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ABSTRACT

A manual intended to help fire departments and Civil Defense organizations train people to support regular fire forces during a national emergency is presented. It contains 11 chapters: Introduction, Modern Weapons and Radioactive Fallout, Role of Fire Service in Civil Defense, Local Fire Department Organization, Role of Support Assistants in Civil Defense Fire Emergencies, Discipline and the Firefighter, Basic Concepts of Fire Behavior, Techniques of Fire Prevention and Fire Limitation, Fundamentals of Fire Suppression, Elementary Firefighting Techniques, and Shelter Duties. (CK)

SM-9.2A (student manual)
July 1971

Firefighting for Civil Defense Emergencies

SUPPORT ASSISTANTS FOR FIRE EMERGENCIES

STUDENT MANUAL — PART A

Developed for The Office of Civil Defense
by The International Association of Fire Chiefs

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INTRODUCTION

Reason for Civil Defense Preparedness

As responsible United States' citizens, persons studying this manual should be aware of the perils that threaten today's free world. The threat of nuclear war is one of the most important sources of tension and conflict afflicting the peoples of the world.

To counter this threat the United States is maintaining a strong military posture. As a deterrent to war, we are also developing a shelter-oriented Civil Defense program designed to save millions of lives from radioactive fallout in case of nuclear attack. There appears no practical program that would avoid large-scale loss of life in a nuclear war; however, an effective Civil Defense program could save millions not killed in the nuclear blast and resulting fire.

The Role of Civil Defense

"Civil Defense" is the support and coordination of plans and operations of local government forces such as fire, police and public works in unusual emergency situations.

Fire Service Responsibility

The fire service has the responsibility of protecting life and property from the ravages of fire and natural disaster at all times. In extreme fire emergencies, natural or manmade, and during National Civil Defense emergencies, the primary responsibilities of the fire service are: (1) to locate, surround, confine, control, and extinguish fires, (2) perform rescue and radiological monitoring activities that relate directly to the fire, and (3) report the radiological findings to the regularly constituted Civil Defense authority.

The fire service, therefore, is an integral part of Civil Defense. The organization and control of fire protection during a Civil Defense emergency is primarily the responsibility of local, state, and federal governments, not the military. As the Secretary of Army stated in his May 5, 1964, address to State Civil Defense Directors:

> "We cannot permit our armed forces to become irrevocably committed to the task of Civil Defense. Our armed forces must retain their capability to deal with any military threat. Great care must be exercised to insure that Civil Defense efforts at federal, state, and local levels are not relaxed. The military forces and resources based in this country, even if committed entirely to Civil Defense operations, could not cope with the requirements since these forces represent less than 3% of the nations manpower and equipment potential."

Purpose of This Manual

This manual is intended to help fire departments and Civil Defense organizations train people to support regular fire forces during a national emergency. These trained citizens would be qualified to suppress small fires stemming from nuclear attack, assist fire fighters, and help defend community shelters from fire. Many local, area, and state fire services have designed fire defense plans to facilitate the organization, mobilization, and operation of their fire fighting resources to most effectively minimize the effects of natural or warcaused disasters. The fire service, with its trained assistants, would work in areas immediately adjacent to target cities and (or) within disaster areas.

Under nuclear fire conditions fire suppression could overtax the regularly organized fire services. Therefore, it becomes imperative that support forces be trained to assist the regularly organized fire service. These forces would be recruited, screened, and trained by the regular fire service. They would always remain under the control of the fire service in a given community. The support forces would also help carry out many of the related duties and activities that are the responsibility of the fire service and are directly associated with fire suppression.

This support and assistance during emergencies can make the difference between success or failure in defending our cities and homes, as well as a sheltered populace, from fires resulting from nuclear attack. Experiences during World War II in the United Kingdom and other European countries led government officials to refer to the fire suppression organizations as the fourth arm of defense.

This manual is prepared with the idea that citizens can be trained to give valuable support to the regularly organized fire service. Also, the manual can help train people to act on their own or lead small groups of untrained citizens in using resources at hand to carry out fire suppression.

The manual does have certain limitations that should be understood. This manual will not make experienced firefighters or Civil Defense specialists out of the students involved in this program. To accomplish this would take much more time than is allotted to this course. It does, however, give an insight and understanding of the fire service's role in a Civil Defense emergency. It illustrates the training required to insure that a support assistant can handle the duties he is likely to be assigned to maintain an orderly and efficient operation during an emergency. Each lesson in this manual is designed to give the student a basic understanding of the material covered by the instructor. The lessons may be supplemented by referring to the publications cited in the bibliography as optional student references. By taking part B of the course for Support Assistants for Fire Emergencies the firefighting Support Assistants will become much better qualified to carry out their responsibilities.

MODERN WEAPONS AND RADIOACTIVE FALLOUT

This chapter was adopted from the OCD/DOD publication "Personal and Family Survival" used in the Civil Defense adult education course across the country. The general background on modern weapons and radioactive fallout gained by reading this chapter will assist you in understanding how a fireman can protect himself from radiation hazards. It will also prepare you to take a more active part in the classroom session that includes handling and use of radiological defense instruments.

Both the military and the civilians of the United States may be endangered by the effects of modern weapons. Our country must prepare to defend itself against any weapon that might be used in an attack. There are four possibilities: conventional, chemical, biological, and nuclear.

CONVENTIONAL WEAPONS

Weapons that depend on TNT or similar nonnuclear explosives are classified as "conventional." These include many of the weapons used during World War II and the Korean War—shells, torpedoes, rockets, mines, and bombs. Preparation for nuclear attack is more than adequate for coping with conventional weapons; the converse is not true.

CHEMICAL AND BIOLOGICAL AGENTS

Studies conducted by the Department of Defense indicate that the threat to the United States posed by chemical and biological agents is less significant than that posed by the nuclear one. Chemical agents are not considered a major strategic threat, because they are effective mainly if used against tactical targets of limited area. Although the use of biological agents against U. S. population centers cannot be ruled out, neither a chemical nor biological threat against the continental United States warrants, at this time, the attention and priority given to defense against the effects of nuclear weapons. However, research on methods of detecting, identifying, reporting, analyzing, and defending against biological agents will continue while there is a potential threat.

NUCLEAR WEAPONS

Destructive Capabilities

A nuclear weapon is usually described in terms of the total energy it can release in comparison with the number of tons of TNT required to release the same amount of energy. Thus, the detonation of a 1-megaton (1-MT)[1] nuclear bomb releases the same amount of energy as the explosion of approximately 1 million tons of TNT.

An enemy might use nuclear weapons in various ways, depending on the results he seeks. He must consider the systems for delivering the weapons, such as aircraft for dropping nuclear bombs or missiles armed with nuclear warheads. He must also consider the effects of various weapons yields and types of burst because an explosion's power and its point of detonation largely determine how much of an area would be destroyed, what types of partial or total damage would be inflicted, and how widespread the radioactive fallout and other secondary effects would be. For instance, a nuclear weapon may be detonated high in the air or at the surface of land or water or even after the weapon has penetrated below the surface.

An air detonation results in small fallout particles that travel with upper level winds for long periods of time. When the particles drift down to earth, they are widely distributed

[1] Megaton = (1 million tons).

and pose small radiation danger. Detonations at or near the surface or below the surface, however, result in "local fallout." This means much larger particles are formed and a large fraction of them settles to earth during the first 24 hours. The early contamination near the burst and for many miles downwind is a far greater hazard than fallout released high in the air which may take years to settle out.

Effects of the Explosion

The point directly beneath the center of a nuclear explosion is called ground zero. The surrounding land, objects, and people would suffer varying amounts of damage, depending on their distance from the ground zero, the intervening terrain, and weapon size.

For weapons that burst at or near the surface, damage varies with distance from ground zero. Closest to ground zero, destruction may be virtually complete with few survivors. Moving away from ground zero, the probability of survival increases, and damage and destruction of structures tend to become less severe. The area of light, but appreciable, damage (shattered glass, kindling of dry fuels) may extend as much as 10 miles from a 5-MT burst.

The results of the World War II bombing attacks on Coventry, England, and Hiroshima, Japan, can be compared. In the Coventry raid, the largest mass air raid on England, 437 aircraft dropped 394 tons of high-explosive bombs, 56 tons of incendiary bombs, and 127 parachute bombs. The result were: 380 persons killed, 800 injured. At Hiroshima, one bomber dropped one nuclear bomb, and 70,000 were killed and 70,000 injured. The weapon used in the Hiroshima raid was of the 20-kiloton (20-KT)[2] "A-bomb" class (equal to approximately 20,000 tons of TNT). Yet, the Hiroshima bomb is now considered a weapon of limited power when compared with current thermonuclear weapons that can produce explosions equivalent to the explosion of many millions of tons of TNT.

A nuclear explosion releases a fairly large proportion of its energy in the form of light or heat. Its intense light and heat can cause skin burns and fires at great distances from the point of detonation. Powerful blast and shock waves are also produced.

Nuclear explosions alone among the various types of weapons produce nuclear radiation. The initial (immediate) nuclear radiation that accompanies the blast and heat wave is usually defined as the radiation occurring within the first minute after the explosion. Its effects are limited to the immediate neighborhood of severe blast damage.

About 90 percent of the total energy released by a nuclear weapon appears in these forms. The remaining 10 percent is released as the residual nuclear radiation associated with the radioactive materials from the explosion. These materials and other debris are drawn upward into the ascending cloud, returning to earth as FALLOUT.

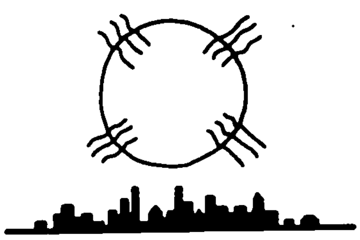
The pattern of effects in an actual explosion would resemble a series of distorted, roughly concentric areas, rather than neat circles, because of the interference by hills, valleys, large buildings, or other obstacles. As the altitude at which the bomb is detonated increases, the areas of physical damage at first increase and then decrease until at high altitude detonations the blast wave may not reach the ground and the predominant effect would be the thermal radiation.

Fire Hazards

A large portion of the energy in the detonation of a nuclear weapon is given off as heat. This heat is intense enough, beyond the range of any physical damage to structures, to ignite "kindling fuels" exposed to it either outside or inside buildings through windows. Papers, fabrics, and thin or dry rotten wood are "kindling fuels." Fires in these materials may spread to heavier fuels—furniture, rooms, fences, porches, etc.—and then involve entire buildings or groups of buildings if fires are not extinguished when small. In the presence of a ground wind, the fires would merge and probably form several large moving fires or "conflagrations" (Figure 2). These conflagrations would be similar to those that swept through Chicago in 1871, Baltimore in 1904, the Maine forests in 1947, and the Bel Air section of Los Angeles in 1961. In the absence of a ground wind and in combination with several other factors—a large congested area with many fires—a "fire storm" (Figure 3) might develop. In a fire storm the fires merge into a large fire with a vertically rising column of hot gases

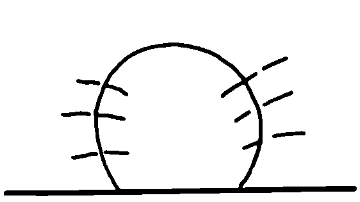
[2] Kiloton = (1 thousand tons).

TYPES OF BURSTS



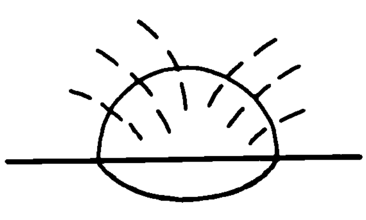
Air burst

An **air burst** is defined as one in which the bomb is exploded in the air so high above land or water that the fireball (at maximum brilliance) does not touch the surface. Great blast and heat hazards are produced. The heat wave resulting from the explosion of a one-megaton nuclear weapon can cause moderately severe burns of exposed skin as far as 12 miles from the point of detonation. The warmth may be felt at a distance of 75 miles. Practically no early or close-in fallout is produced.



Surface burst

In a **surface burst,** the ball of fire touches the ground. Because of its intense heat, large amounts of rock, soil, and other materials will be vaporized and will rise up into the cloud. An important difference between a surface burst and an air burst is that in the surface burst the atomic cloud is much more heavily loaded with this vaporized material; therefore. a surface burst causes much more early radioactive fallout than an air burst.



Subsurface burst

A **subsurface burst** is one in which the center of a nuclear explosion occurs under the ground or under water. Underground or underwater shock is produced, and according to the depth at which the explosion occurs, some of the shock will escape to produce air blast. Much of the heat wave and immediate nuclear radiation is absorbed within a short distance by the ground or water. However, large amounts of earth or water near the explosion will be contaminated with radioactive materials.

Consider a one-megaton blast 50 feet underground. The resulting crater would be about 300 feet deep and 1,400 feet across. This means that 10 million tons of rock and soil would be hurled upward from the earth's surface.

FIGURE 1.—Types of Bursts

and smoke. Strong inblowing winds are created, which, in turn, fan the fire to a greater intensity. The conditions for this type of fire are believed to exist only in certain portions of a few American cities and are not considered as serious as the thousands of individual fires and numerous conflagrations that would probably occur.

The spread of fires from a nuclear attack would be limited by barriers such as open space, rivers, wide expressways, rainfall, and distribution of burnable material. The number of fires that might initially occur from a nuclear attack could be significantly reduced by proper building maintenance, cleanup programs, and extinguishment of individual fires while they are still small and easily controlled.

An example of the possible effects are illustrated by the following description of a 5–MT surface burst. Large weapons are possible and detonations may be at various altitudes—all would change the effects from those in Figure 4.

Effects of a 5-MT Burst

A 5–MT nuclear weapon explodes with a brilliant flash that lasts about a minute. A quick burst of nuclear and heat radiation emerges from the fireball.[3] The spurt of initial nuclear radiation can be lethal within a radius of 2 miles. The heat rays and immediate radiation

[3] The fireball is the large, swiftly expanding sphere of hot gases, producing brilliant light and intense heat, that is the first manifestation of a nuclear explosion. After about a minute, the fireball has cooled enough to lose its brilliance.

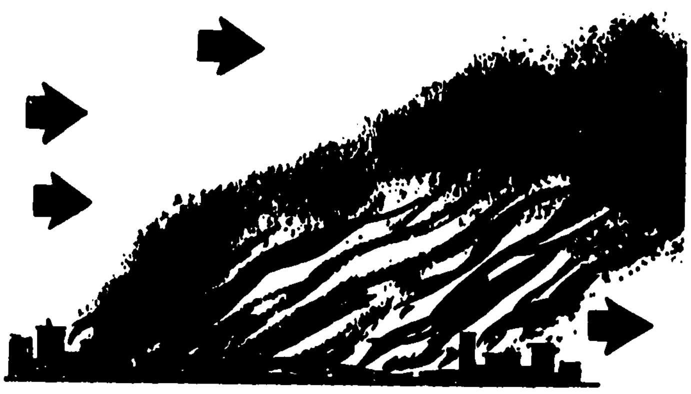


FIGURE 2.—Fire Conflagration

are followed by a blast (shock) wave that loses much of its damaging force over a distance of about 10 miles. With the blast wave comes a violent wind that picks up loose objects and carries them outward.

FIGURE 3.—Fire Storm

A 5-MT burst at ground level would leave a crater about one-half mile wide in the explosion area; it would destroy nearly everything within the radius of a mile from ground zero and would also destroy most buildings 2 miles from the point of explosion and start fires.

The destruction 5 miles away would be less severe, but fire and early fallout could be significant hazards.

Ten miles away, most buildings would remain intact, but fires would be started by the heat radiation. The blast wave could rupture gas lines and short circuit wires within houses and buildings, which would add to fire hazards. Flying glass and early fallout would also be major dangers.

Somewhat farther away, all buildings would remain standing. The fading blast wave would take longer to arrive, but would still shatter many windows. The most acute danger at these greater distances downwind from the explosion would be from early fallout, which might begin to arrive in some areas within one-half hour to a few hours, depending upon distance and wind conditions.

The blast, heat, and fire caused by a nuclear explosion could cause widespread destruction, but radioactive fallout would be a much greater hazard. It could spread over thousands of square miles, a much greater area than that endangered by fire and blast, and sicken or kill unprotected people. Although only a small fraction of the total energy expended by a nuclear explosion is released as nuclear radiation, it is a highly important fraction. What, then, is radioactive fallout?

THE NATURE OF FALLOUT

In a surface burst, large quantities of earth or water enter the fireball at an early state and are fused or vaporized. When sufficient cooling has occurred, the fission products and other radioactive residues become incorporated with the earth particles as a result of the condensation of vaporized fission products into fused particles of earth, etc. A small proportion of the solid particles formed upon further cooling is contaminated fairly uniformly throughout with radioactive fission products and other weapon residues, but in the most the contamination is found mainly in a thin shell near the surface. In water droplets, the small fission product particles occur at discrete points within the drops. As the violent disturbance due to the explosion subsides, the contaminated particles and droplets gradually fall back to earth. This effect is referred to as the "fallout." It is the fallout, with its associated radioactivity that decays over a long period of time, that is the main source of the residual nuclear radiations.

Time of Fallout Arrival

It takes time for fallout to drop from the nuclear cloud, even close to the burst, and the particles size is important in determining the rate of its return to earth.

Significant amounts of fallout begin to arrive in the immediate vicinity outside a blast area

EFFECTS OF A 5 MT BLAST

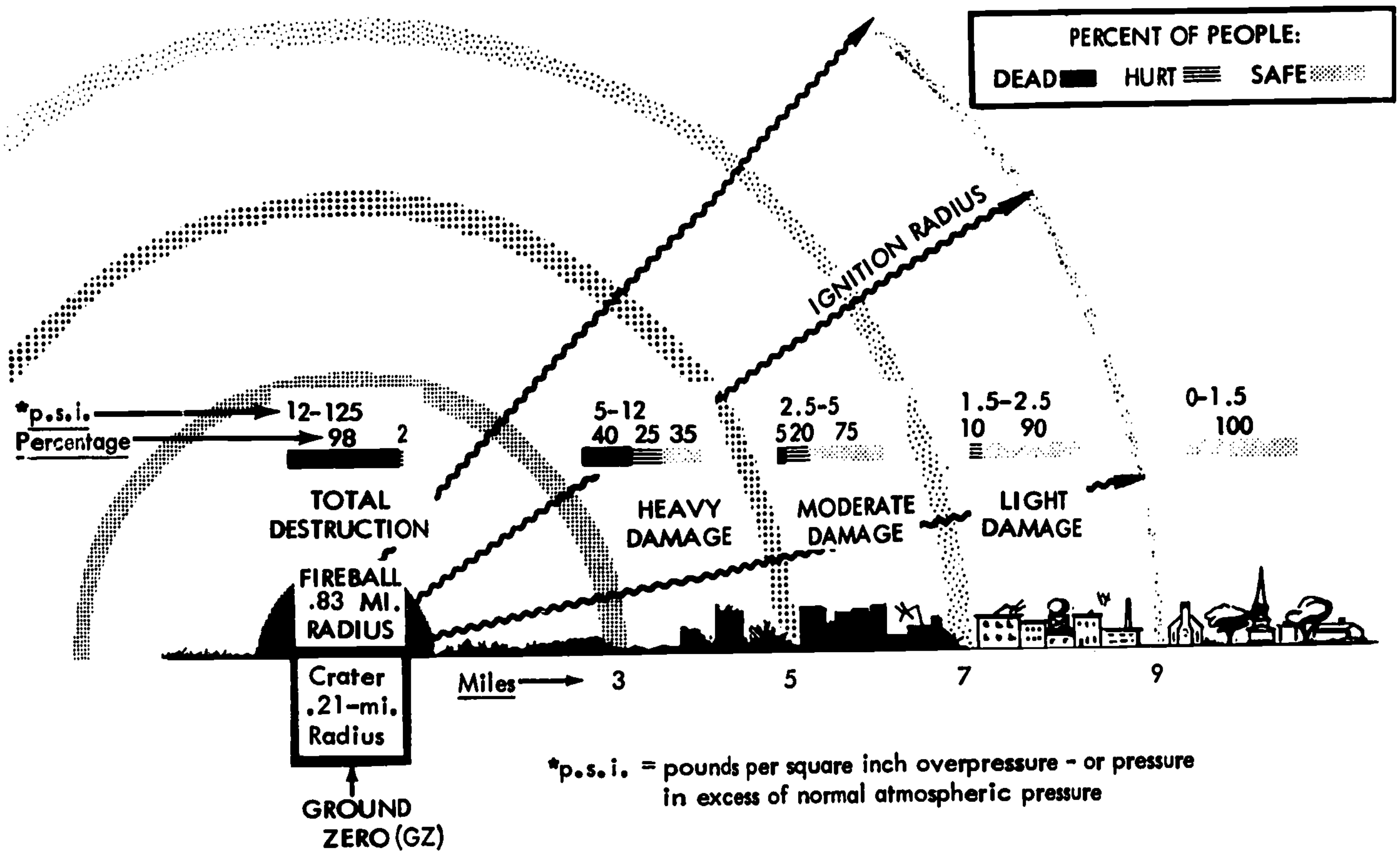


FIGURE 4.—Effects of 5-MT Burst

about 30 minutes after an explosion. People 20 miles away may have an hour to seek protection. At a distance of 100 miles, the fallout may not arrive for 4 hours or more. The fallout will continue to cover an increasingly large area and may eventually cover several thousand square miles. Some areas that will receive fallout might not get it until 24 hours after the explosion, and lighter deposits of fallout may continue for many hours afterwards. Outside of areas affected by blast and heat, then, the earliest and most immediate serious danger following a nuclear attack could be from local fallout.

