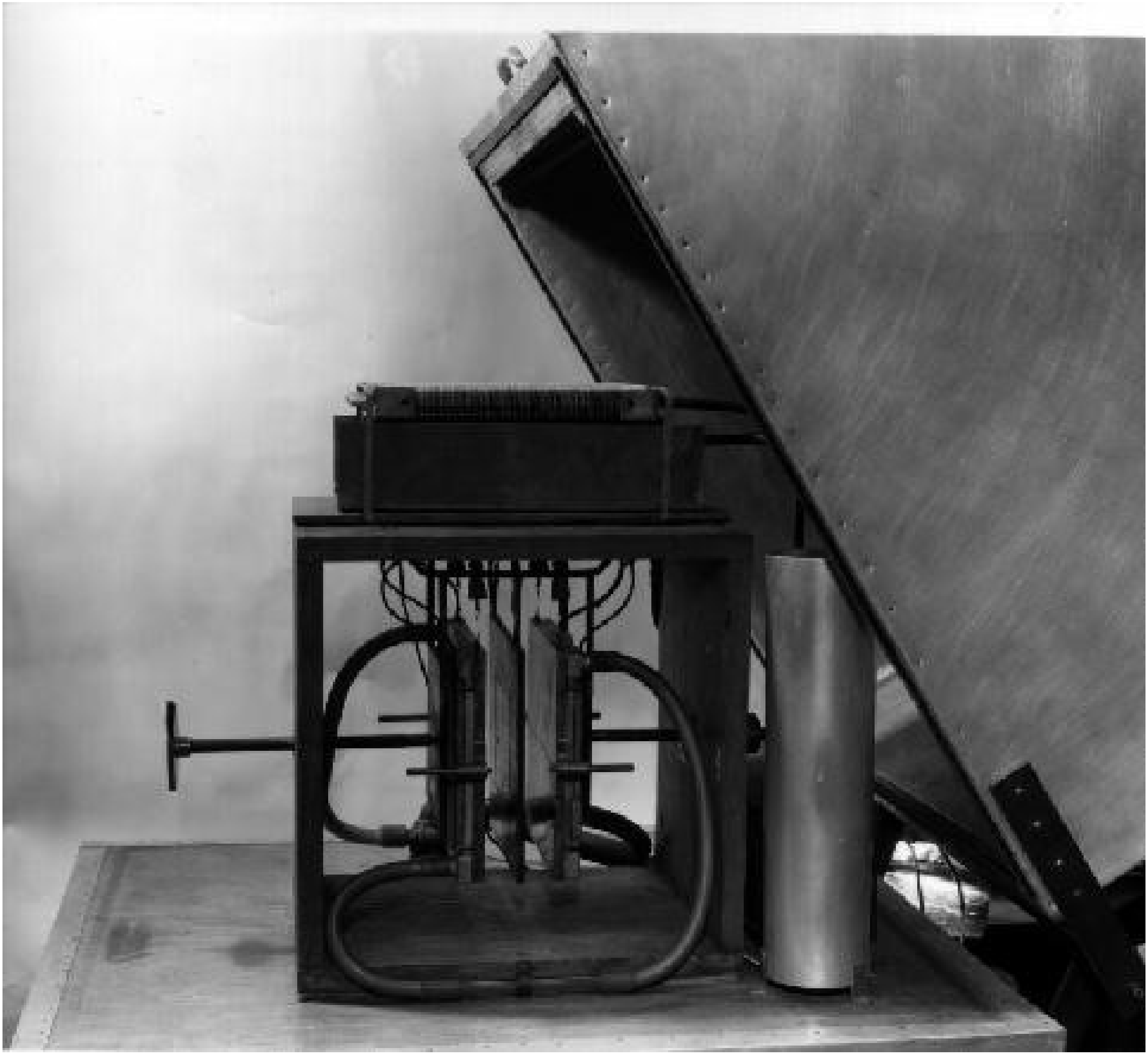
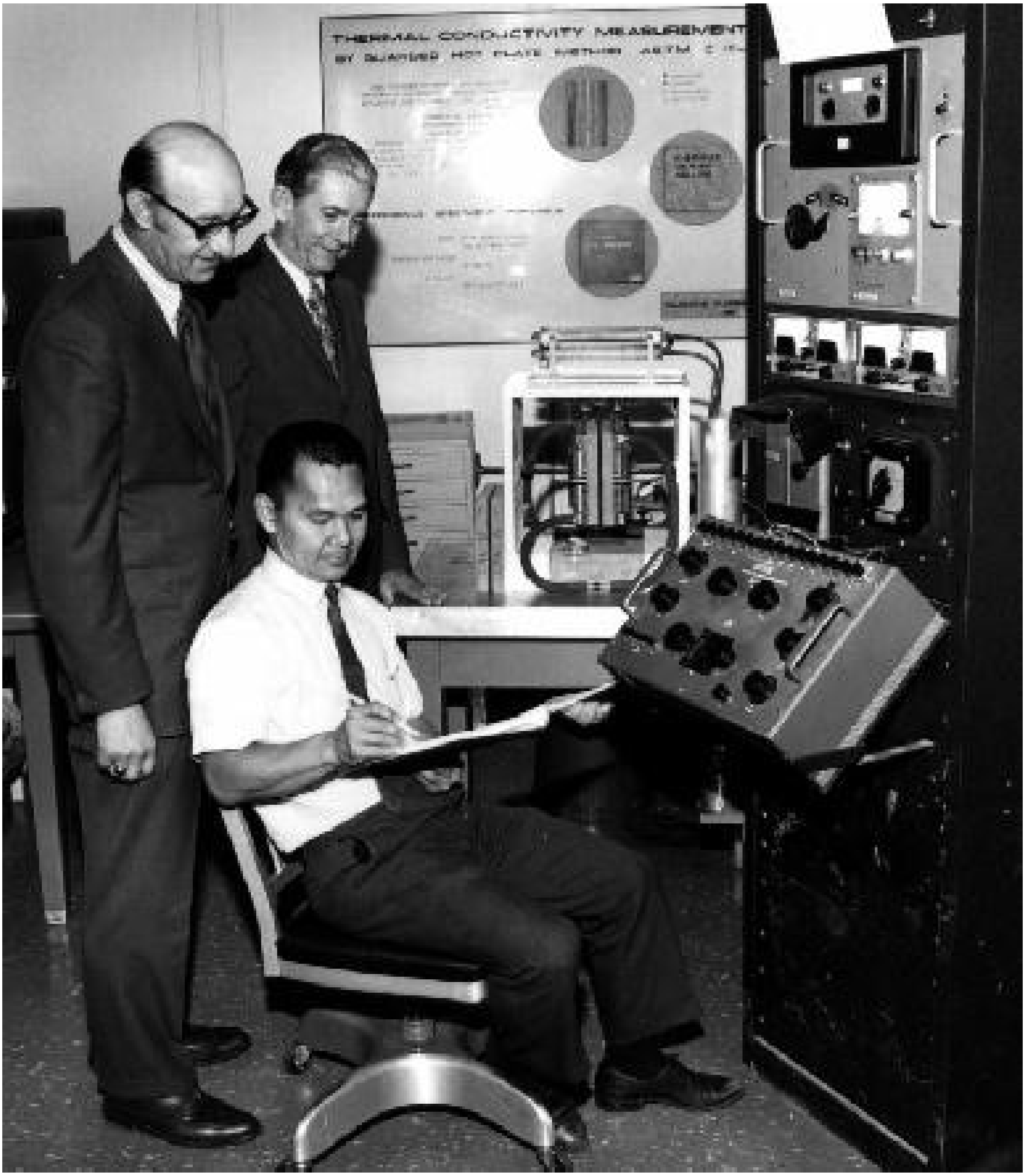
Photograph Gallery of NIST Guarded-Hot-Plate Apparatus

