A. He must train assigned personnel in the proper performance of their emergency duties. He must see that they are familiar with the locations of fire stations, fire-detecting alarm stations, portable fire extinguishers, nearest telephone to their stations, how to secure all damage control fittings, how to maintain watertight integrity and, most important of all, how to report and fight a fire.

4. Q. After fire occurs and is reported in his zone, what is the responsibility of the zone area officer and/or his assistant officer-in-charge?

A. He supervises setting up secondary boundaries and investigation of all surrounding areas above and below including: Use of portable $CO_2$ or soda-acid extinguishers as appropriate; break-out of hoses if necessary; cooling adjacent deck, bulkheads, and overhead with water; and removal of personnel casualties.

5. Q. What are the duties of zone area personnel assigned to patrol stations?

A. They patrol assigned areas and make all closures; they detect and report any indications of damage or of fire, in their or adjoining compartments; and they report the correct locations, description and extent of fire or other damage. In case of small fires, after reporting, they attack and if possible extinguish the fires with portable extinguishers as appropriate; they lead out the nearest fire hose ready for use by the repair party on arrival; and during drills, they inspect all equipment on their stations within assigned patrol areas and report any deficiencies.

6. Q. How should zone area personnel patrol their assigned stations?

A. Zone area personnel must patrol their stations, keeping alert for any signs of damage and paying particular attention to areas adjacent to damage in other zones. They must be alert to detect any signs of fire, smoke, hot bulkheads or decks, water leaks, ruptures in piping or electric cables, and any or all signs of damage.

7. Q. What are the four points to know in investigation of damage?

A. In the investigation of damage you must be <u>thorough</u>, be <u>cautious</u>, <u>report</u>, and <u>repeat</u> investigations and reports.

8. Q. To whom is the zone area officer directly responsible?

A. The zone area officer is directly responsible first to the damage control officer and, secondly, to the repair party officer when the casualty is in his zone.

9. Q. What duties, in addition to those assigned, may zone area personnel be required to perform?

A. Stretcher bearing in case of personnel casualties; administering artificial respiration; tool and material bearing such as for shoring; investigating damage when not prevented by smoke, fumes or gases; and assisting in rigging pumps and hose for unwatering.

10. Q. What are the two conditions of readiness for damage control in MSTS civil-service-manned ships?

A. "Emergency" or "buttoned up", which means securing all fittings and systems when all-hands are called to emergency stations. Also "cruising" condition which is set by closing all fittings below the bulkhead deck when entering or leaving port, in confined or inland waters, in heavy weather, heavy traffic, low visibility, or in a combat zone.

B. Application. Check application by having crew members perform any of the following practical demonstrations:

1. How to make closures.

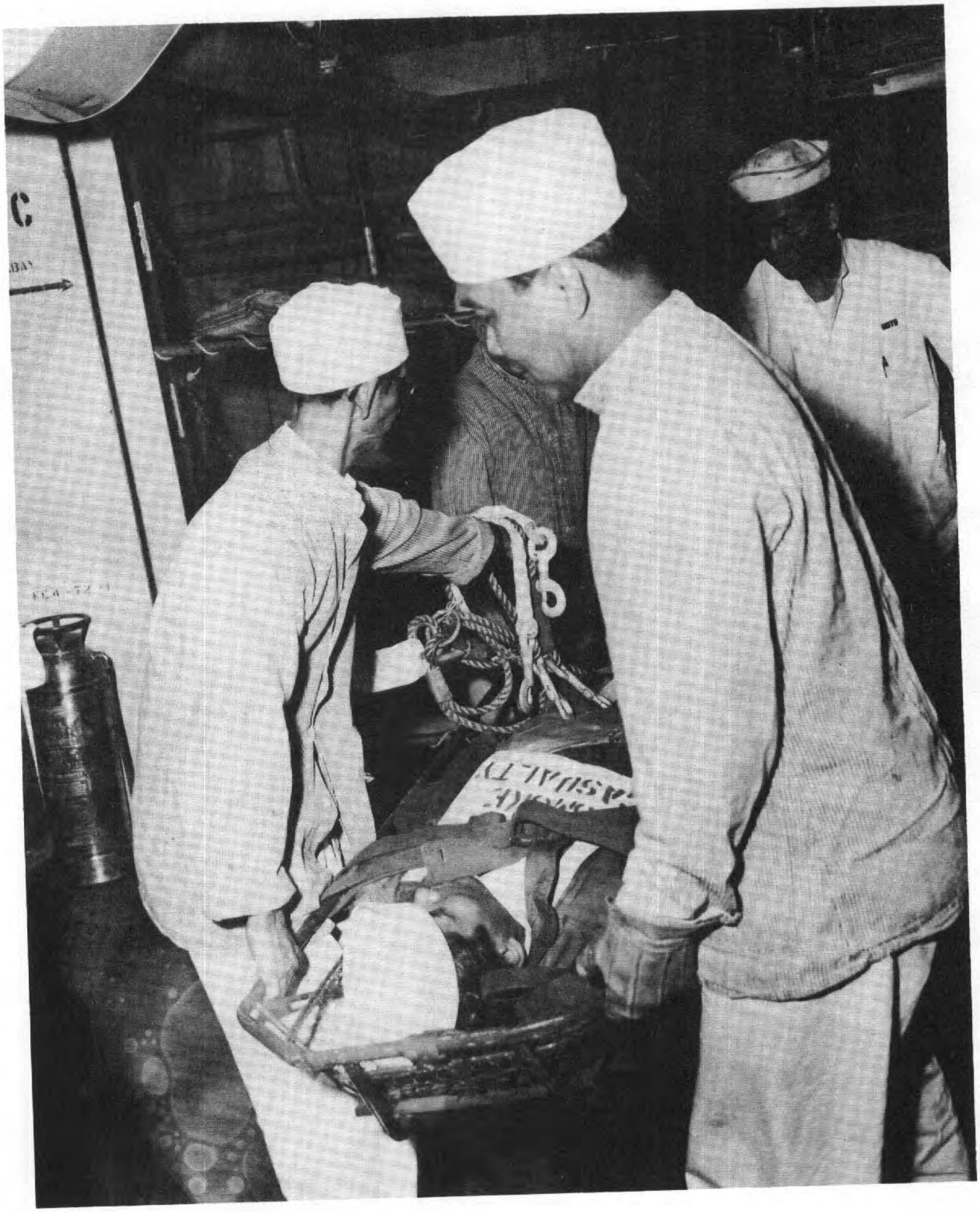
2. How to investigate an assigned station properly.

