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**NOT FOR PUBLICATION  
OR FOR REFERENCE**

**NATIONAL BUREAU OF STANDARDS REPORT**

4559

PROJECTS RELATED TO BUILDING RESEARCH

AT THE

NATIONAL BUREAU OF STANDARDS

FOR FISCAL YEAR 1956

Compiled by the  
Building Technology Division  
D. E. Parsons, Chief



**U. S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS**

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 is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section is engaged in 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 of the back cover of this report.

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

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

**Heat and Power.** Temperature Measurements. Thermodynamics. Cryogenic Physics. Engines 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.

**Mineral Products.** Porcelain and Pottery. 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.** Components and Techniques. Digital Circuitry. Digital Systems. Analogue Systems.

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

**Radio Propagation Physics.** Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services.

**Radio Propagation Engineering.** Frequency Utilization Research. Tropospheric Propagation Research.

**Radio Standards.** High Frequency Standards. Microwave Standards.

● Office of Basic Instrumentation

● Office of Weights and Measures

# NATIONAL BUREAU OF STANDARDS REPORT

**NBS PROJECT**

**NBS REPORT**

1000-40-1099

March 1, 1956

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## INTRODUCTION

This report lists unclassified projects concerned with building research and related subjects in progress at the National Bureau of Standards in Fiscal Year 1956.

Most projects mentioned are directly related to engineering and research in the building field. However, other NBS projects not directly related, such as those on instrumentation and properties of gases, are included in the belief that the basic information is sometimes applicable to building research.

Each project is identified by ten digits. The first four, followed by a dash, indicate the division and section at NBS which is carrying out the work. The next two indicate the scientific activity class, as follows:

- 10 Research
- 20 Development
- 30 Testing, Calibration, and Specifications
- 40 General Scientific Services

The last four digits identify the projects within the basic organizational unit. Thus, project 1003-20-4832 refers to a Division 10, Section 3, development project.



KEY TO ABBREVIATIONS  
APPEARING IN THIS REPORT

	<u>Abbreviation</u>
American Society of Heating and Air-Conditioning Engineers . . . . .	ASHAE
American Society of Refrigerating Engineers . . . . .	ASRE
American Society for Testing Materials . .	ASTM
American Standards Association . . . . .	ASA
Atomic Energy Commission . . . . .	AEC
Federal Housing Administration . . . . .	FHA
General Services Administration . . . . .	GSA
Illuminating Engineering Society . . . . .	IES
International Organization for Standardization . . . . .	ISO
National Bureau of Standards . . . . .	NBS
National Electrical Manufacturers Association . . . . .	NEMA
Office of the Chief of Engineers, Department of the Army . . . . .	OCE
Standards Electronic Automatic Computer . .	SEAC





## ACOUSTICS

### 0601-20-0600 Acoustic Calibration Procedures

Objectives: To conduct researches into and to develop methods for absolute measurement of sound pressures and intensities over wide ranges. Application of such methods to maintenance of standards for normal threshold of hearing. Development of sound sources for use in calibrating microphones for measurement of high sound intensities.

Importance of the Project: This project is concerned with maintenance of standards for acoustic measurements. Absolute measurements of sound intensity are basic to researches in acoustics. Calibrated microphones are required for measurement of sound radiated by loudspeakers, and for the measurement of noises and other complex sounds. They are required also for audiometric measurements. Consequently, calibrated microphones are used by industrial, academic and governmental laboratories. Calibrations of these microphones are effected by comparison with standards maintained in the Sound Laboratory.

Activity Summary: Microphone calibrating equipment for both free-field and pressure measurements has been overhauled during the year as part of the long-term program on the absolute measurement of sound. A regular schedule has been set up for calibrating our own laboratory standard condenser microphones by the reciprocity technique. The free-field ("dead") room is being rebuilt; a study of the properties of existing sound-absorbing wall coverings has been made. The room interior will be covered with wedges of sound-absorbent material, designed to minimize reflections of sound over a wide frequency range.

The work on audiometric standards was carried on by summarizing recent preliminary data on the mechanical impedances of the foreheads and mastoids of ten subjects. The results indicate that a simple artificial mastoid can be built for calibrating bone-conductors used in measurement of hearing. The system need consist only of a small mass associated with a stiff spring, rather heavily damped and mounted on a massive base. Foreheads and mastoids are similar in stiffness, but the mastoid appears to be less dense than the frontal bone. The results conform to the idea that the spring force encountered arises from flexing of the skull in the vicinity of the driving tip, and the mass encountered is the plug of the bone and flesh set into motion by the driving tip.

0601-20-0600 - continued

A sound source for ear impedance measurements which appears to have stable impedance characteristics has been developed and checked. Equipment for measuring the impedance of ears and mastoids has been checked and worked over, preliminary to carrying out measurements on 50 to 100 subjects at the Forest Glen Annex of Walter Reed Hospital. Assistance was provided to the Forest Glen Annex staff for work they are undertaking in investigating the source of the differences between British and American standards for normal threshold of hearing.

0601-30-0605 Acoustic Measurements

Objectives: (1) To measure the sound absorption of acoustic materials; (2) to measure the sound insulation properties of wall and floor constructions; (3) to perform standard calibrations of microphones, sound level meters, earphones, and audiometers.

Importance of the Project: Large quantities of acoustic materials are used annually by the Government and the performance of the material used is measured under this project, to check its compliance with Federal Specifications SSA-118-B, and SSA-111. Measurements of the sound absorption of acoustic materials, and of the sound insulation of building constructions are also made for industry and private individuals. The reason is that measuring methods in this field are not yet fully standardized, and systematic differences between results obtained in various laboratories have not yet been resolved. (Work is in progress under Project 0601-10-0632 to standardize on good measuring techniques in this field.) The performance of standard calibrations of microphones and other electro-acoustic devices has been requested by various laboratories, including Governmental as well as industrial and university laboratories.

Activity Summary: This is a continuing project that was started about thirty years ago. During Fiscal Year 1955 the following tests were reported: 18 reverberation-room tests, 9 sound transmission loss tests, 6 microphone calibrations, 10 impedance tube tests, 4 box tests, 1 sound level meter calibration, 2 miscellaneous acoustical tests.

Objectives: (1) To investigate the basic physical phenomena involved in the transmission and absorption of sound in acoustic materials, building materials and building structures; (2) to develop new measuring techniques in architectural acoustics and improve existing techniques; (3) to assist in developing appropriate standards in this field.

Importance of the Project: As the noise levels produced by society increase, more attention has to be paid to reducing noise levels inside buildings. Acoustic materials are widely used for reducing noise and for improving the acoustics of buildings, and new techniques are being developed for improving the sound insulation of walls, floors and doors. Many of the phenomena of sound propagation in materials and structures are imperfectly understood, and need theoretical and experimental elucidation before advances can be expected. Measuring techniques in this field are generally antiquated and poor, and require much improvement. For example, reverberation room measurements of the sound absorption of acoustic materials made in different laboratories often produce different results for the same material. The same is true of sound insulation measurements of wall constructions. There is urgent need for improving these measuring techniques. Another item of importance is the development of sound insulation standards for building codes. The United States is lacking such standards although several European countries and Canada have them; this project would be the logical place to develop them.

Activity Summary: This is a continuing project which was started about thirty years ago. During the past year the main effort has been in the following three activities: (1) Investigation of the effect of interference patterns on reverberation room-measurements. Measurements on the patterns confirmed the theoretical predictions, and the results have been published in the Journal of the Acoustical Society. These results are important in that they explain aspects of reverberation-room measuring technique which were not understood before, for example, the effects of sample position in the room. The work will result in significant changes in measuring methods. An ASTM standard on sound-transmission-loss measurement is being redrafted, and will incorporate some results obtained in this work. (2) A new impedance tube was designed and built to replace an older one that was defective. The new tube embodied several improvements and is operating very well. (3) The limitations of the reverberation-room

0601-10-0632 - continued

method of measuring the sound power output of noise sources were studied. It was established that above 4000 cps a correction becomes necessary to account for air absorption. A correction was derived theoretically and is being checked experimentally.



AIR CONDITIONING, HEATING, REFRIGERATION

0603-30-0613 Testing-Wind Equipment

Objectives: To calibrate wind-measuring equipment to develop test methods.

Importance of the Project: Wind-measuring instruments are widely used by the weather services and in the heating and ventilating field. Government agencies, private users, and manufacturers have need for calibrated instruments either for direct use or for checking the accuracy of other instruments. Instruments in the field are periodically returned for recalibration. Other instruments are checked for conformance to government specifications. Manufacturers use calibrated equipment in the development of new instruments and as standards for manufacturing.

1000-20-1003 Refrigerator Safety

Objectives: To cooperate with the National Electrical Manufacturers Association in preparing performance criteria for devices to prevent suffocation in refrigerators, home freezers, and ice boxes.

Importance of the Project: The House Committee on Interstate and Foreign Commerce requested the Bureau to work with industry in a determined effort to obtain a solution to the problem of suffocation of children trapped inside refrigerators, home freezers, and ice boxes. According to the evidence accumulated by the Committee, the problem is serious and the frequency of deaths of children due to this cause is increasing, in spite of the enactment of laws in a number of states regulating treatment and storage of refrigerators and similar equipment not in use.

Activity Summary: Active participation in this work by the Bureau was initiated in September, 1955. Since that time, the Bureau has worked with the National Electric Manufacturers Association in developing tentative performance criteria for refrigerator safety devices, and has worked with the Children's Bureau in making tests to determine the forces exerted by children in attempting to free themselves from confinement in a small enclosure. These data are required to determine a reasonable maximum value of the force that might safely be required to operate certain types of safety release mechanisms.

1000-20-1003 - continued

Plans for Fiscal Year 1956: Continue to work with the NEMA on the problem of acceptable criteria for refrigerator safety devices, and to give engineering assistance in the design, instrumentation, and conduct of such further experiments as may be required to provide information needed in the development of acceptable criteria. It is expected that this project will have a limited scope and short duration, and that the testing of proposed safety devices for conformance to the criteria will be undertaken by the Underwriters Laboratories.

1003-20-1014 Heating and Air Conditioning Equipment

Objectives: To develop test methods for heating, air conditioning, and air cleaning equipment, and to provide the data essential for developing specifications, codes, and standards for heating, refrigerating, air conditioning and associated equipment.

Importance of the Project: There is a continuing need on the part of government agencies, professional societies, and industry for the basic data essential for preparing and improving codes and standards for heating, air conditioning, refrigerating, and air cleaning equipment. The following three fields are examples of this need. A survey has shown that the Federal agencies purchased between two and three million dollars' worth of self-contained air conditioning units during 1954. All agencies recognize that the ratings applied to these units by industry are not consistently reliable. Laboratory and field tests of typical units at NBS have corroborated these conclusions. The Federal specification for self-contained air conditioning units needs revision and its use should be encouraged.

Little factual data are available about the magnitude of air leakage in residences or larger buildings. This is probably the greatest unknown factor in both heating and cooling load calculations. NBS has developed a portable infiltration meter applicable to field measurements of air leakage that could be used to develop data on air leakage as affected by type of building construction, ambient temperature, and wind velocity.

The air filter industry working in collaboration with the American Society of Heating and Air Conditioning Engineers has failed to attain agreement on standard test

1003-20-1014 - continued

methods and test dusts. NBS has conducted extensive surveys of air cleaner performance for the Public Buildings Service and remains the sole source of comprehensive comparative data on air cleaner performance.

Activity Summary: This is a continuing project. During the last year a report was completed and published on "Water Demand Rates for Electric Drinking Water Coolers"; the first draft of a manuscript on forced warm air heating in a one-story house was completed; the chapter in Codes and Standards in the ASRE Data Book was revised and brought up to date; a survey on the use of package air conditioners was planned and conducted in cooperation with the Federal Construction Council.

Plans for Fiscal Year 1956: (1) Conduct investigations in cooperation with ASHAE on the infiltration in one and two-story residences under summer and winter conditions as affected by wall construction and floor construction, (2) revise the Federal specification on self-contained air conditioners, (3) prepare a paper on the studies of panel heating in the Test Bungalow, (4) complete the paper on forced warm air heating in one-story houses.

#### 1003-20-1015 Heat Transfer Measurements

Objectives: To determine the thermal conductivity and heat transfer properties of materials and building constructions, and make calibration measurements on specimens for reference use by other laboratories; to improve apparatus and develop new methods; to furnish advisory technical information in the field of heat transfer to governmental agencies regarding design, specifications, standards and special applications.

Importance of the Project: The thermal conductivity and heat transfer measurements made in this laboratory on insulating and building materials are relied on for purposes of design, specifications and procurement by governmental agencies. They are considered by governmental agencies, private industry and technical societies as a paramount source of dependable data for guidance in this field. Governmental, industrial, university and private laboratories utilize its services for calibration of reference specimens for standardizing their equipment. The services provided in regard to measurements and



1003-20-1015 - continued

calibrations of the thermal conductivity of metals at temperatures up to 800°C appear not to be furnished by any other laboratory in the country; they have been in continuous use for the past two years by defense agencies and a few industrial laboratories. The experience of its personnel is sought on an advisory basis by an increasing number of governmental and private laboratories in regard to proposed methods and apparatus for measurements in this field.

Activity Summary: This is a continuing project. For the past three years, an annual average of eight calibrations and 74 other measurements have been made on insulating materials; in 1955, calibration measurements were made on nine metal specimens. A new method for metals, having promise for measurements from low to high temperatures, has been developed and preliminary trials of it made, preparatory to construction of an improved apparatus. A paper, "Determination of the Thermal Conductivity of Porcelain Enamels", was prepared for oral presentation, and submission to the Editorial Committee. Advisory services have been furnished to governmental agencies, and to a considerable extent to technical societies in connection with compilations of data for publication.

Plans for Fiscal Year 1956: Continue services on thermal conductivity measurements and calibration of reference specimens; construct apparatus for comparative measurements on thin specimens of materials such as rocks, ceramics, etc.; develop new apparatus for more rapid measurements on insulations, involving a new design of heat flow meter; prepare publications on accomplished phases of work.

1003-10-4831 Air Conditioning Underground Structures

Objectives: To obtain engineering data essential for proper design of heating and air conditioning systems for underground spaces or installations.

Importance of the Project: Underground installations are recognized as an important protective means for essential material, equipment, and activities in modern warfare. Certain inherent advantages may lead to their use for other than military purposes in some instances. Such installations are seldom suitable for occupancy without



heating and air conditioning systems and present design data for such systems are inadequate. There are no comprehensive publications on the subject.

Activity Summary: During the past year, observations at an experimental site were completed and the premises were vacated by our staff. The approximation method of computing rock heat absorption from underground spaces based on solution of the relevant differential equations by means of the SEAC computer, was developed to a state of practical workability and the results were checked against the experimental observations. Available literature was reviewed to gather information based on experience with underground air conditioning systems in this and foreign countries as far as possible. Existing data on properties of materials and physiological effects were gathered and considered as a basis for recommended air conditions for underground installations. A draft of a manual on air conditioning underground structures is about 60 percent complete. Copies of four of the proposed six chapters were submitted to the sponsor for comment.

