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THE COMMITTEE ON FIRE RESEARCH

1 July 1962 - 30 June 1965

NATIONAL ACADEMY OF SCIENCES - NATIONAL RESEARCH COUNCIL

THE COMMITTEE ON FIRE RESEARCH

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Editor of Fire Research Abstracts and Reviews

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D. W. Thornhill, *Executive Secretary*

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FINAL REPORT
1 July 1962 - 30 June 1965

under

Contracts OCD-OS-62-287 and OCD-PS-64-34
Office of Civil Defense, Department of Defense
(U. S. Forest Service, National Bureau of Standards
National Science Foundation as co-sponsors)

and

INTERIM REPORT
1 July 1964 - 30 June 1965

under

Contract NSF-C 310 Task Order No. 86
National Science Foundation

Prepared for

The National Academy of Sciences

by the

COMMITTEE ON FIRE RESEARCH
Division of Engineering and Industrial Research
National Research Council

OCD REVIEW NOTICE

This report has been reviewed in OCD and
approved for publication. Approval does
not signify that the contents necessarily
reflect the views and policies of the OCD.

National Academy of Sciences - National Research Council
Washington, D. C.
1965

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OCD Research Projects

This report covers work performed during the period 1 July 1962 through 30 June 1964 under contract between the Office of Civil Defense and the National Academy of Sciences, with the U. S. Forest Service, the National Bureau of Standards, and the National Science Foundation as co-sponsors. On 1 July 1964, the National Science Foundation entered into a separate contract with the National Academy of Sciences, and the Office of Civil Defense continued its contract with the Forest Service and the National Bureau of Standards as co-sponsors.

OPERATION FLAMBEAU

On 6 November 1962, the Director of Research of the Office of Civil Defense, sent a letter to the Committee on Fire Research asking for assistance on a project entitled "Operation Flambeau." (Appendix A)

The Research Directorate of the OCD had been "exploring the possibilities of an effective research approach to the mass fire problem, a most controversial area among both authorities and laymen interested in civil defense. The need for definitive information on the nature of fire storms and conflagrations in order to develop countermeasures and design requirements for shelters is pressing. Although a number of projects are being pursued in this area, it is believed that novel experimental plans must be developed if major progress is to occur.... It appears feasible to produce a mass fire over at least one square mile under controlled and instrumented conditions."

The Committee on Fire Research met in the Pentagon on 27 November 1962 for briefing on Operation Flambeau by the OCD and to hear reports of some work already sponsored by OCD.

In the briefing, OCD divided its present sponsored work into three categories:

- 1) Basic research - review of weapons tactics, fire characteristics, vulnerability, psychological and physiological effects of fire on personnel.
- 2) Countermeasures - attenuation of thermal radiation and reduction of vulnerability.
- 3) Control measures - detection, command problems, operational analysis, training methods and fire-fighting techniques.

In particular, the OCD mentioned projects on the interrelation and interactions of mass fire and environment; a fire spread model input data for the computer program; and a large project on prevention and control of mass fires having four areas - first, an evaluation of fire development and spread in urban areas (mainly historical); second, determination of required fire control by studying fire development and extinguishing media and equipment; third, evaluation of effectiveness of personnel and fire control efforts, both in ordinary situations and then as applied to life in shelters; and fourth, reduction of fire vulnerability in urban areas, studying actual shelters of various sizes and various structural types and analyzing for the type of fire protection system needed. One other small project was described - fire environment analyses, a model approach to an understanding of the fire column by measuring temperature velocity and gas composition with the gas column.

This was the background against which Operation Flambeau was discussed. The Forest Service had informed the OCD that it could supply a "big" fire when needed; this would be a continuation of the Forest Service project on mass fire and environment. The size of the fires would be increased to 60 acres and after that to the one square mile.

What was not known was what questions could be answered through mass fire testing, how big the fire should be and how many fires would be needed. Very little is known about what is meant by the word, "fire storm." The Chairman mentioned some of the unknowns; - it is possible that a fire of enormous extent might well not involve large velocities; it is not known whether atmospheric lapse rate, or "circulation," or what, is needed to produce fire-storm conditions; the proper design of a large experiment to study fire storms is unknown. There may be a temptation to assume that there is already available a system of equations expressing vertical and radial force balances, mass transfer phenomena, heat transfer phenomena, and other items; but this is not so. The fundamentals of large fires may not be productive within a stated length of time; but they are essential if the answer is to be found. These are problems of a complexity that force the support of a significant amount of pure analysis.

The Director of Research of OCD had stated in his letter of 6 November that there was need for "definitive information on the nature of fire storms and conflagrations in order to develop countermeasures and design requirements for shelters." The Committee agreed that this was most desirable but could not see how any prognosis could be made on the length of time to acquire it.

In the course of the general discussion that followed, many questions were posed and the Chairman of the Committee on Fire Research listed a number of questions for which answers would be needed in toto or in part before a large experimental fire could be set with any hope of simulation and even then it would be experimentally experimental. He summed up

the discussion by saying "I do not want to be misunderstood. My viewpoint is that an informed pessimism is the best atmosphere for the design of a good experiment."

In closing the Chairman indicated that the operation of such a project as Flambeau should be in charge of a full-time, hard-working group. He stated that the Committee would gladly do what it could on the problem.

On 15 January 1963, Mr. Christian in a letter to the Executive Secretary of the Committee on Fire Research presented the following questions as a restatement of what OCD would like to have from the Committee:

- 1) What are the Committee's comments of the present state of OCD's fire research program and the approach to it?
- 2) What specific problems could be solved by short-term research studies?
- 3) What mass fire testing is desirable for our research problems?
- 4) What are the Committee's ideas of the type of organizational structure that would be required to undertake whatever mass fire testing is desirable?

In a follow-up letter on 23 January, attention was called to the third question to note that OCD had changed from "asking advice on a one-square mile fire, per se. to what mass fire (or large fire) testing is desirable."

On 18 January, the Committee sent a letter to some thirty persons interested in fire research, posing five questions designed to bring in opinions that would prove helpful in planning Operation Flambeau.

- 1) Has our measurement capability with fires of smaller size developed to the state that we are able to technically characterize them?
- 2) If so, do we have sufficient understanding of their behavior to describe the variables which must be controlled to achieve reproducibility?

- 3) To what extent can the behavior of experimental fires of this type be reproduced at different times and with differing fuel variables?
- 4) Has there been any systematic study of the influence of ambient weather, including wind conditions and lapse rate, on the behavior of such experimental fires?
- 5) Do we have any basis for correlating the behavior of wild land fires with those of urban character?

The letter requested that the Committee be furnished with references to or preferably copies of reports or papers on:

- 1) Technical studies of outdoor fires.
- 2) Results of analysis of experimental or natural outdoor fires, especially those studies directed toward finding the controlling variables.
- 3) Laboratory-type fires in which an attempt has been made to relate such fires to behavior of large area outdoor fires.

On 29 January, several members of the Committee on Fire Research met with the Chairman in Cambridge, Massachusetts to discuss a reply to the request of OCD in connection with Operation Flambeau. As a result of this meeting, on 30 January the Chairman wrote a letter to the Director for Research of OCD stating his personal views. (Appendix B). Several members of the Committee also wrote to the Director of Research sending their personal opinions.

On 5 April 1963, a meeting of the Committee was held in Washington, D. C. for further discussion of Operation Flambeau and the drafting of a formal answer for the Office of Civil Defense.

This letter, dated 17 July 1963, signed by all members of the Committee on Fire Research and addressed to Mr. Walmer E. Strobe, Director for Research, Office of Civil Defense, was submitted to Mr. Strobe by

Dr. S. D. Cornell, Executive Officer, National Academy of Sciences on 19 July 1963. (Appendix C)

"A STUDY OF FIRE PROBLEMS" (Report of a Summer Study arranged by the Committee on Fire Research. Held in Woods Hole, Massachusetts in 1961)

This report had wide distribution and its recommendations were reviewed and considered, favorably and unfavorably, in many places. Among them was the Federal Council for Science and Technology which referred the report to the Department of Commerce for further consideration of the conclusions and recommendations therein. (Appendix D)

A meeting of the Fire Research Conference had been held on 14 June 1962, attended by the Assistant Secretary for Science and Technology of the Department of Commerce who asked at that time for written comments on the recommendations of the Woods Hole Report. A subcommittee of the government-connected members of the Conference was appointed by the Chairman of the Conference to study the report, look at what was recommended, assess the reaction of their respective agencies to the recommendations, decide how much of this should be done, and what the priorities should be. Dr. Richard Tuve of the Naval Research Laboratory was appointed Chairman of this subcommittee.

In August 1962, the Assistant Secretary of the Department of Commerce wrote the Chairman of the Committee on Fire Research: "In connection with the Department's responsibility to establish a program to increase Federal support and participation in the Nation's fire research efforts, I have asked Dr. I. C. Schoonover, Associate Director, National Bureau of

Standards, to assist me in formulating a plan to implement the recommendations of the Committee on Fire Research."

From time to time, Dr. Schoonover conferred with members of the Committee on Fire Research and the National Bureau of Standards included in its FY '64 budget a proposed fire technology program.

The House Appropriations Committee held closed sessions on the budget and there appeared to be strong opposition to the program outline by the National Bureau of Standards.

On 4 April 1963, Dr. Schoonover called a meeting at the National Bureau of Standards for the purpose of attempting to clear up the apparent misunderstanding regarding the proposed fire technology program. Some members of the Committee on Fire Research attended, together with representatives of diverse interests in the fire problem. It seemed that the misunderstanding of the program stemmed back to an early draft of a survey conducted in April 1962, intended only to be tentative and for use in further study. Of the program resulting from Dr. Schoonover's subsequent work, Dr. Schoonover said "the program currently proposed by the National Bureau of Standards was drafted after many discussions with individuals in the fire technology field and it differs significantly from the earlier drafted program. The currently proposed program is aimed solely at providing assistance to existing organizations which are conducting effective programs to reduce losses resulting from unwanted fires. It is our belief that providing support to these groups would be the most effective and efficient means for providing Federal assistance to this national problem."

Dr. Schoonover explained that after the initial survey, the Department of Commerce prepared a three-pronged program: (1) to increase support of the work of the Bureau of Standards in fire research including a full-time director; (2) support in the amount of \$500,000 to provide the Bureau with capability for contract research in a number of areas in which the Bureau is not capable of work; (3) explore the possible establishment of a regional fire center at a university as a test case to see if it would serve. The total budget suggested was \$1,200,000; 500 thousand for the Bureau's work; 500 thousand for contract work; and 200 thousand for the regional study experiment.