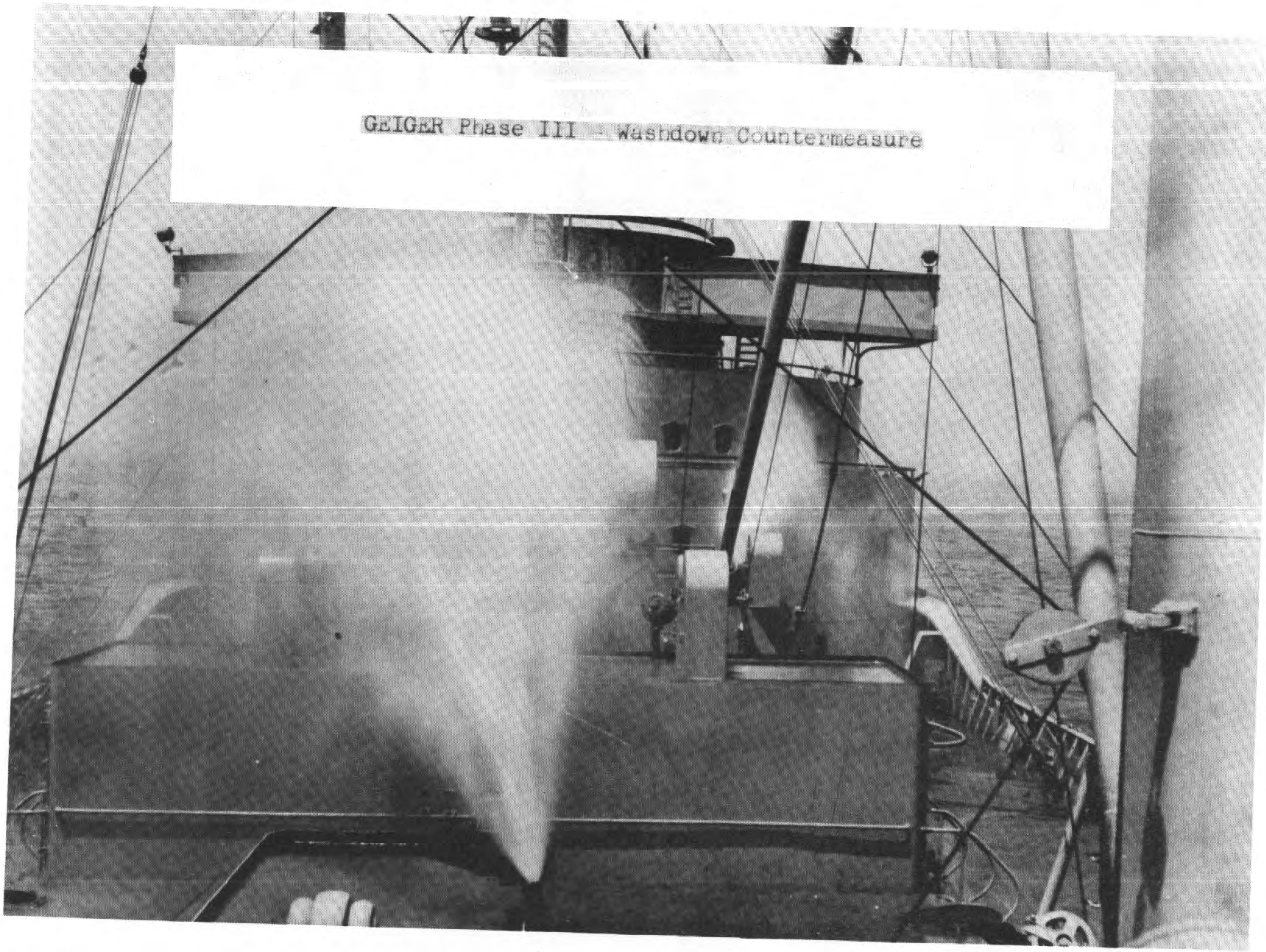
3. How to report damage.

4. How to take initial action.

5. How to apply artificial respiration.

6. How to handle personnel casualties and serve as stretcher bearers.





GEIGER Phase III - Washdown Countermeasure

# CHAPTER 2

## BASIC DAMAGE CONTROL - For All Hands (Lesson Plan)

Section 2.13

## EFFECTS OF ABC ATTACKS



I. OBJECTIVES.

A. To familiarize all hands with the effects of the various types of atomic explosions.

B. To acquaint all hands with the special characteristics of the nuclear bomb.

C. To familiarize personnel with the effects of biological and chemical warfare agents most likely to be encountered in wartime.

D. To inform personnel of effective defensive measures against NBC (ABC) attack.

II. MATERIAL.

A. Training Films.

1. .MN-7358, "Effects of an Atomic Bomb Explosion - Blast, Heat, and Radiation Effects".

