*Henry Kramer, Parkersburg, W. Va.*

Fire 101-13 Ann Street, Parkersburg, West Virginia, July 15, 1951.

*See pages 81-89 and 102-109.*

# FIRE FIGHTING TACTICS

*by*

*Lloyd Layman*

(Reprinted March, 1955; October, 1957; March, 1962;
October, 1964; July, 1966; July, 1967;
December, 1968; April, 1970.)



NATIONAL FIRE PROTECTION ASSOCIATION
INTERNATIONAL
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## FOREWORD

For more than thirteen years Chief Layman's book "Fundamentals of Fire Fighting Tactics" was a standard reference and textbook for the fire fighting service. More recently, his book "Attacking and Extinguishing Interior Fires," published by the National Fire Protection Association, set down the fundamentals that should be understood in dealing most effectively with the problem of excess heat in burning buildings. Later, Chief Layman revised and expanded the book on Fire Fighting Tactics to take cognizance of advances in the fire fighting art during and subsequent to World War II. This text lays down the fundamentals of tactical operations upon which a fireground commander must build in order to successfully size up, confine, and extinguish a fire, while utilizing available forces with reasonable efficiency.

Because "Attacking and Extinguishing Interior Fires," and "Fire Fighting Tactics" are complementary to each other, the National Fire Protection Association has published both texts as valuable information on fire fighting by a practical fire fighter of national reputation. We would like to make clear that "Fire Fighting Tactics" is Chief Layman's book. It has not been acted upon or reviewed by any technical committees of the Association.

During World War II, Chief Layman served as Commandant of the United States Coast Guard Fire Fighting School at Fort McHenry, Baltimore, Maryland. He retired after twenty years as Chief of the Fire Department at Parkersburg, West Virginia, and, prior to his death, served as a member of NFPA Committees on Firemen's Training and Fire Department Equipment.

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CHAPTER I

# INTRODUCTION

THE primary purpose of this text is to outline a system of training designed to enable officers and future officers of the fire service to familiarize themselves with the art of directing operations on the fireground. Major fires present complex problems. No two situations are alike. Each offers its own pattern of circumstances. This text offers no rule or formula which will enable an officer to produce logical and practical solutions to the many and various problems that may confront him on the fireground. Each problem demands its own solution and each solution must be the product of his own mental effort. This calls for the necessary professional knowledge, skill, and the ability to think clearly and logically under the pressure of an emergency. Success or failure of a commanding officer on the fireground depends upon his ability to estimate the situation, weigh the various factors, apply basic principles, decide what action should be taken, formulate a plan of operation, and see that the plan is executed promptly and efficiently. "A battlefield does not give an opportunity for study, one does what he can to apply what he already knows, therefore, it is necessary that he know thoroughly and be able to use his knowledge quickly." — Marshal Foch. The art of war and the art of fire fighting have much in common and the words of Marshal Foch are as true of the fireground as they are of the battlefield.

Modern fire fighting is an art which requires a vast store of professional knowledge and skill. It is impracticable for an individual to attempt to acquire adequate knowledge and skill from experience alone, a major part must be acquired through systematic study and training. An article entitled "Fires and Fire Departments" by James M. Bugbee (father of the former General Manager of the National Fire Protection Association), appeared in the July issue, 1873, of the *North American Review* in which Mr. Bugbee quoted Chief Officer Massey Shaw of the London Metropolitan Fire Brigade as follows:

"When I was last in America, it struck me very forcibly that although most of the Chiefs were intelligent and zealous in their work, not one that I met even made a pretense to the kind of professional knowledge that I consider so essential. Indeed, one went so far as to say that the only way to learn the business of a fireman was to go to fires. A statement about as monstrous and as contrary to reason as if he had said that the only way to become a surgeon would be to commence cutting off limbs without any knowledge of the human body or of the implements required.

"There is no such short cut to proficiency in any profession and the day will come when your fellow countrymen will be obliged to open their eyes to the fact, that, as a man learns the business of a fireman only by attending fires he must of necessity learn it badly. Even that which he does pick up and may seem to know, he will know imperfectly and be incapable of imparting to others.

"I consider the business of a fireman a regular profession requiring previous study and training as other professions do. I am convinced that where training and study are omitted and men are pitchforked into the practical work without preparation, the fire department will never be found capable of dealing satisfactorily with great emergencies." Certainly, no individual will question the self-evident truths contained in the statement made by Chief Officer Shaw, eighty years ago. Considerable progress has been made in this country in training firemen but little, if any, progress has been made in training tactical officers. Regardless of the efficiency of the individual fireman and his tools, his efforts must be directed and coordinated by intelligent and capable leadership if satisfactory results are to be achieved on the fireground.

Army officers dare not await the hour of battle to learn the fundamentals of military tactics. Volumes upon volumes have been written on the subject and a combat officer is schooled in this art from the time of entry into the service until he retires. How can the fire service hope to attain a high degree of efficiency in combating major fires without some system of training its operational officers in the art of tactical leadership on the fireground? No doubt, through years of fire-fighting experience, a resourceful operational officer will develop some system of estimating a situation and employing his forces effectively on the fireground, although he may not be entirely conscious of having developed a definite habit of tactical procedure. If he is unable to teach other members of the profession the fundamentals of his system, it becomes necessary for them to depend upon experience alone in order to develop an individual habit of tactical procedure. This is certainly an expensive and hazardous method of learning. A system of teaching fire-fighting tactics will be presented in this text which is intended to serve as a bridge between theory and experience. It is designed to enable officers and future officers of the fire service to understand better the problems of command on the fireground and to utilize their future experience to greater advantage.



Fire-fighting tactics may be defined as the art of directing and employing personnel, apparatus, equipment and extinguishing agents on the fireground. This subject includes all the operations which are performed in connection with attacking, controlling and extinguishing a destructive fire. A major fire presents a complex operational problem and this is especially true of all major fires involving buildings or other structures. The most logical and practical method of evaluating a complicated situation is to simplify it by dividing it into relative parts. Once this has been accomplished, it is possible to examine and study the individual parts. On the fireground, it is not possible to tear a complicated situation into definite parts but it is possible to train the mind in the habit of surveying and analyzing a complicated situation in a systematic manner. Tactical procedure on the fireground can be divided into fairly definite parts and this appears to offer the only logical and practical solution to the problem of studying and teaching fire-fighting tactics. In this text tactical operations on the fireground will be divided into eight basic parts; each will be defined, examined, operational problems reviewed and the important governing principles presented.

## BASIC DIVISIONS OF FIRE-FIGHTING TACTICS

| | | |
|---|---|---|
| SIZE UP OR ESTIMATE OF THE SITUATION | 1. RESCUE | |
| | 2. EXPOSURES | A. VENTILATION |
| | 3. CONFINEMENT | |
| | 4. EXTINGUISHMENT | B. SALVAGE |
| | 5. OVERHAUL | |

The basic divisions, one to five, are arranged in proper sequence. Ventilation and salvage have not been numbered but have been designated by the letters (A) and (B) because these operations may be required at any time following the initial size up.

This system of teaching has been developed in view of its application to major fires involving buildings which are usually the most complicated situations with which fire-fighting organizations have to contend. A resourceful instructor can readily expand this system of teaching to include other types of fires and emergencies.

The basic divisions of fire-fighting tactics may be defined as follows:

SIZE UP OR ESTIMATE OF THE SITUATION is the mental evaluation made by the operational officer in charge of a fire or other emergency which enables him to determine his course of action and to accomplish his mission.

RESCUE includes those operations which are required to remove human beings (or valued livestock) from an involved building or other hazardous situation and convey them to a place of safety.

EXPOSURES include those operations which are required to prevent a fire from extending to uninvolved buildings or separate units.

CONFINEMENT includes those operations which are required to prevent a fire from extending to uninvolved sections of a building.

EXTINGUISHMENT includes those operations which are required in attacking and extinguishing the main body of fire.



OVERHAUL includes those operations which are required to complete the extinguishment of remaining fire, prevent rekindling and to place the building in a safe condition.

VENTILATION includes those operations which are required to displace a heated and contaminated atmosphere within an involved building with normal air from the outside atmosphere.

SALVAGE includes those operations which are required to protect buildings and contents from preventable damage due to water or other elements.

The first edition of this material was published in 1940 under the title *Fundamentals of Fire Fighting Tactics*. In that edition, the tactical employment of water was based primarily upon the solid stream form of application. During World War II the author conducted an extensive study of the problem of controlling and extinguishing fires aboard commercial and naval vessels. The experimental work in connection with this project was performed by members of the instructors' staff of the U. S. Coast Guard Fire Fighting School, Fort McHenry, Maryland. This study and experimental work resulted in development of the "indirect method of attack." Complete and detailed information regarding this method of attacking interior fires can be obtained from the publication by the author entitled *Attacking and Extinguishing Interior Fires*. (Published by the National Fire Protection Association, 1952. $3.75 per copy.) The material presented in this text will be of limited value without thorough comprehension of the professional knowledge contained in *Attacking and Extinguishing Interior Fires*. Tactical employment of water, as explained in this text, will be based upon its application in the form of finely divided particles. The author's convictions are expressed in the following paragraph from the text mentioned above.

"The development of equipment that enables fire-fighting personnel to apply water in the form of finely divided particles was the most progressive advance in equipment since the advent of the power-driven pumping unit. This development has provided the basic weapon that is destined to revolutionize the art of fire fighting. Little, if any, progress can be made toward improving the tactical employment of water in fire-fighting operations until the fire service recognizes the gross inefficiency of the solid stream form of application. Development of the water particle or fog nozzle does not mean that the solid stream form of application will be eliminated. Small solid streams are very useful in extinguishing spot fires and to penetrate smouldering materials. Situations are encountered from time to time where a solid stream may be used to good advantage. The solid stream will continue to have a limited degree of usefulness in fire-fighting operations but it is destined to become the secondary form of application. Progress in the tactical employment of water in fire-fighting operations demands that water be applied in the form of finely divided particles. To exploit this development to its ultimate degree, the fire service must discard antiquated tactics and replace them with tactics based upon scientific facts and natural laws. Then and then only can the vast extinguishing action of water be released and utilized effectively in fire-fighting operations."



# Chapter II

# SIZE UP

SIZE up or estimate of the situation is the mental evaluation made by the operational officer in charge of a fire or other emergency which enables him to determine his course of action and to accomplish his mission. Size up is the responsibility of the officer in charge of first alarm units and becomes the responsibility of any officer who may later take charge of operations at a fire or other emergency.

A major fire usually presents a complicated and rapidly changing situation. The early operational phase may be accompanied by considerable confusion and excitement. A commanding officer must quickly survey and analyze the situation, weigh the various factors, apply basic principles, decide what action should be taken, formulate a plan of operation and exercise command. Success or failure on the fireground depends to a major degree upon the ability of a commanding officer to perform these essential functions in a practical and skillful manner. This requires a disciplined mind which has been trained in the art of clear and logical thinking. This mind must possess the necessary professional knowledge and be able to apply such knowledge in a skillful and resourceful manner. Individuals who are unable to maintain self-control and to think clearly and logically amid confusion and excitement on the fireground should not aspire to positions of operational command. Success on the fireground demands capable, resourceful and aggressive leadership not only from the commanding officer but from the entire chain of command.

The following system of mental training is designed to enable an operational officer to develop a definite habit of mental procedure in dealing with a fire or other emergency:

## BASIC MENTAL EVOLUTION OF SYSTEM

1. Facts
2. Probabilities
3. Own Situation
4. Decision
5. Plan of Operation

## OUTLINE OF SYSTEM

1. FACTS

- (*a*) TIME OF EMERGENCY
  - Month, day, hour
- (*b*) LOCATION OF EMERGENCY
  - Location of building or buildings involved
  - Position of involved building or buildings in relation to streets, alleys, open spaces, exposed buildings and other materials
  - General physical surroundings
- (*c*) NATURE OF EMERGENCY
  - Fire — Accidental
  - Explosion
  - Smoke — Incendiary
- (*d*) LIFE HAZARD
  - Occupants of involved building or buildings
- (*e*) EXPOSURES
  - Life — Occupants of exposed buildings
  - Property — Buildings or other materials exposed
- (*f*) BUILDING OR BUILDINGS INVOLVED
  - Occupancy
  - Contents
  - Construction
  - Height, size
  - Openings into other buildings
  - Doors, windows
  - Fire escapes, exterior stairways
  - Interior stairways
  - Vertical shafts
  - Air conditioning system
  - Forced draft system
  - Automatic sprinkler system
  - Standpipe system
  - Other essential facts



- (*g*) FIRE
  - Smoke: nature, volume, floors involved
  - Exterior involvement:
    - Nature of fuel
    - Extent of involvement
  - Interior involvement:
    - Floor or floors involved
    - Area of major involvement
    - Phase of development
    - Location of burned-out windows or other breakthroughs
- (*h*) WEATHER
  - Wind: direction — velocity
  - Temperature
  - Rain, snow, ice
  - Atmospheric inversion
  - Relative humidity

2. PROBABILITIES

- (*a*) LIFE HAZARD
  - Occupants of involved building
  - Occupants of exposed buildings
  - Spectators
  - Own personnel
- (*b*) EXTENSION OF FIRE
  - To exposed buildings or materials
  - Within the involved building
- (*c*) EXPLOSIONS
  - Smoke
  - Dust
  - Contents
- (*d*) COLLAPSE OF COMPONENT PARTS OF INVOLVED BUILDING
  - Roof
  - Floors
  - Walls
- (*e*) WEATHER CHANGES
  - Wind: direction, velocity
  - Temperature
  - Rain, snow, ice

(*f*) PREVENTABLE DAMAGE

| | |
|---|---|
| Water | Involved building and contents |
| Smoke | |
| Heat | |
| Other causes | Exposed buildings and contents |

3. OWN SITUATION

(*a*) PERSONNEL AND EQUIPMENT — Apparatus, hose supply

(*b*) ADDITIONAL ASSISTANCE AVAILABLE

(*c*) WATER SUPPLY — Mains, hydrants, auxiliary supply, other extinguishing agents

(*d*) PRIVATE FIRE PROTECTION — Sprinkler systems, standpipe systems. Other protective devices which could be used to protect exposures or confine fire.

(*e*) ACTION THAT HAS BEEN TAKEN

4. DECISION

(*a*) INITIAL DECISION

(*b*) SUPPLEMENTAL DECISIONS

5. PLAN OF OPERATION

(*a*) ORDERS AND INSTRUCTIONS

(*b*) SUPERVISION OF OPERATIONS

## EXPLANATION OF SYSTEM

1. FACTS

A commanding officer should ascertain the essential facts of a situation and arrange them in his mind in a systematic manner.

(*a*) TIME OF EMERGENCY

The month, day and hour may be an important factor in an emergency. A fire in a school building when classes are in session presents a problem different from a fire in the same building during other hours. Time of emergency and type of occupancy are related factors.



(*b*) LOCATION OF EMERGENCY

First: Locate the building or buildings involved. The alarm may have been received in such a manner that only the general locality of the emergency is known.

Second: Obtain a clear mental diagram of involved building or buildings in relation to streets, alleys, open spaces, exposed buildings and surrounding area.

Third: Observe any conditions which may interfere with or obstruct operations such as overhead wires, high-voltage lines, railroad tracks or parked vehicles.

(*c*) NATURE OF EMERGENCY

Ascertain if the emergency is the result of fire, explosion, smoke or other occurrence. Commanding officers and members of his staff should be on the alert for indications of incendiarism.

(*d*) LIFE HAZARD

Ascertain the nature of occupancy, number of persons within the involved building or buildings, and the immediate danger to their safety.

(*e*) EXPOSURES

Determine if there is immediate danger of fire extending to or causing damage to exposed buildings or other property. Attention is directed to Chapter IV — EXPOSURES.

(*f*) BUILDING OR BUILDINGS INVOLVED

Most of the essential facts are itemized in the outline. (See Chapter VI — EXTINGUISHMENT for additional information.)

(*g*) FIRE

The basic facts pertaining to a fire are itemized in the outline. (For explanation see Chapters entitled — EXPOSURES, CONFINEMENT, EXTINGUISHMENT, and VENTILATION.)

(*h*) WEATHER

A commanding officer should consider the weather conditions existing at the time of emergency and how this factor may affect fire-fighting operations. (See Chapters entitled RESCUE, EXPOSURES, and VENTILATION.)

2. PROBABILITIES

In this mental evolution a commanding officer should consider existing conditions and estimate future probabilities.

(*a*) LIFE HAZARD

Estimate whether future developments may endanger the lives of occupants of involved building or buildings, occupants of exposed buildings, spectators or own personnel.

(*b*) EXTENSION OF FIRE

(See Chapters entitled EXPOSURES, CONFINEMENT, and VENTILATION.)

(*c*) EXPLOSIONS

(See Chapters entitled EXTINGUISHMENT and VENTILATION.)

(*d*) COLLAPSE OF COMPONENT PARTS OF INVOLVED BUILDING

This estimate should be based upon consideration of the following factors: Type of construction, degree of involvement, extent of destruction, nature and quantity of contents and their susceptibility to water absorption and expansion.

(*e*) WEATHER CHANGES

Estimate weather changes which would affect the situation. Consider official fire danger forecasts if available. (See Chapter IV — EXPOSURES.)

(*f*) PREVENTABLE DAMAGE

Estimate the probabilities of preventable damage to involved and exposed buildings and contents. (See Chapters entitled EXPOSURES, EXTINGUISHMENT, VENTILATION, SALVAGE, and OVERHAUL.)

3. OWN SITUATION

In this mental evolution a commanding officer reviews the facts of his own situation and estimates what he can accomplish with the resources which he has at his command.

(*a*) PERSONNEL, APPARATUS, EQUIPMENT, HOSE SUPPLY

Consider these factors in relation to the estimated requirements of the situation.



(*b*) ADDITIONAL ASSISTANCE AVAILABLE

Determine if additional assistance is needed to meet the estimated requirements of the situation.

(*c*) WATER SUPPLY — MAINS, HYDRANTS, AUXILIARY SUPPLY, OTHER EXTINGUISHING AGENTS

Consider the volume of water or other extinguishing agents which are available in relation to the estimated requirements.

(*d*) SPRINKLER SYSTEMS — STANDPIPE SYSTEMS — OTHER PROTECTIVE DEVICES

Consider the primary protective equipment of involved and exposed buildings such as sprinkler systems, fire doors, fire shutters and wired glass windows. Estimate the effectiveness of these devices and the action required to insure their effective operation.