On 5 April 1963, the Committee on Fire Research met in Washington. Dr. Schoonover attended and further discussion was given to the proposal of the National Bureau of Standards. It was Dr. Schoonover's impression that there was acceptance of the program and no real objection to expansion as given in the present request to Congress, but he felt there was still misunderstanding about funds for contracting and there were mixed feelings about an experimental regional center, through fear of duplicating what has already been done.

The Chairman of the Committee on Fire Research noted that the concept of this program is different from the concept of the Woods Hole Report. He thought that it was clear that some of the objections voiced at the NBS meeting were a protest not of a changed program but of any increase whatever in fire activity under Federal control.

The Woods Hole Report describes the Federal interest in fire in this manner: "The problems of fire are only in part the technical problems of prevention, detection, and extinguishment. They also cut deeply into the

social and political fabric of the nation and raise important questions of management, organization, and economics."

TECHNICAL MEETINGS

The Committee held its fourth technical meeting at the National Bureau of Standards on 19 June 1963. The subject for discussion was "Methods for Fire Tests of Building Materials and Structures," broken down into the following items: experience during building fires, fire endurance test methods, material characterization, structural behavior (steel), structural behavior (concrete), spread of flame in buildings, two tunnel tests, and a radiant panel test. Nine participants were invited to discuss these subjects before the Committee and twenty-five guests. The Committee continues to believe that the informality of these small meetings is conducive to a freer scientific discussion than would occur with a larger audience. As is usual for this kind of meeting, no record was made. Plans call for more of this type of meeting during the coming year.

VISIT TO U. S. FOREST SERVICE LABORATORIES

In September 1963, at the invitation of the Forest Service, the Committee visited the Forest Service laboratories at Missoula, Montana and Riverside, California. At Missoula, one and a half days were spent in listening to presentations of the projects under way and in viewing laboratories and experimental procedures. In Riverside, the Committee attended the dedication of the new laboratory.

OCD CONTRACTORS CONFERENCES

The first such conference was held in Chicago, 10-11 October 1962. The Executive Secretary of the Committee attended and reported to the Committee. The following June the Chairman of the Committee was requested by the Office of Civil Defense to review a draft of the final report on "Fire Storm Analysis" by the Armour Research Foundation, one of the projects that had been presented at the Chicago meeting. The Chairman's letter in reply is appended as Appendix E.

The second OCD Conference was 11, 12, 13 September 1963, concurrent with the visit of the Committee to the Riverside Laboratory.

In 1964, the Office of Civil Defense delegated the responsibility for technical monitoring of its fire research program to the U. S. Naval Radiological Defense Laboratory in San Francisco. (This change was consistent with recommendations in Appendixes B and C of this report.) In July 1964, USNRDL submitted to OCD a proposal entitled "Fundamental Fire Research Survey and Requirements Study" as a background for future work under their newly acquired responsibility. OCD in turn requested the Committee on Fire Research to give its views on the appropriateness of the study, approach, and timing, and whether this would be a job that could, or should, be done by the Committee; and if so, a rough estimate of a reasonable completion date. This was discussed at a meeting of the Committee in November 1964 and the Chairman wrote a letter to OCD expressing the viewpoint of the Committee. (Appendix F)

The third conference of the fire research contractors of OCD was held in Washington, D. C. 17, 18, 19 May 1965. Members of the Committee attended, made suggestions from the floor, and wrote letters of evaluation. Two of these appear as Appendixes G and H.

INTERNATIONAL SYMPOSIUM

The Committee on Fire Research co-sponsored with the Combustion Institute two sessions of the Tenth Symposium (International) on Combustion at Cambridge University, Cambridge, England, 17 to 21 August 1964. One session was on Fire Research and the other a discussion on Aerodynamics in Combustion. The discussion on Aerodynamics in Combustion was arranged by Dr. Emmons of the Committee. Professor Hottel served as Chairman of one of the sessions on Free Burning Fires. Six members of the Committee attended the meeting. The papers presented are published in the Proceedings of the Symposium.

FIRE RESEARCH PROGRAM AT THE NATIONAL BUREAU OF STANDARDS

To assist the National Bureau of Standards in the consideration of its fire research program, the Committee held extended discussions during its meeting of 7 November 1964 and drafted a letter to Dr. Frederick Seitz, President of the National Academy of Sciences for transmittal to Dr. Allen V. Astin, Director of the National Bureau of Standards reviewing some of the actions taken by the Committee on Fire Research and restating the Committee's position with respect to fire activities of the National Bureau of Standards. A copy of the letter is attached as Appendix J, together with a minority letter report from one member of the Committee.

RECONSTITUTION OF THE COMMITTEE ON FIRE RESEARCH

During 1964, the Committee began to think that it was time for stocktaking. It recognized certain influences it had exerted in the fire effort but, at the same time, frustrations and some failures were evident.

It believed that a reorganized Committee might be beneficial. Accordingly in the spring of 1965, a letter on behalf of the Committee was written by the Chairman to Dr. Frederick Seitz, President of the National Academy of Sciences expressing views on the future of the Committee and recommending names for membership on a reorganized Committee. The Committee broadened both its membership and objectives to include the advancement of applied research in fire problems. The Committee believes that in so doing it can be of more assistance to government and private groups in solving practical fire problems while continuing efforts to stimulate needed fundamental research in the complex phenomena of fire. It continues to be available to government agencies with fire interests, for suggestions or criticisms of proposed programs; and it proposes to handle specific assignments requiring technical expertness in specific areas in part by ad hoc subcommittees with membership partly outside the continuing Committee.

Committee members now will serve on a three-year rotational basis, with initial appointments for one, two, and three years. The Committee has the following new members, whose appointments became effective 1 July 1965: Walter G. Berl, Applied Physics Laboratory, The Johns Hopkins University; Perry L. Blackshear, Professor of Mechanical Engineering, University of Minnesota; John Rhodes, Director of Engineering and Research, Factory Mutual Engineering Division; George M. Tryon, Technical Secretary, National Fire Protection Association; Richard L. Tuve, Head, Engineering Research Branch, U. S. Naval Research Laboratory; Edward E. Zukoski, Professor of Jet Propulsion and Mechanical Engineering, California Institute of Technology. Earlier members who continue to serve with new appointments are: Professor H. C. Hottel

(chairman), Director, Fuels Research Laboratory, Massachusetts Institute of Technology; Howard W. Emmons, Professor of Mechanical Engineering, Harvard University; and Walter T. Olson, Assistant Director, NASA Research Center.

MANPOWER FOR AD HOC PANELS AND COMMITTEES

To make the Committee more effective, experts in specific areas will be brought in as pro-tem members. A list is being built up ready for use.

PROPOSED FIRE RESEARCH PROGRAM

A Proposed Fire Research Program was set up by the Committee in 1958. At a meeting of the Committee on May 17, 1965, this was discussed and it was recommended that the Program be revised.

FIRE RESEARCH ABSTRACTS AND REVIEWS

After six years of service as Editor of Fire Research Abstracts and Reviews, Dr. Walter G. Berl retired as of 1 January 1965; Dr. Robert Fristrom of the Applied Physics Laboratory, The Johns Hopkins University took over as Editor. The publication began with a small distribution list compiled by members of the Committee and Conference. The present readers belong to widely different groups: government agencies, the military, state and city governments, private research institutes, universities, industry, insurance companies, editors of other journals, fire departments and individual firemen, public libraries, trade associations, and various others. Foreign distribution includes twenty-eight countries. A number of new abstracters have been added.

DIRECTORY OF FIRE RESEARCH IN THE UNITED STATES

The Committee published the first Directory in 1961 and a revision in 1963. A revision to include work performed during the period 1 July 1963 through 30 June 1965 is in process.



APPENDIX A

DEPARTMENT OF DEFENSE
OFFICE OF CIVIL DEFENSE
WASHINGTON 25, D.C.

NOV 6 1962

Contract No. OCD-OS-62-287

Dear Mr. Thornhill:

For the past several months the Research Directorate has been exploring the possibilities of an effective research approach to the mass fire problems, a most controversial area among both authorities and laymen interested in civil defense. The need for definitive information on the nature of fire storms and conflagrations in order to develop countermeasures and design requirements for shelters is pressing. Although a number of projects are being pursued in this area, it is believed that novel experimental plans must be developed if major progress is to occur.

A project concept has been proposed that appears at this moment to offer great promise. It appears feasible to produce a mass fire over at least one square mile under controlled and instrumented conditions. This operation, which we are calling Operation FLAMBEAU, could be in conjunction with reforestation operations of the United States Forest Service in large burned areas of the western United States.

The test would be in a fire-safe area. The test fuel would be stags and other undesirable vegetation from the burned-over area. The fuel would be arranged in masses to simulate the fuel quantities of congested urban areas. Representative shelter buildings, homes with family shelters, and underground shelters of various designs would be constructed or mocked up among the "buildings" of forest fuels. The shelters, the surrounding area, and aloft would be instrumented to obtain the needed data. Fire defense and rescue operations would be studied also. Participation by key DOD groups, other Federal, State, and local Agencies, nongovernment groups, and foreign agencies will be encouraged.

A feasibility study of the project concept will be conducted to:

1. Explore the desirability and need for mass fire testing, and the capability for conducting such an effort
2. Explore the critical test parameters, and estimate the potential information to be gained

3. Make a critical analysis of the project concept, with recommendations, and if warranted
4. Prepare a test management and experiment plan, including data to be obtained, timing, and costs.

A Working Group will be organized to conduct this study. The organization and mission of, and groups to be represented in, the Working Group are listed in Enclosure A.

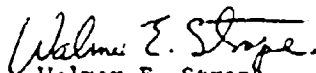
There will be a Steering Group to provide advisory and consulting services to the Working Group through the Research Directorate on Operation FLAMBEAU. Specifically the Steering Group will:

1. Provide initial guidance for the Working Group, and
2. Critically review the progress of the Working Group at selected intervals and advise the Research Directorate of their findings.

