NATIONAL BUREAU OF STANDARDS REPORT

3962

FIRE RESEARCH WORK IN BRITAIN AND FRANCE

by

A. F. Robertson

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Fire Protection Section
Building Technology Division

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ABSTRACT

A report is presented of a trip made by the writer to Britain and France. Brief descriptions are included of visits to various laboratories where work is under way on different aspects of the fire research problem. Some new unpublished experimental data are presented here. Numerous references are included, many of which are to unpublished reports made available to the National Bureau of Standards by the British Fire Research Station.

INTRODUCTION

A visit was made to Britain and France between the dates of 19 September and 21 October 1954 for the purpose of becoming better acquainted with fire protection research work under way in those countries. This rather voluminous report has been prepared as a practical means for passing on much of the information gained during the visit. It was originally planned that the report would be completed during the voyage back to the States. A portion was prepared at that time but poor weather and pressure of other work after return to Washington have prevented its completion prior to this date.

The report has been organized first by the organization visited and secondly by the phase of fire protection work considered. It is expected that this will permit more ready reference to the particular subject of interest. An attempt has been made to include a rather complete list of references to material under discussion. Since many of these as well as technical information in this report have not been published, care must be exercised to avoid their misuse with resulting displeasure of those who so kindly made them available to us.

1. THE FIRE RESEARCH STATION

The Fire Research Station is located at Boreham Wood about 20 miles northwest of London. It is jointly supported by the Fire Offices' Committee, (an organization somewhat similar to the National Board of Fire Underwriters) and the Department of Scientific & Industrial Research. They have a staff of about 80 people and occupy 9 buildings. Some of these are over 20 years old but many are of more recent construction. Plans are in process for a considerable enlargement of their space.

I first visited this station on Monday 20 September. I met Mr. Clarke the Director and Mr. Lawson, his assistant. They were cordial and asked me to make myself at home and use the laboratories as my headquarters. They made suggestions as to laboratories other than theirs which I would find profitable to visit and offered to help in making plans for such visits.

Later I met Mr. Fry and Dr. Kingman who together with Mr. Lawson are the three Technical Division Chiefs reporting to Mr. Clarke. I spent Monday and a portion of Tuesday in learning my way around and becoming acquainted with the organization of the laboratory. An organization chart which is believed to be correct is presented as a diagram A*. Most of the technical work of the station is performed at Boreham Wood. However, funds and technical advice are made available to the Safety in Mines Research Establishment and some work is performed at Imperial College where their facilities are considered better suited for certain problems.

I will discuss the various phases of the work conducted at the station in turn.

1.1 Smouldering of Materials

I spent some time with Palmer on Tuesday 21 September discussing his work on smouldering. Much of his work has been reported in laboratory reports. He is now at the point where he considers his work nearly complete and is preparing a manuscript for publication.

Recent work completed has been on smouldering spread of combustion throughout cubical containers of sawdust within and on the bottom of which ignition was started. He finds that the time for fire to break through the surface of such a pile is proportional to the square of the lateral dimension. Such stacks of sawdust do not collapse during the period that combustion is under way. Burning times of about 12 days have been observed for cubical stacks about 3 ft on a side.

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*At back of Report.

Palmer mentioned that jute sacking had been observed to break into flame after ignition by a smouldering material (cigarette for example) in an air velocity of about 1 mph. He also stated that the smouldering rate of combustible powder trains was relatively independent of their depth but depended chiefly on the air velocity over them.

a. References

"The Smouldering of Dusts", F.E.T. Kingman & K. N. Palmer, Chemistry and Industry, pp. 739, 1952.

"Smouldering in Dusts and Fibrous Materials", Part IX Cocoa and Grass Dusts Under Airflow Conditions, K. N. Palmer & M. D. Perry, FR Note No. 89/53.

"Smouldering in Dusts and Fibrous Materials" Part VII Fiber Insulating Boards under Airflow Conditions, FR Note No. 73/53

"Smouldering in Dusts and Fibrous Materials", Part VI Deal Sawdust Under Airflow Conditions, K. N. Palmer & M. D. Perry, FR Note No. 50/53.

"Smouldering in Dusts and Fibrous Materials", Part V Beech Sawdust with an Incident Air Draft, K. N. Palmer & M. D. Perry, FR Note No. 48/52.

1.2 Burn Out Test at Birmingham

On Wednesday 22 September we went by train to Birmingham where we were met by Mrs. Hinton and station wagon driver who took us to a small house which the city building officials had constructed to simulate a type of prefabricated construction which was quite frequently used after the war. This type had been involved in several fires in which people had been killed. The materials used in construction of the house in Birmingham were the same as those used for this type of house. The house was however rather hurriedly assembled and joints were not as tight as would be expected in the prototype. The house was fitted with a fire alarm system and the test was being conducted to determine the speed with which it would respond, the rate of build up of toxic atmosphere in a bedroom, and the rapidity of destruction of the house. Samples of room gases were obtained from a position just above a bed in a room the door of which remained open.

Fire was set to some wood chips between an overstuffed chair and an interior wall of the living room. It developed rather quickly and cotton curtains in the windows of the kitchen were completely charred by 3 min. At the same time gas samples showed lethal mixtures in bedroom No. 1. Flash-over occurred in the living room about 7 minutes after ignition. All wall finish material was completely burned off and studs were falling 20 minutes after ignition. While the fire alarm system did operate as desired the striking thing about the test was the rapid rate of spread of the fire and destruction of the house. A series of color slides are available showing the progress of this fire.

It appears likely that the test results will prompt orders for replacement of all of this type of housing.

Tests of this type have been used for the purpose of comparing flame development tests in models with that observed in a full scale structure.

1.3 Electronic Analogue and Instrumentation

On Thursday 23 September I visited with Mr. McGuire who is doing most of the electronic instrumentation work, a considerable amount of work on the theory of heat transfer, as well as most of the work on the electrical analogue.

He was interested in our work on use of SEAC for development of scaling factors for fire research tests. He pointed out that our work on T beams was applicable to columns when depth of beam is great compared to width. Thus our work can be applied not only to beams and slabs but to columns as well.

He considers that the most profitable application of an analogue to fire test work is in the prediction of time scaling factors. He is now in process of developing a variable shape signal generator for simulation of other than standard time-temperature curves. This will be used to study the effect of variation of fire exposure on endurance of various types of specimens.

The analogue they have built although it has been used for two dimensional problems has most frequently been used for problems involving one dimensional heat flow. In preparation of models he has usually maintained components to two percent of the intended value. All measurements of temperatures at given times are made by means of the time base scale which can be raised and lowered on the oscilloscope screen to intersect the performance curve which can be picked off any part of the model.

The construction of an analogue somewhat similar to theirs would not be too difficult but its value is questioned as compared with other needs we now have.

a. References

"The Solution of Transient Heat Flow Problems by Analogous Electrical Networks", D. Lawson and J. H. McGuire, Inst Mech Eng Proc (A) V167, pp 275-290 1953.

"Nomograms for Solving One Dimensional Steady State Conduction Problems Involving Cooling to the Atmosphere", J. H. McGuire, J. Inst Heating & Vent Engr, November '53.

"Heat Transfer by Radiation", J. H. McGuire, Fire Research Special Report No. 3, Her Majesty's Stationary Office (HMSO) 1954.

