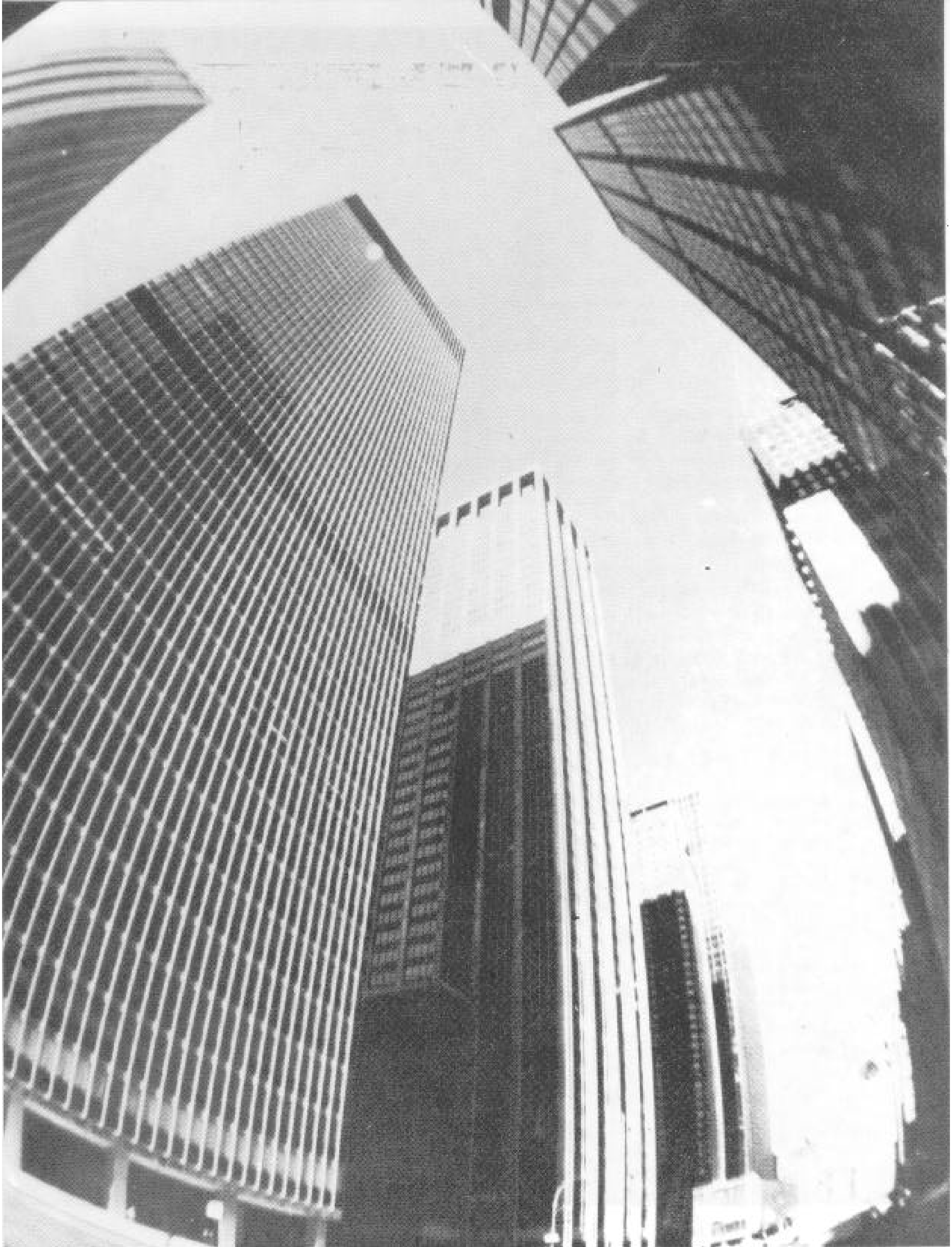

8

THE HAZARDS WE HAVE CREATED

The United States is an advanced nation technologically and is increasingly urban in character. Another way of saying this is that most Americans live in an environment of concentrated man-made objects. Their homes-which are generally close to neighboring homes (and sometimes in the same building) -are complexes of building materials, finishes, chemicals, paper, foodstuffs, and utility systems, all composed of objects processed by man. When the American breadwinner goes off to work in the morning, he may cross over a small patch of natural environment called a lawn. But when he arrives at the carport or the street corner, he enters another complex, man-made environment : a car, a bus, or a subway. At work-whether it is a factory bench, an office desk, or a sales counter-he is usually among a concentration of people in a similarly complicated environment of man-made objects, And when the vacationing urbanite seeks escape from this man-made environment, the usual conveyance is a man-made enclosure: if not a car or bus, then a train or airplane.

In this built environment, as it is called, Americans live side by side, day and night, with ignitable materials, combustible furniture and upholstery, and products and appliances which through wear or misuse may offer dangerous fire potential. Fumes from their gasoline, their paint thinner, or their cleaning fluid fill the atmosphere with combustion potential. The structures in which they live and work, through flaws in design and poor maintenance, often encourage entrapment rather than escape from fire. Few give these hazards any thought-until a fire occurs.

Available statistics give some idea, if not a complete picture, of where the hazards lie in the built environment. Certainly the vast majority-close to 95 percent-of America's fire losses, both life and property, result from fires in the built environment. Fires in buildings (as opposed to vehicle fires)[1] account for most of these losses. Of the nearly $2.7 billion in property losses sustained yearly, about 85 cents out of every dollar lost is attributable to a building fire. About two-thirds of the 12,000 deaths that occur annually result from building fires. What types of buildings are involved offer a key to where the emphasis should lie in the effort to reduce the Nation's fire losses (Table 8-1) .

[1] In 1971, 3,950 died in motor vehicle fires; property losses from such fires amounted to $112.7 million or about 4 percent of the total national fire problem. Fires in other transportation systems, such as airplanes, were insignificant in number. but are of concern to us because of the many lives risked in each fire incident.

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Table 8-1. Estimated 1971 Building Fire Losses and Relationship to Total Fire Record *

Category	Life loss		Property loss		Fires	
	Number	Percent of total	Dollars, Millions	Percent of total	Number	Percent of total
Residential (houses, apartments and hotels),	6,600	56	874.1	31.9	699,000	25.6
Commercial (Public assembly, educational, institutional, mercantile and office),	970	8	580.5	21.1	141,400	5.2
industrial (basic industry, storage, manufacturing and miscellaneous)			811.6	29.6	156,500	5.7
Building total	7,570	64	$2,266.2	82.6	996,900	36.5

* From published and unpublished NFPA data. Refer to Appendix V for complete table of fire losses in U. S.

Residences

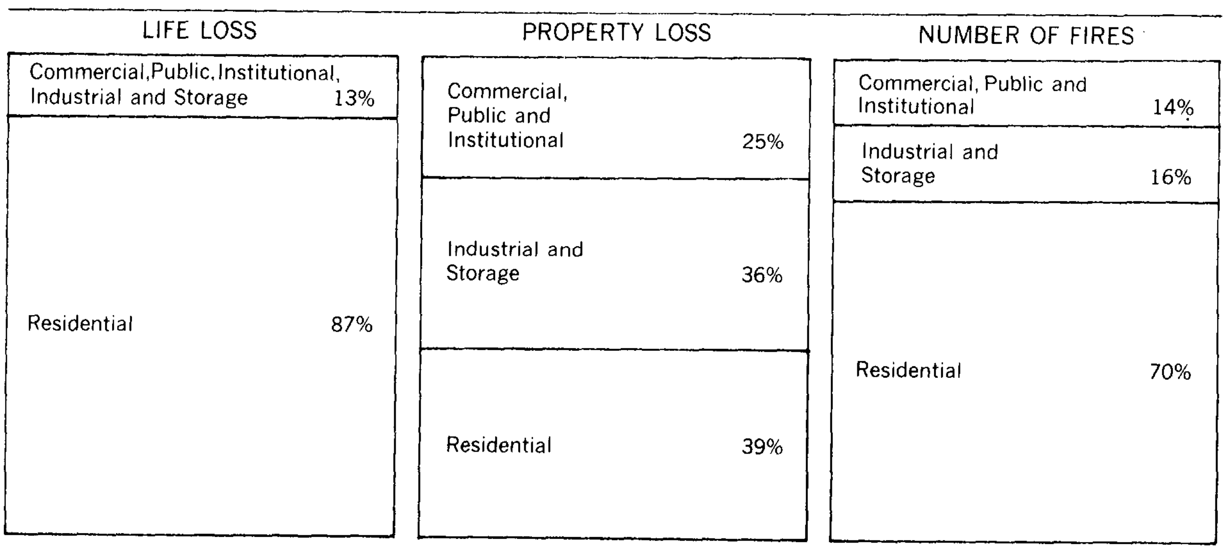
Of the nearly 1 million building fires that occurred in 1971, almost seven out of ten occurred in residential occupancies (Table 8-1)[2]. The chances are that the average family will experience one fire every generation serious enough to have the fire department respond. Residential fires account for about half of all fire deaths and a third of all property losses. (If the losses from non-building fires are excluded, residential fires account for about 87 percent of the deaths and 39 percent of these property losses [Figure 8-1]) From the standpoint of life loss particularly, the structures in which Americans live must be the prime focus of the national effort to reduce fire losses.

[3] This includes apartments, dwellings, hotels and motels, rooming and boarding houses, summer cottages, trailers, mobile homes, and miscellaneous structures.

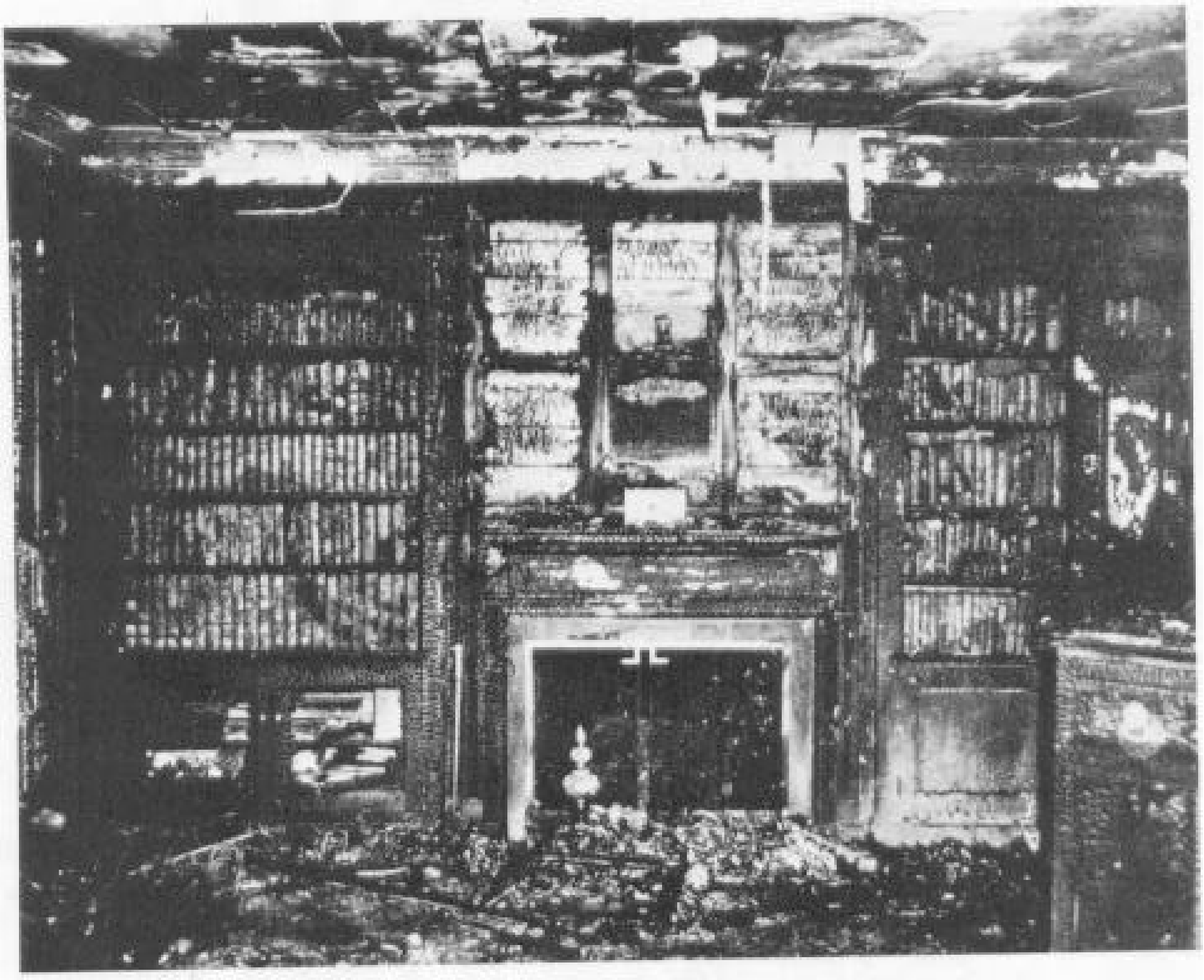
The experience of every urban fire department confirms what statistics only suggest: that a disproportionate number of residential fires-and fire deaths-occur in low-income neighborhoods. It is not difficult to see why. Crowded conditions, dilapidated buildings, unsafe heaters, and the heavy use of alcohol-all contribute to a higher incidence of fire and a heavier toll in injuries and deaths. The higher proportion of working mothers means more children are left unattended and, hence, more exposed to fire accidents. The ignorance among the poor about fire hazards is matched by the indifference or inability of landlords to get rid of the hazards.

But as every urban firefighter can attest, fire does not victimize the poor only. There is no ground for complacency about residential fires among more affluent citizens. There, too,

Figure 8-1. Fires in Buildings, 1971, United States*



*Estimates from published and unpublished NFPA data.



Fire knows no class distinctions. In this 16-room home in Ohio, it caused $150,000 in damages in 15 minutes.

ignorance breeds indifference. No less than in a slum, a single spark can set off a chain of events that guts a mansion and kills its inhabitants. Fire, like sin, knows no class distinctions.

