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FIRE SERVICE TRAINING.

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OHIO STATE DEPT. OF EDUCATION, COLUMBUS
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DESCRIPTORS- *TEXTBOOKS, *TRADE AND INDUSTRIAL EDUCATION, *FIRE FIGHTERS, ADULT VOCATIONAL EDUCATION,

STUDENTS MAY USE THIS REVISED MANUAL IN FIRE STATION OR TRAINING CENTER EXTENSION PROGRAMS FOR IMPROVING THE COMPETENCIES AND SKILLS OF LOCAL FIRE PERSONNEL IN THE SPECIALIZED FIELD OF FIRE SERVICE. IT WAS DEVELOPED BY A STATEWIDE COMMITTEE OF FIRE-FIGHTING CONSULTANTS AND ADVISORY GROUPS. THE 26 CHAPTERS PROVIDE BOTH BASIC AND ADVANCED TECHNICAL INFORMATION ON PARTICULAR PRINCIPLES AND PRACTICES OF FIRE FIGHTING. SOME CHAPTER TITLES ARE (1) COMMUNITY FIRE DEFENSE, (2) WATER AS USED IN FIRE FIGHTING, (3) FIRE PUMPS, (4) LADDERS, (5) RESCUE, (6) POST-MORTEM CONFERENCE, (7) INSPECTIONS, AND (8) RADIATION HAZARDS. PICTURES AND DIAGRAMS ARE USED THROUGHOUT THE MANUAL TO SIMPLIFY PROCEDURES. THE MATERIAL IS TO BE USED BY INDIVIDUAL STUDENTS UNDER TEACHER DIRECTION FOR 34 HOURS. THE TEACHER MUST BE A QUALIFIED FIREMAN, AND STUDENTS SHOULD BE VOLUNTEER OR EMPLOYED FULL-TIME FIREMEN. A RELATED WORKBOOK, "LEARNER'S WORKBOOK-BASIC COURSE" (VT 000 723), CONSISTS OF A SERIES OF ASSIGNMENT SHEETS TO ENABLE EACH DEPARTMENT TO TAILOR THE TRAINING COURSE TO FIT ITS EQUIPMENT AND FIRE PROTECTION NEEDS. AN INSTRUCTOR'S MANUAL (VT 000 722) IS ALSO AVAILABLE. THIS DOCUMENT IS AVAILABLE FOR $3.44 FROM OHIO TRADE AND INDUSTRIAL EDUCATION SERVICE, INSTRUCTIONAL MATERIALS LABORATORY, THE OHIO STATE UNIVERSITY, 1885 NEIL AVENUE, COLUMBUS, OHIO 43210. (HC)

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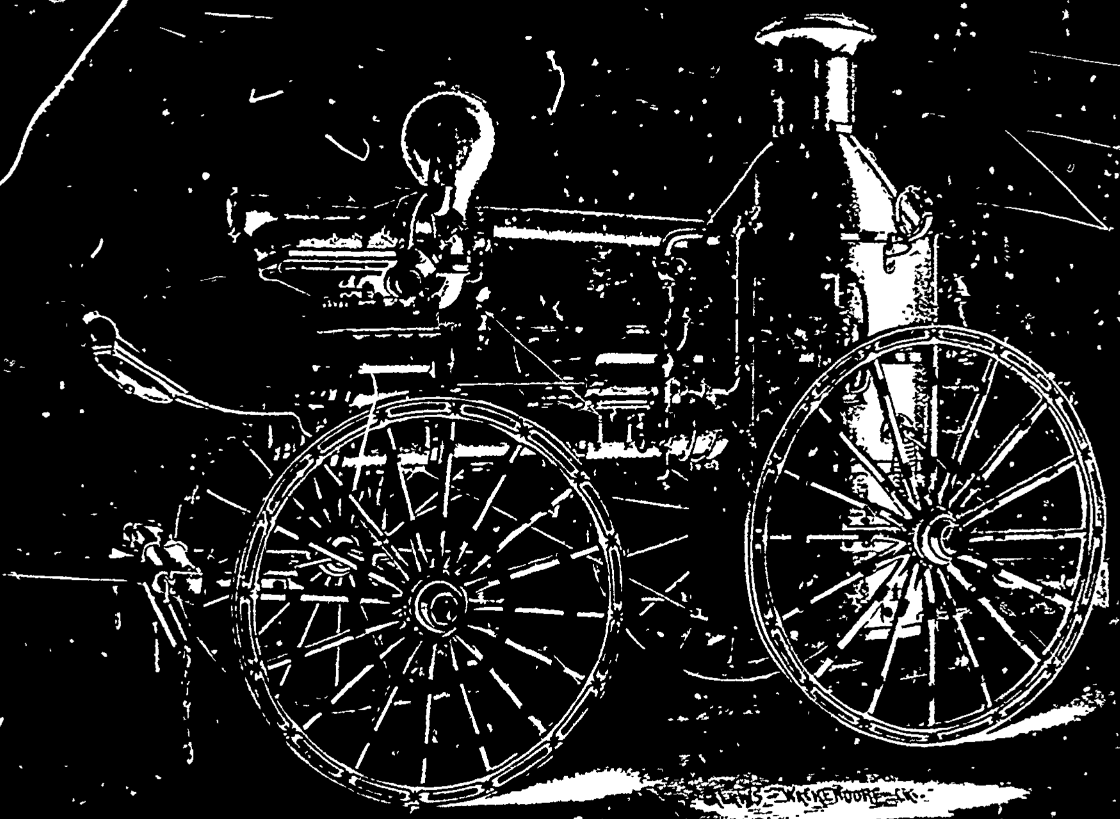

OHIO TRADE AND INDUSTRIAL EDUCATION SERVICE

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OHIO TRADE AND INDUSTRIAL EDUCATION SERVICE

DIVISION OF VOCATIONAL EDUCATION
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PREFACE

The State Department of Education has been instrumental in providing trade and industrial training to the citizens of Ohio since 1918, originally through its State Board for Vocational Education and presently through the Trade and Industrial Education Service of the Division of Vocational Education.

Training in trade and industrial education enables young men and women to prepare for initial employment in trade or industrial occupations. In addition, it enables adults who are already employed to upgrade themselves and advance in their chosen occupations, and retrains those who are temporarily unemployed.

In the adult category, training is also provided for public service personnel such as fire fighters, rescue and emergency personnel, peace officers, school bus drivers, custodial employees, hospital housekeepers and electric linemen. The purpose of this training is to upgrade the service rendered to the general public by increasing and providing additional skills and/or knowledge.

In the field of public service occupations, Ohio can be truly proud of the aid given local communities for the training of their volunteer and paid fire fighters, including the industrial brigade fire fighters, by the Trade and Industrial Education Service. The training received by local firemen has certainly increased their operating efficiency and no doubt has saved countless lives and thousands of dollars in property losses since the program started in 1939.

It has long been the policy of the Trade and Industrial Education Service of the Division of Vocational Education, whenever possible, to utilize the personnel and services of the universities and colleges of the state and local boards of education in providing needed training in the local communities. We appreciate the services of Kent State University, University of Cincinnati, The Ohio State University, University of Toledo, and the many local boards of education who for many years have cooperated with the Division of Vocational Education in providing fire department training to hundreds of communities in the State of Ohio.

E. E. Holt, Superintendent of
Public Instruction

Ralph A. Howard,
Director of Vocational Education

FOREWORD

The Trade and Industrial Education Service, Division of Vocational Education, has sponsored a program of fire department training since 1939. The training, over a period of 23 years, has been presented to 64,800 paid and volunteer fire fighters in 2,061 training classes in the State of Ohio.

The objectives of fire service have not changed greatly over the last decade. Increased emphasis, however, has been placed upon them in view of mounting fire losses in life and property throughout Ohio and the nation. The primary objectives of this training program as they apply to the local community are as follows:

1. To determine local, county, regional and state needs and to implement a program to adequately meet these needs on a continuing basis.
2. To improve the competencies and skills of local fire personnel in the specialized field of fire service.

The state supervisor and the fire service training coordinators of the Trade and Industrial Education Service utilize the services of the State Fire Service Advisory Committee in order to effectively achieve the above-stated objectives and to determine the principles and policies of the fire service training program and the manner in which it is conducted in Ohio. This advisory committee is composed of representatives of international and statewide organizations interested in fire protection and fire fighting. The organizations represented are as follows:

Association of Ohio Fire Fighters

Fire Marshal's Office

International Association of Fire Fighters

Ohio Fire Chiefs Association

Ohio Inspection Bureau

Ohio State Firemen's Association

A comprehensive training program in all areas of fire fighting is currently in effect. The following types of training are now being conducted:

- Basic Training
- Advanced Training
- Officer Leadership Training
  - Human Relations
  - Conference Leadership
  - Effective Speaking
  - Instructor Training
- Industrial Brigade Training
- Emergency and Rescue Training
- Radiation Hazards Training
- Special Training
  - Regional Fire Schools
  - State Fire School
  - Fire Prevention
  - Arson Detection
  - Public Service Employees

The intent of this revised manual is to provide the necessary instructional material which will serve as an up-to-date and comprehensive source of information covering the practices and techniques of fire fighting in order to conduct an effective and efficient fire service training program.

It is our sincere desire that fire fighting personnel, officers and fire fighters, throughout the state will realize the ultimate benefits to be gained by use of this manual and adaptation of it to local training situations.

Byrl R. Shoemaker, Supervisor
Trade and Industrial Education Service

ACKNOWLEDGMENT

The Trade and Industrial Education Service wishes to acknowledge the personnel, educational institutions, fire associations and manufacturers who so graciously contributed their time, cooperation, resource materials, and illustrations for the original manual by this title which was first published in printed form in 1953. In addition to the original printing, it was reprinted thirteen times as a result of the wide distribution and acceptance it received.

This Fire Service Training manual is a complete and extensive revision of the above-mentioned manual and contains five additional chapters with the addition of 162 pages. A complete reorganization of the material has brought the content up to date, making it more comprehensive. Special acknowledgment is extended to the present Fire Service Training Coordinators of the Trade and Industrial Education Service for their diligent efforts in revising and organizing the content. They are as follows: Robert P. Fry, The Ohio State University; Charles J. Getz, Kent State University; Harry A. Ohlrich, University of Cincinnati; Elmer W. Weis, The Ohio State University; and Glen C. Rehfuss, a former staff member at the University of Toledo.

Acknowledgment for the content and illustrations contained in the chapter titled "Radiation Hazards" is extended to the Trade and Industrial Education Branch of the U.S. Office of Education, U. S. Department of Health, Education and Welfare and the Office of Industrial Relations of the U. S. Atomic Energy Commission. The material contained in this chapter was taken in part from their joint publication titled "Peacetime Radiation Hazards in the Fire Service," Basic Course, Resource Manual.

Acknowledgment is also extended to the members of the State Fire Service Advisory Committee and to the international and statewide organizations which they represent, as listed in the Foreword, for their encouragement and direction in the development of the manual.

Manufacturers contributing photographs of equipment illustrated in the manual are acknowledged for their contributions. They are as follows:

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New York, New York

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Columbus Fire Department
Columbus, Ohio

Loudonville Fire Department
Loudonville, Ohio

National Association of
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Indianapolis, Indiana

National Board of Fire Underwriters
New York, New York

State of Ohio, Division of State Fire Marshal
Columbus, Ohio

Toledo Fire Department
Toledo, Ohio

Special mention and acknowledgment is extended to the staff of the Instructional Materials Laboratory for Trade and Industrial Education; to William M. Berndt, Consultant, Instructional Materials Laboratory, for directing the development and production of the manual, and to Wilbur F. Stover, of this staff, for his able assistance. Appreciation is also extended to Merle E. Strong for initially starting the revision, while in the capacity of Consultant.

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INTRODUCTION

Only through adequate and up-to-date instructional materials can the fire fighter become acquainted with the skills of fire fighting and the trade technology necessary to perform these skills. Recognizing this problem, the Ohio Vocational Trade and Industrial Education Service presents this revised fire training manual.

An examination of the table of contents reveals that the material consists of a series of twenty-six chapters. Each chapter deals with particular principles and practices involved in fighting fires. Pictures and diagrams are used throughout the manual to simplify the evolutions and procedures.

The material contained in the manual covers both basic and advanced training and was written by firemen who have had years of experience in the occupation. In presenting the information an attempt was made to make it simple and, in every case possible, to avoid the use of technical terms and data. At times, however, the reader will encounter words and phrases not normally used in everyday conversation. Such words and phrases are trade terms universally used by firemen, and the learner must master them if he is to become an efficient fire fighter.

A workbook accompanies this manual which is titled "'Learner's Workbook - Basic Course." This workbook consists of a series of assignment sheets which will enable each department to "tailor make" the basic training course to fit its equipment and fire protection needs. The workbook also becomes a study guide and a self check on the mastery of the subject matter when used by the individual learner.

> Each assignment should be completed by first reading the list of questions to get clearly in mind what information is needed for answering the questions.
>
> Next, the assigned reading should be studied and the appropriate answer written after each question.
>
> The entire list of questions and answers should then be reviewed to assure thorough understanding of each.
>
> Any points that are not fully understood should be brought up for discussion at the next class session.

The utilization of the manual and its corresponding workbook will vary with each instructor, but usually the learner is given the assignment in the workbook which will cover the topic to be discussed in the next class session and is asked to study it and master the questions. This learning procedure provides the fireman with an opportunity to ask his instructor to review those points in the material that he does not thoroughly understand. It also provides a basis upon which the instructor can build his instruction and make the course better meet the needs of individual departments. By preparation beforehand, the learner also has some knowledge about the topic to be discussed, thus making it easier for the instructor to present additional information that may not be contained in the manual. This previous preparation by the learner will provide him with a much better understanding of the demonstrations given by the instructor covering the skills that must be mastered if he is to become a proficient fire fighter.

The information contained in this manual should not be considered complete or final; it is, and always will be, subject to change. Some methods and procedures used by firemen a few years ago are now considered obsolete by present-day fire fighters. Newer types of building construction, the activities being carried on in them, and new types of equipment have all brought about many of these changes. It is only by continually making revisions and changes that fire training programs can remain up-to-date and effectively meet the needs of the local community.

It might be said in conclusion that one's success in the mastery of the content of this manual will be in direct proportion to the effort that he puts forth. The entire manual is within the comprehension of anyone who has a sincere desire to become a proficient fire fighter.

CHAPTER 1

COMMUNITY FIRE DEFENSE

INTRODUCTION

Fire protection is not the simple problem that it was in past years. The fact that a community has fire apparatus and various tools and equipment at its disposal does not shield its people from the possible ravage of fire. A well organized and well trained fire department must concern itself with many factors which are important to their overall plan of operation for fire defense. Any department, fully paid, part-paid, or volunteer, is responsible for protecting life and property. The successful performance of this obligation depends on the department's willingness to use all its means in a proper manner. Each member must have an equal share in the responsibility of contributing to an overall plan of operation which will give the community the best possible defense service.

But, the preceding is not the entire picture. The local community has definite responsibilities to its fire department. The best manned department cannot do a good job unless it receives the consideration and support of the citizens and their local governing body. Whether or not these groups are willing to contribute moral and financial support can mean the difference between a good or a poor fire department.

For all practical purposes, the good will of the people can usually be gained by maintaining the best possible public relations and showing a willingness to be of service.

When it comes to finances, the solution is not that simple. Governing bodies control allotments for fire department operation and sometimes these governing bodies fail to recognize their obligation to protect the life and property of their citizens. This situation hinders the efforts of fire department personnel to perform their duties willingly and to the best of their ability.

For those who serve the public and are responsible for safeguarding lives and property against the destructive forces of fire, a grading schedule is used as a means of evaluating the communities' defenses and physical conditions.

In cities and communities with a population of over 25,000, the National Board of Fire Underwriters makes the primary inspection and evaluation work. Where a population of less than 25,000 is involved, the Ohio Inspection Bureau makes the inspection and evaluation. The results are based on the same rating schedule used by the N.B.F.U. This inspection service is available to each community without charge. In addition, consultant services are available to communities planning water system improvement or the purchase of new fire fighting equipment. In all cases, it is advisable to make full utilization of this service.

GRADING SCHEDULE

TABLES

As this chapter cannot go into all the facets incorporated in a grading schedule, it is advisable to contact the N.B.F.U. and/or the Ohio Inspection Bureau for available information and material on the grading schedule tables.

In this text we will outline the various features considered in fire defense on Table 1, with the relative value and deficiency points allocated to each. Table 2 shows the relative grading for each classification.

A ninth class municipality is one receiving 4,001 to 4,500 points of deficiency or one receiving less than 4,001 points but having no recognized water supply. A tenth class municipality is one receiving more than 4,500 points of deficiency or one without a recognized water supply and having a tenth class fire department grading, or one with a water supply and no fire department, or one with no fire protection.

In brief, this information will at least point the way for a community concerned, presently or in the future, with plans for reducing their fire insurance rates by attaining a better classification.

In order to examine each of the features listed in Table 1 for further study, it will be necessary for them to be separated into urban and rural classifications. The urban classification includes those municipalities having a population of 25,000 or more. The rural classification includes communities and areas having a population of less than 25,000.

As previously stated, evaluation of every item on these schedules would be impossible to include in this text. Only those items which pertain to both the

TABLE 1

RELATIVE VALUES
AND MAXIMUM DEFICIENCY POINTS

Feature	*Per Cent*	*Points*
Water Supply	34	1,700
Fire Department	30	1,500
Structural Conditions	14	700
Fire Alarm	11	550
Fire Prevention	6	300
Building Department	4	200
Police Department	1	50
	Totals 100	5,000

TABLE 2

RELATIVE GRADING OF MUNICIPALITIES IN
FIRE DEFENSES AND PHYSICAL CONDITIONS

Points of Deficiency	*Relative Class of Municipality*
0- 500	First
501-1,000	Second
1,001-1,500	Third
1,501-2,000	Fourth
2,001-2,500	Fifth
2,501-3,000	Sixth
3,001-3,500	Seventh
3,501-4,000	Eighth
4,001-4,500	Ninth
More than 4,500	Tenth

urban and rural classifications will be discussed. Conclusions and comparisons can be subsequently determined by the reader.

URBAN GRADING SCHEDULE

Water supply - There are 32 items listed under this feature in the Grading Schedule used by the National Board of Fire Underwriters when making an evaluation and survey. Since an adequate and reliable water supply is an essential part of fire fighting facilities, this item is rated highest on the schedule percentage-wise and draws the greatest number of deficiency points. Obviously, the concern here is with a reliable water supply system and provision of sufficient water for normal use and maintenance of a sufficient reserve for fire fighting operations. Thus, every one of the thirty-two items concerned in the schedule plays an important part in summing up the total effectiveness of the system. Their relative value is based on the predetermined percentages of the deficiency scale for that area. Therefore, in terms of importance, each item is relative and can not be arranged or placed in any specific order. Some of these items are as follows:

Employees
Plans and Records
Electric or Power Supply
Condition of Equipment
Pumping Station
Supply Mains
Arterial System
Dead Ends
Hydrants
Size of Hydrants

For information on additional items it will be necessary to consult the N.B.F.U. Standard Schedule For Grading.

Fire Department - In reference to the N.B.F.U. Standard Schedule For Grading, 34 items are actually involved in the evaluation procedure. The ones most important to the fire department are:

Personnel (Firemen, officers, and chiefs)
Apparatus, tools, and equipment
Hose and hose stream appliances
Radio Communications
Training
Fire Methods (Fire fighting techniques)
Building Inspections
Record System

At this time, it will not be necessary to analyze each of these items. Some of them will be treated individually in other chapters of the text. The intent here is to call attention to these items in the early stages of the manual. This is done so they will not be overlooked in the general plan of organization.

Structural Conditions - Fourteen items are involved in this area of the N.B.F.U. Grading Schedule. This

subject rates third in the listing and is important in the overall evaluation for determining the conditions which might jeopardize positive fire control. This section of the N.B.F.U. Schedule should be examined carefully. In it are many factors which can be used as a guide for determining an adequate community fire defense when planning future fire department operations. Some of the items are listed as:

Street Widths
Heights of buildings other than fire resistive
Wall and floor openings
Areas of wood frame or unprotected construction
Conflagration breeding blocks (a block extremely susceptible to fire)

Fire Alarm - A good fire alarm system is a must for any fire department operation. Failure to answer a fire call promptly usually results in heavy fire losses and even loss of life. The fire department must get to the emergency as quickly and as safely as possible. The only way the department can learn of the fire is by means of its fire alarms. Therefore, everyone involved in community fire defense must have the type of alarm which will service the community in the best possible way. There are many kinds of alarm systems in use today. Telephones, boxes, and radios are a few that can be named. Looking into all the various types of approved systems is important when planning a system for your community. After all, local needs must be considered the first stepping stone when planning for community fire defense. Alarm systems are expensive; therefore, it is highly important to carefully select a system which will be most suitable to the community.

In the N.B.F.U. Schedule, 23 items are listed for consideration. Some of these are:

Headquarters
Operators
Current Supply
Box Locations
Fire Alarm Boxes
Radio
Telephone
Tests and Records

Fire Prevention - In recent years fire prevention has developed to a point where it is directly interrelated to the fire fighting activity of a well organized fire department. There are very few paid departments today who are operating without a fire prevention bureau or a systematic fire inspection service. In the past, fire prevention was regarded as a fringe benefit afforded only by large departments. Today, this service is provided not only by fire prevention bureau personnel, but by all fire department members in terms of "in service" company inspections. There are no specific standards which can be adopted to set up a foolproof plan of operation. Organization must be geared to fit and comply with local needs and available manpower. The N.B.F.U. Grading Schedule requirements are based on seven items, namely:

Electrical Wiring and Equipment
Establishment and Enforcement Regulations of the Bureau
Controls of Miscellaneous hazards
Manufacture, storage, transportation, and use of flammable Gases
Manufacture, storage, transportation, and use of liquid gases.
Enforcement Agency for Fire Prevention
Electrical and Fire Prevention Records

Firemen should be familiar with all the implications included in the N.B.F.U. Schedule on this subject. Fire prevention is important and lack of it draws deficiency points which could jeopardize the evaluation survey for the community.

Building Department - The building department is the enforcement agency and has positive control in determining and enforcing structural requirements affecting the safety and welfare of the citizens in the community. Fire fighting tactics in restricting the spread of fire can be greatly facilitated by adequate building codes and the proper enforcement of same. It is therefore apparent that an active and well organized building department is an important factor in the evaluation program. As there are only five items included in this area, all of them are listed below:

Supervision
Fire Limits
Adequacy and Enforcement of Building Laws
Roof Coverings
Records

It should be pointed out, however, that regardless of the number of laws enacted to obtain proper structural requirements, lack of subsequent enforcement is considered equivalent to absence of such laws.

Police Department - As the introduction to this particular feature of the N.B.F.U. Grading Schedule is brief but conclusive, the entire content is provided

here for further examination.

"From the standpoint of fire protection, the duties of the police are: the discovery and reporting of fires, the preserving of order at fires, including control of traffic, and the reporting of building construction, alteration, or repair without a permit.

"Adequate service requires proper communication systems, of telephone, teletype, or radio, singly or combined, including street boxes, such as to meet the needs of the municipality. Provision should also be made for quickly concentrating police at fires.

"Municipalities of less than 2,000 population should have a watchman on duty day and night in the high value district, and for over this population there should be an adequate number of patrolmen on duty day and night. For over 15,000 population, a signaling system shall be provided and also sufficient vehicles for transportation and ropes for fire lines."

The items thus included are:

Cooperation with the fire department
Signalling and emergency service
Cooperation with building department.

The police department has an important part in community operations and good results can be obtained by establishing mutual understanding of their problems and responsibilities.

RURAL GRADING SCHEDULE

Water Supply - If the community or area to be served has a public water supply system, the same requirements for that system will prevail as those recommended for a municipality or urban area. Thus, every item in the water supply factor must be recognized and included in the evaluation survey of that community for protection against fire.

In determining fire insurance classification in rural areas where there are no public water supply systems, the Ohio Inspection Bureau has established Class A and B specifications. These are now in effect and were established by the Bureau in the reprint of June 1, 1958. They are as follows:

1. Farm Property
   The A and B fire insurance rate credits to which these fire department specifications are related apply to *farm property only* and not to dwellings and other classes of property. Farm property is rated under the Ohio Farm Schedule which contains certain fire insurance rate credits which apply when a Class A or B fire department has been recognized in the appropriate rate publication. The Class B credit is based on booster stream service and a small quantity of water. The Class A credit is somewhat greater than Class B and is based on larger pumping capacity and water supply. For Class A credit, the total amount of water transported to any fire must be 1,300 gallons on two or more pieces of apparatus. Additional credit is in order if the property comes under Eighth Class protection (see below).

2. Dwelling and Mercantile Property
   Ninth Class rate credit for other than farm property requires at least a Class B fire department responding.

Eighth Class rate credit requires an acceptable public waterworks with hydrants suitably located and a fire department having a piece of apparatus with a 500 g.p.m. pump, 1,000 feet of 2½" hose and otherwise meeting at least Class B fire department specifications.

Where water must be transported to the scene of the fire, the following requirements are stipulated:

To be eligible for Class A tanker credit, the tank should be of at least 1,000 gallon capacity, should be mounted on a suitable chassis, and shall respond regularly with pumper apparatus. A portable booster pump shall be carried or an engine driven pump provided on the tanker.

NOTE: The recommended tanker capacity is based on the minimum pumper booster tank capacity of 300 gallons. The final criterion is a total of 1,300 gallons of water transported to a fire on two or more pieces of apparatus.

SPECIFICATIONS FOR CLASS "A" RURAL FIRE DEPARTMENT

DEPARTMENT

An organized volunteer or call fire department shall consist of not less than 15 members. There shall be a chief, an assistant chief, and at least five other members who are appointed drivers and are capable of operating the pump. The department shall have completed the course in firemanship offered by

the State Department of Vocational Education. The response to fire calls shall not be made with less than five men.

Full paid departments responding to rural areas shall send at least three men.

FIRE STATION

Apparatus shall be suitably housed in a building reserved for fire department, municipal, or township use only. Hose drying facilities are required.

RECORDS

Complete records shall be kept of all fires covered in the district. The fire department shall have a record of the significant water supplies at each farm risk in the district. The rural Fire Safety Program, sponsored by the State Fire Marshal's office, is the recommended standard for compilation of farm records.

CLOTHING

Fire clothing (hats, coats, and boots) for all weather conditions shall be part of the fire department equipment.

APPARATUS

The apparatus shall have a minimum pump capacity of 500 g.p.m. at 150 p.s.i. and shall be of a type having a 12 hour test listing by the N.B.F.U. Booster tank capacity shall be at least 300 gallons. Total weight of the apparatus when loaded for service must not exceed the chassis manufacturer's maximum gross vehicle weight. Computation of the probable load to be carried will be based upon a full booster tank plus 3,500 pounds for hose, men, and miscellaneous equipment.

The following major items of equipment are required:

Hose:

500' - 2-1/2" c.r.l. (cotton-rubber-lined)(1,000' of 2-1/2" required for eighth class credit. See page 4)

300' - 1-1/2" c.r.l.

300' - 1" booster, on reels

40' - Hard suction (20' of 4-1/2" or larger), with strainer and mud bucket or equivalent strainer protective devices.

Nozzles:

1 - 2-1/2" shutoff

2 - 1-1/2" combination fog and straight stream

1 - 2-1/2" x 1-1/2" gated wye

Extinguishers:

2-5 gallon water, fire department pump type (Class A fires)

1-2-1/2 gallon foam, 15 pounds CO_2, 10 pounds dry chemical (Class B fires.)

1-10 pounds CO_2, 10 pounds dry chemical, or two 1-1/2 quarts vaporizing liquid. (Class C fires.)

Ladders:

1 - 12' roof

1 - 30' extension

Portable Booster Pump:

A portable booster pump, driven by a gasoline engine and having a capacity of not less than 100 g.p.m. at 60 p.s.i.

Minor appliances shall include:

1 - Fire Axe

1 - 10' pike pole

2 - Electric hand lights, fire department type

1 - 3' crowbar

1 - shovel

100'- 5/8" manila rope

2 - pitchforks

1 - pair heavy duty wire or bolt cutters

6 - rope hose-tools or the equivalent

SPECIFICATIONS FOR CLASS "B" RURAL FIRE DEPARTMENT

DEPARTMENT

An organized volunteer or call fire department shall consist of not less than 15 members. There shall be a chief, an assistant chief, and at least five other members who are appointed drivers and are capable of operating the pump. Not less than five men shall respond to fire calls.

FIRE STATION

Apparatus shall be suitably housed in a building reserved for fire department, municipal, or township use only.

RECORDS

Complete records should be kept of all fires in the district covered.

CLOTHING

Fire clothing (hats, coats, and boots) for all weather shall be part of the fire department equipment.

APPARATUS

Apparatus shall be of a design suitable for fire service and equipped with a minimum pump capacity of 60 g.p.m. at 120 p.s.i. The booster tank capacity shall be at least 300 gallons.

The following major items of equipment are required:

Hose:

2 - 150' (or longer) lines of 1" booster, attached to the pump (300' - 1-1/2" c.r.l. is also acceptable.)

20'- Hard-suction, with strainer

Nozzles:

2 - Combination fog and straight stream for booster hose

2 - 1-1/2" shutoff if 1-1/2" hose is carried

Extinguishers:

2 - 5 gallon water, fire department pump type (Class A fires)

1 - 2-1/2 gallon foam, 15 pounds CO_2, 10 pounds dry chemical (Class B fires)

1 - 10 pounds CO_2, 10 pounds, dry chemical, or two 1-1/2 quarts vaporizing liquid. (Class C fires)

Ladders:

1 - 12' roof

1 - 30' extension

Minor appliances shall include:

1 - Fire axe

2 - Electric hand lights, fire department type

1 - 10' pike pole

1 - 3' crowbar

1 - Pair heavy duty wire or bolt cutters

STRUCTURAL CONDITIONS

This area must not be overlooked by rural fire departments when planning their community fire defense program. Although it might seem that the potential hazards, obligations, and problems are not as obvious as those in a large community, they are present just the same. Farm properties present many varieties of structural conditions. For example, large barns used for cattle and storage of grain and hay create a problem similar to a wood frame building in an urban area. Problems caused by heights of buildings may be compared to a grain elevator or feed mill and a multi-story building in the city. The close proximity of a highly combustible barn and farm dwelling creates the same exposure hazards as buildings built closely together in urban developments. Consequently, the Ohio Inspection Bureau, when in the process of making its evaluation survey, observes the same pattern as outlined in the N.B.F.U. grading schedule.

FIRE ALARM

Specifications established by the Ohio Inspection Bureau are broken down into two areas for evaluating this factor.

Class "A" Rural Fire Departments - An electric siren (at least three h.p. size) shall be provided with reliable arrangements for receiving fire calls by telephone and sounding the siren from the point of receipt. There shall be provision for transmitting fire locations to the fire station. The fire station shall be provided with a telephone.

Class "B" Rural Fire Departments - An electric siren (at least three ! p. size) shall be provided with reliable arrangements for receiving fire calls by telephone, sounding the siren, and transmitting the fire location to the fire station.

For rural areas, these specifications might infer that there is not too much to be expected or too much to be done in respect to providing proper facilities for handling fire alarms. Yet, this is one of the most important phases of community fire defense. Fortunately, in recent years, great strides have been made in developing fire alarm systems for rural areas. Due to expansion of outlying areas, the telephone has been a boon in providing more adequate alarm notification. Recently, radio has entered this field and much is being done to incorporate this feature in alarm systems. Consultation with the Ohio Inspection Bureau and with local utility or private companies for information on this subject is recommended when considering the installation of any type of alarm system. A dependable communication system is the only guarantee the fire department has at its disposal when the need is greatest for the saving of life and property.

FIRE PREVENTION

Generally, a rural community does not have the facilities nor can it provide the means of operating a fire prevention bureau on the same lines as a large municipal fire department. Still, this should not be a deterrent to the efforts of a rural fire department to give the community fire prevention service.

Through the efforts of the Fire Marshal's Office, rural inspection programs have expanded to a point where they are an accepted factor in the operation of the local fire department. When the ordinances are not available for enforcement, the State Building Code, State Rules and Regulations governing and controlling the manufacture, storage, handling, and use of flammable liquids and gases, state laws relative to inspection practices, etc., are available.

By enforcing these state laws, private fire departments excepted, it becomes apparent that the rural fire department can do a tremendous job in fire prevention.

BUILDING DEPARTMENT

Small communities are often handicapped because the local government does not provide the services of a building department. Yet, this should not deter from activity in this field because state laws can be enforced by the fire chief. There are state building codes to guide in the enforcement of state minimum building construction requirements. State laws are very definite in their application to school buildings and places of public assembly. Special requirements concerned with building construction are recommended in bulletins available from the State Department of Industrial Relations.

In some areas of the state, county wide building codes ha̵ve been developed to fill the gap between municipalities and rural areas. By enforcement of these county codes, the smallest community or rural area can do a good job in protecting the life, property, and welfare of the people.

POLICE DEPARTMENT

Though this feature is not specifically mentioned in the Ohio Inspection Bureau Grading Outline, it must not be overlooked in the rural area of operation.

It is suggested that reference be made to page 4, (Police department under the urban schedule) and study be given to the information incorporated therein. Results will indicate that the same general principles are involved. Possibly, the inclusion of the sheriff's office, the state patrol, etc., will indicate in which direction the police powers must be correlated. This factor is vital in alleviating fire fighting problems on highways and in rural communities. Local officials must strive for close cooperation between these agencies in any fire defense plan of operation.

CREDITS AND ADDITIONAL DEFICIENCIES

Credits for superior construction and protection in the high value district are applied in the form of di-

rections from the total number of points obtained under structural conditions. Items under this include:

Superior construction and protection

Maintaining pumpers in service with full fire flow available as direct hydrant streams. (This means that even though a full fire flow stream is available from the hydrant supply, fire engine pumpers in the district add additional credits to this feature)

High pressure fire system

Deficiencies are created by unusual situations, characteristics, or disadvantages which may exist in any area. These items include:

Adverse climatic conditions

Other unusual or exceptional occurrences

Divergence in class between water supply and fire department

The N.B.F.U. schedule must be consulted for a further breakdown and explanation of these features, which may be applicable to either the urban or rural evaluation. Knowledge of the reasoning and implications for considering them by the inspecting agency is obvious. Therefore, any community, whether it be classified as urban or rural, should be acquainted with the present or potential circumstances which might create favorable or adverse results affecting the promotion of an adequate community fire defense program.

ADDITIO FACTORS IN COMMUNITY FIRE DEFENSE

SELECTION OF FIRE DEPARTMENT PERSONNEL

The successful operation of any fire department, whether it be paid, part prid, or volunteer, depends upon the efforts of every member. With this thought in mind, it becomes apparent that personnel should be carefully considered when structuring a fire department organization.

The following list of qualifications can be used to determine the capability and potential of a person being considered as a fire fighter. This list is by no means complete, nor are the items listed in any special order of importance. It should be used comprehensively and collectively in the selection of an individual who will contribute the most to the department.

1. He must be available. There is no point in having a man on the department when his presence may be questionable at the time of the alarm. A man whose private work takes him out of the community would not be a wise choice. However, if there are a number of men involved in the same situation, it might be well to give some thought to the idea of placing these men on a day or night platoon system. In doing so, fire department personnel would be available on a round-the-clock basis. This situation would not prevail in a paid department.

2. He must be dependable. Dependability is of the utmost importance. This virtue gives assurance that the individual will carry out assignments to the best of his ability.

3. He must have a good reputation. A person's good name and standing in public esteem must definitely be considered in the analysis. The public must have confidence in the fire fighting personnel. In short, is the man under consideration a good citizen?

4. He must present a good appearance. A slovenly, dirty, unkempt individual will cause the general public to look with disfavor on a public servant whether he be in or out of uniform. A fireman is often called upon to take part in civic functions, parades, events, inspections, etc. A well groomed appearance is always a walking advertisement of the position a man holds.

5. He must have a pleasant personality. Arrogance and superiority shown by an individual will be quickly resented. There have been instances where a general dislike for all fire department personnel has been caused by the actions of one individual. The ability to be courteous and understanding will always open the door for better relationship.

6. He must be cooperative. This characteristic calls on a person's ability to harmonize, pull together, work shoulder to shoulder, and go along with others. People do not always think alike but nevertheless should act together under emergency situations. There is no time for bickering at the scene of an emergency. Orders and methods must be carried out even if they are not to individual liking.

7. He must be definitely interested in the job. Fundamentally. this is a specialized field and

there will always be new and different approaches, techniques, and procedures advanced in fire fighting. If he has the desire to learn, study, and keep abreast of the times, such an individual will definitely be an asset to the department.

8. He must have initiative. A person's ability to determine for himself what has to be done, and then to be able to go ahead and do it, is an important qualification for fire department work. The necessity to deal with unusual situations, conditions, and circumstances make it imperative that fire department personnel have this qualification.

9. He must be cool, level headed, and have the ability to use common sense. Emergency situations call upon the individual to use these qualities because of the acute excitement, stress, and turmoil which exists during the time of a fire. The situation, when handled wisely and properly, will make matters easier for everyone concerned.

10. He must have an aptitude for training. The study and training time involved in learning to be a rookie fireman is not always a long term indoctrination of practice and knowledge. Therefore, the ability to learn quickly and have a natural talent to apply this training is an important factor in personnel selection.

11. He should have leadership ability. "As ye lead, so shall they follow" may be a safe axiom to apply in this case. Emergency situations always call for immediate use of authority and command. When used wisely, this quality will make it easier to control the situation.

12. He must be in good health and physical condition. One never knows exactly what is involved when responding to a fire alarm. He may have to climb, run, pull, push, or do other types of physical exertion. Therefore, it is very important that the selectee be blessed with the normal good health and physical abilities needed to perform his duties in a way that will not be detrimental to the people involved, his fellow firemen, or himself.

PUBLIC RELATIONS

The creation and maintenance of good public relations between the fire department and the people of the community has a powerful and beneficial influence on whatever results are established by this relationship. The operation of a fire department is no different from the operation of a business or industry whose keynote to success is based on its ability to sustain a good relationship with the public. The extent with which the public accepts and condones the services of its fire department depends on the efforts of the department to establish itself as an integral part of the everyday way of life in the community.

When such a relationship is established, the morale of the department will increase. This will tend to attract a higher and better qualified type of individual into the fire service. Each individual fireman plays an important part in the establishment of a good reputation for his department. He must be willing and cheerful in his efforts to render the services essential for the protection of life and property in his community. If people are aware of these intentions, they will appreciate and encourage the members of the department to perform their duties to the ultimate satisfaction of everyone concerned.

An efficient fire department must consist of capable and well trained personnel if it desires to receive the moral and financial support of the people it serves.

An understanding public is always willing to furnish the financial support necessary to equip and educate fire personnel so that they can perform their essential duties more efficiently.

A community acquainted and on good terms with its fire department will always encourage its progress. However, such a situation will not prevail unless a good public relations program is in existence. Thus, every fireman on the department has an equal share in the responsibility of securing the confidence and respect of the public to strengthen their relationship. It must be remembered these relationships, whether good, mediocre, or bad, are determined by the effort extended. In many instances, the department is collectively judged on the basis of individual contact. The identifying stamp of approval or disapproval for the entire department is based on the action of each individual. Thus, each fireman has the key for opening the door to success or failure.

Truth, knowledge, confidence, courtesy, understanding, and a sincere desire to get along are the basis for good public relations. In this respect, the little things that are done are just as important as the big ones and should never be underestimated. People think differently, and what may be minor to one person may be important to another.

A direct, satisfactory answer cannot be given in terms of how to promote a public relations program. It may be wise, however, to begin in the department itself. Internal strife or discord cannot result in good public relations. In many cases, even the slightest hint of internal difficulties can cause public criticism and dissatisfaction. Problems within the department should be settled by the department and not by uninformed citizens. Fire department gossip is exactly what the name implies. It should remain in the department and not be heard at the fire scene, the neighborhood store, or on the street corner. The bragging, bluffing, gossiping, argumentative type of fireman never makes the kind of impression that goes along with promoting good public relations.

Efficient fire administrators and chiefs know the value of good public contacts. In recent years, department members have been brought more and more in close contact with the public. Fire prevention activities, emergency squad operations, and company inspections are examples of modern fire department responsibilities. Because of this, the role of the individual fireman in the field of public relations is becoming more important. His actions set the pattern of judgment by the people. It has been said many times that "good will, like a good name, is won by many good acts -- and lost by one bad act." A single wrongful act by one fireman may require many, many good deeds by the fire department to overcome and outweigh the one mistake.

MUTUAL AID

In recent years, the phrase "mutual aid" has become a by-word in fire department organization and operation. As a result of studies of conflagrations throughout the country, it has become apparent that conditions could arise in practically any community, large or small, that might result in a conflagration. When one occurs, it is quickly apparent that the local fire fighting facilities are not sufficient to handle the siutation. More apparatus, more equipment and more manpower is the only solution to this emergency. This means the movement of men and equipment from neighboring communities, either to the scene of the fire or to "fill-in" positions in stations vacated by those already on the fire scene.

Examination of the N.B.F.U. Grading Schedule indicates many references to supplementary help which affects the evaluating procedure. The Ohio Inspection Bureau also bases its evaluation on the auxiliary aid provided for each community. In the publication titled "Laws Governing Ohio's Fire Service," available from the Division of State Fire Marshal, reference is made to statutes which legally authorize contracts between municipalities for additional emergency protection. It contains samples of various contracts dealing with this subject.

In this text, no attempt will be made to enter into every phase of involvement which does or could exist in the application of a contract for mutual aid or outside help. The furnishing of fire protection service beyond corporate limits has long been a major problem from an administrative, legal, financial, and local policy standpoint. Many factors including arrangements, costs, physical limitations, running schedules, manpower, apparatus, etc., must be considered by local administrators and fire officials when planning this service. The important point to consider is that mutual aid plays a valuable part in community fire defense and must not be ignored in the overall plan of operation.

Surveys of cities made periodically by the N.B.F.U. show that most cities in the United States send men and fire apparatus beyond the city limits under one condition or another. By this method, communities throughout the United States have successfully strengthened their fire fighting facilities to the mutual advantage of the people in their area. But, regardless of the size of the community, effective mutual aid must be predicated upon a well thought out and laid out plan in order to operate effectively. Some of the factors to be considered are:

1. Signaling or notification system
2. Apparatus responding
3. Manpower available
4. Running cards
   a. Fire scene
   b. Stand-in
5. Availability of radio
6. Equipment available
7. Hose couplings and adapters (matching threads)
8. Water supply
   a. Water system
   b. Portable (Tanker)

9. Authority to call for aid

10. Distance responding

11. Time of travel

12. Cooperation of assisting organizations

    a. Law enforcement agencies

    b. Public utilities

    c. Public service department

    d. Construction companies

Other agencies can also be utilized. Local conditions and policy will have a great deal to do with effecting a mutual aid plan.

Another reason for considering and using mutual aid for emergencies is the swift development of atomic weapons and guided missiles. With this new concept of warfare, disaster will be swift and without warning. Furthermore, the blast caused by these weapons will primarily result in fire. Thus, a unity in organization will have to be expedited to provide service and protection for the people. It is recommended that now is the time for every community, large or small, to reappraise its fire defense capabilities. The objective is to insure the most effective use of its facilities, not only in terms of an emergency within its own borders, but also in terms of one confronting the department's neighboring communities.

EMERGENCY DISASTER PLANNING

Each year hundreds of lives are lost and millions of dollars in damage is caused by sudden disaster inflicted on communities all over this country. Explosions, floods, conflagrations, tornadoes, and many other forces of devastation which strike suddenly or with very little warning create a situation which cannot be handled by routine operations. Community fire defense planning must encompass these conditions if it desires to insure the protection, safety, and welfare of the inhabitants in disaster situations.

Mutual aid is a correlating factor in this respect but does not cover every area of need and protection. It is apparent to everyone involved in fire department operations that regardless of the type of emergency, the fire department will be called upon to alleviate the crisis. Therefore, it would be well to explore the potential meaning and responsibilities of emergency disaster planning. For example, reference can be made to the Texas City Disaster which involved ammonium nitrate explosions, the Brighton gas fire and explosion, the East Ohio Gas Company disaster in Cleveland, various floods, tornadoes, and many other emergencies of a similar nature. In all of these, the fire department had the leading role but had to rely on the valuable service provided by other agencies. A random listing of such agencies includes the:

Electric company
Gas company
Telephone company
Excavating or road equipment source
Radio and television stations
Red Cross
Hospitals, doctors, nurses
Sheriff's office
Highway patrol
Municipal or county service departments
Radiation monitoring service

There are others that could be included in this list, depending on the local situation.

Evidently, if a complete disaster plan is to be feasible, out of sheer necessity it must include all qualified agencies that can lend a hand when needed.

Local fire departments should come to the front and make their desires clear and purposeful. They should contact qualified agencies and discuss this problem in terms of community planning. It is amazing how efficiently and easily a plan can be put into operation if the ground work for same has been previously structured. The fire personnel will have their hands full in dealing with the conflagration end of a disaster. Their job and responsibilities at the scene will be made a lot easier if they know that other agencies are handling the other problems. It should be the fire department's responsibility to make whatever contacts are necessary to assure the development of an overall emergency disaster plan. Cooperation of city officials may sometimes be necessary or even mandatory in order to keep in line with legal procedures. This should be no stumbling block, because government personnel are usually willing to lend aid to an enterprise which will promote good relations with their citizens.

The important point to remember is the fire department's responsibility in the promotion and development of a community emergency disaster plan. A better public relationship is always gained when the people realize that efforts are being made in their behalf.

FIRE DEPARTMENT RECORDS

Records, whether they pertain to climatic conditions, water consumption, fire losses, or many other subjects too numerous to mention, are identified as statistics and play an important role in most of our daily enterprises. Although there is no direct relationship between the ability to keep good records and the ability to fight fires, comprehensive records are an essential part of good fire department operations. Facts from such records provide supporting data to a city administrative head or council when discussing the need for additional personnel, fire apparatus, or equipment. Records have also proven most helpful and valuable in many other respects.

The extensiveness of any record system will depend upon the size of the fire department and the adequacy of personnel assigned to its maintenance. Basically, the records of any department should cover all the following items:

1. The department files should include:

   a. A complete personnel file showing members' blood type, full name, address, personnel date, date and place of birth, date of joining the department, date of promotion, disciplinary action, salary, company assigned to, and leave of absence and military data. This file should be kept as confidential data in the department.

   b. A file showing dates when members were off sick or absent for other reasons.

   c. A folder for each member with personal data, original application, civil service information, merit marks, and correspondence. (Usually confidential.)

   d. A file of inactive members.

   e. A file of department correspondence.

   f. Copies of payrolls, invoices, etc.

   g. A chart showing assignment of members to companies. It is important that this be kept daily for the large departments.

   h. A master fire report book showing all alarms by date, time, type of alarm, name of person reporting alarm, address, owner, occupant, cause of fire, fire companies and chief responding, how the fire was put out, insurance and loss data, and evaluation of building and contents.

2. The company records should consist of:

   a. A company journal. The most common arrangement is in diary form. Daily entries should show roll call and reason for any absences, details of members, battery, gasoline, city water pressure readings if taken daily, fire or emergency runs made, hose used or changed, time and type of drills or school held, special operations, inspections made, any repairs of apparatus or station and any unusual events such as visitors to the station, accidents, etc.

   b. A posted sheet showing vacation and working schedule.

   c. A sheet showing address and telephone numbers of all men assigned to the station posted in front of company journal or wall mounted.

   d. Bound notebook containing equipment and hose inventories, notices of streets, bridges, and railroad crossings closed and hydrants out of service, fuel and supplies received, etc.

   e. Copies of fire report sheets and hazard inspection blanks.

   f. A special book with full data on all emergency runs.

3. The training officer's records should consist of:

   a. A log or journal of the daily events applying to the work of the drill school.

   b. A roster of company members showing dates of attendance and drills covered together with a list of stragglers. Some schools even keep grades of companies and members and assign efficiency ratings.

   c. An inventory of equipment assigned to the school.

d. A complete reference library

4. The repair shop or the master mechanic should keep the following records:

   a. Apparatus records, showing basic data in regard to cost, date of purchase, serial numbers, size of motor and pump, extent of repairs, replacements, routine maintenance, battery and tire information.

   b. Hose records showing purchases, costs and tests.

   c. A master inventory of equipment assigned to companies and stations, with special notes for parts and replacements.

   d. An inventory of spare parts and spare equipment.

   e. A time sheet for shop personnel.

   f. Records of pumper tests.

5. The fire prevention bureau should keep extensive records which are summarized as follows:

   a. A correspondence file. (Combined with department files in the smaller departments.)

   b. An inspection schedule for bureau inspectors and company members.

   c. Copy of inspection blanks for all inspections made, either by the bureau or company members.

   d. Plans of hazardous buildings, for study at company training sessions.

   e. A file of incendiary fires and arson suspects.

   f. Miscellaneous cross-file records for quick reference as to previous fire locations, where inspections have been made, hazards found and corrective measures taken, and other important information applying to buildings such as construction, size, owner, and occupant.

FIRE DEPARTMENT RECORDS AND REPORTS

In order to properly set up any type of record system in a fire department, it will be necessary to correlate it with some means of reporting the desired information to the proper person or office. Usually, the department will devise a form based on its own needs. The person who has the responsibility for making such reports is determined by the fire chief. It is his duty to designate who shall make out these reports, to see that they are properly handled, and to make certain they are forwarded to the correct person or office or filed for future reference.

In some departments, fire reports are handled in the following manner: Each officer or person in charge of the apparatus has a pad of standard forms made up by the department. These forms note the information to be obtained at the scene of the emergency. The information is then transferred to a "run report" after the run has been concluded and the officer has returned to the station. The run reports are then sent to fire headquarters and kept on file. This, however, is only one method of obtaining and expediting a report. There are countless other methods that can be used to accomplish the same results. Proper procedure rests with the department.

Record and report forms can also be devised for many other items pertinent to fire department operations. This matter can be carried out as far as it is practical and feasible by the local department. The problem may increase as the size of the department decreases because of shortage of personnel and facilities for handling such data. Yet, this problem should not deter efforts to maintain the required records and reports. It is important, it is sound operating procedure, and it has a great deal of value in the general structure of the fire department to maintain adequate records and reports. Sample record and report forms are shown in Figures 1 through 7 on the following pages.

DAILY REPORT

Division of Fire

PERSONNEL RECORD

Platoon______ On Duty From 8:00 a.m.______ to 8:00 a.m.______

			Cause of Absence			
Distribution	Present	Absent	Sick	Vac.	K. Day	Others
Chief Officers						
F. P. Bureau						
Maintenance						
Alarm Office						
District #1						
District #2						
District #3						

FIRE PREVENTION BUREAU

Inspections Today______ Carried Forward______ Total to Date______

ALARM STATISTICS

For 24 Hours Ending Midnight ______

Number of Alarms

Today	
Carried Forward	
Total to Date	
Total Last Year	

Alarm Office Personnel

On Duty	Operator
12:00 M. - 8:00 A.M.	
8:00 A.M. - 4:00 P.M.	
4:00 P.M. - 12:00 M.	

Record of Alarms

Time	Location	Dist.	Apparatus	Type	Cause	Loss

______
Chief of Fire Department

Fig. 1 - Sample Daily Report

DAILY PERSONNEL ATTENDANCE REPORT
Division of Fire

DISTRICT NO. ____________ PLATOON NO. ____________ DATE ____________

Name	Pres.	Abs.	Reason	Remarks
TOTALS				

Submitted by ____________

Fig. 2 - Sample Daily Personnel Attendance Report

DISABILITY REPORT
Division of Fire

Name ________________________ Date ________________

Station ______________ Company __________ Rank ______________

Disability Occurred On Duty ______________ Off Duty ______________

Address Where Disability Occurred ________________________

Type of Disability ________________________

Doctor ______________________ Hospital ______________

Witnesses ________________________

____

Officer in Charge ________________________

Remarks ________________________

____

____

____

____

____

____

____

____

____

____

____

____

Reported by ________________________
(Signature)

Fig. 3 - Sample Disability Report

TRAINING REPORT
Division of Fire

Company No.__________ Instructor__________

Location__________ Subject__________

Date__________ Start_____ Finish_____ Total_____

Company Officers and Men	Pres.	Abs.	Reason	Remarks

Instructional Data__________

Remarks__________

Approved by

Fig. 4 - Sample Training Report

______ Company No. ______ FIRE DEPARTMENT Report No. ______

District ______

COMPANY RUN REPORT

Date ______ 19 ____ Time alarm was received ______ M.

Location of fire, or origin of alarm (street and number) ______

Type of Bldg. ______ No. of Stories ______ No. of Suites ______ No. of Stores ______

How Rec'd - Alarm ______ By ______ Station No. ______

Reported to cover Company No. ______ at ______ M., on authority of ______

Ordered home by ______ at ______ M. In quarters at ______ M. Miles traveled ______

CLASSIFICATION OF ALARM Check the proper square		Alarm Where There Was No Fire	EQUIPMENT RESPONDED WITH
	☐ Fire in building	☐ Rescue or emergency	Pumper ______ GPM
	☐ Fire in brush or grass	☐ Needless call	Booster tank ______ gals.
	☐ Fire in rubbish near building	☐ Accidental alarm	Ladder truck ______
	☐ Fire in rubbish in vacant lot	☐ False alarm	2½-in. hose ______ ft.
	☐ Fire in dump	______	No. waterproof covers ______
	☐ Other fire outdoors		
	☐ Fire in vehicle in street		

EXTINGUISHERS USED		HOSE LINES USED			SALVAGE COVERS USED	
No.	Type	No.	Size	Total Feet	No.	Floor
	Soda-Acid		Booster			
	Pump Tanks		1½-inch			
	Foam		2½-inch			
	Loaded Stream		1 - inch			
	Carbon Tetrachloride	LADDERS USED				
	Carbon Dioxide	No.	Type	Total Feet		
	Dry Chemical		Aerial			
	Water Pails		Wall			
			Roof			

Working time of hose lines:
______ ft. { hydrant / pumper } line, ______ in. hose, ______ in. nozzle, ______ hrs. ______ min.
______ ft. { hydrant / pumper } line, ______ in. hose, ______ in. nozzle, ______ hrs. ______ min.

Working time of pumper ______ hrs. ______ min. Total amount of water used (approximate) ______ gals.

Equipment lost or found ______

Equipment damaged or destroyed ______

Men responding to alarm ______

______

Names of personnel injured on alarm ______

______

Off-duty members responding (names) ______

______

Fig. 5a - Sample Company Run Report (front side)

DETAIL OF OPERATION

Owner ______ Owner's Address ______

Occupant ______ Who called ______

Value of Bldg. ______ Value of Contents ______ Auto Make ______

Ins. on Bldg. ______ Ins. on Contents ______ Year ______ Lic. ______

Loss ______ Loss ______ Val. ______ Ins. ______ Loss ______

Name of Ins. Co. ______ Name of Ins. Co. ______

Cause ______

By ______
Officer in charge Rank

Fig. 5b - Sample Company Run Report (back side)

DISPATCHER ALARM REPORT
DIVISION OF FIRE

Address Date

Run No. A. Run B. Run

Apparatus	Time Out	Time In	Mileage
Engine #1	A.M. P.M.	A.M. P.M.	
Engine #2	A.M. P.M.	A.M. P.M.	
Engine #3	A.M. P.M.	A.M. P.M.	
Truck #1	A.M. P.M.	A.M. P.M.	
Truck #2	A.M. P.M.	A.M. P.M.	
Rescue Squad	A.M. P.M.	A.M. P.M.	
Reserve	A.M. P.M.	A.M. P.M.	
Mutual Aid	A.M. P.M.	A.M. P.M.	

Recd. By How Recd.

Police Notified Name

Utility Notified Gas Electric Telephone

Wind Vel. Wind Direction

Weather Condition

Fig. 6 - Dispatcher Alarm Report

DATA OBTAINED AT FIRE

Location		
Who Called		
Owner		
Owner's Address		
Occupant		
How Occupied		
Construction		
Roof		
No. Stories	No. Suites	No. Stores
Value of Bldg.		
Ins. on Bldg.		
Name of Ins. Co.		
Value of Contents		
Ins. on Contents		
Name of Ins. Co.		
Auto Make		
Year		Lic.
Cause		

Fig. 7 - Sample Form For Data Obtained at Fire

CHAPTER 2

CHEMISTRY OF FIRE

INTRODUCTION

A knowledge of the chemistry of fire is an important factor in the development of an effective and well trained fire-fighter. Fires have many characteristics which have a direct effect on the method used in their extinguishment. Therefore, the fire-fighter must be able to recognize these characteristics as well as how to use the proper extinguishing agent and equipment.

HOW THINGS BURN

Combustion or burning may be defined as a chemical process accompanied by the evolution of heat. This process is a special form of union with two other substances, one of which is oxygen. In most cases, our conception of a substance burning is that it gives off heat and exhibits a glowing mass.

Everyone is familiar with the fact that coal can generally be ignited by first building a wood fire, and that the wood must in turn be ignited by paper, which in turn is ignited with a match. In this series, the burning of each material raises the temperature of the next material until it, in turn, finally is ignited and burns. The temperature at which a substance will catch on fire and continue to burn is called the ignition temperature. However, temperature is only one of the necessary elements (temperature, oxygen and fuel) which produces combustion. The chemical union referred to does not take place until the substances involved are heated to their ignition temperatures. For example, phosphorus, as in a match, ignites when heated through friction. Sulphur will ignite from a small spark. Carbon must be heated to a glowing temperature before it burns, and magnesium must be heated to an even higher temperature. One can readily see that before a substance burns, it must be heated to its ignition temperature and this temperature varies for different materials.

Another important factor involved in the ignition of a substance is the size or mass of the substance to be heated. A page of a book is ignited easily, but the book itself, a compact mass of pages, ignites slowly. A needle and a bar of steel are of the same material, but the former is so small that when placed in a flame, it is quickly raised to the temperature of the flame. When the same amount of heat is applied to the steel bar it will become heated slowly. Likewise, a wood shaving, presenting a small mass for heating, will ignite more quickly than the block of wood from which it was cut. It is necessary that a solid must first be heated sufficiently to cause it to change into a combustible gas before it will ignite.

The previously described principle also applies to flammable liquids. The temperature at which a flammable liquid gives off vapor sufficient to form an ignitable mixture with the air near the surface of the liquid or within the vessel containing the liquid is called the "flash point." This temperature varies according to the density of the liquid. A burning match thrown into cold kerosene will be extinguished, but if the kerosene is converted into a gas, the burning match will ignite it. The great danger of gasoline lies in the fact that it passes off a combustible vapor at ordinary temperature and is then in a state favorable for ignition.

Spontaneous ignition of a material is caused by the gradual development of heat due to a chemical change within the material. It continues to generate heat until the ignition temperature is reached. If cloths soaked in linseed oil are packed together, they present a fine opportunity for spontaneous ignition to occur. The oil spread over the surface of the cloth absorbs oxygen, and if the conditions are such that the heat generated is not dissipated, the heat results in further oxidation which raises the temperature until the whole mass is hot enough to burst into flame.

There are many other flammable products. Liquids with a flash point lower than 200° F. are considered flammable, but any combustible liquid, when heated above its flash point, will produce flammable vapors. For example, heavy fuel oil when heated above 300° F. may release vapors as flammable as those of gasoline at its flashpoint temperature, which is less than 0° F.

Flammable liquids are divided into three classes. Class I includes those having flash points at or below 20° F. Class II includes those having flash points above 20° F., but at or below 70° F. Class III includes those having flash points above 70° F. but below 200° F.

Flash point, though the commonly accepted criterion of the relative hazard of flammable liquids, is by no means the only factor in evaluating the hazard. The ignition temperature, explosive range, rate of evaporation, density, and rate of diffusion of the vapor also have an important bearing. The flash point and other factors which determine the relative susceptibility of a flammable liquid to ignition have comparatively little influence on its burning characteristics after the fire has burned long enough so that the liquid is thoroughly heated.

For sources of additional data and information on flammable liquids and gases, it is suggested that firemen contact such agencies as The National Board of Fire Underwriters, The Division of the State Fire Marshal, The Factory Mutual Insurance Company and the Ohio Inspection Bureau.

For an element to burn, it must first unite with oxygen. For a compound to burn, each element must first unite separately with oxygen. Whenever a compound of carbon, hydrogen, oxygen, or nitrogen is oxidized, either by rapid burning or by the slower process of decay, the final result is the same. This result is carbon dioxide, water and free nitrogen. Therefore, burning is the final way of disposing of organic materials.

Due to the fact that gasoline is made up of two elements, carbon and hydrogen, the burning of gasoline is more complicated. Both of these elements have an affinity for oxygen when heated; hence, a combination of them burns rapidly. Each element present unites with oxygen as readily as it would if it were by itself.

Smoke is always the result of incomplete combustion. When compounds such as coal, wood, fats, and petroleum burn, the heat of the fire expels hydrogen and oxygen along with carbon, and these burn as gases. As they burn, they do not meet with sufficient oxygen, and besides, they are cooled. The hydrogen in these gaseous combinations burns more quickly than the other gases; therefore, some unburnt carbon is liberated as soot and carbon monoxide. This is called smoke.

In other words, fire is a rapid chemical change in which combustible substances burn and give off heat. Substances which easily combine with oxygen to form new substances and produce a high degree of heat in the process are classed as combustibles. Three things necessary to support combustion are:

1. A combustible substance, *fuel*.

2. Sufficient *oxygen* to support combustion.

3. Sufficient *heat* to ignite the substance.

Normally, air is 21% oxygen. When the oxygen content of the air around a flame is reduced below 16%, the flame is extinguished. The percentage of oxygen around a flame may be reduced in two ways:

1. By cutting off the supply of oxygen through smothering so that the flame will consume or exhaust all of the oxygen around it.

2. By displacing air with a noncombustible gas such as carbon dioxide or water vapor.

Oxygen does not necessarily have to be supplied by air. It may be furnished for combustion artificially as in chlorates, nitrates, thermite, etc. Substances which furnish their own oxygen, such as pyroxylin plastics, will burn under water. Also, hot coke and many hot metals will burn brighter when water is applied because the tremendous heat decomposes the water, freeing oxygen and hydrogen. The oxygen supports the combustion and the hydrogen itself burns, being very combustible and explosive.

When firemen are able to determine the characteristics of a fire they can decide which method of extinguishment to use.

EXPLOSIONS

Explosions are of four principle kinds:

1. Release of heat energy by rapid oxidation, (gasoline vapor-air explosion).

2. Release of energy by decomposition, (dynamite explosion).

3. Release of energy by release of pressure, for example, a fluid which is under pressure at a temperature above its normal boiling point, (boiler explosion).

4. Release of energy by atomic fission, (atomic bomb explosion).

All are characterized by the release of energy so rapid as to be substantially instantaneous. The force of an explosion depends upon the rate of release of energy even more than upon the amount of energy released.

The fireman is principally concerned with fire explosions, which are caused by the release of heat energy through rapid oxidation. There is no sharp line of demarcation between an explosion, and a very rapidly spreading fire, such as those in gasoline, which are often described as explosions. "Flash

fires" would be a more accurate description. Explosions occur where flammable vapors, gases, or combustible dusts are mixed with air in proportions such as to produce very rapid oxidation of the entire mass when a source of ignition is provided. The violence of the explosion usually depends upon the rate of oxidation. There is a considerable difference in the rate at which explosions propagate, though the entire phenonemon is so rapid that it can be measured only by special instruments. In a detonating explosion, the rate of travel is very high as compared with ordinary flame travel through combustible mixtures.

Finely divided particles of nearly all combustible materials can produce violent explosions if the particles are suspended in air in the proper concentration and ignited. Whether or not a dust cloud will ignite is governed by the particle size, dust concentration, uniformity of dispersion, amount of impurities present, and strength and duration of the source of ignition. As is true with gases and vapors, there are limiting concentrations of dusts (explosive limits) within which an explosion can occur. The generally accepted figures for lower explosive limits range from 0.015 oz. per cu. ft. for light readily dispersible dusts to 0.5 oz. per cu. ft. for some of the heavy powders, but ignitions at concentrations well below 0.015 oz. per cu. ft. have been reported. Minimum explosive concentrations and ignition temperature of clouds of typical dusts are shown below:

	Minimum Explosive Concentration (Oz. Per. Cu. Ft.)	Ignition Temp. °F.
Aluminum	0.025	1190
Magnesium	0.020	965
Zirconium	0.040	*
Phenolic Resin	0.025	925
Coal	0.035	1125
Sulphur	0.035	370
Cornstarch	0.045	875

*Zirconium powder dispersed in air at room temperature was ignited in certain instances apparently by static electrical discharge between particles in the dust cloud.

Dust explosions usually occur in pairs. The first explosion, involving dust which is already in suspension, dislodges dust from beams, ledges, etc., and forms a second cloud through which the secondary explosion propagates. The nature of the dust, degree of confinement, amount of explosion venting provided, and quantity of dust in suspension (or in the case of secondary explosions, the amount still remaining to be thrown into suspension) are factors influencing the intensity of the explosion.

Explosions have been most prevalent in grain elevators, flour and feed mills, and cereal plants. The dust explosion hazard, however, is not confined to grain-handling plants. It also exists in a wide range of industries such as starch manufacturing, sugar refining, woodworking, sulphur crushing and pulverizing, hard rubber recovery, cork grinding, aluminum, magnesium and other metal powder plants, fertilizer plants, powdered milk plants, chocolate, cocoa and candy factories, and plastic and textile works.

There is no sharp line of demarcation between flammable liquids and gases. Liquids become gases at elevated temperatures, and gases become liquids at lower temperatures. Strictly speaking, flammable liquids are not a fire cause, though often referred to as such, for a spark or other source of ignition which might otherwise be harmless may cause fire in the presence of flammable liquids. Some liquids, such as carbon disulfide, ignite at temperatures considerably lower than required for the ignition of ordinary combustible materials. However, the improper use and handling of flammable liquids does cause many fires with resultant loss of property and life.

It is the vapor from the evaporation of a flammable liquid rather than the liquid itself which burns or explodes when mixed with air in the presence of a source of ignition. The hazard lies in the evaporation of the liquid when exposed to the air or under the influence of heat. Gases or vapors from flammable liquids are combustible and, when mixed with air in certain proportions, are explosive. For gasoline, these proportions range from slightly over 1% to about 6% by volume. One gallon of gasoline, if completely vaporized and mixed with air, will form explosive mixtures in volumes of from about 500 cubic feet to well over 2000 cubic feet. The explosive or flammable limit is that which includes the concentration of a mixture of flammable vapor or gas in air by volume, in which a flash will occur or a flame will travel if the mixture is ignited. The lower percentage at which this occurs is the lower explosive limit, and the highest percentage, the upper explosive limit. If such a mixture is confined and ignited, an explosion results. Many common flammable liquids and gases have very wide explosive ranges. Mixtures outside these limits are either too "lean" to explode or too "rich" to explode. The too "lean" mixture is below the lower explosive limit since it

does not have sufficient flammable vapor or gas in proportion to the amount of air, while the too "rich" mixture has too much flammable vapor or gas in proportion to the available air. Familiarity with the properties and characteristics of these flammable liquids and gases is important to the fire service because with such knowledge firemen can fight fires more effectively, reduce property damage and save lives. As it would be impossible to list every flammable liquid or gas, Figure 1 will characterize some of the most common ones encountered by the firemen.

Name	Synonyms	Flash Point Deg. F. Closed Cup	Explosive Limits % by Volume		Ignition Temperature Deg. F.	Specific Gravity (Water = 1.0)	Density of Vapor (Air = 1.0)	Rate of Diffusion (Air = 1.0)	Boiling Point Deg. F.	Suitable Extinguishing Agents
			Lower	Upper						
Acetaldehyde	Ethanal Acetyl Aldehyde	-36	4.1	55	365	0.78	1.52	0.81	70	3
Acetic Acid (Glacial)	Ethanoic Acid	104	5.4	......	800	1.05	2.07	0.74	245	1, 2A, 3
Acetone	2 Propanone Dimethylketone	0	2.6	12.8	1000	0.79	2.00	0.71	134	1, 2A, 3
Acetylene	Ethyne	Gas	2.5	81	635	none	0.90	1.05	-119	4
Acrylonitrile	Propenenitrile	32(oc)	3.0	17	898	0.80	1.83	0.74	171	2A, 3
Ammonia (Anhydrous)	......	Gas	16	25	1204	none	0.58	1.28	-37	4
Amyl Acetate-n	Banana Oil	77	1.1	......	750	0.88	4.49	0.48	300	2, 3
Asphalt	Petroleum Pitch	400+	......	......	905	0.95-1.1	......	......	700	1, 2, 3
Benzene	Benzol	12	1.4	7.1	1000	0.88	2.77	0.61	176	2, 3
Butadiene-1, 3	Erythrene	Gas	2.0	11.5	842	0.62	1.87	0.73	24	4
Butane-n	Methylethylmethane	Gas	1.8	8.4	1010	0.58	2.01	0.70	14	4
Butyl Alcohol	1-Butanol	84	1.4	11.2	650	0.81	2.55	0.63	243	1, 2A, 3
Carbon Disulfide	Carbon Bisulfide	-22	1.3	44	212	1.30	2.64	0.62	114	1, 3
Carbon Monoxide	......	Gas	12.5	74	1204	none	0.97	1.01	-314	4
Cellosolve	Ethylene Glycol, Monoethyl Ether	104	1.8	14.0	460	0.93	3.10	0.57	275	2A, 3
Chlorobenzene	Phenyl Chloride	85	1.3	7.1	1100-1200	1.11	3.88	......	270	2, 3
Cyclopropane	Trimethylene	Gas	2.4	10.4	928	none	1.45	0.83	-29	4
Dichloroethylene-1, 2	Acetylene Dichloride	43	9.7	12.8	......	1.28	3.35	0.55	141	1, 2, 3
Ethane	Methylmethane	Gas	3.0	12.5	950	none	1.04	0.98	-128	4
Ethyl Alcohol	Ethanol	55	4.3	19.0	793	0.79	1.59	0.78	173	1, 2A, 3
Ethyl Bromide	Bromoethane	......	6.7	11.3	952	1.43	3.76	0.52	100	1, 3
Ethyl Chloride	Chloroethane	-58	3.8	15.4	966	0.91	2.22	0.67	54	3
Ethyl Ether	Diethyl Ether	-49	1.9	48	356	0.71	2.56	0.62	95	2A, 3
Ethyl Methyl Ketone	......	30	2.0	10.1	374	0.70	2.07	0.63	50	3
Ethylene	Ethene	Gas	3.1	32	842	none	.98	1.01	-155	4
Ethylene Dichloride	1, 2-Dichloroethane	56	6.2	16	775	1.26	3.42	0.54	183	1, 2, 3
Ethylene Oxide	1, 2-Epoxyethane	<0	3.0	80	804	0.89	1.52	0.81	51	1, 3
Fuel Oil No. 1	Range Oil	100 min.	0.7	5	490	<1.0	......	0.47	304-574	2, 3
Fuel Oil No. 2	No. 3 on West Coast; Diesel Oil	100 min.	......	......	494	<1.0	......	......	......	2, 3
Fuel Oil No. 4	......	130 min.	......	......	505	<1.0	......	......	......	1, 2, 3
Fuel Oil No. 5	......	130 min.	......	......	......	<1.0	......	......	......	1, 2, 3
Fuel Oil No. 6	......	150 min.	......	......	765	1.0±	......	......	......	1, 2, 3
Gas, Illuminating	......	Gas	5.3	31	1094	none	......	1.24	......	4
Gas, Natural	......	Gas	3.8	13	......	none	......	1.34	......	4
Gas, Oil	......	Gas	6.0	13.5	637	none	......	......	......	4
Gas, Producer	......	Gas	14.1	95.6	......	none	......	......	......	4
Gas, Water	......	Gas	7.0	72	......	none	......	......	......	4
Gasoline	......	-45	1.4	7.6	......	0.75	3.0-4.0	0.53	100-400	2, 3
Heptane	......	25	1.0	6.0	452	0.68	3.45	0.54	208	2, 3
Hexane-n	......	-15	1.2	7.5	500	0.66	2.97	0.58	156	2, 3
Hydrazine	......	......	4.7	100	518	1.01	1.10	0.95	236	......
Hydrocyanic Acid	Prussic Acid	0	6	41	1000	0.70	0.93	0.82	79	1, 4
Hydrogen	......	Gas	4.0	75	1085	......	0.07	3.81	-422	4
Hydrogen Sulfide	......	Gas	4.3	45	500	......	1.18	0.93	-76	4
Kerosene	No. 1 Fuel Oil	100	0.7	5	490	<1.0	......	0.47	304-574	2, 3
Lubricating Oil	Paraffin Oil	300-450	......	......	500-700	<1.0	......	......	680	1, 2, 3
Methane	Marsh Gas	Gas	5.3	14.0	999	......	0.55	1.34	-258	4
Methyl Alcohol	Methanol	52	7.3	36	867	0.79	1.11	0.95	147	2A, 3
Methyl Chloride	Chloromethane	Gas	10.7	17.4	1170	0.92	1.78	0.75	-11	4
Mineral Spirits	Turpentine Substitute	104	0.77@212°	......	473	0.80	3.9	......	300	2, 3
Naphtha, Safety Solvent	Stoddard Solvent	100-110	1.1	6.0	450-500	<1.0	......	......	300-400	2, 3
Naphtha, V. M. & P.	Petroleum Naphtha	20	0.9	6.0	450	<1.0	3.75	......	212-320	2, 3
Naphthalene	White Tar	176	0.9	5.9	1038	1.15	4.42	0.48	424	1, 3
Pentane	Amyl Hydride	<-40	1.5	7.8	588	0.63	2.48	0.64	97	2, 3
Petroleum, Crude	......	20-90	......	......	......	<1.0	......	......	......	2, 3
Phenol	Carbolic Acid	175	......	......	1319	1.07	3.24	0.55	358	1, 3
Propane	Dimethylmethane	Gas	2.2	9.5	871	......	1.56	0.81	-45	4
Styrene	Vinylbenzene	90	1.1	6.1	914	0.91	3.60	......	293	2, 3
Toluene	Toluol	40	1.4	6.7	1026	0.87	3.14	0.56	232	2, 3
Transil Oil	Transformer Oil	295(oc)	......	......	......	0.90	......	......	......	1, 2, 3
Turpentine	......	95	0.8	......	464	<1.0	4.84	0.46	300	2, 3
Vinyl Chloride	Chlorethane	<0	4	22	......	0.97	2.15	0.68	7	4
Xylene-o	o-Xylol	63	1.0	6.0	900	0.88	3.66	0.52	291	2, 3

Courtesy: National Board of Fire Underwriters

Fig. 1 - Physical and Chemical Properties of Flammable Liquids and Gases

CHAPTER 3

CLASSIFICATION AND USES OF FIRE EXTINGUISHERS

INTRODUCTION

First aid fire-fighting appliances are essentially portable first aid devices used to extinguish fire. The ease of handling, the ability to provide the necessary extinguishing agent to put out the fire quickly and efficiently, the fact the extinguishers are ready for use when needed, make the extinguishers a necessary part of fire-fighting operations. However, the extinguishers are designed to cope with fires in their infancy and are not intended to act as a substitute for automatic sprinklers, standpipe and hose, or the fire department. Various types of first aid fire extinguishers will be described here. Each type is of value, but all are not equally effective upon all classes of fires. Therefore, consideration must be given to the class of fire involved, and the proper type of extinguisher to be used. As fires are classified, fire extinguishers are also classified. This is in accordance with the ability to extinguish the particular material or substance on fire.

CLASSIFICATION OF FIRES

For all practical purposes, there are three general classes of fires.

CLASS "A" FIRES - defined as fires in ordinary combustible materials such as wood, cloth, and paper where the "quenching-cooling" effect of quantities of water or solutions containing large percentages of water is most effective in reducing the temperature of the burning material below the ignition temperature.

CLASS "B" FIRES - defined as fires in flammable petroleum products or other flammable liquids, greases, etc., where the "blanketing smothering" effect of oxygen-excluding media is most effective.

CLASS "C" FIRES - defined as fires involving electrical equipment where the electrical nonconductivity of the extinguishing media is of first importance.

CLASSIFICATION OF FIRE EXTINGUISHERS

Based upon the preceding classification of fires and also upon fire extinguishment potentials as determined by physical testing of fire extinguishers by Underwriters' Laboratories, Inc., classifications have been established for first aid fire extinguishers.

This classification consists of a NUMERAL and a LETTER. It appears on the label affixed to the appliances labeled by Underwriters' Laboratories, Inc., and Underwriters' Laboratories, of Canada. The following explains the use of this system.

NUMERALS

Class "A" Extinguishers - The NUMERAL is indicative of the approximate relative fire extinguishing potential of various size Class "A" fire extinguishers, for example, a 4-A appliance can be expected to extinguish approximately twice as much as a 2-A appliance.

Class "B" Extinguishers - The NUMERAL is also indicative of the approximate relative fire extinguishing potential of various size Class "B" fire extinguishers, and in addition, the NUMERAL is an approximate indication of the square foot area of deep-layer flammable liquid fire which an average operator can extinguish. For example, a 10-B unit can be expected to extinguish ten square feet of deep layer flammable liquid fire when used by an average operator.

Class "C" Extinguishers. No NUMERAL is used since Class "C" fires are essentially either Class "A" or "B" fires involving energized electrical wiring and equipment. The size of the Class "C" extinguisher installed should be commensurate with the size and extent of the area involving the electrical hazard or containing equipment being protected, considering that it must be covered or blanketed by the Class "C" extinguishing media for effective fire extinguishment.

Type	Size	Classifications Under Old Method	Approximate Classifications Under Present Method
Chemical Solution (soda-acid)	1¼, 1½-gallon	A-2	1-A
	2½-gallon	A-1	2-A
	17-gallon	A	10-A
	33-gallon	A	20-A
Water and Antifreeze (Calcium Chloride Solution) (Expellant-Gas Operated)	1¼, 1½-gallon	A-2	1-A
	2½-gallon	A-1	2-A
	17-gallon	A	10-A
	33-gallon	A	20-A
Water (Pump Tank) (Pails in Tanks)	1½-gallon	A-2	1-A
	2½-gallon	A-1	2-A
	4-gallon	A-1	3-A
	5-gallon	A-1	4-A
	Six 10-quart pails and 25-gallon cask or tank (minimum)	A-1	2-A
Loaded Stream	1-gallon	A-2,B-4	1-A
	1¾-gallon	A-1,B-2	2-A,½-B
	2½-gallon	A-1,B-2	2-A,½-B
	17-gallon	A	10-A
	33-gallon	A	20-A
Foam	1¼, 1½-gallon	A-2,B-2	1-A,2-B
	2½-gallon	A-1,B-1	2-A,4-B
	5-gallon	A-1,B-1	4-A,6-B
	10-gallon	A,B	6-A,8-B
	17-gallon	A,B	10-A,10-B
	33-gallon	A,B	20-A,20-B
Vaporizing Liquid (carbon tetra-chloride base)	1, 1¼, 1½-quart	B-2,C-2	½-B,C
	2, 2½-quart	B-2,C-2	½-B,C
	1, 1½, 2, 3, 3½-gallon	B-2,C-1	1-B,C
Vaporizing Liquid (chlorobromo-methane)	1, 1½, 2-quart	B-2,C-2	1-B,C
	2½-quart	B-2,C-1	2-B,C
	1-gallon	B-2,C-1	2-B,C
Carbon Dioxide	6 or less pounds of carbon dioxide	B-2,C-2	1-B,C
	7½ pounds of carbon dioxide	B-2,C-1	2-B,C
	10 pounds of carbon dioxide	B-2,C-1	4-B,C
	12 pounds of carbon dioxide	B-2,C-1	4-B,C
	15 and 18 pounds of carbon dioxide	B-1,C-1	4-B,C
	20 pounds of carbon dioxide	B-1,C-1	4-B,C
	25 and 26 pounds of carbon dioxide	B-1,C-1	6-B,C
	50 pounds of carbon dioxide	B-1,C-1	10-B,C
	75 pounds of carbon dioxide	B-1,C-1	12-B,C
	100 pounds of carbon dioxide	B,C	12-B,C

NOTE: Carbon dioxide extinguishers with metallic horns do not carry any C classification.

Type	Size	Classifications Under Old Method	Approximate Classifications Under Present Method
Dry Chemical	6¼ or less pounds of dry chemical	B-2,C-2	4-B,C
	7½ pounds of dry chemical	B-2,C-1	6-B,C
	10 and 12 pounds of dry chemical	B-1,C-1	8-B,C
	15 pounds of dry chemical	B-1,C-1	8-B,C
	20 pounds of dry chemical	B-1,C-1	16-B,C
	30 pounds of dry chemical	B-1,C-1	20-B,C
	75 to 350 pounds of dry chemical	B,C	40-B,C
Wetting Agent	10 gallons	A,B	6-A
	20 gallons	A,B	12-A
	45 gallons	A,B	25-A
	50 gallons	A,B	30-A

Courtesy National Board of Fire Underwriters

Fig. 1 - Conversion of Extinguisher Classifications

LETTERS

The LETTER refers to the class of fire on which the use of the particular appliance is approved for most effective fire extinguishment.

Examples - A foam extinguisher, rated 2-A, 4-B should extinguish approximately twice as much Class "A" fire as a 1-A appliance, and four times as much Class "B" fire as a 1-B appliance. Also, the extinguisher should extinguish a fire in a deep-layer flammable liquid, such as a dip tank having a surface area of four square feet, when used by an average operator.

A dry chemical extinguisher, rated 6-B, C should extinguish six times as much Class "B" fire as a 1-B unit and should successfully extinguish a deep-layer flammable liquid fire of six square feet area when used by an average operator. It also is safe to use on fires involving electrical equipment.

TABLE FOR CONVERSION OF CLASSIFICATION OF OLDER EXTINGUISHERS TO APPROXIMATE PRESENT CLASSIFICATION

The method of classifying extinguishers used in the 1955 and earlier editions of NBFU No. 10 differs from the presently described method. The object of this table is to enable evaluation of older extinguishers in terms of the present method of classifying portable fire extinguishers.

Under the present method of classification it is possible for units of the same size to have different classifications. For example, 15 lb. carbon dioxide extinguishers may have a classification of 4-B:C, 6-B:C, or 8-B:C, according to the fire extinguishing potential of the individual units as determined by the Underwriters' Laboratories, Inc., and the Underwriters' Laboratories of Canada. Therefore, an exact conversion from the old method to new method of classification is not possible.

Wherever fire extinguishers are found with the present classification on the label, this table should not be used.

Wherever fire extinguishers are found with the old classification on the label, use this table for approximate conversion and use the resulting classification value. For example, a 15 lb. carbon dioxide extinguisher has the classification B-1, C-1 on the label. From this table, it is found that the approximate classification under the present method is 4-B,C. See Figure 1.

TYPES & USES OF FIRE EXTINGUISHERS

In accordance with the preceding classifications, a number of fire extinguishers have been developed for use in fire-fighting and fire protection. As it would be impossible to mention every type now in use, or now on the market, reference is made only to those normally used in fire-fighting operations. But regardless of the type used, it is well to keep in mind that only those extinguishers which carry the Underwriters' Laboratories Seal of Approval are guaranteed for capability and performance. It is also extremely important that instructions regarding maintenance are fully adhered to. Fire extinguishers must always be fully charged and in a condition which will permit efficient operation at any moment without delay.

WATER EXTINGUISHERS

These appliances are effective on small fires in ordinary combustible materials such as wood, paper, textiles, rubbish, etc., that is, Class "A" fires where the quenching and cooling effect of water or a solution containing a large percentage of water is of first importance. The extinguishers are not effective in fires in flammable liquids, greases, etc., in vats, tanks, open vessels, or any other Class "B" fire where the blanketing effect is essential. These appliances can be used, however, on small fires on floors made of combustible materials soaked with oils, greases, etc., where the cooling and quenching effect of water is important.

The use of these appliances in connection with Class "C" fires in electrical equipment such as panelboards, switchboards, motors, etc., is not recommended. While the stream is usually most effective if close to the fire, in case of necessity it can be directed from a distance of 30 to 40 feet horizontally.

Where freezing temperatures may be encountered, extinguishers should be filled with an anti-freeze solution consisting of granulated flaked calcium chloride (free from magnesium chloride) dissolved in water. Figure 2 shows approximately the temperature at which the resultant solution will freeze.

Anti-freeze solutions shall be mixed thoroughly in exact accordance with proportions given in Figure 2. Common salt must not be used as it may cause corrosion and make the extinguisher dangerous for use.

Extinguishers shall be kept full (to filling mark) at all times and recharged immediately after use. Re-

Proportions of Calcium Chloride & Water to Make 2-1/2 Gallons of Anti-Freeze Solution		
Approx. Freezing Temp. °F.	Water	Calcium Chloride
10^0	2 gals., 1 qt.	5 lbs.
0^0	2 gals., 1 pt.	6 lbs., 4 oz.
-10^0	2 gals.	7 lbs., 6 oz.
-20^0	2 gals.	8 lbs., 6 oz.
-30^0	2 gals.	9 lbs., 2 oz.
-40^0	2 gals.	10 lbs.

Fig. 2 - Proportions of Calcium Chloride and Water to Make 2-1/2 Gallons

weighing is the only method of determining whether or not the cartridge (of cartridge operated extinguishers) is fully charged. In recharging, all parts shall be thoroughly washed with water and the water flushed through the hose.

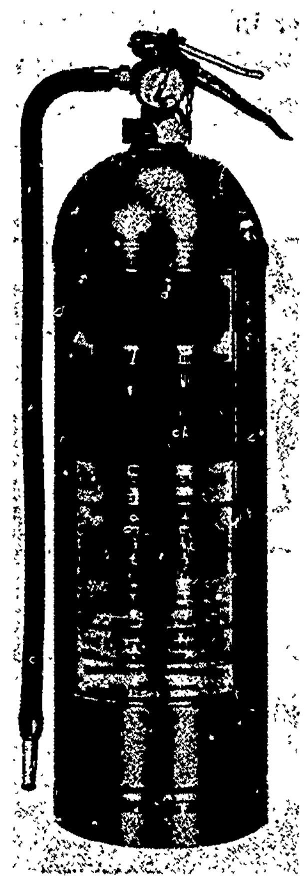
Extinguishers should be examined at regular intervals to detect deterioration, damage, clogged orifices, condition of hose, gaskets, and to see that the appliances are filled to the proper level. Pump operated extinguishers should be tested by operating with several strokes, then putting a drop of thin lubricating oil on the piston rod packing. At least semi-annually the cartridges of cartridge operated extinguishers should be removed, examined, and weighed on an accurate scale to detect loss of weight caused by leakage.

If a loss of ½ ounce or more from the original weight stamped on it is indicated, the cartridge should be replaced with a new one. Extinguishers of the stored-pressure type should be examined regularly to determine that the pressure as indicated on the extinguisher gauge is in the operable range.

Four types of water fire extinguishers most commonly found in the fire service are shown in Figures 3 through 10.

SODA-ACID EXTINGUISHERS

These appliances are effective on small fires in ordinary combustible materials, such as wood, paper, textiles, rubbish, etc., that is, Class "A" fires where the quenching and cooling effect of water, or a solution containing a large percentage of water is of first importance. The extinguishers are not effective on fires in flammable liquids, grease, etc., in vats, tanks, open vessels, or any Class "B" fire where the blanketing effect is essential. The appliances can be used, however, on small fires on floors made of combustible materials soaked with oils, greases, etc., where the cooling and quenching effect of water is important. The use of these appliances in connection with Class "C" fires in electrical equipment such as panelboards, switchboards, motors, etc., is not recommended.



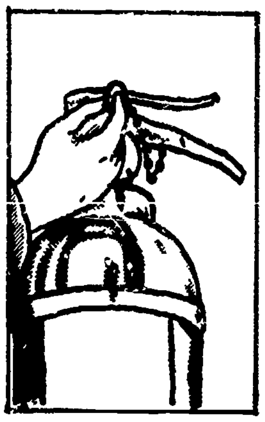
Courtesy The Fyr-Fyter Company

Fig. 3 - Pressurized Water Extinguisher

Ingredients such as common salt, calcium chloride, wetting agents, etc., must not be used in extinguishers of this type as these may either reduce the effectiveness of the discharge, or may corrode the extinguishers so as to make them dangerous for use.

The chemicals used are bicarbonate of soda and sulphuric acid. In the most common 2½ gallon size, 1½ pounds of the soda are dissolved in 2½ gallons of lukewarm water and placed in the shell, and 4 ounces of commercially (CP) pure sulphuric acid are placed in the acid bottle. To operate, the extinguisher is inverted causing the chemicals to mix. The resultant chemical reaction creates carbon dioxide gas which exerts a pressure of about 125p.s.i. within the container and expels the liquid from the tank. While the discharge does contain products of the chemical

HOW TO OPERATE



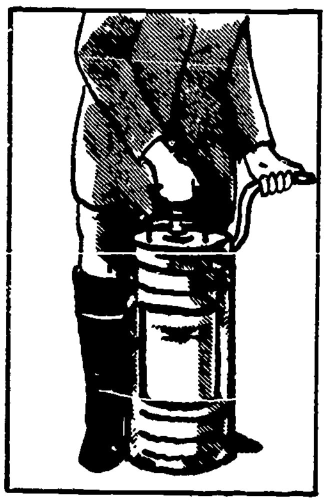
(1)
Keep extinguisher in upright position. Pull safety pin to break seal wire.

(2)
Aim nozzle and squeeze operating lever down to release stream.

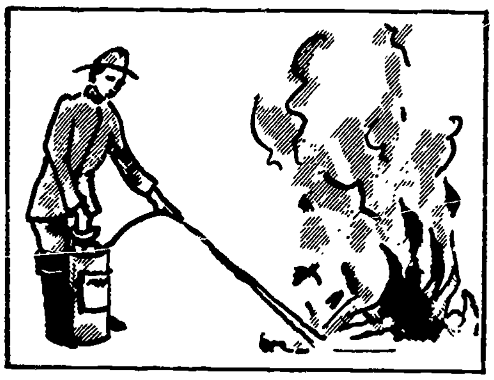
(3)
Direct stream at base of fire.

Fig. 4 - How to Use Pressurized Water Extinguisher

HOW TO OPERATE

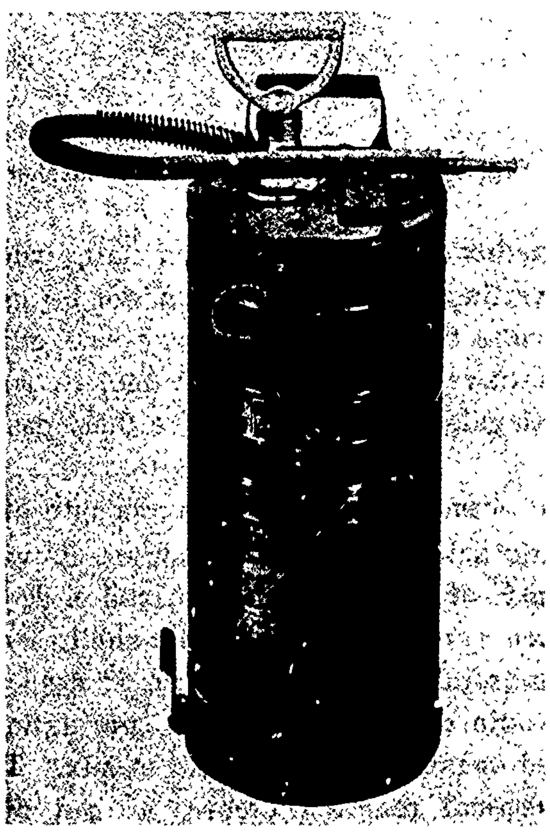


(1)
Raise and lower pump handle. Use foot-rest to hold tank steady.



(2)
Direct stream at base of fire.

Fig. 6 - How to Use Pump Operated Water Extinguisher



Courtesy The Fyr-Fyter Company

Fig. 5 - Pump Operated Water Extinguisher

Courtesy The Fyr-Fyter Company

Fig. 7 - Cartridge Operated Water Extinguisher

HOW TO OPERATE

(1)
Grip hose and ring with one hand. Grasp handle at bottom with other handle.

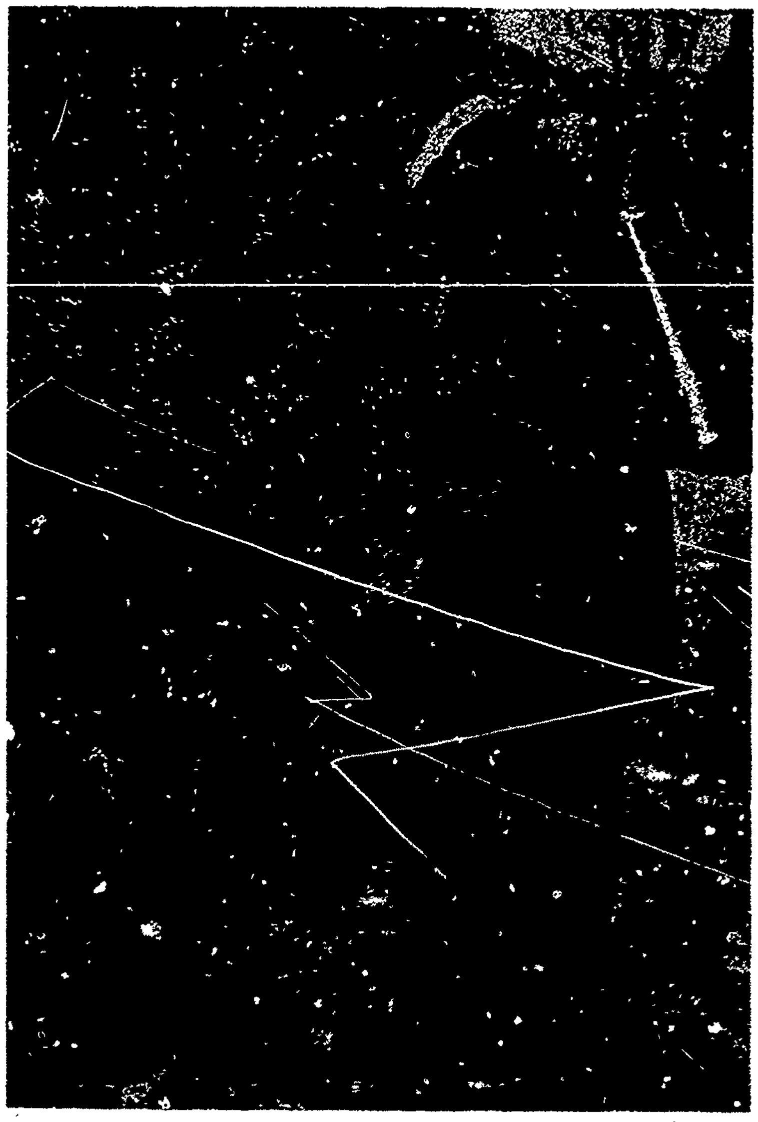
(2)
Invert and tap plunger on floor or ground. Keep grip on hose.

(3)
Direct stream at base of fire.

Fig. 8 - How to Use Cartridge Operated Water Extinguisher

Courtesy D. B. Smith & Company

Fig. 9 - Indian Fire Pump



Courtesy Loudonville, Ohio Fire Department

Fig. 10 - Indian Fire Pump In Use

reaction, the extinguishing agent is principally water. Although the stream is usually most effective if used close to the fire, in case of necessity it can be directed effectively from a distance of 30 to 40 feet horizontally. The force, range, and duration of the stream are not dependent on the operator. The 2½ gallon size discharges an effective stream of liquid for approximately one minute.

Extinguishers should be kept full (to the filling mark) at all times, and recharged immediately after use. In recharging, all parts should be thoroughly washed with water, and water flushed through the hose.

Extinguishers should be examined at regular invals to detect deterioration, damage, clogged orifices, condition of hose gaskets and to be sure of filling to the proper level. Extinguishers or parts which are not in good condition should be replaced immediately. It is important tha acid bottles, stopples and cages, when replaced, should be duplicates of those originally provided with the extinguisher. Otherwise the discharge may be impaired or the extinguisher rendered inoperative.

If not used, soda-acid extinguishers must be emptied and recharged annually. The appliances must also be protected against freezing. A conventional soda-acid extinguisher and its various parts are shown in Figures 11 and 12.

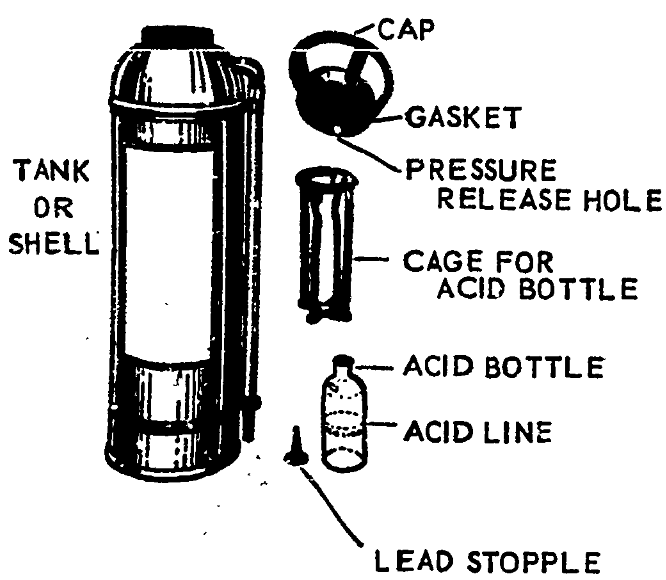


Fig. 11 - Soda-Acid Extinguisher

HOW TO OPERATE

(1)

Grip hose and ring with one hand. Grasp handle at bottom with other hand.

(2)

Turn upside down. Keep grip on hose.

(3)

Direct stream at base of fire.

Fig. 12 - How to Use Soda-Acid Extinguisher

FOAM EXTINGUISHERS

These appliances are effective on fires in small quantities of flammable liquids, greases, etc., in vats, tanks, open vessels, on floors, or any other Class "B" fire where the foam may be retained as a blanket on the burning material. Unless specifically noted on the name plate, these extinguishers are not to be used on fires involving alcohol, ether, acetone, lacquer thinner or carbon disulfide, because without the proper additive the foam bubbles are broken down rendering the smothering action ineffective. While these extinguishers are primarily intended for use on Class "B" fires, these are somewhat effective on incipient fires in ordinary combustible materials, such as wood, paper, textiles, rubbish, or other Class "A" fires. This is because 85% of the weight of the extinguishing agent is water. Therefore, it has some value in controlling fires where the cooling and quenching effect of water or solutions containing large percentages of water is important.

The use of these extinguishers in connection with fires in electrical equipment such as panelboards, switchboards, motors, and other Class "C" fires is not recommended.

Anti-freeze ingredients such as common salt, calcium chloride, etc., must not be used in extinguishers of this type, as these chemicals may either reduce the effectiveness of the discharge or may corrode extinguishers so as to make them dangerous for use.

Chemicals used to recharge this extinguisher are bicarbonate of soda and a foam stabilizing agent dissolved in water for the outer compartment, and aluminum sulphate dissolved in water for the inner cylinder. To operate, the extinguisher is inverted causing the chemicals to mix. The resultant chemical reaction produces a foam extinguishing agent, and also creates a pressure within the container which expels the foam through the hose. While the stream is usually most effective when directed from a distance, it may be used close to the fire. In case of necessity it can be directed effectively from a distance of 30 to 40 feet horizontally.

On flammable liquid fires, best results are obtained when the discharge from the extinguisher is played against the far inside wall of the vat or tank just above the burning surface, so as to permit the natural spread of the foam back over the burning liquid. The stream should not be directed into the burning liquid.

Where possible, the operator should walk around the fire while directing the stream, so as to get maxi-

mum coverage during the discharge period.

The force, range and duration of the stream are not dependent upon the operator. The 2½ gallon extinguisher discharges an effective stream of foam for approximately one minute.

Extinguishers should be recharged immediately after use. In recharging, all parts should be washed thoroughly with water, and water flushed through the hose.

Extinguishers should be examined at regular intervals to detect deterioration, damage, clogged orifices, condition of hose, gaskets, and to see that the appliances are filled to the proper level. Extinguishers or parts which are not in good condition should be replaced immediately. If not used, foam extinguishers

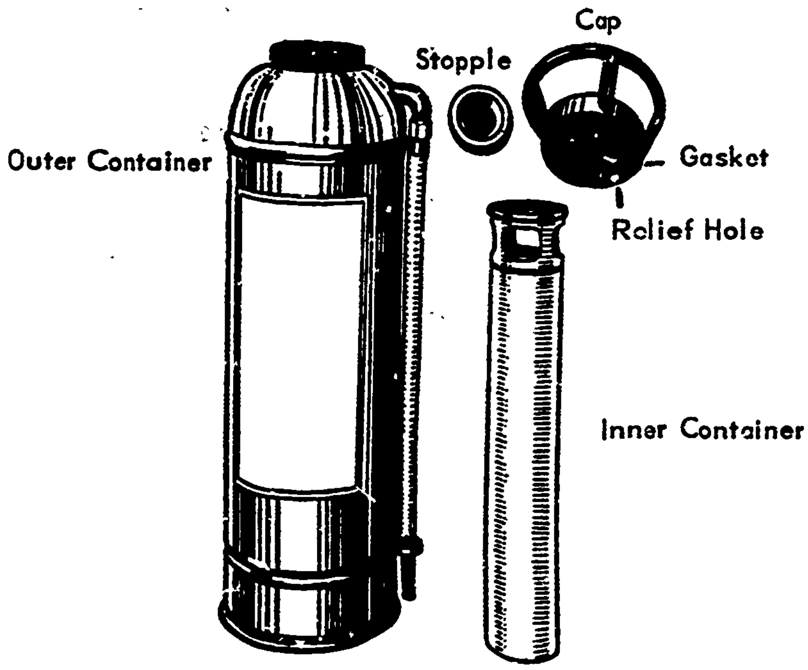


Fig. 13 - Foam Extinguisher

must be emptied and recharged annually. Only charges supplied by the manufacturer should be used. The chemicals must be thoroughly stirred and dissolved in water and in exact accordance with the instructions given on the charging units. They also must be protected against freezing.

Generally, about a 50% water solution of aluminum sulphate is used in the inner chamber; 8% bicarbonate of soda, 89% water and 3% stabilizer is used in the large outer container. The stabilizer may be of secondary extract of licorice, saponin or chicle, etc. Its purpose is to make the bubbles smaller in size and more tenacious. It takes no part in the reaction other than a purely physical one. The principal extinguishing agent consists of minute bubbles of carbon dioxide entrapped in walls of insoluble aluminum hydrate which form a strong, tough, elastic, and adhesive foam. It is composed of 90% carbon dioxide gas by volume, and forms a blanket of bubbles which excludes the oxygen, and, at the same time cools the surface. The maximum pressure generated is about 100 pounds, and the common 2½ gallon size will produce about 20 gallons of foam when properly charged. A conventional foam extinguisher and its various parts and use is shown in Figures 13 and 14.

HOW TO OPERATE

(1)

Grip hose and ring with one hand. Grasp handle at bottom with other hand.

(2)

Turn upside down. Keep grip on hose.

For Burning Liquids

Aim foam against inside of container *above* liquid, *never into* liquid.

For Wood, Paper, Textiles, etc.

Direct stream at base of fire, and spread foam over burning surface.

Fig. 14 - How to Operate Foam Extinguisher

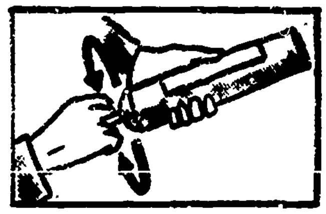
VAPORIZING LIQUID EXTINGUISHERS

These extinguishers are effective on fires in small quantities of flammable liquids, greases, etc., in vats, tanks, or other open vessels or on floors or surfaces involving Class "B" fires where the gas formed by the vaporization of the extinguishing liquid may be retained as a blanket on the burning material. These are also effective on small fires in electrical equipment such as motors, panelboards, switchboards, or other Class "C" fires, where a nonconducting extinguishing agent is of importance. These appliances are also suitable for use on automobiles.

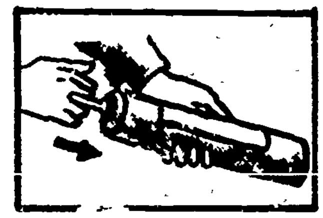
Courtesy Walter Kidde & Company, Inc.

Fig. 15 - One Quart Pump-Type Carbon Tetrachloride Extinguisher

HOW TO OPERATE



Unlock handle with quarter turn to left or right.



Pull out handle, push in. Stream starts immediately.

FOR ELECTRICAL EQUIPMENT

Turn off current, if possible. Aim stream into burning part.

FOR BURNING LIQUIDS

Aim stream against inside of container *above* liquid, *never into* liquid.

Aim stream at nearest flames. Sweep out fire while advancing.

Fig. 16 - How to Use Pump-Type Carbon Tetrachloride Extinguisher

The extinguishers are not effective on deep-seated fires of ordinary combustible materials such as wood, paper, textiles, rubbish, or other Class "A" fires which require the quenching and cooling effect of water for complete extinguishment. These may, however, be of some value on surface fires in small quantities of such material where the smothering effects of the gas may be utilized.

In using extinguishers of this type, especially in unventilated spaces, firemen should take precautions to avoid the effects caused by breathing the gases or vapors liberated or produced. Studies made of the effects of these vaporizing liquids indicate the gases are toxic both before and after decomposition. In the presence of flame or hot surfaces carbon tetrachloride may decompose and form hydrochloric acid, phosgene, and free chlorine. Chlorobromomethane, like carbon tetrachloride is a halogenated hydrocarbon, whose vapors are toxic and even have a higher narcotic action. When used on a fire CBM decomposes and produces traces of hydrochloric acid, phosgene, bromophosgene, and in some cases free bromine and chlorine. It is recommended that gas masks be worn when using these types of vaporizing liquid extinguishers.

These extinguishers are either of the hand-operated type, where the liquid is expelled by means of a manual pumping action, or, the stored-pressure type where the liquid is expelled by pressurized moisture-free dry air or nitrogen. While the stream is usually most effective if used close to the fire, it can be directed from a distance of 20 to 30 feet horizontally.

On all fires the stream should be directed at the base of the flames. On flammable liquid fires, best results are obtained when the discharge from the extinguisher is played against the inside of the wall of the container, just above the burning surface, so as to break up the stream near the burning surface. The stream should not be directed into the burning liquid. Where possible, the operator should walk around the fire while directing the stream, so as to get maximum coverage during the discharge period. The force, length, and duration of the stream are dependent upon the operator, but under average uses, the liquid will be completely discharged in 3/4 of a minute of continuous operation in the smaller sizes.

The extinguishing agent used is a specially treated, nonconducting liquid, having a freezing point of at least 50°F below zero, and a corrosive inhibiting ingredient. Do not use water in extinguishers of this type. Liquid other than that furnished by the extinguisher manufacturer should not be used in these ex-

Courtesy The Fyr-Fyter Company

Fig. 17 - Manually Operated Pressurized Carbon Tetrachloride Extinguisher

tinguishers because it is liable to render the extinguisher inoperative or make it dangerous for use.

Extinguishers should be kept full at all times and be refilled after use. Extinguishers should be examined at regular intervals to detect damage, corrosion, condition of pump or pressure, and to see that the orifice of the nozzle is not clogged. If an extinguisher of the stored pressure type shows evidence of corrosion or mechanical damage, it may be unsafe for further use and should be returned to the manufacturer for examination. Manually operated pump type extinguishers should be tested by discharging a portion of the liquid with the stream directed alternately upward and downward. Those in poor condition or operating improperly should be replaced or returned to the manufacturer for examination. Two types and how to use them are shown in Figures 15 to 18.

Fig. 18 - How to Use Pressurized Carbon Tetrachloride Extinguisher

CARBON DIOXIDE EXTINGUISHERS

These extinguishers are effective on fires in small quantities of flammable liquids, greases, etc., in open vessels, tanks, vats, or on floors or any other Class "B" fires where a smothering action is required to extinguish the flame. These are also effective on small fires in electrical equipment or Class "C" fires where a nonconducting extinguishing agent is of importance. The extinguishers are suitable for use on automobiles, motor boats, etc., but are not recommended for use on deep-seated fires of ordinary combustible materials such as wood, paper, textiles, rubbish, or other Class "A" fires which require the quenching and cooling effect of water for complete extinguishment. The appliances may be of value for surface fires in smaller quantities of such material where the smothering effects of the gas may be utilized.

When the trigger or lever on the extinguisher is operated, a cloud of carbon dioxide gas with some snow is expelled from the container through the horn. As the gas is inert and does not support combustion, the flame is smothered for lack of air and the fire is extinguished. This type of extinguisher contains liquid carbon dioxide under a pressure of 800 to 900 p.s.i. at normal room temperature. The pressure will vary at different temperatures. See Figure 19. The expansion of the liquid carbon dioxide as it escapes from the orifice in the horn chills it to low temperatures so that approximately 30% of the liquid carbon dioxide is converted into solid carbon dioxide "snow" or "dry ice". Although the cooling effect of this snow is a factor in preventing flashback, it is negligible and unimportant in the extinguishment of the fire compared to the smothering action of the gas itself. This gas when it leaves the container expands at a ratio of 450 to 1. One pound of liquid carbon dioxide converted to gas at room temperature will occupy approximately 8.6 cubic feet. Carbon dioxide at ordinary temperature and atmospheric pressure is one and one-half times heavier than air.

The force, range, and duration of the discharge are independent of the operator when the valve is open. On flammable liquid fires best results are obtained when the discharge from the extinguisher is employed to sweep the flame off the burning surface, applying the discharge first at the near edge of the fire and gradually progressing forward, moving the

Pressures in CO_2 Fire Extinguishers at Varying Temperatures	
Temp. °F.	Pressures, P.S.I.
Minus 10	245
Zero	295
Plus 10	345
" 20	400
" 32	489
" 40	550
" 50	635
" 60	729
" 70	834
" 80	960
" 90	1190
" 100	1450
" 110	1710
" 120	1980
" 130	2250
" 140	2530
" 150	2810
" 160	3090

Fig. 19 - Pressures in CO_2 Fire Extinguishers at Varying Temperatures.

discharge cone slowly from side to side. The 20 and 25 pound size usually found in the fire service has an effective range of approximately 8 feet and a period of discharge of about one minute. One of the advantages of this type of extinguisher is that there is no residue from the extinguishing agent. Carbon dioxide like any inert gas, may produce suffocation due to oxygen deficiency if high concentrations of the gas are breathed for extended periods of time. Thus, when extinguishers of this type are used in confined spaces, firemen should take precautions to avoid the effects which may be caused by breathing the vapors or gas liberated or produced.

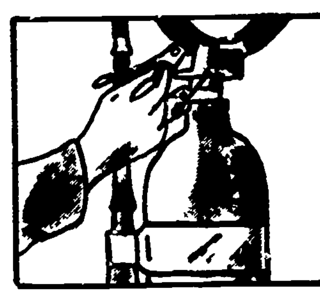
While the extinguisher is being used, it must remain in an upright position to eliminate the possibility of liquid carbon dioxide entering the expelling tube. Care should also be taken when directing the discharge to keep it away from the eyes. Before approaching the fire, it is recommended that the extinguisher be tested by briefly squeezing the grip to check for workability.

Extinguishers should be kept full at all times. Reweighing is the only method of determining wheth-

Courtesy The Fyr-Fyter Company

Fig. 20 - Carbon Dioxide Extinguisher

(1) Lift extinguisher from bracket and carry near to fire.



(2) Pull out safety lock pin.

(3) Grasp handle of discharge horn. . . pull horn out of clamp.

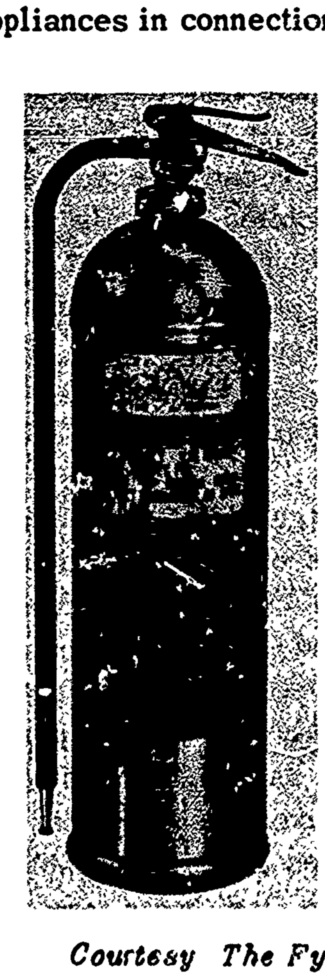
(4) Squeeze grip to open valve. Aim discharge at base of flames, using a sweeping motion.

Fig. 21 - How to Use Carbon Dioxide Extinguisher

er or not the extinguisher is fully charged. It is recommended by the NBFU that extinguishers be refilled immediately after use even though only partly discharged. At regular intervals extinguishers should be examined to detect damage, deterioration, or leakage. Extinguishers and parts which are not in good condition should be replaced. Any extinguishers which show a loss of 10% or more of the rated capacity stamped on it should be recharged. Extinguishers of this type must be sent to the manufacturer, an authorized agent of the manufacturer, or a producer of carbon dioxide for recharging unless recharging facilities are available. These appliances do not need to be protected against freezing. A 15 lb. carbon dioxide extinguisher is shown in Figures 20 and 21.

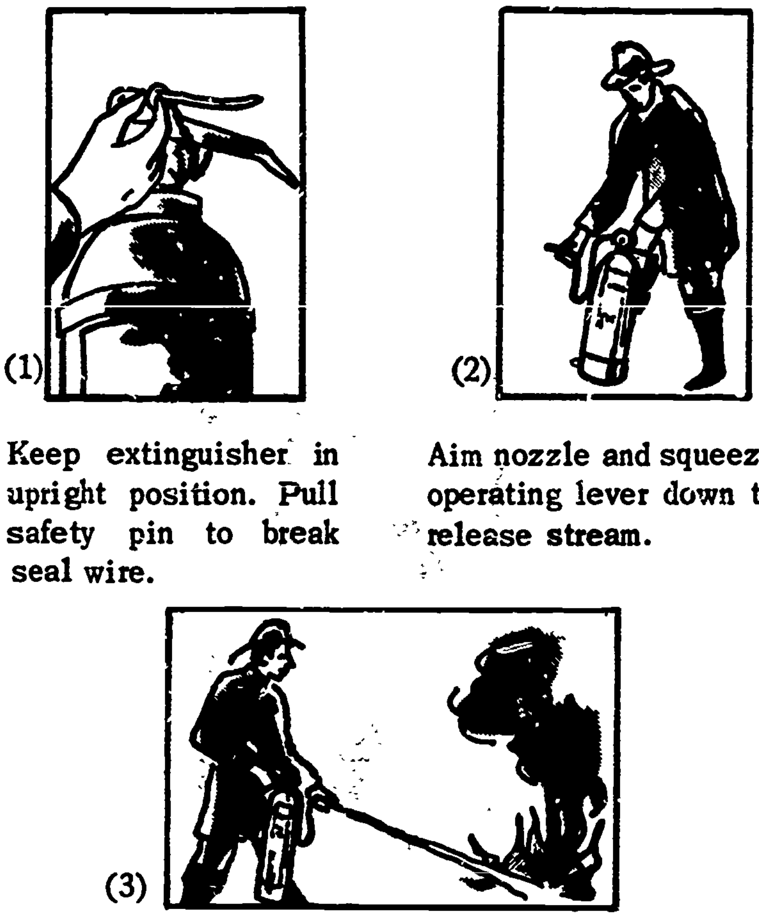
LOADED STREAM EXTINGUISHERS

These extinguishers are effective on small fires in ordinary combustible materials such as wood, paper, textiles, rubbish, or other Class "A" fires where the quenching and cooling effect of quantities of water or a solution containing a large percentage of water is of first importance. The appliances are somewhat effective on fires in small quantities of flammable liquids, greases or other Class "B" fires in vats or open vessels, or on floors made of combustible materials soaked with grease or oil. The use of these appliances in connection with electrical



Courtesy The Fyr-Fyter Company

Fig. 22 - Pressurized Loaded Stream Extinguisher



(1) Keep extinguisher in upright position. Pull safety pin to break seal wire.

(2) Aim nozzle and squeeze operating lever down to release stream.

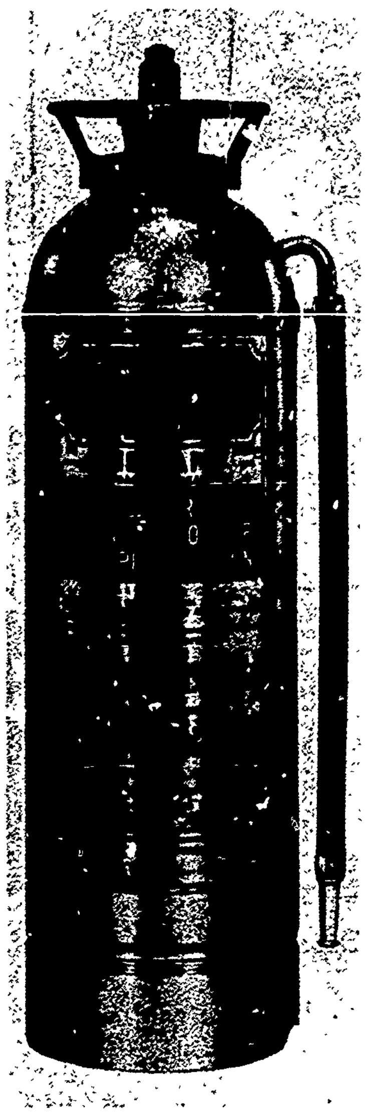
(3) Direct stream at base of fire.

Fig. 23 - How to Use Pressurized Loaded Stream Extinguisher

fires such as panelboards, switchboards, motors, and other Class "C" fires is not recommended.

The chemical used is a solution of alkali-metal-salt, which has a freezing point of 40°F below zero. Pressure to expel the liquid is produced either by a carbon dioxide gas cartridge which is pierced when the extinguisher is inverted and bumped on the floor, or, by air pressure in the cylinder which is released by squeezing a handle or lever on the top of the unit.

While the alkali-metal-salt solution produces a chemical reaction which tends to inhibit or restrain oxidation, it does not produce a smothering vapor to blanket the fire. The solution acts as a fireproofing agent coating the material, thus preventing rekindling. The force, range and duration of the stream are not dependent upon the operator. The effective range is approximately 30 to 50 feet, and the 2½ gallon size will discharge an effective stream for approximately one minute. On all fires, the stream should be directed at the base of the flame. On flammable liquid fires, best results are obtained when the discharge from the extinguisher is played against the inside wall of the container, just above the burning surface. The stream should not be directed into the burning liquid. Where possible, the operator should walk around the fire while directing the stream so as to get maximum coverage during the discharge period.



Courtesy The Fyr-Fyter Company

Fig. 24 - Cartridge Operated Loaded Stream Extinguisher

HOW TO OPERATE

(1)

Grip hose and ring with one hand. Grasp handle at bottom with other hand.

(2)

Invert and tap plunger on floor or ground. Keep grip on hose.

(3)

Direct stream at base of general combustible fires.

Fig. 25 - How to Operate Cartridge Operated Loaded Stream Extinguisher

Extinguishers should be kept fully charged at all times and recharged immediately after use. Weighing is the only method of determining whether the cartridge (of cartridge-operated units) is fully charged. In recharging these extinguishers, all parts should be thoroughly washed with water and the water flushed through the hose. All water should be removed from the hose to prevent clogging of the hose and nozzle due to freezing. In the pressurized type, the pressure gauge should indicate an air charge of 125 pounds. Chemicals and cartridges other than those furnished by the manufacturer should not be used in these extinguishers, because these are liable to render the extinguishers inoperative or make them dangerous for use.

At regular intervals extinguishers should be examined to detect corrosion, deterioration, damage, clogged orifices, condition of hose gaskets, and to see that they are filled to the proper level. Extinguishers or parts which are not in good condition should be replaced or returned to the manufacturer for examination and correction. The cartridge should be removed and weighed. If it shows a loss of weight of ½ ounce or more from the original weight stamped on the cartridge, it should be replaced with a new cartridge. In the cartridge or pressurized type, no recharge is required annually, only the cartridge weight or correct pressure must be maintained. Pictures of loaded stream extinguishers can be seen in Figures 22 through 25.

DRY CHEMICAL EXTINGUISHERS

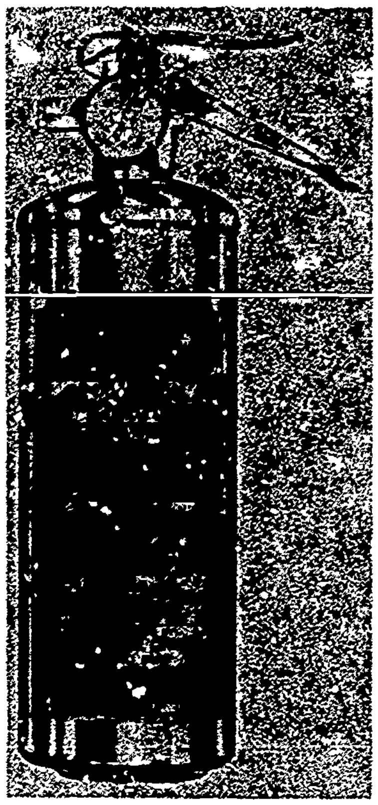
These extinguishers are effective on fires in small quantities of flammable liquids, greases, and other Class "B" fires in open vessels or on floors where the cloud of chemical may be employed to smother the flame. These are effective on small fires in electrical equipment such as panelboards, switchboards, motors, and other Class "C" fires where a nonconducting extinguishing agent is of importance. These appliances are also suitable for use on fires involving automobiles, boats, etc. Dry chemical extinguishers are not recommended for deep-seated fires in ordinary combustible materials such as wood, paper, textiles, rubbish, and other Class "A" fires

which require the quenching and cooling effect of water for complete extinguishment. The extinguishers may be of some value for surfcce fires in small quantities of material where the smothering effect of the extinguishing agent may be effective. The fire extinguishing agent used is a specially treated sodium bicarbonate in dry powder form with components for producing free flow and water repellency.

When the pressurized extinguisher is operated, gas or air expels the dry chemical from the chemical chamber in a cloud from the nozzle. In the case of a cartridge-operated extinguisher, release of the gas from the cartridge is accomplished by pushing the handle down which punctures a sealed disc in the cartridge. This released gas pressurizes the dry chemical chamber and expels the dry chemical. The discharge is controlled by the shut-off nozzle at the end of the hose. With a pressurized dry chemical extinguisher, both the dry chemical and expellent are stored in a single chamber under a pressure of about 150 p.s.i. By squeezing or gripping the extinguisher valve, the valve is opened allowing the stored air pressure to expel the dry chemical from the chamber through the hose. Release of the extinguisher valve provides a shut-off feature.

Best results are obtained by attacking the near edge of the fire and progressing forward, moving the nozzle rapidly with a side-to-side sweeping motion. Some extinguishers have relatively high velocity nozzles, and to prevent splashing when used on depths of flammable liquid, care should be taken to direct the initial discharge from a distance not closer than 6 to 8 feet. This warning is usually prominently marked on the extinguisher's name plate. On surface fires involving textiles, the discharge should be directed at least 3 or 4 feet above the flame from a distance of 8 to 10 feet. By this procedure, the dry chemical provides a coating on surface areas, preventing rekindling. It also inerts the material, thus retarding progress of the fire. With the nozzle open and the extinguisher in full operation, the force, range and duration of the stream are not dependent on the operator. An effective continuous discharge is obtained for approximately one minute. The extinguisher must remain in an upright position when being discharged to prevent the possibility of the powder not being expelled properly. Before approaching the fire, it is recommended that the extinguisher be tested by briefly squeezing the grip to check workability.

Extinguishers should be kept full with the specified quantity of dry chemical at all times. In the case of cartridge operated extinguishers, cartridges



Courtesy: The Fyr-Fyter Company

Fig. 26 - Pressurized Dry Chemical Extinguisher

shall be kept fully charged. Weighing is the primary method of determining whether or not the cartridge is fully charged. In the case of pressurized extinguishers, proper expelling pressure must be maintained. Examination of the pressure guage indicates whether or not the extinguisher is properly pressurized. Extinguishers should be refilled immediately after use, even though only partly discharged. Before recharging, the hose should be cleaned of all dry chemical.

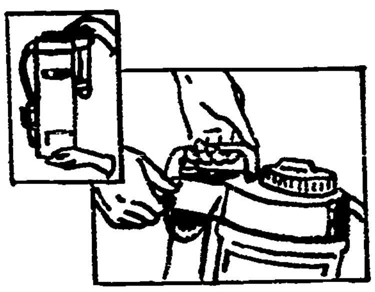
Extinguishers should be examined at regular intervals, to detect injuries, clogged orifices, and to see they are filled. At least semi-annually cartridges should be removed and weighed to detect any loss of contents by leakage. If the loss of weight is in excess of that permitted by the manufacturer, the cartridge should be replaced. Gaskets, hose, and the tightness of the threaded connection must also be examined to make certain the extinguisher will operate properly.

The powder in these extinguishers should be stirred frequently to keep it from packing.

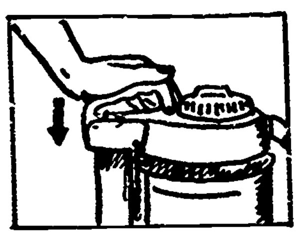
Extinguishers or parts which are not in good condition should be replaced or returned to the manufacturer for examination and repair. Chemicals or cartridges, other than those furnished by the manufacturer, should not be used in these extinguishers, and manufacturers' recharging instructions should be carefully followed. Extinguishers of this type do not need to be protected against freezing. A moisture trap is recommended to be used when recharging pres-

Courtesy. The Fyr-Fyter Company

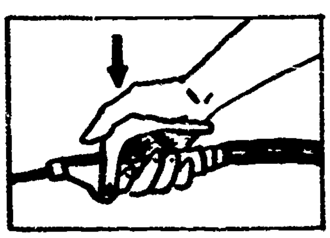
Fig. 27 - Cartridge Type Dry Chemical Extinguisher



(1) Pull out safety pin on handle.



(2) Push handle down to puncture cartridge.



(3) Squeeze valve to release discharge.

(4) Sweep off nearest flames by moving nozzle rapidly from side to side while advancing.

Fig. 28 - How to Use Cartridge Type Dry Chemical Extinguisher

surized type extinguishers. These extinguishers are illustrated in Figures 26 and 27. The use of the pressurized dry chemical extinguisher is the same as shown in Figure 18, page 35. The use of the cartridge type dry chemical extinguisher is shown in Figure 28.

A, B AND C DRY CHEMICAL EXTINGUISHERS

These extinguishers are a new development in the area of fire extinguishment and only recently have been approved by the N.B.F.U. Due to their newness in the field, a thorough description of their use and operation is somewhat limited. However, in keeping with the contents of this chapter, they are described as follows:

They are approved for all classes of fires, and are available in three sizes -- 5 lb., 15 lb., and 25 lb. The poundage denotes the weight of the powder contained in each unit. The chemical action of the powder, upon contact with fire, has the following effect on the various classes of fire:

Class A. Insulation is provided automatically by the deposit formed by the powder on the burning material. Cooling is effected because the change from powder to deposit utilizes and absorbs heat.

Courtesy Alim Corporation

Fig. 29 - ABC All Class Extinguisher

Class B. The powder has a smothering and cooling effect on fires of this classification.

Class C. The powder is a non-conductor of electricity and is approved for live electrical fires requiring a non-conducting extinguishing agent.

Magnesium (combustible metal). The powder forms a cooling, insulating armor on burning materials which require a heavy smothering and cooling extinguishing agent.

Units are pressurized with nitrogen at 150 p.s.i. Powder contents are discharged by squeezing the grip on the operating lever. The powder cloud is non-toxic and non-abrasive. The unit is operable to -40° F. This extinguisher is shown in Figure 29.

GENERAL INFORMATION

1. Every five (5) years extinguishers which have been in service should be subjected to a hydrostatic pressure test to determine whether the appliances are still capable of safely withstanding the pressures which might be generated during operation. The National Board of Fire Underwriters' Bulletin #10 outlines, in Section 71, the recommended test procedures for determining the safety of the extinguisher.

2. Department records should be maintained for each extinguisher, indicating date of purchase, date used, inspection dates, recharging, replacements, repairs, etc. for future reference.

3. In some cases, fires in electrical equipment may be such that the cooling and quenching effect of water or a solution containing a large percentage of water is necessary. In such cases, the main power supply to the electrical equipment involved should be turned off before applying water or water solutions.

4. All extinguishers should be examined at least once a year to positively determine if they are in proper operating condition.

5. First-aid fire extinguishers are designed for use on fires in the early stages and cannot be expected to be adequate if applied after a fire has spread to a large quantity of combustible material.

6. Each type of fire extinguisher described in this chapter is of value. The extinguisher should be of the correct type and size to extinguish the class of fire involved.

7. The instructions of the manufacturer of the extinguisher regarding charging, maintenance and operation should be followed exactly.

8. Extinguishers containing stored gases or acids should not be kept in an area subjected to freezing or where the temperature will exceed 120° F.; these conditions will damage the extinguisher.

9. In regard to foam compatible dry chemicals, it has been fairly well established that sodium bicarbonate base dry chemicals and mechanical foam are incompatible. The ordinary dry chemicals contain stearates or silicones which are intended to impart free flowing and non-caking characteristics to the powder. It is these stearates and silicones which are the bad actors in the breakdown of mechanical foam. It has been well established that if a fire is attacked with dry chemical extinguishers and then followed up with mechanical foam, the foam will break down so rapidly that the ordinary recommended rates of discharge will not be sufficient to extinguish the fire. There have been a few exceptions in experiments, but in general it can be regarded that the application of mechanical foam will be ineffective after a fire has been attacked with dry chemical.

TYPES, SIZES AND USES OF FIRE EXTINGUISHERS

The various types, sizes and uses of fire extinguishers are shown in the chart in Figure 30.

FIRE EXTINGUISHERS - TYPES, SIZES, USE

	VAPORIZING LIQUID	SODA ACID	FOAM	CO_2	WATER	LOADED STREAM	DRY POWDER
TYPES AND SIZES USED	1 quart to 3-1/2 gallons	1-1/4 gallons 2-1/2 gallons	1-1/4 gallons 2-1/2 gallons	5 to 25 pounds	1-1/2 to 5 gallons	1 to 2-1/2 gallons	5 to 20 pounds
OPERATION	Pump type Air pressure	Invert	Invert	Open valve	Pump air cartridge gas pressure	gas cartridge	Gas cartridge air pressure
MAINTENANCE	Inspect for leakage	Recharge annually	Recharge annually	Inspect for leakage by weighing	Keep full Inspect for leakage	Inspect for leakage	Inspect for leakage
CONDUCTOR OF ELECTRICITY	No	Yes	Yes	No	Yes	Yes	No
RANGE	Approximately 20 - 40 feet	Approximately 30 feet	Approximately 30 feet	Approximately 8 feet	Approximately 30 feet	Approximately 50 feet	Approximately 6 to 8 feet
TIME REQUIRED TO EMPTY	Rate of pumping 1/2 to 2-1/2 minutes	Approximately 1 minute	Approximately 1 minute	Approximately 1 minute	Rate of pumping 1/2 to 2-1/2 minutes	Approximately 1 minute	Approximately 1 minute
CHEMICALS USED	CCl_4 CBM CB	Bicarbonate of soda sulphuric acid acid	Alum sulphate - bicarbonate of soda foaming agent	Liquid CO_2	Water	Solution of alkali metal salts	Chemically processed dry powder
NEED OF FREEZING PROTECTION	No	Yes	Yes	No	Yes	No	No
EXTINGUISHING EFFECT	Smothering cooling	Quenching cooling	Blanketing cooling	Smothering by cooling	Quenching cooling	Quenching cooling	Blanketing smothering
EFFECT ON CLASS "A" FIRES	Poor	Excellent	Fair	Poor	Excellent	Excellent	Poor
EFFECT ON CLASS "B" FIRES	Fair	Poor	Excellent	Good	Poor - should not be used	Good	Excellent
EFFECT ON CLASS "C" FIRES	Excellent	Poor - should not be used	Poor - should not be used	Excellent	Poor - should not be used	Poor - should not be used	Good

Courtesy National Board of Fire Underwriters

Fig. 30 - Types, Sizes, and Uses of Fire Extinguishers

CHAPTER 4

WATER AS USED IN FIRE FIGHTING

INTRODUCTION

Due to its high heat absorption capacity, water is the most widely used extinguishing agent. Many cities, villages and some townships have water systems that are used for fire fighting purposes, while other communities depend upon wells, cisterns, ponds, rivers, tank wagons and booster tanks to provide water for fire extinguishment. Regardless of the source of supply, the local fire department must be equipped to transport this water through suction hose, pumps, fire hose and nozzles to the place where the water can best be used to extinguish the fire.

All firemen should know the loss that can occur when water is improperly used to extinguish a fire. Because water is a principal extinguishing agent, all firemen must know its extinguishing powers and the amounts available in each community.

Successful fire fighting depends upon an adequate fire stream, which may be defined as one that cools the material below its ignition point. One individual type of fire stream, at a common pressure, will not always meet the demand. Consequently, there are different types of fire streams used to meet different conditions.

When used as an extinguishing agent, water must be applied properly to achieve the highest extinguishing effect with the least amount of water damage. Therefore, firemen should know how to use modern fire fighting equipment in order to obtain the most efficient fire streams possible.

HEAT ABSORPTION OF WATER

The function of water in extinguishment of fires is to absorb heat from both the burning material and the heated gases until the temperature falls below its ignition point. This cooling effect can be explained as follows: When cool or cold water contacts the burning material, the temperature of the water rises rapidly to the point where steam is produced. As the heat from the burning material is absorbed by the water, the temperature of the burning material falls below its burning temperature. The steam, formed by the rapid absorption of heat from the burning material, also helps to extinguish the flame by a smothering action cutting off the supply of oxygen in the air.

In the laboratory the standard measurement of heat is the British Thermal Unit, (generally expressed as the B.T.U.), and is defined as the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit. Another point to be remembered is that 970 B.T.U.'s are required to turn one pound of boiling water into steam. It has also been demonstrated in the laboratory that in order to bring one pound of water at 60° F., (which might be considered the average temperature of water used for fire fighting), to the boiling point, (212° F.), it would require 152 B.T.U.'s (212° F. minus 60° F. equals 152° F.). Therefore, to bring this pound of water from 60° F. to steam, it would require 152 B.T.U.'s plus 970 B.T.U.'s for a total of 1,122 B.T.U.'s.

152 B.T.U.'s + 970 B.T.U.'s = 1,122 B.T.U.'s

This illustration shows the enormous heat absorbing capacity of water; and from it, it can easily be seen that the nozzleman should direct the water in a manner that will cause it to change to steam as quickly as possible. This can best be accomplished by the indirect application method.

INDIRECT APPLICATION OF WATER

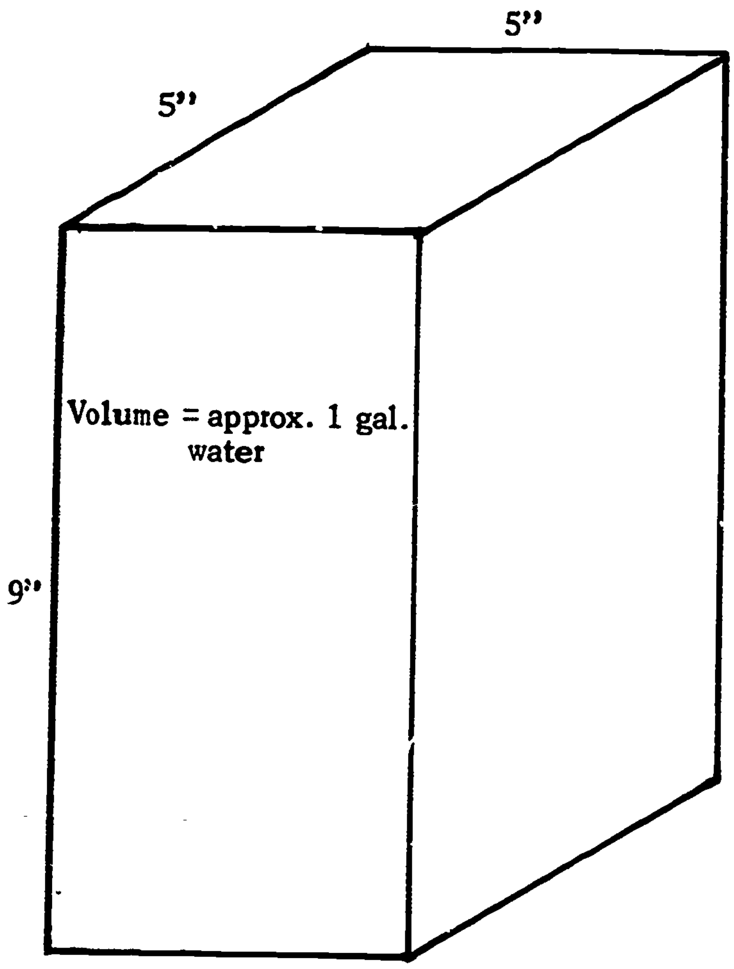
Ignition Temperatures - In order to understand the indirect application of water method of extinguishment, it is necessary to review a few facts concerning the ignition temperatures of materials usually found in a building fire. See Figure 1.

From this chart it can be seen that ordinary combustibles, found in the average building, have ignition temperatures ranging from approximately 325° F. to 887° F. Once the temperatures have reached 887° F. it can be expected that most combustible materials will be found burning. When this occurs, additional heat develops and the temperatures continue to rise, sometimes reaching 2000° F. The best known extin-

Material	°F. Ignition Temperatures
Hard pine shavings	442
White pine shavings	507
Paper	446
Cotton cloth	464
Cotton batting	401
Nylon cloth	887
Synthetic rubber	824
Matches (head)	325
Paint film	864
Oxidized linseed oil	864

Fig. 1 - Ignition Temperatures

guishing agent for class A fires is water. In addition to this, water is the most readily available, as well as the least expensive agent. Therefore, most of the extinguishment of fires is done with water.



5 x 5 = 25 x 2 = 50 sq. in.
5 x 9 = 45 x 4 = 180 sq. in.

230 sq. in. of exposed surface

Fig. 2 - Exposed Surface of a 5" x 5" x 9" Cube

Exposed Surfaces - To understand how we can better accomplish complete heat absorption and vaporization of the water, it is necessary to know this principle: *The rate of the heat absorption of water is increased in proportion to its exposed surface.*

As shown in Figure 2, a cube nine inches high and five inches square, representing approximately one gallon of water, (231 cu. in.), has six exposed surfaces. Using the rule that the rate of heat absorption of water is increased in proportion to its exposed surfaces, this cube can only absorb water through its six exposed surfaces. These six sides comprise a total of 230 square inches. Thus, there are 230 square inches of exposed surface to absorb heat. Break this cube into one inch cubes and there will be 225 cubes. See Figure 3.

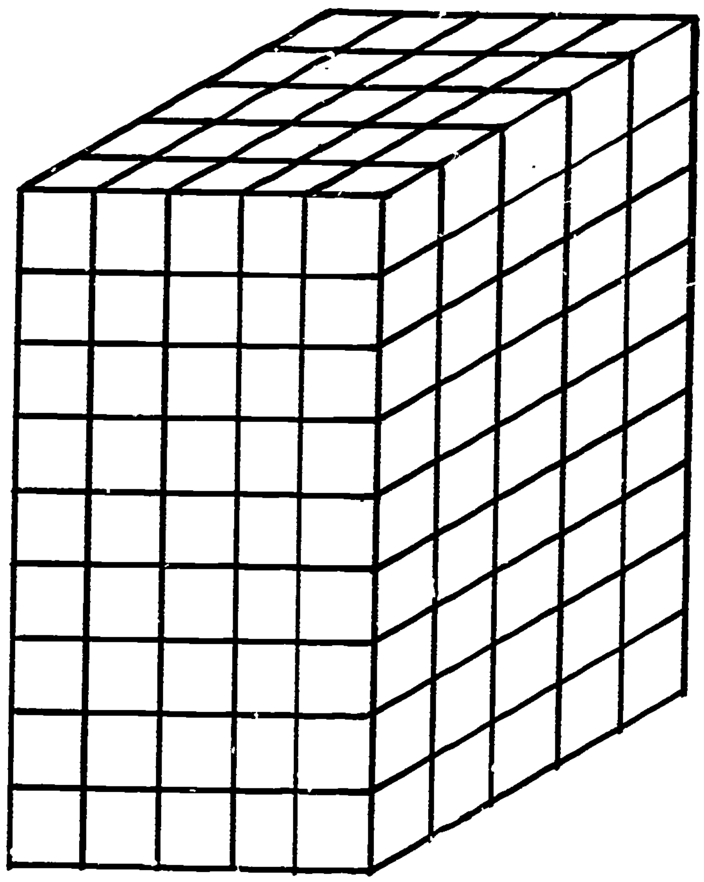


Fig. 3 - Exposed Surface of 225 One-inch Cubes

Each of these 225 cubes have six exposed surfaces, having a total of six square inches of exposed surface with which heat can be absorbed. Multiply these six square inches of exposed surface times the 225 cubes and this will equal 1350 square inches of exposed surface capable of absorbing heat. This is six times the original surface. By dividing each of these one-inch cubes into 1/8 inch cubes there will be a total of 512 in each of the one-inch cubes. Refer

to Figure 4. Multiply 512 cubes times the original 225 cubes and there will be 115,200 cubes. Each of these cubes has an exposed surface of 3/32 of a square inch. By multiplying this exposed surface 115,200 cubes there will be 10,800 square inches of exposed surface capable of absorbing water or 46 times the exposed surface of the original gallon of water before it was broken up.

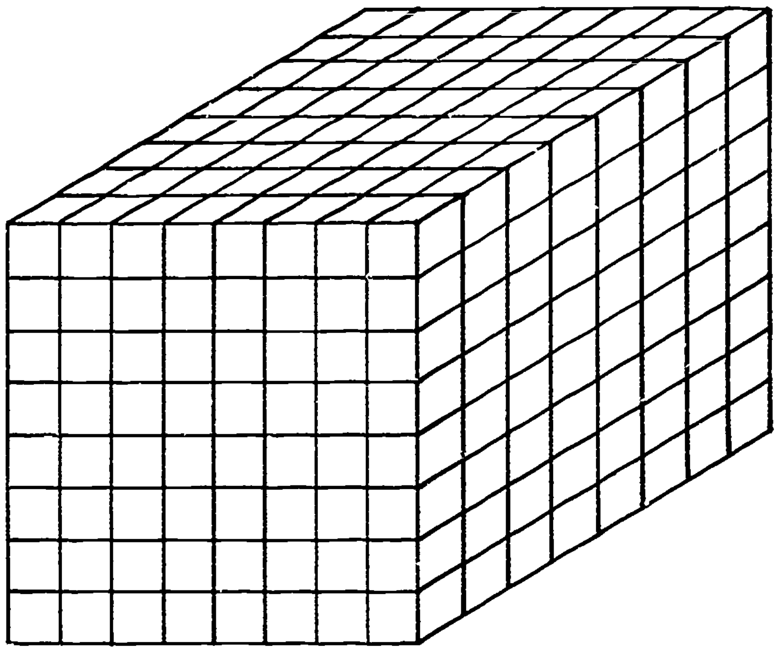


Fig. 4 - Exposed Surface of 512 1/8 Inch Cubes

Applying this same principle of heat absorption to fire fighting methods, the water may be broken up into many smaller particles by using equipment designed for this purpose. This will increase the heat absorption ability of water, not 46 times but probably several hundred times.

When approaching a burning building, the approximate amount of heat involved must be considered to determine the method of extinguishment to be applied. The ability to make this decision with a fair degree of accuracy is best gained through practical experience. When using the indirect method to apply water to extinguish a fire, the hot air and gases will cause the water to turn to steam. This increases the atmospheric pressure inside the confined area because each cubic foot of steam demands a cubic foot of space, thus the smoke and gases are forced out through the openings of a building. As the steam condenses, the atmospheric pressure decreases allowing fresh air to enter the building. When all the steam has condensed, the space within the building will contain normal air and the building will have been ventilated.

THE PHYSICAL PROPERTIES OF WATER

Sometimes fires are encountered after they have gained considerable headway. In these instances, it may be impossible for the firemen to fight the fire from close range because of smoke and heat, possible explosions, collapse of the building, etc. In such events, large amounts of water are used, but only part of this water is effective in extinguishing the fire. The water remaining in the building absorbs some heat, but it could also create a dangerous situation because of the added weight and the weakened structure. For safety reasons, firemen should be concerned with the weight of water.

1. The vertical pressure of a liquid is proportional to the height alone and is not influenced by the size or shape of the container.
2. There are 1728 cubic inches in one cubic foot.
3. There are 231 cubic inches in one gallon.
4. There are 7.5 gallons of water in one cubic foot.
5. One cubic foot of water weighs 62.5 pounds.
6. One gallon of water weighs 8.35 pounds.
7. Pressure is a measurement of energy referred to in pounds per square inch, (p.s.i.).
8. A column of water one foot high and one inch square exerts a pressure of .434 p.s.i. on its base.

   Example: Height x .434 = p.s.i. on its base
   1' x .434 = .434 p.s.i. on its base
9. A column of water 2.31 feet high exerts a pressure of 1 p.s.i. on its base.

   Example: Height x .434 = p.s.i. on its base
   2.31 x .434 = 1.00 p.s.i. on its base
10. Static pressure is the pounds pressure per square inch exerted by a body of water at rest, either horizontally or vertically.
11. Back pressure is the pounds pressure per square inch created by a column of water on its base. See examples under 8 and 9.

12. The area of a square or a rectangle is equal to its length times its width.

Example: Using a 4' x 6' rectangle

Area = L x W
= 4' x 6'
= 24 square feet

13. The area of a circle equals diameter times diameter times .7854.

Example: Using a 4' diameter

Area = D x D x .7854
= 4' x 4' x .7854
= 16' x .7854
= 12.56 square feet

14. The volume of a cylinder equals the area of its base times the height of the cylinder.

Example: Using a 12' tank having a 4' diameter

Volume = Area of base x height
= (D x D x .7854) x H
= (4 x 4 x .7854) x 12
= (16 x .7854) x 12
= 12.56 x 12
= 150.72 cubic feet
(volume of cylinder)

15. For all practical purposes, it must be understood that water cannot be compressed. Since water remains at a constant volume, it can be said that a given weight of water will occupy the same amount of space at all times regardless of the shape of its container.

16. The hose size, its gallon content, and the weight of the water in each section of hose is indicated in Figure 5. A 50 foot section of dry, 2½" double-jacket nylon or dacron hose and a 50 foot section of dry, 2½" single-jacket cotton hose with forged couplings weigh approximately 38 pounds each. Add to these figures the weight of the water within the hose to obtain the approximate total weight of the hose and water. This item must be considered when hose is elevated up the side of a building or ladder. This emphasizes the need for a supporting means, such as a rope hose tool or hose strap, to relieve some of the weight from the hose couplings in the elevated hose line.

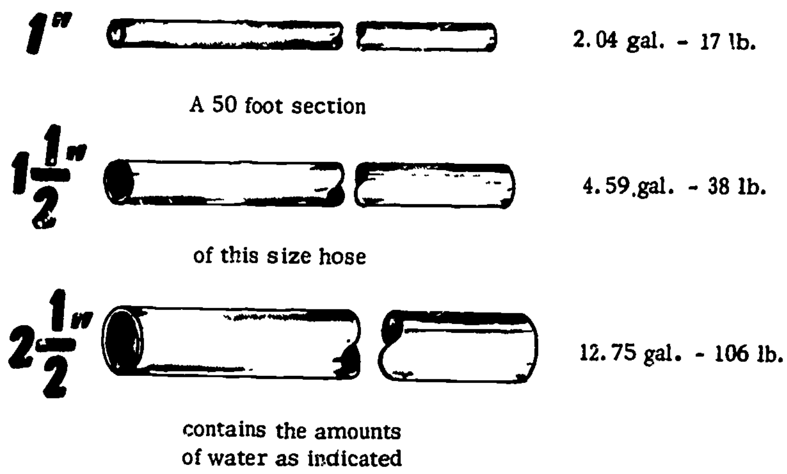


Fig. 5 - Volume and Weight of Water in 1 Inch, 1-1/2 Inch and 2 1/2 Inch Hose

WATER FROM DRAFT

When water is supplied to a pumping unit by means of an operation known as "drafting water", a vacuum reading is recorded on the vacuum-pressure gauge, Figure 6, and is identified in terms of inches of mercury or feet of lift. It must be understood that a column of mercury one inch high exerts approximately the same pressure per square inch (p.s.i.) on its base as a column of water one foot high; therefore, either

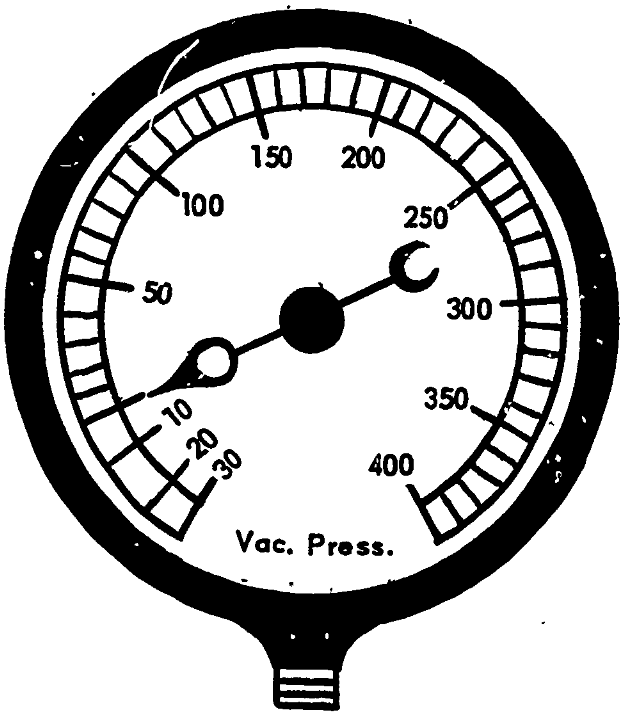


Fig. 6 - Vacuum Pressure Gauge

expression is accepted as correct. In most cases, when pumping water from draft, the actual measured feet of lift may numerically exceed the inches of vacuum recorded on the vacuum gauge. This difference is partially caused by friction loss within the suction hose and the pump. To lift water a specified

number of feet requires an amount of pump energy equal to that amount required to force an equal quantity of water upward an equal number of feet at an equal velocity.

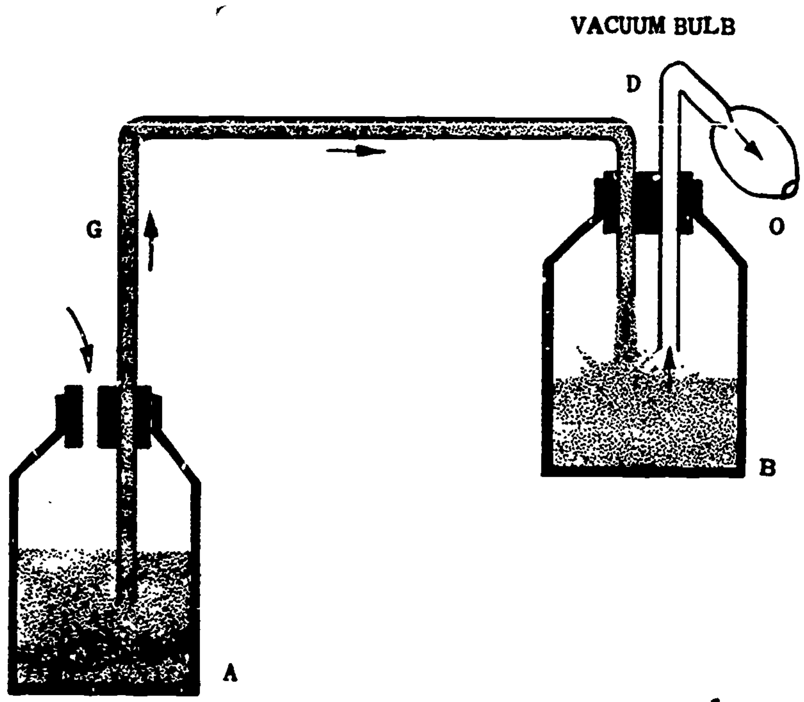


Fig. 7 - Demonstration of Suction Lift

DEMONSTRATION OF SUCTION LIFT

Exhaust air from bottle B through tube D by means of bulb O. As the atmospheric pressure in bottle B is lessened, the normal atmospheric pressure bearing upon the surface of the water in bottle A through hole H causes the water to rise through tube G into bottle B. The degree of vacuum in bottle B must be great enough to overcome the difference in elevation of bottles A and B. When the water level in bottle B rises to the bottom of tube D, the "pump" may be said to be primed and discharging from draft.

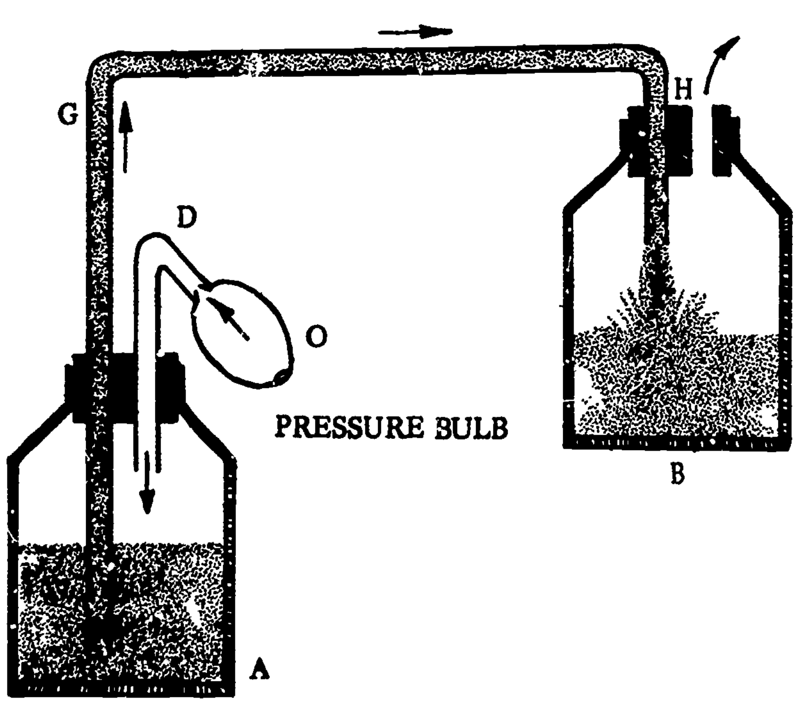


Fig. 8 - Demonstration of Pressure Lift

DEMONSTRATION OF PRESSURE LIFT

The energy output of any pump and its power unit is limited. Therefore, the higher the suction lift the more energy is required to obtain water into the pump. Figures 7 and 8 illustrate that the same amount of energy is required to force water up a given distance as is required to lift or draft an equal amount of water an equal distance.

Air pressure is created by force-pump bulb O, entering through tube D and exerting itself on the surface of the water in bottle A, causing it to rise through tube G into bottle B. The opening H in bottle B allows the air to escape from bottle B as it fills with water from bottle A. The degree of air pressure on the surface of the water in bottle A must be great enough to overcome the difference in elevation and, in addition, must have a minute margin left to overcome friction loss.

Water, being drafted from any body of water, is caused to rise through the hard suction hose by expelling the air from the pump housing and the attached hard suction. When air is expelled from the pump and suction hose, a vacuum is created. The atmospheric pressure pushing down on the surface of the body of water forces the water to rise through the hard suction and into the pump. Upon reaching this stage, the pump begins to force the water through hose lines connected to the open discharge gates. Normal atmospheric pressure at sea level is approximately 14.7 pounds per square inch. In theory, a perfect vacuum pump could draft water 33.9 ft. at sea level. In the fire service, a pump that will draft water to an approximate height of 25 feet is considered to be in good operating condition.

Other points that must be considered when drafting water are the size and depth of the suction hose, air leaks, volume of water to be discharged, condition of both the pump and the engine plus the knowledge and ability of the pump operator.

Figure 9 shows the Fire Engine Tests and Fire Stream Tables by the National Board of Fire Underwriters. By studying this table it can be seen that where a high lift is necessary, small suctions will restrict the capacity of a pumper. This table clearly indicates what size suctions are necessary under different conditions. These figures are based on the ability of a fire pump to maintain 23" of vacuum. This table shows the maximum lift in feet when drafting quantities of water with a pumper in good condition.

Since everything must be perfect to create the most perfect vacuum possible, it can easily be seen that any air leakage in the suction connection of the pumper may prevent the drafting of water. An air leakage after the pump has taken suction may cause the pump to lose its water. With positive displace-

TABLE SHOWING MAXIMUM LIFT, IN FEET, WHEN DRAFTING VARIOUS QUANTITIES OF WATER WITH A PUMPER IN GOOD CONDITION

Quantity of Water, Gallons per Minute	Maximum Lift In Feet, Pumper Drafting						
	3-Inch Suction	3½-Inch Suction	4-Inch Suction	4½-Inch Suction	5-Inch Suction	6-Inch Suction	
300	16	20	22½	24	24½	24½	
400	8½	17	20	22½	24	24½	
500		12½	18½	20½	23	24	
600		7	15	19½	21	23	3 lengths of suction
700		4½	11	17	19½	22½	
800			6½	14½	19	22	
900			6	11½	17	21	
1,000				8½	14½	19½	
1,100				7½	12	18½	
1,200				4	9½	18	2 lengths of suction
1,300					6½	17½	
1,400					9½	17½	
1,500		1 length of suction				15	

Fig. 9 - Table of Maximum Lift With Pumper Drafting

ment type pumps a small leakage of air may not be sufficient to prevent the drafting of water, but it will create defective streams and cause the pressure gauge needle to vibrate. This makes it necessary for the pump to turn more r.p.m.'s in order to supply the g.p.m. required.

Under normal conditions, a 1,000 g.p.m.(rated capacity) centrifugal pump at 150 p.s.i. (rated pump pressure) working from a draft of ten feet, is capable of discharging 1,000 g.p.m. at 150 p.s.i., pump pressure. However, the rated pump pressure of 150 p.s.i. may be exceeded when the desired g.p.m. is proportionately reduced below 1,000 g.p.m.

WATER SUPPLY FROM HEAD PRESSURE

Head pressure is the term used to describe the operation of supplying water to a pumping unit when such units are connected to a fire hydrant or when connected in relay with one or more pumpers. The maximum pump capacities at maximum pump pressures are partially dependent upon the quantity of water and its pressure per square inch as it enters the pump. Low intake pressures with a sufficient volume are more efficient than high intake pressures with insufficient volume.

With a positive displacement pump (piston or rotary gear) it is theoretically impossible to discharge more water than the rated capacity of the pump, either from draft or from a head pressure. When working from a head pressure the pump may exceed its rated pump pressure but not its maximum rated capacity. However, in practical application, the maximum rated capacity may be exceeded due to the manufacturer's efficient design and construction of such positive displacement pumps to assure complete efficiency of their pumping units.

TYPES OF FIRE STREAMS

SOLID STREAM

A solid stream for fighting fires is one which discharges water through an orifice at an effective pressure, developing a stream having impact and range.

BROKEN STREAM

A broken stream is one which discharges water from a nozzle as a solid stream, then breaks it into parts by an outside force such as a wall, a partition, a ceiling, materials, etc.

SPRAY OR VAPOR STREAM

A spray or vapor stream is one that has many jets of water being discharged through a specially designed nozzle. It is used mainly in the extinguishment of fires by means of the indirect application method.

WATER CURTAINS

A water curtain is any stream or spray of water used to protect interior and/or exterior exposures.

MASTER STREAMS

A master stream is any heavy duty stream that is formed by connecting two or more big lines into a single heavy duty water distributing tool.

USES OF TYPES OF FIRE STREAMS

SOLID STREAMS

Firemen should fight fires at as close range as possible. This will enable them to locate the fire, apply water efficiently to extinguish the fire, and avert unnecessary water damage. Conditions at every fire will not always permit firemen to fight the fire at close range. They are often kept back due to the amount of heat, smoke and gases thrown off by the

fire. This makes the use of solid streams necessary. Solid streams are obtained from nozzle tips normally ranging in size from 1/8" to 2" in diameter and increasing in size by 1/8" graduations. In instances where larger streams are desired, the larger tips are used, providing there is a sufficient amount of water available to fulfill its obligation. Here, too, the limitations of a pumper which is controlled by its rated capacity and its rated pump pressure must be considered. This broad range of tip sizes permits firemen to select the size best suited to bridge the gap between the nozzle and the fire. An efficient, solid stream is considered to be one having approximately 90 per cent of the water passing through an imaginary circle having a 15 inch diameter at the break-over point. See Figure 10.

For example, one use of a solid stream might be to direct it through a window 40 ft. from where the nozzle is stationed. In this case it is evident that the stream must hold together until it has passed through the window It should be directed against ceilings, partitions, and other materials in order to break the stream into small parts to gain greater absorption of heat from the fire. If the stream should break before entering the window, much of the water would be wasted. Another objective of a solid stream is to direct it in an efficient manner to accomplish deep penetration when required.

Penetration and Deflection - Penetration refers to an effective fire stream reaching into the building a desired distance. Deflection refers to what happens to the stream after it strikes an object. The idea of penetration and deflection is to achieve the highest efficiency of a fire stream. As an example, suppose a fire stream is being directed into a 3rd floor room involved in fire. If this stream penetrates to the ceiling, then deflects to the wall, and then runs down to the floor, the water will have been used three times. Figure 11 illustrates this principle.

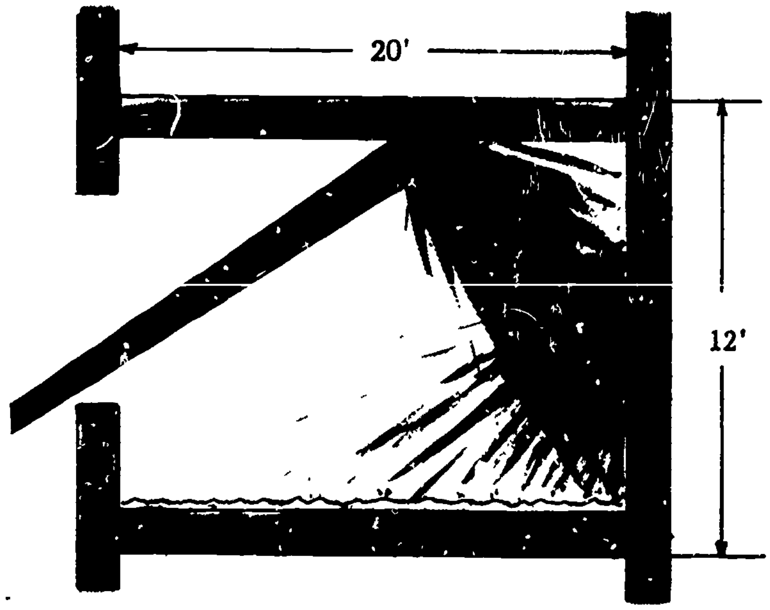


Fig. 11 - Penetration and Deflection

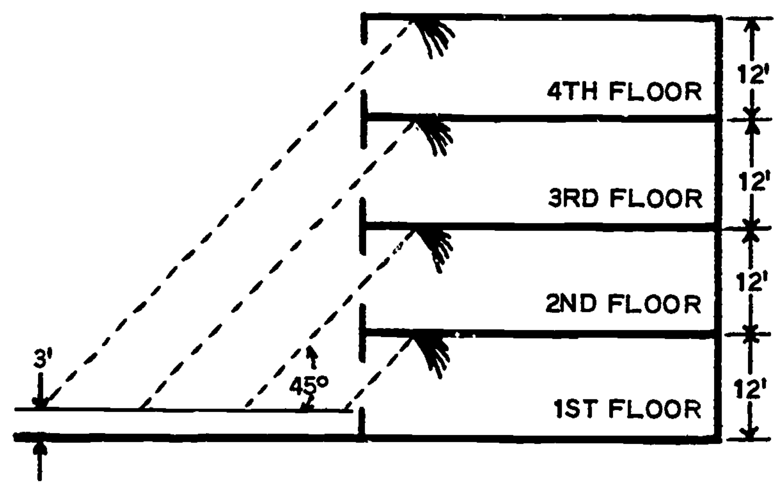


Fig. 12 - Poor Penetration

Figure 12 shows street streams being directed into the windows of a building at the first, second,

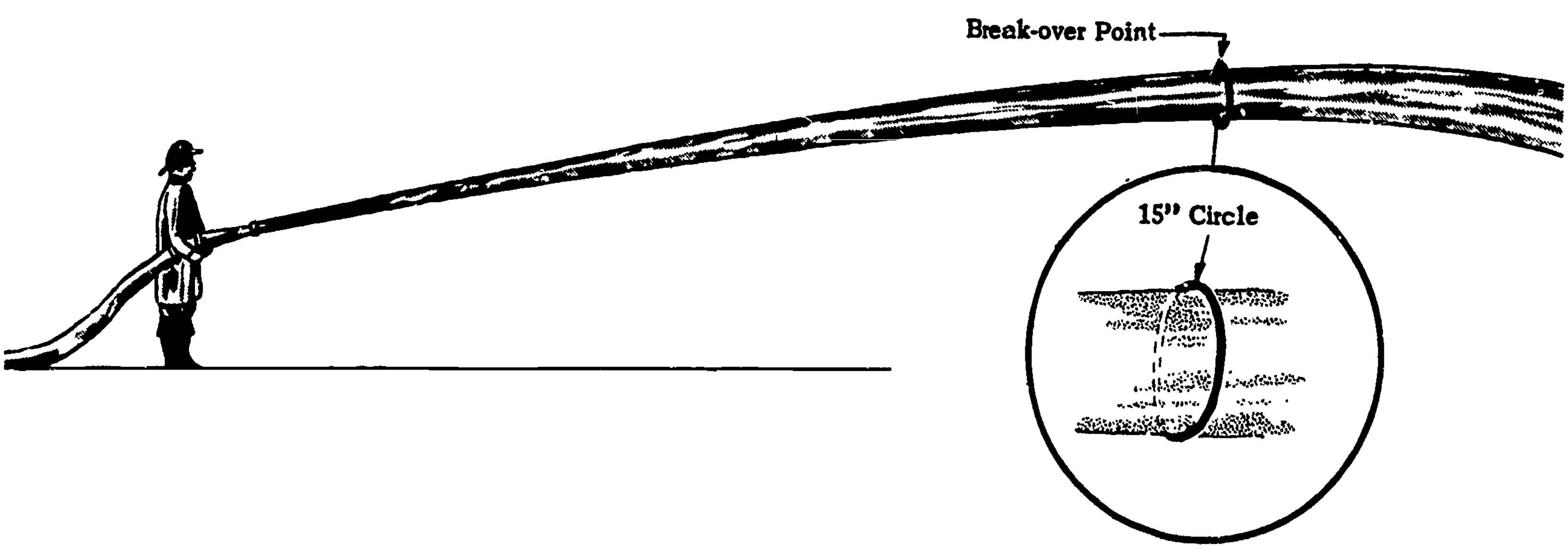


Fig. 10 - An Effective Solid Stream

third and fourth floors. All of these streams are at a 45° angle, figuring the nozzle to be three feet above the ground. These streams would not be very effective if there was a large floor area involved in fire because they could not penetrate far enough into the building. Therefore, in order to obtain maximum efficiency, the angle of the stream should be less than 45°. See Figure 13.

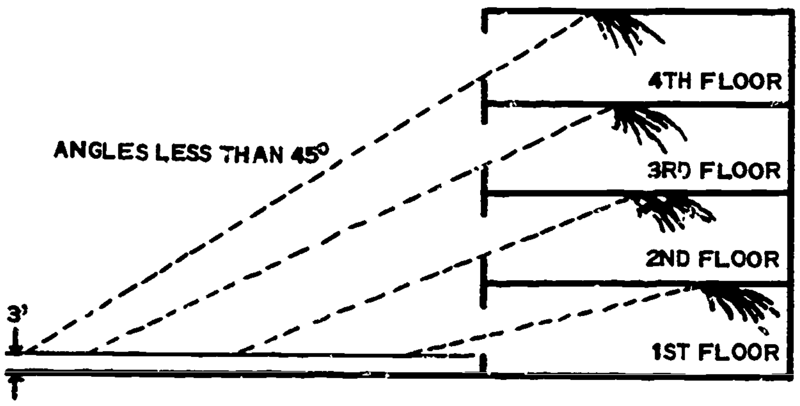


Fig. 13 - Good Penetration

From our study it can be assumed that streams directed from the street would not be very effective for penetration purposes above the fourth story. To reach a higher story necessitates moving the nozzle farther away from the building in order to keep the angle of the stream less than 45°. By moving the nozzle farther away, the stream has to travel farther before it reaches the building. Due to this, the possibility of its breaking into spray is greater, and increasing the range of the stream necessitates more nozzle pressure to work effectively.

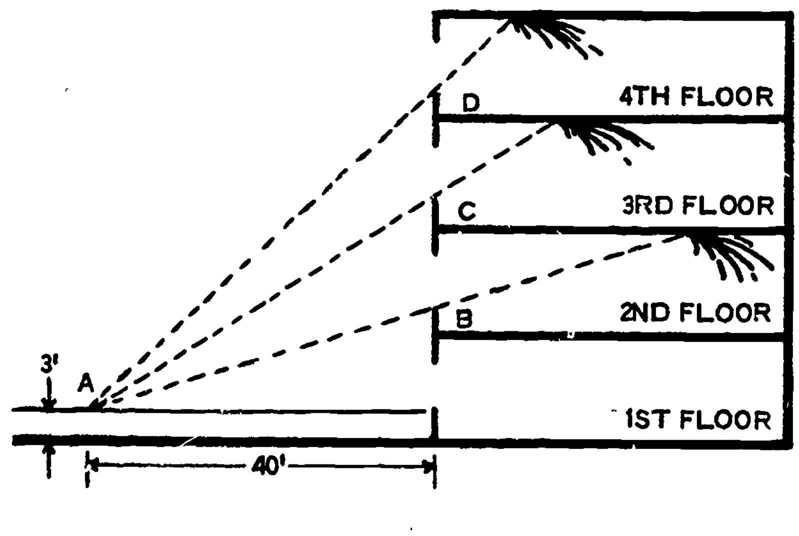


Fig. 14 - Good Penetration at "B"

In Figure 14 it is evident that effective penetration is secured by directing the stream from the nozzle through the window at B on the second floor. A considerable amount of good penetration can also be secured at the third floor window at C.

A stream crossing the sill at point B passes into the building at a sufficient distance before it strikes the ceiling. This allows the water to deflect downward to the opposite wall. Due to the additional height of the third floor, the stream thrown here is approximately at a 30° angle. For this reason, while beneficial results will be obtained, the stream will not be as effective as that thrown on the second floor because of the shorter distances of penetration at the third floor. Above the third floor less penetration is obtained, resulting in less effective fire stream. Therefore, only in exceptional cases, or for special purposes, should solid streams be used for penetration purposes where the angle formed by the stream is greater than 45°. Deep penetration is sometimes impossible and a large amount of the stream's effectiveness is lost. To remedy the situation, it would be necessary to elevate the nozzle above street level and direct the streams from water towers, ladders, other buildings, etc.

A quick method used to determine the approximate distance of penetration that can be expected from a street stream directed into upper stories of buildings is as follows: Divide the horizontal distance the nozzle is from the building by the story into which the stream is to be directed. For example, Figure 15 illustrates a five story building having a street stream being directed into the fourth story just above the window sill. This stream originates from an approximate horizontal distance of 33 feet from the building. Through the process of dividing the horizontal distance of 33 feet, by the story (4), it is possible to arrive at an approximate distance of penetration that can be expected, which, in this case, is 8 feet.

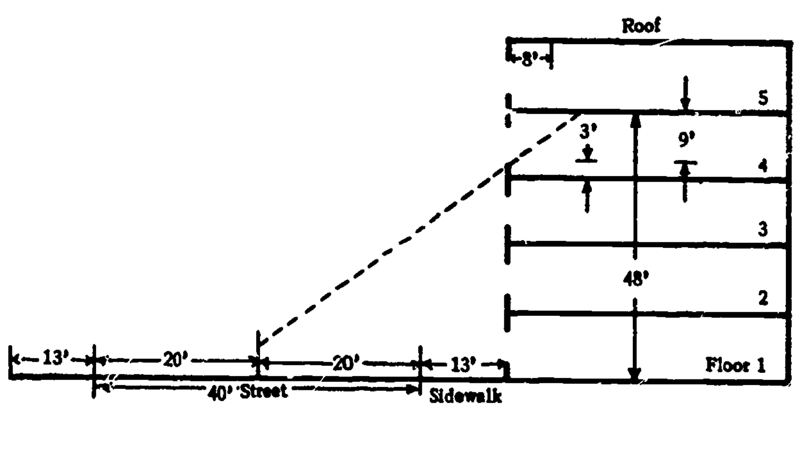


Fig. 15 - Calculating Penetration From Ground Level

When the nozzle is elevated to an upper story or roof of a nearby building, aerial ladder, or a water tower, the story that is horizontally on a line with the nozzle shall be considered the ground level and all calculations made from that point. See Figures 16 and 17.

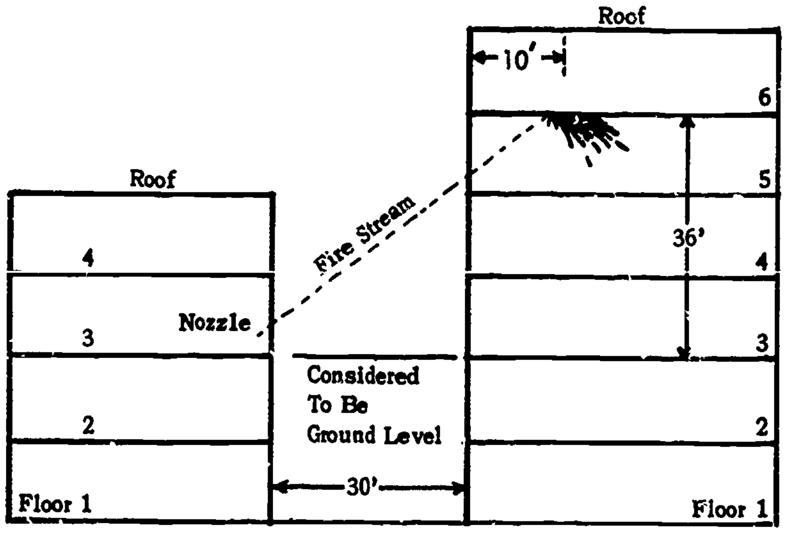


Fig. 16 - Calculating Penetration When Nozzle is Elevated in Another Building

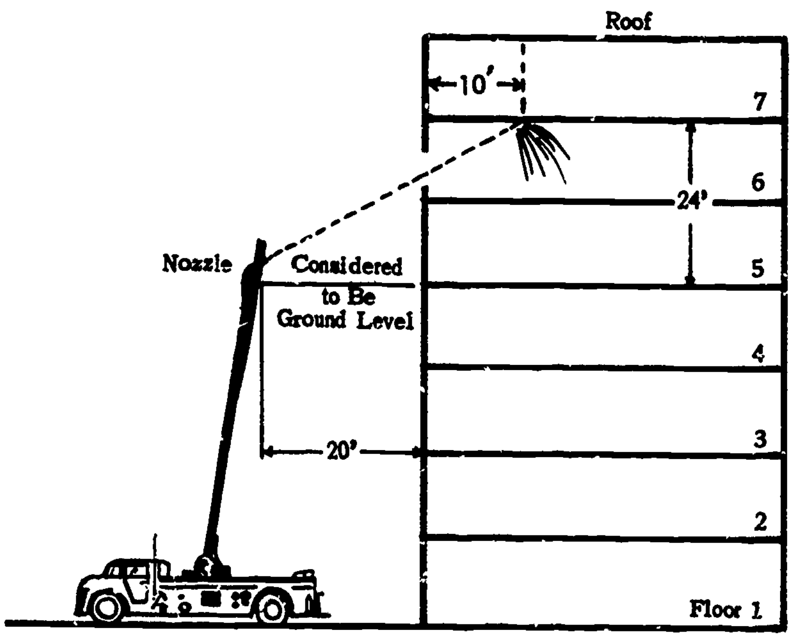


Fig. 17 - Calculating Penetration When Nozzle Is Elevated on Aerial Ladder

When penetration is desired from a horizontal stream, the nozzle pressure is determined by allowing one p.s.i. for each foot the stream must travel, keeping it within the accepted range of a good fire stream.

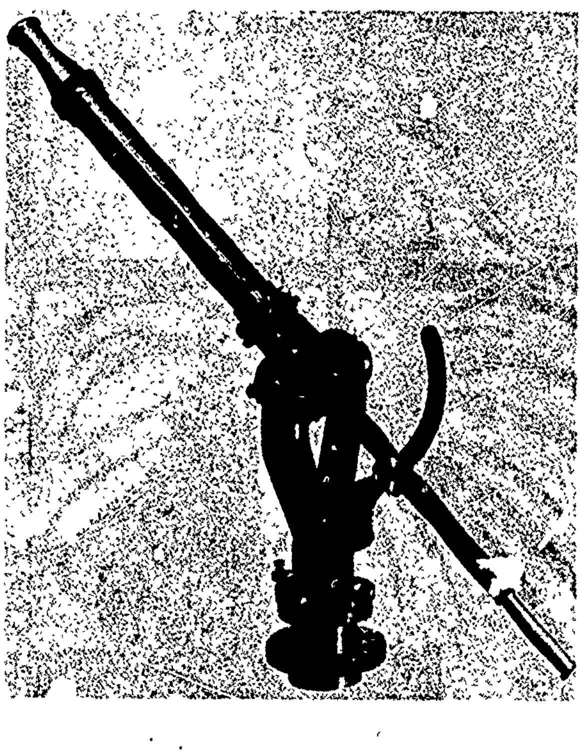
Master Streams - Master fire streams are solid streams of greater capacity than those that can be controlled manually. Other than having a greater capacity, they have the same characteristics as the mobile or portable solid stream. Large volume requirements may be augmented with higher pressures if additional water is supplied. This combination makes it necessary to use stationary equipment, such as turret pipes, deck guns, deluge sets and water towers. Such equipment should have sufficient adjustment to allow for both vertical and horizontal operation.

Deluge or monitor-type nozzles, as shown in

Courtesy Akron Brass Manufacturing Co., Inc.

Fig. 18 - Monitor Type Nozzle

Figure 18, are often used for producing master streams. The back pressure developed is absorbed by the cross stream arrangement in the nozzle base and by the anchoring device. Some monitor nozzles have a vertical adjustment only, while others have, in addition, a swiveled base which provides a horizontal adjustment. The nozzle uses a range of tips from 1-1/4" to 2" and in some instances tips of larger sizes are used. Figure 19 shows a deck pipe or turret nozzle used for developing master streams. The mechanical



Courtesy Wooster Brass Div., The Fyr-Fyter Co.

Fig. 19 - Deck Pipe

principle is the same as used in the monitor-type except that the nozzle is permanently mounted on the apparatus; hence the term "deck pipe." An advantage of elevation for stream penetration and deflection is provided in this form of installation.

BROKEN STREAMS

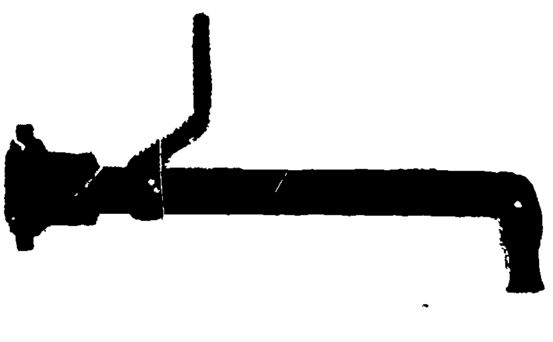
It has been determined that it is advantageous to divide the water into smaller parts for application on the fire. To accomplish this objective, the water is deflected from the ceilings, walls or materials. Conditions where these deflections can be used for breaking up the fire stream do not prevail at all fires. A similar effect can be obtained by partially opening the shut-off valve on the nozzle. By doing this, the water will strike the partly-opened valve and be deflected to the side of the tip. Here it will be broken into smaller parts and come through the tip as a "broken stream." Other mechanical means of producing broken streams are sometimes used. These include the distributor or rotary nozzle, the partition nozzle and sprinkler heads.

1. Distributor or Rotary Nozzle - The distributor nozzle, regardless of type, operates on the same principle as the ordinary garden or lawn spray. The pressure of the water in the line creates a turbine effect on the nozzle, causing it to rotate at high speeds as it delivers water in a shower effect. The nozzle is lowered through a hole cut in the floor. Most effective results are obtained by raising and lowering the nozzle while in operation. See Figure 20.

Fig. 20 - Using a Cellar Nozzle

When placing the nozzle that is directly attached to the hose in the hole, it should be lowered far enough to find if there are any obstructions. It can then be raised high enough to spray anything within reach. If a hose clamp is available, it should be placed approximately eight feet directly behind the operator, because one type of distributor nozzle does not have a shut-off. This nozzle coverage is limited to approximately a 20 ft. radius. Therefore, in certain instances, holes must be cut in the floor about every 30 feet apart in order to get good coverage of a basement or cellar. An exception to this is when a good vapor spray would be more effective.

2. The Partition Nozzle - Partition nozzle is a term applied to a group of nozzles which afford a method of obtaining a broken stream inside a partition or other similar spaces. These nozzles usually consist of a pointed nozzle with lateral holes or slots back of the point. The sharp point makes it possible to drive the nozzle through a partition, thus distributing the broken stream into the area. See Figure 21.



Courtesy Wooster Brass Div., The Fyr-Fyter Co.

Fig. 21 - Partition Nozzle

3. Sprinkler Heads - Sprinkler heads are a type of broken stream nozzle and illustrate the principle of a broken stream in fire extinguishment.

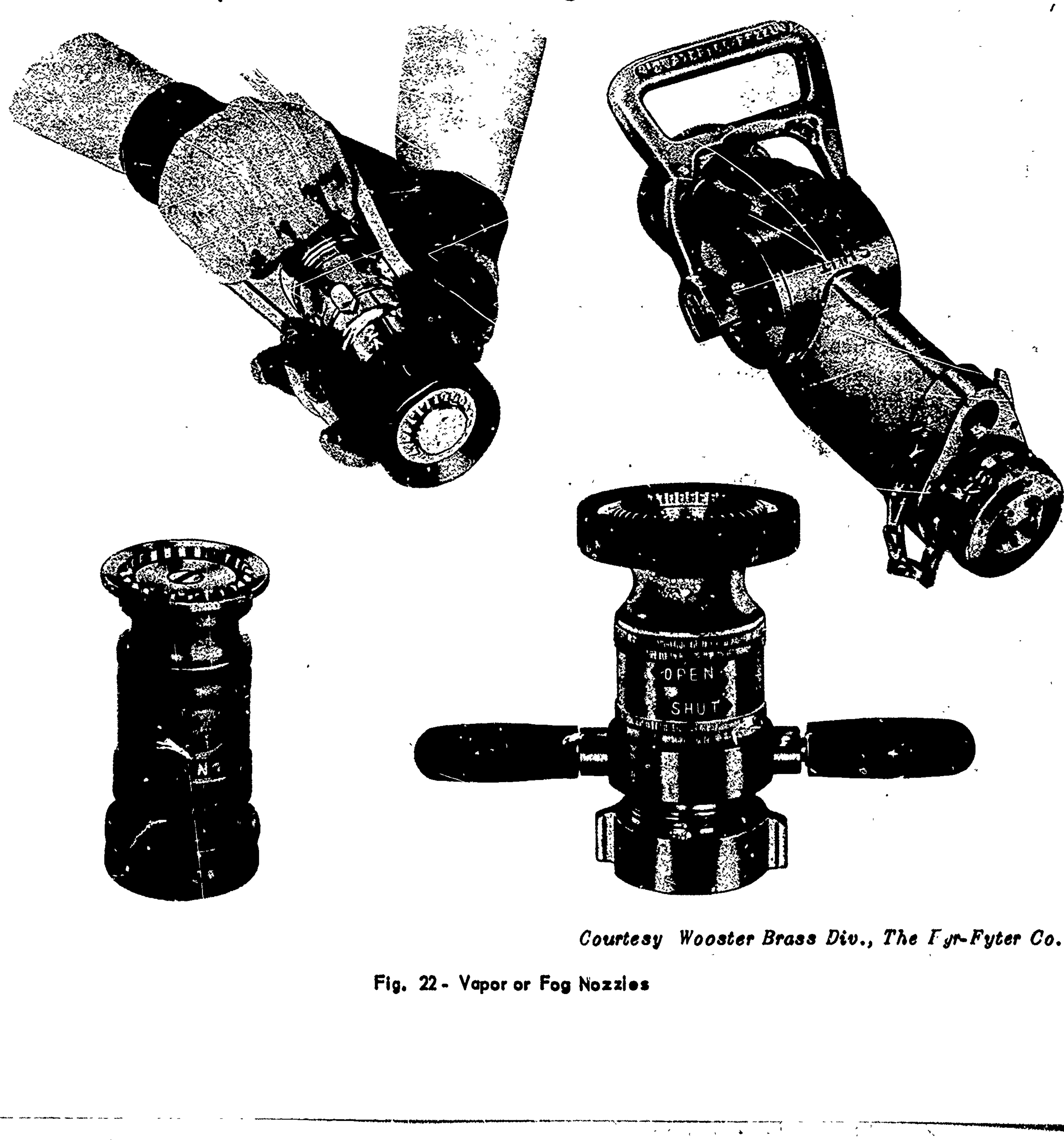
Use of Broken Streams in Basement Fires - A basement fire is considered one of the worst types of fire to control. In some instances the basement is used as a catch-all which aids in the spread of fire. Because ventilating basements is difficult, it is considered good practice to use a broken stream at some such fires.

Use of Broken Streams for Cooling Effect - Some fires generate a large amount of heat. Heat rises and, if

not cooled by some means, it will ignite combustible materials with which it comes in contact. There have been many cases where heat from a low building has risen alongside an adjoining building and, without previous warning, the fire has extended to the upper floors of the second building. It is necessary, therefore, when directing fire streams on these heat waves, to direct them as high as possible and move them around in all directions. This forms a broken stream and provides an excellent cooling effect. The smaller the particles of water, the more quickly the heat will be absorbed, thus indicat that the broken stream is better for this operation.

Use of Broken Streams Around Electrical Equipment - The fact that a fire stream is a conductor of electricity is well known to firemen. If the stream is broken, it is evident that its ability to conduct an electrical current is lessened. Consequently, if water must be used at a fire where electrical equipment is involved, a broken stream would be much less hazardous than a solid one.

Use of Broken Streams in Chemical Fires - Fires in buildings where chemicals are stored, such as hospitals, drugstores and chemical warehouses, create a very dangerous hazard for those fighting the blaze. To direct a solid stream into a room where chemicals are stored may cause a greater hazard due to the effect of the stream's velocity. Therefore, a broken stream played upon the chemicals would be much more efficient. Water soluble gases may result from chemical fires, such as escaping ammonia. These may be dispersed with a broken water stream. The finer the water particles, the more readily the gas will be absorbed and the more rapidly the air will be cleared of gas.



Courtesy Wooster Brass Div., The Fyr-Fyter Co.

Fig. 22 - Vapor or Fog Nozzles

Use of Broken Streams in Overhauling - Broken streams can also be used to excellent advantage when overhauling, whether the stream is to be used inside or outside of buildings. By getting close to the fire and using a broken stream, the department can apply only the amount of water required, thus eliminating unnecessary water loss.

VAPOR OR FOG STREAMS

The purpose of the vapor or fog stream is to increase heat absorption by dividing the water into smaller particles than can be obtained by any other method. In the study of fire streams, we have learned that a solid stream takes its shape in the nozzle tip. Figure 22 shows a variety of vapor nozzles.

Facts substantiate the use of water vapor in the extinguishment of fires. It is apparent that very little water loss will result as compared with solid or even broken streams. However, to change water to vapor, some of the stream velocity must be sacrificed to mechanical resistance and the stream, therefore, cannot be expected to reach a long distance.

Use of Vapor or Fog Streams on Confined Fires - Vapor fire streams can be used very efficiently upon confined fires, which include fires in spaces such as attics, basements, partitions, clothes closets, floors, etc.

Use of Vapor or Fog Streams on Flammable Liquid Fires - Vapor streams are also very effective upon flammable liquid fires, such as the average filling station, cleaning plant, automobile, restaurant kitchen and grease rack fires.

Use of Vapor or Fog Streams on Chemical Fires - The danger of chemical fires should not be underestimated. Vapor streams are effective in absorbing water soluble gases in this type of fire. In fact, on most fires that can be approached at close range, a vapor stream is even more effective than a broken stream.

Pump Pressure for Vapor and Fog Streams - A much higher pump pressure must be maintained for an effective vapor stream than for an effective solid or broken stream. When using a conventional low pressure of 140 to 150 p.s.i. on 1-1/2" hose and 200 p.s.i. on the 2-1/2" hose will, in most situations, produce an effective vapor stream. It is apparent, therefore, that effective vapor streams cannot always be produced from ordinary hydrant flow pressures.

WATER CURTAINS

Use and Purpose of Water Curtains - The prevention of heat communication, whether it be conduction, convection or radiation, is one of the main objectives at every fire. Water curtains can be used to an excellent advantage to check the danger of fire spread. Radiated heat travels in a straight line and is radiated equally in all directions.

A great deal of damage can be caused from radiated heat at major fires where the exposures are neglected. This matter should receive the immediate attention of the size-up officer and steps should be taken to combat the danger from radiated heat. A water curtain provides a good way to overcome this emergency.

A water curtain is a sheet of water, the purpose of which is to protect a building close to one that is involved in fire by breaking down the heat waves. Regardless of whether the water curtain is a permanent installation or is one derived from fire streams, it is still a water curtain and used for the same purpose.

Ways to Form Water Curtains - A simple means of obtaining a water curtain to cover exposures is the use of a permanent installation as shown in Figure 23. The heads are either open or fused, and the system operates either automatically or manually, much the same as a sprinkler system. Figure 24 shows how the curtain is formed when in operation.