Plans for Fiscal Year 1956: Observe heat transfer phenomena and performance of air conditioning equipment in one existing and one proposed underground installation; gather experimental data on the air conditioning effect of tunnels or shafts and on the heat absorbing capacity of an underground reservoir serving as a heat sink; compare the results obtained with those of an approximation method based on analysis; continue the literature survey; compile data on the thermal properties of rock; complete the draft of the manual including the results of the above work; furnish consultation service as required.

#### 1003-20-4832 Refrigeration and Field Equipment

Objectives: To develop portable and mobile refrigeration and field equipment with improved military characteristics of performance, size, and weight by improving designs, developing new methods and components, analyzing the performance of prototypes, recommending modifications in prototype equipment, revising Federal specifications, and standardizing capacities, rating conditions, and certain physical components of such equipment.

Importance of the Project: The Office of the Quartermaster General makes wide usage of portable and mobile refrigeration equipment for the preservation of food and medical supplies, transportation of food, manufacture of ice cream and for similar purposes during both war and peacetime conditions. During World War II commercial equipment was modified to meet emergency requirements in many cases. This solution was not considered adequate on a permanent basis, however, because the operating conditions were often more severe in military applications, mobility imposes special problems of durability and places a premium on small size and weight, gasoline engines are used for prime movers when an electrical distribution system is too remote, and the factors of vibration and atmospheric dust make ordinary controls inadequate in some cases. In addition, the need for stocking spare parts in remote areas of the world emphasizes the need for standardization of parts and a reduction in the number of models or sizes of units that are to be used. The preparation and revision of Federal specifications enable the military agencies to buy commercial items in some cases in a way to take full advantage of competition among many manufacturers.

Activity Summary: This is a continuing project started in 1944. During the last year a study was completed showing the effect or capacity of a complete refrigerating system of varying the speed of the compressor, condenser fan, and evaporator fan proportionally and of varying the compressor speed and the two fan speeds independently; the performance of a typical hot-gas defrosting system was analyzed in both an empty and loaded warehouse; the Federal specification on domestic refrigerators was completely revised; development of an exhaust-gas-to-refrigerant heat exchanger for warehouse heating was undertaken; the development of a complete modulating thermo-mechanical control system for a portable refrigerating system was commenced; several warehouse panels were investigated for simultaneous heat and vapor transmission characteristics; and investigation on a newly-developed inverted gasoline lantern was completed; and advice and consultation was provided on test methods for standardization of refrigeration compressors.

Plans for Fiscal Year 1956: (1) Complete the design of an exhaust-gas-to-refrigerant heat exchanger for the 1-ton warehouse unit, (2) complete the design of a modulating

thermo-mechanical control system for the 1-ton warehouse unit; (3) revise the Federal specification for commercial refrigerators; (4) evaluate the standardization procedures proposed for refrigeration compressors by testing some specimens and making recommendations for modifications of the procedures; (5) continue with the study of vapor transmission in insulated warehouse panels; (6) perform tests of prototype refrigerated trailers, refrigerating units, etc.

1003-10-4881 Insulation of Underground Pipe

Objective: To provide data on the insulating properties, water permeance, expansion characteristics, mechanical and chemical stability of insulating materials and methods for underground steam and hot water lines as a basis for the preparation of adequate specifications for such materials by Federal agencies.

Importance of the Project: Central heating plants often require extensive underground piping systems for distribution of steam or hot water to the area of usage. Such piping systems are usually insulated to reduce heat losses and to prevent rapid corrosion of the pipe as a result of chemical and electrolytic action. Some of the characteristics desired for underground pipe insulation are low thermal conductivity, low moisture permeance, high crushing strength, suitable expansion characteristics, adequate stability at temperatures ranging from below freezing to 350°F, and long life. Many types of insulation and embedment have been used in addition to various kinds of tunnel construction. The Corps of Engineers of the Department of the Army expends several million dollars each year for installations of this type and require information on the performance of such insulating materials in order to prepare adequate specifications for purchase. Their experience has indicated that not all of the materials offered as underground pipe insulation possess the important characteristics to the required degree.

Activity Summary: This is a continuing project which was started in the third quarter of fiscal 1954. Some modifications were required to the apparatus constructed for this project during fiscal 1955 to provide accurate measurements of the heat transfer from the measuring section of the insulated steam pipe. The heat loss per



1003-10-4881 - continued

unit length of a pipe insulated with 4 inches of Gilsulation was determined with dry earth surrounding the pipe and with the water table one foot below the center line of the pipe, at the center line of the pipe, and one foot above the center line of the pipe. The expansion and contraction characteristics of the material were studied under cyclic heating and cooling of the steam pipe and the polymerization of the material were studied by a chromatographic method.

A prefabricated conduit called Durant Insulated Pipe was studied in an outdoor trench to determine its insulating qualities, the softening characteristics of the asphalt covering, and whether or not the insulation could be adequately dried out either buried or above ground if it became wetted during installation. Information was obtained on the movement of water vapor in a radial direction under the influence of the temperature gradient around a hot steam pipe.

Preliminary studies have been made on the insulating qualities and water permeance of an envelope for a steam pipe made of a mixture of portland cement and granulated reclaimed rubber known as Wicor.

Plans for Fiscal Year 1956. (1) Complete investigation of thermal conductivity and heat transmission of Wicor as influenced by water table and study its resistance to moisture penetration; (2) study the characteristics of Hylag insulation consisting of a fire clay mixture surrounded by an impregnated paper tube; (3) study the characteristics of an insulating concrete called Z-crete; (4) determine the thermal insulating properties of dry and damp earth around a steam pipe and the distribution of moisture in earth under the influence of a temperature gradient.

1003-10-4882 Reflective Thermal Insulation

Objectives: This project is sponsored by the Aluminum Company of America under the NBS Research Associate Program to provide information as to the thermal insulating value of aluminum foil and reflective surfaces in various applications, either alone or in combination with other materials.

Importance of the Project: Data obtained at the National Bureau of Standards in regard to the thermal insulating

value of plane reflective air spaces have resulted in great interest on the part of insulation producers and users in its potential applications, and generated a need for additional data as to its performance in various applications. Among the questions of interest are (a) its use in combination with other insulating materials, (b) applications in conjunction with air spaces of uneven thickness, (c) the effects of air leakage and moisture in reflective air spaces, (d) the permanence of its reflective qualities, (e) experimental determination of the theoretically great value of reflective surfaces in insulating against heat flow downward from attics in summer. Information in connection with these matters is needed by the insulation industry and users to provide a sound basis for the further development of reflective insulation products and for their proper installation and use.

Plans for Fiscal Year 1956: The several items proposed for investigation are: (1) Combinations of aluminum foil and other insulations; (2) use with air spaces of uneven thickness; (3) insulating effect of reflective surfaces exposed in an attic application to radiation from a solar heated roof; (4) effect of air leakage between reflectively insulated air spaces; (5) permanence of reflectivity of aluminum foil surfaces; (6) study of moisture and condensation problems with reflective insulations; (7) effect of installation in air spaces with one side open; (8) thermal conductivity of various aluminum alloys. Priority will be given to Items 1, 2, and 3; the remainder will be dealt with as time permits. The results of the work are to be prepared for publication.

## CEMENT, CONCRETE, AND MASONRY

### 0903-20-4428 Qualities of Refractory Concretes

Objectives: To determine whether specimens of concrete that have been cured, heat-treated, and tested for Young's modulus of elasticity and flexural strength have changed structurally after exposure to the elements for a year or longer.

Importance of the Project: Refractory concretes for jet aircraft warm-up aprons have been tested for various properties to evaluate their usefulness for that purpose. In order to complete the evaluation of such concretes, it would be desirable to learn whether the bonding cement has rehydrated during weathering, thereby increasing the strength of the concrete which had been subjected to heat treatments. Because concrete aprons are subjected to heating and weathering the information gained from the tests of weathered specimens could be correlated with actual service conditions.

Activity Summary: This is a continuation of a project started in July 1951. The work includes the study of hydraulic cements and aggregates and the design and testing of concretes that might be suitable for jet aircraft aprons. During the past year, four aggregates have been used in designing 12 concretes. Each aggregate was used with three different cements. The concretes were mixed, and specimens were fabricated, cured, and tested after different curing periods and increasing heat exposures.

Plans for Fiscal Year 1956: To determine Young's modulus of elasticity by the sonic method of a wide variety of tested and weathered refractory concrete specimens and also to obtain information on their compressive strengths. Approximately four months will be required for this phase of the work, which should complete the project.

### 0906-20-0910 Physical Properties of Concreting Materials

Objectives: To provide basic information leading to a better understanding of the effects of environmental factors upon the performance of concrete and to relate the physical properties of concretes and their ingredients to performance.



Importance of the Project: Approximately \$700,000,000 worth of portland cement is used annually in the United States. By the time this cement is incorporated in concrete a several-fold increase in cost is involved. Some of this concrete fails to give satisfactory service, with a consequent large economic loss. The mechanisms responsible for several types of disintegration are partially understood, but needed is additional fundamental information on the properties of concrete and concrete aggregates, as well as additional development of techniques to measure these properties.

Activity Summary: The results of a preliminary study of the volume changes which take place in concrete during freezing and thawing were reported in the NBS Research Paper 2000. This work was done with a mercury displacement dilatometer. Tests were made at various cooling and heating rates and with concretes of various moisture contents. It is proposed to continue this type of work, using imbedded SR-4 strain gages to measure the volume changes.

Comparisons have been made of the relative resistance of various concretes when exposed to the four types of laboratory freezing and thawing cycles specified by the ASTM. This work has also involved cooperative investigations with ten other laboratories.

Approximately 200 samples of portland cement representing most of the types and sources of United States production have been subjected to all of the standard physical and chemical laboratory tests, as well as to additional special tests. Concretes from each of these cements have been subjected to wetting and drying, freezing and thawing, and other exposure tests.

Plans for Fiscal Year 1956: Recent laboratory work has demonstrated that imbedded SR-4 strain gages can be used to give the same type of information as that obtained with the mercury displacement dilatometer. Using this technique, it is proposed to chart and interpret the dimensional changes in cement paste specimens in which the following properties of the specimens are varied: (1) degree of saturation; (2) size of specimens; (3) curing of specimens; (4) casting of specimens; and in which the exposure is varied in the following respects: (a) rate of cooling and thawing; (b) extent of cooling and thawing;

0906-20-0910 - continued

(c) exposure of specimen to moisture. Measurements will continue on the exposure-test specimens, and a few additional cements may be added to the 200 which will be under test at the start of the fiscal year. Attempted will be correlations between measured properties of the cements and their concretes.

0906-10-0923 Chemical Properties of Cementing Materials

Objectives: To provide basic information leading to a better understanding of the mechanism of hardening of cement and related materials, and of the reactions attending the deterioration of these materials under various conditions of use.

Importance of the Project: Cementing materials, including portland and other cements, lime, plaster, and the aggregates employed therewith, are used in great quantities in the construction of highways, dams, and nearly all types of buildings. Portland cement production in the United States alone amounts to about 50 million tons a year. Occasionally these materials fall short of standard performance in service, and considerable economic loss results from deterioration of concrete, mortar, and plaster. In many cases the causes of failure are not entirely understood, perhaps because of imperfect knowledge of the reactions that normally occur in the hardening processes. The various cements and plasters have in common the property of reacting chemically with water, thereby hardening and developing strength. Much is already known, in an empirical way, about the relation between chemical and physical properties and performance in service, but it is increasingly evident that more fundamental knowledge is required

Activity Summary: Work on the system lime-silica-water has involved the following: (1) An extensive literature survey; (2) a study of phase equilibria in the system at 180°C; (3) a thermochemical study of reactions in lime-silica gel pastes; and (4) a study of rate of reaction between lime and silica gel in excess water. These tasks are in various stages of completion. Hydrothermal studies are being made of the formation and the composition of the hydro-garnet phase in the system lime-alumina-silica-water. A related study, in which strontia was substituted for lime, has been completed. Measurements of the surface areas of hydrated cements have been made



0906-10-0923 - continued

by water and nitrogen sorption, and the causes of the observed reduction in surface on storage are being sought. Studies of the alkali-aggregate reaction in concrete have demonstrated large volume increases and the development of considerable pressure. Microscopic studies have been of aid in observing the course of the reaction. The setting of oxychloride cements has been studied by thermo-chemical methods.

Plans for Fiscal Year 1956: (1) Completion of a literature survey on the system lime-silica-water; (2) study of phase equilibria in the system lime-silica-water at selected temperatures below 180°C; (3) completion of the thermo-chemical study of lime-silica gel pastes; (4) study of the reaction rate between lime solution and silica gels, and attempted correlation with other properties; (5) completion of hydrothermal study of the lime-alumina-silica hydrogarnets; (6) investigation of the cause of "instability" of surface of hydrated portland cement; (7) study of the effect of carbonation at different relative humidities on the surface of hydrated cement; (8) measurement of pressure developed by aggregates in cement paste, by means of cells using SR-4 strain gages; (9) microscopic study of diffusion of Na and Ca into aggregates; (10) determination of heats of formation of natural and synthetic hydrated calcium silicate.

0906-30-4415 Cement Reference Laboratory

Objectives: To standardize and improve the testing of portland cement at laboratories throughout the country.

Importance of the Project: The NBS carries on a large cement-testing program and, in connection therewith, does work on the development and refinement of test methods. The tests are somewhat empirical in nature and, for this reason, comparable test results between laboratories are obtainable only through standardization of equipment and techniques. The work of this project makes an important contribution to this need.

Activity Summary: The Cement Reference Laboratory sends qualified men, together with calibrating equipment, to cement-testing laboratories throughout the country. Upon request, these men check and calibrate cement-testing equipment, demonstrate testing methods, and observe the

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methods used in other laboratories. The laboratory also distributes cooperative test samples throughout the industry and analyzes the test results reported. It also makes contributions to test methods and apparatus and takes an active part in technical committee work.

Over 250 cement-testing laboratories take advantage of this service, and each is visited at approximately 3-year intervals.

0906-30-4433 Acceptance Testing, Cement

Objectives: To make acceptance tests on portland cement used by the various Federal agencies throughout the United States.

Importance of the Project: Most of the projects for which cement is tested are of a permanent nature (large dams, air fields, etc.) and the cement-acceptance program prevents difficulties with the concrete resulting from the use of sub-standard cement.

Activity Summary: This project has been in continuous operation for over 40 years. Currently, samples representing approximately 13 million barrels of cement per year are being tested in laboratories located in San Francisco, California; Seattle, Washington; Denver, Colorado; Allentown, Pennsylvania; and Washington, D. C.

Plans for Fiscal Year 1956: It is expected that the project will continue at substantially the same level. Some reduction in testing volume will result from a proposed statistical testing plan which is expected to go into effect during the year.

The volume of testing is somewhat seasonal. During slack periods work will also be accomplished on development of test methods, both physical and chemical, and on cooperative test programs with other laboratories.

