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# NATIONAL BUREAU OF STANDARDS REPORT

3142

PROJECTS RELATED TO BUILDING RESEARCH AT THE  
NATIONAL BUREAU OF STANDARDS  
FOR FISCAL YEAR 1954

Compiled by the  
Building Technology Division  
Mr. 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.** Resistance and Reactance Measurements. Electrical Instruments. Magnetic Measurements. 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. Cryogenic Engineering.

**Atomic and Radiation Physics.** Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Measurements. Infrared Spectroscopy. Nuclear Physics. Radioactivity. X-Ray. Betatron. Nucleonic Instrumentation. Radiological Equipment. Atomic Energy Commission Radiation Instruments Branch.

**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 Control.

**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.

**Electronics.** Engineering Electronics. Electron Tubes. Electronic Computers. Electronic Instrumentation. Process Technology.

**Radio Propagation.** Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Frequency Utilization Research. Tropospheric Propagation Research. High Frequency Standards. Microwave Standards.

● Office of Basic Instrumentation

● Office of Weights and Measures.

# NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT

NBS REPORT

1000-00-9010

March 1, 1954

3142

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AT THE

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FOR FISCAL YEAR 1954

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

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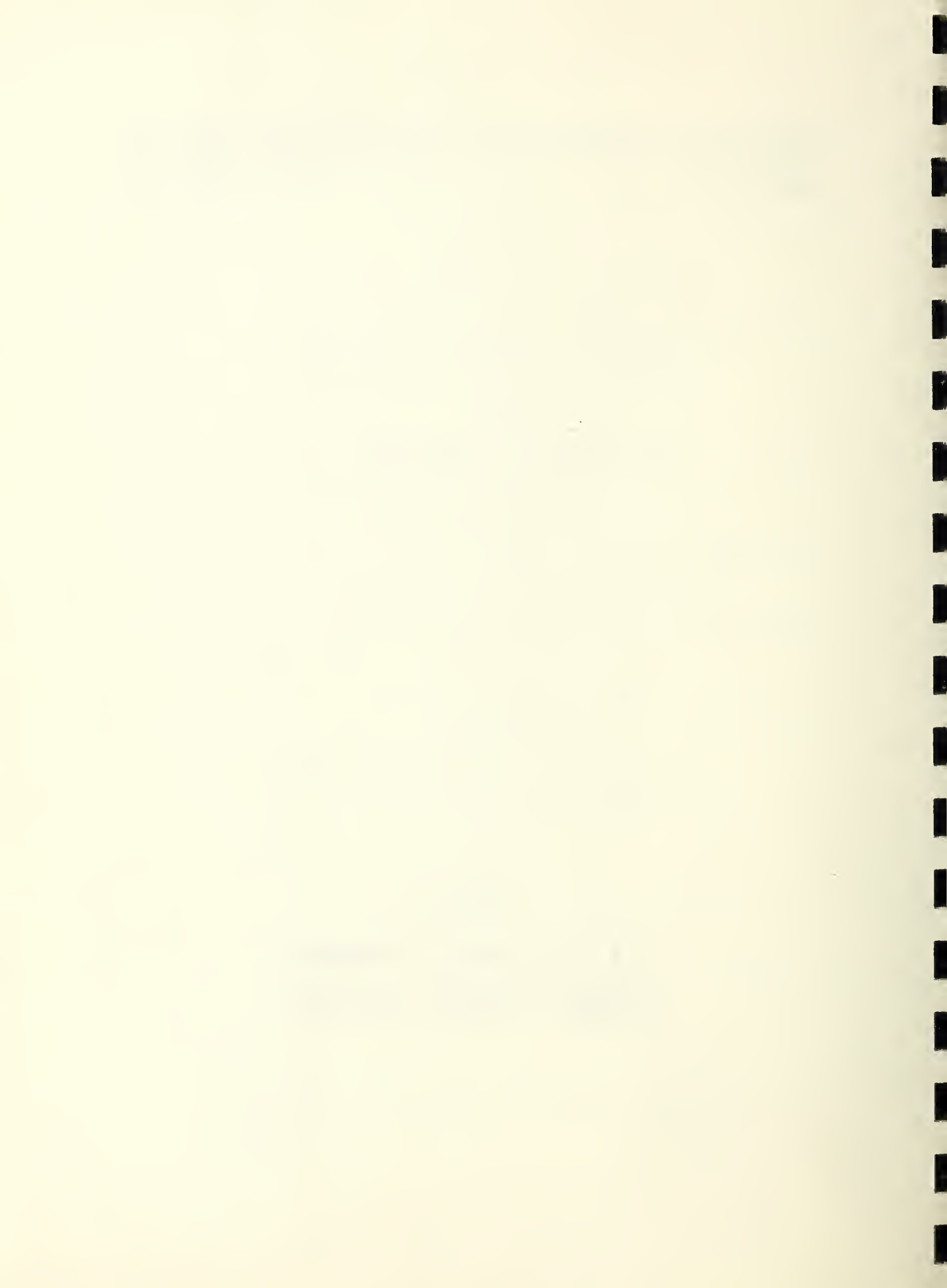
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## INTRODUCTION

This report lists unclassified projects concerned with building research and related subjects in progress at the National Bureau of Standards in Fiscal Year 1954.

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 numbers 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 development project being undertaken in Division 10, Section 3.





## ACOUSTICS

### 0601-20-0600 Calibration Procedures (Acoustic Equipment)

Objectives: Researches on, and development of, methods for absolute measurement of sound pressure and intensity over wide frequency and intensity ranges. Application of such methods to determination of the threshold of hearing.

Background: Absolute measurements of sound intensity made by means of calibrated microphones, which are used by industrial, academic, and Government acoustical laboratories. These calibrated microphones measure sound radiated by loudspeakers, noise, and other complex sounds. They are required also for audiometric measurements. Calibrations are effected by comparison of the microphones with standards maintained in the NBS Sound Laboratory.

Tasks: (1) Extension of the range of calibration of condenser microphones to very low frequencies. (2) Production and measurement of high-intensity sound fields at audio frequencies.

### 0601-30-0605 Acoustic Measurements

Objectives: To measure the sound absorption of acoustic materials and the sound-transmission properties of wall and floor constructions. To calibrate and measure the performance characteristics of electro-acoustic devices such as microphones, loudspeakers, earphones, sound level meters, and audiometers. To test acoustic devices such as dictating-machine cylinders, phonographs, etc.

Background: (A) Measurements of the sound absorbing properties of acoustical materials and the sound insulation of building structures require large-scale testing facilities. Those available in the NBS Sound Laboratory are used in making tests for the building industry and for Government agencies. (B) Microphones, sound level meters, and other electro-acoustical instruments require calibration in order to be useful in the laboratory. Such calibrations are performed under this project.

Tasks: The following measurements are made on a continuing basis: (1) Sound absorption coefficients of acoustical materials. (2) Sound insulation of wall and floor constructions. (3) Calibration of microphones, sound level meters, and earphones. (4) Miscellaneous sound measurements.

0601-10-0632 Architectural Acoustics

Objectives: Research on basic physical phenomena involved in the transmission and absorption of sound in building structures. Improvement of existing and development of new measuring techniques in architectural acoustics.

Background: Acoustical materials are widely used in buildings for reducing noise and improving acoustics of auditoria. The reduction of sound transmission from one part of a building to another part is an important technological problem. Researches on this project are for the purpose of standardizing the methods of measurement in architectural acoustics. Many of the phenomena of sound propagation in structures are imperfectly understood and require experimental and theoretical elucidation before improvements can be made in the present standard measuring techniques.

Tasks: (1) Investigation of interference patterns in reverberant sound fields. (2) Improvement of methods of measuring sound transmission loss and sound absorption. (3) The transmission loss of double walls.

0601-10-3550 Ground Sound

Objectives: The purpose is the measurement of the propagation of sound through soils up to distances of the order of three hundred feet, and correlation of the data with the theory for such propagation.

Background: Data on the propagation of sound through soils are needed in order to insulate buildings against vibrations transmitted through the ground. NBS is carrying on researches in order to determine how sound is propagated through soils up to distances of the order of 300 feet.

Tasks: (1) Measure the acoustical impedance of the ground as seen by a vibrator located on the surface. (2) Measure the velocity and attenuation of sound in soils as a function of distance and frequency of vibration. (3) Carry on a mathematical analysis of the propagation of vibrations over the surface of a semi-infinite solid having the properties of the ground, and correlate the theory and experimental data.



## AIR CONDITIONING, HEATING, AND REFRIGERATION

### 0302-10-0305 Thermal Conductivities of Gases

Objectives: Determination of thermal conductivity of gases, such as air, nitrogen, oxygen, carbon dioxide, and other gases. These measurements up to 500° C and 100 atmospheres pressure will permit reasonable extrapolation to higher temperatures and pressures and should serve to check on the present theories of thermal conduction of gases. Measurements of the thermal conductivities of helium and argon are also needed to serve as standards for calibrating apparatus.

Background: The accurate measurement of thermal conductivities of gases is difficult even at normal temperatures and pressures. Although measurements at high temperatures and pressures have been needed for a long time, very few have been made because of the difficulties involved. Much time has been spent on this project in the development of apparatus. The apparatus now is apparently operating satisfactorily and measurements on nitrogen are under way. There is need for accurate data on a number of gases so that conductivity values at very high temperatures can be obtained by extrapolation. There is also need for data on gases such as helium and argon which can be used as standards for calibrating apparatus.

Tasks: (1) It is expected that measurements of thermal conductivity will be completed on nitrogen at temperatures up to 500° C and 100 atmospheres pressure during FY 1954.

