DOCUMENT RESUME

ED 062 594 AC 012 548

TITLE	Support Assistants for Fire Emergencies; Student Manual, Part B. Firefighting for Civil Defense Emergencies.
INSTITUTION	International Association of Fire Chiefs, New York, N.Y.
SPONS AGENCY	Office of Civil Defense (DOD), Washington, D.C.
REPORT NO	SM-9-2B
PUB DATE	Jul 71
NOTE	82p.
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	Adult Education; Behavior Standards; *Civil Defense; Cognitive Processes; *Course Content; Educational Programs; Emergency Programs; *Fire Protection; *Manuals; Objectives; Service Occupations; *Skill Development; Students; Task Performance

ABSTRACT

A course designed to develop performance capabilities in the student of the fire service is presented in a manual. Each chapter is designed to give the student a basic understanding of the material covered in class. Specific objectives are: (1) To train "Support Assistant" B personnel to augment and assist firefighters, (2) To train personnel to instruct in emergency procedures, and (3) To train emergency firefighting personnel to supervise untrained people in the suppression of fires and the use of firefighting equipment and other resources. There are 15 chapters: Introduction, Alert and Fire Operations Plan, Fire Behavior, Ventilation, Forcible Entry, Ropes and Knots, Operating Characteristics of Portable Extinguishers, Hose and Hose Practices, Ladders, Protective Breathing Equipment, Hose Streams, Overhauling, Emergency Water Supplies, Pumping, and Rescue Under Fire Conditions. (Author/CK)

SM-9.2B (student manual)
July 1971

Firefighting for Civil Defense Emergencies

SUPPORT ASSISTANTS FOR FIRE EMERGENCIES

STUDENT MANUAL — PART B

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

Firefighting For Civil Defense Emergencies

SUPPORT ASSISTANTS for FIRE EMERGENCIES

STUDENT MANUAL—Part B

SM-9.2B, July 1971

Developed for the Office of Civil Defense

by

International Association of Fire Chiefs

TABLE OF CONTENTS

INTRODUCTION—"SUPPORT ASSISTANT" PART B

As graduates of the Support Assistants for Fire Emergencies Part A Course and as citizens sincerely interested in the welfare of the United States, the Office of Civil Defense and the Fire Service welcomes you to "Support Assistant" Part B. This course will consist of approximately 24 hours and will cover a variety of advanced subjects designed to contribute to the Support Assistant's overall understanding of the fire problem and to his functions in Civil Defense emergencies.

This course's primary objective is to develop performance capabilities in the student of the fire service. Specific objectives are: (1) To train "Support Assistant" B personnel to augment and assist firefighters, (2) To train personnel to instruct in emergency procedures, and (3) To train emergency firefighting personnel to supervise untrained people in the suppression of fires and the use of firefighting equipment and other resources.

This course will not make a professional firefighter out of the student. It will give the student a much better understanding of what is expected of him during and after a disaster. It will develop his ability to carry out these responsibilities.

Each chapter in this manual is designed to give the student a basic understanding of the material covered by the instructor in the class. To obtain additional information, the student should refer to the publications cited in the bibliography. Each lesson should be read and understood before entering class to obtain maximum benefit from the instructor's presentations.

As in "Support Assistant" Part A of this course, the term "Support Assistant" Part B is used to identify lay persons being trained to augment regular fire forces during Civil Defense emergency or natural disasters.

As a graduate of "Support Assistant" Part A you are aware that you were recruited, screened and trained by the regular fire service. You are further aware that you are responsible to and under control of the regular fire forces in your locality.

ALERT AND FIRE OPERATION PLAN

Emergency Standard Operating Procedures

All Civil Defense actions prepare for emergency operations. This is the meaning of Civil Defense: civil government, industry, and the public prepared for effective action in time of disaster.

Certainly, the preparation of a nation-wide fallout shelter system is the key element of Civil Defense. The fallout shelter has life-saving capability by itself. It is essential to all other Civil Defense preparations in the damage limiting systems of national defense. All other Civil Defense emergency operations are secondary to the shelter system and support it. Developing Civil Defense capability automatically increases community effectiveness in handling lesser emergencies.

Warning

One of the essential supporting systems is the warning system. For people to receive the maximum benefit from the fallout shelter system, they must receive timely warning of attack so that they can move to the best available fallout protection before fallout arrives. A Department of Defense study indicates that having an effective warning system could mean the saving of an additional 2 to 8 percent of the pre-attack population—depending on the type of severity of the attack and other factors. This represents a saving of something like four to fifteen million lives.

The present Civil Defense warning system is a combination of federal, state and local systems. The federal portion of the system is termed the National Warning System (NAWAS). This system is essentially an extension of the military warning and detection systems that feed into the combat operations center of the North America Air Defense Command (NORAD), at Colorado Springs, Colorado. Segments of NAWAS have been used for severe weather warnings.

The North America Air Defense Command and the Ballistic Missile Early Warning System are jointly allied warning radar networks scattered across the northern part of the western world and tie into a general warning system.

The backbone of the Civil Defense Warning System is the NAWAS. This system consists primarily of the three major Office of Civil Defense Warning Centers plus backup centers at the Office of Civil Defense Regional Headquarters that are linked by special voice communications system to more than 700 warning points located in key facilities and population centers throughout the nation. These warning points, manned on a 24-hour basis, are located at state police, local police, and fire dispatching headquarters and at similar emergency facilities including key federal installations. Through a relay system, these warning points send warning information to local authorities who are responsible for sounding public warning devices, such as sirens and other outdoor warning devices.

Warning Signals

The principal means of warning the public is the outdoor attack warning siren system. In some areas horns, whistles, or other devices are used for the same purpose. Everyone should be familiar with the signals used on the public warning system and know what to do when the signals are sounded.

Attack Warning Signal

The attack warning signal is a three to five minute wavering tone on sirens or series of short blasts on horns or other devices, repeated as necessary. This signal means that an actual attack against the United States has been detected and that protective action should be taken immediately. As a matter of National Civil Defense policy, the attack warning signal is used for no other purpose and has no other meaning.

THE WARNING NETWORK

Here's what would happen if an enemy air attack were launched against our continent:

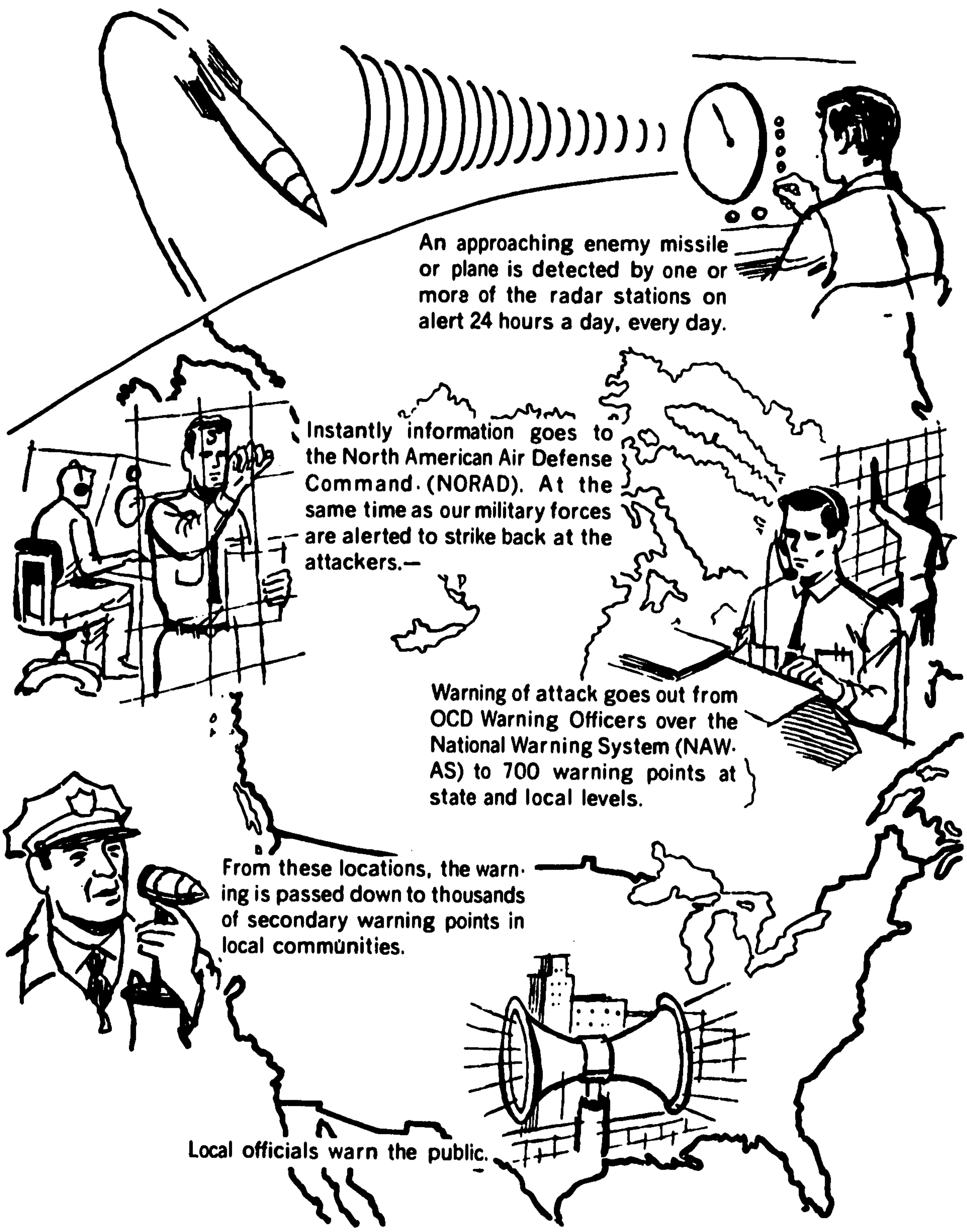


FIGURE 1.—The Warning Network

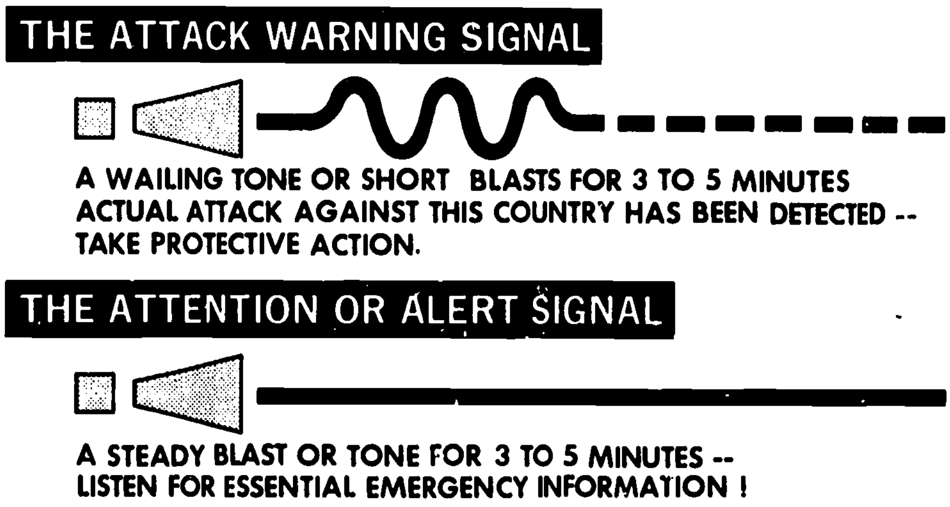


FIGURE 2.—Warning Signals

Attention or Alert Signal

Warning devices may be used to get public attention in emergencies. The signal is known as the Attention or Alert Signal and is a three- to five-minute steady tone. It may be sounded at the option and on the authority of local government officials. They will determine the circumstances under which the signal is to be activated (including whether it is to be used for warning of natural disasters). In addition to any other meaning or requirement for action as determined by local government officials, the signal means to all persons in the United States "Listen for essential emergency information."

The outdoor public alerting system is limited in its effectiveness. For several years studies have been conducted to develop a practical indoor warning system, and research is still going on.

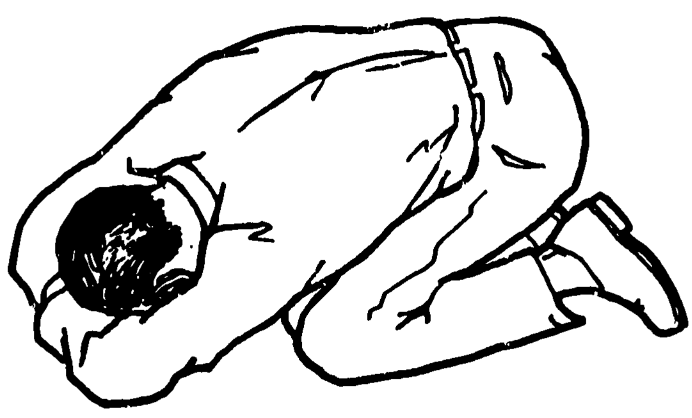
Individual Action on Alert Warning

In the absence of an organized procedure, the individual citizen should seek cover in the designated or best available shelter areas. A National Shelter Survey has marked most of the logical fallout shelters in many local communities. When the take-cover warning is given, the support assistant firefighters should report to the nearest available shelter if there is no predetermined plan.

When the Support Assistant reports to the first available shelter, he should help the fire guard leader organize and carry out the prescribed shelter-fire guard duties.

Under a No-Warning Condition

Under a no-warning condition the individual should take the necessary personal protection measures to avoid the blinding flash, the blast effects and the intense heat that will be present for a few moments. The individual should then seek the best shelter available for fallout and survival protection.



MINIMUM COVER POSITION

FIGURE 3.—Minimum Cover Position

FIRE OPERATIONS PLAN

All fire departments should have, or be part of, a fire defense plan for nuclear attack conditions. This plan should be coordinated with plans at county, area, and state level. The plan should be based on: an assessment of the fire potential in the area; an inventory of equipment and apparatus; an inventory of trained firefighting personnel and supporting equipment and manpower that may be needed.

The plan should prescribe some operating procedures such as where do firefighting forces report and who is in charge of what.

The plan should specify emergency operating centers, communications control points, communication links with Civil Defense and other vital elements.

Mutual Aid arrangements are a desirable part of any local fire defense plan. Although each fire organization may be required to operate independently for a short time, one of the main purposes of an area fire-defense plan is to bring about coordination of effort and resources to achieve maximum effectiveness.

Communications capability is a necessary part of fire-defense planning. Resources, such as equipment and manpower, can only be managed as far as the organization can communicate. Therefore, a complete operational communications capability needs to be maintained by the fire-defense organization. It is extremely important that this communications net be tied in with the local or area Civil Defense Operating Center.

If there is no fire defense operational plan, some confusion may result within the regularly organized firefighting forces, and effectiveness will be limited. Fires that can be anticipated as a result of nuclear attack could overcome individual fire-defense organizations very quickly.

The individual Support Assistant should be familiar with the type of alarm he might receive and the procedures he would be expected to follow during extreme emergency. He should know his station assignment and the ways-and-means of getting to his station if at all possible. The regular fire forces will be overtaxed. The Support Assistant may find that he will have to take untrained people, organize, and lead them on small missions related to fire control, using the limited resources that may be available.

Fire-defense operations plans and the familiarity with these plans by all firefighting personnel, "Support Assistant" or otherwise, are vital for effective functioning of the Fire Service.

FIRE BEHAVIOR

In the "Support Assistant" Part A course fire was discussed in connection with the fire triangle. The three legs of the fire triangle were shown solidly connected at the corners. Actually, this is somewhat of an oversimplification. Rather than fire, this solidly constructed triangle would illustrate the components of an explosion. The process of combustion is more correctly illustrated by the second triangle.

THE FIRE TRIANGLE

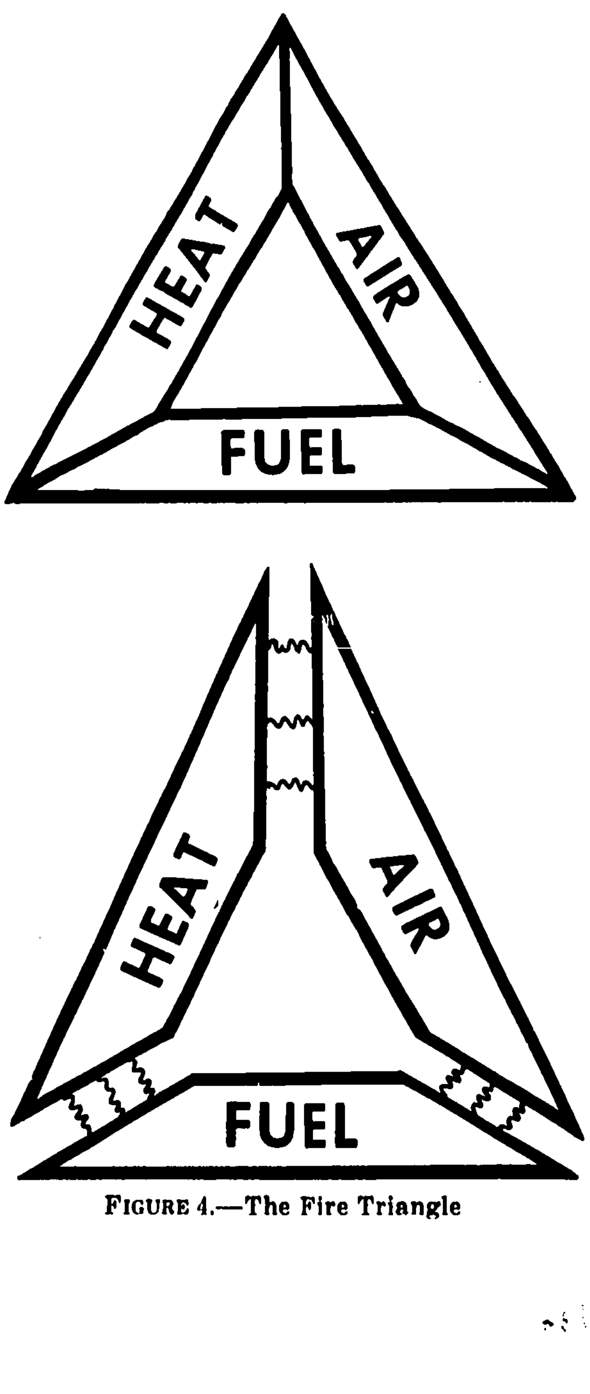


FIGURE 4.—The Fire Triangle

Here the process of combustion is illustrated with variable connections between the three legs. In actual fire situations, one or more of the three connections can be considered somewhat less than a solid connection. For example, most fires burn with a limited oxygen supply as evidenced, in part, by the amounts of smoke produced by ordinary fires. On the heat side of the triangle the fire loses much of its heat. From the fire's standpoint the ideal would be if all the heat released was used for vaporizing more fuel. On the fuel side of the fire triangle many of the fuel vapors released are wasted, either because the ignition temperature is not present or sufficient oxygen is not available. This again is illustrated by the amounts of smoke produced in ordinary fires. Clean complete combustion as illustrated by the natural gas burner on the cook stove does not produce smoke.

Fire can be a very tenuous thing as anyone can testify who has attempted to light a campfire on a cold damp day. The firefighter controls fires by taking advantage of the inherent weaknesses of the combustion process.

Although fire raging through a structure unchecked may not seem a tenuous process, it may, nevertheless, be controlled by attacking it at its weakest point. To take full advantage of these inherent weaknesses it is helpful if the firefighter has a more complete understanding of the three components of fire than was included in the "Support Assistant" A course.

Oxygen

Oxygen (O) is the most important and plentiful of the elements, making up 21 percent of the atmosphere, about 89 percent (by weight) of water, and about 32 percent of the earth's outer surface.

For simplification, the terms "oxygen" and "air" may be used interchangeably in this manual when referring to fire behavior. It must be

remembered, however, that it is the oxygen in the air that makes combustion possible.

Many materials, such as wood, have oxygen in their chemical makeup. In most cases, however, the oxygen contained in such materials is in the form of oxides. Oxidation is oxygen already partially or totally combined with other elements and not available for the combustion process.

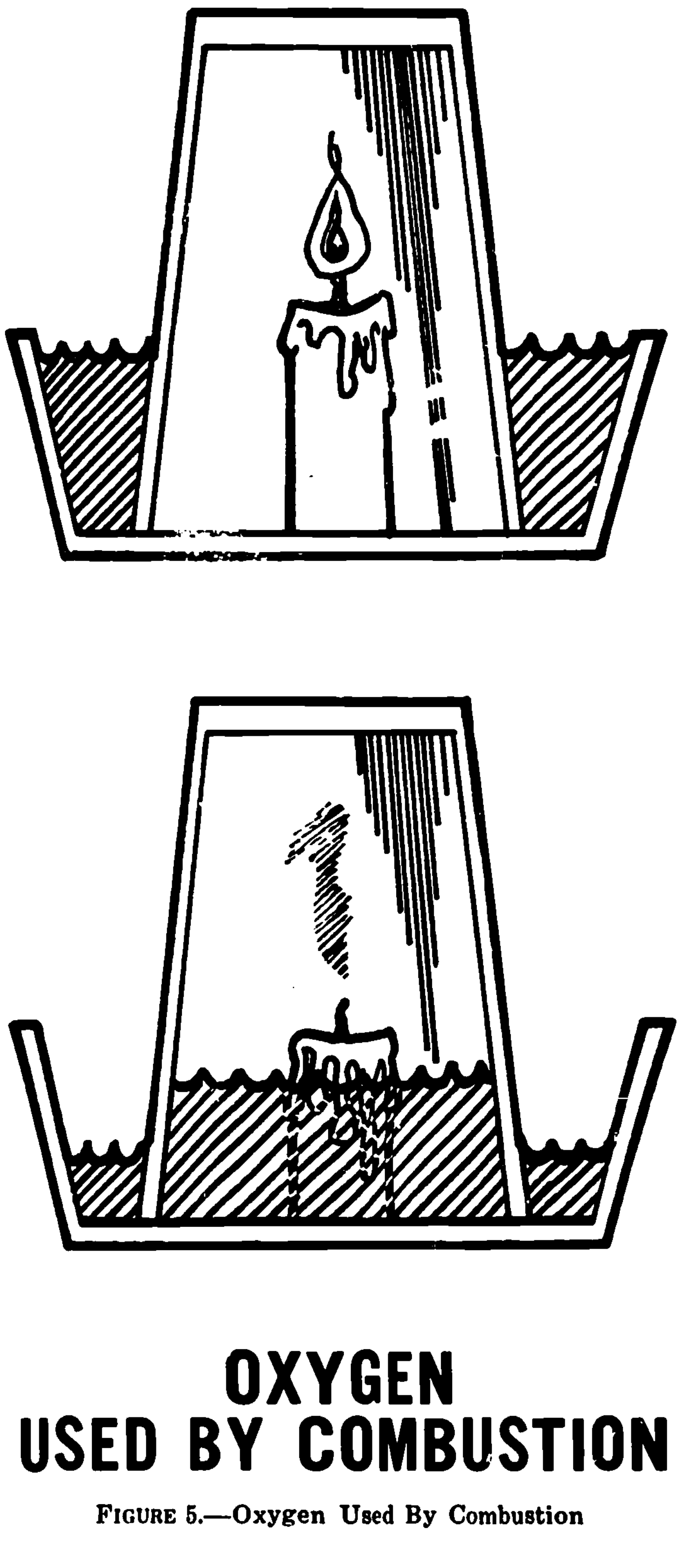


FIGURE 5.—Oxygen Used By Combustion

Some materials contain free oxygen or oxygen only partially combined with other elements and therefore available for the combustion, or oxidation process. Gun powder and some of the early plastics, such as celluloid, are examples of this material. These materials have violent fire behavior because both the oxygen and fuel is present, and only heat is necessary to start the process.

A simple experiment can be performed with a candle, a clear glass tumbler and a shallow pan of water. The burning candle is set upright in the shallow pan of water, and the tumbler is placed over the candle. In a short time, the flame gets smaller and smaller until it goes out. It has used up the available oxygen inside the tumbler. At this point, note that the water has risen inside the glass tumbler. It has moved in to replace the mass that has been converted by the fire into gas. A close examination of the tumbler will indicate that the water vapor formed in the process of combustion had condensed on the inside of the glass allowing room for the water to rise in the tumbler. If the air remaining inside the tumbler were analyzed, it would be found to have a relatively high concentration of CO_2.

This same process might occur in shelters where the ventilation was limited. Shelter occupants would breathe in oxygen and give off carbon dioxide and water vapor. As in the experiment, the water vapor would condense on the walls and the CO_2 would accumulate in the area. CO_2 is a breathing stimulant, and the shelter occupants would be adversely affected by rising amounts of CO_2 before they actually smothered from lack of oxygen.

Fuels and Heat. For simplification fuel and heat were discussed separately in the "Support Assistant" Part A Manual. But fuels and their behavior under ordinary combustion are so dependent on the effects of heat, they will be discussed jointly in this manual. The student should keep in mind or review the basic information given in "Support Assistant" Part A.

All matter including fuels may exist in three forms, depending on the pressures and temperatures at which they are considered:

1. As a solid, such as iron, wood or ice.
2. As a liquid, such as alcohol, gasoline or water.

3. As a gas, such as oxygen, hydrogen or steam.

Materials can exist in more than one form depending on the temperature or pressure at which they are found. Water, for example, at normal atmospheric pressure (14.7 P.S.I. at sea level) and below 32° F. is a solid, ice. At 32° F. the ice turns to liquid, and at 212° F. the liquid changes to a vapor or gas. Each time a material undergoes a physical change, such as, freezing or melting and vaporizing or condensing, it absorbs or gives off heat. For example, it requires 144 BTU's to melt a pound of ice. If the pound of water freezes, it gives up the 144 BTU's. It requires 970 BTU's to vaporize a pound of water, and when the steam again condenses, it gives up this 970 BTU's.

All fuels, like water, require a given number of BTU's to melt and (or) vaporize them. As pointed out in the "Support Assistant" Part A Manual, the vaporization of a fuel is necessary in order for it to mix with oxygen and undergo combustion.

It was also pointed out in the "Support Assistant" Part A Manual that wood contains a considerable amount of free carbon, which resists vaporization at ordinary combustion temperatures, and, therefore, seems to burn as a solid. A substantial portion of wood, however, is subject to vaporization and does vaporize and burn as a gas leaving only carbon as a glowing coal. These glowing coals must wait for actual contact with the oxygen to complete the combustion process. This type of combustion is characteristic of all Class A fuels. Charcoal contains a very high percentage of free carbon and such flaming as is seen over charcoal will be largely the combustion of carbon monoxide gas.

An ordinary candle is an excellent example of the melting, vaporizing, and combustion of the fuel. The wax is melted by the flame's heat, the liquid moves up the wick closer to the flame where there is sufficient heat to vaporize it, and it mixes with oxygen and undergoes combustion. The wick of the candle is a (Class A) carbonaceous material and cannot burn as long as it is covered with liquid because the oxygen cannot penetrate to burn off the carbon. When the candle is blown out, one can often observe a small glowing coal at the tip of the wick. When the liquid wax cannot rise high enough to protect the end of the wick, oxygen is free to contact the carbonaceous material so the wick burns off. Another interesting experiment with the candle is to snuff it out rather quickly and then hold a match a short distance above the candle in the smoke or vapors still rising from the wick. The flame will jump down the stream of vapors to the wick reigniting the candle.

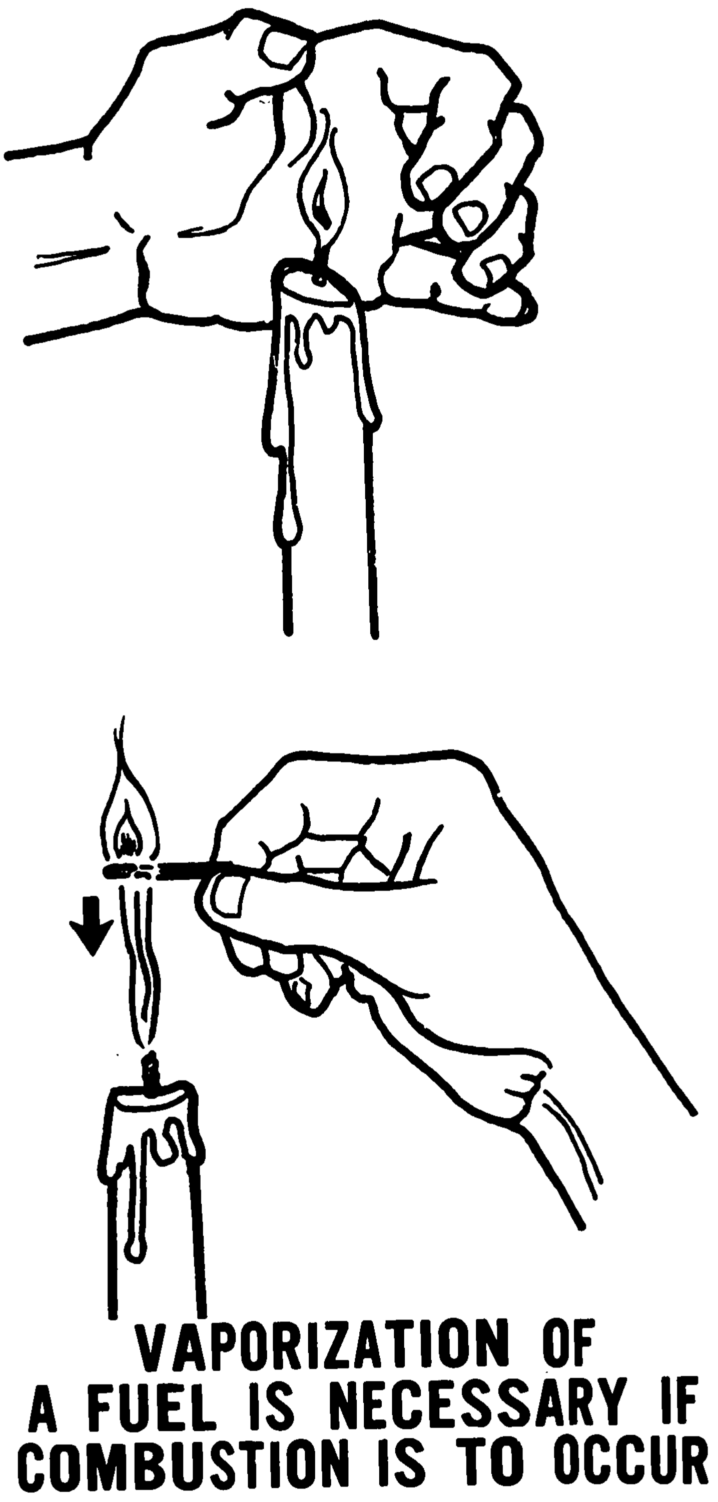


FIGURE 6.—Vaporization of Fuel

It was pointed out in the "Support Assistant" Part A Manual that wood shavings can be ignited much easier than a block of wood because the fuel is sufficiently fine that the heat of a match can vaporize and ignite the material. This example can be carried farther by considering the wood as being ground to dust. If this wood dust is suspended in the air where every particle is surrounded with oxygen, it can be ignited with explosive violence. There are very few dusts that will not explode in this manner. For example, many women have been seriously burned emptying a vacuum sweeper bag over a bonfire or into an incinerator. When fires are fought in dusty locations such as grain elevators or flour mills, care must be exercised to prevent throwing quantities of dust into the fire area with the hose stream.

Fire Sources

Nuclear weapons may ignite fires either directly or indirectly—directly by the heat of the nuclear fire ball and indirectly from the blast damage.

Thermal Radiation.—The heat of the nuclear fire ball is so intense that it may start fires outdoors or indoors through windows as much at 25 to 30 miles away. The heat of the nuclear flash is very intense, but of short duration. The duration is short enough that most solid combustibles will not be ignited much beyond the area of complete destruction. However, kindling fuels, such as paper, dry grass, etc., can be easily ignited by the thermal energy of the bomb.

Blast Damage.—Gas lines in buildings would be ruptured by the blast, and leaking gas in many instances would find a source of ignition, especially where gas appliances had been left burning. Electric shorts would occur in damaged buildings as well as where electric lines were knocked down. Many fires would probably be ignited from this source.

Spread of Fire

Once ignited a fire will continue to spread as long as it has fuel and oxygen and nothing is done to rob it of its heat. We commonly talk about the spread of fire without stopping to consider that this is actually secondary. Heat for vaporization and ignition of additional materials must spread ahead of the fire in order for the fire to spread.

The "Support Assistant" Part A Manual defined the three methods of heat transmission or travel: radiation, convection, and conduction. Since the spread of fire depends on the spread of heat (consequently that fire will spread by all three means).

The spread of fire by conduction is of minor importance, primarily because most fuels are good insulators; that is, poor conductors of heat. However, the spread of fire by conduction must be guarded against. Certain noncombustible materials used in partitions are good conductors of heat and may, by conduction, ignite kindling fuels on the other side of the partition. Examples of such materials are asbestos board, sheet metal, and steel bulkheads in ships. Steel rods and pipes through brick walls have been known to conduct enough heat to ignite fires on the opposite side.

Radiation can be considered the most dependable means for the fire to spread its heat, primarily because heat travels by radiation like light, equally in all directions from a point source. Large fires are intense sources of radiant heat. Fires have been known to jump streets as much as 90 feet wide against the wind.

In contrast to radiated heat, heat transmitted by convection travels primarily upward, except where the convection currents may be turned laterally by ceilings or strong winds. Vertical channels, such as stair wells or elevator shafts, make excellent chimneys in which convection currents can build up and allow a fire to spread upward sometimes with almost explosive speed.

In some cases convection currents actually work to inhibit the spread of a fire. Consider a fire burning across a dry meadow on a still day. The convection currents above the fire are pulling in cool air at the base of the fire and actually tending to keep the fuels ahead of the fire cool. Because the fire must depend on its radiant heat to spread and has convection currents working against it, it spreads very slowly. If, however, there is sufficient wind to force the convection currents close to the ground where both convection and radiation can work together, the fire spreads very rapidly.