0906-30-4444 Miscellaneous Testing

Objectives: To make tests, both acceptance and of other types, on a variety of materials, such as hardened and fresh concrete, concrete aggregates, soils (engineering

0906-30-4444 - continued

properties) bituminous aggregates, filter trickling media, floor hardeners, integral concrete admixtures, and spelters.

Importance of the Project: The information obtained from this project enables the various Federal agencies to control the quality of concrete and other materials going into Federal construction in the D. C. area. It furnishes information (on soils) required in engineering designs. It contributes to the determination of the causes of failure in performance of unsatisfactory concretes.

Activity Summary: This is a continuing project, with the major portion of the work being accomplished in the Washington D. C. laboratory, although a few tests each year are made in the Seattle and San Francisco cement-testing laboratories.

0907-10-0914 The Chemistry of Portland Cement

Objectives: To obtain fundamental data on the structures and mechanisms involved in the burning of portland cement clinker and the hardening of concrete, leading to improved understanding of these processes and ultimately to technological improvements; and to develop new experimental techniques needed in obtaining the required data.

Importance of the Project: This research project, carried on by the Portland Cement Association Fellowship since 1924, has developed a number of different types of basic information which have had great importance in cement technology. Among these are formulas of the major cement clinker constituents, their heats of hydration, and the effect of cooling rate on crystal growth in clinker. The results of those investigations now affect almost all cement manufacture.

Activity Summary: This is a continuing project. During the past year a study was initiated of phase equilibria in the system  $K_2O-Na_2O-CaO-Al_2O_3-Fe_2O_3-SiO_2$ . This complex system could be studied only through use of the high-temperature centrifuge which had previously been developed, together with the other more usual methods. The work has already given data on the whole course of crystallization of two typical clinker compositions. A knowledge of the composition of the liquid reaction zone of an actual



0907-10-0914 - continued

clinker at kiln temperatures is provided for the first time by these results.

A study of the system  $\text{CaO-C}_2\text{S-C}_{12}\text{A}_7\text{-C}_2\text{F}$  was also carried forward during the year<sup>2</sup> to establish more clearly the nature of the fourth major crystalline phase in cement clinker, which is the main iron-bearing constituent.

Further work was done with the application to X-ray structure analysis of the hot-wire apparatus previously developed for high-temperature microscopy. Diffraction data were obtained at high temperatures from single crystals of calcium hydroxide and tricalcium silicate.

Continued was the study of the hydration of calcium silicates by electron diffraction and electron microscopy, with emphasis (1) on a survey of specimens prepared by various techniques, to establish unequivocally the morphology in situ of the hydrated calcium silicates, and (2) on comparisons of the diffraction patterns with those of well-characterized compounds obtained in other ways.

Other activities, incidental to the main research programs, included contributions to the establishment of facilities for routine crystal-structure calculations on SEAC, the large NBS electronic computer, and publication of the review articles "Cement" (Encyclopedia Americana, 1955 Revision, vol. 6, pp.188-91) and "The Calcium Silicate Hydrates" (International Congress of Industrial Chemistry, Brussels; September, 1954), by R. H. Bogue.

#### 1001-10-1000 Masonry and Reinforced Concrete

Objectives: To secure basic data in the laboratory on the strength, behavior under load, elastic properties and durability of masonry, concrete, reinforced concrete, natural building stone, brick, concrete masonry units, masonry mortars, and lightweight concretes.

Importance of the Project: Data on properties of masonry and reinforced concrete are needed as a means of establishing satisfactory specifications and code requirements for various service conditions and for effecting economies. In order to predict durability of brick and stone under various conditions of weathering, there is need for correlating various physical properties determined in the

laboratory with results of outdoor exposure tests. In order to improve design practices and conserve steel, it is necessary to study the behavior of reinforced concrete structural members under load with respect to their strength, stiffness, elastic properties, and modes of failure. Collaborative work with the Fellowships of the American Iron and Steel Institute and Masonry Research is needed to provide information on methods of controlling widths of cracks in reinforced concrete beams and on structural properties of masonry and masonry components.

Activity Summary: This is a continuing project. During the past year one phase of the study of factors affecting the width and spacing of tensile cracks in reinforced concrete beams and slabs was completed and a paper presenting the results was prepared. The paper presents an empirical expression which will enable designing engineers to estimate widths of tensile cracks in beams and slabs. The study of properties of lightweight concretes containing large percentages of entrained air instead of aggregate was completed and the results were published. The study also included a comprehensive survey of foreign and domestic literature on this subject. Work is continuing with studies of durability of building stone. The study of properties of a large number of commercial portland masonry cements was completed and work was started to determine their bond strength with masonry units.

Plans for Fiscal Year 1956: (1) Width of Cracks in Reinforced Concrete Beams: Determine the effect of strength of concrete on the width and spacing of tensile cracks in collaboration with American Iron and Steel Institute Fellowship. (2) Shear Strength of Reinforced Concrete Beams: Continue the study of distribution of strain in portions of beams resisting shear for the purpose of determining the mechanism of failure by diagonal tension in beams having no web reinforcement. Preliminary results indicate a nonlinear strain distribution not previously reported in the literature. (3) Durability of Brick and Stone: Continue periodic examinations of stone exposure test wall and analyze observations from long-term masonry exposure tests. (4) Properties of Masonry: Determine bond strengths of masonry assemblages containing portland masonry cement mortars in collaboration with Masonry Research Fellowship. (5) Mechanism of Failure by Freezing and Thawing: Determine by means of mercury dilatometer and bonded wire strain gages the length changes occurring in masonry during freezing and thawing with the view of studying the mechanism of failure by freezing and thawing.

1001-10-4811 Precast Thin-Shell Concrete Structures

Objectives: To evaluate and develop prototype design of thin-shell precast and prestressed concrete elements and structures.

Importance of the Project: Precast thin-shell ribbed panels and hollow-section framing members are a relatively new type of construction, particularly those containing prestressed reinforcement. Buildings making use of structural members of this type are being planned at present by the Bureau of Yards and Docks and technical data are urgently needed on such design aspects as the cross-section of the members, orientation and amount of reinforcement, elastic stability, adequacy of watertightness and resistance to fire.

Activity Summary: This is a continuing project which was started in 1953. During the past fiscal year extensive work was performed to determine the load-carrying capacities and other properties of a variety of prestressed and nonprestressed thin-shell roof panels, and panel frames assembled by means of bolted and welded connections. An evaluation of two box girders with welded splices indicated that the addition of a trifling amount of web reinforcement near the splices increased their resistance to shear by about 50 percent. A number of slabs consisting of hollow concrete cells assembled in a checker-board fashion and suitably prestressed in two directions were studied with a view toward their utilization in floating structures. The NBS was called upon to devise the casting technique and to produce cellular concrete blocks suitable for the prestressed assemblies.

Plans for Fiscal Year 1956: (1) Further Evaluation of Prestressed Cellular Assemblies: Prestressed slabs consisting of cellular concrete blocks, with grouted and mortarless joints are to be studied with regard to their stiffness, flexural strength, resistance to shear, and loss of prestress with time. (2) Watertightness of Joints Between Precast Elements: An experimental structure, about 12 by 30 ft to be erected on Bureau grounds will provide several bolted joints which will be filled with different joint fillers and mastics to determine their suitability in a long-term watertightness test. (3) Behavior of Thin-Shell Structures Under Sustained Loads: Observations will be continued on several thin-shell precast roof panels placed under test to determine their plastic behavior under sustained loads.



1001-10-4812 Stresses in Masonry

Objectives: To determine by means of tests of small-scale models and by approximate theoretical analysis the directions and relative magnitudes of stresses in masonry walls which are restrained from shortening at the foundation level while undergoing drying shrinkage or thermal contraction.

Importance of the Project: The widespread cracking of walls of concrete masonry has necessitated large expenditures for repair. Both the results of tests conducted in laboratories and of extensive experience with structures indicate that the drying shrinkage is responsible for much of the cracking observed. Despite the widespread interest in this problem, the literature contains no method by which engineers can estimate the minimum spacing of control joints and the least amount, the location, and the form of reinforcement that would be most effective in minimizing objectionable cracking under various conditions.

Activity Summary: This is a continuing project which was initiated in 1953. A second progress report submitted to Sponsors during the past year described the development of the general elastic theory for stresses in a restrained wall undergoing shrinkage and presented numerical solutions for certain special cases of this problem. The numerical solutions were obtained for a wall having a length of twice its height. The theoretical results were compared with experimental data obtained with several plaster of paris and concrete models.

Plans for Fiscal Year 1956: (1) Theoretical Work: Stresses will be computed for walls in which the length and height are equal and in which the length is four times the height. These solutions are to be obtained on the assumption that the foundation is sufficiently rigid to prevent all shortening along the line of attachment. (2) Experimental Work: Further experimental work is underway with models of concrete containing internal strain gages to determine strains in walls undergoing actual shrinkage. These models will also be subjected to load tests to determine to what extent the load tests simulate the state of strain produced by actual shrinkage.

1001-40-4813 Control of Leakage Through Cast-Stone  
Panel Masonry

Objectives: To determine a method of controlling leakage of wind-driven rain through walls of cast concrete panels.

Importance of the Project: Thermal and moisture length changes in exposed aggregate cast concrete panels used as facing in one particular Government building have resulted in leakage of wind-driven rain through the joints between panels. In an effort to find a remedy for this problem, the Bureau of Yards and Docks requested the NBS to undertake a study of the movement of the joints and to determine means of controlling the leakage through the joints in this structure. This problem is encountered commonly in monumental buildings faced with large cast stone panels.

Activity Summary: This project was started in May 1954. During the past year, the movements of the vertical joints between cast-stone panels were measured periodically to determine the effect of moisture as well as seasonal temperature changes. The measurements covered periods before and after treatment of the panels and grouting of the joints carried out according to specifications prepared by the NBS. Laboratory tests of the properties of the original cast-stone have been completed. Fifty samples of calking materials were procured and their suitability for use with cast-stone masonry is being determined. As no cast-stone specimens were available for the tests of calking materials, a large number of suitable specimens of cast-stone had to be prepared in the NBS laboratories.

1001-10-4814 Design Stresses in Reinforcement

Objectives: To provide basic data needed for determining proper design tensile stresses in concrete reinforcement of different physical properties.

Importance of the Project: For the national welfare, it is obviously desirable that allowable design stresses be as liberal as is compatible with reasonable safety and satisfactory performance of reinforced concrete structures. Test data indicate that the resisting bending moments of beams failing by yielding of reinforcement are a linear function of the yield strength of the reinforcement. If failures by yielding of the reinforcement were the only manner of failure possible, immediate increases in



allowable design tensile stresses would be warranted for some types of reinforcement. Unfortunately, there are other possible causes of failure and of unsatisfactory performance, and their probability often is not predictable. Test data are needed to enable designing engineers to predict loads causing diagonal tension failures, deflections, widths of cracks, and bond strengths when the reinforcement is subjected to unusually high tensile stresses.

Plans for Fiscal Year 1956: (1) Flexural Strength of Beams:

Determine the effect of yield strength and stress-strain characteristics of concrete reinforcement of six different types on the resisting moments and manner of failure of beams having reinforcement of the same total yield strength. (2) Strength of Beams in Shear: Repeat the above with beams designed to fail in diagonal tension to determine the effect of increased steel stresses on the shearing strengths of beams having no web reinforcement. (3) Prepare report on results of the study suitable for publication.

## CODES AND SPECIFICATIONS

### 0501-30-0501 Preparation of Specifications and Standards for Paints, Varnishes, Lacquers, and Component Materials

Objectives: To provide Federal Specifications for organic coating materials and for the products used in their formulation. Also, to participate in the development of standards for similar materials by ASTM and ISO.

Importance of the Project: The competitive bidding system under which most Government paint purchases are made depends for its success on the availability of documents that provide accurate and adequate descriptions of the products purchased. Specifications furnish such a basis for mutual understanding between the industrial supplier and the Government buyer. Government procurement agencies, notably the General Services Administration, have long depended on the Bureau to assist them in the technical aspects of specification writing. Participation in the standardizing activities of technical societies provides an opportunity to keep abreast of developments in this area and to utilize them to best advantage in the Federal program.

Activity Summary: The Bureau has been responsible for the development of paint procurement specifications for many years. During fiscal year 1954, specifications for brushing lacquer and alkyd flat wall paint were drafted and submitted to GSA for issuance as interim documents. A substantial number of specifications prepared by others under the "assigned agency" system were reviewed and comments submitted. The international program on standardization of shellac was continued in addition to the ASTM project on phthalocyanine blue pigments of the non-crystallizing, non-flocculating type.

Plans for Fiscal Year 1956: (1) Incorporate departmental comments, when received, in interim specifications for brushing lacquer and alkyd flat wall paint to complete these assignments; (2) undertake preparation of new specification to cover polyvinyl acetate emulsion paints and revise other specifications to bring them up to date. (3) continue active cooperation in ASTM and ISO activities.

Objectives: To assist in the preparation of safety and construction standards either by serving as a sponsor or by furnishing technical service to committees under the sponsorship of other technical or scientific organizations.

Importance of the Project: Uniformity of safety and construction standards is of the utmost importance to industry and to the public. If every city and state were to prepare different requirements, mass production of such items as elevators, crane hoists and derricks, would not be possible. Each piece of equipment would have to be designed and built to meet local laws and ordinances. The common use of standards and data by all organizations in the field has the effect of gradually reducing unnecessary differences in technical safety requirements and of producing uniformity where that is practicable and desirable. The Section cooperates in efforts to bring about greater uniformity on a voluntary basis, recognizing that there are some local conditions that justify differences in safety requirements.

Activity Summary: In addition to the preparation of standards, the Section is called upon for information and advice in connection with the activities of numerous bodies engaged in work on building and plumbing codes, including New York State Building Code Commission, the Joint Committee on Building Codes, the Building Officials Conference of America, and the Coordinating Committee for a National Plumbing Code.

During the current year, active work has been carried on in connection with: (1) a complete revision of the Elevator Code, which is now awaiting ASA approval; (2) revision of the Code for Lightning Protection which has been completed; (3) the work of revising Part 2 of the National Electrical Safety Code on which considerable progress has been made; (4) the revision of the Code for the Protection of Heads, Eyes, and Respiratory Organs which has been brought almost to the point of completion; (5) a study of wind pressures on buildings which has been carried on with special consideration to maximum values that may be expected in various geographical locations; (6) a revision of the Manual of Fire-Loss Prevention of the Federal Fire Council, which has been completed; and (7) The National Plumbing Code on which considerable work has been done.

