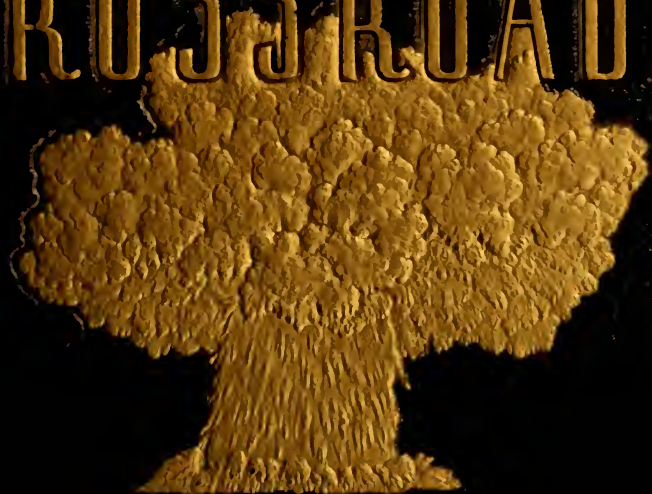


# OPERATION CROSSROADS



the official pictorial record















# OPERATION CROSSROADS

*The Official Pictorial Record*

The Office of the Historian  
Joint Task Force One

1946  
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*A Message from the Commander  
Joint Task Force One*

**T**HIS pictorial record of Operation CROSSROADS must be dedicated to the 42,000 men—civilians and servicemen, who made the gigantic experiment possible. It is the record of a job well done. It is a record which makes impressively clear the extent of the preparations made over a period of months. The variety of activities constituting Joint Task Force ONE is also evident. The Operation called for a multitude of skills and talents. And from every man it demanded hard work. All this is apparent from the record.

From the standpoint of the general public, Operation CROSSROADS constitutes a further example of the type of cooperation between the services—the Navy, Army Air Forces, Army Ground Forces, and civilian scientists and technicians, to which the people of the United States became accustomed during the recent war.

For obvious reasons these photographs no more than hint at the tremendous amount of data obtained concerning the effect of the bombs upon ships and material. They necessarily slight the technical and scientific lessons learned at Bikini. They do, however, evidence an incontestable truth. The Atomic Age is here. It is no myth. Nor is the atomic bomb "just another weapon." It is the most lethal destructive agent yet devised by man. Its energy release is staggering; its radioactivity is slow-killing poison.

The purpose of these tests was to determine the effect of the atom bomb against various types of naval vessels. With the information secured, we can improve our ship design, tactics, and strategy, to minimize our losses in the unfortunate event of war waged with atomic weapons. A reliable and continuously effective plan to avoid competition in atomic armaments is the best possible defense against surprise attacks. With such a plan, atomic energy can in time become the controlled slave of man's peacetime pursuits. In the face of this new knowledge, these recently discovered truths concerning the atom, so suddenly thrust upon an already chaotic world, not only warfare but civilization itself literally stands at the Crossroads. Hence the name of this operation.

*W. M. Blum*

## Foreword

**N**O MAN really saw what happened at Bikini. Approximately 42,000 persons, drawn from the four corners of the globe, travelled thousands of miles to stage and witness the tests. But an atomic bomb defies scrutiny. It shuns publicity. It shields its intense life-span in a flash of light many times the brilliance of the sun. It dazzles human eyes. It limits its life to a matter of millionths of a second. It enshrouds itself in a cloud. And then it dies, mushrooming grotesquely to high altitudes as if for a better view of the havoc it has produced.

Even if pent up beneath the surface of a lagoon it resists observation. Where before it blinded the eye here it succeeds in blinding the mind. In a matter of seconds it tosses up a column of tons of water higher than the Empire State Building. It sinks ships in a moment and crushes others into the deformed, stepped-on shape of a child's bath-tub toy. Itself the result of man's intellect, the bomb defies examination by its creator.

And yet the Bikini tests were thoroughly observed. Supplementing human onlookers were 10,000 instruments, and among them cameras, constructed to record what the human eye could never see. Cameras are inquisitive instruments with long memories. In the field of atomic research they are indeed star witnesses. Their story may appear differently to the scientist and the layman. But all may grasp its general significance.

For those who attended the tests these photographs may serve as the lasting momento of a unique experience. For those who did not they should serve to provide perspective concerning the atomic bomb, and give better knowledge of one of the largest scale ventures in experiment ever attempted by man. This foreword has been written with that end in view, and to place Operation CROSSROADS properly in the history of the bomb.

### Previous Bombs

**P**RIOR to July 1946 three atomic bombs had been detonated—one above the New Mexico desert, two more above the Japanese cities of Hiroshima and Nagasaki. For an already weakening Japan these bombs spelled defeat. The bombing of Hiroshima, on August 5, 1945 (Greenwich Mean Time) constituted the first military use of the bomb. Nagasaki was hit on August 9 (G.M.T.). On August 14, only nine days after Hiroshima, Japan surrendered unconditionally.

Now it could be told . . . the "best-kept secret of the war," the story of secret research in the field of nuclear physics, the successful tapping of the tremendous energy of the atom, the mass production of materials to make use of this energy in the form of a bomb. The perplexing language of science dominated the columns of the daily press. Laymen throughout the United States scratched their heads and attempted to understand.

One thing was clear. The bomb constituted a revolution in pre-existing concepts of tactics and strategy. The tremendous striking power of the single, unaccompanied bomber over Japan, taken to be a reconnaissance weather plane by those on the ground, was retold with each succeeding bulletin describing the doomed cities. But just how much of a revolution did the bomb represent? No one knew the answer to that question.

### Trinity Test

It was true that Bomb Number One, the first atomic bomb ever detonated by man, had been exploded "under laboratory conditions." This was the so called Trinity Test, conducted in the great, roofless laboratory of the New Mexico desert near Alamogordo on July 16, 1945. The Trinity Test had been observed by scientists, military observers and by hastily-set up instruments. But the instru-



mentation was meagre. The test was carried out during wartime with emphasis on secrecy and the rapid development of a bomb for use in bringing to an end a war that had already cost the lives of millions. Alamogordo represented a proving ground, not an elaborately instrumented experiment. As a source of scientific data concerning the bomb it left much to be desired.

The subsequent uses of the bomb at Hiroshima and Nagasaki were carried out under combat conditions. They, too, were of little significance from a technical point of view. They did provide data concerning the effect of the bomb on a city of the Japanese type; but this data was entirely in the form of rough estimates proving little.

### Bomb vs Ships

TO many this question arose: What effect would an atomic bomb have on a fleet of naval vessels? Much thought had been given to this question during the development phases of the bomb. As early as 1944 the Manhattan Engineer District, charged with development of the bomb, had given serious consideration to the possibility of "testing" one of its atomic bombs against the Japanese Navy at Truk Island. And just after the surrender of Japan Senator Brien McMahon of Connecticut made a speech in the Senate in which he advocated the use of the atomic bomb against the captured Japanese fleet.

Speculation on this subject followed diverse lines. What amount and type of damage would the bombs produce in the first instance? To what extent should accepted principles of ship design be altered in future construction? What defensive measures could be taken by a ship attacked with atomic missiles? Were traditional tactical practices outmoded?

### Joint Task Force ONE

TO answer questions like these the Joint Chiefs of Staff, with Presidential approval obtained on January 10, 1946, created Joint Task Force ONE; its mission: to carry out the atomic bombing of a target array of naval ships. Vice Admiral W. H. P. Blandy was designated Commander. This Task Force comprised a total of more than 200 ships, 42,000 men, and 150 aircraft. It included members of the Navy, Army Air and Ground Forces, and civilian scientists. Its directive ordered one test of the bomb in air above the target fleet,

and a second detonation in the water, slightly below the surface.

Two tests were necessary. The air and subsurface bursts constituted quite different test situations. This difference can be quickly told. When exploded in air at low altitude, as in Test "Able," an atomic bomb subjects everything in its vicinity to violent air-blast and intense radioactivity. Much of the radioactivity is dissipated into the upper atmosphere in the so-called "mushroom cloud." Ships subjected to the bomb were expected to receive, and did receive a severe air blast or concussion. Crews on the test ships, had there been any, would undoubtedly have suffered many casualties from the lethal radioactivity.

Test "Baker," the underwater shot, utilized the bomb's tremendous energy release in a different way. The huge pressure built up by the bomb under the water was transmitted to the underwater portions of the neighboring ships. Ship hulls were by this pressure forced inward on all sides at once. Furthermore, since the bomb was submerged in the lagoon, its radioactivity was prevented from passing instantly into the upper atmosphere. Intense and lasting radioactivity was produced in the water of the lagoon. The ships, drenched by tons of water thrown up by the explosion, became similarly contaminated. The extent of such contamination proved a matter of great interest.

### Bikini

THE Bikini Atoll, a typical Pacific Ocean island group in the Marshalls, was chosen as the site of the test. It is 2000 miles southwest of Hawaii, and 4150 miles from San Francisco. Several factors made Bikini an excellent choice. Its size was ideal—an atoll of several small islands surrounding a lagoon 20 miles long and 10 miles wide. Average depth of water inside the lagoon was approximately 200 feet, a good anchorage for the target ships. The Atoll is remote from fishing areas, steamer lanes. It is located 250 miles north of Kwajalein, a suitable base from which the bombing plane could operate. Its weather conditions were excellent.

### Preparations

PLANS for the Operation went forward during the Spring and early summer of 1946. Surveys of the Bikini lagoon were made, its waters combed for truant Japanese mines, its natives evacuated

to another island. The islands were sprayed with DDT to insure healthful conditions for Task Force personnel. Towers to house cameras and television apparatus were built. At Kwajalein the available airfield installations were readied for the arrival of the Air Group. Laboratories for chemical analysis and photograph processing were constructed. Little by little the ships of the target array assembled and were brought to Bikini, most of them through Pearl Harbor, which hummed with activity. Installations of special equipment had to be made on many vessels. Salvageable ship materiel was removed. Army equipment scheduled to be secured to the decks of the target ships and exposed to the bomb's destructive force was placed aboard. The German cruiser "Prinz Eugen" moved from European waters to Philadelphia and on to the Pacific. From Japan steamed the captured Japanese battleship "Nagato" and the light cruiser "Sakawa." Also to their rendezvous with destiny came the valiant old battleship "Pennsylvania," commissioned in 1916 and once flagship of the United States Fleet, the 30-year-old veteran "Nebraska," first of the Navy's oil-burning super-dreadnaughts, the rugged carriers "Saratoga" and "Independence."

Several plans for the arrangement of the target fleet were considered and revised. The directive creating the Operation specified a disposition of ships to give a gradation of damage from maximum to minimum. Major damage to ships close to the explosion point, minor damage to ships at the outskirts of the target circle, would provide valuable means of analyzing the bomb's elusive fury. The final disposition appears schematically at a later place in this book. The concentration of ships, from a Navy point of view, was obviously artificial. More than 20 ships were compressed within 1000 yards of the bulls-eye ship. Ordinarily such an area would be used to contain but a single capital ship in a carrier force at sea, or three capital ships in a normal anchorage. The principle of using an arrangement that would provide graduated damage, instead of one representing a tactical formation or anchorage, was followed in both tests.

### Instrumentation

THE instrumentation program at Bikini constituted the heart of the Operation. More than 10,000 instruments were placed about on target ships, in shore and observer ship and aircraft in-

stallations. Simple and complex, the instruments included many that were familiar long before Bikini, many developed specifically for these tests. Various staff divisions under the Technical Director concentrated on apparatus. Their names hint at the breadth of scientific observation planned: bomb operation; pressure and shock; wave motion and oceanography; electromagnetic propagation and electronics; radiological safety; radiation; radiometry; technical photography.

The ships themselves were in a real sense instruments, their recorded behaviour in the face of the explosions revealing much of the nature and development of the gigantic forces produced. Ingenious instruments on the ships measured roll and pitch, recorded strain experienced by plates and ribs, wrote down the temperature of ship interiors, tested surrounding air for contaminating radioactivity, radioed their findings to the observer fleet miles outside the lagoon. Drone, or unmanned, radio-controlled boats and planes played an important part. The boats collected samples of the radioactive lagoon water when it was still too "hot" to handle. Drone planes penetrated where no man could have ventured, flew through the mushroom cloud on photographic missions, sampled its poisonous content, televised to remote onlookers their instrument panel readings for flight analysis.

Cameras at Bikini took more than 50,000 stills and 1,500,000 feet of movie film. One camera, presumably the world's largest aerial camera, used a 48-inch focal length telephoto lens capable of taking a legible photograph of the dial of a wrist watch a quarter of a mile away. One high-speed movie camera operated at the rate of 1000 pictures per second.

### Pre-test Training

THE tests required special training of the 42,000 men who serviced the Operation. Procedures were set up for placing the thousands of instruments, for their care and activation, the collection of their data. Underwater photography techniques were developed as an aid in recording the data from sunken ships. The drone plane and boat programs, Army and Navy, greatly advanced the art of radiocontrol apparatus and its manipulation. The fact that Test Able was but the third atomic bomb ever dropped from a bomber provided the Army Air Forces with an incentive for considerable

valuable and much-needed training in a practically untried field. AAF training for Bikini began in January 1946 at Roswell Field, New Mexico. It concerned drone operation and the bombing mission, the crew for which was selected after rigorous competition.

At Pearl Harbor the Navy trained fire-fighting and damage control teams for the exacting work of first reboarding the target ships after each test. This work was important in saving instruments from destruction from secondary causes following the explosions, and in advancing the time for safe general inspection of the ships. To safeguard personnel from radioactivity, radiological monitors were schooled in the use of Geiger counters, which detect contaminated areas.

As July 1, 1946 (Bikini time), the date set for Test Able, drew near—weather permitting—weather forecasters frowned deeper over the inexorable data on their charts, and in the end made a perfect prediction of clear weather suitable for the tests. Much depended upon their accuracy. Drone planes tried their wings over Bikini; and the varied photographic, reconnaissance, and press planes of the Operation plan rehearsed once more the detailed courses they

were to follow. On "Queen Day" the dress rehearsal of Test Able was held. Everything went smoothly. Months of training and planning had borne fruit.

### The Tests

ON July 1, 1946 it was the real thing. The conspiracy of men and instruments against the bomb came into the open. Soon after the first test the collection of data began—the reading of the apparatus, the amassment of facts which would take months to appraise. On July 25 Bikini time (July 24 G.M.T.) came Test Baker, with the bomb slightly below the surface of the water in the lagoon. This time the work of reentry was retarded by the contamination of the water. Ships were washed down and made "Geiger sweet," that is, free from harmful radioactivity. Concerning the atomic bomb, time for bombast had ceased, the time for analysis of results had begun. The photographs that follow make no pretense at providing results and conclusions that are even now being prepared. It is however hoped that they will aid a greater understanding of Operation CROSSROADS and, more important, further the intelligent discussion of the momentous issues it so urgently represents.

Office of the Historian,  
Operation CROSSROADS.

Washington D. C.  
1 November 1946



**THIS IS BIKINI.** The picturesque village street of Bikini, with coarse particles of coral underfoot and coconut palms overhead is typical of the Marshall Islands. Tranquil beside the clear water of the lagoon it borders, Bikini is nowhere more than ten feet above the level of the sea. Its temperature

is high and uniform the year round, averaging 80 degrees Fahrenheit, with night temperatures but 12 degrees lower. Humidity is high, with a heavy precipitation of rainfall, about 80 inches per year, or double what it is in Washington, D. C. The tropical heat is mitigated by strong sea breezes.



**MAP OF THE PACIFIC.** The Bikini Atoll, one of 34 atolls making up the Marshall Island group, is but a dot on the navigator's chart of the vast reaches of the Pacific. Even in the modern age of flight it may accurately be described as one of the remote places of the earth. Its very re-





moteness favored its selection as the site of the atomic bomb tests. Discovered in 1526 by a Spanish sea captain, the islands were rediscovered and named by the English captains Gilbert and Marshall in 1788. The islands became a Japanese mandate after World War I.







#### NATIVE GRAVEYARD. ABOVE.

In this native cemetery lie the ancestors of the modern Bikinians who, in February 1946, agreed to give up their homes and memorials to permit the staging of the atomic bomb tests. Gravestones at Bikini are often shaped in the outline of a man's head and shoulders, as shown in the center of the above group. During the war Japanese saki bottles and colored glass floats, salvaged from Jap fish-nets, became popular as grave decorations. RIGHT. Private property among the young is hampered by the lack of pockets. OPPOSITE. ABOVE. With ample supplies of pandan available for thatch, no housing shortage exists anywhere in the Marshall Islands. The mild climate permits light construction with open sides and matted floors. BELOW. Map of Bikini Atoll. The target array was located in the northeast part of the Lagoon, about 2 miles southwest of Bikini Island.





**ATOMIC BOMB BRAIN TRUST.** On March 20, 1946 Major General Leslie R. Groves, Commanding General of the Manhattan Engineer District, presented the Medal for Merit and citations from President Truman to five University of Chicago scientists known throughout the world for their pioneer researches in nuclear physics. Left to right: Gen. Groves; Enrico Fermi, self-exiled Italian physicist and Nobel Prize winner, who built the first slow-neutron chain-reaction pile (fall of 1942); Robert S. Stone, visiting professor of roentgenology; Harold C. Urey, Nobel Prize winner, discoverer of heavy water; Samuel K. Allison, Director of the M.E.D. Metallurgical Laboratory at Chicago; and Cyril Smith, an associate division head at Los Alamos in charge of preparation of fissionable materials for bomb construction.