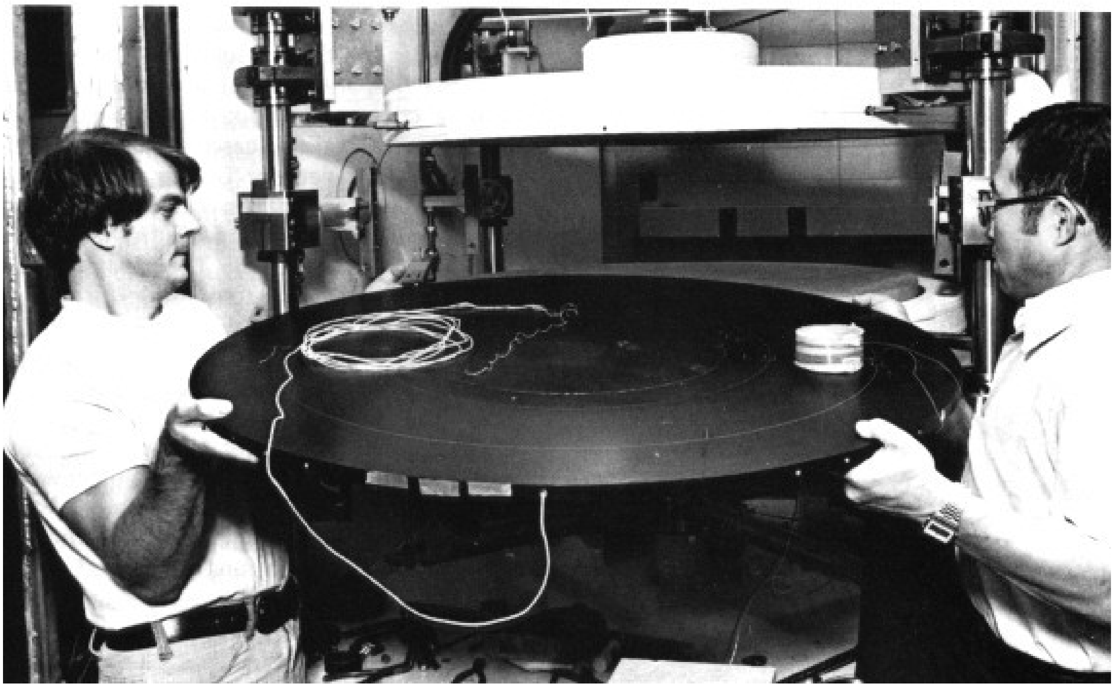
Welcome to the History of the Guarded-Hot-Plate Apparatus at NIST