Plans for Fiscal Year 1956: Work will be started on the Elevator 'Inspectors' Manual, a companion volume to the Elevator Code. As it refers to the Code, it could not be started until that work was completed. The Code for the Protection of Heads, Eyes, and Respiratory Organs will be completed and prepared for printing after approval of the sponsors and the ASA. Work on Part 2 of the National Electrical Safety Code, Overhead and Underground Transmission Lines, will be pushed to completion and work on Parts 1, 3, and 4 will be started. Code on Radio Installations (formerly Part 5 of the National Electrical Safety Code) will be undertaken. Development of requirements for design loads for buildings and for other structures, including tall towers, will be continued. Coordination of requirements of building codes (in cooperation with the Joint Committee of Building Codes) will be continued. A report will be prepared on combustible loads in buildings. Studies of flow through horizontal runs of soil pipe will be made to supply data for use in connection with the National Plumbing Code.



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to prepare reference tables and papers for information on the fire hazard presented by storage of combustible materials under various conditions. (3) Fabric flammability: Review methods currently being proposed for fire retardant treatment of fabrics and perform an investigation of the effectiveness of such treatment methods to show relative merit. (4) Preparation of Papers: The preparation of technical papers on work previously completed will be continued. Important subjects, papers on which are expected to be completed in 1956, include: burnout studies of buildings and rooms, the radiant panel flame spread test method, and method of studying the ignition characteristics of materials by means of the adiabatic furnace.

1002-30-4824 Marine Material 1954

Objectives: To obtain data on the constructional features and evaluate operating behavior of equipment and materials requiring Coast Guard approval for marine use (confined to work authorized in fiscal year 1954).

Importance of the Project: The Sponsor is charged with the maintenance of safety aboard United States vessels. Because of this responsibility it is necessary to perform examinations and tests on new devices and materials as well as studies on parts which have shown poor behavior in service. Because of the diversity of types of examination and testing procedures required, it has been considered necessary to have the work performed at the NBS.

Activity Summary: About sixty percent of the work authorized was completed in fiscal year 1954. The remainder consisting mainly of the development of a new photometric test method has shown good progress during the past year but because of certain procurement difficulties and pressure of other work, is not expected to be completed this year. This project was superseded by project 1002-30-4827 Marine Material 1955.

Plans for Fiscal Year 1956: The small amount of work remaining to be done on this project will be completed and a report submitted to the Sponsor.

1002-30-4827 Marine Material 1955

Objectives: To obtain data on the constructional features and evaluate operating behavior of equipment and materials requiring Coast Guard approval for marine use (confined to work authorized in fiscal year 1955).

Importance of the Project: The Sponsor is charged with the maintenance of safety aboard United States vessels. Because of this responsibility it is necessary to perform examinations and tests on new devices and materials as well as studies on parts which have shown poor behavior in service. Because of the diversity of types of examination and testing procedures required, it has been considered necessary to have the work performed at the NBS.

Activity Summary: Most of the work authorized in fiscal year 1955 is expected to have been completed and reported to the Sponsor during the year. It is, however, expected that a small amount of work will remain to be completed in 1956. This is caused by the nature of the authorized studies and authorization of work late in the year.

Plans for Fiscal Year 1956: Work remaining uncompleted at the beginning of the year will be finished and reported to the Sponsor. A new project 1002-30-4829 will cover work authorized by the Sponsor in 1956.

1002-30-4829 Marine Material 1956

Objectives: To obtain data on the constructional features and evaluate operating behavior of equipment and materials requiring Coast Guard approval for marine use (confined to work authorized in fiscal year 1956).

Importance of the Project: The Sponsor is charged with the maintenance of safety aboard United States vessels. Because of this responsibility it is necessary to perform examinations and tests on new devices and materials as well as studies on parts which have shown poor behavior in service. Because of the diversity of types of examination and testing procedures required, it has been considered necessary to have the work performed at the NBS.

Activity Summary: Not applicable.

Plans for Fiscal Year 1956: Examinations, performance tests, and development of new test procedures will be performed as requested by the Sponsor.



1002-30-4871 Flame Spread of Interior Finishes

Objectives: To secure data on the flame spread behavior of a large variety of interior wall finishes.

Importance of Project: In specifications of wall finishes for buildings it is desirable to have information on the flame spread behavior of materials considered. Because of the previous lack of a simple method of test of this fire characteristic of materials no comprehensive study of this type has been completed. The completion of development of the radiant panel flame spread test method has now made this study possible. Results obtained from this study will be used as the basis for specification of types of interior finishes of Defense Department buildings.

Activity Summary: This is a new project designed to supplement the information previously obtained on flame spread behavior of materials. Previous work has been described in the papers: "Evaluation of Flame Spread and Vapor Permeability Properties of Interior Finishes" and "Radiant Panel Test for Flame Spread", October issue of Technical News Bulletin.

Plans for Fiscal Year 1956: The work to be done is essentially an evaluation study of the behavior of standard finish materials. Two main classes of finishes will be studied:

I. Coatings

These will be considered in two groups. First the liquid coatings which include paints and varnishes and secondly, films or sheets such as linoleum wall coverings, papers, metal foils, plastic films. All of these will be tested as applied to four base materials; fiberboard, plywood, gypsum board, and asbestos cement board.

II. Panels

This class of materials will be tested in the thickness supplied (presumably greater than 1/8 in.). Included here are; plastics, coated metals, building finish boards, vapor barrier materials as furnished on various semirigid insulation materials.

A report will be prepared describing the results of the investigation.



1002-30-4871 - continued

Plans for Fiscal Year 1957: It is expected that the described study will be completed within the fiscal year. However, results of the study may make it desirable to continue certain phases of the study in FY 1957.

1002-10-4872 Fire Resistance of Reinforced Concrete

Objectives: To provide basic information on the factors affecting the fire endurance of reinforced concrete constructions.

Importance of the Project: In 1953, fire resistance tests were performed for the Corps of Engineers on specimens involving use of a reinforced concrete beam associated with concrete channel slabs forming a roof deck. The fire endurance of these specimens was much less than that anticipated by the designers. Because of this the NBS has initiated a theoretical study of performance of monolithic structures. Such calculations are at best, however, only approximate indicators of fire endurance performance. The work proposed is intended as a check on the applicability of the theoretical calculations and also for the purpose of developing basic fire endurance data to be used for design purposes.

Activity Summary: This study was actually started about a year ago on NBS funds with the construction of four monolithic beams having varying amounts of cover or protection over the steel reinforcing rods. These specimens have been conditioning prior to test.

Plans for Fiscal Year 1956: 1. Perform fire resistance tests on one or two beams presently being conditioned. 2. Complete theoretical analysis of the scaling relationships of beams and prepare report on same.

Plans for Fiscal Year 1957: 1. Perform fire resistance tests on two or three specimens remaining from FY 1956. This study should result in information on the effect of concrete cover on the fire endurance performance of such specimens. It will also provide some of the necessary information for correlation with the theoretical analysis already completed. 2. Prepare and fire test two additional specimens similar to one of those studies under 1. These will be tested after short

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conditioning periods for the purpose of determining the effect of improper curing procedures on fire endurance.

3. Prepare a series of specimens for the purpose of determining the effect of size of beam (scale size) on fire endurance.

## PLUMBING AND FLUID MECHANICS

0603-10-0618 Fluid Mechanics Research

Objectives: To provide basic information on the mechanics of flow of water and air.

Importance of the Project: In nearly every phase of technology problems arise in connection with the flow of fluids or movement of bodies through them. Solutions to these problems mean better performance of equipment, new means of accomplishing some objective, or more reliable means of calculating performance. The problems arise mainly through ignorance of the basic mechanisms connecting the physical properties of the fluid and the forces which induce flow both in the body of a fluid and in the neighborhood of boundaries. This project is devoted primarily to the investigation of such fundamental processes where, by the very nature of the problem, long-term continuity of effort is required, or where a line of investigation must be pursued before phenomena are sufficiently well understood to see the scope and promise of the undertaking. The latter provides the means whereby originality of thought and method are directed toward devising new methods of attack and the discovery of new phenomena.

Activity Summary: During the past year progress was made in studies of the initial characteristics of density currents flowing from a canal lock; on the analysis of data on the form of the surface of reservoirs in severe wind storms; and on saline intrusion in sand beds. Some preliminary studies were made of the possibilities of obtaining coexisting laminar and turbulent flow near grooved surfaces, the object being to determine the possibilities of reducing skin friction by this means.

Plans for Fiscal Year 1956: It is anticipated that work will be done on the following problems: (1) initial characteristics of density-current flow from a canal lock, complete analysis and write paper; (2) action of severe wind storms on the form of the surface of a reservoir, complete analyses of data; (3) coexistence of laminar and turbulent flow near grooved surfaces, produce groove-walled pipe and make measurements using air; (4) flow visualization techniques as may be applied in water, study of methods, application and analysis to learn what types of information can be derived about turbulent motions.

Objectives: To develop culvert inlet designs of greater hydraulic efficiency than those currently used and to determine the hydraulic characteristics of the more common types of non-rectangular culverts now being used.

Importance of the Project: The sponsor of the project estimates that approximately 12% of the costs of multi-lane highway construction, amounting to several hundred million dollars per year, is required for culvert installations. These high costs of modern culverts exert substantial economic pressure upon the sponsoring agency to develop culvert design methods of increased hydraulic precision, both with regard to the design runoff and to the ability of the culvert to economically discharge the design runoff. The research program of the sponsoring agency, in regard to the hydraulics of culverts, is therefore aimed at the dual problem of (1) developing means, by consideration of hydrological and meteorological data, to increase the precision of estimating the peak runoff of drainage areas and (2) developing methods of increasing the ability of economically sized culverts to discharge these peak runoffs, particularly on supercritical slopes.

Activity Summary: This project was started in July 1954. A substantial portion of the year was required to construct the experimental apparatus. This has consisted of the design and construction of a 50-foot adjustable slope (0 to 10%) channel in which model lucite culvert designs, of barrel diameter 5.5 inches, are tested and an installation in the 12-foot flume of the laboratory where 12 and 30-inch diameter models are to be installed. The 50-foot variable slope installation has been completed and experimental work has been underway for some months. The installation in the 12-foot flume is approaching completion.

Experimental work during the past year has been confined to short smooth culverts with a variety of inlet designs. Experimental work so far completed has shown that the regime of flow in the culvert and therefore its hydraulic efficiency is greatly influenced by upstream approach conditions to the culvert entrance.

These experimental observations in the 50-foot variable slope channel have indicated that the results of previous investigations of small culvert models with narrow approach channels must be used with caution in



0603-10-3586 - continued

predicting flow regime in full-sized culverts with natural approach channels and have led to an expansion of the proposed work to be done at the larger model sizes in the 12-foot flume.

Plans for Fiscal Year 1956: (1) To determine the location of the pressure line at the outlet of circular and pipe arch culverts for a variety of outlet conditions. (2) To determine the effect of barrel length, slope and roughness on the flow regime in circular culverts for a limited number of conventional inlet designs. (3) To develop one or more inlet designs which will permit culverts, particularly those on high supercritical slopes, to flow full with consequent greater discharge when the entrance is submerged. (4) To determine the model law for transferring data from the small scale model tests to the prototype under natural conditions.

0804-10-0815 Mechanism of Corrosion Processes

Objectives: To determine the nature, mechanism and rates of the corrosion of metals by different processes in various corrosive media and environments.

Importance of the Project: Corrosion costs billions of dollars annually through the destruction of metal and the necessary replacement of parts. Corrosion is not a simple process and little is known of the fundamentals of its operation. It may occur as a simple general overall attack, as very deep local pitting, by a combination of stress and corrosion or in other ways possibly closely related or interconnected. When the fundamental nature of corrosive attack is understood, effective means to prevent it can be undertaken with considerable savings to the national economy.

Activity Summary: During the year, (A) the relative orientations of crystals adjacent to intercrystalline stress corrosion cracks were determined, and the similarities and differences of stress corrosion cracking in alpha and beta brasses have been studied, with a view to proposing a theory of the process which may be satisfactory for both materials. (B) It has been established that monocrystalline aluminum is corroded by certain acids and alkalies in accordance with regular patterns, the pattern varying with the corrosive agent and the rate of

corrosion varying with the crystallographic orientation of the exposed surface and with the corrodent. (C) For the past two years considerable attention has been paid to the effect of current and its measurement in galvanic corrosion. Two papers, on geometric factors and on measurement of corrosion rates from the polarizing characteristics of metals, were issued during the last year. The effect of carbon content and heat treatment of steels on the corrosion rates were studied.

Plans for Fiscal Year 1956: (A) Complete metallographic studies of initiation of stress corrosion cracking in brasses; continue studies of stress corrosion of decarburized steels and of steels in metal vapors at high temperatures; continue studies of stress corrosion of cast and wrought magnesium alloys. (B) Analyze data already obtained on pitting of monocrystalline aluminum; study the effect of surface films, lattice distortions and irregularities, etc., on the pitting of monocrystalline aluminum. (C) Study the effect of conductivity of electrolyte on corrosion of steels; study the pitting rates and polarization of iron containing from 0.5 to 25.0 percent of chromium with and without other alloying elements.

## PROPERTIES OF MATERIALS

### 0302-10-0303 Calorimetric Measurements

Objectives: To develop and maintain calorimetric standards used in measurements of heat capacities, heats of transitions, and heats of reactions. Also, to determine the thermal properties of selected pure substances of importance in thermodynamics; to use calorimetric measurements to determine chemical purities of very pure materials.

Importance of the Project: Calorimetric standards make it possible for laboratories to make accurate calorimetric measurements by a "comparison" method with the minimum of effort. The importance of these standards has been pointed out in recent years by the efforts of Calorimetry Conferences (U.S.) which have asked NBS help in developing heat capacity standards in addition to the existing heat of combustion standards. As a result of the unique facilities of the NBS which encourage the highest accuracy in measurements, the NBS is frequently asked to make calorimetric measurements on pure materials for which very accurate thermodynamic data are urgently needed to resolve differences in existing data. Accurate calorimetric measurements also are used to evaluate the chemical purity of very pure materials, thereby serving as an independent check on chemical and spectroscopic methods.

Activity Summary: The adiabatic calorimeter for heat capacity measurements up to 500° C has been completed, and measurements on the empty calorimeter are under way. This calorimeter incorporates many novel features for minimizing errors and manpower needs while maintaining an accuracy of about 0.1%. The use of numerous electronic devices for automatically regulating and recording temperatures, together with an electronic integrator which gives the total heat leak for an experiment, has made it possible for one person to operate the apparatus. Using this calorimeter, the upper temperature limit of adiabatic calorimetry will be extended from 100° to 500° C. Design has been completed and construction started on a new "drop" calorimeter which will extend the temperature range using this method from 900° C to 1500° C. For measuring very small heats of reaction or solution near room temperature, a new type of calorimeter has been accurately calibrated. In the study of liquid-vapor phase equilibria of nitrogen and oxygen and their mixtures, the results of measurements of compositions, pressures, and surface tensions have been



0302-10-0303 - continued

calculated and prepared for publication. A preliminary study has been made of the design of a calorimeter for measuring heat capacities of gases up to 300° C. In conjunction with the NBS titanium project, chemical purity determinations were made on several samples of very pure titanium chloride and bromide.

