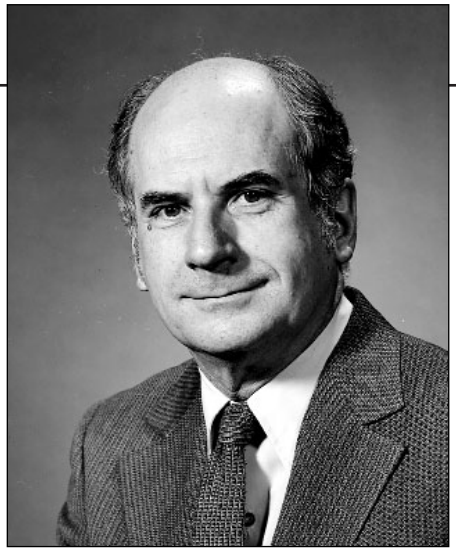
4. CENTER FOR FIRE RESEARCH IN THE 80s

4.1 OVERVIEW

The decade saw the Center for Fire Research survive repeated attempts at its elimination by the Administration. Subsequent budget reductions resulted in staff reductions and a refocusing of the technical program over the period.

The 1974 legislation establishing the Center for Fire Research and the National Fire Prevention and Control Administration (FPCA) in the Department of Commerce called for directly appropriated funding. In 1978 FPCA became the United States Fire Administration (USFA), which was transferred to the newly formed Federal Emergency Management Administration. At the start of FY 1981 almost 72 per cent of the $5.7 million appropriation for the Center for Fire Research came through USFA and the rest came from NBS. Reimbursable funding totaled $3.1 million. In 1982 CFR faced a major financial problem caused by FEMA's proposal to eliminate financial support for CFR for the year 1982 and beyond. After much discussion among the agencies, the White House and with Congress the funding was restored for 1982 and transferred to the NBS budget for 1983. In 1983 the Administration again decided to eliminate CFR. After widespread private sector support accompanied by strong Congressional support, funding was approved for fiscal year 1984. However, Administration efforts to eliminate or severely reduce CFR continued for six more years. Accompanying these budget reduction proposals were proposals to combine CFR with the Center for Building Technology. 1990 was the last year for separate centers for fire research and building technology. Congress authorized their merger in June 1990, and the successor Building and Fire Research Laboratory began to operate at the start of fiscal year 1991.

In 1981 CFR had a staff of 100 directed by Fredrick Clarke. In the summer of 1981 Fred Clarke and Irwin Benjamin, chief of the Fire Safety Engineering Division resigned to form a consulting company, Benjamin Clarke Associates. Clark and Benjamin were replaced by Jack Snell and Andrew Fowell respectively. CFR was then reorganized, with Clayton Huggett continuing as deputy director. Robert Levine headed the Office of Fire Research Resources, Richard



Clayton Huggett, Deputy Director, CFR

Gann became chief of the Fire Measurement and Research Division and Andrew Fowell became chief of the Fire Safety Technology Division. By 1984 the staff had increased to 108 people, with an additional 22 research associates from industry. However, the repeated budget reductions reduced the federal staff to 90 in 1985. Staff remained at about this level for the rest of the 1980s.

Early in the decade the technical program was re directed to address smoke hazards, fire modeling and fire model validation, fire growth and extinction, fire toxicology, and exploratory fire research. The Center continued its fire research grants program supporting research at a number of the country's top universities and research organizations.

Technical products produced by the Center included: HAZARD I, a computer program based on zone fire modeling; a smoke control design manual; a fire safety evaluation system to support the National Fire Protection Association's Life Safety Code; a guide for the safe installation of solid fuel heaters and chimneys; safety guidelines for Navy fire fighter trainers; guidelines for combustion of oil spills at sea and the suppression of oil and gas well fires; and a computerized data base of research documents relating to fire. The decade also saw the commercialization of the Cone Calorimeter, a device developed in the Center for measuring the heat release of materials. Heat release is a key input to fire growth models.

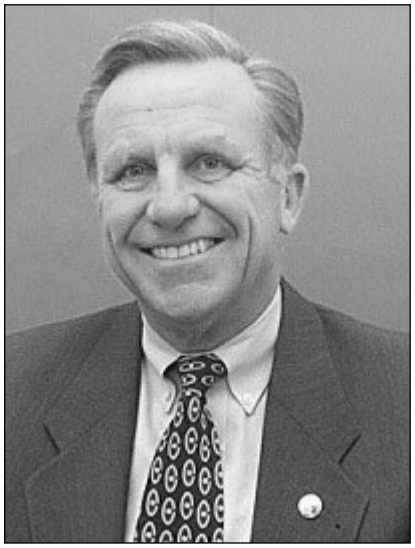
New legislation included the Cigarette Safety Act of 1984, and the Fire Safe Cigarette Act of 1990. The Center carried out a number of fire investigations including the MGM Grand Hotel in Las Vegas, and the DuPont Plaza Hotel in Puerto Rico.

