NBS SPECIAL PUBLICATION 416

U. S. DEPARTMENT OF COMMERCE • National Bureau of Standards

ATTACKING THE FIRE PROBLEM

A Plan For ACTION

Center for
Fire Research

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards [1] was established by an act of Congress March 3, 1901. The Bureau's overall goal is to strengthen and advance the Nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the Nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau consists of the Institute for Basic Standards, the Institute for Materials Research, the Institute for Applied Technology, the Institute for Computer Sciences and Technology, and the Office for Information Programs.

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Applied Mathematics — Electricity — Mechanics — Heat — Optical Physics — Nuclear Sciences [2] — Applied Radiation [2] — Quantum Electronics [3] — Electromagnetics [3] — Time and Frequency [3] — Laboratory Astrophysics [3] — Cryogenics [3].

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.
[2] Part of the Center for Radiation Research.
[3] Located at Boulder, Colorado 80302.
[4] Part of the Center for Building Technology.

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THE OFFICE FOR INFORMATION PROGRAMS promotes optimum dissemination and accessibility of scientific information generated within NBS and other agencies of the Federal Government; promotes the development of the National Standard Reference Data System and a system of information analysis centers dealing with the broader aspects of the National Measurement System; provides appropriate services to ensure that the NBS staff has optimum accessibility to the scientific information of the world. The Office consists of the following organizational units:

Office of Standard Reference Data — Office of Information Activities — Office of Technical Publications — Library — Office of International Relations.

Attacking the Fire Problem: A Plan for Action

Kenneth Giles and Pamela Powell, Editors

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Institute for Applied Technology
National Bureau of Standards
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PREFACE

On October 29, 1974, President Ford signed into law the Federal Fire Prevention and Control Act of 1974. This legislation, the direct result of the findings of the President's Commission on Fire Prevention and Control, reflects the Commission's findings that America's fire losses are disgraceful and totally unacceptable to a country whose level of technology and human resources is the highest in the world.

The Congress intended the Federal Fire Prevention and Control Act of 1974 to provide new impetus to solving the Nation's fire problem. Section 18 of the Act provides for the establishment of a Fire Research Center and, accordingly, amends the 1901 Organic Act of the National Bureau of Standards. The Fire Research Center is charged with understanding fundamental processes of fire, including its physics and chemistry; its behavior, spread and growth in buildings; the fire hazards uniquely arising from transportation of combustible fluids and materials; and design concepts for increased fire safety in the built environment. Further, the Congress authorized the Fire Research Center to carry out investigations into the biological, physiological, and psychological factors affecting the victims of fire. In particular, the biological and physiological effects of toxic substances on fire victims, and the psychological and motivational characteristics induced either by fire stress or fire trauma are to be systematically studied for the first time.

Thus, the Congress has created within the National Bureau of Standards a Fire Research Center with a broad mandate for understanding fire and its myriad effects, and for reducing the unconscionable losses which attend it.

Attacking the Fire Problem
A Plan for Action

FIRE SCIENCE

Information & Hazard Analysis

Chemistry

Physics & Dynamics

FIRE SAFETY ENGINEERING

Fire Prevention
- Products

Fire Control
- Furnishings

Fire Control
- Construction

Fire Detection & Control Systems

Design Concepts

Goals

Tools to reduce fire losses by 50%

CONTENTS

Abstract

The mission of the Center for Fire Research is to insure the development of the technical base for the standards and specifications needed in support of the National goal to reduce fire losses by 50% over the next generation. A systems approach to accomplish this mission is described. The Center consists of three basic programs in the area of Fire Science and five applied research programs in the area of Fire Safety Engineering. Each applied program addresses an aspect of the Fire Problem, using fundamental information supplied by the basic research function. Active participation by staff members in voluntary standards organizations is the principal means of making this technology available for codes and standards need to reduce the Nation's fire loss.

Key words: Building design; consumer protection; fire control; fire detection; fire research; fire spread; flammability.

Center for
Fire
Research

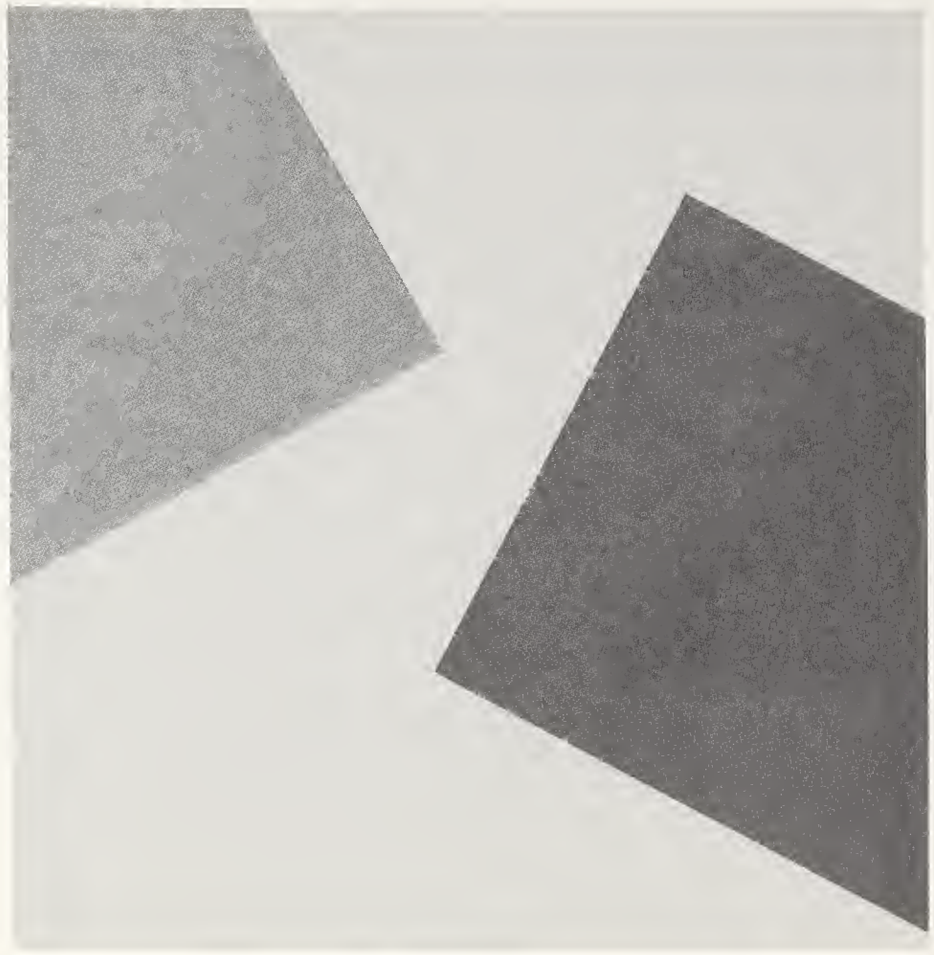
MISSION

ATTACKING THE FIRE PROBLEM

The goal of the
Center for Fire Research
is to insure the development
of the technical base for the
standards and specifications
needed in support of the
National goal to reduce
fire losses by 50%
over the next
generation.

CONFRONTATION:

Attacking the Fire Problem



Unwanted fire reaps a grim toll in the United States. Each year more than twelve thousand of our citizens die in fires and several hundred thousand more suffer serious burn injuries. In addition to this human suffering, property damage drains some eleven billion dollars from our economy. These figures, stark in themselves, are all the more shocking when they are contrasted with figures from other industrialized countries. For example, Japan reports 0.61 fires for each thousand persons as compared to 13.0 for the United States. Japan has 14.2 fire deaths for each million persons vs. 57.1 in the United States. Figures can be recited for several European countries to the same effect. While the statistical basis for these figures is less than perfect, the unfavorable position of the United States seems beyond dispute.

No one knows why our Nation's losses are so great, although some of the very characteristics which make the United States unique may also contribute to the problem. For example, our homes are generally of wood construction, as compared to the stone and concrete commonly used in Western Europe, and they are replete with plush furnishings. Further, there is some correlation between energy consumption and fire incidence. An important social factor is the attitudes people have: in the United States we view fire as a misfortune or an unavoidable accident, while Japan deals with the fact of having a fire as a felony.