0507-20-0532 Utilization of Fuel Gases

Objectives: To conduct research on fuel gases and gas-burning appliances, their use and control.

Importance of the Project: Since 1910, NBS research on methods of testing gases to determine their useful properties and on the design, adjustment and use of gas-burning appliances has been the basis of many State Public Utility regulations, a large part of the American Gas Association's appliance approval of program, and of various safety codes. A continuation of the work is needed to meet the needs of government, industry, and public for standards and technical guidance in this field.

Activity Summary: Work on the project has been devoted largely to a study of the factors affecting the accuracy of recording gas calorimeters. A publication giving the results of the work is in preparation. Limited work has been done on several other subjects including plans for the supply, in cooperation with the gas industry, of gases of standard heating value for calibrating calorimeters, and safety codes (National and District of Columbia) involving fuel gases.

Plans for Fiscal Year 1956: Plans include the completion of publication on recording calorimeters, revision of the gas code of the District of Columbia, the completion of plans for the distribution, probably by the American Gas Association, of gases to be used as heating value standards with NBS cooperation in their standardization, and the tentative revision of "Standards for Gas Service," the basis of most of the official State regulations on this subject.

0702-10-0731 Research on Properties of Textiles

Objectives: To provide basic information on the properties of textiles; in particular, on the effects of corrosive atmospheres, elevated temperatures, and high energy radiation on textiles.



Importance of the Project: Loss of strength and color changes in textiles are often attributed to atmospheric contaminants such as dinitrogen tetroxide and sulfur dioxide, but the chemical and physical effects of exposures to low concentrations of these gases in air of controlled humidity and temperature have not been thoroughly investigated. The results of such an investigation should serve as a basis for selecting textiles for specific uses and for developing protective treatments for textiles. As wet-dry regions occur frequently on textiles during processing and use, a more complete understanding of "interface" degradation is of practical as well as of theoretical importance. Because of the highly oriented structures and relatively high ratio of surface area to volume shown by textile fibers, the effects of radiation on these fibers may differ somewhat from those of the same polymers in bulk or film form. A study of the effects of high energy radiation on textile fibers may, therefore, open up new ways of modifying natural and synthetic fibers to obtain improved properties.

Activity Summary: During the past year, a number of cellulosic fabrics were exposed at room temperature for periods of time ranging from 0.5 to 12 hours to air of 45 percent relative humidity and dinitrogen tetroxide contents ranging from 0.1 percent to 0.6 percent by volume. Fabrics of the morphologically diverse fibers cotton, ramie, and commercially deacetylated acetate, were found to retain essentially the same percentage of their initial strengths under identical conditions of exposure. They retained a lower percentage of their initial strengths than purified viscose rayon fabrics. Five components were isolated by means of paper chromatography from the brown-line material formed at a wet-dry interface on purified cotton fabric. Attempts to identify these components by chemical methods were unsuccessful. A representative selection of textile fibers was exposed to gamma and neutron irradiation in the nuclear reactor at North Carolina State College. A similar set of samples was exposed to beta radiation by the Army Quartermaster Research and Development Command. Stress-strain measurements are now in progress on the original and on the irradiated fibers.

Plans for Fiscal Year 1956: (1) Prepare a manuscript describing the results of the work on dinitrogen tetroxide resistance of cellulosic textiles. (2) Determine resistance of cottons and rayons to air of specified temperature, relative humidity, dinitrogen tetroxide, and hydrogen chloride content. (3) By means of infrared

0702-10-0731 - continued

spectrophotometry, follow oxidation of cotton and of rayons containing different properties of "skin" as a function of time and temperature. (4) Obtain infrared absorption spectra of the 5 components isolated from the "brown-line" material by means of paper chromatography. (5) Determine stress-strain behavior and other properties of textile fibers before and after irradiation.

0707-10-0733 Research on Properties of Plastics

Objectives: To provide basic information on the properties of plastics; in particular, the degradation mechanism of polyvinyl chloride, the effect of atomic irradiation and atomic gases on plastics and the fracture behavior of plastics.

Importance of the Project: The multi-billion dollar plastics industry has produced a multitude of new materials. Basic information on the properties of these materials is necessary for their development and improvement. Studies of basic mechanisms, such as those involved in degradation, fracture, and resistance to nuclear irradiation, and the relationships between the chemical structure and physical properties of the materials are providing information that is helpful in the selection and utilization of these materials to meet specific military and industrial needs.

Activity Summary: Mass spectrometric data of the gases evolved and infrared spectrophotometric patterns of changes in chemical structure during degradative treatments of polyvinyl chloride were obtained. Some difficulty has been encountered in interpreting this information, particularly the mass spectrometric data. Irradiation of plastic materials with beta, gamma, and nuclear radiation has shown that future studies can best be made with beta and gamma radiations, using a Van der Graaf generator and Cobalt-60 for the respective sources. Exposure of plastic materials in an atomic pile has been terminated. The radiation work is confined currently to irradiation of films with subsequent study of chemical and physical properties of the irradiated materials. Preliminary experiments indicate that further study of the attack of atomic gases on plastic materials will be profitable. A study of changes in fracture patterns with change in molecular weight of polymethyl methacrylate was completed and reported.

0707-10-0733 - continued

Plans for Fiscal Year 1956: (1) Study the changes in chemical structure and physical properties of plastics when bombarded by atomic gases and beta and gamma radiations. (2) Complete the investigation of the degradation mechanism of polyvinyl chloride. (3) Study fracture mechanism in various plastics.

0901-10-0942 The Mechanism of Plasticity

Objectives: To obtain a scientific understanding of the physical and chemical properties of matter determining plastic behavior. Involved is a fundamental explanation of plasticity and a method for its measurement.

Importance of the Project: Clay-water systems, partially because of their plastic nature, are the most widely used of all raw materials in the making of ceramic objects (approximately 2 billion dollars<sup>0</sup> worth of ceramic products are produced annually in this country). The so-called "plastic materials" are distinctly different in their behavior from viscous substances, and a scientific understanding of what plastic behavior is, and of the properties of matter determining, controlling, and measuring it, has not yet been developed. This is one phase of the broad field of rheology. So long as objects were formed from plastic materials by manual operations, a basic knowledge of plasticity was scientifically interesting but not a necessity. Now, however, with the increasing use of automatically controlled mechanical devices, it is imperative that this knowledge be developed. Mechanization of the ceramic industry is dependent upon the "workability" of clay, which in turn results from the application of plasticity. Furthermore, this dependence will become more acute, and scientific knowledge a virtual necessity, as the natural resources of the most desirable clays are exhausted; and scientific information will be required to so treat lower-quality clays that their plasticity will supply the desired workability.

Plans for Fiscal Year 1956: (1) By electro dialysis, adsorbed ions on clay as found in nature will be removed and replaced at will with certain ions known to influence plastic behavior. (2) By this means, the nature of the surface will be controlled, and the research will resolve itself into two tasks--(a) the investigation of particle shape and surface area; (b) the development or adaptation of a device for relating surface area and surface properties to a numerical evaluation of plasticity.



0901-10-4400 Properties of Ceramics at  
Elevated Temperatures

Objectives: To obtain fundamental information on properties of certain ceramic materials.

Importance of the Project: The data are used in the AEC program for reactor design, and the emphasis of the program is reviewed each year to meet both current and future needs.

Activity Summary: This is a continuing program in the sense that the ultimate objectives remain the same. However, certain phases have been completed. One of these is the study of the system  $\text{Be}_2\text{C-UC-UC}_2$ ; the results appeared as NBS R.P. 2584. Another is a bibliography of solid-state reactions of the uranium oxides, NBS Circular 535. Another paper, on high temperature reactions of  $\text{UO}_2$  with various metal oxides, has been submitted for editorial reading.

Plans for Fiscal Year 1956: The program consists of two tasks. The first is a study to develop optimum mechanical properties in pure  $\text{UO}_2$  and  $\text{ThO}_2$ , to establish values for these properties at elevated temperatures, and to ascertain the factors and the mechanism involved in the determination of the properties. The second is a further determination, at elevated temperatures, of the elastic properties and other engineering data on 35 materials.

0903-20-0903 Physical Properties of Refractory  
Materials

Objectives: To investigate the physical properties of refractory materials for the purpose of obtaining data that will be useful in revising existing standards, including Federal Specifications, or forming the basis for the technical requirements of new specifications for such materials.

Importance of the Project: New refractory products are continually being developed by industry, improvements made in existing ones, and new applications found for these products. In order to keep abreast of such developments, both from the standpoint of current Federal Specifications and the inauguration of new ones, a knowledge of the properties of the products under service conditions is highly desirable. There is a dearth of information on the properties of refractory castables, and the Bureau is in a unique position to obtain this information. Furthermore, there is a lack of information on the relative volatility of the fluxes present in alumina-silica refractories and



0903-20-0903 - continued

the effect of such volatilization at high temperatures on the properties and mineralogical changes of such materials. Conversely, information is necessary on the relative rate of absorption of different alkalis by the refractory at high temperature. Investigation in this field should supply information which will clarify previously unexplained phenomena. This clarification will be of considerable value to the consumer of refractory materials.

Activity Summary: This is a continuing project covering the type of materials which constitute over 90 percent of those used industrially. During the past year a large number of specimens of refractory castables have been prepared and cured. Young's modulus of elasticity by the sonic method has been determined to establish uniformity of the specimens and thermal length changes measured from 20° to about 1300° C.

Plans for Fiscal Year 1956: Study of the physical properties of the refractory castables will be continued. This will include thermal expansion or contraction during heating, the elastic and strength properties in flexure at several different temperatures, and the effect on those properties of preheating the specimens at selected elevated temperatures. Undertaken will be a new task relating to chemical reactions occurring in silico-alumina refractory materials heated at high temperatures. Attempts will be made to collect fractions of volatilized fluxes at consecutively higher temperatures and identify them. The refractory will also be subjected to high-velocity gas flames, and the loss of the fluxes will be measured by means of spectrochemical analyses.

0907-10-0917 Properties of Crystalline Solids

Objectives: To study the effect of changes of chemical composition on the stability and thermodynamic properties of inorganic solids and related glasses.

Importance of the Project: In inorganic materials where the composition can be widely and continuously varied, as in glasses or in members of isomorphous series, a study of the relation of such changes to physical properties is particularly rewarding. This is true because in such series all factors, such as structure and chemical surroundings, remain unchanged, while one factor alone, one element, is varied. From studying such a series we can

0907-10-0917 - continued

determine the effect of the change of a single element on properties such as density, melting point, primary phase, transition temperatures, unit cell size, decomposition temperature, and energy of decomposition or transition. From data of these type, information on bond type and strength and atomic or ionic size may be obtained, as well as information on how to vary chemical composition to obtain crystals or glass with particularly desirable and useful properties.

Activity Summary: During the last year the details of the decomposition of bivalent carbonates of various compositions were studied. The relative thermal effects and the compounds formed at the different temperatures and in different atmospheres with the Mn, Fe, Ba and Pb carbonates and the solid solution between them were investigated and reported. Completed in Fiscal Year 1955, a compilation of Phase Equilibrium Diagrams of Interest to Ceramists will be published by the American Ceramic Society.

## SURFACE FINISHES AND COVERINGS

0201-20-0203 Spectrophotometry and Its Application  
to Colorimetry and Photometry

Objectives: (1) To develop and to maintain spectrophotometric standards; (2) to study improvements in spectrophotometric instruments and techniques, particularly for the standardization and specification of color; (3) to determine the permanence of standard samples of ceramics, glasses, pigments, paints, papers, plastics, textiles, and other materials of special interest in colorimetry; and (4) to correlate (a) instrumentally obtained data of spectral transmittance or spectral reflectance of materials converted mathematically into psycho-physical terms of color specification with (b) similar data of the same materials either obtained visually by the human eye, directly or with the aid of instruments, or photoelectrically by means of additive or subtractive colorimeters, color difference measurement instruments, or by means of physical photometers.

Importance of the Project: Spectrophotometry is a research and analytical tool in physics, chemistry, engineering, and technology. One of its most important uses relates to the subject of color. It is the fundamental basis of colorimetric analysis, standardization, and specification. It is the only fundamental means of analyzing a color for research or other purposes. It is the only means of standardizing a color that is independent of material color "standards" which are always of questionable permanence, and independent of abnormalities of color vision, existing among even so-called normal observers, and in this sense it is the fundamental basis for color specification. The NBS has applied the spectrophotometer to its color research, development, and testing, and to various other work, for nearly 50 years. It pioneered in the development of the photoelectric spectrophotometer and in its application to the colorimetry of diffusing materials. With the advent of commercial photo-electric spectrophotometers, the NBS began preparing and issuing spectrophotometric standards of various kinds, and hundreds of these standards are now in use, affording checks on the reliability of the various scales of these instruments in industrial, national, and international laboratories, interested in colorimetry, photometry, and spectrophotometry.



0201-20-0203 - continued

Activity Summary: This is a continuing project which started in approximately 1905. During the past year, because of lack of funds, most of the personnel and equipment identified with this project were diverted to the Air Force sponsored project 0201-20-2325, Color Reconnaissance Studies, in which some of the same methods were applied. However, progress was made in the following: (1) first steps were made in the international adoption of the Safety Color Code for marking physical hazards; (2) the acceptance by the military of the NBS specified radiation hazard warning colors, purple and yellow; (3) redetermination of the spectral reflectance of the sets of light sensitive papers for calibrating weatherometers and fadometers; (4) the publication of data for a standard solution for calibrating the photometric scale of ultraviolet spectrophotometers; (5) the national acceptance by all of the State governments of National School Bus Chrome Yellow for painting the school buses of the Nation; (6) the determination of a new color difference formula based on measurements, both visual and spectrophotometric, made on 200 porcelain enamel on steel color plaques.

0201-20-0205 Photometry

Objectives: To maintain the national photometric units of luminous intensity and luminous flux; to develop and maintain standards of illumination and luminance; to participate in international and national comparisons of photometric standards; and to study the relative luminosity factors of the human eye by means of which the luminous intensity and luminous flux of lights of different colors are evaluated.

Importance of the Project: The maintenance of the national units for photometric values for lights of all colors is one of the basic functions of the Bureau. Lamp companies, commercial laboratories, universities, and government agencies depend upon the photometric standards calibrated or issued by the Bureau. Standards representing the national photometric units of the United States are sent to the International Bureau of Weights and Measures for intercomparison with similar standards from other national standardizing laboratories. Intercomparisons with lamp laboratories in this country insure uniformity in the United States while the international intercomparisons insure uniformity throughout the world.

Activity Summary: Groups of 8 lamps at each of the four points of the photometric scale (luminous intensity at 2042° K, luminous intensity at 2353° K, luminous flux at



0201-20-0205 - continued

2353° K, and luminous flux at 2788° K) were seasoned and calibrated. The 4 most stable lamps from each group were selected and carried to the Bureau Internationale des Poids et Mesures where they will be intercompared with the corresponding groups of lamps submitted by the other participating national standardization laboratories. Several papers relating to the work on photometry have been written.