4.2 1981

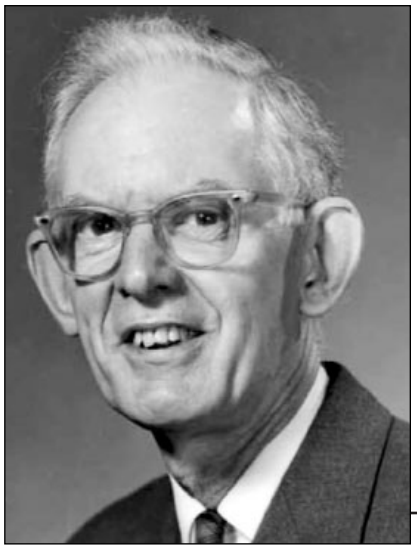
1981 witnessed a change in management and reorganization of the Center for Fire Research. At the beginning of the year Fredrick Clarke was director and Clayton Huggett, deputy director. Huggett was revered as a skillful scientist and manager. The management team was composed of Richard Gann, head, Exploratory Fire Research, Robert Levin, chief, Fire Research Resources Division, Irwin Benjamin, chief Fire Safety Engineering Division, and James Winger, chief Fire Performance Evaluation Division. At the end of 1981 Clarke and Benjamin resigned to form their own consulting company, Benjamin Clarke Associates. Jack Snell, who had been director of the Office of Energy Conservation in the National Engineering Laboratory became the new director. Richard Gann became chief of the new Fire Research Division. Gann's insightful and incisive research and management of programs and people contributed greatly to CFR and BFRL. Andrew Fowell became Chief of the Fire Safety Technology Division. He joined CFR after serving as chief of the Product Performance Engineering Division in the Center for Consumer Product Technology. He worked very effectively externally to the Center to obtain support for research and implementation of its results. Robert Levine became chief of the Office of Fire Research Resources, which directed the Fire Grants program. The total staff numbered 100 and funding totaled $8.8 million. Appropriated funding came from NBS ($1.6 million), and the U.S. Fire Administration ($4.1 million). Reimbursable funds amounted to $3.1 million.

The scientific and technical work of the Center continued to move toward the prediction of fire growth through fire modeling, the development of accurate test methods for fire data collection and the development of practical tools for use by fire safety engineers. The Department of Commerce Silver Medal was awarded to Howard Baum and Ronald Rehm for outstanding progress in developing the large eddy simulation model for fire-driven flows. They and their colleagues also published a number of papers on the development of the method. William Parker published Calculations of the

Richard Gann, Chief, Fire Research Division.



(top) Andrew Fowell, Chief of the Fire Safety Technology Division.
(bottom) Alexander Robertson recipient of ASTM's Award of Merit and Rank of Fellow



Heat Release Rate by Oxygen Consumption for Various Applications, NBSIR 81-2427, which became the basis for the development and worldwide use of the cone calorimeter for measurement of materials' potential contributions to fires. The Fire Safety Evaluation System, a cost-effective approach to achieving fire safety in health care facilities and other occupancies, was adopted by the National Fire Protection Association into the Life Safety Code. The system was developed by Harold Nelson. CFR and the American Iron and Steel Institute constructed a large scale steel building frame, representative of the mid height of a twenty story office building, and measured its response to a severe fire. The results were made available for the testing of computer simulations for structural fire endurance that would become the basis for more rational design of fire resistant steel structures.

In cooperation with the U.S. Fire Administration and the National Fire Protection Association, CFR investigated the fire at the MGM Grand Hotel in Las Vegas, NV. Deaths remote from the actual fire illustrated the hazard of combustion products and the documentation of the fire provided basis for evaluating models for movement of smoke and combustion products in large buildings.

Alexander Robertson received the Award of Merit from ASTM and the rank of Fellow in ASTM in recognition of 25 years of leadership in the development and advancement of national and international standardization of fire test methods for materials, building products and construction assemblies.

4.3 1982

The new long-range plan for CFR expressed its goal more succinctly: *To provide the scientific and technical basis for reducing fire losses and the costs of fire protection by 50 percent.*

The technical program strategy was:

1. To promote the continued advance of fire science.
2. To promote the development and widespread use of scientifically based fire protection engineering practices.
3. To provide technical support for timely resolution of major fire-safety issues/problems.

CFR's new management faced a major financial problem. The Federal Emergency Management Agency (FEMA) proposed to eliminate financial support for CFR for fiscal year 1982 and beyond.