2. MN-7396A, "Biological Warfare Defense".

3. MN-7396B, "Chemical Warfare Defense".

4. MN-9221, "Washdown Countermeasures".

B. References.

1. Instruction Guide for Shipboard Atomic Defense, NAVPERS 10886.

2. ABC Warfare Defense, NAVPERS 10099.

3. Atomic Attack Instructions for MSTS-Operated Ships in Port, MSTS Form 3541-4.

4. Chapter 77, BUSHIPS Technical Manual.

C. 1. Handout - The Voyage of the Lucky Dragon, Readers Digest May 1958 reprint.

2. Atomic, Biological and Chemical Warfare Pocket Reference Card, NAVPERS 10699.

III. INTRODUCTION.

A. Introduce self and subject (Effects of NBC Attacks).

B. Fear of Unknown. Many misapprehensions about nuclear energy exist in the public mind. Knowledge of the facts should lessen this fear.

C. Possibilities of Being Endangered. These exist due to:

1. Wartime attacks.

2. Fallout from peacetime tests.

D. The Law of Radiation. Whether it is a light bulb radiating light or a radiator radiating heat, the law of radiation is that the intensity diminishes inversely with the square of the distance. If you are twice as far away from ground zero as somebody else, you are four times as safe from the initial radiation. You may still be endangered by the radioactive cloud or fallout.

E. Biological and Chemical Defense. Generally, measures taken for protection against nuclear attack will serve for biological and chemical defense. You should know the characteristics of each of these weapons and the measures you can take for self-protection against their effects.

IV. PRESENTATION - Effects of ABC Attacks.

A. Nature of Atomic Energy.

1. The atom is the smallest unit of matter, so small that it cannot be seen with a microscope. In some atoms, particles (or neutrons) are thrown off. This is called radioactivity. Radioactivity is either natural or induced. Naturally, radioactive elements, such as radium, emit particles continuously; this is known as radioactive decay. Other elements can be bombarded by shooting particles (neutrons) into them with the right amount of energy. The delicate balance of the atom is thus destroyed and transmutation takes place, changing one atom to another, such as nitrogen changing to oxygen.

2. When a chain reaction of neutrons is set up, tremendous energy is released instantaneously according to Einstein's formula, $E = MC^2$. (Energy equals the mass lost, multiplied by the speed of light squared). In an atom bomb, the very heavy elements, such as uranium or plutonium, are split into medium weight elements. This is called fission. In a hydrogen bomb, the lightest elements are combined into medium weight elements. This is fusion. However, the hydrogen bomb must be triggered by an atomic bomb in order to attain a temperature of 1,000,000 degrees centigrade.

B. Types of Atomic Explosions. Atomic weapons may be used against us in many ways. However, there are just four basic types of atomic explosions (only the air and underwater bursts will be covered in detail):

1. Air.

2. Surface.

3. Sub-surface.

4. Underwater.

C. Types of Thermal Radiation. Atomic bursts result in blast, heat and radiation effects. The thermal or heat radiation effect consists of:

1. Infra-red rays which comprise 99% of the thermal effect.

2. Ultra-violet rays which have a very high temperature but short range; they are absorbed by air.

3. Blinding visible light which causes temporary blindness.

D. Types of Nuclear Radiation.

1. Gamma rays are long range high energy rays like X-rays

(not solid particles). They are very penetrating and lethal and therefore present an external hazard. An unshielded person 4,000 feet from surface zero would receive a lethal dose.* Gamma rays psss completely through the human body, leaving a path of injured or destroyed body cells behind them.

*OF COURSE THE NUCLEAR WEAPON YIELD AND TYPE OF BURST WILL AFFECT THE [illegible]

2. Beta particles are medium range, very light particles. They present an internal hazard if taken into the system through contact with the skin or if inhaled or swallowed.

3. Alpha particles are short range, heavy particles. They also present an internal hazard if inhaled or swallowed. However, they are stopped by light cotton clothing and may not even pierce the skin.

E. Air Burst of an Atom Bomb.

1. General. A 20 KT (kilo ton or thousand ton) bomb is equivalent to 20,000 tons of TNT. It is generally detonated about 2,000 feet above ground for maximum effect. Its fire ball, which is about 900 feet in diameter, will of course be above ground. At Hiroshima and Nagasaki, the effects on personnel were about as follows:

a. Blast and heat caused 85% of the casualties.

b. Radiation caused only 15% of the casualties. (In Japan, deaths from radiation were about 10%. This figure can be reduced with better medical care.)

2. Blast Effects:

a. The A-bomb's blast destruction is due to the shock of the explosion followed by its sudden reversal. After the shock front has traveled outward, it will reverse and air is sucked in toward ground zero.

b. When the primary shock wave strikes the ground, it is reflected and increases (possibly by as much as three times) the force of the direct pressure. This fusing of the reflected shock wave with the direct shock wave is called the "Mach" effect. In a 20 KT bomb, it creates wind velocities of about 270 MPH.

c. Ships are remarkably resistant to blast damage as a result of the requirements which must be built into them to withstand load and wave stresses. Further, a ship floating on water can yield to the blast effect by rolling or heaving without damage due to this motion. In contrast, a fixed building on land would be severely damaged by blast effect which would merely toss a ship around.

3. Thermal Radiation Effects.

a. Heat radiates from the fire ball for about three seconds at the speed of light. Therefore surfaces of exposed objects will be burned. Burns will be caused on exposed skin at distances up to two miles.

b. The extreme heat will start many fires but the air blast arriving a few seconds later will blow some of them out. The blast also causes secondary fires from overturned stoves, short circuits, etc.

4. Nuclear Radiation Effects:

a. Unit of measurement is a roentgen(**r**).

b. Gamma Rays. The following shields cut the very penetrating gamma rays in half:

Steel - $1\frac{1}{2}$ inches
Concrete - $4\frac{1}{2}$ inches
Earth - $7\frac{1}{2}$ inches
Water - $10\frac{1}{2}$ inches

c. Alpha Particles. These can be stopped by light cotton clothing, thick paper or by the skin. They are dangerous if inhaled or swallowed.

d. Beta Particles. Most of these are stopped by 1/8" thickness of metal. They are dangerous to personnel if in contact with the skin or if inhaled or swallowed.

e. Residual radioactivity presents a dangerous hazard in view of the dangerous penetrating effect of gamma rays and the serious contact hazard of beta particles. If radioactive dust emitting alpha and beta particles and gamma rays is inhaled, eaten with food, or enters the body in any way, it will cause grave effects since this contamination is difficult to remove from the human body.

f. Radiation Sickness.