A design for the mechanical part of a physical tristimulus colorimeter to use with the thermopile and measuring equipment was worked out and will be built as funds and time permit.

The material originally prepared for possible use as an NBS circular became the IES General Guide for Photometry and has appeared in part in two issues of Illuminating Engineering and will be available shortly as a separate reprint in full.

0201-30-0207     Standards of Light and Color

Objectives: The calibration and issuance of lamp standards of candlepower, luminous flux and color temperature; spectrophotometric standards and standards of color, transmittance, reflectance, opacity, gloss and luminance.

Importance of the Project: Standards of light and color are in continuing heavy demand by Government and industry for the calibration of instruments or working standards or for the testing of materials and devices for compliance with specifications. Among the industries served are the following: lamp and lighting fixture, paint, paper, plastics, enamel, photographic, textile, television, oil and public utilities.

Activity Summary: During fiscal 1955 more than 450 standards and calibrations were supplied as requested. An NBS letter circular, LC-1017, Standards for Checking the Calibration of Spectrophotometer (200 to 1000 mu) was issued.

Plans for Fiscal Year 1956: Standards are to be calibrated and issued as demanded and as the budget permits.

Objectives: Formulation and revision of Federal Specifications for lamps, auxiliary equipment and colors, and cooperation with ASA in allied fields in order to attain coordination, particular stress being placed upon the development of improved qualification test for lamps, on insuring interchangeability of lamps, and on the assignment of uniform designations to lamps.

Importance of the Project: The qualification testing of lamps under Project 2320 (see Testing, Materials and Products) which provides the basis for the purchase of lamps by the Government depends upon this project to provide necessary specifications. New specifications must be formulated and existing specifications revised periodically so that the qualification tests may afford the means for qualifying only manufacturers who can supply to the Government an acceptably high level of quality of lamps. Under this project, also, American Standards and Federal Specifications for the items covered by the project are coordinated so that there will be no avoidable disagreement or duplication. The development of American standards which meet Government needs and the incorporation of these standards in Federal Specifications by reference reduces Government printing costs as well as the possibility of having unnecessary inconsistent requirements in Federal Specifications and American Standards.

Activity Summary: An amendment to the Federal Specification for Fluorescent Lamps (W-L-116) and 1956 Supplements to the Federal Specifications for Large Incandescent Lamps (W-L-101e) and Miniature Incandescent Lamps (W-L-111b) incorporating more stringent requirements for these types of lamps were formulated. Progress was made on the development of a Federal Specification for Projection Lamps and an Interim Federal Specification was formulated, but lack of funds retarded the progress of the work and it was agreed to transfer the development of this specification to the Signal Corps. Cooperation with ASA in the development of American Standards resulted in the drafting of Federal Specifications for Enamelled Conduit (WW-C-571a), Zinc-Coated Conduit (WW-C-581c) and Fluorescent Lamp Starters (W-S-755) which incorporate all of the technical requirements in the American Standards by reference.

Plans for Fiscal Year 1956: The scope of the project will be somewhat reduced by eliminating electrical supplies other than lamps and allied auxiliary equipment. The Federal

Specifications for incandescent, fluorescent and photographic flash lamps will be revised so as to keep them current and cooperation will be given ASA in the development of American Standards covering interchangeability of lamps and lamp auxiliary equipment.

0904-10-0908 Properties of Inorganic Coatings

Objectives: To study the fundamentals controlling the behavior of inorganic materials in the fused or glassy state; also, to develop evaluation criteria for coatings of these materials on metals. More specifically, the objectives will be to investigate (1) the surface chemistry of such inorganic materials as a function of composition and temperature, (2) their electrolytic properties over a wide temperature range in relation to the basic characteristics of constituent ions, (3) the development of adequate methods for evaluating their properties when applied to metal bases, and (4) their susceptibility to diffusion of gases and their related protective properties at high temperatures.

Importance of Project: The expanding use of inorganic (ceramic) coatings (approximately 1 1/2 billion dollars' worth of enamel products were produced in 1954), along with the extended utilization of ceramic coatings for specific high-temperature applications, including both civilian and military purposes (jet engines, rockets, and atomic energy power plants), has introduced a whole new series of problems in this general field which will require a more basic approach to their solution. For example, in the high-temperature applications, basic data on such properties as electrolytic behavior (resistance) and permeability to gases, as well as a knowledge of other general properties as a function of composition and temperature, are badly needed. Also, in many applications chemical stability is the reason for the choice of these materials; thus the study of surface chemistry of such vitreous materials, and the mechanisms controlling their chemical durability, are matters of considerable technological importance. The currently attainable corrosion resistance is frequently inadequate. This results from a lack of knowledge concerning the complicated physico-chemical processes at the glass-solution interface and from the incompleteness of our theoretical understanding of the nature of the glassy state. Studies of the fundamental mechanisms involved in the hydrolysis and dissolution of vitreous materials, the determination of rate-controlling steps, and the clarification of surface



processes affecting the rate will provide basic information in this little-understood field. Along with fundamental studies of this type, new and adequate methods must be developed for evaluating the behavior of such coatings in the new fields in which they are being used.

1004-10-1017 Properties of Roofing, Waterproofing,  
Flooring and Coating Materials

Objectives: To ascertain the causes and the chemical and physical processes of deterioration of asphalts when exposed to the weather and the relations between the chemical and physical properties of flooring, roofing and waterproofing materials and their performance in service.

Importance of the Project:

- (1) Work on Asphalt: At least 90 percent of the roofing used in this country contains asphalt. Asphalt used in roofing is a by-product of the petroleum industry, extremely complex in composition, with properties that vary with the source and the method of preparation. The Bureau has undertaken a fundamental study of the degradation of asphalt on weathering to be able to distinguish between good and poor weathering asphalts and to establish methods for improving the weather resistance of asphalts.
- (2) Work on Flooring Materials: The compositions and constructions of flooring materials have undergone appreciable change in the past several years, notably vinyl plastic floor coverings. Needed most are satisfactory methods for evaluating the resistance to wear and maintenance and the dimensional stability of floor covering materials. Comparable and up-to-date information on different types of materials and their installation is of interest to Government agencies, architects, builders and consumers.

Activity Summary:

- (1) Work on Asphalt: This is a continuing project supported in part by the Asphalt Roofing Industry Bureau under the Research Associate Plan. During the past year, a chromatographic method was developed for the separation of asphalt into four distinctive groups of components (RP2577). Work was initiated, with about



20 asphalts, to determine chemical composition of the asphalts and of their components and changes in the components as the asphalts are weathered.

- (2) Work on Flooring Materials: Because of budget and manpower limitations, very little was accomplished on this project during the past year. The leader of the project retired in November 1954. His time and that of his assistant, who assumed charge when he retired, was spent mainly on a project sponsored by the Office of the Chief of Engineers, Department of the Army, on the evaluation of flooring materials in field installations.

Plans for Fiscal Year 1956:

- (1) Work on Asphalt: (I) Complete chemical analyses of asphalts and components under study. (II) Continue work on the fractionation of asphalts into groups of similar components and determine, by the chromatographic method, changes in the distribution of components when the same base flux is blown to produce asphalts of different softening points. (III) Initiate work to determine (a) the structure of the water-soluble degradation products of asphalt, (b) the gaseous products produced when asphalt and its components are exposed to oxygen in the presence of light and moisture and (c) the relationship between the rate of oxygen absorption and the formation of water-soluble products for various asphalts and their components.
- (2) Work on Flooring Materials: Budget and manpower limitations will preclude further flooring work on this project during Fiscal Year 1956. However, oral assurance of sponsorship of a project for the development of improved methods of testing and performance criteria for flooring materials has been received from the Air Force. The Air Force is endeavoring to make this a joint Army, Navy, and Air Force project that will continue for several years.

1004-40-4844     Stapler Method of Applying  
Asphalt Shingles

Objectives: To evaluate a stapler method of applying asphalt shingles.

Importance of the Project: A stapler method of applying asphalt shingles is currently not acceptable to FHA because it is not endorsed by manufacturers of asphalt shingles. However, numerous representations have been made that the method reduces roof costs appreciably and at the same time provides a durable, water-tight roof. Most new dwellings are roofed with asphalt shingles and a large percentage of new dwellings are covered by FHA mortgage insurance. Section 10.4 agreed to make an evaluation of stapled roofs, mainly by field inspections in different sections of the country.

Activity Summary: Field inspections of stapled roofs have been made in Seattle, Washington; Dayton, Ohio; Savannah, Georgia; Peoria, Illinois; Lansing, Michigan; Washington, D.C.; and Baltimore, Maryland. It is expected that field inspections will be completed in Fiscal Year 1955.

Plans for Fiscal Year 1956: Make laboratory determinations necessary to establish: (1) Relative resistance to tear of asphalt shingles applied by nailing and by stapling, with staples placed horizontally, vertically, and at an angle of 45° to the base line of the shingles; (2) The practicability of the stapling method for applying asphalt shingles to 5/16-in. plywood decks. Prepare a final report.

1004-20-4846     Research on Flooring

Objectives: To prepare classifications or ratings of floorings that are of current and potential usefulness to the Department of Defense. The classification would indicate the suitability of each flooring for each of a variety of service conditions. The first rating would of necessity be incomplete and highly tentative because of the inadequacies of existing methods of testing and the lack of data indicating quantitative relationships between the results of tests and service qualities. As improved methods of testing are developed and correlated with service conditions, the reliability of the revised classification would be improved. There would then become available both the means for obtaining quick evaluation of new floorings and reliable guides for the selection of floorings for any purpose.

Importance of the Project: A need exists for the development of improved methods of testing and performance criteria for flooring in several categories including those for resistance to wear, dimensional stability, slipperiness, electrical conductivity (hospital operating room floors), moisture penetration, underlayment materials, effect of aging and maintenance practices, cleaning ability, comfort value (resilience and temperature), etc.

The establishment of satisfactory performance criteria must be preceded by the development of laboratory methods for evaluating floors and flooring materials in measurable quantitative terms correlated with performance in actual service. Some methods are well established; others are reasonably well established for some materials, but need to be perfected further; while still others need to be developed.

The project is planned to cover several years of work. It is divided into two parts, the first dealing entirely with conductive flooring for hospital operating rooms; the second with flooring materials in general. The part dealing with conductive floors has been planned and work on it will be carried out cooperatively with Division 1.

Activity Summary: This is a new project initiated about December 1, 1955.

Plans for Fiscal Years 1956 and 1957:

1. Work on Conductive Floors: (1) Work done and being done by others. Make a thorough literature search and contact interested persons and agencies. (2) Electrical Work - Developmental. Make a study of methods of measuring electrical resistance of floors, and of correlation of established methods with the action of floors in reuniting electrostatic charges in use. This involves a study of effects of magnitude of applied voltage, type of voltage wave, and size, shape and weight of electrode, and should include actual tests of floors with electrostatic generators. Electrical resistance of most types of flooring depends so much upon its condition at the time of measurement that the method of test must closely approach the conditions under which a floor is expected to function in reuniting charges. (3) Initiate a testing program to make determinations of electrical resistance by currently available methods on specimens of each type of conductive flooring and method of application.



2. Work on Flooring Materials in General: Tasks outlined for the complete program, covering several years of work, are listed, although it is realized that only a small beginning could be made on any of them in Fiscal Year 1956 if the work on conductive flooring is given priority.

(1) Resistance to Wear: Develop a laboratory method, or methods for evaluating resistance to wear of flooring materials. Because of the several varieties of flooring materials that are available, ranging from the resilient materials composed mainly of organic substances to the rigid, ceramic materials, and the wide range of service conditions, it is not expected that a single method can be made to serve.

(2) Underlayment Materials: Determine the effect of such underlayment materials as plywood, magnesium oxychloride cement, the various asphalt mastics, etc., on the behavior of flooring materials, including resistance to wear, indentation, effect of aging and maintenance. (3) Dimensional Stability: Study the effect of aging and maintenance treatment on the dimensional stability of flooring materials under various conditions of temperature and humidity.

(4) Comfort Value: To be studied from two viewpoints: (a) As a function of resiliency, to determine fatigue characteristics; (b) As a function of heat transfer, to determine comfort value with respect to temperature. (5) Moisture

Movement: Study of moisture movement in floors as it affects adhesion of cemented materials and conditions in spaces with controlled humidity. (6) Fire Hazard of Flooring Materials: Determine the relative fire hazards in the use of various organic flooring materials, including the formation of toxic gases on combustion.

3. Work on Conductive Floors: Complete work not finished on (2), (3), and (4) in Fiscal Year 1956.

4. Work on Flooring Materials in General: Continue work outlined for Fiscal Year 1956.

1004-40-4847 Standards for Built-Up Roofs

Objectives: To determine the relative merits of asphalt and coal-tar pitch when used in built-up roofs on which water collects and stands and to develop improved methods of testing asphalt and coal-tar pitch for built-up roofs. To compare the performance of double-slagged, asbestos felt, glass membrane and cold process built-up roofs with that of conventional built-up roofs.



Importance of the Project: Government specification writers have been under pressure in recent years to accept asphalt and coal-tar pitch on an equal basis for the construction of built-up roofs on dead level decks. So-called double slagged and cold process built-up roofs and roofs constructed with asbestos-felt and glass fiber membranes are being used increasingly. Single application materials are frequently recommended for concrete decks.

Activity Summary: This is a new project initiated about December 1, 1955.

Plans for Fiscal Years 1956 and 1957: A combined laboratory and field study is planned, as follows:

1. Secure specimens of asphalt and coal-tar pitch intended for dead-level roofs from major suppliers, the suppliers to furnish data on the source and physical characteristics of the materials. Determine physical characteristics.
2. Determine the effects on asphalt and coal-tar pitch specimens of long-time immersion in water, both in the dark and exposed to ultraviolet light. Some of the effects to be determined are: Changes in weight and volume; amount of water absorbed; nature and quantity of material leached out; effect of wetting and drying under conditions simulating service. Determine resistance to outdoor and accelerated weathering and amount of oxygen absorbed during the photo-oxidation process.
3. Develop methods for determining low temperature ductility and cold flow in asphalt and coal-tar pitch and determine these characteristics for the specimens available.
4. Conduct a field study of the performance of dead-level built-up roofs in the United States. Only roofs on which complete data concerning construction and subsequent maintenance are available will be examined. Sources of information concerning roofs to be examined will be confined, as far as possible, to the sponsors of the project and other agencies of the Government such as the Public Buildings and Veterans Administrations. It is expected that these sources will prove adequate for coal-tar pitch roofs. A list of 85 flat or nearly flat, mineral-surfaced, asphalt, built-up roofs more than 10 years old has been furnished by the Asphalt Roofing Industry Bureau. Individual manufacturers have listed numerous roofs applied recently with low-slope asphalt.

1004-40-4847 - continued

5. Study the performance of double-slagged, cold process, asbestos-felt and glass-fiber built-up roofs to determine possible advantages or disadvantages of these roofs over conventional built-up roofs.