**AT HOME ABROAD.** OPPOSITE. King Juda, sitting on bench, relaxes with some of his subjects and listens to the regular noonday broadcast from Station WXLG on Kwajalein, 250 miles south of Bikini. This photograph was taken on Rongerik Island, 130 miles east of Bikini, to which the Bikinians were evacuated after their island had been selected as the site of the atomic bomb tests. Buildings of the new village on Rongerik appear in the background. The Kwajalein station makes regular broadcasts to the natives within listening distance. Bikinians take pride in their one radio receiver, powered by a small generator presented to them by the Navy. No need to use Winston Churchill's admonition "More tooth!" when photographing these natives. Their excellent sense of humor is evident.





**THE STAFF MEETS.** Smooth functioning of the vast Crossroads organization was assured by weekly staff meetings. A thousand-page Operation Plan was drawn up and printed specifying the plans and responsibilities of all participating groups. ABOVE. Seated, left to right: Major General W. E. Kepner, Deputy Task Force Commander for Aviation; Vice Admiral Blandy, Commander; Rear Admiral W. S. Parsons, Deputy Task Force Commander for Technical Direction; Major General A. C. McAuliffe, Ground Forces Adviser. Rear: Brigadier General T. S. Power, Assistant Deputy Task Force Commander for Aviation; Brigadier General K. P. McNaughton, Captain C. H.

Lyman, Assistant Chief of Staff for Operations; Colonel T. J. Betts, Assistant Chief of Staff for Intelligence; Colonel D. H. Blakelock, Assistant Chief of Staff for Logistics; Dr. Ralph A. Sawyer, Technical Director; Captain Robert Brodie Jr., Assistant Chief of Staff for Personnel, and Captain G. M. Lyon, Safety Adviser.

OPPOSITE. LST 1108 moves outrigger canoes from Bikini to Rongerik, while the native owner watches anxiously, wondering whether Uncle Sam's sailors will handle his primitive craft as well as they do their own. These sailing canoes are used for hundred-mile trips in the open sea from atoll to atoll.









**MOVING DAY, BIKINI TO RONGERIK.** On March 7, 1946, the population of Bikini was moved to Rongerik in LST 1108, a total of 161 persons making the trip. Rongerik had been the first choice of nine of the eleven family heads, called alaps, as the new home for the evacuees. The island is roughly triangular in shape with good topsoil and relatively heavy growth of coconuts, pandanus,

breadfruit, and arrowroot. Beaching facilities were good. The Bikini church and community house were dismantled and transported to Rongerik. Pandanus thatching for the new village on Rongerik was prefabricated. **OPPOSITE.** Seabees and Marshallese at work installing temporary canvas roofs on the new houses. Later, thatch replaced the canvas.





**CORAL HEADS ARE DYNAMITED.** Important in the preparations of the site itself for the atomic bomb tests was the blasting of coral heads from the lagoon floor. Over 100 tons of dynamite had to be used for this work. Coral heads constitute the skeletal remains of the minute animal organ-

isms also called corals, which once inhabited them. At a distance coral heads roughly resemble cubical boulders 30 feet on a side. Distinct obstructions to navigation, they were charted in initial surveys of the lagoon, which were made using fairly reliable Japanese maps as an aid, and then removed.



**CURTAIN RAISER.** These clouds of spray thrown up by the dynamite charges used to remove coral heads from the lagoon floor are but a microscopic suggestion of the titanic blast plumes heaved aloft by the second of the two atomic bomb explosions. The tempest in a teacup shown here was necessary

to aid navigation in the lagoon, to facilitate uniform mooring of target vessels, and to permit accurate study of the spread of underwater shock waves produced by the bombs. Some were removed to permit the larger landing craft access to the island beaches,



**OPEN HOUSE AT RONGERIK.** Completed houses built on Rongerik for the evacuated Bikinians resemble the one shown here. In addition to trim structures like this, nine 8 by 8 by 5-foot concrete cisterns for catching rainwater were built. A total of 23,000 gallons of fresh water was

put ashore at Rongerik to tide the village over until the beginning of the rainy season. Rongerik rainfall being slightly heavier than at Bikini, adequate fresh water was assured. Rongerik affairs are watched over by military government officials under the Kwajalein Island Commander.



**SURPRISE POSTPONEMENT.** The Bikini tests, originally scheduled for May 15, 1946, were postponed six weeks by President Truman, to July 1, in order that members of Congress, knee-deep in legislative problems, might better be spared from Washington to serve as official observers at Bikini.

**ABOVE.** Brigadier General Roger M. Ramey, Commander of Task Group 1.5, the Army Air Forces group in Joint Task Force One, reads a San Francisco headline announcing the surprise shift in dates. The delay gave more time in which to perfect the set-up at Bikini.



**SCALE MODEL "ATOMIC BOMB" TESTS.** In preparation for the Bikini tests a number of scale model experiments were conducted at the Taylor Model Basin near Washington D. C. to aid in estimating the size and character of waves that would be produced by the actual atomic bomb explosions. Scale model Victory ships were constructed of thin sheets of brass and floated in the "lagoon" shown above. Scaled amounts of TNT were used to simulate the atomic bombs. These tests were made in a specially-constructed tank known as "Little Bikini." Other studies were made on a larger scale, using 500-pound amounts of explosive, in tests conducted at the Naval Mine Warfare Test Station at Patuxent, Maryland. In both types of scaled experiments effects noted were the size of the water crater, height, persistency and diffusion of plumes. **OPPOSITE.** Scale charge is detonated.







**INSTRUMENT GRANDSTANDS GO UP.** Instruments, the eyes of the Operation, were installed on top of steel towers erected on various islands surrounding the Bikini lagoon. Television cameras mounted in these lofty grandstand seats were focussed on the target array and, when the tests occurred, permitted scientists miles from Bikini to witness what was going on at the test site. Still and motion picture cameras were also berthed on top of towers to make a permanent photographic record of what occurred. Towers were assembled on the ground and hoisted into place.





**TOWER GROUP, ENYU ISLAND.** A further view of the types of tower installations made to house delicate apparatus used to record the characteristics of the blasts. Many of the photographs in this volume and many of the best newsreel views of the explosions were taken from towers such as these. Cameras were installed inside lead-walled vaults, the doors of which were arranged to close automatically after the filming had been accomplished, thus protecting film from the harmful effects of gamma radiation. Each tower amounted to an extensively equipped observation station..



**\$64 QUESTION.** Rear Admiral W. S. Parsons, Deputy Task Force Commander for Technical Direction, clarifies a press conference query at a typical pre-Bikini session in Washington. At the table, left to right: Colonel T. J. Betts, Assistant Chief of Staff for Intelligence; Commodore J. A. Snackenber, Chief of Staff; Rear Admiral T. A.

Solberg, Director of Ship Material; and Dr. R. A. Sawyer, civilian scientist and Technical Director. Extreme right: rear row, Commander Roger Revelle, in charge of oceanographic and wave motion studies. Standing: Colonel Stafford E. Warren, Radiological Safety Adviser, and Lt. Colonel J. A. Derry of the Manhattan Engineer District.



**FROM REVOIR TO MANHATTAN.** The veteran battleship "New York," built in 1914, is nudged down the Hudson River in New York Harbor as she starts the long trip to Bikini to join the group of target vessels destined to feel the might of atomic bombing. Old and overweight by modern standards, the

"New York" saw action in both World War I and II. During the recent war the "New York" was placed on convoy duty, participated in North African landings, saw action off Iwo Jima and Okinawa. Attacked by Jap torpedoes, bombs, artillery and planes she was hit only once, at Okinawa.





#### SHIPS OF THE SUPPORTING FLEET. OPPOSITE.

Glittering with planes like a tiara-ed grande dame headed for an opening night at the theatre, the aircraft carrier "Shangri-La" passes through the Panama Canal en route to Bikini, where she was to join the supporting fleet. As shown in the upper photograph, the canal locks were so narrow that the ship's barbettes, or side gun platforms, had to be removed to permit passage. Even at that it was a tight squeeze. At Bikini the "Shangri-La" controlled the operation of Navy drone planes. The name of the "Shangri-La" commemorates the historic raid of Tokyo in April 1942 by Lt. Colonel Jimmy Doolittle's AAF B-25 bombers launched from the carrier "Hornet." The take-off place of this daring strike was referred to cryptically for a year afterwards merely as "Shangri-La." ABOVE. Brain center of the supporting fleet off Bikini was Admiral Blandy's flagship "Mount McKinley." This ship is classified as an amphibious warfare flagship.



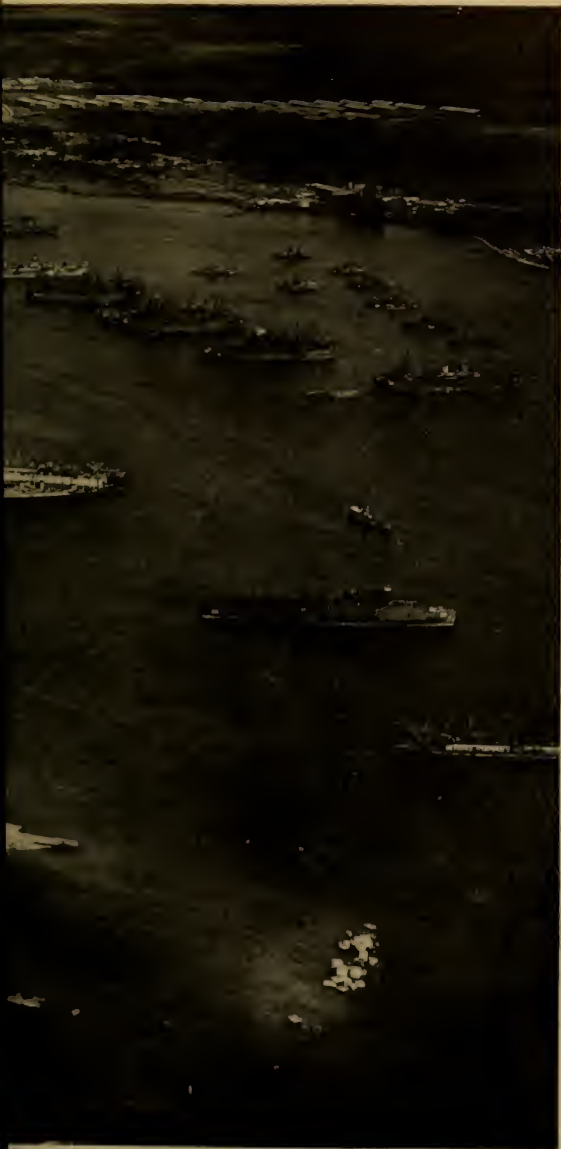


**CORAL HEADS.** Systematic surveys made prior to the tests uncovered valuable information on marine life and reef structure. At 26 localities around the atoll detailed traverses were made, showing reef profile, with its channels, pools, and caverns, and the relative abundance of various organisms and sediments. Shown above are two typical coral heads, some six feet in diameter, on the lagoon reef off Oruk Island. The central portion of these heads is a brilliant pink coral, with a different variety, yellow-green in color, forming the platelike exterior.

**HERE'S A PRETTY KETTLE OF FISH!** This remarkable photograph of small tropical fish caught at Bikini gives an excellent suggestion of their brilliant coloring and varied patterns. To determine the effect of the explosions on fish and other marine life censuses were taken before and after the tests. Fish were caught by many traditional methods such as nets, spears, and tackle; but newly developed techniques for poisoning fish were also used in carefully limited areas. Rotenone was placed in the current along the outer reefs, and the fish gathered in as they came to the surface

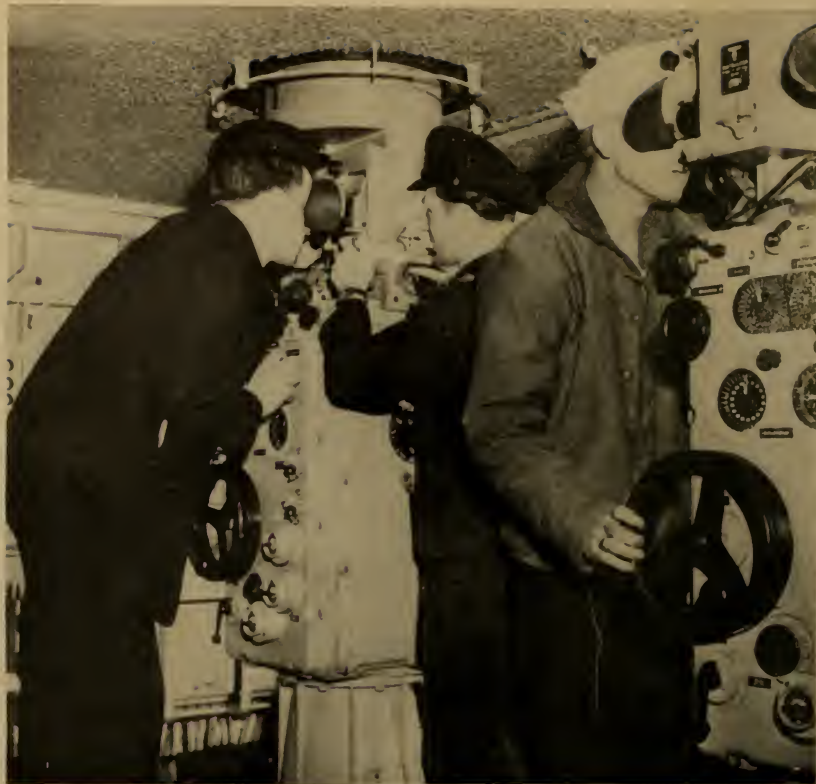






**ASSEMBLY LINE, PEARL HARBOR.** Ships of the Task Force assemble at Pearl Harbor en route to Bikini. Ship preparations for the Operation were made at various Navy Yards, including Philadelphia, Terminal Island, San Francisco, Mare Island, Bremerton, and Pearl. As means for measuring various overall effects of the atomic bomb the target vessels were themselves instruments on a grand scale, and of crucial importance. It was therefore necessary to place ship equipment and machinery in good working order, so that injury produced by the explosions could be accurately determined. Power plants, machinery, guns, turrets and other equipment were placed in the best condition possible, and the watertightness of compartments tested and improved. Army trucks and tanks were hoisted aboard and made fast. Sturdy brackets and pedestals were installed to support the thousands of instruments to be mounted when the ships reached Bikini. For some installations special electric wiring was necessary.





**PRINZ EUGEN EN ROUTE TO BIKINI.** The German cruiser "Prinz Eugen" was one of three foreign ships used in the target array, the others being the Japanese cruiser "Sakawa" and the Jap battleship "Nagato." The "Prinz Eugen" was the second of the "Admiral Hipper" class heavy cruisers built by the Germans for use in World War II. She fought several important actions in the Atlantic, Baltic Sea, and English Channel, including the engagement in 1941 which resulted in the sinking of the

"Bismarck." She accompanied the German battleships "Scharnhorst" and "Gneisenau" in their dramatic flight through the English Channel to Norway in 1942. Later beleaguered by Allied attacks of varied types, the "Eugen" was forced to Brest for repairs resulting from mines, and received a heavy bomb hit while still in drydock. Subsequently she had her stern blown off by a British torpedo. ABOVE. American sailors take over in Boston Harbor.





**PUT THAT PISTOL DOWN.** The "Prinz Eugen" is stripped of her armament at the Philadelphia Navy Yard prior to continuing to Bikini for a place in the target array. Bottled up in Gdynia during the closing years of the war, the "Eugen" was handed over intact to British Naval authorities when Germany surrendered. She made the trip to America

with a German crew, Americans replacing the Germans at Boston and Philadelphia. She was of all-welded construction. In view of her elaborate compartmentation she was generally comparable in damage resistance to a modern U. S. heavy cruiser. Former pride of Hitler's navy, she represented his "guns instead of butter" policy.





**GENTLEMEN OF THE PRESS.** Ace photographers from Acme, International News Service, Associated Press, and Life Magazine, some of whose work appears in this book, were assigned to cover the atomic tests. Photographs were handled under a pool agreement, all pictures in the pool being freely usable by pool members. The problem of security in releasing photographs was handled by a photographic panel representative of the varied responsibilities of the Task Force. ABOVE, About to embark on the "Shangri-La," left to right: Clarence L. Hamm, A. P., Sonnee Gotlieb, I. N. S., and Bob Landry, Life Magazine. OPPOSITE, ABOVE. Foredeck of the Jap battleship "Nagato," showing U. S. seamen at work freeing the wildcat on the starboard anchor chain. "Nagato" was a 35,000 ton mainstay of Japan's navy and one of her two heaviest pre-war battleships. Commissioned in 1919, she was modernized in 1936. In October 1944, when the Japs attempted to choke off American landings in Leyte Gulf, "Nagato" was part of the southern Jap naval force which tried to force the San Bernardino Straits. In July 1945 she was heavily damaged by Navy carrier planes at the Yokosuka Naval Base. BELOW. American sailors try out a community bathtub on the "Nagato."



**EVALUATION BOARD CONFERS.** The Joint Chiefs of Staff Evaluation Board, shown here in conference with Admiral Blandy, kept in close touch with the Operation even in the early planning phase, and subsequently travelled to Bikini to witness the tests. In the above view, members of the Board examine a model of Bikini Atoll with model target ships in place in the lagoon. Shown left to right are: Vice Admiral Blandy; Lt. General Lewis H. Brereton, Commanding General, First Air Force; Dr. Karl T. Compton, President, Massachusetts Institute of Technology; Rear Admiral Ralph A. Ofstie, Senior Naval Member, Bombing Survey, Naval Analysis Division; Vice Admiral John H. Hoover, Assistant Chief of Naval Operations for Materiel; Maj. General Thomas F. Farrell, USA (Ret.), former Deputy Commander, Manhattan Engineer District; and the late General Joseph W. Stilwell, until his death Commanding General, Sixth Army.