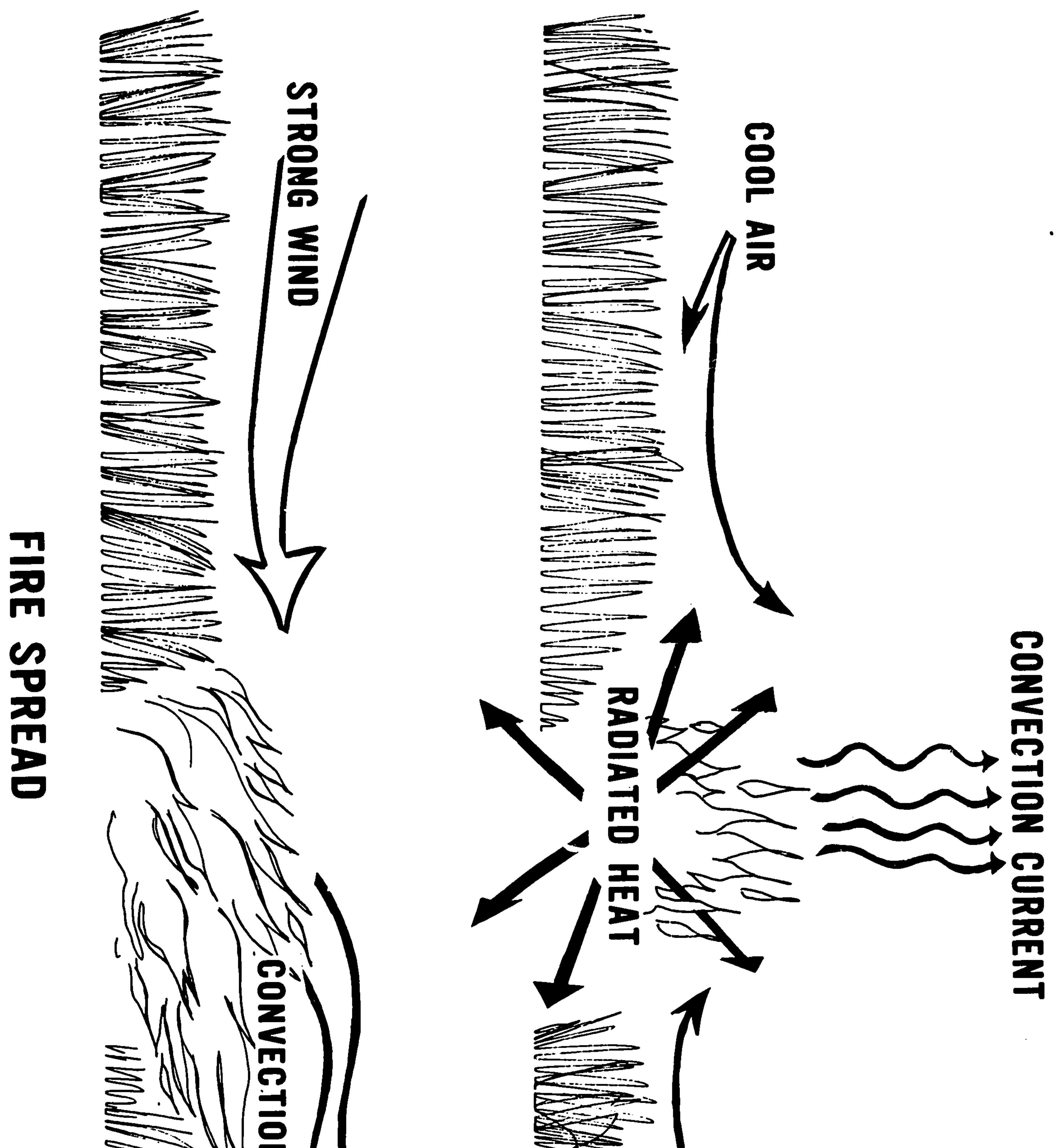


FIGURE 7.—Fire Spread

In the next chapter, ventilation will be considered. With proper ventilation the firefighter takes advantage of convection currents to rob the fire of some of its heat.

In large fires, convection currents can be strong enough to be instrumental in spreading the fire over a considerable distance. The heavy updraft or thermal column carries brands high into the air where they may be borne by the air currents for a considerable distance to rain down on combustible materials. In large fires these brands are much more than just sparks. It is not uncommon, for example, for glowing 1 x 12 lumber to be carried aloft as a fire brand.

The spread of fire by fire brands might be considered an exception to the ordinary means of fire travel by radiation convection and conduction because the actual fire is being transported by the air currents rather than the heat.

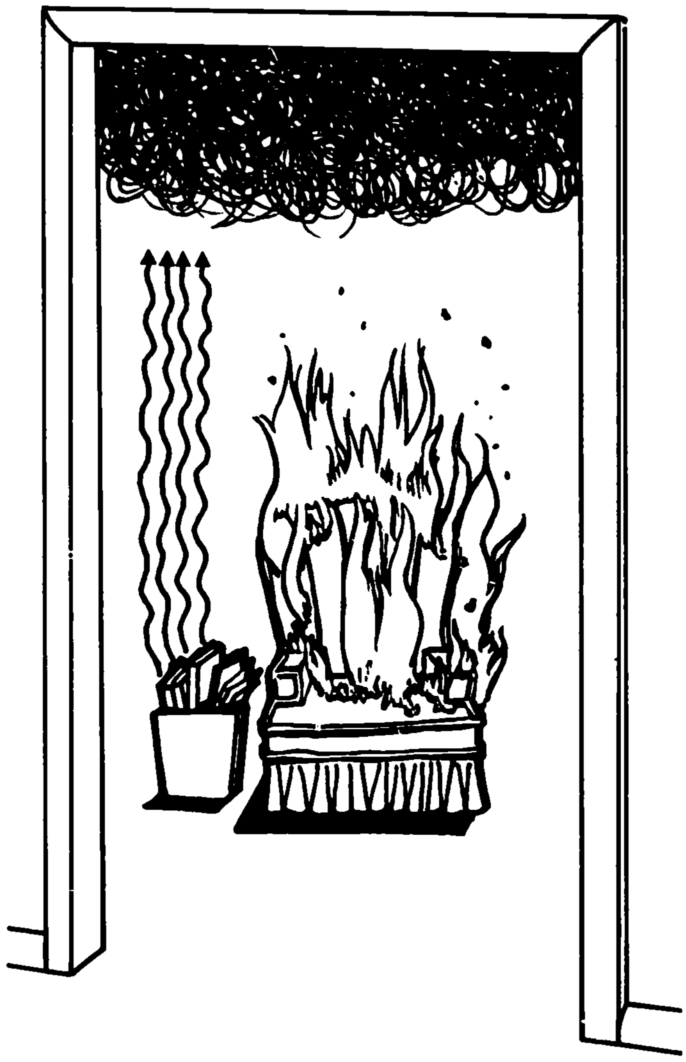


FIGURE 8.—Fire Buildup

Fire Buildup

Fire behavior in confined areas has certain characteristics with which all firefighters should be familiar. When a fire is ignited within a structure, it behaves initially like any bonfire we might ignite in the open air. Its speed will depend almost wholly on the nature of the fuel. In large piles of kindling fuel, for example, the fire will build with almost explosive violence. To understand fire behavior inside a structure we will consider a fuel arrangement that will cause the fire to build up somewhat slower.

For a model fire we might consider an overstuffed chair with a few newspapers and a magazine rack alongside. This fire might build up to where flames were reaching about half way to the ceiling. At this point convection currents are carrying away much of the heat, and portions of the overstuffed chairs are being heated by radiant heat. In the flame zone, temperatures will be high enough to ignite the vapors being given off, and there is good combustion. However, where the materials are being heated by radiant heat, they will give off flammable vapors that may not be hot enough to ignite and may travel towards the ceiling as smoke. For practical purposes we can consider the vapors given off from ordinary combustibles similar to natural gas.

In addition to these distilled vapors, there will be some carbon monoxide gas formed closer to the actual flame zone which will rise to the ceiling without being ignited. These combustible vapors and the products of combustion from the fire itself will build up at ceiling level, but heat is also being lost along the ceiling because the ceiling is absorbing heat. Whether the temperature at ceiling level rise to the danger point will depend on the heat loss and the size of the fire. If the fire is of sufficient size and intensity, temperatures at ceiling level will rise to around 1000° F. About 1000° is the ignition temperature of the flammable vapors pocketed at ceiling level, and at this stage, things happen rather suddenly. The area directly over the fire will be the hottest, and the flames over the fire itself will seem to reach toward the ceiling and ignite the entire mass of flammable vapors at ceiling level. This phenomenon is termed flash-over and often traps people attempting to fight fire or persons who have gone back into a building to attempt to save valuables.

When the fire flashes over, the heat within the room becomes so intense that all the combustibles within the room are ignited. If enough doors and windows are open to provide oxygen to the fire, it will spread very rapidly through available openings to other parts of the structure. But if sufficient doors and windows are not open to provide oxygen to the fire, it will consume the available oxygen and go into a smoldering or backdraft stage. The backdraft stage will be considered again under ventilation.

In some cases fuel arrangements are such that the fire burns clean. Only water vapor and CO_2 with very little smoke will accumulate at ceiling level. In these cases the danger of flash-over is low.

Experienced firefighters have learned to sense the imminence of flash-over and guard against being caught. Support Assistants who enter buildings for the purpose of rescue or extinguishment should watch carefully for signs of flash-over. Be wary if considerable amounts of dark smoke cling to the ceiling and if the flames from the fire seem to be licking towards the ceiling.

Once a structure is fully involved, fire can spread quite easily to other buildings. It is not uncommon for fire to spread by radiant heat 50 to 60 feet against the wind. With the wind, when radiation and convection are working together to spread the head, fires can jump greater distances to involve other buildings.

Where relatively strong winds are blowing, 20 to 30 miles per hour, fires may develop on a broad front and move with the wind burning everything in their path. This type of mass fire is referred to as a conflagration.

In a few cases during World War II in Germany, mass fires developed that were termed fire storms. In areas where there is a heavy concentration of combustible buildings, this type of mass fire may be possible. The fire storm develops when a large number of structures are involved in fire over a wide area and ground winds are light. The mass fire develops its own air currents. Convection currents over the fire become very intense, and ground winds develop, moving inward to the fire base from all directions. Upward convection currents and incoming winds at ground level become so intense that a recirculating pattern is set up on the perimeter of the fire storm. The rising mass of heated gas is so intense that it builds up pressure aloft, and these pressures force convection currents on the fire perimeter to spread laterally and be sucked back down to the ground by the lower pressures and the intense inward flowing winds. Because of this re-circulation of combustion products, the air near a fire storm may have a low oxygen content.

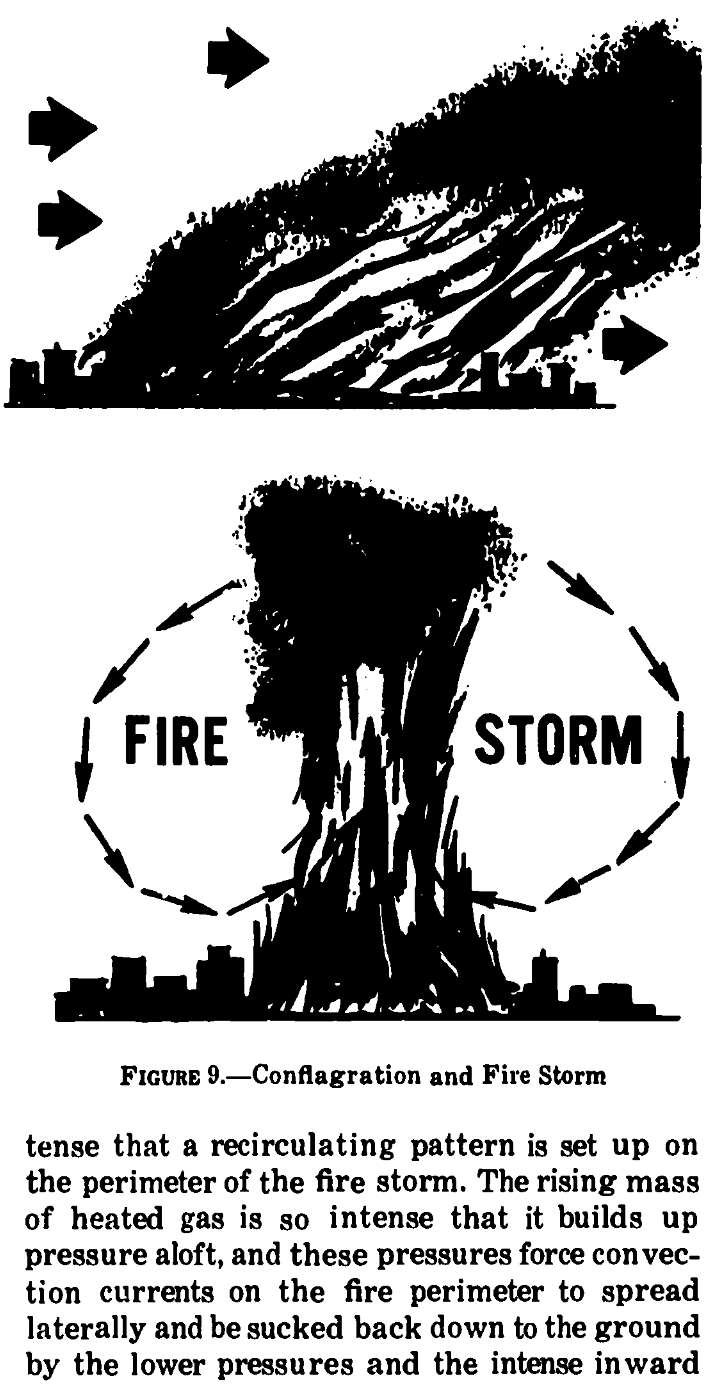


FIGURE 9.—Conflagration and Fire Storm

The conflagration type of mass fire is a distinct possibility in U. S. cities if they were to undergo nuclear attack. Fire storms are considered unlikely for two reasons: (1) a quite large area of combustible buildings is necessary for a fire storm to develop and (2) the destructive power of a nuclear weapon is such that it would quite probably flatten portions of such areas, lessening the probability of a fire storm.

VENTILATION AT FIRES

If we take a davenport and two overstuffed chairs, place them in an open field, and ignite them, the resulting fire will not be difficult to extinguish with a small amount of water. Indeed, we could walk up close and extinguish the fire with a pump tank or pail of water

But if the same furniture were burning in its ordinary location, the living room, extinguishing the fire would not be so easy. In many cases, firefighters would be hampered by the smoke. In some cases, large amounts of water would be used. In other instances, the failure of the firefighters to get in close and quickly extinguish the fire would result in extreme damage to the building.

What causes the difference? The amount of ventilation. The furniture burning outside is no problem because the heat and smoke rapidly dissipate into the atmosphere. The same furniture burning in a building will cause large amounts of heat and smoke to build up within the structure because heat and smoke can't escape to the outside atmosphere fast enough. Consequently, firefighters have to advance to the fire under very unpleasant conditions caused by the confined heat and smoke. Even if they are protected by masks, the high heat will be punishing and lack of visibility will cause problems.

Difficulties posed by the interior fire can be greatly reduced by making the conditions as similar as possible to those of the outdoor fire; that is, by thoroughly ventilating the building. However, ventilation should not be performed in a haphazard manner. It is a subject in firefighting second in importance only to the application of water. In many cases ventilation is essential to permit the proper application of water. Every firefighter should be thoroughly acquainted with it.

What is ventilation?

Ventilation, applied to fire fighting, means the planned and systematic removal of smoke, gases, and heat from a structure.

Why is this done?

Ventilation is performed for any of several reasons:

1. To save life by removing smoke and gases endangering building occupants who are trapped or unconscious.
2. To allow firefighters to enter and remain in the building to extinguish the fire and search for helpless occupants and for hidden fire. At most fires, ventilation permits the firefighters to advance close to the fire and extinguish it with a minimum of time, water, and damage.
3. To prevent backdraft or smoke explosions. The so-called backdraft or smoke explosion is actually an explosion of carbon monoxide and other fuel gases mixed with air. Carbon monoxide is given off at fires where there is insufficient ventilation for complete combustion. If a door is opened and sufficient air enters to mix with carbon monoxide to form an explosive mixture and if there is sufficient heat present to ignite this mixture, an explosion may result. This is a rare occurrence, but a dangerous one responsible for many deaths and injuries; therefore, the possibilities must be considered. Proper ventilation may prevent it or lesson its harmful effects.
4. To control spread of fire. Heat rises until it meets an obstruction, such as a roof or ceiling. It then travels horizontally, seeking an opening where it may rise again. An opening made in a roof will "pull the fire" to that opening and allow it to vent upward into the atmosphere. Air currents are set up that cause the fire to move in that direction and tend to keep it from spreading elsewhere. Such an opening made at another spot will draw the fire to that location.

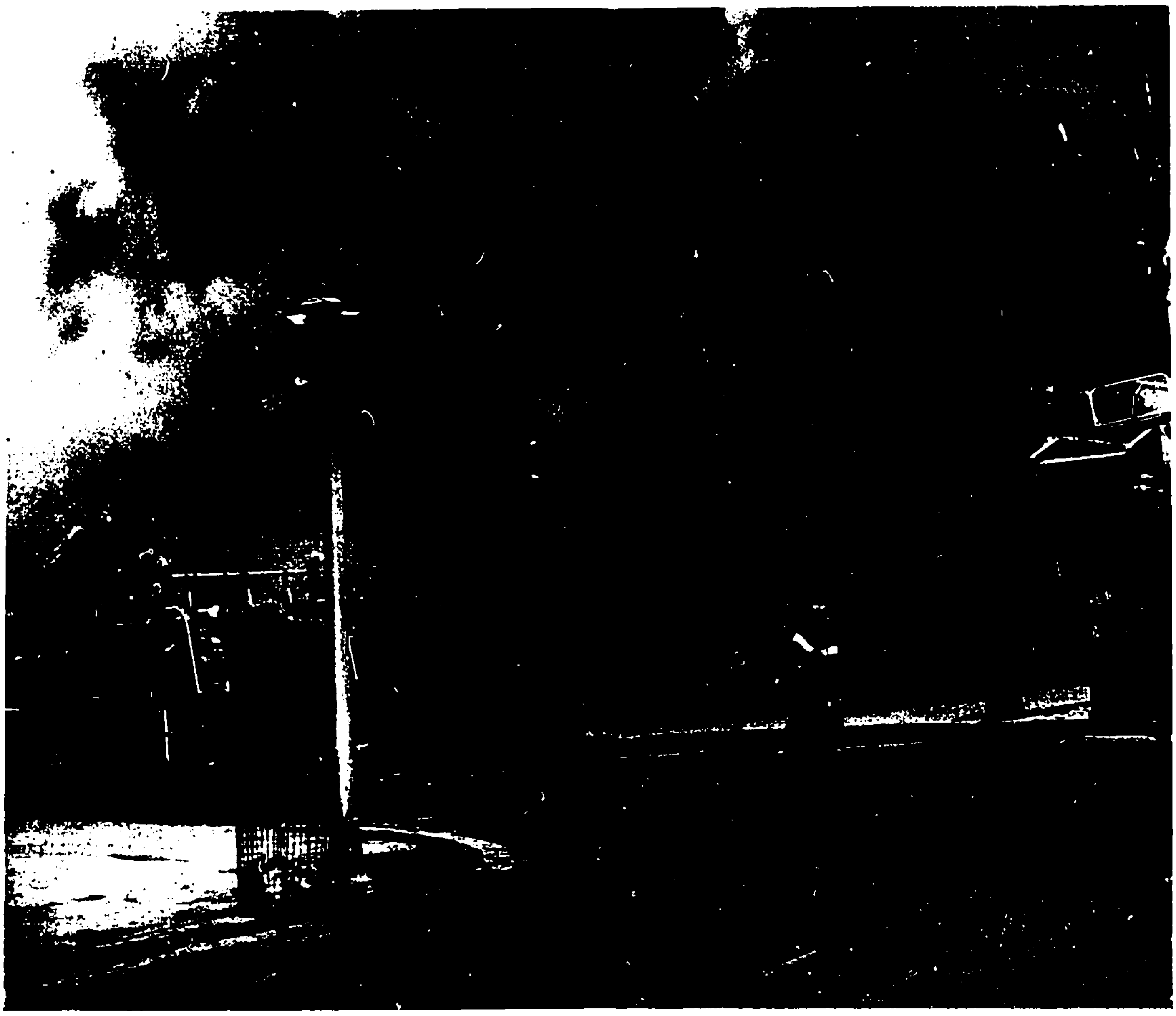


FIGURE 10.—Fire before ventilation

When should ventilation be performed?

Ventilate buildings, ships or other enclosures where smoke is present. Also ventilate where gases or fumes have accumulated from causes other than fire.

When should ventilation start?

Start ventilation as soon as water is up to the nozzle; not before. Ventilation will allow more air to get to the fire; this will accelerate burning, and a charged hose line must, therefore, be ready to be moved into action as soon as ventilation begins. There is an exception to this rule: The skylight, scuttle cover or door at the top of the stairway or other vertical arteries in a multi-storied building may be opened to prevent "mushrooming" (heat and smoke banking up on the top floor), when mushrooming would endanger human life. This can be done without waiting for water.

Where should we ventilate?

1. *At the roof:* Heat and smoke rise, accumulate at the topmost point, and then start banking down. A roof opening will allow the smoke and heat to escape rapidly. When there are no natural openings in the roof such as skylights, scuttle holes, etc. and conditions are not severe enough

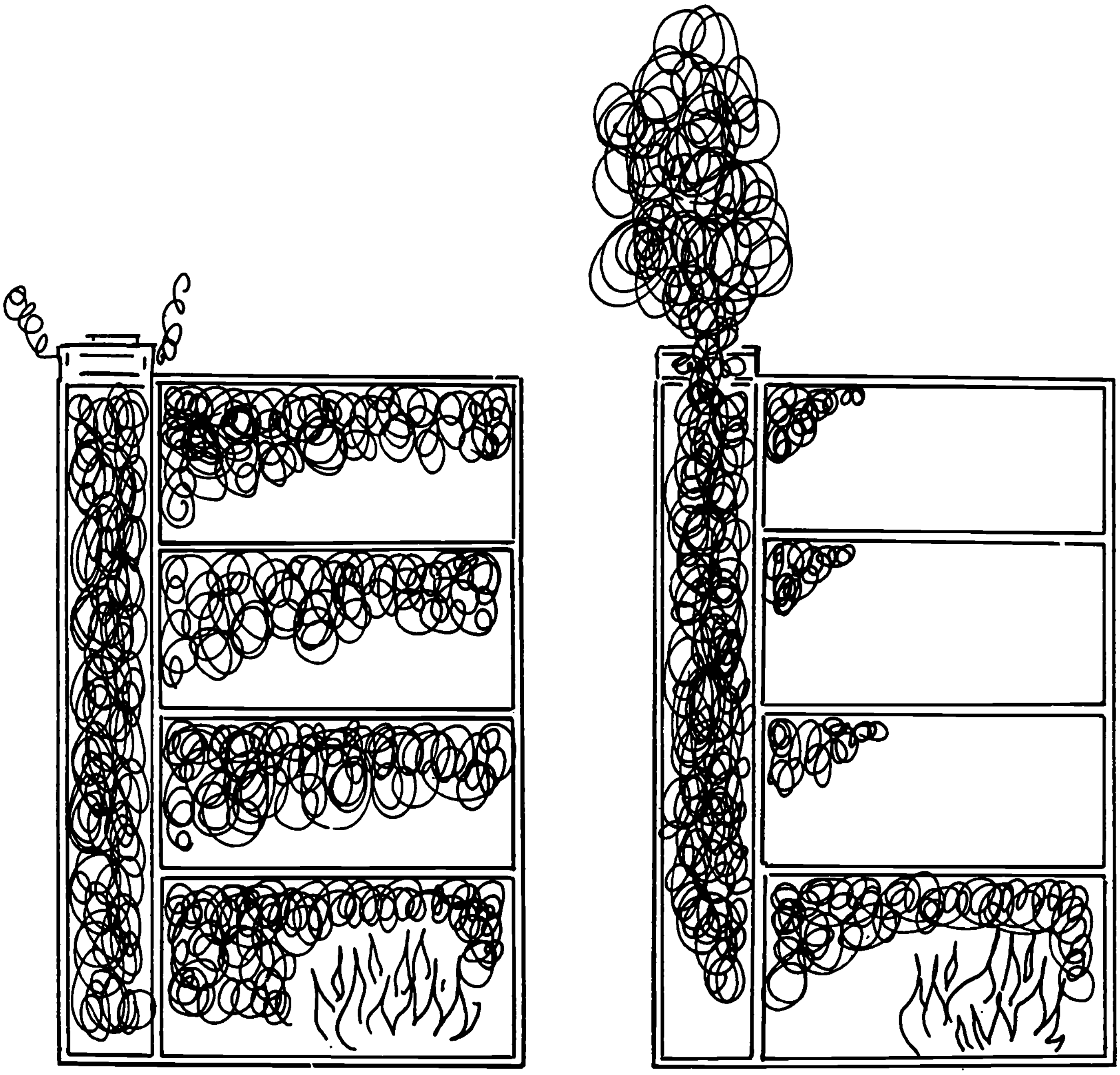
FIGURE 11.—Fire after ventilation

to warrant cutting a hole, ventilation of the attic or top floor may suffice. Roof ventilation is often valuable though the fire is in the lower part of the building, even the basement. A hole may be cut in the roof when fire is in the cockloft or top floor and sometimes when fire is elsewhere in the building but a heavy smoke condition prevails on the top floor that cannot be removed sufficiently by other means.

2. *At windows:* Windows should be opened on the floor where the fire is located and on all floors above that where smoke has accumulated. Usually there is no advantage to opening windows on floors below the fire.
3. *At doorways:* Doors should be opened to permit air circulation to remove smoke.
4. *Other points:* Any other covered or partly covered opening on a level with or higher than the fire should be opened.

How should ventilation be performed?

By opening roof: Firemen go to the roof and remove scuttle covers, skylights, etc., and cut holes in the roof. One large hole is better than several small ones. It should be cut directly over the fire, if possible, but not at a



BEFORE (ROOF CLOSED)

AFTER (ROOF OPENED)

AN OPENING AT TOP OF STAIR OR ELEVATOR SHAFT PREVENTS "MUSHROOMING" OF SMOKE AND FIRE.

FIGURE 12.—Building interior before and after ventilation

point that would endanger an adjacent building. Skylights may be removed by prying them loose at the coaming and lifting the skylight or by loosening the coaming on three sides, leaving the fourth for a hinge, and folding the skylight back onto the roof. When removing the whole skylight is not feasible, individual glass panes may be removed without damage by prying up the metal divider strips and sliding the glass out. If no other means will work, the glass may be knocked out with an ax or any other tool.

By opening windows: On the fire floor and floors above it, the windows should be opened. If conditions permit, this should be done by firefighters working from the inside. Blinds and shades should be raised or removed and drapes and curtains pushed back or removed to permit the smoke to escape. Screens should be removed and storm windows removed or broken out. Some say that double hung windows should be opened ⅔ of the way from the top and ⅓ from the bottom, but this is of little consequence. The main point is to get the window open at the top and let the smoke escape. Fresh air will find its way in to replace it. Good cross-ventilation can be accomplished by opening the windows on the leeward (away from wind) side of the building at the top, and those on the windward side from the bottom, allowing the wind to blow in the open bottoms and pushing the smoke out through the open tops.

Casement and factory-type pivoting windows have to be opened according to their design. Many windows are difficult or impossible to open in the allotted time. If some conditions warrant it, they should be broken. Glass is the cheapest part of the building. Much valuable property has been destroyed by fire because firefighters hesitated to break windows that couldn't be opened.

A quick way to break windows above the ground floor is to raise a ladder and let the top of it fall against the window. It can be moved from window to window, doing the job much quicker than could be done by a man working from a ladder—and is safer. However, there is danger from falling glass whenever glass is broken; therefore, men at the base of the ladder should avoid looking up when the ladder is dropped in or pulled out. Above the plate glass show window in most stores there is usually a lighter glass transom. This is easily broken and often affords adequate ventilation; the show window is allowed to remain intact. In extreme cases the whole show window may be removed. In either situation, if there is a partition between the store and show window, it must be removed.

Basement Fires

Basement or cellar fires present special ventilation problems. Of course windows, when present, and doors should be opened. Sometimes windows are recessed in enclosures and covered with an iron grating at street level. This grating may be removed by breaking the concrete at the corners; or the bars may be spread and a pike pole inserted to break the window glass. When deadlights (small sections of heavy glass) are present in the sidewalk over a basement, they may be knocked out with the back of an ax or a maul. Removing coal chute covers may also assist ventilation. In some stores, removing panels under the front of the show window gives direct access to the basement, affording good ventilation. Where no other means is effective a hole may be cut in the floor above the basement. This must be guarded by a charged hose line. Hot air heating grilles in floors can be used by removing the grille and pushing down the hot air duct. This will have the same effect as cutting a hole in the floor and is quicker and less damaging.

Venting Entire Building

When an entire building is to be ventilated, such work should generally begin at the top of the structure and proceed downward, floor by floor. If the lower part of the building is opened first, fire may break through the window openin there and make ventilation of upper floors impossible—or even endanger men who may be ventilating or performing other duties above the fire.

Mechanical Ventilation

In addition to the methods of ventilation by natural means, movement of smoke, gases, and air can be forced by mechanical devices. Fans of varying sizes are used by many fire depart-

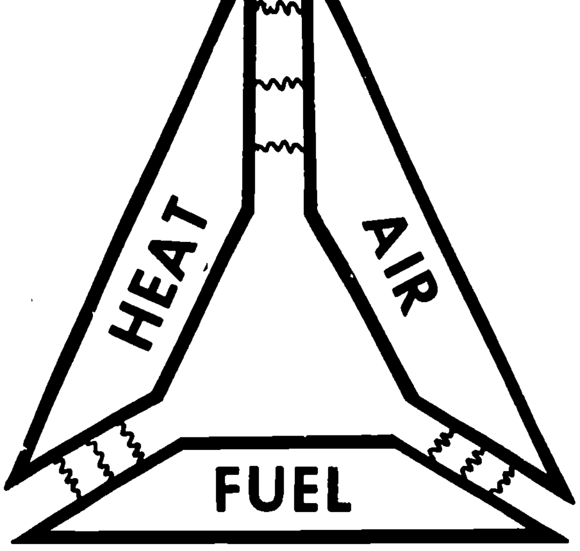


FIGURE 4.—The Fire Triangle

it at its weakest point. To take full advantage of these inherent weaknesses it is helpful if the firefighter has a more complete understanding of the three components of fire than was included in the "Support Assistant" A course.

Oxygen

Oxygen (O) is the most important and plentiful of the elements, making up 21 percent of the atmosphere, about 89 percent (by weight) of water, and about 32 percent of the earth's outer surface.

For simplification, the terms "oxygen" and "air" may be used interchangeably in this manual when referring to fire behavior. It must be

ments. These usually range from 5,000 to 15,000 cubic feet per minute capacity. Common fog nozzles induce a great amount of air to follow the fog stream and can move from 10,000 to 30,000 cubic feet per minute, depending upon size, type, fog pattern, and location of nozzle.

Since the use of fans has become popular, there is a noticeable tendency of some fire departments to neglect natural ventilation. Indeed, many poorly trained fire departments depend almost entirely on mechanical ventilation and overlook the advantage of opening windows, etc, as previously described. Smoke ejectors can be valuable when properly used, but they are best when used as an adjunct to natural ventilation or in cases where natural ventilation is ineffective. In many instances, the time and energy used to put smoke ejectors to work would be better used in effecting natural ventilation.

After normal means of natural ventilation have been accomplished and results are not satisfactory, the smoke ejector can be put to work. It must be remembered that if not properly used, these fans can do more harm than good. An exhaust fan will draw the smoke and fire toward the place where the fan is located; therefore, the location of the fan must be carefully selected. This problem was exemplified at a fire in the attic of a one-story dwelling. The firefighters were able to enter the ground floor with ease; only a slight amount of smoke was present there. They placed a blower fan in the front doorway and an exhaust fan in the rear doorway. In a moment a large volume of smoke was drawn from the attic into the first floor, and the firefighters were driven out of the building.

Fog nozzles have been used for ventilation for more than 80 years; yet, today many fire departments use them only for extinguishing the fire. To remove smoke with a fog nozzle, the nozzle is held inside the window or doorway and aimed toward the outer air. Experiments show that the wider the fog pattern, the greater the air movement, but the pattern should not cover the entire opening. Also, better results were obtained when the nozzle was a few feet from the opening than when it was close to it. The same precautions mentioned for using fans apply also to using fog nozzles for ventilation; in addition, care must be exercised to avoid water damage.

Ship Fires

Some fire departments may be called upon to fight fires aboard sea-going cargo ships. Ventilation aboard these ships calls for "trimming" ventilators (that is, turning the ventilating funnels away from the wind), removing hatch covers (it should be remembered that there may be additional hatch covers at the "tweendeck" level), and opening lazaret hatch doors.

Engine rooms are often equipped with skylights similar to those on the roofs of buildings, which may be treated in the same manner to effect ventilation.

Precautions

Remember that a hose stream aimed into a window, doorway, skylight, hole, or other opening has the same effect of nullifying ventilation as if the opening had a cover placed over it.

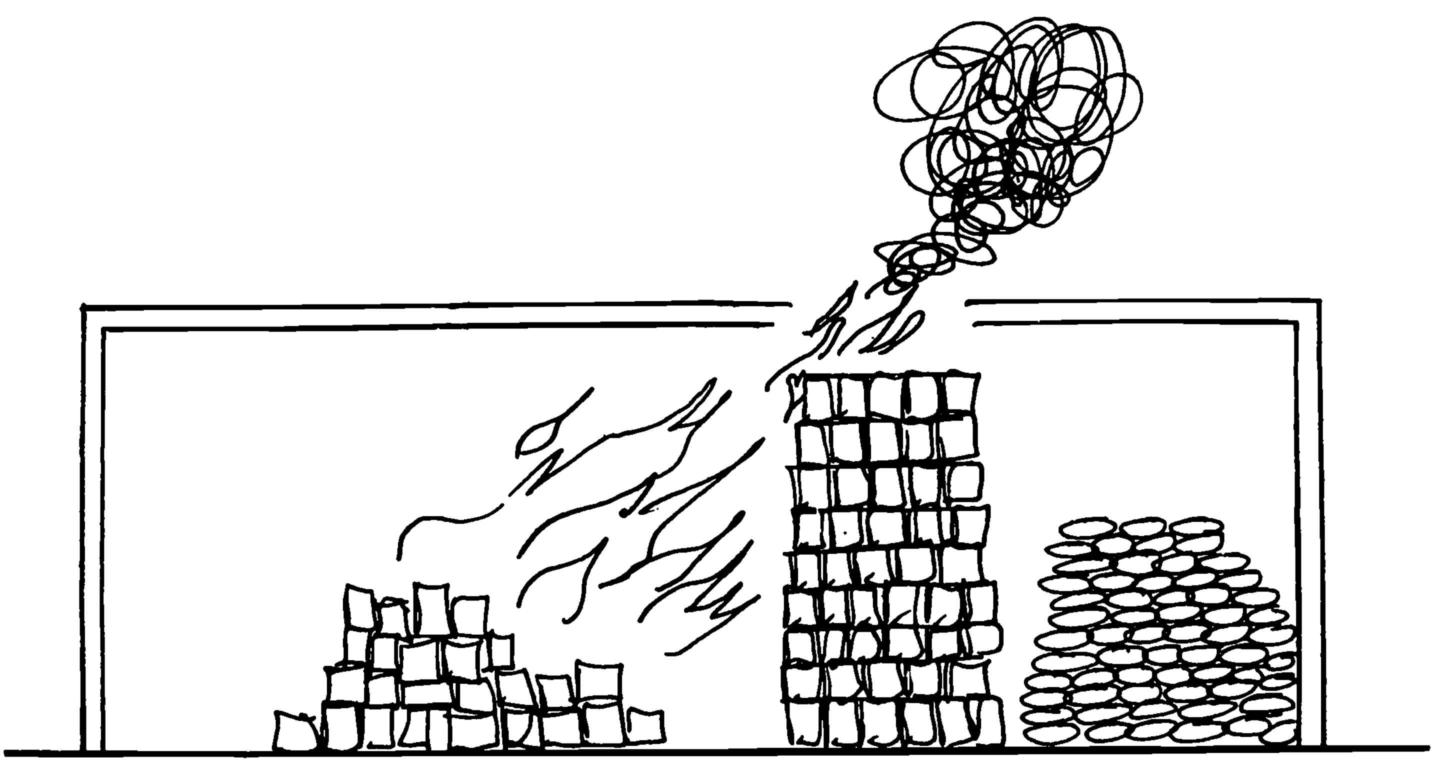
Openings should not be made where they may jeopardize nearby structures by extending the fire unless adequate protection in the form of hose streams is at hand.