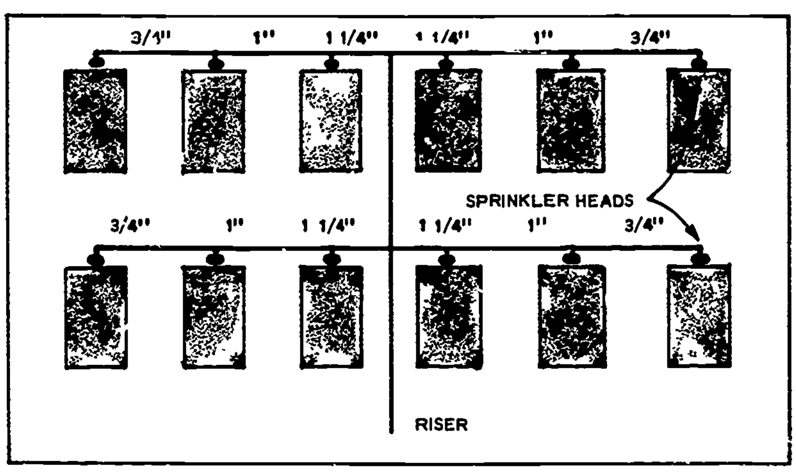


Fig. 23 - Water Curtain Installation

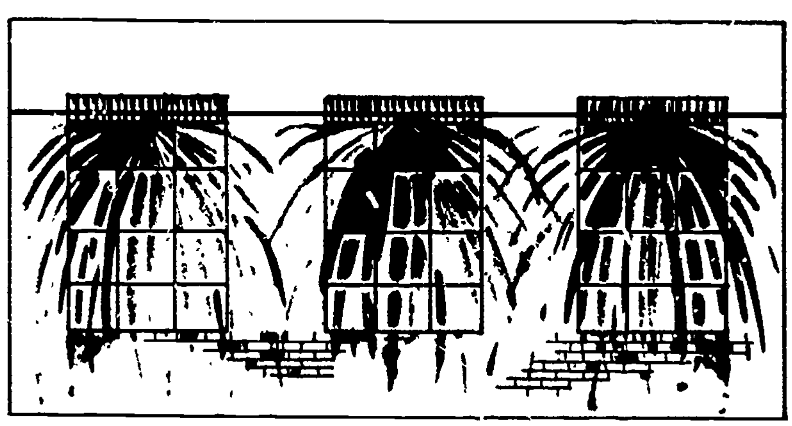


Fig. 24 - External Water Curtain

An efficient water curtain may also be formed with one or more solid streams. To form a curtain using this method, it is necessary to raise and lower the stream from a vertical plane to a horizontal plane, alternately. When it is necessary to have two such streams operating, one should be placed at both ends of the building being protected. Figures 25 and 26 illustrate both methods.

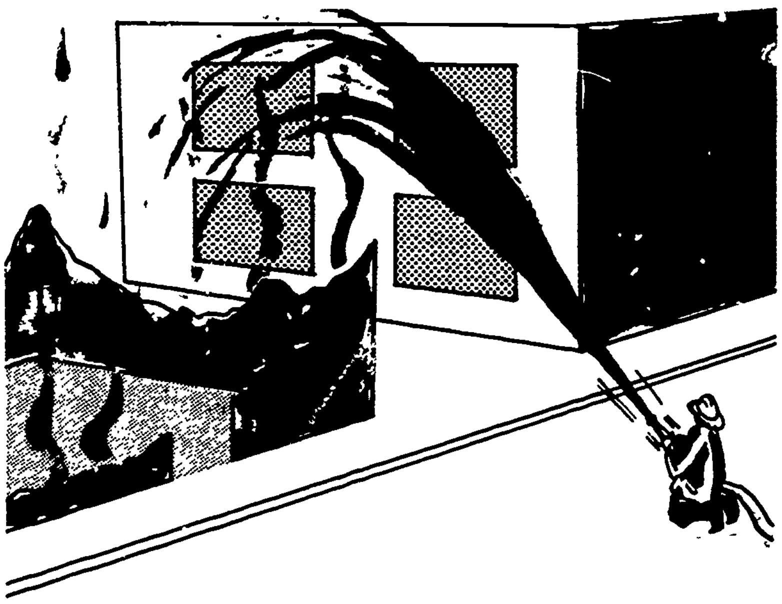


Fig. 25 - Water Curtain Using One Stream

Fig. 26 - Water Curtain Using Two Streams

EQUIPMENT FOR FIRE STREAMS

The following equipment is necessary to produce a fire stream:

1. adequate water supply under pressure
2. sufficient hose line
3. proper type and size of nozzle

If a given volume of water is supplied to a line of hose, that same volume may be expected to flow or be discharged from the hose since water is non-compressible. If a pump is producing 500 g.p.m. through a line of hose to a fire, exactly 500 g.p.m. will be discharged from the nozzles. Likewise, if a hydrant has sufficient pressure and size to put 500 g.p.m. into a line, the same volume can be expected from the nozzle. The size of the hose will be the principle factor to determine the velocity of the water in the hose. The smaller the hose the greater the stream velocity.

With an unlimited source of water supply, any volume, within the limits of the combined apparatus and equipment, may be obtained by controlling the velocity of the water. If the supply is from a hydrant, the size of the main, the hydrant, and the hydrant pressure will determine the amount of water that can be put into the hose. However, if the main is of sufficient size, the pressure may be increased by a pump. Therefore, a greater volume flow is possible.

It is imperative that all departments make a complete study of their entire water system in order to know the size of the various mains, the amount of water obtainable from them, and the pressure, both static and flowing, at the fire hydrants. These factors must be given serious consideration if firemen are to obtain effective fire streams.

CAUSES OF DEFECTIVE STREAMS

The following are causes of defective streams:

1. Insufficient Nozzle Pressure - Insufficient nozzle pressure may be caused by insufficient pump or hydrant pressure or a hose lay too long for the size tip being used.

2. Too Much Pressure - Using too small a tip with high pressures often causes streams to break into a spray within a few feet of the tip whereby the effectiveness of the stream is lost.

3. Nozzle Burr - A nozzle tip having a small burr will break the stream in the orifice and cut down its effective range.

4. Bend in Hose Near Nozzle - An unnecessary bend in the line within approximately 10 feet of the nozzle causes a whirling motion, which in turn results in a defective stream as it leaves the nozzle. The remedy is to have the line of hose leading up to the nozzle have but one bend behind the nozzle.

5. Wind - The velocity and direction of the wind will affect the distance the stream will travel.

6. Obstructions - There are two types of obstructions -- internal and external. Internal obstructions result from foreign materials entering the hydrant, pump, hose line, nozzle, or may be caused by defective lining or protruding hose gaskets. External obstructions are caused by wires, signs, trees, etc., which might be in the path of the stream.

7. Defective Shut-Off - In the use of nozzles, care should always be taken not to twist or bend the handle of the shut-off. Either of these conditions may prevent the valve from opening fully or may permit the valve to go past the full opening. In both instances, the waterway would not be fully open and the effect would be a broken stream.

8. Protruding Nozzle Gaskets - Should the gasket in the nozzle protrude into the waterway, it would tend to divert a part of the water and break up the fire stream. See Figure 27.

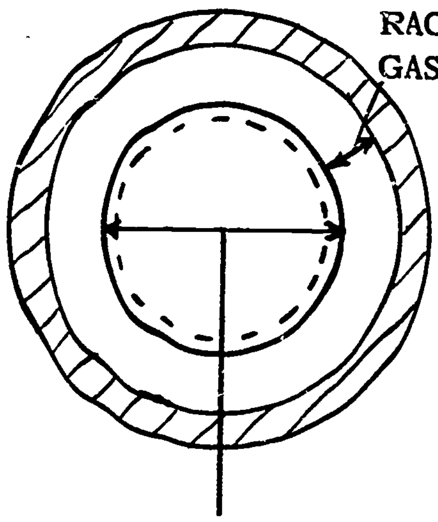


Fig. 27 - Protruding Nozzle Gasket

9. Untrained Personnel - This is the major cause for defective and ineffective fire streams. Each person who performs a part of the duties necessary to obtain efficient fire streams must be a well-trained fireman who understands what he is doing and why it is being done. Proper training will reduce errors that cause defective fire streams.

HYDRAULICS

Successful fire fighting depends upon adequate fire streams, properly applied. The water, from the point where it leaves the nozzle until it reaches the desired point, is called a "fire stream."

The information presented in this section was prepared with the knowledge that there are several approved, practical methods used by firemen to arrive at approximate answers for fire department hydraulic problems. Also, throughout this study of simplified fire department hydraulics, it must be accepted that the calculations presented herein will give only approximate solutions; yet these are satisfactory for all practical fire department problems.

After receiving an order to supply water through a fire hose line connected to the discharge of a pump, the pump operator shall immediately start some water flowing within that hose line at a safe pump pressure of 50 to 75 p.s.i. This procedure shall take precedent over any and all suggested fire department hydraulic formulas used to calculate pump pressures for any situation. The prime purpose is to supply water immediately.

Pump operators must have a complete understanding of fire department hydraulics in addition to being fortified with a good working knowledge of the pump. This will enable the operator to discharge the desired quantity of water a desired distance from a specific nozzle in order to accomplish a desired task.

TERMINOLOGY RELATING TO HYDRAULICS

1. Hydraulics - "The science of the use and movement of water, especially pertaining to the extinguishment and control of fires." Certainly, from this definition, it is indicated that hydraulics is a fire department function that should be understood by all firemen.
2. g.p.m. - gallons per minute
3. p.s.i. - pounds per square inch
4. FL - friction loss
5. PP - pump pressure
6. NP - nozzle pressure
7. EL - elevation
8. . - feet (measurement)
9. + - plus (addition)

10. − - minus (subtraction)

11. ÷ - divided by (division)

12. x - times (multiplication)

13. Story - 12 feet, the space from the floor to the ceiling

14. Floor- that part which is walked upon

15. Width of streets - a 40 foot span (for common understanding)

16. Width of sidewalks - considered to be 13 feet

17. Back pressure - (elevation) the water pressure being exerted against a pumper discharge. This pressure is overcome by adding five p.s.i. for each 12 feet the nozzle is elevated above the pumper.

18. Hydrant pressure - flowing pressure from a hydrant

19. Static pressure - pressure of water at rest

20. Residual pressure - the amount of pressure remaining on the intake side of a pumper while water is being discharged from pump outlets

21. Pull-back pressure - the backward pressure created by the velocity of the water flowing from a nozzle. For general information the following chart may be used:

Pull-back pressure for:

7/8" tip equals approx. 1 times the NP

1" tip equals approx. 1-1/2 times the NP

1-1/8" tip equals approx. 2 times the NP

1-1/4" tip equals approx. 2-1/2 times the NP

1-1/2" tip equals approx. 3-1/2 times the NP

1-3/4" tip equals approx. 4-1/2 times the NP

2" tip equals approx. 6 times the NP

The chart concerning how to determine pull-back pressure is not intended for use while working at fires but is offered as general information to increase the safe pump operating pressures for all persons concerned.

FRICTION LOSS

Friction loss in fire hose, nozzle tips, nozzles, etc., is the resistance encountered by the free flow of water. To further explain friction loss as it pertains to fire department operations, the following hose layouts will be considered:

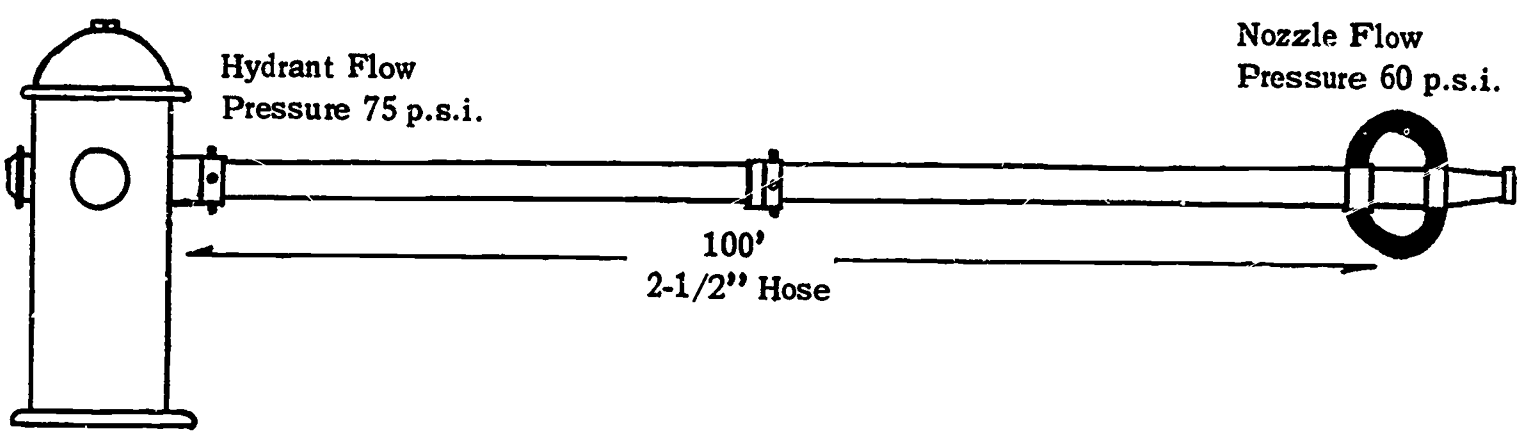


Fig. 28 - Figuring Friction Loss in One 100 Ft. Line

1. A straight line of hose is stretched over a level surface with one end connected to a hydrant and the other end connected to an open nozzle. Figure 28 indicates a hose lay from a fire hydrant having a hydrant flow pressure of 75 p.s.i. and a nozzle pressure of 60 p.s.i. Thus, there is a difference of 15 p.s.i. in the two pressures, which is the amount of friction loss (resistance) created within this layout.

2. In a second illustration, Figure 29, a pumper is discharging a specific amount of water at a specific pressure through 300 feet of good fire hose. This illustration indicates that within each hose-lay (single line from pumper to nozzle) each 100 feet of hose of the same diameter will have an equal amount of friction loss. Any additional increase of hose in the hose-lay will require a proportional increase in the pump pressure.

3. Through our study of Figure 29 we learn that pump pressure equals nozzle pressure plus friction loss when the hose is stretched over a level surface with the nozzle level equal to the pump level. However, when elevation (EL) becomes a factor in determining the necessary pump pressure, 5 p.s.i. is added to the pump pressure for each 12 feet the nozzle is elevated above the pump discharge. Also, 5 p.s.i. is subtracted from the pump pressure for each 12 feet the nozzle is below the pump.

$$\begin{aligned} PP &= NP + FL + EL \\ &= 60 + 24 + 0 \\ &= 84 \text{ p.s.i.} \end{aligned}$$

4. Regarding friction loss in fire hose layouts, it must be realized that when separate hose lines of equal size (diameter and length), having equal nozzle pressures are used, the hose line having the larger tip will be discharging more water, and therefore will create a greater amount of friction loss per 100 feet than the line with the smaller tip. See Figure 30.

5. When firemen arrange the physical set-up of any hose layout, the friction loss, the elevation, the hose size, the nozzle tip size and the approximate gallons-per-minute to be discharged must be considered. Such facts, when used properly, will assist firemen in doing a good job. There are, however, certain limitations that must be considered to have an efficient hose layout and water discharge. See Figure 31.

Combating Friction Loss - There are several methods used to overcome excessive friction loss in hose lines while working at a fire. They are:

1. Reduce the nozzle pressure.

2. Reduce the size tip and maintain the same nozzle pressure.

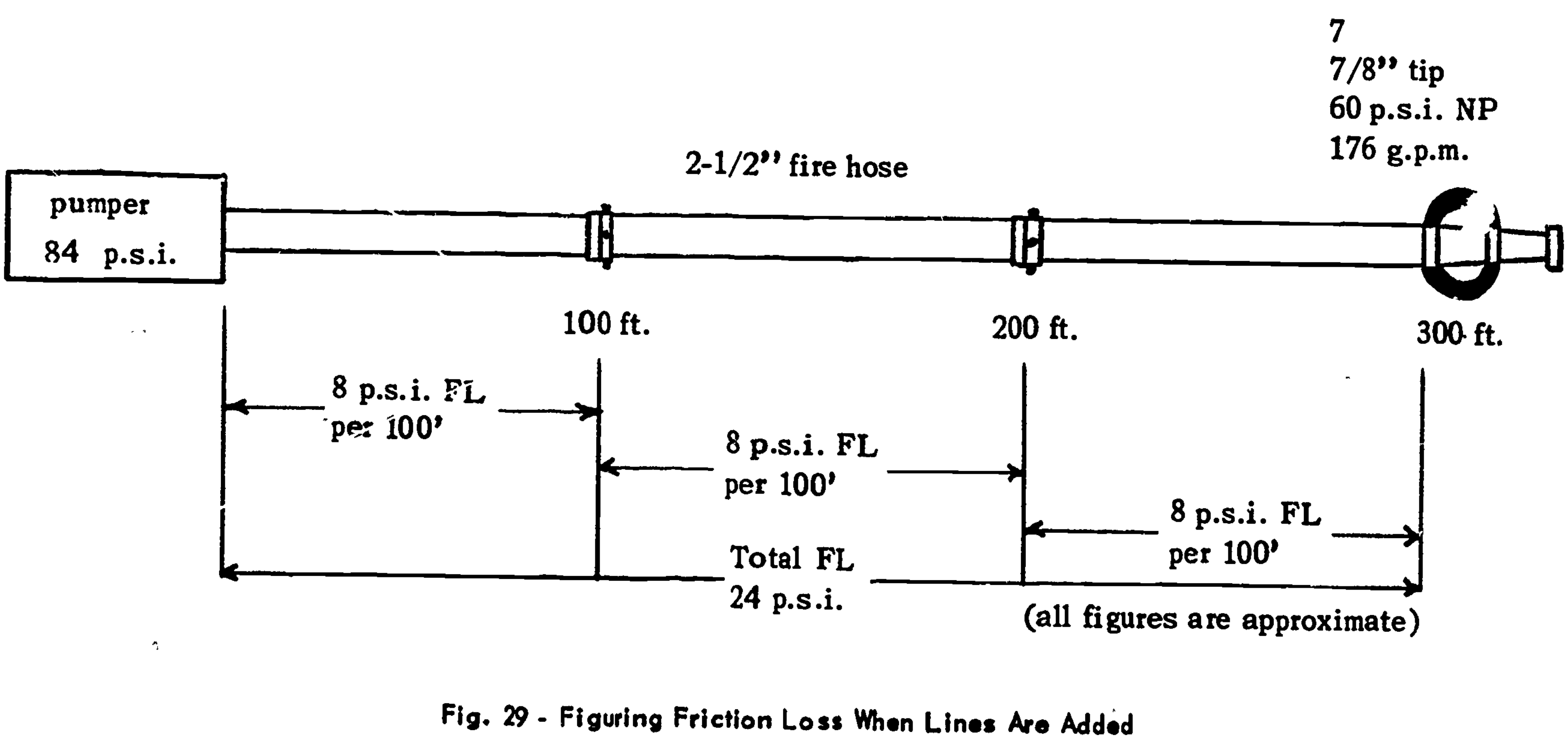
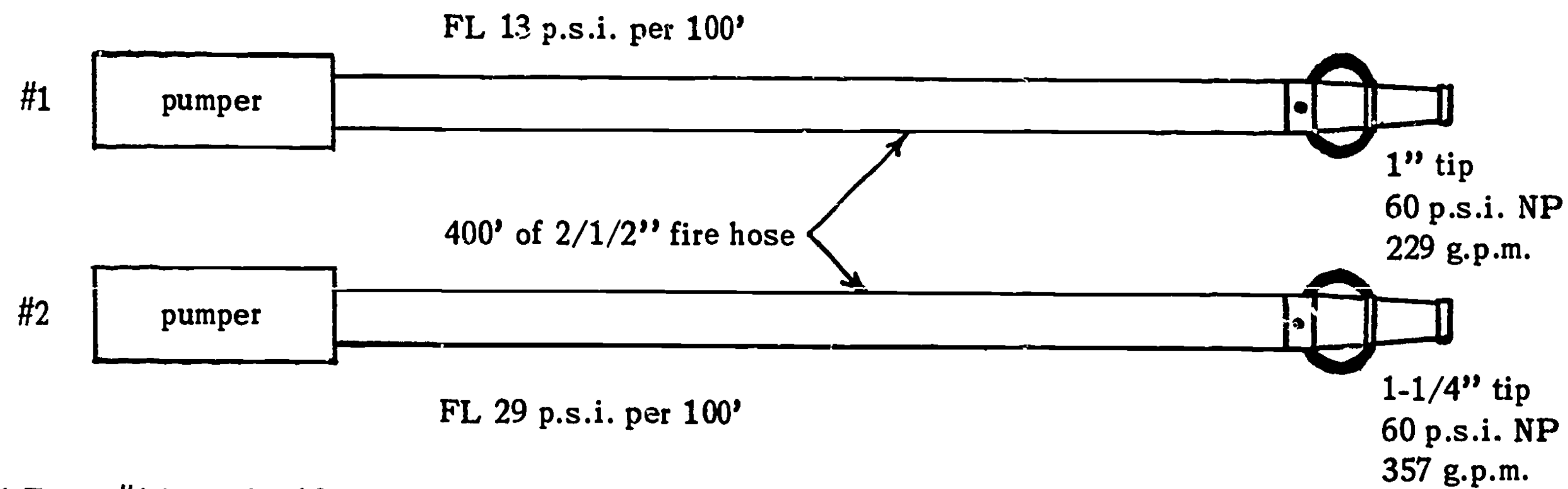


Fig. 29 - Figuring Friction Loss When Lines Are Added



Total FL in #1 line 4 x 13 or 52 p.s.i.
Total FL in #2 line 4 x 29 or 116 p.s.i.

#1 PP = NP + FL + EL
= 60 + 52 + 0
= 112 p.s.i.

#2 PP = NP + FL + EL
= 60 + 116 + 0
= 176 p.s.i.

Fig. 30 - Friction Loss With Different Size Nozzle Tips

3. Siamese the hose lines; i.e., arrange two lines from the pumper feeding one line to the fire.

In number one, if the nozzle pressure is reduced the g.p.m. will be less; therefore, the friction loss will be less. This may not permit the stream to perform the required task.

To reduce the size tip, as indicated in number 2, and maintain the same nozzle pressure would reduce the g.p.m.; then the quantity of water being discharged might not be sufficient to cool the fire in order to accomplish the extinguishment effectively.

When using the third method to combat friction loss in hose lines, with all other factors remaining constant, the friction loss will be reduced to approximately one-fourth (1/4) that indicated for the corresponding single 2-1/2" hose line. Referring to Figures 32 and 33, a comparison of the two hose layouts can be evaluated. In Figures 32 and 33, it can be noted that all the component parts are identical except the hose and the FL/100 feet. Here it is indicated that by changing the hose layout from a single line layout to a siamesed layout, (two into one), friction loss per 100 ft. is reduced from 23.8 p.s.i. to 6.6 p.s.i., which is approximately one-fourth the friction loss in the single layout. In addition to this, the pump pressure was reduced from 145 p.s.i. to 77 p.s.i., a drop of 68 p.s.i.

For 2½" Size Hose All Answers Are Approximate Elevation Is Not Included			
Length of Line	Maximum Size Tip Recommended	Maximum gpm Recommended for these Layouts	FL per 100'
Short Line 0' to 400'	1-1/4"	360 gpm	30 psi
Medium Line 400' to 800'	1-1/8"	300 gpm	21 psi
Long Line 800' to 1500'	1"	230 gpm	13 psi
Over a Long Line 1500' to 2000'	7/8"	130 gpm	8.5 psi

Fig. 31 - Considerations in Hose Layouts

Friction Loss in 1-1/2" Hose - Due to the smaller quantities of water normally discharged through 1-1/2" hose, a very simple calculation can be applied. For example, consider all nozzle pressure on 1-1/2" hose nozzles at 50 p.s.i. Using a 1/2" nozzle tip provides a discharge of 53 g.p.m., creating in a single 1-1/2" hose line approximately 8 p.s.i. friction loss per 100'. Assuming there is a 300' - 1-1/2" hoselay, the PP would be calculated as follows:

PP = NP + FL + EL
= 50 + (3 x 8) + 0
= 50 + 24 + 0
= 74 p.s.i.

For simple calculations it can be estimated that a nozzle pressure of 50 p.s.i. on a 1/2" tip attached to a 1-1/2" hose will provide a friction loss of 10 p.s.i. per 100 feet. This will provide a good working pressure in most all situations.

SINGLE 2-1/2" HOSE LINE		SIAMESE LINE TWO 2-1/2" INTO ONE	
Nozzle Pressure	50 p.s.i.	Nozzle Pressure	50 p.s.i.
Size Tip	1-1/4"	Size Tip	1-1/4"
g.p.m.	326	g.p.m.	326
Hose Line	400' (one 2-1/2" hose)	Hose Line	400' (two 2-1/2" hose lines siamesed into one)
FL (per 100')	23.8 p.s.i.	FL (per 100')	6.6 p.s.i.

Employing the above facts in both situations we learn that in the

SINGLE LINE	SIAMESE LINE
PP = NP + FL + EL	PP = NP + FL + EL
= 50 + (4 x 23.8) + 0	= 50 + (4 x 6.6) + 0
= 50 + 95	= 50 + 27
= 145 p.s.i. approximately	= 77 p.s.i. approximately

Fig. 32 - Comparison of Single and Siamese Lines

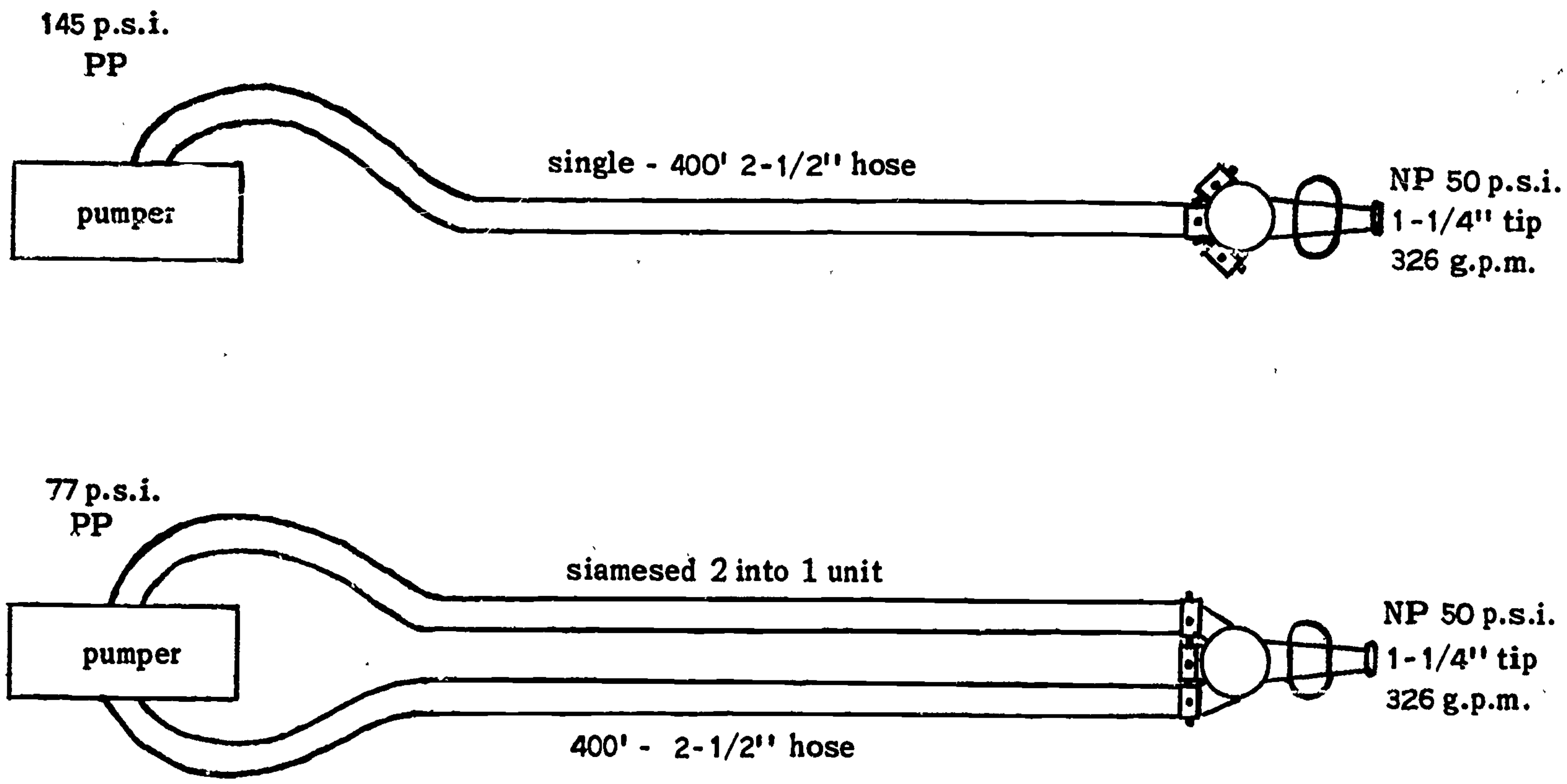


Fig. 33 - Single and Siamese Lines into Deluge Nozzle

Example #1: 800' of 1-1/2" hose; 1/2" noz. tip; 50 p.s.i. NP.

$$\begin{aligned} PP &= NP + FL + EL \\ &= 50 + (10 \times 8) + 0 \\ &= 50 + 80 + 0 \\ &= 130 \text{ p.s.i.} \end{aligned}$$

Example #2: 150' of 1-1/2" hose; 1/2" noz. tip; 50 p.s.i. NP.

$$\begin{aligned} PP &= NP + FL + EL \\ &= 50 + (10 \times 1.5) + 0 \\ &= 50 + 15 + 0 \\ &= 65 \text{ p.s.i.} \end{aligned}$$

When two 1-1/2" hose lines are siamesed into one, here, too, the friction loss per 100 ft. will be reduced to approximately one-fourth the friction loss in a single line of 1-1/2" hose, while discharging an equal g.p.m.

If a lay of 1-1/2" hose is supplied by a 2-1/2" hose line, the friction loss in the 2-1/2" hose can be calculated on the basis of friction loss for 1-1/2" hose, using the figure of 10 p.s.i. FL per 100 ft.

DETERMINING G.P.M. DISCHARGED

Much has been said about friction loss and how the increased or decreased amounts of water passing through a hose line, suction and pump have a direct bearing on the g.p.m. being discharged. For these reasons, it is important that a simple formula be accepted whereby it is possible to mentally calculate the quantity of water flowing from a nozzle rather then using a complicated one requiring paper and pencil. To further explain this, we must start with the more complicated formula; g.p.m. equals $(29.7 \times D^2) \times \sqrt{NP}$. The first step is to multiply 29.7 times D^2 for each straight nozzle used by the department, such as -- 7/8", 1", 1-1/8", 1-1/4", 1-1/2", 1-3/4" and 2". This will determine the factors to be used in the simple formula. These tip sizes and their g.p.m. factors are as follows:

Size Tip	7/8"	1"	1-1/8"	1-1/4"
Factor	20	30	40	50

Size Tip	1-1/2"	1-3/4"	2"
Factor	70	90	120

With the aid of these factors a mental calculation to determine g.p.m. discharge can be easily made.

Example: 1-1/4" noz. tip; 65 p.s.i. NP

$$\begin{aligned} \text{g.p.m.} &= \text{Factor} \times \sqrt{NP} \\ &= 50 \times \sqrt{65} \\ &= 50 \times 8 \\ &= 400 \text{ g.p.m.} \end{aligned}$$

The symbol $\sqrt{NP}$ indicates the square root of nozzle pressure which, in this problem is 65 p.s.i. The square root of any nozzle pressure in fire department hydraulics is calculated to the nearest whole number and used to obtain an approximate answer. Examples of this are as follows:

The square root of 64 is 8

The square root of 70 is 8

The square root of 50 is 7

The square root of 55 is 7

The square root of 80 is 9

The square root of 90 is 9

It can be recognized that the g.p.m. flowing from any given straight stream nozzle is dependent on two things:

1. The size tip
2. The nozzle pressure employed

The following example further explains this g.p.m. formula:

Example: 1" nozzle; 50 p.s.i. NP

$$\begin{aligned} \text{g.p.m.} &= F \times \sqrt{NP} \quad \text{(square root of nozzle pressure)} \\ &= 30 \times \sqrt{50} \\ &= 30 \times 7 \\ &= 210 \text{ approximately} \end{aligned}$$

DETERMINING REQUIRED PUMP PRESSURES

Pump pressure equals FL plus NP plus EL. Before proceeding with this study, a review of the "Friction Loss in Fire Hose" table from the *Fire Engine Test and Fire Stream Tables* booklet by the National Board of Fire Underwriters is in order.

The friction loss for:	For mental calculations use:
200 g.p.m. flowing through 2-1/2" hose is 10.1 p.s.i. per 100 feet.	10 p.s.i.
300 g.p.m. flowing through 2-1/2" hose is 21.2 p.s.i. per 100 feet.	20 p.s.i.
400 g.p.m. flowing through 2-1/2" hose is 36.2 p.s.i. per 100 feet.	40 p.s.i.
500 g.p.m. flowing through 2-1/2" hose is 55.0 p.s.i. per 100 feet.	50 p.s.i.

Example: What pump pressure is required for a 300 ft. 2-1/2" hose line having a 1-1/8" nozzle tip with 60 p.s.i. NP at no elevation?

(Factor for 1-1/8" nozzle tip is 40)

Answer:

$$\begin{aligned} \text{g.p.m.} &= F \times \sqrt{NP} \\ &= 40 \times \sqrt{60} \\ &= 40 \times 8 \\ &= 320 \text{ approximately} \end{aligned}$$

$$\begin{aligned} PP &= NP + FL + EL \\ &= 60 + (3 \times 20) + 0 \\ &= 60 + 60 + 0 \\ &= 120 \text{ p.s.i.} \end{aligned}$$

Note: When elevation (the vertical distance that the nozzle tip is above the pump) is involved, add to the pump pressure an additional five p.s.i. for each 12 feet of elevation or subtract 5 p.s.i. for each 12 feet the nozzle is below the pump.

It is most important for pump operators to be able to determine friction loss, nozzle pressures, gallons per minute, etc., by means of mental calculation, but it is more important, while working at fires, that some water be supplied through hose lines to the nozzleman at a safe (50-75 p.s.i. PP) pump pressure *immediately* upon receiving orders to "start the water." After the water has been started, the pump operator should check the pump pressure and the pump operating position and then make any changes necessary.

As an aid to the pump operator, it is recommended that a N.B.F.U. Fire Engine Test and Fire Stream Tables book or its equivalent be available for quick and accurate reference by the pump operator. Following this procedure will enable firemen to accomplish accurate results.

Pump Pressure Formula for Two Into One Siamese Lines - It has been established that the friction loss created within the siamese lines is approximately one-quarter the friction loss created within a single line layout, discharging an equal g.p.m. To determine the pump pressure for a siamese layout, using 2-1/2" hose, the following equation may be used.

Single line layout versus two into one layout:

Single line layout -- 1-1/8" tip; 400' of 2-1/2" hose; 50 p.s.i. NP; no elevation.

$$\begin{aligned} \text{g.p.m.} &= F \times \sqrt{NP} \\ &= 40 \times \sqrt{50} \\ &= 40 \times 7 \\ &= 280 \end{aligned}$$

Friction loss for 280 g.p.m. is approximately 20 p.s.i. per 100' of 2-1/2" hose; therefore,

$$\begin{aligned} PP &= NP + FL + EL \\ &= 50 + (4 \times 20) + 0 \\ &= 50 + 80 + 0 \\ &= 130 \text{ p.s.i.} \end{aligned}$$

Siamese line layout - 2-1/2" hose; 1-1/8" tip; 400' of 2-1/2" hose in each line joining into one; 280 g.p.m.; 50 p.s.i. NP FL per 100' of 2-1/2" hose in a siamese line is approximately one-fourth (1/4) that in the single line discharging an equal g.p.m.

$$\begin{aligned} PP &= NP + FL + EL \\ &= 50 + [(1/4 \times 20) \times 4] + 0 \\ &= 50 + (5 \times 4) + 0 \\ &= 50 + 20 + 0 \\ &= 70 \text{ p.s.i.} \end{aligned}$$

From the above calculations it is determined that there is a reduction of 60 p.s.i. pump pressure in the siamese layout vs. the single line. In each layout the same nozzle pressure and the same size nozzle tip were used.

Other Siamese Line Layouts - When using two or more pumpers to supply a siamese layout, each pumper discharges a quantity of water in direct relation to the number of hose lines connected to that pumper, such as:

1. When using one line from each of two pumpers, each pumper will discharge an equal amount of water, (approximately 1/2 the total amount discharged).

2. When using two lines from one pumper and

one line from another, the g.p.m. discharged from each pumper is approximately 2/3 from the pumper with the two lines and approximately 1/3 from the pumper having only one line when both are supplying the same nozzle or other water distributing tool.

Example: Size tip 1-3/4". NP -- 80 p.s.i. g.p.m. 810 (total).

Using two pumpers -- one with two 2-1/2" hose lines from pumper to nozzle, and one having one line from pumper to nozzle. See Figure 34.

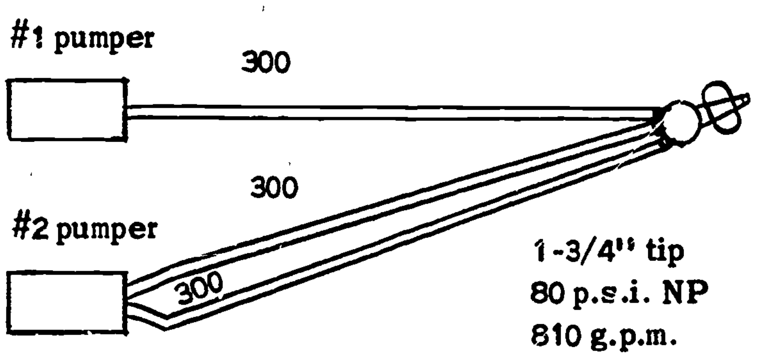


Fig. 34 - Two Pumpers With 3 Lines Into 1 Nozzle

Pumper #1:

g.p.m. = 1/3 of 810 (total g.p.m.)
= 270 g.p.m.

FL/100' in a single line for 270 g.p.m. = 20 p.s.i.

Therefore:

PP = NP + FL + EL
= 80 + (3 x 20) + 0
= 80 + 60 + 0
= 140 p.s.i. approximately

Pumper #2

g.p.m. = 2/3 of 810 (total g.p.m.)
= 540 g.p.m. - two lines into one

FL per 100' in a two line siamese for 540 g.p.m. equals 20 p.s.i. per average 100' of 2-1/2" hose from the pumper to the nozzle.

Therefore:

PP = NP + FL + EL
= 80 + (3 x 20) + 0
= 80 + 60 + 0
= 140 p.s.i. approximately

Refer to the Friction Loss Table in Figure 35 to determine the FL per 100 ft. of various hose sizes, calculated in loss of pounds per square inch. For example, with a flow of 280 g.p.m. through a 2-1/2 inch hose the FL will be 18.7 p.s.i. However, if two lines of 2-1/2 inch are siamesed, the FL at 280 g.p.m. is only 5.2 p.s.i. (approximately 1/4 the loss of a single line layout). Also, it is noted from the table, that a flow of 550 g.p.m. is possible from two siamesed 2-1/2 inch lines with a FL of 18.1 p.s.i. (approximately double the flow in a single line 2-1/2 inch layout at the same FL).

Relay of Pumpers (Head Pressure) - In some instances, when a fire department arrives at a fire, it finds that the fire is several thousand feet away from

Flow, Gallons Per Minute	Pressure Loss In Each 100 Feet of Hose Pounds Per Sq. Inch				Flow, Gallons Per Minute	Pressure Loss In Each 100 Feet Of Hose Pounds Per Sq. Inch		
	2½" Hose	3" Hose	3½" Hose	2 Lines of 2½" Siamesed		3" Hose	3½" Hose	2 Lines of 2½" Siamesed
140	5.2	2.0	0.9	1.4	525	23.2	10.5	16.6
160	6.6	2.6	1.2	1.9	550	25.2	11.4	18.1
180	8.3	3.2	1.5	2.3	575	27.5	12.4	19.0
200	10.1	3.9	1.8	2.8	600	29.9	13.4	21.2
220	12.0	4.6	2.1	3.3	625	32.0	14.4	23.0
240	14.1	5.4	2.5	3.9	650	34.5	15.5	24.8
260	16.4	6.3	2.9	4.5	675	37.0	16.6	26.5
280	18.7	7.2	3.3	5.2	700	39.5	17.7	28.3
300	21.2	8.2	3.7	5.9	725	42.3	18.9	30.2
320	23.8	9.3	4.2	6.6	750	45.0	20.1	32.2
340	26.9	10.5	4.7	7.4	775	47.8	21.4	34.2
360	30.0	11.5	5.2	8.3	800	50.5	22.7	36.2
380	33.0	12.8	5.8	9.2	825	53.5	24.0	38.4
400	36.2	14.1	6.3	10.1	850	56.5	25.4	40.7
425	40.8	15.7	7.0	11.3	875	59.7	26.8	43.1
450	45.2	17.5	7.9	12.5	900	63.0	28.2	45.2
475	50.0	19.3	8.7	13.8	1,000	76.5	34.3	55.0
500	55.0	21.2	9.5	15.2	1,100	91.5	41.0	65.5

Based on tests of best quality rubber lined fire hose. Rough rubber lining is liable to increase the losses given in the table as much as 50 per cent.

Fig. 35 - Friction Loss in Fire Hose

the nearest source of water supply. The water supply may be a fire hydrant, well, cistern, creek, river, etc. The total friction loss that would develop in the hose line to transport the water to the fire scene would be enormous. In order to overcome friction, two or more pumpers are connected in line to eliminate subjecting the hose and pumpers to excessive pressures.

There are several things to be considered:

1. length and size of hose between pumpers

2. capacity of pumpers

3. gallons per minute that will be discharged from the pumper closest to the fire

4. friction loss in the hose from one pumper to the next

5. difference in elevation between the pumpers and the elevation of the nozzle

Example: A fire is 2400 feet from the nearest source of water. Three pumpers are available and each contains 1000 feet of 2-1/2" hose. If a one-inch nozzle is used with 50 p.s.i. nozzle pressure, the pump pressures required on pumpers one, two and three are as follows: (no elevation involved) 1" noz. tip; 50 p.s.i. NP; 200 g.p.m. creating friction loss of 10.1 p.s.i. per 100' of 2-1/2" hose.

Therefore: With #1 pump connected to the hydrant and discharging 200 g.p.m. to pump #2, the pump pressure on #1 should be FL plus NP plusEL.

Pump #2, having the same layout, shall proceed in the same manner as pump #1, which is also discharging water at 150 p.s.i. pump pressure.

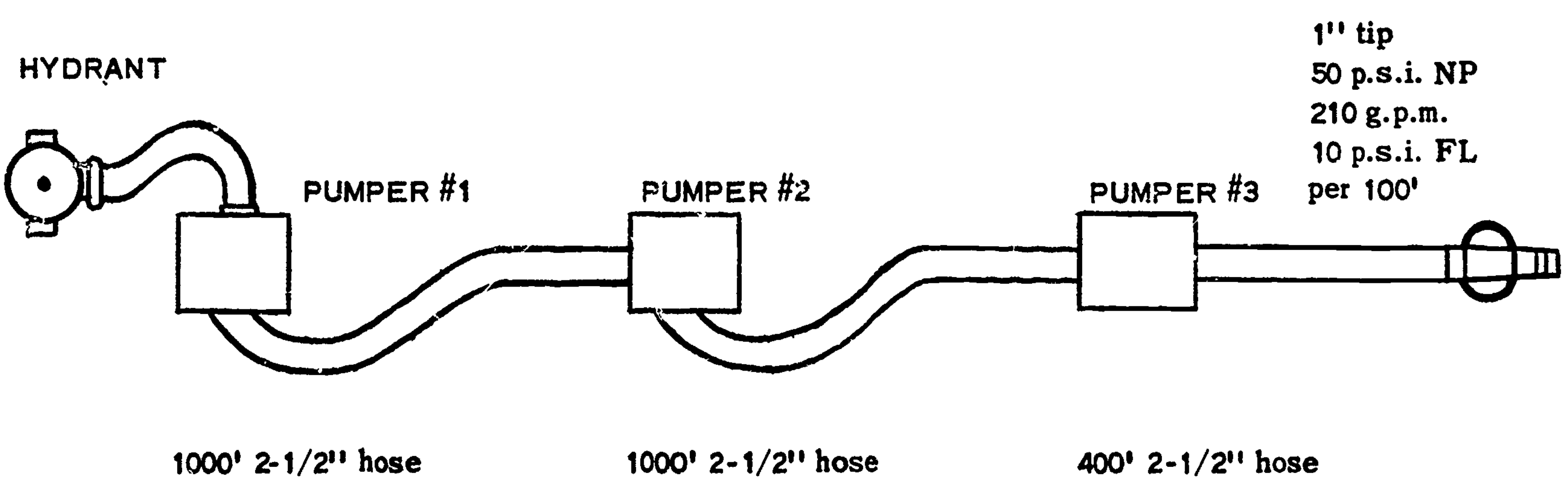
Pump #3 has 400 feet of 2-1/2" hose to nozzle; therefore, that problem will be (10 x 4) plus NP plus EL. See Figure 36.

When working in relay, every pumping unit must overcome the total friction loss within the hose between that pumper and the next one. To that pressure add the nozzle pressure desired at the fire. The pumper nearest the fire can be operated the same as if directly connected to the hydrant. Should the pumper closest to the fire discharge water through a second or third line and an increase in the g.p.m. output be created, the pump pressure for each pumper in the relay must be increased proportionately. With the aid of Figures 37 and 38, a pump operator can determine the pump pressure required.

1. Locate in column 1, 50 p.s.i. NP

2. Locate g.p.m. column for 1" tip.

3. Locate the g.p.m. figure that is vertically in line with the 1" tip and horizontally in line with the 50 p.s.i. NP, (209 g.p.m.)



PP = NP + FL + EL	PP = NP + FL + EL	PP = NP + FL + EL
= 50 + (10 x 10) + 0	= 50 + (10 x 10) + 0	= 50 + (4 x 10) + 0
= 50 + 100	= 50 + 100	= 50 + 40
= 150 p.s.i.	= 150 p.s.i.	= 90 p.s.i.

Fig. 36 - Three Pumpers For 2400 Feet of Hose

NOZZLE PRESSURE	Gallons of Water Flowing Per Minute at Various Nozzle Pressures and Sizes — NOZZLE SIZES												
	5/8"	3/4"	7/8"	1"	1 1/8"	1 1/4"	1 3/8"	1 1/2"	1 5/8"	1 3/4"	1 7/8"	2"	2 1/4"
30	63	91	124	162	205	253	307	365	429	498	572	651	823
32	65	94	129	167	212	261	317	377	443	514	591	673	854
34	67	97	133	172	218	269	327	389	457	530	610	693	880
36	69	100	137	177	224	277	336	400	470	546	627	713	905
38	71	103	140	182	231	285	345	411	483	561	645	733	930
40	73	106	144	187	237	292	354	422	496	575	661	752	954
42	75	108	147	192	243	299	363	432	508	589	678	770	978
44	77	111	151	196	248	306	372	442	520	603	694	788	1000
46	79	113	154	200	254	313	380	452	531	617	710	806	1021
48	80	116	158	205	259	320	388	462	543	630	725	824	1043
50	82	118	161	209	265	326	396	472	554	643	740	841	1065
52	84	121	164	213	270	333	404	481	565	656	754	857	1087
54	85	123	167	217	275	339	412	490	576	668	769	873	1108
56	87	125	170	221	280	345	419	499	586	680	782	889	1129
58	88	127	173	225	285	351	426	508	596	692	796	905	1149
60	90	130	176	229	290	357	434	517	607	704	810	920	1168
62	91	132	179	233	295	363	441	525	617	716	823	936	1187
64	93	134	182	237	299	369	448	533	627	727	836	951	1206
66	94	136	185	240	304	375	455	542	636	738	850	965	1224
68	96	138	188	244	308	381	462	550	646	750	862	980	1242
70	97	140	190	247	313	386	469	558	655	761	875	994	1260
72	98	142	193	251	318	391	475	566	665	771	887	1008	1278
74	100	144	196	254	322	397	482	574	674	782	900	1023	1296
76	101	146	198	258	326	402	488	582	683	792	911	1036	1313
78	102	148	201	261	330	407	494	589	692	803	924	1050	1330
80	104	150	204	264	335	413	500	596	700	813	935	1063	1347
82	105	151	206	268	339	418	507	604	709	823	946	1076	1364
84	106	153	208	271	343	423	513	611	718	833	959	1089	1380
86	108	155	211	274	347	428	519	618	726	843	970	1102	1396
88	109	157	213	277	351	433	525	626	735	853	981	1115	1412
90	110	159	216	280	355	438	531	633	743	862	992	1128	1429
92	111	160	218	283	359	443	537	640	751	872	1002	1140	1445
94	112	162	221	286	363	447	543	647	759	881	1012	[illegible]	1460
96	114	164	223	289	367	452	549	654	767	890	1022	1164	1476
98	115	165	225	292	370	456	554	660	775	900	1032	1176	1491
100	116	167	227	295	374	461	560	667	783	909	1043	1189	1506
105	119	171	233	303	383	473	574	683	803	932	1070	1218	1542
110	122	175	238	310	392	484	588	699	822	954	1095	1247	1579
115	124	179	244	317	401	495	600	715	840	975	1120	1275	1615
120	127	183	249	324	410	505	613	730	858	996	1144	1303	1649
125	130	187	254	331	418	516	626	745	876	1016	1168	1329	1683
130	132	191	259	337	427	[illegible]	638	760	893	1036	1191	1356	1717
135	135	194	264	343	435	536	650	775	910	1056	1213	1382	1750
140	137	198	269	350	443	546	662	[illegible]	[illegible]	1076	1235	1407	1780
145	140	201	274	356	450	556	674	803	[illegible]	1095	1257	1432	1812
150	142	205	279	362	458	565	686	817	960	1114	1279	1456	1843

Fig. 37 - Gallons of Water Flowing Per Minute at Various Nozzle Pressures and Sizes

4. Referring to Figure 38, locate in the first column, (g.p.m. flowing), the figure 200 g.p.m.

5. Then, under the vertical column that indicates the hose layout, which in this case is a single line of 2-1/2" hose, locate the friction loss that is horizontally in line with the 200 g.p.m.

6. Now multiply the FL per 100 feet times the number of 100 foot lengths between the supplying and receiving pumper. This will indicate the total FL in the 2-1/2" hose

FRICTION LOSS IN LBS. PER 100 FT. — RUBBER LINED HOSE														
G. P. M. Flowing	Single Line 1½" Hose	Two Lines 1½" Hose—Siam.	Single Line 2½" Hose	Single Line 3" Hose	Two Lines 2½" Hose—Siam.	G. P. M. Flowing	Single Line 2½" Hose	Single Line 3" Hose	Two Lines 2½" Hose—Siam.	Single Line 3½" Hose	G. P. M. Flowing	Single Line 3" Hose	Two Lines 2½" Hose—Siam.	Single Line 3½" Hose
50	8.0	2.2				280	18.7	7.2	5.2	3.3	650	34.5	24.8	15.5
60	11.2	3.1				300	21.2	8.2	5.9	3.7	675	37.0	26.5	16.6
70	15.0	4.1				320	23.8	9.3	6.0	4.2	700	39.5	28.3	17.7
80	19.5	5.2				340	26.9	10.5	7.4	4.7	725	42.3	30.2	18.9
90	24.5	6.5				360	30.0	11.5	8.3	5.2	750	45.0	32.2	20.1
100	30.5	8.0	2.5			380	33.0	12.8	9.2	5.8	775	47.8	34.2	21.4
110	37.6	9.6	3.0			400	36.2	14.1	10.1	6.3	800	50.5	36.2	22.7
120	45.5	11.4	3.6			425	40.8	15.7	11.3	7.0	825	53.5	38.4	24.0
130	54.5	13.3	4.3			450	45.2	17.5	12.5	7.9	850	56.5	40.7	25.4
140		15.4	5.2			475	50.0	19.3	13.8	8.7	875	59.7	43.1	26.8
160		20.0	6.6	2.6	1.9	500	55.0	21.2	15.2	9.5	900	63.0	45.2	28.2
180		25.0	8.3	3.2	2.3	525		23.2	16.6	10.5	950		49.9	31.2
200		31.0	10.1	3.9	2.8	550		25.2	18.1	11.4	1000	76.5	55.0	34.3
220		37.8	12.0	4.6	3.3	575		27.5	19.0	12.4	1050		60.2	37.8
240		46.0	14.1	5.4	3.9	600		29.9	21.2	13.4	1100	91.5	65.5	41.0
260		55.0	16.4	6.3	4.5	625		32.0	23.0	14.4	1150			44.6

Fig. 38 - Friction Loss in Lbs. Per 100 Ft. of Hose

between pumpers. To this FL must be added approximately 30 to 50 p.s.i. NP, which will be the operating PP for the relaying pumper.

Pump Pressures for Special Equipment - Each of these special tools present individual problems when figuring the necessary pump pressures required to obtain an efficient service. In some cases, a number of deluge nozzles of the same design, having been purchased from the same manufacturer at the same time, each have different degrees of friction loss when tested under identical circumstances. For this an average friction loss must be determined that is applicable to each situation. (The manufacturer can often furnish the department with this information.) These special tools are illustrated in Figures 18, 19, 39 and 40.

Suggested pump pressures with corresponding g.p.m. for:

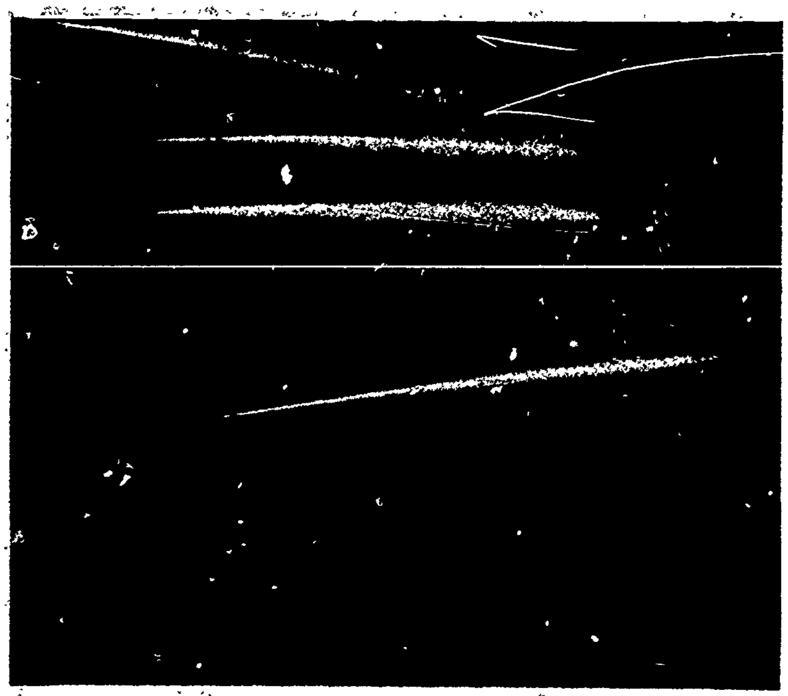
1. Ladder pipe --

1-1/4" nozzle tip attached to a short line

50# NP	100# PP	approx. 326 g.p.m.
75# NP	120# PP	approx. 400 g.p.m.

1-1/4" nozzle tip attached to a medium line

50# NP	130# PP	approx. 326 g.p.m.
75# NP	160# PP	approx. 400 g.p.m.



Courtesy Columbus, Ohio Fire Department

Fig. 39 - Using Deck Pipes or Turret Nozzles

1-1/2" nozzle tip attached to a short line

50# NP	130# PP	approx. 472 g.p.m.
75# NP	160# PP	approx. 578 g.p.m.

1-1/2" nozzle tip attached to a medium line

50# NP	160# PP	approx. 472 g.p.m.
75# NP	200# PP	approx. 578 g.p.m.

2. Jumbo vapor nozzle -- approximately 400 g.p.m. with 0' to 800' lines

   PP = 100 p.s.i. plus 10 p.s.i. FL per sec. plus EL.

3. Rotary cellar nozzle -- approximately 400 g.p.m.; PP = number of sections of (2-1/2" hose times 20) plus 40 p.s.i.

4. Sprinkler systems -- maintain 150 p.s.i. pump pressure at all times.

5. Stand pipe systems -- maintain 50 p.s.i. nozzle pressure on the fire floor.

   PP = NP + EL
   = 50 p.s.i. + 5 p.s.i. for each story of elevation

6. Foam generator - (see Figure 40) -- maintain 100 p.s.i. on the intake gauge of the generator.

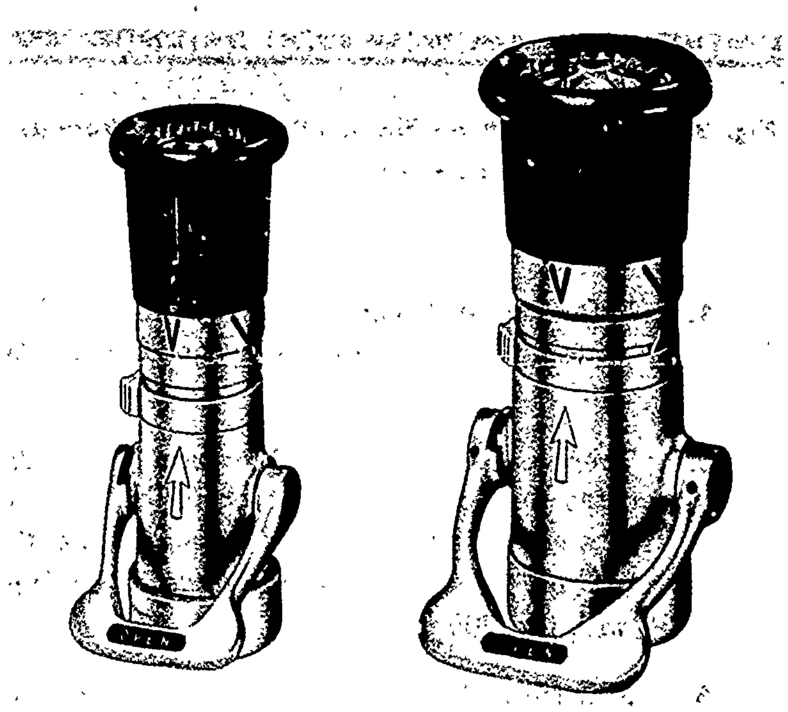
<u>Fog and Vapor Streams -</u> Nozzles that will produce fog and vapor streams are not designed so that the nozzle pressure and the g.p.m. being discharged can

Courtesy National Foam System, Inc.

Fig. 40 - Chemical Foam Generator

be determined with a Pitot Gauge. These nozzles are usually visually checked by firemen to determine a pump pressure that will give good results when operating at a fire.

A new type vapor nozzle is the "Spitz-All." See Figure 41. By pressing a button, this type nozzle cleans itself of foreign materials that have entered the nozzle from within the hose line. No shutting-off of hose lines is required while cleaning the nozzle. This nozzle is designed for use on 1-1/2" and 1" hose.



Courtesy Akron Brass Manufacturing Co., Inc.

Fig. 41 - "Spitz-All" Vapor Nozzles

The following is a list of various fog nozzles and their operating pressures used in the fire service. (Courtesy of the Toledo Fire Dept.)

2-1/2 inch Elkhart Mystery Nozzle

Stream or Cone	g.p.m. discharge at: 50# NP	100# NP	150# NP
Straight	90	135	170
30 deg.	110	160	190
60 deg.	114	170	210
90 deg.	123	194	230

1-1/2 inch Elkhart Mystery Nozzle

This nozzle has been adapted to a 2-1/2 inch barrel. It can be identified by the shut-off handle on the barrel.

Stream or Cone	g.p.m. discharge at: 50# NP	100# NP	150# NP
Straight	57	71	83
30 deg.	62	90	118
60 deg.	64	98	125
90 deg.	74	113	145

2-1/2 inch Rockwood S.G. 48, 1 inch straight stream, 60 degree fixed cone

Nozzle Pressure	g.p.m. discharge
50	90
100	115
150	135

2-1/2 inch Akron "Fog Hog" -- Factory recommended nozzle pressure -- 100 lb.

Stream or Cone	NP	g.p.m.
Straight	100	367
30 deg.	100	446
60 deg.	100	470
90 deg.	100	560

1-1/2 inch Rockwood S.G. 48 - 1/2 or 5/8 inch straight stream - 60 degree cone

Nozzle Pressure	g.p.m.
50	38
100	50
150	58

1 inch Booster Rockwood S.G. 48 - 1/4 inch straight stream

Nozzle Pressure	g.p.m.
50	12
100	16
150	20

Akron Fog Applicator

A minimum of 60 lbs. pressure at the fog head is necessary to produce effective fog. Pressures below 60 pounds will be considered water spray.

Nozzle Pressure	g.p.m.
20	24
40	36
60	45
80	54
100	58
120	63
140	66
160	67
180	69
200	70

It was previously stated that the total discharge from a pumper must be kept within the limits of the pump capacity and the safe operating motor speed in addition to the available water supply. If this is not done, poor and ineffective fire streams will result.

Fire Hose vs. Suction Hose - Supplying water to a pumper by a 2-1/2" fire hose vs. a 4-1/2" suction hose is as follows:

Area of 2-1/2" hose equals (2.5" x 2.5") x .7854 equals 4.9 square inches.

Area of 4-1/2" suction hose equals (4.5" x 4.5") x .7854 equals 15.9 square inches.

15.9 sq. in. divided by 4.9 sq. in. equals 3.2 times greater; therefore, one 4-1/2" suction hose connected to a hydrant will supply a pumper with approximately three to four times more water than can be supplied through one 2-1/2" fire hose from the same hydrant.

FOAM EQUIPMENT

Chemical Foam Equipment - Foam generating equipment and supplies are used to combat fires in tanks of oil, gasoline and other volatiles. Many bulk oil

and gasoline installations and similar industries have fixed foam systems that are placed in service manually by either a trained group of employees or fire department personnel that respond to extinguish the fire. Firemen should have a thorough knowledge of the location, construction and operation of such installations.

The principle on which these generators work is one of a chemical action. A foam substance is produced when the ingredients are mixed with water. This operation consists of feeding a pre-mixed powder into a hopper and forcing water, at 100 p.s.i. pressure, through an injector type device which draws the powder into the generator and mixes the powder with the water in proper proportions, thus producing foam.

The weight of the generator is approximately 65 pounds and can be handled very easily by one man. To prevent clogging, the powder should never be pushed down in the hopper. The hopper must be kept well filled during the discharge period.

Foam will be available in 10 to 15 seconds after the generator is put into operation. The intake of the generator is equipped with a pressure gauge which enables the operator to observe the water pressure as it enters the generator.

Not over 150 feet of 2-1/2" hose or 100 ft. of 3" hose should be used from the generator to the nozzle.

Foam generator powder is a finely ground material. It is packed in sealed cans, each containing about 45 pounds. A generator operating at 100 p.s.i. intake pressure will consume about two cans of powder per minute. The approximate results are listed as follows:

1. Pressure at generator intake gauge - 100 pounds.
2. Maximum length of 2-1/2" hose - discharge to nozzle - 150 feet (3 sections)
3. Type of nozzle - smooth bore nozzle and tip
4. Size of tip - 1-3/4"
5. Pressure at generator outlet - 34 pounds
6. Pressure at base of nozzle tip - 6 pounds
7. Amount of water used - 53.4 gallons
8. Amount of powder used - 100 pounds
9. Quantity of foam produced - 515 gallons
10. Quality of foam - very good.
11. Pounds of powder per gallon of water - 1.87 pounds

The following steps should be followed in putting the generator into service:

1. Place the generator about 100 feet away from the fire and, if possible, on the windward side.
2. Connect 150 feet of 2-1/2 inch hose to the discharge side of the generator. The nozzle would not be equipped with a shut-off, and the size of the tip should be 1-3/4 inches or larger.
3. Lay a line of hose from the pump discharge to the generator. The length of this line does not make any difference as long as 100 pounds intake pressure is maintained at the generator.

Mechanical Foam Equipment - A method of producing foam mechanically rather than chemically is often used. The foam is produced by the combination of water, foam solution and air passing through a specially constructed play pipe. See Figure 42.

Courtesy Akron Brass Manufacturing Co., Inc.

Fig. 42 - Mechanical Foam Play Pipe

The equipment necessary for producing mechanical foam consists of a foam compound and a foam nozzle designed for mixing the water and foam solution. The foam nozzles are so constructed that they can be used on a hose size from 3/4 inch to 2-1/2 inches and will operate efficiently at nozzle pressures ranging from 75 to 200 pounds. The manufacturers furnish detailed information on the proper pressures to be maintained for various size hose. These instructions should be followed when operating the equipment.

The foam solution is generally packed in 5 gallon containers, with each gallon producing approximately 350 gallons of foam. This equipment is operated by coupling a specially constructed nozzle to a hose line. This nozzle is fitted with a tube through which the proper amount of foam compound is automatically drawn into the water stream. The water and foam compound mixture is then forced through several openings; air is drawn in through larger openings, and the foam is physically produced.

CHAPTER 5

FIRE HYDRANTS

INTRODUCTION

A fireman must know the fire fighting tools available for effective extinguishment with none being more important than an ample water supply. It is necessary, therefore, for every member, and especially the officers, to know the water supply and distribution system of the city.

Each fire station should have a map showing mains, hydrants and valves within the district. Maps should show the main to which the hydrant connects. In many cases one hydrant on a large main may give an ample supply while another, connected to a small main, will give a small supply.

Fire flow tests made by the water department or by the underwriters should be studied. Hydrants which have been proven *not to have* an ample supply should be so indicated on the map.

The size of all hydrants should be known; many old hydrants' capacities are too small for present day fire apparatus. In general, hydrants with barrels less than six inches in diameter and those without large outlets cannot supply engines of more than 600 g.p.m. capacity.

The ability of the water supply to feed automatic sprinkler systems is important. Unless pressures are high and the main to which the sprinklers are connected are 12 inches or larger, the pumpers connected to these hydrants will usually draw pressures down to a point where the sprinkler system may be without water. Under these conditions, one or more pumpers should be connected to and supply water to the sprinkler system exclusively.

Firemen should know the general range of pressure and the location of dividing gate valves between different services or supplies. The officer in charge should determine whether it would be advisable to have a heavy user of water temporarily shut down and if advisable to restrict lawn sprinkling.

As an emergency provision, the fire department should have knowledge of all other sources of water which could be used in case the normal water supply is interrupted. These would include private wells, rivers, canals or ponds.

CODING HYDRANTS

In order that fire department personnel may know the quantity of water available at a hydrant, various methods of marking have been devised. One method is to indicate on each hydrant, by means of a color code, the size of the main supplying it and its pressures. Also paint of a distinctive color on the next to the last hydrant on each dead end main indicates that only one more hydrant can be expected beyond that point.

Although this method of hydrant markings provides needed information, it gives no assurance when a considerable number of pumpers are working that these hydrants will be able to deliver the necessary quantity of water. A potential condition of this kind should be tested by running fire flow tests on groups of hydrants. Where it is found that these hydrants are not supplying a sufficient amount of water, the grid should be strengthened.

HYDRANT PRESSURES

When using normal nozzle pressures while discharging water from two hose lines, each with an 1-1/8" tip or each with 1-1/4" tips or three lines each with 1" tips, they will deliver between 500 and 600 g.p.m. of water. The more common sizes of pumpers are those of 500, 750 and 1,000 g.p.m. rated capacity. It is thus seen that deliveries of 500 to 600 g.p.m. may be required from any hydrant.

Many water systems, installed years ago, contain considerable 4 inch pipe for street mains. Some cities and towns continue to install 4 inch pipe, but it is recommended that a minimum size of 6 inch pipe be laid for mains supplying hydrants. For flows of 500 to 600 the friction loss in a 4 inch pipe with good interior condition is 10 to 15 pounds per 100 feet. From this it can be readily seen that with 40 to 60 p.s.i. a 4 inch dead-end main more than 300 or 400 feet long will not deliver a sufficient supply to a

FIRE HYDRANT RECORD

Street Location____________________ Date Installed____________________

Between____________________ and____________________ streets.

		No. of Outlets	Size of Outlets	Static & Flow Pressures - G.P.M. Available					
				Date	Static P.	Flow P.	Outlet Used	G.P.M.	By Whom
Water Main Size									
Lead-in Pipe Size									
Type Street Valve									
Street Valve Opens									
On a Dead End Main									

Type of Neighborhood ☐ Residential ☐ Small Business ☐ Commercial

Type Hydrant Construction ☐ Standard ☐ Break-Type

Street Valve Location From Hydrant	Front	Rear	Right	Left
	______ ft.	______ ft.	______ ft.	______ ft.

Fig. 1 - Fire Hydrant Record Card

REPAIRS MADE

DATE	Operating Nut	Stem Nut	Rod-Stem	Hydrant Valve	Cage Valve	Drip Valve	Seat Ring	Top Gasket	Bottom Gasket	Hydrant Top	Bonnet-Cap	Stuffing Box	Oil Nut	Spear Plate	Hydrant Shoe	Extension	Joint Caulked	4-1/2" Nozzle	3" Nozzle	2-1/2" Nozzle	4-1/2" Nozzle Cap	3" Nozzle Cap	2-1/2" Nozzle Cap	Hyd Replaced	Hydrant Reset	Hydrant Stock	Hydrant Moved	Safetop Set	Hyd Abandoned	Locate Valve	Hydrant Thawed	Cement Walk	Brick Walk	Unimproved			REPAIRMAN
HYDRANT SERVICE RECORD	DATE	IN																																			
		OUT																																			

Fig. 2 - Hydrant Service Record Card

pumper. If the main is fed from both ends the pumper will be able to get 600 g.p.m. even though the total length is up to 2,000 feet; but if two pumpers are put to work, one or both will get an insufficient supply. Where 4 inch pipe is in use, more than one pumper can seldom be used to advantage. Other pumpers should go to hydrants on larger mains even though longer hose lines might be necessary.

This chapter would not be complete without considering the industrial plants' private yard hydrant system. If there is such a system in the community each chief and company officer should become thoroughly familiar with it. Most of these have hydrants and standpipes so located and under such pressures as to permit good operation direct from the hydrants. Pumpers should never be connected to one of these hydrants if the private system has its own pumps and is intended to be operated as a hydrant stream system. If a pumper takes supply from such a system the result may be an inadequate sprinkler supply in addition to poor hand lines from the other hydrants.

EXPLANATION OF ITEMS ON HYDRANT RECORD CARD

See Figure 1.

1. Location - Record street address and between what two streets it is located, such as: 1212 Beacon Street, between John and Allen Streets; or other geographical features describing the location.

2. Date Installed - Record date hydrant was installed.

3. Main - Record size of main supplying hydrant.

4. Lead-In - Record size of lead-in from main to hydrant.

5. Street Valve - Record type of key necessary to operate valve, such as "fork key," "water works key," etc.

6. Opens - Record whether street valve opens clockwise or counter-clockwise.

7. Number and Size of Outlets - Record number and size of discharges on hydrant.

8. Static Pressure - Record last static pressure reading - p.s.i.

9. Flow Pressure - Record last flow pressure reading - p.s.i.

10. Outlets Used. Record the number of outlets and the sizes used in flow test.

11. Gallons Per Minute - Record g.p.m. flowing on test.

12. Dead End - If dead end hydrant place an "X".

13. Valve Locations - This means the street valve that is used to turn off the hydrant supply because the hydrant is not serviceable. Sometimes these valves are covered by a street surfacing material and cannot be easily located. Therefore, a record of the distance of the street valve from the center of the hydrant stem to the center of the valve lid should be recorded. These measurements are determined by the person making this survey while facing directly forward into the street with his back to the hydrant, thereby positively determining the "front, rear, right and left" - terms used. When a hydrant is moved, the measurements for the street valve must be corrected.

14. Survey Date - Record the date the last rating survey was made.

15. Nature of Neighborhood - Record whether it is a district of factories, multiple dwellings, one-family residences, etc.

16. Last Survey Inspection Made By - Record name of person making inspection.

17. Repairs Made - Figure 2, which is the back side of Figure 1, suggests a simple hydrant repair record chart.

Figure 3 is for use in recording inspection of hydrants.

TYPES OF FIRE HYDRANTS

GENERAL TYPES

There are two general types of fire hydrants in use today: (1) The "break" type hydrant and (2) the "standard" type hydrant. See Figures 4 and 5. The principle difference between these two types of hy-

HYDRANT INSPECTION RECORD

Division of Fire

Hydrant No.________________

Location________________

Hydrant Size________4"________6" ________2-1/2" to 4"

No. of Openings________2-1/2"________4"

Hydrant Tested		Out of Service		Maintenance & Repairs	
Date	Result	Date	Reason	Date	

Fig. 3 - Hydrant Inspection Record Card

drants is that in the "break" type hydrant the standpipe and stem are each in two sections joined a few inches above the ground level by a special ring carefully designed to withstand all ordinary blows. It will break cleanly in most cases if the hydrant is struck by a smashing blow which would normally cause serious damage to a standard hydrant, which is constructed in one section.

SELF-DRAINING HYDRANTS

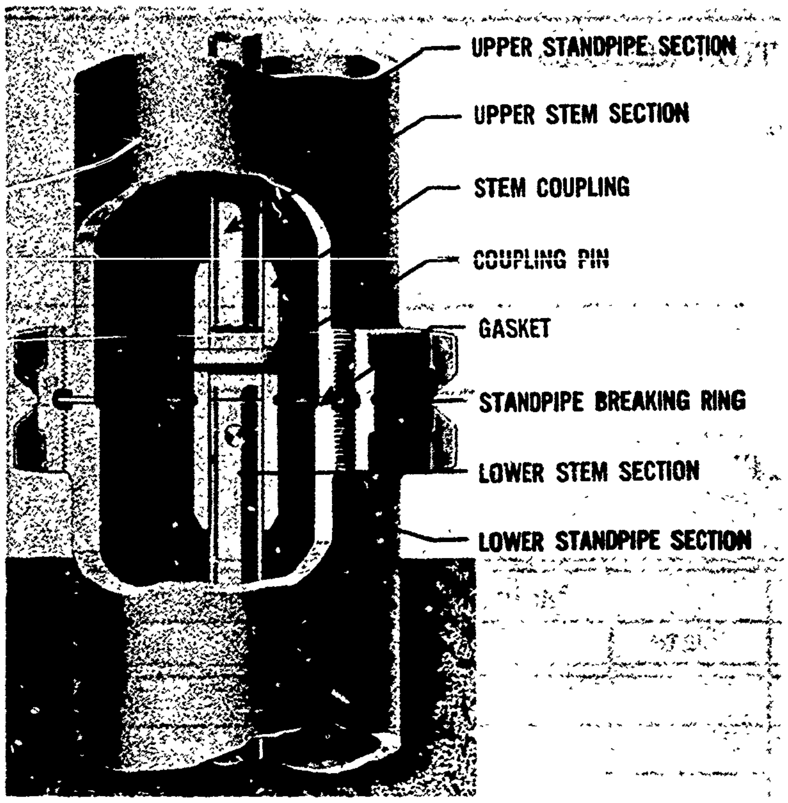
Many hydrants are constructed to permit the water remaining in the hydrant barrel to drain out through the drain ports from within the hydrant to the surrounding underground drainage area after the hydrant has been used and fully closed. See Figure 6.

Special consideration must be given to hydrants located where the surface water surrounding the hydrant is higher than the drainage ports within the hydrant. When this situation continually exists it is recommended that these drain ports be plugged to prevent the surface water from entering the hydrant barrel. This hydrant then becomes a non-self draining hydrant. In rare situations, a few handfuls of salt can be inserted in the hydrant to prevent freezing.

HIGH PRESSURE HYDRANT

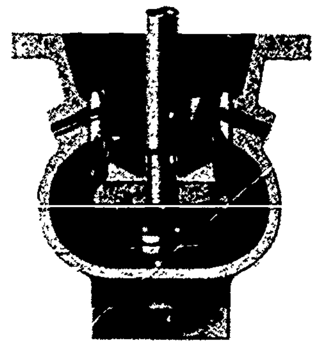
These hydrants are generally supplied by a special water system whereby the high pressure is developed when needed, with the aid of a special high pressure pumping unit located in a nearby pumping station. In emergency situations these high pressure systems are often supplied with high pressure by utilization of fire boats when such boats are available. Figure 7 indicates one type of high pressure hydrant.

One example of a high pressure pumping station and equipment consists of four 10 inch 5-stage horizontal centrifugal pumps, each with a rated capacity



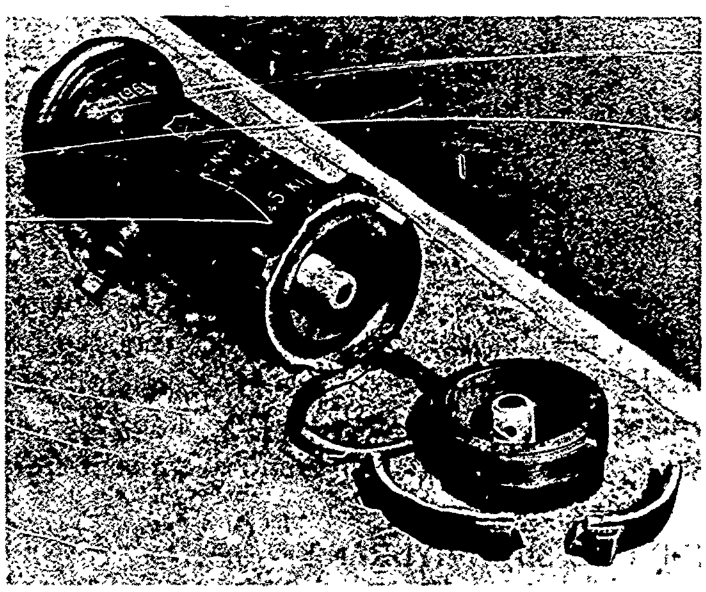
Courtesy Kennedy Valve Manufacturing Co.

Fig. 4 - Construction of Safety Breakable Section of the Kennedy Safetop Fire Hydrant



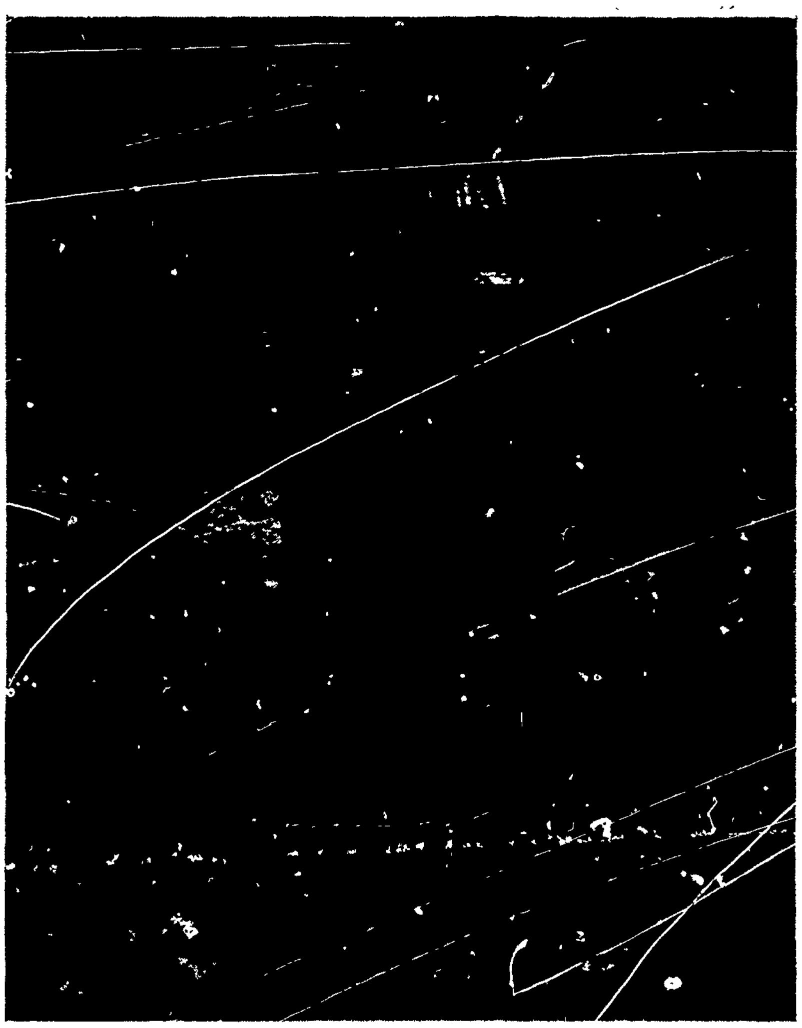
Courtesy Kennedy Valve Manufacturing Co.

Fig. 6 - Self-Draining Hydrant Valve



Courtesy Kennedy Valve Manufacturing Co.

Fig. 5 - Kennedy Safetop Fire Hydrant After Rupture of Safety Breakable Section



Courtesy Toledo, Ohio Fire Department

Fig. 7 - High Pressure Hydrant

of 2,000 gallons per minute at 300 pounds pressure. It receives its water supply from a nearby river.

On receipt of an alarm of fire in the district served by the system, one pump is started raising the pressure to 175 pounds. This pressure can be raised or lowered at the request of the officer in charge at the fire. Two 4 inch gated connections from a header discharging to the river are manually oper-

ated to control the pressure . The system is kept full at 15 pounds pressure from a tank under the roof of the station and supplies 66 Mathews High Pressure hydrants.

To Operate a Mathews High Pressure Hydrant - Be positive that all discharge valves are closed. Place the hydrant wrench on the main operating nut and turn counter-clockwise five turns. The main hydrant stem travels downward, closing the drain orifice and then opening the relief valve, permitting water to enter the hydrant barrel and equalizing the pressure below and above the main valve. After five turns are given, remove the cap on the hydrant and connect the hose to the outlet. Open the main valve all the way. When water is called for, slowly turn the independent valve counter-clockwise until water begins to enter the hose. Then continue opening the valve for the service required.

Second, third and fourth lines, operating from a hydrant that has one line already in operation, are controlled by the independent shut-off valves which sit directly over each outlet.

To shut down any line on the high pressure hydrant, turn the independent valve, directly above the line to be shut down, clockwise until the valve is closed. Remove the hose from the hydrant and replace the hydrant cap.

To shut down the hydrant completely, all four independent valves must be closed first. Then the main valve is closed by turning the main operating nut clockwise.

Hydrants must be drained after use, especially in the winter time. After the main valve is closed remove the hose and open one of the independent valves slightly to allow air to enter the hydrant barrel. That permits the water remaining in the hydrant barrel to drain out through the open drain valve. After the hydrant has drained properly, close the independent valve and replace the cap on the hydrant.

In a few situations, gravity flow is sufficient to maintain a reasonable amount of high pressure (160-180 p.s.i.) for a limited number of fire lines working at a fire. This system, like other high pressure fire hydrant systems, receives and distributes the water independent of all domestic water supplies. Also, this pressure is often augmented by a fire pumper connected to the high pressure system and distributing the water from the high pressure system through the pump and hose lines to the fire.

HOW TO TURN A FIRE HYDRANT ON AND OFF

A specially designed hydrant wrench, having a fixed dimensional opening equal in size and shape to fit the operating nut on top of the hydrant, should be readily available for this purpose. *No adjustable or open-end wrench of any design should be used to turn any fire hydrant on or off.* The purpose of this policy is to eliminate the possibility of damaging the top nut on the hydrant to an extent that prevents the use of the hydrant when needed.

Before any fire hydrant is turned on, the hydrant caps on the discharges not being used should be tightened to prevent water discharge from these points. Also, the direction of the arrow on the hydrant bonnet should be noticed to learn which direction to turn the stem to open the hydrant. When turning on a hydrant that opens against the pressure, the first turns will be the hardest. After the valve has been removed from the valve seat, water will flow to the top of the valve, equalizing the water pressure on both sides. Now the hydrant valve stem will normally turn freely. There are many other hydrants in service that open with the pressure and are equally efficient when in good order.

When turning off a fire hydrant, care must be exercised not to "pull down" the hydrant valve stem so tightly that the steel operating-stem damages the bronze stem-nut, which would make the hydrant inoperative. Quite often the damage to the valve stem was caused by prior usage, but such damage was not realized at the time.

When turning off a self-draining hydrant the valve should be pulled down sufficiently to stop the flow of water. The hydrant man must wait a few minutes to allow the water to recede through the drain ports into the ground. Then the hydrant must be tested with a measuring strap or hydrant pump-hose to determine if all the water has drained from the hydrant. If not, then an additional pull must be made on the valve stem to further close the valve. This is the danger point to the operating stem, and it is often damaged at this time. When turning off a hydrant that does not have operating drain ports, the hydrant stem should be pulled down far enough to stop the flow of water from the lowest hydrant discharge. To speed up operations at this point, the hydrant man can, with his hand, drag out the water resting on the inside of the hydrant discharge nipple and wait a few seconds to see whether the water builds up again as before, or if it remains dry. The results of this operation will indicate whether or not the hydrant valve is completely closed. If it is not, the hydrant stem must be turned to the closed position slightly more, being careful not to strip the hydrant stem nut threads while performing this operation.

When it is difficult to stop the dripping of water from the lowest discharge of the hydrant, best results

are often obtained by opening the hydrant sufficiently to flush obstructing particles from the valve seat. After flowing the hydrant for a few minutes (this need not be a maximum flow) the procedure to close the hydrant should be repeated. After a reasonable number of attempts fail to accomplish what is desired, the hydrant should be reported to the proper authority as is defined by local policy.

When turning off most hydrants that close with the pressure, the hydrant operating valve stem will turn freely until it reaches a near-closed position. Then an added resistance is often met for approximately one-half turn.

INSPECTING AND TESTING FIRE HYDRANTS

In some communities, fire department personnel do not have the responsibility of routine inspecting and testing of fire hydrants located within their territory. In these cases, it is a responsibility of another department. The best procedure to follow can be determined only by those in charge at each individual community. However, the success of a fire department in extinguishing fires is often dependent on the quantity of water available. It is, therefore, advisable for the fire chief or a representative of the chief to keep a close check on the fire hydrant system and make certain that these hydrants will be ready for emergency use.

For those fire departments who do inspect and/or test the in-service fire hydrants, the following should be helpful. There are five hydrant inspection procedures.

1. The semi-annual inspection (April and October)
2. The winter daily inspection (October to April)
3. The summer weekly inspection (April to October
4. The new installation inspection, including annexation
5. The after repair inspection, including floods

THE SEMI-ANNUAL INSPECTION

The objective for the semi-annual inspection is to check the operating features of each individual fire hydrant following six months of winter and again after six months of summer. Also, a visual inspection is made of the hydrant barrel, caps, chains and secondary valves for any defects that may have occurred.

THE WINTER DAILY INSPECTION

The objective for the winter daily inspection is to make certain that these hydrants are not frozen or filled or partially filled with water which may freeze. Also, these daily inspections are a "follow-up procedure" to determine if those people having a "hydrant use permit" are reporting the use of these hydrants according to policy in each local community during the winter season.

THE SUMMER WEEKLY INSPECTION

The objective for the summer weekly inspection is to observe the condition of the hydrant and its component parts, to remove any weeds for a radius of at least four feet around the hydrant, and to make certain that the secondary valve lid is not covered with mud, cement or road surfacing materials that would make it difficult to locate if needed.

THE NEW INSTALLATION INSPECTION (INCLUDING ANNEXATION)

The objective of the new installation inspection is to test the water flow from the hydrant to ascertain if this hydrant is ready for use by a fire company during fire extinguishment operations. This hydrant should be flushed to clear the main of stones and other foreign materials. Also, the threads should be matched with corresponding thread adapters to check thread type and size. The discharges must be observed for proper positioning and should be reported if incorrectly installed. The same procedure should be adopted for all hydrants inherited through the process of annexation.

AFTER REPAIR AND AFTER FLOOD INSPECTION

The objective for the after repair inspection is to determine whether or not the secondary valve is fully open and the hydrant ready for service. The other objective is to follow up on the defects reported and determine if repairs have been made.

During a flood situation the supply of water to the hydrant should be turned off at the secondary valve whenever it is evident that the flood waters will reach the hydrant. After the flood waters recede the secondary valve must be opened to restore normal operation.

FIRE HYDRANT INSPECTION RECORD

Date__________ Plug No.__________

Location __________

Manufacturer __________

Size Steamer Opening__________

Thread Size - 2-1/2" Openings__________

Turn to Open - Clockwise__________ Counter Clockwise__________

Turning Nut on Head - Square__________ Pentagon__________

Turning Nut on Caps - Square__________ Pentagon__________

Did you Grease Cap Threads __________

Are You Sure Caps Are Just Hand Tight__________

Is There Any Leakage When Closed__________

Are There Any Obstructions ' ear Plug __________

Did You Flush__________

Does Drain Function Properly__________

Static Pressure__________

Flow Pressure__________

G. P. M.__________

Remarks__________

Recommendations to Water Dept.__________

Signed__________

Fig. 8 - Sample Fire Hydrant Inspection Record

TOOLS AND SUPPLIES USED FOR INSPECTION

1. One 8 inch crescent wrench
2. One medium size screw driver
3. A one quart oil can filled with three parts lubricating oil to one part coal oil
4. Regulation size hydrant wrench
5. Hydrant pump
6. Extra top nuts and top screws
7. Hydrant caps and chains
8. Notebook or prepared inspection form. See Figure 8.
9. Rag of medium size and stiff scrub brush

SERVICING HYDRANT

1. Remove top-nut or oil screw (if either is provided) with the crescent wrench or the screw driver. Replace with new one when required.
2. Pour a small amount of oil into oil hole and replace the top-nut or the oil screw, whichever applies. If alemite fitting, lubricate; see Figure 9.
3. Remove all discharge caps and clean all threads with rag and stiff brush.
4. Replace all hydrant caps tightly except one from which water will test flow.
5. Use regulation size hydrant wrench to flow test the hydrant. This need not be the full flow from the hydrant, especially when this operation might result in damage to property. Also, consideration must be given to the fact that this function most generally muddies the water in the main, making it unfavorable for domestic use.
6. The hydrant pump is used after the hydrant has been flow tested in October to prevent the water from freezing during the cold weather months. This is not necessary in the April servicing.
7. Where required, broken hydrant caps and missing chains should be replaced.

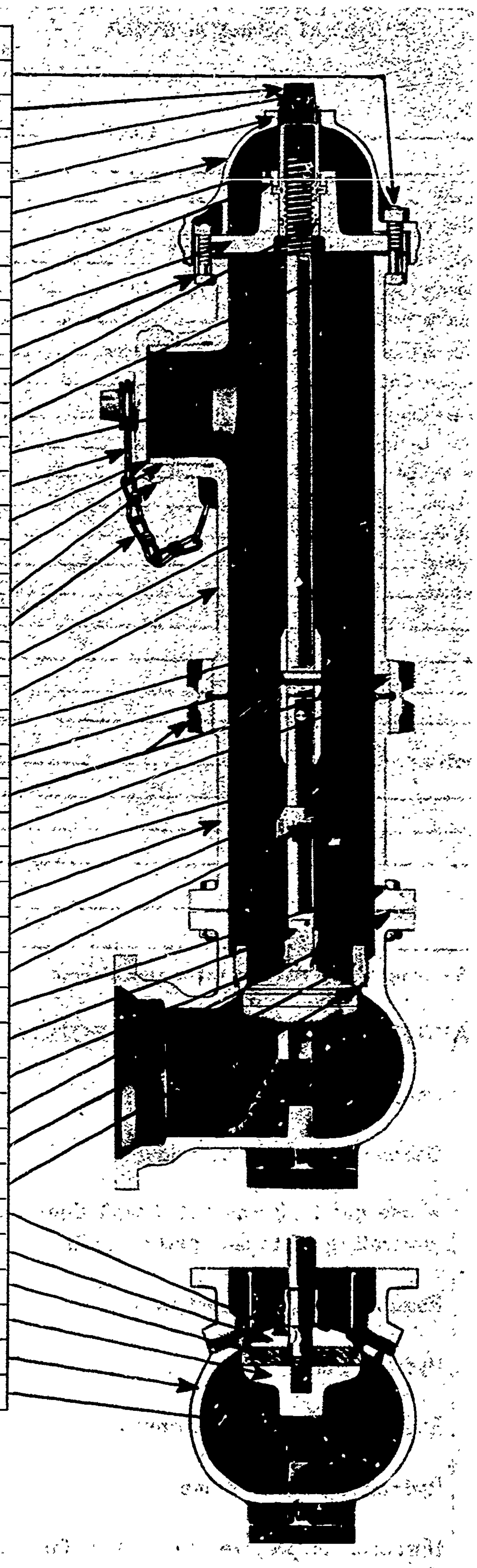
PRESSURE TEST

After flushing, the hydrant should be subjected to a pressure test. To do this a tapped hydrant cap with gauge attached should be placed on one outlet, the caps on other outlets drawn tightly, and the hydrant opened wide. The pressure should be recorded and the hydrant checked for leaks. After these observations have been noted, the hydrant should be shut down and observations made as to whether it is a self-draining hydrant and functioning properly.

Where hydrants are set so that the drain port is in ground water, this port should be plugged; or if they have previously been plugged the hydrant should be [illegible] out immediately after each use in freezing [illegible].

[illegible] female hose coupling should [illegible] screwed on each outlet to determine if a connection can be made. Chains, if provided, should be freed of exces[illegible] paint

PART	MATERIAL
CAP BOLT NUTS	BRONZE
OPERATING STEM NUT	BRONZE
ALEMITE FITTING	STEEL
"O" RING WEATHER SEAL	BUNA N SYNTHETIC RUBBER
CAP	CAST IRON
ALLEN HEAD SETSCREW	STEEL
LOCK NUT	BRONZE
COVER PLATE	CAST IRON
COVER PLATE BOLTS AND NUTS	RUST-PROOFED STEEL
"O" RING PRESSURE SEAL	BUNA N SYNTHETIC RUBBER
COVER PLATE GASKET	CORK FIBRE
NOZZLE SCREW	BRONZE
NOZZLE CAP HOOK	STEEL
NOZZLE CAP GASKET	RUBBER
NOZZLE	BRONZE
NOZZLE CAP	CAST IRON
NOZZLE CAP CHAIN	STEEL
UPPER STEM SECTION	C.R. STEEL
UPPER STANDPIPE SECTION	CAST IRON
STEM COUPLING	CAST IRON
COUPLING PINS	RUST-PROOFED STEEL
STANDPIPE BREAKING RING	CAST IRON
STANDPIPE GASKET	SPECIAL COMPOSITION
LOWER STEM SECTION	C.R. STEEL
LO[illegible]ANDPIPE SECTION	CAST IRON
SEA[illegible]VING WRENCH GUIDE	BRONZE
WRENCH GUIDE SETSCREW	BRONZE
ELBOW BOLTS AND NUTS	RUST-PROOFED STEEL
DRAIN VALVE FACING	LEATHER
DRAIN VALVE	BRONZE
ELBOW GASKET	CORK FIBRE
SEAT RING	BRONZE
SEAT RING GASKET	COPPER ASBESTOS
DRAIN VALVE KEY	STEEL
TOP PLATE	CAST IRON
MAIN VALVE	BALATA
FULL COVER BOTTOM PLATE	CAST IRON
ELBOW	CAST IRON
DRAIN TUBING	BRONZE



Courtesy Kennedy Valve Manufacturing Co.

Fig. 9 - Hydrant Parts

and should be straightened to insure free movement on the hydrant cap.

INSPECTING HYDRANTS WITH GATE VALVES

Some hydrants are equipped with gate valves. See Figure 10. These valves are manually moved to close off a discharge port and must be inspected for possible defects. Sometimes a part of these gate valves are broken off and fall to the bottom of the hydrant barrel. Should this occur, such parts should be flushed out if possible. Otherwise, some other means must be employed to remove it. In either case, a repairman must be notified to take the necessary action to correct this situation.

The Mathews High Pressure hydrant, shown in Figure 11, has an 8 inch gated branch from the main to the hydrant and a 12 inch barrel with four independently gated 3-1/2 inch outlets, reduced to 2-1/2 inches.

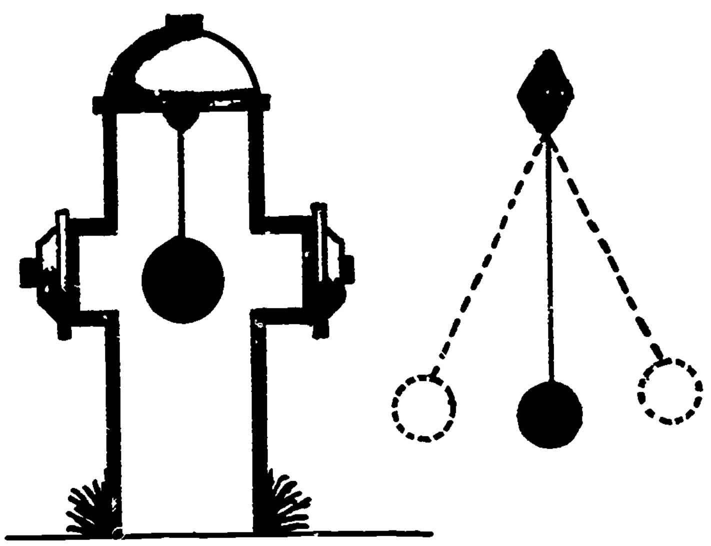


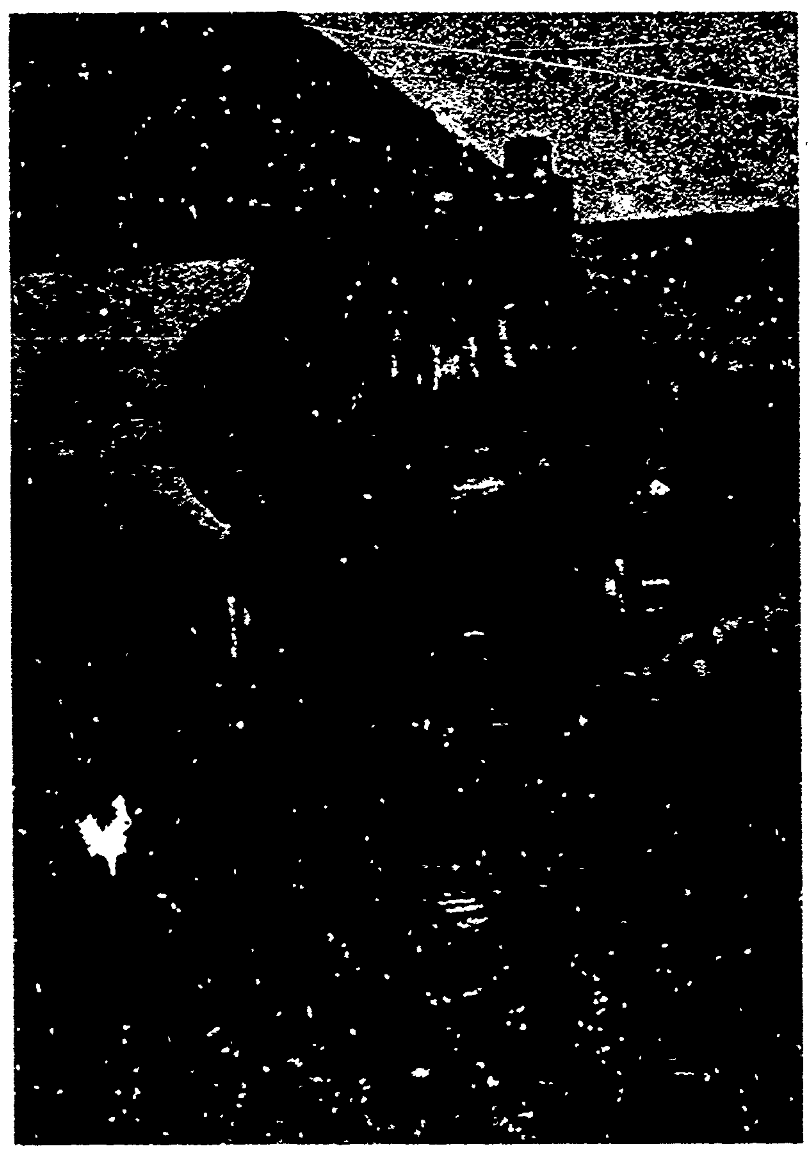
Fig. 10 - Hydrant With Gate Valve

INSPECTING DEFECTIVE HYDRANTS

Leaning Hydrant - Very often a hydrant inspector encounters a leaning hydrant. This is an indication that the hydrant was damaged and, in most cases, it is advisable to turn off the secondary valve located near the hydrant and identify it as (O.O.S.) out of service. This should be reported to all parties concerned. After repairs are completed it should be reported "in service" again.

Stripped Bronze Stem Nut - This defect - stripped stem - is easily recognized because the operating stem will turn freely and it will neither open nor close the hydrant stem valve. See Figure 9. If this occurs while in the process of opening a hydrant, the hydrant that opens against the pressure generally remains closed. A hydrant that opens with the pressure will remain open and require the closing of the secondary valve located nearby to stop the flow of water from the hydrant.

After the source of water supply has been eliminated by closing the secondary valve, the hydrant should be reported (O.O.S.) out-of-service immediately.



Courtesy Toledo, Ohio Fire Department

Fig. 11 - Mathews High Pressure Hydrant

Hydrant Valve Defects - A normal situation is one where the hydrant valve-seat is damaged. If not operated, the valve sometimes sticks and is often damaged when it is pulled away from the valve seat. Sometimes a piece of foreign material gets between the valve and the valve seat which allows the hydrant to fill with water and in many cases will leak through the discharges. In the latter situation, when flushing the hydrant fails to remove the foreign material, the

hydrant supply should be closed at the secondary valve and reported as (O.I.S.) off-in-street. Some fire departments have small metal tags, like those shown in Figures 12 and 13, which are attached to a defective hydrant to indicate the disorder.

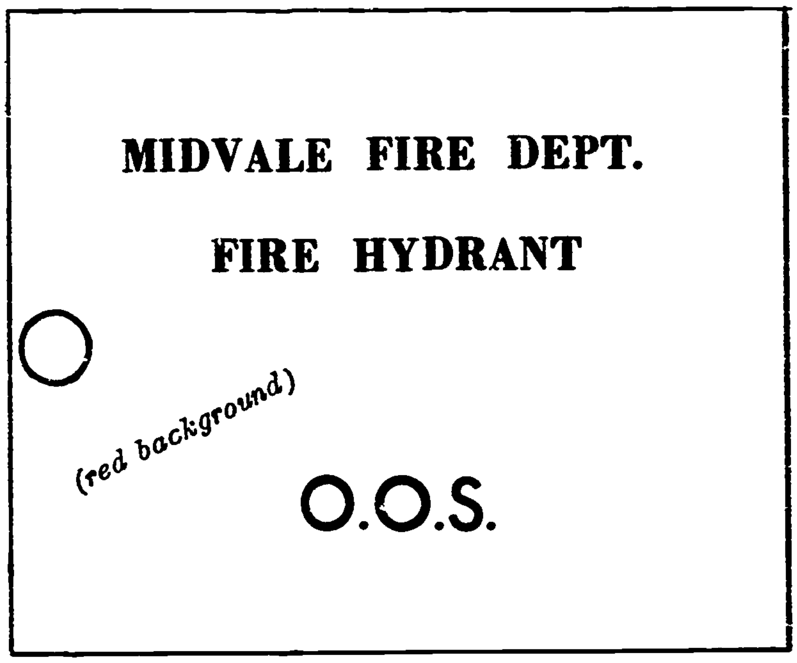


Fig. 12 - Metal Tag for Out-of-Service Hydrant

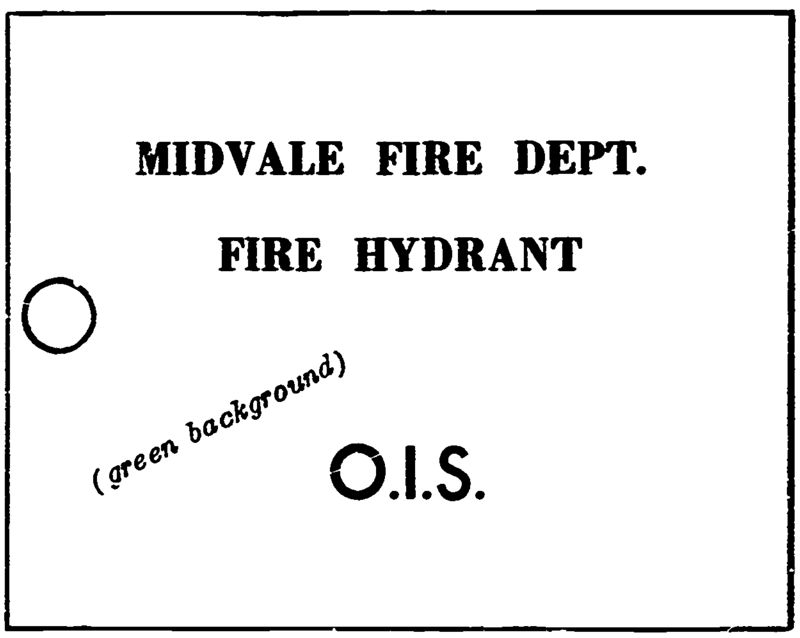


Fig. 13 - Metal Tag for Off-in-Street Hydrant

Frozen Hydrant - When an inspector locates a frozen hydrant it should be thawed out immediately. One of the methods of doing this is to pour hot water on the operating nut and stem through the discharges and on top of the hydrant stem. This is a long process in severe cases. With the aid of a hydrant wrench (spanner) maintain a slight pull toward the open position. When the ice within the hydrant begins to thaw, the valve stem will turn slightly, permitting the water to swirl internally, eventually freeing it of all ice.

After thawing the hydrant should be inspected for leaks. If found to be leaking, the necessary procedures, as outlined by the local fire department, should be followed.

SECONDARY HYDRANT VALVES (STREET STOPS)

It is equally important that firemen inspect the secondary hydrant valves and the chambers as well as the hydrants. The firemen must look for defects that would prevent the use of this secondary valve should it be needed to shut off an individual hydrant.

Hydrants that are located in flood territory should be recorded in a logbook along with the water height that affects each hydrant. When the height of the flood waters near the point where it will involve the hydrant, that hydrant should be turned off at the secondary valve until the flood waters have receded. The purpose of this is to eliminate the danger of a boat, log or other object breaking the hydrant, causing the water from the hydrant system to escape. This would be a hindrance to the water supply in other parts of the system not affected by flood waters.

FIRE FLOW TESTS

For many years the engineers connected with the fire insurance agencies have conducted the fire flow tests on the water distribution system of the cities and towns in the United States. The information obtained has been of considerable value since the quantity of water available for fire department use can be determined from such tests.

The tests are made by flowing water from one or more hydrants. Since a hydrant represents a pumper working at a fire, it is good practice to flow not less than 600 g.p.m. from each hydrant and use as many flowing hydrants, usually not in excess of six, as the delivery strength of the system will permit. The quantities discharging are measured simultaneously by observing the velocity pressure at each hydrant flowing in the group. The pressure in the main before and during the flow test is observed at a hydrant reserved for this purpose located near the center of the group. From the aggregate quantity flowing and the drop in pressure in the main, the quantity of water that would be available for any drop in pressure can be calculated.

These fire flow tests can be of great value to fire chiefs and company officers. From these tests it is possible to determine whether there is an adequate supply of water for fires of the magnitude which might occur.

When schools, hospitals, shopping centers, warehouses and industrial plants are built in the outskirts of a city, as is now very common, a fire chief will do

well to see that a flow test is made to determine the quantity of water available.

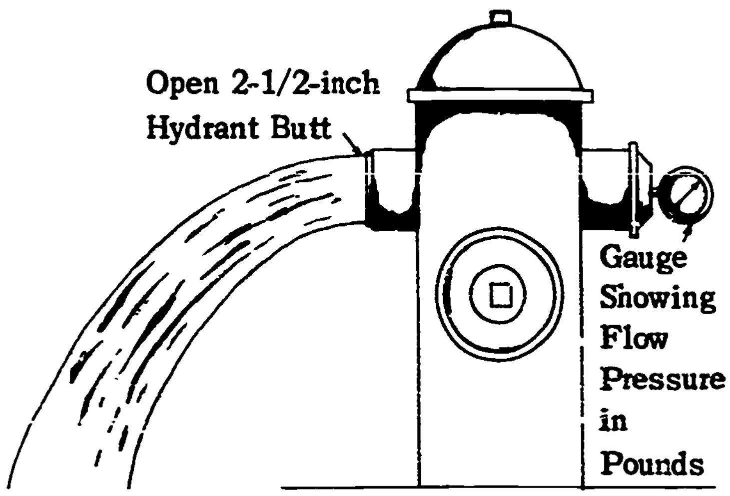


Fig. 14 - Determining Flow Pressure

FLOW TESTS USING PITOT TUBES AND GAUGES

In making fire flow tests engineers of the National Board of Fire Underwriters and the various fire insurance rating boards and bureaus use Pitot tubes and gauges to measure the velocity pressure at the flowing hydrants. If Pitot tubes are not available, the discharge from a hydrant can be determined by flowing one outlet of a hydrant and observing the pressure on a gauge attached to another outlet. See Figure 14. To do this, a hydrant cap must be tapped to permit a gauge to be screwed into it. This cap is then placed on one outlet of the hydrant. Another outlet is uncapped and the hydrant opened fully. Care should be taken so that the flowing water will not damage surrounding property. When the hydrant is flowing the gauge is read and the discharge can be determined from the chart in Figure 15.

DISCHARGE TABLE FOR CIRCULAR OUTLETS*

Outlet Pressure Measured by Pitot Gauge

Outlet Pressure in lbs. per sq. inch	OUTLET DIAMETER IN INCHES											
	2⅜	2½	2⅝	2¾	2⅞	3	3⅛	3⅞	4	4⅜	4½	4⅝
	U. S. Gallons per Minute											
1	150	170	180	200	220	240	260	400	430	510	540	580
2	210	240	260	290	310	340	370	570	610	720	770	810
3	260	290	320	350	380	420	450	700	740	890	940	990
4	300	340	370	410	440	480	530	810	860	1030	1090	1150
5	340	380	410	450	500	540	590	900	960	1150	1220	1290
6	370	410	450	500	540	590	640	990	1050	1260	1340	1410
7	400	440	490	540	590	640	690	1070	1140	1360	1440	1520
8	430	480	520	570	630	680	740	1140	1220	1450	1540	1620
9	450	500	550	610	670	730	790	1210	1290	1540	1640	1720
10	480	530	580	640	700	760	830	1280	1360	1630	1730	1820
11	500	560	610	670	730	800	870	1340	1430	1710	1810	1910
12	520	580	640	700	770	840	910	1400	1490	1780	1890	1990
13	530	610	670	730	800	870	950	1450	1550	1850	1960	2070
14	570	630	690	760	830	900	980	1510	1610	1920	2040	2150
15	590	650	720	790	860	940	1020	1560	1660	1990	2110	2220
16	610	670	740	810	890	970	1050	1620	1720	2060	2180	2300
17	620	690	760	840	910	1000	1080	1660	1770	2120	2240	2370
18	640	710	780	860	940	1030	1110	1710	1820	2180	2310	2440
19	660	730	810	890	960	1050	1140	1760	1870	2240	2370	2510
20	680	750	830	910	990	1080	1170	1800	1920	2290	2430	2570
22	710	790	870	950	1040	1130	1230	1890	2020	2400	2550	2700
24	740	820	910	1000	1090	1180	1290	1970	2110	2510	2660	2810
26	770	860	940	1040	1130	1230	1340	2050	2190	2620	2770	2930
28	800	890	980	1070	1170	1280	1390	2130	2280	2720	2880	3040
30	830	920	1010	1110	1210	1320	1430	2210	2350	2820	2980	3150
32	860	950	1050	1150	1260	1370	1480	2280	2430	2910	3050	3250
34	880	980	1080	1180	1290	1410	1530	2350	2510	3000	3170	3350
36	910	1010	1110	1220	1330	1450	1580	2420	2580	3080	3260	3440
38	930	1040	1140	1250	1370	1490	1620	2480	2650	3170	3350	3540
40	960	1060	1170	1290	1400	1530	1660	2550	2720	3250	3440	3630

* Computed with coefficient, c=0.90, to nearest 10 gallons per minute.

Fig. 15 - Discharge Table for Circular Outlets

A sufficient number of Pitot tubes or tapped hydrant caps with gauges will be needed for each hydrant flowed during a test. See Figure 16.

In order to observe the pressure in the main before and during the flow test, a tapped hydrant cap and gauge will be needed for the central hydrant at which this observation is made. The gauge and cap are placed on one of the outlets and the hydrant is opened and kept open during the entire test. No flow, however, takes place from this central hydrant. See Figure 17. In connection with fire flow tests it is well to bear in mind extreme accuracy is not a factor. The purpose is to determine how many fire streams can be obtained. Since the average fire stream discharges 250 to 300 g.p.m., fire flow test results are usually given to the nearest 50 g.p.m. for quantities of less than 1000 g.p.m. and to the nearest 100 g.p.m. for quantities above 1000 g.p.m.

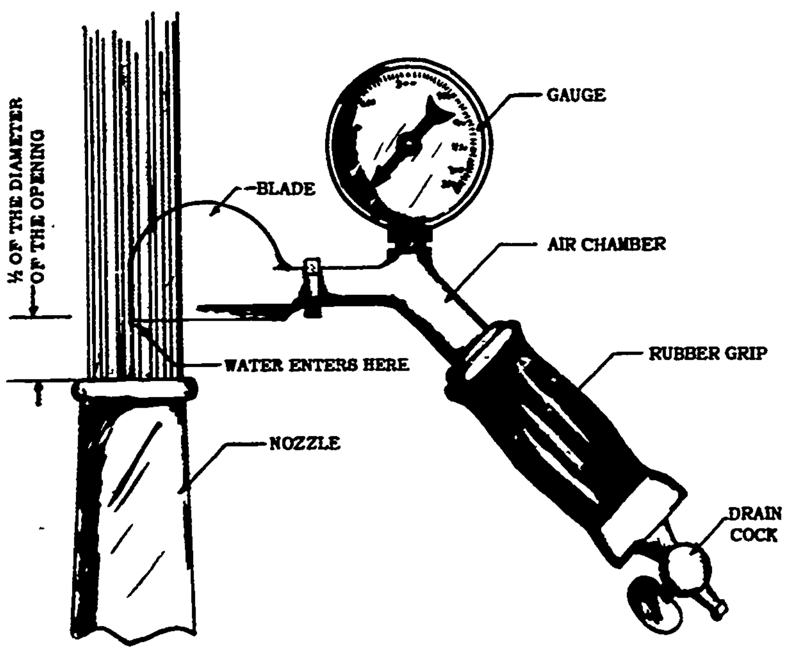


Fig. 16 - Pitot Tube and Gauge

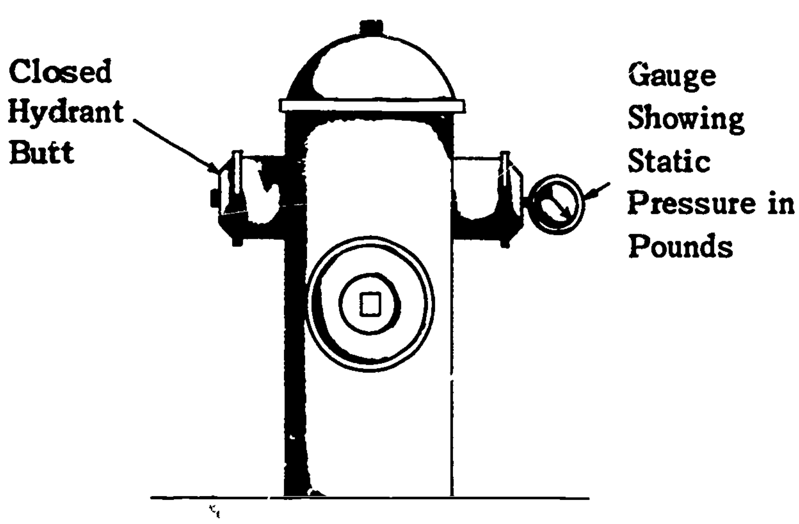


Fig. 17 - Determining Static Pressure

VISUAL FIRE HYDRANT FLOW TEST

Sometimes a visual hydrant flow test can present a satisfactory result without the aid of Pitot tubes and gauges of any kind. This test is especially effective on dead-end water mains having one hydrant at the end and another on the same water main within 500 feet. To make this test, one man stations himself at the dead-end hydrant and the second man at the hydrant located within 500 feet of the dead end. Both men remove the largest discharge cap from the hydrant and tighten all other caps. The man at the dead-end hydrant opens the hydrant fully (using all precaution previously mentioned) and allows it to flow for a couple minutes to relieve any air within the main. This man then signals the other man to free-flow the other hydrant by turning it on fully. The hydrants are now ready for the visual inspection which is as follows:

1. Did the dead-end hydrant continue to flow at near capacity or did the flow drop off by a considerable amount?

2. Should this dead-end hydrant continue to flow at near capacity, a third hydrant on the same water main can be opened fully and then by observing the quantity flowing from each hydrant the firemen will present a fairly accurate conclusion whether or not there is a sufficient water supply for the area involved.

Note: Before making any hydrant flow tests, consult the water department superintendent for special information pertaining to the local water system.

CHAPTER 6

STANDPIPE AND HOSE SYSTEMS, SPRINKLER EQUIPMENT AND AUTOMATIC ALARMS

INTRODUCTION

Standpipe and hose systems, sprinkler systems and automatic alarm systems constitute the first line of defense against fires wherever they are installed. Such installations provide firemen with a ready means and accurate method to approach the seat of the fire while, at the same time, they protect the exposures; thus they prevent the spread of fire.

The basic knowledge of how these systems operate, along with the "know-how" of what to do and how to do it, is essential for all firemen. Thus, the material presented herein is instruction for all fire department personnel, not for only a select few.

For supplemental study material pertaining to the subject matter of this chapter, the following publication is recommended: N.F.P.A. No. SP -1-1961 titled "Fire Department Operation in Protected Properties."

STANDPIPE AND HOSE SYSTEMS

Next to the automatic sprinkler equipment, a well designed, properly equipped, and reliably maintained standpipe system constitutes the best means for the extinguishment of fire in buildings. Each of these systems is capable of furnishing a class of service of which the other is incapable, and, in most cases, they should be made to serve as complements to each other. The standpipe system provides the only reliable means for obtaining effective fire streams to the upper stories of tall buildings and supplying these streams in the shortest possible time.

Standpipe and hose systems provide readily all that is required for the class of service intended, such as:

1. For use by fire departments and others trained in handling heavy fire streams required during the more advanced stages of fire on the inside of buildings, or for exposure fires.

2. For use by the occupants of buildings as first aid fire protection, for the control of small fires by the occupants of buildings during working hours, and by watchmen and those present during the night time and holidays.

Standpipe systems are classified as follows:

1. Wet standpipe system having supply valve open and water pressure maintained at all times.
2. Dry standpipe having no permanent water supply.

Standpipes properly located and maintained are of value to a public fire department in reducing the time required to put hose lines into action on upper floors of tall buildings where the fire department is equipped with pumping engines, or where other adequate high pressure supplies are available through hose lines from high pressure water works, systems, etc.

The size of standpipes in a given case is governed by the size and number of fire streams likely to be needed simultaneously and by the distance of the outlets from the source of water supply.

STANDPIPES AND HOSE CONNECTIONS

The number and arrangement of standpipe equipment necessary for proper protection is governed by the local conditions such as occupancy, character and construction of building, exterior exposures and accessibility.

The number of standpipes for 2-1/2 inch hose in each building and in each section of a building divided by fire walls are determined so that all portions of each story of the building are within 30 feet of a straight stream nozzle attached to not more than 100 feet of 2-1/2 inch hose.

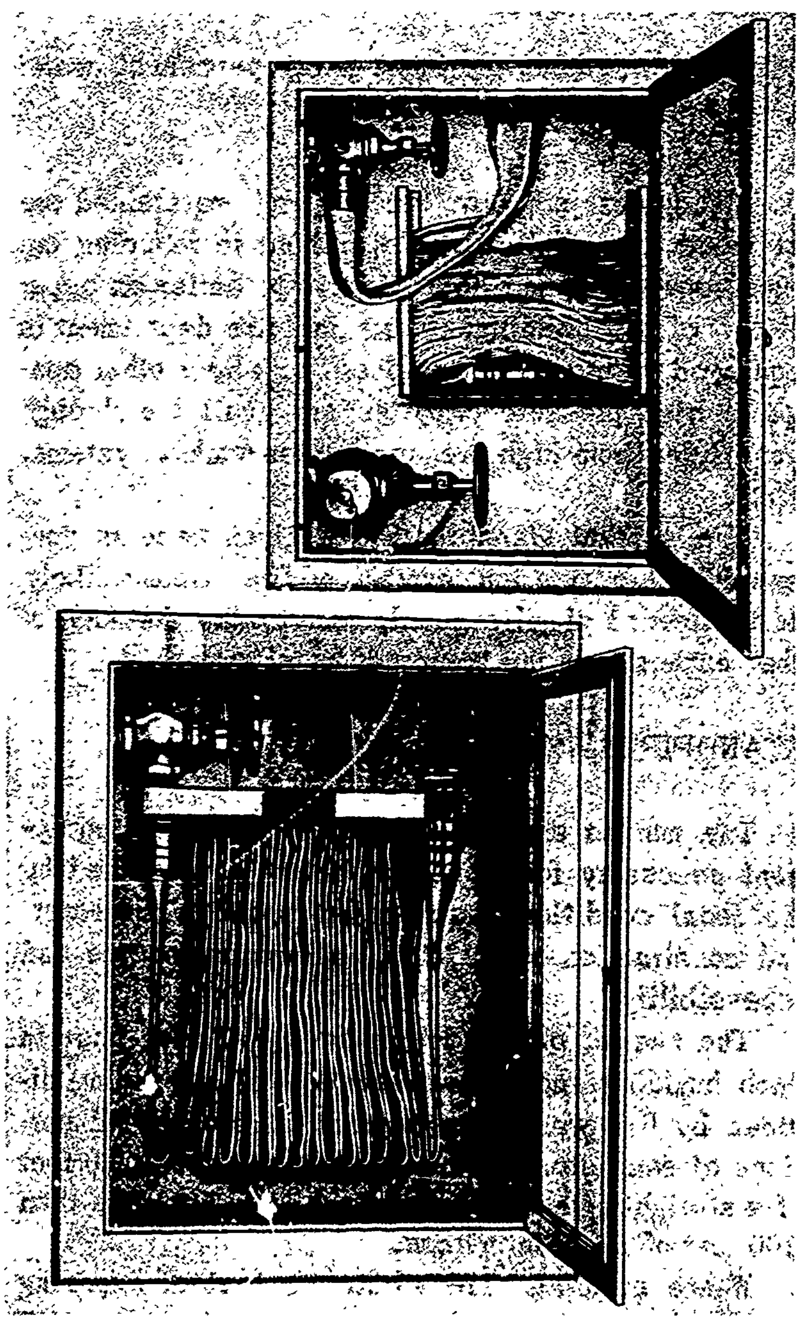
Where buildings are within 75 feet of exposing buildings, standpipes for large streams are located to afford protection against exterior exposures as well as to the interior of the buildings.

In buildings divided by numerous partitions, standpipes are so located that the streams can be brought to bear in any room.

Standpipe hose connections for 2-1/2 inch hose are provided with a 2-1/2 inch hose connection on each floor.

The equipment at hose stations constitutes the working end of the system and furnishes the means for the application of water upon the seat of fire in the shortest time. This equipment should, therefore, be complete and at all times ready for instant use. These hose stations are located within easy reach of a person standing on the floor and in no case should be over six feet from the floor.

Closets and cabinets used to contain fire hose are of sufficient size to permit the installation of the necessary equipment at hose stations and so designed as not to interfere with the prompt handling of the hose and apparatus at the time of the fire.



Courtesy Elkhart Brass Manufacturing Co., Inc.

Fig. 1 - Fire Hose Cabinets

These cabinets should be used for fire equipment only, and each should be provided with a conspicuous sign reading, "Fire Hose." See Figure 1.

Valves of approved type are provided between the main riser and the branch lines to hose outlets, so that in the event that the first aid branch is broken during the fire, the fire department may shut off this branch, conserving the water.

Where a standpipe system is supplied by a stationary fire pump, one 2-1/2 inch hose outlet for each 250 gallons pump capacity may be provided in the form of an outside wall hydrant (see Figure 2) located at the ground level, from which the fire department may take water for use on exposure fires. Each outlet is controlled by a separate valve and should be properly capped when not in use. These control valves should be accessible to the fire department only.

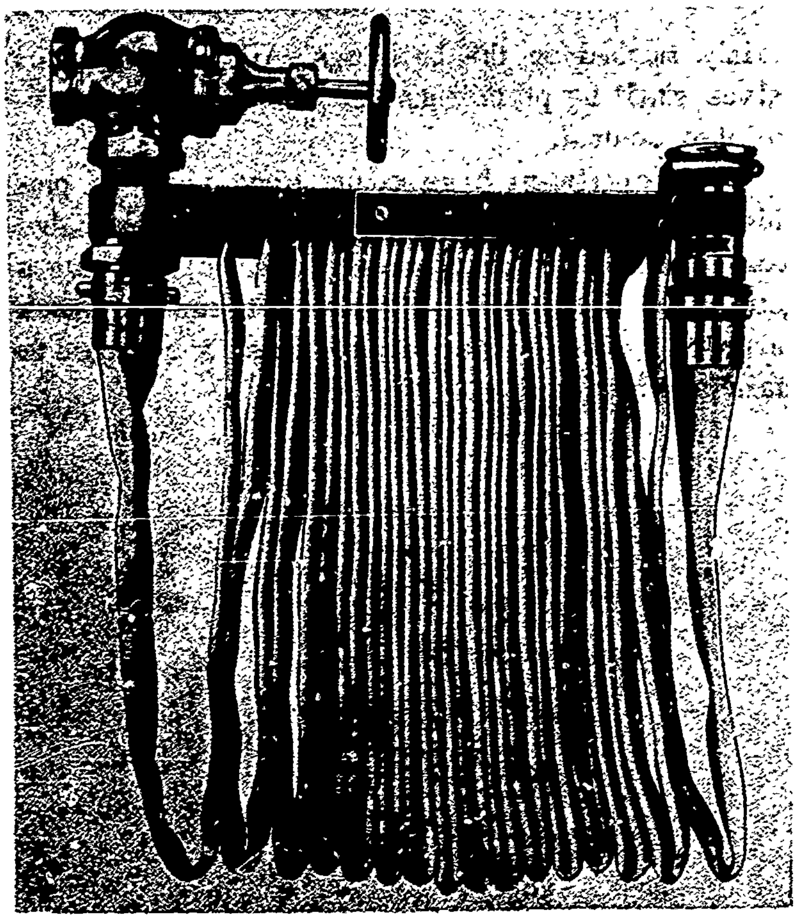
Courtesy Elkhart Brass Manufacturing Co., Inc.

Fig. 2 - Wall Hydrant Control

When required, each standpipe outlet provided for the use of those trained in handling large fire streams should be equipped with not more than 100 feet of approved 2-1/2 inch fire hose attached and ready for use.

Each hose outlet provided for the use of occupants shall be equipped with not more than 75 feet of approved small fire hose, attached and ready for use. (See Figure 3)

As 2-1/2 inch fire hose can only be effectively handled by several persons, automatic or partially automatic racks are unnecessary. The rack should be of substantial construction, of the swinging type,



Courtesy Elkhart Brass Manufacturing Co., Inc.

Fig. 3 - Fire Hose for Use by Occupants of Building

and so designed that the hose can be quickly laid by those at the nozzle without its catching in the rack or falling to the floor in a tangle. Water should never be turned into 2-1/2 inch hose until it is laid and the signal is received from the person at the nozzle.

With hose racks of the "semi-automatic" or "one-man" type, the hose valve should be opened fully. The nozzle should then be grasped firmly and the hose line drawn toward the fire. The water is automatically released as the last few feet of hose are pulled from the rack. Where racks are of the non-automatic type the services of two men are likely to be required. One man should grasp the nozzle firmly and draw the hose line toward the fire. When the hose is fully extended the hose valve should be opened by the man stationed at the valve for the services required.

Each rack for 2-1/2 inch hose should be provided with a conspicuous, durable, and permanently legible sign reading, "For Fire Department Use Only." Each rack for small hose should be provided with a similar sign reading, "Fire Hose for Use by Occupants of Building." Signs shall be securely fastened in position.

Where the hydrostatic pressure at any standpipe outlet for 1-1/2 inch hose exceeds 100 lbs., an approved device should be installed at the outlet to reduce the pressure to such a value that the nozzle pressure will be approximately 80 lbs. Where the hydrostatic pressure at any standpipe outlet for 2-1/2 inch hose exceeds 55 lbs., an approved device should be installed at the outlet to reduce the pressure to such a value that the nozzle pressure will be approximately 50 lbs.

Reducers are not required on standpipe outlets for 2-1/2 inch hose when the persons likely to use them are trained in handling large fire streams.

Hose valves on wet systems are provided with a suitable open or automatic drip connection so installed that any slight leakage past the valve seat will be carried off and prevented from entering the fire hose. The fire hose is the most perishable part of the equipment and every precaution should be taken to prevent its deterioration by the leakage of water into it.

Hose valves on standpipes provided for those trained in handling large fire streams should be provided with threads compatible with those of the fire department.

Nozzles shall be of an approved type. Size of nozzles for small hose shall be not over ½ inch. Sizes of nozzles for large hose are 1 inch to 1-1/8 inch.

Shutoff nozzles may be desirable where water damage is of major consideration.

Combination nozzles which give a spray or a solid stream are advantageous in certain locations where the use of a solid stream may contribute to the spread of fire by scattering the burning material or where the existence of flammable liquids makes the use of a spray stream desirable.

Each hose connection on dry standpipes is provided with a conspicuous, durable and permanently legible sign reading, "Dry Standpipe for Fire Department Use Only."

The water supply for standpipe systems is dependent on the size and number of fire streams likely to be required at any fire and the length of time such streams will have to be operated.

CHARACTER OF WATER SUPPLIES

Standpipe systems other than dry standpipes should have an approved water supply, preferably from two independent sources. A single source of supply may be used where it is capable of automatically supplying all of the fire streams required for the full protection of the property.

Acceptable water supplies may be:

1. Public waterworks system where pressure is adequate.

2. Automatic fire pumps.

3. Manually controlled fire pumps in combination with pressure tanks.

4. Pressure tanks.

5. Gravity tanks.

6. Manually controlled fire pumps operated by remote control devices at each hose station.

Minimum supplies for standpipe systems for use by fire department or specially trained men (2-1/2 inch hose and 1-1/8 inch nozzle) shall be sufficient to provide at least 250 gallons per minute for one standpipe, and at least 500 gallons per minute in buildings where two or more standpipes are required, for a period of at least thirty minutes. These supplies should preferably be such that a pressure of 40 to 50 lbs. per square inch will be maintained at the topmost outlet (not including roof outlet) while water is being discharged through the 50 feet of 2-1/2 inch fabric rubber-lined hose with a 1-1/8 inch nozzle. A water supply which provides less than 20 lbs. per square inch flowing pressure at the topmost outlet (not including roof outlet) is considered inadequate. The water supply or combination of supplies shall be sufficient to comply with the requirement.

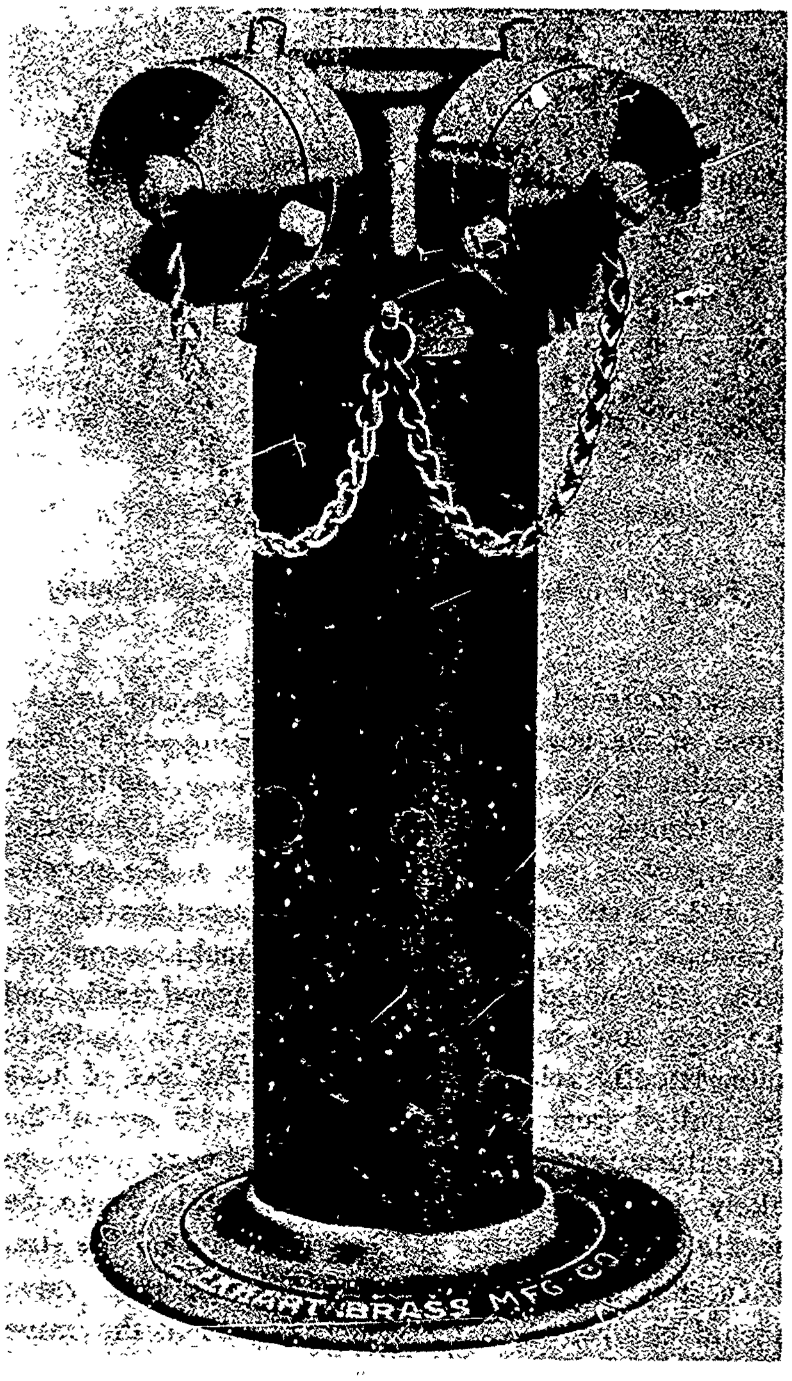
At least one fire department connection should be provided for each standpipe system. The fire department may pump into the system from its pumpers to maintain a sufficient supply at all times.

Connections to each water supply, except fire department hose connections, are provided with an approved gate and check valve located close to the supply, as at tank, pump, and in connection from waterworks system. Where the water supply feeds the standpipes in more than one building or section of a building, the check valves are placed in a safe position in the underground connections, or where not exposed to danger from fire or falling buildings.

Sufficient stop valves or check valves should be provided to permit cutting off any standpipe riser without interrupting the supply to other risers from same source of supply.

Connections to public waterworks systems should, where feasible, be controlled by post indicator valves of an approved type, placed where they will be readily accessible in case of fire and not subject to damage. Where post indicator valves cannot readily be used, as in a city block, underground gates should conform to the above as far as possible and their locations and directions to open shall be plainly marked on the buildings. All post indicator valves shall be plainly marked to indicate the service they control.

Fire department hose connections shall be provided with an approved straightway check valve located in the building or valve pit, but not with a gate valve. See Figure 4. Piping between the check valve and outside hose connections is arranged to drain automatically.



Courtesy Elkhart Brass Manufacturing Co., Inc.

Fig. 4 - Standpipe or Sprinkler Sidewalk Siamese Connection

The systems should be provided with a number of drain pipes large enough to carry off the water from the open drains while they are discharging under pressure. The drains should be so arranged as to be free from the possibility of causing water damage and not exposed to freezing. If practicable,

the drains are so arranged that the discharge will be visible from the point of operation of the drain valve.

An approved 3-1/2 inch dial spring pressure gauge is connected with each discharge pipe from fire pump and public waterworks, at the pressure tank, at the air pump supplying pressure tank, and at the top of each standpipe. Gauges are located in a suitable place where water will not freeze. Each gauge is controlled by a valve, having arrangements for draining.

The valves in the main connections to the automatic sources of water supply shall be open at all times. The hose valves at the hose stations should be frequently examined to see that they are serviceable. Leakage at the hose valves may be detected by inspection of the drips at the valves, and care should be taken to see that these drip holes are not clogged with dirt or sediment. The hose stations should be frequently inspected to see that the fire hose is in proper position on the racks, and that all of the equipment is in place and in good condition. The hose should be removed and re-racked at 60-day intervals changing position of the folds and new gaskets installed when required. Where couplings are polished, make sure that the polish used has not touched the fabric of the hose. If this occurs, notify management to have such practices discontinued.

When a standpipe is out of service for any reason, notice should be given to the local fire department and a sign should be posted on each fire department connection indicating that the standpipe is out of service.

STANDPIPE INSTALLATIONS IN BUILDINGS UNDER CONSTRUCTION

Tall buildings while in the process of construction offer a very serious problem to the fire department in fighting fires at the higher levels. A standpipe system, either temporary or permanent in nature, should be installed before the building has reached the height of approximately 70 feet or six stories above the street grade and carried up with each floor. Suitable means, other than interior stairways, shall be provided so that the fire department may quickly reach all parts of the building. Other factors to be considered are:

1. Standpipe shall be securely and adequately supported at each alternate floor.

2. At the ground level there shall be provided at least two 4-inch, two-way connections for attaching 2-1/2 inch hose lines from fire department pumping engine or other source of high pressure water supply. Connections shall be readily and easily accessible to the fire department at all times. They shall be of sufficient strength to withstand the pressure to which they may be subjected.

3. At each floor level there shall be provided at least one approved hose valve for attaching fire department hose. Valves should be kept closed at all times and guarded against mechanical injury. All threads on hose connections shall conform to the local fire department hose thread.

4. Standpipe shall be carried up with each floor and securely capped at the top. Top hose outlets should at all times be not more than one floor below the highest forms, staging, etc.

5. At the highest hose outlet there should be maintained a substantial box, preferably of metal, in which should be kept a sufficient amount of hose to reach all parts of the floor, a 1-1/8 inch nozzle, spanner wrenches and hose straps.

6. Temporary standpipes shall remain in service until the permanent standpipe installation is complete.

7. Where fire department connections are not readily visible from the street, a sign should be posted in a conspicuous place directing the fire department to same.

8. Telephone systems or other means of intercommunication should be provided in buildings of large area and great height, while under construction.

SPECIAL TYPES OF DRY-PIPE SYSTEMS

Figures 5 and 6 illustrate two potential uses of dry-pipe systems.

Figure 5 illustrates a combination foam and water system that is sometimes installed at bulk gasoline service stations. This illustration portrays an automatic operating system that can be augmented through the use of fire pumpers connected to hydrants from which water is pumped into the system through 2-1/2 inch hose lines connected to a battery of intakes.

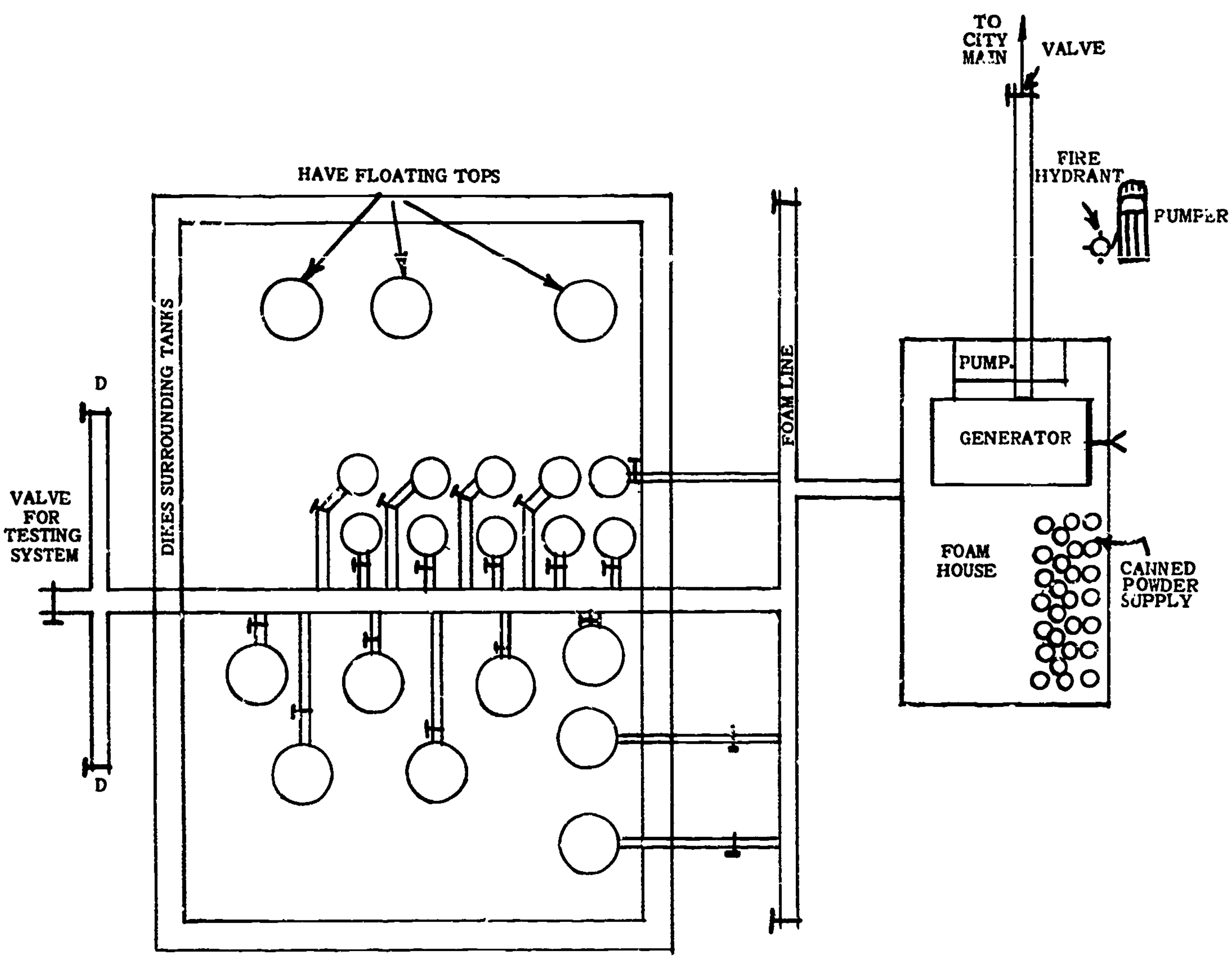


Fig. 5 - Combination Foam and Water System

Figure 6 illustrates a dry-pipe system having intakes on both sides at the bridge with division valves and discharges inserted for efficient operation and use.

FIRE DEPARTMENT PROCEDURES AT BUILDINGS EQUIPPED WITH STANDPIPES

Pre-Fire Planning and Inspection

1. Identify and locate all standpipe systems in the district, village, city, etc.

2. Locate the hydrant and other water supply facilities that may be used in an emergency.

3. Confer with the maintenance supervisor and map out an inspection program, as an aid to keeping the standpipe system in good condition.

4. Develop a training program within your fire department that will include instruction and practice in fighting fires with the aid of a standpipe system.

5. Be observant of all structural changes that may have been made, and such changes should be reported to all persons concerned.

6. Inspect the siamese intake connections and clapper valves. Threads on the female intake must conform with that used on the fire department hose. If not, proper adapters shall be provided to compensate for this situation. Caps for the siamese intakes should be provided and be free for easy removal. Do not confuse the "siamese intakes" for the sprinkler or standpipe system with "wall hydrants." Read the description on the face piece attached to the outside wall.

During the Fire - When fighting a fire in a building equipped with a "standpipe system" from which a hose line can be attached, the following procedure may be applied. The officer-in-charge of the fire

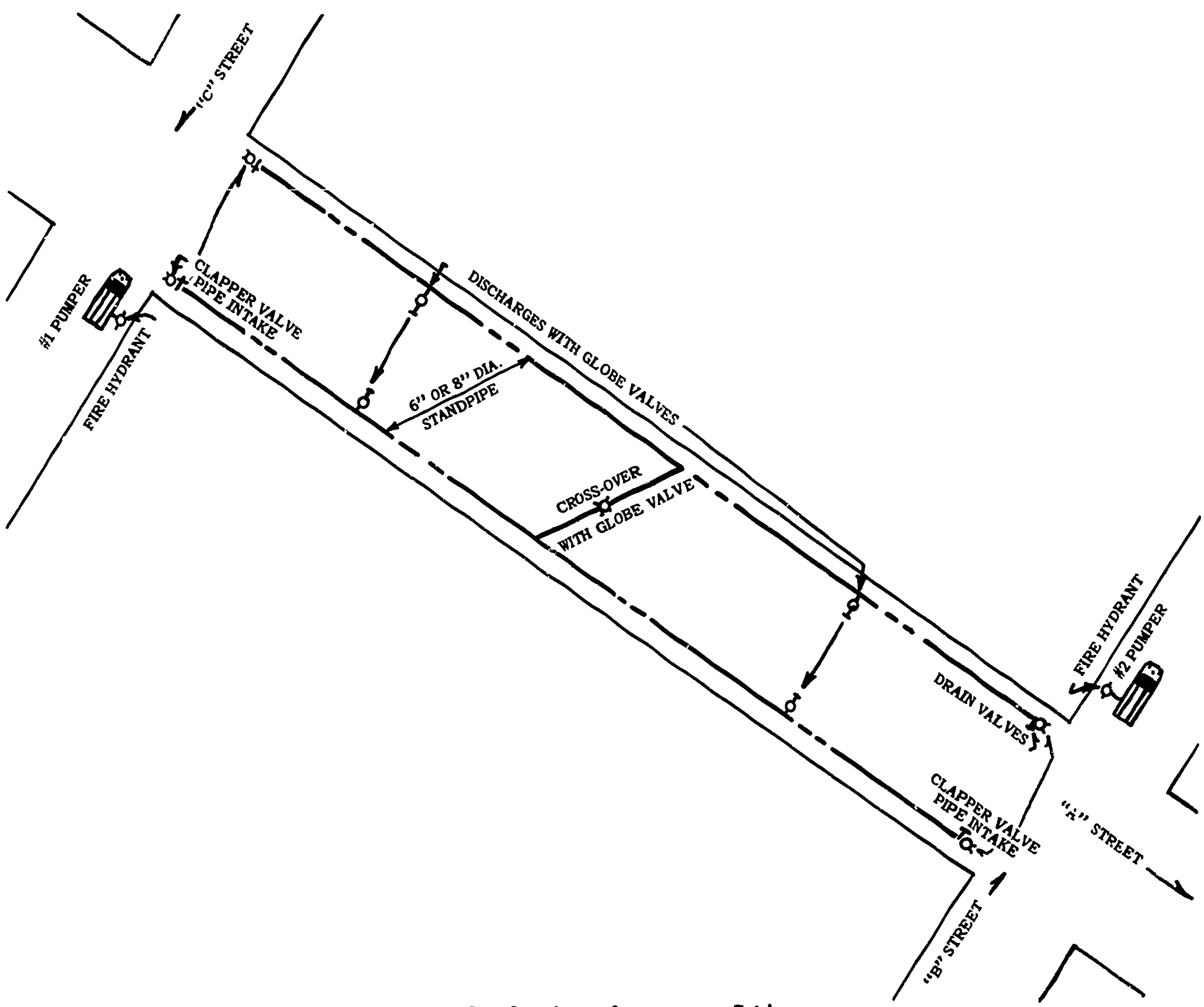


Fig. 6 - Dry Standpipe System on a Bridge

may alter these instructions at any time in order to fulfill a need to aid in the extinguishment of the fire.

1. One or two 2½ inch supply lines shall be laid from the pumper and connected to the intake of the standpipe. Other hose lines may be laid from the pumper direct to the fire, if practical. The order of procedure to be taken must be left to the judgment of the officer-in-charge of the fire.

2. Water is started into a standpipe system on orders of the commanding officer, whose judgment of procedures is governed according to existing conditions.

3. When so ordered, the pump-operator shall compute the pump pressure by allowing 50 p.s.i. NP plus elevation.

4. When preparing to work from the standpipe system, the fire department personnel should enter either the fire building or an exposure building equipped with a standpipe system, with two sections of 2½ inch hose, play pipe with shutoff and proper size tip, one or two sections of 1 inch or 1½ inch hose and necessary fittings to make the desired connections. This equipment may be advanced toward the fire by means of an inside stairway, fire escape, or on an elevator if one is available.

Should an elevator be used to transport firemen to upper stories of a fire building, the elevator should stop at the floor below the fire to discharge the firemen, from which point they will advance to the fire floor via inside stairway or fire escape.

CAUTION: A fireman who elects to use the ele-

vator as a means of reaching the fire floor *should never* rush out of the elevator cab until he has had sufficient time to size up the situation and until he is certain another means of exit is available.

It is recommended that the connection to the standpipe discharge be made to an outlet on the floor below the fire when the fire floor outlet is not accessible.

As soon as the fire department hose line is ready, the "house-line," if in use, shall be shut off and, where necessary, disconnected from the standpipe discharge and replaced with fire department hose.

After the Fire

1. Close the control valve being used.

2. Disconnect fire department hose and replace with house lines where this applies, this to be done after water has been drained from the house hose line.

3. With the aid of maintenance personnel, drain the dry standpipe system.

SPRINKLER EQUIPMENT

Sprinkler equipment consists of a series of pipes connected and interconnected, filled with water or compressed air, and equipped with automatic devices to release water for fire fighting purposes from one or more sprinklers. See Figure 7.

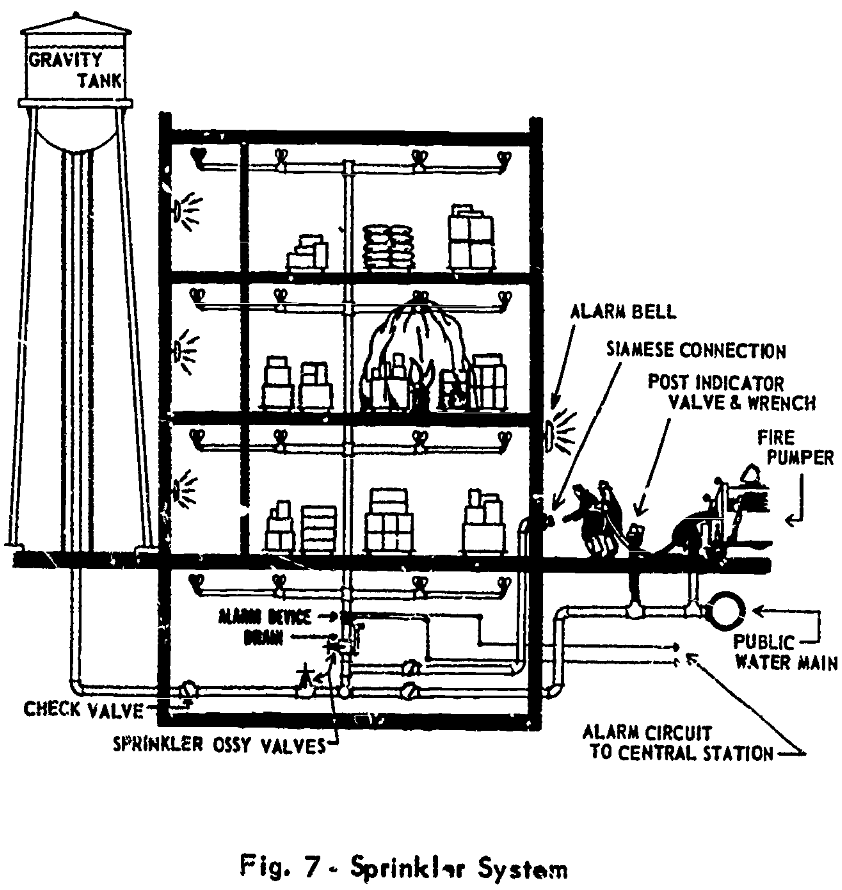


Fig. 7 - Sprinkler System

The value of sprinkler protection in safety to life and in safeguarding property is receiving increased recognition on a nationwide scale. Along with this swing to sprinkler protection, there arises the need for greater appreciation by fire departments of the tremendous value of protection by sprinklers in the planning and actual fire fighting operations. The trend for relocation of plants in suburban areas makes it essential that all fire departments (village and township as well as metropolitan) be thoroughly familiar with sprinklered properties and the methods which can be followed to utilize the sprinkler equipment for maximum protection.

WATER SUPPLIES

Siamese Connections for Fire Department Use - While the siamese connection is *not* an automatic water supply, in this text it is mentioned first under "Water Supplies" because it is the most important feature which should be given prompt consideration and attention by a fire department when responding to an alarm from a sprinklered property. Normally a sprinkler installation is connected to an automatic water supply such as city water mains, gravity and pressure tanks, and/or fire pumps installed on the premises.

A few fundamental principles should always be kept in mind. Generally, a sprinkler system covers an entire property and, therefore, affords the most ready and effective means of delivering water at the seat of the fire. Sprinkler system piping is normally designed on the assumption that a fire will be controlled by the operation of a relatively small number of sprinklers. If a considerable number of sprinklers should be opened, the normal water supply may be less effective; however, the full effectiveness of the system usually can be approached simply by reinforcing the water supply through pumping into the siamese connection, thus permitting the sprinkler system to distribute the water where it is most needed. See Figure 8.

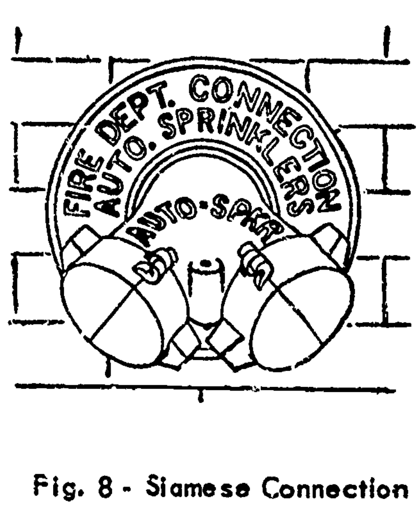


Fig. 8 - Siamese Connection

These siamese intake connections through which a fire department can pump water into the sprinkler system make a desirable auxiliary supply. For this purpose, one or more fire department connections are provided in most cases. See Figure 9.

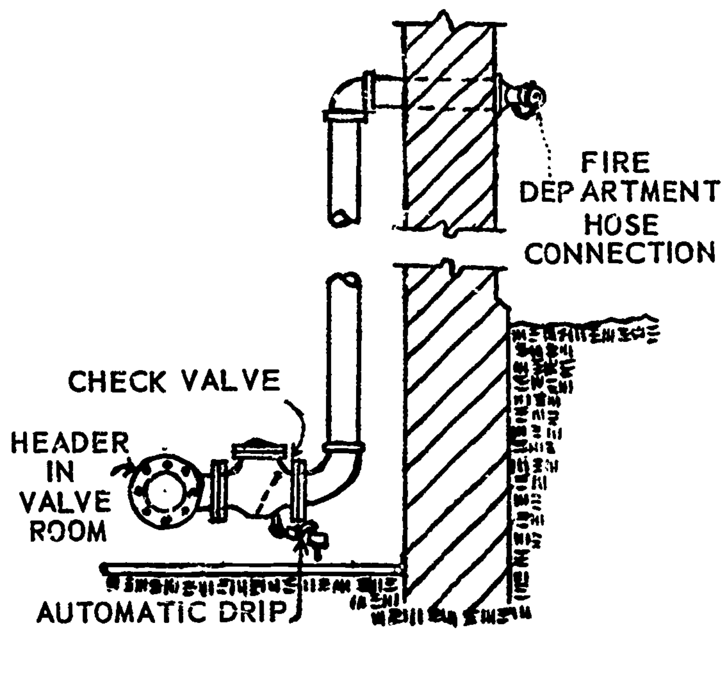


Fig. 9 - Fire Department Connection

On wet-pipe systems having a single riser, the connection to the system is normally made on the system side on the gate, check and alarm valves in the riser. On dry-pipe systems having a single riser, the connection to the system is made between the gate valve, check valve, and the dry-pipe valve.

An approved straightway check valve is installed in each fire department connection and located as near as practicable to the point where it joins the system.

Siamese intake hose connections should be of the approved type, conforming to the standards for the local fire department hose connections. They are located on the outside of the building to permit prompt and easy connection of hose from the pumper. They are equipped with standard caps, properly secured and arranged for easy removal by fire departments. Hose connections are marked on the face plate by raised letters at least one inch in size, cast on plate or fitting reading for the service designated: Viz. "AUTO-SPKR", or "OPEN SPKR." Many of these types of connections are marked "Standpipe", or "Wall Hydrant." They should be avoided when it is the intent to reinforce the sprinkler system.

Other Water Supplies - These are normally automatic in character (Viz. ready to supply water at all times). These supplies are briefly described to acquaint fire department personnel with their general nature as well as their relation to the system. These "other water supplies" constitute the primary and secondary supplies which maintain automatic protection around the clock and, therefore, are highly important. They should be given attention by the fire department when responding to an alarm from a sprinklered risk. This attention consists of checking control valves to see that they are open by first checking the control valves of the system that is protecting the area in which the fire is located, and second, the control valves of all water supplies to the sprinkler system.

1. City Water

Figure 10 shows a cross sectional view of a building equipped with automatic sprinklers connected to a city water supply main. With this type system, the water supply control valves are "Post-Indicator Valves" (P.I.V.) or "Outside Screw and Yoke Valves" (O.S.&Y.). The P.I.V. valve is generally located outside the building at ground level while the O.S.&Y. valve is located in a pit or in the basement. The Inspectors' Test Connection shown at the left top corner of the drawing is installed for the use of accredited inspectors of the Underwriters having jurisdiction over the risk and for periodic tests of the alarms on the sprinkler equipment by the maintenance personnel.

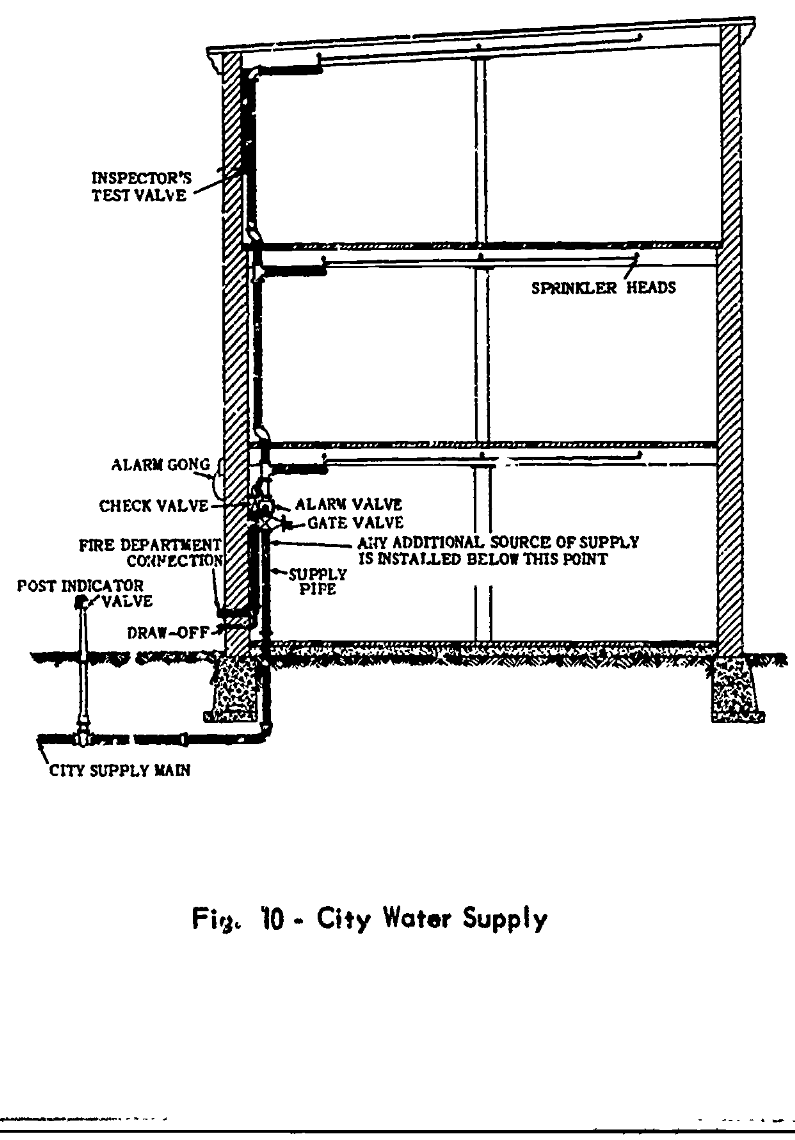


Fig. 10 - City Water Supply

2. Gravity Tank

Figure 11 shows in detail a sprinkler system having a gravity tank as a source of supply.

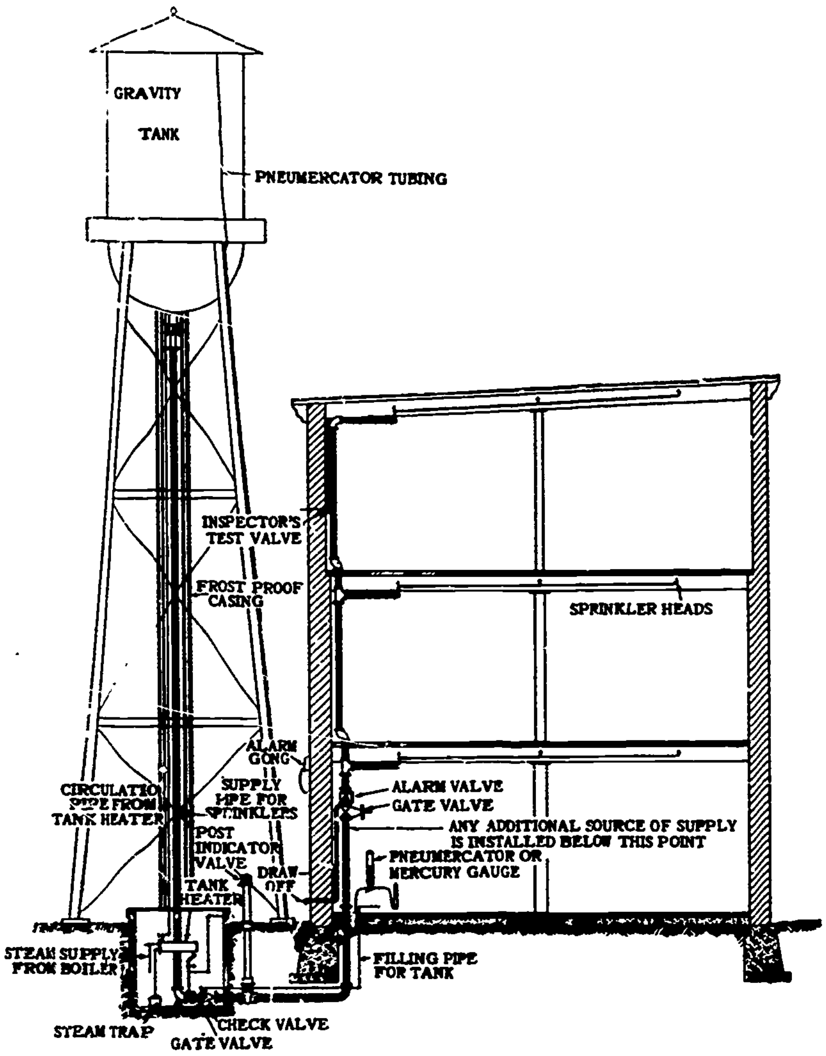


Fig. 11 - Gravity Tank

Special precautions are necessary in the winter to see that the gravity tank does not freeze. Provisions for adequately heating the water in the tank and riser leading from the tank to the underground valve pit, or to the top story of a building when the tank is above the roof, are usually provided by the installation of a tank heater. Special precautions should be taken to see that tank heaters of any sort are started up before freezing weather sets in, so that it will not be necessary to heat a large body of water at freezing temperature. The temperature of the water is indicated by a thermometer installed near the base of the tank riser, and the temperature of the water should never be allowed to fall below forty degrees F.

In addition to open valves, a full tank properly heated is important. The frost proof casing shown about the riser leading from the gravity tank is to confine the heat from the tank heater and help prevent the freezing of water in the tank riser. Care should be taken to see that it is intact. The filling pipe shown is used to provide water for the gravity tank, and supply for the same is taken either from city water, where pressure is sufficient, or from a tank filling pump.

3. Pressure Tank

While pressure tanks are quite reliable, they are of limited capacity; therefore, they are only used in conjunction with other water supplies for the protection of smaller properties. See Figure 12. Pressure tanks are normally located on the top floor or in a heated enclosure on the roof and are connected to the sprinkler system under ground level. The water level and the air pressure for these tanks are maintained at a predetermined level and pressure through the installation and use of a special water pump and air compressor equipment.

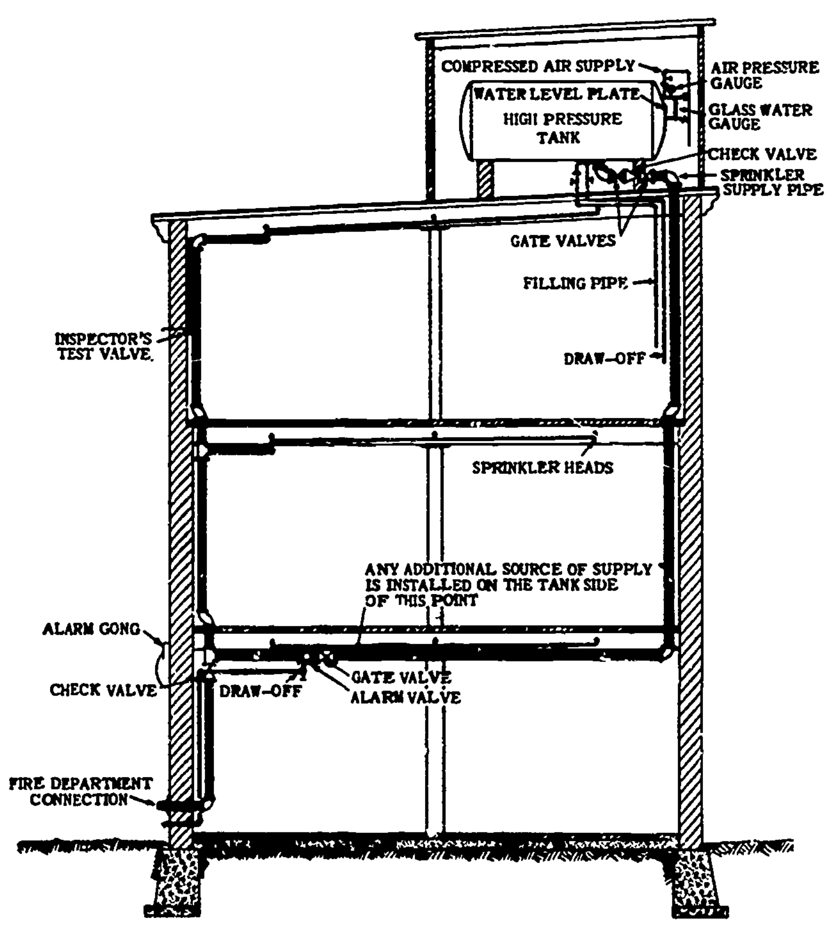


Fig. 12 - Pressure Tank Supply

4. Fire Pumps in Buildings

These pumps may be the "steam-driven reciprocating-type" which was most common in years past, with some still in service in many sprinkler protected properties. The "centrifugal-type" fire pumps that are electrically driven are more commonly used today although their source of power may be provided by diesel or gasoline engine or a steam turbine power unit. Figure 13 illustrates a steam driven pump connected as a supply to the sprinkler equipment.

TYPES OF SYSTEMS

Wet-Pipe - A wet-pipe system operating procedure is a simple one; that is, if for any reason the fusable link in the sprinkler head is released, water will instantly flow from the open head and at the same time cause the automatic alarm valve to function, signaling that an emergency problem is in progress.

Dry-Pipe - This system employs automatic sprinklers attached to a piping system containing air under pressure, the release of which, as from the opening of a sprinkler, permits the water pressure to open a valve known as a "dry-pipe valve." The water then flows into the piping system and out the opened sprinklers.

A dry-pipe system is installed where a wet-pipe system is impracticable, as in rooms or buildings

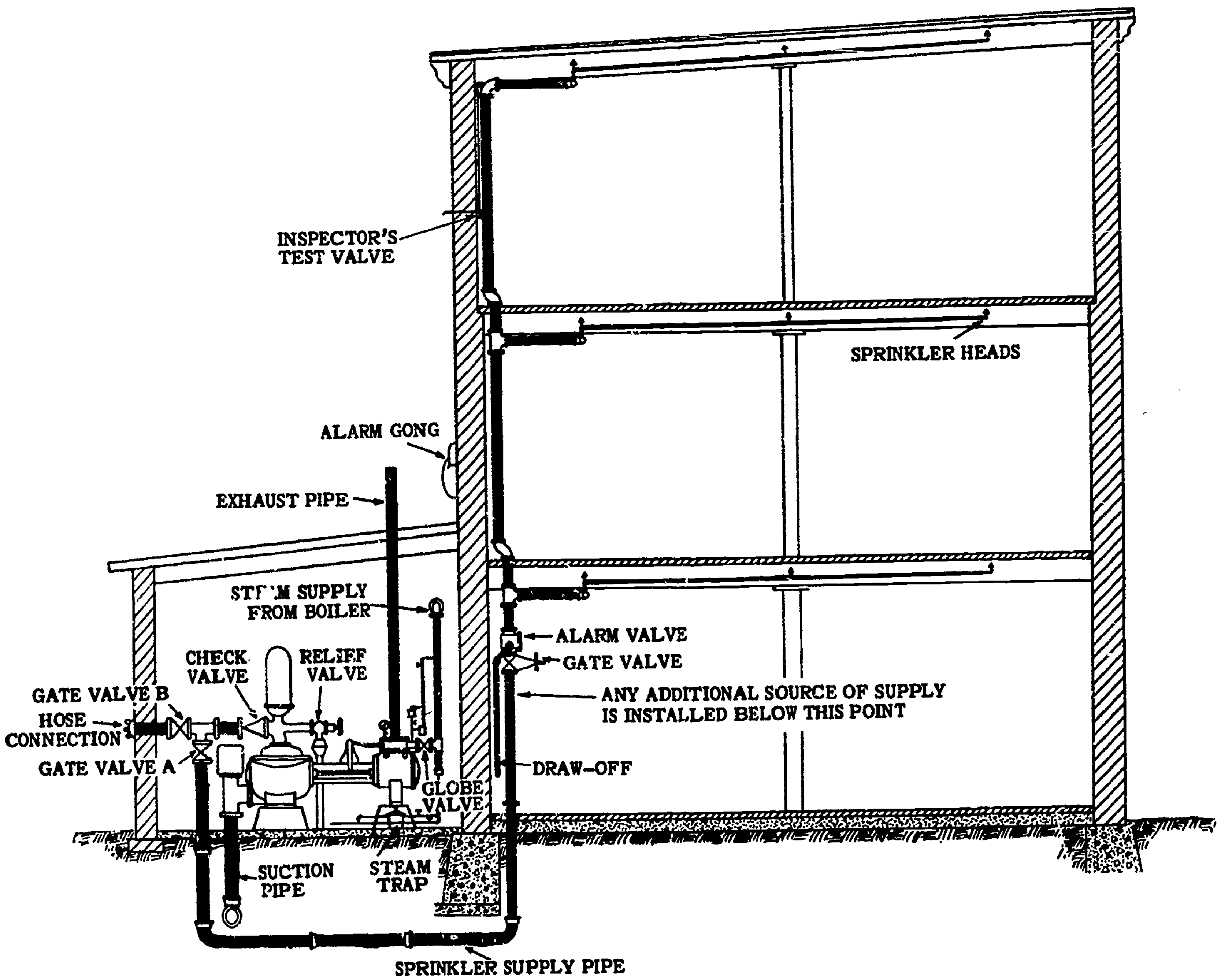


Fig. 13 - Fire Pumps in Buildings

which cannot be properly heated.

Air pressure should be maintained on dry-pipe systems throughout the year. The compressed air supply should be from a reliable source available at all times which has a capacity of restoring the required air pressure in the system within a period of thirty minutes. An approved relief valve is provided between the compressor and the check valve and is set to relieve at a pressure five pounds in excess of the maximum air pressure carried in the system.

Pre-action and Deluge - Pre-action and deluge systems are almost identical in construction and operation. They receive their source of water supply in the same manner as a wet or dry system. The main difference is that in the pre-action system the sprinklers are not fused, therefore water cannot flow from these sprinklers until the temperature in the area protected has risen sufficiently to release the fusible link in the sprinkler heads. In the deluge system no links are installed on the sprinkler heads; therefore, whenever a sprinkler alarm is received from an area protected by a deluge system, the water begins to flow immediately from each open sprinkler. Both of these sprinkler systems are actuated by the "rate-of-rise" principle, and each is without water in the piping under normal conditions. The water supply is controlled by an automatic valve operated by a heat responsive device whenever a rapid increase is present, e.g., a heat rise of 15 degrees in one minute. Generally, sprinkler systems of this rate-of-rise design are supervised by an outside supervisory agency (or the local fire department) by means of an alarm signal installed in their quarters.

Antifreeze - Antifreeze solutions are sometimes used for maintaining automatic sprinkler protection in small unheated areas which would otherwise be shut off and drained during freezing weather. Antifreeze solutions are recommended only for systems not exceeding 20 sprinklers. The cost of refilling the system or even of replenishing caused by small leaks makes it more advisable to use small dry valves where more sprinklers are supplied.

Special Types and Designs - There are many types and designs of sprinkler systems used today, but only one of the following five will be described here:

1. One capable of making a water curtain around an escalator in a department store.

2. A carbon dioxide system for special hazards.

3. Foam systems.

4. Systems installed within transformer stations.

5. Mulsifyer systems installed outside transformer stations.

Figure 14 portrays a large outside transformer station having 6 to 8 transformers containing 2400 to 3000 gallons of oil protected by approximately 140 projectors placed at different angles, each throwing a single vapor stream toward the transformers at a nozzle pressure of 40 to 70 p.s.i. This is spray-type protection designed primarily to cool the transformers and hold the temperature of the oil contained therein below its ignition temperature.

OTHER FEATURES

Control-valve sealing - As a part of a regular inspection procedure, all control valves not sealed in an open position should be reported for attention. Most insurance organizations maintain a valve sealing service on the principle control valves of a system. Absence of these seals may indicate a condition requiring prompt attention.

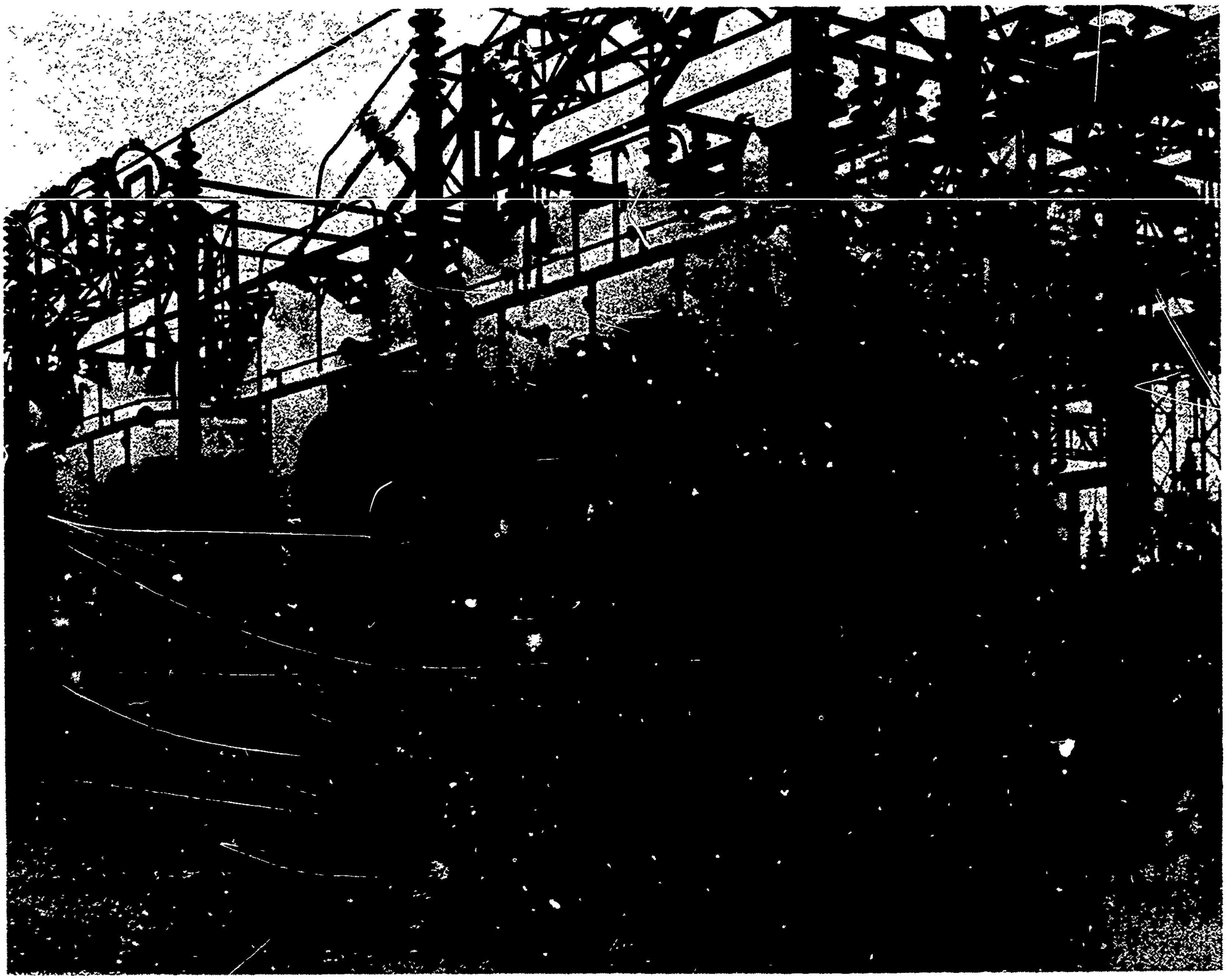
Control-valve identification -

1. Post Indicator Valve (P.I.V.)

   Where sprinklers are supplied from a water main service outside the building, an approved outside post indicator valve will generally be found at a safe distance from the building. The glass windows at the top of the post indicator valve will show the word "open" when the valve is properly set to allow a maximum amount of water to flow into the system from the city main.

2. Outside Screw and Yoke Valve (O.S. & Y.)

   Another type of control valve is the approved outside screw and yoke valve commonly referred to as the O.S. & Y. Valve. When an O.S. & Y. Valve shows maximum length of the threaded stem, the valve is wide open to permit a maximum amount of water to flow into the system.



Courtesy Cincinnati Gas and Electric Company

Fig. 14 - "Mulsifyre" System Installed Outside Transformer Station

3. Floor Control Valves

In some special situations floor control valves may be required in manufacturing and mercantile buildings or where contents are more than ordinarily susceptible to damage. They are sometimes placed just outside the operating room of a hospital.

4. Standard Identification Signs

Control valves, drain valves, test and alarm valves should be identified with the aid of standard designed signs adopted by the automatic sprinkler industry. Each should be securely fastened and visible in all situations.

Sprinkler Equipment Subjected to Flood Waters - Where sprinklers are installed in buildings subject to recurring floods, special attention shall be given (1) to the arrangement of piping and location of valves so that valves will be accessible during high water, (2) to the location of alarm devices and equipment so as to keep as much of the equipment as possible operable during "high water", (3) to the location and protection of pumps and air compressors and their power supply so as to provide every reasonable safeguard against interruption. Firemen should note these conditions on routine inspections and record them for use in such emergencies.

SPRINKLER HEADS

Temperature Ratings and Color - The standard temperature ratings of automatic sprinklers are as follows: (The frame arms only are colored to show temperature rating.)

Rating	Operating Temperature, °F.	Color	Maximum Ceiling Temperature, °F.
Ordinary	135° - 150° - 160° - 165°	Uncolored*	100° F.
Intermediate	175° - 212°	White*	150° F.
High	250° - 280° - 286°	Blue	225° F.
Extra High	325° - 340° - 360°	Red	300° F.
Very Extra High	400° - 415°	Green	375° F.
	450°	Orange	425° F.
	500°	Orange	475° F.

*The 135° sprinklers of some manufacturers are half black and half uncolored. The 175° sprinklers of the same manufacturers are yellow.

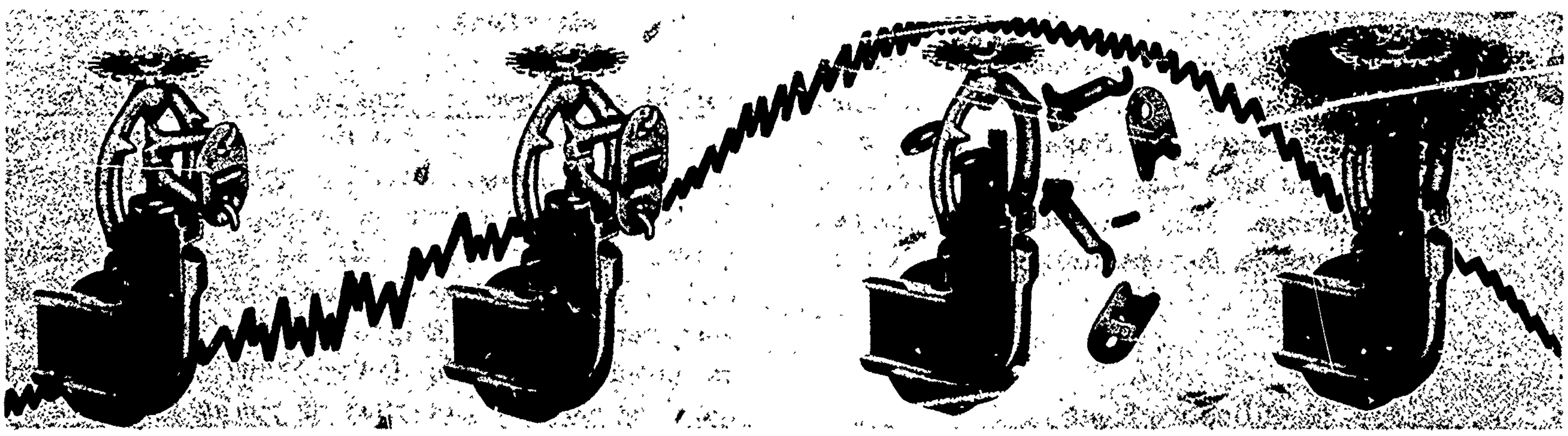
Where higher temperature sprinklers are necessary to meet extraordinary conditions special sprinklers as high as 600° are obtainable.

From fire department viewpoint it is important that heads in all areas be of proper temperature rating. Failure to observe this can lead to premature operation and consequent water flow and water damage, where a head of low rating may have been used in an area of high temperature. Conversely, the improper use of a high temperature head in an area of ordinary temperature will delay the operation of the head and permit a fire to gain greater headway. See Figure 15 for effect of heat rise on sprinklers. A rule of thumb--the fusing temperature of the heads should be at least 50° over the maximum temperature found in the area in which it is located.

Special Situations

1. Painting Sprinklered Areas

   When the sprinkler piping is given any kind of a coating, such as whitewash or



Courtesy The Reliable Automatic Sprinkler Co., Inc.

Fig. 15 - Heat Rise Affecting a Sprinkler

paint, care must be exercised to see that no portion of the automatic sprinkler is covered. Painting sprinklers after installation interferes with the free movement of parts and may render the sprinkler inoperative. Sprinklers so painted should be replaced with new sprinklers. When painting sprinkler piping or in areas near sprinklers, they may be fully protected by covering with a paper bag which should be removed immediately after painting is finished.

2. Special Purpose Sprinklers

Sprinklers used for special purposes and locations are of types specifically approved for such use. Special care should be taken in the handling and installation of wax coated sprinklers to avoid damaging the coating. Corrosion resistant coatings should not be applied to the sprinklers by anyone other than the manufacturer of the sprinklers being used. Sprinklers having special discharge characteristics may be required where either a fine spray or directional discharge of water is needed. Sidewall sprinklers may be used where preservation of limited headroom under low decks and ceilings is necessary, or where special types of apparatus or occupancy conditions such as coal conveyors, rug racks, etc., require directional water flow.

Supply of Extra Sprinklers - There should be a supply of extra sprinklers (never less than six) *on the premises* of a sprinkler risk so that any sprinklers that have operated or have been damaged may be promptly replaced. Such sprinklers must correspond with the types and temperature ratings of the sprinklers in service. A special sprinkler wrench should also be provided for the removal and installation of sprinklers.

A small stock of replacement sprinkler heads should be carried *on fire apparatus* so that replacement of fused heads can be started even when the plant stock cannot be located.

SPRINKLER ALARMS

A local alarm unit is an assembly of apparatus approved for the fire service and so constructed and installed that any flow of water from a sprinkler system equal to or greater than that from a single automatic sprinkler will result in an audible alarm signal on the premises.

WHERE REQUIRED

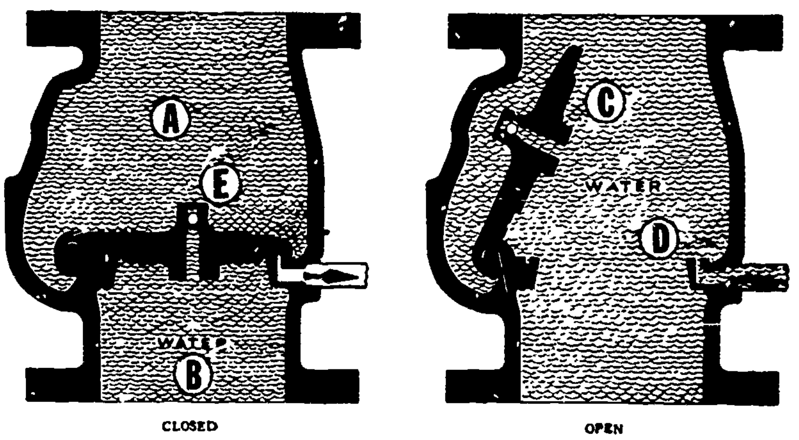
1. Water flow alarms should be provided on all sprinkler installations. Central station water flow alarm service is desirable but does not necessarily waive the local alarm requirement.

2. Either an outdoor water motor or electric alarm gongs should be installed in every case where a sprinkler system is not provided with an approved water flow alarm to a central station.

3. Under conditions where central station alarm service is not available, it is advisable to connect electrical alarm units to public fire department headquarters or to the nearest fire department station or other suitable place where aid may be readily secured.

PHYSICAL ARRANGEMENT FOR:

Wet-Pipe System Alarm - The alarm apparatus for a wet-pipe sprinkler system consists of an approved alarm check valve, having the necessary attachments required to give an alarm. See Figure 16.



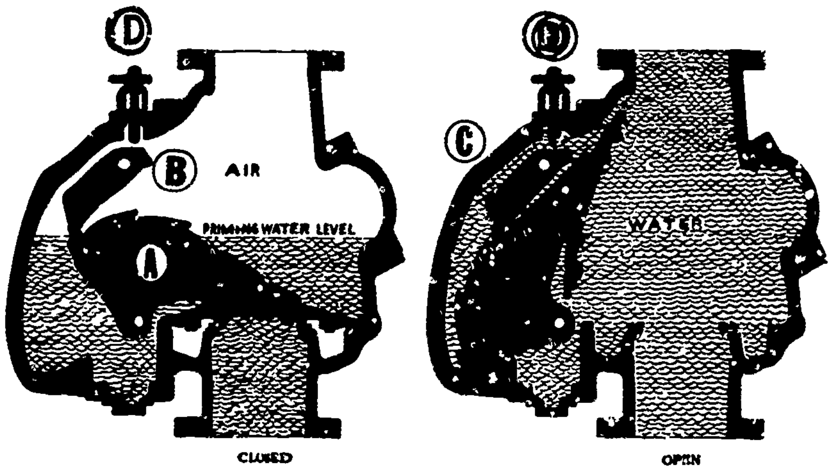
Courtesy Rockwood Sprinkler Company

Fig. 16 - Wet-pipe System Alarm Valve

When water flows from a wet-pipe sprinkler system, the pressure on the sprinkler side of the valve marked "A" is reduced, thereby permitting water pressure in chamber "B" to force sprinkler clapper "C" to open, thus allowing the water to flow through alarm port "D" to sound the water

motor or electric alarm. Under "water hammer" conditions, excess pressure builds up on the system side and escapes through a small ball check "E" which eliminates the opening and closing of the clapper.

Dry-pipe System Alarm - The alarm apparatus for a dry-pipe sprinkler system is illustrated in Figure 17. It has a pivoting counter-weighted clapper "A" and a latch "B" to hold it in open position as shown at "C". The clapper is a differential type which permits 15 pounds of air to hold back 80 pounds of water. (This is an approximate six to one ratio.) When a sprinkler head opens, an air exhauster empties the system of air immediately, (this release takes place at the valve not at the fire), and the water flows straight through with no obstructions and with minimum hydraulic friction loss. The latch release "D" is used when resetting the valve.