We request that the Committee on Fire Research undertake, as part of the Scope of Work of Contract Number OCD-OS-62-287, to establish a Steering Group of nongovernment members to provide the above services. We suggest that consideration be given to augmenting the Steering Group with such people as Drs. R. Friedman, R. R. Long, and H. P. Galliher, and Messrs. H. C. Thomas and W. Y. Kimball. The proposed membership shall be coordinated with Mr. John F. Christian, Fire Research Coordinator, who will be the Chairman of the Working Group and the Steering Group's point of contact in the Research Directorate.

We would like to have an initial briefing of the Steering Group in conjunction with the presently planned meeting of the Committee in late November.

Sincerely,


Walmer E. Strobe
Director for Research

Enclosure

Mr. Dan Thornhill
Executive Secretary
Committee on Fire Research
National Academy of Sciences
National Research Council
2101 Constitution Avenue
Washington 25, D.C.

APPENDIX B

NATIONAL ACADEMY OF SCIENCES
NATIONAL RESEARCH COUNCIL

COMMITTEE ON FIRE RESEARCH
AND THE
FIRE RESEARCH CONFERENCE

OF THE

MAILING ADDRESS
1215 CONSTITUTION AVENUE
WASHINGTON 25, D. C.

DIVISION OF ENGINEERING AND INDUSTRIAL RESEARCH

OFFICES
1346 CONNECTICUT AVENUE, N. W.

January 30, 1963

Dr. Wilmer E. Strobe
Director for Research
Office of Civil Defense
Department of Defense
Washington 25, D. C.

Dear Dr. Strobe,

At a meeting yesterday in Cambridge, four members of the National Academy-National Research Council Committee on Fire Research discussed your letter of November 6 and Mr. Christian's of January 15 and 23 to our Committee. This is responsive to those letters and is a summary of yesterday's comments, but it is to be taken as a personal communication rather than as an expression of the official position of the Fire Research Committee, for the obvious reasons that I am releasing it without having it checked even by the small group that participated in yesterday's conversations to say nothing of the fact that I have no way of being assured that the whole Committee would agree fully with its contents. By sending a copy of it to the members of the Fire Research Committee I am hereby inviting them to write you their views directly. If you wish further to discuss the matter with our Committee after study of this letter we shall be glad to reserve a portion of our next Committee meeting time for such a discussion and for presentation to your organization of a perhaps more satisfying Committee consensus.

Our discussion of yesterday centered around the originally proposed Project Flambeau. We believe that the biggest single problem in the national defense area in relation to fire is that of acquiring sufficient understanding of very large fires, including fire storms, to permit visualization and prediction of the effect of such fires on the problems of ventilation of protective structures within the fire area and on the spread of fire at its edges. This enormous question cannot be answered in our opinion, or experiments be effectively planned to yield the answer, until we first have answers to many lesser questions; and a listing of some of those

lesser questions in the approximate order in which they might profitably be attacked, should be of help to any group planning an experimental program on large-fire phenomena. The questions that deserve study include these:

1. How do regularly spaced fires interact? What is the effect, on the flow patterns of rising hot gas columns in a gravity field, of the spacing of fires and of individual-fire size? (The unit fires of the complex must be of a minimum size large enough to guarantee turbulent natural convection within the fire plumes.)
2. What is the pattern, in time, of buildup of flows in interacting fires?
3. What is the influence of the fuel bed, - its mean hydraulic radius and that of the internal air, - on the burning rate?
4. What is the influence of randomness of placement of combustion centers on the interaction phenomena referred to in items 1 and 2.
5. To what extent does a large fire interact with atmospheric lapse rate and humidity, i.e., what is the effect of the latter variables on the currents above fires of various sizes, and on the horizontal inflows? (Both lapse rate and humidity are included because the first determines the extent to which a parcel of heated and combustion-moisture laden air continues to maintain a net upward buoyancy force as it rises into air which, if the lapse rate is subadiabatic, will ultimately stop the buoyancy; and the second helps determine the extent to which the phenomenon of buoyancy creation by condensation of rising moisture laden air - analogous to rain formation in tropical cyclones - contributes a force to the fire column.)
6. Is the peripheral inflow to such fire systems high enough to explain fire-storm phenomena? How does rotation in the atmosphere, - which is always associated with the existence of a horizontal gradient in wind velocity -, affect the flow pattern around and through a fire on a controlled area? Is rotation an essential ingredient for fire-storm buildup?
7. How do concentrations of CO_2 , O_2 , CO and smoke vary at ground level under various combinations of meteorological and target conditions mentioned? (There is an expectation here of many answers; certainly no prospect that smoke or CO concentrations found to be

representative of some conditions of target and weather are necessarily applicable to other conditions.)

These are difficult questions calling for a very extensive and expensive research program. They cannot be attacked all at once with anything like the economy of man hours and material that would attend their consecutive attack, although several could profitably be under attack simultaneously. I cannot see any measure of success to be expected from large-scale (mile square) burns without some considerable headway having first been made on some of the above seven items. Some of them will of course themselves involve fairly large-scale field tests.

As to the extent to which your present program embraces studies of the above type, it is difficult from reading contract proposals and progress reports to determine whether the seven items above are receiving attention. I suspect that if they are, it is presently quite inadequate.

The above comments may appear not to be directly responsive to Mr. Christian's four points raised in his letter of January 15; certainly, however, they are indirectly so. But let me take up the four points more specifically:

1. "Committee's comments on the present status of our fire research program and approach." Our Committee has never been briefed by your contractors and is properly doubtful of its ability to decide on whether a contractor has a valid conception of his problem until we hear his own representative defend his proposal. We are aware that this kind of assessment is costly and time-consuming and, sometimes, an apparent duplication. When you think the time is ripe for such a presentation we shall be happy to convene a meeting of the Fire Committee.
2. "What specific problems could be solved by short-term research studies?" Some of the preparatory work on fire-storm field studies, items 1-3 of the above 7 items for example, could get under way fast with large laboratory and small field tests; and associated development of theory should be initiated simultaneously. In an entirely different area, tests of adequacy of several fire-proof shelter designs could get underway. A cheap and an expensive presumed-to-be-fireproof shelter design could each be tested in the same intensity of fire environment. These tests would not read on questions of ventilation based on any use of air drawn in from the exterior fire area; they would simply assess the adequacy of a design for resisting fire for one or two hours, would disclose possibly unexpected thermal leaks that would cause undue interior temperature rise, etc.

3. "What mass fire testing is desirable for our research problems." This item has already received considerable comment above.
4. "Type of organizational structure required to undertake mass fire testing." This needs more Fire Committee discussion before we can comment effectively. My personal view is that an existing large industrial research consulting laboratory group should be given full responsibility for the large-fire problem, including the 7 items above which must in some measure precede any very-large scale testing, and including coordination and, in some cases, perhaps reorientation of your existing contracts in this area.

As indicated early in this letter, our Fire Committee plans an early meeting. I suggest that Commander Thornhill and you pick a date mutually satisfactory to our two organizations.

Sincerely,

H. C. Kottel, Chairman
National Academy-National Research
Council Committee on Fire Research
(but expressing personal views).

APPENDIX C

NATIONAL ACADEMY OF SCIENCES
NATIONAL RESEARCH COUNCIL

COMMITTEE ON FIRE RESEARCH
AND THE
FIRE RESEARCH CONFERENCE

OF THE

MAILING ADDRESS:
2101 CONSTITUTION AVENUE, N.W.
WASHINGTON 25, D. C.

DIVISION OF ENGINEERING AND INDUSTRIAL RESEARCH

OFFICES:
1155 16TH STREET, N.W.

July 17, 1963

Mr. Walmar E. Strope
Director for Research
Office of Civil Defense
Department of Defense
Washington 25, D.C.

Views of the National Academy-
National Research Council Committee
on Fire Research on Project Flambeau

Dear Mr. Strope:

At the April meeting of the Committee on Fire Research of the N.A.S.-N.R.C. a discussion was held on the possible merits of and need for a group of Civil Defense field tests on fire, generally referred to as Operation Flambeau. Col. Karr and Mr. Christian of the O.C.D. were present, and asked that the consensus of the meeting be covered in a letter to the Office of Civil Defense. You will recall that Operation Flambeau has been the subject of earlier comments from individual members of our Fire Research Committee (e.g., my letter to you of 30 January); but these have been personal views. This letter is to express more formally the views of our Committee.

It is desirable first to agree or disagree on the nature of the need for and the objectives of Operation Flambeau. An examination of the records of the two meetings of the N.A.S.-N.R.C. Fire Research Committee with OCD representatives indicates that the OCD concept of Flambeau is that it is primarily a series of effects tests, building up finally to a large fire, perhaps one mile square. As an indication of objectives the following phrases are taken from the minutes of the April meeting: some phenomena of fire "are never to be known and OCD does not want to waste time or money on those things"; OCD is "interested in the reliability of shelters and the safety of people in them, consequently in the environment created by fire storms, the nature of the air movement, and oxygen availability"; "should people move out of or into shelters in a fire storm"; with respect to fundamental vs effects tests, "the urgency of the CD question is such that they must work both sides of the street". Our Fire Research Committee sympathizes with these objectives, and believes they are included in the following more general statement of proposed needs in relation to any contemplated fire test series:

There is need to know

1. Whether the transition from conflagration to fire storm increases the hazards of nuclear attack
 - a. By affecting the problem of air supply to shelters within the fire storm area,
 - b. By affecting the capacity of fire-resistant structures to give protection to personnel using them as shelters,
 - c. By affecting the expected rate and magnitude of fire-spread in the event of nuclear attack and, thereby, affecting any conclusions drawn from present analyses of savings achievable by various shelter programs.
2. Whether fire storms affect any existing plans to fight fires from a nuclear attack.
3. Whether a better understanding of fire storms might suggest novel approaches to fire-fighting or containment.
4. Whether, without regard to the existence of fire storms versus conflagrations, accumulated experience with large planned fires will significantly increase our understanding of some of the fire problems associated with nuclear attack, such as
 - a. the construction of shelters to make them fire-resistant,
 - b. the ventilation of shelters,
 - c. fire-fighting problems.