The time of fallout arrival at various distances and directions from the points of explosion (ground zero) depends on the winds and upon the explosion height. Layers of air move with various speeds and directions at different heights. Fallout distribution is determined primarily by high-altitude winds that often blow in a quite different direction from the ground level winds. In a 1954 test of an H-bomb, the fallout reached a point 160 miles downwind about 8 hours after the explosion and continued to fall for several hours.

As much as 80 percent of the radioactive material from a land-surface burst of a nuclear weapon may return to the earth as early fallout within the first day; this fallout will assume an irregular pattern stretching downwind from the neighborhood of the blast-damaged area. Early fallout descends so quickly and in such heavy concentration that the hazard from it is much greater than that of the widely distributed, slow-falling types of world-wide fallout. The remaining radioactive material rises high into the sky, is blown around the world by high winds, and falls back to earth over months or years.

Some peacetime tests of nuclear weapons have caused worldwide fallout. Quantities of radioactive isotopes have risen into the stratosphere and have come slowly down afterwards as very light fallout, creating fears of health hazards. It should be understood that slow-falling worldwide fallout resulting from a war waged with nuclear weapons would be much greater in quantity than the fallout from peacetime tests. The main concern, however, should be protection against wartime close-in or local fallout.

Area of Severe Fallout

The region of severe local fallout lies downwind from the point of burst. It is impossible to accurately predict how large this area will be or what shape it will take because so many conditions can affect it. The area of severe local fallout might stretch 5 miles or more upwind of ground zero and 150 to 200 or more miles downwind depending on wind strength and bomb yield. The pattern could be irregular in outline, and fallout within the area might not be evenly distributed. There might be local or regional hot spots as well as areas with very little fallout. These variations could result from differences caused by local hills, valleys, lakes, and streams or from wind, rain, and other local weather conditions. Generally, the heavier deposits will be in central areas rather than at the periphery.

The extent and location of a fallout area and the levels of radiation in that area are determined by:

1. Altitude of the bomb burst.
2. Power and design of the bomb.
3. Size, shape, and density of the fallout particles.
4. Atmospheric conditions such as air currents and the direction and speed of the winds, particularly those up to 80,000 feet.
5. Snow and rain.
6. Nature of the ground surface.

The Nature of the Atom

All matter is made up of one or more simple materials known as elements. The total number of naturally occurring elements is 92. Among the common elements are gases—hydrogen, oxygen, and nitrogen; solid nonmetals—carbon, sulfur, and phosphorous; and various metals—iron, copper, and zinc. A less-familiar element, which is used as a source of atomic (or nuclear) energy, is uranium, normally a solid metal.

The smallest part of any element that can exist and still retain the characteristics of the element is an atom. Thus, there are atoms of hydrogen, iron, uranium, etc. The hydrogen atom is the lighest, but uranium atoms are among the heaviest found in nature. An atom is the smallest unit of one element that can combine with the atom of another element to produce a chemical reaction. For example, common salt, known as sodium chloride ($NaCl$), is a combination of one atom of sodium (Na) and one atom of chlorine (Cl). When atoms unit chemically, they form molecules; for example, one atom of oxygen is represented by the symbol O, but normal oxygen exists as a molecule, a combination of two atoms, or O_2.

Atomic Structure

The atom contains three primary types of particles—protons, neutrons, and electrons. The inner core of the atom, called the nucleus, is composed of both protons and neutrons. The protons are electrically charged and are referred to as having a positive (plus) charge, whereas the neutrons are not electrically charged. The only atom that is an exception to this is hydrogen, which does not contain a neutron.

Electrons are very tiny particles that carry a negative electrical charge. They surround the nucleus and can be thought of as revolving around it in about the same fashion that the earth and other planets revolve around the sun. Every atom can be pictured as a tiny "solar system." The "sun" of the atom is its' nucleus, and the "planets" of this sun, revolving in orbits around it, are the electrons.

Radioactivity

The essential difference between atoms of different elements lies in the number of protons in the nucleus. A hydrogen atom, for example, contains only 1 proton; a helium atom has 2 protons; and a uranium atom has 92 protons. Although all the nuclei of a given element contain the same number of protons, they may have different numbers of neutrons. The resulting atomic species, which have identical atomic numbers (numbers of protons) but differ in their masses because of the number of neutrons, are called "isotopes" of the particular element.

Radioactivity is the process whereby isotopes of certain elements spontaneously emit particles and (or) rays from the nuclei of their atoms.

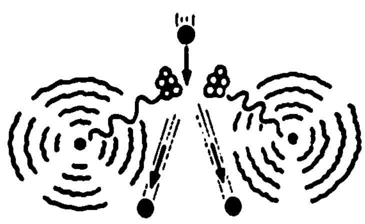
Some elements are naturally radioactive, whereas others can be made artificially radioactive by bombarding the nuclei. Significant initial radiation from a nuclear explosion includes gamma radiation and neutrons. Significant later radiation (from fallout) includes gamma rays and beta particles. Beta particles are highspeed electrons, and gamma rays are similar to X-rays although usually more penetrating than X-rays.

Natural radioactivity is characterized by the ability of certain types of atomic nuclei to decay spontaneously, giving off alpha, beta, or gamma radiations or combinations of these. Radium, for example, is one of about 50 naturally radioactive atomic species.

In a nuclear explosion, various isotopes of many normally stable elements can be created. Most are radioactive producing beta and gamma radiation; none produce alpha.

Fission

Nuclear fission is the splitting of heavy atomic nuclei. The nucleus of an atom of a heavy element, such as uranium, may be split into two or more parts. When a fissionable nucleus is split by a neutron, it releases energy and one or more neutrons. These released neutrons may split other fissionable nuclei, releasing more energy and more neutrons and becoming self-sustaining. Self-sustaining fission reactions occur only with the heavy elements uranium, plutonium, or thorium.



Fission. In the process of "fission" (splitting), the atoms of some heavy element, usually Uranium, are broken into and divided. As each nucleus is split, neutrons break free and energy is released. During the process of fission, isotopes are created.

FIGURE 5.—Fission Process

Fusion

Nuclear fusion, on the other hand, is the joining together of light atomic nuclei to form a heavier nucleus. Such fusion can only be accomplished under very high temperatures (millions of degrees). If two nuclei of light atoms fuse, a great deal of energy is released. The sun's energy, for example, results from the fusion of certain light atoms to form heavier ones. Much of the energy from the so-called hydrogen bomb (H-bomb) results from fusion. Atoms formed by fusion are not radioactive; atoms formed by fission process are radioactive.

Detecting the Presence of Fallout

Radioactive debris—fallout—may be of many sizes. Of course, the larger, heavier particles come down closer to the explosion. Particles the size of sand or table salt may be carried some miles downwind from the explosion. Smaller particles stay in the air much longer and travel much farther before reaching the ground. Whether or not the particles are visible, the nuclear radiation given off by them cannot be detected directly by the senses. *The radiation cannot be seen, heard, smelled, tasted, or felt; instruments must be relied upon to detect and measure the radiation.*

There are various types of radiation-measuring instruments, including dosimeters, used to measure the total radiation exposure of personnel, and survey meters, used to measure the rate of radiation. Civil Defense personnel, called radiological monitors, have been given special training in the use of these instruments.

Radiation Not Transferred From Fallout

Nuclear radiation from fallout can damage living things, but it does not cause the damaged matter to become radioactive. Thus, if fallout particles are on the body of a person or animal, instruments may detect nuclear radiation coming from that contamination, but if the fallout particles are removed, no radiation will be detected.

If radioactive fallout drops on a body of water, the water itself does not become radioactive. After the radioactive fallout has been removed, the water itself is not radioactive. The same principle applies to water in storage tanks or to food in cans or other containers. More ex-

FUSION. In nuclear fusion, a pair of light nuclei unite (or fuse) together, to form a nucleus of a heavier atom. An example is the fusion of the hydrogen isotope known as deuterium or "heavy hydrogen." Under suitable conditions, two deuterium nuclei may combine to form the nucleus of a heavier element, helium, with the release of energy. The fusion of all the nuclei present in one pound of deuterium would release roughly the same amount of energy as the explosion of 26,000 tons of TNT.

FIGURE 6.—Fusion Process

posure to radioactive fallout does not make the water or food dangerous.

Kinds of Radiation

Fallout from a nuclear explosion emits beta particles and gamma rays.

Beta particles have a maximum range of only 10 to 12 feet in open air (average range 3 to 4 feet), but they do not penetrate materials easily. Several layers of clothing can protect the body. But if enough new fallout remains on exposed skin for some time (hours), the beta particles can cause severe burns. Some beta particle emitters have long half-lives, and if substantial amounts enter the body, some damage may result.

Fallout Distribution

The size and design of a nuclear weapon, type of burst, and wind condition chiefly determine the amount and distribution of radioactivity in a fallout area. Since these things can't be known or predicted accurately, actual field measurements of nuclear radiation would be necessary following an attack.

Measurements of radiation levels are made at sheltered monitoring stations, where monitors can take quick readings outside of the shelter, and by mobile monitors when levels are low enough to allow extended field activity. An area of high radioactivity may be monitored from an airplane.

Radiation dose is measured in units called "roentgens" (pronounced "rentkins"). It is named after W. K. Roentgen, the discoverer of X-rays, and is a measure of X-ray or gamma radiation. A smaller unit often used is a milliroentgen, which is one-thousandth of a roentgen. Remember that the roentgen is a unit of radiation exposure.

HEALTH HAZARDS FROM RADIATION

Internal and External Radiation

During the early post-attack period, external radiation is the primary problem and is the major concern in this section. However, radiation damage can result from either internal or external radiation. Consumption of heavily contaminated food and water could cause some internal radiation damage. This damage would be minor in relation to the external radiation danger.

Foodstuffs contaminated with fallout contain many different radioisotopes. Once inside the body, some of these isotopes are concentrated in specific organs, tissues, and bones. For example, iodine 131 concentrates in the thyroid gland. Strontium 90 behaves much like calcium and is deposited primarily in the bones.

Radiation From Natural Sources

Living things are exposed to radiation from natural sources every day. Natural nuclear radiation comes from radioactive rocks and soil; other radiation comes from far out in space. The individual sees nothing and feels nothing, but the radiation damages or destroys some of his body cells.

Inside the body there are very small amounts of naturally radioactive materials (potassium 40 and carbon 14). Additional amounts are taken in through food, water, and air. Soil and rocks contain potassium 40 and uranium, thorium and radium. Tiny amounts of these materials are taken into the body with food and water.

Small amounts of radiation can be received for medical purposes without significant harm. The average tuberculosis chest X-ray exposes the chest to an amount of between one-tenth to one-half roentgen. Even large amounts of radiation can be applied to limited areas of the body without being fatal. Cancer specialists often bombard a cancerous area with massive doses of radiation, destroying more cancer cells than normal cells.

During the average lifetime, every human being receives about 10 roentgens of radiation from natural sources.

Exposure to Radiation

When large amounts of radiation are absorbed by the whole body in short periods of time, sickness and death may result. In general, the effects of radiation exposure stay with people and accumulate over a period of time. Few people get sick who have been exposed to 100 roentgens or less. Exposure to more than 500 roentgens over a few days will cause sickness and may cause death. Death is expected for almost everyone who receives an exposure of 600 roentgens over a few days. The effects of similar exposures over months or years are still under study although, in general, even a fairly large dose of radiation absorbed over months or years is not as dangerous as when absorbed over a few days. In the former case, the body is able to repair much of the cell damage as it occurs.

The table below shows the effects of various amounts of short-term radiation exposure.

Radiation Dose *(Roentgens)*	*(Effect)*
50	Smallest dose detectable in an individual by laboratory methods.
75–100	May cause transient nausea on day of exposure in 10 percent of the people exposed.
200	Largest dose that does not cause illness severe enough to require medical care in most people (90–95 percent).
450	Will cause death to about 50 percent of the people exposed, 3 to 4 weeks after exposure.
600	Will cause death to almost everyone so exposed, 2 to 3 weeks after exposure.

Radiation Sickness, Not Contagious

Persons and animals exposed to large amounts of radiation will develop radiation sickness. *Radiation sickness is neither contagious nor infectious; a person cannot "catch it" from others.* People or animals suffering from radiation sickness can be helped without fear of "catching" radiation injury from them. However, a person or animal with "radiation sickness" could be suffering from a massive infection, and should be treated accordingly.

Again, fallout radiation cannot make anything radioactive. Food and water that have been exposed to fallout radiation are contaminated only to the extent that they contain fallout particles or dissolved radioactive material. Exposed food that may have particles on it should be washed, brushed, or peeled, as appropriate. Fallout particles can be removed from water supplies by sedimentation or filtering. People who have fallout particles on their bodies or clothing probably would not carry enough to endanger other people, but they should clean themselves for their own protection.

Radiation Sickness

People may show symptoms of radiation sickness if they have received a dose of from 100 to 550 or more roentgens. Such symptoms as nausea, vomiting, or diarrhea, may appear in the first day or so, then about a week may pass before other symptoms appear. These later symptoms may include loss of weight, loss of appetite, bleeding, discolored spots on the skin, paleness, redness, swollen mouth and throat, and general discomfort.

Symptoms of three degrees of radiation sickness are: (1) Mild—the especially sensitive person will show some nausea, lack of appetite, and fatigue within a few hours after exposure. He should rest, but can continue normal activities. Recovery will be rapid. (2) Moderate—the same symptoms appear, but well within 2 hours of exposure, and more markedly. Vomiting and even prostration may occur. By the third day, recovery may seem complete, but symptoms may recur in the next few days or weeks. (3) Severe—again all the early symptoms show up and may vanish after a few days. But after a week or more, fever, mouth soreness, and diarrhea may appear; gums and mouth ulcerate and bleed; and, in about the third week, the patient's hair may start to fall out. Recovery may take 7 to 8 weeks. When exposure has been overwhelming, death comes in hours.

YOU CANNOT "CATCH" RADIATION SICKNESS FROM VICTIMS

FIGURE 7.—Radiation Sickness is not Catching

RADIATION SICKNESS

Early Symptoms: Nausea, Vomiting, Diarrhea
Later Symptoms: Loss of Weight, Appetite
Bleeding
Discolored Spots on Skin

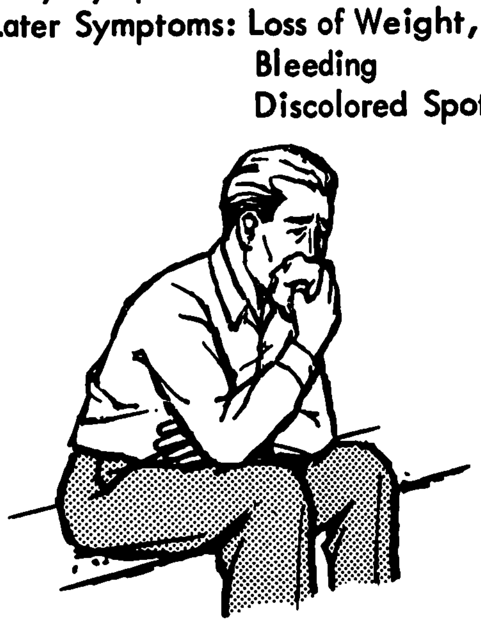


FIGURE 8.—Radiation Sickness

Symptoms should be treated in this way: Prescribe general rest. Give aspirin for headache. Give motion sickness tablets for nausea. Give liquids for diarrhea and vomiting, but not until vomiting has stopped (ideally, 1 tablespoon of table salt to 1 quart of cool water, to be sipped slowly). This solution can be used as a mouthwash for sore mouth.

It is important to remember that certain of the symptoms may also appear in people who do not have radiation sickness at all. Symptoms such as nausea, lack of appetite, and fatigue may be seen in persons subject to extreme anxiety and emotional stress.

Individual Exposure Dose

Radiation exposure of individuals should be kept as low as possible. This would be done in the immediate post-attack period by using the best available shelter for the period of time necessary to ensure survival. If it becomes necessary to leave shelter for essential items, the dose rate and the time of exposure will determine the amount of radiation that an individual receives. A simplified method of calculating dose would be to multiply the dose rate by the time of exposure (e.g., 3 roentgens per hour times 4 hours equals 12 roentgens). Generally, individuals should obtain guidance on permissible dose from their local Civil Defense officials.

Median Lethal Dose

A measuring point for the effects of extreme whole-body exposure that is often used is called the median lethal dose. Usually abbreviated as MLD, or LD/50, it is the radiation dose delivered over a short period of time that is expected to kill 50 percent of exposed individuals within about a month. An acute dose is that received when the whole body is exposed for a short period of time—up to about a week. About 450 roentgens (acute dose) is the estimated median lethal dose for man, as compared with about 325 roentgens for dogs or 800 to 900 for rats.

A somewhat smaller acute dose would be fatal to some individuals. For example, the first death out of an average population of 100 people might occur with an acute dose somewhere between 200 and 300 roentgens.

RADIOACTIVE DECAY

Radiation rate or intensity from fallout decreases with time—that is the radiation level, as measured in roentgens per hour, drops lower and lower. This falling off is known as radioactive decay.

Half-life

The "half-life" of a radioactive element is the time that it takes for a given amount of the isotope to decrease in radioactivity to half its original value. For instance, a form of cobalt (cobalt 60) has a half-life of about 5 years. This means that a measurement of 200 R/hr., if repeated under identical conditions 5 years later, would have fallen to about 100 R/hr; 5 years after that it would have fallen to about 50 R/hr., and so on.

Each radioactive isotope has a different half-life, and this ranges from a small fraction of a second to billions of years. The passage of 7 half-lives of a radioactive isotope decreases its radiation level to about 1 percent of its initial radiation level. The passage of 10 half-lives decreases the radiation to about one-tenth of 1 percent of the initial radiation.

Decay Rate For Fallout

The mixture of isotopes formed after a nuclear burst—the mixture that makes up fallout—is so complex that it is not possible to calculate the exact decay rate. However, from experimental measurements, a rough approximation indicates that for each sevenfold increase in time, the radioactivity of the mixture found in fallout drops to about one-tenth of its former value. In general, the radioactivity at 49 hours after the explosion will have dropped to about 10 percent of its amount at 7 hours. By the end of about 2 weeks, the radioactivity can be expected to decay by another factor of 10. But even this level of radiation can be dangerous if there is a heavy concentration of fallout, and the decay rate may differ in some cases.

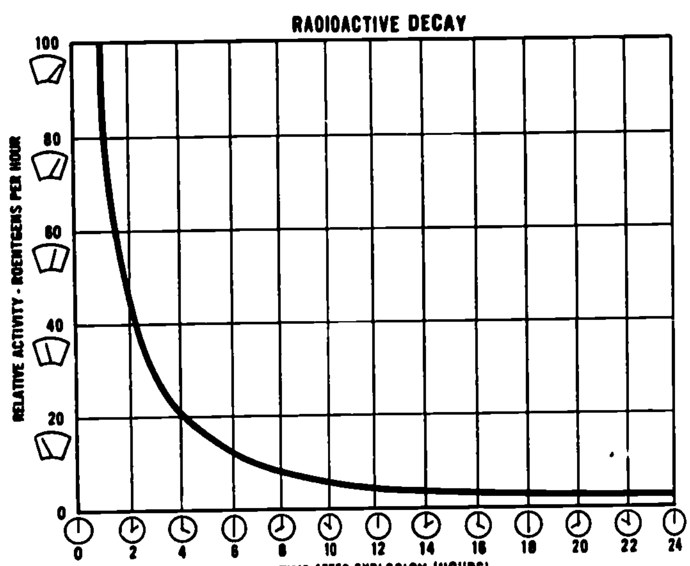


FIGURE 9.—Radioactive Decay

Decay Cannot Be Speeded Up

It must be emphasized that the radioactivity in fallout cannot be destroyed. Boiling, burning, treatment with chemicals, any other action will not destroy or neutralize radioactivity. Because of radioactive decay, fallout will become less harmful with the passage of time, but there is no known way to speed up the decay process. Fallout cannot be made harmless quickly. However, fallout can be removed from many contaminated surfaces.

PROTECTIVE MEASURES AGAINST RADIATION

Protection from external radiation exposure is a combination of three things; time, distance, and shielding. That is, a person may protect himself by:

1. Shielding (shelter).
2. Distance (decontamination, movement).
3. Exposure control (combination of 1 or 2 with time-scheduled exposure).

In a fallout area, shielding is the only dependable means of protection. People within a well-stocked shelter have placed mass between themselves and the source of radiation, and they should remain behind this mass until the radiation has decayed to levels permitting activity outside of the shelter.