### 0302-10-2631 Thermodynamic Properties of Air

Objectives: The conduct of experimental and theoretical research on the thermodynamic properties of air over a wide range of temperatures and pressures.

Background: The correlation of the existing experimental data on air for the NBS-NACA tables revealed the need for experimental data for air. Such charts as exist are based only upon Joule-Thomson and meager PVT data at low temperature. These data are not reliable enough to permit tabulations over an extended temperature range at pressures over 100 atmospheres. The first stage of this project involves the experimental determination of the data of state (P, V, T). These data and the earlier data will be fitted in accordance with existing theory to a Lennard-Jones potential function, from which the other thermodynamic data can be computed.

Tasks: (1) Measurements of the data of state of dry air from 100 to 300° K and to 200 atmospheres. (2) Correlation of the PVT and other thermodynamic data for air.

Objectives: To investigate infrared optical properties of sources, window materials, reflecting or absorbing surfaces, and calibrate devices for the detection and/or quantitative evaluation of radiant energy and the measurement of humidity by radiometric instruments.

Background: The Radiometry Section has carried out many tests and researches on the transmission of materials, on filters, the radiant energy emitted by various sources, and the spectral sensitivity of different types of detectors. The present program will endeavor to find specific filters, detectors, and sources which will give the best combination in certain narrow regions of the infrared and in certain narrow regions of the ultraviolet. At present the work for the Weather Bureau consists almost entirely of calibration of pyroheliometers and similar devices used in the measurement of solar and sky radiation, and methods of determining humidity in the atmosphere.

Tasks: (1) To measure the spectral response of photoconducting elements. (2) To measure spectral response, temperature dependence of response, and other properties of pyroheliometers for the Weather Bureau. Tests of other energy measuring devices, such as special phototubes, as supplied. (3) To measure the scattering properties of diffused filters.

0507-20-0532 Utilization of Fuel Gases

Objectives: Research on fuel gases and gas-burning appliances, their use and control.

Background: 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 State Public Utility regulations, a large part of the AGA appliance approval program, and of various safety codes. A continuation of the work is needed to meet the needs of Government, industry, and the public for standards and technical guidance in this field.

Tasks: (1) Study of factors affecting the accuracy of recording gas calorimeters. Work continuing with cooperation of the Government of the District of Columbia, the Washington Gas Light Company, and the American Gas Association (which is supporting a Research Associate assigned to the problem). (2) Testing of gas appliances including laboratory burners. (3) Experimental work on technical questions involved in the interchange of gases. (4) Studying safety and other regulations in the field of fuel gas utilization and assisting in their development. (5) To assist in the inauguration of a program of supply of gases of standard heating value for instrument calibration.

0507-20-0559 Air Pollution

Objectives: To isolate, identify, and estimate gaseous air pollutants in various locations, under different industrial and meteorological conditions. To study sources and chemistry in the air in the light of the composition of the smog concentrates.

Background: Because of extensive experience in the analysis of unusual gas mixtures, NBS was invited by the U. S. Bureau of Mines and Los Angeles County authorities to apply certain specialized techniques to the identification of the gaseous constituents of Los Angeles smogs. The successful outcome of this work has led to requests for assistance from other areas where smogs constitute a serious nuisance and public health problem.

Tasks: (1) To complete the analysis of data collected in the work at Los Angeles. (2) To analyze smog concentrates collected at Detroit. (3) To advise and possibly cooperate in a study of Holland Tunnel Air to determine the contribution of automobile exhaust gases to the gaseous mixtures found in smogs.

0603-30-0613 Wind Equipment

Objectives: To conduct tests and calibrations of instruments and equipment applied to air movement, to devise test equipment and techniques.

Background: One of the basic functions of the NBS Aerodynamics Section is the testing of a variety of equipment applied to the measurement of air flow. These activities include the calibration of vane, cup, thermal anemometers, and pitot tubes; the testing of instruments to measure pressure; maintenance of velocity standards and test apparatus, and devising of test methods as required by new equipment.

Tasks: (1) Calibrate and test anemometers and pitot tubes for Federal and State agencies, universities, manufacturers, and users. (2) Devise methods and test equipment as necessary.

0603-20-3512 Wind-Measuring Systems

Objectives: To assist the Weather Services in development and selection of wind-measuring systems for field use.

Background: The Bureau of Aeronautics requested the NBS to investigate commercial types of wind-measuring systems in order to assist in the selection of suitable equipment for field use. The U. S. Weather Bureau has also requested limited assistance in their program of anemometer development. A general study of anemometry has been made and is continuing, with particular attention being paid to gust measurements.



Tasks: (1) Wind tunnel and exposure studies to be continued on present wind intensity and direction systems and extended to as many new systems as become available. (2) Investigation of time-response of present systems and development of systems with quick response to be continued. (3) Act as consultants on wind-measuring problems and development of new systems.

1003-20-1014 Heating and Air Conditioning Equipment

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

Background: There is a continuing need for collaboration with other Government agencies, professional societies, and with industry in preparing and improving codes and standards for heating, air conditioning, refrigerating, and air cleaning equipment. At present, for example, there is no one standard method for testing and rating baseboard radiators and convectors. The NBS, working with industry associations, has proposed certain test methods and some progress is being made toward a uniform rating code. Another example results from the increased use of package air conditioners by the Federal Government and the entry of many new manufacturers into production of these units, which has placed new emphasis on Federal specifications and on the testing and rating codes for such devices. It has also created demands for humidity control and capacity control not covered by existing standards and specifications.

Tasks: (1) Complete the development of the portable infiltration meter designed at the NBS for use in studying the air leakage in heated or air-conditioned buildings. (2) Complete papers for publication on the performance of a panel heating system in the Test Bungalow and on the performance of three different panels in the panel-heating calorimeter. (3) Complete paper for publication on the factors affecting comfort and heat requirements in forced warm-air heating systems.

1003-30-1015 Heat Transfer Measurements

Objectives: To develop and maintain equipment for accurately determining the thermal conductivity of materials for Government and scientific agencies, and to calibrate suitable specimens for the standardization of similar equipment in other Government, scientific, and industrial laboratories. To make thermal conductivity measurements for referee purposes.

Background: The need for accurate and complete data on the thermal properties of materials, and for the improvement and standardization among laboratories of equipment for determining such properties, is continuous. Commercial, industrial, Government, university, and scientific laboratories depend upon the NBS as a source of assistance in calibrating their devices and standardizing their methods of measurement for determining the thermal conductivity of solids.

Tasks: (1) Continue to develop and maintain equipment for more accurate thermal conductivity measurements on various materials, including thermal insulations and building materials; undertake cooperative calibrations for standardization purposes in this field; conduct required referee measurements. (2) Continue development and use of apparatus for determining the thermal conductivity of metals and solids of high conductivity, to obtain accurate data on materials and for the calibration of equipment in other laboratories. (3) Undertake establishment of a stock of suitable metals of accurately measured thermal conductivity for use by other laboratories as calibration and reference specimens available at low cost upon request. (4) Prepare a paper for publication describing a rotatable guarded hot box heat transfer apparatus and presenting data on the thermal conductance of air spaces.

#### 1003-10-4831 Air Conditioning in Underground Structures

Objectives: To obtain the engineering data essential to the proper design of air conditioning equipment for underground protective structures. This involves problems of heat transfer in large rock masses, the removal of moisture from underground spaces, the changes in sensible and latent heat content of ventilating air drawn through long underground shafts in all seasons, the investigation of promising heat sources and heat sinks for use with underground air conditioning, and the effect of these phenomena on the insulation and construction methods to be used for underground protective structures.

Background: Lack of information on the magnitude of heat and moisture transfer in underground spaces surrounded by large rock masses has made it impossible to systematically design air conditioning equipment for such spaces, with the result that too much capacity or the improper kind of equipment has been installed in a number of instances. To prevent such loss in the future, and because the need for such information could become critical at any time in the future, the Corps of Engineers initiated this project at NBS about three years ago. A large primary site is now being occupied at Ft. Ritchie, Md., and observations of heat and moisture-transfer in ventilating air shafts and in the surrounding rock are planned during the shake-down tests of all mechanical equipment. An experimental site at Mr. Weather, Va., has been in operation for more than a year and a large amount of data has been taken at this site. Experiments at this site are still in progress. This project is a part of the Bureau's basic program of study of the properties of building materials and structural elements.



Objectives: To determine by means of laboratory investigations, the extent to which portable and mobile refrigerating units and systems for military use can be improved in performance and reduced in size and weight by utilizing improved designs and newly-developed components; and to prepare and revise specifications for refrigerating equipment used by the Military Services.

Background: The NBS Heating and Air Conditioning Section has conducted this program of research and development on refrigeration equipment for the Office of The Quartermaster General since 1944. It represents a continuing effort on the part of the Research and Development Branch of the Office of The Quartermaster General (1) to develop portable and mobile refrigerating systems for the Army that will have the desired military characteristics of performance under extreme temperature, of ruggedness, and of durability without excess weight for size by incorporating new developments and materials in their construction whenever they are beneficial; (2) to standardize equipment or components thereof with other branches of the military where similar equipment is required; and (3) to revise specifications where possible, so commercial items can be purchased. Many of the systems used during World War II were hastily assembled for rapid production without sufficient consideration for adequate performance with the minimum of size and weight. This project is a part of the broad program of the NBS in developing devices for the special needs of the Government.