1. Final version of NIST guarded-hot-plate apparatus built in 1929 by Van Dusen

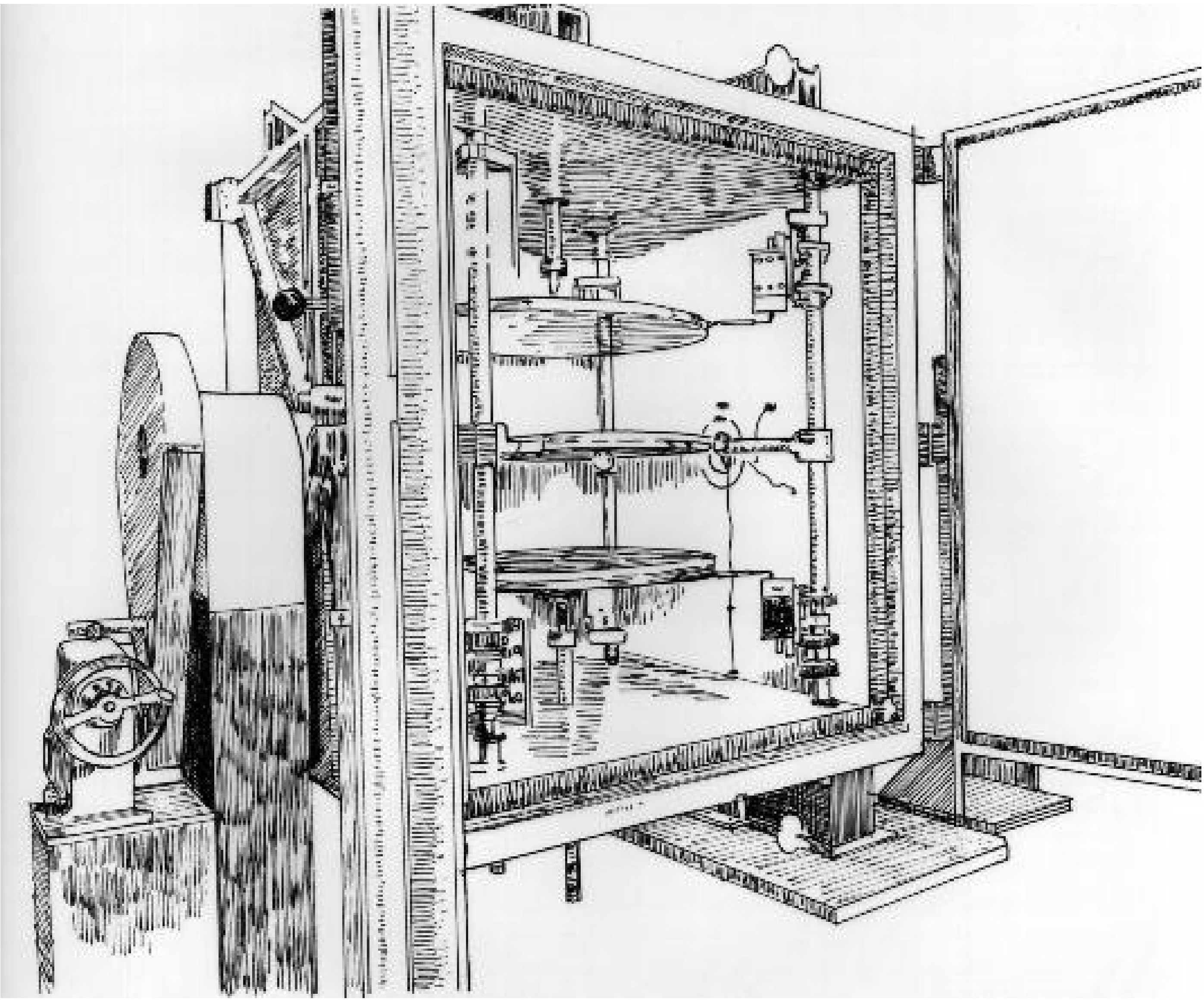


2. Chock Siu (sitting), Frank Powell (1), and Tom Watson in Front of 1929 NIST guarded-hot-plate apparatus (1973)



4. The circular "hot plate" being installed by Research Associate Dave Ober (1) and mechanical engineer Mahn HeeHahn

5. Technicians John McAuley (1) and Rick Petersen instrument the new 1000-mm guarded hot plate.



6. NIST one-meter line-heat-source guarded-hot-plate apparatus (198).

Early Guarded-Hot-Plate Apparatus

https://www.nist.gov/el/energy-and-environment-division-73200/early-guarded-hot-plate-apparatus

Early Guarded-Hot-Plate Apparatus

The earliest work at NIST (formerly the National Bureau of Standards) on heat transfer through thermal insulation and building materials began about 1910 following a request by the American Society of Refrigerating Engineers to provide the coordinated and usable data pertaining to heat transmission in insulation needed for design purposes. At the time, however, a precise method for measuring heat transmission through insulation was unavailable. In 1912, Dickinson conceived and built the first guarded hot plate apparatus at NIST for this purpose. Later, while traveling in Europe, he learned that Poensgen in Germany had been using a guarded hot plate for thermal conductivity measurements since 1910. Prior to the development of the guarded hot plate, heat transfer through insulation had been determined by methods in which heat was transferred through panels of insulation from warm air on one side to cool air on the other. The results of tests of this type were in many cases expressed as thermal conductivities, but are now defined as thermal transmittance values.