Defense Against Fallout

Persons seeking shelter after a nuclear attack should remember that the introduction of radioactive material into shelter areas can be minimized by such ordinary precautions as closing doors and windows. Unnecessary movement in and out of shelters should be avoided whenever there is a possibility that fallout is near. Prolonged contact with fallout material is hazardous.

Following a nuclear attack the air would be contaminated by radioactive fallout to the extent that it contained fallout particles. The most hazardous fallout particles—early fallout—would reach the earth in the first day after the detonation, but their mere passage through the air would not contaminate the air. Some radiation will probably penetrate all shelters, but fallout particles in harmful amounts should be and can be kept out of shelters. People in underground shelters could keep fallout particles out of their shelters by having a simple hood over the air-intake pipe. Special filters are not needed for small basement family shelters. However, group shelters that have high velocity air-intake fans might need filters on the air-intake system to keep fallout particles out.

Special Clothing Offers Little Protection

Fallout gamma radiation would pass through any type of protective clothing that would be practical to wear. Heavy and dense materials such as earth and concrete are needed to stop the highly penetrating gamma rays. Tightly woven outer clothing could be useful—particularly for emergency workers—in keeping fallout particles off the body, but the wearer would not be protected from the gamma radiation given off by the particles. The worker would wear the outer clothing when in a fallout contaminated area and then leave it outside or brush or wash it thoroughly before entering an uncontaminated area.

No Special Antiradiation Medicines

Many experiments have been conducted to develop a special medicine to protect against the effects of radiation. Thus far, there seems little likelihood that a pill, or any other type of medicine, will soon be developed that can protect people from the effects of fallout radiation.

Decontamination

Contamination is the deposit of radioactive material on the surface of structures, area, objects, or people following a nuclear explosion.

Decontamination is the reduction or removal of contaminating radioactive fallout from a structure, area, object, or person.

Self-decontamination

Contamination could be caused by fallout material settling on persons outdoors while fallout was descending or by entering a very dusty ara after fallout had ceased.

Self-decontamination should be accomplished only after a person has assured himself that he is protected from the far greater hazard of the fallout field of radiation in his area. Therefore, if one is caught in the open when fallout begins, he should immediately seek shelter and then remove any contamination from his person by brushing, shaking, or washing, as appropriate under the circumstances. Some community shelters may contain a decontamination area in which showers would be available and a change of clothing might be appropriate. In most cases simple wiping or washing of hands, face, and clothing, would reduce the contamination to insignificant levels.

Decontaminating Food and Water

It is unlikely that food and water inside a building would be sufficiently contaminated to be dangerous to eat or drink. If food supplies do become contaminated many types of food can be treated to remove the radioactive material. Fresh fruits and vegetables can be washed or peeled to remove the outer skin or leaves. Food in cans, covered jars, or closed containers such as plastic bags can be decontaminated by washing or wiping the material off the container. The contents would not be contaminated. Similar cleaning methods appropriate to the type of food involved would in most cases be sufficient.

Water supplies in the home (water heater or toilet tank) or shelters would not require decontamination. However, there is a possibility of contamination of public water supplies. Serious contamination of public water supplies is unlikely. Should this occur, however, a water softener in the home is an effective method of decontamination, as is distillation when practical. It should be noted that mere boiling of water contaminated with fallout is of absolutely no value in removal of the radioactivity. But the regular water treatment (coagulation, sedimentation, filtration) by public authorities will remove most of the contaminated material.

Area Decontamination

The decontamination of buildings, streets, and equipment might be necessary before an area could be used for its intended purpose. Civil Defense authorities would undertake this type of decontamination operation. Since radioactive contamination is similar to dirt, its removal by water or sweeping could be done by fire department or public works personnel using their day-to-day operation equipment. Many communities have organized decontamination teams for this purpose.

For the individual who might have occasion to decontaminate in his home, common methods of cleaning could be used. Thus, brooms or vacuum cleaners might be useful. But this should be undertaken only on instructions from local authorities.

MEASUREMENT OF RADIATION

As mentioned previously, the unit of measurement for gamma radiation doses is roentgens or milliroentgens.

In evaluating the effect of nuclear radiation on living things we are concerned not only with total amounts of radiation received (that is, the dose) but also with the dose received within a given amount of time—the dose rate. We want to know not only how much the total exposure dose is, but also how fast the exposure dose is building up.

Total accumulated radiation exposure, or total dose, is expressed as so many roentgens. The rate of radiation exposure at a place of interest is expressed as roentgens per unit of time (usually roentgens per hour). This is sometimes called radiation intensity, or radiation level, but more often "dose rate." Because the human senses cannot detect nuclear radiation, special instruments have been developed to measure it. These devices are either ratemeters or dosimeters (dose meters).

A ratemeter will indicate the intensity of the radiation. It is analogous to a speedometer in a car, except that it measures roentgens per hour rather than miles per hour. Thus, an indication of whether to leave the shelter for a brief period can be obtained from a ratemeter reading made just outside the shelter. The dosimeter can be used to show the total amount of radiation to which a person has been exposed during an emergency period. It is analogous to a mileage indicator (odometer) in a car, but it measures total roentgens rather than miles.

Relation of Federal, State, and Local Monitoring

Wind currents determine where fallout would be deposited as the result of a nuclear attack. The U. S. Weather Bureau, therefore, routinely prepares and issues wind data that would be used for forecasts and estimates of areas likely to be covered by fallout to states and territories. These forecasts can be used to predict where fallout is likely to be deposited and approximately when it will arrive there. The intensity of fallout radiation, however, would not be predicted. Intensity can be determined only after the attack when measurements will be made with instruments.

A federal network of fixed monitor stations is being developed that uses the facilities of many federal agencies. Many facilities of the

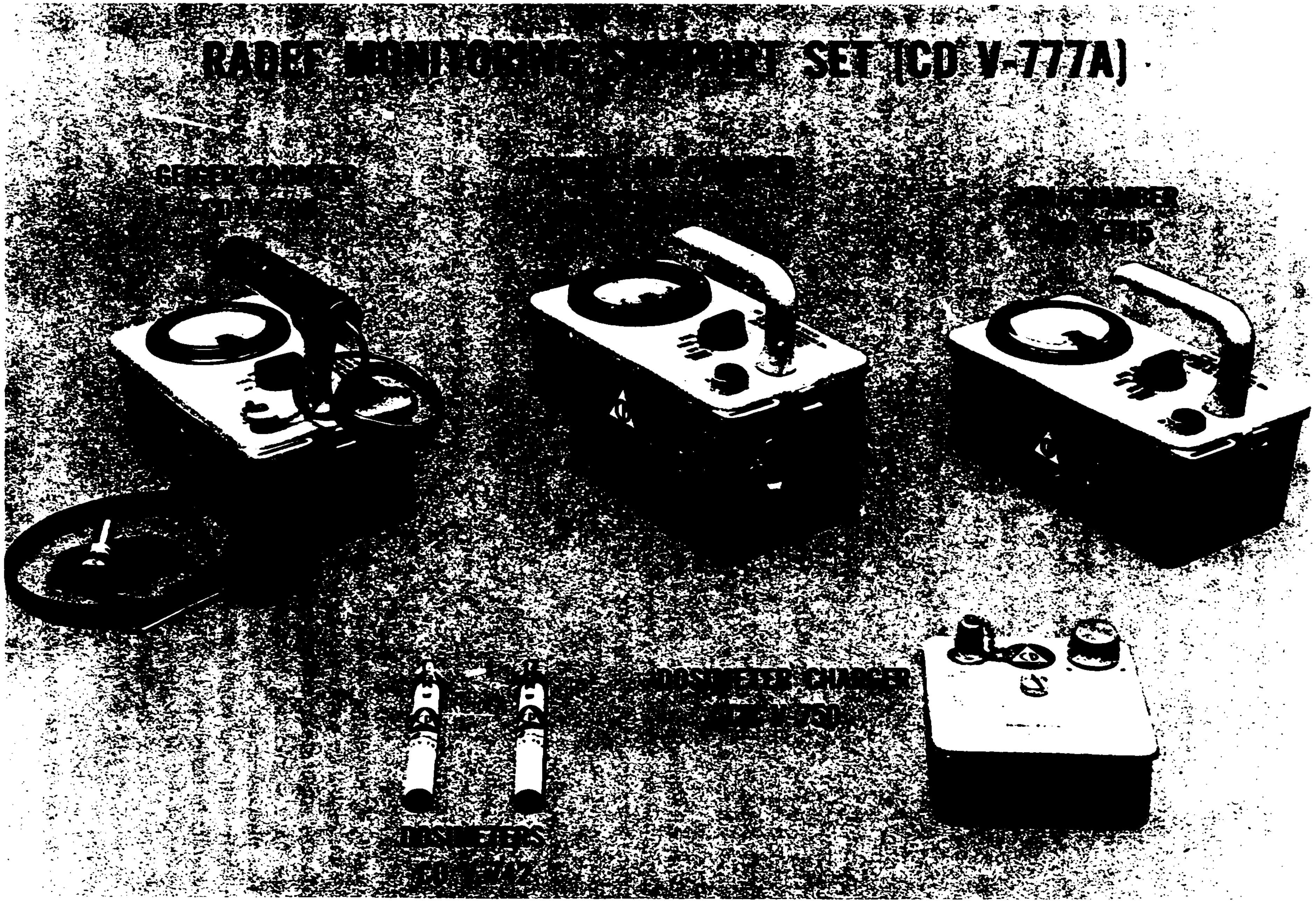


FIGURE 10.—RADEF Monitoring Instruments

Weather Bureau, the Federal Aviation Agency, and the Department of Agriculture are already in use. This network, combined with state and local monitoring, is designed to provide radiation information that can be used to assist in making decisions for protective, remedial, and recovery action.

The federal government is providing equipment for radiological monitoring stations and operators are being trained to use this equipment. A total of 150,000 monitoring points are being established in protected locations, with communications capabilities to the local emergency operating center.

Radiological Monitoring in Community Shelters

A Radiological Defense (RADEF) officer, serving in the local government's emergency operating center, directs the technical operations of monitors in his area.

Some community shelters will be selected to serve as special monitoring and reporting stations. Such stations will evaluate and report the radiological situation in the shelter and also measure and report unsheltered radiation dose rates and dosages.

A radiological monitoring kit is provided that contains dosimeters, ratemeters, charging units, accessories, batteries, and instruction manuals. With these instruments, the monitor will be able to provide information to the shelter manager and the local emergency operating center. For example, if dose rates in shelters vary in different locations, it might be advisable to move persons to minimize the dose they would receive.

Note: Further guidance and advice on protection from nuclear radiation will be provided to state and local governments and their supporting elements as continuing study and experimentation to bring new developments to light. Such guidance and assistance will enable local governments to make maximum effective use of fallout protection for use by the supporting elements, upon which their operational capability depends.

ROLE OF THE FIRE SERVICE IN CIVIL DEFENSE

The importance of local and area plans to cope with nuclear fire problems cannot be over emphasized. Such plans exist in many local communities, areas, and states.

For example, the fire service may be responsible for controlling of mass fire under nuclear fire conditions. *Few fire service organizations have ever had actual experience with this type of operation.* The problems of fire control in urban areas where a sheltered populace would be located also require detailed local and area planning as to manpower use and fire-suppression resources during the unusual conditions of nuclear attack.

State Fire Defense Plan

The following policies form the basis for one sample state fire defense plan:

a. The basic concepts of Civil Defense are self-help and mutual aid.

b. Civil Defense is a task that must be shared by all political subdivisions, industries, and individual citizens.

c. The State Fire-Defense Plan must form a practical and flexible pattern for the development and operation of day-to-day mutual aid on a voluntary basis within the fire service. This plan integrates all fire-fighting resources and personnel within the state into such a pattern and provides for mutual aid, radiological monitoring, and decontamination for fire service operations on a mandatory basis during a war or declared disaster. The plan is based on normal fire department operating procedures, including day-to-day mutual-aid arrangements and agreements developed by local fire officials to deal with disasters that require aid from outside communities. In addition, because the intensity of radioactive contamination can only be determined with suitable instruments, this plan provides that the fire service develop and promote a radiological monitoring capability sufficient to enable it to carry out its mission without undue risk to its personnel.

d. In developing the local mutual aid and disaster preparedness plans, consideration must be given to liability and property damage and to insurance coverage on apparatus and equipment used beyond the territorial limits of the political subdivision. Consideration must also be given to the rights, privileges, and immunities of paid, volunteer, and support firefighting personnel in order that they may be fully protected while performing their duties under a mutual aid task or a disaster preparedness plan.

e. Maximum use will be made of existing facilities and services within each community.

f. Political subdivisions will reasonably exhaust local resources before calling for outside assistance.

g. Political subdivisions will render the maximum practical collective effort and assistance to all disaster and war stricken communities under the Fire-Defense Plan.

h. Political subdivisions will: (1) maintain their fire-defense organizations substantially in accordance with recognized standards, (2) provide for the annual inventory of all fire department personnel, apparatus, and equipment, and (3) provide for receiving and disseminating information, data, and directions affecting the fire service.

Local Fire Defense Plan

As has been shown, fire protection is a governmental function and, therefore, is only a part of the total survival or restoration effort. One prime objective of the fire service is to plan to maintain organized strength capable of carrying out the mission of fire control and suppression. There will be many factors in a nuclear attack condition that organizations have not experienced, and therefore, many command decisions will have to be made at the appropriate levels to determine how an organized fire service can best be used.

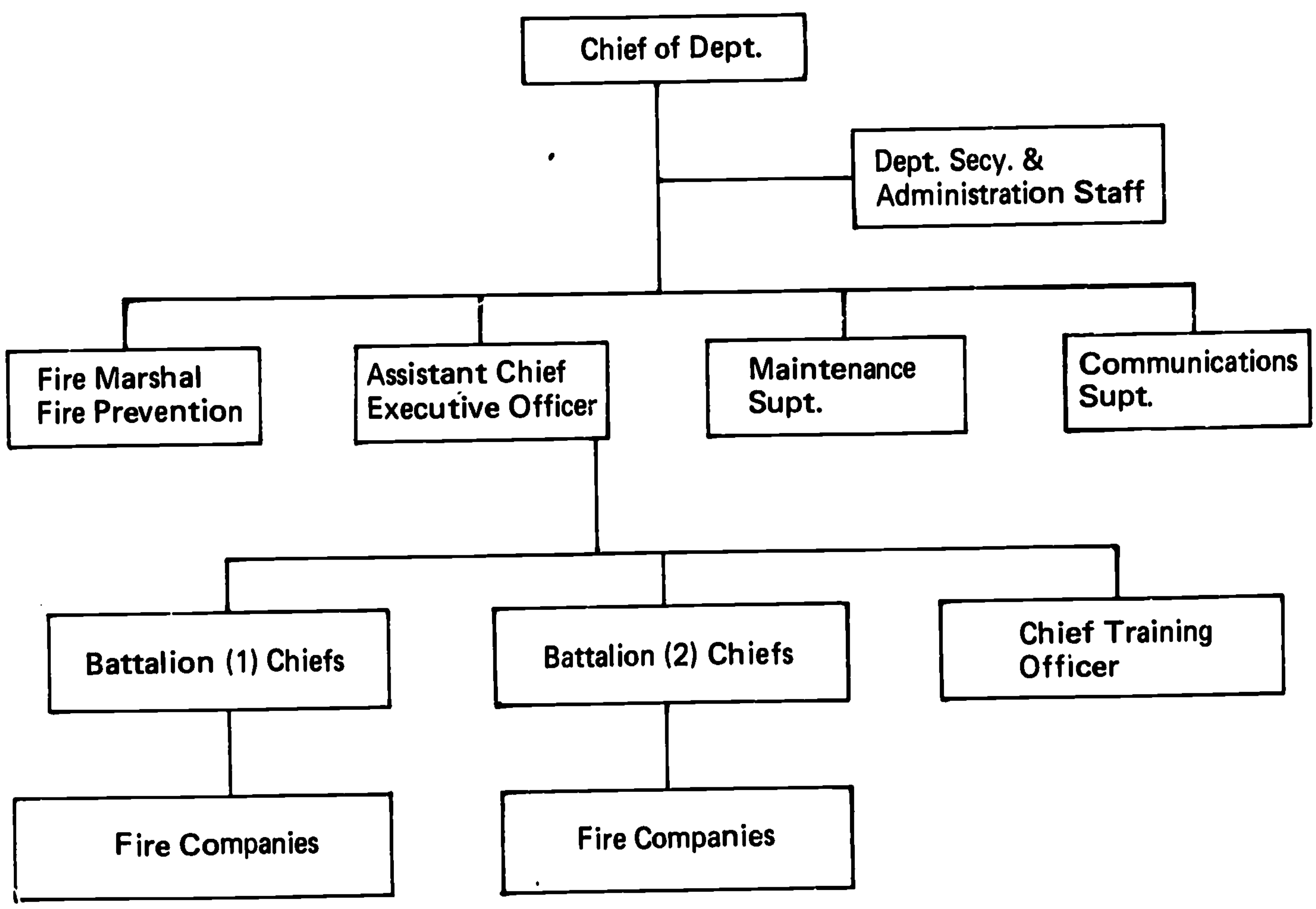
It becomes important, therefore, that the "Support Assistants" for firefighting understand the relationships and interrelationships of all governmental and other organizations with specific roles and assignments to be carried out in a survival or restoration effort.

It is likewise important that the "Support Assistants" realize that they are a supplement to and a part of the regularly constituted fire forces and as such are responsible to and under the control of the regular fire service.

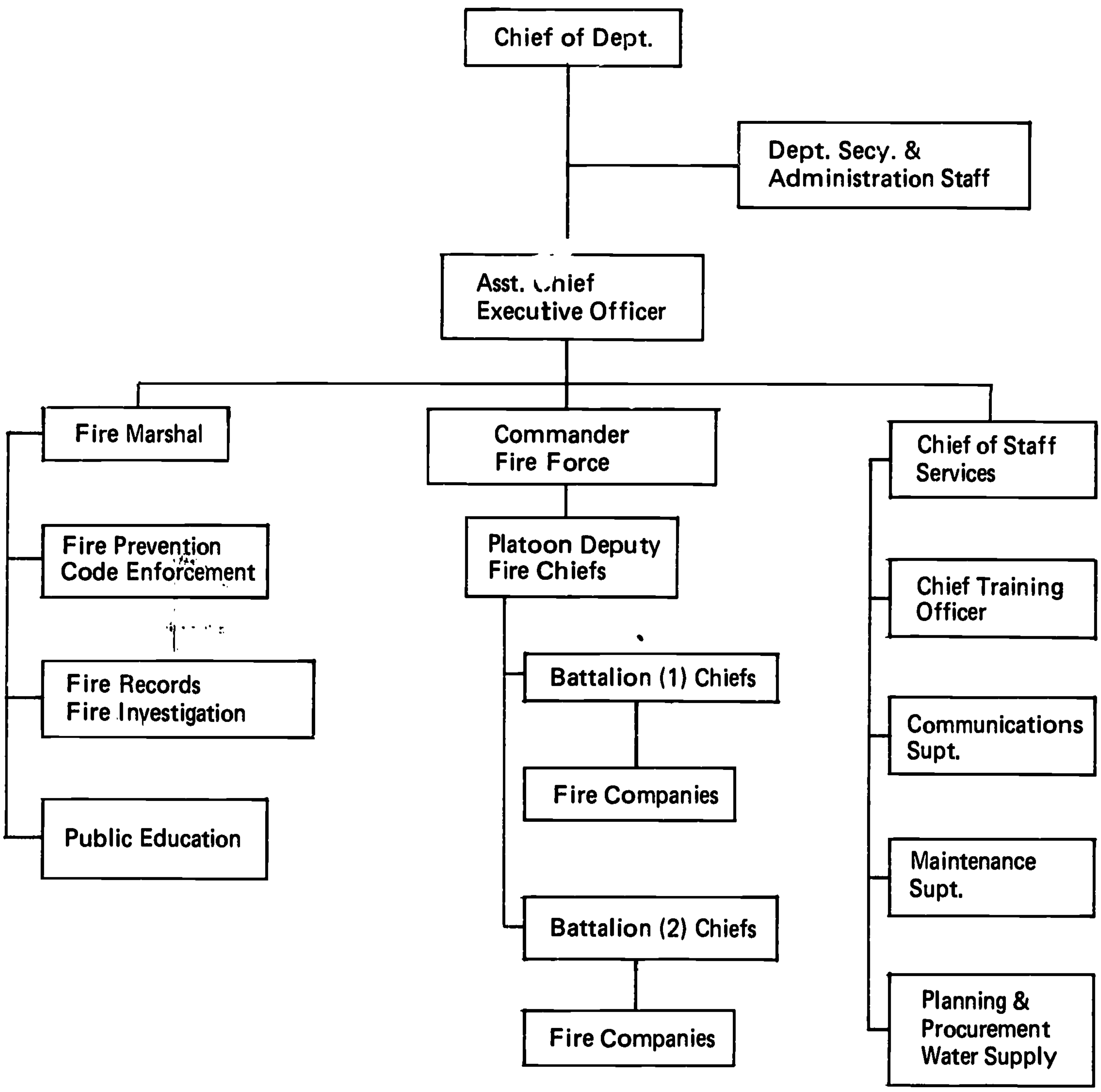
LOCAL FIRE-DEPARTMENT ORGANIZATIONS

Following are some typical organization structures of existing fire-service organizations. In the plans above local level, these organizations become a part of an over-all organization structure such as an area mutual-aid district or mutual-aid pact arrangement. Also included is a sample organization structure up to the state level. Note in the sample organization structures that only the fire function is shown in relation to all governmental functions.