Tasks: (1) Complete study of the effect of independent speed variations of the compressor, condenser fan, and evaporator fan on the capacity of several plug-type refrigerating units. (2) Complete study of the basic requirements of an automatic defrosting system for refrigerating units operating near 0° F. (3) Complete portions of a study of the air distribution in loaded and partially-loaded refrigerated trailers. (4) Complete portions of a study of the temperatures attained on the insulated doors of refrigerated warehouses with particular attention to the gasketed areas and latch areas as they affect the tendency for doors to freeze shut. (5) Revise the Federal Specification on electric refrigerators to include requirements on automatic defrosting, door racks, low-temperature compartments, and other special features. (6) Report on performance of special dehydrators using calcium carbide, calorimeter measurements of capacity for a special compressor, performance of gasoline lanterns with special deflectors to prevent excessive mantle breakage.



Objectives: To conduct experimental studies and establish criteria by means of which deterioration of the structure or insulating value of prefabricated sectional refrigerated chambers due to moisture condensation and accumulation can be prevented or minimized.

Background: The cost of prefabricated sectional refrigerators purchased by the Armed Forces each year totals several million dollars. Common construction employs metal skins on inner and outer surfaces and often uses structural members of wood because of its low heat conduction and good strength. However, complete protection against moisture entry and accumulation is often not obtained, and accumulated moisture causes early deterioration of insulating value, rot or decay of insulation and wood members, or corrosion of metallic fasteners and faces. While studies have been made of many types of wall constructions for heated buildings to avoid moisture condensation within the structure, no comprehensive studies have been made for sectional refrigerator construction (a much more severe service) in regard to relative vapor permeances of panel faces, effect of leaks, materials and design of construction, and of ventilation, to assure adequate protection against moisture and retention of insulating value under various conditions of inside and outside temperature. Because of its long-term concern with the purchase and maintenance of such refrigerated structures, the Office of The Quartermaster General requested that the facilities of the NBS in connection with heat transfer measurements and moisture problems in buildings be applied to this research program. The studies have a direct relationship to the problems involved in the construction and maintenance of buildings in arctic climates.

Objectives: To develop enclosures for weather instruments that will permit more accurate measurement and recording of temperature and humidity on board ship or on land under all weather conditions than is possible with existing wooden enclosures.

Background: The Bureau of Aeronautics initiated this project at the NBS about five years ago because it had been found that the standard wooden enclosures (thermoscreens) did not provide an environment for the weather instruments that permitted sufficiently accurate measurements of temperature and humidity under certain weather conditions. A small, inexpensive thermoscreen for large scale use is desired that will have an accuracy of 1° F under all conditions and a second thermoscreen of greater accuracy is desired for more limited use with elaborate electronic recording apparatus.

Tasks: (1) To complete the design of a small pilot model thermoscreen having an accuracy of 1° F under all weather conditions and to build five prototypes of this model. (2) To complete the design of a precise thermoshield for use with electronic recording equipment and build a prototype. (3) To compare these two thermoscreens with a specimen wooden thermoscreen of the type currently in use. (4) To prepare a final report of the test results and the development of these devices. It is expected that this project will be completed in FY 1954.

1003-20-4835 Grease Filters

Objectives: To determine the factors essential to the establishment of a test method for evaluating the effectiveness of grease filters and to determine the requirements of a standard specification for grease filters for use in the exhaust ducts of kitchens and galleys. This includes studies of the factors that affect the deposition of grease in ducts and of the effectiveness of various methods for cleaning grease filters.

Background: Grease deposits in uptake ducts from kitchens and galleys continue to be a serious fire hazard and heretofore no test method has existed for determining the effectiveness of a material for removing the grease from the stream of air entering the uptake or exhaust duct. This project was initiated by the Bureau of Ships about five years ago with a request that a test method for grease filters be developed. The NBS has developed a test method for determining the effectiveness of filtering media in removing grease from an air stream and has used it on a number of commercial filters and some special water-cooled filters developed by the Bureau here. Investigations of filter-cleaning methods have resulted in recommendations to the sponsor on the best procedure to be used. It is desirable to continue and conclude this investigation so that requirements for the performance of grease filters can be included in Government specifications for such items.

Tasks: (1) Apply NBS test method to special prototype flatfin filters and to a commercial grease arrester using the centrifugal principle. (2) Continue and complete the investigation of the effect of lint and duct temperature on the thickness of grease deposits and the possibility of draining off grease accumulations at selected places in a duct system. (3) Prepare a final report on the development of a test method for grease filters and recommend requirements for specification use. It is expected that this project will be completed during FY 1954.

1003-30-4837 Air Cleaner Tests

Objectives: To determine the performance of air cleaners of various types selected by Public Buildings Service in regard to dust-arresting efficiency, pressure drop, dirt-holding capacity, and cleanability, and to assist in preparation of PBS procurement specifications for such equipment.



Background: The latest general specification for air-filter equipment issued by PBS was about 1934. Since that time, commercial units have been improved and new types of equipment have made their appearance. Accordingly, PBS has requested that information be obtained on representative units of all types of current importance as a basis for new specifications and file data as to equipment which will meet specifications. This work constitutes an effective means of directly applying the methods of determining air-filter performance developed at NBS to assist in procurement of the most satisfactory air cleaning equipment for Government service.

Tasks: (1) Conduct tests of representative models of four types of air cleaning equipment: Group I - Electrostatic Air Cleaners, Group II - Automatic Oil Filters, Group III - Replaceable Media Filters, Group V - Throw-Away Type Filters.

1003-20-4838 Air Filter Systems for Army Aircraft

Objectives: To develop and construct models of air cleaners that will be more effective than present devices in protecting aircraft and helicopter engines from excessive wear in dusty atmospheres. This involves gathering existing information on air cleaning methods and a study of all known physical principles that may be used for removing dust from a moving air stream.

Background: 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. It is highly desirable that present information on the subject be gathered and correlated and that steps be taken to assure that the best physical principles are applied to the development of more effective air filters for aircraft engines.

Tasks: (1) Survey of past work; visits to other laboratories, Government and private, to inspect existing test methods and procedures and to consult with technical personnel with experience in this field. (2) Dismantle and inspect specimens of aviation engines after use in the field to determine where damage is due to dust, and to microscopically examine any dust residue in manifold passages, combustion chambers, and air cleaners. (3) Obtain samples of dust, through Army channels, from various flying fields, domestic and foreign, for microscopic analysis.

1003-30-4839 Thermal Conductivity of Inconel

Objectives: To measure accurately the thermal conductivity of four Inconel alloys of special interest to the National Advisory Committee for Aeronautics.

CEMENT, CONCRETE, AND MASONRY

0903-20-0903 Development of Evaluation Criteria and Methods for Refractory Materials

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

Background: Castable refractory is a comparatively recent addition to this group of commodities. Its importance to industry is increasing because of the present shortage of men capable of laying up firebrick. The properties of castables are being investigated for the purpose of establishing technical requirements for a new Federal specification and to publish information on compositions and properties as an aid to industry.

Tasks: (1) Firebrick: Inactive, (2) Plastic Fire-Clay Refractories: Accumulated results of tests to be written into manuscript form. Change of length to be studied during heating from 20° to 1500° C of proprietary brands of materials. This test work is planned for the latter part of the year and is dependent upon the progress made on Task 3. (3) Castable Refractories: Length changes with increase of temperature from 20° to 1350° C and strength and elastic properties at a number of high temperatures to be investigated.

0903-20-4428 Evaluation of Refractory Qualities of Concretes for Warm-Up Aprons for Jet Aircraft

Objectives: The evaluation, on the basis of physical properties, of the suitability of concretes prepared with each of three different types of hydraulic cement and a wide variety of aggregates, as warm-up and power check aprons for jet aircraft.

Background: The inventions of the turbojet, the ramjet, the rocket engine, and the use of jet planes have brought with them the problem of suitable materials of construction for warm-up and power-check aprons for aircraft and launching pits for rockets. The intense heat developed preceding takeoff or launching of jets may cause destruction of ordinary portland cement concrete because of cracking, spalling, or deterioration in strength. In addition to resistance to destruction by heat, such installations must have and maintain high strength and the aggregates, if concrete is used, should preferably be readily available, both as to quantity and proximity to the site of the installation.

Tasks: (1) The design of refractory concretes using portland, portland pozzolan, and high alumina hydraulic cements with a wide variety of dense or heavy aggregates and the fabrication of several types of specimens therefrom for test purposes. (2) The determination of certain physical properties of the concretes, such as thermal expansion and contraction, hardness of the aggregates, thermal conductivity, strength, Young's modulus resistance to abrasion.

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

Objectives: (A) To compare the resistance of various concretes as subjected to four different cycles of freezing and thawing and to attempt to correlate the resistances found with volume changes, both transient and residual, pore properties, etc. (B) To continue development work on methods of determining pore sizes in concrete and its constituents by adsorption and porosimeter methods.

Background: The durability of stone and concrete under exposure to the action of freezing and thawing, wetting and drying, salt action, etc., is of major concern to the construction industry and those who employ such materials. The durability is so closely related to the pore size, pore distribution, and fine structure of the solids that information on the latter is of prime importance. The study of volume changes accompanying exposure is expected to throw new light on the disintegration process.

Tasks: (1) Construct a mercury porosimeter to measure the larger size pores which cannot be evaluated by the existing low temperature adsorption methods. (2) Continue work on the relationship between pore size and durability of aggregates. (3) Determine the effect of a number of variables such as freezing rate, thawing rate, moisture content, etc., on the resistance of concrete to laboratory freezing and thawing. (4) Continue work on determination of the mechanism of the deleterious reaction between high alkali cements and certain reactive aggregates.