Commercial and Industrial Fires [3]

While commercial occupancies make up about 14 percent of all building fires, they result in 25 percent of the Nation's property loss in building fires. Likewise, industrial fires are only about 16 percent of all building fires but account for 36 percent of the building property loss. Together, industrial and commercial fires account for 13 percent of deaths in building fires (Figure 8-1) .

Major Fires

The National Fire Protection Association defines as a major fire one in which three or more die, or one in which property losses are $250,000 or greater. (Some fires, of course, meet both criteria.)

In 1971, there were 208 fires in which three or more persons died, but together these fires accounted for 8 percent of the fire deaths that occurred during that year. In eight out of ten cases, these major fires occurred in residences. In many instances, late detection of the residential fires contributed to the heavy losses in lives and property-as indicated by the fact that about 80 percent of the multiple-death fires occurred between 11 p.m. and 6 a.m. when most people are asleep, as compared with the 20 percent that occurred between 6 a.m. and 11 p.m. when people are active.

Those fires producing major property losses were also a tiny fraction of total fires (0.02 per-

[3] "Commercial" includes public and institutional occupancies, and "industrial" includes storage occupancies.

Industrial and warehouse fires occur infrequently, but are difficult to control and often result in huge losses.

cent), but they accounted for 11 percent of the dollar losses in 1971. In all these cases the Building was not sprinklered in the area where the fire originated.

Causes and Remedies

It appears that considerably more than half the Nation's fires are caused by the careless actions of man. The rest have environmental causes, such as hazardous products, defects in the home, and lightning. A more detailed analysis of the causes of building fires is provided annually by the National Fire Protection Association (see Table 8-2). These are approximations only, based on experience in typical States. As for causes of fire-related deaths, data from Canada (there are no comparable U.S. statistics) attribute 71 percent of deaths to man's actions, 9 percent to products or processes, and 20 percent to defects in buildings.

Table 8-2. Estimated U.S. Building Fire Causes*

	Percent of fires	Percent of dollar losses
Heating and cooking	16	8
Smoking and matches	12	4
Electrical	16	12
Rubbish, ignition source unknown	3	1
Flammable liquid fires and explosion	7	3
Open flames and sparks	7	4
Lightning	2	2
Children and matches	7	3
Exposures	2	2
Incendiary, suspicious	7	10
Spontaneous ignition	2	1
Miscellaneous known causes	2	6
Unknown	17	44
Total	100	100

*NFPA estimates.

The consequences of a fire depend, however, not only on how it starts, but on what happens after ignition. Human beings can intervene to lessen the consequences of a fire caused by a defective product. Products can be designed to lessen the consequences of human carelessness, as for example, with matches and cigarettes. And whatever the cause of a fire, buildings can be designed and maintained to ease fire suppression and the evacuation of potential fire victims. The

INDUSTRIAL FIRE SAFETY

Although it is recognized that there are still other important areas for problem solving, it would be a serious omission if no note were taken of the many positive strides which have been made in the prevention and control of fires by industry, Comparisons of the industrial and residential losses in the United States show that industry appears far in advance in terms of the relative number of lives lost and the dollar amount of property destroyed. In 1971, for example, the National Fire Protection Association reported the dollar losses to basic industry and manufacturing occupancies to be $390,700,000, versus $874,100,000 for residential occupancies; and of the 11,850 lives lost to fire in 1971, it is estimated fewer than 1,000 were lost in industry. In addition, the chart below shows a trend in decreasing numbers of fires annually in industry.

Industrial Fire Record"

Year	Number of basic Industry and Manufacturing fires
1968	66,000
1969	58,500
1970	56,200
1971	41,300

*NFPA published estimates.

Industry's success in lowering fire incidence is attributable to the incorporation of features such as sound construction, special attention to hazards, emergency planning, and wide use of automatic detection, alarm, and extinguishing devices.

consequences of fire, in short, depend on man-environment interactions.

We have already addressed the issue of what fire departments can do to reduce fire losses. In Chapter 20 we discuss what citizens can do to reduce fire losses. In this and the next four chapters, our concern is not with the human factors but with ways of altering the built environment to reduce fire hazards-through changes in fire safety technology, materials characteristics, building design and construction, and code regulation and enforcement.

The Environment as a Security Blanket

Before turning to environmental factors alone, it is appropriate to consider one aspect of the **man-**environment interaction that tends to be overlooked. The ways in which man acts upon the environment to cause fire come readily to **mind.** What is not so obvious is that the built environment influences the behavior of man in a way that aggravates the fire problem.

The modern urban environment imparts to people a false sense of security about fire. Crime may stalk the city streets, but certainly not fire, in most people's view. In part, this sense of security rests on the fact there have been no major conflagrations in American cities in more than half a century. In part, the newness of so many buildings conveys the feeling that they are invulnerable to attack by fire. Those who think only of a building's basic structure (not its contents) are satisfied, mistakenly, that the materials-concrete, steel, glass, aluminum-are indestructible by fire. Further, Americans tend to take for granted that those who design their products, in this case buildings, always do so with adequate attention to their safety. That assumption, too, is incorrect.

Around the turn of the century, in the wake of many conflagrations so-called fireproof buildings began to be constructed. They had thick walls and floors to keep fire from spreading. Like older buildings, they still had windows that could be opened to allow heat and smoke to escape. They had fire escapes or internal fire stairs, and seldom were they too tall for the topmost occupants to escape.

Fires, some of them disastrous, occurred in these buildings nonetheless. Then, after World War II, a new generation of buildings began to appear : the modern high-rise building. Lighter construction systems and many new materials were used, especially for interiors. Windows were permanently sealed so that central air conditioning would operate efficiently. Walls and floors were left with openings for air conditioning ducts and utility cables. Each of these features compromised the fire safety of these buildings.

The built environment was created to serve the needs of people. When a portion of that environment goes up in smoke, those needs are not being served. How the hazards in the built environment can be reduced is the subject to which we now turn.

Major turn-of-the-century fires, such as Baltimore's in 1904, aroused concern about fire safety in buildings.

9

THE HAZARDS CREATED THROUGH MATERIALS

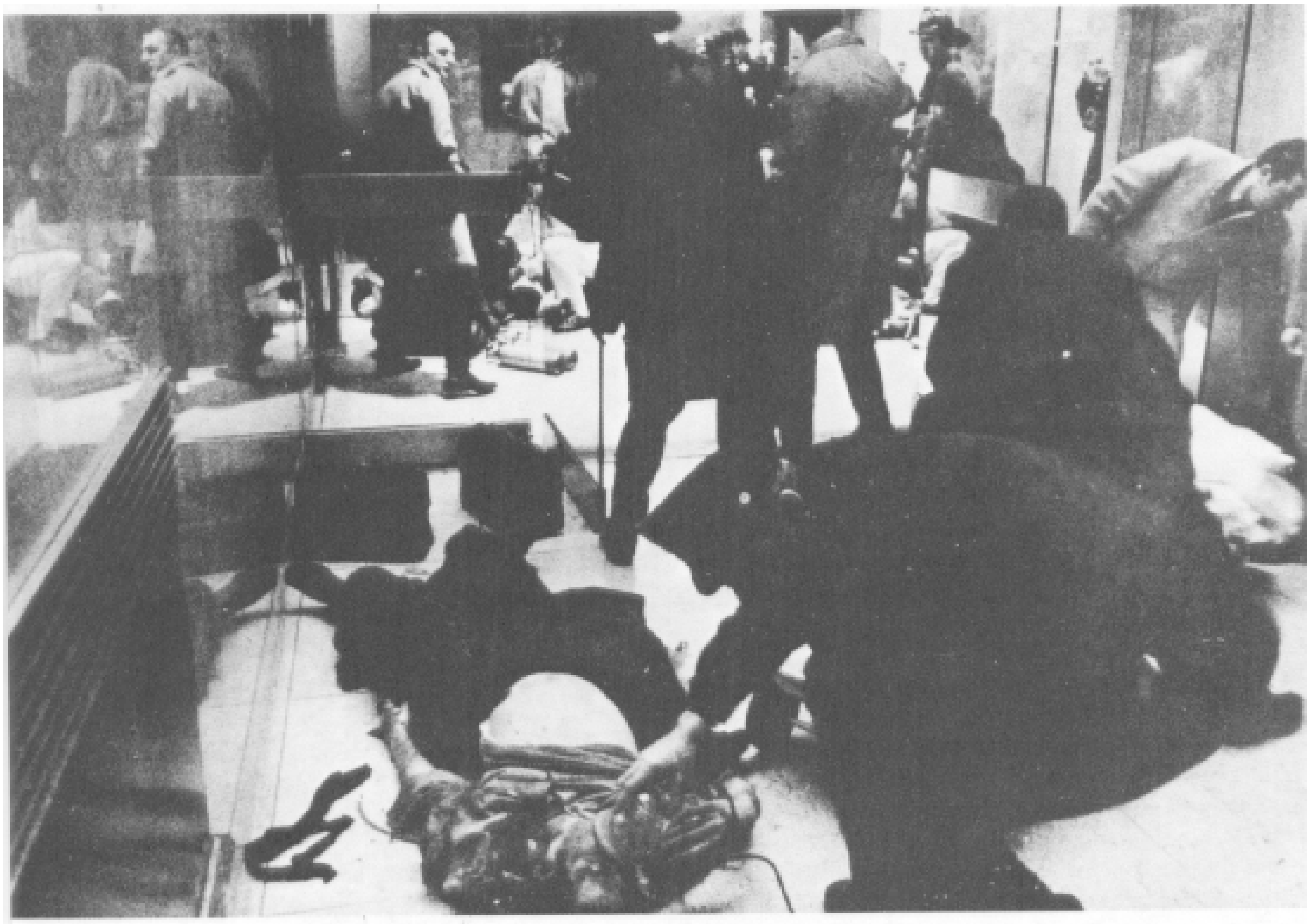
The dazzling terminal buildings at New York's John F. Kennedy Airport are virtually a museum of contemporary architecture. But one of those buildings has demonstrated that man's monuments to his technological genius can turn on him with a vengeance, at the mere touch of a flame.

The new west wing of the British Overseas Airways Corporation building at Kennedy International had not yet been opened to the public when, on August 26, 1970, it caught fire-probably at the hands of an arsonist. Swiftly, flames moved from one seat to the next along the 330-foot length of the wing. Gases from the incomplete combustion of the seats gathered in clouds along the ceiling. When flames approached the clouds, the gases ignited explosively, spreading the fire and igniting other groups of seats. The explosions knocked out the terminal's huge glass windows. As the ceiling melted, combustible liquid dripped toward the floor, further spreading the fire. In the end, all 600 seats in the wing were consumed. Damages totaled $2 million. The seats, which played the predominant role in spreading the fire, were like those in many airline terminals: layers of plastic and rubber foam covered by plastic upholstery material.

No lives were lost in the BOAC terminal fire. But 3 months later, a synthetic material was implicated in a fire that killed 145 teenagers. It happened in a door-locked dance hall in St. Laurent-du-Pont, France, that had been lavishly sprayed with a plastic foam to give the appearance of a cave. The fire raged furiously within seconds after it began, leaping "like a red panther in a small cage," in the words of one survivor,

By no means do synthetics stand alone as hazardous materials. A frame house can be a tinderbox. Restaurants decorated with natural materials, basements full of old newspapers and warehouses storing lumber or paper products provide the fuel for major fires. Inadequately protected structural elements of steel or concrete still collapse if a fire is intense enough. Burning silk and wool release deadly quantities of carbon monoxide and cyanide gas-and these and many other natural materials ignite at lower temperatures than many synthetics do. Plastics manufacturers contend that synthetics based on carbon, hydrogen, and oxygen exclusively are generally no more toxic, when burned, than natural materials. On the other hand, other synthetics containing sulfur and the halogens are not so innocuous

Although plastics production has doubled in the



In the modern environment of synthetic materials, smoke and toxic gases have become increasingly important hazards.

past 7 years, it is only about one-tenth that of wood, paper, and associated products. The contribution of plastics to the fuel load in buildings, especially older buildings where fires occur more frequently, is therefore certainly well under 10 percent. But their use is increasing. Wool rugs are giving way to synthetic fibers, wooden desk tops to plastics made to look like wood, glass lighting diffusers to clear plastic panels. There is hardly a use to which "classical" materials have been put that has not been challenged by synthetics. Clearly, the advantages which plastics offer to consumers and manufacturers are many, and plastics will fill an increasingly large proportion of the built environment.

What makes plastics relevant to our discussion of materials is not only that many of them have introduced hazards previously uncommon, but that they are sold and used without adequate attention to the special fire hazards they present. The major investigation of the 'fire problem of some plastics by the Federal Trade Commission has highlighted a form of misleading representation of the combustion behavior of certain plastics.

How to Die in a Fire

Most people, when they think of fire as a killer, think of flames. Those who have set fire safety standards for materials have emphasized flame resistance. Yet, in a list of the five ways in which fire can kill, when arranged in declining importance, flames rank last.[1]

Asphyxiation. Fire consumes oxygen from the surrounding atmosphere, thus reducing its concentration. If the oxygen concentration falls below

[1] This ranking and much of the following discussion is from Irving N. Einhorn, director of the Flammability Research Center, University of **Utah.**

17 percent, thinking may be an effort and coordination difficult. Below 16 percent, attempts to escape the fire may be ineffective or irrational, wasting vital seconds, With further drops, a person loses his muscular coordination for skilled movements, and muscular effort leads rapidly to fatigue. His breathing ceases when the oxygen content falls below 6 percent. At normal temperatures, he would be dead in 6 to 8 minutes.

Attack by superheated air or *gases.* With temperatures above 300° F., loss of consciousness or death can occur within several minutes. In addition, hot smoke with a high moisture content is a special danger since it destroys tissues deep in the lungs by burning.

Smoke. Inhalation of smoke-or, more correctly, of the products of incomplete combustion-kills people who suffer no skin burns at all. In addition to carrying toxic products, such as carbon monoxide and hydrogen cyanide, thick smoke may be laden with organic irritants, such as acetic acid and formaldehyde. In the early stages of a fire, the irritants, which attack the mucous membranes of the respiratory tract, are often the more important danger. Smoke often blocks the visibility of exits.