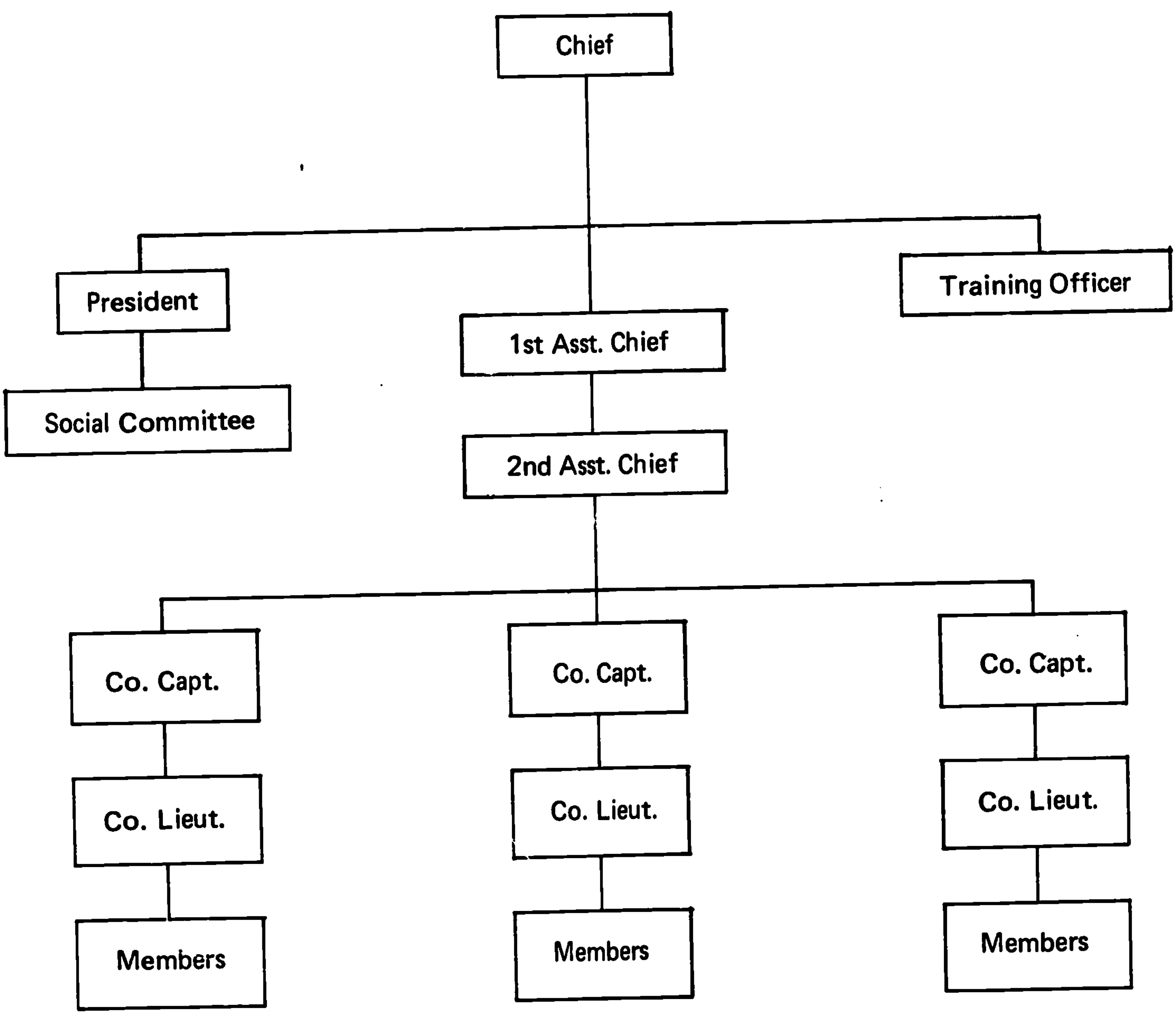
LIMITED F. D. STAFF ORGANIZATION



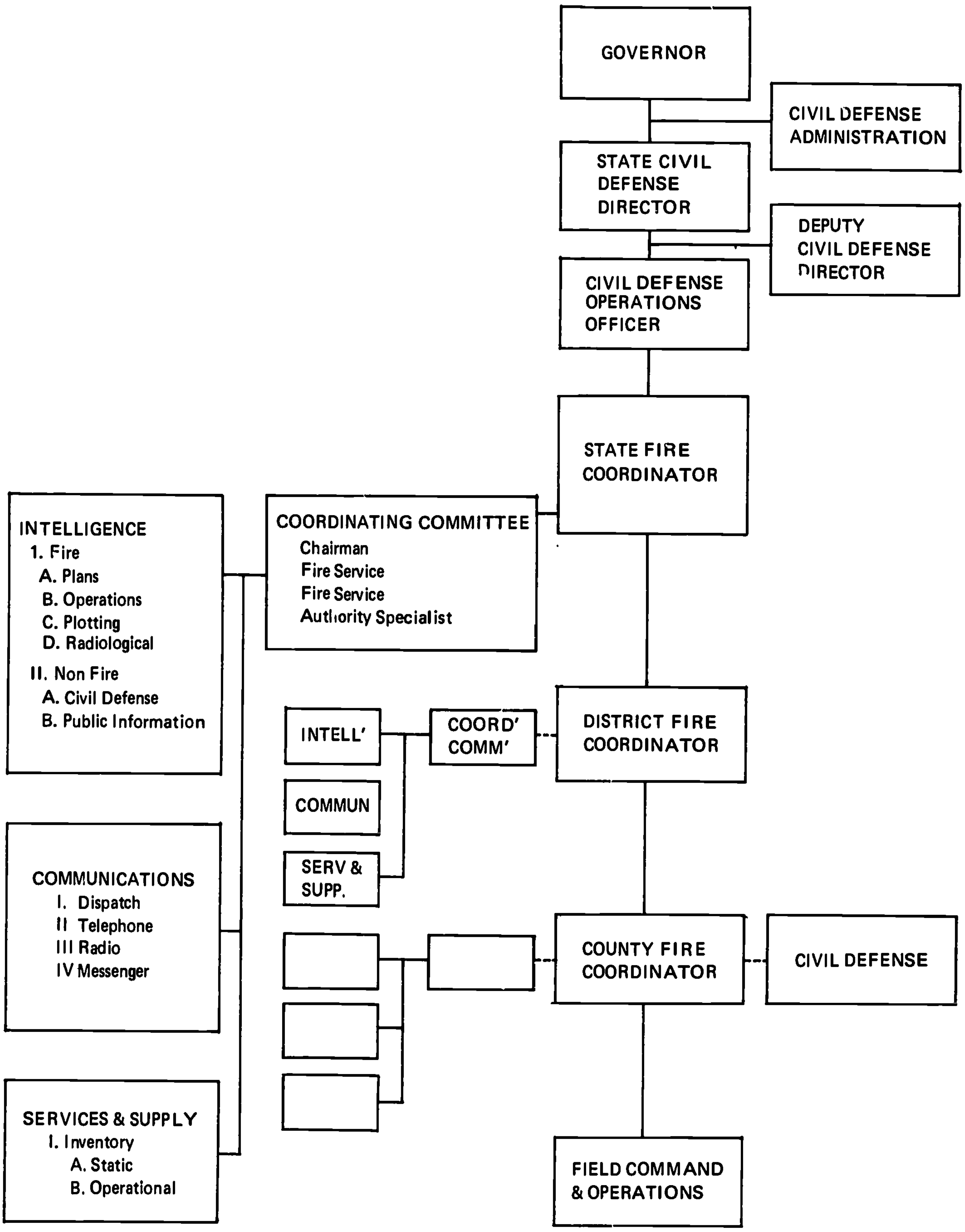
FULL F. D. STAFF ORGANIZATION:



COMBINATION VOLUNTEER AND PAID FIRE DEPARTMENT



SAMPLE STATE FIRE DEFENSE ORGANIZATION



NOTE: This Organization chart shows only the line for the fire function. No other functions are shown.

ROLE OF SUPPORT ASSISTANTS IN CIVIL-DEFENSE FIRE EMERGENCIES

Under day-to-day fire conditions, many fire-service organizations find themselves taxed to the limits of their capabilities. This is the primary reason for establishing area, county, or intra-county mutual aid arrangements. The fire problems that the fire service may encounter because of a nuclear attack could overcome existing fire organizations.

Need

It is obvious, then, that fire-suppression training should be an integral part of citizens preparedness for civil-defense emergencies. A "Citizen Self-Help Fire-Training Program" has been developed. The objective of this program is to train the citizen to suppress incipient and small fires when the regularly organized fire department is not able to reach him. The Support Assistants for Fire Emergencies would: (1) give organized support to the full-time organization in fire-suppression efforts, (2) assist in defending community shelters from fire, (3) control or assist in controlling the spread of fires in or near their shelters or in their neighborhoods. The firefighting Support Assistant will become a very important key in the entire fire function at the time of maximum need.

Organization

The Support Assistants will be organized to supplement the existing fire department organization during major emergencies, and they will always be supervised by the regular fire service personnel. They will be made aware of the organization structure, the chain of command, and technical information related to the fire suppression so that they can follow experienced people.

The Support Assistant when so assigned by regular fire service personnel will also aid shelter managers and help in Civil-Defense Fire-Prevention efforts. In the absence of the regularly organized fire-suppression organization, the Support Assistants may well need to provide the leadership for fire suppression actions. He should, however, realize his responsibility to the regular fire forces and make every effort to establish contact with such forces.

DISCIPLINE IN THE FIRE SERVICE

Discipline in the fire service means "willing and dutiful submission to control." Discipline in the fire service goes beyond the concept where a lapse by a team member causes only a delay or a missed score. In firefighting, missed or ignored signals can lead to disastrous consequences in terms of lives and property.

Firefighting operations take place in the midst of emergency situations. The operations must be carefully planned, well-disciplined, designed to stabilize the situation, and not become in themselves emergency operations. To maintain discipline in the midst of chaos calls for strong discipline on the part of the firefighter.

Fire department operations are similar to military operations; when discipline breaks down, the battle is lost. Even retreat must be a disciplined operation.

Both fire-department and military operation call for strategy to be determined, plans to be made, and operations carried out. Plans often call for sequential, carefully-timed operations and procedures. A sequential fire operation, for example, might be decision, lines laid, pump hooked up, water turned on, building laddered, building ventilated, fire attacked, and results evaluated.

Decisions on the fire ground are made by the highest ranking officer, and operations are carried out according to orders sent down the chain of command. If orders are missed or ignored or certain procedures delayed, the entire operation can be jeopardized.

The chain of command has two purposes: (1) to facilitate successful operations and (2) to protect the individual firefighter. Firefighting is dangerous and can be more so when attempted in a free-enterprise haphazard manner. The chief officer, through his subordinate officer, must be in touch with all firefighters at all times to assure efficient operations and personnel safety under constantly changing conditions. Many firefighters have lost their lives because of a break in the chain of command.

The individual firefighter must discipline himself to keep in touch with members of his company or his immediate superior officer at all times. After he is lost or pinned in a building on fire it is too late to wonder if anyone knows where he is.

Heat, smoke, and fire, especially in confined situations, make firefighting a tough, dirty job. Often the individual firefighter is called upon to carry out assignments or hold his ground under very difficult situations. It requires strong personal discipline to stand rather than run; yet the individual must realize that in many situations he literally holds the life of his fellow firefighters in his hands, and vice versa.

Discipline is so important to fire-ground operations that it must be practiced off as well as on the fire ground. In training sessions, drills, and meetings, the officers should always be addressed by their proper titles. This helps to assure that the "chain of command" will hold during combat operations.

As a "Support Assistant" you may be called upon to take part in disciplined fire-service operations. For maximum accomplishment and your personal safety you must understand the need for and practice "willing and dutiful submission to control."

BASIC CONCEPT OF FIRE BEHAVIOR

In its simplest form the process of combustion or fire can be represented by a triangle.

THE FIRE TRIANGLE

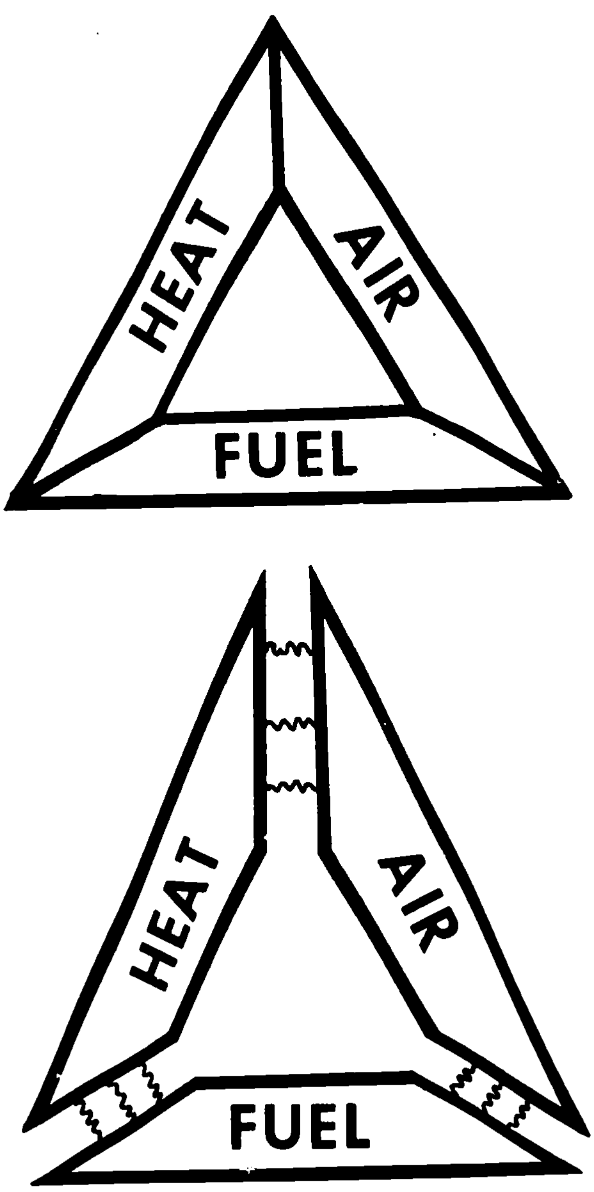


FIGURE 11.—The Fire Triangle

The three components necessary for fire are represented by the triangle's legs. These are fuel, oxygen, and heat.

Whenever these factors are brought together in the right form and proportions, a fire results. To understand the process of fire, we will first review the three legs of the fire triangle in their simplest form and then in somewhat greater detail.

Fuel

Many of the materials that we encounter in everyday life can be classed as fuel and will burn under ordinary conditions. Other materials considered as fireproof under ordinary conditions might be classed as fuels under special conditions, and examples of these will be given later. Natural gas is a common fuel composed primarily of carbon and hydrogen.

Oxygen

Under ordinary conditions the second leg of our triangle, oxygen, is supplied by the normal oxygen (O) content of the air, which is 21 per cent. Natural gas and oxygen are both gases at normal temperatures and can be readily mixed to form a combustible mixture; however, nothing will happen to this mixture at normal temperatures.

Heat

Heat is a form of energy evidenced by the vibration of the molecules of a substance. This very rapid vibration of the molecules of substance is what gives us the sensation of feeling of heat when we touch a hot object. A common measure of the intensity of these vibrations, or heat, is degrees Fahrenheit. If we take the natural gas and oxygen mixture just discussed and heat it to ignition temperature (around

990° F. for this mixture) combustion, or fire, will occur.

Fire

Combustion is the union of oxygen with a fuel. Fire is the visible light energy released by that union. The molecules of the natural gas and oxygen mixture have sufficient vibrational energy at 999° F. to literally knock each other apart and reunite to form new compounds. The breaking up and reuniting of molecules in the combustion process releases heat energy—energy stored in the molecules when they were formed.

The following illustration gives a more complete picture of the combustion process than the fire triangle.

Common Fuels

Most common fuels are compounds of carbon, hydrogen, and oxygen. As with the preceding example, the products of complete combustion will be water vapor and carbon dioxide. Where other elements are present in the fuels, the products of combustion will include oxides of these elements. For example, if sulphur is burned, the combustion products include sulphur dioxide.

Fuels may be found in any of the three states of matter, solid, liquid, or gas. For practical purposes combustion can occur only when fuel is in a gaseous form. Since the fuel must be mixed with oxygen and oxygen is a gas, it cannot be readily mixed with a liquid or a solid. Temperatures at which various fuels change from a solid to a liquid and then to a gas vary with the fuel.

The temperature of major importance in fire control is the vaporization point or flash point of a fuel. Technically, there is usually a variation of a few degrees between the flash point and vapor point of fuel. But, for practical purposes in fire control, they may be used interchangeably. Flash point is important to the firefighter because this indicates the temperature at which the fuel begins to give off vapors that will mix with oxygen in the air and need only ignition to flash into flame. Gasoline, for example, has a flash point of 45 degrees below zero. Therefore it is always giving off flammable vapors at normal temperatures and requires only a sufficiently hot spark for ignition. Kerosene, on the other hand, has a flash point of above 110° F. and below that temperature would not be giving off flammable vapors and could not be ignited by a spark that would ignite gasoline. If, however, we heat the kerosene to a temperature above its flash point, it will give off flammable vajors; and these vapors can be ignited by the same temperature, about 500° F., as the gasoline vapors.

Oxygen and Combustion

Since combustion is the union of oxygen with

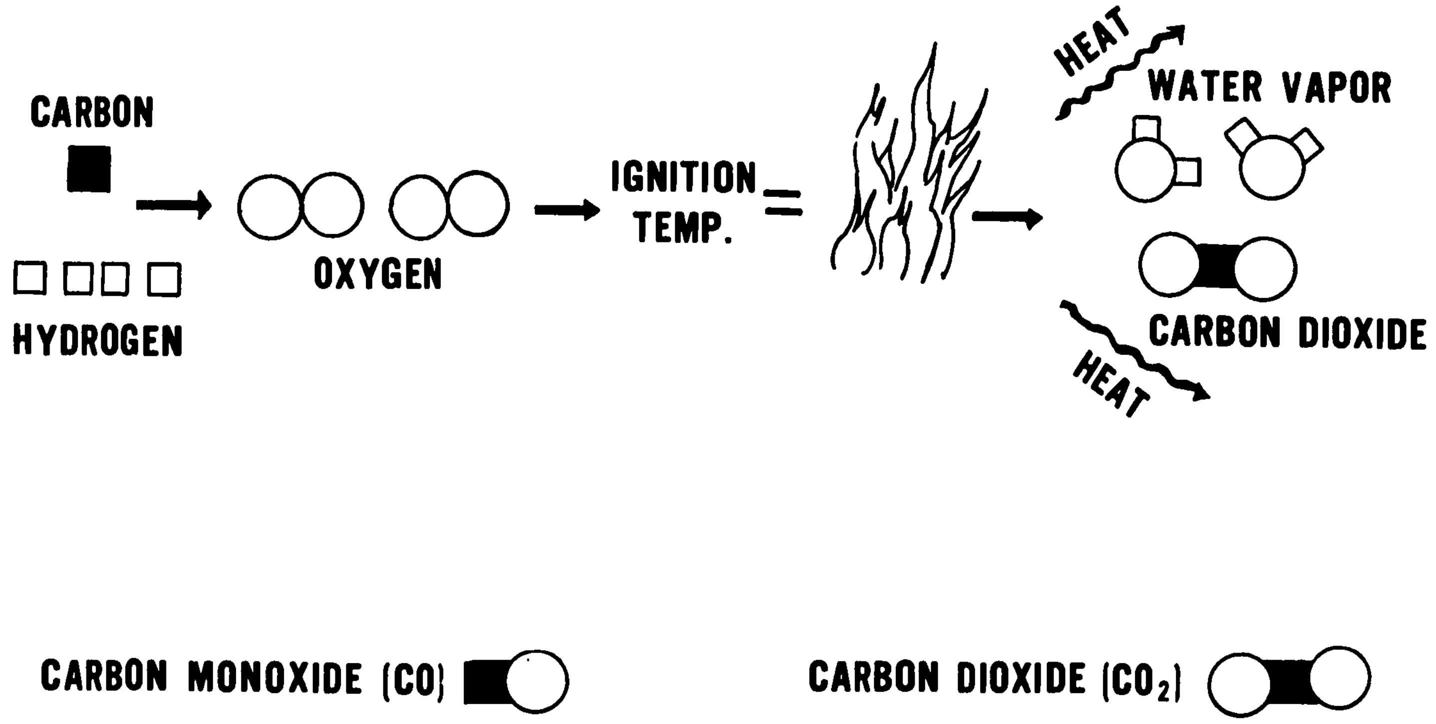


FIGURE 12.—The Process of Combustion

a fuel, it follows that combustion cannot occur without oxygen. Thus, the intensity of the fire will vary with the percentage of oxygen. For practical purposes, when the oxygen content of the air falls below 15 per cent, the fire will be arrested. On the other hand, if the oxygen content is raised above the normal 21 per cent, the intensity of combustion will increase. Steel wool, for example, will only glow if heated in a flame in normal air. If, however, this glowing steel wool is dropped into a container of pure oxygen, it will burn with a flash.