(*e*) ACTION THAT HAS BEEN TAKEN

Routine action may have been taken upon arrival of early units, a commanding officer should review the action that has been taken and consider the locations of units and apparatus, and how far he has already been committed.

4. DECISION

(*a*) INITIAL DECISION

A commanding officer should always keep in mind that his primary mission is to prevent additional loss of life and property. On the fireground, the decision is formed through an evolutionary process. As a commanding officer ascertains the facts, estimates the probabilities, surveys his own situation; his decision should be in the process of formation. It should be the logical and practical conclusion resulting from his evaluation of these factors. The decision should be a clear and precise mental outline of the action to be taken and the objectives to be achieved.

In his book, *Fire Fighting*, the late John Kenlon, for some twenty years Chief of the New York Fire Department, describes how he surveyed the situation, arrived at his decision and formulated his plan of operation at the great Equitable Building

Fire of 1912, which was the most complicated and serious fire-fighting problem of his career.

Due to the necessity of immédiate action to effect rescue or to meet other urgent requirements of a situation, a commanding officer may be forced to commit a unit or units to action before he has had an opportunity to survey the entire situation. This should be avoided unless such action is absolutely necessary. Both time and effort can be wasted by allowing individual units to become immobilized before the initial decision has been made and a definite plan of operation has been formulated. This does not mean that precious time should be wasted by units awaiting completion of the size up. A commanding officer should issue such orders and instructions to unit commanders as may be required to place their units in condition and position to carry out his decision upon completion of the initial size up.

(*b*) SUPPLEMENTAL DECISIONS

On the fireground size up is a continuous mental operation. A commanding officer should continuously review the facts, probabilities and own situation; filling in his mental diagram with the essential changes in the situation. From this "up to the minute" diagram of the entire situation he should make such supplemental decisions as may be required to deal with new developments and to achieve his objectives.

## 5. Plan of Operation

The plan of operation is a mental diagram showing how a commanding officer intends to employ his personnel, apparatus, equipment and extinguishing agents to enforce his decision and to achieve his objectives. Simplicity should be the guiding principle in developing a plan of operation. A complicated plan of operation is of little practical value on the fireground. From time to time a commanding officer should make such modifications and adjustments in the initial plan of operation as may be required to enforce his supplemental decisions.

(*a*) ORDERS AND INSTRUCTIONS

Orders and instructions should be clear and concise. If



possible, unit commanders should be advised regarding the existing situations, decision and plan of operation. This should enable them to use better judgment and render more intelligent cooperation in the execution of their orders and instructions. Unit commanders should be given definite assignments in compliance with the plan of operation. Each should know where his unit is to be employed and the objectives to be achieved.

(*b*) SUPERVISION

A commanding officer should be in contact with the entire situation. He should keep informed regarding the progress of operations and of new developments. The most perfect plan of operation is of little practical value unless it is prosecuted in a skillful and aggressive manner. Successful execution of the plan of operation depends to a major degree upon capable supervision and this is the responsibility of the commanding officer and members of his staff.

At small fires, the problem of supervision is not difficult for a commanding officer can personally survey the situation and confer with his officers and men. At large fires, supervision is complicated by the problem of providing suitable means of communication between a commanding officer and units of his command. When directing major operations, a commanding officer should establish a command post at an advantageous location and supervise operations through staff officers and aides who are trained and qualified to perform such duties. A properly equipped command unit (automobile or truck) offers the most practical answer to the problem of providing a commanding officer with a communication and control center. Two-way radio appears to be the most practical solution to the problem of communication on the fireground.

It should be emphasized by the instructor that this system of size up has for its purpose the training of the mind to a habit of logical thinking under the pressure of an emergency. It outlines the mental evolutions by which an operational officer assembles and classifies the essential facts of a complicated situation, thinks out for himself a solution which these facts compel, thereby arriving at a decision and formulating a plan by which his decision can be executed. This habit of thinking can be utilized in any emergency as effectively as it can be employed in solving a fire-fighting problem in the classroom or on the fireground. Once this habit has been formed an operational officer will automatically ask himself: what are the essential facts of the situation? What are the probabilities which these facts indicate? What are my own capabilities of dealing with the facts and probabilities? From these three simple mental evolutions he should decide what action should be taken and how he will employ his resources to enforce his decision.


*Courtesy Boston Fire Department*

Lighting Plant No. 2 of the Boston Fire Department used as a command and communications car. Note loud speakers and radio speaker on roof.



## CHAPTER III

## RESCUE

RESCUE includes those operations which are required to remove human beings (or valued livestock) from an involved building or other hazardous situation and convey them to a place of safety.

Rescue should always receive first consideration at a fire or other emergency. The officer in charge of first arriving units should survey the situation immediately upon arrival to determine if human life is in danger. His initial size up should answer the following questions:

(1) Is the fire or other emergency of such a nature as to endanger the lives of occupants or other individuals?

(2) Are there any occupants within the involved building?

(3) Do conditions demand their immediate removal?

(4) How many persons must be removed?

(5) Do I have available sufficient personnel and equipment to accomplish my mission?

Problems of rescue can range from the very simple to the most complicated. We would emphasize that only general principles can be outlined for the guidance of a commanding officer in solving a major rescue problem. A practical solution to a major rescue problem depends upon the ability of a commanding officer to employ every resource at his command in an efficient and resourceful manner. Limited fire-fighting operations may be required in order to effect rescue of entrapped occupants. Ventilation may be required or it may be necessary to employ water to protect avenues of escape. In some instances, it may be advisable to attack the fire in order to control it until rescue operations can be completed. A major rescue problem calls for adequate personnel and equipment. Personnel should be thoroughly trained in all phases of rescue operations. This also applies to members of a police department for they may have to render assistance in a serious rescue situation. Successful rescue operations depend to a certain degree upon adequate knowledge of the involved building. Fire-fighting personnel should familiarize themselves with the life hazard of public, commercial and apartment buildings within their operational area by frequent surveys and group discussions. They should study under competent guidance the construction, interior arrangement, interior and exterior avenues of escape, and other essential facts which would enable them to cope with a major rescue problem in these types of occupancy.

In places of public assembly, schools, or any building or enclosure where a considerable number of persons may be present, a serious rescue problem may develop from causes other than fire. Panic is a factor that must be considered in estimating a rescue situation in these types of occupancy. (For information regarding this factor see *NFPA Fire Protection Handbook*.)

Time of emergency and nature of occupancy have a direct relation to the problem of rescue. Certain types of occupancy have a variable life hazard depending upon the time of emergency. Dwellings, hotels and similar types of occupancy usually offer a greater hazard during the early morning hours. Most of the occupants are asleep and a fire may gain considerable headway before being discovered. Theatres, schools and other places of assembly present major hazards during active hours. Time of emergency and nature of occupancy should be considered in a rescue problem.

Weather conditions at the time of emergency may be a factor in a rescue problem. Cold weather with the presence of snow and ice may make rescue operations more difficult and may endanger the health of persons removed from an involved building. There may also be the problem of providing first aid, medical care, ambulance service and hospitalization for the injured. Age, sex and physical condition of occupants must be considered. Women, children and disabled individuals may complicate a rescue problem. These factors should receive due consideration in estimating a rescue situation.

Care should be exercised to prevent persons who have escaped from an involved building from re-entering in an at-



tempt to effect rescue or to secure personal property if such action would endanger their lives or interfere with operations. Necessary precaution should be taken to prevent untrained persons from exposing themselves to hazardous conditions.

PRINCIPLES AND SUGGESTIONS:

(1) Rescue receives first consideration at a fire or other emergency.

(2) Fire-fighting operations should in no way interfere with or endanger the prompt and orderly evacuation of an involved building unless such operations are necessary to protect the lives of occupants and to insure their escape.

(3) A command unit equipped with amplifier system may be used to good advantage in directing operations and to advise occupants who are awaiting rescue.

(4) Police assistance is necessary in a serious rescue situation. The officer in charge of the police detail should take immediate action to clear the emergency area of spectators and establish necessary fire lines.

*H. V. Muhlmann, Parkersburg, W. Va.*

Fog cone from ladder pipe fitted to fly ladder of modern aerial truck.



## Chapter IV

# EXPOSURES

EXPOSURE protection includes those operations which are required to prevent a fire from extending to uninvolved buildings or separate units. Any major exterior fire in the vicinity of combustibles usually presents an exposure problem. An interior fire which has not broken through to the outside atmosphere may present an exposure hazard to adjoining buildings. In fire fighting, it is of utmost importance that prompt and intelligent action be taken to prevent ignition of exposed buildings, separate units or other combustibles. Other than rescue of human beings, the immediate mission of first alarm units is to provide adequate protection for exposures.

Major fires and other emergencies call for advance planning by both the fire and police departments. There should be definite agreement regarding the responsibilities of the police department on the fireground. The officer in charge of the police detail should take necessary action to prevent interference with rescue and fire-fighting operations. Fire lines should be established promptly and the operational area cleared of spectators and unauthorized motor vehicles. Traffic controls should be maintained on streets and highways surrounding the operational area to secure freedom of movement for apparatus and equipment. Where there is a life hazard to occupants of exposed buildings, evacuation should be conducted under police supervision. Police cooperation is necessary in a major emergency to enable fire-fighting units to operate at peak efficiency.

The basic factors that contribute to the rapid extension of fire are well known and much has been written on the subject. It is impracticable to provide adequate information regarding these factors in this text. This is also true regarding the natural laws and fundamentals which govern combustion, generation and transfer of heat, and the controlling and extinguishing action of water. Information regarding these factors can be obtained from the *NFPA Fire Protection Handbook* and *Attacking and Extinguishing Interior Fires.*

THERE are various types of permanent protection for exposed buildings and they may be summarized briefly as follows:

DISTANCE OF EXPOSED COMBUSTIBLES FROM THE FIRE. Sufficient distance provides the most effective protection against extension of fire. Each situation presents its own variables and only by alert and keen observation on the fireground can the sufficiency of distance be estimated.

PARAPETED FIRE WALL WITHOUT OPENINGS. Fire walls provide a very effective type of permanent protection but their effectiveness may be reduced or destroyed by:

(*a*) Adjoining wall falling on roof.
(*b*) Damage to fire wall resulting from an explosion.
(*c*) Heat or flames passing over parapets and igniting combustible roof, penthouse or other superstructure.
(*d*) Heat or flames extending around fire wall and entering building through unprotected openings.
(*e*) Sparks or brands igniting combustible roof.
(*f*) Sparks or brands entering building through openings.
(*g*) Unauthorized openings made in wall.

FIRE-RESISTIVE WALLS WITHOUT OPENINGS OR WITH PROTECTED OPENINGS. The effectiveness of fire-resistive walls can be reduced or destroyed by any of the causes listed for fire walls and also the following:

(*a*) Conduction of heat through wall to combustibles within exposed building.
(*b*) Failure of fire doors or other protective devices to prevent extension of fire into exposed building.
(*c*) Failure of wall due to structural weakness.

OUTSIDE SPRINKLER SYSTEMS. Effectiveness of this type of permanent protection depends upon design and water supply. These systems require a large volume of water and may prove ineffective unless fitted with fire department connection, turned on early and supported by pumper.



INSIDE SPRINKLER SYSTEMS. Provided the exterior walls and roof are of fire-resistive construction and the system is properly designed, it should prevent major involvement of an exposed building. Failure to maintain necessary water supply and pressure will nullify the effectiveness of this type of protection. The effectiveness of an automatic sprinkler system may be reduced or destroyed by the following:

(*a*) Adjoining wall falling on roof.
(*b*) Ignition of combustible roof.
(*c*) Damage resulting from an explosion.
(*d*) Any condition which would cause breakage of piping or a larger number of heads to open than piping and water supply will support.
(*e*) Demand upon water supplies supplying sprinklers by pumpers supplying hose streams (unless an adequate supply is pumped into the sprinkler system).
(*f*) Contents hazard too severe for ordinary sprinkler system.

NONCOMBUSTIBLE ROOFS. The various types of permanent protection previously described may prove to be of limited value if roofs of exposed buildings are susceptible to destruction by fire.

WHEN confronted with a major fire in a congested area there is insufficient time for a commanding officer to familiarize himself with the essential facts regarding the involved and exposed buildings. It is impracticable for an officer to depend upon memory alone for the essential facts regarding the various buildings within his operational area. In high valued and hazardous districts, the essential facts should be obtained from surveys and map study (Sanborn Maps). These should be recorded in a simple and systematic manner for reference on the fireground by a commanding officer and members of his staff. Some years ago the author had an opportunity to make a comprehensive study of this problem. A review of available information revealed that within cities and towns having organized fire departments, fires are usually confined to the block in which they originate. This does not indicate that the open spaces provided by streets of ordinary width are suf-


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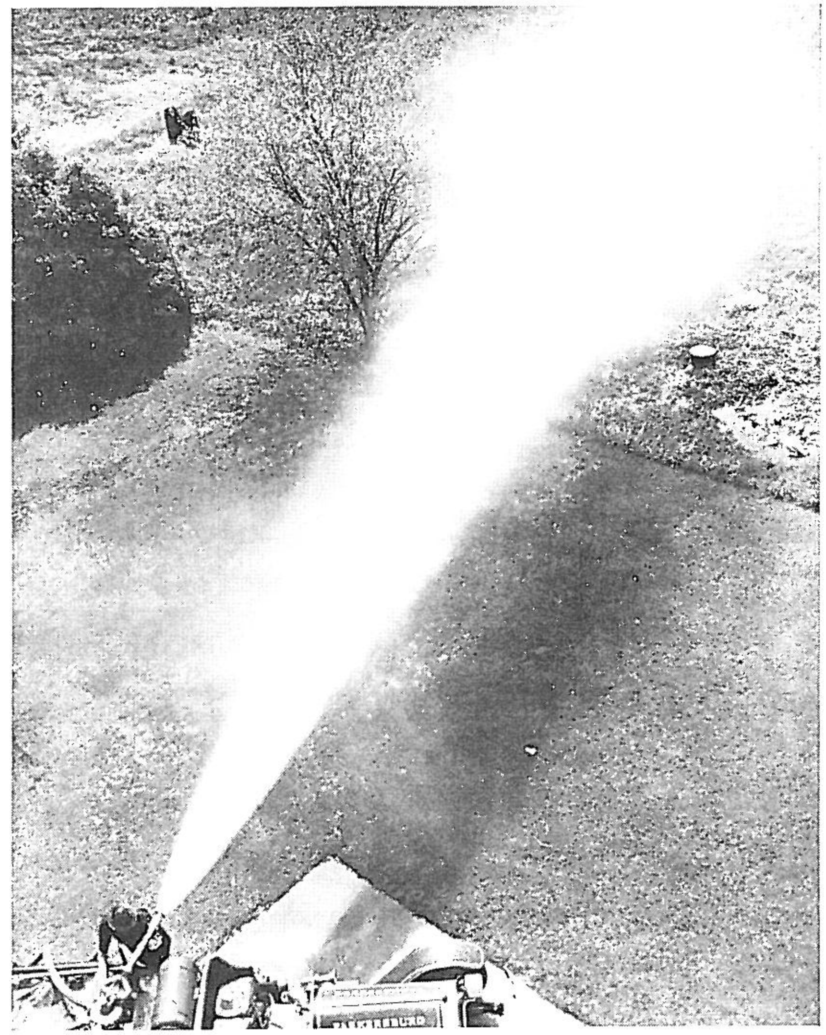
A large calibre fog nozzle in straight stream position. Nozzle pressure 100 pounds per square inch. Volume approximately 630 U. S. gallons per minute.





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Another large fog nozzle with 100 pounds per square inch nozzle pressure. Volume approximately 400 U. S. gallons per minute.

ficient to prevent ignition of combustibles by radiant heat generated by a major exterior fire, from sparks or brands, explosions, or under unfavorable weather conditions to prevent flame contact or ignition by convection. It does indicate that fires are usually discovered before they have extended beyond their block of origin and fire-fighting units arrive in time to prevent such extension. From this study it appeared that operational plans should be based upon the individual block. A simple system of block planning was developed together with a definite method of organizing and recording the essential facts regarding the important buildings within a block. These plans were designed for use in directing operations on the fireground but may also be used in preparing and solving tactical problems. This system of planning is explained in Chapter X, TACTICAL PROBLEMS AND OPERATIONAL PLANS.

The fire-fighting resources of many departments are inadequate to cope with major exposure fires. Fire departments of nearby communities are usually called upon to render assistance. A properly developed Mutual Aid Plan should provide a definite system of dispatching and utilizing outside assistance. Such a plan should anticipate the requirements of various situations but should not deprive participating communities of minimum fire protection during an emergency. There should be definite understanding regarding command and staff arrangements.

EXCESSIVE heat is the hard core of every fire-fighting problem. Fire extends its boundaries by transmitting excessive heat to exposed combustibles. Excessive heat must be adequate in volume and intensity to increase the heat content of exposed combustibles to a degree that is sufficient to actuate self-sustained combustion. All ordinary combustibles require a heat content that exceeds 300° F. before they will ignite and burn. This is a very conservative statement in view of the fact that many ordinary combustibles require a heat content ranging from 500° to 1000° F. before self-sustained combustion can occur. In this text, heat in excess of 300° F. will be referred to as "excessive heat."



The most practical method of controlling and extinguishing fires involving ordinary combustibles is to transfer excessive heat from the involved and exposed combustibles to a non-combustible substance. Nature has provided a non-combustible substance in liquid form which has a greater heat absorbing capacity per unit than any known substance. Water is nature's answer to the problem of transferring excessive heat from involved and exposed combustibles. Water exerts its maximum cooling action (heat absorption) in the process of vaporization. Therefore, to obtain the maximum controlling and extinguishing action from a given volume of water it must be applied in a form and at a rate which will allow a high percentage of the total volume to be converted into steam. Water vaporizes at 212° F. (sea level boiling point). Most exposed solid combustibles do not ignite until their heat content far exceeds the boiling point of water. One sweep of a wall or roof with a fog cone will determine if the exposed materials contain excessive heat. The presence of excessive heat will be indicated by a cloud of condensing steam. The volume of condensing steam coming from the zone of combustion and from exposed materials is a positive indication as to the amount of heat which is being transferred from involved and exposed materials. Fire officers should emphasize the importance and necessity of obtaining a high percentage of vaporization in fire fighting. Personnel should be trained to recognize condensing steam and to evaluate the information it conveys on the fireground.

