5431

NATIONAL BUREAU OF STANDARDS REPORT

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FIRE RESEARCH IN BRITAIN AND EUROPE - 1957

by

A. F. Robertson

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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NBS PROJECT | **NBS REPORT**

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FIRE RESEARCH WORK IN BRITAIN AND FRANCE

ABSTRACT

This report presents brief notes on discussions and observations made during a recent visit to Europe. An index is provided to facilitate its use for reference purposes. Further information on specific subjects may be available in the original notes of the writer.

Tuesday 21 May

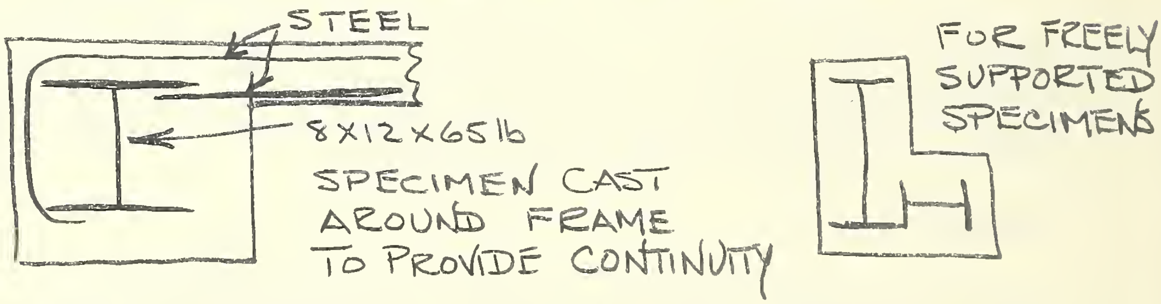
I arrived in London and went out to the Fire Research Station after lunch. I visited with Shorter and Clarke and discussed plans for my visit including a short trip to the Building Research Station. I ~~spent some time~~ looking over new facilities under construction.

Wednesday 22 May

I spent the morning in town arranging details of visits to France and Sheffield. Went out to the Fire Research Station just after noon. Spent an hour with McGuire discussing analog and other problems. He tells me that they have not used analog recently. He is using short cut methods of estimating fire performance. Discussed his high impedance current generator and he indicated that they have only used it with constant input signal or one developed as an electrical transient. Further references to high impedance current generators are in Electronic Engineering, April 1956, p. 179 and May 1956, p. 223. He indicated that they were very careful about predictions based on analog solutions involving surface cooling phenomena. It appears that this may be related to manner of generating their time temperature curve. Some discussion of this and his short cut methods of prediction of fire resistance to be in paper in process.

He indicated they had done some work on use of photo transistors for fire detectors. These are both temperature and light sensitive devices. His paper on these is in Electronic Engineering, December 1956.

I visited Mr. Ashton briefly and discussed fire resistance test methods. Their new furnace has been completed and appears to be a considerable improvement over previous one. The opening is 12 ft x 22 ft 6 in. It is built so that a partition can be placed across width permitting use of only one half of furnace. There are two furnace flue openings from the floor of the furnace. It was indicated that these performed well after short preheating of the stack gases by burner placed at bottom of stack. They find that operation is satisfactory at a gas rate of 30,000 cubic feet per hour of 500 BTU/ft^3 gas. Their maximum gas rate is 35,000 cubic feet per hour. The restraining frames they use are of steel sections with concrete protection about as shown in figures below.

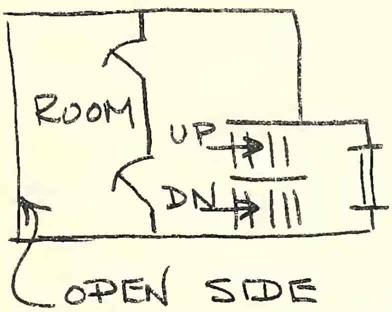


In cases where continuity is desired, structure is poured around steel to form both specimen and frame as shown at left.

I discussed briefly the question of bare thermocouples and was assured that oxidizing conditions existed in the furnace. Pressures are somewhat lower than atmospheric.