Despite the fact that unwanted fires are complex phenomena with cause and effect poorly understood, simplistic solutions abound. Some call for intense public education as the only answer, on the assumption that most fires are caused by people. Others believe that using such devices as automatic sprinklers in all occupancies will solve the Fire Problem. Yet, both of these approaches have their limitations. For example, much of human behavior, especially that of infants, the very old, and the mentally handicapped, is uncontrollable. The victims of this behavior may be other innocent persons, perhaps asleep in neighboring rooms. We must deal with the problem on the assumption that people will, on occasion, be careless and that accidents will happen. Yet, life safety is often endangered well before a fire reaches the detectable threshold for sprinkler systems, however reliable they may be. Therefore, it should be clear that a single remedy for the entire scope of the Fire Problem does not exist or, if it does, it will only be uncovered by further research.

The National Bureau of Standards has been the Nation's fire research laboratory for over five decades;[1] our laboratory facilities for fire research are excellent. The staff cooperates closely with the individuals and groups at home and abroad who are working to decrease fire losses. The fire services, the Congress, various universities, the program on Research Applied to National Needs (RANN) at the National Science Foundation, the National Fire Protection Association, building code officials and voluntary standards organizations share with us the challenge to make our environment safer from the ravages of fire.

We are just now gaining a measure of quantitative understanding of fire phenomena. Fire technology is moving slowly from childhood to adolescence, but it is a long way from being a mature science. Nevertheless, action on fire cannot wait for a total understanding of the appropriate physical and chemical phenomana.[1,2] The world demands, now, criteria and recommended practices for controlling fire hazards. In short, an attack on the problem is needed!

Only a balanced approach will provide interim solutions that are both technically sound and immediately applicable. Fire science--its chemistry and physics--and statistical analysis of fire incidence serve as inputs and guides. Fire safety engineering transforms these inputs into the tools the Nation needs to reduce fire loss. The National Bureau of Standards (NBS) directs the results of all these activities to the agencies and organizations with authority to set standards and specifications.

While the urgency of the Fire Problem cannot be understated, its scope and complexity require that we take a sophisticated systems approach comprised of a balanced attack along a broad front of fire research. The following pages outline that approach and constitute a blueprint for action for the NBS Center for Fire Research.

[1]America's Not for Burning, Nat. Bur. Stand. (U.S.), Dimensions, Vol. 57, No. 11, 264-267 (Nov. 1973), GPO; SD Catalog No. C13.13:57/11; $0.65.

[2]Lyons, J. W., A Look at Fire Research, Nat. Bur. Stand. (U.S.), Dimensions, Vol. 58, No. 6 (June 1974).

Attacking the Fire Problem

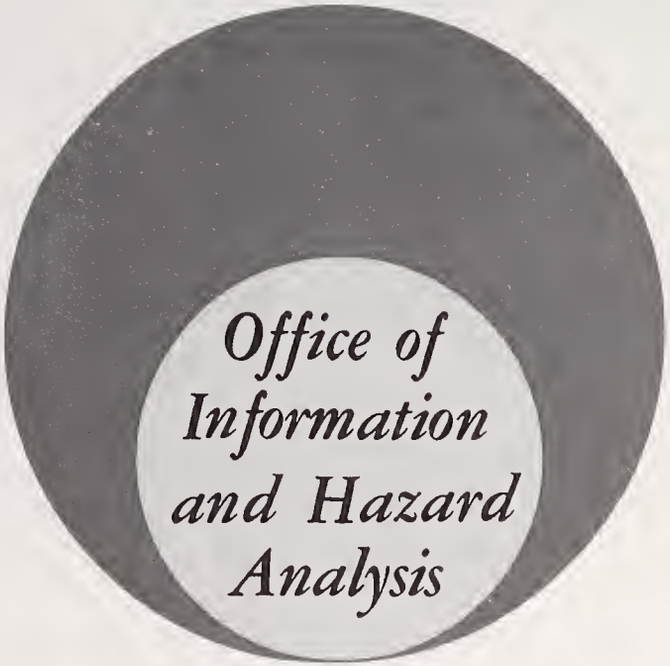
Center for Fire Research

Accidental fire is the result of complex physical phenomena and human action. The first task in a program for loss reduction is understanding each component of an accidental fire.

One begins by collecting and analyzing fire incident data to reveal how fire accidents happen and to spotlight particularly acute problems. This task falls to the Office of Information and Hazard Analysis. Solutions to these problems lie in the fundamental knowledge of fire processes.[3] Broadening our knowledge of flame physics, flame chemistry, and flame retardants is the assignment of the Program for Chemistry and the Program for Physics and Dynamics.

Only when we have an understanding of the physical and human causes of fire incidents can we begin to formulate solutions to the Fire Problem.

[3]Flammability: A New Look at an Age-Old Problem, Nat. Bur. Stand. (U.S.), Vol. 58, No. 6 (June 1974).



Objectives: to characterize national fire hazard and loss . . . to identify problem areas, to provide a detailed knowledge of them, and to establish priorities for action . . . to establish a baseline for measuring program effectiveness . . . to keep in-house staff and others aware of developments in the fire field.

Office of Information and Hazard Analysis

Benjamin Buchbinder, Acting Chief*

Current Activities:

- A survey by the Bureau of the Census to determine the frequency of household fire incidents has recently been conducted under joint sponsorship by NBS and the Consumer Product Safety Commission.
- Through a survey, the possible fire hazard and contribution of curtains and draperies to real-fire situations will be ascertained.
- Contractors study selected fire accidents in detail.
- In-depth hazard analysis studies of selected problems (such as high-rise building fires and fires involving synthetic polymers) are being conducted to identify those aspects of the problem vulnerable to future fire research.
- An analysis of the burn injuries as a function of the physical characteristics of the burning garment and the actions of the victim is being conducted. A documentation of the real-fire hazard of plastics is being conducted to provide guidance in developing fire prevention or fire control tests of various plastic materials.
- A collection of technical documents is being cataloged and indexed by subject and author for ease of retrospective searches.
- Over 2,000 documents have been abstracted, indexed, and entered into the National Aeronautics and Space Administration Aerospace Safety Research and Data Institute (ASRDI) computerized information system.
- NBS is supporting the production of the National Academy of Sciences' Fire Research Abstracts and Reviews, summarizing and disseminating recent achievements to the fire community.

*Henry Tovey, Chief, is on detail to the National Fire Prevention and Control Administration.

OIHA Publications:

1. Buchbinder, L. B., Human Activity Patterns and Injury Severity in Fire Incidents Involving Apparel, J. of Fire & Flammability/ Consumer Products Flammability, Vol. 1, 4-18 (Mar. 1974).
2. Buchbinder, L. B., Human Behavior Patterns vs. Injury Severity for Apparel Fire Victims, Nat. Bur. Stand. (U.S.), NBSIR 74-455, Proceedings of the Seventh Annual Information Council on Fabric Flammability Meeting held in New York, December 5, 1973 (Mar. 1974). NTIS Order No. Com 74-10865; $4.50.
3. Buchbinder, L. B., Study of Relationships Between Activity, Reaction, Garment Parameter Patterns and Injury Severity for Fire Incidents Involving Apparel, Nat. Bur. Stand. (U.S.), NBSIR 73-145 (Apr. 1973), (limited distribution).
4. Jason, N. H., Katz, R. G. and Powell, P. A., Fire Research Publications 1969-1972, Nat. Bur. Stand. (U.S.), NBSIR 73-246 (July 1973), NTIS Order No. COM-74-10989; $4.00.
5. Katz, R. G., United States and Canadian Fabric Flammability Standards, Nat. Bur. Stand. (U.S.), Tech. Note 742 (1973), GPO; SD Catalog No. C13.46:742; $0.60.
6. Kuvshinoff, B., Katz, R. G. and McLeod, S., Directory of Workers in the Fire Field, NASA CR-121149 (Feb. 1973), NTIS Order No. N73-27-954; (not available).
7. Robertson, A. F. and Rappaport, M. W., Fire Extinguishment in Oxygen Enriched Atmospheres, Nat. Bur. Stand. (U.S.), Final Report, Contract NASA C-506273, NASA-CR-121150, NTIS Order No. N73-24926; $5.25.
8. Slater, J. A., Fire Incidents Involving Sleepwear Worn by Children Ages 6-12, Nat. Bur. Stand. (U.S.), Tech. Note 810 (Dec. 1973), GPO; SD Catalog No. C13.46:810; $0.50.
9. Vickers, A. K., Drapery and Curtain Fires--Data Element Summary of Case Histories, Preliminary Report, Nat. Bur. Stand. (U.S.), NBSIR 73-234 (July 1973), NTIS Order No. COM-74-10128; $3.50.
10. Vickers, A. K., Kitchen Ranges in Fabric Fires, Nat. Bur. Stand. (U.S.), Tech. Note 817 (Apr. 1974), GPO; SD Catalog No. C13.46:817; $0.60.