Toxic products. Many toxic components of smoke are responsible for the damage done-including oxides of nitrogen, aldehydes, hydrogen cyanide, sulfur dioxide, and ammonia, to name only a few. There is ample evidence that the hazard of two or more toxic gases is greater than the sum of the hazards of each. Moreover, low oxygen and high temperatures increase the toxic effects. In addition to toxic gases that attack the lungs, there are irritants that attack the eyes with blinding effect, preventing escape. Some fire gases dull the senses of the victim or his awareness of injury.

Flames. Since the aforementioned factors can debilitate, confuse, blind, or kill without warning, the person who goes to sleep confident that advancing flames will provide sufficient warning for escape may be taking a fatal gamble.

Until such time as all five of these hazards have been well-studied and controlled by materials standards, too little will have been done to control the built environment and thus reduce the gamble Americans take in their daily lives.

Ironically, efforts to make materials fire-retardant-that is, with less tendency to ignite or spread flames-may have increased the life hazard, since the incomplete combustion of many materials treated to increase fire retardancy results in heavy smoke and toxic gases. The technology of fire-retardance is often unsatisfactory in other respects: The additives are generally costly, can reduce the strength and weather resistance of the material to which they are applied, and often lose their effectiveness through washing or prolonged exposure to the elements.

Where There's Smoke, There's Damage

That concern about flames alone is insufficient is pointed up by the ample evidence that smoke and toxic gases are powerful forces of destruction. Smoke from restaurant fires renders uncontainered food unusable ; fabrics permeated by smoke can be altered beyond use even after cleaning. And a little smoke can go a long way: A department store recently lost $100,000 of its merchandise and 3 days' business for cleanup-all because of smoke that seeped through walls from an adjoining building on fire.

Again, efforts to make materials flame-resistant have not always been beneficial. The sooty smoke given off by many of these materials leaves a thick, black coating on whatever it touches. Moreover, the chemical compounds added to reduce combustibility often contain halogens (bromine, chlorine, and fluorine) which are corrosive and toxic.

Why Be Half Safe?

According to the Society of Plastics Industry, Inc., manufacturers of plastics spend $40 million annually on research to improve the fire safety of their products. That organization issued to manufacturers, in 1964, a fire safety bulletin setting flammability standards for cellular plastics, Fire resistance or fire classification standards for all sorts of construction materials are set by such organizations as the American Society for Testing and Materials and the National Fire Protection Association. Building codes incorporate many of these standards. Underwriters' Laboratories, Factory Mutual Research Corp., and other organizations test materials to see that they comply with such standards.

Yet, for all these efforts, the American public remains inadequately protected from combustion hazards in their midst.

Smoke and toxic gases have been underrated hazards. Recognition of these hazards has come belatedly, with the result that there is still little understanding, and hence little quantifiable knowledge, of the destructive effects of smoke and toxic gases.

As a result, *there are no nationally recognized test methods for measuring smoke production (both rate and amount),* The American Society for Testing and Materials does have a tunnel test which measures the density of smoke produced. Development of more sophisticated tests-for example, ones which would measure toxic and corrosive products of combustion-is hampered by the complexity of the smoke problem. A single material can give off many different products of combustion under varying conditions of temperature, humidity, pressure, and other factors; buming cellulose, for example, can produce 96 different compounds.

Most tests do not simulate complexities of real fires. Nationally recognized test methods for evaluating the ignition and flame-spread hazards of conventional materials in conventional applications may not be appropriate for evaluating these materials when used in new ways or for evaluating new materials.

For example, the ASTM's tunnel test for building materials, devised long before the advent of plastics, would register a low rate of flame spread for a particular plastic, whereas, in a real fire environment, that same material will bum with an explosive intensity. As a result, architects, design engineers, building contractors, and ultimately the consuming public may grossly misinterpret or inappropriately extrapolate those test results as indicative of fire safety.

Existing large- and small-scale tests suffer from an inability to predict exact consequences of a real fire, particularly those involving foamed plastics. Improvement of test methods is dependent, to a large degree, on a better understanding of the basic processes of ignition and combustion and the mechanisms of fire retardancy and smoke generation and correlating these with actual fire experiences, **The Commission recommends that research in the basic processes of ignition and combustion be strongly increased to provide a foundation for developing improved test methods.**

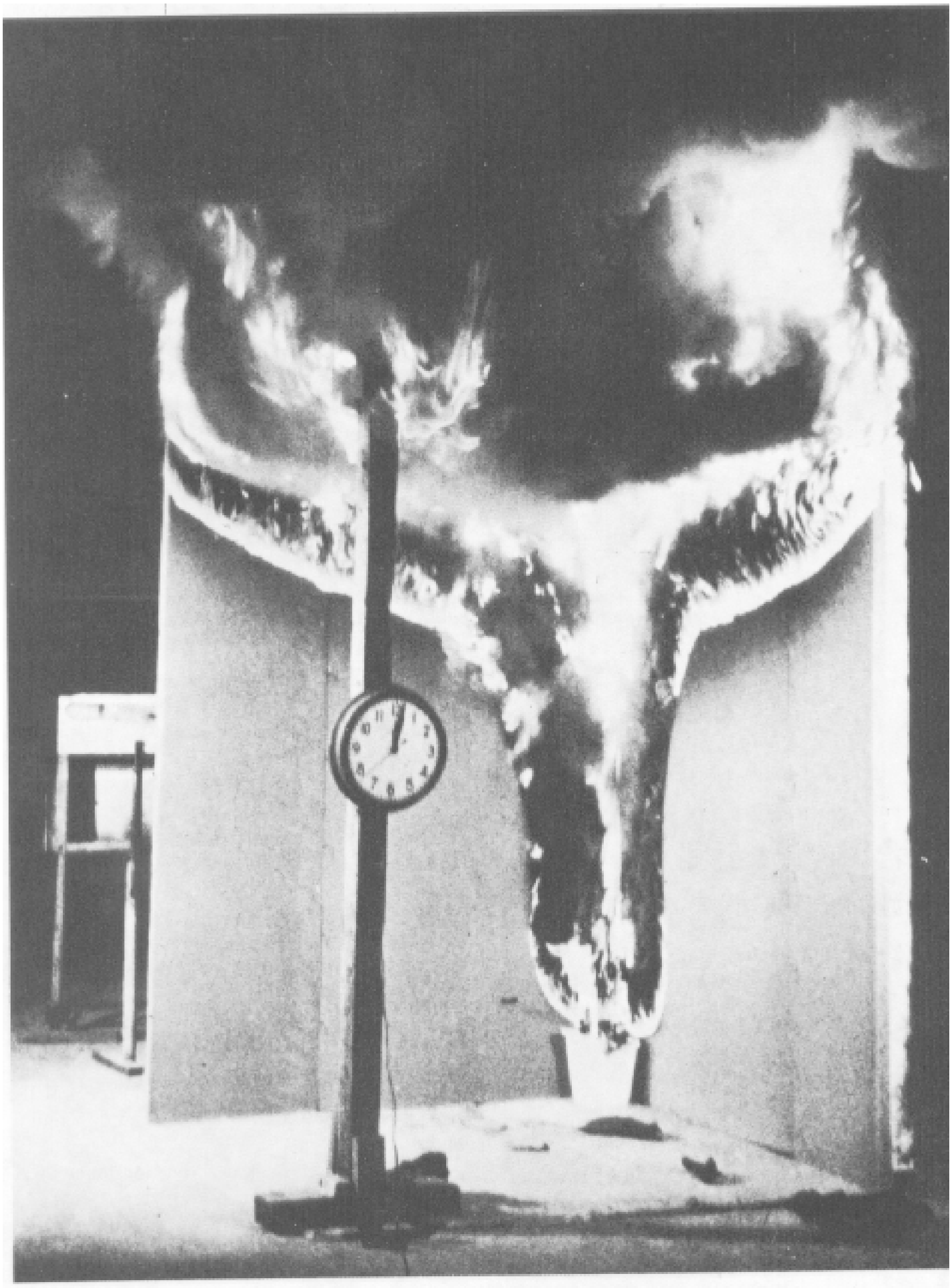
The economic interests of manufacturers, installers, vendors, and others often run counter to stringent fire safety requirements. For example, in many West Coast communities, because of industry pressures and public preferences, building codes do not outlaw untreated wood shingle roofs, despite their potential for spreading fire.

Some important hazards are not covered by building codes. The fire safety requirements of building codes apply mostly to construction materials and interior materials used on walls and ceilings. Comparatively little attention has been paid to floors and floor coverings, since in the past their contribution to fire spread was minimal. The advent of synthetic rugs and tiles has made greater attention to floors imperative.

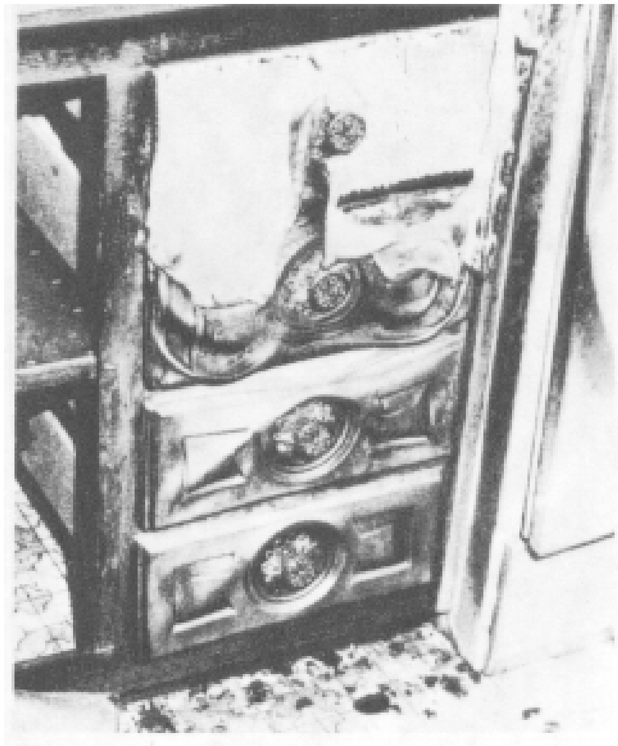
Building codes do not cover interior furnishings. While most political jurisdictions that have building codes also have fire prevention codes, designed to ensure fire safety after a building is constructed and occupied, the fire prevention codes, too, have little to say about interior furnishings. Moreover, seldom do fire prevention codes apply to private dwellings. Interior furnishings are not regulated partly because they are felt to be the province of the owner or tenant and partly because until recently there was no motivation to develop tests on which to base code provisions. They would, indeed, be difficult to regulate, since they are subject to continuing change.

While furnishings are likely to remain outside of code provisions, the fact that they contribute significantly to combustion hazards means that building codes only partly satisfy the demands of fire safety. The present practice can be compared to installing a burglar alarm at the front door and leaving the back door wide open. Only to a limited extent is this mitigated by Federal flammability standards for fabrics.

Consumers use materials with inadequate knowledge of their combustion hazards. Except for flammable liquids and the materials that are used in appliances and wiring, few of the materials that go into the home carry labels vouchsafing their fire resistance or warning of their hazards. The unlabeled hazards are found in draperies, rugs, storage cabinets, upholstered chairs, and other furniture. At present, the housewife working at the kitchen range has no way of knowing that her shiny new kitchen cabinets over-.



Although considered "safe" by standard tests, this foamed plastic wallboard burns furiously in a "corner" test.



The plastic drawer fronts lack the fire resistance of the wood they simulate, and some synthetic garments burn furiously.

head are an invitation to a disastrous fire if their surface is a hot-dip polystyrene coating. A sudden flare-up from burning grease in a skillet might readily ignite the finish on the cabinets, and in no time at all fire could spread explosively throughout the kitchen.

Clearly, homeowners and building tenants need to know the relative hazards of furnishings as well as other materials so that they can minimize the risks, Fire inspectors, whether enforcing a fire prevention code or educating homeowners and tenants, need to know the hazards to carry out their tasks effectively,

New Efforts by Government and Industry

Federal initiative is needed to help close the gaps left by the voluntary action of industry and the loopholes in material standards and building codes.

In 1972 Congress created the Consumer Product Safety Commission, authorizing it to "conduct research, studies, and investigations on the safety of consumer products and on improving the safety of such products." The Commission can set standards of composition and design which consumer products must meet; it can require labeling of hazards or instructions for safe use; it can ban products that present "an unreasonable risk of injury."

The materials that go into the built environment come under the purview of the Consumer Product Safety Commission. **This Commission recommends that the new Consumer Product Safety Commission give a high priority to the combustion hazards of materials in their end use.** Specific needs are refined understanding of the destructive effects of smoke and toxic gases, development of standards to minimize those effects, development of labeling requirements for materials, and outright ban of materials in uses that present unreasonable risks.

The development of a labeling system identifying combustion hazards is especially important. The purpose of such a system is not to regulate the lives of Americans, as an overly rigorous set of standards would do, but to enable consumers to evaluate the combustion hazards of the materials and products they bring into their homes. Further, in public buildings, nursing homes, and other occupancies subject to regulation, the labeling system would enable inspectors to verify adherence to fire load requirements. Though considerable research and testing would be needed, the eventual goal of the labeling program should be to identify fuel contribution, smoke production, and the production of toxic and corrosive gases, as well as such characteristics as ignition temperature and flame spread.

We feel we should be candid in expressing our concern that, because the Consumer Product Safety Commission is still in its formative stages, and because other hazards (many of them better publicized than combustion hazards) will be competing for attention, the problem of fire safety may become a delayed priority. The Consumer Product Safety Commission could, on the other hand, give early and deserved attention to the problem of fire safety by tapping the research capabilities of the National Bureau of Standards, universities, the national standards and testing organizations, and private industry, through contracts and cooperative arrangements.

Indeed, we do not see the Consumer Product Safety Commission supplanting the efforts in the private sector, but complementing them, For one thing, the program we have recommended is extensive and long-range. Protection of the public cannot await completion of such a program; other steps must be taken. Material producers owe to various publics----building designers, code officials, fire service personnel, and consumers an expanded and more candid effort to explain the fire charactertistics of the materials they sell.