**42,000 SHOTS IN THE ARM.** Thanks in part to the requirement that all personnel going to Bikini be inoculated for typhus, typhoid, and tetanus, and vaccinated for smallpox, the JTF-1 Medical Officer, Captain W. E. Walsh, succeeded in keeping contagious diseases to an extremely low level.

However, there was one brief outbreak of dysentery on the "New York," which was temporarily quarantined off Kwajalein. Bikini Island was sprayed every two weeks with DDT, and other islands of hospital ships received few patients. the Atoll were sprayed at least once. The three







**INSIDE A GREEN HORNET.** Interior view of a big Douglas C-54 plane of the so-called "Green Hornet" line used to transport personnel and freight from the United States to Kwajalein, 250 miles from Bikini. The original "Green Hornets" were the planes of the Manhattan Engineer District's private airline used to shuttle key personnel to Tinian Island in the Marianas at the time of the atomic bombing of Japan in 1945. The new "Green Hornet" line's 12 ships were in constant trek between Fairfield Suisun, California, and Kwa-

jalein, with one or more trips scheduled daily. Usually the passenger limit was 26 persons. To the hundreds of air travellers, these specks on the global map became trite names: Hamilton Field and Fairfield Suisun in California; Hickam Field, Hawaii; Johnson Island, the Pacific's famed "unsinkable aircraft carrier"; and Kwajalein, end of the hop and 4,200-odd miles, or roughly 23 hours flying time, from San Francisco. Over these great sea distances the airline operated for months, and without accident.

**LEGISLATORS EMBARK.** Ten Representatives and four Senators journeyed to Bikini to view the atomic bomb tests. Two of the Senators, Carl A. Hatch (D) of New Mexico and Leverett Saltonstall (R) of Massachusetts, were members of the President's Evaluation Commission set up by President Truman to supplement the Evaluation Board created by the Joint Chiefs of Staff. **BELOW.** Ready to exchange one tropical clime for another, Sena-

tors and Congressmen en route to Bikini stand in the shade of the plane waiting to ferry them 7500 miles from the National Airport at Washington, D. C. to the Marshall Islands. Left to right: Senator Guy Cordon of Oregon, Senator Hatch, Senator Saltonstall, Representative Dean M. Gillespie (R) of Colorado, and W. S. Newell, civilian member of the President's Evaluation Commission, all wearing parachute harnesses.





**KWAJALEIN ATOLL.** This tiny Pacific atoll played a significant part in Operation Crossroads. From its airstrip, one end of which appears above, the atomic bombing plane "Dave's Dream" took off for its mission over Bikini. Visible in the background is the support ship "Albemarle," "Able



Mabel,<sup>10</sup> tied up at the old Japanese concrete dock. For the purposes of the Operation new asphalt plane parking areas were prepared, special fire fighting systems were installed along the runway, and special facilities were constructed for servicing the atomic bomb.









**PONTON BRIDGE INSTALLATION.** On the beach at Bikini Island, Army Ground Group engineers assemble ponton bridges, temporarily anchored off Enyu and later included in the target vessel array. Types M-4 and M-4-A2 are shown here, the M-4 utilizing the sausage-shaped pneumatic rubber floats, the M-4-A2 using a newly developed type of all-metal float (seen in shallow water just off shore). M-4 pontoons played important parts in river crossings during the advances across France and Germany in 1944 and 1945. The pneumatic floats of these bridges are inflated by means of small gasoline-powered air pumps. The standardized roadway "planks," consisting of hollow aluminum beams each weighing only 175 pounds, are quickly lifted into place. Metal floats used by Navy Construction Battalions were called (and spelled) "pontoons;" they were used at Amen and Bikini as buoyancy members of portable docks.



**RADIO-CONTROLLED FLYING FORTRESS.** At Eniwetok Island, 190 miles west of Bikini, a B-17 Flying Fortress drone plane with its landing flaps down eases in over the beach to a three-point landing. Landings and take-offs of these huge crewless planes are controlled by transmitters on

the ground. Here the transmitter is mounted in the jeep shown below the plane. Once in the air the drones are controlled by "mother" planes flying near them. Prior to Operation Crossroads, smooth radio-control of planes the size of Flying Fortresses had been thought virtually impossible.



**PUSH BUTTON FLIGHT—CARRIER BORNE.** On the deck of the carrier "Shangri-La" a Navy F6F Hellcat drone plane, its tail mooring still in place, is warmed up and controls given final adjustment prior to being sent into the air. In the foreground Lt. Commander W. G. Maurer completes tests of

the control mechanism at his finger tips. "Push button" flight is actually a misnomer. Manipulation of the electronic controls must be done by a trained flyer. Control of aircraft by radio is difficult in that the remote pilot is deprived of the actual "feel" of the plane.



**OPERATION KILOWATT HOUR.** At Kwajalein Island, during an important period in the preparatory phase of the atomic tests, electric power on the island, normally supplied by two 250-kilowatt generators, suddenly failed, with no possibility of repair until special parts had been obtained from the United States. To bridge the gap a destroyer equipped with special generator facilities was dispatched to Kwajalein, to serve as the Kwajalein supply for as long as necessary. Shown above, amphibious members of the 2,750 Air Corps personnel stationed in the Marshalls bring ashore from a power boat (not shown) the end of an electrical cable extending under water to the destroyer in the background.

**FIRST THE FISH MUST BE CAUGHT.** Dr. Leonard P. Schultz, Curator of Fishes, U. S. National Museum, left, and Captain Earl H. Herald, AUS, members of the fisheries group of the oceanographic section, examine their catch in a floating laboratory on the AGS-4 "Bowditch." Over 20,000 fish were caught by hook, net, and seine. Sonar acoustical devices were used to locate schools of fish. Some fish were caught by swimmers armed with spears and wearing face masks. Many hitherto unknown varieties of fishes were found. Some were brought back to Washington D. C. for study. Unfortunately, a large number of the specimens gathered were lost when the YP 636 carrying them went aground south of San Francisco.







**ORBIT POINT PREPARATION.** In Washington D. C. Vice Admiral W. H. P. Blandy, Commander JTF-1, and Maj. General W. E. Kepner, Deputy Task Force Commander for Aviation (both standing) and Brig. General T. S. Power (kneeling) study a "mock-up" of the air operation planned for Test

Able. The Air Plan, a sizable annex to the Operation Plan, specified position and course of each plane to be airborne on Able Day. Planes were provided for: bomb, pressure-gages, weather reconnaissance, cameras, radiological reconnaissance, drone boat control, and observers.



**PHOTOGRAPHIC MOSAIC.** Navy pilots piece together overlapping photographs, taken from high altitude, to form a single mosaic of an area, in preparation for similar projects at Bikini. Photographic mosaics were used to give accurate rendition of details of target ships and islands during the tests. Developed during the 1930's, photographic mosaic work is now a well established art. Definition is so good with the cameras used that the enlargement of a photograph of a German motor convoy, taken from an altitude of 20,000 feet, can be used to determine the license number of individual vehicles.





**PROBLEM FOR OLD SALTS.** In ten seconds estimate the number of ships visible in this picture. The correct answer is 50? 100? 200? During June, July, and August Bikini was anything but quiescent. In among the target vessels and ships of the supporting fleet innumerable puny boats ploughed the water from dawn to dusk in their endless ferrying of men and equipment from ship to ship and from ship to beach. Water taxis were in particularly great demand for ferrying VIP's and scientists to conferences and for taking technicians to the sites of their apparatus. Many of the delicate instruments used required repeated adjustment and checking; conditions of starting switches, batteries, and recording mechanisms were constant sources of concern. In the late afternoon the water gap between fleet and shore was interlaced with the wakes of boats carrying roughly 10,000 men to the shore, then rushing them back to their floating homes for chow and the invariable post-chow movie. **OPPOSITE.** Supplies come aboard. For the 42,000 men of JTF-1 daily requirements were: 70,000 candy bars, 30,000 cigarettes, 40,000 pounds of meat, 89,000 pounds of vegetables, 4,000 pounds of coffee, 38,000 pounds of fruit.





**TRANSPACIFIC GAMBIT.** Halfway across the Pacific on the 14-day voyage from California to Bikini, newspapermen aboard the press ship "Appalachian" indulge in a silent game of chess. Octavio Guzman, Mexican journalist, at the left, plays A. M. Khokhlov, Russian newspaperman. Thoughtful kibitzers of the game include Stephen

White, New York Herald Tribune, extreme left, and in the rear center, Sam Shaffer of Newsweek and Don Morris of the Philadelphia Record. Called "the Apple" by her crew, "Appalachian" was equipped with many thousands of dollars worth of electronic communication equipment for flashing messages and radiophotographs.





**WHO'S A LIAR??** . . . in all probability the man responsible for the sign at the Bikini recreation area which stated, simply, "Ice-cold beer." Refrigeration, like the cultivation of heavy beards, has a future in the Marshall Islands. Chilled beer quickly warmed up in the humid tropical weather.

The recreation area at Bikini was constructed by Seabees who reached the Atoll in March of 1946. It included a beer garden, ice cream parlor, swimming beach, softball diamonds, courts for horse-shoe pitching and volley ball, and table tennis, called by the natives "ping-pong."



# PACIFIC ACTION OFF KWAJALEIN. ABOVE.

In waters once Jap-infested the CVE carrier "Sador" launches an F6F Hellcat, shown here making its turn into the wind, while on the carrier deck handlers spot another plane into a take-off position. "Sador" was used as the home base of Navy drone planes. OPPOSITE ABOVE. A Navy helicopter idly approaches "Sador" before making a landing on the forward end of the flight deck. BELOW. Wet morning at Kwajalein. Weather statistics indicated that on only a few days in the month of July would weather be clear enough and winds suitable to permit holding the atomic bomb tests. The drenched B-29 planes and the cloud heavy on the horizon are typical of rainy mornings in this section of the Pacific. Tail-markings on these planes show their particular function as part of Task Group 1.5. The F-markings indicate B-29s modified for use as photographic ships. At the left, rear, the arrow-in-a-circle marking is that of a plane used to drop air-pressure gages from high altitude during the first test. At the rear, center, B stands for bomber. During the war Kwajalein was hardly so peaceful. In Japanese hands it was a threat to the American-Australian life line. It was first attacked in January, 1942.







**LANDING PARTY.** Army and Navy personnel hit the beach from an LCI water taxi and head for the recreation area and a swim at Bikini. **OPPOSITE.** Something for the spear fishermen, surveying groups, and other technicians on the outer coral reefs at Bikini to watch out for—the giant *Tridacna*, a marine bivalve of the oyster family. The rugged, jaw-like shell halves are operated by

powerful muscles permitting them to fasten a death grip on any object that gets between them whether it be some form of marine life or the leg of a luckless underwater swimmer. Ranging in color from white and pastel pink to deep orange red, these heavy oysters are beautifully camouflaged by the coral background on which they live. They attain weights of as much as 500 pounds.







**GROUND FORCES INSTALL EQUIPMENT.** ABOVE. Bow of the battleship "Arkansas" with Army Ground Force equipment in place. A contrast in weapons is presented by the lethal gun of the M-26 heavy tank on the port bow, the 12-inch rifles of the "Arkansas," center, and the Mark 36 90-mm gun mortar carriage on the starboard side of the ship. The rugged supports seen on the starboard deck and on the top of the gun turret,

center, are bases for aluminum foil gages, yet to be installed, used to measure shock wave. Ground Forces equipment placed on various target ships for exposure to the explosion included heavy tanks, delicate radar and sound devices, flashproof clothing, fresh and canned rations, fuel and lubricants, numerous kinds of ammunition. OPPOSITE. Officers and a group of enlisted men attached to the Army Ground Force Group.



**AN ARMY TANK JOINS THE NAVY.** At the U. S. Naval Shipyard at Bremerton, Washington, a new light 26-ton tank armed with the Air Corps 75 mm cannon is hoisted aboard the "Pennsylvania" for the trip to Bikini. Explicit in the directive of the Joint Chiefs of Staff creating Operation Cross-roads was the requirement that, consistent with

the primary object of determining the effects of atomic bombs on vessels, all possible information should be obtained concerning the effects of the bombs on military equipment. A wide variety of Army materiel, including signal, engineer, chemical warfare, ordnance, and quartermaster, equipment was exposed.





**RATS, RADIATION, AND HISTORY.** Bikini-bound rats were transported on the APA 67 "Burleson," which left San Francisco very late (June) so that the animals might be in the best possible condition when the tests occurred. The animals transported to Bikini consisted exclusively of pigs, goats, rats,

mice, and guinea pigs. Pigs were chosen because their skin and hair are fairly comparable to man's; goats because their weight roughly equals man's, and their bodily fluids are ample for analysis. Four goats were chosen because of their psychoneurotic tendencies.







**BRIEFING ROOM AT KWAJALEIN.** Briefing in the well-appointed Operations Room of Task Group 1.5 at Kwajalein was aided by the use of maps and charts painted with fluorescent pigments and irradiated in semi-darkness by ultra-violet light. At the left of the central chart is a simulated radar screen showing what the pilot will see in his own radar screen as his plane approaches its goal. During briefing each B-29, F-13, or C-54 plane's crew occupied a particular row in the center section, seating being according to rank. **OPPOSITE.** Experimental wing panels installed by Task Group 1.4 personnel on the deck of a target vessel, to find the vulnerability of such panels to atomic bomb explosions. Visible also along the deck are a tail assembly, stabilizer, range-finder, and rear support of a small mobile gun.



**IS EVERYBODY HAPPY?** Congressman W. G. Andrews (R) from Buffalo, New York, acts as master of ceremonies at a "Happy Hour" aboard the AGC 3 "Panamint," which transported many of the observers to Bikini. Featured on the Andrews Hour was a Quiz Program in which several of the ship's messboys, previously well coached in the difficult lore of nuclear physics, put to shame some of the professional scientists aboard, to the sincere delight of the audience. **OPPOSITE. ABOVE.** Army nurses stationed at Kwajalein relax with friends. There were 37 nurses in the Task Forces. **BELOW.** On the beach at Bikini men of the Task Force try out the swimming facilities of the recreation area at the south end of the island. Lagoon water temperature averaged 82 degrees, a tepid bath. Swimming at Bikini was banned immediately after Test Able until the extent of radioactivity contamination could be determined. Contamination proved negligible, and the ban was lifted.





**LOOK PLEASANT PLEASE.** This mass grouping of cameras used by the Army Air Forces to photograph the atomic bomb explosions gives some idea of the extent of the aerial photographic coverage

of these tests. Not shown here is navy camera equipment used in planes and on ships, or in fixed shore installations used by various technical groups. The AAF camera roster totalled 328, including aerial motion and still cameras, and among them





the world's largest still camera, a giant instrument with a 48-inch focal length telephoto lens. Other unusual cameras included gunsight cameras and ultra high-speed cameras capable of taking 10,000 frames per second under ideal conditions. The

multiplicity of cameras was necessary to insure a wide variety of filter combinations, lenses, and exposures, and in general to insure obtaining full records of results, particularly damage results.





**PREFACE TO PRECISION.** On a Boeing F-13 plane altered for use as a photographic ship two motion picture cameras are installed in one of the plane's gun turrets. These cameras were controlled from the top fire control blister shown in the background by the same sighting and firing mechanisms normally used with the plane's machine guns. Shown here at Roswell Field, New Mexico, are Corporal Harold Johnson, outside the plane, making adjustments on the cameras, while Sergeant Henry R. Zarnoski mans the controls in the top fire control blister. In the background can be seen another turret, slotted cover in place, housing a similar motion picture camera installation.

**FOCUS ON PHOTOGRAPHY.** Brigadier General Roger M. Ramey, Commander Task Group 1.5, discusses Army Air Forces photographic plans with Colonel Paul T. Cullen, in charge of technical photography at Kwajalein. In the foreground are 16 and 35mm type motion picture cameras, operated at 2000 frames per second, such as are used in the F-13 photographic ships. The extreme humidity at Bikini presented a serious problem to aerial photographers: as a plane descended and the air pressure in the plane increased, there was a tendency for moisture to condense on the photographic film, hurting the emulsion. To avoid this, pilots descended very slowly, sometimes over a period as great as an hour. In many planes the difficulty was avoided by installing the cameras in constant-pressure chambers.



**POSTERITY VIEWS THE TESTS.**

Inside a C-54 photographic plane flying at high altitude, a row of cameramen aim their lenses at the Lagoon below. On Able Day photographers in some planes were vigorously buffeted by the primary and secondary shock waves, forceful enough to knock down one photographer caught off balance. **BELOW.** At Kwajalein a huge photographic laboratory was built, its atmosphere cooled and dehumidified to prevent damage to film. The bulk of the photo-processing work was done at the U. S. Naval Photographic Science Laboratory at Anacostia, D.C. In the entire operation over 50,000 still films and millions of feet of movie film were exposed.





**WANTED: A LEFT JAB.** Scrappy Air Forces boxers battle it out in the humid night air at Kwajalein. Mid-summer boxing matches in the Marshalls are not recommended for those who wish to keep a crisp and cool appearance. Boxing matches afloat and ashore were a popular form of entertainment.

On the carrier "Saidor" the airplane elevator, raised to a level three feet above the main hangar deck, served as an improvised ring. The AV-14 "Kenneth Whiting" held inter-ship bouts on the seaplane deck. Devotees of the Golden Gloves tournaments were not disappointed.