0906-20-4415 Cement Reference Laboratory

Objectives: Standardization and calibration of equipment in cement-testing laboratories throughout the United States

Background: This project is jointly supported by the NBS, the Bureau of Public Roads, the Corps of Engineers, and by funds received through the ASTM. The project was started in order to standardize cement-testing procedures and equipment and to clarify specifications for portland cement.

0906-30-4433 Portland Cement Testing

Objectives: To make acceptance tests on portland cement as requested by other Federal agencies and investigate and inspect test methods and procedures.

Background: Acceptance tests of portland cement are normally performed on samples obtained while the cement is being transferred to storage silos or bins. The cement is held in storage until the tests are completed and, upon acceptance, is shipped as orders are received. It is not practicable for the manufacturers to maintain separate stocks of tested cement for each Federal agency and hence, the need for a single testing agency for Federal Government purchases. The National Bureau of Standards has been rendering this service for over 40 years and currently operates testing stations at San Francisco, Seattle, Denver, Kansas City, Allentown, and Washington, D. C. Inspection facilities are maintained at some 90 cement plants while at others samples are submitted to the Bureau by the Inspector of Naval Material. During fiscal 1953, samples representing some 13,000,000 barrels of portland cement were tested. Development and comparative work on test methods for cement are a proper adjunct to the testing program.

Tasks: (1) Samples will be tested as submitted. (2) Cement-testing equipment will be inspected. (3) Comparative tests will be made as follows: (a) European vs American tests on cement. (b) Flexural tests vs compression tests. (c) Similar specimens subjected to four different freezing and thawing procedures. (d) A variety of representative cements will be used to fabricating concrete specimens for long-time outdoor exposure.

0907-10-0914 The Chemistry of Portland Cement

Objectives: To improve the usefulness, the dependability, the quality, and the economy of cement in concrete and to contribute to the fundamental knowledge of the physical chemistry of cementitious materials.



Background: A considerable number of advances in the technology of cement production and in the art of designing cement for special purposes have resulted from investigations which have been supported jointly by the Portland Cement Association and the National Bureau of Standards for the past 29 years. At the present time, investigations are in progress that are making possible designed control of the molecular structures by virtue of which cement functions as a bonding agent. These studies include X-ray crystal structure, phase equilibria, differential thermal analysis, and electron microscopy. Incidental discoveries are being developed that are proving of value in the entire field of physico-chemical research. Such are precision temperature control, growth of perfect single crystals, high-temperature furnace centrifugation, and mathematical contributions to increase the applicability of phase-rule techniques.

Tasks: (1) The crystal structure of cement compounds is under study in several laboratories in various countries. NBS studies in this field were initiated three years ago and a part of this work, the crystal structure of tricalcium aluminate, is now nearing completion. (2) The gels of hydrated cement compounds have been under study at NBS for over a year by means of electron microscopy. The ultimate particles of calcium silicate hydrate have been observed for the first time and this part of the investigation should be completed during the next year.

0908-10-0924     Composition and Durability of Plasters, Cements,  
and Mortars

Objectives: To study the composition and durability of cements, limes, and mortars in relation to the properties of the magnesium and other oxides contained in the cementitious materials.

Background: The durability of cementitious materials, particularly those containing magnesia, cannot at present be predicted. It is believed that a knowledge of the activity of MgO and the effect of the history of the MgO on that activity will go far toward explaining the failures in service that occur in such materials. A study should also be made of the properties of lightweight aggregates being used in lieu of sand in plasters.

Tasks: (1) Critical study of methods for determining the cement content of mortars and concrete. (2) Workability characteristics of hydrated limes. (3) Measurement of the activity of magnesia. (4) Properties of lightweight aggregates used in plaster. (5) Method for measuring pozzolanic activity.

0908-10-0943 Physical Chemistry of Hydrated Silicates,  
Aluminates, and Ferrites

Objectives: To study the physico-chemical relations at normal and elevated temperatures in aqueous systems containing silica, alumina, ferric oxide, or combinations of these, together with hydroxides of the alkaline earths; also to determine the composition and means of preparation of compounds occurring in such systems.

Background: Previous work in this field by NBS includes a study of the hydration of the calcium aluminates, a study of the system  $\text{CaO-Al}_2\text{O}_3\text{-H}_2\text{O}$  at 21° and 90° C, a study of the system  $\text{CaO-SiO}_2\text{-H}_2\text{O}$  at 30°, hydrothermal synthesis of calcium silicate hydrates and the calcium hydrogarnets, and a study of calcium silico-aluminate hydrates. This has aided in the interpretation of the mechanism of the hydration of cement, and of the effect of steam-curing and autoclaving of cement.

Tasks: (1) A study of the system  $\text{CaO-Al}_2\text{O}_3\text{-H}_2\text{O}$  at temperatures above 100° C. (2) a study of solid phases formed in the system  $\text{CaO-Al}_2\text{O}_3\text{-SiO}_2\text{-H}_2\text{O}$  at room temperature. (3) Mechanism of reaction of water on calcium aluminates in light of system  $\text{CaO-Al}_2\text{O}_3\text{-H}_2\text{O}$ .

1001-10-1000 Masonry and Reinforced Concrete

Objectives: To secure basic data in the laboratory on properties of masonry, concrete, and reinforced concrete, including stone, brick, concrete masonry units, masonry mortars, lightweight concrete, and reinforced concrete. These data will indicate ways to improve specification requirements for various service conditions and for effecting economies in the use of critical materials.

Background: In order to predict durability of brick and stone under various conditions of weathering, there is a need for correlating various properties determined in the laboratory with results of outdoor exposure tests. Exposure tests of brick started on the NBS grounds in 1936, on roofing slate in 1933, and on building stone in 1948, are being continued in this connection as one phase of this project. Another large phase is the work done in collaboration with the producers of masonry cement on Masonry Research. Such research is needed to provide information on the structural properties of masonry to indicate how the various materials available can be used in the most economical ways. Continuation of a study of properties of reinforced concrete is another phase. It is also planned to continue collaborative work with the Fellowship of the American Iron and Steel Institute. This will include research and development of theory needed to formulate new design practices with respect to control of the width of cracks and resistance of reinforced concrete to shear.



**Tasks:** The study is of continuing nature. The following tasks will be continued and/or initiated during FY 1954: (1) Make periodic examinations of stone exposure test wall, study effects of 20-year exposure of roofing slate, and analyze observations from long-term masonry exposure tests. (2) Study of thermal and moisture characteristics of marble, sandstone, and limestone over natural temperature range. (3) Collaborate with Masonry Research Fellowship by conducting a survey of portland masonry cement and by performing tests of masonry assemblages. (4) Complete comparative tests of conventionally reinforced columns and specimens containing high-strength welded wire fabric as reinforcement. (5) Collaborate with American Iron and Steel Fellowship in performing tests and analyzing data on shearing strength of reinforced concrete and formation of tensile cracks in beams and slabs.

1001-10-4811 Precast Thin-Shell Concrete Structures

**Objectives:** To evaluate and develop prototype design of thin-shell precast and prestressed concrete elements and buildings. This will include the determination of strength, elastic stability, adequacy of joint watertightness, and resistance to fire, of precast thin-shell ribbed concrete panels and hollow-section framing members, with and without prestressed reinforcement.

**Background:** Precast thin-shell ribbed panels and hollow-section framing members are a relatively new type of construction, particularly those containing prestressed reinforcement. Technical data on design aspects such as the cross sections of the members, orientation and amount of reinforcement, and losses in prestress resulting from plastic flow are urgently needed. Buildings making use of structural members of this type are being planned at present by the Bureau of Yards and Docks.

**Tasks:** This study is of a continuing nature in which the designs of structural members evolve as the evaluation tests proceed. The following tasks are in progress: (1) Upon selection of a panel design following tests completed in FY 1953, several panels of the selected type are to be assembled into a single unit and adequacy of prestressing in securing watertight joints is to be determined. (2) Determine effect of fire on strength of panels with and without prestress. (3) The evaluation of the strength and rigidity of hollow-section prestressed concrete frame is to be carried out on a full-scale structure with particular emphasis on checking the continuity provided by prestressing units at the junctions of individual structural members. (4) The evaluation of the strength and rigidity of a thin-shell panel prestressed transversely with welded wire fabric and longitudinally with the conventional prestressing rods. (5) The evaluation of properties of autoclaved thin-shell cell-like blocks with emphasis on their possible use in prestressed slab and beam assemblies.

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

Background: Both the results of tests conducted in laboratories and of extensive experience with structures indicate that the drying shrinkage of walls of concrete masonry and of monolithic concrete is responsible for much of the cracking observed. Despite widespread interest in cracking resulting from drying shrinkage, the literature contains no method by which design engineers may 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.

Tasks: (1) Complete preliminary study to select appropriate material and testing technique for small-scale models. (2) Complete preliminary study to ascertain which of the several analytical methods will yield useful results at the least cost. (3) Initiate study to determine the effect of length on the direction and relative magnitude of the stresses in plain walls attached to rigid foundations. (4) Same as Task 3, except that height of wall is to be the variable factor.

#### CODES AND SPECIFICATIONS

0201-30-0208      Specifications for Electrical Supplies,  
Lamps, Colors

Objectives: Formulation of Federal Specifications for electrical supplies, lamps, and colors, and cooperation with ASA and IES in allied fields in order to obtain coordination, particular stress being placed upon the development of improved qualification tests for lamps, on insuring interchangeability of lamps, and on the assignment of uniform designations to lamps.