This directly appropriated funding was called for by the 1974 legislation establishing CFR and the National Fire Prevention and Control Administration in the Department of Commerce. When FEMA was founded in 1978, the latter became the U.S. Fire Administration in FEMA. The funding was crucial to the CFR program as 72 percent of its directly appropriated funding, and 47 percent of its total funding in 1981. After much discus-

sion among the agencies, the White House and with Congress, the funding was restored for 1982 and transferred to the NBS budget for 1983 and beyond. However, relief was short lived as the Administration decided in the summer of 1982 to eliminate funding for CFR in fiscal year 1984 and beyond.

Technical work continued productively. John Klote completed work on the Building Smoke Control Systems Design Manual as a joint project between CFR and ASHRAE. Collaborations with the Office of Applied Economics in the Center for Applied Mathematics led to the incorporation of a cost optimization model in the Fire Safety Evaluation System. The Cone Calorimeter was constructed. Barbara Levin and colleagues completed and published the NBS Toxicity Test Method report based on work from 1976-1982.

Harold Nelson received the Department of Commerce Silver Medal for the development of the Fire Safety Evaluation System and James Quintiere received the Silver Medal for leadership in the mathematical modeling of fire growth and spread in buildings. Daniel Gross received the Ingberg Award of ASTM for his contributions to fire standards.

4.4 1983

The Administration recommended that CFR be eliminated. In its hearings for reauthorization of NBS for fiscal year 1984, Congress heard from the communities affected by the CFR programs. Senate hearings were first on February 23, 1983. The Senate received testimony supporting the restoration of funding for CFR from the National Academies' Evaluation Panels for the National Bureau of Standards, the Statutory Visiting Committee of the National Bureau of Standards, the former chairman of the National Fire Prevention and Control Commission, the American Society of Civil Engineers, Factory Mutual Research, the Mineral Insulation Manufacturers Association, the National Fire Protection Association, the National Institute of Building Sciences, the Society of Fire Protection Engineers, the U.S. Chamber of Commerce, and the Wood Heating Alliance. As a precedent for all following hearings on the subject, no private sector organizations supported the Administration's proposal.

House hearings were held on March 22 and 23, 1983. Testimony supporting continuation of CFR was received from Allied Tube and Conduit Corporation, the American Institute of Architects, the American Iron and Steel Institute, the American Society of Civil Engineers, the American Society of Heating Refrigerating and Air-conditioning Engineers, the Asphalt Roofing Manufacturers Association, the Brick Institute of America, the Carpet and Rug Institute, the Council of American Building Officials, the General Electric Corporation, the Man-Made Fiber Producers Association, the Mineral Insulation Manufacturers Association, the National Fire Products Association, the National Fire Protection Association, the National Institute of Building Sciences, the Society of the Plastics Industry, Sheet Metal and Air-conditioning Contractors of North American, the Society of Fire Protection Engineers, the U.S. Chamber of Commerce, Underwriters Laboratories, the Westmoreland County Firemen's Association, United McGill and the Wood Heating Alliance.

The Senate Report [1] recommended:
The administration has proposed the elimination of CFR. Both the testimony received at the hearing and other communications to the Committee confirm the judgment of the Committee that such a step is ill-advised and unwarranted.

The fire research program is the only Federal research effort aimed at reducing annual fire losses, particularly from residential fires. The U.S. continues to be among the leading nations in incidence of building fires and fire-related deaths. Fires in residences account for 46 percent of the dollar losses and 77 percent of the fire-related deaths. Results of the research performed at CFR are used by designers, builders, standards committees and state and local codes officials to prevent fires develop efficient fire-control practices. Through its grants program, CFR provides the link between university research and the needs of fire technology. This role is consistent with the Administration's policy to support education and training in the context of Federally funded research.

The private sector, either in contract research laboratories or in individual corporations, has neither the incentive nor the resources to conduct a comprehensive broad-based fire research program such as exists at NBS. Private efforts, such as those conducted by the Factory Mutual Research Corporation, are mission-oriented and relatively narrow in scope. Factory Mutual, for example, addresses fire protection and loss reduction in industrial buildings. Factory Mutual has stated that its small effort in fundamental fire research would probably cease should CFR be terminated and, in any case, could not be expanded.

The Committee is not convinced that the private sector would assume the role of carrying out primary research in the fire sciences. Moreover, the Committee believes that a credible, neutral source of information such as that found in CFR is essential to protect the public interest as well, since the work performed at CFR affects public health and safety.

The House report [2] recommended:
The Committee strongly supports the continuation of the Center for Fire Research, proposed for elimination in the Administration's fiscal year 1984 budget request. This program provides the scientific and technical basis for the reduction of the Nation's fire losses and the cost of fire protection.