11. Vickers, A. K., Krasny, J. F. and Tovey, H., Some Apparel Fire Hazard Parameters, Nat. Bur. Stand. (U.S.), NBSIR 74-455, Proceedings of the Seventh Annual Information Council on Fabric Flammability Meeting held in New York, December 5, 1973 (Mar. 1974), NTIS Order No. COM 74-10865; $4.50.

12. Slater, J. A., Buchbinder, B. and Tovey, H., Matches and Lighters in Flammable Fabric Incidents: The Magnitude of the Problem, Nat. Bur. Stand. (U.S.), Tech. Note 750 (Dec. 1972), GPO; SD Catalog No. C13.46:750; $0.55.

13. National Fire Data System--System Design Project, Auerbach Associates, Inc., AUER-2080-TR-3 (1973), NTIS Order No. COM-73-10951; $6.00.

14. FFACTS (Flammable Fabrics Accident Case and Testing Systems), Nat. Bur. Stand. (U.S.), Tech. News Bull., Vol. 57, No. 5, 114-116 (May 1973), GPO; SD Catalog No. C13.13:57:/5; $0.65.

15. Fire: Human Action and Reaction, Nat. Bur. Stand. (U.S.), Dimensions, Vol. 57, No. 11, 270-271 (Nov. 1973), GPO; SD Catalog No. C13.13:57:/11; $0.65.

Program for Chemistry

Objectives: to upgrade understanding of the structure and chemical composition of flames and the effect of chemical retardants on flame structure . . . to identify and quantify the evolved smoke and combustion gases . . . and to evaluate the effect of flame retardants on smoke and toxic gas formation.

Program for Chemistry

Clayton Huggett, Chief

Current Activities:

- The structure of typical flames, including flames containing chemical retardants, is being studied experimentally by mass spectrometric techniques and theoretically through thermodynamic calculations.
- Major components in combustion samples are quantitatively determined using gas chromatographic, infrared spectroscopic, and wet chemical techniques. Combustion gas analysis equipment will be improved to monitor components (e.g., hydrogen cyanide) continuously. Correlation of laboratory and full-scale smoke and gas measurements will be made.
- Liaison is maintained with other fire research programs to study flame retardants and other aspects of flame chemistry.
- Contracted research studies chemical kinetics and flame dynamics and develops models of flames and flame inhibition.
- A study of the fire safety aspects of polymeric materials is being jointly sponsored with the National Academy of Sciences.
- Under NBS grants, the University of Pittsburgh and the University of Utah are studying the toxicity of combustion products from plastics.
- Princeton University, under an NBS grant, is modeling the generation of toxic gases by smoldering combustion.
- Charring polymer flame retardant mechanisms are being studied for NBS by the University of California.
- The chemistry and methods of controlling cellulosic fires is researched for NBS by the University of Montana.
- Clemson University is studying flame retardation mechanisms in fabrics for NBS.
- An investigation of hydroxyl radical reactions of fundamental importance to flame initiation and propagation is being carried out at the University of Maryland.
- Johns Hopkins University is conducting a fire fatalities study for NBS.

Program for Chemistry Publications:

1. Birky, M. M., Einhorn, I. N., Seader, J. D., Kanakia, M. D. and Chien, W. P., The Effects of Fire Retardants on the Combustion of Rigid-Urethane Foams, J. of Fire & Flammability/Fire Retardant Chemistry, Vol. 1, 35-55 (Feb. 1974).
2. Birky, M. M., and Yeh, Kwan-nan, Calorimetric Study of Flammable Fabrics, Part 1, Instrumentation and Measurements, J. Appl. Polymer Sci., Vol. 17, 239-253 (Jan. 1973).
3. Chien, W. P., Seader, J. D. and Birky, M. M., Monitoring Weight Loss in an NBS Smoke Density Chamber, Fire Technology, Vol. 9, No. 4, 285-298 (Nov. 1973).
4. Hastie, J. W., Mass Spectrometric Studies of Flame Inhibition: Analysis of Antimony Trihalides in Flames, Combustion and Flame, Vol. 21, 49-54 (1973).
5. Hastie, J. W., Molecular Basis of Flame Inhibition, Nat. Bur. Stand. (U.S.), J. of Research, Vol. 17A, No. 6, 733-754 (Nov.-Dec. 1973).
6. Huggett, C., Habitable Atmospheres which do not Support Combustion, Combustion and Flame, Vol. 20, No. 1, 140-142 (Feb. 1973).
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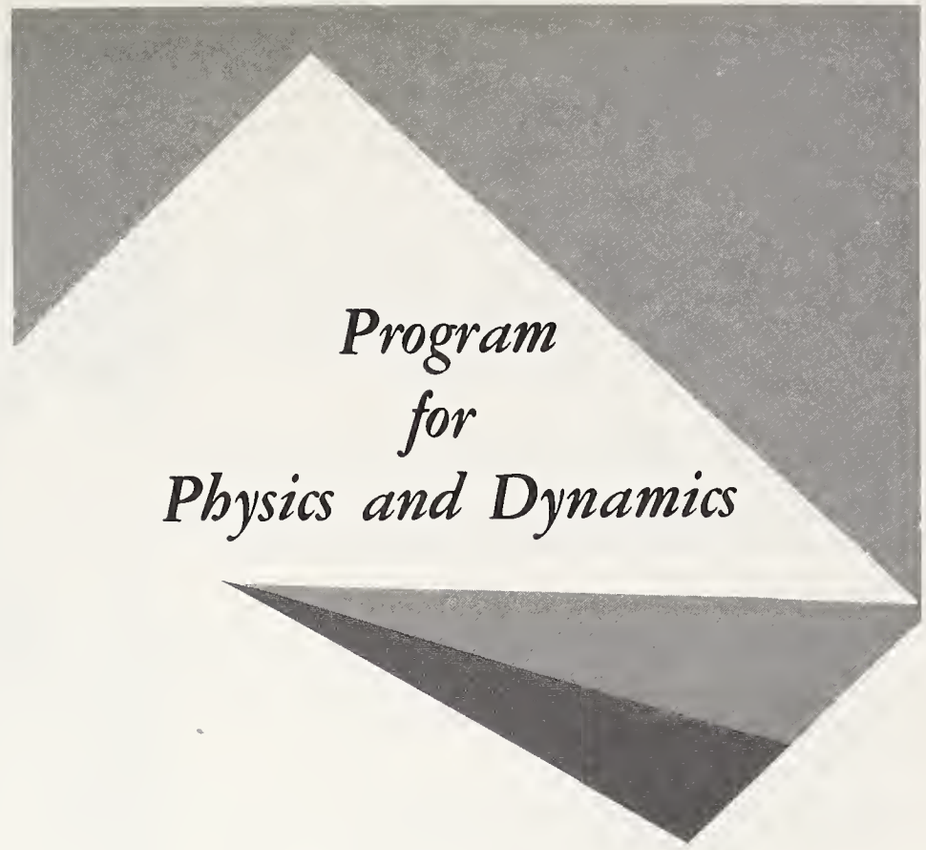
8. Robertson, A. F., Tests Indicate Venting Increases Smoke From Some Polymerics, Fire Engineering, Vol. 126, No. 9, 97-98 (Sept. 1973).
9. Yeh, Kwan-nan, Birky, M. M. and Huggett, C., Calorimetric Study of Flammable Fabrics, Part 2, Analysis of Flame Retardant Treated Cotton, J. Appl. Polymer Sci., Vol. 17, 255-268 (Jan. 1973).



Program for Physics and Dynamics

Objectives: to analyze ignition, fire spread, and hot gas circulation . . . to determine the dominant controlling mechanisms of fire phenomena, and to relate them to fire hazard test results . . . to analyze the characteristics and dynamics of smoke aerosols as a fire indicator and hazard.