Our Committee concurs in the proposal of your office to proceed with studies aimed at a better understanding of the problems of growth and spread of large fires and protection against them, and believes that field tests can be used effectively to support the program. It is however doubtful about the validity of what it believes is the present OCD conception of the program, and believes that for the purpose of clarifying that conception there is need, on the part of OCD, for the following:

1. Closer coordination of the efforts of your various contractors assigned problems of large fires. To that end, either (a) development of in-house competence by employment, on an on-leave basis, of an engineer or scientist familiar with fluid mechanics in relation to meteorology and natural convection phenomena or (b) in the absence of availability of such an individual, the placing of the coordinating responsibility with a contracting laboratory, - one of the present contractors who has shown planning competence, or perhaps a new one.
2. Increased recognition of the fact that fire storms are of high complexity, that experience with a single large-scale fire has a negligible chance of increasing our knowledge of fire storms without extensive supporting knowledge in the form of research on both experimental and mathematical models. That

combination of built-upness, combustibility, simultaneity of ignition, atmospheric instability (as measured by lapse rate), and atmospheric circulation (as measured by horizontal velocity gradient in the approaching wind) which is required to produce fire storms is now quite unknown; and a single large fire which does or does not produce a fire storm will leave us with no improved understanding of what it takes to produce another unless the test is backed up by many smaller tests which have already given enough partial answers to the problem to indicate a clear need for the larger fire as the next step.

3. A plain statement of the extent to which Flambé is to be planned primarily as a series of "effects" tests. While effects tests appear to be easier to plan and interpret than tests integrated into a program aimed at a broad understanding of large fire behavior, the differences are subtle and easily misleading. From use of the term "effects test" to describe other effects of nuclear weapons one is easily misled into viewing fire effects similarly. But all fire "effects" depend on the general properties of fire and one is forced to conclude that "effects" is used in contrast to "behavior" to mean "assessment of effects without understanding or controlling their cause". This is possible, but only by statistical methods; and no one can rationally suggest building up a knowledge of the characteristics of square-mile fires by planned fire-setting if the results must be treated statistically. This is not quibbling over words. The effects of a particular square-mile fire can be meaningless without some understanding of the factors which caused it to behave as it did and if many of those factors are quite liable to be entirely different at the next light-off. Some of the effects of large fires do appear in fires which are not very large, and statistical studies of field tests of these smaller fires may be feasible and worthwhile. But if the objective is to find, for example, the effect of fire size itself by field tests, the chance of getting anywhere is quite negligible without coordinating the tests with experimental and mathematical model work. If a representative time-temperature curve is desired for testing structures, one might learn something; but experience with large building fires has already given the fire engineer a probably adequate curve for use in testing fire resistance of structures. If a knowledge of oxygen availability and presence of contaminants in the air is desired, we already know that at points on the ground midway between burning structures where there is no burning rubble there is a supply of substantially uncontaminated air in many large fires. But we do not know what fire storms do to this picture, - what intensity of burning coupled with other not-understood phenomena is necessary to invalidate the earlier conclusion as to oxygen availability.

Since the members of the Fire Research Committee have had an opportunity to react to my letter to you of 30 January and have expressed general agreement with its contents, those comments may now be considered as expressing a Committee consensus.

It is well known that the success of a research program depends more on the quality of personnel involved than on the objectives appearing in contract proposals written by professional proposal-writers. The Committee on

Fire Research suffers from not having heard directly from the contractors who will be most concerned with Project Flambeau, and welcomes the opportunity in September to hear progress reports directly from those contractors.

Very truly yours,

N.A.S.-N.R.C. Committee on Fire Research

William H. Avery

Horatio Bond

A. A. Brown

Howard W. Emmons

Joseph Grumor

J. B. Macauley

Walter T. Olson

A. F. Robertson

H. C. Hottel, Chairman

APPENDIX D

Taken from A Study of Fire Problems

(Report of the Summer Study at Woods Hole, 1961)

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

During the course of the summer study on hostile fire, certain features of the over-all fire problem have been clarified in the minds of the participants; the purpose of this section is to discuss these features briefly.

The problems of fire suppression and prevention have been under study for a great number of years by a wide variety of private and governmental organizations, and at the present time some 20 million dollars are spent annually in fire-related research and development work in the United States. However, most of this effort is applied work, a good deal of which is directed toward problems of satisfying code requirements and finding remedies for very specific problems. In addition, because the effort is supported by a wide variety of organizations, the direction of the total effect is diffuse, and areas of economic interest to the whole nation are often of insufficient interest, to any one group, to produce a desirable over-all level of attention.

The consensus of the summer study group is that a fire group should be established within the structure of the Federal Government to ensure that the national effort is a balanced one. This group would have as its prime functions the following:

1. The continuous assessment of the complete program of fire prevention and suppression, including the fire-related research and development work being carried out in the nation.
2. Based on the assessment of the national effort, the group should arrange for the execution of work not adequately supported. Where possible, this arrangement should take the form of encouragement and/or financial support to the private and public organizations already carrying out work in the deficient areas. Where necessary the fire group should actively support new work either by contract with existing organizations or by work within the organization of the fire group itself.

To carry out these functions effectively, the fire group should consist of a staff of technical people who devote full time to the project. Although the use of consultants and advisory committees may be desirable, the existence of a permanent organization with full-time director and technical staff is necessary. Of equal importance is the assurance of a budget which would permit a sustained effort.

An attempt has been made to estimate a reasonable budget for the fire group. It is felt that an initial annual expenditure of about three million dollars would be required. Of this sum, approximately one-third would be spent on fundamental research problems, one-third on problems associated with obtaining information of a fundamental and applied nature from large-scale controlled or natural burns, and one-third on studies of fire-related problems in the areas of economic and operational research. As the program develops, greater effort in these areas would be possible, and problems of an applied nature could be attempted in

CHAPTER VI. CONCLUSIONS AND RECOMMENDATIONS

following years. The sustained effort required to support this fire group work may become as great as three times the initial effort.

It should be emphasized that the study group was aware of the efforts presently being made in industry and by government groups to support and encourage fire-prevention and -suppression work. One of the major functions of the proposed fire group should be to stimulate such work; and where feasible, the resources of these organizations should be used in carrying out the proposed program.

The purview of the fire group should include all aspects of the fire problem. Thus, the group should be free to sponsor investigations of any problem which, in its judgment, is critical. These investigations should specifically include fundamental research problems in the pertinent fields of science, applied and developmental problems, operations research, economic analysis of problems at various levels of government, and educational problems.

The summer study group feels that a number of specific programs are required and should be initiated as soon as possible by the proposed fire group. These suggested programs reflect the potentially broad scope of the work of the fire group. General areas of interest will be discussed in the following paragraphs; specific recommendations for action are given later in this chapter.

At the present time there exists a great body of knowledge concerning fire-prevention and -suppression activities. This information includes areas such as techniques for good public educational programs, good fire-fighting tactics, and good professional training programs. Such information is used well in some areas and not at all in others. One of the important actions of the fire group should be to search for ways and means of achieving the adoption by state and local fire authorities of the best techniques available. Similarly, the fire group should also encourage the dissemination of fire-prevention information through the available communications media, to reach the general public, and through the support of regular and continuing programs in schools, to reach the young people of the nation.

In any study of fire problems, from the point of view of operations research or economics, it immediately becomes apparent that a tremendous amount of information is available but that this material is often incomplete, nonuniformly reported, or inaccurate, and that pertinent corollary data are often not collected at all. In order to facilitate the useful collection of data, two programs should be initiated. First, sufficient studies of the important economic and operational problems should be carried out to identify the desired information, and second, this information must be increasingly accurate, collected in a consistent and uniform manner.

The economic problems of importance certainly include the determination of the best level and distribution of expenditures for fire-prevention and -suppression measures at national, urban, and personal levels, and the examination of the economic incentives which operate to reduce fire costs. In the latter category, the determination, allocation, and regulation of fire costs, including insurance and taxes, should be studied.

CHAPTER VI: CONCLUSIONS AND RECOMMENDATIONS

Both the economic and the operations-research studies should be directed at the problem of establishing the best use of fire-fighting funds. For example, there is at present no rational way of determining the relative value of funds spent on fire-prevention work and on fire-fighting equipment. The fact that a great diversity of practices exists in the fire departments of the United States suggests that the best practices may be sorted out by the correct operational analysis. In any event, the techniques of operational analysis should be used to extract as much information as possible from the fires which annually destroy about 1.5 billion dollars worth of property.

Available techniques should be used to construct model fires and educational "games" for the training of firemen and for the evaluation of new fire-fighting practices.

Controlled burning of condemned structures or selected forest areas can be used to obtain quantitative information of interest in operational research and fundamental and applied research. Information obtained from controlled burns can be an invaluable supplement to information which can also be obtained from hostile fires. A major effort should be made to develop appropriate instrumentation and necessary techniques for this type of investigation.

The fire group should investigate the present national effort in applied research and should support needed work. Because most of the work being done in this field is supported by industrial concerns with immediate objectives in mind, the summer study group feels that supplementary efforts will be necessary.

Finally, the summer study group feels that the present effort in fundamental research is relatively weak. The fire group should support work on fundamental problems covering the entire purview of the group. For example, studies are needed on such fire-related phenomena as pyrolysis, ignition, fire spread, atmospheric interactions, fuel properties, effects of moisture, and extinguishment. These projects should be supported by direct contracts, where possible, but, where necessary, should be carried out by the staff of the fire group.

The fire group should also have the responsibility for translating the results of basic studies, as far as possible, into useful fire-suppression tools. Thus, the ill-defined area between "fundamental" and "applied" work should receive particular attention.

As a principal part of the translation mentioned in the last paragraph, the fire group should be responsible for increasing the dissemination of information at all technical levels. The group should hold meetings and support publications with the purpose of bringing the fire problem to the attention of the engineering and scientific community, increasing the exchange of information between scientists, engineers, and professional fire people. Although a technical journal devoted to fire problems may be inappropriate at this time, an abstracting journal such as the Fire Research Abstracts and Reviews serves a very useful function.

In the foregoing discussion, the general problems falling within the purview of the proposed fire group are discussed in general terms. More specific recommendations follow.

CHAPTER VII: CONCLUSIONS AND RECOMMENDATIONS

Recommendations

I. A fire group should be established within the Federal Government to take over all responsibility for the fire problem. This fire group should note and encourage work now in progress as supported by diverse public and private units; assess progress continually; seek, encourage, and develop new ideas on fire control; arrange for the execution of work not now adequately supported.

For these purposes, the fire group should:

1. consist of a director with an adequate staff of full-time personnel,
2. be given authority and have responsibility to contract for necessary work with universities and nonprofit research groups, industrial concerns, and government organizations, and
3. be provided with a budget adequate for the work.