The National Bureau of Standards has been involved in fire research since its inception in 1901, as authorized by the Organic Act. The Center for Fire Research was established by the Federal Fire Prevention and Control Act of 1974 as a direct result of a 1973 Report of the National Commission on Fire Prevention and Control, which stated that there was no existing organization conducting basic fire research.

The program's strategy is to develop the technical basis for fire hazard assessment in order to provide the fire community with new and improved practices for reducing fire hazards. In addition, as an integral part of the program, $2 million is provided annually to about 30 universities and organizations for fundamental fire research. These grants currently represent the only funding source for research through which our Nation's new fire scientists are trained.

The Committee believes that the private sector has neither the incentive nor the resources to conduct a comprehensive broad-based fire research program such as that existing at NBS. Furthermore, the Committee believes that research on subjects protecting the health and welfare of the Nations' citizens is a Federal responsibility and that the Bureau is a source of credible, impartial information in an essential area. The Committee has, therefore, restored funding for the Center for Fire Research in the sum of $6.4 million for fiscal year 1984.

Funding was appropriated for fiscal year 1984 in response to the private sector and Congressional support. However, Administration efforts to eliminate or severely reduce CFR continued for six more years.

Good technical work continued in spite of the budget turmoil. Howard Baum and Ronald Rehm began transient 3-D computer simulations of flows generated by fires in compartments. Harold Nelson and colleagues issued the Fire Safety Evaluation System for Board and Care Facilities. Thomas Ohlemiller completed a major review article on smoldering combustion. Bernard McCaffrey received the Department of Commerce Bronze Medal for pioneering research on the processes underlying large fire plume behavior.

4.5 1984

The Administration again proposed to eliminate CFR, this time for fiscal year 1985 and beyond. Substantial efforts by the fire community and CFR management again resulted in restoration of the budget by Congress.

In August 1984, CFR and the National Fire Protection Association sponsored the first National Fire Research Strategy Conference to develop a coordinated private and public sector national strategy for fire research. CFR was advised to "assume the crucial role of spear-heading and coordinating basic engineering and applied fire research through: independent research within the Center; by provision of grants, fellowships and technical support to independent researchers and universities and similar institutions; and by serving as an objective forum for reviewing and coordinating the national fire research effort."

Recognizing that funding would be constrained for the duration of the Administration, management moved to tighten technical objectives, tasks and

major staff assignments to fit available resources and focus on a central technical objective:
The central technical objective of the Center is to develop means to predict fire safety and to suggest and evaluate ways to reduce risk and hazards of fire.

Research priorities included:
1. Quantitative tools to estimate the hazards of fire such as heat and smoke toxicity.
2. A consistent set of practical models of relevant fire phenomena and their complex interactions.
3. Data and measurement methods to support fire models.
4. "Benchmark" fire and smoke models to check or qualify simpler engineering models.
5. Practical fire protection engineering methodologies and user-friendly application tools.

The Fire Safety Technology Division took on the following four thrusts:

Fire Safety Performance led by Harold Nelson involved the development of practical engineering methods for fire safety design, performance evaluation and analysis of fire risk.

Smoke Hazards led by Richard Bukowski involved the development of research models and associated computer codes to predict smoke transport and smoke hazard development in buildings and the establishment of a data base of material properties, building and people characteristics suitable for use in fire growth and smoke transport models.

Room Fire Modeling led by Leonard Cooper with the aim of developing a room fire computer code for use in research and as a benchmark for fire protection engineering methods and user-friendly computer codes.

Fire Growth and Extinction Research, led by James Quintiere, with the aim of developing fundamental understanding of the elemental processes of fire growth and extinction and develop models and algorithms to characterize their contribution to fire growth and smoke movement.

Fire Measurement and Research Division also took on four thrusts, namely:

Fire Performance and Validation led by Sanford Davis. The goal was to generate the generic methodology for testing and assessing the accuracy and limitations of fire models and measurement methods. The plan was to conduct unique, highly instrumented experiments to establish fire behavior on a realistic scale for aiding the understanding of fire phenomena.

Fire Toxicology led by Barbara Levin who was asked to identify and measure potentially harmful combustion products and quantify their effects on living organisms.

Furnishings Flammability led by Vytenis Babrauskas involved the development of quantitative measures of the ignitability and fire contribution of furniture and furnishings for use in modeling fires and to provide guidance for less hazardous composition.

Exploratory Fire Research led by Walter Shaub included the development of fundamental scientific knowledge of the phenomenology, which underlies incomplete combustion and materials degradation.

The first order toxic hazard model was completed and published by Bukowski in the NFPA Fire Journal. The ISO working group on rate of heat release selected CFR-developed cone calorimeter for international standardization as the technique for heat release rate measurement. William Twilley received the Department of Commerce Bronze Medal for design, construction operation and maintenance of flammability apparatuses including the cone calorimeter.