I was shown photographs and a movie of the large beams tests. These had a span between supports of 24 ft. One specimen of the same size as those studied at NBS was included in the study. Results on this specimen were much the same as we observed. In the larger specimens those without the additional cover reinforcement failed in short order, about one hour, due to sloughing off of the cover and longitudinal shear through the beam close to the top slab. When auxiliary reinforcement was used, the lower corners sloughed off but major portion of cover remained in place. The additional steel prevented the longitudinal shear failure and beams failed in diagonal shear at end of beam. They hope to have a report for publication near beginning of next year. A brief review of their program is to be presented at the symposium on prestressed concrete on the West coast in the fall.

I visited briefly with Lawson and discussed things in general we took a look at their new buildings under construction. These include two brick rooms for study of fire fighting methods. One four story stack of rooms with stairway for studies of vertical fire spread from one floor to another. One wall of each room was not fitted so that various closures could be tested. We took a brief look at the large burn building which is under construction. It is of 150 x 50 x 40 ft in height. They have a pit at one end 12 ft on a side and provisions for directing winds up to 30 mph over the 15 x 15 x 10 ft high volume above it. The roof of the building is removable from the area above the pit. The building is to cost about one quarter million dollars.



ONE FLOOR OF VERTICAL BURNS BLDG.

Thursday 23 May

Spent the morning in discussion of plans for Paris meeting. I was asked to present ten minute discussion of work at National Bureau of Standards on fire research. I agreed on condition that it was not to be published and that I could review any notes circulated to members of conference based on talk.

After lunch I spent some time with Dr. Kingman discussing their work on flame traps. They have worked almost entirely with bare screens, usually of brass. They have worked with various mesh sizes and find velocity with which the flame approaches the screen is the important variable in determining whether it is penetrated. They have done no work on use of additives for reducing flame penetration but mentioned work being done by W. Mansfield at the British Internal Combustion Research Association, 111 Buckingham Avenue, Slough, Bucks, on the oil wetting of gages for reducing diesel crank case explosions. He presented a paper before the Institution of Mechanical Engineers in April 1956.

They are making photographic records of flame propagation through screens for measurement of velocities. Pressure records are also obtained for studies of gas behavior. They find that when ignition occurs near the open end of the tube the flame velocities are lower than if tube were closed.

Dr. Rashbash is directing work on the study of vents for ducts. This is related to screen study but is with special reference to the use of vents in ducts for relief of gas pressures which may build up.

I mentioned our interest in powders to Dr. Rashbash and he mentioned work he had done on the erosion of dust layers by wind streams. He also referred to a report on this subject by J. Dawes in Safety in Mines Research Establishment, Research Report No. 3 of about 1950.

Dr. Rashbash raised a question about the United States requirement that dry chemical powders not pick up more than 0.4 percent on weight basis when exposed to high humidity conditions. He indicated that they observed such performance for standard dry chemical but for powder without coating a weight loss was observed, probably resulting from increase of vapor pressure as a result of moisture absorption.

Friday 24 May

Mr. Shorter and I visited Drs. Burgoyne and Weinberg at Imperial College. They had just moved into their new building and were rather rushed with preparations for a grand opening with the Queen Mother present.

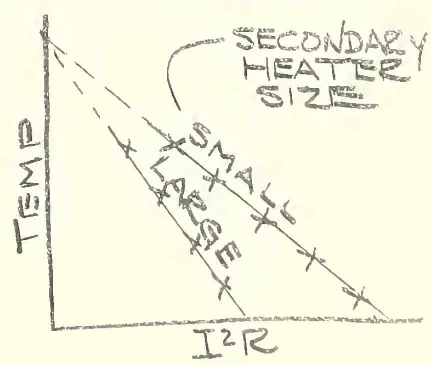
Dr. Weinberg briefly reviewed projects.

Mr. J. Reck is working on the suppression of methane-air flame propagation with alkali halide particles. They use a nozzle of rectangular section to produce a uniform gas velocity and permit stabilization of an inverted V flame having flat sides. Very fine salt particles are introduced into the gas and these are used with stroboscopic light source for observation by means of Tyndall scattering of the light. These particles permit gas velocity measurements being made and thus also falme velocities. They are studying the effect of salt concentration on flame velocity. I got the impression that Reck was more interested in the techniques than the use of them.