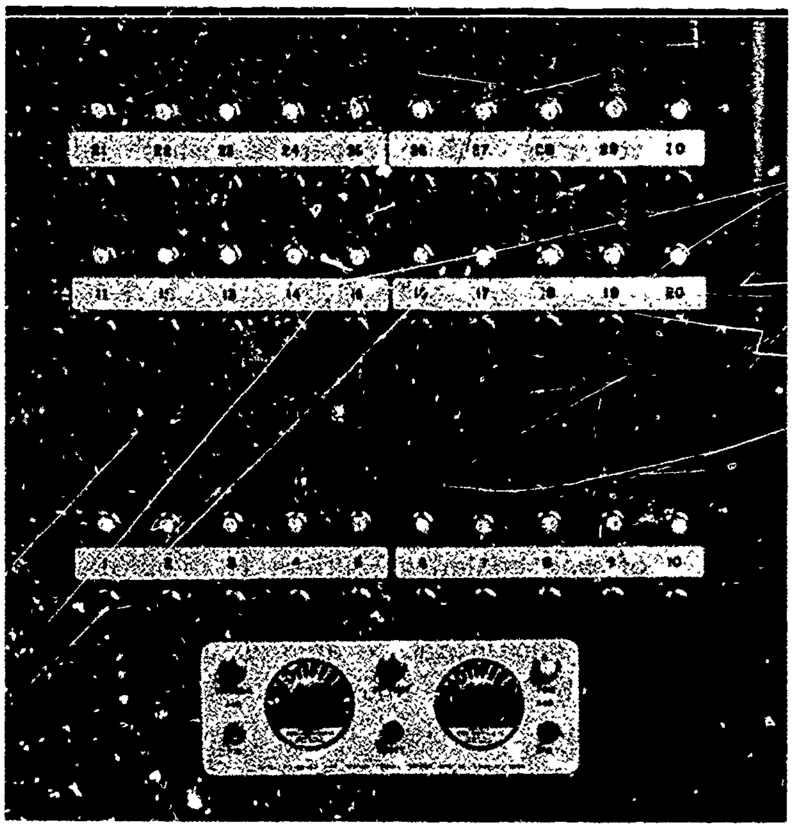
Courtesy Rockwood Sprinkler Company

Fig. 17 - Dry-pipe System Alarm Valve

Pre-action and Deluge System Alarms - The alarm apparatus for a pre-action and/or deluge system consists of approved electric alarm attachments actuated by thermostatic controls using the rate-of-rise principle, (temperature rises 15 degrees in one minute, approximately) and acts independently of the water flow.

OTHER ALARM DEVICES

Rate-of-rise Alarm - Sometimes rate-of-rise alarm systems are installed in buildings as separate and independent alarm systems. This is done in such places as art museums, china stores, etc., where water would in most cases do more damage than the fire itself. Installed on such a system is an instrument known as an "annunciator" which indicates the area of the building involved. This saves time and permits quick access to the fire by firemen. An annunciator is often installed on an outside wall which indicates the location of the alarm. See Figure 18.



Courtesy Notifier Corporation

Fig. 18 - Annunciator

Alarm Device Identification Signs - It is desirable and often essential to provide approved identification signs for outside alarm devices. The sign should be located near the device in a conspicuous position and should be worded, for example, "Sprinkler Fire Alarm — When alarm sounds call fire department or police."

FIRE DEPARTMENT PROCEDURES

The scope of fire department training should be broadened at all levels to include a need for adjustment of procedure and practices to take maximum advantage of sprinkler equipment for maximum protection. Toward this end, the planning and operations of any fire department could be developed through the application of the following check list.

Pre-Fire Planning

1. Identify and locate all sprinklered property.

2. Know all areas and structures not protected by automatic sprinklers.

3. Record the location of fire department siamese connections.

4. Locate the hydrant or hydrants which may be used to supply additional amounts of water to the sprinkler system through the siamese sprinkler intakes with the aid of a pumper.

5. Determine for each sprinkler location who is responsible (what local person or persons) for replacing fused sprinkler heads and also for resetting the dry valve of a dry-pipe system.

6. Develop a training program that will include instruction on proper procedure when fighting fires in sprinklered properties within the local community.

A considerable number of the instances of inoperable sprinkler systems have been due to the water being shut off. This demonstrates the importance of notifying fire department personnel whenever the sprinklers are to be cut off for any reason so that the fire department can plan alternate measures of control. Fire department personnel should emphasize this point to management at all sprinkler installations. A quick opening of the control valve may be possible, thus putting the system back into service, or the insertion of a plug in a leaking or ruptured pipe may permit the restoration of the water supply to at least a portion of the plant.

Sprinkler Inspection Procedures

1. Determine that the sprinkler equipment is in operating service.

   a. By observation, determine that all control valves are open (where required), and valve seals intact.

   b. See that the gauges are recording the proper pressures.

   c. Such inspections should be made in the presence of an assigned company employee.

2. Inspect all areas to determine where sprinkler protection is and is not provided.

3. Inspect for obstructions to sprinkler distribution such as partitions, beams, high stock piling, etc. Where found, request the condition be corrected.

4. Look for structural and stock storage changes made since the last inspection. Such changes should be discussed with all fire department personnel and recorded on the inspection report.

5. Inspect the siamese intake connections and clapper valves. Do the threads on the female intake conform with that used on the fire department hose? If not, are the proper adapters provided to compensate for this situation? Are caps for the siamese intakes provided, and can they be removed easily? Is there a hydrant of sufficient value from which water may be supplied through a pumping unit to increase the efficiency of the sprinkler system when required?

6. Request management to have available an extra supply of sprinkler heads with the right fusing temperatures for their respective locations. Also with each extra supply of sprinkler heads there should be sprinkler wrenches, sprinkler wedges and/or sprinkler tongs.

7. Encourage management to report to the fire department all instances when the sprinkler protection is out of service. Management should also be requested to report when the sprinkler system is at normal operation again. The fire department personnel in charge should assign someone to make an immediate inspection of this situation and direct an alternate fire fighting procedure during such a period.

For suggested Inspection Form, see Figure 19.

Sprinkler Installation and Maintenance - Sprinkler system layout and installation should be entrusted to only fully experienced and responsible parties. Sprinkler system installation is a trade in itself; therefore, fire department personnel cannot be expected to act as working superintendents or be expected to correct errors of maintenance.

When changes involve shutting off the water from any considerable number of sprinklers for more than a few hours, temporary connections should be made to sprinkler systems so that reasonable protection can be maintained. The members of the private fire brigade, as well as the public fire department, should

Name of Building ....

Fire Inspection District No. ....

Location .... Fire Alarm Code No. ....

Description of Property ....

Plant Official Responsible for Sprinklers ....

Phone (Day) .... (Night) ....

Type of Automatic Sprinkler System (Wet, Dry, Deluge, etc.)

....

No. Sprinkler Heads .... Size of Connection to Main.............

Automatic Sprinkler Valves:

Location .... Type .... Controlling ....

Cold Weather Valve ....

Water Supplies to Sprinklers:

Public Main ...., Gravity Tank......., Pressure Tank ....

Private Fire Pump ...., Volume in Storage ....

GPM Available......., Static Pressure ....

Fire Department Connections:

Location ....

Company assigned to Pump into Sprinkler System on First Alarm ....

Hydrant to be Used (Normal procedure) ....

Supplemental Pumper Supply Available ....

Sprinkler Alarm Indicators:

Local Waterflow .... Master Alarm Box ....

Central Station ....

Supervised by ....

Remarks: Include any pertinent special information that may affect fire department operations ....

....

....

....

Inspected by ....Approved by ....Date ....

Fig. 19 - Inspection Form for Sprinklered Properties

be familiar with these conditions and how they will affect fire fighting operations at such locations.

Water Distribution Improvements - During the years 1952 and 1953, sprinklers were redesigned which resulted in greatly improved water distribution. As a result of these changes the water is discharged in all directions below the plane of the deflector. The spray pattern is roughly that of a half sphere completely filled with water spray. Little or no water is discharged upward to wet the ceiling. The distribution pattern for approved standard sprinklers is more uniform than from the old type sprinklers. At a distance four feet below the deflector there is a useful intensity of water discharged with a diameter of about fifteen feet when discharging at fifteen p.s.i. at the head.

The new sprinklers may be used on old installations, but the old type sprinklers cannot be used on new installations, simply because the sprinkler outlets are spaced farther apart, thus leaving much of the area unprotected.

During the Fire - Most sprinkler systems in buildings are provided with outside fire department connections through which the fire department can pump water into the system regardless of the condition of other supplies. Therefore, it is essential that a hose line from a pumper be connected to the sprinkler system of the building on fire and also to the sprinkler system of any building seriously exposed to the fire. Whether this is the first or second line to the fire or from the first or second engine company to arrive at the fire depends upon the situation at hand. The proper order or sequence in which this operation is to be performed is a responsibility of the officer in charge.

A set of operational rules will not always apply when confronted with a fire involving a sprinklered building or buildings because of the many physical differences encountered. Therefore, the officer in charge at a fire involving sprinkler equipment must follow the same fire fighting principles as he would at any other fire, such as:

1. What are the life hazards?
2. Where and how did it start?
3. What is involved?
4. Where is it going?
5. What is in its path?
6. How can it be reached?
7. What equipment and personnel are available to remove the life hazard and to extinguish the fire?
8. How can the officer get what he needs?

The answers to these questions are different at most fires, thus changing the procedure of operation at the time and location of each emergency.

Where the fire involves a large area, additional pumpers should be connected at a siamese intake. A 750 gallon pumper can supply only about 35 sprinklers and a 1000 gallon pumper about 50 sprinklers. This is also dependent on a sufficient water supply.

Many departments carry appliances known as sprinkler tongs which are used to stop the flow of water from an individual sprinkler prior to closing

the valve. See Figure 20. Another procedure may be to close the riser or floor control valve. It is of prime importance, however, that no "cutting off" of the sprinkler systems by closing the control valves be done until there is positive assurance that the fire is out and that it has not extended to any other part of the building.

Fig. 20 - Use of Sprinkler Tongs

Despite appreciation of the value of sprinklers in the control of fires, cases continue to arise involving poor judgment by the fire departments or their lack of adequate knowledge in failing to immediately connect up to the outside siamese connection and maintain sufficient supply, or in robbing systems in order to supply hose lines, or in premature shutting off of sprinkler systems.

The practice of *not* shutting off sprinklers, except when convinced that further operation will simply waste water and serve to produce heavy water damage, should be one of the cardinal rules in every set of fire department regulations. When a shutoff is made by the fire department at the riser valve, the same person, when possible, should be left at the sprinkler valve until the sprinklers can be replaced and the water supply restored to normal. If the system cannot be put back into service, a watch service should be maintained on each floor, in addition to a man at the control valve, until all danger of rekindling has past.

After the Fire -

1. Close the riser control valve. (This valve is usually an outside screw and yoke valve, referred to as an O. S. & Y. valve. When this valve is open, the stem threads can be seen; when it is closed, the stem threads cannot be seen.)

2. **Drain the system involved by means of the drain valve located at the sprinkler-riser.**

3. Replace (or have management replace) all fused sprinkler heads and equipment, and reset the dry valve if any. Note: Some situations may require the fire department to return to its quarters before the dry valve is returned to normal operation. When this occurs during the winter months, a fireman or other responsible person should be detailed to remain at the riser location for the purpose of placing the system into operation should another fire develop. If this situation arises in the summer months, the system may be allowed to fill with water and operate as a wet-system until the dry valve can be reset by those responsible for such action.

In case of an accident to the system, the gate valve, just below the alarm valve, should be immediately closed and the draw-off valve opened, so as to draw off the water from the system as quickly as possible. The same thing applies in case of fire, but this gate valve should not be closed until some responsible person has so authorized it to be done, and then only after being sure that the fire is completely extinguished. As soon as the system is again in order, the draw-off valve should be closed.

CHAPTER 7

FIRE PUMPS

INTRODUCTION

The fire pump has become so important that it is considered an absolute "must" in the construction of a fire truck and is one of the main factors upon which any fire service must depend. The pump serves the important function of increasing pressure when streams are furnished from hydrants. Where water must be drafted or taken from the booster tank of a truck, the pump becomes the sole source of pressure. Many departments now have portable pumps that are used to supply water from creeks, ponds, and cisterns for small fires. In many localities, where tankers are used, a portable pump is mounted on the truck and used to draw from and refill the tanker with water. The pump on a fire truck, mounted either amidship or in front, is operated by the truck engine.

The operation and care of the pump is the responsibility of the pump operator. In order to operate the pump efficiently, the operator should have a good understanding of its construction and working principles.

TYPES OF PUMPS USED IN FIRE SERVICE

There are three types of standard pumps. They are as follows: piston pump, rotary gear pump and centrifugal pump.

While these three types are designed for the same purpose, they operate on different mechanical and scientific principles which are either: (1) the positive displacement of a liquid, or (2) the imparting of velocity to a liquid by the use of a moving blade or impeller.

Piston and rotary gear pumps operate on the first named principle and are, therefore, called positive displacement pumps. The positive displacement pump does not need priming. The centrifugal pump operates on the second principle and creates pressure by velocity. This type of pump requires some form of positive displacement or vacuum priming.

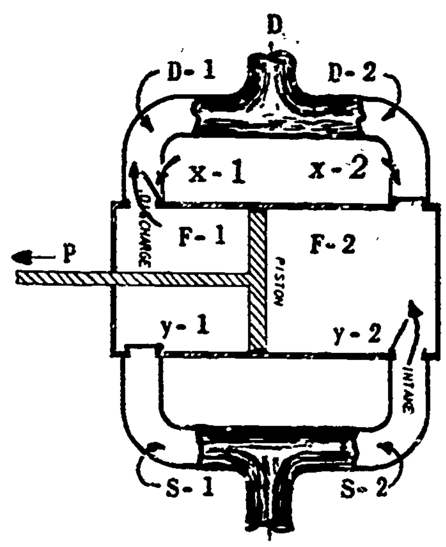


Fig. 1a - Double Action Suction and Force Pump -- Outward Stroke

DOUBLE-ACTING SUCTION AND FORCE PUMP

The development of the double-acting suction and force pump has eliminated most of the pulsation caused by the outmoded single action suction and lift pump.

The double-acting pump was devised to provide a discharge on every directional stroke, thereby producing a more continuous stream. Figures 1a and 1b show diagrams of the operation of a typical double-acting suction and force pump. A study of the diagram will reveal that this type of pump closely resembles two common suction and force pumps placed end to end with a common piston moving within a common cylinder. Piston (P) divides the cylinder into two suction and force chambers, (F-1) and (F-2).

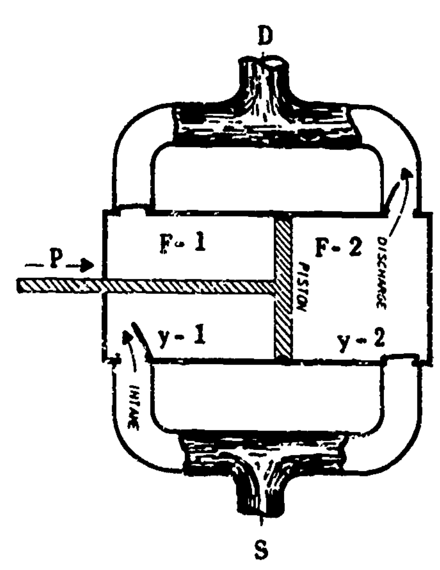


Fig. 1b - Double Action Suction and Force Pump -- Inward Stroke

Branches (S-1) and (S-2) of common suction tube (S) connect with chambers (F-1) and (F-2) through valved openings at (y-1) and (y-2) respectively. Discharge from either chamber takes place through valve openings at (x-1) and (x-2) into discharge manifold (D). Figure 1a shows valve action with piston (P) moving to the left. As explained in the common suction and force pump, compression in (F-1) closes valve (y-1) and opens (x-1), permitting air or water therein to be discharged from (f-1) through (D-1) into (D). At the same time the expansion of (F-2) causes atmospheric pressure to raise the water in (S) and (S-2), opening valve (y-2), and filling (F-2) at the same time the discharge pressure from (D-1) is transmitted into (D-2), closing valve (x-2). In Figure 1b, the piston is traveling to the right. As the action in Figure 1b reverses, discharge takes place from (F-2), and suction is taken in (F-1).

MULTIPLE CYLINDER PUMP

By connecting the suction and discharge branches of two or more pumps into a common suction tube and discharge manifold, the multiple cylinder types of piston pumps as used in fire service are obtained. The object in doing this is to increase the capacity performance without involving excessive size, speed or unnecessarily bulky machinery. Multiple cylinder pumps are built for fire service, utilizing from two to six cylinders. These double-acting pumps have cylinders in pairs in which the operational direction of stroke in the cylinders is also staggered. Here again, the object is to get proper balance and a more continuous stream.

ROTARY GEAR PUMP

Rotary gear pumps, like piston pumps, are of the positive displacement type. However, they differ greatly in appearance and in general operation from the piston pump. Figures 2 and 3 show, by diagram, cut-away sections of the interiors of two of the more typical rotary pumps used in the fire service. Although the two types shown differ in appearance, their actions in operation are practically identical. All rotary pumps consist of two meshing gears or cams revolving in opposite directions within a close-fitting casing. Variations occur mainly in the shape of the rotors and in the transmission of power to gears or cams. Fig. 2 shows the pump with its two eight-tooth rotors. Rotors "R-1" and "R-2" intermesh to resemble a conventional gear train and revolve within their casing (C). Suction inlets (S-1) and (S-2) connect with a suction manifold (S), opening into the bottom of the pump casing below the rotors. A discharge manifold (D), at the top of the casing connects with discharge outlets (D-1) and (D-2) in a counter-clockwise direction so that both rotors move away from each other on the suction side and toward each other on the discharge side, each moving from suction side to discharge side along the wall of the casing. In operation, air or water is trapped in the suction side in the pockets formed by the two adjacent teeth and the casing wall. As the teeth pass by the suction inlet, the water or air is carried along the wall of the casing toward the discharge outlet. As each tooth leaves the casing wall near the discharge outlet, the air or water trapped in the pocket between the teeth is released, and the pressure is again built up by the meshing of the rotor teeth as they return toward the suction side, squeezing the air or water out through discharge manifold (D). The meshing of the rotor teeth also prevents the air or water, which is under pressure in the discharge side of the casing, from returning to the suction side. Although discharge from each rotor is intermittent,

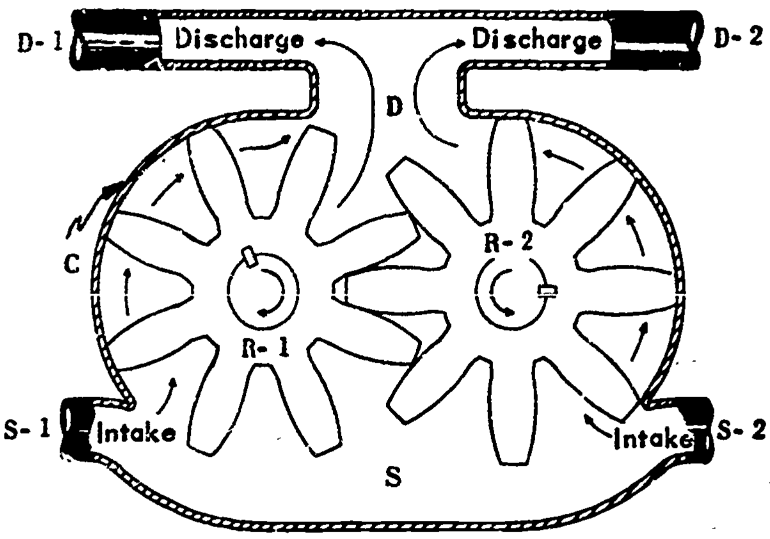


Fig. 2 - Rotary Gear Pump -- "Gear Teeth"

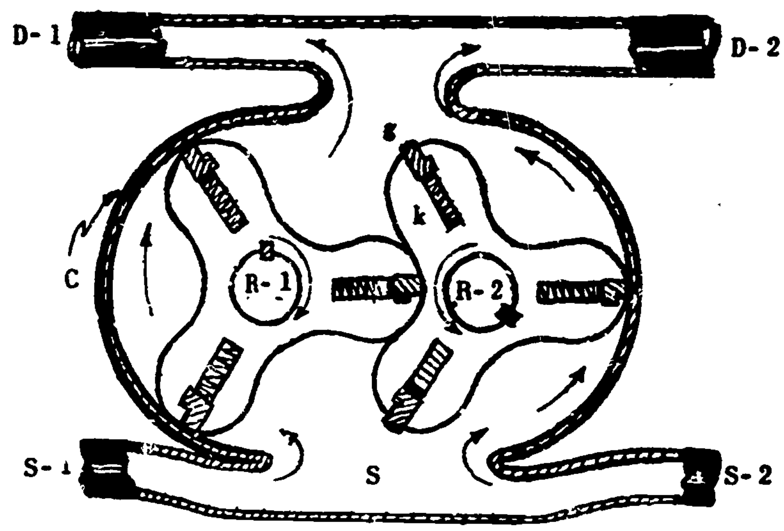


Fig. 3 - Rotary Gear Pump -- "Clover Leaf"

the rotors are so arranged that as discharge is being completed from the space between the two teeth on the one rotor, the corresponding space on the other rotor is just beginning to discharge. This produces a more continuous discharge from the pump and reduces pulsation. Fig. 3 shows a three-tooth or "clover leaf" shaped rotor in which the action is similar to the gear tooth pump. This diagram also shows a method whereby sliding gibs, (g), backed by springs, (k), are frequently introduced at the tips of the rotors. The springs behind these gibs serve to maintain contact between the rotors and the casing, thus compensating for any wear that might take place.

It may be well to note that although there are no valves in the rotary pump proper, the waterways are not continuous as they are blocked off by the teeth of the rotors. Since these pumps are of the positive displacement type, they are capable of expelling air as well as water from the pump; therefore, the pump can produce sufficient vacuum for self priming.

CENTRIFUGAL PUMPS

<u>Single-Stage Centrifugal Pump</u> - The centrifugal pump, unlike the piston and rotary pumps, is not of the positive displacement type, and there is no definite discharge taking place with each revolution of the pump. In theory, the operation of the centrifugal pump is based on the principle that a rapidly revolving disc will throw water introduced at the center toward the outer edge of the disc. This principle may be easily demonstrated by swinging a pail of water in a circular motion over the head. The centrifugal action holds the water to the enclosed bottom of the pail, which performs the outer arc of the circle, and no water is spilled from the open end of the pail which performs the inner arc of the circle. If a small hole is cut in the bottom of the pail, the stream of water emerging through the hole gains in intensity and distance as the pail is swung faster or, in other words, as the velocity of the pail increases.

The single-stag centrifugal pump (Fig. 4a), consists of a single disc-like impeller (EYE) mounted on a shaft within and usually eccentric to a pump casing, (C), as shown. Figure 4b, with a cut-away section to show the waterways, shows more clearly the construction of a typical impeller. As the impeller revolves in the direction shown by the arrow, water from suction tube (S) enters through the center of the impeller at (O). The water is then picked up by the curved vanes (v) as they revolve with the impeller, and it is thrown to the outer edge of the impeller by centrifugal force. It is then hurled through openings (p) into the open space in the casing. Since the

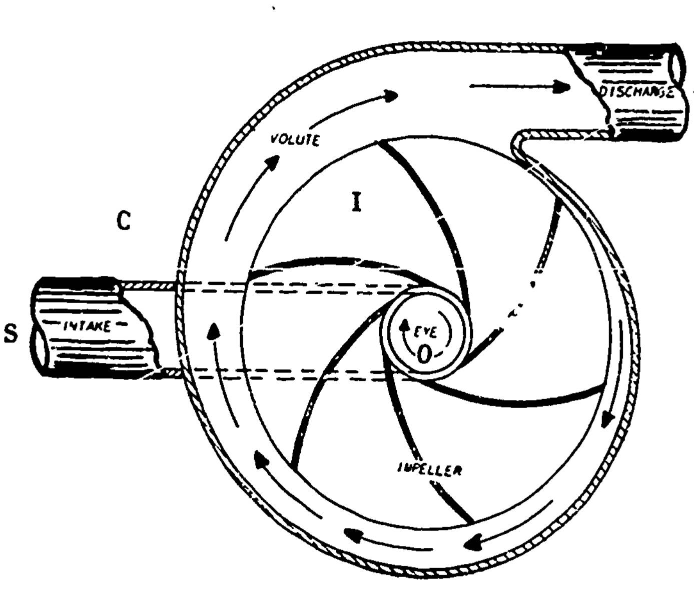


Fig. 4a - Centrifugal Pump

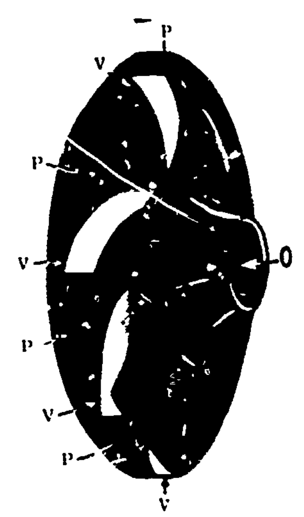


Fig. 4b - Centrifugal Pump Impeller

circumference of the impeller disc is greater at the outer edge of the blade-like vanes (v) than at the inner edge (O), the outer edge of the impeller travels at a rate of speed greater than the speed at (O). Thus the velocity of the water is increased as it passes through (p) and is hurled into the pump casing from (C) to (p). Likewise, as the rate of rotation of the impeller increases, the velocity with which the water is thrown from (p) into the pump casing increases. It will be noted that the cross sectional area between the outer edge of the impeller and the wall of the casing is constantly increasing as it approaches the discharge outlet. This increase produces what is known as "volute." This is necessitated by the fact that water is thrown from the impeller around the entire circumference, and the total quantity of water passing through the casing is increasingly greater toward the discharge outlet. The action of the volute is to enable the pump to handle this increasingly greater quantity of water and, at the same time, permit the velocity of the wat [illegible] remain constant or decrease gradually and main[illegible] continuity of flow.

In some forms of centrifugal pumps, the volute

principle is not used, and the flow of water is directed toward the discharge outlet by a series of stationary diffusion vanes fastened to the inner wall of the pump casing. The movement of the impeller creates a velocity in the water, and the velocity is converted into pressure as it approaches the confining space of the discharge pipe. Water under pressure in the discharge side of the pump casing is prevented from flowing back into the pump by the rapid movement of the impeller developing pressure in the pump casing and the close fit between the pump casing and the impeller.

Attention is called to the fact that, since the centrifugal pump is not the positive displacement type, there are no valves or other blockades within the pump proper. A continuous waterway is presented through the pump from the suction intake to the discharge outlet. Passageways through the impeller are frequently small and may clog if foreign matter is permitted to go through the pump. Since clogging of the impeller will seriously affect the operation of the pump, extreme care should be taken that a proper screen is provided in the intake to catch foreign materials.

Multiple-Stage Series Centrifugal Pump - By connecting two or more single-stage centrifugal pumps in series, with the discharge of the first pump connected directly to the suction of the second pump, there results what is known as the multiple-stage centrifugal pump. Figure 5 shows the typical arrangement of a two-stage centrifugal pump. Since the quantity of water passing through the second pump is limited to the amount delivered to it by the first pump, the quantity passing through both pumps will be the same.

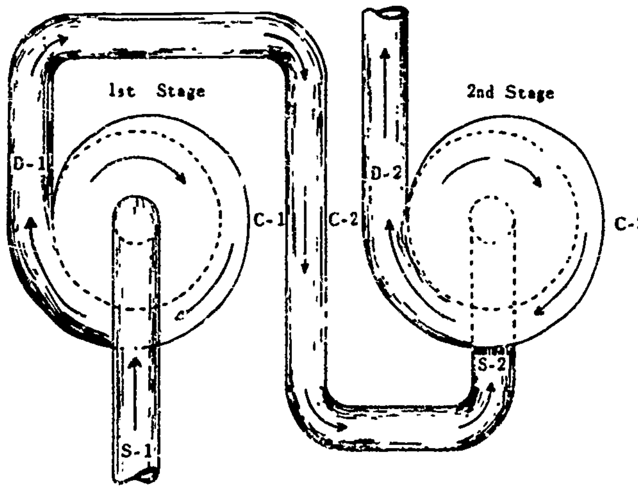
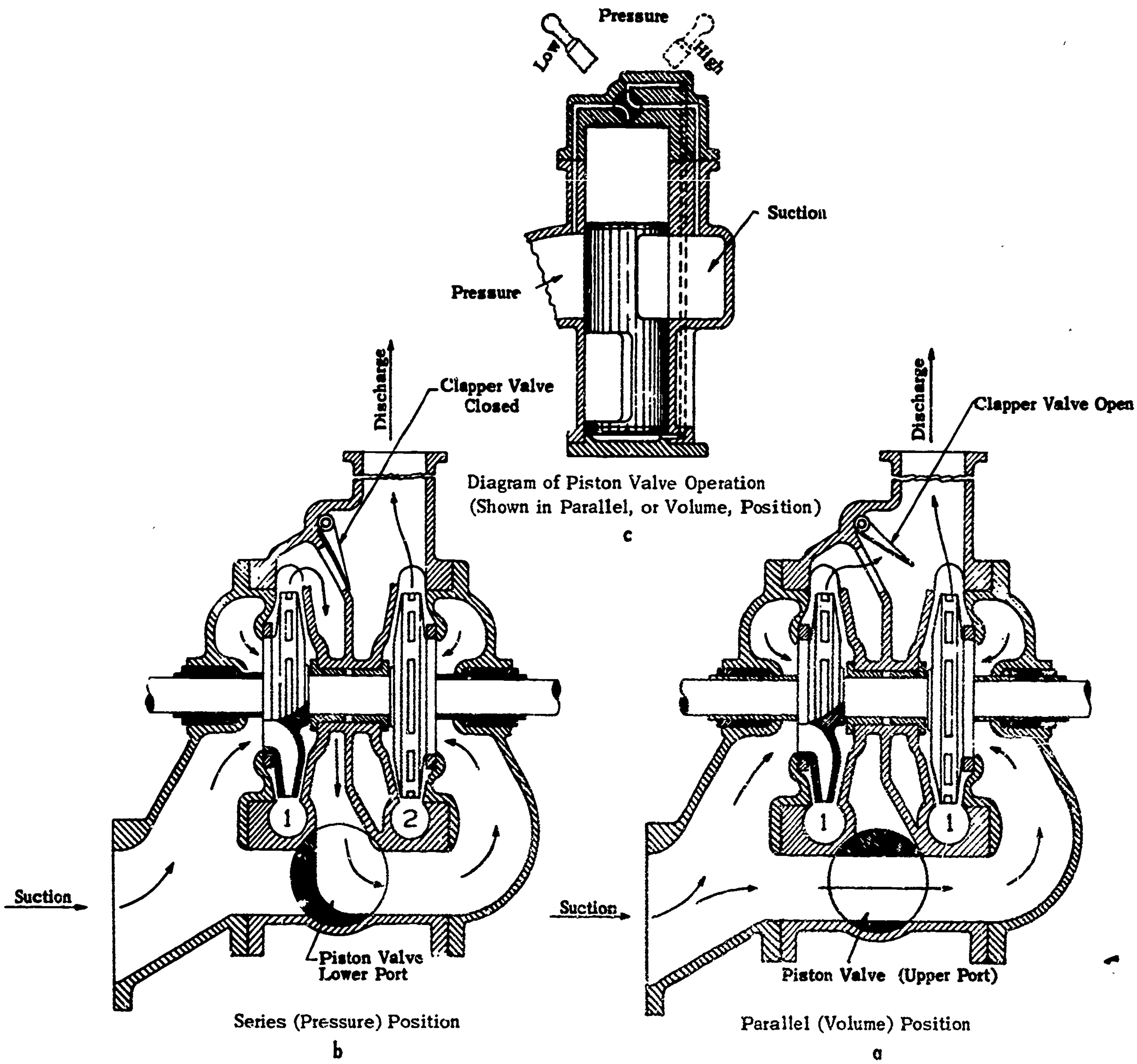


Fig. 5 - Multiple Stage Centrifugal Pump

In other words, the quantity taken in through the suction of the first pump will be the same as the quantity discharged from the second pump. However, each pump will add an equal amount to the pressure created if they are of identical design and operating at the same speed. For instance, in Figure 5, the first pump delivers at a rate of 500 gallons per minute and creates a pressure of 100 pounds per square inch. At the entrance to the suction of the first pump, the flow will be 500 gallons per minute, and there will be no effective pressure; however, when pumping from a hydrant, the flow pressure into the suction side will proportionately reduce the effort of the pump to produce the desired pressure. The first pump will deliver to the suction of the second pump at a rate of 500 gallons per minute at 100 pounds pressure. The second pump, since its water supply comes from the first pump, will also deliver at a rate of 500 gallons per minute, but an additional 100 pounds of pressure will be created in going through the second pump and the final discharge will be at 200 pounds pressure.

The advantage of this pump over the single-stage type lies in its ability to deliver greater quantities of water at higher pressures without involving excessive speed, particularly in pumps of larger capacity. In actual practice, multiple-stage pumps are generally built as single units with all the impellers mounted on a single divided casing. Each impeller unit division represents an additional stage of pumping.

Multi-Stage Parallel--Series Centrifugal Pumps - This parallel-series type of pump means that both pumps operate side by side from a common suction and discharge into a common discharge for parallel operating. These pumps may then be changed so that the first impeller discharges into the second impeller for series operation. This type of pump will give greater efficiency over a wider range than is obtained by either single stage or multi-stage straight series pumps. For example, a 750 gallon parallel-series pump will deliver 375 gallons per minute from each of the two impellers or 750 gallons per minute at 150 p.s.i. when in parallel volume position. When the pump is switched to series it will deliver 375 gallons per minute at 300 p.s.i. or half of its parallel capacity at twice its pressure. In Fig. 6a, the diagram shows the flow of water in the parallel position. The water entering the suction is divided, half going to one impeller and half to the other, and the discharges from each join in the discharge passage. Fig. 6b shows the flow of water in the series position. All the water enters the first impeller and is discharged into the suction passage leading to the second impeller and into the discharge. The pump is easily and quickly changed from parallel to series operation by moving the control knob of the changeover valve shown in Figure 6c. This change is accomplished hydraulically by means of pressure devel-



Schematic Section of Pump Showing Water Flow in Series and Parallel Positions

Fig. 6 - Multiple Stage Parallel-Series Centrifugal Pump

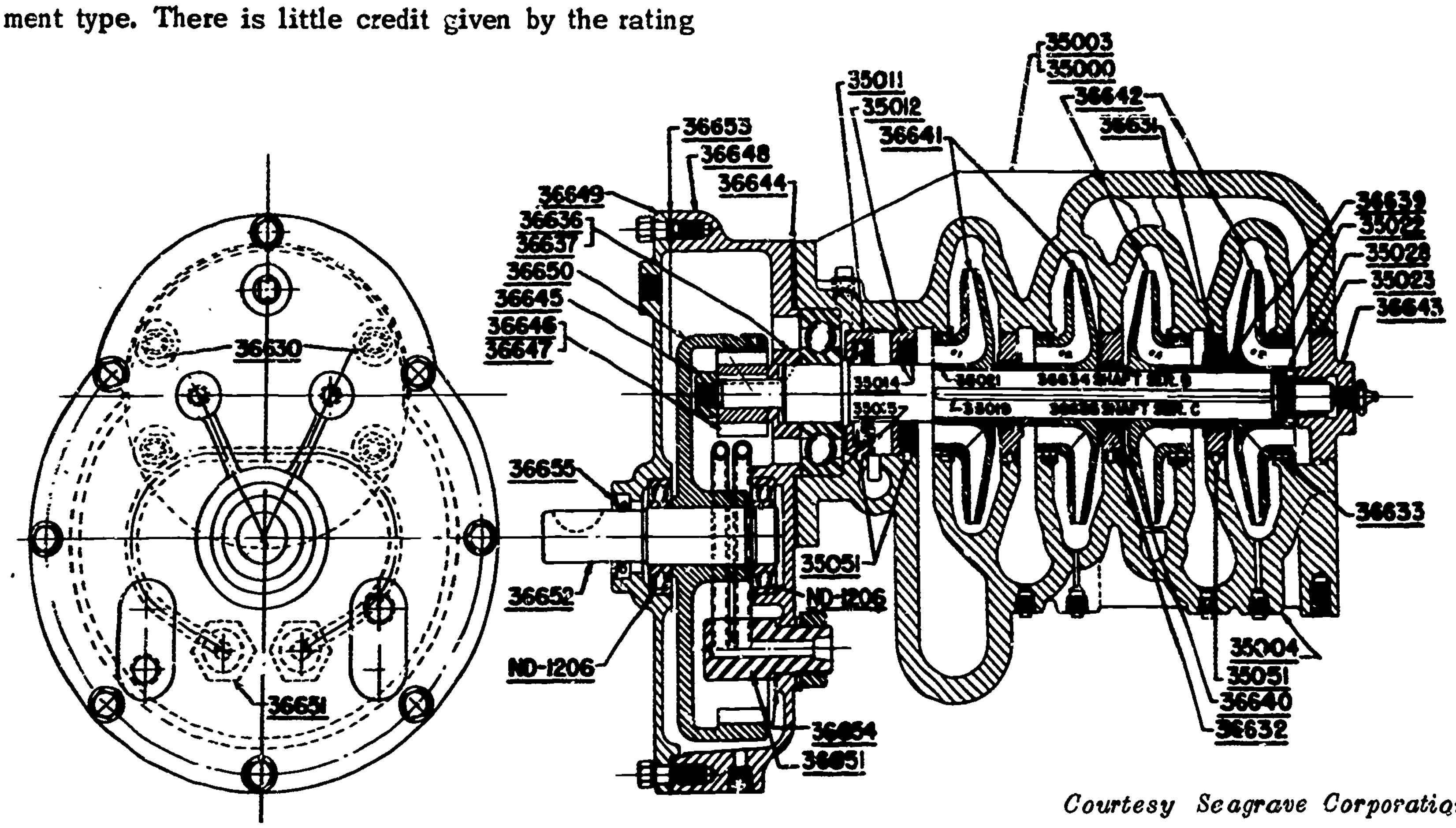
oped in the pump and applied to the piston valve. The valve controlling the piston and the lines leading to the piston are all built into the pump and cannot be seen; however, other types of change-over valves operate manually or electrically. The piston valve, (6c), shows the pump is in parallel or low pressure position.

The advantage of this type of pump lies in its ability either to operate at maximum volume or maximum pressure within a comparatively close range of speed. This type of pump can be operated in series with little more speed than is required for the parallel operation. Other types of centrifugal pumps require quite an increase of motor speed to increase the pressure.

HIGH PRESSURE PUMPS

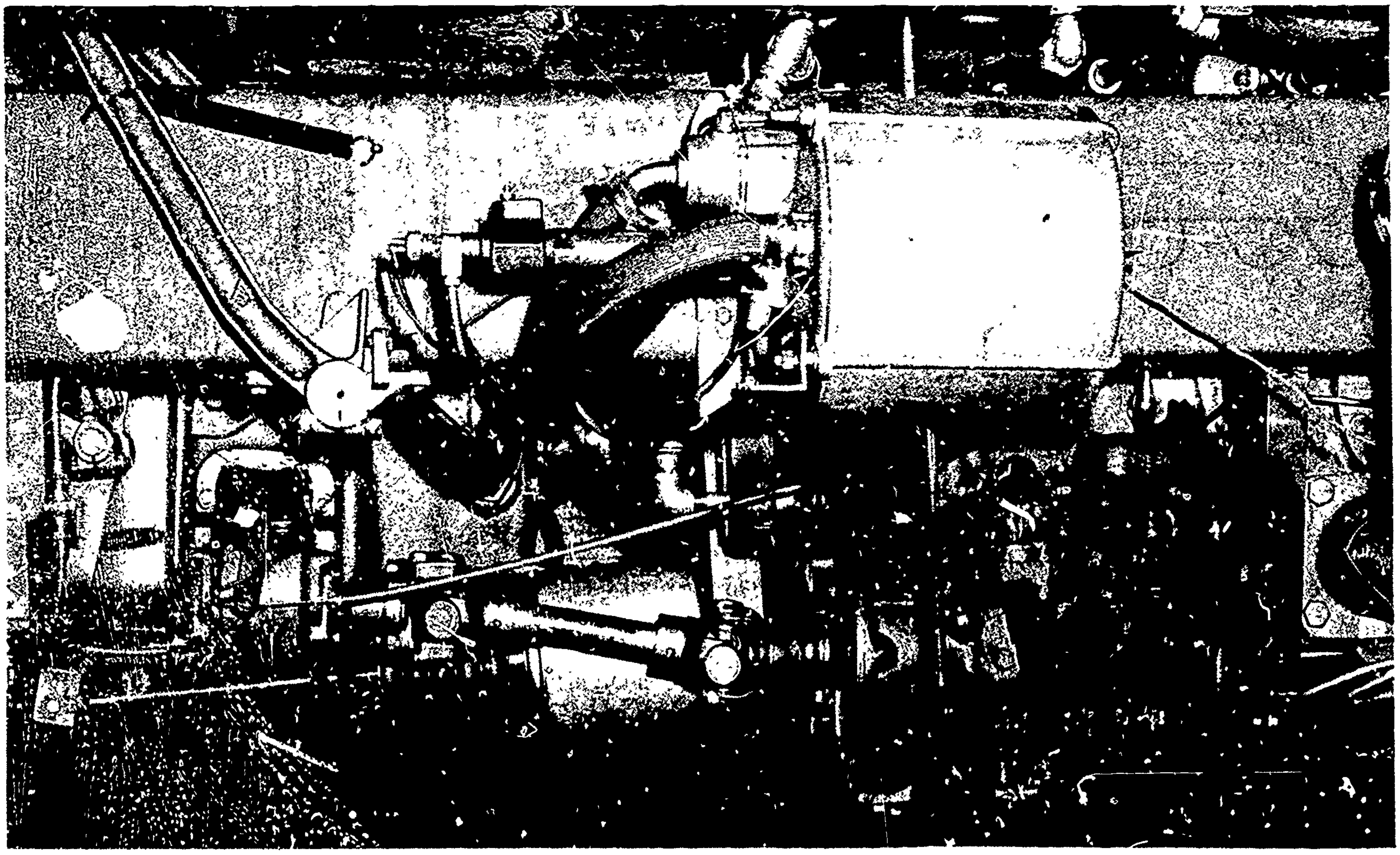
These pumps develop a pressure of from 800 p.s.i. to a much higher pressure in some instances. High pressure is usually gained by a four stage centrifugal pump either as a quantity pump or a separate unit

powered by power take off. See Figures 7 and 8. There is a fire pumper on the market that is entirely high pressure. This pump is of the positive displacement type. There is little credit given by the rating bureaus for this piece of equipment because of the lack of a quantity pump to supply large amounts of water when needed.



Courtesy Seagrave Corporation

Fig. 7 - High Pressure Pump, Sectional View



Courtesy Seagrave Corporation

Fig. 8 - High Pressure Pump

COMMON PUMP CONTROL MECHANISMS AND PRINCIPLES OF THEIR OPERATION

PRIMING

As previously stated, the centrifugal pump is incapable of creating its own vacuum; therefore, it is unable to prime itself for suction. In view of this fact, it can readily be seen that other means must be used to prime the centrifugal pump. There are two methods in general use for accomplishing this purpose. One method is to provide a pump of the displacement type to create the vacuum as shown in Figure 9. The other method is to utilize the vacuum naturally created in the operation of the gasoline engine, as in Figure 10. In using the latter method, the most effective vacuum is created at slightly above idling speed with little load on the motor. Many difficulties experienced in priming can be traced directly to excessive speed of the motor.

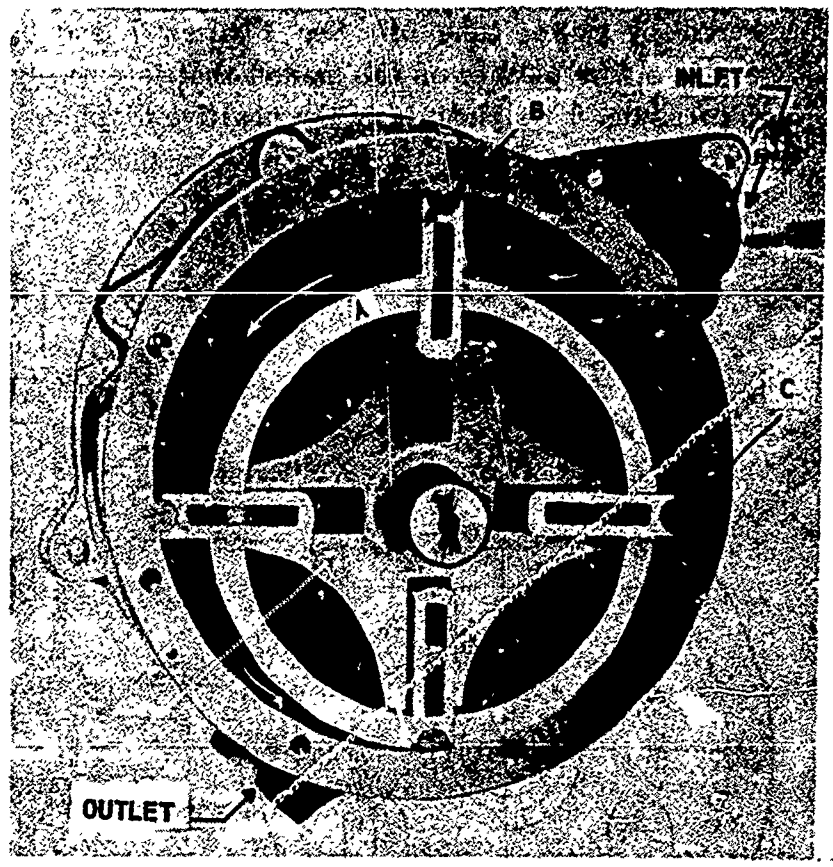


Fig. 9 - Displacement Type Priming Pump, Exposed View

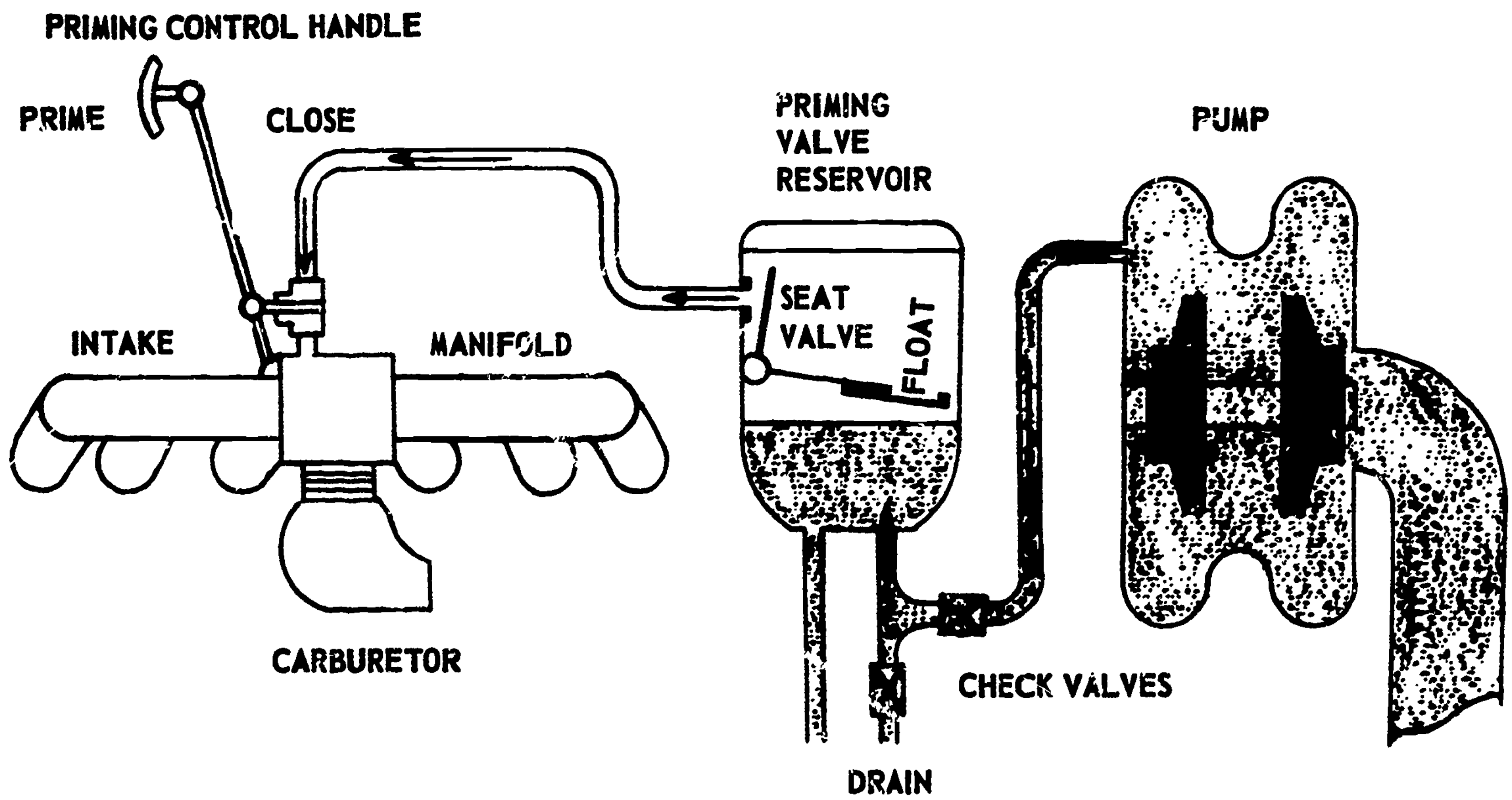


Fig. 10 - Vacuum Type Priming Pump

CHURN VALVE

When the flow of water is stopped in the positive displacement pump, such as shutting down a hose line, the pump stops, since the discharge is directly proportional to the pump speed. In order to eliminate stopping the pump, a churn valve is provided on displacement type pumps. The churn valve is simply a manually controlled by-pass between the suction and discharge side of the pump. When this valve is opened, water from the discharge side passes into the suction side. Since the centrifugal pump is not of the displacement type, the churn valve is not a necessity on such pumps although it may sometimes be provided.

AUTOMATIC RELIEF VALVE

The pump operator seldom knows in advance when a hose line is to be shut off. If a single line is operating from a positive displacement pump, sudden closing of the line will result in stalling the pump before the operator can open the churn valve. Before this takes place, however, a momentary "backing-up" of pressure in the pump may be sufficient to blow the hose line, pump casing or connections and may be injurious to the motor. If several lines are operating and one line is suddenly closed, the pump will usually continue to run, but the pressure built up may be sufficient to dangerously affect the operating lines. The consequences of such an action may be serious, particularly if a line is being operated from a precarious position. To prevent this an automatic by-pass around the churn valve is provided. Such a valve is known as an automatic relief valve. There are several different types of modern automatic relief valves in common use, but all operate upon the same general principles. In brief, the relief valve consists of an arrangement of valves and springs. When the pressure on the discharge side exceeds the pressure at which the controlling spring is set, the valve is opened by the pressure and permits water to flow into the suction side of the pump, thus relieving the discharge pressure. When the pressure drops below the setting of the spring, the valve closes and the flow from the discharge to the suction side is interrupted. Figure 11 illustrates one type of churn and relief valve.

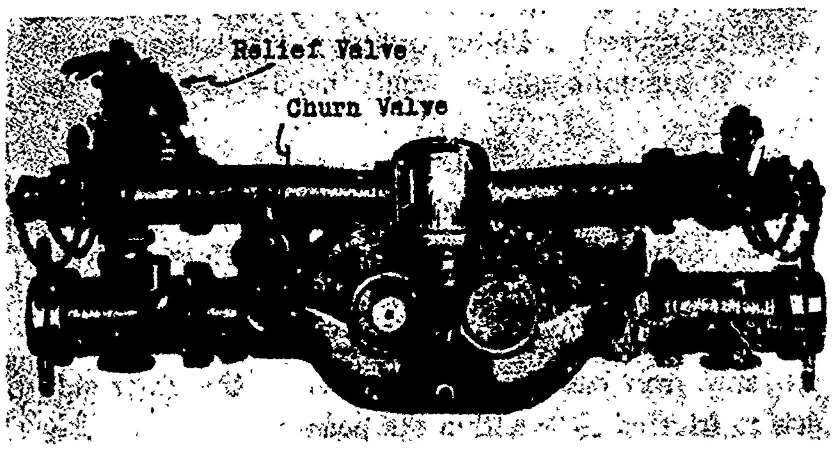


Fig. 11 - Churn and Relief Valves

AUTOMATIC PRESSURE REGULATING GOVERNOR

Sudden shutting off of the nozzle on a hose line on a centrifugal pump will not cause the pump to stop rotating or the motor to stall as it will with a positive displacement type pump, since there is a continuous passageway through the pump between the suction and the discharge sides. However, shutting off of the nozzle will stop the flow of water through the pump and will churn the water in the pump casing. When the flow of water is stopped, the pump, and consequently the motor, will be relieved of a great portion of this load. When the load is relieved the motor's speed will increase greatly, and since the pump speed is proportional to the motor speed, the speed of the pump impeller will also increase. This can be illustrated readily by releasing the clutch of an ordinary automobile when the car is in gear and the throttle depressed. It has already been stated that there is a direct relationship between the speed of the centrifugal pump and the resultant pressure. Theoretically, the pressure will increase at a rate equal to the square of the speed increase; therefore, it may be easily seen that even a slight increase in speed would result in an appreciable increase in pressure.

If such pressure increases were permitted to take place every time a nozzle is shut off, the results might be quite similar to those described under the discussion of relief valves. For this reason, centrifugal pumps are frequently provided with automatic relief valves similar to those used on positive displacement-type pumps. If there is no relief valve, some other form of an automatic pressure regulator should be provided, such as a pump pressure governor.

The pump pressure governor is of the spring loaded diaphragm type hydraulic remote control and is illustrated in Fig. 12. The governor proper is mount-

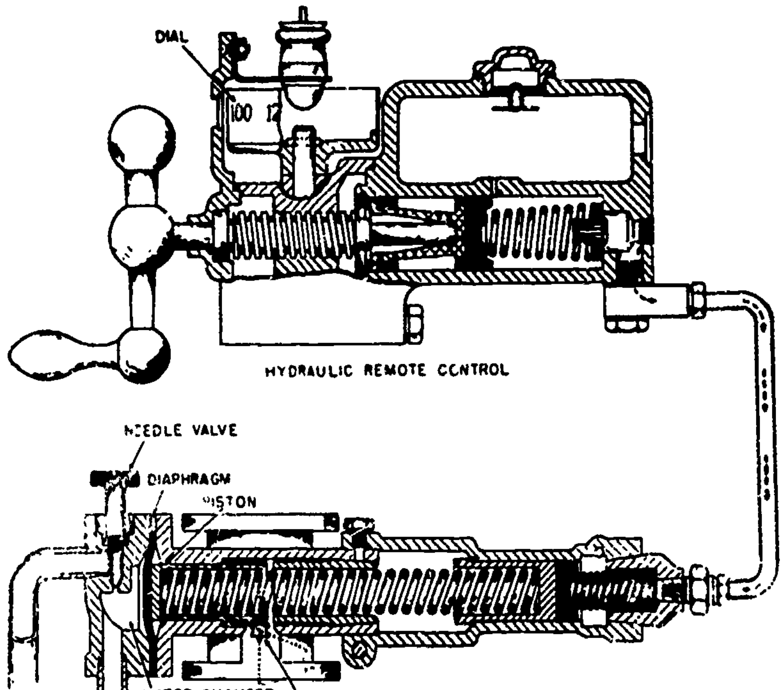


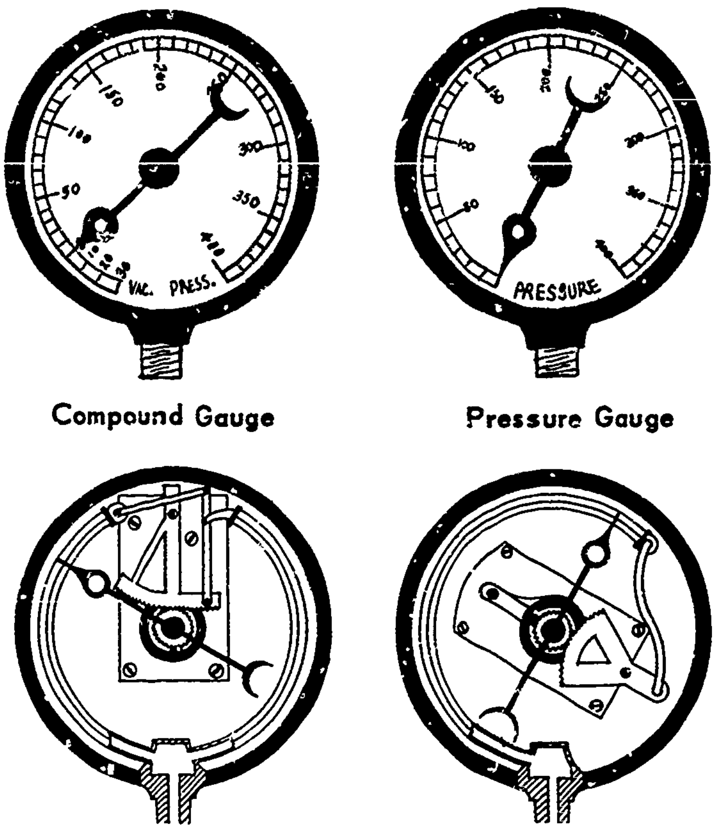
Fig. 12 - Pump Pressure Governor

ed on the engine under the carburetor, and consists of a throttle box and shaft, the latter having a gear on the outer end which is engaged by teeth turned on the governor piston. The piston is held against the governor diaphragm by the governor spring which normally holds the throttle wide open. Pump pressure enters the governor head through the connection shown and, if sufficient to overcome the spring pressure, it will force the diaphragm and piston back and thereby close the throttle until the pump pressure corresponds with the governor setting.

GAUGES

The installation of direct reading gauges on the pump is necessary to provide the operator, at all times, with first hand information as to the intake and discharge pressures while his pump is in operation. Gauges used on fire department pumping engines are what are known as the Bourdon type, named after their inventor. While less sensitive than the complicated mercury tube gauges used to indicate pressure in more painstaking experimental work, the Bourdon type of gauge is sufficiently accurate for all normal pumping operations. For fire department service, Bourdon gauges consist of two general types, namely, the pressure gauge which indicates the amount of positive pressure, and the compound gauge which is used to indicate both the positive and vacuum pressures at points which may, under different conditions, be subjected to either. Bourdon gauges are also of two types of construction, the single-spring and the double-spring. The latter is used almost exclusively for fire pumps because of its more rugged construction and greater stability.

Fig. 13 shows the face markings of pressure and compound gauges as well as the internal construction of both single and double spring types. All operate on the same principle. Pressure enters through the threaded gauge fitting and passes into the Bourdon tubes, which consist of single or double thin, curved, hollow metal tubes closed at their upper ends. Pressure inside these tubes creates a tendency for the tubes to straighten out slightly, causing a slight movement in the upper ends of the tubes which are free. This movement is transmitted and multiplied by a series of levers connecting to a rack and pinion which controls the movement of the indicating hand. A hair spring attached to the pinion shaft holds the assembly together tightly and serves to modify the movement of the needle. Positive pressure in the Bourdon tube causes the needle to move clockwise over the calibrated gauge face. Vacuum pressure in the tubes tends to increase the curvature of the tubes and causes the needle to move in a counter-clockwise direction.



Compound Gauge — Pressure Gauge

Double Spring — Single Spring

Fig. 13 - Pressure and Compound Gauges

Pressure gauges are installed on the discharge side of all positive displacement pumps. A compound gauge is installed on the suction side of all pumps and is usually provided in place of the straight pressure gauge on the discharge side of centrifugal pumps. The reason for this is that the centrifugal pump normally presents a continuous waterway and when a vacuum is applied to the pump, such as when taking suction, it applies to the entire pump until the pump is primed. Under ordinary circumstances, a straight pressure gauge would be damaged by such use.

Many of the modern-day pumpers are equipped with individually gauged pump discharge outlets. These individually gauged discharge outlets give the operator a better control of the various lines for pressure control. There is frequently a variation of 10# pressure from one side of the pump to the other side due to friction loss within the pump.

Gauges are usually provided with valves in their connection with the pump. These valves should be closed to a point where the gauge gives a good steady reading without undue vibration. Drains are also provided and should be opened after use. Bourdon gauges are calibrated and marked in comparison with a standard master gauge or mercury column gauge. Due to mechanical failures, they should be tested and re-calibrated at frequent intervals by

means of a master gauge or special deadweight tester.

TACHOMETER

To enable the pump operator to know at all times the conditions under which the motor is operating, a permanently attached speed indicator or tachometer should be provided. The function of the tachometer is to register the approximate direct speed in revolutions per minute at which the motor is operating. In some types of pump assemblies, where power to turn the pump is provided through normal road transmission gears, suitable markings on the speedometer are substituted for the direct reading tachometer. These markings indicate the proper equivalent miles per hour when the pump is operating within the capacity range at the different pressure requirements. While this method serves to give warning and guards against excessive motor speeds, it has the disadvantage of not giving the direct motor speed at all times.

BOOSTER TANKS ON FIRE APPARATUS PORTABLE PUMPS

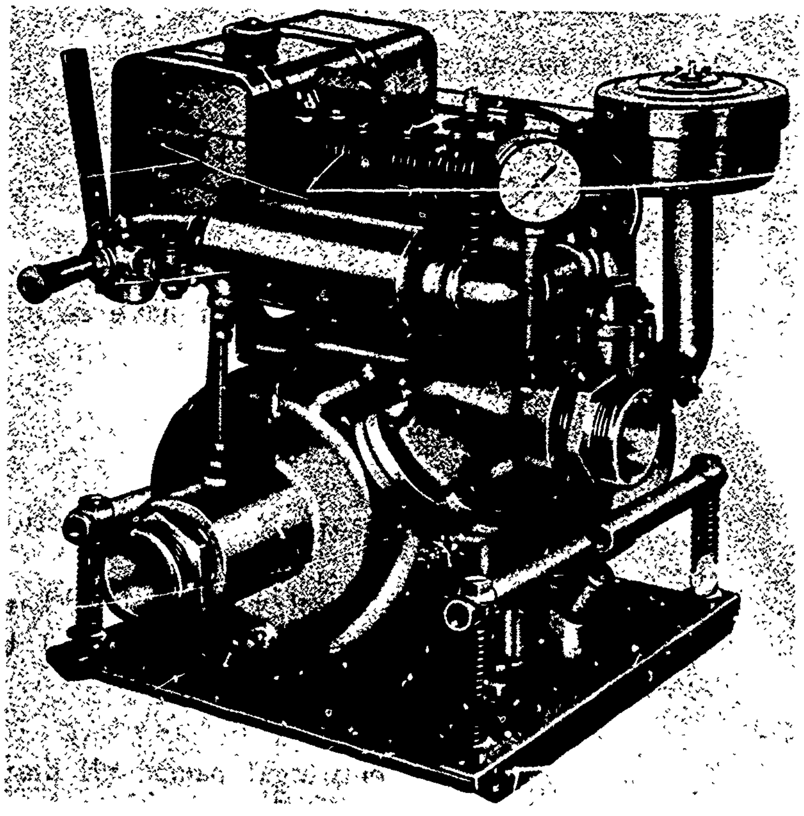
PURPOSE AND USE

The booster tank and pump on fire apparatus have almost entirely taken the place of the former chemical tank in supplying small fire streams. Such streams are of great value in controlling small fires without causing undue water damage. The capacity of booster water tanks has a wide range, but for normal service a minimum capacity of 200 gallons is recommended for municipalities. Where circumstances warrant, such as in rural areas and in the forest service where any potential source of water is lacking, tanks of much larger capacity, ranging in general from 200 to 500 gallons, can be provided. In determining the size of a tank, it is well to remember that water weighs approximately 8 1/3 pounds per gallon and that 100 gallons will weigh 833 pounds. The weight of the booster tank must be considered.

Tanks may supply water either to the main fire pump, which is operated at a slow speed, or to an independent high pressure booster pump. Where independent high pressure booster pumps are provided, they are usually the previously discussed small rotary or centrifugal types having a capacity of from 40 g.p.m. to 100 g.p.m. Rotary pumps for priming should not be used as booster pumps. These priming pumps should be subjected to a minimum of wear in order to maintain them in good condition. Their use for booster service will subject them to damage.

PORTABLE PUMPS

The portable pump has come into its own in the fire service. See Figure 14. This type of pump is used extensively to supply water to, and withdraw from, the water tanker used in rural areas. Many of these pumps are able to produce up to 100 p.s.i. using 1½" hose with ½" tips or fog nozzles. They are driven by a gasoline motor and have an exhaust prime for the centrifugal pump. Normally this pump will deliver water within ½ minute from the time the prime is started. This type of pump is used to supply water by a relay method to the fire pumper from a pond, stream, or well. The importance of this piece of equipment is shown by the fact that many departments have two or more of these portable units, most of which are of the single-stage centrifugal type.



Courtesy The Gorman-Rupp Company

Fig. 14 - Portable Pump

PROCEDURES TO BE FOLLOWED IN OPERATING PUMPERS

The proper procedure to follow in operating fire department pumpers, either from draft or from hydrants, will depend largely upon the type, make, and model of the pumper being used. Manufacturers publish an instruction manual which accompanies each

apparatus when it is delivered and experienced mechanics are usually provided to give detailed instructions in the proper methods of operation and maintenance. The manufacturer's manual should be studied carefully and rigidly followed in operating pumpers.

To pump water into a fire hose, there are three needs: power, water and open valve.

POWER

1. The motor of the apparatus must be running.
2. The apparatus must be in pump gear.
3. The apparatus clutch must be engaged.
4. The throttle must be controlled.

WATER

1. Open valve from booster tank.
2. Open hydrant to supply line.
3. Open valve to suction side of pump.
4. Draft from supply
   a. Centrifugal pumps must have an air-tight system.
      (1) Tight connection
      (2) Good gaskets in hard suction
      (3) A whirlpool will result if hard suction is not submerged to proper depth
      (4) On centrifugal pumps all drain cocks must be closed. On positive displacement pumps an air release must be provided, such as opening a discharge valve.

DISCHARGE VALVE

1. Make sure the proper valve is opened.

CARE OF THE FIRE PUMP

Careful observance of pump performance at fires will indicate necessary repairs and adjustments. In addition to the pump, all connections, and the auxiliary engine cooling system used while pumping, should be carefully checked at regular intervals for adjustment and lubrication. It is sometimes desirable to drain the pump in cold weather. Drain cocks are provided and the necessary detailed instructions for draining procedure are given in the manufacturer's manual. These instructions should be followed closely in order to prevent the pump valves and lines from freezing during cold weather.

CLASS OF FIRE PUMPERS

Class "A" fire pumpers are those which will deliver rated capacity at 150 p.s.i. net pump pressure, 70 per cent of capacity at 200 p.s.i., and 50 per cent of capacity at 250 p.s.i. The net pump pressure is the sum of the pump discharge gauge pressure, corrected for any gauge error, plus the vertical distance from water level to the gauge (lift), plus suction losses. Prior to January 1st, 1957, the National Board of Fire Underwriters recognized a class "B" rating. This class has been eliminated and all pumpers must be rated class "A" since that date. This class "A" classification applied to the purchase of new pumpers; however, a department with a class "B" pumper, within age limit, will be given credit by the rating bureau until such time as its age outlaws it.

FIRE TRUCK MOUNTED FOAM-WET WATER SYSTEM

For the fire department, where the use of a truck exclusively for foam is not justified, a foam system is necessary for the fire truck.

The ideal system should be versatile, easy to operate and maintain and economical.

A versatile system permits the use of protein foam (mechanical) in both 3% and 6% concentrations, regardless of the type of foam liquid normally carried by the truck. This will insure performance with mutual aid groups, civil defense and for catastrophe control in general, where foam liquid may be drawn from a common stock. It permits the use of an efficient penetrant foam, such as "Unox", for control of Class A fires which require the use of a controlled-application wetting foam, as well as for all Class B fires. It also permits using low concentration non-foaming wetting agents. The versatile system gives an unimpaired water stream from any foam outlet when foam is not required, and also permits simultaneous use of foam and water from the same truck so that exposures may be protected by conventional water streams while the fire itself may be attacked with foam.

It is important that a truck additive system be designed so that it does not hurt the function of other truck components. The practice of pumping wetting agents through a pump may result in premature failure of pump packings, and may, because of its penetrating action, accelerate corrosion of booster tanks and piping where wetting agents are premixed in the truck tanks. Some protein foams show corrosive characteristics, particularly at the air-liquid surface, and corrosion of foam tanks is to be expected unless special tank materials are used. Protein foams also generally acquire a gummy characteristic when exposed to air and will eventually harden into a rubbery sheet. Unless care is exercised in flushing all lines and fittings thoroughly after use, service difficulties will be encountered.

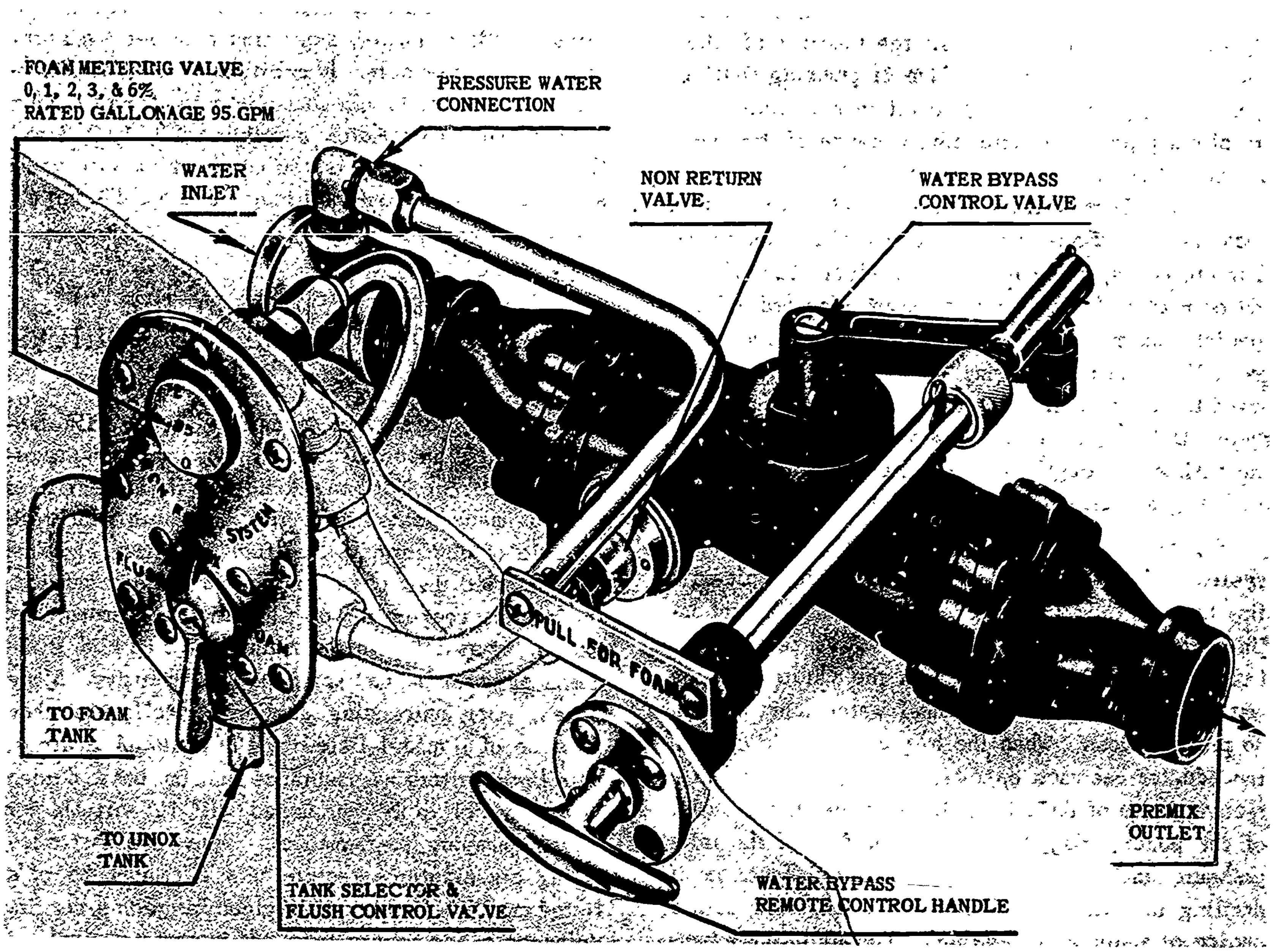
Figures 15 and 16 illustrate a truck mounted foam system which is ideal for a foam producing unit on a fire truck. This system consists of an efficient inline eductor connected in tandem with a remote control by-pass valve so that with the valve open the water line will serve its normal water function with no pressure loss. When the by-pass valve is closed, the eductor becomes operative. This eductor has a recovery rate of 80%; i.e., the pressure at the outlet of the eductor may be as high as 80% of the inlet pressure and still perform its required function of drafting foam liquid. This unit is supplied with a choice of water gallonage and, like all inline eductors, should match the gallonage of the nozzle with which it is to be used. While the foam system may be designed to use any desired length of hose from the eductor to the nozzle, 150 feet is generally considered adequate. It should be pointed out that the high recovery and correspondingly low operating pressure possible with this eductor result from the use with it of a fog-straight stream and foam nozzle that give the same gallonage in all stream patterns. This nozzle is available with a quick-coupled aspirating tip to provide a good quality, well-expanded protein foam. This system also has a selector valve so one or two separate tanks containing protein foam or penetrant foam may be quickly selected to meet any fire fighting requirement. This same selector valve also provides for selection of water to completely flush out the foam system after use. It is only necessary to select the flush position and to leave the pump operating for a few minutes to completely flush the entire foam system, excluding of course the tanks themselves which should be closed off at this time. The tanks available for use with this unit are supplied in a variety of gallonages and are of corrosion-proof, high strength fiberglass with integral filling hopper, expansion chamber, sediment trap, and access hole. In addition to the tank selector control, a precision foam liquid metering device is supplied. This meter is calibrated 0, 1, 2, 3 and 6%. The 1% setting is for non-foaming wet water additives, 2% for penetrant foams and the 3% and 6% for protein foams.

PUMPER LISTINGS BY THE NATIONAL BOARD OF FIRE UNDERWRITERS

As a public service to municipalities, manufacturers of fire apparatus and fire insurance rating organizations, the National Board of Fire Underwriters has for many years listed fire apparatus which are capable of discharging specified quantities of water at specified net pump pressures. This service, through the cooperation of all parties concerned, has materially assisted in the maintenance of high standards of performance throughout the industry. Many cities, when purchasing pumpers, specify that they must be of a model listed by the National Board of Fire Underwriters as assurance that the basic design of the model to be purchased will be suitable for proper pumping performance. Many fire insurance rating organizations require that a pumper be of a listed model before credit is given in grading the fire defenses of the city or town. It is now practically a universal custom for a fire department to require a three-hour acceptance test to be conducted on each pumper when delivered and in most instances, no pumper is eligible for such a test unless a similar type of assembly made by the identical manufacturer has already been listed by the National Board of Fire Underwriters.

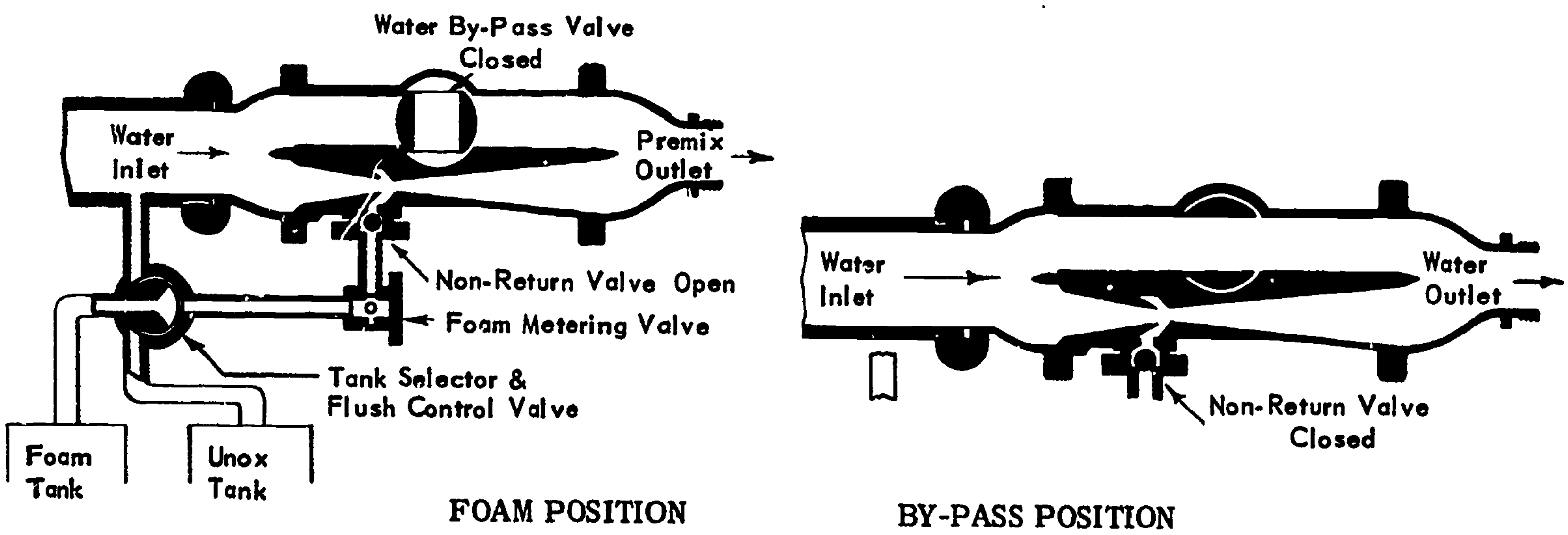
There are two methods of listing pumpers. One is based on the twelve-hour test as described in the National Board of Fire Underwriters' booklet, "Fire Engine Tests and Fire Stream Tables." This method is required for new manufacturers and for assemblies having new combinations of motor or pump and gear ratios not previously listed.

The other, known as Performance Listings, may be used with established and recognized manufacturers for assemblies differing from a previously listed model in only minor respects, as having, for example, a larger motor. In this case, the results of a four-hour run-in test by the manufacturer at the factory is accepted as an indication that the change from the previously listed pilot model will result in proper deliveries and pressures.



Courtesy Akron Brass Manufacturing Co., Inc.

Fig. 15 - Bypass for Truck Mounted Foam System



Courtesy Akron Brass Manufacturing Co., Inc.

Fig. 16 - Bypass Valve in Foam and Bypass Position

Listings may be withdrawn should it develop that subsequent assemblies of a model do not conform in performance of the listed pilot model.

To secure a listing for a pumper, the apparatus manufacturer must first present to the National Board of Fire Underwriters the following data:

1. Form 126A of the National Board of Fire Underwriters' completely filled out giving the essential mechanical details. See Figure 17.

2. A brake horsepower curve of the engine without accessories.

3. A pump certification sheet from the pump manufacturer showing the expected performance results.

4. The results of a four-hour factory run-in test.

When a listing is given, Form 126, signed by an authorized official of the National Board of Fire Underwriters, is issued to the manufacturer. This form lists the essential data of the engine and pump, the gear ratio between them, and the results of either the twelve-hour test or, if a performance listing, the four-hour factory run-in test. A pumper should not be considered as listed unless the manufacturer furnishes a photostatic copy of a properly signed Form 126 describing an assembly identical in the basic essentials of motor, pump, and gear ratio. All fire insurance rating organizations are notified periodically of listings issued.

The issuance of Form 126 and listing of the apparatus does not imply that features other than the delivery capacity of the apparatus at or near sea level are in conformance with the National Board of Fire Underwriters' Pamphlet No. 19, "Suggested Specifications for Motor Fire Apparatus" adopted jointly by the National Board of Fire Underwriters, International Association of Fire Chiefs, and the National Fire Protection Association. However, certain devices are required to be provided on the pumper before a twelve-hour test or three-hour acceptance test will be run. These are:

(1) A readily accessible, permanently attached speed indicator, such as a tachometer, which shall indicate the speed at which the engine is operating when driving the pump.

(2) Provision by means of which the engine speed can be conveniently and safely checked with a hand revolution counter.

(3) A device on all gear shifts used for pumping which insures that the gear shift cannot be accidentally knocked out of mesh. When pumps do not operate through the road transmission and propelling power can be applied to the wheels while pumping, a device shall be provided by which the road transmission can be positively held in neutral; if it is desired to pump while in motion, this device need not be interlocked with the pump lever.

(4) A plugged tee or other suitable connection to enable the attachment of a separate test gauge for determining pump pressure.

(5) If a downdraft carburetor is used, the gasoline tank must be located so that the top of the liquid in the tank is below the float level or provis' 'n shall be made to prevent flow to the carbr etor when the ignition is off.

(6) Means for controlling pressure at the pump through an automatic relief valve or pressure regulator controlling engine speed.

(7) A heat interchanger of suitable capacity so arranged th^t it will maintain normal operating temperature and, if cross-connected for refilling the radiator, will not cause undue pressure therein.

(8) A positive control of the throttle.

If the pumper is purchased under and complies with the aforementioned "Suggested Specifications", the above requirements will be met. A listing test may be accepted in lieu of a three-hour acceptance test on the particular apparatus upon which the listing test was conducted, but in all cases the rating bureau, controlling the area, reserves the right to require an additional three-hour acceptance test. This is frequently the case where the delivery destination has a considerably higher altitude than that where the original test was conducted.

PUMPER ACCEPTANCE TEST

WHEN, WHY, AND HOW TESTS ARE CONDUCTED

Every pumper, on delivery, should be given a three-hour acceptance test. The fire insurance rating organization or bureau having jurisdiction should

FORM NO. E126-A. 6M-REV. 2-61

National Board of Fire Underwriters

COMMITTEE ON ENGINEERING

PUMPER DATA

Date

1. Manufacturer
2. For City of
3. Manufacturer's Model Manufacturer's Serial No.
4. Engine: Make Model Engine No.
5. No. Cyl. Bore in.; Stroke in.; Displ. cu. in.; Comp. Ratio to 1
6. Peak of Brake Horsepower developed without accessories at Governed rpm
7. Peak of Foot-Pounds of Torque developed without accessories at rpm
8. Ignition: System Voltage Spark Plugs per Cyl. Magneto: Make
9. Generator: Output Watts; Alternator: Output Amperes
10. Battery: Single? Dual? Capacity Amp.-Hrs.; Make and Model
11. Electrical Arrangement
12. Carburetor: Type No. of jets (barrels) Above Top of Fuel Tank?
13. Fuel: Gasoline Tank: Capacity Gallons; Location
14. Type of Feed Anti-Siphon Device?
15. Fuel Octane Recommended Used on Test
16. Throttle Control: Location Type Rigid?
17. Cooling System: Heat Exchanger? Radiator Refill Line?
18. Size: Radiator Refill Line in. diam.; Radiator Overflow in. dia.
19.
20. Transmission: Gear Ratios: Fifth to 1. Fourth to 1. Third to 1.
21. Second to 1. First to 1. Reverse to 1.
22. Automatic: Describe
23. Drive to Pump through Transmission? Special Clutch?
24. What Trans. Gear Used: 150 psi 200 psi 250 psi
25. Locking Device: on Transmission Gear Shift: Type Rigid?
26. on Pump Shift: Type Rigid?
27. Pumping Condition Marked: On Trans. Shift? On Pump Shift? For Priming?
28.
29. Gear Ratios: Engine to Pump: 150 psi 200 psi 250 psi
30.
31. Pump: Make Model Capacity gpm; Pump No.
32. Type Impeller Diameter inches
33. Priming Device: Type Theoretical Pump Displacement g/r
34. Pressure Control: Relief Valve? Pressure Regulating Governor?
35. Power-operated Controls: Describe
36.
37. Separate Booster Pump? Make Model
38. Chassis. Make Model Chassis No.
39. Wheel Base in.; Width in.; Differential Gear Ratio to 1
40. Booster Tank: Capacity Gals.; Shape and Location
41. Weight: Max. Allowable Gross lbs.; Without Men, Hose, Water, Equipment lbs.
42. Vehicle Weight Distribution: Front Wheels lbs.; Rear Wheels lbs.
43. Axles: Rated Capacity: Front Wheels lbs.; Rear Wheels lbs.
44. Tires: Size and Ply: Front Rear Dual Rear?
45.
46. Testing Facilities: Tachometer: Location Kind
47. Hand Counter Speed Check Readings taken from
48. Ratio to Engine: 1 to Permanently and Easily Accessible?
49. Connection Provided for Test Gauge? Location
50. Data collected by
51. Remarks:

Courtesy The National Board of Fire Underwriters

Fig. 17 - Pumper Data Form

be notified by the manufacturer's representative of the place and time of the test. Where such a test is not witnessed by a representative of the rating bureau, it is desirable that the results of the test be sent to the bureau. The manufacturer's delivery representative must be capable of running an acceptance test and be provided with proper testing equipment. Acceptance tests will not be witnessed by a rating bureau representative unless the pumper is equipped with all essential devices that are required for a listing test.

The three-hour acceptance test is run to verify the listing test as furnished by the manufacturer. This test is usually run by the chief of the fire department, the fire department mechanic, the representative of the manufacturer, and a representative of the rating bureau.

The three-hour acceptance test shall consist of drafting water with a suction lift of not less than ten feet. The pumper is required to pump rated capacity against a net pump pressure of 150 p.s.i. for a continuous period of two hours. This is to be followed by two one-half hour periods of continuous pumping, the first half-hour to be 70 per cent of rated capacity at a net pump pressure of 200 p.s.i. and the second half-hour to be 50 per cent of rated capacity at a net pump pressure of 250 p.s.i.

The apparatus shall also be given a short overload test to demonstrate its ability to develop 10 per cent excess power. The test shall consist of discharging rated capacity at 165 p.s.i. net pump pressure.

A vacuum test, with a capped suction at least twenty feet long, shall develop twenty-two inches of vacuum and hold the vacuum with a drop not in excess of ten inches in ten minutes.

The stops during tests shall be only such as are necessary for changing hose and nozzle. During and after the tests, the engine, pump, transmission, and all parts of the apparatus shall show no undue heating or excessive strain or vibration; likewise, the engine shall show no loss of power, overspeed, or other defect.

ANNUAL PUMPER TEST

The National Board of Fire Underwriters recommend that all fire departments make at least an annual testing of all their fire pumpers. This test is usually run for fifteen minutes at rated capacity, ten minutes at 70 per cent rated capacity, and ten minutes at 50 per cent rated capacity. The annual pumper test is to be made with the same testing equipment and following the same procedure as used for an acceptance test. It is further recommended that a vacuum test be made of the pump dry by capping the intake side, pulling at least twenty inches of vacuum and holding it for ten minutes with the pump shut off. The drop in vacuum should not exceed ten inches in the ten minute time. A similar test should be made by coupling the hard suctions together, attaching the intake side of the pump, capping the other end and going through the same procedure as followed for testing the pump vacuum. For fire departments that are not familiar with the testing procedure for a fire pump, it is recommended that the pamphlet, "Fire Engine Tests and Fire Stream Tables" be obtained and the procedure be followed as set up in this pamphlet.

A record of all tests should be kept so the department has the results available at any time.

Any time that a department has had a job where there may have been undue work for the pump, it is recommended that the pumper be given a good test of short duration of the same procedure as for the annual test.

WEEKLY PUMPER TEST

It is recommended that the pump on the fire pumper be given at least a weekly check. This should include complete operation of all procedures for pumping both from drafting and pressure supply, such as booster tank or hydrant. The check is to include operation of *all* valves and controls.

CHAPTER 8

FIRE HOSE

INTRODUCTION

Fire hose, universally used in fighting fires, is one of the most essential items of a fire department. Firemen must be thoroughly familiar with the construction, care and use of hose because of its importance in successful, efficient fire control and extinguishment.

Successful fire fighting depends upon adequate fire streams and adequate fire streams depend upon well made and properly maintained hose. Hose selection and care must be given much attention if the department is to operate efficiently. The dependability and life of fire hose rests upon such factors as quality of hose purchased, purposes for which the hose is used, operating pressures used by the department and care of the hose in quarters and at fires.

Neglected hose may burst at the scene of a fire and the time required to replace it may permit the fire to get beyond control.

Leaks in hose lines reduce the effectiveness of the fire streams and leaking lines within buildings may result in unnecessary water damage. In many cities and villages, water supplies are limited and, in order to use the available supply to the best advantage, it is essential that no water be wasted by leaking hose or couplings.

Fire hose is designed for use at fires and not the many purposes for which it is sometimes used such as settling dust, flushing sewers, streets, etc. It should be a strict rule that fire hose must not, with rare exception, be used for other than fire purposes until such a time as it is found unfit for fire service. Violation of this rule may result in hose being defective, missing, or useless at the time of a fire.

TYPES OF FIRE HOSE

The types of fire hose most commonly used for fire fighting operations are:

UNLINED LINEN HOSE

Unlined linen hose, as the name implies, has no rubber lining. It consists of a fabric tube made of closely woven linen yarn. Due to the nature of the linen, when the water first passes through, it will leak, but the fibers will swell within a very short time close the spaces and make the hose water tight. This type of hose is used mostly for installation at standpipes inside buildings and is not for ordinary fire department use.

RUBBER-LINED HOSE

Rubber-lined cotton, nylon or dacron jacket hose is available in single, double or, in some instances, a triple jacket of woven cotton lined with rubber. This hose is considered very efficient and, if given proper care, will stand up very well against the heavy usage encountered in fire service.

RUBBER-LINED, RUBBER-COVERED, REINFORCED HOSE

Rubber-lined, rubber-covered (reinforced) hose, better known as hard suction hose, has the added feature of metal set in rubber between the reinforcing layers. The metal is a heavy, round wire which is either galvanized or copper-coated. The construction of this hose is such that the round reinforcement will prevent collapse of the hose when the pumper is operating from draft or from a low pressure hydrant. It is generally manufactured in ten foot lengths.

RUBBER-LINED, RUBBER-COVERED HOSE

Rubber-lined, rubber-covered hose is constructed of cotton canvas covered both on the inside and the outside with rubber. Examination will show that the ends of this type of hose are sealed with rubber to prevent the cotton from being injured by acids, moisture, etc. This extra outside rubber covering provides protection against rough or sharp surfaces injuring the canvas and prevents deterioration when in contact with chemicals or acids. This type of hose is usually used for booster, chemical hose and high pressure lines.

In purchasing any fire hose, the standards set forth by the Underwriter's Laboratories, Inc., 207 East Ohio Street, Chicago 11, Illinois, should be followed. This will assure a good quality; however, all newly purchased hose should be thoroughly tested and examined before putting it into service.

The most commonly used sizes of fire hose in the fire services are:

¾" and 1"	Rubber-lined with rubber cover
1"	Rubber-lined with fabric jacket
1½"	Rubber-lined with a single or double fabric jacket
1½"	Unlined linen
2½"	Rubber-lined with single, double or triple fabric jacket
3"	Rubber-lined with single, double or triple fabric jacket
3½"	Rubber lined with single, double or triple fabric jacket
4", 4½", 5"	Hard suction intake with steel reinforcement
4", 4½", 5"	Soft suction intake with multiple woven fabric cover

CARE OF HOSE

CARE OF RUBBER LINED FABRIC JACKET HOSE

The length of service obtained from this type of hose will greatly depend upon the care it is given. Good hose will last a long time if it is not abused and is given proper care. Several principal ways that hose may be damaged are listed in the following paragraphs:

Mechanical Injury - Cuts, snags, and abrasions resulting from dragging hose over the ground, paved streets or rough surfaces account for a large amount of damage to hose. While the jacket is resistant to such treatment, there is a limit to the amount of abuse the material in a hose will stand. Hose should not be folded in the same place each time it is placed in service in the bed of a pumper. Wear on the jacket can be prevented by the use of hose rollers when hoisting hose over roofs, cornices, and into windows. Pump operators should eliminate the chafing of hose caused by friction between hose and curbing or street while the pump is operating. This damage can be eliminated by the use of the chafing blocks; see Figure 1.

Hose should not be exposed to traffic damage any more than necessary. One of the most common causes of damage to hose is the crossing of hose lines by vehicles. However, when the hose is charged and under good pressure, it is not as apt to become seriously damaged as when it is not charged or under low pressure.

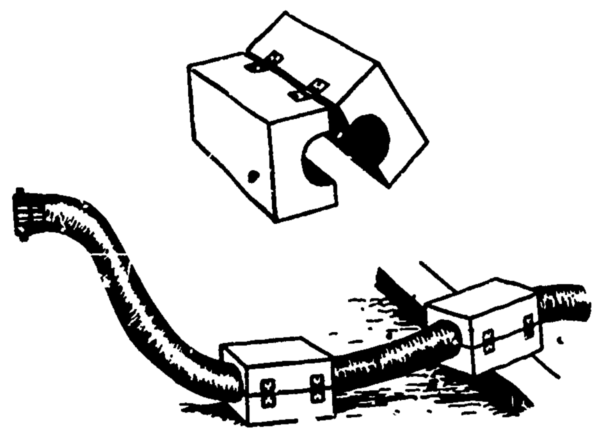


Fig. 1 - Chafing Blocks

A piece of hose may not appear to be damaged after having been crossed by the wheels of a vehicle but if this section were to be opened, it would no doubt be found that the lining has separated from the jacket or even torn apart. A vehicle is propelled forward by the friction resulting from the contact of the wheels with the ground or pavement. When the wheels, either front or rear, cross a line of hose, they are exerting a tremendous force forward and all the power required to push the vehicle ahead is applied through the hose to the ground. Likewise, as the wheel starts over the edge of the hose, the lining is forced into a wad at one edge and the jacket is also acted upon in such a manner as to peel it free from the lining.

Where detours for traffic cannot be maintained, hose bridges should be used; see Figure 2. Only in case of extreme emergency should vehicles be permitted to cross hose lines.

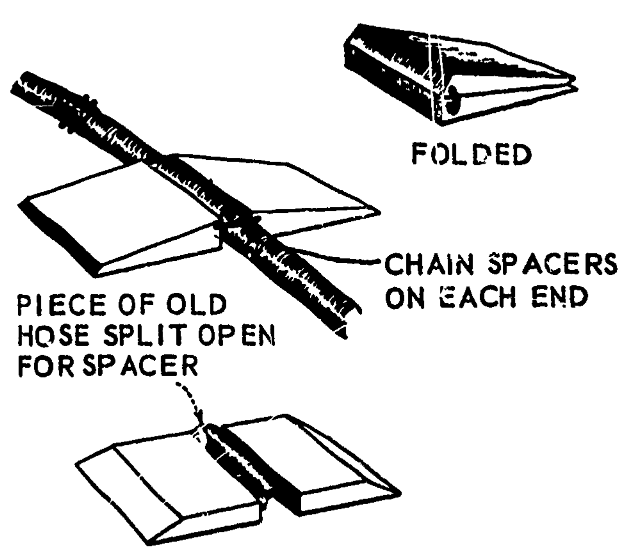


Fig. 2 - Hose Bridge

When laying the first lines to the fire, the location and selection of the hydrant in relation to the fire must be considered. It may, at times, be a good policy to select a hydrant on the same side of the street as the fire in preference to one closer but at the opposite curb-line. The final decision in such cases, however, should be the responsibility of the person in charge of the fire.

Should no hydrant be available on the same side of the street as the fire, a hydrant on the opposite side of the street must be used. This hose line should be laid parallel to the curb on the same side of the street as the hydrant up to a point opposite the fire. The only point where a hose line should cross the street is in the close vicinity of the fire. Any apparatus entering the fire zone after the lines are laid will not have to drive over the hose lines already stretched across the street unless the apparatus has to pass the building to get to a point on the far side; see Figure 3.

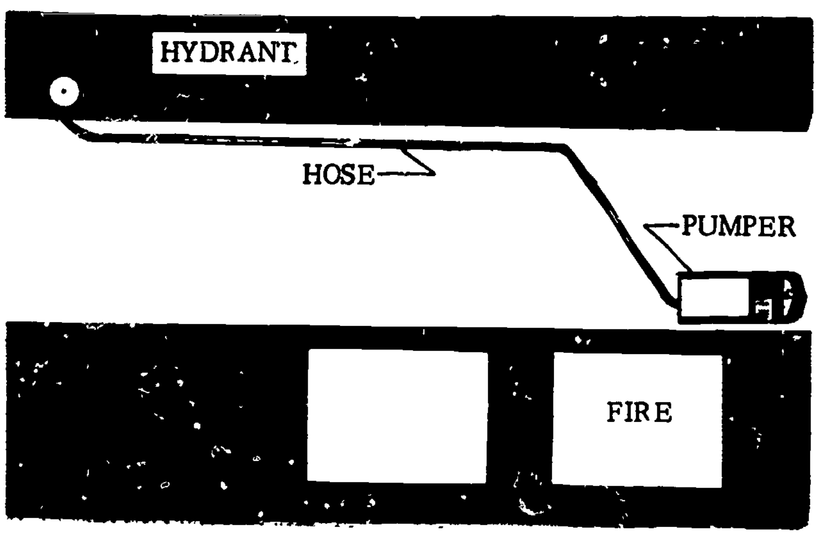


Fig. 3 - Laying Hose Line Across a Street

In addition to the previous statements, fire hose can be mechanically injured when not in use. Hose is manufactured in 50 foot sections and if it is hung on drying racks for a considerable period of time, the cotton and rubber is under a strain at various points which may cause permanent kinks to form. An example of what happens can be seen by hanging a length of garden hose over a nail and leaving it there for some time. A kink will develop at the point of contact with the nail. These kinked places are weakened points which will break through under high water pressure. Frequent changing of the hose folds helps to avoid the strain which causes these permanent kinks. The position of hose on reels or racks should be changed at regular intervals.

The sudden pressure built up by shutting off nozzles too abruptly is another way that fire hose is damaged. Rubber hose, carried on reels attached to the apparatus, should be given special care when it is being placed on the reel. Pulling on the hose while it is being wound on the reel will stretch the hose and decrease the size of the waterway to such a point that sometimes the water will not flow through in any appreciable amount. This hose should be placed on the reel loosely but not sloppily. When it is difficult to obtain water through the booster reel hose, the entire amount should be removed from the reel at once.

Heat Injury - The lining of fire hose is made of a pure rubber which, in its natural state, has about the same consistency as putty. When rubber lined hose is subjected to excessive heat vulcanization of the rubber may result which hardens and toughens the rubber.

Damage is occasionally done to hose by dragging it over burning embers and cinders during operations at fires. When this happens the jacket is damaged at points and the lining usually remains uninjured. Heated oils, greases, and water encountered in fire fighting may produce the same effect on the lining of the hose and would hasten the vulcanization process.

One of the common causes of hose becoming vulcanized by heat is storing it near steam pipes or radiators. Although the hose may not actually be in contact with the radiator, it may be near enough to absorb a great deal of the heat radiated by the pipe. As a consequence, portions of the lining of the hose become hardened and crack when used, resulting in a leaking hose. Care must also be used in regulating the temperature of the storerooms or drying towers so that hose will not be subjected to excessive temperatures.

Mildew and Mold Injury - Mildew, mold, and other forms of fungus growth appearing on the hose are caused by improper drying processes. Fungus growth of all kinds thrive where it is warm and moist. This fungus growth breaks down the fibers and weakens the jacket. Care should be observed, except in emergencies, to make sure that the hose loaded on trucks is thoroughly dry. Hose should not be coiled for storage when wet and should not be stored in a damp place.

Injury by Freezing - A common cause of hose injury during the winter months is handling it when it is in

a frozen condition. Such hose should be picked up with great care since the frozen fibers are apt to break.

Removing hose from the street when frozen is an exceedingly difficult task; see Figure 4. No attempt should be made to pull the hose out of the ice. Instead, the ice should be chopped with an axe to free, both the ice and the hose, using care not to cut the hose. Any ice attached to the hose should be permitted to remain there. The hose should be placed in the truck in a manner requiring the least bending.

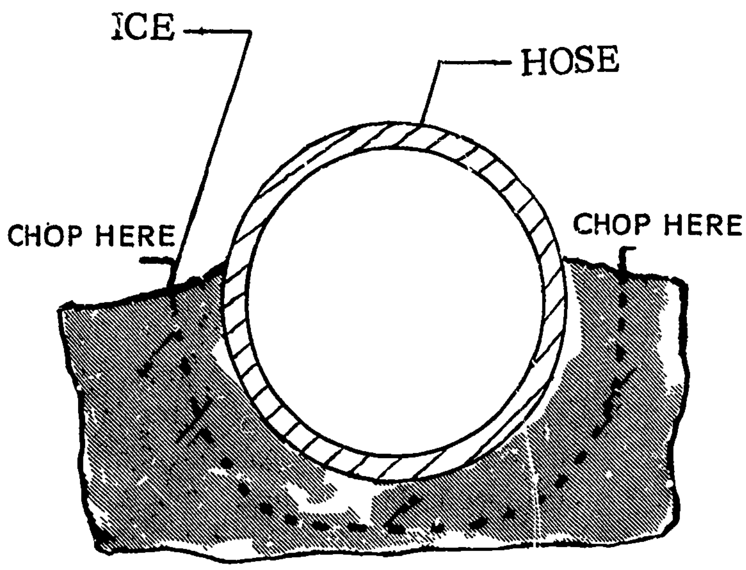


Fig. 4 - Removing Hose From Frozen Street

It is not hard to imagine the serious damage that would result from trying to put frozen hose into a truck in the position it normally occupies. Not only would it be practically impossible but there is a good chance that such an attempt would make the hose entirely unserviceable. A good rule to follow is to handle frozen hose as little as possible and get it into the fire station to let it thaw out so it can be given the proper care.

Chemical Damage - It is hard to guard against damage by chemicals. For example, if there is a large amount of water flowing out of a building where the department is operating, it is not always possible to know if the water contains chemicals. The result is that the hose is frequently discolored through exposure to chemicals without the department knowing this occurred.

While it may be impossible to protect hose inside a building from water charged with chemicals, some precautions can be used to eliminate this hazard on the outside. In most instances, water flowing out of a building will run along the curb. If hose lines are laid parallel to the curb, they should be laid far enough away from the curb so that the water will flow between the hose and the curb, thus reducing the damage from chemicals.

Gasoline has been found responsible for a large amount of damage to fire hose because it is a solvent for rubber. If the least bit of gasoline gets on the hose jacket, it works its way through and dissolves the cement which holds the lining to the jacket and the lining soon becomes loose. When this hose is used again, the lining may be forced down in one end of the hose and cause a partial or full stoppage of water flow. Not only does gasoline dissolve the cement in the hose and permit separation of the jacket and lining, but it will also act directly on the rubber lining and cause its rapid deterioration.

Depending upon their composition and fluidity, oils and greases have varying effects on fire hose. Thin oils and greases which easily go through the jacket do more serious damage than the thicker oils and greases which are inclined to stay on the outside. Almost any oil that soaks through and comes into contact with the rubber lining tends to destroy it. Once it penetrates the jacket and reaches the lining, it remains there and continues its damaging work. If there is evidence of oil or grease on hose after returning to the station, it should be thoroughly scrubbed with a stiff brush and warm (not hot) water. This will prevent it from working into the lining.

Paints tend to destroy fire hose because of their oil content. The same care should be exercised in keeping fire hose away from paint as in keeping it away from greases and oils. Also, the practice of using metal polish on hose couplings should be discontinued for the same reasons described above pertaining to greases and oils.

It is surprising to note the number of cases in which paint has damaged fire hose. For example, a fire department sent a section of hose back to the manufacturer, claiming that the lining had separated from the jacket along one side. A chemical examination was not required to uncover the source of the trouble because the outside of the hose, over its entire length, was painted with a white strip. An inquiry revealed that this strip had been painted to identify the hose at fires so that each company, when picking up, would get its own hose. The idea of hose identification by this department was excellent, but the oil in the paint soaked through, dissolved the cement, and separated the lining from the jacket. Therefore, never use an oil base paint in any

form for marking fire hose. If it is necessary to mark the hose, stencil it with indelible ink using only enough ink on the brush to color the surface of the jacket.

Where lines of hose are used in paint or varnish plant fires, damage from greases and oils may not be entirely avoidable. Care should be taken against letting the hose rest in paint or grease or similar materials unless absolutely necessary.

Even weak solutions of acids will cause extreme damage to fire hose. Those who have had experience in working around storage batteries have found how quickly a drop of the solution from the battery will make a hole through a garment. This gives an idea of how serious it is to get acid on fire hose even though in a very diluted form. Some acids brown the hose jacket instantly, while others cause the fiber in the jacket to take on a powdered form. It is sometimes not possible to visually determine which acid has injured the hose, but there should be no question as to whether or not it is acid that has caused the damage.

Where there is a suspicion that hose has been subjected to acid, this should be noted in the records and the hose taken out of service until the damage can be determined. It is essential that the hose be washed thoroughly after exposure to acid or acid fumes.

In fighting large fires, hose lines at times come in contact with the flame and a scorched jacket is the result. Scorched fibers lose their strength and the hose is unfit for use. A scorch cannot be removed from a piece of hose; the only remedy is to cut off the scorched piece and, if practical, relocate the coupling on the remaining good portion.

CARE OF HOSE WHEN NOT IN USE

The care of hose when it is not in use is of great importance. Both the hose stored in the station and the hose on the apparatus demand care.

If the hose is permitted to remain in any set position for any extensive length of time, it will eventually harden in this position and crack when straightened. This hardening can be prevented to a certain extent. If the lining of the hose could be continually in contact with water while the outside or jacket was continually dry, the ideal set-up for storing hose would be achieved. But, since this is not possible, the best that can be done is to flush out the hose occasionally and thoroughly dry the jacket afterward. Another situation which arises in the storage of hose at the station and in the apparatus hose bed is the formation of "bends." If the hose is folded sharply, the rubber lining at the point where the bend is made is under great stress. If permitted to remain in this position for a long time, the rubber eventually loses its elasticity. When straightening out the hose, the rubber may not respond to its original shape but, instead, may be in a lifeless condition. The only way to eliminate this condition is to rearrange the hose so it will not remain in one position for an extended period of time. This applies to hose on the apparatus and in storage. Care should be taken that the bends are at different points when placing it on a drying rack.

Washing and Drying - All dirt should be thoroughly brushed off each time the hose has been in use at fires or has been subjected to a test. Should it be impossible to remove the dirt by brushing, the hose should be scrubbed with plain water. If hose has been exposed to oil or other materials of this nature, it may be cleaned by washing with soap or a mild, alkali solution and rinsed thoroughly. The hose should then be hung in a hose tower which is provided at some fire stations. Where towers are not available, drying racks or hose dryers are recommended. A rack for drying hose should be 52 feet long, one foot high at the lower end, and at least three feet high at the upper end. In addition, it should be so designed that the hose is supported throughout its length and does not hang in loops. While draining the hose that is in the process of drying, care should be taken in arranging so that the dripping water from an upper section does not come in contact with the jacket of the lower lengths of hose on the rack. Where limited space is available (less than 52 feet) a double-deck type of rack with a half-barrel edge at the upper end of the top deck is recommended. This gives good drainage for a 50 foot section of hose and occupies a space only 27 feet long. See Figures 5 and 6.

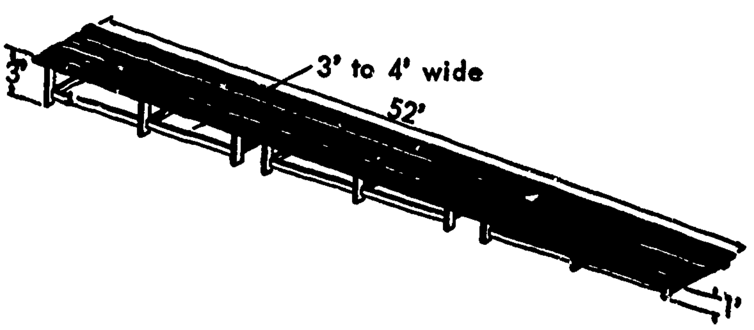


Fig. 5 - Washing and Drying Rack

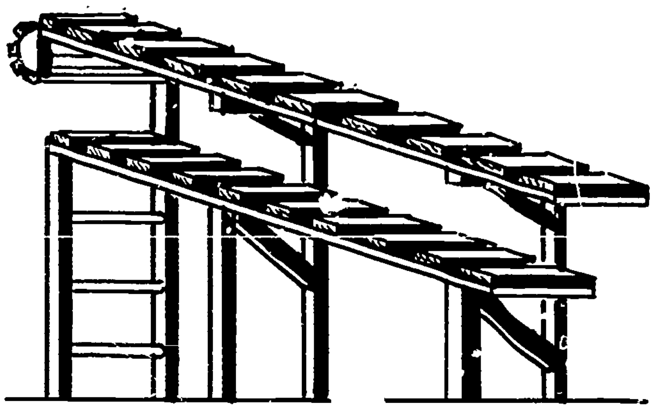


Fig. 6 - Drying Rock

SUMMARY ON CARE OF HOSE

In view of the fact that a large amount of unnecessary damage can be done to fire hose, the following general rules will assist in reducing this loss to a minimum:

1. When laying and picking up hose lines, hose should not be unnecessarily dragged over pavement or rough surfaces.

2. Fire hose should not be exposed to traffic damage any more than necessary.

3. Pump operators can reduce the chafing of hose jackets by the proper setting of the relief valve and the use of chafing blocks.

4. When hoisting hose onto roofs and into windows, use hose rollers, if available. If not available, use all precautions to avoid unnecessary damage.

5. Do not shut off nozzle too abruptly.

6. Avoid unnecessary damage in caring for frozen hose.

7. Hose should be kept out of contact with gasoline, greases, oils, acids, etc., as much as possible.

8. Give hose additional care when not in use, such as checking for mildew and mold, running water through hose, changing hose loads, etc.

9. Rubber-lined, rubber-covered hose used as a booster, chemical, and high pressure hose should be thoroughly washed after use. This hose should be rotated in position on the reel as previously stated.

10. Suction hose should always be kept clean.

11. Care should be taken to make sure that couplings and gaskets are always in good condition.

HOSE COUPLINGS

There have been several different designs of hose couplings used in the fire service but the most commonly used today is the "rocker lug" type. These couplings are constructed of a brass alloy and are so threaded (male and female) that two or more sections can be joined together. Couplings are attached to the hose by expanding a brass ring that forces the hose jacket and lining against the inside of the coupling. The portion of the coupling against which the hose is forced is rough to provide a grip for the hose and to prevent the coupling from being blown or forced off under normal conditions.

CARE OF HOSE COUPLINGS

Couplings should be kept in first class order so that they can easily be screwed together by hand. After the hose is used, the threads should be examined and any injured or defective couplings should be repaired or replaced. Hand-tight couplings with good, live rubber gaskets will not leak under ordinary pressures. All couplings should be maintained to meet this requirement.

Oil or grease should never be used on couplings as either may penetrate into the lining where the hose is connected to the coupling and cause damage to the hose or gaskets. When couplings become hard to turn due to grit and dirt, the washers should be removed from the coupling and dipped in a bucket of warm water in which a small amount of mild detergent is present. Uncoupled couplings should never be dropped or dragged over the street, etc., unless absolutely unavoidable. Care should also be taken to prevent vehicles from passing over them.

The need for a securely fastened coupling to the hose is important, especially when hose is being elevated to upper floors or roofs of buildings by means of a rope. A 50 foot section of dry, 2½" double-jacket nylon or dacron hose and a 50 foot section of dry, 2½" single-jacket cotton hose with forged couplings weigh approximately 38 pounds. The weight of the water inside the hose is approximately 106 pounds. Because of these excessive weights, an elevated, charged line should be supported approximately every 25 feet.

When a double coupling is encountered near the position where the supporting rope is to be attached the rope should be placed in around the hose approximately six inches below the double coupling; see Figure 7. The purpose of this is to relieve the strain or downward pull of the hose from the attached couplings.

STANDARD THREADS FOR HOSE COUPLINGS

Uniformity in fire hose coupling screw threads must be given serious consideration if success is to be attained in Fire Fighting Tactics. This was demonstrated in Baltimore in 1904 when fire apparatus from other cities was powerless to aid because dissimilarity in hose couplings and threads made it impossible to connect their hose to the hydrants in Baltimore. Through the work of a committee of the National Fire Protection Association, a national standard for hose couplings has been established. This committee's recommendation has been approved by the National Board of Fire Underwriters, the Associated Factory Mutual Fire Insurance Companies, the International Association of Fire Chiefs, American Water Works Association, and many other important organizations interested in fire protection. This standard is now in use in the larger part of the United States as a result of the cooperation of fire departments and municipal authorities along with the passage of state laws in converting non-standard couplings to the standards listed under National Standard Couplings.

NATIONAL STANDARD FIRE HOSE COUPLING THREAD

Hose Size	Number of Threads Per Inch
4½"	4
2½"	7½
1½"	9
1"	8
¾"	8

Community fire departments having a mutual aid agreement with another community fire department should test their hose coupling threads against those of the other departments to be absolutely certain that connections can be made to their equipment. Under certain conditions it may be necessary to

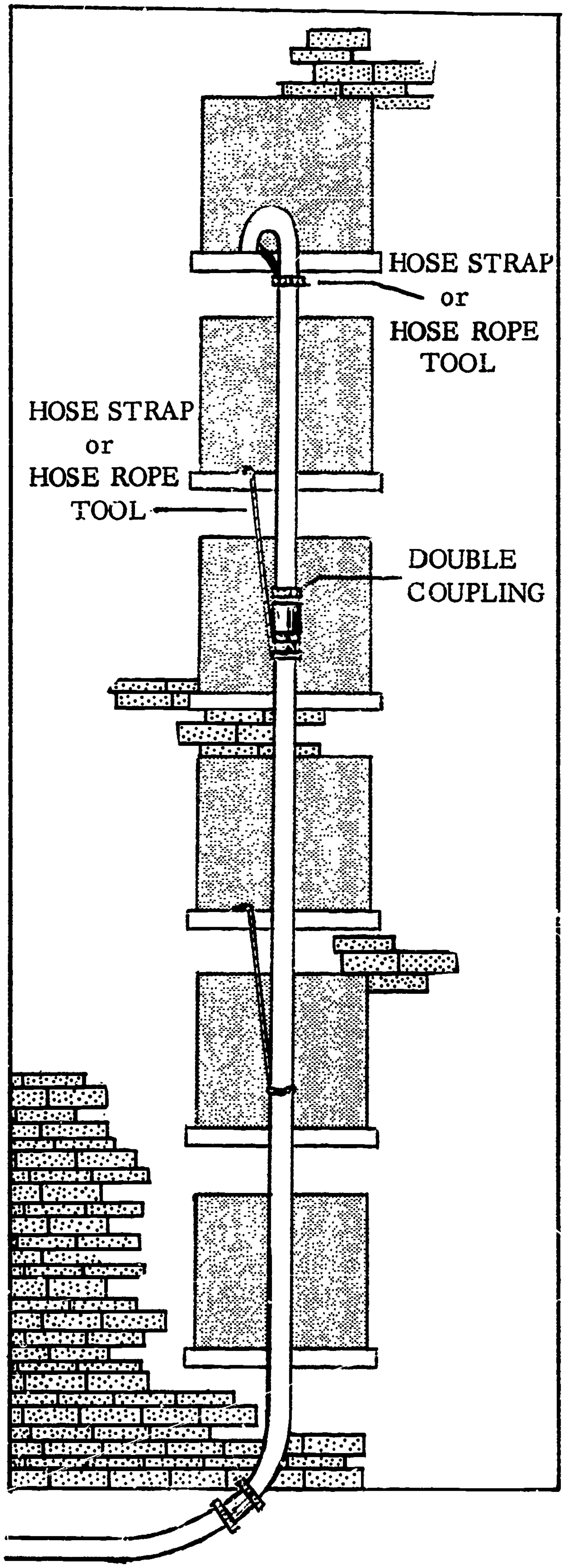


Fig. 7 - Supporting an Elevated Hose

have special adapters made to complete this task rather than to change the entire lot of couplings. This special adapter should be carried on the apparatus.

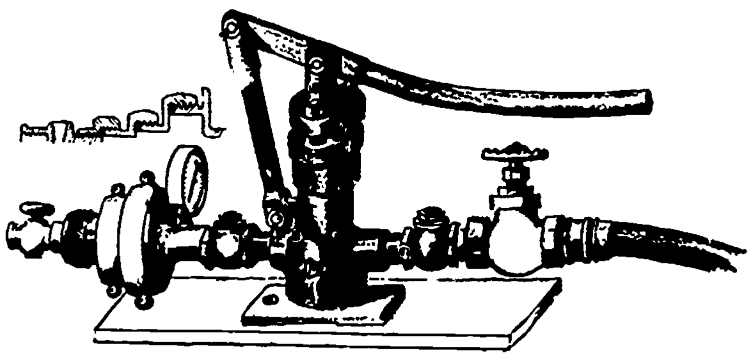
HOSE GASKETS FOR COUPLINGS

Gaskets should be composed of a plastic material or good live rubber. They should be replaced as often as conditions warrant because leaking couplings on hose lines results in additional water loss. In localities where the water supply is limited, the water that would be wasted through defective gaskets might be used to excellent advantage in extinguishing the fire. When gaskets are to be purchased for hose or any other water-distributing tool, the inside and outside dimensions should be specified in addition to the thickness of the gasket. Very often the "raceway" within a female hose coupling differs in size from that of another manufacturer's brand. If the gaskets are allowed to protrude into the waterway, this will reduce the effectiveness of the fire stream. Gaskets should be inspected each time a hose change or hose test is made to insure good connections. A gasket that has become hard and has lost its elasticity should be replaced.

TESTING HOSE

Customary test pressures for new hose are 300 pounds for single jackets and 400 pounds for double jackets. This test should be made with full-length single sections. Hose which bears the Underwriter's label is so constructed that this test will not place undue strain on it or cause it to burst. In regular tests, such as those made annually on all hose in service, test pressures should not exceed 200 pounds unless conditions of service require unusually high working pressures. In cases such as the latter, the test pressure should be about 50 pounds in excess of normal working pressures at fires. Hose used in industrial plants is sufficiently strong if it will stand 150 pounds p.s.i. when normal working pressures are not over 100 pounds. The test may be made with the pumper although a more convenient and reliable method is to hook up each length of hose, one at a time, to a small hand or power pump assembly with which the hose may be quickly tested to any static pressure desired; see Figure 8. This pressure should be held for at least three minutes. When making this hydrostatic test, care should be taken to remove all air from the hose before the desired test pressure is developed. Hose can be tested at any time, but many departments prefer to do this work each spring. Any faulty or defective lengths should be replaced.

Hose to be taken from a truck, hydrant house or reel for testing purposes should be replaced with reliable spare hose in advance so that the required amount of hose will be available and ready for fire fighting purposes.



Courtesy Wooster Brass Division

Fig. 8 - Hose Tester

HOSE LOADS

The basic principle in loading hose in a hose bed is to arrange it so that the hose will pay out smoothly and without kinking. The hose must not be placed in the bed too tightly as this may cause binding. It is necessary to load hose snugly enough that it will not shift and chafe against the sides and bottom of the bed when driving over rough roads or streets. The principle points to consider in loading a hose bed are to get the most hose in the space provided, to have a minimum number of short bends, and to arrange the hose so that it can be removed in a smooth and speedy manner.

The loading of hose on the apparatus is of vital importance. It must be done in such a way that when an emergency occurs and the hose is needed, it may be easily put into operation. No effort will be made to designate the best type of load since this depends largely on local conditions. Water supply, hydrant pressure, and equipment available are some of the items that must be considered. A study of these local conditions will determine the best type of hose load to be used in each community. Hose loads commonly used include the following, each of which features several variations:

A. Horseshoe or U load

B. Accordion load

C. Divided load

D. Combination load

HORSESHOE OR U LOAD

One form of this load is shown in Figure 9 and its end view in Figure 10. It is started at the right front corner of the bed. The hose is laid around the inside of the bed as in Figure 9. Every other fold at the rear of the bed is made about six inches shorter in order to make the bends less sharp and to make paying out easier. The layer is completed in the center. The hose is then carried diagonally over the bends in the left front corner. Making a left-handed bend in this corner, the second layer is started. In finishing the second layer, the diagonal line will be in the right corner and the third layer will begin in the same corner as the first layer. The principal objections to this load are: In bringing the hose over the top of all the bends in order to start the next layer, raised places are made in the front corners and the hose is often crushed between the layers. It is not adaptable for a shoulder load carry.

Another form of the horseshoe or U load is shown in Figures 11 and the end view in Figure 12. It is started in the right corner of the bed as indicated. The hose is laid around the inside of the bed and alternate rear folds are made shorter as in the load previously described. The rear bends on the right half of the bed should be about two inches shorter than those on the left. The end of the first layer of hose, which terminates at the center of the hose bed, is brought around the ends of the right half of the hose load and tucked between the hose and the right side of the bed. This hose is raised gradually until it reaches the right front corner. Here the second layer is started by following the inside of the bed. On this layer the rear hose bends on the left half of the bed are made shorter to allow bringing the end of the second layer of hose around these ends to start the third layer. A disadvantage of this load is that a twist may form at the rear corner when beginning to pay out another layer. This hose load, like

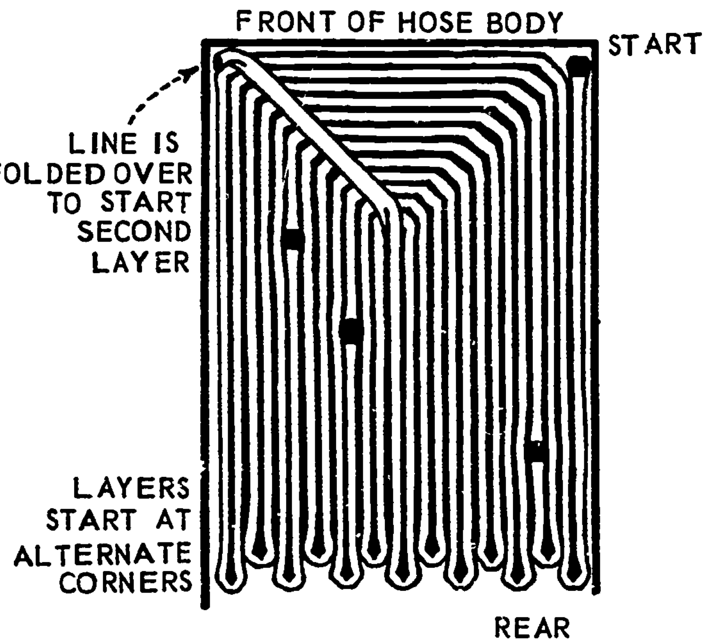


Fig. 9 - Horseshoe Load

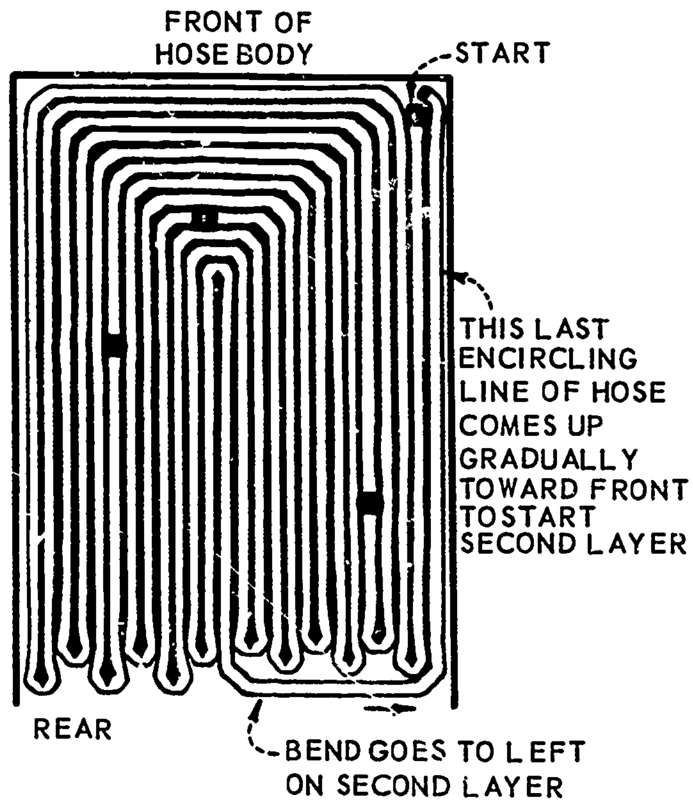


Fig. 11 - Horseshoe Load (2nd Method)

Fig. 10 - End View of Horseshoe Load

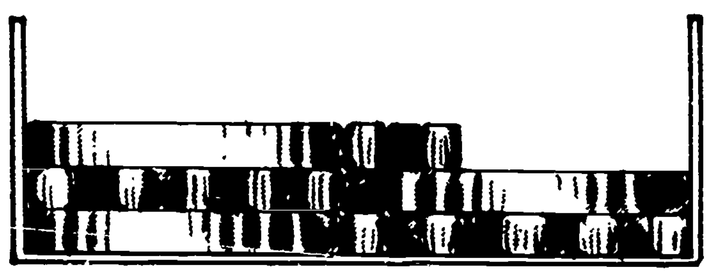


Fig. 12 - End View of Horseshoe Load

other horseshoe loads, is not adaptable to the shoulder hose carry.

ACCORDION LOAD

The accordion load is rather simple to place in the hose bed and is used in many departments. However, all of the bends are sharp and tend to cramp the rubber lining. This load is started with either coupling (determined by local application) in the right front corner of the bed and the hose is folded back and forth from right to left as shown in Figure 13. Every other bend at each end of the hose bed is made about six inches shorter than the preceding one so that the bends will be less sharp and pay out easier. When completing the layer at the left side of the bed, the last length is gradually raised from front to rear until it is on top of the first layer. As each fold is completed, the remaining width of the hose bed decreases; therefore, when this width has decreased to such an amount that a double-coupling cannot turn freely when it is being unloaded by means of a straight pull, a reverse bend should be made. Figure 13 emphasizes the placement of the double coupling to the rear of the reverse bend. The purpose of this is to best utilize the space available and to allow the hose to pay freely from the hose bed. This practice may also be followed at other couplings to prevent two couplings in different layers from coming in contact with each other. Also, the position of couplings in the same layer should be staggered to permit a better hose load.

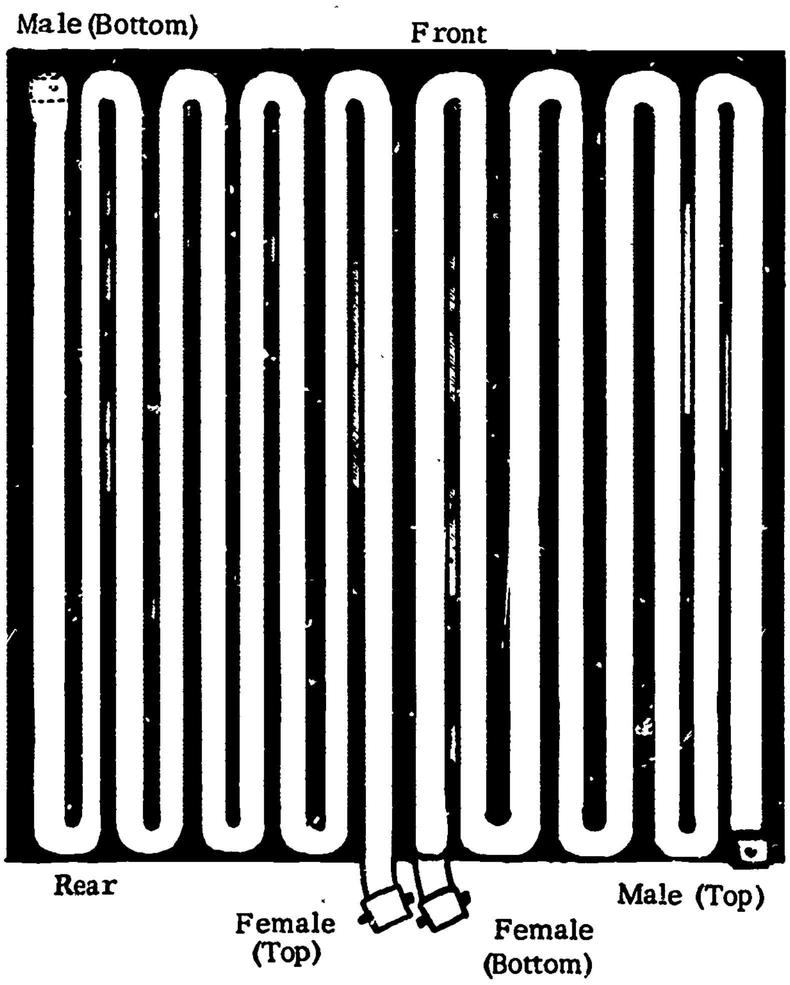
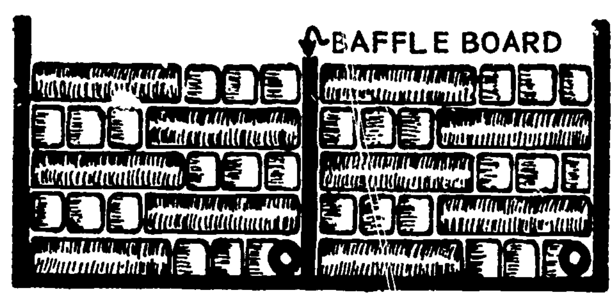


Fig. 13 - Accordion Load

DIVIDED LOAD

Figure 14 illustrates the method to follow in loading the divided load with a baffle board to divide the load. The objective of this load is to allow departments to lay two lines of hose at one time. This is important in high value districts where short lines and heavy streams are likely to be required. The arrangement of this hose load is prepared as shown in Figure 12 except for the baffle board arrangement and the hose load for the second side; it is started at the inside rear corner. This permits the double load to be connected if a long line is needed.

Where hydrants are numerous, another advantage of the divided hose load is that it makes it possible to carry one side loaded to lead off with the female coupling for a hydrant to fire lay and the other half loaded to lead off with the nozzle for a fire to hydrant lay. Due to the limited amount of hose carried on each side, it is not considered good practice to use this load where long lines are required.



END VIEW OF BAFFLE BOARD LOAD

Fig. 14 - Divided Load with Baffle Board

COMBINATION LOAD

A great many departments consider it good practice to use a combination load of 2½ inch and 1½ inch hose. The 2½ inch hose should be placed in the bed of the pumper with one of the methods previously described. In one method, the 1½ inch hose is made into two lines pre-connected to outlets at the rear of the pumper; see Figure 15. The 2½ inch hose is laid as a supply line from the discharge of a hydrant to the intake of the pumper.

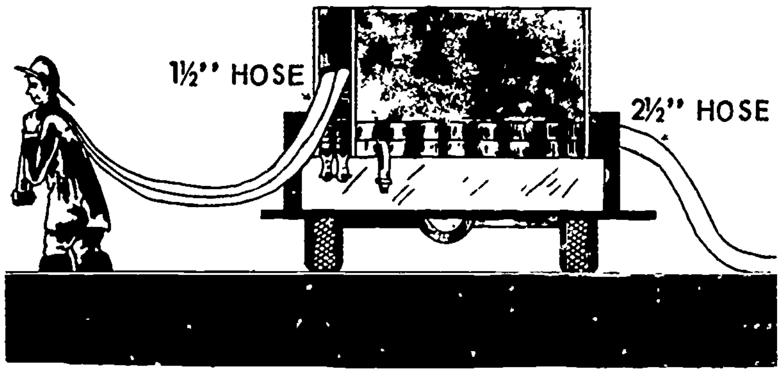


Fig. 15 - Combination Load

SUGGESTED HOSE LOAD FINISHES

Several good methods of hose load finishes will be described and each department can choose the one that is best suited to local conditions. These hose load finishes are:

"DO-NUT" ROLL IN CONNECTION WITH A HOSE LOAD

Some departments prefer to use a do-nut roll in connection with their standard hose load. Figure 16 illustrates the do-nut roll. It is dropped from the bed of the pumper allowing the pumper to proceed forward, paying out additional line.

The purpose of this is to allow the fireman "catching" the hydrant to have sufficient hose to efficiently complete the operation. When placing the do-nut roll on the load, care should be taken to see that the roll does not catch on hose loops or coupling lugs. The roll should also be so made that the pair of couplings will be within the first coil to prevent them from damaging equipment or injuring a man riding on the tailboard of the apparatus when the hydrant man drops off with the roll. It is advisable that any man riding the tailboard get into the pumper aisle or ride the side platform when paying out hose.

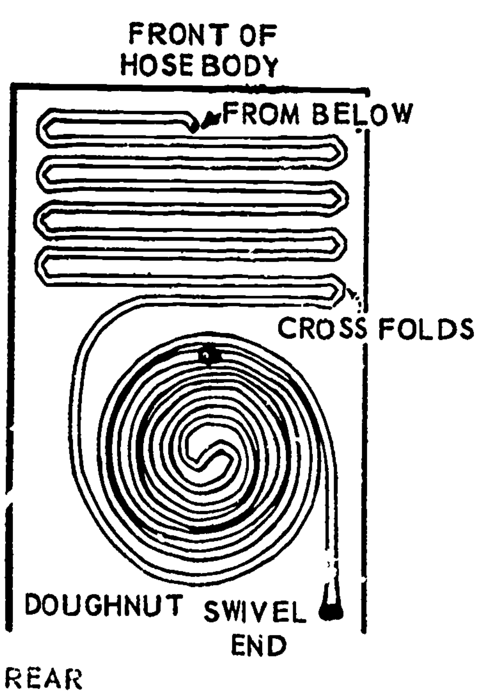


Fig. 16 - Do-Nut Roll with Standard Hose Load

SKID LOAD FINISH

Where hose bodies are loaded for fire to water supply layout, the skid load finish, illustrated in Figure 17, provides an excellent method of having extra hose for the nozzle man. The truck stops at the fire and the skid load is pulled off by grasping the two hand holds provided by the looped hose.

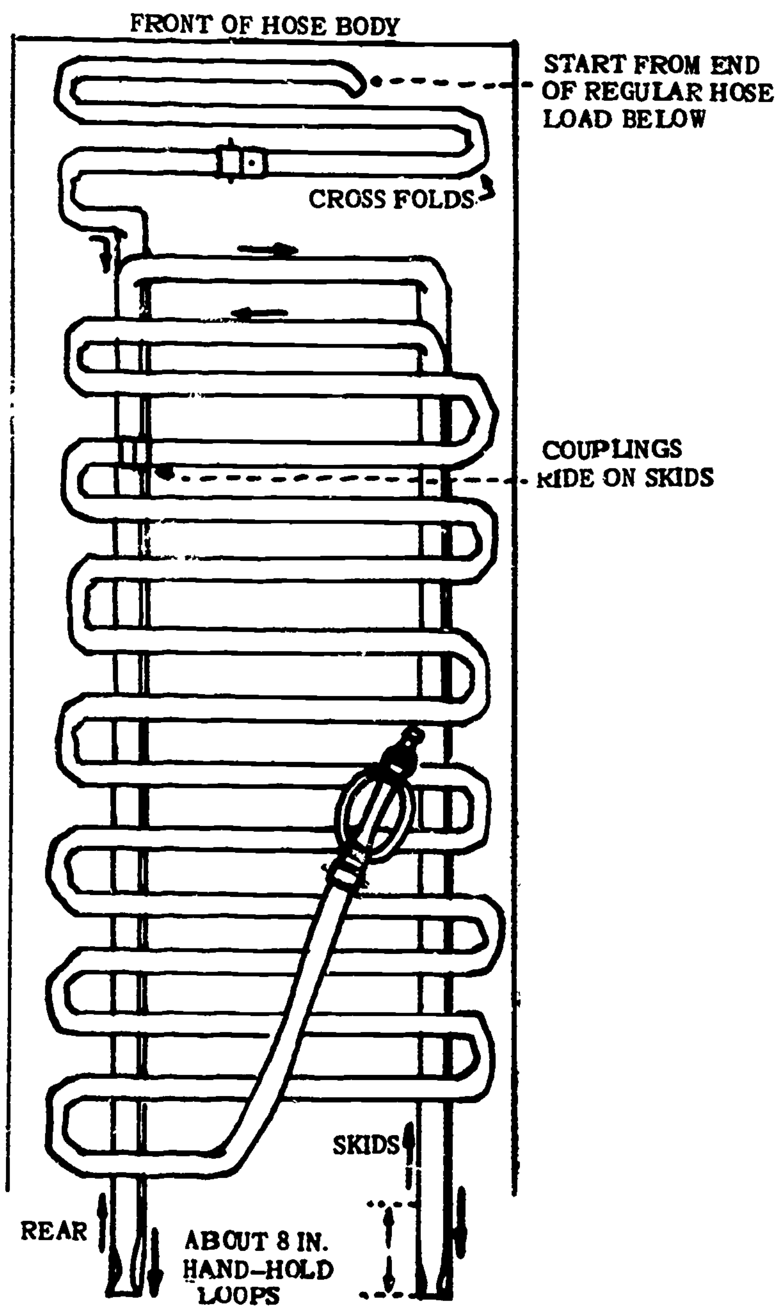


Fig. 17 - Skid Load Finish

After the skid load is dropped off, along with sufficient hose to reach the fire, the pumper proceeds to the hydrant. The weight of the skid load on the ground helps to unload the other hose as the truck proceeds to the hydrant. This procedure eliminates waiting while sufficient hose is pulled off by hand at the fire.

Another advantage of this method is that it simplifies the problem of estimating the amount of hose that may be required. This eliminates guesswork as to whether enough hose has been removed from the apparatus. The skid load, consisting of about 125 feet of hose, is placed on top of the regular load. The layer upon which the skid is placed should be level and free from protruding lugs. The skid load is started a short distance away from the front of the hose bed. First, several crossfolds are made and then a pair of skids are made with the hose. The first skid is formed by laying the hose flat to the rear of the bed. At the rear or open end of the hose body, a loop is made by bending the hose back on itself and giving it a half-turn. This loop, which will provide a hand-hold, should be about eight inches in diameter and overhang the regular hose load. The second skid is made in a similar manner. After the skids have been completed, cross folds are made on them beginning at the rear. There should be plenty of clearance on the skids and couplings should ride on the skids. This will prevent couplings from becoming snagged or damaged when the skid load is pulled off the pumper. The nozzle should be placed well back and on top of the cross folds of the skid load.

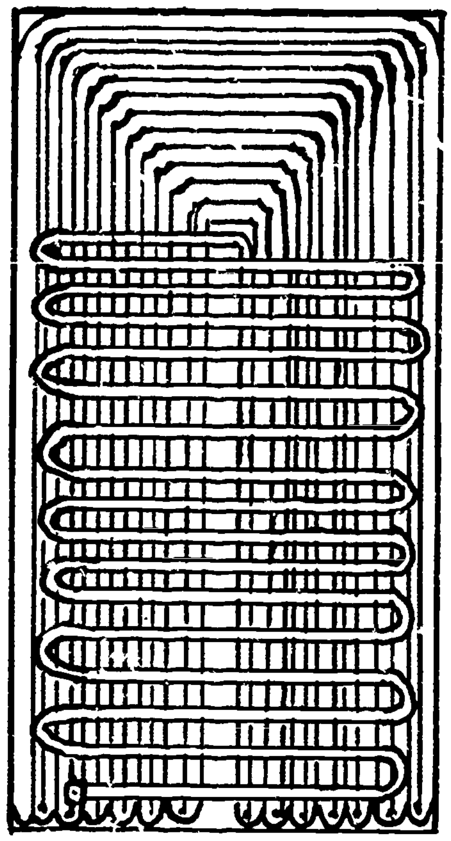


Fig. 18 - Cross Fold Finish

CROSS FOLD FINISH

Where the horseshoe or U load is laid in tight, difficulty is sometimes encountered in starting to unload due to friction. In order to have sufficient hose to make the hydrant connection, the cross fold load finish is used. These cross folds lie loosely enough to pay out easily and thus give the hydrant man enough time and sufficient hose to secure the hose around the hydrant; see Figure 18.

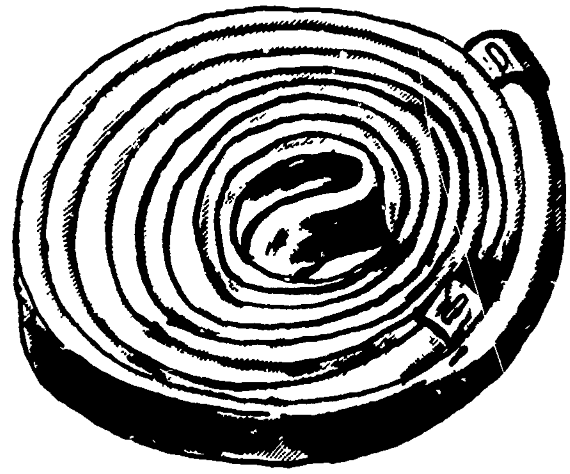


Fig. 19 - Do-Nut Roll

"DO-NUT ROLL"

This is a single section of fire hose rolled double to the shape of a round doughnut; see Figure 19. It is very useful for replacing a burst section of hose, to attach an additional section of hose to the coupling nearest the fire in order to lengthen it or to connect the discharge of a pumper to the intake of a sprinkler system or standpipe intake when one 50 foot section will suffice. One or more do-nut rolls should be carried in a compartment or some other accessible place. Make sure it is securely fastened wherever it is stored.

In making the do-nut roll with one man, the section of hose is stretched on the ground and the man straddles it six feet past center, or approximately 10 paces toward the female end. Facing the female end, he grasps the hose, making a small loop and fold-over on the hose. The hose is then rolled toward the

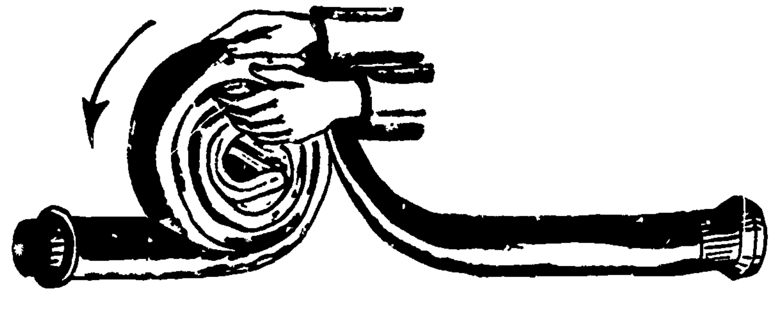


Fig. 20 - One Man Roll

male coupling; see Figure 20. This method will protect the threads on the male coupling because the male threads will not be dragged along the ground.

To make the do-nut roll with two men, place a section of hose flat on the ground. Then place the male end over the top of the hose about four feet short of the swivel end. One man then rolls the loop end while another man guides the slack hose. A hand hold should be left at the center of the roll for carrying. Facing the male end, the man rolling the loop grasps the hose, and makes a small loop and fold-over on the hose. The hose is then rolled toward the two couplings as shown in Figure 21.

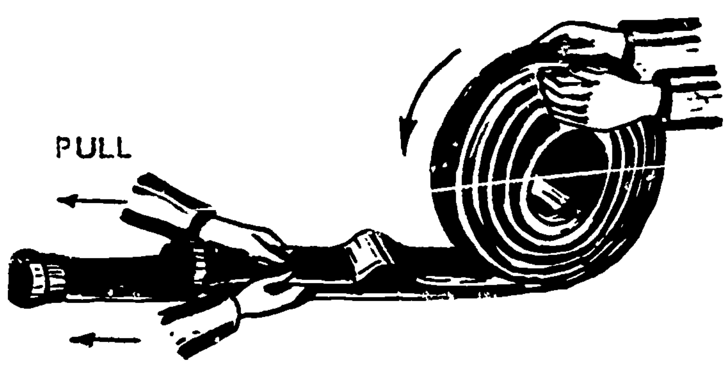


Fig. 21 - Two Man Roll

One method used to unroll a do-nut roll is for one man to grasp the male end of the hose while another man grasps the female end and then each walks in an opposite direction. In most instances, the man with the male end would go toward the nozzle while the other man would go in the opposite direction toward the pumper.

To carry a do-nut roll with the hands, the roll is placed on edge with couplings toward the rear for safety precautions. The hand is placed in the center opening and the roll is lifted up and pressed against the body with the forearm. Some departments provide a leather harness for carrying a do-nut roll on a man's back. This allows both hands to be free for climbing ladders or opening doors. Other departments use a strap to prevent the roll from opening while being carried. The roll is strapped from the center to the outer edge near the coupling.

If neither strap nor harness is available, a rope hose tool provides a convenient way to carry the do-nut roll and leave the hands free. This is used by passing the loop of the rope hose tool through the center of the roll, carrying the hook over the outside down to the center and catching the rope loop. The two large rope loops thus formed can be slipped over the shoulder.

HANDLING HOSE LINES

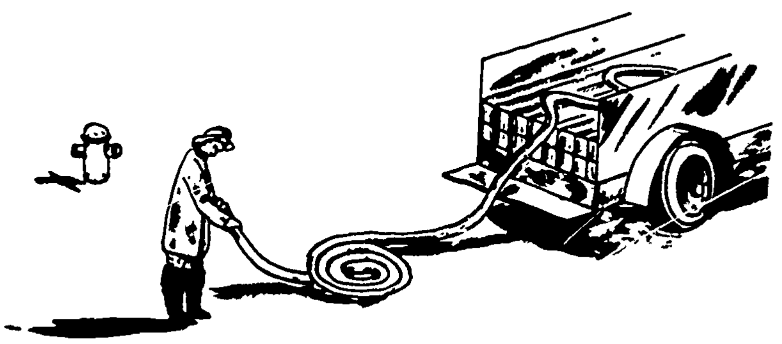
For efficient and successful fire fighting it is necessary that the handling of hose lines be uniform throughout the department.

HANDLING UNCHARGED HOSE LINES

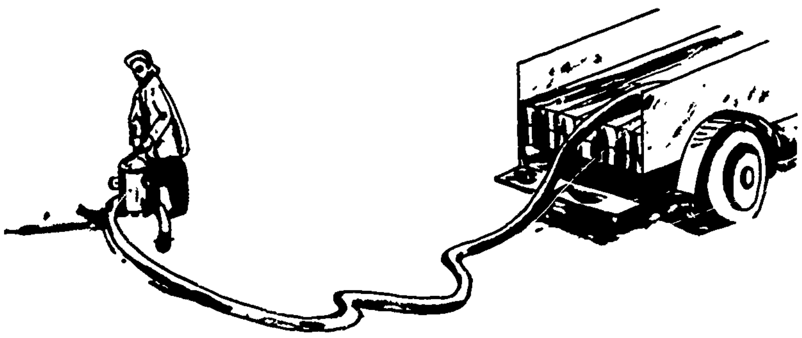
Catching the Hydrant - While this is a simple operation, there are some points and safety hints that are worthy of consideration. When a hydrant is to be caught, the driver should swing the apparatus close to the curb beside the hydrant and *stop* to allow the man catching the hydrant to step off the rear step of the truck without danger of losing his footing and causing injury to himself. The fireman should grasp the hose with the hand farthest from the hydrant; that is, if the hydrant is on his left, he should hold the hose with his right hand. Handling the hose in this manner allows the operator to proceed from the truck to the hydrant without having the hose in front of his knees. When the apparatus has stopped, the fireman steps off of the apparatus and, with ample hose, proceeds directly to the hydrant. He then makes a loop around the hydrant with the hose, places his foot on the hose close to the coupling, and holds it there until he is ready to make the connection; see Figure 22.

Fig. 22 - Catching the Hydrant

When ready to make the connection the hydrant cap is loosened with the hydrant wrench and then is placed on the operating nut on top of the hydrant. The hydrant cap is then taken off, the hose removed from around the hydrant, and the connection made to the outlet. Figures 23a and b illustrate how this is done when using a do-nut roll hose load finish.



23a



23b

Fig. 23 - Using Do-Nut Roll

Fig. 24 - Coupling Hose

Fig. 25 - Coupling Hose (2nd Method)

Coupling Hose - Coupling hose is generally a one-man job. When companies are shorthanded much time can be saved by having one man extend lines or make replacements. The operator stands, somewhat stooped, with his feet spread apart as shown in Figure 24. The hose should never be straddled when it is being coupled together. The female end is brought over the right thigh and the swivel is worked with the right hand while the male end is held in the left hand. When a man is using this method, he will be pushed clear of the hose should it be jerked by accident. Another method of coupling two sections of hose is shown in Figure 25; this method provides freedom of both hands to make the connection.

Putting on the Nozzle - The nozzle may be attached to the hose as shown in Figure 26. Usually, on pavement or dry ground, it is only necessary to step with one foot directly behind the male coupling. This forces the male coupling up so that the nozzle can be attached easily. To attach the nozzle by another method, the coupling is held in the cupped palm of the left hand and the nozzle is firmly grasped in the right hand just above or below the shutoff, according to its weight, and then is screwed on as shown

Fig. 26 - Putting on Nozzle

Fig. 27 - Putting on Nozzle (2nd Method)

in Figure 27. With a little practice this can be done easily and quickly. Where ground conditions are favorable, the threads may be further tightened after attaching the nozzle. This is done by placing the coupling on the ground and putting a foot on the

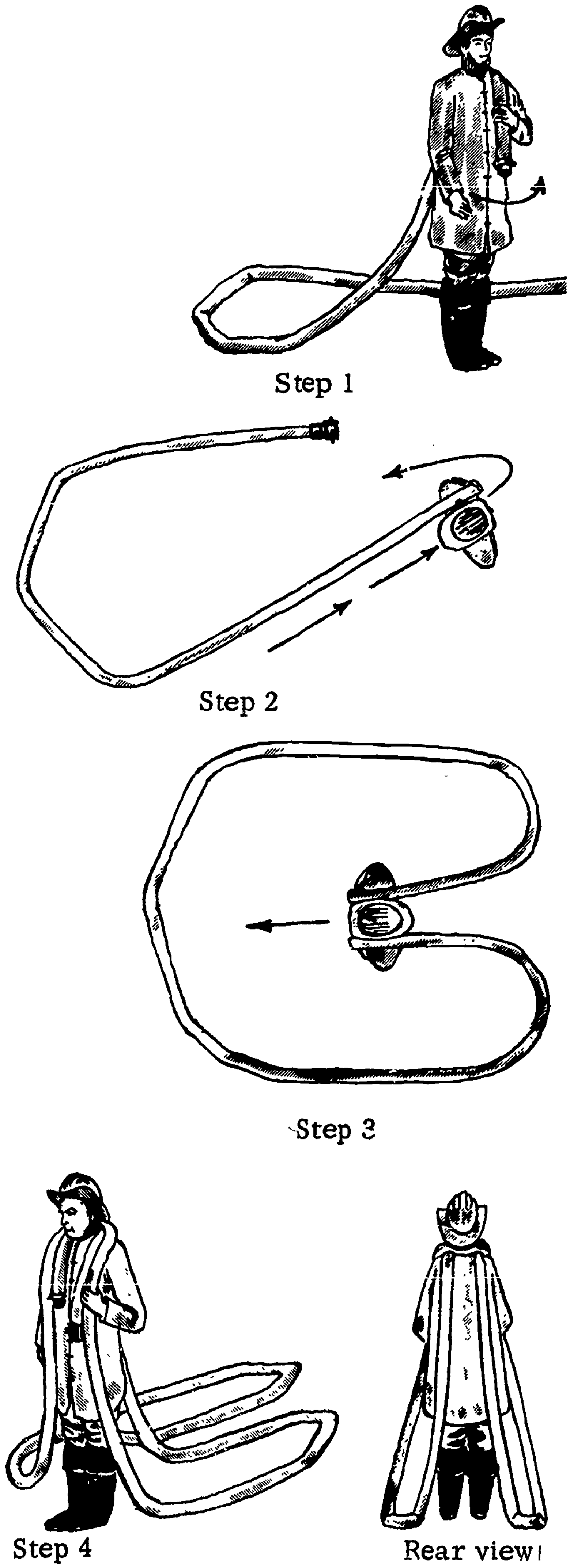


Fig. 28 - One Man Section Hose Carry

hose which forces the coupling to tilt upward so the nozzle can be tightened using both hands. Nozzles must be carefully handled and a check should always be made to make sure that gaskets are in place.

One-Man Section Hose Carry - The four steps shown in Figure 28 illustrate a method by which one man can carry a 50 foot section of hose and have his arms and legs free to walk or climb a ladder. With the hose stretched out at full length, flat on the ground, the man starts at one end by picking up a coupling and bringing it over his inside shoulder so that it hangs down to about the lower part of his chest and somewhat above his waist as illustrated in Step 1. He then walks two steps past the other coupling, turns around as shown in Step 2, and picks it up. With a twist of the wrist he places this end of the hose over the other shoulder. The couplings hang straight down over his shoulders. Caution: The male coupling should hang a little lower than the female coupling so that the male threads will not be damaged in case the couplings strike each other. Holding the hose against his chest, the man walks toward the center loop as shown in Step 3. He then picks up the center loop with both hands, places it back over his head, lets it rest on the back of his neck and shoulders, and continues walking as shown in Step 4. When climbing a ladder the loops hang outside the beams except on aerial ladders with large side rails. To unload the hose, he passes his arms behind the hose, grasps the couplings, swings the arms outward and lowers the couplings to the ground.

Laying Short Lines by Hand Straight-Away - This practice is desirable where short lines, usually not over 300 feet, must be laid by hand. It can be done from any hose bed style of loading hose. When laying hose lines by hand, it is advisable not to drop the hose in the street behind the apparatus. A great deal of time will be lost pulling the hose from the truck into the street. This is due to the fact that when the folds are stretched out, the hose must be picked up and extended to the fire. The procedure suggested in the next paragraph will advance the hose to the point of operation as it comes from the truck.

In Figure 29, if the nozzle *is not* carried attached to the line of the apparatus, the nozzle man, upon stepping from the apparatus, takes the first single coupling in his left hand and a nozzle in his right. He then moves about 20 feet behind the apparatus to be out of the way of the other members of the crew while he attaches the nozzle. Where the hose is loaded to lead off with a female coupling, the nozzle man must use a double male coupling to connect the nozzle to the line. Under these conditions it would be necessary to use a double female coupling to connect the hose to a hydrant or pumper.

The nozzle man slides his shoulder under the hose, places the nozzle on his back, and starts for the fire. The second man takes the hose at the next coupling, places the hose over his shoulder with the coupling in front, and follows the nozzle man as in Figure 29b. The third man repeats the evolution as described for the second man, see Figure 29c. The first three men proceed to the fire walking approximately 25 feet apart. The loops of hose will provide needed line at the point of operation. The fourth and following men also take the hose at couplings but walk 50 feet apart, pulling the hose straight from the apparatus; see Figure 29d.

Laying A Line When Shorthanded - The following procedure is valuable to departments whenever it is necessary to use only one or two men to lay a line of hose. A man who has not had proper training and practice will soon become exhausted by the weight of the hose dragging on the ground. If, however, the line is laid by moving only a part of the hose at a time, it is possible for one man to run out any desired amount of hose in a very short time. The procedure illustrated in Figures 30a thru 30d is very simple and should be carried out as follows:

1. Drag 100 feet of hose from the truck toward the fire.

2. Go back 50 feet and pick up hose at double coupling.

3. Extend this coupling to a point parallel with the head of the line, 100 feet from the truck.

4. Repeat operation b until the desired amount of hose is laid in loops on the street in rear of the apparatus.

5. Step over to adjacent loops of hose and advance them toward the fire, moving 100 feet of hose at a time.

6. The head of the line is extended to the point of operation.

While the illustrations show the firemen dragging the hose from their shoulders, some men prefer to drag hose from their waist. A much greater "drag"

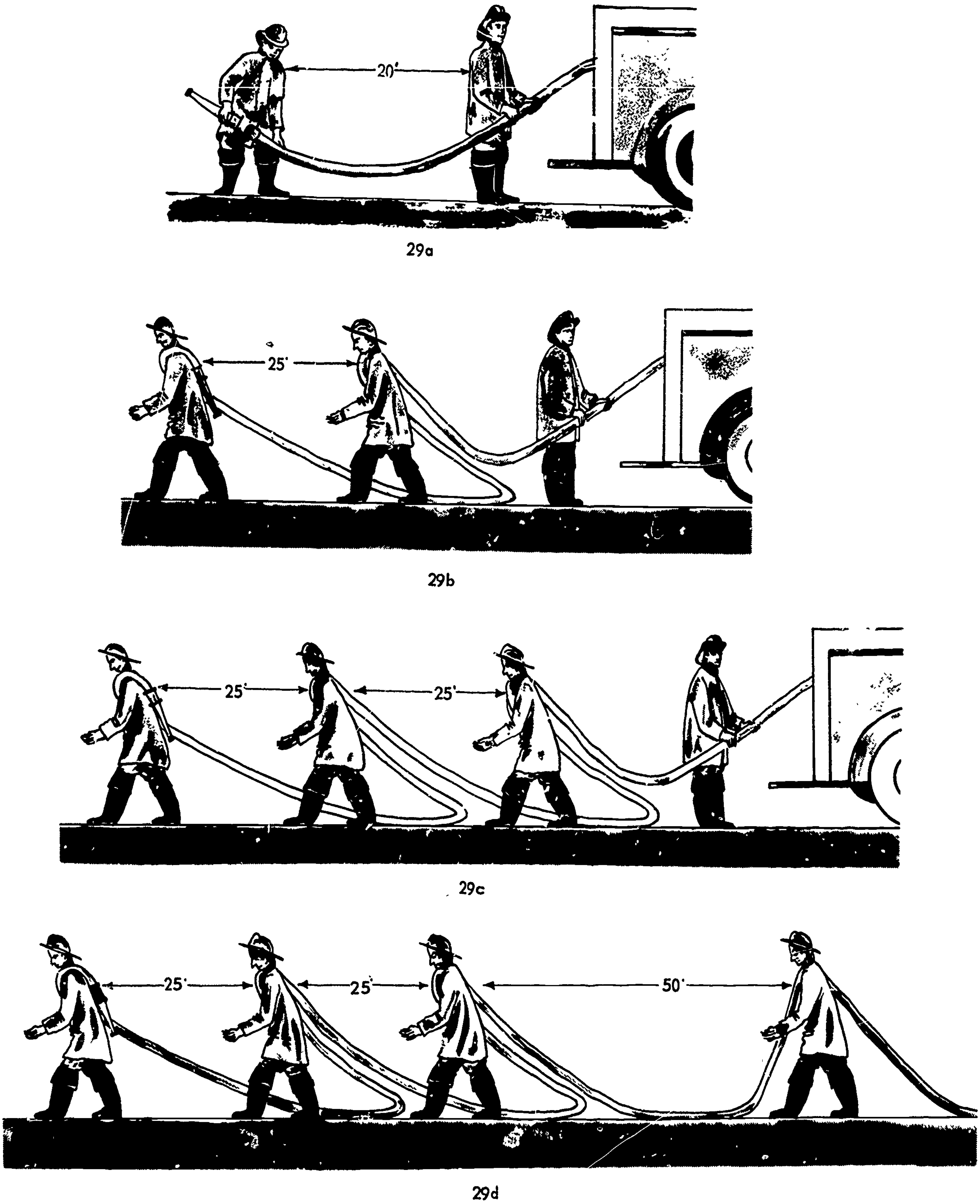
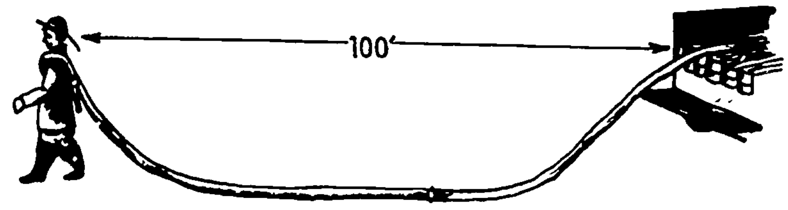
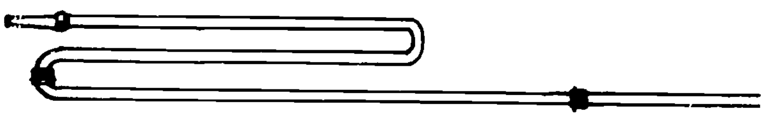


Fig. 29 - Laying Short Lines by Hand

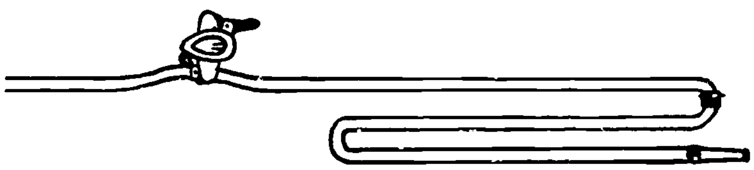


30a

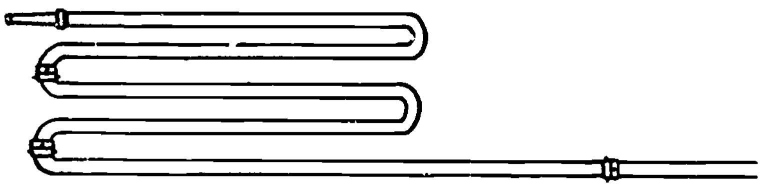
30b



30c



30d



30e

Fig. 30 - Laying Line Shorthanded

can be obtained by using the powerful thigh muscles which also helps to avoid strained backs and sore muscles.

Shoulder Hose Carry - Firemen often take a great deal of punishment in trying to lay a line up a stairway because their department has not adopted a practical method of extending hose lines inside of buildings. When the department is required to take a line up a stairway to the upper stories or roof of a building, dragging the hose by sheer force, the hosemen become too exhausted to fight a fire. Such a condition may be avoided by the use of the shoulder hose carry method. This method, if properly done, puts no undue strain on the hoseman. However, it can only be used if the accordion hose load is used by the department.

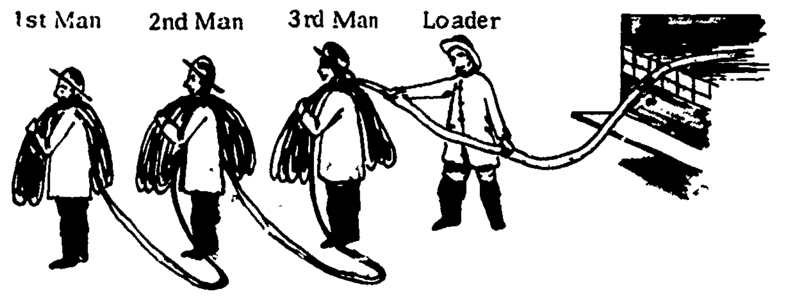
Before proceeding with this evolution, the person in charge shall estimate the amount of hose needed to reach the desired position, plus one fifty foot section for advancing purposes. The amount of hose needed to advance by way of an inside stairway shall be determined by allowing one 50 foot section for each story the hose must be elevated in addition to the number of feet needed from the pumper to the bottom of the stairway unless previous knowledge of the situation requires an alternative amount.

The play pipe with nozzle and tip of proper size is attached to the hose. The "loader" stands on the rear platform to do the loading.

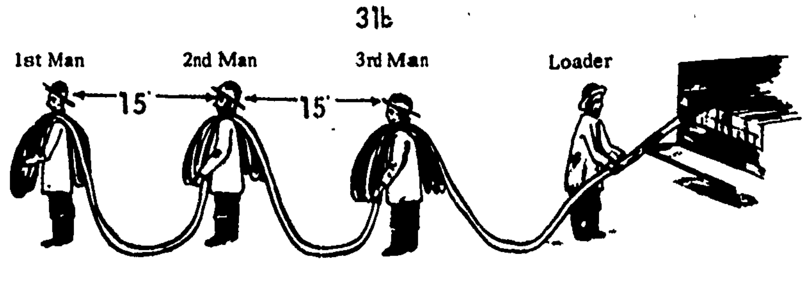
1. The first man to be loaded faces the rear of the pumper and slides the play pipe, with hose attached, over either shoulder, with the play pipe coming to rest high on his back; see Figure 31a. He then turns backward toward the shoulder the hose is resting on until his back is to the rear of the pumper. Now the hose should be in front, across his chest, underneath the opposite arm, and to the rear. The loader then places two loops of hose on the first man's shoulder then drops one loop of hose from the hose bed on the ground and the #1 man steps out two or three paces.

1st Man

31a



31b



31c

Fig. 31 - Shoulder Hose Carry

2. A second man takes a position with his back to the rear of the pumper and near the rear platform. He then places himself in a position to assist the loader in placing three or four loops on the same shoulder as #1 but makes certain that the lead-off hose will be to his rear and on top of the hose resting on his shoulder. The loader again throws out one loop of hose to the ground and instructs both the #1 and #2 man to step out two or three paces. Should there be a double coupling in the hose line between the #1 and #2 man, or any succeeding men, that coupling should be carried in the hand of the nearest man. Otherwise, the rear man shall carry the hose which is on the ground in the hand corresponding to the shoulder carrying the hose. Each succeeding man, as shown in Figure 31b, repeats the evolution as described for the second man, except, in each case, a greater number of hose loops are placed on each man's shoulder. This is done because the latter men have the shortest dist..ce to carry their load. After unloading, each man assists the preceding man with his load.

   An 8 foot hose bed contains approximately 16 feet in each hose loop; therefore, four loops on a shoulder plus one on the ground will equal approximately 80 feet or 1½ sections of hose. Smaller or larger hose beds will vary this situation.

After all the men have been loaded with hose, the loader then secures a sufficient amount of hose to allow him to make connections to a discharge on the pumper and then calls to the other men to proceed to the fire, as shown in Figure 31c.

As the men proceed to the fire, each watches to his rear to observe when all the hose behind him has been removed from the following man's shoulder and laid on the ground, free of kinks or bends. When this has been completed, the next man allows the hose to be pulled from his shoulder, one loop at a time, until his hose is on the ground. Any and all succeeding men assigned to carry hose perform this evolution in the same manner.

When advancing with hose up the stairway, each man carrying the hose must take additional care to avoid any possible damage that may be caused by careless handling of the hose. These procedures demonstrate the value of teamwork among all firemen engaged in this operation.

Advancement of 2½ Inch Hose Up A Ladder - Hose streams operated from ladders are another means of attacking fires in the upper floors of buildings. Getting a line of hose up a ladder is not easy unless the men are thoroughly trained in a practical method of doing the job. Should too many men crowd onto the ladder, a serious accident might result. Before a hose line is taken up a ladder, the ladder must be properly placed at a safe angle and be securely tied-in (see chapter on ladders). Should the ladder be placed too straight and not properly secured, the pullback pressure created by the hose stream may force the ladder away from the building and cause the ladder and men to fall.

When advancing a 2½ inch hose up a ladder, a dry line should be used if at all possible. There are occasions when time and effort would be saved by draining a charged line before advancement is made. This can be done easily with the aid of a hose clamp. Figure 32 shows a practical method for ad-

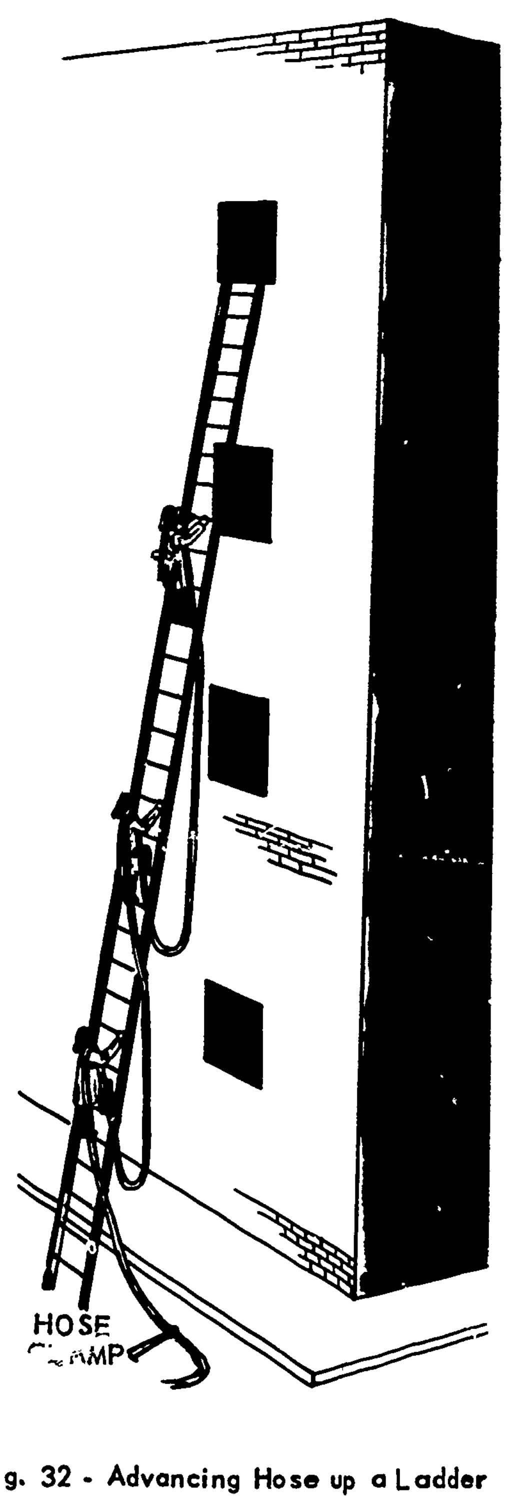


Fig. 32 - Advancing Hose up a Ladder

vancing a dry line up a ladder. The men should climb 10 to 12 feet apart with about 20 to 25 feet of hose between them. Additional hose should be fed to the men on the ladder to assist them in advancing the line. When sufficient hose has been advanced to a position to attack the fire from the ladder, the line should be anchored at the nozzle, preferably to some part of the building, and to the ladder every 25 feet below. The anchor should be made with a rope, hose tool, chain, or strap at a point approximately 6 inches below a coupling, if possible, in order to remove the strain on the coupling connection to the base.

ADVANCING HOSE UP A LADDER

NOTE: The nozzle man places the play pipe over his left shoulder with the hose under his right arm and over his right hip. The hosemen carry the hose on their right shoulder because the hose line is coming from their right. If the hose is coming from the left these positions are reversed.

HANDLING CHARGED LINES

When it is necessary to handle charged lines, the following suggestions will be helpful:

1. When fighting a fire it is advisable to have 50 feet of hose available for advancement purposes before the line is charged with water.
2. When working a line from a ladder, do not start the water in that line until the play pipe is securely strapped in place.
3. When a simple wye, a siamese, or a gated wye is to be inserted in the line, the second line should be prepared before the first line is broken and water should be started again as soon as possible.
4. When opening and closing a shut-off nozzle, it should be done slowly to avoid a surge in the hose line that may cause the hose to break.
5. It is considered good practice to carry the shutoff nozzle in the open position when carrying it on the truck, and it should be closed immediately when attaching it to a hose line. This procedure informs the nozzle man whether or not the shutoff is in proper working order.
6. As an aid in preventing the water in the hose from freezing in cold weather, permit a small flow of water to be discharged from the nozzle to a place where no further water damage will result.

Fire Escape Evolution - Figure 33 illustrates a nine foot pike pole, having a ring attached to the bottom end, which is used for taking hose to the fourth floor with four men.

Fig. 33 - Pike Pole

Hose with play pipe attached should be flaked on the ground at the point of elevation. Use a pike pole hook to pull down the fire escape ladder, keeping your body in the clear so as not to get injured. If no ladder is permanently attached to the fire escape, then use a ladder carried on the truck. The first two men climb the ladder and advance to the third floor; the next man advances to the second floor. The last man remains on the ground for duty at that point.

The first line should be advanced up the end of the fire escape, opposite the stairway if possible, placing the hose at the most supported position of the fire escape as a safety measure.

The man on the ground prepares the hose for advancing. He first hooks the pike pole on the second level of the fire escape. He then places his hose-strap or Rogers rope tool securely around the hose, approximately 3 feet from the play pipe and secures this hose strap or rope tool to the pike pole through the ring. Then the man on the second floor grasps the pike pole with the hose attached and passes it hand under hand to a man on the third floor who grasps the pike pole and advances it until the hose has reached the top of the fire escape railing. See Figure 34a; the hook of the hose strap is then hooked to the top railing of the fire escape. The second man on the third floor fire escape assists at this point by grasping the play pipe and pulling it over the railing. After accomplishing this operation, the other man on the third floor fire escape places the pike pole in a safe place and assists to advance the hose up the fire escape stairway to the fourth floor. See Figure 34b.

All men below the fourth floor continue to advance the hose until they have approximately 50 feet of hose on the third floor level for additional advancing

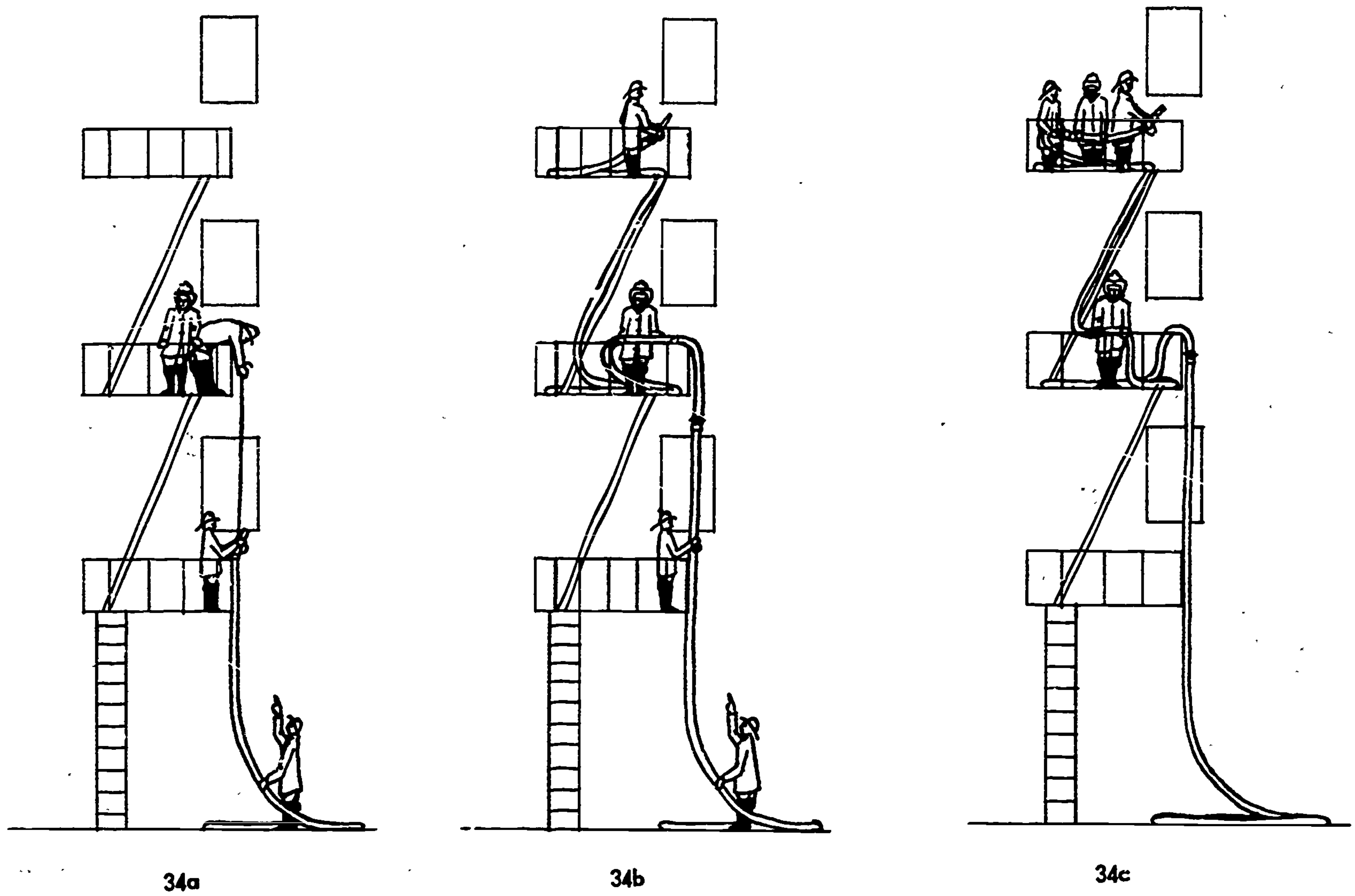


Fig. 34- Advancing Hose up a Fire Escape

purposes. See Figure 34c. At this point the water is ordered to be started in the hose line.

The hose should be supported by strap or rope at the third and fourth floor levels. A man should then remain at each position until the line is fully charged in order to release the elongation and kinks in the hose line at that point. The men should then advance to the nozzle. When the hose is to be advanced, the hose straps involved must be released before this can be accomplished. After the advancement is completed, the hose straps should again be secured.

When draining elevated hose lines, the hose clamp should be placed at the first double coupling on the ground outside the building between this coupling and the nozzle. The pump operator stops the flow of water and releases the pressure at the pumper. The line can now be broken and the water released onto the street by removing the hose clamp.

To lower the hose line, the operations of elevating the hose line are reversed.

Working a Charged Nozzle Through a Ladder at a Window - There are two good ways to control a charged line easily and effectively when working it through a ladder. Both of these necessitate the use of rope hose tools or similar equipment. Care should be taken to make sure that the ladder is ready for climbing. The ladder top can be placed within or above the window. In either case, the man on the ladder will be subjected to a considerable amount of heat. Therefore, it is advisable to pass the nozzle through the ladder at the rung just above the window sill. The large hook frequently found on nozzles is of little use because it is too near the tip and will not safely permit free movement of the nozzle.

1. In the first method, as shown in Figure 35, the line remains uncharged until the set-up is completed. Pull the nozzle and uncharged line through the ladder until a few inches of hose are beyond the rung. Put a loop around the hose starting from the front side of the rung and pull it tight. Take one full turn around the right hand side of the rung, cross over the hose diagonally to the inside of the ladder and the left side of the hose, put one or more turns around the rung, and anchor the hook on the rung above. When the hose expands under

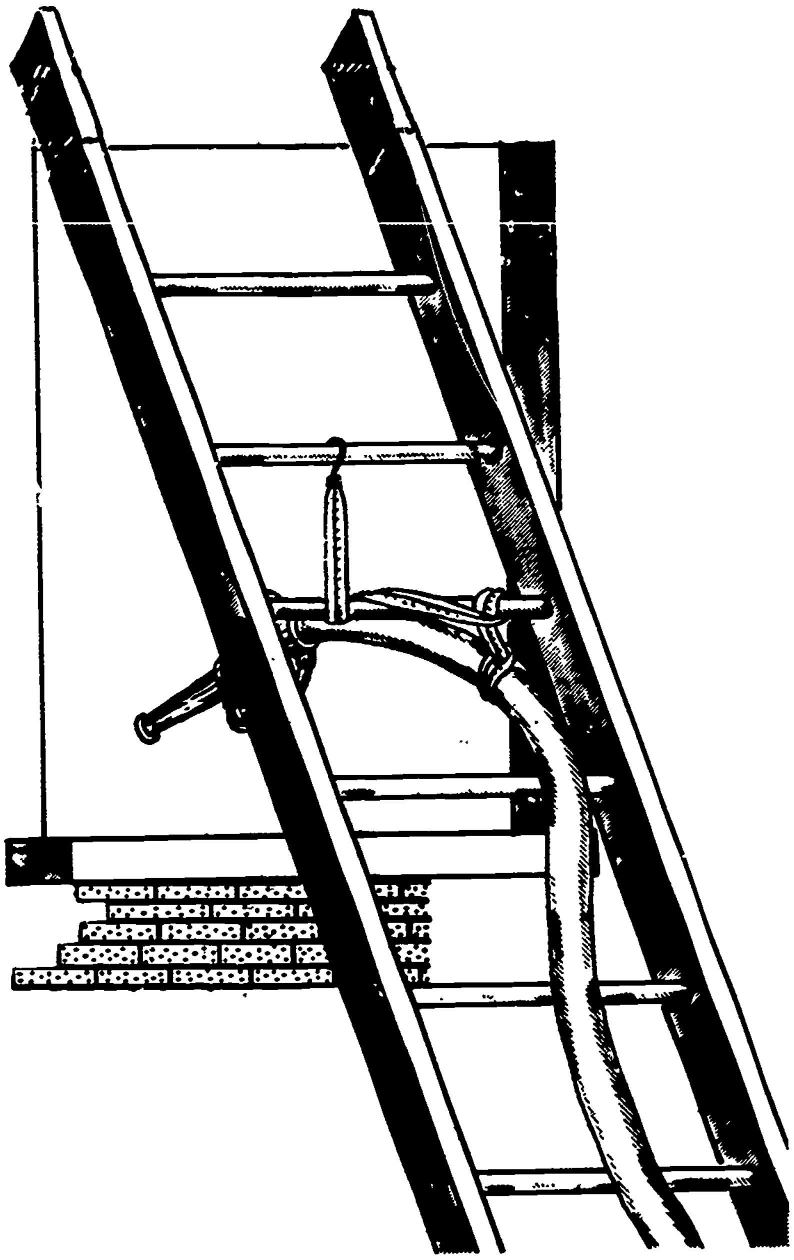


Fig. 35 - Line Set up While Uncharged

pressure, it will be found that the rope will anchor it tight to the ladder rung, permitting a wide range of movement that one man can easily control.

2. In the second method, as shown in Figure 36, the charged line is carried to the desired location on the ladder. A rope hose tool is placed on the hose near the nozzle; the ropes are then wrapped around the rung above and the hook is pulled up and anchored to the second rung above the hose. Another rope hose tool is used 10 to 15 feet from the nozzle. This tool is lifted until a large bow forms in the hose on the side opposite the nozzle. By working the bow in the line, one man can control the movements of the nozzle and still remain out of the heat and smoke emanating from the window.

Replacing A Burst Section of Hose or Extending A Line - Whenever it becomes necessary to replace a burst section of hose or extend a line, that particular line must be shut down for a period of time. This involves the use of a hose clamp and one or more sections of hose. See Figure 37. Every effort should be made to complete this operation in the shortest possible time in order that the line will not be out of service any longer than necessary. It is considered good practice to have the required amount of hose laid in place so that connections can be made quickly. The hose clamp is then applied and the operation is completed. When replacing a burst section of hose, it is sometimes necessary to bring in two dry sections as the original section may be stretched under pressure.

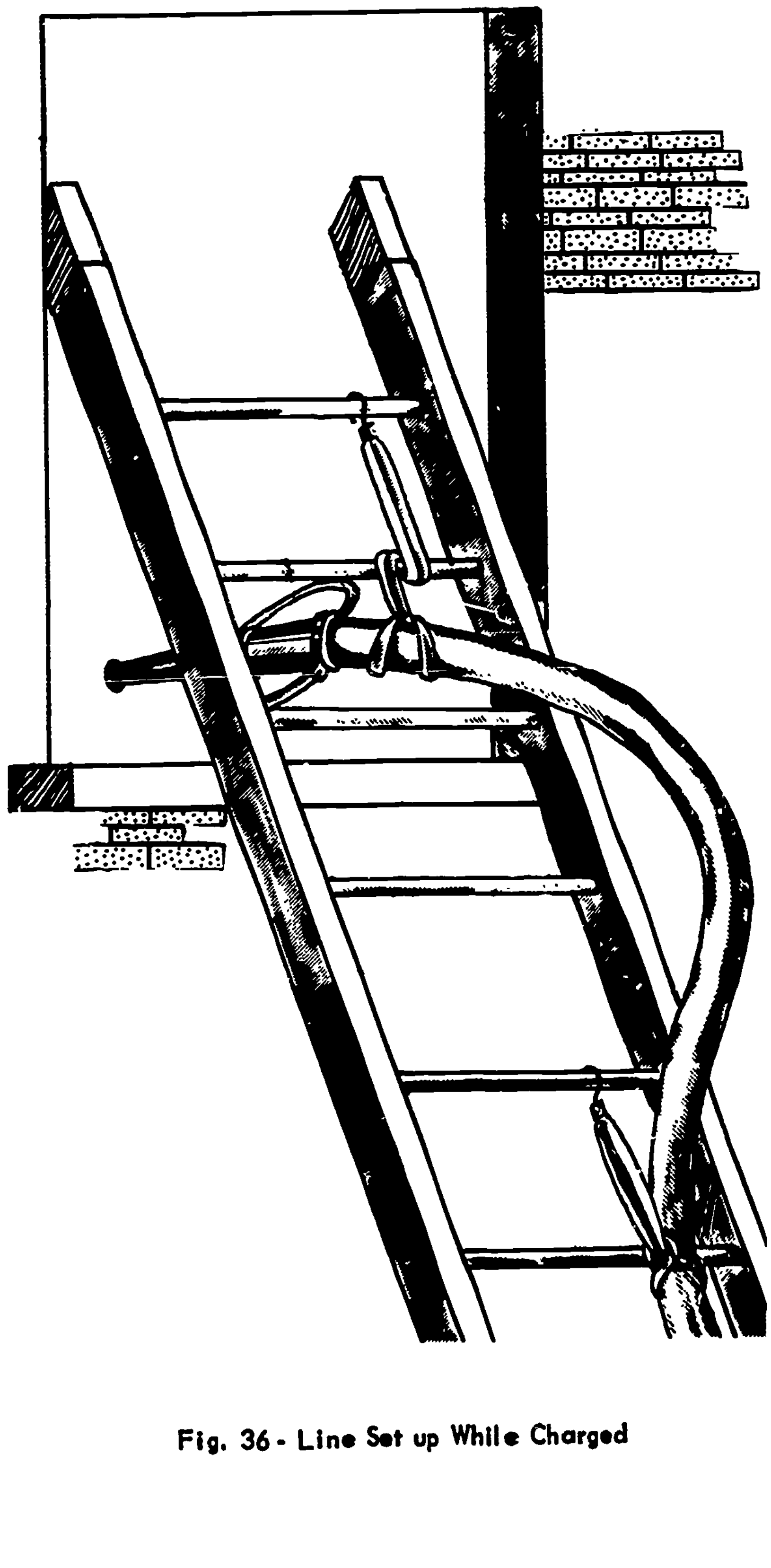


Fig. 36 - Line Set up While Charged

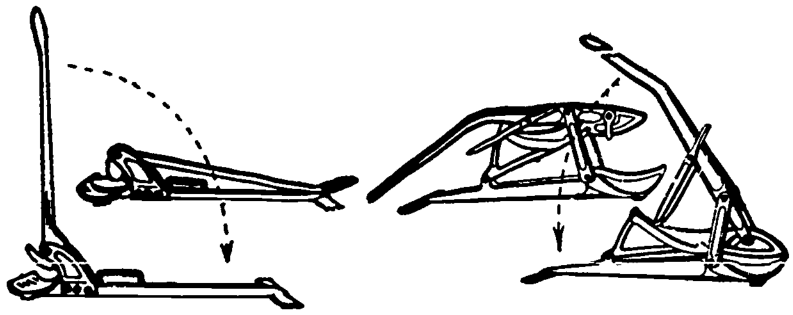


Fig. 37 - Hose Clamps

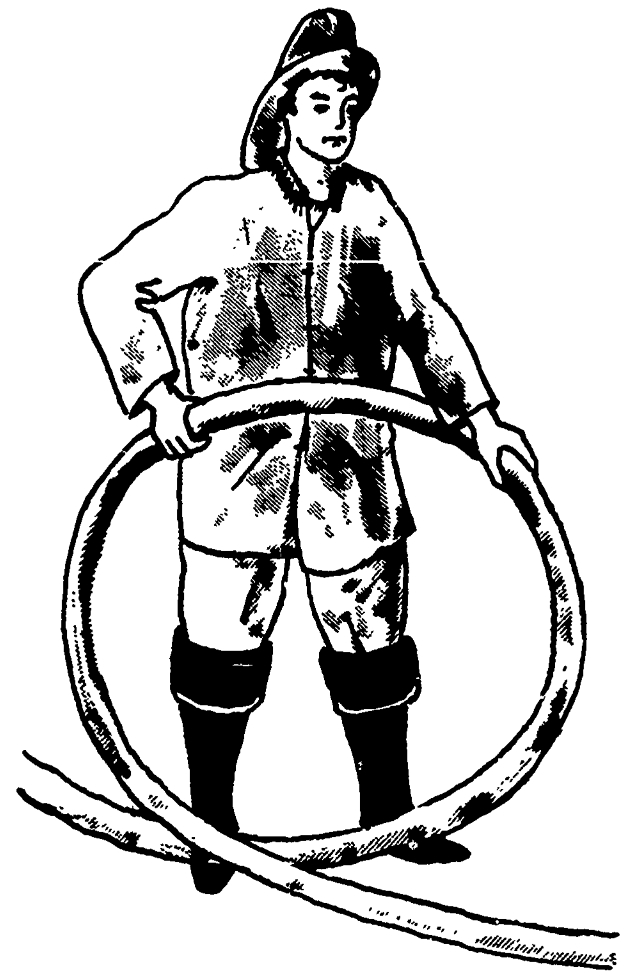


Fig. 38 - Advancing Charged Line

Advancing Charged Line Using the Slack Roll Method - Where some slack or excess hose is near the hydrant or pumper and is needed near the nozzle, it can be rolled forward, like a wheel, by one man. The slack is first crossed on itself; then the resulting loop is lifted to a vertical position and rolled forward as shown in Figure 38.

Keenan Hose Loop - The advantage of this loop is that it will permit one fireman to control a hose stream operating under substantial pressure which otherwise would require several men to do the job. The importance of this loop may be appreciated by visualizing a situation in which a crew of two or three men arrive at a major fire that is threatening exposed property on several sides. The need for powerful streams is evident but only enough men are available at the start to provide one man for each stream needed. Each man, using this method, can control a line of hose. When the line has been brought to the desired point, the fireman makes a loop with the hose as shown in Figure 39. Additional ease of control and safety may be secured by lashing the crossover with rope if the operation is to be of considerable duration. The fireman then sits on the line and calls for water. The pump or hydrant operator should always be careful not to turn water into the line too suddenly.

HOISTING LINES

HOISTING CHARGED LINES

The charged hose line illustrated in Figure 40 should always be raised with the hoisting rope attached to the hose below the nozzle coupling. This will put all of the strain on the hose and not on the coupling. This placement of the rope will also help to make a better "break over" of the nozzle and keep it from being scraped over the hose roller or cornice. The nozzle shutoff should be securely tied so that

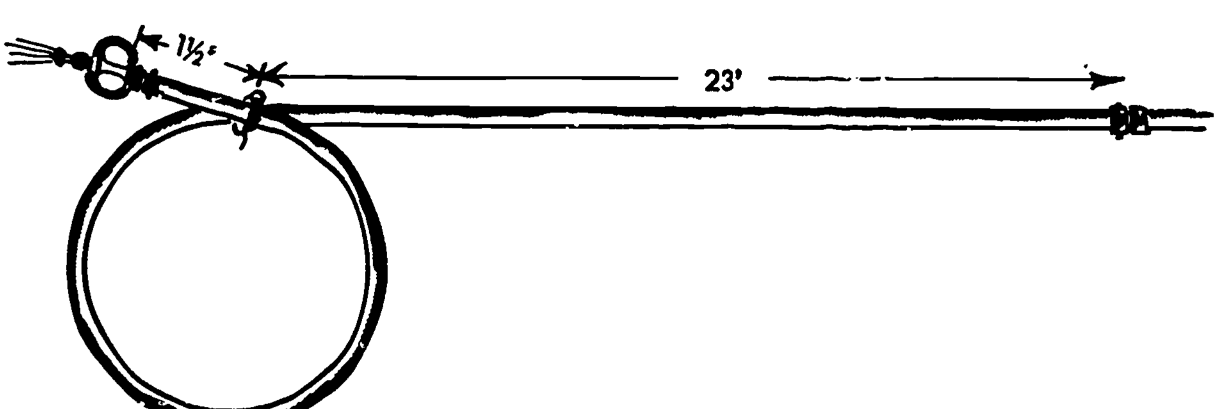
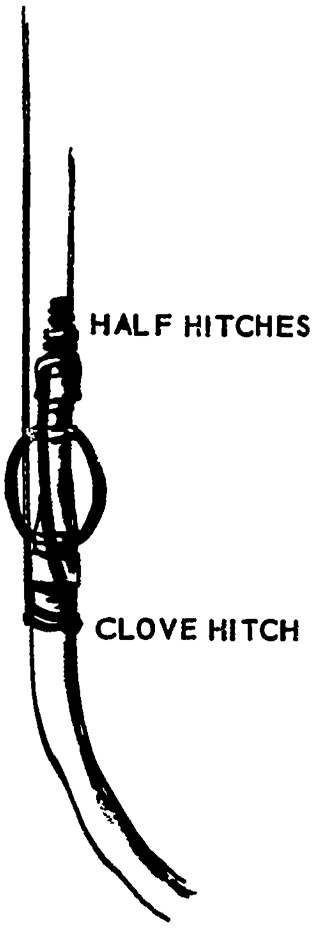


Fig. 39 - Keenan Hose Loop

it will not be knocked open while the line is being elevated. See Figure 41. This is done by passing the rope, doubled, through the shutoff handle, passing it over the top and then throwing two half hitches and a safety over the top.