**SEEING EYE DRONE.** This close-up view of the plexiglass nose of a B-17 drone plane shows a television camera in the position normally occupied by the bombsight. Shown checking equipment is Captain Renee Dussaq, flight technician. Television relayed what the drone plane "saw" to television receivers miles away; the received images were studied by scientists and recorded on motion picture film. Televised images of the drone's instrument panel helped the remote-control personnel keep the drones flying smoothly.

**SPOTLIGHT ON ELECTRONICS.** A battery of heat lamps serves to dry out electronic equipment used at Bikini. High humidity, a principal source of discomfort to men, plays havoc with delicate electronic devices such as those shown. Fungus grows on connections and insulation, attacks circuit components, and changes their electrical properties. The effect on instrument performance may be very harmful—to an extent first fully realized by our Armed Forces when the ground fighting began in the Pacific theatre in 1942.







**INSTRUMENTS—THE PROOF OF THE OPERATION.** UPPER. Technicians prepare panels of fabrics for exposure to the effects of the atomic bombs. LEFT. Rear Admiral W. S. Parsons, Deputy Task Force Commander for Technical Direction. He was responsible for all principal technical activities involving bomb detonation and determination of all scientific and technical results.

**OPPOSITE, ABOVE.** Experts examine pyramidal orientometers on a target ship. These devices indicate the direction from which the heat and radiation from the atomic bomb came, in terms of burns produced when radiation passes through the tiny holes shown and strikes the base of the instrument. **BELOW.** Dr. C. W. Lampson of Princeton University and Captain A. E. Uehlinger, USN, inspect an aluminum foil gage.









#### AIR FORCES LINEUP, KWAJALEIN.

A few members of Task Group 1.5 are photographed in front of a C-54 photographic plane at Kwajalein. Special apertures were made in the fuselages of these planes to accommodate cameras. Some of these planes carried as many as 28 cameras, still and motion picture. Photographic planes had to be exactly at their prescribed positions and altitudes, and on the prescribed courses, at the time of the bomb drop, to permit accurate concentration of cameras on the designated parts of the target area. Accuracy of timing required cooperation of air crews and photographers. Accuracy was achieved through careful and detailed planning, and through rehearsals held first at Albuquerque, N. M., and later in the Marshalls. To supplement the roster of photographers an appeal was made to ex-servicemen with experience in photography to leave their civilian jobs temporarily and help Operation Crossroads. Nearly one-half of the final photographic staff consisted of veterans brought back from civilian life.



**NAVY PHOTOGRAPHIC BRIEFING.** At their San Diego training station Navy carrier-based pilots from the "Saidor" are briefed prior to making practise flights. Later, pilots like these made photomosaics of the Bikini Atoll and flew many photographic missions before and after each test, recording locations and conditions of target ships. In some of this work tri-metrogon cameras were used. These cameras are virtually three cameras

in one, with one lens pointed vertically downwards and the other two lenses pointed to right and left to cover all the remaining field from horizon to horizon. For this photographic work the Navy used six Navy F6F-5P's, four TBM's, three PBM's and four F6F drones. Cameras in planes were in some instances accurately synchronized with cameras on towers and on surface ships in order to show the test from various angles at the same instant.



**RESPONSIBLE PARTY.** The assembly and arming of atomic bombs are intricate operations known to very few. R. S. Warner Jr., shown at the left is one of the few. He had been a central figure in the Bomb Design Section of the Los Alamos Laboratory since 1944 and was the logical choice for Head of the Bomb Operation Group at Bikini. With him are Lt. Colonel R. J. Cunningham, cen-

ter, and Colonel P. T. Cullen, right. Final preparation of the Test Able bomb was made by two Navy officer "weaponers" who flew with the bomb in Dave's Dream. In Test Baker Mr. Warner completed final preparation of the underwater bomb and, with Rear Admiral W. S. Parsons, was among the very last to leave the Zero-point Ship LSM-60, beneath which the bomb was suspended.









**SHIPS OF THE TASK FORCE.** Representative ships of the Task Force fleet—three of them target ships and two of them supporting ships, appear on this and the opposite page. ABOVE, UPPER, "Panamint." LOWER, "Nevada." OPPOSITE, from the top down: "Sakawa," "Pennsylvania," "Appalachian." The AGC-13 "Panamint" served as headquarters for congressional, scientific, and United Nations observers. During the tests she made a reputation for excellent chow, and literally teemed with VIP's. The battleship "Nevada," bulls-eye ship at Test Able, was painted orange-red to aid

the bombardier. The battleship "Pennsylvania," once flagship of the U. S. Fleet, was one of the five heavy ships in the target array. The "Pennsy" served the United States for 29 years and was among the ships damaged at Pearl Harbor. The AGC-1 "Appalachian," "The Apple" served as the press headquarters ship for 169 newspapermen, photographers, commentators, and magazine writers covering Operation Crossroads. From her antenna-cluttered masts flowed about 258,000 words of copy in 24 hours after Test Able, in five languages including Polish and Russian.



**ATOMIC DIARISTS EMBARK.** Standing before their big B-17 plane are four newsmen who covered the atomic bomb tests from the air. At Test Able there were 166 newsmen, including 10 representatives of the foreign press. Two writers, one from the independent press and one from the wire services, were selected by the correspondents to

write accounts of the tests as viewed from the air. The radio commentator was chosen by lot. Shown above, left to right: John M. Carlisle, Detroit News, representing independent newsmen, Lt. Colonel J. F. Moynahan, Public Information Staff JTF-1, Bill Downes, Columbia Broadcasting System, and Frank Bartholomew, United Press.



**GENERAL J. W. STILWELL.** The late Commanding General of the Sixth Army Area and member of the Joint Chiefs of Staff Evaluation Board, in Mae West life preserver and parachute harness, is ready for his observation flight on Able Day. The seven-man Evaluation Board was available for

advising Vice Admiral Blandy during preparations for the tests, and, shortly after each test, presented the Joint Chiefs of Staff with a preliminary evaluation of the results. The Board's final evaluation awaits completion of the full official report by the JTF-1 Historian.





**THE WEB AND THE ROCK.** This curious web-shaped framework is the artificial electrical ground of an ingenious instrument called a sonobuoy, used to measure underwater sound waves produced by the atomic bomb explosions. Each sonobuoy consists of delicate listening apparatus beneath the barrel-shaped float which houses an automatic radio transmitter. Sound picked up by the buoy

is transmitted to a distant listening post. The vertical rod sprouting from the float is the antenna for the transmitter. Use of such an artificial electrical ground eliminated the effect of surface wave motion on the instrument's operation. During the war smaller types of sonobuoys were used to detect submarines. Parachuted from a patrol plane, they made accurate bombing possible.





#### DRONE BOAT PREPARED FOR OPERATION.

Radio-controlled drone boats, like drone planes, had an important function at the Bikini tests. Guided by radio pulses received on the tiny antenna mounted in its bow the drone boat acted as an automatic monitor, moving throughout the lagoon collecting water samples and radioing back data of their radioactivity. The drones were con-

trolled by transmitters aboard the "Begor." Spotting assistance was provided by planes circling above the lagoon. Shown above is the smoke-making apparatus used to assist the planes in following the drone's course. The cylinders emitted a yellowish-green smoke which had good visibility from the air. These drones became very "hot" radioactively, particularly after Test Baker.



**CHIAROSCURO.** The tangled branches of a *tournefortia* tree make an interesting subject for Life photographer Fritz Goro. Named for the famous 17th Century French botanist Tournefort, this tree is one of the half-dozen species commonly found on the Bikini Atoll. Trees and other

flora were studied by Dr. W. A. Taylor of the University of Michigan as part of the general investigation of changes produced by the atomic bomb explosions. It was thought that the atomic bomb radiations might produce some interesting mutations in plant life.



**THE WORLD IS THEIR GARDEN.** At an improvised field laboratory set up in the very environment they are studying, Lt. Commander M. C. Sargent and T. S. Austin determine concentration of phosphate and oxygen in samples of sea water from a reef section just north of Rongelap Island,

130 miles east of Bikini. Their study was concerned with determining why certain animals and plants grow where they do and what factors limit their growth. Studies were made at islands somewhat removed from Bikini to serve as "control" studies for comparison with data amassed at Bikini.







**FOR HUMAN SAFETY.** Aboard the APH-112 "Haven" Col. Stafford L. Warren of Rochester, New York, radiological safety adviser to Joint Task Force One, explains the operation of a Geiger counter to Captain A. C. Thorington, skipper of the "Haven." It was Col. Warren's responsibility to see that no man of the 42,000-man Task Force received injury from radioactivity produced by the bombs. Specially-selected technicians were assembled and trained in radiological safety monitoring. In appraising radioactivity, they made extensive use of Geiger counters. These consisted of gas-filled tubes each containing two electrodes, one

of them at high electrical potential. When placed in the vicinity of a radioactive substance, whether it be radium in a research laboratory, samples of radioactively-contaminated Bikini Lagoon water, or the deck of a "hot" ship, a Geiger counter becomes intermittently conducting, transmitting tiny pulses of current. When amplified, these pulses produce a crackling noise in headphones. They may also be "counted" in terms of current passing through an ordinary ammeter. **OPPOSITE.** Samples of Lagoon water are taken using a Nansen bottle. Analysis of sea water was important scientifically and as a matter of safety.





**VIP'S ORIENTED AT KWAJALEIN.** In the Army Air Forces briefing room on Kwajalein Island VIP's (very important persons) drawn from military, Congressional, and civilian ranks enjoy a ten-minute break in a briefing session. Front row, left to right: General George C. Kenney, Commanding General of the Strategic Air Command; Stuart Symington, Assistant Secretary of War for Air; General Curtis E. LeMay, Deputy Chief of Air Staff for Research and Development. Second row: Colonel Kenneth B. Nichols of the Manhattan Engineer District. Second row, center, Senator Leverett Saltonstall engages in conversation with Postmaster General Robert E. Hannegan, Chairman of the Democratic National Committee.



#### RUSSIAN OBSERVERS BOARD THE PANAMINT.

At Oakland, California, Lt. (j.g.) G. W. Osten checks in Russian observers as they board the "Panamint" bound for Bikini. These scientists from the Soviet Union were part of the United Nations Observer Group, made up of official representatives of the 11 foreign countries having membership in the United Nations Atomic Energy Commission. These countries are: Australia, Brazil, Canada, China, France, Egypt, Great Britain, Mexico, Netherlands, Poland, and the U.S.S.R. All members of this group sailed on the "Panamint." Shown above, left to right: Lt. (j.g.) Osten, S. P. Alexandrov, of the United Nations Atomic Energy Commission, and Dr. A. M. Mescheryakov, Head of the Physics Department, University of Leningrad.





**RECREATIONAL AREA, BIKINI.** Dr. Marshall G. Holloway and Dr. Ernest W. Titterton, well known nuclear physicists, experiment with fast ping pong particles on Bikini Island. In the background are tennis, horseshoe and volley-ball courts, and dressing tents. Dr. Holloway headed the Los Alamos Laboratory group at Bikini, was charged with the heavy responsibility of preparing the two atomic bombs used in the tests. Dr. Titterton, one of Dr. Holloway's principal assistants, was concerned with time signals. **OPPOSITE. ABOVE.** Coral head in shallow water, showing the boulder-like shape taken by these heavy masses. Blocks of coral like this one, found as far as 400 feet from the reef edge, are torn from the margin of the reef by storm waves and deposited on the reef flat. The one shown, found 100 feet from the reef edge on Erik Island, was 25 feet in diameter and 12 feet high. The coral formation of the Bikini Atoll, as shown here and in other photographs in this collection, was of great scientific interest. Seismic surveys made by methods used in prospecting for oil revealed that the coral cap forming the Bikini Atoll is thousands of feet thick. **BELOW.** The pause that refreshes, Enyu Island.





**FOUR AND TWENTY SAMPLES BAKED IN A PIE.** Even the humble pie plate played a useful part in the complex instrumentation program used at Bikini. Modified as shown above the pie plates were made into thermal plaques for measuring type and intensity of optical radiation from the

bomb. Mineral samples of various kinds were placed at the small holes shown, and the plates then filled with Plaster of Paris. Radiation from the bomb passed through the holes, producing measurable changes in the physical characteristics of the samples.





**FORECASTLE FOCUS.** In the hematology laboratory aboard the APA-67 "Burleson" technicians make blood counts. Before and after each test, blood counts were made for all animals used in the atomic bomb tests, and symptoms of disease produced by radiation were carefully checked. Tens

of thousands of samples were examined, from which many lessons applicable to human beings were learned. Biological and biophysical data obtained were among the most important, although not the most spectacular, of the bomb test contributions.



**ATOMIC PARI MUTUEL.** As the exacting preparations for the first atomic test approached completion, and as the date of the first explosion drew near, informal pools were organized as to how many ships would be sunk, or as to the exact time when the bomb would actually be detonated. Seen above, Rear Admiral T. A. Solberg, Director of Ship Material, with N. J. Holter, project physi-

cist for wave measurement, watches Major Harold H. Wood, bombardier of "Dave's Dream," the bomb-drop plane, keep the record on a "minute of detonation" pool. Of 60 possible choices, Holter's paid off. **OPPOSITE.** On Kwajalein an Army Air Forces weather balloon goes aloft. Suspended beneath it can be seen the radiosonde instrument for taking readings of pressure and temperature.





**TARGET ARRAY PREPARATIONS.** At Pearl Harbor experiments were conducted to perfect the controlled submerging of crewless submarines. On the submarine rescue vessel "Widgeon" men watch the submarine "Apogon" as she is test-submerged. **OPPOSITE.** Men of the Navy salvage ship "Reclaimer" hoist a 14-ton anchor over the side. Anchors of this type were used to hold submarines in place during the second atomic bomb test. Larger ships were secured more strongly; a 20,000 pound mooring block was placed on the lagoon floor, and held in place by three anchors of the type shown above. This hefty mooring system was connected to a mooring buoy on the surface and thence to the target vessel in question. Central target ships were moored fore and aft.







**DOWN BUT NOT OUT.** A diver from the "Widgeon" goes down to adjust cable attachments on the submarine "Apogon." In the external control method of submerging a submarine, heavy weights are attached to it at bow and stern by cables of carefully chosen length. The weights overcome the sub's positive buoyancy and draw her down to the desired depth. To surface the sub, air is pumped into the ballast tanks. Submergence and surfacing were controlled from a salvage ship.



**WAS KILROY THERE?** Navy diver in light face-mask comes up to report on connections completed between pressure control apparatus on the salvage ship and ballast tanks of the "Apogon." Special skills had to be developed for the submerging operation, since never before had there

been occasion to submerge submarines without crews aboard. Performance of the submarines in the Bikini tests was of particular interest since some of our most modern subs were used. This was in contrast to the other combatant-type target ships, which were for the most part outmoded.



**EVEN STEPHEN.** The sub "Apogon," surfaced but with underwater control weights in place. Submarines proved to be useful "instruments" for subjection to the enormous pressures created by the atomic bombs, since their hulls are expressly designed to withstand high pressures produced by the ocean at great depths of submergence, and

by exploding depth charges and mines. For Test Able eight submarines were used, all of them on the surface, where destructive effects were expected to be greatest. In Test Baker greatest destruction was expected to result from pressure in the water; for that test, therefore, all submarines were submerged, and at various depths.



**RELUCTANT SEA DRAGON.** The submarine "Apogon" is shown here partly submerged, controlled from the "Widgeon." This and preceding photographs illustrate the types of problems encountered in Operation Crossroads for which new techniques had to be developed. The submarines were moored at various distances from the bulls-

eye ship; some were broadside to the explosion, others were head-on. The eight submarines used were: "Searaven," "Skipjack," "Tuna," "Dentuda," "Skate," "Apogon," "Pilotfish," and "Parche." Many of these have impressive records of attacks on Japanese shipping, many of which took place in regions of the Pacific near Bikini.





**ANIMALS IN THE SERVICE OF MANKIND.** This deck view of a typical target ship shows how the test animals were placed for exposure to the atomic bomb explosions. For Test Able 176 goats, 146 pigs, 109 mice, 57 guinea pigs, and 3,030 white rats were used. They were placed on 22 target ships, in positions normally occupied by ship personnel. In addition to effects on fully exposed animals, effects on animals partially shielded from the radiations were studied. It was desired to learn, for example, how deadly the instantaneously produced gamma radiation would be to personnel below decks and in gun turrets. White rats were placed in various sites from the

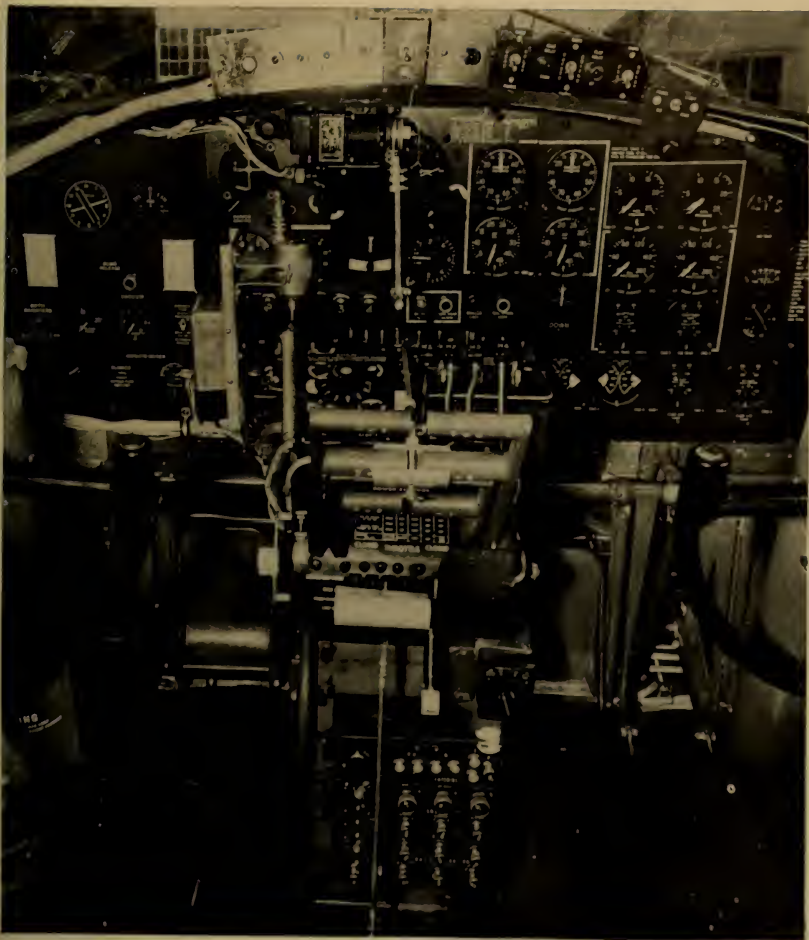
engine room to halyards to check all locations.