Program for Physics and Dynamics

John Rockett, Acting Chief

Current Activities:

- A model corridor test facility is being used to investigate the use of partial scaling relationships in simulating full-scale corridor fire spread over flooring materials.
- A mathematical model of ignition phenomena has been constructed which successfully predicts ignitable boundaries of various solid fuels under various environmental conditions.
- Preliminary measurements are being made of the aerosols and gaseous products given off in the early stages of a smoldering upholstery fire.
- Contractors are working to develop mathematical models of fire under a variety of conditions.
- Under an NBS grant, the Massachusetts Institute of Technology studies the physical and chemical kinetic models of flame propagation and inhibition.

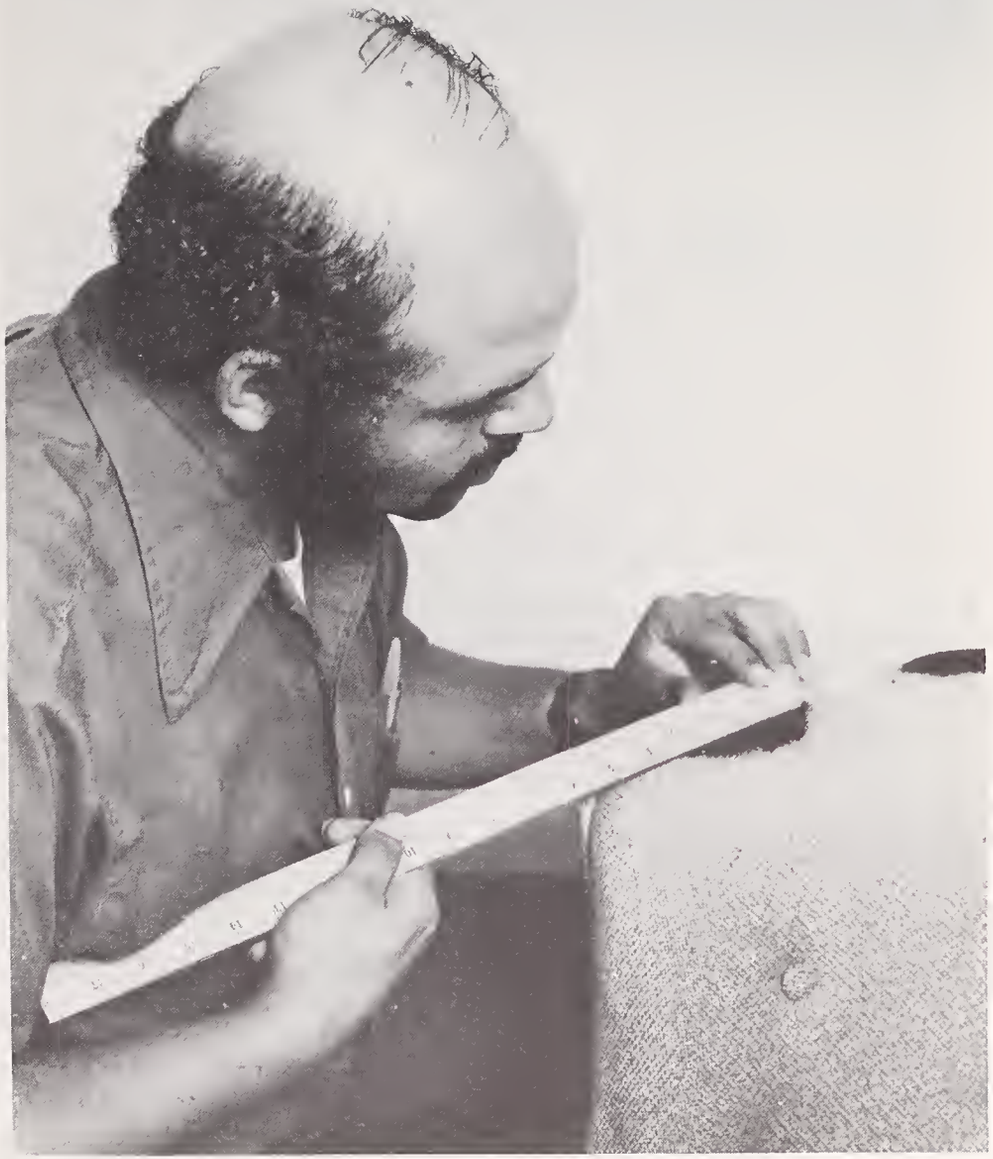
Physics and Dynamics Publications:

1. Denyes, W. and Raines, J. W., A Model Corridor for the Study of the Flammability of Floor Coverings, Final Report, Nat. Bur. Stand. (U.S.), NBSIR 73-200 (May 1973).
2. Denyes, W. and Quintiere, J., Experimental and Analytical Studies of Floor Covering Flammability with a Model Corridor, Final Report, Nat. Bur. Stand. (U.S.), NBSIR 73-199 (May 1973), NTIS Order No. COM-74-10129; $8.00.
3. Denyes, W. and Quintiere, J., Experimental and Analytical Studies of Floor Covering Flammability with a Model Corridor, J. of Fire & Flammability/Consumer Products Flammability, Vol. 1, 32-109 (Mar. 1974).

Attacking the Fire Problem

Center for Fire Research

Fire Safety Engineering addresses the solution of real-life fire problems. Progress in these problem areas generally depends on the use of new fundamental knowledge, particularly that generated by the NBS Fire Science Programs. Improved laboratory test methods, procedures, and recommended practices for products and construction assemblies are the results of the Programs for Fire Prevention--Products, Fire Control--Furnishings, Fire Control--Construction, Fire Detection and Control Systems, and the Program for Design Concepts.



Program for Fire Prevention

• Products

Objective: to develop and recommend standards or other regulations to control fire safety aspects of consumer products, particularly in support of the Consumer Product Safety Commission.

Program for Fire Prevention--Products

James Winger, Chief

Current Activities:

- Flammability test method development and other work on upholstered furniture proceed. Technical support documents for standards are being prepared.
- To determine whether standards are necessary, flammability studies are being conducted on wearing apparel.
- Contractors study the effects of seams, garment construction, fabric weight, laundering, and other variables on fabric flammability.
- The Textile Research Institute, under NBS contract, studies the flammability and combustion behavior of textiles.
- For NBS, the University of Maryland is investigating ease of extinguishment as a measure of flammability hazard.
- The effect of dry cleaning on flame retardant fabrics is being studied.

Fire Prevention--Products Publications:

1. Craw, A. R., Analyses for Decision in the Office of Flammable Fabrics: The Level of the Standard, Status Report, Nat. Bur. Stand. (U.S.), NBSIR 73-182 (Apr. 1973), NTIS Order No. COM-73-11284; $6.75.
2. Krasny, J. F., Abstracts of Papers on Testing and Analysis of Flammable Fabrics from October 1972 to October 1973, Nat. Bur. Stand. (U.S.), NBSIR 74-455 (Mar. 1974), NTIS Order No. COM-74-10865; $4.50.
3. Mandel, J., Steel, M. N. and Sharman, L. J., National Bureau of Standards Analysis of the ASTM Interlaboratory Study of DOC/FF 3-71 Flammability of Children's Sleepwear, ASTM Standardization News, Vol. 1, No. 5, 9-12 (May 1973).
4. NBS Promoting Use and Development of Fire-safe Clothing, Nat. Bur. Stand. (U.S.), Dimensions, Vol. 57, No. 11, 268-269 (Nov. 1973), GPO; SD Catalog No. C13.13:57/11; $0.65.
5. NBS Seeking "Child-Proof" Matches, Nat. Bur. Stand. (U.S.), Tech. News Bull., Vol. 57, No. 6, 134 (June 1973), GPO; SD Catalog No. C13.13:57/6; $0.65.
6. New Kitchen Range Standards, Nat. Bur. Stand. (U.S.), Tech. News Bull., Vol. 57, No. 4, 88-90 (Apr. 1973), GPO; SD Catalog No. C13.13:57/4; $0.65.

Objective: to characterize the fire hazards of interior furnishings and to develop test methods for their control.

