NATIONAL BUREAU OF STANDARDS REPORT

5208

A STUDY OF RM-42R CELLS

By

Earl M. Otto

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS

A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

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

- Office of Basic Instrumentation
- Office of Weights and Measures

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

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

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

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A STUDY OF RM-42R CELLS

Manufactured by

P. R. Mallory & Co., Inc.

By

Earl M. Otto

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

A STUDY OF RM-42R CELLS

1. INTRODUCTION

The tests described in this report were carried out to determine if the use of RM-42R mercury primary cells would provide a practical source of electrical energy for operating certain types of lights required by the Bureau of Aeronautics. This type of cell had previously given evidence of unusual shelf life which would be of great advantage in these applications but insufficient information was available on the performance characteristics at low temperatures and relatively low discharge rates.

2. MATERIAL SUBMITTED

Eighty cells manufactured by P. R. Mallory in February 1956 were supplied at the time the request for test was made. Approximately one month later ninety new cells (about one month old) were brought in. The RM-42R cells are equal in size to D size Leclanche dry cells, being nominally 2 1/4 inches high by 1 1/4 inches in diameter.

3. TESTS REQUESTED AND MADE

At first it was requested that cells be discharged initially and after six months storage at +21°C. The older cells which were then eleven months old, were intended to be used in setting up the tests and making preliminary discharges. As will be shown later, the results of the preliminary discharges agreed so closely with the tests on the new cells that it was agreed the six months delayed tests would add little information.

The program of testing involved the intermittent discharge of individual cells (run in triplicate) for periods of 4 hours on discharge and 20 hours off. Three rates of discharge were adopted. These discharges were to be through constant resistances chosen to result in drains of about 0.2, 0.4 and 0.6 ampere. The required resistances were found to be 5.55 ohms, 2.7 ohms and 1.7 ohms. Discharges were scheduled to be conducted at +21°, 0°, -20° and -40°C. Here, too, a modification of the plans had to be made. The performance was found to be so low at 0°C that plans for -20° and -40°C were abandoned and discharges at -10°C on only the lighter drains were substituted. 4-ohm discharges were also made because of the ready availability of the corresponding resistors and because they would fall between the light and the medium drains. For all discharges a voltage of 1.00V. was taken as the end voltage.

4. RESULTS OF TESTS

Data observed during these discharges and the results calculated from them are shown in the appended table. A graph was made from the average of the three-cell results for each discharge test. One of these graphs, plotted for the one month old cells discharged at +21°C through 5.55 ohms, is included in this report as figure 1. The initial closed circuit voltage for the first day of discharge was not the peak voltage. One to five minutes were required to reach the peak. After the first day there never occurred the large initial upsurge, but the voltages then passed through a minimum at one half to one hour after the day's discharge began. Exception to this latter peculiarity occurred when the battery was nearing exhaustion.

There was very good agreement between the three cells used for each test. As long as the cells were above the 1.00V end-voltage, the three cells agreed with their average to within ± 1% at + 21°C and ± 2% at 0° and -10°C, with one exception. This exception was found among the 11-month old cells. This cell had either been discharged before being received for test or was defective in manufacture.

It is impossible to ascertain the condition of a cell by its open circuit voltage. Open circuit voltage readings were read each day before closure was made. The one-month old cells which had been discharged at +21°C through 5.55 ohms were kept on the program after the end voltage was reached. Six hours of discharge after the last cell had passed the end-voltage, the closed circuit voltage was as low as 0.27V, yet on open circuit the cells recovered to 1.34V. However, after the next four hours of discharge and 20 hours of rest the recovery was only to 1.32V, and one more cycle resulted in an average of 1.26V for the open circuit voltage. Thus, it is seen that the open circuit voltage remains substantially constant (on a 1000-ohm-per-volt voltmeter) until well over 14 ampere hours have been delivered.

Attention should be called to the fact that the electrical output of the RM-42R cell in both ampere hours and watt hours was greatly reduced by lowering the temperature or by increasing the current to 0.4 or 0.6 ampere and still further reduced by making both of these changes at the same time. The loss in output in the

change from 0.2 to 0.3 ampere is small indicating that scarcely any gain would be shown at lower current drain than 0.2 ampere (see fig. 2). The ampere-hour capacity on the 0.2-ampere discharge at 0° is only 2.8% of that at +21°C, and, at -10°C, it is only 0.4%.

5. CONCLUSIONS

At the completion of the tests the results were discussed with Mr. A. L. Lewis of the Bureau of Aeronautics. The concise summary given below supports the conclusion that the RM-42R cells could not be considered acceptable for the anticipated use because of the extremely unsatisfactory performance at low temperatures.

Nominal Current (Amp.)	0.2	0.4	0.6	0.2	0.4	0.6
Temperature °C	Ampere Hours			Relative capacities*		
+21	14.3	10.7	4.7	1.00	0.75	0.33
0	0.4	0.05	0.02	0.028	0.003	0.001
-10	0.06	-	-	0.004	-	-

* Values are fractions obtained by dividing the several ampere-hour capacities by the ampere-hour capacity for 0.2-ampere drain at 21.0°C

The study is being terminated and this is the final report.