The National Cancer Institute supplied white mice with predilections for or against cancer. They were exposed in order to determine whether the intense radiations would produce genetic changes. The mice were returned to the Institute immediately after Test Able to be bred and studied. In Test Baker only 200 white rats and 20 pigs were used, on four target vessels. Since this was to be an underwater shock, it was expected that mechanical injuries would be far more prevalent than injuries from the instantaneously produced gamma radiation. Animals used in Test Able were not used in the second test.









**EXIT THE BACKSEAT DRIVER.** This view of the control panel of a B-17 Flying Fortress drone plane shows what some persons look for in postwar automobiles. Operation of these crewless, remote-controlled planes proved a distinct success. The eight drones used, four by Navy and four by Army, made scores of successful flights and flawless landings. Accidents were very few; one Navy plane was lost at sea, one Navy and one Army plane suffered minor damage. Reliable and precise

control of the drones was vital not only to flying and landing them smoothly but also to bringing them to their correct Able Day positions exactly on schedule and to maintaining proper heading for aiming automatic cameras and other instruments at the desired sections of the target array. Control was made difficult by the safety requirement of keeping the mother planes well away. **OPPOSITE.** Recalcitrant porker finds himself caught in the draft, on USS "Burleson."



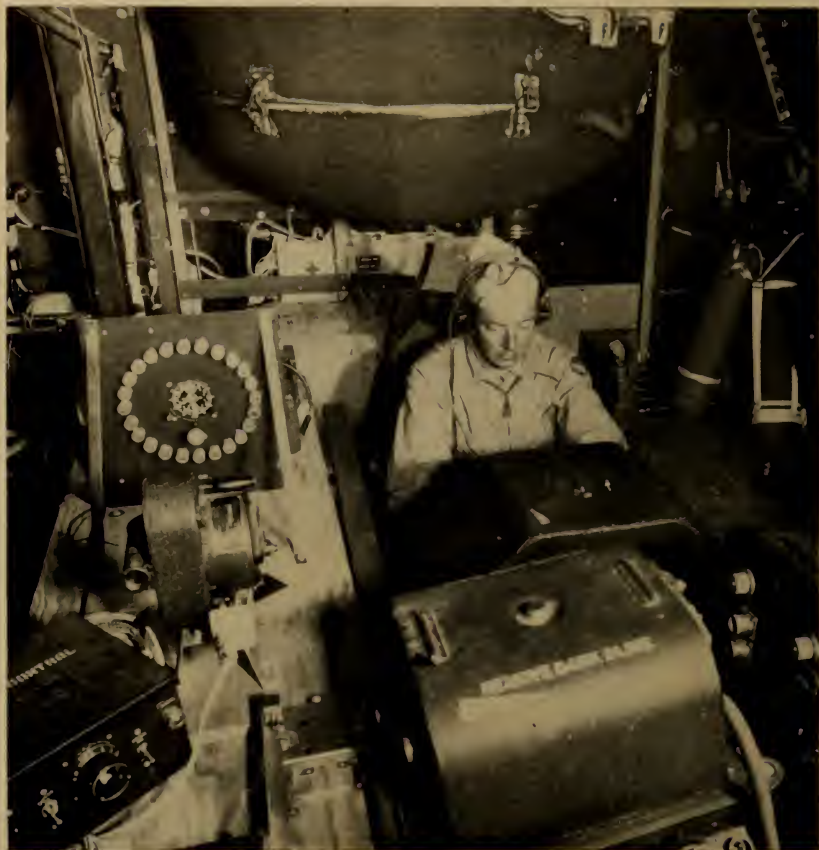




**QUEEN DAY EVACUATION.** On Queen Day, eighth day before the first atomic bomb test, a complete dress rehearsal was staged. The bombing plane made its runs, dropping a flash-powder bomb which went off near the Bullseye Ship "Nevada" at 0914. In the air, manned and unmanned planes followed the courses prescribed in the Air Plan prepared 3 months before. Vital to the success of Queen Day was the evacuation on the previous day of the 42,000 men of the Task Force

from the target vessels, the Lagoon, and the encircling islands. Every man had to be accounted for, including the technicians who had made hurried, last minute adjustments on scientific instruments on target ships and islands. ABOVE. Gun turret doorway is dogged and marked secure. OPPOSITE. ABOVE. Personnel of the "Pennsylvania" go over the side. BELOW. Men of the "Pennsylvania" are checked off as they abandon ship.





**AT 25,000 FEET, A CANDID SHOT.** View inside one of the C-54 planes converted for use as an Army Air Forces photographic ship. At the left can be seen the equipment used to record time of operation of each one of the plane's 28 still and motion picture cameras. Each tiny light in the circular panel array represented a particular camera installed somewhere in the plane. Each

time that camera's shutter clicked the light on the recording panel flashed on and was recorded by means of a motion picture camera shown just in front of the panel itself. The clock at the center of the circle of indicator lamps was photographed at the same time, completing the accurate record made. Special wiring and power supplies were necessary to make possible the indicator system.



**QUARTERDECK CONFERENCE ON THE ADMIRAL'S BARGE.** Touring the Bikini Lagoon while in earnest conference with Admiral Blandy are Major General W. E. Kepner (left), Deputy Task Force Commander for Aviation, and Hon. James Forrestal, Secretary of Navy. So large and ramified was the Operation that weeks were required to give visitors real understanding of the interplay

of technical and operational problems presented by the tests. Admiral W. H. P. Blandy was a logical choice to command Joint Task Force One. Long distinguished in the field of ordnance engineering, and Chief of the Bureau of Ordnance from 1941 to 1943, Admiral Blandy saw action in the Pacific, was latterly Deputy Chief of Naval Operations, Special Weapons.



**FINAL PREPARATIONS IN THE LAGOON.** Long before July 1, 1946, the date set for Test Able, ships of the target array had been placed in their assigned positions in the northeast part of the Lagoon. In the view shown above several key ships of the target array are visible. At the top, right of center, "Nevada," the bulls-eye ship, is



clearly discernible, painted bright orange-red to aid recognition by the bombing plane. Close beside "Nevada," left and right respectively, are the carrier "Independence" and the cruiser "Pensacola." At the extreme left of the array is the carrier "Saratoga," identifiable by her long flight deck and oblong "island."



**BOMBARDIER'S VIEW OF TARGET ARRAY.** This diagram of the Test Able target array, when compared with the two typical tactical arrays pictured on the opposite page, demonstrates the abnormally high concentration of target vessels in the Bikini tests. This concentration was necessary to meet the Joint Chiefs of Staff requirement of securing graded damage on all principal types of

vessels, graded damage meaning damage ranging from negligible, as in the case of ships at a considerable distance from the explosion, to lethal, in the case of ships close in. Subject to this requirement, sinkings were kept to a minimum, to preserve instruments and the valuable data they had recorded, and to save the ships themselves insofar as it might be possible.



**TYPICAL HARBOR ANCHORAGE.** This diagram, depicting an area identical to that of the target array shown on the preceding page, shows a typical harbor anchorage of naval vessels, and, by contrast, emphasizes the high degree of concentration of the target ships used at Bikini. In the harbor anchorage only four to eight ships would normally appear in an area of one square mile, instead of 20, as at Bikini. When the test plans were first announced many persons erroneously assumed that the target array selected would be a tactical one. Actually, the array was entirely artificial, and of no tactical validity.



#### **CARRIER FORCE AT SEA.**

Shown here for further comparison is a diagram of a carrier task force in cruising formation. Only one capital ship is included in an area of one square mile. In studying the target array opposite, note that the various types of vessels were arranged in curved lines radiating from the bullseye ship "Nevada." Each line was composed of ships of a single type, such as APA's, destroyers, LCI's, LST's, or LCT's. The individual ships served as excellent gages for determining how damage to a given type of ship varied with distance from the bomb burst. For Test Baker the arrangement of ships was generally similar to that used for Test Able.



**FLIGHT-DECK BRIEFING ON SAIDOR.** Grouped in front of an F6F-5P photographic plane, pilots of the "Saidor" planes receive final briefing from Captain J. H. McElroy, Photographic Operations Officer, shown kneeling, center. Looking on are Captain A. P. Storrs, skipper of "Saidor," and Commander J. H. McCurtin, Air Officer. Mission of these photographic pilots was to make an accurate photomosaic of the target array the hour before detonation of the Test Able bomb. Careful

timing and spacing of the planes was required in order to cover the entire target array in one sweep. Four planes at high altitude took vertical pictures for an "uncontrolled" mosaic, or mosaic arranged by eye. Supplemental trimetrogon photographs were taken by two other planes in order that a "controlled" or highly accurate mosaic could be made. Other planes made before-and-after runs at low altitude, taking stereoscopic pictures of the target ships.



**FORECAST FOR BIKINI AND VICINITY.** Major Delmar L. Crowson, left, officer in charge of the Crossroads Weather Central, Kwajalein, and Major Paul L. Fackler, right, of the Army Air Forces weather group, plot reconnaissance "tracks" or courses to be followed by weather planes in their daily flights out over the Pacific prior to Test Able. Favorable weather conditions were absolutely necessary before the day on which to conduct test could be decided upon. Actually Test

Able was held on July 1, the first possible date set for the test; weather conditions predicted for that day were ideal, and they were borne out fully. On the day preceding Able Day, as well as on Able Day itself, three especially significant weather reconnaissance flights were made. Daily weather conferences were held between forecasters at Kwajalein and Captain A. A. Cumberlandge, USN, and Col. B. G. Holtzman at Bikini, aboard "Mount McKinley."







**THIS IS IT!** Crew members of "Dave's Dream," big B-29 Super Fort atomic bombing plane, prepare for the bombing mission. Major Woodrow P. Swancutt, center, "pulls through" a blade of one of the ship's huge four-bladed Hamilton propellers. Propellers are turned through four complete revolutions in this fashion in order to determine that engine cylinder heads are free from accumulated oil. **OPPOSITE.** Winners of a hotly contested competition in which the country's finest

very-heavy-bomber crews took part, the crew of "Dave's Dream" pose in front of their ship. Front row, left to right: 1st Lt. Robert M. Glenn, flight engineer, T/Sgt. Jack Cothran, radio operator, Cpl. Herbert Lyons, left scanner, Cpl. Roland M. Medlin, right scanner. Back row: Capt. William C. Harrison, Jr., co-pilot; Major Woodrow P. Swancutt, pilot; Major Harold H. Wood, bombardier; and Capt. Paul Chenchar, Jr., radar operator.





**DAVE'S DREAM ON THE BOMBING RUN.** This photograph of "Dave's Dream," taken from an accompanying photographic plane on Able Day, shows the big B-29 on the actual bombing run, her bomb-bay doors open, shortly before the atomic bomb was released at high altitude above the target array. More than five miles below lie the lagoon and the 93 target ships, void of human life, their only occupants the test animals. Outside the lagoon, at predetermined points of vantage, wait the observer ships, camera men poised, instrument technicians on the alert, crews assembled topside. Army and Navy Officers and enlisted men, Congressmen, newspaper men, scientists rub elbows at the rails of their ships.

**CREW LINEUP ON SAIDOR, TEST ABLE.** Officers and men of the carrier "Saidor," assembled on the flight deck, rehearse the safety procedure followed on Able Day to protect their eyes from the blinding light emitted by the explosion. The most intense portion of the flash, many times the brilliance of the sun, lasts for but a few millionths of a second. As a cause of injury to human sight the flash makes up in intensity what it lacks in duration. Even after the fading of the flash to a state of lesser brilliancy it is still a hazard to the eye. To guard their eyesight persons without goggles were ordered to stand as shown above with their backs toward the blast and to remain in this position until the all-clear signal was given several seconds after the instant of explosion. The Task Force also used a total of 6000 pairs of dark goggles, developed primarily for use by scientists and members of the technical and observer groups during the moment of greatest brilliance.





**EARLY PICTURES OF THE FLASH, TEST ABLE.**

This and succeeding photographs of the Test Able atomic bomb explosion are included here for their representative nature and dramatic quality. They are not necessarily arranged in chronological order, and they do not purport to tell a complete

technical story. In nearly every instance their interpretation is a highly complex matter, involving a knowledge of position and altitude of the camera, focal length, type of film, type of filter, and, most important, the precise time at which the exposure was made.



**AIRMAN'S VIEW, TEST ABLE.** This picture taken at high altitude, gives the impression that the Test Able bomb was detonated in darkness. Actually the bomb was exploded at nine o'clock in the morning in bright sunshine; the darkness of the photograph is due to the density of filter used.

The flash itself was sufficiently intense to appear brilliant through even the darkest filters commercially available. Typical statistics recorded were: type of film, exposure time, filter values, lens aperture, starting time, means of starting, interval between pictures, and aiming point.



**CLOUDS HIGHLIGHTED BY FLASH.** This photograph, like the others in this group, was taken from a distance of about 15 miles from the bomb detonation point. From a photographic standpoint Able Day was excellent, with bright sunshine and few clouds. The clouds shown in these pictures

were at an altitude of two or three thousand feet, or considerably higher than the altitude of the bomb itself at the moment of explosion. At sea level there was brilliant sunlight. Comparison of positions of clouds shown in these views suggests the relative position of the cameras.





**EDISON ECLIPSED.** Light emitted by an atomic bomb covers all portions of the spectrum—light visible to man plus ultraviolet and infrared light. During the initial flash lasting for a few millionths of a second the total quantity of light emitted is so great as to far exceed what would be produced

if all the electric light bulbs ever manufactured, from Edison's time to the present, were amassed and turned on simultaneously. The flash was so bright that it could have been readily detected by a man on the moon. Timing and aiming the cameras required great technical skill.



**CONDENSATION CLOUD FORMED, TEST ABLE.**

This photograph was taken instants after the brilliant "first flash" of the bomb. That flash, as previously stated, lasts for but a few millionths of a second. The pictures on this and the succeeding page were made not more than a second or two

later. The so-called "fireball" is in process of formation, screened from the camera by a wall of mist. This wall, the shape of a hollow inverted hemisphere, is the condensation cloud resulting from expansion of the atmosphere immediately following passage of the shockwave.



**CONDENSATION CLOUD, CLOSER VIEW, TEST ABLE.** This closer view of the condensation cloud shows ships of the target array silhouetted against the brilliant backdrop that reaches thousands of feet into the air. The vessels visible are those at the edge of the target array. A portion of an

island at the edge of the lagoon can also be seen, its outline dark since the camera was set for the bright condensation cloud as its primary subject. The shock wave itself is visible on the water's surface in the form of a bright ring that has already enclosed most of the target ships.



**PROGRESS OF THE SHOCK WAVE.** In this remarkable photograph the Test Able explosion is shown in another early stage of development. Location of the shock wave is indicated by the flat white ring expanding across the lagoon's surface from the center of the explosion and its enveloping

condensation cloud. This view also gives a good impression of the general relation of the bomb test site to the Bikini Atoll, seen here as a sprawling elliptical chain of islands linked each to each by shallowly submerged reefs. The large island in the foreground is Enyu.



**CONDENSATION CLOUD, TOWER VIEW.** This picture, taken from one of the camera towers on Bikini Island, records a closer impression of what went on inside the lagoon instants after the Able bomb exploded. Dazzling light from the condensation cloud obscures most of the target ships, although the "Saratoga" is visible at the left of the photograph, and the end of one of the radial lines of evenly spaced smaller craft can be seen. The

striped poles and striped marking on palm trees in the foreground were used to measure wave heights at both tests. The long framework building at the edge of the beach is a Marine recreation building. Its tarpaulin roof has been removed to prevent destruction by the shock wave. When this picture was taken the shock wave had not yet hit the beach. Shock wave location is indicated by the sharp bright area near the "Saratoga."



**OPERATION  
CROSSROADS,  
BIKINI ATOLL,  
0900 JULY 1, 1946.**

This photograph indicates perhaps better than any other, the dramatic quality and vast scale of the first of the atomic bomb tests. The tethered ships of the target array are dwarfed by the giant white ring, the condensation cloud. The huge fireball at the center is already beginning to make its swift, silent ascent. Reflection of the fireball's brilliance is clearly seen, interrupted by ruffled water whipped by the rapidly expanding shock wave. By the time this picture was taken most of the damage shown on the following pages of this book had been already inflicted. The formula was simple: one airplane, one bomb.