(1) 100 r. or more - nausea and vomiting are the first symptoms of exposure to such a dose of radiation. Later symptoms might be fever, loss of weight, diarrhea, etc.

(2) 200 r. - Most persons receiving this dosage will become sick, but nearly all should recover.

(3) 450 r. - About half the persons exposed to this dosage would die.

(4) 600 r. - This amount of radiation would be fatal

to most people.

(5) Radiation "collects" in the body. If it "collects" faster than you recover from it, the effect will be the same as a large dosage in a short time.

F. Underwater Burst (Bikini):

1. General. Underwater bursts would probably be by 20 KT atom bombs, detonated at about fifty feet below the surface. A ball of fire forms and throws water up into the air. At the same time, a shock wave travels through the water and a blast wave through the air.

2. Base Surge. A million tons of water in spray forms rises 6000 feet into the air. In ten to twelve seconds it falls back to form the base surge, a cloud of radioactive mist, moving at a mile a minute.

3. Tidal Waves. The first wave will be about 94 feet high traveling at high speed and followed by waves of decreasing height.

4. Effects.

a. The air shock wave is the equivalent of an 8 KT bomb (The Hiroshima bomb was 20 KT).

b. The shock wave in water is much more powerful and travels outward more rapidly than in the air. However, pressure falls off rapidly with distance. It will cause:

(1) Severe damage to ships' hulls at distances up to 800 yards.

(2) Moderate damage to hulls at distances up to 1000 yards.

(3) Light damage to hulls at distances up to 1500 yards.

(4) Damage to machinery, which is most susceptible to underwater shock.

c. Water waves will be:

94 feet high at 350 yards.
36 feet high at 1000 yards.
16 feet high at 2000 yards.
9 feet high at 4000 yards.

d. Radiation Effects.

(1) Gamma rays and neutrons emitted at the instant of the burst are nullified by the water.

(2) The base surge is highly radioactive. Vapor passing over the ship leaves a transit dose, while droplets of water leave a contamination dose which will emit beta and gamma radiations.

(3) There will be a radioactive fallout from the water column and cloud.

5. Thermal effects are negligible since the heat is absorbed by the water.

G. Hydrogen Bomb.

1. Hydrogen bombs are in the megaton (million tons of TNT) range. Thus, a one megaton hydrogen bomb is fifty times as powerful as a twenty kiloton (20,000 ton) atomic bomb. (1,000,000 divided by 20,000 equals 50.) However, due to the limitations of the law of radiation, the hydrogen bomb is not fifty times as destructive as the atom bomb.

2. Fallout danger is greater from a hydrogen bomb. Cite the Japanese fisherman who gathered up the fallout ash as a souvenir. (See handout.)

3. Defensive measures against a hydrogen bomb are the same as for an atomic bomb.

H. Defensive Measures.

1. Evasive tactics of the ship will depend upon the air raid intelligence received and will consist of maneuvering to avoid the danger zone using knowledge of wind, weather, currents, cloud shielding, etc.

2. "Buttoning-Up" the ship will include:

a. Making all closures of vents, ports, fire screen and watertight doors, hatches, scuppers, manual ventilation dampers, etc.

b. Rigging fog nozzles to produce a washdown water-fog umbrella. This can be up to 95% effective in countering fallout. In ships which are equipped with a built-in washdown system, this system will be activated.

c. Getting all personnel inside and down into the interior of the ship. Personnel self protective measures are covered in the training film "Self Preservation in an Atomic Bomb Attack".

3. Monitoring. All weather deck areas are surveyed with

radiac meters and the contamination is plotted. Dangerous areas are roped off. Monitors must wear protective clothing and their exposure periods must be timed. Film badges and dosimeters are used and exposures recorded.

4. Decontamination.

a. Topside - consists of jettisoning and hosing down.

b. Shipyard decontamination - includes use of steam, sand-blasting, acids, etc.

c. Personnel decontamination - consists of thorough soap and water scrubbing in hot showers at decontamination stations, monitoring, and re-scrubbing and re-monitoring as necessary. Contaminated clothing is disposed of and clean clothing is issued. Decontamination stations and routes are specified and marked. These routes and decontamination procedures are closely adhered to and order is maintained.

I. <u>Biological Warfare</u>.

1. Definition. Biological or bacteriological warfare is defined as the use of living agents or their toxic products to produce disease or death of personnel, animals or plants. Biological agents cannot be detected by the physical senses. Laboratory examination is required.

2. Agents. Agents are living micro-organisms such as bacteria, ricket-tsiae, viruses, fungi and protozoa. Major infectious causes might be anthrax, botulism, cholera, dysentery, fungus infections, etc.

3. Use. Spreading of biological agents would be accomplished by explosive munitions, spray devices, release of insects or animals carrying the disease, and by sabotage. Aerosols, or clouds of fine particles might be released to pollute the air.

4. Defense. Biological warfare is aimed at contaminating food and water supplies and killing personnel and animals. Since medical technicians are needed to detect biological agents, the best defense is to:

a. Report immediately any suspicious matter that could be biological agents.

b. Rely on the ABC defensive washdown countermeasure.

c. Be careful of food and water supplies.

d. Keep healthy to ward off infections.

e. Refer to Atomic, Biological and Chemical Warfare Pocket Reference Card, NAVPERS 10699, for detailed instructions.