4.6 1985

The Administration again proposed to eliminate CFR, this time for fiscal year 1986 and beyond. Substantial efforts by the fire community and CFR management again resulted in restoration of the budget by Congress.

The goal of the Cigarette Fire Safety Bill, passed by Congress in 1984, was to reduce the one-third of residential fire casualties caused by cigarettes dropped inadvertently on upholstered furniture and bedding. The Bill's objective was the study the feasibility of producing commercially acceptable cigarettes with significantly lower

Group photograph of CFR staff taken in 1985.

propensity to ignite soft furnishing substrates than the majority of current brands. CFR was charged to understand the mechanism for ignition of soft furnishings by cigarettes with the objective of finding means to reduce cigarette ignition propensity.

Substantial progress was made on improved fire modeling. Walter Jones and colleagues released a second-generation model of the transport of combustion products (FAST V17) in both mainframe and PC compatible versions. The model includes multiple floors, improved modeling of conduction, and a simplified toxicity calculation. To support the use of computer models in fire safety engineering, CFR established the Fire Simulation Laboratory and began conducting short courses in the use of fire simulation programs.

Kermit Smyth and colleagues published a landmark paper on the most detailed and complete chemical structure measurements ever made in any flame [3].

Howard Baum and Ronald Rehm received the Department of Commerce Gold Medal for their unique and highly sophisticated mathematical model, which can accurately describe the evolution of smoke and gases in rooms or enclosures of various shapes. George Mulholland won the Department of Commerce Bronze Medal for his research concerned with the physics and chemistry of smoke particle generation and growth, which resulted in clarification of new and fundamentally important information about the process of soot growth and coagulation in fire environments.

4.7 1986

The Administration's budget proposal for CFR for 1987 and beyond continued to call for elimination of CFR. However, Congress and the Administration arrived at a "compromise" whereby in exchange for a cut of $0.5 million in directly appropriated funding for CFR the Administration would not seek further reductions for the remainder of the Administration (fiscal years 1988 and 1989). The cuts occurred as agreed, but the Administration subsequently reneged on the compromise and proposed large cuts, but not elimination, for the next two budget cycles.

CFR refocused its program to accommodate the cuts. Andrew Fowell moved to deputy director and James Quintiere became chief of the renamed Fire Science and Engineering Division. Its program areas became:

1. Predicting the burning rate of materials.
2. Modeling wall fire growth.
3. Development of a first-order suppression model.
4. Development of a benchmark compartment fire model.
5. Development and dissemination of a comprehensive method for fire hazard analysis.
6. Combustion of oil spills on the seas and suppression of oil/gas well fires.
7. In-flight fire and ventilation characteristics of aircraft cabins, smoke control in buildings, and analog simulation for smoke movement in buildings and ships.

Objectives for Richard Gann's Fire Measurement and Research Division were:

1. Combustion product prediction.
2. Fire model validation.
3. Fire-safe polymers.
4. Cigarette safety.

Hazard I, the first version of the hazard assessment methodology, was completed and made fully operational on

desktop computers by Richard Bukowski and colleagues. FIRST, the prototype benchmark compartment fire model computer code, was produced by Leonard Cooper and colleagues. The cone calorimeter, which was adopted by ASTM, was produced by instrument suppliers. Takashi Kashiwagi and colleagues reported on the thermal degradation of polymers.

Vytenis Babrauskas received the Department of Commerce Bronze Medal for his research on the measurement of heat release from burning materials and his development of the cone and furniture calorimeters. Thomas Ohlemiller received the Bronze Medal for his pioneering research in understanding the complex physics and chemistry of smoldering combustion.

4.8 1987

The Administration's budget proposal for CFR for fiscal year 1989 called for a 40 percent reduction, below the amount for 1987 after the "compromise" cut of $500,000, and a merger of CFR with the Center for Building Technology (CBT). Continued strong support from both fire and building communities led to rejection of these proposals and continued funding for CFR and CBT, but without restoration of the cuts of $500,000 each that occurred in 1987 with the "compromise."

The Office of the Inspector General inspected the Center and reviewed three of its grants. Its report was complimentary.

The Center is managed effectively and efficiently, the Center is unique and technically competent, funding uncertainty is a cause for concern, private sector interest in fire science is limited, local government could not do the Center's work, OMB's research parallels ours, the Center has limited success in technology transfer, and the extramural grant program is managed effectively.

The fire hazard assessment method, HAZARD I, began a beta test to be applied to real problems by volunteer participants throughout the fire community. CFR-developed quantitative modeling tools were used to reconstruct the conditions that occurred in the Dupont Plaza Hotel in Puerto Rico, and the results were presented to a Congressional hearing on hotel fire safety.