A first-year budget of \$3,000,000 is suggested. Perhaps three times this sum will be needed as the program develops. The fire problem, costing society \$5,000,000,000 per year, deserves to be considered along with other national problems of this magnitude at the highest levels--the Departments and Congress. The fire group should, therefore, have authority at this level.

II. The fire group should make use of existing public and private organizations in carrying out its program.

III. The program of the fire group should include the following important activities:

1. Search for ways and means of achieving universal adoption by state and local fire authorities of the best techniques which have been developed by the more progressive states and communities. These include fireman training, prevention measures, and prefire planning.
2. Support public education in fire-prevention measures and fire consciousness. Additional study will be needed to develop specific measures.
3. Collect, organize, analyze, and disseminate data on fires. The most urgent need is a quantitative evaluation of the relative importance of organizational and operational factors in fire control and their economic consequences. To be useful, pertinent data of adequate accuracy must be collected in a consistent and uniform manner. This will involve state and municipal organizations, and urban and forest fires.
4. Study the economic aspects of fire, including common-pool problems and cost-benefit relationships.

CHAPTER VI. CONCLUSIONS AND RECOMMENDATIONS

5. Study the effect on total fire cost of the variable factors of fire-control organization and response. These factors include leadership, fire-fighting tactics, prefire planning, and personnel training. To carry through this study, a scale of "fire hazard potential" for area classification and a general measure of "total fire cost" should be developed.
6. Examine the determination, allocation, and regulation of fire costs, including insurance and taxes, required to promote more equitable distribution of costs and to produce an economic incentive to reduce risk.
7. Support a wide variety of fundamental research connected with fire phenomena, such as fuel properties, pyrolysis, ignition, fire spread, atmospheric interactions, effect of moisture, extinguishment, etc.
8. Support those special items of applied research that are of important social consequence but poor economic prospect. These items include special hazards, test methods and standards, and development of new techniques lying between fundamental research and commercial exploitation.
9. Use controlled burning of condemned structures and selected forest areas to acquire data on fundamental fire phenomena and the response of fire to extinguishing agents. Data should also be obtained on the effect of the various organizational and operational factors in (5) above.
10. Develop player-participation games for the training of fire-fighting personnel, for the investigation of fire-fighting techniques, and for the planning of interagency cooperation in fire-suppression activities.
11. Sponsor meetings and publications as required to bring the fire problem to the attention of the scientific and engineering community and to disseminate new knowledge to all interested parties.

JUL 1 1963

June 27, 1963

Mr. John Christian
 Research Division
 Office of Civil Defense
 Department of Defense
 The Pentagon
 Washington 25, D. C.

Dear Mr. Christian:

I have spent some time reading the Armour Research Foundation Report "Fire Storm Analysis", the final report on ARF Project A6004. You asked for my comments.

Part I is a good start on the burning-plume theory, with more nearly rigorous allowance for forces due to density variations along the column due to combustion progress than has been done before. However the following must be pointed out: The chief objective of the increased rigor of treatment must be to determine radial velocities and gas concentrations and temperatures near the ground; and these objectives will never be achieved by assuming a top-hat profile of properties. The author is aware of this, and suggests the need for a more sophisticated treatment which allows for ground drag and for turbulent mixing at the plume base.

It is interesting to compare the results of Figures 4-11 with those obtained very simply by unadorned point-source thermal plume theory (see the dittoed sheets transmitted to you or Col. Karr from Dr. McRae on the day I called at your office). Point thermal-source theory may be used only above the neck of the plume and even then with recognition of its approximate character. According to the dittoed notes, Appendix B to Section I, eq. 6:

The vertical velocity is given by

$$u = \frac{5}{6\alpha} \left(\frac{g\alpha Q}{10x} \right)^{1/3}$$

α = entrainment coeff.
 x = height

where

$$Q = \frac{g q (\gamma - 1) / \gamma}{\pi p}$$

Figure 4 of the present subject report refers to structures containing 56,000 lbs wood on 25x50 sq. ft., and covering 50% of the ground area, and to a total ground area covering a circle of 5,000 feet radius.

$$\begin{array}{l}
 \text{number of building units} \\
 \text{total pounds wood} \\
 \text{consumption per second} \\
 \text{fractional gassification and} \\
 \text{heat liberation} \\
 \text{heating value per pound, Btu.} \\
 \text{conversion to ft. lbs.}
 \end{array}$$

$$q = \frac{\pi 5000^2}{25 \times 50 / 0.5} \times \frac{56000}{51 \times 60} \times 0.3 \times \frac{8000}{778} = 1.08 \times 10^{12} \text{ ft}^4/\text{lb}^3$$

$$Q = \frac{1.48 \times 10^9 \times 32.2 \times 0.4 / 1.4}{3.14 \times 14.7 \times 144} = 1.48 \times 10^9 \text{ ft}^4/\text{sec}^3$$

Take a height of 2000 feet as being well above the plume neck. If the same α of 0.17 is used in the above relations as in the subject report, the vertical column velocity is found to be 238 ft/sec* vs about 230 from the subject report, Fig. 4; and the column radius is 408 vs about 320. However, the dittoed notes used an α of 0.09, which gives $u_{2000} = 364$ ft/sec. and radius = 216 feet. (The subject report presents some results with an alternative α of 0.10, but not for the conditions of Fig. 4). Of course thermal point-source theory gives ridiculous answers near the ground but, as I have pointed out, the subject report does not give values which are good enough to use because of neglect of drag, mixing, and radial property variations near the ground.

A much more serious deficiency of the approach in the subject report is that is, as well as the thermal point-source plume theory of the dittoed notes, indicates plainly that in fires of the size known to have produced fire-storms in Germany, the horizontal velocities to be expected on the ground are far below those actually experienced. Radial velocities were not calculated in the report, but the following argument constructed from it should be convincing: The vertical flow is assumed to lie all within the "radius of the column". At an altitude of 100 feet the vertical mean velocity within the column is about 65 feet/sec. and the column radius is about 160 feet. But the fire perimeter is $2\pi \times 5000 = 31,400$ ft., and

$$*u = \frac{5}{6 \times (10^3)} \left(\frac{9 \times 0.17 \times 1.48 \times 10^9}{10 \times 2000} \right)^{1/3} = 238$$

3.

if all the air rising from the fire 100 feet up flows inward through a vertical cylindrical wall 50 feet high and 31,400 feet long, its velocity will be only $\pi \times 160^2 \times 65 / 31,400 \times 50 = 3.33$ ft./sec! If all the air rising at 1000 feet up (where the vertical velocity is 300 ft/sec and the column radius 240 ft) flows in radially through an area equal to the fire perimeter times a vertical distance of only 50 feet, the radial inward velocity will be

$$\frac{\pi \times 240^2 \times 300}{\pi \times 31400 \times 50} = 35 \text{ ft/sec.}$$

or 24 miles an hour, possibly approaching but still sub-firestorm velocity. What would make the air feeding a fire column at heights up to 1000 feet come in through the perimeter so close to the ground? Some think only tornado-type flow, which would require some existing "circulation" or horizontal cross-wind velocity gradients in the air approaching the fire. I therefore strongly recommend that if Armour goes on with the problem (and they have made good headway) some consideration be given to the problem of "circulation" existing in the atmosphere. H.C.

I am intrigued by the treatment of Part II which gets at oxygen deficiency by use of turbulent diffusivities combined with the view of a fire as an oxygen sink. Of course the effect of buoyant forces on the mixing process and, therethrough, on the diffusivity may be much larger than the only effect allowed for in the calculations, that of horizontal velocity on turbulent diffusivities. It is perhaps accidental that the report concludes oxygen will be deficient at 800 to 2000 feet within the perimeter of a firestorm, vs our previously-referred-to dittoed notes, p. B-4, which gives an example of oxygen running out in about 1/3 mile from the edge of the fire. I doubt both conclusions; I think there is an oxygen supply problem inside a firestorm area but not that big a one.

For the record, will you please ask Mr. Nielson this one: I am not clear on his calculation of energy liberation. Does he say that about 64% of the wood (the fire "load") appears as gas and tar above the site, that this corresponds to only about 30% of the heat of combustion of the original wood, that since the latter is about 8000 Btu. per pound the gases from one pound of "load" have a heat of combustion of $8000 \times .30 / .64 = 3750$ Btu/lb? Is that about the number by which the Fuel Gas Generation Rate of Figs. 4-11 is to be multiplied?

Sincerely,

H. C. Hottel

HCH/k

APPENDIX F

December 24, 1964

Mr. John Christian
Project Coordinator, Support Systems Research
Office of Civil Defense, Department of the Army
Office of the Secretary of the Army
Washington, D.C., 20310

Dear John:

While I was in Europe last fall you sent me a copy of an N.R.D.L. proposal with a request for comment. On the faint chance that my comment may have some pertinence despite the long lapse of time, here it is:

1. You ask about the appropriateness of the study. It is not just appropriate, it is necessary for a group monitoring the Civil Defense Fire Program to have a background of knowledge of the kind to which the proposal refers. Acquisition of that is so much a part of the function of monitoring that I am somewhat puzzled at the suggestion of the need for a separate contract to cover it. I had thought there already was a contract for monitoring. Another point under "appropriateness" is that any special acquisition of competence through a survey operation is most effective if it resides in the individual having the prime responsibility for the monitoring operation. I am not clear as to the extent to which that is Martin's function.

2. The approach and timing. As to how much of the total picture one has to get before settling down on a research problem, that is hard to answer. Certainly much less than all of it if the investigator is himself to imitate research thereafter; broader, but in less depth if his is primarily a responsibility for coordinating or monitoring. If Martin's

objective is self-preparation for research it appears to me more sound for him to focus in his survey, on an area which meets the two criteria: (1) he already knows quite a bit about the field, and (2) it has ultimate implications to the C.D. program. You can see from these comments that I am not clear on the objective.

Another point under "the approach". I have reread the old N.A. - N.R.C. Committee on Fire Research Program". While it is too broad in its objectives to fit C.D. needs directly, it appears to me to offer a reasonably good framework on which to hang a new outline. I have photocopied and enclose a few pages from it, and as I read it, I see much applicability to C.D. In many areas, of course, significant work has been done since it was written; but most of the problems presented are still not understood.