Background: Closely related to the acceptance and qualification inspection and testing of lamps for the Government which have been conducted at NBS for many years, are applicable Federal Specifications developed under this project for electrical supplies.

Objectives: Utilization of NBS laboratory results and specialized knowledge in connection with recommendations for safe building construction, safety of building equipment, industrial safety, and home safety.

Background: Government officials, construction and safety engineers, and the general public look to the NBS for technical information to be used in regulations and manuals designed to prevent injuries and loss of life. As a consequence of presenting data to various standardizing bodies, results of NBS work find application in State and local codes and in National safety standards. Among the organizations concerned are the American Standards Association, American Society for Testing Materials, National Safety Council, National Fire Protection Association, Federal Safety Council, and Federal Fire Council.

Tasks: Activities are of a continuing nature, requiring (1) development of new safety standards, (2) periodical revision of existing safety standards, (3) determination of factors affecting personal safety, and (4) technical research on safe use of materials and assemblies in buildings, building equipment, industrial processes, and the home.

#### FIRE DETECTION AND PREVENTION

##### 0801-10-0802 Properties of Metals at High Temperatures

Objectives: To determine the influence of stress, strain rate, temperature, and thermal and mechanical history upon the characteristics and mechanism of creep and the failure of metals at elevated temperatures.

Background: Numerous formulas have been proposed to predict the time-temperature relationship in single and polycrystalline metals but none is entirely satisfactory. Additional studies, under carefully controlled conditions, are essential before a theory completely acceptable can be established. A fundamental knowledge of the mechanism of deformation, including the physical and metallurgical changes occurring during deformation at different temperatures, is essential for the most economical utilization of the present metals and alloys and for the development of new materials for the defense agencies and industrial applications.

Tasks: (1) Complete tests and prepare papers summarizing the results of creep tests on high purity nickel and short-time high temperature tests of both high-purity and commercial 70% Ni, 30% Cu alloys. (2) Make creep tests on high-purity 70% Ni, 30% Cu alloy. (3) Make short-time high temperature tests on 30% Ni, 70% Cu alloy.



Objectives: To investigate methods of preventing and reducing losses resulting from accidental fires. This involves the determination of the fire-resistive properties of various types of materials and constructions and investigations of (1) the self-ignition characteristics and ignition temperature of materials; (2) the stimuli and sensing devices which may be used for fire detection; (3) the mechanism of fire spread; and (4) the methods of fire extinguishment.

Background: There is a constant need for up-to-date information on the fire-resistive properties of new building construction materials and of fabricated assemblies, particularly those designed to reduce weight and cost as far as possible. A better knowledge of the basic mechanism of fire spread in full-scale structural members and of the mechanism of extinguishment by available agents is essential for effective detection and control of fires.

Tasks: (1) Investigations of (a) the spontaneous heating and ignition of materials; (b) the fire-resistive properties of materials and constructions; (c) the efficacy of various fire-retardant treatments and coatings; and (d) the mechanism of extinguishment of oil fires by dry powders will be continued. (2) Preparation of papers leading to publication of results of those phases of the fire research studies completed during the present and previous fiscal years.

Objectives: To study the properties and characteristics of flame, in order to ascertain which might be used for the detection of fires in aircraft engine nacelles and compartments; to evaluate the various possible methods of fire detection, and to recommend to the Air Force the most feasible method to be used for further development.

Background: The Air Force is not satisfied with present commercial fire detection systems for aircraft engine nacelles. One of the principal reasons for this is frequent false alarms, which negate the positive detecting value of the instrumentation. As a result of many failures, the Air Force has decided to turn back to a study of fundamentals in order to be able to decide as to which direction further instrumentation development should turn.

Tasks: (1) Continue studies on characteristics of flames which might be useful for fire detection in aircraft including spectral emission, fluctuation of radiant energy, air ionization, and contact heating ability. (2) Evaluation of flame characteristics in relation to operating requirements of fire detectors as specified by the Air Force. (3) If desirable, construct and test prototypes of promising types of detectors. (4) Write final report.



1002-30-4822 Fire Tests of Prestressed Concrete Beams

Objectives: To perform fire-resistance tests of six prestressed concrete beams as a part of a joint investigation of this type of beam by the Fire Research Station of Great Britain and the NBS.

Background: Prestressed concrete construction provides one excellent method by which economy in the use of steel for building construction may be accomplished. Although a number of buildings have been erected in which prestressed concrete has been used, very little information is available on the fire-resistance behavior of such structures. The Fire Research Station of Great Britain has started an investigation of prestressed concrete beams and has requested that the NBS cooperate with them by testing larger specimens than is possible in their furnaces.

Tasks: (1) Complete conditioning of specimens. (2) Perform fire-resistance tests. (3) Analyze the results and, if possible, correlate them with the results of previous tests of small-scale specimens. (4) Prepare a summary report on the subject.

1002-30-4824 Evaluation of Marine Use Material

Objectives: To obtain data on the constructional features and evaluate operating behavior of equipment and materials requiring Coast Guard approval for marine use.

Background: Each year for several years, the NBS has made numerous individual tests for the U. S. Coast Guard and has provided them with technical data to permit action to be taken on materials and equipment submitted for approval for marine use. The purpose of this project is to coordinate this work under one transferred fund, thereby assuring better control and simplifying procedures.

Tasks: (1) Continuation of tests and examinations of equipment and materials as required by the U. S. Coast Guard. Typical work includes type tests of fire extinguishers submitted for U. S. Coast Guard approval and a program for evaluation of various methods for test of flame-spread hazards of materials.

## PLUMBING

0603-10-0618 Research in Hydrodynamics

Objectives: To investigate various basic problems of hydrodynamics which have direct importance in engineering applications, or which are of importance in advancing basic knowledge of hydrodynamic phenomena.

Background: This project constitutes the NBS continuing research program covering the broad field of hydrodynamics. It is desired to expand fundamental research of this type and to enter fields not now being covered. One such field is that of sediment transportation. Previous work included studies of floor waves, solitary waves, wind effects on water surfaces, and flow in open and closed conduits.

Tasks: One of the tasks is to complete analysis on form of surface of reservoir under severe wind storms. Another is to make experiments on saline intrusion in sand beds.

0804-10-0817 Underground Corrosion Circular

Objectives: To revise Circular C450, Underground Corrosion, as a final report and summary of the 30-year program.

Background: For many years, the National Bureau of Standards has conducted a wide program of tests of engineering materials exposed to a variety of soils underground. This work has been completed and all of the specimens have been returned and the corrosion damage evaluated. The results are now being incorporated in a revision of Circular C450, Underground Corrosion, which was first published in 1945. This work is the only authoritative publication on the subject and has had wide circulation.

## PROPERTIES OF MATERIALS

0103-30-2020 Tests of Electric Distribution Line Components

Objectives: This project comprises the development of methods of testing for essential properties of various components used in high voltage distribution lines; the relative evaluation of the suitability of available devices such as lightning arrestors, line insulators, and other components; experimental and advisory assistance in the preparation of improved specifications for the purchase of line components.

Background: Work of this type has been requested for several years by the Standards Group of the REA to give them engineering data on which to base recommendations for the construction of transmission lines by their subsidiaries. Electrical work is done by Division 1, mechanical tests by Division 6.

Tasks: (1) Further tests of line insulators using very high rates of rise of voltage. (2) Comparative tests of lightning arrestors. (3) Mechanical strength tests on transmission line hardware.

0204-10-0221 Thermal Expansion

Objectives: Investigation of thermal expansion of metals, alloys, and other solid materials as required for science and industry.

Background: Determinations of thermal expansion of chemical elements and alloys, and the magnitudes of the dimensional changes that occur during transformations in various temperature regions, are necessary for progress in science and industry. In particular, such data on low-expanding alloys should lead to new applications in connection with length standards; also for thermostats, pendulum rods for clocks, indicating pyrometers, and other devices having special thermal properties.

Tasks: (1) Completion of investigation and preparation of manuscript on thermal expansion of low-expanding alloys, to be completed about January 1954. (2) Compilation of references is a continuing task. (3) Completion of investigation and preparation of manuscript on thermal expansion of some rare metals to be completed about June 1954.

0302-10-0303 Calorimetric Measurements

Objectives: To investigate the need and satisfy the demand for improved standard substances to be used in calorimetric work in the range 12° to 2000° K. This includes measurements of heat capacities of solids, liquids, and gases, heats of transitions, and heats of reactions such as in combustion. To determine the thermal properties of selected pure substances which are of fundamental importance to thermodynamics and related fields. Also, to determine the purity of certain materials, using calorimetric measurements.



Background: The need for more and improved standard substances has been widely recognized by those making calorimetric measurements. NBS is participating in the program for standard substances proposed by the Fourth Conference on Calorimetry (U.S.). Further work needs to be done, both on heat-capacity standards and on standard substances to be used for calibrating calorimeters. With the increasing importance of high-temperature thermodynamics, it is desirable to extend the temperature range of the present heat-capacity measurements. Accurate measurement of heat capacity of solids, liquids, and gases are essential to the evaluation of the thermodynamic functions enthalpy, entropy, and free energy. The calorimetric laboratories in the NBS Thermodynamics Section are able to measure with the highest accuracy all of the following: (a) heat capacity of solids and liquids over the temperature range 12° to 1200° K, (b) heat capacity of gases at moderate temperatures and pressures, and (c) heats of combustion and heats of solution. The measurements on gases have added significance in that they permit a check on the interpretation of molecular spectra and structure which is used to extrapolate thermodynamic functions to very high temperatures where it is impossible to make accurate experimental determinations.