#### THE CURTAIN RISES WITHIN THE LAGOON.

This is one of the earliest views obtained of the target array as it appeared after bombardment. The base of the condensation cloud that previously shielded the ships from the prying eyes of remote and shore-based cameras has disappeared. Its upper portion still remains, hanging over the lagoon like a thick gray blanket. Somewhere in that blanket of vapor another atomic bomb phenomenon, the familiar mushroom cloud, has started its rapid ascent to the stratosphere. Black clouds of soot were dislodged from the interior of funnels by the impact of the shock wave and air-blasted skyward by the turbulent wind currents following it. Smoke from fires started by the bomb can also be seen. **OPPOSITE.** The mushroom cloud as seen from an observer ship standing 20 miles off Bikini. Heat from the bomb, travelling with the speed of light, was felt simultaneously with the first flash.





**TEST ABLE PANORAMA.** This awe-inspiring view of Bikini Lagoon was made instants after the condensation cloud had completely disappeared, revealing the target ships and the turbulent mushroom cloud rising above them. The shock wave from the explosion has not yet had time to cross the lagoon to the location of the camera, but can be seen as a sharp black line racing towards the





beach. A moment later it reached the palmtrees at the edge of the water. Newsreels of this phase of the explosion showed the trees abruptly shaken like dishmops in a giant hand as the shock wave rushed by them. Slightly to the left of the base of the mushroom can be seen the "Arkansas." The "Nevada," if it were visible, would appear slightly to the left of "Arkansas." (See page 116)



**INTERNATIONAL ACADEMY MEETS ON THE PANAMINT.** High on the superstructure of the "Panamint" cruising about 15 miles off Bikini, foreign and American observers occupy a good vantage point from which to view the atomic tests. Shown here are, left to right, Dr. John H. Yoe, of the University of Virginia (in white shorts); Dr. Michael Mescheryakov, of Russia; Lt. Colonel Juan Loyo Gonzales, of Mexico; Professor Semyon P. Alexandrov, of Russia; Captain G. B. Salm, Netherlands Navy; Dr. Nabor Garillo, of Mexico; and Professor Carl O. Dunbar, of Yale University. Such

crowded rails were the rule on all the ships of the observer fleet. Once the spectacle had reached its conclusion the question uppermost in the minds of many was: How soon will reentry of the lagoon be possible? Promptly-completed preliminary radiological surveys proved that it was safe to enter the lagoon on the afternoon of that same day. At that time it was possible to approach only the outlying ships. It was several days before the ships could be generally visited. Residual radioactivity after Test Baker was considerably greater than it was after Test Able.



**INDUSTRIOUS INFERNO.** As the mushroom cloud climbs higher into the sky, a second smaller mushroom-top appears high on the "stem." The stem itself is composed of a mixture of ascending vapor, steam, spray, smoke, and radioactive fission products. In the vicinity of the stem there is a powerful updraft which sucks inwards and upwards the soot and smoke spouting from the target ships, and spews forth its insidious content into higher altitudes. When this photograph was taken the cloud had risen to about 12,000 feet.



**THE SKIES LOOK DOWN.** High above Bikini lagoon an aerial camera caught this impressive view of the Able Test. Note that the shock wave, the circular arc clearly visible on the surface of the water, has just about reached the Atoll islands nearest to the bomb detonation point. In the same space of time the bomb cloud has risen many

thousand feet into the sky. Position of the shock wave indicates that all this action has required no more than about five seconds. It was essential to the safety of the Task Force personnel that the radioactive cloud be dissipated into the upper atmosphere without being brought back into the area by high altitude counter-winds.



**SELF-CLEANSING SHOT.** In this view the mushroom cloud has risen considerably higher than the altitude indicated in the preceding photograph. The top of the mushroom is beginning to flatten out somewhat; on the under side of the top spurs of vapor have begun to form, extending downwards. The Test Able shot has been described as

a "self-cleansing" shot since the bomb was detonated in the air and the upward column of gases served to remove most of the radioactive fission products from the lower atmosphere. This "cleansing action" was not experienced to the same extent in Test Baker, in which the bomb was detonated underwater.







**ENYU ISLAND VIEW OF TEST ABLE.** From Enyu Island, approximately five miles from the center of the target array, the Able Test mushroom appears in an advanced stage, dramatically illuminated by the clear morning sunshine. The cloud has already drifted appreciably downwind, to the southwest. Among the target ships embroiled in the mushroom base are "Saratoga" and "Nagato," whose outlines are discernible here. Smoke coming from

behind the "Saratoga" is from fires on the carrier "Independence." **OPPOSITE.** Close-up view of the explosion cloud, which is beginning to slow up somewhat as it approaches the top of its climb. Manned planes had to stay miles away from this seemingly innocent cloud, the radioactivity of which was roughly equivalent to what would exist in the vicinity of 100 tons of radium. Drone planes were flown right through the center.



**JOHN M. CARLISLE REPORTS. OPPOSITE.**

"Those were dramatic seconds in sheer beauty. The cloud was a pheasant brown with white patches at first. Then it began an amazing transformation in colors and shapes before our eyes. It seemed to steam and boil and churn at the bottom. There it turned laundry white. It was pinkish in the middle, salmon colored at the top. In less than two minutes it climbed higher than the altitude of our ship "The Voice." The mushroom broke out suddenly at the top, and the cloud changed colors.

It was a fascinating picture. For a few minutes it looked like a giant ice cream cone as it turned completely white. Looking at it then through binoculars it seemed like floating layers upon layers of whipped cream. Again it changed colors, now to peaches and cream. It broke into two mushrooms, the second quarter of the way from the crest. All this time the trade winds were driving it hard . . ." (From the Able Day Pool News Report). ABOVE. The bomb cloud photographed by a drone B-17 about to pass right through it.





**FURTHER VIEW, ENYU ISLAND.** In this later view of the Able Test mushroom the cloud has risen so high that an icecap has begun to form. Gases rising just above the mushroom top are greatly expanded and therefore cooled; their water vapor content changes from gaseous to ice

crystal state. A thin layer of myriad horizontal crystals forms slightly above the top surface of the mushrooms proper. This layer becomes increasingly thicker, gradually settling down over the top of the mushroom. Even after the formation of the icecap the mushroom continues to rise.



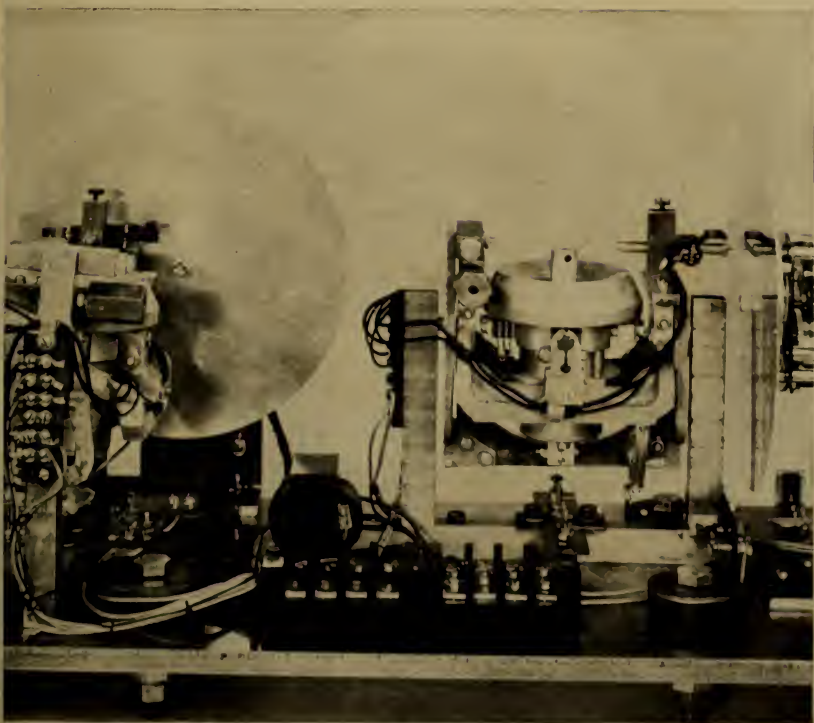


**YOUNG MOTHER HUBBARDS VIEW ABLE PHOTOGRAPH.** At Rongerik Island, former Bikini residents in their traditional modest Mother Hubbard smocks crowd forward for a better view of a Test Able photograph. In remotest San Francisco, 4200 miles from this scene, newspapers received initial photographs of the mushroom cloud a mere three hours after the bomb was detonated, a new time record for radio photograph transmission over such a distance. Transmissions were made from mobile units aboard "Mount McKinley," "Appalachian," and the Army communication ship "Spindle Eye." During July the "Mount McKinley" alone transmitted 400 photographs.



**PENDULUM TYPE INCLINOMETER.** One of the simpler pieces of apparatus used at Bikini was this pendulum-type inclinometer used to measure pitch and roll of target ships. Although any sea voyager knows in a general way what constitutes pitch and roll of a ship, scientifically these terms refer to the angle with the vertical made by the ship's long and short axes. Each instrument contained identical assemblies mounted at right angles as shown. The weighted arm was designed to remain vertical at all times, angle of pitch or roll being measured and recorded as scratches on the shiny discs provided.

**GYROSCOPE TYPE INCLINOMETER.** Similar in purpose to the pendulum-type inclinometer shown on the preceding page is this gyroscopic instrument. In this design the standard of verticality is achieved not by a weighted bar but by electrically driven gyroscopes. As in the pendulum-type instrument two complete units are mounted at right angles, one to measure pitch, the other to measure roll. Both these instruments were developed for the Bikini tests at the Material Laboratory of the New York Naval Ship yard. They are but single examples of the total of 10,000 instruments used to gather important data.







**BLUE-RIBBON JURY GATHERS EVIDENCE.** Members of the Joint Chiefs of Staff's Evaluation Board and the President's Evaluation Commission tour the Bikini Lagoon for a first-hand view of damage produced by the Able Day test. Members of the Evaluation Board witnessed the explosion from an airplane 20 miles distant, and later approached to within nine miles for a brief view. The day following, as soon as safety clearance had been received, the Board members began examination of ship damage. In a report made public the Board stated various findings: The only major combatant ships within one-half mile of the bomb explosion point were the battleships "Nevada" and "Arkansas" and the heavy cruiser "Pensacola." Little damage had been done to the hulls or main turrets of these ships but their superstructures had been badly wrecked. There was relatively little damage to ships at distances greater than three-quarters of a mile. The group includes, left to right: Captain Horacio Rivero, Vice Admiral J. H. Hoover, Mr. Bradley Dewey, Dr. Karl T. Compton, the late General J. W. Stilwell, Mr. Fred Searls Jr., Senator Leverett Saltonstall of Massachusetts, Lt. General L. H. Brereton, Dr. E. U. Condon, Representative W. C. Andrews (R) of New York, and Mr. T. F. Farrell.







**REENTRY DAY VIEW OF INDEPENDENCE. OPPOSITE.** The carrier "Independence" seen by the vanguard of persons reentering the lagoon following Test Able. The light carrier was badly wrecked by the explosion, gutted by fire, and further damaged by explosions of low order, including those of torpedoes. The Joint Chiefs of Staff's Evaluation Board made a terse statement which was issued to the public from the White House. The

bomb, they said, had exploded with an intensity approaching that of the best of the three previous atomic bombs. It had exploded at a point 1500 to 2000 feet westerly of the assigned target, and at approximately the planned altitude. The light carrier "Independence" was within one-half mile of the explosion point. **ABOVE.** Blasted portside of the carrier, her plates molded to her frame by the explosion.



**CLOSE IS NEAR ENOUGH.** The light carrier "Independence" is a shambles. Visible to the inspecting newspapermen are the combined results of the tremendous pressure wave and intense heat produced by the bomb: the bulged and torn flight deck, charred remains on flight and hangar decks. Invisible are the lingering effects of the bomb's radiation, which even as these pictures were made make the grotesque wreck still too "hot" for more than brief visits. This gutted ship incontestably

evidences the great range of effectiveness of the single atomic bomb which had exploded high above the surface of the water, about one-half mile from the doomed ship. Under these circumstances "Independence's" position was virtually a front row seat. **OPPOSITE.** Heavy damage to the carrier's stern. Despite her gaping wounds "Independence" remained afloat, available for careful study and for exposure to the second explosion to be held twenty-four days later.









**TIN FISH, OR RHINOCEROS?** The submarine "Skate" was one of the target ships close to the explosion point of the bomb, the blast and heat from which turned her superstructure into a mass of scrap. Her tough hull refused to succumb to the bomb's onslaught, however. She was put back into operation by her crew a few days after Able Day, although the damage to superstructure still made it unsafe to submerge her. **UPPER.** Crew of "Skate" stands at quarters as the sub passes Admiral Blandy's flagship. **LOWER.** Damage to periscope shear. **OPPOSITE, UPPER.** "Skate" in pre-Test condition. **LOWER.** Portside view of damage.





**DAMAGE ABOARD SKATE.** A specially-trained monitor from the Radiological Safety Group uses a Geiger counter to measure the radioactivity on the wrecked bow section of the submarine "Skate." The photograph reveals the extent to which the submarine's superstructure was stripped away, ex-

posing the pressure hull. During Admiral Blandy's initial tour of inspection of the target area, the "Skate" was too "hot" to be boarded. When Geiger counters were brought near her by monitors in the inspecting picket boat the counters' indicator-needles were driven off scale.

**SUPERSTRUCTURE DAMAGE ON ARKANSAS.**

The 34-year old battleship "Arkansas," oldest battleship of the United States Fleet, was one of three major combatant ships within one-half mile of the explosion point. Although little damage was done to her hull and turrets, her wrecked superstructure showed the hammer-like effect of the bomb. Amidships she was a shambles. When

the Lagoon was first reentered after Test Able the "Arkansas" was still sending up clouds of smoke from smouldering fires on her decks. "Arkansas" was definitely put out of action and would have required extensive repairs at a principal naval base. In Test Baker she was near the bomb detonation point, took brief but terrific punishment, and sank almost instantly.





**OUT OF PROXIMITY, DOOM.** The Japanese cruiser "Sakawa's" superstructure and hull suffered major damage from the bomb explosion. Visible in the photograph above are the mid and stern sections of the ship, a mass of metallic rubble. Invisible are the breaches in her hull below the waterline, due to which she slowly filled with water and sank. Many observers wondered how a mere shock wave in air could wreck such havoc on a steel ship. The situation can be understood with the use of simple arithmetic. According to a well-known law of physics a gas expands by  $1/273$  of its volume (at zero degrees C.) for every degree

Centigrade that it rises in temperature. If its temperature rises 273 degrees its volume doubles. But the high temperature instantaneously produced at the heart of the atomic bomb explosion is measured in millions of degrees; the resulting expansion is obviously extremely great. Out of this expansion, so suddenly produced, the overpowering shock wave is born. **OPPOSITE.** The day following Able Day "Sakawa" sinks slowly beneath the water of the Lagoon. In the background is the battleship "Arkansas" which, like "Sakawa," received major damage to superstructure, although the battleship's hull received little injury.









**USED CAR, ABOARD NEVADA.** This ruined two and one-half ton Army truck is on the stern of the bullseye ship "Nevada." The bomb exploded 1500 to 2000 feet west of the ship, and the shockwave struck "Nevada" on her stern quarter. Even at this range the light gage metal of which the truck is

built was quickly turned into the crumpled wreck shown. A member of the Army Ground Group checks damage, using forms prepared before the tests to insure thorough reporting of data. In addition "before" and "after" photographs were made of all equipment exposed.



**SHREDDED AIRPLANE, NEVADA.** The crumpled remains of a Navy seaplane on the stern of "Nevada" demonstrate further the destructive power of the atomic bomb even at a distance of 1500 to 2000 ft. Collectively such damage data together

with the scientific results obtained from the tests, will prove valuable not only in naval and military engineering but also in many important scientific fields. The results of Operation Crossroads go much further than military questions alone.



**THIS MAKES A WILDCAT WILD.** On the weather deck of the APA-77 "Crittenden" an FM-2 "Wildcat" airplane is given a thorough examination following Test Able. The plane has a broken fuselage and boat wings as a result of its exposure to the bomb. The effect of shock wave on equipment like this was to some extent influenced by shielding afforded by portions of the ship's structure and by other test material. Concerning personnel, the Evaluation Board stated that casualties due to blast would undoubtedly have been high for those in exposed positions on vessels within one-half mile of the explosion center.

**GENERAL DAMAGE ON STERN DECK, NEVADA.** Such spectacular damage to equipment exposed on the decks of target ships, in this case "Nevada," was produced only in Test Able. The Test Baker damage was primarily in the form of ships sunk by the underwater blast wave, and ships afloat but dangerously contaminated by the huge amounts of radioactively noxious water that had poured down upon them. "Nevada's" coat of bright orange-yellow paint, put on to aid the bombardier's aim, was badly scorched by the heat of the explosion.









**TEST ABLE AFTERMATH: NEVADA AND DAWSON.** ABOVE. The scorched port quarter of the "Nevada," blackened from waterline to top deck, is evidence of the consuming heat to which the ship was subjected. Note the crazy angle assumed by "Nevada's" airplane crane as a result of the combined heat and shock wave. The big battlewagon's superstructure has been heavily damaged, as indicated by the torn smokestack and bent antenna masts. Visible on her deck is an amphibian truck or "duck," developed during the war by the Office of Scientific Research and Development, the same agency, which, until the formation of the Manhattan Engineer District on August 13, 1943,

directed the meteoric progress of the atomic bomb project. The "Nevada" was no stranger to attacks. The 30-year old battleship was a target for Japanese bombs and torpedoes at Pearl Harbor, subsequently took part in 52 bombardment missions in the Atlantic and Pacific. OPPOSITE, APA 79 "Dawson" was not very severely hurt by the Test Able explosion, although some damage was suffered, as shown. Her outer stack casing shows a considerable dent, and her radar mast has been pried from its support. On the top of the house, extreme right of the ship, was placed a support for gages used for measuring shock wave pressure.