6. Prepare standard specifications for asphalt and coal-tar pitch for built-up roofs in which the requirements reflect the new data obtained.

7. Initiate work to evaluate materials other than asphalt or coal-tar pitch which may be of value in built-up roof construction.

## TESTING OF MATERIALS AND PRODUCTS

0201-30-2320      Qualification Inspection and Testing  
of Lamps for the Government

Objectives: To conduct qualification tests of manufacturers currently supplying incandescent, fluorescent, and photo-flash lamps to the Government by inspecting and life-testing the lamps supplied in order to determine compliance with applicable Federal Specifications; also to conduct qualification tests of prospective bidders not currently supplying lamps to the Government.

Importance of the Project: In accordance with the procedure followed for over 40 years the contract between the Government (Federal Supply Service) and the suppliers of lamps to the Government specifies that the lamps supplied shall comply with the applicable specifications, and that the necessary inspection and testing to determine compliance with the specifications be performed by the National Bureau of Standards. Since 1935 contracts to supply lamps to the Government have been awarded only to suppliers who have passed qualification tests conducted at the National Bureau of Standards in accordance with the applicable specifications. This procedure has been found to be effective in obtaining for the Government delivery of specification-quality lamps with a minimum of delays resulting from rejections for failure of lamps to comply with specification requirements.

Activity Summary: During Fiscal Year 1955 samples inspected represented over 3,000,000 lamps of which approximately 5.8% were rejected on initial inspection at the factories of the suppliers. Lamps of current suppliers started on life test totaled 4099 and those rejected represented approximately 1.2% of those accepted on initial inspection. In addition two qualification tests of prospective bidders not currently supplying the tested categories of lamps were made--one for fluorescent lamps and one for photographic flash lamps.

Plans for Fiscal Year 1956: (1) The inspection and qualification testing of all groups of all brands of lamps supplied to the Government for which qualification requirements are specified. (2) Qualification tests of lamps manufactured by prospective bidders not currently supplying lamps to the Government, as requested by GSA.



0204-30-2312      Calibration of Surveying Equipment

Objectives: To calibrate precision base-line tapes, steel tapes, leveling rods, and other basic equipment used in geodetic surveys.

Importance of the Project: The equipment listed in the statement of objectives is used for precision surveys in Central and South America that are directly related to national defense and development. The NBS provides the only reliable source of service available for the required standardizations of this surveying equipment. These standardizations include the initial standardizations of new equipment and subsequent restandardizations after use in the field.

Activity Summary: This has been a continuing project for several years. Since July 1, 1954, 38 invar base-line tapes, and 61 leveling rods were calibrated. Determinations of the coefficients of thermal expansion were made on 8 of the 38 baseline tapes.

0502-30-3241      Analysis and Evaluation of Detergents and Miscellaneous Materials

Objectives: To test detergents, waxes, and miscellaneous materials for conformance to Federal and other specifications; identification, analysis and evaluation of a wide variety of miscellaneous products that are not covered by any specifications. Development of new specifications and test methods for detergents and miscellaneous materials, and revision of the Federal Specification for Methods of Sampling and Testing Soaps and Soap-Products (including Synthetic Detergents). Technical services of analytical, investigative and advisory nature pertinent to regulatory or judicial functions of governmental agencies.

Importance of the Project: The primary function of this project is to provide services to other sections of the Bureau and to other agencies of the Government. The importance of the testing program as related to Government purchasing is shown by the large percentage of the samples that have failed to meet the appropriate specification. Miscellaneous products for which no Federal specifications exist are examined and evaluated for other agencies and other sections of this Bureau. The Federal Trade Commission and the Post Office Department frequently submit samples for examination to obtain evidence for use in their regulatory functions. Both agencies also frequently seek advice and opinions on questions related to the work



0502-30-3241 - continued

of this project. The General Services Administration relies upon the personnel assigned to this project to review, revise and develop individual specifications and the specification for Methods of Analysis related to the work of this project.

Activity Summary: During the past year over 100 samples were tested for Veterans Administration, Post Office Department, Army Map Service, Department of State, District of Columbia, GSA and different divisions of the Bureau. The work is kept up to date.

Plans for Fiscal Year 1956: This is a continuing project. No changes in the program have been planned.

0900-30-4447 Acceptance Testing of Ceramic Materials

Objectives: To test ceramic materials for compliance with the technical requirements of Federal or Departmental Specifications.

Importance of the Project: The Federal Government is a large purchaser of ceramic materials. Since a very substantial cost is involved in the erection of structures and in other fabrication from these materials, acceptance testing assumes a major importance in a number of cases. This is particularly true in the use of refractories for boilers, incinerators, and similar installations; therefore, most of the testing work under this project is concerned with refractory materials.

Activity Summary: The materials submitted for acceptance testing required the assignment of one employee full time to this project. A total of 971 tests were performed on 120 samples.

Plans for Fiscal Year 1956: Approximately the same quantity of testing is expected during 1956.

1000-30-4801 Properties of Building Materials

Objectives: To obtain data on the properties of building materials, equipment, and structural assemblies as a means for assessing their probable service performance and their value for use in military structures.

1000-30-4801 -continued

Importance of the Project: Periodically, and as requested by the Office of Chief of Engineers, the National Bureau of Standards is requested to make specific investigations on the properties of building materials, equipment, and structural assemblies. Examples of these are protective coatings, flashings, walls, brick, protected metals (protected against weathering and fire), door locks, and concrete structures. Since parts of assignments, and sometimes entire assignments, are accomplished best by divisions other than the Building Technology Division, it has been found advantageous over the years to group all assignments under the subject project with one project leader.

Activity Summary: Six assignments were made by OCE during fiscal year 1955. Examples of these are:

(a) Thermal Insulation of Roofing Material. An investigation of the effect of dampness on the performance of thermal insulations for roof decks. This task involved subsection of typical insulating panels to accelerated vapor conditions and conditions simulating exposure to the sun. Both summer and winter conditions were considered.

(b) Tests of Weep Holes in Panel Walls. These tests are designed to determine the practicability of the use of weep holes in panel walls supported on spandrel beams in concrete frame construction.

(c) Protected Metals. Tests were made on four types of protected metals, to determine their effectiveness after weathering and after fire tests.

Plans for Fiscal Year 1956: This is a continuing project. The project level will depend upon the tasks submitted by OCE.

1004-30-4845 Testing, D. C. Government

Objectives: Control testing of bituminous highway materials.

Importance of the Project: In 1933, the Congress directed that the testing of highway materials for the District of Columbia should be done by the National Bureau of Standards. Since most of the bituminous testing is for the purpose of controlling materials in daily use, it is required that tests and reports be handled as expeditiously as possible, usually the day the materials are received.

1004-30-4845 - continued

Activity Summary: This work has been carried on under Project 1000-40-4800 for the past several years. However, the amount of the work has become sufficiently great to justify placing it in a separate project. During Fiscal Year 1954, 1950 materials were tested. During Fiscal Year 1955, 2411 materials were tested.

Plans for Fiscal Year 1956: It is expected that work will continue on a somewhat increased level due to the additional funds for highway work available to the District of Columbia.



## MISCELLANEOUS

0604-20-0614     Development of Techniques for Static  
and Dynamic Load Measurements

Objectives: To develop elastic load-measuring devices for calibrating testing machines, methods for the calibration of elastic load-measuring devices, and methods for the evaluation and comparison of hardness testing machines.

Importance of the Project: The efficient use of structural materials requires an accurate, detailed knowledge of their strengths under various conditions. This is especially true for aircraft and missile purposes where the highest possible strength-weight ratio is required. Tests of materials and structures are therefore made in testing machines having capacities ranging from a few pounds to several million pounds. These testing machines must be kept in proper operating condition. To this end a means of calibrating all machines over their entire range is badly needed. Rapid, accurate means of force measurement are also needed to measure the thrust of jet and rocket engines, to weigh highway and rail vehicles in motion and to weigh a large variety of industrial materials and products not only under static conditions but also in motion. Military and commercial requirements for increased range and accuracy of force measurements are constantly increasing. There is an urgent need for improved methods for calibrating elastic load-measuring devices at both low and high loads. Present deadweight facilities should be extended to make possible the accurate calibration of devices above 111,000 lb or improved devices should be developed to make calibration by means of other calibrated devices more accurate and less time-consuming. Hardness testing has an important part in modern production methods as a non-destructive control method which measures a combination of desirable engineering properties of materials. Development of micro-hardness test equipment during the past ten or twelve years has opened many new possibilities for research and has created problems of standardization of the instruments. There is urgent need for an explanation of certain anomalies in tests made with dash-pot controlled machines as compared to motor-driven machines. In addition, there is need for satisfactory methods of load calibration for the newer machines and for a specification or manual covering the applications of these methods.

0604-20-0614 - continued

Activity Summary: This is a continuing project. Dynamometers of 1,000,000- and 3,000,000-lb capacity were recalibrated in order to obtain a history of their stability with time and use. These tests indicated that dynamometers of these sizes are satisfactory for many purposes but further improvement is desirable. Further modification of the special dynamometers and totalizing circuit for the calibration of devices from 111,000 lb to 300,000 lb was found to be necessary before comprehensive evaluation tests can be undertaken.

0604-30-0616     Calibration of Mechanical Testing  
Machines and Apparatus

Objectives: To calibrate mechanical testing machines, dynamometers, load cells, force strain, displacement, velocity and acceleration measuring equipment; to develop test equipment and methods; to assist in the formulation of specifications.

Importance of the Project: The NBS provides the only service available in the United States for the accurate calibration of elastic devices used for calibrating testing machines. Devices ranging in capacity from a few hundred pounds to several million pounds are calibrated for government agencies and commercial laboratories. The accuracies of the testing machines used by the Government and by producers and consumers are dependent on periodic calibrations with devices calibrated at the NBS. Calibration cells used by manufacturers of aircraft weighing devices and load cells for measuring the thrust of jet engines and weighing the contents of bins and hoppers are calibrated in the NBS dead weight machines. Calibrations of strain and displacement measuring equipment are performed for other government agencies.

0604-10-0636     Dynamic Properties of Materials

Objectives: To provide basic information on the mechanical properties of materials when subjected to high rates of loading, develop methods of testing, evaluate current theories as related to dynamic properties, and develop a more exact theory of strain energy propagation in materials.

0604-10-0636 - continued

Importance of the Project: Investigations of the behavior of structures when subjected to rapidly applied loads has increased the need for more exact knowledge of the dynamic properties of structural materials. Studies of the fundamental mechanisms of propagation of the elastic and anelastic components of strain energy will provide information for deriving the elastic constants and stress-strain characteristics of materials. Accurate information of the dynamic properties of structural materials will greatly reduce the uncertainty in current analyses of the response of structures to dynamic loading.

0604-20-3601     Investigation of a Prestressed  
   Cellular Drydock

Objectives: To provide experimental data on the mechanical performance of prestressed aluminum slabs of cellular construction to assist with the development of gasketing systems and the mechanical components required for joining and assembling, and to make methods of assembly studies.

Importance of the Project: Seaplane operations of the Navy require considerable mobility of the bases of operations. A portable prefabricated drydock which can be assembled with a minimum of skills and tools would increase the mobility of seaplane operations.

Plans for Fiscal Year 1956: (1) Determine strains and deflections in a flat slab under uniform loading; (2) investigate watertightness of gasketed elements and devise improved system if required; (3) make assembly studies; (4) develop the related mechanical components and accessories as required.

0900-40-0999     Mineral Products Division  
   Consultative and Advisory Services

Objectives: To provide consulting services on a wide variety of ceramics problems of interest to government agencies, industry, and the public.

Importance of the Project: The National Bureau of Standards has, in areas within its competence, responsibility for providing advisory and consulting assistance to other government agencies. The Mineral Products Division implements this responsibility in the general field of non-metallic minerals through its staff of specialized scientists and engineers.



0900-40-0999 - continued

Activity Summary: In addition to the normal, continuing calls for advice on relatively routine applications of ceramics in industry and government, there has been an increasing interest in higher-temperature problems and in materials for use in atomic power plants. Many of these consultations are of a classified nature, involving ordnance and military aircraft.

Plans for Fiscal Year 1956: It is expected that activity under these projects will continue to increase gradually as ceramics assume a more important role in military and industrial applications.

1000-40-1099     Building Technology Division  
Consultative and Advisory Services

Objectives: To provide technical information on materials, construction and equipment for buildings to governmental agencies, scientific, professional and industrial organizations, and the general public.

Importance of the Project: Other governmental agencies, scientists and engineers depend upon the National Bureau of Standards to assist them in solving their technical problems by supplying accurate and unbiased information on building materials and structures including that on strength, fire resistance and durability, and on heating and air-conditioning. Many of the inquiries are not answerable properly by reference to readily available publications or other source of information, as scientists and engineers ordinarily appeal to the Bureau after their failure to obtain satisfactory answers to their questions from their immediate associates. Specialists of the Bureau often are able to provide the best available information or the result of their own researches, their studies of the scientific literature, and their wide and close association with other specialists in the subject.

The Bureau's assistance usually is given while expenditures for new construction, maintenance or repairs are being contemplated; hence, accurate estimates of the value to the Government of the advice given cannot be made. Nevertheless, the relatively large amounts indicated in the small number of instances for which the value could be estimated indicate that the total amount is many times the cost to the Bureau. The value of the Bureau's assistance in the preparation of standards for products and constructions is not measurable but is thought to be greater than the total of the advice on individual construction projects.

Activity Summary: This is a continuing project. Representative services in 1955 were:

(a) A government hospital was rapidly becoming dangerous to ambulatory patients walking about the grounds because of spalling of the masonry veneer on the outside wall. Pieces as large as 12 by 6 inches had fallen. The NBS recommended a method for relieving the veneer of the excessive loading which our investigations had shown to be the cause of the damage.

(b) The NBS was requested to assist in the determination of the cause of a serious plaster failure. While the largest portion of the determination was financed by direct transfer of funds, an appreciable portion was financed by the subject project, as well as assistance to the Government in determining the advisability of lawsuit.

(c) Because of highly acid content of animal excretion, the conventional floors in the cages at the Washington Zoo deteriorate at an unusually rapid rate. Upon the advice of the Bureau laboratories, a new type synthetic-resin floor is under consideration and will probably be adopted.

There were many other services of this nature. However, a large portion of the consultative services consisted of work with committees of technical societies such as the American Society for Testing Materials, American Standards Association, and the American Society of Heating and Ventilating Engineers.

Because of the expanding building program in the nation, inquiries by telephone, letter or personal visit tend to increase each year. Many of these from individuals relate to air conditioning, heating problems, structural stability and durability of materials and other problems associated with small buildings. Others from builders and architects relate to construction of large buildings and to masonry, concrete construction, fire protection, heating, and air conditioning.

1000-20-4800 Miscellaneous Investigations  
and Testing

Objectives: To perform such tests on building materials, equipment, or structures, as requested by Federal Agencies in accordance with appropriate fee schedules.