Tasks: (1) Formulate and publish the heat capacity studies in the range 12° to 1200° K on n-heptane and aluminum oxide (sapphire) used as heat capacity standards. (2) Measure in the range 12° to 400° K the heat capacity and compute entropy of  $\text{Cl}_2\text{C}:\text{CCl}_2$  or  $\text{CF}_3\text{-SF}_5$ . (3) Construct an adiabatic calorimeter for use to about 500° C, capable of 0.1 to 0.2 percent accuracy. Test the calorimeter by making measurements of the heat capacity of aluminum oxide (sapphire) over this range. (4) Review literature and make preliminary investigation of promising reactions suitable for calibrating calorimeter used in the measurement of small quantities of heat. (5) Complete measurements and analysis of gas heat capacity of fluorocarbons started earlier.

0901-10-0942     Special Porcelains for High Temperature  
                  Service and Improvement of Glazes

Objectives: (A) To conduct an exploratory study of special oxide systems. (B) To study the effect of composition and firing of glazes on their "bubble structure" and related wear resistance.

Background: (A) The constantly increasing demands for high-temperature duty materials in missiles and for military weapons requires that other materials be investigated as replacements for metallic alloys. The inherent refractoriness, strength, and corrosion resistance of ceramic oxides indicate that they should be completely explored. Previous work at the NBS has shown that basic combinations of beryllia with zirconia have great promise, due in large part to the high thermal conductivity of beryllia and strength imparted by the zirconia. This basic composition, modified by other oxides, produce ceramics that cannot be found in any other ceramic-oxide combinations. (B) The ultimate objective is the improvement of resistance to abrasion of tableware glazes. This applies to ware used in homes, public restaurants, and in the mess halls of the various Defense agencies. The immediate objective is the study of the effect of composition and firing on bubble structure for the purpose of decreasing or eliminating such bubbles, and thereby to enhance the serviceability of the ware.

Tasks: (A) The general equilibrium diagram and maturing behavior having been determined for the systems  $\text{BeO-TiO}_2\text{-ZrO}_2$ ,  $\text{BeO-CeO}_2\text{-ZrO}_2$ , and  $\text{BeO-Cr}_2\text{O}_3\text{-ZrO}_2$ , there remains the preparation and physical testing of specimens and the writing of the report. (B) A suitable laboratory space and equipment must be prepared for the storage of materials and the preparation of specimens. Physical testing will consist of microscopic examinations, hardness tests by diamond indentation, and simulated wear tests.

0604-20-0614     Static and Dynamic Techniques for Load and Strain Measurements

Objectives: Development of elastic load measuring devices for calibrating testing machines; development of techniques for determining mechanical properties of materials at high rates of loading; development of methods for evaluation and comparison of hardness testing machines.

Background: As a part of its work on the development of methods for testing materials and mechanisms, the NBS is extending its study of methods of load calibration of testing machines. A new method for obtaining stress-strain relationships for structural materials at high rates of loading is also being developed. The study of methods for the measurement of hardness is being continued, principally along the line of a study of the performance of existing equipment for hardness testing.

Tasks: (1) Extend the range of static load calibration equipment above 500,000 lb and below 200 lb. (2) Investigate and improve methods for the determination of dynamic stress-strain characteristics of structural materials. (3) Investigate factors in the field of hardness and micro-hardness tests bearing on the accuracy and reproducibility of the results. (4) Study improved methods for measuring the output of elastic load calibrating devices using wire strain gages.

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

Objectives: Calibration of mechanical testing machines, dynamometers, load cells, force, strain, displacement, velocity and acceleration measuring equipment; development of test equipment and methods; assistance in the formulation of specifications.

Background: The NBS provides the only service available for the accurate calibration of elastic devices used for calibrating testing machines. Some 250 devices per year 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 made with devices calibrated at NBS. Calibrations of strain and displacement measuring equipment are performed for other Government agencies. Assistance is given in reviewing the requirements for mechanical tests included in specifications.

0604-10-3516     Engineering Structures

Objectives: To determine the stress distribution and strength of structural connections at bulkhead intersections in welded ships.

Background: The large number of structural failures in welded merchant ships during World War II led the Ship Structure Committee to initiate long range studies of the design and methods of construction of welded ships. A part of this investigation was to be concerned with design details of structural discontinuities. At the request of the Bureau of Ships, Navy Department, a program of tests on design details of bulkhead intersections and interrupted longitudinals for welded tankers was undertaken at NBS in 1948.

Tasks: (1) Preparation of final report on measurements of elastic stress distribution at room temperature, plastic strain distribution at 0° F, and energy to fracture on welded bulkhead intersection ship specimens.



0604-30-3567 Survey of High-Temperature Strain Measuring Devices

Objectives: To make available in the form of a critical survey comprehensive information on the current status of development of high-temperature strain gages and calibration methods, and an evaluation of their theoretical and practical limitations, useful in the planning and conduct of research and development on such devices and methods, and useful for provision of general guidance in instrumentation problems concerned with high-temperature strain gages.

0707-10-0733 Research on Properties of Plastics

Objectives: To determine the properties of plastics, in particular, the physical and chemical properties of plastic films and the mechanism of degradation of polyvinyl chloride.

Background: (A) Plastic films are being used in an ever-increasing volume by Government and industry, but data on the properties of these materials are not complete and manufacturers' data are frequently not comparable or variations from material to material occur because of variations in test methods. These data will be used to prepare specifications and guide their use by Government agencies. (B) The degradation of plastic materials is one of the most important problems of the plastics industry and one of the least understood. The empirical accelerated aging tests are not satisfactory. A more basic understanding of the reasons for deterioration will be of assistance in providing better products and in guiding the use of plastics into proper channels. The Government, as the largest user of plastics, would benefit immeasurably. At present, the degradation of polyvinyl chloride is being investigated.

Tasks: (1) Determine the resistance to chemicals, gas permeability, stiffness, and physical properties of plastic films. (2) Investigate the effects of hydroperoxide groups on the degradation of polyvinyl chloride.

0803-10-4120 Investigations of Fractures in Welded Ships

Objectives: To conduct metallurgical examinations on plates from fractured ships for evidence bearing on the cause of failure.

Background: For several years the NBS Metallurgy Division has conducted examinations of plates from fractured ships at the request of the Ship Structure Committee. This work has resulted in important conclusions concerning the effect of the properties of the steel on the probability of failure. During the past year much of the effort has been spent on analysis of data and writing of summary reports, with the result that a large backlog of plates are now on hand awaiting test. The results of these examinations will provide additional experimental evidence of the correlations which have been observed and will be of value to the industry by providing a record of the detailed information on recent ship fractures.

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.

Background: (A) The mechanism of corrosion processes has never been completely understood. Stress corrosion, in particular, is quite baffling in its inception and progression. In certain metals it starts and proceeds along grain boundaries, in other metals it avoids boundaries and proceeds across grains. This phenomenon is being studied to develop a working theory for this type of corrosion. (B) Pitting corrosion is a different type of phenomenon. Its mechanism is not understood any better. (C) Galvanic corrosion implies not only couples of unlike metals but also metallic surfaces where difference in potential exists because of corrosion products, non-metallic inclusions, segregation, etc.

0907-10-0917 Effect of Heat on Crystal Structure of Inorganic Minerals

Objectives: To determine the mechanism of crystal formation in the solid state after decomposition of hydrates or carbonates.

Background: The complex changes which crystals undergo between dehydration (or decarbonization) and new crystal formation is not well understood. This phenomenon is important in clays, refractories, and in crystal chemistry. This work will add to knowledge of solid state reactions, the structure of hydrates, and to the mechanism of approach to equilibrium.

Tasks: (1) A paper on the calcite-type carbonates will be written and the study completed of the aragonite-type carbonates. (2) A study will be made of thermal effects in amphiboles, zeolites, and hydrogarnets.

0908-10-0923 Thermochemistry of Mineral Products

Objectives: Determination of the thermochemical relations of compounds occurring in mineral products.

Background: Thermodynamic data are scanty or lacking for most of the substances occurring in mineral products or in related systems of oxides. Such data are needed for understanding the energy relations and determining the stability of the compounds controlling the behavior of mineral products. Additional data is also desirable for a better understanding of the heat evolved in the setting of cements in mass concrete.

Tasks: (1) Preparation of compounds in the system  $MgO-MgCl_2-H_2O$  and determination of their heats of formation. (2) Preparation of compounds in the system  $CaO-Al_2O_3-H_2O$  and determination of their heats of formation. (3) Completion of construction of decomposition-pressure apparatus and measurement of the decomposition pressure of hydrated minerals, specifically  $Mg(OH)_2$  and compounds prepared in above tasks.

1000-30-4801 Properties of Building Materials

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

1000-10-4803 Building Technology Services

Objectives: To provide building technology services of a specialized nature, financed by small-scale transfer funds, to various agencies of the Government.



## SURFACE FINISHES AND COVERINGS

### 0201-20-0203 Spectrophotometry and Colorimetry

Objectives: To develop and maintain spectrophotometric standards, to study improvements in spectrophotometric instruments and techniques, particularly for the standardization and specification of color and the determination of the permanence of standard samples of ceramics, glasses, pigments, paints, papers, plastics, textiles, and other materials of special interest in colorimetry.

Background: Spectrophotometry is the only fundamental basis for the analysis, standardization, and specification of color. It is also a research and analytical tool in physics, chemistry, engineering, and technology. The color of a standard sample is always of questionable permanence, and spectrophotometric information concerning the change of color of these standards is required in art, industry, and science.