When holes for ventilation are cut in a floor, they should be near a window if possible. The smoke will go through the open window, and if the men with the protecting hose line are driven out of the building, upward extension of fire through the hole can be prevented by a hose stream from the outside through the window.

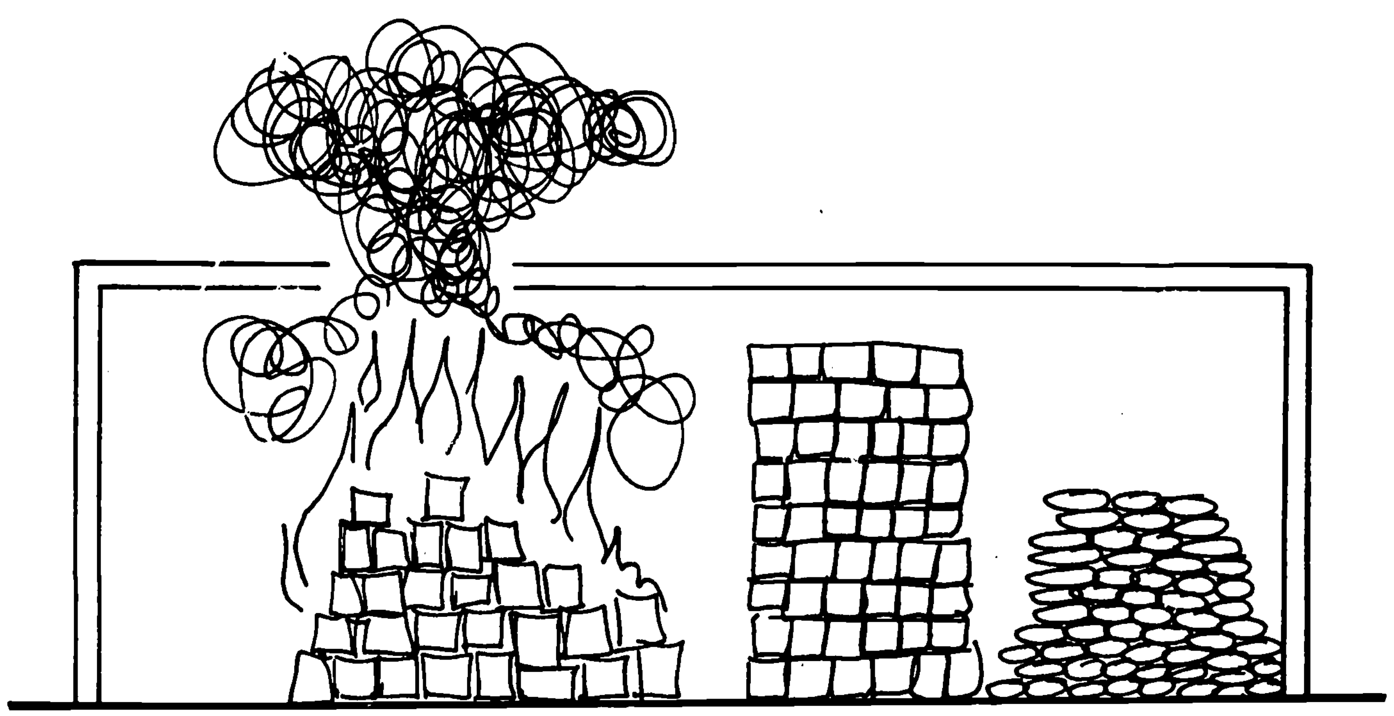
It is not desirable to cut holes in the firefighters' path of travel because they may step into them.

Whenever a hole is cut in roof or floor, or whenever a skylight or scuttle cover is removed, the opening should be probed with a tool to find if there is any obstruction, such as a ceiling, below the hole. When such an obstruction is found, it should be opened or pushed down.

When breaking glass, make sure no one below will be struck by falling glass. Warning should be given in ample time.

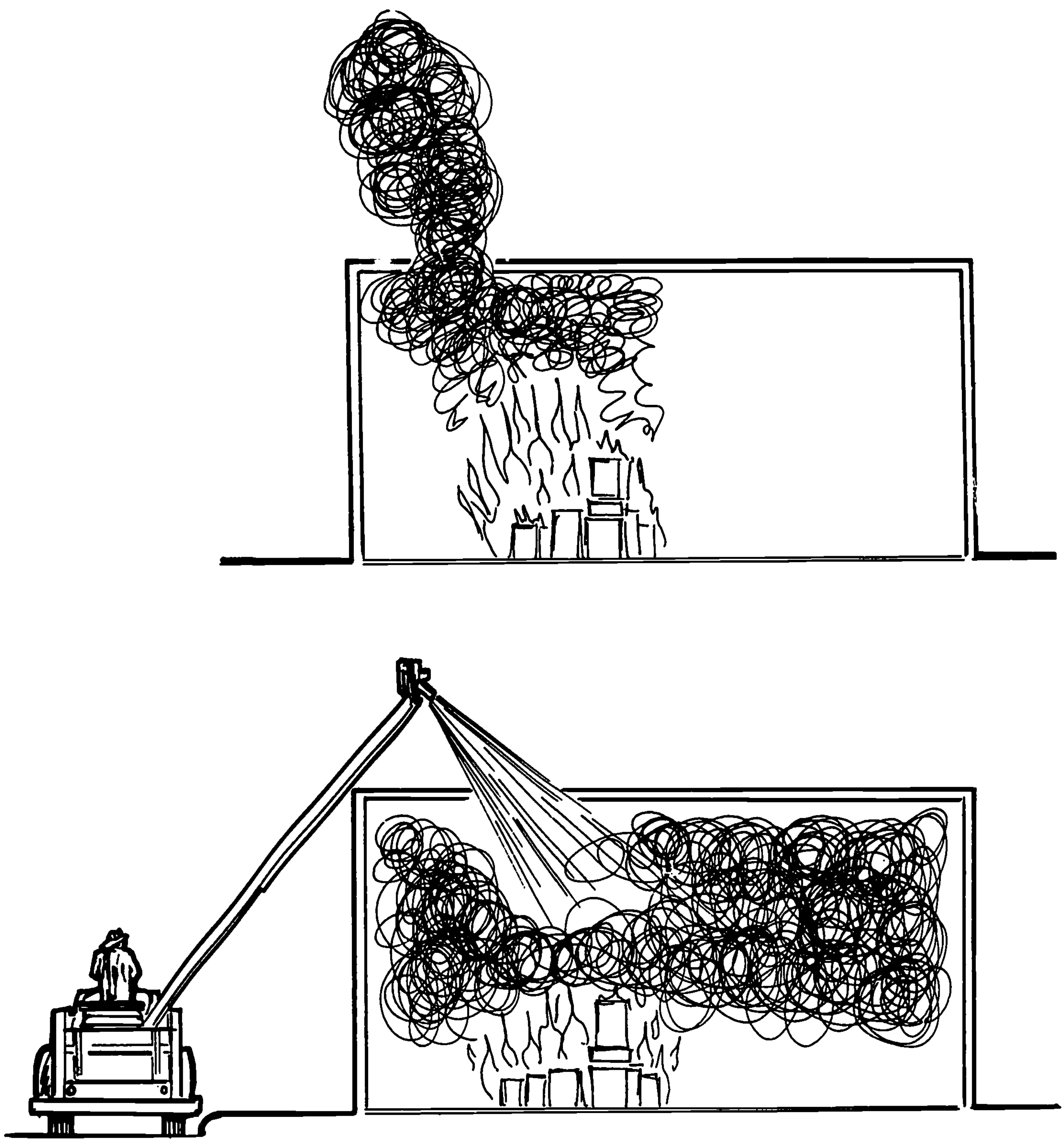


WRONG- DRAWS FIRE TO OTHER END OF BUILDING.



CORRECT-HELPS TO HOLD FIRE NEAR POINT OF ORIGIN.

FIGURE 13.—Correct ventilation will hold fire near point of origin



LADDER PIPE STREAM SHUTS OFF VENTILATION FROM HOLE IN ROOF, THUS CREATING HEAVY SMOKE CONDITION IN BUILDING.

FIGURE 14.—Ladder stream may nullify ventilation

FORCIBLE ENTRY TOOLS

It is easy for the average citizen to understand why firefighters use water to extinguish fire, but most people do not appreciate the great need for the other phases of firefighting performed with tools rather than water. Locked doors must be forced to gain entry and locked windows opened or broken for ventilation. Floors, walls, and ceilings must be opened to discover and extinguish hidden fire.

Most of this work is performed with the same few versatile tools, known as forcible-entry tools to distinguish them from tools used primarily for other purposes. Those most frequently used are the ax, pike-pole (hook), and claw-tool. There are several others; some are general purpose, such as the Halligan Tool and the pry-ax. Others are for specialized use, such as the Hale and Detroit door openers, both of which are made to force doors inward.

COMMONLY USED FORCIBLE ENTRY TOOLS

The Ax

The Ax is a tool that certainly predates organized firefighting but that was adopted for fire service use with some modification. In firefighting, although the primary function of the ax is cutting, it is used for such purposes as removing baseboards and trim, lifting off shingles and other roof coverings, forcing locked doors and windows, and other uses that are not chopping operations. Consequently, fire departments use both flat-head and pick-head axes. The pick-head ax can be used for "picking" and *minor* prying, as well as cutting, but a wood ax handle will not stand the strain of heavy prying. The advantage of the flat-head ax is that the flat back can be well used as a hammer, especially in driving other tools, such as the claw, Kelly, or Halligan.

Ax blades should be kept reasonably sharp, and a sharp blade is a hazard if not carefully handled. When carrying or using an ax, a man should be careful not to injure himself or others. Those nearby when an ax is being used should be careful not to step into a position where they could be injured.

The Pike-Pole or Hook

This tool, called a hook in some sections of the country, is more commonly called a pike-pole. It comes in various lengths of which the 6-foot length is the most useful; although lengths up to 20 feet are also carried for special use. The most frequent use of the pike-pole is for pulling down ceilings to discover hidden fire. The ideal pole length for this purpose is two feet less than the distance from floor to ceiling; i.e., 6 feet when ceiling is eight feet high.

The pike-pole is also used to make openings in plaster walls, to break windows that can't be opened, and in many other cases, when it is necessary to move an object beyond ordinary reach. Remember that this tool is designed for pulling, not prying. The handle will break under strenuous prying.

The pole should be carried in a careful manner to protect others from the sharp point. Careless use has caused many injuries both to the user and others working near him.

Particular care should be taken to protect eyes and face from plaster and other materials suddenly pulled loose and to not strike others with the long handle, especially when working in close quarters.

The Claw-Tool

The claw-tool (called a "New York bar" in parts of New England) is made of heavy steel and is designed for strenuous prying. It has a multitude of uses such as breaking padlocks; forcing locked doors; prying up floor boards; removing molding, trim, etc.; making wall openings; shutting off gas service valves; and countless other tasks that require leverage.

In certain cases the hooked end or "claw" is quite useful, and in many others the forked end is used to advantage.

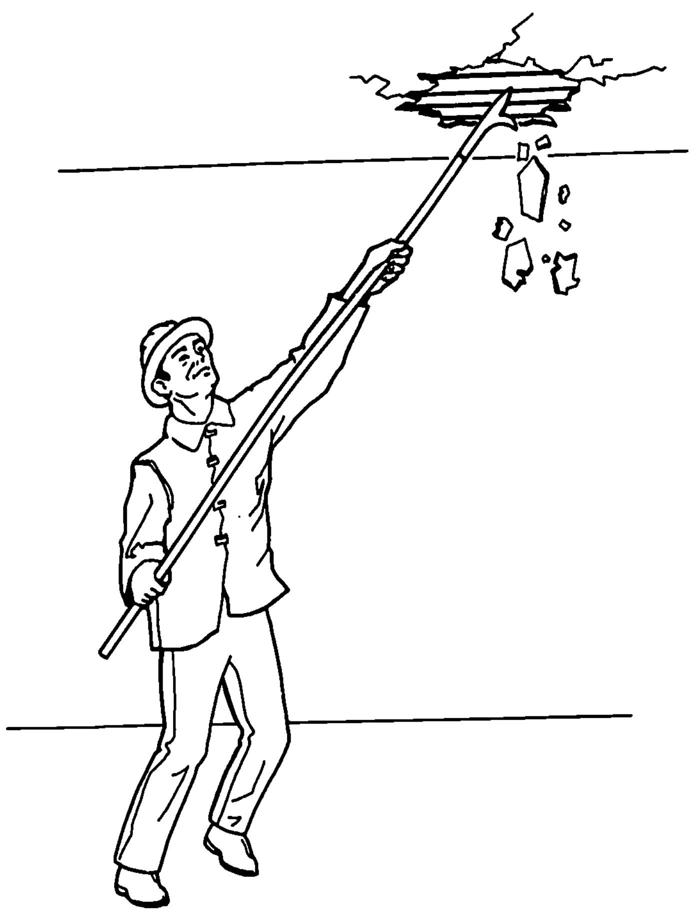


FIGURE 15.—The Pike-Pole

Other Hand Tools

Although, the ax, pike-pole, and claw-tool are the "big three" of forcible entry tools, there are others that can supplement or even replace them. One is the Kelly tool, a steel bar that is excellent for forcing doors that open outward. But it lacks the versatility of the claw-tool. The Halligan Tool is a combination of the best features of the claw and Kelly tools and can be used to do everything that both those tools can do. The pry-ax is another multipurpose tool—probably the most versatile—because it combines features of the ax, claw-tool, and Kelly tool.

Power Tools

Many fire departments are now using power tools to speed up ventilation and overhauling work. Portable power saws, both rotary blade and chain saw, are used to cut floors and roofing. Some power-saw blades can cut metal and concreate. Air hammers and drills are also used.

USING FORCIBLE ENTRY TOOLS

Forcible entry tools are used largely for three purposes: ventilation, overhauling, and forcible entry. Ventilation has been described in a previous chapter. Overhauling will be discussed later.

Forcible Entry

Forcing entry into a locked building does not involve much theory; it is mostly a matter of applying leverage and is best learned from demonstration and by observation. This does not mean that forcing entry is not an important subject. It is an art that can have strong bearing on the outcome of a fire. Considerable skill is required to force entry in a manner that will save time and lessen damage.

There are several types of doors, and the methods of forcing them vary with type of door involved.

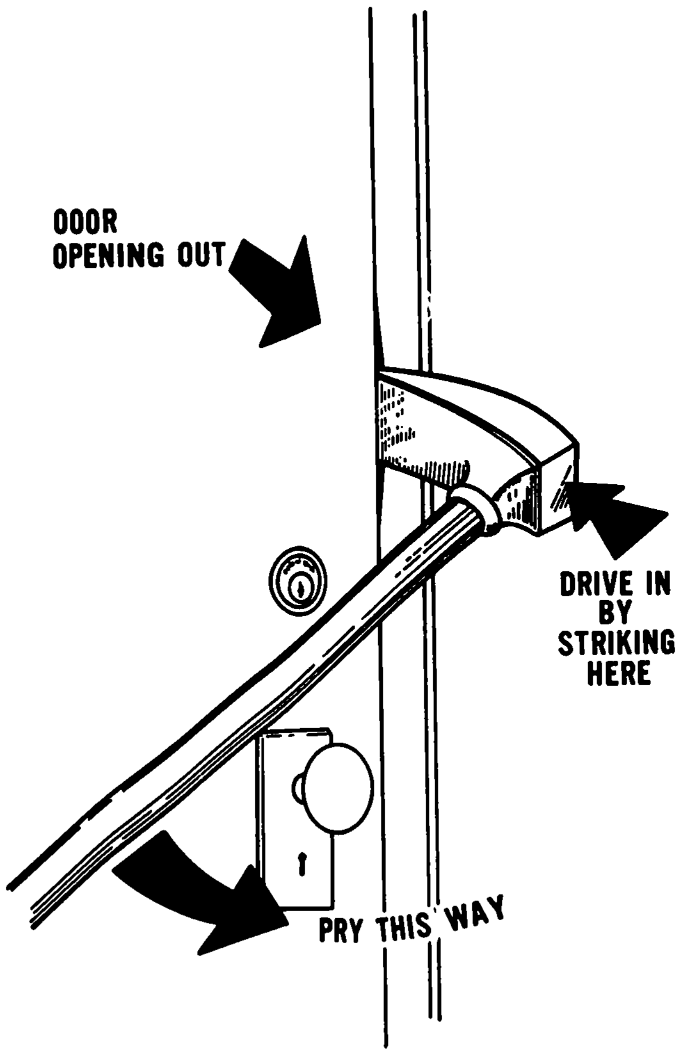
Forcing Locked Doors

Forcing locked doors is a job that calls for more skill than force if done properly. Consideration must be given to the type of door and the way it opens in deciding upon the method and tools to be used to force it. Doors are usually forced in the direction they normally open (in, out, or up).

Forcing doors that open out, or toward the operator, is usually best accomplished by driving the adz end of a Kelly or Halligan tool into the crack between the door and jamb, just above lock, and using the back of an ax as a hammer, until this end of the tool has a sufficient "bite." Then the bar is pulled toward the operator, prying the door open.

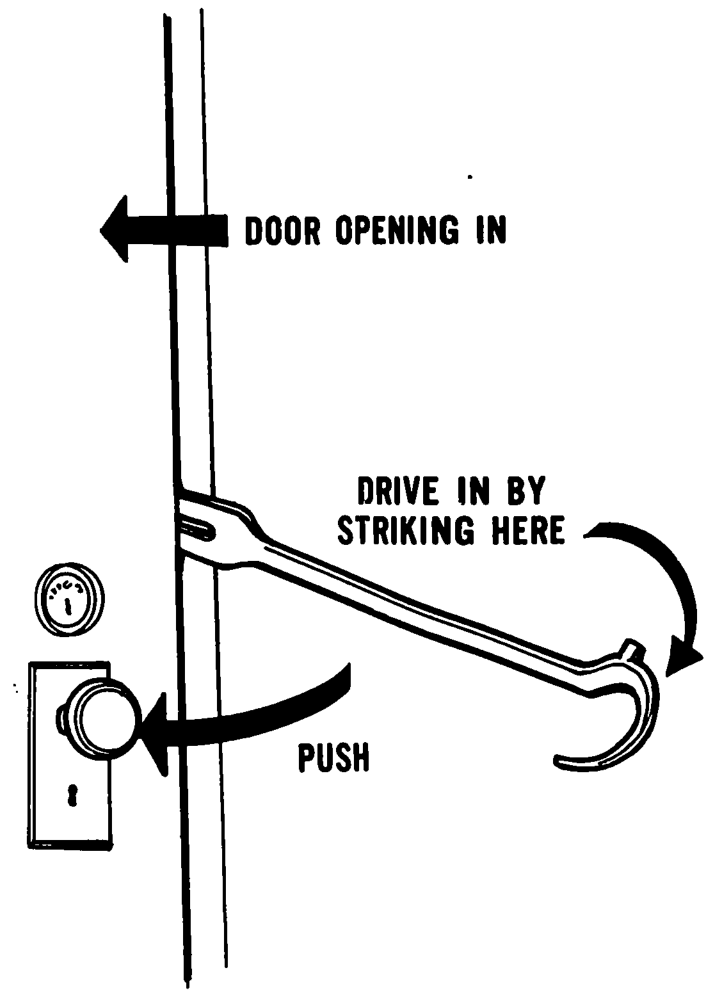
Another method for doors that open out is to remove the hinge pins, and pry the door in the manner described above, except that the tool is driven in on the hinge side of the door. Sometimes a door with a glass panel can be best forced by breaking the glass and opening the lock from the inside if it is obvious that the lock can be opened from the inside without a key.

Doors that open inward are usually forced by driving the forked end of a claw-tool, Halligan tool, pry-ax or the similar end of a Kelly tool into the crack between the door and jamb just above the lock, using an ax for a hammer. When



KELLY TOOL

FIGURE 16.—Use of Kelly Tool



CLAW TOOL

FIGURE 17.—Use of Claw Tool

the tool end has been driven in sufficiently far, the door is pryed inward.

Another method, which works well when the door is on a street entrance, is to place the end of the ladder against the lock side of the door with the end of one beam above the lock and the end of the other beam below. If four or five men grasp the ladder, hold it parallel to ground, and push it steadily against the door, the door will usually spring open. The ladder should be pushed steadily and not banged against the door or used as a ram because such use might damage the ladder.

There are many other door types such as overhead, revolving, sliding, etc., and there are many varieties of locks including types that are quite difficult to force, such as the Fox and the Siegal. There are not many districts where these locks are common. The fire officers in those districts who have had experience in forcing such locks can demonstrate methods found effective. It must be realized, however, that there are some doors that cannot be forced or removed in a reasonable length of time and that *in some cases other means of entry must be found.*

Forcing Windows

There are many varieties of windows and types of locks. Entry can be gained in many cases by breaking out the glass. If glass is broken to provide entry, then care should be taken to remove all jagged shards of glass that could cause injury to anyone climbing in or out through that window.

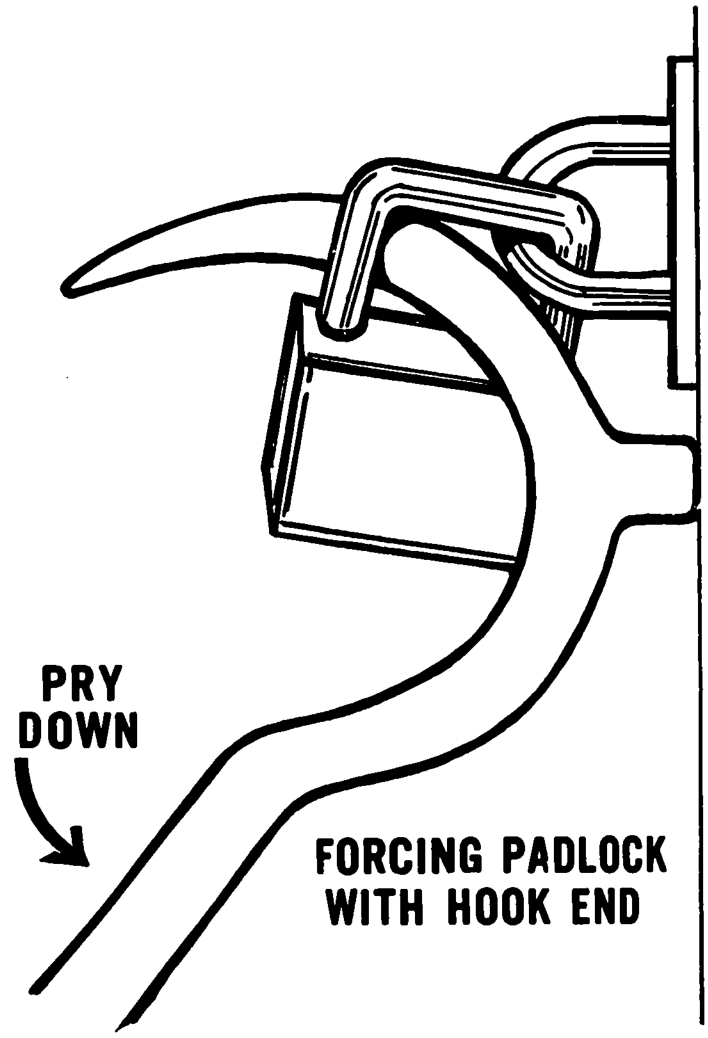


FIGURE 18.—Use of Claw Tool on Lock

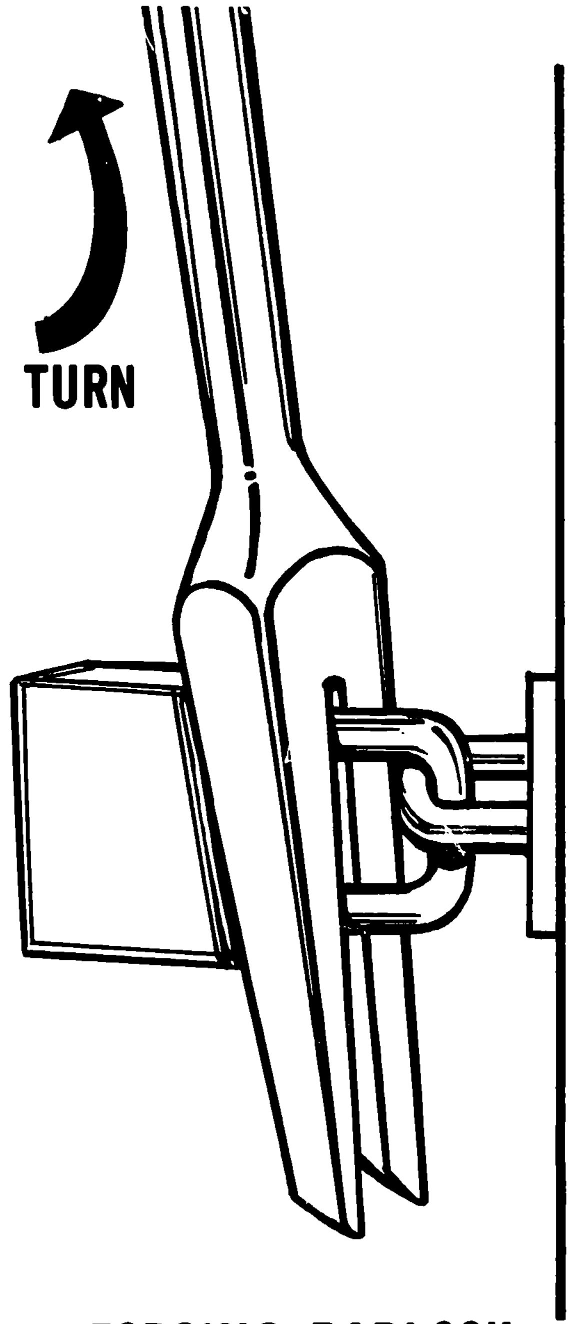


FIGURE 19.—Use of Fork End on Padlock

THE USE OF ROPE AND BASIC KNOTS

There are several situations where the rope can be used in firefighting. It is used to hoist hose lines, ladders, and tools to the roofs of buildings; to lower unconscious persons from the upper portions of buildings, and to lower firefighters to make rescues. Rope is also used to secure hose lines to substantial objects, and there are various other ways that rope can be quite useful to firefighters.

Rope comes in several sizes. The most *common* sizes used by fire departments have diameters of 5/8 or 3/4 inches and lengths of 100 or 150 feet. Although rope is available made from different kinds of natural and synthetic fibers, the most common in the fire service are: manila, sisal and hemp.

In using rope, a large margin of safety should be allowed. A rough rule is not to exceed one seventh of the breaking strength of the rope. The breaking strength may be roughly calculated by multiplying the square of the diameter of the rope (in inches) by 7200.

One reason for a large safety factor is that a bend or knot sharply decreases rope strength at that point as long as the bend or knot exists.

The following table is for 3-strand manila rope:

DIAMETER INCHES	CIRCUMFERENCE INCHES	STRENTHS BREAKING	WORKING
1/4	3/4	600	120
3/8	1 1/8	1350	270
1/2	1 1/2	2650	530
5/8	2	4400	880
3/4	2 1/4	5400	1080
1	3	9000	1800

FIGURE 20.—Rope table

Care of Rope

Vegetable-fiber ropes are subject to damage from mildew and mold and, therefore, should be kept in a dry place and dried thoroughly after being wet.

Rope should be inspected periodically and after use. When any of the following conditions, which may indicate serious weakening of the rope, are discovered, they should be reported to the appropriate officer:

1. burns
2. cuts
3. broken fibers
4. extreme softness (sign of much wear)
5. other unexplained condition or color

These items can be detected by visual external examination. There are other weaknesses which show only when the *inside* of the rope is examined. This can be done by separating the strands at three-foot intervals along the length of the rope and looking for:

1. broken fibers
2. fine powder
3. mildew or mold
4. change in color

Knots, Hitches and Bends

Most of the common "knots" are more properly called bends. A "bend" is a way of fastening a rope to itself or to another rope. A "hitch" is a method of attaching a rope to a post, hose line or other object.

Another common term in the use of rope is the word "bight." A bight is made when the rope is turned back on itself forming a partial circle.

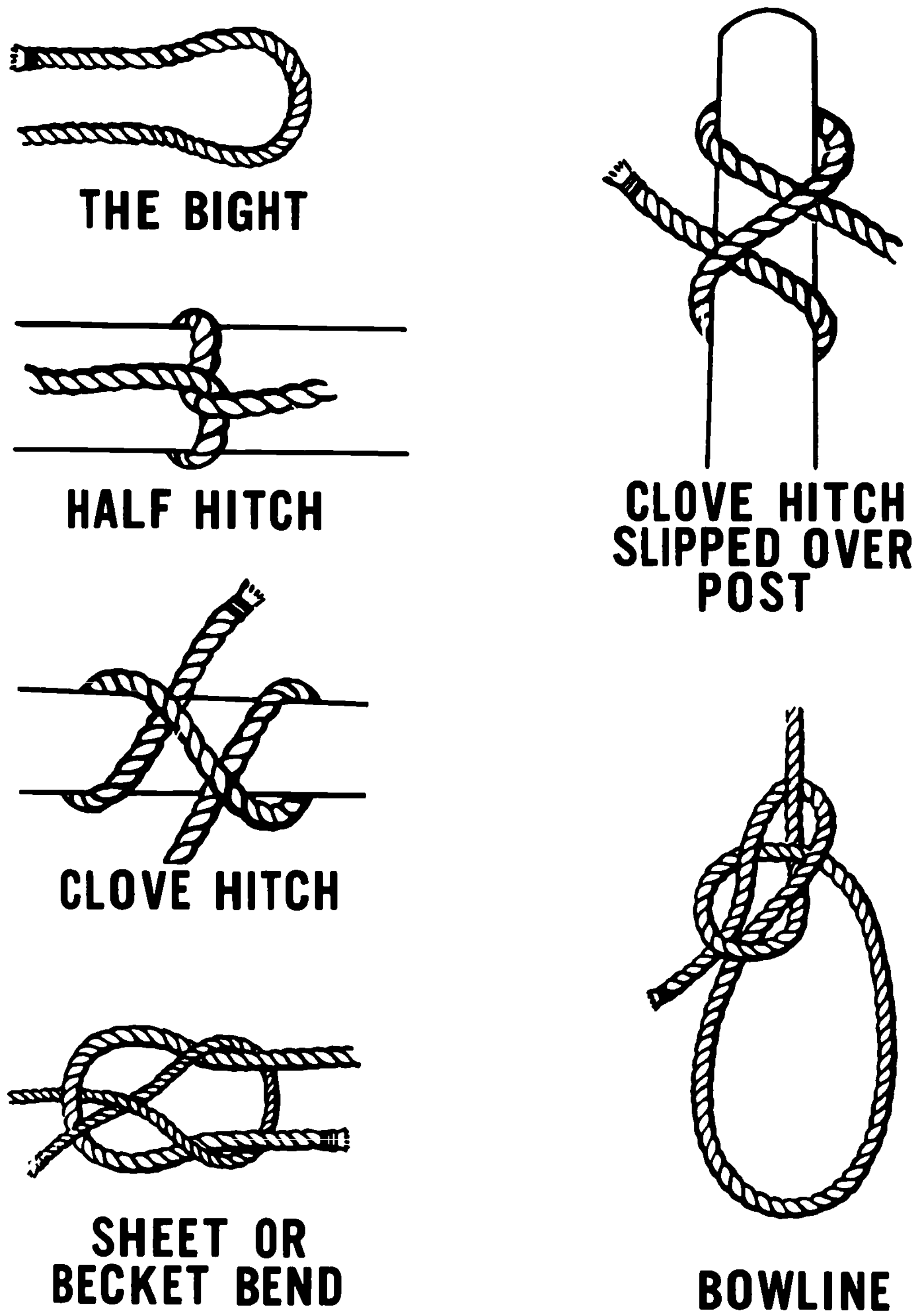


FIGURE 21.—Common knots used by firefighters

Half Hitch.—The simplest hitch is that known as the "half hitch." It is easy to make and although it is not often used alone, it is frequently combined with other knots and hitches. In the half hitch, the free end of the rope is brought under itself in a bight.

Clove Hitch.—One of the most commonly used hitches, the clove hitch, is used to fasten a rope to a post, pipe or similar stationary objects and is also used to attach a rope to hose or tools and equipment that are to be hoisted or lowered. It is similar to the half hitch, but is a more complete hitch because it involves two turns of the rope (going in opposite directions) and will not become undone if properly tied. The clove hitch is sometimes called, "two half hitches," because it consists of two half hitches leading in opposite directions.

Two Ways of Tying the Clove Hitch.—1. Ordinarily, the clove hitch is tied by taking two turns around the object (post, hose, pipe, etc.). On the second turn, the short end is taken over the first turn and then under itself to complete the turn.

2. If the post or object over which it is to be tied is short enough for the hitch to be dropped over the tip of it, there is a quick way to tie the clove hitch. One bight is made to the right and one to the left; one is then moved over the other, and both are dropped over the object and pulled tight.

Bowline.—The bowline is called "the knot that never slips" and is used when a nonslipping knot is required. It often is used in the end of a rope.

To tie a bowline, start by making a bight in one hand (the left hand for a right-handed person), with the long part of the rope forming the top of the bight. The short end of the rope is taken in the other hand, passed through the bight around the long part of the rope, and back through the bight.

Sheets Bend or Becket Bend.—The sheet bend, also called the becket bend, is sometimes referred to as the fisherman's bend. It is used to tie two ropes together, especially two of different diameter. A bight is made in one rope and held in one hand with the index finger pointing along the top of the bight. The other rope is held in the other hand. The end of it is put through the bight, passed over the index finger, and taken around both sides of the bight before being passed through the bight again, thus making a bight in the second rope. The bights are held, one in each hand, and pulled until tight.