The studies of cigarette ignition propensity called for by the Cigarette Fire Safety Act of 1984 were completed and reported to Congress. It was shown that thinner cigarettes with less tobacco and less porous paper significantly reduce the chance of igniting soft furnishings.

FIREDOC, the Center's computerized bibliographic database came on line with references, abstracts and key words for more than 8,000 of the 30,000 documents in the Fire Research Information Service. The Center's public access computer bulletin board also came on line with access to FIREDOC, and information on the Center's fire simulation programs, conferences, and recent reports.

Kermit Smyth and Houston Miller completed studies of soot nucleation in methane/air diffusion flames. Fluorescence, multi-photon ionization, Rayleigh-Mie scattering and mass spectroscopy were used to describe chemical structure and the nucleation of soot particles.

Howard Baum and Ronald Rehm developed a mathematical model of combustion in a turbulent eddy based on solutions of the Navier-Stokes equations. The technique allowed three-dimensional simulation of physical and chemical processes in turbulent, reacting flows.

Takashi Kashiwagi and Thomas Ohlemiller studied the gasification of PMMA and developed a new model based on thermally driven rearrangement of the primary polymer radicals which gave better agreement with experimental results than previous models and gave consistent values for degradation kinetic constants.

Daniel Gross received the Rosa Award of NBS and the ASTM Award of Merit for his contributions to national and international standardization organizations over his career at NBS. Kermit Smyth received the Condon Award of NBS for his paper "The Chemistry of

Daniel Gross researcher and leader of standardization efforts.

Molecular Growth Processes in Flames" in Science. Jack Snell received the Gold Medal of the Department of Commerce for technical leadership in fire safety, and Richard Peacock received the Bronze Medal of the Department of Commerce for his research on the fire safety of solid fuel heating appliances and chimneys. Harold Nelson was the first recipient of the Harold E. Nelson Award of the Society of Fire Protection Engineers.

4.9 1988

The Administration's budget proposal for CFR for fiscal year 1990 again called for a merger of CFR with CBT and funding both for a total of $5 million. Continued strong support from both fire and building communities led to rejection of these proposals and continued funding for CFR and CBT with both centers receiving small increases in appropriations.

CFR management realized at the start of the fiscal year that it faced a serious funding shortfall because of the reduction of base funding from the "compromise" funding for fiscal year 1987, the completion in fiscal year 1988 of the cigarette study funded by the Consumer Product Safety Commission, and limited research funds in many government agencies. In response and to focus the program, in-house research on human behavior in fire was terminated to free resources for priority projects. Staff reductions were associated with this move. Supervisory and research staff were encouraged to work with colleagues in other federal agencies to identify their fire research needs and to follow up with research proposals that would complement CFR's research performed with directly appropriated funding. Many of these proposals were funded, often as multi-year projects, to give good prospects for future funding and staff growth.

The technology transfer effort headed by James Winger was upgraded to become an Office of Technology Transfer incorporating the Fire Research Information Service, the Simulation Laboratory and the Computer Bulletin Board.

Full-scale building fire tests were felt to be increasingly important because of the need to verify new generation fire models. Expansion began in fire exhaust capability in Building 205 to gain a calorimeter capable of free burn fires up to 1.5 MW. Planning began for a three-fold increase in the working area for Building 205.

Barbara Levin developed the "N" gas model for toxicity of multiple combustion products to cover four principal gases and exposure times from one minute to sixty minutes.

James Quintiere, Robert Levine and Harold Nelson reconstructed events in a two story residential house fire in Sharon, PA on September 26, 1987, in which smoke and heat from a fully developed kitchen fire killed three residents on the second floor. The fire was reconstructed in the large fire facility. Data showed that current fire models underestimated hazard conditions, particularly carbon monoxide.

James Quintiere, John Klote and Harold Nelson assisted the Los Angeles Fire Department and the U.S. Bureau of Alcohol, Tobacco and Firearms in the investigation of the First Interstate Bank Fire. It completely gutted floors 12-15 of a 62-story building. CFR modeled effects of open landscape office spaces, desktop computer equipment, flame projection from windows, and smoke propagation in vertical shafts.

Mark Nyden produced the first of an important series of computer simulations of heat driven fragmentation of a polymeric molecule. This capability led to better understanding of how more fire-stable polymers can be produced while preserving salient commercial properties.

Richard Gann worked with the U.S. Air Force and the New Mexico Engineering Research Institute to develop an eight-year, $20 million pro-

gram to develop replacements for halogenated fire suppression agents. These two highly effective agents, (halon 1301, CF_3Br, and halon 1211, CF_2ClBr) are strong contributors to depletion of stratospheric ozone and were being removed from production. Replacement agents must quench flames, be non-toxic and non-corrosive, leave no residue and not deplete ozone. This began a very significant CFR/BFRL program.