The first important publication in this field by Dickinson and Van Dusen in 1916 was described as containing accurate determinations of heat flow through air spaces and through 30 insulating materials. This publication also promoted the usage of standard terminology for thermal transmission measurements obtained by means of the hot plate method. Subsequent measurements of insulating materials were reported by Van Dusen in 1920 and Van Dusen and Finck in 1928 using similar apparatus. During these years, NIST continued to improve and standardize the hot plate method. About 1929, Van Dusen built what was to be the final version of this type of guarded-hot-plate apparatus. This particular apparatus operated consistently for NIST for more than fifty years until 1983. In 1987, the apparatus was officially relocated under the guardianship of the NIST Museum for preservation and display.

In 1945, the American Society for Testing and Materials formally adopted the guarded-hot-plate method as a standard test method based, in part, on NIST's design. In 1947, Robinson and Watson extended the temperature range of the guarded hot plate apparatus and in the next few years completed the first interlaboratory comparison of thermal conductivity tests of insulations among laboratories, jointly sponsored by the American Society of Heating and Ventilating Engineers and NIST. This series of tests clearly demonstrated the need for suitable means to calibrate the apparatus of industrial and other laboratories. Shortly thereafter a program was devised for supplying to industry measured samples of suitable insulating materials for calibration purposes. By 1977, more than 300 laboratories had been served, resulting in considerable improvement in the quality of thermal conductivity data on insulating and building materials reported in technical journals and handbooks.

Line-Heat-Source Guarded-Hot-Plate Apparatus

In 1964, Robinson first presented the basic design of the line-heat-source guarded hot plate to a thermal conductivity conference sponsored by the National Physical Laboratory in England. The design was reported in Nature (1964) as follows:

H.E. Robinson (U.S. National Bureau of Standards) discussed forms of line heat sources that could be used as heaters in apparatus for measurements at lower temperatures on insulating materials in disk and slab form. These new configurations lend themselves more readily to mathematical analysis, they are more simple to use and would appear to be able to yield more accurate results.

The design was novel. In contrast to a (conventional) guarded hot plate that used uniformly distributed heaters, line-heat-source guarded hot plates utilized circular line-heat sources at precisely specified locations. By proper location of the line-heat-source(s), the temperature at the edge of the meter plate can be made equal to the mean temperature of the meter plate, thereby facilitating temperature measurements and thermal guarding. The benefits offered by a line-heat-source guarded hot plate included: simpler methods of construction; improved accuracy; simplified mathematical analyses for calculating the mean surface temperature of the plate as well as determining the errors resulting from heat gains or losses at the edges of the specimens; and, use under vacuum conditions.

In 1971, Hahn conducted an in-depth analysis of the line-heat-source concept and investigated several design options. The design, mathematical analysis, and uncertainty analysis for a prototype line-heat-source guarded-hot-plate were published in 1973 by Hahn, Robinson (posthumously), and Flynn. Construction of the prototype apparatus was completed in 1978 and described by Powell and Siu. The performance and uncertainty analysis were published in 1981 by Siu and Bulik. Because of the promising results from the prototype, NIST began plans for a second, larger line-heat-source guarded hot plate apparatus. Construction of this apparatus was dramatically hastened due to a ruling by the U.S. Federal Trade Commission in 1980 concerning the labeling and advertising of home insulation.

Near the end of 1980, the second line-heat-source guarded-hot-plate apparatus was completed under the efforts of Hahn and Peavy of NIST and Ober, a guest worker from private industry. Almost immediately, measurement services for the public began early in 1981 with the laboratory providing the first full thickness reference materials comprised from a low-density glass-fiber thermal insulation. From 1981 to 1996, more than 75 measurements have been provided. This apparatus eventually replaced the earlier guarded hot plate apparatus that was constructed in 1929 and is still in service today. In 1996, the American Society for Testing and Materials (ASTM) formally adopted the line-heat-source concept as a standard practice based, in part, on NIST's design. The ASTM standard also includes an adjunct with blueprints of both the NIST prototype and second-generation line-heat-source guarded hot plate apparatus.