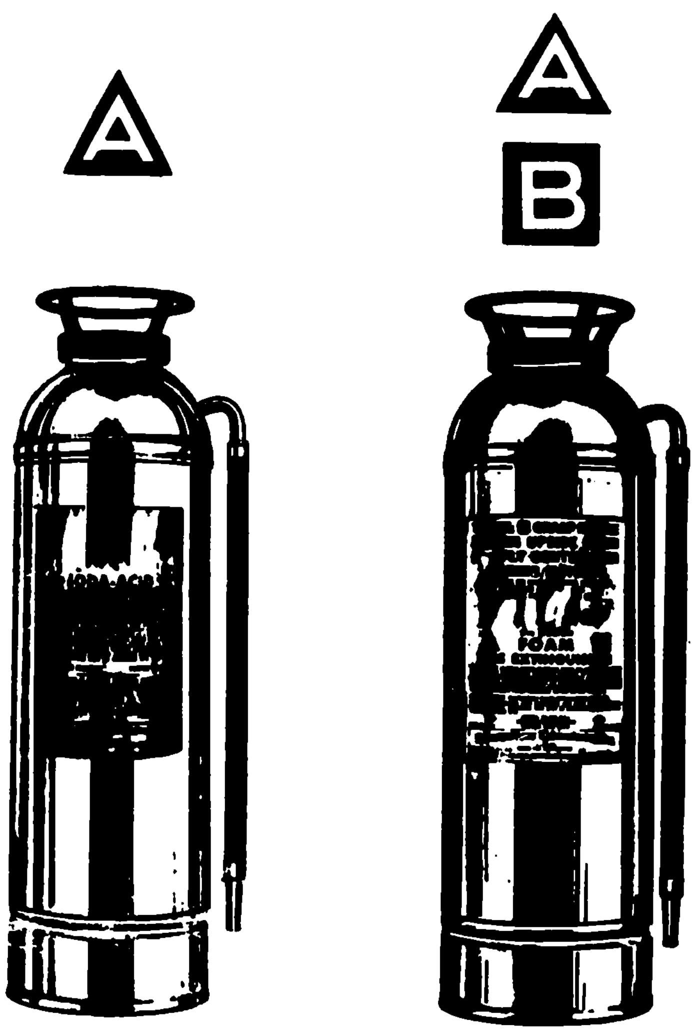
Measuring Rope.—In the long run, time will be saved if the man about to tie a knot will measure the rope to insure that he has sufficient rope. The rope can be measured by holding one hand in front of the face and the other at arms length. The length from face to hand will approximate three feet. The amount of rope needed for each knot can be determined by practice and should be remembered for fireground application.

OPERATING CHARACTERISTICS OF PORTABLE EXTINGUISHERS

Extinguishing agents and the methods of expulsion used with portable extinguishers were covered in "Support Assistant" Part A. In this manual the operating characteristics of the etxinguishers will be considered, as well as some maintenance procedures. Extinguishers found in buildings usually have tags attached that indicate when they were last recharged or serviced. Checking these tags against the maintenance information in this chapter can give some indication of the condition of the extinguisher.

Soda Acid

The soda-acid extinguisher is a water agent to be used only on burning Class A materials. This extinguisher is found in 2½, 17, and 33 gallon sizes. The 17 and 33 gallon are wheeled units. The most common size is the 2½ gallon. This extinguisher must be inverted so that the 4 ozs. of sulphuric acid will be mixed with the 2½ gallons of soda water to cause a chemical reaction and pressurize the extinguisher. The stream produced will reach between 30 to 40 feet, and the extinguisher will be discharged in about one minute. This type of extinguisher may be turned off by setting the extinguisher right side up. The soda-acid extinguisher must be recharged immediately after use and must be recharged at least once every 12 months. The extinguisher, in fact, must be stored in heated areas.



Soda Acid Foam

FIGURE 22.—Soda acid and foam fire extinguishers

Foam

The foam extinguisher agent contains 2½ gallons of water, and therefore, may be used on surface fires involving Class A materials. The extinguishing agent discharged from the extinguisher is a tough foam made up of bubbles filled with carbon dioxide gas. This is an effective smothering agent, found in the 2½ gallon size. However, wheeled units of the 17 and 33 gallon size are available. The 2½ gallon foam extinguisher is identical in outside appearance to the 2½ gallon soda acid. As with the soda acid extinguisher, its action is chemical, and it must also be inverted to operate. When the extinguisher is inverted, the two chemical solutions react to form CO_2 gas to pressurize the extinguisher and to make about 17 to 20 gallons of foam. When using the foam extinguisher on burning Class B fuels, completely cover the surface of the fuel involved to prevent flashback. The stream of the foam extinguisher has a

range of from 30 to 40 feet, and the unit will be discharged in approximately 1½ minutes. The extinguisher will require recharging immediately after use and must be recharged every 12 months. The extinguisher will freeze and must be stored in heated areas.

Air-Pressurized Water

The air-pressurized water extinguisher contains 2½ gallons of water, and should only be used on burning Class A fuels. The unit is pressurized by 90 to 150 pounds of air pressure and may be put into operation by pulling a safety pin and operating a squeeze-type handle valve located on the extinguisher's top. This extinguisher may be operated intermittently by opening and closing the valve. The extinguisher stream has an effective range of from 30 to 40 feet and will be discharged in about one minute under continuous operation. The extinguisher must be recharged immediately after use. Normal maintenance of this extinguisher involves checking the air gauge to determine if there is sufficient air pressure in the extinguisher to expel the agent. Under normal conditions it is not necessary to recharge this extinguisher until it has been used. A wetting agent added to the water in these units will increase the effectiveness. The unit will freeze and must be stored in heated areas.

Air-Pressurized Loaded Stream

The air-pressurized loaded stream extinguisher looks and operates exactly as the air-pressurized water. This extinguisher is available in a 1-gallon size through 17 and 33 gallon wheeled units. It is most commonly found in the 2½-gallon size. The extinguishing agent is a water base with chemical additives that have some fireproofing effect on Class A materials. The chemical also has an emulsifying effect on the surface of Class B fuels. The extinguisher will not freeze down to −40° below zero, and, therefore, it may be placed in unheated areas. The maintenance of this extinguisher is the same as that of the air-pressurized water.

Cartridge-Operated Water

This is a water extinguisher that may be used only on burning Class A fuels. It is found in the 2½ gallon size. The method of operation is to invert the extinguisher and bump it on the floor. This action punctures a CO_2 cartridge that pressurizes the container, forcing the extinguishing agent through the hose. The extinguisher may be turned off by setting upright and allowing the gas to drain off throuh the hose. The effective range of the stream is from 30 to 40 feet, and the discharge time is approximately one minute. The extinguisher must be refilled and a new CO_2 bottle installed immediately after using. Although the extinguisher requires no annual recharging, the water level should be inspected and the cartridge weighed at least twice a year. The extinguisher will freeze and must be stored in heated areas. Antifreeze solutions may be added to this type of an extinguisher to protect them to 40° below zero, providing, however, that the extinguisher shell is copper or at least a 70% pure copper, and 30% hard nickel construction.

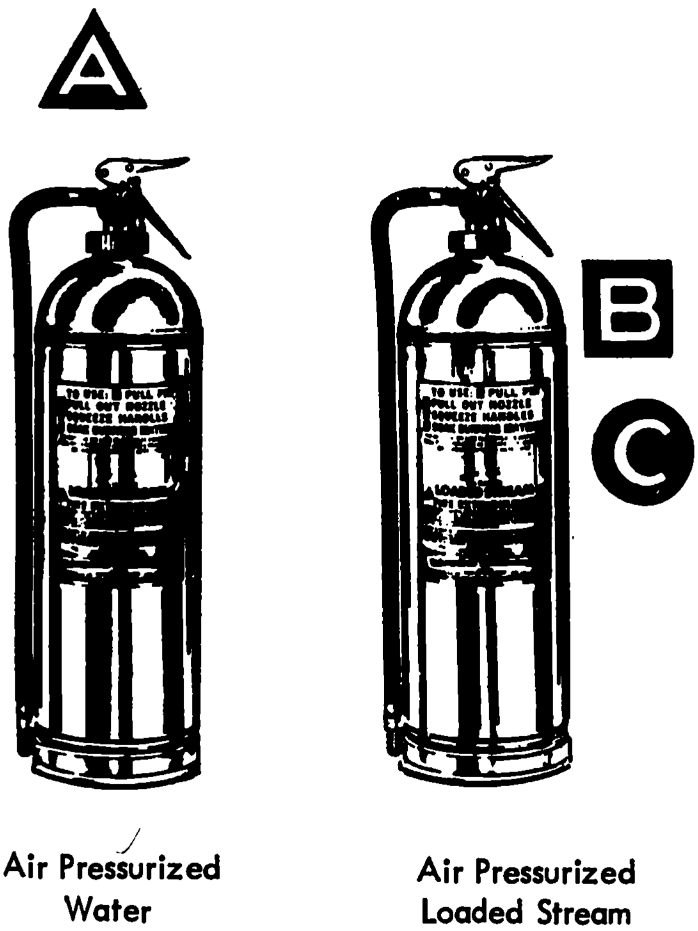


FIGURE 23.—Air pressurized water and air pressurized loaded stream extinguishers

Water Pump Tanks

This is a water extinguisher, and can be used

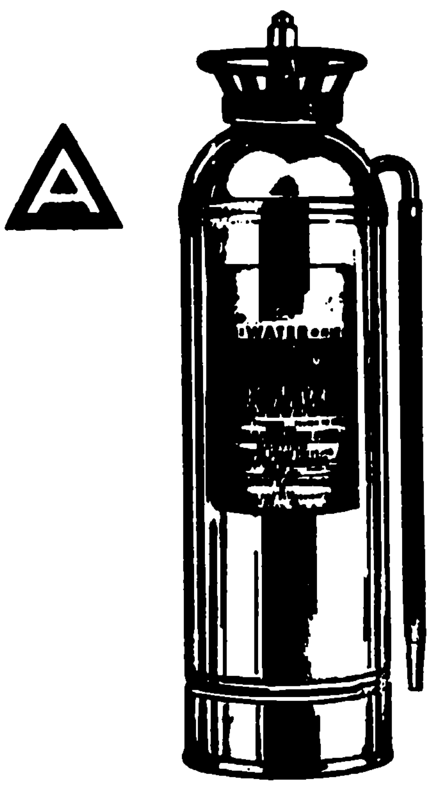


FIGURE 24.—Cartridge operated water extinguisher

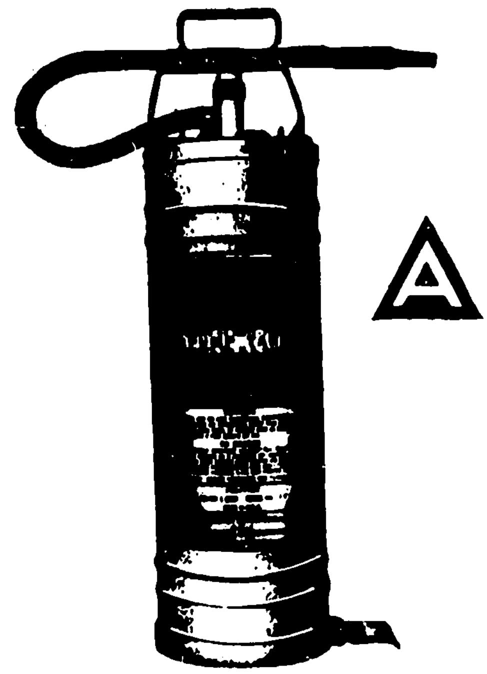


FIGURE 25.—Water pump tank

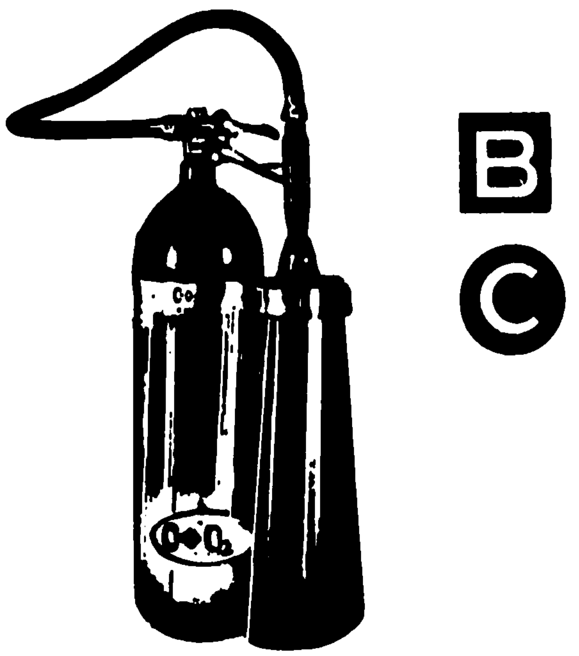
only on burning Class A fuels. These extinguishers are found in the 2½ and 5 gallon sizes and provide effective, inexpensive protection for Class A fuels. A folding anchor plate is located at the bottom of the extinguisher on which the operator may place his foot to steady the unit. The extinguishing agent is expelled by hand pumping through a small hose line. It can be refilled while the extinguisher is in operation and has an effective range from 30 to 40 feet. The 2½ gallon extinguisher will be discharged in about 1 minute and the 5 gallon from approximately 2 to 3 minutes. Antifreeze solutions for protection to 40° below zero may be added, providing the extinguisher is of copper and the pump of brass construction. Maintaining this unit is simple: inspect the extinguishing agent level and work the pump a few strokes at least twice a year.

Carbon Dioxide

The carbon dioxide extinguishing agent is a gas that is heavier than air. This extinguisher is effective on small Class B fires, especially where there is some confinement. Where there are strong air currents, its effectiveness is limited. It is a nonconductor of electricity, and because the gas leaves no contaminating residue, it is favored for use on Class C electrical fires. Carbon dioxide units are found from 2 to 26 pounds in the hand units. Wheel units are available in the 50 to 100 pound size. Generally, the hand units may be put into operation by pulling a locking pin and squeezing the lever valve.

Carbon dioxide units are characterized by the large plastic discharge horn, with hose attached to the extinguisher. Carbon dioxide gas is directed toward the base of the flame area with a sweeping motion as if trying to lift the flame from the fuel surface area. The gas should be discharged over all the fuel involved for extinguishment. Care should be taken to prevent a flashback, and the operator should avoid touching the extinguisher's horn since it may be cold enough to freeze the skin. The horizontal range of the discharge stream is from 3 to 8 feet, and the approximate time of discharge is from 8 to 30 seconds, depending on extinguisher's size. The extinguisher must be weighed and refilled with liquid carbon dioxide to bring it up to its full weight. The full and empty weights of the extinguisher will be stamped on the valve assembly. Special equipment is required to refill these units; however, this equipment is usually available at centrally located points about the country. Maintenance of the carbon dioxide extinguisher requires that the unit be weighed at regular intervals—from

3 to 4 times a year. Extinguishers found to weigh less than the full weight stamped on the valve should be refilled. The extinguisher is not subject to freezing and may be stored and placed in unheated areas.



Carbon Dioxide

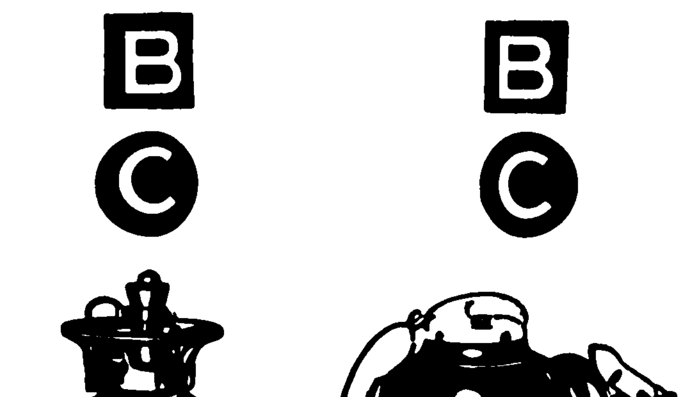
FIGURE 26.—Carbon dioxide extinguisher

Dry Chemical

Both sodium bicarbonate and potasium bicarbonate-based dry chemical extinguishing agents may be used on fires involving Class B fuels. Both extinguishing agents are nonconductors and may be used on Class C fires. These units are usually found in the hand portable sizes from $2\frac{1}{2}$ to 30 pounds. Larger wheel units are available in the 75 to 350 pound sizes. Two methods of expelling the extinguishing agent are used: the stored pressure and cartridge operated. With stored pressure, a locking pin is pulled, and the hand squeeze valve is opened and closed at the discretion of the operator.

When using cartridge operated dry chemical extinguishing units, two methods of pressurizing the extinguisher will be found. Some manufacturers install a small CO^2 cartridge on the outside of the container. With these, a locking pin must be pulled and a hand lever pushed down to puncture the CO^2 cartridge. Other manufacturers locate the CO^2 cartridge under the filling cap of the extinguisher, and with these, the extinguisher must be inverted and bumped on the floor to puncture the CO^2 cartridge. In either case, the hand-operated squeeze-type valve will be found at the end of the discharge hose. This valve may be operated intermittently so that the operator has control of the discharge of dry chemical.

The extinguishing agent is directed into the flame area just above the surface of burning Class B fuels. That area of the flame must be covered by the extinguishing agent. Care must be taken when extinguishing burning Class B fuels because of the possibility of a flashback. When using a dry chemical extinguisher on fires involving energized electrical equipment, burning materials should be coated with the dry chemical. Since many fires involving energized electrical equipment will involve burning Class A materials, the equipment should be watched carefully for some time to make sure that a rekindling does not occur. Fires involving oil-cooled electrical equipment will be handled much the same as fires in any Class B burning liquids.



Dry Chemical Dry Chemical

FIGURE 27.—Dry chemical extinguishers

34

The horizontal range of the chemical stream will be from 5 to 20 feet, and the discharge time will be from 8 to 20 seconds, depending upon unit size. The units must be recharged immediately after use. Maintaining a stored pressure unit calls for frequent checks of the air-pressure gauge found on the discharge assembly to make sure that the unit contains enough pressure to fully discharge the chemical when put in use. Maintaining the cartridge-operated extinguisher requires that the CO^2 cartridge be removed and weighed at regular intervals, 3 or 4 times annually. The extinguishers are not subject to freezing, and may be stored in unheated areas.

Multi-purpose Dry Chemical

The multi-purpose dry chemical extinguishing agent is specifically designed to be effective on the three major classes of fire. As with the regular dry chemical units, multi-purpose dry chemical extinguishers can be discharged by either the stored pressure or cartridge operated method. The multi-purpose extinguishing agent has the ability to stick to burning Class A fuels and will give a fire-retardent effect. Therefore, when using the extinguishers on Class A fuels, the chemical should be applied to cover as much of the fuel involved as possible. When using multi-purpose agents on fires involving Class B burning liquids and Class C energized electrical equipment, the application of the power is the same as with the regular dry chemical units.

HOSE AND HOSE PRACTICES

Fire department hose comes in several sizes ranging from ¾" to 4½" in diameter. The most commonly used sizes are 1½" and 2½" although so-called booster lines of ¾" or 1" are frequently used on small fires. Hose size is determined by its nominal inside diameter. Hose with an internal diameter of 1½" is called 1½" hose, etc. The standard length for sections of fire hose of all diameters in the U.S. is 50 feet. This amount is called one "length" or one "section" of hose. (Some fire departments are using hose that measures 100 feet per section.)

Booster lines are made of semirigid hose, which is rubber covered as well as rubber lined, so that it doesn't have to be changed after use. Booster lines are usually carried on reels and vary in length up to 300 feet.

Hose of diameter greater than 1" is rubber lined with outer jackets woven of cotton or synthetic yarns or a combination of both. Although much industrial fire hose is single-jacket hose, fire department hose—because it gets more use—is almost always made with two jackets. This double-jacket hose has an inner jacket for strength and an outer jacket to protect the inner jacket from wear. Synthetic materials have supplanted the cotton to a great extent because they are lighter in weight (for equivalent strength). Such hose needs less storage space and is easier to fold.

Most fire hose is tested initially at a working pressure of 400 psi although some departments require a higher test pressure. After it has been in service, however, hose is usually tested annually to a pressure of 250 psi. This should be considered the maximum safe working pressure, but many departments have different test pressures and procedures.

Most, but not all, U. S. fire departments use hose couplings with screw threads. These couplings, also called "butts," are made of brass and are attached to each end of every length of hose so that one length can be connected to another. In order that this connection can be made, one end of each length has a coupling with threads on the outside, and the other end has a coupling with threads on the inside. The coupling with threads on the outside is called a "male," and the one with threads on the inside is called a "female" coupling.

Although most hose threads in the U. S. now conform to the so-called National Standard for diameter and number of threads per inch, many fire departments have couplings that are different from National Standard. This incompatibility of threads could cause difficulties during a national or other major emergency when several fire departments may have to work together.

These difficulties can be overcome to some extent by using adapters that have the ability to connect hose lengths of the same size with different threads.

Couplings can usually be tightened sufficiently by hand, but sometimes a spanner wrench is needed to make a water tight connection or to disconnect hose lengths. Therefore, each coupling has "lugs" protruding to provide a point for the spanner to grip. There are two popular type of lugs: rocker lugs and pin lugs.

Inside each female coupling is a rubber washer to insure a tight seal. These washers are easily removed and sometimes become dislodged accidentally. Also, they are prone to deterioration from age. Leaky couplings result from missing, aged, or poorly fitting washers.

Care of Hose

Fire hose is rugged but does need a certain amount of care. This care would be of great importance during war when critical materials may be in short supply. There are several ways hose can be damaged. Some of the common ways are:

1. Oil, gasoline or grease gets on hose, penetrates jackets, and dissolves rubber lining. Natural rubber is easily injured by petroleum products.

2. Hose that is allowed to remain wet for extended periods and is made of cotton, or part cotton, will mildew. This weakens the cotton fibers.
3. Heat. Hose should not be stored near radiators or in other places where temperatures are high because heat damages the rubber.
4. Driving over hose. It is not recommended that vehicles be allowed to ride over hose except in emergency because the weight may cause separation of lining from jacket.
5. Dragging hose over rough surfaces. This, although sometimes necessary, can cause abrasion or cuts of the outer jacket.
6. Sudden closing of nozzle. This can cause a tremendous increase in pressure throughout the hose line (water hammer). Sometimes this increased pressure is much greater than pump pressure and far above the burst strength of the hose. *This is probably the greatest cause of burst hose.*
7. Dropping couplings may knock them out of round or injure the threads on male couplings.

Hose should be brushed or washed clean after use to remove grit that may injure fibers and oil that could harm lining. It should be dried after washing by use of a hose tower, drying rack, or drying cabinet.

When hose is being placed on apparatus, each female coupling should be checked to see that its washer is in place and in satisfactory condition.

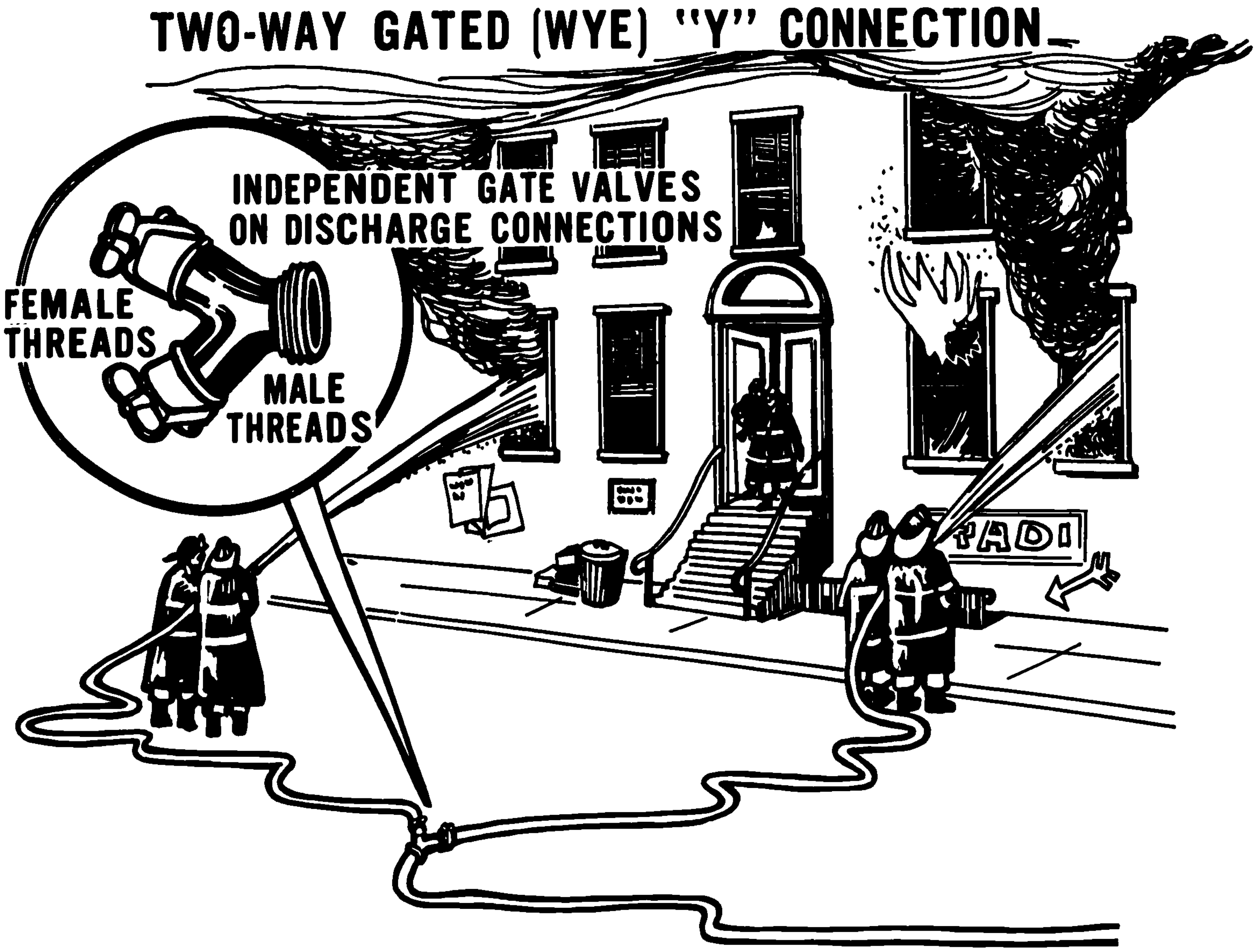
Hose Fittings

One type of fitting has already been mentioned. That is the adapter to connect hose lengths of same diameter but differing threads. The other common types of fittings used with hoses are:

1. *double male*—to connect two female couplings.
2. *double female*—to connect two male couplings. Usually one side of the double female will swivel to make connection without twisting hose. Swivel side should be connected last.
3. *reducers*—reducing couplings are used to connect a hose length of one diameter with that of the next size. Thus 3" hose can be connected to 2½", and 2½" can be connected to 1½". The female end of the reducer is of the larger size. (If the female is of the smaller size, then the fitting is an "increaser".)
4. *adaptors*—already described.
5. *"Siamese" connections*—this is used to connect two or more lines into one hoseline. It usually has two female inlets (although some have more) and one male outlet.
   The inlets are equipped with check valves (called "clappers") that permit water to flow only in one direction so that it can't back out an unused inlet.
6. *The "Y" or "Wye" connection*—Although early models were uncontrollable, the "Y" or "Wye" connections most in use today have gate values so that each side may be operated independently. The purpose of this appliance is to allow one hose line to be divided into two. This is also called a "two way gate." Usually, but not always, the inlet side is of the next larger diameter than the outlets.
7. *single gate valves*—Single gates are used with distributors, cellar pipes, etc., to provide a means of shutting off the water when there is no such control at the pipe (nozzle) and can be used on a hydrant so an outlet can be controlled independently of the other outlets.
8. *"water thief"*—This is a term used for an appliance that has one 2½" inlet and three outlets, two of which are 1½" and one which is 2½". It is not practical to use all three outlets at the same time because the total flow through the line supplying the device would be so great that friction loss would eat up the pressure.

Hose Appliances

1. *hose clamp*—This is used to shut off water by crimping the hose at any given point. There are three basic types: screw, lever, and hydraulic.
2. *burst hose jacket*—This is placed over a burst in the hose. Although it doesn't al-



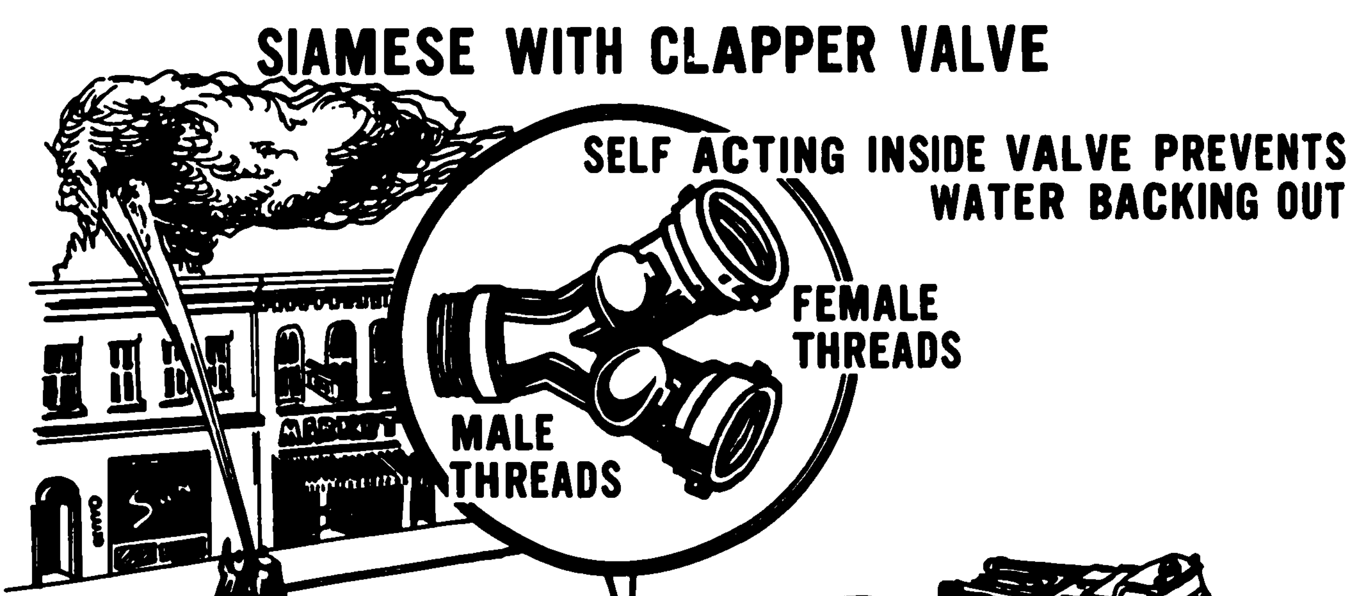


FIGURE 28.—Hose fittings

ways provide a perfect seal, it will often reduce the leak to negligible proportions and prevent shutdown at a critical time. It can also be used to connect lengths with differing threads if no better means is available. Hose jackets come in different diameters, and the diameter selected for use must be that of the hose involved.

3. *pipe-holder*—This device is used to hold nozzle in position when a heavy stream is being used; i.e., nozzle tip greater than 1¼" diameter. There are several types.
4. *hose roller*—The hose roller (sometimes called a "hose hoist") is a roller arrangement with metal guides used to roll hose over the edge of a roof or window sill without chafing.

Suction Hose and Hydrant Connections

In order for a pumper to draft water from a static source (river, pond, etc.), the hose connecting the pumper to the source must be able to withstand a vacuum without collapsing. Hose used for this purpose, therefore, is reinforced to prevent collapse and is known as "hard suction" because of its rigidity. It comes in several sizes, the nominal inside diameters of which are:

2½"	4½" (most common)
3"	5"
4"	6"

Suction hose sections vary in length from 8 feet to 20 feet, but the most common length is 10 feet.

A few fire departments also use the hard suction to connect pumpers to hydrants, but most use what is commonly called "soft suction," but is more properly called a "hydrant connection," because it is soft and can't take suction. The soft hydrant connection is flexible and actually is just a short piece of large diameter hose. Hydrant connections are available in diameters from 2½" up to 6" in ½" increments.

Most hydrant connections have female couplings at both ends because both the hydrant outlets and the pump inlet have male threads.

Male threads on the pump inlet are the only exception to a general rule that all male fittings point toward the nozzle (or in direction of flow) and all female toward the source of the water.

"Stretching" Hose

When hose is pulled off the apparatus and put in position to be used at a fire, the procedure is called "stretching" or "laying" hose. There are several ways in which this can be done. When hose is stretched from *fire* to *hydrant*, the procedure is called a "back-stretch" or "reverse lay." The opposite procedure, laying hose from *hydrant* to *fire*, is termed a "running stretch" or "straight lay." Usually, the pumper is used to lay the hose because of the saving of time and effort. However, after a pumper has been positioned at a hydrant or other water source and additional hose lines are taken from it, they may have to be pulled into position by hand. This is known as a "hand-stretch."

Many fire departments have pumpers equipped with divided hose compartments in which hose on one side is loaded for a straight lay and on the other side for a reverse lay. The side loaded for a straight lay has a female coupling leading off; the reverse lay side has a nozzle (attached to a male coupling) leading off. There are several variations of hose loads and leads. Some are standard in some departments, while other departments standardize on other types. Some departments have two-piece engine companies (two pumpers) with each piece loaded differently.

Many fire departments use preconnected 1½" hose lines; and some even use 2½" preconnects. These lines are carried already connected to a discharge gate of the pumper to permit a fast attack. The pumper stops near the fire, and as the preconnected line is pulled into position, the pump is engaged and water from the supply tank (booster tank) on the truck is pumped through the preconnected line, making it—in effect—a large booster line. Most departments that use preconnected lines use them in conjunction with a straight lay. A supply hose is laid from hydrant to fire and connected to inlet of pump. After this line is charged, the booster tank is shut off and the water from the hydrant is pumped through the preconnected line. However, some departments use other procedures. The chief limitations of preconnected lines are initial fixed length and low discharge (gallons per minute).