J. Chemical Warfare. This type of warfare was used extensively in World War I but was avoided by both sides in World War II (with minor exceptions). Our being prepared for chemical warfare should again deter its use in another major war.

1. Chemical warfare agents are classified as follows:

a. Blister gases - mustard, Lewisite, etc.

b. Choking gases - phosgene, chlorpicrin.

c. Nerve gases - induce paralysis.

d. Vomiting gases - adamsite, etc.

e. Tear gases.

f. Screening smokes - phosphorous, etc.

g. Incendiaries - thermite, magnesium.

2. Detection of chemical agents.

a. Be alert to means of spreading chemical agents--by aircraft spray, grenades and bombs, smoke pots and candles, chemical cylinders, etc.

b. Personnel should be suspicious of all acrid smells and any strange odors such as garlic, geraniums, shoe polish, bitter almond, fly paper, apple blossoms, sour fruit, etc.

c. A chemical detection kit makes identification possible by testing air samples.

d. Special litmus papers turn color on contact with various gases.

3. Defense measures include the following:

a. "Buttoning-up" the ship to make it gas tight.

b. Use of the ABC defensive washdown countermeasure.

c. Use of gas masks and protective clothing, and use of special medical injections for nerve gases.

d. Decontamination of all exposed surfaces.

e. Refer to Atomic, Biological and Chemical Warfare Pocket Reference Card, NAVPERS 10699, for detailed instructions.

V. SUMMARY.

A. Emphasize importance of understanding the need for frequent drills and stern discipline to assure maximum survival rates.

B. Review "Must Know" points of lesson.

C. If time, show film MA-7325 "Self Preservation in an Atomic Bomb Attack".

VI. TEST.

A. Use these and additional questions as an oral quiz.

1. Q. What are the factors involved in defensive measures against ABC attack?
A. Military intelligence, preparation, maneuvering, and weather conditions.

2. Q. What is meant by "Buttoning-up" or securing the "Gas Tight Envelope" of a vessel?
A. Thorough securing of the ship's ventilation system, both intake and exhaust, and manual ventilation dampers, all watertight doors, all ports and deadlights, all scupper valves, all hatches, and all other openings.

3. Q. What are the four types of atomic explosions?
A. (1) Surface burst.
(2) Air burst.
(3) Sub-surface burst.
(4) Underwater burst.

4. Q. What are the three main effects of an atomic explosion?
A. (1) Blast - shock or pressure wave.
(2) Heat - infra-red, ultra-violet, and visible rays.
(3) Radiation - alpha and beta particles, and gamma rays.

5. Q. What is meant by the "Mach" effect of an atomic air burst?
A. When the initial shock wave of the explosion strikes the earth's surface, it is reflected back. At a certain point, depending on the energy of the explosion and the height of the burst, this reflected shock wave and the direct shock wave fuse. This fusion

phenomenon is called the "Mach" effect.

6. Q. What are the effects of thermal radiation resulting from an atomic burst?
A. Exposed skin will be burned at distances up to two miles. Extreme heat will start many fires.

7. Q. What are the types of nuclear radiation emitted by an atomic explosion and how do they affect exposed personnel?
A. Nuclear radiation emitted from an atomic explosion are alpha and beta particles, and gamma rays. They cause about 15% of personnel casualties. In an air burst, due to their short ranges and the height of the explosion, the alpha and beta particles will not reach the earth and so may be disregarded. Gamma rays are emitted in the actual fission process and are very penetrating.

3. Q. What are biological warfare agents?
A. Biological warfare agents are living micro-organisms which fall into the following types: Bacteria, viruses, fungi, and protozoa.

9. Q. What are major diseases induced in an enemy population by the use of biological warfare agents?
A. The major diseases induced by the use of biological warfare agents are anthrax, botulism, cholera, dysentery, and a group of fungus infections.

10. Q. What are the two major purposes for using biological warfare?
A. The two major purposes for using biological warfare are to kill personnel and animals and to contaminate food and water supplies.

11. Q. Based on their effect on enemy personnel, how are gases classified?
A. Based on their physiological effects, gases are classified as choking gases, blister gases, nerve gases, tear gases, and vomiting gases.

12. Q. How can a gas attack be detected?
A. There are three principal methods of detecting gas attacks. These are by means of litmus detection papers, by the physical senses, and by use of a chemical detection kit to test air samples.

VII. <u>HANDOUT</u>. "The Voyage of the Lucky Dragon", Reprinted from Readers Digest, May 1958.

## THE VOYAGE OF THE LUCKY DRAGON

Reprinted from Readers Digest, May 1958

The moving story of a tiny Japanese fishing vessel and her 23 crewmen, on whom catastrophe broke from the skies--with effects that have meaning for everyone everywhere.

Condensed from the book of the same name by Ralph E. Lapp, published by Harper & Brothers, New York City.

On that pre-dawn of March 1, 1954, the 93-foot Japanese trawler Fukuryu Maru (Lucky Dragon) drifted with silent engines on the calm waters of the central Pacific. She had thrown her tuna lines for the last time and soon would be heading back for her home port of Yaizu, 120 miles south of Tokyo.

Suddenly the skies in the west lighted up and a great flare of whitish yellow light splashed against the clouds. It was as though the gradual transition to dawn had been ripped aside abruptly to let light flood over the ocean. The color changed to a yellow-red, finally to an orange-red ball of flame on the horizon. The gaudy display looked like a setting sun, except that it was several times brighter, though not bright enough to hurt the eyes.

On the bridge, Fishing Master Yoshio Misaki stared incredulously at the strange spectacle. The crew clambered up on deck, jabbering in excited voices. "The sun rises in the west!" one blurted. Another said, "I wonder if it's a pika-don?" The word is new to the Japanese tongue. Born in terror at Hiroshima, it is a compound of "thunder" and "flash."