Tasks: (1) Spectrophotometric and colorimetric permanence study of nitrocellulose paint deposits, NBS Standard Samples of Paint Pigments, Artists' Oil Paints, light-sensitive papers, and other materials subject to natural and accelerated weathering including the effects of radioactive irradiation on human and building materials. (2) Specification of special sets of material colors such as signal target enamels and glasses, safety color code for physical hazards, radiation hazard warnings and other colors related to safety. (3) Spectrophotometric study of optical glasses, species of foliage, eggs, skin, teeth, blood, hair, crops, sand, and other materials.

### 0501-30-0501 Preparation and Revision of Federal and Other Specifications for Paints, Varnishes, Lacquers, and Ingredient Materials

Objectives: To prepare, revise, or amend when necessary, Federal Specifications for (1) paints, enamels, varnishes, lacquers, putties, and similar coatings and filling materials; (2) ingredient raw materials including pigments, oils, resins, driers, thinners, plasticizers, and solvents; and (3) methods of testing, paint colors, and other special organic coatings requirements. Also, to participate in the specification work of Committee D-1, ASTM, and of the ISO Committee on Shellac, and to assist Government agencies in the development of departmental specifications for special products.

Background: This project is a part of the continuing NBS program of cooperation with Government and technical organizations in the development of adequate procurement specifications and testing methods.

0904-20-0908 Development of Evaluation Criteria for  
Porcelain Enamels

Objectives: To develop laboratory test procedures by which commercially important properties of porcelain enamels and enameled items may be evaluated; to evaluate test methods by comparison of laboratory results with performance data, providing a basis for selection of test procedures giving the most reliable criteria of performance in service, particularly by aqueous solutions encountered in service.

Background: Work on the development of standard tests for porcelain enamels has continued at NBS since 1934. Industry has cooperated through the research associateship maintained by the Porcelain Enamel Institute. Tests developed have been adopted by the PEI as standards and by the ASTM as standards. A procedure for evaluating tests in terms of service conditions is an indispensable part of any test development program, and in this case it is being arrived at by actual service testing of various porcelain enameled items. A basic knowledge of the structure of porcelain enamels, particularly of the structure of the surface layer, and the mechanisms by which this structure is destroyed in service, is necessary to develop laboratory tests which form the best basis for predicting relative service life.

Tasks: (1) Make field inspections of installations at Fall River, Mass., Cambridge, Mass., and Toledo, Ohio. Organize and reduce data obtained, and start correlation of field data with results of laboratory tests. (2) Establish conditions to be recommended for testing porcelain enamels for alkali resistance. (3) Make limited exploratory investigations into the mechanism of attack of alkaline solution on porcelain enamels.

0904-10-4412 Mechanism of Adherence of Ceramic Coatings to Metals

Objectives: To investigate ceramic coatings and, in particular, to obtain a fundamental insight into the adherence mechanism.

Background: Early work on this project yielded ceramic coatings that are currently being applied in substantial volume to production parts including many aircraft components. While these coatings improve service life of the parts, they suffer from certain deficiencies that restrict their widest acceptance and use. The development of a suitable and consistent adherence of the coating to the alloy is one of most pressing problems. Progress toward solution of the adherence difficulties has been hindered by a lack of information concerning the fundamental mechanisms. Considerable progress was made during fiscal 1952 and 1953. Continued work should lead to an ultimate solution of the adherence problem.

Tasks: (1) Determine the effect of the oxygen content of the firing atmosphere on the adherence of ground coats to steel and of ceramic coatings to alloys. (2) Determine how copper oxide improves adherence of ceramic coatings to stainless steel without increasing surface roughness. (3) Determine bond mechanism of coating for molybdenum consisting of CrB-Ni glass and investigate effect of coating composition and durability. (4) Determine correlation, if any, between oxygen permeability of a coating as determined with the recording balance and its electrical conductivity.

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

Objectives: To determine the properties of floor, roof, and wall covering materials and to formulate specifications and safety codes applicable thereto.

Background: (A) The principal roofing materials used in this country contain asphalt. Since the deterioration of such roofing materials is closely associated with the degradation of the asphalts, the work on roofing materials, at present, consists primarily of fundamental studies of the degradation of asphalts and of methods of retarding this process. The work on this subject at the NBS since 1946 has been carried on in collaboration with the Asphalt Roofing Industry Bureau. (B) Another phase is development of specific tests for evaluating properties of flooring materials and the establishment of requirements for specifications and safety standards. This work is necessary in light of the development of new flooring materials and processes since publication of the Bureau's extensive investigations along these lines in the period 1939-1943. (C) Modern practices of tight construction and the increased use of insulation and air conditioning have emphasized the importance of moisture control in structures. Water-vapor barriers are one means of exercising such control. Requests from other agencies of the Government for information on the water-vapor permeance of structural elements and coating materials necessitates basic work by the Bureau in this field.



Tasks: (A) Roofing Materials: (1) Assemble and calibrate micro-combustion apparatus to follow the shift in the composition of the components of asphalt as they degrade under exposure to light and water. (2) Develop methods for following the physical changes which take place in asphalts during degradation. (3) Write summary reports on the results obtained in the work on mineral stabilizers in asphalt coatings and prepare publications on these results. (4) Develop a macro method for the separation of weathered and unweathered asphalts into groups of components. (5) Develop a method of analysis for the functional groups in asphalts. (6) Develop test procedures for bituminous roofing, waterproofing, and road materials. (B) Flooring Materials: (1) Determine the resistance of flooring materials to abrasion and cleaning materials. (2) Study the antislip characteristics of floor surfaces and protective coatings. (3) Develop methods for evaluating the relative performance of flooring materials. (C) Coating Materials: (1) Preparation of a report for publication on work completed.

1004-40-4841 Maintenance of Waxed Floors

Objectives: Preparation of a floor maintenance manual with special emphasis on the proper use of floor waxes in protecting and satisfactorily maintaining different types of flooring materials found in Navy establishments.

Background: The wax industry has undergone considerable change in the past several years. Much emphasis has been placed on research and the development of new materials for floor polishes, some as additive materials to the commonly used water-emulsion waxes. An evaluation of present-day materials and recommendations for their safe and economical use are needed.

Tasks: (1) A study of literature and information now available on floor maintenance materials and procedures. (2) Inspection of floors for which cleaning and maintaining methods are known. (3) Limited laboratory investigations for specific properties of some materials such as slip resistance. (4) Preparation of floor maintenance manual.

1004-40-4842 Evaluation of Flooring Materials in Field Installations

Objectives: To determine by means of laboratory tests and pilot field installations, the most economically suitable flooring materials for Army kitchens.

Background: During the prosecution of the NBS project on Evaluation of Flooring Materials in Field Installations in FY 1953 (1004-40-4726), studies were made of various types of floors in Army buildings, and specific recommendations were made from the results of these studies. These showed that certain types of floors were satisfactory for use in Army kitchens. However, data showing the types of materials which might be economically suitable for this use were not obtained. This project is intended to obtain such information.

Tasks: (1) Investigation by laboratory means of the relative resistance of selected flooring materials to abrasion, alkalis, and grease. (2) Observation of the most favorable materials in pilot installations at a convenient Army base to be selected by OCE. (3) Preparation of final report and recommendations to OCE.

1004-40-4843 Revision of Roofing Manual

Objectives: Revision of War Department Technical Manual TM5-617, Roofing, Repairs and Utilities.

Background: War Department Technical Manual TM5-617, Roofing, Repairs and Utilities, published in June 1945, was prepared to deal mainly with roofing problems occasioned by wartime construction and conditions. Changed conditions and the development of new materials and procedures make desirable a revision of this manual to meet current needs.

Tasks: (1) Review current roofing literature and discuss methods of maintaining and repairing roofs with Army engineers and industry representatives. (2) Inspect roofs in Army buildings, particularly those which have been maintained or repaired by methods developed recently. (3) Prepare a revision of Technical Manual TM5-617, Roofing, Repairs and Utilities.

#### 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 photographic 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.

0501-30-3240 Analysis and Testing of Paint, Varnish, Lacquer,  
and Related Materials

Objectives: To test and analyze paints, varnishes, lacquers, enamels, and ingredient raw materials for compliance with specifications. Also to examine and evaluate organic coating materials for which no specifications exist, and to conduct special tests and investigations for regulatory agencies.

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

Objectives: Testing 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. Technical services of analytical, investigative, and advisory nature pertinent to regulatory or judicial functions of Government agencies.

Background: The services outlined are required by other Government agencies for procurement of materials and in carrying out their assigned functions.

Tasks: (1) Continuation of testing detergents, waxes, and related materials. (2) If time permits, study, improve, and develop methods for the analysis of products containing synthetic detergents. (3) Continuation of the identification, analysis, and evaluation of miscellaneous materials.

0506-20-0526 Permeability and Protective Value of  
Electroplated Coatings

Objectives: To develop and evaluate methods of measuring porosity in electroplated coatings and determine the cause and effect relationships.

Background: The protective value and life of plated coatings are considered to be related to the porosity of the coatings, but at present, the relation has not been satisfactorily determined due to the lack of a suitable method of measuring the porosity.

Tasks: (1) Exploratory experiments to determine feasibility of using radioactive isotopes to detect and measure porosity. (2) Further refinement of a photographic method of measuring porosity.



0702-20-0709 Development of Methods for Testing Textiles

Objectives: To develop new methods for evaluating the properties of textile fibers, yarns, fabrics, and products of importance to the Government and other users. To improve and standardize existing methods.

