INTERNATIONAL ASSOCIATION FOR DENTAL RESEARCH

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I. Inaugural Address: Impressions of Operation Crossroads

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Under the able leadership of Vice Admiral Wm. P. Blandy, the organization of Joint Task Force 1 was entirely comparable in magnitude to one of the amphibious operations of the war. However, in addition to the customary problems of supply, operations, and security; the work anticipated at Bikini lagoon involved a major problem of safety. This problem was of such magnitude and so unusual that a special section, the Radiological Safety Section, was set up under the direction of Col. Stafford L. Warren of the Army and Captain George Lyon of the Navy. This section is proud of the summary which can be made of its activities; not one man is known to have been injured by the special hazards of the atom bomb tests.

ABLE DAY

On ABLE DAY the bomb was dropped from a bomber high in the air, as were the bombs dropped at Hiroshima and Nagasaki. The bomb exploded high in the air over the target fleet; from which height the bomb exhibited a maximum of concussion force (blast effect) and of heat destruction—but a minimum of radioactivity was left on the surface. By "maximum blast effect" is meant the force

[1] Sessions of the International Association for Dental Research preceded, by agreement, the Annual Meeting of the American Association of Dental Schools, in the same hotel, June 23–25 and the Annual Meeting of Omicron Kappa Upsilon on June 24.

[2] The General Secretary of the Association, E. H. Hatton, rendered invaluable assistance to the Editor in preparation of these Proceedings.

which reduced the hearts of the cities of Hiroshima and of Nagasaki to rubble, with the exception of certain modern earthquake proof buildings still standing, but in which walls and floors were so disturbed and twisted that demolition may be necessary. At Bikini, the blast effect accounted for the immediate sinking of several big ships. By "a maximum of heat destruction" is meant the kind of heat which left a shadow of a Japanese pedestrian on the pavement some $\frac{3}{10}$ of a mile from the zero-point over Nagasaki. The shadow was used to help fix the exact point of explosion by having a soldier stand in the footprints of the Japanese pedestrian, and sighting from the apex of the shadow over the head of the soldier to the point where the bomb exploded. The shadow was the unburned part of the pavement. By a "minimum of radioactivity" is meant so little radioactivity that when our forces entered Hiroshima and Nagasaki, some six weeks after the bomb drops, nowhere on the surface of the ground was there an amount of radioactivity even remotely comparable with the amount present on the dial of a luminous-faced watch. I wish to repeat—when the bomb exploded high in the air the blast effect is maximal, the heat effect is maximal—but the radioactivity remaining is minimal.

The reason the radioactivity is minimal should be made clear: At the instant of the detonation, the upper half of the explosion went immediately toward the stratosphere, carrying with it a large share of the radioactivity. This half of the explosion formed the puff ball at the top of the famous mushroom cloud. The lower half of the explosion drove with enormous velocity toward the surface of the water, struck with terrific force, and rebounded to form the lower part, the pillar, of the mushroom cloud. Most of the radioactivity in this part of the explosion was therefore also carried up into the stratosphere. At great heights, the total radioactive matter was mixed with air, diluted, and dispersed. Carried by the air currents, it may have encircled the globe. Only traces remained on the surface of the lagoon.

From the air Bikini was a long, narrow expanse of green, surmounted on the eastern aspect by the white coral reef. This tiny island, roughly one mile by one-quarter, was the only substantial piece of land for many miles in any direction. In the lagoon off the island of Bikini was the impressive array of the target fleet at anchor. The battleship NEVADA, center of the target fleet, was painted a brilliant orange-red, except for the top of the ship and the installations. This color made it a striking target for the bombardier high in the air. Ironically, there was enough overcast so that the bombardier could not see it on ABLE DAY.

Army material of all sorts was placed on the decks of the target ships to be exposed to the effects of the atom bomb; it was a veritable museum of Army equipment. There was a huge 47-ton tank, a duck, a jeep, a seemingly endless array of guns—from giant howitzers to BAR. Some experimental animals were also distributed in strategically-chosen locations throughout the target fleet to obtain maximum information about the effects of the atom bomb on living creatures.

Just before 9:00 o'clock on the morning of ABLE DAY, a group of specialists under Capt. Fred. Bryan, M.C., assigned to a gun boat, were gathered amidships

at the command of "All hands on deck." At the direction of the skipper we turned our backs to the Bikini lagoon, 18 miles west of us, and faced the mid-morning sun. We closed our eyes and covered our eyes with one arm. Standing in this position we heard over the radio, through much static, the bombardier call, "Bomb away," and the metronome ticking off the last seconds. Suddenly there was the sensation of a flash of light. We distrusted this sensation because one sometimes gets "flashes of light" by closing the eyes in broad daylight; but a second later, when it felt as if someone slowly brought a hot iron up behind our heads and slowly removed it, we were no longer in any doubt as to whether the bomb had exploded. There was a clearly-discernable heat wave at a distance of 18 miles! We turned then and watched the mushroom cloud start to ascend. It was full of color, especially browns and yellows, from the nitrogen oxides produced by the extraordinary heat and radiation. (The ball of fire has a temperature estimated to be of the order of 100 million degrees Centigrade.) A sound like that of a distant blasting came over the water. In a few minutes the cloud reached a height of about 25,000 feet, at which point a lovely scarf cloud of ice crystals seemed to grow out over the top of the ball. In a minute or two more the cloud had reached its final height of approximately 40,000 feet; the ball part of the cloud, at that time about five miles across, still retained a yellow tint.