Mr. A. F. Roberts was studying ignition and spread of flames on liquid surfaces. Initial work was being done with alcohol in shallow tray maintained at various temperatures. Ignition was started at one end of the pan and the spread of flame between asbestos cement boards was observed. The technique used appeared crude but seemed to show good promise of providing useful results. We should follow this work.

Mr. K. G. Payne was studying the electrical properties of flames, the thought being that it might be possible under certain conditions to increase heat transfer rate by using electric fields.

Mr. J. A. Sage was studying ignition criteria of gas mixtures. This involved use of a flow type ignition furnace of cylindrical form. Premixed air and fuel flowed through a heater element upon entering the furnace. Guard heaters were used to reduce heat losses from the flowing mixture. This mixture was forced past a small refractory electrically heated bar placed across the flow passage. Measurements were made of the initial temperature of the mixture just sufficient to cause ignition at the second heater element. These were plotted against the electrical imput to the secondary heater element. The resulting data were extrapolated back to the theoretical temperature required for ignition with no additional heat imput. It was suggested that this provided a measure of the temperature of the mixture as combustion was initiated.



Monday 27 May to Wednesday 29 May

I attended meetings of the Fire Research Working Party of Conseil International du Batiment pour la Recherche l'Etude et la Documentation in Paris. The meetings were conducted in the offices of Centre Scientifique et Technique du Batiment in the western part of the city. Nine countries were represented:

1. Britain - Mr. S. H. Clarke (Chairman)
2. Canada - Mr. G. W. Shorter
3. Austria - Dr. tech. Rister
4. Netherlands - Dr. C. van Hoogstraten
5. Federated Germany - Dr. Ing. Schubert
6. Sweden, Denmark, Finland and Norway - M. Johannesson
7. Italy - Gen. Dott. Ing. Fortunato Cini
8. France - M. le Colonel Fackler (Secretary)
9. United States of America - Dr. A. F. Robertson

The meetings were conducted in both the French and English languages. Although we are not member, I had been asked to participate in the meeting and discussions. A detailed report of these meetings is being prepared by the chairman and secretary. In this report I will only mention some of the more important points in the discussions. *

The first morning meeting was comprised of brief introductory descriptions of work under way and considered important in the different countries.

The afternoon session included reports of "round robin" tests for measurements of flame spread behavior of finish material, an analysis of the desirable characteristics of a useful test evaluation method and discussion by various delegates of their own problems. It was obvious that the methods currently being used for flammability tests of this type have not been well enough justified on the basis of full scale tests to warent consideration of one method as superior to others.

Tuesday morning was devoted to discussion of fire resistance test methods. Reports were made on tests performed in three laboratories on the fire resistance of three types of wall panels. The results of many of these

* A complete list of papers presented and now available in the Fire Protection Section files is included at the end of this report.

were surprisingly close when consideration is given to the extent of variations in test procedure and conditioning of specimens.

It was stated that the working party would initiate a request to the International Standards Orgznization to take steps necessary to start establishment of an international standard for fire resistance tests.

There were discussions of the importance of proper moisture conditioning of specimens prior to test and desirable minimum sizes of furnace that seemed necessary. Methods of heating furnaces and restraint of specimens were discussed.

In the afternoon discussions were presented on the problem of fires in high buildings or "flats." Sweden has performed some fire tests to determine the hazards of fire spread. Some mention was made of a new roof fire test developed in Britain and also of studies of fire stop doors performed in France and Sweden.

Wednesday morning was spent in discussing the chimney problem, plans for future meetings, and a reply to the petition made by the fiberboard lobby.

The afternoon was spent in a visit to the laboratories of CSTB at Champs sur Marne. It appeared that they had been quite busy in the field of fire resistance studies of partitions and chimneys.

In summarizing the experiences achieved during this conference and the value of such meetings, it seems obvious that although the technical value to us may be limited, the possibility of encouraging international cooperation and standardization of fire test methods is of great value and should be encouraged. There seems little doubt that the advantages of such meetings to the smaller nations may be very great.

Friday 31 May

Pleasant visit at the Fire Research Institute TNO in the Netherlands. Dr. van Eltern was in midst of preparing for visit to Germany so I was turned over to T. T. Lie, an Indonesian, who is apparently third in command. Obviously he is very familiar with all their work.

