c
REEVES, G. A., S2c
RISSE, E. J., S2c
RITCHEY, J. W., S2c
SCHOWALTER, D. W., S2c
SEGURA, R. M., S2c
SNYDER, R. R., S2c
SWARD, K. L., S2c
TAYLOR, J. R., S2c
THOMAS, D. S., S2c
TOMASZEK, G. J., S2c
VOGT,,L. J., S2c
WILLIAMSON, R. M., S2c
WRIGHT, R. E., S2c

[redacted]

ELECTRONICS GROUP

ENGLEMAN, C. L., Capt.

BUSENKELL, C. C., Comdr.
HAWES, W. W., Comdr.
HOUPIS, J. G., Comdr.
MILLER, J. L., Comdr.
RICE, J. E., Comdr.

BUCKLES, R. A., Lt.Comdr.
CRAFT, J. H., Lt.Comdr.
FRITTS, F. S., Lt.Comdr.
HAYLOR, R. M., Lt.Comdr.
JORDAN, R. A., Lt.Comdr.
NORTON, H. M., Lt.Comdr.
RAGSDALE, J., Lt.Comdr.
REASER, R. L., Lt.Comdr.
RUPERT, C. S., Lt.Comdr.
VAN LIERE, W. R., Lt.Comdr.

BELL, O. K., Lieut.
BERSHAD, L., Lieut.
BOYCE, E., Lieut.
BRANNIN, F. H., Lieut.
CRENSHAW, W. H., Lieut.
DOWNEY, C. L., Lieut.
EARL, W. C., Lieut.
EVERINGHAM, L. R., Lieut.
GERUNTHER, B., Lieut.
HENRY, L.H., Lieut.
HORTON, W. H., Lieut.
IJAMS, C. C., Lieut.
LEGERSKI, J. R., Lieut.
LEWIS, B. G., Lieut.
LOVE, U., Lieut.
MELLISH, R. W., Lieut.
MILLER, C. E., Lieut.
MURPHY, N. F., Lieut.
NICHOLS, R. L., Lieut.
PEARSON, R. B., Lieut.

RAGAZZINI, L. J., Lieut.
SIGDA, J. R., Lieut.
SIZER, E. V., Lieut.
TOPP, I. H., Lieut.

ANDERSON, E. E., Lt.(jg)
BISSETT, E. B., Lt.(jg)
BROOKS, W. L., Lt.(jg)
DOBBIE, C. B., Lt.(jg)
GYTON, W. J., Lt.(jg)
HOCKFIELD, R., Lt.(jg)
HOLTON, D. S., Lt.(jg)
HOTZE, J. A., Lt.(jg)
KELLY, D. E., Lt.(jg)
MASTERMAN, H. W., Lt.(jg)
MEAD, O. J., Lt.(jg)
MORRIS, J., Lt.(jg)
MUETHER, H. R., Lt.(jg)
NITCHALS, J. L., Lt.(jg)
READ, C. J., Lt.(jg)
REGAN, J. P., Lt.(jg)
ROBERTSON, H. L., Lt.(jg)
SCHUSTER, N. A., Lt.(jg)
VAN RENNES, A. B., Lt.(jg)
VAN RENNSSELAER, C., Lt.(jg)
WILLIAMS, R. L., Lt.(jg)

ANDERSON, G. W., Ens.
ARNOLD, C. E., Ens.
BADORF, C. E., Ens.
BANKS, R. B., Ens.
CALLAHAN, J. H., Ens.
CONWAY, J. F., Ens.
COSTAS, M. P., Ens.
FAND, R. M., Ens.
FITCH, J. L., Ens.
FORREST, H., Ens.
FUSS, E. L., Ens.
GEROW, G. P., Ens.

GRAETER, R. J., Ens.
HOFFER, E. S., Ens.
JARRIS, D. S., Ens.
JAPSON, R. S., Ens.
KNOX, T. B., Ens.
LEAR, W. E., Ens.
MARSHALL, J. W., Ens.
MC CARTHY, J. R., Ens.
METTLER, R. F., Ens.
MOORE, H. C., Ens.
RITT, R. K., Ens.
STELZER, R. S., Ens.
YEAKEL, A. H., Ens.
YOUNG, F. W., Ens.