Each of us can probably recall many instances where we have observed the oxygen supply to a fire increasing its intensity. We fan the campfire or the charcoal for barbecuing to bring it to life or we may have observed a rubbish fire spreading and getting out of hand when the wind increased.

Amounts of Heat

In the foregoing discussion of heat, we mentioned only heat intensity as measured in degrees Fahrenheit. In fire control, another unit of heat measurement is very important. This is the total amount of heat present. A spark, for example, may have a temperature well above 1000° F., but actually would do very little to warm us on a cold day. Amounts of heat are measured in BTU's or British Thermal Units. A BTU is the amount of heat necessary to raise 1 pound of water 1° F.

In the foregoing discussion of fuels we used the example of kerosene as having a flash point of about 110° F. If the amount of kerosene involved was one pint it would take about 40 BTU's to bring the kerosene to its vapor point. This could not be accomplished with an ordinary kitchen match, which will produce about 1 BTU when totally consumed. If, on the other hand, we dip a piece of paper in kerosene and use the ordinary kitchen match, it will provide both the heat necessary to bring the small amount of kerosene to its flash point and the 500° F. temperature necessary for ignition. The heat released by the combustion of the kerosene and the paper will bring more of the kerosene and paper to its vapor point to provide more vapors for continuing combustion, and we have a going fire.

The principles just illustrated also apply to ordinary fuels such as wood. A finely divided fuel will be more easily heated to its vapor point where it can be ignited than a solid block. An ordinary kitchen match will easily vaporize and ignite wood shavings but not a short section of 2 x 4. On the other hand, if sufficient BTU's are present the 2 x 4 can be raised to its vapor point and ignited.

Heat Transmission

Heat released by combustion travels in three ways, radiation, convection, and conduction.

Radiation.—Heat travels by radiation like light. We feel this when we hold our hand next to a glowing object or move closer to the stove on a cold day.

Convection.—A flame heats the surrounding air (gas) causing it to expand and become lighter. These lighter gases rise. In fire-protection terminology, this rising column of hot gases is often referred to as the thermal column.

Conduction.—Earlier, heat was described as the vibrations of the molecules of a substance. In solid materials these vibrations will be transmitted through the solid. For example, the heat of a fire might travel through a metal partition and set fire to combustibles on the other side.

Ways of Producing Heat

Heat sufficient for the vaporizing and igniting a fuel can be produced in several ways. It is not always necessary to have a flame to ignite fuels. For example, a soldering iron heated to about 500° F. will ignite paper. Three of the most frequently encountered ways of producing heat will be discussed here.

Electricity.—When more electrical energy is allowed to flow through a wire than the wire was designed to carry, the wire will heat and eventually melt and separate. If the wire is in contact with the right kind of fuel, ignition will occur or the wire may ignite its insulating cover, and this fire may involve other fuel.

Electrical sparks from loose connections, switches, or arcing electrical motors frequently start fires where flammable mixtures of air and fuel are present. This frequently occurs around gasoline-loading facilities or in situations where fuels gases, such as natural gas, have leaked inside a structure.

Spontaneous Ignition.—The process of combustion is often referred to as oxidation. However, the process of oxidation can occur without the evolution of flame; but the process of oxidation always produces some heat. The rusting of iron, the greying of lumber, the browning of sliced fruit, and drying of paint are examples of slow oxidation. If this slow oxidation occurs under circumstances where the heat produced cannot escape or be dissipated, the temperature of the materials involved will be raised and may be raised to the point where the fuel will begin to vaporize and eventually ignite. This process of spontaneous ignition can occur with many different materials and under varying conditions, but the most frequently encountered example might be with paint that has a vegetable oil base. If a rag is wet with linseed oil and then wrapped inside of other rags and placed in a cardboard container, spontaneous ignition will frequently occur.

Friction.—Primitive man first learned to make fire by using friction. He accomplished this by rubbing two sticks together or spinning a stick in a small hole in a larger block of wood. Dry bearings or rubbing belts on conveyors often start industrial fires. A leading cause of fires in the trucking industry is the friction generated with a flat tire on a dual wheel where the truck operator may not realize the tire is flat. The tire quite frequently becomes so heated that when the truck is stopped the tire bursts into flame.

Fire Extinguishment

Fires can be extinguished or controlled by taking advantage of the fires' dependence on fuel, heat, and air.

The fuel can sometimes be removed from the fire or from the path of the fire. Forest and grass land fires are quite often controlled by this method. Fire breaks are made by removing the fuel along a line in the fires' path.

Many fires can best be controlled by smothering. For example, fires in containers of flammable liquid can be extinguished by getting some kind of lid over the container.

Fires in ordinary combustibles are most often extinguished by cooling. Water is the best and most frequently used agent for this purpose. Water is used to cool the involved fuel below its vapor point and thus control the fire.

TECHNIQUES OF FIRE PREVENTION AND FIRE LIMITATION

Fire department experience over the years leaves little doubt that most fires can be prevented if good fire prevention practices are followed. A few fires will always occur even where good fire prevention practices are followed, but good practices will limit the spread of and help control the few fires that do start.

Before the Emergency

Eliminating fuel is essential in preventing fires. We cannot limit the air supply to a fire if people are to live and work in the area, and unfortunately, we cannot always control or predict what heat sources "people" will bring into an area. Fire protection personnel often refer to the three main fire hazards as man, woman, and child. In this course, we are concerned with the heat source from a nuclear weapon over which we may have no control. So again our best means of limiting fire occurrence and fire spread is by limiting fuel for the fire, especially those fuels that might be most easily ignited by the flash of heat from the weapon.

Rubbish Removal.—Within buildings one of the most practical ways to limit the fuel available to a fire is to remove the rubbish or stored odds and ends that accumulate. Cast off articles, such as old clothes, draperies, newspapers, and magazines, are often stored in closets, attics, and cellars. These not only offer a good place for a fire to start but make firefighting very difficult. It is difficult to get water to the center of a pile of clothes or boxes; also, these materials usually produce large amounts of smoke making it difficult to locate the fire.

Outdoors, rubbish, dry weeds, grass, brush, and other easily ignited materials would be a major fire hazard in the event of a nuclear attack. A clean neighborhood could make the difference between success and failure of fire control attempts after a nuclear attack.

Storage Precautions. Flammable liquids, such as gasoline, benzine, naphtha, and similar fluids, generally should not be used or stored indoors. There is danger that these fluids may be spilled or leak from the containers, in which case they vaporize, mix with the air, and form explosive mixtures. These fluids should be stored in safety cans outside the home.

Rags or paper towels that have been used with waxes, furniture polishes or to wipe up paint thinners or vegetable oils should never be kept in the home even for short periods because they are subject to spontaneous ignition.

Thermal-Flash Precautions.—Research on the nuclear fire problem indicates that the most important single fire-prevention action during periods of international crisis is for householders to shield windows by keeping window blinds and shades closed, or by painting, coating, or otherwise covering the windows.

There is strong evidence that most ignitions causing sustained fires would occur in the interior of rooms exposed to the heat flash of nuclear weapons. Ignitions caused by the heat flash would occur before blast damage to blinds or other coverings, and can thus be prevented in large part by covering the windows or closing blinds or shades prior to attack.

Other important fire prevention actions include removing curtains, and removing ignitable furniture from window areas.

Plans for control of gas and electric utility service can reduce the incidence of fires caused by blast damage.

Fire prevention actions of these types must be carried out in every building, including public shelters, in the jurisdiction, and require the cooperation of all citizens.

Research indicates that the countermeasure of shielding windows—including closing blinds or shades—combined with other self-help fire-prevention measures, in an effort requiring 8 man-hours per household, could reduce the number of home ignitions by as much as 65 percent; and that a last-minute prevention program requiring only one-half man-hour per household could reduce ignitions by as much as 40 percent.

Both from the standpoint of preventing ignition of materials in buildings by the thermal flash of the bomb and everyday fire safety, the flammability of the building furnishings should be carefully examined. Curtains and such items as furniture slip covers should be of fire resistive material or should be treated to make them fire resistant. Flammable clothing should always be avoided.

When in doubt about the flammability of a particular item, cut a small slip of the material from one of the seams and test it. Take it outdoors and observe how rapidly it burns when ignited with an ordinary kitchen match.

Rayons and cottons can be made fire resistant by dipping them in a solution of nine (9) ounces of borax and four (4) ounces of boric acid to a gallon of water. This must be repeated each time the garments are washed, and it tends to lose its effectiveness with age. Treating fabrics in this manner will not make them fireproof, but it will lessen their chance of being ignited and will materially retard the spread of a fire. Fire-resistant drapes could be instrumental in preventing the ignition of material inside the home from the thermal flash. They might also prevent the occupants from serious burns.

Shutting Down Utilities.—Many fires could be prevented in buildings damaged by a nuclear attack if utilities such as gas and electricity were shut down before the attack. However, the wholesale shutting down of utilities can cause major problems. *Local utility companies have instructions in these matters and their directives must be followed.*

Postattack Suppression of Fires

As previously discussed, Support Assistants for Fire Emergencies may find themselves responsible for leadership in suppressing fires following a nuclear attack. Theirs may not be the envied position. There might be more fires ignited than can be controlled in the time span between attack and the arrival of fallout. Postattack firefighting might have to be carried on with a limited amount of equipment. Firefighters would have to make some careful choices. They would have to quickly, yet carefully, weigh three main factors:

1. The life hazard.
2. The chance of success.
3. The danger of the fire spreading.

The Life Hazard.—The first concern of the firefighter is the saving of life. Where lives are endangered by fire his first efforts are usually devoted to rescue or extinguishing a particular fire to effect a rescue.

In a nuclear fire emergency, the firefighter would also be concerned with the survival value of a particular building. Public fallout shelters would obviously have high value.

Chance of Success.—Perhaps the first factor that firefighters should consider is the chance of success in extinguishing a particular fire. They must first know what resources they have on hand and then determine the chance of controlling a particular fire with these resources. Fire departments that respond to rural areas where the only water they have is in their fire truck have always had to make this type of decision. They quite frequently do not use their water on the building on fire, but use it to protect the exposures. If they use their water on the building on fire and are not able to extinguish the fire, they sometimes run the risk of losing an entire group of buildings.

Fire Spread.—The third factor firefighters must weigh is the chance of a particular fire spreading to other structures. If the building on fire is well isolated from other buildings and the wind direction is such that the sparks and convected air currents do not endanger other buildings, then, with limited resources firefighters decide to let that building burn. If, on the other hand, it is obvious that the fire will spread to other buildings, the firefighters would take a bigger chance in using available resources to extinguish that particular fire.

Shutting Off Damaged Utilities.—The shutting off or disconnection of damaged utilities, such as gas and electricity, should be done only by personnel who know what they are doing. The indiscriminate throwing of valves or switches by uninformed people can create serious problems. The most important utility from the firefighting standpoint is probably water. Broken water lines in individual buildings should be shut off if possible. If the lines to individual buildings cannot be shut off and they are broken, firefighters might want to consider plugging the drains in basement areas of these buildings. This might provide an invaluable source of water for firefighting.

Kindling Fuels.—Where decisions are made to leave particular buildings or fires burn, probably the best means of limiting the fire spread is to remove the kindling fuel in the fire's path or in the areas where the sparks may fall. Sparks or embers carried with the wind have a limited number of BTU's and fires will not spread in this manner, except where the sparks fall on kindling fuel. Fuel that is easily vaporized and ignited should be removed from the fire's path.

Firefighters attempting to extinguish neighborhood fires during the immediate post-attack phase should keep in mind the time limitation before the arrival of fallout. If they have no radiological monitoring instruments and cannot obtain information on fallout in the area, they should probably seek shelter not later than 30 minutes after the bomb burst. However, some calculated risks may need to be taken. If the only available shelter from fallout was threatened by fire, it would be folly to seek such shelter until the threat of fire had been controlled. Careful study of the radiation section of this manual will help firefighters determine how quickly they should seek shelter and what risks they might take. Also, if they stay out in the open to fight fires after fallout has begun, they should decontaminate before entering a shelter.

It is not anticipated that "Support Assistants" would make the type of decisions considered above as they would if at all possible be working under personnel of the regular fire service.

FUNDAMENTALS OF FIRE SUPPRESSION

Principles of Fire Extinguishment

A good understanding of combustion principles leads to the understanding of fire control principles. Under this heading we consider specific means for removing one of the three sides of the fire triangle.

Cooling.—That cold is merely the absence of heat and is accomplished by the dissipation of absorption of the heat is fundamental to the understanding of fire control. In structure fires, the partial heat dissipation is often accomplished by ventilation. Ventilation to assist in controlling structure fires is a detailed subject and will be considered in the B course for support assistants in firefighting emergencies.

Where fires are small enough that the firefighter can approach within range, the most efficient method of removing heat is cooling the fuel involved. If the fuel involved can be cooled below its flash point, the fire will be controlled.

The most efficient agent by far for cooling is ordinary water. Water will absorb a substantially larger amount of heat than any other extinguishing agent available.

It was mentioned earlier under "amounts of heat" that the BTU was the standard for measuring heat. BTU was defined as the amount of heat necessary to raise one pound of water 1° F. It follows, then, that one pound of water heated from 62° F. to 212° F. (the boiling point of water) will have absorbed 150 BTU's. The larger amount of heat, however, is absorbed in water vaporization. One pound of water at 212° F. will absorb 975 BTU's during vaporization. It follows, then, that the most efficient use is made of the water only when water is converted to steam. Water left on the floor after extinguishing the fire was obviously wasted.

Support Assistants attempting to extinguish neighborhood fires following a nuclear attack would probably be quite short of water, and it is very important that they understand this point.

Removing Fuel.—One of the most often used methods to control forest, brush, and grass land fires is fuel removal. This is accomplished by building fire lines where fuels are removed leaving bare ground or rock. Other types of fires may sometimes be controlled by this same method. For example, some fires may be fed by gas or flammable liquids, and shutting off valves can starve the fire.

Some of the extinguishing agents, which will be discussed later, act to form a crust over fuels and can be said to work by removing the fuel side of the triangle.

Removing Oxygen.—The simplest example of extinguishing fire by smothering is placing a lid on a container of flammable liquid on fire. Another example might be wrapping a person whose clothing is on fire in a blanket or rug.

Some of the fire extinguishers that will be discussed later extinguish fires by covering the fire area with a blanket of inert gas such as carbon dioxide. This blanket replaces the air supplying the fire with oxygen and thereby starves the fire of its oxygen.

Classification of Fires

For minor extinguishment and the use of portable fire extinguishers fires are classified in four categories.

Class A Fires.—This class of fire involves ordinary combustibles, such as wood, paper and textiles, that leave glowing coals when they burn. Because of the glowing coals, this type of fire is often quite stubborn and is usually best extinguished by water.

Class B Fires.—This class of fire involves flammable liquids, gases, greases, and some homogeneous solids such as wax. In contrast to the Class A fire this fire does not leave glowing coals.

Small fires of this class are usually safely extinguished by using the smothering principal, covering the involved area with a lid or a blanket of inert gas or foam.

Class B fires involving flammable liquids with a flash point above 100 degrees can be extinguished with water by cooling the fuels below their flash point. The great danger, however, in using water on these fires is that the velocity or force of the water stream may scatter the fire.

Class C Fires.—This class of fire involves energized electrical equipment.

Note: It is important to recognize here that this classification, as opposed to A and B fires, is not a classification of the fuel involved but rather a classification by the hazard involved. If the extinguishing agent conducts electricity, the operator of the extinguisher may receive a severe electrical shock. Extinguishing agents listed for this class of fire must be nonconductors, and every effort should be made to shut off the current before using the extinguisher.

It is also important to know that we only use this classification where voltages are high enough to be dangerous to the operator of the extinguisher. A fire in automobile wiring, for example, would not be a Class C fire because the voltages involved are not sufficiently high.

Class D Fires.—This is a relatively new classification for fires and includes fires of combustible metals, such as magnesium and sodium. These materials are often used in incendiary bombs and are quite difficult to extinguish. Using water on these materials can be dangerous, and special extinguishing agents or methods should be used.

Precautions in Fire Fighting

Fumes from Burning Materials.—In addition to products of complete combustion discussed earlier under basic concepts of fire behavior, a variety of fumes will be given off from burning materials. There is seldom enough air flow around materials involved in fire to completely oxidize all the vapors given off by the fuel under heat. Also, temperatures may not be hot enough in certain parts of the fire to ignite some of the vapors or fumes given off by the heated fuels. Consequently, fires will give off a wide variety of fumes or vapors in addition to the products of complete combustion. Fortunately, many of these fumes have strong odors and are irritating to the nasal membranes. This forcefully warns the firefighter against breathing them unless he stays in the area long enough to desensitize his nasal membranes. The firefighter should not depend on his sense of smell to tell him when dangerous fumes are present. Many of the most dangerous gases are completely odorless. The most common toxic gas encountered in fire areas is carbon monoxide. It is completely colorless and odorless. One half of one percent breathed for 10 minutes can be fatal. To understand why there will always be some carbon monoxide gas present in the fire area, we can reexamine the example of the combustion of natural gas given earlier. Recall that the products of complete combustion of this material were carbon dioxide and water vapor. If the oxygen supply is limited, the products of combustion will include carbon monoxide instead of carbon dioxide.

In the case of natural gas we were considering a Class B fuel undergoing combustion and possibly giving off carbon monoxide gas. Solid combustibles often give off much larger amounts of carbon monoxide gas because of their composition. Wood, for example, is made up primarily of carbon and hydrogen, but contains considerable amounts of free carbon; that is, carbon not bonded with any other element. Carbon bonded with another element such as hydrogen or natural gas can be vaporized and can be driven to the wood's surface where it combines with oxygen and undergoes combustion. Free carbon, however, cannot be vaporized at ordinary temperatures. The glowing coals we observe in the burning of Class A materials are made up primarily of carbon, which by itself cannot be vaporized to mix with oxygen and burn. The carbon in the glowing coals must depend on oxygen in the air moving into the coal, where the carbon can unite with oxygen and form carbon monoxide gas. The carbon monoxide gas then rises to the coal's surface, where it completes its conversion to carbon dioxide gas if sufficient temperatures and oxygen are present. The surface of glowing coals can be below 1000° F., the approximate ignition temperature of carbon monoxide gas, and it becomes obvious why the fumes from glowing coals might contain a very high percentage of carbon monoxide gas. The fumes from a dying bed of charcoal might be a good example of this.

Heat

Temperatures above a fire (at ceiling level, for example) rise quite rapidly. Fourteen-hundred degree temperatures at ceiling level are quite common in residence fires after three or four minutes. The human body cannot stand temperatures in excess of 150 degrees, except perhaps for a short period in very dry air, and air in the vicinity of a fire is not dry air.

Suffocation.—Even if a fire produced no smoke and the combustion products were non-toxic, the oxygen content of the air could be too low to support life. We can illustrate this by considering a natural gas space heater or even the ordinary kitchen range. These appliances premix the air and fuel before it reaches the combustion zone. The combustion process is efficient and complete, producing only water vapor and carbon dioxide. If either of these appliances were allowed to burn in an air tight room, occupants of the room might not be aware that anything was wrong. The room might seem hot and steamy, and water might begin to condense on the windows. This process of burning the oxygen would continue until the oxygen content reached perhaps 15 percent. At about this point, the burners on the stove would start producing carbon monoxide gas in place of carbon dioxide gas. Still the occupants of the room might not notice anything wrong and would simply go to sleep. In other words, they might be extinguished at about the same time the fire in the appliance was.

A good analogy can be drawn between people in a closed room and a fire in a closed room. The life processes by which people live and breathe are almost identical to the principles illustrated by the fire triangle. People eat carbohydrates, compounds of carbon and hydrogen, primarily in the form of sugar and starch that provides energy for the life processes. We breath oxygen to oxidize these fuels and extract the necessary energy from them. The products of this oxidation are CO_2 and H_2O and are exhaled through the lungs. A number of people in a closed room will use the oxygen supply and replace it with carbon dioxide and water vapor. The room will become hot and stuffy and the people will eventually be overcome. Civil Defense specifications for shelters provide for a minimum amount of fresh air in the shelter to avoid this possibility. Where shelter ventilation is at a bare minimum, the occupants are advised to be as quiet as possible to conserve the life-sustaining oxygen.

There is one exception to our analogy. People do not give off carbon monoxide gas. Indeed, this is the main reason for the toxicity of carbon monoxide gas. When it is breathed, it goes into the blood stream, and the blood stream does not give it up easily. Carbon monoxide accumulates in the blood stream until the blood stream is no longer capable of carrying life-sustaining oxygen to body tissues. People sometimes die of carbon monoxide poisoning even after they are removed to fresh air because of the body's inability to get rid of the carbon monoxide.