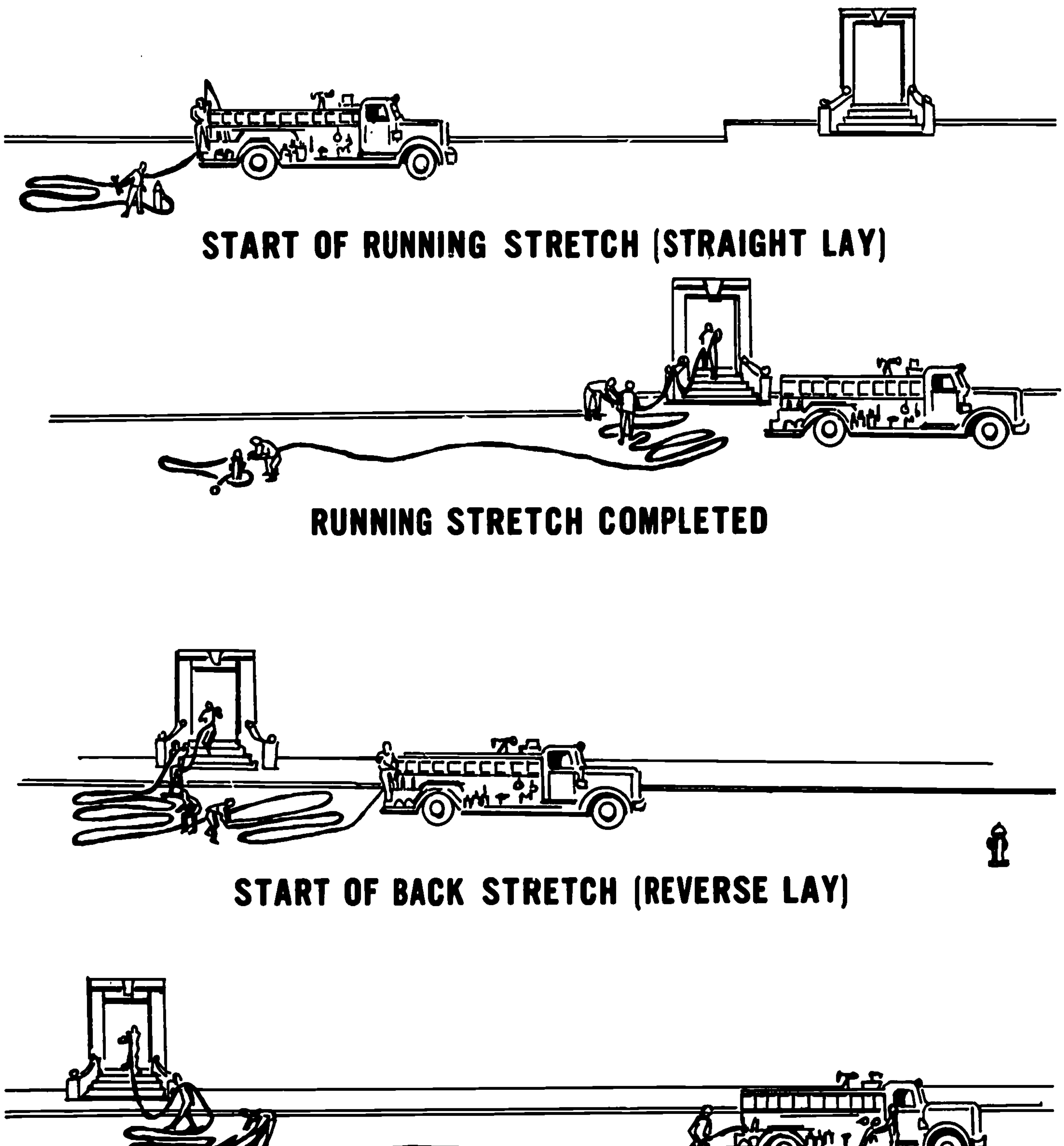


FIGURE 29.—Laying hose

When the *reverse* lay is used, the pumper stops at a point near the fire (in front of the entrance, if the fire is in a building) and sufficient hose is removed to reach the fire. As this hose is pulled into position, the pumper is driven—laying a hose line enroute—to the hydrant (or other water source) and made ready to supply water.

The *straight* lay is made by stopping the pumper momentarily at the hydrant while a man drops off with the female end of the hose. As he attaches the hose to the hydrant, the pumper and remainder of crew proceed to fire. The usual procedure then calls for the supply line from the hydrant to be connected to a pump inlet while another line is stretched from pumper to fire.

In cases where hydrant pressure is high and the distance to fire is short, some departments do not use the pump. *However, it is considered good practice to use the pump at all times because of the control it affords over pressure and volume.*

No matter which method of stretching is used, it is desirable to closely estimate the amount of hose needed to effectively reach the fire. It is better to have more than enough rather than to have insufficient hose to reach the fire. On the other hand, too much surplus hose may impede operations. Hose should be stretched close to curb and preferably on same side of street as hydrant to keep the roadway clear for other apparatus.

Whenever hose is "paying out" from the hose bed of a moving pumper during a stretch, men should stand well clear to avoid being struck by hose and especially a coupling, which could cause serious injury. There is usually no need to help the hose pay out from a moving pumper; the weight of the hose already in the street will quite effectively pull additional hose out of the hose bed if it has been properly loaded.

Handling Hose

When hose is pulled off apparatus by hand, several folds should be pulled off together and dropped on the ground. This is quicker and safer than pulling off one fold at a time, hand-over-hand.

At the end of a reverse lay, the hose leading to the fire must be uncoupled from that in the bed and attached to a pump outlet. This uncoupling is called "breaking" a line. It is also done at the end of a straight lay after sufficient hose has been removed by hand to reach the fire. Then after the line has been broken (uncoupled), a nozzle is attached and the line is taken into position.

Uncoupling, or disconnecting, two lengths of hose (with screw couplings) can be done by one man or two men. Remember that when the female coupling is held facing toward the male to which it is connected, the connection is tightened as the female is turned right (clockwise) and loosened as turned in the opposite direction. Therefore, if the female is grasped in this manner and turned *left*, it will become uncoupled. This can be done by one man if he steps on the hose just in back of the male coupling. This will not only hold the hose in place but will tilt the couplings up at an angle that enables him to disconnect them. Two men can disconnect hose by facing each other; one man holds the male butt securely, and the other turns the female toward his left. Couplings that are too tightly fastened to be opened by hand can be disconnected with spanners. The spanner is a wrench designed to fit the lugs of hose couplings so that couplings may be tightened or loosened with greater leverage than could be applied by hand. In selecting the proper spanner, hose size and types of lugs must be considered.

Hose couplings can be connected—or a nozzle attached to a male coupling—by using the procedure just described for disconnecting two lengths of hose, except that the female would be turned clockwise to fasten.

There are occasions when it would be necessary to connect two male couplings by using a double female connection. In this case, the non-swivelling side of the double female is connected first; then it is not necessary to twist the hose to make the second connection. Two females can be easily coupled by connecting first one and then the other to a double male.

If a reducer is going to be used to connect lines of different diameters, it should be attached to the larger line first. An increaser should be attached to the smaller line first. In each case, the *first* connection is made to the *male* coupling.

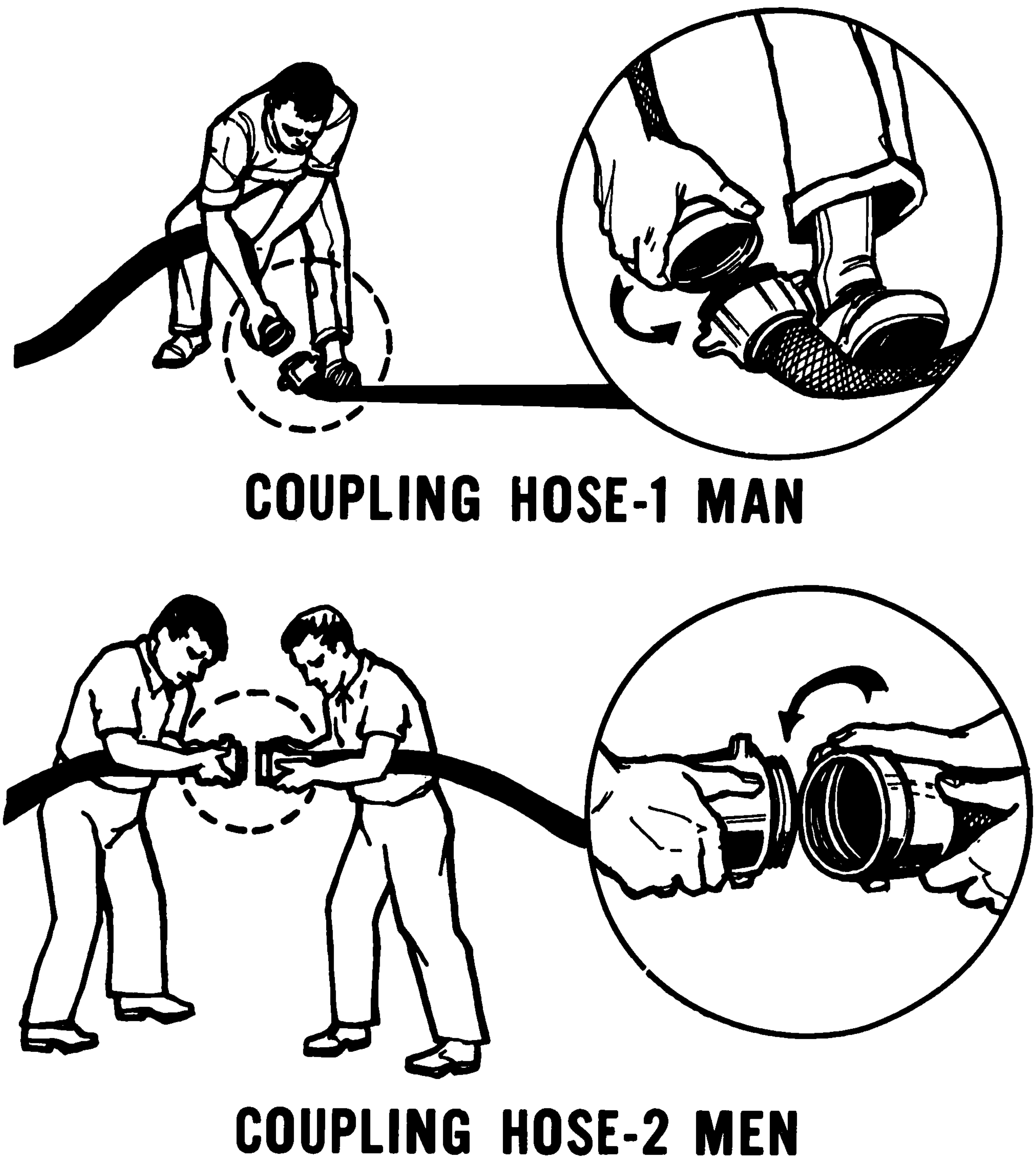
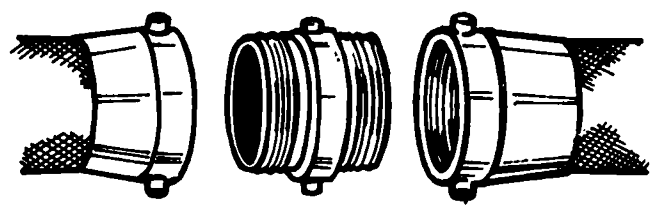


FIGURE 30.—Coupling hose

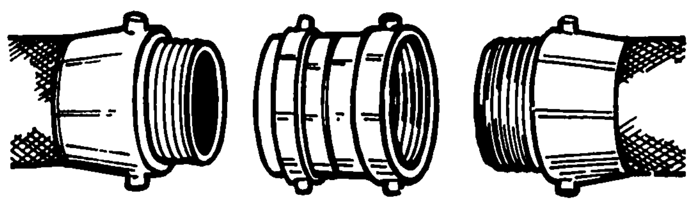
Advancing Hoselines by Hand

When it is necessary to stretch an uncharged or "dry" line by hand, it is usually desirable to carry the hose on the shoulder and let the whole body share the work of moving the heavy hose. When hose is being moved, couplings should be kept clear of snagging obstructions. Therefore, the logical place to pick up the hose is just behind a coupling so that the coupling is off the ground (and protected) as the hose is dragged.

If the hose has not yet been charged with water, one man can drag a 50-foot hose section up to 3" diameter on the street or fairly level ground. When there are few men for the amount of hose being stretched, it will be less exhausting if they each drag hose for 50 feet, drop it, go back and pick up the next length, and drag that up alongside the first, repeating this process until all the hose needed has been



DOUBLE MALE HOSE CONNECTION



DOUBLE FEMALE SWIVEL CONNECTION

FIGURE 31.—Hose couplings

laid side by side in long folds. The same steps are repeated for another advance.

Taking hose up a stairway is hard work at best, but some ways are easier and faster than others. In one method, hose is passed up the stairwell hand-over-hand from a man on one landing to one above. This method requires less hose than if the hose were laid on the stairs and also leaves the stairway unobstructed; however, it is probably more energy consuming than the method in which each man carries two or three folds of hose on his shoulder, and each —starting with the last man in line—lets the hose pay off his shoulder as he mounts the stairs.

A rule commonly followed in estimating the amount of hose that should be taken into the average building is to allow one 50-foot length for each floor below the fire and two for the floor where the fire is believed to be (usually termed the "fire floor").

Hose can be taken up a ladder and onto a roof or in through a window; or it may be left on the ladder, and the nozzle operated from the ladder.

Whatever method is used to advance hose up a ladder, sufficient hose to reach the objective should be flaked back and forth on the ground at the foot of the ladder before the men start pulling it up.

When the hose is in place on the ladder, it should be anchored to the ladder by a hose-strap at the nozzle. Another strap at the base of the ladder is desirable. Water flow should not be started until hose is securely strapped to the ladder.

A hose line can be readily advanced up a fire escape by the "fire escape stretch," which involves using a fire escape hook, a rod about 10 feet long with a sliding noose attached to one end and with a hook on the other. Sufficient hose should be taken up the fire escape to reach all points on the floor above the fire, if that should become necessary.

The procedure calls for the hose (with nozzle attached) to be flaked on the ground below the fire escape. The men mount the fire escape with the first man stopping on the first balcony, the second man on the second balcony, and so on until the fire floor is reached. As the first man arrives at the first balcony, he reaches over and grabs the hook from the man on the ground. He then passes it up to the man on the second balcony who should be just reaching his position in time to grab it. As the hook is passed up, each man below pulls up on the hose, passing it to the man above until sufficient hose has been accumulated on the balcony below the fire. The surplus hose on the balcony below the fire is draped over balcony rail, and hose, and hose straps are attached at alternate balconies to take the strain off the couplings.

As soon as the line is in position on the floor below the fire, the call is made for water to be started. When the line is charged with water, it is then ready to be taken up to the fire floor (or above) and put to work.

The hook is left hanging from the balcony on the fire floor where it is placed by the topmost man before he takes the hose from the noose. Of course, when sufficient hose has been pulled up on the balcony below the fire, each man goes up the fire escape to that point to assist in advancing the line up and into the building.

It is far easier to advance an empty hose line than one full of water. For that reason it is often desirable to break and drain a charged line that is going to be taken upward to a considerable height. For short distances this procedure would not be so effort saving, but when

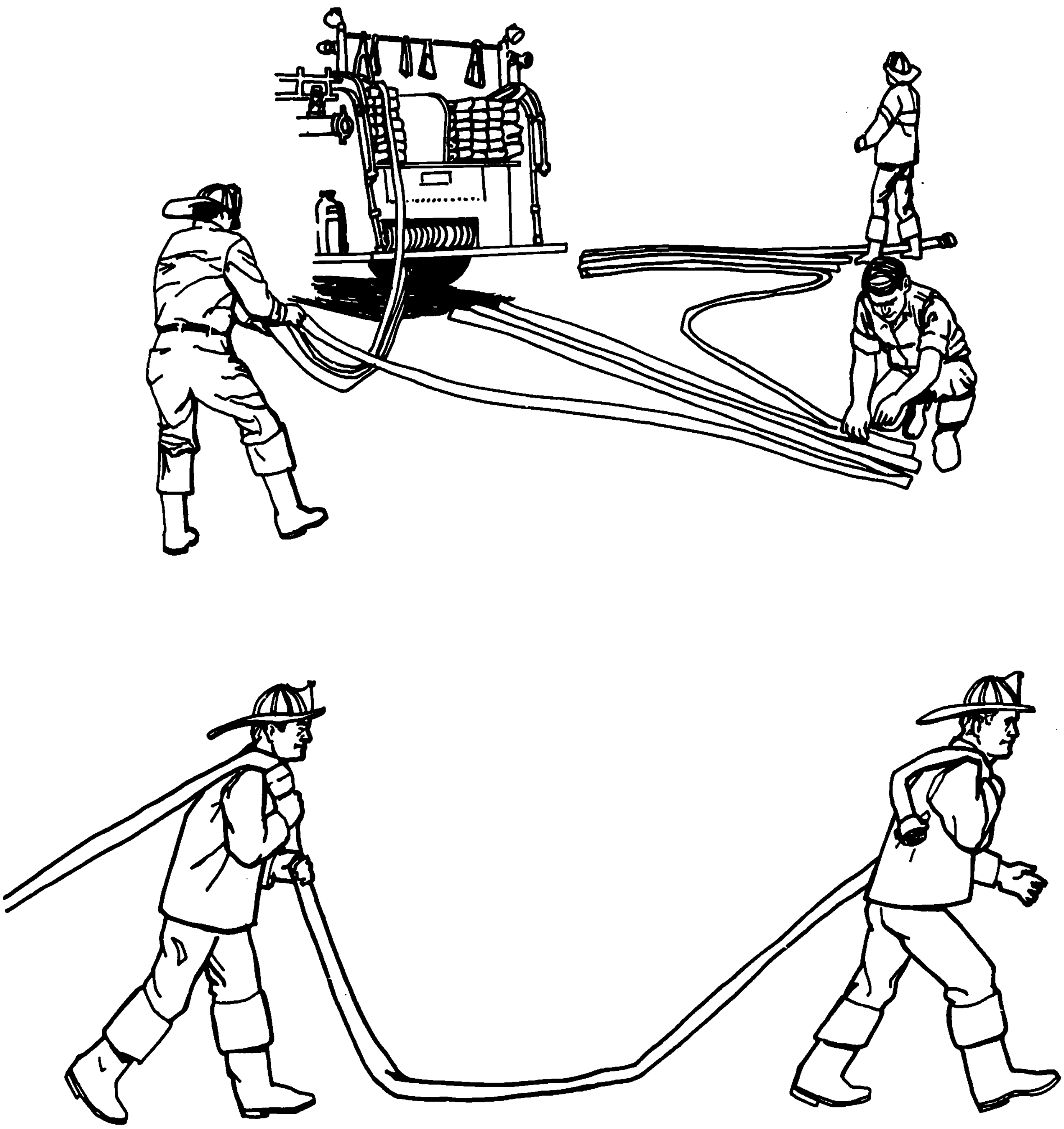


FIGURE 32.—Advancing hoselines by hand

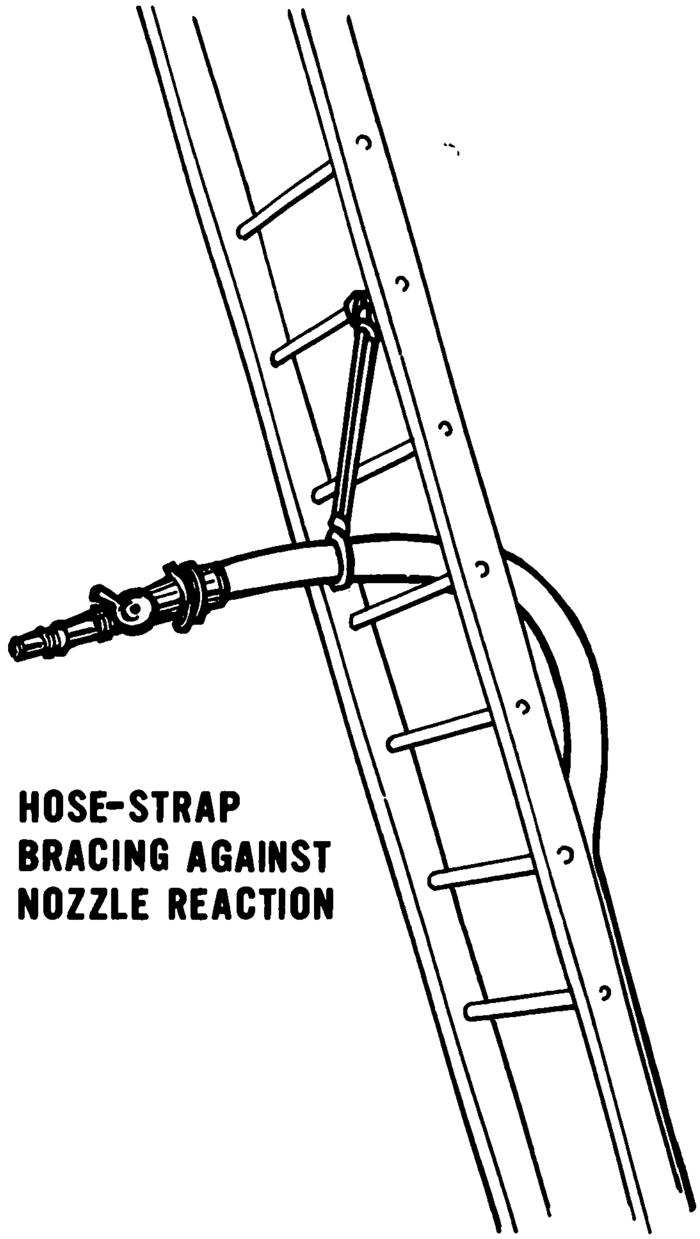


FIGURE 33.—Hosestrap bracing

height is more than a couple of stories, it may save time in the long run. The water is shut off, the hose disconnected at a distance back of the nozzle greater than the height to be reached, and then as the line is taken aloft, the water drains out.

When a charged line must be moved along the ground, it can be rolled as a hoop by forming a loop about 5 feet in diameter, raising the loop to a vertical position, and rolling it forward.

Picking Up

The procedure for picking up hose depends upon whether or not the hose had water through it. If the hose was not wet or soiled, it can be repacked at the fire scene; and the simplest and most effective way is to drive the apparatus, straddling the hose line, over the line as it is repacked in the hose bed. This method is quick, safe, and efficient. One man drives, another stands on the apparatus to tuck the hose in the bed as the other men walk behind and feed the hose up to him.

Hose that has water in it should be drained before being replaced on the apparatus. Some departments drain each length by "walking" it and then pile the used lengths back into the hose-bed (temporarily). If the jacket contains cotton and has been wet, most departments roll the used lengths into "doughnut" rolls or single rolls and place the rolls on the apparatus to be removed and dried upon return to quarters.

In freezing weather, hose may be covered with ice and even frozen to the street. In such cases, the ice should be chopped with an ax, using great care not to cut the hose, leaving some ice attached to the hose. Frozen hose should be handled and placed on the apparatus with the least possible bending because bending might break the frozen fibers of the hose.

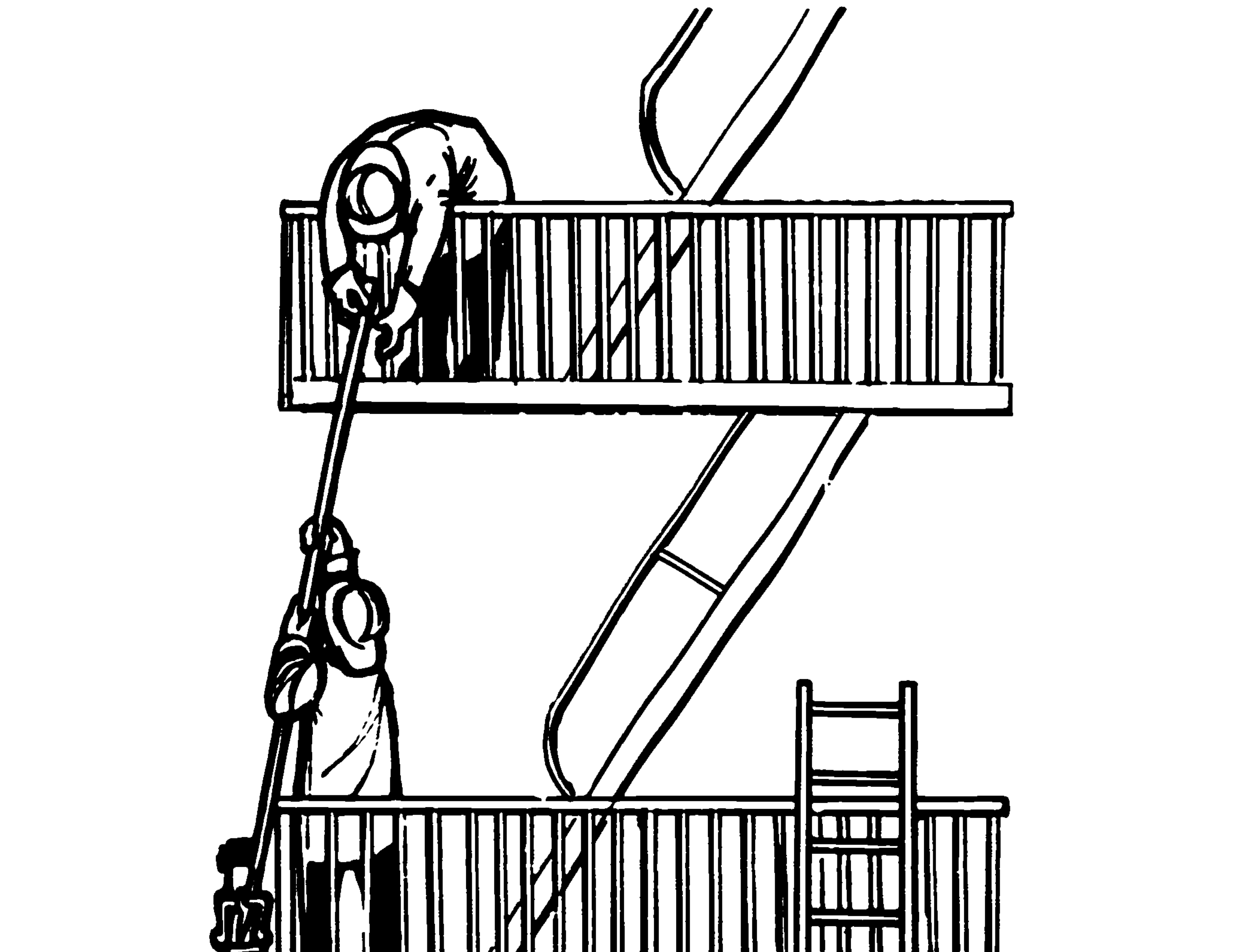
Rolling Hose

The single roll referred to is very simply made by bending the hose a few inches back of the male coupling so that it rests on the hose and then rolling the length so that the male coupling is the center or core of the roll.

The double roll, also called a "doughnut," is made by folding the hose once, slightly past center, so that the male coupling rests on the hose about 4 feet from the female end. One man grasps the fold and rolls the hose toward the female end, while another man moves ahead of him to keep the hose aligned.

This roll can be made by one man unassisted. The hose is stretched flat and straight, and the man, facing the female end, straddles the hose and grasps it at a point about 6 feet nearer the female end than the center. He makes a small fold and continues rolling the hose until the female end is reached.

Note that in all these hose rolls, the male coupling is protected. that male couplings have outside threads that are easily damaged should be constantly remembered.



HOSE LINE VIA FIRE ESCAPE

FIGURE 34.—Hose line via fire escape

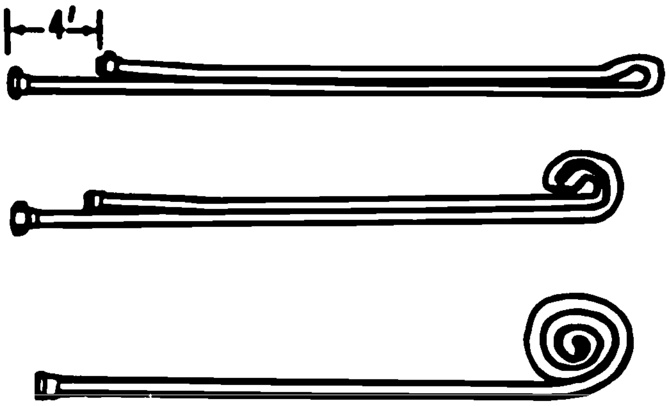


FIGURE 35.—Hose rolls

Hose Loads and Finishes

There are many ways of loading hose on the apparatus and many ways of finishing these loads to allow for quick and easy stretching. Inasmuch as there is so much variety in this subject area, support assistants should learn the methods approved by and used in the departments with which they serve.

Handling Burst or "Wild" Hose

Every effort should be made to keep complete control of hose under pressure. If a nozzle is let go of or if hose bursts completely through, there is a strong possibility that someone will be seriously injured by the rapidly whipping hose. Nozzles should never be dropped without first being shut-off, and nozzles should never be left in the open position when hose is dry or when pressure fails. Small bursts in hose can be covered with a burst hose jacket without even shutting pump off, but control of a complete burst or wild nozble is not easily established and is, at best, a dangerous procedure. A man can pounce on the hose-line a short distance back of the burst or wild nozzle and crawl on top of the line up to the end of control, pinning it with his body until water is shut off. A somewhat safer method, if a short ladder is available, is to leap on the hose with the ladder and slide it crossways up to the burst.

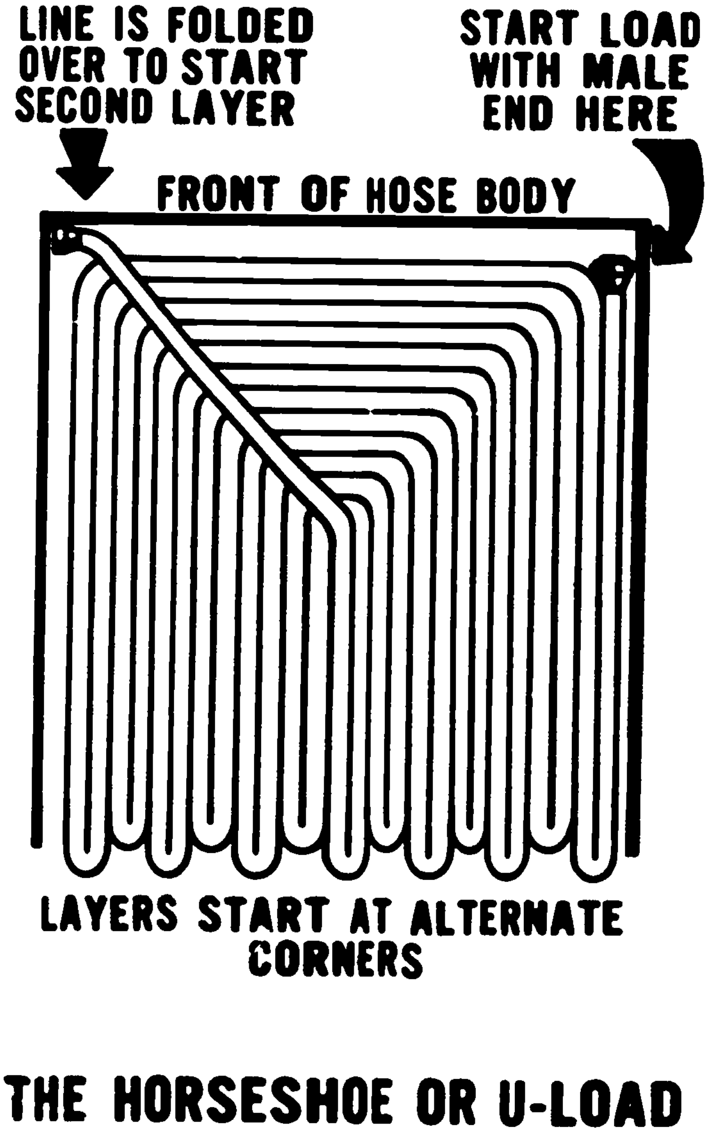


FIGURE 36.—The Horseshoe or U-Load

LADDERS

Ladders are vitally important in firefighting. They are used principally to gain access to higher or lower elevations for rescue, entry, ventilation, and the operation of hose lines. They can also serve other purposes, such as forcing doors as described under forcible entry, and as support frames for an improvised water storage basin. They can also be made into emergency bridges, especially for hose.

Fire department ladders are stronger than ordinary ladders. They vary somewhat in design and construction. Some are made of wood; some are made of metal. Three types of alloys are most commonly used in metal ladders: aluminum, magnesium, and steel.

Ladders that consist of only one section are called "straight" ladders and are sometimes called "wall" ladders.

The "beam" is the principal structural member, and the rungs are supported in it. It is also called a "rail." There are solid beam ladders (also called "solid side") that use solid material for maximum strength, and there are those with trussed beams using assembled parts for light weight and maximum strength.

The "rungs," also called "rounds," are the cross members between the beams, which are stepped upon when the ladder is climbed.

The "butt," also called "heel," is the end of the ladder, which is the bottom when the ladder is vertical. The "butt plates" are metal projections at the butt of the ladder.

The "tip" is the end of the ladder that rests against the building when the ladder is in use or that is the topmost point when the ladder is vertical (also called "top").

Tie-rods are metal cross-members that help hold the ladder together and strengthen certain rungs.

An extension ladder is composed of two or more sections. The ground section is known as the "bed ladder," and the part or parts that can be raised from the bed is known as "fly ladders."

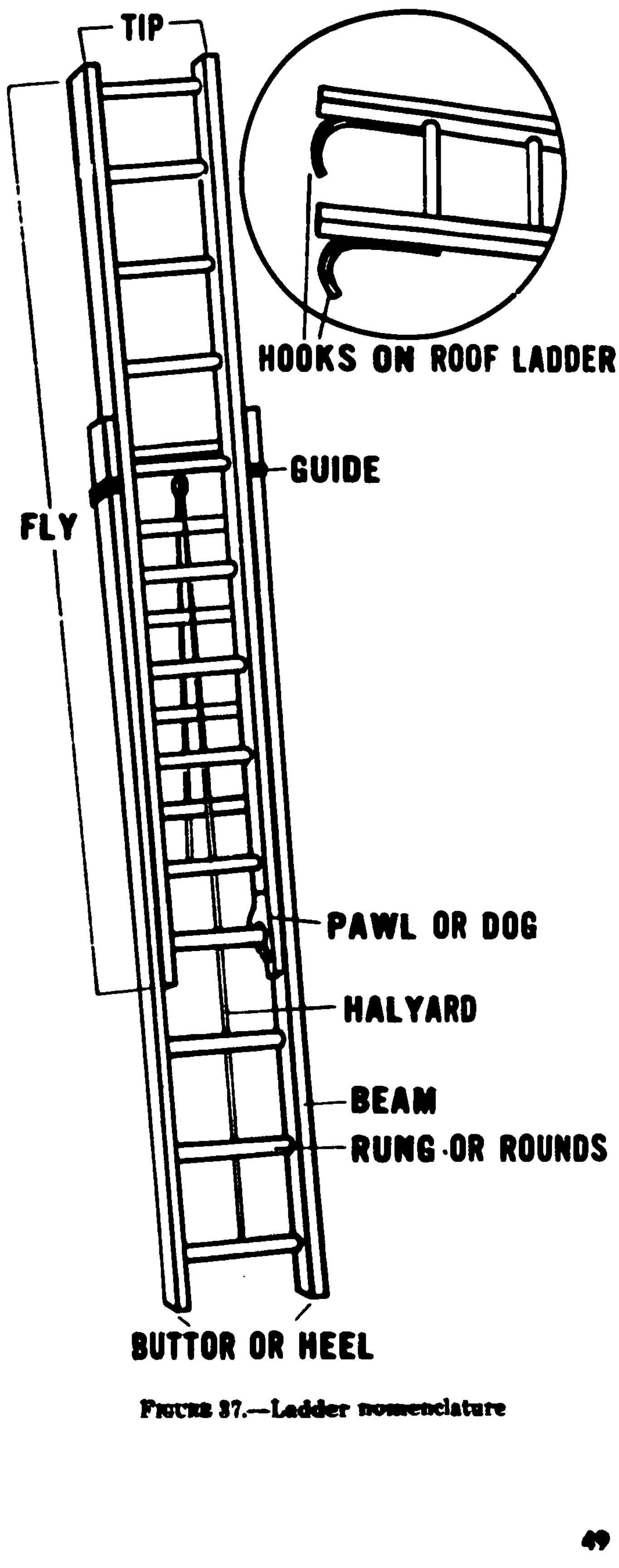


FIGURE 37.—Ladder nomenclature

The "halyard" is the rope used to extend the fly.