Further, the emergence of labeling requirements for materials will not eliminate the need for technical reports-that is, papers describing test data in detail. There will continue to be a body of technically oriented users who need detailed analyses.

Technically oriented users will, for example, have to have knowledge of fuel loads beyond that provided by the labeling system. In this connection, **the Commission recommends that the present fuel load study sponsored by the Gcnera1 Services Administration and conducted by the National Bureau of Standards be expanded to update the technical study of occupancy fire loads.** The information in the National Bureau of Standards' "Building Materials and Structures # 149," a report on various fire loads found in different occupancies, published in 1957, is now largely out of date.

Flammable Fabrics

In 1971, the Department of Health, Education, and Welfare reported that, in recent years, more than 3,000 Americans die annually after their clothing catches on fire, and more than 150,000 are injured from this cause. One out of four whose clothing catches fire is a child under 10. Those 65 and over account for 15 percent of the clothing fires, even though they are less than 10 percent of the Nation's population. The very young and the old are also the persons least able to tolerate burns.

When clothing catches fire, the extent and depth of burns arc more severe than skin burns on uncovered areas; from the standpoint of fire safety, the human species would be better off naked. A recent study by the National Burn Information Exchange showed that clothing burn victims were four times more likely to die than burn victims spared clothing fire. Their burns covered nearly twice as much body surface.

The power to set flammability standards for fabrics now resides with the Consumer Product Safety Commission. During the 5 years that the flammable fabrics program was shared by the Department of Commerce, the Federal Trade Commission, and the Department of Health, Education, and Welfare, only a few standards were promulgated : those for young children's sleepwear (up to size 6X), rugs, small carpets, and mattresses.

These standards do nothing to protect the elderly smoker, the housewife whose sleeve passes over the kitchen burner, or the group of 8-year-olds playing with fire in a vacant lot. Notably they bypass most children between the ages of five and nine, who account for 13 percent of clothing fire accidents.

The Commission recommends that flammability standards for fabrics be given high priority by the Consumer Product Safety Commission. Specific needs are research to improve fire retardant processes, extension of flammability standards to further categories of fabric use, development of labeling requirements for other categories, and educational efforts to make consumers aware of fire hazards from clothing and other fabrics. The Commission does not favor unbridled extension of flammability standards to all categories of fabrics. Only grossly hazardous fabrics and fabrics implicated in a very large number of fire accidents should be banned from the marketplace. A preferable direction of emphasis is toward labeling requirements as to combustion hazards. This would honor the cherished principle of free choice, while at the same time informing consumers of potential risks and reminding them of the importance of fire. If reinforced by consumer education on fire safety, labeling requirements would have the effect of spurring manufacturers to improve the flame-resistance of fabrics.

Fireworks

One material hazard that has declined over the years, but not to the point of negligible concern, is fireworks. In recent years, fireworks have claimed an average of about 600 reported injuries and 10 deaths annually. Sixty years ago the annual toll from fireworks was more than 5,000 injuries and 200 deaths.

In 1938, the National Fire Protection Association published its "Model State Fireworks Law" (NFPA 494L), which, where enacted, prohibits the use of all fireworks except those in supervised public display?. Today, a majority of Americans remain insufficiently protected from fireworks accidents, since only 18 States have laws as stringent as the NFPA's model law and an additional eight have laws similar to the model but with exceptions. **The Commission recommends that all States adopt the Model State Fireworks Law of the National Fire Protection Association, thus prohibiting all fireworks except those for public displays."**

The Importance of Research

Adequate regulation of materials in the built environment depends upon adequate testing, and adequate testing, in turn, depends on adequate understanding of combustion and its hazards. That is not to say, however, that progress cannot be made at all three levels simultaneously.

Improved testing methods are being pursued. Scientists and engineers at the National Bureau of Standards, for example, are utilizing a smoke chambler which measures, in addition to the density and rate of smoke produced by a sample, the concentration of specific gases emitted. Experts there and elsewhere arc improving devices for measuring heat release, ignitability, flame spread, and fire endurance. Other scientists are working on model testing techniques to simulate the conditions of full-scale fires,

The technology for more sophisticated testing and the technology for basic research on fire overlap, and the two activities go hand-in-hand. It is appropriate that the National Bureau of Standards continue to provide leadership in both these areas. The Consumer Product Safety Commission should champion the strengthening of NBS efforts in these areas. At the same time, ongoing efforts of university scientists, manufacturers, and industrial testing laboratories should be encouraged and expanded.

[3] The National Society for the Prevention of Blindness. Inc., lists the following groups as supporting the limitation of all fireworks to licensed public displays only: the American Academy of Pediatrics, the American Public Health Association, the California Fire Chiefs Association, the Fire Marshals Association of North America, the International Association of Fire Chiefs. the National Fire Protection Association, the National Safety Council the National Society for the Prevention of Blindness, Optimist International.

One basic goal of research should be to improve understanding of the dynamics of fire-not of flames alone, but of smoke, heat, toxic gases, and oxygen depletion, which together cause more deaths than flames do. **The Commission recommends that the Department of Commerce be funded to provide grants for studies of combustion dynamics and the means of its control.**

Medical research is also pertinent. In Chapter 2 we recommended that the National Institutes of Health undertake a major program of research concerning smoke inhalation injuries. One outgrowth of that research should be new knowledge concerning human tolerances of various products of combustion. From this knowledge standards can be derived setting maximum allowable outputs of various products of combustion for materials. **The Commission recommends that the National Bureau of Standards and the National Institutes of Health cooperatively devise and implement a set of research objectives designed to provide combustion standards for materials to protect human life.** It would be appropriate for NIH to bring these objectives to the attention of the community of medical scientists, to incorporate appropriate objectives in its own research programs, and to transmit to the Consumer Product Safety Commission pertinent research results.

A Question of Priorities

The hazards of materials in the built environment will never be eliminated completely, and they cannot be significantly reduced overnight. Tinderbox houses will remain in the environment until economic circumstances favor their replacement or until wear and tear dictate their removal. In settings where we are forced to live with hazardous materials, we must turn to engineering means-automatic sprinklers, for example, or early-warning detection and alarm systems-to compensate for the dangers. But for the future, we as a Nation cannot rely on these systems alone to protect us; the materials themselves must be improved for fire safety. True, a building constructed of fire-safe materials and having an automatic extinguishing system as well offers a certain redundancy of protection. But one without the other leaves open possibilities of disaster.

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HAZARDS THROUGH DESIGN

In the afternoon of August 5, 1970, fire broke out on the 33rd floor of One New York Plaza in lower Manhattan. The air conditioning system spread smoke throughout the building. Smoke and hot gases shot upward through the gaps between floor slabs and exterior walls. An elevator was automatically summoned to the 33d floor, the products of combustion activating the call button. The elevator jammed there, and two people died.

Other features of high-rise design contribute to the hazards of fire: sealed windows that cause heat to build up, interior materials that give **off** thick smoke and toxic gases when afire, utility channels and other gaps in walls and floors that spread smoke and gases. Elevators can be death traps. Exitways can very quickly become overcrowded. When fire breaks out on upper floors, beyond the reach of ladders, firefighters must lug heavy hoses up the stairways.

From the standpoint of life loss, high-rise buildings have made a very small contribution until now. But they are a matter of special concern. Recent high-rise fires in other countries with heavy life loss suggest that luck may run out for the United States. On Christmas Day, 1971, 163 died in a hotel fire in Seoul, Korea. Two months later, 16 died and 375 were injured when fire consumed a high-rise in Sao Paulo, Brazil. As more and more Americans choose to live or work in high-rise buildings, their importance as a fire problem will increase.

But high-rise buildings are not the only modern creation in which design impairs fire safety. In many homes, stairwells help to carry fire and the products of combustion upward to sleeping areas. Slim horizontal windows under the eaves of single-story dwellings-a fashionable feature of ranch-style homes-hamper rescue efforts. Two children died in a Maine fire because firemen couldn't get through windows of this type. Tragedies of this sort have recurred many times,

Clearly, fire safety lags behind other considerations, such as aesthetics and economy, in the design of buildings. There are a number of reasons for this.

Fire safety analysis is lagging behind innovation in building design. For example, there is an understandable trend toward ever-lighter structural members which reduce the cost without significantly reducing strength. Building designers introduce these innovations while two important questions go unanswered. First, arc the structural members adequately protected from fire for the entire life of the building as well as during a fire that may occur tomorrow? Second, are existing tests for fire safety adequate for measuring the fire protection afforded by the particular innovation?

There is little incentive to invest in fire safety. Clients of building designers, to the extent that they think of fire safety at all, believe fire is a small risk in the future of their building. Or they judge that potential losses are adequately covered by their insurance policies. Owners of private homes might build in fire protection if their insurance premiums were thereby reduced, but no such incentive exists. While the reduced-premium exists for builders of commercial and industrial building?, the fire safety requirements for reduced rates often are not extensive.

For the designer, the chief goals are to plan a building that serves its intended architectural function, as pleasing in appearance as can be done, and as cheaply as possible. With top priority being placed on these goals safety becomes, for most designers, nothing more than a necessary evil for compliance with local codes.

Building codes have characteristics which encourage the outlook that they are nuisances. New requirements are piled on top of old and outmoded ones, with the effect that the codes become increasingly inflexible. Often the requirements are excessive : For example, in places where the contents that will be added would all burn in about half an hour, requirements for 3 to 4 hours of fire resistance in bearing walls are not uncommon. While excessive requirements exist for some characteristics, early warning of occupants, smoke movement, and toxic gas production are virtually ignored.

Tested uses and actual uses of materials can be two different things. The set of conditions under which materials are tested by manufacturers and private test laboratories may represent only a segment of the uses to which those materials are actually put. When a designer uses a material in a way that has not been tested, he has no way of knowing how or whether the fire safety characteristics are different.

The knowledge on which fire safety standards are based is deficient. Fire safety standards are based mostly on judgments gained from actual fire experience and on a limited range of conditions used in testing. They are based, in other words, on empirical knowledge rather than fundamental understanding of the behavior of fire. This lack of theoretical and experimental underpinnings contrasts sharply with such fields as mechanical or electrical engineering. In the latter field, for example, the effects of changing the diameter of a wire, or the design of a circuit, **or** the amount of current pushed through the system can be expressed as mathematical equations and predicted quite accurately. If such equations could be written to predict the effects of fire and its combustion products, then changes in a material or its use would lead to known changes in fire safety characteristics-without expensive testing.

From Research to Application

In 1969, the Committee on Fire Research of the National Research Council published its report, *A Proposed National Fire Research Program.* Thorough in its scope, the report will provide a helpful guide to fire research priorities in the decade of the Seventies. Much of the basic research on fire behavior recommended by the report will have a bearing on how buildings ought to be designed to minimize fire hazards.

Four years have passed since the report was issued. An assessment of what has been accomplished thus far is imperative. In areas of research where an added push is needed, additional research should be encouraged. In areas where results have begun to come in, efforts should be made, to incorporate the new information into a systematic body of fire analysis and to explore the implications for codes and building design.

The Commission urges the National Bureau of Standards to assess current progress in fire research and define the areas in need of additional investigation. Further, the Bureau should recommend a program for translating research results into a systematic body of engineering principles and, ultimately, into guidelines useful to code writers and building designers. No less important than the needs of designers of large structures are the needs of designers of single-family houses. The National Bureau of Standards should carry out these responsibilities in cooperation with other government agencies, nationally

This new Third Avenue building met New York City's building code, yet three died and 20 were injured in the fire.

recognized testing and research laboratories, and with the major standards-writing organizations : the National Fire Protection Association, the American National Standards Institute, and the American Society for Testing and Materials.

What Can Be Done Today

The present state of fire protection engineering does not leave today's building designer in a condition of helplessness. Much of what is known about fire safety is simply being ignored. Indeed, enough is known about fire safety to permit a reliable application of a sophisticated systems approach to fire safety design. In the systems approach, in contrast to the "that's the way it's always been done" approach, objectives are set for the building as a whole, and then the most cost-effective technology is applied to meet those objectives, In such an approach, relationships among components are important, and trade-offs are sought. For example, if alarm and sprinkler systems are installed to provide quick and effective response to a fire, then fireproofing requirements for walls and floors may be reduced. Another important aspect of the systems approach is that backup measures are provided in case part of the system fails. But redundancy for the sake of redundancy is avoided.

A systems approach was taken in the design of San Francisco's Transamerica Building in 1971. In addition to a full sprinkler system, smoke detection devices, and a central alarm system, the designers provided the building with emergency refuge areas, two-way voice communications with public areas, and an underground communications and command control center. Windows pivot so that burning rooms can be vented. In the event of a power failure, diesel pumps will maintain water pressure, and a diesel-run generator will light exitways and power the elevators. Should city fire mains be disrupted, there is an emergency water supply. While these provisions are costly, they are offset by savings they allowed : lower fire resistance requirements for floors and corridors, the elimination of fire dampers from the air conditioning system, and a sprinkler system that permitted the use of smaller pipes.

The General Services Administration has also adopted a systems approach, its first result being the Federal Office Building in Seattle. The build-

"NOTHING MYSTERIOUS"

Poor judgment often results in unnecessary fire potential in buildings. In the fire that consumed McCormick Place, Chicago's convention hall, in 1967, two gross errors in design contributed to the extensive damage. On the assumption that temperatures could not reach a level to threaten the roof structure, the designers left the steel joists unprotected ; the roof collapsed during the fire. Second, large aluminum space dividers were installed directly over expansion joints in the floor, with the result that molten aluminum flowed through the expansion joints into the lower level. In addition, exhibitions in McCormick Place often added a heavy fuel load in the form of flammable displays, yet the building had no sprinkler system.

As a result of its investigation the National Fire Protection Association concluded that "the principles of good fire protection have been known for many years and there was nothing mysterious about the destruction of McCormick Place. The building was almost entirely unprotected from a fire hazard so great that one wonders why it was not obvious all along."

ing was given a structural integrity three to four times as strong as the most severe situation will call for it to withstand. Each story was made a self-contained, fire-resistant compartment. When a fire breaks out-and the GSA estimates that about 100 ignitions will occur in the next 50 years-one of several alarm systems will notify the Seattle Fire Department and the emergency control center in the building. Immediately, a prerecorded tape will broadcast instructions to people on the fire floor. Air flow will be adjusted to prevent smoke and other products of combustion from spreading. Elevators will be "captured" and reserved for handling the emergency. As with the Transamerica Building, the costs of these provisions are largely offset by savings in other aspects of the building's design.