Program for Fire Control--Furnishings

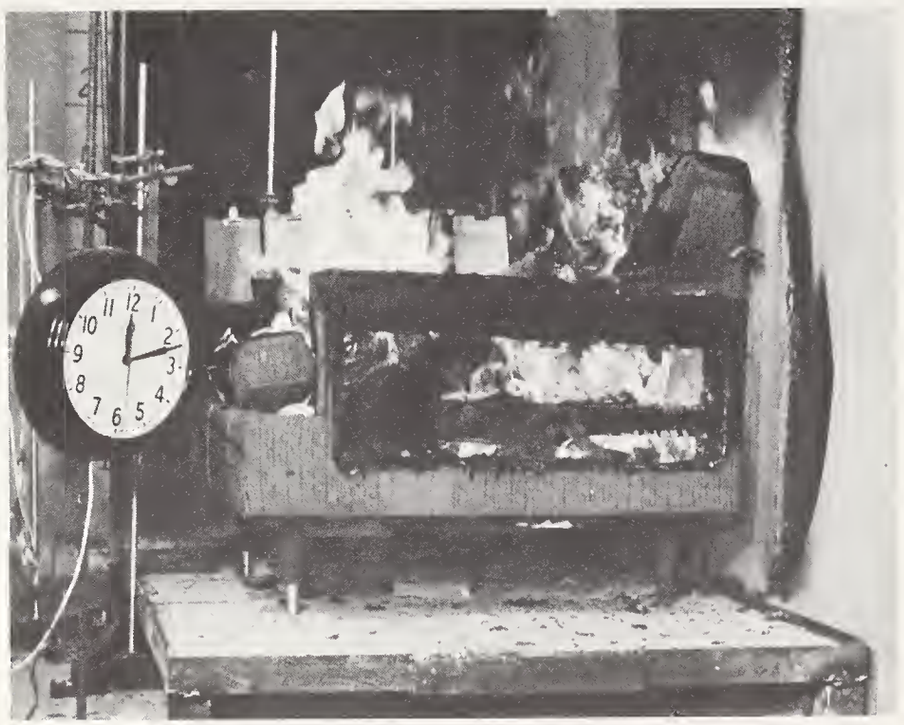
Sanford Davis, Acting Chief

Current Activities:

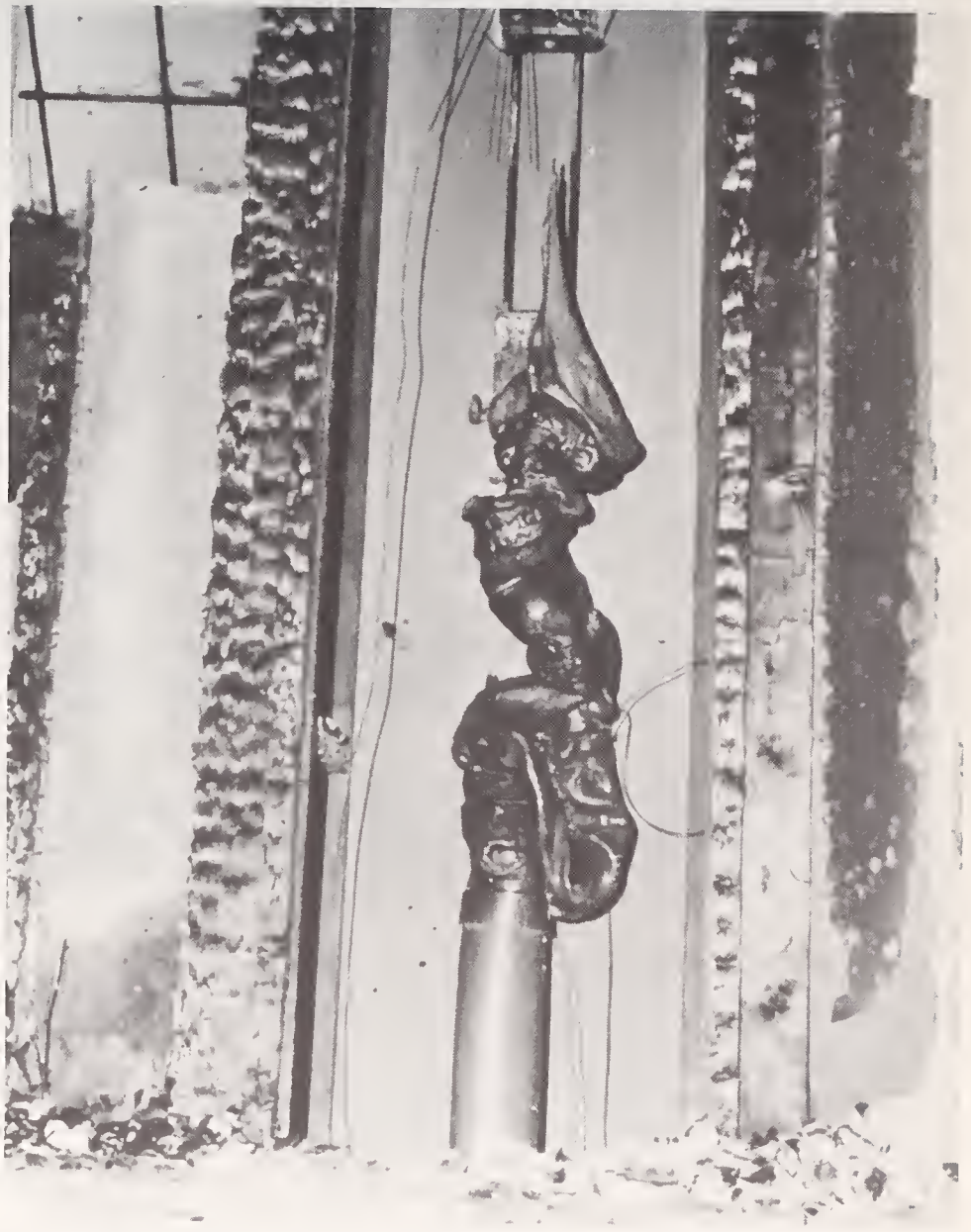
- The Society of the Plastics Industry is providing support to study the hazard of flexible foam underlayment for carpets and the general hazard of plastics in furnishings.
- Full-scale fires of flooring materials are being studied to determine the factors promoting flame spread and to quantitatively evaluate these effects where possible.
- The flammability of interior furnishings is studied. Improved test methods to measure the smoke and gas hazard of interior furnishings will be developed.
- With NBS support, the University of California is studying the fire safety of furniture.
- A market study of the anticipated future uses of plastics in furniture has been recently conducted to determine which plastics should be used in NBS tests.
- A floor covering flammability test method using a radiant panel is being developed for submission to standardizing bodies for use in codes and product standards.

Fire Control--Furnishings Publications:

1. Huggett, C., Carpet Flammability and the NBS Corridor Fire Program, ASTM Standardization News, Vol. 1, No. 5, 16-20 (May 1973).
2. Lee, T. G. and Huggett, C., Interlaboratory Evaluation of the Tunnel Test (ASTM E84) Applied to Floor Coverings, Final Report, Nat. Bur. Stand. (U.S.), NBSIR 73-125 (Mar. 1973), NTIS Order No. COM-73-11189; $3.50.



Program for • Fire Control Construction



Objective: to study the flammability characteristics and fire performance of construction materials and assemblies . . . to develop test methods for various building components . . . to develop models to predict the course of fire in buildings.

Program for Fire Control--Construction

Daniel Gross, Acting Chief

Current Activities:

- The fire endurance of structural wall, floor/ceiling, and column assemblies is being studied for application in buildings.
- Fire growth is being studied in interior finishes in residential occupancies; the fire behavior of plastic pipe as a component of structures, ducts, and flexible connectors is being determined.
- The flammability characteristics of wood, plastic and other construction materials are being studied for application in buildings.
- Mathematical models are being developed to estimate the fire resistance of composite walls and to predict the structural effects of fire in buildings.
- Fire loads are being surveyed to update basic data for codes.
- The smoke density chamber test is being used for new research applications.
- A versatile flame spread test is being developed.
- Methodology is being developed for establishing and evaluating new fire test methods dealing with ease of ignition and flame spread.
- Fire growth and spread in mobile homes are being studied.
- A program analyzing the characteristics of smoke generated in simple room fires is being proposed.
- The development of analytic methods for estimating the thermal restraint forces in concrete floor and roof assemblies is carried out by the Portland Cement Association for NBS.
- An experimental study for environment and heat transfer in a room fire is being conducted at the California Institute of Technology.
- Princeton University is conducting a study, "Fire Safety in Building Design and Urban Planning: A Social, Economic, and Technical Approach," for NBS.
- Realistic thermal restraint during fire tests of floor and roof assemblies is being simulated for NBS by the Portland Cement Association.
- Stanford Research Institute is conducting an analysis of the American Society of Testing and Materials (ASTM) E119 Fire Test and is also conducting a study, "Characterization of the SRI Large Scale Heat Release Rate Calorimeter."