"Pawls," also called "dogs," are locks used to support a fly after it has been raised.

"Guides" are wood or metal strips that guide the fly as it is being raised or lowered.

"Stops" are wood or metal blocks that prevent the fly from being raised completely out of its bed.

A "Bangor" is an extension ladder with poles attached for aid in handling. In some parts of the country "Bangor" may have another meaning, and in some places this ladder is called a "pole" ladder.

The poles attached to Bangor ladders are called "tormentors"; the term "tormentor" is also applied to the stabilizing ground jacks on an aerial ladder.

An "aerial" ladder is one that is permanently mounted on a truck and raised or lowered mechanically.

A "roof ladder" is a straight ladder with hooks for securing it to the roof peak.

An "attic ladder" is a folding ladder for ease of handling in confined spaces.

A "pompier," or "scaling" ladder, is a single-beam ladder with a large "goose-neck" hook at the top. These ladders, which vary in length from 10 to 14 feet, are used to scale the outside of a building from floor to floor by putting the hook in the window above, climbing the ladder, and then repeating procedure. This is usually used only as a "last-ditch" attempt to reach a point that can't be gained by other means.

Inspection of Ladders

Ladders should be inspected at regular periods and after each use to discover any defect or weakness that may have developed. On wood ladders, rungs should be examined for looseness, cracks, splinters, rot, wear, and need for varnish. Beams should be inspected for any of these defects and also for warping.

Metal ladders should be examined for signs of looseness, weakness, at welds, or deformity. A rainbow-hued discoloration on a metal ladder indicates that the ladder may have been weakened by heat, although the ladder can be weakened by heat without visible evidence.

On both metal and wood ladders, halyards should be inspected for weakness, wear, and rot; pawls, guides, and stops should be checked for defects. If there is any doubt as to a ladder's condition, a test should be made by personnel familiar with proper test procedure.

Care of Ladders

When wood ladders get dirty, they should be washed with plain cold water. They should be scraped and revarnished when varnish has worn off to an easily noticeable degree. The varnish protects the wood from water penetration, which could start rotting or warping.

Metal ladders, when dirty, should be washed with plain water, a mild soap solution, or a prescribed cleaning fluid. They should be lubricated as needed.

Neither metal nor wood ladders should be exposed to flame unnecessarily. Metal ladders are quickly damaged by heat, and wood ladders may ignite. All ladders should be handled carefully and not dropped!

Handling and Carrying Ladders

The first step in using a ladder is to take it off the truck. This makes it essential to know how the ladder is fastened to the truck and how it can be properly removed.

The next step is carrying the ladder from the truck to where it is to be used. There are prescribed ladder carriers that make the task easier, safer, and more quickly done. Commonly approved methods of carrying ladders are shown in the accompanying illustrations.

Vertical carries may be necessary in tight quarters and to move a ladder from one window to another. (It is not desirable to scrape a ladder tip along a wall.)

Whenever a ladder is being moved into a vertical position, a sharp lookout should be maintained to make sure that tip will clear all obstructions, especially wires. Firefighters have been electrocuted by moving a ladder into contact with high voltage wires.

Teamwork is especially important in the vertical carry because the ladder's position makes balancing difficult and tricky. Of course, the ladder doesn't weigh any more than it does in the horizontal position, but it seems heavier because of the additional leverage due to extension. The important thing is to maintain the ladder in a perfectly vertical position by proper balancing. When the tip of the ladder starts

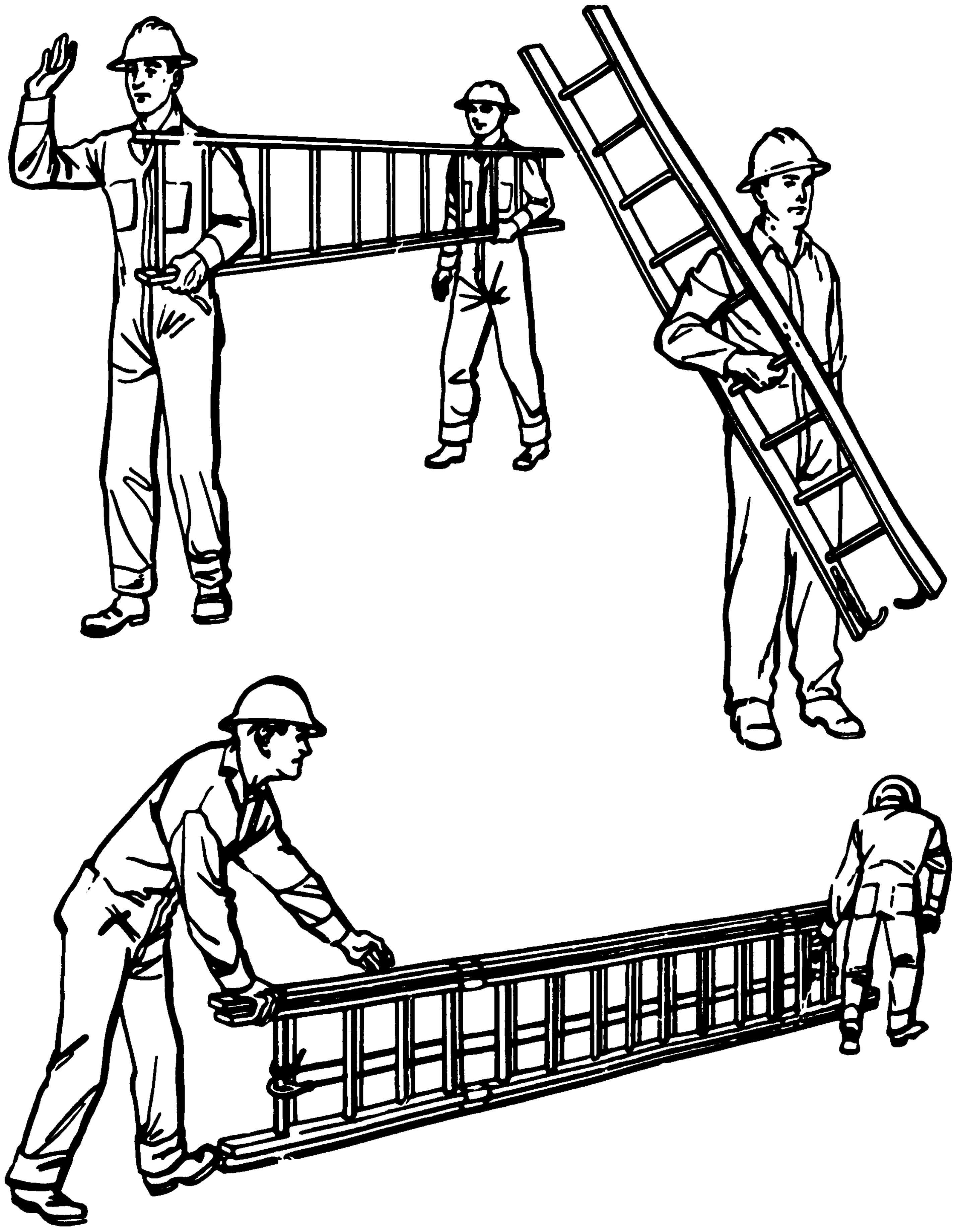


FIGURE 38.—Carrying ladders

moving off balance, it must be straightened quickly but smoothly. Once it moves more than a short distance, it is almost sure to fall. The men must lift the ladder in unison and start walking simultaneously, using short steps. They should look up constantly to observe the tip of the ladder. The officer or another man should walk ahead to keep a lookout for wires or other obstructions both aloft and on the ground. He should warn and direct the men carrying the ladder.

Raising Ladders

The usual practice if for the man (or men) carrying the butt of the ladder to carry it to the point where it will be located when the ladder is in the raised position. He lowers the butt to the ground, and then assumes the position of "butt" man for the raise. The man (men) at the other end lowers the tip to the ground and then assumes the position of "raise" man. On command, the ladder is raised by all men working in unison.

It is a good practice when raising to place the ladder parallel to the building, turn it a half turn when vertical, and then lower it against the building. This allows the ladder to be raised between obstructing wires and the building or in a narrow alley or walk . on a sidewalk without having to surmount such obstacles as parked cars or apparatus. The natural tendency of the amateur is to raise the ladder at a right angle to the building, which, even if there are no other handicaps, usually requires the raise men to step up on a curb they can't see.

In some departments, the "beam raise" is used most often with ladders small enough to be raised by two men. The ladder is placed on the ground resting on one beam with rungs vertical: The butt-man holds one foot on bottom beam at the butt end, leans toward the other end of the ladder, and grasps the upper beam. The raise man then lifts the tip end of ladder and walks toward the butt raising the ladder by moving his hands along the lower beam as he walks. The butt man assists by pulling on the upper beam.

One man, unassisted, can raise a short ladder (up to 20 feet) by placing the butt against a building or other substantial object—even a bush if he has to—and lifting the tip end of the ladder. He then walks toward the butt, either pushing both beams up simultaneously with both hands or pushing upward on the center of every other rung, using his hands alternately. The hands cannot be used alternately on the beams because this would throw the ladder off balance.

Other methods of raising ladders vary somewhat among fire departments; therefore, support assistants should learn and follow the methods of the department to which they are attached. Although the methods or raising may vary in minor details, they are basically the same in that the ladder is "butted" by one or two men and raised by one or two men, with the number of men butting or raising depending on ladder size.

When the ladder is raised, the butt man should lean forward and grasp the farthest rung he can reach (usually this is the third or fourth from the butt). He should place his feet on the bottom rung (with some ladders this is not practical, and he must place his feet against the butt places). As the raise men lift the opposite end of the ladder, the butt man should assist by pulling on the rung he is holding. As the ladder comes up, he should squat, throwing his weight backward to help swing the ladder upright.

The raise men start by facing each other at a point near the tip of the ladder. (The nearer they are to the tip, the easier it will be for them to lift the end of the ladder off the ground.) The usual procedure is for them to turn toward the ladder tip, then reach down and grasp the nearer beam with the hand on that side, lift the beam until the ladder is about waist height, and then place the other hand under the beam to push the beam upward as the body is turned to face the butt of the ladder. All this is done in one uninterrupted motion.

The beam is pushed upward until the arm is fully extended above the head. Then the raise men walk toward the butt, raising the ladder by pushing upward on the beams, one hand at a time. as they walk.

The raise men should keep their arms stiff and slightly forward of the head, with the body rigid and in straight line with the arms. If an arm is bent or not placed sufficiently forward, the ladder may get out of control. It is also essential that the ladder beams be kept at the same level as the ladder is raised because any

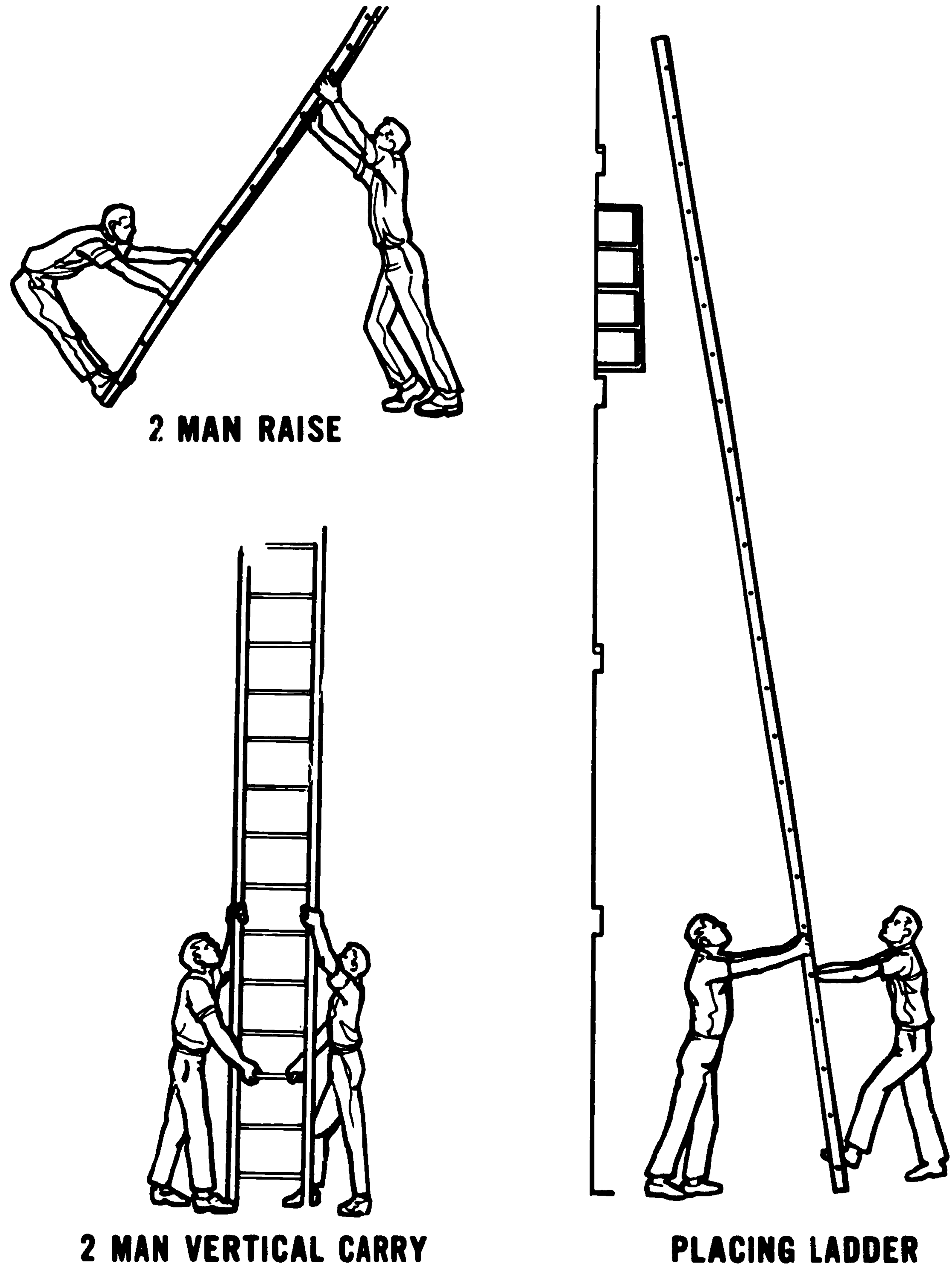


FIGURE 39.—Raising ladders

tilting may allow the ladder to get out of control. The raise men keep the ladder level by staying side by side if they are the same height. When one is much taller than the other, the ladder is kept level by the taller man staying a slight distance in back of the shorter man.

As the ladder reaches a vertical position, each butt man places one foot on the bottom rung and one on the ground; the raise men do likewise. Usually, the butt men hold the ladder by grasping a rung at convenient height, while the raise men hold the beams. If the ladder is to be pivoted, it is turned, leaving one beam on the ground while the other is raised slightly. The men on the side nearer the beam that is the pivot each keep one foot on the bottom rung by using the foot next to that beam. The other men keep their feet off the ladder until it has been turned.

The fly section of an extension ladder is raised to the desired height when the ladder is in the vertical position. Two men hold the beams of the bed ladder, while a third man unties the knot (if there is one) in the halyard and raises the fly by pulling the halyard until the fly is up to the height wanted. He then makes sure the dogs are locked and ties the halyard with a clove hitch after taking a turn in the rope around the center of the third rung. It is important that the dogs be locked. This can be ascertained in the dark by listening. There are two sounds as the dogs pass a rung and re-open. The halyard should be released slowly after the first sound and the fly lowered a fractional distance until the dogs lock on the rung. These sounds (two to the rung) can also be used to gauge the height to which the fly has been raised.

When the ladder has been extended to the desired height, it is then lowered into position against the building (or other objective). This should be done smoothly and gently. Ladders should never be dropped into place. Commonly, the raise men face the building, each holding one foot on the bottom rung and grasping the rung nearest chest level. The butt men face the raise men, each holding a beam and each with both feet on the ground. The ladder is given a slight push to start the tip moving toward the building and all men hold the ladder to control its progress so that the tip moves smoothly into position.

After it has served its usefulness, the ladder is lowered by reversing the process by which it is raised. With the men assuming the same positions that they did during the raise, the ladder is pushed away from the building to the vertical position, the fly is lowered, and the ladder is pivoted and reclined to the horizontal position on the ground, with each man assuming the position he did during the raise and acting just as though the raise were being done in reverse.

This rising and lowering procedure will vary from department to department and with the size of the ladder, but the way described is generally similar to whatever method is official within a particular department. The training given within that department will illustrate the variations specified for the department to which the "Support Assistant" is assigned.

The raising and handling of Bangor ladders is more involved than that of ordinary extension ladders without poles. The use of ladders with poles attached calls for more men and more maneuvering although the extra manpower makes the task easier and permits the raising of ladders longer than 40 feet.

The disadvantage of pole ladders is that they need a minimum of five men (usually six); which are distributed as follows: butt, one or two men: raise, two men: and tormentor poles, two men (one on each pole).

With this amount of manpower, ladders as long as 55 feet can be raised when the men have had proper instruction and practice.

The commonly accepted steps in raising this kind of ladder call for the butt and raise men to act in the same fashion as they did in the raises heretofore described. The difference is in the use of the poles.

Ordinarily, the butt men release the poles and pass them to the beam men who in turn give them to the pole men. As the butt men and raise men go through the same process described previously, the pole men assist by pushing upward on the poles. They can help greatly in raising a heavy ladder. However, if they push prematurely, it may be difficult for the butt men to keep the butt from sliding.

Although the point to which the ladder is to be raised is the primary factor in determining the angle at which the ladder should be placed, there is also the consideration of safety. The

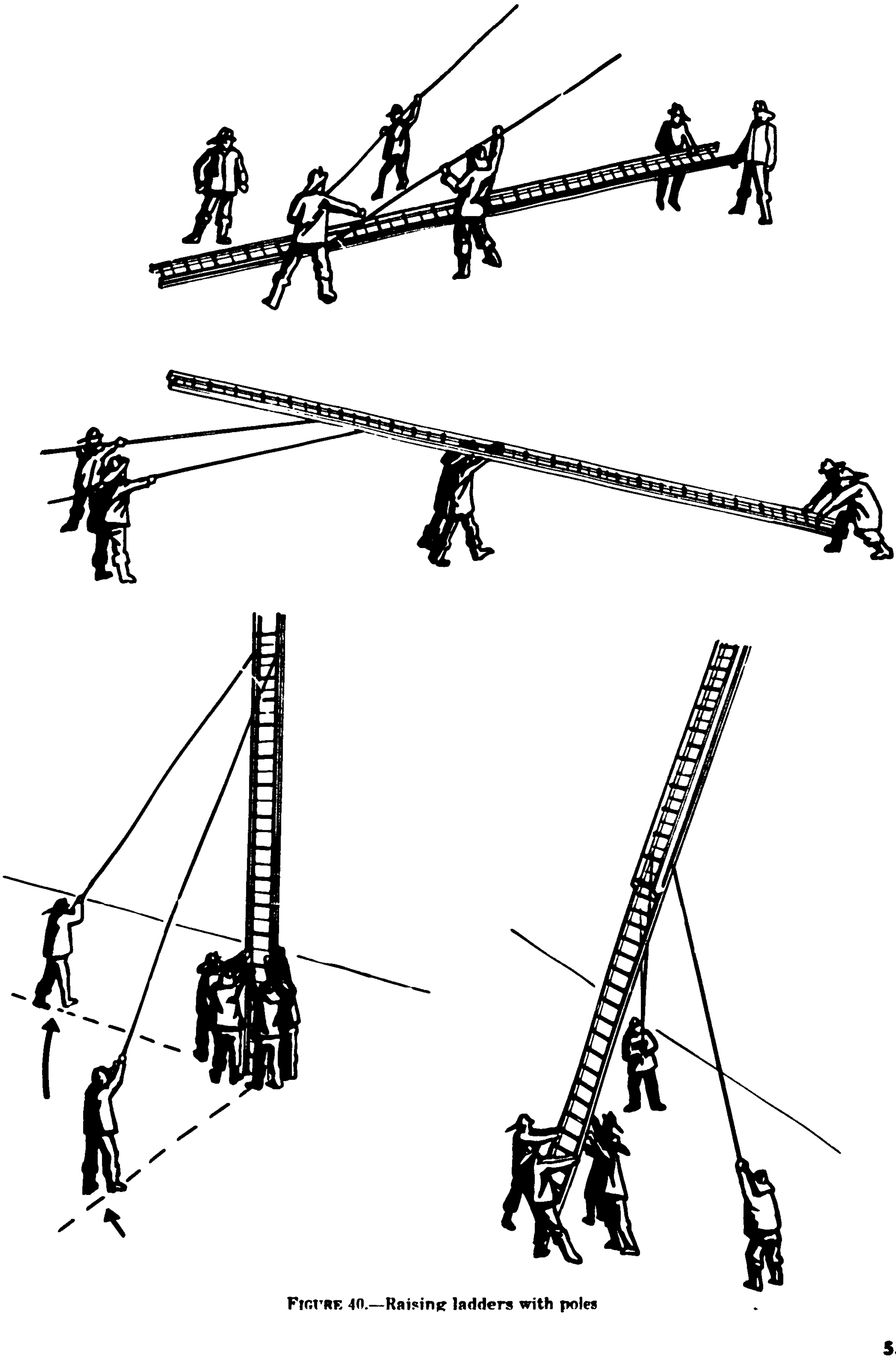


FIGURE 40.—Raising ladders with poles

nearer the ladder is to vertical, the greater will be its strength. This has led to the general acceptance of a rough rule that a ladder should be positioned with the base set at a distance from the building equal to one quarter of the height that the ladder tip is above the ground. In other words, the height to which the ladder is to be raised is divided by four, and the ladder butt is placed that far from the building.

This rule is good for painters' ladders and other ladders of unproven strength, but fire ladders are strong enough to be placed at somewhat lower angles. Slightly lower angles make working on the ladder easier and safer, especially when a nozzle is being operated from the ladder. There is less danger of the ladder sliding or falling away from the building when it is at a low angle. Most departments do not use a set formula to arrive at this distance, but place the ladder so that its base is two or three feet farther from the building than one quarter of the height. When placed at such an angle a ladder will reach to about two feet less than the length to which it has been extended. Thus, a ladder extended to 32 feet will reach a point slightly more than thirty feet above the ground when the base is ten feet from the wall of the building.

Some departments place a truss ladder (wood), with the curved side always toward the building. Some departments insist that the fly section be on the building side of the ladder; others require the opposite. Each department may have valid reasons for its requirements. The important thing to learn is the procedure followed in *your* department so that all members work in harmony and avoid confusion.

The raising and handling of ladders is best learned by practice under direction of a competent instructor. This is also the way in which the necessary teamwork in ladder handling is acquired.

There are, however, some generally applicable hints for greater safety in ladder operations:

1. When a ladder is removed from a truck, a ladder positioned behind it may be secured by the same locking attachment. If so, the attachment should be secured again to prevent the second ladder from being accidentally dislodged.

2. Ladders that have been removed from trucks, but not raised, should not be left where they may create a hazard; rather, they should be placed next to and parallel to the truck or building to reduce chances of someone tripping over them.

3. Ladders raised to a roof should be extended a few rungs above the roof so as to be easily seen and mounted by men finding it necessary to leave the roof in a hurry.

4. Whenever anyone is on a ladder, the ladder should be *securely dogged or butted*. The usual method of butting is for one man to place a foot on the bottom rung, hold the beams with both hands, and place the weight against the ladder. Another way is to place both feet against the beams at the butt and hold the ladder. Still another method has the butt man on the underside of the ladder holding a rung at chest height. Some departments dog a ladder to a window by using a chain and hook designed for this purpose or a rope hose tool. This type of dogging is a good safety feature, but requires that the dog be released before the ladder can be moved.

5. When it is planned to enter a window or assist someone from a window via a ladder, it can usually be done easier if the ladder tip is placed slightly below the window sill, although in some departments it is felt that the ladder tip should be inside the window.

Ladder Climbing

Before a man ascends a ladder, he should make sure that the ladder is in a safe position and not already overloaded. (Most fire department ladders will safely hold one man of average weight for every 10 feet of length when in a normal position, with a maximum of four on any ground ladder).

The man should not hug the ladder, but keep his body well back when climbing. If he plants each foot on the center of the rung instead of the end, it will minimize wobbling of the ladder.

Whether he should place his hands on the beams or the rungs is sometimes a matter of department policy and sometimes optional. There are arguments for and against both methods. Whichever method is used, the main aim should be to climb smoothly. Speed is not as important as form. Good form will minimize bounce and ladder stress.

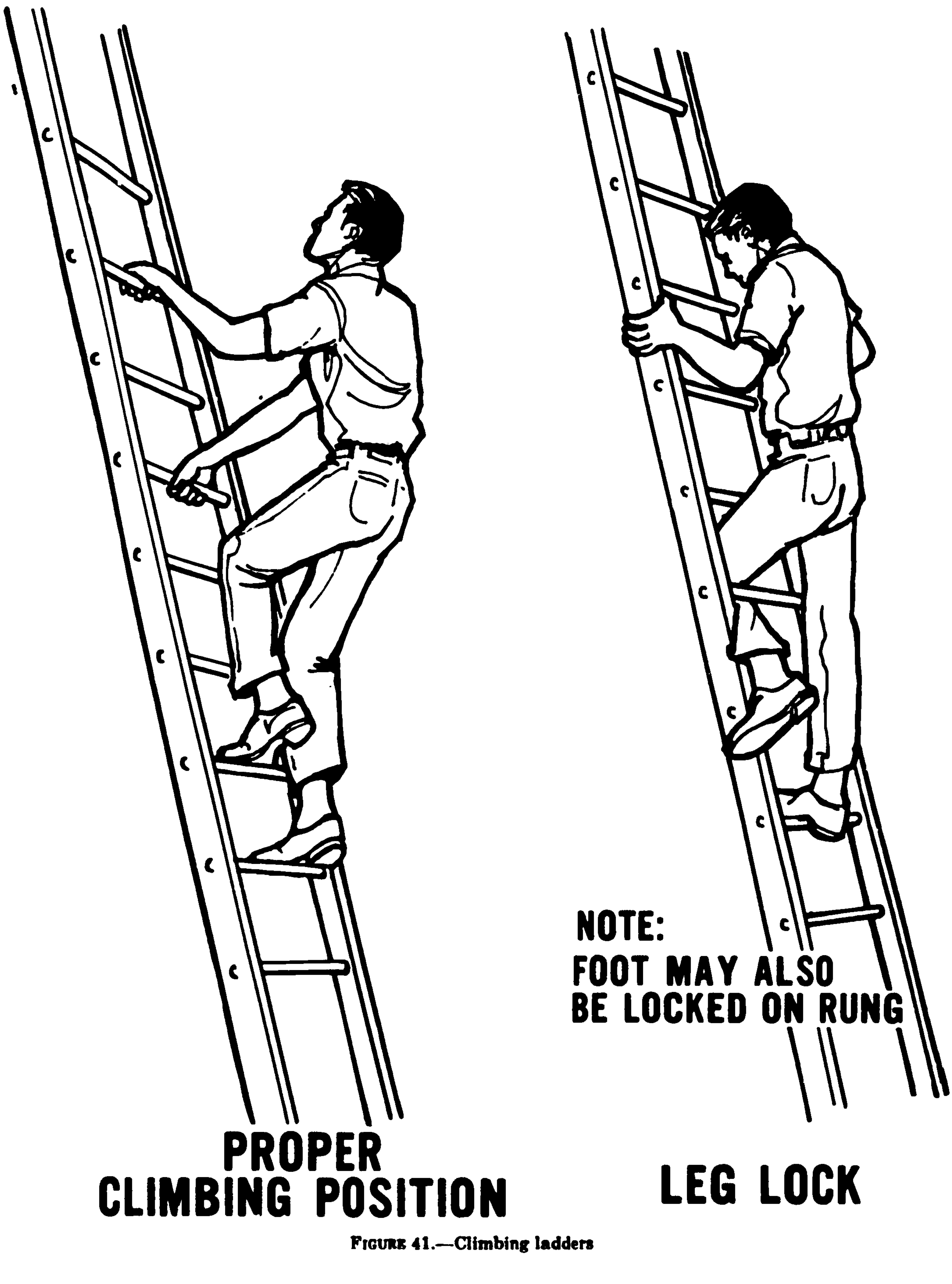


FIGURE 41.—Climbing ladders

When carrying a tool or other object that restricts the grasp of the ladder to one hand, a safe method of climbing is to slide the free hand along the underside of the beam from the outside. Thus, it is in position to grasp the beam quickly when necessary.

When a man is going to leave the ladder to step onto a roof or in through a window, he should make sure that he is not stepping into a void. Men have been killed by stepping off ladders into shaftways, stairways, or other openings. This happens most often when visibility is obscured by darkness or smoke, but can happen also when visibility is good and the man makes an erroneous assumption.

Working from a Ladder

When operating a nozzle or performing other work from a ladder, the man should be "locked on" to the ladder for his safety. This can be done by using a life-belt or ladder belt or by taking a leg lock when no belt is readily available.

If a belt is worn, the safety snap should be kept to the side when climbing, but when it is to be clamped to a rung, the safety snap is moved to the front by sliding the whole belt. When the snap is fastened to a rung, the man may lean back and work with both hands secure in the knowledge that the belt will keep him from falling off the ladder.

The leg lock is taken by placing one leg over a rung and the foot of that leg under a lower rung or against a beam in a manner that will keep the man from falling if he lets go with both hands and leans back. Thus, he is standing with one foot on a rung and the other locked onto a rung or beam. The leg to be locked should be the leg on the side *other* than the side he is going to work on. If he is going to work to the right of the ladder (his right), he should lock on with his left leg. He will have greater freedom of movement this way.

When a nozzle is operated from a ladder, the hose should be attached to the ladder with a hose strap or rope hose tool. Operating without such protection would be quite dangerous.

Ladder Bridges

Many times people have been rescued by crawling across a ladder that was placed as a bridge between two buildings. Although a ladder can be used in a horizontal position, care should be taken to avoid overloading it because it was not designed for this kind of stress.

A bridge of ladders can also be used to carry hose lines over a busy highway so that traffic will not have to stop.

Replacing Ladders

Support assistants may frequently be called upon to return ladders to their proper positions on the trucks. Therefore, they should become fully acquainted with the places and ways the ladders are carried and how they should be fastened. The latter is quite important because if a ladder came off while the truck was underway, it could cause serious injury and damage.

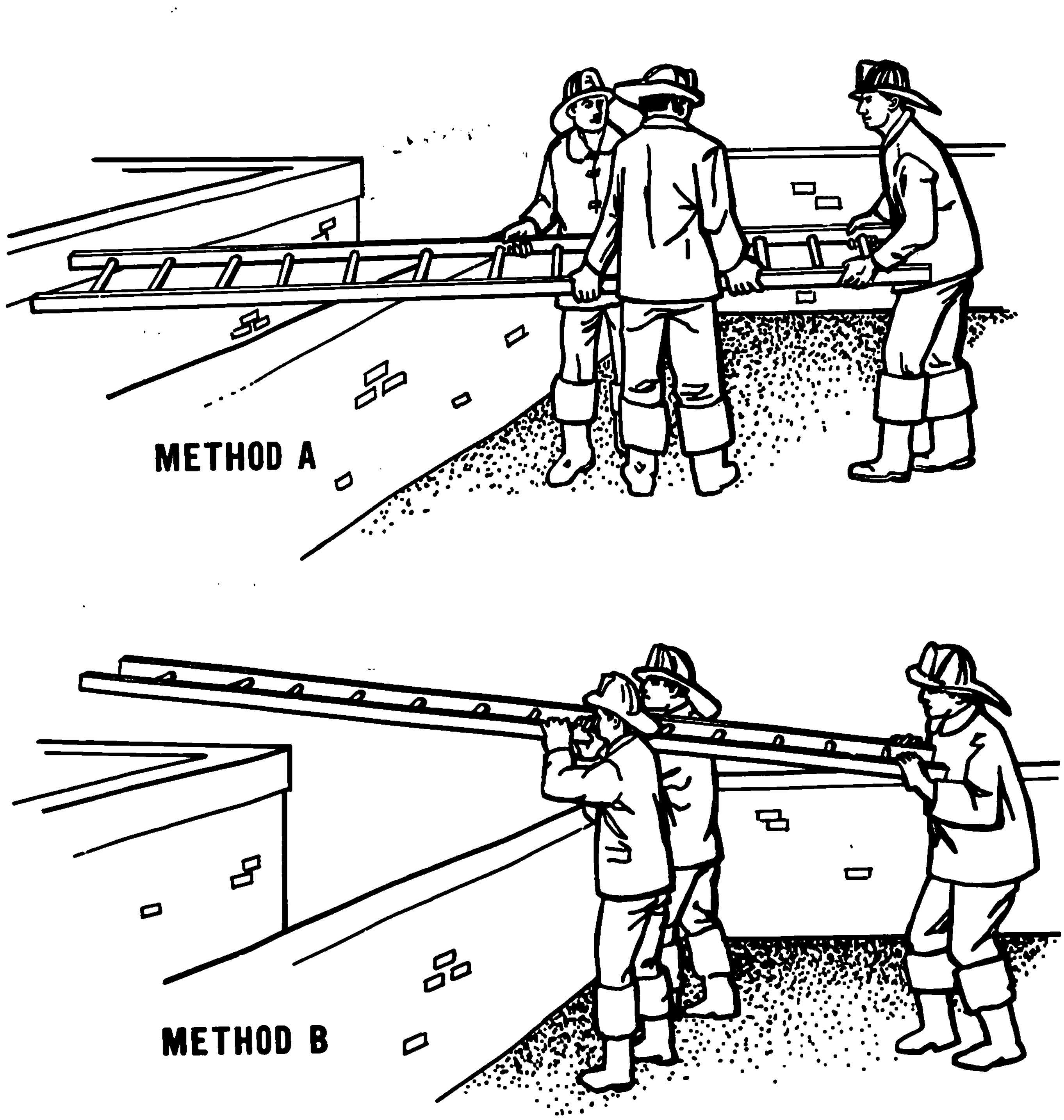


FIGURE 42. Ladder bridges

PROTECTIVE BREATHING EQUIPMENT

In order that firefighters may survive in atmospheres contaminated by smoke and gases caused by fire and also where toxic fumes have been released from other causes, they are provided with protective breathing equipment. This equipment protects the firefighter's life and also allows him to stay longer and work better in contaminated atmospheres.

It is important to understand at the outset that no breathing apparatus yet designed provides foolproof, guaranteed protection under all fire conditions that may be encountered. Each type has its limitations and men have been killed while wearing all types. Many of those killed, died because they did not thoroughly understand the limitations of the equipment they were wearing. Others who have died, knew, but gambled that they could exceed the limitations and get by.