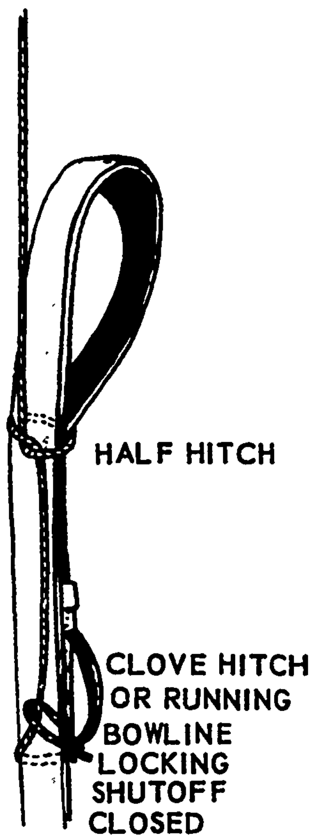


Fig. 40 - Hoisting a Charged Line

Fig. 41 - Hoisting an Uncharged Line

HOISTING UNCHARGED HOSE LINES

Double the nozzle back, as shown in Figure 41, on the hose so as to protect the tip. Slip a clove hitch or, preferably, a running bowline around the hose and nozzle over the shutoff, locking it closed. Then put one or more half-hitches around the loop of the hose. It should be noted that the rope should be along the flat side of the hose opposite the nozzle. Carefully start the hose upward and guide it all the way. The hose will form its own tail rope. Always have the nozzle point in the direction opposite to travel. After the hose reaches the top, the half-hitch can be slackened, and the nozzle tip pulled out from under the rope. The running bowline knot may be left so that the hose may be lowered, raised or fastened to some object to relieve the strain on the man using the hose.

HOSE AUXILIARIES

DOUBLE MALE AND FEMALE COUPLINGS

Most fire departments have a regular method for placing hose in the hose bed of trucks and for taking it out at fires. This makes the right coupling, male or female, available for proper connections. The method used will be governed by hydrant pressures, spacing of hydrants and other considerations toward insuring best results. Thus, a female end is used for connection to the hydrant and a male end for the nozzle. To meet situations which cannot be foreseen, a double male and female connection is carried. They are used in an emergency when it is required to connect two male or two female couplings together. At times, operating practice calls for laying the line from the hydrant to the fire; at other times from the fire to the hydrant. With double connections available, a line can be promptly laid in either manner.

SIAMESE AND WYE CONNECTIONS

Each of these connections can be used to make one line into two or two lines into one providing there are no clapper valves within the unit to control the direction of flow. Where a "gated wye" as in Figure 42 is used the water flow is controlled by a manual operation, namely, closing or opening each valve by turning the handle of the gate valve. When a siamese wye having clapper valves, Figure 43, is used, the direction of water flow will be limited by operating arrangement of the clapper valves built within the unit.

HOSE CLAMP

The hose clamp, Figure 37, is used for shutting off water in hose lines in order to: (1) replace burst sections of hose, (2) to extend hose lines, (3) to stop the flow of water within a hose line, or (4) for any other purpose desired without shutting the water off at the source of supply. The clamp can be used when laying a hose line from the hydrant to the pumper at the fire. When performing this operation, it is possible for the hydrant-operator to open the hydrant before the opposite end of the line is connected to the pumper intake or some other water distributing tool. This hose clamp is placed on the hose line near the pumper, etc., at such a position to permit easy handling of the hose without the lifting of the clamp from the ground. In this evolution the procedure is as follows:

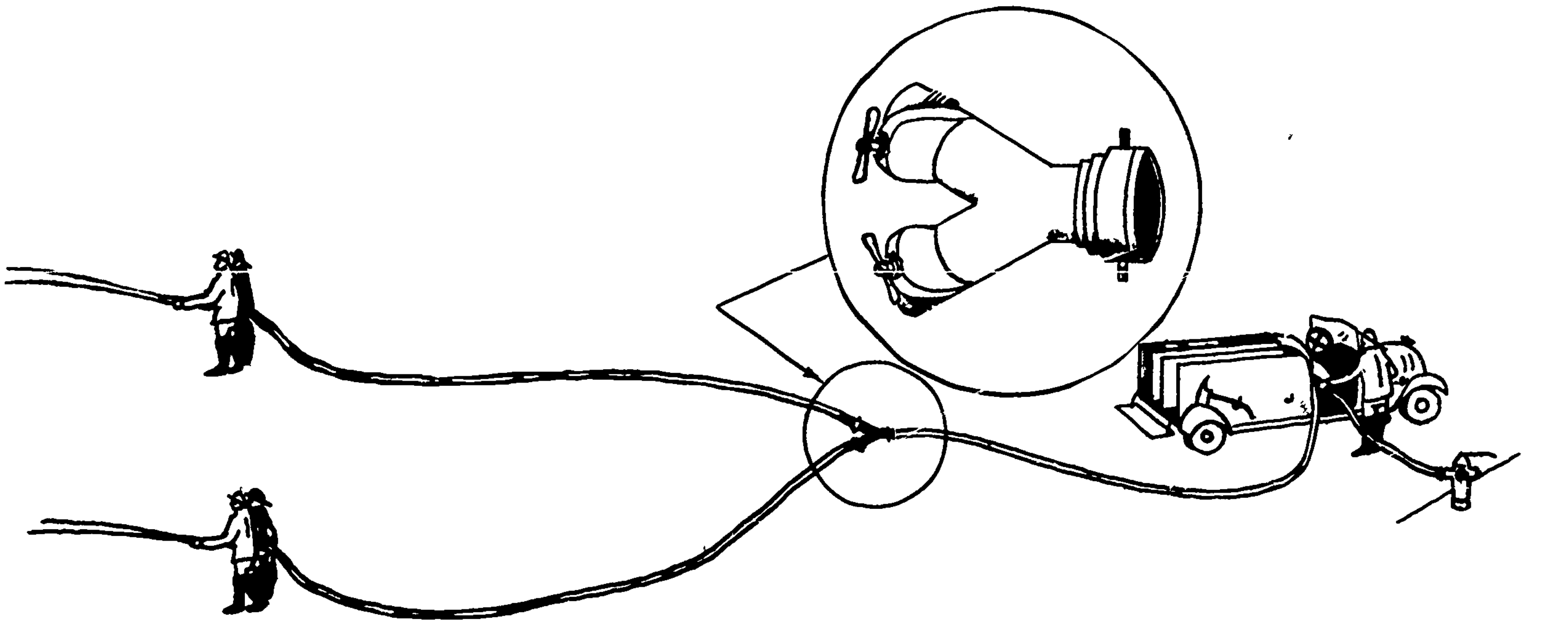


Fig. 42 - Gated Wye

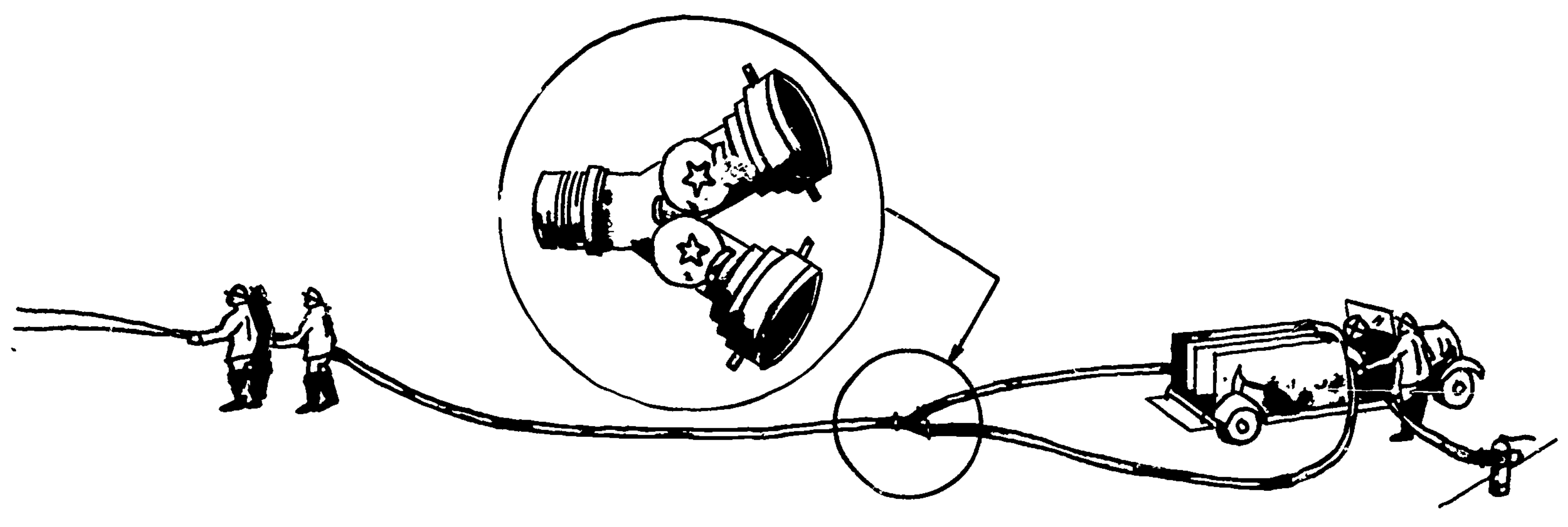


Fig. 43 - Siamese Wye

1. Lay off hose from bed of pumper for hydrant connection.

2. Pumper proceeds to the fire.

3. The hydrant man connects hose to hydrant and places hydrant spanner that was attached to hose on hydrant top nut.

4. The pump operator places hose clamp on the hose lying on the ground immediately to the rear of the hose bed.

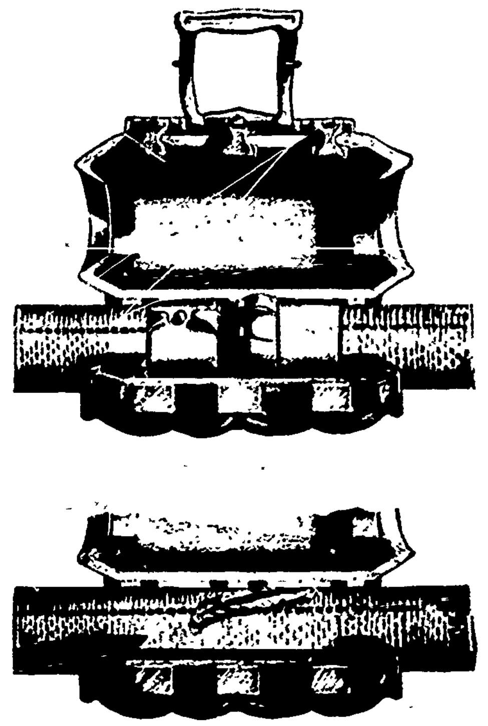
5. The pump operator signals for the hydrant to be turned on.

6. The hydrant man then turns on the hydrant and advances to the nozzle.

7. At any time during this operation, the hose from the hose bed can be disconnected from that remaining in the hose bed and then connected to the pumper or water distributing tool as planned.

HOSE JACKET

The Cooper hose jacket, as shown in Figure 44, is used when small cuts or breaks occur in hose lines while in operation. The jacket is opened and is placed on the ground a short distance from the leak. The hose is lifted by two men--one on each side of the leak--and turned as much as possible to direct the water in a downward direction while, at the same time, placing it in the bottom side of the hose jacket. After this is accomplished, the top side (with the handle) is moved up and over the hose, and snapped together, preferably using foot pressure to lock it in place.



Courtesy Wooster Brass Division

Fig. 44 - Cooper Hose Jacket

FIRE DEPARTMENT HAND SIGNALS

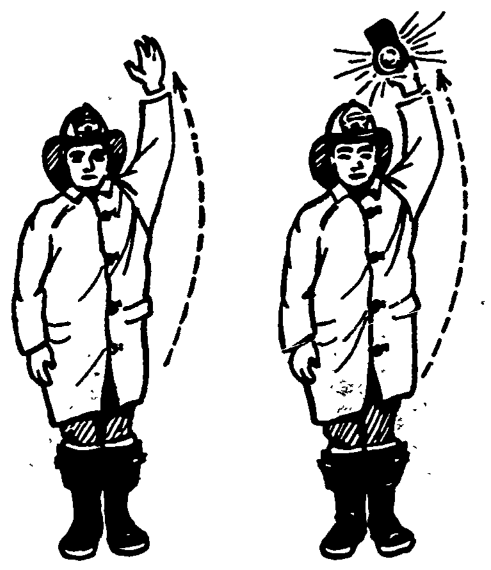
The difficulty of promptly getting water after the line is in position is known to every fireman. No matter how quickly a line is stretched to an advantageous position, there is an inevitable delay while a man goes back to call for water. Noises on the fire grounds, the roar of motors, and the sirens of approaching apparatus often make verbal signals indistinguishable, if not inaudible, even at short distances.

Such difficulties in sending messages to the pump operator may be overcome by the use of a simple system of signals. The signals are given by arm movements in the daytime and by a flashlight at night. They cover all of the important orders at a fire which are usually sent to the pump operator by the officer in charge. They are easily learned and understood. The signal itself, in each case, suggests the action. In some departments, it may be considered desirable to develop signals for additional messages. However, it is essential, in every case, that signals be understood by all members. Signals made in a careless fashion are liable to be misunderstood and are worse than no signal at all. All signals should be continued until acknowledged by the pump operator. The pump operator should return each signal to show that it is understood. If more than one line is in use, the signal must be given so that it is clear which line the signal is intended to cover. The following simple, yet efficient, set of signals will aid greatly in fire fighting procedure.

HAND SIGNALS FOR BOOSTER LINE

Day — Raise one arm vertically from shoulder, palm of hand to front. Hold stationary. See Figure 45a.

Night - Raise one arm vertically from shoulder, hand holding flashlight to front. Hold stationary. See Figure 45b.



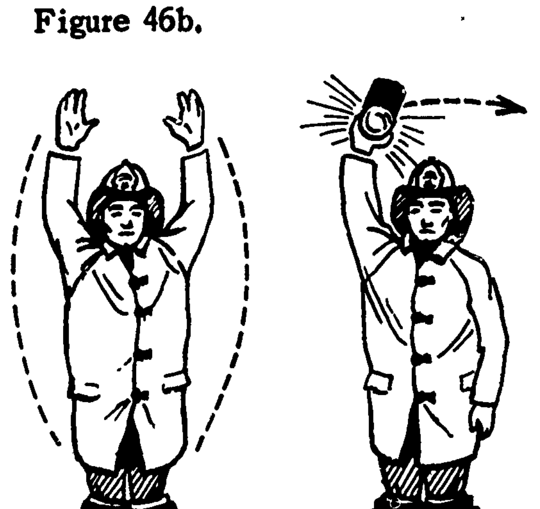
45a 45b

Fig. 45 - Charge Booster Line

HAND SIGNALS TO TURN WATER INTO LINE

Day — Raise both arms vertically from shoulders, palms or hands to front. Hold stationary. See Figure 46a.

Night - Extend hand holding flashlight vertically from shoulder, swing horizontally above head. Swing with light point forward. See Figure 46b.



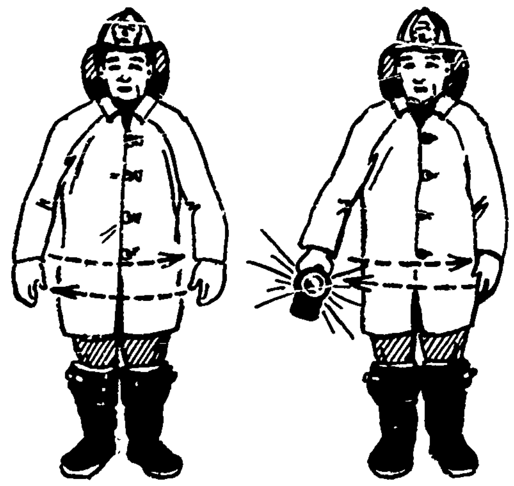
46a 46b

Fig. 46 - Turn Water into Lines

HAND SIGNALS TO SHUT WATER OFF IN LINE

Day -- Extend both arms downward at a 45 degree angle, cross arms in front of body and swing back and forth. See Figure 47a.

Night - Extend one arm horizontally from shoulder, hand holding flashlight forward. Raise and lower arm to a 45 degree angle. See Figure 47b.



47a 47b

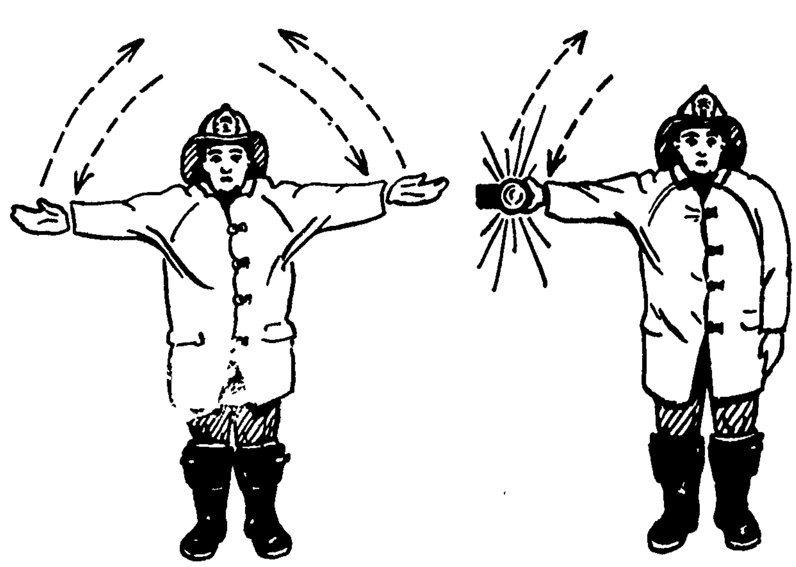
Fig. 47 - Shut Off Water in Line

HAND SIGNALS TO INCREASE PRESSURE IN LINE

The pressure raise in pounds is to be predetermined by department rules.

Day -- Extend arms horizontally from shoulder, palms up; then raise and lower arms to a 45 degree angle. See Figure 48a.

Night - Extend one arm horizontally from shoulder, hand holding flashlight forward. Raise and lower arm to a 45 degree angle. See Figure 48b.



48a 48b

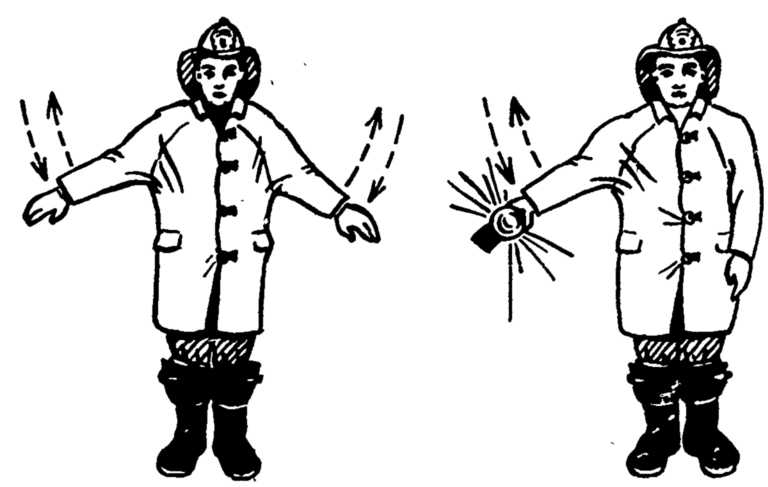
Fig. 48 - Raise Pressure

HAND SIGNALS TO LOWER PRESSURE IN LINE

The pressure decrease in pounds is also predetermined by department rules.

Day -- Extend arms horizontally from shoulders, palms down. Lower arms to a 45 degree angle and repeat this signal. See Figure 49a.

Night - Extend one arm horizontally from shoulder, hand holding flashlight forward. Lower arm to a 45 degree angle and repeat this signal. See Figure 49b.



49a 49b

Fig. 49 - Lower Pressure

HOSE RECORD FILE CARD

Every fire department, whether a small volunteer or a large city department, should maintain a "Hose Record File Card" for each section of hose, including suction hose, in service in its department. This record should include any hose in storage that has not been assigned to any apparatus or unit. A well maintained hose record will indicate where each section of hose is assigned, its condition, age, when the last test was made and results of the test. The Ohio Inspection Bureau utilizes hose records as one of the many factors in rating a department. A hose record system will also provide supporting data to a city administrative head or council when determining the need for new or additional hose.

Form No. 6

SIZE	IDENTIFICATION NUMBER	FIRE DEPARTMENT **HOSE RECORD**	
OWNER	BRAND	Cost Per Ft.	Date of Purchase
MANUFACTURER	VENDOR	GUARANTEE	

Date in Service	Co. No.	LENGTH TESTED			OUT OF SERVICE		REMARKS	Tested By
		Date	Pressure	O.K. or Failure	Date	Reason		

Fig. 50 - Hose Record File Card

CHAPTER 9

TOOLS AND EQUIPMENT

INTRODUCTION

It is essential that each fireman know the proper use and care of the small tools and appliances used in the fi-e service. Some of these tools are homemade and many have been developed to meet the needs of the local department. The tools and equipment, with their use and care, are described herein. When buying equipment, remember, *only the very best is good enough for the fire service.*

TOOL MAINTENANCE

Tools will last indefinitely if given proper care. They must be maintained in first class condition at all times. To attain this goal, the proper care of these tools should be as follows:

CARE OF TOOLS

1. Wood handles must be free of cracks and splinters and be tight in the head.
   a. Cracked handles must be replaced.
   b. Splinters must be sanded to make handles smooth.
   c. All wood handles should be varnished or rubbed with linseed oil. They should never be painted for the following reasons:
      (1) Paint is a good conductor of electricity.
      (2) Cracks that are painted over cannot be detected.
2. Moving parts of tools must be oiled lightly to assure free movement and to prevent rusting.
3. All unpainted parts of tools must be kept free of rust. This can be accomplished by wiping weekly with an oiled cloth.
4. Painted tools must be kept clean at all times and repainted when necessary.
5. Chromed tools must be kept free of dirt and finger marks. This can be done by wiping daily with a soft, dry cloth.
6. Cutting tools must be sharp and free of nicks. When grinding tools, care must be taken to prevent the metal from overheating. This will remove the temper and the metal will become soft. After sharpening, the edge should be rubbed over an oil stone to remove the keen edge. A keen edge is not desirable as it will be dulled after several strokes.

MOUNTING AND CARRYING TOOLS AND EQUIPMENT

A place for every tool and every tool in its place should be the aim of every fire department. By doing this, the tools will be protected and the men will be able to find the proper tool without delay.

This is also of great value in checking equipment or at pick-up time. It is recommended that tools on all apparatus be carried in uniform locations on similar apparatus as much as is possible. Mounting brackets for all tools carried on the apparatus are very essential, for tools should not be carried loosely in compartments. Portable light generators and portable pumps must be fastened securely but in such a manner that they can be removed easily and rapidly. Special care for other equipment will be covered under their respective listing and description.

STRIKING TOOLS

Striking tools are generally used for forcible entry in order to get to the fire, assist in rescue work or to open buildings for the purpose of ventilation.

HAMMER HEAD PICK

The hammer head pick, as shown in Figure 1, is a serviceable, double purpose tool. It has a long, slender, sharp-pointed pick for digging dirt, cinders, concrete, planking, etc. It is also very useful for chopping holes in ice to accommodate a suction hose

for a draft. The hammer head can also be used as a sledge, although it does not have the weight and striking power of a sledge. This tool is also often used to free iron bars set in masonry.

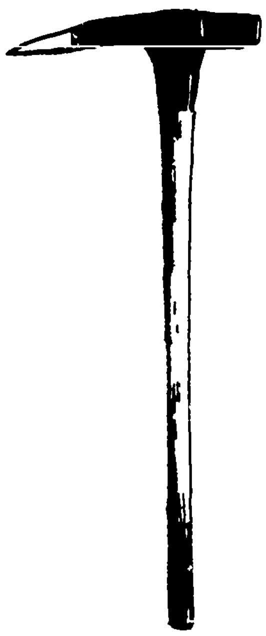


Fig. 1 - Hammer Head Pick

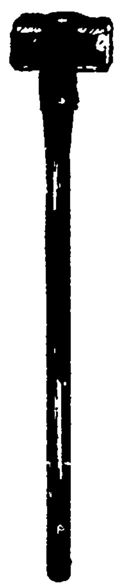


Fig. 2 - Sledge Hammer

SLEDGE HAMMER

The sledge hammer is a tool with considerable weight and tremendous striking power. See Figure 2. It can be used effectively to break out concrete, tile, walls, floors, roofs, etc., or to free iron bars set in masonry.

RUBBER MALLET OR LEAD HAMMER

The rubber mallet or lead hammer is carried by some departments. Its main use is for tightening suction couplings when preparing to draft water.

BATTERING RAM

The battering ram in Figure 3 is used to breach brick walls or to force doors that cannot be opened in any other way.

Fig. 3 - Battering Ram

CUTTING TOOLS

HANDLED HAMMER HEADED CHISEL

The handled hammer headed chisel is generally used for forcible entry and rescue work. It can be used to cut rivets, padlocks, bars, hinges, etc. It is also used for splitting heavy planking.

HAND HATCHET

The hand hatchet, shown in Figure 4, is similar in design to the flat head axe but smaller in size. It is designed for hand use in confined spaces and for light cutting operations.

Fig. 4 - Hand Hatchet

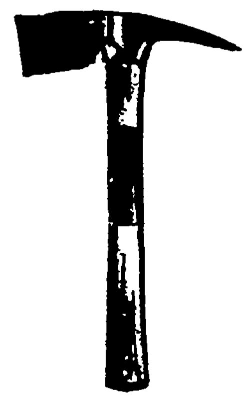


Fig. 5 - Pompier Hatchet

POMPIER HATCHET

The pompier hatchet, (Figure 5), is also a one-hand hatchet. It is similar to the pick-head axe except that it is smaller. It is designed for still lighter work than the hand hatchet. The pick end is useful for ripping off shingles, as well as a light pry bar. This type of hatchet is easily carried in a belt.

THE CRASH AXE

The crash axe can be used to cut plaster, wood, and light metals. It is very handy for work in close areas. See Figure 6.

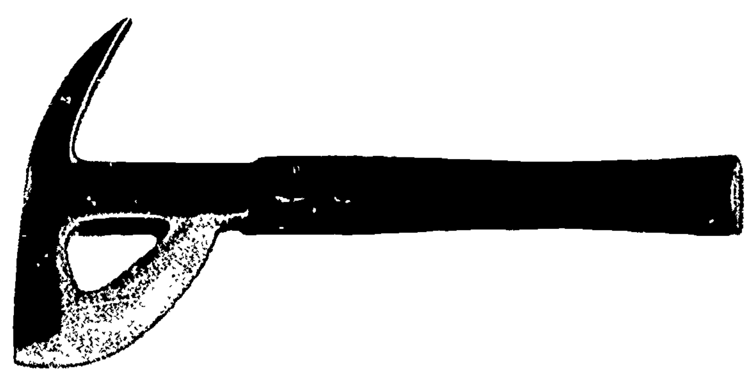


Fig. 6 - Crash Axe

METAL ROOF CUTTERS

Metal roof cutters, as shown in Figures 7 and 8, are used in the removal or cutting of metal roofs. Metal roofs are sometimes covered with tar and gravel that must be scraped away to protect the cutter as much as possible.

Two different types of metal roof cutters in common use are the one with a rotating cutting disc, as in Figure 7, and the one with a fixed blade similar to a can opener, as in Figure 8.

Fig. 7 - Roof Cutter With Rotating Cutting Disc

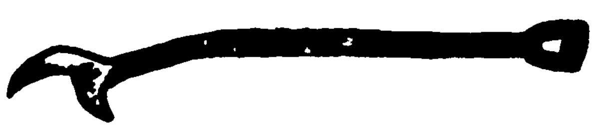


Fig. 8 - Roof Cutter With Fixed Blade

BOLT CUTTERS

Bolt cu[illegible] as illustrated in Figure 9, are used for cutting [illegible] bolts, nails, wire, etc. However, they should never be used to cut electric wires or materials made of tempered or hardened steel.

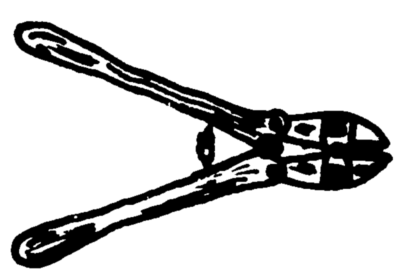


Fig. 9 - Bolt Cutters

THE PICK HEAD AXE AND FLAT HEAD AXE

These two axes are probably the most widely used tools in the fire department. They can be used as a cutting tool, a striking tool or a prying tool; see Figures 10 and 11.

Fig. 10 - Pick Head Axe

Fig. 11 - Flat Head Axe

WIRE CUTTERS

Two types of wire cutters are used in the fire service. Figure 12 shows the scissors type with insulated handles and a hook in front of the cutters to help center the wire between the cutting edges. Figure 13 shows the tree-trimmer type with long, non-conducting handles. Wire cutters should be carried in a protected area on the truck and must be tested periodically to determine if they will withstand the necessary voltage.

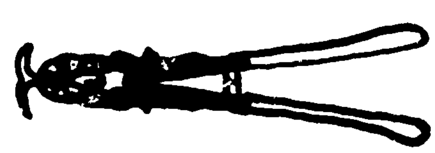
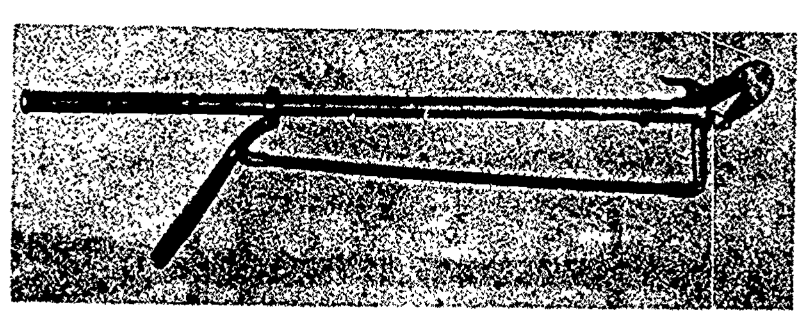


Fig. 12 - Scissors-Type Wire Cutters



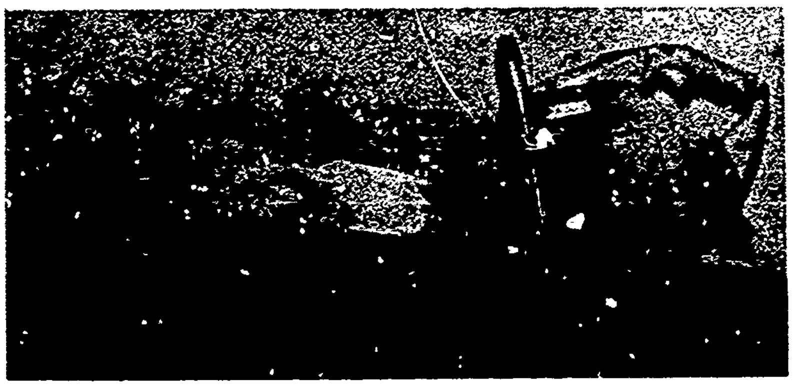
Courtesy A.B. Chance Company

Fig. 13 - Tree-Trimmer Type Wire Cutters

POWER SAWS

The power saws used today by fire departments are of three types; the power chain saw, power saber saw and power circular hand saw.

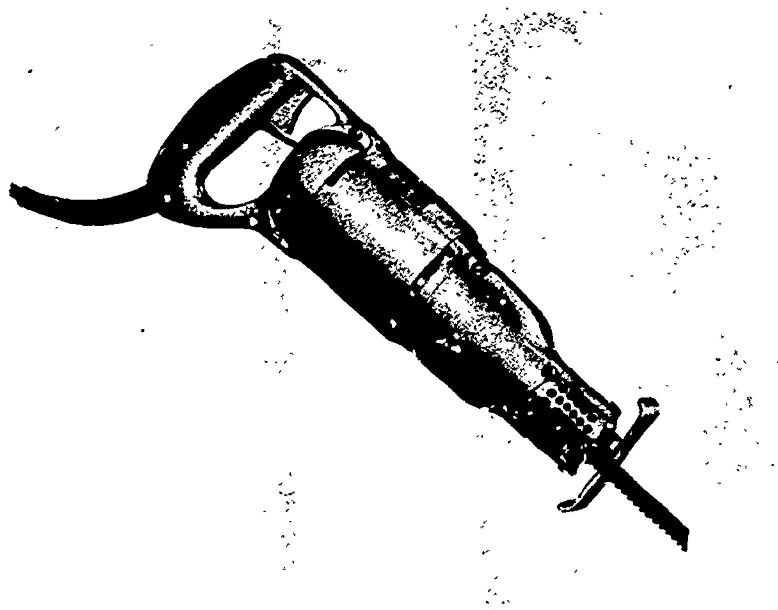
The Power Chain Saw - This saw can be used to open floors and cut large wood beams, and is available in either gasoline or electrically powered units. See Figure 14.



Courtesy McCulloch Corporation

Fig. 14 - Power Chain Saw

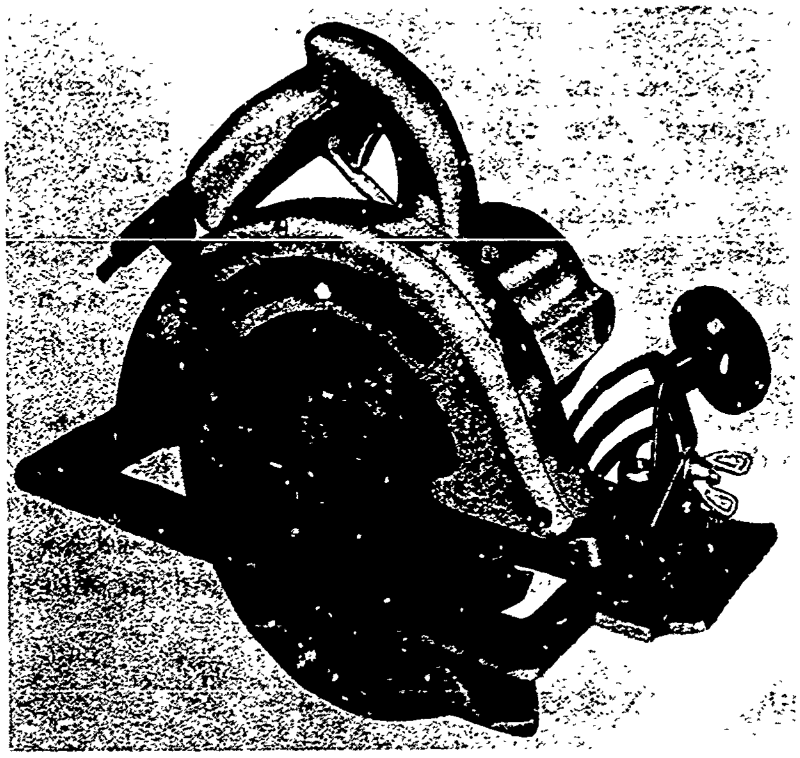
The Power Saber Saw - The power saber saw is used to cut metal or wood. It is very useful in ventilation and rescue work. See Figure 15.



Courtesy Black & Decker

Fig. 15 - Power Saber Saw

Power Circular Hand Saw - The power circular hand saw is used for opening floors and is illustrated in Figure 16.

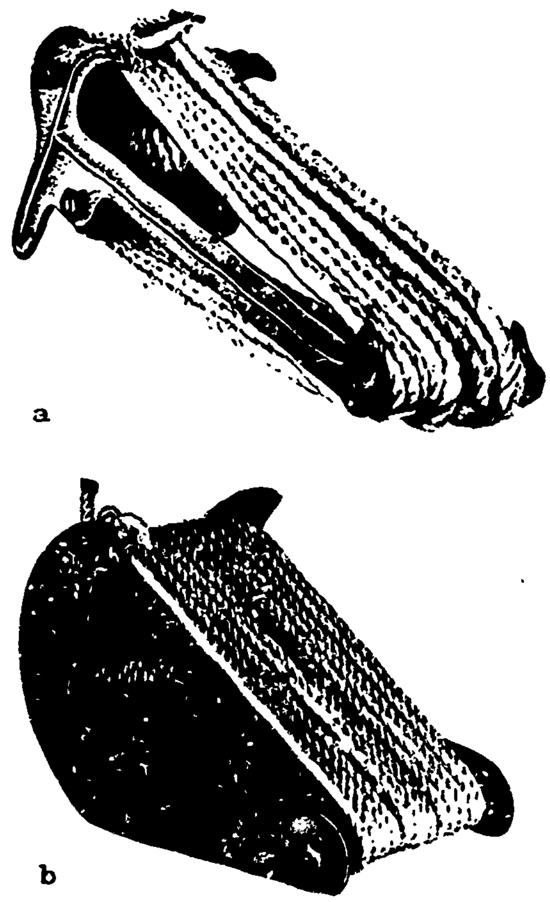


Courtesy Black & Decker

Fig. 16 - Power Circular Hand Saw

HOISTING AND PULLING TOOLS

Hoisting and pulling tools are very important tools for all fire departments.



a

b

Fig. 17 - Hose Rollers

HOSE ROLLERS

Hose rollers are used in hoisting or lowering equipment when operating in buildings above the ground level. See Figures 17a and 17b. To put a hose roller in operation, place it on a cornice of a building or over a window sill and make fast to some object with the rope attached to the roller. If no projections are available, a hole can be made in the roof and the roller fastened to a beam.

After the roller is made fast, lower the roof ropes to the men on the ground who will, in turn, fasten the rope around the hose. The line is then in a position to be hoisted to the roof. In caring for the hose roller, keep it free of rust. Wind the rope around the roller so that it will not become tangled.

PULL DOWN HOOK

Pull down hooks, as illustrated in Figure 18, are used in overhauling operations for pulling down unsafe walls, removing obstacles, etc.

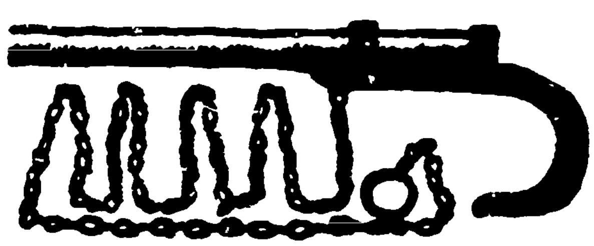


Fig. 18 - Pull-Down Hook

GRAPPLING HOOKS

Grappling hooks are carried for use in dragging for bodies under water. They should be kept clean and free from rust. Each time they are used, the rope should be dried before being put away.

SHEATHING HOOK

The sheathing hook is similar to a hay hook except that it is longer; see Figure 19. It is used to pull off sheathing and siding and can also be used to remove lath and plaster from closets or other close places where a pike pole would be more difficult to use.

Fig. 19 - Sheathing Hook

PLASTER HOOK

The plaster hook in Figure 20 is similar to the pike pole, but it will penetrate plaster, lath and metal ceilings easier because of its spear-like head. It has two knife-like wings that close when going through an obstruction and then automatically open or spread by means of self-contained springs to permit a better grip on the obstructions that are to be removed.

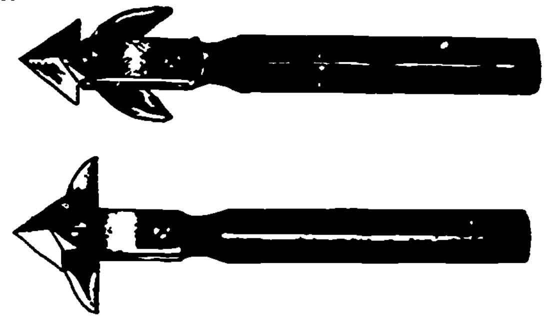


Fig. 20 - Plaster Hook

PIKE POLES

Pike poles, as in Figure 21, are carried in various lengths and style heads. They are used to remove lath and plaster from walls and ceilings and to roll up metal roofs after they have been cut in widths with metal roof cutters. They are also used for hoisting and lowering equipment and in raising and lowering windows, transoms, etc., and for supporting salvage covers.

Fig. 21 - Pike Poles and Hooks

PRYING TOOLS

Prying tools like battering tools are used many times for forcible entry or in effecting a rescue. If not used properly they can be very destructive and cause much property damage. Every fire fighter should learn the right way of using these tools.

CLAW TOOL

The claw tool in Figure 22 is a very handy tool in forcible entry work. It is used for opening or removing hinges, locks, doors, windows, transoms, sidewalk elevator doors, sidewalk gratings, manhole covers, flooring, etc.

Fig. 22 - Claw Tool

DOOR OPENERS

Door openers are manufactured by several concerns. Two popular makes are the "Detroit" and the "P & Q". See Figures 23 and 24.

Fig. 23 - Detroit Door Opener

Fig. 24 - P and Q Door Opener

CROW BAR

The crow bar, shown in Figure 25, is an all-purpose tool for prying, forcing and all other forms of heavy entry work requiring great leverage.

Fig. 25 - Crow Bar

BUSTER BAR

The buster bar in Figure 26 is a light form of door opener and prying tool designed for convenient carrying. It is provided with a wedge-shaped tip and an adjustable fulcrum for providing greater leverage.

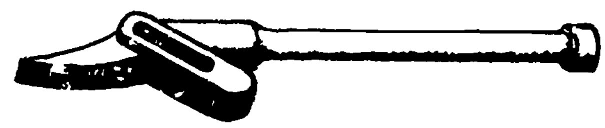


Fig. 26 - Buster Bar

HUX BAR

The hux bar, in Figure 27, is similar in design and use to the claw tool. It can also be used as a metal roof cutter and hydrant wrench.

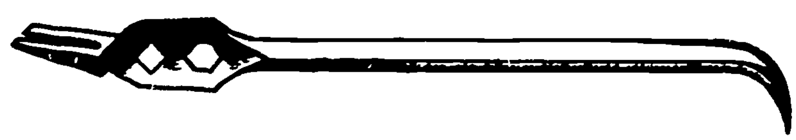


Fig. 27 - Hux Bar

KELLY TOOL

The Kelly tool, shown in Figure 28, is widely used for prying or chiseling. It can be used as a pry in opening doors and windows, as a chisel to cut off bolt heads, padlocks on doors, chains or wherever a cold chisel is needed.

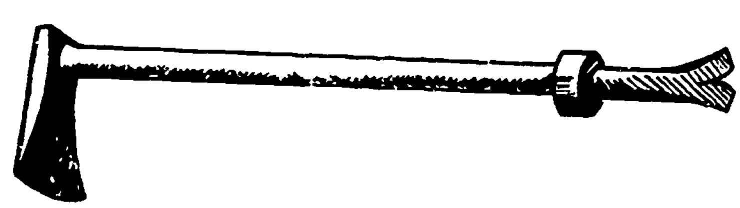


Fig. 28 - Kelly Tool

BORING AND DRILLING TOOLS

Boring and drilling tools are an absolute necessity if certain types of jobs are to be done in the fire service.

WOOD AUGER

A wood auger is used in connection with boring holes in flooring and roofs, to start wood saws and for draining operations in floors. See Figure 29.

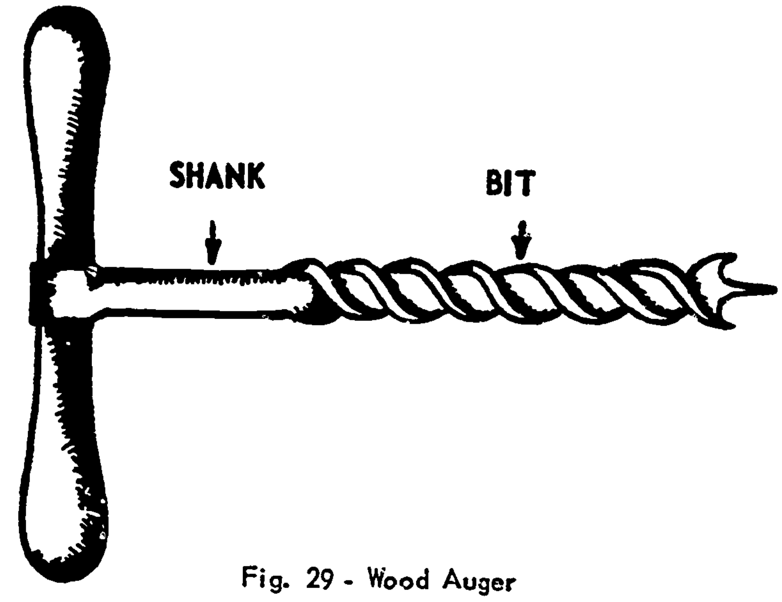


Fig. 29 - Wood Auger

BRACE AND BITS

The brace and different sized bits, shown in Figures 30, 31 and 32, are carried by some departments. Figure 31 shows a bit that is designed for boring in either wood or metal. Figure 32 is an auger bit, which is designed for boring in wood only.

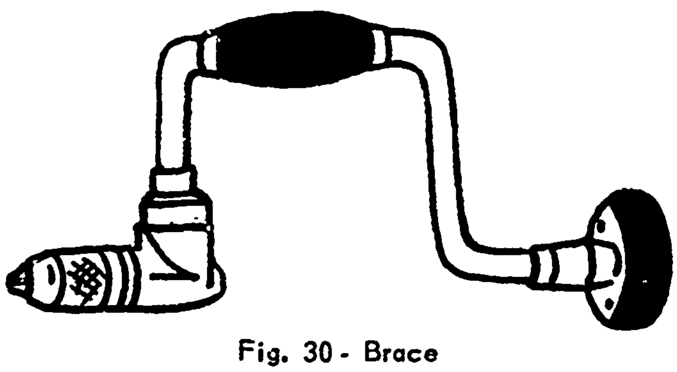


Fig. 30 - Brace

Fig. 31 - Bit for Boring in Wood or Metal

Fig. 32 - Auger Bit

PURPOSE AND USE OF OXY-ACETYLENE CUTTING TORCHES

Every fire department should be equipped with an oxy-acetylene cutting torch for emergency purposes, such as cutting bars to release imprisoned persons, and opening up metal doors or other metal coverings which cannot be otherwise opened. Firemen are many times called to automobile wrecks to extract persons who are pinned in the wreckage and the use of the oxy-acetylene cutting torch is the simplest way to extract them. The oxy-acetylene cutting torch in Figure 33 can be used for cutting steel, wrought iron and other ferrous metals. The equipment is portable. It consists of one tank containing oxygen and another one containing acetylene. Hose, regulators, gauges, cutting torch, lighter, goggles, extra tips, tip cleaners, wrench, leather gloves and yellow or white chalk or soapstone must be included in the equipment.

Courtesy National Welding Equipment Co.

Fig. 33 - Cutting Outfit

PORTABLE GENERATORS

Portable generators are carried by many fire departments; see Figure 34. They are used to furnish power for lights as well as power tools. The fire department is often called to furnish power to hospitals having power failure. This service has saved many lives, enabling the hospital staff to carry on with operations, operate iron lungs, etc. Maintenance and operating instructions are furnished by the manufacturer and should be followed. Do not overload the generator - check the plate on the generator for output capacity.

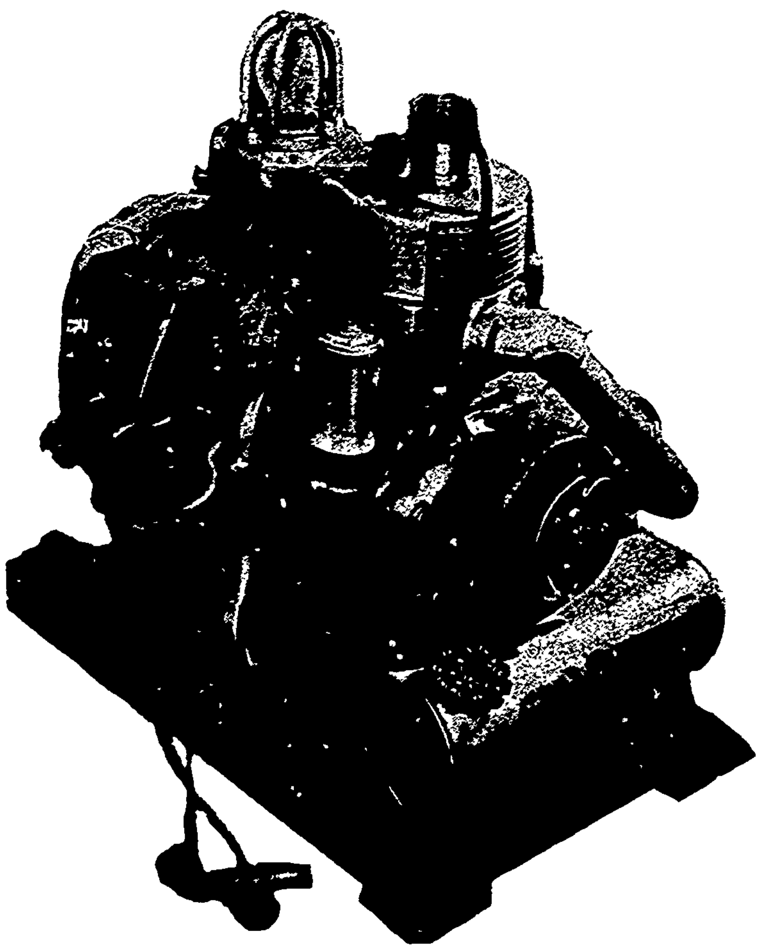


Fig. 34 - Portable Generator

LIGHTS

In many cases, the successful operation of a department depends upon the availability of proper types of lights. The safety of both the public and firemen depends on lights of various kinds. Included in this section are the types of lights used in the fire service:

FLASHLIGHT

It is a good policy for each member of the department to carry a flashlight. They are useful when operations depend on hand signals at night and also when making inspections. Each man should be responsible for seeing that the batteries and bulb are in good condition.

ELECTRIC HAND LANTERN

The electric hand lantern is carried for general use. Both wet and dry cell types are used. Figure 35 shows a dry cell type. They must be inspected often to see that they are in good condition. Extra bulbs and batteries should be available for replacements.

There are many models of flood and spot lights used in the fire service. Figure 36 shows two models of spot lights and Figure 37 shows a popular type flood light. The power for these lights usually comes from a portable generator carried by the department.

These lights must be checked after each use and also be included in the daily and weekly check list. It is recommended that adapters be carried so the lights may be plugged into house sockets and other sources of electrical supply. To obtain the best results and longer life, they must be kept clean.

Spot lights with a retractable cable case are one of the popular types used today in the fire service. See Figure 36. Note conversion pig tail assemblies for each light.

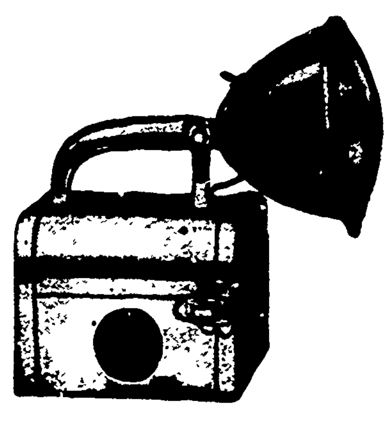


Fig. 35 - Hand Lantern

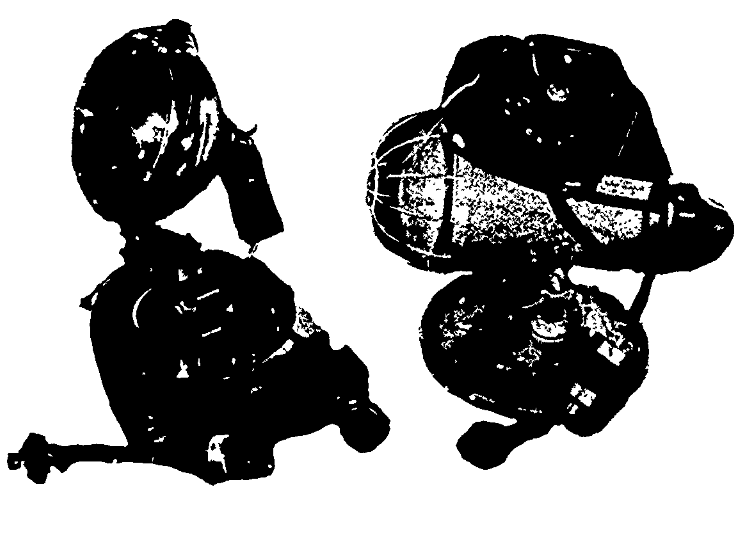


Fig. 36 - Spotlights

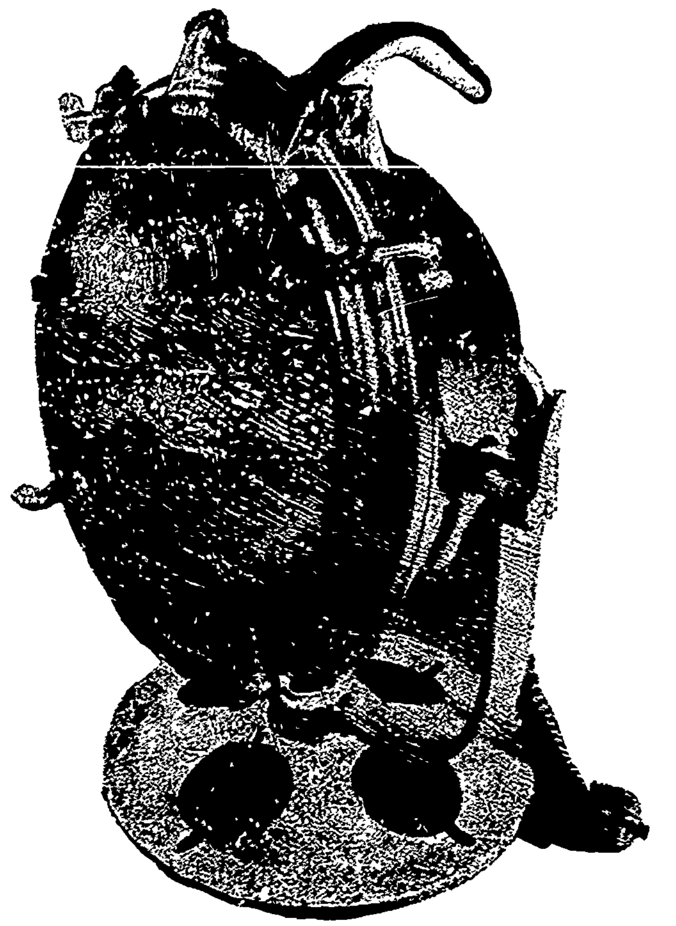


Fig. 37 - Floodlight

MISCELLANEOUS TOOLS AND EQUIPMENT

In addition to the tools listed in the various categories as striking, cutting, battering, there are other tools and equipment that are just as important to the fireman and, as yet, have not been described.

THE HOSE STRAP

The hose strap, shown in Figures 38 and 39, is used to carry or drag hose, hold lines on ladders, and to tie ladders to windows and fire escapes. The hose strap has a split link on one end that makes it easy to fasten and adjust. The other end has a combination hook and handle for lifting or fastening over the rung of the ladder, window sill, etc.

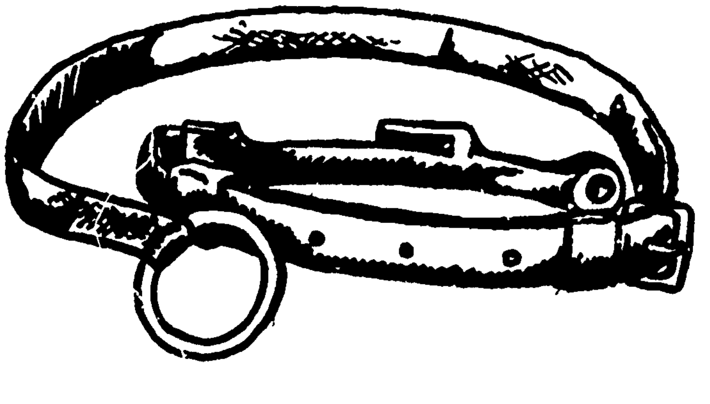


Fig. 38 - Hose Strap

Metal parts should be kept free from rust and the web strap checked for cuts or excess wear. Damaged web straps should be replaced before the strap is placed in service.

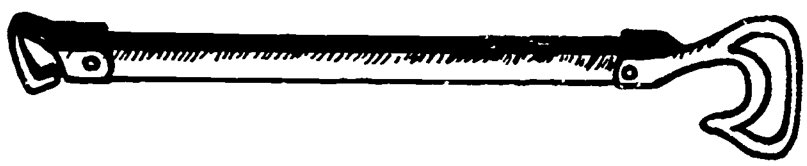


Fig. 39 - Hose Strap

ROPE HOSE TOOL

The rope hose tool in Figure 40 can be used in a great many different ways.

It is usually made of about ten feet of 5/8 inch or 3/4 inch manila rope and has a loose splice with a steel hook; see Figure 41. The actual size needed for an individual is determined by measuring over his rubber coat or winter clothes. The owner's initials should be stamped on the hook. When making the rope hose tool, the splice is made loose and the strand ends may be sewn with sail twine. When making this splice, be sure to take about four complete twists of the rope to secure a perfect loop. In order to avoid loop twists when the rope becomes wet, it is advisable to soak or oil them thoroughly and then stretch them while drying. A specially treated rope can also be purchased. Do not use rope that is too new, and always be sure it is very limber.

Some of the many uses for the rope hose tool are:

1. As a life belt on a ladder.
2. To lash an unconscious person to a fireman for carrying. See Rescue chapter.
3. To anchor the nozzle of a charged line.
4. To help support the weight of a hose on a ladder rung.
5. To carry an uncharged or charged hose up a ladder.
6. To carry a do-nut roll.
7. To "fasten a ladder in" at the top over a parapet, through a window, or on a fire escape.

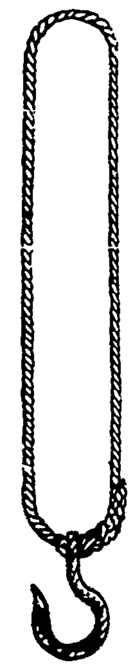


Fig. 40 - Rope Hose Tool

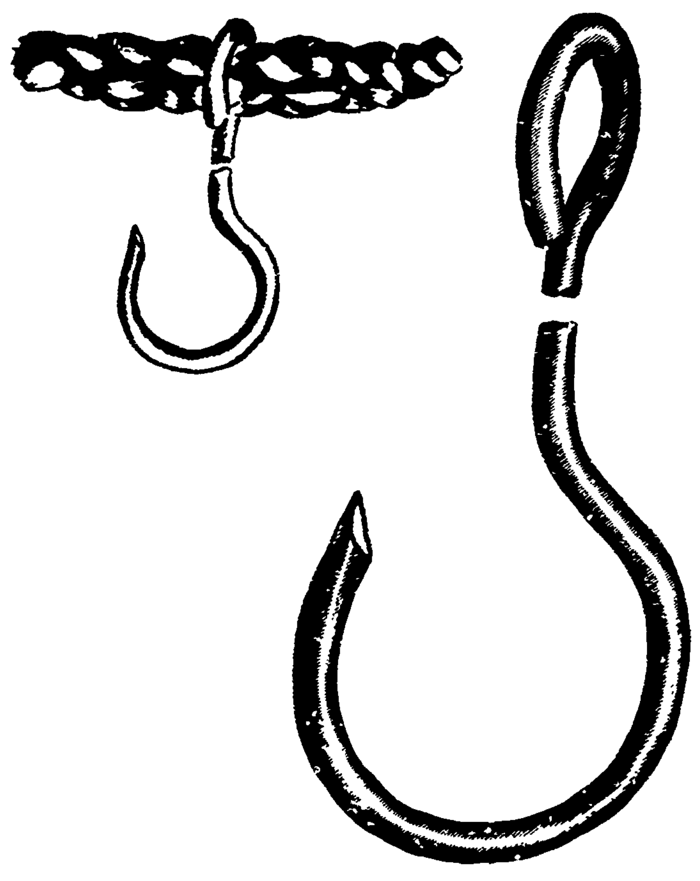


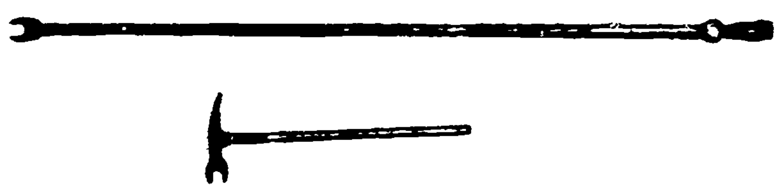
Fig. 41 - Rope Hose Tool Hook -- Made from ½ Inch Cold Rolled Steel

GAS AND WATER KEY

Gas and water keys are carried on the apparatus and are used to turn the gas or water supply on or off at the curb box for any dwelling or building. Local utility companies should approve the proper keys to be obtained by the department. Gas keys have a fork at one end and a socket for removing covers at the other end; see Figure 42a.

The water key is T-shaped with both ends of the cross bar shaped for use as a pick to remove dirt from around the lid; the other end includes a socket. See Figure 42b.

Water Key



Gas Keys

Fig. 42 - Gas and Water Keys

SPANNER WRENCH AND HOLDER

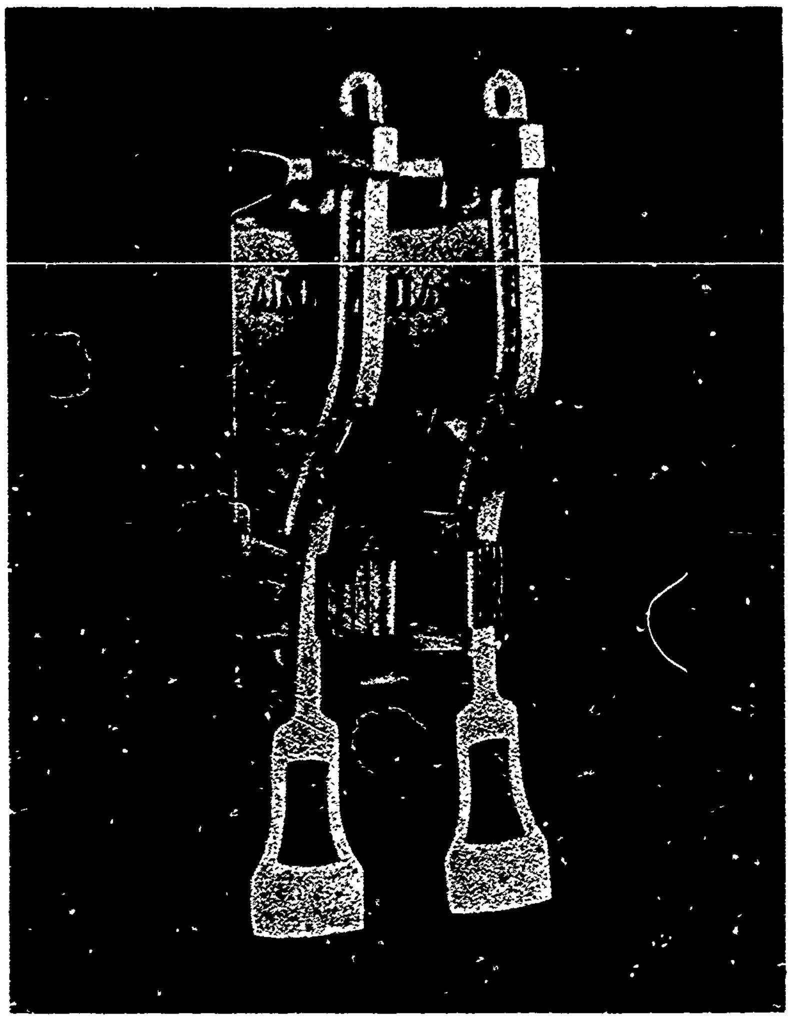
A spanner wrench is used to tighten or loosen hose couplings; see Figure 43. They may also be used as a shut-off for gas meters, a light hammer or a window jimmy. The holder eliminates the searching for spanner wrenches at the scene of a fire.

HYDRANT WRENCH

Hydrant wrenches are carried on the apparatus with the hose load and are used on hard-to-remove hydrant caps and to open or close hydrants.

SMOKE EJECTORS

Smoke ejectors, as illustrated in Figure 44, are used to assist in the removal of such gases as smoke, refrigeration fumes, etc., from dwellings or other types of buildings. The fan may be placed in a window, door or similar openings. The motor must be the sealed or safety type which will not cause an explosion by a spark as the ejector is exposed to explosive gases.



Courtesy Akron Brass Co., Inc.

Fig. 43 - Spanner Wrench and Holder

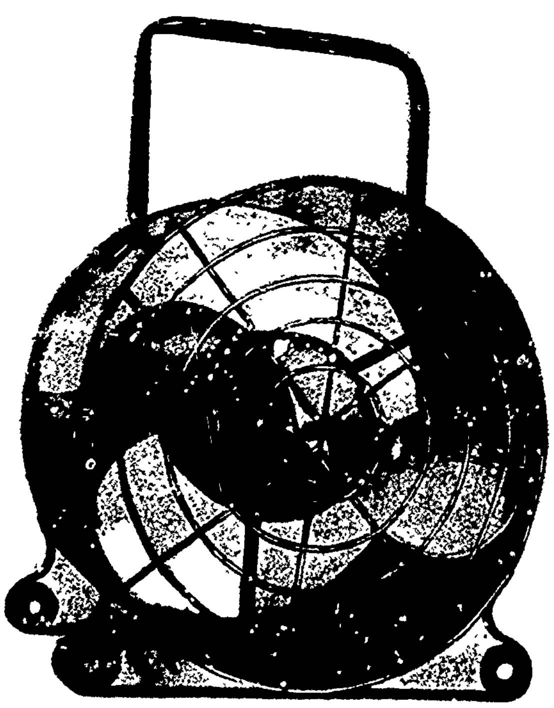


Fig. 44 - Smoke Ejector

THE VOICE POWER MEGAPHONE

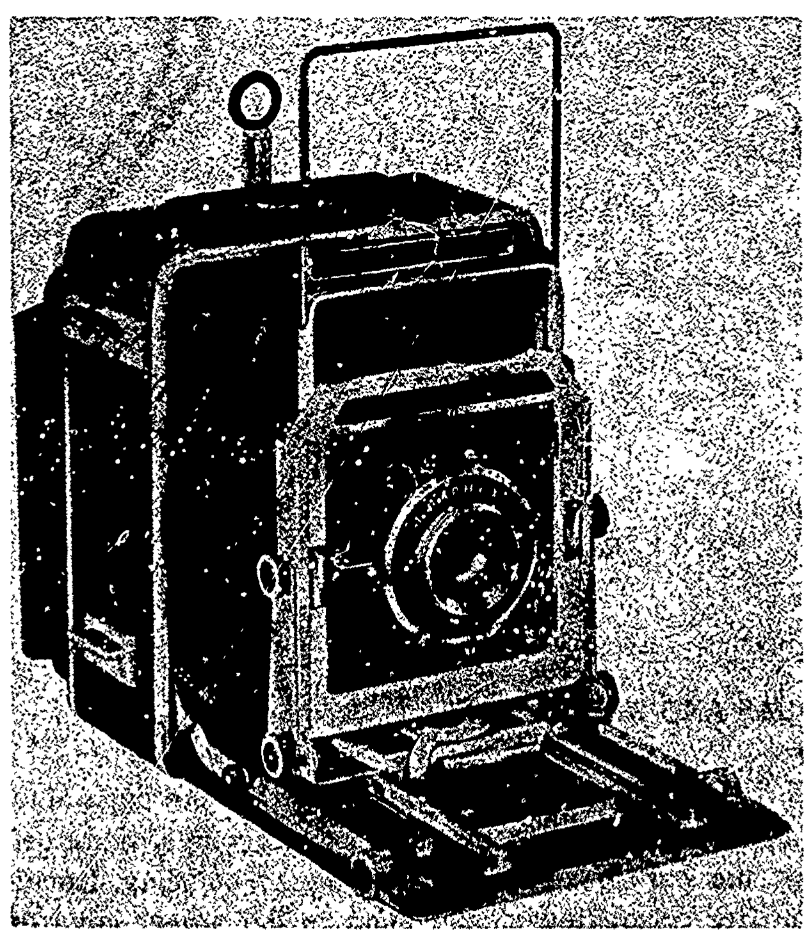
This device is used to deliver commands and give instruction to men working at fires, or at the training tower; see Figure 45.

Courtesy Motorola Inc.

Fig. 45 - Voice Power Megaphone

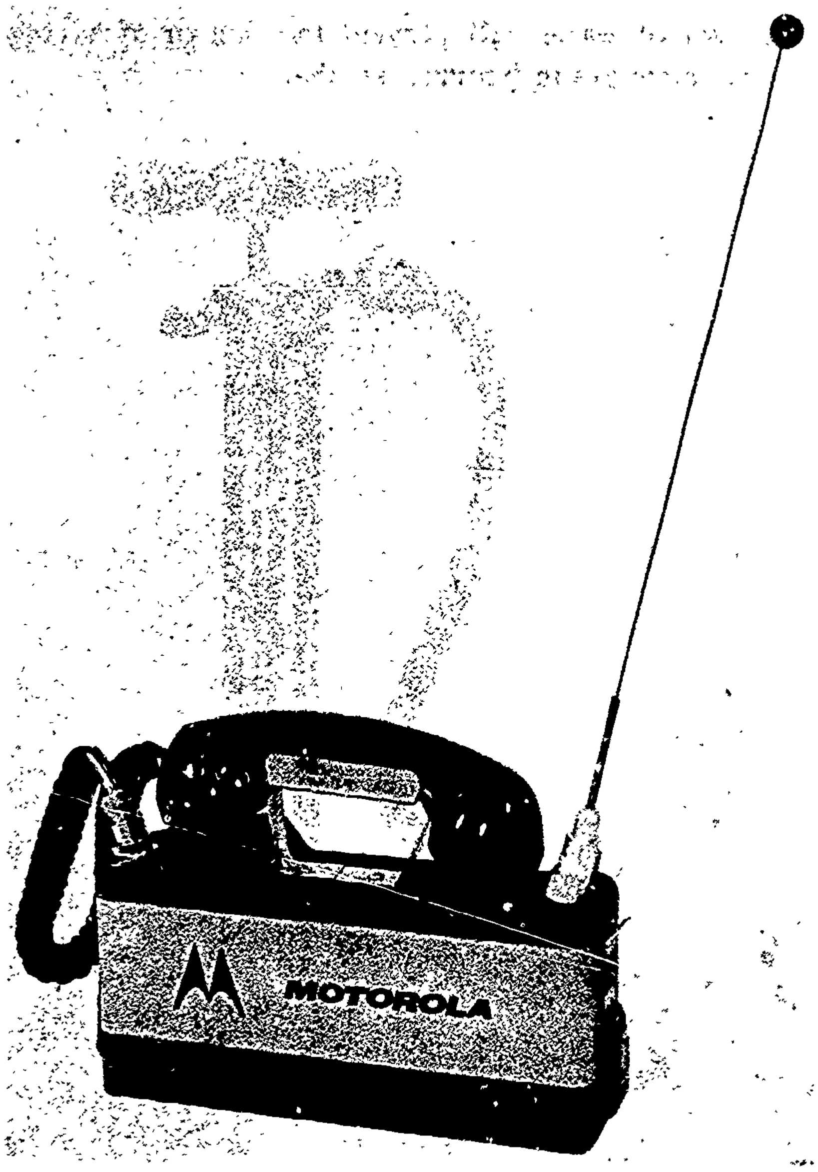
CAMERA

Today, many departments carry a camera on their apparatus. They are used to take pictures of fires of suspicious origin. They may also be used in fire prevention, condemnation proceedings and training activities. They should have a flash attachment and be simple to operate. The camera, extra film and flash bulbs should be carried in a protected area. See Figure 46.



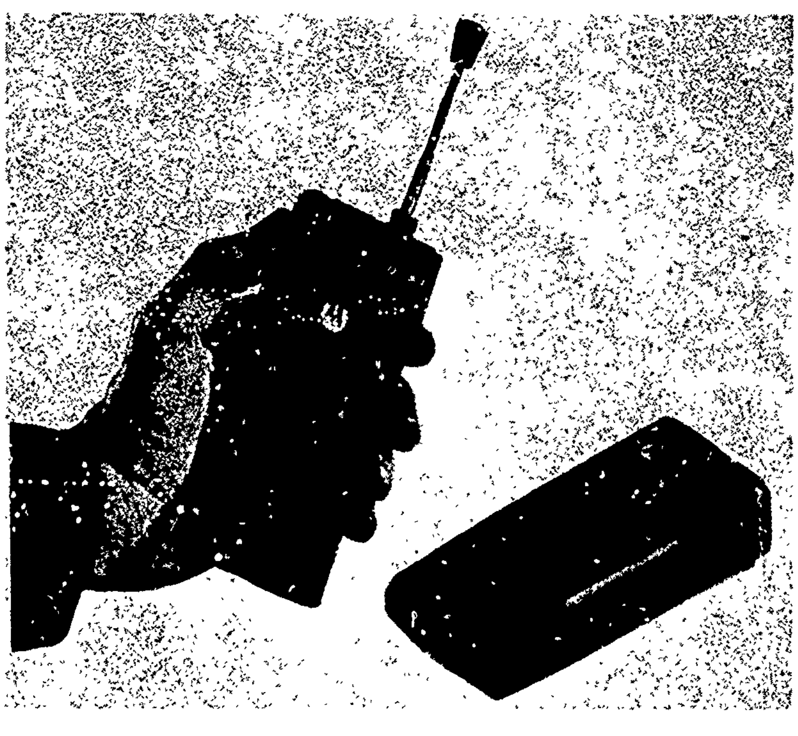
Courtesy Graflex, Inc.

Fig. 46 - Graphic Camera



Courtesy Motorola Inc.

Fig. 47 - Walkie-Talkie Radio



Courtesy Motorola Inc.

Fig. 48 - Pocket Transmitter and Receiver

THE WALKIE-TALKIE AND POCKET TRANSMITTER

The walkie-talkie and the pocket transmitter and receiver are used by many departments. By their use, the chief can be in contact with his officers in the fire area. They save time and eliminate errors in giving or receiving orders. See Figures 47 and 48.

HOSE EXPANDER

Hose expanders are used in the repair of hose. Some are hand operated, while others are of the hydraulic type, operated by an electric motor. Figure 49 shows the hydraulic type while Figure 50 shows the hand operated type.

To operate, a brass expansion ring is inserted in the hose and the coupling is fitted over the outside.

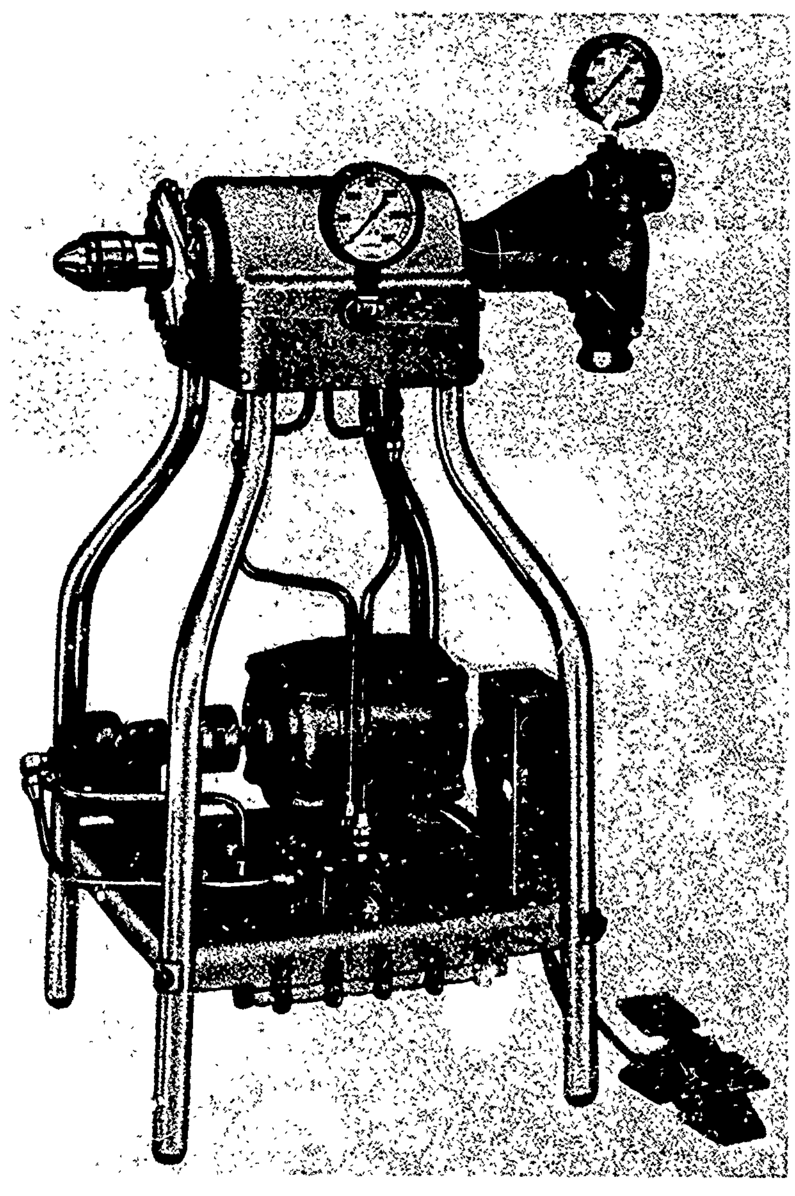


Fig. 49 - Hose Expander -- Hydraulic Type

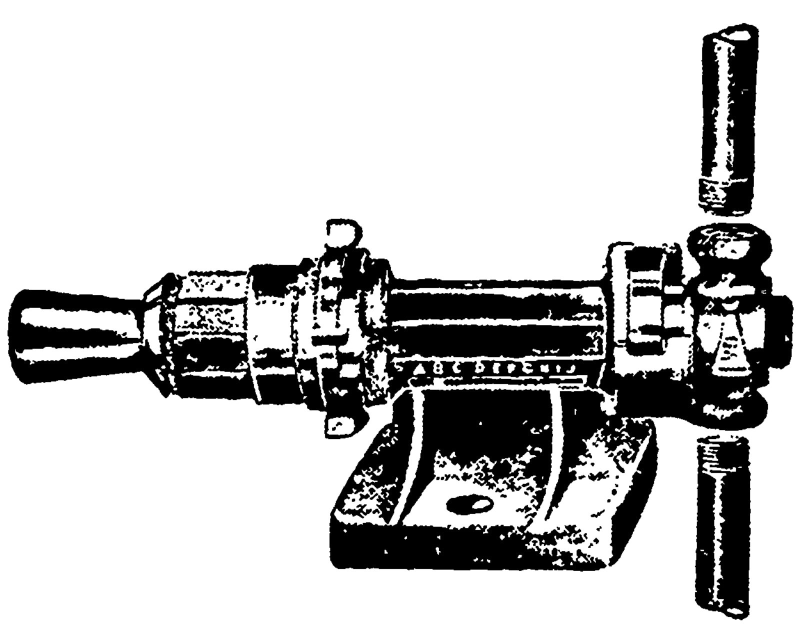


Fig. 50 - Hose Expander -- Hand Type

The ring and coupling are then placed over the expander and the lever of the expander turned to expand the brass segments. Pressure is then applied either by hand or with the electric motor depending on the type. The hose expander should be kept clean and the moving parts lubricated.

HYDRANT PUMP

A hydrant pump, as shown in Figure 51, is used to remove water from the barrel of a fire hydrant. The removal of water will prevent the danger of having frozen hydrants in freezing weather.

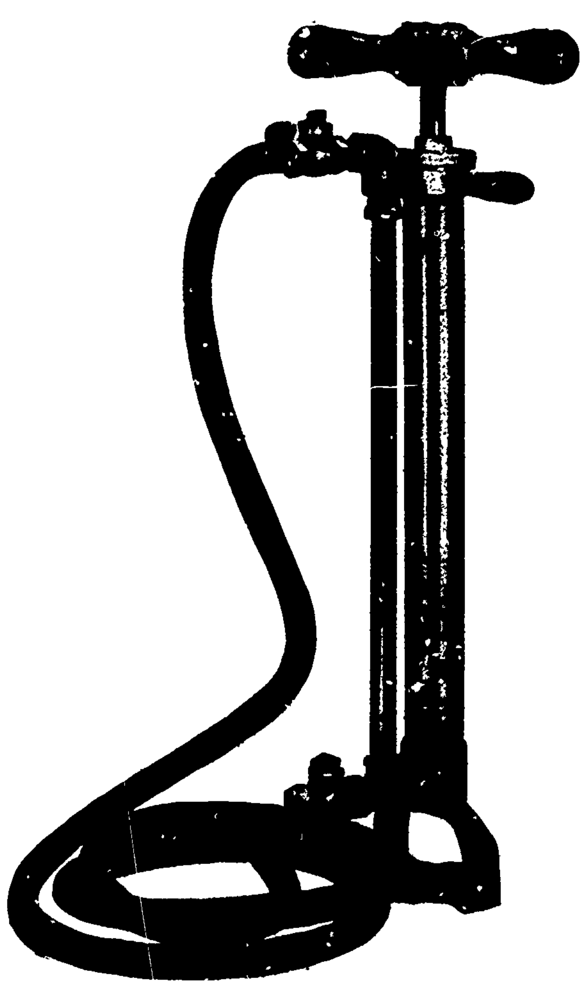


Fig. 51 - Hydrant Pump

CHAPTER 10

ROPE IN THE FIRE SERVICE

INTRODUCTION

In the fire service, rope is one of the most important pieces of equipment that a department can have. Many departments, unfortunately, do not have the proper complement of rope; other departments that do have the proper selections have let their ropes become unserviceable or have put them away where they are almost inaccessible. This chapter provides information on the construction, types and strength of rope as well as data on the various uses of rope, rope coiling and principles of rope splicing.

Many knots and hitches are used in the fire service. Several of the common knots and hitches, such as the half-hitch, square knot and sheep shank are basic to most departments and are standardized over the entire service. With the aid of an instructor and the material and illustrations on knots, bends and hitches in this chapter, firemen can become proficient in knot tying and usage.

ROPE - GENERAL INFORMATION

CONSTRUCTION

Although rope is made of different fibers, manila, sisal and hemp are used most extensively in the fire service. Manila comes from the abaca plant or wild banana of the Philippine Islands. A plant commonly known as henequin, a sort of palm from Yucatan, produces sisal fiber. Hemp comes from the annual hemp plant which grows in many parts of the world, especially in Italy, Russia and the United States. Rope is made by first twisting fibers together to make a yarn. The yarns are then twisted together to make a strand and the strands are twisted together to make a rope. It is reversing the twist at every step of building up a rope that locks it together. The twist in one direction offers an equal resistance to the twist in the opposite direction which balances the rope and keeps it in proper shape. The direction of twist is indicated by the terms "left hand" and "right hand" or, "with the sun." To determine the direction of twist, face and point a portion of the yarn or strand of rope toward the sun. If the direction of twist is the same as that of the sun's motion it is said to be "right hand" or "with the sun," but if it is in the opposite direction it is said to be "left hand."

Rope has a tendency to untwist and lengthen if a weight is suspended from its end. Because of this tendency, it is recommended that new rope be hung from a tower several days with sufficient weight attached to stretch it before use. This stretching can be done by fastening the top end by clamping, then attaching a weight to a clamp at the lower end of the rope. This does away with the kinking of the rope at both ends by making a tie in the rope itself. See Figure 1a and 1b. Rope may also be straightened by

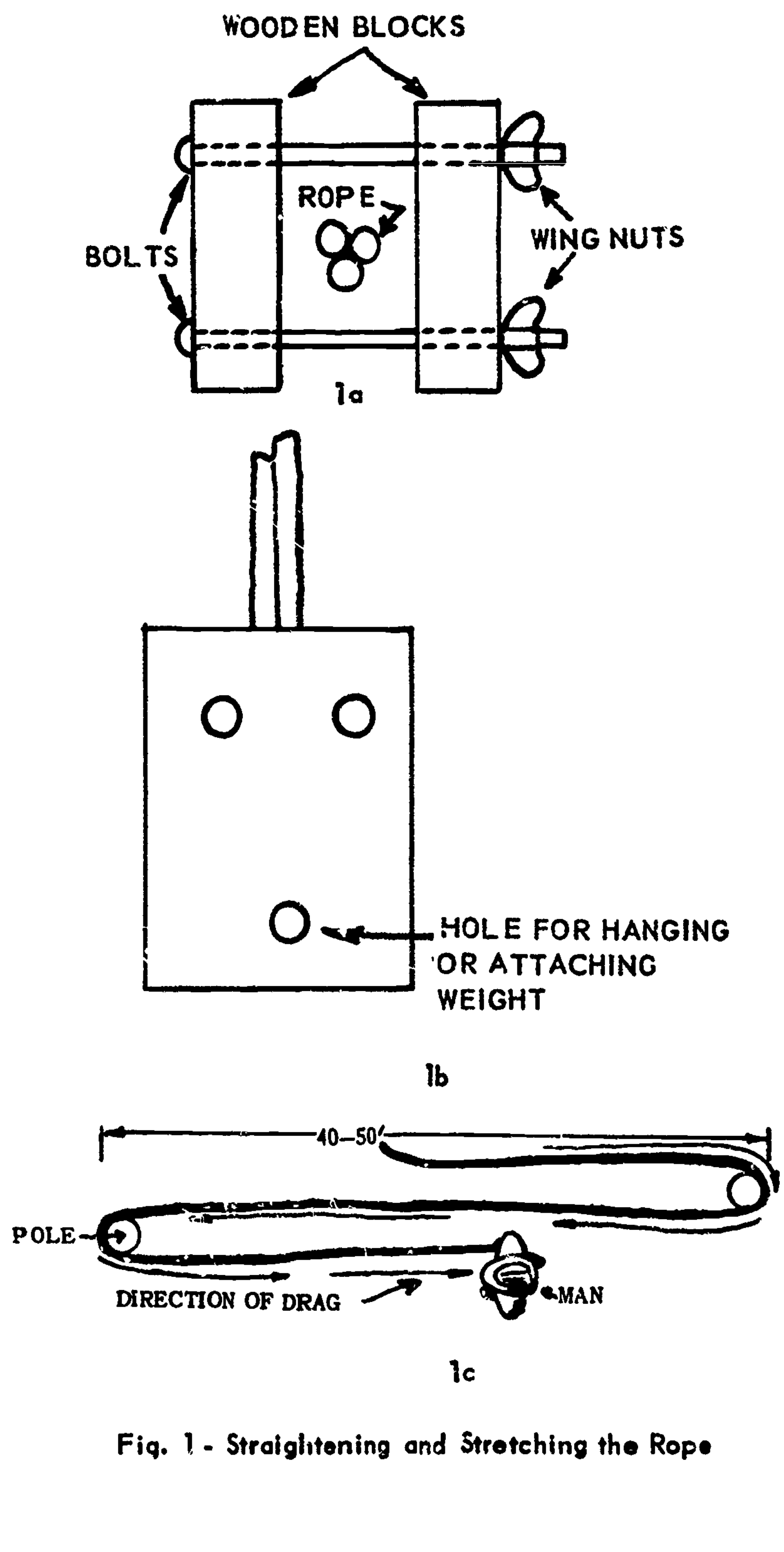


Fig. 1 - Straightening and Stretching the Rope

having a man walk back and forth around two stationary poles, dragging the rope until it straightens out. See Figure 1c.

A rope so treated will handle much easier when put into actual service. Figure 2 shows the manner in which this tendency to untwist and lengthen is overcome. A number of fibers are twisted in a "right hand" direction as shown at C. From two to twenty yarns are formed "left hand" into a hawser-laid rope as shown at A. In each of these successive steps, the twisting has been in opposite directions. As soon as the rope, as a whole, begins to untwist, the individual strands forming it are twisted tighter. The rope can untwist only far enough to bring these opposing forces to an equilibrium.

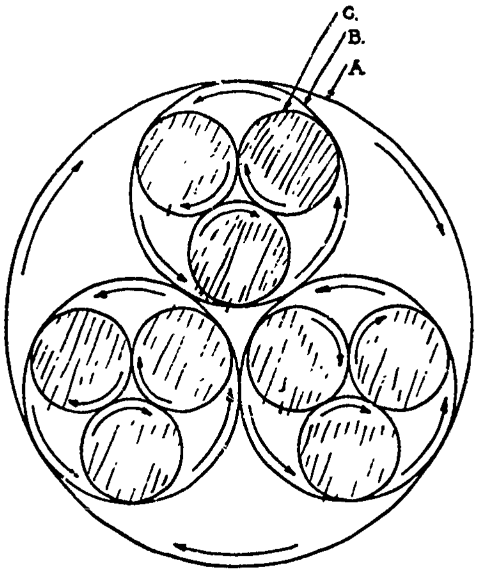


Fig. 2 - Twisted Rope

TYPES OF ROPE

Three strands laid up in a "right hand" direction, as shown in Figure 3, form a hawser-laid rope. Four strands laid up in a "right hand" direction, having a central core as illustrated in Figure 4, form a shroud-laid rope. Three hawser-laid ropes laid up in a "left hand" direction form a cable-laid rope.

Most of the rope used in the fire service is hawser-laid. The principal use of shroud-laid rope is for power transmission. Larger ropes used in well drilling and mining are cable-laid.

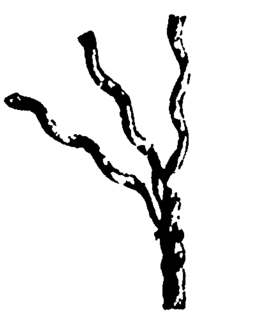


Fig. 3 - Hawser-Laid Rope

Fig. 4 - Shroud-Laid Rope

SIZE OF ROPE

Rope of all kinds is usually described by giving its diameter in inches. Rope is purchased by giving the diameter and the number of feet desired but is sold by the pound. The size of a given type of rope is varied by changing the number of yarns in a strand.

STRENGTH OF ROPE

In choosing rope for a given purpose, a large measure of safety should be used. As an example, to elevate 775 pounds at a time, do not select a rope with a maximum or breaking strength of 775 or even 1,000 pounds but rather one with about seven times times this amount of breaking strength.

Figure 5 shows the breaking strength of a new 7/8" manila rope to be 5,440 pounds. One-seventh of 5,440 pounds is 777 pounds, or about the same as the load to be lifted. Therefore, a 7/8" rope is the proper size for the present problem.

For a new manila rope, the breaking strength in pounds may be roughly calculated as follows: Square the diameter in inches and multiply the product by 7,200. The safe load can be found by dividing the breaking strength by seven.

Exposure and wear are the most important factors in deteriorating the strength of rope and a liberal allowance should be made for both when estimating the strength of old rope for any purpose.

INSPECTION OF ROPE

A length of rope may appear badly worn on the outside and still be much better than another length which looks good on the surface. Chafing occurs in rope by the inner fibers rubbing or chafing against each other, especially where a rope bends when going through a pulley. Many of the central fibers become broken into dust and short pieces. Because of this, rope should be checked each time after being used, for this check may save a life. In view of the many conditions that can affect the strength of rope, and since only a part of the rope may be affected, an examination of the entire length should be made at least once every six months.

If, upon examination, any of the following conditions are found to exist, and if the condition of the rope is such that there is any doubt as to its being safe to use, the condition should be reported to a superior officer.

On the surface of the rope:

1. Abrasions (broken fibers)

2. Cuts

Diameter Inches	Circumference Inches	Weight of 100 feet Pounds	Length of Each Pound Feet	Inches	Safe Load Pounds	Breaking Load Pounds	Diameter of Pulley Inches
3/16	9/16	2	50	0	35	230	1-1/2
1/4	3/4	3	33	4	55	400	2
5/16	1	4	25	0	90	630	2-1/2
3/8	1-1/8	5	20	0	130	900	3
7/16	1-1/4	6	16	8	175	1240	3-1/2
1/2	1-1/2	7-2/3	13	0	230	1620	4
5/8	2	13-1/3	7	6	410	2880	5
3/4	2-1/4	16-1/3	6	1	520	3640	6
7/8	2-3/4	23-2/3	4	3	775	5440	7
1	3	28-1/3	3	6	925	6480	8
1-1/8	3-1/2	38	2	7	1260	8820	9
1-1/4	3-3/4	45	2	2	1445	10120	10
1-3/8	4-1/4	58	1	8	1855	13000	11
1-1/2	4-1/2	65	1	6	2085	14600	12
1-3/4	5-1/4	97	1	0	3070	21500	14
2	6	113	0	10	3600	25200	16
2-1/2	7-1/2	184	0	6-1/2	5630	39400	20
3	9	262	0	4-1/2	8100	66700	24

Fig. 5 - Facts About 3-Strand Manila Rope

3. Extremely soft (badly worn rope is extremely soft and has lost its stretch)

4. Decay or burns (caused by high temperatures or chemicals)

To examine the inside of rope, separate the strands at three foot intervals and observe the inner parts for:

1. Broken fibers

2. Fine powder (indicates the presence of grit)

3. Mildew or mold

4. Change in color of the fibers

Rope should not be carried in a truck compartment that is damp or contains sharp-edged tools. It must always be carried coiled, ready for use.

USE OF ROPE

Because rope is such a necessary and important item of equipment, it should be carried on all apparatus and vary in number and size according to department requirements. Generally, the sizes vary from one-quarter inch to one inch and the length from 100 feet to 15^ feet.

There are a number of purposes for which rope can be used to good advantage, some of which are:

1. To operate the fly ladder on extension ladders

2. To hoist ladders, tools and appliances

3. As a life line in rescue work

4. To aid in maintaining fire lines

5. To lash ladders together to extend the length

6. For wrecking operation

7. As guy lines when hoisting equipment

8. As a permanently attached hoisting line on aerial ladders

KNOTS, BENDS AND HITCHES

A knot is a knob in a piece of rope which serves as a stopper or a button and is formed by interweaving the strands of the rope. A bend is a method of fastening one rope to another, to ring or loop, etc., by passing the rope through a loop and fastening it back upon itself. A hitch is a temporary knot or noose with which a rope is fastened around a timber, pipe,

or post in such a manner that it can be easily untied. These definitions or distinctions are very loose in their application, and it should be remembered that most of the knots ordinarily used are, strictly speaking, bends.

Knots stay tied due to the frictional resistance of the rope which prevents its parts from slipping and thus untying the knot. A knot or hitch must be so devised that the taut part of the rope bears on the free end in such a manner as to pinch and hold. In a knot, the free end is held against another part of the rope; in a hitch, against the object to which the rope is attached.

The usefulness of a knot should be judged by the following essential factors:

1. Rapidity with which it can be tied

2. Ability to hold fast when pulled tight

3. Ease with which it can be undone

In forming knots, bends and hitches, the rope used assumes the following shapes which are described as the "round turn," the "open bight" or "loop," and the "bight," as shown in Figures 6, 7, and 8, respectively.

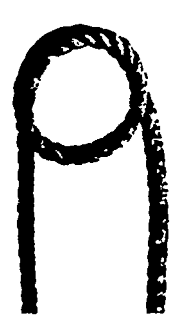


Fig. 6 - Round Turn

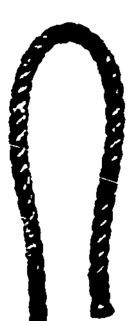


Fig. 7 - Open Bight

Fig. 8 - Bight

EFFECT ON THE STRENGTH OF ROPE

Rope has its maximum strength when the strain from a load is applied evenly to all fibers. When a knot is tied in a length of rope, the weakest part of the rope is at the knot. In all knots, some more than others, the rope is cramped or has a very short bend which throws an overload on those fibers that are on the outside of the bend. This causes the fibers to break, and the rope will part. The shorter the bend, the less the tensile strength of the rope. The following list shows the decrease in tensile strength according to various knots:

1. Square knot - 50%

2. Bowline - 40%

3. Clove hitch - 35%

4. Short splice - 20%

WHIPPING THE END OF THE ROPE

The end of a rope that is to pass through pulleys or other small openings should be finished by whipping. The whipping is done with a very stout linen or cotton cord as follows: Make a loop in one end of the cord, hold the loop along the rope as shown in Figure 9a, and wrap the long end B of the cord tightly around the rope in the same direction in which the strands are twisted, as in Figure 9b. When within about ½ inch of the end of the rope, slip the end of B cord through the loop, as shown in Figure 9c. With the end A, pull the loop beneath the whipping as far as possible, as shown in Figure 9d. Both ends may now be cut close to the rope. The finished end is shown in Figure 9e.

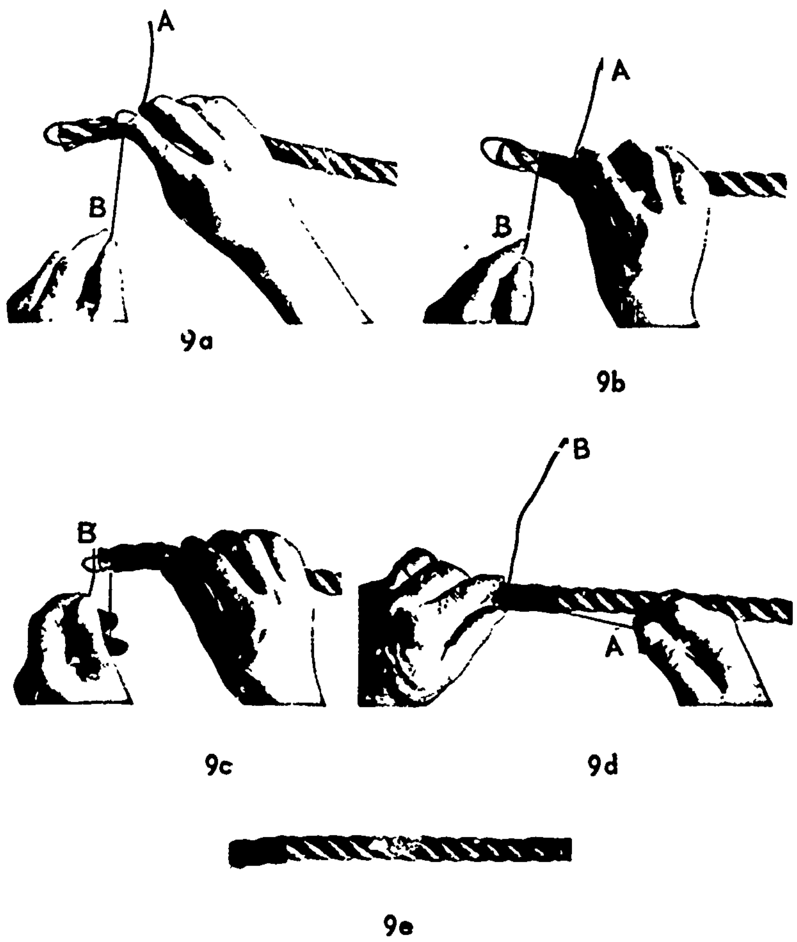


Fig. 9 - Whipping the End of the Rope

THE HALF-HITCH

Of all the hitches, the "half-hitch" is most widely used, both alone and in combination with a variety of other knots. It is very easy to make. As shown in Figure 10, the rope is fastened to a timber by a single half-hitch. In tying the half-hitch, the free end of the rope is brought around the tension end and then brought under itself.

Fig. 10 - Half Hitch

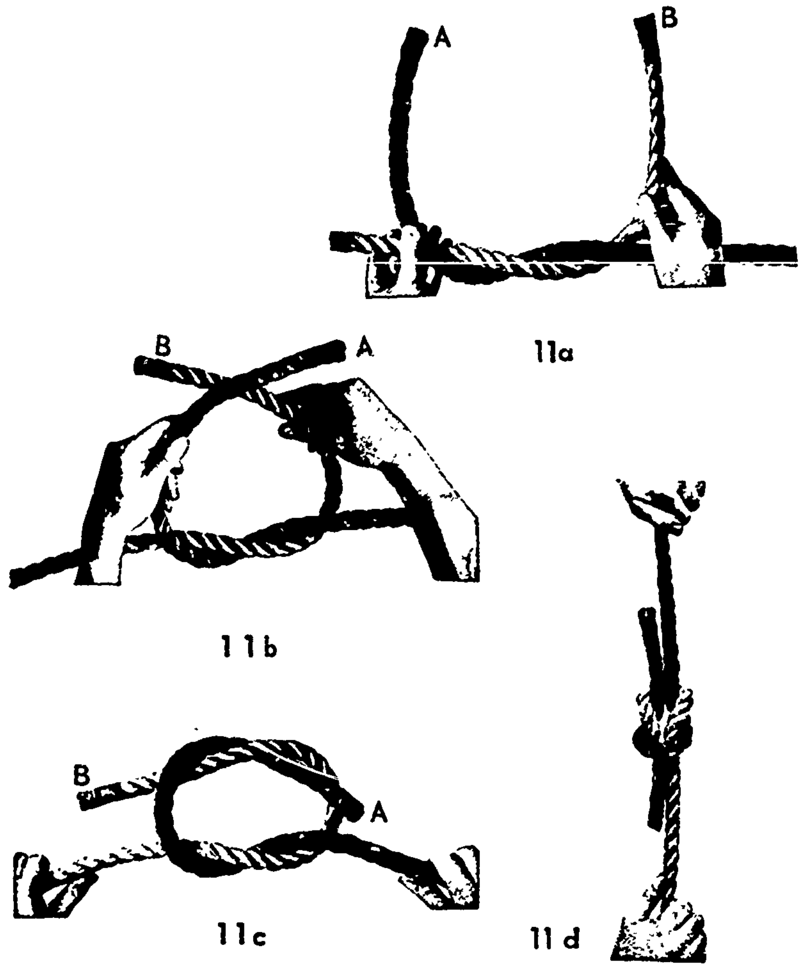


Fig. 11 - Tying a Square Knot

THE SQUARE KNOT

The square knot is used in tying two ropes of the same size together. It will not slip when drawn tight and is easily untied. It is tied as follows: Bring the two ends together and cross them as shown in Figure 11a. Place end A across B as shown in Figure 11b, and then move A around B as shown in Figure 11c. Care should be taken that the knot is tied and assumes a final shape as shown in Figure 11d, otherwise a granny knot rather than a square knot will result. See Figure 12. Be sure to observe this difference.

Fig. 12 - Incorrect Square Knot (Granny Knot)

THE CLOVE HITCH

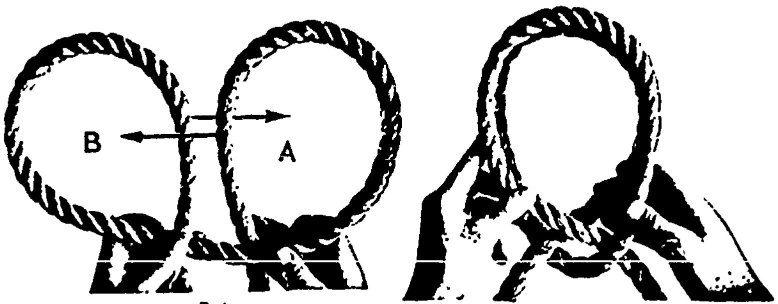
The clove hitch is used to fasten a rope to a stake, pipe or pos' It is the hitch commonly used in the fire service for raising or lowering small equipment. It may be tied by using either of the following two methods:

First Method - Give one end of the rope two turns around the post, cross over the long portion and place the short end beneath the second turn, as shown in Figures 13a and 13b.

Second Method - Throw one bight in the rope to the right and another to the left, as shown in Figure 14a. Move bight A over on bight B as indicated by the arrow and shown in Figure 14b. Place the hitch over the end of the object and pull the long end in any direction.

13a 13b

Fig. 13 - Clove Hitch Around Post



14a 14b

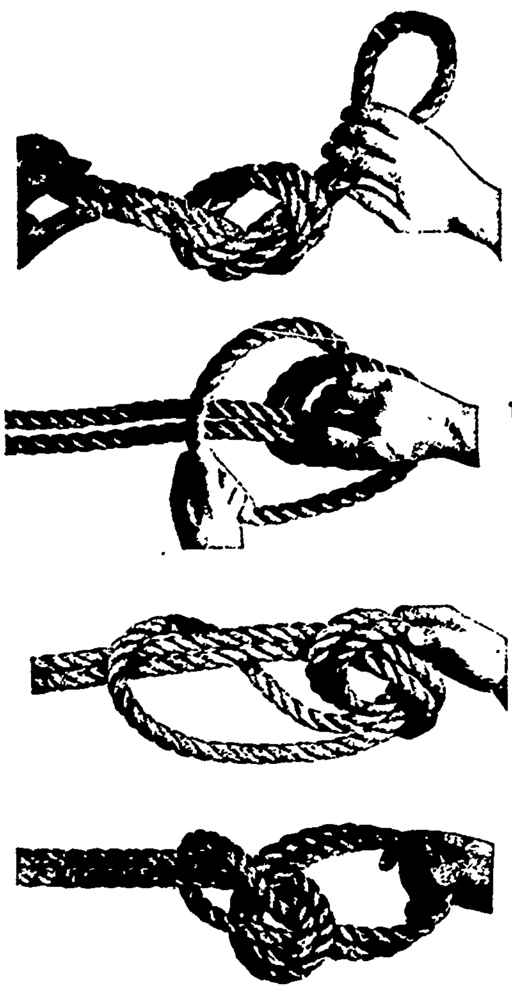
Fig. 14 - Slip-over Clove Hitch

THE BOWLINE

The bowline has been rightfully called the king of knots. See Figures 15a - 15e. This knot is probably used more than any other in the fire service, for it never slips and is always easily untied. It can be used wherever a loop is desired in the end of a rope. It may be tied as follows: Place the end of the rope through a ring or around an object. Throw a bight, having the long portion of the rope on the side of the bight nearest you, as shown in Figure 15a. Move the end of the rope through the bight in the direction shown in Figure 15b. Bring the end of the rope around the long portion, as shown in Figure 15c. Next, push the end of the rope up through the bight, as illustrated in Figure 15d. The finished knot is shown in Figure 15e.

THE BOWLINE ON A BIGHT

The bowline on a bight is used to form a loop at some point on a rope other than at the end. Like the ordinary bowline, it is easily untied. It is made as follows: Tie an overhand knot in a doubled portion of the rope, as shown in Figure 16a. Bring the loop back over the knot, as shown in 16b, and then pull the loop out through the knot as shown by the hand in 16c. The finished knot is shown in 16d. This knot is extensively used for rescue work and also to form a saddle sling for lowering men into manholes and similar places.



16a 16b 16c 16d

Fig. 16 - Bowline on a Bight

15a 15b 15c 15d 15e

Fig. 15 - Bowline

THE CHIMNEY HITCH

The chimney hitch, shown in Figure 17, is used to obtain a tight line, to secure hose, hose roller or some similar object. It is made as follows: After the free end of the rope is passed around an object, it is brought back alongside the standing line. The free end is' then passed over the standing line and between the lines. This is repeated, but on the third time around, the free end is cinched in behind the first turn. A "safety" or "binder" is then put out in front on the single line. The entire knot, thus formed, can be slipped along the main rope to take in or let out slack, and it will hold its position wherever set.

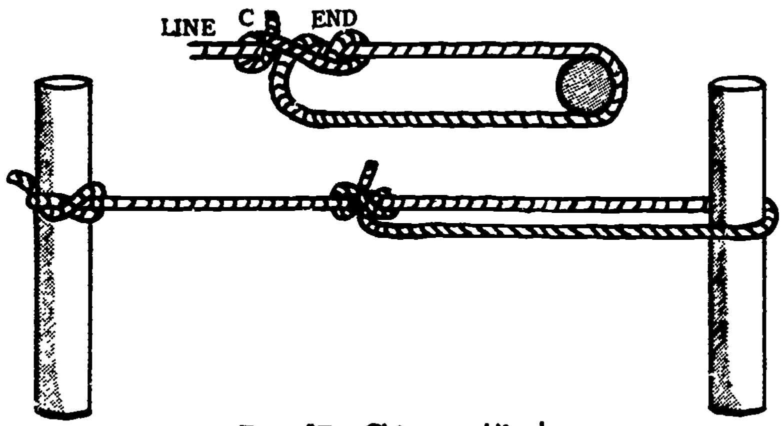


Fig. 17 - Chimney Hitch

THE SHEEP SHANK

The sheep shank, shown in Figure 18, is a hitch used to temporarily shorten or strengthen a defective section of rope. It is tied in the following manner: Make two loops in the rope as shown in Figure 18a. Make a bight in the main part of the rope near the loop A. Push A through this bight, as shown in Figure 18b. Likewise, make a bight in the main part of the rope near loop B through this loop. The completed hitch is shown in Figure 18c.

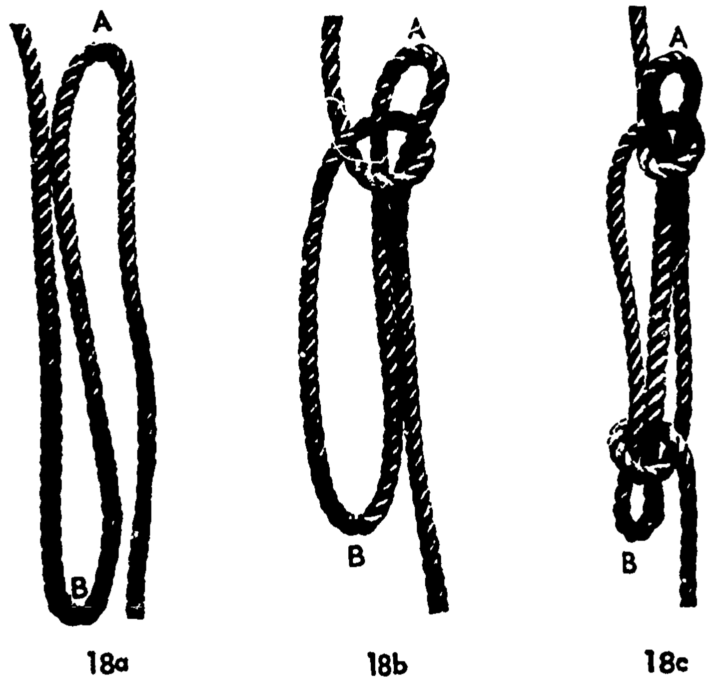


Fig. 18 - Sheep Shank

THE BECKET KNOT

This tie is usually used to fasten two ropes of different sizes together. The procedure is shown in Figure 19. Make an open bight with large rope A. Take small rope B around back of rope A, bring rope B over rope A and pass beneath original rope B. Draw knot tight.

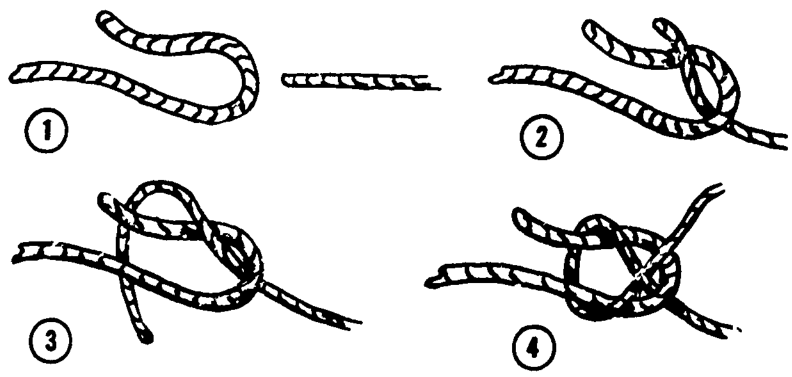


Fig. 19 - Tying a Becket Knot

THE RUNNING BOWLINE

This tie is used to take the strain off couplings on hose going up the side of a building. The bowline is slid down the hose to approximately 6 inches below the coupling, drawn up tight, and the rope is then tied off to hold the weight of the hose. This tie may be used anywhere that a slip noose is needed. Step-by-step procedure for the running bowline is shown in Figure 20. Place the rope around the hose and make an open bight around the standing line, make a bight in the main rope, pass the end of the rope from beneath the bight, continue the end around back of the main rope and pass it down through the bight. Pull knot up tight and the running bowline is completed.

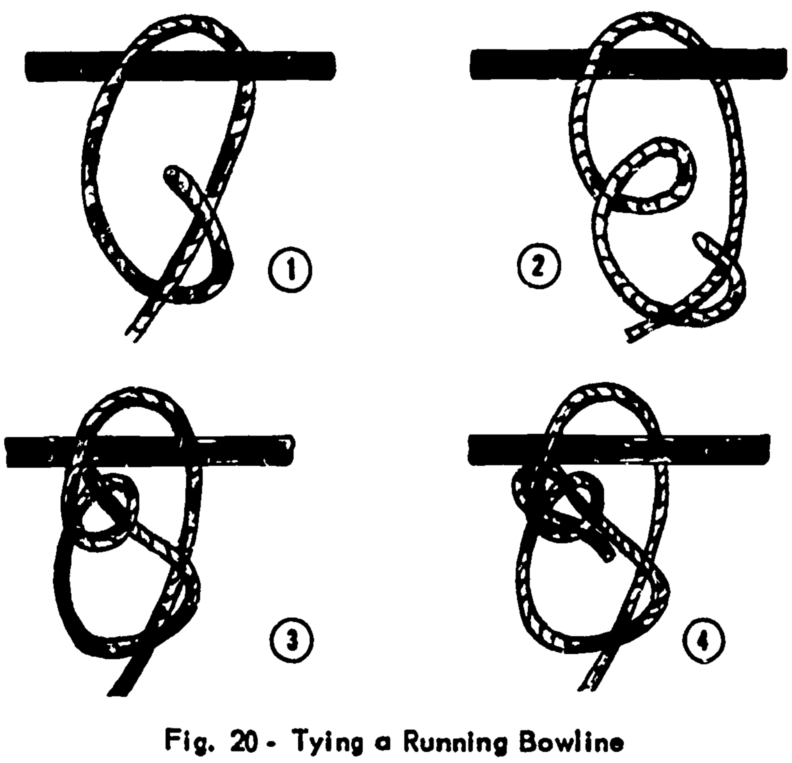


Fig. 20 - Tying a Running Bowline

ROPE SPLICING PRINCIPLES AND TECHNIQUES

It has been found that a rope that breaks usually has weak spots other than at the point at which it broke. Rope that has become weakened in small areas can be reclaimed by removing the weak portion and splicing the remainder together. Only in case of dire need should a rope be spliced for use in the fire service. For general use of rope, other than for emergencies, they may be spliced. This section will be devoted to describing how to follow the principles of rope splicing, which are:

1. Unlaying the strands
2. Placing the ends together
3. Tucking the ends of the strands

The two splices described are the short splice and the long splice. In each of them, and in the spliced crown which is also described, the ends of the strands are tucked in exactly the same way. Therefore, if the making of one splice is mastered, the others are easily learned.

THE SHORT SPLICE

Where it is not necessary for a rope to pass through a small pulley, or where only a small amount of rope can be spared for making a splice, the short splice is very satisfactory as it is as strong as the long splice. The method of making it is as follows: Count seven turns of the strands from the ends to be spliced and tie strings around the ropes at these points. One turn of a rope is that part shown in Figure 21a at A. Unlay the ends back to the points where the strings are tied, as shown in Figure 21a.

Before placing the two parts together, be sure to open each end as shown in Figure 21b *and not as shown in Figure 21c*. That is, not a strand should cross between the other two. Bring the two parts together so that each strand of one part altemates with a strand of the other as shown in Figure 21d. With a string, tie one set of strands around the rope, as shown in Figure 21e at A. Next, begin tucking the strands from the left side by bringing a strand from the right side down under the next, as shown by the marline spike in Figure 21e. The tucking should be done at right angles to the direction of twist in the rope. Give each of the other two strands from the left one tuck in exactly the same manner. The splice should now appear as shown in Figure 21e. Next, cut the cord shown in Figure 21f at A and give each strand from the right side one tuck, just as was done with the strand from the left. Figure 21g shows all the strands tucked once. Give each of the six strands two more tucks, always remembering to bring the strands to be tucked over the one nearest to it and under the second, in a direction about at right angles to the direction of the twist in the rope.

Next, divide each strand into two parts, as shown in the left of Figure 21h. Give one part of each strand two more tucks. Cut all the ends off and roll the splice beneath the foot on the floor or between boards to give it a smooth appearance. The finished splice should appear as shown in Figure 21i.

THE LONG SPLICE

The long splice is more desirable than the short splice when it is necessary for the rope to pass through small pulleys. It also has a neater appearance. To make a long splice in a three-strand rope, count fifteen turns from the ends to be spliced and tie strings around the rope at the points thus determined. Unlay the strands back to the strings, as shown in the lower part of Figure 22a. Before bringing the two parts together, be sure to open each end as shown in Figure 21b of the short splice and not as shown in Figure 21c; that is, no strand should cross between the other two. Bring the two parts together, making each strand from one end alternate with a strand from the other, as shown in Figure 22a at A. Next, beginning at the point where the two parts are placed together, unlay one of the strands to the right. Lay carefully in its place the corresponding strands from the left. This latter operation should follow closely the unlaying of the strands to the right. Stop at five turns of the end of the strand from the left, as shown in Figure 22b at B. There are still two pairs of strands left at point A where the two ends were placed together. Run one of these pairs to the left exactly as the first pair was run to the right. This is shown in Figure 22c at C. Before starting to unlay toward C, Figures 22c and 22d fit together as a pair. Next, cut off all the long ends of the strands about five turns from the main rope, as shown in Figure 22d.

The next part of the splicing consists of tucking the ends of the strands. There are three strands. All are tucked in exactly the same way, which is as follows: Be sure that the ends of the strands pass each other as illustrated in Figure 22e at A and *not* as at B. Bring the strand from the right up over the nearest strand from the left and under the next strand, as in Figures 22f and 22g. Give the strand from the left one tuck, as shown by the marline spike in the upper part of Figure 22h. Each strand should now be given two more tucks in a direction almost at right

angles to the direction of twist in the rope as shown in Figure 22i. When all three pairs of strands have been tucked, cut the ends off and smooth by rolling beneath the shoe or between two boards. The finished splice should appear as shown in Figure 22j.

THE SPLICED CROWN

Where a slight enlargement is not objectionable, the spliced crown is a desirable way to finish the end of a rope. See Figure 23. It is made as follows: Unlay six turns of the rope. Form a loop in strand A, bringing the end between strands B and C, as shown in Figure 23a. Next, move strand C between the loop in strand A and strand B, as shown in Figure 23b. Pull strand B through the loop in strand A, as indicated in Figure 23c. Draw up tight the crown thus formed, as in Figure 23d. Give each strand one tuck by bringing it over the strand nearest to it and under the second as in rope splicing. This is shown in Figure 23e. Figure 23f shows the first tuck complete. Give each strand two more tucks and cut off the ends of the strands. Smooth the crown by rolling beneath the foot on the floor. The finished crown is shown in Figure 23g.

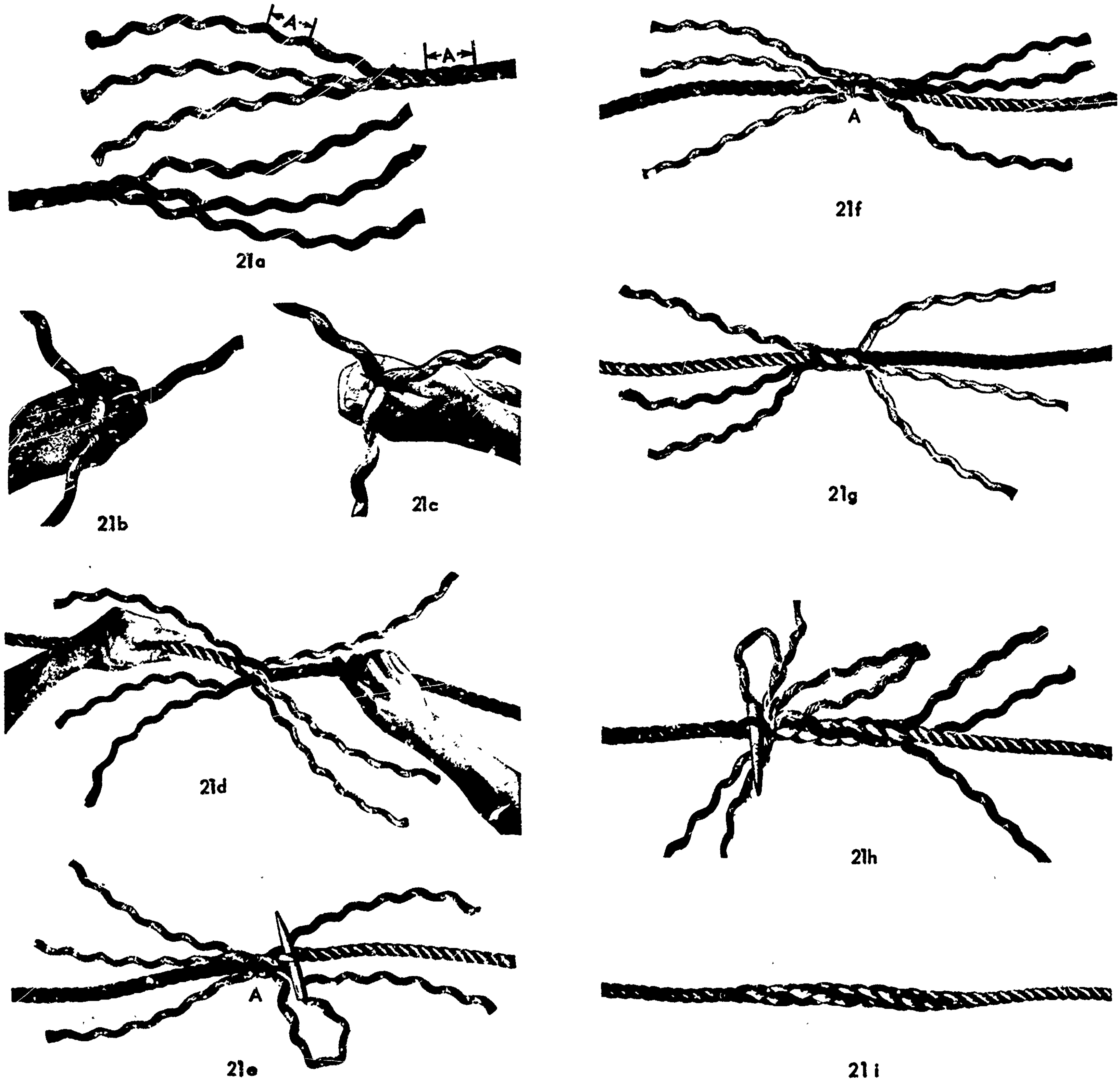


Fig. 21 - Short Splice

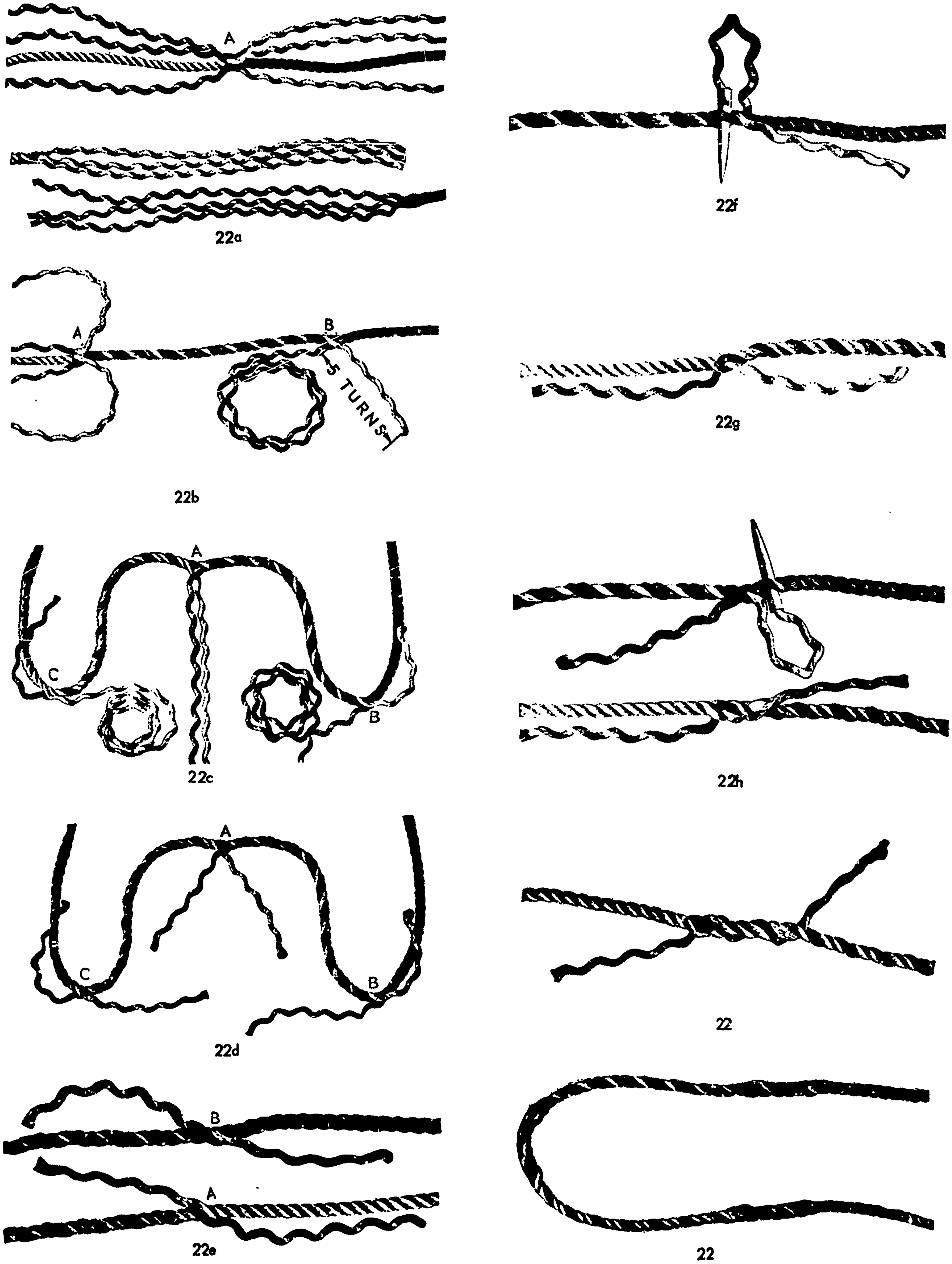


Fig. 22 - Long Splice

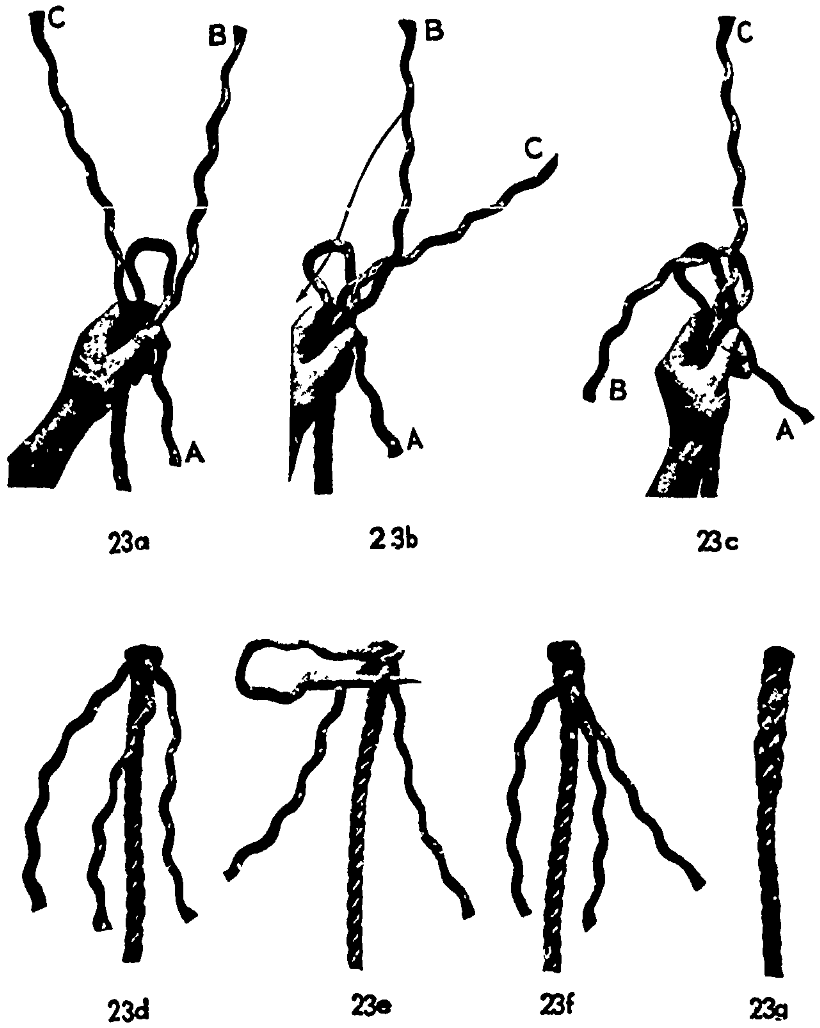


Fig. 23 - Spliced Crown

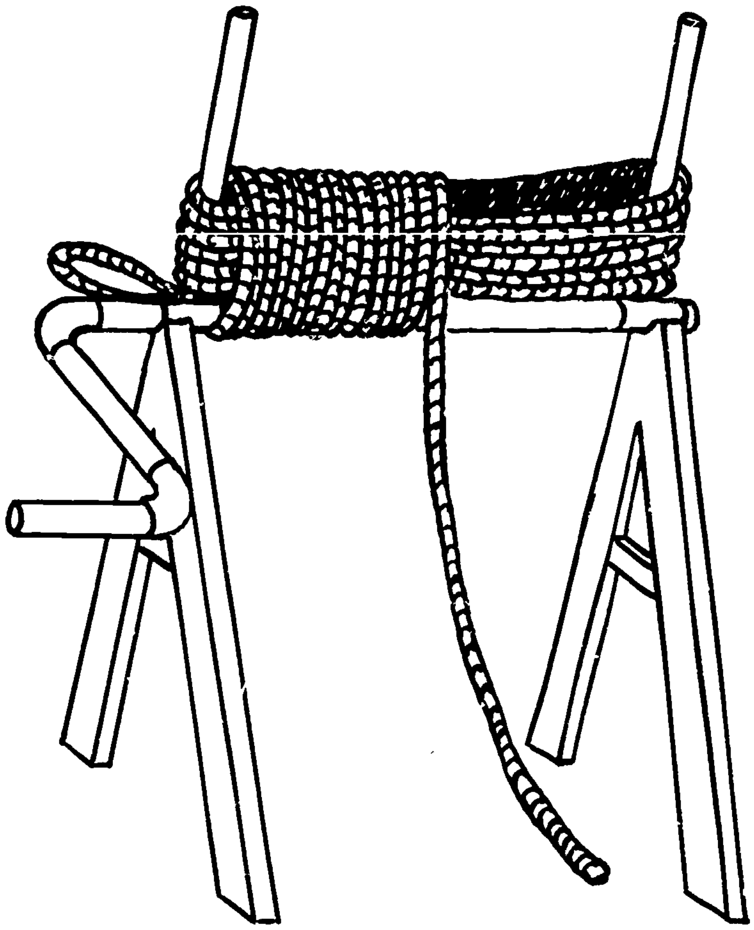


Fig. 24 - Rope Coiler

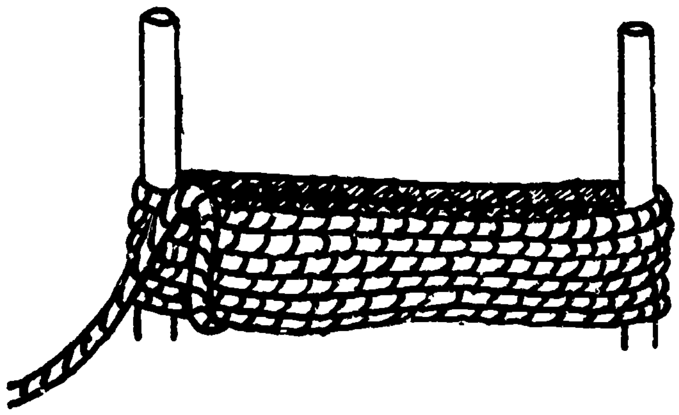


Fig. 25 - Begin to Coil

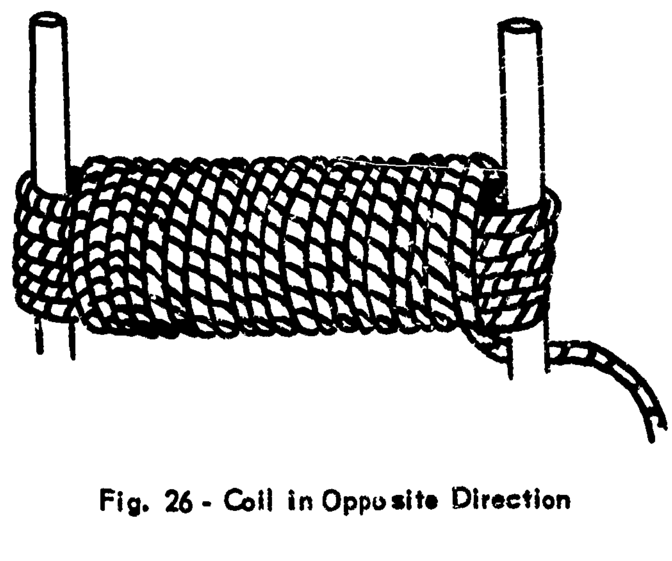


Fig. 26 - Coil in Opposite Direction

ROPE COILS

In the fire service, a knowledge of how to coil a rope correctly is essential. Many times an improperly coiled rope may result in the failure of an evolution.

COILING ROPE

In starting the coil, face the "coiler," but somewhat to the right. See Figure 24. Hold a short length of the free end of the rope inside the left coiler shaft with the heel of your left hand resting on the shaft. Take one short turn around the left shaft, then make long loops over and under both shafts.

Coil the rope around the shafts of the coiler until a sufficient amount of rope is used. See Figure 25. This amount can be determined only by trial. Next, coil the rope in the opposite direction, as shown in Figure 26, by turning the coiler in the frame. When the wrap is finished, as shown in Figure 27, remove the coiler shafts, handling the coil with care. Now double the remainder of the rope and pass the loop through the opening in the end of the coil, as shown in Figure 30, then through the opposite end of the

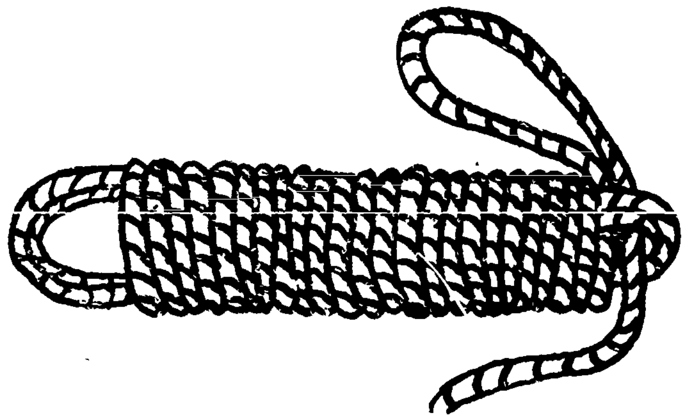


Fig. 27 - Finished Coil

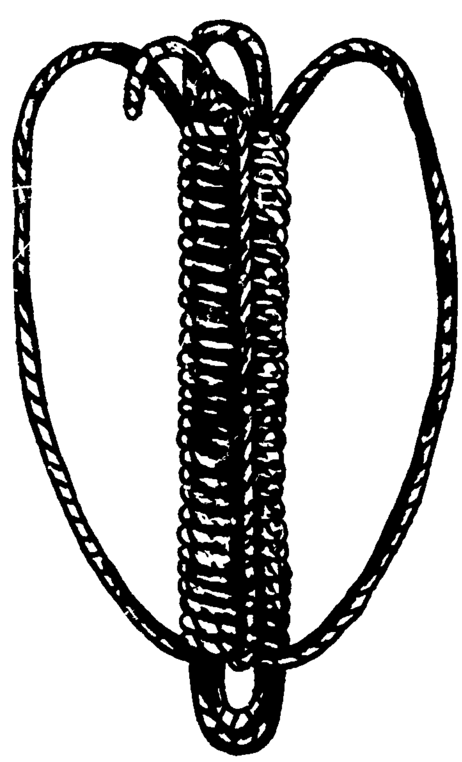


Fig. 28 - Coil Finished and Ready for Carrying

coil. Next, insert the loose ends of the rope through the loop end and pull the loop up tight. See Figure 28. If the lengths are right, the loops formed will be large enough to permit a man to load the coil on his shoulders, as shown in Figure 29. The shoulder loops may be adjusted by shortening the loose end of the rope. To undo the shoulder loops quickly, grasp the free end near the center of the coil and pull away from the coil, thus unlocking the end, and continue pulling until the shoulder loops come clear of the coil. This long end is dropped with the coil.

When dropping the coil from a height, grasp the inside free end and pull several feet out from the core. Retain this aloft. When pulling out on the ground, also pull out the core first. Figure 30 shows a method of making a convenient rope coiler. However, any type of coiler may be used.

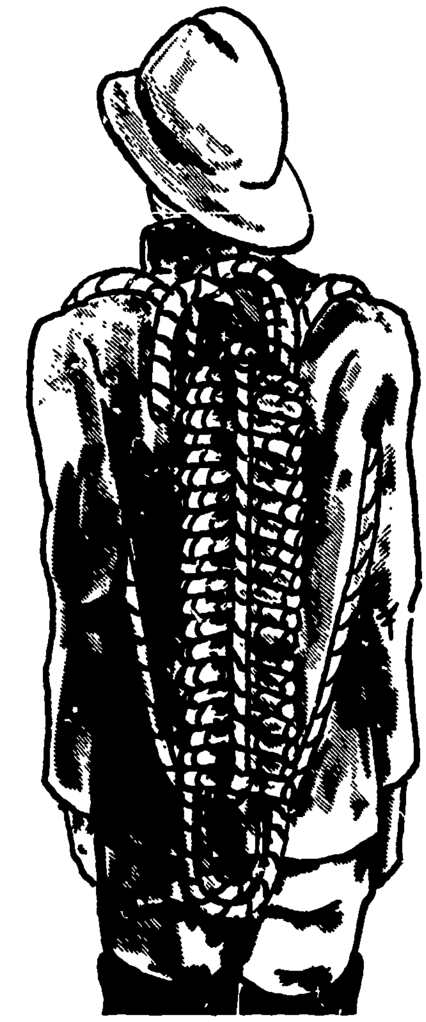


Fig. 29 - Carrying Coil

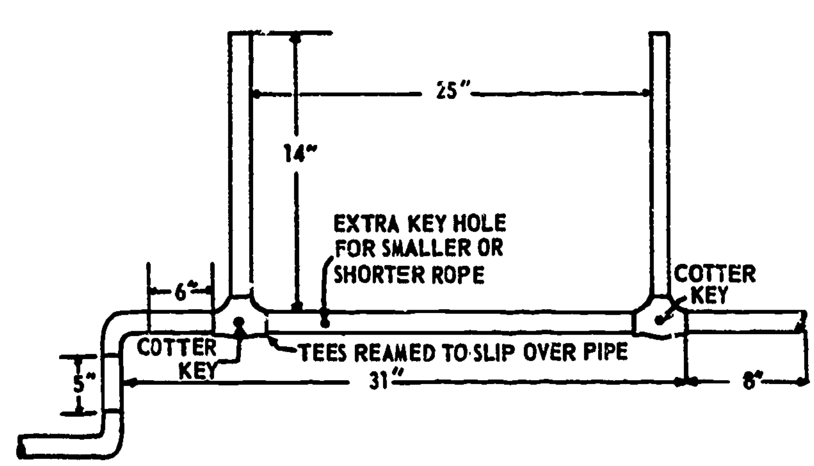


Fig. 30 - Detail of Rope Coiler

COIL FOR THROWING ROPE

At times it becomes necessary for a rope to be thrown from a roof, upper story, or over an object. There are several ways in which rope can be coiled for throwing. A good method is as follows: Coil several loops not over 18 to 20 inches long, like A in Figure 31. Carry the next loop through the slack and

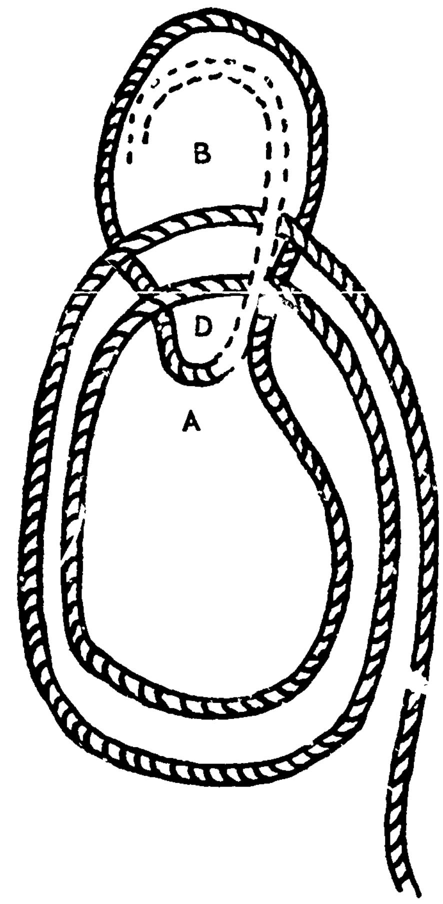


Fig. 31 - Coil for Throwing Rope

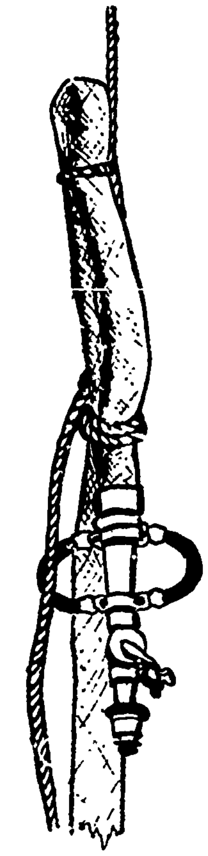


Fig. 32 - Hoisting Uncharged Line with Running Bowline

up to make loop B. Then hold loop B in the right hand with loop A hanging in loop B at D. Next, coil a series of small loops about 12 inches in diameter on top of loop B in the right hand. The rope is now ready to throw. Practice is necessary to throw accurately and to determine the amount of coiled rope necessary for the distance to be covered. Rope will straighten out completely on the throw.

SUPPLEMENTARY ILLUSTRATIONS OF KNOTS AND HITCHES

In the preceding section, detailed instructions were given on tying the various knots and hitches used in the fire service. Very little information was given, however, as to their actual use. Figures 32 to 38 illustrate actual usage of several of the knots and hitches as well as additional ways of making some of them.

The tackle knot shown in Figure 38 is a hitch used for pulling operations when blocks are not available or for stretching a tight line. If used for the latter purpose, the pull rope should be taken back and tied around both ropes A and B using the chimney hitch.

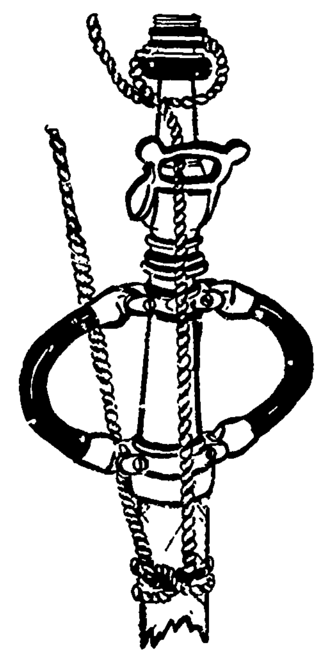


Fig. 33 - Hoisting Charged Line with Clove Hitch & Half Hitch - Method 1

For hoisting ladders with a bowline, follow the procedure in Figure 39. The tie is made at about one-third of the length of the ladder from the top end. Start rope around beam and out the front side and continue with rope around opposite beam bringing it out behind the cross rope. Next, a bowline is made with the hand next to the ladder while facing the top.

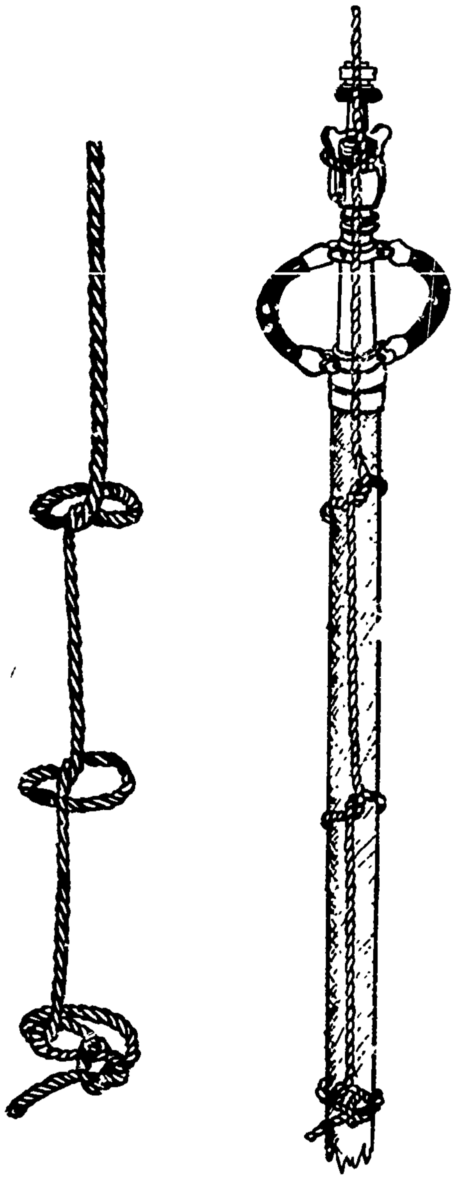


Fig. 34 - Hoisting Charged Line with Bowline and Half Hitches – Method 2

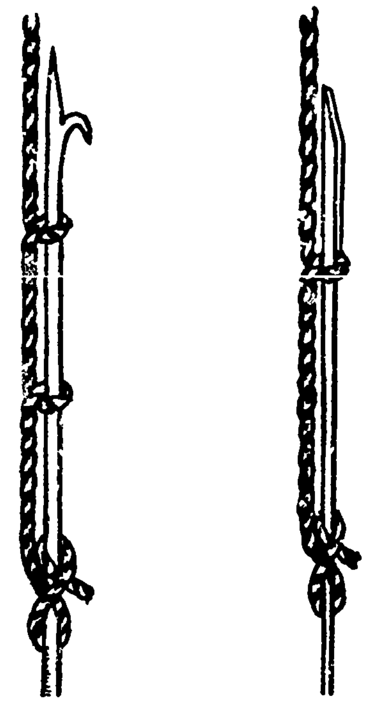


Fig. 36 - Hoisting Pike and Bar

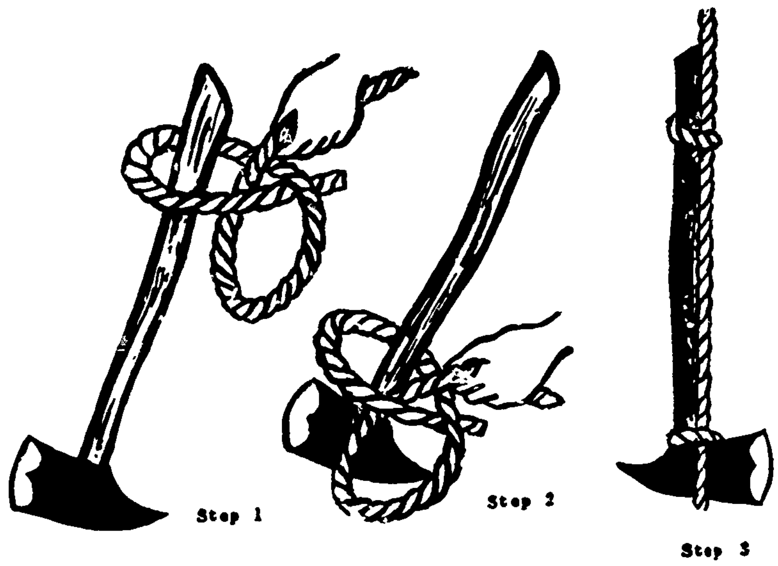


Fig. 37 - Hoisting Axe

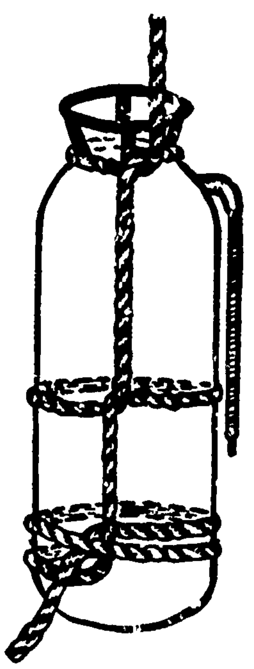


Fig. 35 - Hoisting Extinguisher

Pull the knot taut. It will lay just above the cross rope. When using this hoist, turn the ladder over so the knot is between the ladder and the building. When hoisting roof ladders the tie should be made on the third rung above center.

The rescue tie is used for raising or lowering a trapped person by use of a bowline on a bight and half-hitch. The legs are passed through the two loops and a half-hitch with standing line is placed around the body and under the arms. A bight is taken in the standing line in front of the chest and the free end of the rope is passed through from front to back. The standing line is then pulled tight to form a rescue knot as illustrated in Figure 40.

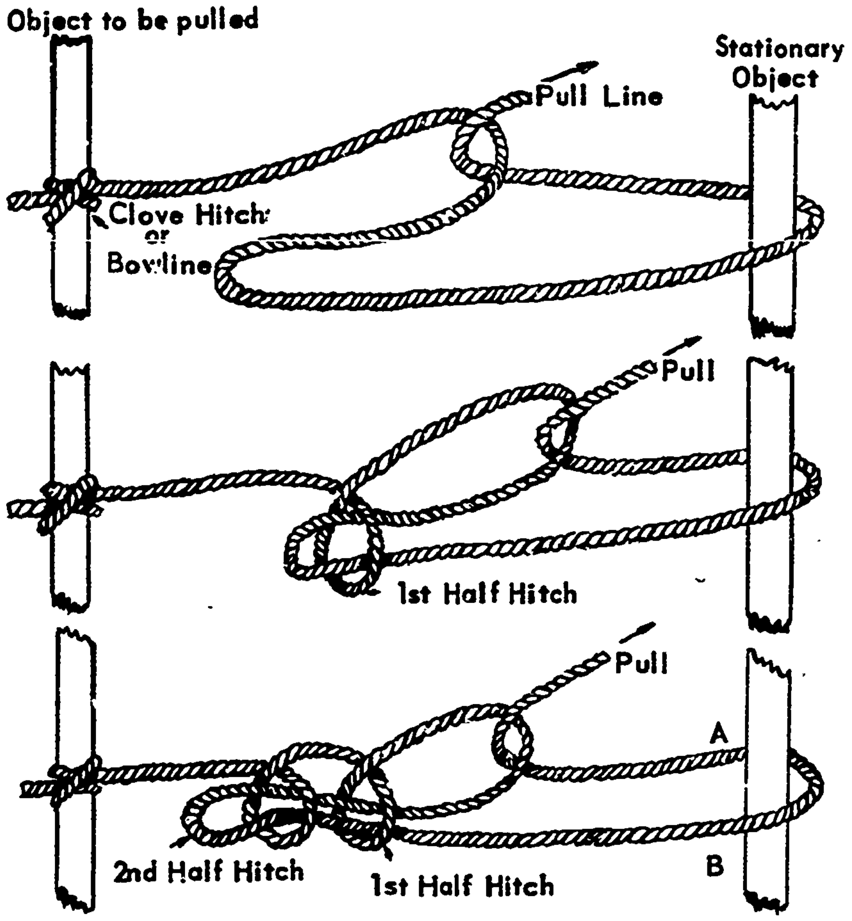


Fig. 38 - Tackle Knot

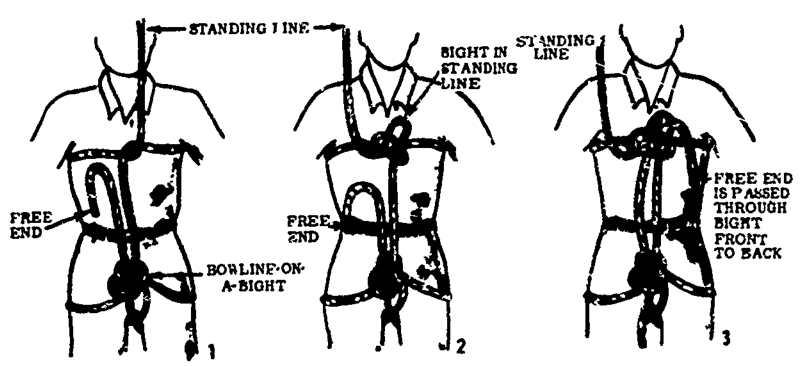


Fig. 40 - Body Tie for Rescue

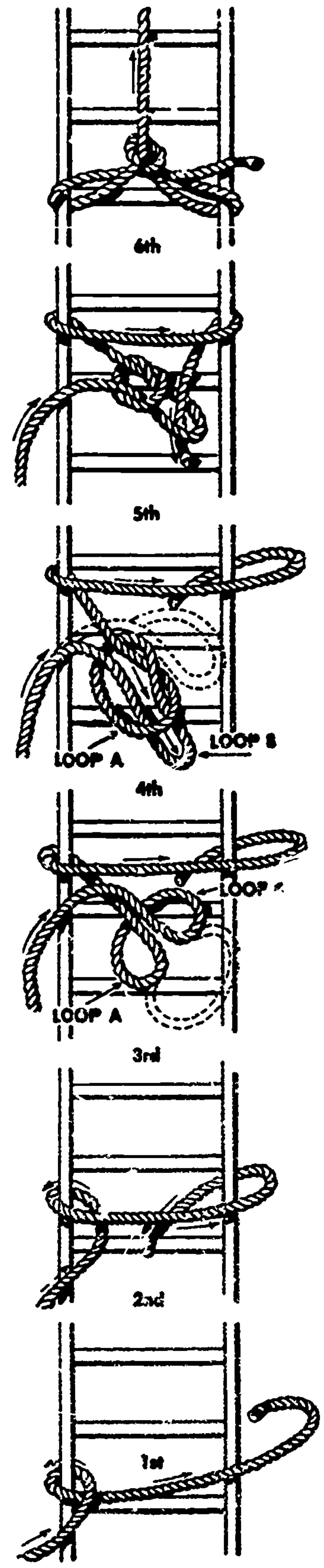


Fig. 39 - Hoisting Ladder Using Bowline

CHAPTER 11

LADDERS

INTRODUCTION

Ladders are of major importance to men in the fire service. A fireman must ascen· ·nd descend from one level to another when extinguishing fires or rescuing victims. Ordinarily, stairways or permanent ladders are accessible but sometimes they may be involved in fire or other hazards, and the firemen must then provide their own means of ascent or descent. Therefore, ladders are as much a part of necessary equipment as hose or forcible entry tools. Ladders are carried on nearly all types of apparatus and kept in a position allowing them to be easily put into service. Ladders are emergency equipment and are generally used at a time when every second counts. Firemen must know how to carry, raise and climb ladders effectively and should practice these procedures until their operation becomes automatic. This will effect an important gain in time and lessen effort in fighting fires.

DESIGN, CARE, AND INSPECTION

Detailed information will be presented on the design, construction, nomenclature, recommendations, types and inspection and care of various ladders. The mastery of this infomation is of vital importance to every person in the fire service.

SOLID AND TRUSSED BEAM LADDER DESIGN, TYPES AND PURPOSES

Ladders are designed with solid or trussed beams. The solid beam is a solid piece of material of the shape and size to provide the required strength. Figure 1 illustrates the design of a solid beam ladder. The rungs are set in the center of a beam. Trussed ladders, as illustrated in Figure 2, are designed to increase stren th in relation to weight. However, if a solid beam ladder is made of good material and properly constructed, it will meet the normal needs of most fire departments. When using longer ladders, trussed beam ladders are preferred for use over the solid beam types by most departments because the weight of a trussed beam ladder will be much less, although just as strong as a solid beam of the same length. Trussed ladders come in several designs. Some are made with beam members of equal size while others are built with one of the beams larger than the other member on the same side of the ladder. In the case of trussed ladders, the term "beam" usually refers to the larger of the two members making up one side of the ladder. Rungs of trussed ladders are set either into the beams of the ladder or into blocks attached to the beam. The rung beam is the name for that beam in which the rungs are inserted, the beam running parallel to the trussed beam.

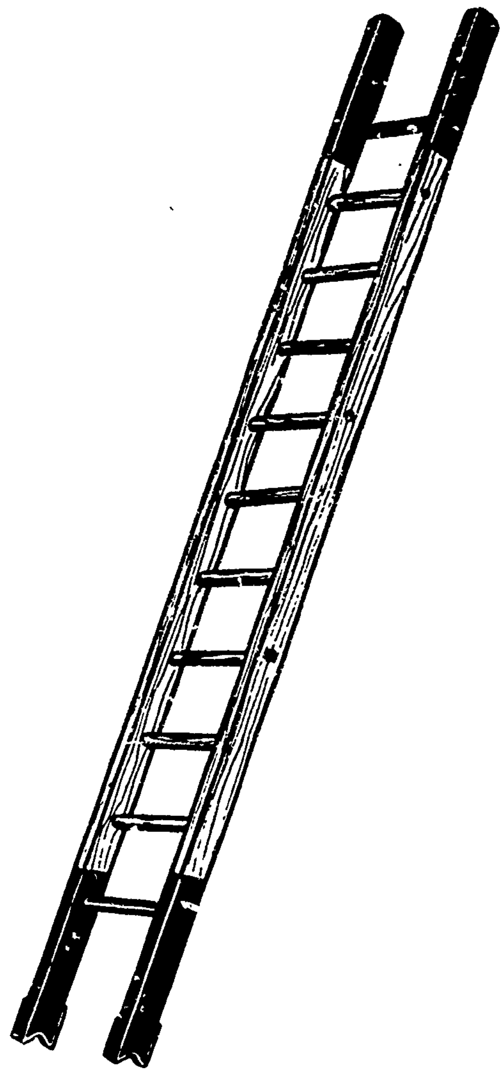


Fig. 1 - Solid Beam Ladder

UNIVERSAL LADDER TERMS

As with other types of fire service equipment, in the study of ladders there is to be found certain terms which apply to the various parts and types of ladders. Since these terms are used universally by departments, each memb[illegible] ould know their meaning

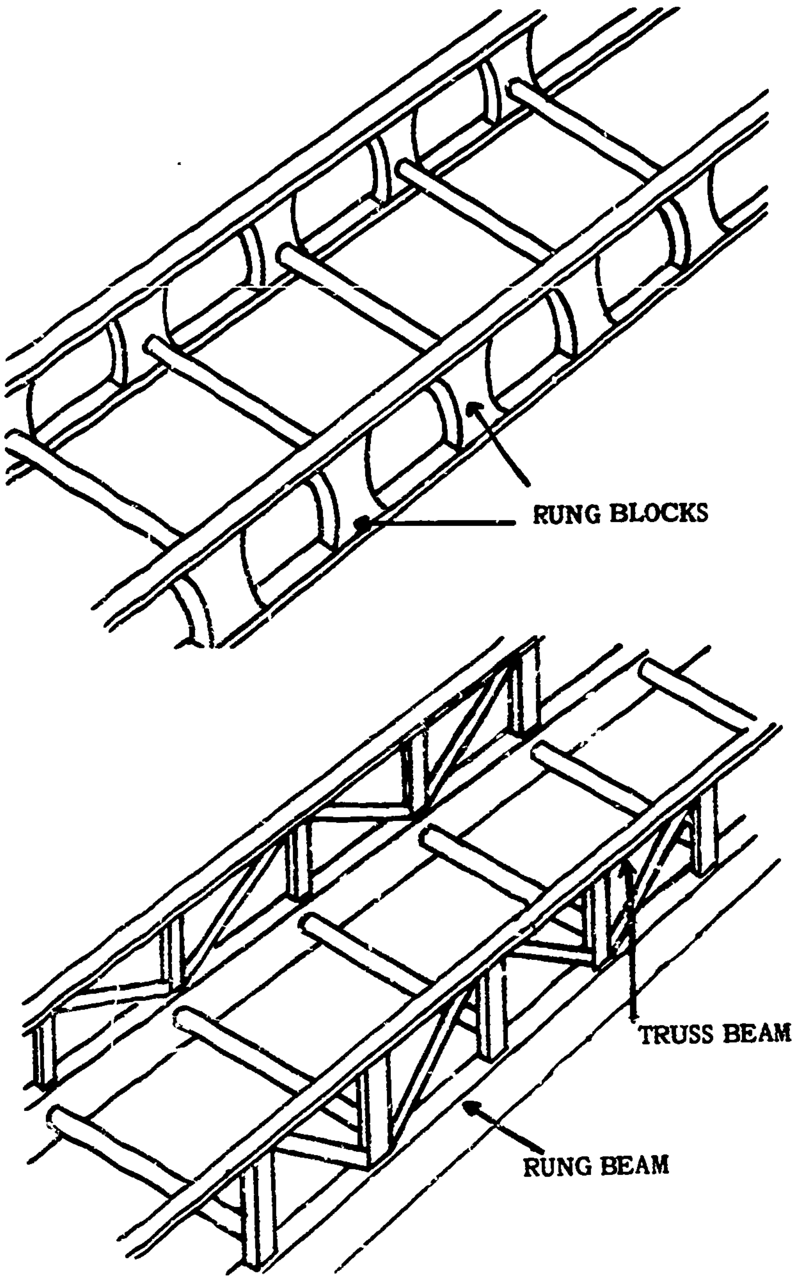


Fig. 2 - Trussed Ladders

and be able to identify each part. The list of terms is as follows:

1. Extension Ladder - A ladder built in two or more sections.
2. Straight Ladder - A ladder of only one section.
3. Bangor Ladder - An extension ladder with poles for handling.
4. Main or Bed Ladder - The lowest section of an extension ladder.
5. Fly Ladder - The upper section of an extension ladder.
6. Heel, Foot or Butt - The bottom or ground end of a ladder.
7. Top or Tip - The top of a ladder.
8. Beam - The principal structural member of a ladder, in which the rungs are supported.
9. Truss - The tension member of a beam, running parallel to the main beam.
10. Rungs - Cross members between the beams, used for climbing.
11. Tormentors - Poles attached to the upper end of the beams of the main ladder of the Bangor type; used to raise, guide and steady the ladder.
12. Spurs - Metal projections at the butt of ladders and poles.
13. Halyard or Fly Rope - The rope used in hoisting the fly ladder.
14. Pulley - Small grooved wheel through which the halyard is drawn.
15. Pawl or Lock - A mechanical lock used to support the fly ladder after it is raised.
16. Truss Blocks - Blocks placed between the beams and truss members of a trussed ladder.
17. Braces - Braces running diagonally from beams to trusses between the blocks of a trussed ladder.
18. Stops - Wooden or metal blocks or stops which prevent the fly ladder from extending out of the main ladder.
19. Guides - Light wood or metal strips on an extension ladder which guide the fly ladder while it is being raised.
20. Tie Rods - Metal rods which hold the entire ladder assembly together.
21. Beam Bolts - Bolts passing through a beam to prevent splitting.

TYPES OF LADDERS

Fire department ladders are classified, as to use and construction, as straight (wall), extension, roof, attic or folding and aerial. A brief but adequate description of each type is as follows:

Straight Ladder - Straight ladders are made in solid or trussed design and in lengths up to 40 feet. However, very few over 30 feet in length are used, and usually the ten foot lengths are of the roof type.

Extension Ladder - As the name implies, extension ladders, as illustrated in Figure 3, are made in two or more sections. The "fly" ladder slides through the guides on the upper end of the ladder bed and is equipped with "dogs" on the lower end that hook over the rungs of the bed ladder when extended to the desired height. On all except the very short ones, the "fly" is raised with a halyard that is fastened to the lower rung of the fly ladder and operated over a pulley on the upper end of the bed ladder.

Extension ladders are made in lengths of 12 feet (the baby extension) to the long aerial ladders. The 12 foot type has no halyards and is raised and lowered by hand. The 24 foot extension ladder is usually found on pumping units.

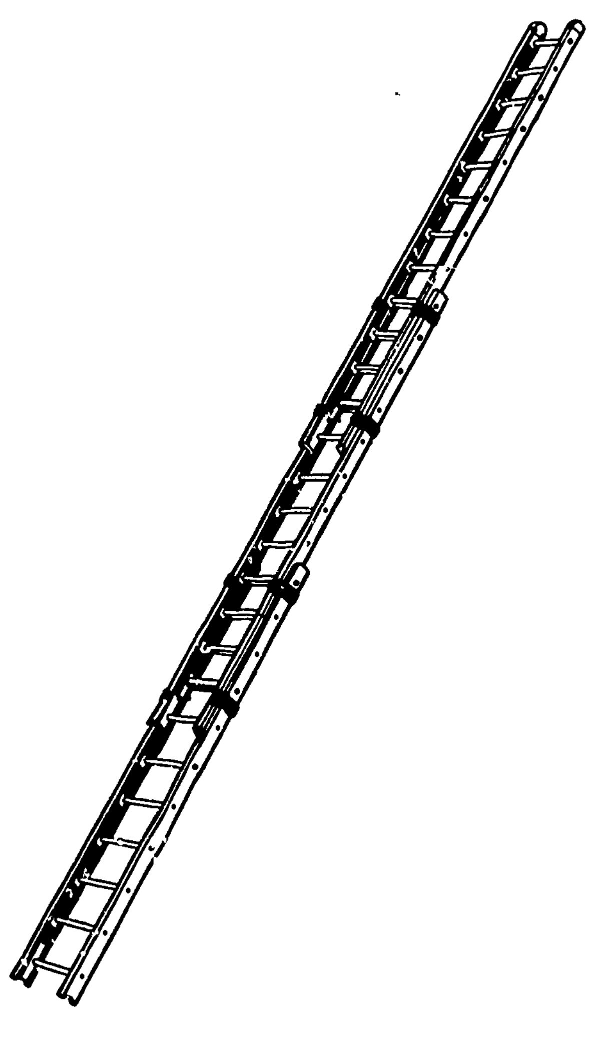


Fig. 3 - Extension Ladder

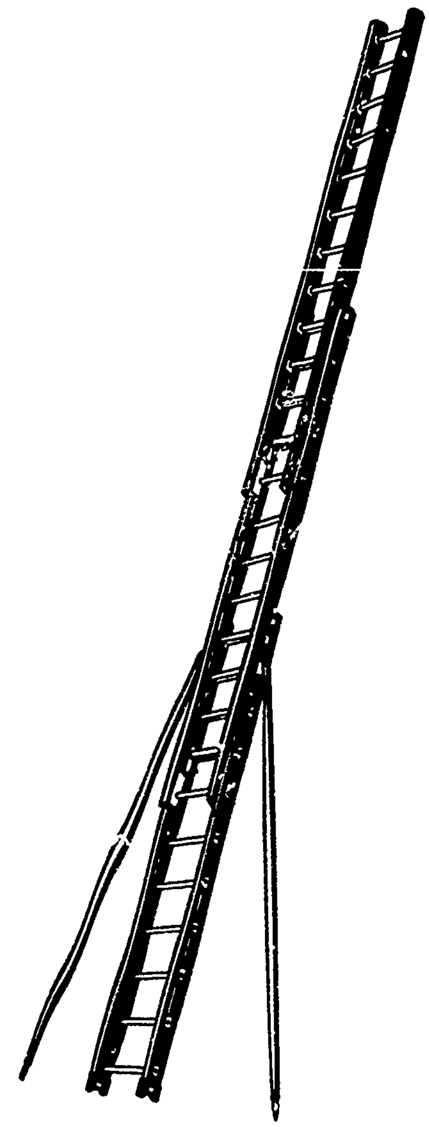


Fig. 4 - Extension Ladder with Poles

Extension ladders 35 feet long and longer are equipped with "tormentor" poles attached to the sides as shown in Figure 4. These poles are used to assist in raising and steadying the ladder. This type of ladder is commonly called a "Bangor ladder."

Roof Ladder - There are several types of roof ladders; one type is illustrated in Figure 5. Most of them have hooks which are mounted on the beams and have a movable socket which permits them to be folded inward when not in use. The roof ladder affords certain advantages over other types of ladders inasmuch as it may be used in getting to peaks of gabled roofs. It can also be used to good advantage in entering scuttle holes or holes cut through flooring or sidewalk openings.

The ladder hooks, if properly placed over roof peaks, sills, walls or the coping of any opening, will make the ladder more safe and reliable, even though its butt is not resting on a foundation of any type.

Roof ladders of the hook type range from 10 to 16 feet. They may be either of the solid beam or the trussed beam type.

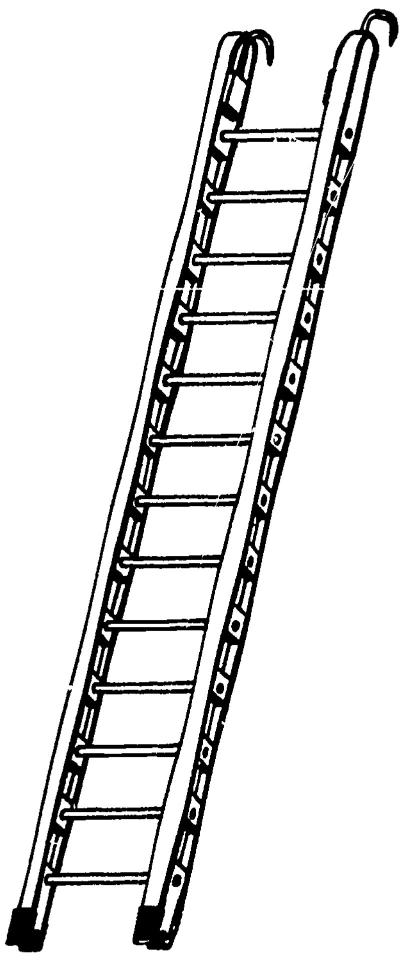


Fig. 5 - Roof Ladder

Attic or Folding Ladder - The ten foot collapsible ladder illustrated in Figure 6 is especially useful for inside work. When collapsed it can be carried up stairways easily and to places where the ordinary ladders would be cumbersome.

Aerial Ladders - The aerial ladder as shown in Figure 7 is mounted on a truck and is mechanically operated. It is made in two or more sections, according to the length. The aerial ladder enables men to reach windows, roofs and burning areas that could not be reached by any other method. Rescue work at high levels is made possible with this ladder. In fact, the aerial acts as the mechanical arm of the fire department. Several types of aerials are manufactured, and the manufacturer's instructions on its use, maintenance and care should be studied and strictly observed.

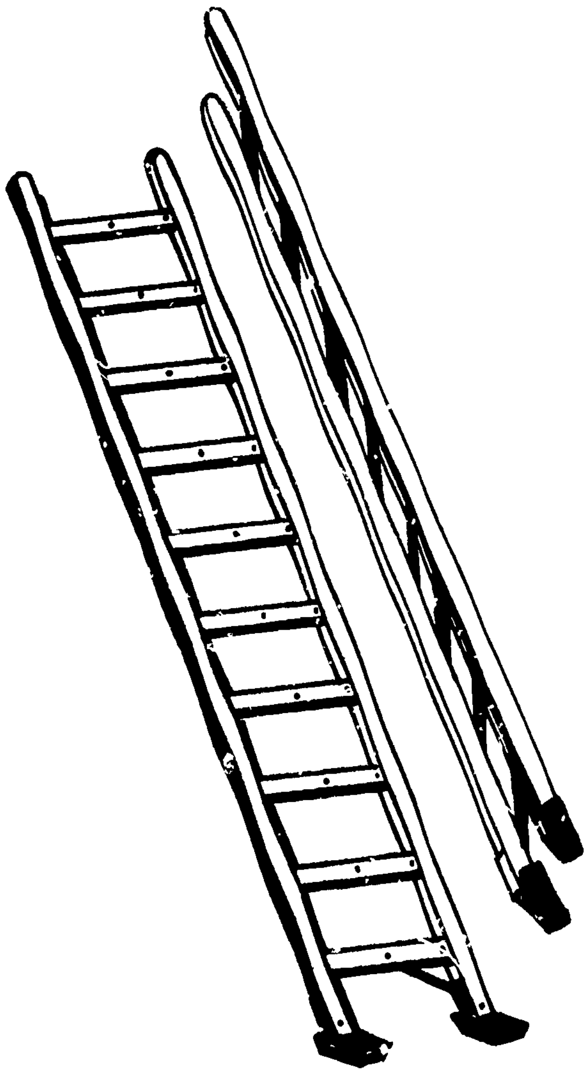


Fig. 6 - Attic or Folding Ladder

Courtesy American-LaFrance Foamite Corp.

Fig. 7 - Aerial Ladder

MATERIALS USED IN CONSTRUCTION OF LADDERS

The beams of all wood ladders, solid or trussed, are made of West Coast Douglas Fir or Navy specification airplane spruce or equivalent wood. Navy specifications call for wood with a straightness of grain which shall not vary more than one inch in 15 inches. It is evident that wood with such a grain will make good ladders.

The rungs of a wooden ladder are usually made of second growth hickory or ash. Such wood is springy, yet will withstand sudden loads without breaking.

At the present time, metal ladders are also being used by many departments. As with wooden ladders, they are designed to carry the loads subjected to them by firemen who may use the ladder in rescue work or in fire fighting. It should be pointed out at this time that any ladder, while in service, that becomes deformed from heat, overload or injury, should be discarded. Its repair and re-entrance into service will always leave a question in the minds of firemen as to whether or not the ladder has been strained beyond its elastic limit, making it unfit for service. Figure 8 illustrates one method of construction of ladders.

RECOMMENDED MATERIALS FOR CONSTRUCTION OF LADDERS

Ladders for fire department use must be of better material and workmanship than those made for ordinary purposes. They should be built especially for fire department service. Ordinary commercial ladders, such as used by painters and construction workers, should never be adapted for use in the fire service. While the following recommendations are not intended to cover all details, they indicate what is considered "good practice" relative to ladder construction. Before purchasing new ladders it is recommended that departments be sure that these recommendations be met. For wooden ladders, the following recommendations should be considered:

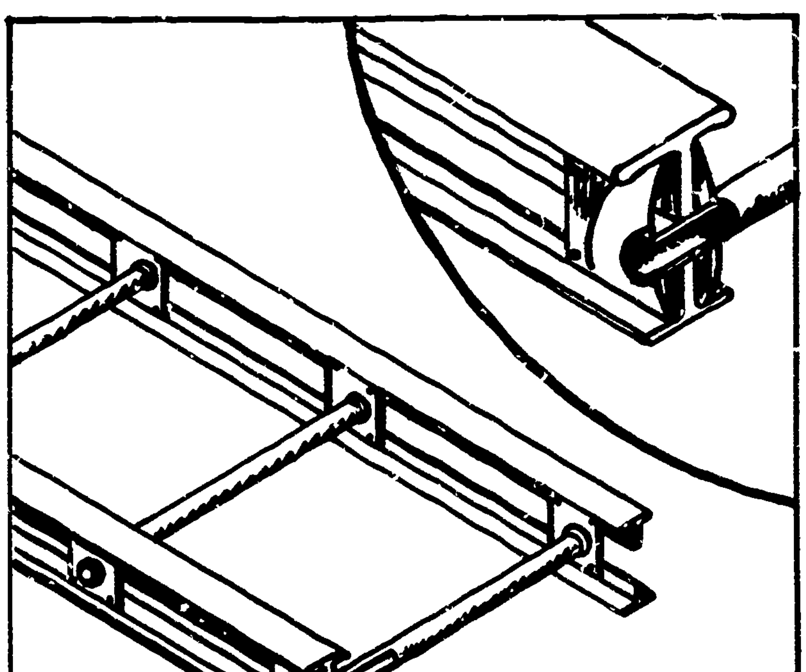


Fig. 8 - Aluminum Ladder Construction

1. Beams or Rails - The wood should be carefully selected, thoroughly seasoned, free of defects and have a straight grain. Douglas Fir or some equivalent wood should be used. Pieces should be free from splinters and the corners slightly rounded.

2. Rungs - Rungs should be of straight grain hickory or ash, secured to beams or rails.

3. Cross or Brace Rods - Should be of steel and bolted. There should be one near each end of the ladder beneath the rung. These rods should not be spaced at more than five foot intervals.

4. Hardware - All hardware should be of rust resisting metal or thoroughly plated or painted. All bolt heads and nuts should be of a type that will protrude as little as possible to avoid catching on window ledges, eaves, etc.

5. Heel Irons or Spurs - All ladders should have heel irons with double nibs extending ¾ of an inch. On wall, single or straight ladders, heel irons should be placed on all beam ends. Extension ladders should have strap metal covering the edges of the top end of the fly ladder to protect the wood.

6. Hooks - The collapsible hooks of roof ladders should be of ample strength, sturdy construction and the hooks should be firmly fastened to the ends of the rail. They should be of the long sweep type so as to make the ladders useful over window sills. In general, hooks should curve from the inside of one rail to the inside of the other. In all cases, the hooks should be so placed that the beam ends will protrude as far as the rounded part of the hooks, thus making the ladder equally useful as a wall ladder.

7. Locks, Dogs, Latches - All of these should be of sturdy construction and positive in action. The nibs or hooks should be plated or painted white or some other color to aid visibility in smoke or darkness.

8. Pulleys - Pulleys should be of plated steel, bronze (or some equivalent metal), self-lubricating, or good diameter, and have an ample rope groove.

9. Ropes - All ropes on extension ladders should be of a good grade of treated manila or nylon and not less than 3/8 of an inch thick. The rope is passed through the eye of the fly ladder and spliced. The free end of the rope should be spliced to a snap for convenience.

10. Finish - The top 18 inches of beams and the top rung of the ladder should be painted some distinctive color such as white to aid visibility in smoke and darkness. Numerals which indicate the working length should be plainly stenciled at the top and bottom of each beam. These numerals should be at least 1 1/2 inches high. A good grade of clear spar varnish should be used on the remaining beams and rungs.

MOUNTING BRACKETS AND NESTING

Brackets and nestings should be of a type that will properly hold ladders on the apparatus while in transit and not allow chaffing. Where a roof ladder and an extension are nested together on the side of a truck, the mounting should be such that the outside ladder can be taken off separately and easily.

Roof ladders should be of such width and length that they will nest inside the "fly" of the extension ladder when carried on the apparatus. This arrangement not only makes it possible to carry additional loads in a given space, but in an extreme emergency, additional height can be gained by lashing the roof ladder to the fly ladder of the extension when it is put into service.

TESTS AND LOADING

Every ladder should be capable of withstanding the following tests without undue strain when set at the proper climbing angle.

1. A dead weight or load of one man's weight every five feet.

2. A live or moving load of 200 pounds every 10 feet.

3. Each rung should be tested separately by hanging or subjecting a dead weight of 400 pounds at the center of each rung.

INSPECTION AND CARE OF LADDERS

A rigid inspection of all ladders used for any purpose should be made after return to quarters. Inspections should be made at regular intervals even though the ladders are not used. This is an important point to be observed because many accidents may result if a haphazard inspection program is carried on by the department.

Things to look for in the inspection of a ladder are:

1. Rungs - Looseness, wear, slivers, cracks or checks, dry rot and need of varnish.

2. Beams - Slivers, cracks or checks, dry rot, protective varnish and warping.

3. Butts - Defects of metal parts and dullness of butt.

4. Ropes - Dry rot, splices, weakness and wear.

5. Locks and Pulleys - Breakage, wear, lubrication and springs.

6. Tie Bolts and Beam Bolts - Tighmess, burrs, sharp edges.

7. Snaps and Ropes - Defects.

Truss rods, tie rods, turnbuckles and beam bolts often require special wrenches for tightening. These wrenches should be readily available when needed. In addition to the regular inspection, ladders should be completely overhauled whenever necessary. This should include cleaning, revarnishing and the replacement of all worn parts. The halyard rope should also be replaced at this time.

When varnish remover is used to soften and remove old varnish, directions on the container should be followed to obtain the best results. The ladder should then be permitted to dry thoroughly before new varnish is applied; otherwise the varnish will not harden. Some departments prefer to remove the old varnish by scraping before revarnishing. The colors for painting the top 18 inches of the ladders which are most frequently used are orange, white, and alternate black and white stripes.

Inspections of ladders require careful attention to details and common sense. The time used in caring for and inspecting ladders cannot be more profitably spent. The failure to detect a flaw in a ladder may cost the life of firemen or those they serve.

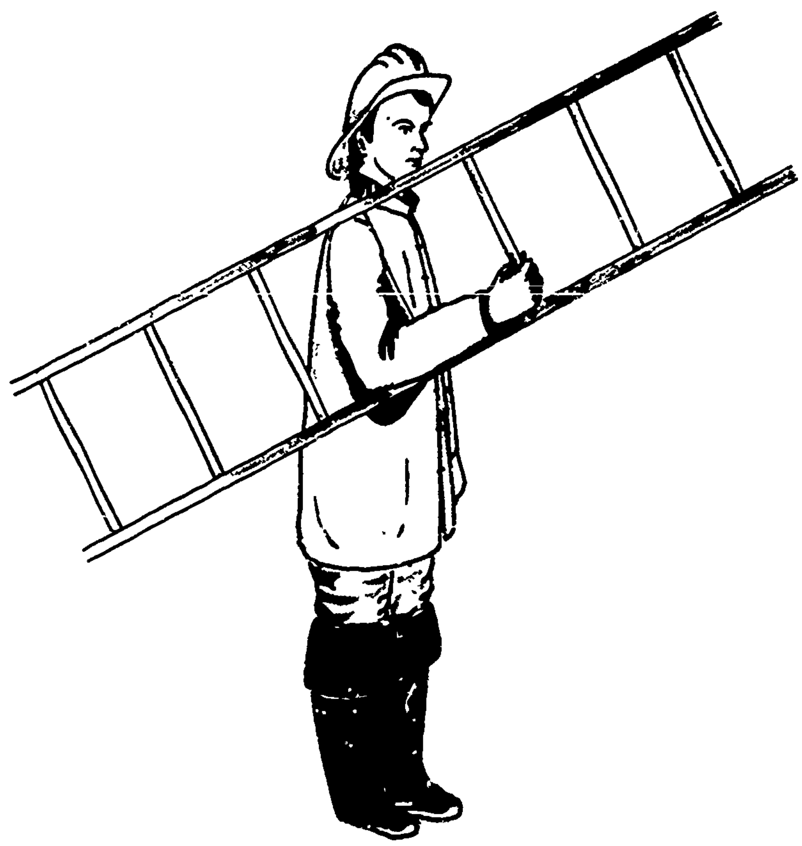


Fig. 9 - One-Man Carry

LADDER CARRIES

In stressing the importance of various ladder practices to the department, a comparison of ladder handling and the handling of an injured man is drawn. If an injured man had to be carried, what would be the preferred method? Would it be better for a group of untrained men to haphazardly pick up an arm, a leg, and the head and drag the victim away or would it be wiser practice for the carriers to be trained in first aid procedures? Remembering this, envision the rhythm, care and cooperative procedure of a well trained group of ladder men. With this comparison, it is rather obvious that the greatest wear and tear comes from mishandling, not climbing ladders.

Good ladder practices not only save equipment and increase efficiency of the department but give a higher measure of safety to men who must use them. This last factor of safety to department personnel is of prime importance.

After reaching the location of a fire, firemen must work as swiftly and efficiently as possible. Therefore, efficient ladder carrying and raising is essential to efficiency and speed.

The following methods of the various ladder carries represent acceptable methods. However, there are other methods that may also be acceptable.

It is generally recommended that the butt end of the ladder be carried forward, in the direction of travel. When carrying a ladder across a street the ladder should be in line with the direction of traffic flow.

ONE-MAN CARRY

Short ladders can be carried, as illustrated in Figure 9, by one man using the following method:

1. Remove ladder from apparatus and place it on either shoulder, depending on the direction of travel.

2. Carry it somewhat in front of the center balance point.

3. The trailing end of the ladder is usually dropped low, allowing the leading end to be above the heads of others.

Fig. 10 - Two-Man Carry

TWO-MAN CARRY

The two-man carry with both men on the same side of the ladder, as shown in Figure 10, is used to carry ladders of medium length.

Remove the ladder from the apparatus and place the beam on the right or left shoulder, depending on the direction in which the ladder is to be carried. An arm is then passed through the ladder and the hand grasps the lower beam or second rung forward, close to the lower beam.

Where man power is lacking, heavier ladders which normally would be carried by four men, may be carried in the manner outlined above by having a third man near the center of the ladder. When carrying a ladder in a crowded place, the lead man will take a position close to the front of the ladder and use the outside hand to prevent injury to persons in the line of travel.

A variation of the two-man carry is shown in Figure 11. This carry can be used to good advantage when the ladder is on the ground. The men pick up the ladder by a rung with the palm of the hand turned down. When the ladder is lifted, it will fall naturally alongside the body.

Fig. 11 - Two-Man Carry Variation

FOUR-MAN CARRY

The ladder is taken from the apparatus and placed on the shoulders of four men as shown in Figure 12, with two men at each end of the ladder. The inside

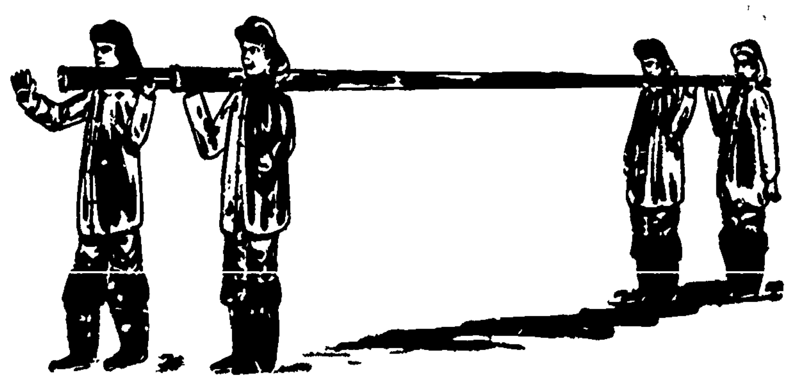


Fig. 12 - Four-Man Carry

hand of each man is placed palm up and forward, grasping a rung on the underside. The butt end of the ladder should always go first toward the building. The men in front should extend their free hands forward to keep the heel irons from injuring someone.

If the ladder is placed flat on the ground, the four men take positions facing the top of the ladder and in the opposite direction from which they intend to go. Grasping a rung of the ladder with the hand nearest it, they raise the ladder, turning under it as it rises. In this way, the ladder is placed upon the opposite shoulder and the men are facing the butt of the ladder, ready to proceed. If they need to reverse their direction, they can turn placing the opposite shoulder under the beam and changing hands, keeping the ladder always under control.

To carry a long and heavy ladder through a narrow gate or passageway, all men swing under it in single file and carry the ladder overhead as shown in Figure 13. The men on the right side of the ladder usually move forward and those on the left side drop back. Hands should be spread wide on the rungs but kept off the beams.

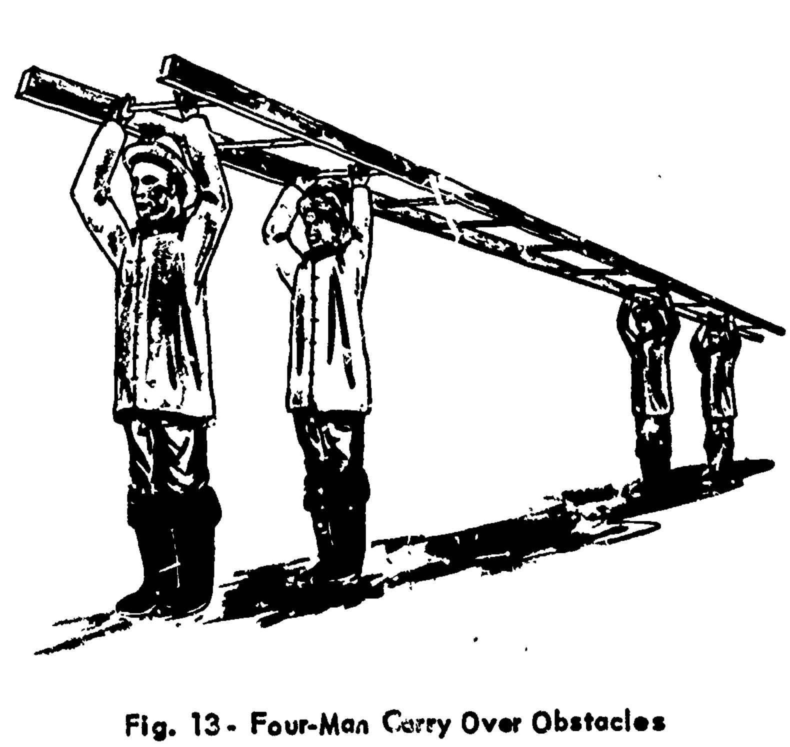


Fig. 13 - Four-Man Carry Over Obstacles

SIX-MAN CARRY

This carry is the same as the four-man carry except two additional men are placed in the middle on opposite sides of the ladder. This is used on exceedingly long ladders requiring six men to raise them.

VERTICAL CARRIES

Vertical carries, as pictured in Figure 14 are usually used for short distances only. The top of the ladder should never be scraped along a wall or window ledge.

Fig. 14 - Vertical Carries

Before vertical carries are started, it should be seen that the top of the ladder is in the clear. Also, the path of foot travel should be carefully noted. Where a vertical carry with an even number of men is used, the ladder should be brought to a vertical position before carrying is started. The men should face in the direction of the carry. Bending knees slightly, each man grasps the second rung near the beam with his inside hand and with the other arm curved in front of the forehead, grasps a higher rung as near the beam as possible. All the hands should be on the same rungs unless men vary greatly in height.