In addition to measurement services for the public, the guarded-hot-plate apparatus has been used to develop Standard Reference Materials (SRMs) for thermal resistance. The Standard Reference Materials Program at NIST provides a valuable service for achieving measurement quality and traceability to national and international standards by distributing over 1300 Standard Reference Materials (SRMs) including several thermal insulation SRMs. The motivation for thermal insulation SRMs began in the 1970's when the American Society for Testing and Materials Committee C-16 on Thermal Insulation published a recommended plan advocating the establishment of an SRM thermal insulation program. In response, from 1979 to 1987 NIST, in a coordinated effort with the U.S. Department of Energy, completed measurements for characterizing three thermal insulation SRMs including fibrous-glass board, fibrous-glass blanket, and fumed-silica board. More recently, in 1996, NIST has established an expanded polystyrene board SRM for standard window test methods. These thermal insulation SRMs were established based on data obtained from the guarded hot plate apparatus described above.

Guarded-Hot-Plate Apparatus Home

Biographies of Distinguished NBS Researchers

https://www.nist.gov/el/energy-and-environment-division-73200/biographies-distinguished-nbs-researchers

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Several prominent scientists and engineers spearheaded the development of the Guarded-Hot-Plate Apparatus.

Hobart Cutler Dickinson
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Volume 40., No. 8, June 15, 1950

Hobart Cutler Dickinson was retired in 1945 at the legal age limit of 70, after having served 40 years as a physicist at the National Bureau of Standards. This emeritus rating gave him the opportunity to put his youthful energy into a new research of his own choosing. This he enjoyed for four years until cancer ended his career on November 27, 1949, only a few weeks after he had started the final plans for the sequel to his earlier book in the field of economics.

Dickinson was born in Bangor, Maine, on October 11, 1875. Although he descended from a line of Congregational ministers, he said from his early boyhood that he wanted to be an inventor. In 1880 his parents left New England to live in the Central States; but in 1890 his father returned to Massachusetts and the boy, then 15, made the trip from Nebraska in a freight car with the family belongings, including two horses that had to be fed and watered. During the trip the car was in a wreck that demolished the animal stalls, and the young lad had to use his inventive ability to get at the tools and repair the damage.

In 1900 he was graduated from Williams College and continued there under Dr. C. W. Waidner to get his M.A. in 1902. He spent the next year at Clark University under Prof. A. G. Webster and returned there in 1910 to get his Ph.D. In 1903 he followed Dr. Waidner to the National Bureau of Standards and in the next ten years was the co-author of several fundamental papers on thermometry. His doctor's thesis was on combustion calorimetry, and his design of calorimeter, with some refinements, is still yielding the most accurate results attainable today. From 1912 to 1917 he was in charge of work at the Bureau of Standards on the constants of refrigeration in a program sponsored by the American Society of Refrigeration Engineers. He contributed to this program as coauthor of papers on the calorimetry of ice and on the thermal conductivity of insulating materials.

At the onset of World War I, the bureau director, Dr. Stratton, asked him to assist in the development of aircraft engines, and he participated in the design of the Liberty Engine, which was one of the engineering triumphs of that time. Dickinson organized the aeronautical powerplant section of the heat division in 1917 and was largely responsible for the design and operation of the first altitude chamber in which full-sized aircraft engines were tested under conditions simulating altitudes up to 35,000 feet. After the war the activities of the section were expanded to embrace automobiles and their behavior on the road, including the performance of headlights and brakes. One of his many articles in this period was entitled "What is Safe Speed?" wherein he established the "clear course rule" which has become accepted in several States as the basic element of traffic regulations. He was instrumental in getting the automotive and petroleum industries to cooperate in research on the mutual adaptation of engines and fuels. >From 1921 to 1923 he organized and directed the research department of the Society of Automotive Engineers at the headquarters in New York City, and in 1933 he was president of that society.

In 1923, after the death of Dr. Waidner, he returned to the Bureau of Standards as chief of the Division of Heat and Power and continued in that capacity until his retirement. During this period he devoted special attention to the power part of the division and organized it into separate sections on automotive research, aircraft engines, and lubrication.

About 1930 he began a study of the factors involved in economic depressions. He applied the physicist's mathematical analysis to economics and constructed a mechanical analogy to illustrate it. This study led to the publication, in 1937, of his book "The Mechanics of Prosperity".