It is impossible to obtain a high percentage of vaporization by the use of solid streams. A high percentage of vaporization depends upon adequate surface exposure of the water being applied and the only way of obtaining adequate surface exposure is by projecting water in the form of finely divided particles. The proper tactical employment of large volume fog nozzles offers the most practical solution to the problem of controlling major exposure fires. The author has had sufficient experience in combating major exposure fires to justify this conclusion.

THE following are some of the essential facts that a commanding officer should observe and evaluate in making his estimate of an exposure situation:

(*a*) Nature, volume and physical arrangement of involved and unconsumed fuel.

(*b*) Volume, height and intensity of exterior flames. (Flame production governs the rate of heat generation except in the burning of charcoal or other pure carbons. See Table of "Flame Temperatures," *NFPA Fire Protection Handbook*.)

(*c*) Intensity of radiant heat.

(*d*) If fire has extended to exposures, extent of involvement should be determined.

(*e*) Proximity of exposures.

(*f*) Nature, volume and physical arrangement of exposed fuel.

(*g*) Susceptibility of exposed materials to ignition or damage from excessive heat.

(*h*) The most dangerous direction of probable extension considering values and other factors.

(*i*) Weather conditions — especially wind direction and velocity. Atmospheric inversion — a low atmospheric inversion will retard the upward movement of smoke by placing a lid on convection. Smoke may linger near the ground in sufficient density to reduce visibility and cause physical discomfort to fire-fighting personnel.

Considering the facts of a situation, a commanding officer should estimate the probabilities. Some of these estimates may be as follows:

(*a*) Increase in volume and intensity of flame production. Collapse of parts of an involved building may accelerate the rate of flame production and release sparks and brands.

(*b*) Direct flame contact with exposures.

(*c*) Ignition of exposures by radiation, convection or conduction.

(*d*) Collapse of walls and probable results.

(*e*) Ignition of exposures by sparks or brands.

(*f*) Increase in velocity or change of wind direction and probable results.

Having obtained the essential facts and estimated the probabilities, a commanding officer should review his own situation



and estimate his capabilities of dealing with the facts and probabilities. The important factors regarding his own situation are outlined and explained in Chapter II. At this time, a commanding officer should have a clear mental diagram of the entire situation and his initial decision should dictate the action to be taken and the objectives to be achieved.

Comments regarding decision, plan of operation and supervision:

(*a*) A major fire usually requires more than the normally assigned first alarm units. A commanding officer should estimate the requirements of the situation. He should consider the availability of additional units, and if needed, should not hesitate to issue orders for dispatch of necessary assistance. It is far better to overestimate an exposure situation than to underestimate it. Too little and too late are the parents of disaster but needed re-enforcements can never justify the failure to employ the resources which are available on the fireground. Limited resources employed in an intelligent, resourceful and vigorous manner may prove to be the decisive factor in an exposure situation.

(*b*) In dealing with an exposure problem, a commanding officer should not limit his thinking to defensive action only. The most effective defense against extension of an exposure fire may be a strong offensive. A commanding officer should estimate his capabilities of concentrating sufficient volumes of water on the main body of fire to reduce flame production and to absorb excessive heat even though extinguishment appears impossible. Excessive heat is the heart of an exposure situation. If excessive heat can be controlled, particularly at the points threatening exposed fuels, extinguishment can be accomplished by allowing the fire to consume the involved fuel.

(*c*) Decisions in major exposure fires are usually based upon calculated risks for which a commanding officer should accept full responsibility. An individual who is unable or unwilling to assume this responsibility should not aspire to positions of operational command. Professional ability and qualities of leadership are as necessary on the fireground as they are on the battlefield.

(*d*) Fire-fighting units should not be allowed to rush into action but should be assigned to definite missions in keeping with the plan of operation. There should be a tactical reserve on hand to cope with unforseen developments.

(*e*) Constant supervision should be maintained to see that the plan of operation is executed properly.

(*f*) A commanding officer and members of his staff should recognize the necessity of conserving personnel and water during a major fire. Indiscriminate employment of hand-operated nozzles usually results in waste of personnel and water supply as may be noted by observing the drop in hydrant residual pressures on pumper inlet gages. Large volume fog nozzles operated from fixed mountings offer the most practical solution to this problem. (See NFPA Manual, *Operating Fire Department Pumpers.*)

Where a small structure such as an ordinary dwelling is involved, exposures may be protected by fog nozzles on booster or 1½-in. hose lines. Where fire has penetrated an exposed building, the only way to prevent destruction of the building is to attack and extinguish the interior fire and protect the opening through which the fire extended. All roof openings and windows located on exposed sides of building should be closed and care should be taken to prevent destruction of window panes.

PRINCIPLES AND SUGGESTIONS:

1. A commanding officer should determine the most dangerous direction of extension and take immediate action to halt the progress of the fire in that direction.
2. Air conditioning or other forced draft systems of heating, cooling or ventilating exposed building should be shut down.
3. Full advantage should be taken of the various types of permanent protection available.
4. Care should be taken to prevent charged electric wires from falling and thereby endangering life and property. Poles and wires should be protected by application of water until wires can be cut or service discontinued. Arrangements should be made for prompt response of an emergency crew of the local utility company to all major fires.



## CHAPTER V

## CONFINEMENT

CONFINEMENT includes those operations which are required to prevent a fire from extending to uninvolved sections of a building. A fire starting in a basement or on lower floors is more difficult to confine than one starting on upper floors or in an attic. The downward extension of fire is slow while its extension from room to room on the floor of origin and to upper floors is usually rapid if not retarded by a sprinkler system or protected openings.

FIRE MAY EXTEND HORIZONTALLY FROM ROOM TO ROOM AS FOLLOWS:

(*a*) Through any unprotected opening by direct flame contact or by circulation of heated smoke and air.

(*b*) Explosion or flash burning of heated smoke, flammable gases, vapors, dust or contents.

(*c*) Conduction of excessive heat through such mediums as unprotected steel beams, pipes or air ducts which extend from involved area to other rooms.

(*d*) Fire entering partitions or other concealed spaces and extending to other rooms.

(*e*) Ignition of combustibles which are too close to walls or protected openings.

(*f*) Burning through interior doors or walls.

FIRE MAY EXTEND FROM FLOOR TO FLOOR AS FOLLOWS:
(UPWARD EXTENSION)

(*a*) Through any unprotected floor opening either by direct flame contact or by circulation of heated smoke and air.

(*b*) Explosion or flash burning of heated smoke, flammable gases, vapors, dust or contents.

(*c*) Fire entering partitions or other concealed spaces and extending to upper floors or attic.

(*d*) Flames coming from windows or other exterior openings and entering upper floor through unprotected openings.

(*e*) Conduction of excessive heat through such mediums as unprotected steel supports, pipes or air ducts which extend from floor to floor.

(*f*) Ignition of combustibles which are too close to protected openings.

(*g*) Burning through floor.

(DOWNWARD EXTENSION)

(*a*) Explosion or flash burning of heated smoke, flammable gases, vapors, dust or contents.

(*b*) Sparks or burning materials falling through vertical shafts or other floor openings.

(*c*) Conduction of excessive heat through such mediums as unprotected steel supports, pipes or air ducts which extend from floor to floor.

(*d*) Collapse of roof or floors.

(*e*) Burning through floor.

An air conditioning or any forced draft ventilating or heating system may contribute to extension of fire. Operation of such a system should be stopped immediately upon discovery of smoke or fire within a building. Modern systems are usually fitted with automatic devices which close a system when the circulating atmosphere becomes contaminated with smoke or contains excessive heat.

A properly designed automatic sprinkler system usually provides an effective type of permanent protection against extension of fire within a building. Permanent protection is also provided by interior walls of fire-resistive construction with all vertical and horizontal openings protected by automatic or self-closing doors. Information regarding standards and limitations of these types of permanent protection can be obtained from the *NFPA Fire Protection Handbook*.



Both officers and firemen should have sufficient knowledge of building construction to enable them to estimate the fire-fighting hazards inherent to various types of construction. The problem of confining a fire in a public, industrial, commercial or apartment building will be greatly simplified if a commanding officer and members of his staff have adequate knowledge of its construction, occupancy and contents. If provided with a Block Plan, a commanding officer and members of his staff can recall to mind quickly the essential facts pertaining to an involved building. From their knowledge of construction and degree of involvement, they should estimate the probabilities of collapse of roof, floors or walls. Where such probabilities are present, officers and firemen should be on the alert for any indication of weakening of the structure.

Excessive heat is the factor that enables fire to extend to uninvolved sections of a building. The most practical method of dealing with an accumulation of excessive heat within an involved building is by the proper employment of the indirect method of attack. A thorough study of Chapter VII — VENTILATION, (Page 53), and of the book *Attacking and Extinguishing Interior Fires* is recommended.

Once a fire has gained access to partitions or floor joist spaces, it can extend to uninvolved sections of a building unless such spaces are fitted with fire stops. The presence of lint and dust within the spaces affords ready fuel to support rapid extension. Discoloration of plaster usually indicates the spaces through which the fire has extended. Checking of walls and ceiling by feeling with the hands will indicate any spaces which contain excessive heat. Involved spaces should be opened and necessary extinguishing action taken. Care should be exercised to trace all possible avenues of extension to make sure that fire has not extended beyond these points.

## PRINCIPLES AND SUGGESTIONS

1. If an involved building is protected by a sprinkler system, determine if sprinklers have opened. If necessary, system

should be provided with adequate volume and pressure from fire department connection.

2. In hazardous types of occupancy, if practical, individual sprinklers from which water is no longer required should be closed by tongs or other closing device. The system should remain in service until firemen have completed extinguishment and have checked the building.

3. If an involved building has air conditioning or any forced draft system and the system is operating, immediate action should be taken to shut it off.

4. Locate the area of major involvement and determine the phase of development of the fire.

5. If there is an accumulation of excessive heat within the building, the indirect method of attack should be employed.

6. Conventional methods of ventilation should not be employed until after excessive heat has been transferred to the outside atmosphere by use of fog nozzles.



## Chapter VI

## EXTINGUISHMENT

EXTINGUISHMENT includes those operations which are required in attacking and extinguishing the main body of fire.

In making the size up, a commanding officer should consider and evaluate the following basic factors:

(*a*) Nature of the involved fuel — this factor determines the type of extinguishing agent that should be employed.

(*b*) Quantity of fuel involved — this factor indicates the volume of extinguishing agent that will be required.

(*c*) Physical arrangement of the involved fuel — this factor determines the method that should be employed in applying the extinguishing agent.

The basic principles pertaining to attacking and extinguishing the following types of fire will be reviewed:

Buildings<br>
Flammable gases and liquids

### BUILDINGS

Building fires usually involve ordinary solid combustibles which require the use of an extinguishing agent that has a high heat absorbing capacity. Water, in liquid form, possesses properties which enables it to absorb more heat per unit than most known substances. It is the most practical and economical medium that can be employed in controlling and extinguishing fires involving ordinary solid combustibles. A high percentage of vaporization is the key to the successful employment of water as a controlling and extinguishing agent. Water which fails to vaporize contributes little toward extinguishment; it is the water which is converted into steam that extinguishes the fire. This factor is so important that every effort should be made to obtain a high percentage of vaporization in combating both interior and exterior fires. Wherever water is employed as a controlling and extinguishing agent it should be applied in a form and at a rate which will insure the highest percentage of vaporization that can be attained under existing circumstances. Water is the only answer to the problem of controlling and extinguishing major fires involving buildings and other ordinary solid combustibles, therefore, the only road to greater extinguishing efficiency is by increasing the percentage of vaporization.

### Interior Fires

The most practical and effective method of combating major interior fires is by the proper employment of the indirect method of attack using the vaporization and expansion of water particles from fog nozzles to absorb and transfer heat and thus extinguish fire. A thorough study of *Attacking and Extinguishing Interior Fires* is recommended.

### Sprinklered Buildings

If a properly designed sprinkler system functions effectively there shouldn't be an accumulation of excessive atmospheric heat within the involved building. Entry should be made and the necessary volume of water applied directly to the burning combustibles. If necessary, adequate volume and pressure should be maintained by pumping through the fire department connection. After the fire has been extinguished sprinklers should be closed by use of tongs or wooden wedges until overhauling has been completed. Fused heads should be replaced and the system returned to service before hose lines are removed from the building.

### Unconfined Building Fires

Flame production can develop very rapidly within a building if exhaust and air-intake openings are sufficient in size and so located that the burning fuel can obtain an adequate oxygen supply by circulation of air from the outside atmosphere. Extinguishment depends on attaining the following objectives:

(*a*) The rate at which heat is transferred to the water being applied must exceed the rate of production minus the natural loss of heat by radiation and convection to the outside. This means that water must be applied in a form and at a rate which will reduce to a major degree the volume and intensity of flame production.



(*b*) Residual heat within the building must be reduced to a degree which will allow fire-fighting personnel to enter and extinguish the remaining fire.

In sizing up a fire of this nature a commanding officer should estimate his capabilities of concentrating sufficient volume of water to accomplish these objectives or to control the rate of burning to an extent that would prevent involvement of exposures. He should consider the size and height of involved building, construction, nature and quantity of contents, rate of burning, extent of destruction, water supply, pumping capacity and other essential facts. In many instances the only practical course of action is to protect exposures and allow the fire to extinguish itself by consuming the involved fuel. In some cases it may be possible to afford adequate protection for exposures and to attack and extinguish the fire in one or more sections of an involved building. It is far better to attain a limited objective than to waste available resources attempting to attain the impossible.


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Monitor unit projecting 30° angle cones

A commanding officer should estimate the probabilities of collapse of roof, floors or walls. Even with the most skillful employment of water fog, it is impossible to obtain as high a percentage of vaporization where a building is well ventilated as is possible in a closed or partly ventilated building. The volume of unvaporized water or "run-off" must be considered in relation to the nature and quantity of contents and their susceptibilities to absorption and expansion. Where such probabilities exist operations should be conducted with due consideration for the safety of personnel. Monitor units offer the most practical answer to the problem of operating nozzles from hazardous positions. Once a monitor unit has been placed and the nozzle or nozzles directed, personnel can be withdrawn if necessary. The loss of a monitor unit would be minor in comparison to the loss of life or a piece of motorized equipment.

An "indirect attack" (see page 42) offers the most practical and effective method of attaining objectives (*a*) and (*b*). The techniques of the indirect attack are as applicable in combating unconfined building fires as they are to fires involving closed or partly ventilated buildings. A much higher rate of application will be required to overcome the rate of heat production. Indirect application should be made through more openings than where a higher degree of confinement exists. An indirect attack should be made in each floor area starting with the first floor of involvement. Some degree of indirect application will be obtained on upper floors but the plan of operation should be formulated in anticipation of an indirect attack being required in each floor area. The effectiveness of the attack can be estimated by the volume of condensing steam being exhausted from the building. An extinguishing efficiency of 50 per cent will result in the generation of over 100 cu. ft. of steam per gallon of water injected into the involved building. Properly equipped and trained personnel can obtain a fair percentage of vaporization in combating unconfined building fires.

Many fire departments are able to attain a high degree of efficiency in combating small and medium sized fires but fail to utilize their resources effectively in combating major fires. Fireground experience in combating major fires is too limited to enable officers and firemen to develop a high degree of efficiency.



Here is a training problem that few departments have attempted to solve. An adequate solution for this problem can not be obtained solely from classroom instruction. Major fires usually require the employment of more than normally assigned units. Actual field training of multiple units, under capable supervision, in solving tactical problems appears to offer the only practical system of correcting this deficiency. This system of training would pay enormous dividends on the fireground providing it was planned properly and conducted in a practical and resourceful manner.

### Principles and Suggestions

1. Fire-fighting personnel should be trained in the use of both fog cones and solid streams and should have a clear understanding of the advantages and limitations of each form of application.

2. Fire-fighting personnel should be trained in the art of attacking, controlling and extinguishing fire by the use of water fog. This training should be conducted under as near actual fire-fighting conditions as are possible to attain. Skill and confidence are essentials to the successful employment of water fog and this method of training is necessary for the development of these essentials.

3. Care should be exercised in placing of pumping units to insure that maximum volume and pressure are available on the fireground.

4. Supervision should be exercised on the fireground to insure the following:

(*a*) Nozzle pressures sufficient to produce effective fog cones.

(*b*) That nozzles are operated from positions which will enable operators to obtain effective results.

(*c*) That fog cones are directed and manipulated to obtain maximum controlling and extinguishing action from the water being projected.

(*d*) That under existing circumstances the most effective form of application (fog cone or solid stream) is being employed.

(*e*) That where practical in combating major exterior fires large volume fog nozzles should be operated from windward side of fire in order to obtain maximum reach and coverage.

## FLAMMABLE GASES AND LIQUIDS

### Flammable Gases

A flammable gas cannot ignite or burn until it obtains a proper air mixture. This mixture of air and gas must be within the explosive (burning) range of the particular gas before ignition can occur. If a compressed gas is escaping from a container, burning can occur only outside the container where the gas is obtaining a proper air mixture. Where a container of compressed gas is exposed to flame or heat, heat will be transmitted to the compressed gas resulting in an increase of pressure within the container. An approved type of container is fitted with a relief valve or other device designed to release at a predetermined pressure. A pressure rupture can occur if relief device fails to function or the gas is being heated so rapidly that the relief opening is inadequate to relieve the pressure. Containers of compressed gases involved in fire or exposed to a hazardous degree of heat should be cooled by application of water. Wherever practicable water fog should be used.

Liquefied petroleum gas is transported in large volumes over highways, railroads and waterways. It is used in manufacturing processes, for commercial and domestic heating and as motor fuel. The major hazard is a release of a large volume of gas which, being heavier than air, may extend over a wide area before coming in contact with a source of ignition. In a populated area, this gas will enter basements and ground-level spaces. Once a source of ignition is encountered the entire gas covered area will be involved in fire and explosions may occur in basements and other low-level enclosures.