He described their spread of flame work. They use a small nearly cubical enclosure in which two specimens are placed to face each other. One of these is heated by gas flames for 3 min and both are heated by measured electrical input after that time in such manner that ignition of second specimen is achieved in 15 min. They use power input as inverse indication of flammability with 0.05 cal/cm^2 as minimum. This provides a somewhat tangible measure of size of fire required to ignite specimen. The time of flashover is arbitrarily taken as that time at which the temperature difference between the furnace air temperature and the specimen surface rises by 15°C/min. If flashover occurs in less than 15 min, then comparison of materials is based on heat release. It was indicated that although they realize the importance of conditioning specimens prior to test, they have not done this to date.

We discussed self ignition phenomena and methods of measurement. Their adiabatic furnace operates with ambient temperatures one or more degrees higher than the specimen and as a result, they supply heat continuously. From the resulting time temperature chart, they select as an ignition temperature that at which the temperature starts to rise quickly. He mentioned that they were having difficulty in achieving uniformity of furnace temperatures and did observe different behavior when specimen size was varied.

I was shown the new apparatus they are developing to study falmmability of fabrics. This uses a specimen held on a vertical frame perhaps 4 ft in length. Flame travel is measured by fine tin wires which melt when heated. A drum chronograph is used to record data.

I visited their Fire Resistance Laboratory. They have a beam furnace for specimens about 24 ft in length, a panel furnace for specimens about 3 x 3 meters, and a floor furnace for specimens about 2.4 x 4.4 meters in size. In no case were really heavy restraining frames used and in both beam and floor furnace, clearance was provided to permit expansion of the specimen. Loads were applied by dead weights and furnace temperatures measured by protected thermocouples. Unexposed surface temperatures were observed by use of asbestos pads over the couples. I saw their concrete floor specimens with L shaped ends permitting the application of a moment to simulate one factor of continuity. None of these have as yet been tested. They are becoming increasingly aware of the importance of moisture and need for conditioning specimens prior to test. It was stated that for CIB, Groupe de travail du Feu (CIB-FRWP) the concrete block specimen had been constructed with a portion of blocks dried and remainder moist. Failure times differed by as much as an hour (2 and 3 hr).

Monday 3 June

Visited with Mr. McGuire at FRS for two hours discussing ignition problems and specially electrostatic hazards. He has recently prepared a survey of this type of hazard soon to be published

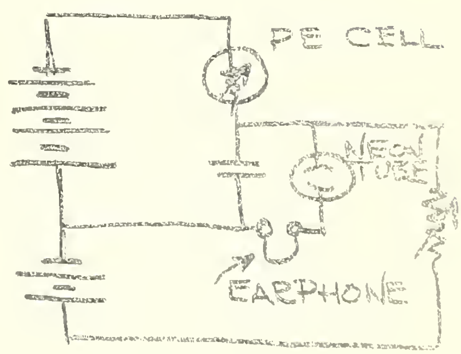
FR Note No. 284 "The Fire Hazard Created by Static Electricity", J. H. McGuire.

Electrostatic ignition hazards in coal mining are reviewed in

"Electrostatic Hazards in Coal Mining" by R. A. Dale, Res. Rept. No. 118, Sept '55, SMRE

Some information on the ignition of explosives may be available from Dr. J. F. Summer of Explosives Research and Development Establishment at Waltham Abbey, Essex (Min Supply).

He also discussed his infra red fire locators and he indicated that his present one made use of a lead sulphide cell. However he indicated that both Mullard and Plessy were coming out with Indium Antimonide type of cell which was useful up to about 7μ. The use of telephones was considered an obvious advantage over an indicating meter.



Shorter and I left at this point for Building Research Station where we were briefly received by Dr. Lea and then spent several hours with Mr. Bevan and Mr. Langden-Thomas. We discussed problems involved in the writing of building codes. They indicated that at present Britain has no building code similar to those in existence in our country. However a committee is now being set up to prepare one for London.

We discussed fires in large factories and learned of one recently in the Jaguar plant. Here wood fiberboard was involved below coated metal roof. Their thinking is that if there had been more adequate protection for the hazardous processes such fires could be controlled without fire walls.

We discussed briefly our proposed calorimeter type combustibility test and Mr. Bevan indicated considerable interest in a test of this type.