3. Is this the kind of a job the Fire Committee could do? Definitely "no", as a committee. Several of the individual members could be helpful in spending a few hours or a day, one at a time with Martin or whoever did the job - preferably after he had got far enough to have partially crystallized his own ideas of an outline. Blind spots could thus be found, or changes of emphasis suggested. I would be glad to sit down with him, and I think Emmons and Olsen and some of the others would. And we could perhaps be helpful in suggesting experts in specific areas.

If you have not already taken action, my recommendation is that the job be done. I am only puzzled that it is not considered automatically to be a part of the monitoring activity.

Sincerely,

H. C. Hottel, Chairman
N.A.-N.R.C. Committee
on Fire Research

HCH:an
cc. to Mr. Thornhill

APPENDIX G

HARVARD UNIVERSITY

37 AVENUE CAMBRIDGE, MASSACHUSETTS 02138

DIVISION OF ENGINEERING AND APPLIED PHYSICS

HOWARD W. EMMONS
GORDON MCGAY PROFESSOR OF MECHANICAL ENGINEERING

May 20, 1965

Mr. John P. Christian
Fire Research Coordinator
Office of Civil Defense
Washington, D. C.

Dear John:

I promised to drop you a note on some of my reactions to the contract reviews on Tuesday and Wednesday mornings. This is the second such review I have attended; the first nearly two years earlier at Riverside. At the Riverside meeting I was very favorably impressed with the program being sponsored. At that time it was largely designed to get quick and dirty answers to immediate problems, together with studies of what would be needed to make these answers better, both in the immediate future by data gathering techniques, and in the more distant future by more careful study of important detailed problems.

This week, two years after the Riverside presentations, I listened again and heard essentially the same story, but this time I am disappointed, since two years should have been sufficient to have made progress with the planning and initiation of some of the more long range phases, rather than an almost exclusive concern for the quick and dirty answers. I detected here and there, in fact, some dissatisfaction with the lack of support for programs which might go on from where we are now. At one point, for example, a voice in the back of the room objected to certain new studies which appeared to the speaker to be a duplicate assessment of fire damage in competition with an assessment technique which is already coded up and operating on various computers. I also heard objections from the front row immediately thereafter saying that the work was not a duplication. However, it sure listened like duplication to me! I have no doubt that the present assessment position will have many shortcomings and will need much new data, some of which is statistical and some of which is of a fundamental mechanistic nature, and no doubt the assessment system will have to be modified and improved as new knowledge is acquired, but any attempt at developing the assessment system further without the new data and new knowledge is a waste of time and money, and I heard several contractors talk about what essentially were new looks at part of the assessment system.

It is always pleasant to find that the technical work one has been doing is of interest, and I was glad of the opportunity to explain some of the elementary aspects of my fire whirl work to interested contractors. This work has an obvious bearing on the discussions of the meaning of the

Best Available Copy

Dr. John F. Christian

-2-

May 20, 1965

terms "mass fire" and "fire storm." It is always nice for a group to be able to get together and have a friendly argument over a topic of this kind. The fact that such an argument can take place in 1965 is, of course, evidence that for the past 20 years, since World War II, OCD has neglected to do its homework properly, since if any significant work had been done at all, answers would have emerged by now -- answers taking the form of an understanding of the effects of atmospheric stability, whirl, and fire plasma development. While it is pleasant to be able to contribute to such a discussion, it is rather horrifying and disappointing to find that one Chinese graduate student is doing all the work of the entire country aimed at clarifying these questions. Where is your fundamental program?

I was disappointed and disgusted to realize that the United States still does nothing to change the situation for 1975 or 1985. I can well imagine attending another session of your, or of your successor's, contractors in 1985 and to participate in another pleasant discussion about a possible meaning of mass fire and fire storm. What I am really complaining about is what I regard as an extremely shortsighted unbalance in your program. The parts of your program that are aimed at immediate answers, parts of an ad hoc research nature are, of course, all necessary and I would be even more disturbed if I saw a program consisting of nothing but fundamental research, but 10 or 20 per cent or so of your budget must go into fundamental research, or we will still be without answers to basic questions 10 or 20 years from now. I can see no excuse for the neglect of the fundamental parts of the program. It is not even good engineering in 1965 to neglect parts of an effort which has a potentiality of leading to precise answers for the future. While I am glad to contribute to the lip service part of a basic program as exemplified by the sessions at the Society of Fire Protection Engineers, I regard such efforts as primarily aimed at the education of fire protection people in their need for more basic knowledge. Presumably you are already aware of this need, but your program suggests that it is only lip service.

You suggested that I should not "hold the horses." Furthermore, I assure you that if you think the proper disposal of this letter is in the wastebasket, it will not hurt my feelings either, but I do think your studies of problems have easily advanced to the point where certain basic studies are clearly a necessary part of a good program in Civilian Defense against fire, and I hope you will take contract steps to implement them.

Sincerely,

Howard

Howard W. Emmons

H. J. J.

cc: D. Thornhill

C.L. Poor, III

Best Available Copy

Appendix H

Comments of H. C. Hottel on OCD Fire Research Contractors' Program

Presentation, 17-19 May 1965

My general impression was that there had been a marked improvement since the last report session I attended two years earlier, in the organization and correlation of the program, that the effect of putting technical guidance largely in the hands of a single laboratory group had been in general salutary, and that there was nevertheless evidence of considerable contracting for rabbit-out-of-the-hat results, particularly in the area of operations analysis where a model of firespread was still missing.

In the narrow technical sense, operations analysis for planning purposes works with what has happened--with what we can infer about the elements of a system, from past experience with various systems composed of those elements--to predict what will happen if those same elements are assembled in a different way. For example, operations analysis to decide where to relocate fire engine houses in a city depends on (1) availability of a large body of data on past city fire experience, related to variations in traffic, equipment, and buildings; (2) the development of models (a) of interaction of traffic patterns with engine delivery to sites, (b) of fire growth in relation to intensity of attack on it and elapsed time from ignition to attack; (3) the use of the models, plus the data, to reconstruct past known performances of past known systems, to see if the proposed model properly predicts what is known to have happened; (4) the modification of the model to bring it into line, and perhaps the accumulation of additional data to fill

out an obvious blind spot; (5) finally, when the model has proven its validity, its use to predict the result of proposed changes in equipment design, city design, traffic handling, or what have you, in arriving at the best new combination of the elements of the system. The solution has validity only if either (1) all elements in the new system were present in the old one, or (2) those present in only one were unimportant in either, or (3) the model is sufficiently sophisticated to allow for the absence of the effect, in performance data from the past, of elements unique to the new system. To take an infinitely simpler system as an example, no fluid mechanics expert would claim that any amount of data taken on laminar-flow systems would predict much worth recording concerning the performance of turbulent-flow systems unless keyed to a model making up in sophistication for the complete lack of experience with turbulence.

Our experience with very large fires is quite negligible (from the possibly seven firestorms created in World War II we know almost nothing quantitative); and we have no experience with large fires set by a near-simultaneous ignition process. We know so little about firestorms* as not to be able even to design field experiments to study them. No amount of navel-gazing will supply a systems analysis with the capacity to predict what happens in firestorms if no data are available to support a model. We need meteorologists and fluid dynamicists supported on a significant scale for laboratory work; we need top-flight applied mathematicians to get at the effect of lapse rate - an effect prohibitively expensive to study on a full scale, at least in our present state of ignorance.

*This term is used in the narrow sense of fires which amplify local atmospheric "circulation" effects and are akin to tornadoes.

I am not suggesting that we do not need to know the results of present systems studies of what kinds of problems will be created by fires in large cities; and I do not deny that many of these problems are but tenuously related to our genuine understanding of the large fire. I do say we are leaving out of the program the facing of the question of whether large nuclear fires are so far beyond our experience as to call in question much of our planning concerning coping with them. And the peacetime byproducts of a better understanding of the physics of fire growth may well be - hopefully will be - a major useful product of our civil defense effort.

Another area of deficient factual knowledge in relation to the construction of any predictive model for determining city fire effects is our inadequate knowledge of (1) the density of ignition centers and (2) the spreadability of fire as affected by building density and quality. I am encouraged by the work on the first of these areas but consider it inadequate. When a large fire develops from a nuclear attack there will be a ring area, spanning an irradiation impulse variation from perhaps 5 to 50 or 100 cal/cm², in which the number of fires initiated per acre is directly dependent on the area density of ignition or kindling sources. Knowledge of the coordinates of the S-shaped curve representing the probable cumulative number of ignition sources per acre as a function of the size of the available thermal impulse can be very important or almost beside the point, depending on what kind of results one wants from a study. This is no plea for knowing the distribution function in great detail or for using it in all its detail on a particular problem. But it is a key part of the raw material from which to construct simpler models adequate for specific purposes; and the systems analyst needs

all the help he can get in this area. With respect to the second item mentioned - spreadability of fire - the aid of fire-protection engineers (particularly from insurance companies) in all our major cities should be enlisted to map these cities in some kind of graded scale of vulnerability to firespread. Fire maps exist for many cities; they need revision in relation to conflagration conditions.

I was extremely unimpressed by one Contractor's fancy block diagram constituting the main theme of the oral report and showing how the Contractor planned to use as "inputs" a combination of "empirical data" and "theoretical studies," leading with arrows to an "analysis" which in turn led to "outputs" labeled "build models" and "determine implications!" How many thousands of the world's problems are covered by so general a diagram! Who can pass on whether anything will come of it?

It is difficult to comment on whether the effort is well balanced. An analysis of some 25 of the 2500 Series on Fire Effects and Protection indicates that they can be divided into some 6 categories: fire behavior; assessments of weapon capabilities, urban vulnerability, hazard and expected damage; fire surveillance and communication of information during attack; rescue; equipment development. The size of these programs not being indicated, there is difficulty in concluding much about the balance of effort. No one can deny the significance of the items as listed. As can be inferred from my earlier comments, I believe the program is weak in the area of fire behavior, though I sympathize with the coordinators on the enormity and complexity of the overall C.D. problem.

During the War, I had responsibility for NDRC research planning basic to incendiary bomb development and assessment of fire effects of proposed raids. We felt time was so precious that the work on understanding how bombs ignite wood and on how fire spreads was cut short in the interest of getting on with bomb development itself. We paid the price of having later an inadequate basis for convincing the military that we could in fact estimate bomb effects, and at war's end were engaged in projects belonging at war's beginning. Fortunately, we had developed some good bombs, but the lesson was driven home that with all our experience we did not understand the process of ignition and fire growth. We know more about it today, but we don't begin to understand large fires.