COLOCHICCO, T. R., CRE
CROSS, R. J., CRE
GREINER, J. L., CRE
MANDIGO, G. P., CRE
MC CORMACK: J. E., CRE
UZUPUS, J. A., CRE
WILSON, H., CRE
NESTER, C. S., CRE

ARMY PERSONNEL

DOUGLAS, R. H., 1st Lt.
MAURY, E. S., 1st Lt.

BUCKSPAN, E., 2nd Lt.
BUNKER, E. R., 2nd Lt.
GERTH, J. H., 2nd Lt.
HILFMAN, H. N., 2nd Lt.
MEREDITH, J. A., 2nd Lt.

ENLISTED

SQUIER, E., jr., CY
VAN SICKLE, R., CY

EGGERT, J. V., Y1c
MALAIER, E. H., Y1c
PERKINS, C. J., Y1c
WILLIAMS, J. B., Y1c

AUSTIN, W. S., Y2c
MC FATRIDGE, T., Y2c
OSMAN, E. D., Y2c
THARP, C. R., Y2c
VACCARI, R. P., Y2c

DE LOSH, D. M., Y3c

LANDRY, R. F., S1c(Y)
SANDERS, G. D., S1c(Y)

JOHNSON, H. C., CETM
LACEY, D. L., CETM
DIGNAN, T. J., ACETM
PETERSON, W. L., ACETM
STUART, R. F., ACETM
STULL, J. A., ACETM

CONKLIN, D. L., ETM1c
FREBEL, N. P., ETM1c
KNOEBEL, H. W., ETM1c
SCOTT, R. P., ETM1c
MARTENS, R. W., AETM1c

ATCHISON, J. L., ETM2c
ARNETT, J. W., ETM2c
BARNETT, D. D., ETM2c
BICKER, R. H., ETM2c
BLACKBURN, C. A., ETM2c
COUCHEY, S. H., ETM2c
BRECKENRIDGE, R., ETM2c
BURGER, R. M., ETM2c
CALLIN, W. J., ETM2c
CARTLEDGE, L., ETM2c

COMER, M. D., ETM2c
DERMOTT, W. P., ETM2c
EICHEN, E., ETM2c
EMERSON, R. N., ETM2c
FUNK, C., ETM2c
FELTS, R. W., ETM2c
FREUND, H. R., ETM2c
GOTTHELF, J. L., ETM2c
HICKMAN, W. E., ETM2c
HOUSER, T. S., ETM2c
HULME, R. L., ETM2c
JACOBS, J. A., ETM2c
JACOBSON, A., ETM2c
KAUTZER, C., ETM2c
LAYTON, R. H., ETM2c
LICHTMAN, D., ETM2c
LOWE, D. K., ETM2c
LOZIER, T. W., ETM2c
MADDEN, D. W., ETM2c
MARFUT, A., ETM2c
MATSON, C. S., ETM2c
MC INTYRE, G., ETM2c
MERRIT, R. E., ETM2c
MIDDLETON, J., ETM2c
MITCHELL, T., ETM2c
MOHN, G., ETM2c
MUDGETT, W. L., ETM2c
NEFF, W. H., ETM2c
OBERHOLTZER, J., ETM2c
OGILIVE, J. L., ETM2c
O'REAR, J., ETM2c
PENTASUGLIO, D., ETM2c
ROSSELL, C. F., ETM2c
RUSPINO, J. C., ETM2c
RYNDERS, R. G., ETM2c
SAVAGE, G., ETM2c
SEARS, N. E., ETM2c
SINCOX, J., ETM2c
SOUTHERLAND, J., ETM2c
SPANGLER, C., ETM2c
SPEARS, M. S., ETM2c
TOURNMAN, J. H., ETM2c