"The Scaling of Dimensions in Heat Conduction Problems", J. H. McGuire, FR Note No. 94/54.

"The Scaling of Dimensions in BS 476 Fire Resistance Tests", J. H. McGuire, FR Note No. 95/54.

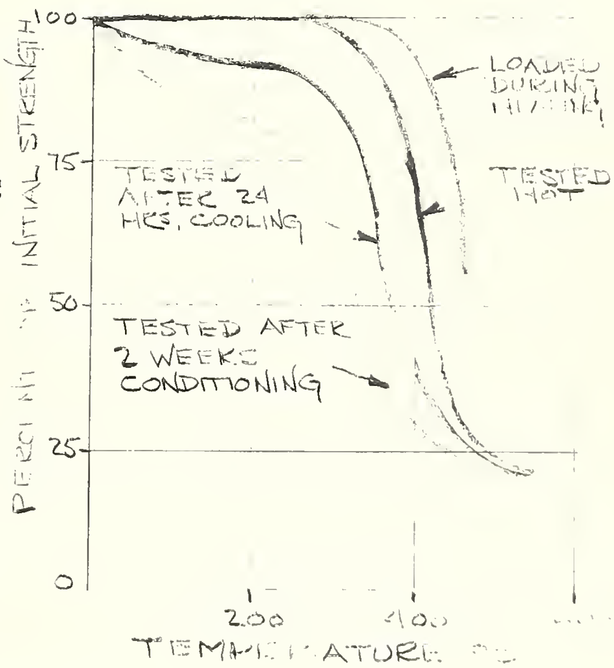
"The Scaling of Heat Conduction Problems", J. H. McGuire, FR Note No. 98/54.

"Spread of Fire by Thermal Conduction" J. F. Richardson, Fuel V28 No. 12, pp 265-272, 1949.

1.4 Concrete Strength at Elevated Temperatures

On Thursday afternoon 23 September I visited with Mr. Malhotra. He is in process of studying the effect of temperature on the strength of concrete cylinders 2 in. dia x 4 in. in length. Work now under way is on river gravel flint aggregate concrete prepared with Portland cement. Three types of tests have been performed. In one the specimens are heated to various temperatures up to 550°C and tested after cooling and aging 24 hrs or two weeks. Another method involves breaking the specimen while in the hot state. Still another involves application of load during the heating period and determining the temperature at which failure occurs.

Heating is accomplished in a special muffle at a rate of about 250°C/hr. It has been found that this permits the temperature of the center of the specimen following the surface temperature within about 100°C. A soaking period, after reaching the test temperature, is used to insure that temperature equilibrium within the specimen is within 20°C before the load is applied. The results are shown at right. Preliminary data seem to indicate that water cement ratio has little effect on the shape of the curves.



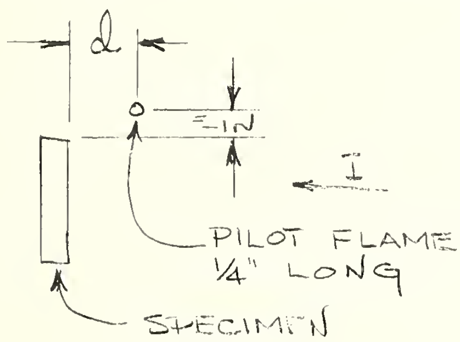
At temperatures below 550°C most of the weakening seems to take place in the mortar matrix while at higher temperatures the aggregate starts to fail.

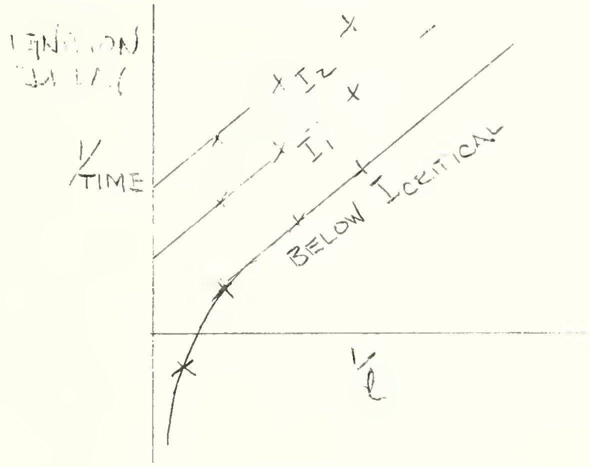
Plans are under way to continue work as follows:

1. River aggregate and High Alumina Cement.
2. Crushed limestone and Portland cement.
3. Crushed fire brick or other refractory mix.

1.5 Ignition of Materials by Radiant Energy

On Friday 24 September visited with Simms who is doing work on the effect of thermal radiation on materials. They are having difficulty correlating results from radiant panel with those from the arc source. They did however mention some interesting results on ignition with gas pilot of 2 x 2 wood specimens when exposed to radiation from gas heated panel.





It was found that with data plotted as shown here the intercept with the ordinate corresponds to time for self ignition and when I $\leq$ I crit no intercept is found.

a. References

"The Radial Temperature Gradient Across the Walls of Cylindrical Pipes Containing Heated Fluids", P. Nash and M. J. Gregsten, J. of the Inst Heating & Vent Engrs, March 1954.

"Ignition of Wood by Radiation", D. I. Lawson & D. L. Simms, British Journal of Applied Physics, V3, pp. 288-292, September 1952 also V3, pp. 394-396, December 1952.

"Radiation from Building Fires", R. C. Benon & C. T. Webster, National Building Studies, Tech Paper No. 5, HMSO, 1950.

"A Copper Block Absolute Radiometer", D. I. Lawson, D. L. Simms, M. Law & R. W. Pickard, FR Note No. 118/54.

1.6 Fabric Flammability and Roofing Test Methods

I visited Mr. Webster on Friday 24 September. He is doing work on fabric flammability. They have not, however, done any work with light weight silks or brushed rayon fabrics. The test criteria mentioned in their report on the semi-circular apparatus (drawings of which were obtained) will not be used for fabrics but may be used in modified fashion for finish materials.

They have made arrangements to be furnished with samples of fabrics which have caused injury through fire. Several light cottons were shown as representative of such materials now on hand.

Mr. Webster is also doing some work on the development of a test method for roofing materials. They have four 12 x 12 in. radiant panels mounted above a roof panel about 4 x 4 ft sq. During the test they run a gas burner along the various shingle courses and consider failure to occur when flame breaks thru to the other side. They find tile roof to last two hours, slate about one hour, and asphalt only 30 to 40 minutes.

a. References

"The Spread of Flame Along Vertically Hanging Fabrics", D. I. Lawson, FR Note No. 129/54.

1.7 Flame Spread and Model Techniques

On Wednesday 29 September I spent the best part of a day with Mr. Hird who is concerned with spread of flame studies and methods for use of models in the study of propagation and growth of fires.