Fire Control--Construction Publications:

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2. Ferguson, J. B., Summary of Flame Spread and Smoke Generation Tests Conducted for OPERATION BREAKTHROUGH, Final Report, Nat. Bur. Stand. (U.S.), NBSIR 73-228 (July 1973), NTIS Order No. PB 222425; $3.00.
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4. Issen, L. A., Report of Fire Test on Flexible Connectors in HVAC Systems, Final Report, Nat. Bur. Stand. (U.S.), NBSIR 73-267 (July 1973), NTIS Order No. COM-73-11955; $3.50.
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9. Shoub, H. and Son, B. C., Fire Endurance Tests of Plywood on Steel Joist Floor Assemblies, With and Without Ceiling, Test Numbers 492-497, Final Report, Nat. Bur. Stand. (U.S.), NBSIR 73-141 (Mar. 1973), NTIS Order No. COM-73-10841; $3.00.

10. Son, B. C., Fire Endurance Test of a Fiber Glass Reinforced Polyester Double Wall Assembly, Final Report, Nat. Bur. Stand. (U.S.), NBSIR 73-168 (Apr. 1973), NTIS Order No. COM-73-10838; PB-221184; $3.00.

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12. Son, B. C., Fire Endurance Test of a Steel Sandwich Panel Floor Construction, Final Report, Nat. Bur. Stand. (U.S.), NBSIR 73-164, NTIS Order No. COM-73-10843; PB-22.642; $3.00.

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Program for Fire Detection and Control Systems

Objective: to develop performance specifications for residential smoke detection devices and systems . . .to develop design requirements for automatic fire suppression systems . . . to develop methods to measure smoke movement in buildings.

Program for Fire Detection and Control Systems

Richard Bright, Acting Chief

Current Activities:

- Laboratory performance tests are being conducted on smoke detectors to outline requirements to be included in future standards.
- Patterns of heat flow in corridors and water flow rates are being studied to determine the most effective types of sprinklers for various fires.
- A design model is being developed to allow a rational base for corridor sprinkler protection.
- Performance specifications are being prepared for smoke detection devices to assure consistent quality of detectors available to the consumer.
- A computer analysis for modeling smoke movement in buildings is being developed and will be used in conjunction with an NBS-developed gas tracer technique to depict smoke movement.
- Under NBS contract, Integrated Systems is carrying out simulation studies on air movement and smoke diffusion.
- Factory Mutual Research Corporation is conducting a study of residental sprinkler protection for NBS.
- The Illinois Institute of Technology Research Institute studies detector sensitivity and siting requirements for dwellings, under NBS contract.
- "Smoke as a Determinant of Human Behavior in Fire Situations," is studied at the University of Maryland for NBS.

Fire Detection and Control Systems Publications:

1. Fung, F. C. W., Evaluation of a Pressurized Stairwell Smoke Control System for a 12 Story Apartment Building, Final Report, Nat. Bur. Stand. (U.S.), NBSIR 73-277 (June 1973), NTIS Order No. PB-225278; $3.50.
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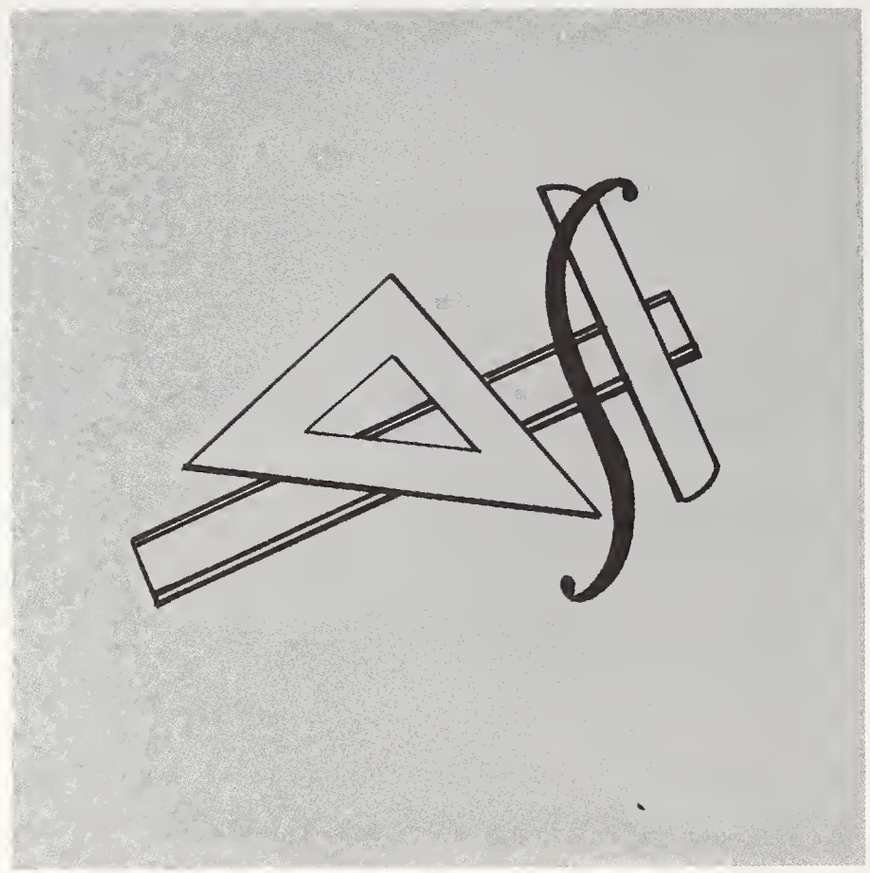
Program for Design Concepts

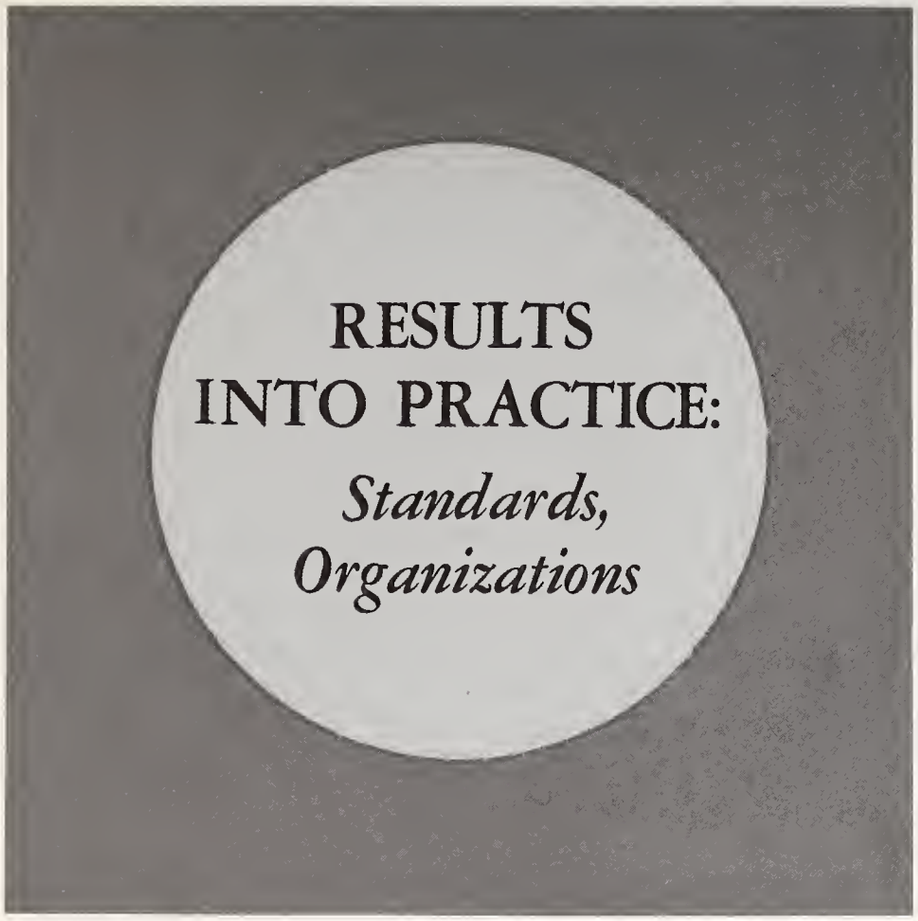


Program for Design Concepts

Harold Nelson, Chief

Current Activities:

- Studies, research, and tests are being conducted to develop a scientific base of knowledge of fire safety for rational approaches to life safety in institutional and similar occupancies.
- A decision analysis study is underway to qualify and quantify hazard-producing and hazard-controlling elements to establish a logic mechanism to achieve optimum safety effectiveness, cost effectiveness, and design flexibility.
- Tests, analyses, and studies are being conducted to improve the ability to predict probable growth rates and ultimate severities of fires in rooms and the impact of these on various types of materials, furnishings, finishes, and arrangements.
- Studies are underway to find recurrent patterns of behavior for individuals and groups which can be used in the development of regulations or which can provide guidance in building design.
- Studies are being undertaken involving human factor laboratory investigations and other studies to determine means and methods of emergency alarm and communication devices, systems, and methodologies.
- Studies are being made of fire and smoke detection systems to improve design data and engineering criteria for the placement and use of detectors and associated devices, particularly in institutional occupancies.
- Tests and evaluations are included to determine the most practical, reliable, and effective means to control smoke movement in both small and large structures.
- Tests and studies are being conducted to cover all aspects of design, usage, capabilities, and cost optimization of automatic sprinkler installations in low hazard occupancies such as hospital rooms, school rooms, or offices.



Attacking the Fire Problem

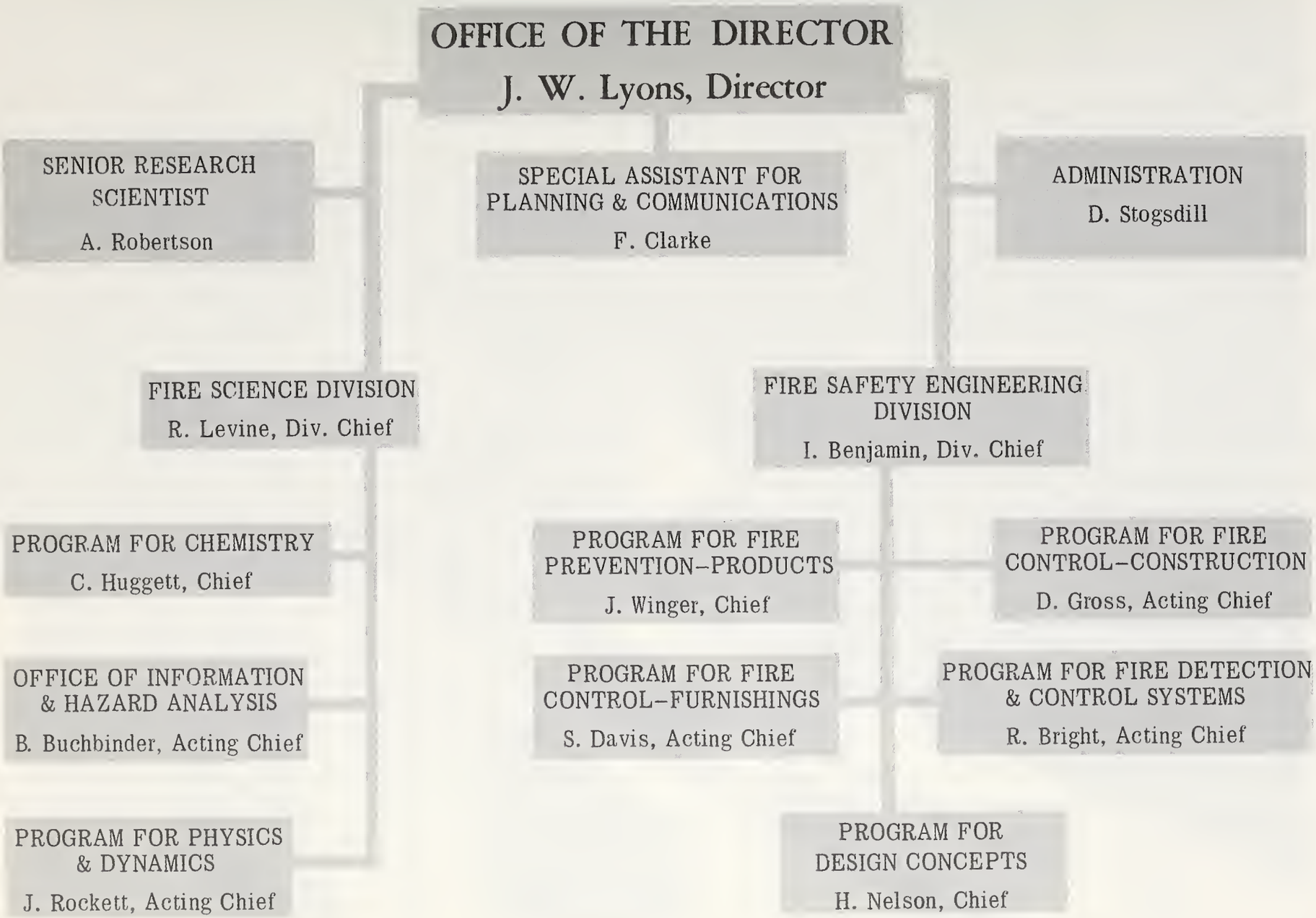
Center for Fire Research

The technical output of the Center for Fire Research must enter the general community to be effective. Standards are the principal mechanism for moving from the laboratory to the public. Thus, cooperation between technical staff and standards-making organizations is essential to insure the wide application of our research. A list of technical committee appointments is given in Appendix B.

APPENDICES

Center for Fire Research

APPENDIX A



APPENDIX B

Staff Participation in Voluntary Standards Organizations

National Fire Protection Association Committee on:

Fire Test (Floor Coverings Subcommittee)	Clayton M. Huggett
Fire Test (Furniture Flammability)	Clayton M. Huggett
Fire Hazards in Oxygen-Enriched Atmospheres	Clayton M. Huggett
Dwelling Fire Prevention and Protection	Richard G. Bright
High-Rise Committee	Irwin A. Benjamin
Home Fire Warning Systems	Richard G. Bright
Sprinkler Committee	Richard L. P. Custer
Safety to Life	Irwin A. Benjamin
Safety to Life (Means of Egress Subcommittee)	Irwin A. Benjamin
Air Conditioning	Irwin A. Benjamin
Sectional Committee on Detection Devices	Richard G. Bright
Electronic Computer System	Richard G. Bright
Committee on Fire Test Methods	Alex F. Robertson
Committee on Static Electricity	Alex F. Robertson
Committee on Aviation Fire Safety	Alex F. Robertson
Committee on Records Protection	Harold E. Nelson

American Society For Testing and Materials

Committee E-5 Fire Tests of Materials and Construction General Committee	Irwin A. Benjamin Lionel A. Issen Alex F. Robertson
5.01 Construction Assemblies Subcommittee	Irwin A. Benjamin Alex F. Robertson
5.02 Smoke and Toxicity Subcommittee	Alex F. Robertson
5.03 Protection of Openings Subcommittee	Irwin A. Benjamin Alex F. Robertson
5.04 Surface Burning Subcommittee	Daniel Gross
5.10 Research Subcommittee	Alex F. Robertson
5.91 Editorial Subcommittee	Daniel Gross
5.92 International Standards Subcommittee	Irwin A. Benjamin Alex F. Robertson
5.93 Guide Criteria for Fire Test Methods Subcommittee	Irwin A. Benjamin
Committee E-39 Fire Hazard Standards	John W. Lyons
39.1000 Planning and Research Subcommittee	John W. Lyons
39.3004 Recommended Practices Subcommittee	Irwin A. Benjamin