VEST, S. E., ETM2c
WHITE, J. E., ETM2c
WINEMAN, T. S., ETM2c
WORKMAN, W. F., ETM2c
ZAK, E. T., ETM2c

AGER, J. W., ETM3c
ALMOND, R. M., ETM3c
BAKER, R. G., ETM3c
BARNES, G. L., ETM3c
BERNHOLDT, A., ETM3c
BORG, W. E., ETM3c
BULEN, C. W., ETM3c
CEARLEY, C. R., ETM3c
CHAMBERS, R. A., ETM3c
CHRISTIANSEN, C., ETM3c
CORNELISON, L., ETM3c
DAVIES, W. R., ETM3c
DEUTSCH, M. J., ETM3c
DEWEESE, R. E., ETM3c
DONKERSLOOT, D., ETM3c
FALL, R. C., ETM3c
FEHRER, K., ETM3c
FLYE, R. W., ETM3c
CABBOW, J. S., ETM3c
GAGNON, A. L., ETM3c
GALLAGHER, A. H., ETM3c
GORDON, H. J., ETM3c
GRAEBER, R. N., ETM3c
GREENBERG, H. I., ETM3c
GROTH, R. A., ETM3c
HARMS, E. A., ETM3c
HANSEN, H. H., ETM3c
HAYES, D. R., ETM3c
HEEBNER, D. R., ETM3c
HEGARTY, J. F., ETM3c
HOLT, H., ETM3c
ING, S. C., ETM3c
JIRAL, J., ETM3c
JOHNSON, D. D., ETM3c
JONES, W. C., ETM3c
JUNKEL, W. C., ETM3c

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KATTNER, D. N., ETM3c
KEISER, V. H., ETM3c
KLEIN, M. L., ETM3c
KOETS, H., ETM3c
KUTTAS, G., ETM3c
LAMBERT, J. A., ETM3c
LASKOWSKI, W. J., ETM3c
LE CLEAR, M., ETM3c
LYNCH, J. B., ETM3c
MAHLIE, J. C., ETM3c
MALMAK, L. D., ETM3c
MC CLAY, A. J., ETM3c
MORTON, C. H., ETM3c
MURPHY, J. J., ETM3c
NASLUND, K. C., ETM3c
NUGENT, K. C., ETM3c
ORDERMANN, F. W., ETM3c
PHIPPS, H. S., ETM3c
PORTER, J. C., ETM3c
POWERS, R. R., ETM3c
REBBEIN, J. R., ETM3c
ROGERS, C. L., ETM3c
ROSEBOOM, E. H., ETM3c
SANDLER, H., ETM3c
SCHROEDER, H. E., ETM3c
SMELOFF, R..K., ETM3c
SPAREY, J. W., ETM3c
STAMLER, R. S., ETM3c
STANLEY, H. T., ETM3c
TIBLIN, B. V., ETM3c
TORKELSON, L., ETM3c
WALMSLEY, H., ETM3c
WENGLER, E., ETM3c
WILLIAMS, R., ETM3c
ZAPLYN, P. A., ETM3c

CARDNER, W. H., AETM2c
CLARK, R. B., AETM2c
DAWSON, R. S., AETM2c
ELLIOT, W. S., AETM2c
GOSLOVICH, S., AETM2c

KESSLER, W. D., AETM2c
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MOEDE, L. W., AETM2c
NAHRSTEDT, V. L., AETM2c
PARKS, D. G., AETM2c
REEBS, D. W., AETM2c
SCHROTH, W. A., AETM2c
SHEAR, H. AETM2c
WILEY, F. L., AETM2c
WORTS, R. B., AETM2c

COLE, R. W., AETM3c
COWDERY, R. R., AETM3c
DENNEY, C. G., AETM3c
DREHNER, T. W., AETM3c
EVERSOLE, W. P., AETM3c
FORTE, M. P., AETM3c
FUGLER, G. C., AETM3c
FUSS, D. L., AETM3c
GARTENBERG, R., AETM3c
GATES, R. F., AETM3c
GELBER, M. Z., AETM3c
GOMBINER, A. A., AETM3c
HARRIS, F. K., AETM3c
HOLLER, R. B., AETM3c
HUNT, F. C., AETM3c
HUNTER, J. R., AETM3c
KASER, K. S., AETM3c
KEENE, A. W., AETM3c
KENNEY, J. J., AETM3c
KIEHLER, F. W., AETM3c
LAFAIR, T. J., AETM3c
MAJESTIC, W., AETM3c
MASEK, G. G., AETM3c
MC CARTHY, C. A., AETM3c
MC CORTRIN, D., AETM3c
MEYER, J. W., AETM3c
MILLER, W., AETM3c
MITCHELL, D. E., AETM3c
MOEHRING, J. T., AETM3c
MONAHAM, N. R., AETM3c