Structural Weaknesses.—Fire may burn through wooden members of buildings, or temperatures of 1400° F. can soften steel supporting members and bring about partial collapse of a structure. Structural failures often occur in mercantile and industrial buildings that have large open areas without supporting columns. Collapse of residential type structures severe enough to endanger firefighters rarely occur. Perhaps the greatest danger to the firefighter from this standpoint is the chance of falling through a weakened roof or floor into the fire. For this reason firefighters who enter buildings for the purpose of rescue usually try to stay close to the walls, especially when the floor has a somewhat spongy feeling.

Keep Exit Clear.—Whenever a firefighter enters a building either for rescue or extinguishment of fire, the exit should always be kept clear behind him. There are two very good reasons for this. First, he needs an escape route. If the firefighter has entered the building for rescue, he will need a clear exit through which to carry or drag the victim. If he has entered the building for the purposes of extinguishment, he will probably stay at the job of firefighting until almost exhausted. Many times he will be forced to seek fresh air almost blind; that is, with his eyes so full of smoke that he cannot see clearly. Second, a clear exit is needed to provide a flow of fresh air. The air in a building, even where a small fire is burning, is never completely clear, and the flow of fresh air through the opening where the firefighter entered can help the firefighter complete his job. One or two persons standing in the opening where the firefighter has entered can cut off his supply of fresh air and keep him from completing his job.

It is dangerous for one man to go very far into a burning building. For great distances, firefighters should always work in pairs, and they should take in with them some trail marker, such as a hose or a rope, to help them to find their way out in case of trouble.

Falling Debris.—Firefighting should not be attempted without some form of protective head gear. Even in relatively small fires window glass may be cracked and fall out. Sections of the eaves may be weakened and fall; or as is quite often the case, large sections of plaster fall. Any of these can cause severe head injuries.

ELEMENTARY FIREFIGHTING TECHNIQUES

Fire Extinguishers

Most fires start small and can be effectively controlled by the proper use of small extinguishment equipment. This equipment is light enough to be carried or moved about on wheeles.

Portable fire extinguishers have some limitations with which the operator must be familiar. Not all extinguishers can be successfully used on the different fire classifications.

Several different methods of expelling the extinguishing agents are used by the manufacturers of the portable equipment, the operator must be familiar with the types used in his location. Also, some knowledge is necessary of the operating characteristics of different extinguishers.

Extinguishing Agents

Water.—Over the years water has been the most commonly used extinguishing agent. Water extinguishes by cooling; it absorbs large quantities of heat and produces steam for a combination cooling and smothering. Therefore, it is the most efficient agent for *Class A* fuels. Because it is abundant and readily available, water is also most economical.

Water may also be mixed with various other materials that will improve its extinguishing characteristics.

Water may be mixed with calcium chloride and can be stored in freezing temperatures in noncorrosive containers.

Adding a wetting agent in proper quantities to water will reduce the surface tension and increase the penetrating, spreading, and emulsifying properties.

Chemical Foam (Water Base).—When water is mixed with two chemicals, aluminum sulfate and sodium bicarbonate, plus a foaming agent and stabilizer in the proper quantities a tough foam is produced. The foam is capable of both smothering and cooling and may be used with some success on both Class A and B fires. Foam extinguishers will not control as much fire as some other extinguishers of about the same size. The advantage of chemical foam is its ability to cover and prevent flashbacks of fires in Class B fuels.

Loaded Stream (Water Base).—Water base is a solution containing water and alkali-metal salts. It can be used in freezing temperatures to 40° below zero. The agent may be used on Class A fires; it seems to extinguish the flame suddenly and leave a fire-retarding effect. Loaded stream may also be used on Class B fuels with some success.

Regular Dry Chemical.—Regular dry chemical powder is composed primarily of sodium bicarbonate or potassium bicarbonate. Although the etxinguishing action of these powders is not fully understood, they are particularly effective on *Class B fires*. They also may be used successfully in conjunction with water "fog" streams. In controlling Class B fires the chemical should be applied as if to separate the flame from the fuel. Dry chemical in either of its forms can be used on Class C fires. Because of the clean-up problem in sensitive switching gear, however, other types of extinguishing agents may be a better choice, if available.

Multi-purpose Dry Chemical.—The chemical makeup of the multi-purpose dry chemical has not been revealed by its manufacturers. However, monoammonium phosphate is believed to be the principal ingredient. As in the case of the regular dry chemical agents, the extinguishing action of multi-purpose powder is not fully understood. It can be used on Class A fires because it adheres to the surface of Class A fuels, forming a coating which retards combustion if not too deeply seated. Multi-purpose powder is also effective on *Class B* fuels and should be used in the same manner as the regular powder. The multi-purpose powder is also a non-conductor of electricity and may be used on *Class C* fires. However, the clean up process may be even more complicated than that of regular chemical, and other types of extinguishing agents may be preferred over the powder.

Carbon Dioxide.—Carbon dioxide was one of the early extinguishing agents successfully used to control *Class B* and *Class C* fires. It has many properties making it desirable for portable fire extinguishers. It is noncombustible and provides its own pressure for discharge from the containing cylinder. There is no cleanup problem, and it may be used successfully on most *Class C* fires. Since it is a gas that does not readily react with most substances, it is a fine agent to use around food stuffs.

It must be noted, however, that carbon dioxide is not as effective as the dry powders on *Class B* fires.

Halogenated Extinguishing Agents (Vaporizing Liquids). These extinguishing agents, because of their highly toxic nature, are not considered practical for use in portable fire extinguishers today. Because of some properties, however, they are beneficial where they are used in engineered systems. They are used in aircraft engine fire-extinguishing systems and in explosion-suppression units in closed containers.

Means of Expulsion

Generally there are four methods of expelling extinguishing agents from portable fire extinguisher: Chemical, Stored Pressure, Cartridge Operated, and Handpump.

Chemical.—In portable extinguishers using the chemical method of explusion, two chemical mixtures in the extinguisher must be mixed together to form a gas, usually carbon dioxide, which will pressurize the extinguisher container. In most cases this is accomplished by inverting the portable extinguisher. The soda-acid and the foam extinguishers are the examples of this equipment.

Stored Pressure. In the stored-pressure type of portable extinguishers, a gas is confined under pressure in the same container that holds the extinguishing agent. In some cases, as in the carbon dioxide extinguisher, the extinguishing agent supplies its own pressure for discharge. In other stored-pressure extinguishers air, nitrogen, or carbon dioxide are introduced into the container. Usually this extinguisher will have a pressure gauge on the valve assembly to indicate the amount of pressure. In most stored-pressure extinguishers other than the carbon dioxide, the expelling gas will be air.

Cartridge Operated.—In the cartridge-operated extinguishers, a small sealed cartridge usually 8 ozs. to 12 ozs. in size will contain a gas to pressurize the extinguisher. The cartridge will contain about 1800 psi of either carbon dioxide or nitrogen. The cartridge will usually be found under the filling cap suspended in the container holding the extinguishing agent. This type of extinguisher must be turned upside down and the cap bumped on the floor or ground to puncture the seal releasing the gas from the cartridge into the container.

In other types of cartridge-operated equipment the cartridge will be found outside of the main container with an operating handle or lever that must be operated to puncture the seal on the cartridge.

Hand Pump Operated.—Some extinguishers have a double-action, hand-pump mechanism to expell the extinguishing agent. The waterpump tank extinguisher of the 2½- and 5-gallon size is the only hand-pump style in general use today. With this type of equipment the extinguishing agent is expelled on both the up and down stroke. The length of stream and the time of discharge with this type of equipment is totally dependent upon the action of the operator. Generally with this type of equipment, the extinguisher must be set on the floor during operation because the extinguisher shell of hand-pump operated equipment is not pressurized.

Maintaining this unit is very simple. Usually, all that is required is to see that the pump leathers are kept in a flexible condition and that the ball-type valves do not stick and are free to operate.

FIGURE 13.—Chemical Extinguisher

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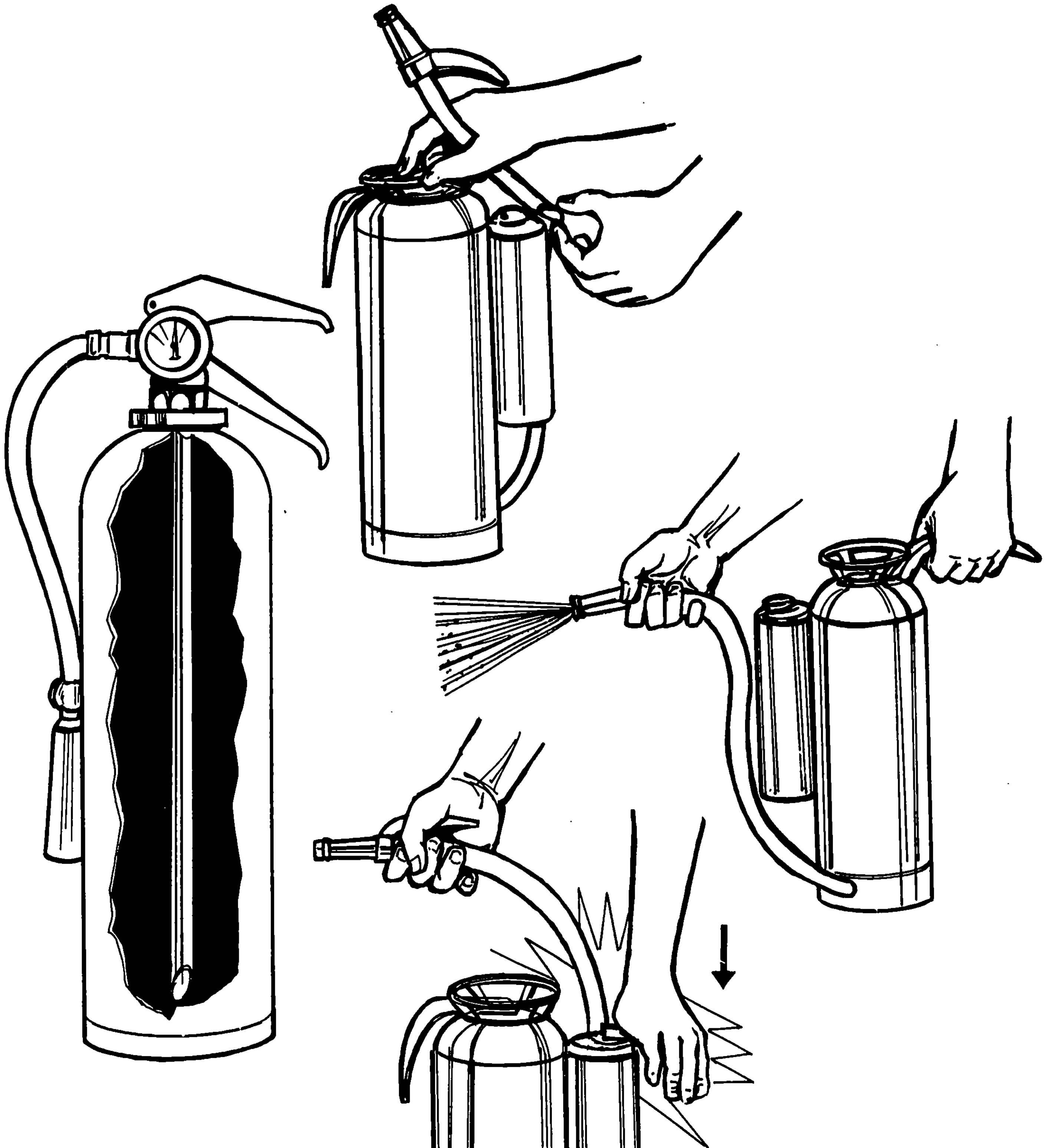

FIGURE 14.—Pressure Extinguisher

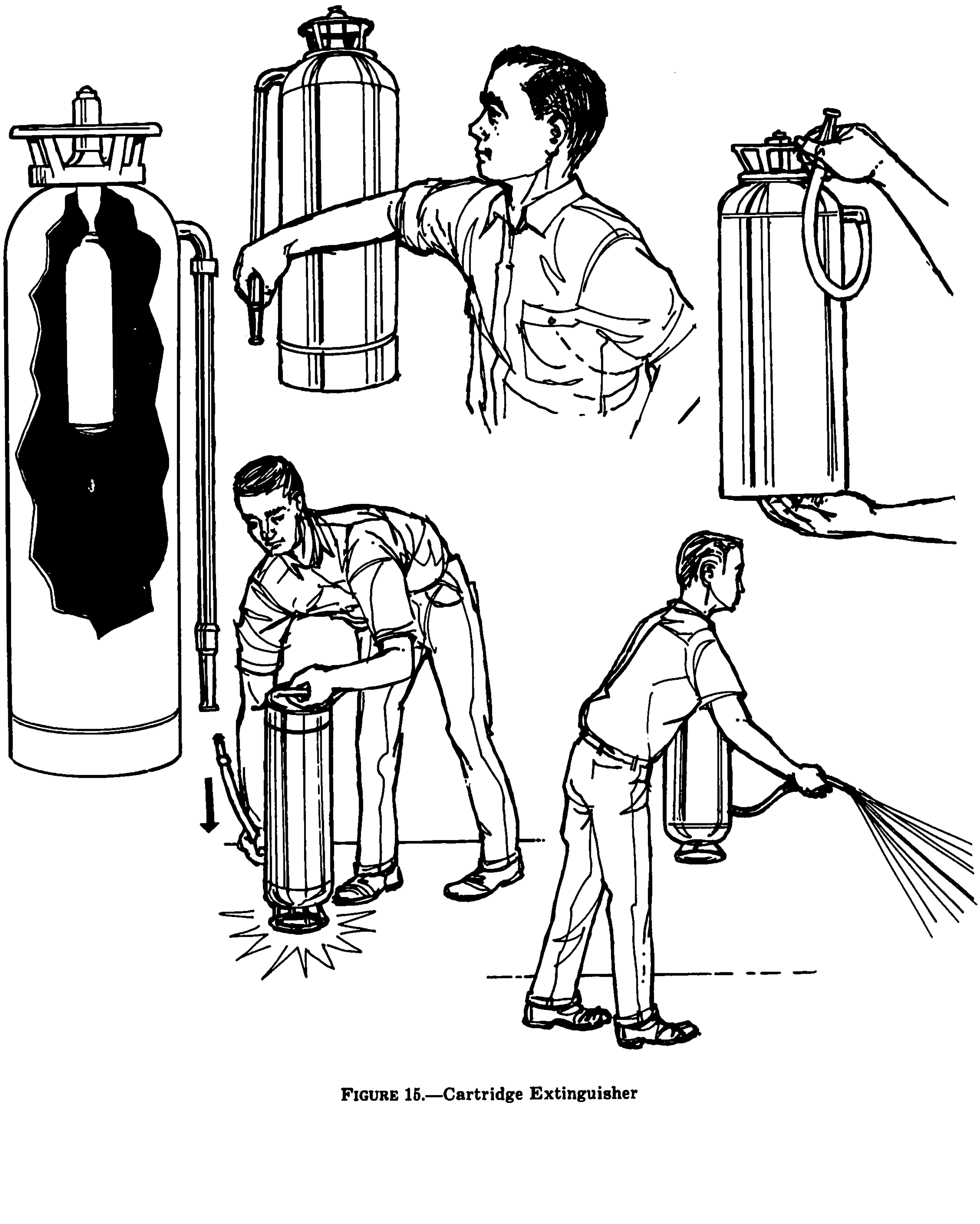

FIGURE 15.—Cartridge Extinguisher

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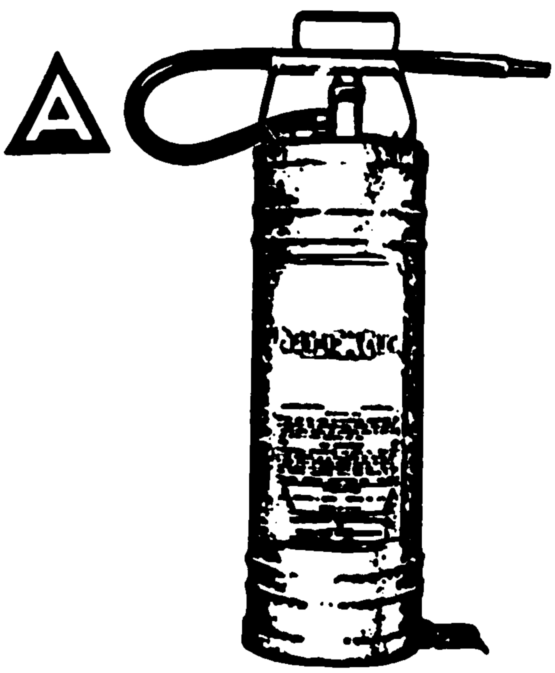

FIGURE 16.—Hand Operated Pump Tank

Numerical Ratings of Portable Extinguishers

The various types of portable extinguishers may be found in many different sizes. Hand extinguishers may range from those containing two (2) pounds of extinguishing agent up to units containing approximately forty (40) pounds. Also, the effectiveness of the various extinguishing agents per pound varies somewhat.

Most of the extinguishers the Support Assistant will be called upon to operate will have an Underwriters' Laboratories label. The Underwriters' Laboratories tests and lists the various extinguishers according to their effectiveness. This listing may be found on the name plate of the extinguisher.

Extinguishers are listed for the class of fire, such as A or B, with a numeral preceding the A or B classification. These numerals have a direct relationship to the extinguisher's effectiveness on the class of fire for which it is listed. For example, a 4B extinguisher will be twice as effective for a flammable liquid fire as a 2B extinguisher.

Buckets and Miscellaneous Containers

In certain cases portable extinguishers might not be available for combating fires; or if fires were extensive, the available portable extinguishers might soon be exhausted. In this case, the firefighter would have to make use of what is available. If the firefighter understands the principals of fire extinguishment and the effort is organized, a great deal can be accomplished with buckets and other miscellaneous containers to move water, sand, or dirt to the fire.

Many fires have been extinguished by the old-fashioned bucket brigade and many more would probably have been extinguished if the persons using the water at the end of the line had understood what they were trying to accomplish. As with the water type portable extinguisher, the water should be carefully applied to cool the fuel actually involved in the fire. Merely throwing the water in the general direction of the fire will only waste water. A much better technique would be to bring the buckets of water to the scene of the fire and empty them into a larger container, such as a tub. The actual firefighter then, with perhaps a couple of smaller containers, could make much better use of the available water. Sizeable Class A fires could be controlled in this manner.

If water is not available, sand or dirt can be thrown on Class A fuels and, again, if the correct techniques are used, can be quite effective. Dirt can also be used efficiently and effectively on Class B, C, or D fires.

Standpipe and Garden Hose

Some buildings have standpipes and hose racks on each floor; all that is necessary here is to extend the line and open the valve on the riser. A garden hose provides continuous flows of water if pressure is available and will control somewhat larger fires than portable extinguishers or buckets of water.

If the nozzle on the standpipe hose or the garden hose is of the solid stream type, it will be effective on Class A. fires only. But if the hose is equipped with a spray nozzle, the spray stream can be used to control some types Class B and C fires as well.

In some buildings the pressure on the standpipe may be high enough to make the hose hard to handle. The riser valve can be partially closed to overcome this problem.