The only practical method of combating a fire involving escaping liquefied petroleum gas is to employ sufficient volumes of water fog to control the rate of burning, to cool the container, and to protect exposures from flame contact and radiant heat. Fog cones should be used to "place a lid" on the burning gas allowing the gas to continue to burn as it escapes from the container. This type of fire should not be extinguished but should be controlled until the flow of gas can be stopped or the supply has been exhausted. Extinguishment may create a more serious situation than by allowing the fire to continue until the available fuel has been consumed. The rate of application of water fog is dependent upon the volume of burning gas. Where a considerable volume is escaping, large volume fog nozzles will be required and hand-operated fog nozzles should be used to protect personnel and to extinguish fires involving exposed combustibles.



Where the flow of gas can be stopped by closing a valve or valves, it may be possible to afford sufficient protection from flame and radiant heat to enable a fireman to approach the valve behind a shield of water fog. Where extinguishment is desirable and will not create a hazardous situation, dry chemical powder under pressure is very effective. The operator should be shielded by fog cones and should approach the opening from the direction in which the gas is flowing. When within effective range dry chemical powder should be directed into the flowing gas so that the powder will be funnelled into the mass of flame. Carbon dioxide can be used but due to its limited reach a closer approach will be necessary.

### Flammable Liquids

The following factors should be considered and evaluated by a commanding officer in sizing up a flammable liquid fire:

(*a*) Characteristics of the liquid or liquids involved and exposed.

(*b*) Quantity of liquid involved and exposed.

(*c*) Physical arrangement of involved and exposed liquids.

The characteristics of the flammable liquid involved will determine the extinguishing agent or agents which will be most effective in controlling and extinguishing the fire. The important characteristics which govern the conduct of a flammable liquid are: specific gravity, explosive range, ignition temperature, vapor density, flash point, viscosity and miscibility with water. The quantity involved and exposed will indicate the volume of controlling and extinguishing agent or agents which will be required. The physical arrangement will determine to a major degree the techniques of employing the controlling and extinguishing agent or agents.

A flammable liquid will expand in volume as its temperature is increased and will contract in volume as its temperature is lowered. An increase in temperature of the liquid in a full or nearly full container may cause sufficient expansion to cause an overflow from the vent opening. An increase in temperature of a liquid in an unvented container may cause sufficient increase in pressure to rupture the container. Rupture of a vented container can occur if the liquid is heated so rapidly that the opening is insufficient to keep internal pressure below the rupturing point. Tanks and other containers, when exposed to flame or heat, should be protected from this hazard by the application of water especially in the form of fog or spray.

The rate of vaporization is governed by the vapor pressure of the particular liquid and the area of liquid surface that is exposed to the atmosphere. Low flash point liquids have higher vapor pressures than those having higher flash points. An increase in temperature of a liquid will increase its vapor pressure resulting in an increased rate of vaporization. Due to their density the vapors of several common flammable liquids tend to concentrate at the lowest level. Hazardous concentrations may remain for a period of time within confined spaces. Forced ventilation may be required to effect dilution and diffusion of a hazardous concentration in a basement or similar space. The presence of a hazardous concentration of flammable vapors can be determined by the use of an explosimeter, combustible gas indicator or flame safety lamp.

An explosion resulting from rapid combustion cannot occur within a full container of flammable liquid but a pressure rupture can occur if the container is exposed to flame or a hazardous degree of heat. Explosions within partly filled containers of low flash point liquids are rare for usually the mixture of vapor and air is too "rich" to burn. Burning can occur near the vent or other opening where the vapor is obtaining a proper air mixture but the mixture within the container usually contains insufficient oxygen to support combustion. Explosions can occur within empty containers or in containers from which low flash point liquids are being removed rapidly, under these conditions it is possible for an explosive mixture of vapor and air to develop. Where a vapor-air mixture is burning at an opening,



there is no immediate danger of an explosion occurring within the tank. If the mixture within the container had been within its explosive range an explosion would have occurred immediately following ignition at the opening.

Flammable liquids having flash points above 100° F. can be extinguished readily by the use of water fog providing the water can be applied to the entire liquid surface at a sufficient rate. Flammable liquids having lower flash points are more difficult to extinguish by the use of water fog. The rate of burning can be controlled by the proper application of water fog but conditions must be very favorable to obtain complete extinguishment. Reignition can occur unless exposed steel and other solids are cooled to below the ignition temperature of the particular flammable liquid. Flammable liquids which have a sufficient degree of viscosity can be extinguished readily by the use of water fog. Crude, lubricating and the heavier grades of fuel oils have a sufficient degree of viscosity to cause froth to form on the surface of the oil when water particles are applied. This froth is formed by water particles being converted into steam in the upper stratum of heated oil. This froth disintegrates very rapidly and reignition can occur if exposed metals or other solids retain enough heat to be above the ignition temperature of the particular liquid. These liquids are susceptible to "boilovers" which may spread the fire and endanger personnel. A "boilover" can be caused by applying too much water or can occur when the heat wave extends into the liquid near the bottom of the tank. Skillful application of water fog is required where open containers of these liquids are involved. Fires involving asphalt can be extinguished readily by the careful application of limited volumes of water fog. Heated asphalt is very susceptible to "boilover" and special care must be exercised where asphalt is in an open container. To avoid a "boilover" the volume of the container above the liquid level must be greater than the volume of steam generated within the heated liquid. A cubic inch of water expands into almost a cubic foot of steam.

Mechanical (air) foam is very effective in extinguishing fires involving most of the common flammable liquids. Ordinary mechanical and chemical foams are ineffective on fires involving alcohol, acetone, carbon disulphide or ether. When ordinary foams are applied to the surface of these liquids a chemical reaction occurs which causes the bubbles to disintegrate. There are special foams which are effective on fires involving these liquids. Carbon disulphide being heavier than water can be extinguished by flowing water gently over the involved surface. This is a practical method of extinguishing a fire in an open container where this liquid is involved. Flammable liquids which are miscible with water, such as alcohol and acetone, can be extinguished by diluting the involved liquid with water. This method would not be practical in a container where the volume of water required to effect extinguishment would exceed the remaining capacity of the container. A low-expansion type of mechanical foam is very effective in extinguishing gasoline and similar low flash point liquids when applied in the form of fog. Water treated with the proper percentage of a standard wetting agent and applied in the form of fog is also effective in controlling and extinguishing fires involving gasoline and other low flash point liquids.

Dry chemical powder under pressure is a very effective agent for extinguishing fires involving low flash point liquids. Where a low flash point liquid is involved, water fog can be used to protect personnel from radiant heat, to control the rate of burning, and reduce the heat content of exposed metals and other solids. Dry chemical powder can then be employed to effect complete extinguishment.

Gasoline and other low flash point liquids are transported and stored in large volumes. Release of a large volume of gasoline will present a serious problem if buildings and motorvehicles are exposed. The techniques and precautions recommended for dealing with liquefied petroleum gas are applicable in situations involving gasoline and other low flash point liquids. One practical method of disposing of a large volume of flowing gasoline may be to direct it into a storm sewer opening. Care should be taken to prevent ignition of vapors within the sewer and after it has escaped from the sewer outlet. It will be necessary to use plenty of water to clear the sewer of gasoline and vapor.



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Two large adjustable pattern fog nozzles projecting fog cones from monitor unit. Total discharge approximately 800 U. S. gallons per minute.

PRINCIPLES AND SUGGESTIONS

1. Fire-fighting personnel should be familiar with the reaction of flammable gases and liquids under fire conditions.

2. Fire-fighting personnel should have adequate knowledge regarding the characteristics of the various flammable gases and liquids with which they have to contend.

3. Fire-fighting personnel should receive practical training in the use of their specialized extinguishing agents.

4. Fire-fighting personnel should receive practical training in controlling liquefied petroleum gas and gasoline fires by the use of water fog.



## CHAPTER VII

## VENTILATION

VENTILATION includes those operations which are required to displace a heated and contaminated atmosphere within an involved building with normal air from the outside atmosphere.

Fire (combustion) is a chemical reaction in which oxygen combines with fuel at a rate sufficient to produce both heat and light. The essentials of this process are: (*a*) Fuel — any combustible gas, liquid or solid; (*b*) Oxygen — sufficient in volume to support the process of combustion and usually supplied from surrounding air; (*c*) Heat — sufficient in volume and intensity to raise the temperature of the fuel to its ignition or kindling point. Normal air contains approximately 21 per cent oxygen by volume and this percentage is sufficient to support active flame production. A decrease of oxygen in the surrounding atmosphere results in a corresponding decrease in the rate of fuel consumption and flame production. Flame production ceases when the oxygen content of the surrounding atmosphere decreases to approximately 15 per cent. Fires involving gases and liquids are extinguished completely when flame production ceases but this is not true in the burning of solid combustibles. When the temperature of a solid fuel is increased sufficiently, the volatile products of the fuel are released in gaseous form. Flame results from the burning of the gases and vapors after they have obtained a proper air mixture. Although flame production ceases when the oxygen content of the surrounding atmosphere falls below 15 per cent, smouldering burning of the solid residue will continue in an atmosphere containing a much lower percentage of oxygen. Smouldering burning is characterized by a slow rate of fuel consumption, limited heat generation and production of smoke in considerable volume. Flame production is necessary for rapid generation of heat and the development of high temperatures except in the burning of charcoal or other pure carbons. Pure carbons will burn without producing either flame or smoke and under favorable conditions of combustion will generate heat very rapidly.

In the burning of ordinary combustibles, the necessary oxygen is obtained from the surrounding air. There are certain combustibles such as gun or blasting powder, pyroxlin plastics, nitrocellulose film and similar materials which are exceptions to this rule. The burning of these materials is not dependent entirely upon the presence of oxygen in the surrounding atmosphere since they contain oxygen in a form which will support combustion. Some materials will continue to burn in an atmosphere containing less than 15 per cent oxygen but for all practical fire-fighting purposes, it may be stated that flame production ceases when the oxygen content of the surrounding atmosphere is reduced to about 15 per cent.

Smoke released in the burning of ordinary combustibles consists of a mixture of vapors and gases in which minute particles of carbon, tar and ash are suspended. Smoke is a product of incomplete combustion. All smoke is toxic to some degree and is an irritant to the respiratory system and eyes. There is usually some carbon monoxide present in smoke and the amount may vary from a small trace to a deadly percentage depending upon conditions of combustion. Smoke contains unburned fuel and when mixed with air in proper proportion may become a flammable mixture. If a flammable mixture of smoke and air develops within a confined space, this mixture may ignite and burn with explosive force. This type of rapid combustion within a confined space is referred to as a smoke explosion or back draft.

Oxygen is necessary to support life and man's efficiency is impaired when required to work in an atmosphere containing less than the normal percentage of oxygen (21%) and his discomfort will increase as the percentage decreases. A flame safety lamp can be used to determine an oxygen deficiency. The flame will lose two-thirds of its brilliancy when the oxygen content of the surrounding atmosphere decreases to 19 per cent and the flame will be extinguished when the oxygen content falls to about 16 per cent. A dangerous concentration of irrespirable gases may be present long before the oxygen content falls to 16 per cent. No one should enter an atmosphere containing less than 16 per cent oxygen without being protected with a self-contained oxygen breathing apparatus or fresh air



hose mask. A filter type or all-service mask can be used to protect against the toxic and irritating properties of smoke but should not be used in an atmosphere where an oxygen deficiency exists. (See *Report of NFPA Committee on Fire Gas Research*, 1952, 32 pp., 75 cents, National Fire Protection Association.)

A building under normal conditions contains fuel (usually solid combustibles), oxygen (21% in normal air) and heat (normal atmospheric temperature). Once the heat content of a portion of the fuel is increased to an excessive amount (sufficient in volume and intensity to actuate self-sustained combustion), the fuel combines with oxygen from the surrounding air and a destructive fire is under way. Excessive heat is generated and transmitted to uninvolved fuel either by direct flame contact or by conduction, radiation or convection. Here it is advisable to review briefly what actually occurs within a closed building during the progress of a destructive fire. An interior fire may be divided into the following phases:

First Phase — Incipient or smouldering period (Oxygen content of interior atmosphere approximately normal, 21 per cent).

If ignition occurs from flame or the involved fuel consists of flammable gases or vapors, this phase of development would not apply. It does apply to fires involving solid fuels where ignition results from a small source of heat. This phase of development is characterized by the following conditions:

(*a*) Smouldering may continue for a period ranging from a few seconds to several hours before flame production develops.

(*b*) Heated smoke will be released by the smouldering fuel and will move to the upper level of the space but loses much of its heat content by transfer to cooler atmosphere and solid materials.

(*c*) There will be little, if any, decrease in the oxygen content of the interior atmosphere.

(*d*) Little, if any, increase in the average temperature of the interior atmosphere will occur.

(*e*) The major damage will be caused by smoke.

SECOND PHASE — Flame production period (Oxygen content of interior atmosphere ranging from 21 to 15 per cent.)

This phase of development is characterized by the following conditions:

(*a*) Rapid increase in the rate of fuel consumption and heat generation.

(*b*) Period of rapid extension and major destruction.

(*c*) Heat content of the interior atmosphere increases rapidly causing it to expand in volume. If the rate of expansion exceeds the rate of escape, interior atmospheric pressure will become greater than that of the outside atmosphere.

(*d*) This increase in pressure amounts to only a fraction of a pound per square inch but may exert sufficient force to cause an outward rupture of window panes which have been weakened by excessive heat.

(*e*) Major concentration of excessive heat will be located at the upper atmospheric level within the area of major involvement.

(*f*) If the fire fails to effect an opening or openings to the outside atmosphere, oxygen content of interior atmosphere will decrease rapidly.

(*g*) Volume of flame production will decrease in proportion to decrease in oxygen percentage of interior atmosphere. Smoke production will increase.

(*h*) When oxygen content of interior atmosphere falls to about 15 per cent, flame production will cease.

THIRD PHASE — Smouldering period (Oxygen content of interior atmosphere less than 15%.)

There are only a limited number of fires that enter this phase and they are usually within basements or in buildings of fire-resistive construction. Most fires within closed buildings are able to break through to the outside atmosphere during the flame-production period. The third phase is characterized by the following conditions:

(*a*) Decrease in rate of fuel consumption and heat generation.



(*b*) Some loss of atmospheric heat due to absorption by cooler solid materials within the space and by convection and radiation to outside.

(*c*) Loss of heat may be sufficient to cause contraction in volume of interior atmosphere, thereby causing interior atmospheric pressure to fall below that of the outside atmosphere. This differential in pressure may be sufficient to cause inward rupture of window panes which have been weakened by excessive heat.

(*d*) If window panes remain intact, pressures will be equalized by seepage of air from outside atmosphere.

(*e*) Atmosphere will stratify according to heat content, the major accumulation of excessive heat will be located at the upper atmospheric level within the area of major involvement.

(*f*) Smouldering burning will continue and the interior atmosphere will become heavily charged with smoke containing a hazardous percentage of carbon monoxide.

(*g*) Interior atmosphere may contain sufficient fuel to form a flammable mixture with air. The third phase appears to produce the basic factors of a potential smoke explosion.

(*h*) A building is not air tight, therefore, some exchange of atmospheres between the interior and outside will occur after a fire has entered its third phase. There appears to be a continuous fluctuation between a negative and positive pressure due to contraction and expansion of the interior atmosphere; smoke being ejected during expansion periods and air seepage occurring during contraction periods. Intermittent flame production will occur at or near the points where air is obtained from the outside atmosphere. In time, a fire will burn through to the outside. This will allow sufficient circulation between the interior and outside atmospheres to enable the fire to reenter its second phase (active flame production).

AFTER flame production has developed within a confined space (second and third phases), the following conditions may be anticipated:

(*a*) Excessive heat will accumulate at the upper atmospheric level throughout the area of major involvement. This stratum of heated atmosphere will become heavily charged with smoke and may extend downward from the ceiling for a depth of several feet. In various fires, the upper layer of this stratum may vary in temperature from a few hundred degrees to over 1,500° F. depending upon a number of variable factors. In a particular fire, the temperature of this stratum may range from about 300 at its lower level to over 1,500° F. at the ceiling. Within a confined space of ordinary ceiling height, the atmospheric and surface temperatures at the upper level may exceed 1,500° F. while the temperature at and near the floor level may be less than the boiling point of water (212° F.).

(*b*) Within the area of major involvement the smoke content of the atmosphere will be of sufficient density to prevent adequate visibility.

(*c*) Within the area of major involvement the atmosphere will contain less than the normal percentage of oxygen and will have toxic and irritating properties.

BEFORE fire-fighting personnel can enter and operate within the area of major involvement, it is necessary to take some action to accomplish the following objectives:

(*a*) Eliminate or reduce the probabilities of a smoke explosion.

(*b*) Increase the degree of visibility to an extent which will enable personnel to operate within the building.

(*c*) Reduce the interior temperature to a degree which will allow personnel to enter and work within the building.

(*d*) Provide an interior atmosphere containing a normal percentage of oxygen.

(*e*) Reduce the toxic and irritating properties of the interior atmosphere to an extent which will enable personnel to operate without respiratory protection or with all-service (filter-type) masks.

IT HAS been an accepted practice to employ direct ventilation in an effort to accomplish these objectives. Direct ventilation is obtained by providing exhaust and air-intake openings, adequate in size and properly located, to allow ventilating currents to develop between the interior and outside atmospheres. Heated smoke and air escaping through the exhaust opening or openings while cool air from the outside atmosphere is entering through air-intake openings causes direct displacement of the interior atmosphere with normal air. Some fire departments have experimented with mechanical devices, such as exhaust fans and smoke ejectors, to accelerate the process of direct displacement. Direct displacement of an interior atmosphere by air from the outside atmosphere will be referred to in this text as "conventional methods of ventilation."



After a fire has entered its second phase and the volume of flame production has developed sufficiently to produce an accumulation of excessive heat within the area of major involvement, there are certain definite risks incurred by direct displacement of the interior atmosphere with normal air. Circulation of air from the outside atmosphere through the area of major involvement will provide sufficient oxygen to support active flame production. Flame production will extend quickly to all combustibles which are heated to, or above, their burning temperatures. A fire may extend its boundaries beyond control before adequate extinguishing action can be taken. If a fire has entered its third phase, admission of normal air may result in a smoke explosion.