MOSER, D. R., AETM3c
NEUBECKER, T. F., AETM3c
PARKS, D. G., AETM3c
PAYNE, D. G., AETM3c
POGUST, F. B., AETM3c
POLAKOFF, A., AETM3c
PROPER, L. L., AETM3c
RAKOSNIA, A., AETM3c
REICHEL, S., AETM3c
RENGUETTE, G., AETM3c
ROBERTSON, R., AETM3c
RODGERS, D., AETM3c
ROSENBLUM, R., AETM3c
SMITH, B. G., AETM3c
SMITH, F. J., AETM3c
SNYDER, R. V., AETM3c
SOUTHARD, J. B., AETM3c
STINSON, M., AETM3c
STONE, A. L., AETM3c
THOMPSON, T., AETM3c
UTZIG, L. J., ETM3c
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CIVILIANS

ALBEE, M. M.
ALDERSON, W. S.
ANDERSON, W. S.
ALLEBACH, F. S.
BAECHLER, C. W.
BALLOU, H. A.
BLOEDORN, C. A.
BONER, J. C.
BRACKNEL, A. H.
BROCKWAY, L. I.
BROOKS, P. J.
BURBAGE, G. H.
BURRUS, R. C.
CAMPAGNA, J. H.
DEBEL, C. A.
DICKSON, J. F.
DONZE, H. E.
EGGERT, J. H.
EWING, R. D.
FINK, D. G.
FISHER, F. W.
FRAUMANN, J. W.
GERTEL, M. V.
GILES, R. C.
GONSTEAD, A. R.
GORDON, H.
GORO, F.
GOSSLAND, J. K.
GRIGGS, R. W.
GUTHRIE, R. C.
HAGADORN, J. R.
HANSCOME, T. D.
HANYSZ, E. A.
HAWLEY, A. A.
HILL, J. E.
HUMISTON, H. A.
INSLERMAN, H. E.
KAN, G. S.
KELL, R. E.
KELLIHER, J. F.
KIMLEY, H. B.
KLEIN, E.
LANIER, R. S.
LAUDON, R. E.
LIENEMANN, L. H.
LIPTON, M. A.
MACKAS, G.
MANYSZ, E. A.
MC CLUNG, R. R.
MC COUBREY, A. O.
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MOORE, W. J.
MORGART, J. M.
MORAN, R. B.

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NELSON, A. A.
OERTEL, M. F.
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PERRIN, A. B.
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RIX, E. H.
ROBINSON, J. G.
SCHAEFER, W. E
SHOUPE, W. E.
SMITH, R. A.
STONE, W. G.
STRAPP, J. P.
SWARTZEL, K. D.
TANNER, H. A.
TAYLOR, W. I.
TISDALE, E. M.
TURK, G. E.
VENN, D. A.
VIOLETTE, R. J.
WAITE, A. H.
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FISHER, D.
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FRIEL, S. J.
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HARTZ, F. J.
HENDRICIAN, J. P.
HORNADAY, G. J.
HUDSON, G. E.
JANSEN, W. R.
JENSEN, H. E.
JOHNSON, C. T.
JOHNSON, H. M.
JOSEPH, H. M.
KSANDA, C. F.
LAMB, T. J.
LOVELL, W. A.
MC GINLEY, J. G.
MC GOLDRICK, H. J.
MITCHELL, W. W., jr.
OLIVER, R. H.
POPIEL, W.
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RIPLEY, K. C.
ROMAINE, W. R.
RUSS, F. J.
SETTE, W. J.
SNIFFIN, M. T.
STILLER, B.
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TAYLOR, I. J.
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WAGLEY, C. A.
WALSH, J. P.

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SARGENT, M. C., Lt. Comdr.
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FULTON, A. S., Ens.
TIMMER, B. W., Ens.