There are four basic types of breathing apparatus available today. They are the filter mask; the self-contained demand-type providing either oxygen or air; the oxygen self-generating; and the type known as oxygen-rebreathing, or "rebreather." Each will be discussed separately.

A. *Filter-Canister Mask:* This is popularly known as the "All-Service" canister mask to distinguish the canister from those used in industry, which are used only for certain specified gases. The "All-Service" is officially known as the type "N" or "Universal" canister. The canister is *red*, and those for limited industrial use are painted other colors, according to their intended functions. The term "All-Service" is misleading because of many limitations of the canister, but has been in common usage in the fire service. Recently fire service authorities have recommended that the use of this type of mask be discontinued for safety reasons.

Some, but not all, of the canister limitations are printed on the label. This label should be read and thoroughly understood long before any attempt is made to use the canister.

The chief limitations are:

1. The canister is merely a filter. It does not provide oxygen; therefore, there must be sufficient oxygen in the atmosphere or the wearer will die of asphyxiation.

2. The filter can only remove gases in limited quantities. This limit should not be exceeded (see label).

3. Perhaps the most dangerous limitation is that "hopcalite," the material in the canister that converts deadly carbon monoxide, can lose its effectiveness. Carbon monoxide is colorless, odorless, and tasteless. When it gets through the canister, the wearer does not realize that he is breathing it.

4. Concentrations of carbon monoxide cause

FIGURE 43.—Filter-cannister mask

heating of a canister that is in good condition and is converting the carbon monoxide. Concentrations of 2 percent or more can cause the air coming to the facepiece from the canister to become too hot to breathe. If the man pulls off his facepiece in such a concentration of carbon monoxide, a couple of breaths of it may cause unconsciousness and death.

Care of Canister

In recent years, canister care has been simplified by adding a visual indicator at the hopcalite layer of the canister. There are two pieces of blue paper side by side in a window. When the canister is new, one paper is of lighter color than the other. Hopcalite is deteriorated by moisture, so the darker paper is treated to become lighter in color as it picks up moisture. When it becomes as light as the other paper, the hopcalite has lost effectiveness and the canister should be discarded.

Hopcalite can deteriorate from ordinary atmospheric humidity in a fire station; therefore, the bottom opening of the canister should be kept sealed until the unit is about to be used at a fire and should be resealed after each use.

It is dangerous to use canisters other than those equipped with visual indicators because it is difficult to estimate whether or not the hopcalite's usefulness has expired. Older canisters were equipped with so-called timers, a dial that merely indicated how many breaths had been inhaled through it and that did not give a true indication of the condition of the canister.

Canister with holes or dents in them should be discarded, as should canisters with cracked or broken glass in the window indicator.

Canisters that cause any strain or difficulty in breathing should be discarded.

Using the Filter Gas Mask

1. Whenever a canister is about to be used, the window indicator should be inspected to ascertain that protection against carbon monoxide has not expired.

2. The seal should be removed from bottom of canister to allow air to enter.

3. The harness is placed over wearer's head so that the window indicator faces away from his body and can be seen when mask is in use. Then the waist strap is tightened.

4. Facepiece is put on (description of donning of facepiece is given later in this chapter because it is the same for all units).

5. Test is made for proper fit and leakage by holding palm side of one hand tightly over the opening in bottom of canister and inhaling deeply. A proper fit without leaking should cause collapse of facepiece and stoppage of inhalation that is quite noticeable.

When these steps have been completed and it is obvious that canister and mask assembly are in good condition and functioning properly, the wearer can enter a contaminated atmosphere provided the atmosphere:

1. Contains at least 16% oxygen.
2. Contains less than 2% carbon monoxide or several other toxic gases, alone or combined.
3. Is not excessively hot.

If the man wearing the mask tastes or smells a foreign odor, retreat to fresh air is advisable because either there is a leak or the canister is failing to filter fully.

If the air being breathed becomes very hot, the man should retreat to fresh air. There may be a large concentration of carbon monoxide causing the canister to get dangerously hot. *He should not pull off the facepiece!*

It is a dangerous practice to wear filter masks in cellars, attics, sewers, tunnels, or other places that may be deficient in oxygen.

It is well for men wearing masks at fires to stay close to the floor. There will be less smoke and carbon monoxide at lower levels. Usually, the concentration is proportionate to the height. Another good reason to stay low is because heat is less at lower levels, and the danger of burns is lessened in case of a sudden flash of fire.

B. *Oxygen-Generating:* This unit also uses a canister, but one that is much different from the "All-Service." This canister is not just a filter, but actually provides oxygen, as well as removing the carbon dioxide from the exhaled breath. It contains an oxidizing agent that generates oxygen when activated by the moisture of the exhaled breath. Thus, there is a continuous closed circuit cycle in which the oxygen is inhaled and the breath that is exhaled is used to generate fresh oxygen. This cycle is continued until the canister is used up, which takes up to

FIGURE 44.—Oxygen generating mask

one hour or one-half hour, depending upon the model used.

The canister must be expended once the seal is broken. It *cannot* be used again because it continues to generate until expired even though not being used.

This unit has a spring wound timer that sounds a bell when a certain time has been reached (one-half hour or 45 minutes, depending upon which model is used). This timer must be started when mask is put into use.

Using the Oxygen-Generating Mask

The following steps can be followed to put the unit to work:

1. Holding mask in front of body, put harness over head.

2. Fasten chest strap.

3. Remove outer seal and discs from neck of canister. Be sure to expose shiny *copper* seal.

4. Holding canister with neck pointing upward lift bale with one hand and push canister upward evenly into recess.

5. Return bale to bottom of canister and tighten compression screw, forcing canister upward until the top of it makes a positive seal.

6. Put on facepiece and test for leakage and fit by squeezing *both* tubes and inhaling deeply. Proper fit without leaks should cause a stoppage of inhalation and facepiece collapse.

7. When proper fit without leakage is assured, the canister should be activated and a reserve of oxygen built up in the breathing bag by doing the following:

a. With one hand holding both tubes closed, pull facepiece away from cheek with other hand and inhale deeply. Then release both hands together and exhale vigorously. Repeat this several times until breathing bag is full.

b. When bag is full, place elbows against it, and while either pressing relief valve or holding facepiece away from cheek, squeeze bag to force oxygen out.

c. Repeat the steps of (a) above.

8. Set timer.

When the unit is being worn, an excess of oxygen generated may create a pressure in the facepiece that could make exhalation difficult. When this happens, the pressure can be relieved by momentarily pressing the button on the relief valve in front of the facepiece. This valve should not be held open too long or the breathing bag may be deflated. If the relief valve fails to work, the pressure can be relieved easily by pulling the facepiece away from the cheek for a fraction of a second.

Canister Disposal

The oxidizing agent in the canister will react explosively with oil and vigorously with water; therefore, an open canister should be kept away from both until it is disposed of.

Safe disposal calls for the canister to be punctured on three sides and placed carefully into clean water in a bucket or container that has never held oil. The water will probably boil

quite violently for a short while. When all boiling and bubbling ceases, the canister is safe for disposal, but it should be remembered that the bucket now contains a strong caustic solution.

C. *Air or Oxygen-Demand-Type:* These are open circuit units and although some use compressed oxygen and some use compressed air, both operate on the same principle. The air or oxygen is stored under high pressure in a cylinder and fed to the facepiece through a regulator valve which reduces the high pressure and supplies the wearer with the amount of air (or oxygen) his inhalation demands.

In the 40-cubic-foot unit, this supply is supposed to be good for one-half hour, and the apparatus is called a "half-hour" unit. However, the full supply can be used up in half that time by a man working hard at a fire. The same is true of the so-called fifteen minute units, which can be exhausted in about seven minutes. Therefore, great care should be taken by men wearing this apparatus to make sure they do not use up their whole supply while still in a contaminated atmosphere. The pressure gauge has a dial with a hand that indicates how much pressure remains. This should be observed frequently, and if the wearer can't see it in heavy smoke, he should withdraw to a point where he can read the gauge even if the apparatus is equipped with a low pressure alarm. The alarm might fail to work. The point at which the wearer should retreat to fresh air should be determined by a combination of the pressure remaining, the rate at which it is being depleted, and the distance to safety, with ample time to allow for delays in the retreat due to obstructions or difficulty in finding the way.

Fire Service authorities have recommended that only units rated for at least 30 minutes be used for firefighting purposes.

Using the Air or Oxygen-Demand Breathing Apparatus

There are several ways of donning this apparatus. The method taught in the member's department should be followed. When the apparatus is in place with all buckles fastened, the facepiece, which is carried separately, is donned and tested for leakage and fit by holding the palm or heel of hand tight against the end of the flexible breathing tube. With a tight fit without leaks a strong inhalation should cause the facepiece to collapse and inhalation to cease.

FIGURE 45.—Oxygen-demand breathing apparatus

Then the cylinder valve should be opened.

The regulator valve (yellow knob) should be in the open position and the bypass valve (red knob) should be closed. The gauge should be read to assure that the supply of oxygen or air is adequate. In connection with this, it is a good practice to open and close the red knob quickly so that any air or oxygen trapped in the high pressure hose from previous use will be released. This prevents a false reading on the gauge.

The next step is to connect the breathing tube from the facepiece to the socket for it on the regulator and tighten the lock nut.

If, during use, breathing becomes difficult, open the bypass (red knob) and close the regulator valve (yellow knob). This feeds a steady supply from cylinder to facepiece and may relieve the difficulty. However, it will use up the supply of air or oxygen more quickly.

Oxygen Rebreathing Apparatus

The so-called rebreathers are a combination

of some of the features of the oxygen self-generating and oxygen-demand apparatus. They operate on the principle of "scrubbing" carbon dioxide out of exhaled breath, using the oxygen of the exhaled breath over again, and supplementing it with fresh oxygen from a storage cylinder. This permits longer service than is available from other type units of comparable weight and consequently, many fire departments keep some of these units for jobs that acquire long duration of supply.

As with the other self-contained units, the gauge should be read frequently during use to assure time for safe retreat.

With older style units, occasional nitrogen purging is necessary during use.

General Precautions for All Units

Apparatus should not be put on after heavy exertion, or when man is breathing hard.

The wearer will experience less difficulty in breathing and get longer use of supply if he succeeds in keeping calm.

If difficulty in breathing is encountered, the wearer should resist the temptation to pull off the facepiece! He should calm down and rest.

Some fire departments use a life line attached to the wearer, but most departments have the men work in pairs so that in case of mishap to one man, the other can assist him.

Some of the harmful gases, notably hydrocyanic acid gas, can be absorbed through skin. No breathing apparatus can protect against skin absorption, of course.

EFFECTIVE USE OF HOSE STREAMS

Operation of Hose Streams

In order for a fire to be extinguished, either the heat, fuel, or oxygen must be removed. Water can extinguish fire by removing all three. Water extinguishes mostly by cooling the burning material to where it no longer gives off vapors that burn. This is both cooling and removing fuel. Water can also be converted to steam, which sometimes aids in extinguishing fire by diluting oxygen. Water is still one of the most effective extinguishing agents yet discovered and is also the most plentiful and economical.

It is amazing to the beginning firefighter how quickly water extinguishes fire when it hits it and how little water is needed when used properly. A typical bedroom fire, with the room fully involved, can be extinguished with a few gallons of water. The big job is to get where the water can be applied most effectively. At a building fire, this usually calls for getting into the building and working up close to the fire, a procedure not always easily done, but which usually must be done.

Untrained firefighters are inclined to stand at a comfortable distance from the fire and attempt to extinguish it by aiming a stream through a window. This is seldom effective because the amount of fire covered by the water is small. Trained firefighters do this only at very large fires or where building collapse is imminent. At ordinary fires, the nozzle is brought into the building and close to the fire before being opened. If a room is well involved with fire, the nozzle is moved around rapidly to get maximum coverage with a minimum of water. *A few gallons of water properly applied is more effective than tons of water wrongly used.*

Inside a building, to cool a very hot fire in a short time, the nozzle is aimed at the ceiling and whipped rapidly around. With a straight stream this bounces the water off the ceiling and causes it to fall like rain over a large area. With a fog stream, this is also beneficial, but a better way of applying fog is to rotate the nozzle so that water strikes all surfaces of the room: ceiling, floor, and walls. Either way, the stream should not be held stationary, but moved rapidly around. As soon as the fire is darkened, the nozzle should be shut off. It can be reopened (on straight stream) and aimed directly at the base of any flame that may reappear.

Opening the nozzle on smoke when no fire is visible is the mark of the amateur. However, sometimes when heat is so great as to make further progress impossible, it is permissible to open the nozzle and cool the area enough to permit closer approach to the fire.

Nozzles

There are two major types of nozzles. One discharges water in a straight or solid stream only; the other can also discharge a spray. All modern handheld, *fire department* nozzles can be opened or closed. Usually, the control valve is operated by a handle that is in the closed position when all the way forward and fully opened when all the way back. Nozzles without control valves are frequently found on *privately owned* standpipe or yard-hydrant hoselines. They are called "open" nozzles because they can't be closed.

Nozzles that deliver water in a fine spray are called "fog" nozzles. Most modern fog nozzles can deliver water in fog patterns of varying width, as well as a straight stream, and are referred to as "combination" nozzles. The types that have control handles provide an advantage in that the pattern can be set before the nozzle is opened. Some older types are opened and closed by turning the upper portion of the nozzle. (This also changes the spray pattern.)

Some fog nozzles are called constant-gallonage nozzles, meaning that they discharge the same amount of water at a given pressure in any pattern. This is not true of all fog nozzles. Those not of the constant-gallonage-type dis-

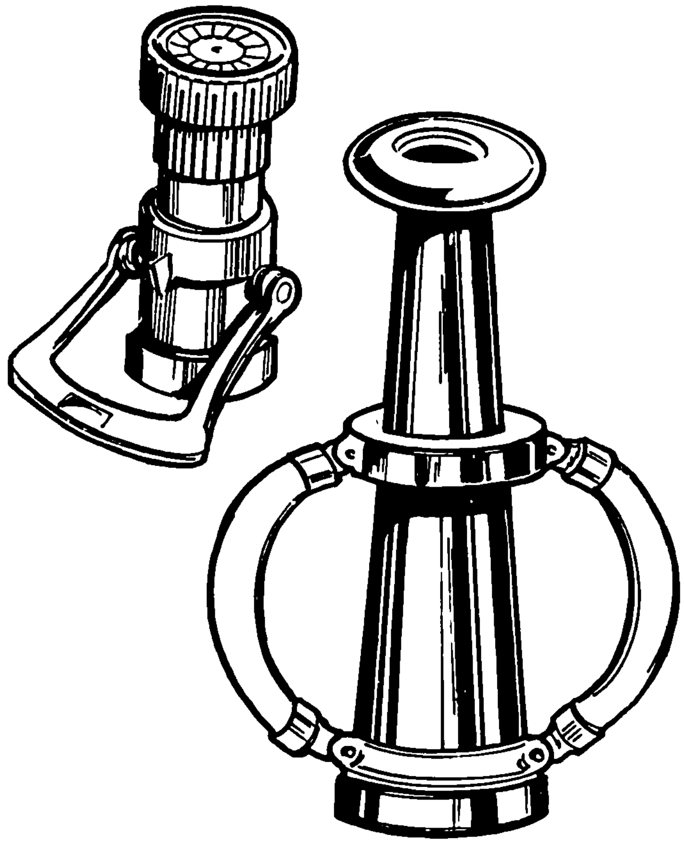


FIGURE 46.—Hose nozzles

charge much more water in the wider fog patterns than in the narrow patterns and straight stream position.

Although the discharge from a solid-stream nozzle can be determined by the size of the tip opening, which can be seen at a glance, the discharge of a fog nozzle cannot be determined from the size or appearance of the nozzle. Many models have the discharge (in gallons per minute) stamped or marked on the nozzle. Where this appears, it indicates what the discharge is at 100 lbs. per square inch (psi) pressure.

Some fog nozzles have variable flow controls, allowing the quantity of water being discharged to be changed. The positions to select various volumes are marked on the nozzle, but should not be regarded as accurate indicators because as the volume position is changed, the pressure will change, and any pressure other than 100 psi will give a different flow from that marked on the nozzle.

Special Nozzle

There are several types of nozzles designed for special uses, mostly for fires in cellars, concealed wall spaces, and attics or cock-lofts. (A cockloft is the space between the top floor ceiling and the roof in a building with a flat roof.)

The most commonly used cellar nozzles are:

Bresnan Distributor—This nozzle has a rotating head, which is moved around rapidly by the water being discharged from it. It has several small openings through which the water emits to cover an area about 40 feet in diameter when used at 50 psi pressure. The flow approximates that of an $1\frac{1}{4}''$ tip. It should be lowered about five feet below floor. Because it has no shutoff, control must be established with a gate valve one length back or a hose clamp. It is good practice to raise and lower it slightly when in use to get better coverage. If it does not extinguish fire quickly it should be moved to other application points.

Hart Cellar Pipe and Baker Cellar Pipe—These two pipes are similar in design. Each has a nozzle at right angles to the vertical pipe, which can be directed from above. The nozzle can be moved up and down and from side to side to provide maximum coverage. Some models can be turned in a complete circle and some have two nozzles pointing in opposite directions.

Bent Cellar Pipe—As the name implies, this is a long pipe with a bend of about 45°. It is designed to be used through a cellar window; whereas the Bresnan distributor and the Hart and Baker cellar pipes are made to be used through holes cut in floors.

Sub-Cellar Pipe—This pipe is longer than the bent cellar pipe and can be lowered down a freight elevator shaft or window well to attack fire in a cellar or sub-cellar. The sub-cellar pipe and the bent cellar pipe can sometimes be used effectively under piers.

Partition Nozzles—Partition nozzles have the tip at a right angle to the rest of the nozzle; thus, the nozzle can be easily inserted in small openings and the water aimed in any direction by turning the nozzle. This can be useful when fire is in between the studs of a wall or partition or in a ceiling or floor space.

Piercing Nozzle—This device has a sharp point so that the nozzle can be driven into a wall or ceiling. When water is turned on it comes out of many small holes in the nozzle to give a

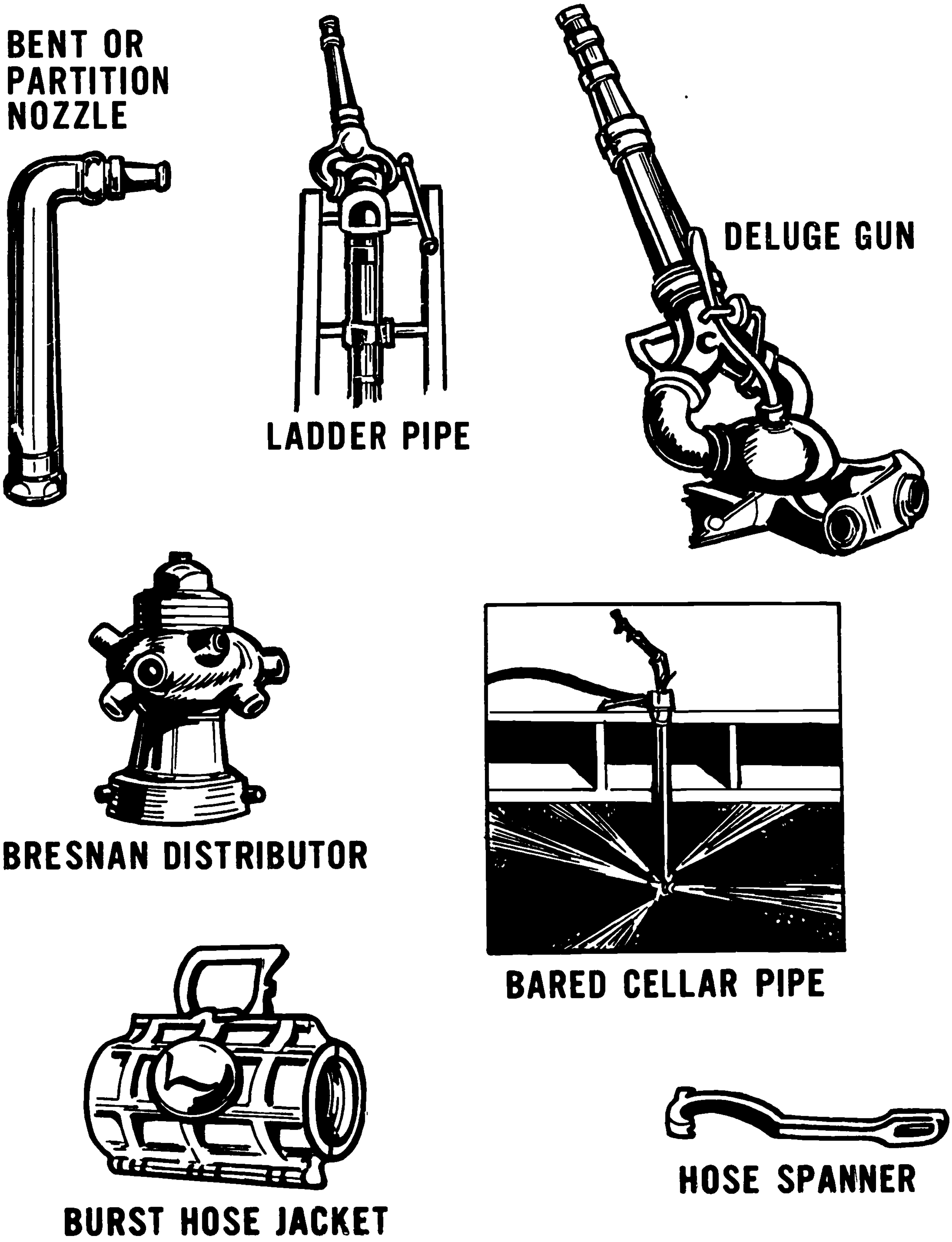


FIGURE 47.—Cellar Nozzles

coarse spray. It can also be used to reach into piled materials.

Fog Applicator—This is a long pipe with a bayonet type mount at one end, to fit a companion nozzle, and a fog head of the impinging stream type at the other end. This gives a soft fog, called "low velocity" fog. One leading use of the applicator is to reach over the edge of a tank in which liquids are burning. If used on an electrical fire, there is a danger that it might make contact with electrical current.

Heavy-Stream Nozzles

The nozzles previously described are all "hand held," meaning that no device is necessary to hold or manipulate the nozzle or pipe.

However, when streams of more than 350 gallons per mintue or nozzle tips larger than 1¼" diameter are used, holding devices should be used. These heavy caliber streams are often called "master streams" and the means of handling them called master-stream devices. Some of the most common of these are described in the following paragraphs:

Deck Pipe—Also called a turret pipe or wagon pipe, as well as a "gun," this device is permanently mounted on a pumper or hose wagon and, in some departments, on special apparatus and ladder trucks. It consists of a large diameter pipe (3" or 3½") with a swivel and tilt arrangement to allow its stream to be moved by one man. Nozzle tips are usually 1¼", 1½", and 1¾", although some departments use other sizes and a fog nozzle. Some are fed through siamese connections although some on pumpers are fed directly from the pump by opening a valve to the deck pipe.

Deluge Gun—(Sometimes called "portable Monitor" or "Street Pipe") This is similar to the deck pipe in appearance, principle, and purpose. However, it can be dismounted and carried to other locations. Deluge guns usually have two or three inlets and have tips the same sizes as deck-pipe tips. Most deluge guns have no shut off.

Ladder Pipes—What the deluge gun does on the ground, the ladder pipe does at elevations. Ladder pipes are attached to the rungs of an aerial ladder. Some are carried already mounted. others are put on the ladder only when about to be used. They have no shut offs and are usually supplied by 3" line from base of the ladder or two 2½" lines siamesed into the pipe.

Nozzle Holders—There are several types of devices designed to hold large nozzles operating at fairly high pressures. Most of these clamp on the hose in back of the nozzle and provide a means of taking up the reaction that makes holding a nozzle difficult.

Heavy-Stream Supply — Heavy caliber streams discharge large volumes of water. Unless the stretch is very short, they must be supplied by hose larger than 2½" in diameter or by more than one 2½" line. This is because friction loss at the volumes required is quite high in 2½" hose. Usually heavy streams or "master streams" use 500 gpm or more.

Water Towers and Elevating Platforms

One of the best means of applying heavy caliber streams at elevations is the apparatus known as the Aerial Platform. It can be operated from the ground as well as the basket and can bring its nozzle right up to a window. Most platforms have built-in piping to carry the water to the nozzle, and large capacity nozzles can be used.

Some departments still have water towers although none have been made in many years. The water tower is also capable of discharging large volumes of water but lacks much of the aerial platform's flexibility.

Somewhat different from both is the telescopic-boom, elevating platform, whereas the so called aerial platform has articulating booms; on this type, the booms telescope. It, like the articulating type, can be used for other functions, such as rescue and gaining access, as well as for the application of heavy streams.

Fog and Straight Streams—Advantages and Disadvantages

A fog stream has great cooling power because the many tiny water particles present a large total surface area and, therefore, absorb much heat. However, fog nozzles lack reach, penetration, and quenching power and are not as effective on large bodies of fire as are straight streams of adequate gallonage. Fog streams of large caliber should be used on large area fires.

Fog has the advantage of being effective on most high-flash-point, flammable, liquid fires on which type of fire straight stream is seldom as satisfactory.

Fog is more easily converted to steam, which is the form of water that absorbs the maximum amount of heat. Water absorbs six times as much heat when being raised one degree at 212° F. as it does when going up 60° to its ordinary boiling point of 212°. Water expands rapidly when turning to steam (about 1700 times), and the expanding steam covers a large area. This steam can have some extinguishing effect in a confined space. It is of no advantage in the open and of little value where there are openings through which steam may escape. It can present a handicap by upsetting the thermal balance and driving firefighters out of the building because sometimes the expanding steam causes the temperature near the floor to rise to an intolerable level.

Fog can provide excellent protection against the heat of the flames and hot air emanating from a fire. Also, it is virtually a nonconductor of electricity, having been tested on currents up to 135,000 volts and found safe at a distance of 3 feet.

When a nozzle is in fog position, there is less reaction ("kick back") than with straight stream, but the high pressure required by fog nozzles makes the hose very stiff. There is not much difficulty with 1½" hose, but presents a problem when 2½" hose must be advanced and maneuvered inside a building.

Fog, when used in a closed area with no ventilation, may cause a flash back of the fire to burn the men at the nozzle. That is why ventilation is necessary when using fog inside a room, especially a small room. It is preferable to have the opening for ventilation on the opposite side of the fire from the nozzle to allow the heat to be "pushed out" by the fog stream.

Selecting the Most Suitable Nozzle and Hose

Choice of the nozzle and the hose size to be used at a fire depends upon several factors:

Type of Fire.—Flammable-liquid fires require fog nozzles (if water is used). Deep seated fires in solid materials require straight stream.

Location of Fire.—Fog has much less reach than straight stream.

Size of Fire.—Large fires require large nozzles to give the required volume of water. If the rate of water discharge is not sufficient to absorb enough heat to stop the generation of burning vapors, the fire will continue to burn.

Length of Stretch.—Long stretches require smaller nozzles or larger diameter hose to reduce friction loss.

A widely accepted rule is never to use a nozzle diameter more than half the hose diameter, to use half the hose diameter for stretches up to six lengths, and deduct 1/8" for every additional 6 lengths.

If long stretches are needed at a large fire and the volume of water needed requires large nozzles, it would create excessive friction loss in one 2½" hose line. Therefore, it becomes necessary to siamese two lines into one nozzle or deluge gun to cut down the friction loss by dividing it between the two lines. Sometimes even three lines into one may be necessary.

For example, with a 1¾" nozzle on a deluge gun at a 68 pound nozzle pressure, the flow is 750 gpm. If this flow were forced through a single line of 2½" hose, the friction loss would be 120 pounds per 100 feet. This is excessive; so we would use two lines siamesed into the deluge set and cut the friction loss down to 32 pounds. The friction loss in two lines siamesed is roughly one fourth that of a single line.

Remember that large nozzles and pressures are needed at large fires, but that when the nozzle diameter is more than half the diameter of the hose, an additional line or lines should be siamesed to reduce the friction loss. The same is done if required engine pressure for one line exceeds 250 psi.

Nozzle Pressures.—Safe rules to follow for selecting nozzle pressures are:

(figures are nozzle-tip diameters)

Inside streams—1", 1⅛", 1¼"—30 psi

Outside streams—1", 1⅛", 1¼"—50 psi

Outside streams larger than 1¼"—60 to 80 psi

(Streams larger than 1¼" are not usually taken inside buildings and are not usually hand held.)

Fog streams—80 to 100 psi

Placement of Streams.—Outside streams should be moved constantly to give maximum

coverage. A heavy stream going in a window will put out all the fire it can reach in about a half-minute; so there is no point keeping it in one window for a longer period.

Hose streams should not oppose each other. This means that if men with a hose line are trying to advance through one doorway, there should be no lines operating from the opposite direction driving heat toward them. This is extremely harmful if the opposing stream is a heavy outside stream. It is not usually good practice to use outside and inside streams simultaneously on the same floor.

There is a simple, easily remembered rule covering placement of hose streams. First, cut off spread of fire, then extinguish fire.

Nozzle Operation.—For every action there is a reaction. The water passing out through the end of the nozzle creates a reaction tending to push the nozzle back in the opposite direction. The greater the pressure, the greater is this reaction, or "kick back." The reaction of a given nozzle pressure *increases* with the nozzle diameter. Nozzle reaction can be calculated as one and one-half times the pressure times the square of the diameter of the nozzle ($1.5 PD^2$). (Nozzle diameter is the diameter of the tip through which the stream emerges.)

For a 1" nozzle diameter at 50 psi, the reaction is 75 lbs. For the same nozzle at 100 psi, the reaction is 150 lbs. For a 1⅛" nozzle at 50 psi, the reaction is 95 lbs., and at 100 psi, it is 190 lbs. In each case the reaction is the pressure forcing the nozzle back that must be overcome by the men holding it. This is done by the nozzlemen leaning forward against the reaction. It is also a reason why he should be well braced. It is good practice to have another man back up the nozzleman and take the greater part of the strain, leaving the nozzleman free to operate the nozzle. It is practically a must to have two men at the nozzle when nozzle diameters exceeding one inch are used.

When nozzle diameters exceed 1¼", it is necessary to use a holding device such as a pipe holder or deluge set to take up the reaction.

There is an old myth concerning nozzle reaction, which still has many believers, that when a solid stream strikes a wall, the reaction is transmitted through the stream back to the nozzle. This does *not* occur and tests have proved there is no difference in nozzle reaction whether the stream is hitting a nearby wall or not hitting anything at all.

Nozzles should be opened and closed slowly. Opening a nozzle quickly causes a sudden release of pressure that may wrest the nozzle from control. The sudden closing of a nozzle causes a pressure surge that exceeds the pump pressure. This "water-hammer", or ram, may burst the hose or damage the pump or water pipes.

Why is the reaction so much less when the water is flowing than at the moment the nozzle is opened? Before the nozzle is opened, the pressure at the nozzle is the same as the pressure at the other end of the hose line (hydrant or pump) if they are on the same level; but as soon as the nozzle is opened and water starts to flow through the hose line, friction loss in the line uses up a great deal of the pressure and the nozzle pressure drops. This will be explained in more detail in the chapter on pumping.

An unsafe practice in the handling of hose streams is the straddling of hose. This is another mark of the amateur and a procedure that could lead to painful injury.

Foam

It is common for laymen to think that chemicals are superior to water in firefighting. Actually, there is very limited use of chemicals because not only do they cost much more than water, but they seldom are more effective, especially when the fire is beyond the incipient stage.

However, there are certain applications where water by itself is not sufficiently effective. For this reason "foam" is used on liquid fires that cannot be extinguished with water alone. Foam is a compound that, when mixed with water, makes tough, viscous bubbles, that can form a blanket over the surface of the burning liquid, excluding oxygen, and smothering the fire. The water contained in the bubble formation also has a cooling effect.

There are two basic types of foam: chemical and mechanical. Chemical foam comes in powder form and is mixed with water in a foam generator. The powder is poured into a hopper atop the generator and stirred with a paddle to obtain uniform mixing. The water should enter the generator at a pressure of 100 psi

and there should be 100 feet of hose between the generator and the nozzle to assure a good quality foam. Most chemical foams have one powder, but some have two powders called "A" and "B," which are mixed together in the hopper.

Mechanical foam comes in liquid form and is mixed with water in either of two ways. One method uses a pick-up tube attached to a foam nozzle. The tube is inserted into the can of foam and the venturi action of the water passing through the nozzle picks the foam liquid out of the can to mix with water and air as it passes through the nozzle.

The second method uses a foam proportioner, a device that can be inserted anywhere in the hose line to mix foam liquid, air, and water. A conventional fog nozzle can be used on the line from a proportioner, provided it is "mated" with the proportioner, meaning that both are designed to provide the same discharge in gallons of water per minute.

It is essential that the foam being used is the same in percentage rating as the nozzle or proportioner. There are "three percent" foams and "six percent" foams to match foam nozzles and proportioners of the same percentage rating. A six percent foam should not be used with a three percent nozzle or proportioner, and vice versa.

There is a special variety of foam liquid known as "all-purpose" or "alcohol" foam. This is for use on fires in alcohols, esters, and ketones, which break down ordinary foam. This foam does not contain alcohol, but is made to be used on alcohol.

High Expansion Foams

The foams just described are protein foams. There are other foams also quite effective on most flammable liquid fires but which are finding a further application in filling basements and similar spaces to extinguish inaccessible fire. These foams are called high expansion foams because some of them have an expansion ratio of 1000 to 1, compared with ordinary foams that expand about 10 to 1. This ratio is calculated as the number of gallons of foam bubbles made by mixing one gallon of foam liquid with the proper proportions of air and water.

Those hi-expansion foams are detergents (synthetic soaps) and are used with special equipment that forces air under pressure and water under pressure through a mixing device to make a large quantity of light, fluffy bubbles. The extinguishing effect of hi-expansion foam is largely one of cooling rather than smothering.

Wetting Agents

Some detergent foams can be used as additives or "water wetters" to reduce the surface tension of water so that it will penetrate better into porous materials.

There are several other types of wetting agents. They may vary in composition, but most work on the principle of penetration through reduced surface tension.

Other Activities

There are other materials, which when added to water, will give it certain properties. Some make it cling. Some make it smoother. Some make it opaque. None of these are in general use as yet.

Applying Foam

Foam should be applied at flammable liquid fires in a manner that will make it flow gently over the surface of the burning liquid. It should not be aimed to plunge under the surface, but directed to strike the side of the tank if the liquid is in a tank. If the fire is in a spill on the ground, the foam can be bounced off the ground in front of the fire to flow onto the fire.

Most foams are *not* compatible with ordinary dry chemicals, but there are special foam-compatible dry chemicals and dry-chemical-compatible foams, neither of which are common in fire departments. If noncompatible foams and dry chemicals are used on the same fire, they may work against each other; therefore, care should be taken to avoid this conflict.