It should be noted that excessive heat is the factor which creates abnormal conditions within an involved building. Excessive heat is responsible for the origin of the fire, for its extension and continuation. Excessive heat is the hard core of the problem of controlling and extinguishing major interior fires. Regardless of how skillful conventional methods of ventilation are employed, they provide neither a logical nor practical solution to the problem of displacing a contaminated atmosphere which contains excessive heat. There is a scientific and practical method of transferring excessive heat from the interior of an involved building to the outside atmosphere. In the process of transferring excessive heat to the outside atmosphere, a heated and contaminated atmosphere is displaced by an inert atmosphere of steam. An inert atmosphere is maintained within the area of major involvement until the transfer of excessive heat has been completed and then the steam condenses and is replaced by normal air from the outside atmosphere. This method, if employed properly, creates a chain reaction within the area of major involvement which results in the extinguishment of surface burning, provides an atmosphere of normal air, reduces the interior temperature to a degree that will enable personnel to enter the building and extinguish spot fires and smouldering burning. This method of displacing a heated and contaminated atmosphere appears to offer a practical solution to the problem of preventing smoke explosions.

These results are obtained by injecting water, in the form of finely divided particles, into the upper stratum of the interior atmosphere within the area of major involvement. This is known as the "indirect method of attack" and complete information is contained in the book, *Attacking and Extinguishing Interior Fires.*

PRINCIPLES AND SUGGESTIONS:

1. If necessary to increase the degree of visibility, conventional methods of ventilation (direct displacement) may be employed while a fire is in its first phase.

2. Conventional methods of ventilation may be employed after a fire has entered its second phase providing flame production has not progressed sufficiently to have developed an accumulation of excessive heat within the area of major involvement.

3. If there is an accumulation of excessive heat at the upper atmospheric level within the area of major involvement, the indirect method of attack should be employed.

4. After an indirect attack has been completed (excessive heat has been transferred to the outside atmosphere) conventional methods of ventilation may be employed to hasten the process of condensation, to lower the humidity and to effect further reduction of interior temperature.



## CHAPTER VIII

## SALVAGE

SALVAGE includes those operations which are required to protect buildings and contents from preventable damage due to water or other elements.

Salvage operations may be divided into two phases: first, the operations which are performed during a fire; second, the operations which are required after the fire has been extinguished.

SALVAGE SERVICE DURING A FIRE MAY CONSIST OF THE FOLLOWING OPERATIONS:

1. Placing of waterproof covers to protect contents and fixtures from water and debris.
2. Use of waterproof covers to "bag" floor.
3. Diverting and removing water from the building.
4. Protecting contents of building from theft.
5. Removing contents of building where it is impossible to provide protection within the building. This action should be taken only where destruction by fire cannot be prevented or salvage equipment is not available.

SALVAGE SERVICE AFTER A FIRE HAS BEEN EXTINGUISHED MAY CONSIST OF THE FOLLOWING OPERATIONS:

1. Removing water from floors and basement.
2. Ventilation of building to remove the remaining smoke, reduce the atmospheric temperature and restore normal humidity.
3. Removing articles of value from debris.
4. Drying machinery, furniture and other contents.
5. Cleaning and oiling machinery to prevent rusting.
6. Removing debris from building.
7. Application of deodorizing agent to reduce smoke damage.
8. Shutting off and draining water system where such action is necessary to prevent leakage or freezing.

9. Providing temporary coverage of roof or other openings to protect interior of building and contents from weather.

AN OFFICER who is assigned to supervise salvage operations during a fire should consider the following factors in making his size up of the salvage job:

(*a*) Height and size of building.

(*b*) Location of fire and area involved.

(*c*) Any condition which would endanger the safety of personnel engaged in salvage operations.

(*d*) Nature and value of contents.

(*e*) Permanent protection against water damage (waterproof floors, scuppers, contents on skids).

(*f*) Estimated volume of unvaporized water or "run-off."

(*g*) Personnel and salvage equipment available.

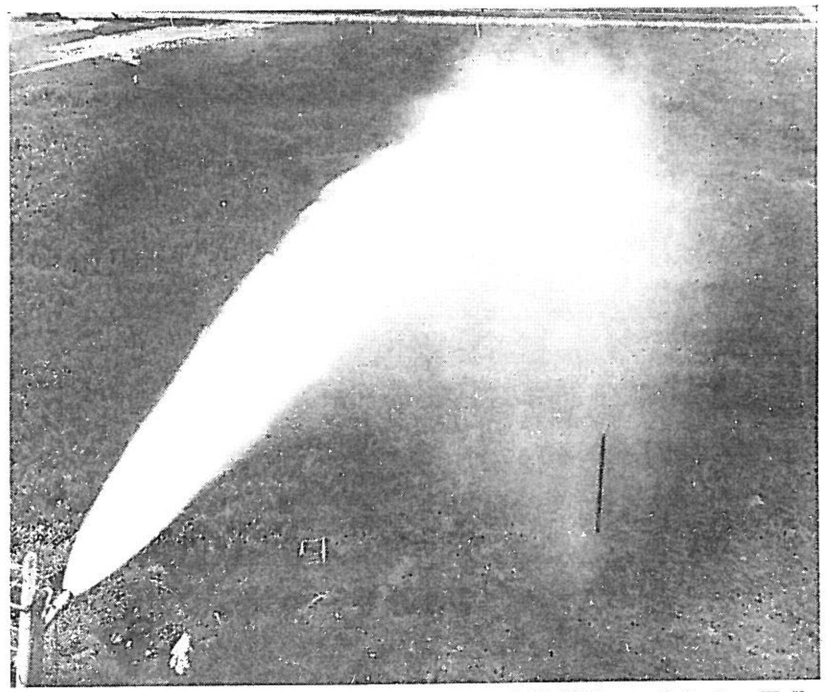
He should give due consideration to these and other essential factors in making his decision and formulating a plan of operation.

In a multiple-story building coverage should be started on the floor directly below the involved area if the nature of the contents and values justify such action. If possible the "run-off" should be diverted from the building or contained by "bagging" the floor.

The "run-off" is the major problem in salvage operations and the most practical answer to this problem is to increase the percentage of vaporization in attacking and extinguishing building fires. Each gallon of water which is exhausted from an involved building in the form of steam has exerted its maximum extinguishing action and has caused no appreciable damage to either the building or contents. Skillful employment of the indirect method of attack will reduce the volume of "run-off" and will contribute materially in solving the salvage problem. Preventable damage can occur where an indirect attack is employed if steam comes into contact with ceiling and walls having temperatures below the boiling point of water. Steam will condense on the ceiling and walls. This condensation will contain carbon, tar and ash particles. If contents are susceptible to damage from dripping of condensation, covers should be spread to protect contents until condensation has been removed.



In industrial plants, stores or public buildings where considerable salvage work will be required after a fire has been extinguished, cooperation and assistance of management and employees may be required to complete the job. The Standard Fire Insurance Policy provides that the insured is responsible for protecting his property from damage after a fire has been extinguished. Owners should be advised of this requirement and reasonable assistance rendered to the owner by the fire department.



*H. V. Muhlmann, Parkersburg, W. Va.*

A large adjustable fog nozzle operating from ladder pipe. 100 pounds per square inch nozzle pressure — volume in excess of 700 U. S. gallons per minute.

PRINCIPLES AND SUGGESTIONS:

1. The most practical method of reducing water damage is to attain a high percentage of vaporization in attacking and extinguishing building fires.

2. Salvage operations should be performed by trained personnel and supervised by a qualified and resourceful officer.

3. Adequate knowledge of building and contents is necessary in conducting efficient salvage service in occupancies other than dwellings and apartments.

4. Adequate personnel and equipment are essentials in rendering prompt and efficient salvage service.



## CHAPTER IX

## OVERHAUL

OVERHAUL includes those operations which are required to complete the extinguishment of remaining fire, prevent rekindling and to place the building in a safe condition.

Efficient salvaging and overhauling will contribute much toward selling a fire department to the citizens of its community. Salvage service after a fire has been extinguished and overhauling are closely related and blend together to a certain extent. Considerable time and labor may be required to complete these two phases of fire-fighting tactics but they never should be omitted or performed in an inefficient manner.

A commanding officer should give consideration to the following factors in sizing up a situation:

1. The structural condition of the building in view of preventing injuries to personnel engaged in after-fire salvage and overhauling.

2. What actions are necessary to extinguish remaining fire and to insure that re-ignition cannot occur?

3. The point of origin and source of ignition, if possible to determine.

4. Where there is evidence of incendiarism, photographs should be taken before removing debris. Care should be exercised in searching for and safeguarding evidence of incendiarism.

5. How debris is to be handled and where it should be placed.

6. Walls or chimneys damaged to a degree that would endanger life or cause damage to adjoining property or might cause future fires. If so, what action should be taken to remove such hazard?

7. What action is necessary to correct any unsafe condition within the building such as loose or water-soaked plaster,

broken or heat-damaged glass in doors or windows, holes in floors, open vertical shafts or other hazards?

8. The time and personnel required to complete the job.

9. Assistance required from management and employees in occupancies other than dwelling and apartments.

Once the main body of fire has been extinguished, small lines fitted with small volume nozzles should be placed in service. Care should be exercised to prevent unnecessary damage in extinguishing remaining fire. Smouldering debris should not be washed with hose streams. Smouldering articles should be sorted out and dipped in a bucket or tub of water. Smouldering mattresses and upholstered furniture may be removed from building and then extinguished. Scorched or partially burned articles should be sorted from debris and laid aside. Articles which have no salvage value may prove useful in preparing an inventory of loss. Partially burned or damaged records should be saved.

Where deep-seated smouldering exists in baled cotton, paper or similar materials, treated (wet) water may be used to special advantage. Special hose units consisting of fifty feet of good grade one-half inch rubber hose, equipped with a combination fog and solid stream shut-off nozzle and fitted with connections for use on standard water faucets may be used to good advantage in overhauling dwelling and apartment fires. This type of nozzle delivers from three to five gallons per minute at ordinary pressure.

PRINCIPLES AND SUGGESTIONS:

1. Take immediate action to complete extinguishment of remaining fire.

2. Inspect all avenues through which the fire may have extended.

3. Check all concealed spaces.

4. Remove broken or heat damaged glass from doors, windows and transoms.



5. Preserve and safeguard any evidence of incendiarism.

6. Check building and contents with owner or authorized agent to determine if there are reasons to believe or charges to be made that the building had been entered prior to the time of fire. Also observe any evidence of theft prior to or during the fire. This action is important where the fire may be of incendiary origin.

7. If electric wiring is damaged, the current should be shut off by pulling main control switch. It may be advisable to have electric company cut service line to building.

8. If natural or artificial gas is supplied to building and the system has been damaged, gas should be shut off at main valve.

9. Unsafe conditions should be eliminated or proper warning notices posted before building is turned over to owner and occupants.

10. Where building is protected by automatic sprinkler system and it is in serviceable condition, fused heads should be replaced and the system returned to service.

11. Advise owner and occupants regarding existing hazards and recommend the necessary precautions.

12. Obtain necessary data for official reports.

13. Turn over building and contents to respective owners, authorized agents or proper police officials.

## Chapter X

# TACTICAL PROBLEMS AND OPERATIONAL PLANS

THE elementary groundwork for this system of training should be prepared through organized classes and under guidance of competent instructors. Trainees should have access to necessary reference and study material. This phase of training should provide each trainee with ample opportunities to obtain a clear and thorough understanding of the basic divisions of fire-fighting tactics. This objective should be attained before any attempt is made to utilize tactical problems.

The second phase of this system of training should be confined to the use of simple tactical problems. Simplicity should be the governing factor in preparing problems for use during this phase of training. An instructor should adhere to the principle of quality instead of quantity in the number of problems used during a training course. A limited number of problems properly prepared, solved and discussed will establish a firm foundation for continuation of this system of training.

The following suggestions should be considered by an instructor and members of his staff in preparing, solving and discussing tactical problems:

1. All problems should be based on conditions existing in the community where the training course is being conducted. Each problem should be based on an actual building, adjoining buildings and conditions existing in the surrounding area. Solutions should be formulated by the theoretical employment of personnel, apparatus, equipment and water supply which would be available to a commanding officer in that area.

2. An instructor should select the building to be used in the problem. Before attempting to write the problem a complete tactical survey should be made of the building, adjoining buildings and surrounding area by the instructor and members of his staff. If an operational plan and briefs of essential facts regarding the important buildings within the block are available they should be checked to verify their accuracy. If an opera-

tional plan is not available one should be prepared together with briefs of essential facts regarding the building and adjoining buildings. These should be reproduced for issue to members of the class.

3. Each problem should be written in view of illustrating the application of certain fundamental principles of fire-fighting tactics. Simple problems designed to illustrate only a limited number of fundamental principles should be used during this phase of training.

4. A written problem should supply the following information:

(*a*) Time of emergency.
(*b*) Location of the involved building.
(*c*) Nature of emergency.
(*d*) Description of fire to be written to convey to members of class conditions which could be observed by a commanding officer in making a survey of an actual fire.
(*e*) Weather conditions at time of emergency should be stated in the problem and also such indications of change as the instructor wishes to include.
(*f*) Where a problem involves taking command after units have been committed to action, the action taken should be fully described in problem.

5. After having written a problem an instructor should write his solution and discussion. These should be reproduced for issue to members of the class after they have completed their solutions.

6. Each member of the class should be given a copy of the operational plan together with briefs of essential facts regarding important buildings within the block. Where it is not possible to provide copies for individual members the original plan and briefs of essential facts should be made available to members of the class. Members of the class should be given an opportunity to survey the selected and adjoining buildings. Each member should be allowed to make such notes and diagrams as he may desire and to refer to them while preparing his solution.



7. Instructor should determine the amount of time that should be allowed for members of the class to write their solutions. Time allowed should be liberal and the amount should be stated on problem sheet.

8. Members of the class should have no knowledge regarding nature of problem except location of building until they are handed the problem sheet in classroom. They should be allowed to refer to the operational plan, briefs of essential facts regarding involved and exposed buildings, water distribution map of surrounding area, and their notes and diagrams. Along with the problem sheet each should be given a copy of the form "Size Up — Tactical Fire Problem." (See page 73.)

9. After members of the class have completed and handed in their solutions they should be given a copy of the instructor's solution and discussion.

10. An instructor should caution members of his class not to accept his solution as the only practical solution for the problem. An instructor should stress the fact that there may be several practical solutions for any tactical fire problem.

11. An instructor should review the solutions submitted, make appropriate comments in writing and return them. It is suggested that percentage grading should be avoided but a broad system of grading may prove desirable.

12. The problem should be reviewed and solutions discussed by instructor and members of his class. Here both the instructor and members of the class will have an opportunity to benefit from the points developed.

13. Success or failure of this system of training will depend to a major degree upon the instructor and members of his staff. A qualified and resourceful instructor can develop this system of training in an interesting and inspiring manner. An instructor and members of his class should realize that this is a system of mental training which, as the result of repeated use, will enable an individual to develop a habit of logical thinking in estimating a situation on the fireground.

AFTER officers and members of a department have obtained adequate basic training in the use of tactical problems this system of training can be continued without classroom instruction. One of the group can be assigned to prepare a problem based upon a certain building or group of buildings. The problem can be given to members of the group with a definite time limit for return of solutions. A copy of the prepared solution and discussion should be given to them when their solutions are completed. Their solutions should be reviewed and returned together with written comments. Later a group discussion should be conducted under guidance of a qualified instructor.

Tactical problems could be used to good advantage in examinations for promotion in departments where this system of training has been adopted.

The following pages present a suggested form for use in solving tactical fire problems.



SIZE UP

TACTICAL FIRE PROBLEM

(Building Fire Form)

Problem Number.................................... Date..............................

Name ..............................................................................................

1. FACTS:

(a) TIME OF EMERGENCY (Month, day, hour)..................................

..............................................................................................

..............................................................................................

(b) LOCATION OF EMERGENCY (Designated by number and street or otherwise the location of involved building. Describe briefly any condition which would interfere with or obstruct operations.)..................................

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(c) NATURE OF EMERGENCY (Fire, explosion, smoke.)..................................

..............................................................................................

..............................................................................................

(d) LIFE HAZARD (State your estimate of number of persons in the involved building at this time. State if they are in immediate danger. Describe briefly any condition which would make their escape or rescue difficult.)

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(*e*) EXPOSURES (State your estimate of number of occupants in each adjoining building. State if they are in immediate danger. State briefly your estimate of the susceptibility of exposed buildings or other materials to ignition or damage from excessive heat.) ........................................

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........................................

(*f*) BUILDING INVOLVED (State briefly the essential facts which you will consider in making your size up.) ........................................

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........................................

(*g*) FIRE (Study description of fire as stated in problem. State briefly your estimate of floor or floors involved, area of major involvement and phase of development based upon description given in problem and your knowledge of building and contents.) ........................................

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(*h*) WEATHER (State if weather conditions given in problem will tend to interfere with operations or affect the situation.) ........................................

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........................................

2. PROBABILITIES:

(*a*) LIFE HAZARD (State your estimate of hazards to occupants of involved building, exposed buildings, spectators and own personnel; based on your estimate of future developments.) ........................................

........................................

........................................

(*b*) EXTENSION OF FIRE (Your estimate of any probable extension of fire: first, to exposed buildings; second, within the involved building.) ........................................

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........................................



(*c*) EXPLOSIONS (Your estimate regarding this hazard within the involved building.) ........................................

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........................................

(*d*) COLLAPSE OF COMPONENT PARTS OF INVOLVED BUILDING (Your estimate regarding collapse of roof, walls or floors.) ........................................

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........................................

(*e*) WEATHER CHANGES (Would any indicated weather change as stated in problem affect the situation?) ........................................

........................................

........................................

(*f*) PREVENTABLE DAMAGE (Your estimate regarding probable damage to involved building and contents and to exposures from water, excessive heat or other causes which could be prevented by proper care and salvage operations.) ........................................

........................................

........................................

3. OWN SITUATION:

(*a*) PERSONNEL — APPARATUS EQUIPMENT — HOSE SUPPLY (State if these are sufficient to deal with situation. If, in your opinion, these are insufficient, itemize additional requirements.) ........................................

........................................

........................................

(*b*) ADDITIONAL ASSISTANCE AVAILABLE (If additional assistance is required state from where necessary assistance can be obtained and your estimate of time required for arrival on fireground.) ........................................

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........................................