We first discussed the methods they have used in construction and use of models for burn out studies. It was pointed out that during the war a large number of experiments had been conducted on the growth of fires in traditional rooms. Since then a number of experiments have been conducted on houses in which different interior finish materials were applied. These experiments were used as the prototypes for development of the small scale burn out experiments. The models discussed were those of a living room scaled down to 1/5 or 1/10 of full size. The technique used is described in the references and so will not be described in detail. It did however involve the use of small "rooms" formed of asbestos cement boards to the interior of which the finish material being studied was fastened. In a series of studies of different wall finish materials similar furniture and wood flooring was incorporated as "kindling". Measurements were made of the elapsed time between ignition and flashover or involvement of the whole interior of the room in the fire. Reference 1, page 6, reports the results of studies on 15 different finish materials. This shows that materials which qualified for the highest classification on the British Standard 476 spread of flame test showed delay periods to flashover of 9 to 17 minutes. However the most hazardous material tested, untreated fiberboard which qualified for a class 4 or most hazardous classification on the BS 476 test method showed a delay to flashover of only 5 minutes.

Because of this behavior the value of the spread of flame test described in BS 476 is being questioned. It appears to the writer that while this test may not be severe enough, the reason for difference in performance of the finish materials when subjected to the two different test methods is largely the result of measurement of different properties. The spread of flame test involves measurement of the behavior of the finish material alone while the model test method involves study of the behavior of the finish material together with the other combustible contents of the "room".

Other work being studied includes development of a new method of evaluating the spread of flame properties of materials and use of models for study of effect of combustible content on growth of fire in a building.

a. References

"Fire Hazard of Internal Linings", D. Hird & C. F. Fischl, National Building Studies Special Report No. 22, HMSO, 1954.

"The Flammability and Flash Point of Cellulose Acetate Film Containing Various Amounts of Cellulose Nitrate", R. W. Pickard & D. Hird, British Kinematography, V22, No. 6, June 1953.

"Fire Retardant Treatments", D. Hird & D. L. Simms, Wood, March pp 92-95, 1953
April pp 134-137, 1953
May pp 176-177, 1953

"A Small Scale Test for Measuring the Spread of Flames Over the Surfaces of Wall and Ceiling Linings", S. Birtwistle, Timber Tech & Machine Woodworking, October 7 November, 1953.

"A Test to Measure the Flammability of Kinematograph Safety Film", R. W Pickard & D. Hird, British Kinematography, V21, No. 3, 1952.

"Fires in Model Rooms", D. Hird & C. F. Fischl, FR Note No. 12/52.

"Fires in Model Houses", D. Hird & C. F. Fischl, FPE Note No. 72/51.

"The Resistance to Spread of Flame of Certain Proprietary Building Materials", FR Note No. 24/49.

1.8 Fire Resistance Experimental Equipment

On Thursday 30 October, I spent the best part of the day visiting with Mr. Ashton who is in charge of the fire resistance laboratory. We discussed relative merits of different types of furnaces. They are at present concerned with furnace design as they are in process of receiving bids on construction of an enlarged floor furnace. This is to accept specimens of 10 x 20 ft size. They burn producer gas but use a system similar to ours whereby the air is fed under pressure and gas is aspirated in at a pressure close to atmospheric. The refractory parts of their furnaces are formed of concrete bricks made from alumina cement and fire brick aggregate. I was surprised to learn that the furnaces were about 20 years old and observe the good condition of the bricks forming the furnace lining. The furnace air supply lines are fitted with motorized valves which are operated by electrical circuits from the office where temperatures are recorded. Thermocouples are connected through selector switches to a galvanometer type temperature indicator rather than one of the potentiometric type.

We discussed further tests on the prestressed concrete beams. I was shown a number of these including some full size specimens (20 ft span). Some of these specimens were fitted with a series of stirrups of about 5/16 in. dia spaced 4 to 6 ins. It was stated these were being used for the purpose of reinforcing the concrete cover as a metal fabric of large mesh size was considered impractical. At the time of the discussion it was anticipated that an additional six months to a year would be required prior to completion of these tests.

I questioned Ashton on methods used for determination of time of load failure of structures during fire test. He stated that in the case of floor or beam structures where collapse does not occur suddenly they use a deflection of one-twentieth of the span as an indication of point of load failure.

I witnessed tests of two corrugated plastic roof light materials. These were assembled over an opening in a metal roof construction. The assembly was then placed on a frame which supported it at an angle of about 45° to their large radiant panel to the radiation of which the complete assembly was exposed. They consider the specimen to have passed the test if no fire breaks through the specimen during or after the exposure period.

I was introduced to Mr. Bigmore who reports to Ashton and is making a study of the effects of fire exposure on the bond strength between concrete and its reinforcement. This is a problem of considerable importance to them because of the almost

universal use of undeformed reinforcing bars. Most of his work to date has involved development of test methods which can be shown to produce reproducible data. He is using highly polished rods with thermocouples attached and plans to use equipment quite similar to that of Malhotra for test of specimens both during the heating process and after subsequent conditioning periods.

a. References

"Comparative Tests on Prestressed and Reinforced Concrete Floors During and After Fires", L. A. Ashton, Civil Engineering & Public Works Review, November 1953.

"The Fire Resistance of Reinforced Concrete Columns", F. G. Thomas & C. T. Webster, National Bldg Studies Research Paper 18, 1953.

"Investigations on Building Fires, Part V Fire Tests of Structural Elements", N. Davey & L. A. Ashton, National Building Studies Research Paper No. 12, HMSO, 1953.

"Fire Endurance of Timber Beams and Floors", D. I. Lawson, C. T. Webster, & L. A. Ashton, The Structural Engineer, September 1952.

"The Fire Resistance of Prestressed Concrete Floors", L. A. Ashton, Civil Eng & Public Works Review, November and December 1951.

"Fire Endurance of Timber Beams and Floors", D. I. Lawson, C. T. Webster & L. A. Ashton, National Building Studies Bulletin 13, HMSO, 1951.

"Fire Resistance of Timber Doors", C. J. Webster & L. A. Ashton, National Building Studies Technical Paper No. 6 HMSO 1951.

"Investigations on Building Fires, I. Estimation of Maximum Temperatures, II. Color Changes in Concrete", T. W. Parker & R. W. Nurse, G. E. Bessey, National Building Studies Technical Paper No. 4, HMSO, 1950.

"The Fire Resistance of No Fines Concrete Walls, Part 1 Non Load-Bearing Walls of Heavy Aggregate", FR Note No. 44/53.

"Fire Resistance of Concrete Beams", L. A. Ashton & H. L. Malhotra, FR Note No. 65/53.

"Results of Tests Made at the U. S. National Bureau of Standards on the Fire Resistance of Prestressed Concrete Beams", L. A. Ashton, FR Note No. 106/54.

"Some Thermoelectric Properties of High Tensile Steel Wire", R. W. Pickard, FR Note No. 69/51.

1.9 Self Heating and Ignition

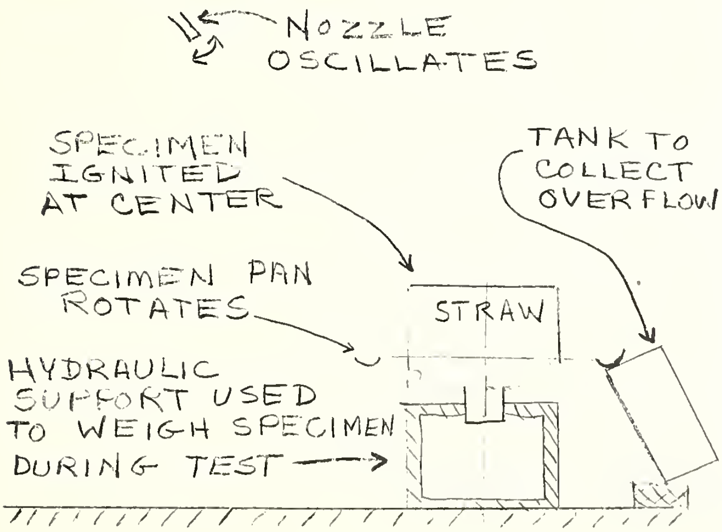
I visited Mr. Bowes on 4 October. Our chief topic of discussion was self heating and ignition phenomena. He has however done a considerable amount of work on fire extinguishment with the aid of wetting agents in water.