Tuesday 4 June

We met at 9:30 at Mr. Fry's office at 19 Cornwall Terrace near Regent Park. Clarke, Isaacs, Lawson, Ashton, Fry, Shorter, and I were there. The purpose was largely to discuss problems of mutual interest in the fire protection field. It took the form of discussion of answers to a list of questions Isaacs had brought. A record of these discussions was made by Mr. Fry and is to be available.

At noon we stopped to go down to the Fire Offices Committee where we had been invited to lunch. Discussions were resumed after lunch.

Wednesday 5 June

I left for Cambridge. I visited the Department of Physical Chemistry where I met Dr. Bowden, Dr. Yaffe, and Messrs B. L. Evans, A. G. McLaren, and P. W. Linder.

The objective of the visit was to discuss problems of drop sensitivity tests of explosives and propellent materials.

I was informed by Dr. Evans that current thinking on initiation of explosives required that the process start with the development of a gaseous explosive mixture which filled voids in granular materials and ultimately exploded initiating a detonation wave in the explosive solid. In granular materials this may be a three stage process the initial gas breaking up crystals and the cloud of fine particles furnishing a source of gas for a larger explosion which may serve as the initiation of the detonation wave.

It was indicated that they had been able to initiate lead ozide by light from electrical sparks. It was thought that the light served directly to initiate chemical decomposition rather than as suggested earlier by an intermediate thermal mechanism.

They consider that for materials which are sensitive to this type of initiation, the test provides a very sensitive means for measurement of sensitivity. They measure this sensitivity in terms of the voltage to which the spark forming capacitor is charged. An indication of the sensitivity of the test may be obtained from the fact that initiation is often determined by a change of voltage of 5 in 2000. They attribute this improved reproducibility to the fact that the mechanism involved is well defined or always the same. This is not the case during a drop test when a large number of modes of heat generation may be involved.

They were inclined to question the usefulness of another new drop sensitivity test method. They did however suggest that it might be useful to visit Dr. A. M. Yuill of Imperial Chemical Industries Research Department, Nobel Division. He has done some work on materials at other than room temperature conditions.

Thursday, June 6

Visited Dr. B. P. Mullins at Pyestock. He spent considerable time describing the work they were doing on ignition temperature measurement. They use a continuous flow apparatus arranged to permit continuous fuel injection into a hot air stream. This work has been described in a series of papers published in Fuel under the title "Studies on the Spontaneous Ignition of Fuels Injected into a Hot Air Stream," I to VIII, starting with April 1953. In these papers he plots τ the ignition delay time against the reciprocal temperature. Thus our adiabatic furnace data may be correlated in a similar manner and possibly tie in with his.

We exchanged drafts of definitions of terms and agreed to comment on them. He is anxious to have us run data on materials he has studied such as n-Decyl Alcohol or Analine. He agreed to forward recent papers he has prepared and requested that we supply him with reprints when available.

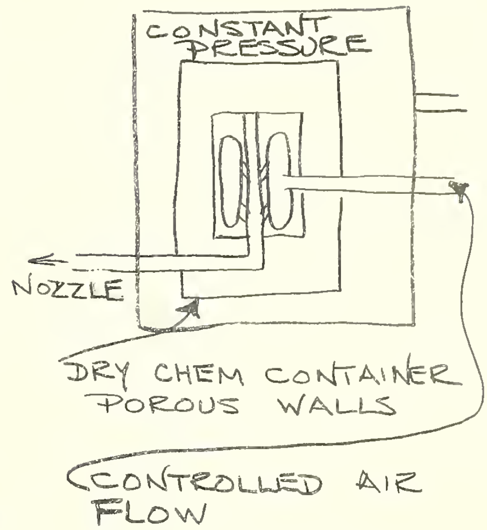
Tuesday 11 June

I spent the morning and part of afternoon at FRS with Dr. Thomas. We discussed the work he had done on correlation of the radiant ignition behavior of cellulosic materials. He is critical of Sauer's report on tests with filter papers on the ground that if the correlation is to be on a chemical basis the use of the E/R term is not sufficient. The rate constant and heat of reaction terms should also be included. He considers the use of the E/R term as an admission that an ignition temperature must still be considered.