(c) WATER SUPPLY — MAINS — HYDRANTS — AUXILIARY SUPPLY — OTHER EXTINGUISHING AGENTS (State if water supply within the immediate area is sufficient to meet requirements of situation considering the number and locations of hydrants and size of mains. If this supply is insufficient state if relay operations are necessary or if an auxiliary supply is available and can be utilized. If situation requires extinguishing agents other than water itemize each and the volume available. State if these are sufficient to meet requirements of situation.)..............................................

....................................................................................................

....................................................................................................

(d) SPRINKLER SYSTEMS — STANDPIPE SYSTEMS — OTHER PROTECTIVE DEVICES (Review briefly primary protective equipment of involved and exposed buildings. State your estimate of the equipment that should be employed and the action required to insure effective operations.)..........

....................................................................................................

....................................................................................................

(e) ACTION THAT HAS BEEN TAKEN (Study problem to determine what action has been taken. No statement required.)

4. DECISION:

(a) INITIAL DECISION (Brief statement outlining the action to be taken and the objectives to be achieved.)..............................................

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5. PLAN OF OPERATION:

(State briefly how you will employ your resources to attain the objectives as stated in your decision, number each separate step.)..............................

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## OPERATIONAL PLANS

THE system of planning described here starts with a penciled outline of a particular block using a scale of one inch equals twenty-five feet. The entire plan is drawn and checked before the penciled lines are traced with ink. This master plan is then used to reproduce photostatic copies reduced to 8½ in. x 11 in. The negative or proof copy (black background) appears to be the most practical for use in binders.

A stiff back, loose leaf binder (9 in. x 11½ in.) is used to hold plan and briefs of essential facts. These briefs follow a definite form and are typed on letter size paper (8½ in. x 11 in.) The block plan is mounted on the inside front cover of binder. A single binder can be used to hold two plans and briefs of essential facts. The second plan can be mounted on the inside of the back cover.

The operational maps supplemented by briefs of essential facts are designed to provide a ready and authentic source of reference for a commanding officer and members of his staff on the fireground. An operational plan will provide a commanding officer with a better concept of an exposure situation in a congested block than could be obtained from a personal survey at the time of emergency. These plans are practical if they are revised as changes occur. Minor revisions can be made on photostats by the use of black or white ink. Master maps should be retained and major revisions can be made by pasting revised drawings on the original map. Major alterations within a block may necessitate replacement of photostats. Briefs of individual buildings should be revised or proper notations made to maintain an accurate record of essential facts. Data can be recorded on a "Building Information Form" shown on pages 78–80.

This system of operational plans is not offered as an ideal solution to the problem of providing a commanding officer and members of his staff with adequate tactical information on the fireground. It is presented as a guide for study and experimentation in devising a practical solution to this important problem.

## BUILDING INFORMATION FORM

BLOCK NO.

NUMBER AND STREET: NAME OF BUILDING

LIFE HAZARD

HEIGHT:

SIZE: Basement

CONSTRUCTION:

Exterior Walls

Interior Walls

Partitions

Floors

Roof

Built — Year and date remodeled

State of Repairs

WINDOWS:



DOORS:

OPENINGS INTO OTHER BUILDINGS:

OCCUPANCY:

CONTENTS:

EXTERIOR STAIRWAYS:

INTERIOR STAIRWAYS:

VERTICAL SHAFTS:

FIRE ESCAPE:

AIR CONDITIONING SYSTEM OR AIR CIRCULATING SYSTEM: ..........

SPRINKLER SYSTEM: ..........

STANDPIPE SYSTEM: ..........

OTHER FACTS:

Heating ..........

Lighting ..........

Skylights ..........

Scuttle holes ..........

Roof ventilators ..........

Deadlights ..........

Watchman service or building custodian ..........

Other information ..........

GAS SHUT-OFF: ..........

ELECTRIC SHUT-OFF: ..........

WATER SHUT-OFF: ..........

REMARKS: ..........



## OPERATIONAL PLAN
## BLOCK (1–0)

100 — block ANN and OHIO Streets
0 — block FIRST and SECOND Streets



STORM SEWER OPENINGS WITHIN THE BLOCK

FIRST and ANN Streets: 1-double and 1-single catch basins.

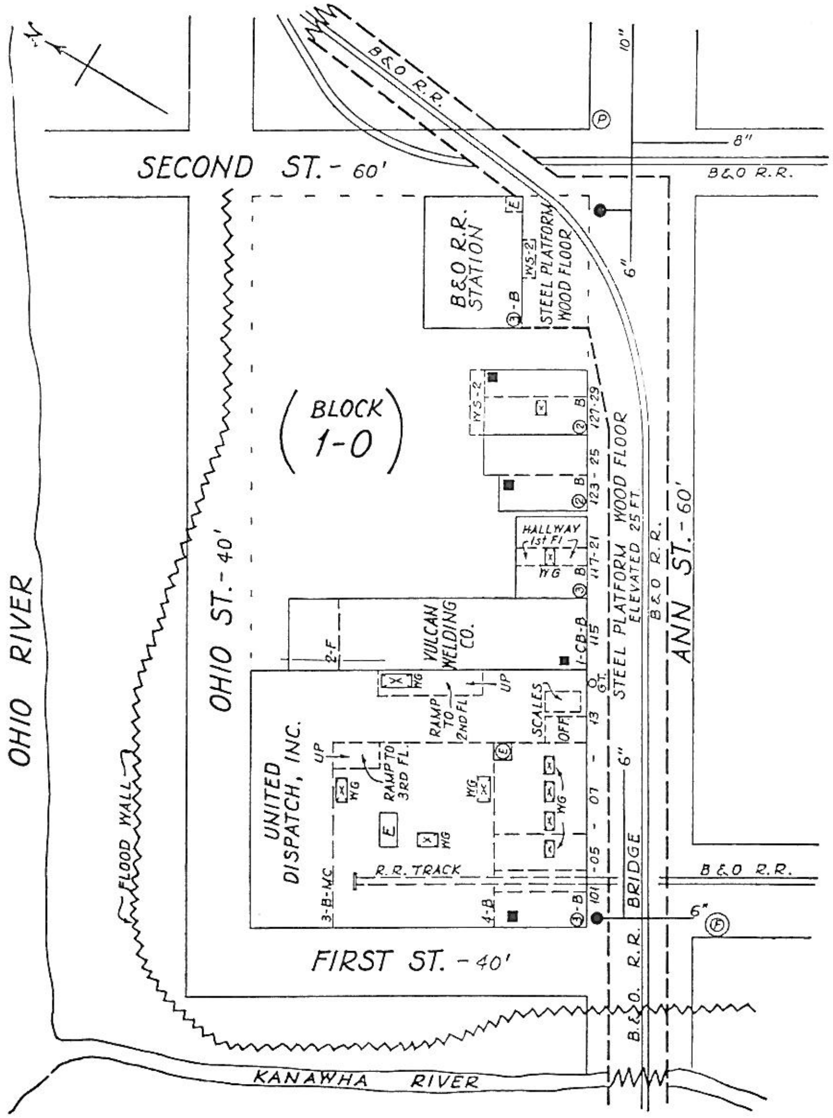
### 101–05–07–13 ANN Street

LIFE HAZARD: Approximate number of persons normally employed in building: Day 5; Night none.

HEIGHT: 3-story sections 39 ft. to 45 ft. 4-story section 50 ft.

SIZE: 3-story section, Front 105 ft. x 50 ft.
3-story section, NE 40 ft. x 105 ft.
3-story section, Rear 145 ft. x 40 ft.
4-story section, 105 ft. x 95 ft. Overall 145 ft. x 185 ft.
Basements under 3-story section, Front, No. 101, 20 ft. x 40 ft.; No. 105, 20 ft. x 30 ft.

CONSTRUCTION: *Exterior walls* — NE wall is party wall with 115 ANN Street, brick, 8 in. to 12 in., without openings. Rear end walls of 3-story section, rear — brick to second floor, 12 in.; second floor to roof — metal clad. Four-story section — brick, 8 in. to 16 in. Other walls — brick, 8 in. to 12 in. *Interior walls* — shown on plan — brick, 8 in. to 12 in. *Partitions* — plaster on wooden lath and studding. *Ceilings* —




Plan of Block (1-0), Parkersburg, W. Va.

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While some of the symbols shown on the above block plan were developed locally for the convenience of the Parkersburg Fire Department, most of these should be understood by reference to Chapter 35 "Standard Plan Symbols," *NFPA Fire Protection Handbook*.



three-story section, front — plaster on wooden lath; other sections — open rafters. *Floors* — first floor concrete except over basements; floor and subflooring wood on wooden joist supported by wooden posts. Second floor, four-story section — floor and subflooring wood on wooden joist supported by unprotected steel beams on iron posts. All others — floor and subflooring wood on wooden rafters supported by heavy timbers on wooden posts. *Roof* — flat, frame, composition covering except three-story section, front — tin, supported by heavy timbers on wooden posts. *Parapets* — 18 in. *Built* — three-story section, front — 1872 for use as hotel; three-story sections, NE and rear — 1910; four-story section — 1917. In good repair except three-story section, rear, was damaged during construction of flood wall. *This section is unsafe and has been vacated.*

WINDOWS: All floors — front, left side and rear; fourth floor-front, right side and rear fitted with metal fire shutters. Front windows of three-story section, NE, wired glass in metal frames.

DOORS: *From Ann to first floor* — single to No. 101; vertical metal to railroad entrance; single to 105, to 107, to 113; vertical metal to three-story section, NE. *From First Street to first floor of four-story section* — vertical metal; *to second floor* — double wooden. *From First Street to first floor, three-story section, rear* — vertical metal.

OCCUPANCY: United Dispatch, Inc. (formerly Parkersburg Transfer Co.), railroad and truck terminal warehouse. Truck repair shop — first floor of four-story section.

CONTENTS: *Basements* — none. *Three-story section front, No. 101* — empty paper containers; *No. 105* — soft drink vending machines, paper cups, cylinders of $CO_2$; *No. 107* — cylinders of compressed gases — oxygen, acetylene, propane; *No. 113* — office equipment and records; *rooms in rear of No. 105 and 107* — motor oil, greases and anti-freeze solution in drums and cans. *Second floor, 13 rooms* — household furniture, truck tires, anti-freeze solution in cans; *third floor, 14 rooms* — household furniture and old records. *Three-story section, NE, first floor* — trucks and trailers; *second floor*, consisting of single space —

furniture and paper drums; *third floor*, consisting of single space — household furniture. *Three-story section, rear, all floors* — no contents. *Four-story section, first floor*, consisting of single space — repair equipment, trucks and trailers; *second floor*, consisting of single space — supplies and surplus equipment, Imperial Ice Cream Co.; *third and fourth floors* — same. Supplies consists of sugar, powdered milk, paraffin coated paper containers and paraffin wax.

STAIRWAYS: *three-story section, front, No. 101* — open wooden stairway from first to third floor, near front. *No. 107* — open wooden stairway from first to third floor, left side of enclosed elevator shaft. *Four-story section* — open wooden stairway from first to fourth floor, front of elevator shaft. Open wooden stairway from fourth floor to elevator bulkhead on roof, rear of shaft. *Ramp* — from first to second floor, next to right side wall. *Ramp* from second floor of three-story section, rear, to third floor of four-story section. (Locations shown on plan.)

VERTICAL SHAFTS: *Three-story section, front, No. 107* — enclosed elevator shaft from first floor to roof, right rear. *Four-story section* — open elevator shaft from first to roof, near center. (Locations shown on plan.) Elevator motors located in bulkheads on roof. *Lightwell* near front of four-story section and one near rear, from first floor to roof, open except wired glass in second floor openings, wooden railings around openings in other floors, wired glass in roof openings. *Lightwell* over ramp, next to right side wall, wooden railing around opening in third floor, wired glass in opening to roof.

OTHER FACTS: *Heating* — gas stoves in offices, no heat in remainder of building. *Skylights* over hallway in roof of three-story section, front; one in roof of four-story section, front of elevator shaft; all wired glass. *Scuttle hole* — to roof from hallway near left rear of three-story section, front, No. 101. (Location shown on plan.)

GAS SHUT-OFF: First floor, No. 113, on right wall near front.

ELECTRIC SHUT-OF: On panel board front of enclosed elevator shaft on wall, second floor.

WATER SHUT-OFF: First floor in floor pit left of ramp to second floor.



## 115 ANN Street

LIFE HAZARD: Approximate number of persons normally employed in building: Day 8; Night none.

HEIGHT: One-story section 18 ft.; two story section 25 ft.

SIZE: 40 ft. x 165 ft. No basement.

CONSTRUCTION: Left side wall, brick, 12 in., party wall with 113 Ann Street; front section of right side wall, brick, 12 in., party wall with 117 Ann Street; front, remainder of right side wall and rear — concrete block, 8 in.; front wall of second floor, two-story section, frame covered with asbestos shingles. *Interior walls* — concrete block. *Floors* — first, concrete; second, wood on wooden joist. *Roof* — flat, frame, composition covering, supported by iron pipe frame. *Built* — 1933. In good repair.

WINDOWS: *First and second floors* — front, right side and rear.

DOORS: One single door and one double sliding door from Ann Street to first floor; vertical door from right side to first floor, next to two-story section.

OCCUPANCY: Vulcan Welding Company.

CONTENTS: *First floor* — electric and acetylene welding equipment, electric motors, cylinders of compressed oxygen and acetylene. *Second floor* — office equipment and records.

STAIRWAY: Open wooden stairway from first to second floor.

OTHER FACTS: *Heating* — gas stoves. *Scuttle hole* — one from first floor to roof (location shown on plan). *Roof ventilator* — one metal in roof one-story section, over blacksmith forge.

GAS SHUT-OFF: For entire building — right front corner overhead.

ELECTRIC SHUT-OFF: For entire building — right front corner overhead.

WATER SHUT-OFF: For entire building — in floor pit near left front corner.

117–21 Ann Street

Life hazard: None.

Height: Three-story 36 ft.

Size: 45 ft. x 36 ft. Basement under entire building.

Construction: *Exterior walls* — brick, 12 in. to 8 in., left side wall is party wall with 115 Ann Street. *Interior walls* — brick, 12 in. to 8 in. *Partitions* — plaster on wooden lath and studding. *Ceilings* — basement, open rafters; other floors, plaster on wooden lath. *Floors: basement* — earth; *first floor* — wood on wooden joist supported by brick piers and wooden posts; *other floors* — wood on wooden joist supported by interior walls and partitions. *Roof* — mansard, tin and slate, supported by wooden trusses. *Built* — date unknown. *State of repair* — poor.

Windows: *All floors* — front and rear; third floor, right side.

Doors: From Ann Street to first floor — three single doors; from open space rear of building to first floor — three single doors.

Occupancy: Vulcan Welding Company.

Contents: *Basement* — none. *First floor* — old records and tools. *Remainder of building* — none.

Stairway: Open wooden stairway from basement to third floor, hallway center of building.

Other facts: *Heating* — gas stoves. *Skylight* — one from third floor to roof (location shown on plan).

Gas shut-off: For entire building — under stairway first floor.

Electric shut-off: For entire building — on right wall, front room, 117 Ann Street.

Water shut-off: For entire building — basement, right front corner.



123–25 Ann Street

Life Hazard: Number of persons living in building — 5.

Height: Two-story 25 ft.

Size: 40 ft. x 55 ft. Basement under entire building.

Construction: *Exterior walls* — brick, 12 in.; right side wall is party wall with 127 Ann Street. *Interior wall* — brick, 12 in. *Partitions* — plaster on wooden lath and studding. *Ceilings* — basement — open rafters; other floors — plaster on wooden lath. *Floors* — wood on wooden joist supported by interior wall. *Roof* — flat, frame construction, tin covering. *Parapets*— 24 in. *Built* — date unknown. *State of repairs* — poor.

Windows: *First and second floors* — front and rear.

Doors: From Ann Street to first floor — one single and one double. From Ann Street to stairways — two single. From open space rear of building to basement — two single; to first floor — two single.

Occupancy: First floor — vacant. Second floor — apartments.

Contents: Basement and first floor — none. Second floor — household furniture.

Stairways: 123 Ann Street — enclosed wooden stairway from Ann Street to second floor, left corner of building. 125 Ann Street — enclosed wooden stairway from Ann Street to second floor, near center of building.

Other facts: *Heating* — gas stoves. *Lighting* — gas. *Scuttle hole* — from second floor to roof (location shown on plan).

Gas shut-off: For entire building — stairway entrance, 123 Ann Street.

Water shut-off: For entire building — right front corner of basement, 125 Ann Street.

127–29 Ann Street

Life Hazard: Number of persons employed in building — Day 3; Night none. Number of persons living in building — 6.

Height: Two-story 28 ft.

Size: 40 ft. x 60 ft. Basement under entire building.

Construction: *Exterior walls* — brick, 12 in., left side wall is party wall with 125 Ann Street. *Interior wall* — brick, 12 in. *Partitions* — plaster on wooden lath and studding. *Ceiling* — basement — open joist; other floors — plaster on wooden lath. *Floors* — first floor — wood on wooden joist supported by interior wall and heavy timbers on wooden posts; second floor — wood on wooden joist supported by interior wall. *Roof* — flat, frame construction, tin covering. *Parapets* — 6 in. *Built* — 1870. *State of repair* — poor.

Windows: *First and second floors* — front, right side and rear.

Doors: From Ann Street to first floor — two sets of double doors; to enclosed stairway — single door. From open space, rear of building to basement — single door; to first floor — three single doors. From exterior stairway to second floor — two single doors.

Occupancy: First floor and basement — Pennybacker Plumbing and Heating Company. Second floor — apartments.

Contents: *First floor and basement* — plumbing and heating supplies, office equipment and records. *Second floor* — household furniture.

Stairways: Enclosed wooden stairway from Ann Street to second floor, left front corner of building. Exterior wooden stairway from open space, rear of building, to second floor.

Other facts: *Heating* — gas stoves. *Skylight* — one from hallway to roof. *Scuttle hole* — one from second floor to roof, 129 Ann Street. (Locations shown on plan.)

Gas shut-off: For entire building — right front corner, first floor, 127 Ann Street.

Electric shut-off: For entire building — front wall, first floor, 127 Ann Street.

Water shut-off: For entire building — right rear corner of basement, 129 Ann Street.



Ann Street — Passenger Depot — B. & O. R.R.

Life hazard: Approximate number of persons employed in building — day 10; night 5.

Height: Three-story 42 ft.

Size: 65 ft. x 55 ft. No basement.