Spontaneous heating studies were started during the war when palm seed oil beans were stored in large piles in the open. Fires would be found within the stacks but closer inspection showed that these were not always in thermally isolated position and usually occurred near the interface of two bags. It was found that the jute bags, if an ignition source were brought near them, would develop a flash surface fire. This usually just involved the projecting fiber ends and not the fabric as a whole. It is now believed that these surface flash fires went into the spaces between bags and were the cause of ignition within the pile.

He showed me his ignition temperature apparatus which involves a rising temperature method. The material tested is pulverized and air for combustion is blown through it.

Their experience indicates that spontaneous ignition has been overemphasized as a cause of fires. An investigation of fires in cotton bales failed to indicate this as a likely hazard.

He has done work on wetting agents and finds little advantage in their use on low density packed materials (straw bales tested) but on high density packages there is considerable economy (50%) in use of water with a wetting agent incorporated.



The test setup for making the measurements was good and as shown at left. When using a wetting agent it was found that large quantities must be used if serious differential absorption is to be avoided. I discussed the Mackey test with him and he says the test was originally intended for study of woolen oils for hazard and oils which showed temperature of less than 200°C after 2 hours of test were considered safe.

In general he considered the test a satisfactory one for its intended use. However, it will pass materials with anti-oxydents which would fail a longer test.

a. References

"Factors Limiting General Application of the Mackey Test for Spontaneous Heating and Ignition", P. C. Bowes, J. App. Chem. 4, pp. 140-144, 1954.

"Spontaneous Heating and Smouldering", F. E. T. Kingman, Inst of Fire Engineers "Annual", 1953.

"Spontaneous Heating and Ignition in Stored Palm Kernels, 1. A Survey of Occurrences of Heating and Fire", P. C. Bowes, J. H. Burgoyne, T. P. Hilditch, & A. Thomas, J. The Science of Food & Agriculture N 12, pp. 360-366, 1950.

"Some Physico-Chemical Aspects of the Use of Wetting Agents in Firefighting, 1. The Loss of Wetting Agent by Absorption on Solids", P. C. Bowes & G. Skeet, FR Note No. 104/54.

"Methods for Assessing Spontaneous Heating and Ignition Hazards, II. The Heating of Oiled Fiber in a Modification of the Mackey Tester", P. C. Bowes, FR Note No. 53/53.

"Note on Spontaneous Heating and Ignition of Iron Pyrites", P. C. Bowes, FR Note 39/52.

"The Determination of the Ignition Temperature of Solids by a Rising Temperature Method", P. C. Bowes, FR Note No. 10/52.

"An Examination of Research Reports on Certain Incidents of Fires Attributed to Spontaneous Ignition", P. C. Bowes, FC Note No. 50/1951.

1.10 Water Sprays on Flammable Liquid Fires

I spent a portion of Monday and Thursday, 4 and 7 October, with Dr. Rasbash. We discussed his work on use of water sprays for extinction of flammable liquid fires. He showed me their facilities for both small scale (laboratory) and full size studies of flammable liquid fires. These latter involved the use of a concrete slab on which a 4 ft dia tub was placed within which oil was floated and burned on water. The test area was sheltered from gusts of wind by an aluminum sheet screen about 20 ft high and 30 ft on a side. Tests in the laboratory are confined to use of fires of one foot or less diameter.

In their experimental work they are more or less standardizing on the use of the following six flammable liquids: alcohol (industrial methylated spirits) benzole, petrol, kerosene, gas oil (diesel oil) and transformer oil.

They have been concentrating on study of the mechanism of extinguishment of flammable liquid fires. Their present thinking suggests that sprays may be effective in two different ways. They may be active in attack on the flame itself or as they affect the vaporizing liquid. These may be outlined as follows:

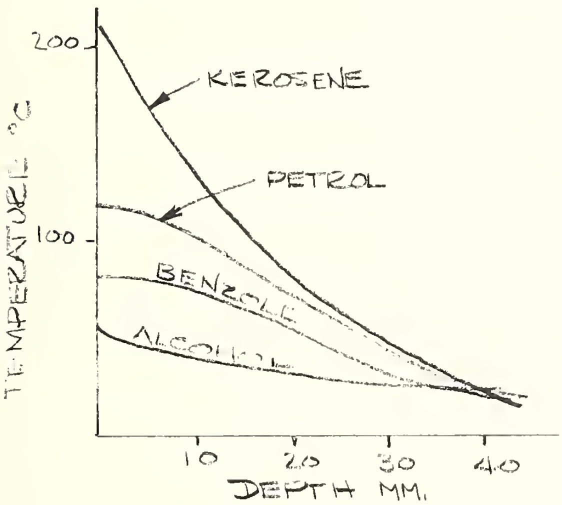
1. Attack on flame
   - (a) Blowing out by air
   - (b) Cooling of flame
   - (c) Smothering by steam formation in flame
2. Effect on liquid
   - (a) Cooling to fire point
   - (b) Formation of steam at hot liquid surface and smothering of flame
   - (c) Emulsion formation of oil in water
   - (d) Froth formation smothers and prevents reignition (water vapor on oil)
   - (e) Dilution of flammable liquid

Reference 1 reports a series of experiments in which the duration of spray application was studied as affected by, spray drop size, preburn time, and type flammable liquid involved. The following results were observed:

(1) In general the time of extinction decreased as volatility decreased.
(2) For alcohol, benzole, petrol, and kerosene, the extinction time increased as the drop size increased.
(3) For gas oil (diesel oil) and transformer oil the mean extinction time was smallest with the coarsest spray.
(4) In a few of the groups of tests the range of extinction times for a given liquid varied widely, other conditions being the same.

It was concluded that at least four different mechanisms of extinguishment were responsible for the behavior noted. It was further observed that quite coarse sprays were effective and reliable in extinction of fires in high boiling temperature liquids. Such sprays would not however be effective against fires in volatile liquids.

As a result of work to date they are inclined to question the need or even the desirability of high pressure sprays for fighting flammable liquid fires. They believe that the conclusions drawn from the studies made in this country are not justified.



They have made a series of studies of the temperature distribution beneath the surface of flammable liquids. A sketch of the type of data resulting is provided at the left. Measurements were made in a 30 cm dia pan having a 2 cm freeboard.

a. References

"The Extinction of Liquid Fires with Water Sprays", D. J. Rasbash & Z. W. Ragowski, Chemistry and Industry, pp 393-5, 1954.

"Absorption and Scattering of Radiation by Water Sprays of Large Drops", P. H. Thomas, British J. App Phys V3, pp 385-393, December 1952.

"The Use of Water Sprays as Protection Against Radiant Heat", P. M. T. Smart, FPE Note No. 66/51.