Miscellaneous Equipment

A ladder is an invaluable tool in firefighting. The extinguishing agent must be applied to the fire, and in many cases, this will not be possible

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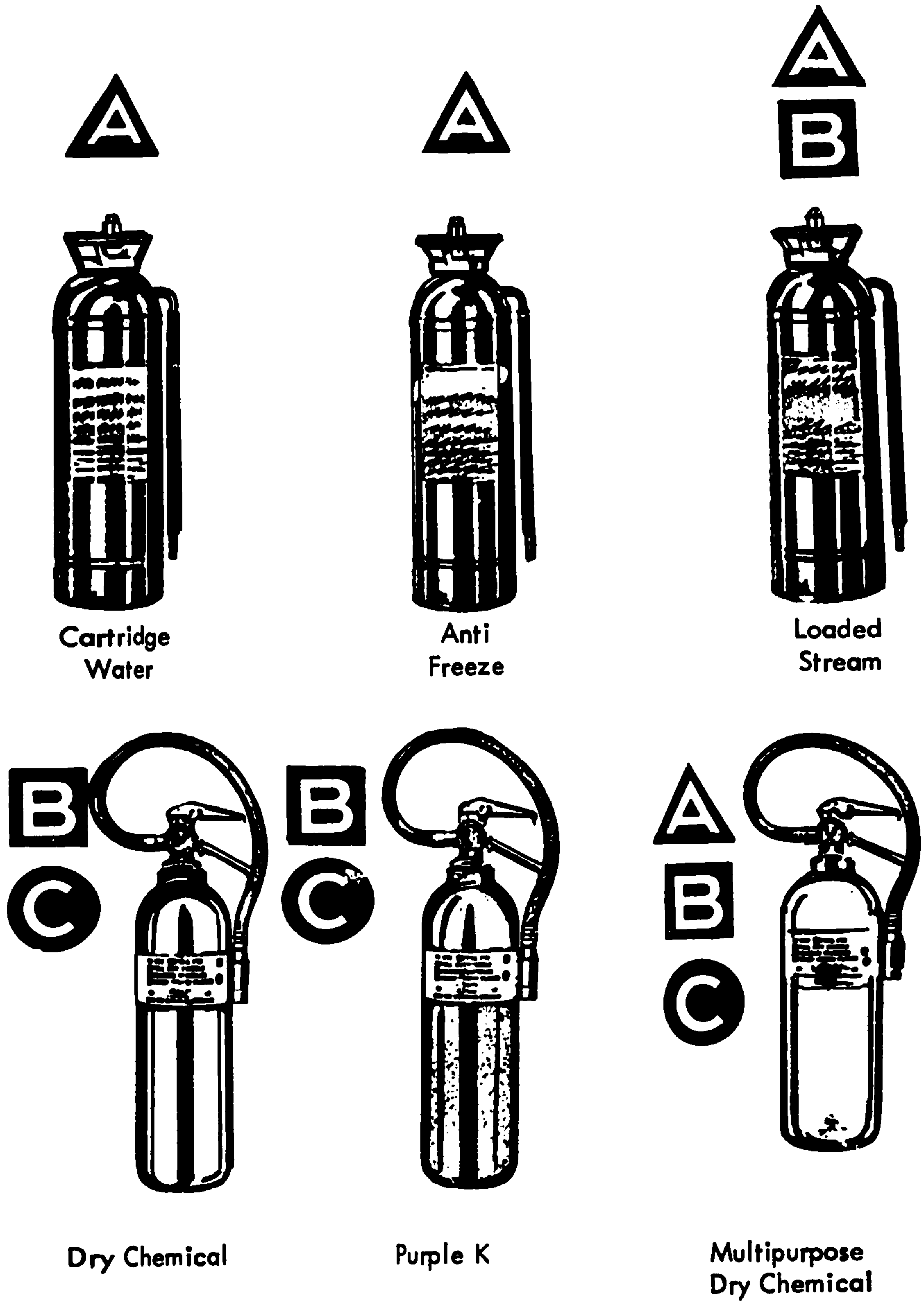

FIGURE 17.—Fire Extinguishers

without a ladder. The ladder is also an invaluable rescue tool when persons are trapped on upper floors.

The firefighter should also have available some sort of ax. He may have to open up walls to complete the extinguishing of fires.

Shovels, rakes, and brooms can be useful tools in controlling brush and grass fires. Heavy brooms and wetted-down sacks or rugs all can be used to beat back a grass or leaf fire along its edges. The burning fuel is raked or beat back into the burned area. Shovels and heavy hoes can be used to construct fire lines somewhat ahead of the fire.

Evacuation

In all firefighting situations perhaps the most important factor is cool deliberate action on the part of the firefighter. "Heroic" impulsive actions have no place in firefighting. They are most likely to lead the individual into situations from which there is no escape. All actions should be planned with alternate plans in mind because conditions change. This does not mean that the firefighter does not take certain chances. Such risks as he does take are carefully calculated and always weighed against the importance of the job to be done. For example, the firefighter takes somewhat greater risks when lives are involved than when only material items are endangered.

These considerations are very important whenever a building is entered for the purpose of rescue or firefighting. Perhaps the most important thing for the firefighter to remember is that fire travels upwards, sometimes with great rapidity. It is especially dangerous to enter a building above a fire, and in most cases this should not be attempted except possibly for rescue. Fires above grade level should usually be approached from below. Basement and other below-grade level fires present special problems. Care should be taken during firefighting operations to maintain an exit from these areas during operations.

Whenever one is in a fire building, the cardinal principle of safety is *KEEP LOW*. The upper levels will be filled with hot air and the

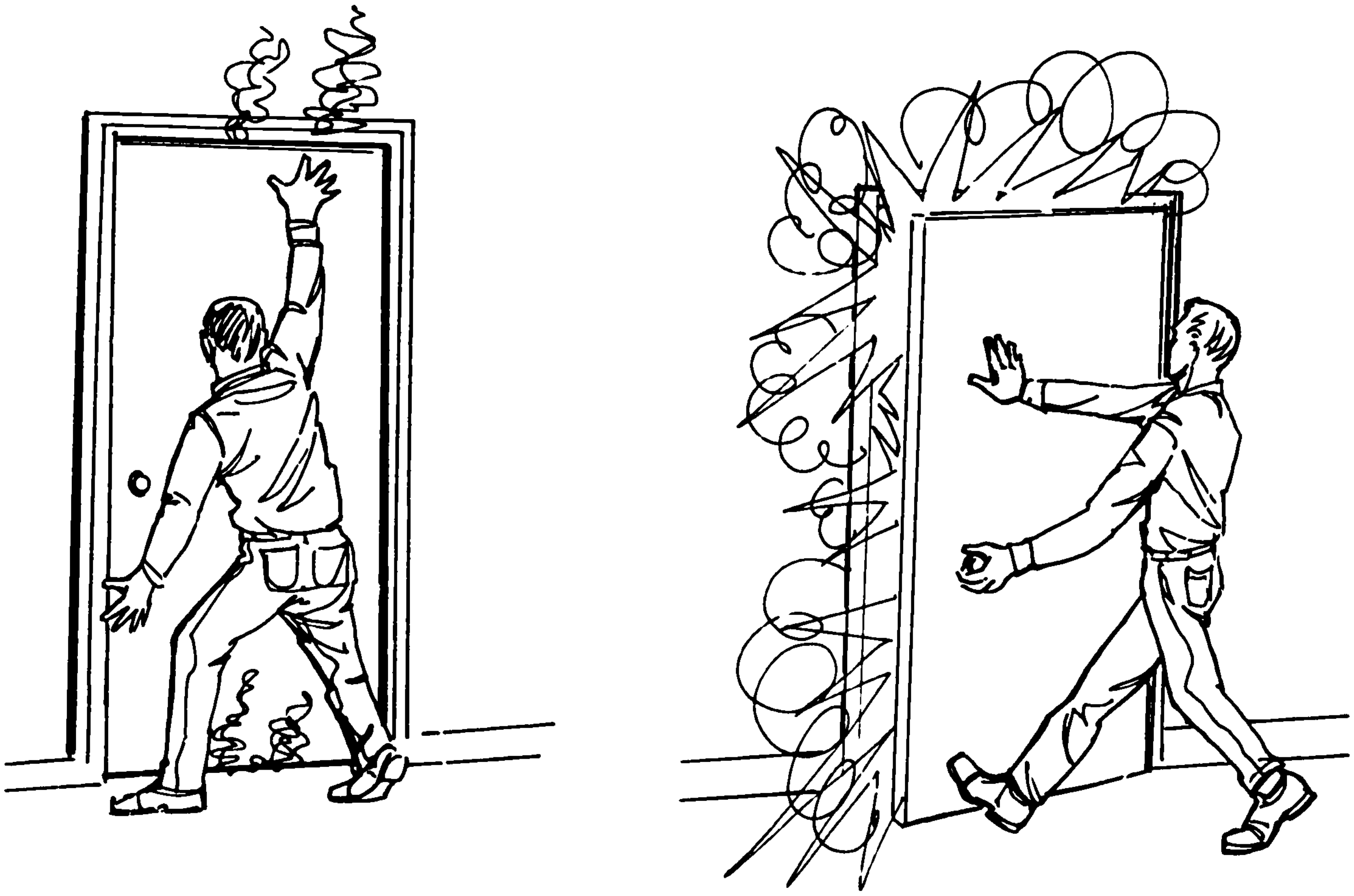

FIGURE 18.—Use Care When Opening A Door

products of combustion. If there is fresh air entering the building, it will be at low levels, sometimes within a few inches of the floor. Even though one may be able to "take it" standing up, the question might be how long. The individual may need to be in the area long enough to get a particular firefighting job done or simply long enough to make good his escape. The individual who keeps low will have a better chance to spot the clear areas (that is, areas where the fresh air is moving into the room) and take advantage of these areas.

All movements within a fire building should be cautious and planned; especially if the individual has entered areas above the fire for purpose of rescue. In general, the firefighter should keep away from the center of the floor because it may cave in first because of the fire below. It is usually safer and easier to follow along the wall to a door. In moving about in a fire building be especially careful of opening a door. Heat and fire may have accumulated on the other side of a door, and if the door is opened, the individual would be met with a blast of hot air. Always feel doors with the hand and open them cautiously.

Another very important consideration when moving about in a building involved in fire is breath control. A few deep breaths of fresh air before entering the building will allow the individual to be more cautious about his breathing upon entering the building. Inside the building watch for and take advantage of channels or pockets of fresh air. Also, smoke will tend to desensitize the nasal membranes and you may lose your sense of smell. This could cause a false sense of security and lead you to stay in the area too long. *Do not stay in a contaminated atmosphere any longer than necessary.*

Although it does not by any means provide breathing protection, a wet rag or handkerchief over the nose can in many cases be very helpful. Not only does it remove some of the larger particles from the smoke, but in case of a flash of fire, it may save the individual from a lung full of hot gases. When the situation warrants it, do not hesitate to wet down your clothing or the clothing of the victim you are attempting to rescue.

Whether you enter a building for the purposes of fire control or are attempting to escape from a building, always consider alternate means of escape. Never take a chance on moving through the fire area if you can escape through windows, especially on the ground floor. On upper floors many times it is much safer to use blankets, sheets, ropes or similar items tied together with square knots to lower yourself to the ground rather than try to get out through the fire. If the door to the room you are attempting to escape from is closed, there should be no great haste. It takes fire a considerable time to burn through even a wooden door, and time should be taken to tie the knots carefully and secure them to a heavy object such as a bed or a dresser. If you have nothing from which to improvise a rope, open window from top and bottom, keep your head out in the fresh air, call for help, and wait as long as possible before dropping to the ground. If forced to drop to the ground, lower yourself as far as possible by hanging to the window sill. Look over the ground beneath you carefully and try to push yourself in the direction where the chance of injury will be the least. For example, you may be able to drop into some ornamental shrubbery. If there are individuals on the ground below you without the means to help you, listen to their advice. They are in a much better position to estimate your danger from the fire below; they may be able to remove dangerous objects such as stakes, from your intended landing point.

Rescue

The Support Assistant may in some cases be responsible for organizing search and rescue efforts. Here again he may have to make some difficult decisions. He may have to decide whether to devote his efforts to search and rescue in demolished buildings or fighting fires in other buildings. In spite of lives immediately endangered, he will need to determine the priorities. Remember that it would do little good to rescue one or two individuals if the only fallout shelter in the area was allowed to burn. In certain cases, the Support Assistant may be charged with responsibility of rescuing people from burning buildings. Here too he may have to choose between immediate firefighting and rescue. Rescue is usually considered of first importance in firefighting, but in many cases where a fire might spread rapidly, rescues can be best effected by first extinguishing the fire, if the necessary fire extinguishment equipment is at hand.

All search and rescue efforts should be carefully organized in order that all areas are searched systematically and time is not wasted searching certain areas over and over again and neglecting others. This is of utmost importance where the building is involved in fire because of the limiting time factor and the difficulty of the search. Searching a building charged with smoke is a very difficult job, especially when the firefighter does not have mask equipment available.

The firefighter should attempt to get all the information he can from other people who have escaped from the building. Determining where certain individuals were last seen could save valuable minutes. Firefighters have learned from experience not to place much confidence in information volunteered by individuals who come from outside the building. Many times a small crowd gathers, rumors fly thick and fast, and almost inevitably some well-meaning individual steps out of the crowd to inform the firefighter about the specific location of a number of people in the fire building.

Whenever possible, search by pairs of firefighters, keeping in close touch and searching each room systematically. They should have a rope, garden hose, or some similar item laid out as they enter in order that they can follow this back to safety or follow the walls. In the total darkness of buildings heavily charged with smoke, firefighters have been known to panic and lose themselves in areas as small as one or two 9 x 12 rooms.

All building corners must be searched carefully. Children will often crawl under beds, behind dressers or into closets in a vain attempt to escape smoke. During the search, the rescuer should always be alert for any sounds, such as the groans of a semiconscious person or the whimpering of a child.

In some cases, people may simply be confused lost rather than trapped in the building. In these cases, they can often be led to safety by simply calling to them from the doorway and continuing to talk to them so that they can move toward your voice.

When victims are located, various techniques may be used for removing them depending upon their condition and the circumstances. Several carries and walking assists are illustrated.

In many cases in fire situations the preferred method of removing victims is the drag. It gets both the rescuer and the victim out of the smoke and fire area in the shortest possible time, and at the same time, it keeps both of them low near the floor where the best air is available. Several different drags are illustrated here.

First Aid

The Support Assistant for Fire Emergencies should have as a minimum the basic first aid course or the training coure in "Medical Self Help." However, in post-attack situations involving nuclear weapons, the Support Assistant should be able to turn first aid duties over to someone else after the individuals have been rescued. He should request volunteers that have had basic first aid or medical self help training.

There are five basic first-aid rules that everyone should know. They are:

How to stop bleeding.—The average adult body contains only six quarts of blood. The loss of one quart is serious; so bleeding has priority over all other emergencies. Apply pressure to the wound at once—with your hand, if nothing else is available, although a bandage, clean cloth, or sanitary napkin will help prevent infection. But don't waste time looking for them. Don't wash the wound. Apply pressure hard and fast bringing the edges of the wound together if you can. You may have to continue the pressure for 30 minutes.

Apply a tourniquet only as a last resort. It may cost the patient his limb.

Breathing difficulties.—Getting air into the victim's lungs fast is vital. Remove throat obstructions, such as mucus, debris, or a jarred-loose denture. If he is breathing, place him on his side so that blood or secretions will not flow into air passages. If he is not breathing, apply mouth-to-mouth respiration. Tilt victim's head back to "sword-swallower" position (a blanket or billow under shoulders will help), pinch his nose shut (see drawing), seal your open mouth over his, inhale deeply through your nose, and exhale deeply into his mouth 12 to 16 times a minute for an adult, 20 for a child. Continue this for two hours, even if life seems extinct, before giving up. As he revives, adjust your breathing rhythm to his.

If the patient has a chest wound, cover it with an airtight dressing.

FIGURE 19.—Moving Victims

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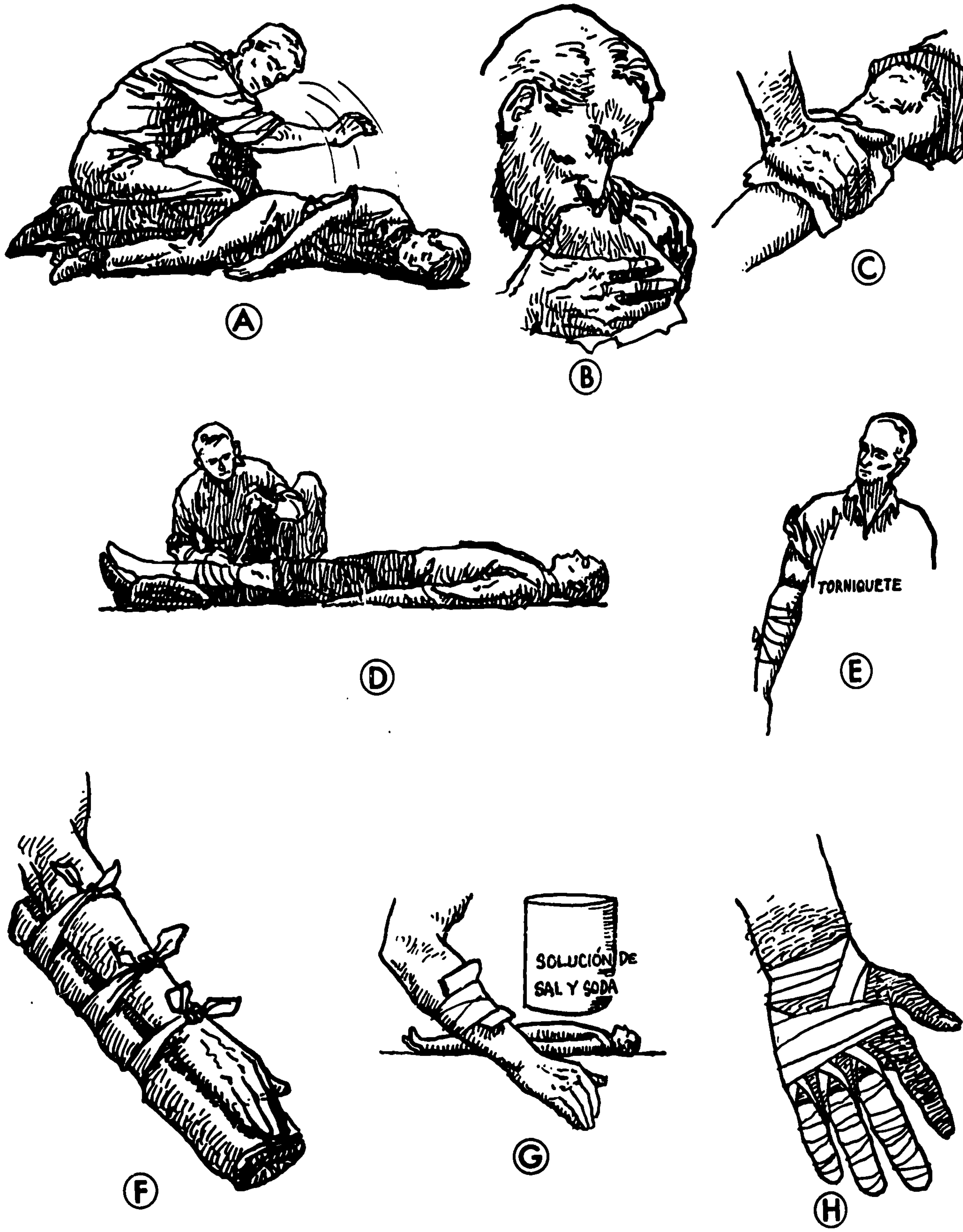

FIGURE 20.—First Aid Methods

If the patient has stopped breathing because of smoke exposure, he is probably suffering from carbon monoxide poisoning. To survive, he is in urgent need of pure oxygen. Give mouth to mouth respiration, and get oxygen to the patient as quickly as possible. If it is not possible to get oxygen to the scene, move the patient to where oxygen is available continuing mouth-to-mouth respiration enroute. Even where breathing is only partially impaired, victims of smoke poisoning should have pure oxygen as quickly as possible. Pure oxygen has the effect of working carbon monoxide from the blood stream and restores the ability of the blood stream to carry oxygen to the body tissues.

Handling Fractures.—Simple bone fractures show themselves by being tender to touch or by the unnatural shape of the affected part or by swelling and change in skin color. Compound fractures are indicated by broken skin, sometimes with the bone protruding. Splint the fracture wherever the patient lies before moving him, firmly supporting the broken limb.

Burns.—Light burns (reddening of the skin) need not be covered, and can be treated with pain relievers or left alone. Deeper burns, where blisters and especially destruction of tissue under the skin occur, should be covered with a clean dressing. No ointments or salves should be used. Fluid that oozes from the burn and forms a crust is a good dressing in itself. Don't puncture blisters unless they are likely to break; in this case, make a small slit at the edge.

If the burns are severe, get the victim to drink a salt solution if possible (one level teaspoon salt to one quart of water) in small amounts. A gallon during the first 24 hours is not too much.

Shock.—"Shock" as used in this section refers to a condition that frequently comes with serious injury, such as severe wounds, burns, bleeding, and broken bones. It is due to a shortage of blood in various parts of the body. This causes the heart to beat faster to pump more blood, resulting in a rapid pulse. Lack of enough circulation through the brain causes unconsciousness.

Obviously, a large amount of bleeding increases the danger of shock. In severe burns the oozing of blood fluids from the burned areas increases the danger. Shock may cause death if not treated promptly even though the injury causes it may not itself be enough to cause death.

The state of shock may develop rapidly or may be delayed and manifest itself hours later. Shock occurs to some degree after every injury. It may be so slight as not to be noticed, but it is a serious condition in many injuries.

Shock is easy to recognize. The skin gets pale and clammy, with small drops of sweat particularly around the lips and forehead. The person may complain of nausea and dizziness. His pulse may be fast and weak and his breathing shallow and irregular. His eyes may be dull with enlarged pupils, or he may be unconscious. A person may not be aware of the seriousness of his injury, and then suddenly collapse.

All seriously injured persons should be treated for shock even though all these symptoms have not appeared and the person seems normal and alert. Treatment for shock may prevent its development.