After the command "carry," the ladder is lifted until the men's knees are straight. Then, the command "steady" is given and all men look at the top and carefully plumb the ladder.

Two commands should always be given for the next movement; a preparatory command "step" and then an execution command, "off." At the command of "off" all step off with the left foot, using short steps similar to a lock step, watching the top of the ladder constantly.

When only one man carries a ladder vertically, he leans it, slightly tilted, on his inside shoulder. His hands will be placed in a position similar to that recommended for the two-man vertical carry.

When carrying extension ladders vertically, be sure to lift with the main ladder rungs, not the fly ladder rungs. Do not carry a ladder with the fly extended.

When carrying pole ladders vertically, the poles should be quartered and both pole men should walk forward.

LADDER RAISES

The same practice and cooperation are necessary in ladder raising as in carrying. In view of the fact that raising is the more hazardous of the two, it requires more training.

Frequently, some of the following raises can be combined with corresponding carries to make one evolution. In such cases, only the heel man lowers his end of the ladder; the other man rapidly takes such a position as to continue the evolution to the top.

PLACING LADDERS
PREPARATORY TO RAISING

There are several methods for determining the distance the ladder heels should be placed from a building. The method most generally used is to take

one-fourth of the extended length of the ladder. For example, a 35 foot ladder divided by four would be approximately nine feet. It must be understood that the "length of the ladder" is that distance between the ground heels and the point of contact with the building. If the ladder is placed against a roof with an overhang, the distance of the overhang will have to be added to the distance the foot of the ladder will be placed from the building.

When placing ladders in windows, it is always best to place them in such a way that men can easily get in or out of the window. Therefore, ladders *should not be placed* in the center of a window. It is a good rule to place the ladder on the far side of the window as you enter. If there is a wind, it is best to place the ladder to the windward side of the window.

TYPES OF RAISES

Heavy extension ladders and straight ladders present different problems in raising practices and will be considered separately. Straight ladders will be dealt with first.

One-Man Flat Raise - With straight ladders, the number of men required to carry the ladder is the number required to raise it. So, ladders that can be carried by one man may be raised by one. The following is the procedure for the one-man raise:

1. Remove the ladder from the apparatus.

2. Carry the ladder, as described under ladder carries, to the desired location.

3. Place the butt of the ladder against a building or some secure object on the ground and as close as possible to the location at which it is to be used.

4. Raise the ladder, using both hands alternating on every other rung, to a vertical position by walking toward the foot of the ladder. Figure 15 illustrates the step just described.

5. Grasp the rungs with both hands about one rung apart and set ladder at climbing angle.

6. To lower the straight ladder, the steps above are reversed.

Two-Man Beam Raise - In making the two-man beam raise, the following steps should be practiced:

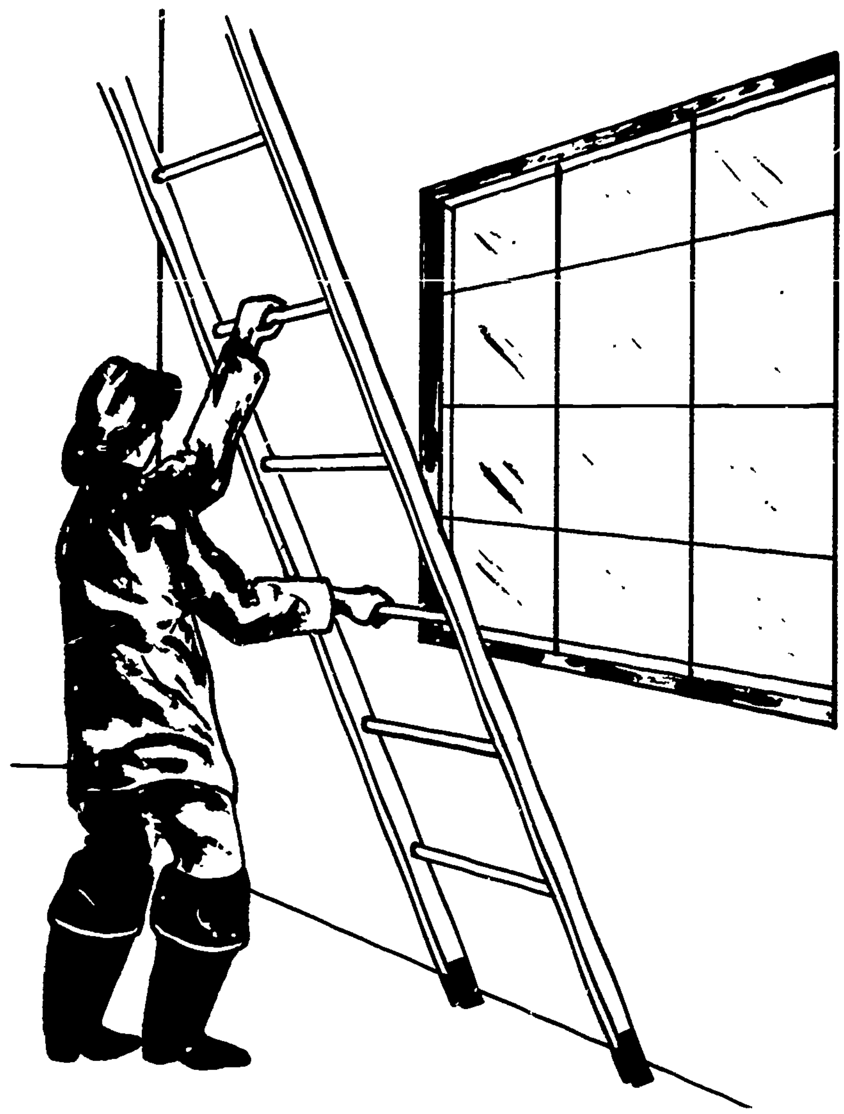


Fig. 15 - One-Man Flat Raise

1. Take the ladder off the apparatus and carry it to the desired location as described under ladder carries for two men.

2. Spot or lay the ladder parallel to the building; place the butt directly below where the top is desired to rest with the outside beam the proper distance from the building.

3. To raise, turn the ladder over on the beams as shown in Figure 16.

4. In order to heel the ladder, one man places his forward foot on the bottom beam and reaches out, grasping the top beam with his hands spread apart. The other leg and foot are held as far back as possible to act as a counterweight. The heel man's most important duty is to put as much weight as possible on the ladder to take out the swing. He can also assist considerably in raising by lifting as much as possible with the left hand while pushing down on the ladder butt with his right hand.

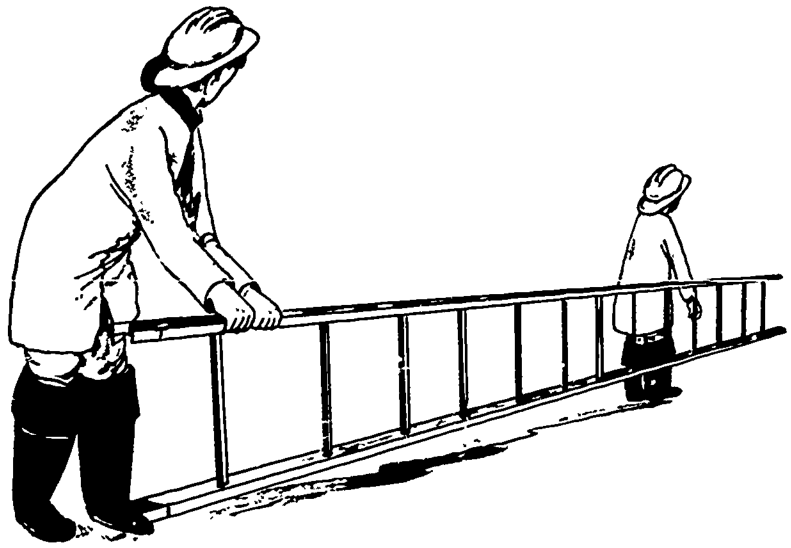


Fig. 16 - Two-Man Beam Raise

5. The other man faces the top of the ladder and with his inside hand, palm back, grasps the rung about one-third of the distance back as pictured in Figure 16. He then raises the ladder over his head, swings under it, and travels toward the ladder heel as shown in Figure 17. As the ladder comes to a vertical position the man raising the ladder places his foot on the lower rung from the building side. This helps to steady the ladder.

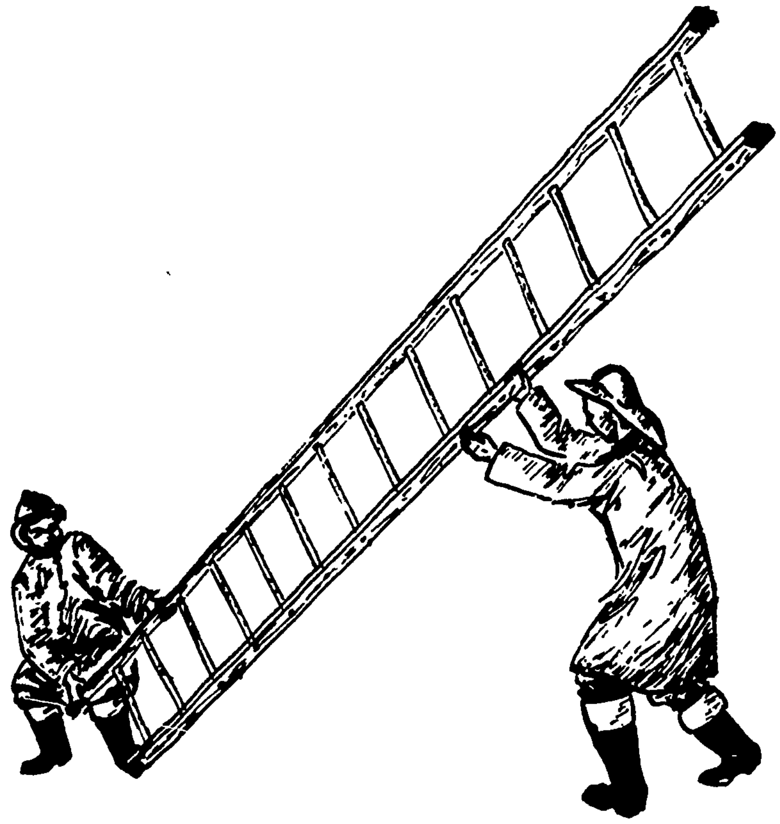


Fig. 17 - Completing Two-Man Beam Raise

6. The ladder is now in an upright position. The two men position themselves facing each other through the ladder. The man on the outside, facing the building, places one foot on the bottom rung and lowers the ladder to the building with the assistance of the man on the underside.

7. To lower the ladder, the above steps are reversed.

To Raise a Ladder at Right Angles to the Building - In this evolution, the ladder is placed as shown in Figure 18, and the same procedure is followed as just described for the two man raise.

Once the ladder is erect, it is pivoted on the beam next to the building as illustrated in Figure 19. Then it is lowered against the building as in step 6 of the Two-Man Beam Raise.

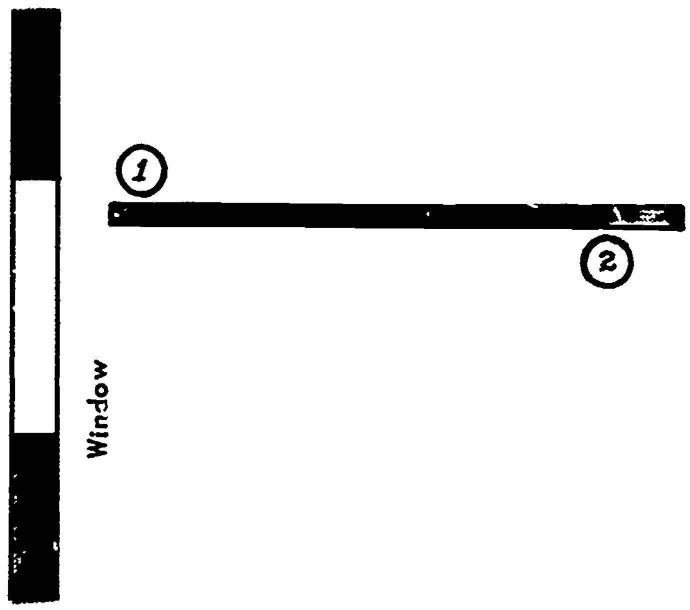


Fig. 18 - Raising Ladder at Right Angles to Building

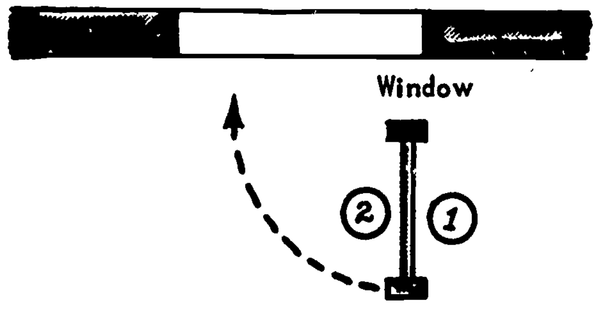


Fig. 19 - Pivoting Ladder

Three-Man Flat Raise - In raising ladders of 28 foot lengths and longer, it is advisable to use three men. The procedure is as follows:

1. Take the ladder from the apparatus, carry it to the desired location and spot it before it is raised. The heel man, (number three) does the spotting as shown in Figure 20.

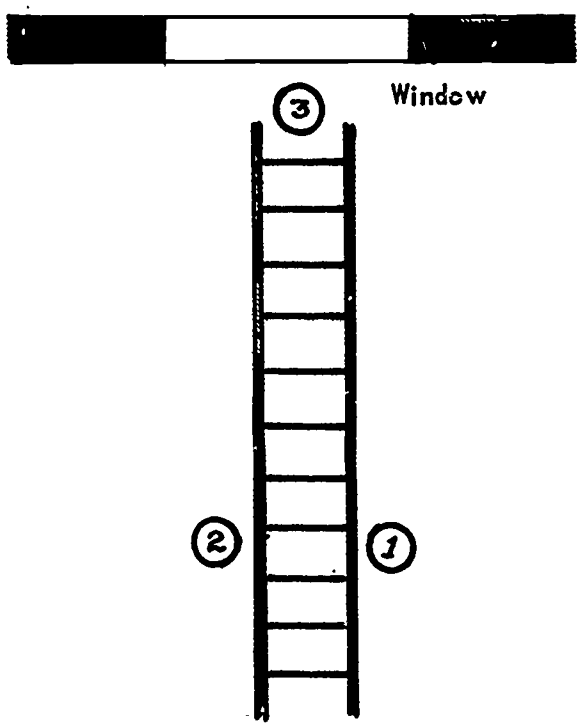


Fig. 20 - Three-Man Flat Raise

2. The ladder is laid flat.

3. The heel man stands on the heel plates, reaches forward and grasps the rungs with his hands. See Figure 21.

4. The other two men, standing and facing the top of the ladder about one-third of the distance from the top, reach down, grasp the rung, and swing under the ladder, facing the heel of the ladder.

5. Raise the ladder hand-over-hand down the beams and lower to the building.

6. To lower the ladder, the steps are reversed.

This same flat raise can be accomplished by two men, using only one man to raise the ladder. He travels under the ladder, grasping the rungs rather than the beams. However, this practice is recommended only with short ladders or when few men are available.

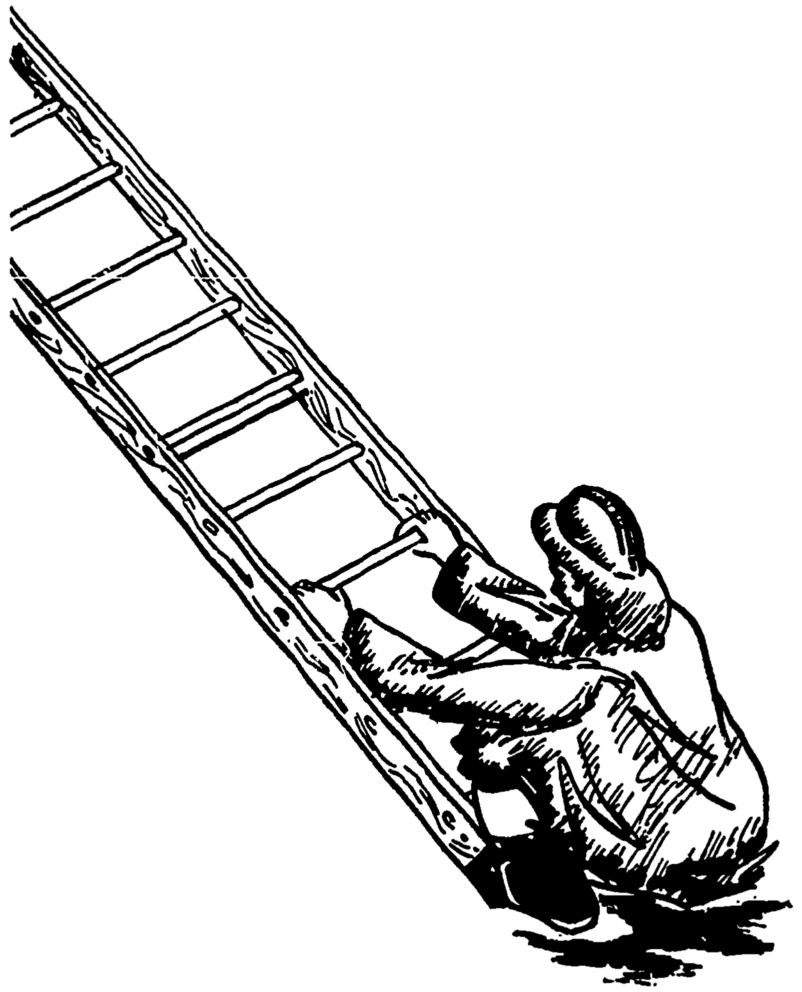


Fig. 21 - Heel Man Butting Ladder

Raising an Extension Ladder With the Two-Man Beam Raise - In raising a 24 foot extension ladder it is advisable to use two men if at all possible. For a ladder longer than 24 feet, three or more men should be used.

For ease in descending the solid beam extension ladder, place the fly ladder toward the building. In the case of truss ladders, the truss may be placed toward the building. This will place the fly ladder on the outside. Manufacturer's recommendations should be followed in this matter.

The following is the procedure for the two-man raise.

1. Take the ladder off the apparatus and carry it to the desired location using the two-man carry.

2. Spot the ladder parallel to the building with the butt directly below where the top is desired to rest.

3. Turn the ladder over on the beam to raise. If raising a truss ladder place the truss side next to the building.

4. In order to heel the ladder, the heel man places his forward foot on the bottom beam

and reaches out, grasping the top beam with his hands spread apart as shown in Figure 22. The other leg and foot are held as far back as possible to act as a counterweight. The heel man's most important duty is to put as much weight as possible on the ladder in order to take out the swing. He can also assist in raising with the left hand while at the same time pushing down on the beam with the right hand.

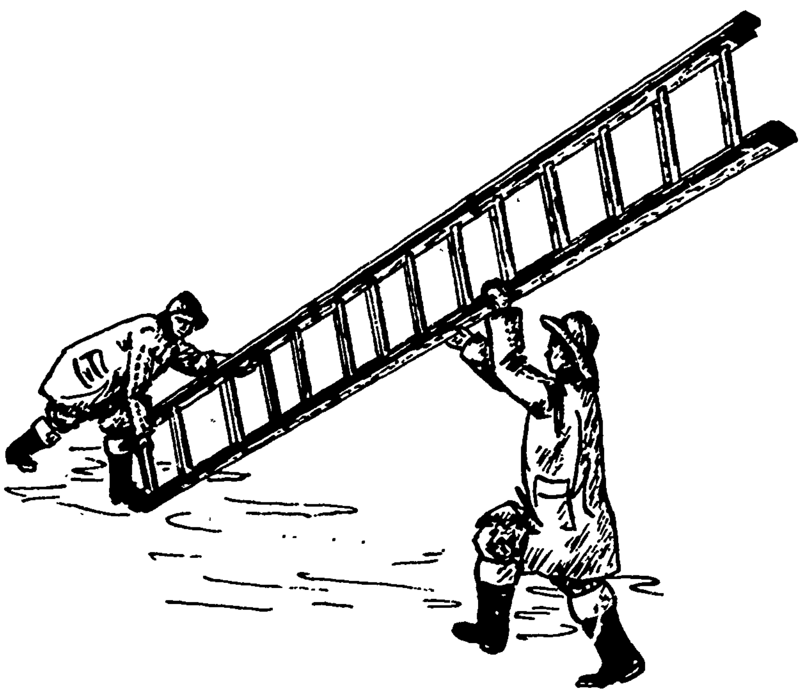


Fig. 22 - Raising Extension Ladder (Two-Man Beam Raise)

5. The other man faces the top of the ladder and with his inside hand, palm back, grasps the rung, about one-third of the distance back and raises the ladder over his head as shown in Figure 22, swings under and travels toward the ladder heel, thereby raising the ladder. When the ladder comes to the the vertical position, the man raising the ladder places his foot on the lower rung against the beam, stepping onto the rung from the building side. This helps to steady the ladder.

6. The ladder is now in an upright position. The two men position themselves facing each other through the ladder. The man on the one side steadies the ladder, while the other man raises the fly.

7. The outside man places one foot on the lower rung of the ladder and lowers it to the building with the assistance of the man on the underside.

8. To lower the ladder, reverse the steps.

9. Caution should be exercised for the protection of hands and feet when extending or lowering the fly.

To raise the ladder at right angles to the building, by the beam raise method, the same procedure is used; but the ladder must be pivoted, as shown in Figure 19.

<u>Raising an Extension Ladder With the Three-Man Raise</u> - The following applies to the raising of a long extension ladder without the use of tormentor poles:

1. Take the ladder from the apparatus and carry it to the desired location, place the heel toward the building, and spot it before it is raised. (The heel man does the spotting.)

2. The ladder is laid in a flat position as shown in Figure 23.

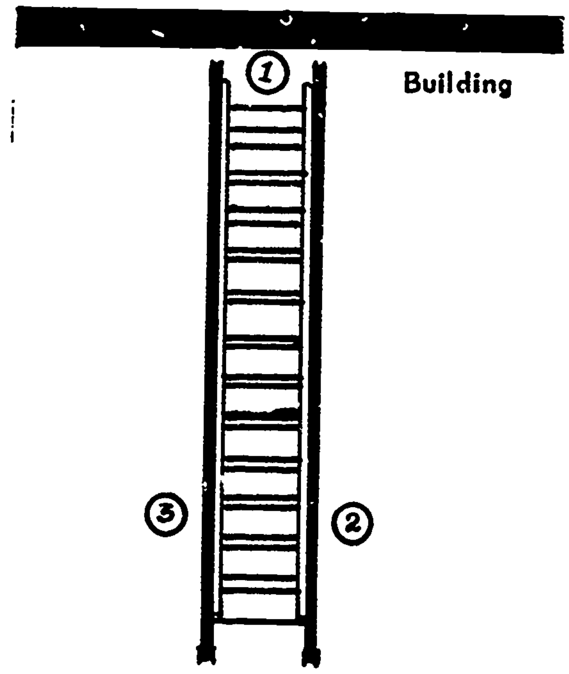


Fig. 23 - Raising Extension Ladder (Three-Man Flat Raise)

3. Numbers two and three men space themselves about one-third of the distance from the top of the ladder, facing the top. They both reach down with their inside hand and raise the ladder, turning the body while raising, and thus coming to face the heel of the ladder.

4. They now walk toward the heel of the ladder, hand-over-hand on the beam, until the ladder is in an upright position. Both men then place their inside feet on the lower rung. This helps to steady the ladder. All men should now watch the top of the ladder.

5. To raise the fly, one man steps back, letting the ladder lean slightly toward the building to counteract the strain made by pulling on the halyard rope. The other two steady the ladder while the fly is raised and locked in position.

6. The ladder is then lowered to the building by all three men. To lower the ladder the procedure is reversed.

This same flat raise can be accomplished by two men, using only one man to raise the ladder. He travels under the ladder grasping the rungs rather than the beams as he makes the raise. The practice is recommended only if the proper number of men are not available. Figure 24 illustrates the position of the men as the fly ladder is being raised.

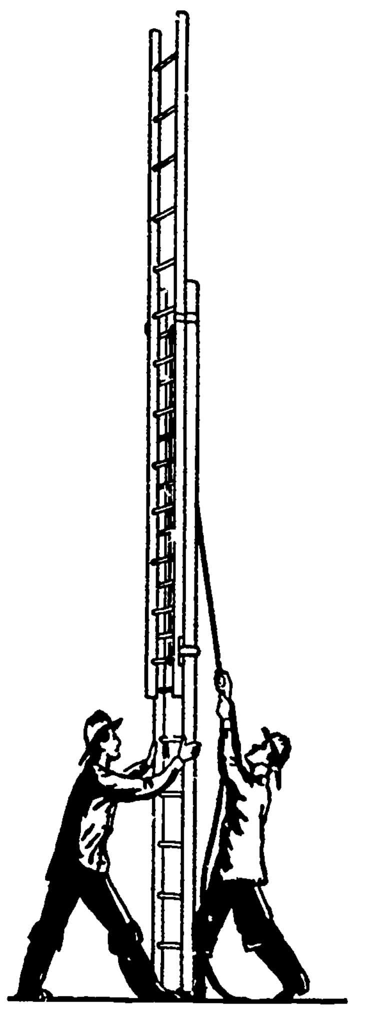


Fig. 24 - Extension Ladder - Two-Man Raise

Raising Ladder Under Overhead Obstructions - As shown in Figure 25, two men hold the top part of the ladder overhead at arm's length and one or two other men pressing down on the heel. The men work in toward each other, raising the top gradually. This procedure is repeated until the obstacle is cleared and the ladder is placed in position.

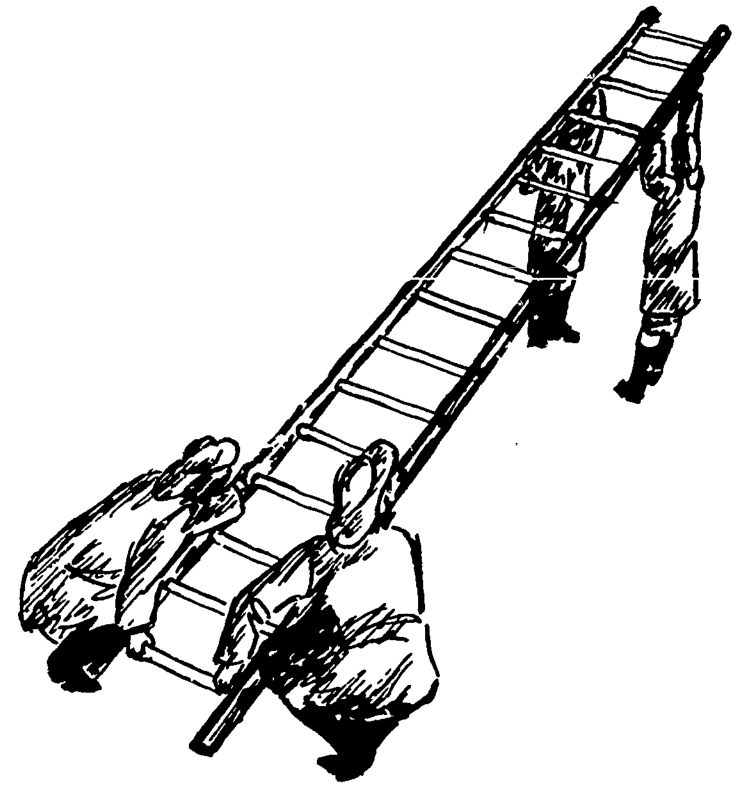


Fig. 25 - Raising Ladder Under Overhead Obstructions

POLE OR BANGOR LADDER TECHNIQUES & PRACTICES

SUGGESTIONS FOR THE POLE MEN

In starting a raise, the heel men should unfasten the poles and pass them to the beam men, who in turn pass them to the pole men. The pole men should receive the poles in their hands at waist level, never above their heads. Poles should never be tossed or thrown.

Pole men should hold the pole with the spike between the first and second fingers, and with the other arm outstretched. When it is necessary for the pole man to pivot, he should change sides if required and always walk forward with the pole. Pole men should watch the top of the ladder and coach each other when laying into the building and also, when necessary, to keep the ladder in vertical position.

Pole men should pivot singly. They should not be in motion when the ladder is being pivoted. Do not wedge the poles when setting them in place under a ladder; merely put them down, preferably, one step forward of the toggle joints towards the building.

SUGGESTIONS FOR THE HEEL MEN

In heeling a ladder, heel men may cross arms to provide better bracing. In lowering a heavy ladder into a building, heel men are not concerned with the top of the ladder. The ladder should be spotted by the pole men. Heel men numbers one and two should use

shoulders to beam. Heel men three and four should should ride the ladder and watch for broken glass, bricks or other debris that may become dislodged and slide down the beams.

SUGGESTIONS FOR RAISING THE FLY

There should be no hands or feet on the rungs of the ladder while the fly is being raised or lowered. Always be sure that the pawls are in place and that there is a tie in the fly rope. In backing the ladder heel away from the building, be sure the fly does not catch on the building and lift itself off the locks. When ready to lower, untie the fly rope until the ladder is in a vertical position.

Do not permit harness snaps on the load end of the fly rope. Replace the ladder ropes frequently; do not wait for an accident. Make sure the ropes are of adequate size and fit the pulley.

RAISING THE BANGOR LADDER

Raising the Bangor Ladder With Six Men - In raising any extension ladder equipped with poles it is always considered the easiest and safest method to use six men to make the raise. The procedure required to make the raise is as follows:

1. To remove the ladder from the apparatus, all six men stand at the rear of the truck, three on each side. The first two men reach for the Bangor or extension ladder and pull it out to the next two men. They, in turn, pass it on to the next two, who continue to advance toward the building. The other four men take their positions for carrying as described under ladder carries, raise the ladder to their shoulders, and advance toward the building.

2. The ladder is then carried to the building and, by instructions given by one of the heel men while the ladder is still on the shoulders of the men, it is spotted the proper distance from the building preparatory to making the raise.

3. After being spotted properly, each man raises up the outside hand, grasps the beam, and at the same time that he lowers the ladder to the ground. *Note: The ladder is placed on the ground with the fly on top, or the truss side up. Some types of ladders, however, may be raised with the fly underneath.*

4. Each man takes his position, as shown in Figure 26, immediately after the ladder is lowered to the ground.

5. The heel men release the ends of the tormentor poles by pulling the keys. Then they raise the pole ends and pass them to the center men, who in turn pass the poles to the tormentor men, who walk to the ends of the poles. The tormentor men hold the spurs of the tormentors between the first and second fingers of the hand nearest the spur when standing outside the tormentor poles. The opposite hand grasps the tormentor pole at arm's length. These men should be about five feet apart.

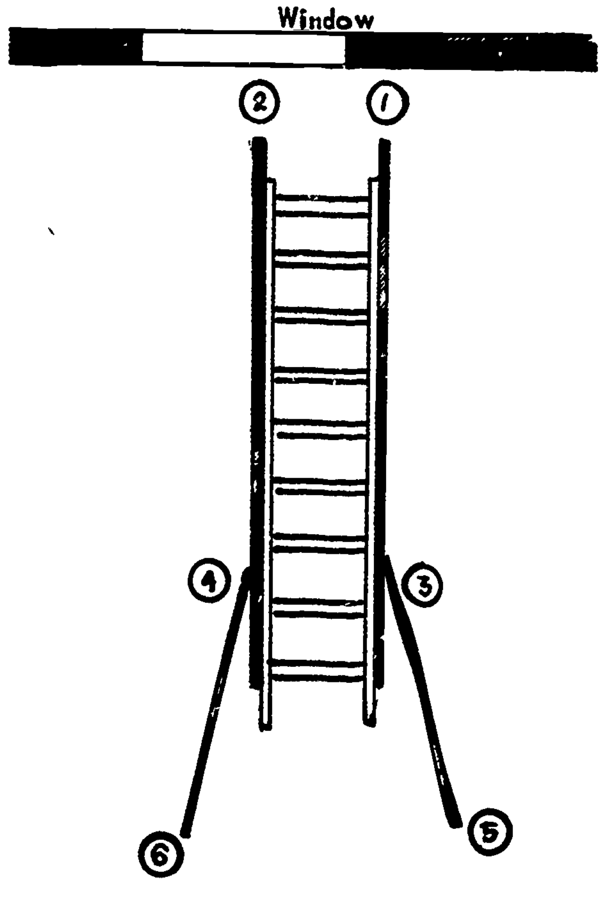


Fig. 26 - Position for Raising Bangor Ladder - Six Men

6. The center men now take their positions below the swivel of the tormentor poles and face the top of the ladder. The heel men stand on the heel plate with the inside foot and reach over and grasp a convenient rung as the ladder is raised.

7. The center or beam men reach over with the inside hand and grasp a common rung with the knuckles up. Then they lift the ladder overhead, swinging under the respective beams, and raise it toward a vertical posi-

tion, using both hands alternately on the beams. *Note: Keep arms straight and rigid at all times.* The tormentor men should take the weight from the beam men as soon as possible when pushing the ladder to a vertical position; however, doing this too soon may cause the heel of the ladder to slide. Tormentor men maintain the five foot distance.

8. When the ladder reaches the vertical position, the tormentor man on the right will swing to the outside of his pole and carry it around to the side at right angles to the other tormentor pole, as shown in Figure 27. *Note: Never walk backward with a tormentor pole.*

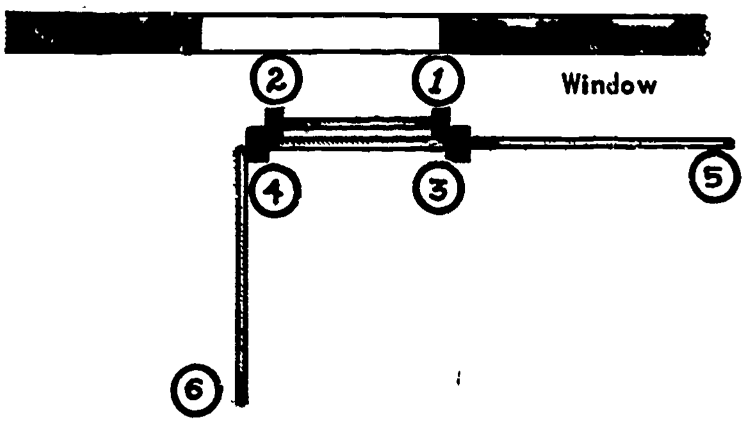


Fig. 27 - Pivoting Ladder

9. The fly ladder can now be elevated by grasping the halyard rope and pulling down hand-over-hand until the fly ladder has reached the desired height.

10. The beam men place the inside foot on the bottom rung and the ladder is lowered against the building. The tormentor men place the poles, preferably one step forward of the toggle joints towards the building so as to prevent side-sway. Do not force the poles under the ladder.

11. To lower the Bangor ladder, the steps are reversed.

Raising the Bangor Ladder With Four Men - Although it is a good and safe practice not to use less than six men in raising a Bangor ladder, there are times when sufficient manpower is not available and four men must be used. When this situation arises, the following procedure can be followed:

1. The ladder is taken off the apparatus as described previously in making the six-man raise, and carried to the point where it is to be raised. The ladder is grounded at right angles to the building with heel close to the building, wall or curbstone, which acts as a substantial heel. The four men take their positions as shown in Figure 28.

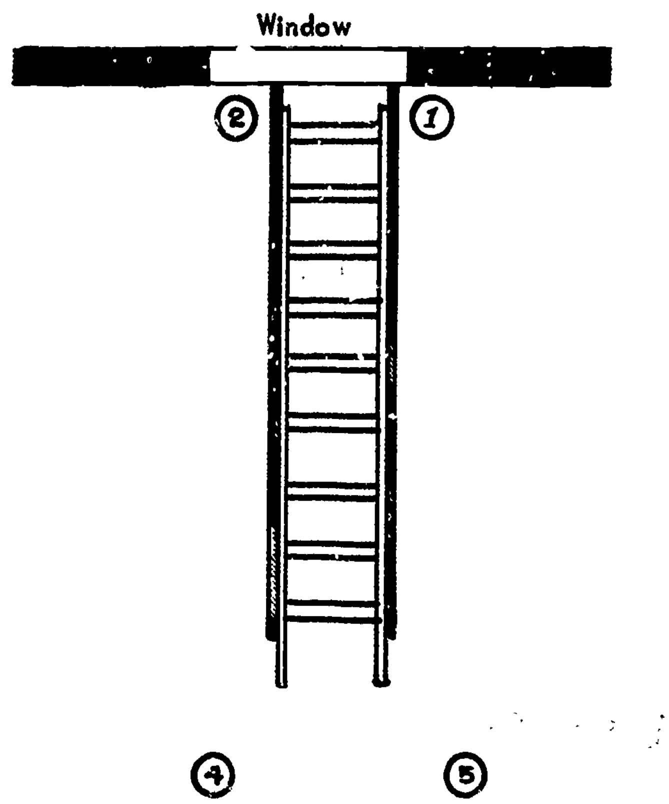


Fig. 28 - Positions for Raising Bangor Ladder - Four Men

2. The two beam men release the tormentor poles by removing the keys and pass them overhead to the tormentor men. Then, the beam men return to their respective places just below the tormentor swivels as shown in Figure 29.

3. Facing the top of the ladder, they reach down, knuckles up, and grasp a common rung. Then they lift the ladder overhead, turn under the ladder beams, and raise it to a vertical position as shown in Figure 30.

4. From this position the two beam men grasp a convenient rung and the opposite beam and carry the heel the proper distance from the building. The top is held next to the building by the tormentor men.

5. Then the beam men, standing on the outside the ladder, place their inside foot on the bottom rung and the tormentor men pull the

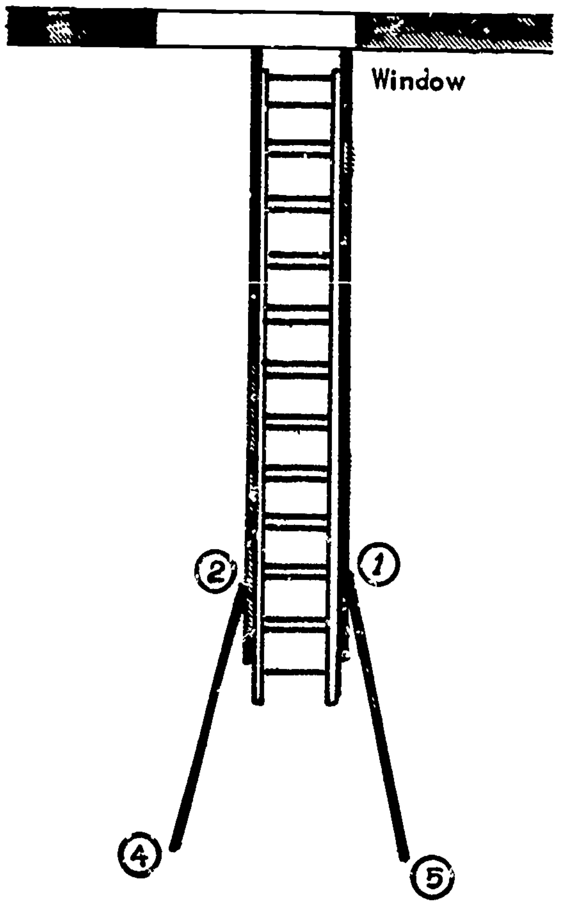


Fig. 29 - Positions After Releasing Poles

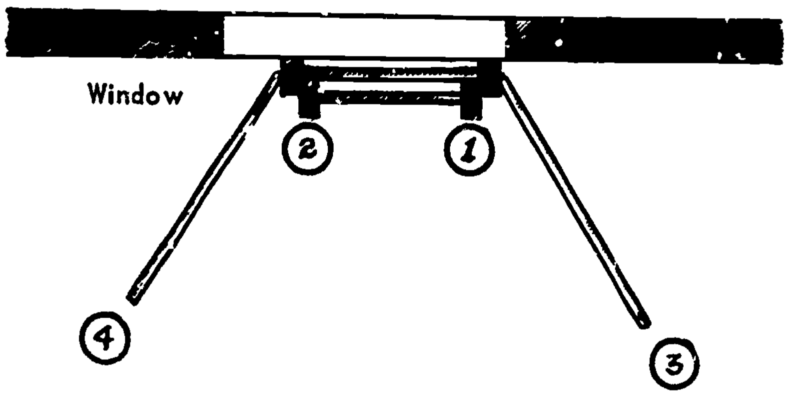


Fig. 30 - Bangor Ladder Raised to Vertical Position - Four Men

top away from the building to a vertical position. Following this, the beam men raise the fly ladder and lock the pawls.

6. While the ladder is held in place by the heel men, the tormentor men lower it against the building. The tormentors are then placed in position.

7. To lower the Bangor ladder, flat raise, at right angles to the building with four men, the steps are reversed.

Raising the Bangor Ladder Parallel to Building - The safest way, of course, to raise a Bangor ladder is at right angles to the building, but there are times when there is not enough room for this procedure and it must be raised parallel to the building. For instance, where a ladder must be raised in a narrow alley the parallel method must be used. In making the raise parallel to a building, position the ladder as shown in Figure 31. The raising procedure is the same as the right angle raise until the ladder is in a vertical position, at which time the following procedure is recommended:

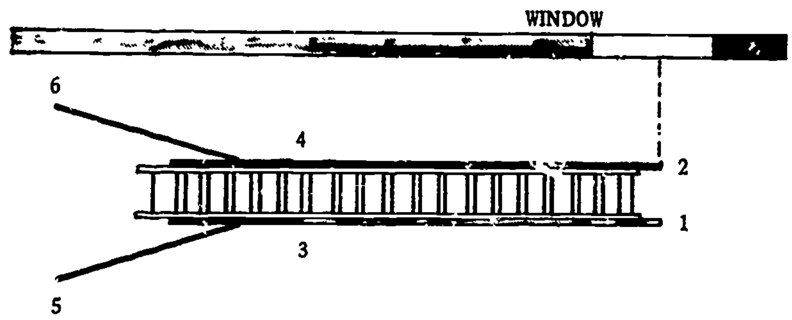


Fig. 31 - Bangor Ladder Raised Parallel to Building

1. When the ladder is in the vertical position, the tormentor man farthest from the building will swing to the inside of this pole and carry it around to the side at right angles to the tormentor pole, as shown in Figure 32. *Note: Never walk backward with a tormentor pole.*

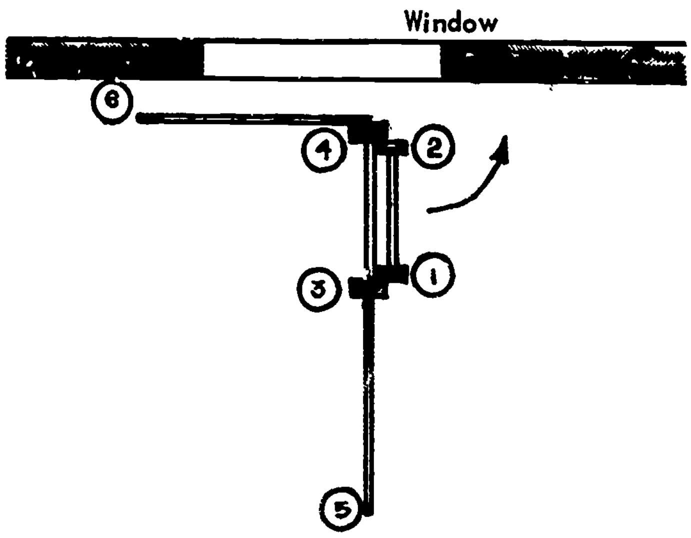


Fig. 32 - Position for Pivoting the Ladder

2. The ladder must then be pivoted to the building. The tormentor man who is facing the building pushes slightly on the pole, shifting the weight of the ladder to the beam next to the building. This allows the beam and the heel men to pivot the ladder to face the building, as shown in Figure 33.

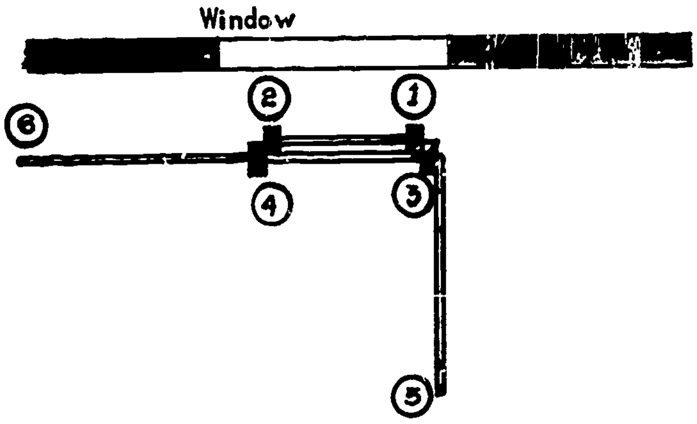


Fig. 33 - Pivoting the Ladder

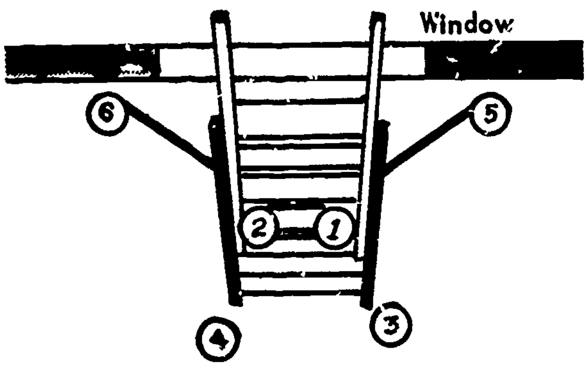


Fig. 34 - Position of Bangor Ladder After Lowered into Building

3. The fly is then raised and the ladder lowered against the building, as usual, as illustrated in Figure 34.

Raising the Bangor Ladder by the Beam Raise - This raise is also used in narrow spaces, behind wires, etc. In executing this raise, the ladder is first placed parallel to the building. Then, the inside pole is extended on the ground and the ladder turned up on the inside beam. The men take their positions as shown in Figure 35 with number one and two acting as heel men and the number six man taking the upper pole. Beam men numbers three and four face the top of the ladder and raise it, walking under the beam, with pole man number five taking a great part of the load. When the ladder is in a vertical position, pole man number six pivots to a position in front of the ladder. Now the ladder is in a position for elevating the fly ladder and placing it at the desired point on the building.

If five men are used, number one takes the pole and also continues to help heel the ladder. The number six man is out. If four men are used, the number three beam man is also out.

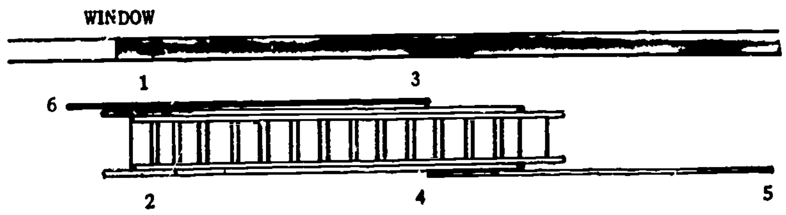


Fig. 35 - Positions for Raising the Bangor Ladder by the Beam Raise

CLIMBING PROCEDURE - SPECIAL USES AND SPECIAL LADDER EVOLUTIONS

CLIMBING PROCEDURE

The man who climbs a ladder well has good form and a certain well-defined rhythm. Both are the result of correct instruction and practice. Figure 36 illustrates the proper stance when climbing ladders.

A good ladderman stays at arm's length from the ladder. Good form consists of keeping the body erect and the arms straight but not tense. When a man holds himself rigid and hugs the ladder, he is in danger of falling because he does not have control of his body. Also, he cannot place his feet on the rungs properly because his knees will collide with the rungs.

Fig. 36 - Proper Climbing Procedure

The only instance where it would be advisable to use the beams rather than the rungs in ladder climbing would be where one is carrying an object.

In order to keep the ladder steady, it should be climbed near the center of the rungs, simultaneously using the same hand and foot when climbing. The climber should not look down or watch his feet. Rather, he should look slightly upward toward the next rung. His hands should be moved on the rungs at a level between the waist and the head. The rungs should be grasped by his hands with the palms down and the thumbs around the rungs. This will avoid body sway and splinters frequently encountered when climbing with hands on the beams. This method is considered the safest because a much firmer grip is possible on the rungs than on the beams, particularly if the climber's hands are not large. The use of rungs in climbing is also advisable because the hands can test the rungs. Thus, a defective rung may be detected before placing the foot upon it. The legs, and not the hands, carry the weight of the body when climbing. At each step the ball of the foot, and not the arch, should be placed on the rungs. A foot should be placed on each rung. However, some men secure the best climbing rhythm by taking every other rung with the hands and every rung with the feet. It is a bad practice to run up or down a ladder. It is best to climb briskly, but smoothly.

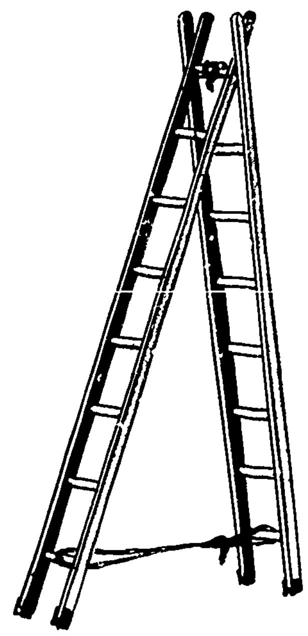


Fig. 37 - Making a Step Ladder

MAKING AND CLIMBING A STEPLADDER

A step ladder may be made from two parts of an extension ladder. To do this, the extension is taken apart and both ends are turned upside down. Then the top rung of the bottom section is laid into the locks of the top section and secured with a rope. A rope is then tied across the bottom rung as a spreader. If other rope is not available, a rope hose tool can be used. When mounting the improvised step ladder, climb the bottom section in order not to open the locks. See Figure 37.

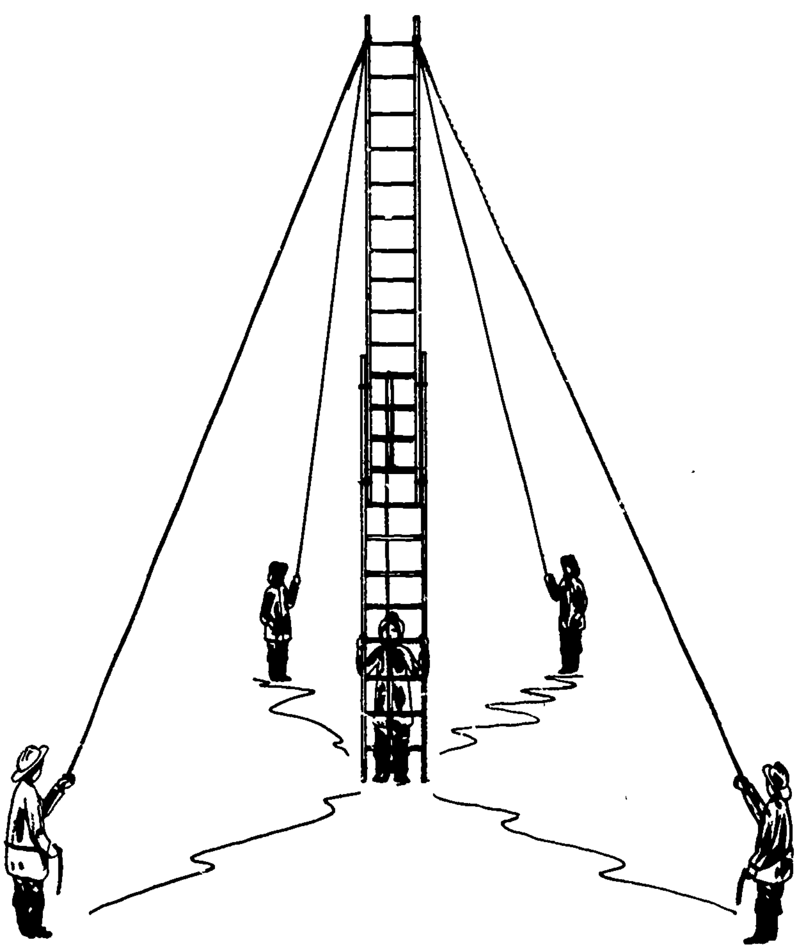


Fig. 38 - High Ceiling or Flagpole Raise

MAKING A HIGH CEILING, CHURCH OR FLAGPOLE RAISE

In making the raise as illustrated in Figure 38, place the ladder on the ground with its heels near the final position. Extend the fly ladder horizontally a short distance and latch the locks. Divide two long ropes evenly and place one on each side of the ladder. With the doubled loop end of each rope, place a half-hitch around the beam below the rung, then slip the loop over the top of the beam, cinching snugly; see Figure 39. *Do not make the hitch over the top of the beams as it might peel off when the fly ladder is lowered.* The ladder is raised by any convenient standard method. If the ladder has poles, they can be used to assist in the raise, but they should then be held out of the way so that the ladder will not rest on them when in the vertical position. After the ladder is vertical, the ropes are spread by four men who are equally quartered all around the ladder. One or

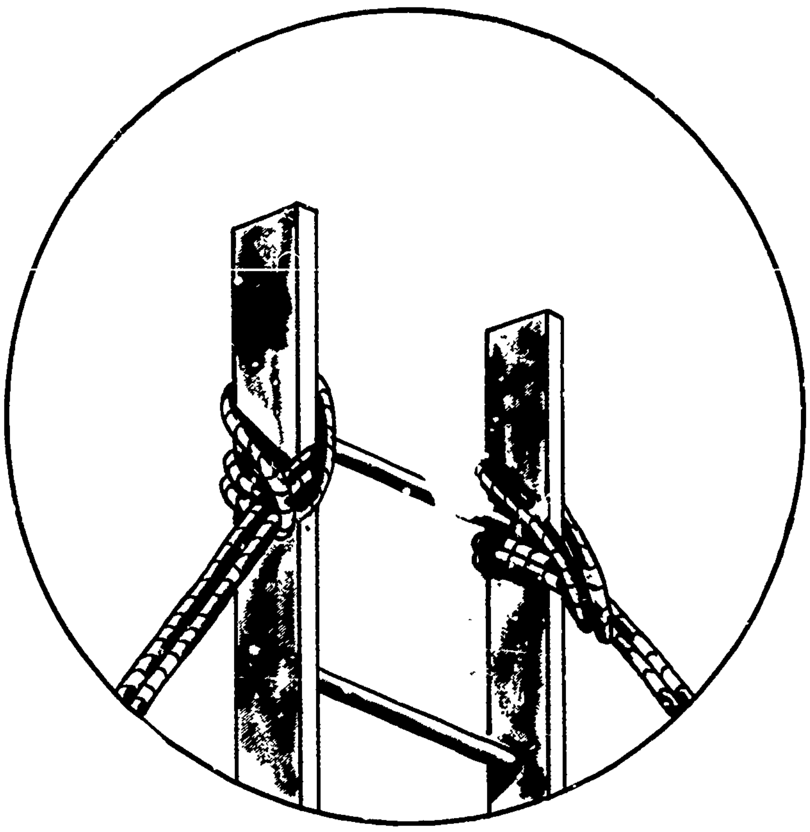


Fig. 39 - Close Up of Ladder Top

Fig. 40 - Leg Lock on a Ladder

two men remain at the ladder heels and raise the fly ladder, while the others carefully give out rope. The rope men pass ropes behind their hips and around to the front of their bodies to a comfortable position for holding. The ropes are not tied around their bodies. When lowering the fly ladder, take in the rope slack carefully. After the fly is down, the top may be leaned slightly away from vertical and held by two ropes while the other men come in to lower the ladder to the ground.

LEG LOCK

When working from ladders, it is frequently necessary to have both hands free to do such work as directing hose streams, handling roof ladders, etc. No man working on a ladder should let go with both hands unless he has safely secured himself to the ladder so that he will not loose his balance and fall. If the man working on a ladder wears a life belt or rope tool, he simply snaps the hook to the ladder and his hands are free.

When such equipment is not available, the fireman must know how to secure himself to the ladder and still have his hands free. This is very easily done by taking a leg lock on the ladder. To take a leg lock, as shown in Figure 40, the ladderman places one leg through the ladder over the second rung above the one upon which he is standing. He then brings his foot back through the ladder between the first and second rungs and places the toe of his foot over the rung above the one on which he is standing. Men of more then average height may prefer to lock the foot around the beam of the ladder just below this rung as shown in Figure 41.

When the work being done does not necessitate facing the ladder, a side-sitting position may be taken on the rung over which the leg has been placed. This type of hold is useful when hauling up tools or other objects from the side of the ladder as shown in Figure 42.

The leg lock is made on the side of the ladder opposite the side on which work is being done. As most work is done on the right side, the leg lock is usually made with the left leg. The arch of the lower foot, on which the weight is carried, should be on the rung near the beam in a position from which it will not slide should the ladder be wet or slippery.

Fig. 41 - Leg Lock Variation

Fig. 42 - Leg Lock to Work at Side of Ladder

MAKING AN END-TO-END SPLICE

The end-to-end splice illustrated in Figure 43 can be made when the main ladder is in line and resting on a window sill. A short ladder with iron heels can be set on one of the upper rungs of the main ladder and held in place by one or two men from inside the ladder. The top ladder heels should be set on the rung of the main ladder, beneath which there is a tie rod.

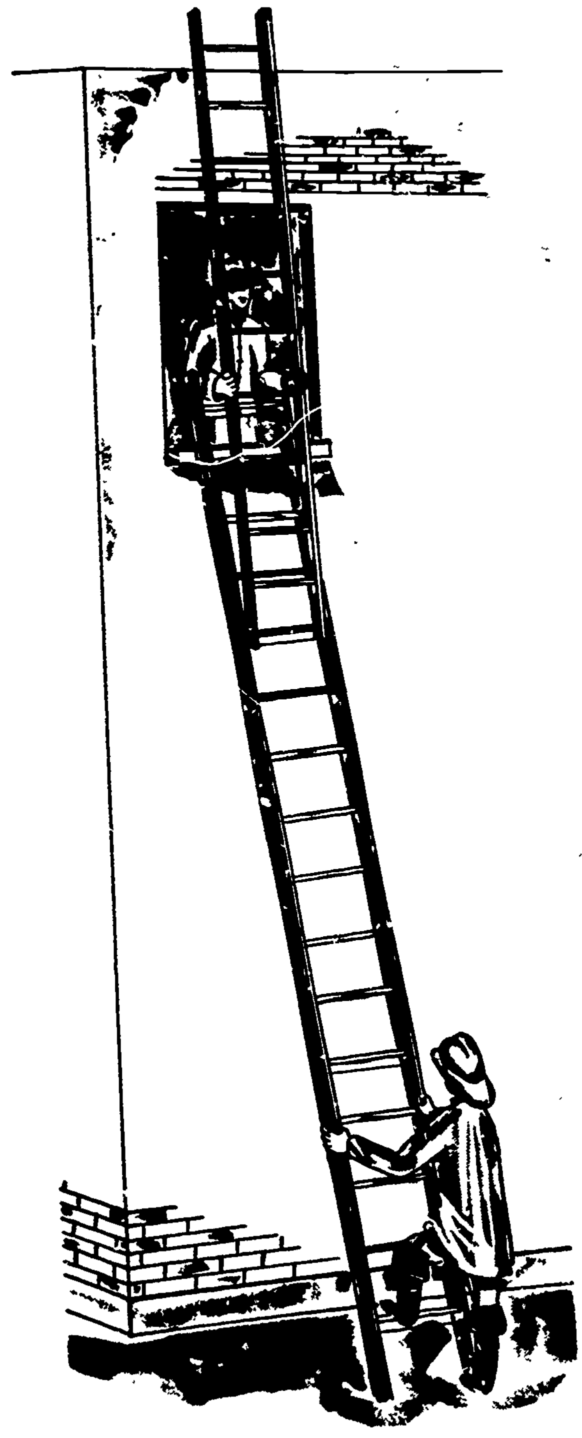


Fig. 43 - End to End Splice

MAKING A HOTEL OR FACTORY RAISE

This raise, as illustrated by Figure 44, is made by elevating a Bangor ladder by any desired method. The ladder must be finally brought to a position in line with a vertical row of windows. The heels should

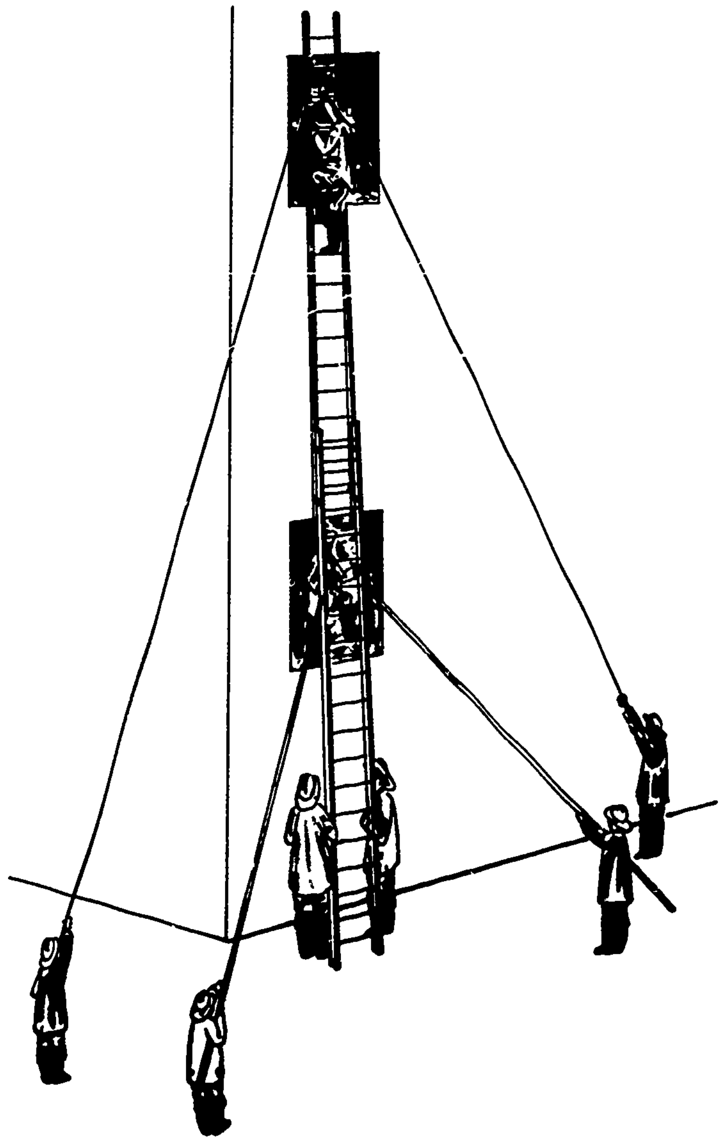


Fig. 44 - Hotel or Factory Raise

be approximately four feet out from the building. *If the cornice of the building is very wide, this must be taken into consideration when setting the ladder heels.* The top of the ladder is placed against the building, having one man at the side of each beam butting the ladder, and one man on each pole. The pole men, out at an angle of 45 degrees, support the ladder. A rope should be secured on each beam, a short distance from the top. One man holds each rope, and they position themselves at the side of the ladder as illustrated in Figure 44. These ropes give the ladder side support. Victims may use both sides of the ladder when descending, but usually those on the lower floors use the inside.

Should it be necessary to move the ladder a short distance to another vertical row of windows to the right or left, the tormentor men pull the top of the ladder from the building. The heel men then lift and carry the ladder to the right or left until the heel of the ladder is properly placed in the new location, at which time the top of the ladder will be placed against the building for further rescue work. Four men may be required to carry the ladder, depending on the length of the extension.

The top of the ladder should never be positioned in the second location until the base of the ladder has been properly placed. This will prevent panic stricken people from getting on the ladder before it is properly placed for safe use.

PLACING A ROOF LADDER IN SERVICE

Figure 45 illustrates the steps to be followed in placing a roof ladder in service. For one story buildings, the man placing the roof ladder does so from the eaves of the building. When the top of the roof ladder is raised to him, he opens the hooks and slides the ladder to its place on the roof. When a two story building is involved, the roof ladder is raised to a vertical position resting on the right side of the wall ladder. The first man then ascends the wall ladder until he is opposite the top of the roof ladder. He then opens the hooks outward. This is a safety measure to prevent the hooks from striking the man carrying the ladder if it should slip from his grasp.

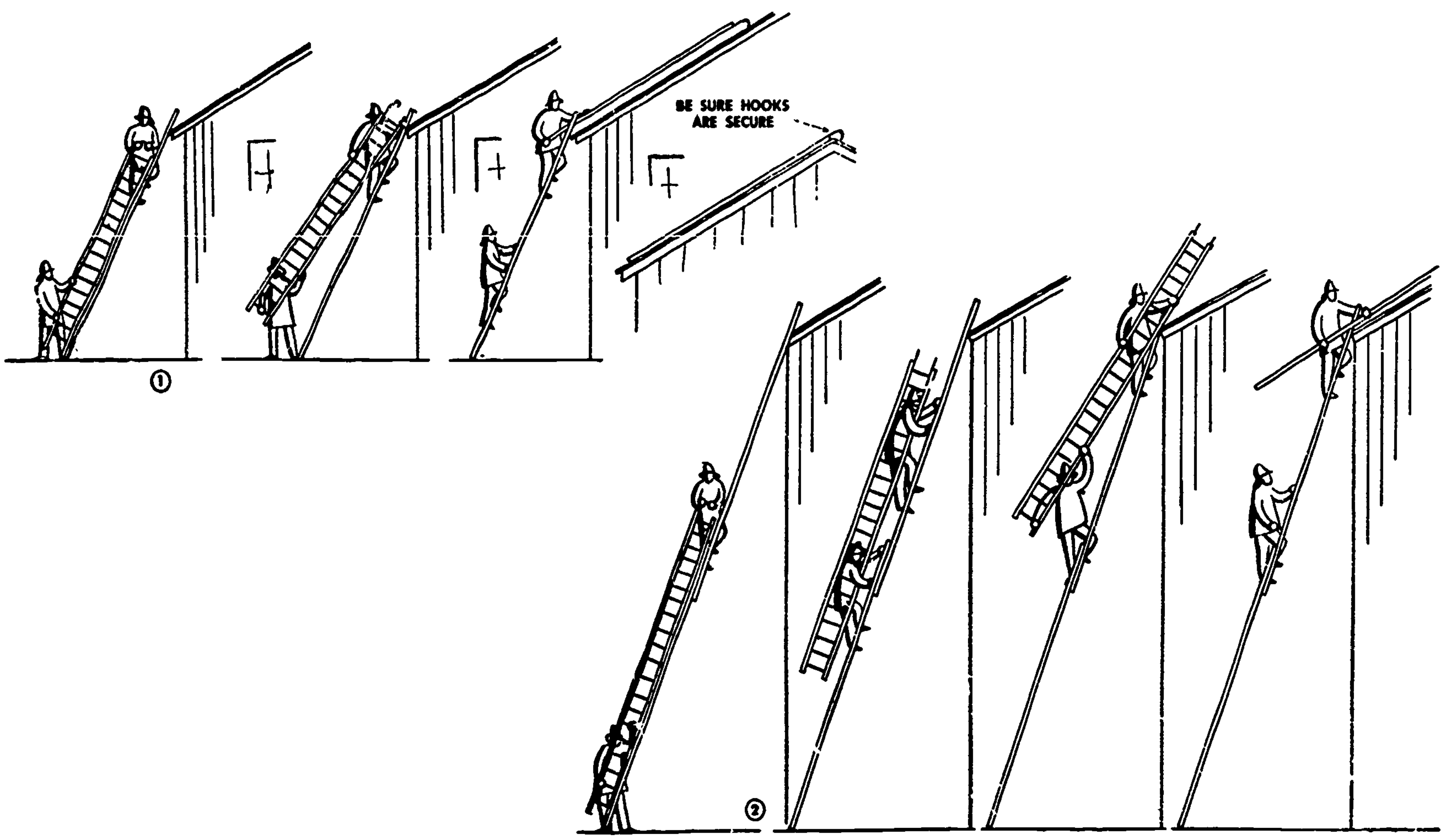
After making sure that the hooks are securely open, the top man steps down and places the roof ladder on his shoulder at a point between its second and third rungs. The second man also carries the ladder on his right shoulder. Each man, then, has both hands free for climbing.

When the top man is waist high to the eaves of the building he stops climbing and takes a leg lock on the wall ladder. The leg lock is made when the leg on the side opposite that on which the roof ladder is carried. He then passes the roof ladder upward, hand-over-hand. When the ladder is half above the eaves, the beam of the roof ladder is allowed to come to rest on the roof. The ladder is then turned flat with the hooks underneath so that they may be used as runners when the ladder is pushed over the ridge of the roof. *Care should be taken to see that the hooks are securely engaged before climbing the roof ladder.*

LADDER BRIDGING AND ANCHORING

The following methods apply particularly well to the conditions stated, but often can be modified to meet other conditions. Some types of bridges are:

From Ladder to Window - In making the "ladder to window" bridge, one man carrying a ladder on his shoulder, at about the third rung from the end, with both hands free, climbs to the desired height on the



① *Short roof ladder placed on one-story building.*
② *Longer roof ladder placed on two-story building.*

Fig. 45 - Placing Roof Ladders

main or wall ladder, placing one leg through the ladder and seats himself on a rung facing a beam. He then places a knee beyond the back of the beam, rests the foot on a rung, swings the bridging ladder down by placing his inside hand under the low beam, the outer hand above the top beam, and then passes the ladder across intervening space into the window using the knee as a support. See Figure 46. The bridging ladder is then pulled back through the main ladder and the rungs of both ladders lashed together with a rope, rope hose tool or a strap. The bridging ladder should be placed so that it slopes slightly toward the building. Since the main ladder heels are seldom more than 15 feet out from the building, a 12 foot ladder will usually be sufficient to make a bridge. When an aerial ladder is used, a longer bridge ladder is required. Care should be taken to avoid the protruding heels of the bridging ladder when climbing the main ladder. When the bridging ladder has hooks, these are placed at the main ladder end.

From Roof to Roof or Roof to Window - In making these bridges, one ladder and three or four men are used. The ladder is held climbing side up, as in

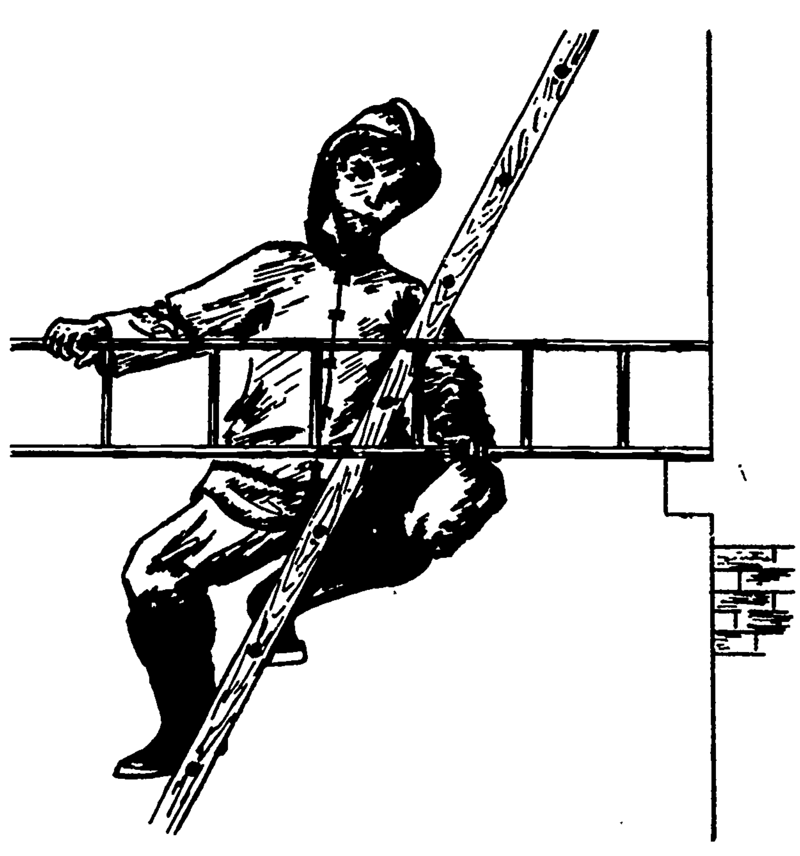


Fig. 46 - Ladder to Window Bridging

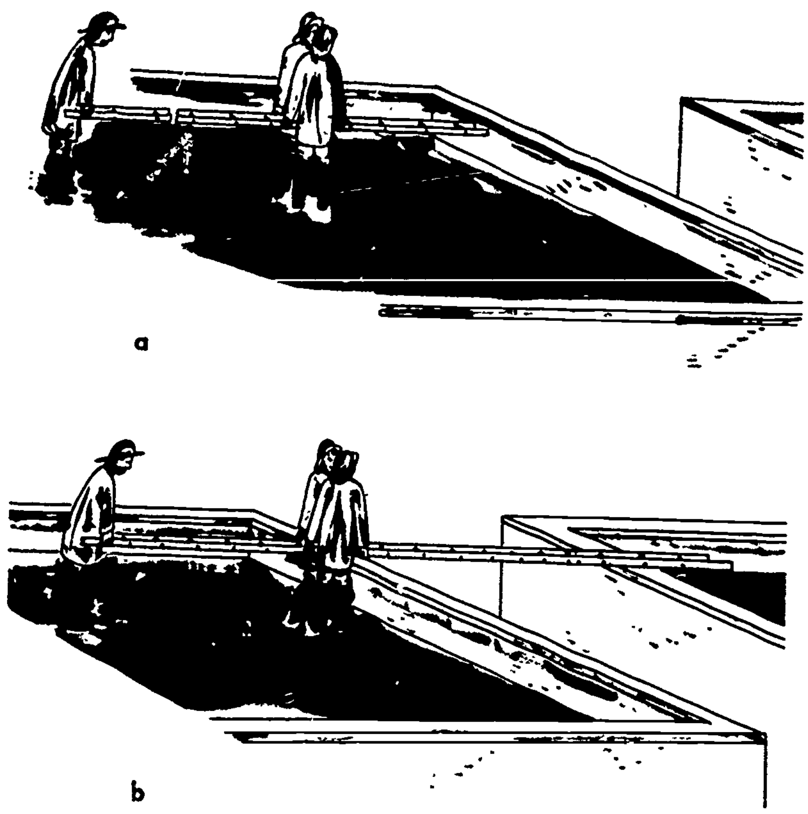


Fig. 47 - Roof to Roof

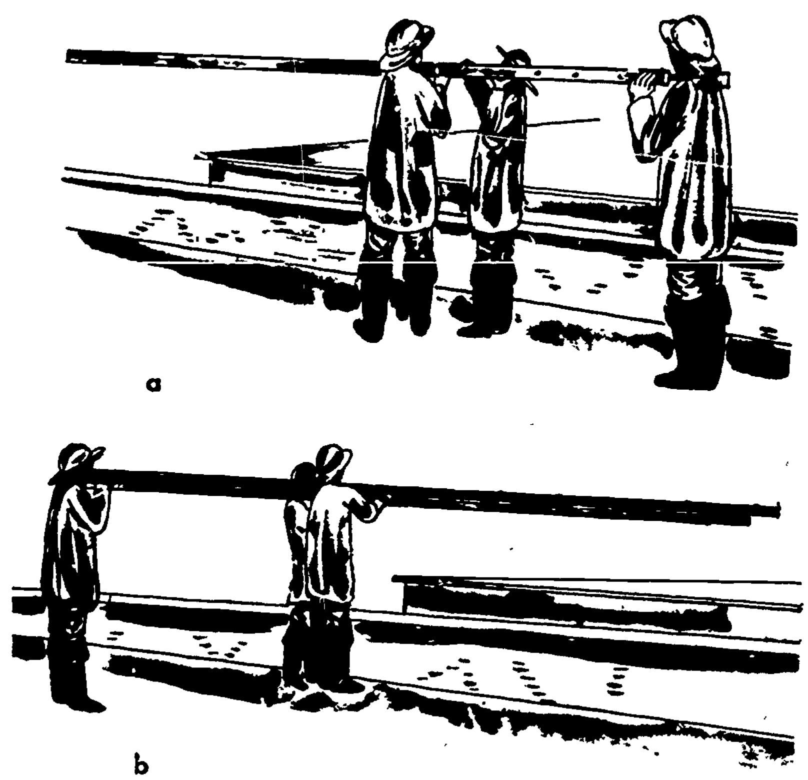


Fig. 48 - Swing Around Bridge

Figure 47a, with the top of the ladder close to the open space. Two men at the top face each other across the ladder with arms and legs straight and palms upward to cradle the ladder. Either one or two men may be used at the heel end. The ladder is then passed out slowly over the open space as shown in Figure 47b.

Where space is too restricted to use the previous method, all the men assemble near the ladder heels and face the top, using the following method: The heel end of the ladder is lifted and placed on the inside shoulders of the front men. The corresponding arm may grasp a rung on the far side of the ladder making a cross arm effect. See Figure 48a.

The heel man or men pull down on the ladder heels and pivot the ladder on the shoulders. All swing around carrying the ladder over the opening. Then, if necessary, the ladder can be transferred to the cradled hands. This is known as the pivot or swing around bridge as shown in Figure 48b.

ANCHORING LADDERS

When it becomes necessary to work from a ladder for any reason, it is good practice to anchor it to the building. The anchor prevents the ladder from vibrating, slipping or turning over in case the load is shifted. The rope hose tool, as shown in Figure 49, makes a good ladder anchor. The slack must be taken from the rope. This can be accomplished by twisting or taking extra turns around the rung.

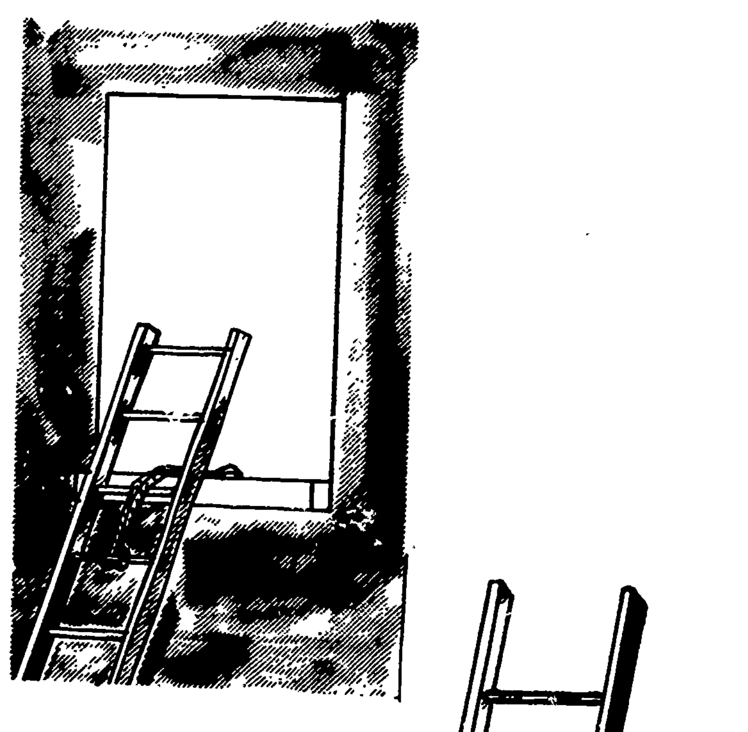


Fig. 49 - Anchoring Ladder Using Rope Hose Tool

HOLDS AND EVOLUTIONS USED IN
LADDER CLIMBING

A good reinforcing hold for backing up a man on a ladder is shown in Figure 50. When using it, however, care should be taken that the top man is not held so closely that he cannot work properly or that he is held in the path of hot gasses, etc. The lower man puts a leg lock on the rung above the one on which the top man is standing; then, if convenient, the upper man's leg may be included in the toe hold of the leg lock. The lower man puts his arms beneath the armpits of the upper man and grasps a rung.

Another hold used for backing up a man working from a ladder, leaving both his hands free, is shown in Figure 51. The lower man puts a leg lock on the rung on which the top man is standing, locking in the top man's leg. The arm on the same side is then passed under the crotch of the top man, grasping the rung just in front. The other foot is placed against the beam and the arm on the same side is extended forward, the hand grasping the beam. The same can be accomplished with the top man facing the outside. See Figure 52.

SAFE PRACTICES AND PROCEDURES
IN THE CARE AND USE OF LADDERS

Much of the following material was listed in the preceding paragraphs of this chapter but is repeated at this time because of its importance.

1. The tops and locks of all ladders should be painted white or some other distinctive color. A mark should also indicate the climbing side. Also, ladders should have small bands painted on them to show proper positions for carrying and hoisting. The

Courtesy Loudonville, Ohio Fire Dept.

Fig. 50 - Backing Up a Man on a Ladder

Courtesy Loudonville, Ohio Fire Dept.

Fig. 51 - Crotch Hold on a Man Facing Building

Courtesy Loudonville, Ohio Fire Dept.

Fig. 52 - Crotch Hold on a Man Facing Away From Building

length of all ladders should be marked on the beam near the end. This eliminates guesswork in the removal and replacement of ladders at fires.

2. The number of men normally permitted on the different size ladders is as follows:

    a. 12 to 16 feet - one man

    b. 18 to 24 feet - two men

    c. 28 to 40 feet - three men

    d. 45 to 55 feet - four men

    Men should be spaced approximately 10 to 13 feet apart when climbing ladders.

3. When placing ladders to windows, use 20 feet for the second story, 30 feet for the third story, (sometimes to 35 feet), and 45 to 50 feet for the fourth story.

4. Do not lean too far over the beam of a ladder, but re-position the ladder instead.

5. To facilitate the handling of hose lines, etc., ladders should be placed at the far side of a window.

6. Ladders should be placed the proper distance from the building with allowances made for cornices, overhangs, etc.

7. When using very short ladders, set them at a good working angle.

8. If set incorrectly, the heel of the ladder may be moved over slightly by one or more men. One man can move a heavy ladder by backing up to the underside and grasping a low rung. Two men in a position like that used at the start of the vertical carry can move a ladder. In backing out the heel, be careful that you do not unlock the fly.

9. Whenever possible, "tie in" the ladder near the top. The rope hose tool is good for this purpose. When the top is not tied in, have the bottom held whenever possible.

10. The first man up the ladder should check the locks. When practicing it is well to close the eyes and feel the locks as if in smoke and darkness.

11. Always tie in the fly rope when the ladder is finally in position.

12. In lowering the ladder, never untie the fly rope until the ladder is in a vertical position.

13. When a fly ladder is being raised or lowered, keep the hands and feet off the rungs and watch for guide irons which can injure the hands.

14. Inspect ladders frequently to make sure that all parts are in good operating condition, beams and rungs are free of splinters, rungs are tight, properly varnished, and the rope is in good condition. Use only a clear, hard varnish on ladders; never use a solid color paint which might cover defects, except where identification marks are necessary.

15. The protruding ends of ladders at the rear of trucks and in stations often are the cause of head and shoulder injuries. In the station these injuries can be prevented by constructing small, loose fitting boxes with rounded outside corners. They are then suspended from screw eyes in the ceiling or supported with a floor standard over the ends of the ladders. They can be painted a bright color to attract attention. Short pieces of 2 1/2" fire hose can be placed over the head irons for protection.

16. All fire department ladders should have heel irons which are maintained in good condition. The collapsible hooks of roof ladders should be set entirely back of the ends of the beams, thus making such ladders more serviceable as straight ladders.

17. Do not set a ladder in front of a door without first locking the door or posting a guard.

18. Do not step over a ladder when it is lying on the ground; walk around the end.

19. If the ladder crashes into a window, men at the foot of the ladder should watch for broken glass sliding down the beams. They should also watch for falling bricks, stones, etc.

20. Always face the ladder when ascending or descending.

CHAPTER 12

GAS MASKS

INTRODUCTION

Although a gas mask is one of many pieces of equipment carried on pumpers and ladder trucks today, it can be stated without reservation that it is considered to be one of the most important. In this modern age of chemicals, plastics, refrigerants, synthetic materials and various compounds used in industrial processes, it must be recognized that it is extremely important and necessary to protect firemen who, in a time of emergency, must operate in atmospheres containing poisonous and toxic gases. There have been many occasions when the life of a fireman has been sacrificed in an attempt to rescue people trapped or overcome in smoke or gaseous areas because the fireman did not or could not protect his respiratory system. For the protection of firemen the Ohio 100th General Assembly passed section 3737.31 of the Revised Code which requires self-contained oxygen breathing apparatus in each fire department operated by a political subdivision. The applicable section of the law is reproduced below:

Section 505.48 R.C.

(A) "Gas mask" means any self-contained oxygen breathing apparatus using oxygen or air in suitable containers that enable their wearers to live in atmosphere containing less than sixteen percent oxygen and poisonous gases in excess of two percent by volume and having been approved by the United States Bureau of Mines for use in irrespirable atmosphere.

(B) Every political subdivision which operates a fire department shall provide at least two gas masks for each fire station and shall further provide that the chief of the fire department give adequate instructions to each member of the fire department in the use of such gas masks. (125 v. H337. Eff. 10-6-53)

IMPORTANCE TO FIRE SERVICE

One of the fundamental rules of fire fighting should be that no one, unless equipped with self-contained or self-generating air supplying apparatus, be allowed in a fire involved area. The ordinary fire department filter type mask will stop the passage of toxic fire gases such as ammonia or carbon monoxide not exceeding 2% by volume, but the masks are definitely not suitable for conditions where a deficiency of oxygen exists.

Providing for the life safety of the firemen should be a paramount responsibility of the officers in charge of a fire. In addition to the duty of training the men in the use of respiratory equipment, the officers should see that firemen use this equipment whenever and wherever necessary.

In recent years, another hazard has been added to the problem of fire fighting; that is, the use of atomic energy in the various areas of our industrial, commercial and educational structure. It is predicted that this problem will become more and more complicated because of the presence and use of radioactive materials at many locations within the area of the fire departments' protective responsibility.

Instructions from the U.S. Atomic Energy Commission relative to radiation hazards in fire fighting, state, "masks should be worn from the time of arrival at the fire where radiation contamination hazard exists, until the hazard no longer exists." Preference indicated as to the type of mask to be worn in such a situation is the self-contained unit.

It would be impossible to list or discuss every hazardous gas encountered today. A few of the most common with which firemen may come in contact are shown on the chart, Figure 1. This chart indicates the certain properties, characteristics, effects and treatments of these gases with which firemen should become familiar.

It is suggested that fire departments make a survey of the community to determine any additional hazardous gases which could be encountered in industrial, mercantile or commercial areas. Then in cooperation with the chemists, engineers or other responsible persons in charge of these operations, a supplementary chart can be prepared and also used for reference. This would be an excellent method by which to gain good public relations with the people in the community. The community will be pleased to

POISONOUS GASES AND THEIR PROPERTIES

GAS	WHERE FOUND OR USED	WEIGHT COMPARED TO AIR	COLOR	ODOR	TASTE	WILL BURN SKIN	WILL BURN EYES	WILL BURN THROAT	ACTION AND EFFECT ON VICTIM	EXPLOSIVE OR INFLAMMABLE	REMOVE FROM CAUSE AND TREAT FOR-
Acetylene	Welding shops and factories	Lighter	No	Sweet	No	No	No	Yes	Slow or delayed	Yes	Shortness of breath or asphyxia; shock
Ammonia	Large cooling plants	Lighter	No	Yes	Yes	Yes	Yes	Yes	Quick and delayed	Yes	Shortness of breath or asphyxia; shock; eyes; burns
Carbon Monoxide	Result of incomplete combustion	Lighter	No	Slightly garlic, usually not noticed	No	No	No	No	Quick	Yes	Keep victim inert, shortness of breath or asphyxia; shock
Chlorine	Purification plants, laundries	Heavier	Greenish-yellow	Pungent	Yes	Yes	Yes	Yes	Quick and delayed	No	Shortness of breath or asphyxia; shock; eyes; burns
Hydrogen Cyanide	Exterminating buildings	Lighter	No	Bitter almond	Yes	No	No	No	Quick	Yes	Shortness of breath or asphyxia; shock
Hydrogen Sulphide	Cesspools	Heavier	No	Rotten eggs	Yes	No	Yes	Yes	Quick	Yes	Shortness of breath or asphyxia; shock; eyes
Menthel Chloride	Refrigeration	Lighter	No	Yes	No	No	No	No	Slow and delayed	No	Shortness of breath or asphyxia; shock
Natural Gas Bottled Gas	Home and industrial use	Lighter Heavier	No No	Yes Yes	No No	No No	No No	No No	Quick Quick	Yes Yes	Shortness of breath or asphyxia; shock
Nitrous Oxide Fumes	Fires and electric welding	Heavier	Deep orange	Pungent	Yes	No	No	No	Slow and delayed	Yes	Shortness of breath or asphyxia; shock
Phosgene	Dry cleaners and fires	Heavier	No	New hay	No	No	Yes	Yes	Slow and delayed	No	Keep victim inert; shortness of breath or asphyxia; shock; eyes
Sulphur Dixoide	Bleaching and fumigating	Heavier	No	Bitter	Acid	No	Yes	Yes	Quick	No	Shortness of breath or asphyxia; shock

Fig. 1 - Poisonous Gases and Their Properties

cooperate when informed that the fire department is interested in the community's safety and welfare.

In addition to the hazard caused by a poisonous gas, firemen must also be aware of the potential explosion hazard involving some of these gases. If in doubt as to whether or not the gas is explosive, every precaution must be taken to prevent a spark. Light switches should not be turned on or off. Equipment and tools made of ferrous metals should be handled carefully so as not to create sparks.

TYPES AND USES OF GAS MASKS

In general, respiratory protective equipment is classified as follows: (1) The filter type canister mask, (2) mask where air or oxygen is supplied from an outside source, and (3) self-contained breathing apparatus. Each of these types of masks is designed for protection of the respiratory tract. It should be kept in mind, however, that for many gases protection of the respiratory tract is not enough, since some gases may harm the body on contact. For these gases, it is necessary to wear protective clothing in addition to the proper respiratory protection.

FILTER TYPE CANISTER MASKS

Several different makes of filter type canister gas masks are manufactured.

The filter type canister mask is designed to provide protection against some kinds of smoke and poisonous gases, including carbon monoxide. It should be borne in mind, however, that all filter type models have definite limitations. They can be worn only in atmospheres containing sufficient oxygen to support life. The best way to detect a dangerous deficiency of oxygen is to observe the flame of a safety lamp. The flame will go out when the oxygen content of the atmosphere falls below sixteen percent. A man should not enter or remain in an atmosphere in which a flame will not burn unless he is protected by a self-contained or supplied air or oxygen breathing apparatus. Although the use of the flame safety lamp is recommended, active combustion is an indication of sufficient oxygen to support life. Another limitation of the filter type masks is that they cannot be worn in atmospheres containing more than two percent by volume of poisonous gases. In addition, heavy-bodied smoke, such as that given off from burning plastic, will clog or gum the intake and interior of the canister. This causes the mask to be inoperative. The major parts of a filter type canister mask with a timer are: (1) The canister, with harness and carrying case; (2) the facepiece, with headbands and flexible tubing; and (3) the timer. See Figure 2.

Courtesy Mine Safety Appliances Co.

Fig. 2 - All Service Mask

Canister - The smoke type canister is painted *red.* A canister painted any other color is designed for a definite and specific group of gases. The red canister is approved for two hours of constant or intermittent use for protection from carbon monoxide. When working where carbon monoxide is present, there is a tendency for the canister to become warm. The degree of warmth will depend upon the concentration of the gas. This is due to the fact that while the chemical is acting as a catalyst in changing the carbon monoxide to carbon dioxide, heat is formed. Canisters should be stored in a cool, dry place. Seals should never be removed from a canister until it is put into service. After canister has been put into service, it should be replaced at least once a year, even though never used.

In assembling the mask, the canister is prepared for service by removing the seals. The canister can be tested by inhaling and exhaling, but it should be remembered that inhalation is possible only from the top opening and exhalation into the bottom opening. An audible click will indicate that these valves are opening and closing properly.

Facepiece - The facepiece must be cleaned after wearing. The inside should be sterilized by cleaning thoroughly with a germicidal solution such as aqueous zephiran 1:1000 solution or staphene solution.

The headbands must be maintained in good working order. Broken, torn or defective bands must be replaced. It is recommended that a facepiece with a defective band be removed from service until repaired or replaced. The conformity of the facepiece to the wearer's face is dependent on the headbands for proper adjustment.

The flexible tubing must be examined carefully for cuts or breaks. Any impairment or defect in this tubing may jeopardize the safety and protection of the wearer.

Timer - The timer is a device which indicates the approximate time the mask can be worn in safety. It is actuated by the respirations made by the user. The pointer, which rotates on a dial face, makes a complete revolution in approximately two hours of continuous or intermittent service. After the pointer has made one complete revolution, the canister must be removed and a fresh one inserted.

The timer is connected to the canister, and the facepiece is connected to the timer. In doing so, it must be made certain that the gaskets are in place at both couplings. The facepiece is then fitted to the wearer by adjusting the headbands. At this point it should be tested for air tightness by holding a hand over the opening in the bottom of the canister and inhaling. If there is no leakage the facepiece will collapse and the mask is ready for use.

In the past, the timer has been used as an indicator to show approximately two hours of breathing time. This period of time coincided with the Bureau of Mines requirement that the canister must contain enough drying agents to adequately protect the catalyst (Hopcalite) from water vapor during a two hour period of use. Since the life of the canister for protection against carbon monoxide is directly related to the ability of the canister to remove water vapor, it follows that the canister will protect against carbon monoxide for a two hour period.

Although the Bureau of Mines test for two hours of protection against water vapor is a realistic test, there are extreme conditions which will render an approved canister ineffective against water vapor absorption in less than two hours. Some of these conditions are as follows:

1. Relative humidity exposure greater than 85%, particularly at elevated temperatures.

2. Extended periods of high demand (over 25 liters per minute) of continuous breathing by a person having a large breathing capacity and performing strenuous work in atmosphere of high relative humidity.

3. Exposure of the canister to modern techniques of fire fighting where "Wet Water" and fog are used. These techniques greatly increase the amount of water vapor dispersed in the air compared to that encountered by previous fire fighting techniques.

4. Accidental introduction of water into the canister by a fire hose, firemen crawling through water on a floor, failure to completely dry the facepiece and breathing tube prior to assembling the breathing tube to the canister, or failure to replace the top and bottom seals of the canister after each use.

Window Indicator Type - The major parts of the window indicator type on filter canister masks are:

1. The canister, with harness and carrying case.

2. The facepiece with headbands and flexible tubing.

3. The check valve.

One of this type of canister contains a round glass window located in the center of the canister, approximately one third of the way down from the top of the canister. See Figure 3. Inside the glass window are two half circles of paper. The right half, stamped "R" (facing the canister) is the reference color and is a very light blue. The left half is the the indicator paper which is a darker blue. When the indicator half of the paper fades to a blue which approaches the color of the reference half, the canister is to be discarded since it will no longer effectively oxidize carbon monoxide to carbon dioxide.

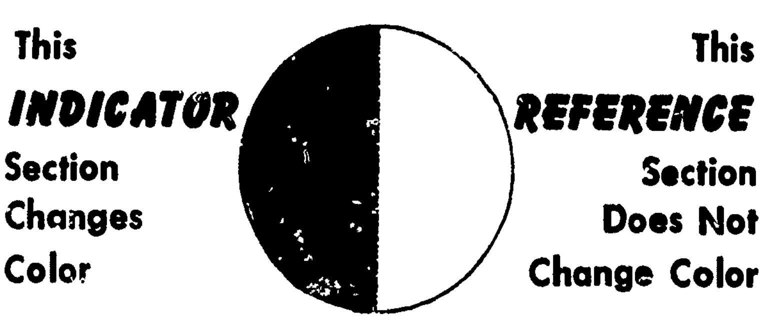


Fig. 3 - Indicator Paper Inside Glass Window of Canister

As long as the canister has not absorbed water vapor to a degree less than that amount which would render the "Hopcalite" ineffective against carbon monoxide, the color difference between the panels will exist. Once excessive moisture has penetrated the "Hopcalite" the colors of the panels will match and the canister must be discarded. Observation of color match should be made under fluorescent type lights or natural daylight when possible.

In the window indicator type canister a check valve fits into the assembly formerly occupied by the timer. The check valve assembly is threaded top and bottom to provide a positive attachment to the canister and the breathing tube. The valve will provide an effective seal at all times against moisture entering the canister from the top. It closes automatically after each inhalation, regardless of the position of the canister. It remains closed, regardless of the position of the mask, in storage or maintenance. The threaded fitting at the top of the valve provides for disassembly of the breathing tube and facepiece for cleaning, while the valve remains on the canister guarding it against moisture penetration from the top. If all the water is not drained from the facepiece and tube after cleaning, the valve prevents the entry of the water into the canister. The canister on the window indicator type will more accurately indicate the actual service time than will the timer type. It is imperative that as much moisture as possible be barred from the canister to obtain maximum service life. The check valve assembly eliminates the necessity of replacing the rubber stopper formerly used.

Courtesy Mine Safety Appliances Co.

Fig. 4 - Putting on Mask

Putting On the Filter Type Canister Mask - Suspend the mask on the chest by means of the neck strap. Next, tighten the body strap so that the canister is drawn snugly against the chest. Check to make sure the headband straps are fully extended. Then grip the facepiece between thumb and fingers as illustrated in Figure 4.

Insert chin well into lower part of facepiece, and pull headbands back over head. To obtain a firm and comfortable fit against the face at all points, adjust headbands as follows:

1. See that straps lie flat against head.
2. Tighten lower or "neck" straps.
3. Tighten the "side" straps. (Do not touch forehead or "front" straps).
4. Place both hands on headband pad and position it on the crown of the head.
5. Repeat operations 2 and 3.
6. Tighten forehead or "front" straps as needed.

Precautions and Practices -

1. Do not enter any contaminated atmosphere with this mask unless you know that the --
   a. Canister is of a filter type, Bureau of Mines approved.
   b. Concentration of the contaminants does not exceed the concentration for which the canister is approved.
   c. Amount of oxygen is sufficient; that is, at least 16% oxygen.
   d. Mask does not leak.
   e. Canister does not need replacing.
2. Register the date the canister is placed in service.

Keep a record on the time the mask is used. *Note:* There is a popular misconception that filter type canisters will afford two hours of protection against 2% concentrations of all kinds of gases; this is not true. The statement applies only to protection against carbon monoxide. The Bureau of Mines Approval Schedule #14 E requires a man-test service life of only 25 minutes in 2% concentrations of organic vapors, and only 15 minutes for 2% concentrations of acid gases or 3% concentrations of ammonia. Naturally, in lower concentrations longer life can be expected. However, the filter type smoke canister, just like the filter type industrial canister, must be replaced as soon as organic vapors, acid gases or ammonia penetrate the facepiece and are detected by the senses.

4. The top and bottom seal on the timer type canister and the bottom seal only on the window indicator type canister should be replaced after each use.

5. Firemen using masks should always work in pairs.

6. It is more difficult to breathe when wearing this mask because the filter restricts the rate of air flow to the face piece.

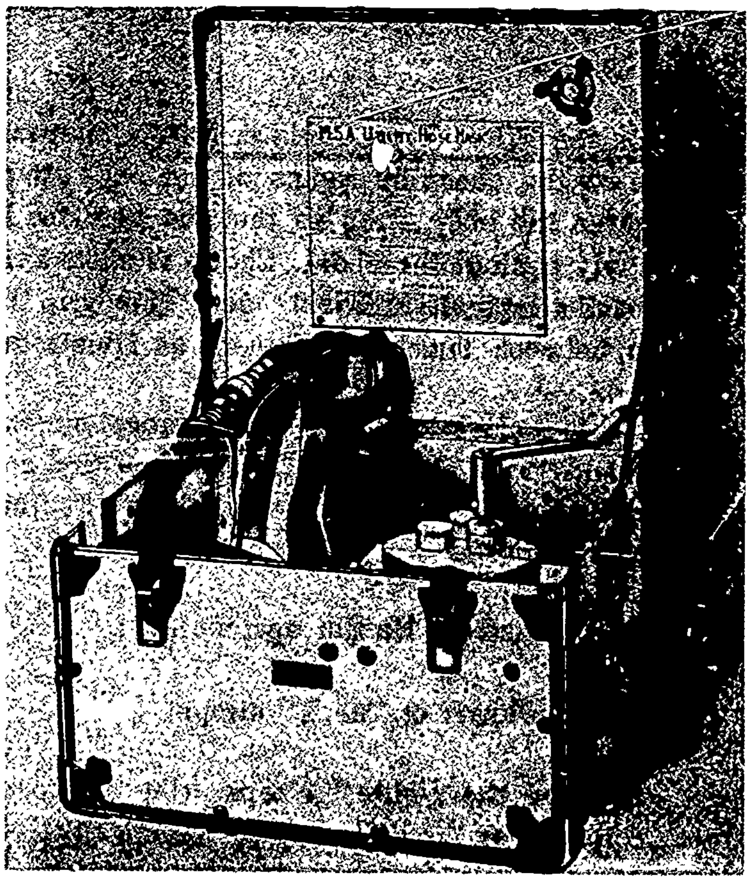
FRESH AIR OR HOSE MASKS

A second type of mask is the fresh air or hose mask which is suitable for respiratory protection against all atmospherical contaminants. The air line mask belongs to this category. These air line masks are entirely dependent upon a mechanical air supply which is not carried by the wearer of the mask; therefore, the failure of such an air supply would prevent escape from deadly atmospheres.

The facepiece of the air line mask is attached to an air system by a hose. Clean air is fed to the facepiece in sufficient quantity to provide the wearer with an adequate air supply. There is little or no resistance to inhalation, and surplus air usually provides a cooling and refreshing effect. The only disadvantage is the necessity of trailing the hose which is connected to the facepiece from the air source.

There are two methods used for supplying air to this type of mask. In the "constant flow" type, the breathable air is continuously fed to the facepiece. By this method there is always a slight positive pressure present in the facepiece to assure against inward leakage. Such pressure is maintained by a compressor system operated "blower". The blowers are of a low pressure type, mostly of centrifugal design, and are available in various sizes depending upon the number of masks to be operated at any one time. The pressure on the air line should be maintained at respirable levels as recommended by the equipment manufacturer. On U.S. Bureau of Mines approved air line respirators, the manufacturer is permitted to specify any range of operating pressure up to a maximum of twenty-five pounds per square inch, as long as a sufficient amount of air is fed to the facepiece within the range specified. Pressure reducing valves as well as relief or blow-off valves are used to control this factor. Precautions must be taken to make sure that a supply of clean air is available at the blower.

Figure 5 illustrates a typical hose mask unit. The facepiece, harness, air hose and blower are usually packed in a trunk which serves to transport the equipment and to provide the blower operator with a convenient seat. The air hose must be highly resistant to petroleum liquids and vapors, and be able to withstand crushing weight. Heavy wire reinforcing is incorporated into the construction of the hose for this purpose. Up to 150 feet of hose can be used on this type of equipment. The air hose connection is supported on the body by means of a heavy-duty harness. The facepiece is of the full face type and is connected to the air hose by means of flexible corrugated tubing.

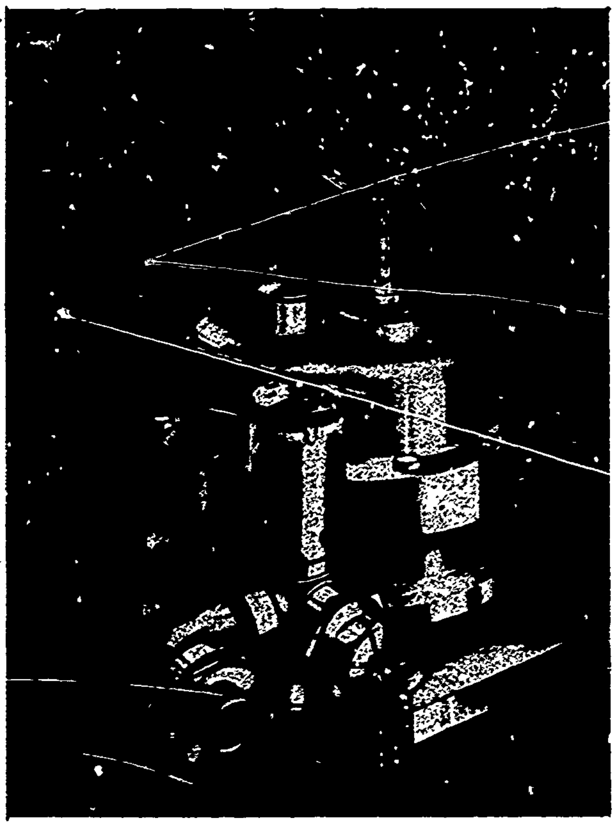


Courtesy Mine Safety Appliances Co.

Fig. 5 - Typical Hose Mask Assembly

In the "demand flow" type, a cylinder of compressed air or oxygen is used in place of the blower. By the inclusion of a small demand regulator, air is fed to the facepiece only upon inhalation of the wearer. The flow ceases upon exhalation. This conserves the air supply and permits one man several hours of service from a standard 220 cubic foot cylinder of air.

Figures 6 and 7 show two different styles of centrifugal blowers used to supply fresh air to the facepiece. Although combined motor and hand operated blowers are available, this type of unit is not approved by the U.S. Bureau of Mines.

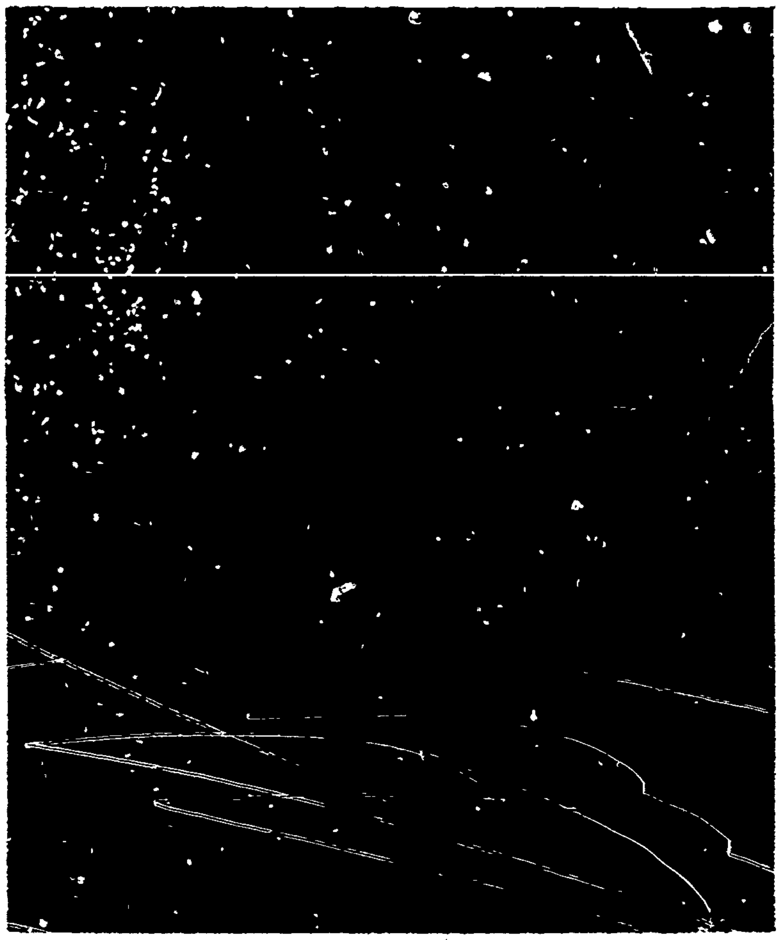


Courtesy Mine Safety Appliances Co.

Fig. 6 - Centrifugal Blower for Fresh Air Mask

SELF-CONTAINED BREATHING APPARATUS

Self-contained breathing apparatus provides complete respiratory protection in any concentration of toxic gases under any condition of oxygen deficiency. The wearer's breathing is independent of the surrounding atmosphere since the wearer is breathing in a system in which no outside air is admitted, and the oxygen or air supply of the apparatus itself takes care of all respiratory requirements. Such devices enable man to work in places where men normally would not be able to live. Self-contained breathing apparatus are divided into three basic types. The three basic types are: (1) oxygen cylinder rebreathing apparatus, (2) demand type apparatus, and (3) self-generating type apparatus. For our purposes here, only two of these will be discussed.



Courtesy Mine Safety Appliances Co.

Fig. 7 - Centrifugal Blower for Fresh Air Mask

Demand Type Apparatus - All demand type apparatus use the same principle of operation; however, some use compressed oxygen while others use compressed air. A number of different models are available. A man wearing the demand type mask never inhales the atmosphere in which he is presently working. The man breathes oxygen or air supplied by a cylinder carried on the person. (See Figure 8) The flow of oxygen or air, regulated by the wearer's breathing, always assures sufficient protection. A pressure gauge indicating the amount of oxygen in the cylinder is generally provided within the wearer's view. The U.S. Bureau of Mines has issued approvals for the use of compressed air or oxygen in the different makes of masks. All are listed as one-quarter hour and one-half hour self-contained breathing apparatus, which indicates the length of time that the cylinders may be expected to last. The detailed instructions or information accompanying each type of mask must be carefully studied and followed before attempting to use it.

Putting On Demand Type Apparatus - The following consecutive steps should be followed in putting on the apparatus before entering a toxic atmosphere:

1. Check the pressure gauge on the cylinder valve to insure that the cylinder is full

Courtesy Scott Aviation Corp.

Fig. 8 - Scott Air Pack

(1800 p.s.i. on small units - 1980 on large units).

2. Put on the apparatus using either of the following methods but in either case caution must be used at all times to protect the regulator assembly from damage:

   a. Connect chest strap buckle, leaving side strap unhooked, swing the apparatus over the head and snap the side strap to the "D" ring. Fasten the waist belt snugly, pull the side straps until the apparatus is supported comfortably, and then tighten the chest strap as much as desired.

   b. Leave the chest strap unbuckled, snap the side strap in place and put the apparatus on like a vest. First the left arm is inserted in the harness, then the right arm. Fasten the chest strap buckle and the waist belt as securely as desired, then adjust the side straps snugly.

3. Open the cylinder valve handwheel fully (at least three turns) and close the by-pass (red) handwheel on the demand regulator.

4. Open fully and lock open with the locking lever the main line (yellow) handwheel and observe the pressure gauge on the demand regulator. The gauge indicates continually the pressure in the cylinder and should read approximately 1800 p.s.i. on small units and 1980 p.s.i .on large units if fully charged. If there is less pressure in the cylinder the service life will be reduced accordingly. Turn off the cylinder valve and watch the pressure gauge on the regulator. There should be no drop in pressure if the equipment is leak tight; and if there is noticeable deflection of the needle, the equipment should be checked and the leak corrected before entering a toxic atmosphere. Again open the cylinder valve handwheel fully and lock in place with the locking lever.

5. The facepiece is then put on using the following method: Check to make sure the headband straps are fully extended. Then grip the facepiece between thumb and finge. Insert the chin into the facepiece and pull headbands back over the head. To obtain a firm and comfortable fit against the face at all points, adjust headbands as follows:

   a. See that straps lie flat against the head.

   b. Tighten lower or "neck" straps.

   c. Tighten side straps (do not adjust forehead or "front" straps).

   d. Place both hands on headband pad and position it on the crown of the head.

   e. Repeat operation b and c.

   f. Tighten forehead or "front" strap as needed.

Check the tightness of the facepiece by sealing the breathing tube with the palm of hand and inhaling gently. The facepiece should collapse on the face if the seal is satisfactory. Connect mask hose to regulator before entering contaminated area. If the facepiece is left disconnected until ready to enter the toxic area, the breathing supply will be conserved to some extent. However,

if the ambient temperature is low, the facepiece will tend to fog, but will not if connected to the demand regulator.

6. Breathe normally, as the apparatus automatically satisfies any breathing requirement.

Precautions and Practices - The apparatus furnishes complete respiratory protection for a period of time governed by the amount of exertion, but approximately 15 minutes (small units) and 30 minutes (large units), at hard work. Therefore, it is necessary to periodically check the pressure gauge on the demand regulator, as it continually indicates the pressure in the cylinder. When the needle approaches the solid colored section of the pressure gauge, *always* return to fresh air because the remaining 300 p.s.i. will last only two or three minutes in the small units, and only four minutes in the large units. During normal use the by-pass (red) valve is closed and is used only if the automatic demand regulator becomes inoperative. It provides a continuous flow and should be opened first, the main line (yellow) handwheel closed, and the by-pass valve adjusted to provide the flow desired.

Removing the Mask -

1. Disconnect the mask hose from the regulator.

2. Remove the facepiece by grasping the snout, pulling down and out, then up over the head.

3. The headstraps should then be fully extended and the facepiece should be adequately cared for.

4. Unlock the lever on the cylinder valve and close the valve using normal pressure. This valve closes leak-tight with little effort.

5. Remove the apparatus from the body and place properly in carrying case.

6. Place facepiece in the proper place in the carrying case.

Care of Breathing Apparatus at Stations -

1. Sterilize facepiece by cleaning thoroughly with a germicidal solution such as aqueous zephiran 1:1000 solution or staphene solution.

2. Replace cylinder:

   A. Disconnect the coupling nut of the high pressure hose from the cylinder valve, using the open end wrench provided with the apparatus.

   B. Release the cylinder clamp drawbolt and remove the cylinder.

   C. Replace cylinder with a fully-charged one and connect the apparatus high pressure hose, making certain that the regulator is positioned properly.

   D. Before putting in case make sure the pressure is released from the regulator and hose by opening and closing the by-pass valve, making sure the main line (yellow) handwheel is locked open.

3. Place the apparatus in the case with the back plate flat at the bottom, folding the harness over the cylinder. Arrange the high pressure hose so that it is not distorted and put the facepiece on the side.

4. *Never use any lubricant on any part of the apparatus, and always keep all parts entirely free from oil and grease.*

SELF-GENERATING OXYGEN MASK

Unlike the conventional type of breathing apparatus which employs cylinders of oxygen or compressed air under high pressure, this apparatus evolves or generates its own oxygen. It operates independently of the outside air and provides complete respiratory protection in oxygen deficient or highly gaseous atmospheres. The wearer breathes into the facepiece through the exhalation tube into the canister. The exhaled breath is purified of carbon dioxide and replenished with oxygen as it passes through the canister, and is then rebreathed. This mask provides protection for forty-five minutes. (See Figures 9 and 10)

The apparatus consists of a facepiece, breathing tubes, breathing bag, breastplate, canister holder, harness straps and a manual timer, all focalized around a central casting just above the canister. The facepiece valve assembly, located immediately below the facepiece, is equipped with a pressure relief valve. This is a one-way valve that acts as a manual pressure release valve when the breathing bag becomes over-inflated. This assembly also contains the exhalation and inhalation valves which control the directional flow into and out of the breathing bag.

Courtesy Mine Safety Appliances Co.

Fig. 9 - Chemox Type Mask

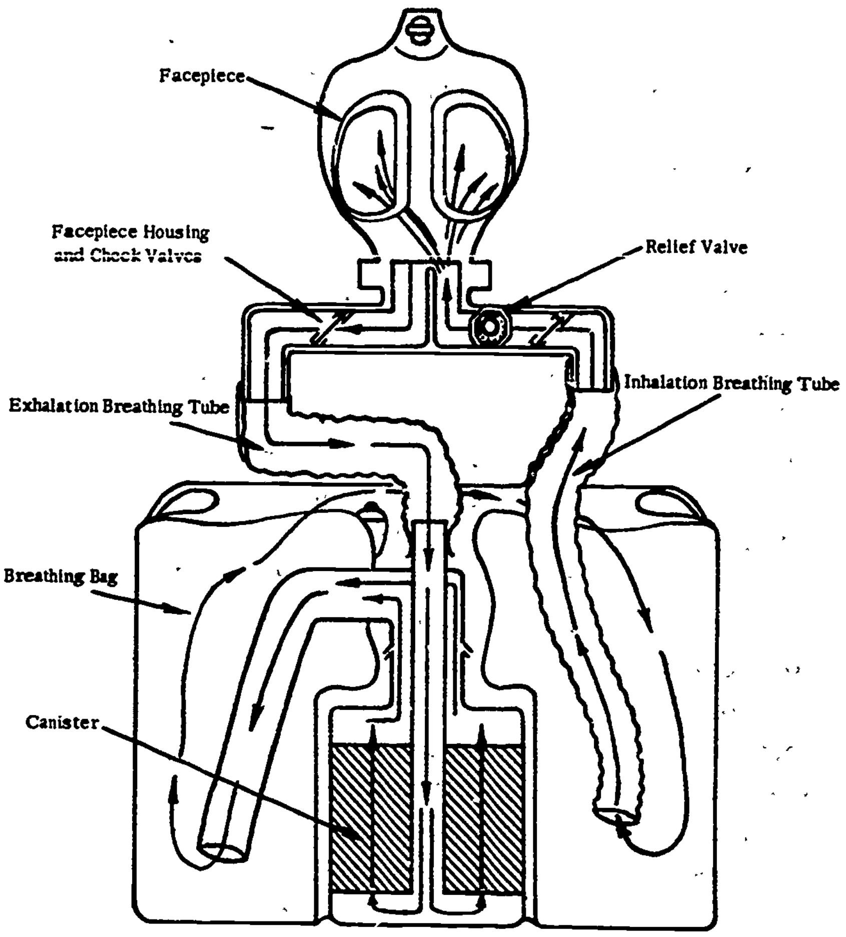


Fig. 10 - Chemox Type Mask (Cross Section)

The breathing bag serves as a reservoir for the evolved oxygen, and at the same time acts as a cooler for the air coming from the canister.

The chemicals in the canister purify the exhaled breath by absorbing the carbon dioxide and generating fresh oxygen for breathing. The resultant chemical action liberates considerable heat in the canister. The wearer is protected from this heat by insulation on the breastplate.

The chemicals in the canister are capable of releasing a high percentage of oxygen when becoming damp from the moisture in the breath. The rate of release is governed by the amount of moisture introduced by breathing. For breathing purposes, the water vapor in the exhaled breath is sufficient to liberate enough oxygen for comfortable breathing. Any excess moisture that enters the canister will cause a sudden reaction and rapid liberation of oxygen. Therefore, do not introduce water into either a used or unused canister except to dispose of it, and then only in a manner which will be described later.

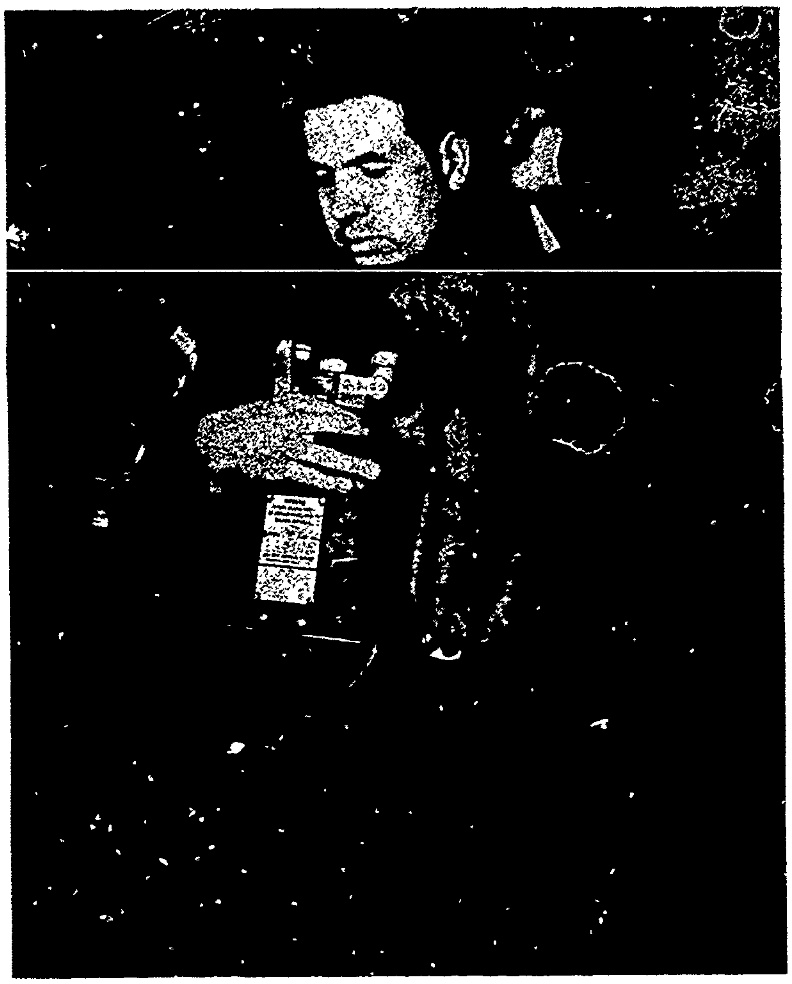
Putting On Self-Generating Oxygen Mask - The following are the consecutive steps in putting on the apparatus before entering a toxic atmosphere. The apparatus must always be put on in fresh air.

1. Unfasten and straighten all harness straps.

2. With one hand, grasp the apparatus by the central casting and drop the facepiece over the hand holding the apparatus. With the other hand, grasp the D-ring assembly where the two large web straps join; place the breastplate of the canister holder on the chest and slip the head through the V-shaped opening formed by the two web straps. See Figure 11.

3. Continue to hold the apparatus on the chest with one hand, and with the other reach around the body at one side and grasp the free end of the web strap on that side. Bring the end of the strap under the arm and snap into the D-ring located on the top side of the breastplate. Repeat this procedure for the other strap.

4. Adjust the position of the apparatus on the body by means of metal slides located on the web harness straps. This adjustment can also be accomplished by twisting the straps



Courtesy Mine Safety Appliances Co.

Fig. 11 - Putting on Apparatus

Courtesy Mine Safety Appliances Co.

Fig. 12 - Removing Metal Tear-Off Cap of Canister

to obtain the proper length. The position of the apparatus on the body should be such that when the facepiece is put on the breathing tubes will permit free head movement.

5. Attach the waist strap to the small D-ring located on the lower corner of the breastplate and pull to a snug fit, then tuck in the waist strap loop.

6. Remove the metal tear-off cap of the canister by pulling the metal tab straight out, then straight back across the top of the cap, exposing the copper foil seal which is the air-tight seal for the canister. *Make sure that the metal and cardboard discs are removed exposing the copper foil seal.* (See Figure 12) With the handwheel screwed down far enough for the bail to be swung outward, swing the bail outward and swing the canister fully into the canister holder with the smooth side toward the front. The canister should be inserted sufficiently so that the copper foil seal is punctured and the rubber gasket fits snugly against the V-shaped recess in the plunger casting. Screw the handwheel clockwise until it is tight against the canister. *The canister must be inserted with the smooth side to the front.* See *Figure 13.*

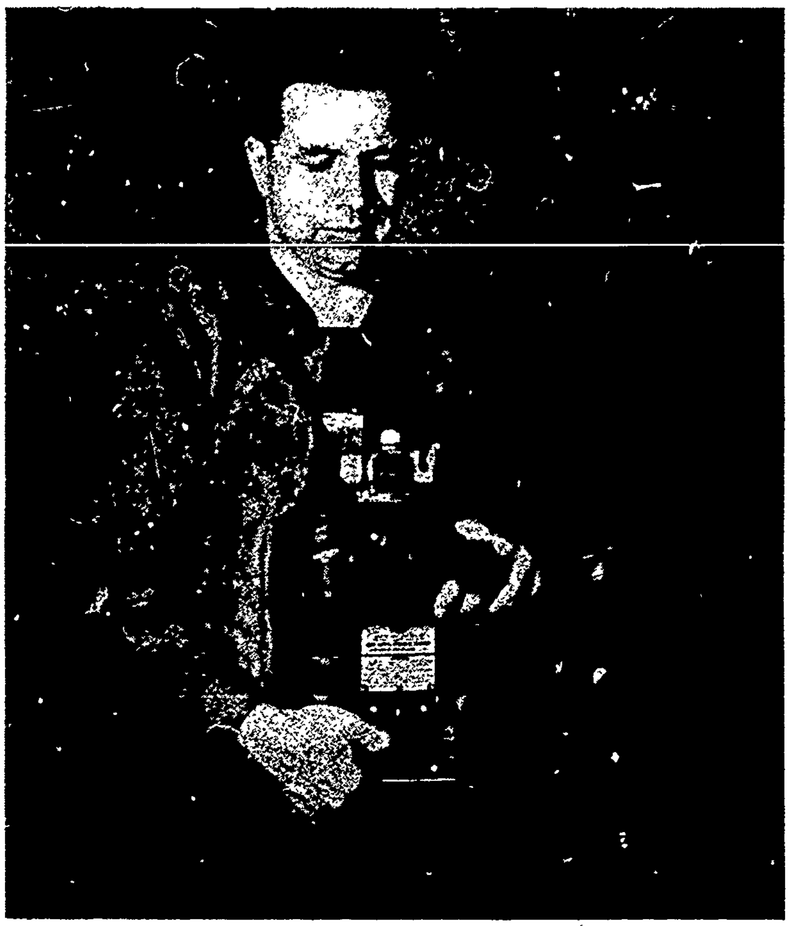
7. Pull out the facepiece straps so that the ends are at the buckles and grip facepiece between thumb and fingers. Insert chin well into the lower part of the facepiece and pull the headbands back over the head. See Figure 14. To obtain a firm and comfortable fit against the facepiece at all points, adjust headbands as follows:

   a. See that straps lie flat against head.

   b. Tighten lower or "neck" straps.

   c. Tighten the "side" straps. (Do not touch forehead or front straps).

   d. Place both hands on headband pad and push it toward the neck. See Figure 15.



Courtesy Mine Safety Appliances Co.

Fig. 13 - Inserting Canister in Apparatus

Courtesy Mine Safety Applinaces Co.

Fig. 14 - Putting on Facepiece

Courtesy Loudonville, Ohio, Fire Department

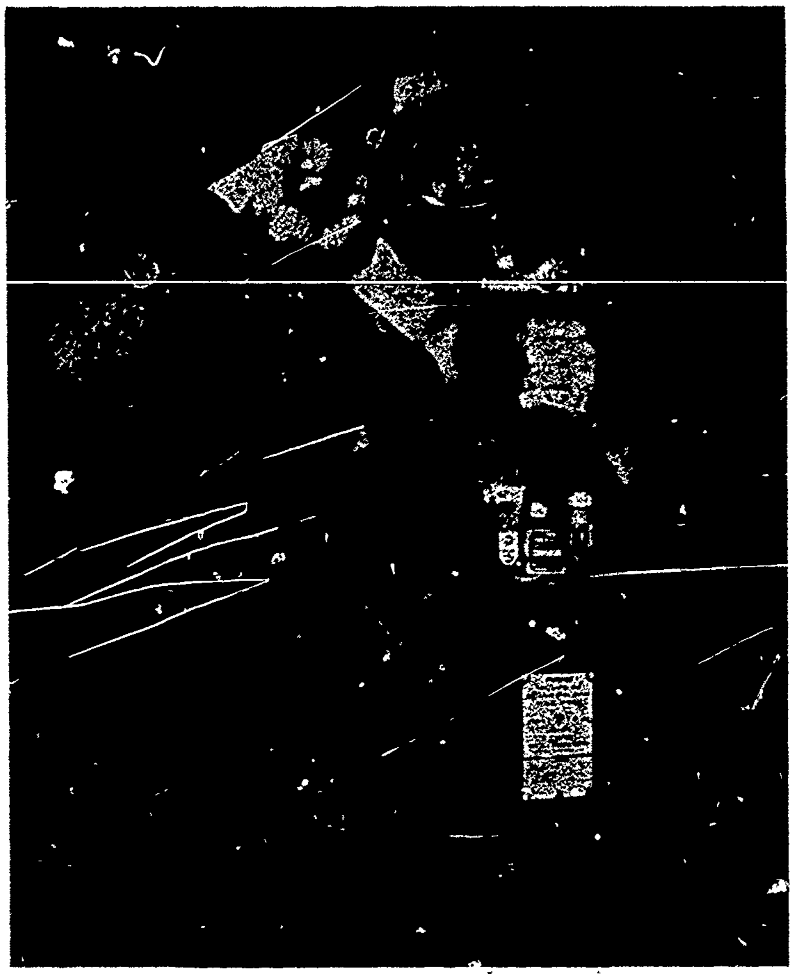
Fig. 15 - Adjusting Headband Pad

e. Repeat operations b and c.

f. Tighten forehead or "front" strap a few notches if necessary.

Check the tightness of the facepiece fit by squeezing the breathing tubes and inhaling. The facepiece should collapse on the face if the seal is satisfactory.

8. Squeeze both breathing tubes with one hand and break the seal of the facepiece against the cheek with fingers of the other hand and inhale, then releasing facepiece with breathing tubes, exhale into the apparatus. See Figure 16. *This must be done in fresh air.* Repeat this procedure until the breathing bag is inflated. In order to be certain the canister is generating oxygen depress the pressure relief valve and force the air from the breathing bag and reinflate the breathing bag by repeating the starting instructions previously explained. When starting the apparatus in cold weather more inhalations from the outside air, with exhalation into the canister, will be required to produce the proper chemical reaction. The best procedure is to keep fully inflating the breathing bag, then deflating it with the elbows until a total of about 15 exhalations have been put through the canister.



Courtesy Mine Safety Appliances Co.

Fig. 16 - Starting Apparatus

9. To check the complete apparatus for tightness:

   a. Grasp the lower end of the inhalation (left) breathing tube and squeeze it tightly. Inhale, and if the facepiece collapses, the facepiece seal is sufficiently tight and the exhalation valve is functioning properly. This will also test the upper part of the inhalation breathing tube for leaks.

   b. Continue to squeeze the lower end of the inhalation (left) breathing tube. Depress the pressure relief valve button. It should then be possible to exhale through the valve. While holding the button down, inhale, and if the facepiece collapses as above, the relief valve is functioning properly.

   c. Release the inhalation (left) tube and squeeze the lower end of the exhalation (right) breathing tube. Inhale and then exhale forcibly. The exhaled air should be forced out between the face and the facepiece only; this will indicate that the inhalation valve is functioning properly and the upper end of the exhalation tube is free of leaks.

   d. With the bag well inflated, grasp the upper ends of both breathing tubes and depress both sides of the breathing bag with the elbows. If the breathing bag does not deflate, the complete apparatus is air tight.

   If a leak or defect is indicated in any part of the apparatus, it should be checked and the condition corrected before use.

10. Breathe normally as the apparatus furnishes enough oxygen to meet most breathing requirements.

11. Since the apparatus has a forty-five minute service life at hard work in an irrespirable atmosphere, it will be necessary to determine the length of time required to return to fresh air from the working place and set the timer accordingly. The timer dial is calibrated in minutes and by turning the pointer clockwise to the number of minutes left after deducting the time for exit, the timer will be properly set. For example, if it will take ten minutes to return to fresh air, deduct ten minutes from forty-five and set the timer at thirty-five. The bell on the timer will ring when the pointer returns to zero, at which time the wearer has ten minutes to return to fresh air.

Precautions and Practices -

1. There is no need to purge nitrogen manually from this apparatus since more oxygen is produced than will be used. To relieve excess pressure, depress the pressure relief valve on the valve housing at the bottom of facepiece.

2. There are two indications in addition to the timer that the canister is becoming expended; namely, fogging of the lenses on inhalation and increased resistance of exhalation. These two indications will not normally appear until after forty-five minutes of use, but may under conditions of extreme hard work become noticeable. The lenses will clear on inhalation until the canister is al-

most expended; then the lenses will begin to fog. Do not confuse excess breathing bag pressure with canister resistance. If excess breathing bag pressure is relieved by use of the pressure relief valve and exhalation resistance is still present, the canister is about expended. If either of these two indications appear, return to fresh air.

After Use - As soon as it is safe to remove the facepiece, this should be done by grasping it at the "snout" with the hand and pulling forward and upward off the head and face. (See Figures 17a and 17b)

To remove the canister, turn the handwheel down, swing bail outward and remove the canister with the hand suitably protected by a glove or other covering since the canister may be hot.

Upon return to quarters, after the mask has been in service, the used canister may be disposed of as follows: (1) Allow the canister to cool. Ordinarily this will take place while returning to quarters. (2) Place the canister on the floor, smooth side up, and gash it with an axe that has been wiped clean of oils, greases or other materials. Two cuts can be made with the axe, one on each side of center. (3) Place the canister in a bucket 2/3 full of clean water. When the chemical reaction or agitation stops, rinse the canisters off with clean water. The water in the bucket should be poured down a sewer or drain. Care should be taken while doing this work, as this water will now be a caustic solution and will irritate the skin if allowed to come into contact with it.

After use, the facepiece of the apparatus should be sterilized using a germicidal solution such as aqueous sephiran 1:1000 solution or staphene solution. Allow the facepiece to hang down while cleaning, so no liquid enters the valve assembly or tubes. Immediately after sterilization, wipe the facepiece dry and replace on the apparatus for service. The canister should not be carried in the canister holder while it is in the carrying case. Each carrying case should contain two canisters and the mask at all times. When a canister has been removed from the canister holder it should not be used again. Care should also be taken that canisters do not come in contact with oils and greases because the chemicals in the canister are capable of generating and releasing a high percentage of oxygen that could cause combustion. Keep the face away from an open canister because of its caustic reaction. This type of breathing apparatus should not be used under water such as in pools, lakes or ponds.

Do not tie a rope to the D-ring on the harness strap of the mask. The inhalation and exhalation check valves are removable from the facepiece and breathing tube assembly by disconnecting the toggle clamps, removing the breathing tubes and sliding the valves out. The valves should be checked periodically for corrosion and replaced if necessary. These valves are marked *"in"* for inhalation and *"ex"* for exhalation, and should be inserted in the respective openings in reassembly.

Figure 17A

Courtesy Loudonville, Ohio, Fire Department

Figure 17B - Removing Mask

While the apparatus is not in use, there should be a periodic check of the plunger and plunger casting (the part which pierces the canister) for cleanliness and free movement of the plunger. The tightness of the apparatus should also be checked periodically,

using the procedure outlined in 9 under "Putting On Self-Generating Oxygen Mask".

When any part shows evidence of failure, it should be replaced immediately with a new part. Apparatus which becomes damaged should be returned to the factory for repair.

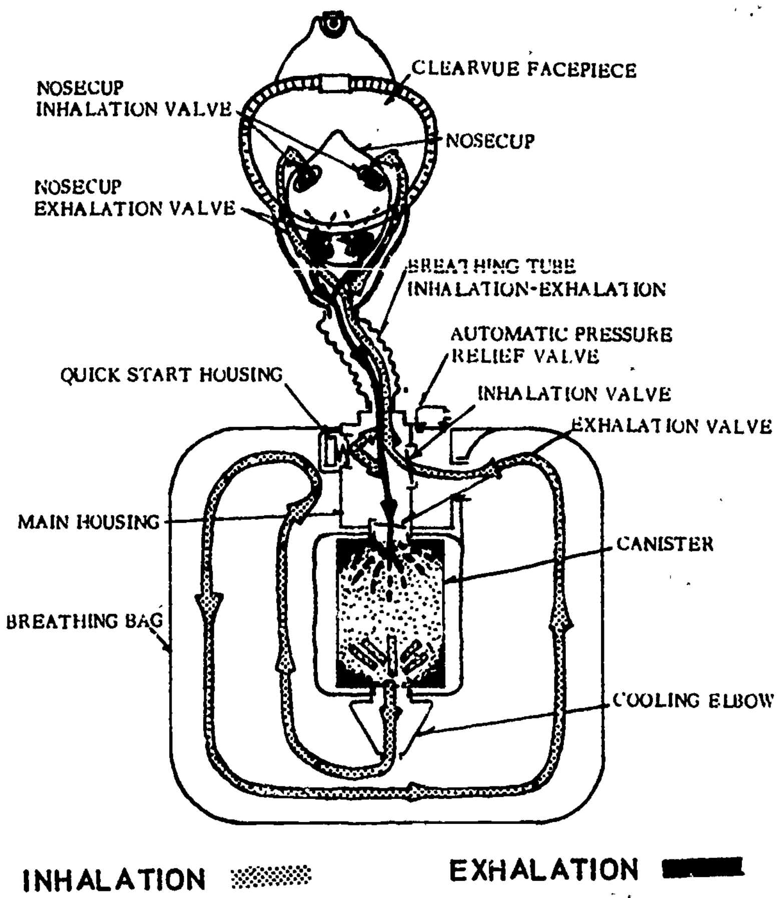
ONE-HALF HOUR SELF-GENERATING OXYGEN MASK

This mask, like the one previously described, is a canister type which evolves or generates its own oxygen, thus being independent of the outside air. See Figure 18. The wearer's breath passes into the facepiece and through the exhalation tube, into the canister. The exhaled breath is purified of carbon dioxide and replenished with oxygen as it passes through the canister and is then rebreathed. (See Figure 19) This mask will provide respiratory protection for thirty minutes.

The apparatus consists of a facepiece, breathing tube, (both the inhaled and exhaled air passes through this one tube), breathing bag, breastplate canister holder, manual timer and harness straps all focalized around a central housing, just above the canister. An

Courtesy Mine Safety Appliances Co.

Fig. 18 - One-Half Hour Chemox



Courtesy Mine Safety Appliances Co.

Fig. 19 - Flow Diagram - Half-Hour Chemox

automatic pressure relief valve is located in the central housing on the inhalation side of the breathing bag. This is a one-way valve and operates automatically when the breathing bag becomes over inflated. Also located in the central housing is the quick starting housing, which is a unit that gives the apparatus instant operation in low temperatures, and the exhalation and inhalation valves, which control the directional flow into and out of the breathing bag. The breathing bag serves as a reservoir for the evolved oxygen.

The timer, located in the central housing, is a safety device to inform the wearer how long the canister has been in service. Since the mask is good for thirty minutes the timer dial is calibrated in minutes from one to thirty. By turning the timer knob clockwise to thirty it is automatically wound. If left untouched in this position it will unwind with a continuous movement to zero. This will indicate the end of thirty minutes and the bell will ring continuously for 17 seconds. The timer is entirely independent of the apparatus and will continue to unwind even though the apparatus is not in use.

The canister on this mask is different in appearance than the canister used on the regular self-generating type in that it is cylindrical in shape and has an opening on each end. The chemical in this canister is the same as in the other canister, so the

same precautions should be taken as to introduction of water or moisture into the canister.

The chemical in the canister purifies the exhaled breath by absorbing the carbon dioxide and generating fresh oxygen for breathing. This chemical action generates considerable heat in the canister. The wearer is protected from this heat by insulation on the breastplate and a cooling elbow incorporated in the canister holder to cool the evolved oxygen before it enters the breathing bag.

Putting On the One-Half Hour Self-Generating Oxygen Mask - The following are the consecutive steps in putting on the apparatus before entering a toxic atmosphere:

1. Unfasten and straighten all harness straps.

2. Grasp the apparatus at the top of the canister holder with one hand and with the other hand grasp the harness D-ring assembly where the two large nylon straps join, placing the canister holder chest plate and slipping the head through the V-shaped opening formed by the straps.

3. Continue to hold the apparatus on the chest with one hand and with the other reach around the body and grasp the free end of one strap. Bring the end of the strap under the arm and snap into the D-ring located on the top side of the chest plate. Repeat this procedure for the other strap.

4. Adjust the position of the apparatus on the body by means of the metal slides located on the harness straps. This adjustment can also be accomplished by twisting the straps to obtain the proper length. The position of the apparatus on the body should be such that when the facepiece is put on, the breathing tube will permit free head movement.

5. Attach the waist strap to the small D-ring located on the lower corner of the chest plate and pull up to a snug fit, tucking in the loose ends.

6. Open the canister holder by pressing on both the pawls at the top and pulling the lever arms outward.

7. Remove the two canister caps by inserting each end in the opener at the bottom of the canister holder and pulling upward (as in removing a bottle cap).

8. Make sure the canister holder lever arms are fully at their bottom position and insert the canister in the canister holder with the top of the canister at the top of the canister holder. Note: The canister label has an arrow pointing to the top and reads: *This end up*.

9. Close the canister lever arms securely.

10. Connect the coupling nut on the facepiece tube to the mating thread on the upper main housing.

11. After the facepiece has been donned, check the tightness of the fit by squeezing the breathing tube tightly and inhaling gently. The facepiece should collapse on the face if the seal is satisfactory.

12. Start the apparatus by one of these two methods, depending upon whether a quick start cartridge is used. For either method leave the automatic pressure relief valve (on side of upper main housing) in the normal starting position. Without a quick start cartridge proceed as follows in *fresh air*.

    a. Squeeze breathing tube with one hand, break the seal of the facepiece at the cheek with a finger of the other hand and inhale deeply.

    b. Release facepiece then breathing tube, and exhale into the apparatus.

    c. Repeat a. and b. until automatic pressure relief valve dumps air.

    d. Force the air from the breathing bag through the pressure relief valve by squeezing the bag with both hands.

    e. Repeat operations a., b. and c. until breathing bag is fully inflated.

If normal starting is to be used, the apparatus should be stored and started at temperatures above 32° F. When the apparatus is stored and started at temperatures above 32° F., the wearer may enter and wear the apparatus down to a temperature of -20° F. When starting the apparatus at temperatures near freezing, more inhalation from the outside air, with the exhalation into the canister, may be required to produce the proper

chemical reaction. The best procedure is to keep fully inflating and deflating the bag until a total of about 15 exhalations have been put through the canister.

The quick start cartridge may be used with the following procedure:

a. Remove cartridge from metal container.

b. Remove cartridge holder cover from front of main housing by unscrewing it.

c. Insert cartridge with solid side with brass percussion cap to front (away fro body).

d. Replace cover, screwing it in tight.

e. With facepiece well fitted, strike the cartridge cover a sharp rap with the heel of the hand. See Figure 20. Oxygen will evolve automatically to fully inflate the bag, and some excess will vent automatically. Nothing further is necessary to start the apparatus.

Courtesy Mine Safety Appliances Co.

Fig. 20 - Starting the Half-Hour Chemox

13. Regardless of the starting method, a tightness test should be performed on the unit as follows:

    a. Set relief valve in the test position. This closes the valve to permit the test without possible automatic venting which is not a leak.

    b. With the bag fully inflated, grasp the breathing tube tightly and depress both sides of the breathing bag with the elbows. If the bag does not deflate, the complete apparatus is tight. If a leak is detected it should be corrected before use in a toxic atmosphere.

    c. Reset relief valve to *normal* position.

Using the Mask - Breathe normally as the apparatus furnishes enough oxygen to meet any breathing requirements.

Set the knob of the timer at 30. When the pointer end of the knob returns to zero the bell will ring continually for 17 seconds, indicating the wearer should return to fresh air.

General Information For Use - The facepiece of this mask contains a speaking diaphragm permitting communications.

The proper care of this apparatus and safe disposal of the canister is the same as is to be followed with the regular self-generating oxygen mask previously mentioned in this chapter.

AUDIBLE COMMUNICATION WITH RESPIRATORY PROTECTIVE EQUIPMENT

Most facepieces on respiratory protective equipment of late manufacture are furnished with a speaking diaphragm. Without such a speaking diaphragm, audible communication between wearers of respiratory equipment is inadequate at best, and at times may be impossible. Facepieces with an exhalation valve provide some measure of voice transmission through this valve, and even those without exhalation valves permit an extremely limited transmission th ough the rubber facepiece. However, a greater gree of audible transmission is provided by modern cientifically designed speakin diaphragms, thus enabling voice communication between wearers of such equipment, where otherwise visible communication might be the only method possible.

Courtesy Loudonville, Ohio, Fire Department

Fig. 21 - Tighten Straps Like This

Courtesy Loudonville, Ohio, Fire Department

Fig. 22 - Do Not Tighten Straps Like This

TRAINING SUGGESTIONS

1. Wear mask for a snort period in fresh air and do some work or exercise. This will allow the man to become accustomed to the mask and learn the breathing technique.

2. Wear mask in gas and smoke to become familiar with conditions where gas and smoke exist.

3. Wear mask in gas and smoke and do some work. It is under these conditions that the mask will be used.

4. Practice donning mask with helper and without helper.

SUMMARY

It is recommended that firemen using gas masks always work in pairs and be in constant audible communication with each other.

The fireman who needs a mask should not run to the truck for same, but it should be brought to him if possible. A mask should not be donned when a person is short of breath.

The harness straps, on all masks, should be previously extended to fit the largest man who may wear the apparatus. Masks having the slower type of adjusting harness strap can be quickly adapted to fit a smaller man by twisting these straps.

After working in areas of highly toxic chemicals, gases or radioactive material, it is advisable not to remove the mask upon return to fresh air until the contaminant has been removed from the clothing.

In donning the facepiece of all type masks the headband straps should be tightened by pulling these straps straight back as shown in Figure 21, and not outward from the side of the head as shown in Figure 22.

Extra tanks and/or canisters should be carried on fire apparatus. A guide line or rope should not be tied to the harness or D-ring of the mask. When a guide line is used it should be fastened around the person's body before the mask is donned.

Where gas masks are not used too frequently, they should be removed from their carrying cases periodically and donned by personnel. This will prevent the materials in the mask assembly from becoming stiff or hardened from lack of use, and keep them pliable.

CHAPTER 13

ADVANCE INFORMATION – THE ALARM

INTRODUCTION

Modern fire fighting is a science which requires a vast amount of professional knowledge and technical training in the use of apparatus and equipment. Officers and members of the fire service cannot hope to gain this knowledge through experience alone. A large part must come through systematic schooling and training. The military has successfully taught tactics by the use of tactical problems. Large fires, like battles, are too few and far between to give the necessary knowledge from experience alone.

The knowledge of advance information that men of the fire department must have prior to a fire or emergency call is of utmost importance. This knowledge has much to do with the efficient operation of the department on the fire grounds or at the scene of the emergency. Members of the department rely on their advance information, realizing that the knowledge they have was gained by many hours of participation both in inspections and schooling.

One of the most important factors in fire department work is the means whereby the alarm is received. There are many ways for a department to receive the alarm and then transmit the alarm to its members. The efficiency with which the alarm is received by department members is becoming increasingly better. This chapter deals with the advance information that is so important to an efficient fire department and some of the methods used in receiving and transmitting the alarm.

ADVANCE INFORMATION

Fire fighting tactics may be considered the art of using manpower, apparatus and equipment on the fire ground. The more advance information the firemen have, the more efficiently they will be able to combat the fire when it occurs. A thorough knowledge of all property needing protection is essential in meeting our fire fighting problems. An effective manner in which this knowledge can be gained is through an adequate inspection program.

Knowledge of the location of all property to be protected is of vital importance in facilitating response to the alarm by the best possible route. Also, if the officer is thoroughly familiar with the location, he will be better able to determine, in the least possible time, the best action to take with the facilities available.

Advance information as to construction and contents play an important part in fire control. Some buildings are of frame construction while others are of fire resistant material with fire walls between structures. The contents of buildings may be classed as slow or fast burning or may be of an explosive or radioactive material. There also may be a combination of any of these materials. Some buildings are equipped with sprinkler and/or standpipe systems while others do not have private protection of this kind. In view of the many complex problems caused by various types of building construction and the different types of contents involved, a thorough knowledge of the construction and contents is necessary to meet and combat our fire problems successfully.

A complete study should also be made of all water supplies available. This study should include the amount in storage, size of all water mains, location of fire hydrants, and the amount of water that may be obtained from various hydrants. If any hydrants are located where departments would be unable to use them because of intense heat and smoke, discussion should be made in advance as to which hydrants would be used under these conditions.

In communities where no water system is available to the department, every effort should be made to use cisterns, ponds, lakes, rivers, etc. A complete study of the availability of these sources of water is necessary to give proper protection. Many communities have supplemented their local water supply with the tanker or tanker-pumper. Usually, this unit has a water capacity of 500 gallons or more. In many localities, this type of unit has made the local department a more efficient fire fighting unit.

In buildings equipped with sprinkler systems, the department should have information as to the supply to the sprinklers, location of shut-off valves, and the siamese connections to be used for supplying water to the sprinklers if needed. For buildings equipped with standpipe systems or water curtains, the same considerations apply.

Attention should also be given to make sure that first aid fire fighting appliances, located in a building, are properly maintained and ready for use.

The proper maintenance of all fire department equipment is very important and should be checked regularly. This can best be done by holding regular drills. Thus, the men can familiarize themselves with the operation of the equipment as well as giving them an opportunity to check its proper operation.

THE ALARM

A dependable alarm system, properly maintained, is an important factor in fire fighting tactics. This system must provide a ready means of summoning apparatus and men to the scene of the fire and, in communities where combined paid and volunteer organizations are employed, an adequate method of notifying all firemen.

There are several ways of receiving the alarm. In cities, there is usually a fire alarm box located on the side of a building, pole, or pedestal. These alarm boxes are operated by pulling a lever on the box. There is also a telephone system located in a box similar to the fire alarm box which operates by picking up the phone in the box and calling in directly to the fire headquarters. There are also instances when the conventional phone is used. These phones usually have a given number for fire calls only. Some communities have phones located in some of the firemen's homes and when the fire call is received in their homes they sound the alarm. There are also communities that have a phone located in a place of business or a home where there is someone to answer incoming calls 24 hours a day. When the call is received, the firemen are notified by phone and the alarm is sounded.

Some communities have a radio system to alert their members. The alarm is received by phone at a central location where there is also a base radio station. The firemen of the community, in some cases the officers, and in others the entire personnel, have monitor radios in their homes that will give them the fire call as it is transmitted from the base station. The siren is sounded even though the members have already been notified.

Large communities list a phone number for fire calls and when the call is received the alarm is transmitted over their conventional alarm system.

Whatever system is used, care should be taken to keep it in first class operating condition so that fire, and other emergency calls, will promptly reach the department.

There have been a number of delayed alarms due to people not being familiar with the department telephone number. This situation can be remedied if the department will conduct an educational program through local papers, radio stations, and other media advising the public what to do in case of fire and how to turn in an alarm to their local fire department. The alarm system is the only method the fire department has of being notified that a fire or emergency exists. For that reason, regardless of the type of system used, it must be properly designed and maintained to fit the needs of the local community.

Additional information on alarm systems is included in the Community Fire Defense chapter of this text.

CHAPTER 14

SIZE-UP

INTRODUCTION

The size-up of a fire or any other emergency is the process of making an estimate and/or analysis of the various existing conditions by the officer in charge. This chapter deals with the many aspects of the emergency situation which should be considered in making a successful size-up.

Upon arriving at the fire it is the duty of the first officer or the "man in charge" to determine the first action to be taken. He must consider many factors before arriving at a practical decision. He must use whatever manpower, apparatus, and equipment is at his disposal in getting the situation under control and in formulating an effective plan of operation. The officer in charge must maintain the self-control needed for a complete survey of the situation. These abilities are acquired through training and experience.

The initial action of a fire department at a fire is very important. Proper, systematic procedure in making the size-up can mean the difference between success and failure. Clear thinking and quick action under the adopted system of the department will result in a good size-up.

ESSENTIAL FACTS

There are times when it is not possible to easily determine all facts pertaining to a complicated and rapidly changing situation. The officer in charge must then depend upon his ability to recall previously gathered information. To this he must add new information collected at the scene of the emergency. He must quickly recognize the following essential facts and group them in his mind:

Life Hazards:

1. The occupants of the involved or adjacent buildings

2. The firemen involved in the emergency and consideration as to the continuation of life hazards until the entire emergency is eliminated

At the time the firemen receive the original information, the involved life hazard must be the foremost consideration.

TIME OF EMERGENCY

1. Month

2. Day

3. Hour

The month, day, or hour may prove an important factor in the problem of size-up. For example, a fire in a school building while classes are in session presents different problems than a fire in the same building during other hours. Time and the nature of occupancy have a direct relationship to each other.

LOCATION OF EMERGENCY

1. Location of building or buildings involved.

2. The position of the building in relation to streets, alleys, open spaces, and other buildings

3. General physical surroundings

In "spotting" the emergency the officer must locate the building or buildings involved and develop a clear mental picture of the building in its relation to streets, alleys, open spaces, other buildings and property. The width of streets, alleys, and open spaces should be noted as well as the distance from other buildings and combustible materials. He must also observe any obstructions such as overhead wires, high voltage lines, parked cars or blocked streets and alleys which may interfere with operations.

NATURE OF EMERGENCY

1. Fire

2. Explosion

3. Smoke and Chemicals

4. Accident of Other Nature

The officer ascertains and considers the nature of the emergency and from his observations he plans his procedure accordingly.

EXPOSURES

1. Life (Occupants of exposed buildings)

2. Property (Buildings or other exposed property)

Firemen must consider the exposures with which they are confronted. These exposures may be defined as interior, exterior, or those objects in the path of an extending situation which can be either property or people. In all cases these exposures must be removed or protection provided.

BUILDINGS

1. Height
2. Size
3. Construction
4. Occupancy
5. Contents
6. Age
7. State of repair
8. Interior layout
9. Air conditioning system
10. Sprinkler system
11. Standpipe system
12. Hydrants, service available

There is but limited time and opportunity for the officer to recognize essential facts. Therefore, the more knowledge he has of the building or buildings involved and exposed the better qualified he is to draw a clear mental picture of the situation. This knowledge should have been obtained prior to the time of the emergency by systematic surveys and inspections of the buildings under his protection. The officer should have a good knowledge of building construction and the conditions common to the various types. With the facts in mind pertaining to the involved and exposed buildings, the problem of size-up is greatly simplified. If the officer does not have these essential facts at the time of the emergency, he must obtain as many as possible from a quick "on the spot" survey of the involved and exposed buildings. Many factors may be met which will prevent other than the most superficial survey. When these factors occur it becomes necessary for the officer to estimate unknown facts from the information which he has been able to obtain.

FIRE

1. Smoke (Color, odor, and density)
2. Nature of burning material
3. Location of fire
4. Stage of development
5. Potential of area that may become involved

The officer's estimate will depend on his ability to organize a mental picture of the fire in relation to the involved building and the surrounding objects. His ability to develop the mental picture is dependent upon advance knowledge and experience obtained through extensive study and practice.

WEATHER

1. Wind - direction and velocity
2. Temperature
3. Rain
4. Snow
5. Ice

The officer in charge must give every possible consideration to the weather conditions at the time of the fire. The direction and velocity of the wind must be considered to prevent unnecessary extension of the fire. Temperature, rain, snow, and ice must be considered from the time the alarm is first received until the fire is extinguished and all apparatus, equipment, and men have safely returned to quarters.

APPARATUS, EQUIPMENT AND MANPOWER

Those Responding to the Alarm - Enroute to the fire the officer should mentally review the type and quantity of fire fighting apparatus, equipment, and amounts of hose that will be available for immediate use at

the fire. He must determine whether or not the same will be sufficient to meet the present situation. Also, it is most important that he consider and make efficient use of the manpower that will be available.

Those on Standby Status- Many fire departments have a "standby" service within their department. Here a reasonable number of men respond to the fire and the remaining members stay at the station to man additional apparatus in the event of another alarm or in case assistance is needed at the first one. Also, most communities have a working agreement with nearby fire departments from which a varying amount of help is available. These plans must be studied as they apply locally.

WATER SUPPLY (MAINS, HYDRANTS, PONDS)

Source of Supply - The officer should know the sources of water supply such as street mains, fire hydrants, rivers, ponds, lakes, tank wagons, and any other source that may be available. He must have this knowledge before the emergency rather than after one develops.

Amounts Available - In this study the officer must familiarize himself with volumes, pressures, and the size of mains supplying the nearby hydrants. Where sprinkler systems receive their water supply from the same water mains as the fire hydrants, consideration must be given to the volume available and whether it will supply both means of extinguishment. Then, too, the use of large tank wagons, put in operation with portable pumps, is to be considered when estimating amounts available for fire extinguishment.

DECISION

The officer in charge must consider and utilize the primary fire protection equipment within an involved and/or exposed building. Such equipment may be inside and outside sprinkler systems, standpipe systems, fire doors, fire shutters, and wired glass windows. He should consider how such equipment can be used to prevent exposures or to confine and extinguish the fire. He must also envision the action necessary to put such equipment in service and to insure its effective operation.

In sizing up a fire, the officer should not underestimate the importance and effectiveness of primary fire protection equipment.

On the fire ground, decisions are formed through an evolutionary process. As the officer accumulates the essential facts, his decision is in the process of being organized and it should be the logical conclusion resulting from his consideration of pertinent information.

He should keep in mind the principles of fire fighting tactics and his responsibility to prevent further loss of life and property. The officer may be forced to make a prompt decision based on a minimum amount of available facts to meet the immediate situation.

An intelligent decision is the product of an officer's ability to see the entire situation with clarity and vision, considering it in the light of previous knowledge and experience. The decision should represent a clear and precise picture of the action he intends to take.

Orders and instructions should be clear and concise. If possible, junior officers should be advised regarding the existing situation and plan of operation. With this information, they will be able to use better judgement and render more intelligent cooperation in execution of orders received. The officer in charge should not await the completion of his size-up to issue any necessary orders. Immediate action may be required to effect rescue of trapped persons, obtain additional manpower, apparatus, water supply, and to execute such other steps as may be required.

Good supervision is important. The officer in charge should be in constant contact with the entire situation at all times. He should keep informed as to the progress of operations and new developments. Coordination and effective use of his forces are essential and can be accomplished only through proper supervision and effective communications. At small fires, the problem of supervision is not difficult as the officer can personally look over the situation from time to time and talk with his officers and men. However, at large fires the problem of supervision is complicated by the necessity of providing suitable communication between the officer in charge and the units of his command. With use of portable radio equipment, this problem is being eliminated.

On the fire grounds the size-up is a continuous mental process. Here, the officer in charge continuously reviews facts, filling in the mental picture with the essential details of a changing situation. From this up-to-the-minute picture he formulates supplemental decisions to the plan of operation.

CHAPTER 15

FORCIBLE ENTRY

INTRODUCTION

Firemen must have means of getting into a building that is closed and locked. Admission must be gained by forcible entry. Entry of this type is used only when all accessible doors and windows are locked and it is impossible to enter the building through normal means. This chapter explains the different methods of forcible entry and the ways of using the tools of the fire department in making a forced entry. The knowledge of how to use them is invaluable when the firemen, upon arrival, find the normal entrance into the building either blocked or locked. Through the efficient methods of forcible entry more property can be saved, life hazards reduced, and better public relations created.

MAKING ENTRY BY BREAKING GLASS

Glass in either a door or window may be broken easily by using the flat side of a fire axe. The man breaking the glass should stand to one side and strike the upper part of the glass first, as shown in Figure 1. In this way, broken glass cannot slide down the axe handle and cut the hands.

After the glass is broken out, all jagged pieces should be removed from the sash starting at the top to avoid injury. This may be done with the pick end of the axe. Removing all pieces will avoid cutting the man that enters through the sash and will prevent damage to hose, ropes or other material that may be passed through the opening. This procedure is recommended where any difficulty is encountered in opening windows, whether in a factory, residence or commercial building. When encountering wire glass, cut at the edge of the sash with the cutting edge of the axe.

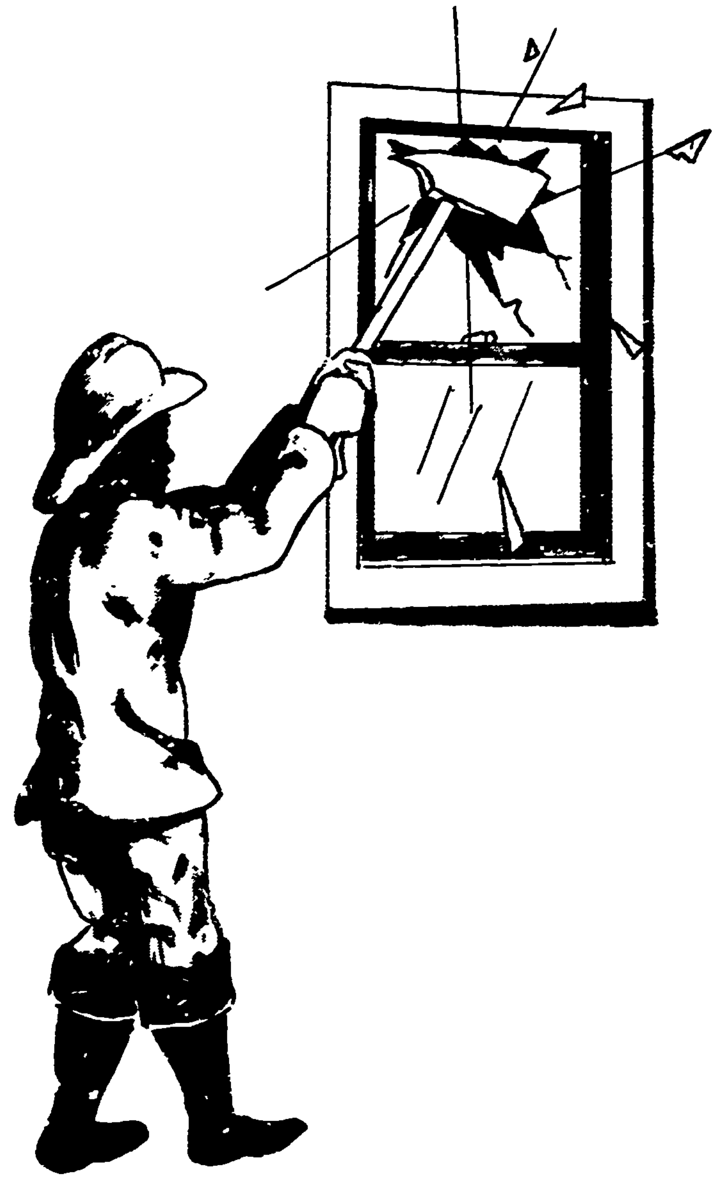


Fig. 1 - Making Entry by Breaking Glass

MAKING ENTRY THROUGH VARIOUS TYPES OF DOORS

Doors are constructed of various materials and are of various types. Examples of some types are the ledge panel, slab, double sliding, single sliding, overhead lift, overhead roll and revolving doors.

Some types of steel doors offer great resistance when trying to open them. Every department should know, by previous inspections, where these types of doors are located and instructions given on how to open them. It is often advisable to find other means of entry if possible. It should be emphasized that in gaining entrance, glass is the most easily broken material and, in most cases, the most easily replaced.

Single-hinged doors that open out may be opened from the swing side with an axe, as shown in Figure 2. The blade of the axe is inserted between the jamb and the door, just above or below the lock. By prying with the handle to one side away from the door, the jamb can usually be sprung enough to let the lock bolt pass under the keeper. The Kelly tool may also be used for this purpose (Figure 3). The Buster bar or Hux bar may be used for prying open a door in a manner similar to the Kelly tool. Either the straight

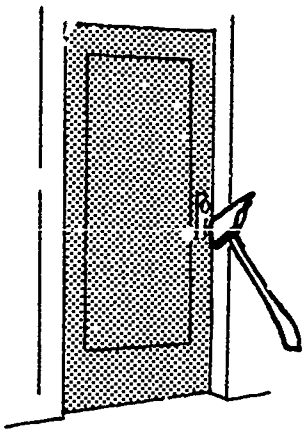


Fig. 2 - Opening Door with Axe

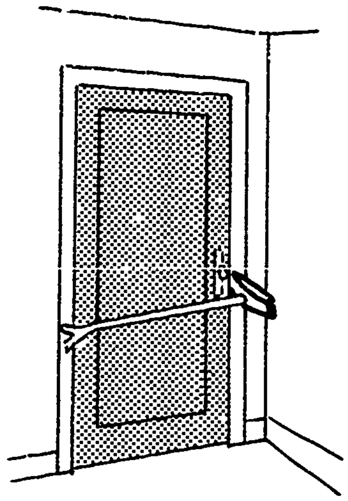


Fig. 3 - Opening Door with Kelly Tool

or the cross head of this tool may be used where a door is near a partition permitting a better leverage with the tool.

In opening a door that swings in from the operator, greater difficulties are presented. If the door is in a stopped frame, the straight head of the Kelly tool may be inserted between the door and the jamb (Figure 4). Then, by prying toward the door, it may be sprung past the lock bolt.

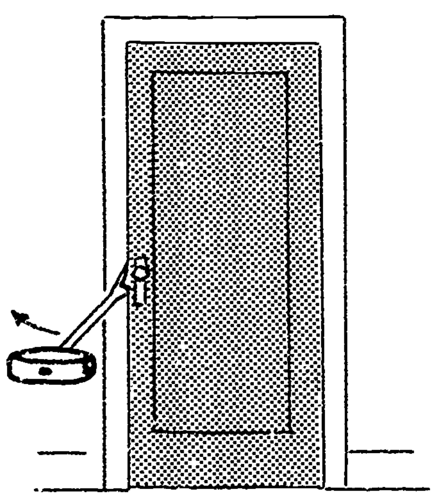


Fig. 4 - Kelly Tool Used for Door that Swings In

If the door is in a rabbeted frame, there is little chance of springing the frame. The cross head of the Kelly tool may be inserted between the door and the jamb as shown in Figure 5 and by prying against the door, the door, the jamb or the lock will break. *If the door has glass in it, it is better to break the glass and manipulate the lock from the inside.*

The Detroit door opener may be used for forcing doors in, as shown in Figure 6, by either breaking the door or spreading the jambs. Double-hinged doors may be opened either with an axe or with the Kelly tool, as shown in Figure 7.

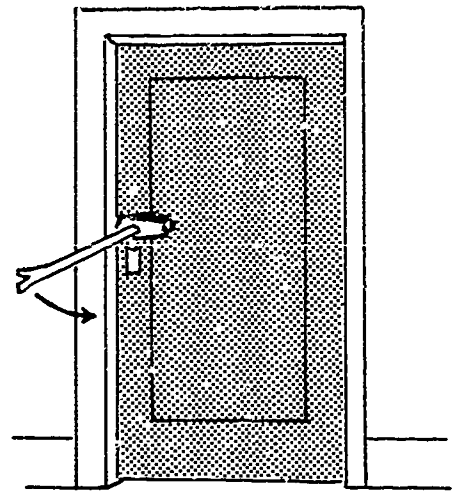


Fig. 5 - Kelly Tool Used for Rabbeted Jamb

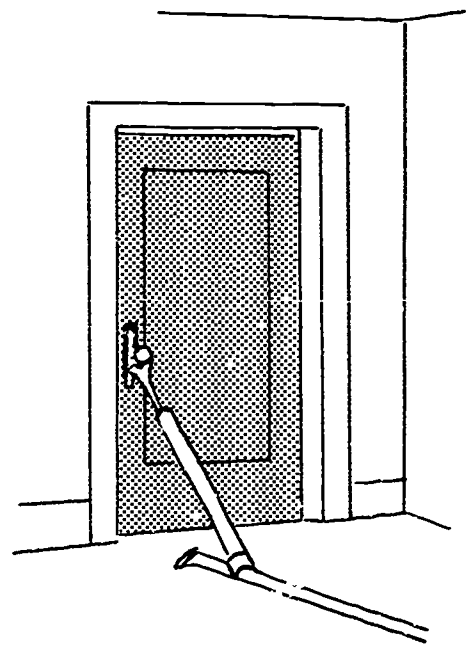


Fig. 6 - Using "Detroit" Door Jamb

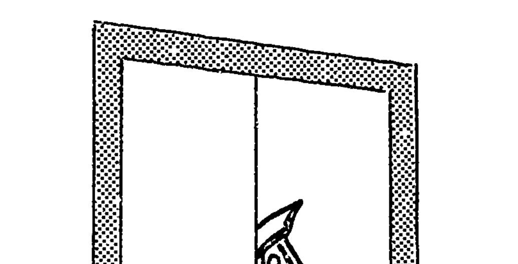


Fig. 7 - Opening Double Hinged Doors

Single-hinged doors on warehouses, stables and other buildings may be locked with a hasp and padlock. If so, the staple of the hasp may be pried or twisted off with a claw tool such as shown in Figure 8. The point of the claw is inserted in the staple end and if a pry will not remove it, it may be twisted off, taking the lock with it.

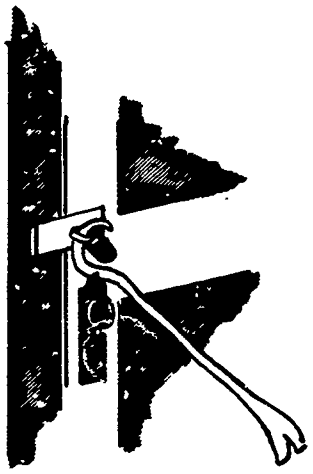


Fig. 8 - Prying Off

Overhead lift doors are easily operated once the lock is released. Generally, they are locked with sliding bars that must be broken or sprung to release the door. Overhead lift doors may be forced by prying upward at the bottom of the door with a crow bar, claw tool, or other good prying tool. Once the lock bar is broken, the door will open easily. Overhead rolling doors are made of steel and offer the greatest resistance of all to forcible entry. Due to the fact that they are operated with a worm gear, the door cannot be raised except by operating the worm with the chain which is provided. Prying the door is liable to spring it so that it cannot be operated even with the worm gear. Therefore, the only alternative is to to knock out bricks along side of the door, making a hole large enough to operate the chain.

Should doors be locked so securely that no other method of forcing them is successful, they should be battered in. This may be done with a battering ram. When forcing a door with the battering ram, use the blunt end of the ram and see that it strikes the door just below the lock and on the rail or solid portion of the door.

In the event of encountering a solid glass door, the only means of forcible entry is to take a sharp pointed tool, such as an axe point, and, using this point, hit the *lower* corner of the door a hard blow. This will cause the door to shatter and permit entry. Caution must be taken to protect the eyes and other exposed portions of the body from the shattering glass.

MAKING ENTRY THROUGH VARIOUS TYPES OF WINDOWS

Residence windows are of these general types: Sliding, awning type, double hung, casement and basement. The double hung window consists of two sashes that meet horizontally. If the sashes are hung with weights, they will be locked at the center of the check rail; that is, the upper and lower sash will be locked together. If the window has no weights, the sash will be locked with bolts in the window sill.

Casement sash are hinged to the window jambs and meet vertically. They are either locked together or each is locked to the window frame. Basement sash generally are hinged at the top and locked at the bottom, or vice versa. Factory type windows are generally constructed with metal sash. The sash is set solidly in the frame and only a part of it may be opened (Figure 9). The movable part is generally pivoted at the center and latched on the inside.

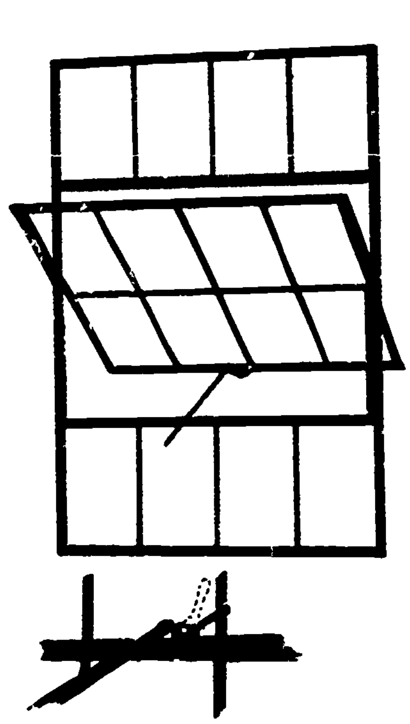
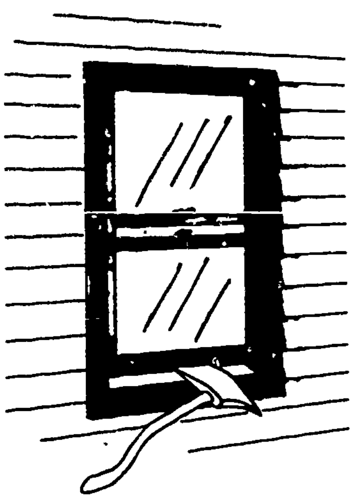


Fig. 9 - Factory-Type Windows

Double hung windows may be opened by prying upward on the lower sash rail. See Figure 10. If they are locked on the check rail, the screws of the lock will give and the sash will operate. If they are locked with bolts, the bolts must be broken or bent before the sash will rise. *Caution should be taken that the prying is done at the center of the sash or else the glass may be broken.*

Casement windows may be opened in much the same manner as double doors. See Figure 11. Generally, they are locked quite securely and it may be necessary to break the glass.



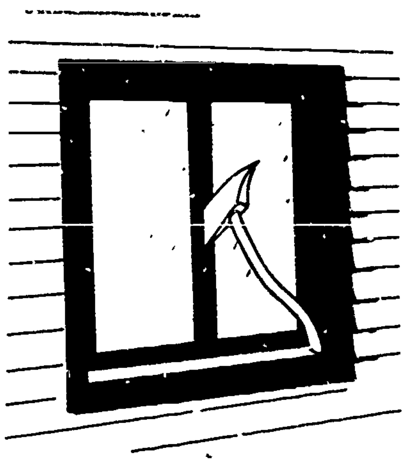


Fig. 10 - Opening Double Hung Windows

Fig. 11 - Opening Casement Windows

Casement windows may be opened with a Kelly tool, much the same as a door in a rabbeted frame. If the prying is done at the center of the lower rail, the lock may be pulled off or sprung. Any of the prying tools such as the Buster Bar or Hux Bar may be used. Chisels, spanners, etc., can be used for prying in this same manner.

It is practically impossible to open factory type windows from the outside and, since they are glazed with small size glass, it is easier and less destructive to break a glass near the latch and reach in to unfasten it.

MAKING ENTRY THROUGH STORM DOORS AND STORM WINDOWS

There has been much discussion on the proper procedure to follow when encountering locked storm doors and windows. The wooden doors or windows, in most instances, can be pried open without too much difficulty and little or no damage to the wood itself. When encountering metal storm doors or windows, the general procedure is to break the glass to open the locked door or window. In this instance, remember to remove the broken glass from the frame before putting the hand through to unlock the door or window. It is not recommended that the metal storm door or window be pried open because of the costly damage to the metal framing.

MAKING ENTRY FROM ROOF

Quite often this means of entry becomes necessary. If the roof covering is of tin, the rotating or can opener type of roof cutter is used. After the metal has been cut and rolled back, the fireman proceeds with his cutting of roof boards to gain entrance. Tar paper, tar and/or gravel should be removed before the cutting procedure. When cutting a hole, whether it be in a floor, roof or wall, it should be made to look as though it had been done by a mechanic - *meaning a fireman who knows how to do the job.*

When cutting with a fire axe, the axe should not not be swung as a wood cutter would use it, but with short quick strokes. Figure 12 shows the method of holding the axe when cutting. By using this method, danger of hitting other men, catching the axe in overhead obstructions, and other such hazards will be avoided and the axe will be under complete control at all times.

Fig. 12 - Holding the Axe to Cut Floor Hole

When cutting flooring, roofing or sheathing, the cut should be made diagonally to the grain of the wood of each board instead of straight across. Figure 13 shows the method to use.

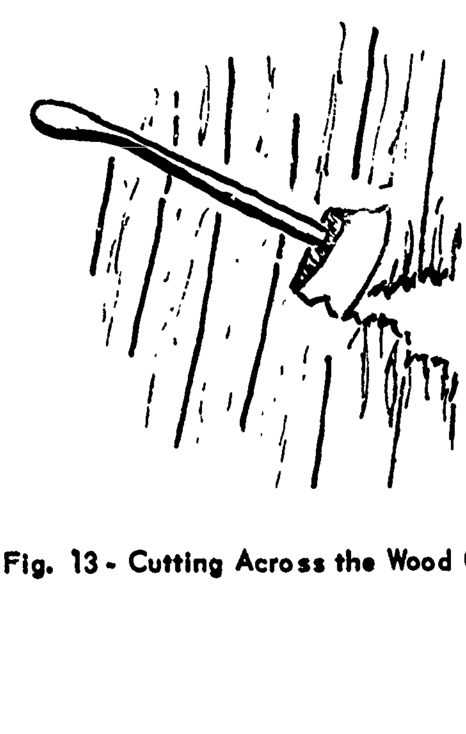


Fig. 13 - Cutting Across the Wood Grain

Diagonal sheathing should be cut whenever possible in the direction toward which it runs. When cut in this manner, the chips have a tendency to split out, while if the cutting is done across the grain of the sheeting, the axe is apt to bind and extra effort will be required to achieve results. Wherever possible, the cutting should be sloped at an angle of 45° to the board instead of vertically. This will provide a firmer base to cut against. Also, cut as close to a joist or rafter as possible.

In cutting roof boards, always stand on the windward side of the boards to be cut, then cut along the inside edge of the roof rafter. In cutting holes to a size wider than one span of rafters, the center rafter or rafters will hold the boards in place until all cuts are completed. All cutting must be completed before any boards are removed. When the cutting has been completed, again standing on the windward side, use the pick end of the axe or pike pole to rip up the boards, starting at a point farthest away from you. If only one board is cut and removed at a time, the hot air and gases rushing from the hole might make it very difficult for a fireman to stand over or near it to finish the job.

A fireman should be able to cut either right or left handed. Cutting in difficult corners and under obstructions can be done in a workmanlike manner by men who have been trained in the proper way to use a fire axe. Good axes and good axemen are important to efficient fire operations.

In some cases a pike pole may be needed to remove plaster and lath from the ceiling below the place at which the hole has been cut in the roof. (Figure 14).

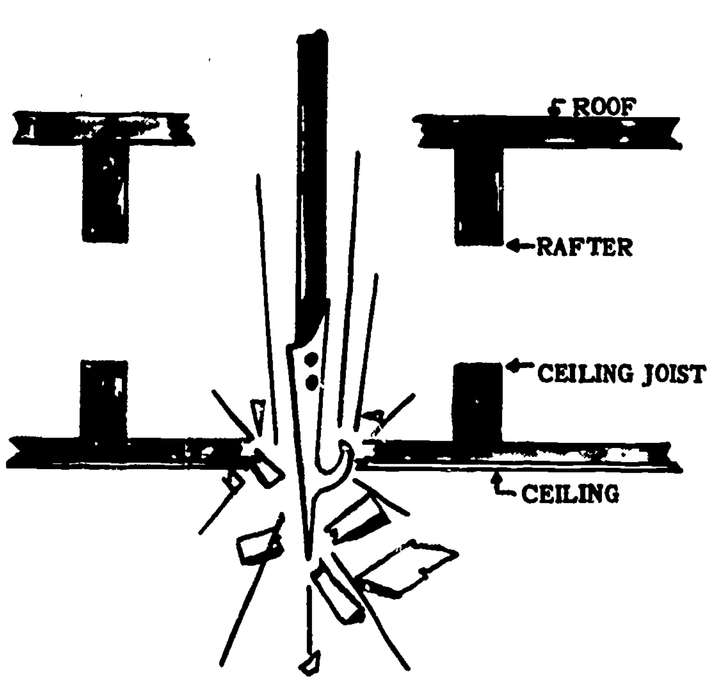


Fig. 14 - Opening Ceilings from Above

MAKING ENTRY THROUGH SKYLIGHT, COCK LOFT OR SCUTTLE HOLE COVER

In making forcible entry through a skylight the pick head axe is usually used. The pick point is placed beneath the edge of the frame (Figure 15) and with prying action of pulling on the axe handle, pressure is exerted to raise the edge of the frame. If the skylight is not raised readily, it is recommended to break the glass, remove broken glass, reach inside and release hooks or bolts. For removal of cock loft cover or scuttle hole cover the same prying procedure is used. If the cover does not remove readily, it must then be cut open by use of the cutting edge of the axe.

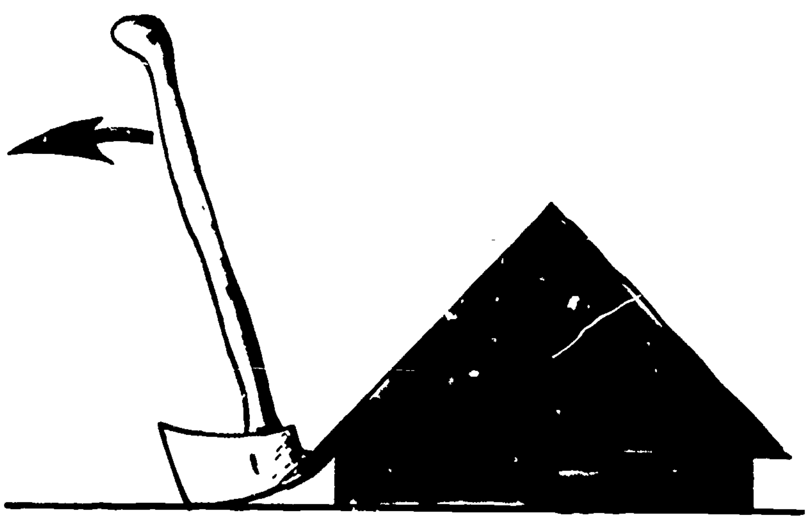


Fig. 15 - Making Entry Through a Skylight

MAKING ENTRY THROUGH GRATINGS, DEAD LIGHTS AND BARRED WINDOWS

Iron gratings may be fastened in several different ways. They may be merely held in position by the friction of the grating against the sill or they may be pivoted on hinges at the rear. They may also be set in masonry and locked in position with hasp and padlock. They may be opened by using the pick end of the axe, forcing it between the sill and the grating and prying up, care being exercised not to break the axe handle.

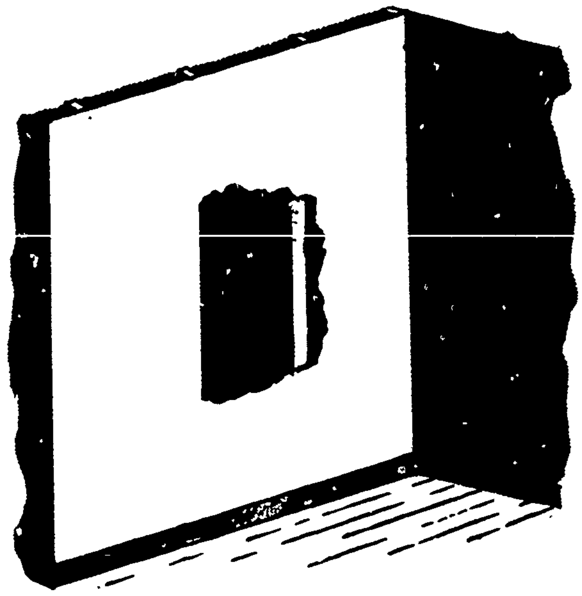
Dead lights are placed in sidewalks under which basements extend. They serve both as a sidewalk and as a ceiling for that part of the basement. They contain heavy glass discs which permit light to enter and are sealed into a steel framework with waterproof material. The steel framework is likewise sealed into the concrete, and to remove the dead light the seal must be broken. Any good, sharp prying tool may be used for this purpose. After the seal is broken, the dead light may be lifted and removed.

Iron bars on windows are usually set in masonry. The sledge hammer can be used to free bars set in masonry by striking the bar with the sledge about ten inches above the sill until the bar is sufficiently bent for removal. Another method is to strike the masonry sill with the sledge directly in front of the bar, breaking away the masonry.

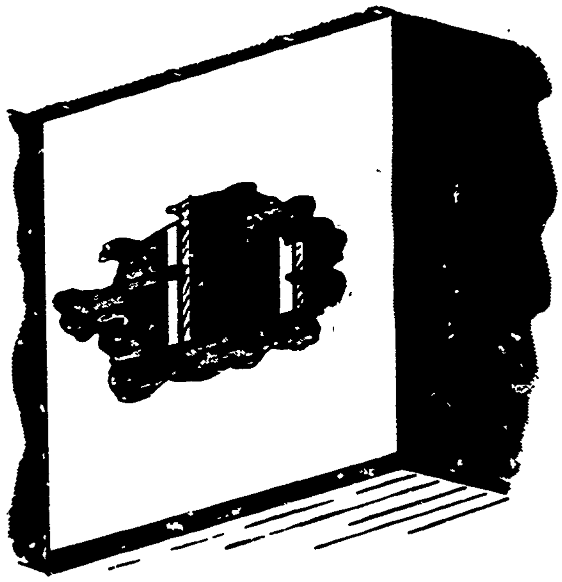
MAKING ENTRY BY BREACHING WALLS

To breach brick walls with the battering ram, (Figure 16), first remove one brick with the hammer head pick, pick-headed axe, sledge or other suitable tool. After the first brick has been removed, two men grasp the handles on each side of the ram, with the forked end toward the wall. They swing the ram back at arm's length, then quickly thrust it against the wall, giving it a slight lifting motion just as it strikes the brick. Remove the bricks one at a time, starting just below where the first brick was removed. The hole should be made diamond-shaped as this does not weaken the wall.

Fig. 16 - Battering Ram



17a - Correct Method



17b - Incorrect Method

Fig. 17 - Opening a Partition

MAKING ENTRY THROUGH OPENINGS IN PARTITIONS AND CEILINGS

When cutting a hole in a partition, care should be taken to make it as neat as possible, Spread a tarpaulin on the floor beneath the place where the hole is to be made; then, with the blade of an axe, cut down along the stud. Do not tear off the lath as this will make a ragged edge and ruin the plaster on both sides of the hole. See Figure 17.

In the opening of ceilings from below, the pike pole or the plaster hook (Figure 18) is used. It should be remembered that when pulling down lath and plaster from ceilings and walls with a pike pole, one should not stand directly beneath the hook after the point and hook have been driven through the plaster. The hook on the pike pole should be pointed down and away from the fireman while pulling down the ceiling. This will prevent the lath and plaster from falling on the fireman.

When metal lath has been used in the construction of a room or office, the operation of pulling down the plaster with a pike pole is often extremely hazardous. The metal lath is usually suspended from the rafter by means of soft iron wire, and when a portion of the plaster is pulled with the pike pole, the weight of the plaster will often cause a whole section, or sometimes several sections, to drop. For this reason it is

Fig. 18 - Plaster Hook

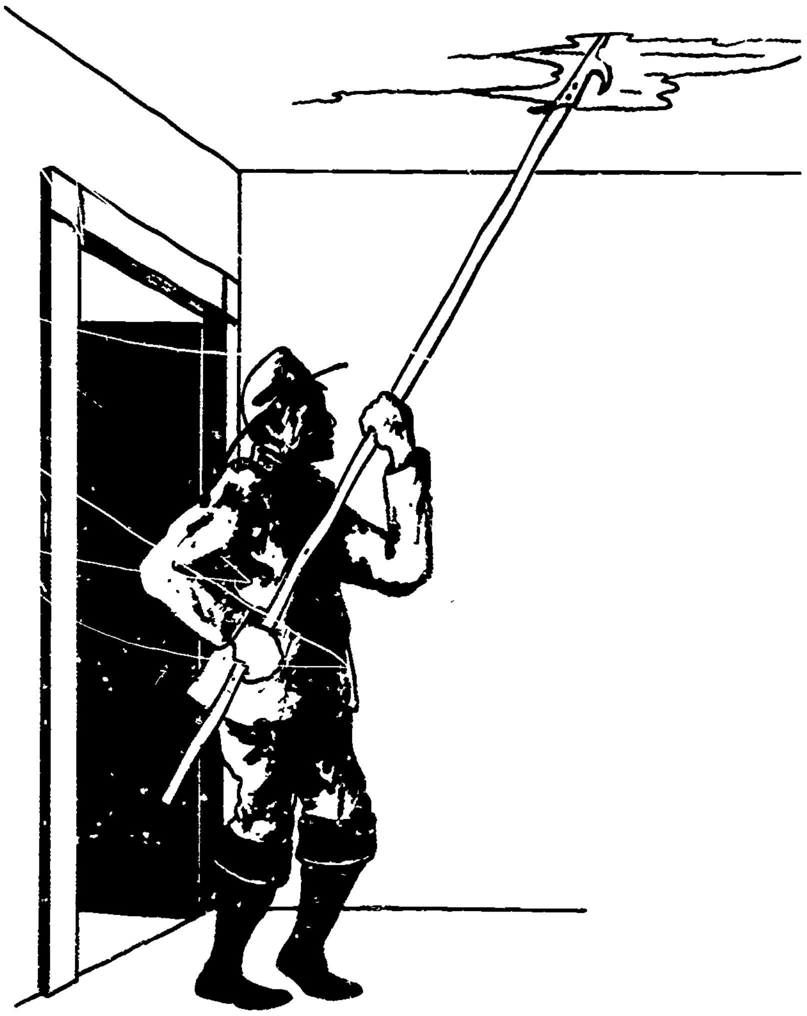


Fig. 19 - Pulling Down Lath and Plaster from Ceiling with Pike Pole

Fig. 20 – Pulling Down Metal Ceiling

important that a fireman, when pulling plaster from a ceiling known to be plastered on metal lath, be close to an open door or window that will enable a hasty, unobstructed retreat from the room if necessary. Several cases of injury to firemen have occurred because this precaution was not observed.

The point of a pick-headed axe or a hammer headed pick can also be used for pulling off lath and plaster from walls in an emergency.

In pulling down metal ceilings, the pike pole is particularly effective. The point is driven through the ceiling with the hook pointing downward and the operator standing well away from beneath the portion of tin to be torn down (Figure 20). When removing tin from the ceiling with a pike pole, if the tin holds tight, the hook part of the pole can be used as the fulcrum for prying the tin from the ceiling. The same principle can be applied in removing tin from roofs.

CHAPTER 16

RESCUE

INTRODUCTION

No greater service can be given by any fire department than the saving of a human life. When fire or other emergency occurs, it is the duty of the fire department to be equipped to render quick and efficient service.

In order to meet this responsibility, firemen must keep rescue equipment in first class condition and be thoroughly trained in the proper use and limitations of that equipment.

RESCUE PRINCIPLES, PRACTICES AND EQUIPMENT

As applied to fire fighting, rescue is the removal of humans from places involved in fire or other disaster. The factor of life saving or "life hazard" decides the first or immediate operating procedure at a fire or other emergency. Rescue is the first action to be taken on arrival at a fire. Therefore, each officer and fireman should thoroughly understand the principles governing rescue.

In case of fire or other emergencies within a building, the first questions to be considered regarding rescue are as follows:

1. Are there any people in the building?
2. If so, are they in danger?
3. Have there been cries for help?
4. Can they be rescued?
5. How can they be rescued?
6. Has any information been given by persons who have escaped from the building regarding persons in the involved building?
7. Has any information been given by neighbors or bystanders regarding persons in the involved building?

The officer in charge should determine whether anyone is trapped in the building. The information secured from answers to the questions above will help greatly in making rescue.

Children may try to escape from flames or smoke by hiding in closets, under beds or furniture. Persons may be found beneath a window which they have tried to open. A careful search should be made when there is any chance of anyone having failed to escape from the involved building. It must be remembered that it only takes a small amount of heated air, smoke or gases to render a person unconscious.

Officers and firemen must know the life hazards found in public, commercial and apartment buildings under their protection. This is done through frequent inspections, surveys and group study. Firemen should know the construction, interior layout, nature of contents, number of persons likely to be found in the building at the time of fire, location of interior and exterior stairways, other avenues of escape, and such other information of value in conducting rescue operations.

Firemen should also know the exact location of all exits from the involved building and the openings in the roofs of the adjoining buildings which could be used in an emergency. Porch roofs, balconies, and in many instances, the roof of the involved building may provide a means of temporary escape from immediate danger for the occupants.