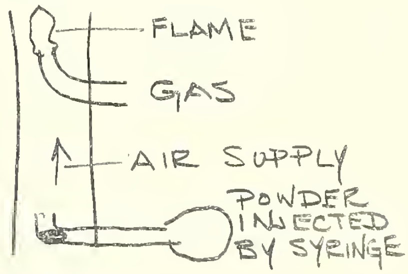
They admit that the paper by Lawson and Sims on the work previously done should be corrected for absorbence and an area effect. They plan soon to get out a new report on the correlation of data based on a technique somewhat similar to that used by Sauer. They are concerned that when this technique is used Sauer's data correlate on the basis of an ignition temperature of about 650°C whereas their data requires the assumption of a temperature of about 500°C.

We also briefly discussed the self heating behavior of materials and the difficulty of correlation of activation energy data from adiabatic furnace with similar data obtained during Mitchell's tests in constant temperature ovens. I said we had observed similar difficulties and would attempt to loan him a draft copy of Genensky's, Ault's, and Gross' papers.

In the afternoon I discussed, in Mr. Hird's absence, the dry chemical work with Mr. Fittes. He described the small scale experimental equipment they were constructing for application of powders, see sketches. Apparently all their work to date has been on full scale tests. They have used two types of nozzles - a cone spray formed by impinging jets and a flat spray formed by a slit about 10 mills wide.



He showed me a translation of a French paper on which he was going to try to get me a reference. The lower sketch shows the apparatus used for this study.



I also discussed with Shorter, Lawson, and Thomas the proposed burnout tests to be performed on the St. Lawrence waterway. I indicated that we were interested in this study but probably would not be able to do much more than send an observer.

Wednesday 12 June

Visited Mr. Webster and breifly discussed fabric flammability test methods. The present status of thinking on this subject is contained in the paper "The Flammability of Apparel Fabrics in Relation to Domestic Burning Accidents". This is published by British Standards Institute, their paper PD 2777. This suggests the use of three different test methods for evaluation of untreated fabrics.

1. A vertical test for common fabrics. This test is in draft form for a new BS. In it a strip $1\frac{1}{2}$ in. wide and about 60 in. long is used. This is suspended vertically and the bottom ignited. The velocity of rise of the bottom

of the flaming portion is used as an indication of flammability. This test is used for fabrics which show inflammation rates of less than 2/3 in/sec. This test has been used because it was developed by the textile people and does not penalize the woolen and nylon type of synthetic fabrics in the same way as the semicircular test method.

2. The AATCC test method (45° incline test. This is used for brushed or otherwise highly flammable fabrics.

3. The semicircular test method which is now in British Standards, BS476. This test method is recommended chiefly for thin films and plastic materials. It is not clear under what circumstances it would be used for fabrics.

For tests of treated fabricsBS 1547-'49 is used. This is somewhat similar to our vertical test although the fabric is hung freely and not supported along its edges. This method is being used to study the behavior of our treated fabrics.

I talked briefly about tests of roofing. Their new test method which makes use of four 12 x 12 in. radiant panels is being prepared as a British Standard. It applies a negative pressure of 1½ mm of water to the back side of the assembly. This is considered the equivalent of a 15 mph breeze. Failure is considered to occur when flame or glow breaks through to back of roof. Endurance times may vary from 15 min to 3 hrs.

I discussed the small crib tests which he is doing on a 1/9 scale. These are in preparation for their four story burnout tests. He is using a five sided asbestos board box with the open side in a vertical plane. They are making continuous weight measurements and also radiation measurements with their copper disc radiometers. He just has preliminary data available to date but this seems to indicate that ventilation is the important variable. The size of sticks is not as important as their spacing. They plan to do both 1/9 scale and 1/3 scale as well as full size tests. This work seems quite similar to that we had throught of.

I attended a project leaders' meeting at which Mr. Ashton and Thomas presented a resume of the Paris conference.

Afterwards I visited with Mr. Clarke and agreed to the following:

1. We would perform fire resistance tests on the same constructions which had been studied by others and on which reports were made at the conference.

2. It was agreed that conferences of the type attended were good in that they tended to encourage standardization of testing procedures as well as permit some of the smaller countries the benefits of work now done in this field.