"Absorption and Scattering of Radiation by Water-Sprays of Large Drops", P. H. Thomas, FPF Note No. 48/51.

"The Effects of Water Spray on Burning Kerosene", D. J. Rasbash & G. Skeet, FC Note No. 41/51.

"The Production of Fire Fighting Sprays by Impinging-Jets", J. F. Fry and P. M. T. Smart, FPE Note No. 42/50.

1.11 Vaporizing Liquid Extinguishing Agents

On Thursday 7 October I discussed with Mr. Coleman the work being done on vaporizing liquid extinguishing agents. Much of the work done in the past has consisted of study of explosive limits of vapors and the effects on them of varying amounts of the volatile inhibitor. Recently however a number of experiments have been performed in an effort to study the relative value of the different materials when applied to fires. For spill fires they use a metal pan 4 ft dia by 1/2 in. deep set on the ground. They find the best means for applying the vaporizing liquids to be a flat spray. They have used the spray formed by impingement of a stream of liquid 1/16 to 3/32 in dia at an angle of 45° to a small plot 1 x 2 in. in size.

Results of recent studies of chlorobromomethane leads them to suggest that as applied to a given fire it shows an advantage of 4 to 15 times over carbon tetrachloride when comparing the volumetric quantities of fluid required for extinguishment.

They have done some work on study of relative effectiveness of CB and dry chemical extinguishers as applied to aircraft fires.

a. References

"Report of Committee on Vaporizing Liquid Extinguishing Agents", Committee DSIR, Fire Research Tech Paper No. 2, HMSO, 1954.

"Limits of Inflammability and Spontaneous Ignition of Some Organic Combustibles in Air", J. H. Burgoyne & R. F. Neale, Fuel V32, N 1, pp 17-27, 1953.

"Some New Measurements of Inflammability Ranges in Air", J. H. Burgoyne & R. F. Neale, Fuel V32, N 1, pp 5-16, 1953.

"The Products of Combustion in Burning Buildings", F. E. T. Kingman, E. H. Coleman, & D. J. Rasbash, J Applied Chemistry 3, pp 463-68, 1953.

"Effects of Fluorinated Hydrocarbons on Inflammability of Limits of Combustible Vapors", E. H. Coleman, Fuel, V31, N4, pp 445-446, 1952.

"The Inflammability of Oil Mists", J. H. Burgoyne & J. F. Richardson, Fuel V28, N 1, pp 1-5, 1949.

"Inflammability of Liquids", J. H. Burgoyne & G. Williams Leir, Fuel 28, N 7, pp 146-150, 1949.

"Limits of Inflammability of Gases in the Presence of Diluents, A Critical Review of Data", J. H. Burgoyne & G. Williams-Leir, Fuel V27, N 4, pp 1-8, 1948.

"The Influence of Incombustible Vapors on the Limits of Inflammability of Gases and Vapors in Air", J. H. Burgoyne & G. Williams-Leir, Proc Roy Soc A Vol 193, pp 525-539, 1948.

"The Decomposition Products of Vaporizing Liquid Extinguishing Agents", E. H. Coleman & C. H. Thomas, Fire Research Board Paper VL/3.

"The Fire Hazard of Acetone and Methylene Chloride", E. H. Coleman & P. S. Tonkin, FR Note No. 88/53.

"The Effects of Certain Halogenated Hydrocarbons on the Inflammability Limits of nHexane and Air", E. H. Coleman & P. S. Tonkin, FR Note No. 1/52.

"The Effect of Methane/Halogen Compounds on the Inflammability Limits of nHexane in Air", E. H. Coleman, FC Note No. 51/51.

1.12 Fire Damage Statistics

On Friday morning 8 October I visited Mr. Fry who is in charge of the Intelligence Division of the Fire Research Station. His office is in London on Lower Regent Street. I was shown the procedures they use for recording data from reports of fires. These reports come to them automatically as part of the reports prepared by each fire brigade on each fire attended. The reports are in the form of a check off list with spaces for entry of information not otherwise provided for. Fry's group use these reports to prepare "Hallorith Cards" (a form of punched card data recording system). The cards are then sent to the National Physical Laboratory where machines are available for sorting them. These cards form the basis on which the annual statistical report is prepared on fire loss. The data obtained in this way appears to be by far the most comprehensive compilation of this type available in any country. In spite of this it has been found that there are always requests for more information than can be furnished from the data tabulated. Recently they have supplied special questionnaires to provide more detailed information on the conditions under which fires have caused injury or deaths in which clothing appears to be an item of importance.

a. References

"Coding of Reports from the Fire Brigades in the United Kingdom for 1954 and Subsequent Years", FRS, Statistics Unit Code List No. 1A, December 1953.

"Statistical Analysis of Reports of Fires Attended by Fire Brigades in the United Kingdom During 1953", G. G. Auber, J. E. L. Hinton & D. W. Millar, FR Note No. 120/54.

"Fires in Post-War Dwellings XXXVIII on Analysis of Reports of Fires Attended by Fire Brigades in Great Britain During 1953", J. E. L. Hinton, FR Note No. 112/54.

"Fires in Post-War Dwellings XXXVII Review of Statistical Work on Reports of Fires Attended by NFS and Fire Brigades 1946-52", D. W. Millar & J. F. Fry, FR Note No. 70/153.

"Distribution of Financial Loss in Large Fires According to the Hazard Involved II", D. W. Millar, FS Note No. 133/51.

"Fires Connected with the Process of Drying Grass Which Were Attended by Fire Brigades in Great Britain During 1949-50", D. W. Millar, FS Note No. 129/51.

"Fires Caused by Television and Wireless Sets IV. Rates of Incidence of Fires 1947-50", D. W. Millar & J. Wallace, FS Note No. 128/51.

"Fires Caused by Sparks from Locomotive II. Incidence of Fire and Weather Conditions", J. Wallace & E. M. Maycock, FS Note No. 122/51.

1.13 Extinguishing Equipment

On Tuesday 12 October I visited Dr. Thomas who is in charge of a group studying problems related to hose, foam, water sprays and hand portable extinguishers.

A study has been recently completed on the application of water fog as compared with solid streams to fight fires in full size rooms. These experiments were performed with the use of regular fire brigade staff. The results indicate that when water for application was stopped shortly after appearance of steam vapors, the fire would be controlled and the quantity of water used would correspond to a steam volume three times that of the room. This is believed to be considerably more than would be required to control the fire but much less than would be applied by solid stream nozzles or application of the water fog by uninstructed fire fighters. Results to date tend to indicate that application of water in the form of fog sprays is more effective on fires in small rather than large enclosures.

The results observed during these full scale fire tests appear to be in general agreement with those resulting from studies by use of small models.

a. References

"The Use of Water to Protect Building from Radiated Heat", P. H. Thomas, FR Note No. 115/54.

"The Distribution of Water by Impinging Jet Sprays", P. H. Thomas, FR Note No. 91/54.

"The Surface Application of Foam to Petrol Fires in a 7 ft Square Tray", R. J. French & P. L. Hinkley, FR Note No. 41/52.

"The Surface Application of Foam to Petrol Fires", R. J. French, P. L. Hinkley & J. F. Fry, FR Note No. 21/52.

"A Brief Survey of Information on Water Sprays for Fire Extinction", J. E. Fry, FPE Note No. 43/50.