In such places of public assembly as schools, churches, hospitals, dormitories, theaters, factories and stores, the actual fire is not the only factor causing a serious rescue problem. Panic, rather than fire, has been the major cause of death in places of public assembly. A false shout of fire, the discovery of smoke, some incident such as an explosion, collapse of part of the building, or any other unexpected event can cause the necessary spark of excitement which can cause panic. The best method of panic prevention is for the assembled people to be trained to perform a well disciplined emergency exit drill. This is the reason that systematic emergency exit drills should be conducted. Where it is not possible or practical to train occupants in emergency exit drills, the only safeguard against panic is for the buildings to have adequate exits. All exits should conform with accepted standards.

Weather conditions at the time of fire or other emergencies have an important bearing on the problem of rescue. Zero weather accompanied by snow and ice will slow up rescue operations. Low temperature, plus exposure, may endanger the health of persons who have been removed from the building.

The use of the new type metal window frames in buildings has increased the difficulty of bringing occupants out through window openings.

The time and nature of occupancy has a direct relationship to the problem of rescue. A hotel fire is a more serious problem in the early morning hours than at any other time. In the early morning, most of the occupants are asleep and a fire may have made considerable headway before discovery. A school building presents an entirely different problem during the time classes are in session than when they are not. So, time and nature of occupancy must be given proper consideration in rescue.

The age, sex and physical condition of the inhabitants of the involved building will also enter into the problem of rescue. Women, children, and the physically disabled will make operations more difficult.

Firemen should make community surveys to determine where these unfortunate events are most likely to strike. A complete record should be kept at all times as to location of homes for the aged, children's homes, jails, hospitals and other institutions.

Periodic surveys of the area firemen are to protect should be made by both officers and firemen to determine the type of rescue tools and equipment that would be required for any emergency that may arise.

Rescue equipment will vary in different locations. For instance, an area with railroad tracks creates the possibility of a train wreck. The presence of lakes, ponds, and other bodies of water may indicate the chance of future drownings. Jails, asylums, etc., constitute places of confinement where iron bars would have to be removed from the windows. All of these would pose different problems in attempting rescue. Discussions should be held regarding these possible rescue problems.

Firemen must be trained in the use of rescue equipment such as ladders, ropes, life nets and gas masks in order to protect their own lives and the lives of others. A knowledge of the chemistry of fire, gases ventilation and first aid is a must for the fireman.

There can be no set rules for rescue as conditions may differ from case to case. Generally the time factor is always pressing, for people must be rescued quickly and taken to a place of safety. The methods used may employ one or a combination of rescue practices. In one case, ladders may be sufficient while in another a combination of ladder, fire streams, and ventilation work might be necessary. It could be necessary to use hose streams to protect avenues of escape or to temporarily confine the fire. In some instances, it might be advisable to attack the main body of fire if such action is needed to rescue trapped people.

In order to be ready for any emergency, firemen must be drilled regularly to develop teamwork in rescue practices.

TYPES AND USES OF RESCUE EQUIPMENT

Listed on the pages to follow will be found items of rescue equipment used by the firemen along with a brief description of their use. The equipment listed not only covers rescue at fires but also other types of emergencies.

AXE

The regular fire axe is designed to be used for many purposes. Some departments carry a fire axe sharpened to a fine edge for emergency cutting only.

ROPE

The size, length, and amount of rope that the department should have can be determined in advance by a survey of the area for which the department is responsible. Rope can be used for lowering people from buildings, lowering firemen into manholes, making rescues from cave-ins, etc.

LADDERS

The general rescue value of ladders is for the removal of persons from the upper stories of buildings. Ladders used for this purpose must be sufficiently strong and kept in perfect condition because of the extra weight they must bear during rescue work.

GAS MASKS

The use of the self-contained gas masks makes rescue possible under extremely hazardous conditions. See Chapter 12 for detailed information regarding poisonous and suffocating gases.

Many times, firemen must make rescue where there is no fire. People are often overcome by various gases in sewers, manholes and tank cars. The use of this gas mask makes rescue possible and safe.

Because of the irritant and poisonous nature of the many types of gases encountered during a fire, no fire department can be considered adequately equipped if it does not have sufficient gas mask equipment for its men.

Each department should determine the type of self-contained mask best suited to meet the emergencies that may arise in their community. For effective operation, a minimum of two masks should be provided for each piece of apparatus and all firemen should be trained in their use and limitations.

LIFE NETS

Life nets, Figure 1, are used where a life or lives are in danger and conditions will not permit raising ladders to make rescue. There are times when people are forced to jump from upper stories of buildings because of intense heat or smoke. These cases occur when their avenues of escape have been cut off or when the fire department ladder cannot reach them. In such cases, life nets have saved the lives of many persons that have been forced to jump to safety. Teamwork on the part of the department is necessary to use the life net properly, and members must be trained until this teamwork is perfected. Practice should include the following:

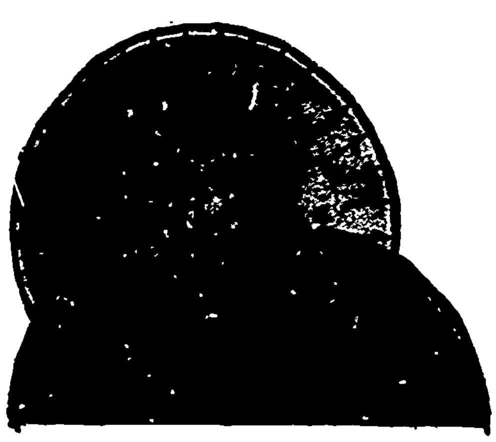


Fig. 1 - Life Nets

Removing Net From Apparatus - Modern life nets are generally folded to quarter size and are carried in a box under the bed of the apparatus. To avoid confusion and delay, firemen should drill on removing the net from the apparatus and opening it to full size. Men located at the "quarter connection" must make absolutely sure that the snaps have caught and that the ferrule covers the connection.

It is considered good practice to open and man the life net at a safe distance from the spot where it is to be used. If carried to the point of use before completely ready, an excited victim may jump before the net is properly manned with the resulting serious consequence.

Running With Net - Speed is a factor when the life net has to be used for it may be necessary to rescue persons from different locations. Since ten men may be required to hold a net, all men forming a circle, it can easily be seen that running with the net could be awkward if not well practiced. While running, all men hold the net with one hand, about waist high, and all face in the direction of travel, starting slowly and then gaining speed.

Spotting Net - To spot a net properly, one man should run in advance of the men carrying the net. When he is under the person who is going to jump, he should judge the distance the net is to be away from the building. The men carrying the net should then run to the man assigned to this job and stop between him and the building.

Holding Net - The number of men needed to hold the net may vary. The hands should be in the spaces provided on the metal ring. The life net should be held shoulder high with both hands of each man cupped, palms up and thumbs under metal ring. Elbows should be held away from the body to enable them to swing past the body on impact. All men holding the net should have their left foot forward to act as a brace.

Making Adjustment to Catch Person - All people do not jump in the same way. Some may jump beyond the net while others may jump short of where the net is stationed. A proper catch is made when the jumper lands in the center of the net. In order to accomplish this and protect themselves from being struck by the person jumping, the men holding the net may have to shift location. Shifting the net in the proper direction and distance would be confusing unless all men holding the net are looking at the jumping person. Therefore, after the net has been located, the spotter should give the command "look up." All should look up at the person about to jump then in unison make the proper shift of the net, if necessary, so that the jumper will land in the center.

Removing Person From Net - When more than one person has to be rescued with the net, speed in getting the first person off the net is necessary. To remove the person from the net, quickly ground that portion of the net farthest from the building. In order to do this, of course, the part of the net nearest the building must be raised. This procedure of unloading will permit the quick removal of the person from the net.

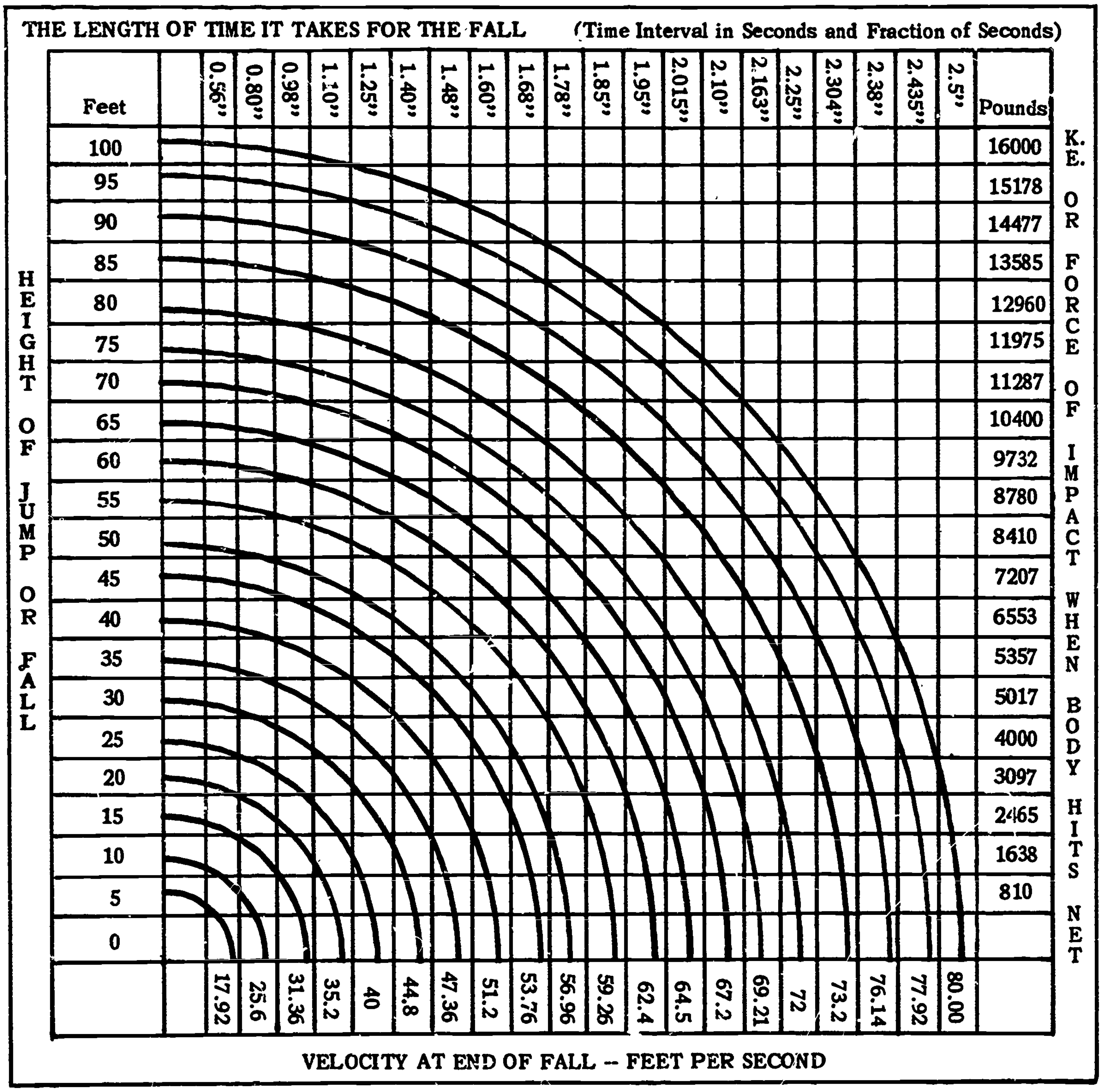
All men holding the life net should have a firm grip on it with both hands to prevent the net from being pulled from their hands at impact. The total weight produced by impact is very high. One life net

manufacturer has stated that the weight produced at impact equals the weight of the jumper in pounds times the height of the jump in feet; see Figure 2.

From Figure 1, one can easily see that the substitution of a blanket or canvas cover for a life net would be of little va[illegible] if the jump were made from a high point. If there is no net available, however, the use of heavy canvas might help break the fall from limited heights.

Life net training can be practiced by using a dum-

HOW TO CALCULATE THE FORCE OF IMPACT OF FALLING BODIES



FORMULA FOR CALCULATION OF OTHER FORCES OF IMPACTS NOT SHOWN ON CHART

$V = tg$

$M = \frac{W}{g}$

KE (Kinetic Energy) $\frac{MV^2}{2}$

(V) velocity
(t) time
(g) 32' per second
(M) Mass
(W) weight

A much simpler method for calculating this kinetic energy is to multiply the height by the weight. Although this method is not as exact as the former, it is an easy, practical way for those not acquainted with the laws of physics which must be taken into consideration when making such calculation.

Courtesy Atlas Safety Equipment Co., Inc.

Fig. 2 - Force of Impact When Body Lands in Net

my. When practicing, use a dummy that weighs from 100 to 125 pounds and so formed or constructed as to resemble the human body as nearly as possible. Such a dummy will distribute weight over a larger surface than a sand bag and makes the impact action more natural. The men prepare and hold the net as previously described. The dummy can then be dropped from a window or roof of a building.

When training first starts, the dummy should be dropped from a height of approximately ten feet until the men become accustomed to handling the net. The height may then be increased as their skill in catching the dummy increases. This training will also give the men the necessary practice in carrying, placing the net, and receiving the impact.

It must be remembered that in making a rescue, in most cases the trapped victim will have had no experience in jumping into a net. Consequently, the spotter should direct the victim. He should not yell, but in a calm voice tell him what to do and how it should be done. A bull horn or speech amplifier should be used if available. Once the victim jumps he is at the mercy of those holding the net and his life depends on the skill and training of the rescuers.

STRETCHERS

There are many departments that carry a folding stretcher on their apparatus. It is used in moving persons who are sick, injured, bedridden or overcome smoke and/or gas.

HEAVY EQUIPMENT

Railroad tracks, auto collisions, cave-ins, collapsed buildings and other emergencies may require heavy equipment to make rescue possible. Departments should carry a book listing all places where such equipment may be secured. A listing would act as a time saver in an emergency. The listing should include such equipment as heavy lifting jacks, tow trucks, winch trucks, block and tackle, heavy ropes, cables, bulldozers, power shovels, etc.

FIRST AID KITS

A first aid kit, as shown in Figure 3, is carried by most departments. It usually consists of gauze bandages, cotton adhesive tape, boric acid, ammonia, burn ointment, tourniquet, scissors and a first aid manual.

Inspect all first aid kits frequently and replace any items that have been used. The kit itself should be stored in a moisture proof container and carried in a dry place on the apparatus.

All firemen should have an active first aid card so they can give more efficient service to their public.

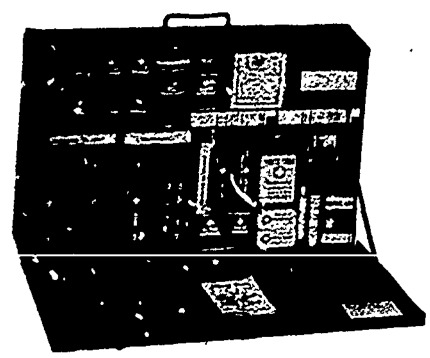


Fig. 3 - First Aid Kit

DRAGGING HOOKS, BOAT AND PIKE POLE IRON

Departments located near bodies of water where people may drown should have a set of dragging hooks, a pike pole and a row boat. These are usually kept at the fire station to be used in cases of drowning or other emergencies on water. If departments are so equipped and respond with little delay, it may be possible to rescue and revive persons that might otherwise be lost. Detailed information on water rescue problems is further outlined.

OPERATION AT SCENE OF DROWNING

At this point it is well to emphasize certain factors pertinent to the safety and welfare of firemen themselves. Entry into the water is recommended when the victim can be seen and is moving, or when there is substantial evidence that the victim has been under water only a few minutes. Obviously, only trained and qualified men should be selected for this assignment.

The use of life jackets should be emphasized as being standard equipment for firemen to wear during boating operations. This rule should apply to swimmers as well as non-swimmers, especially when entering swift or rough water. It is also a good precaution to assign a man to shore duty, and have him remain there as long as men are working in the boat. His main responsibility will be to watch the men in the boat. Should the men in the boat run into trouble or encounter difficulty, the man on watch could quickly find help to assist them. He could also gather information from witnesses on shore which could aid the boatmen in their size-up and search.

GENERAL INFORMATION ON DROWNED BODIES

A body will usually remain in the near vicinity of where the drowning occured. Even though there is a strong current on the surface of the water, the body will not move very far from the spot where the victim

was last seen. It has been noted that a body in a swimming suit, when sinking, will not be more than 1 1/2 times the depth of the water away from the spot where the body sank. For example, if a body sank in water 20 feet deep it would probably be found within 1 1/2 x 20 = 30 feet from the spot of sinking.

Sometimes, bodies that are very fat and bodies of small children may not sink after drowning but will remain floating on the surface of the water. Also, a body will rise to the surface when enough gas is fomed in the intestinal tract to make the body buoyant. The temperature of the water and the contents of the stomach will have a bearing on the time needed to generate the gas. In summer, the average time is from 18 to 24 hours. In winter, however, or when the water is very deep and cold, the time will be much longer.

A body does not rise suddenly from the bottom. Only gradually, as more gas is fomed in the intestines, does the body become buoyant enough to reach the surface. After the body rises to the surface its movement is directed by the current or wind and may be found several miles downstream.

A victim drowned in rapid water will probably be found in the first deep hole downstream. If man power is available, it is advantageous to send one detail downstream to search the eddies and the center of the stream.

DRAGGING

In the early stages of any body search, dragging and probing with grappling irons, grappling hooks, and pike poles are the usual means employed. Even under the best circumstances, dragging is a blind operation.

Types of grappling equipment which have been used very successfully can be made in accordance with the following information:

Grappling hooks are made of No. 9 iron wire. Two pieces 18 inches long are bent in half and twisted as four strands, leaving an eye at one end and four prongs at the other end. Space the hooks and line as illustrated in Figure 4.

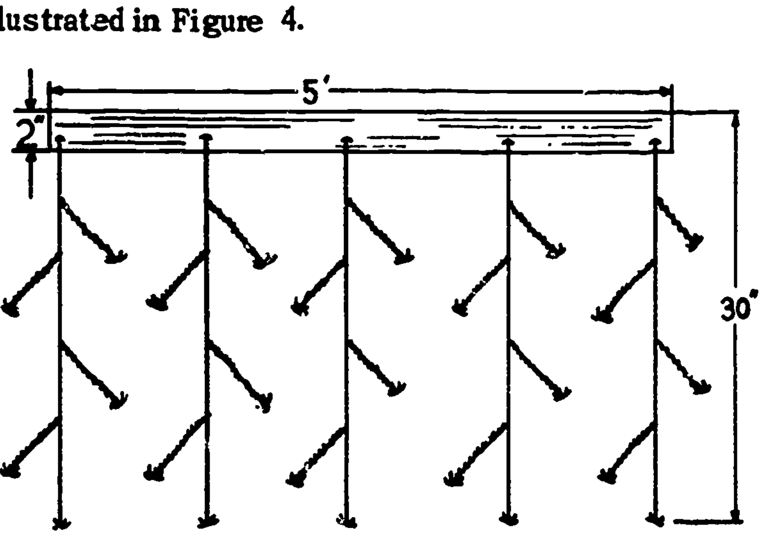


Fig. 4 - Grappling Hooks

The iron shown in Figure 5 is not very practical for rescue work, but may be used in very deep water for body or equipment recovery. The iron weighs from five to ten pounds.

The pike pole iron is the only type that can be used in waters with stumps. The pole should be in four foot sections and not exceed 20 to 25 feet in length.

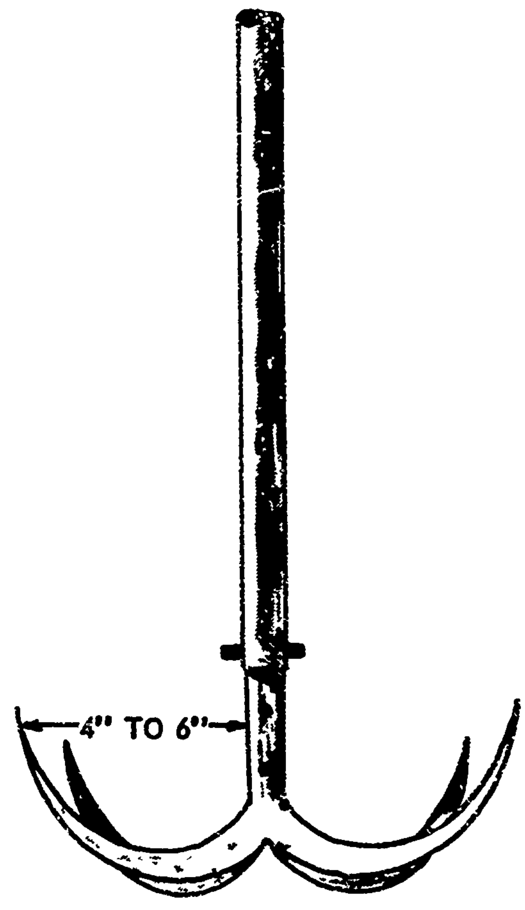


Fig. 5 - Pike Pole Iron

SIZE-UP

Proper size-up, before and during the operation, will be of much assistance in making a rapid and successful recovery. In making the size-up, the man in charge should consider the following factors:

How long has the victim been under water?

Where was he last seen?

How was the victim dressed? (Swim suit or clothed)

Survey of body of water as to:

- Type of bottom
- Currents
- Snags and obstructions

Depth and width of water

Conditions of banks (undergrowth, trees, etc.)

Direction of wind

HOW TO LOCATE BODY FOR GRAPPLING PURPOSES

In Figure 6 a witness at point A last saw the victim in line with tree Y; a witness at point B last saw the victim in line with tree X.

Then, by drawing imaginary lines between point A and landmark Y, and between point B and landmark X, the location of the body can be detemined as being approximately at the point where the lines cross.

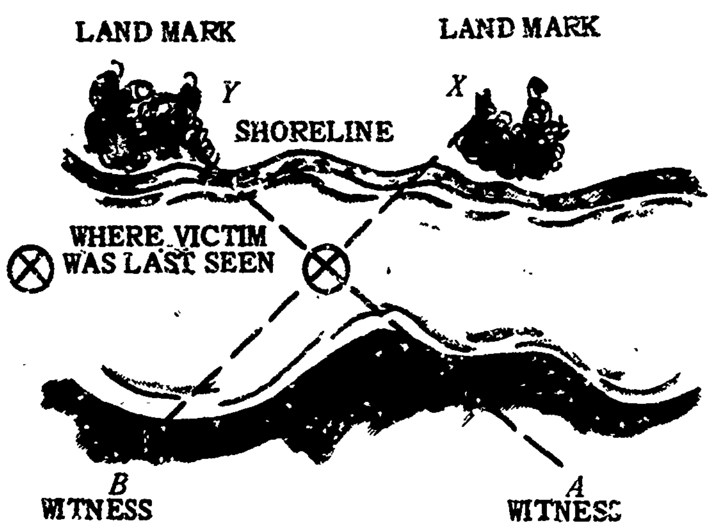


Fig. 6 - Locating a Body

METHODS

There are many dragging methods which may be used. An attempt is made, however, to show only the more successful ones.

Shore to Shore Grappling - When grappling from shore to shore, the following procedures should be followed:

1. The length of the rope should be more than twice the width of the area to be covered.

2. Fasten hooks to center of rope.

3. Fireman number one will drop hooks straight down until bottom is hit. He then signals number two fireman to draw hooks slowly to him, allowing them to drag the bottom of the entire width of the area.

4. If nothing is hooked, fireman number two side steps one-half the length of the bar in the direction the victim was last seen.

5. Number one then side steps the same distance in the same direction.

6. Number two then lowers the hooks straight down to the bottom and signals number one to pull the hooks slowly to him.

7. This procedure is continued until the entire area is covered. Procedure is then reversed so that the area will be covered twice.

8. If the body is not yet recovered, the area should be extended in both directions and the procedure repeated.

Boat to Shore Grappling - The following procedure is recommended: (See Figure 7)

1. The boat must be anchored securely.

2. The man on shore does all the moving, side stepping one-half the length of the bar.

3. If the victim is not hooked after position A, the boat should then be moved to position B and anchored securely. Procedure is then repeated from this new position.

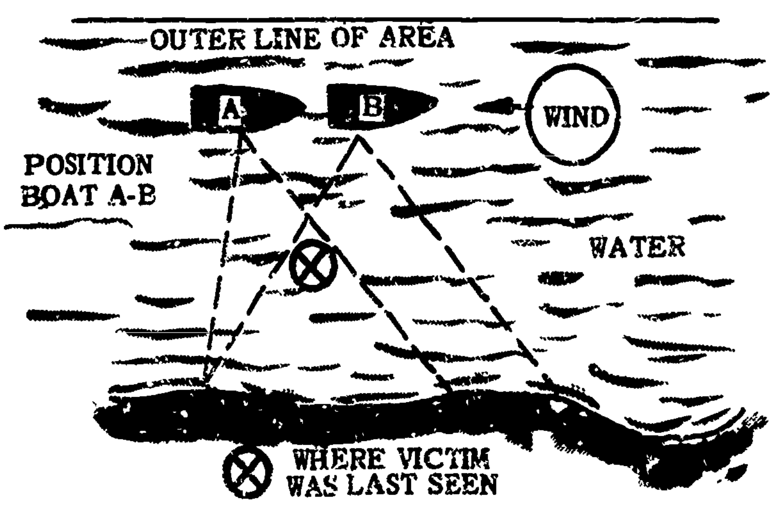


Fig. 7 - Boat to Shore Grappling

Boat to Boat Grappling - The following procedure is recommended: (See Figure 8)

1. Place four buoys to mark the area to be covered. See Figure 8.

2. Boats should be anchored from bow and stem.

3. Boats should be headed in the same direction.

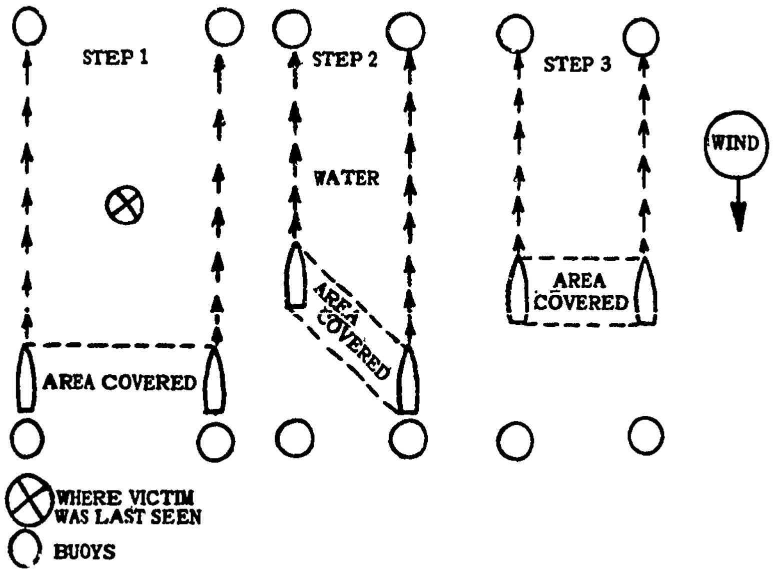


Fig. 8 - ᴗoat to Boat Grappling

4. Boats should be broadside to each other at all times.

5. The entire length of the boat is grappled, then number one moves forward the length of the boat.

6. Then number two moves in line with number one boat.

Grappling From Moving Boat - The least advantageous method of grappling is from a moving boat. The movement of the boat cannot be controlled perfectly so the entire bottom of the area may not be covered. When grappling from a moving boat it is best to move with the current. This will help keep the hooks on the bottom. If the current is very strong, the oarsmen should back water so that the boat movement will not be too fast and pull the hooks off the bottom.

The men using the hooks should kneel on the stem seat and operate the hooks over the stem of the boat.

In rough waters a motor may be used. It is best to use the motor to move the boat upstream with hooks out of the water. The boat should then be allowed to float slowly downstream with the hooks dragging the bottom. The following steps are recommended for dragging from a moving boat:

1. Upon arrival at the scene, remove all equipment from the boat that is not needed to start operations.

2. Launch boat with two men.

3. Place red buoy where victim was last seen and start dragging at once.

4. If the body is not recovered within one hour, place four yellow buoys in a square approximately 100 feet apart and start systematic dragging operations.

5. Row boat into the wind; it is easier to keep on a straight course.

6. Do not start rowing until hooks hit the bottom.

7. Hold rope to hooks in your hands at all times. The operator can feel when an object is hooked. The slack end of the rope may be tied to the boat as a precaution against the rope and hooks being pulled from the operator's hands.

8. Boat must be rowed slowly and must not get too far ahead of hooks.

Grappling With Pike Pole Iron - Use the method shown in Figure 9 to cover the area. This method is very good when the stream or lake bottom is full of tree stumps and heavy brush. See Figure 9.

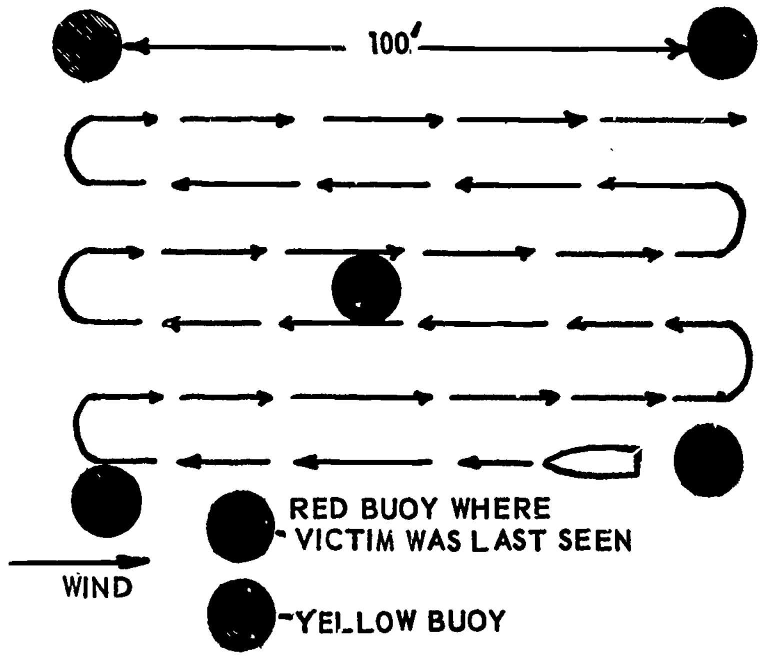


Fig. 9 - Grappling with Pike Pole Iron

Grappling for a body with pike pole irons differs somewhat from the actual dragging methods usually associated with a body recovery operation. Pike pole irons are not dragged or pulled along the bottom. Instead, the fireman holds the pole in a vertical position and tamps the bottom with quick up and down strokes while the boat is moved along slowly. See Figure 10. The resulting probing action enables the operator to feel and determine what is being struck with the end of the pole. This action also eliminates

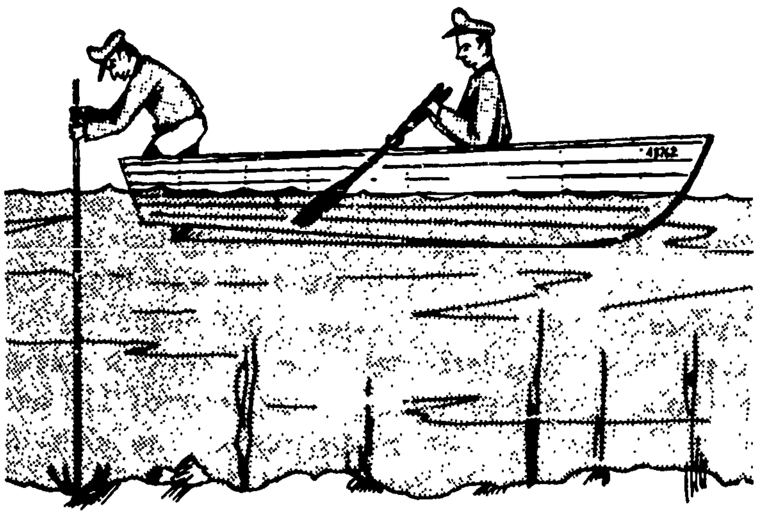


Fig. 10 - Holding Pike Pole Iron

the possibility of the iron becoming fouled in the debris on the bottom. The boat must continue to move very slowly during the searching operation until the entire area has been thoroughly covered. At the point in the proceedings when the body is located the boat must be stopped and held stationary until the body has been securely hooked and raised to the surface.

CUTTING TORCHES

On many occasions, fire departments must rescue people trapped or confined by metal. One method of making an effective rescue under such a condition is by using a cutting torch. Since this tool is obviously important, it is essential that firemen be familiar with its correct use and limitations plus its care. The succeeding paragraphs will give this information.

OXY-ACETYLENE CUTTING TORCH

The oxy-acetylene cutting torch can be used for cutting steel, wrought iron, and other ferrous metals. The equipment is portable. It consists of one tank containing oxygen and another one containing acetylene. Hose, regulators, gauges, cutting torch, lighter, goggles, extra tips, tip cleaners, wrench, leather gloves, and yellow and white chalk must be included in the equipment.

There are several companies which manufacture good cutting torches and equipment. However, since space is limited, this manual will not list all of them.

In selecting cutting equipment, it is advisable to obtain one similar to the assembly shown in Figure 11. This type is a sturdy outfit which will cut efficiently and economically. Its tough construction gives it a long life and it can be used with large commercial tanks as well as with small portable ones.

Figure 11 shows a complete cutting outfit which includes:

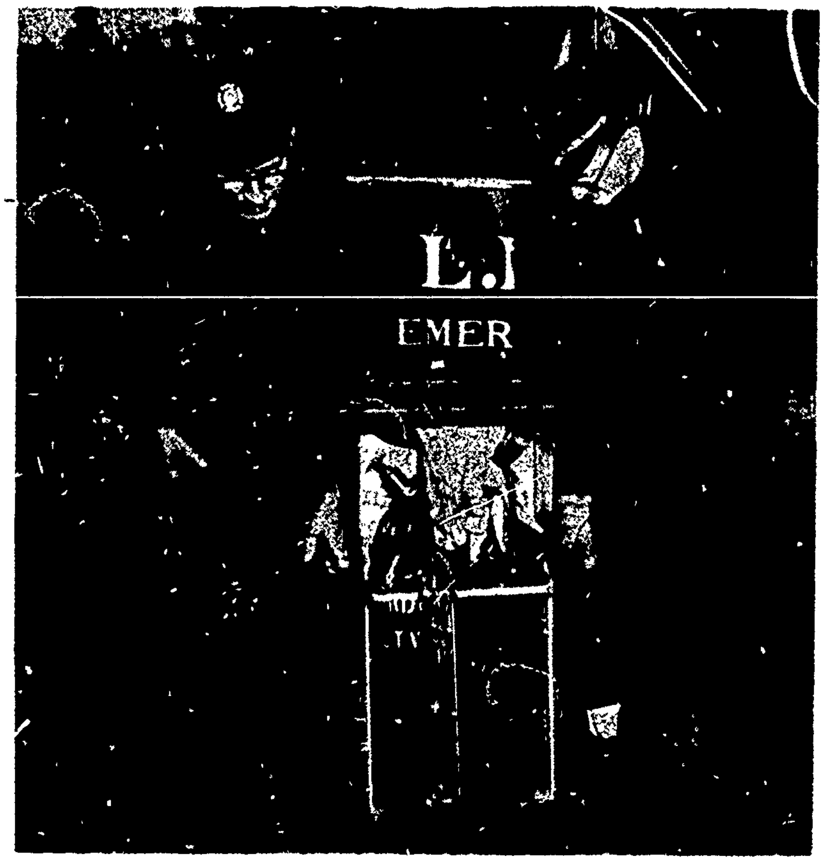


Fig. 11 - Portable Cutting Torch

1 Cutting torch (90 degree head)

4 Cutting tips; sizes 1, 2, 4 and 6

1 Two-stage oxygen regulator (200 lb. and 3000 lb., 2 1/2'' gauges)

1 Two-stage acetylene regulator (30 lb. and 400 lb., 2 1/2'' gauges)

1 Wrench (5-way)

Recommended Accessories:

1 Pair of goggles

1 Flint lighter

25' 1/4'' Twin line hose

4 Hose connections (2 each oxygen and acetylene)

4 Hose ferrules

<u>Assembling Cutting Torch and Hose</u> - The torch consists of a handle, or torch body, to one end of which may be attached any one of the various cutting tips, ranging in size from 0 to 8. See Figure 12. On the opposite end are two valves which control the rate of flow of oxygen and acetylene gas into the

torch. The rubber hose supplying the two gases are attached to these valves.

The acetylene tank and hose connections of all makes of torches have *left-hand threads.*

A good wrench should always be used to tighten the torch parts and hose connections - *never use pliers*. It is important to keep the packing nuts and torch valves fairly tight so that the valve setting does not change while the torch is in use. Always use an open end wrench. Valves that turn too easily are likely to be accidentally thrown out of adjustment when they brush against something.

Operating Pressure Regulators - The rubber hoses from the torch fasten to two pressure regulators; one regulating the pressure of the acetylene gas in the acetylene hose and one regulating the pressure of the oxygen gas in the oxygen hose. It is necessary to keep the pressure of the two gases constant at all times and low enough not to overload the hose. Two to five pounds to the square inch is about right for small torch tips. It must be remembered that gas pressure in the cylinders is constantly growing less.

By turning the cross bar or handle of either pressure regulator, the desired hose pressure can be obtained. This pressure is shown on the pressure gauge of the regulator. Screwing the cross bar in (clockwise) increases the hose pressure. Both oxygen and acetylene regulators have cross bars with right hand threads.

Regulators connect directly on the oxygen and acetylene cylinders; a second pressure gauge is used that shows the pressure within the cylinder.

Some manufacturers of welding regulators provide a small storage space in the center of the cross bars in which are kept extra seats to be used as replacements as wear occurs inside the regulators.

It should be stated here that if the torch "acts up" it is quite possible that the regulators are at fault. Two rules, if followed, will greatly prolong the life of regulators. First, always screw the cross bars out until they are loose before opening the cylinder valves which are located on the tops of the oxygen and acetylene cylinders. This prevents the suddenly released pressure from over-loading and damaging the delicate valve mechanism inside the regulator. Second, occasionally lubricate the threads on the cross bars with beeswax. Never use oil or grease anywhere around a gas welding outfit; that is, on any of the parts of the apparatus itself. Under pressure, oxygen will occasionally cause oil to ignite if conditions are just right.

SAFE HANDLING OF OXYGEN AND ACETYLENE CYLINDERS

The Oxygen Cylinder - Commercial oxygen, used in cutting, is stored in steel cylinders. The manufacture of all commercial oxygen is controlled by the United States Department of Commerce to insure safety.The cylinders are made of seamless steel with a fusible plug near the valve at the top. This plug allows the gas to escape at a safe rate in the event that the cylinder should be subjected to a dangerously high temperature. Oxygen gas is pumped into the steel cylinders to a pressure of about 1,800 pounds to the square inch. Cylinders are made in various sizes, the two most common having a capacity of 110 and 220 cubic feet of gas respectively. The shut-off valves mounted on the tops of the cylinders are of special design because of the extremely high pressure they have to hold. They have a right-hand thread and, when opened, should be turned as far as they will go. This prevents leakage by causing the valve to seat in the top of the valve body. Commercial oxygen is usually obtained from air and seems much like air in many ways, since it is odorless, harmless to breathe, and non-inflammable.

The Acetylene Cylinder - Acetylene gas is stored safely by pumping it into special steel cylinders. It is also controlled in its manufacture by the Department of Commerce. Unlike the oxygen cylinders which have no liquid or solid material whatever inside, the acetylene cylinders are loosely filled with asbestos absorbent which is saturated with a liquid called acetone. Acetone has the ability to dissolve acetylene gas under pressure. The result is that when 220 cubic feet of acetylene gas is pumped into a cylinder of approximately the same size as the one used for oxygen, the pressure is only 250 pounds to the square inch. This greatly increases the safety of handling and transporting compressed acetylene. The acetone remains in the cylinder as the acetylene is allowed to escape during welding and is used repeatedly with practically no loss. Fusible plugs in both the bottom and top of each cylinder are an additional safety factor. The acetylene cylinder valves are not subjected to as much pressure as the oxygen valves and do not require the special sealing feature - the packing used in the valves being ample to prevent leakage. The valves have right-hand threads and should be opened only one and one-half turns to allow for rapid shutting off in an emergency. They require a special, square socket wrench which can be obtained from the firm supplying the gas. The diameter of the threaded outlet for the regulator is smaller than that on the oxygen cylinder.

Attaching Cylinders - Before attaching fresh cylinders of gas to the welding outfit, the valves should be opened slightly and a small amount of each gas be allowed to escape. Oxygen will not burn but acety-

lene will. One should be certain that no open flame is near when the acetylene valve is opened. The escaping gas blows out any dust or particles of grit that may have become lodged in the valves during shipment. All fittings must be perfectly clean before screwing them on the cylinders.

As mentioned before, be sure all regulators are in the "off" or loose position before turning the gas on at the cylinders.

In turning the gas off at the cylinders, extreme care should be taken to make certain the valves are completely closed. The two torch valves should then be opened to "bleed off" the remaining gas in the hose. The pressure regulators should then read zero.

TO USE CUTTING TORCH

All types operate on the same principle and are provided with tips of various sizes for cutting metal of different thicknesses.

In contrast with the welding torch which has a single orifice at the tip, the cutting torch has five or more. The center orifice is for oxygen only and is supplied with a quick acting oxygen valve. This central oxygen orifice is surrounded with four or more orifices for the oxy-acetylene pre-heating flames. These pre-heating flames are adjusted independently of the oxygen cutting valve and, once adjusted, keep burning steadily regardless of whether the oxygen cutting valve is opened or closed.

One can use the oxygen cutting torch with excellent results on any kind of steel or wrought iron. Cast iron is somewhat more difficult to cut.

First, select a cutting tip of a size suitable for the thickness of metal which is to be cut. A tip with an oxygen orifice drilled at the factory with a number 66 drill is suitable for cutting steel one quarter of an inch in thickness. Number 52 is used for one inch and number 48 for three inch. The larger the wire gauge drill size number, the smaller the orifice.

The torch, valves, and connections should be checked for leaks before the torch is lighted. This can be done by passing the face near and around the torch, valves, and connections. If an acetylene gas leak is present, it can be detected by smell. If an oxygen leak is present, it can be heard or felt blowing upon the face.

Next, adjust the acetylene hose pressure as for cutting. The oxygen hose pressure depends upon the tip and the thickness of the steel being cut and varies from ten pounds to 150 pounds. Tables supplied with torches indicate oxygen and acetylene pressure for each tip and thickness of metal to be cut. These pressures vary with different makes of torches and sizes of tips. See Figure 12.

Cutting TIP SELECTOR CHART—including tip drill sizes

(1) IF . . . . the metal thickness you want to cut is as shown below. . . . . . .

(2) THEN . . . . select the cutting tip size shown on the same line for your model of torch. . . .

(3) SET YOUR REGULATOR . . working pressures as indicated below, in pounds per square inch. . . . .

(4) TO KEEP YOUR TIPS CLEAN . . . . use tip cleaners of the correct drill size for each hole or orifice of the various tip types as shown below. . . . .

In Inches	400	300 310	219	25	Oxygen	Acetylene	Center Hole All Types	Preheating Holes for Types: AA-D	AS	SC	Others
1/16 to 1/2	0	0	0	0	10-20	3	60	73	66		63
1/8 to 3/4	1	1	1	1	15-30	3	57	72	65		62
1/4 to 2	2	2	2	2	15-50	5	54	70	64		61
1/2 to 4	3	3	3	3	20-60	5	51	68	63	66	60
2 to 6	4	4	4		30-70	5	46	66		61	59
4 to 8	5	5	5		60-80	8	42	64			58
6 to 10	6	6			70-100	8	37	61			57
8 to 12	7				100 and up	10	32	58			56
10 to 14	8				150 and up	10	30	56			55

(1) The most desirable metal thickness to be cut by any given tip size will depend partially upon the condition of the metal surface and how advanced your skill in flame cutting.

(2) Select that cutting tip size and type which gives YOU the best results. Do not use larger tip size than that recommended for your model of torch.

(3) The wide latitude of suggested Oxygen pressures for each tip size is related to the thickness to be cut. The highest pressure, of course, for the thickest metal. Here too, the oxygen pressure will depend greatly upon your skill, surface condition and type of ferrous metal to be cut, and how WELL you handle the cutting starting time.

(4) A clean cutting tip will do much better work for you than a neglected one. Suitable tip cleaners will keep your tips at top operating efficiency. Wire and make shift methods may damage the tip ports. Make your tips cut cleaner over a longer period by taking good care of them. Neglect costs money.

Courtesy National Welding Equipment Co.

Fig. 12 - Cutting Tip Selector Chart

The oxygen valve on the torch body should be opened far enough to give full oxygen pressure through the torch for cutting. This is an important point for beginners.

Adjust the pre-heating flames to neutral and try the cutting valve to see that full oxygen pressure is feeding through to the oxygen orifice in the tip. It is also important to keep the orifice clean and round. Tip cleaners of correct size should be used. Slag that sticks to the end of the tip can be loosened with a pocket knife without damaging the tip. If the flames do not burn properly, shut them off and clean the tip.

With the luminous, pre-heating cones of the cutting tip just touching the steel to be cut, heat the edge or other point where the cut is to begin. Be sure to have the torch well supported and pointed at the work. When the steel begins to melt, the cut can be started by slowly pressing down the cutting-oxygen-valve lever.

During the cut, the tip of the torch should be kept at a constant distance from the work. This will vary from 1/16 of an inch to 3/16 of an inch depending upon the thickness of the metal. This gap should not change as the torch is moved along the cutting line. The bottom of the "kerf" or cut should be kept a little ahead of the top.

It is important to move the torch at a uniform speed which is slow enough to allow the oxygen to cut all the way through. In turning off the gas at the cutting torch, the acetylene should be turned off first.

CUTTING TORCH CARE

To summarize the care of this tool, the following list has been prepared:

1. Always use a good wrench to tighten torch parts and hose connections.
2. Never use oil or grease on any parts of the torch or tanks.
3. Always check tank, hose, and torch for acetylene leaks before lighting torch.
4. Be sure all regulators are in off position before turning on the gas cylinders.
5. Hose and equipment should be kept free of oil or dirt.
6. Caution should be taken to protect hose from being cut by glass, sharp metal, or hot molten metal.
7. Keep torch in box provided for its storage.
8. Check hose for deterioration.
9. See that goggles are not broken and are clean.
10. Frequently inspect tanks for leaks and to see that pressure is maintained.
11. Care must be taken to protect the victim from the dangers of heat, smoke and burns which might be received from the flame, torch, molten metal or sparks. A fire resistant or wet blanket is very useful for protecting the victim from these dangers.

The operator of the cutting torch should wear heavy leather gloves for his own protection.

A fireman should be assigned to the job of standing by with the proper extinguisher (do not use carbon tetrachloride) or booster lines to protect exposures during cutting operations.

Overhaul should be made after the victim has been removed to make sure all fire and sparks have been extinguished.

As portable tanks will contain only enough gas to cut for a limited time, it is a good policy to have a list of owners of larger tanks that can be called upon in case they are needed for long cutting operations.

CARRIES AND DRAGS

HOW THEY ARE USED

Many times persons who have been subjected to intense heat, heavy smoke, gases, or falling materials may become injured or unconscious. Firemen should be prepared for such emergencies and know the methods for carrying or dragging such people to safety. Some of the common methods used are as follows:

Chair Carry - The chair carry is a good method for transporting a person and is even better than a stretcher in places where sharp turns must be made or where steep stairways are encountered. The chair should be tested before use to make sure it is solid and will support the victim. After the victim is placed in the chair, the man in the rear tilts the chair back to enable the man in front to get into his position easier. Carry as shown in Figure 13.

Fireman's Carry - To get the victim on the shoulder for this carry, balance and coordination of movement is very important. With this method, a fireman can raise any victim that he is able to carry. He places the victim on his back, knees up, and feet against buttocks, as shown in Figure 14a. He then grasps the

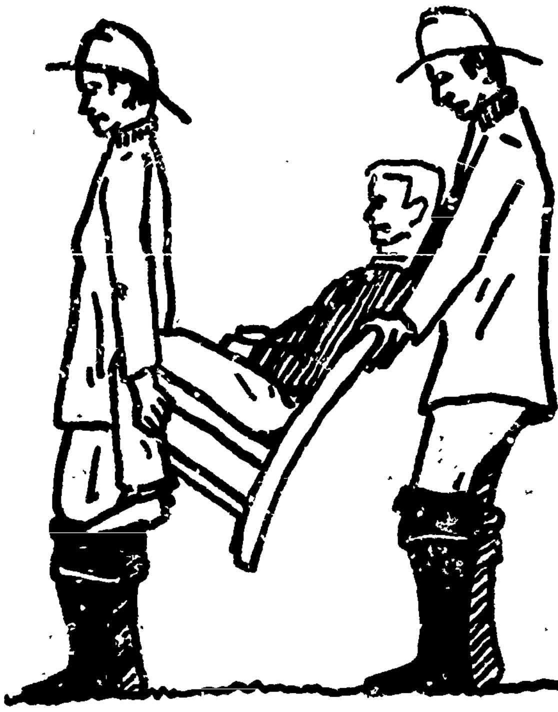
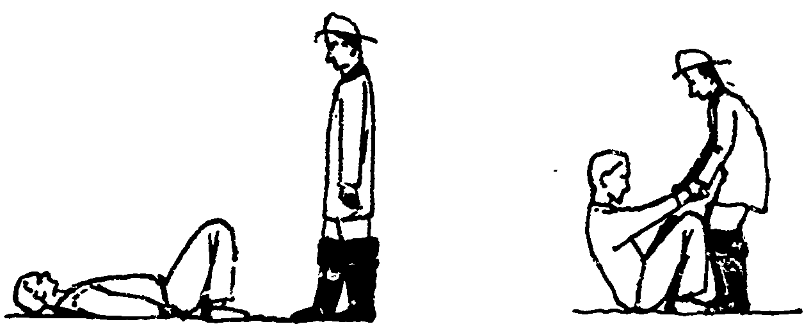
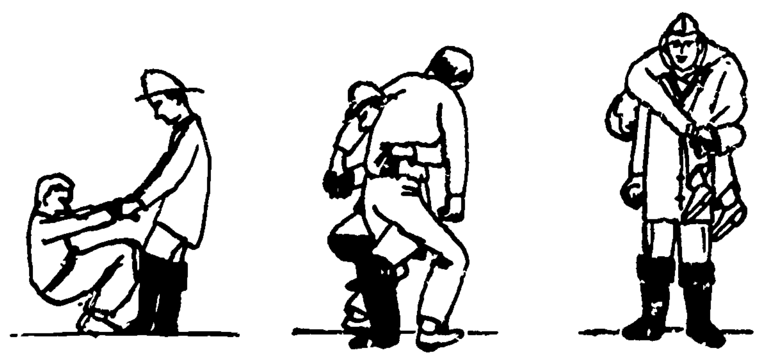


Fig. 13 - Chair Carry



14a 14b



14c 14d 14e

Fig. 14 - Fireman's Carry

victim's wrists with his palms down. See Figure 14b. The rescuer places his feet and legs against the victim's feet and legs, as shown in Figure 14c. Then, by leaning back and pulling the victim forward and up at the same time, the victim will rise and fall over the rescuer's shoulder. See Figures 14d and 14e.

Carrying in Arms - To carry a patient in the arms, lift him, if he is unconscious, to an erect position as described in the fireman's carry. Support the patient with one arm about the body. Kneel on one knee and allow him to rest on your other knee. Pass your other arm under his thighs. Roll the patient into the hollow of the elbows and rise. See Figure 15.

Fig. 15 - Carrying in Arms

Carrying Astride Back - Carrying astride the back is a comfortable one-man method of transportation, but is limited to carrying a conscious victim who can at least partially stand alone. The rescuer assists the victim to a standing position. Standing in front of the victim, he turns his back to him, taking the victim's arms over his shoulders and crossing them. He then bends forward until the victim rests on his back. He grasps each thigh, and with a humping motion, raises him well upon his back. Passing the forearms under the victim's legs, the rescuer then takes a wrist in either hand and the victim is loaded. This carry is so secure that the victim may become unconscious and yet be carried safely and easily. See Figure 16.

Fig. 16 - Carrying Astride Back

Front Piggy Back - This is a one man carry and is excellent to use to carry conscious victims. See Figure 17. To get the victim in position for this carry, face victim and place hands under his arm pits, and lift as he jumps up putting his legs around the midriff, above the hips. The victim places his arms

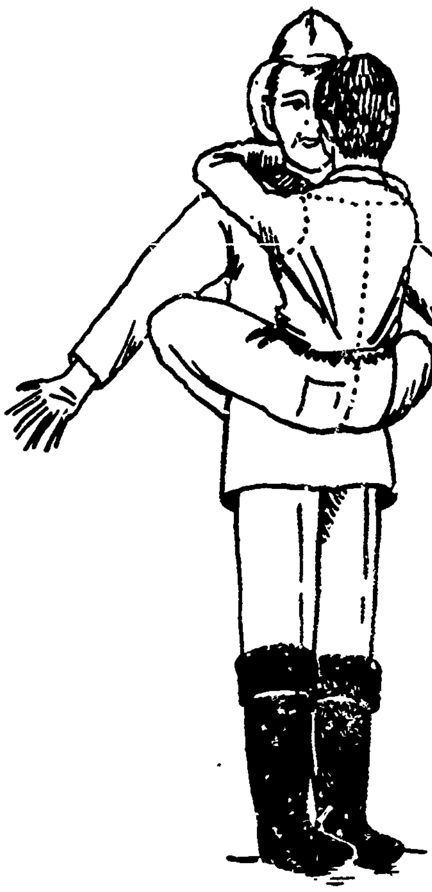
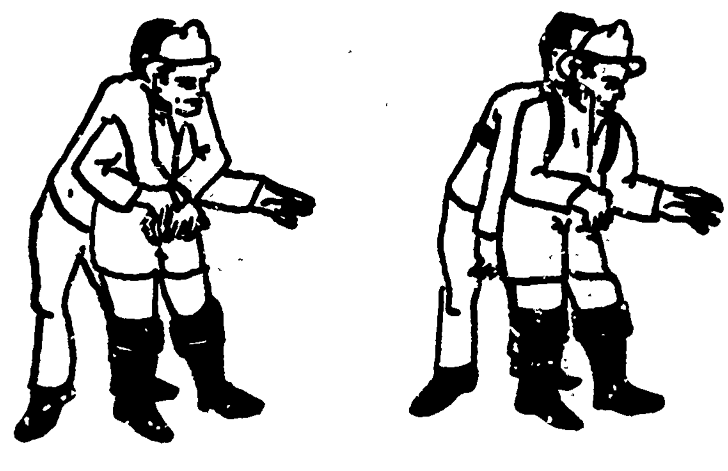


Fig. 17 - Front Piggy Back

around the rescuer's neck. The rescuer has both hands free to climb or descend a ladder, open a door, etc. In case trouble develops while descending the ladder, the rescuer can pin the victim against the ladder until help arrives or the trouble is eliminated.

Pack Strap Carry - The pack strap method is a one man carry that has two applications, one for a conscious and one for an unconscious victim. For a conscious victim, the loading is done exactly as described in the first part of the "astride back" method. See Figure 18a. When the victim is on the rescuer's back, the rescuer grasps his crossed arms at the wrists, bends forward, humping the victim well up on his back and proceeds in that manner shown in the illustration. Note that the victim's legs are dangling but that the rescuer has one hand free.

If the victim is unconscious, the loading is more difficult, likewise the carry. To make the carry, an improvised "pack strap" is used. The carry gets its name from the pack strap used. The pack strap consists of a loop of some type of material. A rope hose tool is excellent for this purpose, but a bed sheet or any other similar material may be used. The rescuer turns the victim on his back and passes the loop through, under his shoulders at the arm pits. He then places his body on that of the victim with his face up, slipping each arm through an end of the loop. The rescuer then rolls himself and the victim over, gets to his knees, then to his feet and from this squatting position rises to an erect position. See Figure 18b. Since both hands are free, the rescuer may proceed down a ladder or through difficult passages. Although the dangling legs of the victim are awkward, he cannot slip from the load. Also, the rescuer can shift the load from his back to leg muscles by bending forward.



18a 18b

Fig. 18 - Pack Strap Carry (Conscious and Unconscious)

Two Man Seat Carry - The seat carry seen in Figure 19a and 19b is a two man means of carrying an injured or unconscious person. It consists of making a seat rest of one pair of arms and a back rest of the other pair. Figure 19a shows how the arms are arranged when completed. The rescuers kneel, one on either side of the victim near the hips, and raise him to a sitting position steadying him with the arm nearest his head around his back. Each then slips the other arm under the victim's thighs, clasping the wrist of the other. Both arise slowly but in unison lifting the victim from the ground. When erect, they adjust the upper arms to form a comfortable back rest and to make the victim secure. See Figure 19b. If conscious, the victim assists the rescuers by grasping them around the necks with either or both arms.

19a 19b

Fig. 19 - Two-Man Seat Carry

Carrying By the Extremities - Carrying by the extremities is a good method of carrying but should not be used if the victim has leg or back injuries. See Figure 20. For this carry, the victim is laid straight on his back, feet apart. One rescuer takes his place between the victim's legs and the other at his head, both facing each other. The rescuer at the feet position grasps the victims wrists with the rescuers palms down and pulls the victim to a sitting position. The man at the head position assists raising the victim to the sitting position by lifting the shoulders. The man at the head position places one knee on the floor and supports the victims back with this leg, then extends his hands, with palms down, with the wrists located under the victim's armpits from back to front. The rescuer holding the victims wrists then places them in the extended hands of the other rescuer, who then grasps the victims wrists with his hands. The rescuer at the feet position turns sround facing the victims feet by kneeling on one knee and passes his hands under the victims knees from the outside. The rescuer at the head position gets into a baseball catchers position, keeping the back vertical. At the order of raise by either of the two rescuers, both rescuers rise with the victim and move forward.

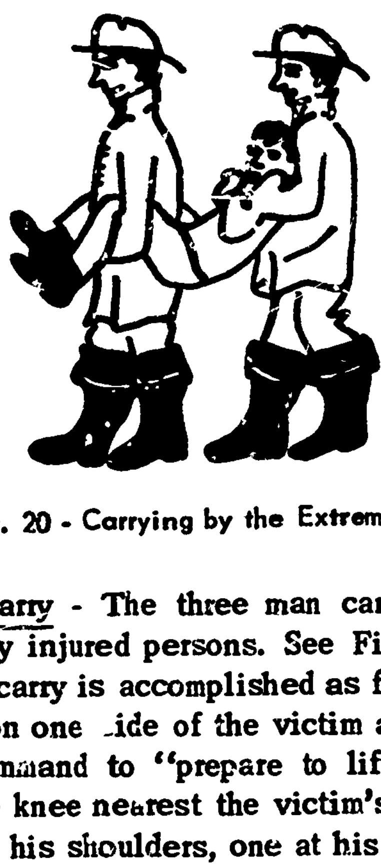
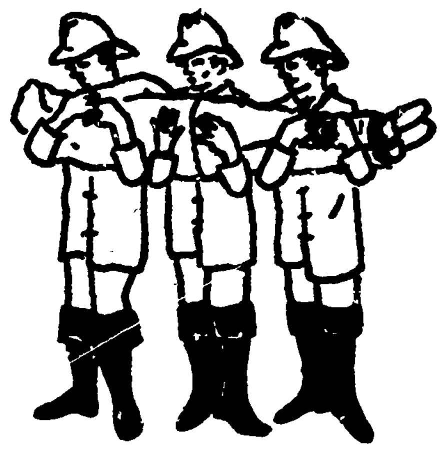


Fig. 20 - Carrying by the Extremities

Three Man Carry - The three man carry is a carry used for badly injured persons. See Figure 21a, 21b and 21c. The carry is accomplished as follows: Three men line up on one side of the victim and the leader gives the command to "prepare to lift." Each man kneels on the knee nearest the victim's feet, so that one man is at his shoulders, one at his hips, and one at his knees. Without further orders, they pass their hands and forearms under the victim, as shown in Figure 21a. The one at the head places his hands under the victim's neck and back, the second under the pelvis and hips, and the third under the knees and ankles. At the command "lift" they raise the victim and place him on their knees, but without releasing their hands. See Figure 21b.

21a

21b



21c

Fig. 21 - Three-Man Carry

At the command "prepare to raise" they slowly turn the victim on his side, toward them, until the victim rests in the bend of their elbows. At the command "rise," all rise to a standing position, holding the victim against their chests, as in Figure 21c. To move directly forward, the command "march" is given and all three step off on the left foot and continue until the command "halt" is given. To move sideways, the command "side step left - or right" is given. The rescuers step off with the foot according to the command, bringing the other foot up to it in even, short steps. The victim is then lowered by reversing the operations but always at the command of the leader.

In actual practice, however, it should not be necessary to give detailed commands. The men should be so well trained that they can move and act in unison with a minimum of commands.

Clothes Drag - When a fireman must rescue a victim that is too heavy to be carried, other means must be used to get the victim to safety. The clothes drag, Figure 22 is one method that can be used. The rescuer's hand should grasp the victim's collar with the victim's head resting on the rescuer's arm for protection.

Fig. 22 - Clothes Drag

Fireman's Drag - In making a fireman's drag, the victim's wrists are tied together with a square knot as shown in Figure 23. The rescuer then straddles the victim and passes his head between the arms, raises the victim's head and shoulders just off the floor, and then, by crawling, drags the victim out.

For descending a stairway when using the fireman's drag, the rescuer's position is reversed and he descends the stairs backwards. This prevents the victim's head from hitting the steps.

Fig. 23 - Fireman's Drag

The Blanket Drag - The blanket drag can be used in place of the clothes drag when the victim is nude or the clothing being worn is too flimsy to be used to drag the victim. Place a blanket on the floor and roll victim onto the blanket. The victim can then be removed to safety as shown in Figure 24.

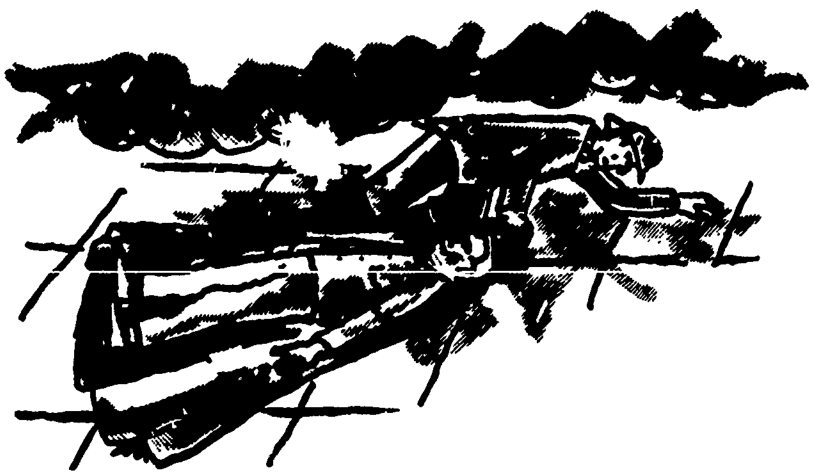


Fig. 24 - Blanket Drag

LADDER RESCUES

SLIDING AN UNCONSCIOUS VICTIM DOWN A LADDER

Generally, this evolution, illustrated in Figure 25, is started from a crotch hold position. The rescuer unlocks his own leg, works up until his arms are beneath the victim's armpits, grasps the rungs in front of the victim's face, while the rescuer's knee is beneath the victim's crotch. The victim's feet are positioned outside the beams and he is slowly slid down the ladder. The rescuer should be backed up by an extra man.

WALKING A VICTIM DOWN A LADDER

As shown in Figure 26, this evolution is executed by taking a position immediately behind and parallel to the victim, but one rung below him. Place the arms around the victim's body below the armpits and grasp a rung. Using one rung at a time, descend slowly. As a precautionary measure the rescuer should keep one knee between the victim's legs to prevent him from sliding through.

WALKING A WOMAN OR CHILD DOWN A LADDER

This evolution differs from the preceding method because the knee of the rescuer is not placed between the legs of the woman or child. The rescuer's arms are placed around the person's body below the armpits and the rescuer grasps the rung immediately below the rung the person is grasping. Come down slowly, descending one rung at a time.

SLIDING A VICTIM DOWN A LADDER ACROSS ARMS

The rescuer who is to slide the victim down the ladder stands on the ladder just below the door,

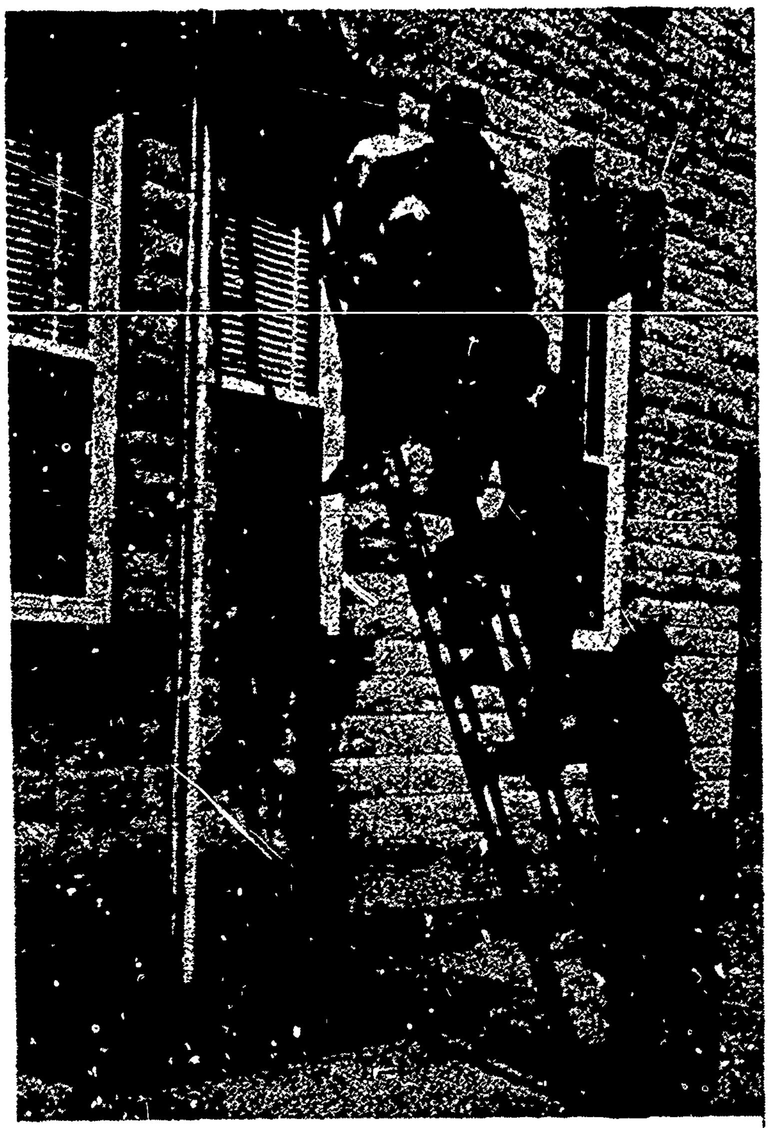


Fig. 25 - Sliding an Unconscious Victim Down a Ladder

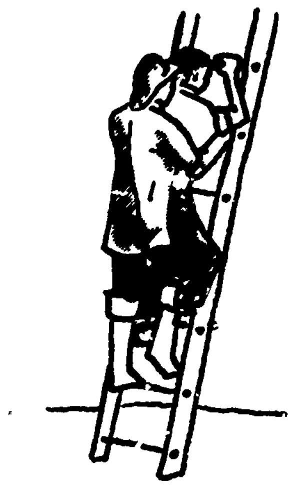


Fig. 26 - Walking a Victim Down a Ladder

window, or roof, grasping the ladder with both hands on the underside of the beams. The other rescuer places the victim across the first rescuer's arms, as shown in Figure 27. The first rescuer then descends the ladder one step at a time with the victim's buttocks resting on each rung of the ladder during descent. The rescuer's hands are slid along the underside of the beam. The rescuer on the ladder should be backed up by an extra man. See Figure 27b.

Figure 28 shows proper way to walk a victim down an aerial ladder.

27a

27b

Fig. 27 - Sliding a Victim Down a Ladder Across Arms

CARE OF VICTIMS AFTER RESCUE

Care should be taken to prevent persons who have escaped from a burning building from re-entering to obtain clothing or other possessions left in the building if the conditions are such as to endanger their

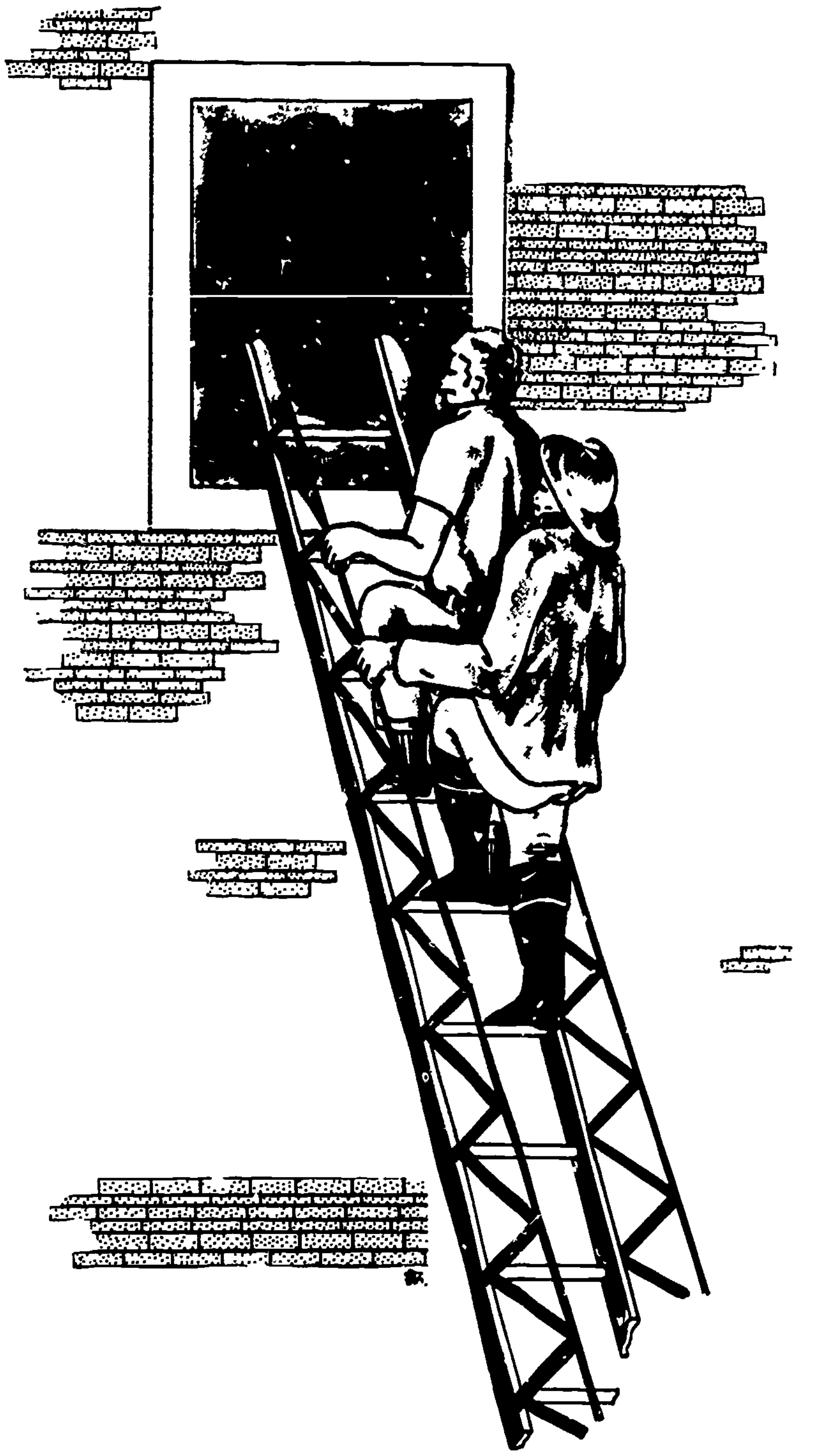


Fig. 28 - Walking a Victim Down an Aerial Ladder

lives or interfere with fire fighting operations. Many times, rescue is a difficult and dangerous operation even for trained and experienced firemen. Therefore, care must be exercised by firemen to prevent untrained persons from exposing themselves to unnecessary danger.

The duty of the fire department does not always end after persons are brought to a place of safety. Infants, children, the sick and the aged all need care and supervision after being brought to safety.

CARE OF INFANTS

When infants are subjected to a sudden drop in temperature after being removed from a heated building, they are liable to incur pneumonia or some other illness. The rescuer should protect them by being sure that they are properly covered and their face protected. They should, if possible, be delivered to some competent person who will see that proper care is given to them.

CARE OF CHILDREN

If left on their own, children may wander around the fire area and become injured. They may even re-enter the burning building seeking a toy or something left behind. For these reasons, they should always be placed in the custody of a competent person who will give them proper care and protection.

CARE OF THE SICK

People taken from a sick bed may suffer a relapse causing the illness to become worse. If the illness is not contagious, refuge for them may be found in a neighbor's home. If the sickness is contagious, provisions must be made as soon as possible to have the patient sent to a hospital. A heated garage may provide temporary shelter but attendance and care must be given to the patient until removed to the hospital. As a precaution, as few firemen as are absolutely necessary should expose themselves to a contagious disease. Those firemen that were exposed should receive a doctor's attention and their clothing should be treated to prevent the spread of the disease. Since all hospitals will not admit contagious cases, the department should prepare itself for this emergency by listing hospitals or agencies that will accept such cases.

CARE OF THE AGED

On many occasions, aged people have lost their lives after being taken to safety. Not realizing the danger, they re-entered the involved building for their possessions which might have been only a picture, the contents of a dresser drawer or some other object they have had for a long period of time. If possible, firemen should bring these cherished objects out with the person. In every case, however, after rescue the person should be placed in the custody of competent persons.

It should also be remembered by the department officers that rescue work at fires may delay extinguishment practices. Men diverted to rescue work are a drain upon the manpower. Officers should be alert in these cases and if necessary make additional calls for aid. If in such cases there is a mutual aid plan, it should be immediately put into operation.

ADMINISTRATION OF OXYGEN

The subject of first aid is so vitally important that it is usually considered a course in itself. Consequently, it should be thoroughly understood by all fire fighting personnel that their knowledge may mean the difference between life and death to the persons rescued.

The ability to administer first aid to the victims that have been overcome by smoke and gases is most essential and all personnel should be thoroughly acquainted with an approved method of artificial respiration.

Fire department personnel should also be trained in the use of the respiratory equipment that is carried on the apparatus. There are quite a number of manufacturers that produce various types of this equipment. Some of these are completely automatic and require no manual assistance of any kind in their operation whereas other types are used in conjunction with artificial respiration. Whatever type of equipment is used, the manufacturer's instruction manual should be closely followed and the entire department thoroughly familiar with all the phases of operation in order to render efficient service. Figure 29 illustrates one model of respiratory equipment.

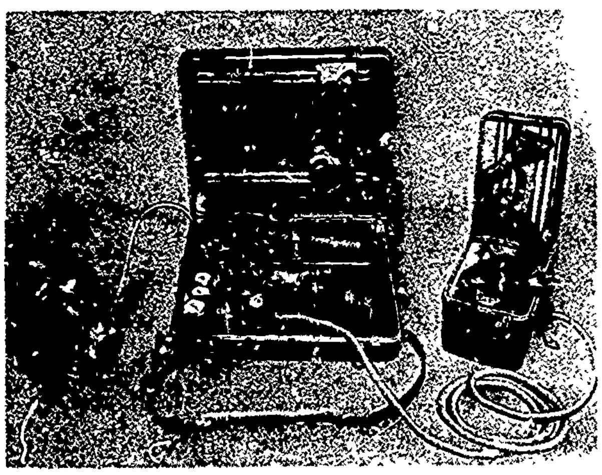


Fig. 29 - Respirator Equipment

ROPE SLIDE

On some occasions ladders or other tools are not available and the fireman must use a rope slide to save himself and/or the victim.

PLACING THE SLIDING ROPE IN SERVICE

The rope is either carried to the roof or upper story of a building or pulled up with the aid of a small line such as used on the life gun which shoots the line to the upper story or roof.

Fasten one end of the sliding rope to some solid object within the building or on the roof. It should be tied at the same level as the edge of the roof or window sill over which it is passing and directly above the center of the window from which the slide is to be made. Place a pad such as a coat under the rope where it passes over these edges to prevent damage to the rope. Be positive that the sliding rope is long enough to reach the ground or a place of safety. The following method is used to slide the rope with the hands and feet.

1. Stand erect in window if possible.

2. Grasp the rope with both hands high above the head and pull down on rope. This will test the rope and take the slack and stretch out of it.

3. Still pulling downward with the hands and with the lower part of the rope hanging down in front of the body between the legs, pass the right leg forward on the right side of the rope, backward on the left side of the rope, and forward on the right side again, far enough that the rope is hanging down on the inside of the instep of the right foot. See Figure 30a.

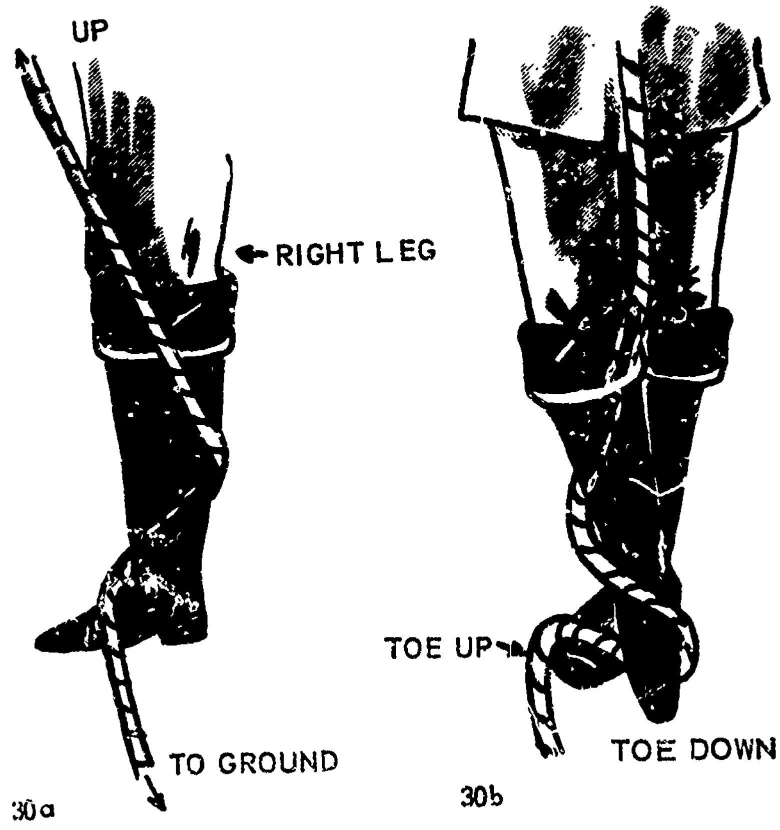


Fig. 30 - Foot Positions on Sliding Rope

4. Extend the right leg out of the window just below the sill and suspend the full body weight with the hands and at the same time pass the left foot under the right foot and press it tightly to the outside of the right foot. Elevate toes of the left foot and lower toes of the right foot. See Figure 30b.

5. By pressing the feet together enough friction is created to hold a man stationary. By releasing the pressure slightly he can slide slowly and safely down the rope. Do not slide hands on rope but use hand over hand method. If the rope slips out from between the feet while sliding, suspend the body by the hands and work the rope back to proper position with the feet.

6. When getting on a sliding rope from the level where the rope is secured, as from a roof top, grasp the rope with both hands and lie on the stomach, over the rope, with the lower part of the body hanging down over the roof ledge. Work the rope into position as shown in Figure 30b and then lower yourself over the edge with the hands until you are in proper position for the slide.

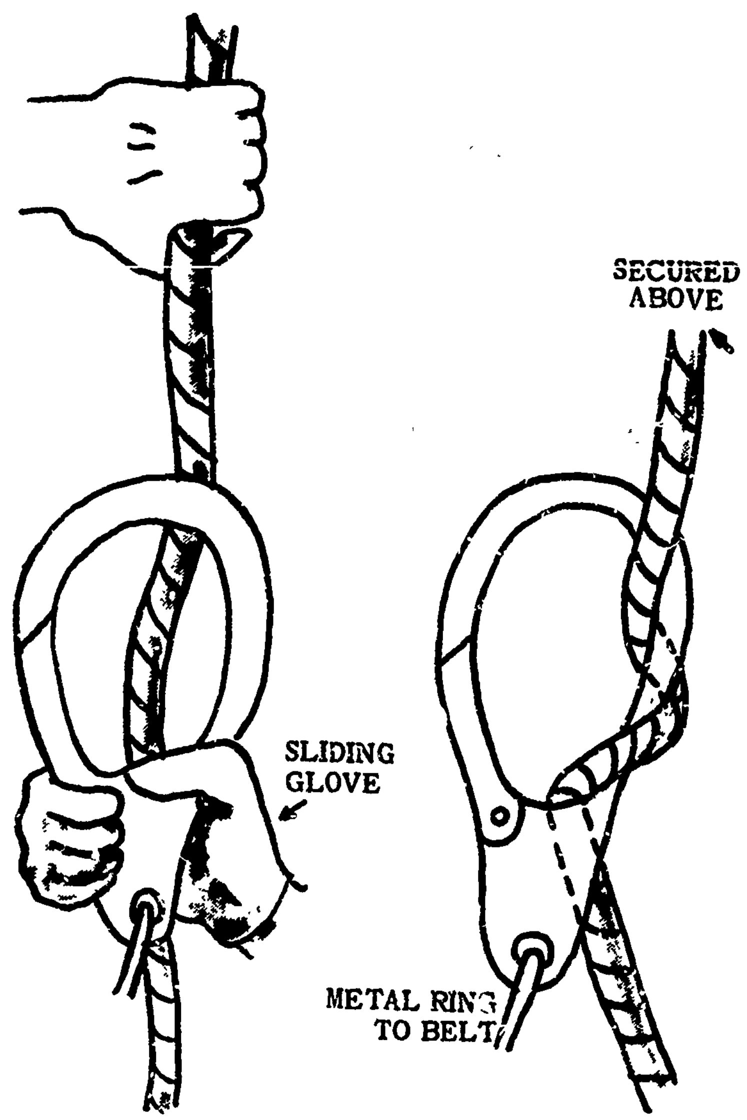


Fig. 31 - One-Man Slide

TO SLIDE ROPE WITH A LIFE BELT – ONE MAN

Strap a life belt snugly about the waist (not so tight as to cause discomfort) with the buckles on the left side and the hook hanging directly in front. Put a leather sliding glove on the right hand. Stand erect in the window, facing the outside. Grasp the sliding rope with both hands, above the head, and pull down hard to test the rope for security and to take out some of the stretch.

Reach down with the gloved hand (right) and take hold of the rope just above the knees and raise it to about the level of the waist to give enough slack to work with. Hold the rope in the palm of the right hand, thumb up. Raise the life belt hook with the left hand so that it is pointing upward. Still holding the rope in the palm, grasp the base of the hook with the right hand and hold them firmly together just above the waist. The hinged or opening part of the hook should be on the left. Grasp the rope a bit above the hook with the left hand, thumb pointing down. See Figure 31a.

Looking at the left hand from underneath, wrap the rope clockwise one and a half turns around the hook, forcing the rope to the inside of the hook through the hinged part each time. The rope will be entwined one complete turn about the hook on its right side. See Figure 31b.

Hold the left side of the hook with the left hand and with the right hand on the rope below the hook, pull the rope through until all the slack is out of the rope above.

Grasp the rope with the gloved right hand, thumb up; straighten the right arm and move it around to the rear of the body and hold the hand (thumb side toward the body) pressed firmly against the center of the buttocks. Have the rope gripped tightly and pulled taut around the right hip.

Remove the left hand from the hook. Bend slightly at the knees and allow the rope to suspend part of the body weight. Turn to the right until the back is to the outside and at the same time ease down until the body is suspended entirely by the rope and the legs are holding the body out from the building with the feet resting against the edge of the sill.

When ready to descend, kick out away from the building slightly and ease the right hand grip on the rope just enough to allow the rope to slide through

the hand. The speed of descent is controlled by the amount of friction created by the right hand grip. To slow up or stop sliding it is only necessary to grip the rope more tightly.

During the slide keep facing the building. Keep the left hand off the rope and hook. Use the left hand and the feet to keep from striking the building during the descent. It may be necessary to kick out from the building several times on the way down, depending on the length of the slide and speed of descent.

Should the right hand become dislodged from its position in the rear of the body and be pulled up to or near the hook, stop at the most convenient place such as the next lower sill and work it back into position.

When the ground is reached, bend at the knees and allow the hook to slide down the rope as low as possible; then stand erect. By holding the hinged part of the hook open with the right hand, the rope is removed from the hook with the left hand, in reverse of the manner of putting it on.

Not more than one sliding life belt can be in use on one rope at one time.

TO SLIDE ROPE WITH A LIFE BELT – TWO MEN

Although no more than one life belt can be in use on the rope at one time, it is possible for two men to descend the rope at the same time. This is performed as follows:

They can both start the slide from the same window, or one man can start from above and pick the other man up at a lower level.

If both men are to slide from the same window, the first man puts the rope on his hook and gets into position with his back towards the outside and his feet holding himself out away from the building the same as in the one man slide except that he wraps the rope two and a half turns around the hook instead of one and a half. See Figure 32. This extra turn is necessary to create enough friction for the added weight of the second man.

When the first man is in position the second man sits on the sill with his legs out the window and between the legs of the first man.

The second man holds onto the first man's belt toward the front with his left hand and with his right hand he snaps his own life belt hook into the ring at the base of the first man's hook. Then he holds onto the first man's belt with his right hand and holds his head and shoulders in close to the first man's waist.

He then eases himself out the window, off the sill, until he is entirely suspended by his hook from the first man.

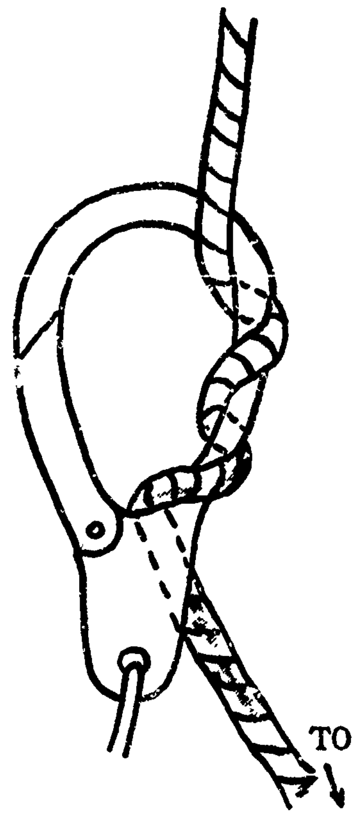


Fig. 32 - Two-Man Slide

As he eases himself out off the sill, the first man kicks out away from the building and they descend to the ground in the same manner as in the one man slide. The second man may also assist in protecting themselves from striking the building during descent if necessary.

If the first man is to pick the second man up at a lower window, he gets on the rope and slides down to that window the same as in the one man slide. He stands erect in that window, facing the outside, gets the necessary slack in the rope, places the extra turn around the hook, and takes the position with his back to the outside again. The second man then hooks onto the first man as previously mentioned and they descend to the ground.

Upon reaching the ground the second man unhooks from the first man; then the first man stands erect and removes the rope from his hook.

A 5/8" cotton braided rope is recommended for this evolution.

ELECTRICAL RESCUE

A fireman is not presumed to be an electrician nor an electrical lineman but his duties make it necessary for him to face situations in which electrical equipment or wiring is involved. It is therefore desirable that he be able to recognize electrical hazards and to know the proper action to be taken.

Saving of property alone never justifies the risk of a man's life. But, where life is involved, the urgency is greater and necessity prompts the fireman to act in the face of great danger. In cases of this

sort, the fireman should *think* before he acts. Moreover, unless he *knows* what he is doing, he should seek the assistance of a qualified person.

The use of electrical power has become so common in modern life that it would be difficult to find a city, town or village in which facilities for supplying electricity are not present in almost every part of the community. Fire department personnel can be aided in dealing with the hazards involved if they are familiar with certain procedures of handling electrical equipment and wiring.

The information contained in this section is merely suggestive. It is predicated upon the assumption that it is the responsibility of the head of the department to consult with the appropriate officials of the power company to the end that there will be a common understanding of the procedures to be followed in case of an emergency involving the power company's property and equipment or any other property where electrical equipment or wiring is concerned. Firemen and all local power company employees who are subject to call when an emergency occurs should be thoroughly familiar with whatever procedure has been mutually approved.

In many cities, a power company unit responds to each emergency where there may be electrical hazards. Regardless of this policy, calling the power company immediately is a must for any emergency involving electrical hazards existing within its area. It is essential that firemen requesting assistance from the power company clearly inform the receiver of the call of the electrical equipment involved, such as transformer, overhead wires, underground cables, etc., and where it is located in order to facilitate a better service through greater cooperation.

WIRES DOWN

If the wires are down on arrival at an emergency, proceed as follows:

Send someone to notify the power company while you move the crowd back from the danger zone (at least one span each way from the break or the sagging wire). This is necessary because:

1. The spans of wire adjacent to the trouble may have been weakened.

2. Any movement of the wires in trouble, caused by wind or rescue work, may burn other wires down.

3. Wires on the ground may burn off at some point and the ends may curl up, roll along the ground, and cause injury to someone.

4. Burns, electric shocks, or eye injuries from electrical flashes may occur even though a person is not in direct contact with the wires; therefore, do not permit anyone to stand near these wires.

Voltage is the amount of pressure applied to cause the current or amperes to flow. It is actually that amount of current or amperage that is caused to flow through a person's body that is dangerous. Under some circumstances a very low voltage can cause enough current to flow through a person's body to bring about serious injury or death. This is particularly true if the person is standing on the ground or on a well grounded structure. The flow of current is from the wire to the ground. Anything or anyone within this path will be subject to becoming the conductor for the current from the point of contact with the wire or electrically charged object to the point of contact on the ground.

In the case of a car or truck, the rubber tires may insulate the vehicle from the ground so that the vehicle itself may be charged though there will be no current flowing from the vehicle to the ground. In such cases, passengers in the vehicle would be relatively safe if they remained inside. A person touching the vehicle while standing on the ground would complete the circuit from the vehicle to the ground, creating a path of current flow through his body, which may prove to be fatal.

An example is that of a woman whose car became energized from a fallen wire as the result of hitting a light pole. In her fright, she jumped out of the car. After moving away from the car, she realized she had left her purse in the seat of the car. She returned to the car and upon touching the door was instantly electrocuted.

If, by accident, either metal or wood aerial ladders come in contact with overhead electric wires, or should these wires fall across the apparatus, a person will be relatively safe providing he *does not* make contact with the apparatus and the ground at the same time. If the equipment is believed to be in contact with a live wire, and you must get off, *don't step off – jump off,* making certain that both hands and feet are clear of the apparatus when contact is made with the ground.

The hazards created by fallen, energized overhead wires are extremely dangerous to those who are inexperienced in the action of wires which are under the stress of a ground or short circuit (all wires are potentially dangerous). Wires lying on the ground may be de-energized one moment and energized the next. When energized, conductors may whip around.

Most power systems make use of automatic equipment to protect the system from surges and grounds. These devices open the circuit when overloaded or

shorted and then in a matter of seconds automatically close the circuit. The setting on this equipment may vary from *one to four seconds.*

In the case of distribution or transmission wires, it must be remembered that they may energize the ground for a considerable area around the point which they contact. This means that it may be dangerous to even approach the wire. It is impossible to give specific rules or distances since the danger area will vary with ground conditions and voltages involved. In general, the hazard is much greater during damp or rainy weather.

Energized wires lying on the ground or across a vehicle may show no evidence of being live yet touching the wire or the vehicle may be fatal. The only completely safe thing to do with fallen wires is to stay clear of them and call the power company. In some cases, however, waiting for the power company crew may mean the difference between life and death. Therefore, it is essential for fire department personnel to have a reasonable working knowledge of electrical hazards and emergency situations that may confront them in each community they serve. It must be remembered that if an electric wire should fall across a fence or telephone wire, it is as dangerous as the live wire itself and the same precautions should be considered.

A METHOD OF HANDLING ENERGIZED WIRES

If, from a reasonable distance, a rope is thrown over wires carrying high voltages, the person throwing it will not be harmed if the rope is dry but if the rope is wet when placed in contact with these wires, the result may be a shock to the man which can be fatal.

In cases where it is necessary to remove a wire from a victim, the rope and weight device pictured in Figure 33 can provide a means to safely handle wires in any weather, providing the men using it are thoroughly trained in its use. It is through the efficiency of the person performing this operation of throwing the weights that the desired results will be obtained, making it possible to pick up a live wire with a large degree of safety regardless of the position in which it falls. The fact that the ground may become energized for some distance around the fallen conductor must always be kept in mind.

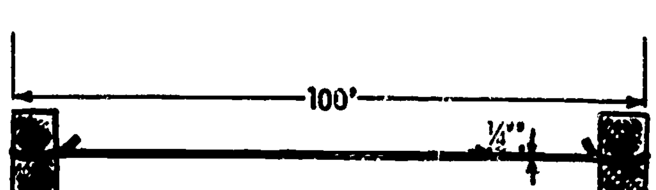


Fig. 33 - Rope and Weight Device

To describe this rope tool, a weight, weighing approximately one half pound, is attached to each end of a one hundred foot, one quarter inch rope. The rope must be free of any metallic substance to be used safely. Any fire department can make this device for little cost and it is recommended that one be in service on each unit in operation. Firemen should be trained in the use of this tool. Only practice can make them proficient in safely handling live wires in this manner.

With this method, a fireman can gain control of a fallen wire without getting near the wire or contacting the rope after it is touching the wire except with approved and adequate insulating equipment. This is done by the use of a pair of approved lineman's rubber gloves and a lineman's clamp stick tested for use on high voltage. With this equipment the wire may be moved as follows:

1. Clear all persons out of the danger area.
2. Put on lineman's rubber gloves.
3. Stand opposite the point to which you want to move the wire and approximately thirty feet from the wire.
4. Toss one end of the weighted rope under the wire to a point nearly equal to your distance from the wire on the other side.
5. Toss the other end over the wire so as to land near the first weight thrown.
6. Pick the two weighted ends up with the clamp stick and back away, dragging the wire out of the way. Do not pull the wire toward yourself, hand-over-hand. Be sure to post a guard who will keep all persons out of the danger area.

It must be remembered that any fallen wire is dangerous and can mean instant death to the poorly trained fireman. However, when a human life is involved, fire department personnel will have to take immediate action to rescue the victim and in such situations the action taken will be based on past experiences and training. Here, every second counts but caution must be used to prevent the seriousness of the original emergency being increased by the careless action of a fireman or nearby person.

REMOVING VICTIM FROM WIRE

When a person is found lying on an energized wire

and the wire is not entangled around his body, a quick method to remove this person from the wire is to make use of a "hot-stick" to push or pull the victim from the wire. The hot-stick, is a specially designed tool used principally by electric company linemen to manipulate energized conductors into a desired position. They are specially treated by the manufacturer to prevent moisture from penetrating the wood and should be kept in a compartment or other container that will prevent damage to the stick while in storage on the apparatus. They should be regularly inspected by a qualified person, even if they have not been used since the last inspection. A person may receive additional burns while being removed from an energized line, but this is not as serious as having him remain in contact with the energized conductor. While performing this operation, the rescuer should stay as far away from the victim or the wire as the hot-stick will permit. If additional help and another hot-stick is available, it may be used as an additional aid in the rescue operation. This may be by holding the live wire in its original position while the victim is being moved from contact with the wire. This additional aid can also prevent the end of a live wire from whipping in a way similar to that of a loose garden hose that is squirting water from an open nozzle. Also, by keeping the wire in contact with the ground, the exposure of a victim to additional shock and burn is kept to a minimum.

In cases where hot-sticks are not available, an alternate procedure may be used.

This alternate procedure is accomplished by the use of a long, dry rope (of a type referred to in Figure 33) to loop around some part of the victim's body in such a way that would permit dragging the victim from the danger area. This procedure may require the fireman to perform the rescue operation from a position much closer to the victim and/or to the wire than the maximum distance allowable when hot-sticks are employed. Here the rescue worker must perform this act, taking all necessary precautions to prevent his own body or clothing from making contact with the victim's body or clothing or the wire itself. These precautions are necessary until the victim has been removed from the danger area. Bystanders should be ordered to remain a minimum of at least one hundred feet from the victim. This will prevent them from coming into contact with anything which may be energized, thus eliminating the possibility of additional victims.

In such cases where artificial respiration is required, it should be started immediately after the victim has been released from contact with the wire. Resuscitation should continue until the victim has recovered or until a member of the medical profession has pronounced him dead. The treatment of any burns from electric shock should be the same as that described for any burn case.

RADIATION RESCUE

The atomic age promises many benefits to man, but with these benefits come added responsibilities and dangers to the fire service -- namely, to protect the public and firemen from the dangers of radiation and contamination. More information on this subject will be found in Chapter 26.

In case of an emergency where radioactive material is present, the victim must be removed from the area with as little contact with the rescuer as possible. The rescuer may use the clothes drag, a pike pole, or a rope effectively to remove the victim to a safe place. He should take any necessary measures to save life, but carry out a minimum amount of first aid until a doctor can be called to the scene. A fireman's protection against radiation is time, distance, shielding and gas masks.

CHAPTER 17

EXPOSURES AND CONFINEMENT

INTRODUCTION

This chapter will cover the various problems dealing with exposures and confinement principles for the effective extinguishment of fire. Every fire the fireman encounters presents an exposure hazard. Exposure, as used in the fire service, means any building or material that is likely to become involved either directly or indirectly with the existing fire. There are two types of exposure hazards, interior and exterior. The study of exposure covers the work that is necessary to prevent the extension of fire to other parts of the involved building or other buildings or property. Confinement of fire is the action which is necessary to limit the fire to the smallest area possible. In many instances the covering of exposures and the confinement of the fire are accomplished simultaneously.

EXPOSURES

WAYS IN WHICH HEAT MAY BE TRANSMITTED

Direct contact with flame is not the only means by which fire may spread. There are three ways that heat may be carried to exposed material, thus causing the spreading of fire. These are conduction, radiation, and convection. An explanation and application of these follow:

Conduction - Conduction is the process of the transmission of heat within a material from one particle to another or from one material to another which is in contact with it, without any visible motion of the material. To illustrate: If a small ¼ inch iron rod is held in a flame, the other end of the rod will, within a very short time, become too hot to hold in the hands. For this same reason it is possible for a fire to start on the opposite side of a brick wall by conduction from the original fire, either through conduction of heat by the brick wall to a combustible material in contact with the wall, or by means of the heat passing along iron pipes, ducts, or drive shafts which extend through the wall. Fires are frequently started in the floor material on upper floors by conduction. Steel I-beams, iron doors, and other metal materials will at times cause fires to extend to other areas due to conduction of heat.

The possibility of fires extending by conduction is the principle reason why building codes require open air space between heating devices and combustible materials.

Metals are, of course, the best conductors of heat, but other materials also conduct heat as shown in the table to follow.

GOOD CONDUCTORS	MEDIUM CONDUCTORS	POOR CONDUCTORS
Silver	Granite	Wood
Copper	Limestone	Asbestos paper
Aluminum	Concrete	Sawdust
Brass	Brick	Paper
Zink	Glass	Linen
Tin	Water	Cotton
Iron	Plaster	Silk
Lead		Wool
		Air

Radiation - Heat radiation is the transmission of heat from one object to another by heat waves or rays. The rays travel through space in a straight line away from the heat giving object. These heat waves are constantly passing into space as radiant energy. This radiant energy becomes heat only when it is absorbed by bodies upon which it falls. These heat waves or rays passing from a hot object are generally referred to as radiant heat.

All bodies do not equally absorb radiant heat. Some, because of their condition, reflect this heat. A light colored object will reflect heat, while a dark object absorbs it. The most common source of radiant heat is the sun. While exposed to the direct rays from the sun, an object will receive the full strength of its radiant heat. If it is placed in the shade, it will be shielded, and whatever object has furnished the shade will either absorb or reflect the direct rays

and give protection to the shaded object. This same principle applies to the spreading of fires by radiation. Whenever combustible material is exposed to the direct rays from a fire, the radiant energy passes from the fire to the material, and when the material reaches its "burning temperature" it will burst into flame. If, however, some insulating substance, such as water, serves as a shield between the fire and the exposed material, the material will not become hot enough to burn. Firemen accomplish this with fire streams. The water not only absorbs the radiant heat but also furnishes the exposed material with a protective covering of moisture that must vaporize before the radiant heat can raise the object to its burning temperature.

Convection - Convection, as it applies to the fire service, is the transmission of heat by the movement of heated gases. In the process of convection, the heated gases from a burning substance *move* forming a current.

The most common fires caused by convection currents are those caused by the passage of heated gases to upper floors of buildings from a fire on the lower floor and the passage of heated gases and embers from one burning building to another building.

Firemen should be acquainted with convection currents as a cause of fire spread. It is the presence of convection currents of heated gases that creates the possibility of "back draft" and/or "mushrooming" of fire within a burning building and also the pre-heating of a building within the path of conflagrations.

The hot, expanded gases that have become proportionately lighter will rise within a building giving off their heat to all the objects with which they come into contact. This rise of hot gases will continue vertically through all openings that will permit their passage, such as stairways, elevator shafts, dumb waiters, non-fire stopped studding spaces, light wells, chutes, pipe holes, etc., until they are arrested. They will then build downward and/or spread horizontally.

All combustible material that has come in contact with the heated gases will be heated. However, there will be no flame or fire due to the fact that one of the factors for combustion, namely oxygen, will be absent.

The admission of air containing oxygen would cause these heated combustible gases or the heated combustible material to burn rapidly. The rapidity of this burning may cause a "back draft". Convection currents are a common means of upward spread of fire, involving entire buildings. In many instances, they will miss or bypass a story and cause fire on one that is higher, such as a fire in an attic, extended from a fire in the basement.

In some instances, the upward surge of the heated gases will continue straight up into the air until they have dissipated their heat. However, if a strong wind is blowing, these very hot gases may be deflected back to earth, still retaining their heat. The distance of travel of convected heat from the original fire depends upon the amount of heat generated and the velocity of the wind. In conflagrations such as large lumber yard fires, where considerable material is burning, convected heat may start fires several hundred feet distant from the original fire due to the heat concentration. The burning embers carried in the upward surge of the heated gases may be carried by the wind and fall on other combustible materials.

Most firemen can recall instances where fire has spread to brush, trees, or buildings leaving untouched material in the intervening area. An example of this is the East Ohio Gas Company conflagration that occurred in Cleveland, Ohio. In this fire the heat and gas traveled over and around many buildings, in some instances skipping two or three buildings and in other instances just scorching other buildings in its course of travel.

How Fire May Extend - It is important for every fireman to know how fires extend from room to room, floor to floor, and building to building. The following outline lists some of the ways fires extend:

1. From room to room on the same floor

   a. Through unprotected horizontal openings, such as are provided for doors, transoms, interior windows, hallways, pipeways, and beltways

   b. By convection of heated air, smoke and gases

   c. By explosion or flash burning of smoke and gases

   d. By fire entering concealed spaces and extending to other rooms

   e. By conduction of heat through such mediums as unprotected steel beams, pipes and air ducts which extend from the involved room to other rooms.

   f. By ignition of combustible materials which are too close to walls or unprotected openings.

   g. By burning through interior walls.

2. From floor to floor in the upward extension

   a. Through unprotected floor openings such as are provided for stairways, elevator shafts, ventilation shafts, lightwells, dumb-waiter shafts, and beltways

   b. By convection of heated air, smoke and gases

   c. By explosion or flash burning of smoke and gases

   d. By conduction of heat through such mediums as unprotected steel supports, pipes and air ducts which extend from floor to floor

   e. Through partitions or concealed spaces which extend to upper floors

   f. By burning through exterior windows and entering upper floors through unprotected openings

   g. By ignition of combustible materials which are too close to unprotected openings

3. From floor to floor in the downward extension

   a. By explosion or flash burning of smoke and gases

   b. By "mushrooming" of heated air, smoke and gases to lower floor

   c. By sparks and burning material falling through unprotected openings such as those provided for stairways, elevator shafts, ventilation shafts, lightwells, dumb-waiter shafts, beltways, and wall partitions

   d. By burning down the inside of unprotected shafts

   e. By conduction of heat through such mediums as unprotected steel supports, pipes, and air ducts which may extend from floor to floor

   f. By collapse of roof or floors

   g. By burning through floors

4. From building to building where one is adjoining or built solidly against the other

   a. Through unprotected wall openings, such as doors, windows, holes, etc.

   b. From cornice to cornice

   c. By flashing over or around parapets and igniting roofs, etc.

   d. Through falling walls, floors, or roofs, causing the scattering of burning materials

   e. Through holes in walls where timbers have been built in

   f. Because of failure of protective devices, such as fire doors, walls, etc.

5. From a building to a building not adjoining

   a. Through combustible exterior walls, etc.

   b. From overhanging roofs

   c. By flying embers and brands

   d. Through unprotected wall openings

   e. By transmission of heat through plain or wired glass, iron doors, etc.

   f. By convection of superheated air, smoke and gases

HOW TO PREVENT THE EXTENSION OF FIRE

It is always the aim and intention of all fire departments to prevent fire from spreading. This may be accomplished in several ways. One way is by quick extinguishment of the fire before the heat generated can be transmitted to exposed combustible material causing the fire to spread. The success attained, however, is dependent upon how far the fire has progressed, the rapidity of the burning, the natural barriers to prevent spread, and the ability of the department and available equipment for quick extinguishment. Another way is by protecting the combustible material exposed to heat generated by the original fire. This protection is generally accomplished by the use of fire streams. For example, the entire personnel and equipment of the first company arriving at the fire may use their entire fire stream

power to prevent the upward spread of fire, the spread from section to section of the involved building, or the spread from building to building until additional apparatus and men respond to combat the original fire.

In another case, a group of farm buildings is involved in fire. In the absence of a water system, pond, or other water source, the responding apparatus, having just a booster tank of water, may use this small amount of water not on the original fire but in "wetting down" the surrounding buildings in order to prevent the fire from extending to one or more of the other buildings.

The ideal situation, of course, is to have sufficient equipment, personnel, and water supply in order that a number of lines of hose can be laid so as to wet down the exposures and extinguish the original fire at the same time.

EXPOSURE PROTECTION

There are many protective devices that may be employed to prevent the spread of fire. These devices may already be a part of modern constructed buildings, or they may be installed in older buildings. In order to be efficient, however, these devices must be in operation at all times, or so constructed that they will give protection automatically when needed. Some of these devices give protection from fire spread within buildings; others prevent the spread from building to building. These are listed as follows:

Fire Resistive Construction - The methods and materials used in present day building construction have done much to lower the amount of life and property damage caused by fire. It is still possible, however, with the new construction, to suffer a heavy loss to both the property and its content.

During the past few years many cities and communities have formulated and passed building codes covering the construction of all types of buildings. In preparing the codes three basic features of construction have been proposed in order to limit the spread of fire in the event it occurs. These features are as follows:

1. That the materials used in construction be of a non-combustible nature, thus preventing the spread of fire

2. That partitions, doors, stair wells, elevator shafts and any other openings in the building be so constructed and protected to prevent the natural tendency of fire to spread upward

3. That all walls be constructed of fire resistant materials and all openings through them be so protected that the horizontal travel of fire will be prevented

The passage and enforcement of building codes containing the features as outlined will help to prevent much unnecessary loss of fire.

Incombustible Solid Walls - Walls constructed of solid fire resistant materials such as concrete, brick or stone, of sufficient thickness, provide the best possible protection against fire spread.

Fire Doors - Where buildings are divided into sections by fire walls and there are openings in these walls, they should be protected by approved and properly installed fire doors.

Vertical Protection - To prevent upward or vertical spread of fire all stairway and elevator shafts must be enclosed. Likewise, protection against the vertical rise of convected heat through chutes, escalators, elevators, dumb-waiters, pipe holes and air conditioning ducts must be provided. In frame buildings all studding spaces should be provided with "fire stops". See Figure 1.

Sprinklers - The automatic sprinkler system is the one most valuable appliance or device for preventing the spread of fire, especially in commercial and factory buildings. It is recognized as being the only safeguard to protect large areas, unprotected openings, and the combustible material in the building structure or its contents.

Window Protection - To protect the building from fire spread through windows, experience shows that the use of the following devices over, in, or above such openings will help tremendously:

1. Fire Shutters - Fire shutters are used on windows that are facing alleys or narrow streets. When properly constructed, installed, and maintained, they afford excellent protection against the spread of fire. The swinging type, which operates manually, must be closed after working hours or they will not be effective. Automatic steel rolling shutters which operate by gravity when released by a fusible link afford much better protection than the manually operated shutters. Both types will transmit heat and combustible material should not be stored near them.

Partition Without Fire Stops

Partition With Fire Stops

Fig. 1 – Fire Stops

2. Wired Glass - Wired glass windows enclosed in metal frames are not as unsightly as shutters, and their use in construction does not add materially to the original building costs. These windows, even when cracked, will afford protection and remain in place when hit by fire streams. It should be remembered, however, that wired glass windows are not a perfect protection inasmuch as they will transmit heat and at high temperatures, above 1600° F., will fuse and melt.

Water Curtain - When properly installed and maintained, water curtains afford protection for a building against exposure fires. The water flowing down the sideof a building will absorb the heat. Water curtains are constructed in various ways: (Refer to chapter on Water As Used in Fire Fighting.)

COVERING EXPOSURES

The covering of exposures as it applies to fire service consists of completely surrounding the fire with streams so that the fire will be checked at each possible avenue of extension. A quick survey by an officer or department member usually determines at just what points efforts to combat the fire have to be exerted.

It may not always be necessary to operate streams on all sides of a building in an endeavor to cover exposures. Some buildings, such as those having solid walls, create only minor exposure hazards. Likewise, when a building faces on a wide street and the wind is blowing in the right direction, there is very little chance of the fire extending across the street by exposure.

Where a fire has involved one building and is endangering a building across an alley, court, or narrow street, the most effective means of confining the fire to that building and preventing its extension is by the use of streams. The size of the streams will depend upon the height of the building and the area to be protected. Ordinarily, heavy solid or vapor streams are far more effective for covering exposures than are small streams. A heavy stream, protecting a building opposite the fire building, may not only be used to cover the exposed building but may under certain conditions be played on the fire as well. For that reason heavy streams provided with some easy means of manipulation, such as deluge sets, fog ladder nozzle multiversal set, etc., are more desirable for this work than small streams.

At this point it might be mentioned that unless a fire has reached considerable size, the danger of exposure is usually not very serious. However, where a fire has become very hot the exposure hazard may be extreme. In view of this condition the use of heavy streams for covering exposures is doubly necessary. If the fire is large and requires heavy streams for its control, the danger to the exposed area will be proportionately increased and will require streams with good range and plenty of volume to properly protect it. On the other hand, if a fire is comparatively small, such as would require the use of only small streams to extinguish it, there is usually little danger of exposure to other buildings. In this case, it will not be necessary to cover exterior exposures.

If available, one of the most effective means of covering exposures is by the use of a "deck gun." It can be placed at such a point as to reach either the fire building or the exposed building and, due to easy manipulation of its stream even under high pressure, it can be quickly switched from side to side as necessity demands. It serves in extinguishing the fire as well as wetting down the exposures and, in

an emergency, can be used for providing back spray from the face of the building to cool the street so that firemen may operate in the street near the building at close range. This is not a minor point as might be supposed. There are on record a number of large fires where the area in a narrow street or alley adjacent to the fire building has become so hot that men could not operate until a spray was provided for their protection.

An adjustable spray nozzle is often used in conjunction with the "deck gun." These are available in sizes of 500 gallons per minute and larger. This type of nozzle is adjustable for spray or solid stream and is easy to adjust while under pressure. The ladder nozzle for aerial ladder trucks has also come into its own for exposure protection. When equipped with an adjustable spray nozzle it is very effective for covering exposures and for using a solid stream for application on the fire.

It should also be remembered in covering exposures that the leeward side (the side away from the wind) is always the most dangerous because hot gases, heated air, and even flames may be carried considerable distances by the wind. Where volatile gases are present, there is always a possibility of these gases being carried into adjoining buildings, where they may be ignited by flames from the burning building. Therefore, when planning to cover exposures, the officer in charge should take the leeward side first and note the conditions.

If the fire has gone through the roof, the buildings which deserve first attention are those on either side of it, especially when they extend above the fire building. Buildings across streets, particularly wide streets, are the last to be considered. Once the positions have been chosen for operation in covering exposures, deck guns, multiversalnozzles, or fire streams are placed into operation. The presence of heavy streams between the fire building and the exposed buildings will reduce the temperature of the air between these buildings and will retard the extending of fire by convection or radiation.

The covering of external exposures of fire buildings, when the fire is about to jump from a floor to a floor above by way of windows, involves the use of streams to prevent its vertical extension. The most effective method of accomplishing this is by getting streams in on the fire where it is coming out of the windows. This will darken the fire and thus prevent its extension on the outside of the building.

Where elevator shafts or hoist shafts ollow a line of windows on the face of a building, it is frequently possible to keep the fire from extending through this inside vertical passageway by the use of properly directed streams through these openings.

In covering interior exposures, small streams are more suitable due to their mobility. Such operations consist of covering the vertical passageways such as dumb-waiters, elevator or hoist shafts, stairwells, pipe ducts, vent shafts, light wells, etc., through which fire may rise.

In most cases the lines are brought in on upper floors, usually the floor immediately above the fire. If the fire has not gained too much headway, a spray stream may be directed into the shaft in which fire is rising to kill the fire and cool down the interior of the shaft. Occasionally, spray streams are brought into the floors below the fire floor to check extension of fire through vertical shafts. At times, burning material drops down to the bottom of such shafts and unless they are properly covered with streams and are wet down, there is a chance of fire starting at the bottom and making a much more difficult problem.

Another method of covering exposures, not involving the use of streams, is to close windows and shutters in all exposed buildings. Closing windows and shutters will retard the spread of fire and sometimes make possible the confinement of fire to a single building.

Other methods of covering exposures within the building or adjoining building consists of closing doors, trap doors, and other openings by which the fire may communicate from one building to another or from one part of a building to another. It is very necessary to see that all wall openings of adjoining buildings are properly protected by fire doors.

THE FIRE FIELD

In the protection of exposures the duty and responsibility of the department does not rest with the original fire building alone. Firemen must be aware of all the conditions in the entire fire field. The fire field includes all buildings or combustible material in danger of becoming involved from the heat of the original fire which is transmitted through conduction, radiation, or convection currents. In addition, the weather conditions, wind direction, and the combustibility of the exposure must be considered.

Hose lines for protection purposes should always be laid and kept in readiness. This precaution is very essential in view of the fact that in the event they are needed a great deal of time will be saved.

All exposed material and buildings should be checked for fire and should not be considered safe until examined in their entirety. This check should be continuous until the fire has been extinguished. It is also necessary that all departments be thoroughly familiar with the buildings in their zone of operation. Frequent and thorough inspections must be made if this is to be accomplished. A complete study, discussion and analysis of conditions found during in-

spection should be conducted in fire department meetings or training sessions.

CONFINEMENT

As applied to the fire service, confinement is that action which is necessary to contain the fire in the smallest possible area.

Modern air conditioning systems have introduced a new problem in confining fires. Non-standard systems may have ducts lined with combustible material and are not provided with interior automatic fire shutters. Such non-standard systems may spread smoke and flames through the entire building. Ordinarily air conditioning systems should be shut down as soon as evidence of a fire is seen. People who are in charge of air conditioning equipment should be instructed to take this precautionary measure. In case such action has not been taken before the arrival of the first fire fighting unit, the officer in charge should see that this is done at once. Officers and men should be familiar with air conditioning systems found in buildings located in their community. They should know the location of the control switch and the hazards involved with each system. Some systems are equipped with detection devices that shut off their operation.

The officer in charge, upon arrival of the department, should note the direction and velocity of the wind and then determine which is the most likely direction the fire might extend and take immediate action to halt the progress of the fire in that direction.

Action must be taken to prevent high tension wires and electrical equipment from catching fire, falling and/or endangering life and property. Poles can be protected with hose streams operated from a safe distance until wires can be cut or control switches pulled by a qualified person.

Check all fire walls or fire-resistant walls within the exposed building to determine if it is necessary to move back combustible material from walls or openings. Determine if it will be necessary to ventilate the exposed building, from the unexposed sides, to reduce the temperature or to take care of smoke seepage.

Hose lines for protection purposes should always be laid and kept in readiness.

Keep a careful check on all possible places in exposed buildings or material where fire, heat, and smoke can enter. Continue checking until fire is extinguished.

If the building is equipped with a sprinkler system, make sure that the system is in operation. See that control valves are open. Lay lines from engine to fire department siamese. Provide necessary pressure if needed.

Make sure that fire doors and other protective devices are closed to prevent the fire from extending to uninvolved sections of the building. Ordinary doors offer much protection against the extension of fire if they are closed.

Protect all avenues of extension such as stairways, elevators, ventilators, and dumb-waiter shafts with hose streams when necessary.

Locate the main body of fire and determine the area involved. Attack the main body of fire but avoid forcing flames and heat into parts of the building not involved.

CHAPTER 18

FIRE EXTINGUISHMENT

INTRODUCTION

The actual practice involved in the extinguishment of fires includes all the various steps taken from the time the fire apparatus arrives on the scene and makes the initial attack on the fire until such a time when the fire is extinguished. The various factors in this series of evolutions are discussed in detail in other chapters of this text. Due to the many circumstances involved in fire extinguishment, all phases of the problem must receive attention. The possibility of human or mechanical failure makes it imperative not to place sole reliance on any one method. To know how to secure the greatest practical measure of safety and fire fighting skill at the fire scene requires wide knowledge and experience and the exercising of good judgment in each fire problem. This chapter will deal generally with the requisites involved in achieving this goal through the use of fire extinguishing media.

THEORY OF FIRE EXTINGUISHMENT

To understand the theory of the particular method used to extinguish the flame, the following information should be studied. In the "Chemistry of Fire" chapter, combustion or burning is defined as a chemical process accompanied by the evolution of heat. It was also stated that three essentials are necessary to have or support combustion, namely the following:

1. Fuel
2. Oxygen
3. Heat

Thus, if a fire is to be extinguished, one of three things must be done:

1. Remove the fuel
2. Reduce the oxygen supply by excluding or exhausting it.
3. Eliminate the heat by cooling the burning material.

In order to explain how this theory is put into everyday use and practice by firefighters, an examination should first be made of the three essentials (fuel, oxygen and heat) which are necessary to have combustion. This can best be illustrated by a triangle, each leg of which represents one of the essentials. By removing any one of these legs or essentials, the fire triangle collapses and there can be no fire due to the fact that the triangle is no longer complete. See Figure 1.

THREE METHODS OF EXTINGUISHING FIRES

REMOVE THE FUEL

In a strict interpretation of this method, firefighting techniques today are not designed along these lines. There are instances, however, when methods are or can be used which do compare with this principle. Scattering the logs and burning embers of a bonfire; chopping down the brush and trees to create a fire stop in a forest fire; digging or bulldozing a ditch, or burning a swath in the path of a prairie fire; pumping or draining the oil from a storage tank; shutting off the gas supply to a burning building; these examples all constitute actual operations where the removal of the fuel stops the fire.

Carrying furniture or removing merchandise from a burning building is not the general practice of a well organized and well trained fire department having

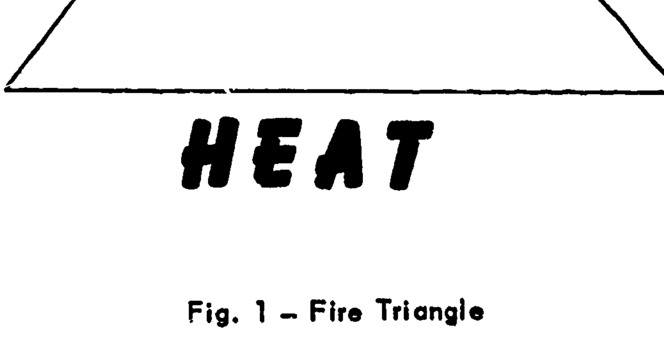


Fig. 1 – Fire Triangle

sufficient equipment and manpower to make an efficient and intelligent attack upon the fire. However, in some communities, w' ~re water supply and equipment are limited, the removal of furniture and merchandise may still be practiced.

Modern fire fighting tactics isolate or remove fuel in the path of fire by covering exposures with water curtains or spray streams, t.us preventing them from becoming involved in the fire. In some cases, it is necessary to remove the fuel when the combustible materials are stored against protected openings or walls. Carrying burning furnitr such as chairs, davenports and mattresses from ı building is another method of removing fuel from the fire.

REDUCE THE OXYGEN SUPPLY

In fire fighting practices this principle is effected in various ways. One is by the use of inert chemicals or gases which do not support combustion. These extinguishing agents, when applied to the burning material, create a blanketing or smothering effect which reduces or excludes the supply of oxygen necessary to maintain combustion. General agents used in this process include carbon dioxide, dry chemical, foam and vaporizing liquid. Steam may also be used to exting sh fires in a manner similar to using carbon dioxide or other inert gases; however, it is not a practical extinguishing agent except where a large steam supply is available. Steam hose lines and smothering installations are widely used in holds of ships to protect combustible cargoes in confined areas. The possible personal injury hazard of burns is another related factor in its use.

Another method in this category, one that came into widespread use just prior to and during World War II, is the use of water spray. It is referred to today as fog, vapor, mist, water particles, indirect application and a variety of other trade names. Although, seemingly, its use is a new innovation in fire fighting and the fire protection practices, spray nozzles have a history dating back to the nineteenth century. When this extinguishing agent is applied to a fire, the water is converted into steam, increasing its volume approximately 1650 times. If sufficient steam is generated by the heat of the fire, oxygen is displaced or excluded and the fire is extinguished by this smothering action. The amount of steam created depends upon the intensity of the fire in relation to the amount of water applied; therefore, the extent of the smothering effect is determined by these two factors.

ELIMINATE THE HEAT

As explained previously in this chapter, if the heat of a fire can be removed faster than it is being generated, the fire will be extinguished. Once the temperature of the burning materials has been reduced or cooled below its ignition point, self-sustained combustion cannot occur, and the material will cease to burn. This form of extinguishment concerns a method or process whereby the removal of heat or the elimination of heat must be accomplished by the application of an extinguishing agent which has such capabilities. Fortunately, the fire service has at its disposal an agent exactly suited for this purpose, that being water. Its abundance, comparatively low cost and ease of manipulation make it the best known general fire extinguishing agent used in the fire service. As water requires more heat to raise its temperature than an equal weight of any other liquid or solid, its tremendous heat absorption quality is an important factor in fire extinguishment. A maximum cooling effect is exerted on fires when water is applied, because its normal temperature is below that of the burning material. The superiority of water spray over solid streams in certain types of fires where it can be effectively applied may be in part explained by the fact that the small particles of water will absorb more heat, thus turning the spray more quickly to steam and exerting the maximum cooling effect. Water applied from a solid stream is merely heated and only a small part is turned into steam. Where water spray is properly applied, extinguishment may be secured with a much smaller quantity of water than would be necessary to absorb the heat produced in a fire when using a solid stream.

FIRE EXTINGUISHING AGENTS

Extinguishing agents used by the fire service, such as carbon tetrachloride, carbon dioxide and dry powder, operate principally through air exclusion but also have some cooling effect.

All ordinary material requires oxygen to maintain combustion, and this oxygen comes from the air. Therefore, if air can be kept away from the material, it will not burn. Likewise, after ignition, if air can be excluded, the burning will stop. If the material remains heated above its ignition temperature or if there are hot coals or embers, re-ignition will occur whenever sufficient air is allowed to reach them. Because of these conditions, air exclusion as a means of extinguishment is most successful with oils, fats and gases which do not leave hot embers.

There are two general methods of extinguishment by air exclusion. The first method is by mechanical means, such as the use of a cover or a blanket. Covers are used in many industries, such as for tar kettles, dip tanks and some dry cleaning machines. Some of

them are manually applied, and others operate automatically. The use of a rug or blanket to smother a fire when a person's clothing is burning is a common form of extinguishment by air exclusion. In industry, asbestos blankets are commonly used for this purpose.

The second method is to apply a blanket of inert gas, that is, a gas which will not burn. Such a gas must be heavier than air and must be so applied that it will settle around and over the fire, thus keeping the air away. The gases used are carbon dioxide and the vapors of carbon tetrachloride or chlorobromomethane. These gases are well adapted to oil fires in tanks or confined spaces, but in large open spaces where there may be considerable draft their effectiveness is often limited.

A combination of both the cover and the inert effects is found in the application of foam, which in its original form consisted of a series of bubbles filled with carbon dioxide, which cling tightly together and form a blanket to exclude the air from the burning material. The principal value of foam is for confined flammable liquid fires, but it may be used on freeburning materials if they are so located that they may be completely covered. Dry powder extinguishers also exert a blanketing effect.

Complete exclusion of air is not necessary to extinguish a fire. If the percentage of oxygen in the air reaching the fire is reduced from 21% (normally in air) to less than 16%, the common combustible materials will no longer burn. They will, however, smolder at lower oxygen concentrations than 16% even though the flames may be extinguished. Applications of carbon dioxide frequently serve to dilute the air to the point where the fire is extinguished by a reduction in the amount of oxygen in the air reaching the fire.

Water, of course, is the best cooling agent. It is adaptable to being forced through pipes and hoses. With precautions against freezing, it can be stored indefinitely except for slow evaporation. It can be applied by hand, as from a bucket; by pressure exerted upon it, as with a pump or compressed air or gas; and it may be delivered by gravity from an elevated tank or reservoir.

Water applied from hose lines can be controlled by using small lines on minor fires and large lines on major fires where powerful and penetrating streams are required.

Water can be applied as a spray to produce greater heat absorption, which widens its range of effectiveness. This will include not only class "A" fires, but also class "B" and some class "C" fires.

Water is also easily adaptable to automatic control. The automatic sprinkler system is an excellent example of such application.

There is no one specific method for applying water to effectively extinguish every type of fire. Some fires are best extinguished by the direct application of the solid fire stream into the burning mass. Other fires are best extinguished by the indirect application of the water in the form of broken, spray or fog streams.

The best extinguishing results are obtained from water if all or most of it that is applied is turned into steam. This is generally indicated by the "blacking-out" of the flame or the formation of clouds of vapor or smoke. To obtain the best results from hose streams, application should be made as near the fire as possible, and care must be taken in the selection of the proper type and size of nozzle.

Caution should be exercised in the application of water because some materials are damaged as much by the water as they would be by the fire. The fluidity of water permits it to flow to places and damage materials that otherwise would not be touched by the fire. Therefore, excessive amounts of water should not be used.

FIRE EXTINGUISHMENT PRACTICES

There are no set rules for extinguishment. Delay in fire discovery, transmission of alarm, or response of apparatus may mean the difference between a small or large fire. Also, the fact that buildings are not constructed the same or of the same material would have an effect on the direction of fire travel. The flammability and the amount and arrangement of the contents will affect the speed of fire travel. These conditions will determine the extinguishing agent which is best suited to control the fire. Conditions such as these and many others make it impossible to have specific rules that would govern operations at all fires.

There are, however, a number of good practices which, when coupled with good judgment, can be used at most fires. Some of these are:

1. Always "size up" the fire.

2. Select the proper extinguishing agent.

3. Fight fire as closely as possible. Water applied inside a burning building is more effective than that applied by streams from the outside. One of the most effective means of applying water to a fire inside the building is through sprinkler heads over or near the seat of the fire.

4. Determine the proper type of water stream to use: solid, broken, spray, etc.

5. Select the proper size nozzle tip.

6. When the fire permits, reduce size of nozzle tip to avoid water loss.

7. Always use proper nozzle pressure for the type of stream being used.

8. Confine fire to place of origin if possible.

9. Work on side of fire in the direction in which it is extending.

10. Be careful not to drive the fire into uninvolved parts of the building.

11. Do not throw water until the fire is seen. However, let the air out of line in advance so that a full stream is immediately available.

12. Attack the fire with the stream until it is "blacked-out." Shut off, investigate, and hit it again if it rekindles.

13. Do not open the nozzle full when a small amount of water will do the job.

14. Avoid putting water on goods or property that is not on fire.

15. Always back up small lines with large lines when manpower and adequate water supply are available.

16. Do not take a hose line into a burning building until water is available.

17. When a room is completely involved, indirect application using a spray nozzle is recommended. However, when a solid stream is used, point the nozzle toward the ceiling so that the water will cascade downward.

18. Fire streams from the outside must have nozzles of sufficient volume so that the stream will penetrate the heat field and strike the burning material without turning into steam before this is done.

19. Fire streams should not be stationary. After the fire in its path is extinguished, a stream should be moved for better coverage.

20. When a nozzle is shut off and not in use, carry it to a window if possible because of leakage or the possibility of being kicked open if on the floor.

21. Take in an axe and a ceiling hook in addition to the extinguishing equipment to be used.

22. The best air in a smoke-filled room is usually from knee high to the floor. Air is frequently better close to the fire than some distance back.

23. A life line is advisable when advancing into a smoke-filled area without a hose line.

24. Do not break open doors or windows unless certain they are fastened or locked.

25. Do not hit hot glass with a stream except as a means to ventilate the building.

26. Firemen should always use all available means for protection.

27. Before leaving fire grounds always do a good job of "overhauling." Check carefully all possible avenues of fire travel. A good rule is to go completely around the location of a fire. If in doubt, leave a man with the necessary extinguishing equipment.

28. When gas meters have been burned off, do not try to snuff out the flame until the main gas supply is shut off.

29. Gas turned off at street or meters in multiple dwellings or apartments should not be turned on except by gas company employees. Pilot lights or leaks would permit gas to escape, creating a hazard.

30. Effective fire streams require short hose lines. Incoming companies should attach their lines to the working pumpers that are located near the fire.

31. Always look for signs of arson or incendiarism.

BUILDING FIRES IN GENERAL

There is an old saying that no two fires are alike. This is true to the extent of the progress of the fire before arrival of the department, but there should be no mystery concerning all other conditions present at building fires. The chemistry of fire dealing with how fire starts, progresses and is extinguished, and the avenues through which fire is most likely to spread, are common knowledge to firemen. There is nothing concerning a building or its contents that a good inspection would not reveal, such as means for entry, places for proper ventilation, horizontal and vertical openings for possible spread of fire, condition of the building, any major changes made since last inspection and the nature, amount and location of the contents. All this could be noted when inspections are made, and whenever necessary a "fire map" should be drawn, especially for any unusual condition. These maps would embrace all data necessary to combat a fire and could be used in formulating a "before fire" plan of action.

The person in command of the first apparatus arriving at a fire must size up the conditions and decide on the initial step for extinguishment. Intelligent deductions and discussions can be made if proper preparations for the fire have been made. All persons who are charged with the responsibility of making these decisions should leave little to chance. They should know all the relative facts about each building and its contents, the source and location of water for extinguishment purposes, what can be expected from the responding apparatus, and from where and how additional apparatus may be secured.

Knowing all the facts as stated above still leaves many important decisions to be made. These decisions are based upon the extent to which the fire has advanced upon arrival at the fire. If the fire is small and conditions permit direct entry to fight the fire close at hand, decisions must be made with the view of minimizing loss from extinguishment practices, such as forcible entry and ventilation, and selecting the proper type of nozzle and the most efficient fire stream for extinguishing the fire with the least possible loss from water.

Fires that first must be attacked with streams from the outside require a diversity of action and no set rule applies. Judgments must be made at the scene. The objective is to enter the building for total extinguishment. This is possible by bringing lines into play immediately, through the proper selection and use of streams to quickly eliminate heat. This is followed by a reduction of stream sizes to accelerate mobility of action so that firemen can advance to positions where they can apply water directly upon the deep-seated fire and finally enter to complete extinguishment.

While final entry for extinguishment should be the aim at all fires, there are cases where this would be hazardous. Persons making this decision should recognize the dangers and take the necessary precautions.

EFFECTS OF BURNING

The duration of burning and the intensity of the heat generated will cause metal structural members to expand. The application of water for extinguishment purposes will cause quick contraction. If the duration of burning was long, the structural members may be expanded throughout and quick contraction or shrinkage of the outside of the members may cause them to warp and set up a condition where entry would be dangerous. The possibility of this occurence is relative to each building; some have no fire protection for the structural members; others have single or double fire protection. The intensity of the heat generated at fires is dependent upon the amount and flammability of the contents.

WEIGHT OF CONTENTS

All buildings are constructed for an intended occupancy and use structural members that will carry the intended weight, plus a margin for safety. Some buildings are used for other than their intended occupancy, and machinery or stock is added which reduces the margin of safety for the load. Also, the stock may be of highly absorbent material; thus a water stream not properly directed, or one held in a direction for a longer period than necessary, may add excessive weight. Water may accumulate to an excessive depth if the floors are not properly scuppered or if floating material clogs or blocks the drains. Good judgment is necessary in these cases before safe entry can be made, or the dangerous condition relieved.

FIRE STREAMS

SOLID

When fires must be fought with streams from the outside, it is necessary to apply sufficient water on the fire to reduce the heat faster than the fire can generate heat so that the progress of the fire can be arrested and the firemen can advance to more strategic locations. If the responding apparatus will not be able to supply the required number of streams, additional equipment should be summoned. Time is an

important factor since companies or departments responding on special call come from far locations. Decisions in such cases should be made quickly in order to get the best results from incoming apparatus.

The number of streams used is dependent upon the ease of bringing lines into play and the avenues through which water can be applied. Some fires can be fought from four sides, others from but one or two sides. The number of streams is also dependent upon the size of the fire and the means by which the water can be applied to the fire.

The penetration of the solid stream into the building is important. To be effective, the water must hit the burning material. Therefore, outside fire streams must be large enough to hold together, have sufficient nozzle pressure to overcome resistance from air pressure, and be able to carry through the heat field and strike the burning material without turning to vapor. If the fire has reached considerable magnitude, the quantity of water necessary to have the proper cooling effect becomes very large. One large stream would be better than an equal volume from a number of small streams. It is always better to attack with streams that can be reduced in size than to attack with small streams that are not effective.

SPRAY

The advantage of using water in spray form, as compared with solid hose streams, is that extinguishment is accomplished with a much smaller quantity of water. Therefore, these streams have a definite advantage in combatting confined fires. Nevertheless, they can be and are used on outside fires in various circumstances and situations.

Where a fire involves a roof or other elevation which cannot be approached directly, effective work may be accomplished by directing water spray into the updraft of the fire in sufficient quantities to reduce heat and permit closer approach for overhaul. Also, while the majority of these spray nozzles are designed for low operating pressures, there is another type of nozzle which delivers small flows at pressures in the 400 to 800 p.s.i. range. This equipment, although designed for fire department use, is supplemental to special apparatus. Either separate high-pressure pumps or extra-pressure stages on volume pumps are required. Water is discharged through reels of 3/4" high-pressure hose equipped with "fire guns" (high-pressure spray nozzles). The quantity of water delivered is approximately 25 to 30 g.p.m. This is more than a fire department booster (1/4" nozzle, but less than a stream from a 1 1/2" hose line with a 1/2" nozzle). This type of equipment provides a spray that will carry 30 feet or more in still air. The need for special high-pressure pumping equipment and heavy high-pressure hose essentially limits this form of protection to specially equipped fire truck units, as distinguished from the spray nozzles of the lower-pressure types which may be attached to ordinary fire department hose lines.

Spray or fog streams have an important advantage in shielding firemen from the heat of a fire, thus permitting closer approach than when using solid streams.

SUGGESTED PRACTICES FOR FIRE EXTINGUISHMENT IN VARIOUS TYPES OF FIRES

SINGLE ROOM

To obtain a good idea of the general practice to follow in extinguishing fires in single rooms, the problem will be divided into two parts: First, where the fire is small; second, where the entire room is in flames.

In both cases, however, if forcible entry is necessary to gain access to the fire area, care must be exercised not only in the proper selection of tools and equipment to do the job, but also in the proper handling and use of such tools and equipment. These factors are important, as they not only expedite fire fighting operations but are a prime factor in the resulting overall damage sustained during the fire fighting procedure.

In the case of a small fire where there may be a minimum danger of fire spread, the fire can be attacked close at hand using a minimum quantity of the proper fire extinguishing agent required to handle the situation. A portable extinguisher or booster line in this case would generally be sufficient.

Where the entire room is in flames and there is a danger that the fire has, or will, spread to adjacent rooms or to an upper story, quick application of water is necessary. When using a fog or vapor stream, the nozzle should be directed into the room through a door or window in the following manner: Grip the hose line about one and one-half feet back from the end of the nozzle. With both hands, swing the nozzle around and around in a circular motion, directing the water towards the ceiling. Since the maximum heat will be located at the ceiling, better distribution, coverage and cooling effects are obtained by manipulating the nozzle and stream in this manner. The effectiveness of this application can be judged by observing the following sequence:

1. The expulsion of the smoke

2. A mixture of smoke and steam

3. Steam with little or no smoke

Injection of water should be continued until the volume of condensing steam has decreased to a noticeable extent. This is a definite indication that the major part of the fire has been extinguished and the heat has been reduced. The application of water should then be stopped.

When more than one opening into the room is available, water should be applied from one location for approximately 15 to 20 seconds. Then the nozzle man should move to the next nearest door or window and again apply water. Firemen can then enter the area and operate from within to extinguish small, deep seated fires that may still be burning. It is advisable that firemen wait 15 to 30 seconds before entering after water application has been stopped to permit better visibility and cooling of condensing steam.

It is also suggested, when operating through a door or window, that the nozzle man keep low or have some protection from the hot smoke and steam which is expelled from the room. Entering or operating at a door or window is especially hazardous when there is but one opening which will afford a means of egress for the hot vapors to leave the room.

When using a solid stream, it should be directed at the ceiling. This method will deflect and break the stream into smaller particles and allow the water to cascade over the burning material.

Regardless of the type stream used, only enough water should be used to stop the progress of the fire and gain control. Ventilation practices can now be employed and further search made in adjacent rooms and upper stories for possible extension and extinguishment of fire. In the meantime, overhaul can be continued with little or no water damage.

MORE THAN ONE ROOM

Even if more than one room is involved, the same process as outlined above can be used, that is, attacking the fire first in one room to arrest its progress, then moving the line and doing the same in the other rooms involved. By moving about the building in this manner, heat and fire are lessened, the fire is under control more quickly, and entry for close attack is made easier. It has been proven in many instances that due to intervening walls and partitions, it is practically impossible to extinguish fire in two or more rooms from one location. Also, heavy water damage usually results from the application of water from one position, because the water is applied for a longer period of time before results are fully determined. Where two or more lines are available, each line can be used for extinguishment in separate rooms.

PARTITION FIRES

Fire may start within a partition or enter from some other source or cause. For example, a fire could start within a partition by the overheating or short circuiting of the electric wiring. Fire could enter into a partition by spread of fire from below or hot embers dropping down from fire above. Heat conduction through the plaster coating could possibly ignite the wood construction, sawdust or shaving residue within. In this chapter, the extinguishment of fires in partitions will be discussed only from the standpoint of the fire within the partition itself and not the origin or source.

Spaces in wall partitions offer a chance for the spread of fire, as do other concealed wall spaces. Partition fires often accompany basement fires, but almost any type of fire in a building with hollow wall spaces is likely to enter the partitions. The use of modern types of incombustible or less combustible wall partition materials is a factor in the spread of these fires. Proper fire-stopping in partitions, as called for by modern building codes, is another. However, even fire-stopping may not be entirely dependable, as often a small hole made by an electrician, plumber, or other workman is sufficient to let fire pass into a partition. The fact that a section or sections of a partition are warm, even to a high degree, does not always indicate a fire in that partition. Heat may be present from a fire below, passing into the partition through small openings. Although this heat might be high enough to cause the combustible material to burn, lack of sufficient oxygen in the confined area would prevent fire from taking place.

The needless opening of partitions indicates poor tactical operation on the part of the fire department. It may later be evidenced that the fire did not reach or involve the area, and the only damage sustained was due to the opening-up operation. Also, additional costs will be added to the fire loss in terms of repairing, replastering and repapering or repainting the area.

On the other hand, fire fighters who have not had enough experience with this type of fire may hesitate to open up partitions to determine whether the fire is or is not in the partition, or whether it has or has not been completely extinguished. Taking a chance in order to save a few dollars worth of additional repair could result in extensive fire damage if the fire extends.

It is the fire officer's responsibility to open partitions where there is a possibility of fire or where there is a probability of a lingering fire which may rekindle and break out again. The latter could take place while the department is still on the scene or

after they have returned to quarters.

To determine whether or not there is fire within a partition, three of the senses can be used to detect such a probability. *Touch* - feeling the partition with the back of the hand for hot spots; *sight* - looking for discolorations on the wallpaper or plaster, looking for evidence of blistering on painted surfaces; *hearing* - listening for the crackling or rumbling sounds accompanying burning.

In some cases, the removal of the baseboard or molding will disclose fire or fire travel into the partition. If this is done, care should be exercised in removing and preserving this material so it can, if necessary, be replaced.

It must be remembered that partitions divide two rooms. If a partition should be opened, it should be done on the side where the cost of repairing would be the least. For example, on a partition between a bedroom and a bathroom, the bathroom side may be tile, while the other side is an ordinary plastered wall with a painted or papered finish. It is obvious which wall would be the cheaper to repair or replace.

When it has been determined there is a fire in a partition and it must be opened up for extinguishment, it should not be opened until a charged line is available for action on the fire. Usually when partitions are opened, the increase of oxygen supplied to the fire will cause it to "blow-out" or burn more intensely and with greater volume.

The opening in the partition should be made in a careful and craftsmanlike manner, as pointed out in Chapter 15 of this manual. A small stream inserted in the opening and directed upward and downward will usually "knock-down" the fire temporarily. The heat will cause the water to turn into steam and thus have a smothering and cooling effect on the fire. The opening then can be enlarged for further examination of the fire spread and extinguishment of smoldering embers. Less damage and subsequent repairs result when openings are made only as large as required. Needless tearing out of lath and plaster add to the size of the hole and subsequent cost of repairs. Further application of small amounts of water into the partition can then be made in accordance with extinguishment needs. Such application will minimize water damage to a great extent.

There are few types of fires that cause as much trouble with rekindling as the hidden partition fire. The dry and fuzzy surface on wood lath often holds dangerous sparks and embers for hours. Playing partition pipes into openings will not guarantee extinguishment. Many partition fires, if not thoroughly extinguished, may rekindle; therefore, overhauling must be complete. Careful examination must be made to make certain all partition fires are extinguished before apparatus is returned to the fire station. In some cases it may be wise to leave a detail at the scene with a charged line or an extinguisher and adequate tools until all opportunity for rekindling has passed.

ATTIC FIRES

Attic construction varies with the purpose for which the attic is to be used. Some attics have no interior finish or flooring, while others have room partitions, ceilings and flooring similar to other stories in a building. Therefore, entry to attic areas will differ, and it is important and advantageous that firemen are familiar with the various construction details which must be recognized and coped with to obtain proper and efficient extinguishment of fire.

A common mistake made in attempting to extinguish attic fires is the failure to operate from the inside of the building. Water directed from the ground may only flow from the roof or may cause heavy damage without killing the flames. It is generally good practice to take the first line up the stairway on the inside of the building to the fire area. If the attic is not finished, entry must be made through any available opening into the area, such as a trap door or scuttle, etc. If no means of entry is provided, openings may be made through the ceiling below. Such openings should be made in a hallway or closet in preference to rooms, as less damage will be incurred to building or contents. When it is necessary to cut holes in the roof to attack the fire, the openings should be neatly cut between joists, so that subsequent repairs may be easily made.

Heat, smoke and gases will rise to the attic, as it is the topmost part of the building, and then push downward within the building when they are confined. As a result of this mushrooming, determining the location of the fire may be difficult because of the dense smoke and intense heat encountered. It then may become necessary to employ ventilation as an aid to gaining entry. If there are windows in the attic, they can be opened from the outside with the use of ladders. If the floor has to be opened to allow smoke and gases to escape, the work should be done in an efficient and workmanlike manner. However, ventilation should never be started until charged hose lines are available to immediately attack the fire when the openings are made. Small streams are effective on attic fires if the fire has not involved too large an area or gained too much headway. If objects or angle of stream prevents hitting the fire directly, a solid stream should be directed at the ceiling so it will be deflected, thereby creating a sprinkler effect and scattering the water over the fire.

Fog nozzles can be used very effectively on attic fires. The indirect application of water in this manner aids tremendously in fire extinguishment due to the high heat absorption qualities of the finely divided water particles and their conversion into steam to cool and smother the fire. In addition, where fog nozzles are properly used, it is common to find only a little runoff water remaining after the fire, thus eliminating excessive water damage.

It should be kept in mind, however, that regardless of the type of stream being used, it is advisable not to use water until the fire is located. If flame is showing, a small amount of water should be applied to cool it off, the nozzle should be shut down and results be checked. This process should be continued until a close inspection of the situation can be made. But, for all practical purposes, fires in attics should be fought as single room fires, as explained previously in this chapter.

As one of the most important factors in fighting a fire in an attic is to avoid excessive use of water, only enough water to control the fire should be used. Excessive amounts of water beyond this point will cause water damage to floors and contents below. Salvage covers should be used to protect such floors and contents as quickly as possible. Usually, ceilings will hold the water for a short period of time. This will give firemen an opportunity to cover and protect floors and contents from additional damage by water or debris.

BASEMENT FIRES

Basement fires generally gain some headway before discovery due to the fact that they are not easily observed from the outside. As a rule, basement fires are slow burning, and large amounts of smoke and gases are formed. This is due to the lack of an adequate supply of air. Consequently, a basement fire presents a particular life hazard to firemen. Men working on hose lines in the basement should always wear self-contained breathing apparatus. Officers should take particular precautions to account for all of the men working in this area. It is always possible for a man overcome by heat or smoke to lose consciousness and drop to the floor. If the water level is deep enough, drowning could result. This could happen to any one person, whether wearing a mask or not. Therefore, it is advisable whenever hose lines are being advanced or operated in a basement fire that at least two men should man each line.

In a fire of this type, it is well to remember one of the fundamental characteristics of heat -- *it rises.* This heat will rise through open partitions, stairways, elevator shafts, dumbwaiter shafts, etc., and finally reach and stop at the top floor or roof, where it could cause a serious extension of the fire. For this reason ventilation is started at the roof or over the stairways and shafts in order to let the heat out. It is then apparent that the first responsibility of the fire department in combatting a fire in a basement is to prevent the upward spread of the fire. Thus, the actual extinguishment of the fire in the basement could be considered secondary in terms of confining it to that area.

Fundamentally, water application and distribution in basement fires is primarily the same as that for attic fires. Fog nozzles, again, should be used whenever available. Here, too, the principle and theory involved in the indirect application of water apply effectively in the extinguishment of this type of fire. In addition, the resultant steam will rise with the currents of heat in the building and aid in smothering and cooling the fire in areas not under direct attack by the hose stream.

If the fire has not gained too much headway, lines may be brought to bear directly into the basement by means of stairways or basement windows. If there are any indications that the fire has already gone above the first floor, additional lines should be laid to head it off. If the basement area is large, it may be possible to attack the fire, both front and rear, from the inside of the building. Caution must be exercised in the procedure so as not to prevent the advance of either crew by forcing the heat and flame in their direction. If conditions do not permit a direct attack, cellar pipes and distributing nozzles may be brought into action. These can be inserted through holes cut in the floor or through basement windows. When operating these appliances, it is advisable to use both a horizontal and vertical motion in their application. Excellent results have been obtained when such cellar nozzles have been equipped with large fog heads. A knowledge of the arrangement of contents and dividing partitions within the basement will aid in effective water distribution by these appliances.

If the heat appears to be building up on the upper floors, the building must be ventilated. This venting should be started from the roof and worked downward to the street floor. This will prevent backdraft explosions, and permit firemen to work in the building.

If the fire seems to be making headway, streams should be set up front and rear to cover the basement fire in case the firemen in the basement are driven outside. Large hose lines should also be set up to cover the upward extension of fire and to cover exposures, even before they are actually needed, to

make certain they are ready for use if the occasion demands. If the heat and smoke are intense, it may be necessary to cool the area with large streams before entry can be made. Fog nozzles do an excellent job when used for this purpose.

Basement fires sometimes get out of control because of improper fire fighting attack. As these fires are usually confined, pent-up heat and gases must be carefully considered. An experienced fireman can often detect this potential danger by observing the amount of pressure pushing out the smoke from the building. This is especially noticeable around the doors and windows, through cracks in the brick or siding, or up around the eaves.

From the standpoint of heat and smoke dissipation, basements are harder to ventilate than any other part of the building, because heavier, unheated air cannot be admitted from underneath but must enter from a level with or above the fire.

Ventilating through basement windows only is a slow process as the incoming outside air and the inside heated smoke and gases must pass through the same window. Perhaps the hottest and smokiest part of the basement is at the stairway entrance since this is the highest point and the heat, smoke and gases will rise and build up there. If the entrance leads to the outside and this entrance is opened along with the windows, ventilation will proceed much faster.

It requires a considerable fire in basements in order to have the entire space from ceiling to floor filled with smoke. Generally from knee high to the floor is fairly clear and firemen who have once gained floor level are protected, especially if they are near an open window. Here the heavier air from the outside will descend to the floor, force the lighter heated smoke and gases away and clear a portion of the basement near the window. Entrance to basements may be made through windows and good protection found at floor level even when heavy smoke is issuing from the same window.

To assist in the removal of smoke and gases from the building, it is recommended that smoke ejectors be used whenever available. This appliance can be placed in a door window or any other opening and will quickly "pull out" smoke and gases not responding to ordinary ventilating procedure. This practical and useful fire department appliance is described further in Chapter 19 of this text. It may be well to explore its possibilities and value in modern fire fighting operations.

To further qualify a previous statement as to a situation where large streams are being used to cool the area to gain entry, the following end results should be considered. As stock or contents are already damaged considerably by the intense heat and smoke in such a situation, and it is physically impossible for firemen to work inside, it is far better to try and cool down the area with water than to force entry and create the possibility of a backdraft which could result in losing the building. It must also be considered that in the process of fighting basement fires, the water is less likely to damage goods on upper floors as in other types of fires where water applied to upper stories subsequently runs down and covers or damages everything below. In any event, the potential hazards involved in fighting basement fires have been proven to be so great and so many, it might be well to consider the fact that some water damage is preferable when compared to a total loss of building and contents or the loss of a fireman's life. Nevertheless, the fact must be kept in mind that the careless or promiscuous use of water under any circumstances is never justified. In basements protected by automatic sprinklers, the recommended fire fighting procedure is to connect hose lines to fire department connections and pump into the system, and then make certain sprinklers are working properly. Thus, in the event there is some delay in laying hose lines for attack on the fire, there is some assurance that water is being applied to the fire area.

APARTMENT, HOTEL, INSTITUTIONAL FIRES

This type of fire has been categorized to include those buildings in which large numbers of people live and sleep. In general, these are apartments, hotels, institutions, nursing homes, dormitories, etc. When responding to fires in these occupancies, one common factor predominant to all of them is the life hazard involved. In these cases, life saving operations are placed ahead of fire fighting operations. This is significant when manpower is inadequate and firemen are not available to do both.

When the officer in charge arrives at the fire he must size up the situation quickly, determine a plan of action, direct his men where their efforts are needed most, position apparatus for efficient operation and maneuverability, and decide whether extra help is needed to handle the emergency. The latter is very important. Even though these extra forces may not be used, it is better to play safe. Having adequate help at the scene is a primary consideration of the officer in charge.

In sizing up the fire, it must be recognized that no two buildings are alike, and plans must be expedited to fit the situation at hand. The height of the building, type of construction, access to inside or outside stairways, the extent of the fire, elevators or

other vertical shafts, number of persons in the building, how the fire is spreading, time of day or night, etc., are a few of the many factors to be considered to properly direct fire fighting operations.

When it is apparent that the initial procedure upon arrival at the fire involves rescue, all available personnel and equipment must operate in that direction. If entry can be made into the building by inside or outside stairways, firemen should use these means to facilitate removal of occupants from the building. If stairways cannot be used, all available ladder equipment must be pressed into service. This will include anything or everything from a short straight ladder, the various lengths of extension and aerial ladders, to a recent innovation - the snorkel. Life nets, where available, are still used in extreme emergencies when people are forced to jump from upper stories because other rescue means are not available. When smoke is, or may be, a problem in effecting rescue, it is advisable that firefighters be equipped with masks, preferably self-contained units, to enable them to enter, search for, and remove victims from the building.

When fire extinguishing media is required, the number, size and type of hose stream depends upon the size of the fire and local operating procedure. If the fire is small, 1-1/2" lines are ample for inside operation. When the fire is beyond the stage where it can be fought from the inside, large streams must be used. Usually, 2-1/2" lines will provide adequate water to combat the fire. When the fire has reached ample proportions and involves the upper stories of a building, turret guns, deluge sets, ladder pipes on aerial trucks, and heavy streams at street level must be placed in operation.

When rescue and fire fighting operations can be carried on simultaneously, units, although operating separately, must maintain a correlated method of procedure. Such methods should be worked out in advance during preplanning sessions. Thus, the duties and responsibilities of personnel and the assignments of apparatus are arranged in advance; all essential factors are taken into account; nothing is left to chance. This system will eliminate conflicting orders and mass confusion when companies operate in a "free lance" manner.

As a general rule, the duty of the first engine company in is to get a line into the building to maintain control over interior vertical channels through which the fire might spread. This means covering and protecting stairways needed for both fire fighting and rescue purposes. Succeeding fire companies then can attack the fire, cover exposures and prevent extension of the fire. While these are not hard and fast rules, they at least provide an initial set-up which will be effective in most situations.

It is recommended, at this point, that it should be the duty of the fire chief or commanding officer to *direct* the rescue and fire fighting operations and not to become involved in actual handling of equipment and hose lines. He should place himself in a position to observe, direct and control both operations. A situation can readily get out of control if the commanding officer, instead of keeping a watchful eye on the entire proceedings, becomes involved in a single operation. This thinking applies not only to this particular type of fire but to every fire.

MERCANTILE FIRES

Included in this category are retail and wholesale stores, restaurants, cafes, bakeries, drug stores, paint and hardware stores, furniture stores and many others which come under this classification and are found within the confines of every community. Recently, another innovation has been added to this classification, and this is the construction of large shopping centers in suburban areas. Acres of roof, covering just about every type of mercantile occupancy, has created another problem in fire fighting. The major factor contributing to the unusually large fire losses resulting from mercantile fires is the delay of discovery. As most of these fires occur during the late night or early morning hours, discovery is not made until after the fire has gained a tremendous headway and broken out through windows or roofs. Thus, upon arrival of the fire department, a major fire is already in progress, and plenty of water must be available to control, extinguish and cover exposures.

In mercantile buildings where basements are involved, the fire usually starts in these areas from heating equipment, careless smoking, refrigerator motors and improper handling of rubbish. Methods to be used in combatting this type of fire and those described earlier in this chapter must be determined by the officer in charge in his initial size-up of the situation.

Confinement of the blaze and cover of exposures warrant immediate consideration because of the compact structural problems involved with adjacent occupancies. In many instances, basements under the various stores are separated by flimsy wood partitions which permit the rapid spread of the fire to other stores in the building. In situations where there are living accommodations or apartments above the stores, an additional life hazard enters into the picture, and life saving and evacuation tactics become foremost in the tactical plan of operation.

Shopping centers as a rule are basementless, but

nevertheless, spread of fire is usually rapid because of construction details which allow fire spread through the cock-loft area. Lack of properly constructed fire walls and inadequate fire partitions between stores contribute to the large fire losses which usually result in these instances. In many of these shopping centers, adequate water supplies are not provided to aid fire fighters in extinguishment.

The construction of windowless buildings in newer mercantile areas has added another problem in fire fighting. Windows can provide a means of exit in time of emergency or a means of release for pent up smoke, heat and gases. To alleviate the seriousness of combatting fire in this type of building, recommendations in building codes are stipulating access openings for department operation at fifty foot intervals in each story of the building to expedite fire fighting and evacuation procedures.

It is apparent, in view of all these various problems, plenty of water, fire fighting equipment and personnel must be available to extinguish and control fires in mercantile areas. Mutual aid response should be stressed in communities where apparatus and personnel on hand cannot cope with a large fire of this nature. A constant and effective fire inspection program in mercantile areas is a determining factor in controlling the extent of the fire and the fire fighting procedure to be followed. Previous knowledge of contents, interior construction, exits, stairways, etc., plays an important part in effecting efficient fire department operation during the emergency. Because of the many and varied types of occupancies involved, each fire problem must be evaluated and handled in accordance with the nature of the occupancy. A complete listing and directive on each would be almost impossible. For example:

A Drug Store Fire - This fire would warrant some consideration in regard to the drugs and/or chemicals carried in stock. Storage of these materials on shelves in paper cartons or boxes, in bottles, etc., indicates careful handling of hose streams during fire fighting operations. Precautions should be exercised in the use of heavy or solid streams to prevent breakage and damage of these items. Spray or fog streams are not only advisable in controlling such damage, but they will aid in effectively diluting, condensing and cooling such materials. For the safety of the firemen, self contained breathing equipment should be worn to protect their respiratory systems. Also, ventilation practices should be adhered to in order to free the building of excessive smoke and gases.

A Hardware Store Fire - This kind of fire presents another problem because of the numerous combustibles, chemicals, ammunition, paints, lacquers, thinners, flammable liquids, etc., carried in stock. Firemen should be alert to the danger of flash fires from flammable liquids released from ruptured or spilled drums and containers. There is also the possibility of explosions resulting from the heating of filled or partly filled containers of paints, lacquers, thinners, etc. The ignition of shotgun shells or other ammunition may create an additional hazard to firefighters, even though their trajectory is limited, especially when confined to the original packaging. Fertilizer stock may contribute another serious hazard in terms of gases resulting from decomposition or exposure to heat and the combustible nature of the material.

In view of these circumstances, large or solid stream application of water is not strictly advisable. Excessive scattering of these products or damage and breaking of containers could lead to dangerous circumstances. Therefore, fog or spray application of water is advisable in terms of minimizing potential damage or disturbance. In addition, this method of water application is compatable with the cooling and extinguishing effects desired in combatting this type of fire.

In some instances, foam, carbon dioxide or dry powder is effective when the fire is still in the incipient stage or when the fire is a result of the flow of flammable liquids. Ventilation is an important factor when fighting the fire, and self contained breathing apparatus should be worn by firemen during the period of extinguishment.

MANUFACTURING, COMMERCIAL AND INDUSTRIAL FIRES

This category includes the various types of occupancies concerned with manufacturing or processing such as woodworking, chemicals, textiles, foods, plastics, metalworking, petroleum products and all other industries which can be classified accordingly.

The economic growth of our country has developed industry to a point where plants having areas of a million or more square feet are no longer uncommon. To make matters worse, inadequacies in construction permit these large plants to be built without too much regard for fire walls, subdivision walls, fire curtains or other forms of protection for area isolation purposes. Consequently, when fire involves these large areas, ordinary fire streams are inadequate because they cannot reach the seat of the fire. Windowless buildings, constructed for reasons coincidental with the operation of the plant, also create additional problems, as firemen are handicapped in their efforts

to gain access to the fire or ventilate the building to facilitate fire fighting procedures. As many of the industries have moved out of the cities and into rural areas, other problems also enter the picture. Such items as water supply, alarm transmission, distance and time for fire department travel, road conditions, etc., all have a bearing on the ultimate results of a fire emergency. Due to the size and scope of modern industrial plants, the large storage of dangerous and combustible materials used in processing or manufacturing creates another situation to contend with. Chemicals, plastics, rubber, synthetic materials, gases, liquids, etc., due to their individual characteristics and reactions, create separate problems in extinguishment. Consequently, it would be futile to attempt to define one specific method for fighting all types of industrial fires. As a directive in terms of the dangers involved in some of these areas, the following information can be used as a guide by firemen:

Acids, Oxidizing Materials, Lime, Sodium, Pyroxylin and Acetylene - Some acids, such as nitric, sulphuric and perchloric, when coming in contact with other materials, can cause fire or explosion. The oxidizing materials, such as nitrates, peroxides, chlorates and perchlorates intensify combustion by furnishing oxygen. Some of these are combustible, and others may be explosive, depending on the conditions. Unslaked lime generates heat upon contact with water. Sodium and similar active metals liberate hydrogen which will ignite upon contact with water. New, clean pyroxylin does not decompose at temperatures less than 200° F., but old scraps and sheets have been known to decompose and ignite simultaneously. As this type of fire can only be extinguished by cooling the pyroxylin below the point of decomposition, large quantities of water must be used in the extinguishment. Acetylene cylinders have been known to explode violently from the shock of being dropped. Therefore, firemen should exercise caution when directing hose streams or performing salvage operations not to knock over the cylinders. In fighting acetylene gas fires, the general rule is to let them burn until the gas flow can be stopped. Therefore, the surroundings must be kept cool with water to absorb the heat and prevent ignition of combustible materials in the area. If the gas flame were extinguished before stopping the flow, an explosive mixture could be formed which upon ignition would cause an explosion.

As information relative to flammable liquids and electrical fires has been offered previously, it can be used to facilitate fire fighting efforts in industrial plants as well. Some general suggestions which can be followed by fire fighters in combatting fires in this category are:

1. Know the amount, extent and locations of the water supply available.

2. Use only enough lines as can be adequately supplied by good working pressures. A few good hose streams are better than a large number of feeble and ineffective streams.

3. If the plant is protected by a sprinkler system, make certain the sprinklers are functioning properly. This will hold the fire in check until proper extinguishment can be made.

4. Connect and pump into sprinkler system with fire apparatus. This will assure a definite supply of water to the seat of the fire. Do not rob the sprinkler systems of water in order to supply other type of lines.

5. Attack the fire with proper and adequate hose streams, whether solid, spray or fog, in keeping with fire fighting equipment on hand, and nature or contents of fire.

6. Concentrate efforts on confining the fire to place of origin by covering and protecting inside exposures.

7. Take proper steps and precautions to protect against outside exposures.

8. Where chemicals, dangerous smokes and gases are involved, firemen should be equipped with proper protective clothing and breathing apparatus.

In view of the many hazards and responsibilities faced by firemen in fighting industrial fires, it appears that some previous knowledge and information must be obtained and a plan of operation determined beforehand, if efficient fire fighting tactics are to be expected. Plant managers, engineers and fire department personnel must work together in the interest of fire protection. A systematic fire inspection program is necessary to acquaint the fire department with materials and processes involved in the plant operation. Cooperation and correlation with plant engineers to determine adequate safeguards for existing or potential fire hazards must be obtained. A complete understanding of mutual problems will lay the groundwork for effective fire fighting evolutions and procedures to be followed by both plant and fire department personnel if a fire occurs. All these responsi-

bilities boil down to one word and that is *preplanning*, a must in efficient fire fighting today. There is an old statement which says -- fires are fought three times,

Before the fire -- for preplanning purposes,

During the fire -- to carry out the plans made, and

After the fire -- for the lesson the fire taught.

Concentration on the first could minimize the second and third.

CHIMNEY FIRES

These fires pertain to the burning of soot, tarry substances and any other products of combustion which have accumulated within the chimney and must not be confused with a fire which has resulted from a defective chimney. Actually, chimney fires could be allowed to burn themselves out if the chimney was properly constructed and in good condition.

Even though these fires seem to be of little consequence, they should not be treated lightly. In fact, authorities agree that chimney fires should call for the same manpower and apparatus response as any other building alarm. In too many cases it has been found upon arrival that the fire has spread through cracks in the chimney to adjacent wood framing, and a serious hidden structural fire is in progress. If adequate manpower and equipment is not at the scene to handle the situation, valuable time is lost before additional help arrives to control the fire spread.

When a chimney is on fire, large sparks or pieces of burning soot are emitted with the result that there is a danger they may fall upon and ignite wood or other combustible roofs. Therefore, upon the arrival of the fire department, the proper procedure is to let the soot burn itself out and to concentrate efforts to protect the building or other places where the sparks are falling. Consequently, ladders should be raised to the roof and a portable extinguisher or charged booster line made available at that point.

The cleanout door at the base of the chimney should be opened and all accumulated soot removed and placed in metal containers. This will also create a better draft within the chimney and hasten the burning of the soot adhering to the sides or lining. While this operation is going on, other firemen should check the chimney from base to roof, particularly the exposed portion in the attic.

A hot chimney fire can be extinguished by applying water at the base; thus the rising steam and water vapor will extinguish the fire. Chemicals are not recommended for removing soot from chimneys or extinguishing fires in them. Some soot removing compounds containing oxidizing agents have been known to cause explosions when thrown into stoves or furnaces. At best, the use of any chemical means for eliminating soot is of uncertain value according to tests by the National Bureau of Standards. The application of sodium chloride (salt) is not effective in removing soot or extinguishing a chimney fire. The theory relative to the use of zinc, potassium chlorate or other chemicals which form oxides, is that the oxide which is carried up the flue by convection will cling to the soot, and the added weight will cause the soot to fall away from the chimney wall. In some cases, the high temperatures required to oxidize the chemicals create an additional danger because of the high temperature then created in the chimney.

Fire protection authorities recommend the use of water from the booster tank as being effective and readily available.

Care should always be taken when placing ladders against a chimney to make certain the chimney will bear the weight of a fireman and ladder placed against it. This is especially precautionary when working from the roof to reach the top of the chimney, which is often the case when chimneys are in the center of the building.

FLAMMABLE LIQUID BULK STORAGE FIRES

Fire departments having storage plants or yards within their jurisdiction are faced with a serious fire fighting problem. Such fires offer the possibilities of a conflagration should an explosion, boil over or tank rupture occur and scatter burning fuel over adjacent tanks and surrounding buildings. If proper diking and run-off facilities are not provided, these fires can quickly spread out of control. With this in mind, a strict application of one of the most important principles of fire fighting, namely, to confine the fire to the smallest possible area, should always prevail.

Hose streams first brought into action should be used for cooling down purposes only. If directed on the tank involved by fire, application should be made below the fire line. If the water is played directly into the tank, it may displace the burning liquid and cause it to flow out of the tank. Usually, the lighter flammable liquids, such as gasoline, will burn in the tank, while the heavier liquids, such as crude oil, will boil over. Fire streams should also be used to cool down surrounding tanks and to prevent ignition by radiated or convected heat. Where fire fighting connections or facilities are available on burning tanks to induce foam or air agitation for extinguishment, no time should be lost in placing such systems

in operation. The longer the fire is allowed to burn freely, the more heat is generated, and the greater becomes the possibility of creating air currents which will again add to the problem of fire and exposure control.

Firemen attempting to extinguish oil tank fires should be aware of the heat factor involved by noting the color changes taking place on the shell of the burning tank. Too many fire fighters have lost their lives because of their unfamiliarity with this factor. Boil-overs, rupture of seams and tank collapse can trap firemen in dangerous positions if they are unable to recognize warning signs preceding these incidents. When a burning crude oil tank changes color from a faint red to a blood red and then to a cherry red it is ripe for a boil-over, especially if water is trapped inside. When a tank glows bright red or salmon color, either from the fire inside or from radiated or convected heat, a blowing off of the top of the tank or an explosion may occur. This is especially true when the tank is not thoroughly or properly vented. When a tank assumes a light yellow or white color, it is an indication that the temperature is high, 1800 to 2200 degrees F., and the tank is ready to collapse.

However, color alone should not be relied upon to indicate the seriousness of the situation. The nature and conditions of the structural members should also serve as a warning measure. The collapse of defective or inadequate supports or unprotected steel foundations can also contribute disastrously to the gravity of the situation.

When fighting tank fires involving bulk flammable liquid or gas storage, it is most seriously recommended that special cognizance be taken of the position of the tank in terms of its installation in either a vertical or horizontal position. Fire fighting experiences have indicated that whenever a tank ruptures or explodes, the contents or force is usually expelled through the top or ends of the tank. For this reason it is most emphatically advised when fire companies are engaged in combatting a fire involving horizontal storage tanks, they should position themselves on the sides of the tank and never in line with the ends.

Most smaller fire departments do not have foam equipment to deal with large flammable liquid fires. It is recommended that arrangements be made with the operators of the storage plant to supply such equipment as an adjunct to their safety program and make it available for use if needed. Otherwise, arrangements should be made with adjoining fire departments or even nearby plants who have foam equipment to make it available for use if needed.

The best policy any fire department can adopt when faced with the problem of coping with a large flammable liquid storage condition in their community is to enlist the cooperation of plant officials in determining what can be done to prevent and control a potential fire. Efforts should be mutual in making studies of water supplies, fire fighting equipment, special fire protection systems incorporating foam, CO_2, sprinklers, fog or water spray, exposure hazards, construction factors, and all other items concerned with safeguarding and protecting the plant and community. From these studies a joint plan of operation should be established deciding the duties and responsibilities to be shared by each. Thus, a mutual understanding and agreement reached beforehand will eliminate the confusion and conflict which inevitably take place at the time of the emergency.

METAL FIRES

Metal is usually considered noncombustible, but actually, nearly all kinds of metal will burn under certain circumstances. Probably one of the earliest introductions to combustible metals was the use of magnesium powder in the photographer's flash pan of many years ago. Recently, new interest in combustible metals has been stimulated on a highly scientific basis. Physicists, metallurgists, chemists and engineers are learning that in certain combustible metals there are sources for atomic energy and rocket fuels and a means for creating new horizons in structural materials. However, there are so many that a complete listing of these metals and their alloys would be impossible. The more common of these and suitable methods for extinguishment are as follows:

Magnesium - Due to the fact that magnesium and its alloys combine readily with oxygen, water applied to extinguish the fire may be decomposed into oxygen and hydrogen, with the result that the hydrogen released will add to the intensity of the fire. For this reason, extinguishing methods depending on water or water solutions are not effective in magnesium fires, except where the water can be supplied in sufficient quantities to cool the magnesium below its ignition temperature. Where large amounts of this metal are involved, the reaction with water may be of explosive violence. Therefore, when hose streams are used, they should be applied from a safe distance or from behind some suitable shelter. Impinging the water stream from above to form a spray has been found to be effective in some cases. Automatic sprinklers do not ordinarily discharge enough water to extinguish the fire by cooling, but their action will prevent the ignition of flammable materials in the area, protect the structure, and thus, localize the fire. It may be

well to mention that magnesium burns more violently on concrete floors than it does on wood floors. This is due to the presence of some moisture in the concrete and the resultant reaction between the burning metal and the oxygen in the concrete aggregates. This is not meant to imply that magnesium should be stored in combustible buildings. The common inert gases, carbon dioxide or nitrogen, are not suitable extinguishing agents, because the affinity of magnesium for oxygen and nitrogen is so great it will continue to burn in atmospheres of the gases.

Carbon tetrachloride should never be used on magnesium fires, as the released chlorine combines readily with the magnesium and will react violently in form of an explosion. Gases such as helium and argon are effective extinguishing agents as they do not react with the magnesium. They have serious drawbacks, however, because in effect they are poor cooling agents and too expensive for general use.

In some instances, sand, talcum, slag and similar fine substances have been used to control or extinguish magnesium fires. However, their value is limited because of the possibility that such materials contain oxygen and moisture which will react with the magnesium, or their cover is not protective enough to insure that air will not reach the fire.

Small magnesium fires on non combustible surfaces may be extinguished by carefully and completely covering the burning material with a layer of coal-tar pitch. When this substance, which has a low softening point (approx. 300° F.), is applied in the hard form, it softens and seals in the burning magnesium with an airtight cover that smothers the flame. Various special extinguisher powders have been developed specifically for magnesium fires. G-1 powder, the most widely used, consists largely of graphite. It is usually applied by scoop or shovel, and its use is accordingly limited to smaller fires which can be approached closely. Other inert or non-caking extinguishing powders used in special first aid appliances can be projected through a nozzle and directed at a fire some distance away.

Titanium, Zirconium, Hafnium, Thorium and Uranium - Both titanium and zirconium have been developed to the point where they can be used for structural and many special purposes in large sections. In the large form, they apparently present no special fire hazards. In finely divided or powder form, however, all five of these metals present a more serious fire hazard than that associated with magnesium and aluminum of the same consistency. Therefore, the common extinguishing agents used in the fire service such as water, foam, soda-acid, carbon tetrachloride, and carbon dioxide should never be used. In fact, it has been recommended that these units should not even be permitted in areas where metals are, just in case they would be used inadvertently to extinguish the fire. Consequently, extinguishment and control is limited to the use of graphite, soda ash, dry talc, dry sand, or other special chemical compounds such as G-1 powder.

The inert gases, nitrogen, helium or argon may also be used satisfactorily if total confinement can be made.

According to the U.S. Atomic Energy Commission, fighting a fire involving burning uranium may be accomplished by shoveling the burning uranium into a drum of water. There is no violent reaction, although some hydrogen gas is generated. The Commission further states this operation should preferably be carried on outside.

Aluminum, Iron, Steel and Zinc - These metals all have a sufficiently high ignition temperature, so that in a large form they do not present a particular burning factor in fires. However, when in a chip, shaving or powder form they do involve a potential fire or explosion hazard. Dry sand or other dry chemical compounds, should be used. Isolation of these fires by surrounding the burning material with these extinguishing agents is recommended whenever possible. Extreme care should be exercised in doing this so as not to stir or fan the dust into the air.

Summary - Actually, there are only a few specific standards for fire extinguishment which can be applied and used on pyrophoric metal fires in general. A lack of uniformity has been prevalent in results obtained with different types of special fire extinguishers. Manufacturers and others who have been trying to develop both liquid and powder type extinguishers that will be effective on pyrophoric metal fires have encountered many baffling problems. In one particular case the extinguisher was found to extinguish a fire in a certain metallic sponge from one plant and oily metallic chips from another plant very readily. Yet, it failed completely in extinguishing a fire of metal chips produced in another plant. Apparently, there is still a great deal to learn about combustible metal fires. It is recommended that fire departments utilize standards available from the N.F.P.A. and the N.B.F.U., or other agencies for further information on this subject in order that they may keep abreast of development in this field. It is also recommended that fire department personnel contact management of industrial plants using these materials in their area and work out a systematic approach to the problem. Prefire planning is a cooperative endeavor between the fire department and plant management. A mutual

understanding of the nature of the hazards in the plant and the fire fighting problems of the fire department is a sure way to eliminate confusion and indecision in attacking the problem when an emergency exists.

MOTOR VEHICLE FIRES

Minor fires in automobiles, busses, trucks, etc., can be quickly extinguished with portable fire extinguishers or booster lines. If the fire is under the hood, the hood should be raised for direct application of the extinguishing media. If the hood cannot be raised, extinguishment can be attempted through louvres, vents or openings into the motor compartment. The application of fog or the contents of a class B or C extinguisher in this manner will generally control the fire until the hood can be opened with an appropriate tool.

After the fire has been extinguished, the vehicle should be checked for signs of leaking gasoline as a result of or cause of the fire. The leak could be from the carburetor, a cracked or broken fuel line, or a damaged coupling in the fuel line. A quick and effective way to stop the leak is to firmly pinch the tube together just back of the leak. Sometimes, elevating the broken tubing above the gasoline level in the tank will stop the leaking. All gasoline should then be flushed away, being careful not to create pools or puddles under nearby cars or in gutters.

If a great deal of gasoline must be disposed of, copious amounts of water should be used for flushing purposes. If the gasoline is being flushed into a sewer, plenty of water should be used in the process. It may be necessary to leave a hose line running into the sewer system for some time to make certain the gasoline has been flushed away. In some instances it may be necessary to conduct explosimeter tests in nearby basements to check for gasoline vapors which may have entered through sewer lines because of dry traps in the sewer.

If the fire involves the interior of the vehicle, one or two small lines equipped with fog nozzles inserted into the interior will quickly kill the fire. This will enable closer examination for extinguishing smouldering fires in the upholstery of cushions and seats. It is recommended that they be removed from the vehicle and completely overhauled.

If it appears the fire in the closed vehicle has been burning for some time and the smoke has the yellowing or brownish appearance of a pent up smoldering fire, caution must be exercised in opening the door or window. The sudden surge of fresh air into the vehicle may cause an explosion similar to a back draft in a building fire, seriously injuring firemen by knocking them down or burning them badly.

Air Suspension Busses - Recently, the automotive industry has come out with a new idea for smoother riding by incorporating the use of rubberized bellows to replace the metal springs used on busses, trucks, trailers, etc. In this air suspension system rubber bellows are installed at each wheel and inflated with an air pressure of 40 - 50 pounds, maintained through the air chambers from a compressor.

This air suspension system is used on the Scenicruiser, the latest type coach in the Greyhound system. For rescue practices the following information is submitted. In extinguishing a fire around the transmission, wheels, or under the engine, extreme caution must be exercised by fire fighters not to place any part of their bodies between the wheels and the body of the vehicle. And under no circumstances should anyone be allowed to go underneath the vehicle for extinguishing or examination purposes without first blocking up the body securely. The blocking is absolutely necessary because the possibility of the bellows being damaged would allow the body to drop suddenly and without warning. This would drop the vehicle practically to the ground and trap anyone underneath.

In the event the engines are running when the fire department arrives on the scene, an emergency stop button is located in the grill of the left side engine door. If the engines cannot be stopped in this manner, CO_2 should be discharged into the air intake located at the right rear corner of the coach. CO_2 is advised by the manufacturer as the only extinguishing agent to use; otherwise, potential injury to firemen may result.

The electrical system is protected by circuit breakers. To kill all the current, the nut holding the cables located at the rear of the engine compartment over the right engine directly under the rear switch panel can be loosened. These cables have notched ends, making it easy to disconnect them. It is very important to be careful when opening the rear engine compartment doors, as there are no safety guards around the fans. The speed of rotation makes them difficult to see. Since the coach has no frame, it is equipped with jack plates located under the body behind the rear wheels. If it is necessary to jack or block under the body of the coach, jack under a solid bulkhead. These bulkheads are located in front and rear of the wheels. Jacks may also be placed under the short engine supports. A support should always be placed under the body before jacking, because the bodies are made of aluminum and will tear easily. All rescue efforts should concentrate on removing passengers through windows when the door is inac-

cessible. To open the windows from the outside, a large screw driver or pinch bar placed under the metal frame around the windows can be used to force the window out. To open the front windshield and skylights, remove the rubber locking strip running around the windshield and the skylights. This strip is forced into place between the wide rubber frame holding the windshield and the skylights in place. By reversing the procedure the windshield, frame and glass will all come out, leaving a smooth opening for the removal of any injured passengers.

Predictions are that the air suspension principle will be used on more and more vehicles in the future. It is recommended that fire departments keep abreast of this movement by learning all they can from manufacturers or users of this equipment. Information similar to that mentioned above can be obtained from the various companies in the field to expedite the course of action at the scene of an emergency involving this equipment.

Petroleum Tank Truck - Fire creates a problem in fire fighting in relation to the size and scope of the emergency involved. Safety features are incorporated in the construction and operation of these vehicles which, under normal circumstances, will permit safe and effective means of extinguishment. The installation of pressure relief vents for each compartment, safety valves to stop flow of liquid either by direct or remote control, fusible plugs which when heated or broken automatically release air pressure and stop flow of liquid, and sturdy construction of bulkheads and tank all indicate that the fire can be safely approached and controlled without fear of explosion. For example:

1. An open dome fire above one of the compartments can be readily extinguished by merely closing the dome cover. The vapors burn only after they rise from the tank and mix with the proper amount of air. There is no flame within the compartment because the mixture is too rich. When the dome cover is closed, the vapors are cut off and the fire goes out.

2. Fires involving the manifold can be extinguished by portable extinguishers or fog nozzles without fear of the fire extending through valves and piping.

3. Overflow, becoming ignited during filling operations, can be extinguished by fog nozzles which simultaneously cool the sides of the tank, thus causing the vents to close as the inside pressure subsides.

A traffic accident, an overturned tank truck or a severe tank rupture caused by a collision with some structural support creates an entirely different condition. The seriousness varies with whether the indicident takes place on a crowded street, a congested section in a downtown area, a busy highway, a country road, or another location. When lives, buildings and other vehicles are involved, quick action is necessary to control the situation. The responsibility for directing the tactics to be followed by personnel and equipment during the emergency rests with the officer in charge.

It is recommended that tactical problems be studied, contact be made with mutual aid departments, and a complete knowledge of the availability of water supplies, foam or special equipment be thoroughly known and understood.

From past experiences with this type of fire, conclusions reached indicate the following factors are important in securing control and extinguishment.

1. Adequate supplies of water should be available for efficient fire fighting purposes.

2. Other extinguishing agents such as foam, foam generators and foam equipment are a necessary adjunct in fighting the fire.

3. Proper pressures on hose streams should be maintained for safe and adequate attack.

4. Fog nozzles, due to their tremendous capabilities, should be used both in attack and control of the fire.

5. Approach of the fire by hosemen should be made in direct line, not one ahead of the other, with an overlapping of fog patterns if possible.

6. Back-up lines must be available to protect advancing fire fighters.

7. Solid streams should not be directed into flaming liquid, as they scatter and stir up the liquid.

8. Direction of run-off gasoline, whether burning or not, should be controlled with hose streams.

9. If liquid is being emptied into sewers, plenty of water should be used for flushing purposes.

10. No-smoking restrictions should be strictly enforced to prevent potential ignition of vapors or liquid.

11. Area should be roped off as quickly as possible to permit efficient operation of fire fighters and to keep spectators and traffic at a distance.

12. Local law enforcement agency or agencies, utility company trouble crews, or other pertinent organizations should be contacted for assistance.

13. Explosimeters or combustible gas indicators should be used to check and determine dangerous vapor accumulations in nearby homes, buildings, basements, or low areas where such vapors could accumulate.

14. Exposure hazards involving surrounding structures, vehicles, etc., should be kept under careful surveillance during the emergency.

15. Protective clothing should be worn by firemen to facilitate fire fighting operations.

FIRES INVOLVING HIGH TENSION LINES AND EQUIPMENT

Increased uses of high voltage lines and equipment to provide power for the everyday needs of the people make it mandatory for every fireman to have some knowledge of the danger involved in the extinguishment of these fires.

Numerous tests have been conducted relative to the dangers, safety limits and conditions under which firemen may safely operate. Conclusions reached were these:

1. A stream of water will carry current back to the nozzle.

2. The current may be sufficient to injure or kill a person.

3. Fires involving electrical charges can be safely controlled and extinguished, providing proper distances and precautions are observed.

The amount of current the fire fighter is exposed or subjected to will depend on certain conditions, namely:

1. *The amount of voltage involved* - The greater the voltage or electrical pressure, the greater the ampere-flow and proportionally greater the amount of current flow.

2. *The distance from the nozzle to the charged wire or equipment* - The greater the distance, the greater the resistance, and therefore the smaller the amount of current. Modern fire equipment, such as aerial ladders, may position a fireman with a hose line within a very short distance of highly charged electrical wires. This would create a short path of resistance and exposure to the current if contact with the high voltage conductor were made.

3. *The size of stream and nozzle* - Streams from large nozzles conduct more current than from small nozzles, because the conducting stream of water is larger.

4. *The purity or conductivity of the water in the stream* - The mineral content of the water determines the conductivity of the water. Water from a well, spring, river, pond, etc., has a greater conductivity because of the free mineral content than distilled water from which the minerals have been removed.

5. *The type of stream--solid, broken or spray* - Beyond the point where the stream breaks, little or no current will be carried, as the separate drops of water do not make a continuous electrical path.

6. *The pressure of the fire stream* - Tests indicate there is a definite point in the pressure at which current passing through the fire stream is at the maximum. For short distances between the nozzle and the charged wire, the low pressure fire stream was relatively compact, but as the distance increased the low pressure stream broke into large drops and no current flowed through it. The high pressure stream held together better for a greater distance, but due to the high velocity of the water through the nozzle, it was less compact than the low pressure stream. The following conclusion then results: Low pressure streams are most dangerous at short distances, and high pressure streams at longer distances, keeping in

mind there is a "limiting distance" at which both streams disintegrate enough to become poor conductors of electricity.

7. *The path of the current* - If the hose is wet and lying on the ground or in a pool of water, the current would be grounded from the hose jacket into the earth. However, if the fireman were standing on wet ground and the hose was elevated because of piled debris or over a parapet or wall, the current would pass, or be grounded, through the fireman's body to the ground. Firemen fighting fires from metal fire escapes must exercise caution to prevent hose streams from coming in contact with high tension lines, as the fire escape could provide a ground for the path of the current.

8. *Protective clothing* - Nonconducting footwear, gloves, raincoats and similar firemen's protective clothing furnish some degree of protection against electric shock. However, firemen's rubber boots should not be relied upon for complete protection, as they may have cracks, leaks or a material composition which would permit grounding.

Electrical Oil Fires - Oil switches, oil filled transformers and other electrical equipment containing oil involve the additional hazard of oil fires. The oil used has a relatively high flash point, but it may be heated and ignited by excessive current or an electric arc. After the current is cut off, such fires can be extinguished by any of the methods used for extinguishing oil fires. If the current cannot be cut off and the fire is small, portable extinguishers of the class "C" type can be used effectively. However, water can be applied with fog or spray nozzles very successfully on these fires. The finely divided drops of water offer an enormously greater resistance to the flow of electricity and thereby consitute a greater factor of safety to the firemen.

Transformer Fires - A transformer on a pole or structure presents a difficult problem in electrical fires. The first responsibility of the fire department on arrival is to contact the local utility company. These companies have trained crews of qualified personnel who are familiar with and capable of handling such emergencies.

Water can be applied and directed from a safe distance on the ground to control the extent of the fire on the pole or structure. This will prevent collapse of the equipment or support which, if allowed to burn, might fall to the ground bringing down the high tension lines to which it was attached.

Neon Sign Hazard - Neon signs present a problem and hazard to fire fighters. As these lights operate with an electric current passing through a glass tube filled with gas, high potentials must be used in starting the lamp, and transformers or auto-transformers form a part of the lighting equipment. Some may operate individually on circuits up to 600 volts and in series on circuits that run as high as 15,000 volts. Although the voltage is very high, the current flow is low. Usual precautions relative to normal lighting must be observed, bearing in mind that due to high voltage involved a fireman could be knocked from a ladder and injured by the fall.

In summarizing this material, firemen should be cautioned to consider every wire a hot wire because of the possibility at fires or other emergencies of any wire being crossed with high voltage lines thereby energizing it to the same degree.

The best practice under any circumstances is to shut off the current if at all possible. If this cannot be done of the fire continues, use the extinguishing means most safe and suitable for the situation. Firemen should not cut or otherwise handle live wires. Exceptions can be made in this type of work for men who have had the necessary experience, or for trained utility companies. Preplanning arrangements should be made with local utility companies whereby service crews can be called and dispatched to emergencies involving power lines or power equipment.

LUMBER YARD FIRES

Where large quantities of lumber are stored in unsprinkled sheds or piled in the open, there is always the possibility of a quick spreading fire. The lumber piles may be of such height and have such limited open spaces between them that a fire, once it has a good start, may be difficult to control and extinguish. In order to combat such a fire it will be necessary to have an adequate water supply and sufficient apparatus and equipment. Weather conditions, such as high wind or extremely dry conditions, may contribute to its rapid spread.

If possible, the fire should be attacked from all sides and every effort made to confine it to the smallest area. Heavy streams from deck guns and deluge sets can be used to attack the main fire, to wet down exposed materials, and to break up radiated heat rays. Care should be taken to protect unburned materials and property from flying sparks and brands.

It is recommended that the fire department contact management to determine a plan of operation in case

of fire. The plan should include:

1. Means of alarm transmission.

2. Watchman and fire brigade duties, responsibilities, and understanding of proper procedure and method for alarm notification.

3. Location plan of water system, water supplies, and other fire extinguishing media and equipment.

4. Location and storage facilities for flammable liquids, including that for vehicle operation.

5. Plan of yard facilities indicating entrances, driveways and arrangements for admittance if area is fenced in.

REFRIGERATOR FIRES

Domestic Electric Refrigerators - Fire departments are frequently called to extinguish fires in domestic electric refrigerators. To some extent there is the impression that these fires are connected with the refrigerant, but such is not the case. The refrigerant most extensively used actually has fire extinguishing properties, and when it escapes the danger is not one of fire but one of an irritant gas. The fire hazard of refrigerators is related to the electrical feature and in the main to the motor.

Losses due to these fires are small and are mainly due to smoke damage and the need to replace the motor. Investigations have disclosed that many of the fires are due to insulation failures in the motors. In many instances the exact cause of these failures could not be determined. The trouble may have been caused by an overloaded circuit or by failure of the brushes on the repulsion type single-phase motors to disengage, which failure may occur when the motor fails to come up to speed because of low voltage. It has been found that low voltage has resulted in many refrigerator motor burn-outs. Investigations disclose that a great number of these fires are caused by poor maintenance, such as failure to oil the motor at proper intervals and permitting combustible dust and dirt to accumulate on and around the motor. The home owner should be advised of the importance of proper maintenance, oiling at suitable intervals, and keeping the space about the motor free of dirt and dust.

Because of the lack of adequate emergency service for electric refrigerators, the local fire department is frequently called upon to handle gas leaks. For this reason fire department members should have a working knowledge of the mechanism in the ordinary electric refrigerator and understand the character of the refrigerants used.

It is hardly reasonable to expect that the fire department responding in such emergencies will be able to ascertain the cause and location of the leaks. Their efforts, of necessity, must consist mainly in safeguarding the occupants of the building. For this reason, it is suggested that the following procedure be adopted:

1. Upon arrival don a self-contained gas mask.

2. See that all persons leave the building.

3. Raise windows and open doors to the outside in order to air out the room.

4. Disconnect the electrical connection of the refrigerator to the house circuit.

Commercial Refrigerators - When fires occur in ice cream manufacturing plants, creameries and other similar occupancies, the chief chemical hazards are in the refrigeration systems. If involved in the fire, these may be a definite hazard to life. Most of the larger commercial refrigeration plants use ammonia, although several other refrigerants are in common use. Each has its special characteristics which make the fighting of fire in and about the refrigeration system difficult and even dangerous. Any of these common refrigerants in too great concentration will reduce the oxygen content of the air below the point where it can sustain human life.