Construction: *Exterior walls* — brick, 16 in. to 12 in. *Interior walls* — brick, 12 in. *Partitions* — plaster on wooden lath and studding. *Ceilings* — plaster on wooden lath. *Floors*— first floor — wood on subflooring, wooden joist supported by heavy timbers on stone piers; *other floors* — wood on subflooring supported by heavy timber and unprotected steel beams. *Attic floor* — wood on wooden joist. *Roof* — mansard, frame construction, slate covering, supported by heavy wooden trusses. *Built* — 1887. In good repair.

Windows: *All floors* — front, right and left sides, and rear.

Doors: From Ann Street to first floor — two double doors. From 2nd Street to first floor — two double doors. From elevated platform, front of building, to second floor — two double doors and one single door.

Occupancy: Passenger Depot, B. & O. R.R.

Contents: *First floor* — office furniture, records, mail and express. *Second and third floors* — office furniture and records. *Attic* — storage of old records.

Stairways: One wooden exterior stairway from Ann Street to elevated platform, second floor of building. One open wooden stairway from first floor to attic, front center of building.

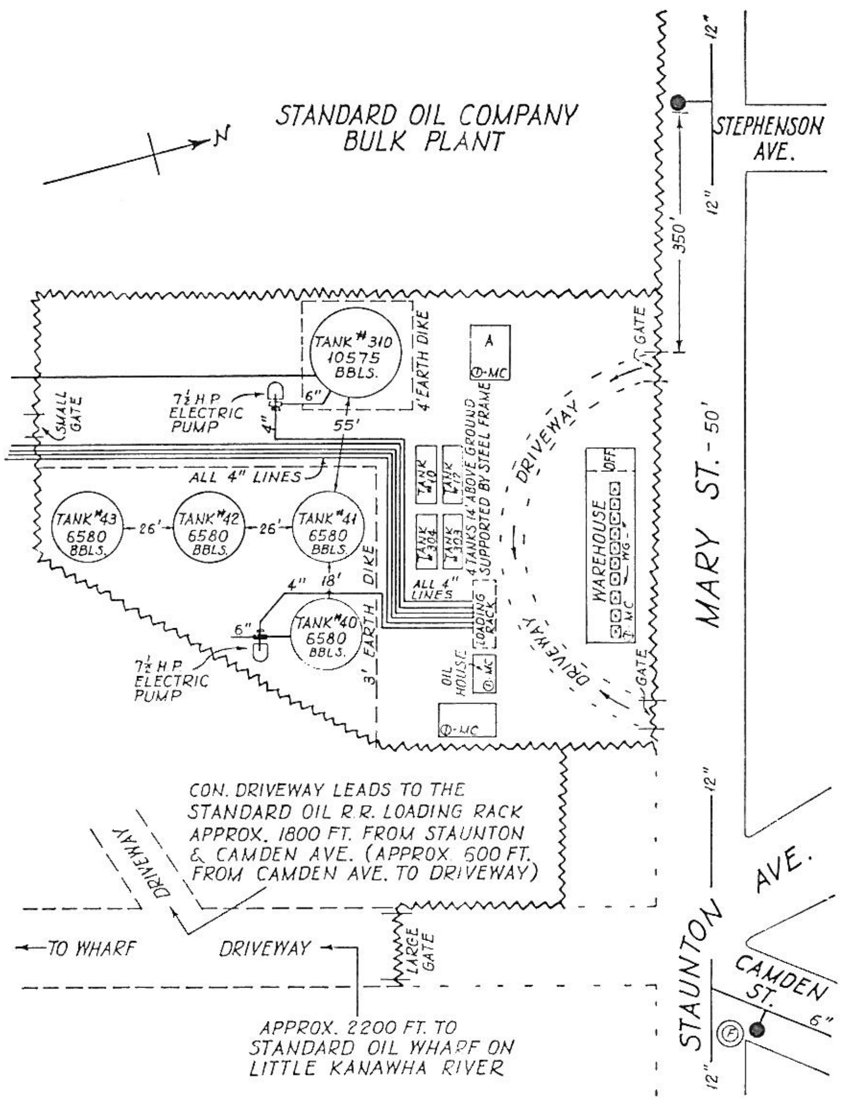
Vertical shafts: One open elevator shaft from first to second floor, right front corner of building (location shown on plan). Elevator motors located on second floor next to shaft.

Other facts: *Heating* — gas stoves and steam radiators, steam piped from Steam Plant, 5th Street.

Gas shut-off: For entire building — left rear corner, first floor.

Electric shut-off: For entire building — left side of elevator shaft, first floor.

Water shut-off: For entire building — in pit, next to fire hydrant, 2nd and Ann Streets.




Map for operational plan covering Standard Oil Company bulk plant.



## Operational Plan

### Standard Oil Company — Bulk Plant

On Mary Street between Stephenson Street and Camden Street



#### STORM SEWER OPENINGS WITHIN THE BLOCK

Mary Street near right corner of Bulk Plant — 2 single catch basins.

At intersection of Staunton, Camden and Mary Streets — 1 double and 2 single catch basins.

#### CONTENTS OF TANKS

| | |
|---|---|
| No. 40–41–42–43–310 | Gasoline |
| No. 303 Capacity 18,000 gallons | Gasoline |
| No. 304 Capacity 18,000 gallons | Kerosene |
| No. 12 Capacity 20,000 gallons | Naphtha |
| No. 10 Capacity 20,000 gallons | Fuel Oil |

### Mary Street — Standard Oil Company Bulk Storage Office and Storage Building

Life hazard: Approximate number of persons employed in building — day 6; night none.

Height: One-story 15 ft.

Size: 120 ft. x 28 ft. No basement.

Construction: *Exterior walls* — metal clad on unprotected steel framing. *Partitions* — plaster board on wood studding. *Floors* — concrete. *Roof* — gable, metal construction, metal covering, supported by unprotected steel frame. *Built* — 1940. In good repair.

Windows: Wired glass windows in metal sash front and right side only.

Doors: *To rear only* — single door to office section and three double metal doors to warehouse section from driveway rear of building.

Occupancy: Standard Oil Company, office and storage.

Contents: Office section — office furniture and records.

Warehouse section — oils, greases, tires, tubes and automobile accessories.

Other facts: *Heating* — gas stoves. *Skylights* — ten flat wired glass skylights in roof, approximately 12 ft. apart (locations shown on plan). *Roof ventilators* — ten metal roof ventilators located in center of roof spaced approximately 12 ft. apart.

Gas shut-off: For entire building — in warehouse near office partition.

Electric shut-off: For entire building — in warehouse section on panel board on office partition.

Water shut-off: For entire building — outside near right front corner of building in pit.

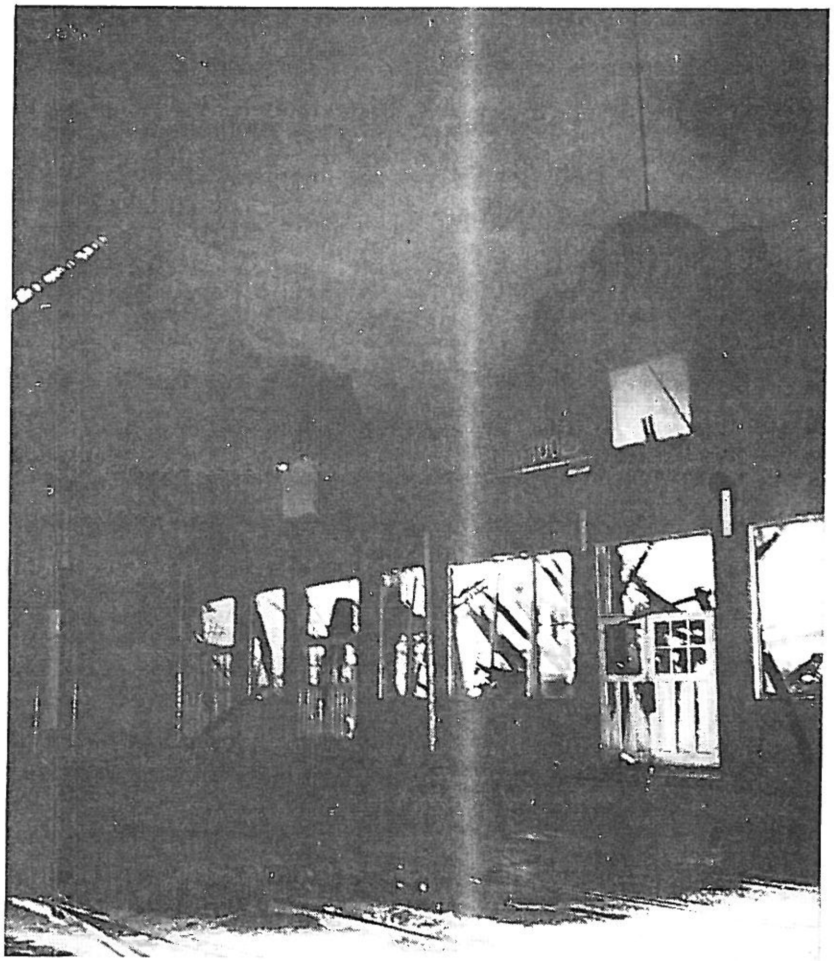


# Chapter XI

## CASE HISTORIES

To illustrate the usefulness and practical application of the tactical exercises and operational plans previously described, three case histories have been selected recording typical major fire-fighting operations. These case histories differ from those in the author's book, *Attacking and Extinguishing Interior Fires*, because the fires reported in the present text all had involved major proportions and were threatening exposures when an alarm was given. These fires also are recommended for study because each involved the application of several of the basic divisions of fire-fighting tactics outlined in this text (see page 10), and also because they throw light upon other factors of interest to fireground commanders such as the results that may be obtained with large calibre fog nozzles at major fires and the value of block plans developed previous to a fire as an aid to forming a realistic estimate of the fireground situation including such factors as the structural areas involved, potential fuel and heat, and water application needed to confine and extinguish a fire.

It may be of interest that the fires discussed in these selected case histories were handled by a fire department consisting of four pumper, one aerial ladder, and one-squad companies with on-duty manpower averaging less than one dozen men. These were backed up by a reserve pumper-ladder truck and off-shift firemen. It is suggested that ability to control major fires with the resources at hand is one of the important benefits to be derived from an effective system of fire-fighting tactics.



*Parkersburg News*

A-1. Front view of machine shop described in "Case History No. 1" before nozzles were placed in service.



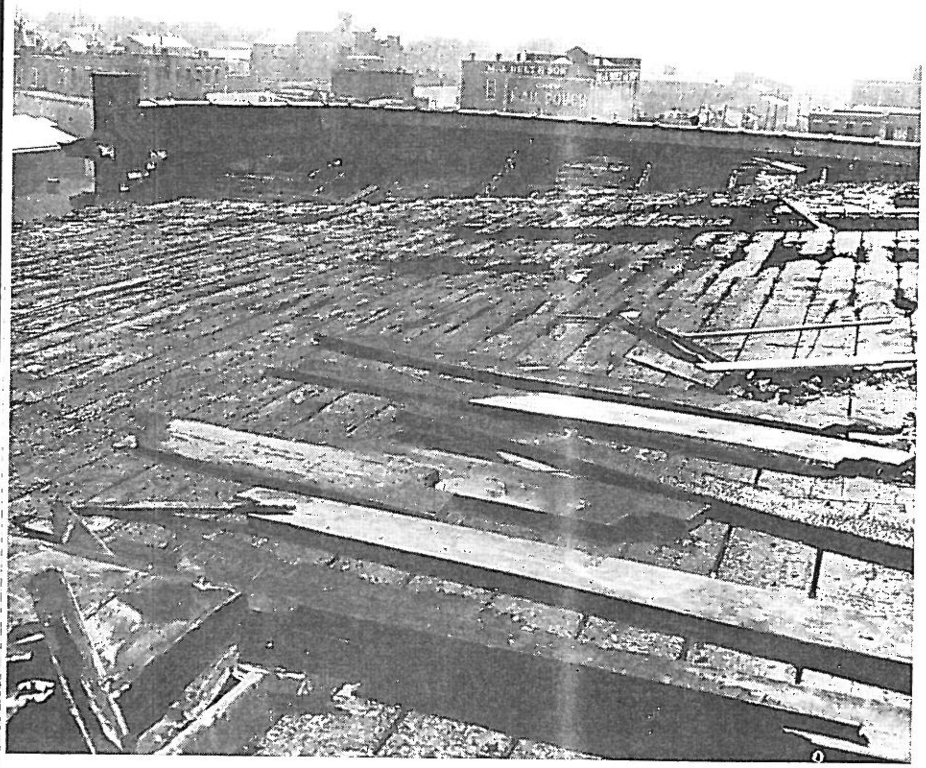
## CASE HISTORY No. 1

THIS fire was of incendiary origin. A machine shop section was entirely involved before alarm was received. Fire extended to roof of exposed warehouse (four-story, brick, at left). Involvement of two-story office section, located at front right of machine shop section, was prevented. Building was of frame construction, 96 ft. x 140 ft., except front wall of machine shop and walls of two-story office section which were constructed of brick.


*Parkersburg News*

A-2. Front view of machine shop after nozzles were placed in service.

MONITOR unit using Elkhart 2½-in. Pl. J-200 nozzle delivering approximately 400 gpm, 100 psi nozzle pressure. This fire was controlled and extinguished by use of water fog.



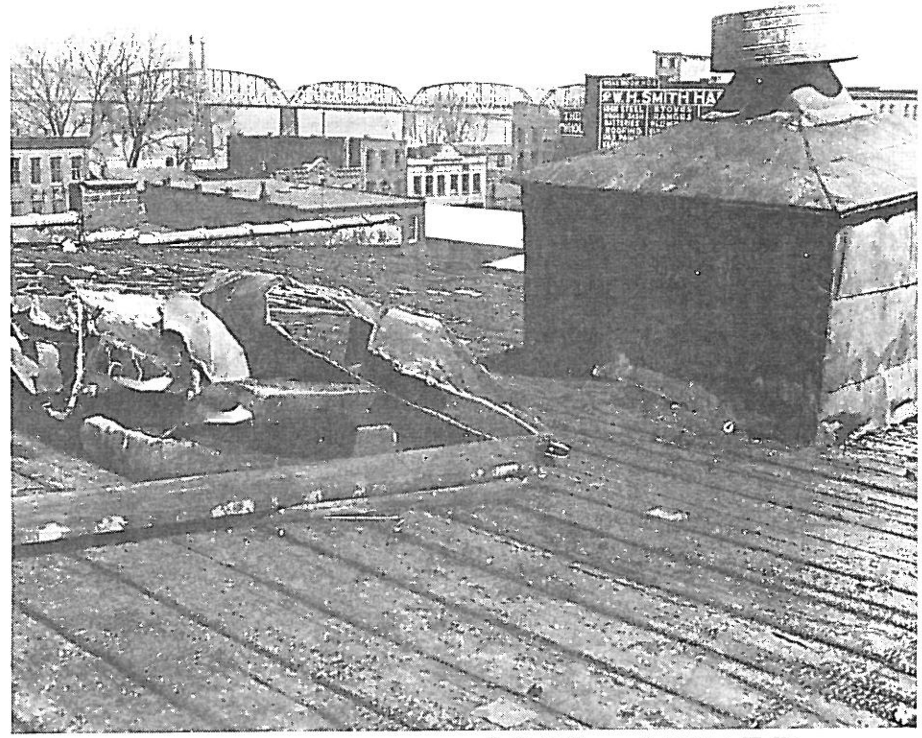
*H. V. Muhlmann, Parkersburg, W. Va.*

A-3. Right front section of roof, 4-story, brick, warehouse shown in Photo A-1

THE rear wall of the warehouse formed the left side wall of machine shop. Rear and left side walls of warehouse were without openings. This warehouse was well constructed except the roof which was of ordinary frame, covered with asphalt roll roofing and rear wall was without parapet. Open rafters and sheathing formed ceiling of fourth floor. Entire building was protected by sprinkler system.

This roof was 86 ft. x 85 ft. Within minutes following ignition the entire roof area was involved. A nine-mile per hour wind contributed to the rapid extension of fire. Aerial truck (65 ft. wooden ladder, bed section equipped with ladder pipe)





*H. V. Muhlmann, Parkersburg, W. Va.*

A-4. Right rear section of roof, 4-story, brick warehouse shown in photo A-1

was moved to position in front of warehouse. Ladder pipe fitted with Elkhart Brass, PL. J-200, nozzle was raised to operating position. This placed the nozzle approximately eighteen feet from front of building and fifteen feet below the front parapet.

At this time the mass of flames extended approximately fifty feet above the roof. A 30° angle fog cone was traversed slowly from right front corner to left front corner and back to starting point. The fog cone was directed into the mass of flames above the roof at an angle that allowed the cone to clear the front parapet. Less than ten minutes were required to complete this operation. During this period the roof fire was blacked out completely. The ladder pipe was shut down and a crew sent to fourth floor of warehouse. One 1½-in. nozzle provided sufficient water to extinguish spot fires and smouldering burning involving sheathing and contents of fourth floor.