**SATURDAY NIGHT BATH FOR CONTAMINATED DRONE.** Use of drone boats as collectors of water samples from Lagoon areas where contamination was great rendered the boats themselves extremely "hot." Like the ships of the target array, they too received a thorough cleaning before they were boarded. For the tests the Navy

perfected eight drones, used four during Test Able, six during Test Baker. The boats were converted LCVP's fitted with a mass of complex electrical gear to operate the starting, steering and sample-collecting mechanisms. Black stripes on a gaudy yellow base aided recognition by the conning aircraft.



**REBOARDING PARTY.** Newspapermen inspect damage to one of the target ships following Test Able. In the foreground are the charred remains of Army Ground Forces equipment exposed to the bomb. The Evaluation Board's initial report stated that primary material effects of the bomb were due to blast, with fire a secondary cause of

damage. Army Quartermaster stores and miscellaneous equipment placed on the decks of the target ships proved more vulnerable than normal naval deck gear. There was no evidence on any of the ships remaining afloat that any of the considerable amounts of explosive ordnance exposed on deck was exploded by direct action of the atomic bomb.



**ALL THE CLOTH THAT'S FIT TO PRINT.** William L. Laurence, center, eminent scientific writer of the New York Times, discusses the tests with Dr. Ralph A. Sawyer, left, Technical Director, and Colonel William Westlake, Deputy Public Information Officer, aboard the press ship "Appala-

chian." Mr. Laurence was the only correspondent to witness the first bomb test, in New Mexico; and he had the unique distinction of riding in the bomber that carried out the Nagasaki mission. Dr. Sawyer was responsible for all scientific instrumentation at Bikini.





**TEST ABLE IS HEREBY ENACTED.** Aboard the AGC-13 "Panamint" members of the House Naval Affairs Committee witness Test Able, from a point about 20 miles off Bikini. Left to right: Representatives George J. Bates (R), Massachusetts, Michael J. Bradley (D), Pennsylvania, Edouard V. M. Izac (D), California, and Jack Z. Anderson (D), California. From the "Panamint" the flash of the bomb was spectacular although no heat or shock

waves were felt and the explosion was only faintly audible. On the afternoon of Able Day ships of the observer fleet reentered the lagoon. Soon afterwards inspection parties in small boats toured the target area. One by one the target ships were examined and then declared "Geiger sweet"—safe for reboarding. Among the ships first reboarded by the observers were "Nevada," "Arkansas," "Prinz Eugen," "Pensacola."





**SANDLOT ACTIVITY, KWAJALEIN.** In a treeless stadium at Kwajalein members of the Army Air Forces play a spirited Island League softball game. In the background are C-54 transport planes of the Green Hornet Line. Scenes like this were the exception, not the rule, beside Kwajalein's bustling airport. From its scorched airstrip planes of the Green Hornet Line departed for Johnson Island, Pearl Harbor, and the United States. Air Transport Command planes used Kwajalein as a way station on their flights to Guam and Tokyo. Unpleasant bedfellow at Kwajalein prior to Test Able was the atomic bomb itself.



**THE POSTMAN ALWAYS LANDS ONCE.** A PBM plane of the Bikini-Kwajalein shuttle service unloads its cargo of mail into a launch from the AVP "Orca," seaplane tender that presided over the seadrome west of Bikini Island. Mail service at Bikini was good. It was no uncommon thing to get mail from the United States in five days. Incoming mail was taken to the LST that served as postoffice, sorted and then distributed to the 42,000 addressees. To guard the seaplanes against injury from floating debris in the landing area a converted PT boat commanded by Ensign Felix Jablonski policed the seadrome.





**NATURAL HISTORY IN THE MAKING.** Surrounded by collecting bags, bottles, knapsacks, and other paraphernalia cherished by naturalists, Dr. Joseph P. E. Morrison, Assistant Curator of Mollusks at the U. S. National Museum, examines a seafaring bird caught at Bikini. Dr. Morrison became a familiar figure along the reefs and beaches of the Atoll. His unusual pistol, which had four interchangeable barrels of different sizes, attracted particular attention. Whatever the size or range of the bird he was gunning for, the right

caliber was quickly available. Dr. Morrison was in charge of collection and examination of birds, land animals, mollusks, crustaceans. **OPPOSITE.** Following Test Able, one of the goats which had been exposed to the effects of the bomb is checked for radioactivity with a Geiger counter. For Test Able 176 goats were used. Some were coated with protective salves, some had portions of their hide shaved to expose parts that would best approximate human skin. No goats were used in Test Baker.



**THE MOVING FINGER WRITES.** In the radiation measurement section of the Instrumentation Laboratory on the AG-76 "Avery Island," Mr. A. H. Waite, Jr., checks the timing of an automatic pen-and-ink recording device. Recorders like this were used on support ships, several miles off Bikini, to make permanent records of data automatically gathered by instruments on the "hot" target ships within the lagoon. Many of the Geiger counters on the target vessels were used in this way; they were equipped with radio transmitters which automatically broadcast the counter readings to these remotely-located recorders. Such continuous records were available for immediate use, or for more detailed analysis at a later time.





**GEIGER COUNTER LOG, BURLESON LABORATORY.** Aboard the APA-67 "Burleson" an officer from the Naval Medical Research Institute examines samples for radioactivity. With far less modern apparatus the Curies in the 1890's tested innumerable samples in their painstaking search

for the elements responsible for the newly discovered phenomenon, radioactivity. On-the-spot laboratories such as "Burleson's" made possible the detection and study of even the earliest symptoms of any radiological diseases contracted by the animals.



**TEST BAKER CINDERELLA SHIP.** In a caisson slung at a predetermined depth below this LSM-60 is the atomic bomb used in Test Baker, which occurred at 0835 on the morning of July 25 by the Bikini calendar (July 24 in New York). Test Baker was the under water shot, designed to determine the effects of an underwater atomic bomb explosion upon ships, particularly ship hulls. Use of a surface vessel from which to suspend the bomb made possible a detonation at exactly the predetermined depth and at the exact center of the target array; all errors in positioning the bomb were avoided. Shown here is the antenna used to receive the radio signal which detonated the bomb. The midship hoist used for lowering the bomb caisson is also shown. **OPPOSITE, UPPER.** Scientist being checked into the well-guarded timing laboratory aboard the AV-17 "Cumberland Sound." **LOWER.** Dr. Marshall G. Holloway, Head of the Los Alamos Laboratory group at Bikini, throws the final electronic control switch on apparatus which a few seconds later detonated the Test Baker bomb. Signals controlled from this panel started automatic cameras and instruments a few seconds prior to the detonation.





**BAKER BURST.** The Baker Day explosion burst through the calm, blue water of deserted Bikini Lagoon at 0835 on July 25, Bikini local time and date. Wind was from the south, and of low velocity; cloud coverage was very slight. Evacuation of the support fleet and of all personnel from the

Lagoon was well underway by dusk of the preceding day; it was completed when the last remaining technicians quitted the Lagoon nearly two hours before the 0835 "Mike Hour." During the hour before the detonation shipboard observers selected vantage points on the uppermost decks.

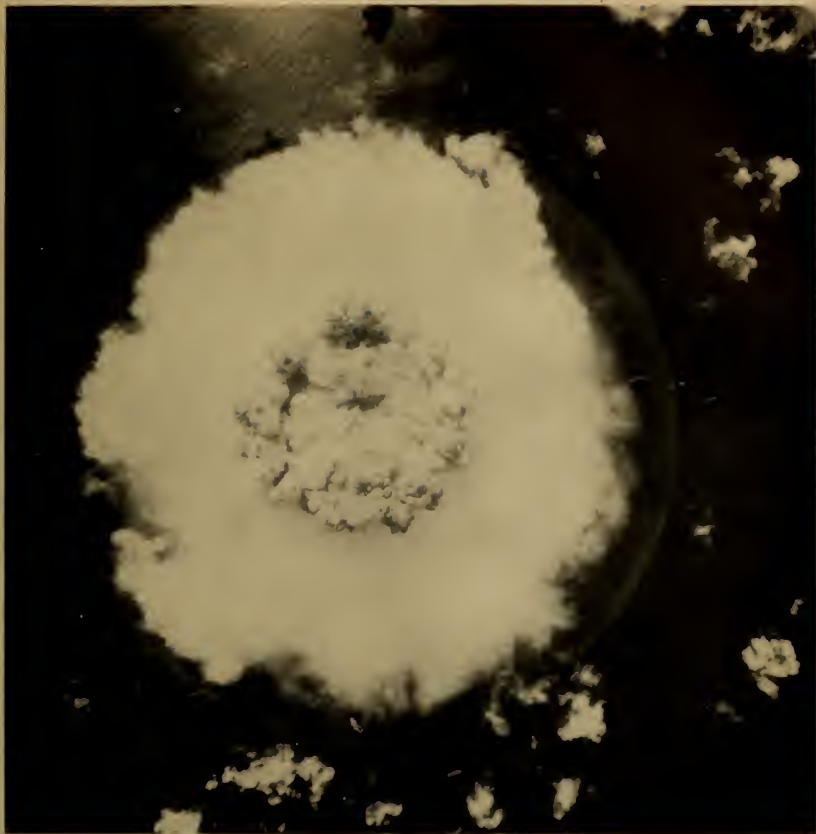


**HIGH ALTITUDE VIEW, BAKER TEST.** This almost perfect birdseye view of the Baker burst was taken from directly overhead by a drone photographic airplane arriving exactly on schedule. To aid discussion of pictures like this, Task Force scientists developed their own terminology. In this photograph the rough central portion, or "cauliflower",

is still in an early stage. Water which lay motionless a second before is now arising toward the camera with the speed of a bullet, spreading slightly as it rises. The surrounding white disc-shaped area, concentric with the cauliflower, is called the "fillet." It denotes the spread of the extremely intense pressure wave.







**PLANNED COINCIDENCE, BAKER TEST.** These photographs of the Baker Test, subject matter aside, are clear evidence of the accurate timing achieved in the second bomb test. By radio control an Army Air Forces B-17 drone plane has been brought to just the right position above the bomb detonation point, exactly at the instant of detonation. Other radio-controlled apparatus has activated the cameras that made these photographs. All such controls were synchronized with the signals

detonating the bomb itself. Two stages in the development of the cauliflower are shown. The shock wave and fillet continue to expand, the cauliflower grows, the condensation cloud begins to assume its roughly spherical shape. Shadows cast by low-lying natural clouds form blotches on the explosion cloud below. Size of the target ships (right, above) indicates the height at which these pictures were taken and gives some conception of the magnitude of the burst.



**CONDENSATION CLOUD, TEST BAKER.** Whether man can ever produce rain is questionable; but that he can produce a large region of fog is proved by this photograph. Dwarfing the ships silhouetted against it, the roughly spherical region contains over one cubic mile of fog. On a gigantic scale

this cloud is reminiscent of tiny clouds produced nearly 50 years ago by the English scientist C. T. R. Wilson, who was experimenting to find the causes of fog and rain. His studies of expansion, cooling, supersaturation of air, made using expandible chambers of metal and glass, won him renown.



**AFTER THE PREDICTIONS, CONFIRMATION.** Oblique view of the condensation cloud and water mass rising up at the center. The Evaluation Board commented on Test Baker as follows: "The explosion was of predicted violence and is estimated to have been at least as destructive as 20,000 tons

of TNT. To a degree which the Board finds remarkable, the visible phenomena of explosion followed the predictions made by civilian and service phenomenologists attached to Joint Task Force One. The blast was followed by an opaque cloud which enveloped half of the target array."



**TEN MILLION TONS OF WATER.** In this striking view of the Baker Day test the condensation cloud has disappeared near the surface of the Lagoon, revealing the target array and the upsurging

column of ten million tons of water. As if resentful of its imprisonment under water the bomb hurled this column of water, fully 2,200 feet in diameter, 6,000 feet into the air. The column is moving up-





ward with such incredible speed that its remarkable mottled appearance is caught only on short exposure photographs such as this. The condensation cloud now covers an area of approximately ten

square miles. The dark hole on the right of the column marks the location of the battleship "Arkansas" which sank within a matter of seconds after the burst.

**ONE MILE BELOW, A MUD-SLINGER.** Shown at about the top of its rise, the millions of tons of water thrown up by the Baker bomb break through the enveloping condensation cloud before descending upon ships of the target array one mile below. Explosion of the bomb beneath the surface of the Lagoon subjected the surrounding water to many unprecedented effects, including intense neutron bombardment. This produced artificial radioactivity, particularly in the sodium, iodine, bromine, and potassium content of the water. Therefore most of the water in the column was dangerously radioactive. The bomb produced an amount of radioactivity estimated to have been the equivalent of many hundred tons of radium. A few minutes exposure to this intense radiation at its peak would within a brief interval have incapacitated human beings and resulted in their death within days or weeks. The drenching of the target ships with this colossal amount of contaminated water makes it understandable that they remained radioactive "hot stoves" for days after the test. Also for this reason animal casualties from radiation were much more pronounced in the Baker test than they had been in Test Able.







**OVER THE HUMP.** When this photograph was made the column of water had just about reached the top of its rapid climb. Its mottled surface has been replaced by individual jets or spurs each one of which is approximately the size of a large ship. In another moment the huge column begins its ominous descent. The condensation cloud is still

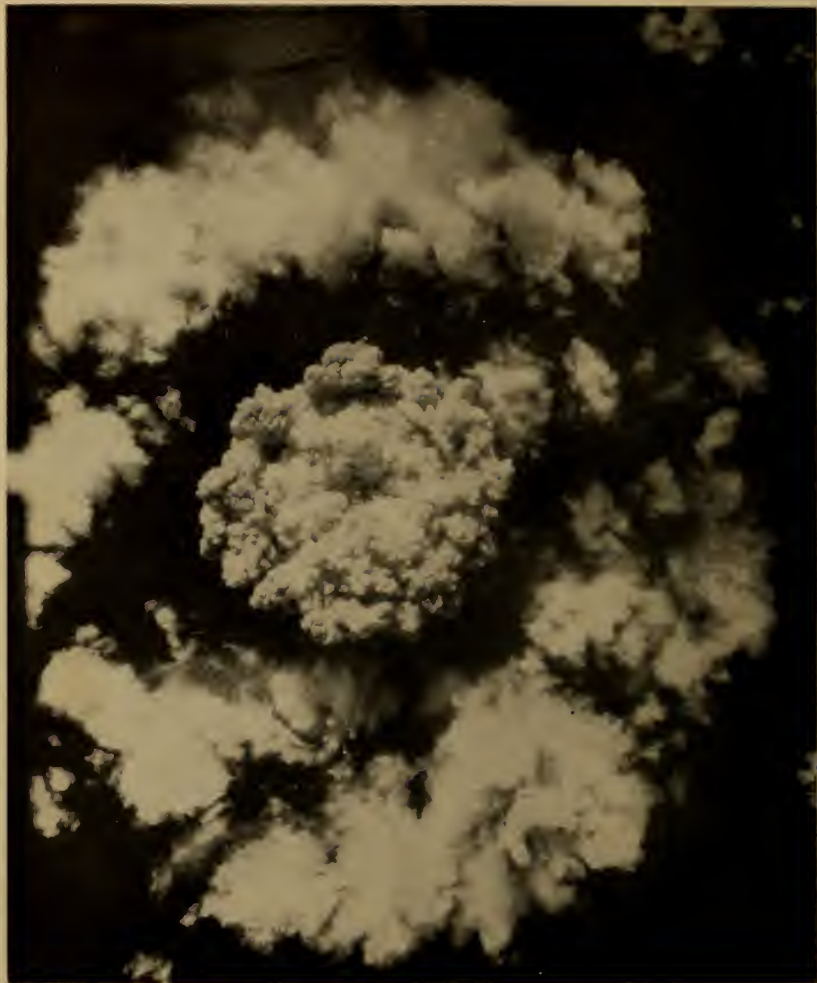
present. In Test Baker the air blast wave was far less intense than it had been in Test Able. There was little optical radiation of any significance. Due to absorption of neutrons and gamma rays by the water of the Lagoon, the first flash of nuclear radiation had very little immediate effect on the target ships.

**SEVENTH VEIL.** Taken a few instants after the picture on the preceding page, this photograph shows the last vestiges of the condensation cloud still encircling the water column. Invisible to the camera's eye, the complex instrument array is recording many statistics concerning this lofty column. Positive conclusions to affect ship design were to come later. On September 7, 1946, the

significant announcement was made that construction on the 45,000-ton battleship "Kentucky," 70 per cent completed, and on the 27,000-ton battle cruiser "Hawaii," 85 per cent completed, would be curtailed until January 1947 pending design changes based on Operation Crossroads as well as on lessons learned during the war. And even more radical changes may be expected in the future.







**EDUCATED CABBAGE.** A drone plane flying directly overhead just as the Baker bomb water column reached its greatest height recorded this interesting view of the cauliflower. Appearance of the condensation cloud suggests that this picture was made but a few instants after the view on the preceding page. **OPPOSITE.** This oblique shot of the Baker burst again emphasizes the height of

the cauliflower, size of which should be compared with the single ship of the target array visible just inside the expanding shock wave. Taking into account the amount of research development work which this single photograph represents, Mark Twain's definition of cauliflower as "a cabbage with a college education" is in point. This photograph was made from an altitude of over 10,000 feet.