The dangers encountered in fighting a well advanced fire in a building with an ammonia cold storage plant are:

1. The presence of ammonia in considerable quantities due to leaking pipes and tanks.

2. The possibility of ammonia tanks bursting under the high pressure created by heat.

3. The possibility of explosion of ammonia fumes.

Ammonia gas is not easily ignited, but may be explosive when mixed with air (explosive range 16% to 25%). The presence of hydrogen gas as an impurity in the ammonia, due to decomposition of the ammonia or lubricating oil used in the equipment, adds to the explosion hazard.

In the strategy of fighting such a fire, thorough ventilation is very important. Tanks, piping and steel cylinders containing ammonia should be wet down and kept cool. Keep the fire away from the tanks if possible. Where strong fumes are present, all firemen exposed should have self-contained gas masks and protective covering -- rubber garments, if available. Firemen should avoid low areas in the building as most of the refrigerating gases are heavier than air.

It is recommended that during the inspection of buildings having commercial refrigerator plants, the inspector ascertain the type of gas in order that the fire department may be able to cope with the situation when a fire occurs in the building.

LIQUIFIED PETROLEUM GAS FIRES

LP gas, sometimes referred to as bottled gas, is used for many household and industrial tasks today. Chemically, the chief constituents of LP gas are propane or butane or a combination of both. It is produced chemically from natural gas or from gases produced in refinery operations. Like other petroleum products, LP gas is hazardous, and firemen must exercise proper precautions and judgment in handling and combatting these fires.

When a cylinder, tank or other container is filled with LPG, the gas is in the form of a liquid so maintained by its own vapor pressure. If this liquid is spilled or otherwise released to the air it becomes a gas, and when the proper mixture with air is attained it becomes a potential fire hazard. By being under pressure when released from the container, it becomes a vapor readily. Such vapors are liable to spread over an area, be blown away by the wind to another area, and become subject to ignition at varying distances from the point of escape or spillage. Butane has a flammable range from 1.6% to 6.5% vapor in air, while propane has a flammable range from 2.2% to 9.5% vapor in air. In comparison, gasoline has a flammable range from 1.0% to 6% vapor in air. Thus, concentrations of LPG less than 1.6% in air are too lean to burn, and mixtures of more than 9.5% in air are too rich to burn. However, it should be remembered that LPG when released to the air gives off vapors at any temperature which when properly mixed with air will burn. The ignition temperature for propane is 871° F., and for butane 806° F., as compared with 500° F. for gasoline. However, other materials in the involved area which ignite at lower temperatures will ignite the vapors from liquified petroleum gas.

LPG contains no toxic components such as carbon monoxide; therefore, the vapors are non-poisonous. They are anaesthetic, however, when concentrations are inhaled over a considerable length of time. If breathed in sufficient quantities over a long period, the vapors will produce nausea, headache, and asphyxiation.

Another characteristic important in fire fighting operations is that LPG is two times heavier than air. Therefore, it will settle in lower levels and create a ventilation and/or ignition problem in a building or in a low spot in an outside area.

As LPG is odorless in its normal state, an odorizing agent is added to facilitate the detection of the gas by smell. Leaks from tanks, cylinders and piping can be detected by the odorant in the gas, the deposit of frost at the point of leakage, or as a mist in the air. The frost or mist is due to the condensation and freezing of the moisture in the air, since LP gases are refrigerants.

The basic precautions in any LPG emergency are:

1. Approach the fire or gas leak from the windward side.
2. Remove all persons in vapor cloud area.
3. Eliminate all sources of ignition.
4. Evacuate any area in the path of the vapor cloud.
5. Keep all civilian personnel at least 200 feet away from the emergency area.

A good LPG installation should be provided with a means for shutting off the supply of gas if a leak develops. If the gas is not on fire, any available valve should be closed which will stop the flow of gas. Most installations are provided with shut-off valves at the container. If a wrench is not available to turn the valve to shut off the gas supply, the tubing can be crushed or crimped tightly together. It is suggested that a wrench be carried on fire apparatus so that one will always be available at an emergency.

Water spray is effective in helping disperse LPG vapor. It should be used as quickly as possible by directing the spray stream across the normal vapor path and pushing the vapor into a safe area. Firemen handling the hose lines should avoid entering the vapor cloud and should keep low behind the spray so they will be somewhat protected from the radiant heat if the vapor should be ignited unexpectedly.

If it becomes necessary for firemen to enter an enclosure where gas vapors have been released, self-contained breathing apparatus should be used. Ventilation can be provided by using air movers and smoke ejectors, while small areas such as pump rooms can be effectively purged of gas concentrations by carbon dioxide. Combustible gas indicators should be used to detect flammable atmospheres in suspected

locations and areas. Sometimes when a tank is leaking and no fire is involved, it may be desirable to move the tank to some remote or isolated area or field away from sources of ignition where it can leak safely. However, if this is to be done, the tank should not be dragged in a manner which might damage valves or piping. Any attempt to right an overturned tank in order to move it to a safe or remote location should be done carefully to avoid damage to valves and piping and to prevent ignition.

Leakage of LP Gas Which is On Fire - In general, a LP gas fire should not be extinguished unless the flow of fuel can be stopped.

If the escaping gas is on fire, immediately apply water to all surfaces exposed to heat, approaching the tank from the sides. An LP gas container is so designed that if it is exposed to an adjacent fire, excessive pressure due to the heat of the fire will open a spring loaded relief valve, or the heat will melt a fusible plug to relieve the pressure. The relief valve is superior to a fusible plug because it will reset itself after a temporary pressure increase. It is possible for a safety valve equipped container to rupture. When flame impinges on a container above the liquid level, the metal weakens and eventually the tank may rupture. However, hose streams directed against the shell of the tank will cool the metal, reduce the pressure and may prevent rupture. Fog streams should be concentrated on containers, their piping, adjoining vessels, equipment and combustible surfaces exposed to flame or intense radiant heat. Heavy stream appliances, such as portable or fixed turrets or hose holders with large capacity spray nozzles are very desirable where continued application of large quantities of water is considered necessary. Do not use solid streams directly on the tank because the force of the stream may cause it to overturn.

If bulk storage facility is involved, the plant operating personnel should be consulted regarding the possibilities of shutting off the fuel supply. If a tank vehicle is involved in fire, stopping the flow of gas should be the first consideration. If the only valve which can be used to stop the flow of fuel is involved in the fire, consideration should be given to the possibility of shutting off the valve by protecting the firemen with water spray streams and protective clothing. This operation should be carried out with caution because of the possibilities of flashbacks trapping firemen in the flames.

The controlled burning of escaping LP gas (which cannot be shut off by closing a valve) is a commonly accepted practice. The application of sufficient water to keep the shell of the vessel and piping cool will allow the fire to consume the product in the tank without danger of the tank rupturing.

Dry chemical extinguishers are best suited for small LP gas fires, and they should be applied at the base of the fire.

A situation may arise where, even though large quantities of water are being applied to the tank, the pressure may be increasing excessively within the tank. This may or may not be accompanied by a bubble or blister forming on the tank shell. This pressure increase often can be noted by an increase in the volume of the fire or the noise level of the escaping gas. Any of these signs should serve as a signal to withdraw all men to a safe location.

Shooting holes in an LP gas tank that is involved in a fire does not serve any useful purpose and should not be permitted.

There is no known material or method that will extinguish a fire in a large quantity of LP gas. Such fires are impossible to blanket, and, unless the fire is small, it is difficult to dilute the air sufficiently to starve the fire to extinguishment. Therefore, in case of a large LP gas fire, if the source of fuel cannot be cut off, the chief concern should be to keep the tank and other exposed equipment as cool as possible and prevent the spread of the fire.

Serious Exposure of LP Gas Equipment From Adjacent Fire - It is always important that any exposure fire be controlled. In the event that LP gas storage vessels or equipment are subjected to serious fire exposure, such as from a nearby burning building or fire involving another fuel, sufficient water should be applied to cool the shell of the LP gas vessel and the piping to prevent or reduce the release of LP gas.

If the LP gas storage vessel becomes heated to the point of causing the relief valve to function, the discharge should be allowed to burn if it becomes ignited; or in some cases, it should be ignited so that it will not create a further hazard. At the same time, water should be applied continuously to the vessel and piping to keep it cool; this will reduce the pressure in the tank and the flame will burn out when the tank pressure is reduced below the set pressure of the relief valve.

Portable LP gas cylinders that are exposed to a serious fire should be removed to a safe location.

AIRCRAFT FIRES

The inherent fire and life safety hazards of aircraft fires complicate fire extinguishment with conventional fire extinguishing agents and methods because of the large quantity and type of fuel involved and the use of magnesium metal in the engine con-

struction and in various other structural and component parts.

Fire fighting in this respect is still in the exploratory stage as operational techniques and types of equipment are to a certain extent conflicting and debatable. Nevertheless, whenever an aircraft crashes, fire should be expected and efforts made immediately to prevent the fire from spreading, or in remote cases from starting. Because of the speed and impact forces involved, the fire will generally spread with exceptional rapidity and violence, making it mandatory that rescue work be performed almost instantly. From a limited series of tests it has been estimated that occupant survival time may range from 50 to 300 seconds in a serious crash fire. This period may even be shortened to 30 seconds where the flame travel is unimpeded within the cabin.

Because of the different techniques and special knowledge required in fighting aircraft fires, it is suggested that firemen, wherever possible, obtain additional information on this subject from air lines or the Air Force. Courses in fire fighting and rescue operations, which will prove beneficial in many ways, are conducted regularly by these agencies.

Firemen are familiar with the specialized equipment developed for handling these fires, which is used by fire departments at the larger air fields. However, it is more important that thoughts be directed as to how the equipment found in the average city or town fire department can be used in this respect.

From experience gained in connection with actual and simulated crash fires, it is judged that no single extinguishing agent is totally sufficient to do the job. Only when teamed with other agents can maximum efficiency be obtained. Each of the three more common agents -- water, foam, and carbon dioxide -- has its particular use and limitation. Their form and methods of application vary and, in some respects, greatly affect their efficiency.

Water applied in fog or spray form has been proven very effective in combatting aircraft fires and facilitating rescue work. It serves not only as an extinguishing agent but can be essential in providing a protective cover for rescue operations. Spray and fog nozzles are available for all sizes of hose and can be used in conjunction with local fire department equipment. The amount of water carried on a fire truck is, of course, limited; therefore, it will suffice for only a very short period of time. Consequently, auxiliary equipment, such as tank trucks and additional pumpers for relay work to pump from sources of supply, must be made available to provide additional water. This can be pre arranged on a mutual aid basis or as a coordinated area plan for emergency operation.

Foam, to be effective on aircraft fires, must be applied at a high rate of volume. Due to its structure, improper mixture, excessive pressure, and continued exposure to heat or water dilution, it may dissipate and break down the foam bubbles. As the principle effectiveness of foam lies in its smothering ability, the value of a foam blanket is lost when the cover is broken.

There have been many questions and discussions relative to the use of protective clothing in fighting fires involving aircraft. Most of these were concerned with comparisons between normal "turn out" or "bunker" clothing and special types of clothing of prefabricated, non-flammable or "heat-reflective" materials. As both faborable and unfavorable opinions have been submitted at meetings involving these discussions, it is suggested that further inquiry on this subject be directed to the following sources:

The National Fire Protection Association
60 Batterymarch Street
Boston 10, Massachusetts

The National Board of Fire Underwriters
85 John Street
New York 38, New York

In lieu of special equipment, paragraph 397 of the N.F.P.A. "Suggestions for Aircraft Rescue and Fire Fighting Service for Airports and Heliports" (N.F.P.A. #403 - May, 1960) recommends the following fire fighters protective clothing:

1. Bunker suit with heat insulating interliners for coat and trousers to afford full arm, body and leg protection, outer garment to be water repellent and flame resistant.

2. Protective gloves of chrome leather with heat insulating interliner and gauntlet wrist protection.

3. Standard firemen boots with wool lining.

4. Fireman helmet with plastic full vision face shield and front and neck protective aprons.

CHAPTER 19

VENTILATION

INTRODUCTION

Firemen must be aware that providing enclosed fires with proper and adequate ventilation is a very important factor in locating, controlling and extinguishing such fires.

All department members should keep ventilation constantly in mind. A thorough knowledge of ventilation principles will insure better working conditions for firemen and reduce loss of life and property.

DEFINITION OF VENTILATION

Ventilation, as used in fire fighting operations, means opening up a building or structure in which a fire is burning. Ventilation practices are performed to achieve three general results. These are:

1. To relieve the structure of accumulated heat, smoke and gases, thereby making entry possible.

2. To draw heat, smoke and gases up a selected channel, thereby preventing the spread of fire.

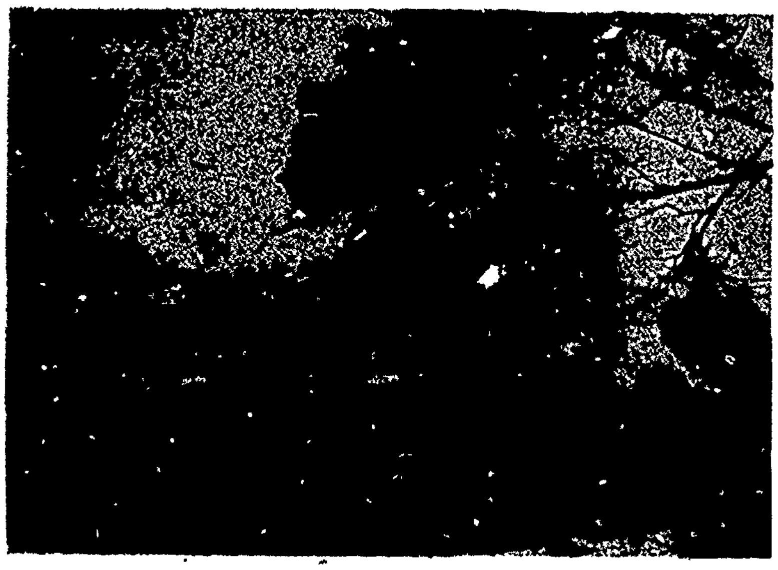
3. To safely remove accumulated heat, smoke and gases, thereby preventing explosion or "back-draft."

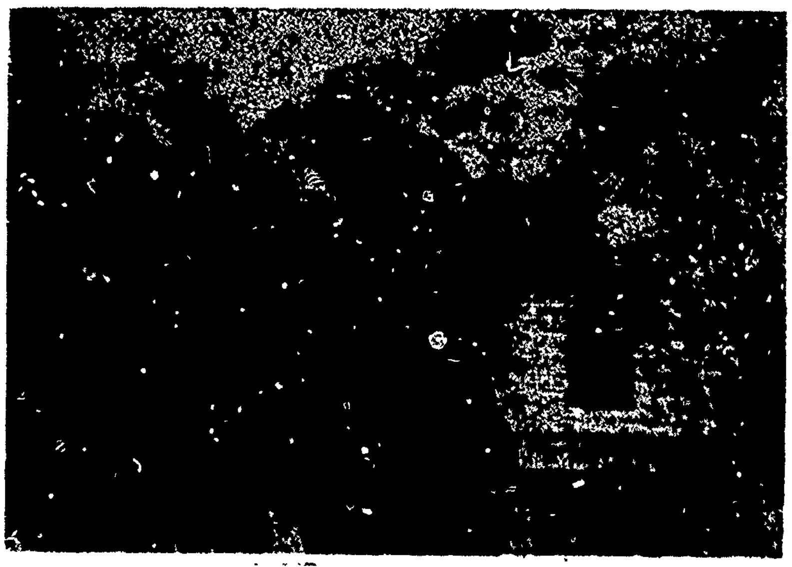
In scientific fire fighting there is no operation more important then ventilation. See Figure 1.

Many persons whose lives were lost at fires might have been saved if ventilation had been given the careful study it should have received from fire department members who were responsible for extinguishing fires. If ventilation is carefully studied and efforts are made to put the results of this study into practice, losses at fires will be greatly reduced. While ventilation itself does not extinguish fires, when properly used it allows firemen to get at the fire more quickly, easily and with less danger and hardship. Many times in the past, after making strenuous efforts through smoke and heat, a fireman has reached the seat of the fire only to find that the area involved was small and a large amount of damage had been done by water thrown indiscriminately at the smoke in the hope that some would reach the fire.

A few years ago, ventilation was ignored by the majority of fire departments because they felt that ventilation meant "draft" and draft meant more work and loss. The hazards to the firemen were accepted as a matter of course and a part of the disagreeable job of fighting fires.

The modern fire department has taken an absolute





Courtesy Columbus, Ohio, Fire Department

Fig. 1 – Good and Poor Ventilation

about face, and ventilation is considered the very backbone of its job of stopping fires. Departments have found that ventilation can make their job less disagreeable and remove much personal hazard that their predecessors had to accept as inevitable.

WHAT IS SMOKE?

Smoke is a mixture of gases and fine particles of carbon resulting from incomplete combustion due to insufficient oxygen in the atmosphere. When there is dense smoke there is usually little fire. Free burning results in little smoke.

WHAT IS BACK DRAFT?

Back draft is an explosion caused by the admission of ordinary air, bearing oxygen to a fire which has not been burning freely. Such a fire usually generates a large accumulation of highly heated flammable gases which are deficient in oxygen content. When oxygen bearing air is admitted below the fire, the gases flash and expand explosively.

Back drafts must be considered every time a fire is approached that apparently has been smoldering a long time. Observable conditions are a sort of greyish-yellow smoke, a pulsating pent-up heat, or smoke pouring out of an opening and then being sucked back in rapidly. If a back draft is suspected, immediately get down on your stomach; then, should the explosion occur, it will probably pass over you.

Conditions existing inside a building before ventilation are: The interior is filled with smoke, heated air and unburned gases which accumulate at the top and mushroom. Seepage air is usually sufficient to prevent fire from smothering out but combustion will be incomplete and will result in the formation of carbon monoxide and other dangerous and disagreeable gases.

When a building is ventilated, smoke, hot air and gases are removed. Free burning and rapid combustion will follow. The fireman should be ready to meet this situation.

When a building is not ventilated it will eventually ventilate itself, and heat will continue to be generated and high temperatures will be attained. The probability is that hose streams directed into the building will not reach the actual fire because of poor visibility. Therefore, unnecessary water damage will result.

ADVANTAGES AND DISADVANTAGES OF VENTILATION

The manner in which ventilation may aid in fighting fire is as follows:

1. Proper ventilation helps prevent "back draft" or "smoke explosion." When the doors or windows in the lower floors of a smoke and gas filled building are opened, oxygen is permitted to enter but gases are not permitted to escape. *In this case, the building having been opened from below, the smoke and gases, being lighter than air, have risen to the highest point in the room or building.* The addition of oxygen will soon bring this mixture within explosive range and an explosion is likely to follow. If proper ventilation is practiced by opening *above* the fire, these heated gases are permitted to escape and pressure is reduced below the danger point. The incoming fresh air and steam vapor from below, then, instead of mixing, tend to force the smoke and gases from the building, thus eliminating the danger of an explosion.

2. Ventilation permits one to promptly locate the seat of the fire. This is essential to quick extinguishment which is virtually impossible in a smoke filled building.

3. Ventilation makes it possible for firemen to promptly search the premises for victims and engage in rescue activities.

4. Ventilation reduces the possibility of excessive water damage as the fire may be promptly located and extinguished.

5. Ventilation reduces unnecessary smoke damage in sections not otherwise involved.

6. It permits prompt and effective salvage operations.

7. It shortens the actual work at a fire; therefore, fire companies can return to quarters more promptly.

Ventilation reduces the hazard of having the fire fighting force incapacitated by asphyxiation, sickness or injuries to its personnel.

9. It removes the biggest source of unpleasantness of the fireman's job - encountering smoke and dangerous gases.

DISADVANTAGES OF VENTILATION

With reference to disadvantages there is only one drawback, and that is not a legitimate one because its elimination lies within the province of the fire department. However, this drawback should be considered as the practice of ventilation is bound to bring some criticism. Most of the criticism will come from people who are not familiar with fire department problems and cannot see any relation between a basement fire and a hole in the roof. This ignorance can be partially eliminated if the department will make an effort to educate the public in the reasons for ventilation. This can be done through public gatherings, newspapers and by frequent public fire department demonstrations.

Criticism will also be brought on by unexpected and disastrous results due to improper ventilation. This can be largely eliminated by proper training and size-up.

HOW TO VENTILATE VIA ROOFS, WINDOWS AND BASEMENTS

FLAT ROOF

Before going on a flat roof to ventilate, the fireman should make [illegible] of a way to escape, as by the ladder or adjace[illegible]lding. If the roof is springy, a ladder should be [illegible]ced flat on the roof to distribute the fireman's weight over a larger area. The direction of the wind should be noted and he should work from the windward side, with his back to the wind.

Roof skylights may be lifted off and need not be broken. But they often have a lower frame of glass which must be opened or broken so the heated gas and smoke can escape. If no skylight or scuttle-hole can be found, it may be necessary to chop a hole in the roof. The proper place to cut the opening can be found by looking for blistered spots or by feeling for hot spots with the ungloved hand.

When chopping a hole, make a good sized one. If two men are working, they should work from diagonally opposite corners. Cut through the boards and lift them out without pulling long splinters back into the roof. Be sure to check for a false ceiling below and punch through it if necessary. Do a neat job.

PITCH ROOF

Ventilating a building with a pitched roof differs in method from a flat roof as the opening must be made, in most cases, at the highest point of the roof, but slightly below the ridge row. As a safety problem is created while cutting, the fireman should work from a roof ladder and a Rodger rope tool should be used for added safety.

In dwellings, the opening of dormer windows or louvers may eliminate the necessity of cutting a hole in the roof. If it is necessary to open the roof, firemen should work from the windward side if possible. *Warning* – Firemen should not go upon any roof to ventilate if there is any doubt about its safe condition.

WINDOWS

Do not open windows indiscriminately on all sides of the building. Note the direction of the wind and work accordingly. Open windows on the lee side first. Open the windows starting from the top floor. If it is necessary to break windows, use an axe or pike pole and not your helmet, hand or foot. Do not break large plate glass windows when desired results can be obtained by breaking adjacent smaller panes.

The top sash can be lowered all the way. A good rule, however, is to lower the top sash two-thirds and raise the bottom sash one-third. Top floor windows can sometimes be opened from the roof with a pike pole.

BASEMENT

In the problem of heat and smoke dissipation, basements are harder to ventilate than any other part of the building because heavier, unheated air cannot be admitted from underneath, but must enter from a level with or above the fire.

There are several types of basement windows. Some swing open from the top, others from the bottom or sides. Some have small catches and can be easily pried open and others are bolted on the inside and require the center pane of glass to be broken before the hand can be inserted to unlock the bolt. Knowing the different types of basement windows will be of great aid and prevent unnecessary breaking of windows when ventilating. All men should carry a small wooden wedge to hold opened windows in position.

Ventilating through basement windows only is a slow process as the incoming outside air and the inside heated smoke and gases must pass through the same window. Perhaps the hottest and smokiest part of the basement is at the stairway entrance since this is the highest point and it is here that the heat, smoke and gases will rise and accumulate. If the entrance leads to the outside and is opened along with the windows, ventilation will proceed much faster.

Heat, smoke and gases from the fire rise to the ceiling or on the underside of the floor above and build downward. Generally, from knee high to the floor is fairly clear and firemen are protected once they have gained floor level, especially if they are near an open window. Here, the heavier outside air will descend to the floor, force the lighter, heated smoke and gases away and clear a portion of the basement near the window. Entrance to basements may be made through windows and good protection found at floor level even when heavy smoke is issuing through the same window. A smoke ejector placed in a basement window on the lee side will be of great aid in pulling the smoke out.

HAZARDS, CONSEQUENCES AND WARNINGS PERTINENT TO VENTILATION

HAZARDS

The hazards involved in ventilation are:

a. Opening below the fire

b. Too soon

c. At the wrong place

d. Insufficiently or too long delayed

e. Life hazards to firemen

f. Involvement of exposed buildings

POSSIBLE CONSEQUENCES

The possible consequences are:

a. Danger of back draft or smoke explosion

b. Ventilation ineffective

c. Poor preparation for attack

d. Increased or excessive loss

e. Entire building involved, or spread of fire to other buildings with resultant excessive loss

WARNINGS

Warnings in connection with ventilation are:

a. Ventilation should not proceed until lines are laid, charged and ready for the emergency.

b. Ventilation should never be practiced where it jeopardizes exposed property until adequate steps have been taken to protect such property.

SUGGESTIONS FOR VENTILATION

As has been stated before, the problem of ventilation varies greatly with the individual building, and no hard and fast rules can be laid down to govern its practice. However, a few basic principles can be discussed, and some common mistakes can be noted and analyzed.

VERTICAL VENTILATION

Building With One Shaft - Take the example of a three story building having a flat roof, a blind attic and an open shaft through all the floors at its north end. In the event of a smoldering fire at the south end of the first floor, smoke and gas will rise to the ceiling, travel north to the shaft, go up the shaft to the ceiling of the top floor, and mushroom out. Thus, it can be seen that the third floor will be the first to be dangerously charged with smoke and gases. After the third floor is filled, the smoke will back down and load the second floor, and after that, the first. It is obvious, therefore, that the most dangerous point is the third or top floor, as illustrated in Figure 2.

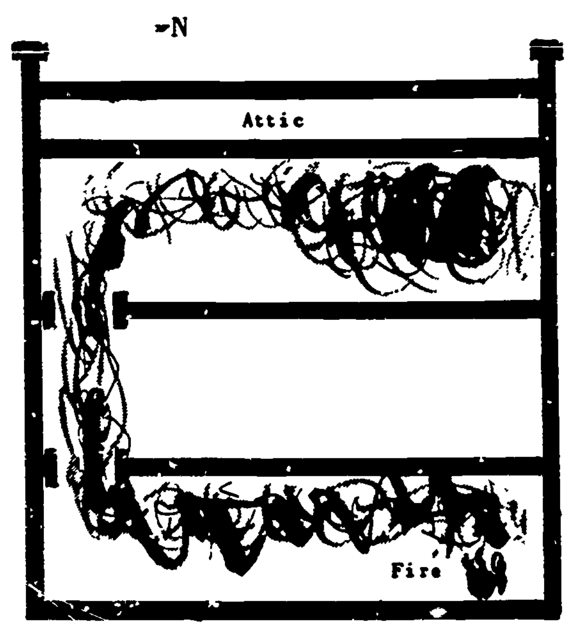


Fig. 2 – Travel of Gas Before Ventilation

In ventilating this building, the proper point at which to open the roof is directly over the shaft; be sure to use a pike pole to break down the ceiling below. Observe Figure 3.

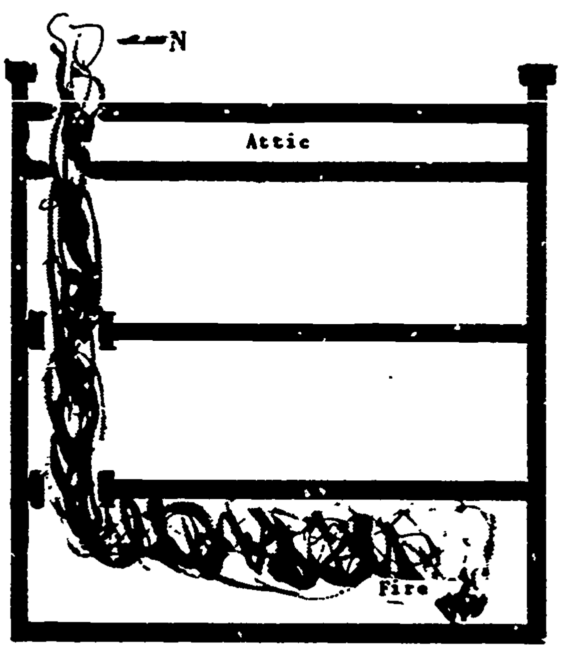


Fig. 3 – After Ventilation

This illustrates one case where a knowlege of building construction is highly essential. Many ventilation attempts have been failures due to the unknown presence of a false ceiling below the roof. When you are not familiar with the building, a pike pole should always be used to make sure a false ceiling does not exist.

Now, in the case of Figure 4, it can easily be seen that fast ventilation cannot be obtained by opening the roof at the south end of the building. Furthermore, should a flash fire occur in the mixture of gases, it is evident that the fire would be drawn from the shaft at the north end and across the floor to the roof opening at the south end. Thus, the entire third floor will be involved in fire, where, if the roof is opened over the shaft, the fire will go out through the roof directly at that point. It should also be noted that ventilation at the south end would draw smoke across the third floor, adding considerably to the smoke damage of the contents even with no occurrence of flash.

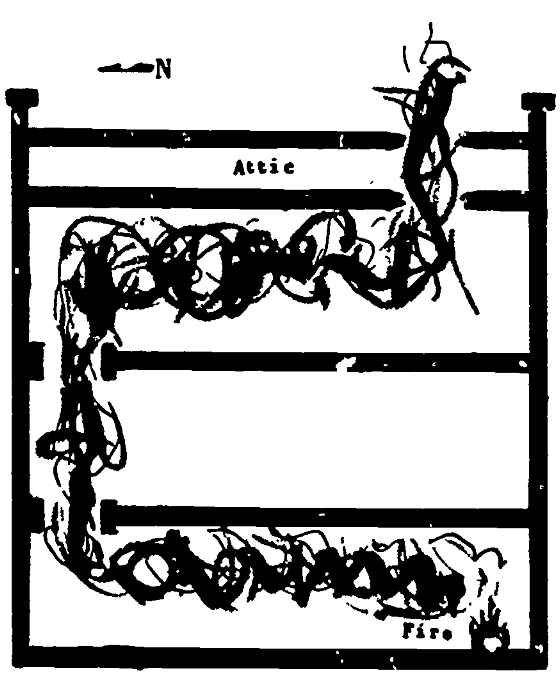


Fig. 4 – Wrong Ventilation

Building With Two Shafts - An important thing to keep in mind is the action of smoke and gases when there is a second vertical opening in the building.(Figure 5) The logical point to ventilate in Figure 5 is, of course, above the shaft. Under ordinary atmospheric conditions the bulk of the smoke will follow the course indicated by the heavy arrows. But atmospheric pressure will force some fresh air down through the opening, thus restricting its size as an outlet for smoke. The same fresh air will have a tendency to force the smoke up the stairs at the opposite end of the building (Figure 6). In the case of a pronounced slope in the roof, a second opening over the stairs will reverse the flow and, as the shaft is the larger, will make for better ventilation.

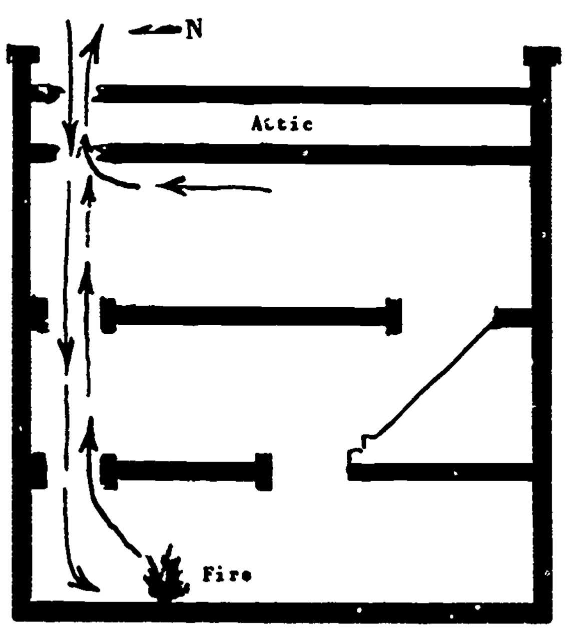


Fig. 5 – Building with Two Shafts

However, the extreme importance of previous inspections is obvious with the realization that a single stair enclosure, a partition, stock piled to the ceiling, an elevator regularly left nights at the second floor level, or any one of many other circumstances can completely upset the ideal ventilation picture. Easily imagined are many variations in construction that can change the ventilation procedure.

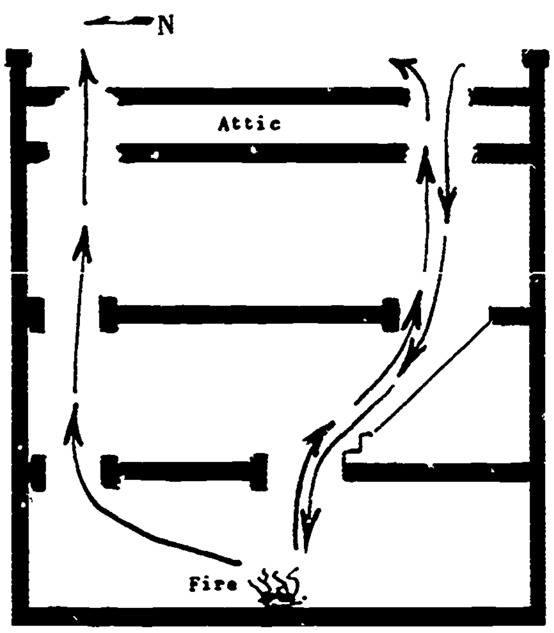


Fig. 6 - Proper Ventilation of Building with Elevator Shaft and Stairwell

CROSS VENTILATION

While direct, vertical ventilation is most satisfactory where possible, there are cases where cross ventilation is better. As an example, assume this same building as having only a stairway with the stairs staggered at opposite ends of the building as shown in Figure 7.

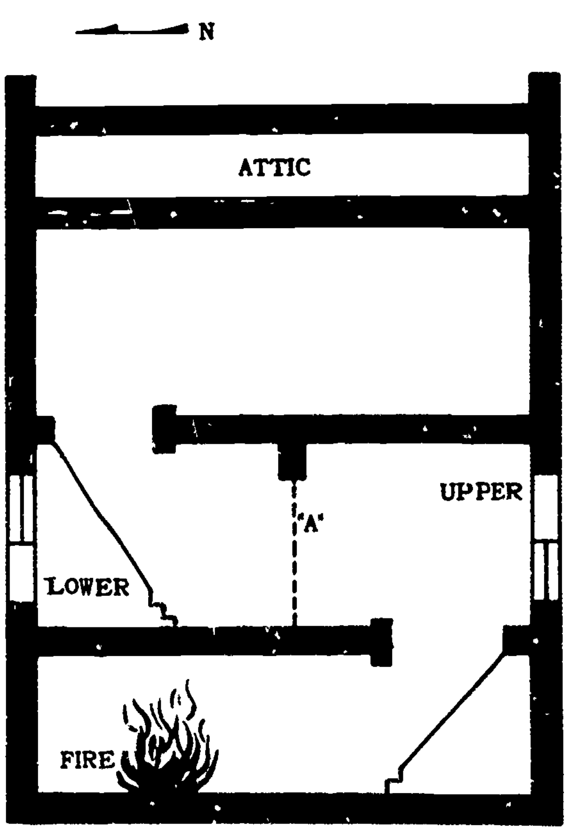


Fig. 7 - Building with Staggered Stairwells

This would be a case for cross ventilation on the floor above the fire floor by opening the lower window sash on the north side and the upper sash on the south side. If there should happen to be a partition at "A," then, if possible, the lower sash should be opened on the east or west sides (with the wind) and the upper or south side. In any event, lines should be laid and ready to prevent the fire from extending to the floor above the fire.

If possible, smoke ejectors should be used in cross ventilation and should be placed on the lee side of the building to pull the smoke out.

Some firemen believe that opening a roof above a vertical shaft will cause the fire to spread rapidly to the contents of the intervening floors. The fact is, that in the absence of severe cross drafts, the spread on intervening floors is retarded. See Figures 8 and 9.

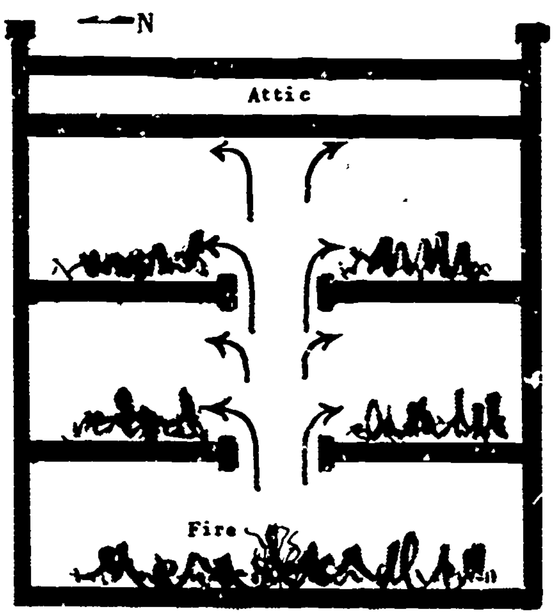


Fig. 8 - Burning Before Ventilation

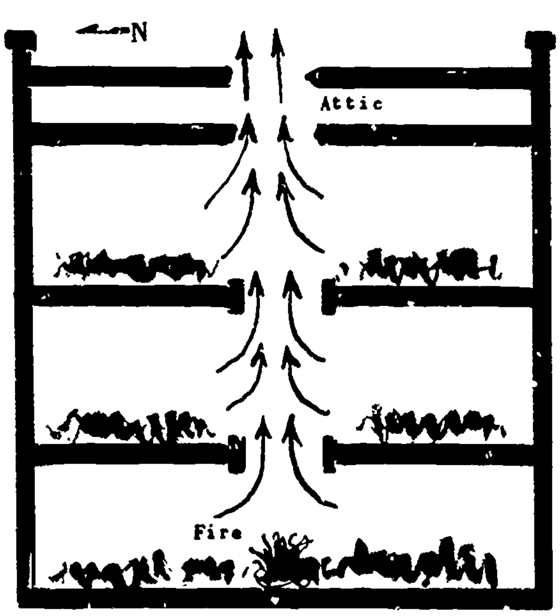


Fig. 9 - Burning After Ventilation

This is due to the fact that, while flammable material near the shaft may ignite, the spread of fire away from the shaft will be slowed down by the draft pull of the venting smoke rushing up the shaft.

In Figure 8, excelsior on the upper floors will ignite from the fire on the first floor and freely burn to the sides. In Figure 9, the excelsior will ignite but, with roof ventilation, a severe updraft condition will develop that will retard burning toward the sides of the building.

SUMMARY

No department can fight fires intelligently or effectively without practicing ventilation. Furthermore, no department can practice ventilation with reasonable success without preceding their fire fighting with thorough inspections of the properties under their jurisdiction.

The knowledge gained from thorough inspections, coupled with good judgement in its application, will make ventilation the keystone of successful fire fighting in any modern, properly equipped fire department.

The question is often raised as to the necessity for ventilation at residential fires. The answer is simply this: Wherever fire is unseen and the building is heavily charged with smoke, ventilation is not only desirable but highly advisable. Severe back drafts have occurred in residential fires and excessive water damage may result because the building was not ventilated.

However, keep in mind that residences can generally be ventilated successfully by opening dormer or upper floor windows. If a fire is in evidence, it is rarely necessary to start ventilation immediately. But it is generally necessary to follow up with ventilation to prevent excessive smoke damage, to facilitate salvage operations and to be sure that the fire has been entirely extinguished. The point to be made clear is that ventilation is not always necessary at the actual location of the fire, but it is highly desirable in conjunction with the various other necessary operations.

The following principles and suggestions should be carefully studied:

1. In order to effectively ventilate a public, commercial or apartment building, it is necessary to have a good mental picture of the building and its interior. This knowlege should be obtained prior to the time of fire through systematic surveys, studies and inspections.

2. Know the chemistry of fire, particularly the travel of heated gases, drafts, etc.

3. Firemen must be reasonably familiar with the type of occupancy, the nature of the contents, and whether the contents are of a fast burning or smoldering nature. Whether or not there is anything in the building of an explosive nature or capable of producing toxic gases in any quantity must also be known.

4. Firemen must have a first hand knowledge of exposures and the contents of exposed buildings. This includes information as to wall construction, roof construction, parapets, wall openings, exposed penthouses, etc.

5. Firemen must be well trained in the use of fire department tools so that any job of ventilation will present a workmanlike appearance and not look as though dynamite had been used to make the necessary opening.

6. Firemen should ventilate directly above the fire if possible. Open penthouses, lift off or break skylights, cut a hole in the roof if necessary, open doors or windows, make openings in ceilings, walls or floors. Be careful not to draw the fire into the unaffected parts of the building.

7. Ventilation should be delayed when an indirect application of fog stream is being used to extinguish the fire. The extinguishment will be aided and the stream will force gas and smoke from the building.

8. Ventilation should be given proper and careful consideration in making the size-up.

9. Ventilation should not be started until sufficient lines are laid, charged and everything is in position to attack and confine the fire.

10. Firemen must realize that mistakes made in ventilation may be disastrous, and that one of the most important factors is good judgement.

CHAPTER 20

SALVAGE

INTRODUCTION

If the definition of salvage were to be looked up in the dictionary, it would be found that it means "saving property." From this definition, it can be safely assumed that salvage should be given serious consideration by every fireman from the time of size-up until the fire is extinguished and the buildings and contents have been given proper care.

The realization that a large percentage of fire loss is actually a water and smoke loss has resulted in an effort, on the part of those in fire fighting to improve loss records by reducing water and smoke damage. Fire department officers and men are learning to extinguish fires in a systematic and scientific manner, thereby reducing to a minimum the losses incidental to extinguishing fires.

Efficient workmanship in forcible entry, ventilation and almost every job in the service is as much a part of salvage technique as the spreading of covers. By doing a good job in salvage, every fire department, regardless of size, can reduce fire loss, secure the good will of the citizens, and gain personal satisfaction that comes with a well-executed job.

One of the more important jobs in connection with salvage is that of making thorough inspections of the property before the occurrence of fire. An inspection will give the department specific knowledge as to the value of stocks, which stocks are easily damaged, those particularly susceptible to smoke and water damage, location of important records and delicate machinery, location of floor drains, scuppers, elevator and stair shafts, and a large number of other items important in salvage operations.

SALVAGE EQUIPMENT

The following is a list of tools and supplies useful in salvage operations. Each department can add to or pick from this list of items that meet their local conditions or requirements:

Sprinkler heads	Sponges and chamois
Sprinkler stoppers (or tongs)	Roll roofing paper
Crow bars	Augers
Pike poles	Sawdust
Claw hammer	Portable lights
Nails (roofing and assorted)	Skids
Scoop shovel	Saws
Brooms (regular and wire)	Pipe wrenches
Gas and water keys	Hasps and locks
Buckets and tubs	Screw drivers
Forcible entry tools	Runners
Salvage covers	Mattress hooks
Debris bag	Deodorant
Bath towels	Wood lath
Squeegees and mops	

Many of these items can be found at the scene of the fire or at neighboring buildings.

Sprinkler heads and stoppers are necessary in salvage work where sprinkler systems are encountered in fire fighting. The stops are for temporarily controlling the flow of water from a released sprinkler head until the system can be turned off, after which new heads can be installed. The carpenter's claw hammer and an assortment of common and roofing nails are essential in salvage operations. They are frequently used for securing salvage covers against walls to protect wall cases and places where covers would not stay in place without being fastened.

A plentiful supply of roofing nails is necessary for securing roll roofing over holes in roofs and

places where roll roofing can be used to protect the contents of a building from the weather. Wood laths or wood strips of a similar size are valuable for fastening roofing paper over doors, windows and roof openings. A scoop shovel is useful in salvage operations for the removal of water and debris from floors and cleaning up and overhauling after a fire. A broom is also useful in salvage operation. It is invaluable for sweeping water and light debris. With it water can be swept from the floor into scoops, thence into buckets or tubs, and carried from the building. The wire broom is more suitable for sweeping heavier debris.

Squeegees and mops are in such common use that they need not be described. They are used for removing water from floors and places where water would cause damage. Sacks of sawdust are used to absorb water from floors and to create dams to keep the water from spreading over a larger area. Sponges, towels, and chamois are useful in salvage work. When cleaning up after fires, covers should be removed and merchandise and furniture carefully wiped and dried to prevent water damage. Sponges can also be used for removing surplus water from hard to get at places.

Roll roofing, at least one roll, should be available for covering openings in buildings caused by fire or cut for ventilation. Salvage covers may also be used for this purpose.

Water buckets and tubs are used extensively in salvage work for catching and carrying water from buildings. Augers can be used to good advantage in drilling holes to drain water.

From three to four floor runners can be made from one old or defective salvage cover cut lengthwise at the seams. Each runner will be about four feet wide and eighteen feet long. They can be used on floors, stairways or over carpets when needed. In placing, they should be lapped to provide a continuous protected path when operating inside buildings. The proper use of this equipment on floors, stairways or carpet will prevent a great deal of damage caused by tracking water, plaster or other debris.

Mattress hooks, Figure 1, make a mattress secure after it is rolled as an aid to removing it from the building.

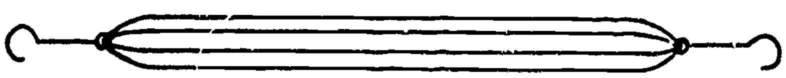


Fig. 1 - Mattress Hook

SALVAGE WORK DURING THE FIRE

a. Throw runner to protect floor

b. Place salvage covers to protect furniture, stock, fixtures, and machinery from water and falling debris

c. Use salvage covers to bag the floors

d. Divert and remove water from building

e. Protect the contents of the building from vandalism

DEBRIS BAG

A debris bag is a container used to carry debris from the building. It is made of waterproof material that is six feet by six feet in size, has 16 grommets and 26 feet of 3/8" rope. See Figure 2.

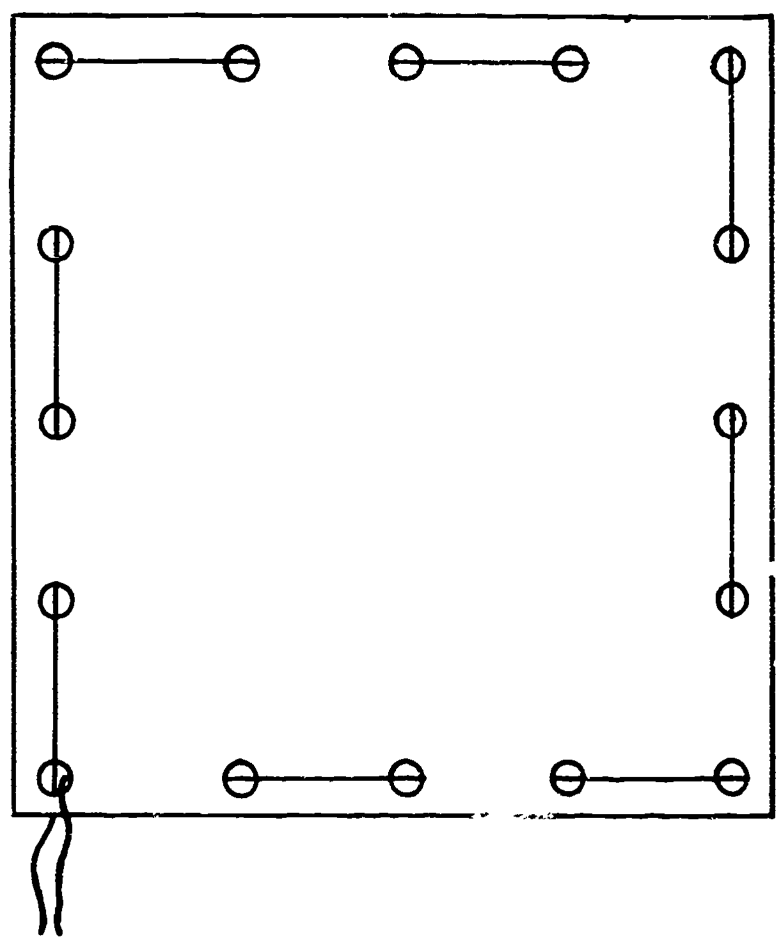


Fig. 2 - Debris Bag

The bag is laid out on the floor as shown in Figure 2, and the debris is placed in the center. The rope is then drawn through the grommets and pulled tight to form a bag. See Figure 3.

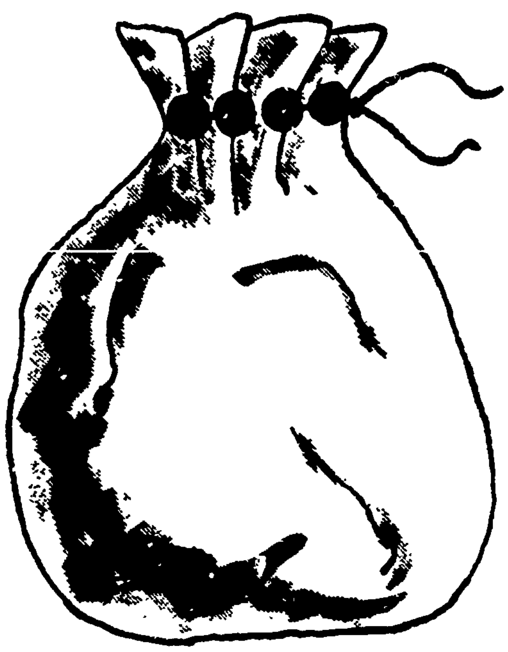


Fig. 3 - Folded Debris Bag

REMOVING MATTRESSES FROM BUILDING

After the fire has been extinguished at a mattress fire, the mattress should be rolled tight and mattress hooks be put in place. The mattress is then wrapped in a salvage cover and carried from the building. This will eliminate the possibility of getting water, fire or dirt in non-involved areas of the house. After the rolled mattress has been carried out, it must be overhauled.

SALVAGE COVERS

TYPES AND SIZES

In fire department operations, a "salvage cover" *is a waterproof tarpaulin of convenient size for covering materials, equipment and furnishings of the involved property.* Salvage covers, varying in size from 9' x 12' to 14' x 18', are used with the latter size being generally preferred. The materials used in the construction of these covers are as follows:

1. Rubber covered (Coated on *both* sides).
2. Rubber covered (Coated on *one* side only).
3. Duck or canvas (Treated with a linseed oil compound).
4. Closely woven canvas (Specially treated).
5. Plastic material

There are differences of opinion on the use of these various types of covers. All agree, however, that a salvage cover should shed and hold water under a reasonable amount of pressure when "bagged".

From the standpoint of being water tight the rubber cover is best. However, this type of cover is about 25 per cent heavier than the better grade of treated canvas covers and has a tendency to slip from shelving and high piles of goods. Also, they are not as well adapted to bagging by rolling the edges. Some grades of canvas covers, when exposed to high temperatures, become soft and sticky and remain in this condition. In other cases, they may become brittle and crack.

The disadvantage of even the best grade of canvas covers is that they leak under pressure after extensive use. This is partially due to the wearing away of the water-proofing solution on them. They are also more difficult to patch and to make waterproof. The duck-type cover treated with linseed oil sheds water but has a tendency to become sticky in warm weather and stiff when cold.

The disadvantages and advantages of the best grades of rubber covers and canvas covers are evenly balanced when used in departments performing constant salvage service. However, for small fire departments which do not do a great deal of salvage cover work, the closely woven, treated canvas or plastic cover may be preferred because of lightness and ease of handling.

FOLDING AND CARRYING COVERS

There are several different methods used in the folding of covers. Which fold is best adapted to a certain department is entirely a matter of opinion. Four of the most common folds used in the majority of departments are:

A. The "one-man throw" fold

B. The "two-man throw" fold, commonly called the "underwriter's fold."

C. The accordion fold

D. The salvage cover roll.

Some departments prefer to keep the seam side of the cover clean. This is known as the salvage side and should be used on the salvage side of the fold.

The "One-Man Throw" Fold - This fold cannot be operated as rapidly or as easily as the "two-man throw" fold; but when man-power is limited, it works to a great advantage.

To fold, place the cover in a flat position on the

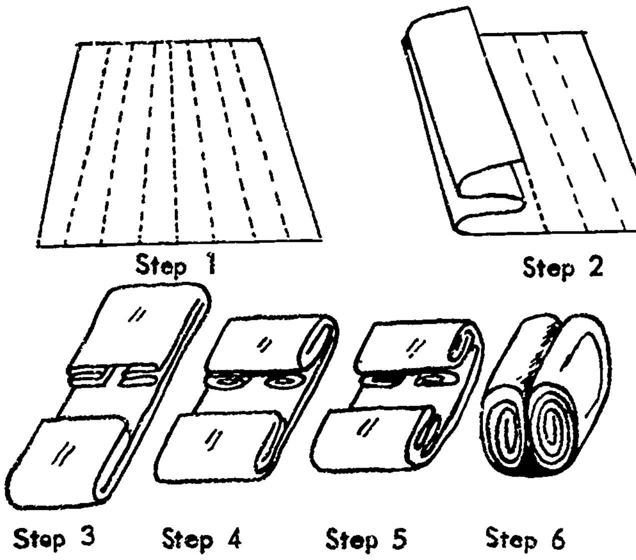


Fig. 4 - Steps for "One-Man Throw" Fold

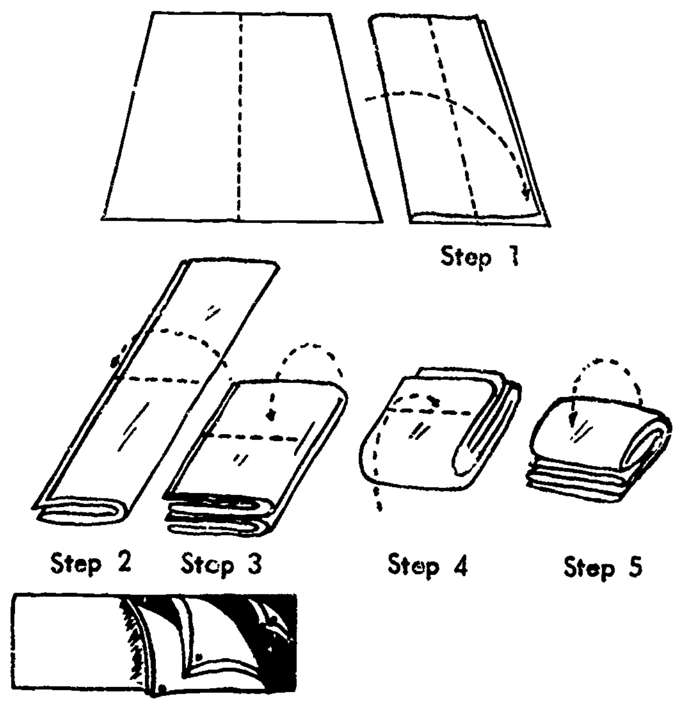


Fig. 5 - "Two-Man Throw" Fold

floor with two men at the center on opposite ends. By sighting, each half of the cover is divided into quarters; see Figure 4, Step 1. Place the hand closest to the center at the quarter mark nearest the center. With the other hand, make the fold toward the center. Remove the hand that was holding the quarter mark and place it on top of the fold. With the other hand bring the edge to the center; see Step 2. The same procedure is followed for the other half.

Next, fold each lengthwise section to within four inches of the center; see Step 3. This is to lay one-half directly on top of the other. Steps 4, 5 and 6 illustrate the steps to be followed in completing this fold.

The "Two-Man Throw" Fold - Spread the cover with the top side up on the floor. Starting at the cover's short side, each man grasps the cover at the center, lifts it, shakes out the wrinkles, swings it to one side and lays it into position on the floor; see Figure 5, Step 1. Each man then grasps the open edges and folds same over to the folded edges; see Step 2. One or both men grasp one end of the folded cover and fold it over to just short of the other end; see Step 3. Continue this folding, Steps 4 and 5, always grasping the open end, bringing this end over just short of the folded end, until the desired fold is completed. With this fold it will be found that all four corners of the cover are together and near the center. This is an important factor in throwing the covers.

The Accordion Fold - To make the accordion fold, spread the cover on the floor with the salvage side down. Then the four corners are folded to just short of the center as in Figure 6, Steps 1 and 2. Then each half is again folded to just short of the center as in Step 3. At this point, the accordion fold begins.

Two men, facing each other at each corner on the same end of the cover, place their outside hands, palms down, about eight inches in from their respective edge. Each then places the other hand about eight inches from the first hand, palm up, underneath the cover and brings the inside hand up and over, making the accordion fold. Care should be taken to keep the folds even as shown in Step 4.

Repeat this operation until the cover is completely folded. The one handicap of this fold is that it is so easily unfolded. Care must be taken not to drop such a fold or its whole effect will be lost.

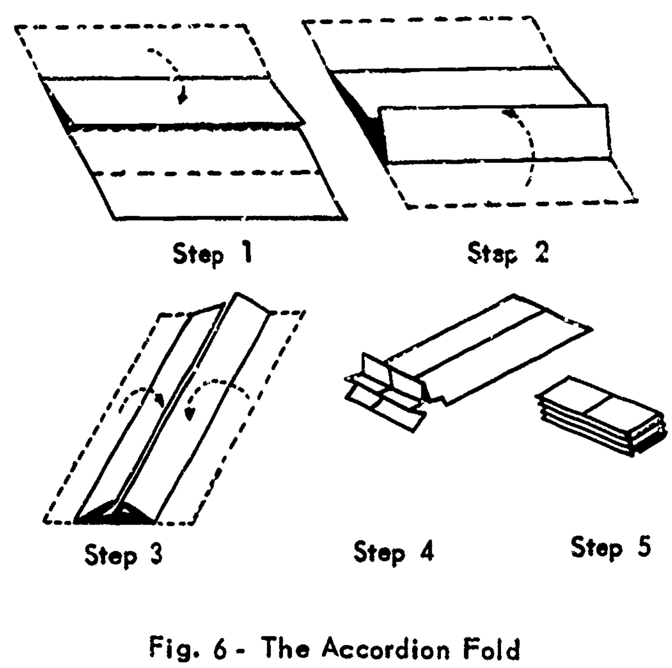


Fig. 6 - The Accordion Fold

The Salvage Cover Roll and Double Roll - This roll is popular in some sections of the country. It can be used by one man and will not become disarranged if a rubber band from an automobile inner-tube is placed around the roll.

The salvage roll is made up in the following manner: The cover should be placed on the floor. Both edges are brought to the center as in Figure 7, Step 1. Both long edges are again brought to the center as in Step 2. This results in the cover being one-fourth the width.

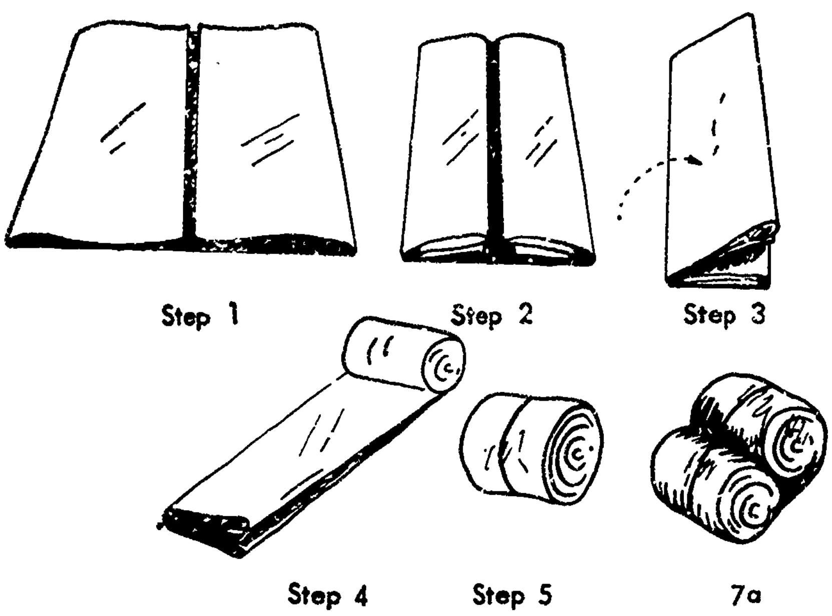


Fig. 7 - The Salvage Cover Roll and Double Roll

At this point, one outside edge along the length of the cover is folded over to the other edge as in Step 3. The folded strip now has an area the length of the entire cover and only one-eighth the width. It is next rolled from one end as tightly as possible as in Step 4. When completely rolled, secure with a rubber band as in Step 5.

The double roll is folded in the same manner as the salvage roll, but both ends are rolled to the center. Figure 7a illustrates the proper method to follow in making this roll.

THROWING AND SPREADING SALVAGE COVERS

"One-Man Throw" - In using the "one-man throw" fold, the cover is placed at the center of the object and then merely unfolded over and around the object. This is done by grasping one end of the cover at the center and walking backwards until the end of the cover is reached. The other end is likewise unrolled and the edges then unfolded over the sides.

If the accordion fold is used, it can be thrown but not ballooned by one man. The folded cover is supported on the forearm and several top folds are grasped with the other hand. Pulling the folds off and back, the cover is thrown over the object to be covered, as in Figure 8. The cover then must be unfolded over and around the material.

Fig. 8 - Throwing the Accordion Fold

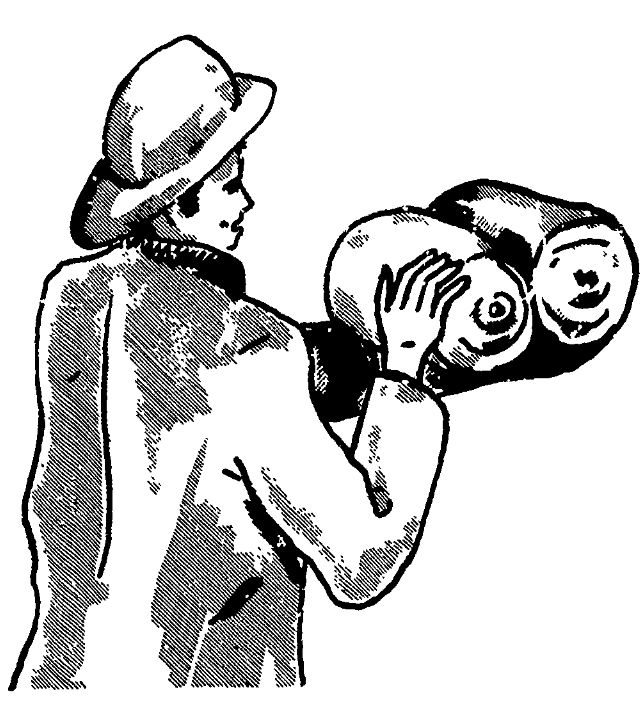


Fig. 9 - Throwing the Double Roll

If the double roll is used, one of the rolls is held in either hand and the throw is made with a "shot-put" motion as shown in Figure 9.

When using the single roll, the left hand grasps the free end, which should be down and towards the fireman. The cover is unrolled by retaining the hold on the free end with the left hand and throwing the roll with the right arm by an under-hand pitching motion; see Figure 10. If desired, the roll may also be thrown over-hand. After it is unrolled lengthwise, the edges are easily unfolded to cover the object.

Fig. 10 - "Pitching" the Single Roll

"Two-Man Throw" - The man holding the cover takes the two bottom corners and the other man takes the two top corners; see Figure 11.

At this point, the men, working together, take a few folds in the hand easiest to operate and move apart, pulling the cover tight to take up sags. The cover is now ready to be thrown.

Fig. 11 - Preparing to Spread Cover

Fig. 12 - "Ballooning" the Cover

To balloon the cover over the objects, proper drills and practice are necessary to make the operation effective. The cover must be thrown in such a manner that the air under the cover will help support it until it is in place over the material to be covered. See Figure 12.

After the cover has been thrown over the material or object, the edges and ends may be tucked in around the bottom or built into a chute to drain off water into another chute or catch-all.

REMOVING SALVAGE COVERS

In removing covers from material, extreme care should be taken to prevent damaging objects which have been covered, or the whole purpose of the salvage operation will be nullified. In removing covers, start with the corners and fold or roll the cover off. Do not drag it off. These covers should then be carried (not thrown) out of the building.

COVER WORK AT FIRES

Consideration as to the amount of water necessary to extinguish the fire and subsequent fire fighting procedures are of vital importance in determining the cover work. Should it be decided that the water can be controlled on the floor below the fire, that floor should be "bagged."

If the amount of water used will not permit holding it in "bags" on the floor below the fire, the officer in charge must make preparations to cover all

stock and furnishings on all floors below, as well as in the basement. When the number of covers is limited, it is advisable to cover the most valuable merchandise and sacrifice the less valuable.

The stock and furnishings in the exposed area are always covered first, then the floors are covered and the edges of the covers are rolled to hold the water. The covers over the stock should be arranged so that the water will drain into the bags. Should the water threaten to run over the rolled edges, the edges can be raised by means of chairs, boxes or any other material that may be available.

STACKING

The grouping of stock and furnishings into compact stacks before covering is important and extreme care should be used to prevent breakage. Stacks should be arranged where they will be least exposed to water damage.

RESIDENTIAL FIRES

Covering the Bedroom -

1. Rug - The rug should first be rolled from the floor. If the rug is tightly tacked down and cannot be rolled, a large cover must be placed over the rug.

2. Bed - Where space is available, the bed should be moved parallel to and near the wall. This will remove it from under the light fixture in the middle of the room and water will not fall on the bed. Also, room floors are stronger near the walls. Care must be taken not to place the bed or other furniture so close to the wall as to hamper the inspection for the extension of fire.

3. Chest of Drawers - If possible, place the chest at the head of the bed. All articles on the chest shall be placed in its top drawers.

4. Vanity - The mirror is removed from the vanity or dressing stand and placed upon the bed, face down. The mirror is held on the back of the vanity by screws. The vanity is then placed at the foot of the bed. The back of the vanity will be away from the bed. All things on the vanity shall be placed in the top drawers.

5. Pictures and Lamps - These are placed on the bed. Remove lamp shades and place upright on bed.

6. Clothing - Remove all clothing from closets and place it carefully on the bed on top of the mirror and pictures.

7. Chairs - Place chairs on top of clothing very carefully.

The rug is then placed over the stacked furniture, extending from the chest to the vanity. This will act as a ridge pole to support the salvage cover. See Figure 13. The cover is placed over all and must be tucked in tight at the bottom to keep out smoke and water.

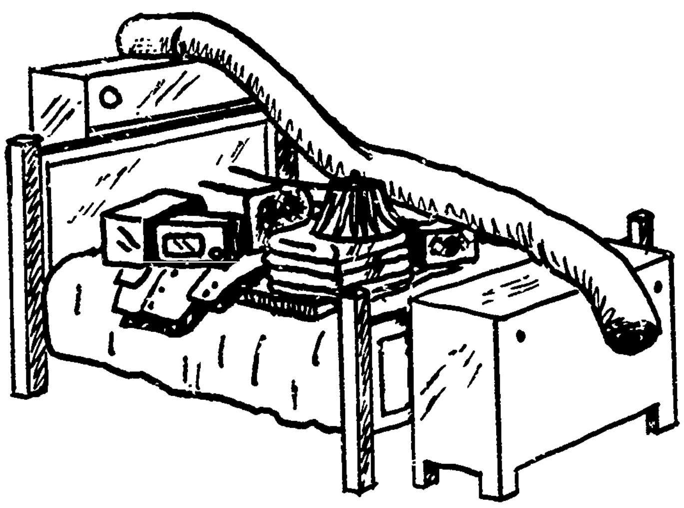


Fig. 13 - Arranging Furniture for "Cover"

8. Floor - Where the floor is exposed it should be covered for protection.

Covering the Living Room -

1. Rug - The rug should be rolled from the floor. (If it is tacked down, the floor must be covered.) After the stack is made the rug is then placed on top of the formed box to serve as the support for the cover. Then carefully place the cover over this stack.

2. Davenport and Overstuffed Chairs - These are placed together forming a box, as in Figure 14. Keep away from under ceiling light fixture.

3. Lamps - Shades should be removed and placed on chair seats. Lamp bases are placed on the stack last.

4. Television Set - The T. V. set is placed on the davenport with the picture tube face down. Large consoles may be covered separately.

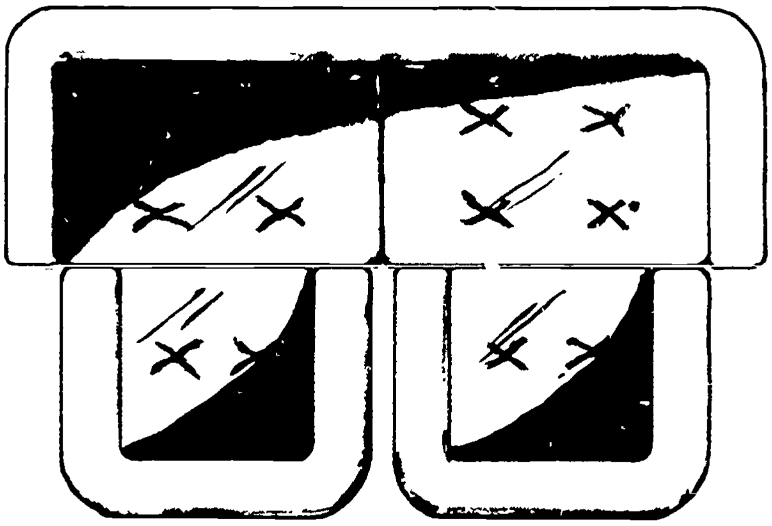


Fig. 14 - Position of Davenport and Chairs for Covering

5. Coffee Tables and Stands - These are carefully placed in the box formed by the davenport and chairs.

6. Book Cases - If moveable they should be placed back of the davenport with the open shelves facing the back of same. If not moveable, the shelves must be covered with another cover. The cover must be rolled at the top or tucked in behind the shelves. If shelving extends to the ceiling or is recessed into the wall, remove the articles from the top shelf and roll the top of the cover into it.

7. Foot Stools - Foot stools should be placed carefully in the formed box.

8. Secretaries and Other Objects - These should be placed at either end of the davenport with the front turned in.

9. Radio and Record Players - These may be placed in the formed box if they are table models, but if they are consoles or floor models, they must be placed next to a chair or the davenport back.

10. Piano and Stool - These will need a separate cover and should not be included in the stack. The fireman must use judgment and not make the stack too large for one cover. At times it will be necessary to use two or three covers to cover the furniture in one room.

11. Curtains and Drapes - These must be removed from the windows, folded and placed in the formed box.

12. Floor - Where the floor is exposed it should be covered for protection.

Covering the Dining Room - The best results will be gained by using two covers in the dining room. The rug should be rolled from the floor. (If it is tacked down tightly, the floor must be covered.)

1. Tables and Chairs - The table should be placed to one side of the room and chairs are then placed upside down on the top of the table. The seat of the chairs should rest on the finished surface of the table to prevent scratching. Arm chairs are placed in an upright position with the seats under the table. Place pictures, curtains, and other articles between the chairs on the table. The rug is then placed on top of the stack to serve as a ridge pole for the cover. Place cover over stack carefully.

2. Side Board and China Closet - These must be placed back to back and covered. Care must be taken so as not to break any dishes while moving the china closet.

3. Floor - Where the floor is exposed it should be covered for protection.

Covering the Bathrooms and Kitchen - These rooms need little attention, if any, because most of the contents are made of waterproof material and can be easily cleaned. However, electrical appliances must be covered or protected.

Covering the Basement - The basements of today differ from those of past years. Play rooms and workshops make it necessary for an extended, full covering operation. Play room furniture must be stacked and covered in the same manner as that in the living room. All tools and equipment in the workshop must also be covered.

If the electric power is to be off for a long period of time, the occupants of the house should be advised to remove food from the freezer and take it to a suitable place for proper storage.

INDUSTRIAL

When covering equipment and machinery, the entire item should be covered if possible. Considerable care should also be taken so that the cover will not be torn or damaged.

File Cabinets - File cabinets must be covered to preserve records and prints. Years of labor and research

are often recorded and the saving of these records is a must. Many of them cannot be replaced and the company will be grateful if files are saved by a quick thinking fireman. Material that may be damaged should be stacked on skids before being covered.

MERCANTILE

This type of building presents difficult problems in arranging stock and furnishings in a suitable manner for coverage.

Shelving built to the ceiling, using a wall of a room for backing, presents a most difficult salvage problem. Water following the wall will damage the stock on the shelves unless precautions are taken. In some cases, it may be possible to remove stock from the upper shelf, spread a cover lengthwise, roll the edge, then force the roll between the shelving and back wall. In cases where shelving is an inch or two from the wall, it is possible to pull the stock away from the back wall, allowing the water to pass without damage.

Shelves may be covered in many cases by using "S" hooks. These may be made from 3/16 inch cold rolled steel sharpened at both ends so that they can be driven with a hammer into wood or plaster and the salvage cover hooked through the grommets. See Figure 15.

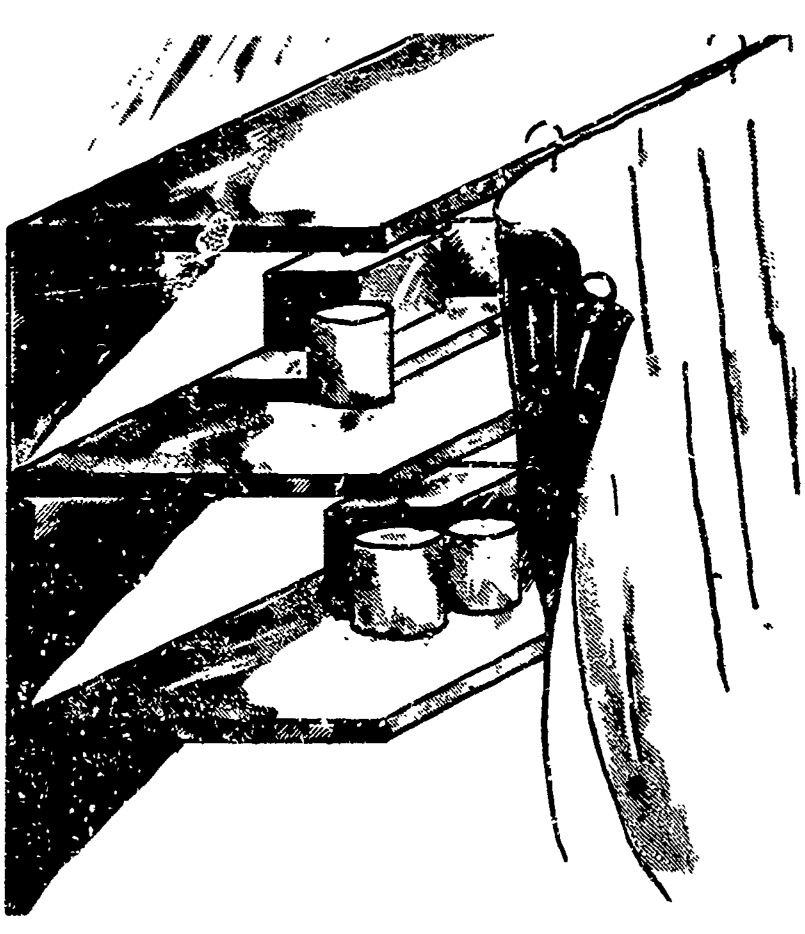


Fig. 15 - Covering Shelving

In some cases, shelves may be given protective covering by taking two or more pike poles and placing the points of the poles through the grommets on the salvage cover, then raising the pike poles and leaning them against the shelves, thus forming a lean-to over the shelves. In most cases the cover over the shelf should lead to a catchall, keeping the water from causing further damage.

In covering show cases, it is advisable to place chairs or other articles across the frame of the cases to prevent men from stepping upon them. When it becomes necessary to pull down ceilings over show cases, additional protection can be afforded by double covering. When water is following pipes, the edge of a cover should be tightly bound around the pipe with twine and the cover "bagged" on the floor to catch the water.

In covering breakable articles on tables, articles of a substantial nature should be placed on the tables to support the covers in a position which permits draining into a catchall. Reckless covering of fragile merchandise will often cause more damage than would be the case if the merchandise were allowed to remain uncovered.

Materials, stacked in piles in storerooms or basements, should be covered for protection and drainage controlled by means of catchalls or chutes. In a great many instances, it is practically impossible to salvage the lower portions of such types of stock when large amounts of water are used. However, if this type of material is already on skids it needs only to be covered. Figures 16 and 17 show an efficient arrangement of covering high stacks of materials, and a method of placing perishables on skids.

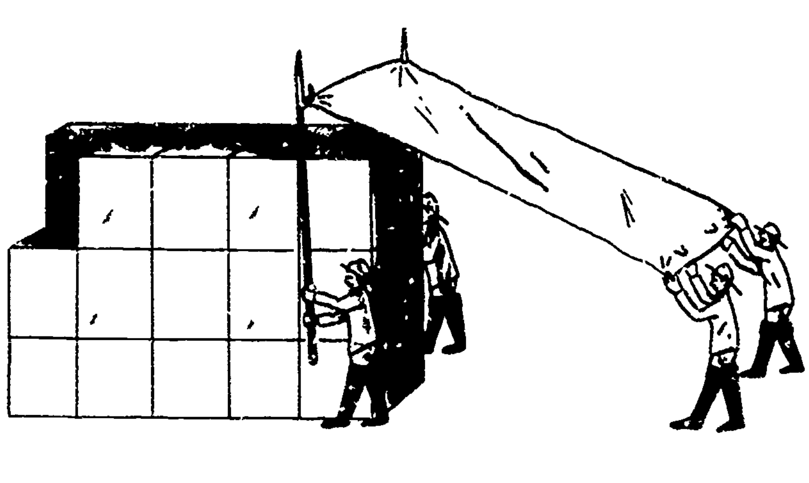


Fig. 16 - Covering High Objects

CARE OF COVERS

When removing covers from stock or machinery, care should be taken to prevent tearing on sharp projections. Unnecessary walking on covers should not be allowed, and covers spread on stairways and floors

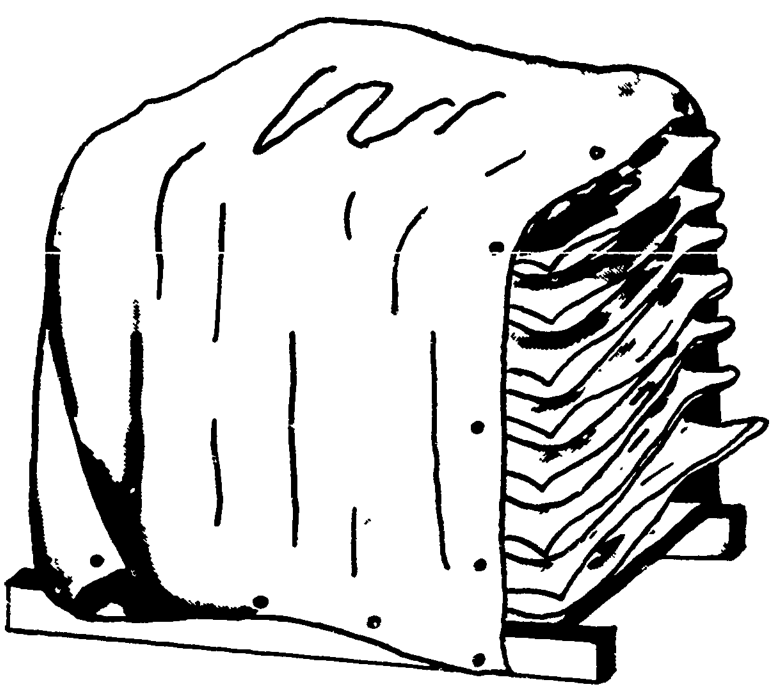


Fig. 17 - Placing Perishables on Skids

should be removed as soon as possible. When it is necessary to fasten covers, the nails should be placed only through the grommets.

When covers have not been used for a period of one month, they should be removed from the apparatus and refolded. Care should be taken when covering roofs to remove all nails, sharp or jagged points of metal or anything that is likely to perforate or tear a cover. Roof covers must always be securely fastened to eliminate wind damage.

Covers should be washed and dried thoroughly as soon as possible after returning from a fire. Officers should personally examine all covers before folding. They should be sure that they are dry, clean and in good repair before returning them to service. When they are found to be unfit for service, they should be placed aside either for repair or replacement.

REMOVING WATER FROM BUILDING

One of the most important, if not the most necessary, phases in salvage work is the removal of water from the building involved. If this can be done prompt- and efficiently much cover work on the lower floors may be avoided. There are six general means of removing large quantities of water from the upper floors.

1. Elevator shafts
2. Stairways
3. Holes cut from floor to floor
4. Chutes to outside
5. Scuppers
6. Breaching walls

Before water is directed into elevator shafts, men should be sent to the basement to cover elevator machinery or any exposed stock. Care should also be taken to ascertain whether or not the basement drains are open. Materials on the floor between the drain and the shaft must either be removed or elevated.

When water is directed down stairways, covers, in most cases, should be opened to half their width and spread on the floors, so as to have ample side elevation and be rolled with well-lapped connections. See Figure 18.

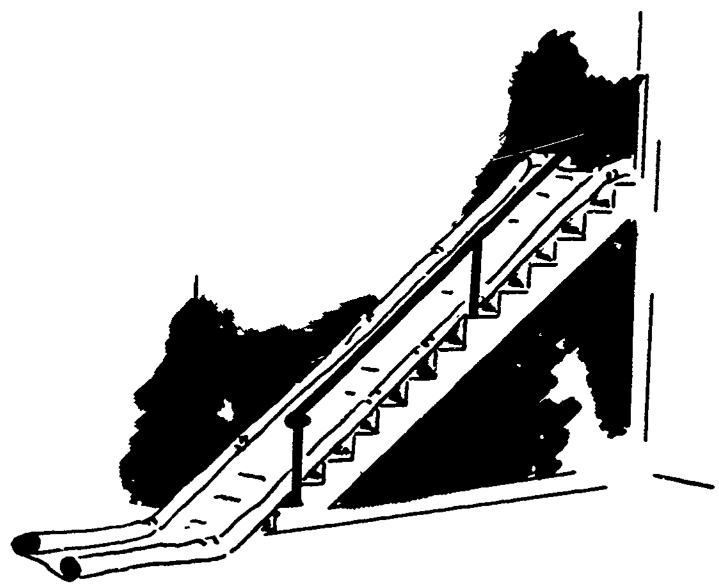


Fig. 18 - Stairway Chute

When it is found impossible to remove water by any other means, holes may be cut from floor to floor. Even in the best constructed factory buildings floors may be out of level from two to three inches, and, for that reason, holes must be cut at the lowest level to be of any value. Before cutting holes, a survey of the lower floors should be made in order that holes will not be cut so as to drain down over stock even though it is covered. A bag should be placed on each floor to catch the water and it should be so arranged as to drain directly into the succeeding hole. Such work should be performed before the floor holding the main body of water is opened.

If a building is being deluged with water, holes should be cut as soon as possible to relieve the floors of weight. This action is especially beneficial when the stock consists of paper, rugs, rags, and similar materials. This type of stock absorbs water and expands excessively. Sections of buildings divided by fire walls but which have fire doors in the

openings frequently receive serious water damage even though they are not involved in the actual fire. Fire doors will withstand fire, but large quantities of water will pass around and under them and spread to the adjoining room. Should a building of this nature contain perishable merchandise and the condition warrant, officers can effectively guard against severe water loss by "opening up" a section of the floor across and in front of the fire door. This operation should be started on the first floor with bags arranged to act as funnels. The cost of repairing these holes is trifling when compared to the damage which might be caused by the exposure to water damage.

A very practical method of draining water from an upper floor or floors of buildings is by means of chutes constructed on the floor below to drain the water through windows or doors. Some fire companies carry chutes about ten feet in length as regular equipment, but improvised chutes can be made with materials at hand. Figure 19 shows a chute constructed with two pike poles and a salvage cover, while Figures 20 and 21 show chutes constructed by the use of a salvage cover and a straight beam ladder.

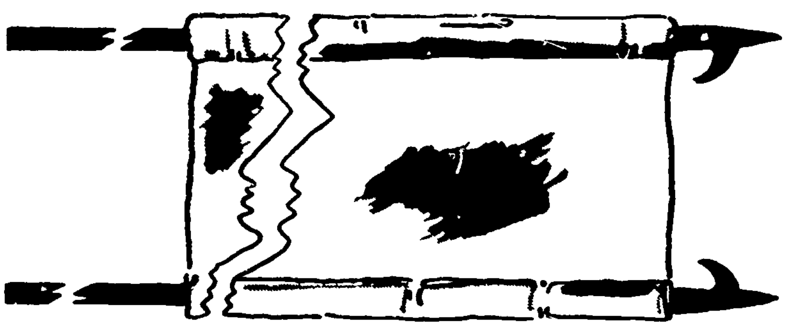


Fig. 19 - Pike Pole Chute

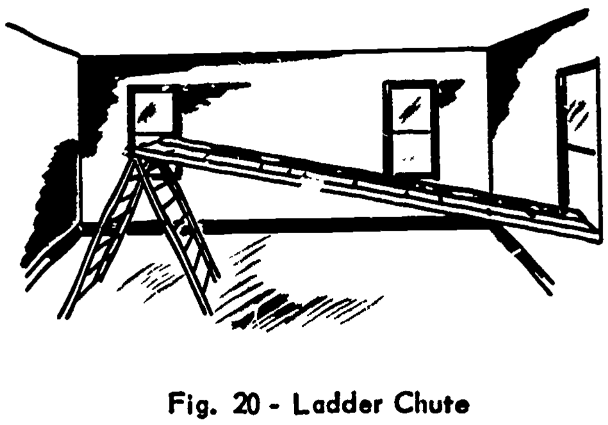


Fig. 20 - Ladder Chute

Holes should be cut in floors only when large amounts of water are present and draining facilities are limited. When it becomes necessary to cut a hole, the ceiling below must be punctured first to prevent the water from spreading over the ceiling. While augers can be used in putting holes through floors and ceilings in buildings of light construction, they have little value in the more heavily constructed buildings.

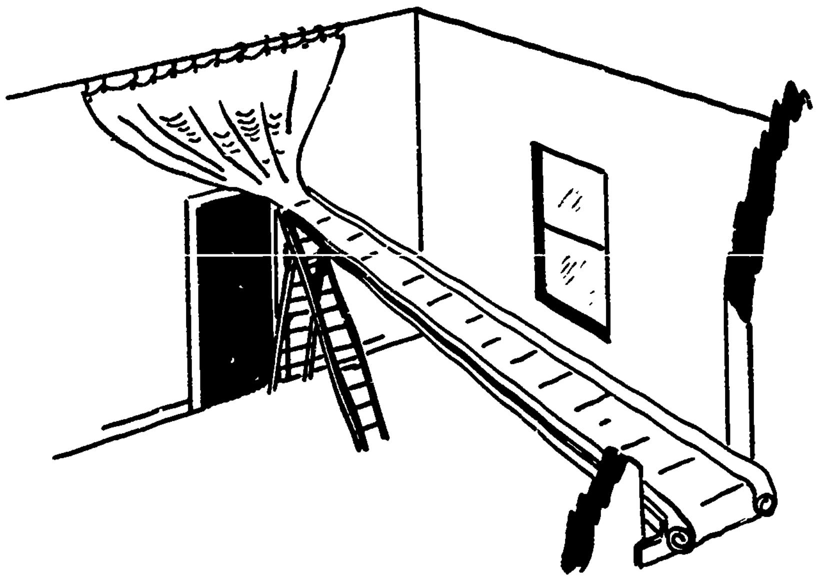


Fig. 21 - Ladder Chute

A neatly chopped small hole provides better facilities for draining and costs only a little more to repair. When small quantities of water collect in floor pockets they should be scooped with shovels into buckets or tubs and removed.

When the amount of water used in the extinguishment of a fire does not make it necessary to route it to an outside opening, a "catchall" constructed with a salvage cover, can be used to good advantage. This is made by rolling in all four edges of the cover to form a shallow dike. Usually, two men will roll one side, then both ends, leaving the other side till last. Corners should be locked as well as possible. This is accomplished by placing the top roll under the bottom roll, see Figure 22. A catchall, if properly made, will hold several barrels of water.

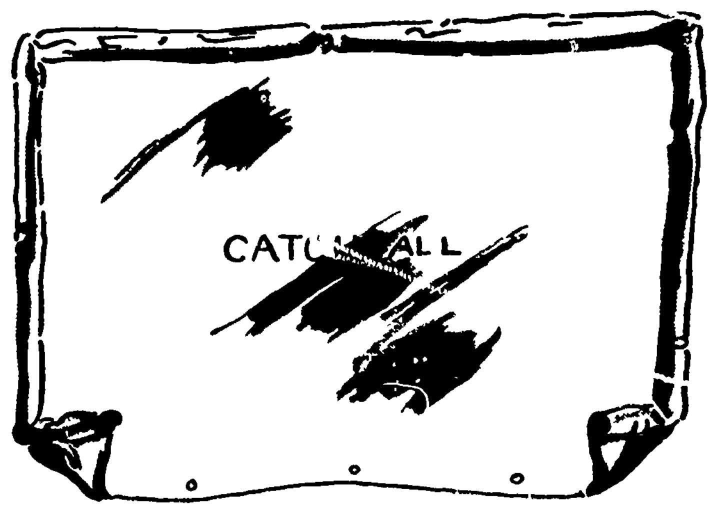


Fig. 22 - Catchall

After the water has been drained from a building, the floors must be dried as soon as possible to prevent warping. While brooms are efficient in sweeping large amounts of water, they leave considerable moisture on the floors. It has been found that squeegees serve the purpose better. The best type of squeegees

have metal tops which make it easier in pushing large amounts of water, and when turned over they can be used as scrapers. The scraper is well adapted to removing water from carpeting prior to removing them for drying.

Sawdust can be used for drying or absorbing moisture under machinery and other places where it is impossible to use a squeegee. It can also be used to good advantage in constructing dikes to prevent the spread or to direct the flow of water.

Water may also be removed from a building by the use of "scuppers," which are tubes or chutes built purposely for draining large quantities of water from buildings which are protected by sprinkler systems. They may be opened through the wall at floor level.

Basement drainage is a difficult problem and, at times, large losses occur from lack of ample and unobstructed drainage facilities. When heavy streams of water are used, attention should be given not only to stock and conditions in the basement involved but also to the condition in adjoining basements. Men should immediately be sent to the basement of the burning building to see that the floor drains are unobstructed. When floor drains prove inadequate or are obstructed, soil pipes leading from roof drains and upper floor plumbing can often be broken at the floor level to aid in draining basements. Toilet bowls pried from the floors leave openings which also serve in the same capacity. Should these methods prove ineffective, the stock should be elevated as high as possible or moved to a higher level if time permits. In the case of adjoining basements, it is often possible to salvage much of the stock by removing it to the upper floors. Salvage by this method will depend upon the type of merchandise and furnishings present, together with the elevators, house trucks and man power available. When employees are present, they can be utilized in salvage work if they are not subjected to danger.

When a large stock of small articles on shelves is involved, the procedure of moving the stock is extremely difficult because of the time required to handle the merchandise. In such cases it is best to move the stock from the lower shelves to the upper and to make every effort to maintain a low water level.

When water rises in basements to the point where it is about to come into contact with motors, refrigerating systems, etc., the motors should be shut off immediately. When it is threatening to rise to dangerous depths, the main electrical switches should be pulled to prevent possible electrocution of men working in water as well as additional damage to electrical equipment.

FIRES IN SPRINKLERED BUILDINGS

Sprinklered buildings present excellent opportuntiies for salvage operations, both in cases of fire and sprinkler leakage. Fire officers should have a technical knowledge of sprinkler systems and their functions. They should be thoroughly familiar with these systems in order to handle them effectively in fire and leakage emergencies. They are installed as aids to fire departments and should be used accordingly.

Sprinkler stoppers or tongs are used extensively to stop the flow of water at sprinkler heads. They are of a particular value when there is a delay due to control valves not being easily found, or an entrance has to be effected to control the valve room. Valves are at times found broken or difficult to set, and tongs, in such cases prevent the release of much unnecessary water. Sprinkler valves should be shut off as promptly as possible to prevent excessive water damage, but the greater danger of fire damage should always be kept in mind when ordering the valves closed. Sprinklers should not be shut off under any circumstances until it has been ascertained that the fire is under control.

A supply of heads of various fusing temperatures should be available for the replacement of fused heads at fires. Sprinkler equipment should always, if possible, be placed in service immediately after a fire to afford protection against not only the fires that are liable to occur in the future but also against a rekindling of the present fire.

It is inadvisable to attempt to reset dry valves, as it requires special knowledge of the particular valves involved. Dry systems in ordinary buildings, during mild weather, can be set in wet as temporary protection when the regular maintenance men are not present. If, however, the conditions do not permit setting in a system wet, it is good practice to get in communication with the person responsible and have him reset the system immediately. As a precautionary measure, it is well to leave a man to watch the premises until the system is placed in service.

The education of watchmen and employees in the proper handling of sprinkler equipment in fires and leakage emergencies is a salvage function and is most certain to attain beneficial results.

SALVAGE OPERATIONS AFTER EXTINGUISHMENT

Some suggestions for salvage work after the fire is extinguished are:

1. Remove water from floors and basement.
2. Remove remaining smoke and heat through complete ventilation of the building.
3. Dry machinery, furniture and stock.

4. Remove articles of value from debris.

5. Clean and oil machinery to prevent corrosion.

6. Shut off and drain water systems to prevent leakage or freezing, if such action is required.

7. Provide necessary coverage for the roof or other openings to protect the interior of the building and its contents from inclement weather.

8. Whenever possible, place the heating plant in operation or see that it is done in order to dry out the building and the contents.

9. Protect the contents of the building from vandalism.

OVERHAUL

While the term "overhauling" is applied in fire service to make sure that all fire has been extinguished and the building is in a liveable condition, there is a considerable amount of salvage work that can be done at the time the overhaul is being carried on. For instance, piles of debris should not be washed or wet down with heavy fire streams, but instead they should be gone over carefully by hand and the smoldering particles dipped in pails of water. Articles that are likely to drip water should be placed in "bagged" covers to keep water off the floors.

Partially burned stock, materials, or other debris should not be thrown from the building since, in many cases, portions of articles are useful in making an inventory of losses. Where there is little space available, it is sometimes necessary to carry materials such as rags and old paper stocks from buildings until sufficient work space has been cleared. There is no objection, however, to removing lath and plaster and articles such as burning mattresses. Burned material should not be thrown from buildings.

When wet articles are liable to damage dry material, they should be placed in separate piles. When packing material is around or over wet stock, it should be removed to prevent damage to the contents. This is of particular importance when stocks of furniture or similar merchandise are wrapped with excelsior padding. If such stock is not dried immediately, the glued parts will loosen up and warping will result. After removing the padding, a chamois should be used to prevent spots on the varnish of the furniture.

It is always good practice to use a chamois or some other absorbent material to wipe dry all furniture and fixtures that are wet. A circulation of air should always be created, and, in cold weather, heating appliances should be arranged to assist in the drying of buildings and stock after they have been exposed to water damage. When it is difficult to ventilate rooms, portable fans can often be used to create a circulation of air and to some extent prevent smoke and moisture damage.

COLD WEATHER PRECAUTIONS

Almost every type of building and its occupancy is affected when exposed to cold weather. Every possible effort should be made to close openings. Heating appliances should be placed in operation immediately after fires. In places where large portions of the roof are burned away, the vertical openings could be covered on the top floor and heat provided for the lower floors. When it is impossible or impractical to maintain heat in buildings, all plumbing fixtures, tanks, and boilers should be drained to prevent freezing. Water should also be removed from all toilet, sink, and wash bowl traps. Salt can also be thrown in the traps to prevent them from freezing.

COVERING ROOFS AND WINDOWS

Covering holes in roofs after fires is a salvage operation of great importance as it is certainly poor practice to salvage a stock of merchandise or household furnishings and have them later destroyed by inclement weather.

In covering small holes on peaked roofs, it is a comparatively simple matter to raise the roof material above the hole, insert the end of a piece of tar paper underneath it, bring it down over the hole and fasten it in place with large roofing nails. Large holes should be covered from the bottom upward, lapping each strip of the paper over the strip below. Lath or boards should be nailed on the edges of the roofing to make it as water tight as possible.

Skylights probably are the easiest of all roof openings to cover and make watertight due to the skylight framework being elevated above the roof level. Open skylights should be covered with a tar paper and nailed down, or salvage cover edges should be weighted down to prevent the wind from blowing them off, as shown in Figure 23.

In covering holes in a flat roof, the roof material around the hole should be raised to a height between four and six inches and blocked in place with pieces of boards, bricks or other material that may be available before final covering is made. This operation will prevent water on the roof from flowing into the hole. See Figure 24.

Where windows have been either burned or broken during the course of fighting the fire, it is advisable

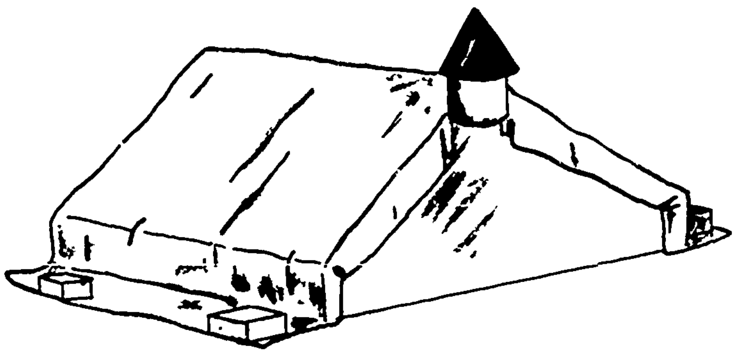


Fig. 23 - Covering Skylights

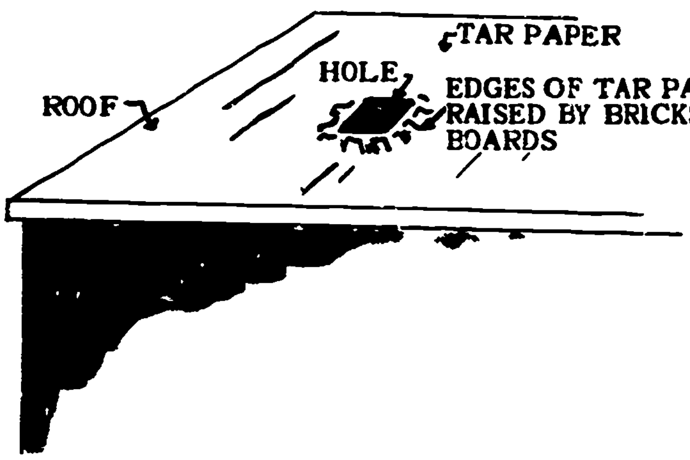


Fig. 24 - Covering Holes in Flat Roofs

to cover the opening to prevent further damage by wind, rain or cold weatner and also to offer some protection from looters. The cover can be placed over the window by using nails through the grommets in the covers or by using tar paper, lath and nails.

SUGGESTIONS FOR DRILLS AND TRAINING

In order for a department to become efficient in the handling of covers, to become acquainted with the principles of salvage and to perfect teamwork, practice drills and instructions are necessary.

While it is impossible to arrange training facilities to conform with all of the actual conditions likely to be found at fires, it is possible to arrange such training facilities so that the principles of salvage and cover work can be practiced. Listed below are suggestions covering the types of drills and instructions which will aid materially in solving salvage problems at fires:

1. Proper method of making catchalls. When and where they should be used.

2. Importance of clean covers. How to cover delicate fabrics and materials are easily that soiled.

3. Instructions on covering goods on counters, tables, and other storage areas.

4. Drills in covering shelves. Pulling stock from walls to prevent damage caused by water following the wall. Instructions to prevent injuries to men performing shelf work.

5. Method of catching water following vertical pipe openings.

6. Importance of covering elevator machinery located in basements when sweeping water down elevator shafts.

7. Methods of draining water from basements.

8. Instruction in the care of plumbing and boilers in freezing weather when it becomes impossible to heat building.

9. Care of fruits, vegetables, and other stock susceptible to freezing.

10. Instruction and drill in covering household furniture, rugs, pictures, drapes, curtains, clothing in closets, and other hangings. Proper method of grouping furniture before covering.

11. Instruction in the care of covers at fires. Refrain from throwing covers from windows, down elevator shafts, the spreading of catchalls over glass and other debris, and walking on covers unnecessarily, and the spreading of covers under dropping fires or in places where they may be burned. Use grommets when nailing salvage covers.

12. Drills in building chutes. When and how to use.

13. Instructions in forcibly opening doors and windows. Methods used on the different types. Importance of opening doors and windows efficiently with small damage.

14. Training on covering flat roofs, gable roofs and skylights. Instruction in raising roofing material and manner of fastening covers.

15. Sprinkler instruction. Drill in using stoppers or tongs, replacing heads, shutting off and draining of system. Special instruction in wet and dry systems.

16. Instruction in cutting holes in floor; when, where, and why to do such cutting.

17. Care of covers in quarters. Drills in folding, washing, drying and general care to prevent deterioration.

18. Proper method of using debris bag.

19. Practice throwing runner.

20. Practice using mattress hooks.

21. Pre-plan for the care of frozen foods when electrical power will be off for a period of time.

CHAPTER 21

OVERHAUL AND PICK-UP

INTRODUCTION

The purpose of this chapter is to discuss the various phases of overhauling and the proper methods to follow in picking up. Overhauling consists of two objectives, namely, making sure the fire is out and leaving the building in as serviceable a condition as possible. This, in many instances, takes a great deal of time for careful checking of the involved building is essential in order to be positive that the fire is completely extinguished and will not rekindle. After the fire is extinguished, there is much to be done in picking up. The section on pick-up will prove helpful in keeping all equipment in first-class condition, ready for the next alarm.

OVERHAUL

METHODS OF OPERATION AFTER THE MAIN FIRE HAS BEEN EXTINGUISHED

"Overhauling", in fire department work, refers to the practice of completing operations at a fire after the main fire has been extinguished and searching for any sparks or fire that may remain in a building or part of a building or in any other place or article which has been subject to the fire. Always make sure that the fire will not rekindle after you leave the premises, and, whenever possible, leave the building in a safe and serviceable condition.

Good salvage work and careful overhauling will go a long way toward selling the fire department to the citizens of the community. Salvage work and overhauling, both done after the fire has been extinguished, are closely related and, to a certain extent, blend together. Considerable time and labor may be required to complete the salvage job and to overhaul the building and contents. Overhauling is performed more often by the fire department than the actual extinguishment of fires due to the fact that some fires are extinguished by the occupants of the buildings, automatic sprinklers, or other agencies. In all these cases, overhauling must be done by the members of the fire department.

The first requisite before proceeding to overhaul is to determine whether or not the building is a safe place in which to work. This is especially true where there has been a big fire and the use of a large amount of water was necessary to bring it under control. Two factors are considered in determining the safety of a building: First, the extent to which the structural parts have been weakened by the fire and second, the additional weight added to the building and its contents from the water used in bringing the fire under control. This, of course, will vary depending upon the amount of water the contents will absorb. A thorough knowledge gained by inspection of buildings and contents before fires occur will aid officers in determining the above factors.

In overhauling, a careful check should be made to determine whether or not the fire has extended to other parts of the building by various vertical openings such as stairways, elevator shafts, dumb waiter shafts, etc., or through partitions, between ceilings and floors, through pipe recesses, or other out-of-the-way openings.

A careful check should be made of roof or floor beams that rest on party walls. If floor beams have burned away at the ends where they enter a party wall the burned ends should be removed and the openings washed out. A check should also be made on the far side to see that the fire or water did not come through. In cases where indications warrant or any doubt exists, open all hollow spaces above, beneath, and adjacent to where there has been a fire. These spaces are liable to contain gas from defective pipes which, if ignited, would cause additional damage.

Where a fire has burned around windows which operate by weights, the ropes in the weight channels should be carefully checked for smoldering embers. Many fires have rekindled because of neglect in this matter.

Where a fire has burned around a door casing, remove the casing to make sure that the fire has not extended to the space behind.

In instances where fire has burned around pipe holes or other small openings, a larger opening should be made to enable careful examination since fire will often follow a pipe for a considerable distance. If the fire has burned around furnace or heating pipes, always examine the woodwork around them carefully. Also, examine the registers on all the floors, as pipes leading to them may be the means of communicating fire.

When a fire has burned around a roof or cornice, always open up the cornice as the fire may have mushroomed against the under side of the roof and followed along the cornice to another building. It may

also be burning several feet beyond where there is any sign of fire until this area is opened for inspection. Great care should be taken when cutting floors or beams which may have been weakened by fire or excessive loads. Avoid heavy jarring when chopping as much as possible.

Common sense should always be used in overhauling in order to eliminate additional damage. A good rule for firemen to follow is to assume that the material being handled is their own and it is uninsured. If this rule is followed, overhauling losses will be minimized.

At the start of overhauling material in a building, it is a good policy to clear away a space at each end of the room where the goods to be overhauled are to be placed. Then commence at the top and work down, always being careful not to scatter or cover any material which retains fire. Whenever possible, repiled material or heavy objects should be placed near walls or over supporting columns to avoid overloading the floors. Care should be taken against throwing clothing or other valuable articles out of windows or handling them in a careless manner.

Smoldering debris within the building should not be wet down with hose streams. Smoldering material can be sorted out and dipped into a bucket or tub of water to extinguish fire. It is essential, however, that a hose line always be kept handy. Smoldering mattresses or overstuffed furniture should be taken from the building and then wet down. It is a good policy to remove only non-salvageable debris, such as plaster, lath, and paper from the building. Scorched or partially burned articles should be sorted from the debris and put aside. Even though such articles have no salvage value, they may be useful in preparing an inventory of loss. Partially burned records should also be saved.

In drug stores, wholesale drug houses, chemical warehouses, paint shops, and other places where explosive, corrosive, or poisonous substances are stored, great care should be taken to prevent breaking bottles or cans. The cans containing highly inflammable material may have been damaged by the heat and, if they are dropped on the floor, serious complications are sure to follow. If the occasion requires the removal of these bottles, cans, or other containers from the shelves, take them down one at a time.

In the handling of leaking or otherwise damaged poison containers, great care should be taken not to mix them or to let them come into direct contact with the body or with foods or to breathe the vapors. Gas masks should be worn in all cases, as small quantities of fumes which cannot be detected are often very poisonous. Afterward, hands and handling tools should always be washed thoroughly.

Care and discretion should always be followed in overhauling. Many people do not have fire insurance and even those who do cannot afford unnecessary loss. When it becomes necessary to pull down plaster and lath, move as much of the furniture as is practical to another room and cover it.

The following procedures should be employed in doing a thorough job of overhauling:

1. Completely inspect the exposed and involved areas of the fire.
2. Be diligent in looking for fires in concealed spaces.
3. Check all avenues through which the fire may have extended.
4. Remove all broken or damaged glass from doors, windows, and transoms.
5. Remove broken glass from sidewalks and streets.
6. Preserve and safeguard any evidence of incendiarism.
7. Check the building and contents with owners or authorized agents to determine if there are reasons to believe or charges to be made that the building had been entered prior to the time of the fire, also, if there is any evidence of theft of contents prior to or during the fire. This action is important where the fire may be of incendiary origin.
8. If the electric wiring has been exposed to fire or damage, the current should be cut off by pulling the main control switch. It may be advisable to have the *electric company* cut the service lines to the building.
9. If natural or artificial gas is supplied to the building and the system has been, or is, exposed to damage, the gas should be shut off at the street valve. If bottled gas is used, it should be shut off at the tank.
10. Unsafe conditions should be eliminated or proper warning notices posted before the building is released to its owner or occupant.
11. Put the building and contents in the best possible condition.

12. Advise the owner and occupants as to the hazards existing and recommend necessary precautions to be taken.

13. In case the building is equipped with an automatic sprinkler system, fused heads should be replaced with new ones and the system returned to service.

14. Use good common sense and care in handling materials. Assume the material is your own and no insurance is carried.

15. Obtain the necessary data for fire reports.

16. Release the building and contents to respective owners, authorized agents, or proper police officials.

17. Whenever any doubt exists about complete extinguishment, always leave a reliable person with a suitable extinguishing agent. "Better safe than sorry."

Note - Additional information pertinent to this subject may be found in the chapter on salvage.

PICK-UP

After the fire is extinguished and the excitement has subsided, there is still much to be done at the scene in picking up and restoring apparatus and equipment to near normal conditions which will then permit return to the station. A good plan to follow is to do all that can be reasonably accomplished on the fire grounds in order to be prepared for the next alarm.

CARE OF FIRE EQUIPMENT AFTER THE FIRE IS EXTINGUISHED

If equipment has been used in fighting a fire where radiation hazards are present, do not remove tools, equipment, or clothing from contaminated areas until they have been decontaminated.

Be positive that all equipment is in place and free from excessive dirt and grime. Officers should detail some member of the department to make a thorough check to be sure that no articles are missing. When tools have been carried into a building and are no longer needed, they should be placed in a corner or against the wall near an exit where they can readily be found.

Drivers of apparatus should not drive over hose lines when picking up. Hose is expensive and easily injured, especially if uncharged. See Chapter 8 for care of hose during pick-up.

On mutual aid or multiple alarms, pick up the equipment that belongs on your apparatus and leave other equipment at the fire scene. If time permits, help the other firemen find their respective hose, tools, and equipment. It is recommended that all tools and equipment be marked. This will save time and errors in the pick-up operation and will assist each department or company in finding its respective equipment.

CHAPTER 22

CARE OF APPARATUS, DRIVING SUGGESTIONS, THE RUN

INTRODUCTION

A large expense is incurred with the purchase of a piece of fire apparatus. Such an investment demands that care be given by those who are charged with the responsibility of proper operation and maintenance so that emergency equipment will last for a reasonable length of time.

Fire apparatus is emergency equipment and unless it is properly maintained and cared for, it may not function properly when necessity arises. To safeguard against unforeseen trouble that may be due to neglect, men responsible for fire apparatus must know the fundamentals of proper operation, maintenance and use.

CARE OF APPARATUS

Fire equipment must be maintained by routine inspection and be kept clean if equipment is expected to remain in first class condition and the department to operate at maximum efficiency. The bright and decorative finish on an apparatus, by itself, is an item of large expense. The finish may be ruined within a short time if it is not given proper care. For the first months, when the finish is new and not thoroughly seasoned, the truck should be washed frequently with clear water which will harden the finish and keep it from spotting. Washing the hood while it is hot tends to affect the gloss of the finish and cause it to become dull. A clean sponge and plenty of water should be used for cleaning the hood. Care should be taken not to turn the hose spray on the hood, for the water may get under the hood and cause trouble with the ignition system of the engine. Mud should be soaked off the apparatus and never wiped off while dry. Never let mud remain on the truck until it is dry. Wash the mud off as soon as possible. If mud is allowed to dry on the truck it will remove the luster and destroy the finish in a short time. Grit, mud, dirt and other deposits are sources of excessive wear on apparatus. Avoid pressure when using a hose since it has a tendency to drive grit and dirt into the finish. Thorough cleaning after each run will lengthen the life of the apparatus.

Dry the truck with a clean chamois skin after washing, rinsing the chamois frequently in clean water. When the truck is covered with a thick coat of dust, it is better to remove this coating by washing rather than by dusting. A soft woolen cloth or one that is chemically treated is recommended for ordinary light dusting.

When possible, care should be taken to keep the truck far enough away from the fire so that the heat will not spoil the finish. Nickel and brass parts should be kept polished. This can be done with any good grade of polish. Stainless steel and chrome trim should be wiped with a soft clean cloth as required.

The care and maintenance of any apparatus and every piece of equipment it carries is the direct responsibility, function and obligation of men assigned to carry out this duty. Regardless of who does the clean-up operation, the officer in charge should direct the work and inspect the results. This procedure is not meant to infer that the men who do a clean up job cannot be relied upon, but it places the different levels of responsibility where they belong. It is the officer's duty to see that his apparatus and equipment is ready to respond at all times.

The apparatus must have certain items checked and inspected after each run to insure instant and efficient performance for the next time it is needed. The following list can be used as a guide for this inspection service. Other items can be added by the local department in accordance with existing policies, rules and regulations.

The following items should be checked for defects and service needed after each run:

1. Brakes and their related parts
2. Gasoline and oil levels - refill if necessary and look for leaks. (When filling gasoline tank, allow for expansion.)
3. Tires should be checked for foreign bodies, cuts and air pressure
4. All gauges and instruments
5. Battery
6. Radiator - water level of cooling system
7. Seat safety belts - if so equipped

8. Lights - head, tail, stop, directional, dash, dome, compartment and warning

9. Steering mechanism

10. Mirrors - rear and side(s)

11. Siren - for proper operation

A complete and thorough check of the automotive equipment should be perfomed periodically by a competent person in addition to the routine inspection. It is recommended that this check be made on at least a monthly basis. The entire apparatus, including the chassis, should be checked for defects. Such an inspection should be put on a report form which will be filed for reference. Responsibility for the inspection should be given to a driver, mechanic, or whoever is qualified for this work as stipulated by local policy. See Figures 1 and 2 which are copies of forms used at the present time by some departments. On one of the forms note that only the signature of the person doing the inspecting is shown while the other shows that an additional signature by an officer is required. The latter indicates to the officer the defects reported and his signature certifies that he is aware of them. Local policy, however, should determine the procedure to be followed in correcting the defects.

DRIVING SUGGESTIONS

Some Do's and Don'ts that Make for Safety in Driving - The following driving suggestions, if put into practice by the driver, will help preserve the apparatus in the best operating condition:

1. The motor should not be run at excessive speed.

2. Release the emergency brake or electric hand brake before engaging the clutch.

3. When shifting gears, be sure that the clutch is entirely disengaged.

4. The gear shift lever should be moved cautiously into proper position and not jammed into place.

5. Engage the clutch gradually.

6. Depress or release the accelerator gradually.

7. Start apparatus in low gear when at a standstill. Do not "jump" the apparatus in starting. Remember that the apparatus is a tremendous dead load and sudden starting

MONTHLY AUTOMOTIVE INSPECTION REPORT

Date ____________ Equipment No. ________________

Note: This report shall be completed by the driver on duty the last day of the month.

No. of Runs this Month ________ Miles traveled ________ End of Month Speedometer Reading ________

No. of Times Repairs were made ______ Out of Service ______ Days ______ Hours ______ Minutes ______

No. of times Mechanical Defects were reason for not completing run ________________

State Reason Why ____

Gasoline Used __________ Gals. ______ Oil Used __________ Qts. ______ Date: Greased ________ Oil Change ________

Accidents this Month ____________________ Driver's Name ________________

Fig. 1 - Monthly Automotive Inspection Report (Example 1)

MONTHLY AUTOMOTIVE INSPECTION REPORT

The following items have been inspected ____________ and found as indicated.
(Date)

1. Are all bolts tight? ____________
2. Are steering connections tight? ____________
3. Are spring clips tight? ____________
4. Are tire lugs & hub bolts tight? ____________
5. Does cooling system leak? ____________
   If so, where? ____________
6. Does motor leak oil? ____________
   If so, where? ____________
7. Are there any other oil leaks? ____________
   If so, where? ____________
8. Is motor oil level proper? ____________
   If not, why? ____________
9. Does clutch (if any) have proper clearance? ____________
10. Do brakes need adjusting? ____________
11. Is battery in proper order? ____________
    If not, why? ____________
12. Condition of tires: Good ____________ Fair ____________ Poor ____________
    F. Left ________ F. Right ________
    R. Left ________ R. Right ________
    Dual Inside Left ____________
    Dual Inside Right ____________
    Spare ________ Other ________
13. Do doors and windows work properly? ____________
    If not, why? ____________
14. State condition of windshield ____________
    Windshield wipers? ____________
    and blades? ____________

Did the following instruments function properly when tested this date? ________
(Date)

1. Ammeter? ____________
2. Heat indicator? ____________
3. Speedometer? ____________
4. Oil pressure gauge? ____________
5. Gasoline gauge? ____________
6. Brake pressure gauge? ____________
7. Brake oil level gauge? ____________
8. Power unit oil levels? ____________
9. Other? ____________

State last date air reservoir tanks were drained ____________
(Monthly)

Driver's signature ____________

Officer's signature ____________

Fig. 2 - Monthly Automotive Inspection Report Form (Example 2)

will increase the possibility of mechanical failure of some of the parts.

8. As a general practice, it is not advisable to shift into second gear until the apparatus is clear of the station and the driver has a clear view of street traffic conditions.

9. Do not drive at an excessive speed. Remember that the first necessity is to get to the fire and speed of response is secondary.

10. Proceed at intersections with caution. Remember that the "other fellow" may prevent the apparatus from reaching the fire.

11. Remember that the safety of fellow firemen has been entrusted to the driver.

12. Become acquainted with the braking reaction of the apparatus. Modern brakes, if applied too rapidly, may be as disastrous in effect as slow application.

13. Under ordinary conditions, and particularly when streets are wet or icy, do not disengage the clutch when braking until the last few feet of forward motion.

14. Driver should anticipate braking failure after apparatus has been driven through deep water.

15. Never attempt to reverse the direction of the apparatus until it has been brought to a full stop.

16. Drivers must anticipate the need of shifting down on hills and turns in order to maintain a maximum safe speed. This will also help prevent overworking of the machine

17. Drivers of fire apparatus equipped with automatic transmissions should adhere to manufactur 's instructions.

THE RUN

Drivers of emergency vehicles are responsible for the safe operation of that vehicle. It is necessary for drivers to understand the limitations involving the use of red warning lights and sirens mounted on the emergency equipment.

RED LIGHT

The flashing red light is a better warning device to on-coming traffic than when used to alert drivers of vehicles being approached from the rear.

When no visual obstruction exists, a red flasher-light on the emergency unit is often more effective as a warning device than a siren be use it can attract the attention of on-coming drive s rom a greater distance straight ahead.

SIREN

The siren is an excellent warning device but has limitations caused by high noise levels, closed automobile windows, and the fact that sound waves created by a siren are directional. Tests were made and the results proved that the siren could be heard approximately three times the distance to the front than was possible to either the side or the rear. When ideal conditions prevail, a person with normal hearing ability, seated in an automobile with only the driver's window open, will hear the siren at a position approximately 1,000 feet to the front of the emergency vehicle. This distance is subject to changes due to the variation of the street noises from trucks, busses, and other sound producing obstacles. When the listener's position is at right angles to the path of the emergency vehicle, the approximate distance that the sound of the siren may be heard is reduced roughly by two-th rus.

There are some techniques and precautions which will result in more effective use of the siren and reduce the danger of vehicle accidents.

When the siren is not automatically controlled, it should be alternately turned on and off to utilize the full range of sound from the lowest to the highest pitch. The varying sound pitch will attract attention more effectively, as many persons are deaf to a certain tone.

The driver of any emergency vehicle cannot depend on the flashing red light or the sound from a siren to guarantee safe passage or "right of way" through an intersecting street or crossroad. Most people do not understand that it is more dangerous at intersections where traffic control lights are in operation than at intersections with *stop* signs, *yield right of way* signs, and intersections having no controls at all.

The public has a right to expect the emergency siren to be used only when a genuine emergency exists. The use of the siren for escorts of distinguished persons, caravans and other non-emergency uses can lead to resentment and eventual disregard.

These practices are becoming less common and should be prohibited.

To gain right of way over other vehicles traveling in the same direction, a siren should be actuated sufficiently in advance to overtaking the vehicle so that the driver will have had adequate warnings of the approach. The sudden use of a siren immediately behind another vehicle may startle the motorist and cause him to stop suddenly or swerve so abruptly that his car may be struck by the emergency vehicle or strike other automobiles or pedestrians.

When an emergency vehicle is preparing to pass another vehicle, it must be done with caution. This is especially true when it is necessary to drive across the center line of the roadway. When a motorist is alerted to this situation he should, if possible, drive to the nearest curb or roadway limit and stop. Such results cannot be expected from all motorists in all situations. The safety of these people rests in the hands of the emergency apparatus driver.

No emergency vehicle should pass another emergency vehicle while responding to an alarm except when an "all clear" signal has been received from the driver or the officer in charge of the first vehicle and then only when in the judgment of the second vehicle's driver it is safe to proceed. A safe distance of five hundred feet should be maintained between emergency vehicles should two or more units be responding to the same alarm.

Special caution should be taken when apparatus is responding from two or more locations. Drivers should be constantly alert for other apparatus in order to eliminate possibilities of accidents at intersections caused by two pieces of apparatus arriving at the same time. The careful selection of sound-thinking and intelligent drivers, properly trained, will help solve this problem.

It is essential that all drivers understand speed in relation to "reaction distance", as explained in the following:

Speed - The miles per hour that a vehicle travels.

Reaction Distance - The distance that a vehicle will travel while a driver, perceiving danger, transfers his foot from the accelerator to the brake pedal.

Braking Distance - The distance a vehicle will travel from the place where the first application of the brakes was made to the place where the vehicle stopped.

Stopping Distance - The sum of the reaction distance plus the braking distance.

These distances will vary due to the physical and mental alertness of the driver, the speed, type and condition of the vehicle; the number, type and condition of the brakes; the tire sizes; and the weight of the vehicle when fully equipped; plus the type and condition of the road surface.

For example, at 40 m.p.h. a vehicle is traveling approximately 59 feet per second. This requires a distance of 44 feet(reaction distance) for the average driver to react and apply the brakes. A pumper equipped with four-wheel air brakes was found to travel approximately 142 feet (braking distance) before it stopped. This adds up to a total of 186 feet (stopping distance) which is the approximate total number of feet required to halt the vehicle. At speeds lower than 40 m.p.h., it is possible to control the apparatus with some degree of safety. With higher speeds, such as 60 m.p.h., the stopping distance was increased to approximately 638 feet.

In addition to having the apparatus under control at all times, there are other things to give consideration to. They are:

1. The number of traffic lights that will be encountered on the chosen route.

2. Dangerous intersections that may be encountered as well as any railroad crossings.

3. The number of turns to make on the route as well as any steep grades that may be encountered.

4. The prevailing weather conditions at the time of the call and also the congestion of traffic. It is considered good policy to have control switches put on traffic lights and these connected to the alarm system so that lights can be controlled on caution or red to assist the apparatus through a congested area. Some cities have traffic light controls mounted on the main pieces of apparatus. This enables them to control the lights as they are approached enroute to the call.

CHAPTER 23

POST-MORTEM CONFERENCE

INTRODUCTION

A post-mortem is an evaluation of what has taken place during the course of the emergency or emergencies. It will point out what can be done in the future to further expedite and obtain a more efficient operation.

A definite pattern for scheduling post-mortems cannot be established as methods of operation may differ within each fire department. However, the material in this chapter is of a general nature and will aid each department in establishing a foundation for conducting post-mortem conferences.

WHY CONDUCT A POST-MORTEM

There is no operation in today's world that is not using evaluation to gear itself for the future. Industry, society and education are continually making surveys of their past performance in order to acquire information which will help point the way to a more efficient handling of future problems. "Passing the buck" when something happens which was not included in the usual routine of instruction is the easy way out. A second chance to save a life or extinguish a fire is never guaranteed in the fire service. Therefore, any advice, opinions, ideas or constructive criticism should be welcomed by every fireman. Consider this phase of fire department work as one involving "fact finding," not "fault finding."

Preplanning has been previously emphasized and referred to in this text. A combination of preplanning and post-mortem is essential to efficient fire fighting. If post-mortems are conscientiously carried out, the mistakes made in the past can be stepping stones to success in the future.

HOW TO CONDUCT A POST-MORTEM

Post-mortems must be based on facts, not hearsay. The report on the case in question should always be used. Such a report should indicate action taken from the time the apparatus left the station until it returned to service. A review of this action should form the basis for the post-mortem discussion. As methods are reviewed, new ideas which may be of value on future calls may be introduced for consideration and evaluation.

It must be clearly understood that these discussions must not be reflections on the judgment of the fire department personnel involved. The officer in charge must emphasize the importance and need of honest, constructive criticism if he wishes to obtain the full cooperation of his men. The post-mortem must be treated wisely and open-mindedly by all concerned.

WHEN TO CONDUCT A POST-MORTEM

The answer to the question of when to conduct a post-mortem must be compatible with the rules, regulations, and methods of operation of the department. In general, however, post-mortems should be held as soon after the run as practical so that the facts will still be fresh in the minds of those who were involved in the call. In the case of paid departments, it is usually possible to hold discussions immediately after the completion of the run. The informal discussion which often takes place while equipment is being checked and cleaned is of much value. In paid departments, post-mortems may be held at the time of the change of shifts. Run reports are often reviewed by officer personnel going on and off duty.

Some volunteer departments have weekly meetings where matters of interest and importance are thoroughly discussed. This is an excellent time to conduct the post-mortem. Thus, personnel not on duty when the run took place can be filled in, briefed on the situation, and have their opinions and ideas evaluated.

In setting up a format for post-mortems, it is necessary to arrive at a plan that can be diligently carried out. The effort made toward providing for worthwhile post-mortems will be justified by the results.

Post-mortems held in conjunction with training sessions are excellent proving grounds for technique and methods which can be tried and practiced.

WHO SHOULD CONDUCT AND TAKE PART IN A POST-MORTEM

The responsibility of post-mortems rests with the person in charge of the apparatus or department operation. At one time, the usual procedure in matters of this kind involved only the officer personnel in a department. Modern thinking belies such tactics. The basic purpose of a post-mortem is to gain the most possible benefits for all personnel. No officer is any more efficient, in a general sense, than the degree of efficiency of his men. Having the cooperation of all personnel creates a feeling of trust and confidence which results in a net gain to all concerned. The surest way to gain a person's cooperation is to ask for his help. If a satisfactory conclusion or evaluation is to be expected, all personnel involved in the action should have a part. They are the ones who will be affected by future policy resulting from the post-mortem.

CONDUCTING A POST-MORTEM

It should be mandatory that the general public and press be excluded from these discussions and the results be considered as classified information for the fire department *only*.

A pattern should be established and followed for conducting such a session. The following items should be covered:

1. Receiving the call
   a. Was there anything unusual about it?
2. Answering the call
   Was there a different route taken?
   b. Was there an unusual traffic problem?
   c. Is there a better route?
3. On arrival
   a. Were there any unusual circumstances?
   b. Extent of fire
   c. Rescues
      1. How many persons involved?
      2. How was each rescue made?
      3. Disposition of each victim?
   d. Color of flame
   e. Color, odor, and density of smoke
   f. Preplanning
      1. Was preplan used?
      2. Was it necessary to deviate from same?
      3. If so, why?
4. Equipment
   a. What equipment was used?
   b. Was it the proper equipment?
   c. Was equipment in place and in good working order?
   d. Was the best hydrant used?
5. Control of family and/or public
   a. Outstanding difficulties and action taken for same
   b. Traffic problems due to hose lays
6. Discuss origin and cause of fire
7. Discuss possibility of arson
8. Other fire fighting tactics to be reviewed
   a. Size-up
   b. Exposures
   c. Confinement
   d. Extinguishment
   e. Salvage
   f. Ventilation
   g. Overhaul
   h. Pick-up
9. Results - Recommendations resulting from the post-mortem should be carried out through proper channels.

CHAPTER 24

FIRE DETECTION AND ARSON INVESTIGATION

INTRODUCTION

The investigation of fires is the basis for efficient fire prevention and fire protection operations in any community. It is only by the accurate determination of the causes of fires, the reason for their spread, and the use of manpower and fire fighting equipment, that knowledge will be obtained which can be intelligently applied for the prevention and control of future similar occurrences. The investigation of fires is also the primary means for detecting incendiarism and securing evidence for the conviction of arsonists.

Subsequently, when the property owner or occupant is fully aware that every fire will be thoroughly investigated, and the cause and responsibility for the fire established, it will have a powerful influence in effective fire prevention programs, regardless of whether the fire is due to mechanical failure or to the human element.

It is an accepted fact that the fire department's first duty upon arrival at the fire scene is to protect life and property. Its primary responsibility at that time is to rescue people trapped in the building and to extinguish the fire. Interest in the actual cause of the fire during these operations, as to whether it be of accidental or incendiary origin, usually remains a secondary consideration. Then after the extinguishment has been completed, overhaul and clean-up operations go into effect, which, in many instances innocently destroy and eliminate possible clues which might clearly indicate the origin and cause of the fire. Fire department members can become proficient in assisting to determine fire causes by intelligent observance of the situation upon arrival at the scene and the series of events which lead to the final extinguishment of the fire. Thus, regardless of whether the fire is of accidental or incendiary origin, at least some information can be advanced pointing to either one or the other. On the other hand, as is true in many cases, the fire investigator is called to the scene after the fire has been extinguished and the overhauling completed. This delay might involve a matter of hours or even a day. Consequently, his unfamiliarity with the situation, and all the various facets involved in the size-up, attack, progress and extinguishment of the fire could be a detriment to him when trying to arrive at a satisfactory solution as to the cause of the fire. Subsequently, these factors introduce very important elements to the field of fire investigation.

FIRE REPORTS

It has been illustrated on many occasions that the success of the investigation depends mainly on the source and amount of information provided. This information is basically the fire report form commonly used by fire departments for recording the many details connected with a fire. The greater the fire area, the more complicated the report and ensuing investigation of the fire will be. All factors contributing to to the nature, spread and extent of the fire should be clearly explained in this report. *Small fires should not be neglected.* Often, seemingly trivial fires, which have been extinguished quickly due to efficient methods of operation by the fire department, supply very important information on fire causes, because the evidence has not been destroyed, as in the case of a major fire.

The extent of the reports made on fire department response to alarms and investigations of fires should be adapted to the relative importance of the alarm. Statistics indicate that more than half of all alarms result in no appreciable loss and are important only as runs. Of the actual fires, the majority are trivial. In general, about 10% of the fires which occur represent 90% of all fire losses. But regardless of these statistics, which seem to indicate a relatively small need for fire investigation work, every fire should be carefully examined and its cause established conclusively. There have been too many instances in the past where the cause of the fire has been "undetermined," when, with a little more effort and investigation, the actual cause could have been ascertained.

In Chapter I, "Community Fire Defense," several types of report forms are presented. However, each fire department handles details differently, in keeping with local policy and organization. In the preparation of forms there must be a practical compromise between one which is all-inclusive and one which can be completed quickly. The former may be too lengthy and require a prohibitive amount of time to complete it, while the latter may fail to provide all the information which may be needed. Thus, no one report form

can be used as a standard in all cases. All forms, however, should contain certain basic data. The following list of items includes those generally covered:

1. Name and address of person reporting fire
2. Location, date and time of fire
3. Time department arrived at fire
4. Names and addresses of owners, occupants
5. Origin and location of fire
6. Extent of fire
7. Spread of fire
8. Construction of building, i.e., number of stories, type of construction, interior and exterior walls, floors, ceilings, roofs, etc.
9. Exposure
10. Alarm transmission
11. Detection of fire
12. Cause
13. Casualties
14. Inside protection, i.e., sprinklers, standpipes, extinguishers
15. Water supply
16. Miscellaneous, i.e., wind, weather, temperature
17. Story of fire, i.e., equipment, apparatus
18. Loss data
19. Insurance data
20. Conclusions
21. Recommendations
22. Name of person compiling report

As this report covers operations by various fire department personnel, it can be broken down into five general divisions:

1. The fire alarm office
2. The company run report
3. The district or battalion chief, etc.
4. The fire investigator, warden, inspector
5. The arson investigator

In smaller communities where the chain of command is narrower, the chief, assistant chief, or whoever is in charge of the fire, takes over these responsibilities.

The investigation of fires to determine causes and whether or not any incendiarism is involved, ends, in many cases, with the work of the company and chief officers. Those responsible for making out the reports previously mentioned decide and indicate the need for further investigation.

DETERMINING THE CAUSE

There are several factors which can be observed when arriving at the scene of a fire which will facilitate efforts to determine the cause:

1. The color of smoke and flame:

   Burning substances can often be identified by the color emitted during the burning process.

2. The odors connected with that particular fire

   Gasoline, alcohol, insulation, chemicals, solvents, etc., have distinct odors which can be recognized.

3. Size, intensity and spread:

   The unusual size of the fire in a short period of time may indicate artificial acceleration. The intensity may indicate added fuels or compounds. Rapid spread may indicate abnormal means of travel.

4. Methods of extinguishment:

   Unusual difficulties encountered in extinguishing the fire with normal agents.

5. One or more fires involved:

   This may be due to natural spread by radiation, conduction, convection, vertical openings, or unnatural spread employed to hasten destruction of the building.

6. Evidence indicating actual cause of fire:
   In many instances, not enough effort is made to determine the real cause of the fire. This may be true for several reasons. Lack of interest, lack of time to devote to investigation, and insufficient knowledge of fire causes are only a few of the reasons. Fires are assumed to be accidental until proven otherwise. But this should not deter any efforts to look for unnatural things which would indicate or arouse suspicion as to the true cause of the fire. Thus, two important possibilities must be considered:

   a. If the fire resulted from natural causes, what indications and proof are available to substantiate establishment of the cause

   b. When no logical explanation or physical evidence can be produced to indicate that the fire was of accidental origin

   In the former, it remains only the duty of those making the investigation to determine and place the responsibility for the accidental fire from the evidence and facts produced. In the latter, the investigation must first establish the fact that the fire could not have been due to accidental or natural causes. Further investigation then becomes necessary to obtain additional facts in order to determine and place the responsibility for the fire. Thus, another phase of fire investigation work becomes involved; namely, arson detection.

ARSON DETECTION

A general pattern has been discussed which can be applied to any fire investigation to establish the cause of a fire, whether it be of accidental or incendiary nature. When the facts and information indicate the fire is definitely a "set" or arson fire, it becomes a crime punishable by state law. Only by diligent efforts of fire department personnel can fires of criminal origin be determined and the persons responsible for them be apprehended, charged and convicted.

There has been an indefinite procedure as to responsibility, participation, duty and action by fire personnel in arson cases. Yet it has been established in most instances that proof of arson depends greatly on circumstantial and indirect evidence. This means only one thing. The gathering and compiling of this evidence must start when the first fire personnel arrive at the scene. Thus, the responsibility of the firemen at any fire is arson detection rather than arson investigation. Any one of six items under "Determining the Cause" can readily indicate an arson case. Therefore, firemen can become proficient in observing conditions during the fire by making mental notes which may later be used to determine a case of arson. Subsequently, additional factors can be supplemented to the original list of six:

1. Locked doors and windows:

   How was entry made into the building to fight the fire? The fact that doors and windows were unlocked may have some bearing on the investigation.

2. Broken doors, windows, or locks or signs of forcible entry on jambs:

   Burglary is sometimes followed by arson to cover up the crime.

3. Unusual or suspicious action by persons on the scene:

   Undue nervousness, willingness to help extinguish the fire, talkativeness about the fire, etc., are some details which may later fit into the picture. Pyromaniacs have a tendency to remain at the scene and sometimes are overzealous in their efforts to assist the firemen and thus attract attention. A familiar face observed at several fires may be a clue. This may warrant an investigation of such a person.

4. A familiar car observed at several fires, or one rapidly leaving the scene of a fire, may be a clue. The license number, color and type of such a car should be recorded.

5. Unusual situations in buildings:

   Open fire doors, inoperative sprinklers, recently made holes in walls and floors, flammable liquid containers, unnatural residue from wax or paraffin, etc.

6. Unnatural burning and char of wood:

   Application of flammable liquids causes deeper and unnatural burning patterns as compared with normal burning from the heat of the fire.

7. Evidence of burning underneath floors where flammable liquid has been applied and then has seeped through.

8. Oil soaked rags, paper, beddings, clothing, etc.

   Oil adds intensity to the fire and is apparent due to unnatural burning.

9. Heating equipment:

   This is sometimes used as cover up in an arson case. An overheated furnace may be used as the reason for the fire, when it can be shown that the heating equipment was not in use at the time.

10. Tracks, footprints and fingerprints:

    Casts of automobile tire tracks may be used to provide evidence that a certain car was at the scene. The same procedure may be applied to footprints and used for comparison with those of a suspect. Fingerprints found on glass, furniture, tools, woodwork, etc., are damaging evidence in an arson case.

11. Flammable liquid containers:

    When found at the scene, they may be helpful in the investigation and should be salvaged for fingerprints.

12. Unusual residue of wax, paraffin, chemicals, acids, etc.:

    Candles and similar materials are often used to ignite trailers to form a path for the fire. Peculiar or unusual burns may indicate something other than ordinary in the course of the fire.

13. Mechanical, electrical or chemical timing devices:

    Many ingenious types of devices have been used by arsonists to start fires. It is well to be on the lookout for unusual apparatus of this type. Electrical appliances such as heaters, soldering irons, toasters, light bulbs, irons, etc., have been used as a source of ignition. Overloaded electrical circuits are also used to induce burning.

14. Open or disconnected fuel lines to stoves or heating equipment:

    Subsequent explosions resulting from this practice may be used to cover up a crime, either by the force of the blast or the resulting fire.

15. Removal of valuable and personal articles prior to the fire:

    In many cases arsonists have resorted to this practice. Sentiment or commercial value may be the reason for their removal.

This list is by no means complete. In general, however, these are some of the most common factors involved in arson detection. Experience, knowledge and the ability to ferret out additional clues rests with the fire department personnel and their desire to investigate the circumstances.

PRESERVING AND SAFEGUARDING EVIDENCE

This phase of arson detection is very important. Firemen must exercise precautions while fighting a fire caused by arson. Disturbing the scene by careless use of hose streams, salvage work or by inability to recognize the situation may result in a total or partial destruction of evidence that may void its usefulness.

Photographs taken at the scene, showing the actual condition of the premises, are excellent exhibits to support proof of arson. However, these must be taken as quickly as possible and before careless or innocent damage can be done. When taking pictures, care should be exercised that fire personnel or equipment are not included in the fire scene.

All evidence discovered should be carefully collected and properly marked for identification. Evidence thus collected can be placed in bottles, jars and cans that are clean and not contaminated with foreign material. In the event the evidence cannot be removed from the scene it must be protected in such a way that it remains exactly as it was discovered. Personnel may be assigned to guard the area, or it can be roped off. Barricades can also be made to safeguard and protect the evidence from being tampered with or disturbed. Only authorized personnel should be allowed on the premises.

RECORDS AND OBSERVATIONS

Memory should never be trusted to make accurate statements of facts, conditions or situations. A suitable notebook should be used to record the signifigant items concerned with the case. Such notes can be used to prepare a permanent record for the department if desired. The notebook can also be used in

court to refresh memories or restate observations or facts. Sometimes arson cases are delayed by court procedures, which makes it imperative that such records and notes be available to answer questions. A fireman is the most important witness in an arson trial. The manner in which he introduces facts and gives a clear verbal picture of the circumstances will help make a good impression from the witness stand. A notebook used in this connection is a definite asset to that impression.

Some of the items that should be observed and recorded in the notebook are:

1. Date (day, month, year)
2. Time of alarm
3. Time of arrival at fire
4. Address of fire location
5. Description of building
6. Description of fire
7. Unusual conditions or circumstances
8. Location and description of clues and evidence
9. Names of owners or occupants contacted on premises and brief notes of conversation
10. Names and addresses of witnesses or persons questioned and notes relative to remarks
11. Sketches or floor plans to supplement descriptions
12. Location and condition of doors and windows upon entry
13. Insurance data (company, agent, amount)
14. Names and addresses must complete and recorded correctly as to spelling and accurately as to street, avenue, etc.

COURT APPEARANCE, DECORUM AND PROCEDURE

The last step in an arson case is the courtroom. Generally, most people are unaware, and probably unconcerned, about what will take place therein. The following is a brief outline of "do's and don'ts" which will help in presenting the case:

1. Be appropriately dressed and well groomed. If in uniform, make certain it will represent your profession in a befitting manner.

2. Qualifying as a capable witness is to satisfy the court as to background, experience, and value of testimony.

3. Be thoroughly familiar with your testimony. Do not attempt to memorize but use your notebook for reference.

4. Be truthful and fair. "To tell the truth, the whole truth, and nothing but the truth," is the obligation when sworn in. Do not deviate from this oath. Be fair in presenting testimony against the defendant. Testimony by a biased witness may be discounted by the court.

5. Testify only to what is known. Hearsay, second-hand information and observations of others are not admissable in court. Only what you saw or heard or action performed is significant.

6. Respect the court, the attorneys and the defendants. A respectful attitude toward the court and the persons connected with it creates a favorable impression.

7. Speak clearly and positively. Turn to the jury when speaking to them; otherwise your answer may be lost. Be positive with your answers. Delay or confusion may result in doubt.

8. Do not be overzealous or overanxious in presenting testimony. The court may discount any testmony which might indicate "going out of your way" to make an impression or gain a conviction. Keep your answers brief.

9. Control your temper. Attempts to confuse or to gain misleading or wrong answers often make a witness angry. Its purpose is to confuse the testimony. Remain calm and control temper regardless of insinuations and questioning techniques.

10. Do not discuss the case with unauthorized persons. This holds true during court recesses, while interviewing witnesses at their home, and even at the fire station. Information may innocently be revealed which could wind up in the hands of the defense attorney and be used to undermine the case. The proper place to divulge any information is at the trial only.

11. If a question is not clear or understood, the witness has every right to ask that it be rephrased or restated. Attorneys sometimes word questions in such a manner that they cannot be answered with a "yes" or "no" without a qualification. If a subsequent positive or negative answer would inadvertently damage the nature of the answer, the witness has the right to have the question reframed.

12. As stated previously, firemen may make reference to notes made at the scene of the fire or during the investigation. However, the notebook is subject to examination, and therefore, any notes made just before the trial would not be permissable in court.

13. The identification of evidence and exhibits relates to material that has actually been collected at the scene. The ability to positively identify such material is important. Labels, marks, numbers or other identification placed on the exhibit by the witness must also be so identified. Sometimes it may be necessary to show the evidence was safeguarded from the time it was discovered until the time it was produced in court. If this is the case, witnesses must prove it was protected properly and not tampered with or disturbed.

14. Circumstantial evidence is evidence that tends to prove a fact in issue by proving circumstances which afford a basis for a reasonable inference of the occurrence of the fact. As is usually true in arson cases, such evidence, when properly linked together, generally convicts criminals of this type. Thus, circumstantial evidence, when introduced and presented by the investigator and the prosecuting attorney, will serve to bring out the true facts in the case.

LAWS OF OHIO
FIRE AND ARSON INVESTIGATION

LAWS AGAINST ARSON AND INCENDIARISM

Revised Code Numbers	General Code Numbers	Titles
2907.01	13387	Threats to Destroy Property for Extortion
2907.02	12433	Arson
2907.03	12433-1	Burning Property to Defraud
2907.04	12434	Burning Property to Defraud Insurer
2907.05	12435	Burning Property of Another
2907.06	12435-1	Attempt to Burn Property
2907.07	12436	Maliciously Setting Fire to Woods or Prairies
2907.08		Malicious Injury to Property
2909.01	12477	Malicious Destruction of Property
2909.02	12478	Malicious Destruction of Trees and Crop
2923.26	13396	Making a False Alarm of Fire

THREATS TO DESTROY PROPERTY FOR EXTORTION

Section 2907.01 (13387)

No person shall, either orally or by written or printed communication, maliciously and willfully threaten to burn, injure, or destroy a building or other property of another with the intent thereby to extort money, goods, chattels, or anything of value.

Whoever violates this section shall be imprisoned not less than one nor more than ten years.

ARSON

Section 2907.02 (12433)

No person shall willfully and maliciously or with intent to defraud set fire to or burn or cause to be burned or aid or procure the burning of any dwelling house, kitchen, shop, barn, stable, or other outhouse that is parcel thereof, or belonging to or adjoining thereto, the property of himself or of another.

Whoever violates this section is guilty of arson, and shall be imprisoned not less than two nor more than twenty years.

The unlawful burning of a shop not part of the curtilage is not arson under this section. Felsman v State, 45 App 428, 187 NE 201.

Under an arson indictment, testimony that rugs were found under some debris in the cellar, which rugs had been soaked with gasoline would not tend to convict accused of two crimes, where it is clearly disclosed that through the trial it was observed that the accused was being tried for arson. Sergi v State, 17 Abs 190.

Burning pieces of personal property is not sufficient to support indictment for arson under this section. Huddell v State, 16 Abs 72.

Under authority of juvenile court code, a juvenile court has exclusive jurisdiction of all persons under age of eighteen years who are charged with a violation of crime of arson or other burnings as contained in 12433 and 12436. 1939 OAG 726. (GC 12433 now RC 2907.02; GC 12436 now RC 2907.07).

A person who pleads guilty or is convicted of arson, may not, because of the provisions of 13452-2, be placed on probation by the court of magistrate. 1927 OAG 662. (GC 13452-2 now RC 2951.04).

BURNING PROPERTY TO DEFRAUD

Section 2907.03 (12433-1)

No person shall willfully and maliciously or with intent to defraud set fire to or burn or cause to be burned or aid or procure the burning of any barn, stable, or other building, the property of himself or of another, not a parcel of a dwelling house, or any shop, storehouse, warehouse, factory, mill or other building, the property of himself or of another, or any church, meetinghouse, courthouse, workhouse, school, jail, or other public building, or any public bridge.

Whoever violates this section shall be imprisoned not less than one nor more than ten years.

Ownership of the building must be positively charged in arson to prejudice the insurer, former 12434, and an indictment merely averring that the building was insured unto the said defendant is fatally defective. Furman v State, 10 App 157. (GC 12434 now RC 2907.04).

BURNING PROPERTY TO DEFRAUD INSURER

Section 2907.04 (12434)

No person shall willfully and with intent to injure or defraud the insurer set fire to or burn or cause to be burned, or aid or procure the burning of any goods, wares, merchandise, or other chattels or personal property of any kind, the property of himself or of another, which shall at the time be insured by any person or corporation against loss or damage by fire.

Whoever violates this section shall be imprisoned not less than one nor more than five years.

Defendant charged with having caused property to be burned with intent to defraud insurer could be convicted of such crime as an aider and abettor. Roth v State, 44 App 420, 186 NE 7.

Indictment, charging offense of burning property with intent to prejudice insurer in words of statute, is sufficient. Roth v State, 44 App 420, 186 NE 7.

BURNING PROPERTY OF ANOTHER

Section 2907.05 (12435)

No person shall willfully and maliciously set fire to or burn or cause to be burned or aid or procure the burning of any barrack, cock, crib, rick, or stack of hay, corn, wheat, oats, barley, or hay or grain of any kind, or any pile of coal, wood, or other fuel, or any pile of planks, boards, posts, rails, or other lumber, or any streetcar, railway car, boat, automobile or other motor vehicle, or any other personal

property, such property being of the value of twenty-five dollars and the property of another person.

Whoever violates this section shall be imprisoned not less than one nor more than three years.

ATTEMPT TO BURN PROPERTY

Section 2907.06 (12435-1)

No person shall willfully and maliciously attempt to set fire to or attempt to burn or to aid or procure the burning of any of the buildings or property mentioned in sections 2907.02 to 2907.05, inclusive, of the Revised Code, or commit any act preliminary thereto, or in furtherance thereof.

Whoever violates this section shall be fined not more than one thousand dollars or imprisoned not less than one nor more than two years.

The placing or distributing of any flammable, explosive, or combustible material or substance, or any device, in any building or property mentioned in such sections in an arrangement of preparation with intent to eventually willfully and maliciously set fire to or burn, or to procure the setting fire to or burning of such building or property in an attempt to burn such building or property.

MALICIOUSLY SETTING FIRE
TO WOODS OR PRAIRIES

Section 2907.07 (12436)

No person shall maliciously or negligently set fire to woods, prairies, or grounds, not his property, or maliciously permit fire to pass from his prairies or grounds to the injury or destruction of the property of any other person.

Whoever violates this section shall be fined not more than one hundred dollars or imprisoned not more than twenty days, or both.

MALICIOUS INJURY TO PROPERTY

Section 2907.08

No person shall maliciously, with intent to cause damage or injury to persons or public or private property, tamper with, destroy, cut, smash, or in any way interfere with communication equipment, electrical wiring, devices, or equipment, or gas, natural or otherwise, or watermains, lines, reservoirs, or storage tanks.

Whoever violates this section shall be fined not more than ten thousand dollars or imprisoned not less than one nor more than twenty years, or both.

Source: GC 12401-1. (Note: This new section was created by deleting from former GC 12401-1. The pertinent language relating only to injury to property in order to follow the Revised Code arrangement which separates injuries to persons from injuries to property.

Malicious injury to property resulting in death, 2901.07.

MALICIOUS DESTRUCTION OF PROPERTY

Section 2909.01 (12477)

No person shall maliciously destroy or injure property not his own.

Whoever violates this section shall be imprisoned not less than one nor more than seven years if the value of the property destroyed, or the injury done is one hundred dollars or more.

If the value is less than one hundred dollars, such person shall be fined not more than five hundred dollars or imprisoned not more than thirty days or both.

Offense of malicious destruction of property is a felony where value of "the property destroyed, or injury done is one hundred dollars or more," and where "the value is less than that sum," offense is a misdemeanor. State v Wening, 81 App 174, 77 NE (2d) 724.

A husband may be convicted of malicious destruction of property belonging to his wife where it appears that at the time of destruction they had separated, or were in the act of separating. Shilling v State, 13 App 376, 31 OCA 588.

As to whether this section is not confined to tangible property: Hellman v Retail Furniture Salesmen's Ass'n., 23 NP (NS) 177.

Inasmuch as malicious destruction of property is a felony if the property destroyed is of the value of one hundred dollars or more, the probate court is without jurisdiction over a cause

where the defendant is so charged. Adams v State, 11 NP (NS) 11, 25 D 77.

It is error to charge the jury, in an action against trustees of a church for removing a fence supposed to divide the church property from the adjoining land, that they had no right to remove the fence unless they were the owners of the property individually; or to refuse to charge that they should be found not guilty, if it appeared that they had a right in the premises, as trustees on account of long use of the land by the church. Adams v State, 11 NP (NS) 11, 25 D 77.

Where malice is an essential ingredient of the offense, it is error to deny to him the privilege of showing to the jury that he acted on legal advice. Adams v State, 11 NP (NS) 11, 25 D 77.

MALICIOUS DESTRUCTION OF TREES AND CROP

Section 2909.02 (12478)

No person shall maliciously cut down, destroy, or injure a standing or growing vine, brush, shrub, sapling, or tree of another, or maliciously injure, destroy, or sever from the land of another a product standing or growing thereon, or other thing attached thereto.

Whoever violates this section shall be imprisoned not less than one nor more than three years if the value of the product or thing destroyed or the amount of damage done to such product or thing or to the land is sixty dollars or more. If the value is less than sixty dollars, such person shall be fined not more than three hundred dollars or imprisoned not more than ninety days, or both.

MAKING A FALSE ALARM OF FIRE

Section 2923.26 (13396)

No person eighteen years of age or over shall knowingly make, turn in, aid, or abet in making or turning in, any false alarm of fire.

Whoever violates this section shall be fined not more than one hundred dollars or imprisoned more than thirty days or both, for a first offense; for each subsequent offense such person shall be fined not less than one hundred nor more than five hundred dollars or imprisoned not less than ninety days nor more than one year, or both.

GENERAL POWERS AND DUTIES OF THE DIVISION OF STATE FIRE MARSHAL

Revised Code Numbers	General Code Numbers	Titles
3737.01	835	Duties and Powers of Fire Marshal and Assistants
3737.02	820-1	Arson Bureau; Qualifications and Duties of Chief
3737.03	820-2	Bureau of Inspection; Qualifications and Duties of Chief
3737.04	820 3	Bureau of Fire Prevention; Qualifications and Duties of Chief
3737.05	821	Powers and Rights of Chiefs of Bureaus
3737.06	822	Advisory Council Created
3737.07	823) 824)	Attorney General Shall be Legal Adviser; Assistants
3737.08	825) 833)	Investigation of Cause of Fire
3737.09	827	Hearing on Cause of Fire
3737.10	828	Arrest of Person Suspected
3737.11	830	Power to Compel Attendance of Witnesses
3737.12	831	Investigation May Be Private
3737.14	834	Right of Entry into Building, Premises, and Vehicles for Examination
3737.15	829	Report to Superintendent of Insurance
3737.16	835-1) 835-2)	Safety Equipment Required in All Public Buildings
3737.17	835-3	Standards and Orders Prescribed for Handling Petroleum Liquids
3737.18	835-4	Standards and Orders Prescribed for Handling Liquid Petroeleum Gas; Definition

GENERAL POWERS AND DUTIES OF THE DIVISION OF STATE FIRE MARSHAL (continued)

Revised Code Numbers	General Code Numbers	Titles
3737.19	835-5	Standards and Orders for Protection of Persons and Property
3737.20	836	Appeal to Fire Marshal; Hearing
3737.21	836-1	Appeals
3737.22	838	Record of Fires
3737.23	839	Compensation for Reporting Fires
3737.24	840	Limitation on Expenses
3737.25	841	Additional Tax Paid by Fire Insurance Companies; Purpose; Deductions; Fund
3737.26	826	Prohibition Against Official Neglect
3737.27	837	Prohibition Against Noncompliance with Order
3737.28	836-2	Effect of Failure to Comply with Order
3737.29	12900	Prohibition Against Failure to Instruct Pupils in Fire Drills
3737.31	-	Gas Masks for Firemen; Requirements
3737.99	-	Penalties

DUTIES AND POWERS
OF FIRE MARSHAL AND ASSISTANTS

Section 3737.01 (835)

If the fire marshal, his assistants, or any officer mentioned in section 3737.14 of the Revised Code, upon an examination or inspection, finds a building or other structure, which for want of proper repair, by reason of age and dilapidated condition, defective or poorly installed electrical wiring and equipment, defective chimneys, defective gas connections, defective heating apparatus, or for any other reason, is especially liable to fire or endangers life or other buildings or property, such officer shall order such buildings to be repaired torn down, demolished, materials removed, and all dangerous conditions remedied. If such officer finds in a building or upon any premises any combustible or explosive material, rubbish, rags, waste, oils, gasoline, or inflammable conditions of any kind, dangerous to the safety of such buildings, premises, or property, he shall order such materials removed or conditions remedied. If such officer finds that any building, structure, tank, container, or vehicle used for the storage, handling, or transportation of petroleum liquids, or of liquified petroleum gases, or the pumps, piping, valves, wiring, and materials used in connection therewith, does not comply with the standards or orders of the marshal, he shall make such order as may be reasonably necessary to insure such compliance. Such order shall be made against, and served personally or by registered letter upon the owner, lessee, agent, operator, or occupant of such buildings or premises, and thereupon such order shall be complied with by the owner, lessee, agent, operator, or occupant within the time fixed in said order.

As to scope of section see 1945 OAG 182, following 3737.28.

Since 154-26, 154-39, constituting part of the administrative code abolished the office of state fire marshal and vested its powers and duties in the department of commerce, all orders issued since that date relating to fire hazards, under 835, 836, must be made in the name of the department of commerce and must have affixed thereto the seal of the department. State v Blickensderfer, 25 NP (NS) 389. (GC 154-26 Repealed; GC 154-39 now RC 1101.04; GC 835 now RC 3737.01; GC 836 now RC 3737.20).

Power of Fire Marshal and his deputies and officers referred to in 835, to order buildings to be repaired, torn down or demolished may be exercised with respect to buildings having dry cleaning establishments. 1948 OAG 3777.

Where a board of education fails to comply with an order of state fire marshal given pursuant to 835 to tear down a school building belonging to said district, but continues to use said building for reason that no other building or rooms are available, such board of education will not be liable for damages to one who suffers loss or injury because of fire or other catastrophe in condemned building. 1948 OAG 3044. (GC 835 now RC 3737.01).

Dwellings constructed or owned by the United States pursuant to federal legislation which preserves to the state and its political subdivisions their civil and criminal jurisdiction over such property, may be entered and inspected by the state fire marshal and his assistants for the purposes mentioned in sections 833 to 837, inclusive. 1945 OAG 189. (GC 833 now RC 3737.08).

Further powers and duties of the state fire marshal discussed. 1929 OAG 636.

ARSON BUREAU;
QUALIFICATIONS AND DUTIES OF CHIEF

Section 3737.02 (820-1)

There is hereby created, in and as a part of the office of fire marshal, an arson bureau consisting of a chief of said bureau, six deputies, and such additional number of deputies as the fire marshal determines necessary for the efficient administration of said bureau.

The chief shall be experienced in the investigation of the cause, origin, and circumstances of fires, and in administration and the supervision of subordinates. The chief and his deputies shall be in the classified service of the civil service.

The chief shall be responsible, under the direction of the marshal, for the investigation of the cause, origin, and circumstances of each fire, and for the prosecution of persons believed to be guilty of arson or a similar crime. The chief shall provide that at least four deputies are located in four zones determined by the marshal on the basis of population.

POWERS AND RIGHTS
OF CHIEFS OF BUREAUS

Section 3737.05 (821)

The chiefof the arson bureau and his deputies, the chief of the bureau of inspection and his assistants, and the chief of the bureau of fire prevention, shall have and exercise, in the performance of general or specific duties assigned to them by the fire marshal, the duties, powers, authorities, and rights which are conferred upon the fire marshal or his assistants, by sections 3737.01, 3737.08 to 3737.14, inclusive, and 3737.26 of the Revised Code.

INVESTIGATION OF CAUSE OF FIRE

Sections3737.08 (824) (825) (833)

The fire marshal, the chief of the fire department of each municipal corporation in which a fire department is established, the mayor of each village in which no fire department exists and the township clerk of each township where no fire department is established, shall investigate the cause, origin, and circumstances of each fire occurring in such municipal corporation or township by which property has been destroyed or damaged, and shall make an investigation to determine whether the fire was carelessness or design. The investigation shall be commenced within two days, not including Sunday, if the fire occurred on that day. The marshal may superintend the investigation.

An officer making an investigation of a fire occurring in a municipal corporation or township shall forthwith notify the marshal, and within one week of the occurrence of the fire shall furnish him a written statement of all facts relating to its cause and origin and such other information as is required by forms provided by the marshal.

In the performance of the duties imposed by sections 3737.01 and 3737.28, inclusive, of the Revised Code, the marshal and each of his subordinates, and any other officer mentioned in paragraph one of this section, at any time of day or night, may enter upon and examine any building or premises where a fire has occurred, and other buildings and premises adjoining or near thereto. (Eff. 8-18-55).

HEARING ON CAUSE OF FIRE

Section 3737.09 (827)

If in the opinion of the fire marshal further investigation is necessary, he, or an assistant fire marshal, shall take or cause to be taken the testimony on oath of all persons supposed to be cognizant of any facts, or to have means of knowledge in relation to the matter concerning which an examination is required to be made, and cause such testimony to be reduced to writing.

ARREST OF PERSON SUSPECTED

Section 3737.10 (828)

If the fire marshal or an assistant fire marshal, is of the opinion that there is evidence sufficient to charge a person with arson or a similar crime, he shall arrest such person or cause him to be arrested and charged with such offense. Such marshal or assistant shall furnish the prosecuting attorney such evidence, with the names of witnesses, and a copy of material testimony taken in the case.

POWER TO COMPEL ATTENDANCE OF WITNESSES

Section 3737.11 (830)

The fire marshal or an assistant fire marshal may summon and compel the attendance of witnesses to testify in relation to any matter which is a proper subject of inquiry and investigation, and may require the production of any book, paper, or document.

POWER TO ADMINISTER OATHS

Section 3737.12 (831)

The fire marshal or an assistant fire marshal may administer an oath to any person appearing as a witness before him. No witness shall refuse to be sworn or refuse to testify, or disobey an order of the marshal, or of an assistant marshal, or fail or refuse to produce a book, paper, or document concerning a matter under examination, or be guilty of contemptuous conduct after being summoned by such officer to appear before him to give testimony in relation to a matter or subject under investigation.

Penalty, 3737.99 (A)

INVESTIGATION MAY BE PRIVATE

Section 3737.13 (832)

Investigation by or under the direction of the fire marshal may be private. The marshal may exclude from the place where such investigation is held all persons other than those required to be present, and witnesses may be kept separate from each other and not allowed to communicate with each other until they have been examined.

Constitutional: Provisions of former section 832 do not contravene Art. I, section 10, or any other section of the constitution of Ohio. 1941, OAG 3599.

By express provision of section 832, an investigation may, at the discretion of the fire marshal, be privately conducted, and a witness called to testify in such an investigation is not entitled to counsel, nor may counsel appear with and speak for a witness if the fire marshal determines that the investigation shall be private. 1941 OAG 3599. (GC 832 now RC 3737.13).

Question of whether or not testimony given by a witness in the public or private investigation of the cause, origin and circumstances of a fire by, or under the direction of, the state fire marshal, may be introduced in the trial of such witness in case he be subsequently indicted and tried, either as a confession, an admission against, or for the purpose of impeachment, is one for the courts of this state, rather than attorney general's office to determine. 1941 OAG 3599.

RIGHT OF ENTRY INTO BUILDINGS, PREMISES, AND VEHICLES FOR EXAMINATION

Section 3737.14 (834)

The fire marshal, his subordinates, the chief of the fire department of each municipal corporation where a fire department is established, the chief of the fire department in each township where a fire department is established, and such members of any such departments as may be designated by such chief, the mayor of a municipal corporation where no fire department exists, or the clerk of a township where no fire department is established, at all reasonable hours, may enter into all buildings and upon all premises and vehicles within their jurisdiction for the purpose of examination. (Eff. 8-18-55).

A city ordinance requiring the consent of the owner or occupant, or the securing of a legal or valid order, before entering a private dwelling for fire examination, is in conflict with the general laws providing for such examinations and therefore inoperative as to any of the officials authorized to make such examinations by section 834. 1950 OAG 2040. (GC 834 now RC 3737.14).

State fire marshal and his assistants have authority, pursuant to sections 833 et seq., to enter all buildings within the state where a fire has occurred, and to enter into all such buildings for the purpose of inspection as to conditions which render such buildings or other buildings in the vicinity liable to fire; and such authority extends not only to privately owned buildings, but to those owned by the state or any of its subdivisions. 1945 OAG 189. (GC 833 now RC 3737.08).

Dwellings constructed or owned by the United States, pursuant to federal legislation which preserves to the state and its political subdivisions their civil and criminal jurisdiction over such property, may be entered and inspected by the state fire marshal and his assistants for the purpose mentioned in sections 833 to 837, inclusive. 1945 OAG 189. (GC 833 now RC 3737.08).

As to scope of section see section 3737.28 and note citing 1945 OAG 182.

An ordinance of a village, creating a zone covering the business area of said municipality, intending to control the construction of buildings therein for protection against loss of property and life from fire and fire hazards alone, comes within the local police regulations a village may adopt and enforce when the same is not in conflict with general laws on that subject. 1924 OAG, p 564.

See Baldwin's Pre-1910 Case Notes.

REPORT TO SUPERINTENDENT OF INSURANCE

Section 3737.15 (829)

When required by the superintendent of insurance, the fire marshal shall report his proceedings, the progress made in all prosecutions for arson and similar crimes, and the result of all cases finally disposed of.

RECORD OF FIRES

Section 3737.22 (838)

The fire marshal shall keep in his office a record of all fires occurring in the state, the origin of such fires, and all facts, statistics, and circumstances relating thereto which have been determined by investigations. Except for the testimony given upon an investigation, such record shall be open to public inspection and such portions thereof, as the superintendent of insurance deems necessary, shall be transcribed and forwarded to such superintendent within fifteen days from the first day of January each year.

PROHIBITION AGAINST OFFICIAL NEGLECT

Section 3737.26 (826)

No officer, named in section 3737.08 of the Revised Code shall neglect to comply with sections 3731.01 to 3731.18, inclusive, 3737.01 to 3737.28, inclusive, and 3739.01 to 3739.19, inclusive, of the Revised Code.

Penalty, 3737.00 (C)

PENALTIES

Section 3737.99

(A) Whoever violates section 3737.12 of the Revised Code may be summarily punished, by the officer concerned, by a fine of not more than one hundred dollars or commitment to the county jail until such person is willing to comply with the order of such officer.

(B) Whoever violates division (B) of section 3737.16 of the Revised Code shall be fined not more than five hundred dollars.

(C) Whoever violates section 3737.26 of the Revised Code shall be fined not less than twenty-five nor more than two hundred dollars.

(D) Whoever violates section 3737.27 of the Revised Code shall be fined not less than ten nor more than fifty dollars for each day's neglect.

(E) Whoever violates section 3737.29 of the Revised Code shall be fined not less than five nor more than twenty dollars.

CHAPTER 25

INSPECTIONS

INTRODUCTION

Fire departments are maintained by villages, townships and municipalities for the purpose of providing the citizens with protection against loss of life and property by fires. For many years, putting out fires was considered the primary purpose of the fire department. Today efficient and well-organized fire departments realize that a full measure of service to the citizens requires as much attention to preventing fires as to putting them out. Therefore, modern fire departments include fire inspection work as one of their responsibilities.

Careful, systematic and intelligent fire inspections are the backbone of effective fire prevention work, and are subsequently a powerful factor in the reduction of loss of life and property. Good inspections not only prevent fires, but, by observation, present opportunities to study and plan for more efficient and intelligent extinguishment of fires. The average businessman and property owner is not trained to recognize fire hazards and does not have a practical knowledge of fire-fighting and the factors influencing the spread of fire. A fire department which has had this training and knowledge can render a better service to the community.

VALUE AND PURPOSE OF INSPECTIONS

Fire department inspections will be of value to members of the department by:

1. Aiding in rescue work
2. Determining fire-fighting procedure
3. Preventing spread of fire
4. Aiding in the self-preservation of firemen
5. Providing knowledge of private fire protection equipment
6. Aiding in fire prevention
7. Determining causes of fires
8. Stimulating cooperation between owners and occupants and the fire department

Each of the preceding will be discussed in the following sections.

AIDING IN RESCUE WORK

The first duty of any fire department is the protection of life. It is generally not difficult to determine the value of buildings and materials of occupancy, but no board of appraisers can set the value of a human life. In order that the firemen may best protect the lives in the community, three things should be known:

1. Where people live
2. Where people work
3. Where people assemble

No department can cope efficiently with its rescue problem unless it is thoroughly familiar with the preceding factors. Inspections are the best means of obtaining this knowledge. Conditions under which people live, work and assemble, in some instances, are of a hazardous nature to human safety. As protectors of life, fire departments have a responsibility they cannot avoid nor delegate to others. In carrying out this responsibility, it will greatly assist them to know in advance where people live, work and assemble and how they may escape or be rescued. The best way to secure this information is to make periodic inspections and surveys.

DETERMINING FIRE-FIGHTING PROCEDURE

It is difficult for a department to attack a fire intelligently without first knowing the building and its occupancy. It is too late to plan procedure and attack after the fire has occurred. It is highly desirable to have a pre-determined course of action to follow when the alarm is received.

For successful fire-fighting the following information, which can be acquired through inspection, is necessary:

1. Type of building and occupancy
2. Life hazard

3. Rescue problems
4. Entrance and exit facilities
5. Methods required for forcible entry
6. Exposure protection
7. Location of hydrants and water supply
8. Sprinklers and other protective devices
9. Hose lines probably needed
10. Ventilation
11. Salvage requirements
12. Potential starting point of fire
13. Potential extension of fire

The preceding are conditions of expectancy, and all go to make up fire-fighting procedure. This knowledge, necessary for the safety of the firemen and occupants as well as for efficient extinguishment of fires, eliminates unnecessary loss of life and property.

PREVENTING SPREAD OF FIRES

The natural course of a fire is to follow the line of the most highly combustible material. Fire that has originated in a basement may travel several floors above before all the combustible materials in the basement have been consumed. Such travel is made possible through open partitions, elevator shafts, chutes and ducts.

Other instances show that fires have started in one building and have traveled to adjoining buildings through unprotected windows, doors and other openings. The travel of fire can be anticipated and in a great many cases prohibited by familiarity with building construction, occupancy, exposures, connecting passage ways, vertical and roof openings and similar features, through inspection practices.

The general public has little appreciation of the great value which structural features, such as stair and elevator enclosures, fire doors and fire partitions have in preventing rapid spread of fire. The fire department, with its added knowledge, should take advantage of every opportunity to emphasize the importance of these factors to owners and occupants.

AIDING IN THE SELF-PRESERVATION OF FIREMEN

No building is worth a fireman's life. In many instances firemen have been killed by walking into open elevator shafts, coming in contact with live wires or falling walls, being cut off from exits and other circumstances which could be due to the fact that the firemen were unfamiliar with the building involved. Inspection will enable firemen to avoid life hazards in a great many buildings in time of fire.

PROVIDING KNOWLEDGE OF PRIVATE FIRE PROTECTION EQUIPMENT

Private fire protection equipment such as extinguishers, standpipes, hose systems, sprinkler systems, private water supplies and alarm systems are installed both as an aid to the fire department and to extinguish fires automatically. Under normal conditions this equipment is not used very often. Since mechanical equipment is apt to be idle for many months at a time, frequent inspections are necessary to keep it in good working order.

Safety of the lives of the occupants may also depend upon the effectiveness of fire protection equipment. Many times such equipment renders the job of fire-fighting much less difficult if it is in good condition. If this equipment does not work when the need arises, it is worse than none at all because the fire department, as well as the owner or occupant of the building, depends upon its correct operation.

AIDING IN FIRE PREVENTION

While fire extinguishment is of vital importance to all fire departments, the trend in a vast majority of departments is to stress fire prevention. A large number of cities maintain a fire prevention bureau in connection with the fire department. There are very few departments that do not assume this responsibility to some extent. The only way to prevent fires is by eliminating fire hazards and causes. In order to accomplish this, it is necessary to inspect all buildings in the community and make recommendations for the removal of, or protection from, such hazards.

DETERMINING CAUSE OF FIRE

Every fire teaches a lesson and for this reason is worthy of study. Knowledge of fire causes, especially of conditions which permit a small fire to become serious, is essential to effective fire prevention. Without such knowledge, inspections become mere routine and waste good effort. Once a fire occurs, it is often too late to determine the cause

since the hazardous condition has been consumed as well as the evidence itself. A better and more defiite method of determining fire causes is to be thoroughly familiar with existing hazards and to anticipate causes. A good way to accomplish this is by thorough inspections. The ends achieved by determining the cause of fires are the discovery of signs of arson and the preservation of all convicting evidence. Also, if fire departments are thoroughly informed as to the cause of a certain fire, it will greatly assist them in their inspection work in prevention of future fires from the same cause.

STIMULATING COOPERATION B TEEN OWNERS AND OCCUPANTS AND THE FIRE DEPARTMENT

Nothing will assure closer cooperation between owners and occupants of buildings and the fire department than the interest of the department in not only preventing fires but in being better prepared to handle the fires when they occur. The inspector should inform the owners and occupants that the fire department is rendering a service in the prevention and control of fires, and it is to the owners' and occupants' advantage to call the department immediately in case of fire. The inspector should also give advice in connection with problems of fire protection and pre ation. These additional efforts will bring about closer cooperation between the public and the department and will serve to increase the standing of the department in the community.

AUTHORITY FOR MAKING INSPECTIONS

The authority of the fire department to enter the property of a citizen of the community to ascertain, correct or protect it from fire hazards is obtained from two sources:

1. Local ordinances

2. State law

LOCAL ORDINANCES

Any city or village that desires to assume the responsibility for efficient fire protection and prevention may pass ordinances, adopt codes and establish authority for inspections. These ordinances and codes can be adapted to local conditions. Data and material for structuring such codes may be procured from:

The National Board of Fire Underwriters, 85 John Street, New York 38, New York.

The National Fire Protection Association, 60 Batterymarch Street, Boston 10, Mass.

The Underwriters Laboratories, Inc., 207 East Ohio Street, Chicago 11, Ill.

The Factory Mutual Engineering Division, 184 High Street, Boston 10, Mass.

The Ohio Inspection Bureau, 431 East Broad Street, Columbus 16, Ohio

The State of Ohio Department of Industrial Relations, Division of Factory and Building Inspection, 813 Ohio Departments' Building, Columbus 15, Ohio

The State of Ohio Department of Commerce, Division of State Fire Marshal, 607 Wyandotte Building, Columbus 15, Ohio

STATE LAW

Under the general powers and duties of the Division of State Fire Marshal, the authority for making fire inspections is stated in the following sections of the State of Ohio Code:

DUTIES AND POWERS OF
FIRE MARSHAL AND ASSISTANTS

Section 3737.01 (835)

If the fire marshal, his assistants, or any officer mentioned in section 3737.14 of the Revised Code, upon an examination or inspection, finds a building or other structure, which for want of proper repair, by reason of age and dilapidated condition, defective or poorly installed electrical wiring and equipment, defective chimneys, defective gas connections, defective heating apparatus, or for any other reason, is especially liable to fire or endangers life or other buildings or property, such officer shall order such buildings to be repaired, torn down, demolished, materials removed, and all dangerous conditions remedied. If such officer finds in a building or upon any premises any combustible or explosive material, rubbish, rags, waste, oils, gasoline, or inflammable conditions of any kind, dangerous to the safety of such buildings, premises, or property, he shall order such materials removed or conditions remedied. If such officer finds that any building, structure, tank, container, or vehicle used for the storage, handling, or transportation of petroleum liquids, or

liquefied petroleum gases, or the pumps, piping, valves, wiring, and materials used in connection therewith, does not comply with the standards or orders of the marshal, he shall make such order as may be reasonably necessary to insure such compliance. Such order shall be made against, and served personally or by registered letter upon, the owner, lessee, agent, operator, or occupant of such buildings or premises, and thereupon such order shall be complied with by the owner, lessee, agent, operator, or occupant within the time fixed in in said order.

INVESTIGATION OF CAUSE OF FIRE

Section 3737.08 (824) (825) (833)

The fire marshal, the chief of the fire department of each municipal corporation in which a fire department is established, the chief of the fire department in each township in which a fire department is established, the mayor of each village in which no fire department exists, and the township clerk of each township where no fire department is established, shall investigate the cause, origin, and circumstances of each fire occurring in such municipal corporation or township by which property has been destroyed or damaged, and shall make an investigation to determine whether the fire was the result of carelessness or design. The investigation shall be commenced within two days, not including Sunday, if the fire occurred on that day. The marshal may superintend the investigation.

An officer making an investigation of a fire occurring in a municipal corporation or township shall forthwith notify the marshal, and within one week of the occurrence of the fire shall furnish him a written statement of all facts relating to its cause and origin and such other information as is required by forms provided by the marshal.

In the performance of the duties imposed by sections 3737.01 to 3737.28, inclusive, of the Revised Code, the marshal and each of his subordinates, and any other officers mentioned in paragraph one of this section, at any time day or night, may enter upon and examine any building or premises where a fire has occurred, and other buildings and premises adjoining or near thereto. (126 v 565. Eff. 8-18-55).

RIGHT TO EXAMINE BUILDINGS, PREMISES, AND VEHICLES

Section 3737.14 (834)

The fire marshal, his subordinates, the chief of the fire department of each municipal corporation where a fire department is established, the chief of the fire department in each township where a fire department is established, and such members of any such departments as may be designated by such chief, the mayor of a municipal corporation where no fire department exists, or the clerk of a township where no fire department is established, at all reasonable hours, may enter into all buildings and upon all premises and vehicles within their jurisdiction for the purpose of examination. (126 v 565. Eff. 8-18-55).

APPEAL TO FIRE MARSHAL; HEARING

Section 3737.20 (836)

If the owner, lessee, agent, operator, or occupant is aggrieved by an order of an officer under section 3737.01 of the Revised Code and desires a hearing he may complain or appeal in writing to the fire marshal within three days from the service of the order, and the marshal shall at once investigate said complaint and fix a place and a time not less than five days nor more than ten days thereafter, for hearing such complaint.

The marshal at said hearing may affirm, modify, revoke, or vacate said order, and unless such order is revoked or vacated by the marshal it shall remain in force, and be complied with by such owner, lessee, agent, operator, or occupant and within the time fixed in said order or within such time as may be fixed by the marshal at said hearing.

APPEALS

Section 3737.21 (836-1)

Any person aggrieved by the final order of the fire marshal as made at the hearing, provided for in section 3737.20 of the Revised Code, may appeal as provided by section 119.12 of the Revised Code. Any person adversely affected by a standard fixed or order made pursuant to sections 3737.16 to 3737.18, inclusive, of the Revised Code, may appeal as provided by section 119.11 of the Revised Code.

PROHIBITION AGAINST NON-COMPLIANCE WITH ORDER

Section 3737.27 (837)

No owner, occupant, lessee, or agent of buildings or premises, and no owner, lessee, operator, or person having the direction and control of any tank, container, vehicle, piping, or equipment, used for the manufacture, storage, handling, sale, or transportation of products subject to sections 3731.01 to 3731.18 inclusive, 3737.01 to 3737.28, inclusive and 3739.01 to 3739.19 inclusive, of the Revised Code shall willfully fail, neglect, or refuse to comply with any order of the fire marshal or any officer acting under him in the performance of the duties imposed by such sections, within the time prescribed in such order, unless an appeal is taken therefrom or from the final order of the marshal, or of the court on such appeal. (125 v 903. Eff. 10-1-53).

EFFECT OF FAILURE TO COMPLY WITH ORDER

Section 3737.28 (836-2)

If any person fails to comply with an order of an officer under section 3737.01 of the Revised Code from which no appeal has been taken or with the order as finally affirmed or modified by the fire marshal or by the court in the event of an appeal, within the time fixed in such order or order of affirmance or modification, then such officer may cause such building or premises to be repaired, torn down, demolished, materials removed, and all dangerous conditions remedied, at the expense of such person. If such person, within thirty days thereafter, fails, neglects, or refuses to repay said officer the expense thereby incurred by him, said officer shall certify said expenses, together with a twenty-five per cent penalty thereon to the county auditor of the county in which said property is situated and the auditor shall enter said expense on the tax duplicates of said county as a special charge against the real estate on which said building is or was situated and the same shall be collected as other taxes and, when collected, shall together with the penalty thereon be refunded to such officer.

PROHIBITION AGAINST FAILURE TO INSTRUCT PUPILS IN FIRE DRILLS

Section 3737.29 (12900)

No principal or person in charge of a public or private school or educational institution having an average daily attendance of fifty or more pupils, and no person in charge of any children's home or orphanage housing twenty or more minor persons, shall willfully neglect to instruct and train such children by means of drills or rapid dismissals at least once a month while such school, institution, or children's home is in operation, so that such children in a sudden emergency may leave the building in the shortest possible time without confusion. In the case of schools, no such person shall willfully neglect to keep the doors and exits of such building unlocked during school hours. The fire marshal may order the immediate installation of necessary fire gongs or signals in such schools, institutions, or children's homes and enforce this section.

Regardless of the size of any community, material and information are available to help organize and facilitate fire inspection services. While it is considered desirable to give the fire department inspection authority under local ordinances, it can be safely assumed that all departments have sufficient authority to conduct fire inspection services in the communities under state laws.

PERMITS AND LICENSES

One of the most effective methods of controlling various special hazards is by a system of permits and licenses. Under this system, the intent of the regulations must be met before any establishment starts operating. The registration and knowledge of such possible hazards is not only an aid in obtaining proper maintenance in these places but aids the fire department in determining fire-fighting procedure in the event a fire occurs. Supervision of such controls will vary with the size of the department. Where fire prevention bureaus are established it will be under this section's jurisdiction. In other cases, the chief of the department or any person designated by the chief can be in control. Which ever method is used, however, details regarding permits and licenses, issuance of corrective orders, examination of plans and approvals of equipment installations, should be subject to final authorization by the chief of the fire department.

DEPARTMENT INSPECTION PROCEDURES

No definite plan or procedure can be established to serve as an exact model for carrying on fire pre-

vention inspection work. Variations in organization, differences in local laws and ordinances, lack of effective enforcement regulations, division of various inspectional functions and authority between departments, and many other factors make a definite inspection plan impossible. To obtain good results, such items as effective administration, qualified and trained personnel, and a continuous inspection service must be incorporated in an inspection program.

COMMON CAUSES OF FIRE

The following table lists the most common causes of fire and their respective percentage, as to the average number of fires thus caused and the average amount of fire loss attributed to that cause. Particular attention should be given those items which indicate a greater frequency of fires and those which contribute the larger losses in our national fire loss picture.

CAUSE	AVERAGE % OF FIRES	AVERAGE % OF LOSS
Chimneys or flues, defected or overheated	5.0	2.9
Sparks on roof	3.6	2.0
Defective or overheated heating equipment	8.2	8.0
Rubbish	5.3	1.0
Combustibles near heaters	1.2	1.0
Open lights, flames, sparks	3.8	2.2
Hot ashes, coals	1.3	1.6
Smoking and matches	16.0	7.8
Children and matches	3.8	1.2
Electrical, fixed services, fires due to misuse or faulty wiring and equipment	9.3	9.9
Electrical, power consuming appliances	3.5	1.6
Flammable liquids, misc., including home dry cleaning and the starting of fires	3.0	3.3
Torches, welding, cutting, plumbers, etc.	0.7	1.0
Lamps, lanterns, oil stoves	4.5	4.0
Gas and appliances	1.0	1.0
Grease, tar, etc.	1.7	0.8
Spontaneous ignition	1.9	3.3
Lightning	4.7	3.7
Thawing pipes	0.3	0.4
Sparks from machinery friction	0.4	0.9
Incendiary, suspicious	1.2	2.1
Explosions (gas, vapor, chemical)	1.6	4.4
Exposure	2.6	3.4
Miscellaneous	7.4	2.5
Unknown	8.0	30.0
Total	100.	100.

PRINCIPAL STRUCTURAL DEFECTS INFLUENCING FIRE SPREAD

To further assist the inspector in determining the potential dangers which may influence fire spread, the following table outlines the various factors with which he should be concerned.

HORIZONTAL SPREAD

1. Fire division walls
   a. too few in attics
   b. too few in basements
   c. too few in other stories
   d. substandard construction
2. Fire wall openings
   a. no protection for opening
   b. fire doors blocked open or inoperative
   c. substandard protection for openings
3. Combustible interior finish
   a. fiberboard
   b. other interior finish
   c. oil soaked floors

VERTICAL SPREAD

1. Stairwells not enclosed
2. Elevator shafts open
3. Non-firestopped walls
4. Conveyor machinery openings not protected
5. Stairwell enclosure substandard
6. Pipe openings not enclosed
7. Elevator shaft enclosure substandard
8. Other openings, no protection or substandard protection

SPREAD TO EXPOSURES

1. Congested combustible construction, no exposure protection
2. Poorly constructed party walls
3. Interconnecting passageways, conveyors
4. Ordinary glass windows
5. Yard storage between buildings

PRINCIPAL PRIVATE FIRE PROTECTION DEFECTS INFLUENCING FIRE SPREAD

To further assist in analyzing and eliminating the potential defects which usually exist whenever fire protection equipment is involved, the following table can be used as a reference.

SPRINKLER PROTECTION

1. No sprinkler system
2. Complete or partial sprinkler system
   a. unsatisfactory performance
   b. hazard too severe for system installed
   c. water supply inadequate
   d. valves closed for miscellaneous reasons
   e. explosion damage potential
   f. valves closed too soon by personnel
   g. fire originating in unsprinklered area
   h. proper supervision and maintenance of system

FIRE DETECTION

1. No watchman or automatic detection
2. Unsatisfactory watchman service
   a. detect fire promptly
   b. area of patrol (inside and outside)

c. size of area patrolled

d. duties of watchman in general

3. Inadequate or unapproved automatic detection

FIRE ALARM TRANSMISSION

1. Transmission delay due to:

a. occupants fighting fire

b. telephone inaccessible

c. possibility of telephone lines becoming burned and inoperable

d. orders to watchman relative to fighting fire

FIRE BRIGADE

1. No fire brigade

2. Insufficient equipment

3. Organization and training

4. Unsatisfactory performance and response

STANDPIPES AND HOSE SYSTEMS

1. No system

2. Unsatisfactory and inadequate

3. Accessibility and usability

4. Maintenance and supervision

SPECIAL EXTINGUISHING SYSTEMS

1. No system

2. Unsatisfactory and inadequate

3. Maintenance and supervision

PORTABLE FIRE EXTINGUISHERS

1. No fire extinguishers

2. Wrong type for class of fire

3. Maintenance and supervision

4. Training of personnel in operation

These last two tables have been organized from data obtained from N.F.P.A. publications relative to fire loss figures over a five year period. Each factor shares a responsibility for influencing fire spread or causing fire damage during that period.

POINTS TO BE CONSIDERED BEFORE MAKING THE INSPECTION

To secure the cooperation of the public when making inspections, good common sense and a friendly attitude are required. The inspector should be appropriately dressed and equipped to do the job by having a uniform cap and badge, clean overalls, flashlight, notebook, and pencil. On occasions a camera may be used to take pictures of situations for further discussion or study and for gathering evidence for prosecution. There are many other factors which should be considered before an inspection is made, but these will depend on local conditions and regulations. Nevertheless, nothing should be overlooked in the preparation for doing a thorough and efficient inspection job from both a mental and physical standpoint. The records of previous inspections, sketches and maps, if available, should be carefully checked before starting the inspection.

At each building or plant to be examined, the inspector should first seek permission of the person in charge to make the inspection, present the badge or other means of identification and explain the reason for the inspection. In stating the object of the visit, it should be pointed out that the inspection is for the benefit of the owner and occupant as well as the fire department. Although it is not legally necessary, permission should always be requested before making an inspection and it is usually granted. The inspector should ask the man in charge, or someone in authority who is familiar with the property, to accompany the inspector, both as a matter of courtesy and for the man's own information.

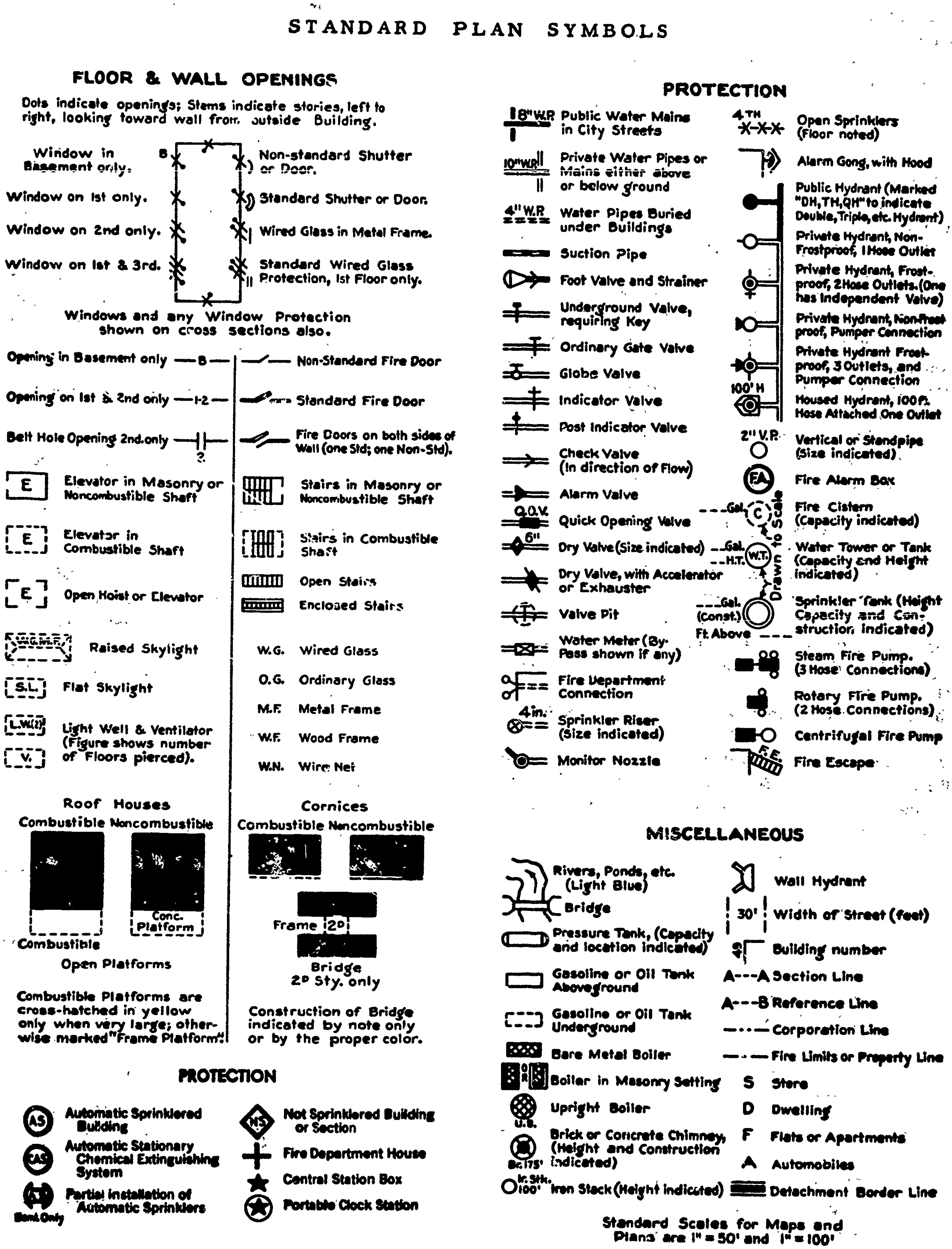
INSPECTION TECHNIQUES

It is recommended that inspections of theaters, night clubs, dance halls, and other such places of public assembly should be made both while in operation and when not in operation. In large industrial plants it may be wise to start by making a trip through the yard to fix in mind the general relationship of the buildings to one another and to adjoining property. Sometimes it may be helpful to start the inspection at the roof of the tallest building on the premises, providing an opportunity to visualize the property as a whole. In many cases ground and building plans of the property are available for study and reference by the inspector. Plans of a property should always be

made on the original inspection. See Figure 1 for standard plan symbols and Figure 2 for property plan record. There will then be no need of duplicating the plans on re-inspections except to include changes or additions. The elaborateness and completeness of the plan rest with the ability of the person making it. It must be remembered that the plan frequently constitutes the most informative part of an inspection report and should be made with neatness and accuracy.

Before entering the building, the inspector should make a general "size-up" of the structure. Much aluable knowledge can be obtained from the outside, such as location of hydrants and fire escapes, location and number of standpipes and sprinkler connections, accessibility to fire apparatus, adjoining fire walls, if any, and other features that would be of benefit in fire fighting. Many inspectors prefer to start at the roof and go down floor by floor to the basement, while others prefer to start in the basement. Where the inspection is started is not important, but it is important that it be done in an orderly manner so that every portion of each floor will be covered. The use of a suitable printed form filled out by the inspector for each building will facilitate this. Sample forms for this purpose are included at the end of this chapter. The forms can be modified to meet local conditions if necessary. Because different types of buildings have hazards peculiar to the kind of building, no effort will be made to list all the things to look for in making inspections. A further study of these special hazards should be made in training class and at the time actual inspection practices are conducted. Some important things to look for in the average mercantile and industrial building, however, are:

1. Accumulation of waste material
2. Kind and location of receptacles for ashes
3. Method of handling and storing waste paper
4. Presence of rags containing paint, vegetable oils, etc.
5. Chimney defects, height above roof and clearance of wood beams
6. Heating equipment installation and defects
7. Electric wiring as to broken fixtures, improper support, damaged insulation, fuses bridged or too large, fuse or switch box covers open or missing, improper use of flexible cord, inflammable materials in contact with light bulbs, location of shutoff
8. Gas piping as to clearance of gas appliances from combustible material, proper venting of appliances, use of rubber hose connections, flexible tubing, location of shutoff in building and at curb
9. Inflammable liquids as to type and construction of storage containers, quantity stored, location, method used for drawing the liquids from the containers, distance from open flame or other sources of ignition
10. Mechanical refrigerating units should be checked for possible leakage, kind of gas contained in system, method of disposal should gas be released
11. Location and condition of cellar drain or drains
12. Structural aspects of buildings, relative to walls, floor and roof construction, locations of stairways, elevators, open shafts, fire doors, etc.
13. Accessibility and use of exits, stairways and other floor openings from both a fire fighting and means of egress standpoint
14. Obstructions created by partitions and merchandise
15. Features relative to ventilation, including windows, scuttles, skylights, elevator, penthouse, etc.
16. Type and nature of contents
17. Exposure to or from adjacent buildings for fire spread
18. Use of adjacent buildings for fire fighting or rescue purposes
19. Location and condition of fire protection equipment, such as sprinklers, standpipes, alarm systems, extinguishers, etc.
20. Violations of laws or regulations relative to construction, installations of equipment, permits, licenses, etc.
21. Salvage operations due to nature and kind of stock on premises
22. Hazards involved through the use of atomic energy or radioactive material



Courtesy National Association of Mutual Insurance Companies

Fig. 1 - Standard Plan Symbols

run card

(Name of Building) (Location)

(Name of Occupant)

(Type Construction) (Type Roof)

(Height) (Type Occupancy)

(Dangerous Storage) (Location)

(Exposure Hazards)

Location Plan (Show Streets - Buildings, Water supply, etc.)