"A Laboratory Method of Comparing the Efficiencies of Fire Fighting Air Foams", J. F. Fry & R. J. French, FPE Note No. 29/50.

1.14 Library

The library facilities of the Fire Research Station appear to be very good. Miss Shakeshaft is in charge and has three or four assistants. My own estimate is that they have more than five thousand volumes as well as many reprints and pamphlets on all aspects of the fire problem. A microfilm copy was obtained of their filing system. Their classification index runs to over 400 pages. Besides the usual library activities of cataloging acquisitions and assisting visitors in use of their facilities, they compile very complete bibliographies on scientific references related to fire research. These are released annually and have been made available to us.

a. References

"References to Literature on Wood and its Relation to Fire Including Fire Retardant Treatments", Shakeshaft et al, FRS Library Bibliography No. 2, August 1953.

"References to Scientific Literature on Fire", Holyrod, Shakeshaft et al,
Part I 1944-47, Library Bibliography No. 5/1948
Part II 1948, Library Bibliography No. 5/Part II, 1950
Part III 1949, Library Bibliography No. 5/Part III, 1950
Part IV 1950, Library Bibliography No. 5/Part IV
Part V 1951, Library Bibliography No. 5/Part V
Part VI 1952, Library Bibliography No. 5/Part VI

2. SAFETY IN MINES RESEARCH ESTABLISHMENT

On Tuesday 28 September I visited the Safety in Mines Research Establishment at Buxton. This organization is somewhat similar to the Bureau of Mines here. It reports to the Ministry of Fuel & Power whereas the Fire Research Station reports to DSIR. However this organization is doing some work on dust explosions on a transferred fund basis for the Fire Research Station. Mr. K. C. Brown is apparently in charge of this phase of the work. A report of a large number of materials studied is available . The materials are tested both in the as received condition and later after drying and sieving through a 240 mesh sieve.

A description of some of the test methods is available as reference 5. In general these consist of arrangements for blowing a cloud of dust particles over a hot platinum igniter wire, or through a heated tube. If combustion takes place then the material has failed the test. The small platinum wire igniter fails to cause ignition in all but most hazardous materials.

They are working on a modified test method in which the quantity of energy passing through a spark gap ignition source can be varied for quantitative measurements of sensitivity of various dusts.

Mr. Brown demonstrated work they were doing on venting of shafts and galleries to reduce the explosion hazard. Some other work on rate of flame propagation in dispersed dusts is also being performed at the Station. Many of these measurements are being made within vertical glass tubes. Cork dust appears to be their standard combustible.

Very interesting work being done on the frictional spark ignition of gases was demonstrated by Mr. W. Thompson. One method of study involved the use of a small gun using metal balls as shot. The target was enclosed in a small box with a cellophane window and could thus be supplied with combustible gas mixtures. A small velocity screen was used for checking projectile velocity. This equipment permits performance of a large number of tests so that statistical methods may be used in analyzing the data.

Results to date with this equipment indicate ignition of methane-air mixtures with steel on steel impact or with steel on lead when the projectile fractures. They find that rusty iron the surface of which has been scored with a piece of aluminum is very subject to sparking when struck with a steel object. They find that any metals hard enough for tools can produce sparks when struck on minerals or stones.

This projectile test has indicated that metal on metal impact is most likely to cause ignition when normal incidence occurs but glancing incidence is most likely to cause ignition by impact of metal on stone.

They demonstrated a much larger drop test apparatus in which a metal slug was allowed to hit a metal plate, all within an enclosed space containing an explosive gas mixture. This provides a striking demonstration of the fact that magnesium or aluminum tools dropped on rusty iron can ignite combustible gas mixtures.

a. References

"Inflammability of Dusts", SMRE, Factory Department Form 830, 1953.

"The Ignition of Inflammable Gases by Sparks from Aluminum Paint and Rusty Steel", F. E. T. Kingman, E. H. Coleman & Z. W. Ragowski, J. Applied Chemistry 2 pp 449-56, 1952.

"Dust Fires I to VI", D. J. Rasbash, Industrial Heating Engr, July-December 1951.

"The Inflammability in Suspension of Mixtures of Combustible and Incombustible Dusts", P. C. Bowes, J. H. Burgoyne & D. J. Rasbash, J. Soc. Chemical Industry, V67, pp 125-30, 1948.

"Review of Methods of Testing Industrial Dusts for Inflammability", K. C. Brown, SMRE Research Report No. 21, April 1951, HMSO.

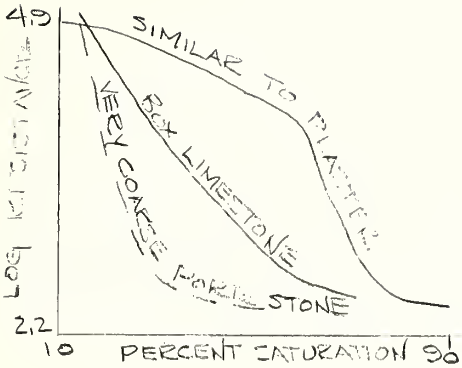
3. BUILDING RESEARCH STATION

On Friday 1 October I visited the Building Research Station at Garston. Here I met the Director, Dr. Lea, and Dr. Davey, Chief of the Engineering Division. I was given a quick tour through the laboratories which are very extensive, a staff of over 500 being employed. Mr. Bevan of the Building Practice Division was very cordial and interested in the work we were doing. With the single exception of fire protection work, the activities of this station cover those of our Building Technology Division and in addition many other phases such as studies of the functional efficiency of buildings which includes physiological and psychological problems. Another phase studied involves methods of construction related to costs. This may be considered as the operational research aspect of their activities.

I was especially interested in one instrumentation technique which was being used for measurement of strains in structures both during laboratory experiments and also in buildings during occupation. This involved a so-called sonic strain gage. This device consists of a wire supported in tension between two rods rigidly fixed to the structure being studied. An electromagnetic coil is used to force vibration of this wire the frequency of which can readily be measured. When proper precautions are observed during use of this gage any change in resonant frequency may be related to change in gage length of the supports and thus a strain in the structure to which they are fixed.

I returned to this station on Monday 11 October to secure more information from Dr. R. J. Schaeffer's group involved with moisture measurement in stone. They have being doing some work with a plaster moisture-gage. This consists of a cylinder formed of plaster of paris incorporating an axial wire electrode and another helical electrode embedded in the cylindrical surface of the gage. This unit is about 1/4 in. in dia by 1 1/4 in. long.

Gages such as these are mounted in a plaster grout within masonry or stone materials. The AC resistance between electrodes is taken as an indication of the relative saturation of the material. It was stated that the value of this type of gage is quite largely dependent on the character of the material within which it is being used.



As indicated by typical calibration curves at the left the shape of the curve is related to the pore structure of the material being studied. The gage is not of much use in study of moisture conditions within stones or materials having very coarse pore structure. BRS is in process of preparing a paper in which use of this gage will be described.

a. References

"The Suction of Moisture Held in Soil and Other Porous Materials", D. Croney, J. D. Coleman, & P. M. Bridge, Road Research Technical Paper No. 24 HMSO, 1952.

"Movement of Water in Soil Due to a Temperature Gradiant", Gurr Marshall & Hutton, Soil Science, V74, N5, November 1952.