The systems approach used by the architects of the Transamerica Building and the GSA Applies to one class of buildings. Similar approaches could be devised for other classes of buildings, including one-family residences. **The Commission recommends that the National Bureau of Standards, in cooperation with the National Fire Protection Asssociation and other appropriate organizations, support research to develop guidelines for a systems approach to fire safety in all types of buildings.**

A different kind of study, though a natural outgrowth of a fire safety systems analysis, is what we have designated as *a fire safety effectiveness statement.* This is an attempt to state, in quantified terms, the potential losses of life and property (both inside and surrounding the structure) should the structure catch fire. The better the design and built-in fire protection of the building, the closer these quantities will approach zero. The effectiveness statement should pay particular attention to the consequences of fires starting in areas of the structure where people or highly flammable materials are concentrated. An additional set of calculations, designed to measure the adequacy of back-up measures, should be based on assumptions of system failures, such as power blackouts or non-functioning smoke detectors. While revealing whether adequate safeguards have been provided, the effectiveness statement has the added value of stating, through implication, the demands that would be put on local fire services should a fire occur. Fire safety effectiveness statements are particularly important for high-risk structures, such as shopping centers, public buildings, fuel storage depots, tankers, and chemical plants.

The Federal Government, through the General Services Administration, has set a valuable example for the private sector through its pioneering work in fire safety systems analysis. A governmentwide example should also be set in the area of fire safety effectiveness statements. Accordingly, **the Commission recommends that, in all construction involving Federal money, awarding of those funds be contingent upon the approval of a fire safety systems analysis and a fire safety effectiveness statement.** The funding agency would certify that the analysis and effectiveness statement have met its fire safety standards.

Product Design

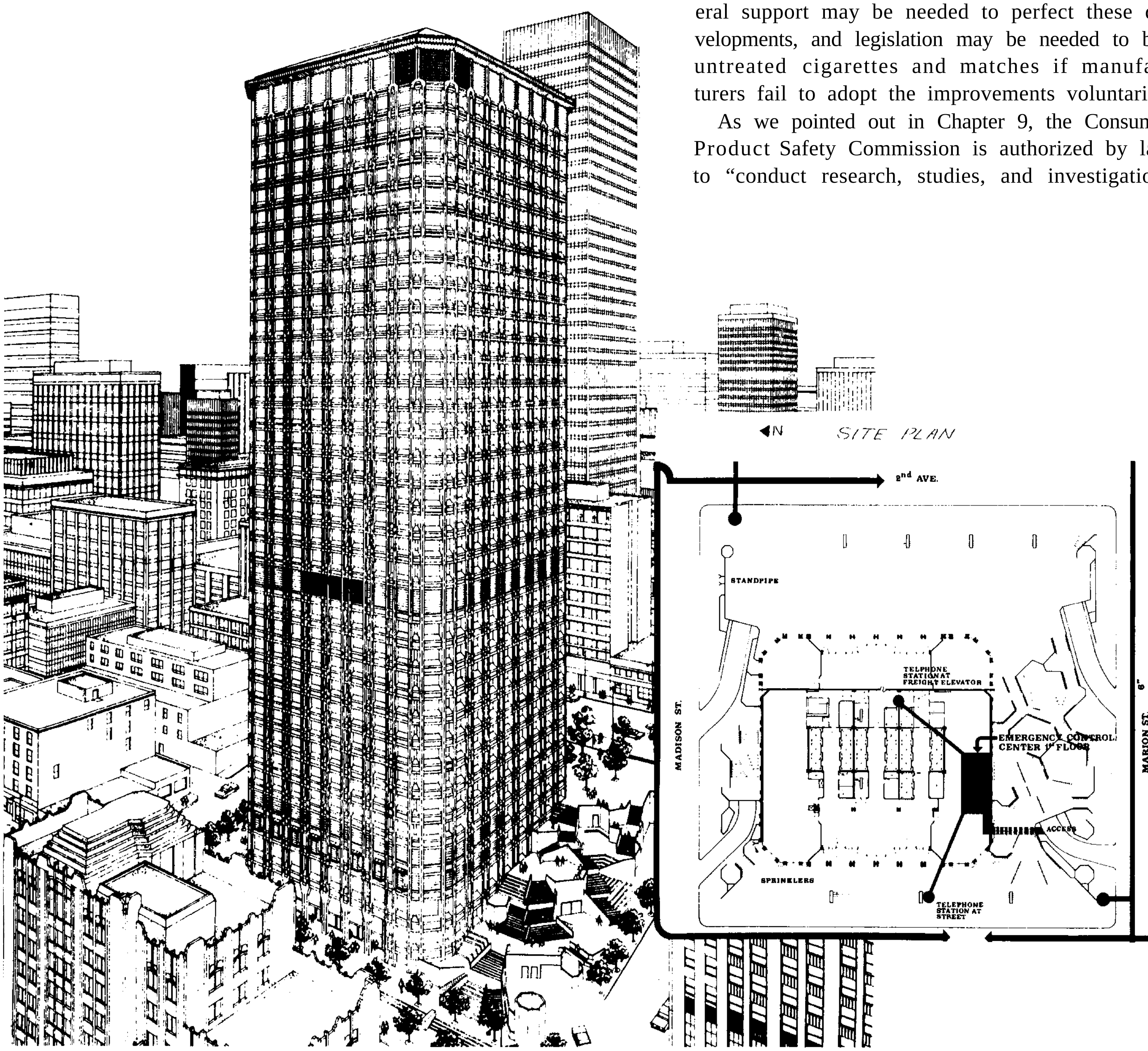
It is not just the large structures of the built environment that need improved design if fire losses are to be reduced. Many products need design improvement. Heating and cooking equipment, faulty wiring, and electrical appliances are major causes of fires. Together with fires caused by smoking and matches, these categories account for nearly half the fires that occur (see Table 8-2).

Over the years, manufacturers and standards-writing organizations have developed ever-improving safety standards in the design of consumer products. Yet some hazards have not been adequately covered. The National Commission on Product Safety, in its 1970 report, identified color television sets, floor furnaces, hot-water vaporizers, and unvented gas heaters as specific fire or burn hazards. Under "unfinished business"-possibly hazardous products the Commission did not study-were listed electric blankets, dryers, hotplates, extension cords, and space heaters. Further studies of fire experience might bring other hazards to light, particularly those that arise from wear and tear. Such studies now lie within the purview of the Consumer Product Safety Commission.

The business of making consumer products safe from fire and burn hazards is, in many cases, recognizably a complicated matter. When kitchen range controls were at the front of the stove, children could reach them and cause burner accidents; now that they are at the back, they can be hazardous to the clothing and skin of people reaching for them over hot burners. No doubt today's appliances could be made completely safe, but food wouldn't get cooked, toast wouldn't get toasted, and clothes wouldn't get ironed. But advances are possible. Within the grasp of technology are burners that can only be activated by the weight of specially designed, snugly fitting pans. (Here, too, one must settle for imperfection; there is residual heat in the burner once the pan is removed.) Further, scientists are working on the principle of generating heat within the substance to be heated, through induction of friction between molecules.

Technology is also being developed to treat cigarettes and matches to minimize their potential for accidentally igniting destructive fires. Federal support may be needed to perfect these developments, and legislation may be needed to ban untreated cigarettes and matches if manufacturers fail to adopt the improvements voluntarily.

As we pointed out in Chapter 9, the Consumer Product Safety Commission is authorized by law to "conduct research, studies, and investigations



For the Federal Office Building in Seattle, the General Services Administration has used a systems approach to fire safety.

on the safety of consumer products and on improving the safety of such products." Since burns are a major form of injury from consumer products, it will be appropriate for that Commission to devote a significant portion of its energies and resources to fire and burn hazards. **This Commission urges the Consumer Product Safety Commission to give high priority to matches, cigarettes, heating appliances, and other consumer products that are significant sources of burn injuries, particularly products for which industry standards fail to give adequate protection.** All of the Commission's important weapons might be brought to bear against these hazards: the setting of standards of performance, design, or materials for consumer products; the requirement of adequate warning labels and user-instructions; and the banning of products that are unreasonable risks to consumers.

Educating the Designer

Few formal education programs anywhere in the United States for architects and engineers have course requirements in fire protection engineering. (Only the University of Maryland and the Illinois Institute of Technology offer 4-year Bachelor of Science degree programs in fire protection engineering.) While some professional societies have committees concerned with fire safety, few designers take an interest in the committees' work. For lack of training, many designers are unable to understand highly technical reports in fire safety design.

This absence of training helps to explain the unenthusiastic attention which architects and engineers, when designing buildings, give to fire safety provisions. If the situation were turned around--that is, if architects and engineers were schooled in the principles of fire safety--then undoubtedly they would participate enthusiastically in the search for alternative solutions and better codes consistent with the principles of fire safety.

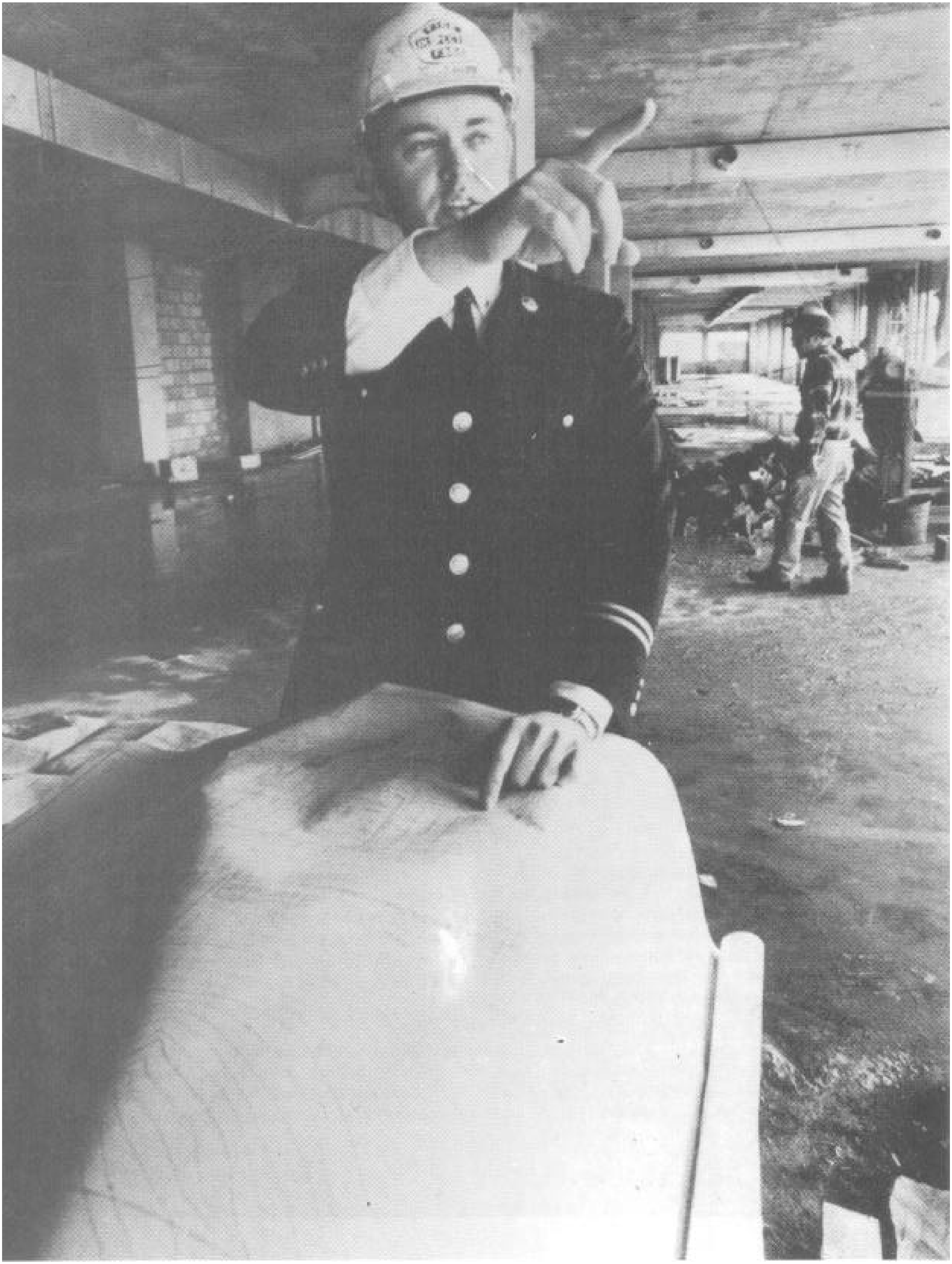
The Commission recommends to schools giving degrees in architecture and engineering that they include in their curricula at least one course in fire safety. Further, we urge the American Institute of Architects, professional engineering societies, and State registration boards to implement this recommendation. Registration boards could require a specific number of credit hours of fire protection engineering to qualify for State licensing for appropriate disciplines within architecture and engineering. After a suitable time to allow local initiative on this recommendation, Federal funds for engineering and architectural schools might be contingent upon those schools having adequate fire protection engineering requirements as part of the degree curriculum.

We recognize that, at present, if the emphasis is to be on basic principles, there is not a great deal available to be taught to architects and engineers in the realm of fire protection engineering. Deciding what *can* be taught-and what should be taught-requires careful study. **The Commission urges the Society of Fire Protection Engineers to draft model courses for architects and engineers in the field of fire protection engineering.** To this end, the Society should call together educators in architecture and the principal engineering disciplines to discuss what information would be desirable to teach architects and engineers.

Since it will take several years to develop fire safety courses in architectural and engineering schools, then several more years before those who have had this training begin to practice, the impact of these curricular additions will not be felt for some time to come. Practicing building designers must also be educated in fire safety. **The Commission recommends that the proposed National Fire Academy develop short courses to educate practicing designers in the basics of fire safety design.**

There is presently enough information and a wide range of technological choices (for example, total communicationssystems, fire retardants, fire-resistant coatings) to permit architects, engineers, and other building designers to plan buildings that are safeguarded from fire. What is needed, in many cases, are incentives.