January 1966.

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APPENDIX J

NATIONAL ACADEMY OF SCIENCES
NATIONAL RESEARCH COUNCIL

COMMITTEE ON FIRE RESEARCH
OF THE

DIVISION OF ENGINEERING AND INDUSTRIAL RESEARCH

November 30, 1964

MAILING ADDRESS:
1200 CONSTITUTION AVENUE, N.W.
WASHINGTON, D. C. 20042

OFFICES:
1155 16TH STREET, N.W.

Dr. Frederick Seitz, President
National Academy of Sciences
Washington, D.C.

Dear Dr. Seitz:

This letter is to acquaint you with some of the past actions of the Committee on Fire Research of the National Academy of Sciences-National Research Council, and to restate its position with respect to fire research activities under the Bureau of Standards. In order that the Bureau have a clear picture of the position of our Committee it is requested that this letter be transmitted to Dr. A. V. Astin, Director, National Bureau of Standards.

It follows a chronology of background facts:

1. In 1953, the Committee on Fire Research prepared, after extensive study, a "Proposed Fire Research Program" designed to encourage more basic studies of the nature of "unfriendly" combustion. It proposed a more effective use of certain fields of fluid mechanics, chemical kinetics, applied mathematics, and operational research.
2. In 1955-9, the Committee invited individual scientists and engineers and research laboratories with a successful record of research in controlled combustion to submit research proposals in the fire area. These were appraised at the direction of the Committee, and recommendations were made for support of some of them by the National Science Foundation.
3. In December 1955, the Committee presented, to a group representing government agencies interested in fire and called together by Dr. Killian, Science Advisor to the President, its "Proposed Fire Research Program." The Committee recommended (1) expenditure, at an initial rate of \$500,000/year, of funds to explore fundamental fire research throughout the nation and under contract with or grant from one of the Armed Services Research Offices or the National Science Foundation; (2) expenditure of an additional \$2,200,000/year on in-house research by government agencies interested in fire; (3) the formation of a Fire Research Agency along the lines of the United Kingdom Joint Fire Research Organization.

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4. Dr. William appointed an ad hoc Committee of government agency representatives, chairmanned by Mr. Gerald Gallagher, to reply to the proposals of the Committee on Fire Research.

5. The Gallagher Committee met on February 7, 1959. It concurred in the desirability of implementing recommendation 1 of the Committee on Fire Research, under the aegis of a single agency; and it recommended that the program be administered by the Bureau of Standards, with a line item in the Bureau of Standards' budget after fiscal '60. On recommendation 3, it suggested that the Bureau of Standards coordinate research under recommendation 1 and give leadership in developing an improved system for dissemination of fire research results, that the National Science Foundation support basic fire research and underwrite conferences devoted to it. On recommendation 2 no action was taken, presumably because expansion of in-house fire research by various agencies was considered their own decision. It was emphasized that implementation of recommendation 1 should in no way limit the right of any agency to carry out a program responsive to its own needs.

Following the recommendation of the Gallagher Committee, the Office of Civil and Defense Mobilization and the Department of Defense transferred \$250,000 for fiscal '60 to the Bureau of Standards for support of out-of-house basic fire research.

7. In July-August 1961, the Committee on Fire Research sponsored and the National Science Foundation financed a "Study of Fire Problems" by some 25 scientists and engineers gathered at Woods Hole. The report of that group, NRC-NRC Publication No. 949, called attention to the minute expenditure of funds on fire research compared to the U. S. annual fire loss of about 5 billion dollars - about 1% of the gross national product. The Woods Hole group recommended establishment, within the structure of the Federal Government, of a Fire Group, responsible for maintaining a balanced and integrated effort on fire-related research, and operating on a first-year budget of \$5,000,000 expanding ultimately to perhaps three times that amount. Detailed recommendations were made concerning activities.

8. In October 1961, the Committee on Fire Research expressed its approval of the current study recommendation to establish a Federal Fire Group, and arranged the proposed activities in what it considered an order of importance. It concluded that fundamental research, statistical studies of factors in fire control, operational studies of fire fighting and profile planning, and controlled "burns" of condemned structures and selected forest areas merited first attention. The position of the Committee was transmitted to Dr. Wiener, Chairman of the Federal Council for Science and Technology.

9. In October 1961, the Gallagher ad hoc Committee was requested by P.C.S.T. to review and evaluate the Woods Hole Study Group's recommendations. The ad hoc Committee made the following cogent remarks:

"The national problem of fire, particularly in respect to urban and industrial fires, merits much more serious attention from the Federal government than it has received. If --- (increased effort) --- is to succeed, it is agreed that it must be given substantial organizational stature in the Federal structure." After presenting the arguments, the Committee concluded: "It is recommended that there be established in the Department of Commerce a Fire Office with a clear statement of mission aimed at accomplishment of the two functions (coordination, with responsibility for research and development in the urban field comparable to that now resting with the Forest Service in respect to forests and wild lands; and conducting an operational program for the urban and industrial fire field) discussed above. \$3,000,000 --- for the first year and perhaps 3 times this sum as the program develops --- is reasonable if an effective organization is developed." "It is recommended that the Department of Commerce seek an appropriation in FY '62 for organizing and staffing and in FY '63 an appropriation of \$3,000,000."

10. In October '61, representatives of the Committee on Fire Research appeared before the Federal Council on Science and Technology, Dr. Wiesner, chairman, and made recommendations substantially corresponding to those in the Woods Hole Report. Response at the meeting was favorable to increased fire research activity. Responsibility for carrying out the recommendations made was assigned to the Department of Commerce, which later assigned the responsibility to the Bureau of Standards.

11. In June '62, after the Woods Hole Report had been in print long enough to study, the Fire Research Conference (a group of 22 fire experts advisory to the Committee on Fire Research) was convened to evaluate the Report (total membership present, including the Committee on Fire Research, 10). There was a unanimous vote favoring federal action - with exact manner unspecified - in support of basic fire research. Item-by-item voting on the various Woods Hole recommendations concerning the detailed nature of Fire Group activities indicated opposition of up to one-third on a few items. On the establishment of a national Fire Group, 12 favored the recommendation with a minor change in wording, 6 abstained.

12. In June '62, the Chairman of the Committee on Fire Research of the Academy-Research Council appointed from among the Fire Research Conference members a subcommittee each member of which was connected with a federal government department interested in one way or another in fire research, R. L. Rye, Chairman, to consider the effect of the proposed creation of a Federal Fire Group or Fire Research Office on the present federal programs on fire. Conclusions: there is need to strengthen and interrelate present fire effort in various federal agencies; the creation of a Fire Research Office would strengthen work in existing agencies.

13. The National Bureau of Standards in the preparation of its budget requested funds from Congress in FY '62 and '63 both to pick up full support for the contract program and to augment its own modest fire research effort. Each year, however, the amount allocated by Congress represented a reduction of the total budget requested and, accordingly, the proposed expansion of the fire research program was not effected. (OED and DOD by transfer of funds in continuously decreasing amounts have enabled NBS to keep active a modest out-of-house fire research program.) For FY '64, the fire research line item was removed by action of the Subcommittee of the Committee on Appropriations of the House of Representatives, Eighty-Eighth Congress, First Session.* The unfavorable action of Congress reflected, in part, the views of an organized opposition to the proposal of the Department of Commerce, notably by the National Board of Fire Underwriters and the National Fire Protection Association. For FY '65, the Bureau of Standards included no out-of-house fire research item in its budget.

This completes the listing of events associated with the attempts of the Committee on Fire Research to strengthen basic fire research. The Committee wishes now to summarize its views and beliefs on this subject, formulated slowly by some years of careful assessment of the status of both fundamental and applied fire research in the United States and abroad:

1. Fire Groups identified with federal laboratories as well as private industry and charged with responsibility for improving our techniques of fire prevention, detection, and extinguishment must identify their programs closely with the direct solution of pressing problems, and their budgets usually depend on their apparent short-term progress in solving such problems. This makes it difficult to give sufficient priority to the continuing development of the fundamental understanding of fire phenomena.

2. There is, in the United States, no federal or other agency engaged in a study of the basic phenomena of fire comparing favorably with the British effort under the Joint Fire Research Organization. A first effort to correct this imbalance was the funding by the National Science Foundation of research proposals selected by the Committee on Fire Research in 1953-59. This effort was quite small and continues at a very low level. Similarly, the total U.S. effort in fire phenomena research is insignificant compared to our effort in fundamental research in other comparable areas. The ratio of basic to applied research is well below that in weather forecasting, space travel, weapons development.

*See Hearings before a Subcommittee of the Committee on Appropriations, House of Representatives (Departments of State, Justice, and Commerce, the Judiciary, and related agencies) for 1964, pp. 948 ff.

3. The relatively large effort of industrial laboratories is primarily concerned with immediate fire problems of industrial clients and the insurance industry. The proportion of the work of these organizations that is directed to basic research does not meet the U.S. needs for long-range fundamental research on fire. Modern instrumentation is expensive, tests must be performed in part in the laboratory and in part on a large scale, fundamental research does not have a guaranteed date of pay-off, and the research program must receive steady support over a very long period of time. Neither private industry nor the municipal and state fire organizations can be reasonably expected to support such work.
4. The National Fire Protection Association is "an international clearinghouse of fire prevention information, fire fighting procedures, fire protection methods and analysis of fire experience." It is interested in fundamental research but has no provision for funding it. Its publications and the activities of its 120 committees made up largely of representatives from industry are of high value. It edits, and very ably, a Fire Protection Handbook.

The position of the NFPA on the proposed Bureau of Standards proposal is summarized in the following quotation from a statement of its General Manager:

"We would observe that much fire research is presently being conducted by various federal government departments, by private research laboratories, and by many industries. Certain fundamental research in fire might well be undertaken by the Fire Research Section of the National Bureau of Standards, but this in our opinion would not involve the setting up of a new widespread research program as suggested in the proposal."

5. The Forest Service is engaged in a relatively sophisticated study of the mechanism of fire spread and has acquired, in several of its laboratories, personnel fully capable of effective basic fire research. There is no counterpart of this activity in the important area of urban fires and urban fire hazards.
6. The Bureau of Standards in-house research on fire is of good quality but quite small in total magnitude compared, for example, to either of the two large British activities - the Fire Research Station at Boreham Wood or the Safety in Mines Station near Sheffield.
7. The biggest opportunities for reduction of national fire losses lie in more effective use of present knowledge, and existing organizations active in the area of education are to be strongly encouraged.