In a few minutes, as we watched, the mist and smoke at the base of the cloud cleared sufficiently for us to see the red-painted mast of the NEVADA—the target ship was still afloat. We felt a sort of disappointment, because, from our position, it was impossible to tell that *any* ships had disappeared from the target fleet. In the succeeding two hours long streamers of black smoke from the burning vessels drifted across the lagoon. We watched these evidences of damage with a great interest. Another extraordinary sight went on overhead—mother airplanes guided radio-controlled drone aircraft through various parts of the cloud to collect radioactive dust in special filters.

As we entered the lagoon, we were first aware of the effects of the heat: blackened, charred paint; vessels afire. Then we became aware of the curious pattern of the bent and twisted masts; many masts were bent nearly at right angles, and on the various ships around the center of the target area, masts were always bent away from the center. Some of the ships' funnels appeared crumpled. In skirting the target fleet, we passed one ship capsized, hull awash, that sank a few hours later. On ABLE DAY afternoon we watched the aircraft carrier INDEPENDENCE burn fiercely; explosions aboard sent gigantic white smoke rings hurtling into the air; a dull glow of fire came from the stern of the ship. The Japanese cruiser, SEGAWA, which sank on the morning of ABLE plus one, seemed crushed and twisted. The enormity of the damage awed us.

BAKER DAY

There was an important difference in events after the BAKER DAY explosion. This bomb was exploded by radio signals sent from a ship (the CUMBERLAND SOUND) several miles away. When the bomb went off, a sub-

stantial part of the radioactive materials were caught in the seawater; and, in addition, the neutron emission converted some salt of the sea water into radioactive sodium and radioactive chlorine. The water, containing various radioactive materials and, incidentally, powdered coral, was thrown high in the air, turned and cascaded down over the ships in the center of the target fleet.

I would like to emphasize the magnitude of the radioactivity in this sea water: In our hospital clinic, we have a few milligrams of radium. These few thousandths of a gram are treated with great respect; many health rules are laid down for the safety of those whose work includes the handling of this material. Special, long-handled instruments are provided; the workers carry pieces of film in the pockets of their laboratory coats; blood counts are made at frequent intervals; and the workers are required to take four weeks of vacation each year. Such precautions are taken with a few milligrams of radium. There are a thousand milligrams in a gram; there are one million grams in a ton; and the water on BAKER DAY contained the equivalent (in gamma radiation) of several thousand tons of radium. Man has never seen before such a stupendous radioactive hazard.

As the BAKER DAY bomb exploded, a column of water was driven skyward in a twinkling, and then the spreading pressure wave with its attendant fog obscured the scene. When the fog evaporated, the water column, one-half mile across, was still ascending. The column of water extended more than two miles in the air, and the top was nearly three miles across—twenty million tons of water. As the column of water began to descend, a tremendous breaker, a wave 600 feet high, arose, which subsided as it traveled toward the island so that it was only a few feet high when it reached the shore. A tremendous mist cloud full of radioactivity drifted along the surface of the lagoon, permeated the ships, and was carried downwind, dropping radioactivity onto the surface of the ocean in an area nearly twenty miles wide and forty miles long. In this area, dangerous radioactivity existed for many hours.

The mighty SARATOGA sank on BAKER DAY afternoon before anyone could get aboard. Tugs sent to tow her into shallow water could not approach close enough to get hold of her anchor chain, because the radioactivity was so intense.

After periods of hours or days the ship-washing processes started; and in due time boarding parties were permitted to inspect the damage. Always a "geiger-man" from the Radiological Safety Section accompanied or preceded such a party and decided whether it was safe for man to stay aboard for ten minutes, one hour, or all day.

Some of the precautions might be mentioned: Shoes became so heavily contaminated that they were dangerous and, when cleaning was impossible, they had to be discarded—fifty thousand pairs were thrown away. Rust in pipes inside ships became contaminated; bunks near these pipes were evacuated. If the rust and paint on the sides of ships became sufficiently contaminated, the outermost bunks next to the hull were evacuated. The big evaporators, which prepared drinking water, accumulated such large amounts of radioactivity in

some ships that engineers could only work a fraction of their working day. Everywhere all possible hazards were anticipated and checked. Some of the ships, even after the most diligent washing, could not be rendered safe. A few of these were taken out into the ocean and sunk. Others were towed to Kwajalein, to our own coast, or elsewhere where disposition has not yet been decided.

A brief comparison might make the problem growing out of BAKER DAY test more easily appreciated. The water on BAKER DAY contained the equivalent of several thousands of tons of radium. This figure should be contrasted with the amounts of radium remaining in the bodies of some of the women employed during World War I as radium dial painters. These women, despite all safeguards, persisted in tipping on their tongues the brushes they were using to apply radium paint to airplane dials. Those unfortunate enough to retain lethal amounts of radioactive material died of cancer from radium deposited in the bones; deaths were recorded five, ten, and even fifteen years later. One of the women who died nearly fifteen years after exposure had in her body at that time only one-millionth of a gram of radium. Contrast these two quantities: the equivalent of several thousands of tons of radium in the water vs. one-millionth of a gram of radium retained in the body producing death by cancer in fifteen years. No wonder the medical men in charge of the Bikini tests have repeatedly given us warning. The frightening possibilities must not be ignored.

A committee headed by Dr. Albert Einstein has given us 6 statements of fact: (1) Atom bombs can now be made cheaply and in large numbers. They will become more destructive. (2) There is no known defense against atom bombs, and none is to be expected. (3) Other nations can rediscover our secret processes by themselves. (4) An atomic armament race is futile, and if attempted will ruin the structure of our social order. (5) If war breaks out, atom bombs will be used and they will surely destroy our civilization. (6) There is no solution to this problem except the international control of atomic energy and, ultimately, the elimination of war.

II. Index of Participants, and Sequence Numerals of Corresponding Abstracts