Vytensis Babrauskas and William Twilley won an R&D 100 Award for development of the Cone Calorimeter. It measures as a function of radiant exposure, the time to ignition, amount and rate of heat release, amount of smoke produced, and amounts of several toxic gases from small samples of materials. Thus, it provides data needed for rational modeling of the contributions of various materials to the development of large-scale fires. Both ASTM International and the International Organization for Standardization (ISO) were developing standard test methods based on the cone calorimeter and two U.S. manufacturers were producing units for the market.

4.10 1989

The Administration's request to Congress for the fiscal year 1990 budget, the last prepared by the Reagan Administration, again proposed to merge CFR and CBT and fund the combined center at a level of $5 million (half their combined bases of $10 million). The fire community again supported full funding for CFR and Congress again restored funding for the fiscal year 1990 budget. Also, CFR and CBT directors discussed the programs with the new Bush Administration officials in the Department of Commerce and the Office of Management and Budget with the result that the cuts no longer were proposed for the fiscal year 1991 budget.

Jack Snell, recognizing the status of CFR (reduced in real funding and staffing substantially in the 80s with remaining resources focused on hazard and risk modeling) and the recommendations of the National Research Council evaluation panel on CFR, produced a new long-range plan for CFR. It sought major technical innovations or breakthroughs to reduce substantially the losses and cost of fire. An NFPA study estimated these costs as $48 billion in 1986. Current resources were focused on fire prediction methods and technical advances to reduce fire losses and costs by up to 10 percent by 2000. An enhanced funding level was proposed to provide the technical basis for reducing fire losses and costs by 50 percent by 2000-2005.

Five objectives were defined:
1. Quantify and communicate fire risk and hazard.
2. Engineered fire-safe products and materials
3. Sense and communicate risky conditions.
4. Control and extinguish fires.
5. Locate, protect, and remove occupants/people.

Eleven priority projects were established for the current resources for fiscal year 1990:
1. Hazard II led by Richard Peacock: plan and implement a second-generation hazard methodology by 1992.
2. Unified Model of Fire Growth and Smoke Transport led by Walter Jones and Glenn Forney: modify the FAST model to incorporate lessons learned from the consolidated compartment fire model by 1990.
3. Toxic Potency Measurement led by Vytensis Babrauskas: provide an accurate bench scale methodology for combustion toxicity measurement by 1991.
4. Furniture Flammability led by William Parker: develop a test and calculation protocol for evaluating the fire hazard of upholstered furniture by 1992.
5. Wall Fire Spread led by Henri Mitler: develop a method for predicting the rate and extent of fire spread on interior surfaces in a room using the fire properties of the materials involved by 1992.
6. Carbon Monoxide Production and Prediction led by William Pitts: develop a fundamental understanding of the mechanisms of carbon monoxide formation in flames sufficient to produce an estimation model in 1994.
7. Burning Rate led by Takashi Kashiwagi: develop by 1992 glob-

al/detailed models able to predict non-flaming gasification rates and horizontal burning rates for thermoplastics after understanding the polymer gasification process and energy feedback mechanisms.

8. Fire Suppression led by David Evans: develop methods for the prediction of sprinkler system performance by 1995 using measurable system parameters such as spray drop size distribution, heat transfer characteristics, and installation geometry.
9. Turbulent Combustion led by Howard Baum: understand and predict energy release and fuel consumption in turbulent systems.
10. Soot Formation and Evolution led by Kermit Smyth: develop a predictive model for the formation of soot in flames and evolution of smoke components from flames by 1992.
11. Engineering Methods led by Harold Nelson: develop the FPETOOL methodology for practical fire safety evaluation and incident reconstruction by 1990.

HAZARD I and eight example applications were released. These became the basis for a course at Worcester Polytechnic Institute and were marketed by NFPA. An agreement was negotiated with the National Association of State Fire Marshals and the Fire Marshals Association of North America to put a visiting marshal in the Center for a year to work on applying new fire protection engineering methods to typical problems.

The California Bulletin 133 room fire test for upholstered furniture was assessed and a proposal developed for improving the repeatability of ignition conditions. LAVENT, a program to predict actuation of fire vents, was developed under sponsorship of the American Architectural Manufacturing Association using parts of the Consolidated Compartment Fire Model. A cone calorimeter was redesigned to allow burning under reduced oxygen conditions. Burning Douglas Fir at 14 percent oxygen quadrupled CO yields. This suggested that the much larger yields recorded in under-ventilated burns depend on total oxygen available.

Richard Gann was named chairman of the Technical Committee of the Halon Alternatives Research Consortium, which included the Air Force, Navy, Army, Environmental protection Agency (EPA), National Aeronautics and Space Administration (NASA), DuPont, ICI, National Science Foundation (NSF), Great Lakes Chemical, Ansul, the Halon Research Institute and Factory Mutual.