Positive incentives are likely to come about through example. We are encouraged that the Federal Office Building in Seattle is serving as a beacon to the community. Now owners of Seattle office buildings still on the drawing boards are applying the same kind of systems approach to provide the best building possible as a way of insuring full rental. They feel they must be able to show potential renters that their building is, among other things, fire-safe.



11

CODES AND STANDARDS

For centuries, governments have exercised the right to regulate how buildings are built for the sake of the public's protection. In the time of Julius Caesar, Roman laws regulated the height of buildings and the distances between them. During Queen Anne's reign, the English found it necessary to have a code to require non-combustible roofs. By the time of America's settlement, the legal concept of codes was well-established. In 1796, for example, the city of New Orleans, then a Spanish province, passed an ordinance against the use of wood roofs.

The public interest justifies these intrusions on individual liberty, but what constitutes the public interest has been a subject of debate and change. Is continuity of business operations in the public interest? States maintain that it is, thus justifying strict code requirements in private industrial plants.

Fire safety is only one aspect of the public interest-and, hence, only one of many matters governed by codes-but in the wake of major conflagrations that struck a number of American cities at the turn of the century, it became a concern of major importance. In 1905, the National Board of Fire Underwriters (now the American Insurance Association) developed and published the National Building Code, the first "model" building code. It had no legal status of its own, but was intended to provide guidance to State and local jurisdictions for the enactment of legal codes. Because its concern was principally central city areas, the code emphasized converting downtown areas from combustible construction, providing adequate separation between buildings, and providing area limits and fire-resistive separations within buildings.

Other model codes have been developed over the years: that of the Pacific Building Officials Conference (now the International Conference of Building Officials) in 1927, that of the Southern Building Code Congress in 1945, and that of the Building Officials Conference of America (now the Building Officials and Code Administrators International, Inc.) in 1950. All of these codes are subject to periodic updating.

None of the model codes is sufficient unto itself. All make references to extensive lists of standards developed by other organizations. These standards usually specify the performance a material or structural member must achieve under certain conditions. Standards are written by such organizations as the American National Standards Institute, the American Society for Testing and Materials, and the National Fire Protection Association.

In addition to the model building codes, there exists the Life Safety Code, published by the National Fire Protection Association. Its intent is ***to*** strengthen provisions for protecting the occupants of buildings, rather than saving the building itself. It covers construction, protection, and occupant) features relative to life safety.

Model codes are not the only source of construction regulations. The Federal Government exerts leverage on the construction industry through such documents as the Minimum Property Standards of the Department of Housing and Urban Development, the safety standards of the Occupational Safety and Health Administration, and the minimum requirements of the Department of Health, Education, and Welfare for grant programs or social security assistance.

Local Code Provisions

The situation of the model codes is complicated, but not nearly as complicated as matters at the local level of code adoption. In addition to the *building code,* for which the model codes are intended to provide guidelines, State and local jurisdictions may have more than half a dozen other codes. A building code, of course, applies principally to new construction and alterations, though it is sometimes made retroactive and applied to existing buildings if past deficiencies are discovered to be critical. Once a building is constructed, a *fire prevention code* may govern the maintenance of the building and the introduction of materials into the building for the sake of fire safety,

Frequently there are other codes as well :

- The *housing* code, which is concerned with livability and sets standards for sanitation and health facilities and building maintenance;
- The *electrical code,* which sets requirements for the materials and equipment used in the electrical system;
- The *plumbing code,* which provides for the delivery of potable water and the safe disposal of flushed wastes;
- The *mechanical code,* which applies to the heating, ventilating, and air conditioning systems;
- The *elevator code,* which governs the materials, equipment, and installation of elevators and their use.

In a city there may be as many kinds of inspectors as there are codes, of which only the fire prevention inspectors are likely to be members of the fire department.

The two most important codes from the standpoint of fire safety arc the Building code and the fire prevention code. Typically, two-thirds to three-fourths of the provisions of a building code apply to fire safety, as do all the provisions of a fire prevention code.

How these codes are adopted varies from one jurisdiction to another, but generally there are public hearings preceding action by the city council or the State legislature. Material manufacturers, suppliers, contractors, labor unions, trade associations, and civic groups are given the chance to support the proposed code or recommend changes. Considering that these groups often differ in their degree of expertise, that they make conflicting claims, and that some do not have fire safety uppermost in their minds, it is hardly surprising that codes are products of compromise amid competing aims and viewpoints. Nor is it surprising that there are wide differences among the 14,000 local building codes that exist in this country. As the National Commission on Urban Problems remarked in its 1968 report, "Building code jurisdictions are thousands of little kingdoms, each having its own way; what goes in one town won't go in another-and for no good reason."

Evidence of the diversity in local codes was discovered during that Commission's survey of the Nation's 52 largest cities. Only 14 were using one of the model codes, 20 had regulations based on the model codes but with significant changes, 13 had adopted codes of their own, and one followed a State-recommended code. (Four cities did not reply to the survey.) Differences among these local codes are not inconsequential; often the process of political compromise leads to serious compromise in fire safety. Here and there in this report we cite examples of tragic fires in buildings that met all local building code requirements.

Feeding the diversity among local codes are the differences among the national model codes. The model codes differ markedly in such matters as permissible heights and areas, interior finish requirements, and specifications of safe travel distances for occupants. At the local level, then, a spokesman for a particular point of view, whether on the side of leniency or stringency, can appeal to the authority of the one model building code which among the four best matches his position. If his subject is fire prevention codes, he has three model codes to pick from.

Attempts to develop some uniformity among the model codes have had limited success. The Model Code Standardization Council, which includes representatives from the Nation's building standards-writing organizations, has been working on uniform definitions of building construction terms and a common format for the model codes. The National Conference of States on Building Codes and Standards is working toward more uniformity in building codes on a state-wide basis. The Conference of American Building Officials is seeking to fill gaps in existing standards and to devise a system to promote and approve research toward better standards,

The most promising start toward greater uniformity came in 1971, when the four model code groups jointly published a "One- and Two-Family Dwelling Code." Having eliminated many of the past differences among model codes, the joint code has thus diminished the justification for wide differences in codes between one jurisdiction and another for single- and two-family residences. However, it has practically no fire safety provisions.

More disturbing than the wide differences among local codes is the fact that many jurisdictions have no codes whatsoever. When the National Commission on Urban Problems surveyed local governments in the United States (18,000 units surveyed), it found that only 46 percent had a building code. On the other hand, a more recent survey of 2,000 cities with over 10,000 population indicates that 97 percent of these cities have building codes.[1] It is the sparsely settled areas, it can be surmised, which are chiefly without building codes, Though there are no statistics on how many jurisdictions have a fire prevention code, it appears there are a significant number of communities which do not have one in force. **The Commission recommends that all local governmental units in the United States have in force an adequate building code and fire prevention code or adopt whichever they lack.**

[1] Milton Applefield, "Fire District Use in North Central Region Cities," Fire journal, January 1973, p. 28.

Local Implementation of Codes

A law is effective only to the extent that it is enforced, and so it is with a fire prevention or building code.

Many serious building fires have been the result, not of code deficiencies, but of lax enforcement (sometimes because of corruption). A fire-resistant floor, for example, is an insufficient barrier to smoke and fire if the architect allows gaps in the floor or a workman punches a big hole in the floor to allow a pipe to pass through. Vigilance is needed in the review of plans and in inspection during construction. Once construction is finished, compromises in fire safety may be hidden from view.

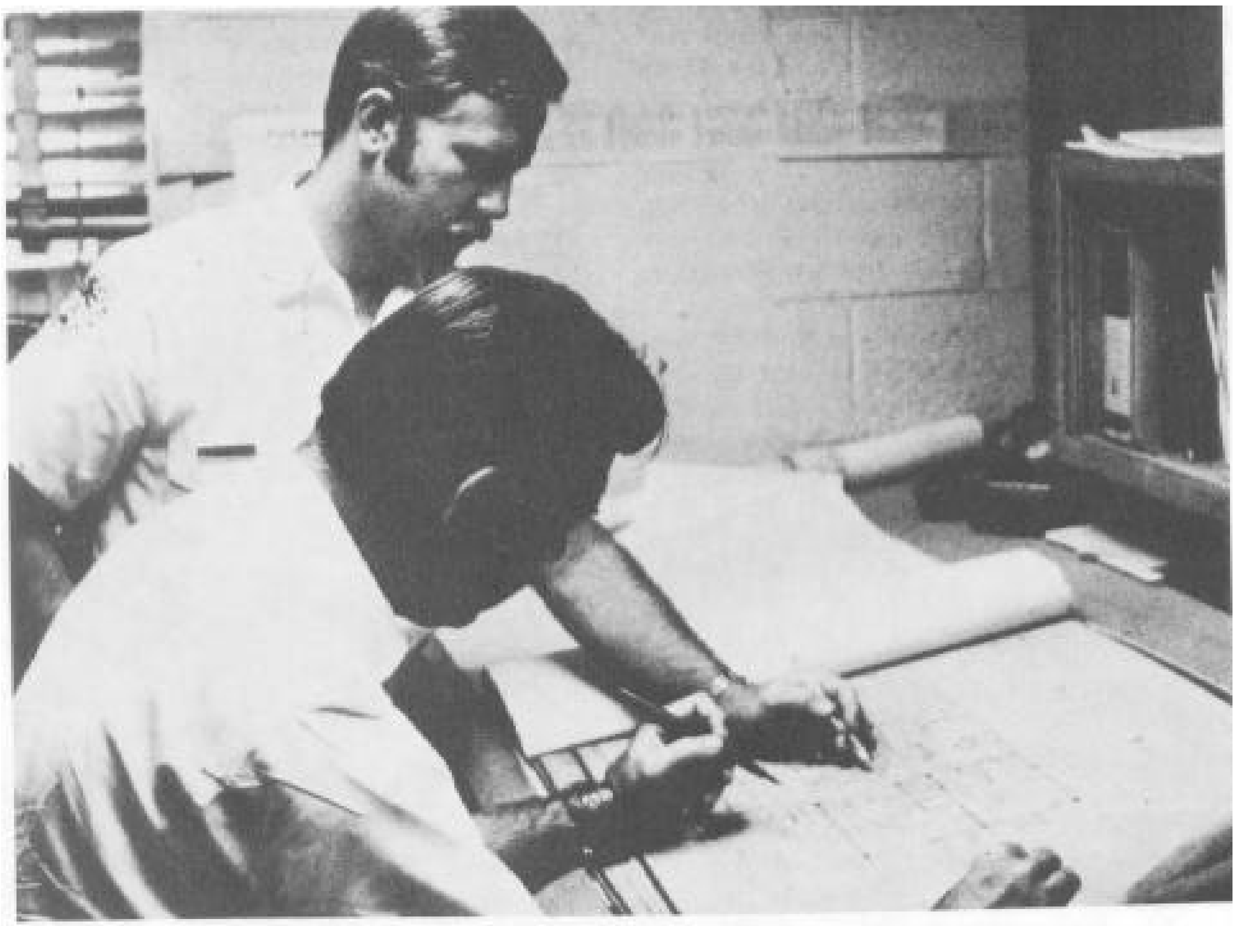
The training of inspectors is, in many places, woefully inadequate. In one major city, the only training for fire prevention inspectors consists of sending them out for a few days with a senior inspector. Architects and engineers complain about inflexibility in the codes, but one reason codes tend toward rigidity and detailed specifications is that local building officials and inspectors are not equipped, because of their inadequate training, to evaluate alternative solutions and trade-offs.

A fire-resistant ceiling is not effective if an architect or a workman allows wide holes for a pipe to pass through, The effectiveness of codes is also compromised by lack of coordination among inspection programs. The building department generally has responsibility for enforcing building codes, the fire department for enforcing fire prevention codes. Because fire prevention bureaus are responsible for fire safety throughout the life of a building, they ought to be consulted by building departments during the design and construction phases. In many local jurisdictions, however, building departments act unilaterally, implementing the building code during these crucial stages without requesting the suggestions and advice of the fire prevention bureau. Since the two codes influence each other but require expertise specific to the enforcement of each, coordination of efforts between the two departments is needed to provide optimum fire protection. **The Commission recommends that local governments provide the competent personnel, training programs for inspectors, and coordination among the various departments involved to enforce effectively the local building and fire prevention codes. Representatives from the fire department should participate in reviewing the fire safety aspects of plans for new building construction and alterations to old buildings.**

Strengthening the Model Codes

Since the model codes exert a powerful influence on local codes, the quality of the model codes is a nationwide concern of considerable importance.

Historically, major changes in the model codes have been made when a particular fire problem achieves a certain magnitude (as is happening in response to high-rise fires) or when a dramatic fire or two focuses public attention on a problem (as happened in the wake of the Coconut Grove nightclub fire in Boston in 1942). The problem of smoke generation, which has been aggravated



Adequate fire safety in buildings depends upon cooperation between inspectors in the building and fire departments.

in recent years by the increased use of synthetic materials, has yet to receive adequate attention. Slowness of change except during crisis is typical of social institutions, but the consequences of that characteristic are, in this instance, vital to public safety.

One consequence of this mode of change is that new requirements tend to be piled upon old instead of replacing them. The result can be needless redundancy and added expense. In some model codes, for example, the addition of an automatic sprinkler system has not been accompanied by trade-off provisions on other fire safety features, such as height and area limitations, maximum travel distances, or the degree of fire-resistive construction.

The model codes have also been slow to respond to the rapid changes in materials and construction technology. Here the fault does not lie ghiefly with the code-writing organizations, since their requirements in these areas usually make references to the standards set by other organizations. As we pointed out in Chapter 9, changes in materials and construction technology have threatened to outrun the standards-setting organizations and testing laboratories striving to keep up with the changes. As we have also pointed out, a firmer grounding of standards in a scientific understanding of fire and its effects would streamline the process of approving for use new materials and technology. Progress in this direction would also improve the codes. As it is now, both specification requirements (such as 1/2-inch thickness for gypsum sheathing) and performance standards (such as 3 hours of fire-resistiveness in certain bearing walls) arc the product of judgments based on past experience or speculation, rather than firm knowledge of fire behavior.'