Importance of the Project: This is a continuing project in which the NBS carries out miscellaneous testing. Examples include: the testing of elevators and elevator parts, air filters, building stones, brick, masonry units, fire extinguishers, roofing slate, insulating materials, heating units, air-conditioning units, and the testing of building constructions for strength, water permeability, fire resistance and heat transmission.

Activity Summary: Although a continuing project with many of the types of investigations and testing being repeated each year, 1955 resulted in an unusual number of requests for large-scale investigations. Two of these are noted below:

(a) At the request of the Civil Aeronautics Administration, measurements were made of the thermal conductances of six types of reflective insulation under several different conditions simulating service applications.

(b) The performance of two furnaces was investigated for the Federal Housing Administration to study the temperature distribution and comfort produced in a small one-story house by a typical wall heater located centrally in the first floor level when the heat is distributed by gravity circulation and alternately by a small booster fan; and to compare this method of heat distribution with that produced by a similar furnace with a conventional blower. A study was also made to provide information on whether or not a gravity furnace should be penalized in capacity when located on the living level of a one-story house, as presently proposed by FHA in their minimum property requirements.

Specifications for door operators were reviewed for the Architect of the National Capitol. At Perry Monument, Lake Erie, a check was made of the elevator, and a series of resistance measurements were made of the lightning protective system. At the request of the National Park Service a study was made of the two existing elevators at Carlsbad Caverns, Carlsbad, New Mexico. These two elevators, now about 23 years old, were renovated in accordance with recommendations made by NBS. Specifications for two new elevators were also prepared with the assistance of the NBS.

A large portion of the program consisted of testing bituminous highway materials for the District of Columbia.



Objectives: To provide a mechanism to assist Federal Agencies in exchanging technical information on the design, construction, and maintenance of structures and to facilitate inter-agency collaboration in this field.

Importance of the Project: In June 1953, the National Bureau of Standards negotiated a contract with the National Academy of Sciences "to provide the necessary committee and staff personnel to advise Federal Agencies on problems concerning the improvement of construction technology for buildings and other structures." Financing was accomplished by fund transfers to NBS from various agencies.

The Council serves as a forum for discussion, study, and evaluation of common problems and a clearing house for exchange of information between the various agencies on technical standards, design and construction practices, administrative matters affecting technical operations, technical investigations, and similar activities relating to the advancement of building research and technology. Periodically, technical reports are prepared for common use by the sponsoring agencies and other Government Agencies. The Chief of the Building Technology Division serves as "Agency Representative" and monitors the work done by the Council. The National Bureau of Standards, as a member of the Council, also participates in many of the technical phases of the program.

Activity Summary: Examples of Technical Reports either completed or under way during 1955 follow: "Survey of Engineering Investigations and Research in Building Technology by Federal Agencies"; "Ceiling Heights in Office Buildings"; "Space Allowances for Offices"; "Summary of Plumbing Research Reports"; and "Packaged Air Conditioners".

Plans for Fiscal Year 1956: Among the tasks in progress or contemplated for fiscal year 1956 are:

(a) Cooling Towers. This is a summary of practices and opinions of agencies on the performance and rating of cooling towers.

(b) Windows. This is a survey of agencies' practices in the selection and use of windows. The report is expected to cover design features such as type, arrangement, operation, and materials used as an aid to proper selection.

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(c) Electrical Loads for Buildings. This is a survey of engineers' opinions and practices on estimating electrical loads for buildings.

(d) Tests on Paint Samples. This is a survey of agency practices on specifying, sampling, and testing of paints.

1003-20-4836 Dust Soiling of Acoustical Tile

Objectives: To study the fundamental processes by which particulate matter is deposited on wall and ceiling surfaces and to provide data on the soiling characteristics of acoustical tile and means for cleaning such surfaces in place as a basis for reducing the cost of maintaining public buildings.

Importance of the Project: It is known that acoustical tile is soiled by the deposition of minute, airborne particulate matter and that this deposition may be due to "breathing action", thermal precipitation, electric precipitation or impingement. Data are lacking on both the absolute and the relative magnitudes of these effects, on the susceptibility of surfaces of different kinds to soiling by the various processes and on the effectiveness of cleaning methods, some now practiced and some recommended for trial. In public buildings, as well as residences, large amounts of money are spent annually for redecoration that is made necessary by deposition of dust on walls and ceilings. Acoustical materials lose much of their effectiveness after being painted once or twice and yet such materials are subject to soiling by airborne particles because of their porous nature. More exact information on the mechanism by which dust is deposited on such surfaces would probably assist in discovery of means for lessening the soiling of acoustical tiles in all types of structures.

Activity Summary: This is a continuing project which was started in January 1955. An apparatus has been constructed in which the relative effects or combined effects of air infiltration, thermal precipitation, and impingement on the rate of dust deposition can be studied under simulated service conditions. This apparatus has been modified and improved so a reproducible degree of soiling of acoustical tile can be accomplished on identical specimens with reasonably small deviations. A separate apparatus has been constructed for making absolute measurements of the air

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leakage through individual specimens for small pressure differences before and after soiling. Preliminary results show a consistent relationship between rate of soiling and rate of air leakage for any given material and that different materials are soiled at different rates under the same exposure.

Plans for Fiscal Year 1956: (1) Determine relative effects of infiltration, impingement, and thermal precipitation on dust deposition on some materials, (2) Determine relative rates of dust deposition on different materials and its dependence on porosity, surface roughness, air leakage, etc., (3) Investigate methods for cleaning acoustical tile in place.

1003-20-4838 Air Filter Systems for Army Aircraft

Objectives: To study the air-borne dust distribution around the rotor of an operating helicopter with respect to concentration and particle size, and to develop and construct models of air cleaners that will be more effective than presently-used devices in protecting airplane and helicopter engines from excessive wear in dusty atmospheres.

Importance of the Project: Wear of aviation engines, both airplanes and helicopters, has caused considerable expense and inconvenience in the past. Aircraft, and especially helicopters, necessarily operate in dusty atmospheres much of the time, and available evidence indicates that present air cleaners for combustion air are inadequate to protect them from excessive wear. Reports of engine failure due to this cause in less than 100 hours are common. Experiments on this subject have been sporadically conducted by various agencies of the United States Government, as well as the governments of other nations. Information is lacking on the dust concentration and particle sizes that exist at various levels above the ground in the vicinity of an operating helicopter nor have adequate sampling methods been developed to secure representative samples for analysis. Air filters currently used in the induction air systems of helicopters are too low in efficiency and are inadequate in dust-holding capacity. This work has been requested by the Office of the Chief of Transportation of the Department of the Army. It is an extension of the work done on air cleaners for tank engines during World War II and the continuing work on air-cleaning devices for heating and air conditioning systems for buildings.



Activity Summary: This is a continuing project which was started in December 1953. An apparatus was constructed for measuring the efficiency, pressure drop, and dust-holding capacity of prototype and stock model air cleaners designed for aircraft engines. Efficiency can be determined by both the gravimetric and dust-spot methods. The performance of commercial filters of paper type, oil-bath type, and cyclone type as well as a prototype centrifugal air cleaner designed at NBS was determined on the test apparatus. Two worn out helicopter engines were dismantled to sample and analyze dust accumulations or foreign matter that could be found in the induction systems, around the piston rings, and in the crankcase oil. A literature search was made and several visits made to aircraft engine laboratories to obtain information on the relation of rate of cylinder wear to the size of particles causing the wear. Modifications were made to the commercial cyclone filter looking toward a decrease in pressure drop and an increase in air flow rate without decreasing the efficiency. An air sampling system for use in surveying the dust concentration and particle size distribution around an operating helicopter has been constructed for use in field measurements.

Plans for Fiscal Year 1956: (1) Seek further improvement of cyclone type air cleaner and build prototype for test, (2) Complete the study of the centrifugal air cleaner developed at NBS as a pre-cleaner and build a prototype for test, (3) Seek improvements in oil-bath cleaner to better adapt it to aircraft engines, (4) Continue development of a sampling system for dusty air around helicopter rotors, (5) Study the air-borne dust distribution around the rotors of operating helicopters to determine dust concentration and particle size, (6) Determine optimum locations for air intake on helicopter engines based on observed dust distribution, (7) Test prototype pre-cleaners and after cleaners for efficiency, pressure drop, dust-holding capacity, self-cleaning features, etc.

1003-20-4832 Refrigeration and Field Equipment

Objectives: To develop portable and mobile refrigeration and field equipment with improved military characteristics of performance, size, and weight by improving designs, developing new methods and components, analyzing the performance of prototypes, recommending modifications in prototype equipment, revising Federal specifications, and standardizing capacities, rating conditions, and certain physical components of such equipment.

Importance of the Project: The Office of the Quartermaster General makes wide usage of portable and mobile refrigeration equipment for the preservation of food and medical supplies, transportation of food, manufacture of ice cream and for similar purposes during both war and peacetime conditions. During World War II commercial equipment was modified to meet emergency requirements in many cases. This solution was not considered adequate on a permanent basis, however, because the operating conditions were often more severe in military applications, mobility imposes special problems of durability and places a premium on small size and weight, gasoline engines are used for prime movers when an electrical distribution system is too remote, and the factors of vibration and atmospheric dust make ordinary controls inadequate in some cases. In addition the need for stocking spare parts in remote areas of the world emphasizes the need for standardization of parts and a reduction in the number of models or sizes of units that are to be used. The preparation and revision of Federal specifications enable the military agencies to buy commercial items in some cases in a way to take full advantage of competition among many manufacturers.

Activity Summary: This is a continuing project started in 1944. During the last year a study was completed showing the effect or capacity of a complete refrigerating system of varying the speed of the compressor, condenser fan, and evaporator fan proportionally and of varying the compressor speed and the two fan speeds independently; the performance of a typical hot-gas defrosting system was analyzed in both an empty and loaded warehouse; the Federal specification on domestic refrigerators was completely revised; development of an exhaust-gas-to-refrigerant heat exchanger for warehouse heating was undertaken; the development of a complete modulating thermo-mechanical control system for a portable refrigerating system was commenced; several warehouse panels were investigated for simultaneous heat and vapor transmission characteristics; and investigation on a newly-developed inverted gasoline lantern was completed; and advice and consultation was provided on test methods for standardization of refrigeration compressors.

Plans for Fiscal Year 1956: (1) Complete the design of an exhaust-gas-to-refrigerant heat exchanger for the 1-ton warehouse unit, (2) Complete the design of a modulating thermo-mechanical control system for the 1-ton warehouse unit, (3) Revise the Federal specification for commercial refrigerators, (4) Evaluate the standardization procedures

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proposed for refrigeration compressors by testing some specimens and making recommendations for modifications of the procedures, (5) Continue with the study of vapor transmission in insulated warehouse panels, (6) Perform tests of prototype refrigerated trailers, refrigerating units, etc.

1003-10-4881 Insulation of Underground Pipe

Objective: To provide data on the insulating properties, water permeance, expansion characteristics, mechanical and chemical stability of insulating materials and methods for underground steam and hot water lines as a basis for the preparation of adequate specifications for such materials by Federal agencies.

Importance of the Project: Central heating plants often require extensive underground piping systems for distribution of steam or hot water to the area of usage. Such piping systems are usually insulated to reduce heat losses and to prevent rapid corrosion of the pipe as a result of chemical and electrolytic action. Some of the characteristics desired for underground pipe insulation are low thermal conductivity, low moisture permeance, high crushing strength, suitable expansion characteristics, adequate stability at temperatures ranging from below freezing to 350° F, and long life. Many types of insulation and embedment have been used in addition to various kinds of tunnel construction. The Corps of Engineers of the Department of the Army expends several million dollars each year for installations of this type and require information on the performance of such insulating materials in order to prepare adequate specifications for purchase. Their experience has indicated that not all of the materials offered as underground pipe insulation possess the important characteristics to the required degree.

Activity Summary: This is a continuing project which was started in the third quarter of fiscal 1954. Some modifications were required to the apparatus constructed for this project during fiscal 1955 to provide accurate measurements of the heat transfer from the measuring section of the insulated steam pipe. The heat loss per unit length of a pipe insulated with 4 inches of Gilsulation was determined with dry earth surrounding the pipe and with the water table one foot below the center line of the pipe, at the center line of the pipe, and one foot above the center line of the pipe. The expansion and contraction



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characteristics of the material were studied under cyclic heating and cooling of the steam pipe and the polymerization of the material were studied by a chromatographic method.

A prefabricated conduit called Durant Insulated Pipe was studied in an outdoor trench to determine its insulating qualities, the softening characteristics of the asphalt covering, and whether or not the insulation could be adequately dried out either buried or above ground if it became wetted during installation. Information was obtained on the movement of water vapor in a radial direction under the influence of the temperature gradient around a hot steam pipe.

Preliminary studies have been made on the insulating qualities and water permeance of an envelope for a steam pipe made of a mixture of portland cement and granulated reclaimed rubber known as Wicor.

Plans for Fiscal Year 1956: (1) Complete investigation of thermal conductivity and heat transmission of Wicor as influenced by water table and study its resistance to moisture penetration, (2) Study the characteristics of Hylag insulation consisting of a fire clay mixture surrounded by an impregnated paper tube, (3) Study the characteristics of an insulating concrete called Z-crete, (4) Determine the thermal insulating properties of dry and damp earth around a steam pipe and the distribution of moisture in earth under the influence of a temperature gradient.

1003-10-4882 Reflective Thermal Insulation

Objectives: This project is sponsored by the Aluminum Company of America under the NBS Research Associate Program to provide information as to the thermal insulating value of aluminum foil and reflective surfaces in various applications, either alone or in combination with other materials.

Importance of the Project: Data obtained at the National Bureau of Standards in regard to the thermal insulating value of plane reflective air spaces have resulted in great interest on the part of insulation producers and users in its potential applications, and generated a need for additional data as to its performance in various applications. Among the questions of interest are (a) its use in combination with other insulating materials, (b) applications in conjunction with air spaces of uneven thickness, (c) the effects of air leakage and moisture in reflective air spaces, (d) the permanence of its reflective qualities, (e) experimental determination of the theoretically great value of reflective

surfaces in insulating against heat flow downward from attics in summer. Information in connection with these matters is needed by the insulation industry and users to provide a sound basis for the further development of reflective insulation products and for their proper installation and use.

Plans for Fiscal Year 1956: The several items proposed for investigation are: (1) Combinations of aluminum foil and other insulations; (2) Use with air spaces of uneven thickness; (3) Insulating effect of reflective surfaces exposed in an attic application to radiation from a solar-heated roof; (4) Effect of air leakage between reflectively insulated air spaces; (5) Permanence of reflectivity of aluminum foil surfaces; (6) Study of moisture and condensation problems with reflective insulations; (7) Effect of installation in air spaces with one side open; (8) Thermal conductivity of various aluminum alloys. Priority will be given to Items 1, 2, and 3; the remainder will be dealt with as time permits. The results of the work are to be prepared for publication.





## THE NATIONAL BUREAU OF STANDARDS

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Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards (\$1.25) and its Supplement (\$0.75), available from the Superintendent of Documents, 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.