"Fire Gradings of Buildings, Part 1 General Principles and Structural Precautions", Post War Building Studies No. 20, HMSO, 1946.

4. FIRE OFFICES' COMMITTEE AND FIRE PROTECTION ASSOCIATION

On Friday noon 8 October I went with Mr. Clarke to lunch with the Fire Offices' Committee in their building at 65 Watling Road. There I met among others Mr. A. Hinshelwood, Chairman, Mr. C. Porteous, Deputy Chairman, and Mr. J. Haworth, Secretary. This organization appears to be quite similar in organization and operation to the National Board of Fire Underwriters in this country. They were very cordial, provided an excellent meal, and asked me to return when another opportunity occurred.

Later I met Mr. N. C. Strother-Smith who has succeeded Mr. Tuckey as Director of the Fire Protection Association. This organization has much the same objectives of NFPA here. The organization is however much smaller and does not operate on a scale comparable to that of its American counterpart. The difference in calibre of the two organizations is probably due to both differences in temperament and customs of the two nationalities as well as an apparent more nationalized feeling of responsibility as provided in the Ministries of Labor and Home Security.

The Fire Protection Association does publish the FPA Journal (quarterly) and both Fire Protection Notes and Leaflets. These are of quite similar calibre to material provided in NFPA Quarterly.

5. IMPERIAL COLLEGE

On Tuesday 5 October I visited Drs. Burgoyne and Spalding at Imperial College, London.

I spent the morning with Dr. Spalding who has just recently accepted a position as Reader in the city and Guilds College (Mechanical Engineering). He was formerly at Cambridge where he was concerned with heat flow and combustion problems. Probably his most significant contribution to the field is his work on mass transfer rates. In the past the usual procedure of calculation of mass transfer rates, as the product of a transfer coefficient and a concentration gradient, has been fairly satisfactory in the absence of chemical changes but has often lead to serious errors when such processes were present or when the concentration difference is large. Dr. Spalding has developed a method of calculation of such transfer rates which appears much superior to the more common methods and can be shown to provide close correlation with experiment. This has been done by demonstration that the process can be described in terms, (a) of an equation relating mass transfer rate to the Reynolds number and other conditions, and (b) of a driving force called the mass transfer number.

Dr. Spalding has developed a considerable interest in the work of the Fire Research Station and apparently plans to do what he can towards further study of combustion behavior of solid fuels.

I spent the afternoon with Dr. Burgoyne who is a lecturer in the Department of Chemical Engineering and Applied Chemistry at Imperial College. He and Dr. F. J. Weinberg a recent graduate have a large group of graduate students working for them on a wide variety of combustion problems. I was especially interested in the equipment developed for production of aerosols of uniform drop size and their studies of the burning velocities of such aerosols. Dr. Burgoyne has spent a considerable amount of time during and since the war on problems relating to fire hazards.

a. References

"The Calculation of Mass Transfer Rates in Absorption, Vaporization Condensation and Combustion Processes", D. B. Spalding, J. Institution of Mech Eng, 1954.

"A Theory of the Extinction of Diffusion Flames", D. B. Spalding, Fuel V33, N3, pp 255-273, July 1954.

"Mass Transfer in Laminar Flow", D. B. Spalding, Proc Roy Soc A V221, pp 78-99, 1953.

"The Laminar Flame Speed of Propane/air Mixtures with Heat Extraction from the Flame", J. P. Batha & D. B. Spalding, Proc Roy Soc A, V225, pp 71-96, 1954.

"The Production of Monodisperse Aerosols of Large Drop Size", J. H. Burgoyne & L. Cohen, J. Coloid Science, V8, N3, pp 364-366, June 1953.

"The Effect of Drop Size on Flame Propagation in Liquid Aerosols", J. H. Burgoyne & L. Cohen, Proc Roy Soc A, V225, pp 375-392, 1954.

"The Determination of Some Parameters Across the Combustion Zone of a Flat Flame", J. H. Burgoyne & F. J. Weinberg, Proc Roy Soc A, V224, pp 286-308, 1954.

6. PYRENE CO. LTD.

I asked suggestions of those at the Fire Research Station as to which manufacturer of fire fighting equipment it might be most profitable to visit. The answer was fairly unanimous that the Pyrene Company was probably not only the most convenient to reach but also one of the more progressive manufacturers of this type of equipment. I visited them on Monday 18 October and in the absence of Mr. H. E. Bedford their technical director, I met Mr. Robins who is both an engineer and a sales official. I was interested to learn of the wide variety of their products ranging from a small pump gun type of extinguisher to an air field crash fire truck. It was stated that they have abandoned their former foam pumping equipment in favor of a truck provided with centrifugal pumps for air and water delivery and means for aspirating foam fluid. They have done this because of the simplification in pumping equipment and the increased flexibility of the system which permits use of the truck as a conventional pumper when the need arises.

On Mr. Bedford's return I visited with him a short while and was introduced to Mr. W. J. Clifford who is in charge of their New Products Division. He is evidently closely connected with any work they may do that could be considered as research. There was not sufficient time to visit their laboratories so that available time was used in discussing test methods they use. Most of these were for the purpose of evaluating foams. One technique they use is however of interest whether or not it is fully justified. This involves the construction of experimental flammable liquid fires on an elongated test area. The fire is then attacked from one end and the length of the tray over which flaming has been extinguished is taken as a quantitative index of the relative value of the extinguisher. This may be a good technique and seems quite worth study.

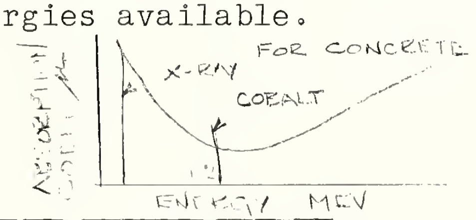
I found my visit to this organization interesting though not too profitable on the technical side. The company is a large one and has just recently "bought itself out" from the American mother organization.

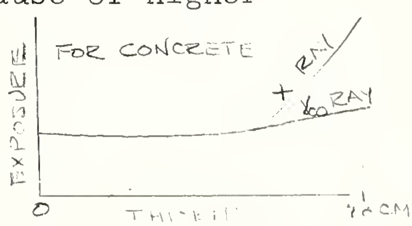
7. CENTRE SCIENTIFIQUE ET TECHNIQUE DU BATIMENT (CSTB) Paris, France

This group appears to be roughly equivalent to the Building Technology Division at NBS with the exception that they are only concerned with buildings on land. M. Fackler was visited as M. Marini the Director was ill. This organization has four technical divisions under: M. Roger (studies of new materials and building practices), M. Démarre (technical advice codes and specifications and architectural studies), M. Fournol (functional studies of buildings, heating lighting, acoustics, and ventilation) and M. Fackler (international relations, safety problems, application of nuclear physics to building, work for the war and interior departments. There are also, a library division under Mademoiselle Flitz, a publications division under M. Perrissoud and a service division under M. Crozet which includes personnel, budget and supply problems. The experimental station is located on the other side of Paris (east) and is directed by M. Brayer who reports to M. Marini.*

M. Fackler seems to be doing a bit of interesting and original work on use of radiographic techniques on study of imperfections in concrete. Studying effects of vibration on uniformity of resulting concrete and glomeration of aggregates.