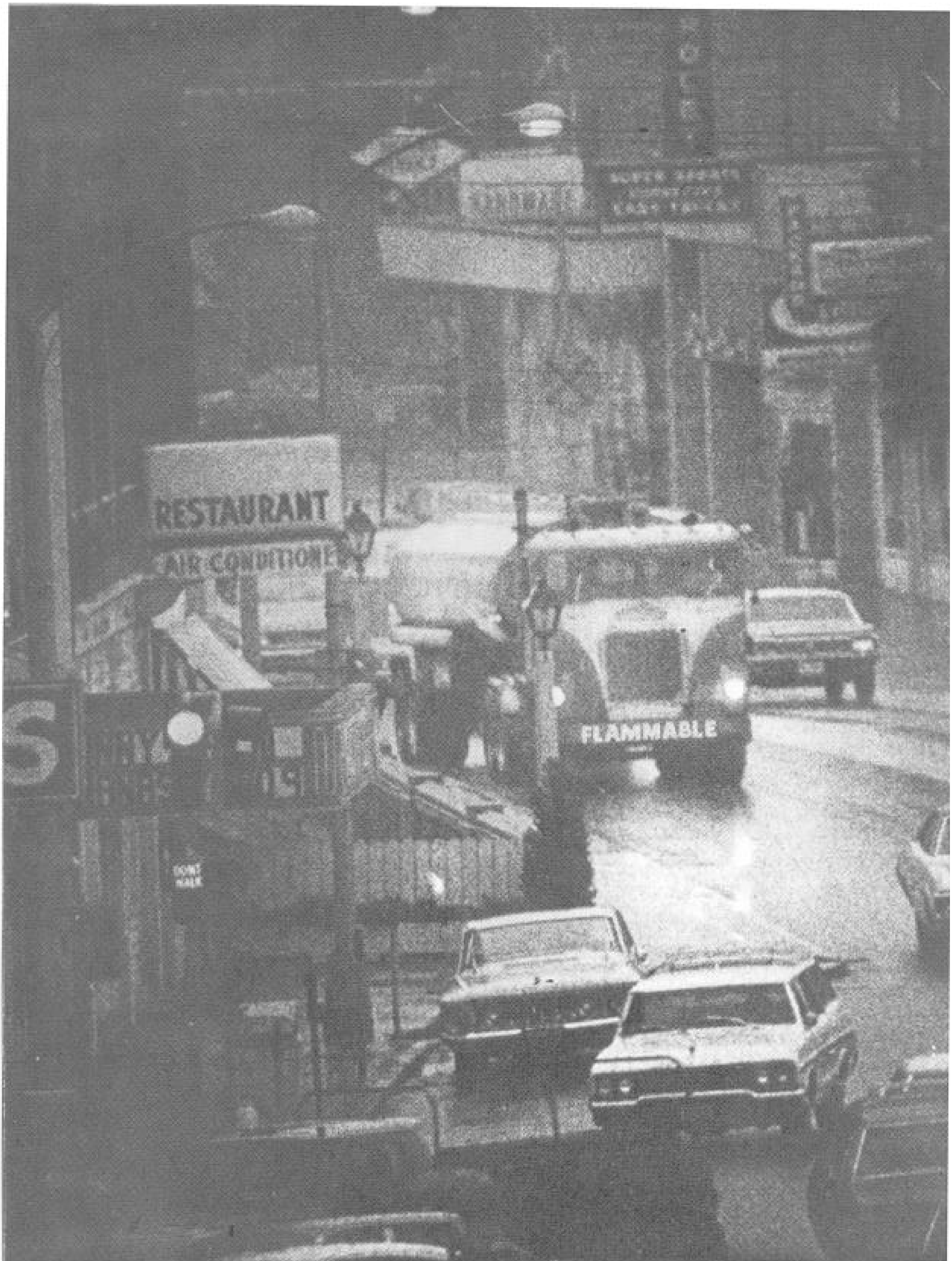
The mechanisms for change to the model codes are similar in the International Conference of Building Officials, the Building Officials and Code Administrators International, and the Southern Building Code Congress. When a change is proposed, a code change committee holds hearings to consider opposing views, then studies the matter further and issues its recommendation While the recommendation is voted on by the organization's membership, the committee's recommendation is usually adopted.

Sitting on these committees are local building officials, who often lack expertise in fire protection, and who in some instances are understandably reluctant to impose stringent requirements on industries which would directly affect local programs. The committee process is, moreover, a slow one.

While the Commission has no suggestions for improving the process whereby the model codes are amended, we do have two specific recommendations for strengthening the model codes. We are firm in our conviction that many lives could be saved, and many injuries averted, if homes were equipped with early-warning fire detectors and alarms. These can be effective sentinels, especially at night when so many tragic fires occur. No less important are early-warning detectors coupled with automatic extinguishing systems in buildings where many people congregate. Automatic sprinklers can pay for themselves in damages prevented, and the model codes should permit other savings by relaxing requirements for other fire safety features when automatic sprinklers are installed. **The Commission recommends that, as the model code of the International Conference of Building Officials has already done, all model codes specify at least a single-station early-warning detector oriented to protect sleeping areas in every dwelling unit. Further, the model codes should specify automatic fire extinguishing systems and early-yarning detectors for high-rise buildings and for low-rise buildings in which many people congregate.** (Examples of this last category include buildings of public assembly, such as theaters and exhibition halls, restaurants, and enclosed shopping center malls.) These recommendations apply as well to State and local jurisdictions, whether or not they follow one of the model building codes.

Of all the actions that can be taken to provide fire safety for Americans in their built environment, these, we believe, are the most important.

[2] The use of more scientifically based information would function both to increase the validity of code requirements and to perpetuate a more uniform scientific base for all codes.


RESTAURANT
FLAMMABLE

12

TRANSPORTATION FIRE HAZARDS

Ever since man learned there was a better way than a pair of feet to get from here to there, he has developed a propensity for not getting there at all. As he has honed his technology of transport, he has also dropped from the sky like a lead weight, sunk to the bottom of the sea, tumbled from the sides of mountains, and met in disastrous collision his fellow man traveling in the opposite direction. In the process he has managed to destroy a considerable amount of the wealth that he felt it necessary to carry from here to there. He has also destroyed human lives.

Fire is not the inevitable consequence of a transportation accident, but in an age of combustion fuels it is a frequent accompaniment. In 1971, about 4,260 Americans, or about one-third of all who died in fires, lost their lives in burning planes, trains, ships, or motor vehicles. The majority of these were lost on the highways. The National Fire Protection Association estimates that, in that year, 521,800 transportation fires caused property losses exceeding $332 million (see Table 12-1) . That was 20,950 more fires, and $63 million more in losses, than the year before.

Several factors have contributed to the growth of transportation fires. First, a citizenry growing in affluence and mobility is using transportation as never before. During the 1960's, passenger miles on U.S. airlines more than tripled, from 34 billion passenger miles in 1960 to 123 billion in 1970. Motor vehicle registrations went from 74 million in 1960 to 108 million in 1970, an increase of 46 percent. A second factor, related to the first, is the Nation's rapidly increasing consumption of goods, which requires more transport vehicles to travel more frequently to meet the demands. Third, hazardous materials which once traveled solely on one mode of transportation are now often exposed during transit to two or more (for example, "piggyback" truck-rail arrangements, and containerized shipping), increasing the amount of handling and straining the capacities of the containers. Fourth, new materials and new forms of old materials (such as liquefied petroleum

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Table 12-1. Estimated 1971 Transportation Fire Losses*

Category	Life loss		Property loss		Fires	
	Number	Percent of total	Dollars-million	Percent of total	Number	Percent of total
Aerospace vehicles and aircraft	125	1.1	$192.0	7.0	200	0.0
Motor vehicles-farm/construction..............	3,950	33.3	16.12	0.6	19,200	0.7
Motor vehicles-pleasure/transportation			{96.54	3.5	482,400	17.7
Ships, railroads, etc...........................	185	1.5	27.60	1.0	20,000	0.7
Transportation (total)........................	4,260	35.9	$332.26	12.1	521,800	19.1

*National Commission on Fire Prevention and Control staff estimate for 1971.

gas) are being introduced at a rate that challenges regulatory measures and firefighting techniques to keep up.

Transport of Hazardous Materials

About 10,000 new chemical products are developed every year. Most never reach the commercial market; some do. And of those that do, there are some that can present severe fire threats as they are moved from place to place.

Real facts about the frequency and causes of transport fires involving hazardous cargoes are hard to come by. Within the Department of Transportation, such agencies as the Federal Aviation Administration, the Federal Railroad Administration, and the Federal Highway Administration investigate accidents in their respective areas of concern. In a study of reporting systems issued 4 years ago, the National Transportation Safety Board, another arm of the Department of Transportation, complained of the "parochialism" of accident reports, and the fact that they "have not contained information appropriate in character, depth, and detail to have much value in preventing hazardous accidents in other modes."

Some of this is changing. The Office of Hazardous Materials, still another Department of Transportation entity, has developed a system for receiving, storing, and retrieving information on hazardous materials accidents. The National Transportation Safety Board has the duty to investigate causes of transportation accidents (excluding aircraft and marine accidents), yet in 1971 the Safety Board reviewed and issued only '22 reports of separate rail, highway, and pipeline incidents. **The Commission recommends that the National Transportation Safety Board expand its efforts in issuance of reports on transportation accidents so that the information can be used to improve transportation fire safety.**

Despite the absence of complete statistics, some generalizations are possible:

- There are more fires and explosions involving tank vehicles during loading and unloading than during actual transit.
- Routine transportation presents little hazard; it is the interruption to smooth transit that causes accidents.
- Regulations concerning the transportation of hazardous materials lag behind current needs; as one commentator has put it, "the regulatory system is a part of the problem and not part of the solution." [1]

In addition, the hazards that are covered can be bewilderingly complex. Whether it is the State police, another enforcement authority, or the fire department that responds to an emergency, rudimentary knowledge is not sufficient. Complications are often present:

- *Physical properties.* A liquefied gas, for example, may have widely different fire and explosion hazards from those that exist when the fuel is shipped in a vaporized form.
- *Mixture of hazards.* A material may well be toxic, flammable, and reactive all at the same time, yet marked for only one of the hazards.
- *Similar names, divergent hazards.* One material with a name quite similar to another may present quite different hazards.

[1] W. M. Haessler, "The Four Problems of Transportation of Goods," ***Fire*** Journal, November 1971, p. 29.

Firefighters and the public alike would also be better served if trucks, tank cars, and other vessels for transporting hazardous materials carried clearly visible, readily understandable markings indicating the hazards therein. The two most universally recognized means of identification of hazardous materials are the National Fire Protection Association's "704M System" and the Department of Transportation's "Hazard Information System" (HI). While the systems are not dissimilar in the important respects, the Nation would be better served if a single system, incorporating the best aspects of each, were adopted universally. **The Commission recommends that the Department of Transportation work with interested parties to develop a marking system, to be adopted nationwide, for the purpose of identifying transportation hazards.** In carrying out this recommendation, the Department of Transportation should seek the cooperation and agreement of the Department of Labor, which, under the Occupational Safety and Health Act, is charged with developing a labeling system for hazardous materials for protection of employees. Since those who must utilize the information gained from these markings often must do so under poor lighting and hazardous conditions, representatives of the fire services should also be consulted.

The complexity of hazards complicates firefighting. While spillage of a highly flammable liquid into a stream may actually reduce hazards, spillage of a toxic liquid into a stream creates a new and major problem. Chemical foams effectively extinguish some tank fires, but are rendered useless if certain solvents are present. For their own safety, firefighters need to know the particular hazards and proper tactics to use with each material, so that they can cope with what is likely to happen next.

In a word, then, firefighters must be well-informed about the hazards they are asked to deal with. While the National Fire Protection Association, State firefighter schools, and some industry representatives have attempted to educate fire departments on chemical hazards and proper tactics to use on transportation fires, the results have been very uneven. Training is likely to be superior in urban areas. But trucks and trains cross vast patches of rural America (at greater speed than in urban areas), where training is likely to be minimal. **The Commission recommends that the proposed National Fire Academy disseminate to every fire jurisdiction appropriate educational materials on the problems of transporting hazardous materials.**

Even with adequate labeling and considerable training, fire departments may face new or unusual hazards in transportation accidents for which their knowledge of appropriate handling is, at best, uncertain. In such instances, they should be able to telephone for advice from a source knowledgeable about the particular hazard.

The Chemical Transportation Emergency Center (Chem-Tree) of the Manufacturing Chemists Association is a long step forward to meeting this need. By tapping its own resources and those of others (such as DOT's Office of Hazardous Materials and the Environmental Protection Agency), it is able to provide instant information for handling emergencies involving hazardous substances. The full potential of this system will not be realized until an adequate labeling system tells fire departments exactly what is inside the containers involved in accidents. **The Commission recommends the extension of the Chem-Tree system to provide ready access by all fire departments and to include hazard control tactics.** The hazard control tactics must come from joint efforts of the proposed National Fire Academy and representatives of the Manufacturing Chemists Association.

The public, too, should become more aware of the risks in accidents involving hazardous materials. An incident that happened near Waco, Ga., in June of 1971, illustrates the importance of this. As a result of an accident, a truck carrying 25,000 pounds of dynamite caught fire. Cars stopped, and people got out to watch. The driver, who escaped the fire, shouted to them to get away-but to no avail. Six people died and 33 were injured when the explosion came.

The awareness can be attained in many ways. Public fire safety educational materials should contain pertinent information. Basic markings (once one system is adopted) can easily be included in school fire safety education. Groups such as the American Association of Motor Vehicle Administration, the American Driver and Traffic Safety Education Association, the American Automobile Association, the North American

Professional Drivers Association, and the National Safety Council can, if given the proper information, include it in literature going to their audiences.