EFFECT OF TEMPERATURE AND RESISTANCE ON THE CAPACITY OF RM-42R CELLS

Tests at +21°C					
Resistance of circuit, ohms		5.55	4.00	2.80	1.70
Age of cell, Mo.	1				
Hours to 1.00V		68.7	48.5	27.5	10.3
Av. voltage		1.130	1.115	1.10	1.05
Av. amperage		0.2036	0.2788	0.393	0.618
Av. ampere hours		14.0	13.5	10.8	6.4
Age of cell, Mo.	11				
Hours to 1.00V		70.6	48.5	27.6	7.6
Av. voltage		1.122	1.115	1.08	1.057
Av. amperage		0.202	0.279	0.386	0.622
Av. ampere hours		14.3	13.5	10.7	4.7
Tests at 0°C					
Resistance of circuit, ohms		5.55		2.70	1.70
Age of cell, Mo.	1				
Hours to 1.00V		1.95		0.13	0.03
Av. voltage		1.1		1.1	1.0
Av. amperage		0.2		0.4	0.6
Av. ampere hours		0.4		0.05	0.02
% of capacity at +21°C		2.8		0.5	0.4
Age of cell, Mo.	11				
Hours to 1.00V		2.1		0.12	0.03
Av. voltage		1.1		1.1	1.0
Av. amperage		0.2		0.4	0.6
Av. ampere hours		0.4		0.05	0.02
% of capacity at +21°C		2.8		0.5	0.4
Tests at -10°C					
Resistance of circuit, ohms		5.55	4.00		
Age of cell, Mo.	1				
Hours to 1.00V		0.32	0.15		
Av. voltage		1.11	1.07		
Av. amperage		0.20	0.28		
Av. ampere hours		0.06	0.04		
% of capacity at +21°C		0.4	0.3		