Harold Nelson received the Gold Medal of the Department of Commerce for outstanding contributions to advancing the science of fire protection. John Klote received the 1988 ASHRAE Best Paper Award for "An Overview of Smoke Control Technology." William Walton received the Director's Award of the Society of Fire Protection Engineers for his work as section editor on the first edition of the Handbook of Fire Protection.

4.11 1990

John Lyons was nominated by President Bush on November 22, 1989 to become NIST director, was confirmed by the Senate on February 8, 1990, and sworn in on February 9. Lyons as founding director of CFR, 1974-1978, and founding director of the National Engineering Laboratory, which included CBT and CFR, from 1978-1990, had first hand knowledge of CBT and CFR programs, people and constituents. It was wonderful to have understanding leadership at NIST! However, budget deliberations did not lead to an initiative for fire research for fiscal years 1991 or 1992.

It was clear that fiscal year 1990 was the last for separate centers for building and fire research. Congress authorized their merger on July 30, 1990, the merger was announced to staff on August 30, and the successor Building and Fire Research Laboratory (BFRL) began to operate on October 1, 1990 (the beginning of fiscal year 1991) although the formal reorganization did not take place until January 31, 1991.

The CFR program in 1990 continued its focus on the technical bases for advanced fire modeling and the verification of the models. Need continued for improvements of the large fire testing facility, but funds were not available for enlargements or major renovations.

CFR commissioned studies of the total costs of fire, fire losses plus costs of fire protection measures [4], and impacts of CFR [5]. The former showed an annual cost exceeding $128 billion; it neglected all government fire losses and fire safety expenditures. The latter showed an annual impact of $5-9 billion for CFR in reduction of fire costs and noted virtually every major contribution from the 70s still was providing benefits. These studies guided the focus of the fire program in BFRL.

P.L. 101-352, *The Fire Safe Cigarette Act of 1990*, directed that:

> *"at the request of the Consumer Product Safety Commission, the National Institute of Standards and Technology's Center for Fire Research, shall: (1) develop a standard test method to determine cigarette ignition propensity, (2) compile performance data for cigarettes using the standard test method developed under paragraph (1), and (3) conduct laboratory studies on computer modeling of ignition physics to develop valid, "user friendly" predictive capability."*

Richard Gann was elected chairman of the Technical Advisory Group created in response to the Act, and led the research effort in CFR.

CFR established a memorandum of agreement with the National Association of State Fire Marshals to improve mutual understanding of the technical needs of the fire services and the delivery and implementation of resultant products of CFR. For additional linkages with users, Jack Snell was elected to the Board of Directors of the National Fire Protection Association and appointed to its Long Range Planning Committee, and David Evans was elected to the Board of Directors of the Society of Fire Protection Engineers.

Jack Snell led in the organization of the Forum for International Cooperation on Fire Research, FORUM, comprised of heads of fire research organizations around the world, and became its chairman. At its 1990 meeting, FORUM developed a common strategy for fire resistance testing of materials and furniture that was based primarily on technology developed by CFR.

In a project jointly supported by U.S. and Canadian agencies, CFR participated in a mass fire experiment outside of Chapleau, Ontario. The results were used to compare predicted fire-induced wind velocities with measured values - important information for developing and validating CFR's large fire models and for understanding urban conflagrations.

Vytensis Babrauskas and colleagues established the first relationship between the toxicity of room fire smoke and that measured in the combustion of small samples. Agreement was within a factor of 3, which is acceptable for prediction of life safety in building fires.

Mark Nyden developed a prototype, ab initio, model of thermal degradation and cross linking of polymers which led to understanding of how less flammable chars are formed. Stimulation of char formation was identified as an important fire retardant mechanism.

William Pitts developed a large-scale apparatus and developed novel techniques to measure the turbulent mixing in fire plumes. Unmixedness dominates the formation of smoke and toxic combustion products.

Harold Nelson was awarded the NFPA's Standards Medal for unselfishly contributing to the fire protection community for over 30 years. Richard Bukowski, Walter Jones, Richard Peacock, Cheryl Forney, and Emil Braun received the Department of Commerce Silver Medal for producing the world's first fire hazard assessment methodology. Vytensis Babrauskas was the first recipient of the Interflam Award of the International Conference on Fire Safety for his leadership in the development and implementation of heat release rate measurement.

A number of departures and retirements of founding staff members accompanied the merger of CFR. James Quintiere resigned as Chief of the Fire Science and Engineering Division to become Professor of Mechanical Engineering at the University of Maryland. Retirements included William Parker, Head of the Fire Dynamics Group, Sanford Davis, research chemist, and Maya Paabo, research chemist.

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