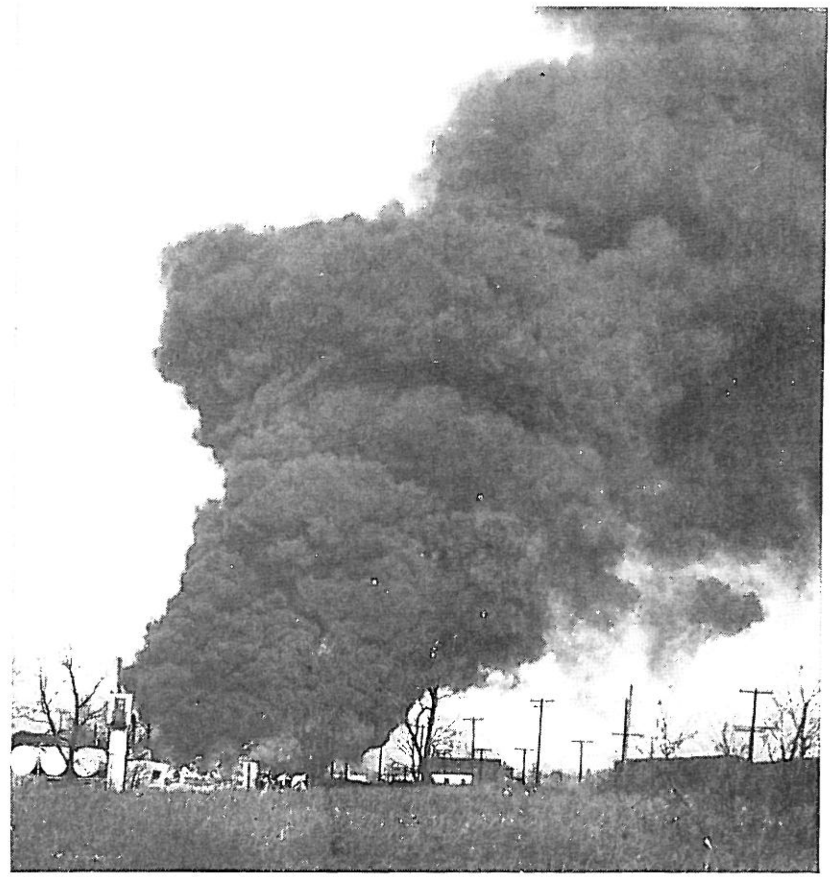
The ladder pipe was supplied by three 2½-in. hose lines and the nozzle pressure was between 100 and 125 pounds per square inch, delivering approximately 425 gpm. The position in front of warehouse placed the nozzle of ladder pipe at the highest elevation that was possible to obtain. From this elevation it was impossible to apply water directly to the involved roof. The author directed this operation and was in position to observe this phenomenon. It appeared that when the finely divided water particles were projected into the mass of flames the cooling action was so rapid that a down draft developed. This down draft (reversal of convectional currents) was of sufficient velocity to carry unvaporized particles of water on to the surface of the roof.

Survey of the warehouse revealed that 115 sprinkler heads out of a total of 127 located on fourth floor and elevator bulkhead had fused. These were the only heads which opened during the fire. The initial flow of water from sprinklers prevented major involvement of combustibles on fourth floor.



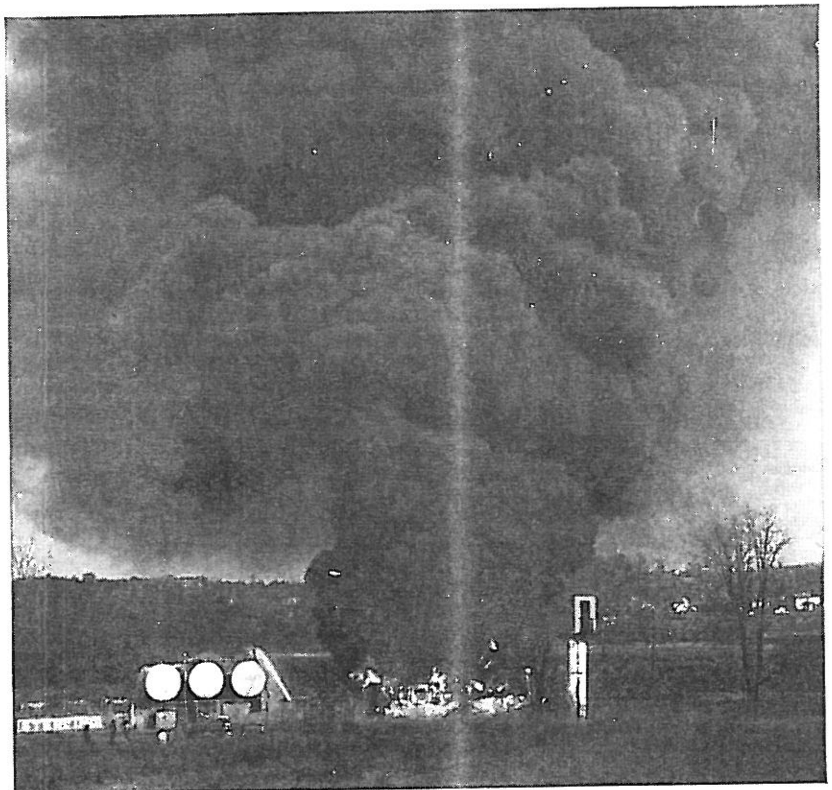
## CASE HISTORY No. 2

THIS warehouse of a bulk oil plant was completely involved when first alarm units arrived. Nearest hydrant was 1,200 feet from warehouse.



*Paul Jack, Inc., Parkersburg, W. Va.*

B-1. Warehouse of bulk plant burning

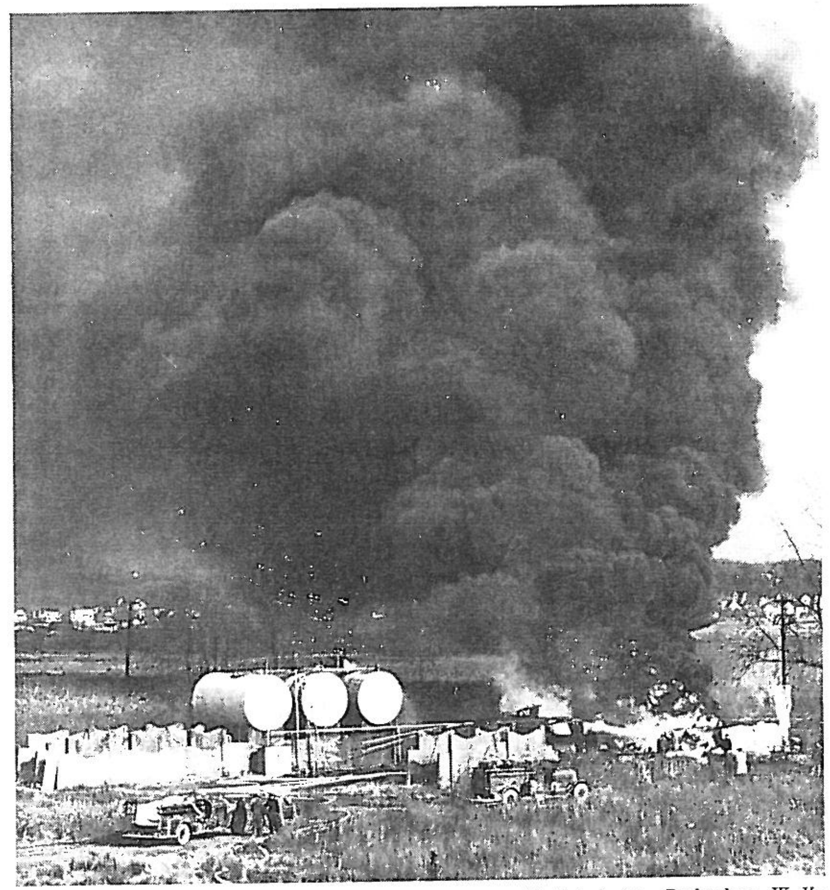


*Paul Jack, Inc., Parkersburg, W. Va.*

B-2. Gasoline storage tank being protected by two 1½-in. nozzles

THE first 2½-in. hose line from hydrant (distance 1,200 ft.) has been laid. One ⅝ in. solid stream and 1½-in. fog line being used to cool gasoline storage tank located twelve feet from burning warehouse. Radiant heat was of such intensity that nozzleman of solid stream had to operate from behind concrete cradle.





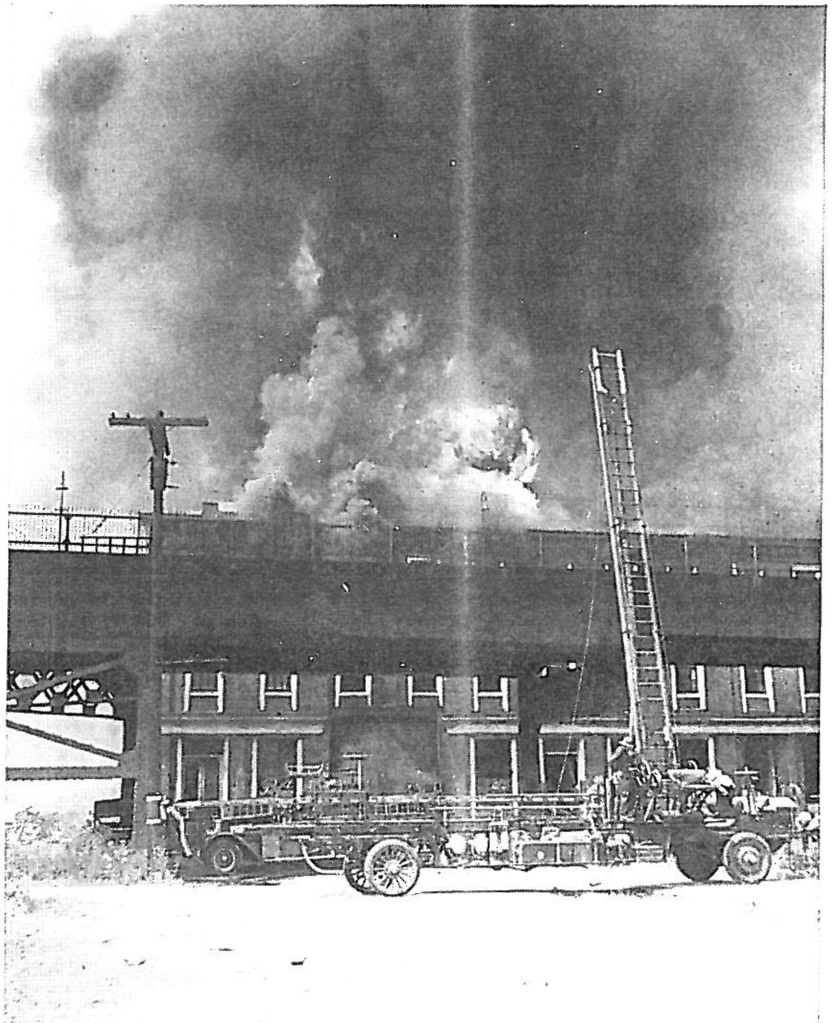
*Paul Jack, Inc., Parkersburg, W. Va.*

B-3. Fire under control

FOUR 1½-in. fog nozzles on 1½-in. lines were used to control and extinguish this fire. Two 2½-in. hose lines were laid and wyed into four 1½-in. lines. Nozzle pressures used — 100 psi.

## CASE HISTORY No. 3

This is a review of fire involving 101–13 Ann Street, Parkersburg, West Virginia, July 15, 1951. See block plan (0-1) Chapter X for essential facts regarding involved building and exposures. Also see frontispiece.



*Schaeffer for Parkersburg Sentinel*

**C-1. Ladder pipe being placed to protect exposed railroad bridge**



*Schaeffer for Parkersburg Sentinel*

**C-2. Fog cone from ladder wetting down exposed bridge**

THIS fire was of incendiary origin. A fifteen-year-old boy ignited loose paper in paper storage area of four-story section about 11:45 A.M. Sunday, July 15, 1951. Over a half an hour elapsed before smoke and flames were observed. The alarm was received at 12:20 P.M. When first alarm units arrived the second, third and fourth floors of four-story section were fully involved and flames were coming from roof. The fire had entered into second and third floors of three-story

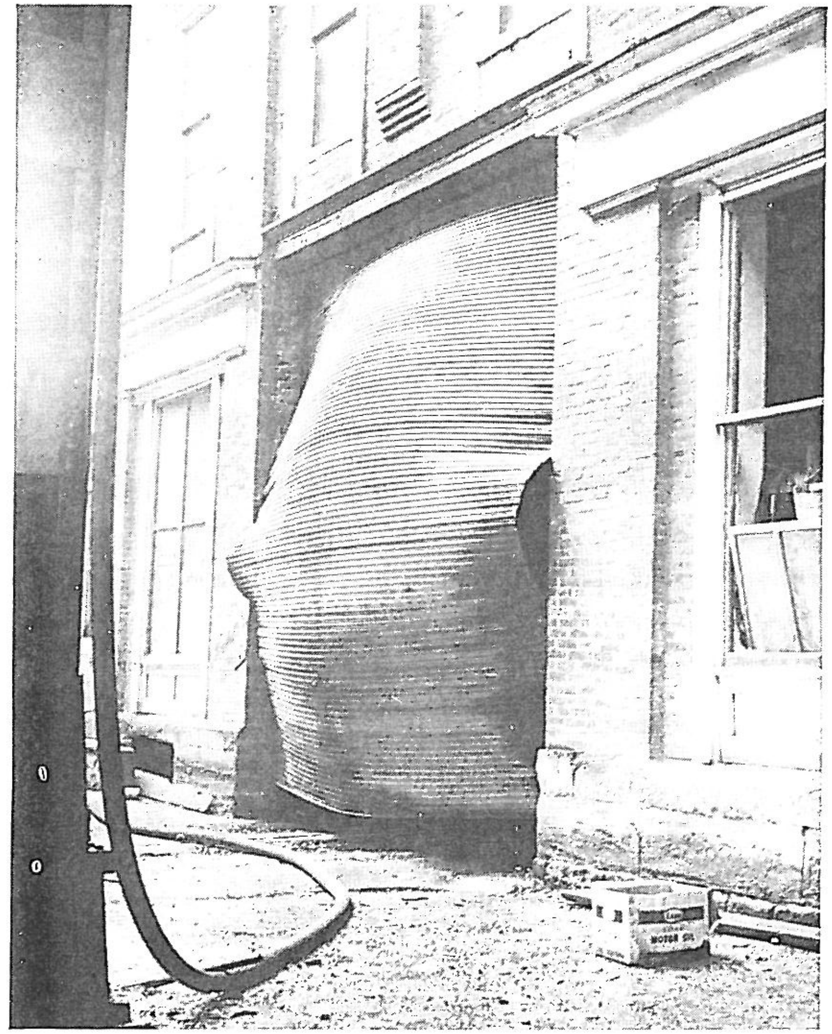
*Schaeffer for Parkersburg Sentinel*

C-3. Explosion within four-story section of 101-13 Ann Street, Parkersburg, W. Va.

sections. A few minutes later metal siding of rear three-story section started falling and second and third floors of this section became fully involved. The floodwall (see plan, page 82), served as a reflector for radiant rays and the radiant heat in area along left side and rear of involved building became so intense that personnel and equipment had to be withdrawn from this area.

Ladder company was ordered to take position on east side of railroad bridge and to use large fog cone from ladder pipe to prevent involvement of exposed bridge. This bridge was located twelve feet from front of involved building and extended





*Schaeffer for Parkersburg Sentinel*

C-4. Damage to railroad entrance door resulting from explosion of paraffin vapors, 101-13 Ann Street, Parkersburg, W. Va.

*Schaeffer for Parkersburg Sentinel*

C-5. Rear three-story section, 101-13 Ann Street, showing involvement of 2nd and 3rd floors (metal clad section)



*Schaeffer for Parkersburg Sentinel*

C-6. Fog cone from monitor unit being directed into 113 Ann Street Parkersburg, W. Va.

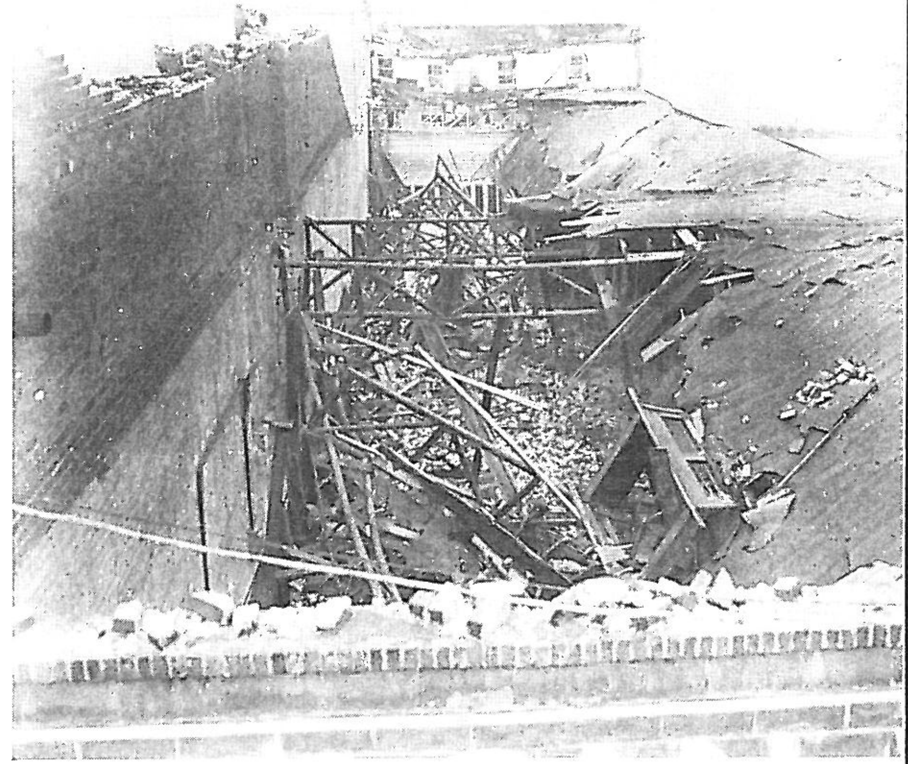
along entire front at third floor level. Before water could be supplied to ladder pipe five violent explosions occurred within the four-story section. The four-story section disintegrated and flames formed a thermal column that extended upward for over two hundred feet above roof of building. These explosions are believed to have resulted from paraffin vapors. Some 75,000 pounds of paraffin were stored on fourth floor of four-story section. Fog cone from ladder pipe was used to extinguish burning debris falling on bridge and to protect it from radiant heat.

Later the right side wall of three-story NE section fell on roof of 115 Ann Street causing considerable damage. Two-story office section of this building and cockloft of 117–21 Ann

*H. V. Muhlmann, Parkersburg, W. Va.*

C-7. Front section of 101-13 Ann Street after fire was extinguished. Railroad bridge at right.





*H. V. Muhlmann, Parkersburg, W. Va.*

C-8. Damage to Vulcan Welding Building, 115 Ann Street, resulting from collapse of party wall

Street were ignited from radiant heat. These fires were extinguished before appreciable damage resulted. The railroad bridge was undamaged. The fire was prevented from extending into front rooms, first and second floors, three-story front section. Contents of these rooms included truck tires, motor oil and anti-freeze solution in cans, and 109 cylinder of oxygen, acetylene and propane. The value of undamaged contents removed from front three-story section after fire was extinguished amounted to over $25,000.