After his retirement in 1945, he returned to NBS as a guest worker and worked on ceramic coatings for rockets and continued his studies on thermal conductivity of insulating materials. He found time, however, to serve on the President's Traffic Safety Council and to enjoy his hobby of mountain hiking.

Dickinson was an ardent hiker and preferred to spend his vacations in the mountains. In his later years he served the Potomac Appalachian Trail Club in its program of shelter building. On his first trip to the Canadian Rockies with the Alpine Club of Canada he took only a small spare blanket and water-repellent sheet when he should have taken all his own bedding. Confronted with bleak prospects he remembered his measurements on insulating materials and with his usual resourcefulness gathered balsam boughs in considerable quantity to put between his blanket and his sheet. The result astonished him, and he soon learned that a relatively small thickness of balsam furnished sufficient insulation to keep him pleasantly warm even on freezing nights.

He was married in 1903 to Elizabeth S. Wells, who died in 1921. He was married again in Scarborough, England, to Mabel V. Kitson in 1923. Their daughter Anne and her husband, Hugh N. Ross, have carried on the scientific tradition of the family. Both graduated in physics at the University of Maryland. Ross is now continuing the research on the thermal conductivity of high temperature insulators that Dickinson chose after his retirement.

Henry Emmons Robinson
NBS Energy Conservation Expert, Dies at 61
Reprinted from the U.S. Department of Commerce News, NBS TRP 9148

Henry Emmons Robinson, a foremost expert in the area of energy conservation and a staff member of the National Bureau of Standards, U. S. Department of Commerce for 35 years, died December 4, 1972 as a result of a fall. He was 61 years old.

A native of New York City, Mr. Robinson was educated at the College of the City of New York (B.S. and M.E., mechanical engineering). From 1933-37, he was employed as an engineer with the Phelps Dodge Copper Products Corporation. In 1937 he joined the National Bureau of Standards, and by 1957 had become Chief of the Heat Transfer Section. In 1965 he was appointed Chief of the Environmental Engineering Section, and in 1968 was named to the post of Senior Research Fellow, which he held until his death.

During his NBS career, Mr. Robinson was primarily concerned with the development and improvement of techniques for measurements of heat transfer, vital to the progress of modern building technology. He also directed experimental activities involving air conditioning, heating and refrigeration, psychrometrics, architectural acoustics, air cleaning, plumbing, and underground facilities. He served as consultant and expert in the field of environmental engineering generally.

In 1956 he received the Commerce Department's Silver Medal for Meritorious Service for comprehensive measurements and publication on the thermal insulating value of air spaces, of importance in connection with buildings and the use of reflective insulating materials.

Mr. Robinson has been honored twice by the American Society for Testing and Materials. In 1970 he received the ASTM Award of Merit for significant developments and improvements in the techniques of measurements of heat transfer and thermal conductivity which brought international recognition to the Society's voluntary standards for evaluation of thermal resistances of materials and constructions.

In October of this year, ASTM Committee C-16 on Thermal and Cryogenic Insulating Materials presented Mr. Robinson with an "Award of Appreciation" for his services to the Committee and to ASTM.

In addition to being a long-time member of ASTM, Mr. Robinson was a member of the International Institute of Refrigeration, the International Union of Testing and Research Laboratories for Materials and Structures, the American Association for the Advancement of

Science, the American Society of Heating, Refrigerating and Air Conditioning Engineers, and the Washington Academy of Sciences. He is listed in American Men and Women of Science.

The author of a number of technical papers in his field, Mr. Robinson was a major contributor to two recent publications of the White House Office of Consumer Affairs: "Seven Ways To Reduce Fuel Consumption in Household Heating..... Through Energy Conservation," and "Eleven Ways to Reduce Energy Consumption and Increase Comfort in Household Cooling." In 1969 he was appointed to a term on the Bureau's Washington Editorial Review Board.

During the last six months, he worked on a report of the Department of Housing and Urban Development sub-panels of the Committee on Energy Research and Development Goals of the Federal Council of Science and Technology.