BASEMENT	FIRST FLOOR	SECOND FLOOR	THIRD FLOOR

Courtesy National Association of Mutual Insurance Companies

Fig. 2 - Property Plan Record

When the inspection is completed, the inspector should have a friendly conference with the owner or manager. In this conference the inspector should say tactfully, "I notice so-and-so, which our experience indicates may cause a fire." The inspector should endeavor to let the owner solve the problem as far as possible. If the owner admits to be at a loss about certain items, the inspector should then offer some suggestions. By mutual cooperation the inspector and owner can find satisfactory and practical solutions to the problems.

The inspector should make every effort to gain the cooperation of the owner or occupant in correcting conditions by leaving a favorable impression. Rather than to find fault, the inspector's mission is to assist in preventing fire and to be better informed on how to fight one should it ever occur. The inspector must also be on guard at all times to insure that all recommendations are reasonable and practical. Care must be taken not to make foolish ones, as this will hurt the entire inspection program and make it more difficult for succeeding inspectors. Should the inspector have any doubt as to certain recommendations, expert advice on the subject should be sought before going ahead. All unfavorable conditions should be clearly pointed out when making recommendations. None should be omitted because they seem to be a minor nature. An apparently minor hazard may cause a major fire.

THE FOLLOW UP ON INSPECTIONS

For the inspection to be effective, a follow-up system is necessary. A clear, concise set of notes should be kept for future reference. Where unfavorable conditions are found, the owner or occupant should be informed that the inspector will recheck to ascertain if corrections have been made. A date for this should be set and punctually met. This will tend to make the owner carry out the recommendations made at the time of the inspection. It will also cause the owner to have more respect for the inspection program since the recheck indicates that the department is sincere in its efforts to assist in fire prevention and protection problems.

ENFORCEMENT HINTS

Only as a last resort should it be necessary to take any action under local ordinances or state laws. Tact and diplomacy will, in most cases, gain the confidence of the owner and lead to compliance with the recommendations. If results cannot be obtained by these means, it may become necessary to use other methods to carry out the recommendations. Where certain conditions are potential causes of fire and no action is taken by persons responsible to correct the conditions, steps to see that inspection recommendations are complied with must be taken. Violations of laws and ordinances which are under the jurisdiction of another department should be reported to the proper authority in that department.

Some success has been achieved in securing cooperation through the local fire insurance agent. The agent's suggestion, that it might be necessary to increase insurance rates if certain recommendations of the fire department are not complied with, have sometimes brought results. When this technique fails, the next step is the use of local ordinances and state laws. Penalties which may be applied under these ordinances will usually persuade the owner to comply with the inspection recommendations.

In case local ordinances are not in force, the chief of the department may act under state laws or may report conditions to state authorities. The official in charge of this work in Ohio is the State Fire Marshal. He has authority to investigate conditions and condemn property where recommendations are not complied with.

TYPES, FREQUENCY AND TIMES OF INSPECTIONS

DWELLING INSPECTIONS

In many communities a large proportion of the total number of fires occur in dwellings. Thus it is obvious that something should be done to cut down the number of dwelling fires. This can be accomplished through an annual inspection.

The initiation of an annual inspection program requires careful preparation since its success depends on the cooperation of the residents. The cooperation can be obtained by enlisting the aid of the fire prevention committee of the local chamber of commerce, by newspaper publicity and posters or stickers prominently displayed. The interest of school children, P.T.A. groups, and women's clubs are of decided value. A home inspection blank for school children has met with definite success and can be of great assistance in this program. This can be arranged between the local school system and the fire department. A copy of the home inspection blank for school children, which has been approved by the National Board of Fire Underwriters, is shown in Figure 3, and is recommended for adoption. While the legal aspects of dwelling inspections does not permit firemen to enter a man's home against his will, this will not be a detriment to the success of a properly managed inspection program. A large majority of residents are not only willing but eager to have

Use this

FIRE SAFETY

Check List

To Safeguard YOUR HOME Today!

THE NATIONAL BOARD OF FIRE UNDERWRITERS
New York San Francisco Chicago

HOME fire safety is a family responsibility. Every member of the family has a vital interest and should take part in a check-up to find fire hazards.

The questions on this fire safety check list are so worded that all may be answered "Yes" or "No." Each question answered "No" points to a serious fire safety hazard.

Since the check list is so designed as to cover the average dwelling, it is quite possible that some of the hazards listed do not exist in your home. For example—if, you live in parts of California, Arizona, or Florida, or in a home that is heated by radiant heat, your dwelling may have no cellar. Therefore, all hazards pointed out as lurking in the basement can not exist in your home. Or, you may live in an apartment and have no yard or garage hazards and, it is quite possible that you do not own a portable oil heater.

Therefore, each question which points out a non-existent hazard may be eliminated by the simple expedient of drawing a line through the entire question.

When the blank is completed, questions answered "No" (√) will stand out and give you an accurate picture of the existing fire hazards. Then you can take immediate steps to eliminate these known fire hazards from your home.

Yard and Garage Hazards

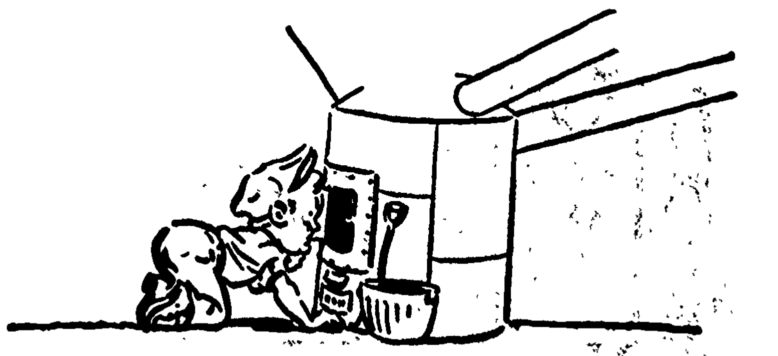
√ Check	Yes	No
Have you removed all flammable rubbish, leaves and debris from your yard?	☐	☐
Have weeds, dried leaves and rubbish been removed from vacant property adjacent to yours?	☐	☐
Is an adult always present during the entire time trash, leaves, etc., are being burned out of doors?	☐	☐
Have you removed all waste, debris, and litter from your garage?	☐	☐
Does your garage have a concrete, brick, or earthen floor?	☐	☐
If you store paint, varnish, etc., in garage, are the containers always kept tightly closed?	☐	☐
If your garage is in the basement, or is a part of the house, is it separated from the living quarters by fire resistant partitions, ceiling, and door?	☐	☐

Housekeeping Hazards

	Yes	No
Do you keep your cellar, storerooms, and attic free from rubbish, old rags, old papers, broken furniture, etc.?	☐	☐
If you use an oil mop, do you keep it in a metal container or other safe, well ventilated place where it will not catch fire?	☐	☐
Do you destroy or safely dispose of oily polishing rags or waste after using?	☐	☐
Do you collect ashes in covered *hole-free metal* containers, and dispose of them at frequent, regular intervals?	☐	☐
Has your family been forbidden to use gasoline, benzine, or other similar flammable cleaning fluids for clothing or on floors in your home?	☐	☐

Heating & Cooking Hazards

	Yes	No
Is your inside basement door at the head of the stairs made of heavy wood or metal and tightly fitted?	☐	☐
Are floors under stoves and heaters protected by metal, brickwork, concrete, or ventilated air space?	☐	☐
If your house is oil heated, is the burner oiled, cleaned, adjusted, and inspected by a qualified service man before the heating season?	☐	☐
Are all stovepipes and chimneys cleaned, repaired and your furnace inspected each fall?	☐	☐
Have you eliminated all stovepipes which pass through attic, closets, storerooms, or frame partitions?	☐	☐
Are walls, ceilings and partitions protected by insulation or adequate separation from overheating of stoves, furnaces and pipes?	☐	☐



SOOTY FURNACE, SOOTY FLUE
DO THEY CAUSE FIRES? AND HOW THEY DO!

Fig. 3 - Safety Checklist for Home

	Yes	No
Are members of your family forbidden to start fires with kerosene or other flammable liquids?	☐	☐
Are all fire places equipped with metal fire screens?	☐	☐
If you have gas connections made of rubber tubing or portable heaters or appliances, are shut-off valves installed in the solid connection or in the metal gas pipe?	☐	☐

Portable Oil Heater Hazards

	Yes	No
Are your portable oil heaters of a type which has been examined and listed by the Underwriters' Laboratories, Inc.?	☐	☐
Is your portable oil heater always set so that it is level, in order to insure proper operation?	☐	☐
Do you always refill the fuel tank or compartment of your portable oil heater out doors and in the daylight?	☐	☐
If you use a wick-type portable oil heater, do you trim the wick and clean it regularly?	☐	☐
Do you regulate the flame of your portable oil heater to keep it from smoking?	☐	☐
Do you always turn your portable oil heater out upon retiring at night?	☐	☐

Electrical Hazards

	Yes	No
Do you allow only qualified electricians to install or extend your wiring?	☐	☐
Do all of your electrical appliances—including irons, waffle irons, mixers, heaters, lamps, fans, radios, television sets, and other devices—bear the label of the Underwriters' Laboratories, Inc.?	☐	☐
Do all rooms have an adequate number of outlets to take care of electrical appliances?	☐	☐
Have you done away with all multiple attachment plugs?	☐	☐
Are your electric irons and all electrical appliances used for cooking, equipped with metal stands and heat controls?	☐	☐
Are special circuits provided for heavy duty appliances such as washing machines, refrigerators, ironers, etc.?	☐	☐

FOR A SURE-FIRE JOB OF HOME-MADE FIRING, JUST PAY NO 'TENTION TO DEFECTIVE WIRING

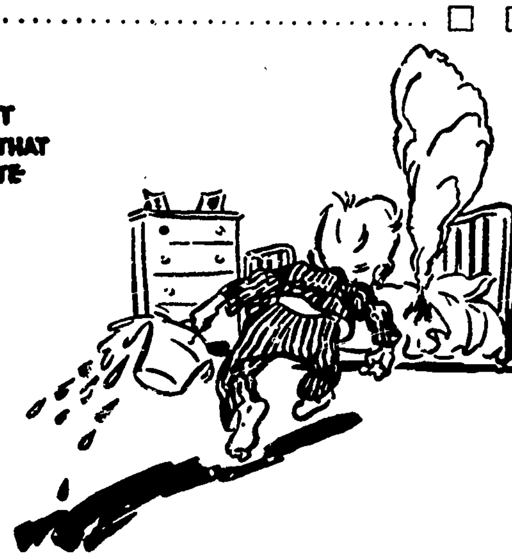
TROUBLE MATCHES FROM THE MATCHES JUNIOR SCRATCHES

	Yes	No
Do you use only 15 amp. fuses in the fuse box for your household lighting circuits?	☐	☐
Are all flexible electrical extension cords in your house in the open—none placed under rugs or over hooks?	☐	☐

Matches & Careless Smoking Hazards

	Yes	No
Do you keep matches in metal containers away from heat and away from children?	☐	☐
Do you extinguish all matches, cigarette and cigar butts carefully before disposing of them?	☐	☐
Do you see to it that there are plenty of ash trays in all rooms throughout the house?	☐	☐
Are all members of your family instructed not to smoke in bed?	☐	☐

OL' MAN TROUBLE YOU AID AND ABET WHEN YOU SMOKE THAT BEDTIME CIGARETTE



What To Do in Case of Fire

	Yes	No
Do you know the location of the alarm box nearest your home?	☐	☐
Do you know how to turn in a fire alarm?	☐	☐
Do you know the telephone number of the fire department?	☐	☐
Did your entire family take part in completing this check list?	☐	☐

....
NAME OF HOUSEHOLDER

....
STREET ADDRESS

....
CITY ZONE STATE

(1,500 M) 6-48-PR

Printed in U. S. A.

Cartoons by Ralph Moses—
Courtesy of National Safety Council Inc., Chicago

Courtesy National Board of Fire Underwriters

firemen inspect their homes and make suggestions for added fire safety.

In the actual inspection it is recommended that firemen work in pairs and that inspections be confined to the hours in which the maximum amount of cooperation can be obtained from the residents. The inspectors should go to the back door and ask permission to make an inspection of the house. They should explain the purpose of the inspection program and ask the housewife, or some other member of the family, to accompany them if possible. Pamphlets, which may be used to good advantage, can be obtained for distribution at the time of inspection.

Municipalities making dwelling inspections have found it worthwhile to repeat the inspection program annually in connection with a Fire Prevention Week campaign. It is found that after the first year, the benefits are significant enough to command the support of the entire community.

Points to notice in dwelling house inspections

1. Items to be checked from outside
   a. condition of roof
   b. condition of chimneys
      1) supported on wood posts or brackets
      2) loose bricks
      3) open joints or cracks
   c. condition of yard
      1) dry grass, leaves, paper
      2) other combustible materials in yard or under porches
   d. condition of garages and sheds
      1) cleanliness
      2) good maintenance
2. Items to be checked in basement
   a. accumulation of waste material
      1) waste paper
      2) oily rags
      3) discarded material
   b. improper storage
   c. ashes in contact with wood
      1) wooden boxes or barrels
      2) piled against wooden partitions
   d. furnaces, stoves or smoke pipes
      1) too close to ceiling
      2) too close to partitions
      3) poorly supported or corroded smoke pipes
   e. gas appliances
      1) corroded piping
      2) rubber tubing
      3) automatic gas devices without thermostatic provisions
   f. oil burner installations
   g. chimney defects
      1) wood beams extending into chimney walls
      2) unused openings not properly closed
      3) clean out door at base of chimney
      4) general condition of chimney
   h. work rooms
      1) removal of shavings or other waste material
      2) safe storage of paints, varnish, etc.
   i. check to determine if basement has fire stops

SCHOOL INSPECTIONS

A fire, no matter how small, in a school may result in disaster. Inspection of all school buildings by qualified fire department inspectors is necessary to safeguard the lives of school children. It is recom-

mended that these inspections be made monthly by a representative of the fire department accompanied by the school custodian and a member of the administrative staff. The self-inspection blank for schools, prepared and distributed by the National Board of Fire Underwriters, as shown in Figure 4, is designed as a guide for these monthly inspections.

Points to notice in school building inspections

1. Good housekeeping
   a. handling and disposal of waste paper
   b. accumulation of discarded material under or near stairways
   c. self-closing metal waste cans in shop areas and all similar work rooms
2. Heating equipment
   a. clearance between combustible material and furnaces, smoke pipes and all hot surfaces
   b. general condition of heating plant
3. Electrical wiring
   a. improperly made extensions
   b. hazardous use of flexible cord
   c. broken fixtures
   d. size of fuses used
4. Ventilation system
   a. combustible material stored where it would send fire and smoke through system if ignited.
   b. equipped with protection devices such as fire dampers in ducts and automatic shutoff for fans
5. Fire extinguishers and standpipe systems
   a. sufficient in number and properly spaced
   b. extinguishers charged annually, protected from freezing and in good condition
   c. fire hose in good condition, properly maintained with nozzle attached
6. Fire doors
   a. installed where required
   b. fully operative
7. Fire alarm system
   a. heard in all portions of building
   b. can be sounded from each floor
   c. general condition of alarm system
8. Exit facilities
   a. each assembly room of large capacity has at least two exits
   b. exit doors open outward and have only panic hardware for locks
   c. stairways, corridors and fire escapes kept free from obstructions
   d. windows near fire escapes should be wire glass in metal frames
9. Fire drills
   a. frequency of drills
   b. time required to vacate building
   c. arrangement made for promptly notifying fire department in case of fire
   d. a definite system to determine all persons are out of the building

FREQUENCY AND TIME OF INSPECTION

No standard policy can be established which will regulate these practices. The local department is in a position of being better informed on conditions in their area, and can subsequently decide how often inspections should be made to control the situation. It is natural to assume that where bad risks are involved, or where more hazards exist, inspections must be made more frequently than in buildings where good housekeeping policies are maintained and where hazards are minimized.

SELF-INSPECTION BLANK FOR SCHOOLS

Prepared by

THE NATIONAL BOARD OF FIRE UNDERWRITERS

Chicago New York San Francisco

Approved and Adopted by

The National Association of Public School Business Officials

Endorsed by the

International Association of Fire Chiefs

If precautions are taken to minimize the danger of fire and to provide for safety in case fire occurs, real progress will be made in safeguarding life and protecting property. Intelligent thought and care in practice can eliminate practically all fires within schools.

INSTRUCTIONS

Inspection to be made each month by the custodian and a member of the faculty at which inspection only Items 1 to 20 need be reported. At the quarterly inspection, a member of the fire department should accompany the above inspectors, and the complete blank should be filled out. The report of each inspection (monthly and quarterly) is to be filed with the Board of Education or School Commissioners.

Questions are so worded that a negative answer will indicate an unsatisfactory condition.

Date..........

Name of School .... City..........

Class: Elementary.......... Junior High.......... Senior High ....

Capacity of School?.......... Number now enrolled ....

1. Are all exit doors equipped with panic locks?.......... Are these locks tested each week to insure ease of operation?.......... Do these lock securely so that additional locks, bolts or chains are not necessary?.......... Are such additional locks open whenever building is in use? ....
2. Are all outside fire escapes free from obstructions and in good working order?.......... Are they used for fire drills? ....
3. Is all heating equipment, including flues, pipes and steam lines:—
   (a) in good serviceable condition and well maintained? ....
   (b) properly insulated and separated from all combustible material by a safe distance? ....
4. Is coal pile inspected periodically for evidences of heating? ....
5. Are ashes placed in *metal* containers used for that purpose *only?* ....
6. Is remote control provided whereby oil supply line may be shut off in emergency? ....
7. Where is outside shut-off valve on gas supply line?..........
   ....
8. Check any of the following locations where there are accumulations of waste paper, rubbish, old furniture, stage scenery, etc., and explain under remarks:— attic, basement, furnace room, stage, dressing rooms in connection with stage, other locations ....
9. Is the space beneath stairs free from accumulations or storage of any materials? ....
10. What material or preparation is used for cleaning or polishing floors? ....
    Quantity on hand? ....Where stored? ....
11. Are approved metal cans, with self-closing covers or lids, used for the storage of *all* oily waste, polishing cloths, etc.? ....
12. Are approved metal containers with vapor-tight covers used for all kerosene, gasoline, etc., on the premises? ....Why are such hazardous materials kept on the premises?
    ....
13. Are premises free from electrical wiring or equipment which is defective? ....
    (If answer is *No,* explain under Remarks.)
14. Are only approved extension or portable cords used?..........
15. Are all fuses on lighting or small appliance circuits of 15 amperes or less capacity? ....

(Continued on reverse side)

125M-6-49. P.R.

Fig. 4 - Inspection Blank for Schools

16. Are electric pressing irons equipped with automatic heat control or signal and provided with metal stand?
....

17. Are sufficient fire extinguishers provided on each floor so that not over 100 feet travel is required to reach the nearest unit? ....

In manual training shops and on stage, 50 feet? ....

18. Have chemical extinguishers been recharged within year? ....

Is date of recharge shown on tag attached to extinguisher? ....

19. Is building equipped with standpipe and hose having nozzle attached? ....

Is hose in good serviceable condition? ....

20. Is a large woolen blanket readily available in the domestic science laboratory for use in case clothing is ignited? ....

Remarks (Note any changes since last inspection)

The following items to be included in each quarterly inspection:—

21. Building construction: Walls.......... Floors.......... Roof..........

No. stories ....No. class rooms ....

22. Which sections of buildings are equipped with automatic sprinklers? ....
....

23. Are there at least two means of egress from each floor of the building? ....

Are these so located that the distance measured along the line of travel does not exceed

From the door of any classroom, 125 feet? ....

From any point in auditorium, assembly hall or gymnasium, 100 feet? ....

24. Are all windows free from heavy screens or bars?..........

25. Do all exit doors open outward? ....

26. Are all interior stairways enclosed? ....

Are doors to these enclosures of self-closing type?..........

27. Are windows within 10 feet of fire escapes glazed with wire glass? ....

28. Are manual training, domestic science, other laboratories and the cafeteria so located that a fire in one will not cut off any exit from the building? ....

29. Is a smoke-tight projection booth, built of incombustible materials, and vented to the outside, provided for the motion picture machine? ....

30. Are heating plant and fuel supply rooms cut-off from the main corridors by fire-resistant walls, ceiling and doors? ....

31. Do all ventilating ducts terminate outside of building? ....

32. State type of construction of any temporary buildings in school yard ....
....

33. Is nearest temporary building at least 50 feet from main building? ....

34. How often are fire drills held?..........Average time of exit? ....

35. Are provisions made for sounding alarm of fire from any floor of building? ....

Is sounding device accessible? .... Plainly marked? ....

36. Give location of nearest city fire alarm box ....
....

How far distant from the premises? ....

Remarks

Inspector.......... Title..........

Inspector.......... Title..........

Inspector.......... Title..........

Courtesy National Board of Fire Underwriters

As a criterion, however, it is recommended that inspections in commercial and industrial buildings be made at least four times a year and in dwellings at least once a year. Schools, theaters and churches and other places of public assembly should be checked at least four times a year on general inspection and weekly or monthly when in use. Target hazards or places where unusual hazards exist should be inspected at least six times a year and more frequently if the hazards warrant closer attention. Occupancies where bad rubbish conditions exist should have weekly inspections.

The proper time for making an inspection will vary in accordance with the size and organization of the inspection activities within the fire department. Men working out of the fire prevention bureau of district fire stations quickly become familiar with working hours and business activities within the jurisdiction of the station and can schedule the inspections to good advantage. Men working out of volunteer departments sometimes have to schedule the inspection activities in the evening on a prearranged basis. Regardless of whatever time schedule is used by a fire department, the cooperation of the owner or occupant can be obtained to do this important job.

During the pre-Christmas or holiday seasons when stores are filled with shoppers and business is at its peak, special attention should be given to these places of business. Excess stock piling, more rubbish accumulation, less attention to fire protection, and overcrowding of facilities prevail. Therefore, special precautions should be taken and inspectors should be on the alert to prevent fires and accidents. See Figure 5 for a sample inspection form for mercantile establishments.

ADDITIONAL HINTS AND SUGGESTIONS FOR INSPECTORS

1. Remember always that an inspector represents the community. A community is made up of all the people living in it and the inspector's actions should be governed accordingly.

2. Be careful from the very beginning. An erroneous method is more easily corrected the first time it is practiced than after it has been in frequent use. The reputation of being slack or "easy" is not hard to come by, but it is very difficult to overcome.

3. When making inspections be friendly with everyone, familiar with no one.

4. Make recommendations or suggestions to those in authority only.

5. Duplicate copies of the results of the inspection should be given to the person in charge as a matter of record for future follow-up and for reference. The inspector's name and the date of the inspection should be noted thereon.

6. *Do not argue.* Refer disputed questions to the chief of the department.

7. The inspector should be sure his judgments are fair, impartial and knowledge of the work is so thorough as to command respect and obedience.

8. The inspector's importance should not be magnified. The results obtained will measure the inspector's ability.

9. Realize the importance of the work. The lives and property of many people depend on the faithful performance of the inspector. Consider these duties seriously and others will do likewise.

   Inspections that are thorough and regular will be of great assistance in educating the public to common fire hazards and will aid in safeguarding life and property by decreasing these hazards. Records show that in towns having good inspection service, fire losses are reduced and kept down each succeeding year. Public relations are of vital importance to a fire department. No single item will accomplish more toward favorably "selling" the department to the public than a courteously conducted and helpful inspection system.

INSPECTION FORMS

To aid departments in establishing a program of inspection in their community, samples of forms which can be used in various occupancies or for various purposes are included in the following pages. These may be used to structure a form designed for a special area or community. Local policy should direct the design.

SELF INSPECTION BLANK

FOR

MERCANTILE ESTABLISHMENTS

(Approved by the National Board of Fire Underwriters)

1. Are there any accumulations of dirt or rubbish on the premises? ....
2. Is the basement clean? ....
3. Are the packing and shipping rooms cleaned thoroughly at closing time? ....
4. Is there any unnecessary combustible material in the yard or court? ....
5. Is there any oily waste or other greasy material outside of approved waste cans? ....
6. Are any waste cans not emptied daily after closing hours? ....
7. Are there any broken windows, plastering, partitions, flooring, or other similar defects? ....
8. Are any aisles obstructed? ....
9. Are any entrances obstructed? ....
10. Is any woodwork or other combustible material too near steam pipes, boilers, flues or furnaces? ....
11. Is the fuel supply safely stored? ....
12. Are there any open flame lights near combustible material? ....
13. Are there any broken electric fixtures or loosened wires? ....
14. Are electric cords looped over nails or in contact with any other metallic objects or surfaces? ....
15. Are any electric fuses replaced by wire or other improper current-carrying materials or devices? ....
16. Are fire doors or shutters ever left open at night, or on Sundays or holidays? ....
17. Are fire escapes obstructed, broken or out of order? ....
18. Are there any violations of rules on smoking? ....
19. Are all water pails, hose, nozzles and chemical extinguishers in place and in good condition? ....
20. Are any sprinkler heads coated or corroded? ....
21. Are any sprinklers obstructed by partitions, piles of merchandise, etc.? ....
22. Are any sprinklers or sprinkler pipes exposed to freezing? ....
23. How many sprinkler heads are kept in reserve? ....
24. Is there any part of the premises that the watchman fails to visit? ....
25. Are window openings protected from exposure fires? ....
26. Is combustible stock storage isolated by fire walls? ....
27. Where is the nearest fire alarm box? ....

Name: .... Address: ....

Courtesy National Board of Fire Underwriters

Fig. 5 - Inspection Blank for Mercantile Establishments

National Board of Fire Underwriters

RECOMMENDED

INSPECTION FORM

FOR CHURCHES

Date..

Name of Church .... City ....

Location ....

EXIT FACILITIES

1. Does every room, balcony or other space having a capacity of 100 or more have two exit doorways?...............

   If building accommodates 300 or more persons, each room, balcony or other space where such assembly occurs should have exit ways to the outside, as follows:

   (a) Not less than 2 exit ways when 600 persons or less are accommodated in such room, balcony or other space.

   (b) Not less than 3 exit ways when more than 600 but not more than 1,000 persons are accommodated.

   (c) Not less than 4 exit ways when more than 1,000 persons are accommodated.

2. Are exit ways provided in accordance with provisions of (a) (b) or (c) above? ....
3. Are exit doorways so located that no point in a floor-area, room or space served by them is more than 125 feet distant, measured along the line of travel? ....
4. Are all exits and fire stairways maintained in good, safe, usable condition and free from obstructions?..........

   ....

5. Are exit doorways marked with exit signs and lights?..............................

   ....

6. Do the exit doors of rooms occupied by 50 or more persons open in the direction of exit travel to the outside?

   ....

7. Are all doors at required exits provided with panic bolts or kept unlocked during occupancy? ....

HEATING EQUIPMENT

8. Is the furnace enclosed in a separate room with fire resistive partitions, with the ceiling also similarly protected? ....
9. Is a self-closing fire door provided at the opening into the furnace room? ....
10. Are metal containers provided for the storage of ashes? ....

    ....

11. Are automatic means for controlling temperatures in duct systems, breaching etc. provided? ....

    ....

12. If oil burner, gas fired or mechanical stoker is provided, are fully automatic safety controls installed?...............

    ....

13. Is all heating equipment including chimney flues, smokepipes and hot air ducts:

    (a) In good serviceable condition and well maintained? ....

    (b) Properly insulated and separated from all combustible material by a safe distance?..........................

Fig. 6 - Inspection Blank for Churches

KITCHEN

14. Is the range safely installed away from combustible material and the nearby floor protected?............................
15. Is there a hood above the range and is it vented to the outside? ....
16. Is vent pipe insulated or separated from combustible material by a safe distance? ....
17. Is fire extinguisher provided and is it in good order?...

....

LIGHTING AND ELECTRICAL EQUIPMENT

18. Are all fuses on lighting and small appliance circuits of not more than 15-ampere capacity?...........................
19. Are all alterations of electrical installations made only by a qualified electrician? ....
20. Does all electric wiring installed within or in connection with organs comply with the appropriate provisions of National Electrical Code? ....

PROTECTION

21. Are sufficient fire extinguishers provided on each floor so that not over 100 feet travel is required to reach nearest unit? ....
22. Is tag showing date of recharging attached to each extinguisher? ....
23. Is the building, particularly the steeples, spires and towers, properly equipped with a system of lightning rod protection and does it carry the Master Label of Underwriters' Laboratories, Inc.? ....

....

24. Where automatic sprinklers or standpipe and hose are installed: Have these been thoroughly inspected within the past year? ....

GENERAL

25. Are decorations of a combustible nature provided in any room or space used for assembly purposes, and if so, have they been flameproofed? ....
26. Is the collection and disposal of trash safely handled in a manner avoiding hazardous accumulations at any point? ....
27. Are spaces beneath stairs free from accumulations of, or storage of any combustible material?..........................

REMARKS

....

....

....

....

....

....

....

Inspector ....

Date ....

ATTACH COPY OF ANY ORDER OR RECOMMENDATION MADE.

Courtesy National Board of Fire Underwriters

SELF-INSPECTION FORM FOR HOTELS

Recommended by
THE NATIONAL BOARD OF FIRE UNDERWRITERS
New York - Chicago - San Francisco

Constant supervision is necessary if hazards to life from fire and panic are to be minimized. This form is provided for use in making periodic checks on the maintenance factors for the purpose of informing the hotel management of prevailing conditions affecting the fire hazard.

INSTRUCTIONS

An inspection should be made at least once each month by the Chief Engineer or other responsible member of the operating staff, and this form when completed should be filed with the manager of the Hotel. It will be of mutual advantage if an arrangement is made for the local fire chief or the officer in charge of the local fire prevention bureau of the fire department to accompany the chief engineer when these inspections are made.

A NEGATIVE ANSWER TO ANY ITEM INDICATES AN UNSATISFACTORY CONDITION.

Date..

Name of Hotel .... City..

EXITS

Are doors into stair shafts at each floor level kept closed?..

Are all exits and fire escapes readily accessible and free from obstructions? ....

Can windows be readily opened in an emergency? ....

Are exits of adequate capacity? ....

NOTE: In case of doubt as to adequacy of exits the Building Inspector and Chief of the Fire Department should be consulted.

Are exit doors equipped with panic bars where needed?..

Will revolving doors collapse? ....

Do exit doors of rooms occupied by 50 or more persons open in the direction of exit travel? ....

Are all exitways properly marked and lighted? ....

Are all stair, elevator and other openings between floors enclosed? ....

LIGHT, POWER AND HEAT

Are all fuses on lighting or small appliance circuits of 15 ampere or less capacity? ....

Are fuse and switch boxes kept closed? ....

Are electric extension cords in good condition?...............Are they restricted to lengths of less than 10 feet?..........

Are motors and motor-operated appliances clean and well lubricated? ....

Are ashes placed in metal containers? ....

Has oil-burning equipment been serviced by a qualified person within the past year? ....

Is all heating equipment, including flues and heating pipes, in safe operating condition? ....

Is all combustible material properly spaced or protected to avoid fire hazard? ....

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Fig. 7 - Inspection Blank for Hotels

HOUSEKEEPING

Is collection and disposal of rubbish safely handled in a manner avoiding hazardous accumulations at any point?

....

Are spaces beneath stairs and at bottoms of elevator and dumbwaiter shafts free from accumulations of, or storage of any combustible material? ....

Are brooms and other cleaning equipment and materials kept safely? ....

Is storage of combustible furnishings orderly and in safe locations with adequate fire protection? ....

Are oily wastes, paint rags, shavings, etc. in engine rooms and maintenance shops kept in covered metal cans?..........

KITCHENS

Are all hoods, exhaust ducts and fans clean? ....

Do ducts extend to outside air in a safe manner? ....

If filters are used in hoods are they in place and regularly cleaned? ....

Is fire extinguishing equipment provided and is it in good order? ....

Has refrigeration equipment been serviced by a qualified person within the past year? ....

LAUNDRY AND TAILOR SHOP

Are all heated devices safely arranged? ....

Are thermostatic controls on driers in good operating condition? ....

Are driers free from accumulations of lint and dust? ....

Are electric irons equipped with pilot lights or with automatic heat controls? ....

Do these controls operate properly?..............................Do all safety pilot lights operate? ....

Are flammable cleaning fluids used only from approved safety cans? ....

MAINTENANCE SHOPS

Are carpentry, upholstery, mattress, paint and other maintenance shops clean and orderly? ....

Do they have adequate room so as to avoid hazardous congestion? ....

Are all combustible supplies kept in a safe location? ....

Is all waste material removed daily, and safely disposed of? ....

PROTECTION

Are fire extinguishers provided on each floor so that not over 100 feet travel is required to reach nearest unit?

....

In maintenance shops, are extinguishers provided so that not over 50 feet of travel is required? ....

Have all extinguishers been properly serviced within the past year? ....

Are automatic sprinklers provided in maintenance shops and any other places where the hazard warrants such protection? ....

Where sprinklers are installed: Are all sprinklers clean and unobstructed?..............................Are all sprinkler valves open?..............................Has the system been thoroughly inspected within the past year? ....

Is all standpipe fire hose in proper place and in good condition? ....

Are all fire alarm devices maintained in good operative condition? ....

Is adequately supervised night watchman service provided at not over one-hour intervals? ....

Are all employees instructed as to their duties in case of fire? ....Have they held a practice drill within the past three months? ....

Is adequate means provided to notify promptly all guests in case of fire? ....

Are responsible employees instructed to call the fire department promptly in case of fire? ....

Do they know exactly how to do it? ....

....

Member of Operating Staff

Courtesy National Board of Fire Underwriters

SELF-INSPECTION FORM FOR HOSPITALS

RECOMMENDED BY

The National Board of Fire Underwriters

CHICAGO—NEW YORK—SAN FRANCISCO

ENDORSED BY

The American Hospital Association

Constant supervision is necessary if hazards to life from fire or explosion and attending panic are to be minimized. Only through periodic check can responsible officials be assured of proper maintenance throughout the hospital plant. Detailed inspections of the buildings will be made upon request by the insurance board or bureau in your territory. This form is provided for your use in making intermediate checks on the maintenance factors.

INSTRUCTIONS

An inspection should be made at least once each month by the Chief Engineer, Supervising Nurse or other responsible member of the operating staff and this form, when completed, should be filed with the Superintendent or other executive in charge of the hospital. It will prove to be of mutual advantage if you will request the local fire chief to accompany your inspectors.

A negative answer to any item indicates an unsatisfactory condition.

Date ....

Name of Hospital .... City ....

EXITS

1. Are all exits and fire escapes free from obstructions? ....
   Are doors into stair shaft at each floor level kept closed? ....
2. Are windows, except those required to be barred, free from heavy screens, bars or obstructions? ....

HEATING EQUIPMENT

3. Are doors to the furnace room kept closed? ....
4. If soft coal is used, is coal pile inspected bi-weekly for evidences of heating? ....
5. Are ashes placed in metal containers used for that purpose only? ....
6. If oil or gas fuel is used, is remote-control valve provided? .... Is it operative? ....
   Give location .... Is it readily accessible? ....
7. Is all heating equipment including flues, pipes and steam lines—
   (a) In good serviceable condition and well maintained? ....
   (b) Properly insulated and separated from all combustible material by a safe distance? ....

KITCHENS

8. Is there a hood above the range? .... Is it clean? ....
   Is the hood vented to the outside? .... Is vent pipe insulated or separated from combustible material by a safe distance? ....
9. Are doors to room containing machinery for refrigerating system kept closed? ....
   Is this room ventilated directly to the outside? .... Is vent clear and unobstructed? ....
   Are pressure relief valves and vents in good working order? ....

LAUNDRY

10. Are doors from laundry to main buildings kept closed? ....
11. Are thermostatic controls on dryers in good operating condition? ....
    (a) Is tumbler free from accumulations of combustible lint and dust? ....
    Is tumbler inspected and cleaned at frequent intervals? ....
    (b) Is vent pipe from tumbler insulated or otherwise safely separated from combustible material? ....
12. Are electric devices and irons equipped with automatic heat controls? ....
    Do these controls operate properly? .... Do all safety pilot lights operate? ....

SPECIAL HAZARDS

13. Are Oxygen and Nitrous Oxide cylinders stored separately from containers of Vinethene, Cyclopropane, Ether, Ethylene or Ethyl Chloride? .... Are store rooms ventilated directly to the outside? ....
    Are cylinders so stored as to prevent tipping over? .... Protected from the direct rays of the sun? ....
    Kept sufficiently removed from steam pipes or radiators to prevent accidental contact? ....
    Is door to storage room kept tightly closed? .... Is electric light switch located outside of cylinder storage room? ....

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Fig. 8 - Inspection Blank for Hospitals

14. Is X-Ray equipment in a separate room used for no other purposes? ....
If adjoining operating room, is door kept closed whenever either room is in use?..........
Are X-Ray films and negatives stored in metal cabinets? ....

15. In operating room—
(a) Is humidity maintained at 60 per cent or more whenever room is in use?..........
(b) Is an adequate system of mechanical ventilation provided? ....
(c) Is sterilizer of a type not involving the danger of sparks or open flames? ....
(d) Are all electrical installations and equipment explosion proof and in conformance with the standards for Class 1, Group C locations as given in Article 500 of the National Electrical Code?..........
(e) Are electrical surgical instruments so designed or used as to safeguard against the spark hazard?..........
(f) Are all switches, outlets and similar devices so designed and installed as to reduce the spark hazard to a minimum? ....
(g) Are provisions made for safeguarding against static electricity and other sources of ignition during operations?.......... Is flooring of suitable electrically conductive type?..........
(h) Is auxiliary source of electric current for emergency lighting readily available? ....
Are batteries fully charged?.......... Is generator in good operating condition?..........
Date tested ....

GENERAL

16. Check any of the following locations where there are accumulations of waste paper, rubbish, old furniture, etc., and explain under remarks: Attic, basement, furnace or boiler room, laundry, kitchen, sewing room, pharmacy, laboratory or other location.
Is space beneath stairs and elevator and dumbwaiter shafts free from accumulations of, or storage of, any materials? ....

17. (a) Are all fuses on lighting or small appliance circuits of 15 ampere or less capacity?..........
(b) Are electric extension cords in good condition?..........Restricted to less than 10-foot lengths?..........
(c) Are all alterations of electrical installations made only by a qualified electrician?..........

18. Are approved metal containers used for all oily waste, polishing or cleaning materials?..........

19. Is all refuse removed from the premises or burned daily? ....

PROTECTION

20. Are all sections of non-fireproof buildings provided with Automatic Sprinklers? ....
Where sprinklers are installed—
(a) Are all heads free and unobstructed?..........Free from paint? ....
(b) Are all sprinkler valves open? ....
(c) Give date of last inspection of sprinkler system ....
(d) Have any structural changes in buildings been followed with proper changes in the sprinkler system?
....

21. Are sufficient fire extinguishers provided on each floor so that not over 100 feet travel is required to reach nearest unit? .... Date recharged? ....
Is tag showing date of recharging attached to each extinguisher? ....

22. Is fire hose with nozzle on interior standpipe in good condition? ....

23. Are fire alarm devices on each floor in each section of building? ....
Are they properly maintained and operative? ....
Are signs giving location of boxes properly maintained? ....
Are boxes unobstructed? ....Plainly marked? ....
Date system last tested?..........Give location of city fire alarm box..........

24. Date of last fire drill?.......... Did all employees and all members of staff participate?..........

REMARKS:

Inspector.......... Title..........
Inspector.......... Title..........
Inspector.......... Title..........

Courtesy National Board of Fire Underwriters

SUGGESTED FORM

OF

SELF INSPECTION BLANK

FOR

INDUSTRIAL PLANTS

Prepared by the National Board of Fire Underwriters, 85 John Street, New York City 7, as a Weekly Report for Plant Owners to have Printed in Quantity for their Individual Use.

Note—The following general rules should be observed by the foreman or other trusted employee selected to make these reports.

Give attention to *every* question on this blank. If the question does not apply to this plant draw a line through the space left for the answer. In this way you can be sure that you have not overlooked anything.

Some questions are to be answered by "Yes" or "No" but others must be answered more fully.

When you find some defect, explain its cause and the steps that you are taking to correct it, in the space headed "CORRECTIONS AND REMARKS," on the last page of the blank. In doing this, *give the number of the question.*

If it ever becomes necessary to shut off the water from the sprinkler system, notify the office of the plant *at once* (even in advance, if possible).

This is important to enable us to notify the insurance companies or association.

If there is anything that you do not understand, consult with the manager at once.

Turn in the report blanks promptly to the manager of this plant.

Remember that these inspections are very important. The safety of this plant from fire is largely up to *you*.

GENERAL CONDITIONS.

Cleanliness and Order.

1. Was your inspection complete, covering all parts of the premises, including looking under benches, into closets, behind radiators, elevator pits, etc.?..........

2. Where did you find dirt or litter?..........

3. Were all clothes lockers clean and in good repair?..........

4. Where did you find oily waste or any other greasy material outside of approved* waste cans?..........

5. Are any waste cans not emptied daily after closing hours?..........

6. Is there any failure thoroughly to clean up shipping and packing rooms at closing time?..........

7. Is there more packing material brought in than is needed for one day's use?..........

8. What rooms or departments were not as clean as they should be?..........

9. Was yard free from combustible material?..........

10. Was basement clean?..........

Maintenance.

11. Is there any part of the plant which the watchman fails to visit?..........

12. Are any watch-clock records unsatisfactory?..........

13. Where were machinery, belts or shafting in bad condition?..........

14. Where were bearings dirty or poorly oiled?..........

15. Where did you find broken window panes, plastering, partitions, flooring, or other defects?..........

16. Were any aisles obstructed in stock room?..........

17. Where do piles of stock or other obstructions interfere with entering any part of building?..........

HAZARDS.

Heating.

18. Where was woodwork or other combustible material too near to smokestacks, flues, furnaces, boilers, steampipes, etc.?..........

* Information regarding approved devices, their use and installation may be secured from The National Board of Fire Underwriters, 85 John Street, New York, N. Y. All questions relating to insurance and the safeguarding of hazards should be taken up with your insurance inspector, agent or broker.

Fig. 9 - Self-Inspection Blank for Industrial Plants

19. Where was anything placed to dry on boiler or steam pipes? ....

20. Was fuel supply safely arranged? ....

21. Can heated irons be set upon combustible material? ....

Lighting and Electrical Equipment.

22. Where were there any open flame lights near combustible material? ....

23. Where were there any broken fixtures or loosened wires? ....

24. Where were ordinary electric cords looped over nails or found in contact with anything? ....

25. Where were any fuses replaced by wire or otherwise defective? ....

26. Where did any panel boards or switch and fuse cabinets need cleaning? ....

27. Where did any motors need cleaning, outside or inside? ....

28. Where was there insufficient oil in any motor bearings? ....

29. In what manner was there any violation of our rules for storing or handling oils, gasoline or other inflammable liquids? ....

30. Did you find dry room disorderly or with dirty steam pipes? ....

31. Where were any fan bearings inaccessible or poorly oiled? ....

32. Where were any screens or dampers in air ducts out of order? ....

33. Whe you find any other than safety matches? ....

34. Where did you find any violation of our rules on smoking? ....

PROTECTION

Fire Doors, Traps, Shutters and Escapes.

35. Where were fire doors wedged open, obstructed or out of order? ....

36. Where were the automatic attachments of fire doors out of order? ....

37. Where were traps or doors on openings through floors out of order? ....

38. Are they ever left open when not in use? ....

39. Are fire doors or shutters ever left open at night, or on Sundays or Holidays? ....

40. Where were fire escapes obstructed, broken or out of order? ....

Fire Apparatus.

(*Note* — Each hose house, watchman station, room or department should be known by a separate number. If you find *any* defect in any items place the station number opposite the item. This will aid in keeping records. At each of these points there should be a card stating the quantity of the various kinds of apparatus which are required at that point.)

(*Inside.*)

41. At what points are there *less* than the required number of

(*a*) *Full* water casks ....

(*b*) *Full* fire pails ....

(*c*) *Full* sand pails ....

(*d*) Feet of hose ....

(*e*) Nozzles ....

(*f*) Spanners ....

(*g*) Chemical extinguishers ....
(*Should be recharged at least once a year.*)

(*h*) Ladders ....

(*Outside.*)

42. Where were post indicator valves poorly oiled? ....

43. Where did indicator valves fail to show open? ....

44. Which yard hydrants are hard to operate? ....
(*Do not open or test hydrants in the winter time.*)

45. Which ones do not drain properly? ....

46. Which ones have you found obstructed with snow or ice? ....

47. Which ones are otherwise obstructed or hard to reach? ....

48. Where have you found that hose, nozzles, or spanners were missing or not ready for use? ....

Fire Pumps.

(*Note* — Pumps must be started at least once a week, discharging water through relief valve, in order to make certain that they are in working order. They must be given a *thorough test* with rated number of hose streams once a year.)

49. Give make, style and size of all FIRE pumps in the plant.

Make	Style and Size
A.	....
B.	....
C.	....

50. Give results of any tests made since last report.

	A	B	C
(a) Time required to obtain water?			
(b) What pressure was maintained?			
(c) Was action smooth?			
(d) Is there an automatic regulator?			
(e) Was priming tank full?			
(f) Was priming gate valve closed?			
(g) Were steam drips open?			
(h) Did steam trap operate?			
(i) Was there enough oil?			
(j) Was suction clear of leaves or other obstruction?			
(k) Was pump reservoir full?			
(l) Were valves in steam connection from boilers to pump wide open?			
(m) How many R. P. M. at 100 lbs. water pressure with all outlets closed?			

For Electric Pumps, Add—	A	B	C
(o) Has current been interrupted since last report?			
(p) What is condition of contact points on switches, circuit breakers, controllers, etc.?			

Gravity Supply from Tanks and Reservoirs.

51. Give location and capacity of each tank or reservoir.

Location	Number of Gallons
A.	
B.	
C.	

	A	B	C
52. What was water level?			
53. Was water frozen?			
54. Was ladder out of order?			
55. Were hoops and supports defective?			
56. Was tell-tale out of order?			

For Pressure Tanks, Add—	A	B	C
57. What was air pressure and was water level correct?			
58. What was tank room temperature?			

City Water Connection.

59. Was valve (on our premises) in connection to city water main wide open?..

60. What was pressure on gauge?........................lbs.

61. Has there been any interruption of city supply since last report?..

62. Give results of any tests since last report:

(*a*) Number of hose streams..............................

(*b*) Diameter of nozzles........................inches.

(*c*) Pressure at nozzles........................lbs.

Sprinkler Supply Valves.

(*Note*—All gate valves must be secured open with leather straps or other approved method, fastened with sealed or riveted padlocks, the keys being held by responsible persons. In inspection, each valve must be given one full turn to make sure that it is wide open and in working order. Drip valves must be strapped shut in similar manner. Valves under approved supervisory system, however, need not be secured.)

Mark every sprinkler supply valve, plainly, with a number. This will aid in keeping record.

63. Give the number of any valves found closed..........

....

64. Give the number of any valves found not strapped

....

65. Give the number of any drip valves found open

....

66. Give the number of any valves to which access was obstructed ....

Dry Valves.

(*Note*—Dry valves should be tested for water column and condition of spring at least once each three months; they should be tripped at least once a year.)

Location	Location
A.	C.
B.	D.

	A	B	C	D
67. What was room temperature?				
68. What was air pressure?				
69. What was water pressure?				
70. Was alarm out of order?				

Alarm Valves.

Location	Location
A.	C.
B.	D.

	A	B	C	D
71. How was valve tested?				
72. Did any bells fail to ring?				
73. Was valve left in order?				

Automatic Sprinklers.

74. Where is stock piled within 24 inches of sprinkler heads? ....

75. Have any sprinklers operated since last inspection? ....

76. Where are any sprinklers coated or corroded? ....

77. Where are any sprinklers obstructed by partitions, joists, etc? ....

78. Where are any sprinklers bent? ....

79. Where are any sprinklers leaking? ....

80. Where are any sprinklers exposed to freezing? ....

81. Where are any sprinklers missing? ....

82. Where are any sprinklers disconnected? ....

83. How many sprinkler heads are kept in reserve? ....

CORRECTIONS AND REMARKS.

(*Note*—Wherever defects are found, steps must be taken *AT ONCE* to have them corrected. If the corrections have been made when this report is turned in, ***this fact*** must be stated below. If the correction has not yet been made, an ***explanation*** must be given below. Always refer to the question by number. ***For example:*** "15—***The broken windows in the shipping room were caused by boys throwing stones. I have reported the matter to the police and have had the broken panes replaced.***")

I have made a careful inspection and to the best of my knowledge and belief the foregoing statements are all correct.

(Signed)

Date.......... ....

Courtesy National Board of Fire Underwriters

INSPECTION BLANK FOR PLACES OF ASSEMBLY

(Including Night Clubs, Cabarets, Dance Halls, Restaurants, etc.)

Prepared by

THE NATIONAL BOARD OF FIRE UNDERWRITERS

An organization serving the Public and the Capital Stock Fire Insurance Companies since 1866

85 John Street, New York 38, N. Y. — 222 West Adams St., Chicago 6, Ill. — 465 California Street, San Francisco 4, Calif.

Date ....

Name of Establishment .... Type of Occupancy ....

Location .... City ....

Questions are so worded that a negative answer will indicate an unsatisfactory condition.

EXIT FACILITIES

1. Does every story for 10 or more occupants have two separate exit ways? ....
2. Does every room, gallery, balcony, tier or other space having a capacity of 100 or more persons have two exit doorways? ....

Each room, gallery, balcony, tier or other space should have exit ways as follows:

(a) Not less than 2 exit ways when more than 200 but not more than 600 persons are accommodated.

(b) Not less than 3 exit ways when more than 600 but not more than 1,000 persons are accommodated.

(c) Not less than 4 exit ways when more than 1,000 persons are accommodated.

3. Are exit ways provided in accordance with provisions of (a) (b) or (c) above? ....
4. Are exit doorways so located that the maximum distance from any point in a floor area, room or space to an exit doorway, measured along the line of travel, does not exceed 100 feet? ....

   Note: If the principal floor is not more than 21 inches above or below grade this distance may be 150 feet.
5. Are all exits and fire escapes maintained in good, safe, usable condition and free of obstructions? ....
6. Are exit doorways other than main entrance, marked with illuminated exit signs? ....
7. Do the exit doors of rooms occupied by 45 or more persons swing open in the direction of exit travel to the outside? ....
8. Are all doors at required exits provided with panic hardware or kept unlocked during occupancy? ....
9. Revolving doors—Do swinging doors adjoin? ....

   Will revolving doors collapse? ....
10. Aisles. Does every aisle lead to an exit doorway, or to a cross aisle leading to an exit doorway? ....

    Note: Describe in detail seating arrangements and what method, if any, is followed to prevent overcrowding and preserve aisle space.
11. Galleries—In galleries or other locations where seats are arranged on platforms of successive tiers and the height of rise from one platform to another below and in front exceeds 21 inches, there should be a substantial railing at the edge of platform along entire row of seats. If seats are so arranged in galleries of place of assembly under inspection, are such railings provided? ....
12. Dressing Rooms—Do dressing rooms have an independent exit leading directly into a passageway, court or street? ....
13. Are employees acquainted with the location and use of emergency exits? ....

P.R. 8-50 REV.

Fig. 10 - Inspection Form for Places of Assembly

14. Are employees trained to assist in the evacuation of the premises under emergency conditions including collapsing of revolving doors? ______

    Note: Illustrate arrangement of exit facilities by a sketch or sketches showing general floor plan of each story or part of story occupied for assembly purposes and indicate thereon location and width of each exit and stairway.

15. Are proper type fire extinguishers provided on each floor so that not over 100 feet travel is required to reach nearest unit? ______

16. Are employees properly trained in the operation of all fire extinguishers? ______

17. Are all employees acquainted with the location of all fire extinguishers? ______

18. Decorations—If decorations of a combustible nature are provided in any room or space, have they been flameproofed? ______

    Note: It is important to know when decorations, draperies, fabrics, etc., were last flame treated. If possible a sample of the material should be secured for testing purposes at a safe location.

19. Electric Wiring.

    Are fuses on lighting or small appliance circuits of 15 amperes or less capacity? ______

    Are all alterations of electrical installations made by a qualified electrician? ______

20. Kitchen.

    Are ranges, heating appliances and connected piping safely installed away from combustible material? ______

    Is there a hood above the range and is it equipped with exhaust duct to the outside? ______

21. Is a smoke-tight booth, built of noncombustible materials, and vented to the outside, provided for motion picture, spot or flood light machines? ______

22. Where automatic sprinklers or standpipe and hose are installed: Have these been thoroughly inspected within the past year and in operable condition? ______

Inspector ______

Date ______

Courtesy National Board of Fire Underwriters

Farm Fire Safety Inspection Blank

Check your home, barns, and other structures for fire hazards and eliminate them promptly. For further information write us for free folder, "Sixty Ways to Prevent Fire," and "Safeguarding the Farm Against Fire," a 60-page authoritative hand book full of useful information, cost 4 cents in stamps or coins.

NATIONAL BOARD OF FIRE UNDERWRITERS
85 John Street, New York 7, N. Y.
222 W. Adams St., Chicago 6, Ill. Merchants Exchange Bldg., San Francisco 4, Cal.

Can persons escape from each room of upper story if fire has involved first floor?..........
What provisions have you made to fight fires?..........
Have you ladders which will reach to roof?..........
Can some of your farm equipment, such as sprayers, be used for fires?..........
Is there any organized fire protection in your community? ....
How would you call for this protective service?..........
Where can fire engines take water?..........
Have the following been checked within the past six months:
Chimneys.......... Smokepipes .... Fireplace screens..........
Floor protection of stoves.......... Location of kerosene..........
Storage of gasoline.......... Storage of oily rags..........
What is the general condition as to leaves under or around the house?..........
Dry grass near buildings?..........
Underbrush endangering buildings?..........
Has danger of ignition of buildings been eliminated in regard to manure?..........
Fodder?.......... Hay?.......... Fertilizer?..........
Are oils (kerosene and gasoline) handled only in the daylight? ....
Only where spillage cannot be ignited?..........
Are all electric fuses of right capacity (15-ampere for branch circuits) ?..........
Are all lights, including electric lights, in the house, barn or other structure so located they cannot come in contact with combustible material?..........
Are places provided in barns, etc., where lanterns can be hung and not set on floor?..........
Is hay loft well ventilated?..........
Can animals be quickly removed from barns?..........
Are incubators and brooders listed by Underwriters' Laboratories, Inc.?..........
Are gasoline stoves and kerosene heaters of types listed by Underwriters' Laboratories, Inc.?..........
Has a suitable incinerator been provided for burning leaves, papers and rubbish?..........
If you have a wooden shingle roof, have spark arresters been provided on stovepipes?..........
Where feed has to be cooked, is this done outside the barn? ....
Do you use gasoline for dry cleaning?..........
How hazardous are the insecticides which you use? ....
Do you give your house, yard and other property a general spring and fall cleaning and get rid of useless things? ....
Do you make a general inspection before retiring to assure all fires and lights are out or suitably protected? ....

Fire prevention is thoughtfulness, and carefulness, combined with action in correcting those things which produce and increase fire. It cannot be a success without expenditure of energy and money.

Courtesy National Board of Fire Underwriters

Fig. 11 - Farm Fire Safety Inspection Blank

FIRE SAFETY

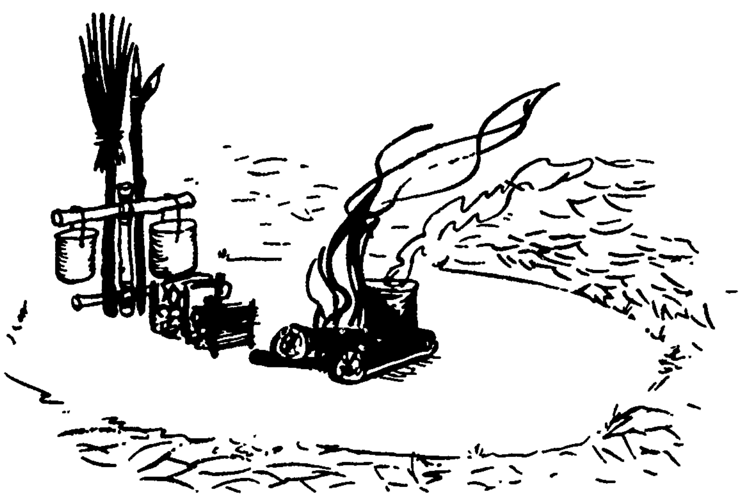
CAMP SELF-INSPECTION BLANK

recommended by

THE NATIONAL BOARD OF FIRE UNDERWRITERS

NEW YORK SAN FRANCISCO CHICAGO

Score your camp's fire safety. Next to each question is a box: check it if your answer is **Yes.** Each question answered **No** points to a serious fire hazard. Do something about these hazards — now! Use the check list at the opening of camp. Consult it frequently during the season. Save your camp — save your forests from fire.



HOUSEKEEPING

	✓ CHECK Yes	No
1. Have you removed all flammable rubbish and leaves from around buildings and tents..........	☐	☐
2. Are grass, brush and small trees cut or thinned out around camp buildings?....................	☐	☐
3. Is fire-fighting equipment within easy reach when trash, leaves, etc. are burned out-of-doors?..	☐	☐
4. Do you keep your storerooms and garages free from rubbish, old rags, papers, etc.?............	☐	☐
5. Do you keep oil mops or paint rags in closed metal containers to guard against spontaneous ignition?	☐	☐
6. Are stoves always kept free of grease? Do you have baking soda or salt handy in case of grease fires?	☐	☐
7. Do you hang towels on special racks, never drying them on or near stoves?..................	☐	☐
8. Do you collect ashes in covered hole-free metal containers and dispose of them when properly cooled?	☐	☐
9. Do you keep matches in metal containers away from heat?..................................	☐	☐
10. Do you use only safety matches in camp?....	☐	☐

	✓ CHECK Yes	No
11. Do you have spark-screens over all chimneys?	☐	☐
12. Are all fireplaces equipped with effective fire-screens?	☐	☐

FLAMMABLE LIQUIDS

	Yes	No
13. Do you start fires with paper and/or kindling only, never with flammable liquids?............	☐	☐
14. Are kerosene or gasoline lanterns hung up or put on tables or shelves and never on the floor?...	☐	☐
15. Are supplies or fuel oil stored away from buildings, preferably in underground tanks?..........	☐	☐
16. Are oils (kerosene and gasoline) handled only in the daylight and where spillage cannot be ignited?	☐	☐
17. Are gasoline stoves and kerosene stoves and heaters of types listed by Underwriters' Laboratories, Inc.?	☐	☐
18. Are your lamps sufficiently heavy-based to prevent tipping?..............................	☐	☐

CONSTRUCTION

	Yes	No
19. Are the roofs of your buildings non-combustible?	☐	☐
20. Are roofs, gutters, eaves of buildings free of needles and leaves?..........................	☐	☐
21. Are all stovepipes, chimneys and hoods above kitchen stoves cleaned and repaired before camp opens?	☐	☐
22. Are floors directly under stoves and heaters protected by galvanized iron, concrete or brick-work?	☐	☐
23. Have you eliminated all stovepipes which pass through closets or storerooms?............	☐	☐
24. Are walls, rafters, ceilings and partitions protected from over-heating of stoves and pipes?....	☐	☐

Fig. 12 - Camp Self-Inspection Blank

ELECTRICITY

√ CHECK Yes No

25. Are electric irons and all electrical appliances used for cooking, equipped with metal stands and heat controls? ☐ ☐

26. Do you use only those electric appliances, fuses, extension cords bearing the label of Underwriters' Laboratories, Inc.? ☐ ☐

27. Are all electric extension cords in the open—none placed under rugs or over hooks? ☐ ☐

28. Do you allow only qualified electricians to install your wiring, make all wire splices? ☐ ☐

30. Do you use standard fuses of proper capacity, never substituting others? ☐ ☐

31. Do you always use safety film for movies, never nitrocellulose film unless the camp has a standard projection booth? ☐ ☐

SMOKING

31. Do you maintain restricted places for smoking—no matter WHO is smoking? ☐ ☐

32. Does the camp insist that all cigarettes and cigar butts be carefully extinguished before they are disposed of? ☐ ☐

33. Do you insist that matches be broken in two before they're thrown away? ☐ ☐

FIRE FIGHTING

34. Do you have simple fire-fighting equipment, such as brooms, rakes, pails of water, pails of sand, shovels? ☐ ☐

35. If you have a fire hose, canvas or rubber, do you test it before camp opens? ☐ ☐

36. Is equipment kept in designated places and in good condition? ☐ ☐

37. Do you have more than one exit from all rooms in main buildings? ☐ ☐

38. Do you have a camp check before retiring to see if all fires and lights are out or suitably protected? ☐ ☐

39. Do you have regular fire drills for all campers and staff? ☐ ☐

√ CHECK Yes No

40. Do you have a place where pumpers can take water? ☐ ☐

41. Do you have approved fire extinguishers in every main building? Are they kept in good working order? Do your personnel know how to use them? ☐ ☐

42. Do you have fire escapes on buildings of more than one story? ☐ ☐

43. Do you have an easily distinguished fire alarm? ☐ ☐

44. Do you have a fire brigade in camp? ☐ ☐

45. Do you have ladders that will reach to the roof of your buildings? ☐ ☐

46. Is there any organized fire protection in your community? ☐ ☐

47. Do you know where or how to call for this protection service? ☐ ☐

CAMP FIRES

48. Do you build outdoor fires only in safe places, on sand or other mineral soil, or on rocks and not near trees? ☐ ☐

49. Do you clear away all flammable material from around your outdoor fire, including incinerator, for at least six feet and never leave your fire unattended? ☐ ☐

50. After putting out an outdoor fire do you stay until ashes are cool enough to test with your bare hands? ☐ ☐

Courtesy National Board of Fire Underwriters

Fire Prevention Form 1.

APPLICATION TO USE, INSTALL, CONDUCT PROCESSES OR CARRY ON OPERATIONS INVOLVING OR CREATING CONDITIONS DEEMED HAZARDOUS TO LIFE OR PROPERTY

____
Date

To Chief of Fire Department, City of________________________

Application is hereby made by the undersigned for a Permit to {Use / Install / Operate / Conduct}

in or on the premises known as________________________Street or Avenue

the following materials, processes or operations.

(Describe briefly what is to be done and state what hazardous materials are to be used.)

____

Conditions, surroundings and arrangements to be in accordance with the Fire Prevention Ordinance.

This application is / is not approved insofar as Zoning and Building Ordinances are concerned.

____
Inspector of Buildings

____
Name of Applicant

____
Address of Applicant

Complete plans and construction details must be filed on all major projects and when requested by the chief of the fire department.

Courtesy National Board of Fire Underwriters

Fig. 13- Application to Carry on Hazardous Operations

Fire Prevention Form 2.

APPLICATION TO MANUFACTURE, STORE, HANDLE OR KEEP FOR SALE EXPLOSIVES, HAZARDOUS CHEMICALS AND MATERIALS AND FLAMMABLE LIQUIDS AND GASES

____
Date

To Chief of Fire Department, City of______________________

Application is hereby made by the undersigned for a Permit to manufacture, store, handle or keep for sale

in or on the premises known as______________________Street or Avenue

the following quantities of { Explosives / Hazardous Chemicals / Hazardous Materials / Flammable Liquids / Flammable Gases

____

____

____

____

____

____

____

____

____

____

____

Conditions, surroundings and arrangements to be in accordance with the Fire Prevention Ordinance.

This application is / is not approved insofar as Zoning and Building Ordinances are concerned.

____
Inspector of Buildings

____
Name of Applicant

____
Address of Applicant

Complete plans and construction details must be filed on all major projects and when requested by the chief of the fire department.

Courtesy National Board of Fire Underwriters

Fig. 14 - Application to Use Hazardous Materials

Fire Prevention Form 3.

FIRE DEPARTMENT

CITY OF ____________________

PERMIT

For Keeping, Storage, Use, Manufacture, Handling, Transportation, or other Disposition of Flammable, Combustible, or Explosive Materials, as stated below:

No. ____________ ____________ (Date)

TO WHOM IT MAY CONCERN:

By virtue of the provisions of the Fire Prevention Ordinance of the City of ____________, ____________ (Name of Concern)

No. ____________ Street, ____________ conducting a ____________ (Business)

having made application in due form, and as the conditions, surroundings, and arrangements are, in my opinion, such that the intent of the Ordinance can be observed, authority is hereby given and this PERMIT is GRANTED for ____________

This PERMIT is issued and accepted on condition that all Ordinance provisions now adopted, or that may hereafter be adopted, shall be complied with.

THIS PERMIT IS VALID FOR ____________

This permit does not take the place of any License required by law and is not transferable. Any change in the use or occupancy of premises shall require a new permit.

____
Chief of Fire Department

THIS PERMIT MUST AT ALL TIMES BE KEPT POSTED ON THE PREMISES MENTIONED ABOVE

Courtesy National Board of Fire Underwriters

Fig. 15 - Fire Department Permit

Form 4-08 Inspection Report

STATE OF OHIO
DIVISION OF STATE FIRE MARSHAL
REST HOME

Name of home ______________________

Street Address ______________________

City ______________________

Maximum number of patients for whom approval is requested ________

Present number and class of patients;	On what floor are they housed:
Ambulatory ____________	Ambulatory ____________
Bedfast ____________	Bedfast ____________
Helpless ____________	Helpless ____________

This to certify that I inspected the building or buildings comprising this home and find:

1.	Indicate type of construction ______________________		
2.	It has adequate and proper means of egress.	1 ( ) Yes	2 ( ) No
3.	Proper facilities for Fire Protection.	1 ( ) Yes	2 ( ) No
4.	Evidence of good housekeeping.	1 ( ) Yes	2 ( ) No
5.	Established and documented evacuation plan.	1 ( ) Yes	2 ( ) No

Date ______________ Inspected by ______________

____
(title)

Date approved ____________ By ______________________
(State Fire Marshal)

The above inspection form will become valid as a certificate of approval upon signature of the State Fire Marshal.

Courtesy State of Ohio, Division of State Fire Marshal

Fig. 19 - Rest Home Approval Request

Fire Prevention Form 4.

Book No. **FIRE DEPARTMENT OF THE CITY OF ....** Notice No.

FIRE PREVENTION BUREAU

M ....

No. .... (Date)

Your attention is called to a violation of the fire prevention ordinance on premises No. ....

.... of which you are ....

....

....

....

....

....

You are hereby notified to remedy the conditions as stated above within .... {hours / days} from the date of service of this notice or show cause why you should not be required so to do. If, at the expiration of this time, the same conditions exist and no cause aforesaid be shown, such further action will be taken as the law requires.

By order of the

CHIEF OF FIRE DEPARTMENT .... *Inspector.*

This form should be printed in triplicate and in book form, with the original copy delivered to the owner or occupant, one copy remaining in the suspense or working office file and the third copy left in the book and later permanently filed.

Courtesy National Board of Fire Underwriters

Fig. 17 - Fire Department Violation Notice

Fire Prevention Form 5.

INSPECTORS ROUTE CARD

Inspector ____________

Date ____________

No.	LOCATION	C	RI	R	NS	PA

C — Complaint.
RI — Reinspection.
R — Regular Inspection.
N.S. — Notice Served.
P.A. — Personally Abated Hazard.

Note—Card can be ruled both sides if desired.

Courtesy National Board of Fire Underwriters

Fig. 18 - Inspector's Route Card

Form 4-08 Inspection Report

STATE OF OHIO
DIVISION OF STATE FIRE MARSHAL
REST HOME

Name of home ______________________

Street Address ______________________

City ______________________

Maximum number of patients for whom approval is requested ________

Present number and class of patients;	On what floor are they housed:
Ambulatory ____________	Ambulatory ____________
Bedfast ____________	Bedfast ____________
Helpless ____________	Helpless ____________

This to certify that I inspected the building or buildings comprising this home and find:

1. Indicate type of construction ______________________
2. It has adequate and proper means of egress. 1 ( ) Yes 2 ( ) No
3. Proper facilities for Fire Protection. 1 ( ) Yes 2 ( ) No
4. Evidence of good housekeeping. 1 ( ) Yes 2 ( ) No
5. Established and documented evacuation plan. 1 ( ) Yes 2 ( ) No

Date ____________ Inspected by ____________

____
(title)

Date approved ____________ By ____________
(State Fire Marshal)

The above inspection form will become valid as a certificate of approval upon signature of the State Fire Marshal.

Courtesy State of Ohio, Division of State Fire Marshal

Fig. 19 - Rest Home Approval Request

Form 4
See instruction sheet for
correct marking procedure

STATE OF OHIO
DIVISION OF STATE FIRE MARSHAL

INSPECTION REPORT
(Original & one copy to office)

Inspected premises located at ________ (number) ________ Street or RR ________ City) Village of) Township) ________ ________ (county)

Name of occupant ________________

STRUCTURAL FEATURES AND CONDITIONS

BUILDING CONSTRUCTION	ROOF	FOUNDATION	WIRING	No. of CHIMNEYS	HEATING	FLUE PIPE	FUEL	GENERAL CONDITION
1 ( )Frame	1 ( )Composition	1 ( )Stone	1 ( )Conduit	1 ( )Brick	1 ( )Furnace	1 ( )Direct	1 ( )Gas	1 ( )Excellent
2 ( )Brick	2 ( )Slate	2 ( )Brick	2 ( )BX Cable	2 ( )Metal	2 ( )Stove	2 ( )Wall	2 ( )Coal	2 ( )Good
3 ( )C. Block	3 ( )Metal	3 ( )C. Block	3 ( )Romex	3 ( ) C. Block	3 ( )Space heater	3 ( )Roof	3 ( )Oil	3 ( )Fair
4 ( )Tile	4 ( )Wood	4 ( )Tile	4 ( )K & Tube	4 ( )Transite	4 ( )Boilers	4 ( )Window	4 ( )LPGas	4 ( )Poor
5 ( )Metal	5 ( )Other	5 ( )Other	5 ( )Other	5 ( )Other	5 ( )Other	5 ( )Partition	5 ( )Electric	GENERAL
6 ( )Other		6 ( )None	6 ( )None	6 ( )None	6 ( )None	6 ( )None	6 ( )Other	HOUSEKEEPING
1 ( )Excellent	1 ( )Excellent	1 ( )Excellent	1 ( )Excellent	1 ( )Excellent	1 ( )Excellent	1 ( )Excellent		1 ( )Excellent
2 ( )Good	2 ( )Good	2 ( )Good	2 ( )Good	2 ( )Good	2 ( )Good	2 ( )Good		2 ( )Good
3 ( )Fair	3 ( )Fair	3 ( )Fair	3 ( )Fair	3 ( )Fair	3 ( )Fair	3 ( )Fair		3 ( )Fair
4 ( )Poor	4 ( )Poor	4 ( )Poor	4 ( )Poor	4 ( )Poor	4 ( )Poor	4 ( )Poor		4 ( )Poor

If "Other" explain ________________

Check only one ( ) ---------- TYPE OF OCCUPANCY ---------- Is building vacant 1 ( ) Yes 2 No ( )

DWELLING	PUBLIC OCCUPANCY	MERCANTILE	MISCELLANEOUS
01 ( )Single family	20 ( )Federal	40 ( )Office	60 ( )Manufacturing
02 ( )Two family side by side	21 ( )State	41 ( )Small Retail	61 ( )Manufacturing & Retail
03 ( )Two family up and down	22 ( )County	42 ( )Large Retail	62 ( )Agriculture Bldg.
04 ( )Apartment	23 ( )City	43 ( )Restaurant	63 ( )Flammable Liquids
05 ( )Lodging House	24 ( )School	44 ( )Wholesale	64 ( )L. P. Gas
06 ( )Hotel	25 ( )Church	45 ( )Storage Warehouse	65 ( )Other Gases
07 ( )Motel	26 ( )Hospital	46 ( )Multiple Occupancy	66 ( )Diversified Manufacturing
08 ( )Rest Home	27 ( )Theatre	47 ( )Dry Cleaning	67 ( )Grain Handling
09 ( )Day nursery	28 ( )Assembly Hall	48 ( )Store & Dwelling	68 ( )Outbuilding
10 ( )Foster Home	39 ( )Unclassified	59 ( ) Unclassified	69 ( )Public Garage
11 ( )Trailer Home			70 ( )Private Garage
19 ( )Unclassified			71 ( )Service Station
			72 ( )Food Products
			79 ( )Unclassified

If "UNCLASSIFIED" explain ________________
State name and specific nature
of occupancy, past or present ________________

Basement ---------------------- 1( )Yes 2 No ( ) 3 Part ( )
Overfused circuits ------------ *1 ( )Yes 2 No ( )
Overloaded circuits ----------- *1( )Yes 2 No ( )
Is building dilapidated --------- *1 ( )Yes 2 No ( )
Is building especially liable to fire--- *1 ( )Yes 2 No ( )
Are explosives or other flammable
materials stored within ------- *1 ( ) Yes 2 No ( )
Exposure to other buildings in feet ________
Number of stories ________
NOTE: If *asterisk is present where checked, explain (use reverse side)

Did you give a verbal order ------------------------ 1( )Yes 2 No( )
Do you recommend an order be issued by this office-- 1( )Yes 2 No( )

Date of inspection ________________

Recommended time of compliance ________________
(use reverse side to list hazardous conditions & recommendations)

Inspector's signature ________________

Fig. 20 - Inspection Report - Division of State Fire Marshal

Whom did you consult relative to inspection. 1 ( ) Owner 2 ( ) Occupant 3 ( ) Agent 4 ( ) Employee 5 ( ) No one

Name of that person ______________________ **Inspection request made by** ______________________

Name of owner(print) ______________________ **or agent (print)** ______________________

Mailing address (print) ______________________

The following hazardous conditions exist
(List all defects briefly)

____

____

____

____

____

____

____

____

____

____

____

____

State recommendations for correction of all defects above listed

____

____

____

____

____

____

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____

____

____

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FIRE CHIEF. . . . . **INSPECTOR** . . . . **.District** . . . . . .

Courtesy State of Ohio, Division of State Fire Marshal

Form No. 4-471

State of Ohio

Department of Commerce

DIVISION OF STATE FIRE MARSHAL

INSPECTION REPORT
DRY CLEANING AND DRY DYEING PLANT
CLASS I

(1) Date of inspection..19.........

(2) Location of plant. Street..City .... County.........................

(3) Trade name or company..

(4) Name of lessee or operator..

(5) How long at present location?.. Years ....Months

(6) Name of former lessee or operator..

(7) Name of owner of plant...

(8) Name of owner of property...

(9) Solvent used for cleaning purposes..(10) Maximum quantity on hand at any time..Gallons.

BUILDING

(11) Year erected 19........... (12) Construction.. (13) Kind of floors...............................

(14) Thickness of walls.......................(15) Kind of roof or ceiling................................ (16) Are windows provided........................ (17) Are they of wired glass........................ (18) Do they readily swing out..........................

(19) Are sky lights provided........................(20) Are they of metal frames........................ (21) Do they have wired glass........................ (22) Do they swing out........................ (23) Does cleaning room have two means of egress to the outside........................ (24) Is cleaning room more than one story in height........................ (25) Is building used as cleaning room closer than ten feet to adjoining lot line........................ (26) Are any of the walls in cleaning room blank........................ (27) How many sides........................ (28) Are walls between cleaning rooms and other rooms blank........................ (29) Are they of masonry construction..........................

(30) Are floors below grade level........................ (31) Is basement under cleaning room........................(32) Are fire doors approved by a nationally known testing laboratory............................

FIRE EQUIPMENT

(33) Is cleaning room equipped with Automatic Sprinkler system, Carbon Dioxide Room Flooding system or Steam Flooding system.. (34) If equipped with steam flooding system, can it be controlled manually by means of quick opening valve outside of cleaning room..................

(35) Is steam provided in this system during the hours of cleaning operation........................ (36) Are fire

Fig. 21 - Inspection Report - Dry Cleaning and Dry-Dyeing Plant

extinguishers provided........................ (37) Are they approved by a nationally known testing laboratory .... (38) Are they approved for class B fires.............................

MACHINERY

(39) Do Washers have overflow pipe leading to underground tank........................(40) Is it one size larger than the supply line to washer........................ (41) Does it have a shut-off valve........................ (42) Are washers equipped with splash proof doors.......... .... (43) Are the doors hinge type........................ (44) Are washers grounded........................ (45) Is each washer securely attached to the floor........................ (46) Does extractor have drain pipe leading to underground tank or to extractor pump........................ (47) Does it have drain pipe 1½ inches or larger........................ (48) Does the basket in the extractor have a rim of non-ferrous metal........................ (49) Is cover on extractor........................ (50) Is it of non-ferrous metal........................
(51) Is extractor grounded........................ (52) Is it securely attached to floor........................ (53) Is each drying tumbler vented to the outside by means of an exhaust fan........................ (54) Is the exhaust pipe 6 feet above the roof of dry cleaning plant........................ (55) Is it provided with clean-out facilities........................
(56) Is each tumbler equipped with a steam jet 3/8 of an inch or larger........................ (57) Are tumblers equipped with self-closing explosion hatches........................ (58) Are all tumblers grounded........................
(59) Is steam or hot water only used to secure necessary temperatures in stills and condensers........................
(60) Does still have automatic heat emergency drain of ample capacity to discharge the entire contents to underground storage tanks in five minutes........................

ELECTRICAL EQUIPMENT IN DRY CLEANING ROOMS

(61) Are all spiders, blades and running rings on all exhaust fans of non-ferrous metal........................
(62) Are all lighting fixtures explosion proof and labeled by a nationally recognized testing laboratory ....(63) Are all electrical switches, motors, and other electrical devices labeled by a nationally recognized testing laboratory ....(64) Is all electric wiring installed according to the National Electrical Code..........................

DRYING ROOM

(65) Where are drying rooms located..
(66) Are they located in same building with cleaning room........................ (67) Thickness of walls between cleaning and drying rooms.................... (68) Do drying rooms have self-closing approved fire doors..................

TANKS—PIPES

(69) Are underground tanks located under public sidewalk, street, alley or private drive..................... (70) Are they two feet or more underground..................... (71) Is fill pipe terminal in non-combustible box five feet from any structure.................. (72) Are vent pipes from tanks 1-¼ inches in diameter................ (73) Do vent pipes from tanks extend 6 feet above the roof of dry cleaning plant........................ (74) Are vent pipes equipped with inverted U caps.................. (75) Are tanks equipped with a liquid level gauge labeled by a nationally recognized testing laboratory.....................(76) Are vent pipes from tanks equipped with flame arresters labeled by a nationally recognized testing laboratory........................ (77) Does cleaning room drain lead to city sewer...................(78) Are there any cleaning fluids left in the cleaning room overnight.... ....(79) Will the ventilation of the cleaning room change every three minutes........................ (80) Are all safety cans labeled by a nationally recognized testing laboratory ....(81) Is any spotting or brushing done outside dry cleaning rooms........................

BOILER ROOM

(82) Is boiler room in separate room from dry cleaning room........................ (83) If not, is it separated by 12" wall....................... (84) What is heating agent for dry cleaning room, Hot Water or Steam........................ .... (85) Are all steam and hot water pipes 1 inch from all woodwork .... (86) Are exposed hot water pipes and radiators screened........................ (87) Is boiler installed according to Law...................(88) What is the general condition of boiler room and building housing it ....

GENERAL

(89) Are No Smoking signs displayed...................... (90) What is the general condition of the cleaning room ....
....

(91) Do you recommend license be issued to this plant........................(92) Indicate findings and recommendations on Form 4. ....

(93) Signature of inspector ....

Courtesy State of Ohio, Division of State Fire Marshal

Form No. 4-47HC

State of Ohio
Department of Commerce
DIVISION OF STATE FIRE MARSHAL

Permit No.________ Yr. 19____

INSPECTION REPORT
HAT CLEANING PLANT

(1) Date of Inspection________________________________

(2) Location of plant, Street__________________________City ____________________County___ ________________

(3) Trade name of company____

(4) Name of lessee or operator____

(5) How long at present location_______________________Years ______________________________________ Months

(6) Name of former lessee or operator____

(7) Name of owner of plant____

(8) Name of owner of property____

(9) Make of machinery or system used____

(10) Solvent used for cleaning purposes______________________(11) Purchases made from______________________

(12) Does plant use flammable solvents____________ (13) If so, how much on hand at any time_______________gallons.

(14) Are safety cans provided____________(15) What are the sizes of the safety cans___________________________

_______________________________________(16) Are they labeled by a nationally recognized testing laboratory_________

BUILDING

(17) Is cleaning plant located on 1st floor level________(18) If not where is it located_____________________________

(19) What is heating agent for cleaning plant_________________________(20) How far are flammable solvents stored from heating plant_____________________________(21) Are there any open flames in the cleaning plant____________

(22) Are all motors vapor proof____________(23) Are all machines fluid tight____________(24) Does the machine have an exhaust fan____________(25) Does it remove all vapors to the outside____________(26) Will the air in the cleaning room change every three minutes______________(27) Is the exhaust outlet closer than 25 feet to any opening in any building______________(28) Are waste cans provided___________ (29) Is all wiring installed according to the National Electrical Code____________(30) Have you tested the non-flammable solvent____________(31) Are fire extinguishers provided_______________(32) How many? soda-acid ( ), foam ( ), C T C ( ), dry powder ( ), size ( ), CO_2 ( ), size ( ) (33) If not, do you recommend extinguishers________________ (34) Number______________

(35) Are stoves vented____(36) What is the general condition of the room housing the cleaning plant____

(37) Do you approve the plant for license?_ ______________If not why____

____

____

Attach Form 4

Order: ☐ Written ☐ Verbal Signature of Inspector____

Courtesy State of Ohio, Division of State Fire Marshal

Fig. 22- Inspection Report - Hat Cleaning Plant

Form 72

State of Ohio
Department of Commerce
DIVISION OF STATE FIRE MARSHAL

FLAMMABLE LIQUIDS—L. P. GASES INSPECTION FORM

TYPE

Flammable Liquids ☐ L. P. Gas ☐

Other ☐ Describe ....

KIND OF ESTABLISHMENT

Bulk Plant .... ☐

Refinery .... ☐

Processing Plant .... ☐

Manufacturing Process .... ☐

Filling Station .... ☐

L. P. Gas Bottling Plant .... ☐

L. P. Gas Industrial Storage .... ☐

Tank Truck .... ☐

Mercantile .... ☐

Residence .... ☐

EQUIPMENT

No. of Tanks ....

Capacity of Tanks ....

Dikes ....

Walkways—Catwalks ....

Piping ....

Pumps ....

Grounding ....

Electrical Wiring ....

Code of L. P. Gas Container ....

Relief Valve Set at ....

Was Owner Consulted ....

Who Was Consulted ....

Remarks ....

....

....

(All names and addresses must be correct.)

City
Village } of ....
Township

County ....

Located at ....

....

Owner ....

Address ....

....

Agent ....

Address ....

....

Operator
or Occupant ....

Address ....

....

Complainant ....

Address ....

....

Mayor ....

Fire Chief ....

Date of Inspection ....

Order: Formal ☐ Verbal ☐

Time Set for Compliance ....

Remarks ....

....

....

....
State Fire Inspector District

Courtesy State of Ohio, Division of State Fire Marshal

Fig. 23 - Inspection Form - Flammable Liquids - L. P. Gases

CHAPTER 26

RADIATION HAZARDS

INTRODUCTION

This chapter is concerned with the peacetime radiation hazards in this atomic era that pertain to the fire service. It is not the intent of this chapter to train firemen to become radiation specialists, nor to qualify them to deal effectively with radiation hazards with which they may be confronted. The intent of this chapter is to serve as a basis for acquainting firemen with the problems in general and to prepare them for more specialized training. Thus, it is to serve an orientation function and is to be presented to firemen as a part of or in conjunction with their basic training.

The general aim of this chapter is to familiarize firemen with the following facts:

1. That radiation is simply another hazard of human existence, neither to be unduly feared nor to be ignored.
2. That a difference exists between internal and external hazards.
3. That adequate pre-emergency planning is necessary.
4. That radioactive materials in ordinary use do not make other things radioactive.
5. That in general the most serious effect of a radiation incident will probably come about from contamination of the surrounding area, and the problem will be reduced to the extent that the contamination spread is limited during fire fighting operations.
6. That an explosion which might occur in the use of radioactive material will be of a chemical nature and will not result in an atomic bomb type of explosion.
7. That safety measures in the design and in the transportation of atomic weapons will preclude a nuclear explosion in the event of an accident. However, there might be a serious detonation of the ordinary explosive materials in the weapon, resulting in possible radioactive contamination.

BENEFICIAL USES OF NUCLEAR ENERGY

The values of radiation and radioactivity to man are of such an important nature that the atomic era is here to stay in spite of the fact that there are certain definite hazards involved in their use. It is important that information about the use of radioactive materials be provided for all citizens in order to eliminate their existing confusion and fear.

Firemen and other emergency control personnel will necessarily be in the forefront during emergencies involving radiation hazards. Therefore, it is imperative that they have factual knowledge on which to base their actions and on which to determine the degree of their risk.

In recent years, the number of users of radioactive materials has increased on almost a daily basis. Indications are that present expansion will continue so that radioactive materials will be even more prevalent in the future. More important than the use of radioactive materials for destruction in wartime is their increasingly greater number of peacetime uses for the benefit of mankind in a variety of ways. Inherent in these many uses are significant problems for personnel in the fire service and other emergency services.

The first item to be considered is that the terms *Radioisotope*, *Radioactive Material*, and *Radiation Emitter*, so far as firemen are concerned, are similar in that there is a potential personal hazard involved from radiation associated with materials described by each. Radioactive material releases energy that can be detected by electrical or chemical means. This energy is released from the center of the atom. See Figure 1.

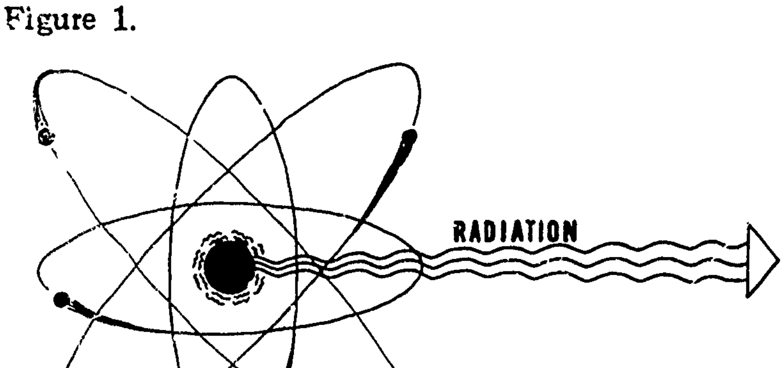

Fig. 1 - Radiation Originates from the Nucleus of an Atom

Firemen should have an understanding of the many uses of radioactive materials and their benefits. Therefore a number of uses will be explained in the following paragraphs.

Radioactive materials give off energy, and this use makes them extremely beneficial to mankind. For instance, they make possible the tracing of certain biological processes in humans, animals, and plants.

DIAGNOSIS OF DISEASE
BY RADIOACTIVE TRACERS

The thyroid gland is a very important gland in the body. It is well known to medical men that the thyroid gland will take up practically all of the element iodine which enters the body. If radioactive iodine is introduced into the body it is still chemically iodine, and therefore it will go to the thyroid gland. By the use of radioactive detecting devices, the doctor can determine whether the thyroid is functioning properly, since the radioactivity present can be compared with what it should be in a normal person. The radioactive iodine does not do anything for the patient or to the thyroid condition from which the patient is suffering. In this case, it is simply being used as a tool to help the doctor diagnose whether or not the thyroid is functioning properly.

Figure 2 shows how a small amount of radioiodine mixed with water (A) and drunk by a patient (B) will collect in varying amounts in the thyroid gland depending on its activity (C). Measurement of radiation by special instruments outside the body (D) assists the doctor in determining the thyroid trouble.

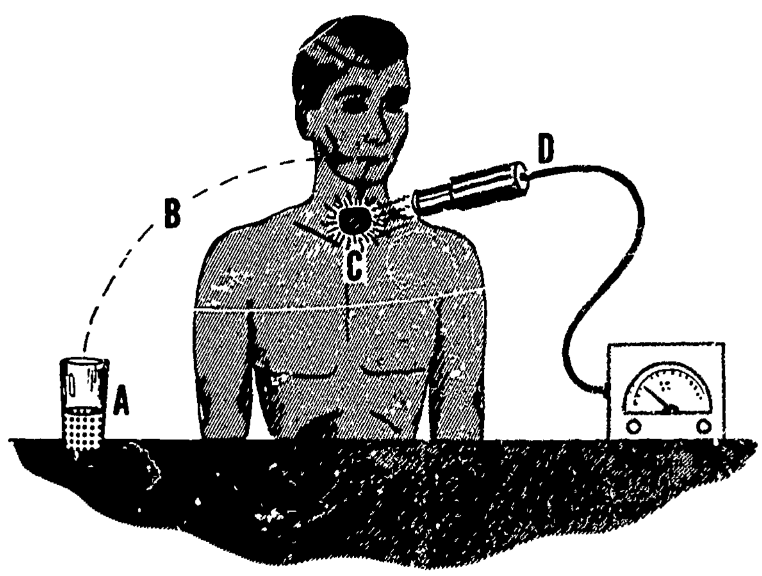

Fig. 2 - Radioactive Iodine Used to Trace Thyroid Gland Disorders

There are many other uses of isotopes as tracers in medicine, and new uses are being discovered every day.

RADIOACTIVE TRACERS IN ANIMAL AND
AGRICULTURAL FOOD PRODUCTION

One of the most pressing problems facing the world is the explosive growth of population and the necessity for adequately feeding more and more people every year. The application of scientific principles to the production of foodstuffs is only in its infancy. Much of the feeding of animals and plants intended for human consumption is, in truth, done at random. By the use of radioactive tracers, scientific knowledge can take the place of guesswork, and man can learn to produce more food. This is of the utmost importance in a world in which many people go to bed hungry every night.

As a typical instance, the use of calcium and phosphorus tracers have provided information which will enable livestock feeders to get maximum efficiency from feed by more careful control of the calcium-phosphorus ratio of the diet, and by eliminating high concentration of elements which adversely affect the absorption of these elements. See Figure 3.

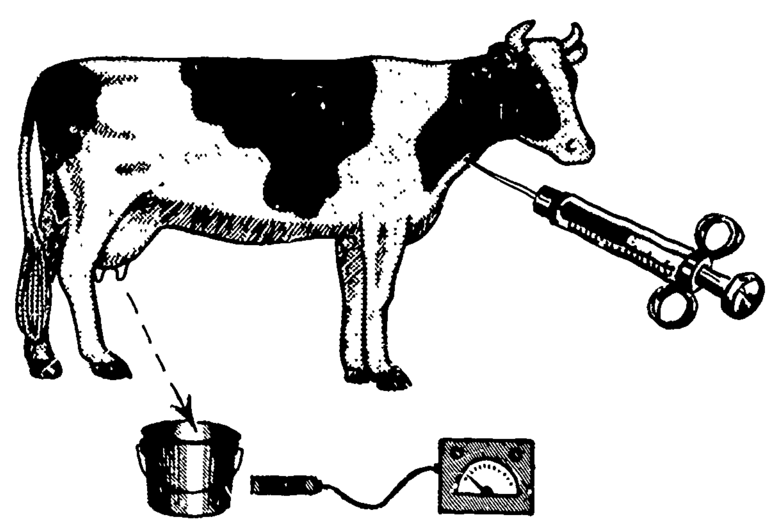

Fig. 3 - Tracing the Efficiency of Cattle Feeding with Radioisotopes

Radioisotopes have proven extremely useful in determining the nature and extent of possible toxic residues in or on agricultural commodities from the use of insecticide compounds. Work with radioactive isotopes has shown that many fertilizers can be applied directly to the leaves of plants and be absorbed through the leaves. It has also shown that fertilizer taken up through the root system can be leached from the leaves by rain. See Figure 4.

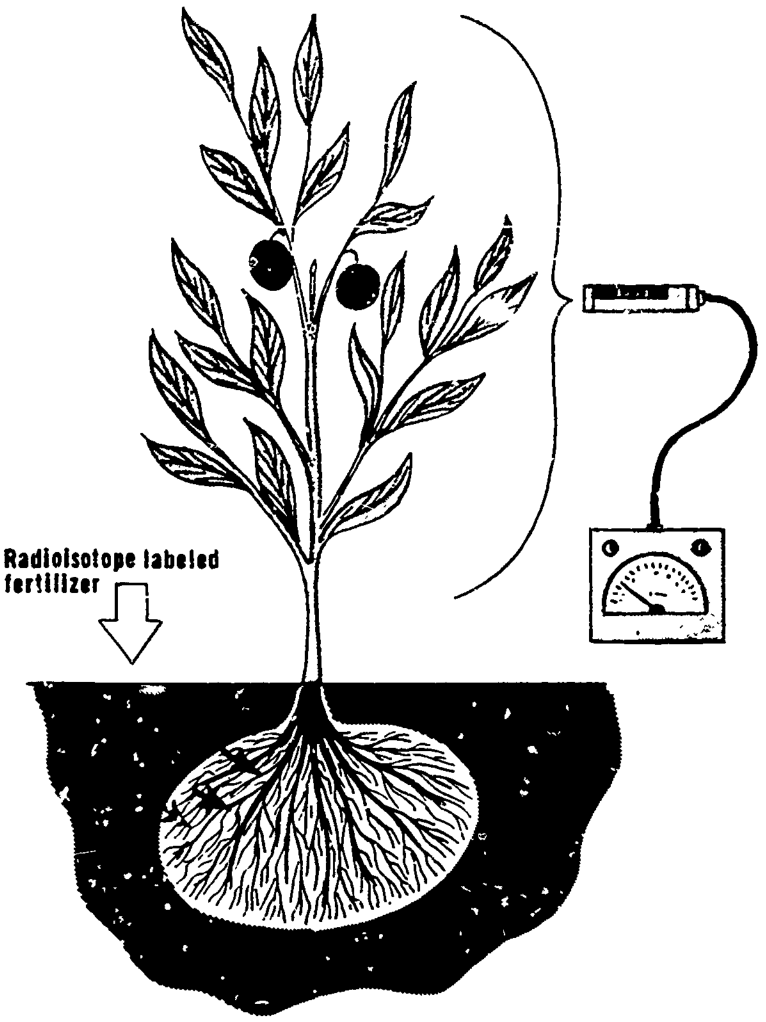

Fig. 4 - Radioisotopes Used to Trace Fertilizer Uptake in Plants

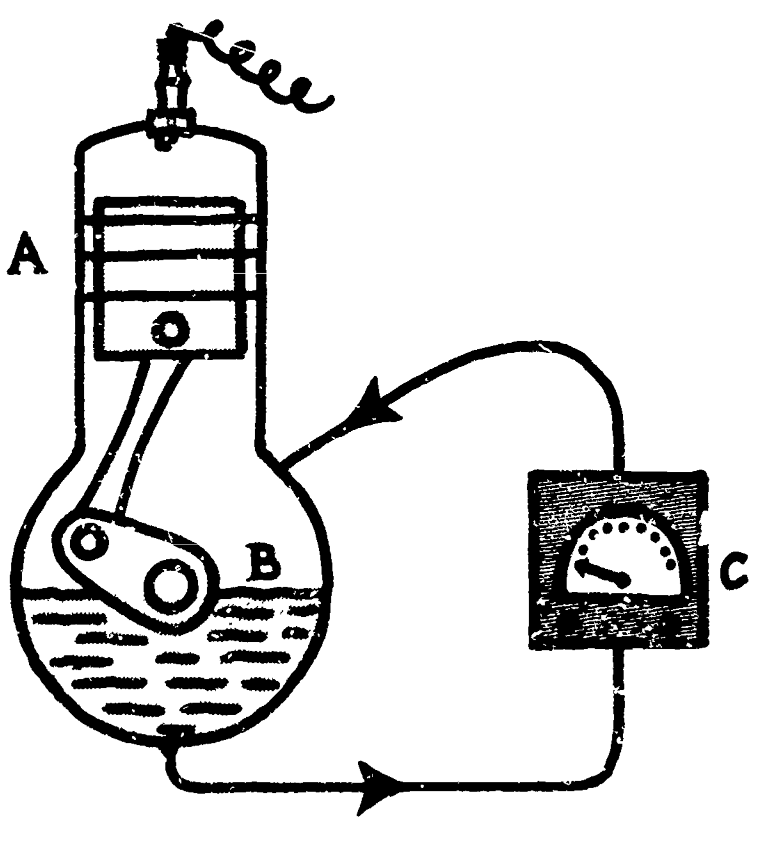

Fig. 5 - Radioisotopes Used to Measure Metal Wear

MEASURING METAL WEAR

Just as biological processes can be traced in man, plants, and animals, physical processes in metal can be traced by making some of the material radioactive, or by including radioactive material similar to the materials which are to be traced. A simple example is the use of radioactive iron to check engine wear. The piston ring is made radioactive. As the piston ring wears, the radioactive iron is detected in the lubricating oil. See Figure 5.

LIQUID FLOW TRACED BY RADIOACTIVITY

Another use is the addition of radioactive isotopes to the product transported in oil pipelines. The radioactive material is introduced at the interface, between two different shipments, providing a means by which one shipment can be differentiated immediately from the next shipment, as illustrated by Figure 6.

RADIOGRAPHY OF HIGH PRESSURE EQUIPMENT

It is very important in some products to know exactly how dense a material is and whether the density is uniform. One example of this is the examination of piping which must hold against very high pressures. When such piping is hydrostatically tested, it has simply been determined that the piping did not fail at the pressure reached on the date of the test. Hydrostatic testing does not show whether there is a potential fault which may fail at a later date. Valves and other such fittings can be X-rayed to determine whether or not there is any defect in the body of the valve. It is generally impossible to take an X-ray machine into the field to make an X-ray of a weld in a pipe, so radioactive materials are used for this purpose. Radioactive cobalt, for instance, is inserted into the pipe at the location of the weld. See Figure 7. The weld is surrounded with X-ray film. The film is sensitive to the radiation coming through the pipe. If some parts of the weld are not as dense as the the rest of the weld, less radiation will be absorbed, the film will receive more radiation, and therefore will be darker at such points.

THICKNESS GAUGING AND QUALITY CONTROL BY RADIATION

The difference in absorption of radiation by various thicknesses of materials is also used by industry for quality control. This is extremely important in metal working industries where metals must

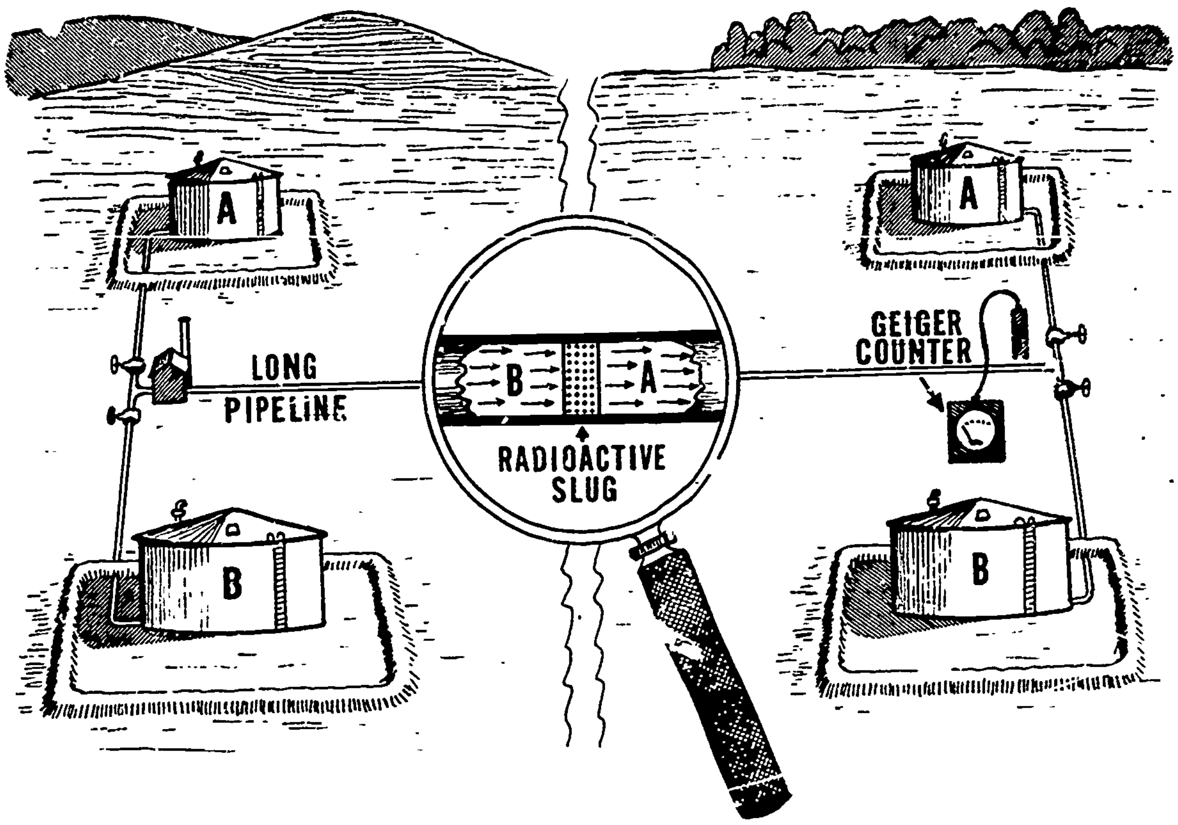

Fig. 6 - Radioactive Slug Used to Trace and Differentiate between Two Different Products in a Pipeline

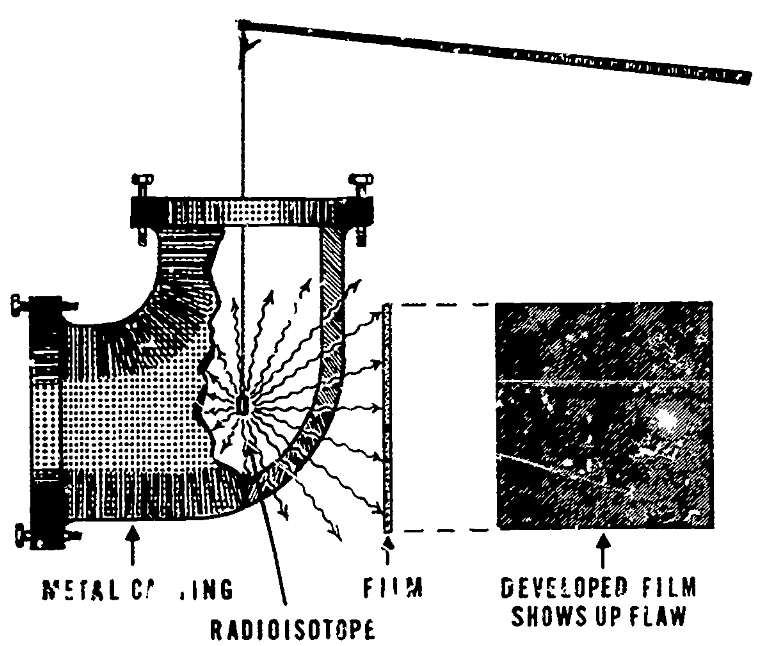

Fig. 7 - Radioisotope Used to Detect Hidden Flaws in Metal Castings

be rolled to an exact thickness at high speed. If the manufacturer waits until the entire roll has been manufactured to determine whether the material is of the proper thickness, he may find that he has a serious loss through the rejection of a product that does not meet standards. The thickness-gauge makes it possible to determine immediately whether the material is being rolled to the proper thickness. Another application of this principle is in the control of various coatings applied to products.

In sandpaper production, as shown in Figure 8, the coating of glue from the dispenser (A) is precisely controlled by radiation (B) which passes through paper and glue to radiation counter (C). Any variation in the layer of glue is detected and registers on dial (D) which is interlocked (E) with the glue applicator which is readjusted automatically. The same principle is used to control the amount of grit applied to the glue (F) in completing the finished sandpaper.

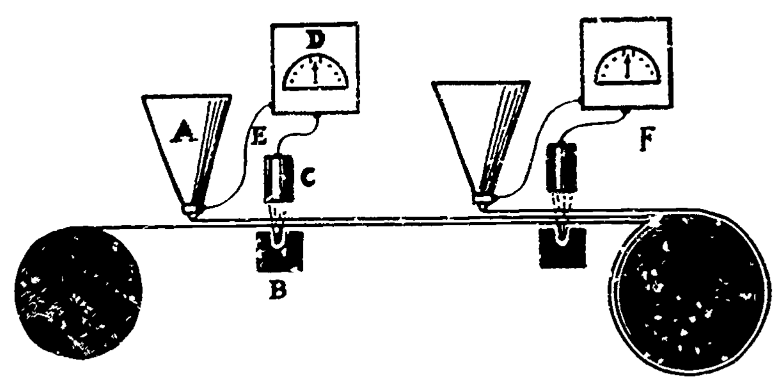

Fig. 8 - Radiation Used to Control Coating of Glue and Grit in Sandpaper Production

All of these uses are applications of the fact that radioactive materials send out signals which can be detected either electrically or chemically.

ELIMINATION OF STATIC ELECTRICITY

The next category of use for radioisotopes is made possible by the fact that they have the characteristic of making the air electrically conductive. The accumulation of static electricity is a serious hazard in those areas where an explosive vapor-air concentration may exist. Static electricity is also a

nuisance industrially because it makes some things stick together, and presents a shock hazard to individuals. Static electricity can be removed by grounding the equipment, or, in some cases, by surrounding it with a humid atmosphere. In some cases, however, neither of these methods is satisfactory.

In the use of radioactive static eliminators, the rays from the radioactive material ionize the air, and provide an invisible path through which the electricity can flow to ground. It is not necessary that there be any contact with the material.

The same principle is used in a smoke detecting device now marketed in this country. Essentially it consists of a double chambered device, one being a reference chamber closed to the atmosphere, the other a detecting chamber open to the atmosphere. Each chamber contains a small radiation source which ionizes the air within (that is it causes the air to be electrically conductive). Both chambers are in electrical balance until the products of combustion enter the detecting chamber, thus changing the ionization and upsetting the electrical balance between the two chambers. This change immediately activates an audible alarm system.

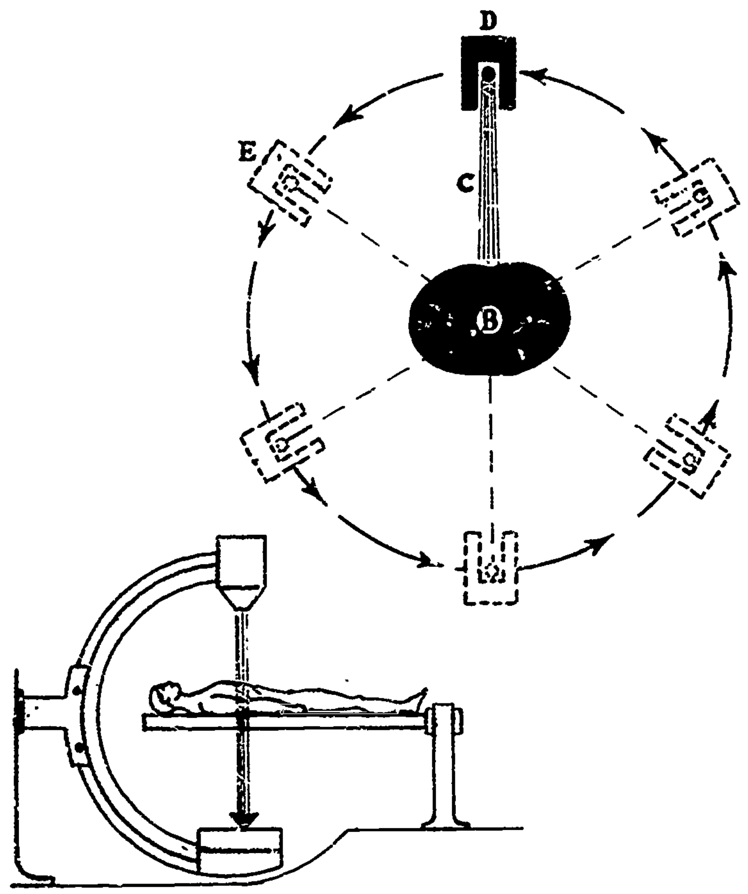

Fig. 9 - Radioisotopes Used to Treat Cancer

TREATMENT OF DISEASE BY RADIATION

Another very important use of radioactive materials is made possible by the fact that they emit energy which can bring about the destruction of living cells. It is because of this characteristic that a hazard exists in the use of radioactive materials.

A simple description of cancer is that it is a group of cells growing much too rapidly. Radiation is used to kill the rapidly growing cells, which brings about an alleviation of the cancer, as shown in Figure 9.

If a cancerous growth (B), located in the middle of the body cross section (A), in Figure 9, is irradiated by an external radiation source (D) which is rotated (E), the radiation beam (C) is concentrated on the malignancy while producing a diffused dose of radiation to the surrounding healthy tissue.

It will be found, however, that there is much confusion on this subject, and that there are people who believe that a direct relationship exists between radiation and cancer, as such. For instance, a man employed on a pipeline in Texas where radium was being used for radiography of welds knew that radium was used to cure cancer. His mother-in-law had cancer. He took the radium home in his pocket intending to use it to cure his mother-in-law's cancer. The result was that he received severe radiation burns to his leg, necessitating its amputation. This confusion may bring about other such instances. Radiation sources, which may be accessible to people who have a very limited knowledge of their use and hazard, should be carefully controlled to prevent such incidents from taking place.

The energy from radioactive material is used to destroy living tissue in the sterilization of food and drugs. Food and drugs are sealed in vapor tight wrappers to prevent any contact with the outside air. They are then subjected to massive doses of radiation so that all living microorganisms in the package are killed.

If all of the microorganisms are killed, the food is sterilized. If a lesser dose of radiation is used, the food can be pasteurized. That is, not all of the organisms are killed, but sufficient numbers are killed so that the food can be stored for a reasonable time without destruction by bacteria. The food itself is not radioactive any more than a person is radioactive after being X-rayed. There is, of course, a great deal of experimental work yet to be done. In some foods, there are very marked changes in color and flavor. In other foods the changes are much less pronounced.

Radiation sterilization is used in the manufacture of drugs. Destruction of bacteria by heat in many cases isn't practical because the heat will also damage the drug. Radiation is used to kill the bacteria without raising the temperature of the drugs.

CHEMICAL CHANGES AND PROCESSING BY RADIATION

Another use for energy from radioactive materials is possible because radiation energy can be used to excite the atoms of certain materials. Radium-dial wrist watches are used universally. It is generally believed that it is the radium which glows in the dark, but that is not so. The radioactive materials emit energy which causes a phosphor, such as zinc sulfide, to glow in the dark.

An important use of this phenomeno~ is in the field of chemical processing. By the use of radiation energy, certain chemical effects can be brought about, thus producing a better product. For instance, when polyethylene was first developed, it could not be subjected to boiling water temperature without damage. Now, at the proper point in the manufacturing process, the polyethylene is subjected to radiation energy from radioactive materials. This "knocks out" a couple of hydrogen atoms, which go off as gas. This changes the manner in which the atoms of polyethylene are linked together, producing *cross-linked* polyethylene, which can be subjected to boiling water temperature. This makes possible many uses of polyethylene as a substitute for glass where the container must be sterilized, such as for baby bottles.

ELECTRICAL PRODUCTION BY RADIATION

Another use for the energy of radioactive materials is in voltage production. This is the direct production of electricity from the energy released by the radioactive atoms. Don't confuse this with the indirect production of electrical energy in power reactors, where fission energy is converted to heat and then to conventional forms of power. The "atomic" battery has use where a dependable source of electrical energy in small quantities is required.

LOCATING NUCLEAR ENERGY HAZARDS

The Atomic Energy Commission licenses the use of source materials, fissionable materials, and by-product radioisotopes; however, this Commission does not have general control over all radioactive materials.

Source materials are materials from which fissionable materials can be made. These are the various natural uranium and thorium ores found in the earth's crust. Fissionable materials are materials capable of self-sustaining chain reactions, such as some types of uranium and plutonium. That is to say, they can be used for atomic power or weapons. By-product radioisotopes are materials made radioactive in an atomic reactor. Many naturally radioactive materials, such as radium, and materials which are made radioactive in a particle accelerator, are not under Atomic Energy Commission regulations.

When Atomic Energy Commission-licensed materials are introduced into a plant, the total radiation hazard comes under the Atomic Energy Commission regulations. The plant management cannot say, "The radiation hazard from the licensed material meets the Atomic Energy Commission standard, and the radiation hazard from this other unlicensed material is no concern of the Atomic Energy Commission." The total hazard from all materials, licensed and unlicensed, must be within the limits permitted by the Federal regulations.

This leaves open the area of radioactive materials not licensed by the Atomic Energy Commission. Some States have highly developed legislation to regulate the use of radioactive materials in areas not covered by the Atomic Energy Commission; others do not. Later, in prefire planning, it will be seen that the only solution for this problem is to develop a close liaison with the local health department.

Radioactive materials may be found in such places as universities, industrial laboratories, industrial plants, hospitals, doctors' offices, atomic power plants, military installations, and in transportation facilities.

The Atomic Energy Commission periodically notifies the State health departments in each State of all persons licensed to use radioactive materials within that State. This information is intended for distribution to other State and municipal agencies. A few State health departments have adopted a plan by which they promptly notify fire and police departments of new licenses issued within their jurisdictional areas. The Division of Licensing and Regulation, AEC, forwards a form letter along with each new license issued, suggesting that the licensee notify the local fire and police departments of his possession of radioactive material. Fire departments should request from their State health departments notification of Atomic Energy Commission licensees in their areas.

Radioactive materials may also be located by a fire department during building inspections. This may come about by a fire inspector noting that radiation warning signs are posted. Firemen should be familiar with the standard radiation warning sign shown in Figure 10, and when found, this information should

be entered on the inspector's building inspection form. Fire prevention building inspection forms should be provided with a special place for the entry of such information.

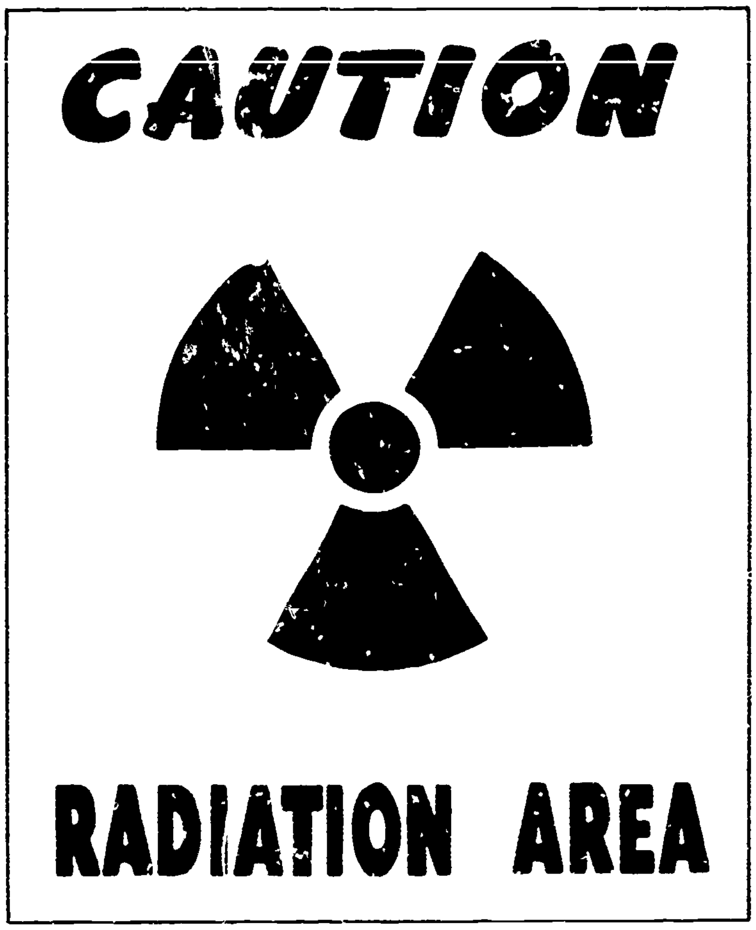

Fig. 10 - The Standard Radiation Warning Symbol

Certain operations of the Atomic Energy Commission are classified because revealing information on the nature of the operation might give assistance to an enemy. Other operations, especially in the field of basic research and the commercial use of isotopes, are completely unclassified. It is the policy of the Atomic Energy Commission to cooperate fully with State and local agencies in the discharge of their responsibilities for the general welfare of all. If it is found that security restrictions make it impossible to discharge an obligation, the plant manager should be asked the address of the Atomic Energy Commission office responsible for that plant. Write an official letter to the Manager of Operations of the Atomic Energy Commission stating the problem. He will assist in every way possible. It may be that an Atomic Energy Commission fire protection engineer who inspects the plant will discuss the problem with those responsible for fire prevention, and it may be possible to arrange for firemen to make an escorted inspection of the plant. If absolutely necessary, arrangements might be made for key fire department personnel to be cleared to make the inspection.

In general, however, security regulations have posed few problems to firemen that cannot be solved with a little common sense and good will. Most major Atomic Energy Commission facilities have highly organized mutual aid plans with the nearby fire departments so that fire fighting operations can proceed intelligently.

In publications dealing with the use of radioactive materials the notation, "Company Confidential," may be found. This is not a Government security classification, but simply means that the company wishes to keep its process confidential from its competitors. This is not uncommon but should be no bar to obtaining information essential to the fire department in the event of a fire. A good relationship between the fire department and the company will certainly aid in obtaining the necessary information.

PROBLEMS OF RADIATION

Radiation materials emit energy which has the power to damage living tissue if received in sufficient quantity. Within certain limits, however, damage can be repaired by the body so that there is no apparent effect.

Radiation is like any other form of insult to the body, whether it be from excessive heat, poison, electrical shock, disease, or wounds. There are various injury limits which the body can stand, based upon the type, severity, and duration of the insult. If the insult is sudden and massive the body's repair mechanism is overwhelmed and death results quickly. There is also a wide middle ground in which continued insults of a lesser nature, when prolonged over a period of time, can gradually overcome the body's ability to repair itself and will cause the individual to sicken and eventually succumb.

Then there is that area in which insults to the body are small enough to cause no demonstrable effects over an extended period of time because of the body's ability to continuously overcome and repair the small amount of damage being produced.

As the knowledge of the safe limits of common toxic materials is used to protect the worker in industry, so is the present existing knowledge of safe radiation limits used to protect the person who works with radiation continuously.

Therefore, when it is known what these limits are, people can expose themselves to radiation in order to accomplish necessary work. It follows, however, that the degree of exposure should be related to the importance of the work to be accomplished.

NATURAL BACKGROUND RADIATION

Unfortunately, no one can avoid exposure to radiation. All living things are exposed to cosmic radiation from outer space, which increases in intensity the higher the altitude. For instance, in Denver, Colorado, the mile-high city, a person would receive approximately twice the radiation from cosmic rays that he would receive at sea level, say at New York City. Suppose a person gets away from cosmic radiation by going down deep in a mine where no cosmic radiation can penetrate. This still will not solve the radiation problem, because there he will be exposed to radiation from radioactive material in the earth's crust. Some of these radioactive materials are, therefore, found in materials used to construct buildings. In addition, there are radioactive elements within the make-up of all persons' bodies, elements that have been radioactive from the beginning of time, such as radioactive potassium, radium, and carbon. A person's body also tends to concentrate radioactive materials that are taken into it, particularly from the water which he drinks. Water, in some parts of the country and particularly from some mineral springs, has appreciable radioactivity. So, from the beginning of time, man has been exposed to an inescapable natural background of radiation.

In addition to this natural background of radiation, the population as a whole receives a certain amount of radiation from medical and dental diagnostic and therapeutic procedures. It is obvious, from a basic premise that radiation can damage living tissue, that some of this medical and dental radiation may have some harmful effects. When harmful effects appear to outweigh the benefits from medical use of radiation, the logical course is to modify the medical procedure, not do away with all medical uses of radiation.

People are exposed to radiation from X-ray machines for the purposes of determination of broken bones, diagnostic techniques for the proper functioning of body organs, detection of lung diseases, and many others. Such devices have been in use for the past 50 years. An example of unnecessary exposure to radiation is the use of shoe-fitting fluoroscope machines which fit children's shoes by the use of X-rays. These are a possible hazard, not only to the child, but also to the shoe clerk. No useful purpose is served which could not be served by other means, and in many jurisdictions these devices have been outlawed.

Probably the chief error in much of the current thinking about radiation hazards is the failure to relate radiation hazards to the other hazards of human existence. All human activity involves risk. Some of them are physical, such as the hazard of being hit on the head by a heavy object dropped from above. Some hazards are more mental than physical, such as those of the advertising executive or play producer, who is under the constant strain of delivering completely satisfactory work or suffering the penalty of being ruthlessly eliminated from the field of his chosen profession. Consciously or not, when a person selects a field of work, he makes an appraisal of the hazards involved, along with the other factors, such as pay, general working conditions, prospects for advancement, and security of employment, all of which must be considered. Each occupation has its own peculiar hazards, inherent in the nature of the work. In controlling the hazard, attempts are made to reduce the probability of accident to a minimum, but absolute freedom from risk cannot be guaranteed.

When thinking about a radiation hazard, however, many people seem to regard it as a hazard apart from all other hazards, and demand that they be absolutely safe from it. In no field of human existence is there absolute safety. In everything that is done the hazard is weighed consciously or unconsciously against the good to be accomplished, and a determination is made.

Everyone, for instance, is quite familiar with the fact that serious diseases can be spread from person to person by improperly washed tableware. Yet most people would consider a man who went into a restaurant and applied a sterilizing solution to the tableware before using it to be somewhat neurotic. In general, they have weighed the risk and found that it is so slight that they prefer to ignore it. However, if a violent epidemic were to break out in a city, the inhabitants might well consider that they should take precautions.

When driving on the highway, despite the fact that many people might maintain their own automobiles in perfect mechanical condition, and despite the fact that they might be truly defensive drivers--mentally driving not only their own cars but also the cars of others--situations can arise in which they and those dear to them, can be maimed or killed under circumstances entirely beyond their control. The only control over this is to stay at home. Yet, while thousands are killed and maimed on our highways, few people refrain from driving automobiles or riding in automobiles because of the terrible accident toll. Having weighed the hazard against the good, the motoring public has made its decision.

If a man doesn't care to accept the exposure to radiation incidental to employment in an atomic energy plant when all of the necessary precautions have been provided and his radiation exposure is no

more than the maximum permissible level, there is only one thing for him to do; he should find other work, the hazards of which he is willing to accept.

Many occupations are fraught with so-called "calculated risks." Regardless of the risks involved most people work safely at these occupations all their lives. This is simply because they have learned to recognize, plan for, and live with the hazards. Fire fighting is a hazardous business which firemen have learned to accept and live with.

When addressing a group of citizens such as the PTA on the subject of fire protection, a fireman would always give them one firm piece of advice: "If your house is on fire, get yourself and your family out of the house immediately, call the fire department, and do not go back into the house." When this fireman arrives at the fire he immediately enters the burning building. This is directly contrary to the advice he gave the citizens, advice based on the fact that it is dangerous to remain in a burning building. Then, why is he entering the building? To save life? Not in this case because upon arrival he was assured that all persons were out.

He entered the burning building because it was part of his job to confine the fire and limit the destruction. In so doing he took risks, but because of his training and experience he knows these risks are reasonable, considering the objective. He would not, however, enter all burning buildings indiscriminately. Little risk is taken by a fireman in fighting a fire in a dilapidated barn. A greater risk is taken by a fireman in fighting a fire in a commercial building. The greatest risk is taken by a fireman in saving lives during a fire in an occupied building.

Firemen must learn to relate radiation hazards in their proper perspective to the other common risks which they face. In addition, they must also learn to adjust their radiation risk acceptance to the necessity of the job to be accomplished.

When firemen have been educated in a sound approach to the hazards of the Atomic Age, they will take the same reasonable view of these hazards that the people working in a radiation plant do, and the same view they take regarding the other hazards of their profession.

The safety record of the Atomic Energy Commission program is phenomenally good. The fatal accident rate is less than half that of the best of American industry. Although approximately 200 people have been killed in the program, only 3 deaths resulted from accidents involving radiation. The others were killed in what are sometimes referred to as "normal" industrial accidents, such as fires, falls, electrocutions, motor vehicle accidents, drowning, and the like.

The effects of excessive radiation exposure on the body are manifested in several ways:

Radiation Sickness - This is a sickness produced by a massive overdose of penetrating external gamma radiation, which causes nausea, vomiting, diarrhea, malaise, hemorrhage, and a lowering of the body's resistance against disease and infection, and, of course, if serious enough, death.

Radiation Injury - Radiation injury consists of localized injurious effects, generally from overdoses of less penetrating external beta radiation and most often to the hands because contact is usually with the hands. This can cause injuries not unlike burns, loss of hair, and skin lesions. Genetic damage is also a form of radiation injury, usually of permanent nature.

Radioactive Poisoning - Radioactive poisoning is illness resulting when dangerous amounts of certain types of radioactive materials enter the body; it may cause such diseases as anemia and cancer. The alpha radiation emitters are the most dangerous in this respect.

After looking at the foregoing, one realizes that a fireman can get into trouble with radiation by two entirely different means - one, by radiation originating from a radioactive source located outside the body from which the radiation comes at the body like a continuous shower of tiny, invisible bullets; the other by exposure of internal body organs to radioactive material which has been taken into the body and which may have collected in these body organs. It should be obvious that precautions against one type of hazard will not be particularly helpful in protecting against the other type of hazard, and that the radiation problem is made up of two separate problems, illustrated in Figure 11.

This is indeed the case. As a matter of fact, certain radioactive materials are no hazard at all outside the body. However, if these same materials got inside the body in sufficient quantity, they could produce a serious case of radioactive poisoning.

Therefore, it is important for firemen to understand that the radiation problem is not one problem, but two problems: That of *external* radiation exposure, and that of *internal* radioactive poisoning. The precautions for protection that must be taken by firemen against various radiation hazards depend upon which particular hazard is present during an incident. Of course it is possible in a given situation that both external and internal hazards are present.

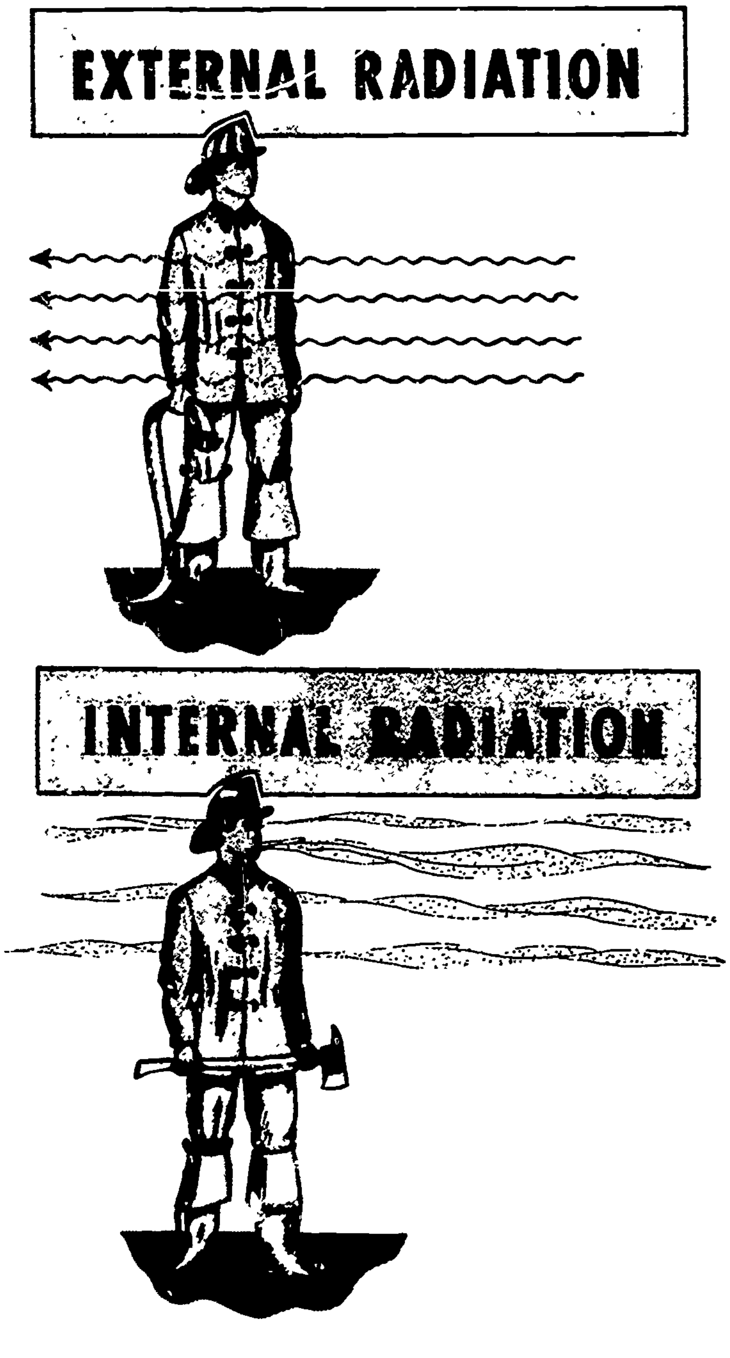

Fig. 11 - Radiation Hazards Are of Two Types—External and Internal

EXTERNAL RADIATION

There are two types of external radiation hazards: (1) long-range, highly penetrating external radiation called gamma; and (2) short-range less penetrating external radiation called beta.

The long-range, highly penetrating external radiation is similar to X-rays, and consists of very short waves of pure energy having no mass or weight. These rays originate from certain radioactive materials which are usually located outside the body, and so the rays come at the body like a continuous shower of tiny, invisible bullets. In order to visualize this, it should be thought of as one ray at a time. Each ray can be considered a bundle of energy. It may penetrate the body to some depth before it does damage and the energy of the ray is spent. (The effect of radiation on the body is a little more complex than this, but this concept will serve the purpose of this text.)

Observe the figure of the man in Figure 12. The rays come at him from the radioactive source which is giving off the penetrating gamma radiation. Each ray penetrates to a different depth in the body before finding its target and producing its effect on the structure of the body. Also note that a sizable proportion of the radiation passes through the man's body. Those rays that pass entirely through do him no harm.

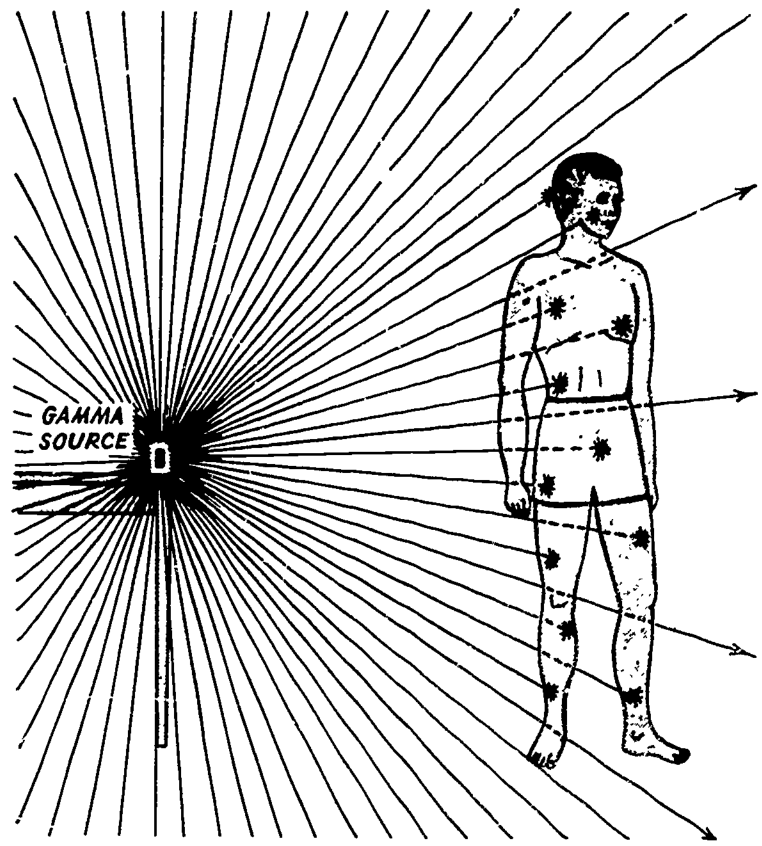

Fig. 12 - The Penetrating Effects of Gamma Radiation on the Body

It is known that exposure to excessive radiation can bring about sufficient damage to cause death. The problem is to regulate radiation exposure to the amount from which there will be no apparent effect. There is no single answer to the question, "How harmful is radiation exposure?"

A simple demonstration helps to prove this point. Slapping the hand on the desk hard enough will make it sting. There is no visible damage, but in all probability some cells in the palm of the hand have been damaged by this blow. If a person strikes his hand harder on the desk, visible damage in the form of black and blue marks will show up. The body will generally recover from this insult after some effort on the part of the body repair system to rebuild the

damage, and there will be no apparent aftereffect. A harder blow would cause broken bones which would not heal properly unless given adequate medical attention. The severest degree of damage would be to break the hand off at the wrist, because this would be irreparable.

Just as there is no simple answer to the question of how harmful is it to slap one's hand on the desk, there is likewise no simple single answer to the question, "How harmful is radiation exposure?"

It is impossible to say how many roentgens it will take to kill any specific individual because each person varies in his resistance to any attack upon the body, whether it is by radiation, electricity, poison, injury, or diseases. It is quite certain, however, that no human being can survive exposure in the neighborhood of 1,000 roentgens of *total body* radiation delivered in a *short* space of *time.*

The effect of 1,000 roentgens of radiation delivered to the whole body is by no means the same thing as 1,000 roentgens delivered to a small portion of the body any more than a third degree burn of the palm of the hand is the same thing as a third degree burn of a large area of the body.

Similarly, the short space of time is an important part of the definition. The *short space of time* is defined as 24 hours, or less. The ability of the body to withstand any abuse is, of course, increased if the same amount of abuse given to the body is spread out over a longer period of time. Whisky can be poisonous, but many people apparently without any demonstrable injury can drink an ounce of whisky each evening before dinner over an extended period of time. If, however, a person attempts to consume a three months' quota of whisky in one sitting, death from alcoholic poisoning will probably result because the body has not been given sufficient time to recover from the poison. A steady drinker can develop a gradual tolerance to increasing amounts of liquor It must be understood, however, that in light of present medical knowledge there is no indication that the body can develop a tolerance to increasing doses of of radiation. The dose it takes to kill one specific individual is not a good measure of the fatal dose to others because of differences in each individual's body metabolism.

The effects of a short term (24 hours or less) whole body exposure to various levels of penetrating external radiation on a representative group of the population are shown in Figure 13. When exposed to 600 roentgens or more, severe to lethal radiation sickness would result in rapid emaciation and some death as early as the second week and with possible death of 100% of exposed individuals.

An exposure of 300 to 600 roentgens would result in severe radiation sickness, with some deaths in 2 to 6 weeks and possible eventual death to 50% of the individuals exposed to about 450 or more roentgens. An exposure of 200 to 300 roentgens would result in moderate radiation sickness. Recovery would be likely in about 3 months unless complicated by previous poor health, superimposed injuries, or infections.

An exposure of 100 to 200 roentgens might result in slight radiation sickness and would be accompanied by blood changes with delayed recovery. Delayed effects may shorten life expectancy by approximately one percent.

At the 25 to 100 roentgen exposure level no radiation sickness would be expected. Slight temporary blood changes would occur, but disabling sickness would not be common, and exposed individuals should be able to proceed with their usual duties.

On an exposure of 0 to 25 roentgens there would be no detectable clinical effects, and exposed individuals would be unaware of any biological damage.

The latter exposure is the emergency or accidental single dose recommended by the National Committee on Radiation Protection and Measurement (NCRP). Firemen should generally be limited to this exposure in carrying out work of extreme importance, such as the saving of life. This is a once-in-a-lifetime emergency dose, applicable only to peacetime radiation emergencies, and is not charged against a person's medical or routine radiation exposure.

In a national wartime atomic disaster, the U.S. Office of Civil and Defense Mobilization authorities have prescribed that higher emergency dosages may be received when necessary. Firemen or other civil defense emergency personnel might be exposed to a total dose of as much as 200 rem over a period of a month or less, if such exposures were required to perform actual high priority fire defense tasks.

Remember that all of these figures are on the basis of whole body radiation within a short space of time. It should also be noted that it is quite difficult for a person to receive high radiation exposure unless there is gross violation of simple safety precautions.

GENETIC EFFECTS

The genetic effect of radiation is one of the areas in which the layman is most completely confused. Some common misconceptions should first be disposed of. There is no relationship between the so-called genetic effect and sterility or impotence. Radiation doses so high as to be nearly fatal can

bring about sterility, which is the inability to conceive children despite normal sexual relations. Impotence is the inability to carry on sexual relations, and radiation has effect on this.

Another misconception is the idea that all congenital (present at birth) handicaps are genetic. Only about half the recognizable congenital handicaps are genetic in origin; the others are caused by disease or other factors.

The next misconception that should be cleared up is the idea that there is any direct relationship between an exposure to radiation and the conception and birth of a defective child in any specific instance. It is true that radiation striking genetic material which is used in the conception of the next generation may cause a mutation which may show up in a future generation. However, the cause of any specific mutant cannot be determined. The mutation may or may not be caused by radiation, but even if caused by radiation, the source of the ray cannot be known. On the other hand, no measurable amount of radiation from any source is so small that it can be positively said to have no genetic effect. The geneticist necessarily is concerned not about individuals but about the population as a whole.

The problem, therefore, is not one of protecting a

600 r or more

Severe radiation sickness with up to 100% deaths for exposed individuals. Rapid emaciation and death as early as 2nd week with possible eventual death of up to 100% of exposed individuals.

300 - 600 r

Severe radiation sickness with up to 50% deaths for exposed individuals. Some deaths in 2 to 6 weeks. Possible eventual death to 50% of the exposed individuals for about 450r.

200-300 r

Moderate radiation sickness. Recovery likely in about 3 months unless complicated by poor previous health, superimposed injuries, or infection.

100-200 r

Slight radiation sickness. Blood changes with delayed recovery. Delayed effects may shorten life expectancy by one percent.

25-100 r

No radiation sickness expected. Slight temporary blood changes. Exposed individuals should be able to resume usual duties.

0-25 r

No radiation sickness. No detectable clinical effects. The exposed person would not be aware of any biological damage.

Fig. 13 - Effects Resulting from Single Whole Body Exposures to External Radiation

specific individual but of protecting the entire population by keeping all exposure to radiation down to the lowest practical limits.

The portion of the population of primary interest to the geneticist are those of a reproducing age. The effect of radiation damage on genetic material is different from the effect of radiation damage on ordinary cell material. When genetic material is damaged, a pattern is damaged. Once a pattern is damaged, it remains damaged. Thus, it is possible that the genetic material damaged by a radiation exposure in a person's early childhood may have its effect in a child conceived by this person many years later, or the damaged pattern may be passed on and show up as a mutant child in future generations. However, the fact must be borne in mind that the only radiation exposure which is genetically significant is that which strikes the reproductive organs of either the male or female. Radiation exposure of other organs or other parts of the body has no genetic effect whatsoever.

PROTECTION FROM EXTERNAL RADIATION

PROTECTION FROM GAMMA RADIATION

The means of protecting a fireman from external radiation exposure are a combination of three things: *Time, distance,* and *shielding.* That is to say, protection is provided by: (1) controlling the length of time of exposure, (2) controlling the distance between the fireman and the source of the radiation, and (3) placing an absorbing material between the fireman and the source of the radiation.

It is not generally possible to use only one factor of protection. The factor of time is always involved, that is, time is usually used in combination with distance, shielding, or both. For comparison, consider the problem of protecting the eyes from ultraviolet rays when taking a sunbath. Ultraviolet rays do the eyes no good. A certain amount can be tolerated, but beyond this point damage may be caused. The eyes can be protected in three ways. First is to regulate the time spent under the sun lamp. Second is to regulate the distance maintained between the eyes and the sun lamp. Third is to shield the eyes with sunglasses. The denser the glasses, the more ultraviolet rays are filtered out and therefore an individual can be closer to the lamp and stay there a longer period of time without hurting his eyes. In order to understand each of the three factors of protection, it is necessary to discuss them separately.

Time - The effect of *time* on radiation exposure is easy to understand, as is illustrated in Figure 14. If a fireman is in an area where the radiation level from penetrating external radiation is 100 milliroentgens per hour, then in 1 hour he would get 100 millirems of exposure. Upon staying 2 hours he would get 200 millirems; if he stayed 4 hours he would get 400 millirems; and if he stayed 8 hours he would get 800 millirems of exposure, and so on.

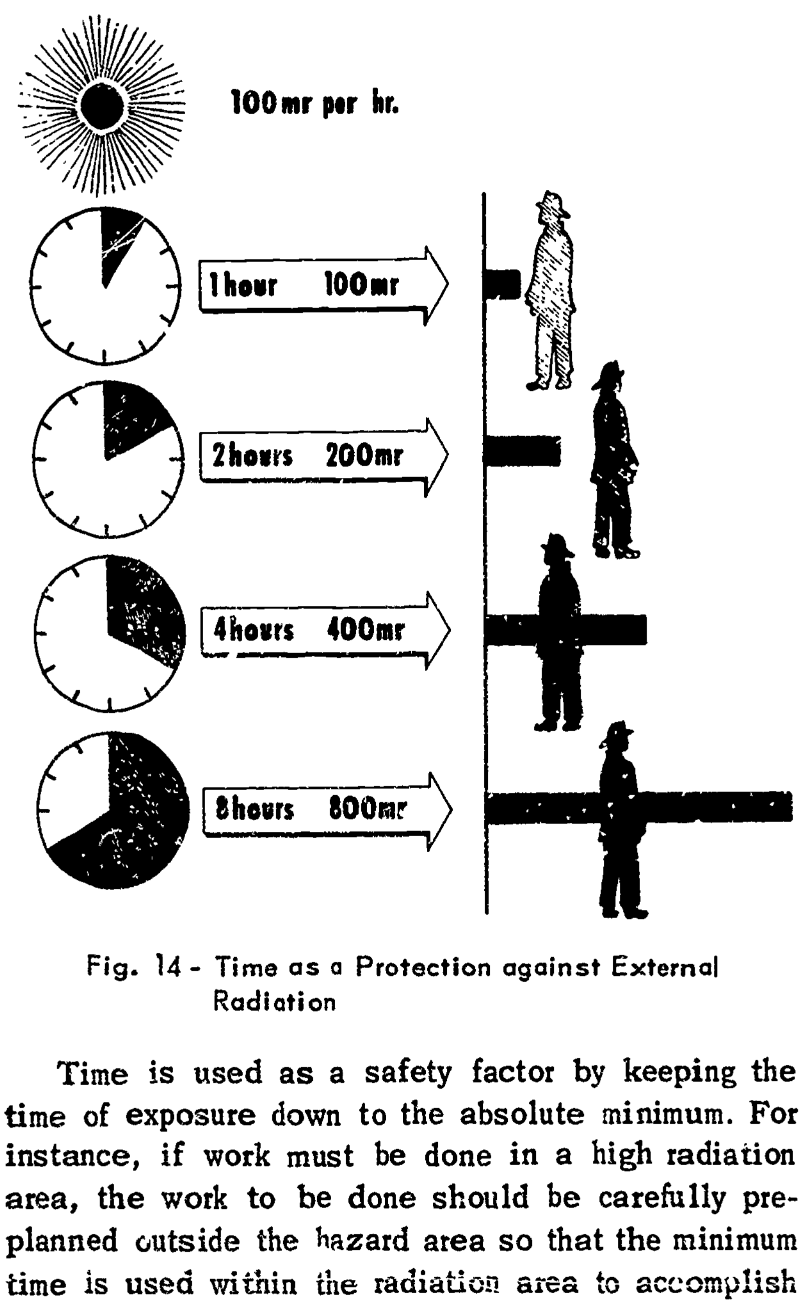

Fig. 14 - Time as a Protection against External Radiation

Time is used as a safety factor by keeping the time of exposure down to the absolute minimum. For instance, if work must be done in a high radiation area, the work to be done should be carefully preplanned outside the hazard area so that the minimum time is used within the radiation area to accomplish the work.

The basic principle, of course, is to limit the exposure of personnel to radiation in all cases to the minimum time necessary to accomplish the task, and to involve the minimum number of personnel so that the accumulated units of exposure will be the absolute minimum.

Distance - The effect of *distance* on radiation exposure is quite startling. This effect is due to the inverse square law. That is to say, the intensity of radiation falls off by the square of the distance from the source. See Figure 15.

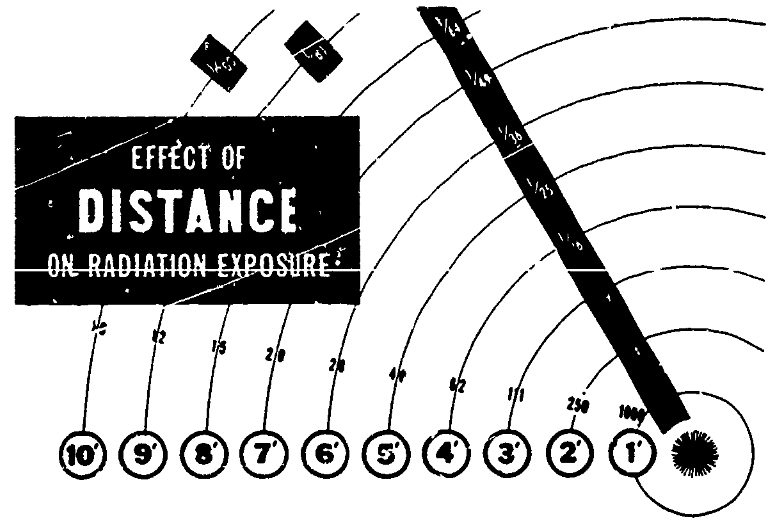

Fig. 15 - Distance as a Protection against External Radiation

For example, standing 1 foot from a source of radiation that was giving off 1,000 roentgens per hour of penetrating external radiation at 1 foot, a person would be exposed to 1,000 roentgens per hour. He would receive only 250 roentgens per hour at 2 feet because he would have doubled the distance, and the effect on the radiation level is to reduce it to $(1/2)^2$ or 1/4. If he tripled the distance he will have reduced the level to $(1/3)^2$ or 1/9 which is 111 roentgens per hour of radiation. At 10 feet away he would receive $(1/10)^2$ or 1/100th of the exposure he received at 1 foot, that is, 10 roentgens per hour.

Shielding - Remember that the damaging effects of radiation come from the fact that the rays impart energy to the electrons in the body and eject them from their orbits, and if this happens to sufficient electrons in the body, radiation damage has been produced. In order to stop a high proportion of the rays before they reach a person, there must be placed between the person and the source of the radiation a material which has many electrons in its make-up. The more electrons there are in the make-up of the material, the more radiation will be stopped.

Figure 16 shows the relative efficiency of various shielding materials. Lead, iron, concrete, and water are efficient in about the proportions shown in the illustration in stopping the same amount of radiation. Various shielding materials are used in different applications, depending upon the purpose to be served. Lead, for instance, is quite compact and is suitable where space requirements are a factor. On the other hand, water is used where it is necessary to see through the shielding material and to work through it in performing necessary operations, such as sawing or cutting the radioactive materials. This can be done with complete safety to the operator with long handled remote control tools through many feet of water in a pool.

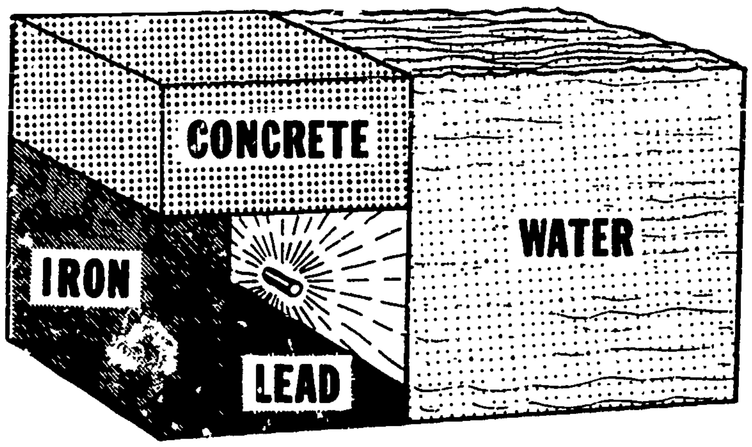

Fig. 16 - Relative Efficiency of Various Materials for Shielding against Gamma Radiation

When considering that matter is mostly empty space, it must be realized that no material can be an absolute barrier to penetrating external radiation. Regardless of the thickness of the material, some radiation can get through the material without hitting any electrons and, therefore, without being absorbed. Some degree of shielding may be obtained by keeping heavy masonry walls or large mounds of earth between fire personnel and the radiation source. Wood walls or the use of water streams from a fire hose offer practically no shielding to firemen from penetrating radiation.

PROTECTION AGAINST BETA RADIATION

Thus far, the discussion has been concerned primarily with long-range penetrating external gamma radiation. There is another but lesser type of external hazard called beta radiation. This radiation is less penetrating, has a shorter range, and represents an external hazard to a fireman only if he comes into close contact with the radioactive materials by handling them or by not promptly washing off any material which may have gotten on his body. Some radioactive materials are quite safe to handle with the bare hands; others are not -- and it is impossible to tell by looking at the material whether or not it is safe to handle it with the bare hands. The general rule is very simple: Don't handle radioactive materials and limit the time a fireman is close to any beta emitting materials.

RADIATION DOES NOT MAKE THINGS RADIOACTIVE

It is a misconception that radiation from radioactive materials can make other things radioactive. Many people believe that a person who works with radioactive materials will become radioactive. If an external radiation source is left on a table, and later the source is removed, they believe that the surface of the table upon which the source rested has been made radioactive by the rays. Materials that are made radioactive are done so in an atomic reactor.

RADIATION DETECTION

GAMMA AND BETA MONITORING

Ionizing radiation emitted from radioactive materials cannot be detected by any of the human senses. A person receiving a large overexposure of external radiation would not be aware of it until sometime later or when radiation sickness developed. Therefore radiation must be detected by mechanical, chemical, or electrical means. Recent research indicates, however, that a person exposed to a massive overdose of external radiation, in the order of 5,000 r or more, would feel the effects almost immediately.

To provide adequate protection to personnel from radiation exposure, it is important to understand the methods of measurement, types, and proper uses of radiation detection instruments.

DOSE RATE METERS

A Geiger-Muller counter or *geiger counter* is one of the available types of radiation detection instruments. It is essentially a low level instrument since the maximum reading available on most geiger counters is 40 or 50 milliroentgens per hour.

Figure 17 shows one type of geiger counter.

Higher levels of beta and gamma radiation are read with an instrument called an *ionization chamber*. Some ionization chambers for Civil Defense use are designed to read as high as 500 r per hour. An ionization chamber is shown in Figure 18.

Radiation detectors such as geiger counters and ionization chambers are dose rate meters, in that they measure the rate of radiation being received by the instrument at the time the instrument is read. If the instrument is removed from the radiation field, the needle will return to background and there will be no indication of the radiation levels to which the machine has been subjected.

Fig. 17 - Geiger-Muller Counter

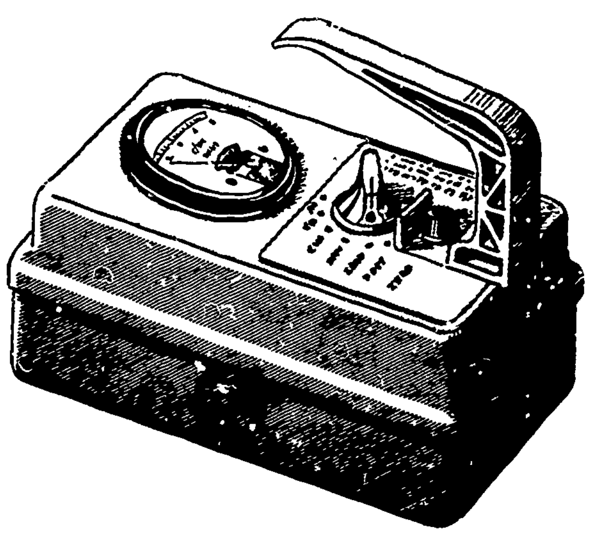

Fig. 18 - Ionization Chamber

Firemen are most likely to have access to the geiger counter and the ionization chamber type instruments. Of these, the ionization chamber will probably be of greater use because of the range in which it operates. Geiger counters may "block out" and give a zero reading in a high radiation field, thereby giving false security to firemen who may be working in a high level of radiation without realizing it. It is for this reason that fire departments contemplating the purchase of only one type of instrument should first consider a low reading ionization chamber rather than the geiger counter.

Developments are rapidly being made in the field of radiation instrumentation, and advice on the purchase of any radiation detection instruments should be obtained from persons who are in a position to keep abreast of the latest developments. All radiation detection instruments, however, require skilled main-

tenance and calibration if they are to serve the purpose for which they are intended. The mere purchase of an instrument or instruments serves little purpose. A complete program should be set up to insure that instruments will be in operating condition when needed and will be as accurate as necessary for the service intended.

ALPHA MONITORING

Since alpha radiation has such a very short range in air and little or no penetrating ability, it must be detected on special alpha measuring meters, and the measuring area of the meter must be brought directly to the contaminated surface. When an area has been contaminated with a pure alpha emitter, the entire surface must be scanned thoroughly, inch by inch, to detect the location of the contamination. Since the alpha radiation has a very limited range, the contamination level at one point is no indication of what the contamination level may be at another point nearby. In addition, determining surface contamination does not give any indication of the amount which may be suspended in the air of the room.

Alpha radiation contamination levels are generally stated in terms of the number of disintegrations per minute per 100 square centimeters of surface. Where the surface is irregular, and the flat surface of the instrument cannot be brought to bear, a piece of tissue is used to wipe a measured area of the surface. Then this piece of tissue is measured to get a figure of the contamination on the surface.

The same wipe technique is used for beta or gamma contaminated surfaces to determine how much of the contamination is removable and how much is fixed to the surface.

DOSIMETRY

For the protection of individuals, devices are needed which will measure the accumulated radiation exposure. These come in two principal types -- *film badges* and *pocket dosimeters.*

A film badge consists of a bit of X-ray film worn in a special metal holder. The X-ray film is sensitive to radiation in various ranges, and when developed by standard photographic techniques the film will be darkened in proportion to the amount of radiation received. When the darkening of the film is compared with the darkening of similar control films from the same batch which have been exposed to a known amount of radiation, the amount of radiation which the film badge has received is indicated. Film badges provide a permanent record of radiation exposure, but not an immediate one, because of the time required for developing the film and reading the badges. A film badge is shown in Figure 19.

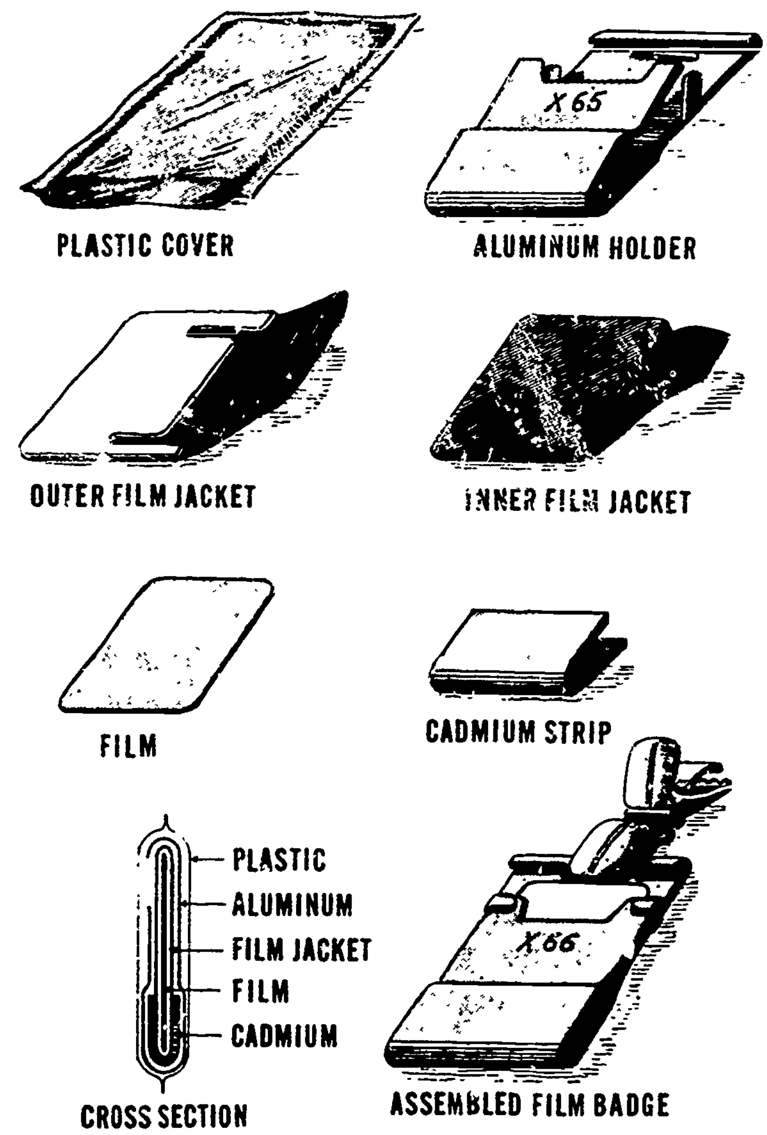

Fig. 19 - Typical Film Badge

For a readily available accumulative record of radiation exposure, a pocket dosimeter is used. A pocket dosimeter is a device which will record the radiation which is received, starting from zero, when the device is properly charged, to the limit of the scale of the particular dosimeter. Some dosimeters can be read directly by holding them up to light; others must be read in a reading device provided for this purpose. Dosimeters may give false high readings due to electrical leakage resulting from being dropped or damaged. Therefore they are generally worn in pairs. Figure 20 shows pocket dosimeters.

Film badges and pocket dosimeters will not record alpha radiation. This is of no consequence since external alpha exposures are no hazard.

The primary rule is to wear the measuring device at all times when in a radiation area and to protect it from radiation exposure when it is not being worn.

Fig. 20 - Direct Reading Types of Dosimeters

In the not-too-distant future it is expected that the use of radioisotopes will become more commonplace and widespread throughout the country. Under these conditions it is reasonable to assume that many fire departments will require the wearing of film badges, or similar comparable devices, by their men at all radiation incidents. This will be necessary in order to obtain valid information on the men's radiation doses so that comprehensible radiation exposure records can be maintained for each man.

INTERNAL RADIATION AND PROTECTION

The internal radiation exposure problem in contrast to that of external radiation, is much more complicated and involves many factors.

The principle hazard associated with internal radiation is due to the nature of the very short range, relatively heavy atomic (alpha) particles. Alpha radiation cannot penetrate beyond the outer dead layer of skin; therefore, it presents no radiation hazard when kept outside of the body. The greatest internal radiation hazard to firemen is that of getting alpha emitting radioactive material into the body.

Internal radiation hazards may be found in certain industries where industrial processes release radioactive materials in finely divided form. This occurs most widely in the rolling, stamping, milling, grinding, and polishing of reactor fuel elements. In some laboratories the possibility of internal radiation hazards also exists. Where radioactive materials are put into chemical solution, they may accidentally be spilled or the containers rupture in a fire, thus spreading contamination which eventually may become air-borne. In normal industrial plant operations these hazards are under control; however, these controls may break down during an emergency, such as a fire. Internal radiation hazards may also exist in transportation accidents.

HAZARDS OF GETTING RADIOACTIVE MATERIALS INTO THE BODY

There are four possible ways to get radioactive materials into the body:

1. By breathing
2. By swallowing
3. Through breaks in the skin
4. By absorption through the skin

The most likely way for radioactive materials to enter the body of a fireman is by breathing and swallowing and to a lesser degree through wounds.

There is a sizable amount of medical information available on the effect of radioactive materials in the body, although much research remains to be done. Many people are familiar with the classic cases in the field of radioactive poisoning. These are the cases of the women in the radium dial painting plant in New Jersey, who pointed up the camel's hair brushes with their lips, and thus introduced radium into their bodies over a period of time which eventually resulted in the death of a number of them from bone cancer.

The introduction of radioactive material through wounds is avoided by standard safety techniques to prevent injury. The hazard of absorption through the skin, where it exists, is handled by the provision of suitable protective clothing and gloves.

PROTECTION FROM INTERNAL RADIATION HAZARDS

Radioactive materials may occur in any physical form, such as dust, powders, liquids, or gases, or they may be dissolved in other substances. In short, they may be in any physical shape.

The fire service is accustomed to dealing with toxic concentrations so deadly that practically immediate death will result if men are exposed to them even for short periods of time. Such gases as carbon monoxide, oxides of nitrogen, and others which are often encountered are recognized as being almost instantly fatal when present in high concentrations. This, however, is not the nature of the hazard of radioactive materials. In general, the hazard is that of getting materials into the body which, over a period of time, may prove detrimental to the individual because of the radiation emitted. The problem is complicated by the fact that these radioactive materials cannot be sensed and may not, necessarily, be accompanied by smoke or irritating fumes which by their very nature are self-protecting in that they tend to drive the firemen out of the hazardous area before they can receive a dangerous amount of toxic material.

Masks - Fortunately, the fire service has at hand the basic means of protection needed for dealing with this situation. The fundamental rule is to require that all personnel entering a radiation area during a fire or other emergency wear the self-contained type of mask equipment until it is determined that no air-borne hazard exists. (See Figure 21.) Self-contained masks are the oxygen and air-demand type, or the oxygen generating type. Such masks provide a man with his own independent air supply and cut him off completely from breathing the contaminated air. Filter masks are used extensively in Atomic Energy Commission plants where radioactive materials are air-borne. However, these are special filter-type masks chosen for use in particular radioactive situations. The self-contained mask is preferable, although wearing of a filter mask certainly is better than entering the area with no mask at all.

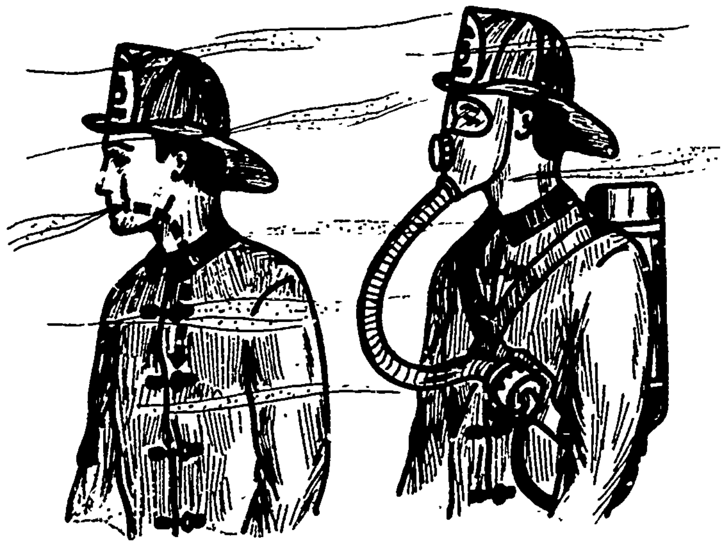

Fig. 21 - Using a Mask as Protection against Internal Radiation

Most modern fire departments have self-contained masks because of the general recognition that it is no longer sound practice to expose personnel freely to the smoke and other gases present at a fire.

It should be realized that even the best masks take time to put on and decrease the efficiency of the wearer in some respects. For this reason, in order to get the first line in operation as rapidly as possible, many fire departments do not require the first company responding to a fire to wear masks. They are aware that the personnel may take severe punishment and should be replaced as rapidly as possible by personnel wearing masks. In the meantime, the fire is being brought under control.

However, in the radiation situation, it is recommended that personnel wear masks from the time the radiation warning sign is noticed until they are assured by competent authorities that there is no further need for the wearing of respiratory equipment. By prefire planning in a specific situation, determination may have been made in advance that the wearing of masks would be entirely unnecessary due to the radiation situation, if only a fixed external radiation source is involved. However, in the presence of a radiation hazard, the nature of which is unknown or questionable, or which is known to present the possibility of an air-borne radiation problem, masks should be worn from start to finish on the firefighting operation. Following this precedure, officers can feel sure that their personnel have not received a body over-burden of radiation.

Proper Mask Removal Procedure - Having kept a man from inhaling radioactive material during the fire accomplishes the greatest part of the job in protecting him from internal radiation. However, as he comes out of the fire area, it is obvious that some of the radioactive material may be deposited on his body or on his fire clothing and equipment. Material on his bare skin, particularly if it is a strong beta emitter, may cause radiation burns. The other problem is caused by the fact that the material on his skin or fire clothes may be transferred to his nose or mouth and then be breathed or swallowed. The procedure should then be to decontaminate the man fully.

The proper procedure for the removal of masks is more complex than that carried out in normal firefighting operations. Refer to Figure 22. Leave the immediate contaminated fire area, *Step 1;* before removing the mask and protective clothing, a thorough and complete washdown with reduced pressure and control of water runoff at the contamination control point is necessary, as shown in *Step 2.* This will generally remove the major portion of the contamination from the outer clothing.

Then remove outer clothing, helmet, and boots as shown in *Step 3.* The mask must be kept on and operative during this procedure. Also, the gloves should be kept on. The removed outer clothing should be kept at the control point and should be checked for contamination when time permits.

The mask is then removed while holding the breath, as shown in *Step 4.* It should also be placed with the discarded clothing. The gloves are the last item removed and placed with the discarded clothing. The hands should then be thoroughly washed as soon as possible, as shown in *Step 5.*

The last procedure, *Step 6,* is to take a cold shower, not a bath, using plenty of mild soap or detergent and water. This should be done as soon as pos-

sible. Showering facilities may be available at the plant site in order to avoid any delay. If not, this should be done promptly upon arrival back at the fire station. Clean, fresh clothing should be put on and the discarded clothing held for check.

Fig. 22 - Mask Removal Procedure

By this time, the situation will be a bit calmer, and more information will be available as to the exact nature of the radiation problem. If the problem is on the serious side, it might then be necessary to check the man over inch by inch to make sure that no radioactive material has been allowed to remain on him.

To summarize, the primary means of protection of a firefighter from internal radiation contamination is the wearing of a self-contained mask from the very start of a fire involving a radiation hazard until the wearing of the mask is no longer necessary. Personal decontamination techniques supplement this protective measure.

CONTAMINATION

In industries which require handling of radioactive materials which can be easily spread, all personnel must be alert to the possibility of the spread of radioactive contamination. Like all other radiation problems, the situation may be relatively minor or extremely severe, depending upon the nature of the material, the type of radiation given off, and requirements for use of the area. For instance, in a laboratory doing very precise radiation measurements, a very small amount of radioactivity insufficient to represent any danger to health may interfere seriously with the work being performed because the background level of radiation in the laboratory is increased by contamination. At the other end of the scale, it is possible to contaminate a building so severely that it is cheaper to abandon the building than to attempt to decontaminate it.

The hazards from radioactive contamination may be from *alpha*, *beta*, or *gamma* radiation.

Contamination is most easily spread during an emergency situation such as an explosion or a fire. An ordinary rubbish fire in a building will quickly bring about an odor of smoke in many points in the building far removed from the source of the fire. When smelling smoke, the nostrils are actually detecting tiny bits of ash, carbon, and other products resulting from the fire which were originally part of the trash which was ignited. Therefore it can be realized that radioactive materials involved in a fire can spread very easily due to the air currents set up by the fire. They can also spread easily if, by some accident, they are introduced into the air conditioning system, or if they are spilled on the floor so they can be tracked around. Personnel working in an area contaminated during an emergency must be extremely cautious that, in their haste to deal with the emergency, they do not make the situation much worse by transferring contamination to the clean areas.

Normally, in firefighting operations, personnel move from the apparatus to the scene of the fire, from the scene of the fire to the areas above, below, and around the fire as the necessity of the fire situation and the orders of the officer-in-charge dictate. After reporting to the officer in the fire area they may even be sent out and into other nearby "exposure" buildings.

If the fire involves radioactive contamination, it is quite probable that the movement of personnel may spread the contamination from the scene of the fire to other clean areas by the simple process of moving from one place to another. A vital duty of the fire department then is to restrict the movement of firemen and thus prevent, insofar as possible, the contamination of the fire department's own equipment and the spread of contamination throughout the fire building and to adjoining areas.

Obviously, it is impossible to prevent the contamination of equipment which enters the fire area. It may necessarily get contaminated in order to accomplish the job. However, the return of that equipment in a normal manner to the apparatus may spread the contamination to the apparatus, to other equipment

on the apparatus, from the apparatus to the fire station, from the fire station to personnel, and from personnel to their homes. Of course, in the spread of radioactive contamination, a point is reached where the spread is so thin that the contamination cannot be appreciably measured -- that is, this safe point is reached by dilution. This is one recognized manner of disposing of a contamination problem. However, as long as the contamination is measurable, no matter how slight the real hazard, it can be a very serious public relations problem, since the general public is not well enough informed to distinguish degrees of radiation hazard levels. The spread of contamination may well reduce the hazard but increase the problems with fire department personnel, their families, and the public in general.

Therefore, it is of utmost importance to contamination control that personnel who enter the contaminated area do not thereafter move to other areas of the fire or leave the contamination control area until they have been decontaminated. The same principle applies to equipment. This requires a totally new approach to the firefighting problem. See Figure 23.

Contamination control is accomplished by two means. First, the available fire forces are designated into *contaminated* and *uncontaminated* firemen. The area to which contamination is to be confined may be a single room, a wing of the building, a single floor, an entire building, a short section of highway, or a large area of a railroad yard, depending upon the circumstances. Whatever the area is, all personnel who enter this area should remain within the area until they have been decontaminated. Of course, if an explosion were imminent in the contaminated area and persons must flee for their lives outside this area, this certainly would be justifiable. Needless to say,

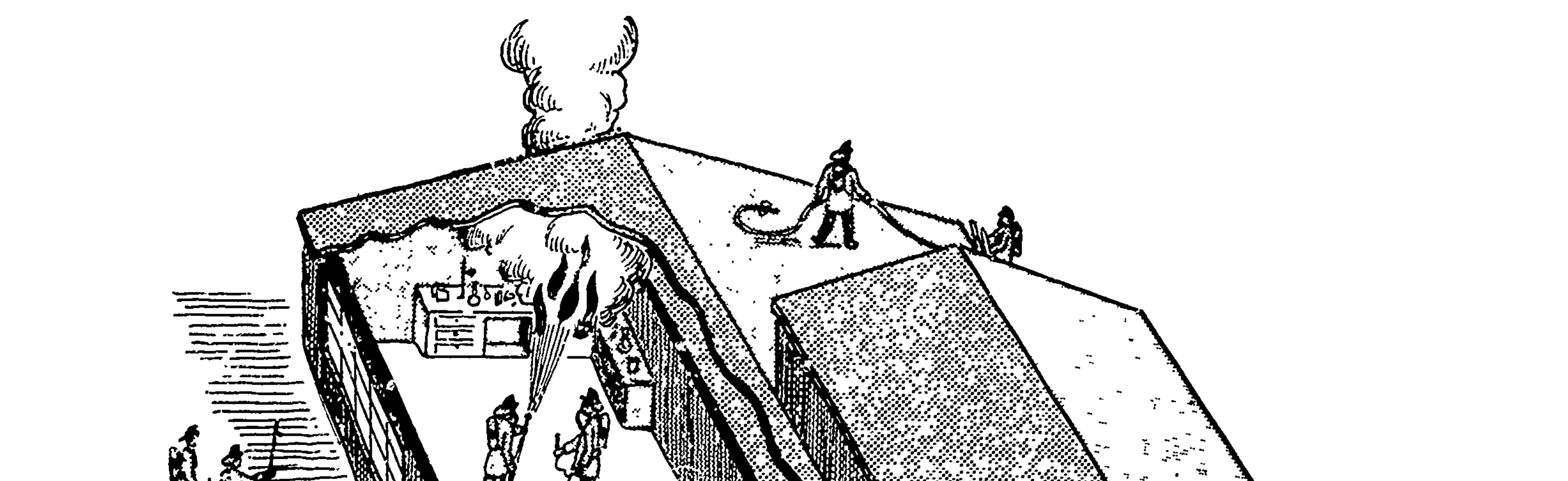

Fig. 23 - Controlling the Spread of Radioactive Contamination during a Fire

the number of firemen who work in an area suspected of contamination should be kept to the absolute minimum required to accomplish the job. Second, contamination control lines or barriers must be set up by the fire forces. These contamination control lines or barriers must be definite physical lines rather than imaginary ones. This can be accomplished by laying hose or ladders on the floor, stretching rope barricades, or using existing room partitions to mark the area beyond which radioactive contamination must not be spread by movement of personnel or their equipment. In some cases it may be necessary to periodically evaluate the contamination situation and move back the control barriers should the firefighting operations expand. If additional equipment is to be provided, word is passed as to what is needed, and uncontaminated personnel bring the equipment to the contamination boundary line and pass it over. Once the equipment is passed into the contaminated area it should not be returned but left there until checked and decontaminated if necessary.

As part of prefire planning, the contamination control point should be determined ahead of time, and, if possible, preassignment of companies made to functions which will take them inside or keep them outside of the contaminated area.

CONTAMINATION SPREAD BY SMOKE AND WATER

Smoke, hot gases, and air being carried by convection from a fire can readily spread radioactive contamination in extreme cases. Large volumes of contaminated smoke cannot usually be controlled by the firefighting forces. Some cases may arise, however, where small volumes of contaminated smoke are encountered that can be diverted in directions where it will do the least amount of contamination damage. In accomplishing this the firefighting forces can use the principles of carefully planned ventilation, smoke ejectors, or fog streams. In some cases water in finely divided form can be employed to settle radioactive material out of the air within the contaminated area and thus prevent its entry into other "clean" areas. If such is the case consideration must be given to the amount of water used, which if excessive may flow into other uncontaminated areas, spreading contamination.

In addition to the smoke, the other most readily available means of the spread of contamination at a fire is by the water used to extinguish the fire. Here again the basic principle of contamination control should be applied; that is, to confine the contamination as closely as possible to the point of origin. If this is not practical, then contamination should get to its final destination as rapidly as possible, with as little chance as possible of the contamination dropping out of the water along the way.

If the fire is small, the minimum quantity of water should be used to extinguish it, and this water should be confined in the area where the radioactive materials are handled and where contamination might normally be expected. Sawdust, salvage covers, etc., and standard fire department salvage techniques should be used to keep the water containing the radioactive contamination as close as possible to the scene of the fire.

If the fire is of larger size than can be handled by the few gallons of water that can be confined at the scene of the fire, then consideration must be given to the problem of what happens to the water which runs off from the fire. This water will very likely contain radioactive materials and thus be contaminated. The radioactive materials will settle out of the water along the way, in accordance with the physical laws that govern the dropout of materials from water. Thus the contamination will be widespread.

In a downtown area of a city where all of the streets are paved, it can be assumed that all water which is used on a fire will eventually find its way to the sewerage system. If the fire is on the upper story of a building and the water is allowed to flow freely, the water will flow down the stairways into the street and along the street to a sewage catch-basin, and from there into the sewerage system. All along the way, a trail of contamination will be left. Since the water must enter the sewerage system, it would be best to get it there as soon as possible. Standard salvage techniques should be applied in order to keep the water from flowing down and through the building generally. Floor drains should be used, or if not available, should be improvised by the removal of toilets, and contaminated water should be broomed or squeegeed down through these openings to reduce to a minimum the amount of water flowing through the building, dropping out contamination as it goes.

The contamination of smoke, water, or other substances by finely divided, gaseous, or liquid radioactive materials will not cause them to become radioactive. They simply become contaminated; that is to say, tiny bits of radioactive material will be mixed with and carried along by the smoke and water. See Figure 24.

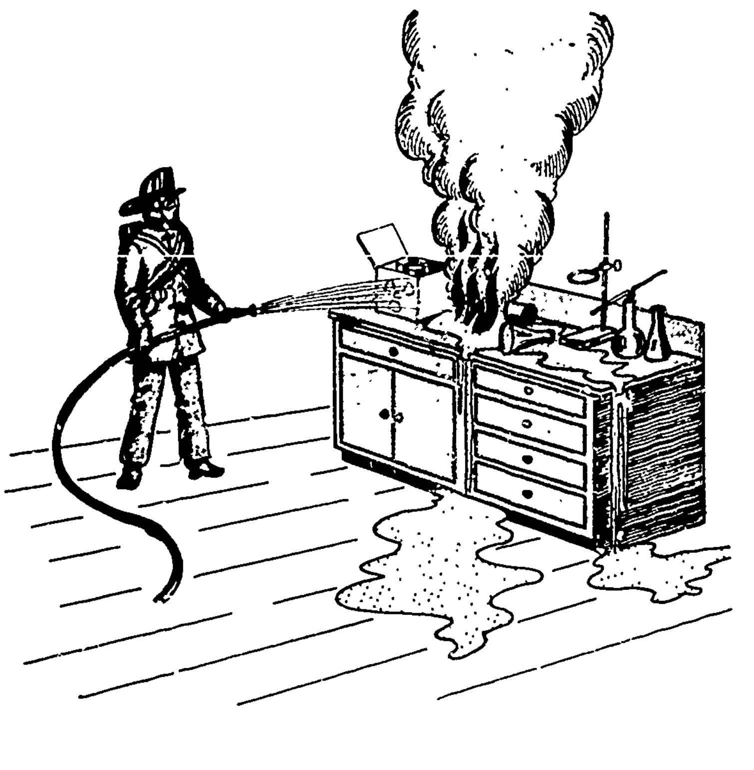

Fig. 24 - Radioactive Contamination Does Not Make Smoke and Water Radioactive

CLEANUP

One of the services that may be provided by a modern, public service-minded fire department is that of cleanup after a fire. Some departments provide services such as drying off wet furniture, supplies, and equipment; mopping up water from floors; removing burned debris from the building; and, in some cases, even deodorizing the premises from the smell of the products of combustion. Obviously if radioactive contamination is present this work should not be carried out due to the danger of further contamination spread. In such a case, the licensee is responsible for cleanup. He may request assistance from the fire department, as it is usually equipped with the necessary tools. This work may be done by firemen as a part of their good public relations program, but only under guidance of qualified personnel in the radiation field with experience in this type of work.

DECONTAMINATION

Decontamination of the fire building would, in general, not be part of the fire department's responsibility. It is its responsibility to conduct the firefighting operations so that, with due consideration given to the primary problem of extinguishing the fire, the contamination is scattered no farther than necessary. The primary principle is to confine contamination as closely as possible to the point of origin, and not to allow equipment or personnel to be the means of spreading contamination to other areas.

Inevitably, however, some of the equipment and apparatus will get contaminated. Decontamination of equipment and apparatus should be done by qualified specialists trained for this type of operation.

FIRE DEPARTMENT RESPONSIBILITIES IN THE NUCLEAR AGE

RADIATION SAFETY OFFICER

It is imperative for the nation's fire service, from the large city departments to the small rural volunteer departments, to understand and accept their responsibilities for the organization, training and preplanning necessary to effectively meet the special problems of the expanding nuclear age hazards.

While all the officers and men of the fire department must have a good basic understanding of the hazards of radiation and precautions to be taken, it is obvious that it will be necessary for fire departments to develop personnel with a better than average knowledge of the subject, just as specialists are developed in other fields such as apparatus, equipment, chemical hazards, fire prevention education, and first aid. This specialist might be called the Fire Department Radiation Safety Officer.

PREFIRE PLANNING

Prefire planning, at least as a formalized and separate procedure, is a relatively new concept to many fire departments. Some prefire planning is done but often as a by-product of other long established and necessary fire department training functions. During recent years, however, fire departments have given more and more attention to this subject. This recognition of the necessity for prefire planning is increased by the fact that progressive fire officials are aware of the expanding use of a wide variety of chemicals, solvents, plastics, and radioactive materials, not only in industry but in many other fields of endeavor. The many complexities and hazards associated with these materials have made it mandatory for fire departments to put into writing, rather than to rely on memory, basic procedures for successfully combating fires and other emergencies in places where these hazardous materials are used.

The hazards of atomic industry vary widely in nature and in the protective procedures necessary. It would be utterly impossible for the best fire chief, even though thoroughly schooled in radiation hazards, to make an accurate and immediate size-up of the entire situation when he arrives at the scene of a

fire in the early hours of the morning and finds a radiation warning sign on the door of the involved building.

The problem of a department in prefire planning is to convince plant management that a potential area of confusion and trouble, if not an actual hazard, exists and that the firemen understand enough about the fundamentals of radiation hazards and protection to discuss the matter intelligently.

If a fire department demonstrates that its concern is not only to prevent possible exposure to its personnel, but also to prevent unnecessary contamination of the plant, the equipment, and possibly the areas outside the plant, it is usually found that plant management will be more than willing to assist in working out detailed prefire planning. In addition, firemen should point out the fact that the subsequent, and often costly, decontamination of the plant, the equipment, and the outside areas in all probability would be the plant's responsibility. Having put across the above points, it should be easy to reach an understanding with the management and come to a determination of the true level of the hazard in the plant. It may well be that the hazard, at the present time, is practically non-existent. However, the management should be requested to give notification should the hazard picture change in the future due to the introduction of other material.

Suggested Prefire Plan Card and Sketch - Many fire departments in developing programs of prefire planning are prone to rely too much upon memory for the various items of information needed at the fire scene. Mental blocks are often experienced, or one or more vital items of information are often overlooked due to the necessity of making split-second decisions, working under stress, and the complexities always associated with fires.

It is therefore necessary that prefire planning information be in writing, in its simplest and most understandable form, and be printed on suitable cards along with whatever building sketches, charts, or diagrams that are required.

A sample prefire plan form is shown in Figure 25 on which one or more radioisotopes can be listed for each licensee. The suggested prefire planning form

RADIATION PRE-FIRE PLAN NO. ______ ______________ FIRE DEPT. DATE ______________

COMPANY OR PERSON (LICENSEE) ______________

ADDRESS (LOCATION OF ISOTOPES) ______________

ISOTOPE	LOCATION IN PLANT OR OUTSIDE AREA	QUANTITY ON HAND (Curies)	HOW CONTAINED	PRINCIPAL RADIATION EMITTED	RADIATION LEVEL OF SOURCE (Unshielded)	HAZARD External	HAZARD Internal	REMARKS AND/OR PROCEDURES

ADDITIONAL INFORMATION: Sprinklers, Valves, Ventilating Systems, Ducts, Filters, Fire Walls, Doors, Exits, Water Drainage, Flammable Liquids, Gases, etc.	PERSON/S RESPONSIBLE FOR RADIOISOTOPES - TO BE CONTACTED IN EMERGENCY	TELEPHONE NO. PLANT	TELEPHONE NO. HOME

NOTE: USE REVERSE SIDE FOR CONTINUATION OF INFORMATION AND PLAN OF BUILDING.

Fig. 25 - Sample Radiation Prefire Planning Form

is not intended to be all inclusive. Some departments may want to elaborate on it or to rearrange it to suit their particular needs. It does, however, embody all the main guide lines necessary for the basic data to assist a fire department in carrying out a reasonably good job at a radiation incident.

In many cases it is important to supplement the basic prefire plan information with a simple sketch of the building layout and equipment.

GLOSSARY OF RADIATION TERMS

ALPHA RADIATION: Consists of high speed, relatively heavy atom particles (consisting of 2 protons and 2 neutrons) having a short range in air (several inches) and very little penetration ability in substances, being stopped by a sheet of paper. Alpha radiation is also called *corpuscular radiation*.

ATOM: The basic building block of nature and the smallest particle that can enter into a chemical reaction. The atom can be subdivided and consists of an inner core or nucleus made up by *neutrons* and *protons*, surrounded by electrons which rotate around this nucleus like planets around the sun.

ATOM SMASHER: Colloquial term for a particle accelerator. A machine generally used in research to speed up atomic particles for use as projectiles in blasting apart the nuclei of atoms.

BACKGROUND RADIATION: This is due to *cosmic rays* from outer space, small amounts of radioactive substances present in our bodies, in many of the materials surrounding us, and in the ground.

BETA RADIATION: Consists of minute sub-atomic particles ejected from the nuclei of many radioactive materials. A beta particle is identical with an electron. Beta radiation has a range of several feet in air and moderate penetrating ability into materials. Beta radiation can be absorbed by a relatively small thickness of material, i.e., 1/8" aluminum, 1" pine wood, etc. Beta radiation is also called *corpuscular radiation*.

CHAIN REACTION: When the nucleus of the atom of a *fissionable material* splits it releases energy and one or more *neutrons*. These in turn split more fissionable nuclei, releasing more energy and neutrons, thus making the process a self-sustaining chain reaction.

Note: Words in italics indicate key terms which are defined in this glossary.

CONTAMINATION: Disposition of radioactive material, generally in a finely divided or liquid form, in any place where it is not desired and may produce a hazard to personnel.

CORPUSCULAR RADIATION: A general term given those types of radiation which consist of particles such as *alpha* and *beta* radiation.

COSMIC RADIATION: Extremely high energy radiation consisting of both particles and rays which originate out in space and constantly bombard the earth. Cosmic radiation has great penetrating ability in all materials.

COUNTERS: Electronic instruments used to count nuclear *disintegration* in order to measure the amount of radioactivity being given off.

CUMULATIVE DOSE: The total dose from repeated exposures to radiation to some portion of the body or the whole body.

DECONTAMINATION: The removal, by physical or chemical means, of unwanted radioactive material from a surface.

DISINTEGRATE: When a radioactive atom gives off its excess energy in the form of radiation, it is said to disintegrate.

DOSE: The amount of radiation delivered to a specific portion of the body or whole body during a given time.

DOSE RATE: The radiation dose delivered to the body per unit of time.

DOSIMETER: A device, usually worn by a person, used to detect and measure a *cumulative dose* of radiation.

ELECTRON: A minute sub-atomic particle having a negative electrical charge. Electrons are found orbiting around the nucleus of all normal atoms.

EMERGENCY ACCIDENTAL DOSE: The National Committee on Radiation Protection and Measurement has recommended that an emergency or accidental dose of 25 rems to the whole body occurring only once in a lifetime of the person need not be added to the person's accumulative lifetime occupational exposure.

EXTERNAL RADIATION: Exposure to radiation from radioactive sources located outside of the body.

FILM BADGE: A piece of specia' -hotographic film contained in ... metal holder an... orn like a badge by nuclear workers. It is darkened by exposure to radiation and after processing the accumulated dose can be determined.

FISSION: The splitting of an atomic nucleus into two parts accompanied by the release of energy, several free neutrons, and radiation. The fission process only occurs in those heavier elements such as *uranium* and *plutonium.*

GAMMA RADIATION: This type of radiation is also called electromagnetic radiation and consists of very short waves of energy similar to X-rays. They avel with the speed of light (186,000 miles per second) and have a long range compared to the other types of radiation (beta and alpha) and great penetration ability into materials. Substantial quantities of lead are used for shielding from gamma radiation.

GEIGER COUNTER: A gas-filled electrical device for detecting and measuring low levels *(milliroentgens* per hour) of radiation.

HEALTH PHYSICS: A name given to that branch of radiation science concerned with the protection of personnel from radiation.

INTERNAL RADIATION: Exposure of various organs to radiation resulting from the introduction of radioactive materials, usually in a finely divided form, into the body by breathing, swallowing, through wounds or absorption through the skin. Once in the body, some radioactive materials tend to collect in certain critical body organs and cause damage.

MILLIROENTGEN: A measure of X-ray or *gamma radiation.* One-thousandth of a *roentgen.*

NEUTRON: One of the basic sub-atomic particles comprising the nucleus of practically all atoms. The neutron has no electrical charge. Neutrons being ejected from atomic nuclei is another form of radiation which can cause body damage.

NUCLEAR REACTOR: An apparatus in which atomic *fission* is sustained in a regulated self-supporting *chain reaction.*

PERMISSIBLE ACCUMULATED OCCUPATIONAL DOSE: The permissible occupational dose for radiation workers to the whole body, head and trunk, active blood forming organs, or gonads accumulated at any age, shall not exceed 5 rems multiplied by the number of years beyond age 18. The dose in any 13 consecutive weeks shall not exceed 3 rems.

PLUTONIUM: A man-made element, atomic number 94. Plutonium is an *alpha radiation* emitter and is primarily an *internal radiation* hazard. Plutonium is a fissionable material and is used in atomic weapons.

PROTON: One of the sub-atomic particles comprising the nucleus of all atoms. The proton has a positive electrical charge.

RADIATION INJURY: Localized injury to a limited portion of the body from overdoses of radiation.

RADIATION SICKNESS: Characterized by nausea, vomiting, diarrhea, hemorrhages, psychical depression, and lowering of the body's resistance to disease following short-time total-body exposure to appreciable overdoses of gamma radiation.

RADIOISOTOPES: Another name for radioactive materials.

REM: (Roentgen Equivalent Man) The quantity of any type of radiation that produces the same damage in man as one roentgen of gamma or X-ray radiation.

ROENTGEN: A measure of X-ray or gamma radiation in air only.

SHIELD: A wall which protects workers from harmful radiation released by radioactive materials.

SUB-CRITICAL MASS: The inability of a fissionable material to support a self-sustained *chain reaction* because of the surface to mass relationship which allows more neutrons to escape from the surface than are being produced in the mass.

TRACER: A *radioisotope* which is mixed with stable material enabling scientists to trace the material as it undergoes chemical or physical changes.

URANIUM: The heaviest naturally radioactive element, atomic number 92. Pure uranium is an *alpha radiation* emitter and an *internal radiation* hazard. Two of the *radioisotopes* of uranium are fissionable and can be used as fuel in reactors. Uranium-235 is the one most commonly used.