3. They hope to prepare a report on the prestressed beam data by the last of this or early next year and we will hear from them prior to its release. They had no objection to brief oral reporting of the apparent features of the tests.

4. They would be quite agreeable to our sending a man to study in detail the work on fire growth they have done.

5. We agreed that we both had similar objectives in our work on dry chemical extinguishers, that of understanding better how to evaluate their behavior.

I left the station shortly before 3 pm.

Thursday 13 June

Went to Sheffield where I visited Professor Thring. We discussed the problems of constructing and using models for prediction of behavior of fires. He showed me about a dozen different experimental setups in which tye were using models of different sorts. He mentioned his new book on the subject which is just being released.

He emphasized the need to make observations on at least one full scale prototype and then the probable need to modify some of the scaling factors to make others of interest behave in a systematic fashion. For instance we discussed the problem of diffusion fires above an oil tank. It was suggested that probably the emissivity of larger fires was higher than that of the model. This would result in the model receiving considerably less back radiation from the fire than the prototype. It was suggested that this might be modified by the use of auxiliary heaters within the oil.

I was invited to dinner with the advisory committee for the Engineering School.

Friday 14 June

Went from Glasgow to Stevenston where I visited Dr. Gurton of the Nobel Division of the Imperial Chemical Industries Ardeer Plant. I spent most of my time with Dr. A. M. Yuill discussing the effects of ambient variables on the sensitivity to initiation by impact of propellent materials. He referred me to the work of W. Taylor and A. Weale entitled "The Mechanism of Initiation of Detonation in Solid Explosives," Proc. Roy. Soc. A, V138, pp 92-116, 1932. The only other work he knew of on the effect of ambient temperatures on initiation by impact was that done by him in his thesis "The Impact Initiation of Explosives", a thesis submitted at Cambridge University. This latter work consisted of drop sensitivity tests at low temperatures from which it was concluded that the increased energy required was simply a function of the additional energy required to raise the temperature of substance to room temperature corresponding to the usual ambient for tests of this type. After considerable discussion of the difficulties associated with impact testing, it was generally concluded that insufficient work had been done in this field and that further work was desirable to explore the effect of ambient temperature on sensitivity to impact. Mention was made of the frictional test, and the combined friction and impact tests described in Dr. Bowden's book. They still, however, consider the heating by compression of air in small cavities as the most likely mechanism of initiation by impact.

In the afternoon I visited with men working on the use of powders for damping of methane explosions caused by blasting in coal mines. I was told that they had run a number of tests on different materials by suddenly admitting a combustible gas mixture into a glass chamber in such a way that a dispersed dust cloud was simultaneously formed. Although a number of materials were discovered which were superior to sodium chloride, they are sticking to this for sheathing explosives for economic reasons. The results of their studies are presented in the paper "The Supression of Methane-Air Ignitions by Fine Powders" by J. E. Dolan and P. B. Dempster, Reprint from the Jour. of Applied Chemistry, September 5, 1955, p. 510-517. They do not plan to do further work on this subject.

LIST OF DOCUMENTS PRESENTED BY THE DELEGATES
AT THE SECOND MEETING OF THE GROUPE DE TRAVAIL DU FEU DU CIB
PARIS, MAY 1957

Austria	
FRWP No. 10/A	Unification and simplification of fire resistance test methods for wood materials and structural parts
Canada	
FRWP No. 4/C	Letter 57-2585 of April 24, 1957 from Mr. Shorter
Denmark	
FRWP No. 26/Da	Report and description of two test apparatus for investigation of surface fires
France	
FRWP No. 3/F	Procès-verbal No. 57.387 concerning a study of the fire resistance of a cellular concrete block partition
	Procès-verbal No. 57.388 concerning a study of the fire resistance of a wood stud and gypsum board partition
	Procès-verbal No. 57.389 concerning a study of the fire resistance achieved by a built-up partition of pine and asbestos paper
FRWP No. 4/F	Study concerning the prevention of fire in elevated and very elevated apartments
FRWP No. 6/F	Study on the influence of rate of heat release on the course of a fire on the temperature attained during the fire
FRWP No. 7/F	Reaction to fire (Flame Spread) measured by radiation
FRWP No. 7/N	Compte rendu No. 56.323-B concerning the measurement of the reaction to fire of materials from the Netherlands