3. The Bureau of Standards was not able to convince Congress of the importance of supporting its proposed program of fire research for FY '64.

The Bureau needs and should be given technical assistance in its presentation of future programs in fundamental fire research. Its program in fire research does not equal its efforts in other major areas. Future plans for developing an understanding of fire should include a laboratory building, equipment and staff comparable to the Bureau's Boulder, Colorado research on radio propagation and atmospheric studies.

9. That a more vigorous national attack is needed on the fire problem is indicated, not only by the 1953 U.S. total annual loss of 11,200 lives and 6 billion dollars, but also by the following reports of losses based on the NFPA Quarterly, October 1964.

Number of fires per year per million population			
Highest	United States		12,000
Second	New Zealand (1)		5,000
Third	Canada		4,400

Annual direct dollar loss per person			
Highest	United States		\$9.5
Second	Canada		7.4
Third	Australia (2)		6.2

Annual deaths from fire per million			
Highest	United States		62
Second	Canada		29
Third	United Kingdom (3)		18

Although comparisons are difficult because of differences in reporting procedures, national wealth subject to fire loss, quality of fire protection, prevailing construction, and social attitudes toward fire prevention, there is no basis in this table for satisfaction.

-
- (1) Fire Department calls only.
 - (2) Building fires only.
 - (3) 1962 figure.

The above views of the Committee on Fire Research lead it to make the following recommendations:

1. The Bureau of Standards should put into its budget an item of significant size - sufficient to support 25 to 50 research people to start - to cover out-of-house and in-house fundamental research on fire, to publish and interpret the significance of its fire research findings, to be cognizant of other fire research activities, and to encourage and assist in the interchange of fire research information.

2. The Bureau of Standards should indicate, by a strong stand and a carefully prepared defense before the Appropriations Committee, that this country is in need of a vigorous long-range fire research program and that this is of vital importance to the national welfare.

3. The Bureau of Standards should assign at least one able research planner in the preparation of the details of NBS attack on various fire problems, both basic and applied; and should as a result be prepared at all times to give priority among various problems in the event of financial support becoming available. The planning should be accompanied by a clear recognition of how the program fits into the over-all needs of the nation.

Sincerely,

H. C. Hottel, Chairman
Committee on Fire Research

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NATIONAL FIRE PROTECTION ASSOCIATION



EXECUTIVE OFFICE, 40 BATTERYMARCH STREET, BOSTON, MASSACHUSETTS, U.S.A. 02110
Organized 1896 • Incorporated 1930 Telephone 402-4735 Direct Dial Prefix: 617

November 20, 1964

Professor H. C. Hottel, Chairman
NAS-NRC Committee on Fire Research
2101 Constitution Avenue, N. W.
Washington, D. C. 20418

This letter constitutes a minority report on the Nov. 30 letter from the Fire Committee to the President of the National Academy. That letter was reviewed and approved, paragraph by paragraph, by all members of the Fire Committee except the author of the present letter. H.C.H.

Dear Hoyt:

I feel that the letter you have drafted to the President of the Academy misleads him as to both the nature and urgency of the fire problem. If you send the letter, please send with it this letter to register points I am sure he would like to know about. Please send with your letter the original of this one as I would like Dr. Seitz to see the list of organizations which, through membership in the National Fire Protection Association, are supporting work on fire. This list is on the reverse of the NFPA letterhead, so I am sending you an extra copy of this letter for your own file.

In the list of events you cite, the National Fire Protection Association and its interests are deprecated as somehow sub-scientific. I would like Dr. Seitz to know that NFPA was organized "to promote the science of fire protection," 60 years before the Academy's Committee on Fire Research was appointed. NFPA has defined 122 major subject areas of the fire problem and has technical committees for each. The Association has developed a rich technical literature and by meetings and discussions and publications provides for an effective exchange of scientific and technical information. The Association has 1,414 persons presently serving on technical committees and over 20,000 members.

A majority of the Committee are combustion scientists. I think you regard it as axiomatic that persons familiar with controlled combustion can contribute to the solution of problems of uncontrolled combustion, but I do not think that this necessarily follows. The "Fire Research Program" you identify was hardly "extensive study" in comparison to the attention people associated with the NFPA have given fire research. The proposed program is narrowly orientated to combustion science, but the real significance of the fire problem lies in the fact that there is practically no human activity which it does not touch, nor any science which does not, to some degree, apply to it.

One paragraph of your letter observes that the proportion of work of industrial laboratories that is devoted to basic research does not meet the U.S. needs for long-range fundamental research on fire. The Directory of Fire

WARREN L. BAKER, President • EDWARD C. WOOD, Vice President • PAUL C. LAMB, Vice President • FRANK J. FEE, JR., Secretary-Treasurer • L. LEBRON DUES, Chairman Board of Directors
PICTY BUGHIE, General Manager • CHARLES S. MORGAN, Assistant General Manager • ROBERTO BOMB, Chief Engineer • GEORGE H. TETON, Technical Secretary

A NON-PROFIT TECHNICAL AND EDUCATIONAL ORGANIZATION. To promote the science and improve the methods of fire protection and prevention; to obtain and circulate information on these subjects and to secure the co-operation of its members and the public in establishing proper safeguards against loss of life and property by fire

November 20, 1964

Research prepared for the Committee on Fire Research shows about 100 agencies in the U.S. with some fire research interest and capabilities and about a dozen with major plants and personnel. Your general statement about basic research is unsupported by any real appraisal of the basic research done by individuals associated with these agencies or by the hundreds of other agencies associated with private industry. If, regardless of where it is done, the total of fundamental research is inadequate, this could be true; but, otherwise, the statement is a condemnation of industrial laboratories.

I do not think that fire research is effectively promoted by having a single center. A single center would tend to discourage work by others. Also at a single center, work is not exposed to competition. In place of a single center, which the British have chosen to provide, the U.S. has many. It is true we do not have its counterpart under one management, but we can much more than match it in respect to number and competence of scientific personnel and in plant and equipment. Our fire research effort has a vitality unmatched anywhere in the world, even when recognizing the outstanding individuals in the British and other research centers. Our superiority lies in the fact that our efforts are dependent on more than one management and on a variety of interests and motivations which produces a healthy and vigorous program. You fail to reveal that the British have tried to avoid the perils of single management by an arrangement where the British fire insurance companies share the management and support of the British organization with the government.

The use of statistics indicates that the Committee is thinking of specifically oriented work which would necessarily be development research and testing. Yet at the same time, these are distinguished from fundamental research. There is confused argument in this. Furthermore, the statistics of fire losses you have quoted from the October 1964 NFPA Quarterly are particularly misleading. The article specifically stated that the figures should not be used as you have used them. Comparisons between countries on the basis of the figures you have used are not only "difficult," as you say, but quite improper. Also, fire losses have been materially reduced in the U.S. The annual figures are only a fraction of what they were a hundred years ago. With respect to both life and property exposed, the losses are less than half what they were 40 years ago.

I would not like to see the NBS fail to get support for appropriate work because, at the urging of the Fire Research Committee and the Academy, it asks for an open-ended program. The figures suggested by the Summer Study of three to nine million dollars and in your letter for 25 to 50 research people are literally pulled out of the air. The recommendations expressed by your letter could lead the NBS to compete with numerous existing programs by other government departments and private industry. I heartily concur with the idea that the NBS should put its best foot forward, but if it asks for a program beyond its immediate capacity, it would be regarded as an attempt by government to supplant private fire research agencies. However, the fire research agencies of other government departments can support NBS work to any degree they consider appropriate.

Sincerely yours,

Ray
Horatio Bond
Chief Engineer

HB:lq

Copy to Members of Committee, D. W. Thornhill and Dr. R. M. Fristrom

THE NATIONAL ACADEMY OF SCIENCES is a private, honorary organization of more than 700 scientists and engineers elected on the basis of outstanding contributions to knowledge. Established by a Congressional Act of Incorporation signed by Abraham Lincoln on March 3, 1863, and supported by private and public funds, the Academy works to further science and its use for the general welfare by bringing together the most qualified individuals to deal with scientific and technological problems of broad significance.

Under the terms of its Congressional charter, the Academy is also called upon to act as an official—yet independent—adviser to the Federal Government in any matter of science and technology. This provision accounts for the close ties that have always existed between the Academy and the Government, although the Academy is not a government agency and its activities are not limited to those on behalf of the Government.

THE NATIONAL ACADEMY OF ENGINEERING was established on December 5, 1964. On that date the Council of the National Academy of Sciences, under the authority of its Act of Incorporation, adopted Articles of Organization bringing the National Academy of Engineering into being, independent and autonomous in its organization and the election of its members, and closely coordinated with the National Academy of Sciences in its advisory activities. The two Academies join in the furtherance of science and engineering and share the responsibility of advising the Federal Government, upon request, on any subject of science or technology.

THE NATIONAL RESEARCH COUNCIL was organized as an agency of the National Academy of Sciences in 1916, at the request of President Wilson, to enable the broad community of U. S. scientists and engineers to associate their efforts with the limited membership of the Academy in service to science and the nation. Its members, who receive their appointments from the President of the National Academy of Sciences, are drawn from academic, industrial and government organizations throughout the country. The National Research Council serves both Academies in the discharge of their responsibilities.

Supported by private and public contributions, grants, and contracts, and voluntary contributions of time and effort by several thousand of the nation's leading scientists and engineers, the Academies and their Research Council thus work to serve the national interest, to foster the sound development of science and engineering, and to promote their effective application for the benefit of society.

THE DIVISION OF ENGINEERING AND INDUSTRIAL RESEARCH is one of the eight major Divisions into which the National Research Council is organized for the conduct of its work. Its membership includes representatives of the nation's leading technical societies as well as a number of members-at-large. Its Chairman is appointed by the Council of the Academy of Sciences upon nomination by the Council of the Academy of Engineering.

THE COMMITTEE ON FIRE RESEARCH functions within the Division of Engineering and Industrial Research to stimulate and advise on research directed toward the development of new knowledge and new techniques that may aid in preventing or controlling wartime and peacetime fires. The Committee was established in December of 1955 at the request of the Federal Civil Defense Administration. It is supported by the Office of Civil Defense of the Department of the Army, the U. S. Department of Agriculture through the Forest Service, the National Science Foundation, and the National Bureau of Standards.