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KINZEK, C. B., Capt. (Army)
TRAYLOR, M. A., Capt. (USMC)

SADLER, M. E., Ylc

MATAZESKI, R. R., T/4
MURRAY, D. E., T/5

CIVILIANS

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ARCOLEO, C.
AUSTIN, T. S.
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BATES, C. C.
BELKNAP, E. C.
BERNIER, H. P.
BLACK, J.
BROCK, V. E.
BUMPUS, D. F.
CHRISTOFFERSEN, A. P.
CLARKE, A. H.
COATES, G. A.
COKE, P. E.
COLE, D. L.
DOHERTY, R.
DOSS, C. L.
EMERY, K. O.
EWING, G. C.
FORBES, A.
FORD, W. L.
GURLEY, E. F.
HARLOW, S. R.
HOADLEY, L. D.
HOFFMEISTER, J. E.
HOLTER, N. J.
HUNT, O. E.
ISAACS, J. D.
IVERSON, H. W.
JOHNSON, J. W.
JOHNSON, M. W.
KEEGAN, H. J.
KIERNAN, E.
KNAUER, R. C.
KOHLER, T. F.
KRANCE, E. K.
LADD, H. S.
LAFOND, E. C.
LYON, W. K.
MANN, H. J.
MARR, J. C.
MARSHALL, C. T.
MC DONOUGH, G. E.
MC INTYRE, A. B.
MILLER, C.
MILLEY, F. C.
MILLEY, R. H.
MORRISON, J. P.
MORSE, L.

MUNK, W. H.
O'BRIEN, M. P.
PARKINSON, J., jr.
PEARCE, T. H.
PENROSE, E. T.
PETERSON, C. W.
RICHARDS, J. L.
RILEY, G. A.
SCHULTZ, L. P.
SHELTON, S. P.
SMITH, L. E.
TAYLOR, G. C.
TAYLOR, W. A.
TRACEY, J. I.
TRIPP, R. M.
TURNER, H. J., jr.
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VON ARX, W. S.
WARNER, S. E.
WEHE, T. J.
WESTERFIELD, R. C.
WESTFALL, H.
WHALEY, H. H.
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WINGATE, N. C.
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ORDNANCE INSTRUMENTATION GROUP

UEHLINGER, A. E., Capt.
MC KEEHAN, L. W., Capt.
SCHUYLER, G. L., Capt.

BRUNAUER, S., Comdr.
LOMBAER, F. R., Comdr.

BALLARD, S. S., Lt. Comdr.
CHEESMAN, E. L., Lt. Comdr.
MILBURN, H. N., Lt. Comdr.
PEARCE, R. E., Lt. Comdr.
SIMONS, J. L., Lt. Comdr.
STROLLO, G. F., Lt. Comdr.
WILCOX, A. R., Lt. Comdr.
YEO, F. L., Lt. Comdr.

ANDERSON, J. H., Lieut.
DURR, H. H., Lieut.
EMOTT, R. W., Lieut.
GARDNER, M. B., Lieut.
HALEY, R. F., Lieut.
KOOS, E. M., Lieut.
RIORDAN, J. J., Lieut.

DOERRES, J. H., Lt. (jg)
EVANS, T. P., Lt. (jg)
KIRMSER, P. G., Lt. (jg)
LEEDOM, E. C., Lt. (jg)
REYNOLDS, J. T., Lt. (jg)
SCHWARTZ, J. A., Lt. (jg)
TOME, J. M., Lt. (jg)
WAKEFIELD, M. T., Lt. (jg)

BRIGHAM, C. W., Ens.
JACOBS, E. E., Ens.
LIMBERG, D. R., Ens.
O'BRIEN, B., jr., Ens.
WALTER, R. I., Ens.
WHELAN, E., Ens.