<u>France</u>

FRWP No. 7/U.K.	Compte rendu No. 56.323-A concerning the measurement of the reaction to fire of materials from England.
FRWP No. 11/F	Metal fire doors not insulated
FRWP No. 12/F	Measurement of the fire resistance achieved by a fire door
FRWP No. 13/F	Furnace for tests of walls and partitions-Recording time temperature curves
FRWP No. 15/F	Note on the time-temperature curve
FRWP No. 29/F	Prevention of fires in public buildings (Building Code) 13 August 1954
FRWP No. 30/F	Studies in the field of fire prevention during construction

<u>Netherlands</u>

FRWP No. 3/N	Fire resistance tests on three types of partitions
FRWP No. 4/N	Rules for fire safety in buildings
FRWP No. 7/1 N	Reaction to fire tests

<u>Fed. German Repub.</u>

FRWP No. 4/D	Building Code BOA 3/55 for the erection of high buildings
FRWP No. 4/D1	Rules of various countries for the safety of persons in high buildings
FRWP No. 8/D	Comparison of different fuels; heat generated by combustible specimens
FRWP No. 9/D	Studies of a specimen after a fire and hose stream test

<u>Great Britain</u>

FRWP No. 3/U.K.	Correlation of fire resistance tests
FRWP No. 3/1.U.K.	Correlation of fire resistance tests(1)
FRWP No. 3/2.U.K.	Correlation of fire resistance tests(2)

FRWP No. 3/3.U.K.	Correlation of fire resistance tests(3)
FRWP No. 4/U.K.	Review of regulations for protection against fires in high buildings, by L. A. Ashton
FRWP No. 5/U.K.	High buildings
FRWP No. 14/U.K.	Report on fire propagation tests carried out in the United Kingdom
14A/U.K.	Addendum No. 1 to Report on fire propagation tests carried out in the United Kingdom
14A2/U.K.	Addendum No. 2 to Report on fire propagation tests carried out in the United Kingdom
FRWP No. 16/U.K.	An analysis of survey information of chimney fires
FRWP No. 17/U.K.	Pressure and nature of furnace atmosphere in fire resistance tests
FRWP No. 18/U.K.	Temperature measurement in fire resistance tests
FRWP No. 19/U.K.	Craks and fissures as criteria of failure in fire resistance tests
FRWP No. 20/U.K.	Some aspects of fire resistance tests
FRWP No. 21/U.K.	British Standard 459: Part 3: 1951 Fire-check flush doors and frames
FRWP No. 22/U.K.	Rules of the Fire Offices' Committee for the Construction and fixing of fireproof doors, compartments and shutters
FRWP No. 23/U.K.	Report on fire resisting doors
FRWP No. 24/U.K.	Proposed external fire exposure roof test
FRWP No. 25/U.K.	Flash-over and fire propagation tests, P. H. Thomas

FRWP No. 28/U.K.	The flammability of apparel fabrics in relation to domestic burning accidents, PD 2777 - British Standards Institution

Sweden

FRWP No. 5/Su	Fire Protection in high residential buildings
FRWP No. 27/Su	Spread of flame, preliminary report from the Government Testing Institute in Stockholm

Switzerland

FRWP No. 31/Si	Fire resistance of steel constructions

INDEX

* Additional reference to items so marked is available in the papers presented at the Paris conference. A complete set is on file in the Fire Protection Section Office. These papers are also listed by title at the end of this report.

continued Page

* See note on previous page.

U. S. DEPARTMENT OF COMMERCE

Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS

A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major field laboratories in Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant reports and publications, appears on the inside front cover of this report.

WASHINGTON, D. C.

Electricity and Electronics. Resistance and Reactance. Electron Tubes. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat and Power. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology and Lubrication. Engine Fuels.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment. AEC Radiation Instruments.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Gas Chemistry. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Organic Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Heating and Air Conditioning. Floor, Roof, and Wall Coverings. Codes and Specifications.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analogue Systems. Application Engineering.

- Office of Basic Instrumentation
- Office of Weights and Measures

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering.

Radio Standards. Radio Frequencies. Microwave Frequencies. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Calibration Center. Microwave Physics. Microwave Circuit Standards.

NBS