Background: A continuing effort is necessary to keep textile testing methods abreast of the needs of the Government and the public because of the novel properties of the products being developed, in particular, the synthetic fiber textiles. Rating of colorfastness to light continues to be a major problem and use of the NBS light-sensitive paper standards is growing and being extended to fields other than textiles. The widely recognized need for adequate laboratory tests for wear resistance of carpets has resulted in the cooperation of fiber producers, carpet manufacturers, and general interests, for a cooperative investigation with special emphasis on the NBS carpet-wear testing machine and carpets containing synthetic fibers.

Tasks: (1) Colorfastness to light: Continue to supply laboratories with calibration standards for fading lamps and put this service on the regular standard sample basis. (2) Carpet-wear tests: Reexamine the NBS carpet-wear testing machine and determine its applicability to carpets made from fibers other than wool.

0702-10-0731 Research on Properties of Textiles

Objectives: To investigate the reaction that occurs at the wet-dry interface of textiles that are partially immersed in liquid. To investigate the surface properties of textile fibers, especially the newer fibers, by nitrogen sorption, moisture sorption, and electron microscopy.

Background: Previous work at the NBS has shown that cellulose undergoes degradation at the wet-dry interface that results upon continuous immersion of one end of a long strip of cotton cloth in water. More recently, evidence of chemical reaction at the wet-dry interface has been obtained with nylon and acetate fabrics partially immersed in water and with cellulose, nylon, and acetate fabrics and quartz paper immersed in organic liquids. Wet-dry regions occur frequently on fabrics during processing and use. Hence, a knowledge of the reactions that occur in such regions is of practical as well as of theoretical interest, and should contribute to our knowledge of the structure of the fibers and to an understanding of the behavior of fibers in processing and use.

0705-30-0719 Preparation of Specifications and Standards  
(Organic and Fibrous Materials)

Objectives: To prepare specifications and standards for organic and fibrous materials, to review and coordinate such specifications for the General Services Administration and other agencies of the Government and for various technical organizations, and to establish and maintain standard samples of rubber compounding ingredients.

Background: This project covers the well-established practice of the NBS of cooperating with Government agencies in the preparation of specifications, test methods, and standards for organic and fibrous materials through leadership and membership on committees.

Tasks: One of the tasks is to prepare test method and commodity specifications for rubber and paper products, textiles, nontextile floor coverings, brushes, and brooms.

0707-10-3862 Relation of Properties and Adhesion of Components  
to Strength of Glass-Fiber Reinforced Plastics

Objectives: To evaluate the basic factors involved in obtaining high strength and durability in glass-fiber reinforced plastics so that the selection of components used in these constructions may be made on a rational rather than the present empirical basis.

Tasks: One of the tasks is to study the comparative degree of adhesion between glass fibers with various treatments and several types of resins using a microscopic technique to observe the wetting of the fiber with the liquid resin. Another task is to determine the strength properties of the glass fibers and the resins.

0906-30-4442 Miscellaneous Materials Testing

Objectives: To make acceptance tests on miscellaneous concreting materials, irrigation water, paints, detergents, metals, petroleum products, etc.

1000-30-4800 Testing Building Materials

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

## MISCELLANEOUS

### 0201-20-0205 Photometry

Objectives: To maintain and develop methods of photometry, visual and physical; to study the luminosity factors of the human eye by means which the candlepowers of lights of different colors are evaluated and luminous transmittance and reflectance are determined; to develop and maintain standards of candlepower, luminous flux, illumination, and luminances.

Background: The maintenance of the national units for photometric values is one of the basic functions of the NBS. Lamp companies, universities, and commercial laboratories throughout the country depend upon the lamp standards calibrated or issued by the Bureau.

### 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; standards of color transmittance, reflectance, opacity, gloss, and luminance.

### 0205-30-0225 Standardization of Screw Threads and Threaded Components

Objectives: The development of unified standards for screw threads and threaded products with Great Britain, Canada, and other inch-using countries; the development of standards for screw threads for use in the design of defense material and other threaded products used by the Government; the development of standards and specifications for bolts, nuts, screws, and other threaded or associated products.

### 1000-40-4802 Federal Construction Council

Objectives: To provide a mechanism for establishing a Federal Construction Council, an organization for the exchange of technical information between various Federal construction agencies, and for general improvement of construction technology in Government buildings and structures.

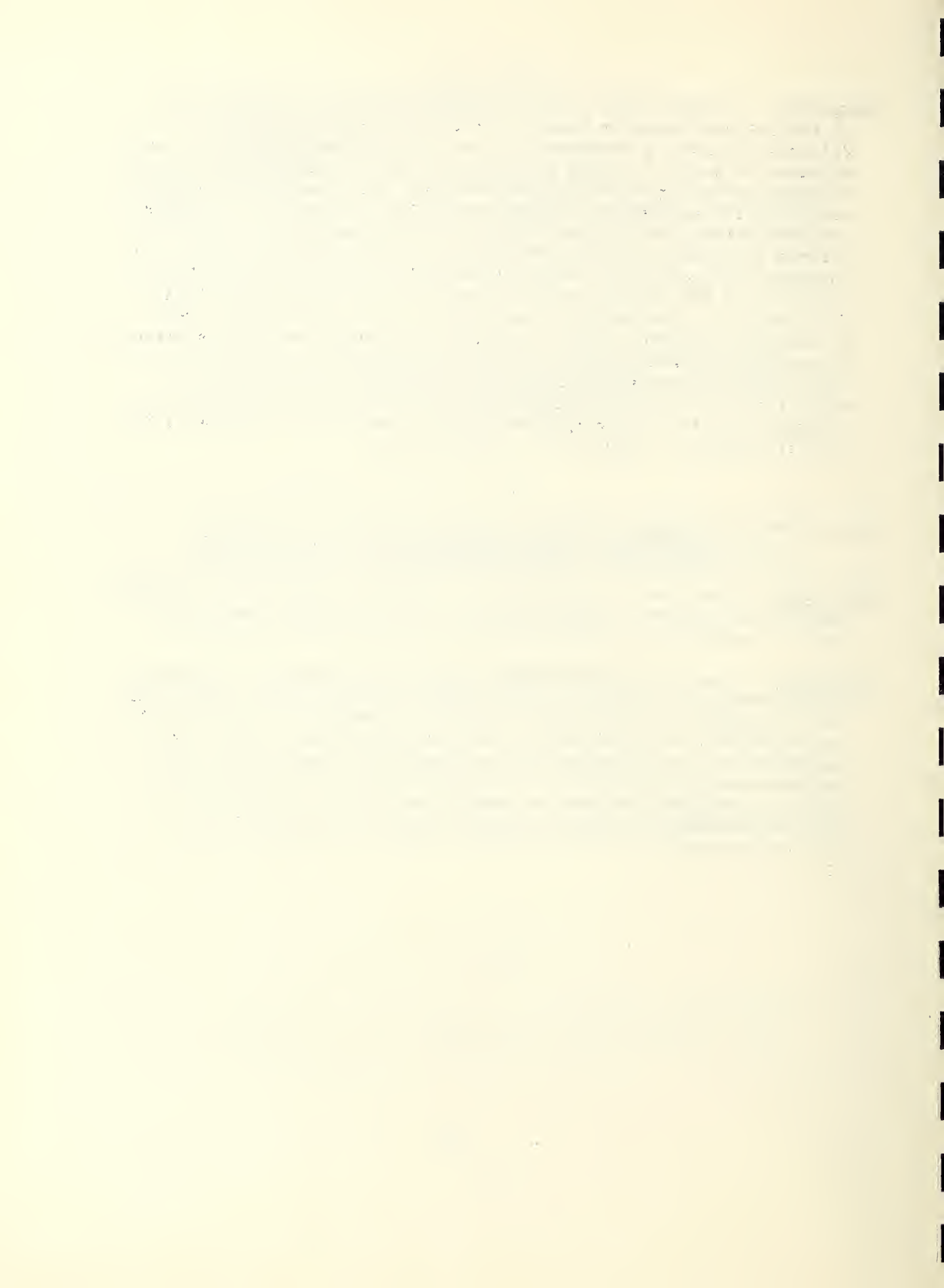


**Background:** In Fiscal Year 1952, the Building Research Advisory Board of the National Research Council, under the National Academy of Sciences, operated a mechanism for assisting Federal agencies in the solution of their technical problems in construction engineering and building technology by exchanging technical information and collaborating on building research. These activities were carried out under contract between the National Academy of Sciences and the Office of Defense Mobilization, but in FY 1953 the latter office was unable to continue the operation. Late in FY 1953 it was determined that continuation of the activity could be achieved only by securing funds from agencies concerned with construction, and the National Bureau of Standards was requested to continue the program using funds transferred to the Bureau by the participating agencies. A contract between NBS and the National Academy of Sciences was negotiated in which the Chief of the Building Technology Division of NBS was designated as the "Agency Representative" charged with responsibility for directing the conduct of the subject work.

3200-04-1752 Coordination of State and Local Weights and Measures Activities, Including Publications Related Thereto

**Objectives:** Promotion of uniformity and efficiency among State and local weights and measures jurisdictions as to laws, regulations, specifications, tolerances, testing methods, and enforcement procedures.

**Background:** Cooperation with weights and measures officials by members of the staff of the NBS dates back to the creation of the Bureau and the first National Conference on Weights and Measures in 1905. Publications of a technical weights and measures character have been issued by the NBS throughout the years promoting uniformity of requirements and procedures. The services rendered by the NBS in matters of weights and measures administration are the only activities of this nature carried on by the Federal Government in this particular field.



## THE NATIONAL BUREAU OF STANDARDS

### Functions and Activities

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

### Reports and Publications

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

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