HARLAN, H., CEM

MOLCHAN, H., CY
MONSANTO, F. M., CY

KELLEY, A. D., MMlc

BENTLEY, J., TM2c

HAMMON, J. C., Slc
SIMONDS, A. C., Slc
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ALLEN, A. B.
ANDERSON, R. R.
ANDERSON, S.
ARMANTROUT, C. W.
ARONS, A. B.
ATANASOFF, J. V.
BEMIS, M. M., Jr.
BENNETT, H. E.
BERESFORD, R.
BIGGART, R. H.
BLAIR, R. H.
BORCHER, C. A.
BOWLES, W. A.
BRADLEY, C. H.
BRAY, C. E.
BROWN, C. S.
BROWN, D. R.
BURCHAM, D. P.
BURLINGTON, R. S.
CARLSON, S. O.
CARR, T.
CARROLL, I. A.
CASSEN, B.
CLARKSON, H. N.

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CLARKESON, H. N.
CLEMENTS, W. A.
COLES, J. S.
COON, R. H.
COURANT, R.
CROXFORD, N. G.
CURTIN, E. L.
CURTIS, W. E.
DAVIS, A. S.
DAVIS, D. B.
DEAN, R.
DOBRIN, M. B.
DOLAN, M. A.
DROSD, R. D.
ENG, D. Y.
ENGELBERG, E. L.
ERICKSON, K. W.
FINK, D. M.
FINKELSTEIN, R. J.
FOSTER, K. W.
FYE, P. M.
GALLOWAY, W. C.
GAMOW, G.
GARDNER, W. A.
GEBALLE, R.
GLASS, J. M.
GLICKMAN, L.
GORDON, W. H.
GRAY, G.
HADDAD, S. P.
HALL, S. T.
HANSON, M. N.
HARTMANN, G. K.
HAUVER, C. C.
HEDELMAN, S.
HELFENBERGER, D. B.
HENDERSON, J. E.
HENKER, M. M.
HIGGS, P. M.
HIXSON, C. E.
HOBLIN, L. E.
HOLMES, E. A.
HULBERT, E. O.
HUMPHREY, R. D.
HUTT, F. O.
JACOBS, I. M.
JENKINS, F. A.
JOHNSON, T. H.
KELLEY, J. E.
KEMBEL, W. H. jr.
KENNEDY, W. P.
KIRKHAM, D.
KIRKWOOD, J. G.
KNUTSEN, C.
KRAMER, F.
KITCHENS, J.
LAMP, E. C.
LAMPI, E. E.
LAMPSON, C. W.
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LEVENSON, A. S.
LEWIS, P. A.
LIEBSON, S. H.
LOOMIS, G. J., jr.
MACDOUGALL, D. P.
MARLOWE, D.
MAYNARD, H. C.
MC ADAMS, J. E.
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MC QUILLING, D. W.
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MILLER, B. C.
MILLER, C. E.
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MOORE, W. H.
MORE, D. E.
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NASH, H. F.
NEAL, I. O.

NELSON, M. L.
NICHOLSON, C. P.
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O'BRIEN, B.
OSBORNE, R.
PEARSON, A. A.
PETERSON, E. F.
PILGRIM, R.
PIPES, D.
POLACHEK, H.
POWELL, J. H.
PURSEL, W. W.
RAFF, S. J.
RAND, P. C.
RANDALL, C.
READ, T.
RITCHIE, J. A.
RITTER, P. B.
ROACH, F. E.
ROBERTSON, J. B.
ROBERTSON, L. M.
RODMAN, I.
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RULAND, B. F.
RUMBAUGH, L.
SANDERSON, J. A.
SCHNEIDER, L.
SCHULTZ, W.
SEEGER, R. J.
SHAFER, P. E.
SIDNAM, R. D.
SILBEY, G. A.
SLUSSER, C. H.
SLUTSKY, M.
SMID, T. C.
SMITH, J. M.
SNAVELY, B. L.
SNYDER, J.
SPROESSER, E. L.
STANTON, J. S.
STEWART, E. C.
STEWART, H. S.
TALBERT, W. W.
TEETER, M. B.
TELLER, E.
THOMPSON, D. A.
TROUNSON, E. F.
TRYTKO, B. P.
UTT, L. M.
VON NEUMANN, J.
WALLACE, B. M.
WEIGEL, W.
WELLER, R.
WERTHEIMER, A.
WEYL, F. J.
WHITE, G.
WHITE, T.
WOTRING, A. W.
WRIGHT, E. R.
WYCKOFF, C.

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