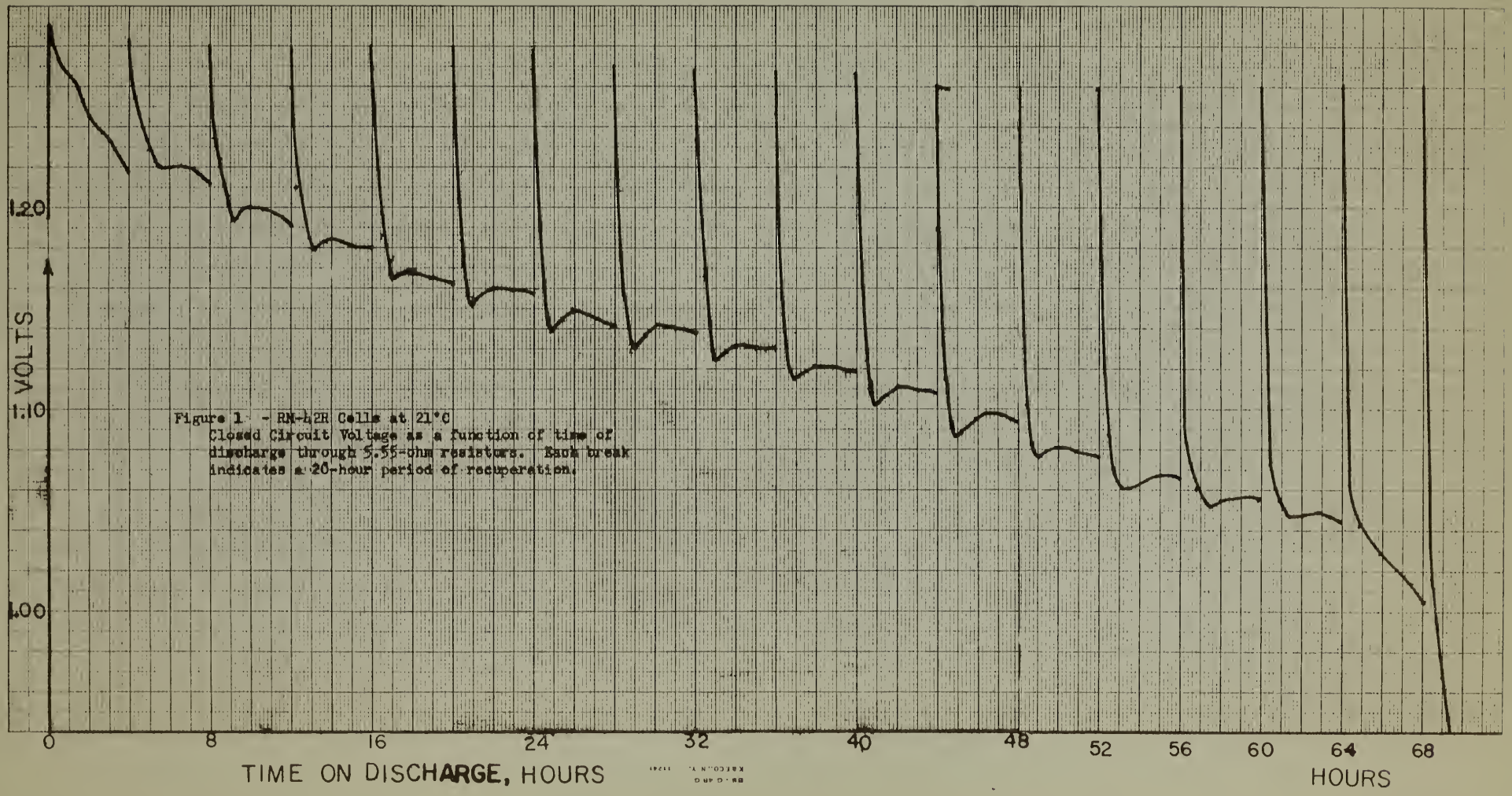
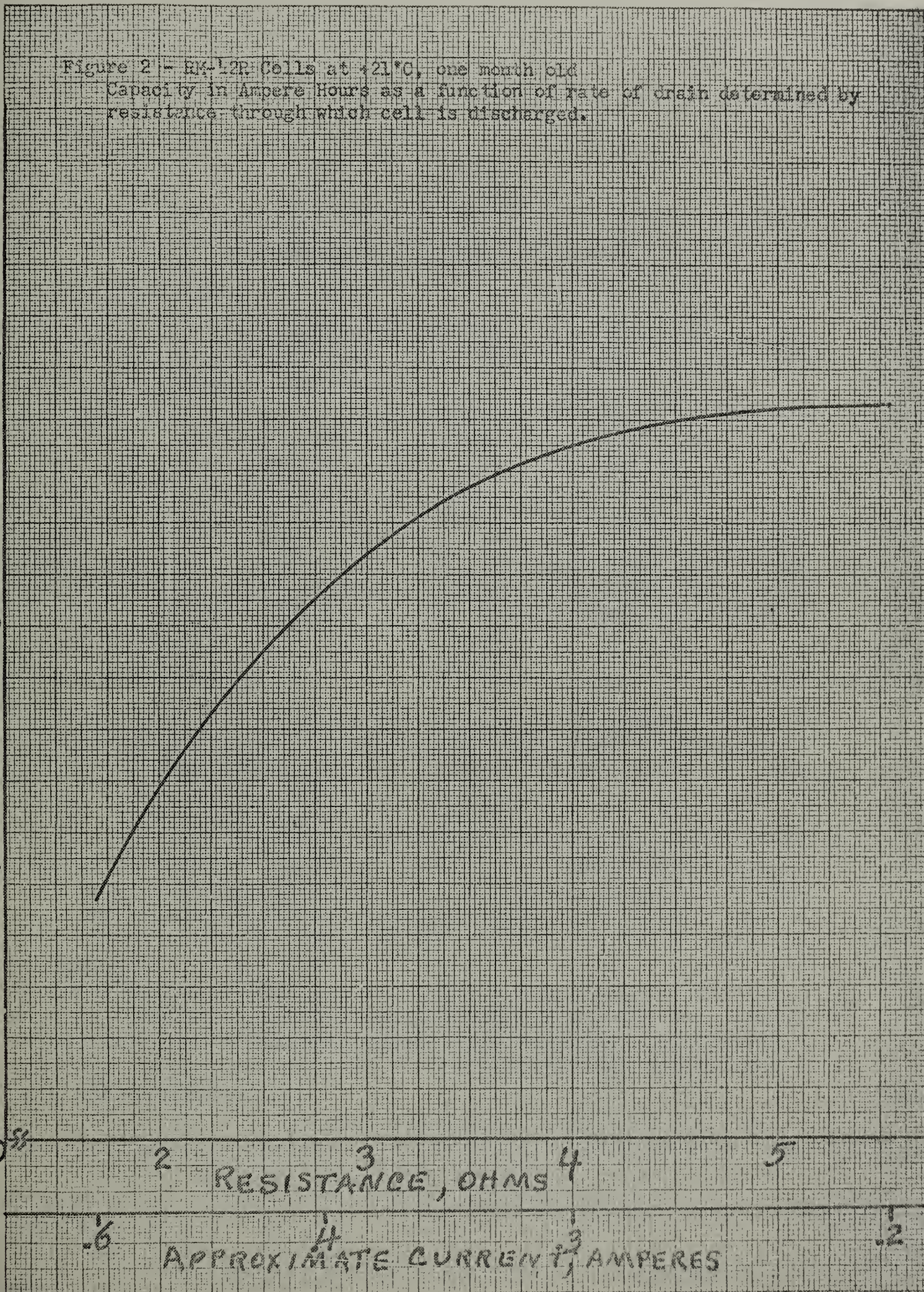


Figure 1 - RN-42R Cells at 21°C
Closed Circuit Voltage as a function of time of discharge through 5.55-ohm resistors. Each break indicates a 20-hour period of recuperation.

Figure 2 - EX-12R Cells at +21°C, one month old
Capacity in Ampere Hours as a function of rate of drain determined by resistance through which cell is discharged.



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.

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

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office. Inquiries regarding the Bureau's reports and publications should be addressed to the Office of Scientific Publications, National Bureau of Standards, Washington 25, D. C.


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