Foam may also be used to put a protective coating on parts of structures exposed to the heat of a fire such as window glass, airplane fuselage, or combustible surfaces. This is an expensive method compared with wetting them with plain water, but could be useful where the water supply is limited. The heat will dissipate the foam in time and then the coating must be renewed if the protection is still needed.

OVERHAULING

What is overhauling? Simply defined, overhauling is a thorough examination to make certain that a fire is completely extinguished. In the usual application, it is the entire process of making sure that no sparks or embers remain to "rekindle" a fire that might again spread through the premises or materials involved. Overhauling should not be considered part of salvage work or determination of fire cause. Overhauling is an important subject, one that should be dealt with separately. It should also be clearly understood that overhauling is not merely "wetting down" burned materials; it is performed more with tools than with water.

Overhauling is necessary because fire tends to remain unnoticed in concealed spaces of a building, behind walls, above ceilings, under floors, in cracks between boards, etc. Also, combustible contents, such as upholstered furniture, mattresses, rugs, clothing, rubbish, and stocks such as papers and cloth may contain hidden fire.

As soon as visible fire is extinguished, overhauling operations should begin. Usually there is no need to start with haste; a little time spent planning for a systematic overhauling job will save time and effort, prevent injuries, avoid needless duplication, and get better results.

Operations should be planned so that an examination is made of every place where fire could possibly remain or have extended. This can range from the opening of a mattress to the shifting of all the contents of a warehouse, from punching a small hole next to a light fixture to pulling down the entire ceiling of a large building.

The plan for overhauling operations should be based on location; intensity and extent of the fire; type of construction involved; and type, amount, and distribution of contents. The first step is to use hearing, sight, touch, and smell to discover hidden fire. Fire in a ceiling or wall may be indicated by a crackling sound or by blisters or by discoloration. Fresh smoke issuing from cracks in floors or around baseboards is another sign of remaining fire. Sometimes the smell of smoke will indicate what material is burning and give a clue to its location. Touch may be used by feeling for hot spots along walls and floors.

Whenever these signs of hidden fire appear, it is logical to make openings to uncover and extinguish the fire. It should be remembered, however, that a wall that has had its surface exposed to the heat of the fire may feel hot and yet not have a fire behind it. An old adage says that if you can hold your bare hand on a latch and plaster wall long enough to say, "It's hot, Chief," then there is no fire at that point.

Of course, one cannot depend entirely on these noticeable signs. There are frequent occasions when judgment is the only guide. If there has been intense fire in a room, it may be reasonably assumed that it might have been conducted through the ceiling; therefore, a small portion of the ceiling may be opened for examination. The point chosen for this examination should be the place where the fire appeared most intense or where there is an opening such as a light fixture or pipe channel. If, after the ceiling is opened, evidence of charring is disclosed, more of the ceiling should be removed until all of the charred area has been exposed. If cobwebs are seen, it means that there has been little or no heat there.

Window and door frames are places that require particular attention. Hidden fire is probably found here more often than in any other part of a building. It is a simple matter to remove the casing or trim, preferably the trim, because it can be taken off neatly without damage and left for the owner to replace.

When an examination is made to discover fire travel in a wall of a room above the fire, the least damaging way to open that wall is to remove the baseboard and puncture the plaster in the area previously covered by the baseboard. When the baseboard is later replaced, it will cover the hole.

Sometimes it is necessary to remove floor boards to get at or discover fire. The most efficient way of doing this from the standpoint of ease of operation and cost of replacement is to cut the boards alongside the beams they rest upon. The location of these beams may be determined by sounding: that is, tapping the floor with the top of the ax head. The hollow area between beams will emit a deeper sound.

It has been assumed that all the structural overhauling mentioned so far will be done from the interior of the buildling. It is not only easier and more effective to open sidewalls from the inside but less damaging in terms of repair cost.

Exterior overhauling operations may include opening of roof, opening roof and window cornices, and removing burned shingles or siding. The same procedure described for floor boards is used to remove roof boards after roofing material has been taken off to expose the boards. Tin or built-up roof coverings are cut and peeled back. Shingles can be pried loose with a claw or similar tool or the pike of an ax. A quick and easy way to remove shingles is with a shovel.

A good way to cut up roof coverings around a skylight or other opening is to cut diagonally outward from each corner and then peel back the roofing material between the cuts.

The overhauling of furniture mostly concerns mattresses and upholstered furniture. Fire can burrow deep into padding material and smolder for days. This requires that the material be pulled apart and thoroughly examined. A safe procedure is to remove a mattress to a place where its re-ignition would do no harm. That a mattress or davenport is well soaked with water is no guarantee that all fire in it has been extinguished. An experiment was once conducted in New York of lowering a burning bale of cotton into the East River and leaving it submerged for a week. When it was removed, the bale was broken open, and fire was still smoldering within it. The use of water containing a penetrant ("wet water") is helpful, but does not entirely remove the necessity for pulling apart burned materials.

Burned clothing should be separated from unburned and examined thoroughly. A common way to overhaul clothing or bed clothes that are still burning is to remove them to the bathroom and submerge them in a bathtub half full of water.

Just as with clothing, the overhauling of combustible stock in a mercantile or storage occupancy calls for separation of the burned from the unburned and close scrutiny of the burned. If fire damage has rendered an article useless, many fire departments feel that no further damage can be done by soaking it. This may be done by forming a basin with salvage covers, putting water from a hose line into the basin and dipping burned materials into this water.

Two common overhauling procedures that are actually seldom necessary are scraping char and the practice known as "washing down." The scraping of char from wood surfaces for fear that the charred area will re-ignite spontaneously is hardly worthwhile because the likelihood is so remote.

The procedure known as washing down is frequently overdone. It seems incongruous that firefighters will endure extreme punishment in getting close to a fire to extinguish it with a minimum of water; then an hour or more later use three times as much water to wash down an area that has been overhauled. If the overhauling has been competently done and the examination has been thorough, there is little justification for the traditional washdown. About the only time it may be justified is when it is believed that fire may remain in some crevices that are difficult to uncover or examine. A small amount of water may be directed into such spaces, but the wetting of exposed surfaces is a useless and sometimes damaging procedure, usually caused by over-caution.

There are some specific overhauling problems that arise frequently. One is the overhauling of an automobile. The first step is to disconnect the battery, unless it has been determined that it had nothing to do with the fire. Burned seat cushions should be removed from the vehicle and thoroughly overhauled. If there is a possibility that fire extended into the contents of the trunk, it should be opened for examination. Burned wires should be scraped or closely examined. Floor mats should be inspected on the bottom; an examination should be made of the underside of the vehicle to see if any grease or insulation is burning.

Fires in lumber yards or other places where stocks of wood are involved will necessitate the

moving of the burned lumber—a tedious, but often necessary, procedure.

The same is true of coal piles, hay storage, and piles of rubbish or similar materials. Burned hay presents a safety problem also. Men should stand on planks or ladders to keep from falling into pockets where the hay has burned to ash.

Fires involving large amounts of baled goods often necessitate moving bales outside the building to be overhauled. Fork-lift trucks or hand trucks are often on the premises and can be used if still serviceable. If the goods to be moved are on upper floors, sometimes a window opening can be continued down to floor level to facilitate removal of burned material. If this is done on more than one floor, the openings should not be made on windows directly above or below each other. The removal of window aprons in direct line may weaken the wall.

If there is much water on the floor, it should be relieved promptly because water is quite heavy. Water an inch deep covering an area 40' x 80' will add about 16,000 pounds to the gross floor load. If water has accumulated on more than one floor, it should be removed from the lowest floor first and then each floor above in turn, working from the bottom upward. This will prevent water from upper floors adding to the load on lower floors.

Common overhauling accidents are:

1. Falls, caused by men stepping into holes in floors, slipping on wet or icy floors, and tripping over debris.
2. Cuts caused by broken glass and metal, especially tin ceilings.
3. Foreign bodies (charcoal, plaster, etc.) in eyes.
4. Strains caused by lifting heavy objects.
5. Injuries caused by falling objects.
6. Men being struck by tools wielded by others.

Item 3, 5, and 6 above are most frequently caused by men working too close together. This can be easily prevented by proper supervision. It should be strongly emphasized that the duty of officers is to supervise—not to join in the work. An officer cannot properly look out for the safety of his men if he is occupied with manual work.

Another safety consideration is the presence of dangerous materials, such as acids or other chemicals that may be hazardous alone or in combination. Special care is needed in handling them, and it should be remembered that containers may have been weakened by heat or water and might fall apart during handling.

Caution is required in the presence of combustible dusts. There have been occasions when firefighters have disturbed dust sufficiently to cause dust explosions during overhauling.

A large overhauling job should be well planned. After the stability of the structure has been ascertained and danger spots noted, the procedure should be laid out so that all points will receive the necessary attention. In this way, no part of the structure will be overlooked and needless duplications are avoided. Starting and finishing points should be selected, work apportioned, and assigned. Suitable tools should be at a convenient point. Adequate lighting is important for safety and efficiency.

Tools required may vary slightly with the job to be done, but the usual basic group consisting of an ax, a 6-foot pike pole, and a Halligan or claw-tool are satisfactory for most of the work. Scoop shovels are needed where debris must be moved. Pitchforks are handy overhauling tools on certain occasions. The use of power tools, especially saws, has become popular in recent years. A common fault of small departments is not having short pike poles or hooks. Those with handles longer than six feet are different to use inside most buildings, especially dwellings.

Other equipment should include lights, and a generator, if necessary. Also, remember that a charged hose line or lines with sufficient hose to reach all points should be on hand ready for any fire discovered. The usual practice is to reduce to lines of 1½" diameter and nozzles of small capacity for easier mobility and less water damage. Pump and engine wear may be saved when hydrant pressure is adequate to supply these lines, but a pumper should be ready for instant use if needed.

Mention should also be made here of "watch-lines." In extreme cases, a chief may decide that the most efficient procedure is to leave a small crew of men with a charged hose line on the scene to guard against rekindle, allowing companies to return to quarters. This is not done until routine overhauling has been completed.

The public relations aspect of overhauling is important. Unfortunately, the public seems to have an image of firefighters as house-wreckers. It is worthwhile to explain the need for overhauling to the owner or occupant of the premises and consideration should be given to his feelings. A neat overhauling job with debris removed and a little time spent cleaning up will make a far more favorable impression than a careless job. This is especially true in a residence.

A good mental attitude for firefighters is to base their activities on this principle: "Suppose that I were the property owner and not a firefighter. What impression of the fire department would I get?"

EMERGENCY WATER SUPPLIES

An aspect of war-time firefighting that differs greatly from peacetime is the possible disruption of water supply. Experience has shown that bombing can paralyze a water system by breaking dams; bursting conduits and mains; knocking out the power of pumping stations; breaking many pipes in buildings; and causing much loss of water and pressure. Any of these alone or combined, can seriously impair a water supply at a time when it would be critically needed to fight fires.

World War II provided some examples of what can happen to regular water supplies during air attacks. When the atom bomb was dropped on Nagasaki, Japan, five breaks in buried pipes occurred in one section of the city, and that section was without water immediately. Six additional breaks occurred, four of them at bridges. When the bomb exploded at 11 a.m., the pressure in the system dropped from about 30 to 10 psi, and by 4:30 p.m. it was negligible. A major factor contributing to the failure was the breakage of about 5,000 house service pipes because of collapse of dwellings from blast or fire.[1]

Some of this damage may be offset by closing off sections of the water distribution system, but this would mean that areas of the city would then be without water under pressure. Therefore, the fire department may face the problems of no water under pressure; water available only in certain areas; or generally weak pressure and supply throughout the city. Even without great damage to the water system, a large conflagration or many individual fires could overtax the system. Therefore, it would become necessary to use emergency water supplies.

Emergency supplies can consist of purposely installed, static, storage tanks that would probably be built—if time permitted—in the event of war. But in any case they also consist of natural water sources, such as lakes, rivers, and bays, and man-made storage, such as swimming pools and industrial water supplies. In some of our larger cities there are many gravity or pressure tanks for sprinkler and standpipe systems in buildings, and many large factories have private water systems.

[1] U. S. Strategic Bombing Survey, Nagasaki P. T. O. 93 Vol. III

Rivers, Lakes, and Bays

These natural sources can be of tremendous value *if* they can be reached. The City of Hachioji, Japan, had over 70 fire department pumpers waiting when struck by an air attack. The public water system soon failed and only 15 pumps were able to get into position to draft from the river.

A pumper in good condition can draft water a vertical distance of about 20 feet. (Theoretically the limit is almost 34 feet, but the 20 foot limit is accepted as being practical.) For this reason, London, in World War II, built platforms below the bridges on the Thames and placed pumps on these platforms to pump water to fire department pumpers above.

Water educators, working on the venturi principle, can bring water up to pumps from considerable distances below, but they require some water flow to initiate the action. Portable pumps can be placed near the water's edge and can pump water to a pumper up to 60 feet above, but the amount of water pumped is relatively small and decreases as the height increases. The best way to assure a supply equal to the capacity of a pumper is to get the pumper close enough to draft directly from the river, bay, or lake.

Swimming Pools

Many communities have public swimming pools. Pools are also found at motels and in the yards of many private homes. It is surprising how many gallons of water are in these pools: for instance, a motel pool that is 20 feet wide and 40 feet long, with a depth from 3 to 9 feet,

can hold well over 30,000 gallons of water. Even a portable pool 10 feet in diameter and four feet deep can contain 2,300 gallons, a 10-minute supply for a $2\frac{1}{2}$" hose line with a $1\frac{1}{8}$" tip.

Private Industrial Water

Large manufacturing plants sometimes have their own water storage in holding basins, ponds, and gravity tanks. Many have their own wells and pumps, which, if gasoline, steam or diesel powered, could be used even if electricity was knocked out. Sometimes hose lines can be taken from the private industrial hydrants and connected to a nearby public hydrant to convey water from one system to the other.

Whenever water is to be taken from an industrial plant care should be taken to make sure it is water and not some other liquid.

Water can be taken from mercantile, hotel, office, and other buildings equipped with standpipe systems, not just for use in the building itself but for general firefighting in the neighborhood. Hose lines from several standpipe systems can be run into one or more pumpers, which can then deliver it under pressure.

Other Emergency Water Sources

When water mains are ruptured, the escaping water may be drafted. This was done by the Honolulu Fire Department during the Japanese attack on Pearl Harbor. They drafted out of bomb craters.

Cisterns are a peacetime source in several cities and one regular peacetime source that may be usable to a certain extent if the rest of the system is disrupted.

Even if a water main is without pressure, it may contain thousands of gallons of water that could be drafted by a pumper connected to a hydrant with *hard* suction. When trying this, it might help to open other hydrants on the same main to let air into the system.

Broken pipes may cause much water to collect in basements where it might be reached for drafting, even if only with a portable pump or educator.

Sewers could in some cases provide a valuable, if indelicately scented supply. A fire emergency is no time to yield to esthetics, and the effectiveness of this effluvium in firefighting should not be underestimated.

Transportation of Water

Many of our rural fire departments must carry their water supply with them. They use tank trucks varying in capacity from 500 to 5,000 gallons. On occasion, they press privately owned tank trucks—milk tankers, etc.—into service to carry water to fires. Even truck-mounted cement mixers can be used. (They can hold about 1,100 gallons of water.) A similar emergency measure is to put cattle tanks on pick-up trucks. (They hold about 250 gallons each.) These tactics may be well suited to wartime use in cities.

Portable canvas storage tanks that come in two sizes (1,000 gallon and 1,500 gallon) are used in conjunction with the transportation of water. A tank can be set up quickly (in a minute or two) next to a pumper. The water from the tank trucks is dumped into the canvas tank from which the pumper then drafts. If enough tankers keep up a shuttle service, the pumper can maintain a steady flow—but usually a very limited one.

Improvised tanks can be made from salvage covers spread over a frame of ladders. Such basins can also be used where mutual aid pumpers cannot connect to hydrants because of incompatible threads.

In other cases of incompatible threads, the local hose can be connected to the hydrant and then run into suction sleeve of the mutual-aid pumper. If the couplings are cut off, two lengths of $2\frac{1}{2}$" hose can be placed into a $4\frac{1}{2}$" hard suction but must be placed into it almost as far as it's inner end or else they will slide out when the water starts flowing. An easy way to get the hose ends far into the suction sleeve is to thread a rope through the sleeve, tie it to the hose ends, pull them through the sleeve, untie the hose, and then connect the sleeve to the suction inlet of the pump. The outboard end of the sleeve can then be bent up to a point at a level above the pump and tied into that position with the rope.

If hose with incompatible threads must be connected and no adapter or hose jacket is at hand, an emergency connection can be made by cutting off the male coupling and pushing the hose end well into the other hose.

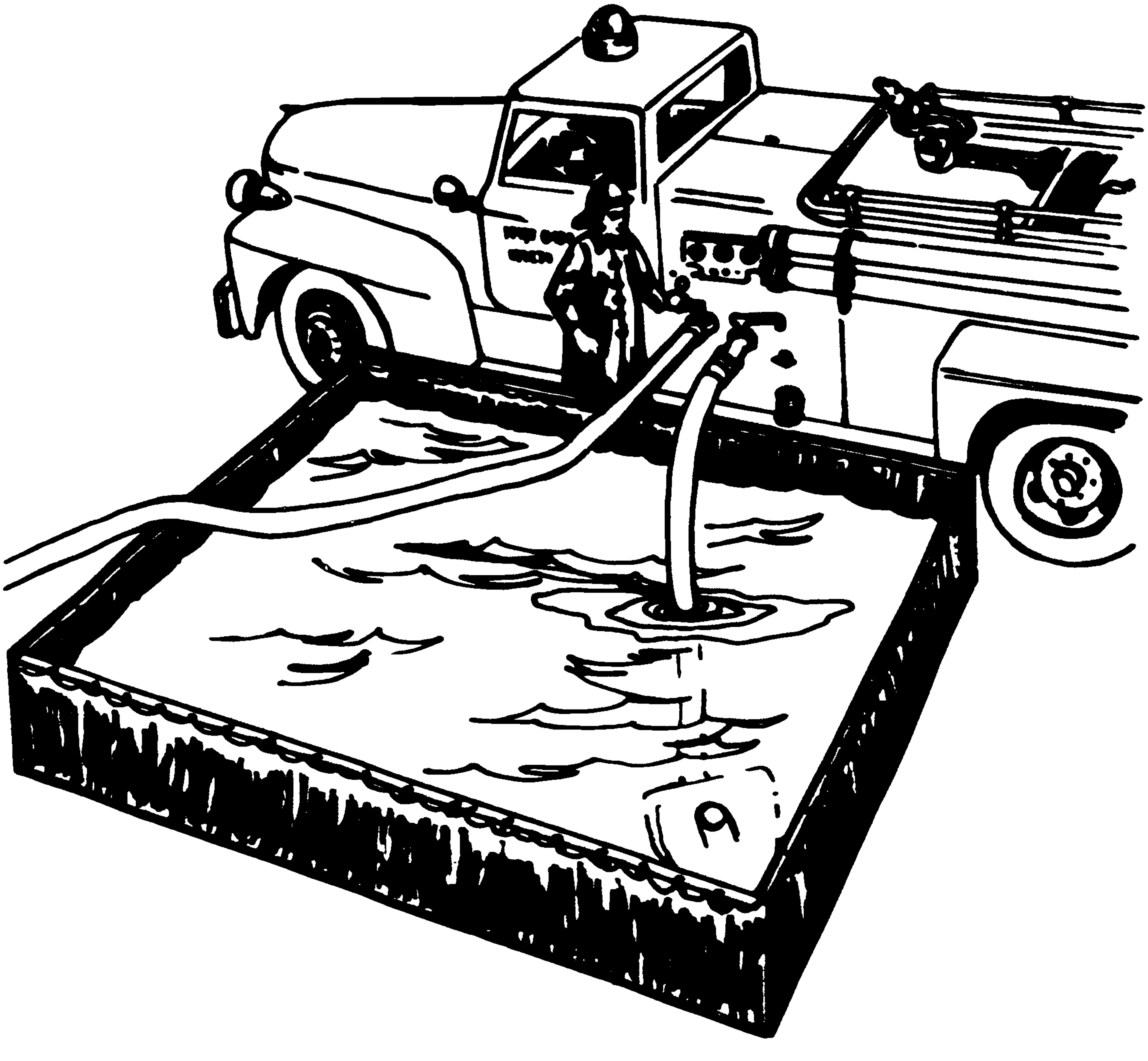


FIGURE 48.—Portable canvas storage tank

PUMPING

Water pumps have been used in firefighting for hundreds of years. Hand pumps were replaced by steam pumps, which in turn gave way to pumps run by gasoline engines and in recent years, diesel engines. In each case, the purpose of the pump was to impart sufficient velocity to water for it to reach the fire.

Although the basic purpose of the pump is to provide velocity, its ability is measured in volume and pressure. Fire department pumps in the United States are classified by their pumping capacity in gallons of water per minute, commonly called "GPM". Generally accepted standards refer to capacity as the discharge of the pump at 150 psi pressure.

Fire department pumping engines consist of a pump; an engine, which not only propels the apparatus on the road but also powers the pump; and a hose body in which hose is carried. Such a unit is called a double combination. If it also carries a tank of water—and most do—it is called a triple combination. Most pumping engines carry short ladders, but some have elongated bodies and carry a full complement of ground ladders. These are called quadruple combination or "Quads." If the vehicle also has an aerial ladder, it is a quintuple combination or "Quint."

Pumps vary in capacity up to 1,250 gpm. (There are some of greater capacity, but they are not in general use.) The common sizes are 500 gpm, 750 gpm, and 1,00 gpm.

Pumps can develop pressures up to hundreds of pounds per square inch. The chief limitation, however, is hose strength. Although special high-pressure hose is available, ordinary fire hose is generally considered to have a safe working pressure (allowing a margin of safety) between 200 and 300 psi. Therefore, pump pressures should be kept below levels that would burst hose, or under 250 psi.

One might quite logically ask why such high pump pressures may be necessary when nozzle pressure above 100 psi are rarely, if ever, used. The reason is that certain losses occur between the pump and the nozzle. One of these is friction loss caused by the water rubbing against the hose lining as it passes through the hose. The other is elevation, or "head" loss (sometimes called "back pressure"), which occurs when water must be pushed up to elevations above the level of the pump.

Friction Loss

When the nozzle of a charged hose line is closed, the pressure is the same at the nozzle as at the pump (if they are at the same level) because when no water is flowing, there is no friction loss. However, as soon as the water starts to flow, some of the pressure will be lost by the contact of the water with the hose lining. The rougher the lining, the greater is the loss of pressure. Sharp bends and appliances in hose lines also increase the loss.

There are important factors relating to friction loss that should be memorized. They are:

1. The longer the hose line, the greater the loss.

   Example: With 200 gpm flowing through 2½" hose, the friction loss is 10 psi per hundred feet of hose. Thus, if the amount of hose is 200 feet, the loss is 20 psi, but if the length of the stretch is 300 feet, the loss is 30 psi.

2. The greater the flow, the greater the friction loss (with same size of hose).

   Example: With a 2½" hose at 200 gpm, the friction loss is 10 psi per hundred feet of hose. In the same hose line with a flow of 300 gpm, the loss is 21 psi.

3. For a given flow, the smaller the hose, the greater the friction loss. Example: With 100 feet of 2½" hose at 100 gpm, the loss is 2½ psi. With the same quantity of water flowing through the same amount of 1½" hose, the loss is 33 psi. The friction loss in 1½" hose is about 13 times as much as in 2½" hose.

Note: It should be understood that the losses quoted here are based upon old, but still com-

monly accepted empirical formulas. Actually, there are presently three varieties of hose with three different friction losses due to changes in manufacturing practices that influence the actual diameter of hose under pressure. Generally speaking, however, the losses will be close to those given here, or less. Usually they will be less in hose made between 1960 and 1966.

Correct nozzle pressures cannot be obtained unless proper allowances are made for hose losses. However, rather than struggling with involved formulas or tables for friction loss, it might be better for support assistants to concentrate on learning the principles and some "rules of thumb" for quick calculations, which are accurate enough for use in emergency situations where time is critical.

Friction loss can be calculated for $2\frac{1}{2}$" hose by figuring a percentage of the nozzle pressure being lost in each 50 foot length of hose. If this percentage is calculated by fractions, the result can be quickly obtained; for instance:

Nozzle size	*Friction loss per length*
1"	1/10 nozzle pressure
$1\frac{1}{8}$"	1/6 nozzle pressure
$1\frac{1}{4}$"	1/4 nozzle pressure
$1\frac{1}{2}$"	1/2 nozzle pressure

(If it is deemed preferable, these fractions may be doubled and the calculation can be made on the basis of friction loss per 100 feet of hose rather than per 50 foot lengths.)

Friction loss for the total stretch is figured by adding the amounts lost in each length. This is done quickly by multiplying the loss in one length by the total number of lengths. This total when added to the nozzle pressure will give the pump pressure. When subtracted from pump pressure, it will give the nozzle pressure.

When the pump pressure is known, but not the nozzle pressure, the friction loss in one length can be found by adding a number of mythical lengths equal to the denominator of the fraction factor and dividing the pump pressure by the total of actual and mythical lengths.

The total friction loss is found by multiplying the loss in one length by the total number of lengths. If this product is subtracted from pump pressure, the answer is the nozzle pressure.

When hose is taken above the level of the pump, another loss is encountered. This is elevation loss, also called "head" loss and "back-pressure." This loss is due to the weight of water and is always 0.434 for every foot of height that the nozzle is above the pump. Thus, if the nozzle is on the second floor of a building, 12 feet above the pump, the elevation loss is above 5 psi ($12 \times 0.434 = 5.208$). So, for easy figuring, 5 psi are considered the loss for each story above the ground floor that the nozzle is taken, and the total elevation loss must be added to the friction loss and desired nozzle pressure to determine the proper pressure at the pump.

Example: Nozzle is on fourth floor of a building. The stretch is 10 lengths of $2\frac{1}{2}$" hose and the nozzle has a $1\frac{1}{4}$" tip. What pump pressure is needed to supply a nozzle pressure of 32 psi?

(1) $\frac{1}{4} \times 32 = 8$ (friction loss per length)

(2) $8 \times 10 = 80$ (total friction loss in ten lengths)

(3) $^{*}3 \times 5 = 15$ (elevation loss)

(4) $80 + 15 + 32 = 127$ (friction loss + elevation loss + nozzle pressure = pump pressure)

Answer: 127 psi, pump pressure

* 4th floor is 3 stories above ground floor.

If the nozzle is at a point below the level of the pump, there will be a *gain* in pressure due to elevation. This gain is also 0.434 per foot of height that the pump is above the nozzle. For fairly close approximation, this can be calculated as $\frac{1}{2}$ psi per foot.

When hose larger than $2\frac{1}{2}$" in diameter is used, friction loss can be estimated by making a conversion from the loss in $2\frac{1}{2}$" hose. For instance, the friction loss in 3" hose is about 0.4 (4/10) the friction loss in $2\frac{1}{2}$" hose (for the same amount of water flowing). So the easy way to find the friction loss 3" hose would be to calculate just as though it were $2\frac{1}{2}$" hose, and then convert the friction loss by multiplying by 4/10. The loss in hose larger than $2\frac{1}{2}$" in diameter will always be less than in the $2\frac{1}{2}$" hose.

Example: If friction loss in 10 lengths of $2\frac{1}{2}$" hose is 90 psi, what would the loss be in the same amount of 3" hose?

1. $4/10 \times 90 = 36$

Answer: 36 psi

Sometimes two $2\frac{1}{2}$" lines will be laid parallel and siamesed together near the nozzle. This is done to reduce friction loss when a large quantity of water is to be moved or where the stretch is quite long. The friction loss in two parallel lines of $2\frac{1}{2}$" hose is about $\frac{1}{4}$ that in a

single line. In three parallel lines the loss would be 1/9 that of a single line. The conversion factor is easily obtained by squaring (multiplying by itself) the number of lines that are siamesed and dividing the product into one.

Example: The friction loss in a single 2½" hose line of 12 lengths is 160 psi. what would the loss be in two parallel lines of 2½" hose for the same distance?

1. $2^2 = 4$ (two lines x 2)
2. $\frac{160}{4} = 40$

Answer: 40 psi

Friction loss is much greater in hose of less than 2½" diameter when compared with 2½" hose (about 13 times as great in 1½" hose and 98 times as great in 1" hose). Thus, it can be understood that the use of small diameter hose requires low flows or short stretches to keep the pump pressure below the burst strength of the hose.

For example, a flow of 1000 gpm will cause a friction loss of 16 psi per length in 1½" hose. In order not to exceed a pump pressure [illegible] psi with this flow, the amount of hose [illegible] not more than *six* lengths (on level stretch) [illegible] fog nozzle at 100 psi is used or not more than *ten* lengths if a ¾" tip is used to get the same flow at 38 psi.

It is a common practice to use a leader line of 1½" hose that is attached by a reducer to 2½" hose. This permits the use of 100 to 200 feet of 1½" to give light weight to the part of the hose that will be carried upstairs and moved the most but still keeps total friction loss low enough for moderate pump pressure.

Remember that nozzle pressure is always proportionate to the pump pressure regardless of elevation of length of stretch. This means that when pump pressure is increased, the nozzle pressure increases by the *same percentage*. Thus, if pump pressure is 100 psi and nozzle pressure is 40 psi, a 10 percent increase in pump pressure from 100 to 110 would increase the nozzle pressure 10 percent from 40 to 44 psi.

This information can be used to advantage when pump pressure is not sufficient to give adequate nozzle pressure and word is being sent to the pump operator to increase pressure.

RESCUE UNDER FIRE CONDITIONS

Those who have never been in a building under severe fire conditions cannot appreciate what it is like, and no amount of description could portray it well enough to convey a true picture to them.

Suffice it to say that would-be rescuers will not be darting about playing tag with the flames, as is often done—and only done—in the motion pictures. Nor will they be using fancy lifts and carries, which are not practical in a heavy smoke condition. Visibility is nil in heavy smoke. The rescuer will have to depend upon his sense of touch. For his own safety he will have to crawl along the floor. When he finds a victim he will have to get that victim out of danger without spending much time in the process. In most cases, he will drag him out as best he can.

Search

There are two essentials in rescues from fire. One is to find the victim; the other is to remove him. The first of these may call for a diligent search if the victim is unconscious or lost in the smoke. There are certain factors that can be learned in advance that will help in making a thorough and systematic search.

1. Don't pay much heed to the statements of excited bystanders as to whether or not all persons have escaped. The firefighters should make their own search to discover entrapped or unconscious occupants or to be sure that all persons are safely out.

2. The search should be conducted systematically to assure maximum coverage in minimum time and to avoid duplication of effort. Certain men can be assigned to search certain portions of the building (and they can ventilate and search for extension of fire as they are searching to make sure no one is left in the building).

3. Man searching should crawl along the floor and sweep arms out to both sides to cover as large an area as possible with each sweep.

4. Children—and sometimes adults—often hide under beds or in closets. These places should not be overlooked.

5. At night, persons may have been overcome in their sleep and may still be in bed under the covers.

6. Sometimes a victim can be discovered through the sound of his heavy breathing.

7. When a door can be pushed open only part way, the chances are good that the obstruction may be a body. It may be necessary to take the door off its hinges to effect rescue. If the door is chain-locked or bolted on the inside, this is a sign that someone is still in the room.

Removal

Conscious and ambulatory victims are best removed by escorting them—not carrying them—to safety. They can be taken to the nearest window for a breath of air, and may be removed via ladder or escorted to the nearest exit. It is not good to give them directions and leave them on their own. They should be escorted all the way to safety. With any victim, the easiest method of removal is usually the best. Why bring them down ladders if the stairs can be used? The average person does not enjoy a trip down a ladder, and some will "freeze" to the top of the ladder and refuse to budge.

When it *is* necessary to take an *ambulatory* victim down a ladder, a rescuer should precede him, staying just below him to assist if needed during the descent.

Of course, an *unconscious* victim must be carried or dragged to safety. The commonest and safety method is to drag him with his *back* on the floor. The rescuer puts his hands under the victims armpits and drags him along the floor.

When the victim has been removed from the zone of smoke and heat, it is no longer necessary to drag him and he can be carried in on the carriers illustrated.

When an *unconscious* victim must be carried down a ladder, the fireman's carry can be used, but it allows only one hand to grasp the ladder. Also, the weight of the victim tends to pull the rescuer off the ladder. The cross-arm slide allows the rescuer to hold the ladder with both hands, and if he wants to rest, he can stop and hold the victim in place with his body.

If the victim is ambulatory at the start of the descent and passes out on the way down, he can be brought down by the front slide. This should only be used when necessary because of the potential damage to the victim's face. It may bounce off every rung on the way down.

Rope Rescue

Sometimes the *only* way to rescue a victim is by use of a rope. Other times it may be the *best* way. There are two basic methods. One is where the rescuer is lowered, or lowers himself, by rope; the other is where the rescuer lowers the victim with the rope.

In the first case, the rescuer may be lowered by other firefighters after tying him in the bowline-on-bight knot; or he may lower himself by the single slide, having taken three turns of the rope around his lifebelt hook.

When the rescuer is tied in the bowline-on-bight and lowered to the victim, he, upon reaching the victim, grasps the victim in such a way that the victim faces him with legs above those of the rescuer who puts his arms around the victim and hugs him close while they are lowered (or raised) to safety.

The "single" slide becomes the "double" slide when the victim is picked up by the rescuer. That is why *three* instead of two turns are taken around the hook of the lifebelt with the rope. The double slide requires that the victim be ambulatory because the rescuer needs both hands to lower himself. In a case where the rescuer slides to an unconscious victim the safest method would be to lower the victim by rope, tied securely in a bowline-on-bight and slippery hitch, if possible. Otherwise, he should be removed by a rescuer who is tied in the same manner and thus has both hands free.

Net Rescue

A last resort, rarely used, is the life net. Occasionally a life net is used with success, and cases have been reported where vitcims jumped from as high as 80 feet and lived after landing in a life net. However, there have been cases of experienced jumpers, suffering severe injuries from jumps of less than 40 feet. Jumping into a life net is dangerous for the rescued and risky for those holding the net.

Those handling the net should make sure it is fully open; that the snaps have caught at the joints, and that each joint is covered by its ferrule.

When the net is in position beneath the potential jumper, all men should look up at the jumper and keep the net high (almost shoulder height), grasping the ring with both hands, palms up. One foot should be forward of the other, and elbows should be in a position to clear the body.

The jumper should land in the center of the net, otherwise he or the men holding the net might get injured. Therefore, if it appears that he will land off center, the net should be moved during his descent, to catch him as near the center as possible.

If more than one person is going to jump, there should be no delay in clearing the net for the next jumper. This is done as soon as the previous jumper lands, by dropping the side of the net farthest from the building and raising the opposite side so that the jumper is quickly rolled out, and the net can be positioned for the next jump.

Sometimes firefighters may be trapped and forced to jump into a net. That is why they are taught how to jump. The proper way to land is in the center of the net in a sitting position with legs forward. Landing feet first may injure feet or legs.

Distribution:
OCD Region, Staff College
State CD Directors

U.S. GOVERNMENT PRINTING OFFICE: 1971 O—429-472