#### DESCENT OF THE COLUMN, BAKER TEST.

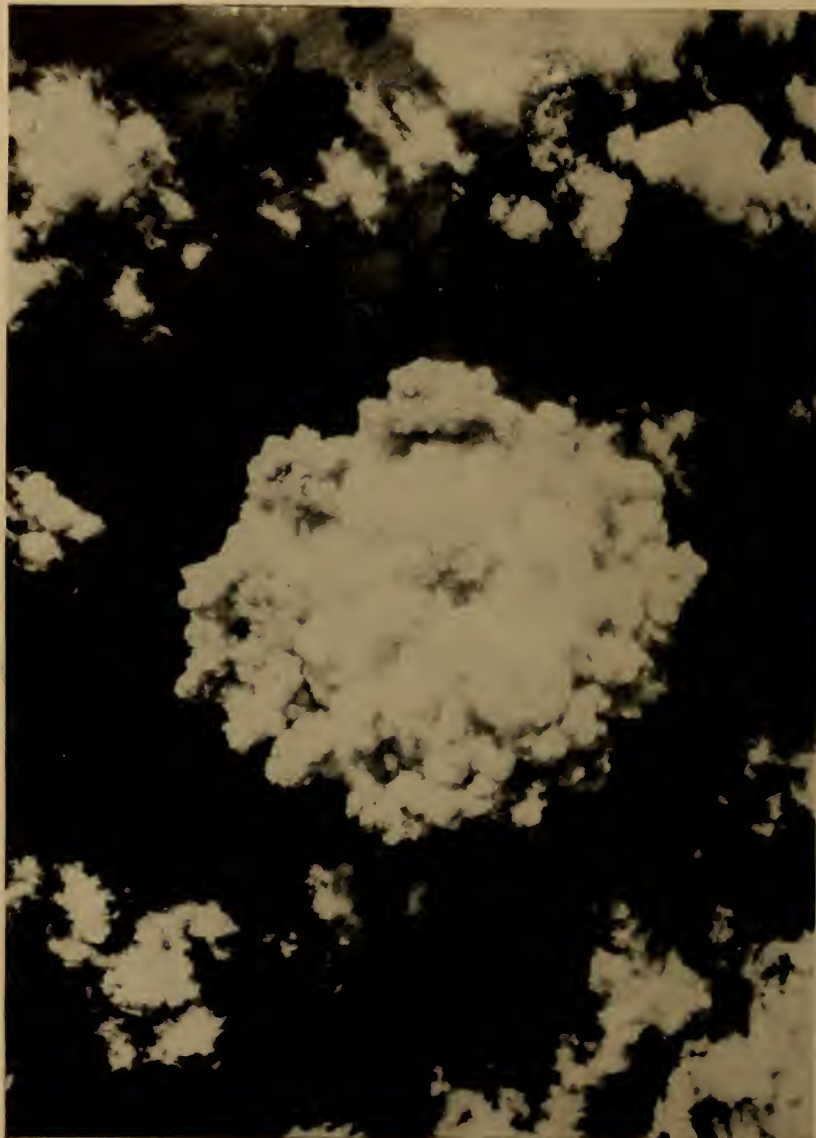
Shown here is the Baker burst water column starting its descent back into the Lagoon. Pulled now only by gravity, a puny force compared with that produced by the bomb, the water drops relatively slowly. Thundered back into the Lagoon from its

mile-high vantage point, the millions of tons of water form colossal waves and an expanding cloud of spray and water plunging outward from the base of the column. Within a few minutes this engulfing mass, called by oceanographers the "base surge," has shrouded approximately half the target array.



**OBLIQUE VIEW, BAKER TEST.** As is well known to photographers, use of yellow, orange, or red filters cuts down the amount of blue and ultraviolet light reaching the film, thus cutting out haze and leaving a dark background of sea and sky. Such filters were put to especially good use at Bikini, and

are in large part responsible for the excellent contrast obtained, particularly in photographs taken from the air. A few polaroid filters were used also. Some of the high-contrast photographs shown here actually provide greater contrast than was available to the naked eye.







**A TREE GROWS IN BIKINI.** Somewhere beneath this tree-shaped watery pile lies the battleship "Arkansas," which was the nearest to the center of impact when the Baker bomb was detonated. "Arkansas" and three other smaller ships sank almost at once. The aircraft carrier "Saratoga," also close to the bomb, sank seven and one-half hours later. The big battleship "Nagato" emerged from the Baker Test with a five degree list, remained in that condition for four days, sank in the middle of the night. Comparing the two tests, the

Evaluation Board observed that ships remaining afloat within the damage area appeared to have been much more seriously damaged by the aerial explosion than by the underwater explosion. Damage to ships in the first test might have been far greater had the bomb exploded directly over the target ship "Nevada." No ship within a mile of either burst could have escaped without some damage to itself and serious injury to a large number of its crew. **OPPOSITE.** Vertical view of Baker burst.





**OUT OF FISSION, CONFUSION.** These photographs re-emphasize the great scale of the Baker burst. They convey an impression that was the commonly-shared experience of on-the-spot observers—the difficulty mentally of taking in the spectacle before them. Note particularly, in the picture opposite, the row of destroyers lying in a sunny patch of sea not yet encompassed by the advancing cloud of water and spray. They are like minnows about to be engulfed by Niagara. Lost in comparison with the towering clouds of spray spreading out from the top of the cloud, some of these ships are shortly to be immersed in the wall of foam coming along the Lagoon's surface from the base of the column.

**BASE SURGE: LAGOON LEVEL.**

The wall of spray and steam at the base of the column rushes precipitantly out from the center, drenching the target ships with its thick poisonous wetness. At the left all but the bow of the battleship "New York" has been overrun by the cloud. In the center and at the right, respectively, the "Salt Lake City" and "Nevada" have only seconds to wait. Small wonder that over 90 per cent of the target vessel array was affected by the deadly radioactivity. Although the amount of damage done to hulls was not very different from predicted damage, the extent of radiological hazards went beyond what had been expected. Lessons in radiological safety formed an important result of Operation Crossroads.











**DISINTEGRATION OF A COLOSSUS.** The cauliflower in this stage is rapidly approaching the appearance of a mere cabbage. The height of the base-surge is easily estimated by comparison with the "Salt Lake City" just at the edge of it. Near the "Salt Lake City" clumps of spray and white marks in the water are splashes made, presumably, by portions of the LSM-60 falling back into the Lagoon after a spectacular flight into the air. Unlike Test Able, the Baker bomb was not a "self-

cleansing" shot. Radioactivity in the Lagoon persisted for weeks. It produced in the salt water lines and condensers of various returning Crossroads vessels a radioactive residue which was disclosed by a precautionary check made when the ships arrived at the West Coast. During the entire conduct of Operation Crossroads no casualties from radioactivity occurred, testifying to the extreme precautions taken. **OPPOSITE.** Second base-surge forms inside first.



**AUTOMOBILE SHOW.** This photograph was taken by an airplane located approximately as far away as were the principal vessels of the supporting fleet. Principal command, laboratory, and observer ships were 10 to 12 miles from the detonation point. Each ship circled slowly in a prede-

termined zone. Zones were named for automobiles, for example, Chevrolet, Chrysler, Ford, Chalmers. The majority of the scientists kept their eyes to their binoculars. Some stood watch over special apparatus. Thin white lines, explosion-generated waves breaking on the reefs, could be seen.

**BEYOND THE HORIZON.** As the base surge completes its lateral spreading, the cloud, drained by gravity of its water content, floats off with the wind. During the first hour her northward progress was easily watched by observers on surface vessels; the cloud retained a slight orange tint, and ap-

peared somewhat larger than other clouds. By the end of the second hour she was practically indistinguishable from the countless clouds dotting the horizon; and all attention reverted to the destruction in the Lagoon. Specially-equipped planes were able to follow the cloud some time longer.





**WAVE MOTION, TEST BAKER.** These waves, shown reaching the beach at Bikini, are the dwindled remnants of waves which at 1000 feet from the explosion center were 80 to 100 feet in height. Largest waves reaching Bikini beach were about seven feet high. Although they did not pass over the Island they flooded the Island roadway and several other areas. No material damage oc-

curred, however. **OPPOSITE.** Dr. G. K. Green, formerly a major in the Army, instrumentation expert of the Army Ground Group, studies a telemetered recording made on an Esterline-Angus recorder on the AG 76 "Avery Island." "Telemetering" is the process in which automatically-made readings of instruments are radioed to a point some distance away and are there recorded.







**COUNTERS, TIDES, AND WINDS.** Two radiological monitors of the Task Force work their way into a contaminated portion of the Lagoon using a Geiger counter to take readings of radioactivity in the water. Readings fluctuated considerably from day to day, depending on tidal effects, drifts in wind, and currents ascending from the bottom of the Lagoon floor. Nature gave some assistance to lessening the radioactivity of Lagoon water; thanks to currents produced by tides and winds the water in the Lagoon is constantly being interchanged with water from the open sea. But this process is slow, approximately 48 days being required for the water inside to be completely replaced. The Atoll has only one large channel to the sea, but at high tide sea water can easily wash over the reefs into the Lagoon.



#### DECONTAMINATION PROCEDURE, USS NEW YORK.

A United States Navy fireboat washes down the decks of the battleship "New York" with sea water shortly after the Baker Test. This procedure was carried out with many of the target ships prior to sending inspection parties aboard. High pressure firehose streams washed much radioactive material from the decks, making the initial reboardings after the test far less dangerous than they would otherwise have been. During the Test Baker explosion great quantities of radioactive water were thrown upon the ships, either by the great column tossed up or by the enormous waves. This innocent-appearing but radioactive water was such a hazard even after four days, that it was still unsafe for inspection parties to spend any useful length of time at the center of the target area.





**END OF THE "SARA."** As the cloud lifted following the Baker blast, and the target array once more became visible, there was no question but that the gallant aircraft carrier "Saratoga," oldest U. S. aircraft carrier afloat, was seriously damaged. All moored planes and material on her deck had been swept into the Lagoon. Much of her superstructure was gone or extensively damaged. The very distinctive stack (shown opposite, upper) was completely gone. When ships of the supporting fleet

began re-entering the Lagoon after the test, and it was certain that "Saratoga" was on her way down, Admiral Blandy ordered tugs to attempt to secure lines to the carrier and tow her to Enyu Island for beaching. This proved impossible since both "Saratoga" and the water surrounding her were too "hot" to permit safe approach. The sinking of Old "Sara" was watched with mixed emotions by members of the Task Force, many of whom had served on her during her fighting days.





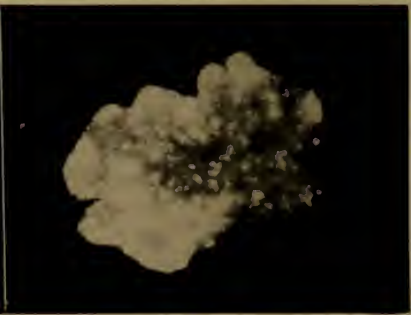
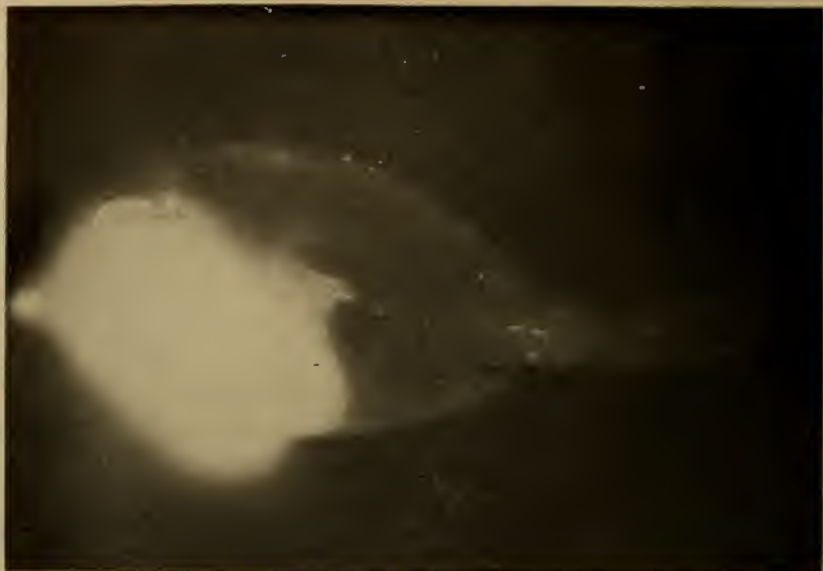
**THE EYES HAVE IT.** The scene is aboard "Panamint" an instant or two before "Mike Hour," detonation time of the Test Baker bomb. The bomb's explosion in a submerged position made it possible for observers to look directly at the explosion point area without recourse to dark glasses or goggles. These men are 11 miles from the bomb. They are focusing on the LSM-60 beneath which it is sus-

pended. The moment for which they have waited is here. In the group are, left to right: Representative Albert J. Engel (R), Michigan (in cap); Commander S. H. K. Spurgeon, Australia; Major H. Bruining, The Netherlands; Mr. J. K. Northrop, president of Northrop Aircraft, Inc.; and Mr. E. S. Stedman, Canada. The man in the foreground was not identified.



**BOMB VS METROPOLIS.** This composite photograph roughly compares the height of the Baker Day cloud with the height of New York's greatest skyscraper. An exact comparison to scale would, if anything, be even more extreme than this; the great cloud rose to approximately 6000 ft., and the

Empire State Building is only 1250 ft. in height. The greatest cauliflower cloud would overshadow a considerable portion of central Manhattan. It requires little study to appreciate that one atomic bomb is capable of producing catastrophic destruction.



**INSIDE THE FISH, A "HOT" SUPPER. UPPER.**

This puffy surgeon fish has gorged itself heavily on radioactive algae, the common seaweed of the Bikini Lagoon. The plant itself had previously absorbed radioactive fission products deposited in the water by the atomic bomb. Radioactivity of the plants will last a long time, is not affected by passing into the fish's stomach. Previous similar dinners already digested and distributed about his body are revealed by the radioactivity of regions

in the neighborhood of nose and eyes. The fish was not killed by the radioactivity, it being apparently true that the more elemental the form of life, the less it is affected by radiation. **LOWER.** Radioactive algae. These "radioautographs" were made by placing the subjects on a photographic film overnight. They suggest Becquerel's 1896 discovery of radioactivity when a key left near some uranium-bearing pitchblende ore similarly "took its own picture" on a piece of film.



**FULL FATHOM FIVE.** Underwater photography was used at Bikini to record damage to hulls and superstructures of sunken vessels. This work was especially significant after Test Baker, in which a particularly large fraction of the interesting me-

chanical damage occurred on ships which sank. The diver shown is preparing to descend from the specially equipped LCM used in this work. He wears a simple face mask and a quick-release type of lead-weighted belt.



**BARRACUDA-EYE VIEW OF UNDERWATER PHOTOGRAPHER.** Underwater photography techniques experimented with at Bikini were not particularly hazardous, although voracious barracuda, sharks, and eels occasionally turned up to see what was going on. Fortunately these fish will avoid

a man who moves about underwater, especially if there is a column of air bubbles escaping from helmet or face mask. Some sharks 12 feet long were seen, but they kept their distance. Smaller fish, less reticent, ventured closer, formed a colorful array of onlookers as the photographic work proceeded.





**DAVY JONES' LOCKER.** Pictures like this were made by photographers working far beneath the surface of the Bikini Lagoon. Artificial illumination synchronized with lightmeter readings aided obtaining good exposures. The extremely clear water of the Lagoon also favored this subsurface work.

After Test Baker the bottom of the Lagoon was found to be covered with many feet of fine silt, pulverized coral resulting from the bomb's explosive force released beneath the water. Divers sank into this silt up to their shoulders. Jagged coral heads and radioactivity added to the difficulties.



**THAT MEN MAY LIVE.** Aboard the laboratory ship "Burleson" a goat suffering from radiation sickness resulting from exposure to the atomic bomb receives a transfusion of whole blood. Plasma used is from a goat blood bank contributed to by certain goats reserved for this purpose. Of the

animals used at Bikini about 35 per cent were killed — 10 per cent by the air blast, 15 per cent by radioactivity, and 10 per cent by research workers after the tests, for study. No exact parallel can be drawn between these figures and estimates of the possible effect of the bomb upon human life.



**HOMEWARD BOUND.** Off Enyu Channel sailors on a San Francisco-bound Task Force ship take a final look back at the scene of the two atomic bomb tests. Many of the 42,000 members of the Task Force left Bikini soon after Test Baker. Others remained there to do necessary post-test "mopping up". For the scientists and service personnel of

the technical groups, however, possibly the most important part of the Operation still lay ahead—the important work of consolidating results. Wise was the scientist who once said that he never knew what the results of an experiment were until he had written them down. By mid-October most of this work had been accomplished.



**OPERATION'S END: THE CONTINUING PROBLEM.** The "Burlington," arriving home from Bikini, symbolizes a cogent truth: The problems with which the atomic bomb confronts us do not, after an Operation Crossroads, remain behind, imprisoned within the coral bounds of a remote Pacific

atoll. At Bikini ships were sent to the bottom: the problems were not. As examples of man's scientific skill and cooperativeness the atomic bomb, and Operation Crossroads, are unrivalled. To those who direct man's humanitarian destiny the challenge is clear.

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