Captain Hisakichi Tsutsui, asleep in his bunk, was slow to react. By the time he joined Misaki on the bridge, the color in the west could hardly be discerned. Darkness settled down once again. All was quiet.

Several minutes later the trawler trembled as though shaken from below, and a great sound enveloped her, seeming to come at once from above and below. In terror some of the crewmen threw themselves to the deck and covered their heads. The officers held a quick conference. Then Misaki gave the order: "Start the engines and haul in the lines." The men worked quickly, anxious to leave these waters.

Radioman Aikichi Kuboyama, at 39, was one of the oldest of the 23-man crew. He was also reputed to be the smartest. Now he proved it by looking up the speed of sound. Almost seven minutes had elapsed between sighting the flash and hearing the sound. Multiplying that time by the speed of sound would give the distance from the ship to the explosion.

This turned out to be roughly 87 miles--and Misaki's calculations with the sextant put the ship's position 85 miles east-north-east of Bikini Atoll in the Marshall Islands. There could be no doubt that the bright flash had come from Bikini.

About two hours later the sky began to change appearance as though a high fog were forming. The men at work on deck were puzzled at first when tiny bits of sandy ash came swirling down. "It looks like the beginning of a snowstorm," one said. Several crewmen suddenly felt pain in their eyes. Winchman Sanjiro Masuda wiped his hair with his hand, rubbed his smarting eyes. A few of the men tasted the whitish-gray flakes. Some said it was salt, some said it was sand. All agreed it was a nuisance.

Shortly after midday all the lines were in. The strange white dust finally stopped falling, and Misaki ordered the wheelsman to head north. Crewmen cleaning up the main deck found there was something queer about these white sands; they did not wash away easily. At lunchtime several of the crew discovered that they had little appetite--an unusual thing for they were always hungry after working so many hours.

After lunch, the crewmen set about cleaning the fishing gear. The miles of wet rope seemed particularly to soak up the white dust. They packed the rope in wooden boxes and stacked the boxes on the stern just aft of the galley.

A strangely sluggish crew awoke next morning. Winchman Masuda found to his dismay that his eyes were glued together by a thick yellow discharge. Chief Engineer Tadashi Yamamoto found it difficult to see when he tried to check the gauges in the engine room. Several men had been nauseated during the night, but only one, whose bunk was in the after cabin, had been so sick that he could not stand midnight duty. The men who had handled the ropes complained of an intense itching and burning in their palms.

One of the sailors gave a sample of the white ash, wrapped in paper, to Kuboyama. The radioman, planning to investigate it later, put the ash under his pillow in his cabin. There it stayed the 14 days until the Lucky Dragon reached port. Other crewmen, too, scraped up samples of the odd ash; one thought it might be a lucky symbol.

On March 2 (March 1 on the other side of the International Date Line) this announcement was released in Washington, D. C.: "Lewis L Strauss, chairman of the U. S. Atomic Energy Commission, announced today that Joint Task Force Seven has detonated an atomic device at the AEC's Proving Ground in the Marshall Islands. This detonation was the first in a series of tests."

There had been no prior announcement by the AEC that a nuclear test would be conducted on March 1. The Japanese Maritime Safety Board had issued a warning notice on October 10, 1953, enlarging the forbidden area around Eniwetok Atoll which had been blocked off for the first hydrogen-bomb test of November 1, 1952. This enlarged area included Bikini Atoll, but neither Captain Tsutsui nor Fishing Master Misaki knew that Bikini was to be the scene of these new tests. Actually, the Lucky Dragon at her nearest approach to the danger zone was still some 20 miles east of its eastern limit. High-altitude winds apparently tugged the bomb cloud in the opposite direction from that expected by the test experts.

Curious things occurred as the little tuna boat voyaged home. The engine room crewmen kept coming on deck, complaining that they felt ill. All the men took on a muddy look, as though badly sunburned. Winchman Masuda told cabinmates he felt feverish. When Boatswain Masayoshi Kawashima scratched his head, hair fell away. Puzzled, he tugged at his head, and a clump of hair appeared in his hand.

This rang a bell in Kuboyama's mind. His aunt had been at Hiroshima when the A-bomb was dropped, and he remembered that loss of hair was an aftereffect of "atomic bomb disease." Kuboyama and Misaki talked over the possibility of a connection between the crew's sickness and the strange ash which had fallen from the sky.

When the Lucky Dragon tied up at Yaizu on March 14, its owner noticed at once how unusually dark the crew were. As soon as the Fishing Master told him about their illness, he agreed that the men should go to the Yaizu hospital immediately.

Dr. T. Ooi, in charge there, could not explain the men's appearance. Masuda, the most seriously affected, was burned on the face and hand, but all appeared in good spirits. One of the fishermen said they had encountered what they thought was an A-bomb explosion. But since the light had not been blinding, the doctor concluded that they must have been a safe distance away; otherwise, some of the men would already have died. Not unduly alarmed, Dr. Ooi agreed nonetheless to send two of the crewmen to an atomic sickness expert in Tokyo. Chosen to go were Masuda, because of his heavy burns, and Engineer Yamamoto, who had the lowest white blood-cell count.

On the morning of Tuesday, March 16, the Yomiuri Shimbun, one of Japan's biggest newspapers, spread this scoop headline across its front page:

JAPANESE FISHERMEN ENCOUNTER
ATOMIC BOMB TEST AT BIKINI
23 MEN SUFFERING FROM
ATOMIC DISEASE H-BOMB?

Alerted by the newspaper story (tracked down on a tip from a

17-year-old schoolboy with relatives in Yaizu), the Sanitary Division of Yaizu's prefecture asked Dr. Takanobu Shiokawa to go to the Yaizu hospital and docks and check for radioactivity. At the hospital Dr. Shiokawa put his Geiger counter near the head of one of the crewmen. The man was radioactive! What must the fishing boat be like?