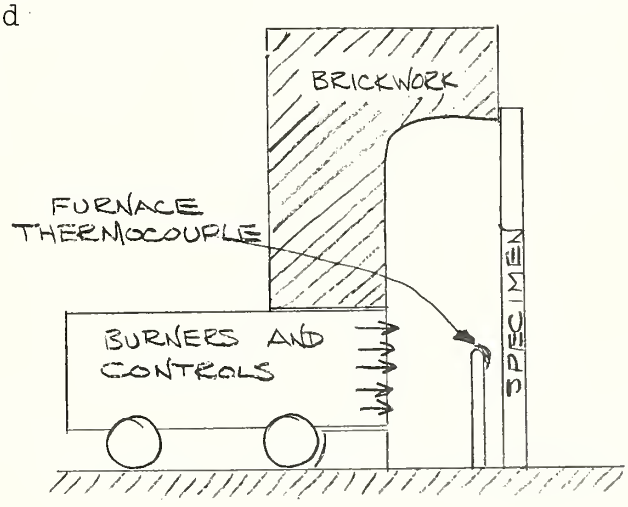
He has used artificial aggregates loaded with axial steel pins to study change of orientation of aggregate during vibration. He also has done work on study of concrete as a shielding material for radiation from radioactive material. He has made a concrete cylinder 3.6 meters diameter and about as high with a series (20 to 30) of one cm holes parallel to the axis and spiralling in to the center to permit measurements of transmission within and from the inside out of the cylinder. He has constructed a portable 3.2 curie cobalt source inside a 40 cm diameter lead sphere. This is arranged on a carriage to roll into position for making measurements in the field. They use both Geiger counter and photographic detectors. Radioactive materials are used rather than electrical sources (x-ray machines) because of higher energies available.





*M. Audige says that the experimental station is jointly directed by CSTB and Ministere de l' Interieur.

I visited the Station Experimentale de Champs-sur-Marne under M. Brayer in the afternoon. There I met M. Fretin and Commandant Chauteud of the Ministere de l' Interieur. The station is a big one and will be larger. Much of it is new in the last two years. One large building was set aside for tests and demonstrations of various wall and floor finishes. This building must have been at least 60 ft x 120 ft. The main building has labs on first floor and offices above. They showed me a new floor tile test device. We then walked to their specimen preparation building. It must have been at least 80 ft x 160 ft and contained one large central fabrication area with overhead crane which ran out of one end of the building to carry specimens to various test devices. On one side of this fabrication area there were shops for wood and metal work. On the other side were several test rooms, one of which involved a heat transfer box of the guarded hot box type suitable for temperatures on the cold side between -20 and 60°C. The specimen was mounted vertically and humidity could be controlled as well as temperature. They then took me to see their acoustic reverberation chambers. These are about 12 ft square and about 10 ft high. There are three different rooms, one for test of surface finish materials, another for floor-ceiling assemblies and the last for walls. All are built underground of reinforced concrete. They showed me the panel furnace which accommodates specimens as large as 3 x 3 meters which seems to be the standard size for all specimens. The furnace is gas fired and automatically controlled to follow the time temperature curve. It seems that only one or two thermocouples are used in the furnace, one of these is used for control purposes. It is protected on the side near the specimen to prevent the type of specimen from influencing the time temperature curve. This furnace was being modified and another similar one was being built. Thin asbestos pads are used over the unexposed surface thermocouple.



They showed me a building setup for test of 24 chimneys at one time. This was about 16 to 24 ft high but only one chimney was set up in place.

Several other test areas were shown. The general impression I got was that a lot of money had been put into

facilities but as yet only very limited use had been made of these facilities. We saw M. Fackler's laboratory for radioactive measurement techniques and his portable cobalt source. He did not show us his analogue computer which has recently been completed.

I saw little evidence of technical staff but they certainly are getting equipment with which to work.

8. INSTITUTE DE RECHERCHES DE LA CONSTRUCTION NAVALE
Paris, France

I visited M. Audige of the Institute de Recherches de la Construction Navale at the headquarters of this organization at 1 Boulevard Haussmann Paris 9e. This organization appears to be a quasi governmental type and has no research laboratories of its own but probably has government money at its disposal. He said he spends his time about equally between this organization and an organization representative of the ship building industry evidentally similar to our trade associations. He attended the 1948 London Conference on safety of life at sea and apparently has taken an active interest, since that time, in the fire hazard problem. He mentioned four government laboratories which do work for them.

1. CSTB mentioned earlier, they are continuing work on flame spread test methods.

2. Laboratoire du Feu de Bellevue, 1 Place Aristride Briand Bellevue-Mevdon.

3. Bureau Veritasse. This organization has done work on paints. It is somewhat similar to "American Bureau of Ships".

4. Laboratoier des Arts et Metier at 292 Rue Saint Martin Paris 3e. This laboratory is operated by the Ministre de Education Nationale and was originally established for evaluation of inventions. They do work on
   a. Fire extinguishers
   b. Flammability of paints
   c. Bulkhead tests
   d. Deck covering tests
   e. Fire detection systems

We spent considerable time discussing flame spread and combustibility test methods. He indicated that there had been a suggestion that all fire research work be centralized at CSTB but so far it was just a happy hope. He did not seem to know M. Fretin but had heard of Commandant Chauteaud.

SUMMARY

It is difficult to summarize the value of a visit such as this in any but very general terms. The trip was without question well worth while since it provided a much clearer picture of how fire research work is being conducted in Britain and France. Perhaps the chief value lies in the personal contacts which were made and the ability to discuss technical problems with those actually doing the work.

The British as was previously recognized are making a much stronger effort than has been done here to analyze the many technical aspects of the fire problem. The work they are doing is paying dividends. The Fire Research Station is held in enviable respect by both the fire fighting organizations with whom they have had close contact and the technical public.

CLARKE

- Intelligence-Fry
  - Tabulation of Fires
  - Statistical Analysis of Fires
  - Library-Shakeshaft
- Chemistry-Kingman
  - Chem Eng-Water Sprays on Liquid Fires-Rasbash
  - Smouldering-Palmer
  - Spontaneous Heating / Storage Problems / Ignition Tem / Wetting Agents - Bowes
  - Vap Liq Exting Agents / Industrial Hazards - Coleman
  - Dust Expl SMRE - Buxton, K. C. Brown
  - Mechanism of Flames / Limits of Inflammability - Imperial College - Dr. Burgoyne
- Physics & Engineering-Lawson
  - Assistant-Nash
    - Extinguishment Equipment - Thomas
      - Hose & Extinguishers - Gordon
      - Foam - French & Hinklay
      - Water Sprays - Smart
  - Fire Resistance Testing-Ashton
    - Effects of Heat on Concrete - Malhotra
    - Bond Strength at High Temps - Bigmore
  - Roofs & Fabrics-Webster-Gregstan
  - Ignition of Materials-Simms-Pickard
  - Models-Hird-Wraight
  - Analogue & Electronics-McGuire-Law

THE NATIONAL BUREAU OF STANDARDS

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The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the front cover.

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The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.00). Information on calibration services and fees can be found in NBS Circular 483, Testing by the National Bureau of Standards (25 cents). Both are available from the Government Printing Office. Inquiries regarding the Bureau's reports and publications should be addressed to the Office of Scientific Publications, National Bureau of Standards, Washington 25, D. C.

NBS