Committee F-12 Security Systems and Equipment	George Sinnott
Committee D-13 Textile Materials	James Winger
Committee D-20 Thermal Properties of Plastics	Leslie Breden
International Standards Organization (ISO)	
Technical Committee 92 Fire Tests on Building Materials and Structures	
Working Group 2 Testing Methods	Irwin A. Benjamin
Working Group 3 Doors and Shutters	Alex F. Robertson
Working Group 4 Reaction to Fire Tests	Irwin A. Benjamin
Working Group 7 Coordination and Correlation of Fire Tests	Irwin A. Benjamin
Working Group 10 Instrumentation	Alex F. Robertson
Working Group 11 Fire Endurance	Alex F. Robertson
Building Research Advisory Board/Federal Construction Council	
Fire Protection/Systems Engineering Committee	
Task Group 57 Qualitative Evaluations	Daniel Gross
Task Group on Federal Fire Standards	Harold E. Nelson
Federal Fire Council	
Design Standards Committee	Daniel Gross
Subcommittee on Air-Handling	
American National Standards Institute	
Committee A9 Building Exits Code	Richard G. Bright
Committee Z39 Library Work, Documentation, and Related Publishing Practices	Henry Tovey
International Conference on Building Officers	
Fire and Life Safety Subcommittee	Irwin A. Benjamin
American Concrete Institute	
Committee 216 Fire Resistance and Fire Protection of Structures	Lionel A. Issen
Intergovernmental Maritime Consultative Organization	
Subcommittee on Fire Tests	Alex F. Robertson
American Survey of Information Science	
Special Group of Technical Information Centers	Henry Tovey

American Chemical Society

Chemical Literature Division Programs	Henry Tovey
Cellulose, Wood and Fiber Chemistry Division	Henry Tovey

American Association of Textile Chemists and Colorists

Flammability and Fire Resistance Committee	Henry Tovey
Correlation of Laboratory Tests with End Use Performance Committee	Henry Tovey
Laundering Technology Committee	Henry Tovey

Information Council on Fabric Flammability

Injury Statistics Committee	Henry Tovey
Research Committee	Henry Tovey

American Apparel Manufacturers Association

Apparel Products Flammability Committee	Henry Tovey

Society of Fire Protection Engineers

Committee on the Measurement of Fire Phenomena	Harold E. Nelson

International Committee on Planning and Design of Tall Buildings

Task Group on Fire and Blast	Harold E. Nelson

APPENDIX C

Measures of Success – Accomplishments in FY 1974

Information and Hazard Analysis:

- Completed design concept for National Fire Data System to give first national fire loss picture.
- Under NBS and Consumer Product Safety Commission sponsorship, Bureau of the Census conducted pretests and completed first series of the National Survey of Fire Experience.
- Began implementation of pilot system for National Fire Incident System, drawing on fire department data sources.

Chemistry:

- Built and used apparatus to continuously monitor HCN in combustion gases.
- Designed and built device to measure rate of heat release from fabrics.
- Developed techniques to study new flame species which may be active in flame retardancy of polymers which should enable design of safer polymers.
- Built prototype system measuring flash fire potential of aircraft interior materials.

Fire Prevention--Products:

- Standard for the Flammability of Mattresses in effect.
- Standard for the Flammability of Children's Sleepwear, sizes 7-14, drafted by NBS, published by Consumer Product Safety Commission.
- Proposed sampling plan for Standard for the Surface Flammability of Carpets and Rugs published.
- Sampling plan for Standard for the Surface Flammability of Small Carpets and Rugs published.
- Completed development of a test method for upholstered furniture. Began inter-laboratory evaluation of upholstered furniture flammability test.

Fire Control--Furnishings:

- Developed model predicting flame spread over the surface of floor coverings.
- Developed test method, now being adopted by industry, for flame spread over carpet surfaces for use in high risk occupancies.

Fire Control--Construction:

- Completed construction of large-scale fire testing facility, Building 205.
- Measured flame spread, ease of ignition, and heat release for a variety of interior finish materials.
- Developed computer program predicting fire resistance of prestressed concrete.
- Completed test series on plastic pipe used in plumbing, showing how to reduce hazards by proper installation.

Fire Detection and Control Systems:

- Smoke detector designs of a number of manufacturers modified as a result of NBS recommendations.
- Conducted computer simulations on effect of stairwell door openings and windows on smoke movement.
- Prepared section of NFPA Life Safety Code on design criteria for smokeproof towers.
- Determined technical feasibility of coupling fast-acting detectors and sprinklers to protect nursing home patients from bedding fires.
- Studied smoke movement in VA hospitals.
- Completed first definitive state-of-the-art evaluation of detection systems.

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The mission of the Center for Fire Research is to insure the development of the technical base for the standards and specifications needed in support of the National goal to reduce fire losses by 50% over the next generation. A systems approach to accomplish this mission is described. The Center consists of three basic programs in the area of Fire Science and five applied research programs in the area of Fire Safety Engineering. Each applied program addresses an aspect of the Fire Problem, using fundamental information supplied by the basic research function. Active participation by staff members in voluntary standards organizations is the principal means of making this technology available for codes and standards needed to reduce the Nation's fire loss.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)* Building design; consumer protection; fire control, fire detection; fire research; fire spread; flammability.

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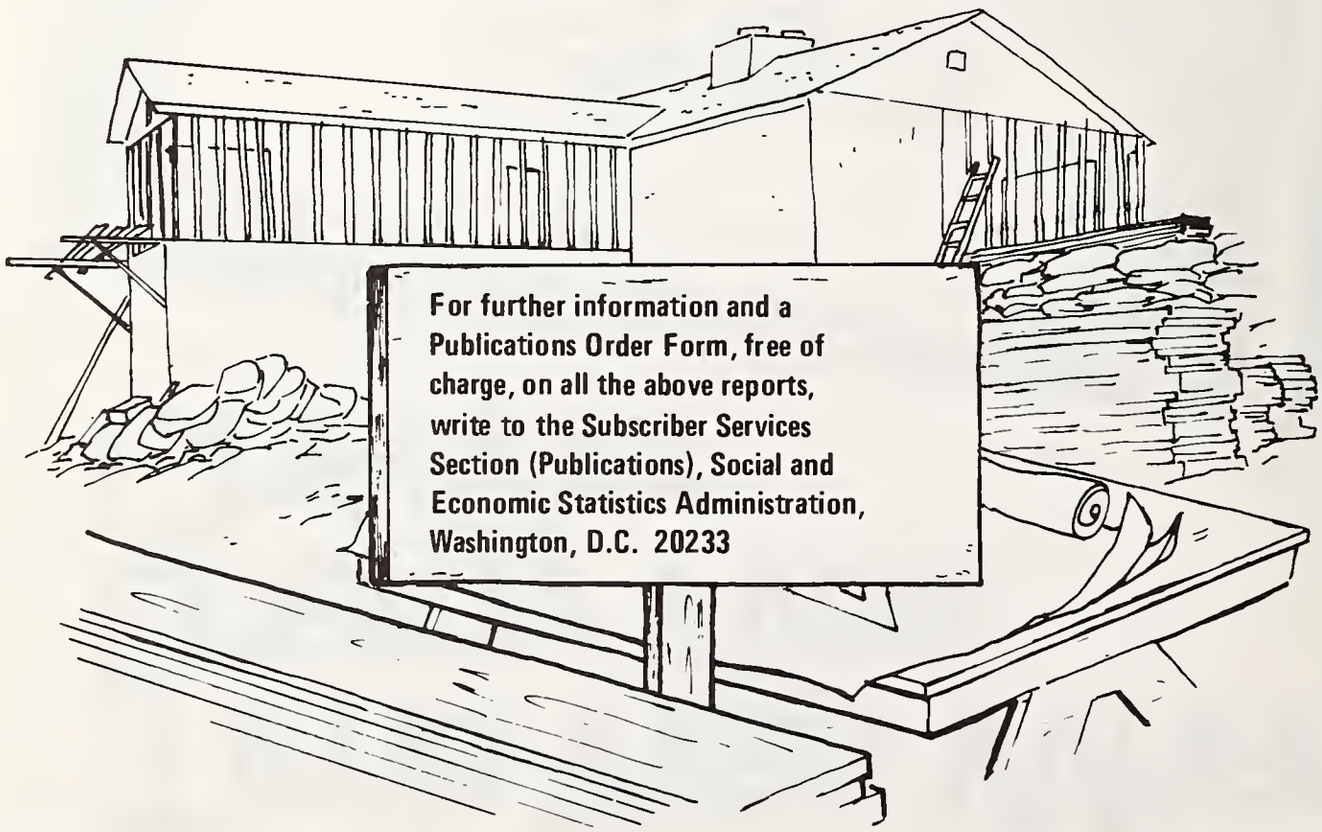

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