Dr. Shiokawa hurried to the waterfront. When he was still 100 feet from the Lucky Dragon, the Geiger counter started clicking at an accelerated beat. Never before had he encountered radioactivity as potent as this. The ship was crawling with newsmen, and as Dr. Shiokawa wedged his way through the hubbub it became obvious that the main source of radioactivity was somewhere above the rear crew compartment. He climbed up on the roof of the crew space. This was where the coils of rope were stacked. They were intensely radioactive. All during their long voyage home the men in the after cabin had been sleeping under a powerful source of radiation.

Yaizu was not the only Japanese city to become excited about radioactivity. At Osaka, Dr. Yasushi Nishiwaki, a biophysics professor at the city university, was summoned to the central market to see if fish from Yaizu had been shipped there. He found a tuna that rattled his Geiger counter at a high count. The bystanders murmured in awe, "The fish are crying!"--and thereafter radioactive fish became known as "crying fish." Officials discovered that contaminated fish had been eaten by about a hundred people. Fear swept through the city, and people immediately stopped buying fish. When it became known that fish had been banned from the Emperor's diet, hysteria spread over Japan. Some fish dealers were forced into bankruptcy.

Meanwhile, the doctors treating the sailors were fighting against time to learn the contents of the ash. They could draw on the medical information gained by a study of thousands of survivors of Hiroshima and Nagasaki. But what confused the situation now was the presence of residual radioactivity. Winchman Masuda's hair, for example, was still so radioactive that a bit of it placed on photographic film reproduced on the developed film a perfect image as though photographed with ordinary light. Even after a thorough scrubbing, the fishermen retained some radioactivity on their skin. This was something for which there was no precedent in medical science.

About this time semi-official information about the huge explosion came out. Representative James Van Zandt, of the United States Joint Congressional Committee on Atomic Energy, stated that the H-bomb exploded at Bikini was of incredible destructiveness. The explosion had equaled the blast of 12 to 14 million tons of TNT, was 1000 times more powerful than the A-bomb exploded over Hiroshima.

By this time all the fishermen had been transferred to two hospitals in Tokyo. They were found to be suffering from a depressed level of white and red blood cells, and, to combat their anemia, they were given repeated transfusions. Antibiotics were administered to bolster their resistance. Since sexual cells are extremely sensitive to radiation, during April and May the fishermen were completely sterile.

As spring came to Tokyo, the patients were encouraged by the healing of their skin lesions and the regrowth of body hair. This was a good sign, for, with near-lethal doses of radiation, there may be permanent impairment of hair growth. It looked as though the men were on the upswing. All Japan breathed more easily, too, when the United States announced in mid-May that the 1954 Bikini bomb tests had been concluded.

Still, the riddle remained: What were the "ashes of death," the shi no hai, which had fallen upon the Lucky Dragon? Twice this question was put to U. S. representatives by Japanese scientists, and twice, for reasons of "national security," it went unanswered. The third time the question was asked, Merril Eisenbud, director of the AEC's Health and Safety Laboratory and an expert on fall-out, made the enigmatic reply: "Ask Dr. Kimura."

Dr. Kenjiro Kimura, a brilliant radiochemist at Tokyo University, in 1939 had teamed with the Japanese physicist Yoshio Nishina in splitting the uranium atom and producing a hitherto unknown type which they named uranium-237. Dr. Kimura and a staff of 16, along with several other groups of Japanese scientists, were now working day and night analyzing the Bikini ash. They had no doubt that most of the ash's radioactivity was due to split atoms of uranium. It was inevitable that Dr. Kimura and the other scientists would learn the truth about the bomb. The man who discovered uranium-237 could scarcely be expected to overlook it once it was put under his nose.

By the spring of 1954 the Japanese scientists had solved the riddle: the Bikini bomb was a super weapon in a three-in-one package. The first stage consisted of an ordinary A-bomb trigger which in turn fired a second stage and caused hydrogen atoms to fuse together. This H-bomb reaction then released a flood of high-energy neutrons which caused a jacket of uranium to split. In the process, uranium-237 was produced as a telltale by-product.

Once the Japanese scientists knew the nature of the radioactive ash, they could calculate the amount of radiation to which the fishermen had been exposed. They figured that crewmen working on deck during the morning of March 1 could have received up to 100 roentgens of radiation until noontime. (A lethal dose ranges from 300 to 700 roentgens.) Each day thereafter the exposure would have dropped.

The Lucky Dragon was not the only ship dusted with fall-out. Ten U. S. naval vessels were standing by, 30 miles from Bikini, to observe the detonation in an area thought to be safe. About an hour after the enormous mushroom cloud had dispersed, officers noted winds pushing remnants of the cloud toward them. Geiger counters on deck started to react. At once the ships were "buttoned-up"; that is, all hands went below after securing the hatches and portholes and covering the ships' ventilators. Vast quantities of water were sprayed over the ships by pipes and nozzles specifically designed to wash off radioactive contamination (the washdown countermeasure). For half a day the crews sweated it out below. Finally it was judged safe to "unbutton" the ships, and men wearing rubber suits, hoods and masks proceeded to clean up (decontaminate) fall-out which the protective screen of water had failed to wash away. Thus the AEC and Defense Department knew within a few hours after the March 1 test the dimensions and intensity of the fall-out. Yet no warning was broadcast to ships in the vicinity, probably because the lips of test officials were sealed by security precautions.

In September the Japanese crewmen suffered a terrific shock: their beloved mate, Radioman Kuboyama, died. With so many blood transfusions the probability of infectious hepatitis had increased. But though the others soon recovered from the jaundice attacks, Kuboyama's persisted. On the night of September 20 he seemed in great pain, and his family was summoned. Once he cried out, "My body feels like it is burned with electricity." On the 23rd he was gone.