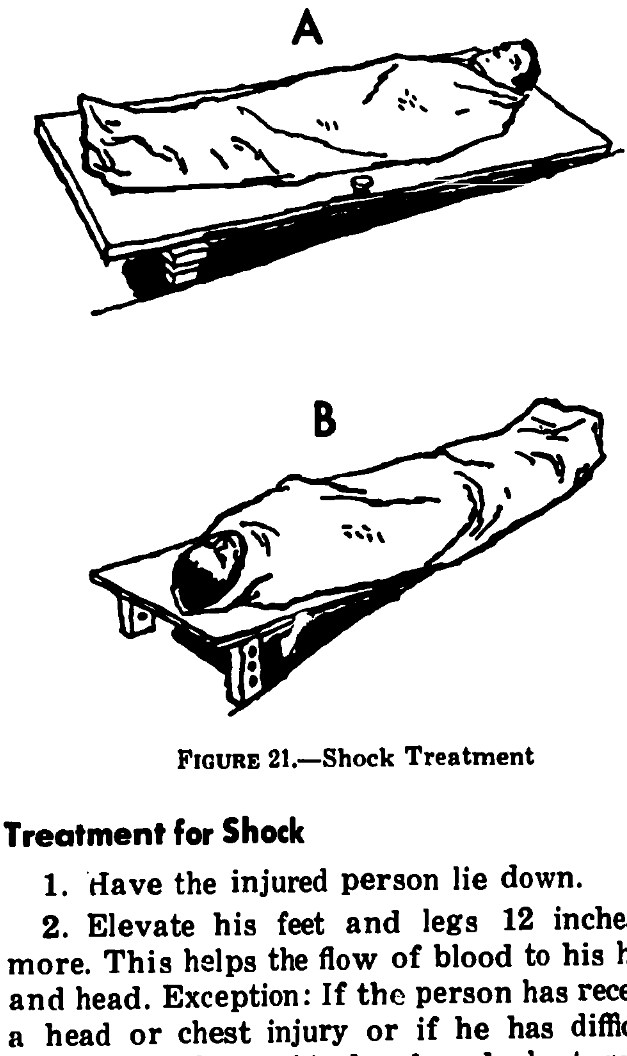

FIGURE 21.—Shock Treatment

Treatment for Shock

1. Have the injured person lie down.

2. Elevate his feet and legs 12 inches or more. This helps the flow of blood to his heart and head. Exception: If the person has received a head or chest injury or if he has difficulty breathing, elevate his head and chest rather than his feet.

3. Keep the person warm, but not hot. Place a blanket under him. Depending on the weather, place a sheet or blanket over him. Avoid getting him so hot that he perspires because this draws blood to the skin and away from the body interior where it is needed. On warm days or in a hot room no covering will be necessary.

4. Give him liquid, about a glassful of salt and soda solution every 15 minutes, if his condition permits. If he is unconscious, do not attempt to give anything to drink. If he vomits or is nauseated, postpone giving liquid until the nausea disappears.

5. Keep the person quiet. See that bleeding is controlled and injured parts are kept still. Assure him that he will get the best care you can give. Reassurance is a potent medicine.

6. A person who has recovered from shock needs to be kept in bed. This is usually not difficult to accomplish because he will feel weak and exhausted. Sleep and rest will hasten his recovery.

SHELTER DUTIES

At the time of a nuclear burst, occupants of fallout shelters will be subject to several potential types of fire exposure.

Those shelter buildings located within the critical ignition energy range of the weapon's thermal pulse will be immediately subject to the possible occurence of one or more incipient fires within the shelter area itself. Also, secondary weapon-related fires due to broken gas mains, broken power lines, etc., are possible although not too probable in areas where shelters are still able to retain their structural integrity.

During the postattack confinement period, shelters will be subject to two additional potential sources of fire. Shelter buildings located sufficiently near to one or more adjacent buildings face the possibility of ignition through radiation from fires that have developed in the surrounding structures. These fires may or may not have been originally weapon-related. In addition, the possibility exists in varying degrees of a nonweapon-related fire originating in unattended portions of the shelter building or within the shelter area itself because of occupant activities.

Shelters located beyond the ignition energy range of the weapon's thermal pulse will be subject only to ignitions from accidental causes during the confinement period, and again, these can occur within the shelter building, the shelter area itself, or can spread from adjacent structures to the shelter building.

The Support Assistant for Fire Emergencies may be called on to act as a fire guard in a shelter. Local Fire authorities may assign the individual to a specific shelter, or in other cases, he may be appointed as a fire guard by the shelter manager after the shelter has been occupied.

Fire Guard Functions

Fire prevention would be very important for the shelter occupants, both during the preattack and the postattack period. The most important single fire prevention action upon occupying shelter buildings is to shield windows by keeping window blinds and shades closed, or by painting, coating, or otherwise covering the windows. There is strong evidence that most ignitions causing sustained fires would occur in the interior of rooms exposed to the heat flash of nuclear weapons. Ignitions caused by the heat flash would occur before blast damage to blinds or other coverings, and can thus be prevented in large part by covering the windows or closing blinds or shades prior to attack.

Other important fire prevention actions include removing curtains, and removing ignitable furniture from window areas. Plans for control of gas and electric utility service can reduce the incidence of fires caused by blast damage.

It was pointed out earlier in this manual that people themselves are also fire causes and with a number of people confined in a shelter, their activities might tend to introduce fire hazards throughout the shelter stay. Periodic inspections of both the shelter area and areas external to the shelter would also need to be made to remove fire hazards. These fire prevention activities would need to continue during the shelter stay.

Since fire suppression equipment within the shelter would probably be limited, it would be essential that fires be discovered in their incipient stage either in unoccupied areas of the shelter building or in buildings immediately adjacent to the shelter building. Periodic patrols of fire guards would need to be established to assure that fires were discovered early.

Fire guards would be responsible for the suppression of fires within the shelter area as well as suppression of fires external to the shelter area that might threaten shelter security.

Selection of Fire Guards

Shelter fire guards would be needed as the cadre or nucleus to direct the fire defense of each public shelter, and they should, if possible, be trained during crisis periods. Shelter fire guard *teams* should be organized from among shelter occupants, with fire guards or any regular fire personnel present taking the lead in organizing the team. Shelter occupants who had completed the Self-Help Emergency Firefighting course would provide a good source for team members. Shelter fire guard teams would operate under the shelter manager.

When enough individuals with fire training were not available the Shelter Fire Guard Leader would need to select individuals with good physical capabilities to serve under those trained people who were available.

The number of personnel selected as fire guards would depend on the many factors including the size of the shelter. The minimum organization would consist of one fire guard (leader) and two fire guards.

Beside shelter size a number of other factors might affect the number of fire guards needed. Sufficient fire guards would need to be selected to man the fire-suppression equipment available in the building. Because people themselves introduce fire hazards into the building, the number and type of people occupying the shelter would be an important factor in determining the number of fire guards.

The area of the shelter would be an important consideration in determining the size of the guard force. Some shelters in tall buildings might have shelters on several different floors. Here it might be necessary to assign a fire guard for each floor. In addition, in this type of building fire guards and fire prevention measures would need to be stressed on the lower floors since even a small rubbish fire on one of the lower floors might make the entire building untenable because of smoke.

Besides the area of the shelter itself, the unsheltered parts of the building would need to be considered in determining the size of the guard force since the entire area of the building would need to be regularly patrolled.

Another factor to consider is the shelter buildings resistance to fire. Buildings constructed of entirely fire-resistive material with closed stairwells would require fewer fire guards than buildings with open stairwells and perhaps some combustible interior finishes. In some areas persons might have to be sheltered in buildings which might be classed untenable with regard to fire. This could be buildings constructed largely of combustible materials or some areas of the building might contain considerable amounts of combustible material.

Other factors to consider would be the radiation level outside, the protection factor of the shelter itself, and the protection factor in the areas of the building that would need to be patrolled. Careful records would need to be kept of the radiation exposure of fire guards operating outside the immediate shelter area. If the radiation level was sufficiently high in unsheltered areas of the building, additional fire guards might need to be assigned to keep the radiation exposure of any one individual at a safe minimum. The radiation exposure of fire guards during patrol would need to be kept at a minimum to provide them with a reserve of radiation exposure time to enable them to suppress fires if and when they occur.

The criteria below are recommended as a starting point of establishing local requirements for shelter fire guards. Note that shelter fire guards—to direct the fire defense of each public shelter—should be oriented or trained during crisis periods. Fire guard team members would be secured from among shelter occupants, after population movement to shelter.

Shelter Capacity (persons)	Shelter Fire Guards (leaders required)
Up to 100	2
100– 300	3
300– 800	4
800–1500	5
1500–5000	7
Over 5000	10, plus 10 for every additional 5,000 persons

Preattack Fire-Prevention Preparations

The entire shelter building should be inspected for kindling fuels that might be exposed through windows or other openings to heat radiation from a nuclear explosion. These materials should either be removed from locations where they would be exposed to heat radiation or the windows through which the radiated heat might enter should be covered. Aluminum foil would be ideal material, but if this is not available, other materials of a noncombustible nature might be used. If there are windows through which radiant heat might enter the shelter area, these should either be covered or shelter occupants should be moved to locations in the shelter area where they would not be exposed to the radiant heat.

To insure the safety and maximum comfort of all the shelter occupants, careful in-shelter fire discipline would be needed. Some aspects of the shelter discipline would probably be enforced by shelter police, but the rules with regard to fire would probably be established by the fire guards in consultation with the fire guard supervisor.

Smoking regulations would need to be established. In shelters where the ventilation was limited, smoking might have to be entirely prohibited since smoking not only would pollute the atmosphere but would consume valuable oxygen. In other shelters, separate areas might be set aside for smoking. Perhaps in less well shielded portions or areas of the building.

People entering a shelter might bring with them materials that could result in a rather substantial accumulation of rubbish of a combustible nature. An area would need to be set aside for the disposal or containment of flammable items. It might also be necessary to remove certain combustible items for the sheltered area to a safe storage area.

Regulations would need to be established with regard to cooking and heating fires. If heating appliances are well vented, these might be allowed to burn. Cooking fires of the gas type are often unvented, and it should be remembered that these would compete with the shelter occupants for oxygen when they were used. The use of charcoal for heating or cooking should not be permitted because this could result in the accumulation of deadly carbon monoxide gas.

Fire Equipment Location

Pre-attack fire control preparations should include the collection and assembly of as many fire extinguishers as possible during the time allowed. These extinguishers might be collected from areas of the shelter building or from buildings immediately adjacent to the shelter.

The fire guards should locate standpipe connections and hoses in the shelter building and familiarize themselves with their operation. They should also locate any controls for automatic firefighting systems and familiarize themselves with their operation.

The fire guards should also locate the valves to shut off the water mains into the building especially where such valves may be located inside the building. If after the attack it becomes obvious that water pressure was being lost because of breaks outside the shelter building, closing the water valves could trap and hold valuable amounts of water in the system of the building for later use.

Utilities Shut-Off

Fire guards should check to see that all cooking and processing equipment used within the shelter building is safely shut down. They should also shut down all heating, electrical, and gas service within the building except those portions that must be maintained in connection with the initial operation of the shelter area and or the approaches thereto.

The process of shutting off utilities during an emergency and of restoring them to service after the emergency has passed requires careful consideration. Each type of utility has characteristics that can contribute to the danger and discomfort of shelter occupants.

Gas

All gas equipment and appliances that are not essential to shelter occupancy should be turned off at each burner control. The pilot light must remain lighted. However, if the supply lines should be ruptured within the shelter facility, shut off the closest valve between the break and the source. The main supply valve should only be turned off as a last resort.

If the gas supply to the shelter facility has been interrupted for any reason, turn off the main gas valve and *leave it off*. When the service is interrupted, all pilot lights go out. If the main gas supply should be restored without the knowledge of the shelter occupants, the leakage from the pilot light burners could accumulate and cause an explosion.

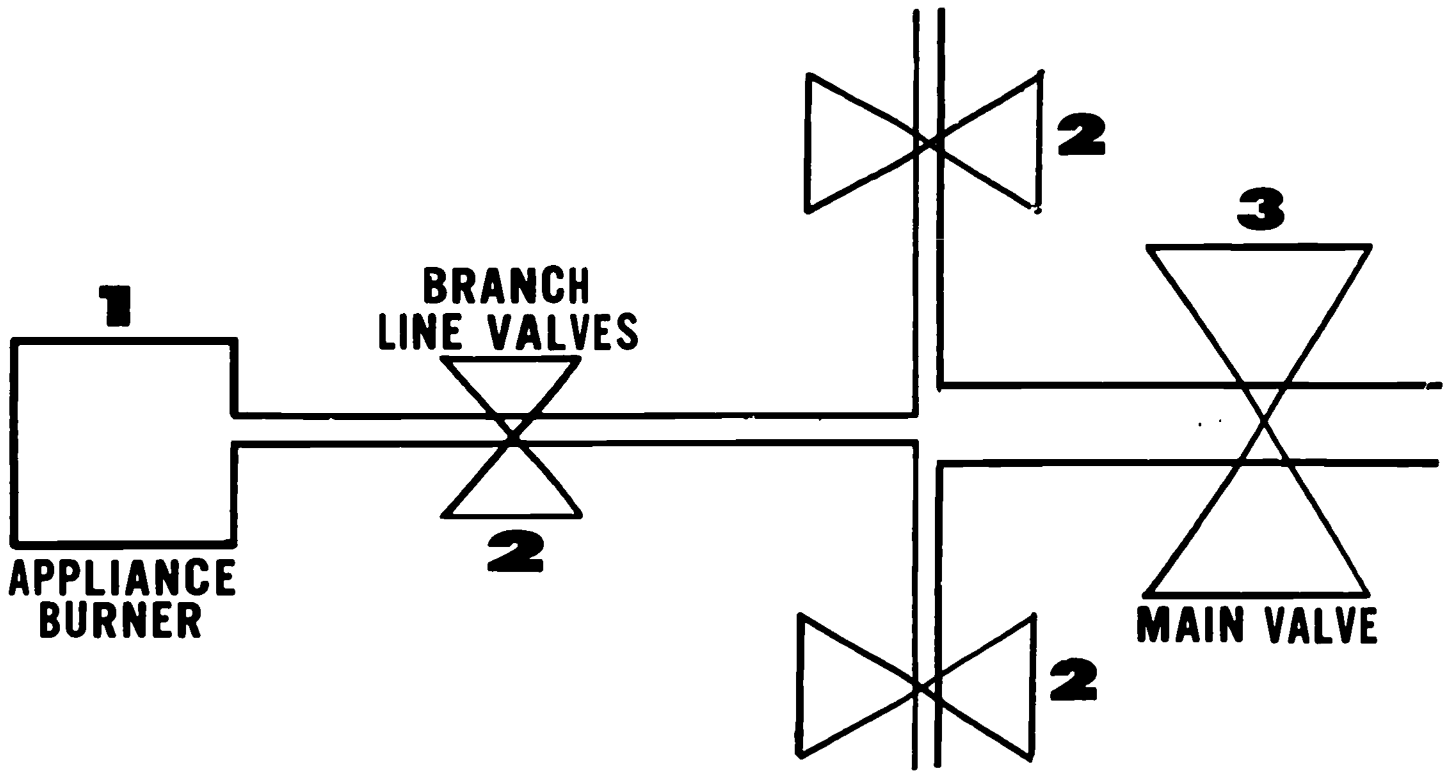

FIGURE 22.—Gas supply valves

The various points for shut-off of the gas supply are illustrated in this schematic diagram.

Electricity

Turn off all nonessential electrical equipment and appliances. It is not necessary to inactivate a whole circuit unless it is the quickest way to shutdown a group of nonessential equipment or there is damage to the circuit.

Water

Water supply should not be shutdown unless there has been damage to the supply line. However, restrictions on the use of water may require the temporary shutdown of some branch lines. AVOID WATER WASTE.

Pre-Plan

The relatively short interval that may be available between the alert and the time of attack, as well as the critical need for prompt suppression of all incipient ignitions, make it imperative that a detailed pre-attack operational plan be established within the shelter building. This plan, which should be implemented by the shelter fire guard (leader) and the fire guards, would be an invaluable aid in completing the necessary steps before attack. The time available for carrying out these steps might be as short as 20 to 30 minutes. Obviously, one of two fire guards could not complete this work and incoming shelter occupants should be screened for personnel to assist the fire guards in these pre-attack preparations. When pre-attack preparations have been completed, these same individuals should be organized into firefighting teams and available firefighting equipment issued to the team members.

If time permits after completion of the pre-attack preparations, the Fire Guard Leader should hold detailed pre-planning and training sessions with the fire guard teams.

Postattack Operations

Following a nuclear burst certain segments of the fire control pre-plan should be put into effect at once. The 30-minute time period before the arrival of fallout has been mentioned earlier and should be considered in postattack fire operations.

If fires have been ignited within the shelter or the shelter building itself, these should be attacked at once. Speed is essential in responding to the nuclear fire threat.

It is of vital importance to promptly suppress ignitions in occupied structures. Removal or extinguishment of ignitions is not difficult or time-consuming—but this must be done within

5 to 10 minutes after the nuclear burst, before the whole room is afire.

During this period fire guards should very carefully monitor the use of extinguishing equipment and agents. At best, these will be in short supply and should not be wasted. Some materials, such as overstuffed furniture, mattresses, and pillows, can require relatively large amounts of water to completely extinguish fires in them. With such materials, the surface fire should be controlled and the materials torn apart or separated to locate the remaining pockets of fire. In some cases after the surface fire is controlled, these kinds of materials can be taken outside. This should not be attempted unless it can be done without spreading the fire. A strong warning note must be sounded here in connection with moving burning fuels to the outside. *Do not* under any circumstances attempt to move containers of flammable liquid involved in fire; this almost always results in the containers being spilled and the fire spread beyond control.

As soon as possible, shelter fire guard teams should be dispatched to survey adjacent buildings to locate and extinguish incipient fires that may have been ignited from the weapon or nonrelated causes. These teams should first inspect and extinguish fires in structures upwind from the shelter building. As with inshelter firefighting, the extinguishing agents should be carefully preserved. Fires that can be safely allowed to burn out should be left to do so under careful supervision.

If postattack inspection and fire suppression outside the shelter building extends beyond the 30-minute period, close coordination with the radiation monitoring teams will be required. Continuing fire control operations outside the shelter will depend on the radiation level, the exposure time of the individuals involved, and the probable benefits of such activities to all concerned.

During the inspection and fire control efforts outside the shelter, the teams should also inspect for utility damage. If during the screening of shelter occupants persons are found to have special capabilities in the area of utility maintenance, these persons should be assigned to accompany firefighting teams on inspections outside the shelter.

Fire Patrol

Within the shelter building regular fire patrol schedules should be established. The frequency and routes of these fire patrols would be set up after considering two main factors. The need for the patrol and the radiation exposure to individuals making the patrol. The need for the patrol and the frequency of the patrol will depend on the fire-hazard potential and construction of the shelter building.

In a fire resistive building with small amounts of fuel, it would be folly to expose individuals to radiation in frequent patrols of such areas. On the other hand, if the fire potential of the building is high, then it must be inspected frequently and the risks of radiation exposure accepted.

When the frequency and the routes of the patrols are established, personnel should be assigned to make these patrols on a regular basis. Radiation exposure levels of all personnel making patrols should be carefully recorded. Adequate rest periods should be allowed for, especially where radiation exposure is high. Radiation exposure places additional stress on the body processes to repair the radiation damage. Personnel exposed to radiation damage would need more rest than during normal peacetime activities.

Restoration of Utility Service

As soon as possible following the attack, *necessary utility services* should be restored in the shelter area. This would of necessity be contingent upon the postattack inspection of utility damage.

Gas

Gas service that has been turned off at any point other than at the appliance burner *should only be returned to service by qualified and authorized personnel.* The hazards of incorrect gas service restoration are explosion, fire, or asphyxiation.

Electricity

Before returning inactivated circuits to service check for obvious physical damage. If none exists, reactivate the circuit. If the fuse should blow or the circuit breaker kick off, it is a sign that the circuit has been damaged. Do not attempt to reactivate the circuit again until qualified and authorized personnel have repaired the damage.

Water

The return to service of damaged water supply lines depends upon the degree of damage. Obviously, a completely broken pipe cannot be put into service. Pipes that have minor cracks or punctures may be packed or plugged and used by turning on the supply valve only when needed.

Shelter Emergence and Damage Assessment

Shelter emergence or stay outside the shelter beyond the initial 30-minute period would depend primarily on the radioactivity present. As discussed earlier in this manual, radioactivity depends on the type of burst and the wind patterns at the time of attack. Radiation monitoring teams assigned to the shelter should be able to make some determinations in this matter. Early emergence of special teams for specific purposes would also be governed to a certain extent by fallout forecasts made by local and state authorities. If the forecasts indicate that radiation levels outside the shelter will go higher, rather than decrease by decay, certain missions outside the shelter might need to be undertaken as quickly as possible.

Teams might be sent out some distance from the shelter to determine blast damage and the number of fires in the vicinity. This information would be vital to governing officials to help them formulate over-all strategy.

Reports from special teams operating outside the shelter would be returned to the shelter fire-guard supervisor. He, in coordination with the shelter manager, would make requests to local authorities for outside help in rescue and fire fighting situations if necessary. He might also make requests through proper authorities to utility companies for damage-repair teams.

Special areas and crews should be set up in the shelter building to assist special survey teams coming back into the shelter with decontamination. Some decontamination procedures were explained earlier in this manual.

Additional guidance on the organization and functions of the shelter fire guards is contained in the Fallout Shelter Fire-Defense Manual.

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