Interstate and, in fact, most intrastate transport can be effectively controlled by the Department of Transportation, but the system sometimes breaks down at international borders. Loading and unloading sometimes occurs in streets and lots, because the Bureau of Customs doesn't have the proper storage facilities. To correct this situation, **the Commission recommends that the Department of the Treasury establish adequate fire regulations, suitably enforced, for the transportation, storage, and transfer of hazardous materials in international commerce.** These efforts must be coordinated with local fire services.

Motor Vehicle Safety

The problem of transporting hazardous materials is dramatic, and failure of the system often causes large losses of life and property in a single incident. However, fires in motor vehicles cause almost 35 percent of all fire deaths in the United States. In fact, more than 450,000 fires occurred in cars and trucks in the United States in 1971, causing upward of 3,500 deaths and average losses of $200 per fire. That same year, the Bureau of Motor Carrier Safety received 729 reports of truck accidents involving fire. These accidents caused 132 deaths, 309 non-fatal injuries, and $7,831,728 in property damage.

For the truck accidents, principal ignition sources, in declining order of frequency, were collision impact, defective wiring, hot tires, and defective or hot bearings. Fires originating in cargo spaces were the most frequent, followed by those originating in other vehicles or objects, and those starting at tires or wheels.

Records kept by Oregon's State Fire Marshal indicate that the most frequent ignition sources in automobile fires are backfires, electrical short circuits, hot mufflers and exhaust pipes, smoking materials, and incendiarism-in that order. The materials first ignited are gasoline and other flammable liquids, electrical insulation, and upholstery.

A number of organizations, such as the National Safety Council, the American Trucking Association, and the National Fire Protection Association, have attempted to educate drivers and trucking companies to high standards of fire safety in the use and maintenance of motor vehicles. Power to prescribe safety features and levels of safety-related performance resides with the National Highway Traffic Safety Administration, established by the Highway Safety Act of 1970. In January 1971, that Administration published a flammability standard for the interior materials of passenger cars, trucks, and buses, to take effect September 1, 1972.

The Traffic Safety Administration also asked the Oklahoma University Research Institute to evaluate the new standard. The Institute found the standard lacking, in that it requires "too mild a test to achieve a significant reduction in property loss, much less injuries or fatalities, from vehicle fires." All that the standard accomplishes, the Institute's report said, is to "discourage use of new materials for vehicle interiors which are more flammable than those currently employed."

Since gasoline spillage is a common cause of vehicle fires, the location, construction, and security of fuel tanks are important design features for fire safety. The most severe losses, in terms of both life and property, occur from fires following rear-end collisions. Next in importance are rollover accidents, followed by front-end collisions. Fuel tanks for passenger cars must meet a Federal standard, which specifies a fixed collision barrier test and the allowable amount of fuel spillage from the tank and its connections in the test. (Somewhat more stringent requirements are imposed on large trucks and buses.) Studies made for the Department of Transportation have indicated that the current procedure is not adequate to evaluate the performance of a car's total fuel system in a fire situation. Studies by the Cornell Aeronautical Laboratory have shown that, while a mid-vehicle location for a fuel tank is probably best, location alone is not the total answer to the fire problem. Improvements can come only through a consideration of the entire system : fuel tank location, fuel line, electrical system and exhaust routing, and configuration of the surrounding structure. Consideration must also be given to the evaporation emission control devices installed on all cars in recent years.

The indications, then, are that motor vehicles, especially cars, are not as fire-safe as modern technology would allow. Improvements could be made in design and materials, without significant additional costs. **The Commission recommends that the Department of Transportation set mandatory standards that will provide fire safety in private automobiles.** Both materials and structural design should be considered in these standards.

Aircraft Fire Safety

On December 8, 1963, a Pan American Airways jet exploded and burned near Elkton, Md., killing all 81 aboard. The frightening aspect for passengers contemplating such an occurrence is that there is no escape: no running from the scene, as on land, no climbing into a lifeboat, as at sea.

Yet fire is the greater killer when it happens after a crash landing. There have been numerous instances when the impact of the landing did not kill passengers, but the ensuing fire did. One such accident cost 43 lives when a commercial aircraft crash-landed near Salt Lake City in November of 1965.

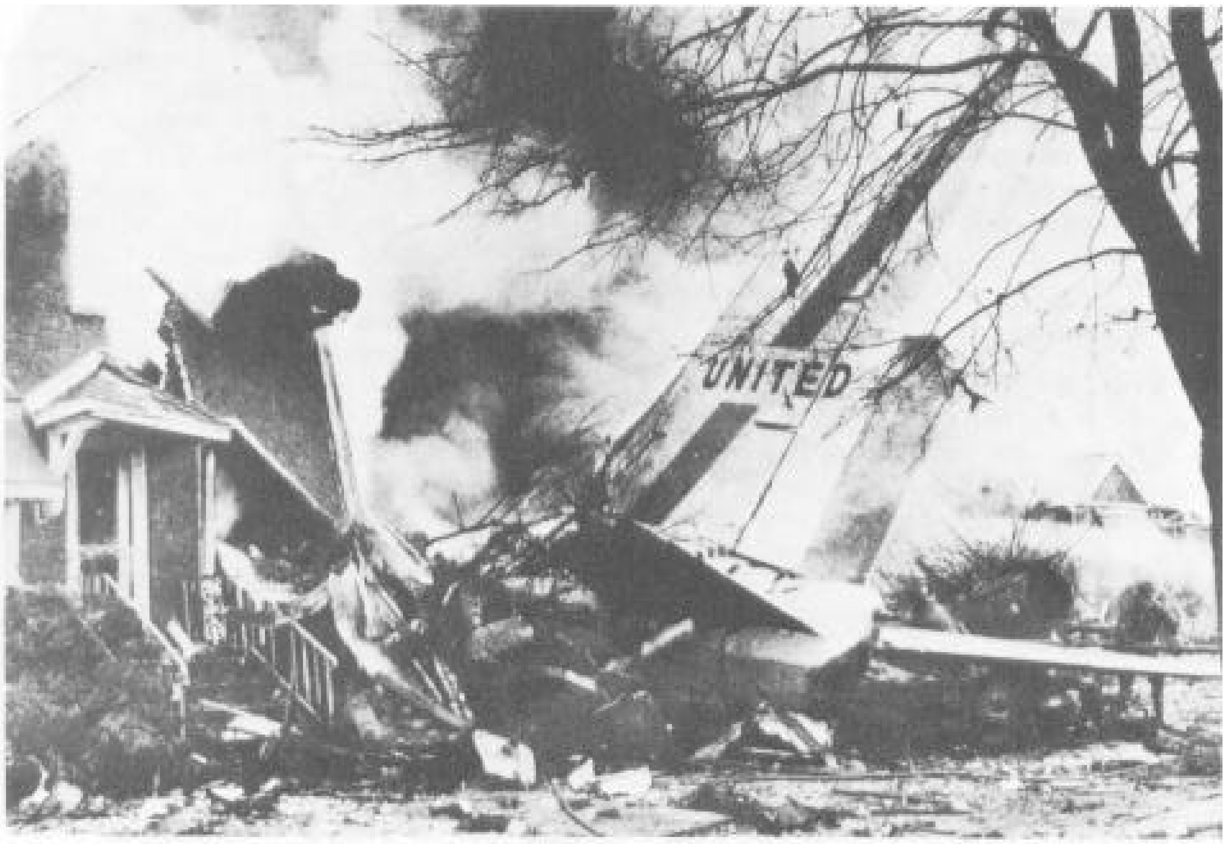
From the standpoint of dollar losses, the most serious fires occur at airports and in hangars, usually during the course of maintenance operations. A spectacular fire of this sort occurred in April of 1969 at the Mercer County Airport, N. J. Before it was discovered, the flames were 25 feet high; before it was contained, it had destroyed 49 aircraft (mostly of the single-engine type), 13 helicopters, a large hangar, the passenger terminal facilities, and the offices of the airlines for a total loss of over $3 million.

Considering the many materials available to burn (propulsion fuels, hydraulic oils, lubricating oils, and ordinary combustibles and plastics), the many sources of ignition (electrical, contamination of oxygen lines or valves, lightning and electrostatic charges, hazardous cargoes, and human carelessness), and the many ways an ignition source can come in contact with the combustibles, it is obvious that there are a large number of potentials for disastrous fires in the relatively confined space that constitutes the aircraft environment.

There are a number of areas in which research and development could improve the fire safety of aircraft :

- *Reduce chance of ignition.* The fuel tanks, the fuels used, and the interior materials are the critical considerations in efforts to reduce the likelihood of fire in aircraft accidents.
- *Increase the chance of survival.* Once a fire has started, the buildup of poisonous fumes and heat is dependent upon many things, including compartmentation, ventilation, and materials used. Standards of construction must consider not only how easily something can be ignited, but also the effect on survival once it is ignited.
- *Detection and suppression* of fires. When on the rare occasion fire occurs during a flight, detection and suppression are normally swift and effective. Aircraft fires during servicing and maintenance are often not so efficiently dealt with. Early automatic detection and suppression systems for parked aircraft, including bet-

Every year, more than 3,500 Americans die in automobile fires. Better design for safety could reduce these tragedies.



Fire results from many airplane crashes. This Boeing 737 crashed near Chicago's Midway Airport in December, 1972.

ter fire suppression agents, seem to be needed at many airports.

Presently, research on various aspects of aircraft fire safety is scattered among several Federal agencies, both civil and military, and aircraft manufacturers. Much research not specifically connected with aircraft fire safety will nonetheless have a bearing on future improvements in that field. Coordination of these research efforts is important-first, to ensure that research priorities reflect the scale of needs for aircraft safety, and second, to promote the transfer of technology among the many segments of the aircraft industry and from outside the industry.

Many fire chiefs express considerable doubt that they can save lives in an aircraft crash if fire erupts before suppression forces arrive. Their fears are supported by Federal Aviation Administration records, which show that of the 57 air-carrier accidents during the decade 1959 through 1968 involving ground fire and fatalities, only 13 occurred at airports and thus within reach of airport firefighting equipment. In only one of these 13 cases were firefighters able to rescue passengers.

The chief emphasis in aircraft fire safety, therefore, will have to be improved design of airplanes and continuation of the careful operation of aircraft that has resulted in an admirably low accident rate for commercial aviation. Still, much can be done to improve the firefighting capabilities at airports. The National Fire Protection Association, the Federal Aviation Administration, the Air Line Pilots Association, and the International Civil Aviation Organization are upgrading standards for airport firefighting. Many airports lag behind current standards. It would he appropriate for airport authorities to review their fire suppression and rescue needs, to produce plans for coordinating the firefighting resources of the airfield and surrounding areas, and to set up capital improvement budgets to bring their firefighting capabilities up to NFPA, FAA, and ICAO standards. **The Commission recommends that airport authorities review their firefighting capabilities and, where necessary, formulate appropriate capital improvement budgets to meet**

current recommended aircraft rescue and firefighting practices. We recognize that a firefighting capability adequate to handle a major disaster is expensive, particularly in terms of manpower, considering the rarity of fire accidents. There are available, however, multiple turret fire vehicles which require smaller crews than the several trucks they replace, and progress is being made in the development of automated apparatus for airport fire safety.

Marine Fire Safety

The position of the Coast Guard in maintaining a high level of marine fire safety is a difficult one. Many factors work against them. Long experience in handling hazardous materials by crews and longshoreman can lead to complacency and carelessness. Pushed by schedules and financial incentives to unload quickly, shippers often fail to use the expertise of chemical tankermen, who are certified by the Coast Guard, or marine chemists, who are certified by the National Fire Protection Association. Since the incentives are often contrary to good fire safety practice, the Coast Guard needs the support of all who can help. Attention should be called to the fact that the Department of Labor has safety responsibilities for the shipbuilders, repairers, and longshoremen. The presence of increasing amounts of high energy fuels and other hazardous substances passing through ports demands special attention. **The Commission recommends that the Department of Transportation undertake a detailed review of the Coast Guard's responsibilities, authority, and standards relating to marine fire safety.**

Railroad Transportation Fire Safety

With 200,000 miles of main track lines, the Nation's rail network is vital to the economy. A fire accident that incapacitates even a small portion of the rail system has an effect far beyond the actual scene of the accident.

An accident can be a local disaster if hazardous materials are involved in the fire. Usually the fault is not with the materials themselves. In January of 1969, 15 exploding tank cars wreaked havoc in Laurel, Miss., all because of a defective wheel on one of the cars. Three weeks after that incident, a misaligned track derailed a train passing through Crete, Nebr., and derailed cars struck a tank car loaded with anhydrous ammonia standing on a siding. Escaping ammonia gas killed six persons and injured 53. In both instances, the cause of the accident was a mechanical failure; the results were thermal and toxic nightmares.

Chronic problems with railroads are fires along rights-of-way, usually started by brake shoe sparks or hot carbon sparks from diesel stacks. In 1970, there were reported 6,645 such fires in or near forest lands; unreported thousands of fires burned grass and croplands.

Responsibility for preventing fire accidents must reside with the railroads themselves. Sound maintenance practices are well known, but often not followed. Rights-of-way should be well-maintained, kept free of flammable materials, and inspected frequently; malfunctioning equipment should be quickly removed from service. **The Commission recommends that the railroads begin a concerted effort to reduce rail-caused fires along the Nation's rail system.** Equipping non-turbo locomotives with exhaust spark arresters, reducing the frequency of mechanical and rail failures, adopting braking procedures and equipment designed to prevent hot brake shoe fragments from spewing, training crews in fire suppression, and providing trains with appropriate fire suppression tools are measures for consideration.

San Francisco's Bay Area Rapid Transit, known as BART, has signaled the beginning of a new era of mass transit construction in the United States. As, these systems are developed, and as existing systems arc modernized, there will be a need to protect the lives of those who must travel through tunnels and over elevated tracks. Tunnels, especially, can be traps: In a Boston subway tunnel fire in February 1973, one person died and more than 100 had to be treated in hospitals, mostly for smoke inhalation.

In a special study in 1970, the National Transportation Safety Board found that no safety conditions were being attached to Urban Mass Transportation Administration grants for rapid Tail transit systems. In support of the Board's findings, **the Commission recommends that the Urban Mass Transportation Administration require explicit fire safety plans as a condition for all grants for rapid transit systems.**