Learning of his death, the crews of countless fishing boats and ships at sea sent messages of sympathy to the hospital. The next day the U. S. Ambassador sent a note to the Japanese Minister of Foreign Affairs, enclosing a check for one million yen made out to Mrs. Kuboyama "as a token of sympathy of the American government and people." (Later, another million and a half yen were added.)

On May 20, 1955, the 22 crewmen were discharged from the two Tokyo hospitals where they had lived for more than a year. Ahead lay an uncertain future--the strenuous work of fishermen would be too much for them. They have since turned to such occupations as farming and shopkeeping; only two went back to the sea, and then on training vessels. The fishermen's sterility was not permanent; serveral have since had normal, healthy children. Eventually the United States presented the Japanese government with two million dollars' compensation--ex gratia, implying no culpability--of which each crew member received approximately $5000; the remainder went to pay their medical expenses and the damage to the tuna industry caused by the fall-out.

What happened to the 23 fishermen aboard the Lucky Dragon on that fateful March morning was a small example of the radioactive peril which would be unleashed in a nuclear war. When men as much as 100 miles from the explosion can be killed by the silent touch of a bomb, the true and terrible striking power of the ravaged atom lies revealed. The bomb exploded at Bikini was a revolutionary new weapon. But for the accident of the Lucky Dragon the world might still be in the dark about the nature of that weapon and its meaning for all men.

*ITALIAN* SS ETRUSCO *blown aground in New England blizzard 16th March 1956.* (USCG Photo)

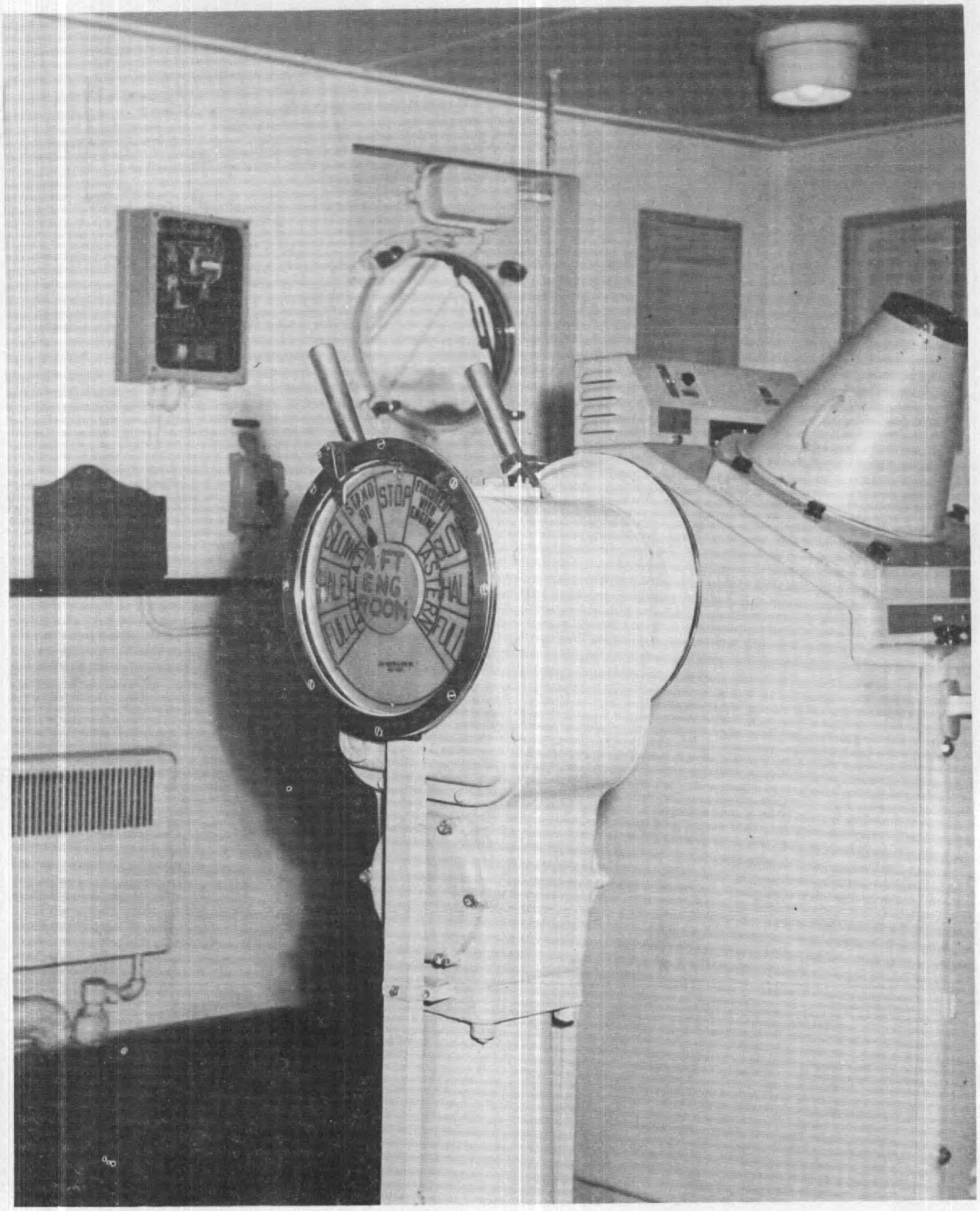
CHAPTER 7

# LESSONS FROM CASUALTIES


*Bow of* SS FORT MERCER *sinking after the tanker broke in two in a snowstorm off the Massachusetts coast 18th February 1952.* (USCG Photo)

# CHAPTER 3

## ADVANCED DAMAGE CONTROL - For Deck and Engine Personnel (Lesson Plans)


STAND BY
STOP
FINISHED WITH ENGINE
SLOW
HALF
FULL
AFT ENG ROOM
ASTERN
HALF
FULL